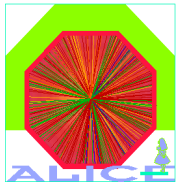

Dielectron Physics with ALICE Transition Radiation Detector (TRD)

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Presentation at ICPA-QGP-05, 10 February 2005, Kolkata, India

Outline

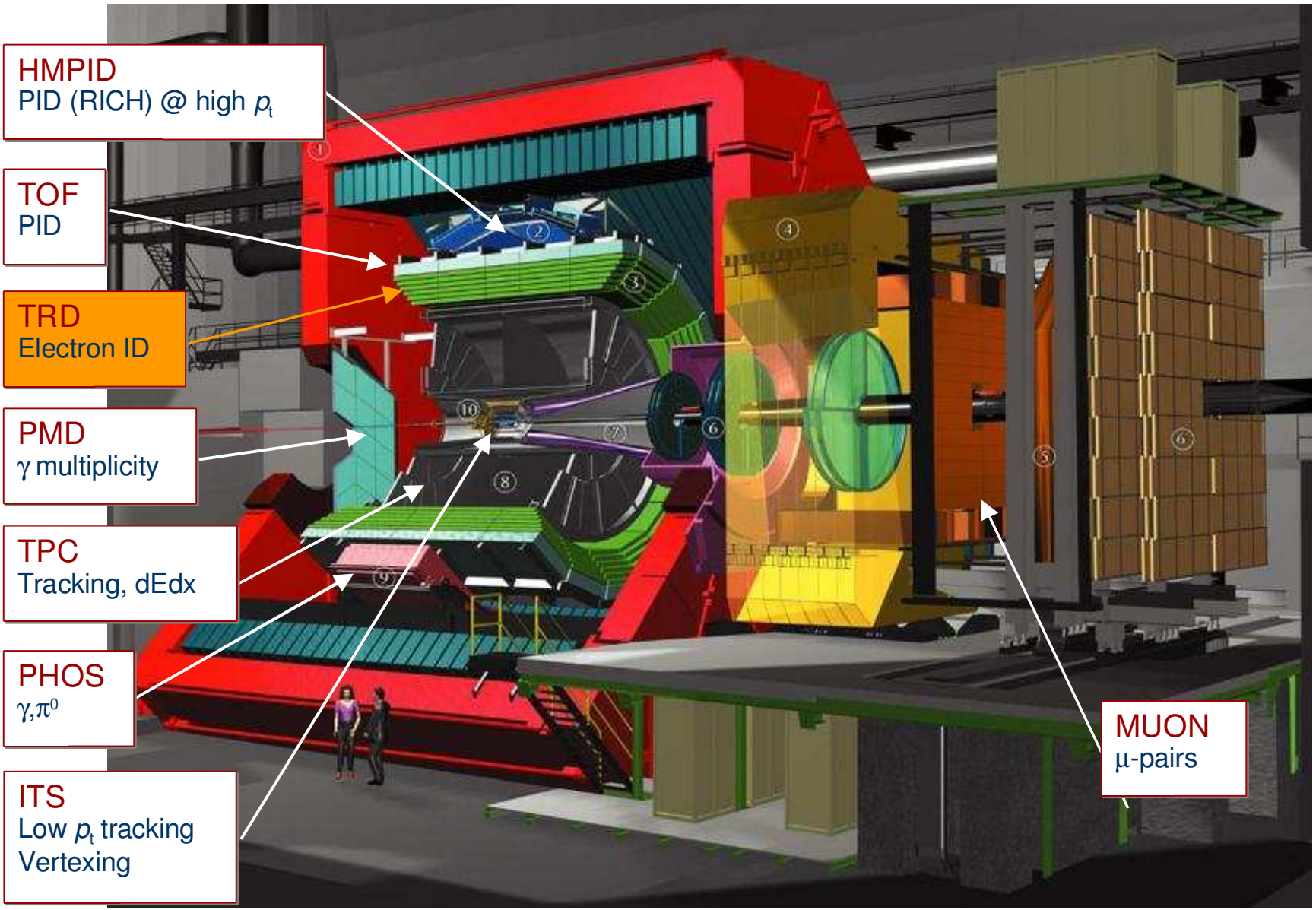
- ALICE Experiment at CERN LHC
- Physics of dielectrons
- Requirements of ALICE Transition Radiation Detector (TRD)
- TRD -- Working Principle, Setup
- TRD Test Beam Results + Simulations
- Electron Pion Identification
- Momentum resolution
- Quarkonia Detection performance
- Summary

LHC at CERN

SPS 1986-2003 Pb upto 20 AGeV

LHC 2007 upto 5.5 ATeV

The ALICE Experiment



What is contained in Dielectron Spectrum

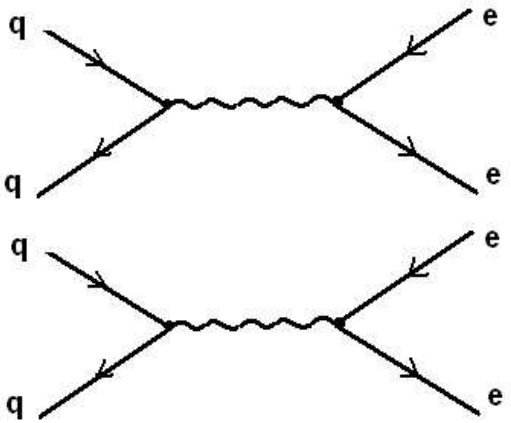
Heavy Quarkonium: J/Ψ, Y through their decays in electron pairs

They will give us information about QGP formation

Continuum:

Drell Yan --> Initial Scattering in the collisions

Thermal --> Intn. Among thermally distributed quarks



Open charm (D), open bottom (B) mesons:

Produced in hadronization of heavy quarks

and decay semileptonically e.g.

D (q Qbar) ---> e^+ + X (12 %)

Dbar (qbar Q) ---> e^- + X (12 %)

Physics with TRD

In conjunction with the TPC and ITS, the TRD provides sufficient electron identification capabilities to study:

- **Di-electron channel: production of light and heavy vector-mesons J/Ψ, Υ as well as the continuum .**
- **Single-electron channel: semi-leptonic decays of hadrons with open charm and open beauty channel using the displaced vertex information provided by the ITS.**
- **Electron Muon Coincidence: correlated DD(bar) and BB(bar) pairs via coincidences of electrons in the central barrel and muons in the forward muon arm.**

Requirements of TRD

- **The TRD should separate electrons within a dominant background of pions**

  Pion rejection factor > 100 required

- **Increase the tracking capability of the ALICE Detector.**

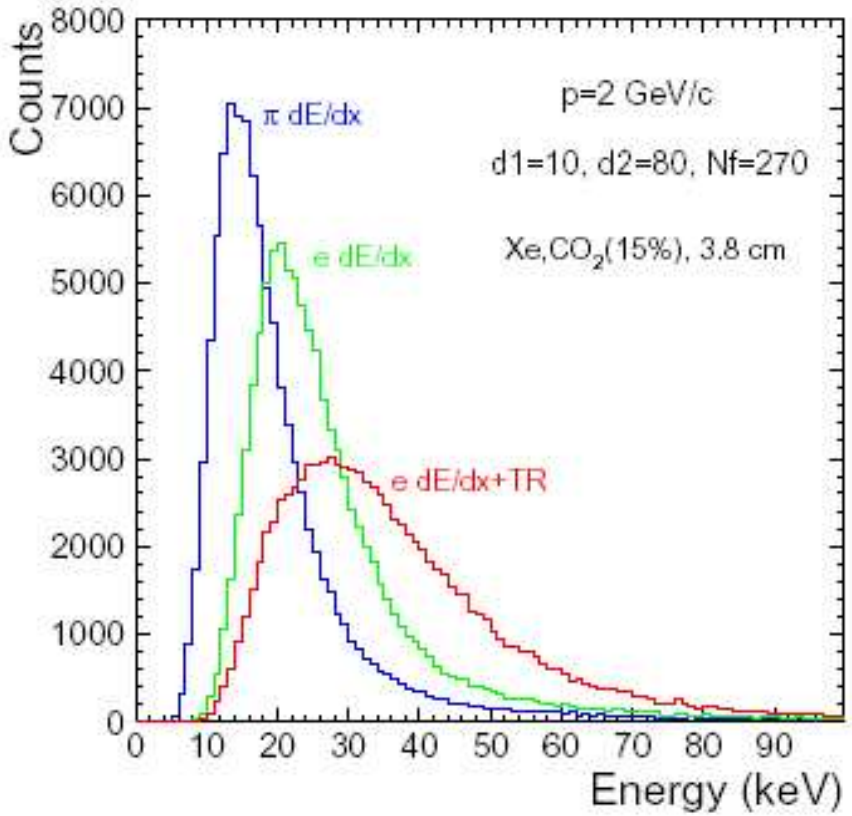
  Good Position (.5 mm) and Angular resolution

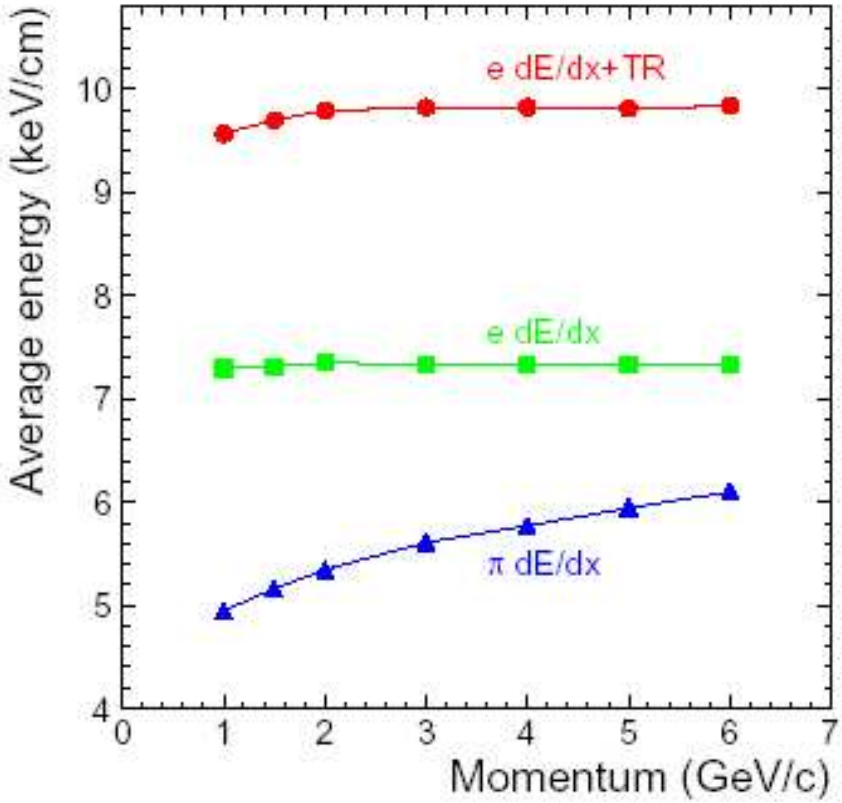
- **Provide trigger on high-p_t > 2GeV/c electrons.**

TRD Working Principle

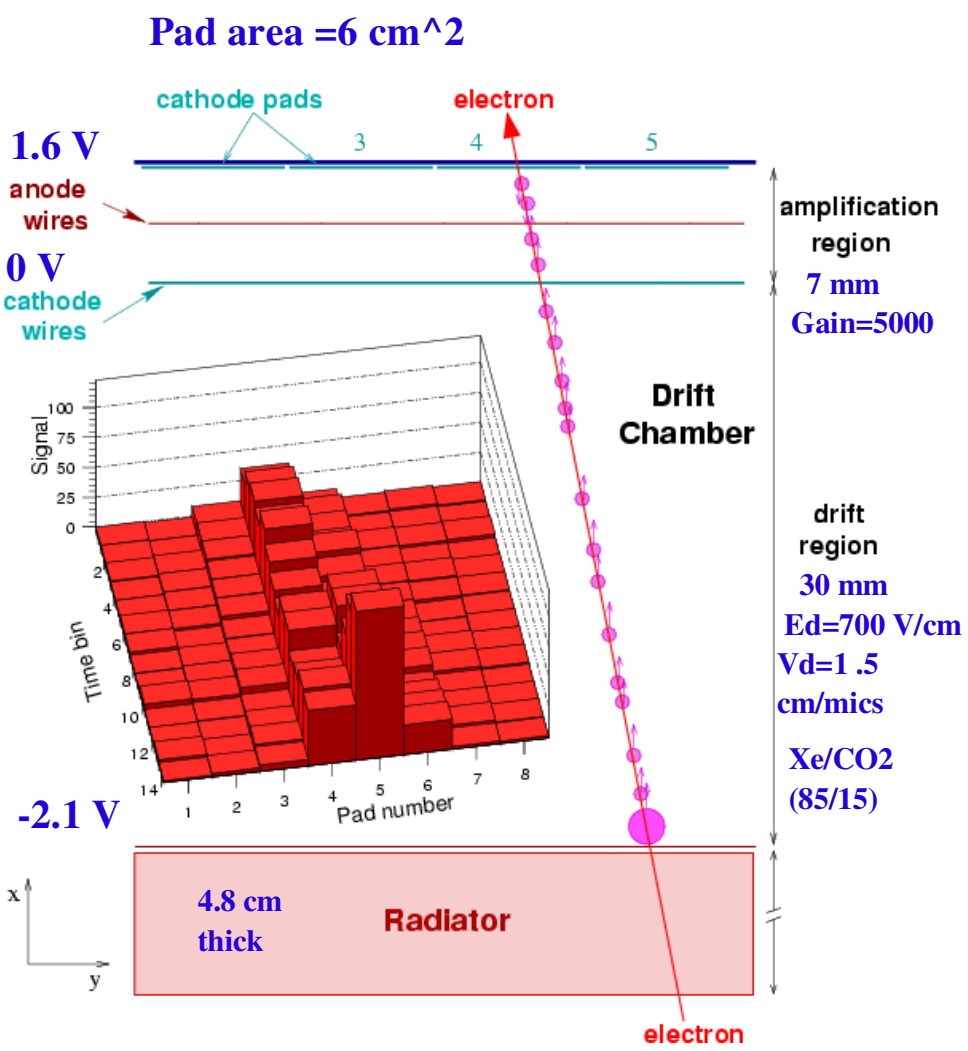
- **Transition Radiation photons are generated by charged particles crossing the border between two different di-electric media**
- **Elektron-/pion-discrimination: (p = 5 GeV/c):**

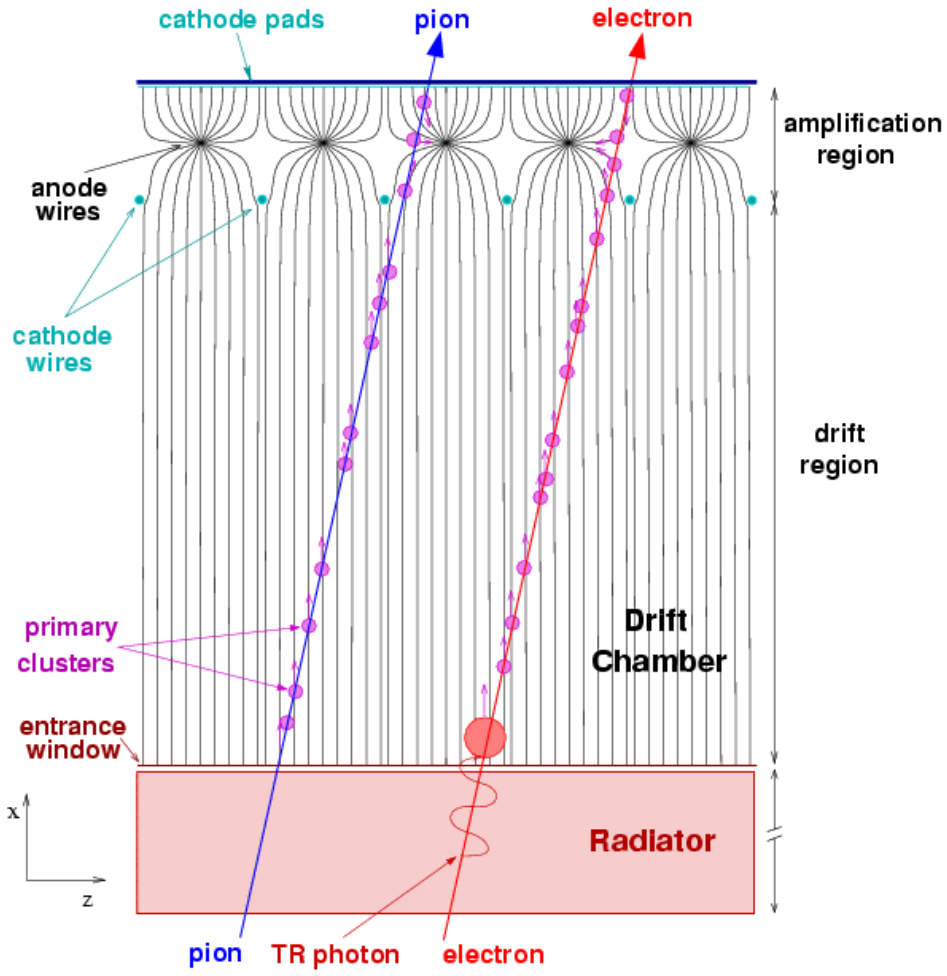
  e^- γ ~ 10000 pi γ ~ 36





TRD Working Principle





Radiator: fiber / foam sandwich PP, 17 μm

The TRD (Transition Radiation Detector)

TRD: Radiator + Drift space + MWPC

Each chamber:
1.45 x 1.20m²
12cm thick
(incl. Radiators and electronics)

The TRD (Transition Radiation Detector)

|eta| < 0.9 45 <Theta <135

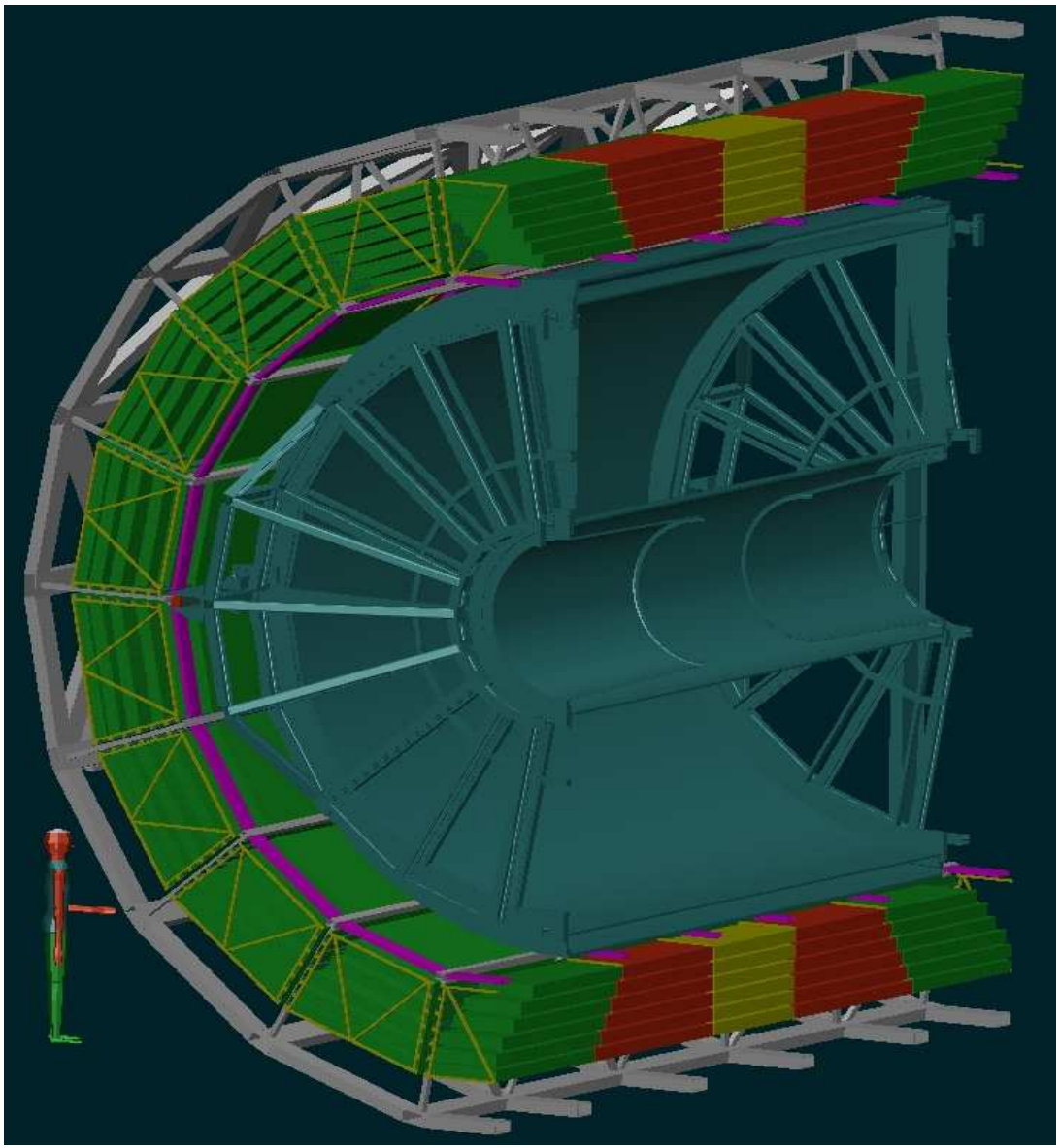
- 18 supermodules in phi sector
- 6 Radial layers
- 5 Z longitudinal stack

$\Rightarrow$ 540 chambers

$\Rightarrow$ 750m^2 active area

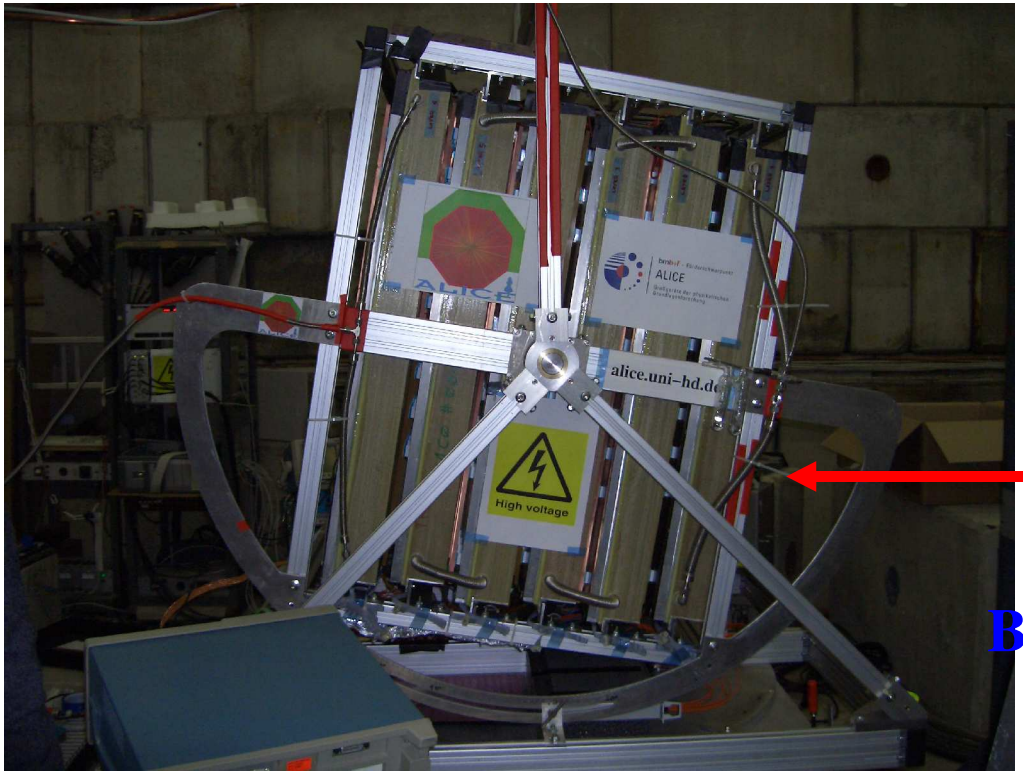
$\Rightarrow$ 28m^3 of gas

in total 1.18 million read out channels



TRD Stack used in CERN test beam

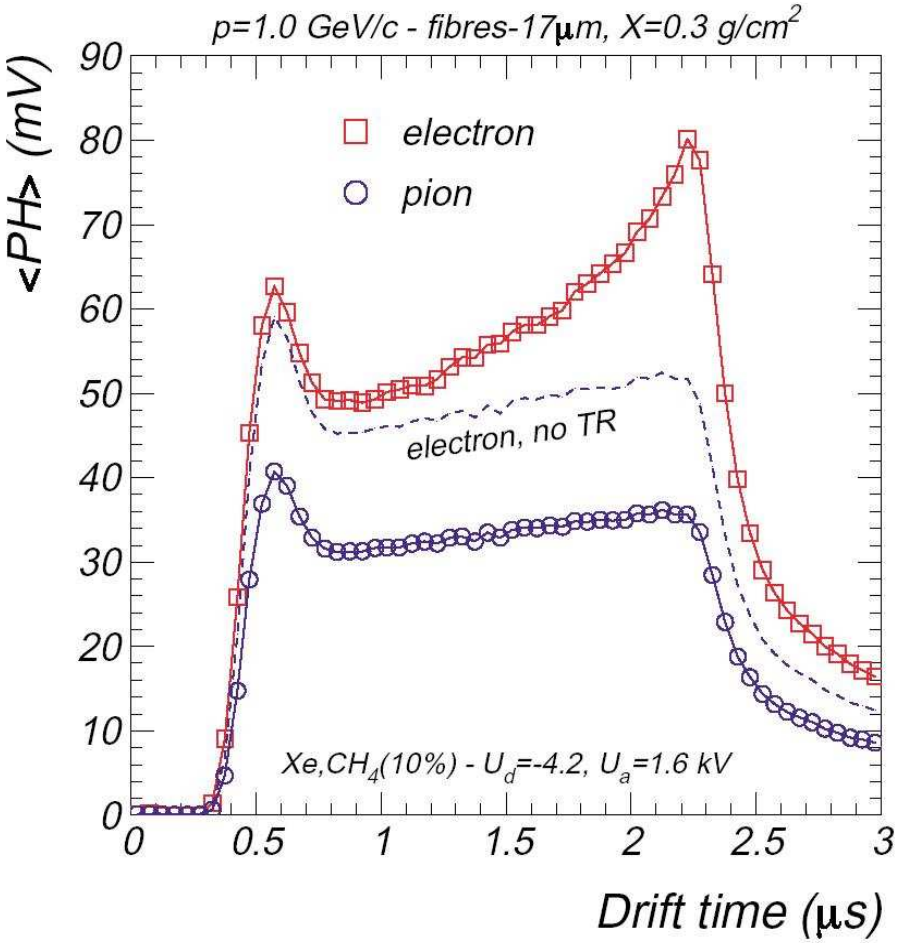
2002, 2004

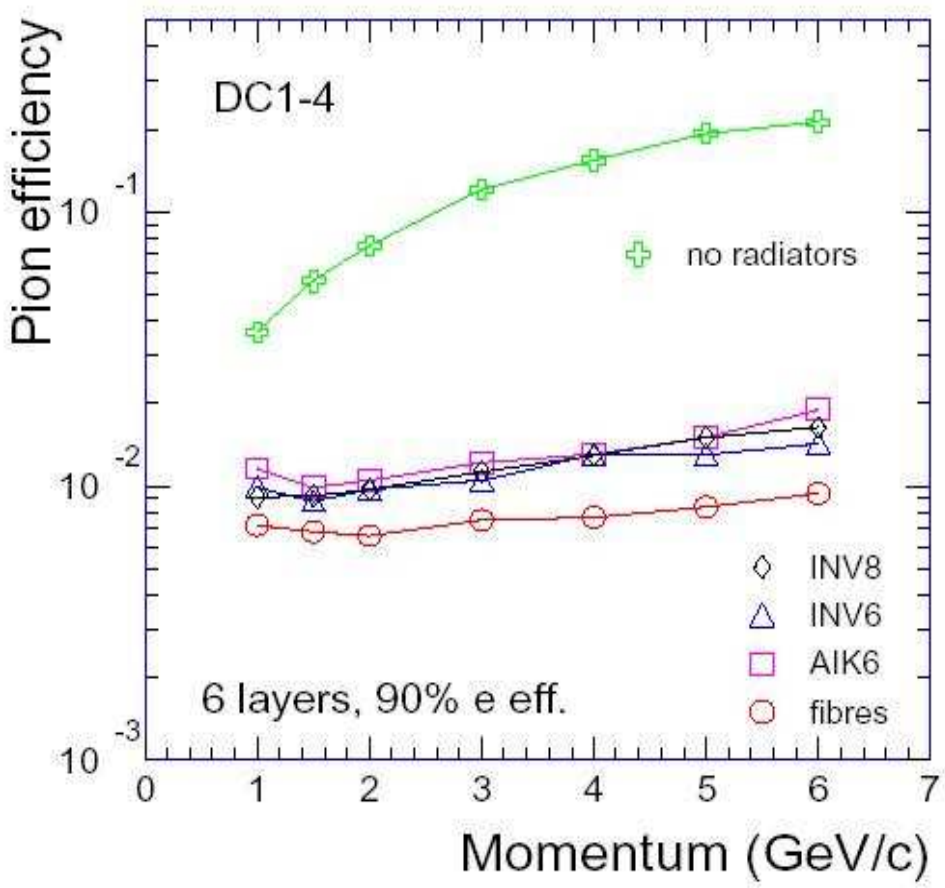


Beam

2004

TRD Test Beam Results



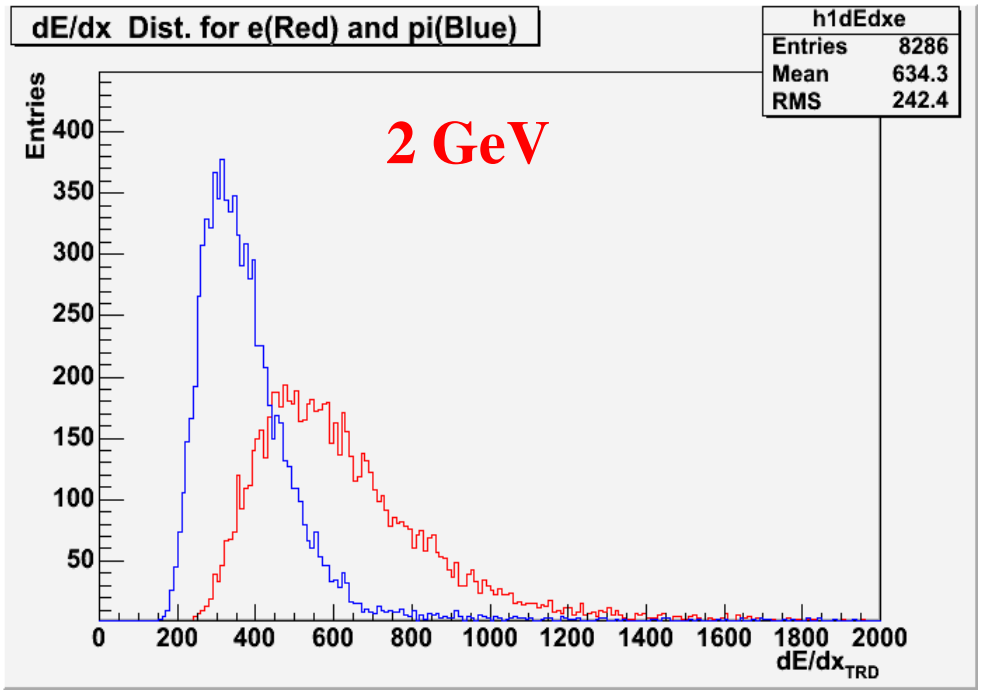


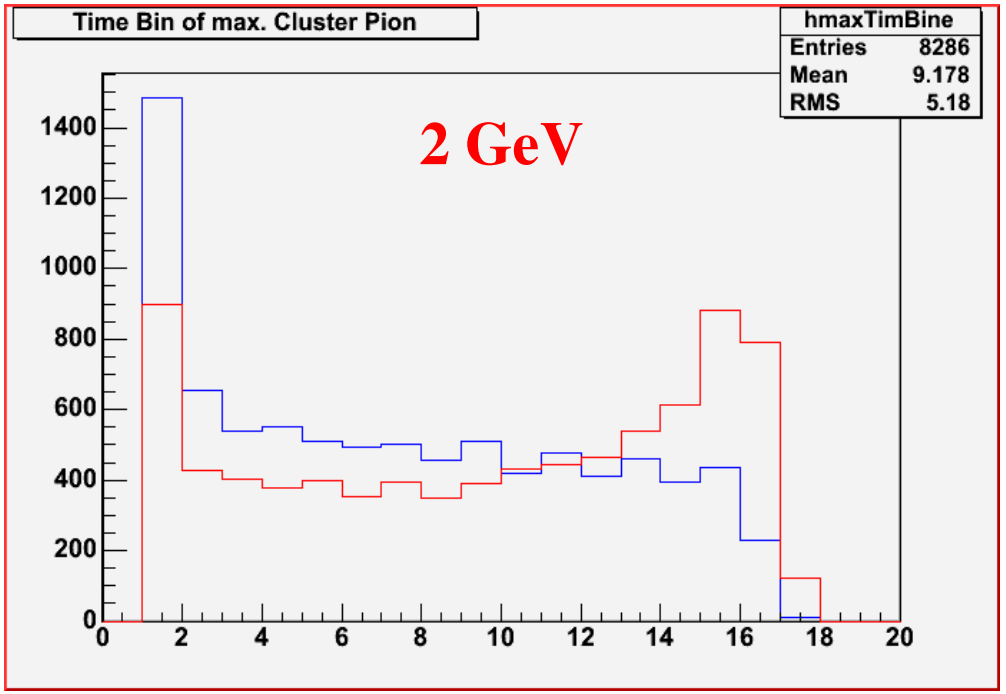
Design value:

Pion suppression factor 100 at 90% electron efficiency

The dE/dx and position of Max charge (Simulated)

2500 electrons (red) and 2500 pions (blue) for 2 GeV





Use pulse height spectrum as probability distribution

Construct likelihood in each plane

Liklihood Distributions (Simulated)

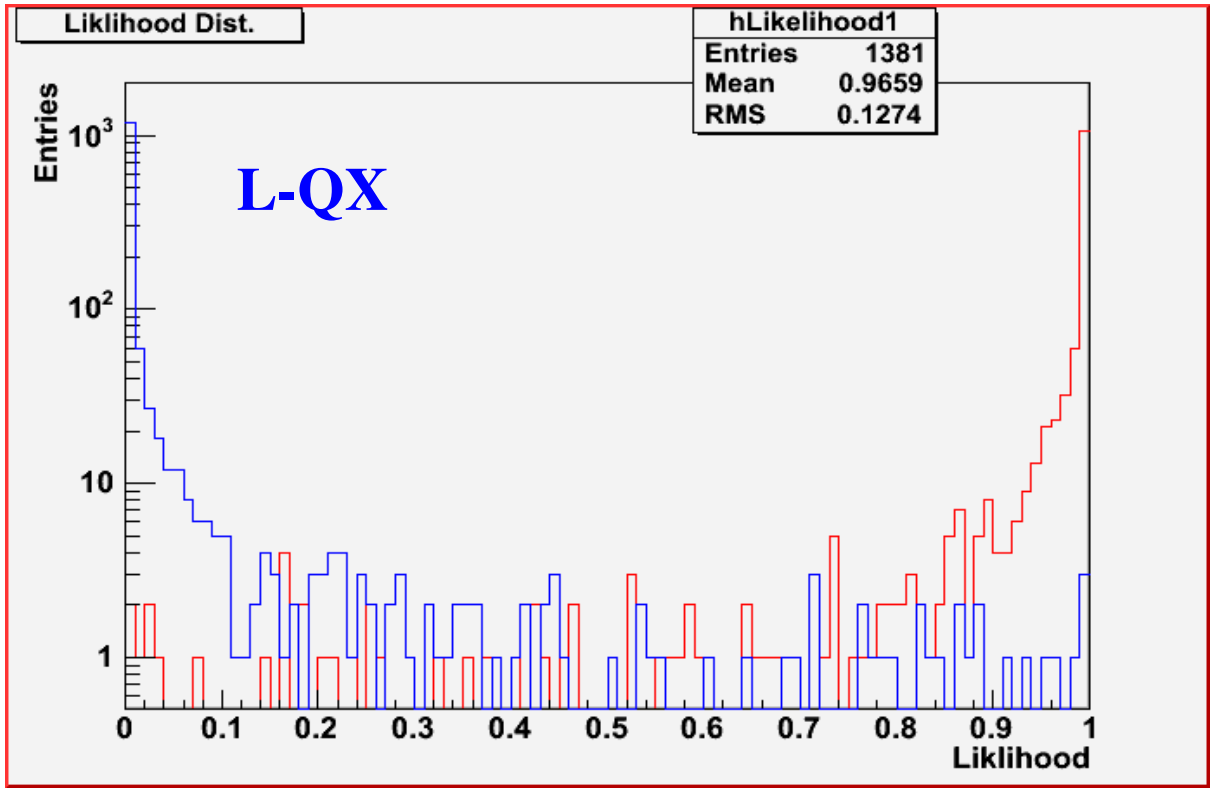
electrons (red) and pions (blue) (p=2 GeV)

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

Q_i - total charge in layer i

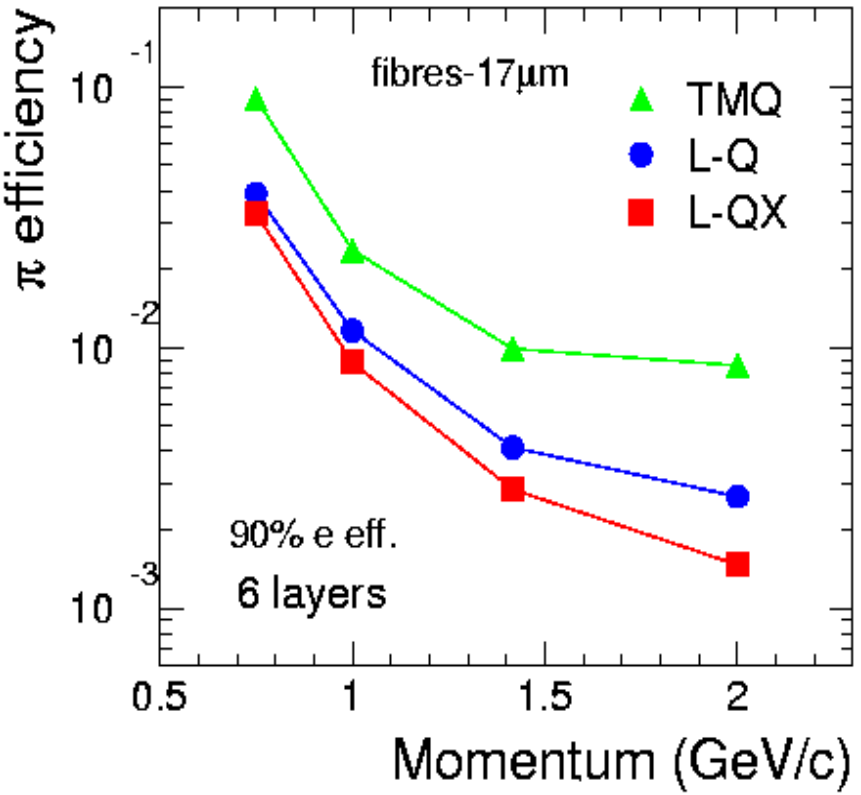
$$L_{QX} : P_{e,\pi} = \prod_{i=1}^{N} P(Q_i|e,\pi) P(t_i|e,\pi)$$

t_i - position of max. time bin

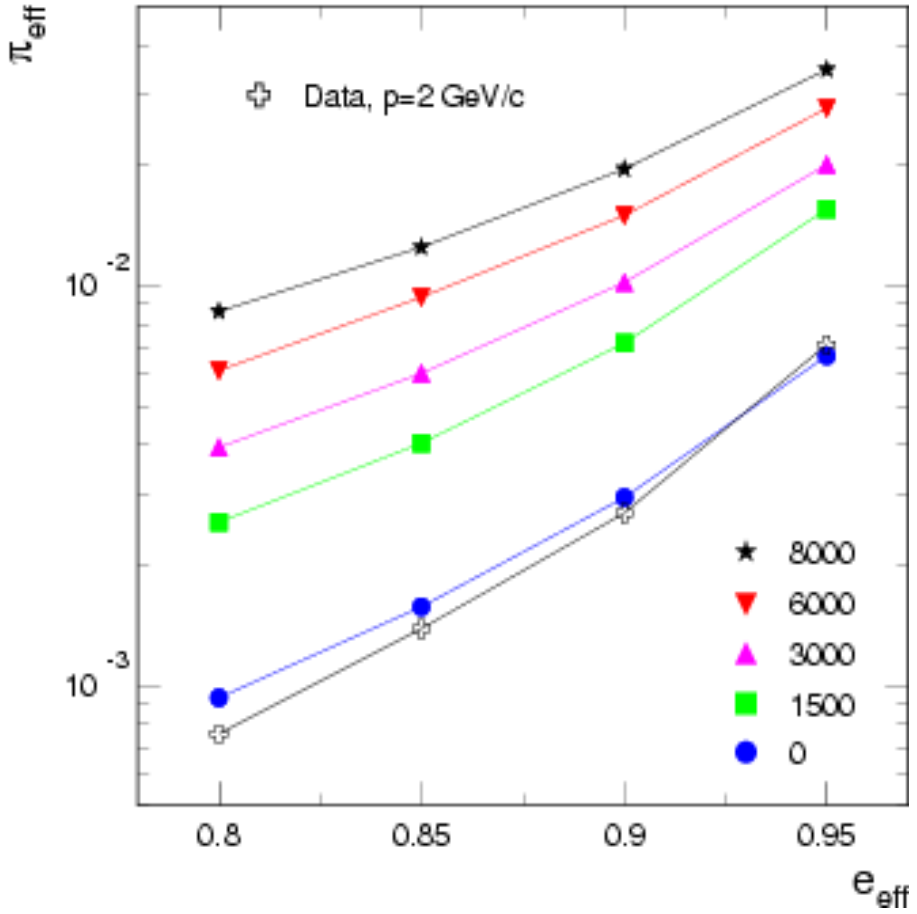


π efficiency vs electron efficiency

Test Beam



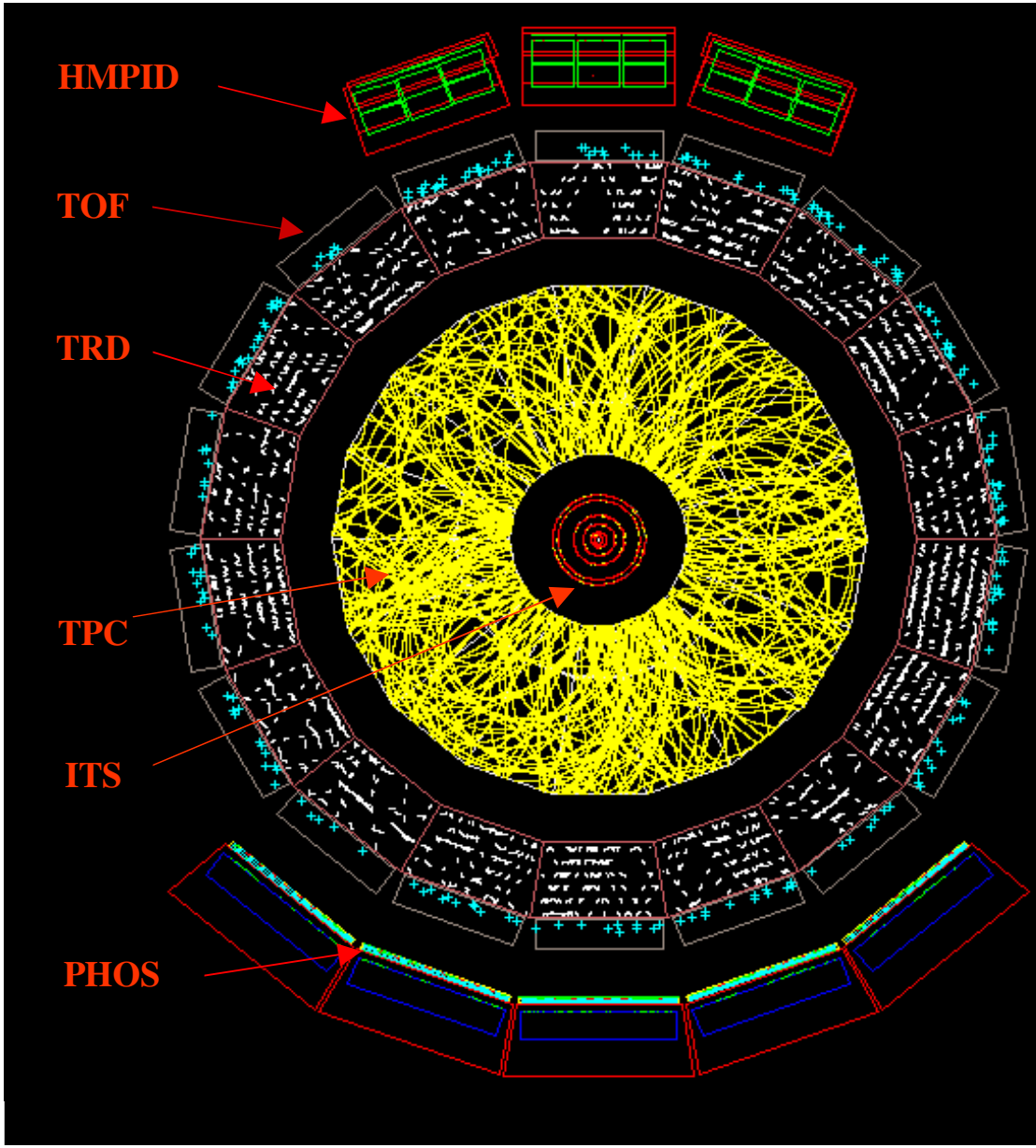
Simulated



Implementation in Event Summary Data

- **TRD Particle identification information in Event Summary Data (ESD):**
  - **Charge sum in each plane (6)**
  - **Time bin of maximum cluster in each plane (6)**
  - **Combined e Liklihood over all layers**
  - **Combined pi Liklihood over all layers**

AliRoot Simulations

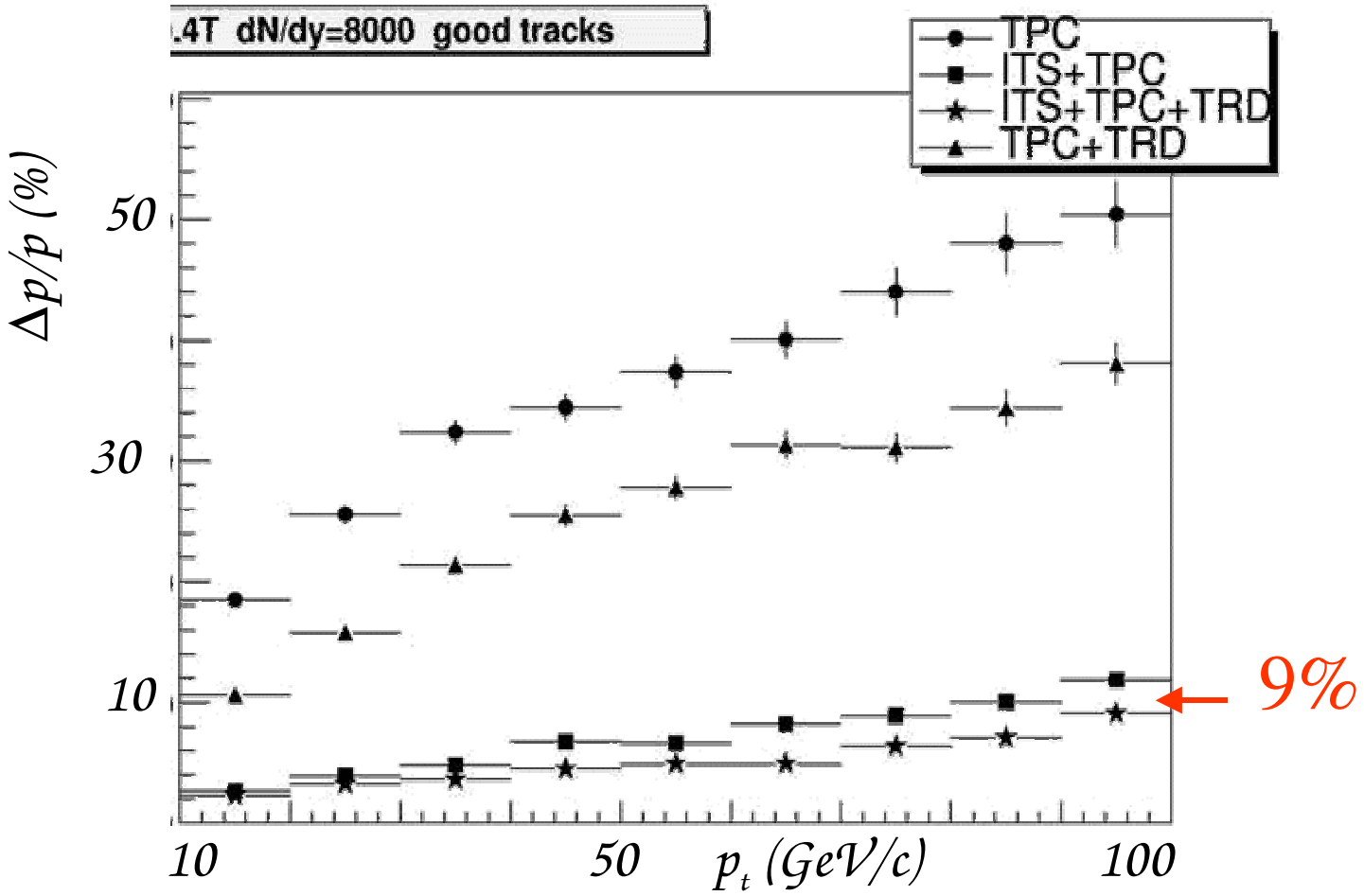


5000 PbPb events
at 5.5 TeV/nucleon pair

dNch/dη ~ 8000

(slice: 2° in θ)

Combined Momentum Resolution



Resolution ~ 9% at 100 GeV/c
excellent performance in hard region!

Cross sections and yields of Quarkonia:

σ^{dir}/nucleon pair (μb) PbPb 5.5 GeV Calculated by NLO	J/ψ	ψ'
σ^{dir}/nucleon pair (μb)	11.7	2.65
Y/evt (5% Centrality)	0.31	0.07

	Υ	Υ'	Υ''
σ^{dir}/nucleon pair (μb)	0.15	0.094	0.057
Y/evt (5% Centrality)	0.004	0.0025	0.0015

$L = 10^{27}\ cm^{-2}\ s^{-1} = 1\ mb^{-1}\ s^{-1}$

Yields for open charm and beauty mesons

Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV centrality selection of 5%

N (DDbar) = 115

Ne^-= 115*0.12=13.8, Ne^+ = 13.8

Ne^-e^+ (corr) = 115*0.12*0.12= 1.66

Ne^-e^+ (uncorr.) = 190

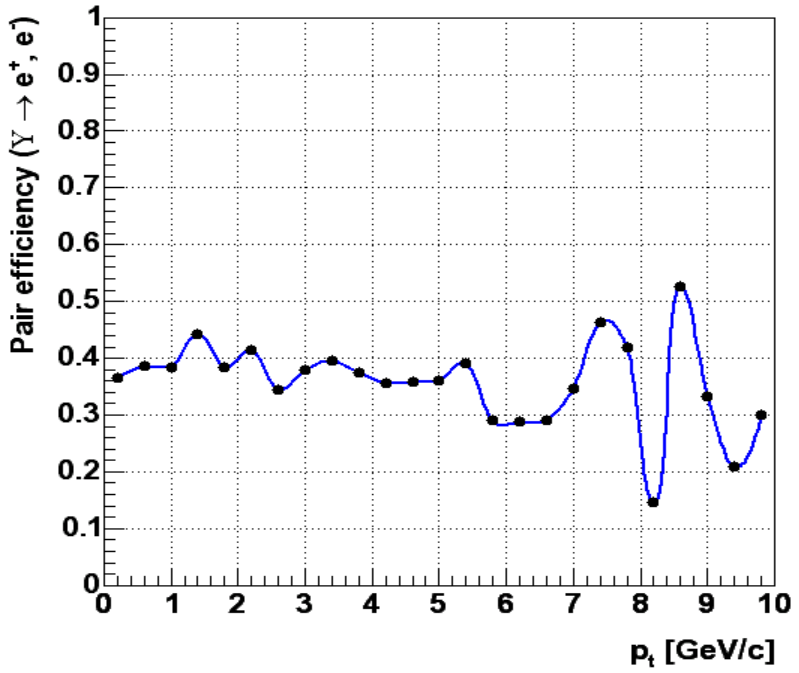
N (BBbar) = 4.56

These values correspond to the average of the result obtained with MRST HO and CTEQ 5M1 parton distribution functions. EKS98 parameterization of nuclear shadowing.

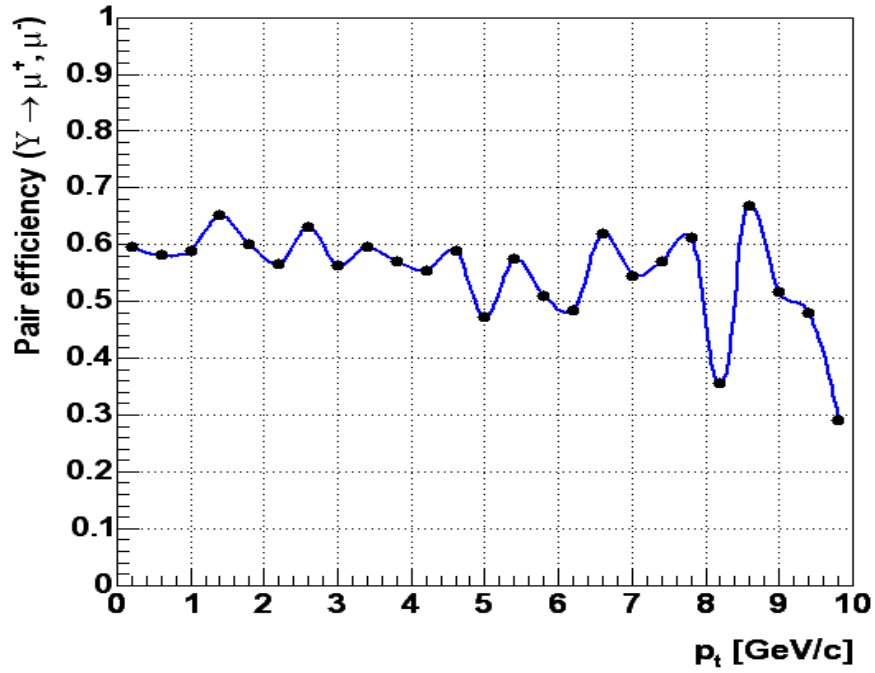
Y tracking efficiency in dielectron channel

- low multiplicity events, defined for Y--> e+e- within TRD acceptance
- ε (Y) = ε (e+) x ε (e-)
- conditions: 2 tracks of opposite charge, single track Pt > 2 GeV/c

- electron channel e+ e-



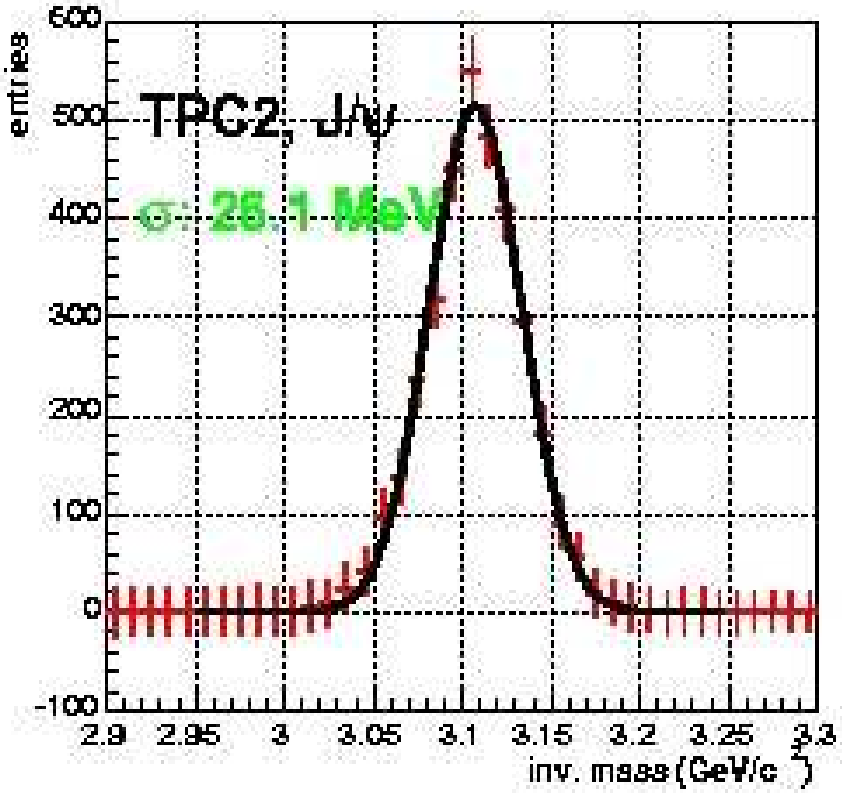
- muon channel μ + μ -

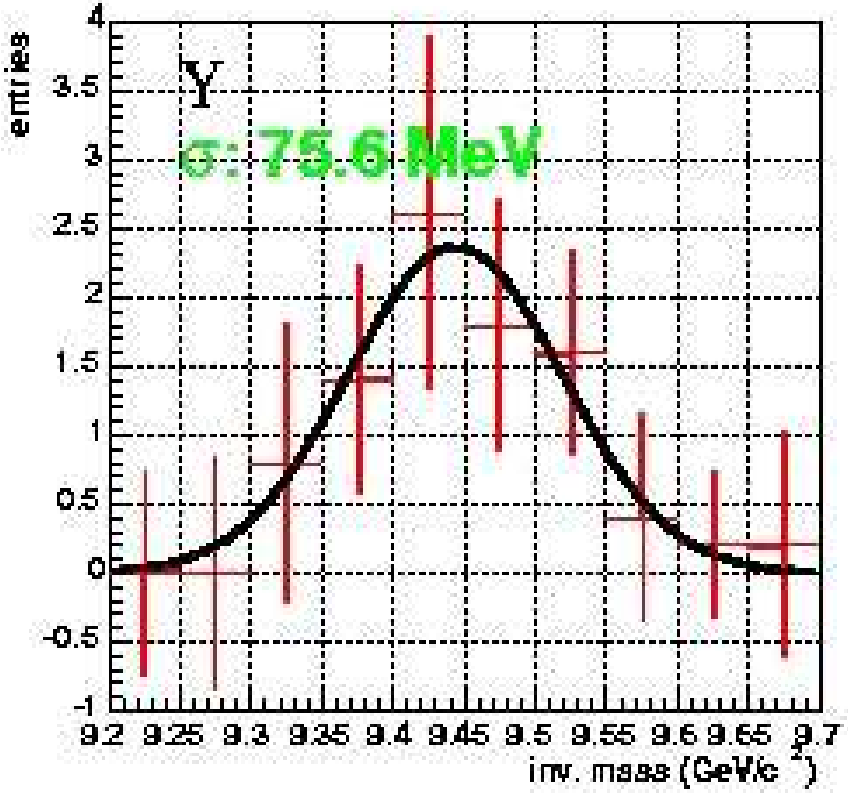


Mass resolution offline J/ψ, Υ

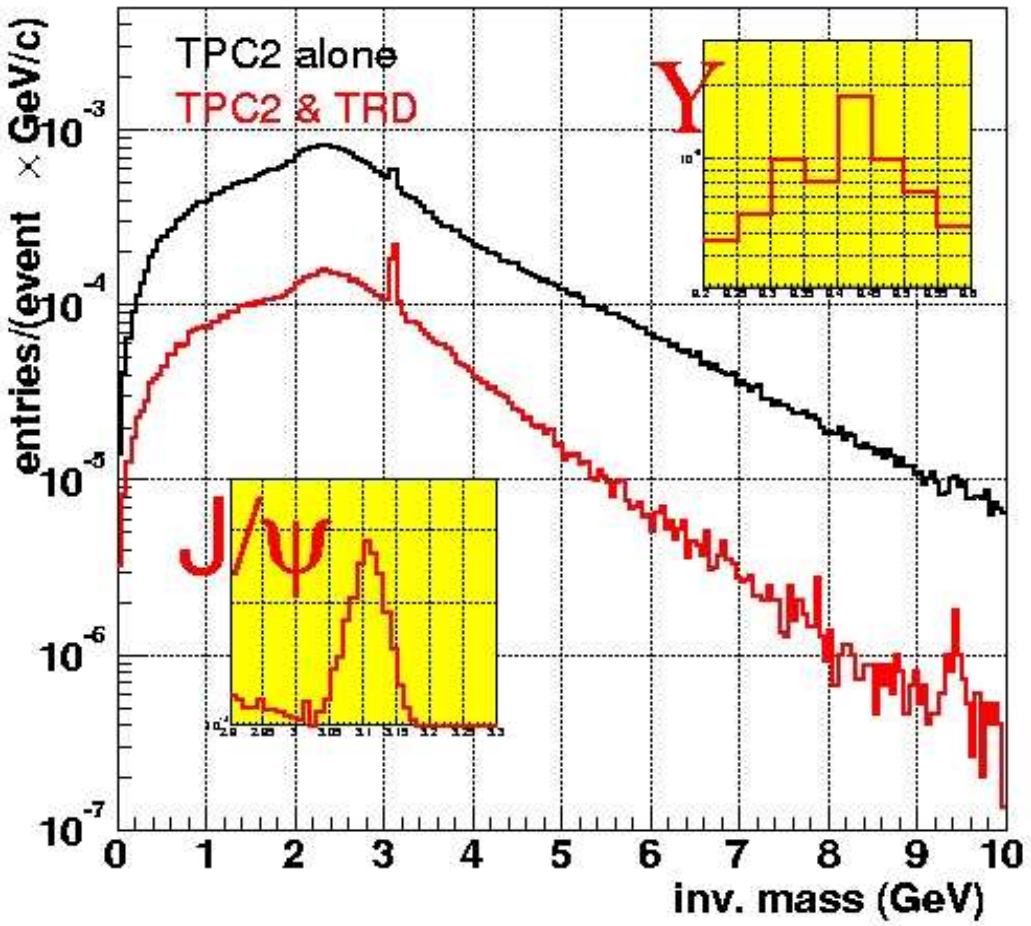
- mass resolution offline:
-TRD, TPC combined

- J/Ψ: σ ~ 27 MeV/c2
- Υ: σ ~ 80 MeV/c2





Invariant Mass spectrum of dielectrons



- mass resolution offline:
-TRD, TPC combined

- J/Ψ: σ ~ 27 MeV/c2
- Y: σ ~ 80 MeV/c2

m(Y)-m(Y') ~ 563 MeV/c2
--> m(Y)-m(Y') ~ 7 σ
m(Y')-m(Y'') ~ 332 MeV/c2
--> m(Y')-m(Y'') ~ 4 σ

J/ψ→ee: about 40000/month
Y→ee: about 1000/month

Good mass resolution and
Good signal to background

Physics Data Challenge : TRD Signal events

10 (J/ψ, ψ') ----> e- + e+

10 (Y, Y', Y") ----> e- + e+

10 (Ds and Dbars) ----> e- + e+

10 (Bs and Bbars) ----> e- + e+

10 (Bs and Bbars) --> J/ψ --> e- + e+

These are the parameterizations of Ramona Vogt results Given in AliGenMUONlib

Underlying Events:

Hijingcent1 --> b (0, 5)

Hijingper1 --> b (5, 8.6)

Summary and Outlook

- **Good Particle Identification : Pion rejection factor 100 at 90 % electron efficiency**
- **Good Momentum resolution : 10 %**
- **Quarkonia Detection performance : Mass resolution of 1%**
- **We look forward to Physics Data Challenge for detailed Physics performance**

Meet ALICE TRD Project

Project leader: J. Stachel, Heidelberg
Technical coordinator: J.P. Wessels, Munster

Participating institutions:

- GSI Darmstadt (chambers, gas system)
- IKF/U.Frankfurt (FEE, chambers)
- IKP/U.Munster (radiators)
- JINR Dubna (chambers)
- KIP/U.Heidelberg (FEE, trigger)
- NIPNE Bucharest (chambers)
- PI/U.Heidelberg (chambers, FEE, trigger)
- U.Kaiserslautern (ADC)
- FH Koln (DCS)
- FH Worms (DCS)

60 people

- U.Tokyo
- U.Tsukuba
- U.Nagasaki