Electron Identification with Early Data for the CMS Experiment at CERN

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Introduction: Motivation for Electron Identification

High p_T ($\gtrsim$20GeV/c) Isolated Electrons

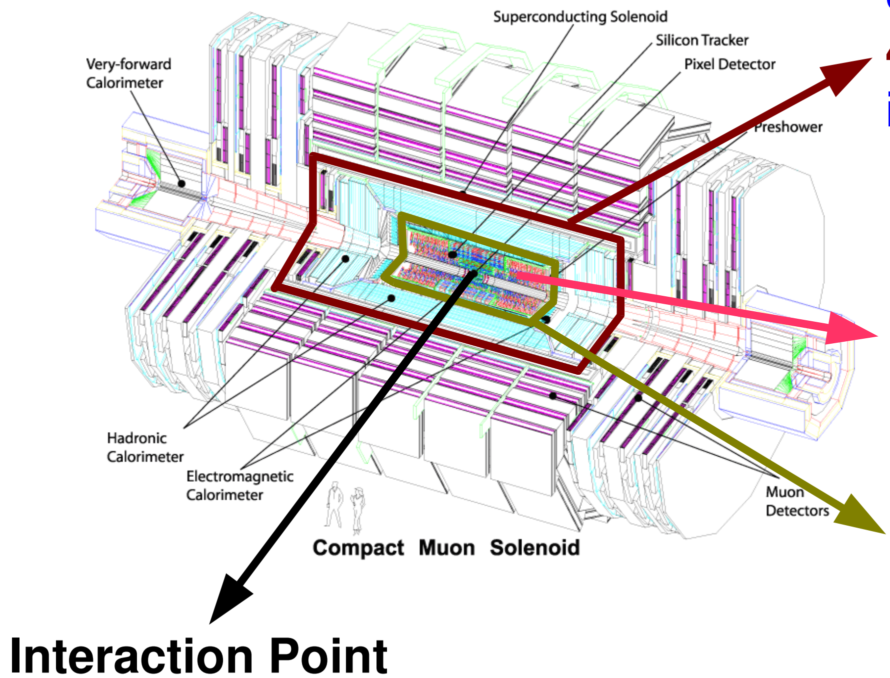
- easy to identify in a hadron collider environment
- good energy/position resolution
- very important for physics studies W/Z, Top, SUSY, Higgs, ...

In this talk I will briefly describe:

a tool to commission and tune electron selections with early data implemented in the context of the CMS experiment

The CMS Experiment at CERN

- The Compact Muon Solenoid (CMS) is a general purpose detector designed to study LHC proton-proton (and heavy ion) collisions



cylindrical geometry: **4T solenoid magnet** that encloses inner tracking and calorimeters

for electrons most important parts:

Inner Tracker: all-silicon, large solid angle coverage $|\eta|<2.4$, excellent position and momentum resolution

ECAL: homogeneous, crystal ($PbWO_4$) calorimeter, highly segmented, excellent energy resolution

Electron Objects at CMS

Electron Candidate:

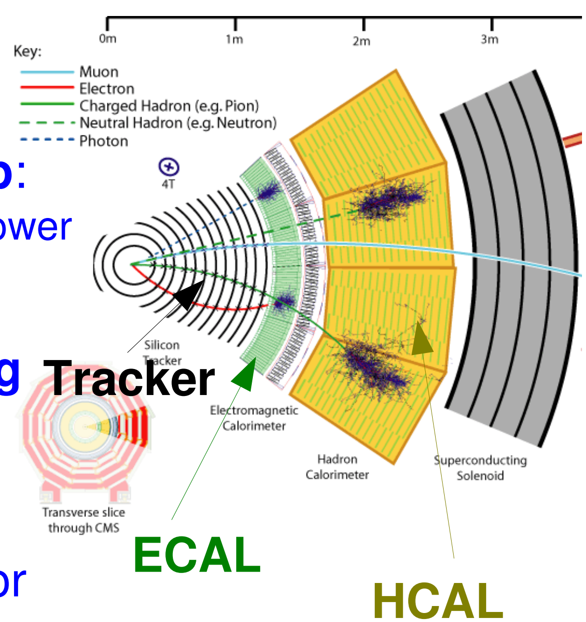
particle that leaves tracker hits and a short/narrow shower in the calorimeters

Signature can be faked!

Charged hadron - π^0 overlap: matched in space with a photon shower from π^0

Charged Hadrons showering early in ECAL, Charge exchange ($\pi^+ n \rightarrow \gamma p$)

Electrons from **conversions** or from **heavy flavor quark decays** (real electrons)



Electron properties indicate how to reject fakes

Shower properties: longitudinal and latitudinal shape of the shower match the electron expectations

Tight Track – Shower matching: rejects accidental matches

Isolation: most hadrons faking electrons belong to jets, hence there have other energy deposits or tracks nearby

Introduction to Selection Tuning

- Task: separate “signal” electrons from “background” (bkg) in a sample of electron candidates
  - Selection: a set of rules to select a “signal” sample
  - **Selection Tuning: define the selection parameters to get the highest bkg rejection for a given signal efficiency**
- For the start-up
  - we will try a simple selection using cuts on selection variables
    - » aim for robustness
    - » powerful handle for understanding detector issues
  - tuning strategy: preferable to be **data-driven**
  - integrated in a broader framework that will help us to understand electron identification behavior in data

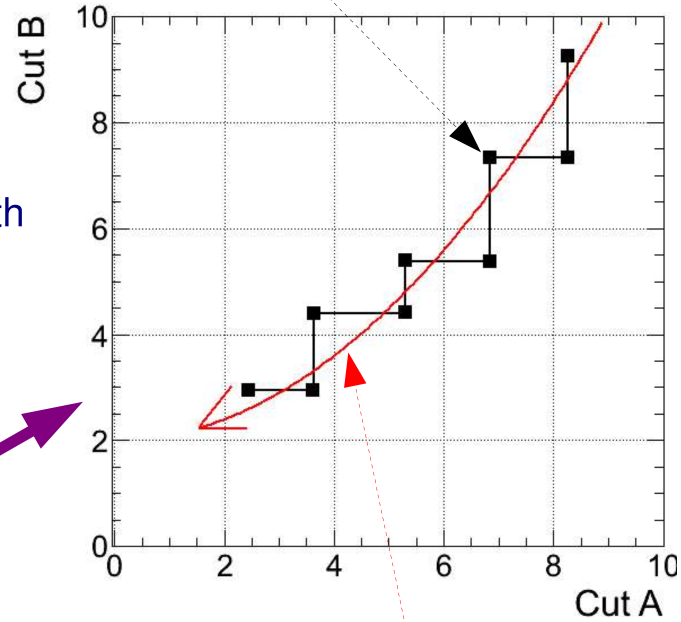
An Iterative Technique to Tune Cut-Based Selections

- We have developed an iterative technique for cut-based selection tuning
  - Steps:

1. start from a configuration with very loose cuts
2. define a target in bkg rejection that is slightly higher than the current one
3. find which **single** cut can achieve this bkg rejection target with the highest signal efficiency
4. change this single cut only to obtain a new selection
5. iterate

iterative algorithm concept illustration for a 2 cut case

path followed by the iterative technique



optimal curve that the algorithm tries to approximate

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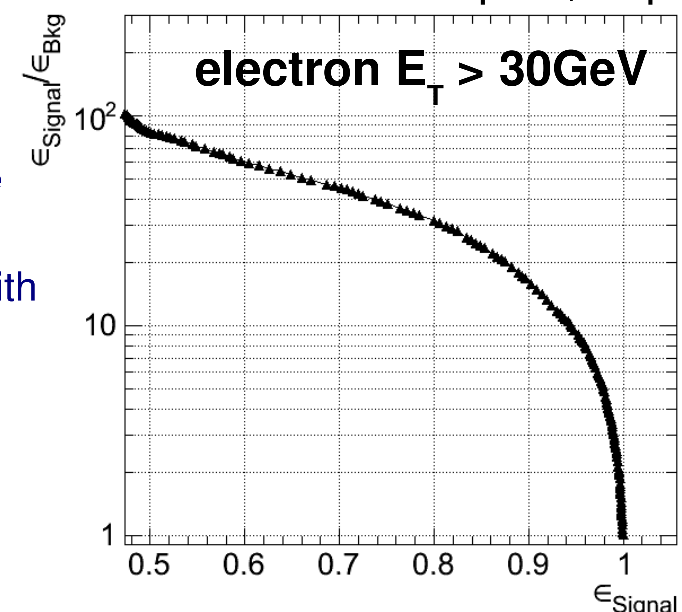
CMS 7TeV Simulated Samples, 10pb^{-1}



  - the outcome of the method can be traced with a plot showing the signal efficiency vs some measure of background rejection

An Iterative Technique to Tune Cut-Based Selections

- It can be shown that in the context of statistical hypothesis testing this technique approximates the optimal solution, i.e. the solution that maximizes the bkg rejection for a given signal efficiency
- Demonstration of the technique
  - » CMS preparation for $W \rightarrow e\nu$ cross section measurement

CMS PAS EWK-09-004

    - signal sample: reconstructed electrons with E_T>30GeV from $W \rightarrow e\nu$ simulated samples
    - bkg sample: reconstructed electrons with E_T>30GeV in simulated samples of QCD dijet and various EWK processes that are backgrounds in the $W \rightarrow e\nu$ cross section measurement

The Iterative Technique as a Data-Driven Method

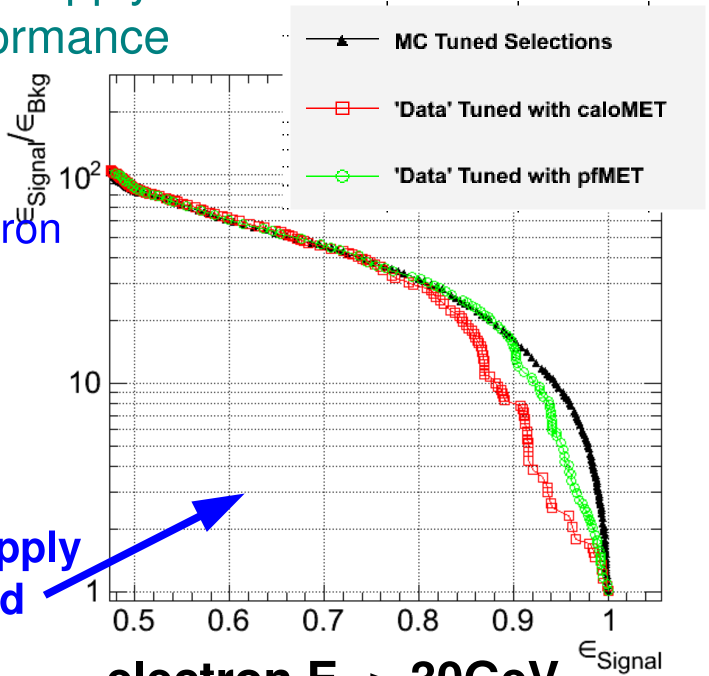
The method is tolerant to some contamination in the input samples

from DATA: tuning using MET-driven samples and apply the selections on pure MC samples to see the performance

signal sample:
- ✓ from Z→ee events, if luminosity permits
- ✓ with a missing E_T cut (e.g. MET>30GeV) in an inclusive electron sample

bkg sample: with a MET cut (e.g. MET<20) in an inclusive electron sample

Tune using MET-driven signal and bkg samples and then apply the selections on pure MC samples: compare with MC tuned selections to see the performance



electron E_T > 30GeV

CMS 7TeV Simulated Samples, $10pb^{-1}$

possible to operate with
very low integrated luminosities: ~$0.1pb^{-1}$

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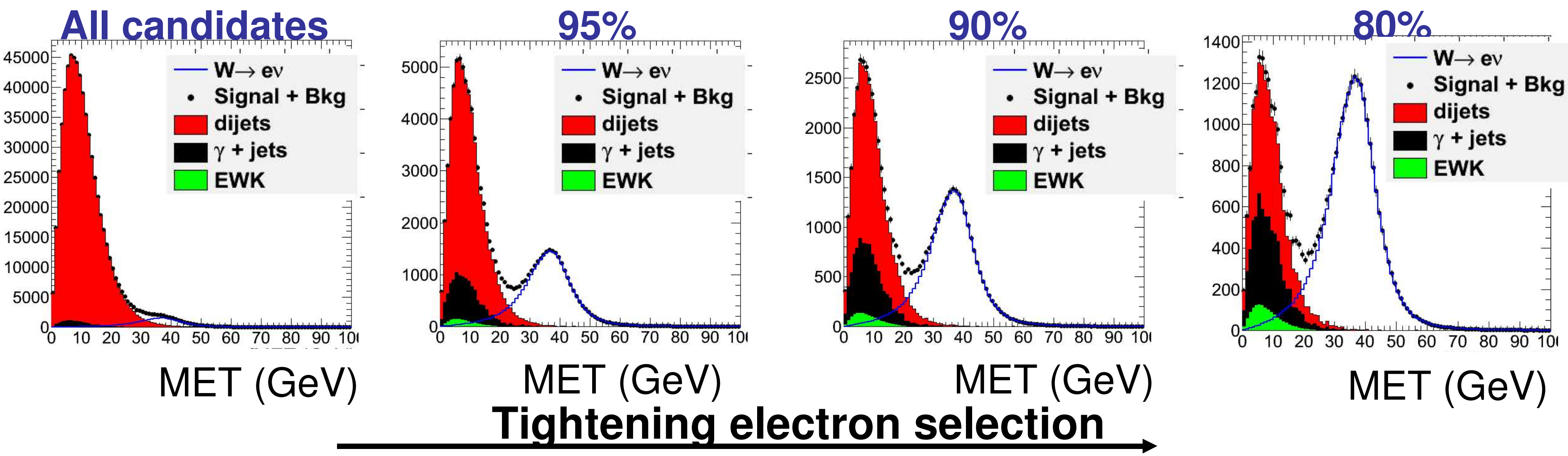
The Iterative Technique as a Data-Driven Method

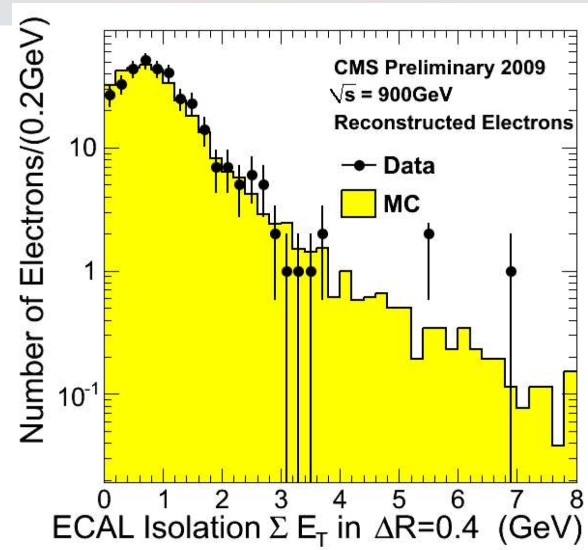
Of course, **we can't see in Data the plot of the previous page**, but we can asses the performance of the method by looking on **how well the W peak is visible** in the MET distribution as we apply tighter and tighter selections



CMS 7TeV Simulated Samples, $10pb^{-1}$

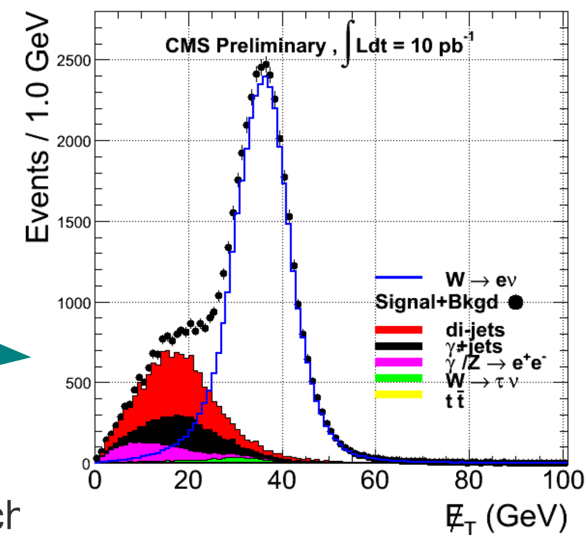
Towards the first Data Operations

- Electron selection variables have been examined in 900GeV LHC collisions →



- The same procedure will be repeated when the first high p_T electrons become available

- Finally, when the number of events become adequate the selections will be tuned and applied to the first $W \rightarrow e\nu$ cross section measurement



Outlook

- We have presented a general strategy to tune a cut-based an electron selection
  - method suitable for start-up
  - data-driven
  - possible to operate in low integrated luminosities (>$0.1pb^{-1}$)
- We plan to use as a tool to investigate electron selections towards the first $W\rightarrow e\nu$ observation / cross section measurement in CMS

Thanks for your attention!

Acknowledgments

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