First Year Summary

by

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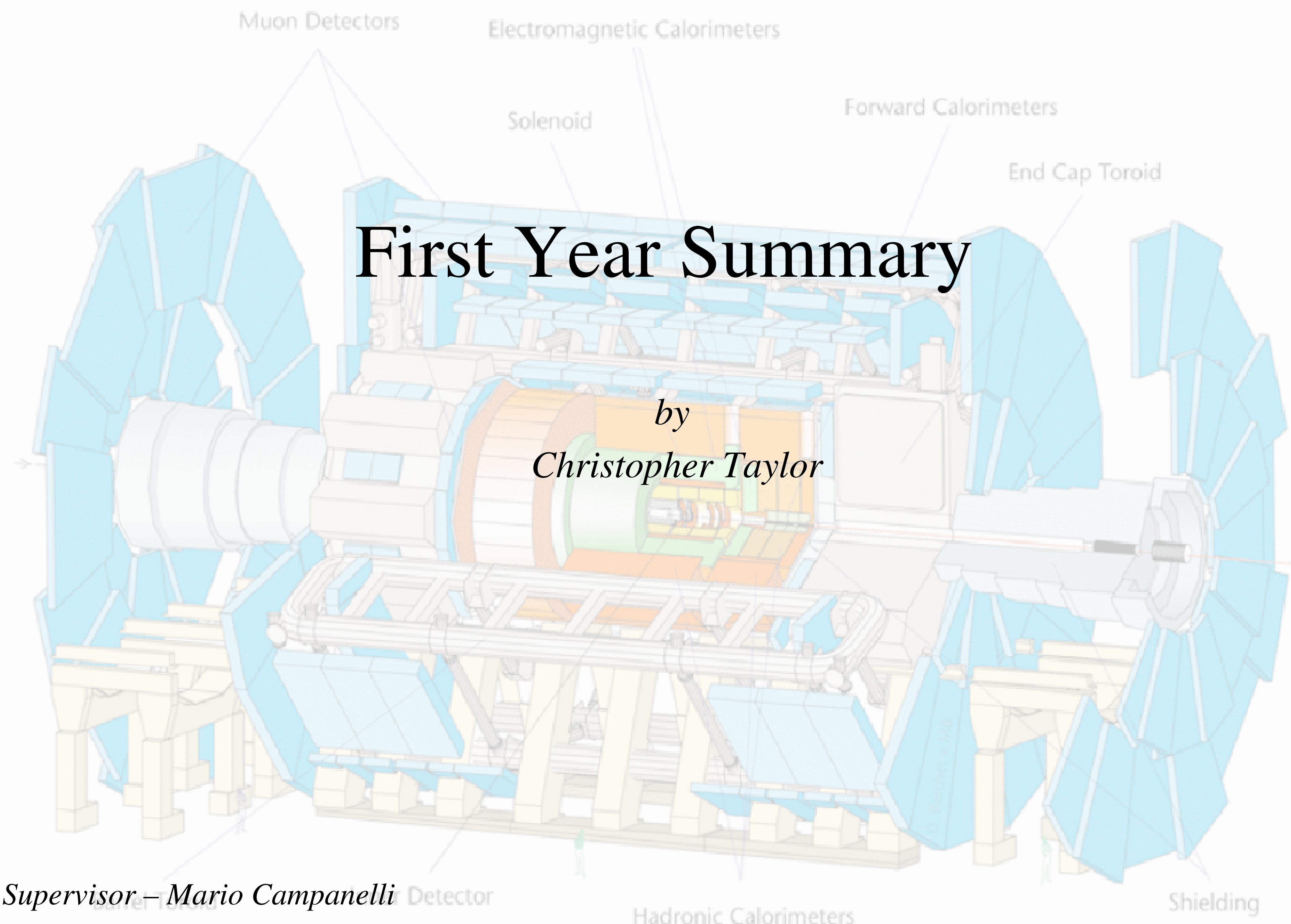
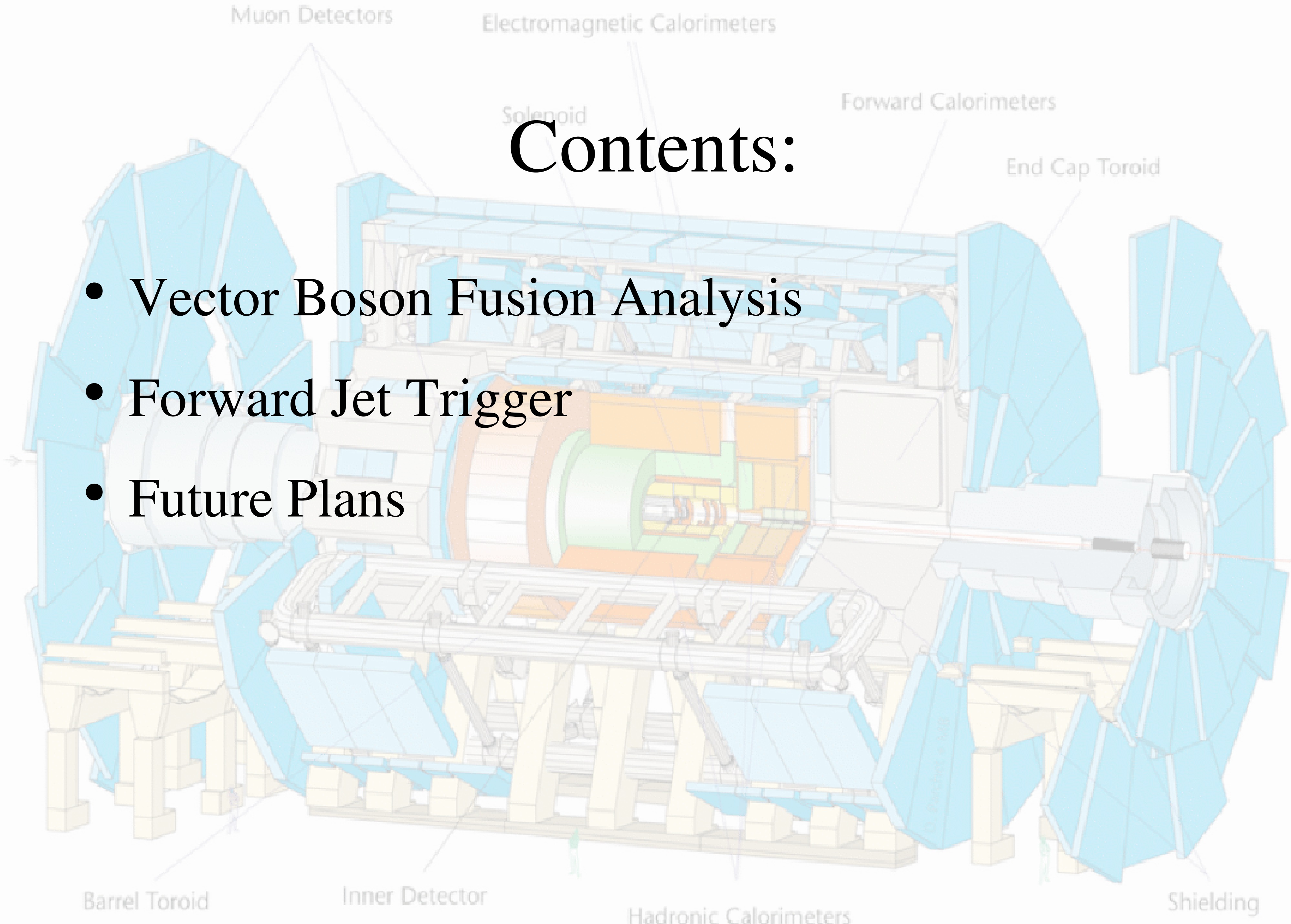


Supervisor – Mario Campanelli

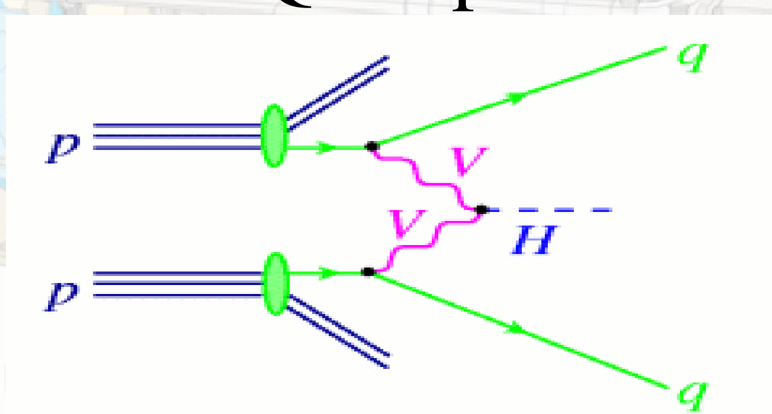
Contents:

- Vector Boson Fusion Analysis
- Forward Jet Trigger
- Future Plans

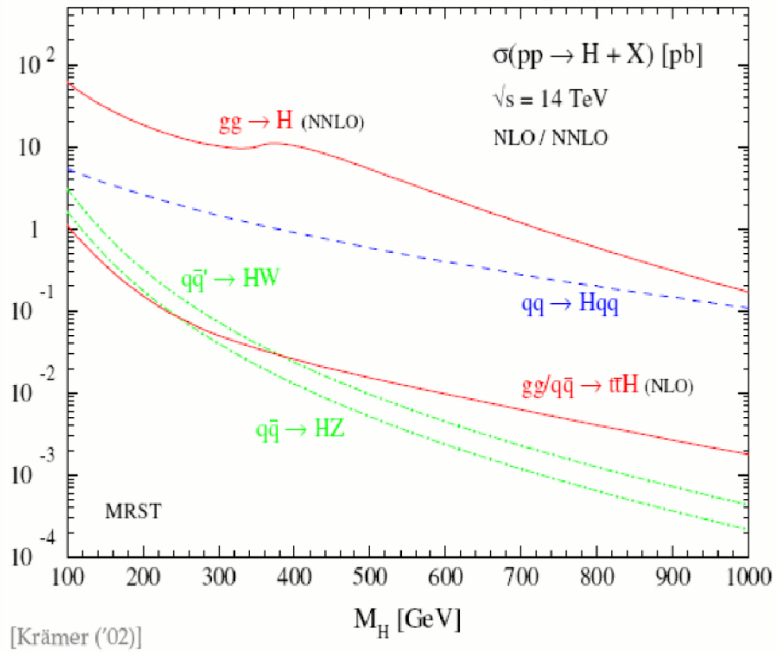


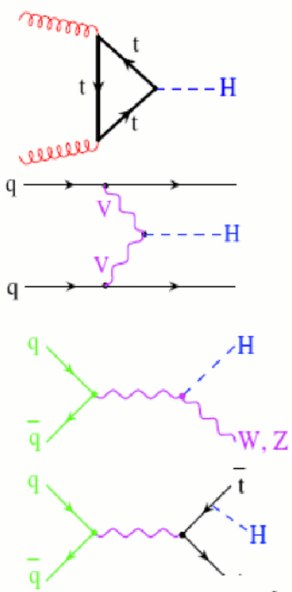
Vector Boson Fusion (VBF)

- VBF channel has unique topology.
- Higgs produced via bosons from quarks in the protons.
- Quarks then hadronise into 'tagging' jets.
- One decay channel is: $H \to \tau\tau \to 2(e/\mu + \nu_{e/\mu} + \nu_{\tau})$
- Fully leptonic – no QCD production from signal.



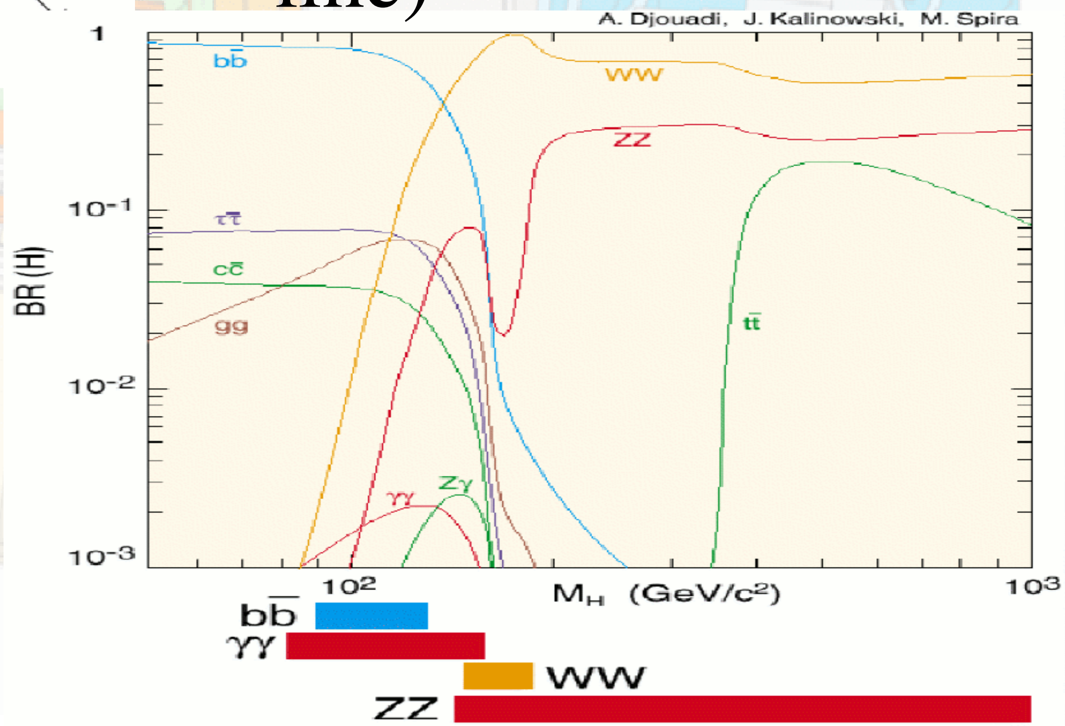
Channel Motivation:





- Cross-section for Higgs production mechanisms (VBF Higgs is dotted blue line)

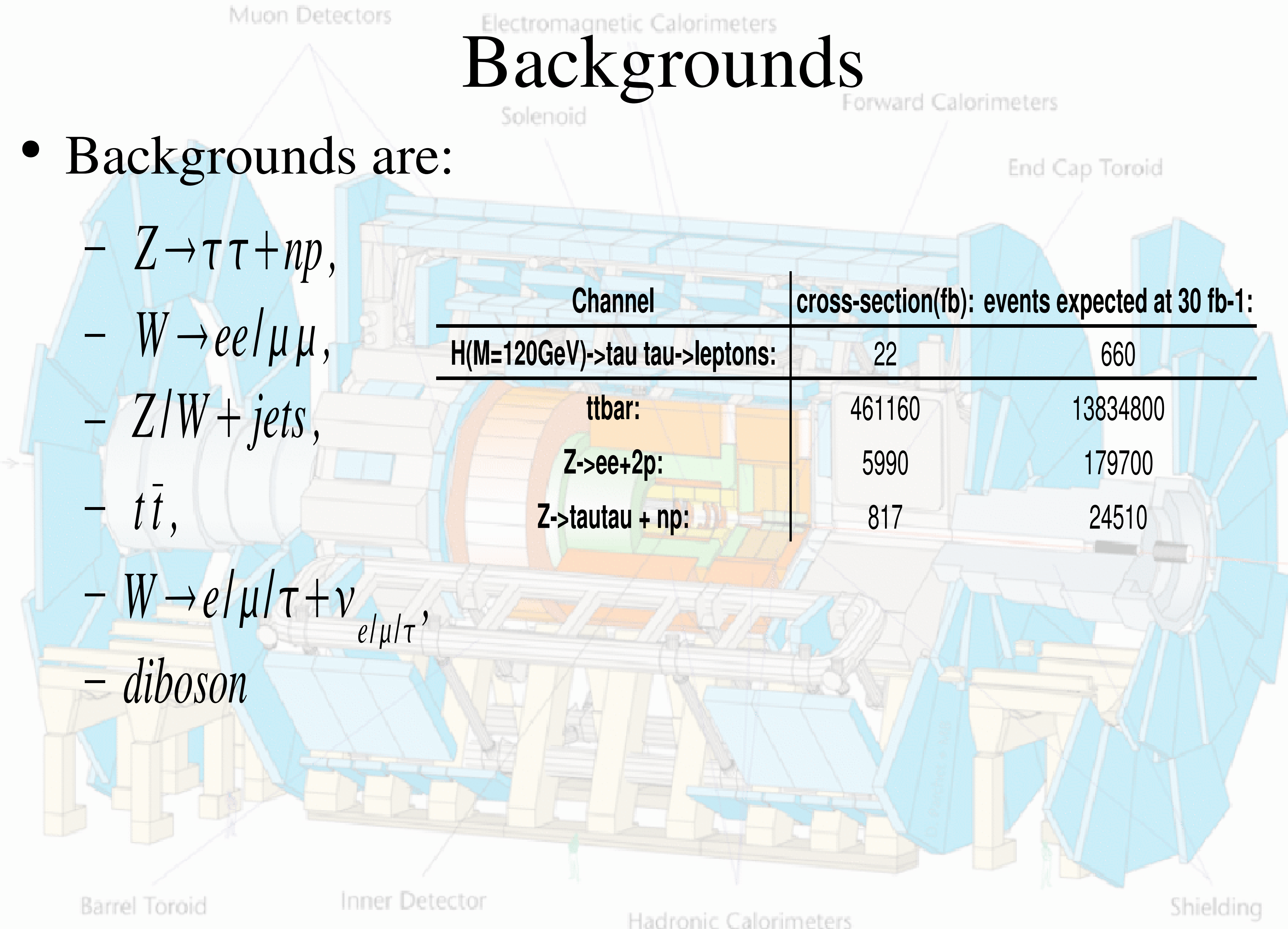
- Higgs Branching ratio (ττ decay is purple line)



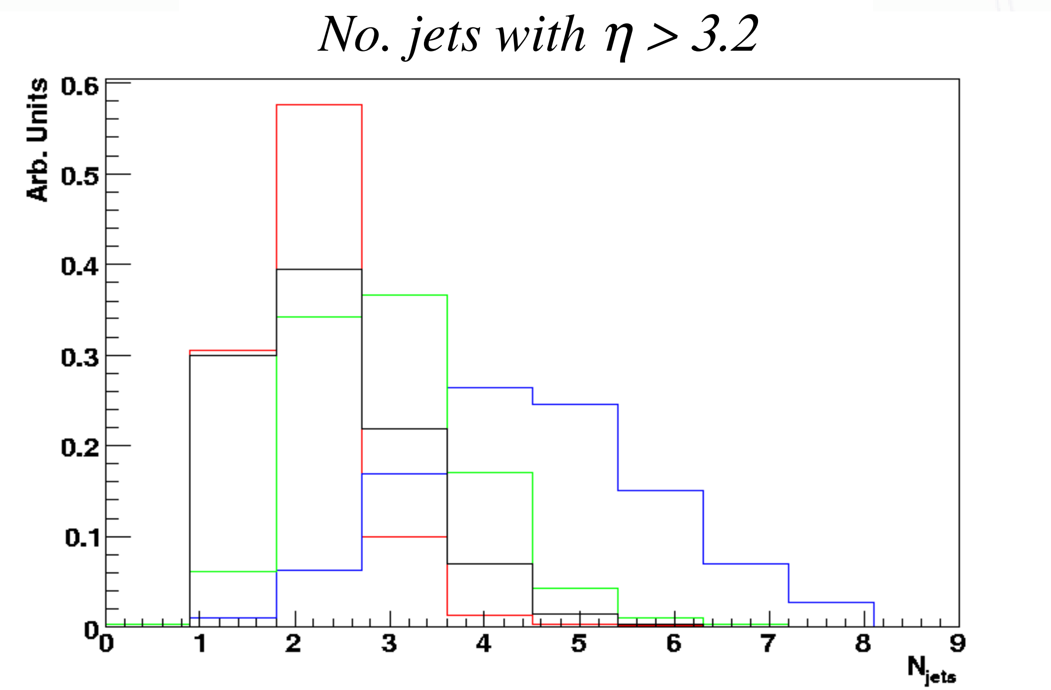
Backgrounds

- Backgrounds are:
  - $Z \rightarrow \tau\tau + np,$
  - $W \rightarrow ee/\mu\mu,$
  - $Z/W + jets,$
  - $t\bar{t},$
  - $W \rightarrow e/\mu/\tau + \nu_{e/\mu/\tau},$
  - $diboson$

Channel	cross-section(fb):	events expected at 30 fb-1:
H(M=120GeV)->tau tau->leptons:	22	660
ttbar:	461160	13834800
Z->ee+2p:	5990	179700
Z->tautau + np:	817	24510



Cuts: Tagging Jets

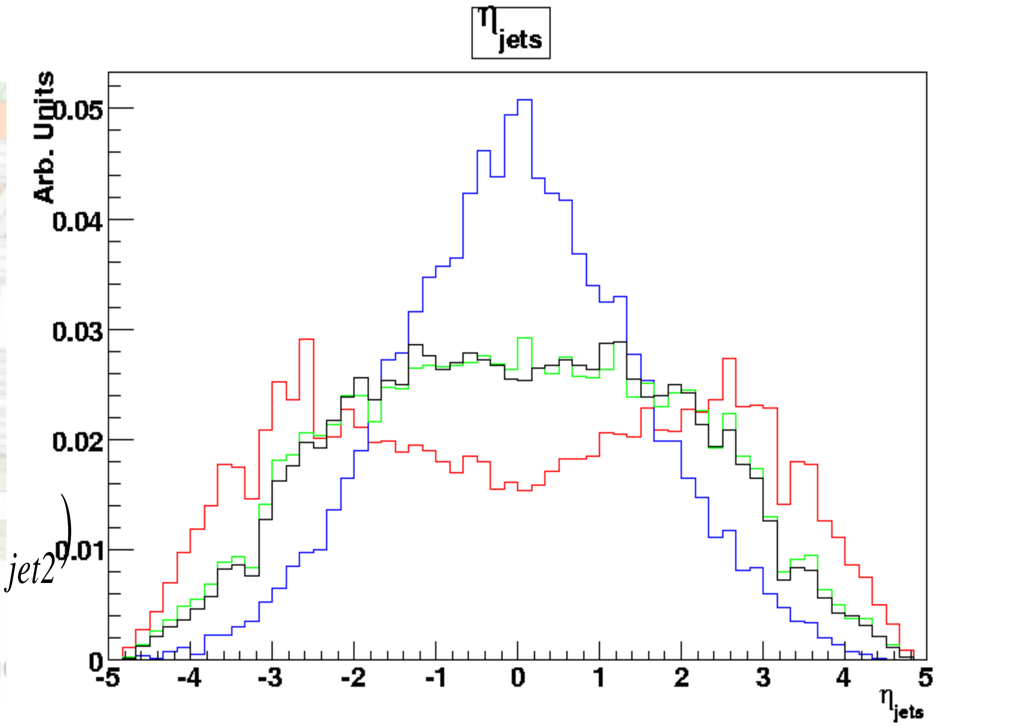


$H \to \tau\tau \to 2(e/\mu + \nu_{e/\mu} + \nu_\tau)$

$t\bar{t}$

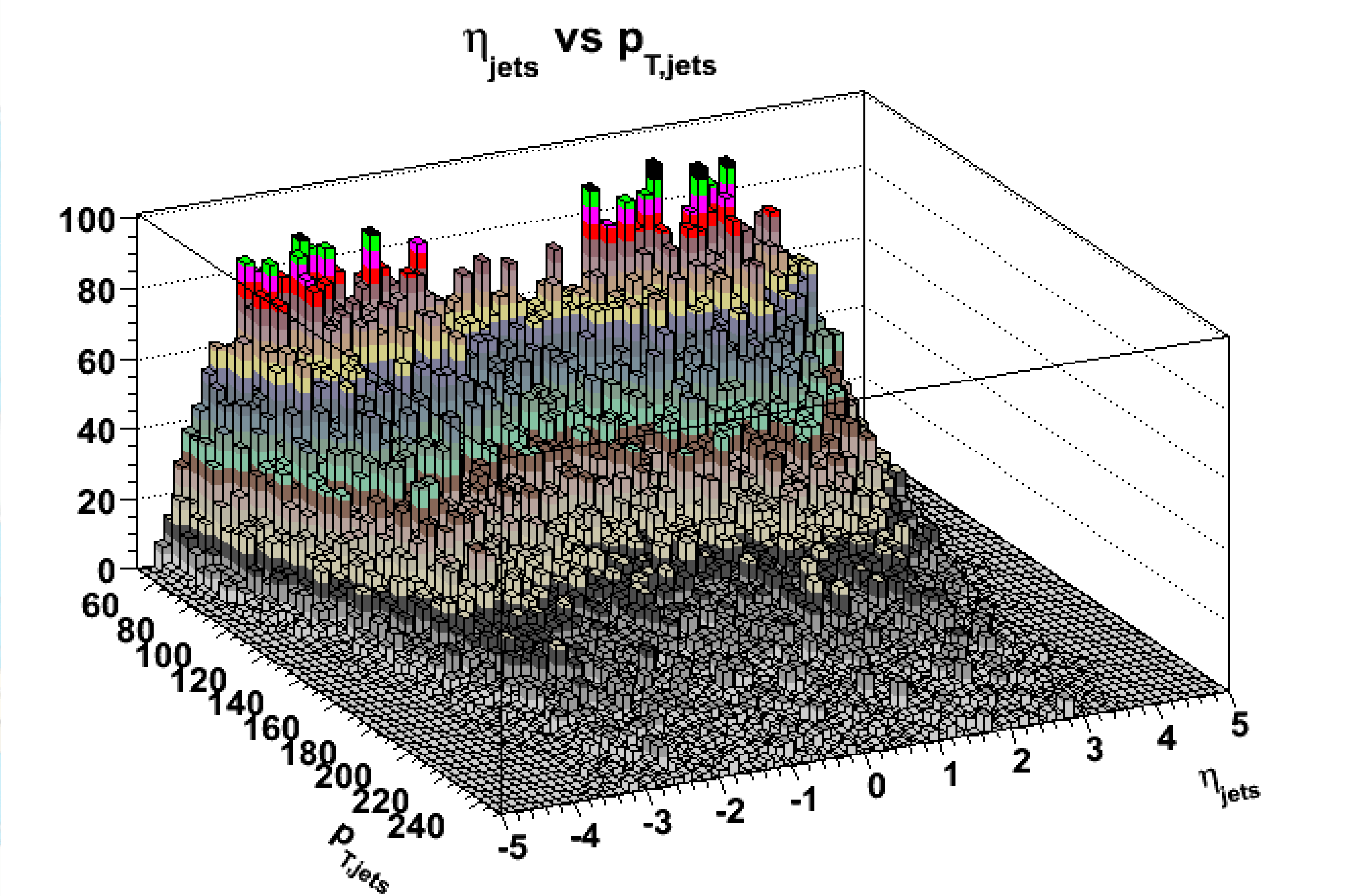
$Z \to ee + 2p$

$Z \to \tau\tau + np$



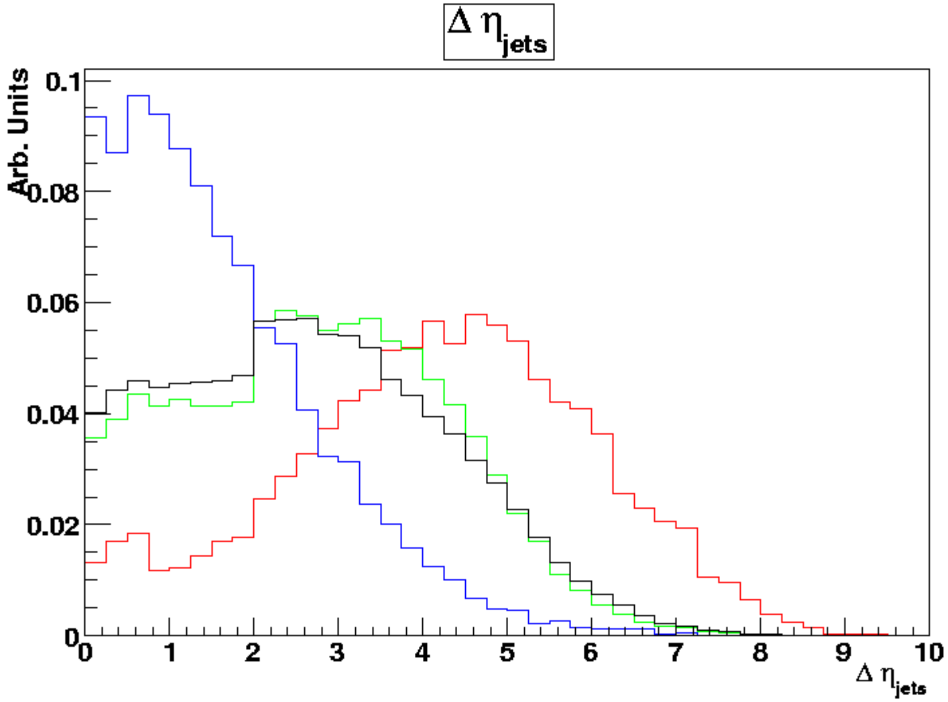
- Cut on no. of jets:
  - $jet_1 \, p_T > 40\,GeV$
  - $jet_2 \, p_T > 20\,GeV$
- Cut on forward jets:
  - $min(\eta_{jet1}, \eta_{jet2}) < \eta_{lep1,2} < max(\eta_{jet1}, \eta_{jet2})$

Cuts: Tagging Jets



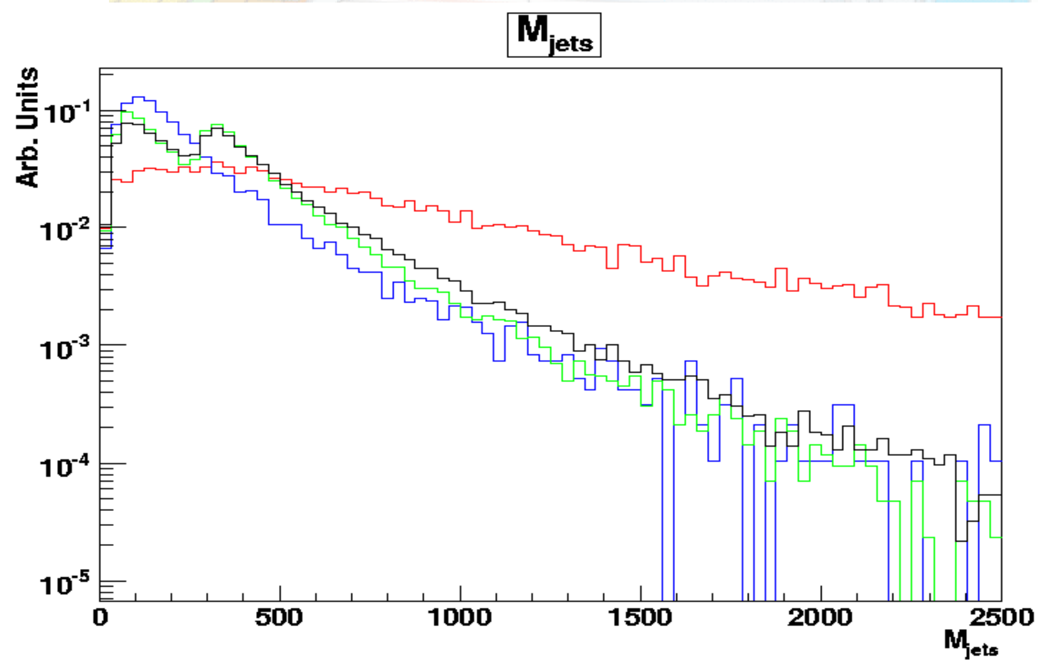
- Central Jet Veto:
  - $For\ p_{T,jets} > 20\,GeV, |\eta_{jets}| \leq 3.2$

Cuts: Tagging Jets



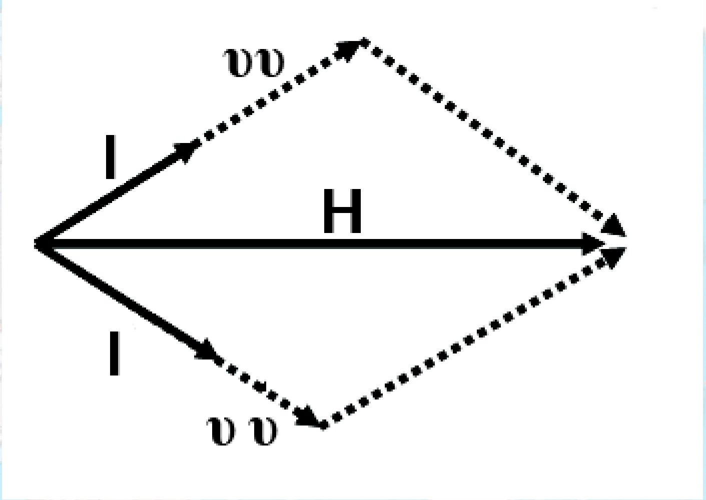
- Cut on η separation of jets:
  - $\Delta\eta_{jets} > 4.4$

- Cut on *M*ass of dijet system:
  - $M_{jets} > 700\,GeV$



Higgs Mass Reconstruction: Collinear Approximation

- A good approx. when parent particle is heavily boosted
- Assume tau decay products are collinear with tau direction:



$$p_{T,\tau l1}+p_{T,\tau l2}=p_{T,l1}+p_{T,l2}+p_T^{MISS}$$

$$\vec{p}_\tau=\vec{p}_l/x_l$$

- Where x is the fraction of tau momentum carried away by visible daughter

- Assuming conservation of momentum constraint, can solve for x, as we have two unknowns and two simultaneous equations.
- So mass can be reconstructed: $M_{\tau\tau}=M_{ll}/\sqrt{x_{\tau l1}x_{\tau l2}}$

Cuts: Tau System

- Trigger (e25i, mu20i)
- Dilepton selection with opp. charge
- Missing Energy (MET > 40 GeV)
- $0 < x < 0.75$ (x from last slide)
- Others:
  - B-jet veto
  - Jet ϕ separation

Cut Factorisation Method (CFM)

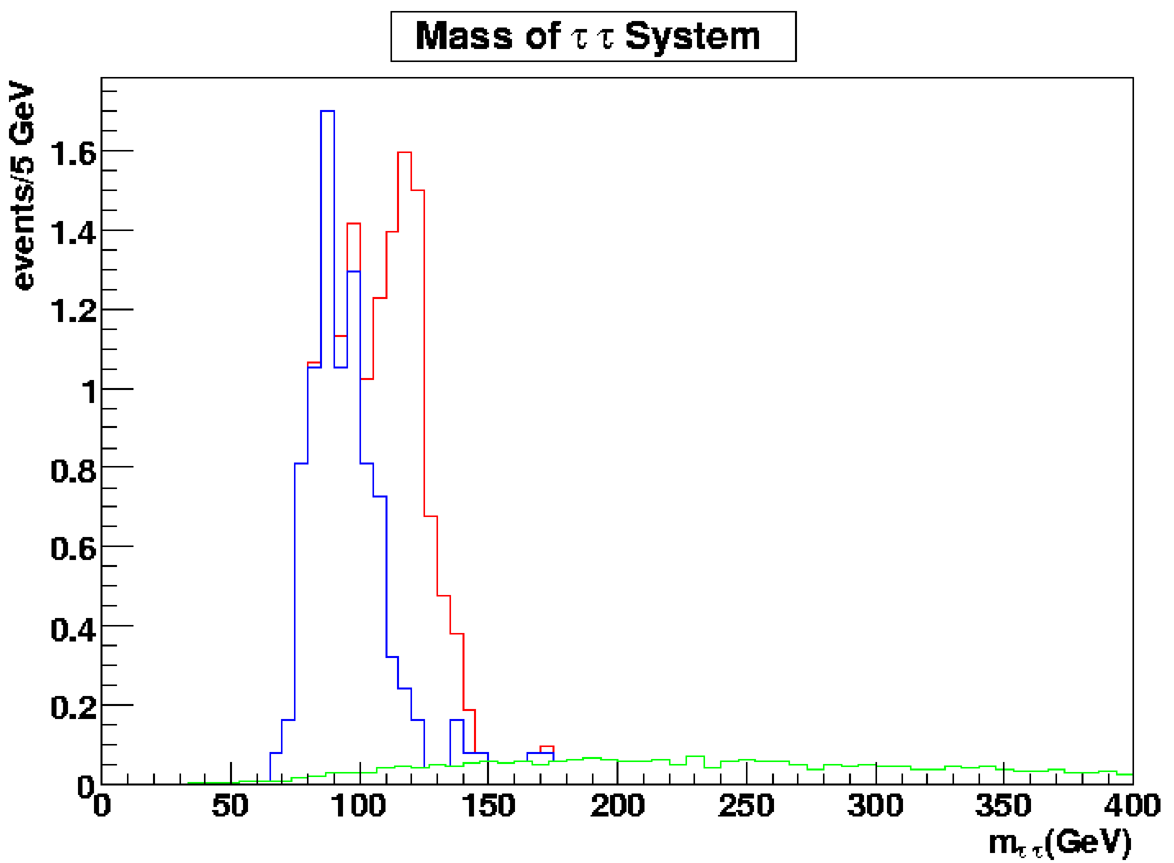
- Cut rejection rate O(10^8)
- Background datasets generated have O(10^5), ~fb^-1
- No statistics!
- Need to estimate background after all cuts:
  - Group cuts by their correlations (jets, taus, both)
  - Calculate efficiencies of the categories
  - Take product

Cut Flow

	Higgs->tautau	Z->tautau+njets	ttbar	Z->ee+2p
Total events	660	24510	13834674	179768
Trigger (Passed_EF_e25i==1)	659.98	24510.06	13834674	179700.04
Lepton (thisElectron==1)	184.32	6214.26	2948493.96	142649.98
Trigger lepton (trigLepPt > 25GeV)	150.73	4825.63	2475353.32	127867.96
Dilepton (thisDilepton == 1)	71.4	2830.92	323144.04	64275.06
Opposite charge leptons (thisOppositeSign == 1)	71.09	2818.45	313317.96	63761.05
Missing energy (MET_RefFinal_et > 40GeV)	49.51	1918.16	272152.64	45328.98
Collinear approx. (tauDau1X > 0.0)	49.51	1918.16	272152.64	45328.98
Collinear approx. (tauDau1X < 0.75)	33.48	1072.08	211186.28	634.32
Collinear approx. (tauDau2X > 0.0)	33.02	1051.61	143445.88	582.37
Collinear approx. (tauDau2X < 0.75)	27.79	888.72	89476.88	131.24
Collinear approx. (tauDauCosdphi > -0.9)	27.17	852.71	57244.36	113.47
Collinear approx. (dPhill < 2.2)	23.85	707.06	46971.64	58.78
N jets ≥ 2 (jet1Pt > 40GeV)	23.1	690.8	25458.48	31.44
N jets ≥ 2 (jet2Pt > 20GeV)	19.31	400.06	11910.4	15.04
Forward jet (thisForwardJet == 1)	17.91	218.48	4764.16	8.2
Centrality (thisCentrality == 1)	16.56	187	4094.2	4.1
B-jet veto (thisBjetVeto)	15.81	180.53	2828.72	1.37
Delta eta of jets (deltaEtajj > 4.4)	13.51	148.89	1116.6	1.37
Delta phi of jets (dPhijj < 2.6)	8.66	31.64	372.2	1.37
Inv. Mass of jets (Mjj > 700GeV)	7.39	18.37	372.2	0
Central Jet Veto (thisCentralJetVeto == 1)	6.28	8.9	*7.07*	*0.00402*

(CFM in italics)

Result



$H \to \tau\tau \to 2(e/\mu + \nu_{e/\mu} + \nu_\tau)$

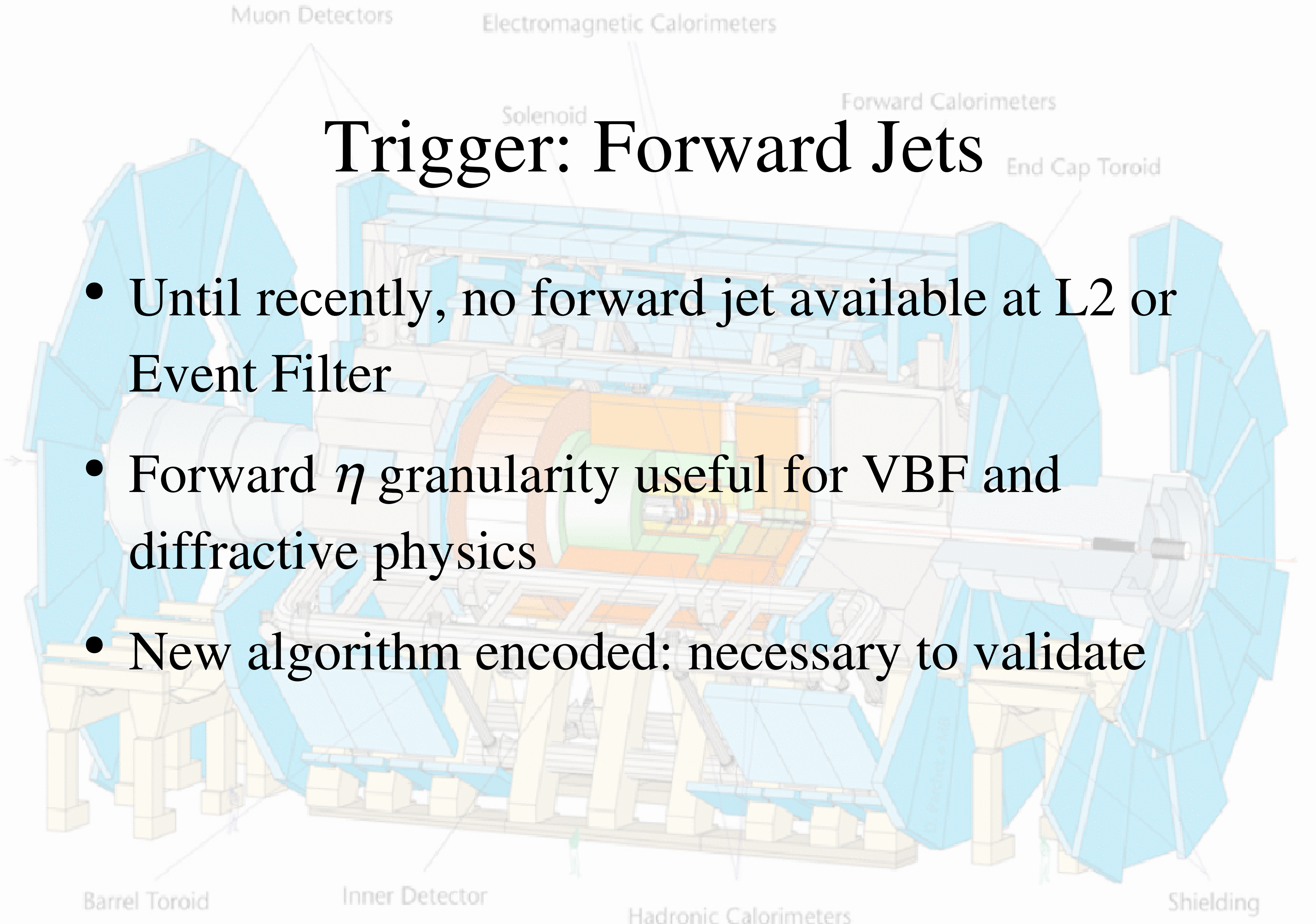
$Z \to \tau\tau + np$

$t\bar{t}$

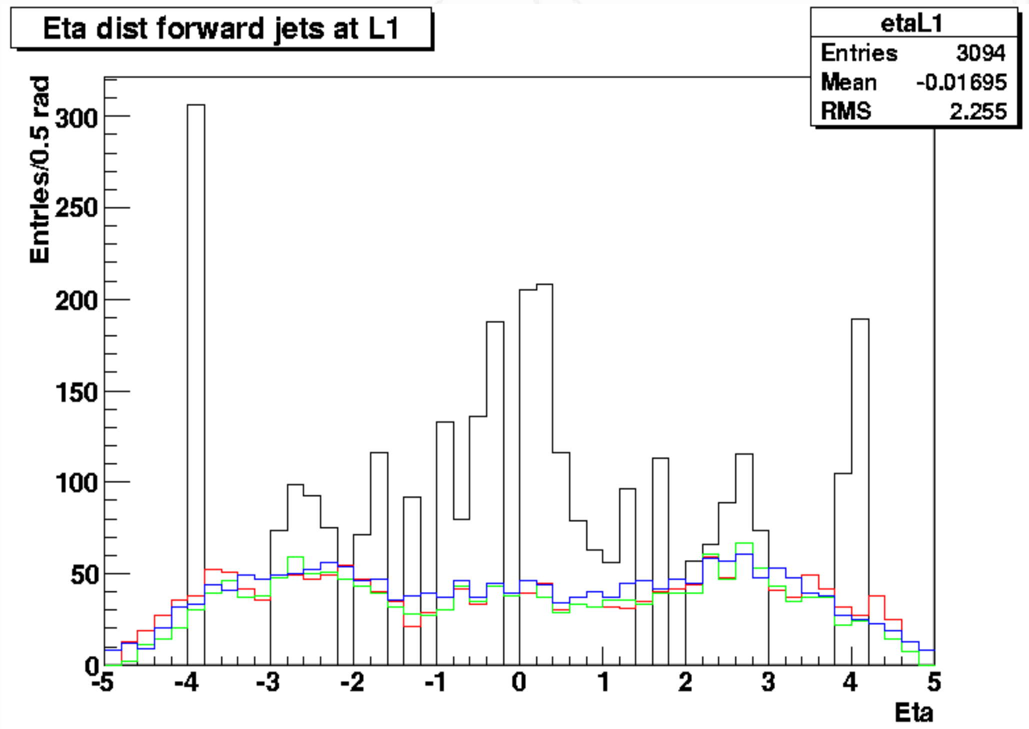
- Use mass window (105-135 GeV) to count signal and background events
- Naive significance (have <10 events): $s/\sqrt{s+b} = 2.1 \; for \; 30 \; fb^{-1}$
- Proper stat. treatment gives 2.9 (CSC note)

Trigger: Forward Jets

- Until recently, no forward jet available at L2 or Event Filter
- Forward η granularity useful for VBF and diffractive physics
- New algorithm encoded: necessary to validate



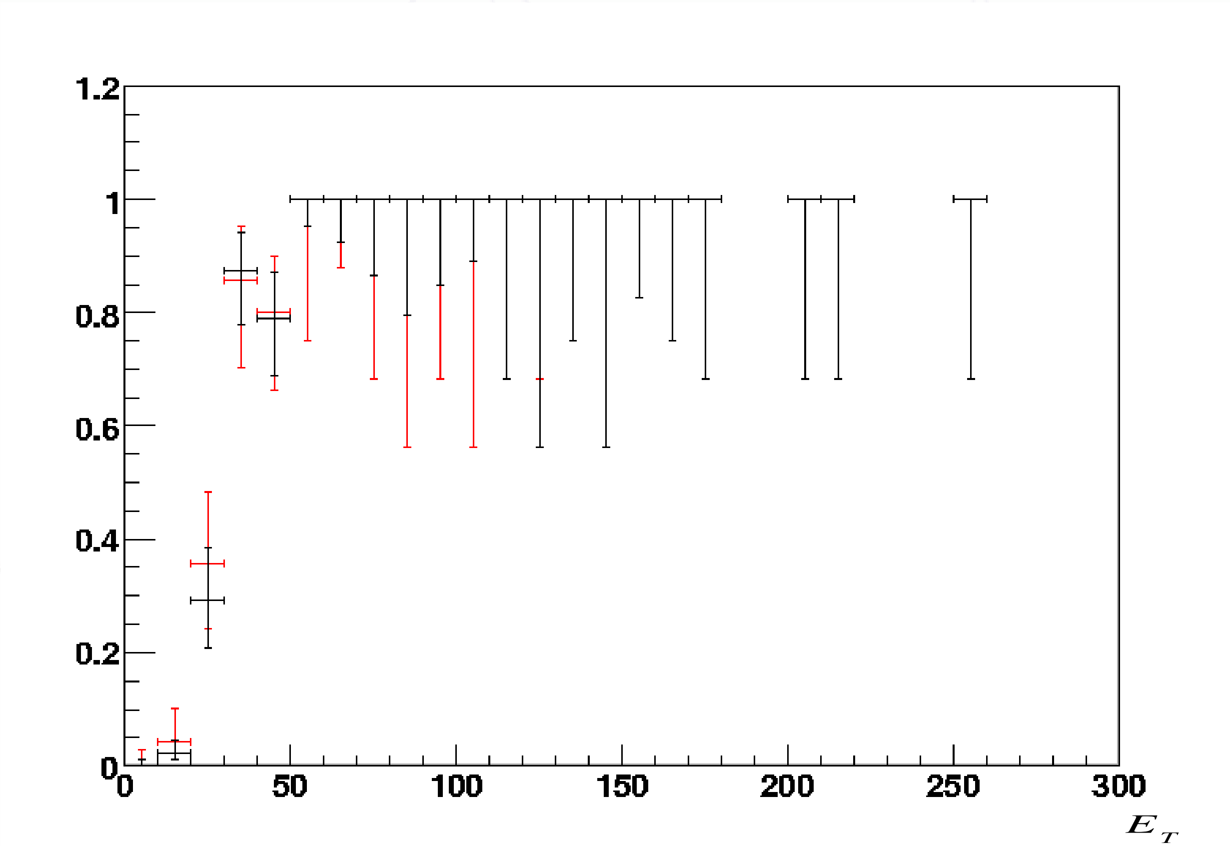
Validation: η Distribution



- L1 -
- L2 -
- EF -
- Truth -

- Jets compared at different levels using Region of Interest (RoI)'words'
- L1 assigns a unique string to area of detector that may contain something interesting that can be accessed at higher trigger levels

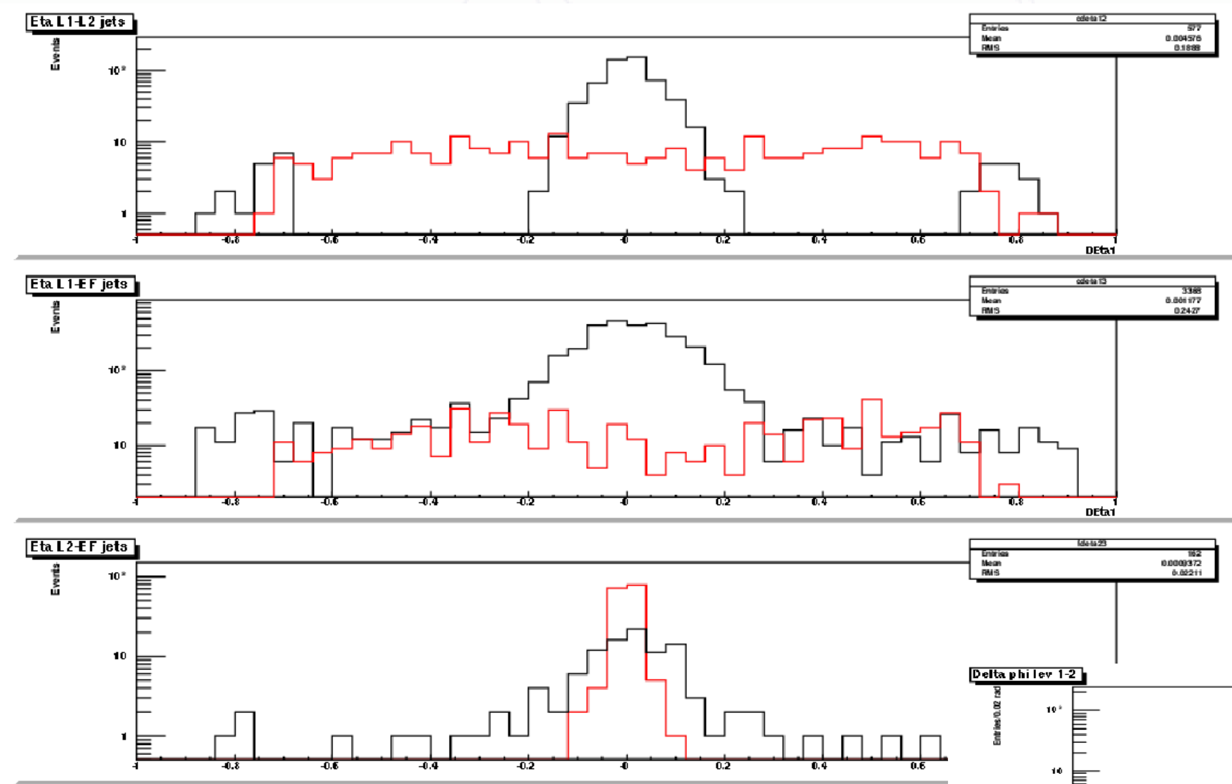
Validation: Efficiency



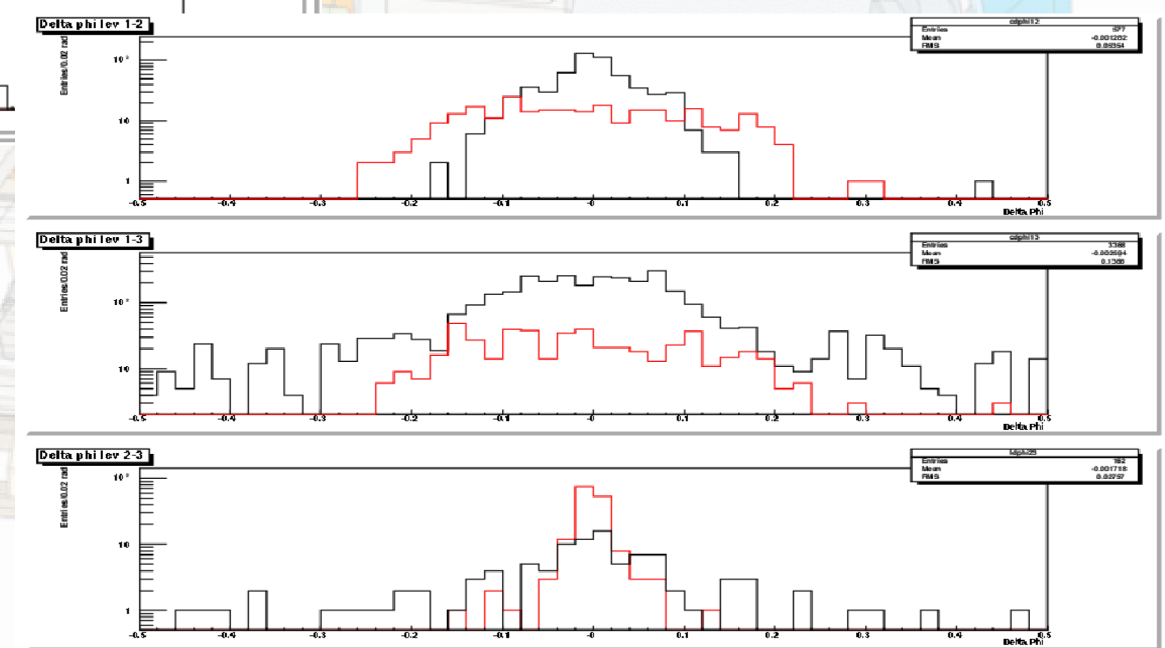
- Forward
- Central

- Includes cut at 18 GeV at all trigger levels, for both central and forward jets.
- Bayesian method used for errors/efficiency .

Validation: Resolution

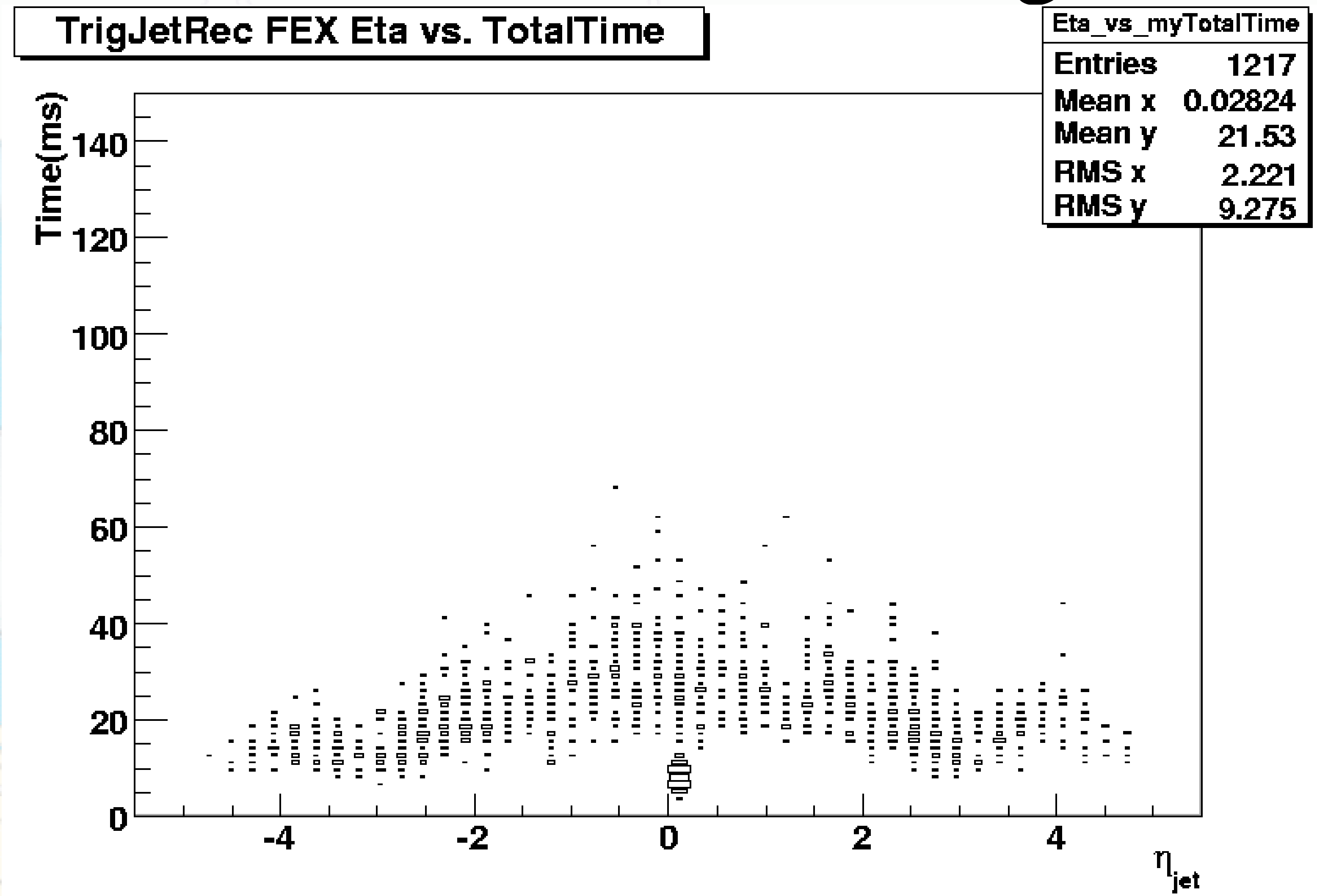


- η Resolution between different levels
- Forward -
- Central -



- ϕ Resolution between different levels

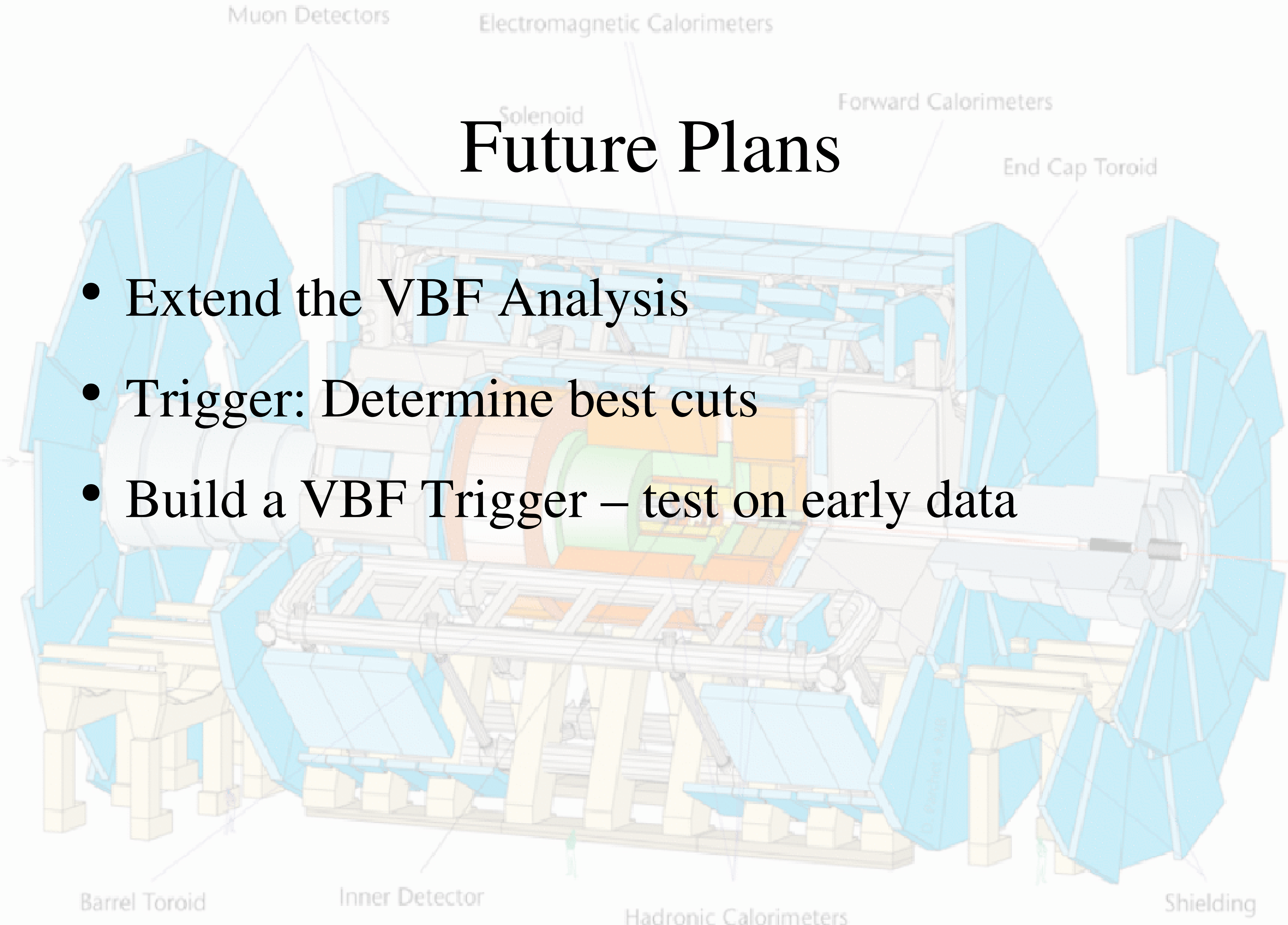
Validation: Timing



- Algorithm tested for memory leaks using Valgrind – none found

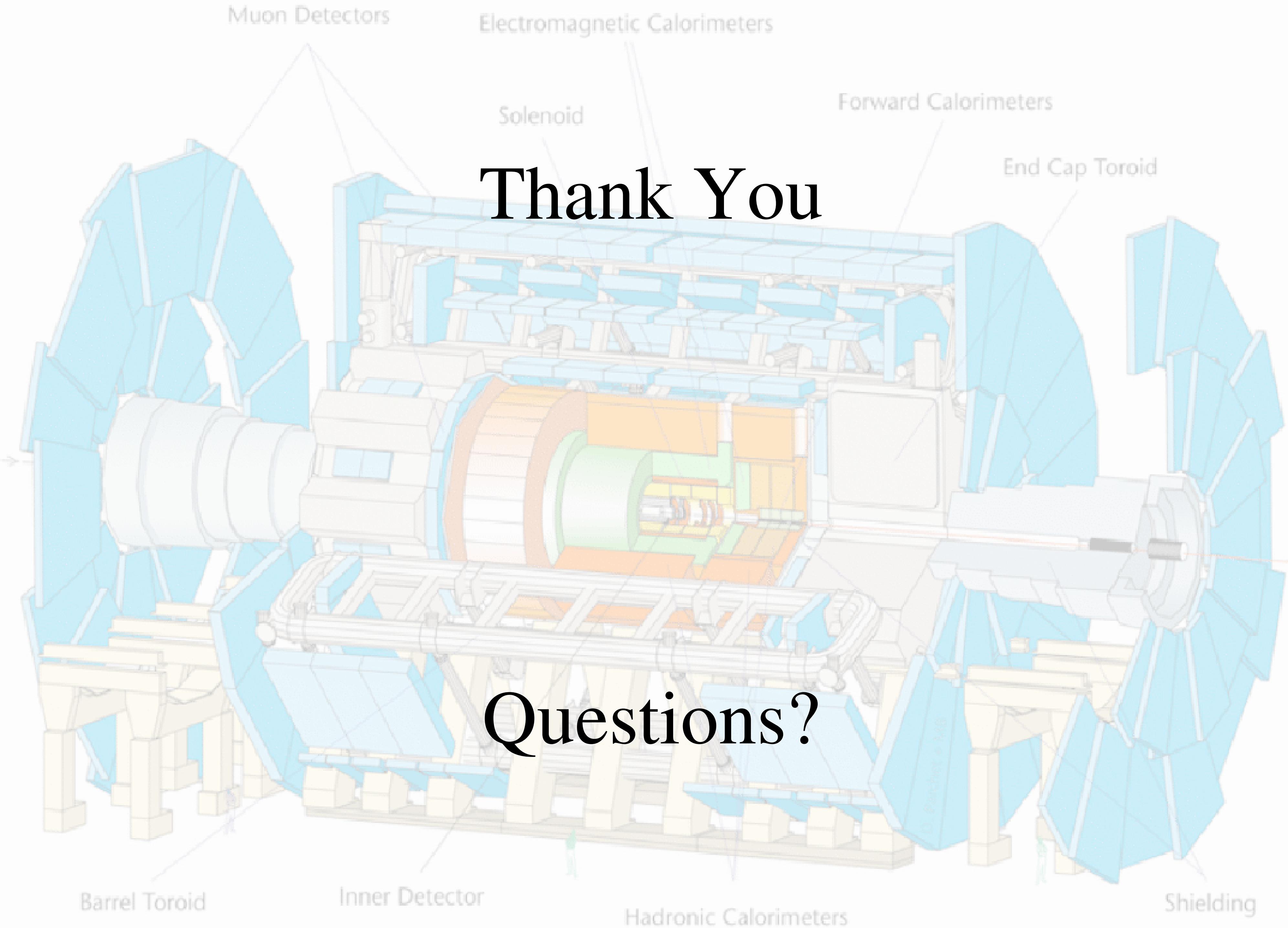
Future Plans

- Extend the VBF Analysis
- Trigger: Determine best cuts
- Build a VBF Trigger – test on early data



Thank You

Questions?



Bayesian Errors:

- Bayesian method: $$P(\epsilon|k,N,I)=\frac{P(k|\epsilon,N,I)P(\epsilon|N,I)}{Z}$$

- Where ϵ is true efficiency, k is events that pass cut, N is total number of events, I is prior information of binomial distribution and Z is normalisation constant.

- Binomial signal probability: $$P(k|\epsilon,N,I)=\frac{N!}{k!(N-k)!}\epsilon^k(1-\epsilon)^{N-k}$$

- Sensible to say that $P(\epsilon|N,I)=1\,if\,0\leq\epsilon\leq1,0\,elsewhere$ as ϵ is an efficiency.

- Just need normalisation constant (by integration).

Bayesian Errors:

- Graphical result shows probability distributions for for the cut efficiency ϵ for N=5, k=0 - 5

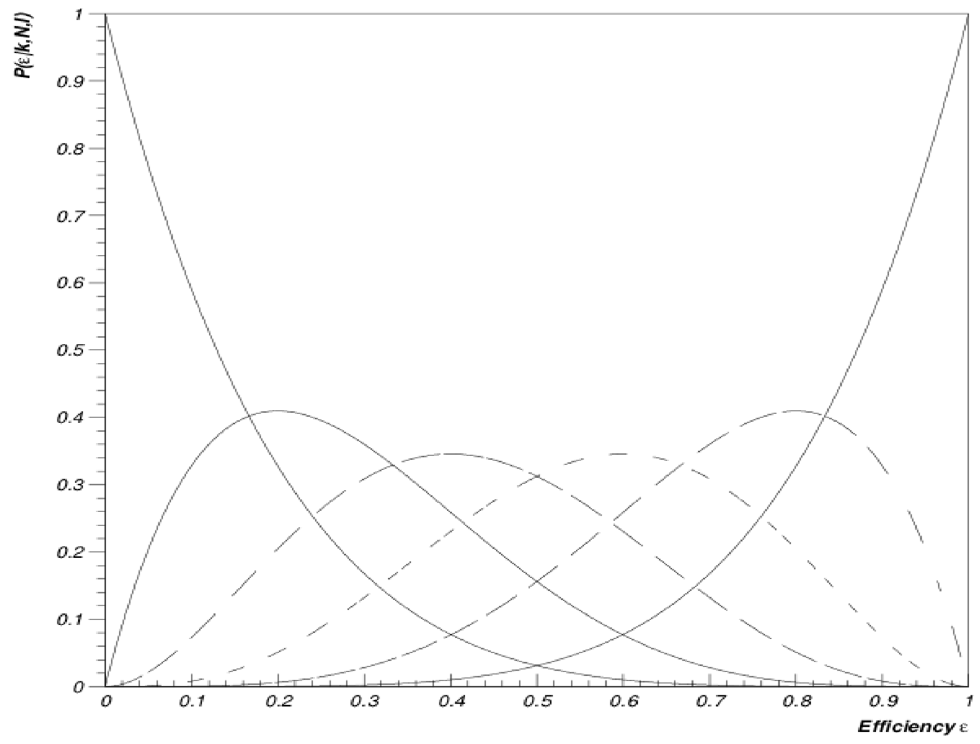


Figure 1: The post-data probability distribution for the cut efficiency ϵ, for $N = 5$, and for $k = 0, 1, 2, 3, 4$ and 5.

Bayesian Errors:

- Uncertainty in efficiency: take 68.3% integral of previous distribution (1σ Gaussian error)
- To find 0.683 probability content in the shortest interval is not trivial
- Computer program to solve problem numerically, written by M. Paterno
- http://home.fnal.gov/~paterno/images/effic.pdf

Pseudorapidity

- In hadron collider physics, the rapidity (or pseudorapidity) is preferred over the polar angle because, loosely speaking, particle production is constant as a function of rapidity. One speaks of the forward direction in a hadron collider experiment, which refers to regions of the detector that are close to the beam axis, at high |\eta|\,.

$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$

- The difference in the rapidity of two particles is independent of Lorentz boosts along the beam axis.