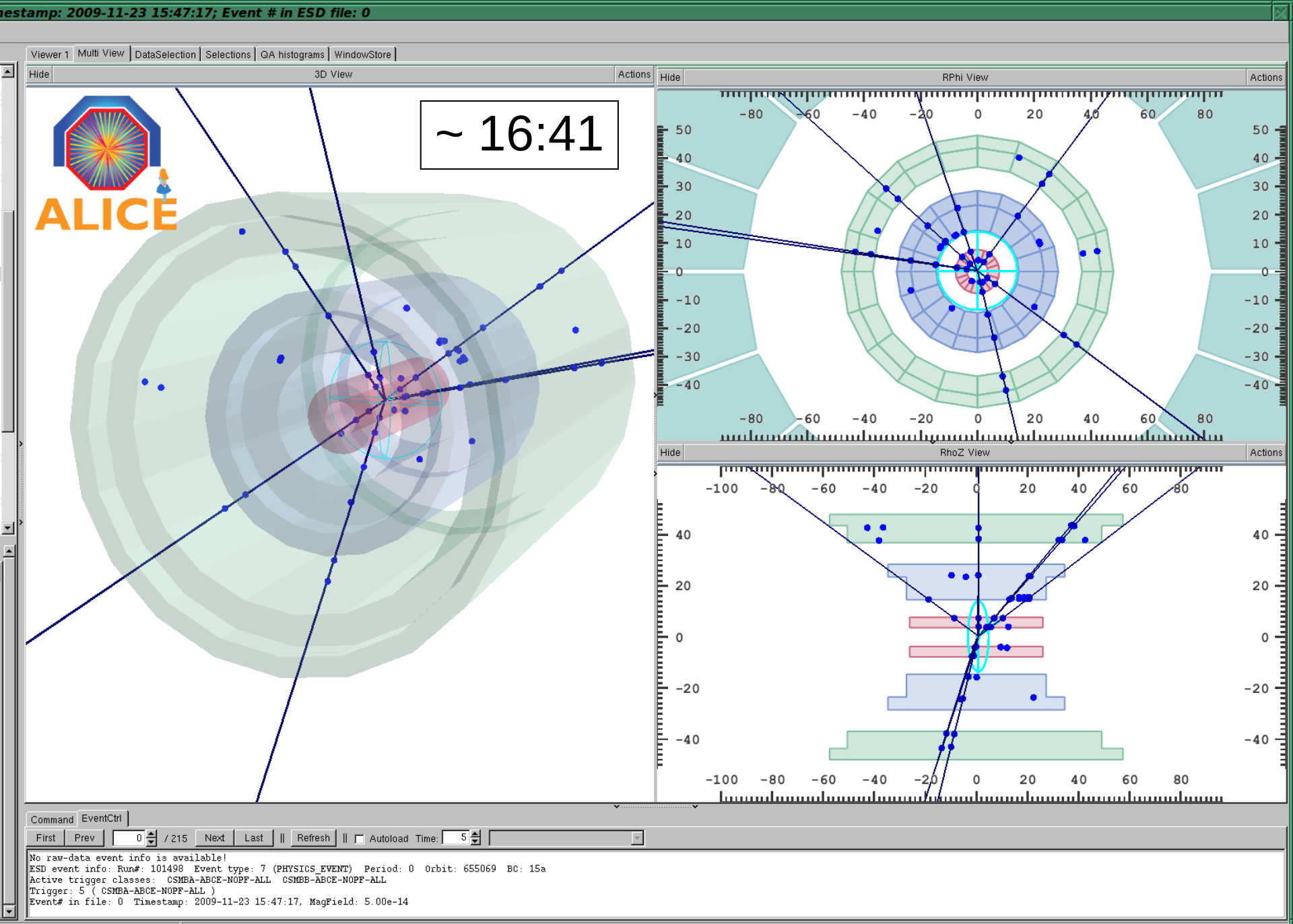
First results from ALICE

A Large Ion Collider Experiment

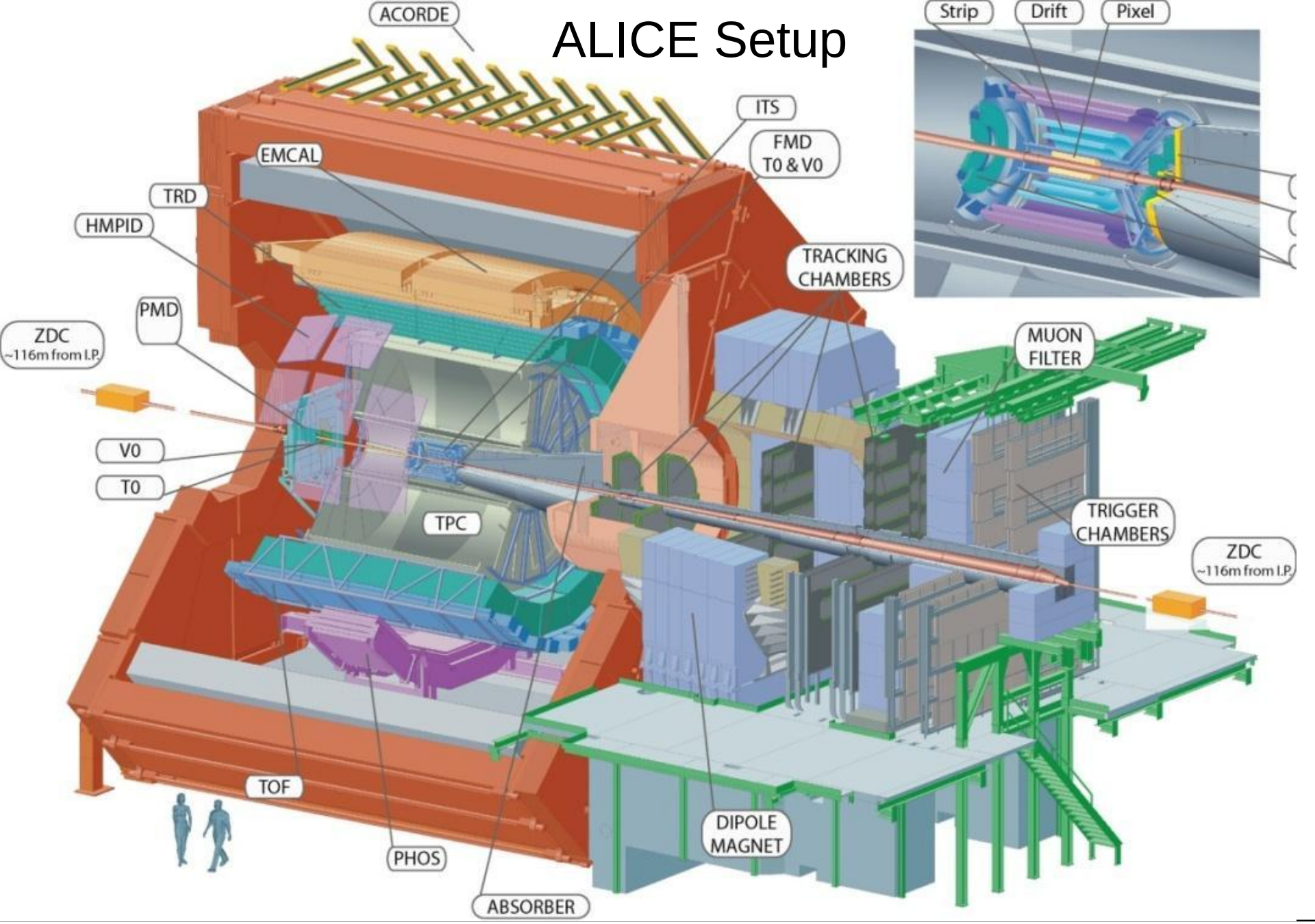
BMBF Forschungsschwerpunkt
ALICE Experiment 201

ALICE Control Room
waiting for collisions, Monday Nov 23, 16:35


Timestamp: 2009-11-23 15:47:17; Event # in ESD file: 0
Viewer 1
Multi View
DataSelection
Selections
QA histograms
WindowStore
Hide
3D View
Actions
~ 16:41
ALICE
Hide
RPhi View
Actions
Hide
RhoZ View
Actions
Command
EventCtrl
First
Prev
0
/ 215
Next
Last
Refresh
Autoload
Time:
5
No raw-data event info is available!
ESD event info: Run#: 101498 Event type: 7 (PHYSICS_EVENT) Period: 0 Orbit: 655069 BC: 15a
Active trigger classes: CSMBA-ABCE-NOPF-ALL CSMBB-ABCE-NOPF-ALL
Trigger: 5 (CSMBA-ABCE-NOPF-ALL)
Event# in file: 0 Timestamp: 2009-11-23 15:47:17, MagField: 5.00e-14

The first pp collision event

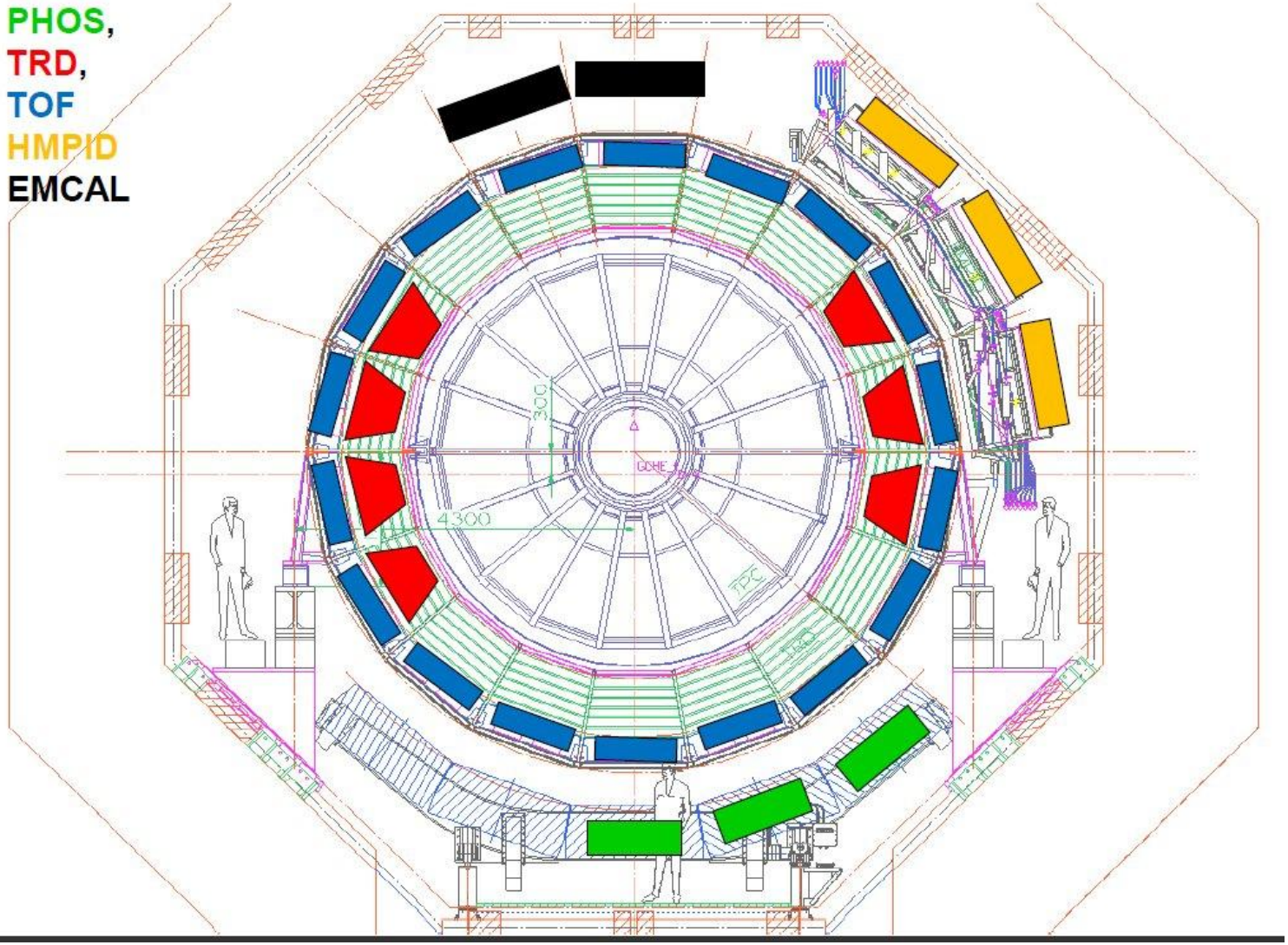
ALICE Setup


ACORDE
ITS
FMD
T0 & V0
EMCAL
TRD
HMPID
TRACKING
CHAMBERS
PMD
ZDC
~116m from I.P.
MUON
FILTER
V0
T0
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
TOF
DIPOLE
MAGNET
PHOS
ABSORBER
Strip
Drift
Pixel

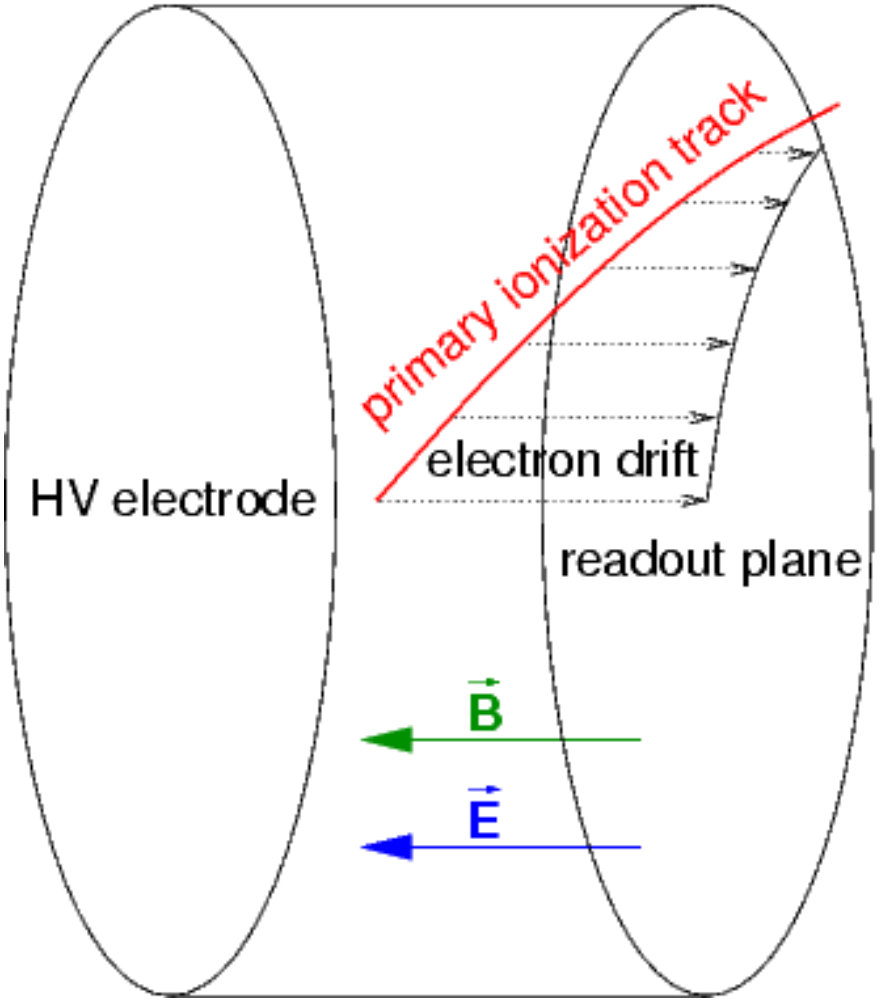
ALICE characteristics

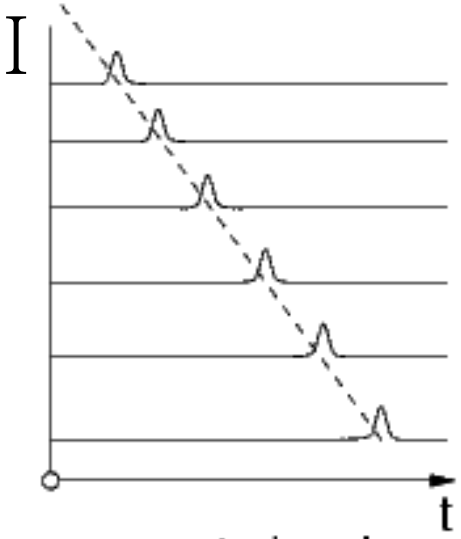
- High charged-particle multiplicity, ~10000 in $|\eta| < 0.9$
  - all tracked
- Large momentum range $0.1 < p < 100$ GeV/c
- $< 10\%$ X_0 up to TPC
- large PID coverage
- photon detectors PHOS, EMCAL, PMD
- electron and muon pair trigger at high momenta
  - $\Rightarrow$ quarkonia
- good secondary vertex resolution
  - $\Rightarrow$ open charm, beauty

ALICE completion status 2009



Time Projection Chamber principle





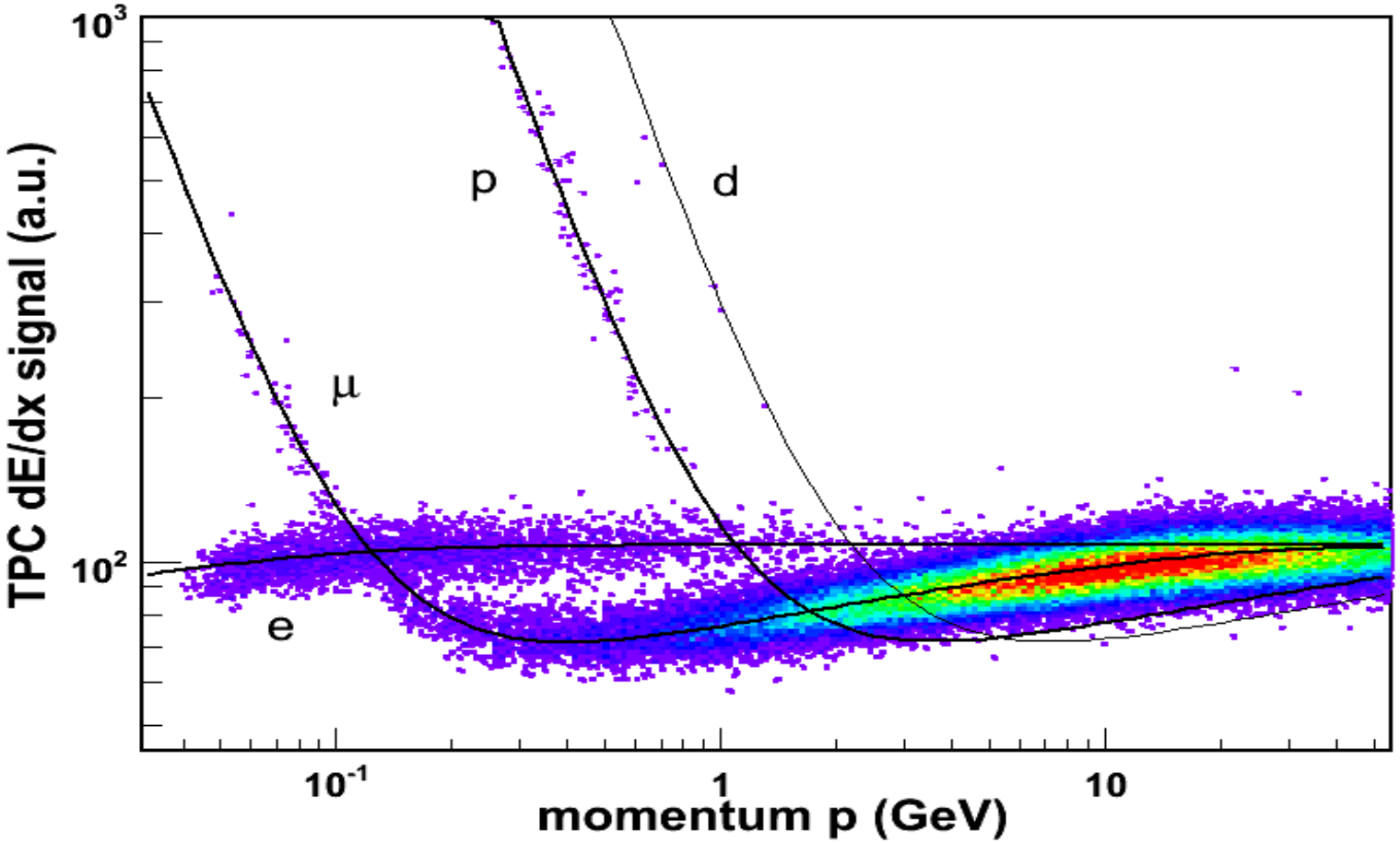
current signal
at readout plane

- 3-dimensional
- track curvature→ momentum
- dE/dx → particle identification

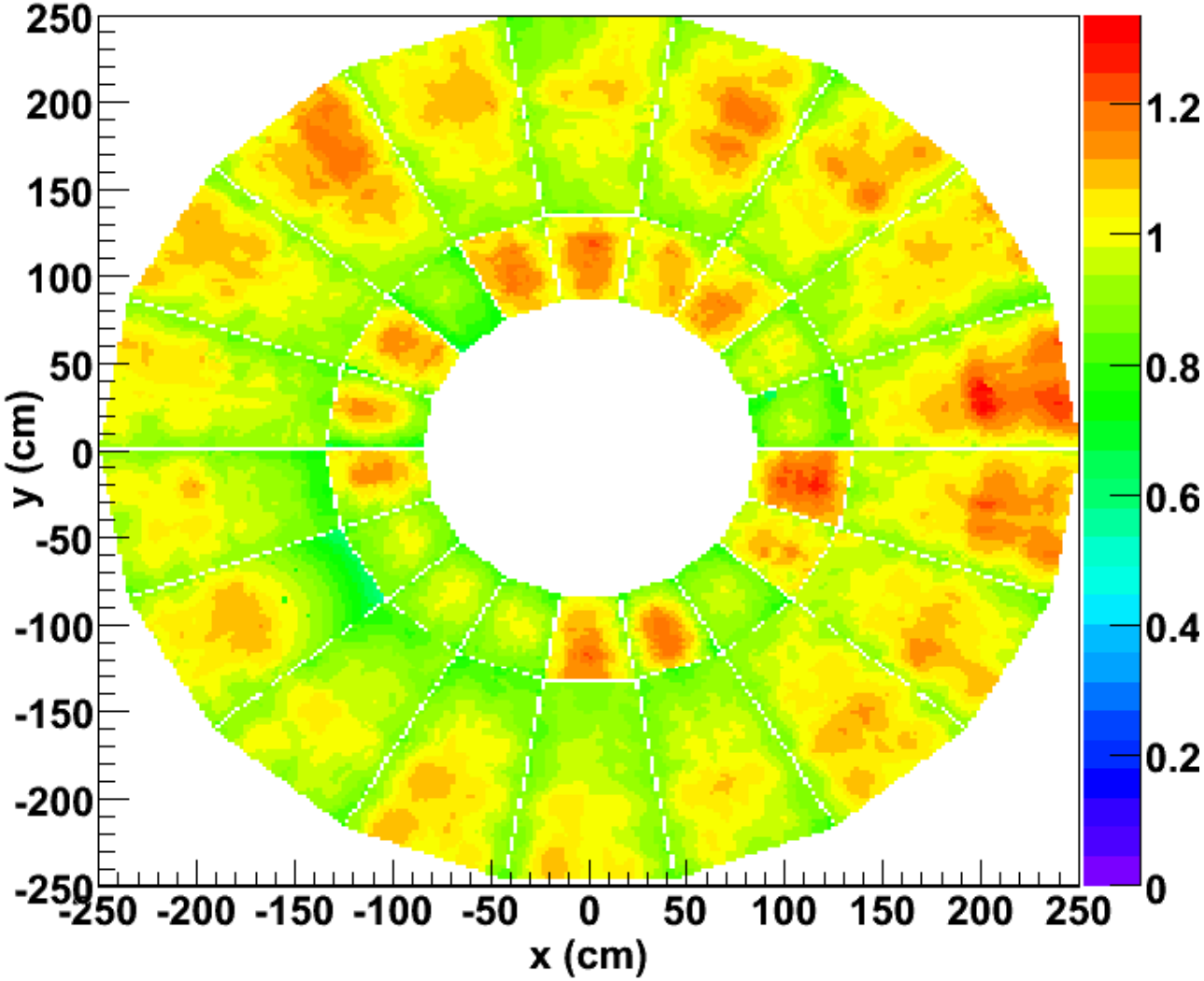
TPC Specs

- $|\eta| < 0.9$ (full length tracks)
- $845 < r < 2466$ mm (cf. STAR: 600 to 1892)
- drift 2 x 2.5 m, 100 kV, 92 μs
- dictated by resolution: thin 'cold gas' with low diffusion:
  - $Ne/CO_2/N_2$ mixture, 95 m^3
  - high sensitivity to E and T, $\Delta E/E \approx 10^{-4}$, $\Delta T \approx 0.1$ K
- event rate for central PbPb 100 – 200 Hz
- MWPC's with pad readout (557,568 channels)
- ΔE: 159 samples (= pad rows)
- gated to minimize space charge

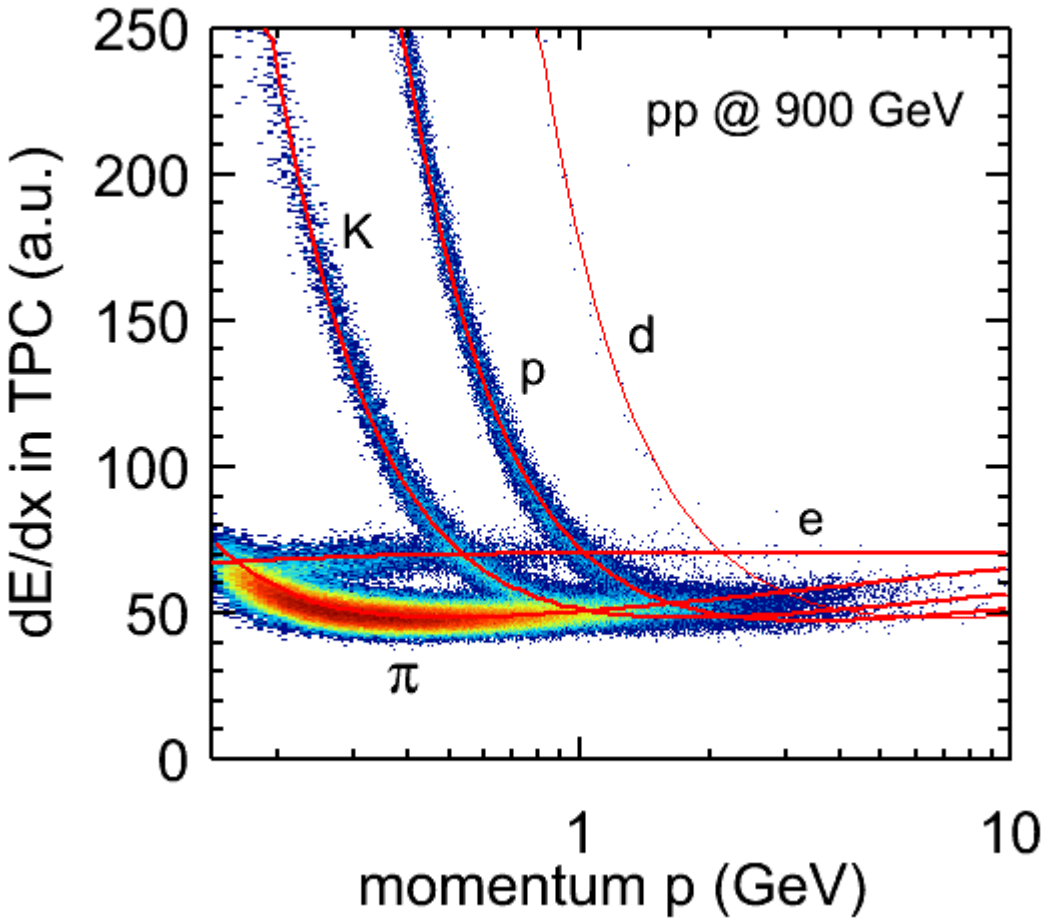
dE/dx in TPC for Cosmics

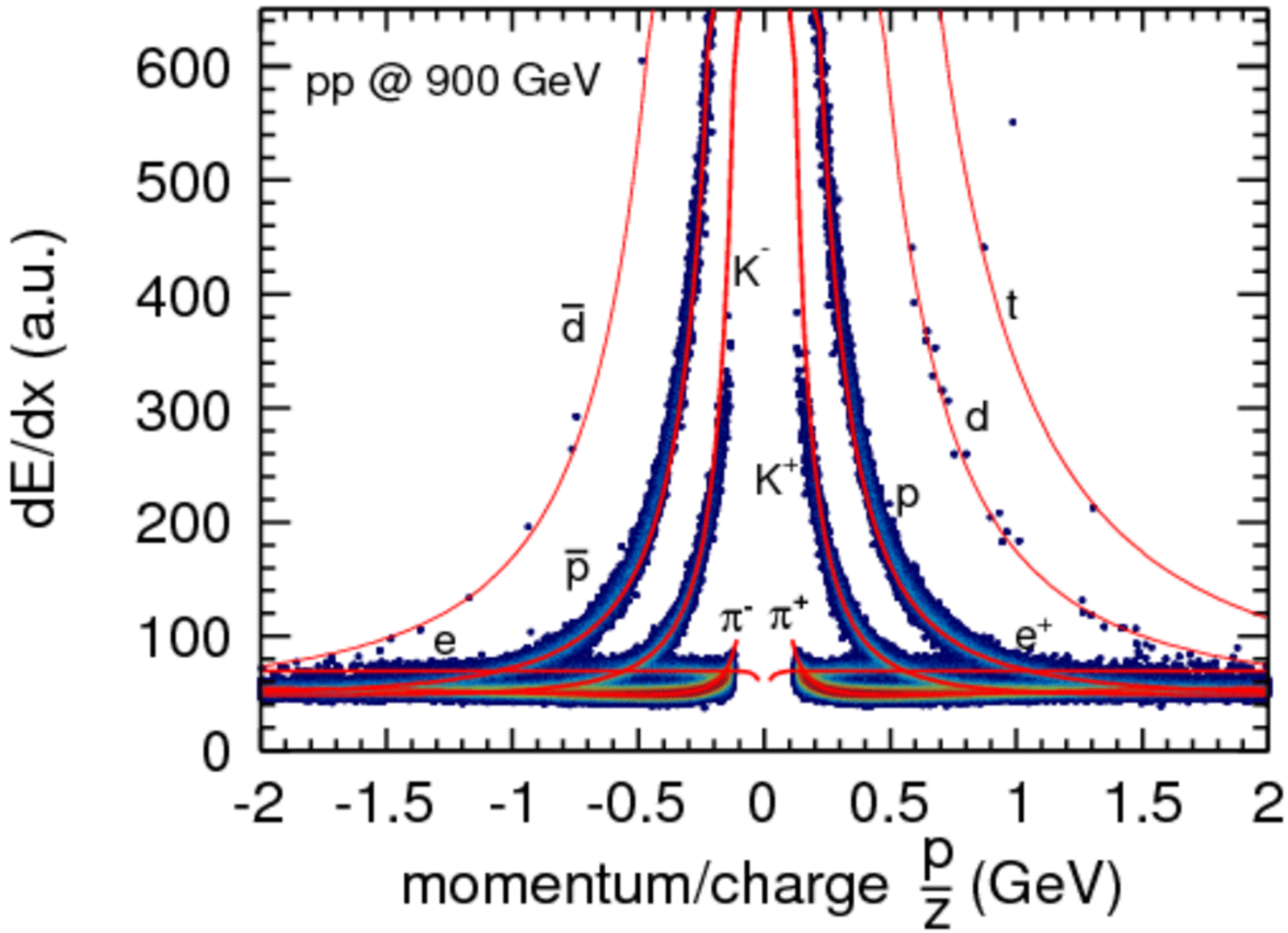


TPC: ^{87}Kr gain map

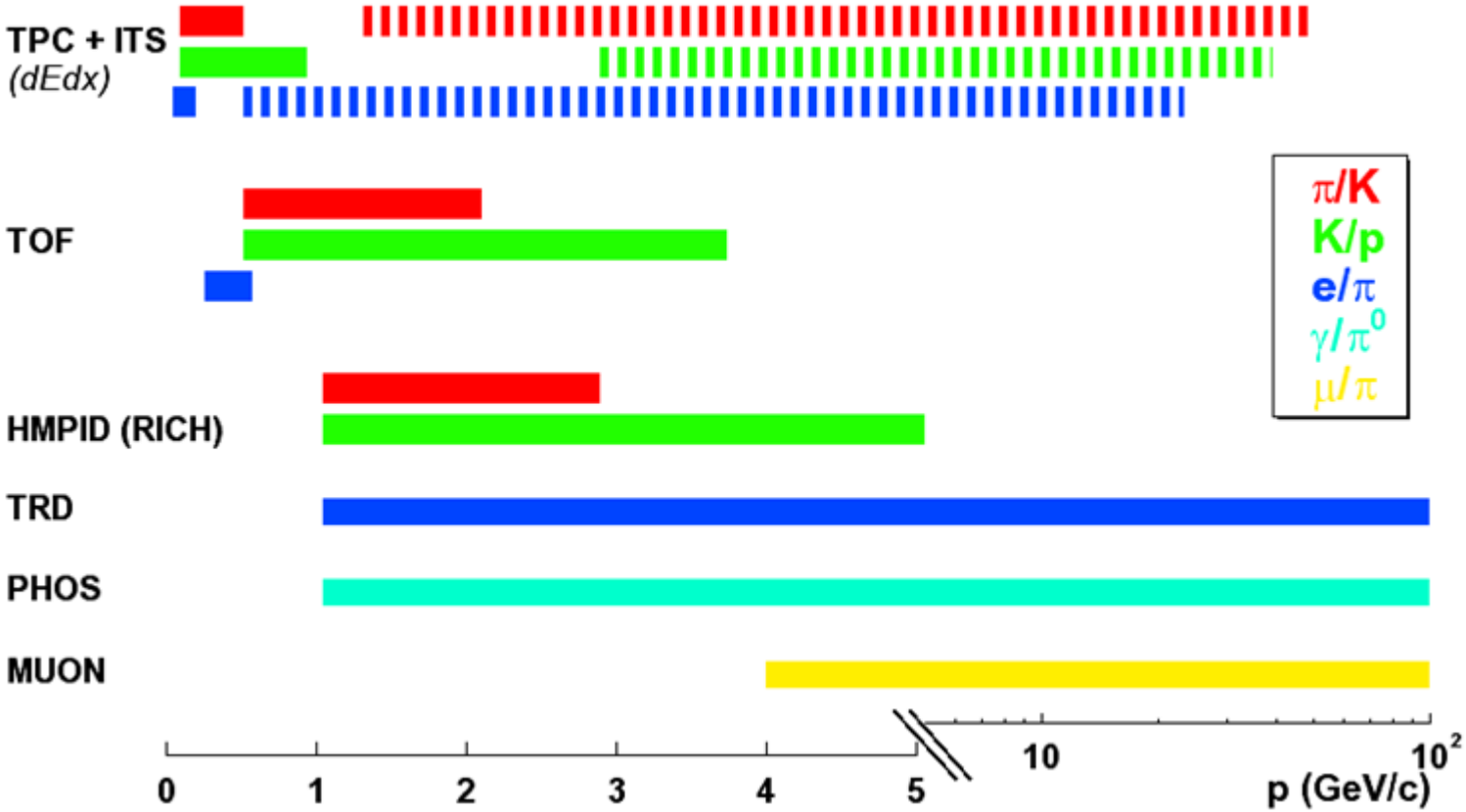


dE/dx in TPC for pp collisions

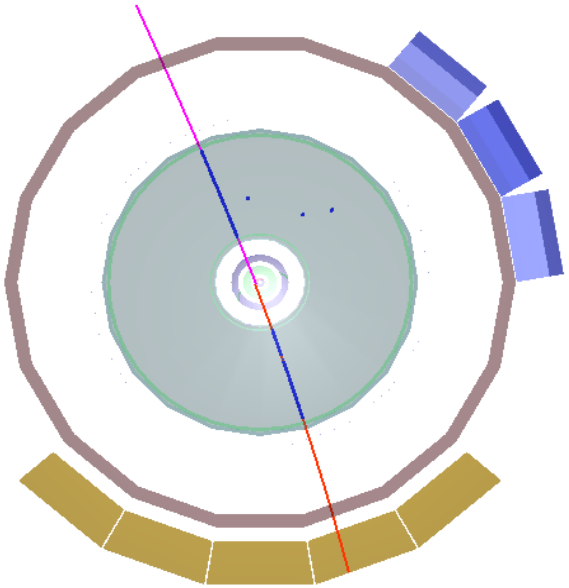


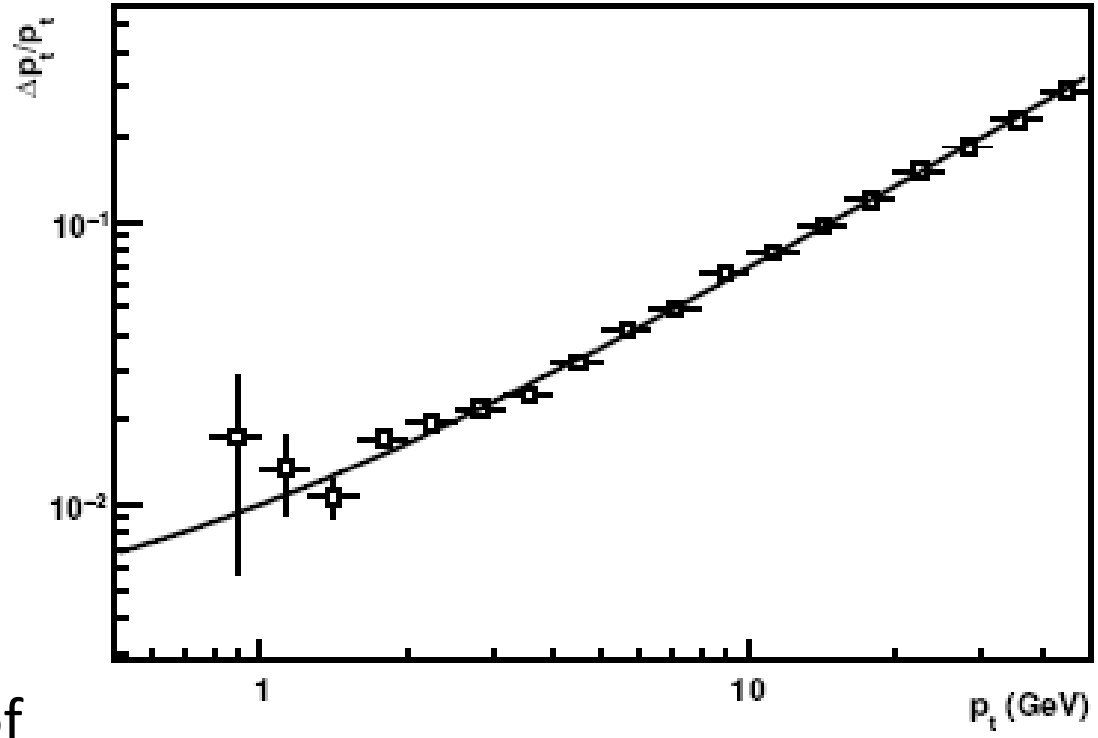

pp @ 900 GeV
dE/dx (a.u.)
600
500
400
300
200
100
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
momentum/charge p/z (GeV)
d̄
p̄
e
K⁻
K⁺
π⁻ π⁺
p
d
t
e⁺

ALICE PID components



TPC momentum resolution



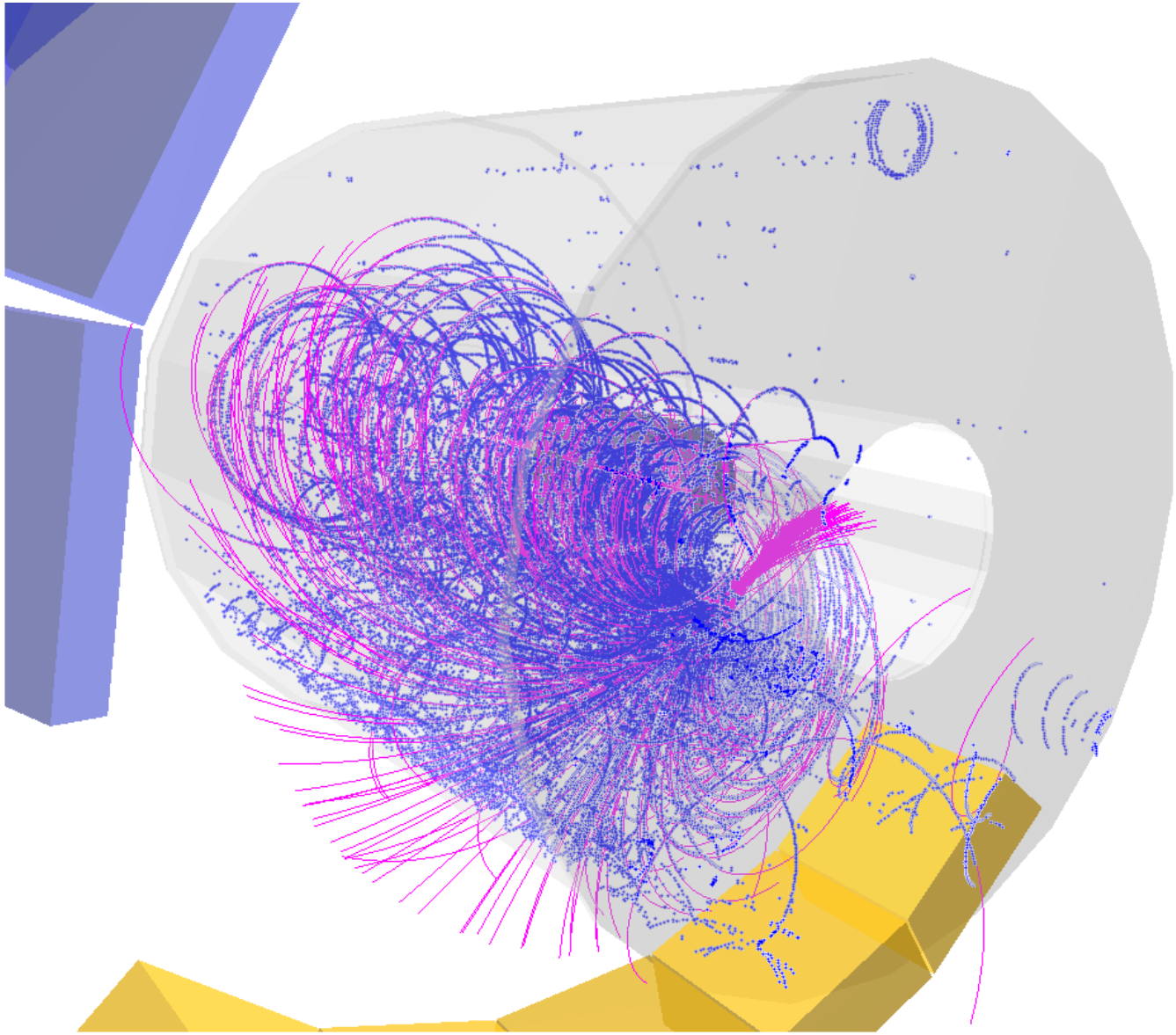


- match track segments of upper and lower half

Preliminary:

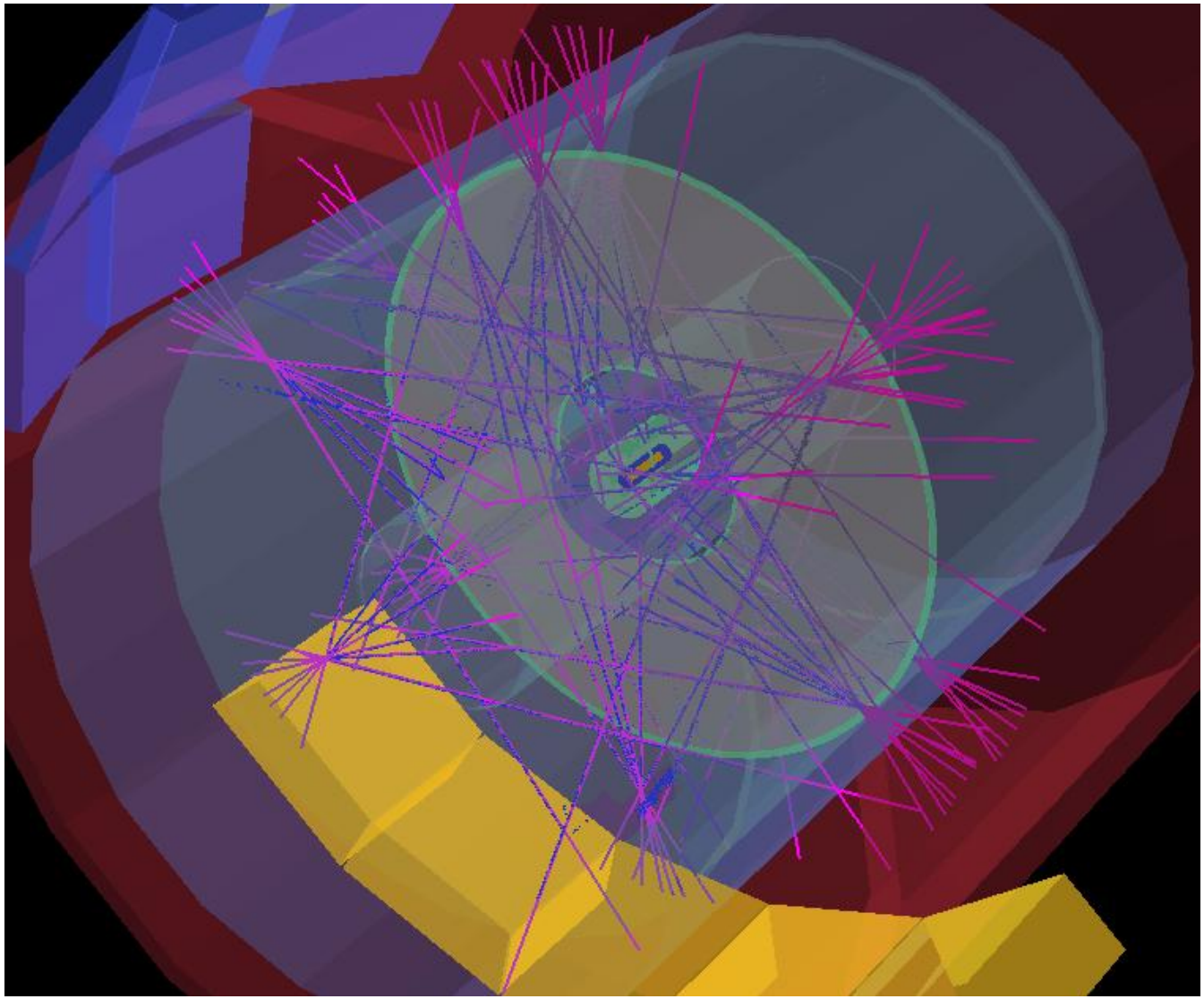
- p_t resolution ~ 6.5% at 10 GeV/c
  ~ 1% below 1 GeV/c
- design value ~ 4.5% at 10 GeV/c

Cosmic ray shower in TPC

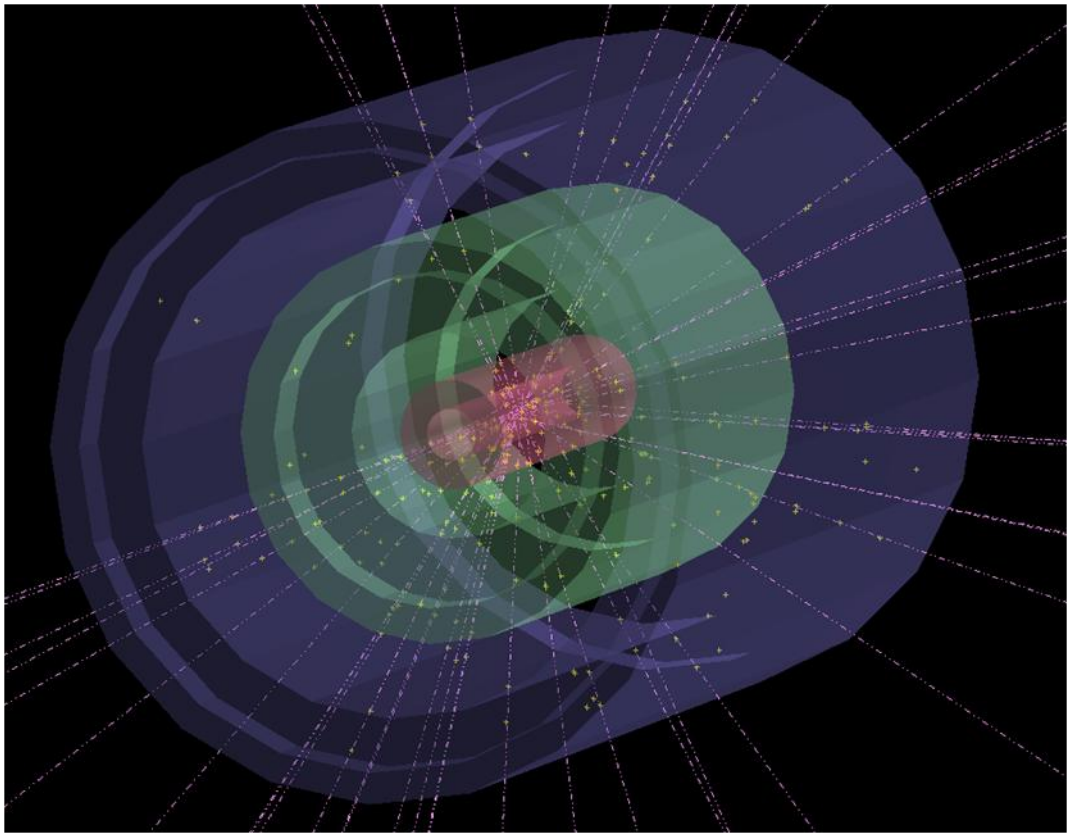


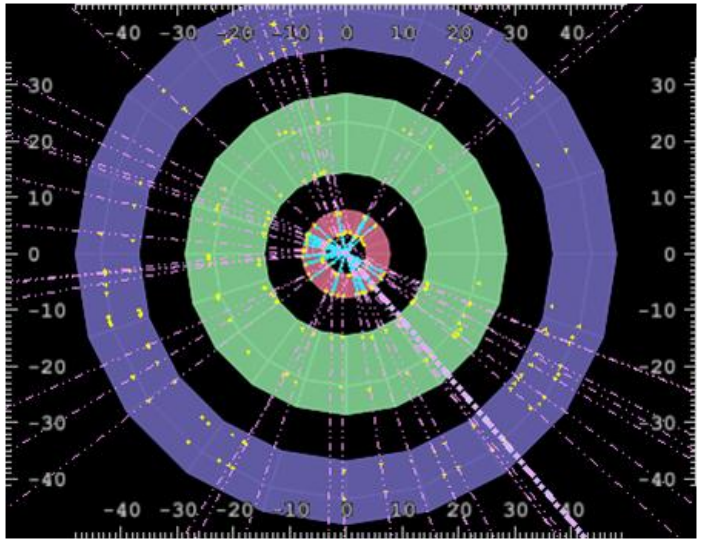
TPC laser event

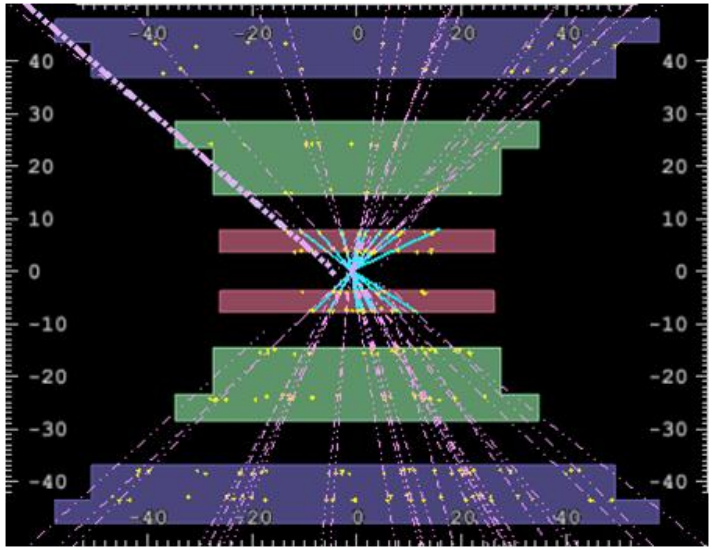
interleaved with collisions



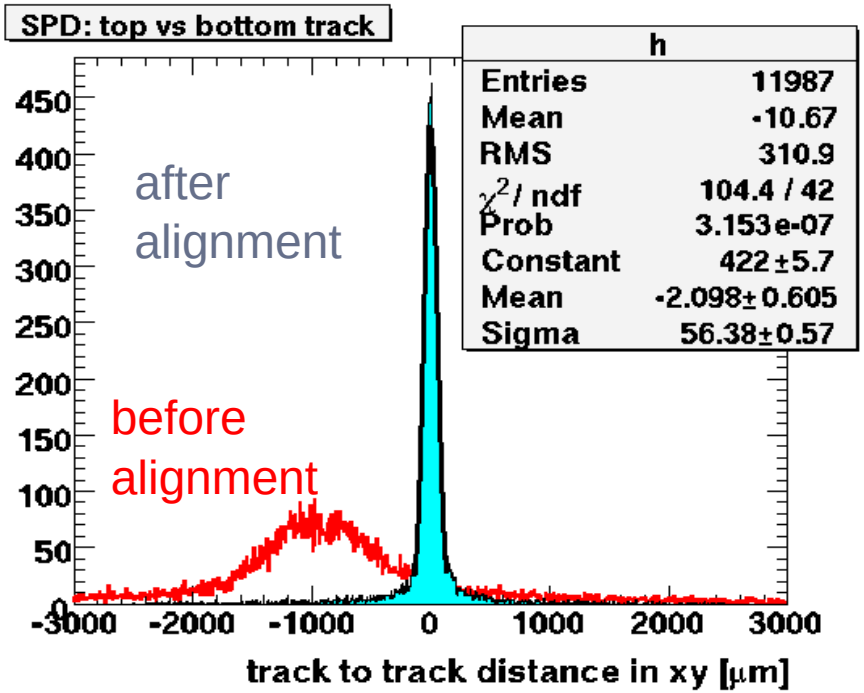
ITS: a high-multiplicity pp event

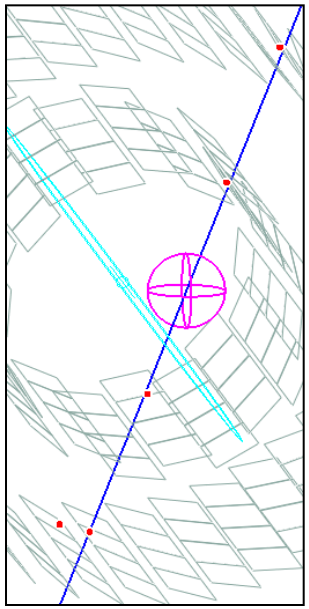






ITS: Alignment with Cosmic Tracks

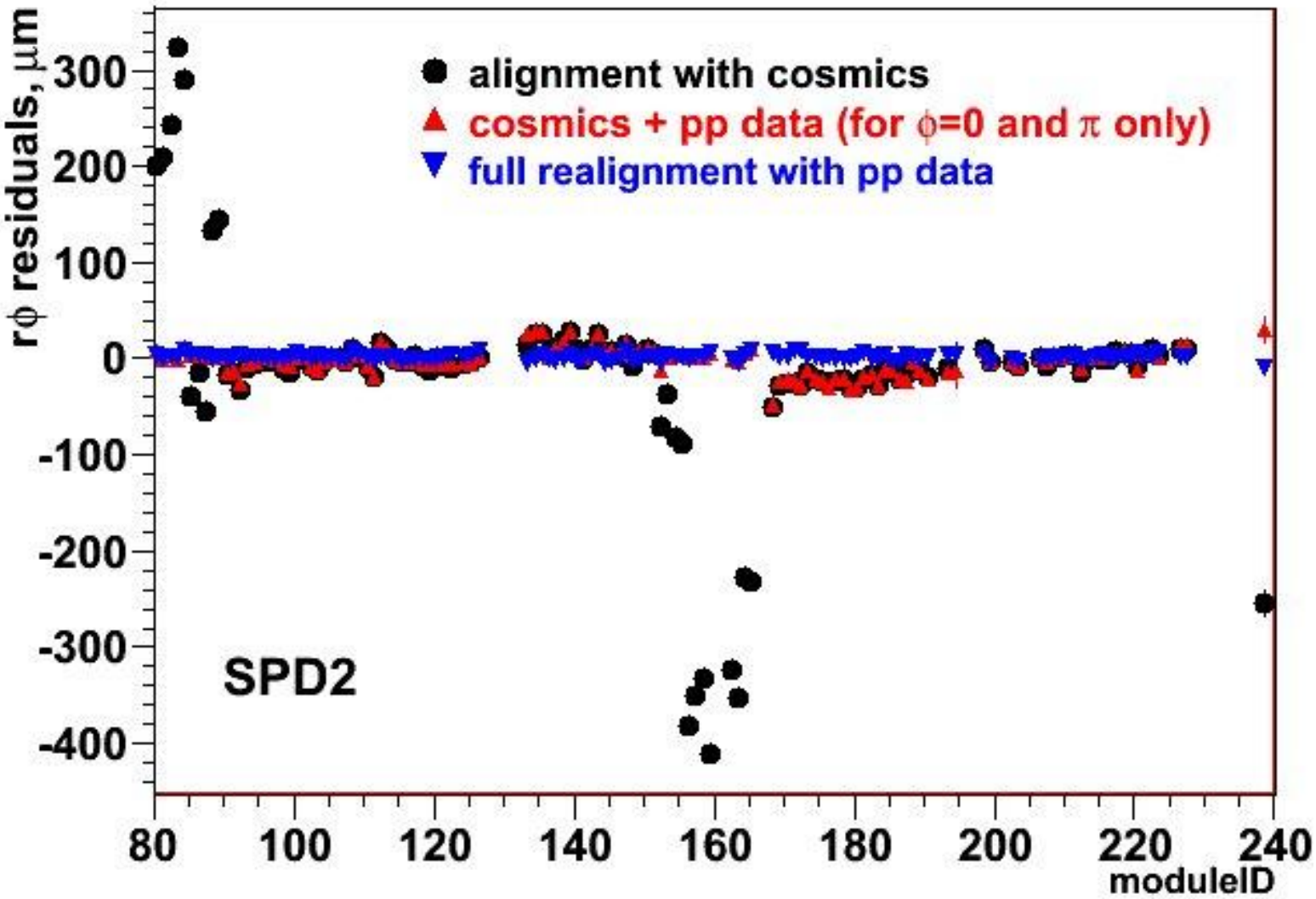




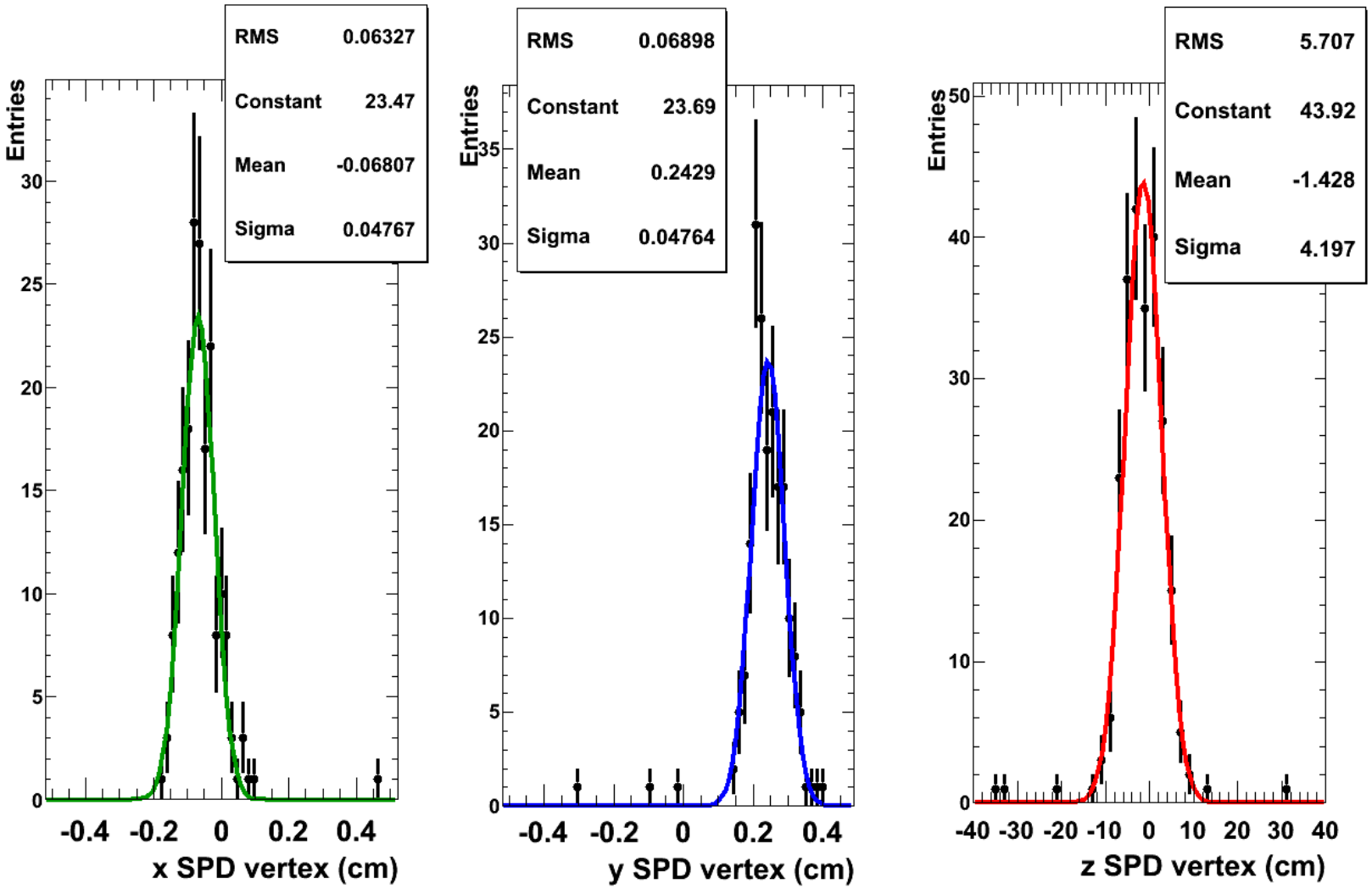
- SPD alignment:
- $\sigma_{r\varphi} \approx 12\ \mu m$
- impact parameter resolution $\sigma \sim 56\ \mu m$
- misalignment < 10 μm

→ close to design values

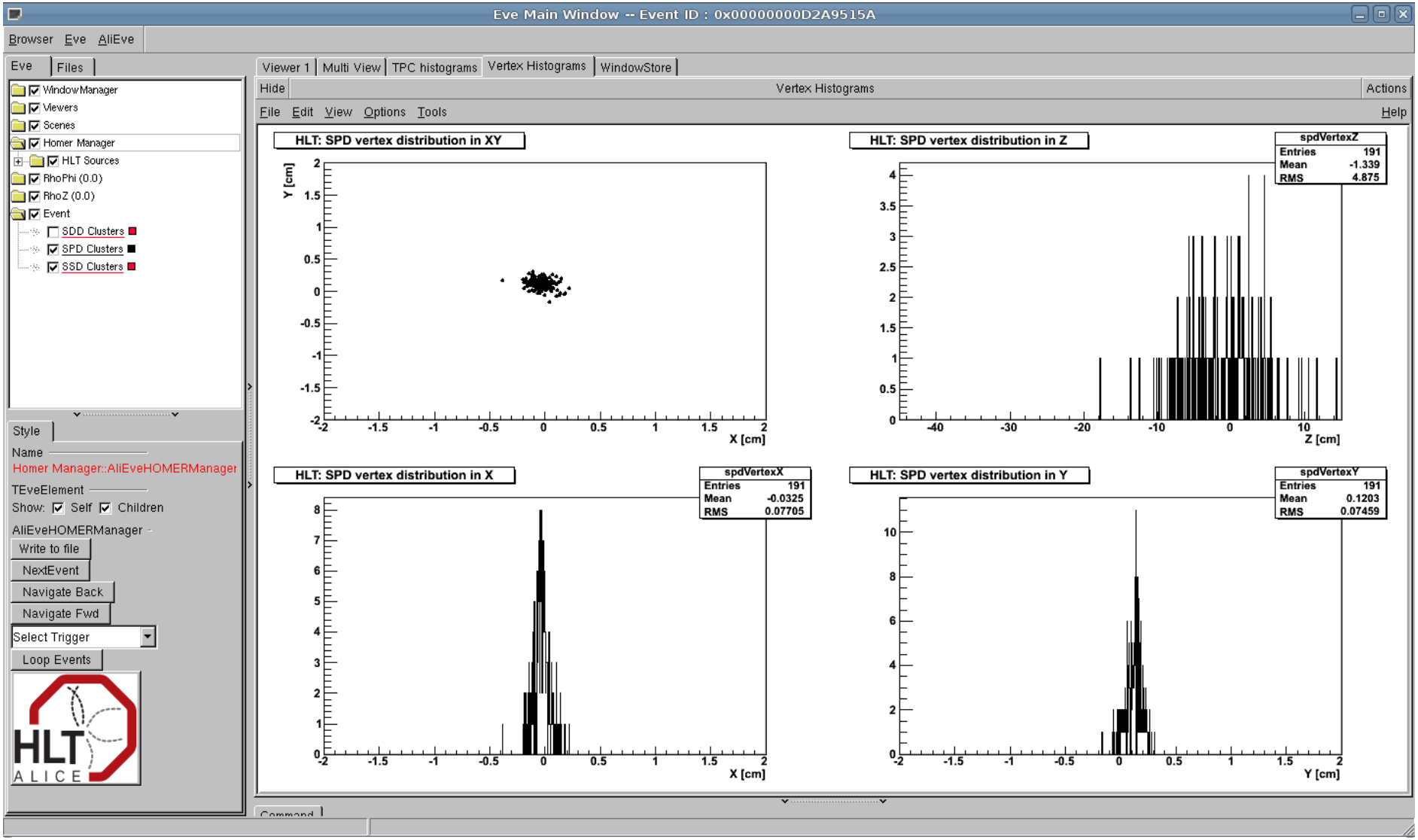
Improved ITS alignment from pp



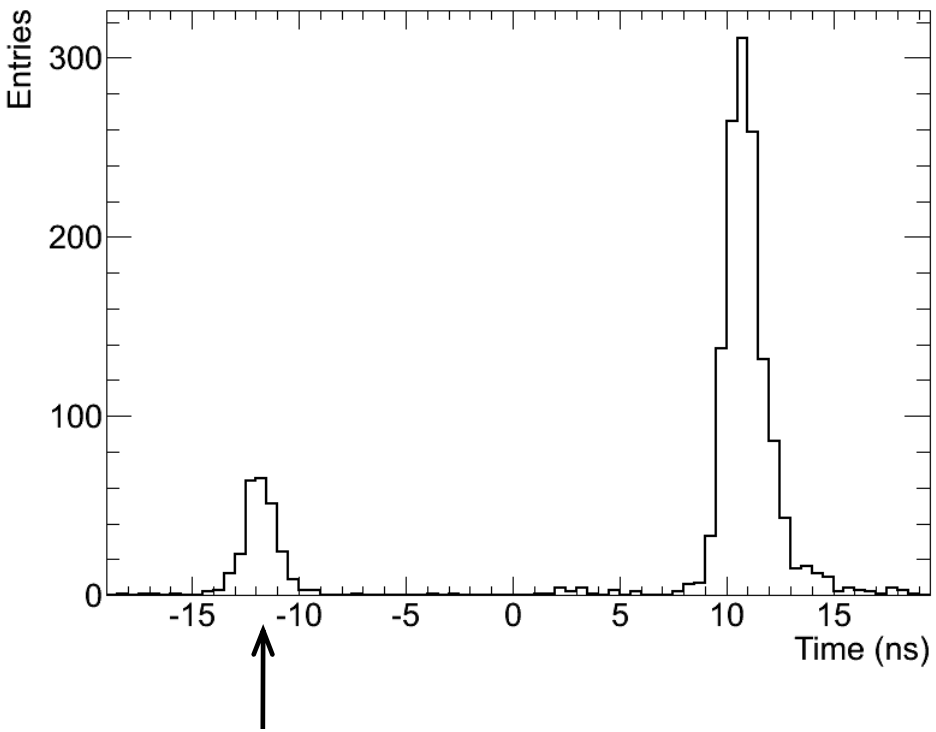
Beam spot (900 GeV pp)



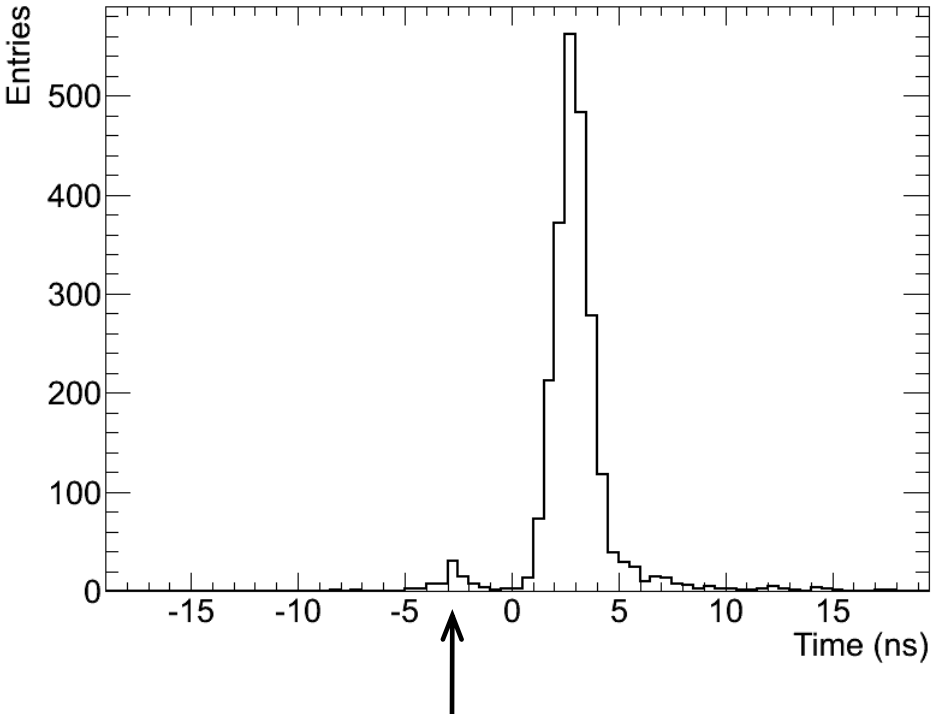
Online display of beam spot (900 GeV pp)



V0 detectors (trigger)

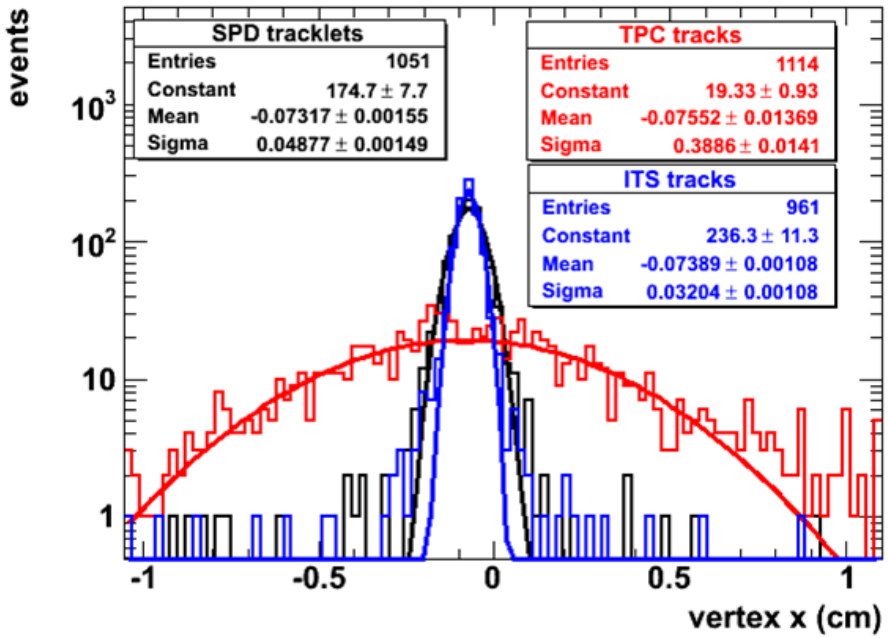


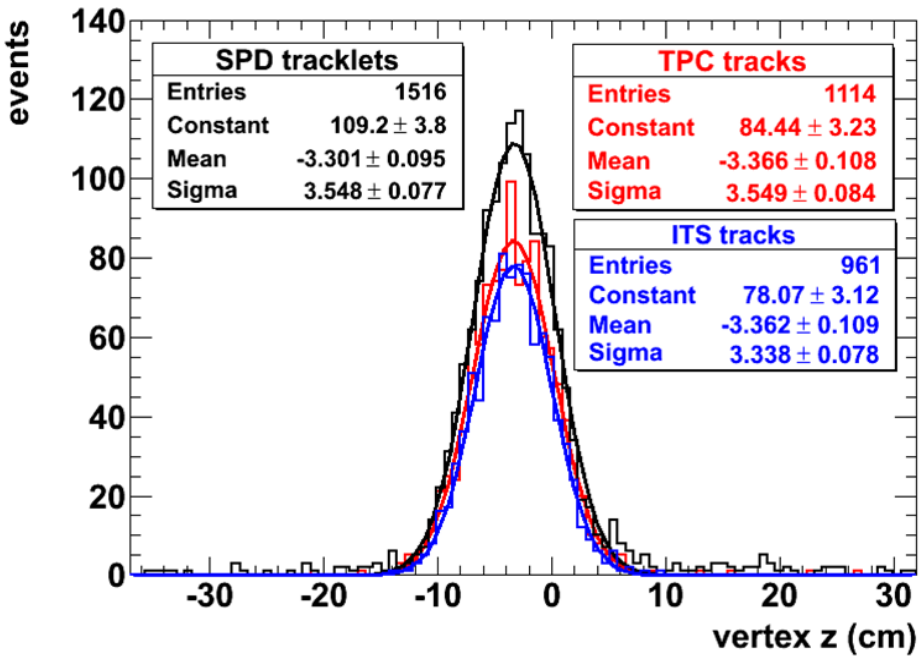
beam halo



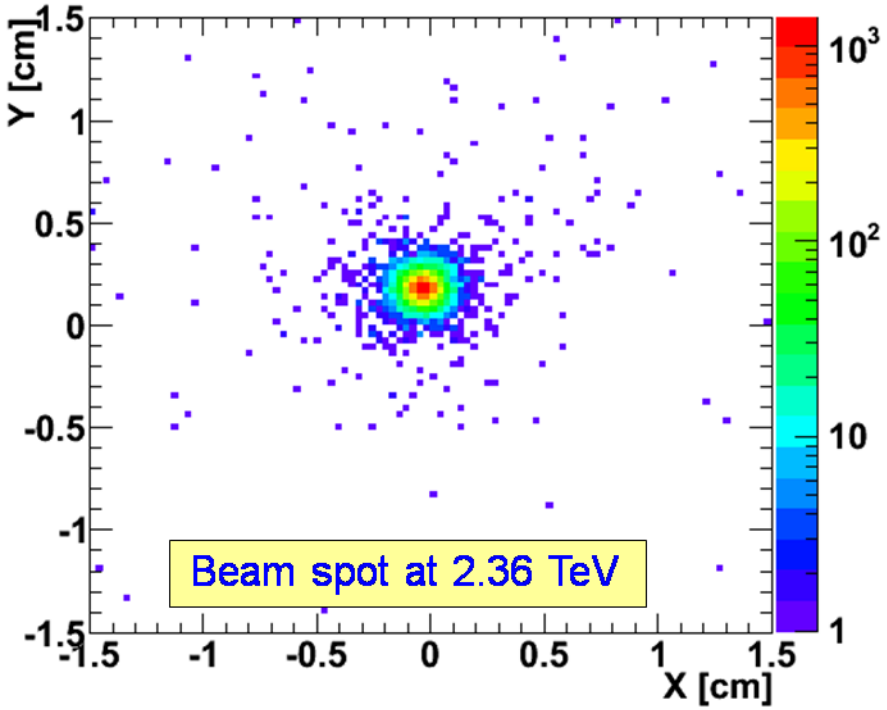
beam halo

Vertex pointing of TPC

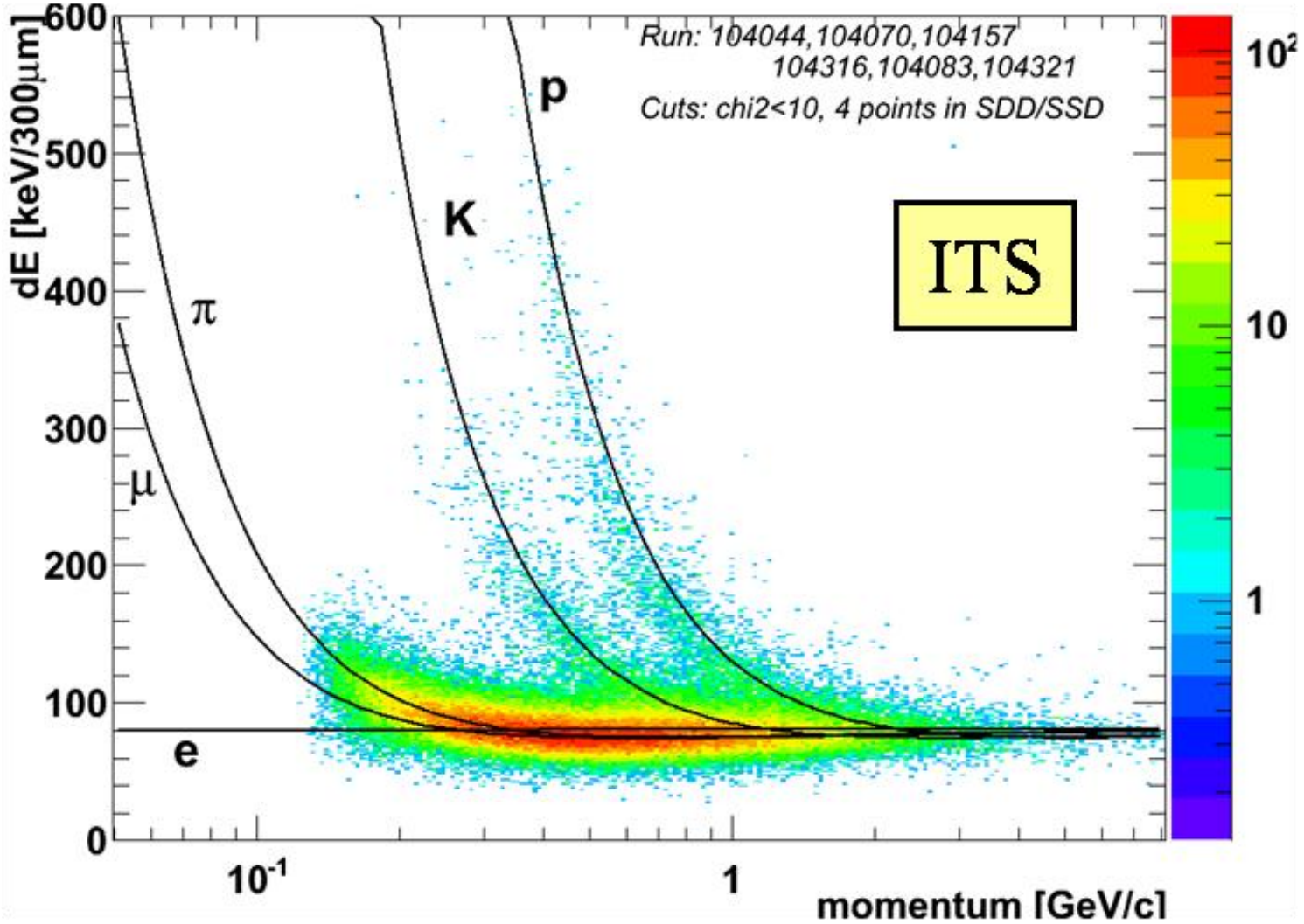




Beam spot at 2.36 TeV

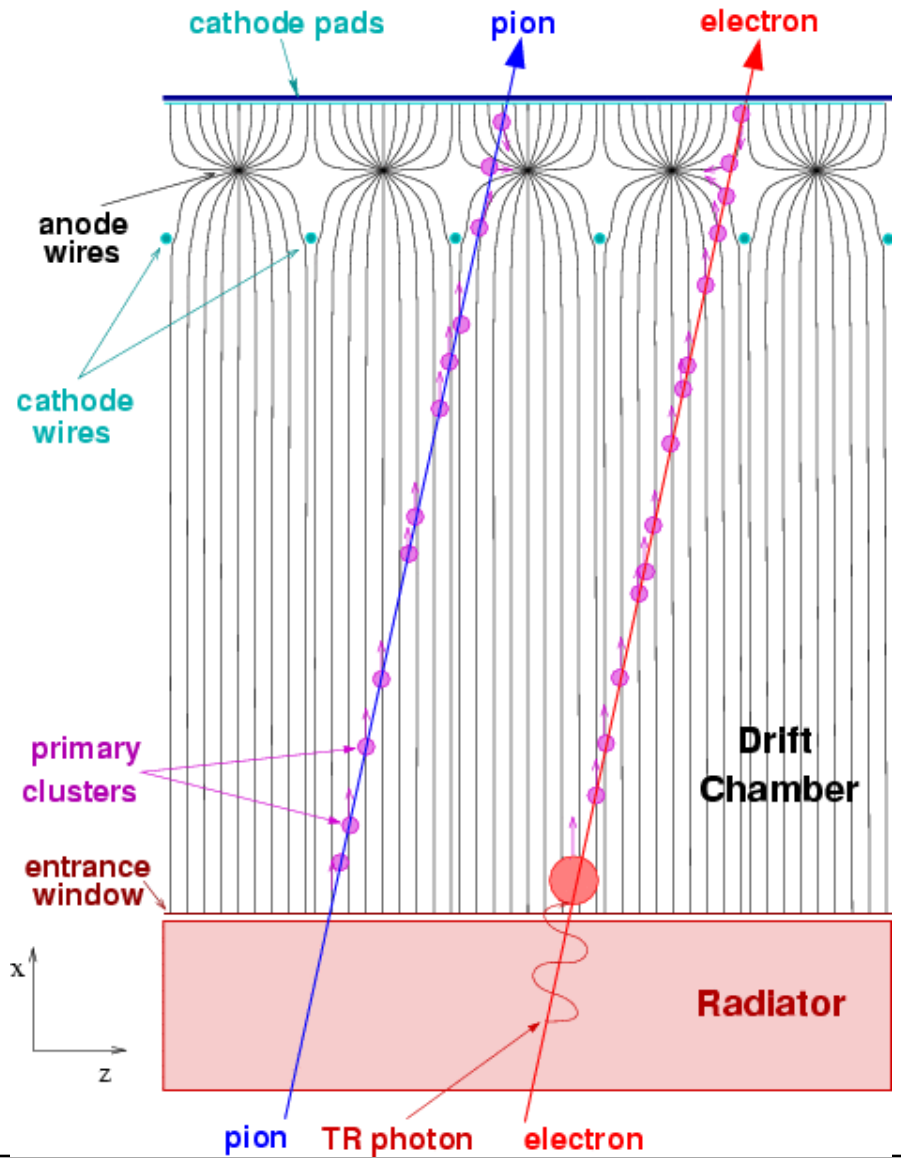


ITS: dE/dx

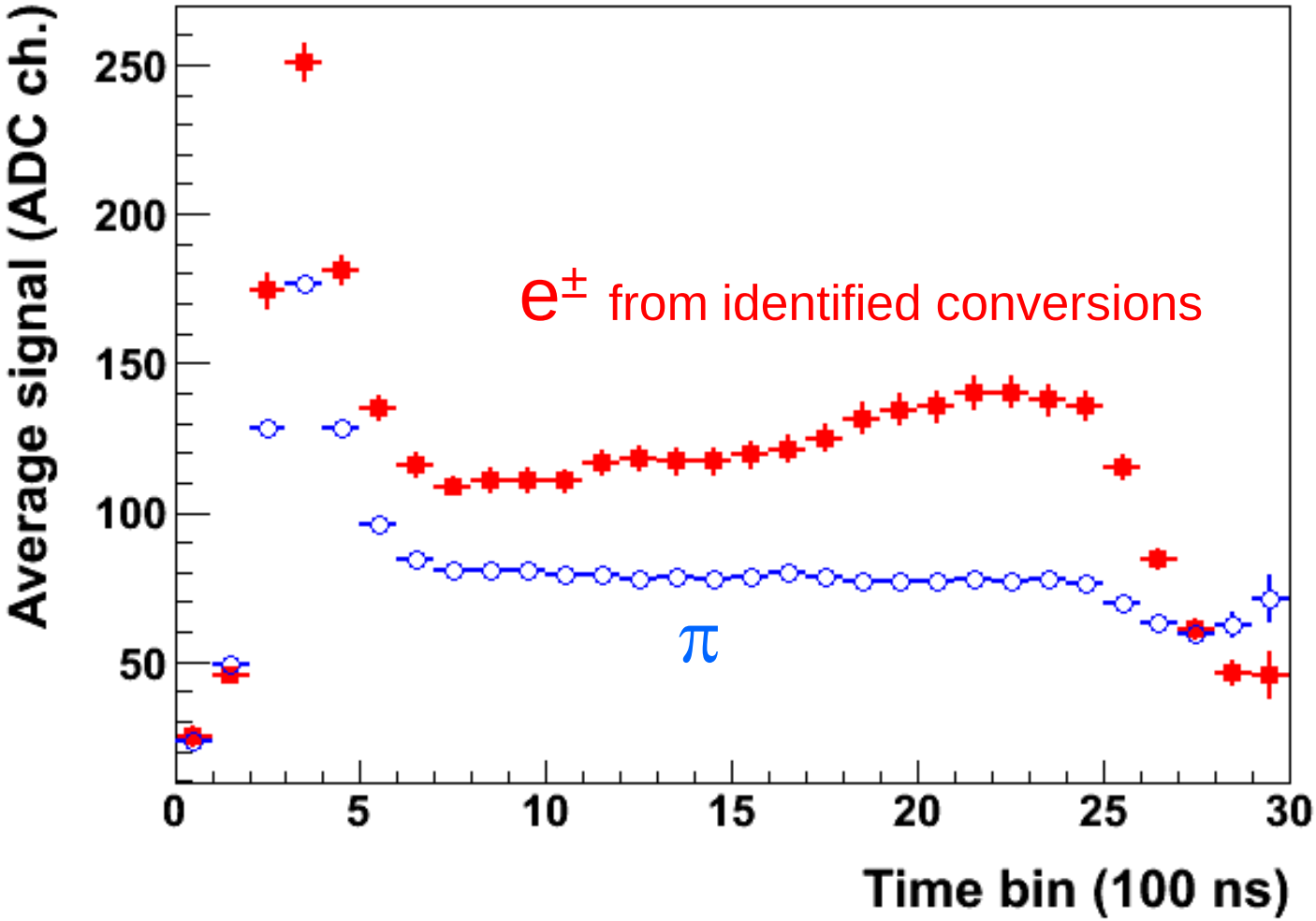

Run: 104044,104070,104157
104316,104083,104321
Cuts: chi2<10, 4 points in SDD/SSD
ITS
dE [keV/300μm]
momentum [GeV/c]
p
K
π
μ
e
600
500
400
300
200
100
0
10^{-1}
1
10^2
10
1

Transition Radiation Detector

- Identification of fast electrons
  - $\gamma > 10000$
  - X-ray quanta generated in radiator
  - conversion in Xenon drift chamber
  - locally enhanced dE/dx
- 6 layers in ALICE
  - misidentifications < 1%
- radiator: fibers

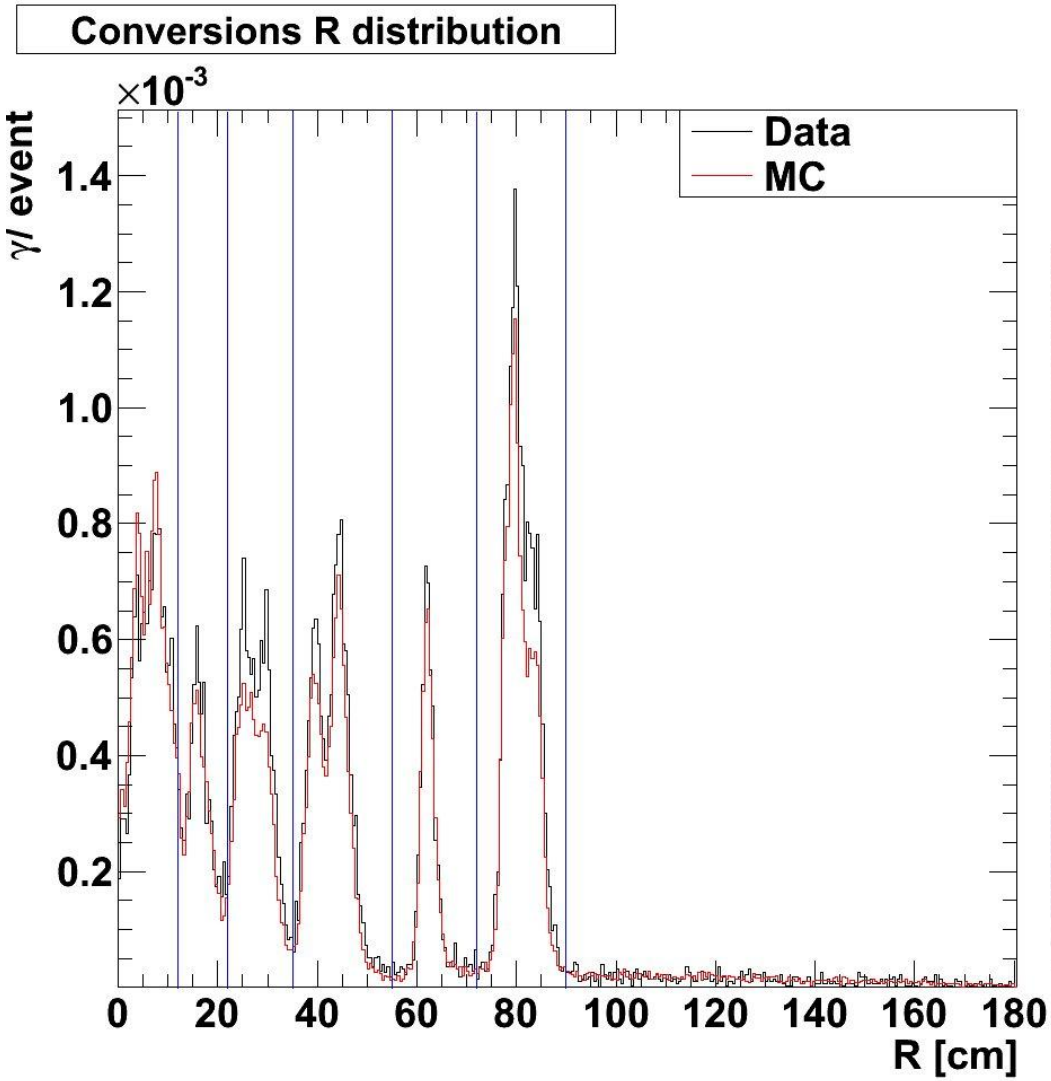


TRD Electron Identification



- ⟨p⟩ only ~1 GeV/c, interesting range p > 5 GeV/c

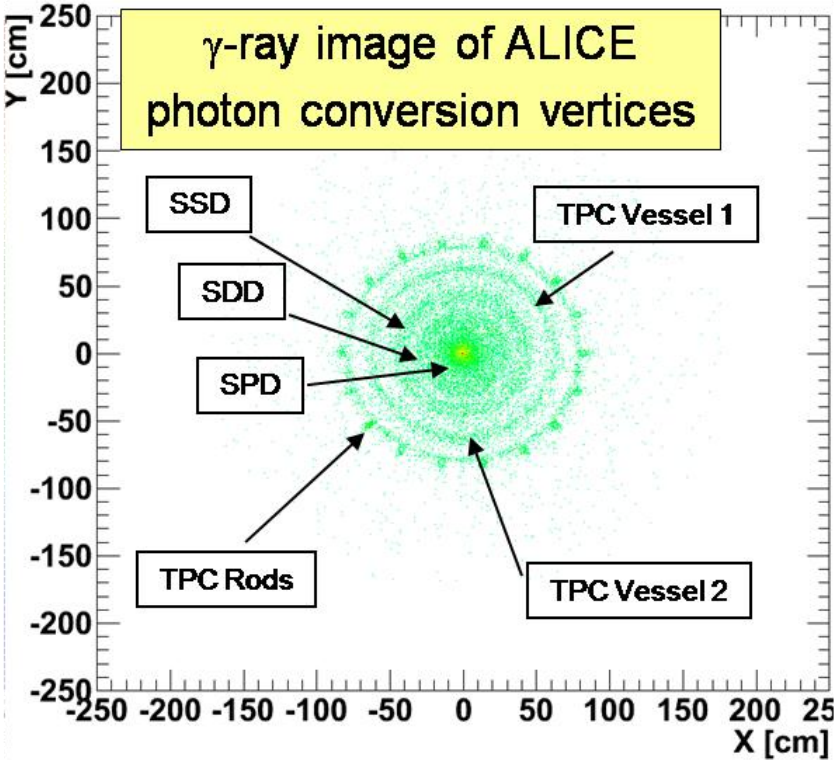
Checking the material budget



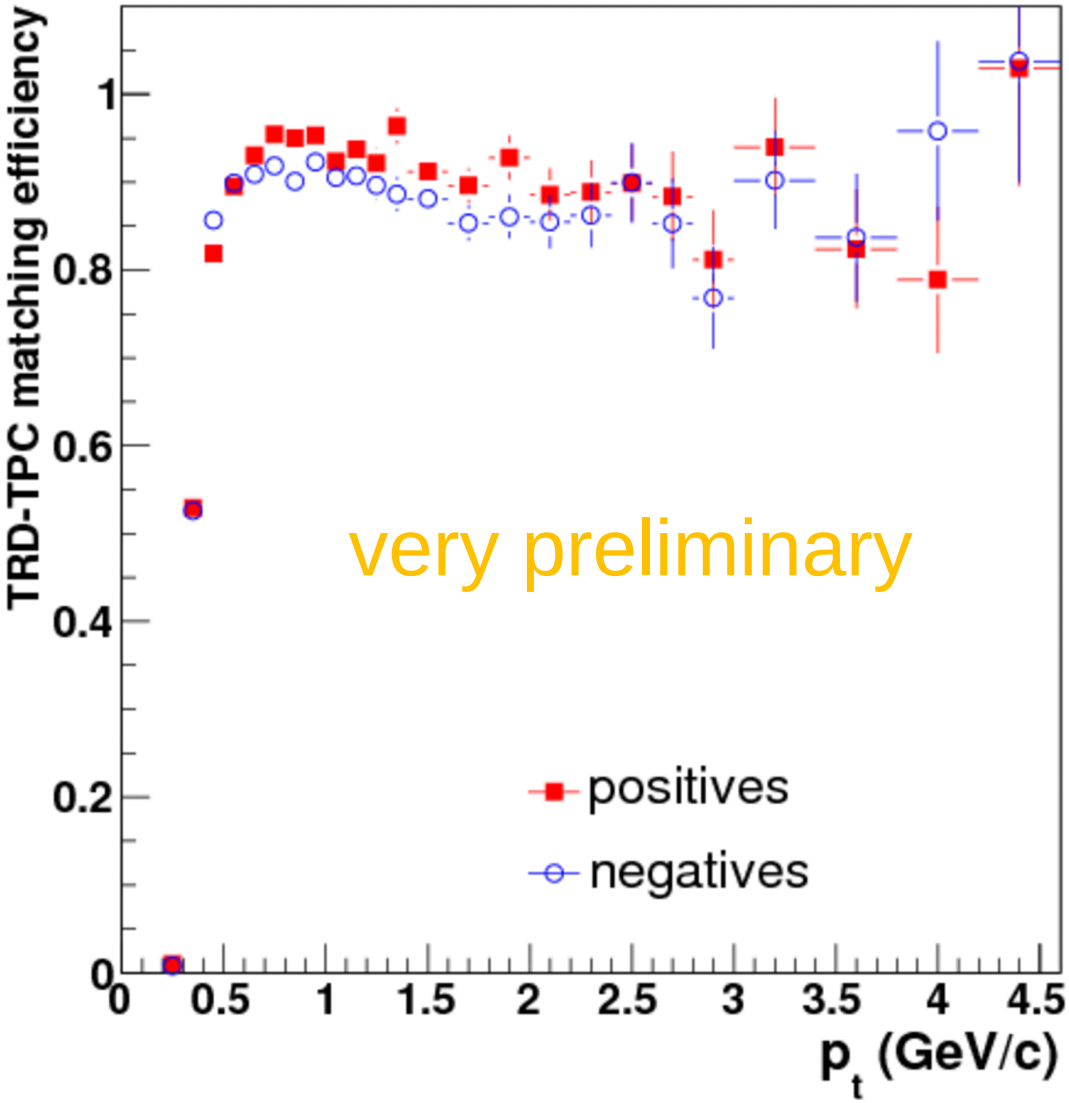
Resolution

$\Delta r\varphi$ ~ 1 … 2 cm

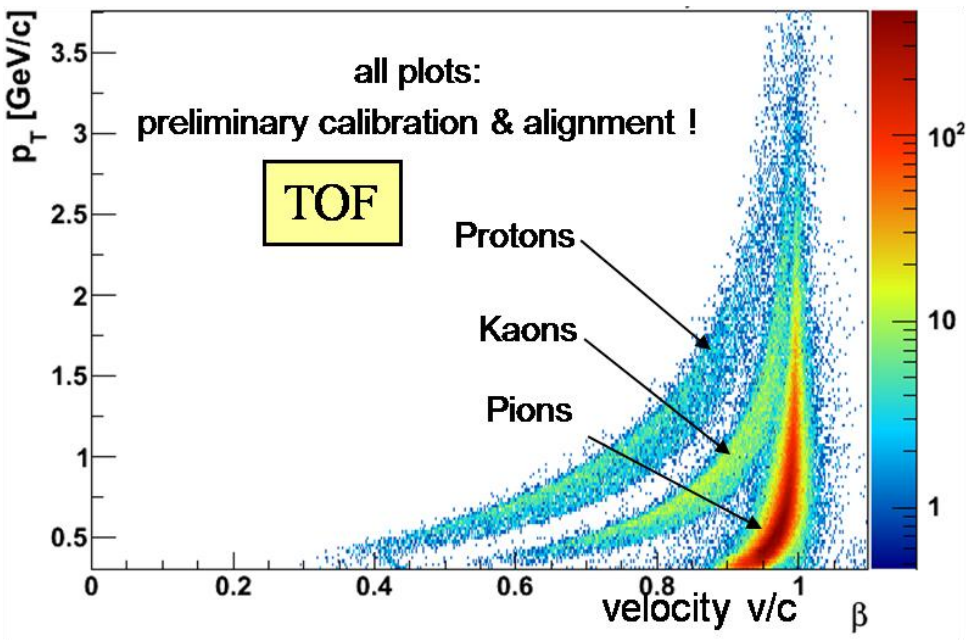
Δr ~ 1 … 5 cm

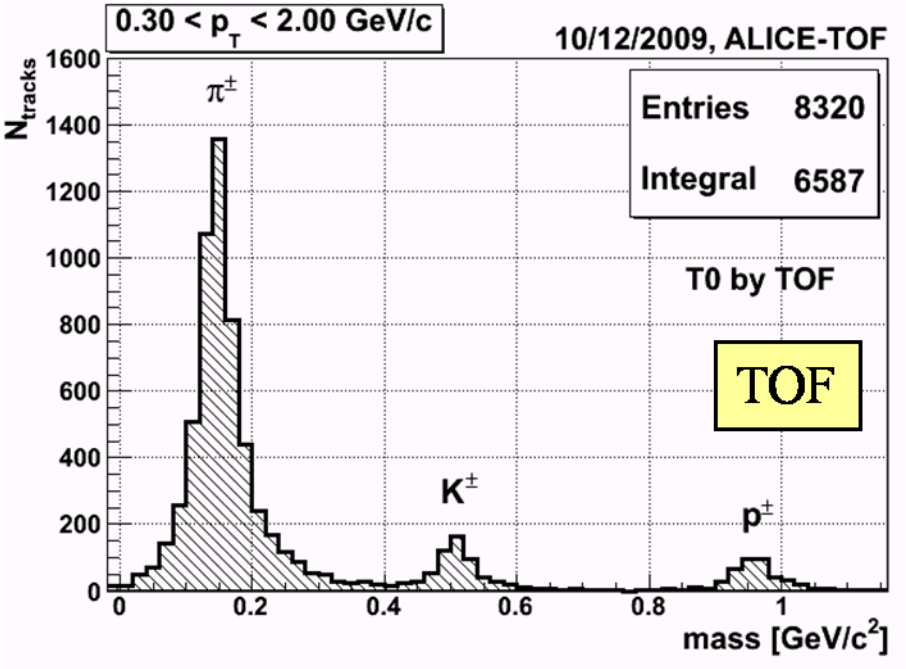


TRD-TPC track matching

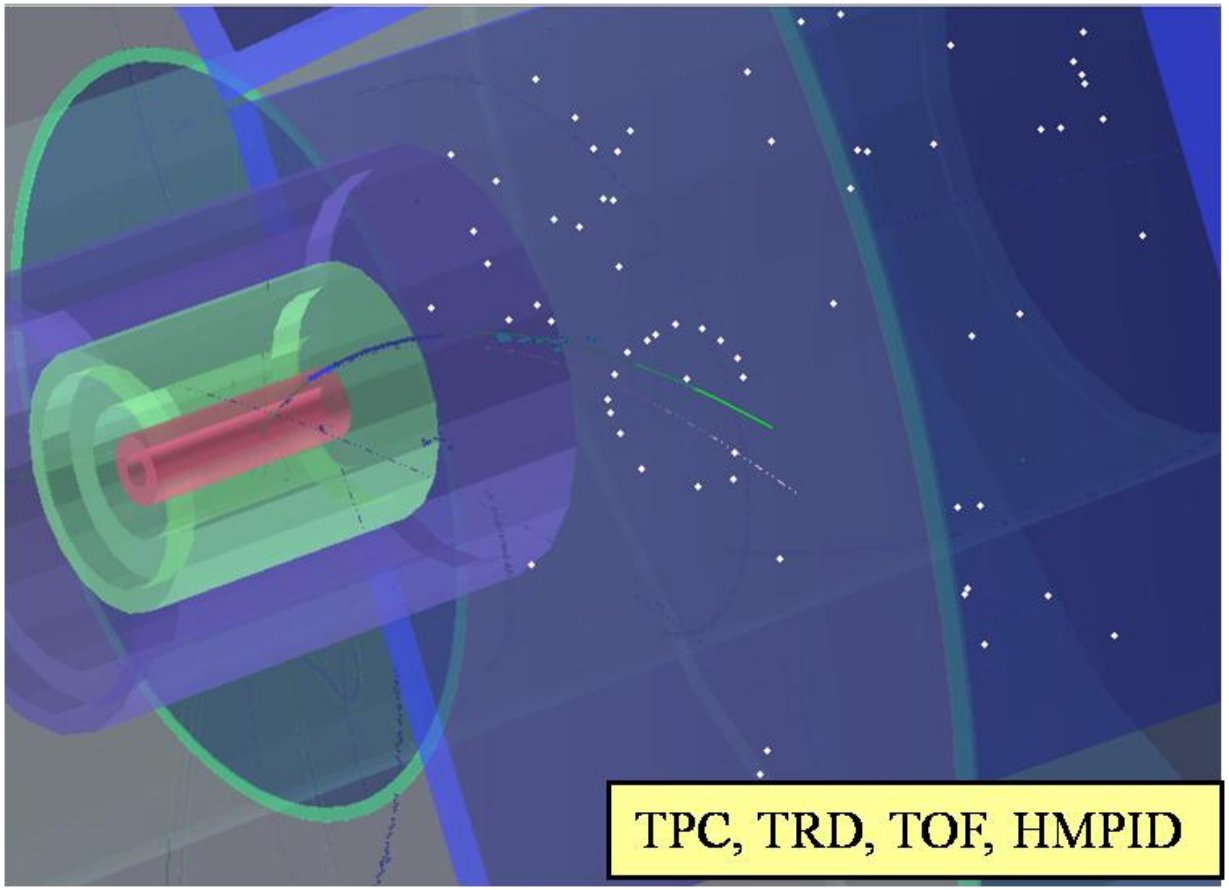


TOF particle identification

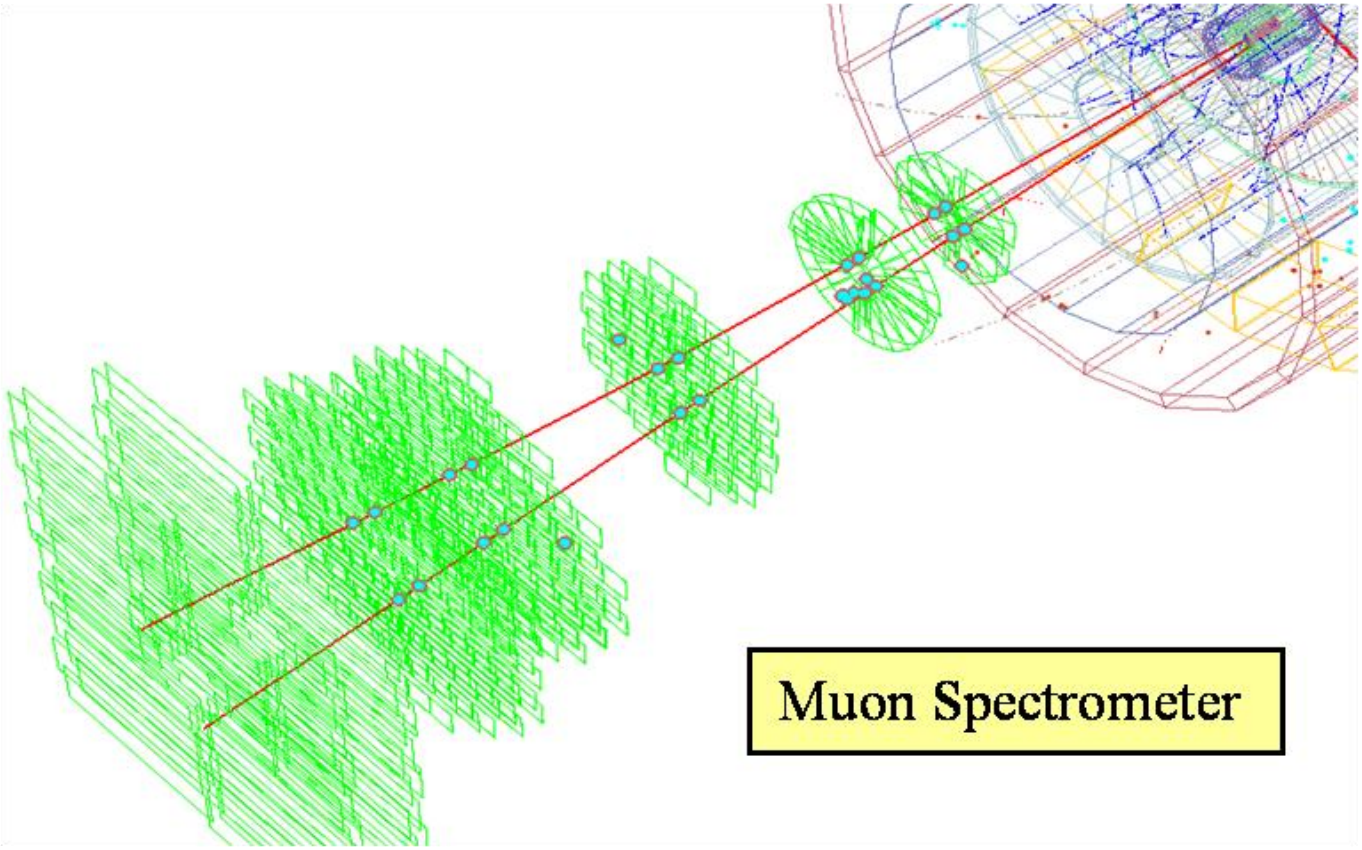




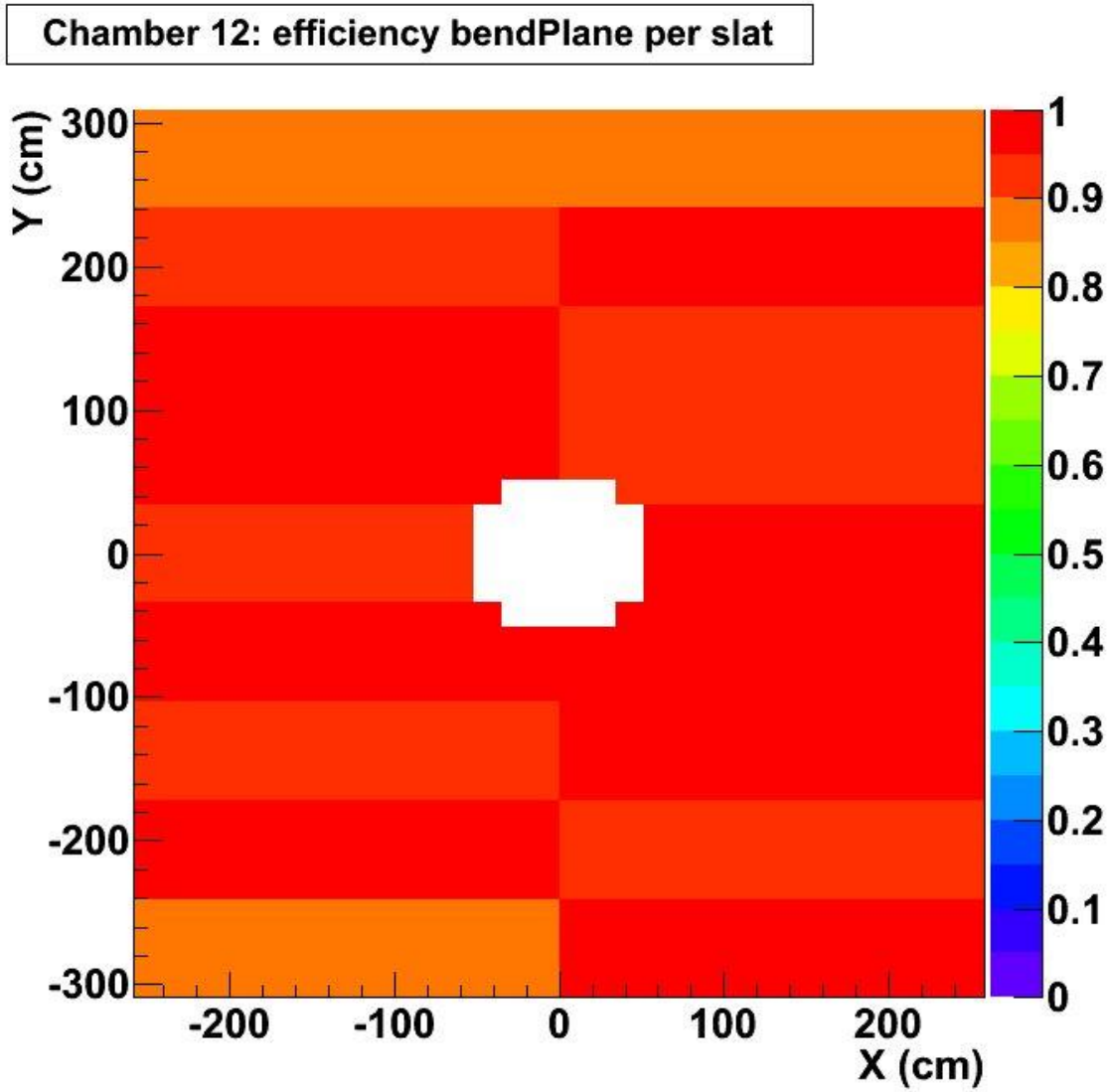
Track in HMPID



Muon spectrometer

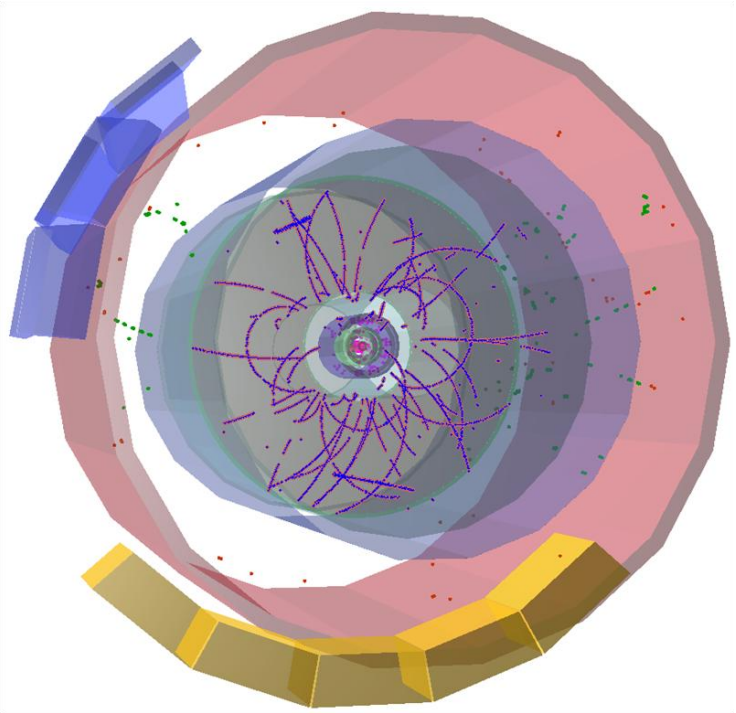


Muon trigger efficiency



‘First physics‘

- $dN_{ch}/d\eta$
- p_t spectra
- p_t vs N_{ch}
- reconstructed K, Λ, …
- particle ratios: $\bar{p}/p$
- HBT
- jets



pp data samples

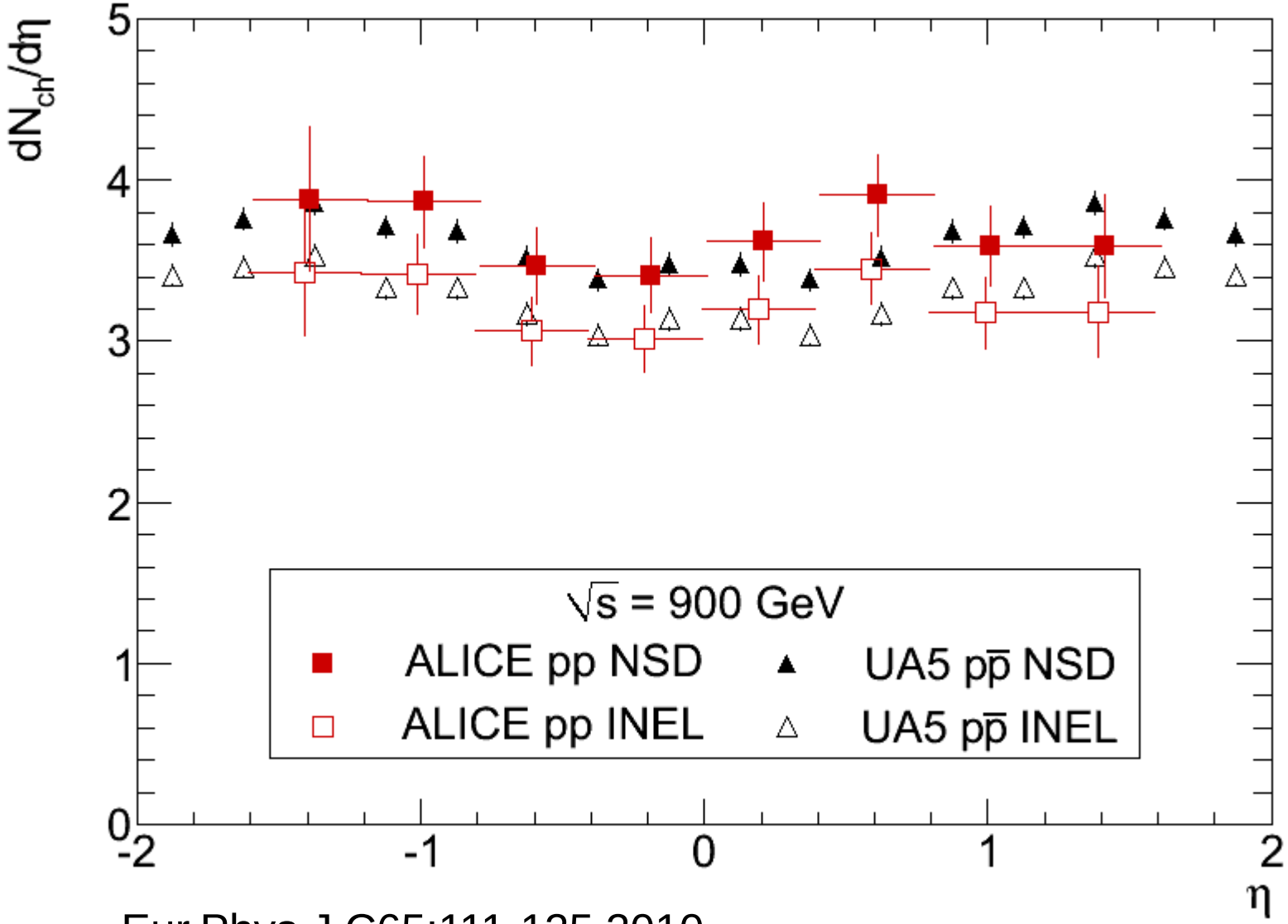
900 GeV

- 360 k B on
- 100 k B = 0
- 10 k B reversed

2.36 TeV

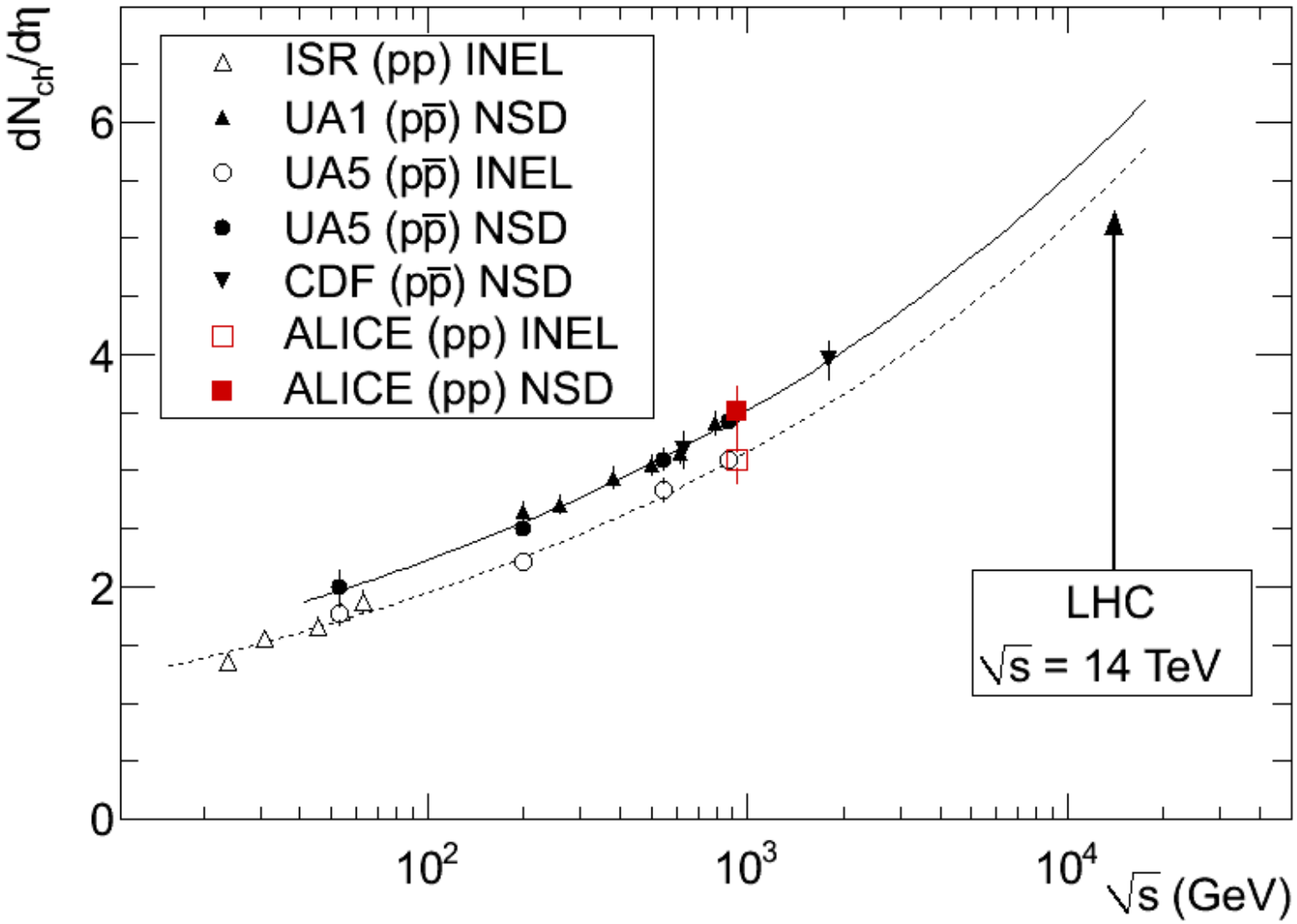
- 30 k

Rapidity distribution

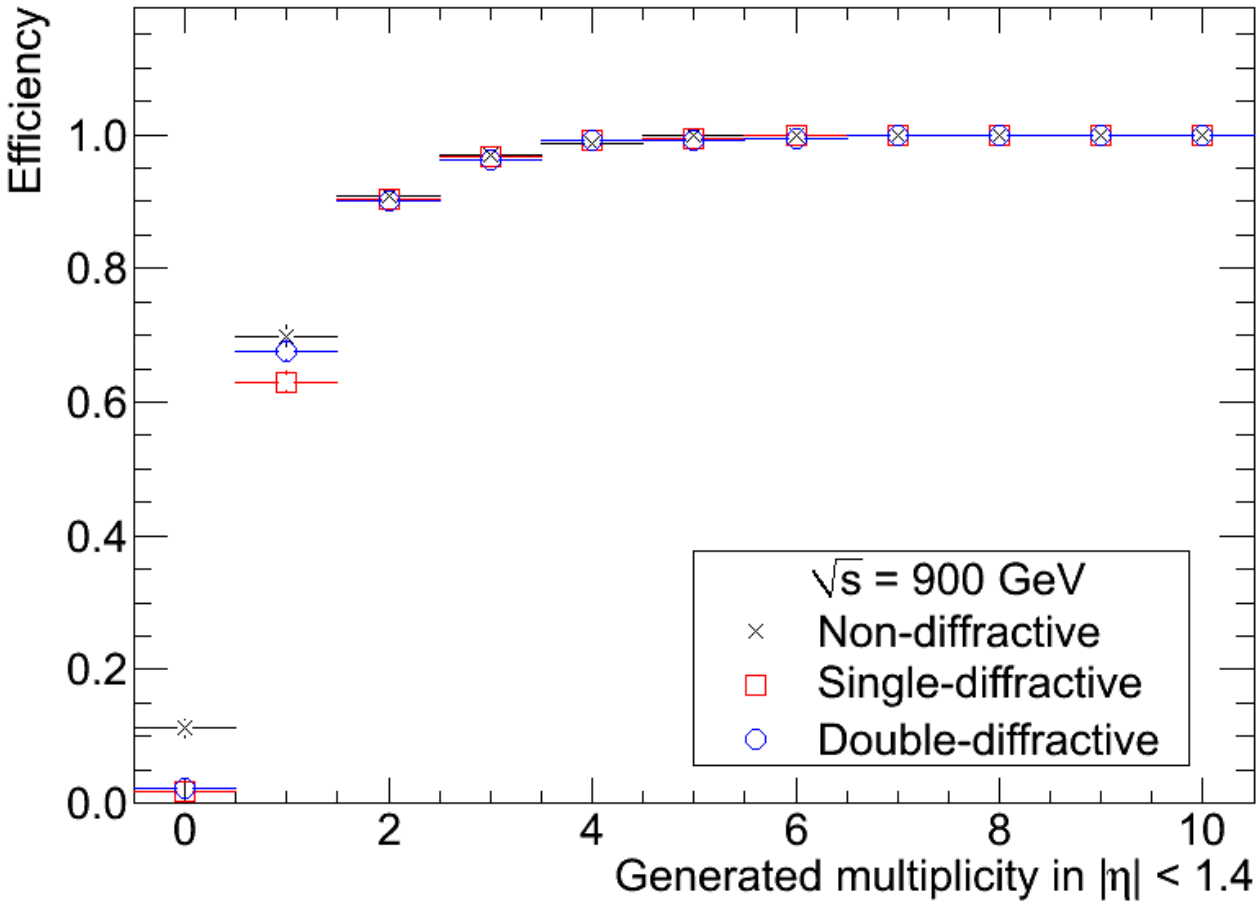


Eur.Phys.J.C65:111-125,2010

$dN_{ch}/d\eta$ systematics

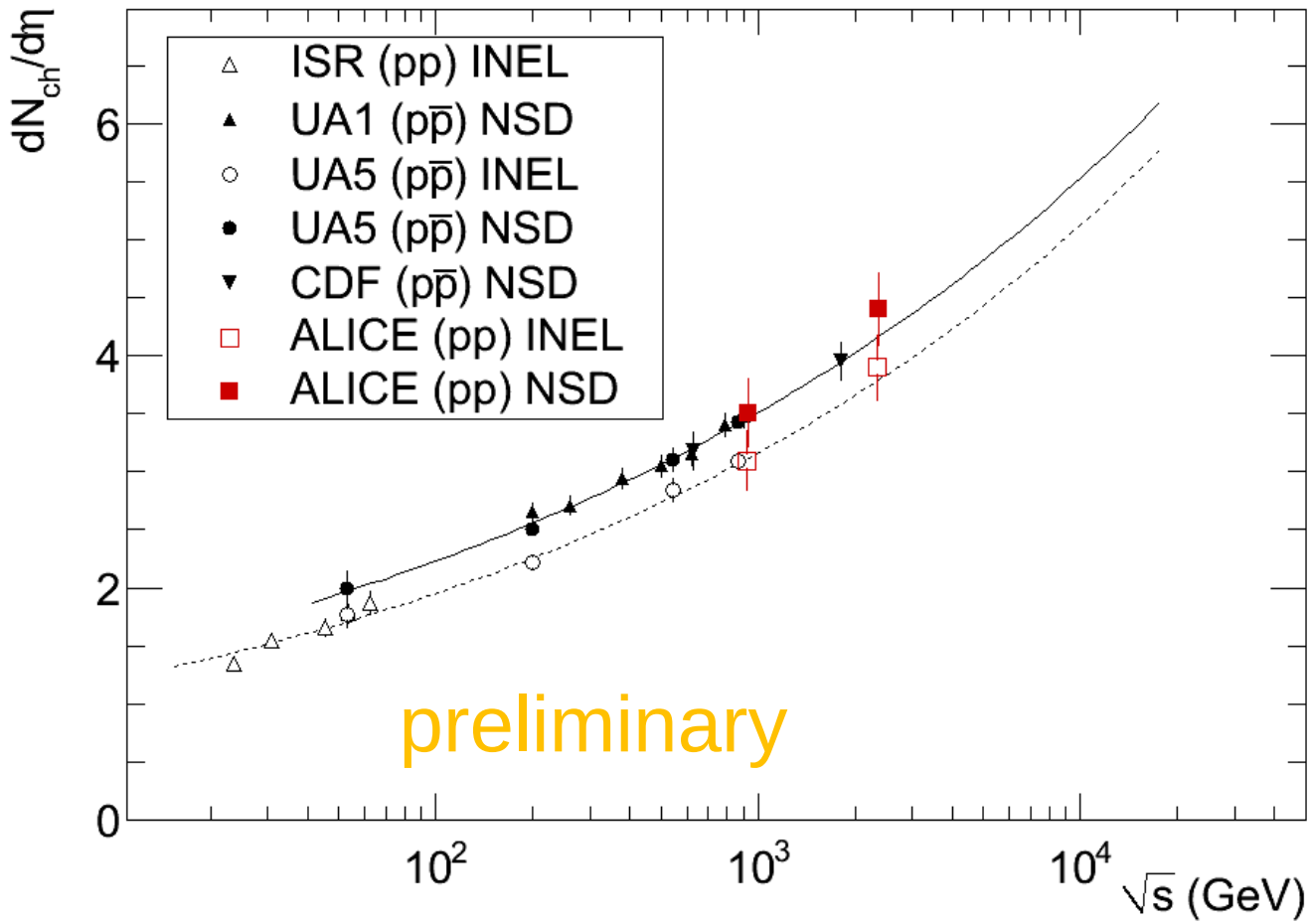


Eur.Phys.J.C65:111-125,2010



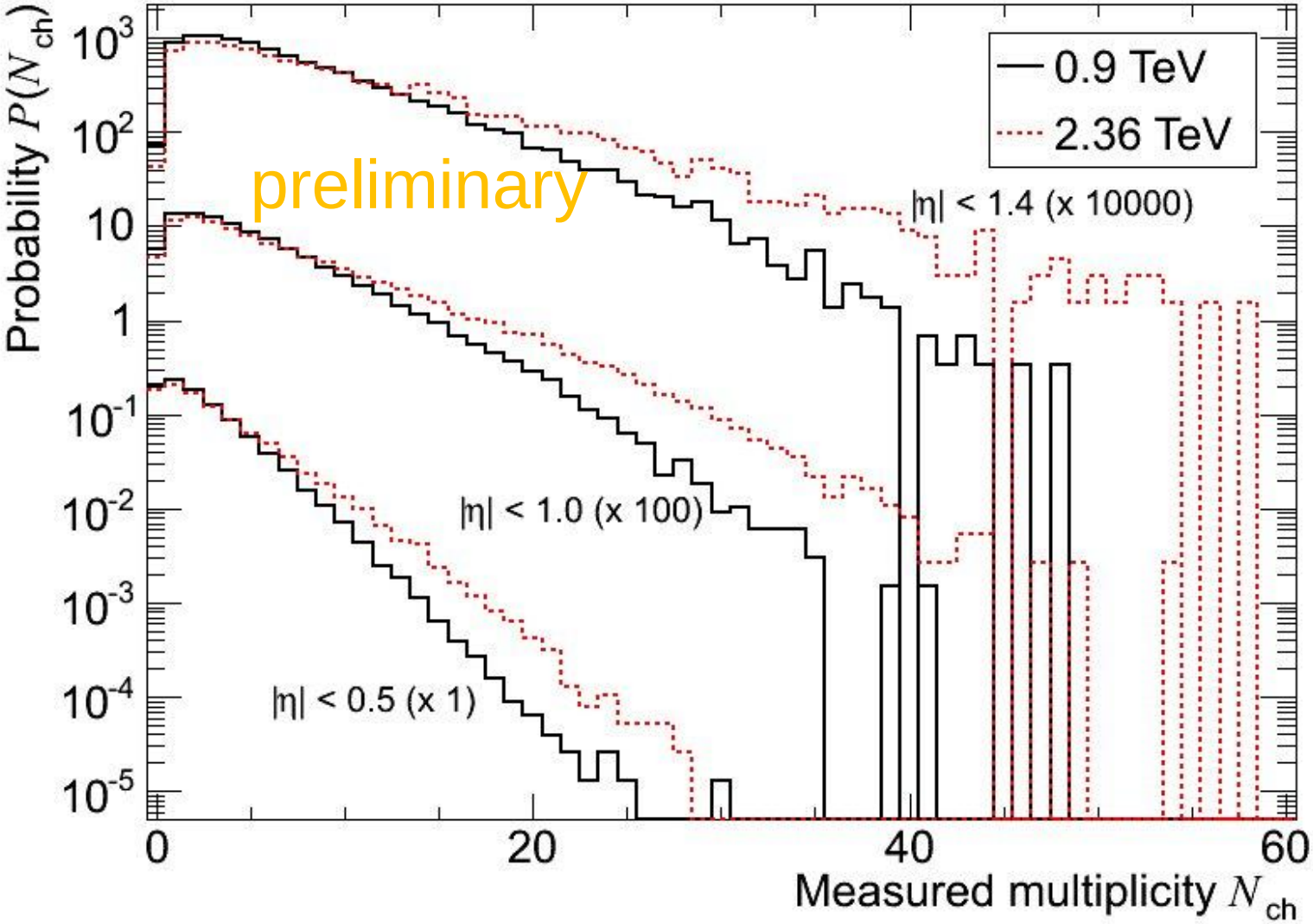
- efficiencies for ND, SD, DD from Monte Carlo
- relative abundances of processes from UA5

2.36 TeV data

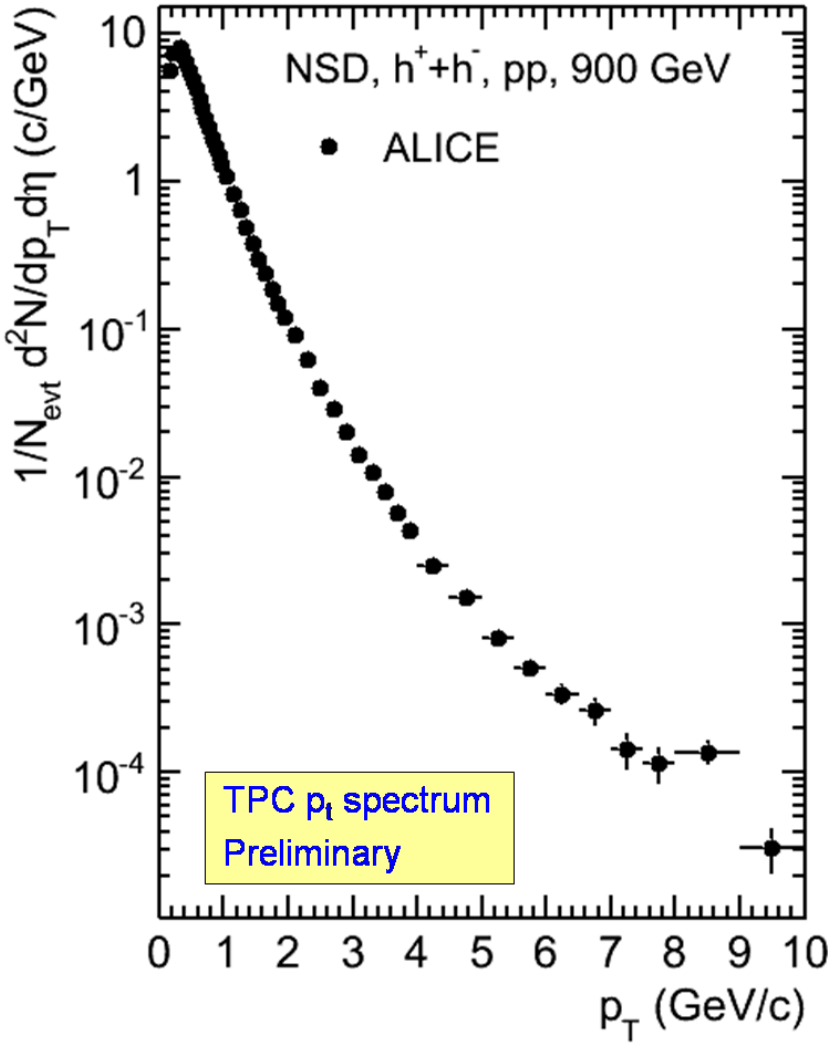


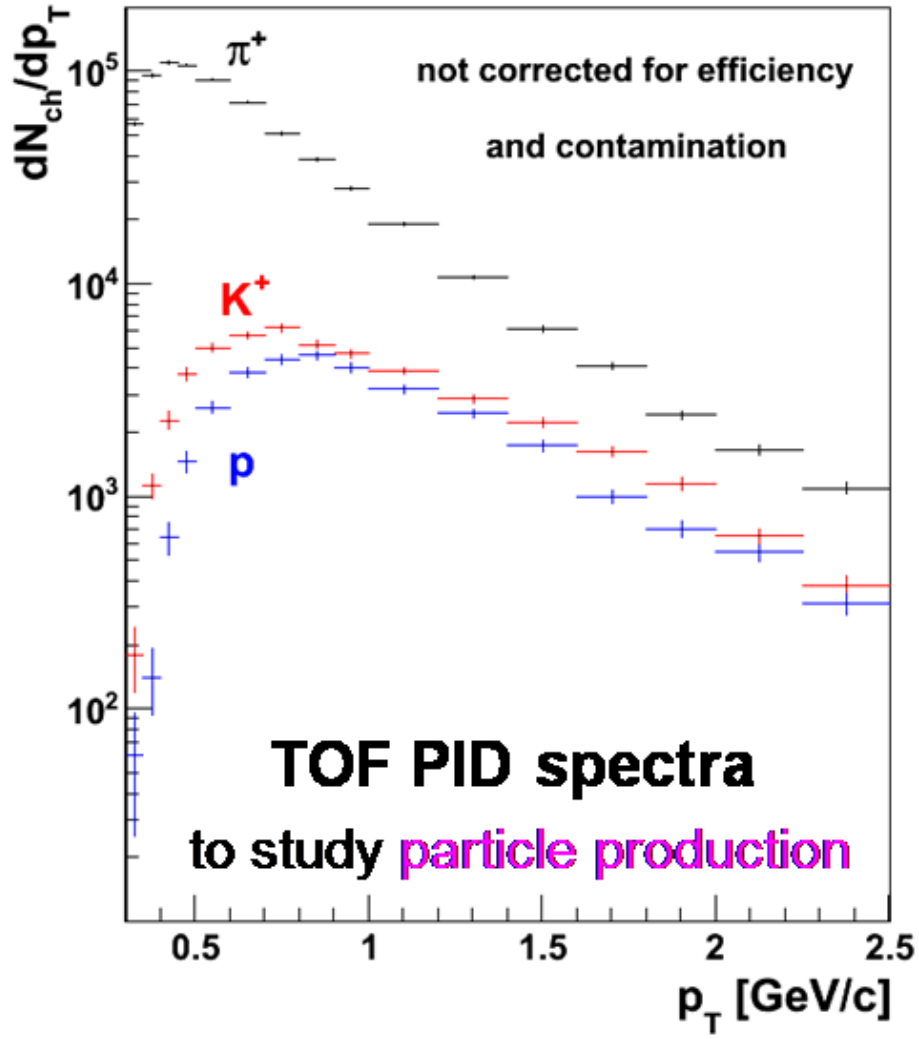
- 30k collisions recorded at 2.36 TeV
- final systematic error on $dN_{ch}/d\eta$ under investigation…

N_{ch} distribution

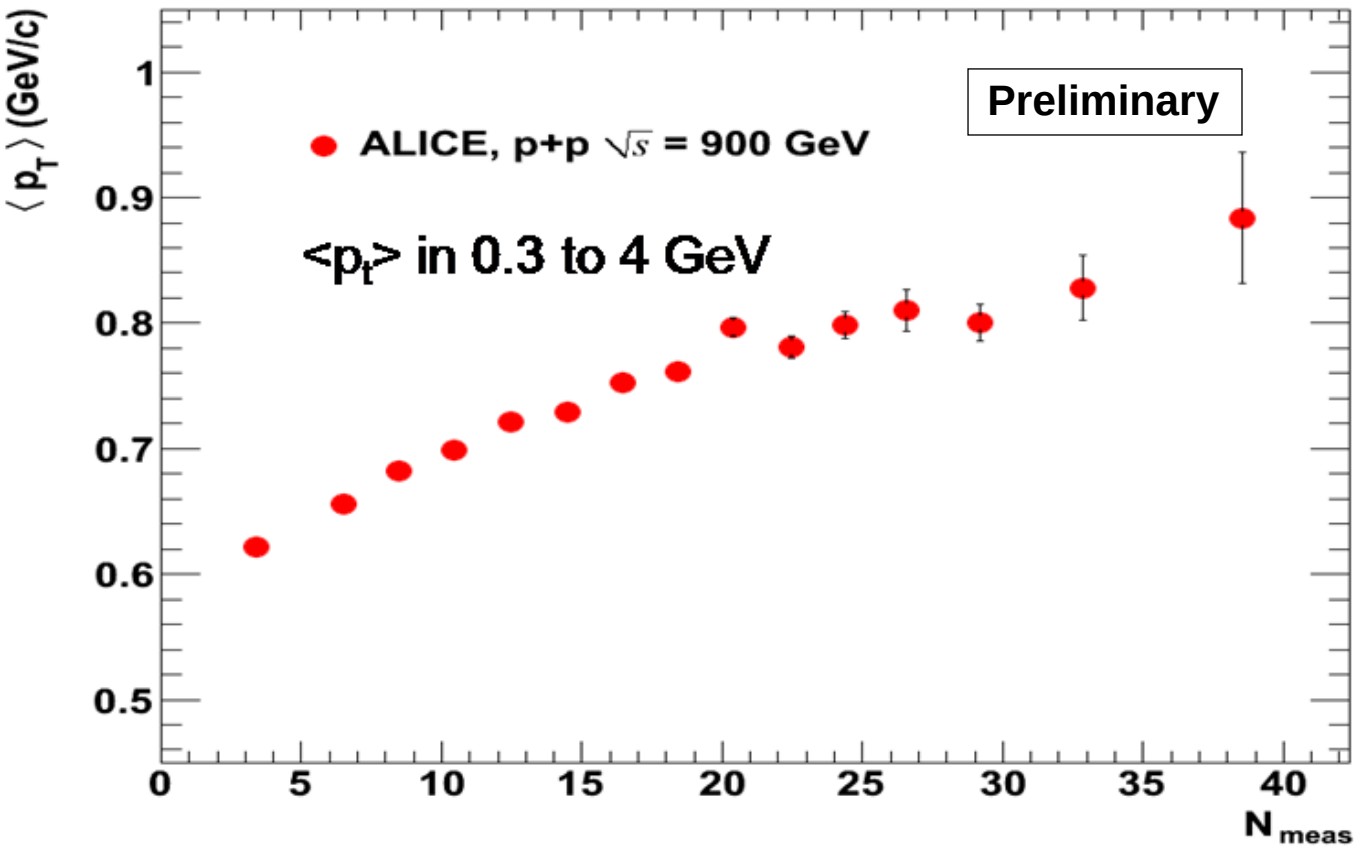


p_t spectra


NSD, h+h-, pp, 900 GeV
ALICE
TPC pt spectrum
Preliminary
1/Nevt d2N/dpTdη (c/GeV)
pT (GeV/c)

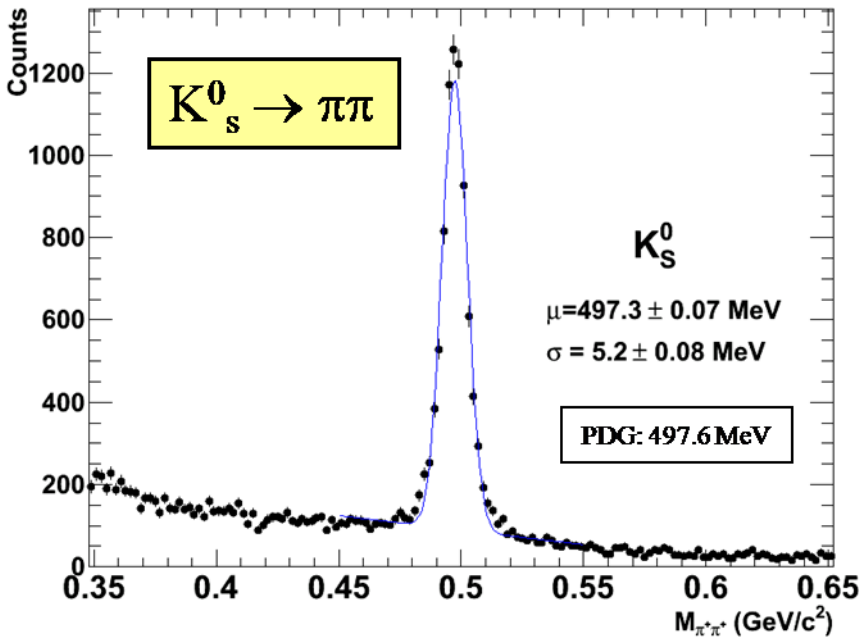

π+
K+
p
not corrected for efficiency
and contamination
TOF PID spectra
to study particle production
dNch/dpT
pT [GeV/c]

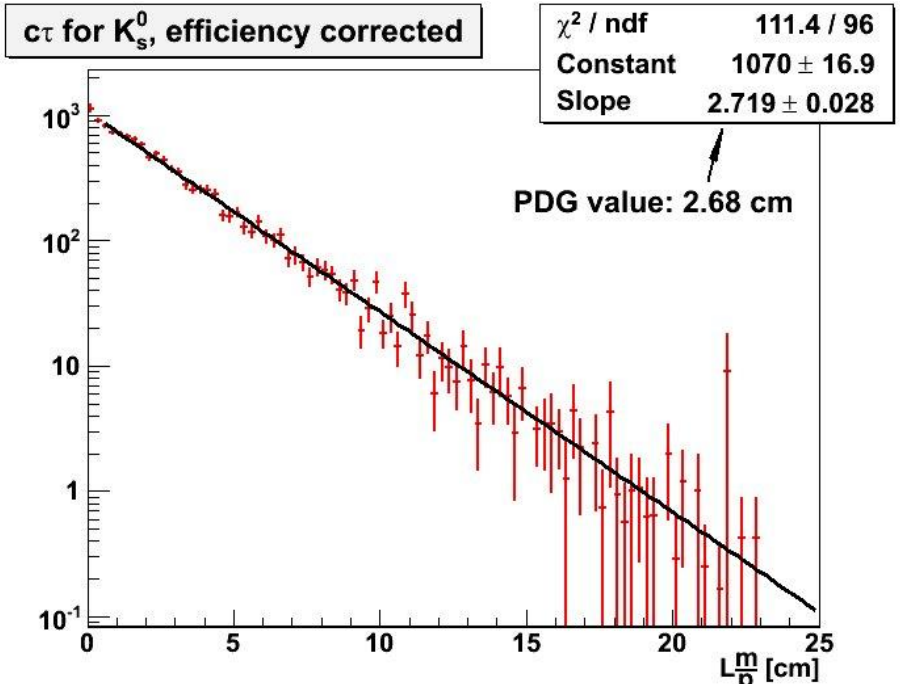
$\langle p_t \rangle$ vs multiplicity

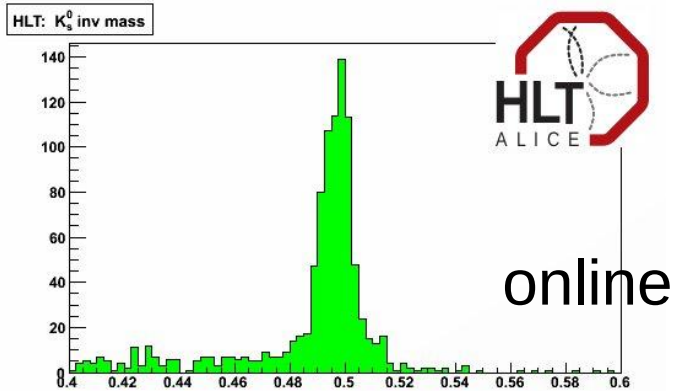


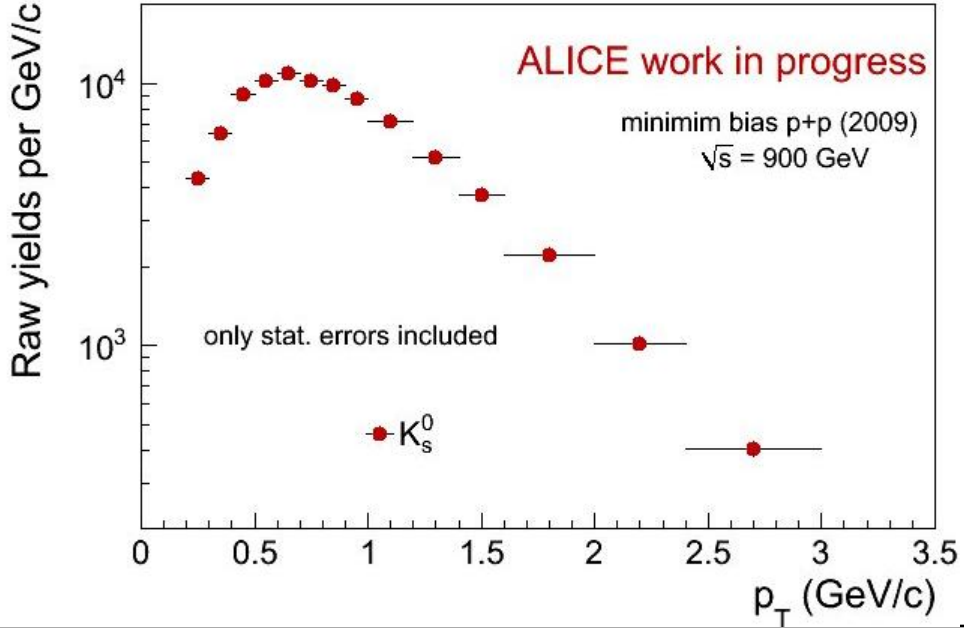
- $\langle p_t \rangle$ in $0.3 < p_t < 4$ GeV/c and $|\eta| < 0.8$
- TPC multiplicity scale not yet efficiency-corrected

Reconstructed K^0_s

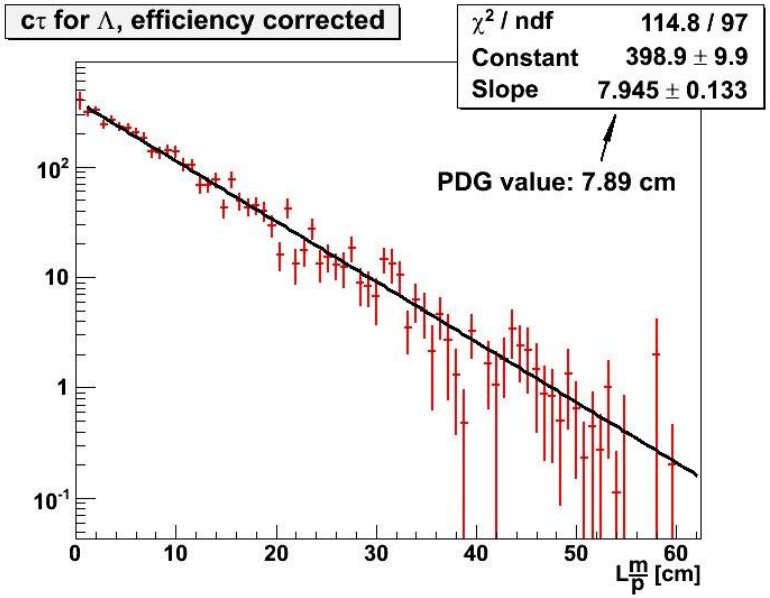


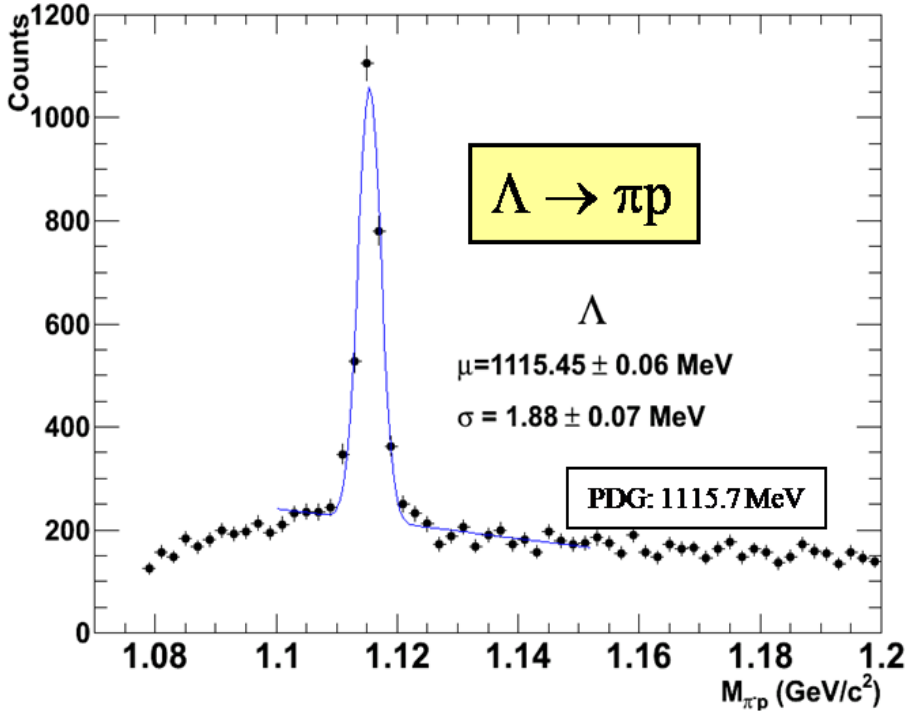


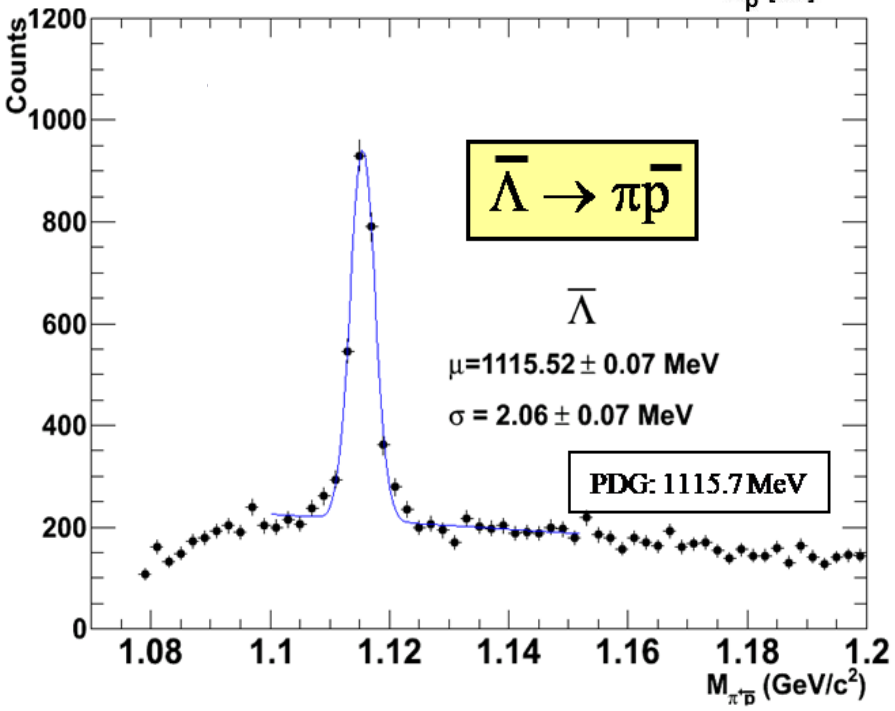


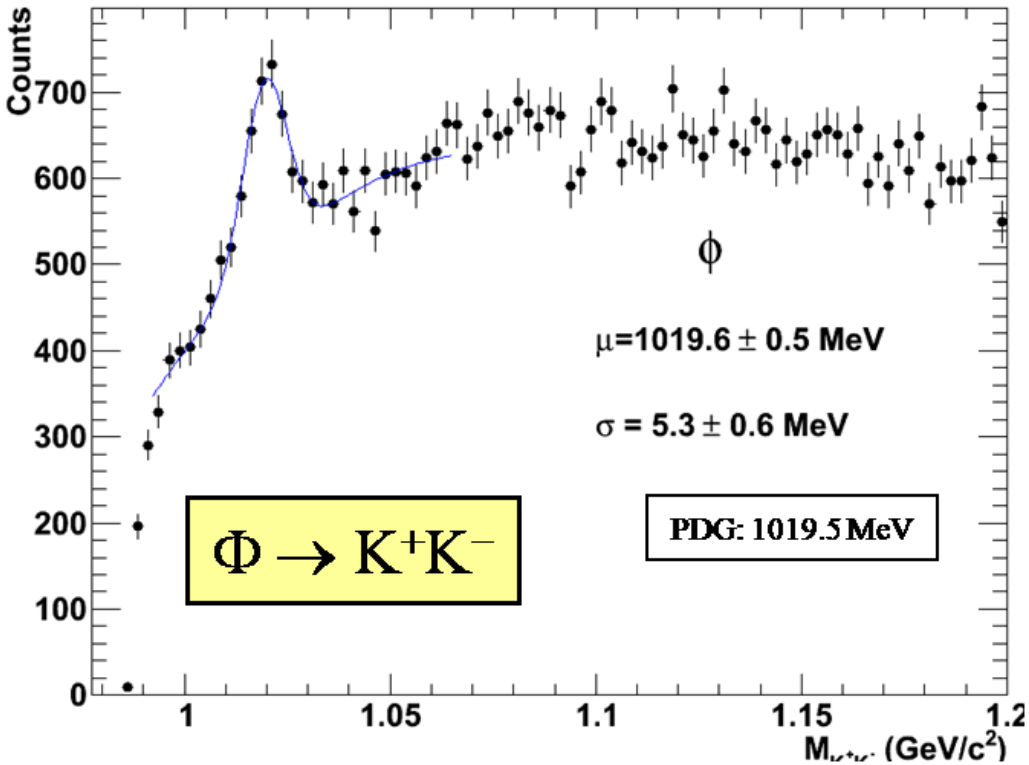


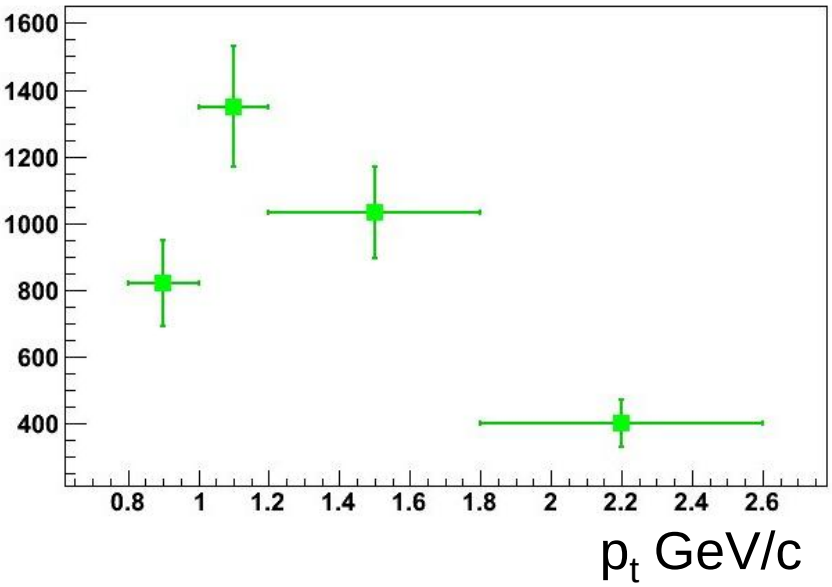
Reconstructed Λ



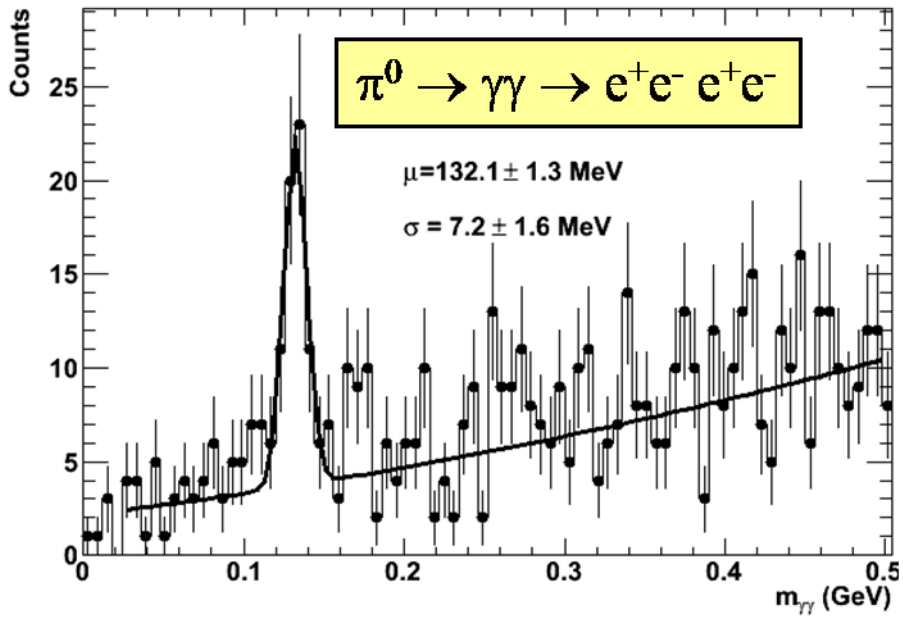


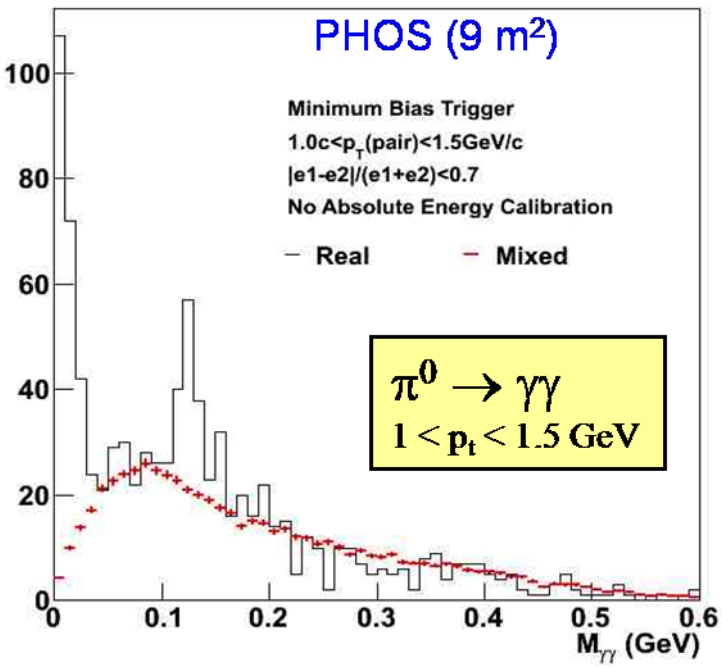



Counts
700
600
500
400
300
200
100
0
1
1.05
1.1
1.15
1.2
(GeV/c²)
ϕ
μ=1019.6 ± 0.5 MeV
σ = 5.3 ± 0.6 MeV
Φ → K⁺K⁻
PDG: 1019.5 MeV

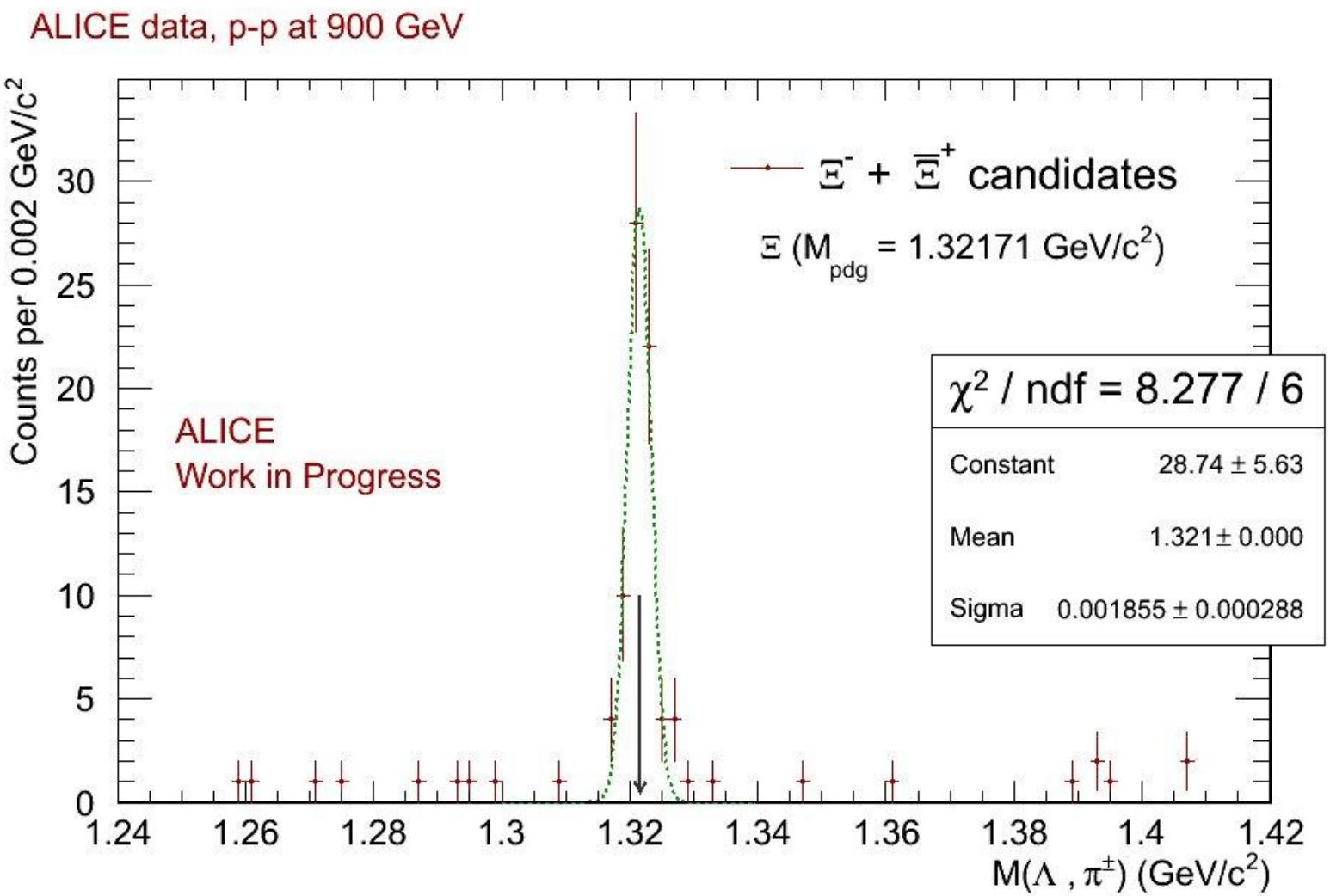

1600
1400
1200
1000
800
600
400
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
p_t GeV/c

Reconstructed π^0



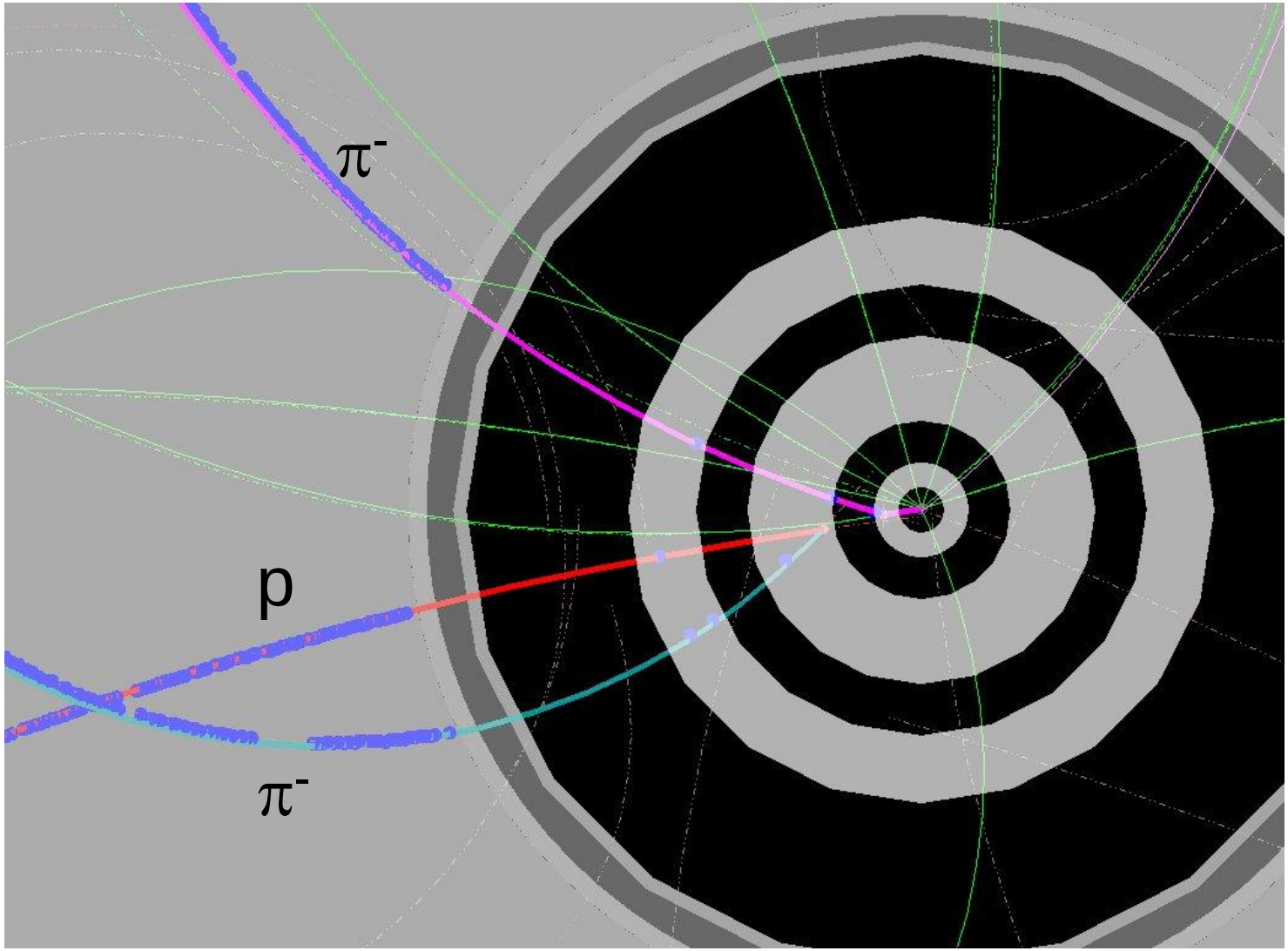


Reconstructed Ξ

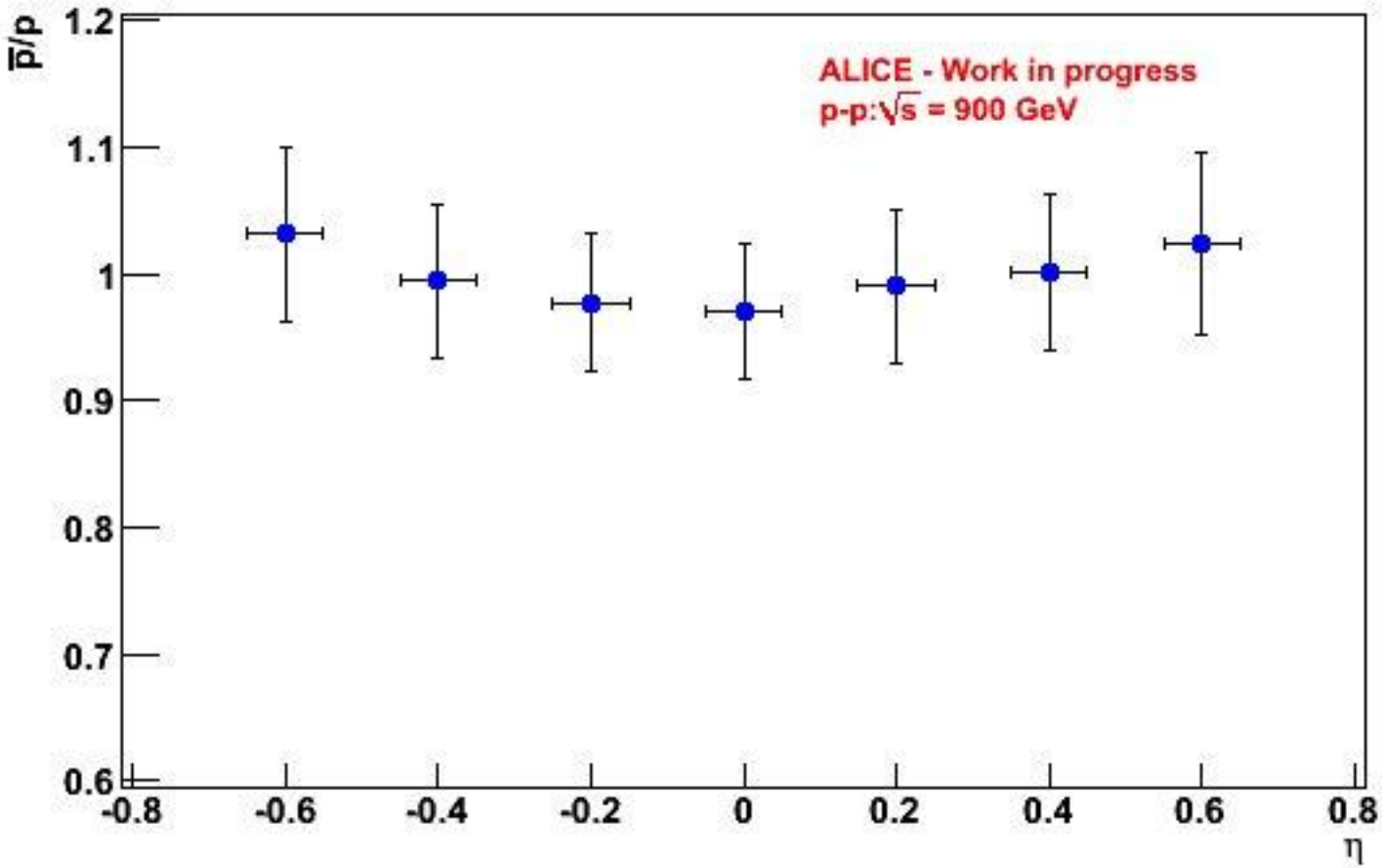


$\Xi^- \rightarrow \Lambda + \pi^- \rightarrow p + \pi^- + \pi^-$

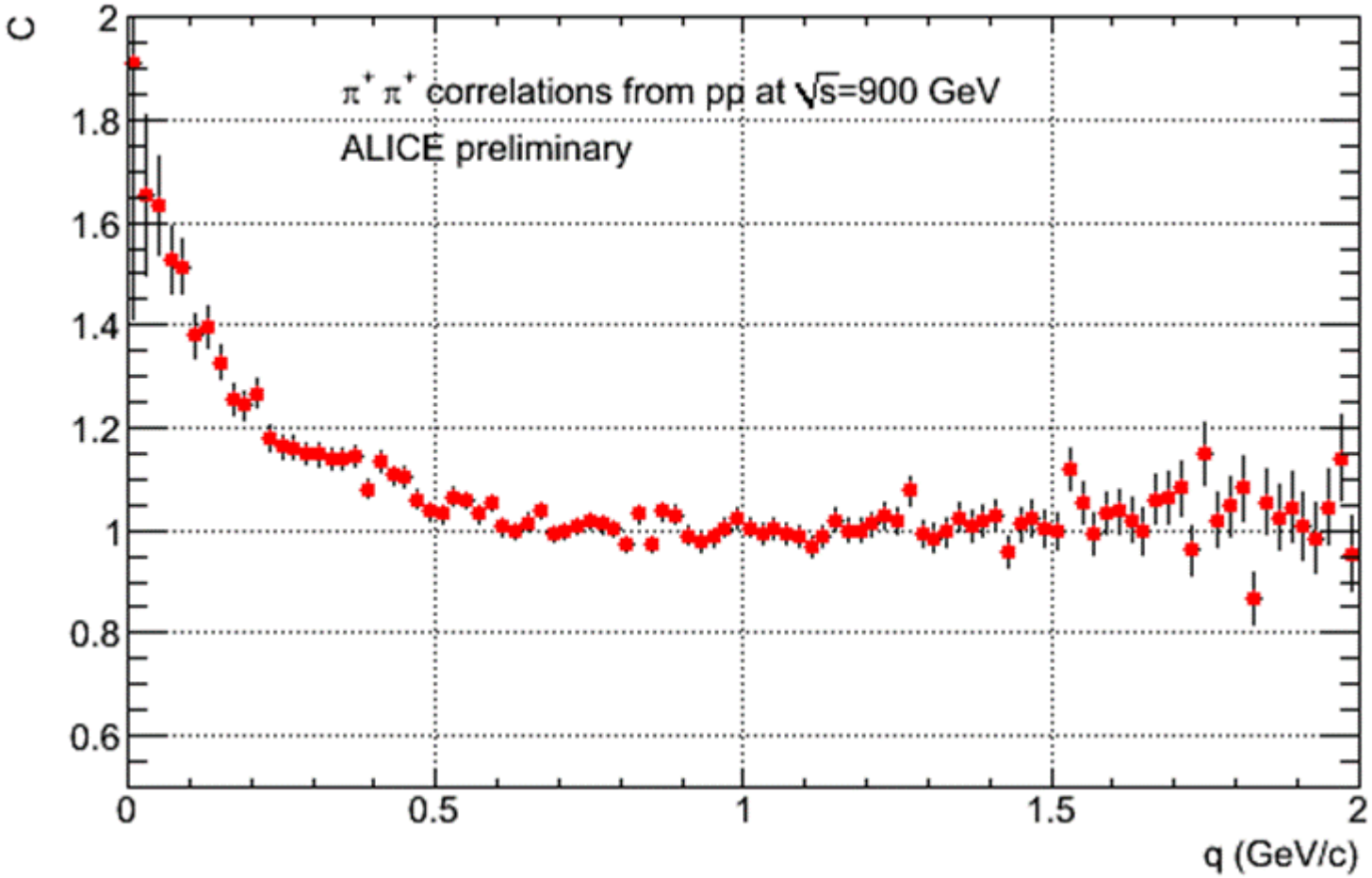
p_t = 1.46 GeV/c
decay length 7 cm



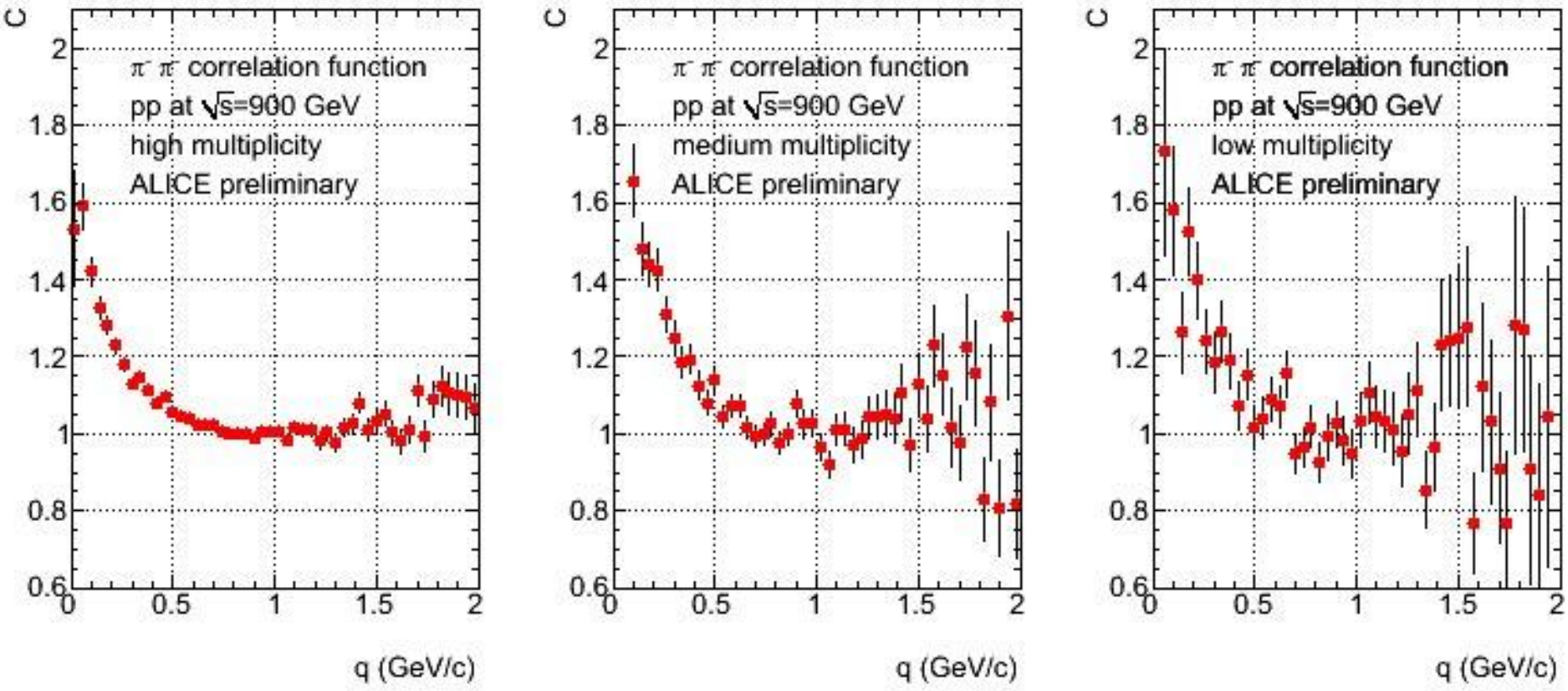
$\bar{p}/p$ Ratio


ALICE - Work in progress
p-p:√s = 900 GeV
p̄/p
1.2
1.1
1
0.9
0.8
0.7
0.6
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
η

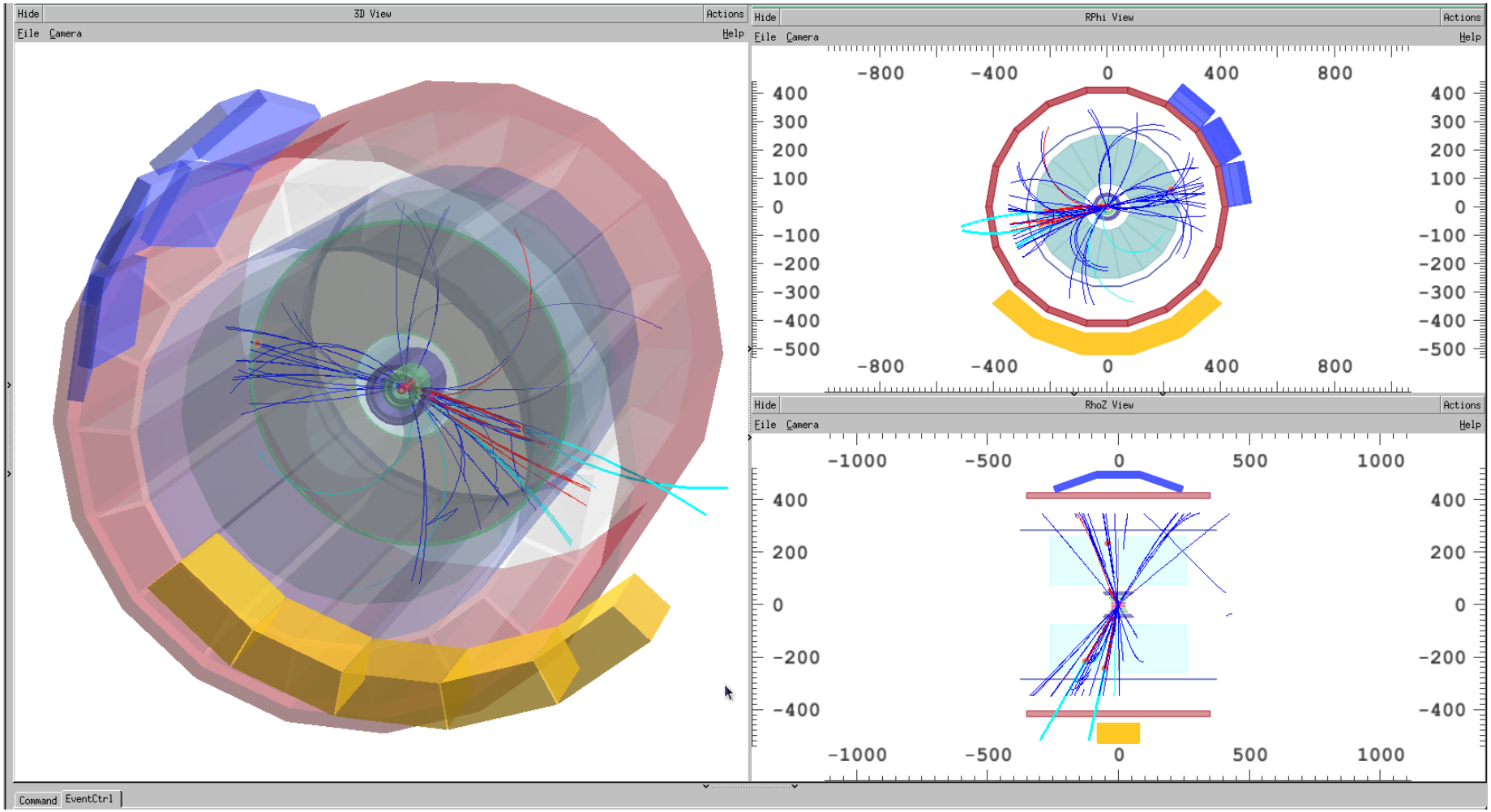
HBT with pions



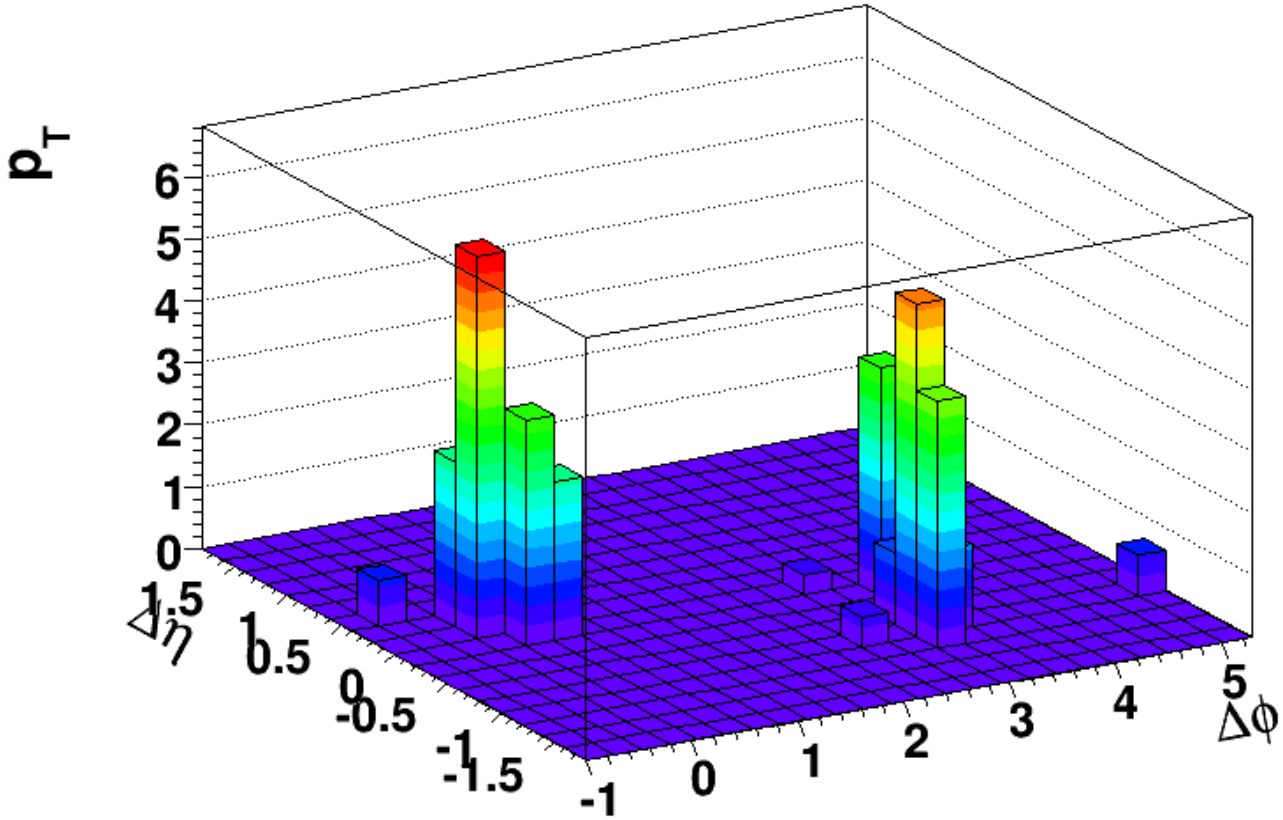
Multiplicity dependence of HBT correlation?



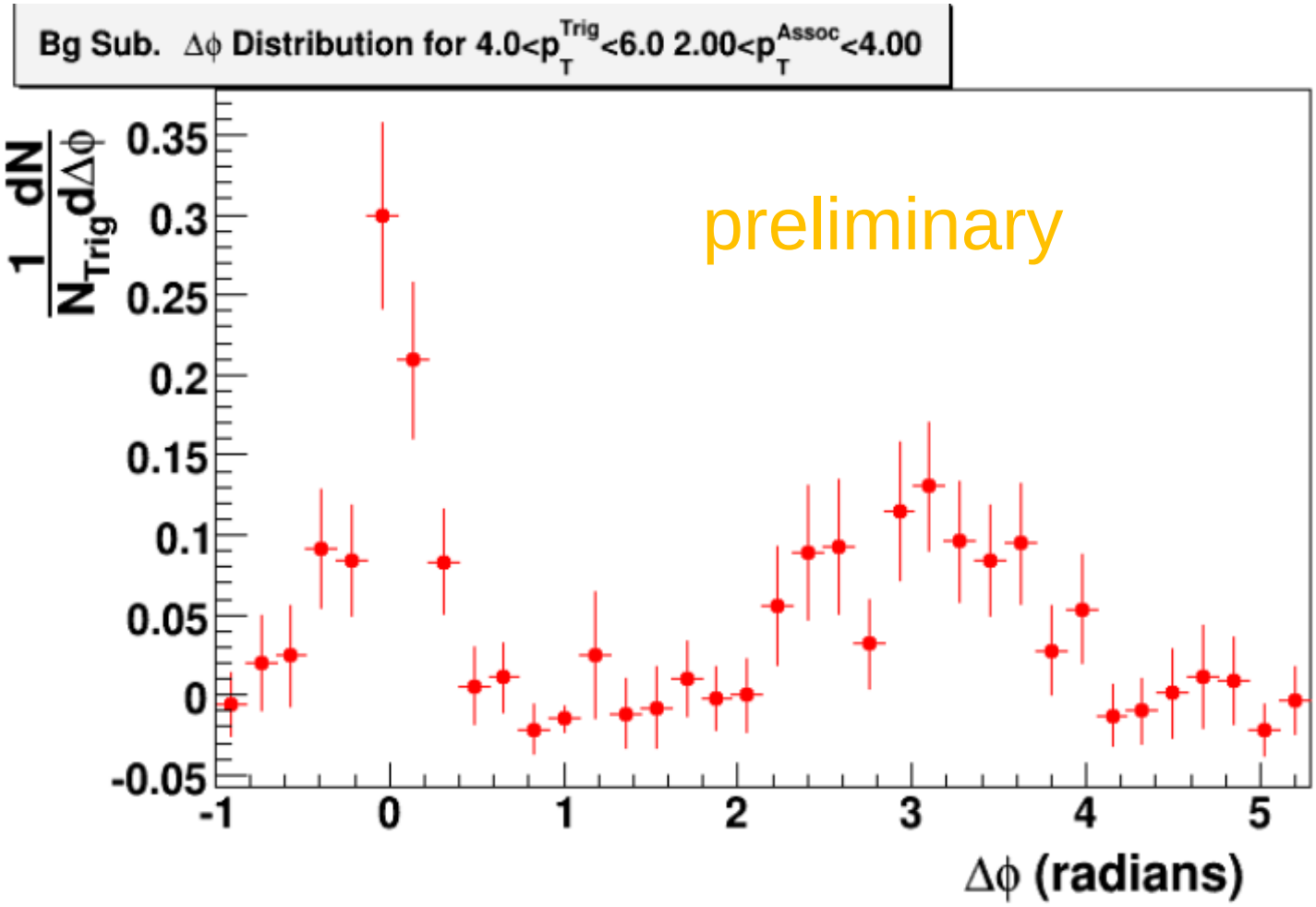
A first glimpse of jets



A first glimpse of jets



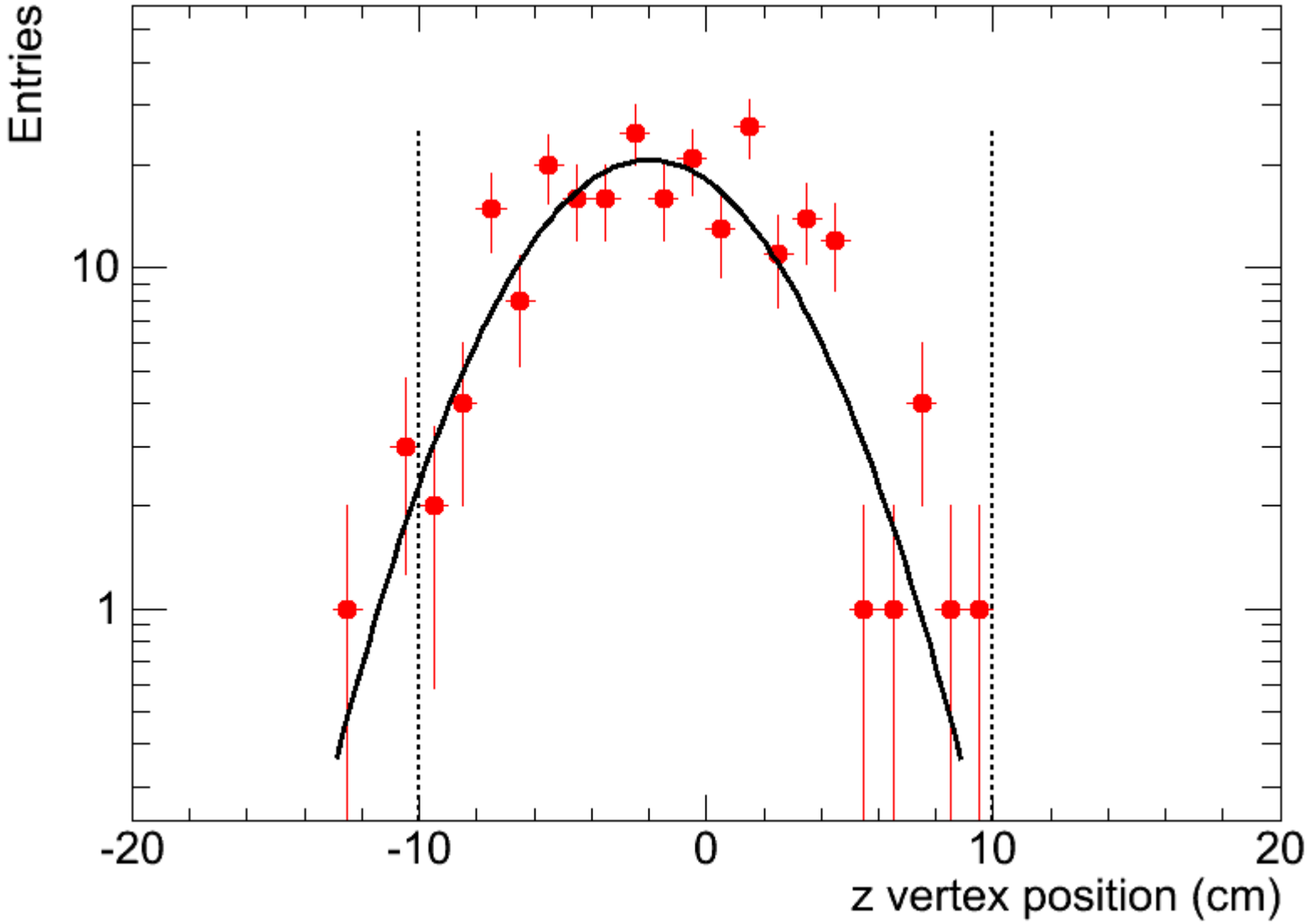
Azimuthal jet correlation

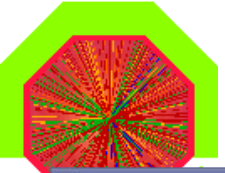


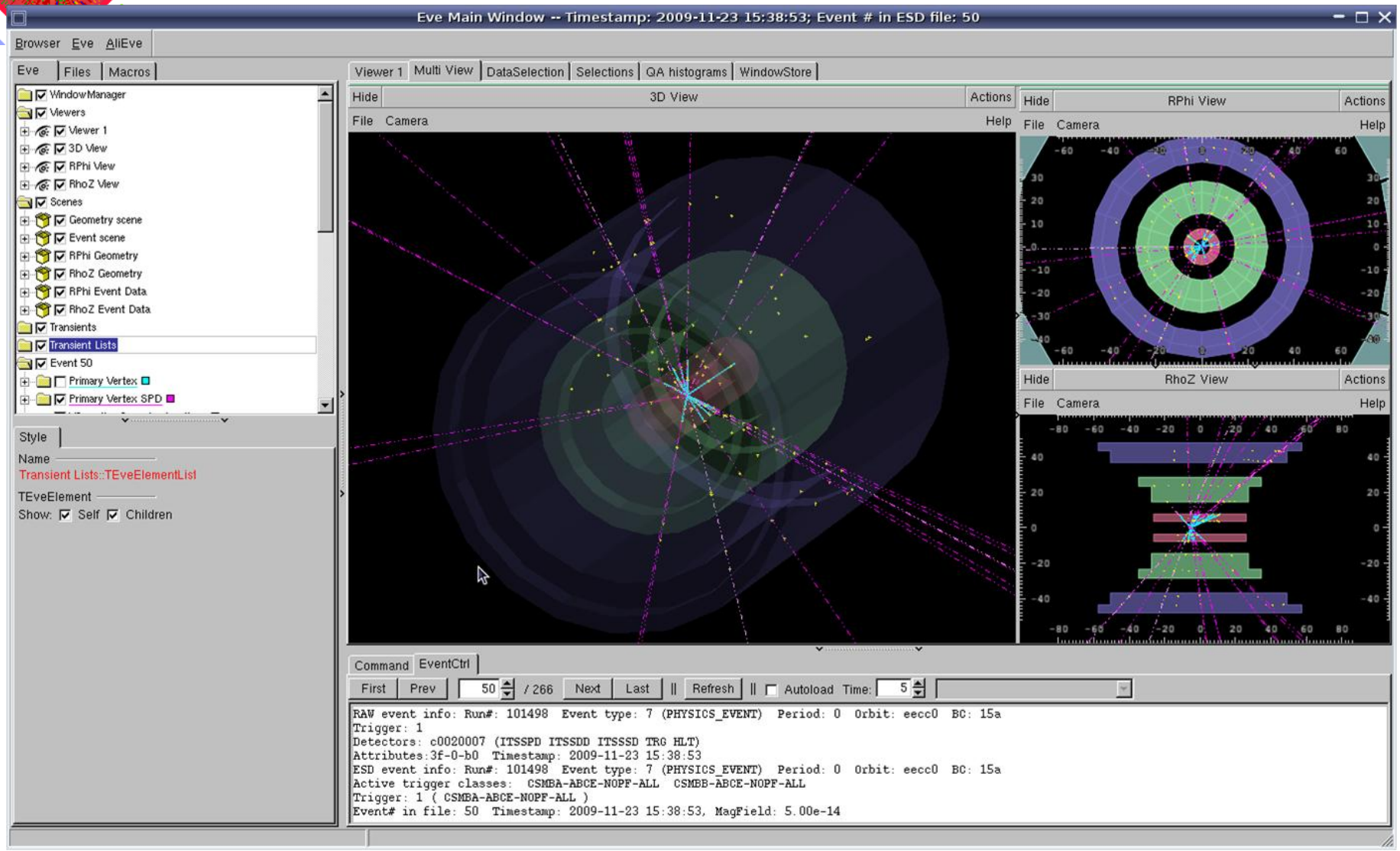
Outlook

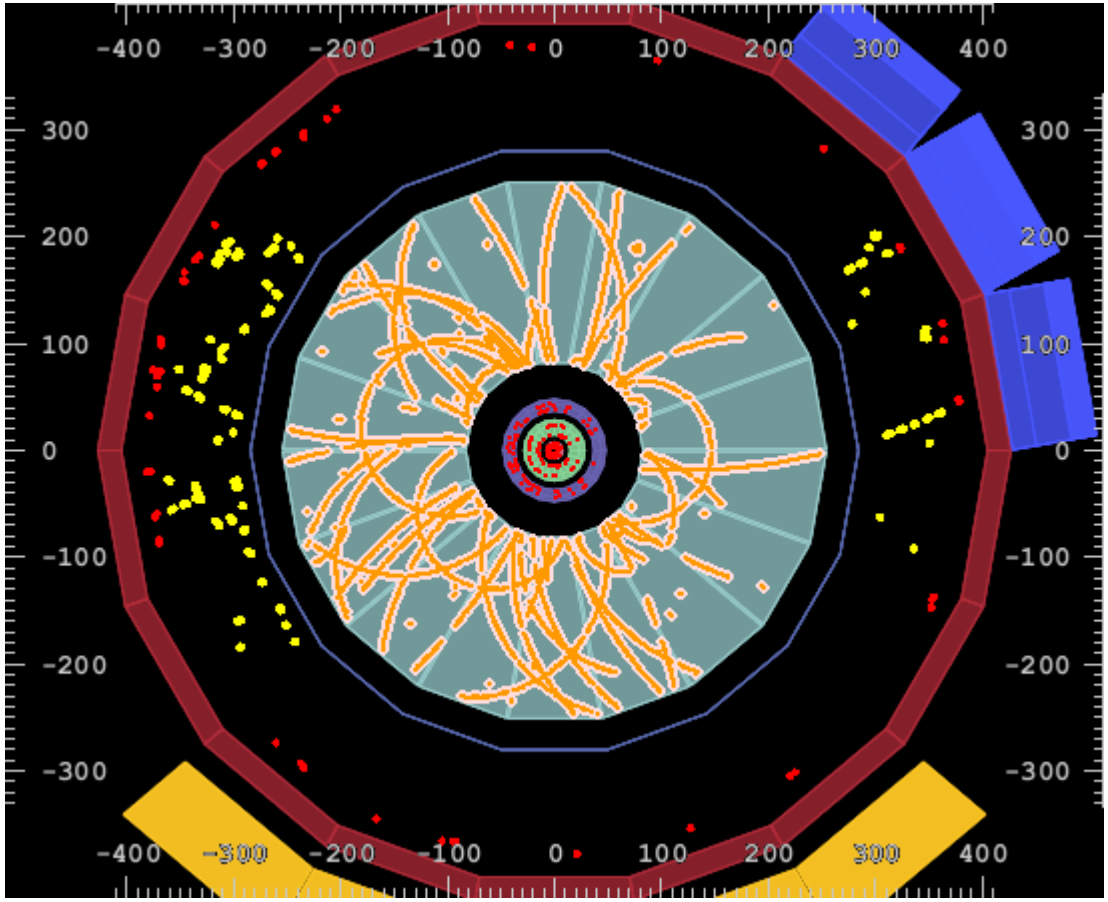
- Detectors are in good shape
- Online and offline have profited from one extra year
- still work to do in alignment
- looking forward to 3.5+3.5 TeV pp and Pb-Pb

The End


Entries
10
1
-20
-10
0
10
20
z vertex position (cm)



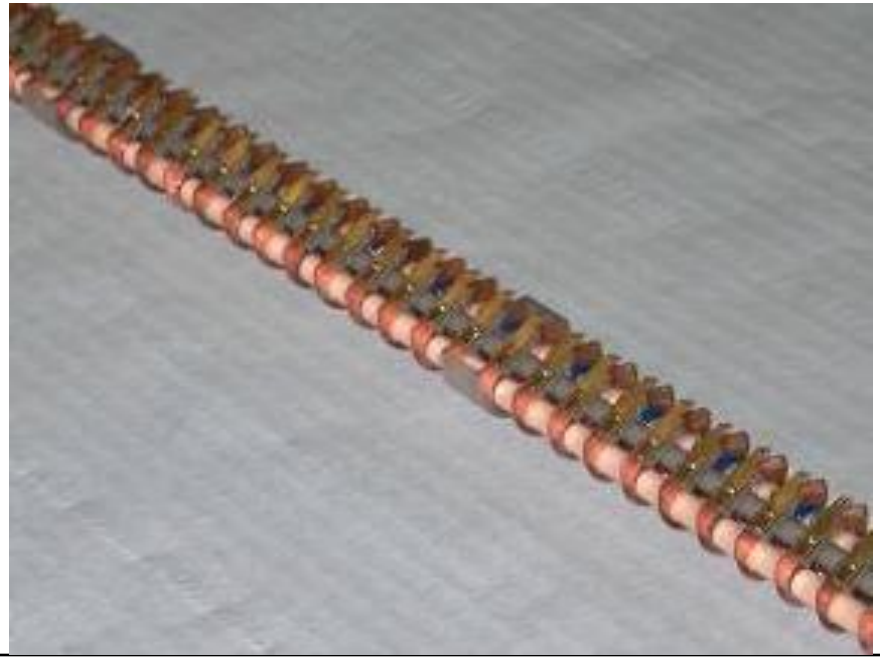

Eve Main Window -- Timestamp: 2009-11-23 15:38:53; Event # in ESD file: 50
Browser Eve AliEve
Eve Files Macros
WindowManager
Viewers
Viewer 1
3D View
RPhi View
RhoZ View
Scenes
Geometry scene
Event scene
RPhi Geometry
RhoZ Geometry
RPhi Event Data
RhoZ Event Data
Transients
Transient Lists
Event 50
Primary Vertex
Primary Vertex SPD
Style
Name
Transient Lists::TEveElementList
TEveElement
Show: Self Children
Viewer 1 Multi View DataSelection Selections QA histograms WindowStore
Hide 3D View Actions
File Camera Help
Hide RPhi View Actions
File Camera Help
Hide RhoZ View Actions
File Camera Help
Command EventCtrl
First Prev 50 / 266 Next Last Refresh Autoload Time: 5
RAW event info: Run#: 101498 Event type: 7 (PHYSICS_EVENT) Period: 0 Orbit: eecc0 BC: 15a
Trigger: 1
Detectors: c0020007 (ITSSPD ITSSDD ITSSSD TRG HLT)
Attributes:3f-0-b0 Timestamp: 2009-11-23 15:38:53
ESD event info: Run#: 101498 Event type: 7 (PHYSICS_EVENT) Period: 0 Orbit: eecc0 BC: 15a
Active trigger classes: CSMBA-ABCE-NOPF-ALL CSMBB-ABCE-NOPF-ALL
Trigger: 1 (CSMBA-ABCE-NOPF-ALL)
Event# in file: 50 Timestamp: 2009-11-23 15:38:53, MagField: 5.00e-14

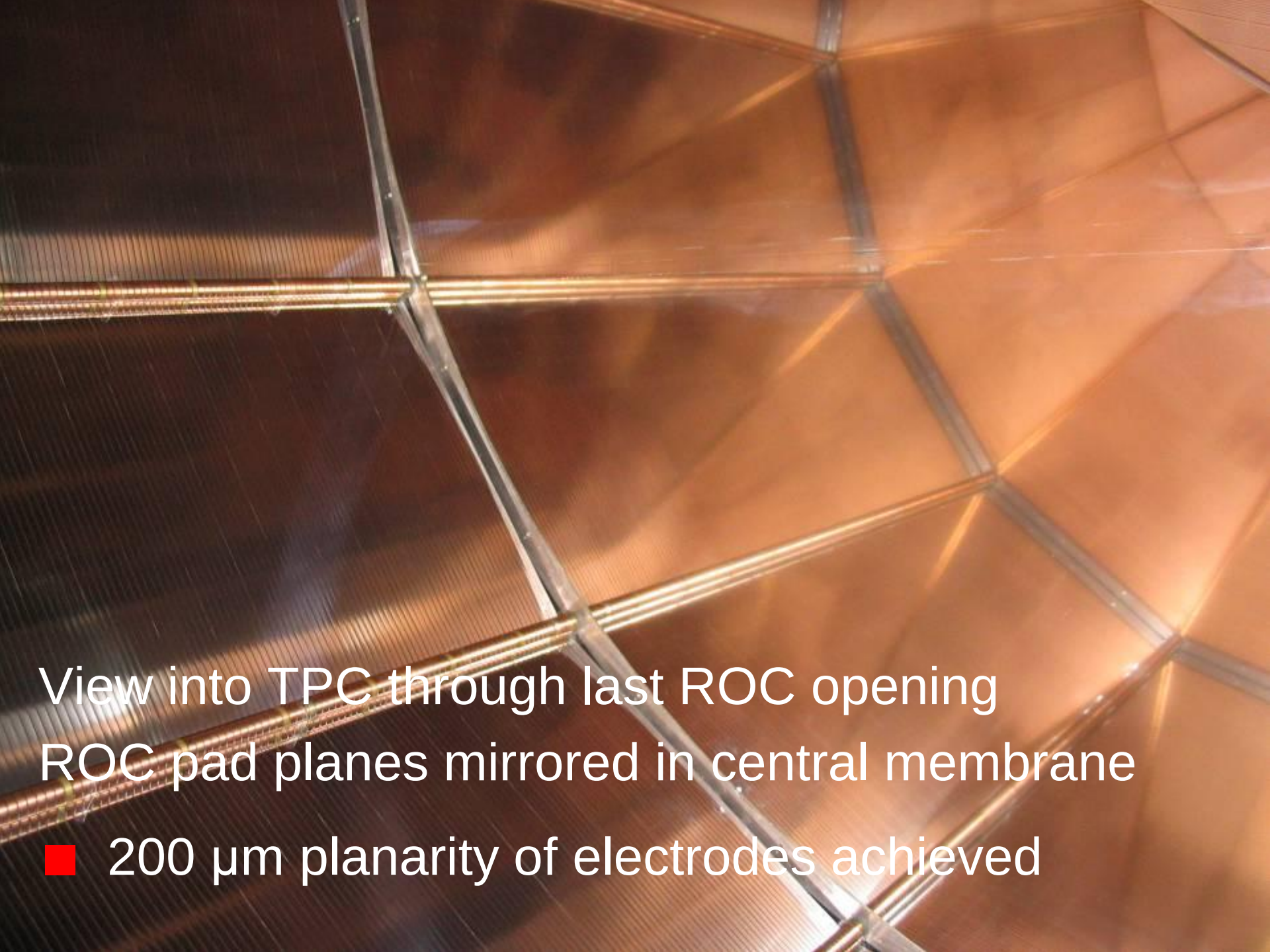

-400
-300
-200
-100
0
100
200
300
400
300
200
100
0
-100
-200
-300

Cooling:
Temperature Stabilization and Homogeneity

- Clearly a challenging item: **$\Delta T \leq 0.1$ K**
- Thermal screens toward TRD and ITS
- Readout chamber Al bodies and pad planes: water-cooled
- Water cooling of FEE boards (total power 27 kW)
- Leakless cooling systems

HV resistive divider rod:
4 x 8 W,
water-cooled



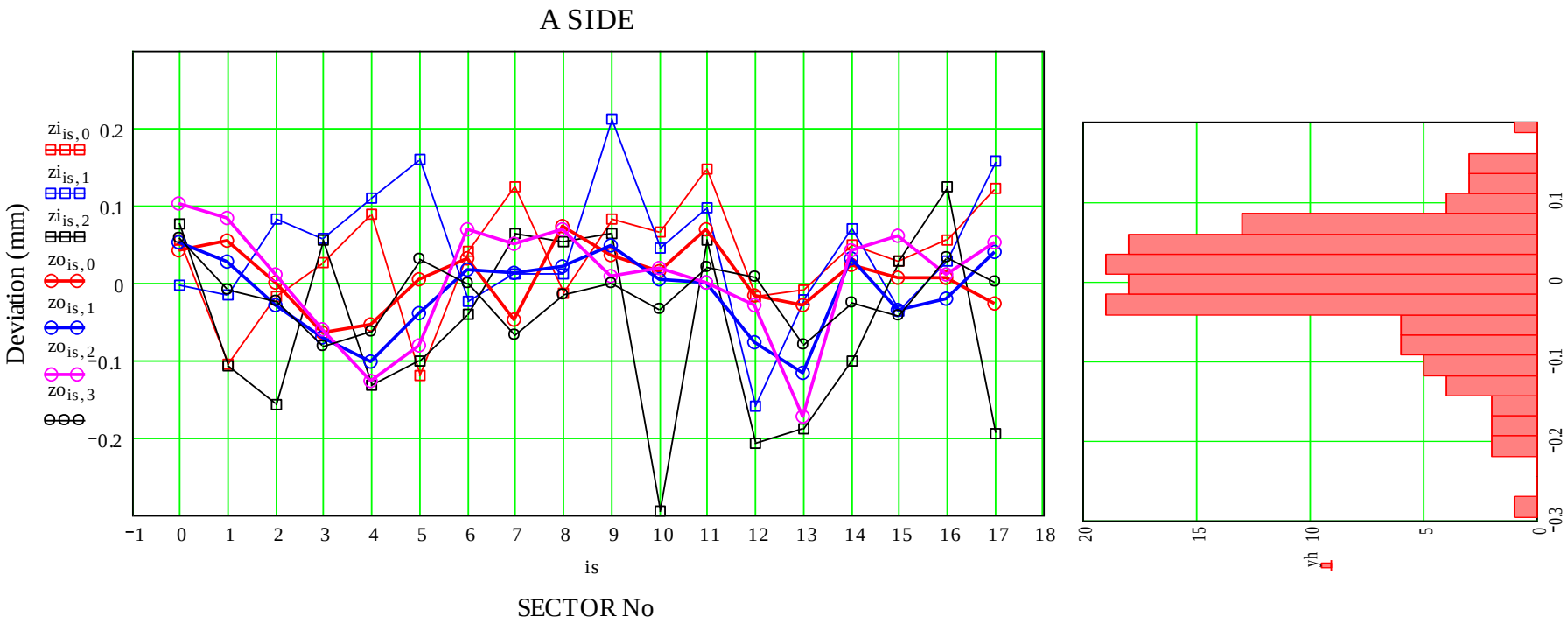


View into TPC through last ROC opening

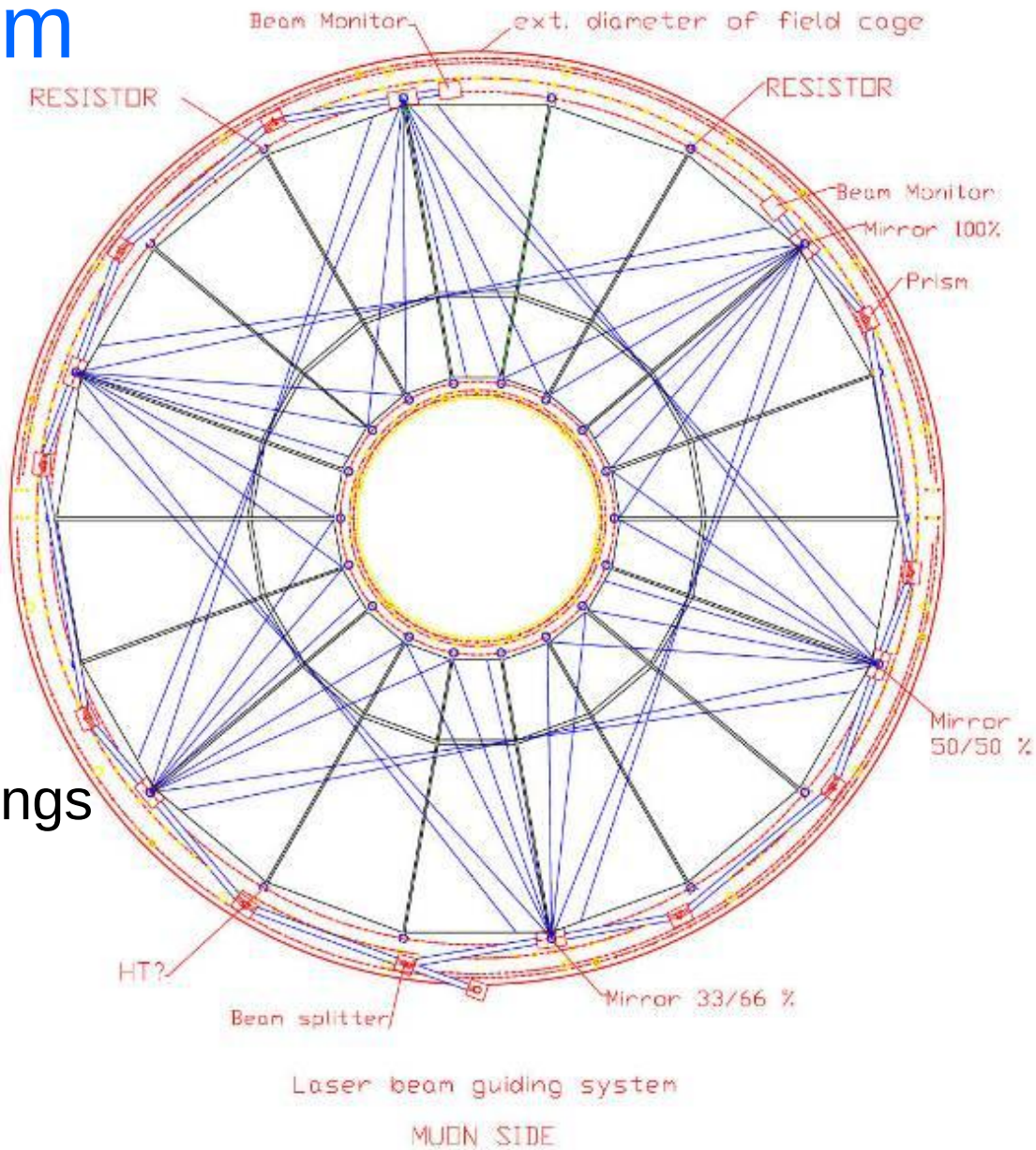
ROC pad planes mirrored in central membrane

- 200 µm planarity of electrodes achieved

Survey result of ROCs, A-side

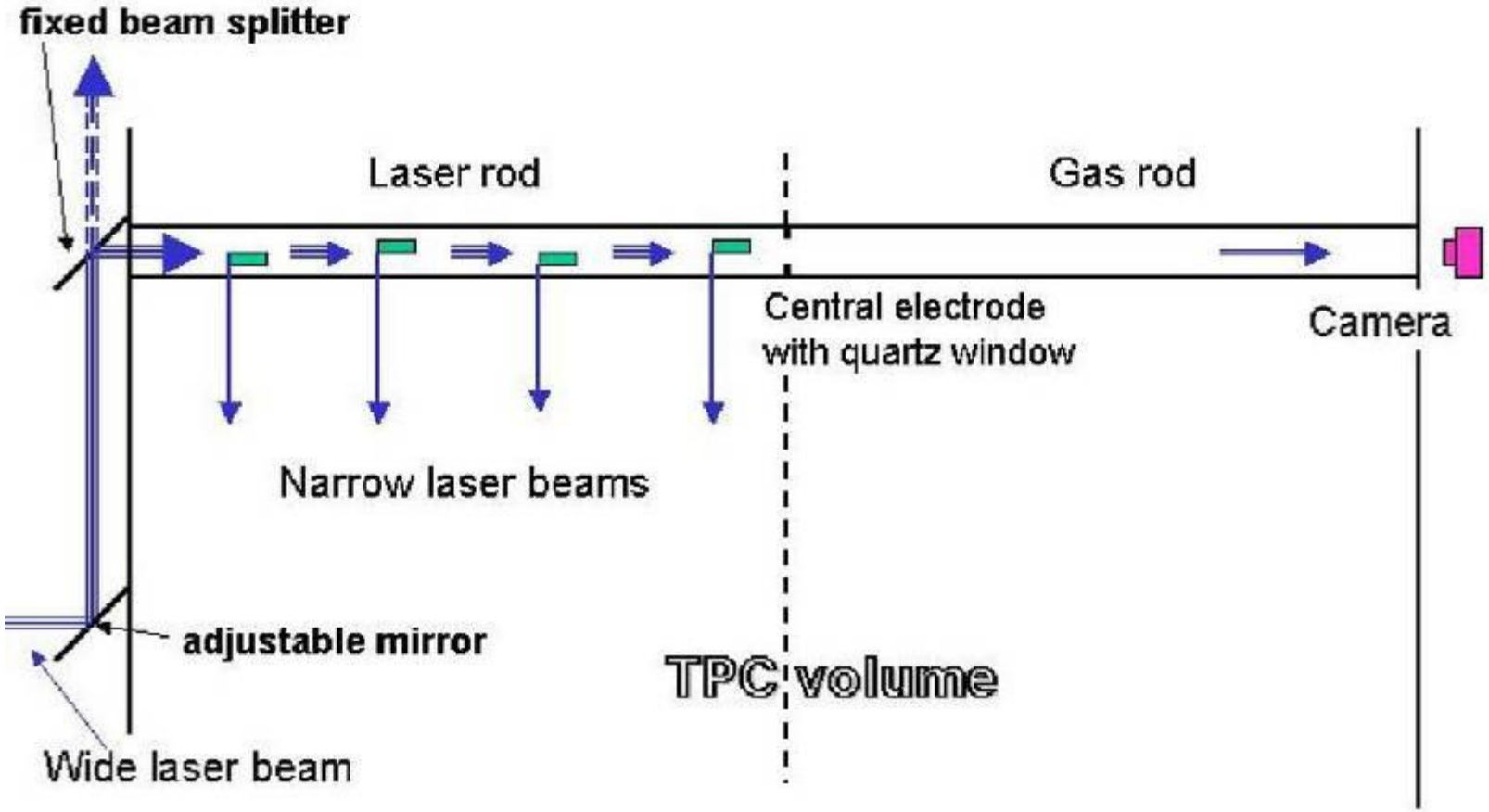


Laser System

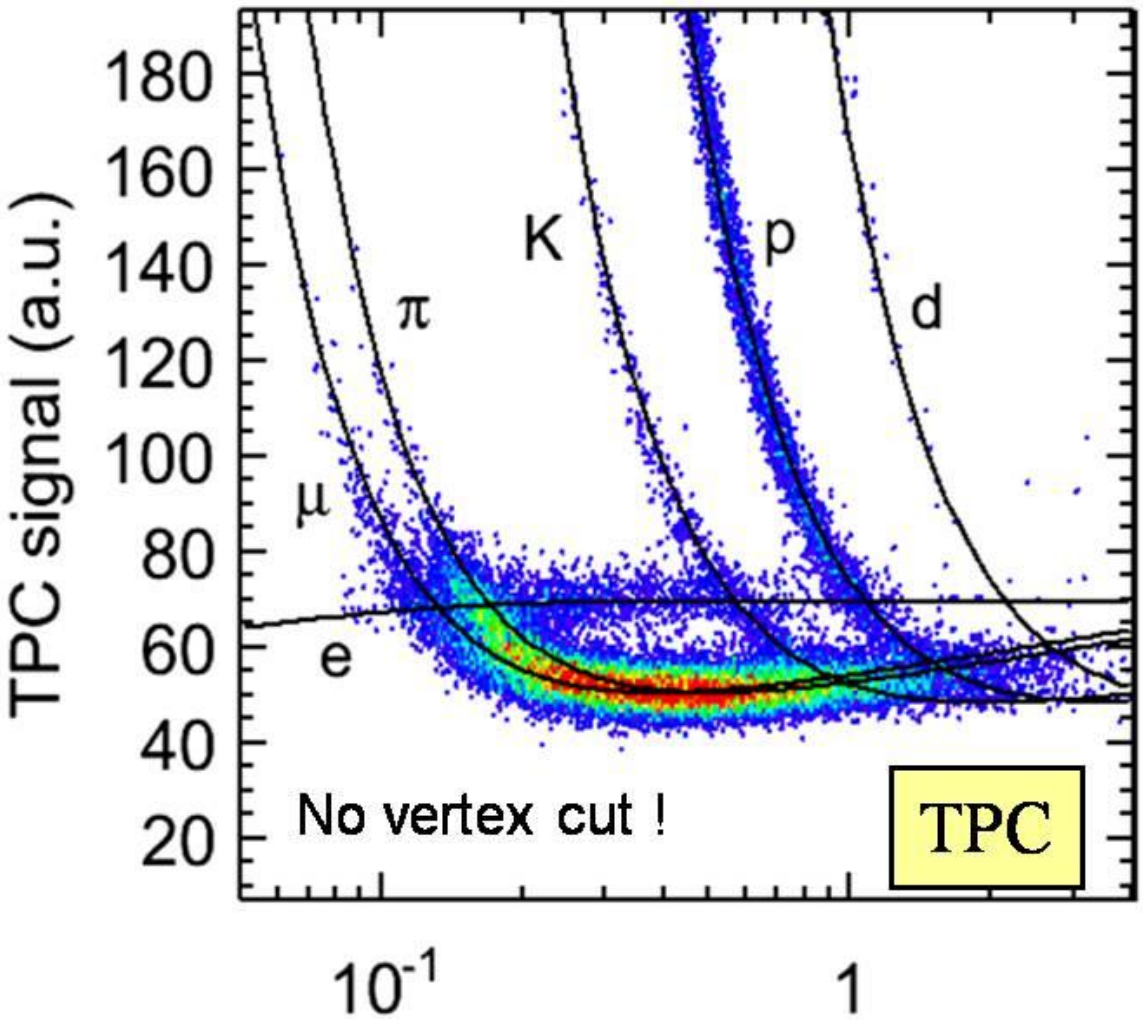


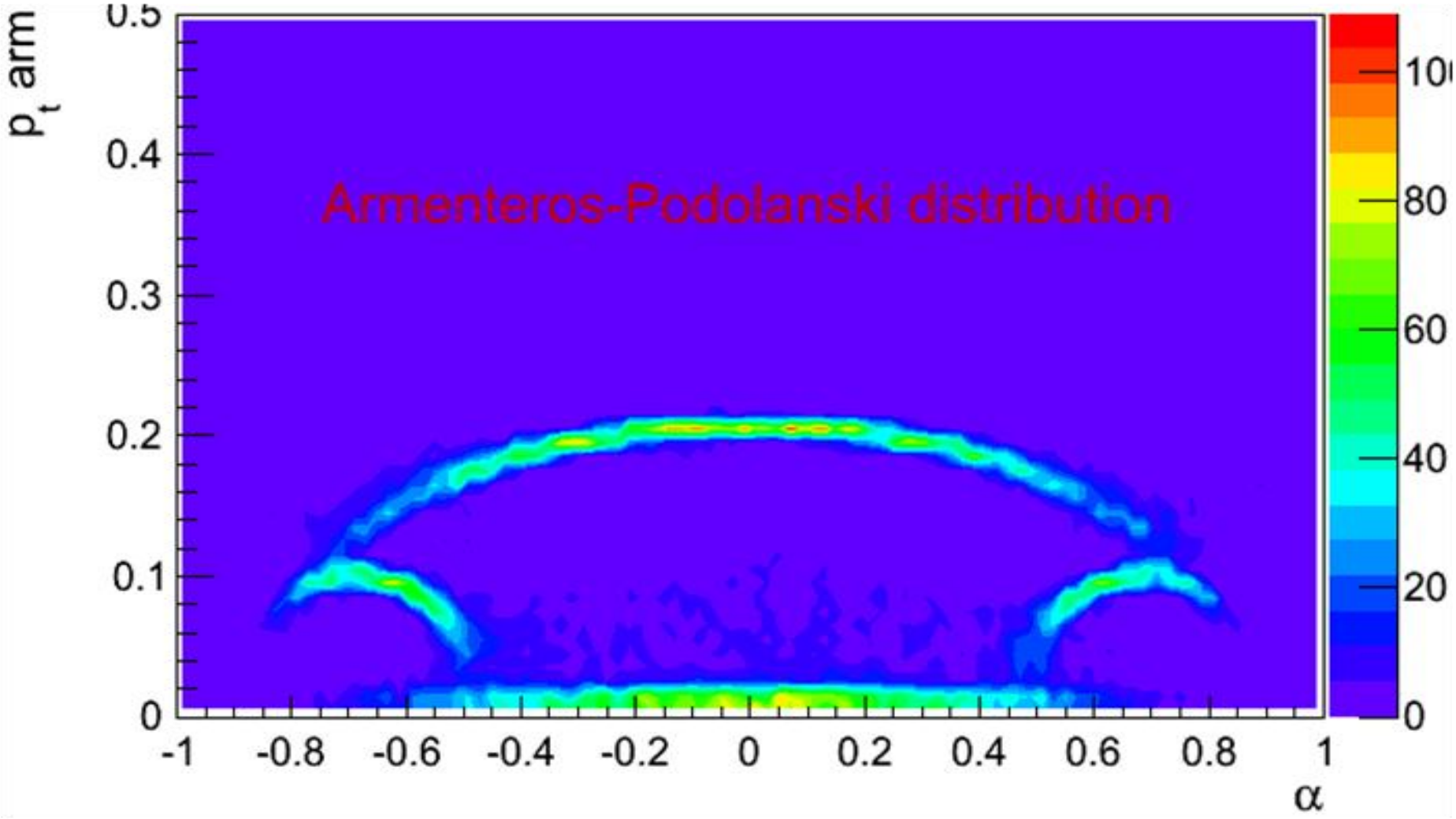
- Rays perpendicular to beam axis
- 2 x 4 z-planes of 42 rays
- Strategic boundary crossings
- Effective ray ∅ ~1mm
- Additional signal from central electrode

Laser Calibration and Monitoring System Principle



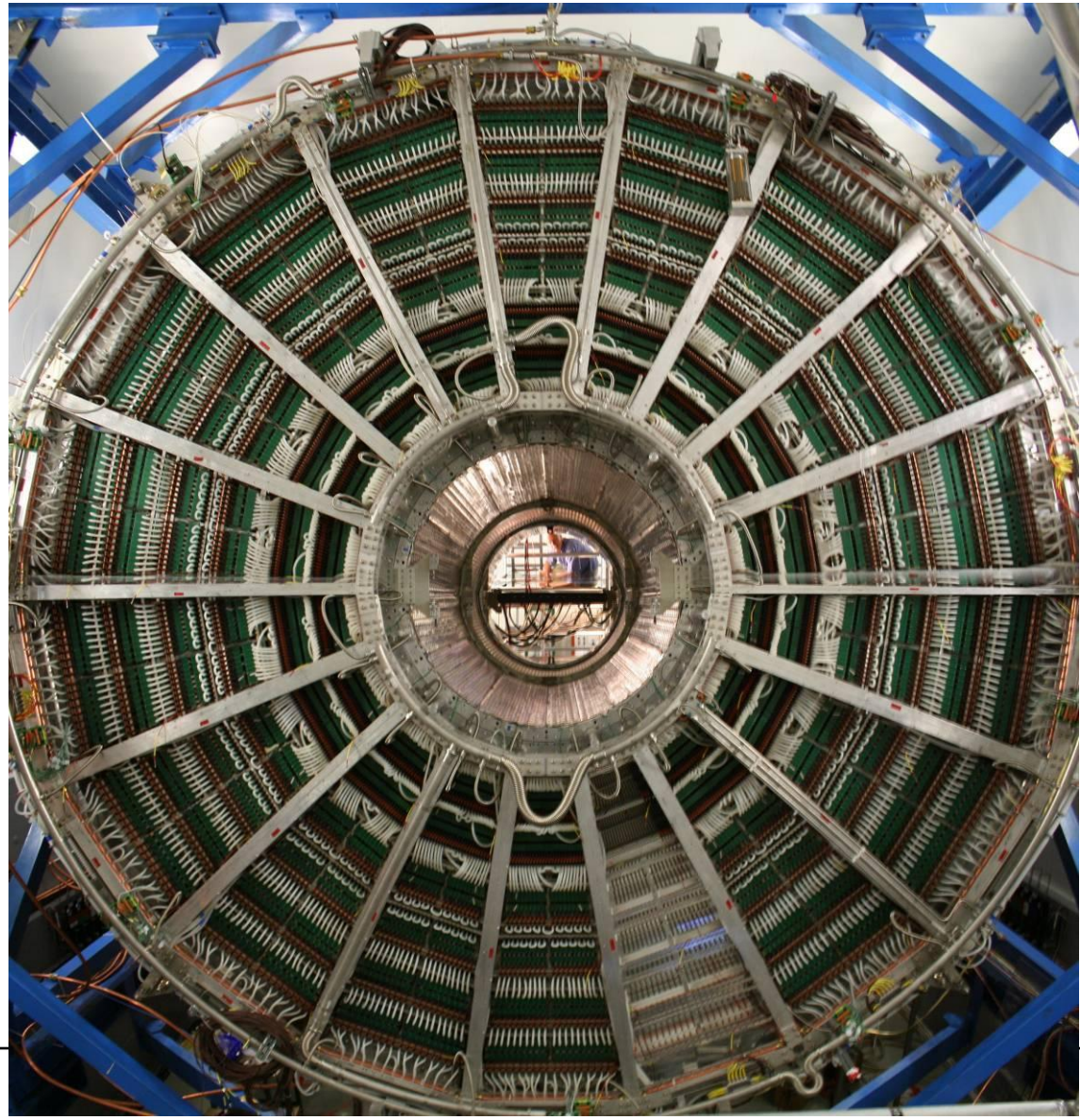
4 micro mirrors along z, alignment check with CCD at other TPC end


TPC signal (a.u.)
180
160
140
120
100
80
60
40
20
K
p
d
π
μ
e
No vertex cut !
TPC
10^{-1}
1

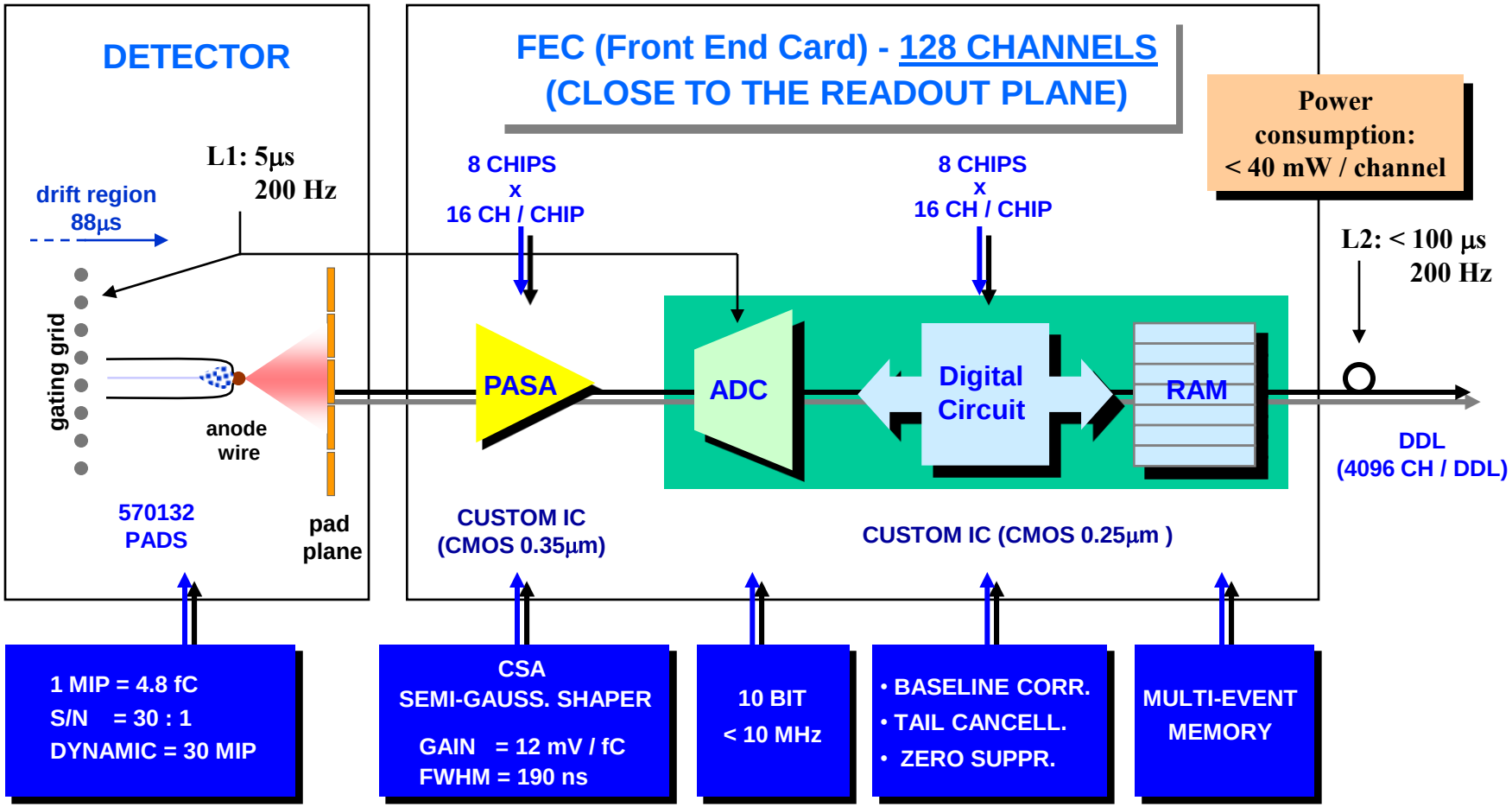

Armenteros-Podolanski distribution
p_t arm
0.5
0.4
0.3
0.2
0.1
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
α
100
80
60
40
20
0

Commissioning of the ALICE TPC
since Apr 06

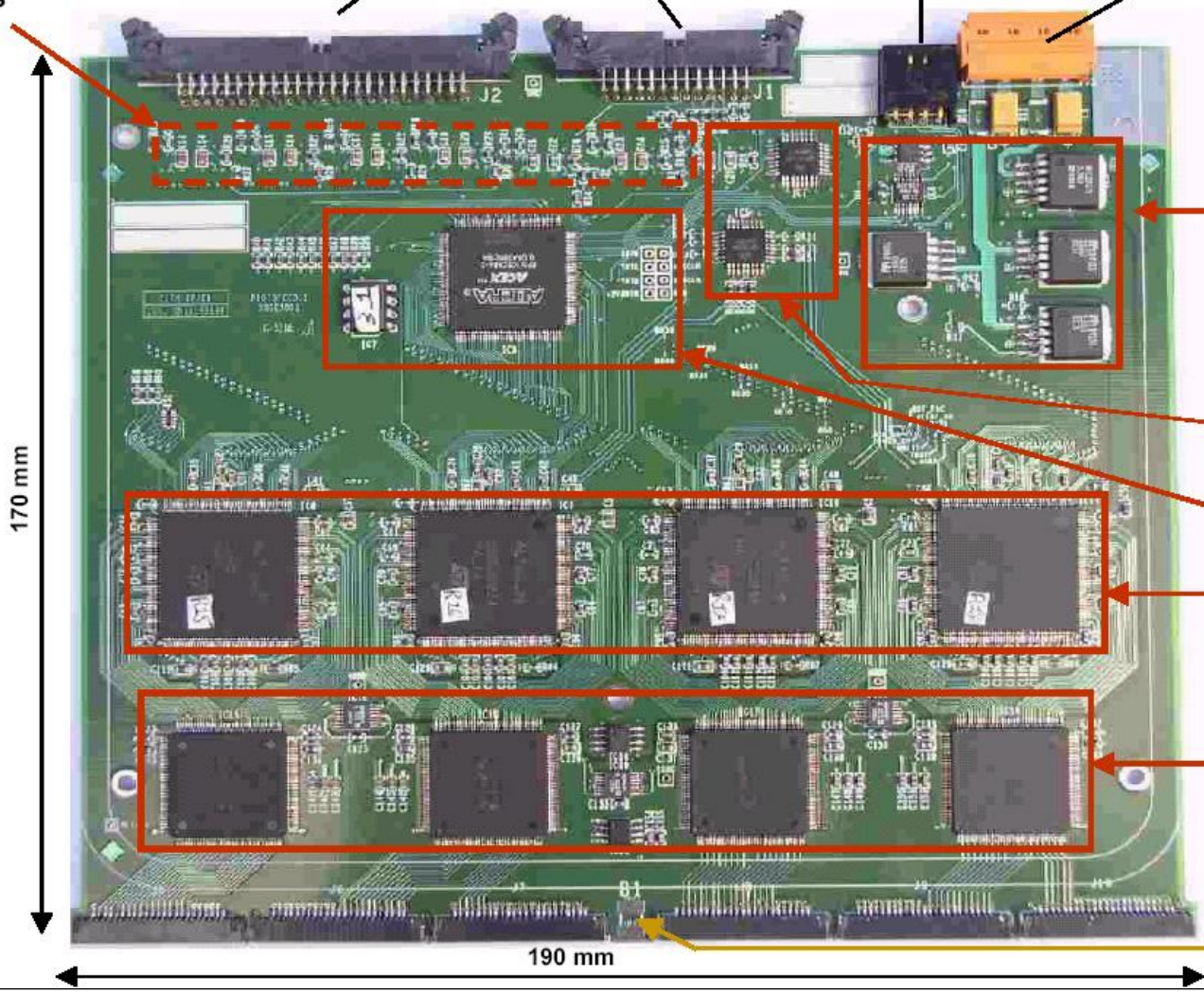
- 72 readout chambers
- 557,568 channels, 1000 time bins each
- 4356 front end cards
- Pre-commissioning:
  - Gas system: 95 m^3 $Ne/CO_2/N_2$ (90/10/5), now 2 ppm O_2
  - 2 sectors at a time
  - Full data chain
  - Cosmic ray tracks
  - Laser tracks
  - Noise $\sigma \sim 0.7$ ADC cts



Frontend Electronics: Architecture

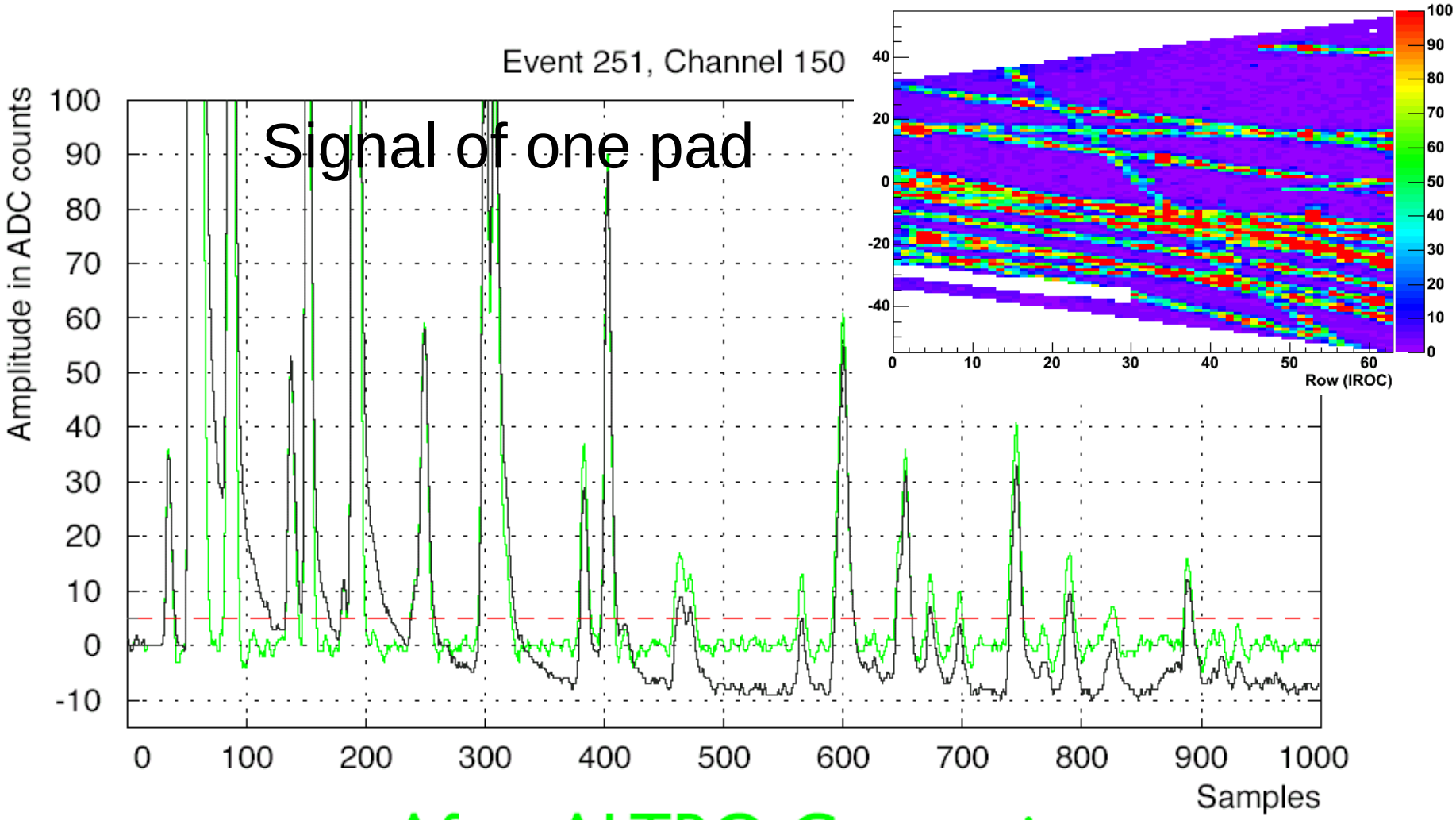


Front-end Card



128 ch

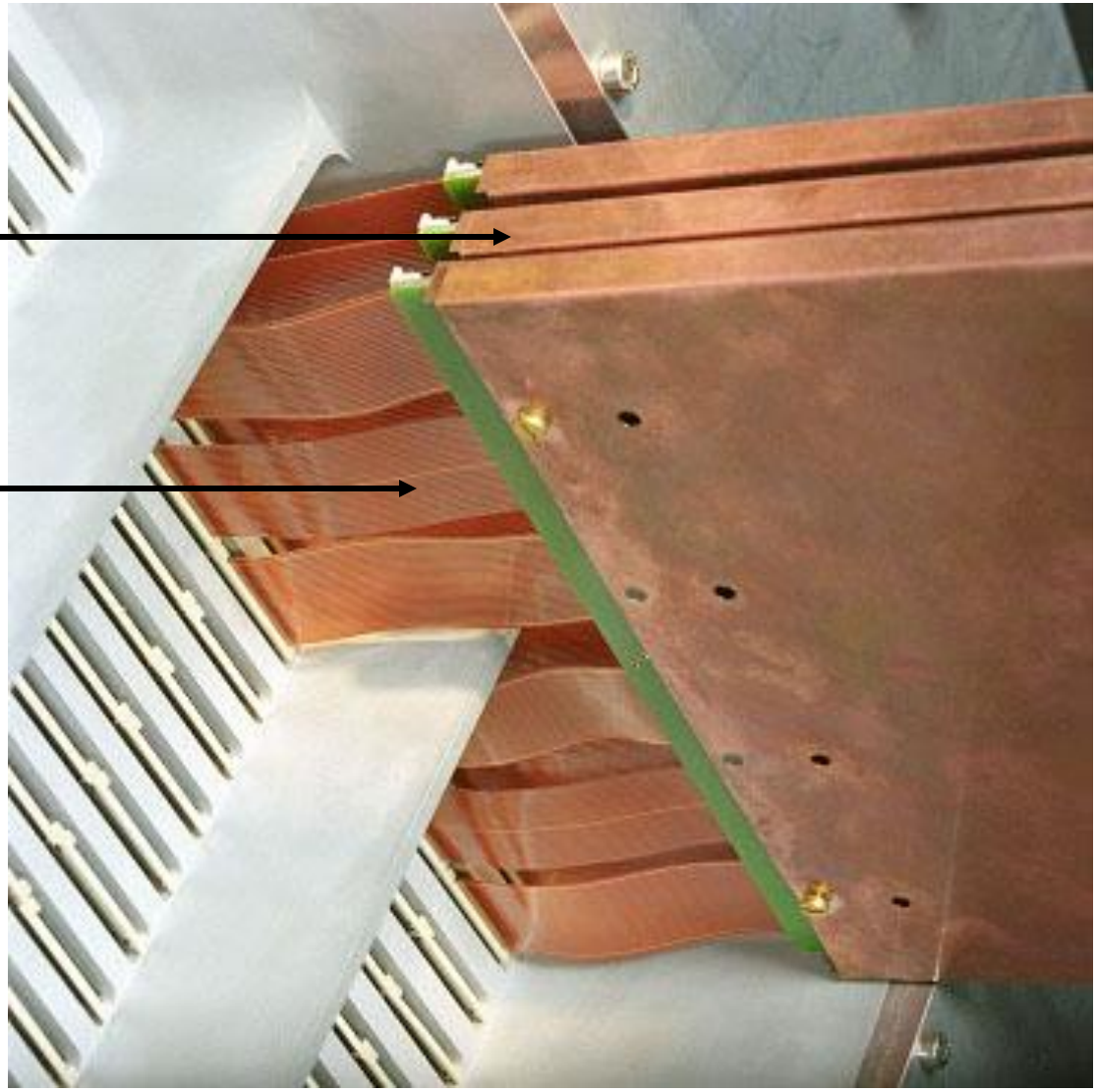
ALTRO digital tail cancellation and baseline restoration



Inner readout chamber connected to front end card

FEC in Cu sandwich

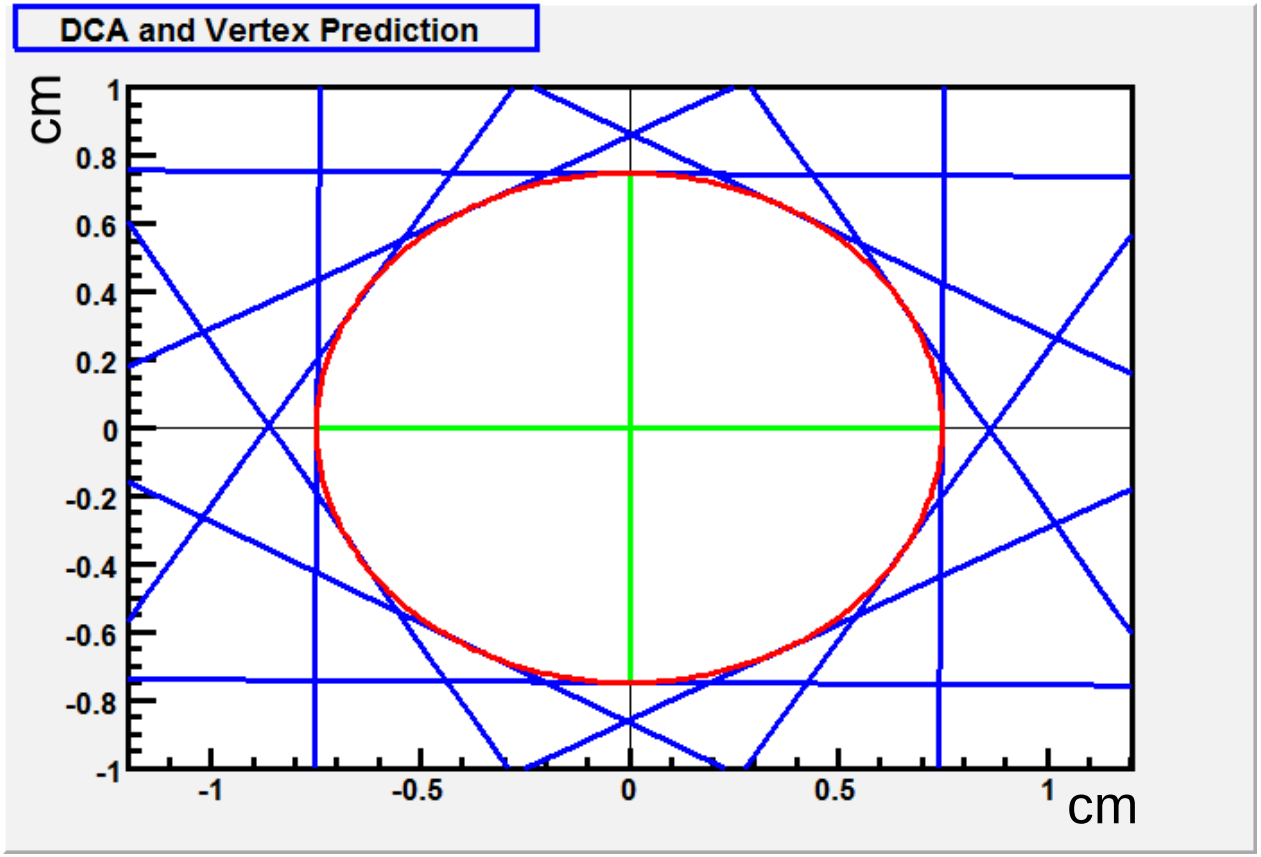
6 cables per FEC



- 128 ch/FEC

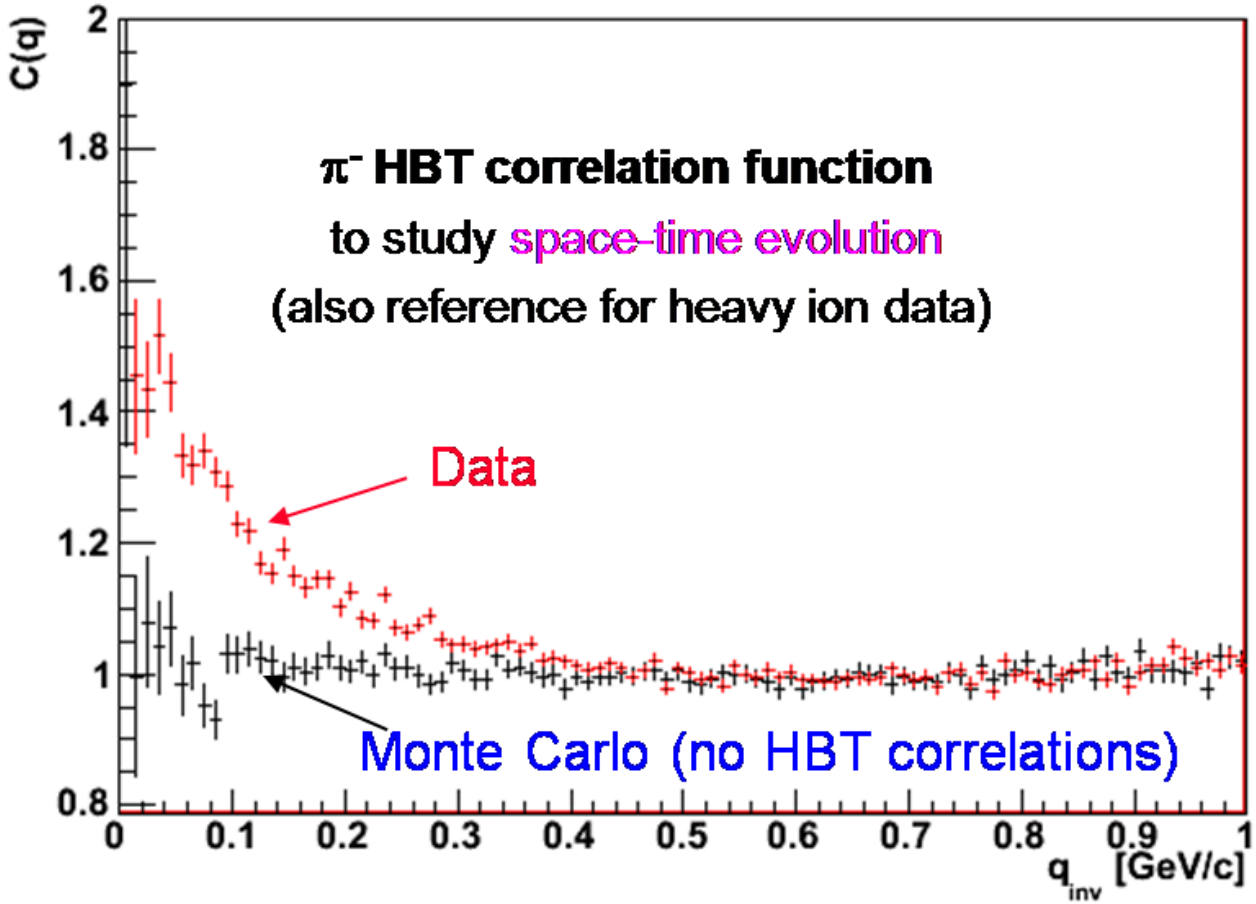
Calculated space charge effect in the ALICE TPC

Jim Thomas
STAR

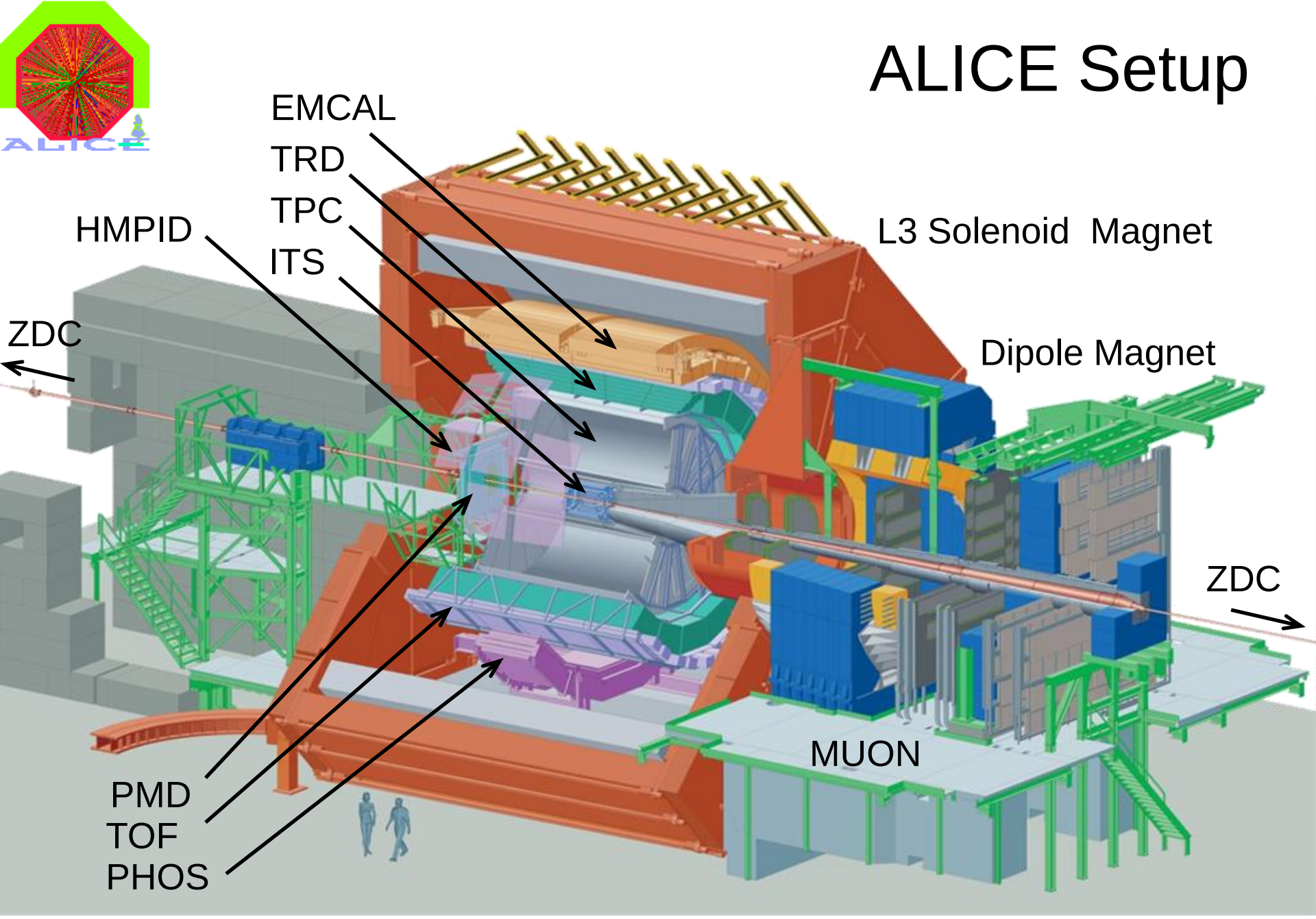


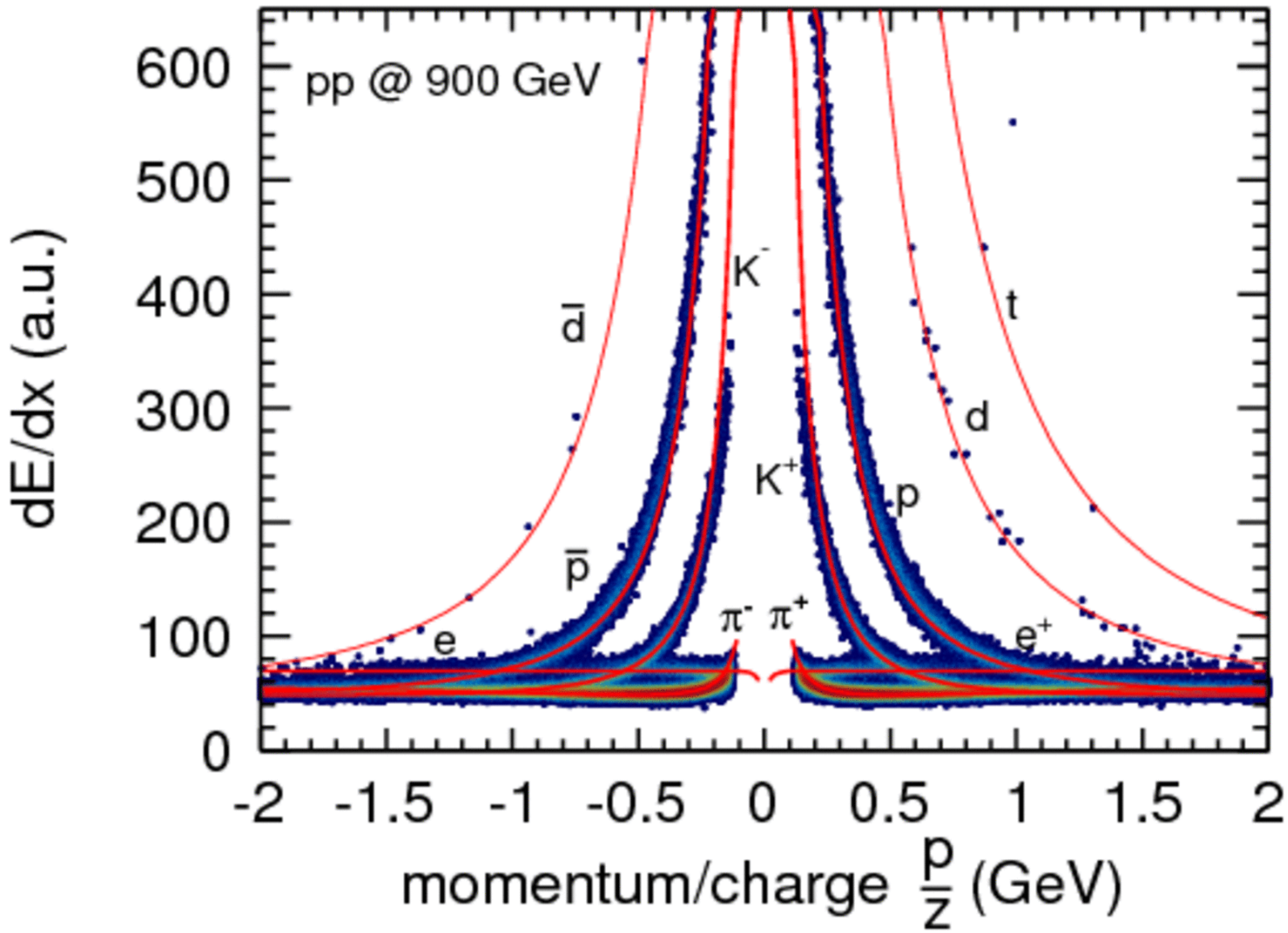
- ALICE geometry
- based on STAR charge density distribution
- 15 kHz collision rate (effect linear with rate)
- event-by-event correction possible

HBT correlations

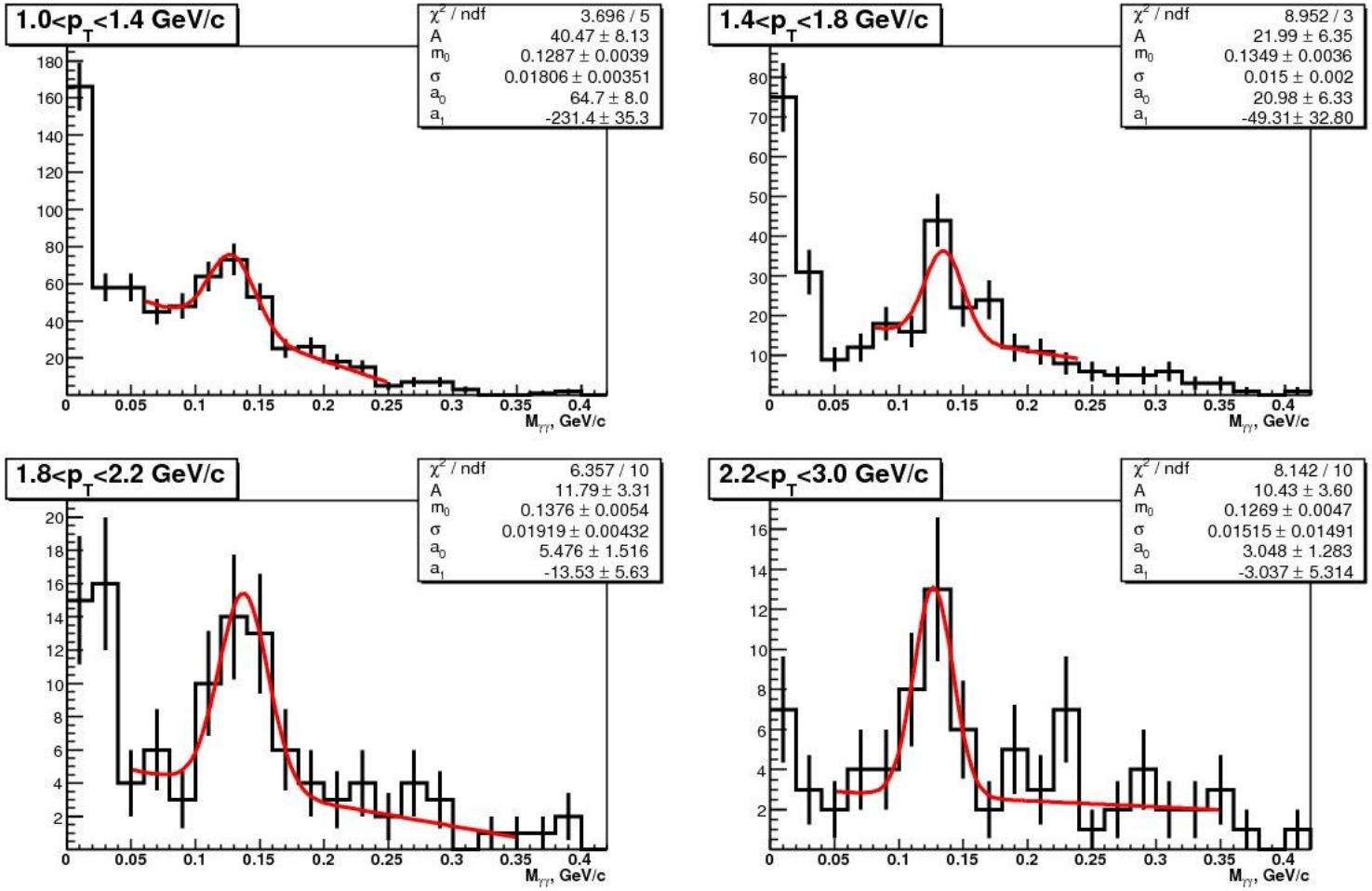


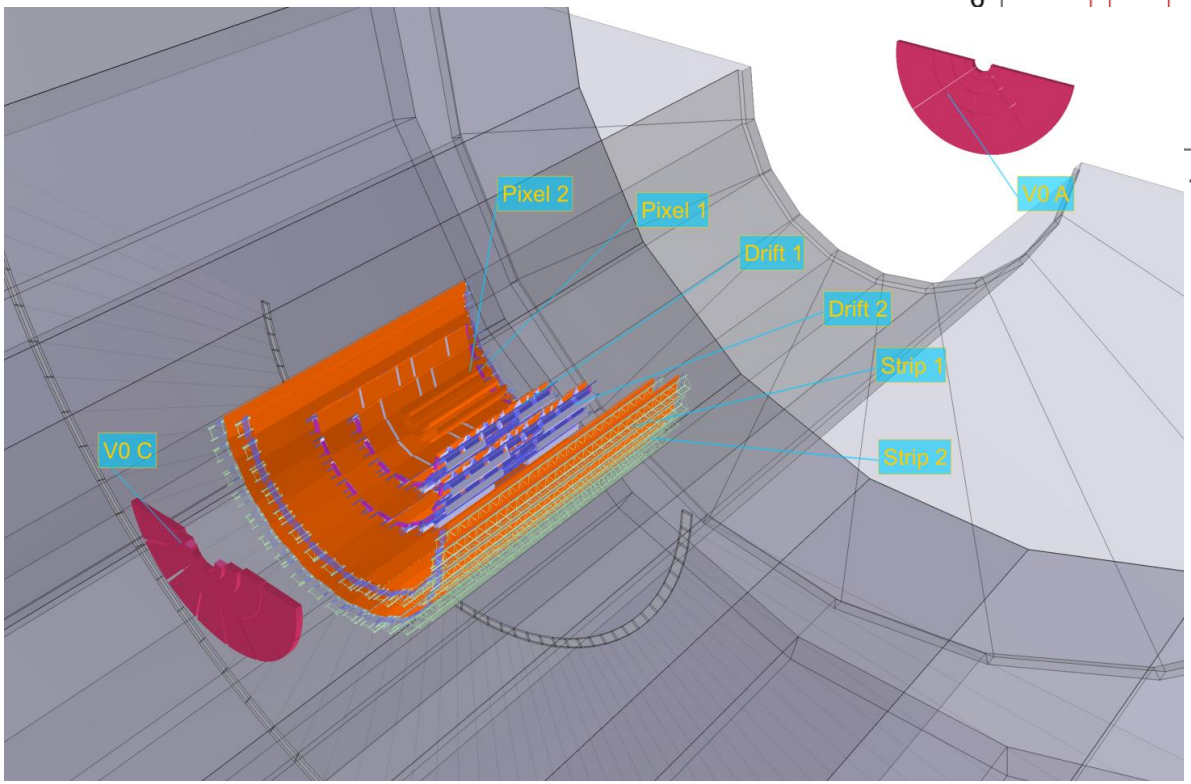
ALICE Setup

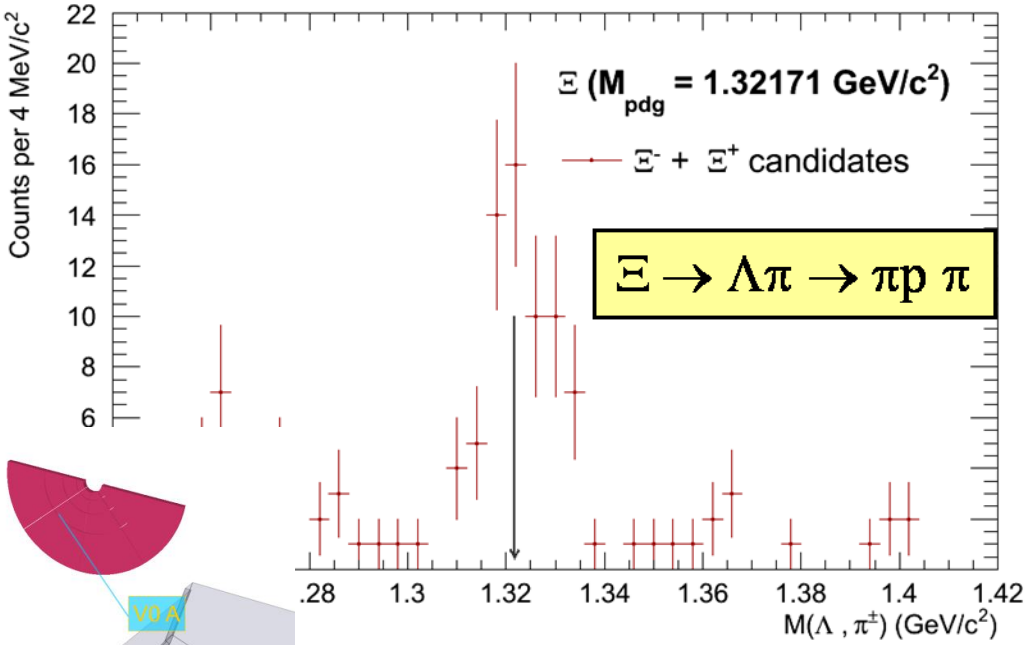

EMCAL
TRD
TPC
ITS
HMPID
L3 Solenoid Magnet
ZDC
Dipole Magnet
ZDC
MUON
PMD
TOF
PHOS


pp @ 900 GeV
dE/dx (a.u.)
600
500
400
300
200
100
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
momentum/charge p/z (GeV)
d̄
p̄
e
K⁻
K⁺
π⁻ π⁺
p
d
t
e⁺

PHOS $\pi^0 \rightarrow \gamma\gamma$




Pixel 2
Pixel 1
Drift 1
Drift 2
Strip 1
Strip 2
V0 A
V0 C


Ξ (M_pdg = 1.32171 GeV/c²)
Ξ⁻ + Ξ⁺ candidates
Ξ → Λπ → πp π
Counts per 4 MeV/c²
M(Λ , π±) (GeV/c²)

ITS: track impact parameter resolution (xy)