TRD Offline PID

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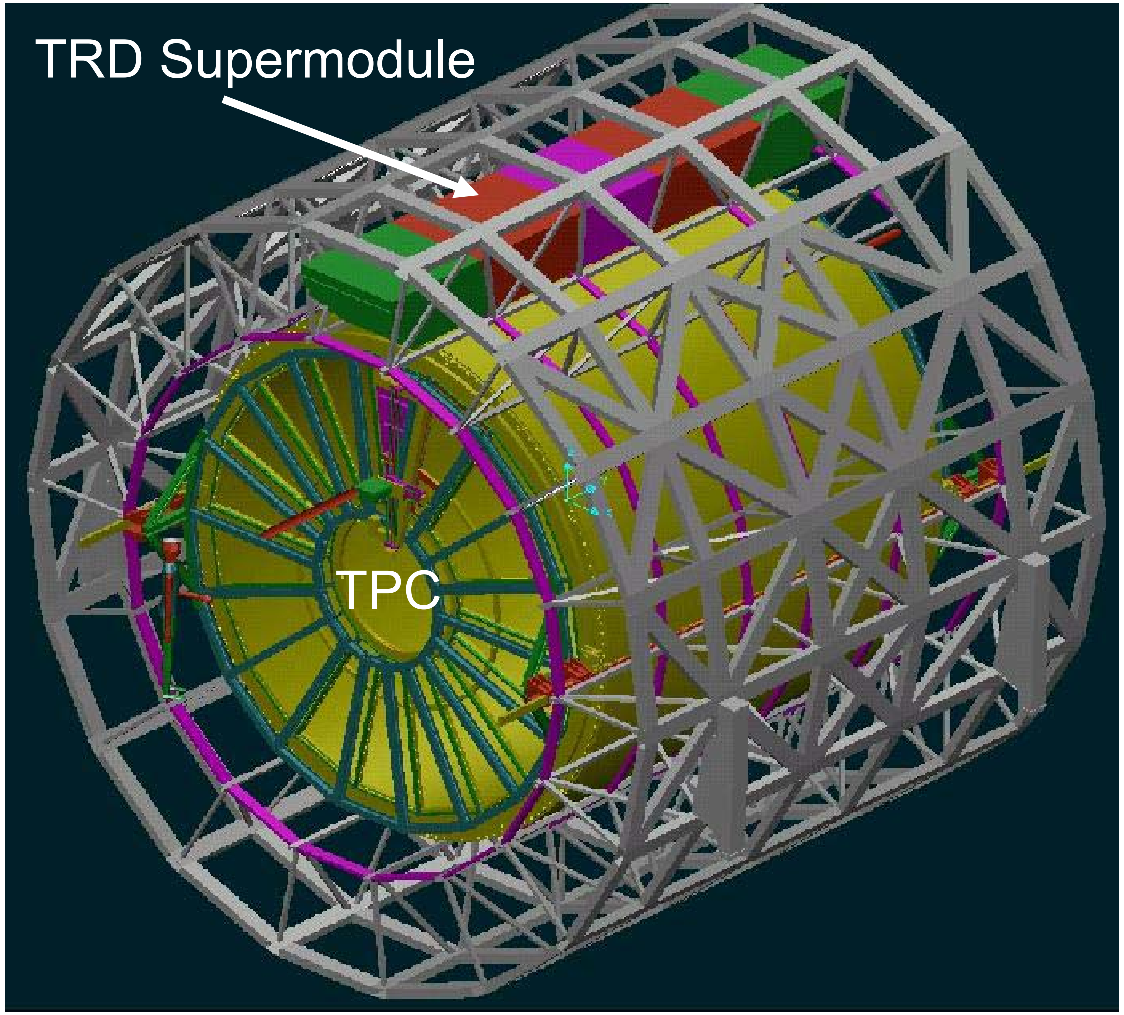
Outline

- Transition Radiation Detector
  - Setup
  - Working principle
  - Test beam results
- Detector response
  - Energy loss simulation
  - TR photon simulation
  - Detector effects
- Reconstruction
  - Implementation in ESDs
  - Electron likelihood

Transition Radiation Detector

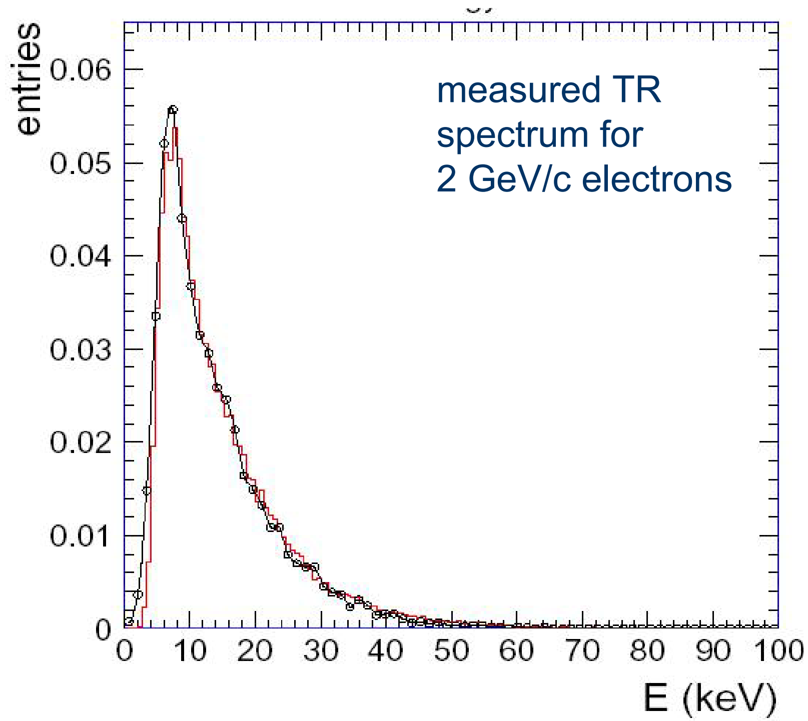
The Setup

- TRD in numbers:
  - 540 chambers
  - 6 planes
  - 18 sectors (supermodule)
  - Number of channels: : 1.2×10^6



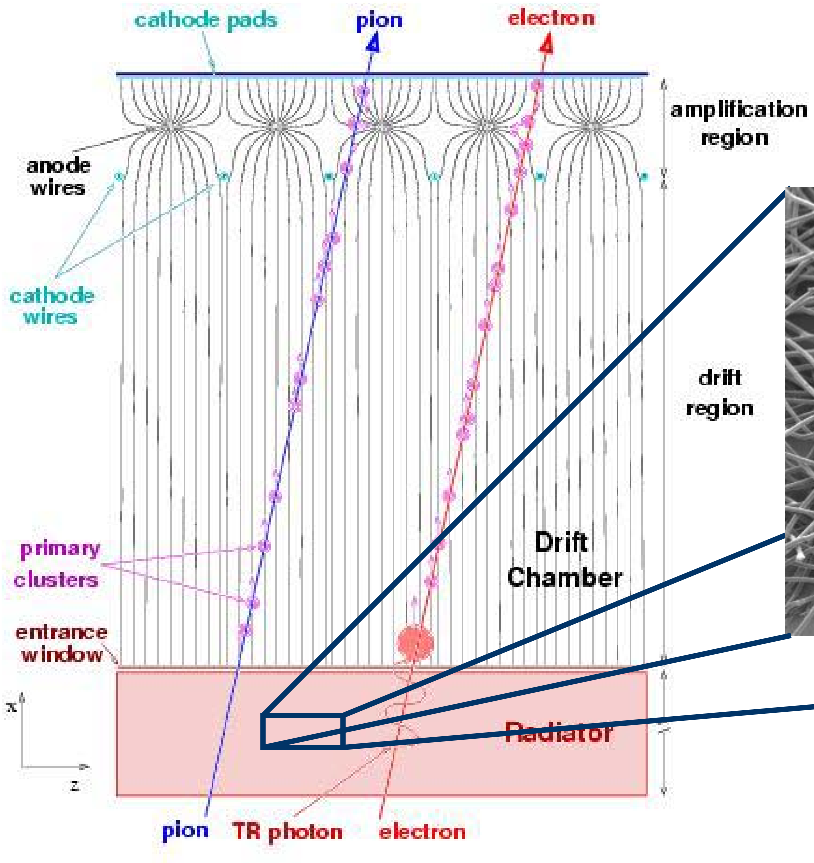
Transition Radiation Detector
Working Principle

- TR photons are generated by charged particles crossing the border between two different di-electric media
- Properties:
    - Energy in keV range
    - Emissionangle $\sim 1/\gamma$
- Spectra and yield are determined by:
    - Number and distance of borders
    - Thickness and plasma frequency of media
    - Velocity of the charged particle $(\gamma > 1000)$

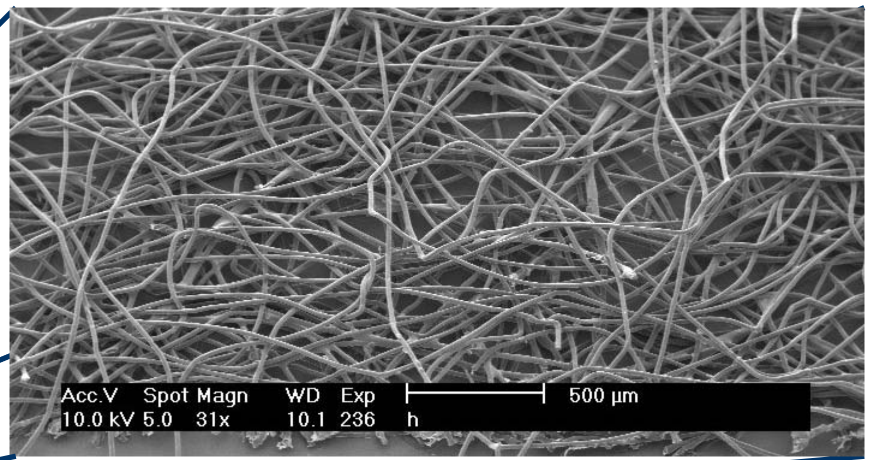


- Radiators:
    - Foil stack
    - Fiber materials
    - Foam-like materials

Transition Radiation Detector
Working Principle



Radiator: fiber / foam sandwich
PP, 17 μm

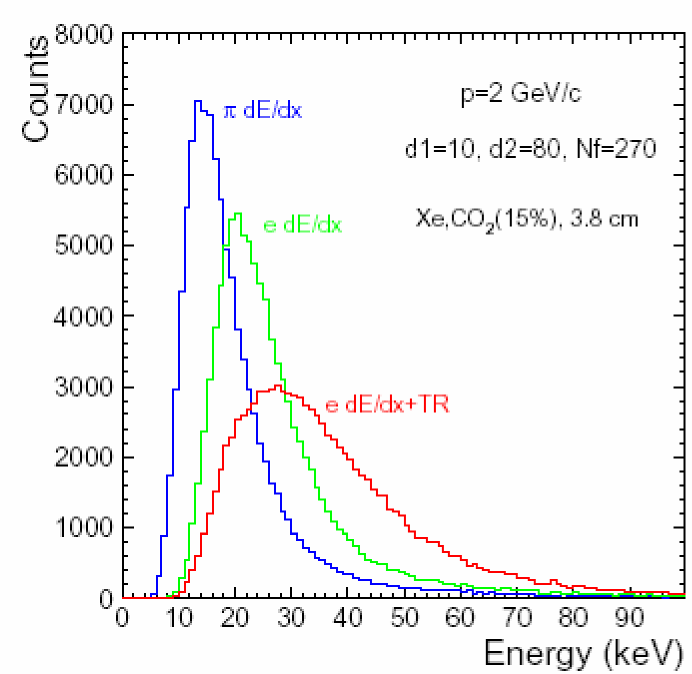


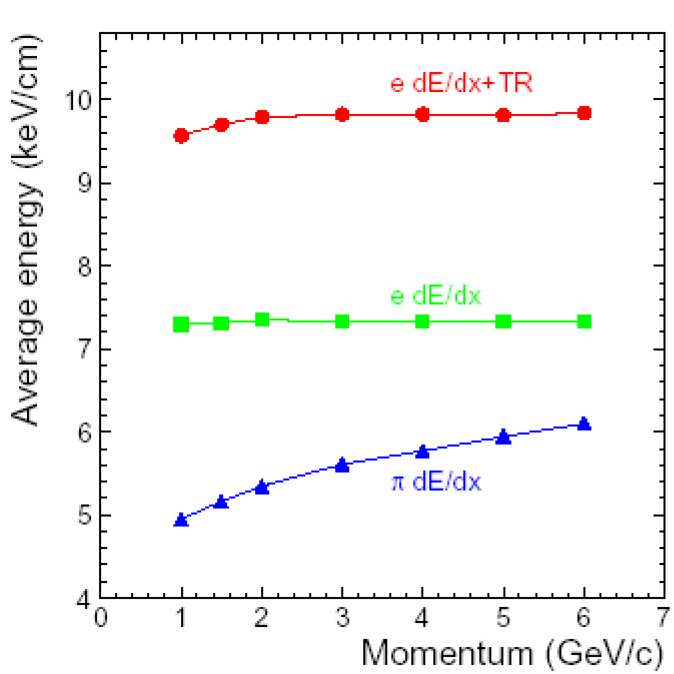
Elektron-/pion-discrimination:

e^{-} (p = 5 GeV/c): $\gamma \approx 10000$

π^{-} (p = 5 GeV/c): $\gamma \approx 36$

Transition Radiation Detector
Working Principle

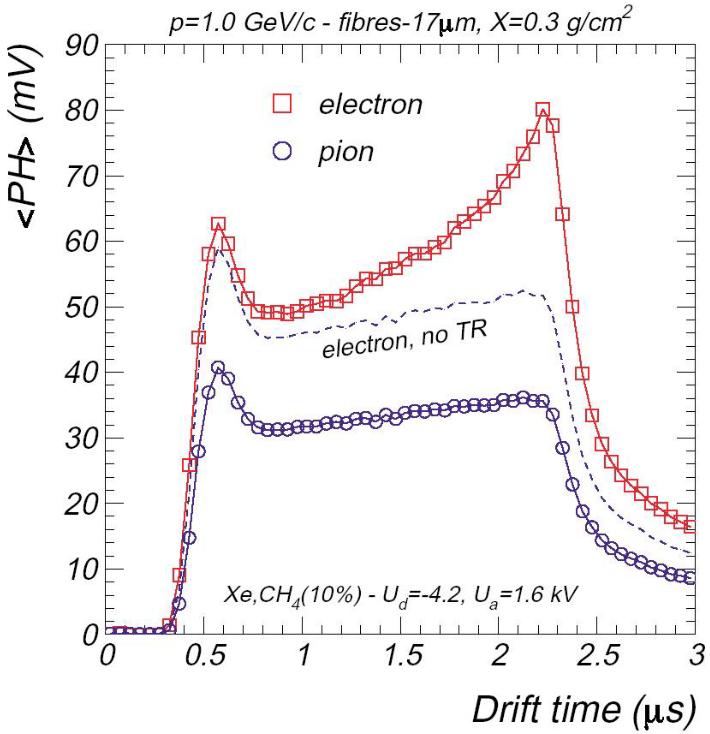


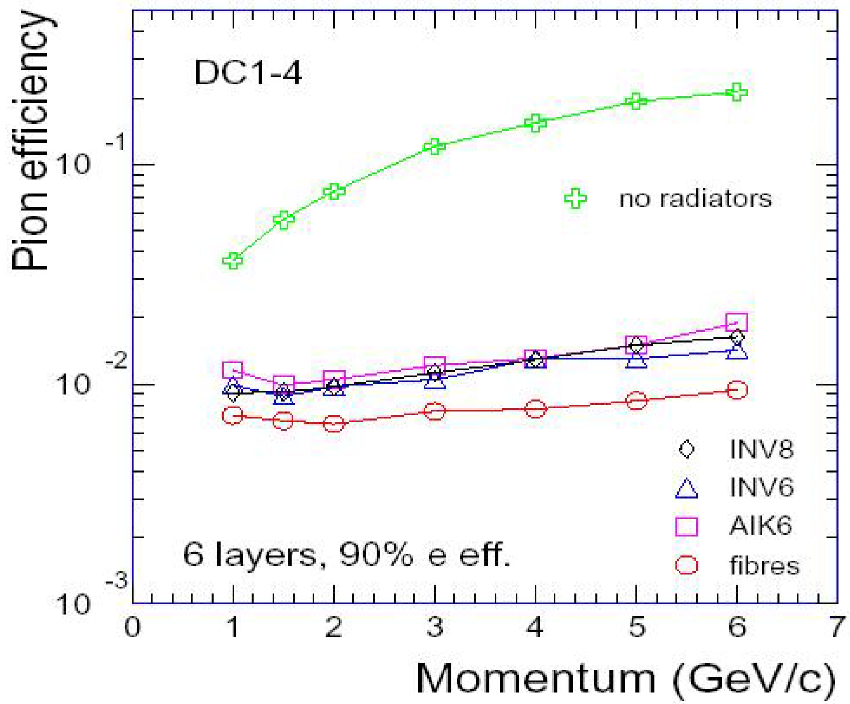


TR enhances difference in pulse height between electrons and pions

Transition Radiation Detector

Test Beam Results





Design value:

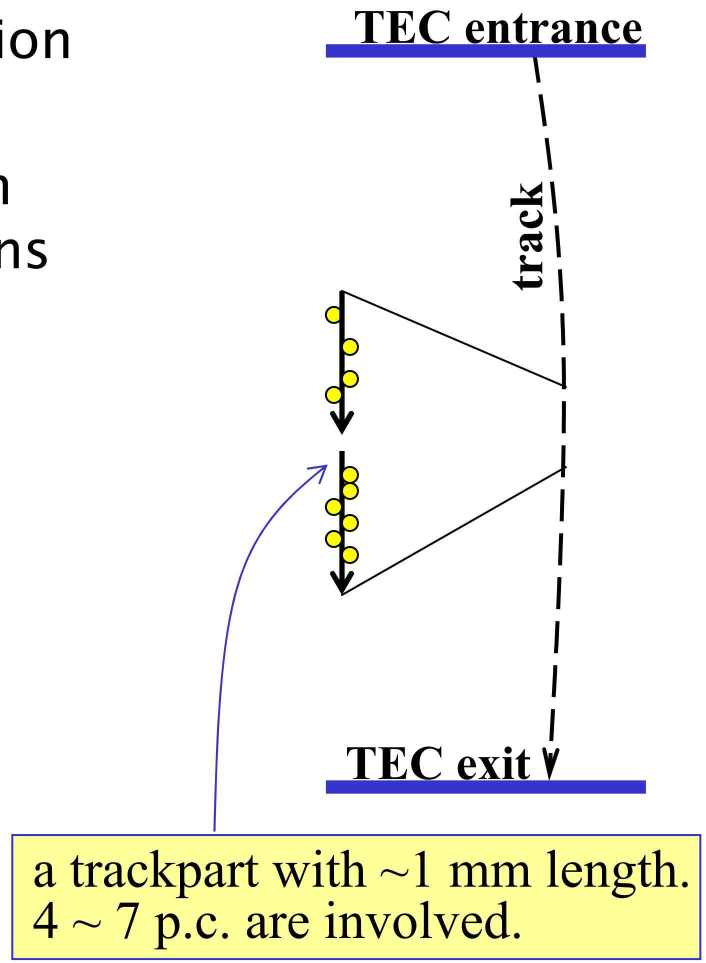
Pion suppression factor 100 at 90% electron efficiency

Detector Response
Procedure

- Detector response as implemented in Aliroot
  - As close as possible to test beam results
  - Needed for detailed simulation of e/π–discrimination
- Generate charge deposit:
  - “Normal” dEdx signal in Xe
  - Signal from absorbtion of TR photons
- Chamber response:
  - Diffusion
  - $E \times B$
  - Pad response
  - Drift length variations
  - Gas gain fluctuations
  - Time response due to slowly drifting ions
  - Cross talk
- Electronics response:
  - Coupling factors
  - Gain factor
  - Electronics noise
  - Time response
  - Digitization

Detector Response
Energy Loss Simulation

- Default Geant3.21 dEdx calculation
  - Fixed step sizes
- Optional: microscopic simulation (energy distribution of δ–electrons from Ermilova et al.)



Detector Response

Energy Loss Simulation: Ermilova ↔ Geant3

Plot (c):

Ermilova: Mean=128.5 eV
GEANT : Mean=230.3 eV

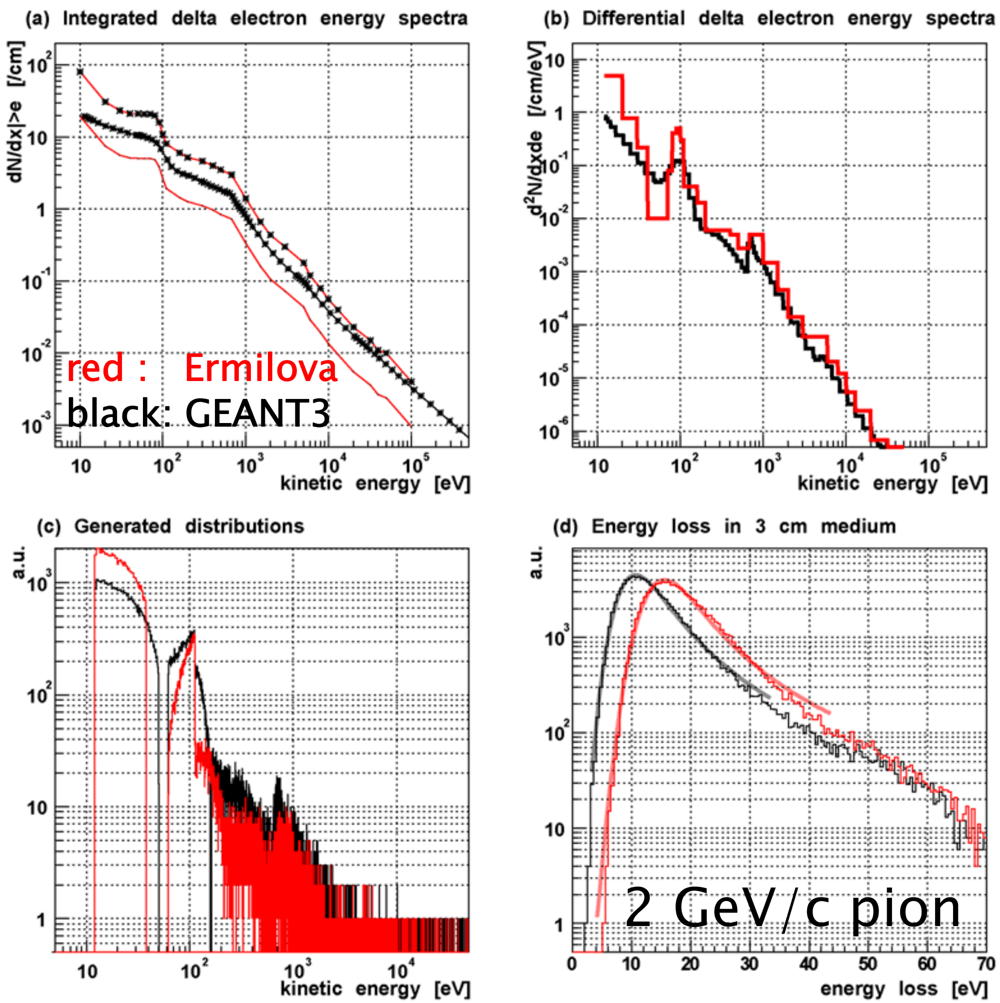
# of primary collisions for 2.0 GeV/c π^+ from Bethe Bloch:

Ermilova: 52.7/cm
GEANT: 21.9/cm

Most probable energy loss:

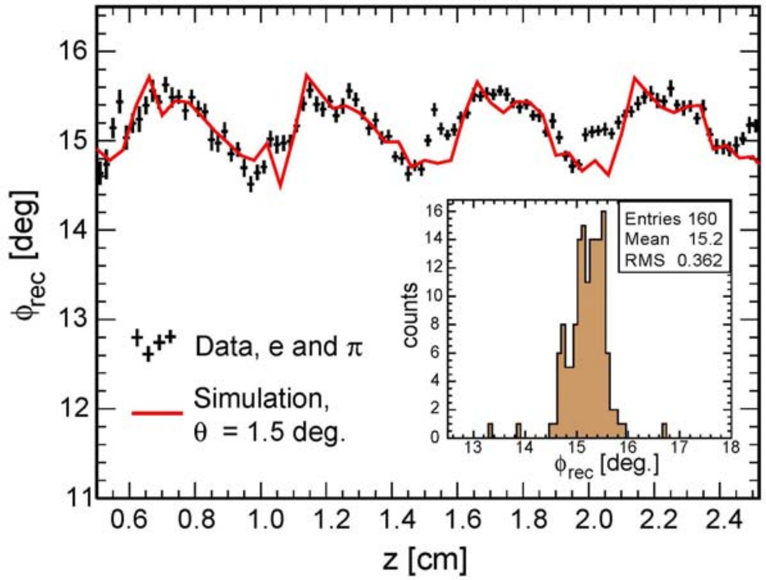
Ermilova: 14.8±0.02 keV
GEANT: 10.1±0.02 keV

Overcompensation by different Bethe Bloch.

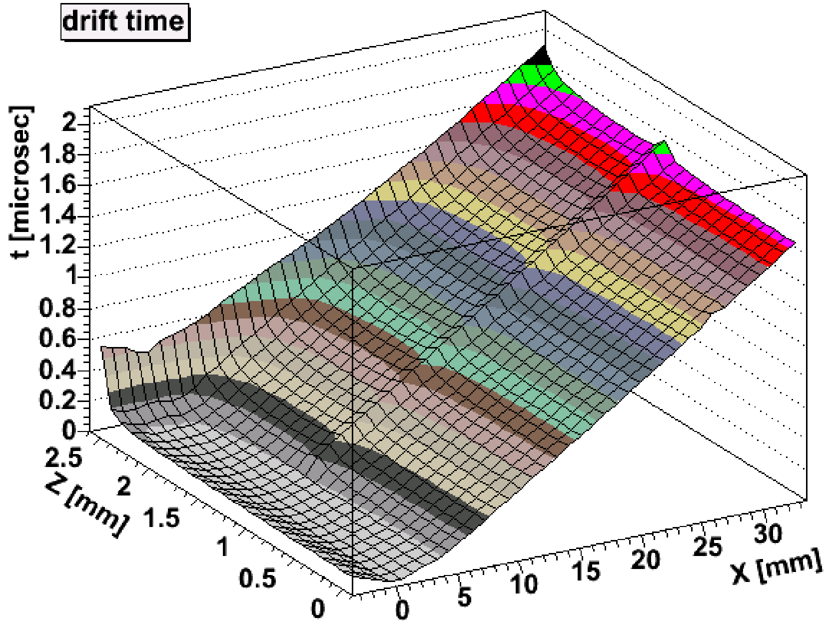


Detector Response

Non-Isochronity of Drift



Resolution depends on distance to wire



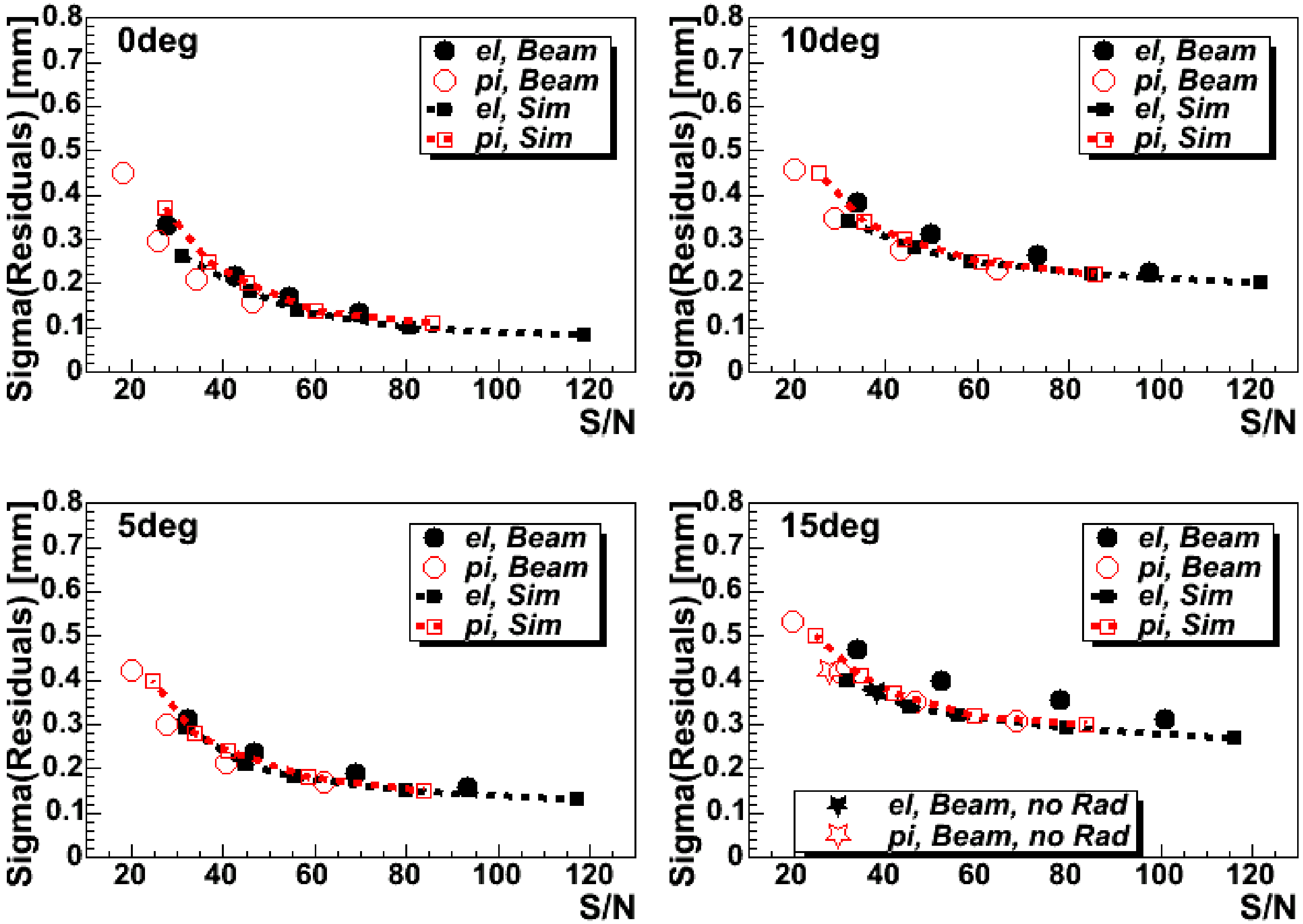
Simulation with GARFIELD

V_a = 1.55kV,

V_d =−2.1kV,

Xe−CO_2 85−15

Detector Response
Position Resolution



Detector Response

TR Photon Spectrum

- TR not part of GEANT 3.21
- Analytical description of regular foil stack

  (C.W. Fabjan and W. Struczinkski, PLB 57 (1975), 483)

$$\frac{\mathrm{d}W}{\mathrm{d}\omega} = \frac{4\alpha}{\sigma(\kappa+1)}(1-\exp(-N_f\sigma)) \times \sum_n \theta_n \left(\frac{1}{\rho_1+\theta_n} - \frac{1}{\rho_2+\theta_n}\right)^2 [1-\cos(\rho_1+\theta_n)]$$

where:

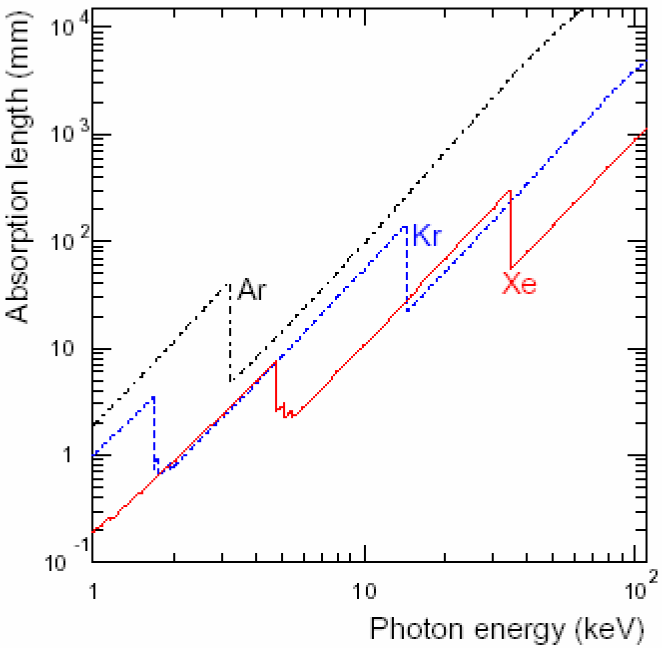
$$\rho_i = \omega d_1/2c(\gamma^{-2}+\xi_1^2), \quad \kappa = d_2/d_1, \quad \theta_n = \frac{2\pi n - (\rho_1+\kappa\rho_2)}{1+\kappa} > 0, \quad \sigma = \sigma_1+\sigma_2 \quad (\text{one} \quad \text{foil}+\text{gap})$$

- Parameters are tuned to match test beam data for given momentum
- Procedure:
  - Generate TR photon at entrance window for entering electron
  - Determine absorbtion position in gas volume according to attentuation coefficient

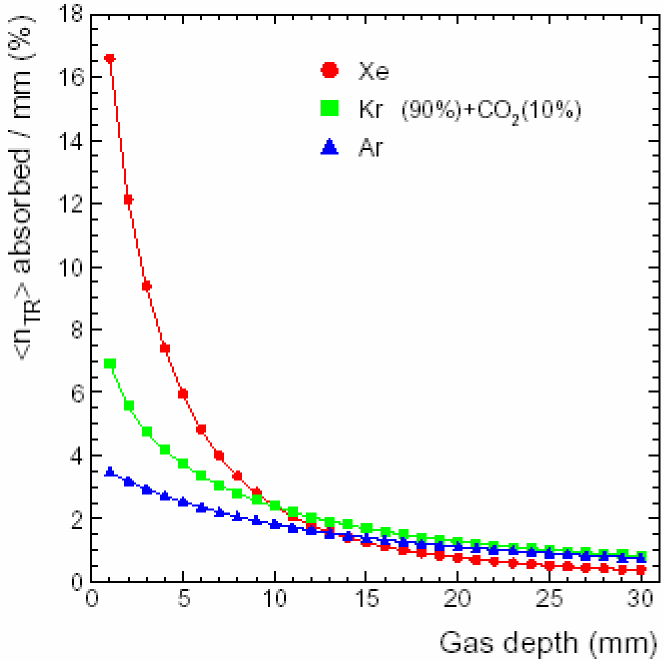
Detector Response

TR Photon Absorbtion

Absorbtion length



Number of absorbed photons



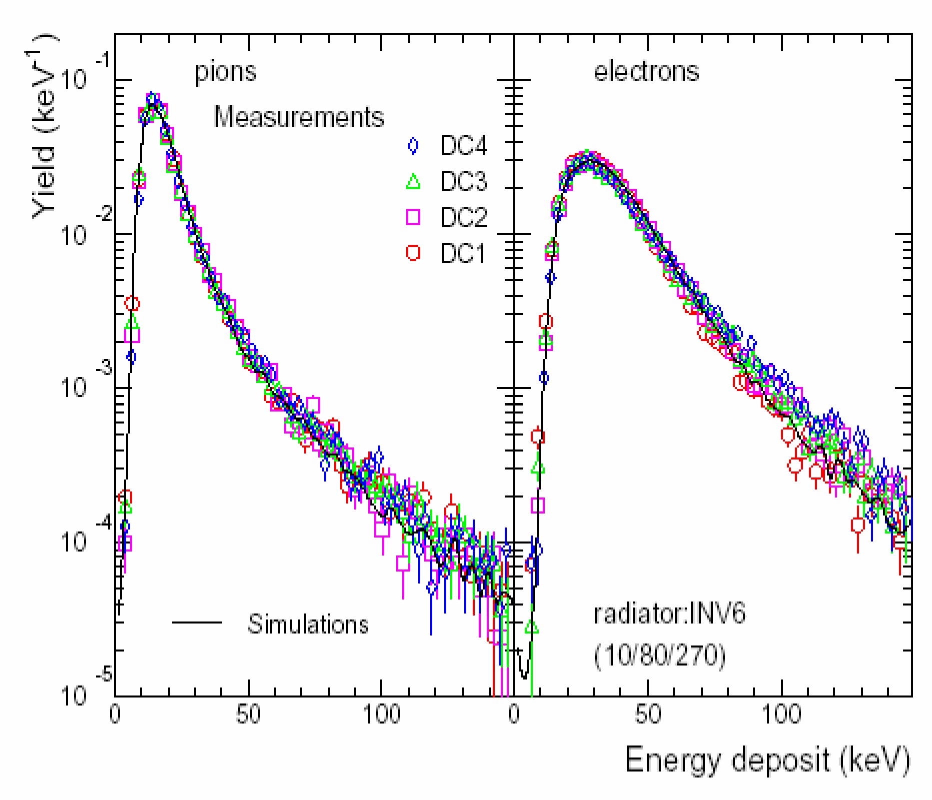
Detector Response

TR photons: Comparison to Test Beam

Measurement for fiber/foam sandwich radiator

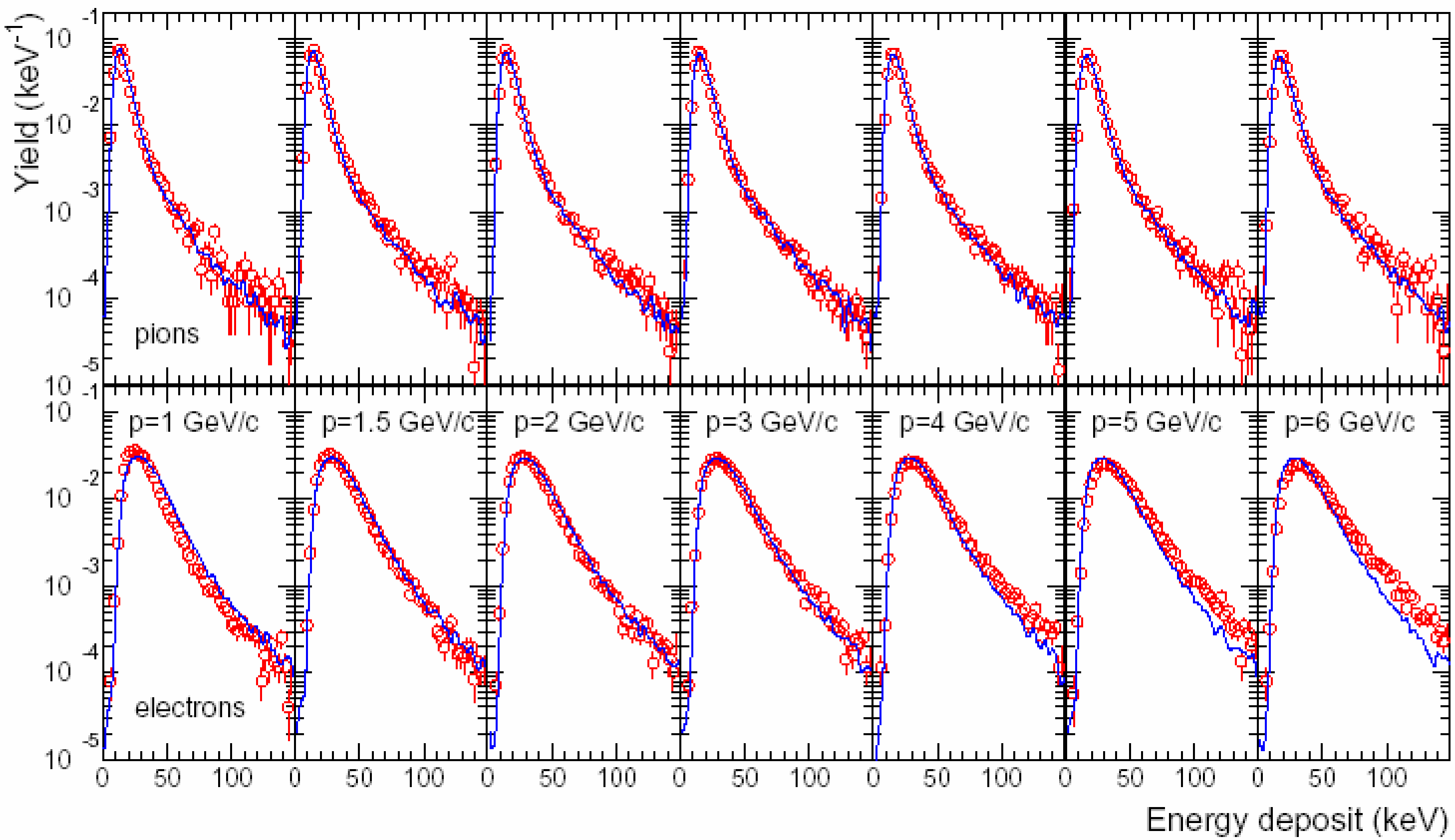
Parametrization for regular foil stack

Good description of data for fixed momentum



Detector Response

TR photons: Comparison to Test Beam (II)

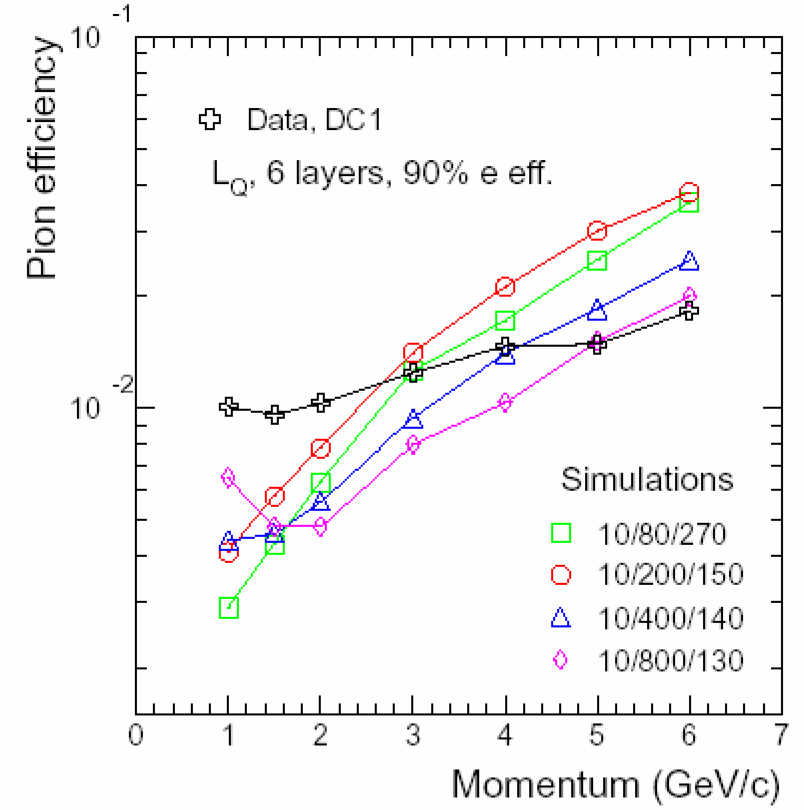


Detector Response

Momentum Dependence of TR photons

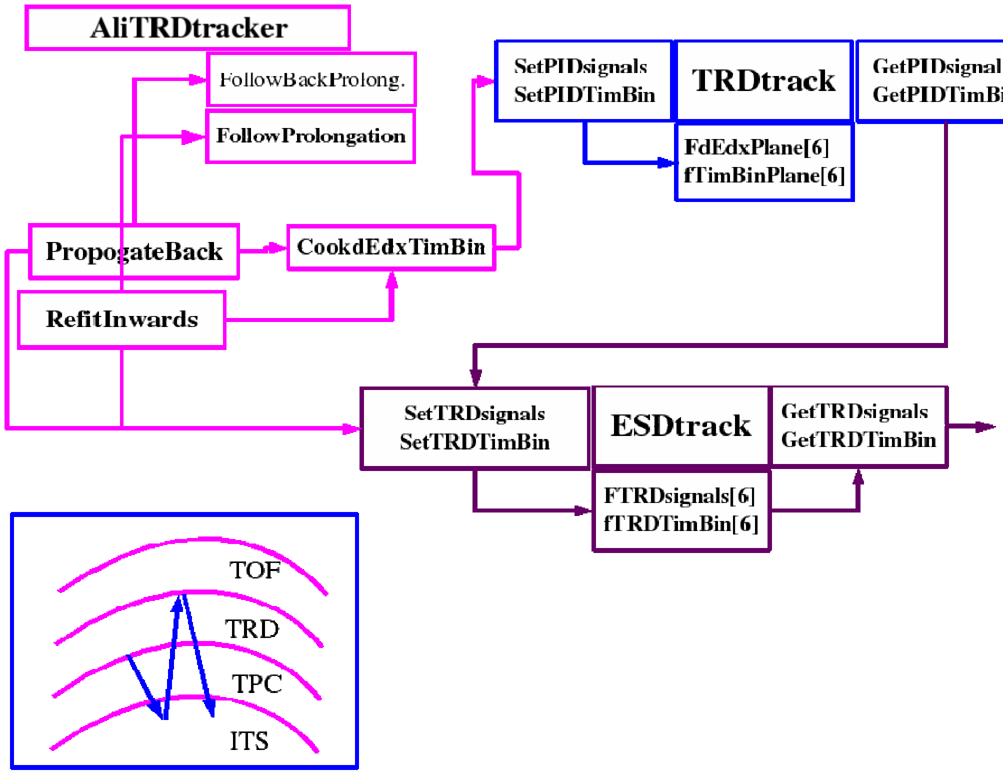
Fixed parameter set does not work for all momenta

→ Adjust parameters in different momentum bins



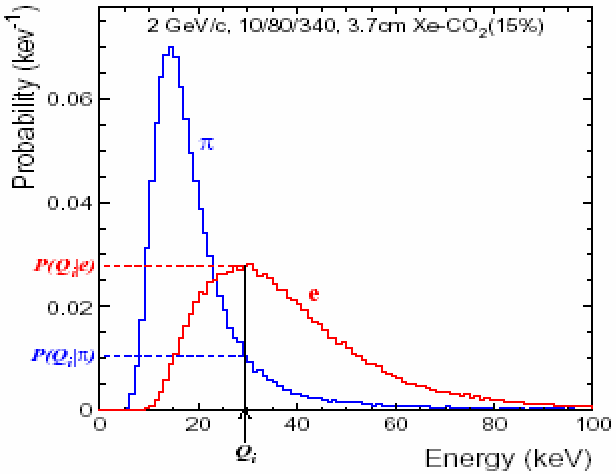
Reconstruction
Scheme

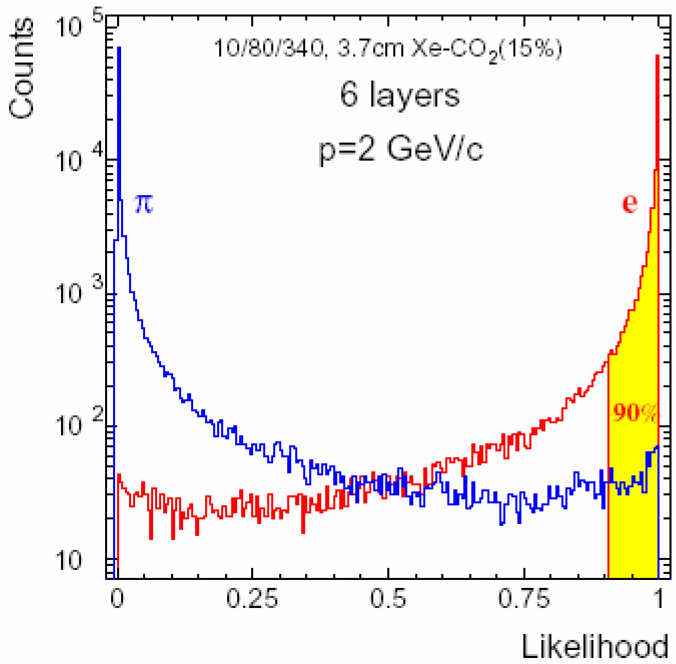
- Cluster finder in TRD
- Track reconstruction following global tracking scheme



Reconstruction

Constructing the e⁻-Likelihood (1-dim, L-Q)





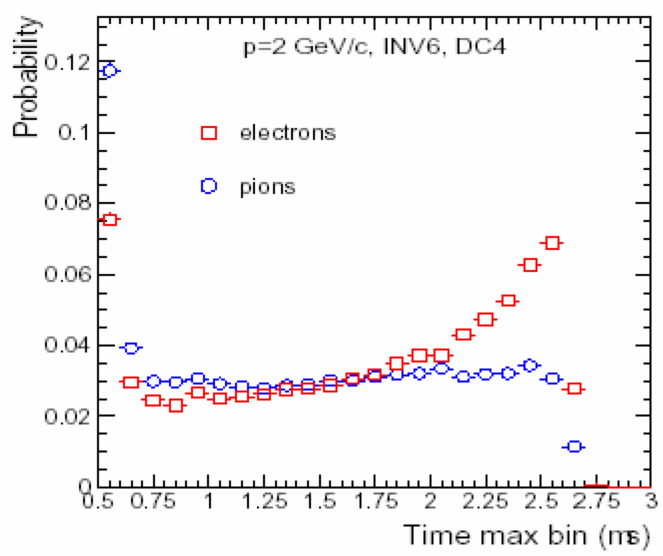
Use pulse height spectrum as probability distribution

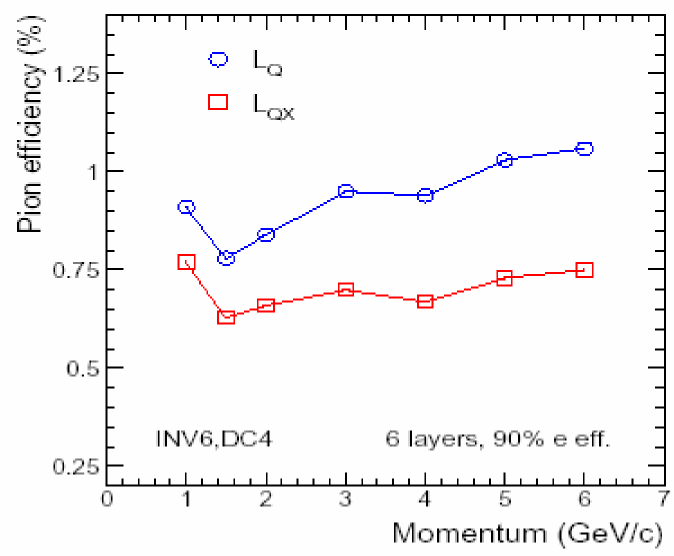
Construct likelihood in each plane

$$L = \frac{P_e}{P_e + P_\pi} \quad P_{e,\pi} = \Pi_{i=1}^{N} P(Q_i|e,\pi)$$

Reconstruction

Constructing the e⁻–Likelihood (2–dim, L–QX)





Additional information from position of cluster with maximum pulse height

$L_Q : P_{e,\pi} = \prod_{i=1}^{N} P(Q_i|e,\pi)$

Q_i - total charge in layer i

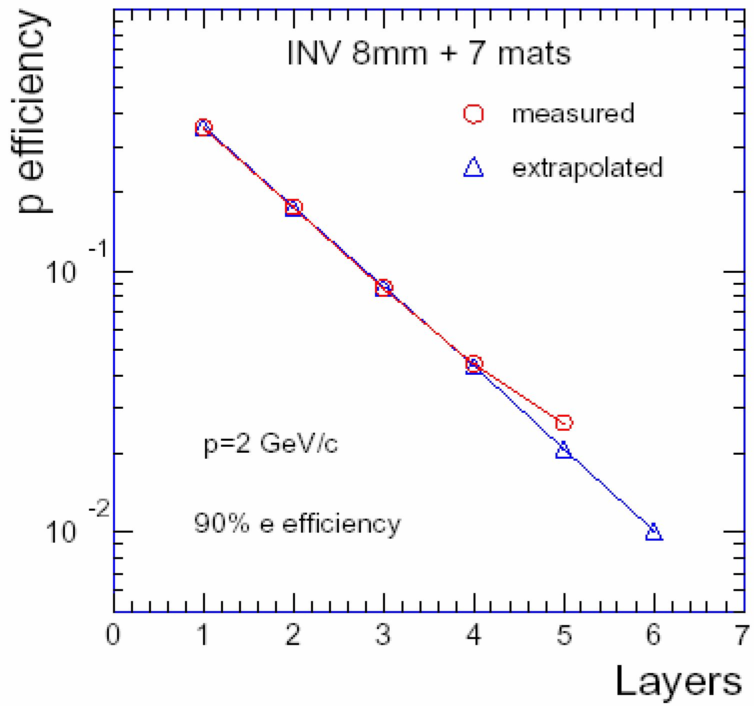
$L_{QX} : P_{e,\pi} = \prod_{i=1}^{N} P(Q_i|e,\pi)P(t_i|e,\pi)$

t_i - position of max. time bin

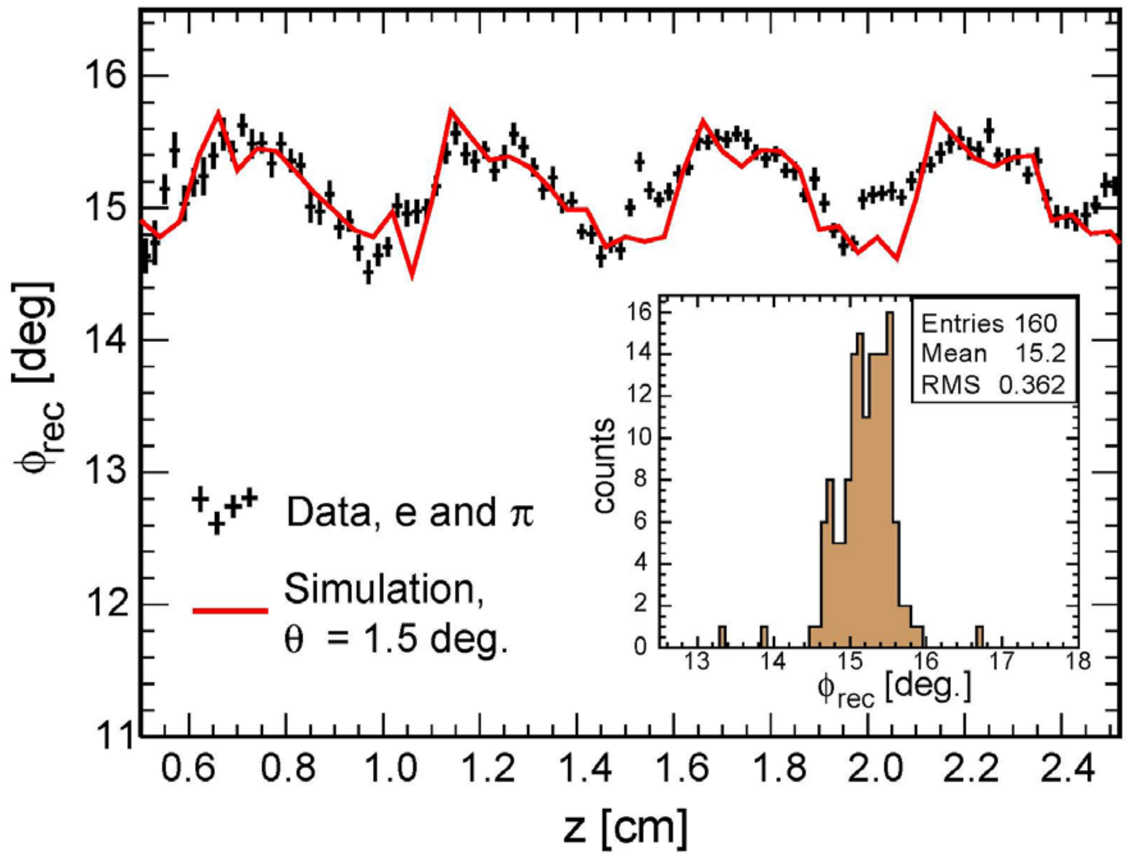
Reconstruction
Implementation in ESDs

- Electron likelihood is being implemented in ESDs for the analysis of the PDC data
- TRD information in ESD:
  - Charge sum in each plane
  - Time bin of maximum cluster in each plane
  - Total: 12 numbers
- Under investigation:
  - Cluster quality cuts (overlapping clusters)

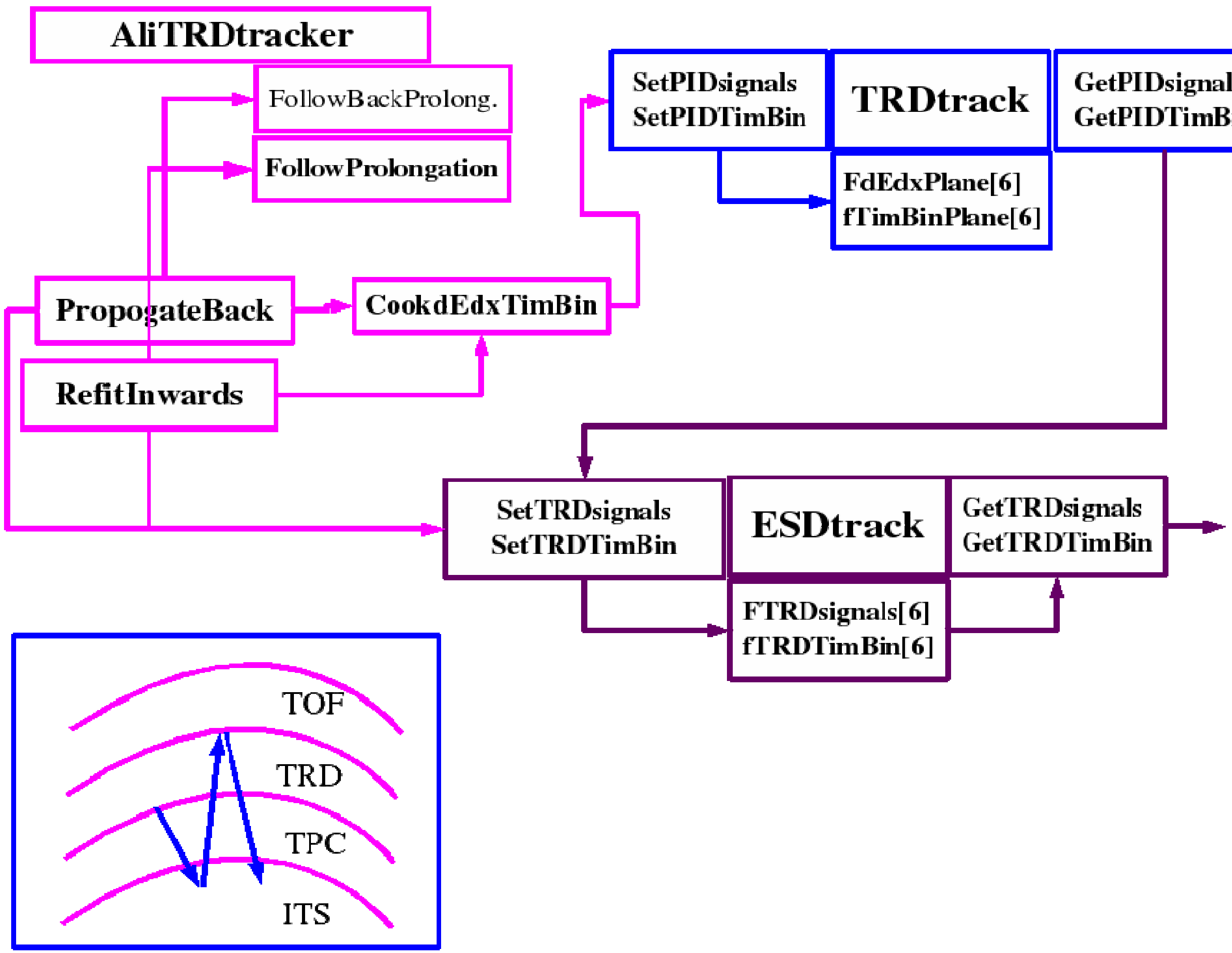
Summary and Outlook

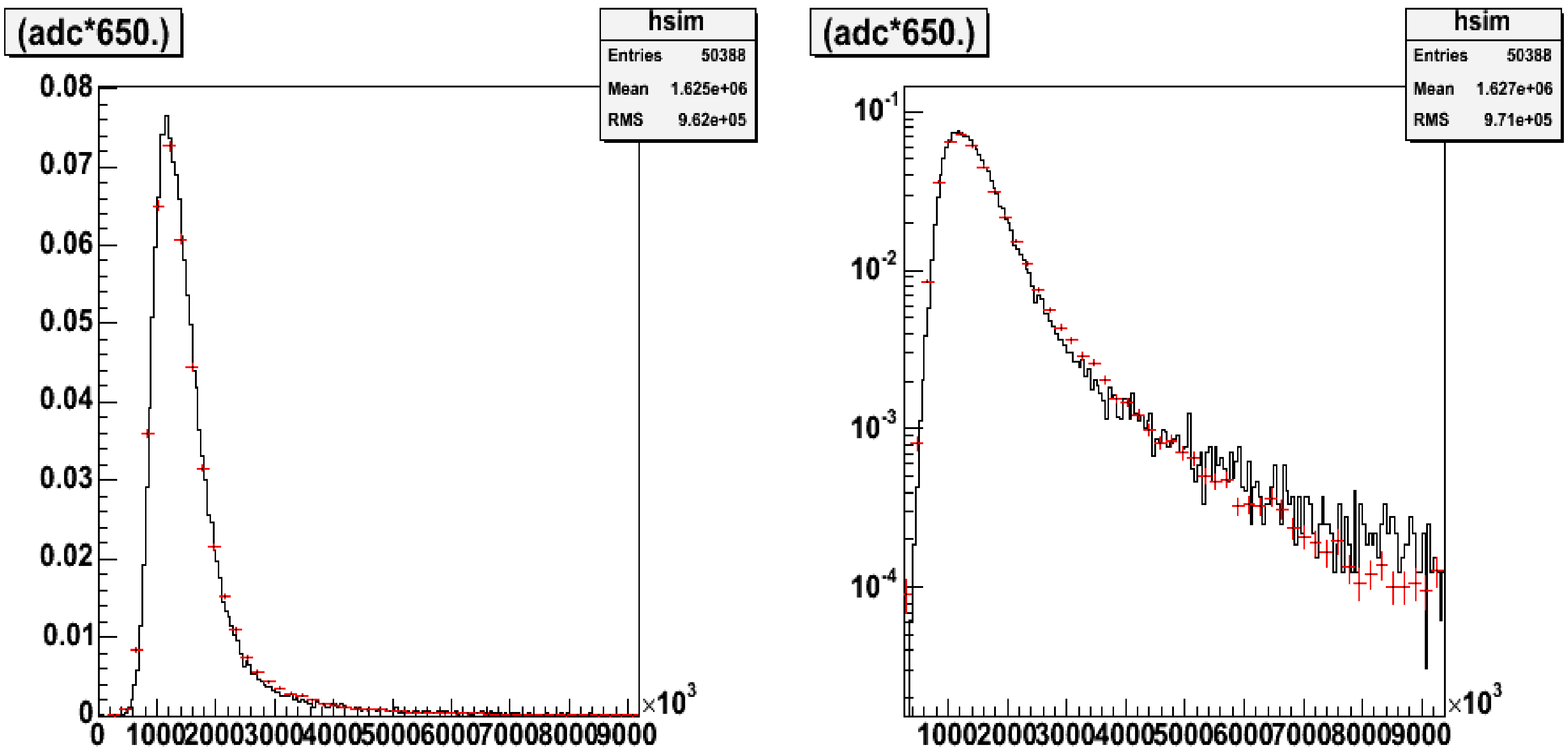


INV 8mm + 7 mats
measured
extrapolated
p efficiency
10^-1
10^-2
p=2 GeV/c
90% e efficiency
0
1
2
3
4
5
6
7
Layers



16
15
14
13
12
11
ϕ_{rec} [deg]
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
z [cm]
Data, e and π
Simulation,
θ = 1.5 deg.
Entries 160
Mean 15.2
RMS 0.362
counts
ϕ_{rec} [deg.]


AliTRDtracker
FollowBackProlong.
FollowProlongation
PropogateBack
CookdEdxTimBin
RefitInwards
SetPIDsignals
SetPIDTimBin
TRDtrack
GetPIDsignals
GetPIDTimBin
FdEdxPlane[6]
fTimBinPlane[6]
SetTRDsignals
SetTRDTimBin
ESDtrack
GetTRDsignals
GetTRDTimBin
FTRDsignals[6]
fTRDTimBin[6]
TOF
TRD
TPC
ITS


(adc*650.)
hsim
Entries 50388
Mean 1.625e+06
RMS 9.62e+05
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 1000 2000 3000 4000 5000 6000 7000 8000 9000
×10^3
(adc*650.)
hsim
Entries 50388
Mean 1.627e+06
RMS 9.71e+05
10^-1
10^-2
10^-3
10^-4
1000 2000 3000 4000 5000 6000 7000 8000 9000
×10^3

pion 3 GeV/c