

Appendix IX

The Coincidence Unit Code

```
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--
-- COSMIC DETECTOR MACHINE
-- Coincidence  Module
--
-----
-- Project:    cosmics
-- File:
-- Description: Coincidence detection
--
-- History:
-- 7/02/03 SB: This file created
-- 25/02/03 SB: Improved for Buttons and Lights test
--
-----
```

```
library IEEE;
use IEEE.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
```

```
entity coincide is
port(
  clk_in   : in std_logic;      -- clock
  rst_in   : in std_logic;      -- reset
  hit_ch_in : in std_logic_vector(16 downto 1);
  button_in : in std_logic_vector(8 downto 1);
  leds_out  : out std_logic_vector(25 downto 1);
  veto_out  : out std_logic
);
```

```
);
```

```
end coincide;
```

```
-----
architecture bhv of coincide is
```

```
  signal clk, rst : std_logic;

  signal veto      : std_logic;
  signal hit_ch    : std_logic_vector(16 downto 1);
  signal button    : std_logic_vector(8 downto 1);
  signal leds      : std_logic_vector(25 downto 1);
  signal hit_pair  : std_logic_vector(8 downto 1);
  signal track     : std_logic_vector(4 downto 1);
  signal counter   : std_logic_vector(31 downto 0);
  signal gate      : std_logic;
  signal rising    : std_logic;
  signal led_event : std_logic;
  signal tebl_pb, tebl_led : std_logic_vector(7 downto 0);
  signal tebl_disp : std_logic_vector(15 downto 0);
  signal loopcount : std_logic_vector(4 downto 0);
  signal led_on1   : std_logic;
  signal led_off1  : std_logic;
```

```

signal led_on2      : std_logic;
signal led_off2     : std_logic;
signal led_on3      : std_logic;
signal led_off3     : std_logic;
signal led_on4      : std_logic;
signal led_off4     : std_logic;
signal led_on_timer  : std_logic_vector(25 downto 0);
signal led_off_timer : std_logic_vector(25 downto 0);

```

```
begin
```

```
    button <= button_in;
```

```
    -- This is needed as outputs cannot be read, but signals can.
```

```

    clk    <= clk_in;
    rst    <= rst_in;
    veto_out <= veto;
    leds_out <= leds;
    hit_ch  <= hit_ch_in;

```

```

--button 1 is 4 way coincidence
--button 2 is 3 way coincidence
--button 3 is 2 way coincidence
--button 4 is for no counting
--button 5 is for vertical counting
--button 6 is for 45 degree (track 2 and not 4) counting
--button 7 is for horizontal counting
--button 8 is for all counting

```

```

async_button : process (clk)
begin

```

```
    -- 4 Way coincidence with no counting
```

```
    if button(8 downto 1) = "10010000" then
```

```

        hit_pair(1) <= hit_ch(1) and hit_ch(9);
        hit_pair(2) <= hit_ch(2) and hit_ch(10);
        hit_pair(3) <= hit_ch(3) and hit_ch(11);
        hit_pair(4) <= hit_ch(4) and hit_ch(12);
        hit_pair(5) <= hit_ch(5) and hit_ch(13);
        hit_pair(6) <= hit_ch(6) and hit_ch(14);
        hit_pair(7) <= hit_ch(7) and hit_ch(15);
        hit_pair(8) <= hit_ch(8) and hit_ch(16);

```

```

        track(1) <= hit_pair(1) and hit_pair(5);
        track(2) <= hit_pair(2) and hit_pair(6);
        track(3) <= hit_pair(3) and hit_pair(7);
        track(4) <= hit_pair(4) and hit_pair(8);

```

```
        counter <= "00000000000000000000000000000000";
```

```
    elsif button(8 downto 1) = "10001000" then
```

-- 4 Way coincidence with vertical counting

```
hit_pair(1) <= hit_ch(1) and hit_ch(9);
hit_pair(2) <= hit_ch(2) and hit_ch(10);
hit_pair(3) <= hit_ch(3) and hit_ch(11);
hit_pair(4) <= hit_ch(4) and hit_ch(12);
hit_pair(5) <= hit_ch(5) and hit_ch(13);
hit_pair(6) <= hit_ch(6) and hit_ch(14);
hit_pair(7) <= hit_ch(7) and hit_ch(15);
hit_pair(8) <= hit_ch(8) and hit_ch(16);
```

```
track(1) <= hit_pair(1) and hit_pair(5);
track(2) <= hit_pair(2) and hit_pair(6);
track(3) <= hit_pair(3) and hit_pair(7);
track(4) <= hit_pair(4) and hit_pair(8);
```

```
if rst = '1' then
```

```
    counter <= (others => '0');
    gate    <= '0';
    rising  <= '0';
```

```
elsif rising_edge(clk) then
```

```
    gate <= track(1);
```

```
    if (track(1) = '1' and gate = '0' and veto = '0') then
        rising <= '1';
    else
        rising <= '0';
    end if;
```

```
    if rising = '1' then
        counter <= counter+'1';
```

```
    end if;
end if;
```

```
tebl_disp <= counter(25 downto 10);
tebl_led  <= tebl_pb;
```

-- 4 Way coincidence with 45 degree counting

```
elsif button(8 downto 1) = "10000100" then
```

```
hit_pair(1) <= hit_ch(1) and hit_ch(9);
hit_pair(2) <= hit_ch(2) and hit_ch(10);
hit_pair(3) <= hit_ch(3) and hit_ch(11);
hit_pair(4) <= hit_ch(4) and hit_ch(12);
hit_pair(5) <= hit_ch(5) and hit_ch(13);
hit_pair(6) <= hit_ch(6) and hit_ch(14);
hit_pair(7) <= hit_ch(7) and hit_ch(15);
hit_pair(8) <= hit_ch(8) and hit_ch(16);
```

```

track(1) <= hit_pair(1) and hit_pair(5);
track(2) <= hit_pair(2) and hit_pair(6);
track(3) <= hit_pair(3) and hit_pair(7);
track(4) <= hit_pair(4) and hit_pair(8);

if rst = '1' then

    counter <= (others => '0');
    gate   <= '0';
    rising <= '0';

elsif rising_edge(clk) then

    gate <= track(2);

    if (track(2) = '1' and gate = '0' and veto = '0' ) then
        rising <= '1';
    else
        rising <= '0';
    end if;

    if rising = '1' then
        counter <= counter+'1';

    end if;
end if;

tebl_disp <= counter(25 downto 10);
tebl_led  <= tebl_pb;

-- 4 Way coincidence with horizontal counting

elsif button(8 downto 1) = "10000010" then

    hit_pair(1) <= hit_ch(1) and hit_ch(9);
    hit_pair(2) <= hit_ch(2) and hit_ch(10);
    hit_pair(3) <= hit_ch(3) and hit_ch(11);
    hit_pair(4) <= hit_ch(4) and hit_ch(12);
    hit_pair(5) <= hit_ch(5) and hit_ch(13);
    hit_pair(6) <= hit_ch(6) and hit_ch(14);
    hit_pair(7) <= hit_ch(7) and hit_ch(15);
    hit_pair(8) <= hit_ch(8) and hit_ch(16);

    track(1) <= hit_pair(1) and hit_pair(5);
    track(2) <= hit_pair(2) and hit_pair(6);
    track(3) <= hit_pair(3) and hit_pair(7);
    track(4) <= hit_pair(4) and hit_pair(8);

    if rst = '1' then

        counter <= (others => '0');
        gate   <= '0';
        rising <= '0';

```

```

elsif rising_edge(clk) then

    gate <= track(3);

    if (track(3) = '1' and gate = '0' and veto = '0') then
        rising <= '1';
    else
        rising <= '0';
    end if;

    if rising = '1' then
        counter <= counter+'1';
    end if;
end if;

tebl_disp <= counter(25 downto 10);
tebl_led <= tebl_pb;

-- 4 Way coincidence all counter

elsif button(8 downto 1) = "10000001" then

    hit_pair(1) <= hit_ch(1) and hit_ch(9);
    hit_pair(2) <= hit_ch(2) and hit_ch(10);
    hit_pair(3) <= hit_ch(3) and hit_ch(11);
    hit_pair(4) <= hit_ch(4) and hit_ch(12);
    hit_pair(5) <= hit_ch(5) and hit_ch(13);
    hit_pair(6) <= hit_ch(6) and hit_ch(14);
    hit_pair(7) <= hit_ch(7) and hit_ch(15);
    hit_pair(8) <= hit_ch(8) and hit_ch(16);

    track(1) <= hit_pair(1) and hit_pair(5);
    track(2) <= hit_pair(2) and hit_pair(6);
    track(3) <= hit_pair(3) and hit_pair(7);
    track(4) <= hit_pair(4) and hit_pair(8);

    if rst = '1' then

        counter <= (others => '0');
        gate <= '0';
        rising <= '0';

    elsif rising_edge(clk) then

        gate <= (track(1) or track(2) or track(3) or track(4));

        if ((track(1) = '1' or track(2) = '1' or track(3) = '1') and gate = '0' and veto = '0') then
            rising <= '1';
        else
            rising <= '0';
        end if;

        if rising = '1' then
            counter <= counter+'1';
        end if;
    end if;
end if;

```

```

        end if;
    end if;

    tebl_disp <= counter(25 downto 10);
    tebl_led <= tebl_pb;

-- 3 Way coincidence with no counter

    elsif button(8 downto 1) = "01010000" then

        hit_pair(1) <= hit_ch(1) and hit_ch(9);
        hit_pair(2) <= hit_ch(2) and hit_ch(10);
        hit_pair(3) <= hit_ch(3) and hit_ch(11);
        hit_pair(4) <= hit_ch(4) and hit_ch(12);
        hit_pair(5) <= hit_ch(5) and hit_ch(13);
        hit_pair(6) <= hit_ch(6) and hit_ch(14);
        hit_pair(7) <= hit_ch(7) and hit_ch(15);
        hit_pair(8) <= hit_ch(8) and hit_ch(16);

        track(1) <= (hit_pair(1) and hit_ch(5)) or (hit_pair(1) and hit_ch(13)) or (hit_pair(5) and hit_ch(9))
or (hit_pair(5) and hit_ch(1));
        track(2) <= (hit_pair(2) and hit_ch(6)) or (hit_pair(2) and hit_ch(14)) or (hit_pair(6) and hit_ch(2))
or (hit_pair(6) and hit_ch(10));
        track(3) <= (hit_pair(3) and hit_ch(7)) or (hit_pair(3) and hit_ch(15)) or (hit_pair(7) and hit_ch(3))
or (hit_pair(7) and hit_ch(11));
        track(4) <= (hit_pair(4) and hit_ch(8)) or (hit_pair(8) and hit_ch(12)) or (hit_pair(8) and hit_ch(4))
or (hit_pair(4) and hit_ch(16));

        counter <= "00000000000000000000000000000000";

-- 3 Way coincidence with vertical counter

    elsif button(8 downto 1) = "01001000" then

        hit_pair(1) <= hit_ch(1) and hit_ch(9);
        hit_pair(2) <= hit_ch(2) and hit_ch(10);
        hit_pair(3) <= hit_ch(3) and hit_ch(11);
        hit_pair(4) <= hit_ch(4) and hit_ch(12);
        hit_pair(5) <= hit_ch(5) and hit_ch(13);
        hit_pair(6) <= hit_ch(6) and hit_ch(14);
        hit_pair(7) <= hit_ch(7) and hit_ch(15);
        hit_pair(8) <= hit_ch(8) and hit_ch(16);

        track(1) <= (hit_pair(1) and hit_ch(5)) or (hit_pair(1) and hit_ch(13)) or (hit_pair(5) and hit_ch(9))
or (hit_pair(5) and hit_ch(1));
        track(2) <= (hit_pair(2) and hit_ch(6)) or (hit_pair(2) and hit_ch(14)) or (hit_pair(6) and hit_ch(2))
or (hit_pair(6) and hit_ch(10));
        track(3) <= (hit_pair(3) and hit_ch(7)) or (hit_pair(3) and hit_ch(15)) or (hit_pair(7) and hit_ch(3))
or (hit_pair(7) and hit_ch(11));
        track(4) <= (hit_pair(4) and hit_ch(8)) or (hit_pair(8) and hit_ch(12)) or (hit_pair(8) and hit_ch(4))
or (hit_pair(4) and hit_ch(16));

        if rst = '1' then

            counter <= (others => '0');

```

```

gate   <= '0';
rising <= '0';

elsif rising_edge(clk) then

    gate <= track(1);

    if (track(1) = '1' and gate = '0' and veto = '0') then
        rising <= '1';
    else
        rising <= '0';
    end if;

    if rising = '1' then
        counter <= counter+'1';

    end if;
end if;

tebl_disp <= counter(25 downto 10);
tebl_led  <= tebl_pb;

-- 3 Way coincidence with 45 degree counter

elsif button(8 downto 1) = "01000100" then

    hit_pair(1) <= hit_ch(1) and hit_ch(9);
    hit_pair(2) <= hit_ch(2) and hit_ch(10);
    hit_pair(3) <= hit_ch(3) and hit_ch(11);
    hit_pair(4) <= hit_ch(4) and hit_ch(12);
    hit_pair(5) <= hit_ch(5) and hit_ch(13);
    hit_pair(6) <= hit_ch(6) and hit_ch(14);
    hit_pair(7) <= hit_ch(7) and hit_ch(15);
    hit_pair(8) <= hit_ch(8) and hit_ch(16);

    track(1) <= (hit_pair(1) and hit_ch(5)) or (hit_pair(1) and hit_ch(13)) or (hit_pair(5) and hit_ch(9))
or (hit_pair(5) and hit_ch(1));
    track(2) <= (hit_pair(2) and hit_ch(6)) or (hit_pair(2) and hit_ch(14)) or (hit_pair(6) and hit_ch(2))
or (hit_pair(6) and hit_ch(10));
    track(3) <= (hit_pair(3) and hit_ch(7)) or (hit_pair(3) and hit_ch(15)) or (hit_pair(7) and hit_ch(3))
or (hit_pair(7) and hit_ch(11));
    track(4) <= (hit_pair(4) and hit_ch(8)) or (hit_pair(8) and hit_ch(12)) or (hit_pair(8) and hit_ch(4))
or (hit_pair(4) and hit_ch(16));

    if rst = '1' then

        counter <= (others => '0');
        gate   <= '0';
        rising <= '0';

    elsif rising_edge(clk) then

        gate <= track(2);

        if (track(2) = '1' and gate = '0' and veto = '0') then

```

```

    rising <= '1';
else
    rising <= '0';
end if;

if rising = '1' then
    counter <= counter+'1';

end if;
end if;

tebl_disp <= counter(25 downto 10);
tebl_led <= tebl_pb;

-- 3 Way coincidence with horizontal counter

elsif button(8 downto 1) = "01000010" then

    hit_pair(1) <= hit_ch(1) and hit_ch(9);
    hit_pair(2) <= hit_ch(2) and hit_ch(10);
    hit_pair(3) <= hit_ch(3) and hit_ch(11);
    hit_pair(4) <= hit_ch(4) and hit_ch(12);
    hit_pair(5) <= hit_ch(5) and hit_ch(13);
    hit_pair(6) <= hit_ch(6) and hit_ch(14);
    hit_pair(7) <= hit_ch(7) and hit_ch(15);
    hit_pair(8) <= hit_ch(8) and hit_ch(16);

    track(1) <= (hit_pair(1) and hit_ch(5)) or (hit_pair(1) and hit_ch(13)) or (hit_pair(5) and hit_ch(9))
or (hit_pair(5) and hit_ch(1));
    track(2) <= (hit_pair(2) and hit_ch(6)) or (hit_pair(2) and hit_ch(14)) or (hit_pair(6) and hit_ch(2))
or (hit_pair(6) and hit_ch(10));
    track(3) <= (hit_pair(3) and hit_ch(7)) or (hit_pair(3) and hit_ch(15)) or (hit_pair(7) and hit_ch(3))
or (hit_pair(7) and hit_ch(11));
    track(4) <= (hit_pair(4) and hit_ch(8)) or (hit_pair(8) and hit_ch(12)) or (hit_pair(8) and hit_ch(4))
or (hit_pair(4) and hit_ch(16));

    if rst = '1' then

        counter <= (others => '0');
        gate <= '0';
        rising <= '0';

    elsif rising_edge(clk) then

        gate <= track(3);

        if (track(3) = '1' and gate = '0' and veto = '0') then
            rising <= '1';
        else
            rising <= '0';
        end if;

        if rising = '1' then
            counter <= counter+'1';

        end if;
    end if;
end if;

```

-- 3 Way coincidence with total counter

```
tebl_disp <= counter(25 downto 10);
tebl_led <= tebl_pb;
```

```
elsif button(8 downto 1) = "01000001" then
```

```
hit_pair(1) <= hit_ch(1) and hit_ch(9);
hit_pair(2) <= hit_ch(2) and hit_ch(10);
hit_pair(3) <= hit_ch(3) and hit_ch(11);
hit_pair(4) <= hit_ch(4) and hit_ch(12);
hit_pair(5) <= hit_ch(5) and hit_ch(13);
hit_pair(6) <= hit_ch(6) and hit_ch(14);
hit_pair(7) <= hit_ch(7) and hit_ch(15);
hit_pair(8) <= hit_ch(8) and hit_ch(16);
```

```
track(1) <= (hit_pair(1) and hit_ch(5)) or (hit_pair(1) and hit_ch(13)) or (hit_pair(5) and hit_ch(9))
or (hit_pair(5) and hit_ch(1));
track(2) <= (hit_pair(2) and hit_ch(6)) or (hit_pair(2) and hit_ch(14)) or (hit_pair(6) and hit_ch(2))
or (hit_pair(6) and hit_ch(10));
track(3) <= (hit_pair(3) and hit_ch(7)) or (hit_pair(3) and hit_ch(15)) or (hit_pair(7) and hit_ch(3))
or (hit_pair(7) and hit_ch(11));
track(4) <= (hit_pair(4) and hit_ch(8)) or (hit_pair(8) and hit_ch(12)) or (hit_pair(8) and hit_ch(4))
or (hit_pair(4) and hit_ch(16));
```

```
if rst = '1' then
```

```
counter <= (others => '0');
gate <= '0';
rising <= '0';
```

```
elsif rising_edge(clk) then
```

```
gate <= (track(1) or track(2) or track(3) or track(4));
```

```
if ((track(1) = '1' or track(2) = '1' or track(3) = '1') and gate = '0' and veto = '0') then
```

```
rising <= '1';
```

```
else
```

```
rising <= '0';
```

```
end if;
```

```
if rising = '1' then
```

```
counter <= counter+'1';
```

```
end if;
```

```
end if;
```

```
tebl_disp <= counter(25 downto 10);
```

```
tebl_led <= tebl_pb;
```

-- 2 Way coincidence with no counter

```
elsif button(8 downto 1) = "00110000" then
```

```

    track(1) <= (hit_ch(1) and hit_ch(13)) or (hit_ch(1) and hit_ch(5)) or (hit_ch(9) and hit_ch(5)) or
(hit_ch(9) and hit_ch(13));
    track(2) <= (hit_ch(2) and hit_ch(6)) or (hit_ch(2) and hit_ch(14)) or (hit_ch(10) and hit_ch(6)) or
(hit_ch(10) and hit_ch(14));
    track(3) <= (hit_ch(3) and hit_ch(7)) or (hit_ch(3) and hit_ch(15)) or (hit_ch(11) and hit_ch(7)) or
(hit_ch(11) and hit_ch(15));
    track(4) <= (hit_ch(12) and hit_ch(16)) or (hit_ch(8) and hit_ch(12)) or (hit_ch(8) and hit_ch(4)) or
(hit_ch(16) and hit_ch(4));

```

```

    counter <= "00000000000000000000000000000000";

```

```

-- 2 Way coincidence vertical counter

```

```

    elsif button(8 downto 1) = "00101000" then

```

```

        track(1) <= (hit_ch(1) and hit_ch(13)) or (hit_ch(1) and hit_ch(5)) or (hit_ch(9) and hit_ch(5))
or (hit_ch(9) and hit_ch(13));
        track(2) <= (hit_ch(2) and hit_ch(6)) or (hit_ch(2) and hit_ch(14)) or (hit_ch(10) and
hit_ch(6)) or (hit_ch(10) and hit_ch(14));
        track(3) <= (hit_ch(3) and hit_ch(7)) or (hit_ch(3) and hit_ch(15)) or (hit_ch(11) and
hit_ch(7)) or (hit_ch(11) and hit_ch(15));
        track(4) <= (hit_ch(12) and hit_ch(16)) or (hit_ch(8) and hit_ch(12)) or (hit_ch(8) and
hit_ch(4)) or (hit_ch(16) and hit_ch(4));

```

```

        if rst='1' then

```

```

            counter<=(others=>'0');
            gate <='0';
            rising <='0';

```

```

        elsif rising_edge(clk) then

```

```

            gate<=track(1);

```

```

            if (track(1)='1' and gate='0'and veto ='0') then
                rising<= '1';
            else
                rising<='0';
            end if;

```

```

            if rising='1' then
                counter<= counter+'1';

```

```

            end if;
        end if;

```

```

        tebl_disp<=counter(25 downto 10);
        tebl_led <= tebl_pb;

```

```

-- 2 Way coincidence 45 degree counter

```

```

    elsif button(8 downto 1) = "00100100" then

```

```

        track(1) <= (hit_ch(1) and hit_ch(13)) or (hit_ch(1) and hit_ch(5)) or (hit_ch(9) and hit_ch(5))
or (hit_ch(9) and hit_ch(13));

```

```

    track(2)    <= (hit_ch(2) and hit_ch(6)) or (hit_ch(2) and hit_ch(14)) or (hit_ch(10) and
hit_ch(6)) or (hit_ch(10) and hit_ch(14));
    track(3)    <= (hit_ch(3) and hit_ch(7)) or (hit_ch(3) and hit_ch(15)) or (hit_ch(11) and
hit_ch(7)) or (hit_ch(11) and hit_ch(15));
    track(4)    <= (hit_ch(12) and hit_ch(16)) or (hit_ch(8) and hit_ch(12)) or (hit_ch(8) and
hit_ch(4)) or (hit_ch(16) and hit_ch(4));

```

```

    if rst='1' then

```

```

        counter<=(others=>'0');
        gate  <='0';
        rising <='0';

```

```

    elsif rising_edge(clk) then

```

```

        gate<=track(2);

```

```

        if (track(2)='1' and gate='0' and veto ='0') then
            rising<= '1';
        else
            rising<='0';
        end if;

```

```

        if rising='1' then
            counter<= counter+'1';

```

```

        end if;
    end if;

```

```

    tebl_disp<=counter(25 downto 10);
    tebl_led <= tebl_pb;

```

```

-- 2 Way coincidence horizontal counter

```

```

    elsif button(8 downto 1) = "00100010" then

```

```

        track(1)    <= (hit_ch(1) and hit_ch(13)) or (hit_ch(1) and hit_ch(5)) or (hit_ch(9) and hit_ch(5))
or (hit_ch(9) and hit_ch(13));
        track(2)    <= (hit_ch(2) and hit_ch(6)) or (hit_ch(2) and hit_ch(14)) or (hit_ch(10) and
hit_ch(6)) or (hit_ch(10) and hit_ch(14));
        track(3)    <= (hit_ch(3) and hit_ch(7)) or (hit_ch(3) and hit_ch(15)) or (hit_ch(11) and
hit_ch(7)) or (hit_ch(11) and hit_ch(15));
        track(4)    <= (hit_ch(12) and hit_ch(16)) or (hit_ch(8) and hit_ch(12)) or (hit_ch(8) and
hit_ch(4)) or (hit_ch(16) and hit_ch(4));

```

```

    if rst='1' then

```

```

        counter<=(others=>'0');
        gate  <='0';
        rising <='0';

```

```

    elsif rising_edge(clk) then

```

```

        gate<=track(3);

```

```

        if (track(3)='1' and gate='0'and veto ='0') then
            rising<= '1';
        else

```

```

        rising<='0';
    end if;

    if rising='1' then
        counter<= counter+'1';

    end if;
end if;

tebl_disp<=counter(25 downto 10);
tebl_led <= tebl_pb;

-- 2 Way coincidence all counter

elsif button(8 downto 1) = "00100001" then

    track(1)    <= (hit_ch(1) and hit_ch(13)) or (hit_ch(1) and hit_ch(5)) or (hit_ch(9) and hit_ch(5))
    or (hit_ch(9) and hit_ch(13));
    track(2)    <= (hit_ch(2) and hit_ch(6)) or (hit_ch(2) and hit_ch(14)) or (hit_ch(10) and
    hit_ch(6)) or (hit_ch(10) and hit_ch(14));
    track(3)    <= (hit_ch(3) and hit_ch(7)) or (hit_ch(3) and hit_ch(15)) or (hit_ch(11) and
    hit_ch(7)) or (hit_ch(11) and hit_ch(15));
    track(4)    <= (hit_ch(12) and hit_ch(16)) or (hit_ch(8) and hit_ch(12)) or (hit_ch(8) and
    hit_ch(4)) or (hit_ch(16) and hit_ch(4));

    if rst='1' then

        counter<=(others=>'0');
        gate  <='0';
        rising <='0';

    elsif rising_edge(clk) then

        gate<=(track(1) or track(2) or track(3) or track(4) );

        if ((track(1)='1' or track(2)='1' or track(3)='1') and gate='0' and veto ='0') then
            rising<= '1';
        else
            rising<='0';
        end if;

        if rising='1' then
            counter<= counter+'1';

        end if;
    end if;

    tebl_disp<=counter(25 downto 10);
    tebl_led <= tebl_pb;

-- nice display

elsif button(8 downto 1) = "11111111" then

    if rst='1' then
        led_on_timer<=(others=>'0');

```

```

led_off_timer<=(others=>'0');
led_on1<='1';
led_off1<='0';

elsif rising_edge(clk) then
if led_on1='1' then
    track(1)<='1';
    led_on_timer<=led_on_timer+'1';
    if led_on_timer="00101101110001101100000000" then
        led_on1<='0';
        led_off1<='1';
        led_on_timer<="00000000000000000000000000";
    end if;
end if;

if led_off1='1' then
    track(1)<='0';
    led_off_timer<=led_off_timer+'1';
    if led_off_timer="00101101110001101100000000" then
        led_on2<='1';
        led_off1<='0';
        led_off_timer<="00000000000000000000000000";
    end if;
end if;

if led_on2='1' then
    track(2)<='1';
    led_on_timer<=led_on_timer+'1';
    if led_on_timer="00101101110001101100000000" then
        led_on2<='0';
        led_off2<='1';
        led_on_timer<="00000000000000000000000000";
    end if;
end if;

if led_off2='1' then
    track(2)<='0';
    led_off_timer<=led_off_timer+'1';
    if led_off_timer="00101101110001101100000000" then
        led_on3<='1';
        led_off2<='0';
        led_off_timer<="00000000000000000000000000";
    end if;
end if;

if led_on3='1' then
    track(3)<='1';
    led_on_timer<=led_on_timer+'1';
    if led_on_timer="00101101110001101100000000" then
        led_on3<='0';
        led_off3<='1';
        led_on_timer<="00000000000000000000000000";
    end if;
end if;

if led_off3='1' then
    track(3)<='0';
    led_off_timer<=led_off_timer+'1';
    if led_off_timer="00101101110001101100000000" then
        led_on4<='1';

```

```

        led_off3<='0';
        led_off_timer<="000000000000000000000000";
    end if;
end if;

if led_on4='1' then
    track(4)<='1';
    led_on_timer<=led_on_timer+'1';
    if led_on_timer="00101101110001101100000000" then
        led_on4<='0';
        led_off4<='1';
        led_on_timer<="000000000000000000000000";
    end if;
end if;

if led_off4='1' then
    track(4)<='0';
    led_off_timer<=led_off_timer+'1';
    if led_off_timer="00101101110001101100000000" then
        led_on1<='1';
        led_off4<='0';
        led_off_timer<="000000000000000000000000";
    end if;
end if;
end if;
end if;

leds(1) <= track(1) and (not veto);
leds(2) <= track(2) and (not veto);
leds(3) <= track(3) and (not veto);
leds(4) <= track(4) and (not veto);
leds(5) <= track(1) and (not veto);
leds(6) <= track(2) and (not veto);
leds(7) <= track(3) and (not veto);
leds(8) <= track(4) and (not veto);
leds(9) <= track(1) and (not veto);
leds(10) <= track(2) and (not veto);
leds(11) <= track(3) and (not veto);
leds(12) <= track(4) and (not veto);
leds(13) <= track(1) and (not veto);
leds(14) <= track(2) and (not veto);
leds(15) <= track(3) and (not veto);
leds(16) <= track(4) and (not veto);
leds(17) <= track(1) and (not veto);
leds(18) <= track(2) and (not veto);
leds(19) <= track(3) and (not veto);
leds(20) <= track(4) and (not veto);
leds(21) <= track(1) and (not veto);
leds(22) <= track(2) and (not veto);
leds(23) <= track(3) and (not veto);
leds(24) <= track(4) and (not veto);
leds(25) <= (track(1) or track(2) or track(3) or track(4)) and (not veto);

end process;

veto <= ( track(1) and track(2) and track(3)) or (track(2)and track(3)and track(4))or (track(1)and
track(3)and track(4)) or (track(1)and track(2)and track(4));

end bhv;

```

Appendix X

Test Bench Code

--vhdl test bench created from source file coincide.vhd -- 15:00:42 02/07/2003

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
```

```
entity testbench is
end testbench;
```

architecture behavior of testbench is

```
component coincide
port(
  clk_in   : in std_logic;
  rst_in   : in std_logic;
  hit_ch_in : in std_logic_vector(16 downto 1);
  button_in : in std_logic_vector(8 downto 1);
  leds_out  : out std_logic_vector(25 downto 1);
  veto_out  : out std_logic

);
```

```
end component;
```

```
signal clk   : std_logic := '0';
signal rst   : std_logic := '0';
signal hit_ch : std_logic_vector(16 downto 1);
signal leds   : std_logic_vector(25 downto 1);
signal veto   : std_logic;
signal button : std_logic_vector(8 downto 1);
```

```
begin
```

```
Ucoinc : coincide
port map(
  clk_in   => clk,
  rst_in   => rst,
  hit_ch_in => hit_ch,
  button_in => button,
  leds_out  => leds,
  veto_out  => veto

);
```

```
-- clock generator
clk <= not clk after 10 ns;
```

```
-- select button
button(8 downto 1) <= "10000001";
```

```

process
begin

    rst <= '1';
    wait for 50 ns;
    rst <= '0';
    wait for 50 ns;

    veto <= '0';

    hit_ch(1) <= '1';
    hit_ch(2) <= '0';           -- track 1 activated
    hit_ch(3) <= '0';
    hit_ch(4) <= '0';
    hit_ch(5) <= '1';
    hit_ch(6) <= '0';
    hit_ch(7) <= '0';
    hit_ch(8) <= '0';
    hit_ch(9) <= '1';
    hit_ch(10) <= '0';
    hit_ch(11) <= '0';
    hit_ch(12) <= '0';
    hit_ch(13) <= '1';
    hit_ch(14) <= '0';
    hit_ch(15) <= '0';
    hit_ch(16) <= '0';

    wait for 50 ns;

    hit_ch(1) <= '0';           -- turn all off
    hit_ch(2) <= '0';
    hit_ch(3) <= '0';
    hit_ch(4) <= '0';
    hit_ch(5) <= '0';
    hit_ch(6) <= '0';
    hit_ch(7) <= '0';
    hit_ch(8) <= '0';
    hit_ch(9) <= '0';
    hit_ch(10) <= '0';
    hit_ch(11) <= '0';
    hit_ch(12) <= '0';
    hit_ch(13) <= '0';
    hit_ch(14) <= '0';
    hit_ch(15) <= '0';
    hit_ch(16) <= '0';

    wait for 50 ns;

    hit_ch(1) <= '0';
    hit_ch(2) <= '1';
    hit_ch(3) <= '0';           -- track 2 activated
    hit_ch(4) <= '0';
    hit_ch(5) <= '0';
    hit_ch(6) <= '1';
    hit_ch(7) <= '0';
    hit_ch(8) <= '0';
    hit_ch(9) <= '0';
    hit_ch(10) <= '1';

```

```

hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- track 3 activated
hit_ch(2) <= '0';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '1';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';

```

```

hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- track 4 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';

```

```

hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- only one out of four scints
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';

```

```

hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- only two out of four scints
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- only three out of four scints
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';

```

```
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '1';      -- two tracks
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
```

```

hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- four random scints
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- three tracks
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';      -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;  
  
wait;           -- will wait forever  
end process;  
  
end;
```

--vhdl test bench created from source file coincide.vhd -- 15:00:42 02/07/2003

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
```

```
entity testbench is
end testbench;
```

architecture behavior of testbench is

```
component coincide
port(
    clk_in   : in std_logic;
    rst_in   : in std_logic;
    hit_ch_in : in std_logic_vector(16 downto 1);
    button_in : in std_logic_vector(8 downto 1);
    leds_out  : out std_logic_vector(25 downto 1);
    veto_out  : out std_logic
);
```

```
end component;
```

```
signal clk   : std_logic := '0';
signal rst   : std_logic := '0';
signal hit_ch : std_logic_vector(16 downto 1);
signal leds   : std_logic_vector(25 downto 1);
signal veto   : std_logic;
signal button : std_logic_vector(8 downto 1);
```

```
begin
```

```
Ucoinc : coincide
port map(
    clk_in   => clk,
    rst_in   => rst,
    hit_ch_in => hit_ch,
    button_in => button,
    leds_out  => leds,
    veto_out  => veto
);
```

```
-- clock generator
clk <= not clk after 10 ns;
```

```
-- select button
button(8 downto 1) <= "01000001";
```

```
process
begin
```

```

rst <= '1';
wait for 50 ns;
rst <= '0';
wait for 50 ns;

veto <= '0';

--test of all possible coincidences

--track 1

hit_ch(1) <= '1';
hit_ch(2) <= '0';           -- scintillators 1,9,13 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';
hit_ch(2) <= '0';
hit_ch(3) <= '0';           -- scintillators 1,5,9 activated
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';

```

```

hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';           -- scintillators 13, 5,9 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';

```

```

hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- scintillators 13,5,1 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';

```

```

hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

--track 2

hit_ch(1) <= '0';           -- scintillators 2,10,14 activated
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';

```

```

hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '1';           -- scintillators 2, 6, 10 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '1';
hit_ch(3) <= '0';           -- scintillators 14, 2,6 activated
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';

```

```

hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';      -- scintillators 14,10,6 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';

```

```

hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

--track 3

hit_ch(1) <= '0';           -- scintillators 3,7,11 activated
hit_ch(2) <= '0';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';

```

```
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- scintillators 3,15,11 activated
hit_ch(2) <= '0';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '1';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
```

```

hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';           -- scintillators 11,7,15 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';

hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '1';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '1';           -- scintillators 7,3 ,15 activated
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '1';

```

```

hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

--track 4

hit_ch(1) <= '0';      --scintillators 8,12,16 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- scintillators 8,4,16 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- scintillators 4, 12,16 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

```

```

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```
-- scintillators 16,4,12 activated
```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
-- turn all off
```

```
wait for 50 ns;
```

```

hit_ch(1) <= '1';
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

```

```
-- veto
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';
```

```
-- turn all off
```

```

hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```

-- scintillators 8,16,4,12 activated

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

-- turn all off

```

```

wait for 50 ns;

hit_ch(1) <= '1';           -- 1 scint activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- two tracks
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';      -- three tracks
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

```

```

hit_ch(1) <= '1';      -- random hits
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '1';      -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';      -- turn all off
```

```
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait;                                -- will wait forever

end process;

end;
```

--vhdl test bench created from source file coincide.vhd -- 15:00:42 02/07/2003

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
```

```
entity testbench is
end testbench;
```

```
architecture behavior of testbench is
```

```
    component coincide
    port(
        clk_in   : in  std_logic;
        rst_in   : in  std_logic;
        hit_ch_in : in  std_logic_vector(16 downto 1);
        button_in : in  std_logic_vector(8 downto 1);
        leds_out  : out std_logic_vector(25 downto 1);
        veto_out  : out std_logic

    );
```

```
end component;
```

```
signal clk   : std_logic := '0';
signal rst   : std_logic := '0';
signal hit_ch : std_logic_vector(16 downto 1);
signal leds   : std_logic_vector(25 downto 1);
signal veto   : std_logic;
signal button : std_logic_vector(8 downto 1);
```

```
begin
```

```
    Ucoinc : coincide
    port map(
        clk_in   => clk,
        rst_in   => rst,
        hit_ch_in => hit_ch,
        button_in => button,
        leds_out  => leds,
        veto_out  => veto

    );
```

```
-- clock generator
clk <= not clk after 10 ns;
```

```
-- select button
button(8 downto 1) <= "00100001";
```

```
process
begin
```

```
    rst <= '1';
```

```

wait for 50 ns;
rst <= '0';
wait for 50 ns;

veto <= '0';

--test of all possible coincidences

--track 1

hit_ch(1) <= '1';
hit_ch(2) <= '0';           -- scintillators 1,13 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';

hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';
hit_ch(2) <= '0';
hit_ch(3) <= '0';           -- scintillators 1,5 activated
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';

```

```

hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- scintillators 5,9 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';

```

```

hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- scintillators 13,9 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '1';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';

```

```

hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

--track 2

hit_ch(1) <= '0';           -- scintillators 2,14 activated
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';

```

```

hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';           -- scintillators 6,10 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';

hit_ch(5) <= '0';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '1';
hit_ch(3) <= '0';           -- scintillators 2,6 activated
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';

```

```

hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '0';      -- scintillators 14,10 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '1';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';

```

```

hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

--track 3

hit_ch(1) <= '0';           -- scintillators 3,7 activated
hit_ch(2) <= '0';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';

```

```

hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- scintillators 3,15 activated
hit_ch(2) <= '0';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '1';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';

```

```

hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';           -- scintillators 11,7 activated
hit_ch(3) <= '0';
hit_ch(4) <= '0';

hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';           -- scintillators 11,15 activated
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';

```

```
hit_ch(15) <= '1';
hit_ch(16) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';
```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';
```

```

wait for 50 ns;

--track 4

hit_ch(1) <= '0';      --scintillators 8,12 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- scintillators 8,4 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';      -- scintillators 12,16 activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```
-- scintillators 16,4 activated
```

```

wait for 50 ns;

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
-- turn all off
```

```

wait for 50 ns;

hit_ch(1) <= '1';
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

```

```
-- veto
```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

-----

hit_ch(1) <= '0';
hit_ch(2) <= '0';
hit_ch(3) <= '0';      -- scintillators 8,16,4,12 activated
hit_ch(4) <= '1';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '1';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '1';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '1';           -- 1 scints activated
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

wait for 50 ns;

hit_ch(1) <= '1';           -- two tracks
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '1';      -- three tracks
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '0';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

hit_ch(1) <= '0';      -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```

wait for 50 ns;

```

```

hit_ch(1) <= '1';           -- random hits
hit_ch(2) <= '1';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '1';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '1';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

```

```
wait for 50 ns;
```

```

hit_ch(1) <= '1';           -- veto
hit_ch(2) <= '1';
hit_ch(3) <= '1';
hit_ch(4) <= '1';
hit_ch(5) <= '1';
hit_ch(6) <= '1';
hit_ch(7) <= '1';
hit_ch(8) <= '1';
hit_ch(9) <= '1';
hit_ch(10) <= '1';
hit_ch(11) <= '1';
hit_ch(12) <= '1';
hit_ch(13) <= '1';
hit_ch(14) <= '1';
hit_ch(15) <= '1';
hit_ch(16) <= '1';

```

```
wait for 50 ns;
```

```
hit_ch(1) <= '0';           -- turn all off
hit_ch(2) <= '0';
hit_ch(3) <= '0';
hit_ch(4) <= '0';
hit_ch(5) <= '0';
hit_ch(6) <= '0';
hit_ch(7) <= '0';
hit_ch(8) <= '0';
hit_ch(9) <= '0';
hit_ch(10) <= '0';
hit_ch(11) <= '0';
hit_ch(12) <= '0';
hit_ch(13) <= '0';
hit_ch(14) <= '0';
hit_ch(15) <= '0';
hit_ch(16) <= '0';

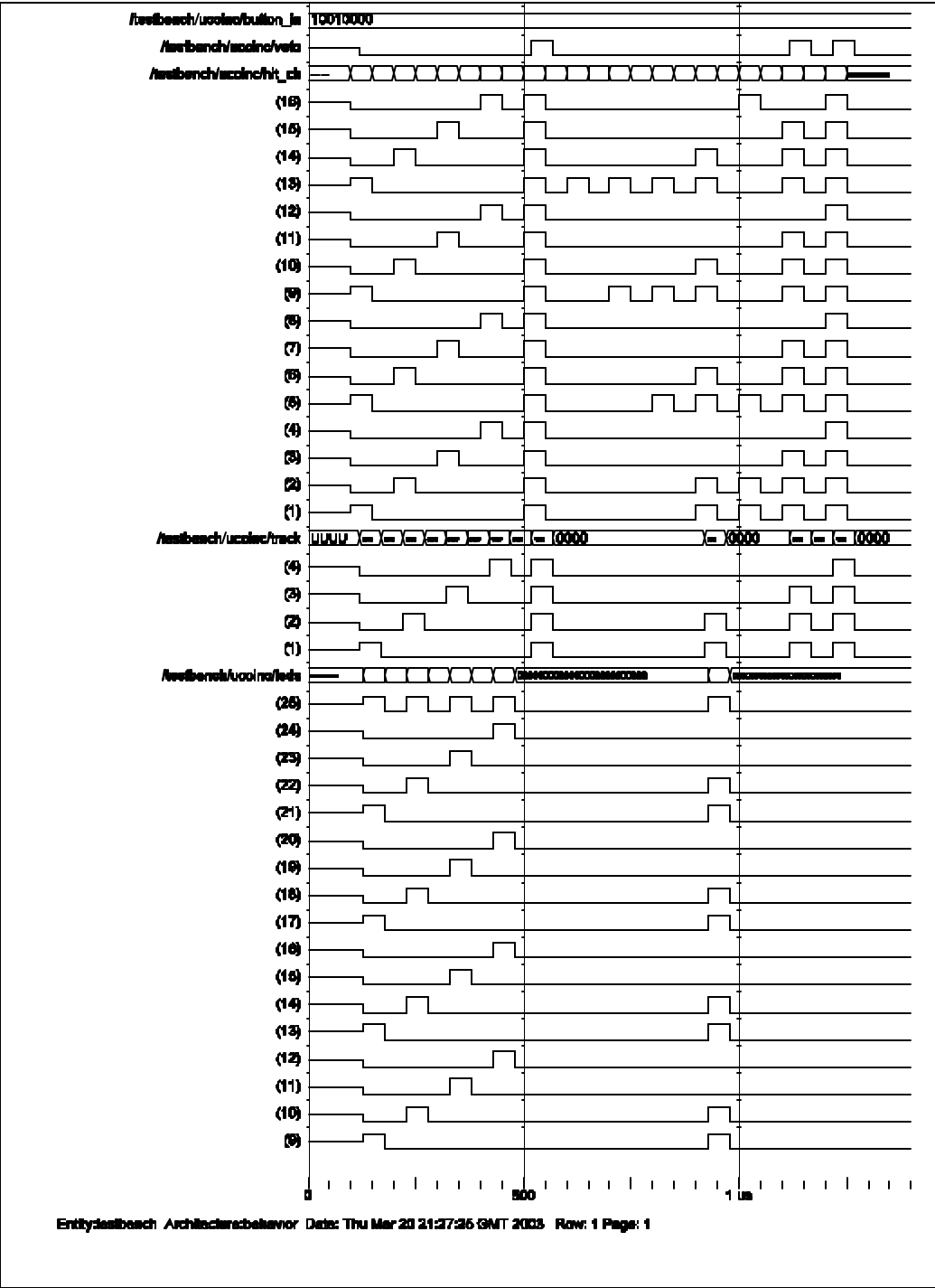
wait;                       -- will wait forever

end process;

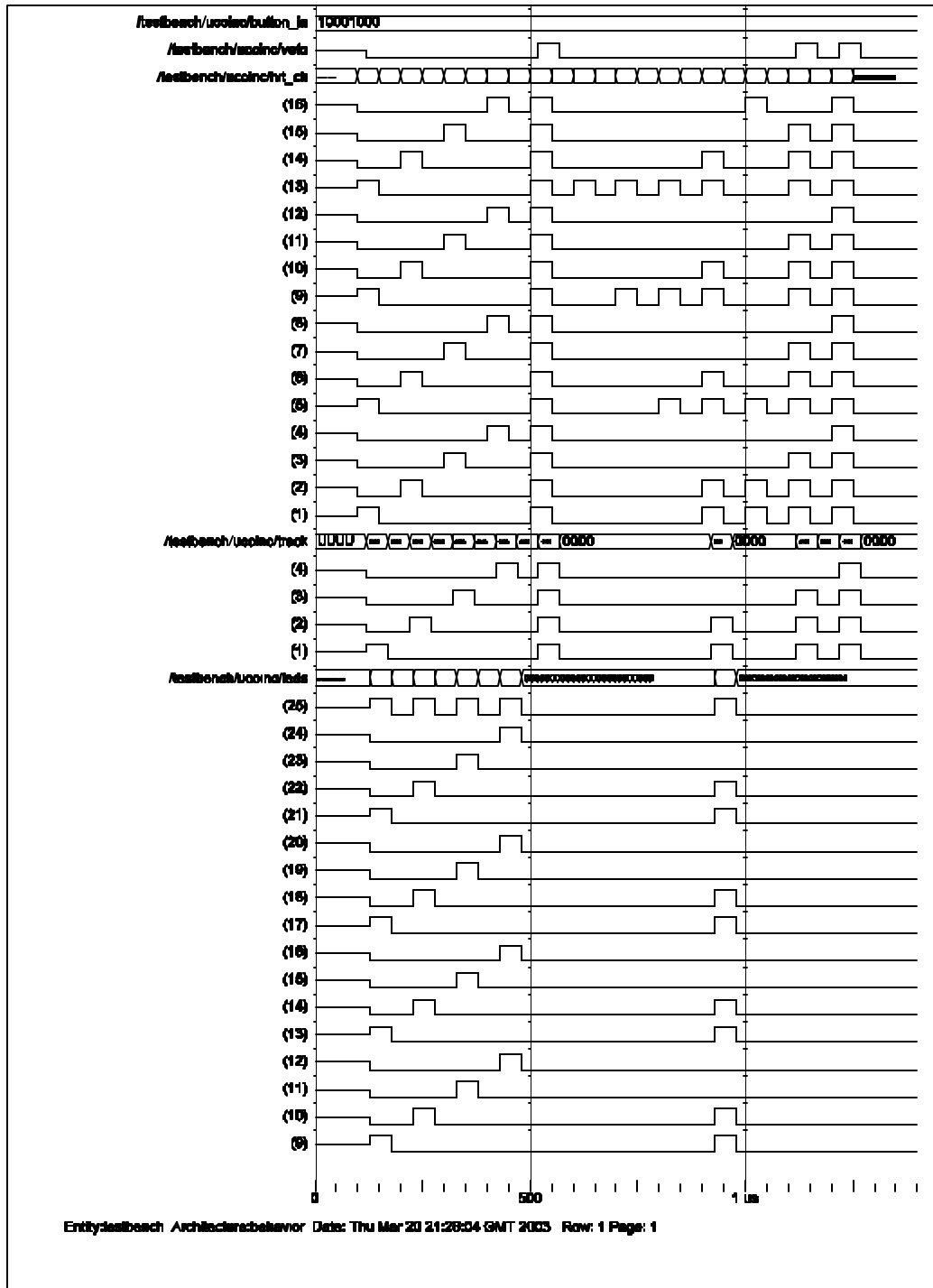
end;
```

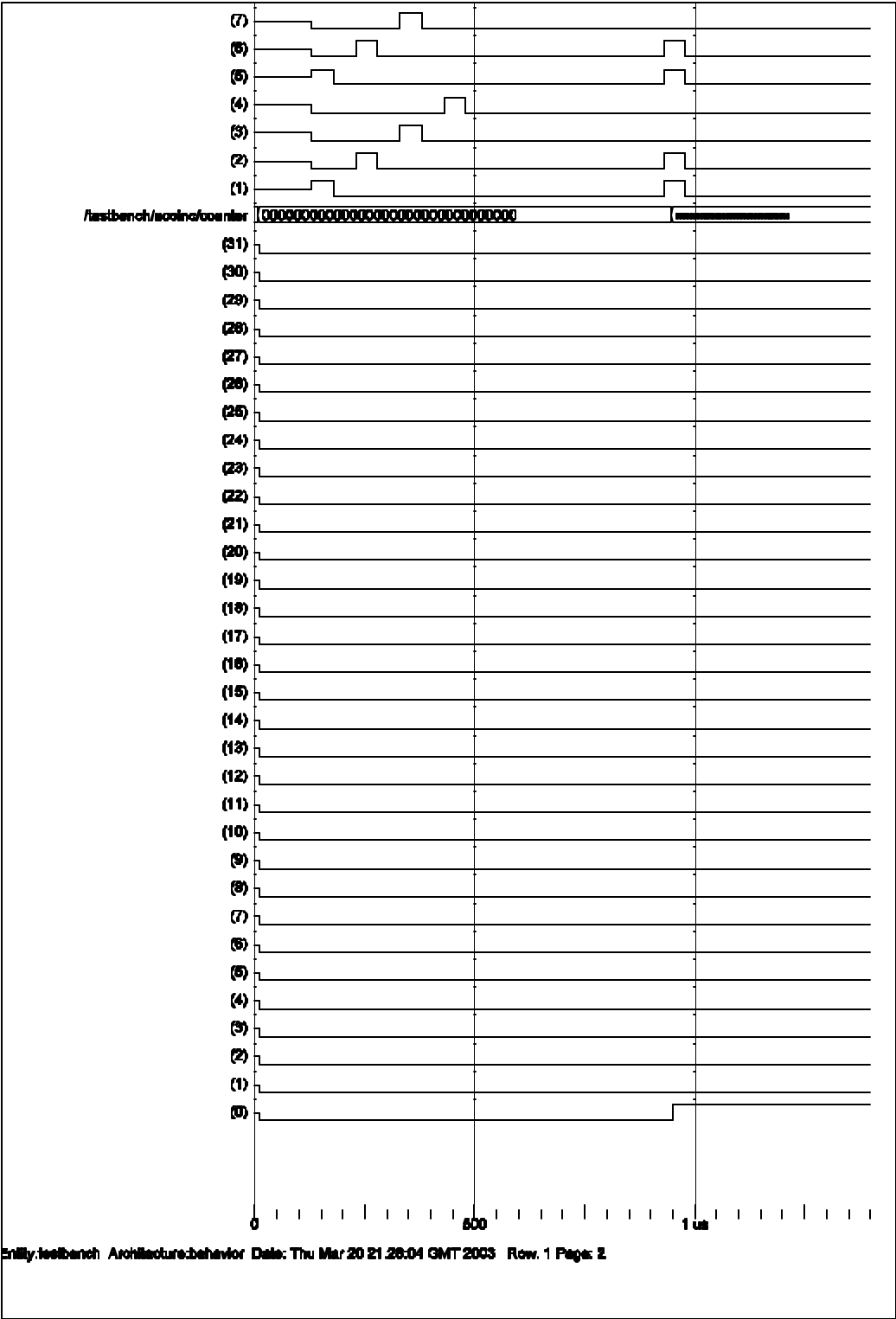
Appendix XI
Test Bench Results

4way coincidence no counter

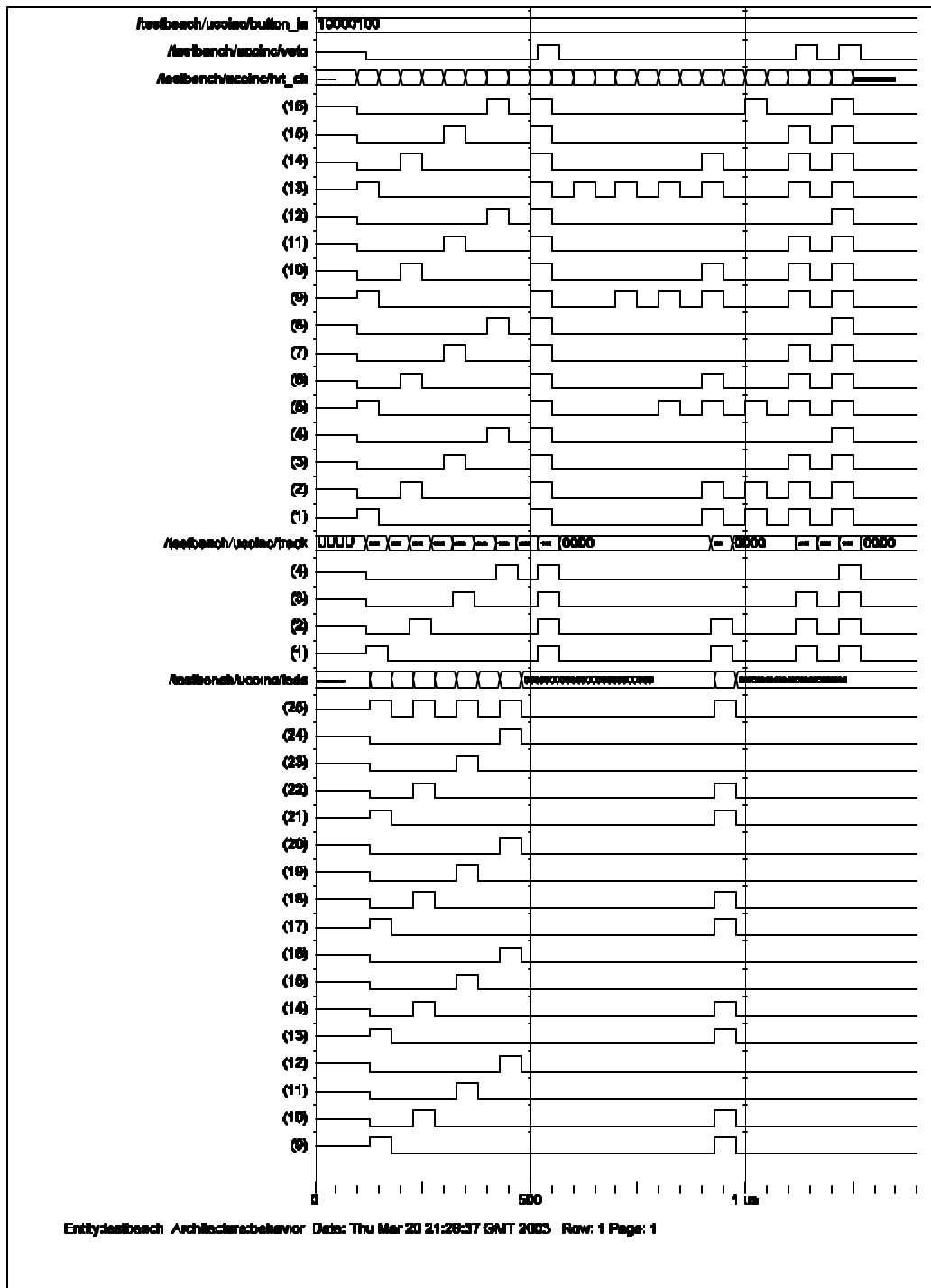


4way coincidence counting all vertical hits



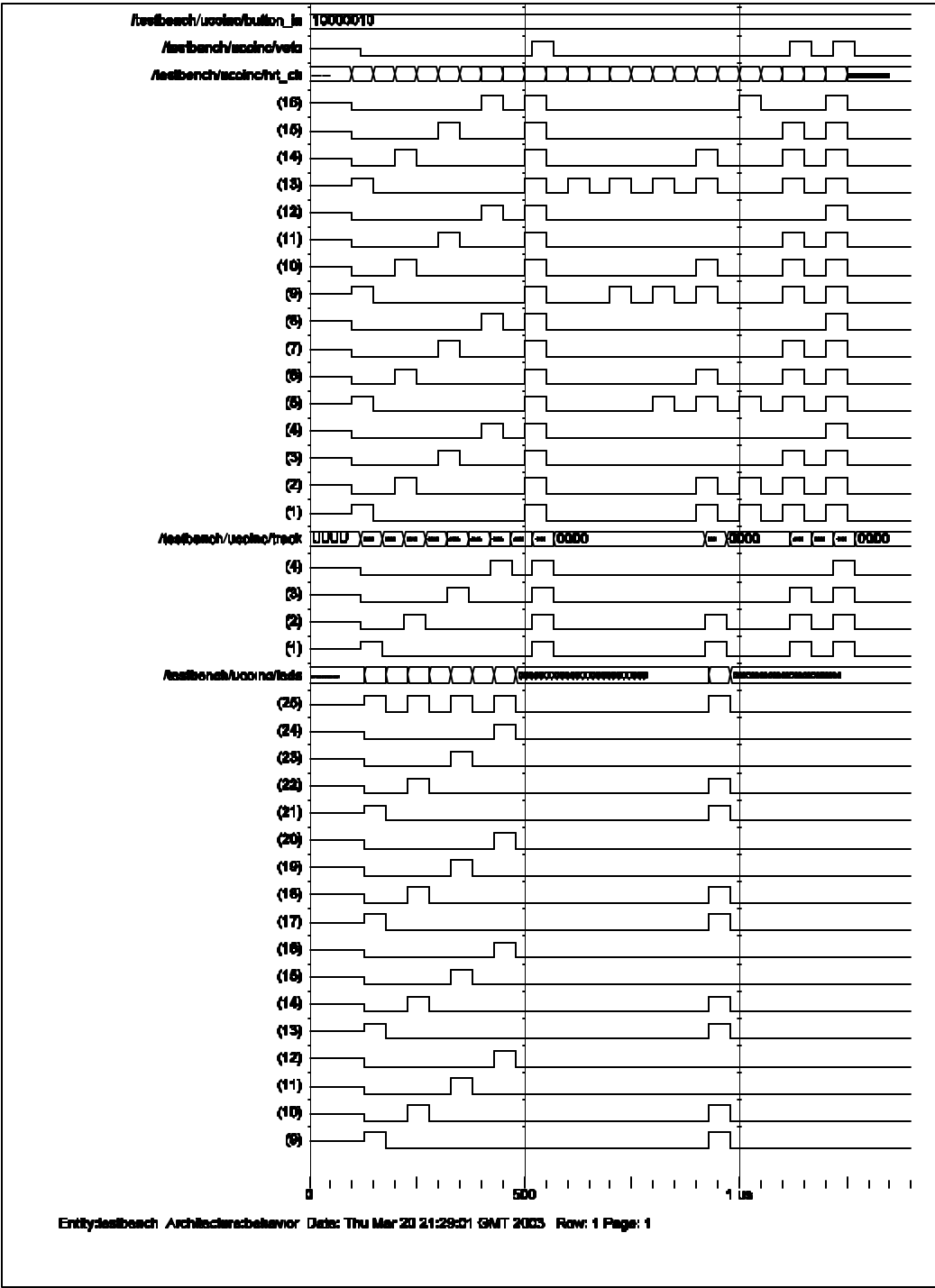


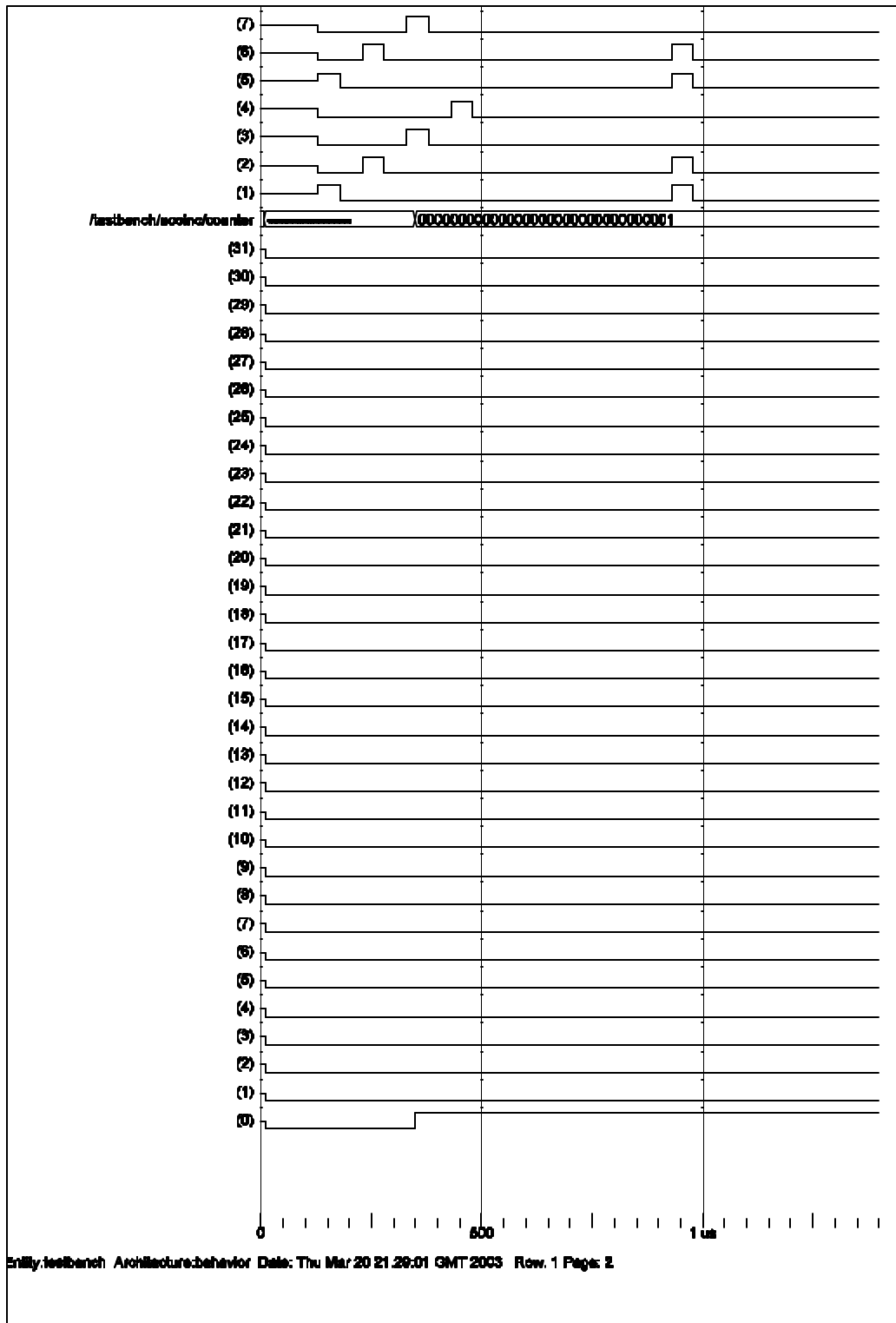
4way coincidence counting all 45 degree hits





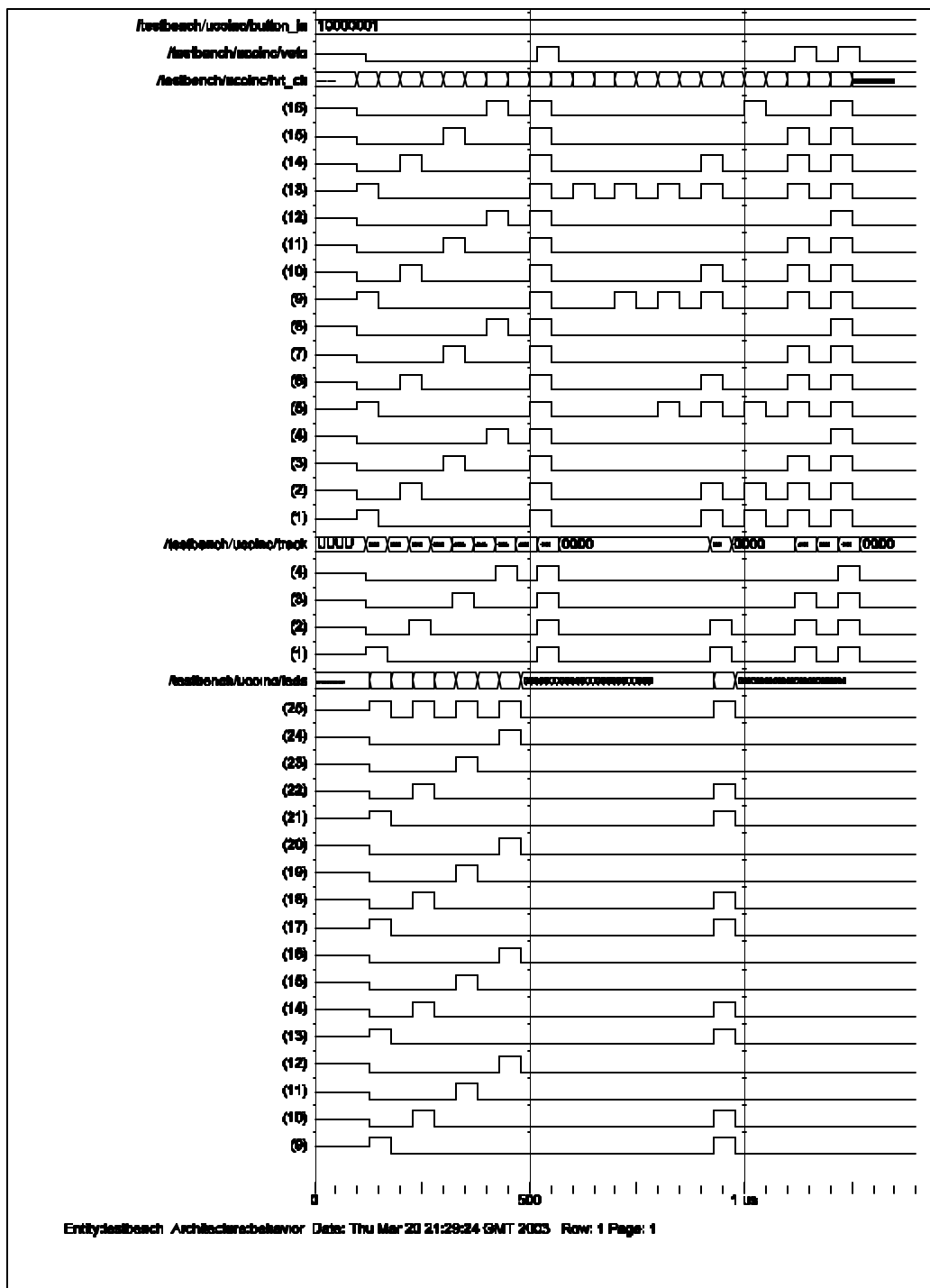
4way coincidence counting all horizontal hits

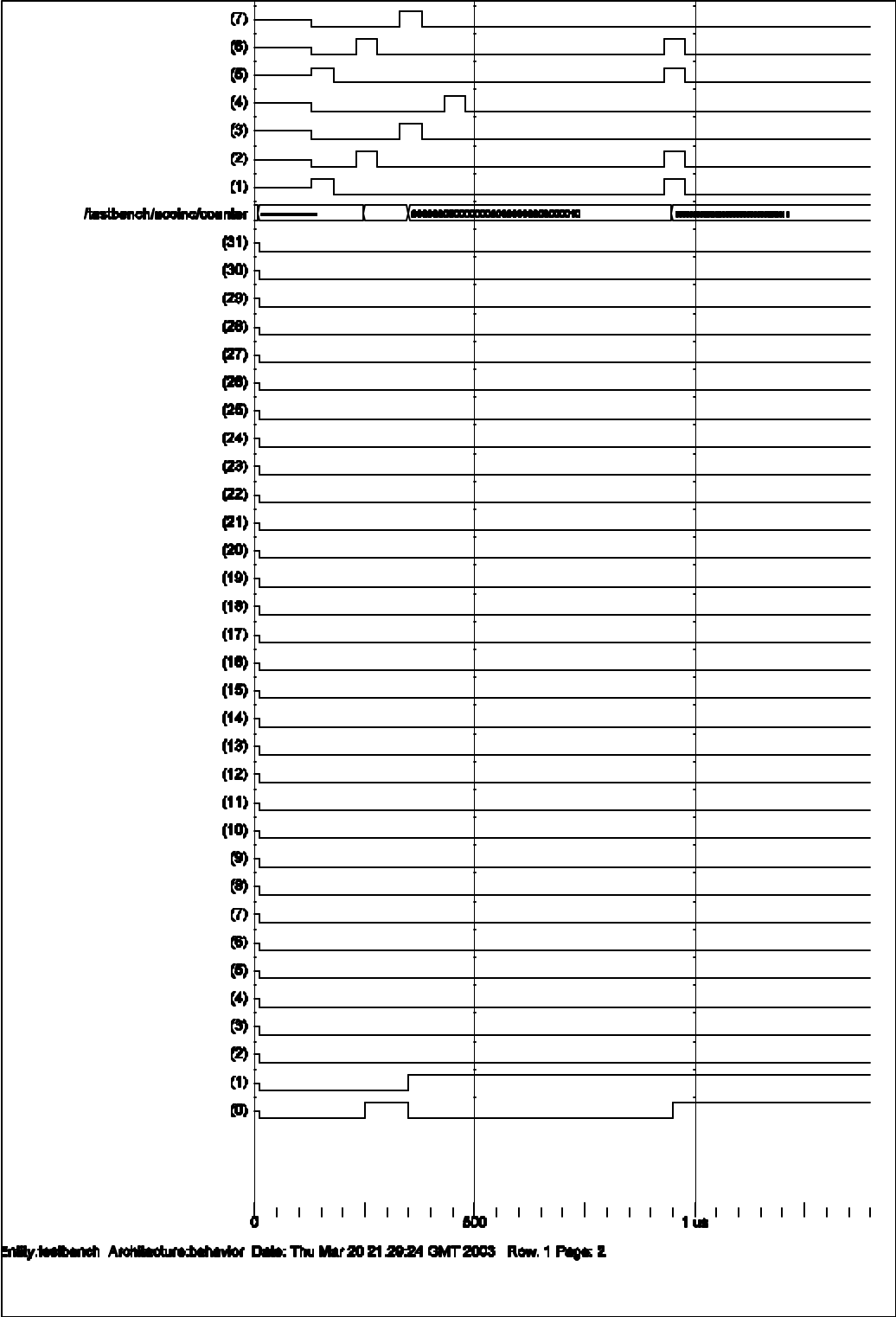




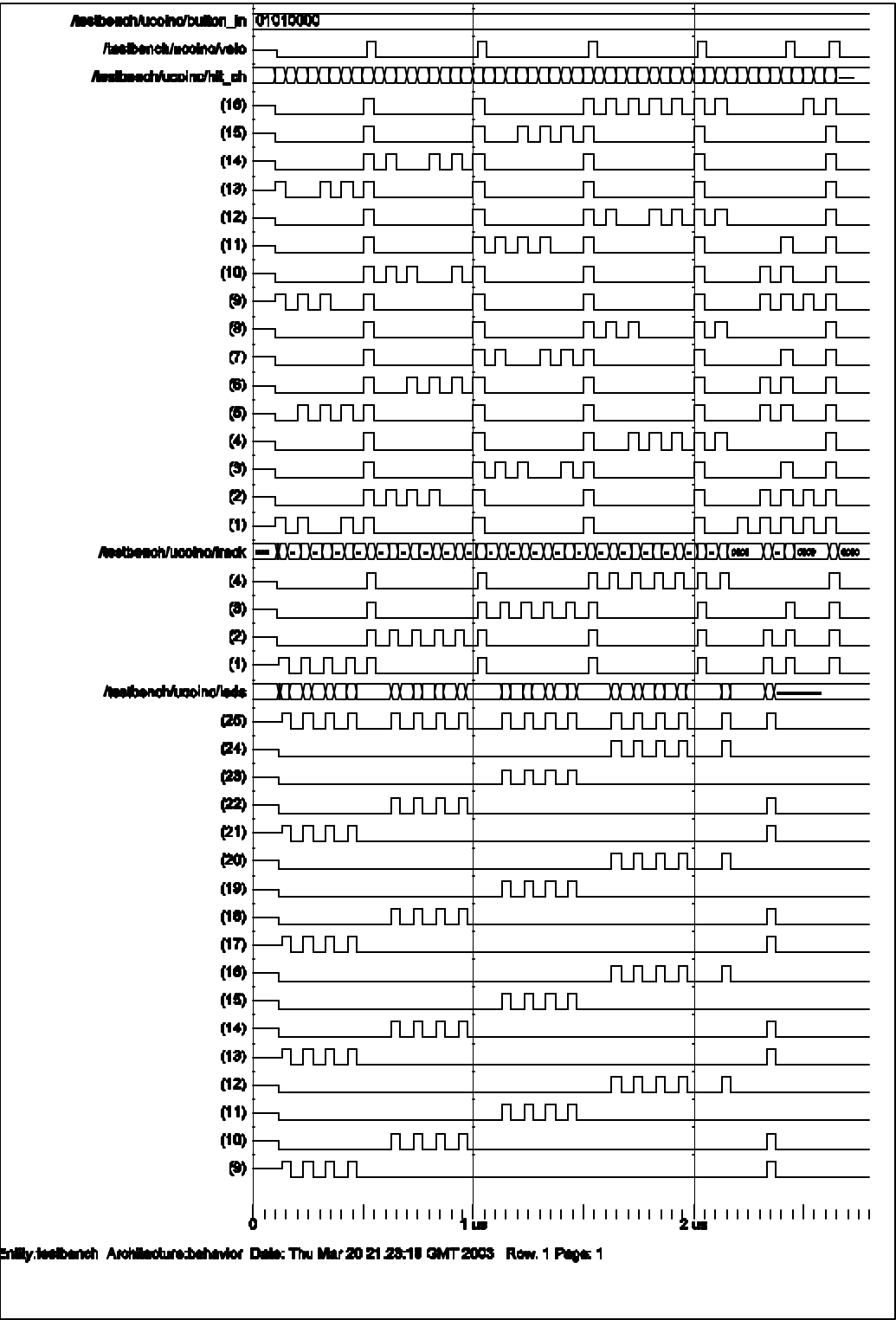
Entity: testbench Architecture: behavior Date: Thu Mar 20 21:29:01 GMT 2003 Row: 1 Page: 2

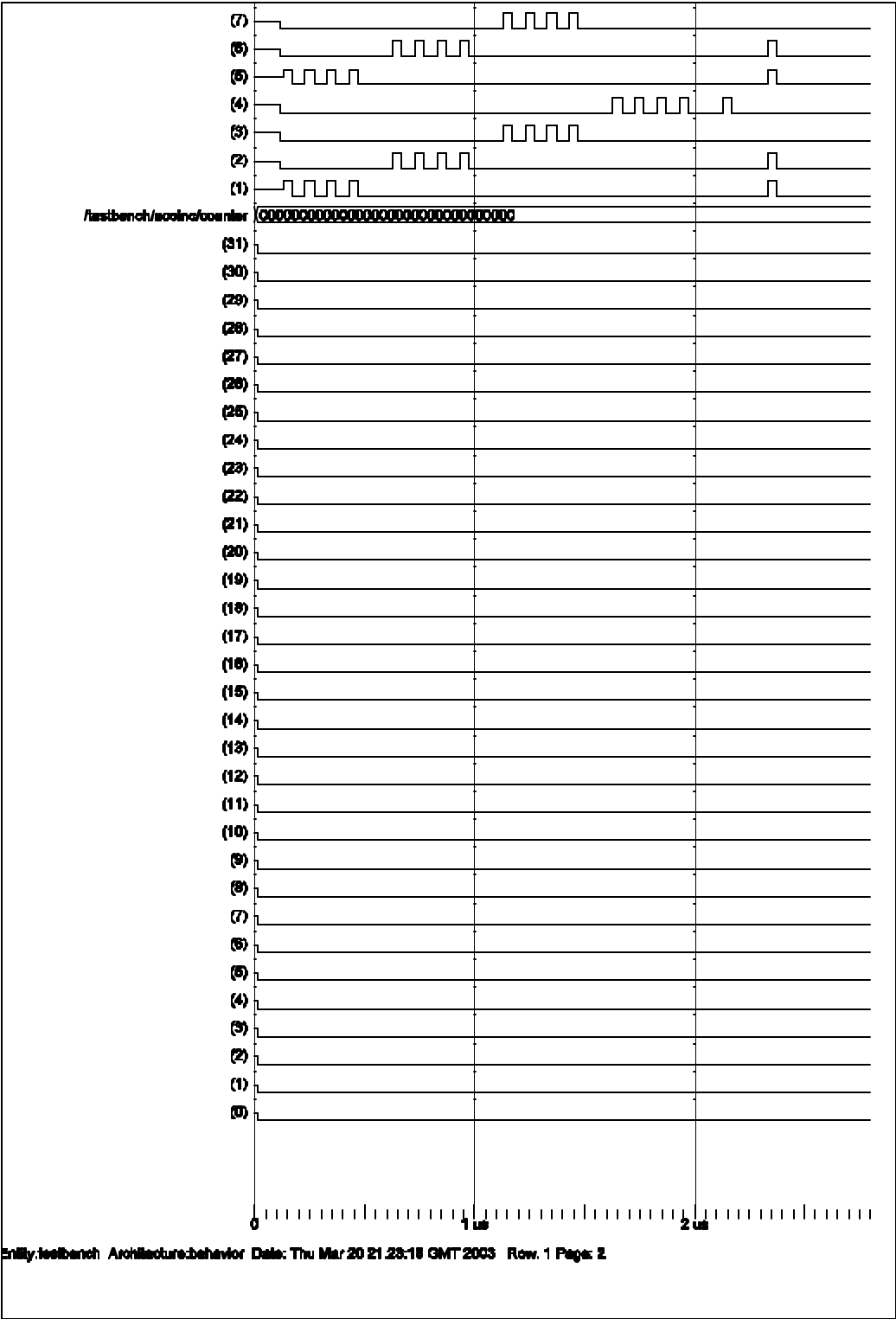
4way coincidence counting all hits



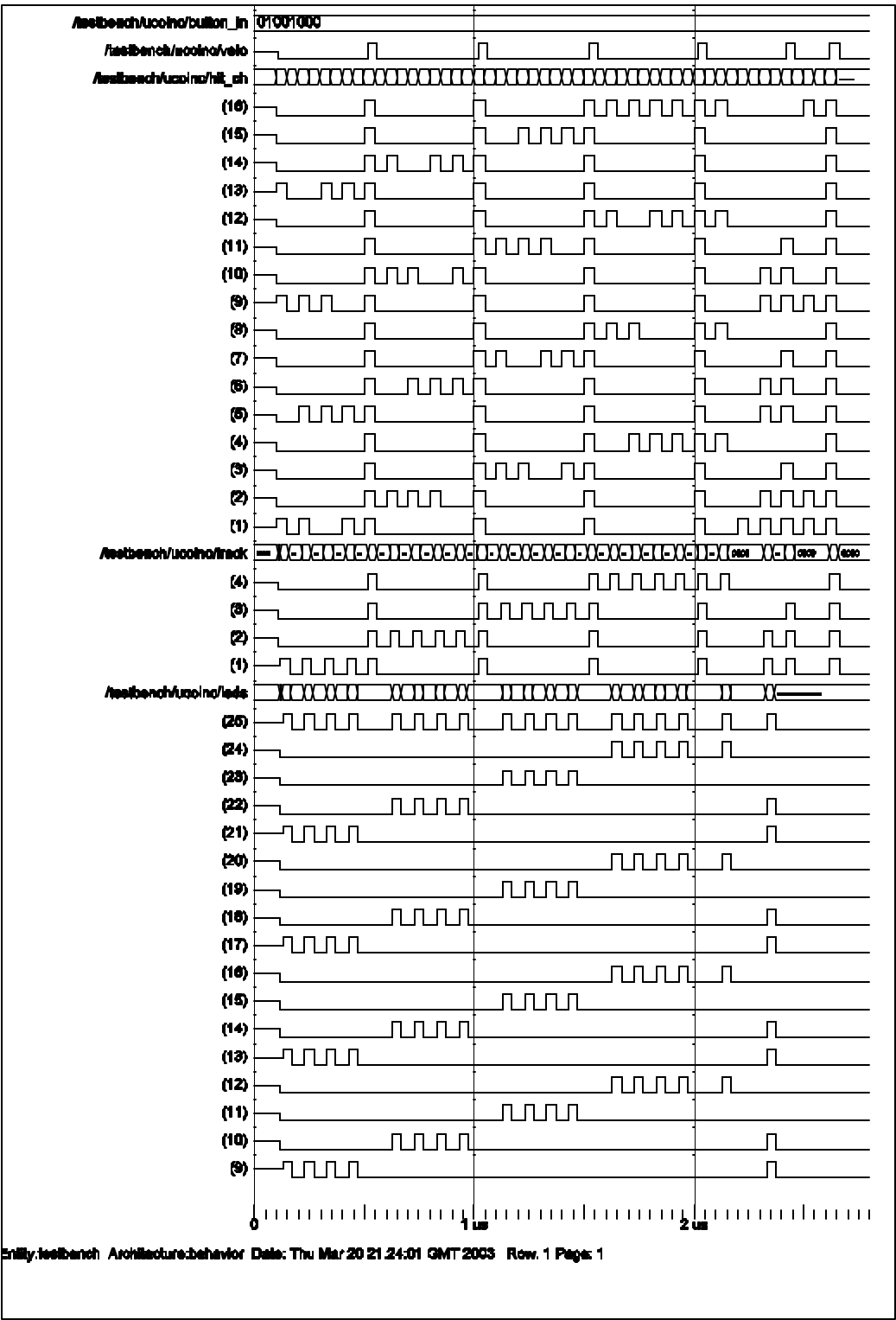


3way coincidence no counter



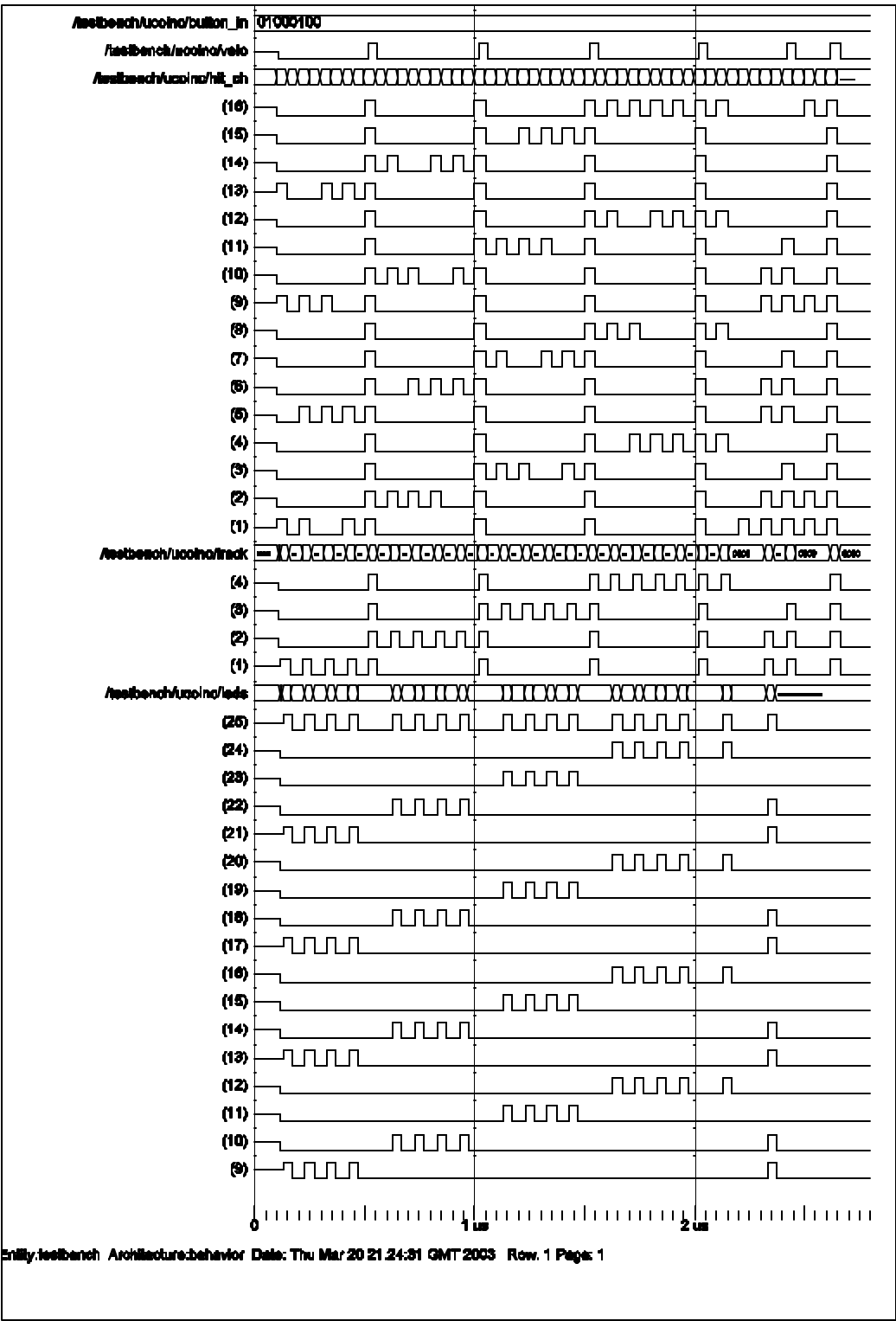


3way coincidence counting all vertical hits



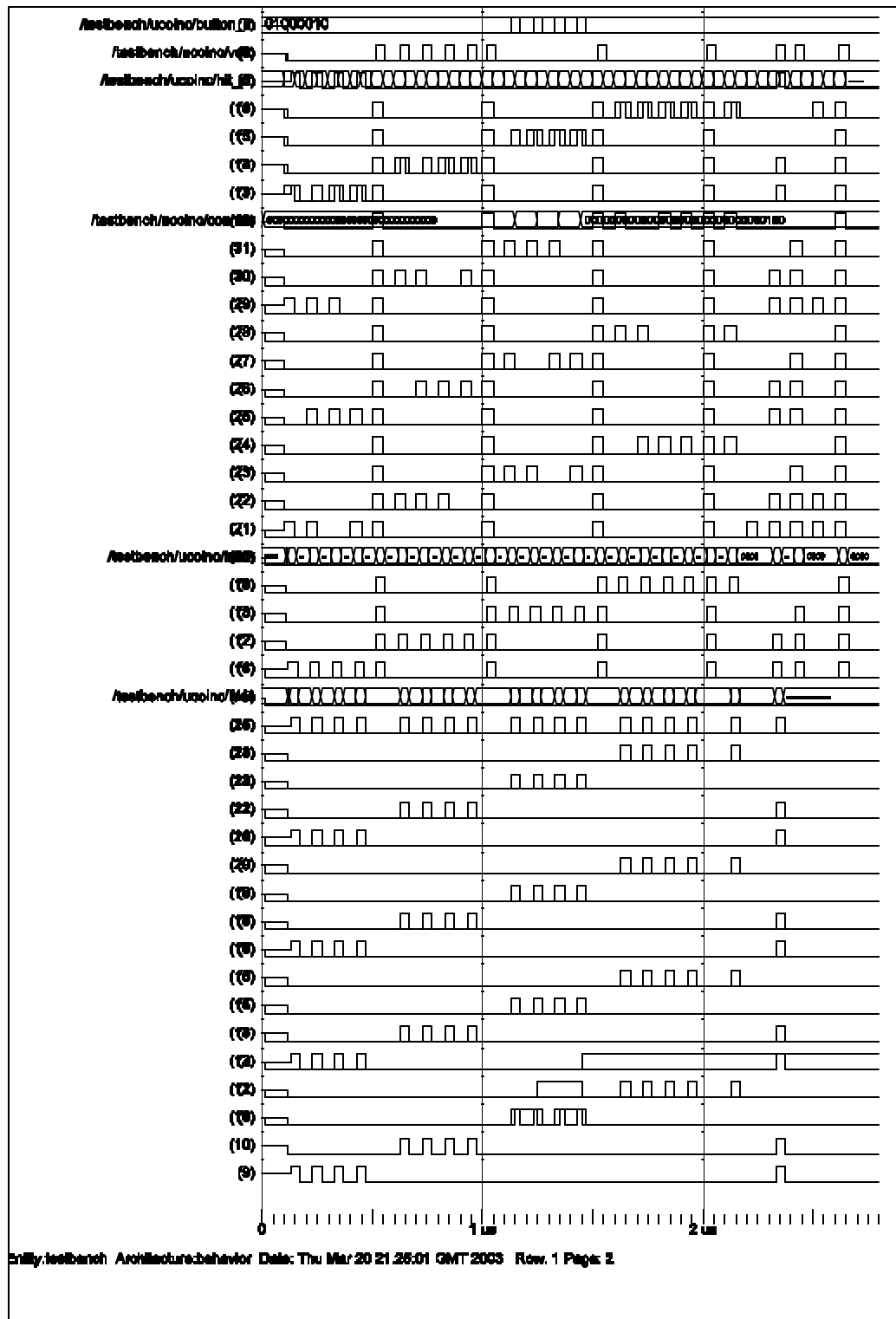


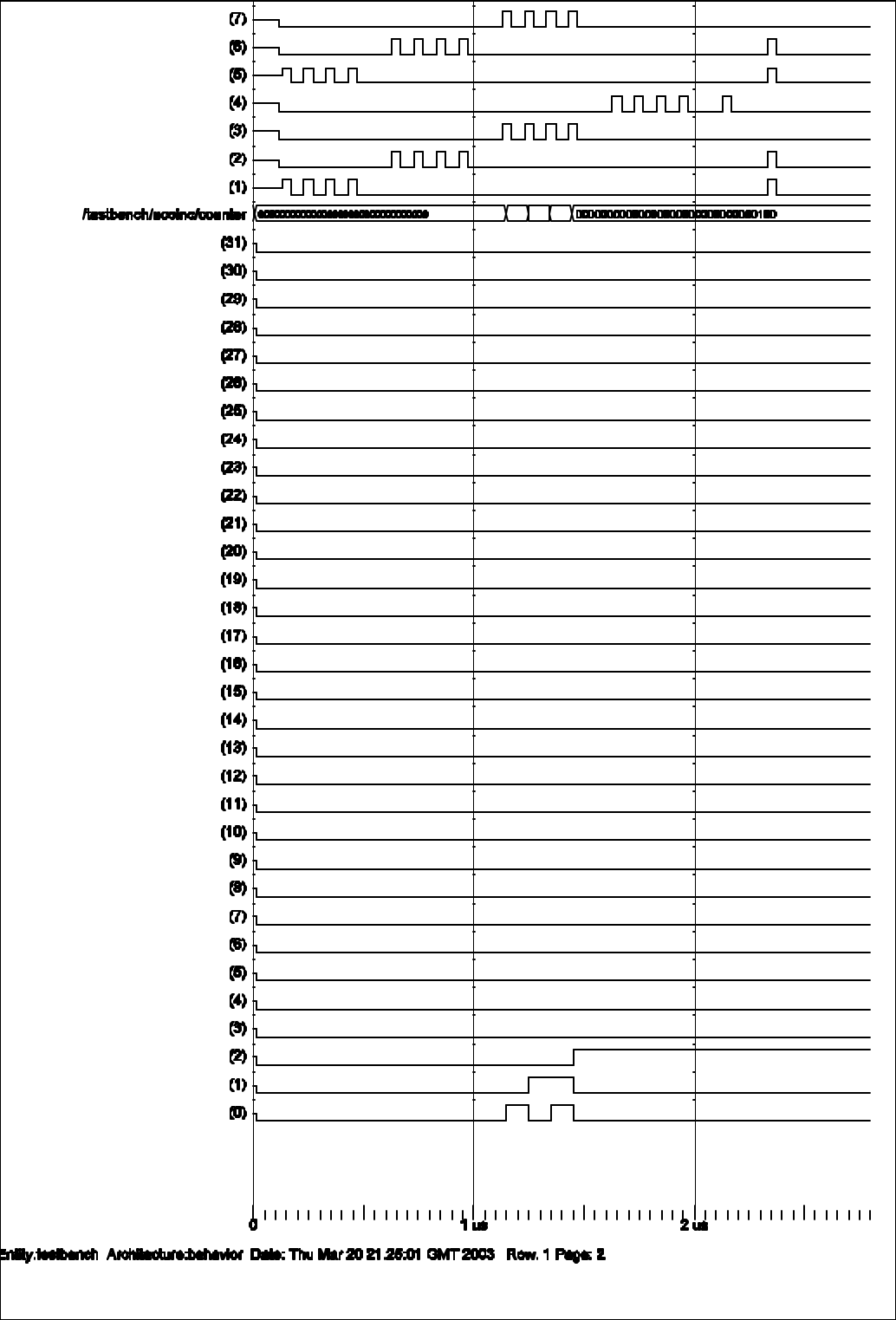
3way coincidence counting all 45 degree hits



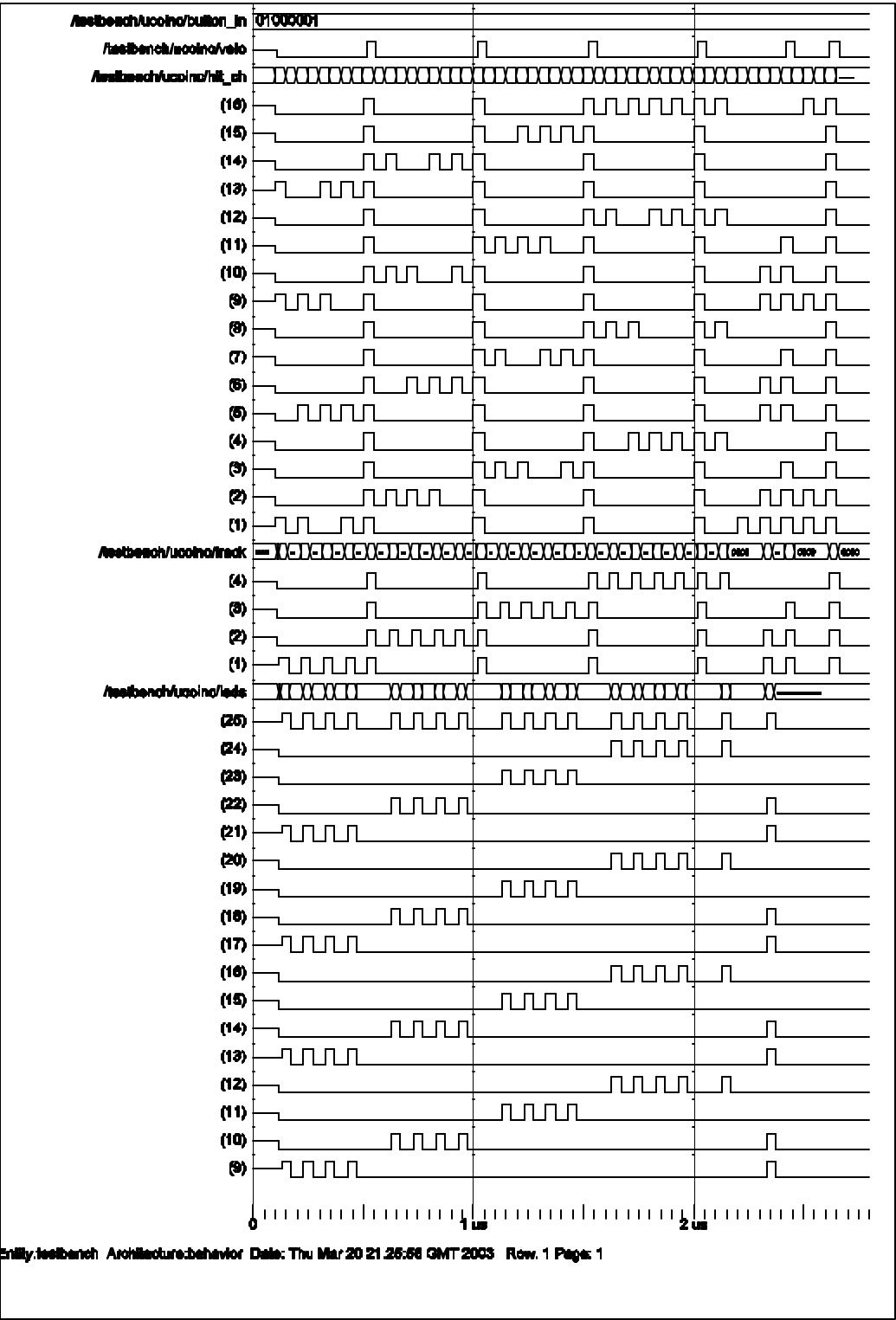


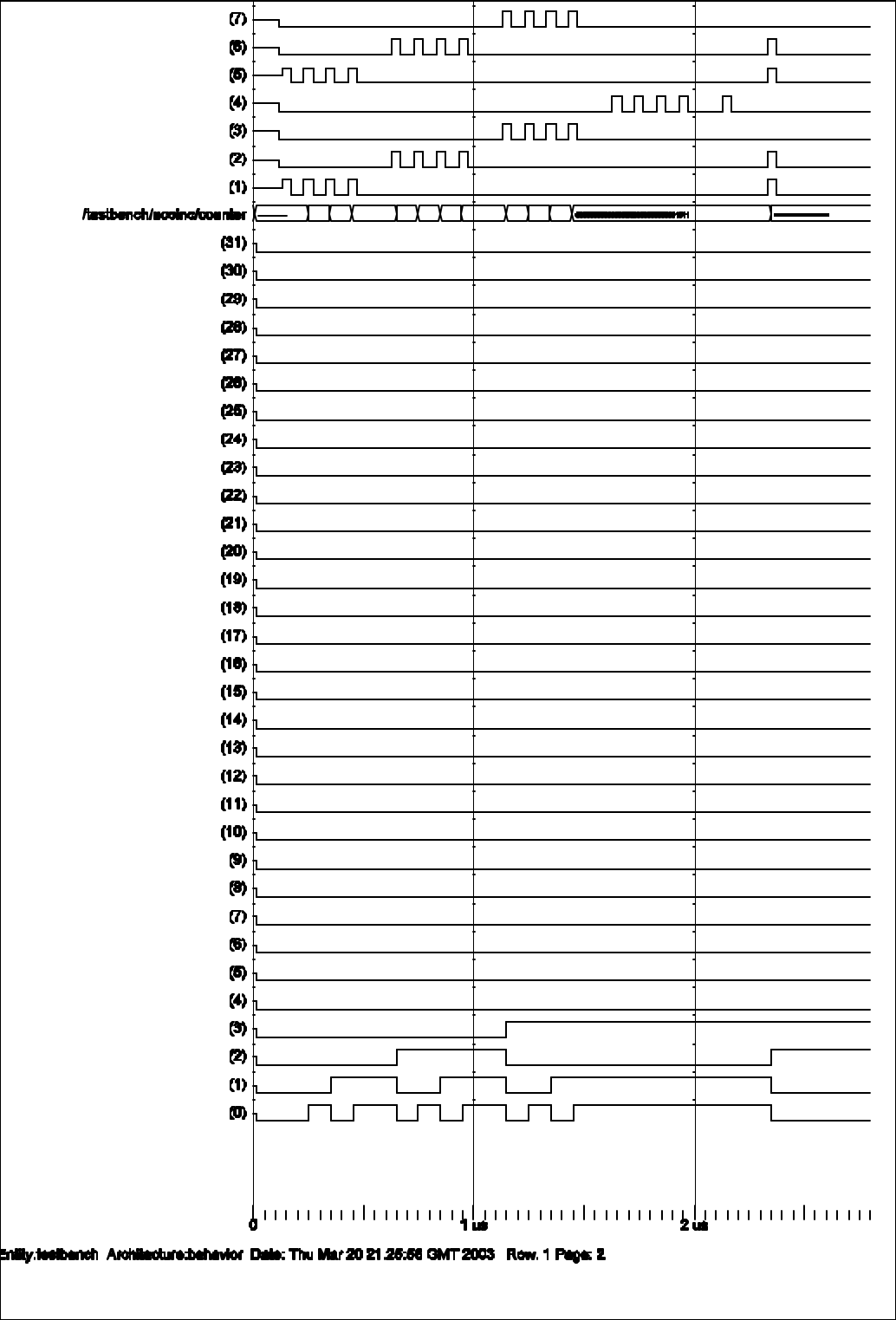
3way coincidence counting all horizontal hits



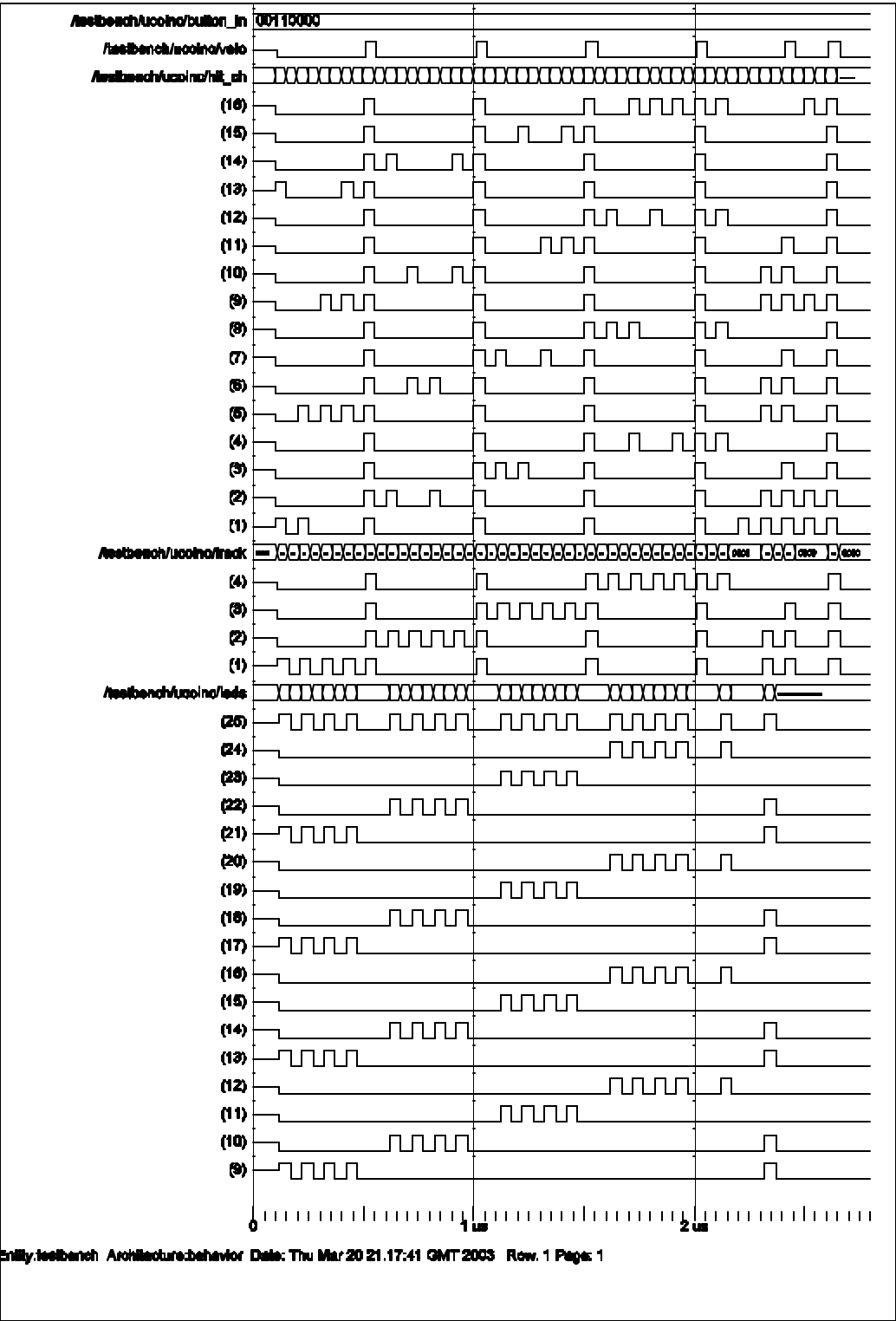


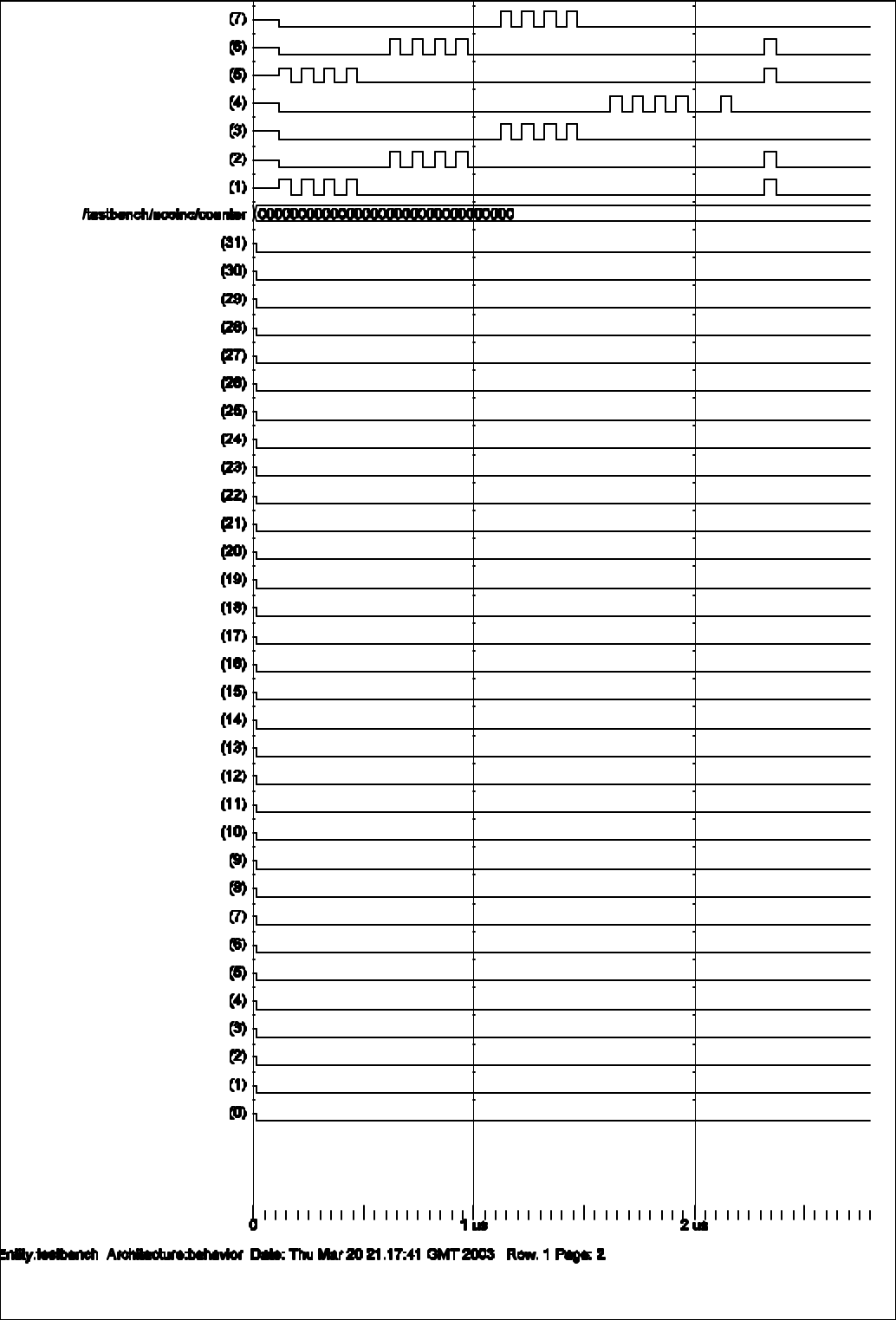
3way coincidence counting all hits



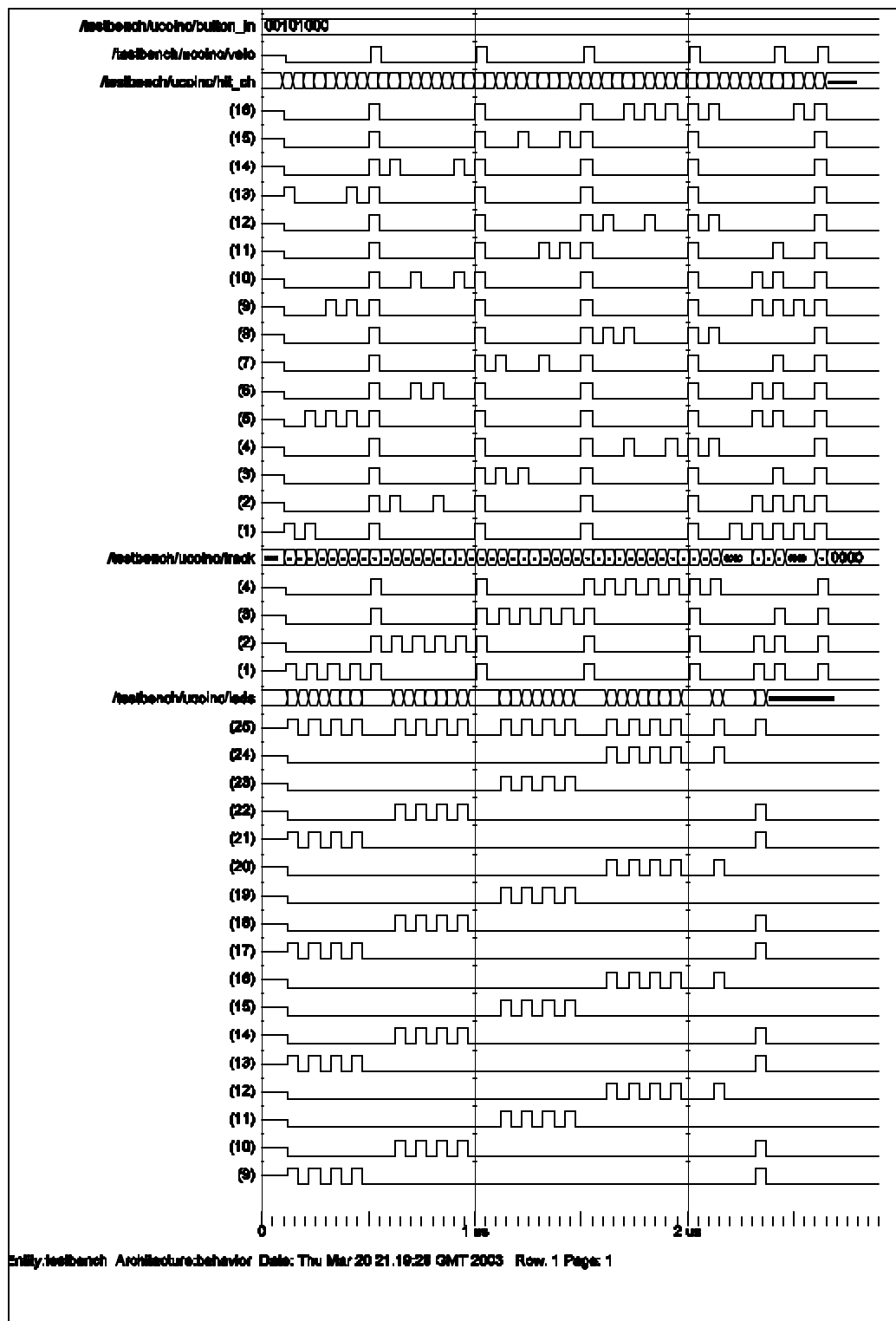


2way coincidence with counter

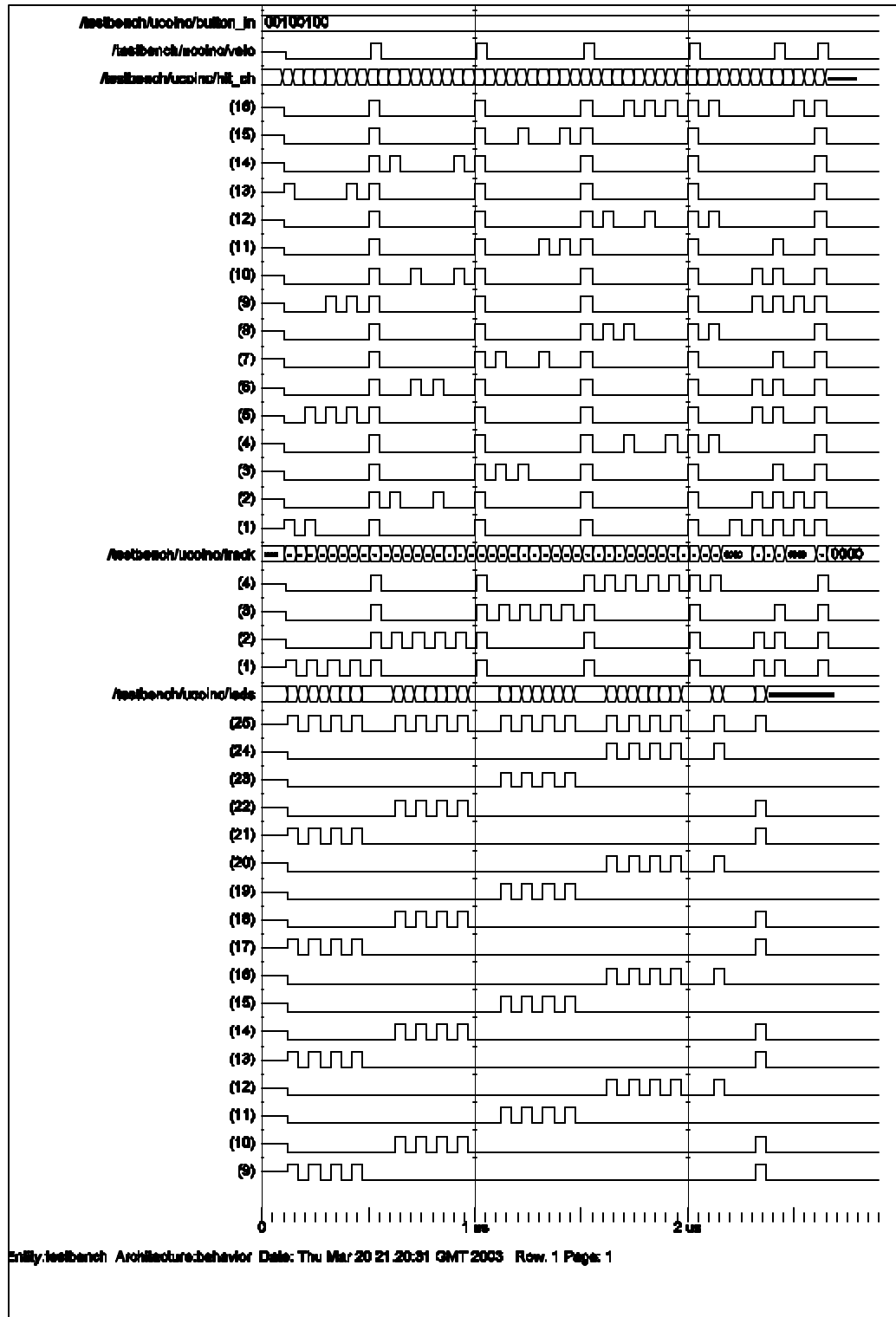


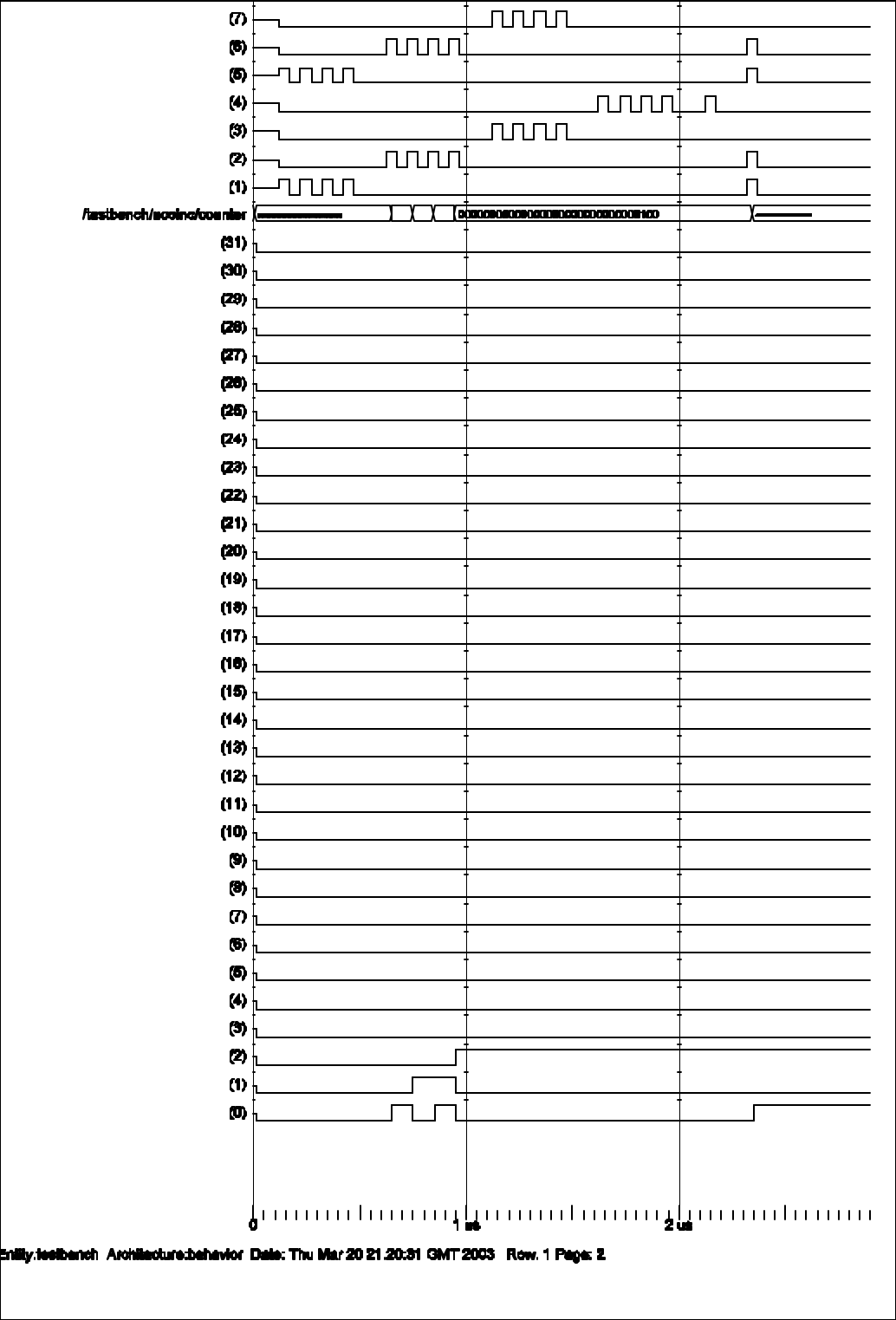


2way coincidence counting all vertical hits

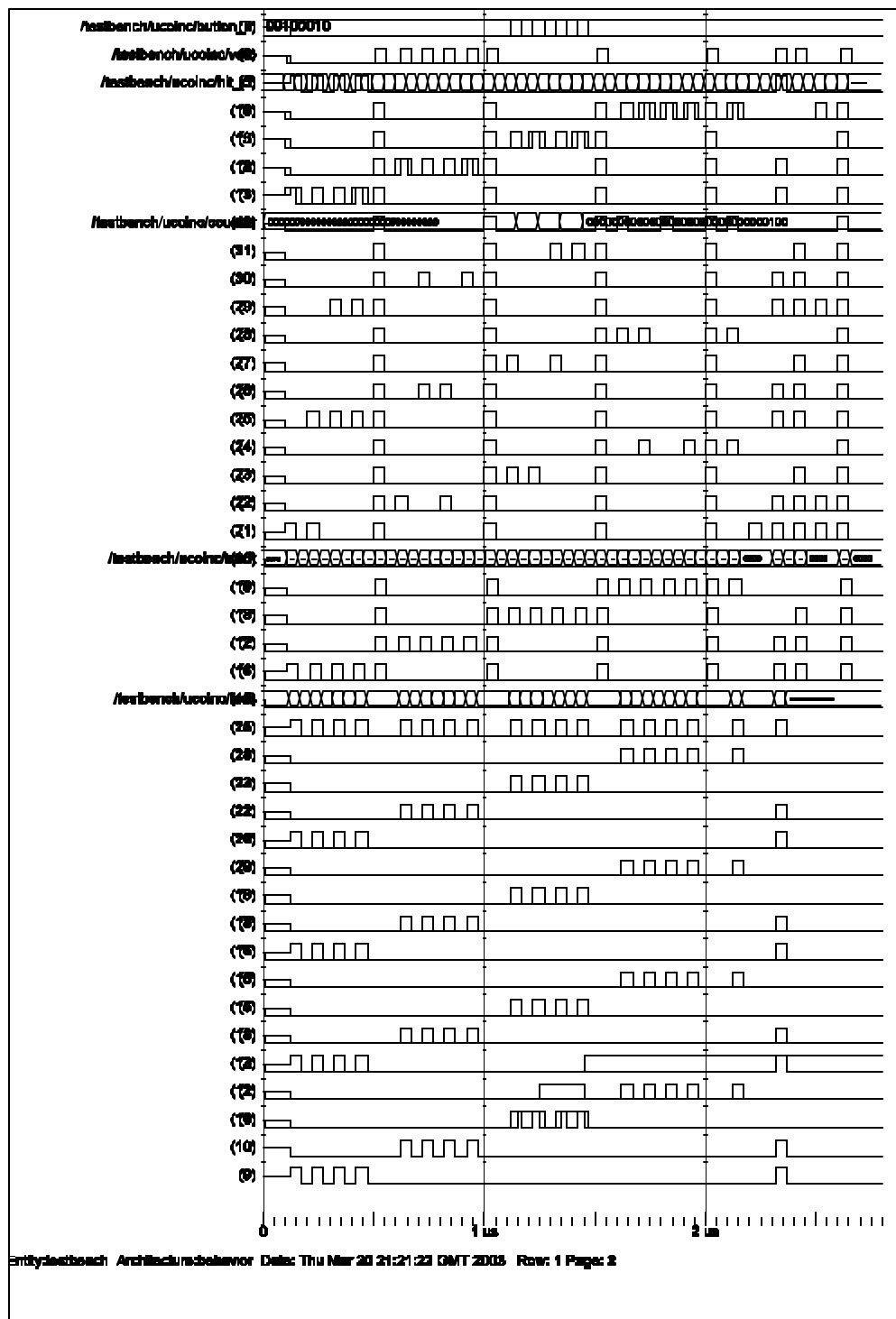


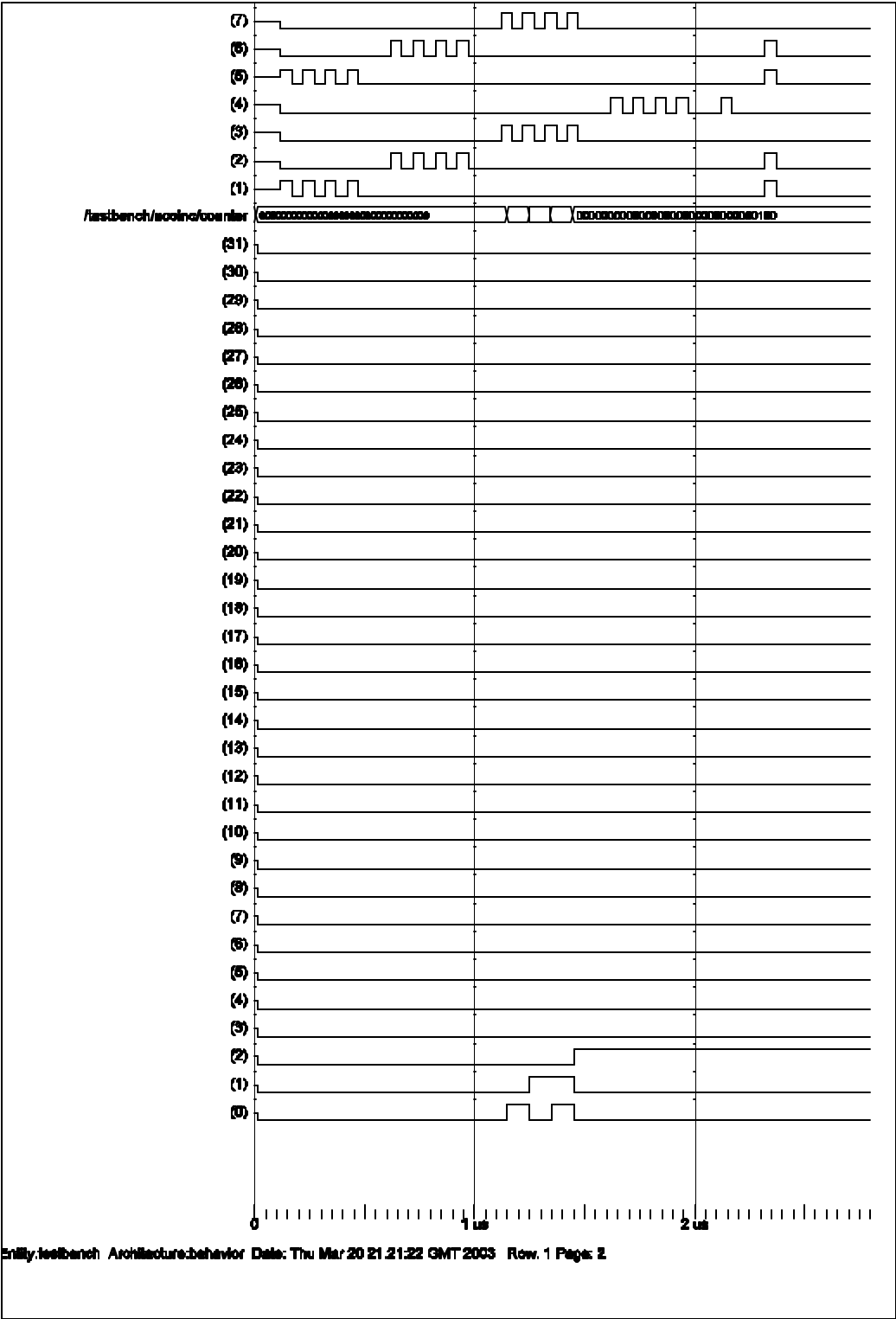
2way coincidence counting all 45 degree hits





2way coincidence counting all horizontal hits





testbench/cooling/over_riser Date: Thu Mar 20 21:21:22 GMT 2003 Row: 1 Page: 2

2way coincidence counting all hits

