Report about "Forward Instrumentation" Issues

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3/06/2008
DESY

- Physics issues
- Calorimetry, Pair Monitor
- Tracking
- Particle ID

Physics issues:

Measurement of the Luminosity , I. Sadeh

Impact on SUSY searches (valid for all signatures with “large missing momentum and small depositions in the Calorimeter),

T. Rizzo, Z. Zhang

The measurement of the luminosity is a prerequisite for any cross section measurement!

1. Required precision is:

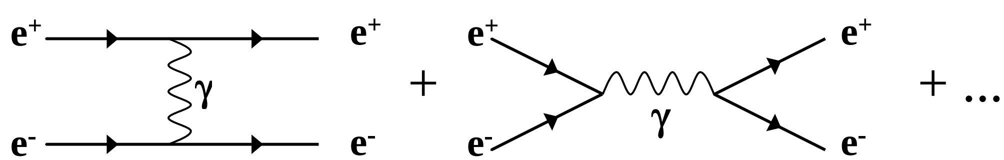
$$\frac{\Delta L}{L} \sim 10^{-4} \quad , \quad \text{GigaZ (hadronic Z decays)} \quad 10^{9} / \text{year}$$

$$\frac{\Delta L}{L} \sim 10^{-3} \quad , \quad e^{+} e^{-} \rightarrow W^{+} W^{-} \quad 10^{6} / \text{year}$$

$$\frac{\Delta L}{L} \sim 10^{-3} \quad , \quad e^{+} e^{-} \rightarrow q^{+} q^{-} \quad 10^{6} / \text{year}$$

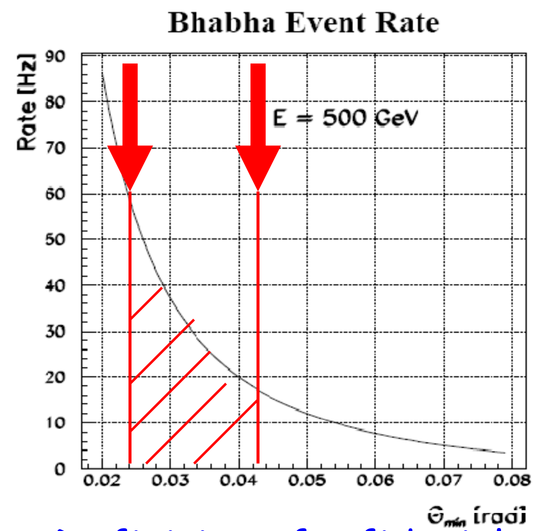
2. Measure luminosity by counting the number of Bhabha events (N):

$$e^{+}e^{-} \rightarrow e^{+}e^{-}(\gamma)$$



$$N = \frac{L}{\sigma} \qquad \frac{d\sigma_{Bhabha}}{d\theta} \propto \frac{1}{\theta^{3}}$$

Input from theorists needed !



Definition of a fiducial volume needs a precison device

SUSY particles

Problem with staus

-Small depositions in the detector

- Large SM backgrounds

$\gamma^*\gamma^* \rightarrow \tau^+\tau^-(E_t>4.5\text{GeV})$: $\sigma\sim4.3\text{x}10^5$ fb

$\rightarrow \mu^+\mu^-$ $(E_t>2\text{GeV})$: $\sigma\sim5.2\text{x}10^6$ fb

$\rightarrow$ hadrons (direct*direct dominant)

ccbar $\sigma\sim8.2\text{x}10^5$ fb

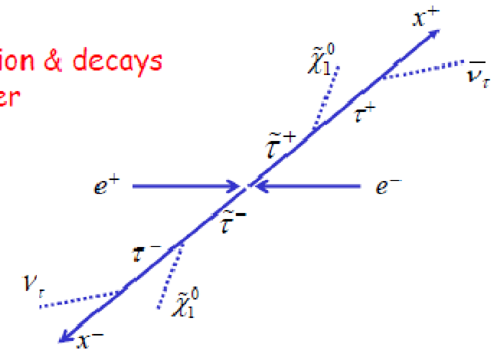
$\rightarrow$ WW

$e^+e^- \rightarrow \mu^+\mu^-, \tau^+\tau^-$: $\sigma\sim1.0\text{x}10^3$ fb

$\rightarrow$ WW

↔ few fb

Stau production & decays @ e+e- collider



Since we don't know how SUSY is broken- study of 242 points in the MSSM parameter space (in particular 162 points leading to "degenerate signatures

Needed: - electron veto in the very forward region

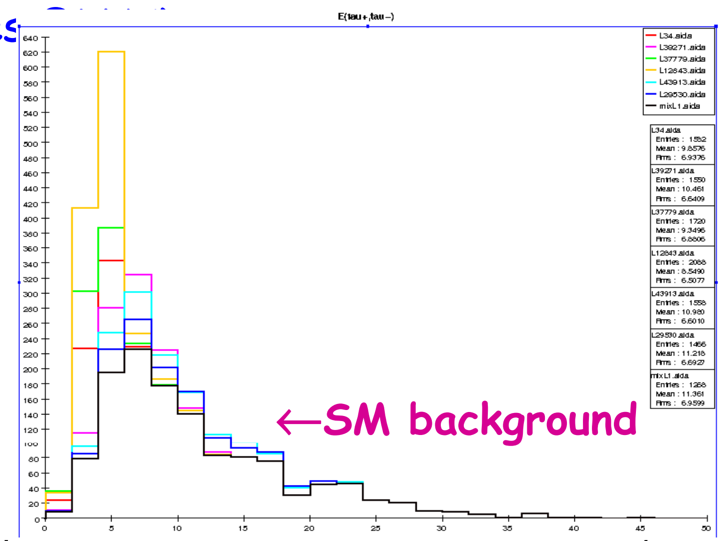
- muon detection down to a few mrad

to suppress e.g.

$\gamma\, e^- \rightarrow e^-\mu^+\ \mu^-$

τ pair signature

May escape @ small angle

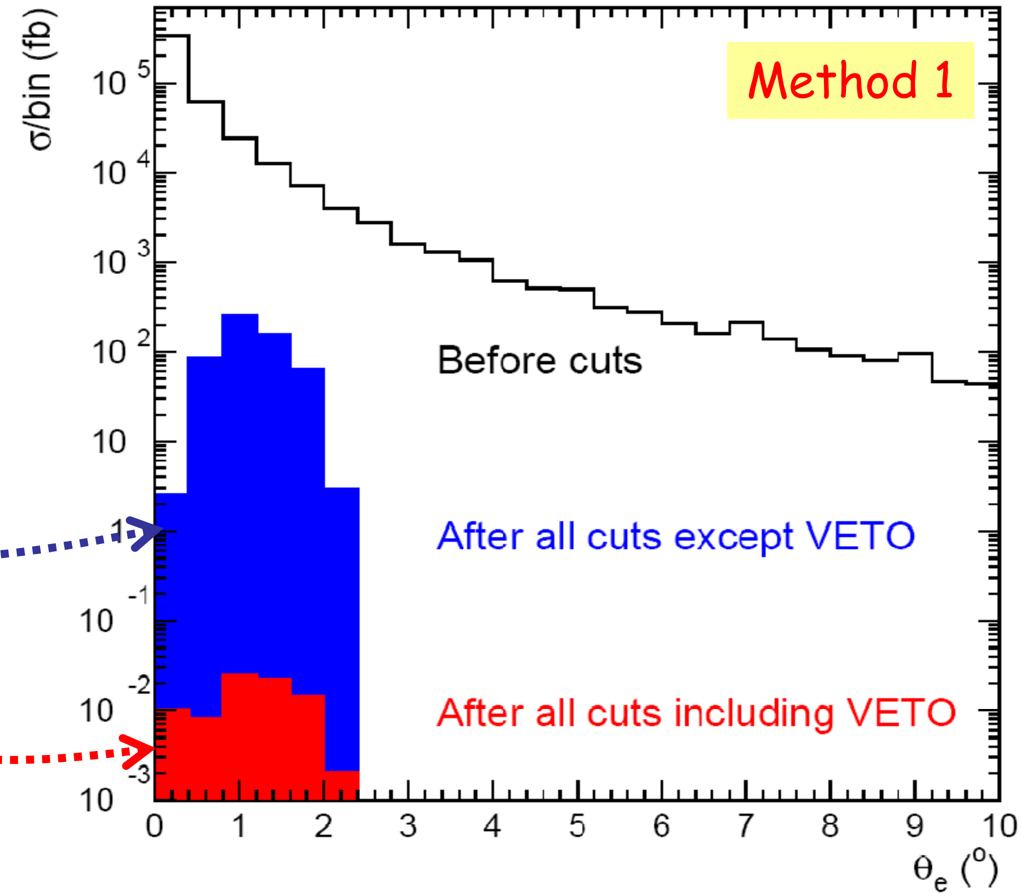


mSUGRA Scenario D′, small Δm:

The angular distribution of spectator $e^\pm$

SM background $\gamma\gamma \rightarrow \tau\tau$ generated at Ecm of 500GeV

Method	1	2
σ_{signal}[fb]*ε_{eff}	0.456*5.7%	10*6.4%
σ_{bkg}[fb] (w/o VETO)	561	168
σ_{bkg}[fb] (+VETO)	0.08	0.26
S/B	~0.3	~2.5



➔High electron VETO efficiency at small polar angles is mandatory

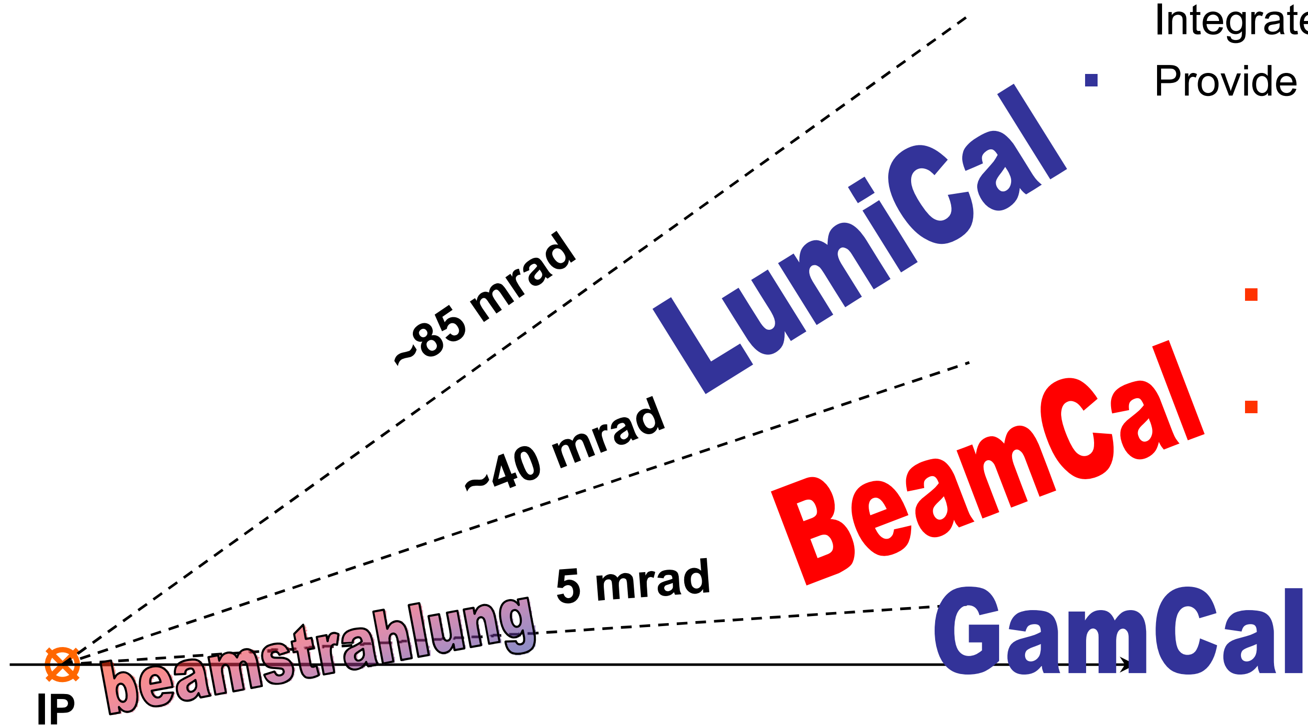
➔ improvent possible in case of mip detection capability at small polar angle

Calorimetry, Pair Monitor:

Forward Calorimeters , I. Sadeh

Pair Monitor: K. Ito, R. Sasaki

Layout of the Forward Region



- Precise measurement o the Integrated Luminosity ($\Delta L/L \sim 10^{-4}$).
- Provide 2 photon veto.

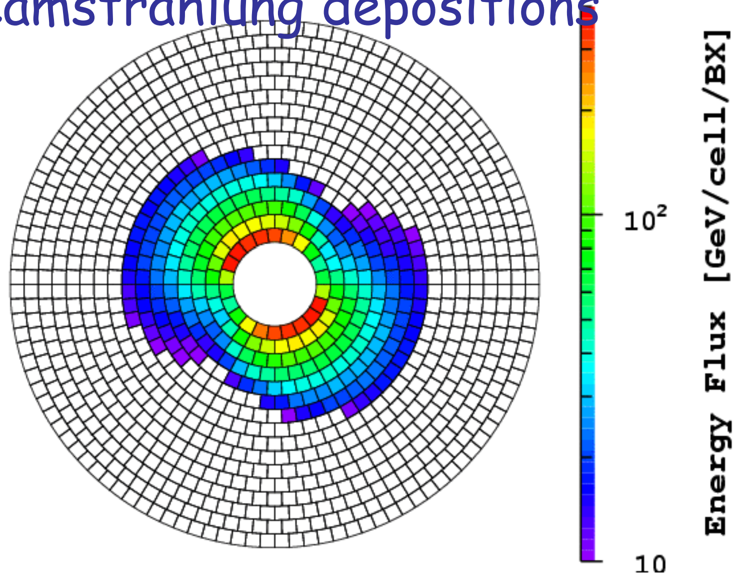
- BeamDiagnostics using beamstrahlung pairs.
- Provide 2 photon veto.

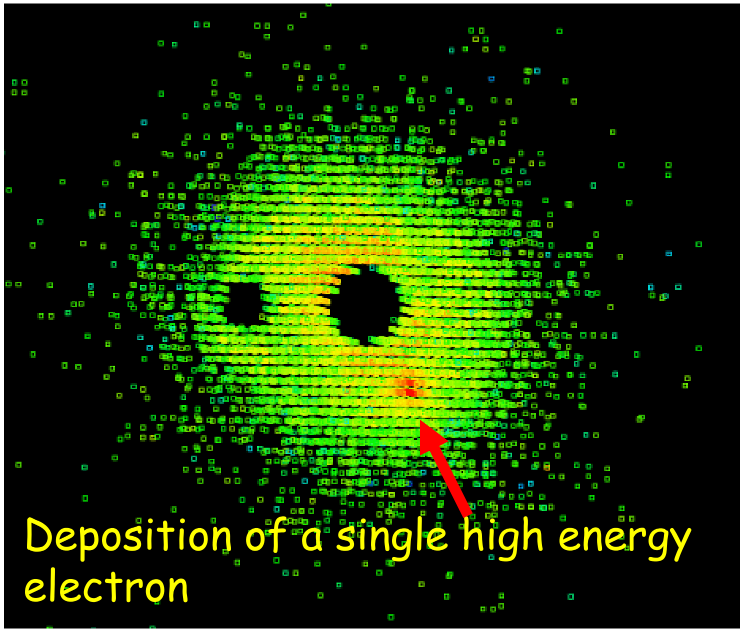
- BeamDiagnostics using beamstrahlung photons.

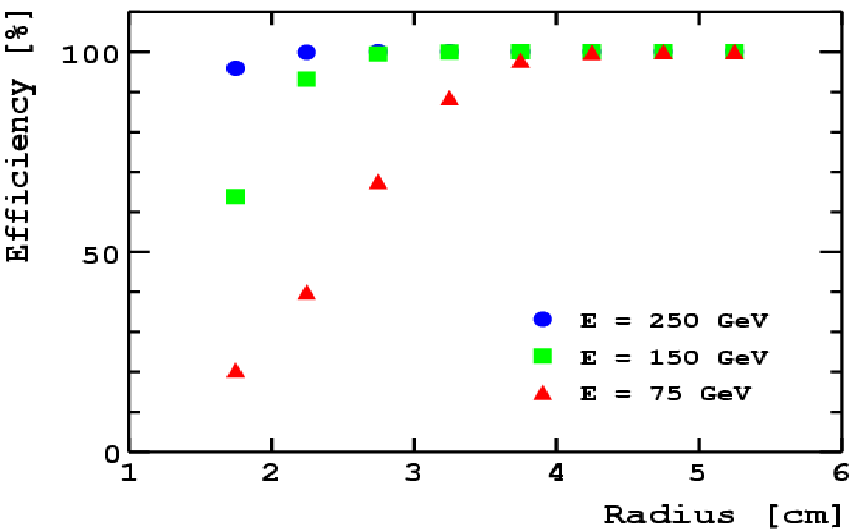
Challenges: High precision, high occupancy,high radiation dose, fast read-out!
LumiCal, BeamCal: compact sampling calorimeters, R_M~1 cm

BeamCal

Beamstrahlung depositions





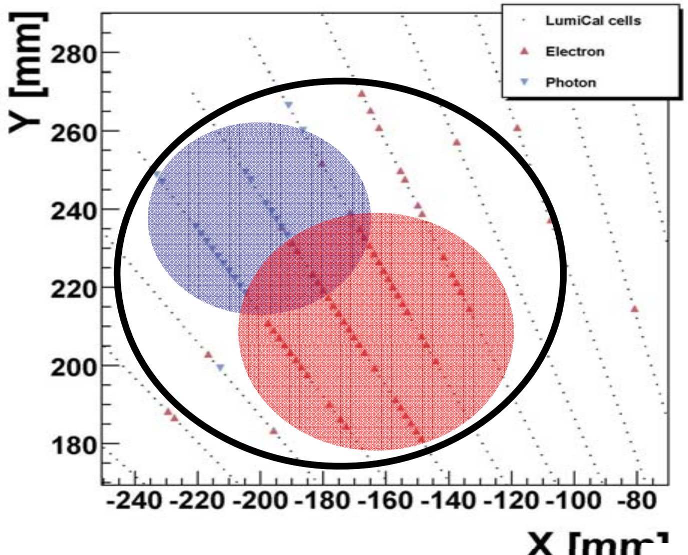


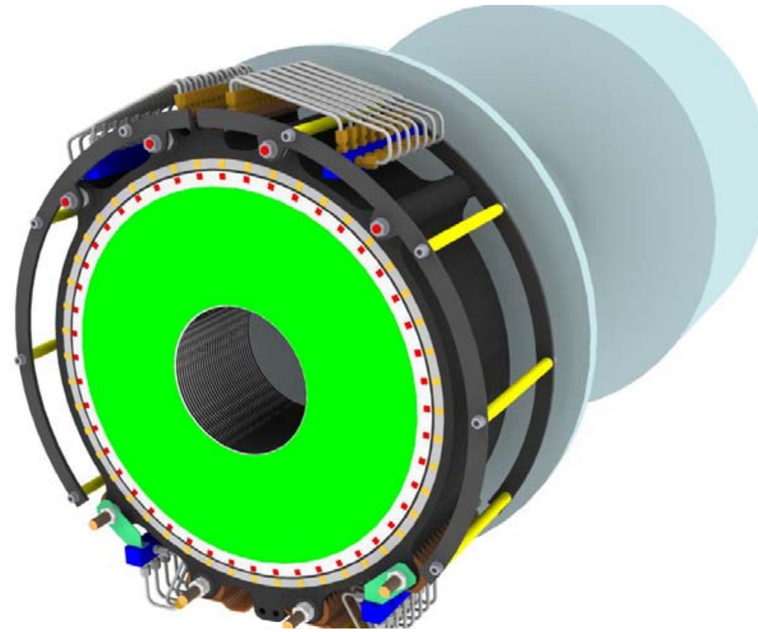
➔High electron VETO efficiency at small polar angles possible

LumiCal

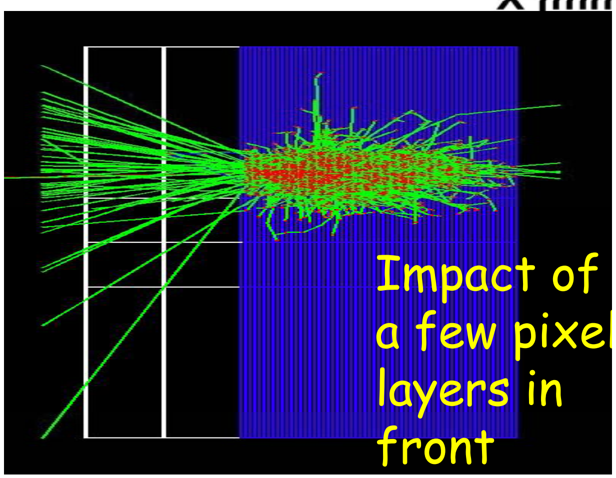
Detaild studies on granularity, systematics, background

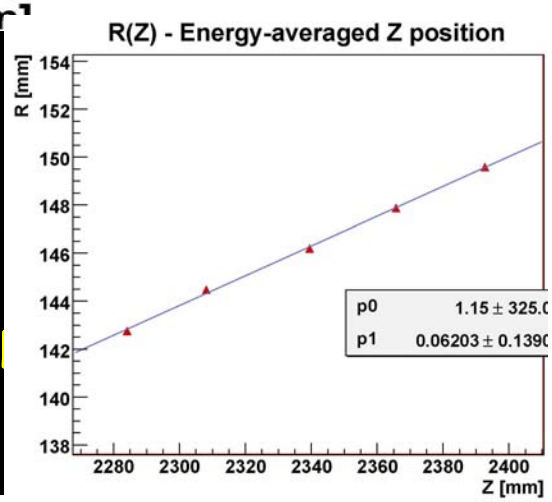
New: cluster separation for $e^+e^-\gamma$

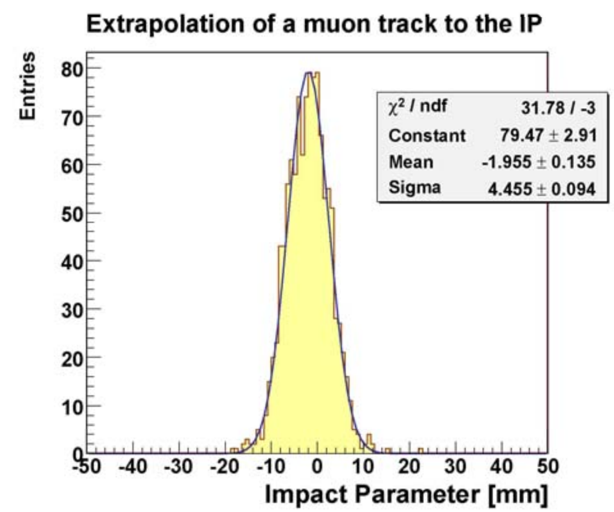




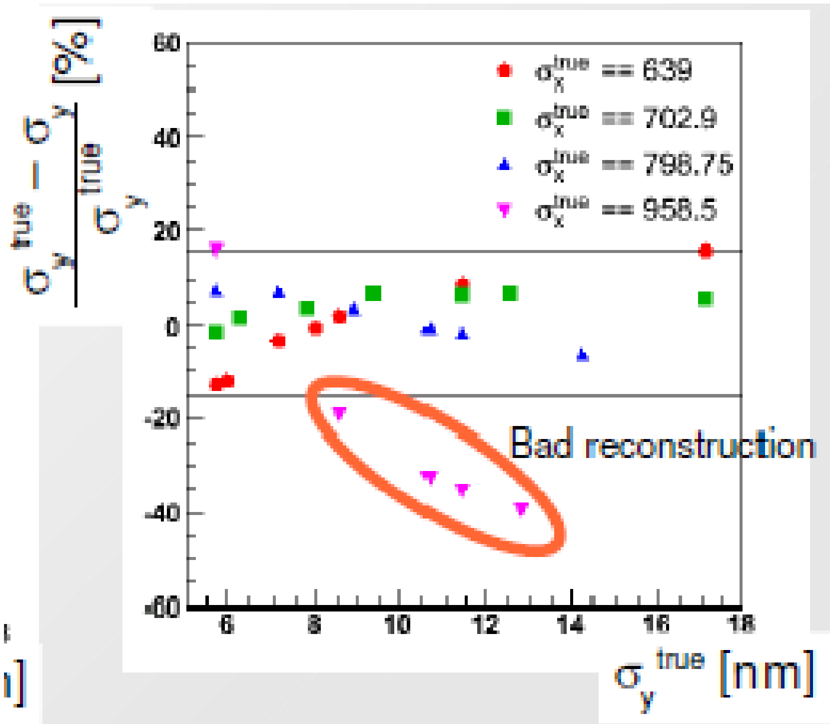
Mip detection capability



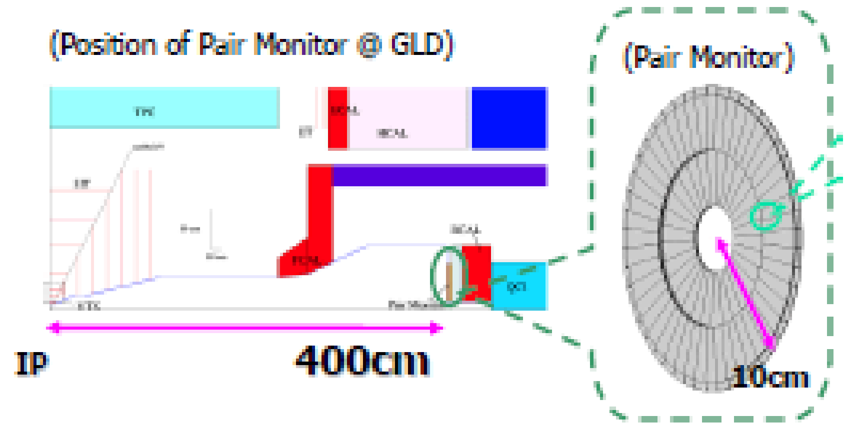




Pair Monitor

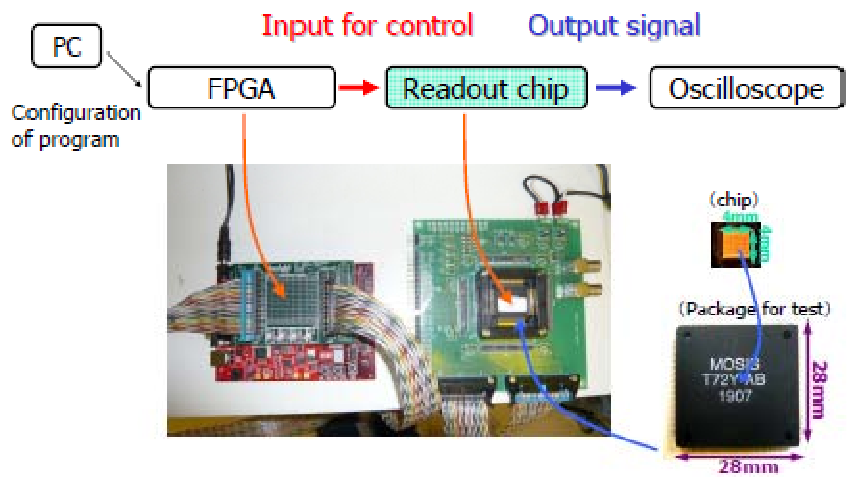


Measurement of the flux density in front of BeamCal to determine beam parameters σ_x, σ_y



Design and prototyping of a readout chip, first tests successful

- Produced by MOSIS
- CMOS 0.25 μm process by TSMC
- Size of chip : 4x4 mm^2
- Size of readout pixel : 400x400 μm^2



Tracking

Silicon pixel tracker , K. Stefanov

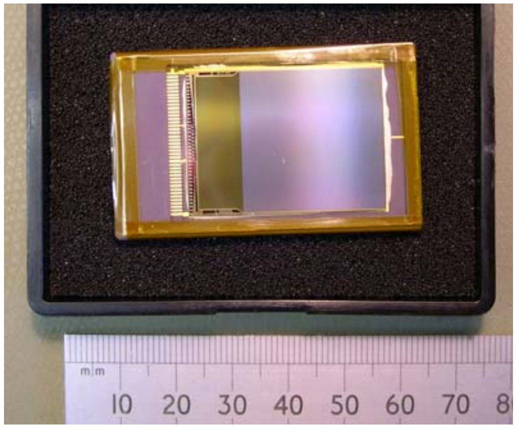
Optimisation studies: W. Mitaroff

TPC endcap material budget: T. Matsuda

Tracking Performance: M. Vos

Silicon Pixel tracker

Replace strip detectors by pixel devices, CCD or MAPS
CCD: integration of a full bunch train,
MAPS: Time slicing or bunch stamping possible



- **70 m^2 tracker with 50×50 μm^2 pixels, 28 Gpixel system**
- **Total power dissipation (CCD) ≈ 600 W (0.86 mW/cm^2)**

Higher occupancy in the forward region may require MAPS technology;

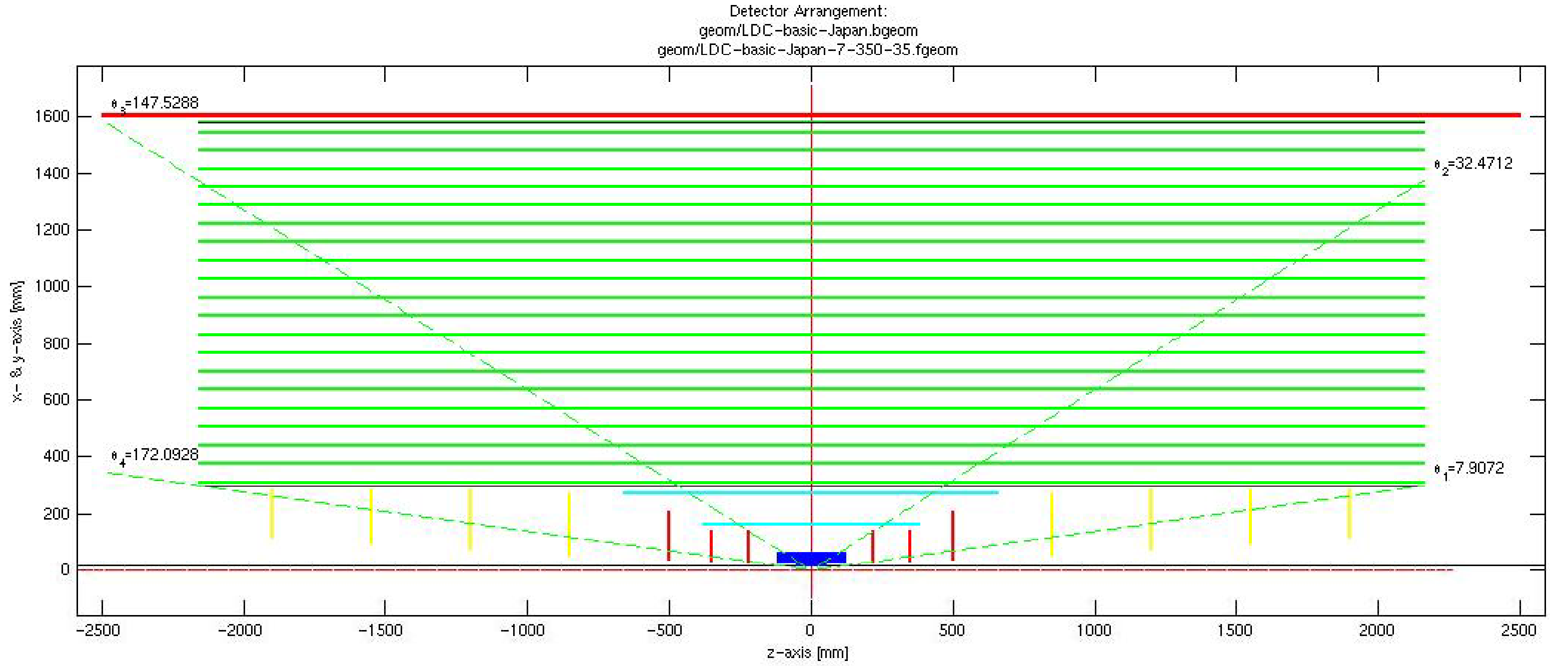
First experience with the CALICE ASIC1 for MAPS-based ECAL (designed at RAL)

- **Functionally very close to bunch stamping tracker**
- **50 μm × 50 μm pixels on 0.18 μm CMOS process**
- **Targets S/N > 10, preliminary S/N = 6.5**

Power dissipation might be an issue. R&D necessary

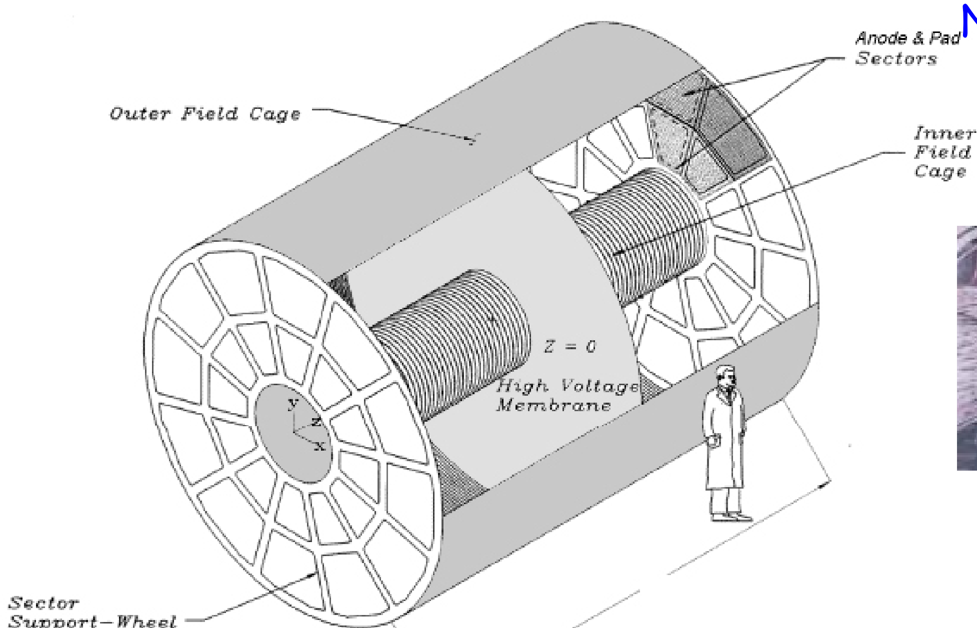
Forward Tracking Optimistion

Using a fast simulation several tracker geometries and pixel sizes are studied



- An additional disc at z = 2160 mm
- Clear improvement of momentum resolution of tracks missing the TPC
  - (Those tracks also miss the Vertex Detector and the innermost Forward Pixel Disc!)
  - 15% gain for low pt
  - 20% gain for high pt
- Same impact of material budget and pitch as before
  - therefore adding an 8th disc is not yet an "overinstrumentation"

TPC Endcap Material Budget

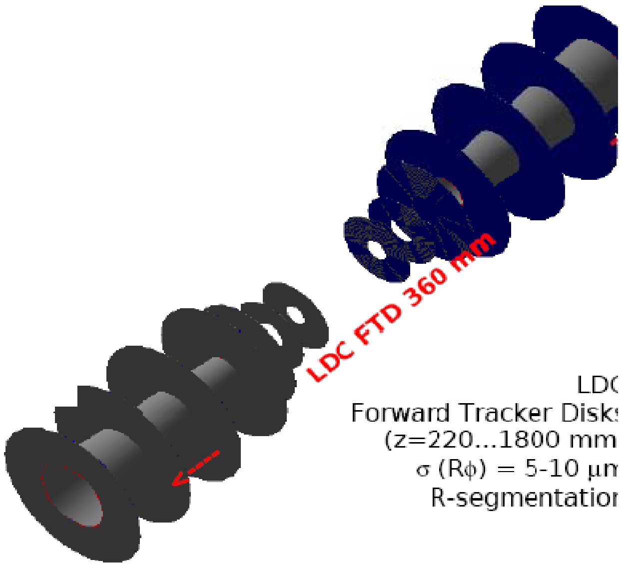


Not stretching wires

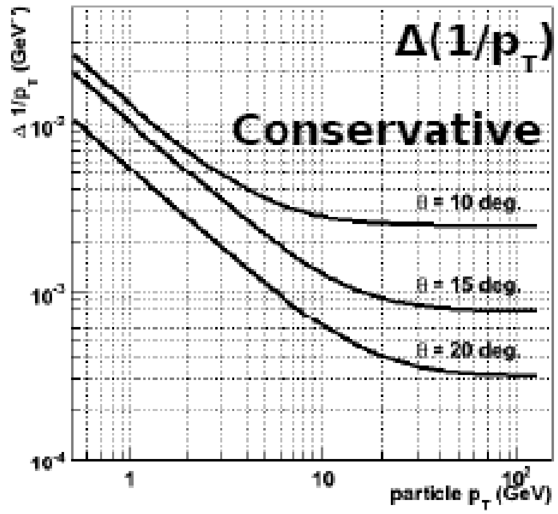
→ Lighter detector module with the new MPGD/SiTPC in principle.

- Thickness (radiation thickness
- Pad plane:
- G10 X0 = 19.4cm 0.4cm → 2 %
- Cu X0 = 1.43 cm 0.03cm (8 layers) → 2 %
- Subtotal 5 %
-
- Endplate (mechanical) : Scaled from ALEPH (Al) = 13%Xo
  Be; Strength (Be/Al) = 4 → ~ 1%
- CFRP Xo (CFRP/Al) = 1.5
- Strength (CFRP/Al) =2 → ~ 4%
- 5 %
  Cooling (piping) Xo (Al) = 8.9cm 0.2cm → 0.2% 1%
- Total 15 %

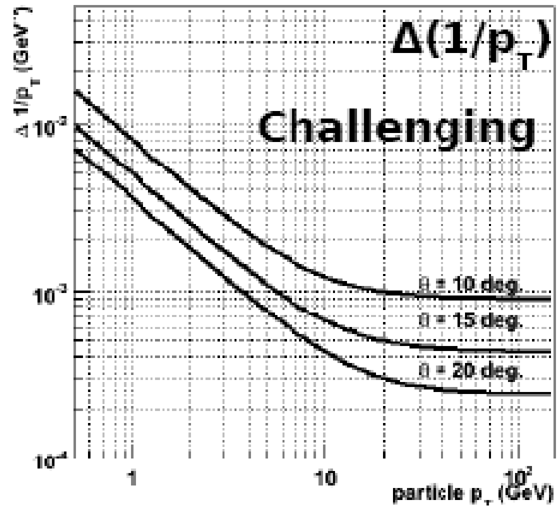
Tracking Performance in the Forward Region



TESLA



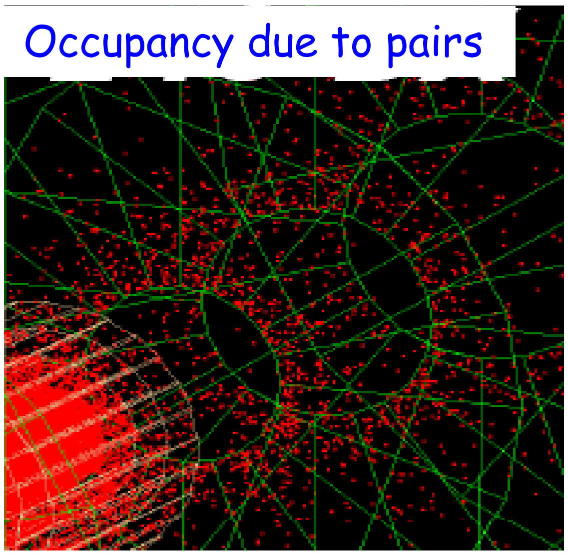
More challenging



(5 μ m Rφ resolution, 1.2 ‰ X0/disk for FTD1-3, 4 ‰ X0/disk for FTD4-7)

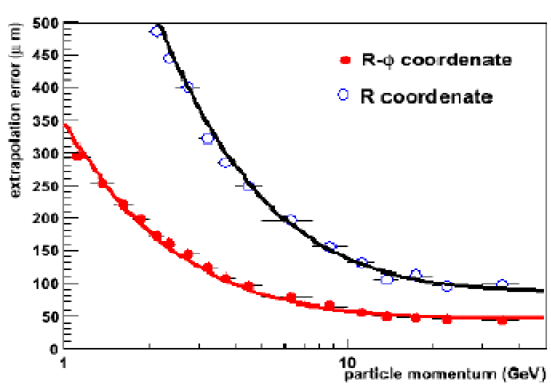
$\Delta(1/p_T)=0.9\times10^{-3}\oplus0.8\times10^{-2}/p_T$

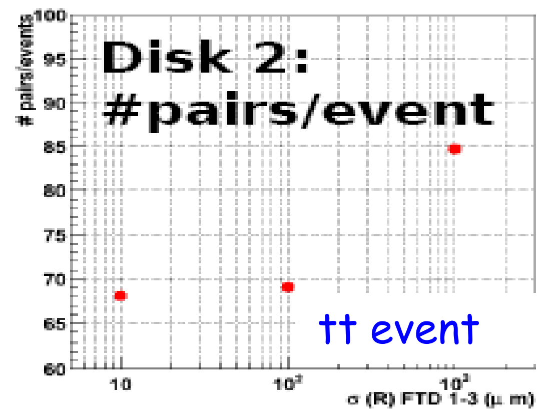
Occupancy due to pairs



Readout after < 10 BX

Large distance (10-30 cm) between disks lead to large extrapolation errors, particular forlow momentum tracks

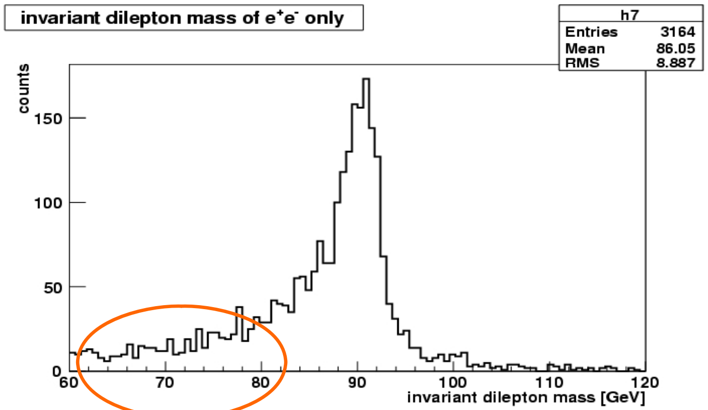


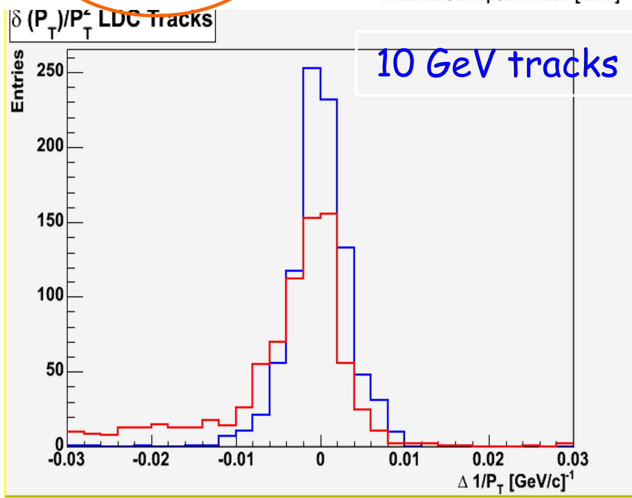


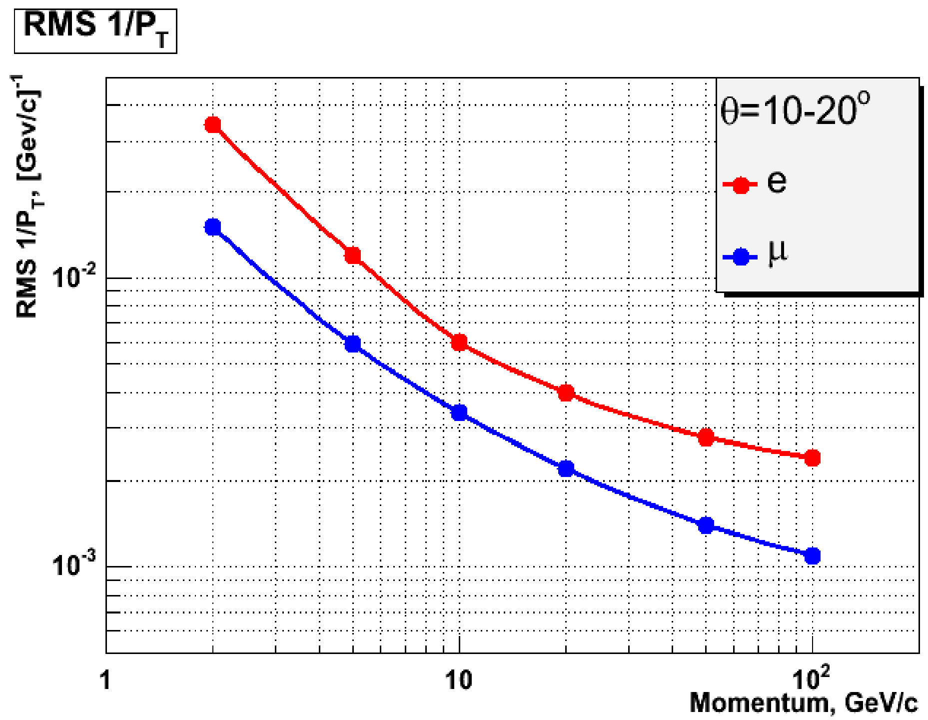
Coordinated effort in Spain ongoing

Particle ID performance: M. Ohlerich

Tracking Performance in the Forward Region





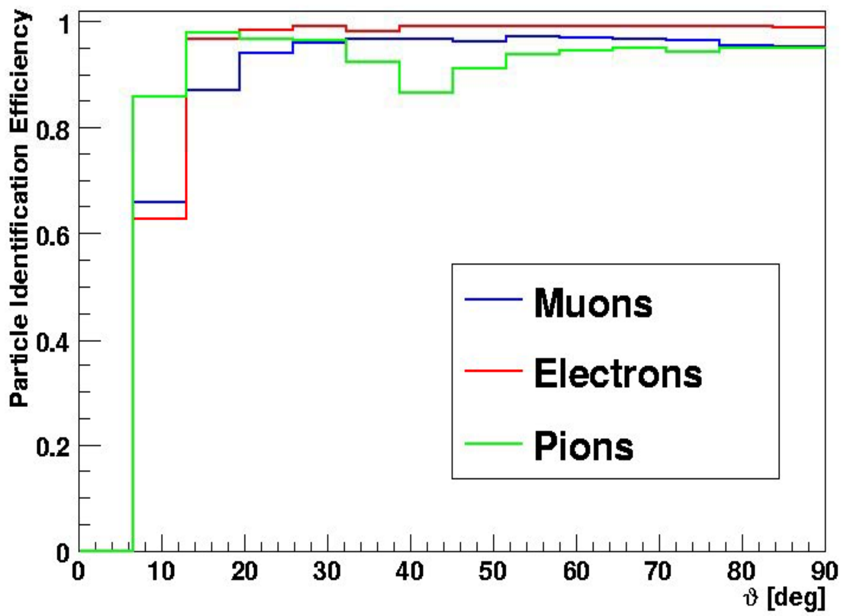


Electron momentum measurement is less performant, due to bremsstrahlung in the detector material

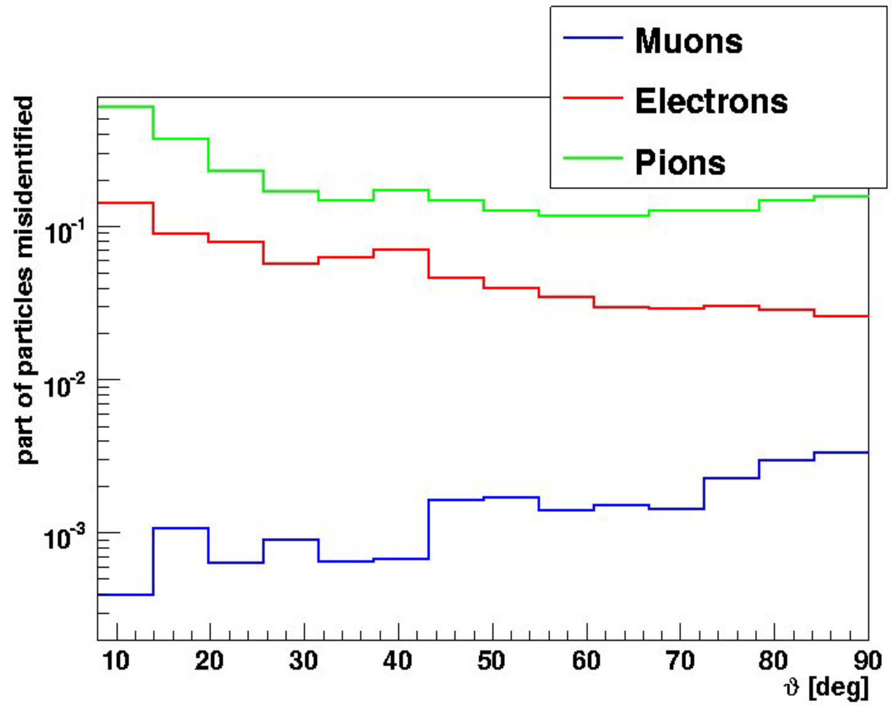
Particle ID performance

Electron, Muon, Pions, Photons, Higgs-strahlung sample

ID efficiency vs θ



ID purity vs θ



Electron sample contains photons, due to conversions,

Pion sample also contaminated by photons because of high particle density in jets