Online TRD tracking and PID (trigger for e^+e^-)

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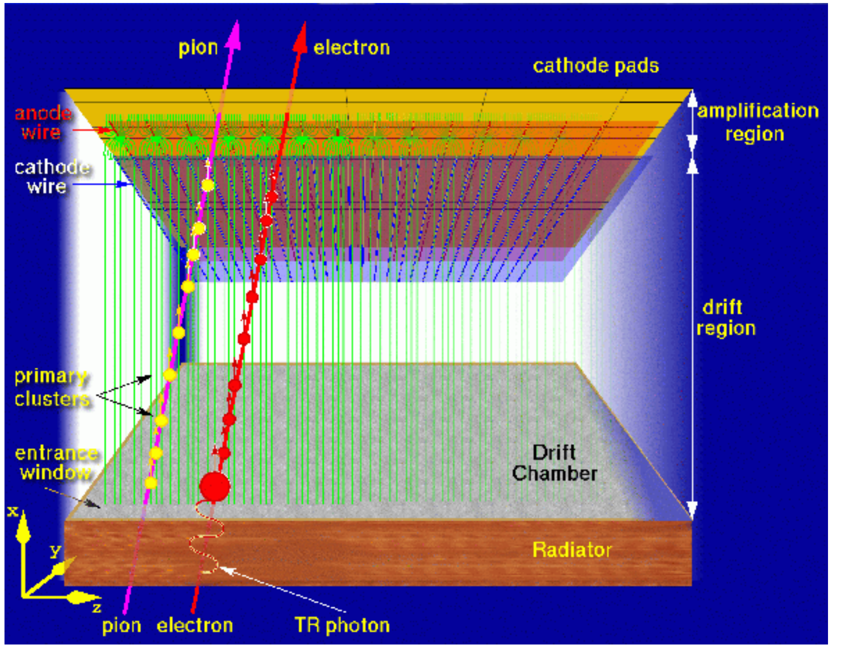
ALICE/TRD collaboration



Quarkonium measurements with ALICE

Measurements of the complete spectrum of resonances: J/ψ, ψ', ψ'', Υ, Υ'

In the dilepton decay channels:

J/ψ → $\mu^+ \mu^-$ with the MUON spectrometer in $2.5 < \eta < 4$

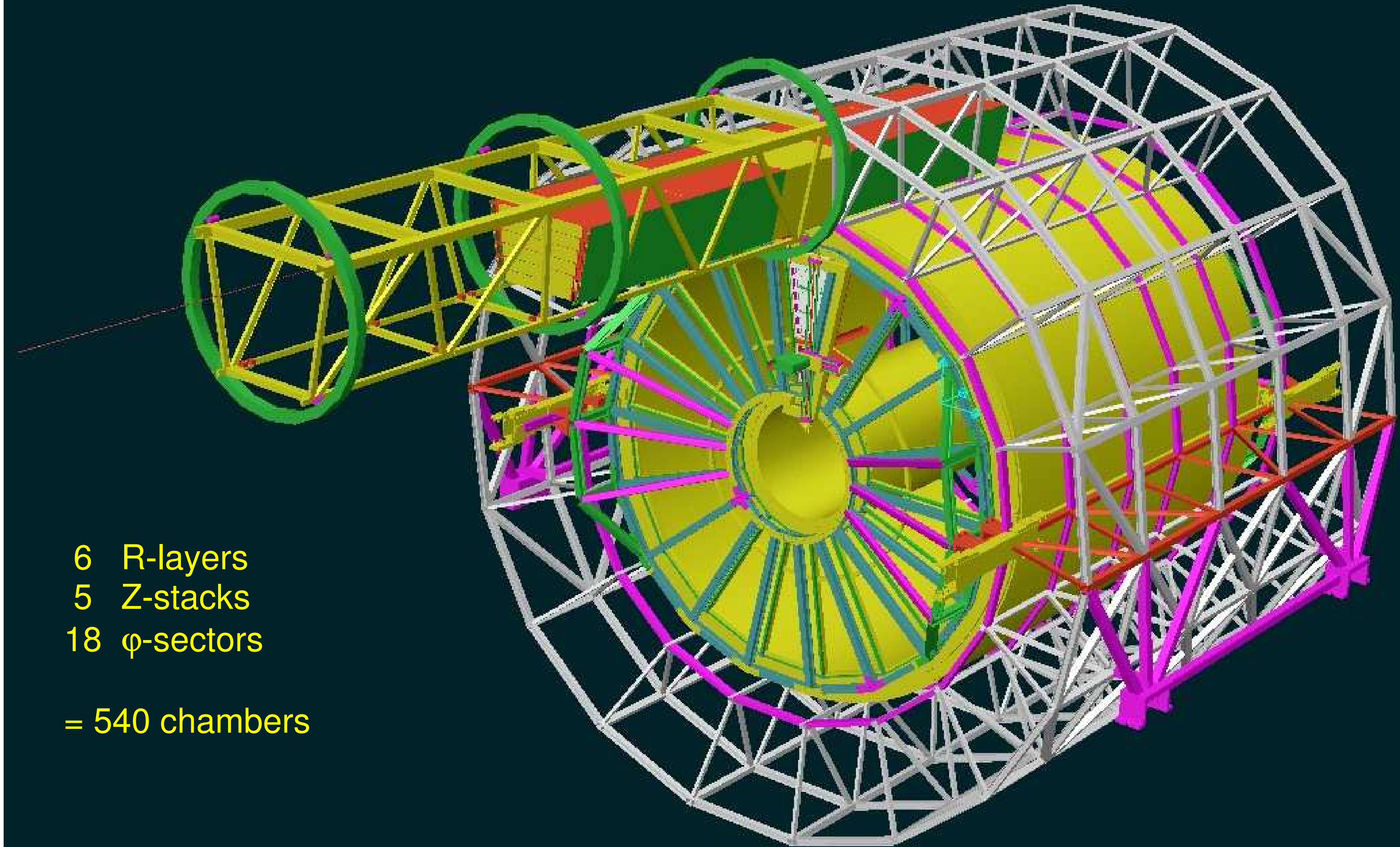
J/ψ → $e^+ e^-$ with TRD (and TPC) electron identification and ITS+TPC+TRD momentum measurement, in $-0.9 < \eta < +0.9$

Cross-sections in minimum bias AA collisions

System	Pb+Pb	Sn+Sn	Kr+Kr	Ar+Ar
$\sqrt{s}$ (TeV/nucleon)	5.5	5.84	6.14	6.3
Resonance	$B_{\mu\mu}\,\sigma_{AA}$ (μb)			
J/ψ	48930	17545	9327	2321
ψ'	879	315	167.6	41.7
Υ	304	108.1	57.4	13.8
Υ'	78.8	28	14.8	3.6
Υ''	44.4	15.8	8.4	2.0

ALICE-INT-2003-042

The ALICE-TRD detector

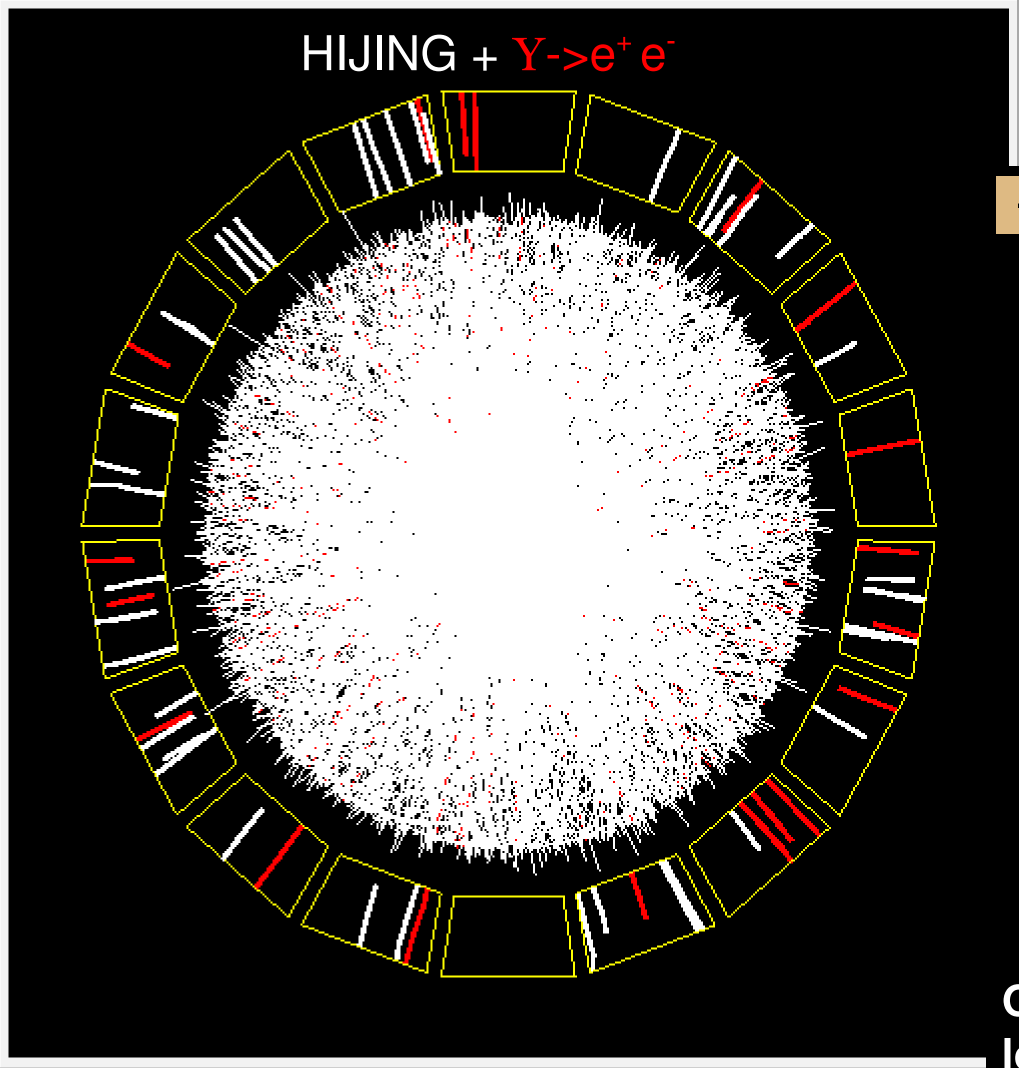


6 R-layers
5 Z-stacks
18 φ-sectors

= 540 chambers

Detector simulations: AliRoot + GEANT 3.21

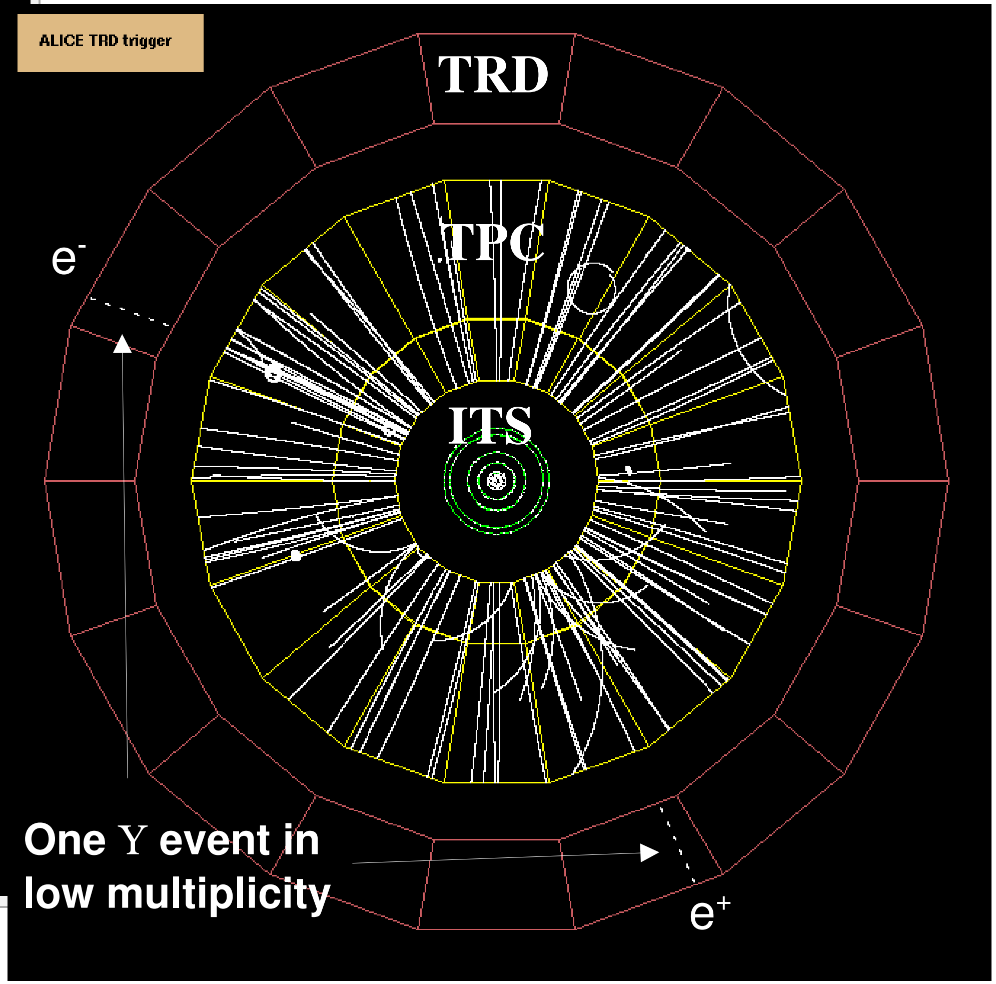
Online tracking of primary electrons + high p_t pions (p_t^{thr} = 2.3 GeV/c)



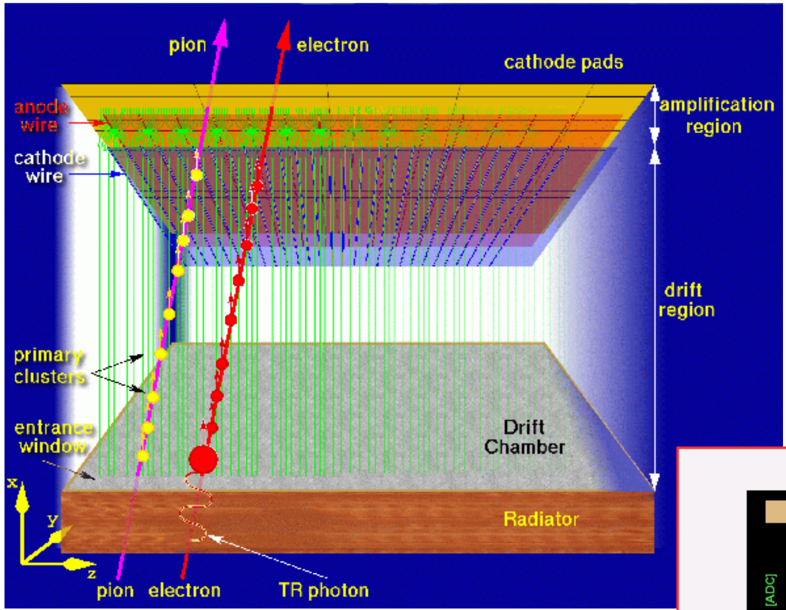
$$(dN/dy)^{ch}_{y=0} = 800$$

Online:

- Measure p_t (with IP vertex)
- Simple PID signature
- Open angle selection (sector number)
- Invariant mass cut ?...



The TRD chamber



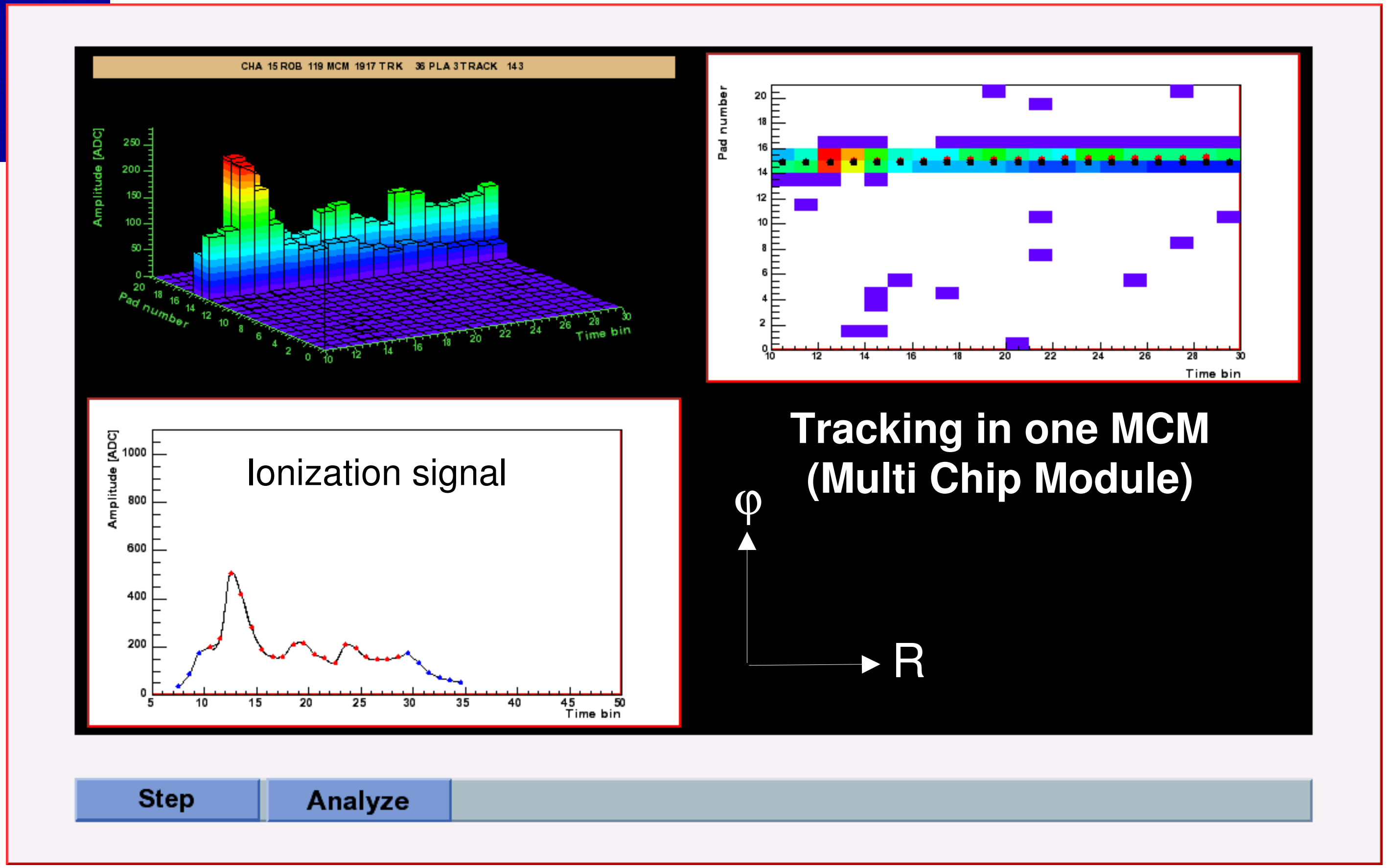
Readout of ~ 1.2 million channels (pads 90 x 8 mm) by the FEE with ASIC MCM (65664 x 18 channels)
Online tracking resolutions:

- 400 μm in the bending plane
- 0.5 deg in slope (a measure of p_t)
- ~ 2.5 cm in z ($L^z_{pad}/\sqrt{12}$)
- PID: $\varepsilon_\pi = 0.02$, $\varepsilon_e = 0.90$ ($\gamma > 1000$ TR)

- Large active area
- Mechanical stability
- Low radiation lenght
- High TR yield
- Highly integrated FEE
- Good cooling

Laboratories:

- Heidelberg
- Darmstadt
- Dubna
- Bucharest



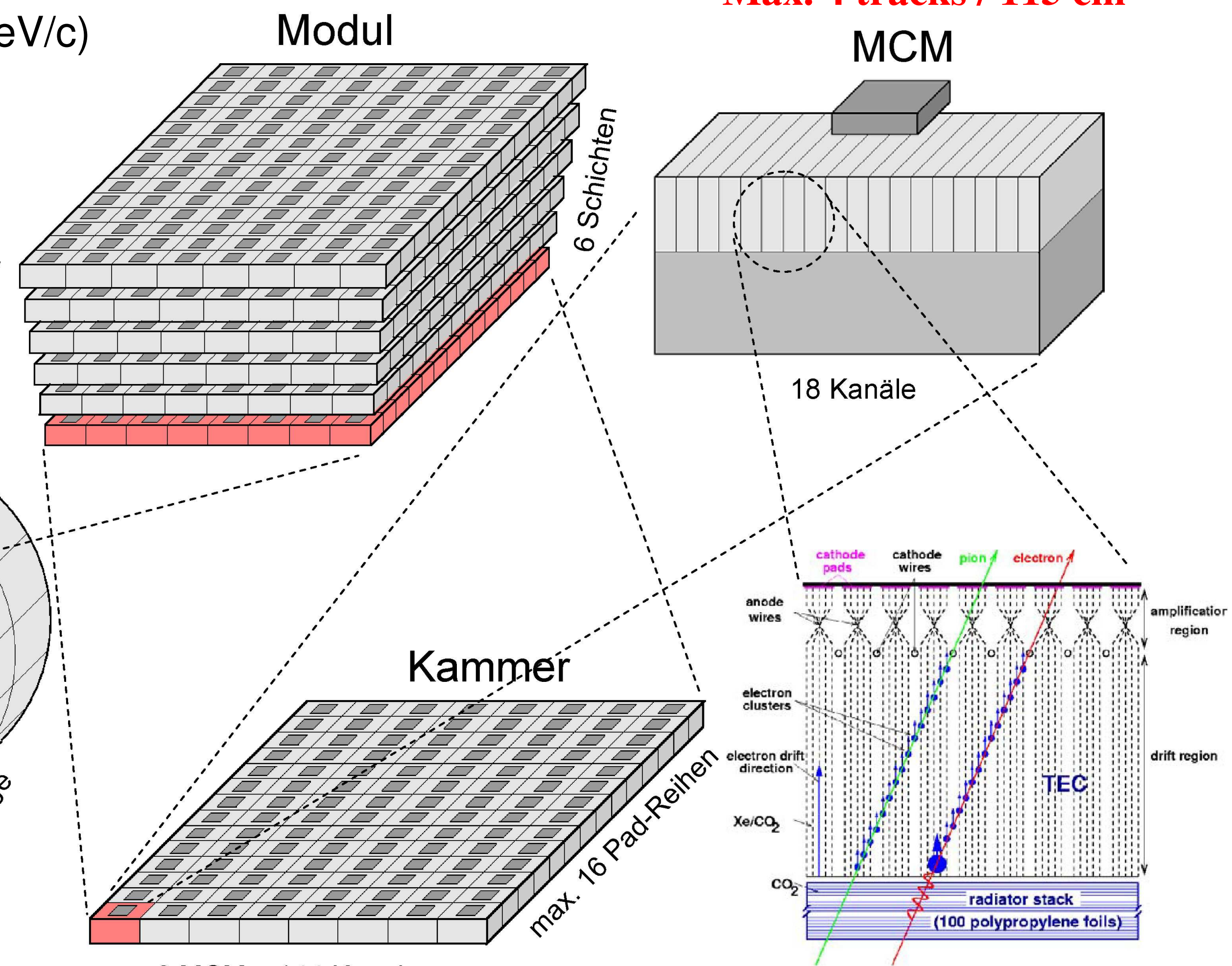
The TRD detector and readout segmentation

Trigger condition:

Trigger time: 2.0+0.5 µs (10 MHz) + 2.0 µs (120 MHz) + 1.6 µs (?) = 6.1 µs

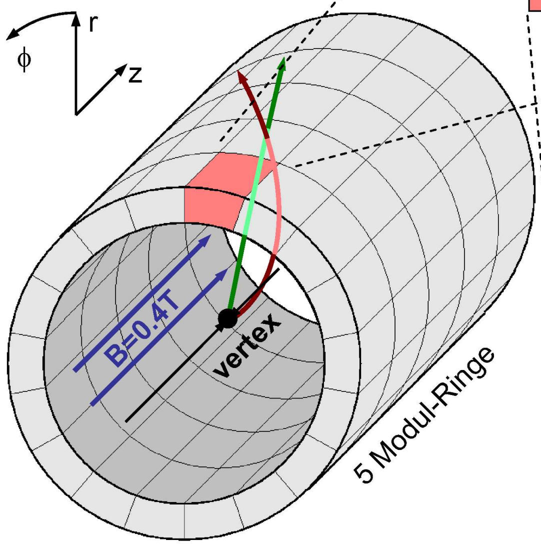
- at least one „+“ „-“ pair
- $p_t > p_t^{thr}$ (2.3, 2.7, 3.0 GeV/c)
- $\Delta\varphi > 80$ deg
- PID = „e“
- M_{inv} ?

Max. 4 tracks / 115 cm²



Übergangsstrahlungs-

Detektor



18 Sektoren in azimuthaler Richtung

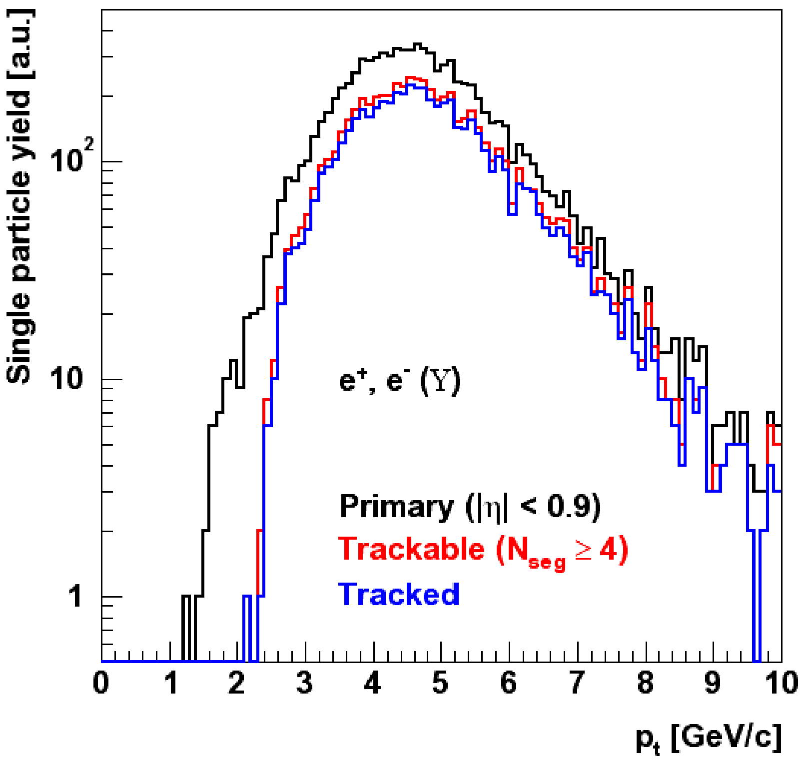
~ 13000 cm²

Online tracking efficiency for single electrons

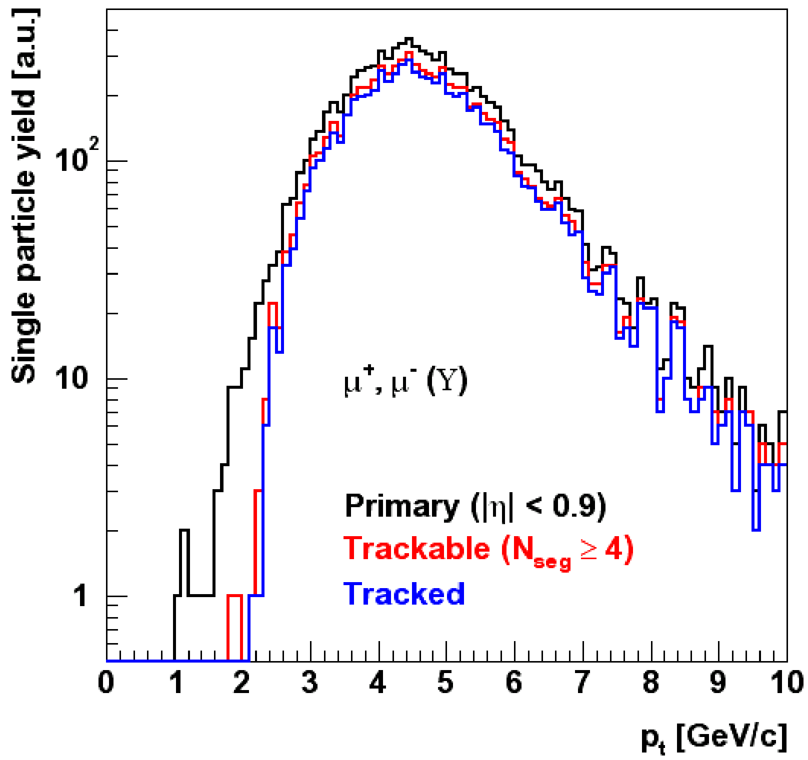
$p_t^{thr} > 2.0$ GeV/c safe for $\Upsilon(1S)$ trigger!

„Trackable“ = at chamber level (found separately in at least 4 chambers)
„Tracked“ = combinatorics over the TRD layers + sliding window matching

Very low multiplicity event



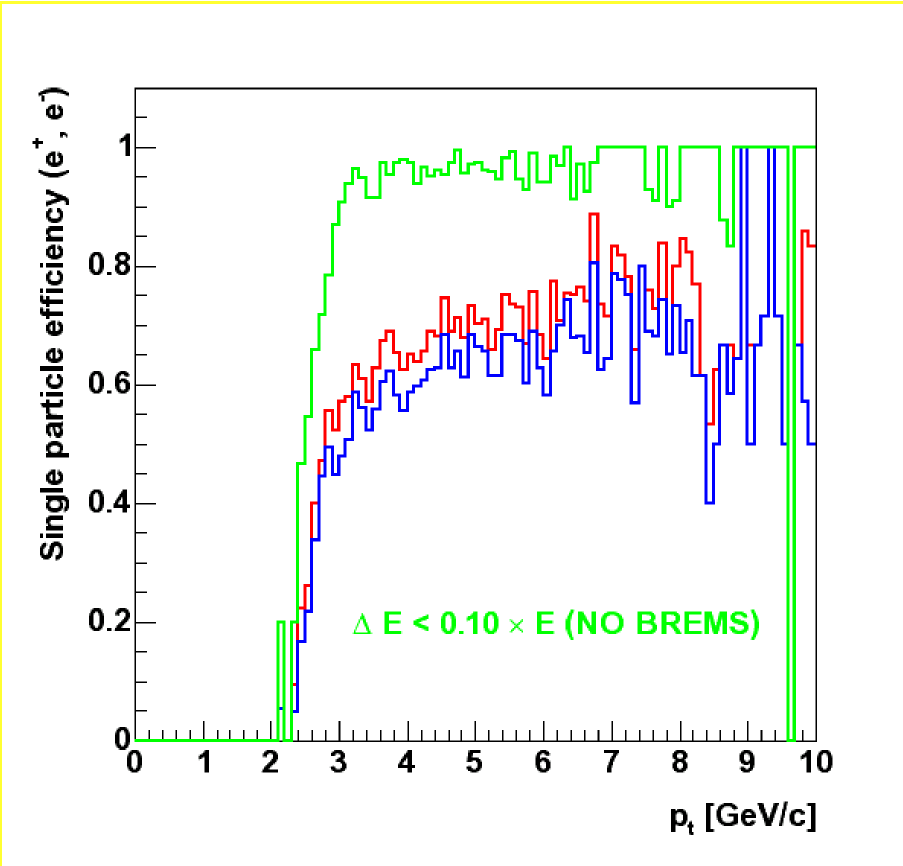
Case study to indicate the effect of the Bremsstrahlung on tracking efficiency.

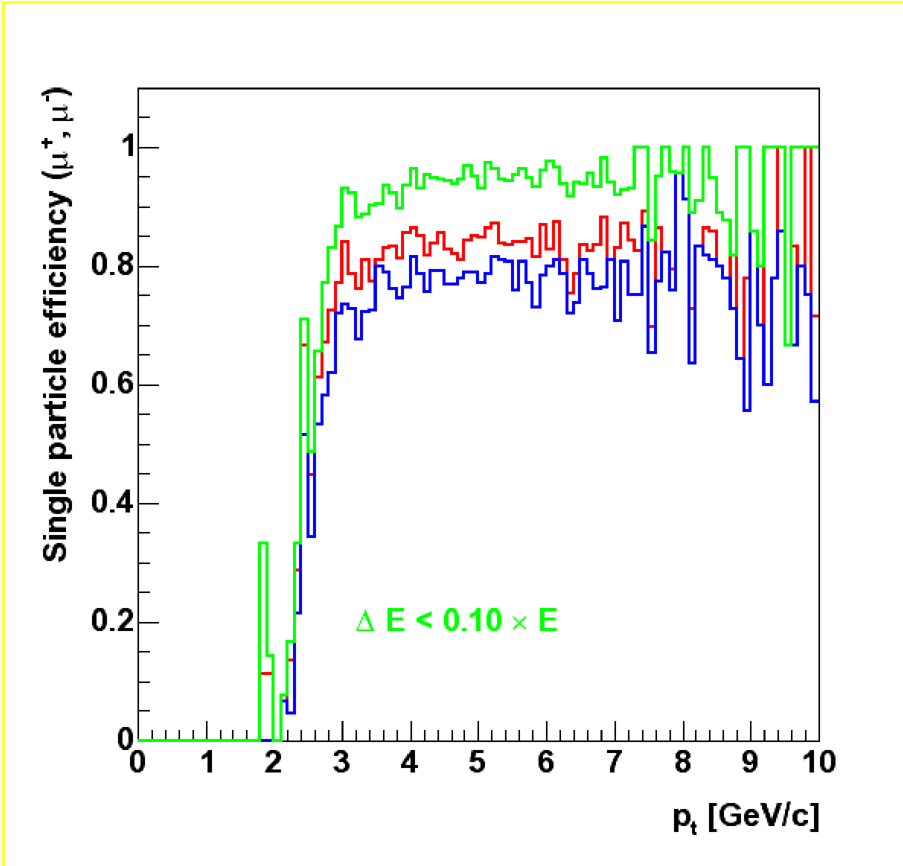


Tracking efficiency (contd.)

Very large effect (70%) of the Bremsstrahlung !
In the $\Delta E < 10\% E$ the tracking efficiency for electrons is slightly larger: higher ionization signal than of the muons.

Regardless of this effect, the „track finding“ efficiency (red -> blue) is similar (90-95%) for electrons and muons...





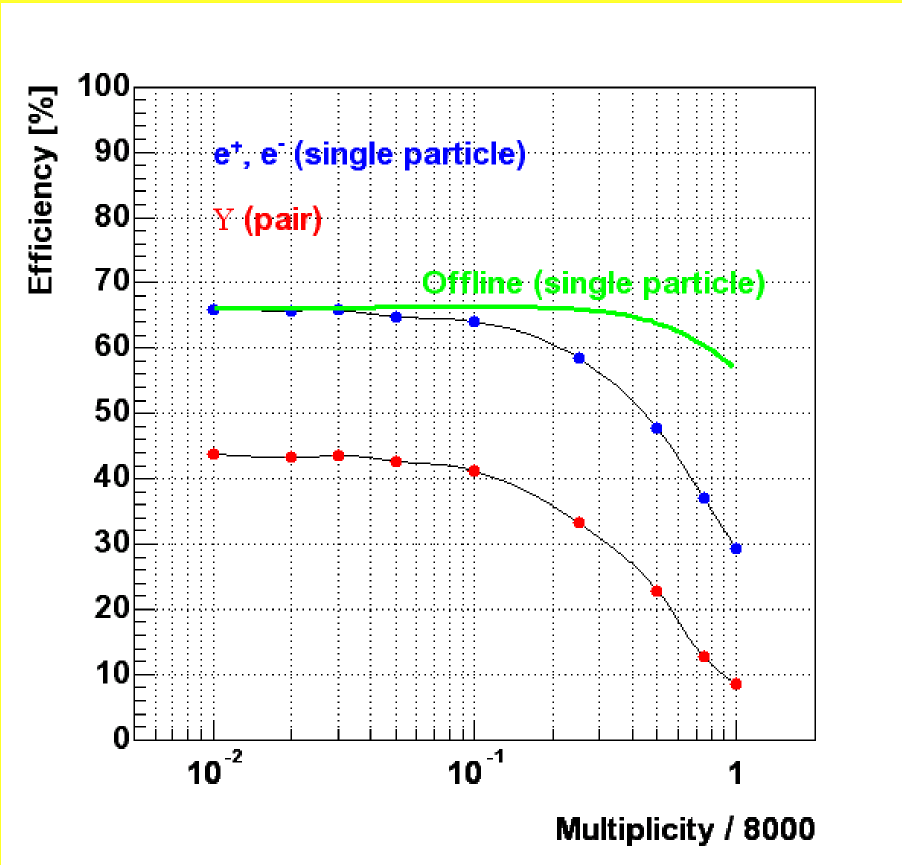
Tracking efficiency and momentum resolution at large particle multiplicity

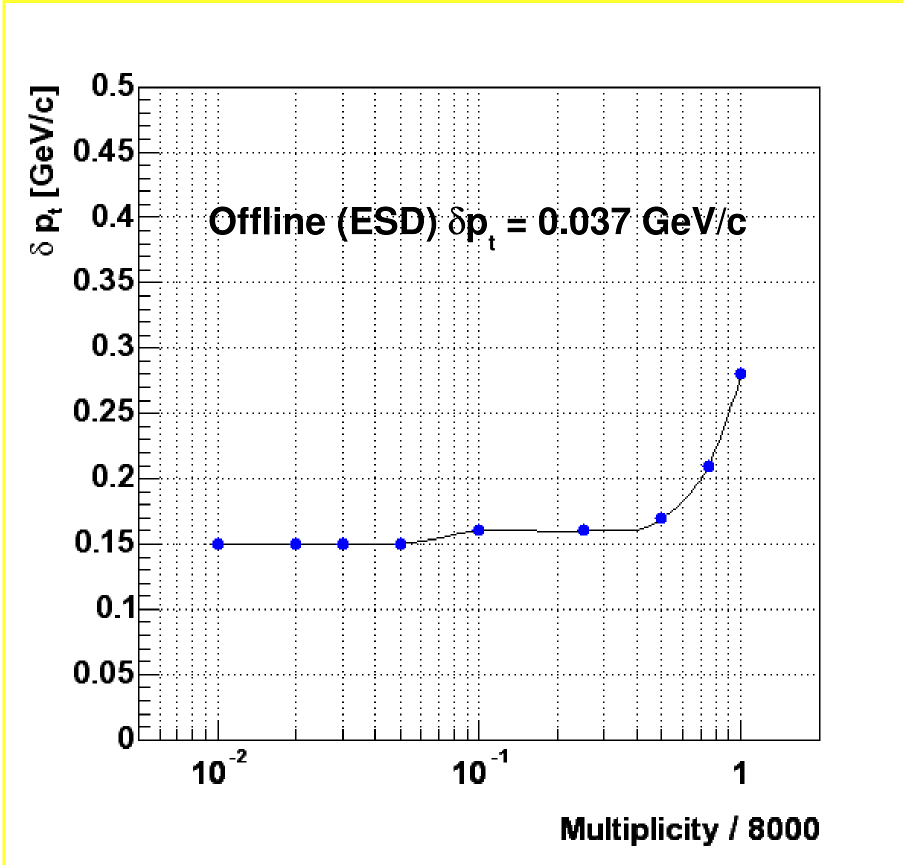
$$M \equiv (dN/dy)^{ch}_{y=0}$$

Centrality bins -> fixed HIJING total number of particles:
1, 2, 3, 5, 10, 25, 50, 75, 100 % of maximum (b=0) M = 8000,
with signal $\Upsilon(1S)$ merged.

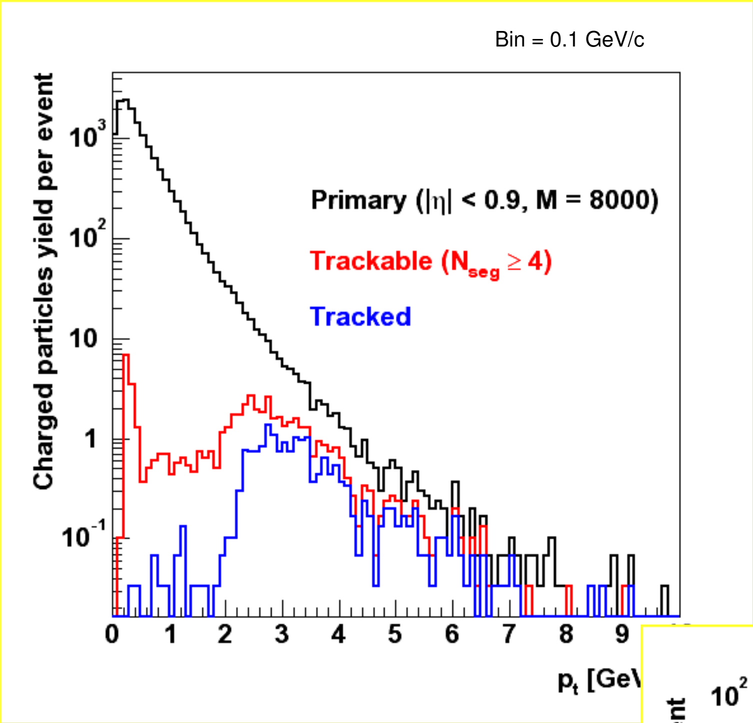
Detector occupancy (granularity limit) is observed at about M = 800.

Bulk (all p_t) resolution: about 3% for M ≈ 0





Trigger background (misidentified pions, secondary electrons)

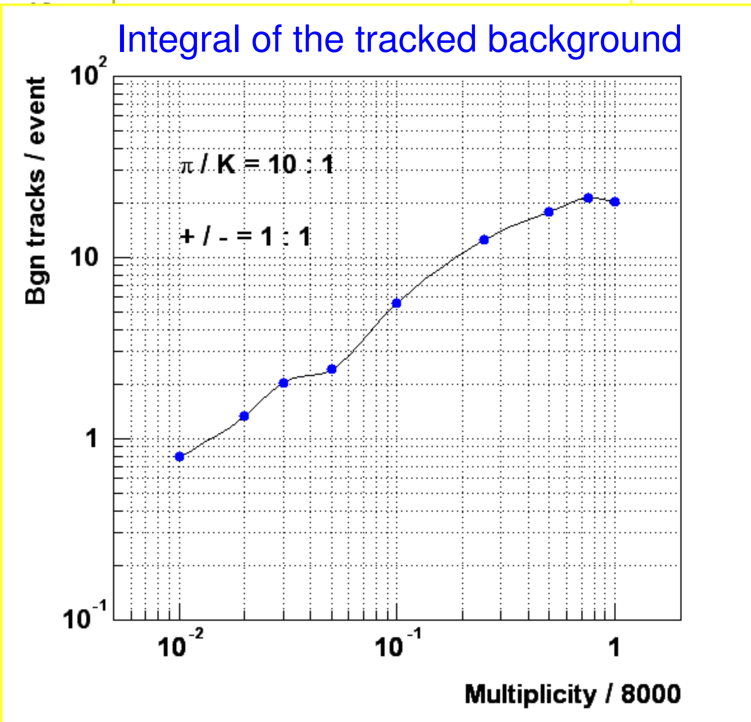


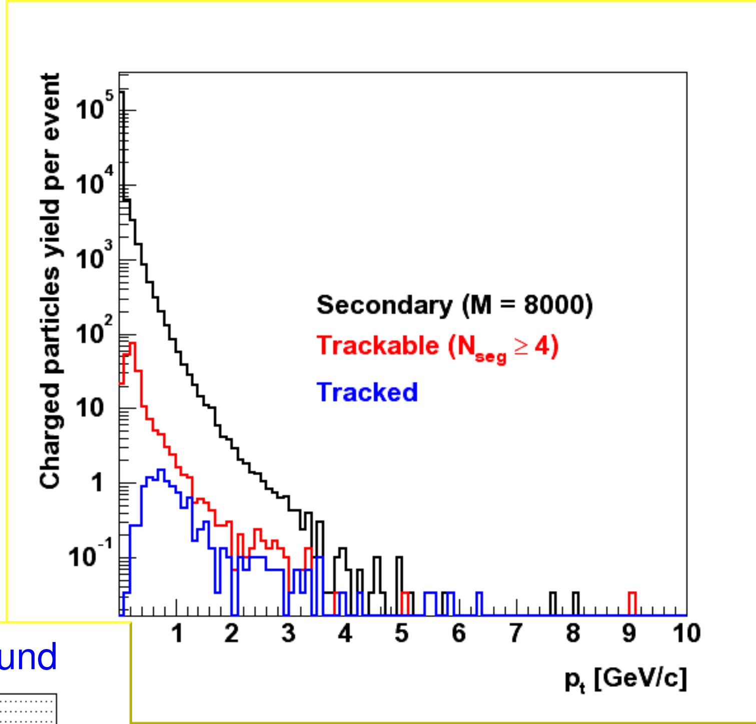
Particles over the threshold (2.3 GeV/c)
- IP real momentum -

dependent on model hardness of the p_t spectrum

Pions (etc) + PID

Still most of the trigger rate!





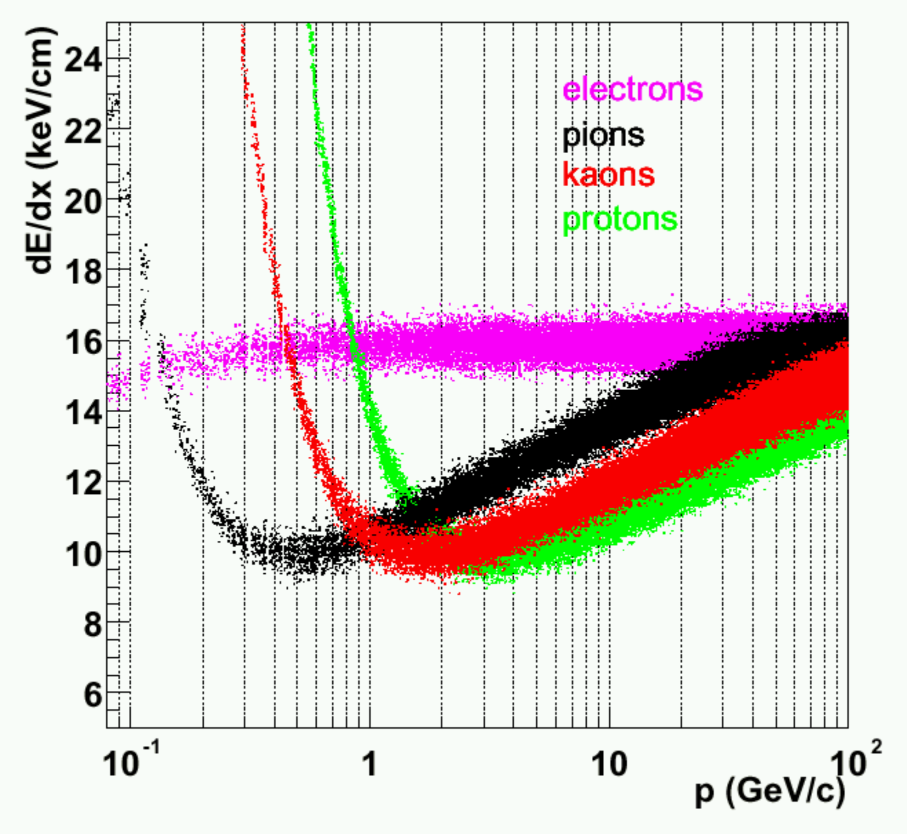
Unmatched p_t due to (wrong) vertex in tracking

Particle identification (π/e separation)

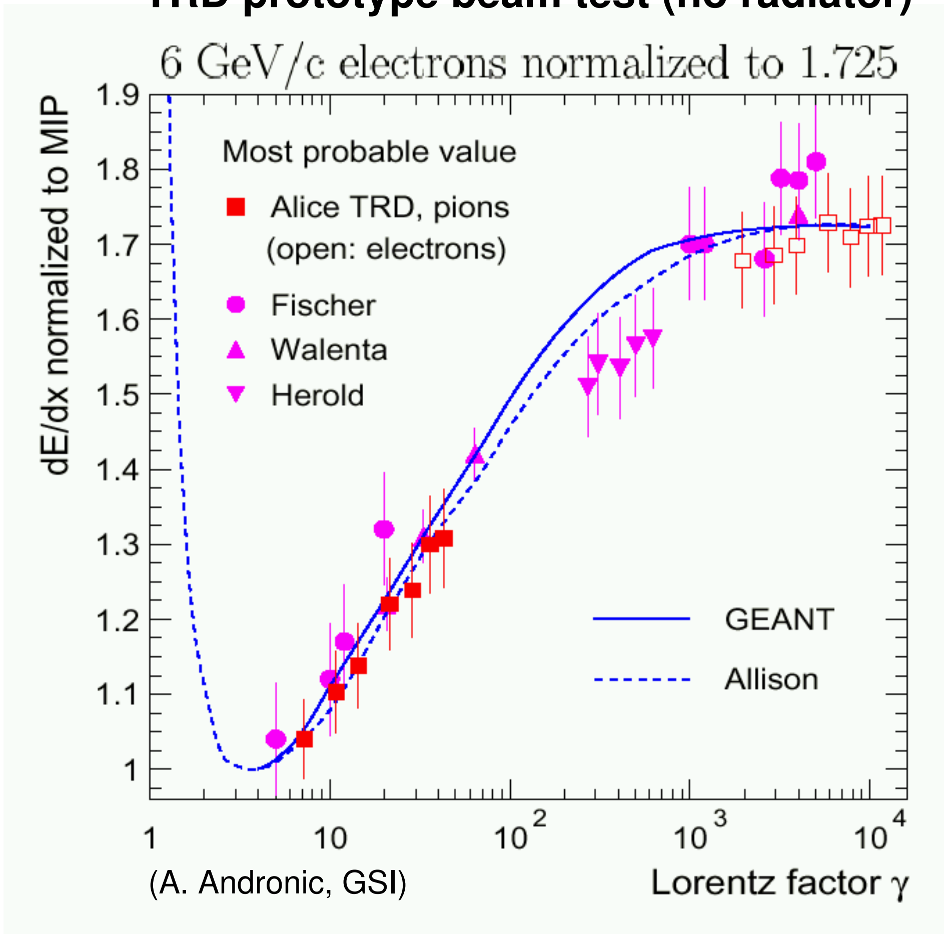
The **Time Projection Chamber** (TPC)
- Large volume, long tracks
- Good tracks separation (x,y,z)
- Small dEdx fluctuations (truncated, log means)

The **Transition Radiation Detector** (TRD)
- Very short track segments (6 x 3 cm)
- PID requires large dynamic range (TR tails)

$\sigma(dE/dx) = (6.9 - 10\ \%)\ dE/dx$



TRD prototype beam test (no radiator)



Measuring the ionization in the TRD chamber

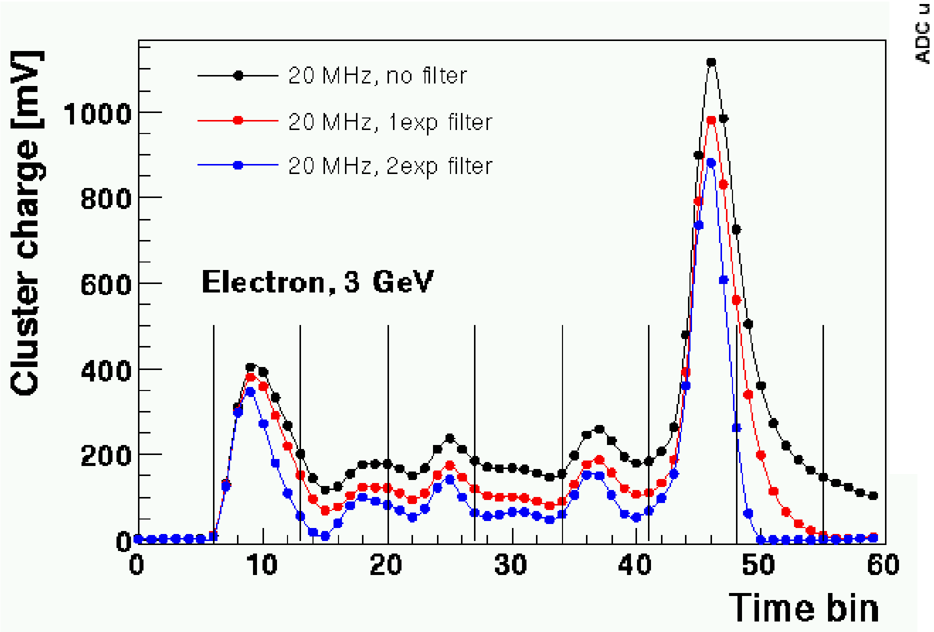
Ionization in 3 cm Xe/CO^2 (85/15)

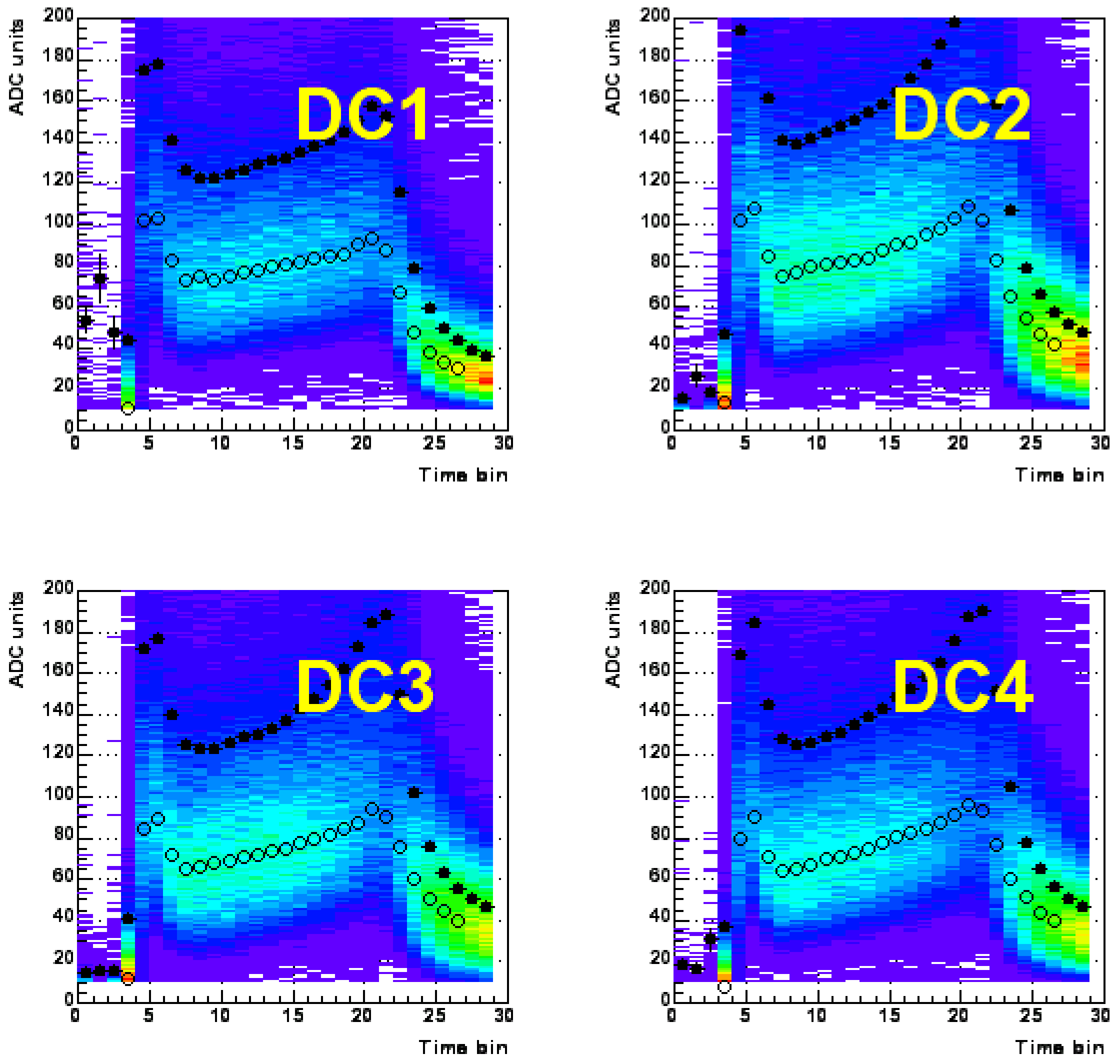
Integration time = 2 μs

Sampling = 10 Mhz

Methods:

- Likelihood on total charge (LQ)
- Likelihood on total charge and position of the maximum cluster (LQX)
- Variations of LQX: LQN-zones
- Neural Network Analysis of the ionization profile (3 x N input data)





Average pulse height time profile

π/e separation methods applied on test data : experimental setup

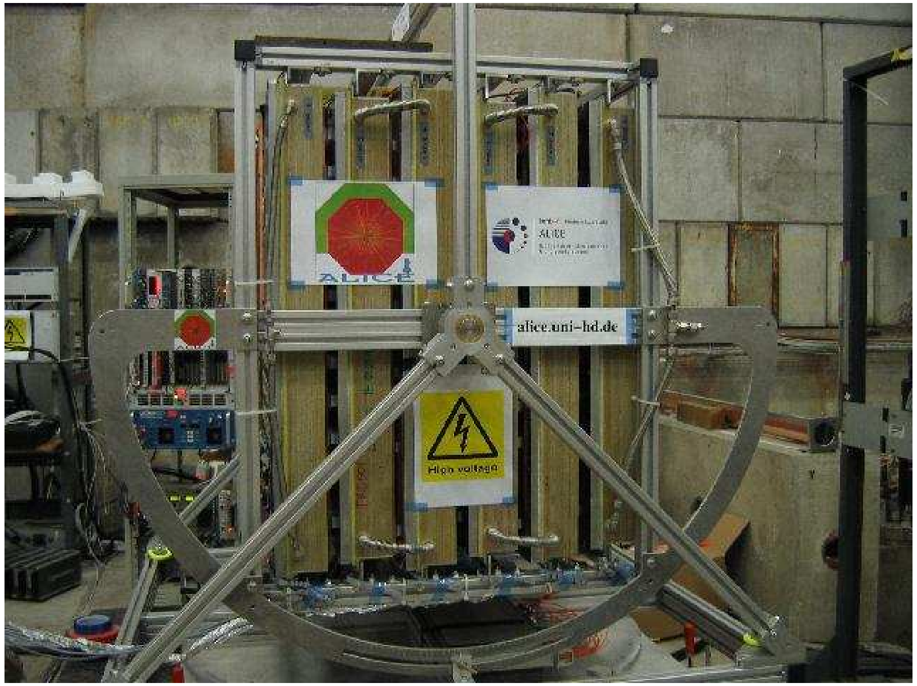
Secondary beam at CERN-PS, 1 .... 10 GeV/c

Small 4 chamber prototypes

PASA + FADC + MBS (DAQ at GSI)

2002, 2004

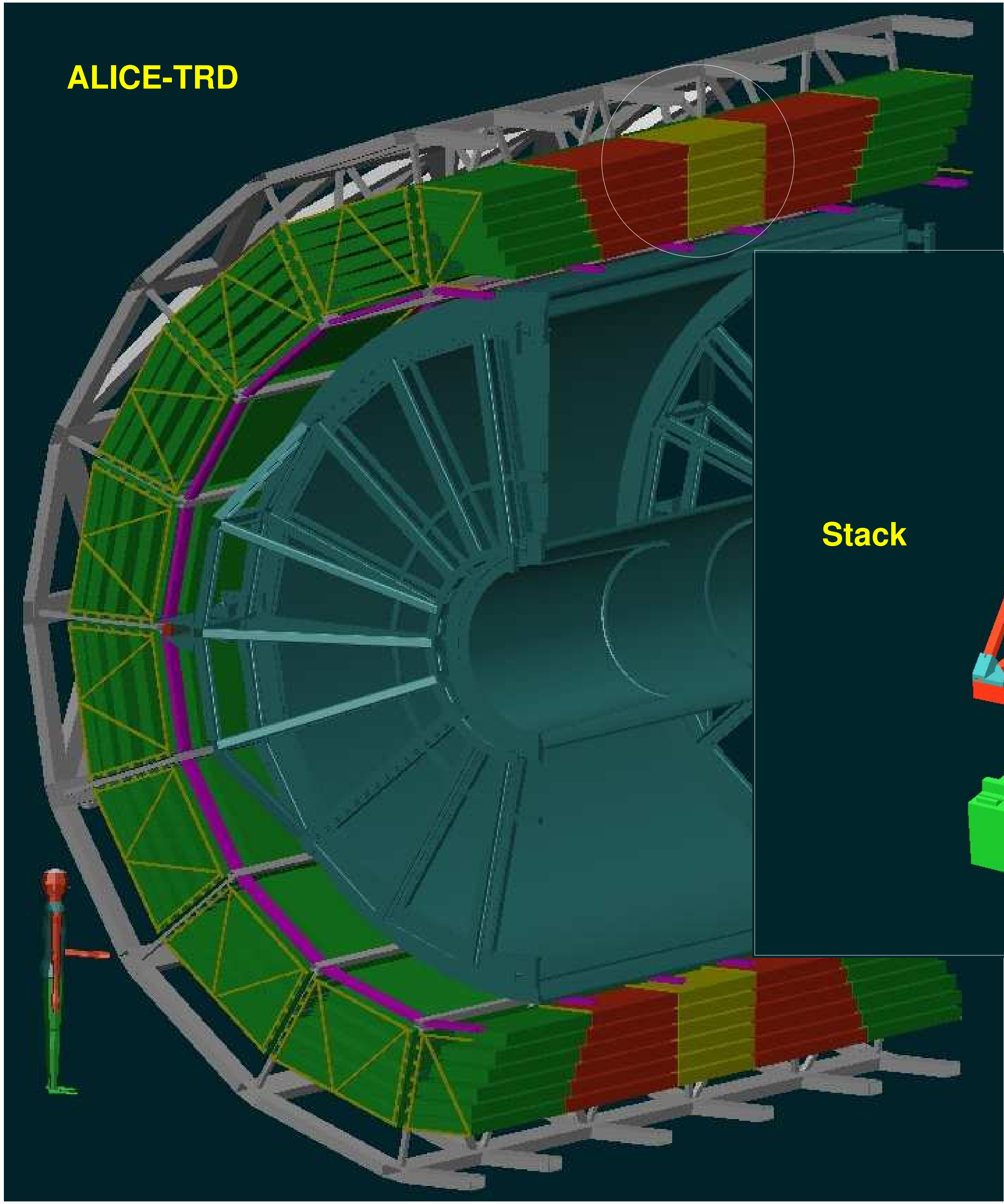
Real size TRD 6-layers stack

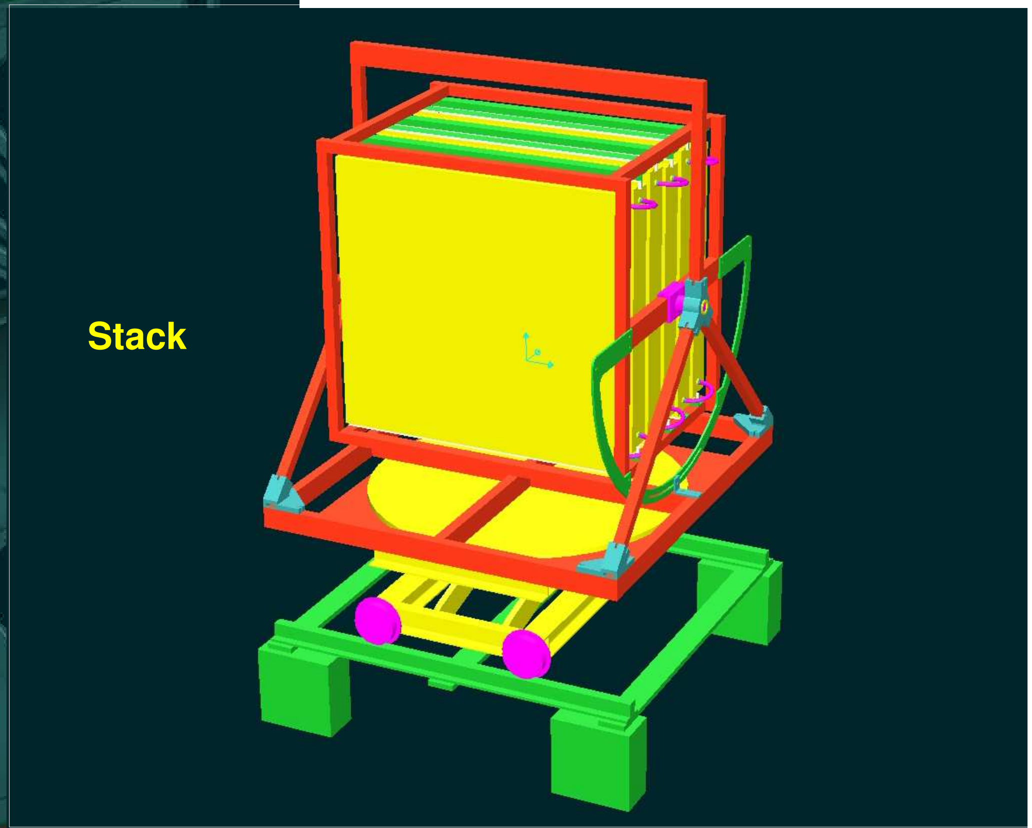


MCM (PASA + ADC + TRAP) + DATE

2004

TRD-stack tests
CERN-PS Oct. 2004

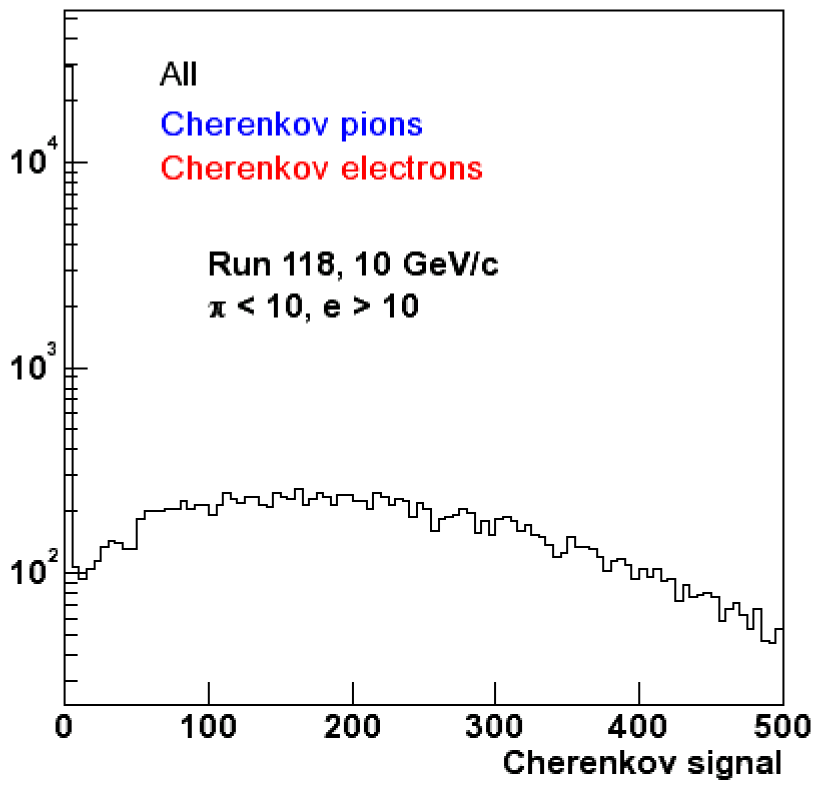


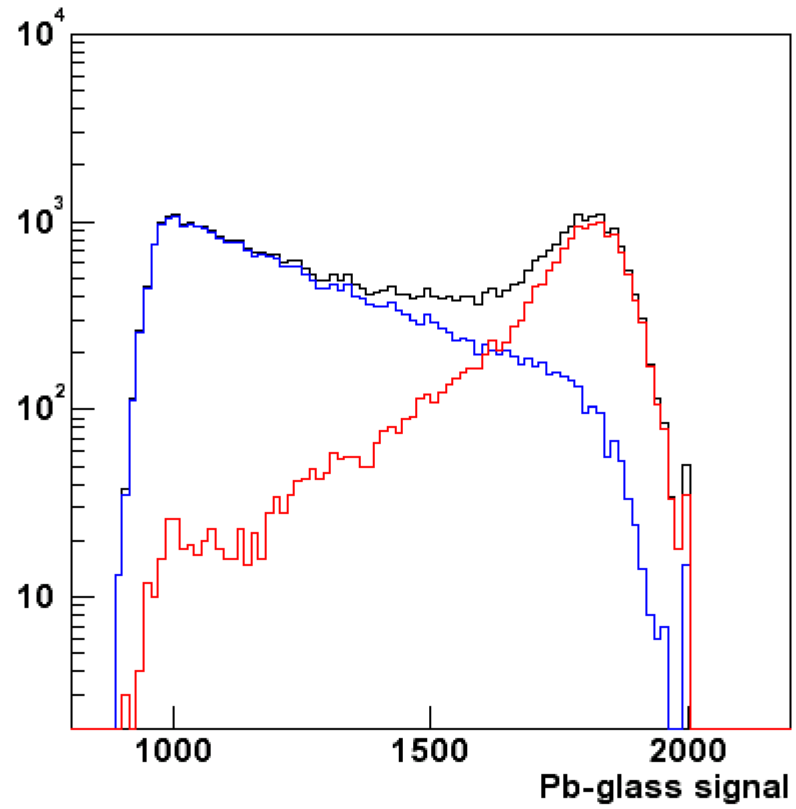


Beam particle selection

Cherenkov tube (up-stream) + Pb-glass calorimeter (down-stream)

π/e contamination ≈ 1 ‰





Building the likelihood for the electron class

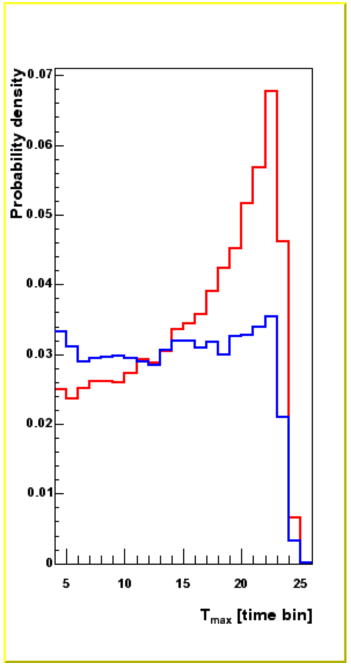
Likelihood on:

- total charge

$P^i(Q_i) \quad i = 1...6$

- total charge and position of maximum „cluster“ in time

$P^i(Q_i, T_i) \quad i = 1...6$



- N intervals charge

$P^i(Q_i^1, ..., Q_i^N) \quad i = 1...6$

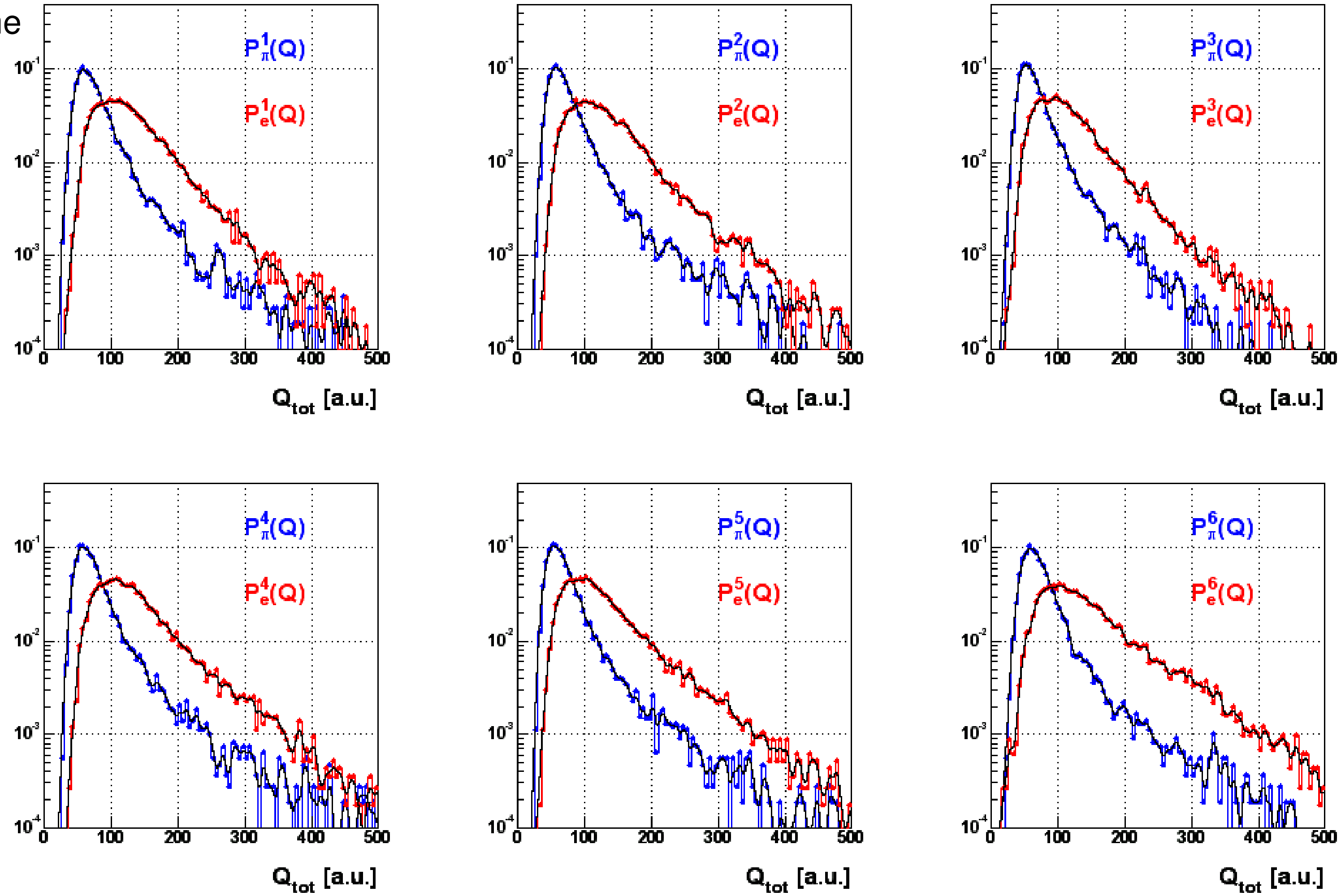
Likelihood on total charge:

$$P_\pi(Q_{1...6}) = \prod P_\pi^i(Q_i)$$

$$P_e(Q_{1...6}) = \prod P_e^i(Q_i)$$

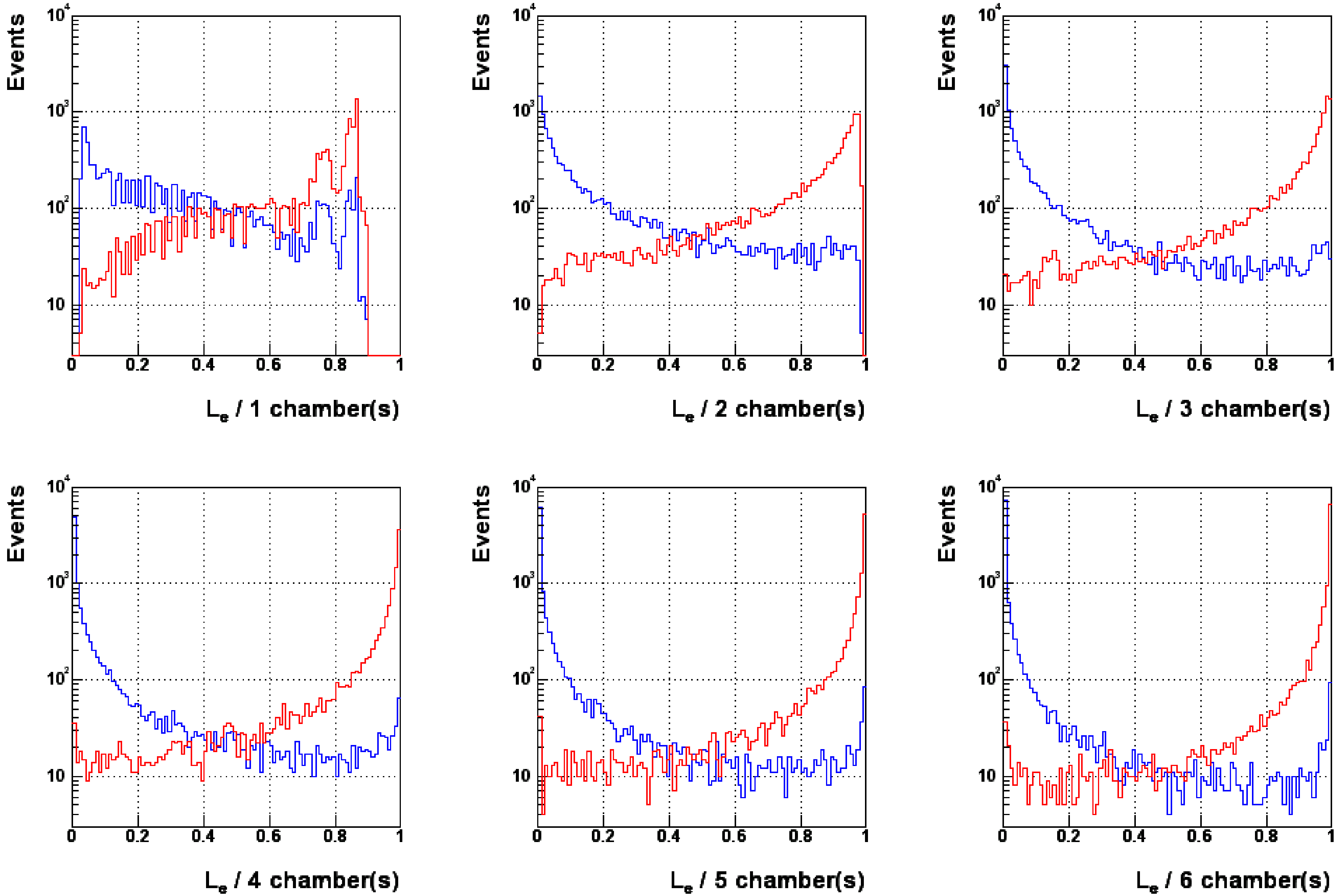
$$L_{\rightarrow e} = P_e / (P_\pi + P_e)$$

Probability density **4 GeV/c**



Total charge likelihood with 1…6 chambers

The pion rejection is calculated with a cut in L at 90% electron acceptance



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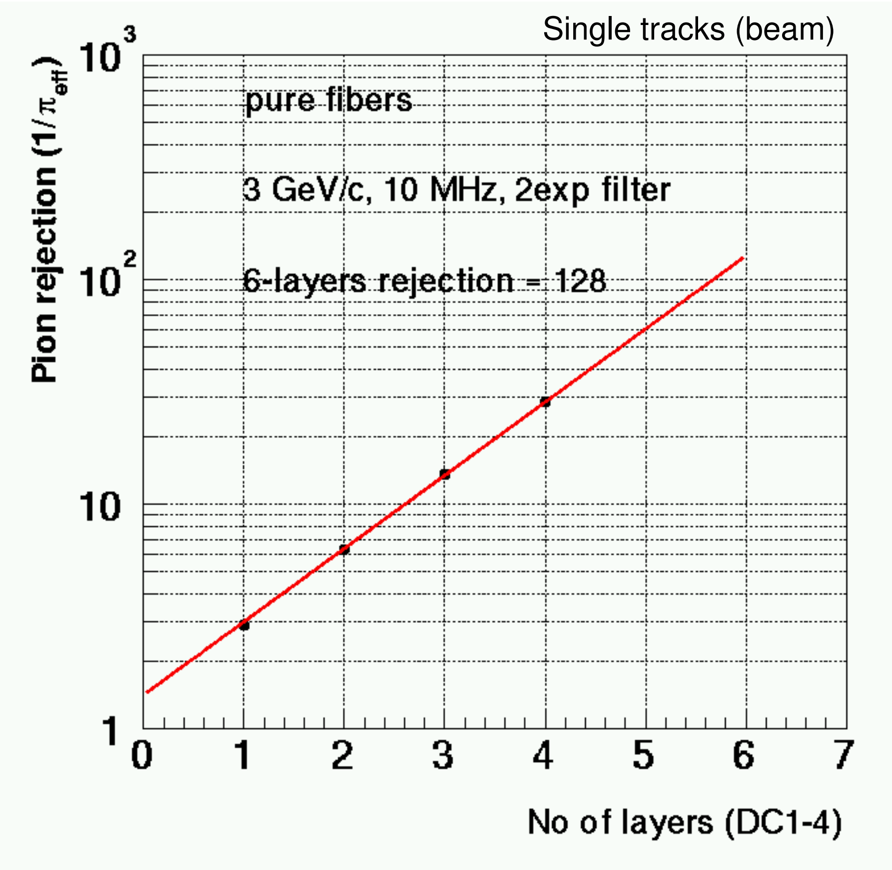
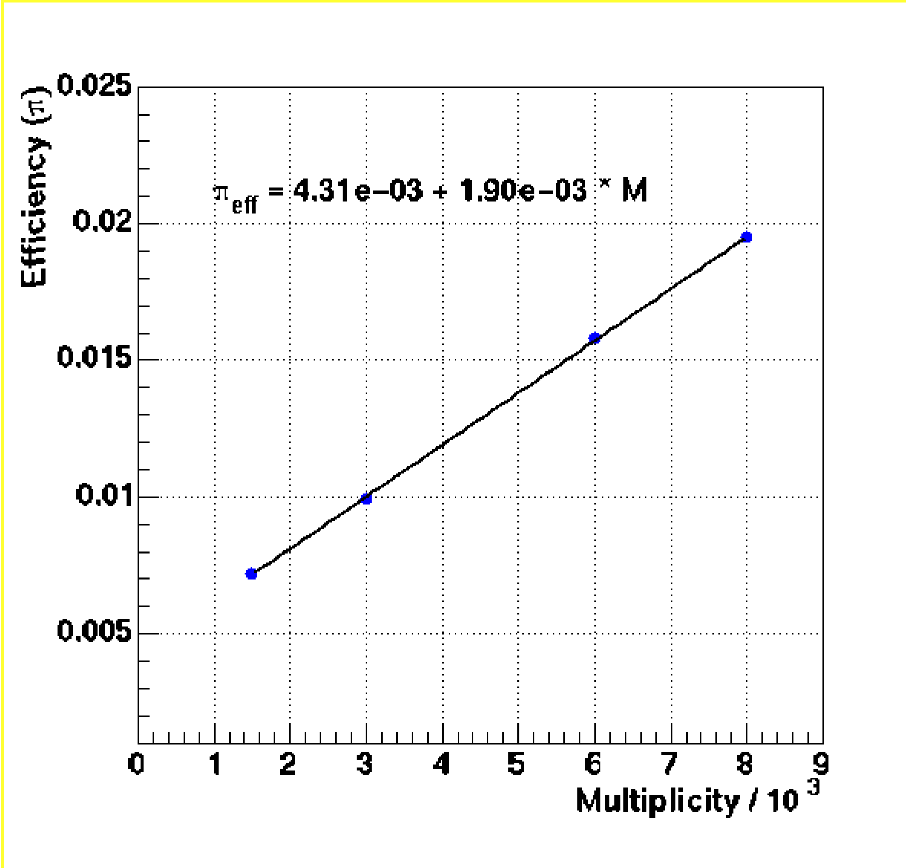
PID dependence on event multiplicity (detector occupancy)

- Number of layers with track segments
  - Minimum 4/6 requested online
- Length of tracklet (number of found clusters)
- Purity of clusters (charge sharing between tracks)
- Signal to noise
- Filter (tail cancelation)

$$1/\pi_{eff} = a \cdot b^n \qquad n = 1 \ldots 6$$
$$a = 1.42 \qquad b = 2.12$$



From AliRoot simulations



PID with Feed-Forward Neural Network (1)

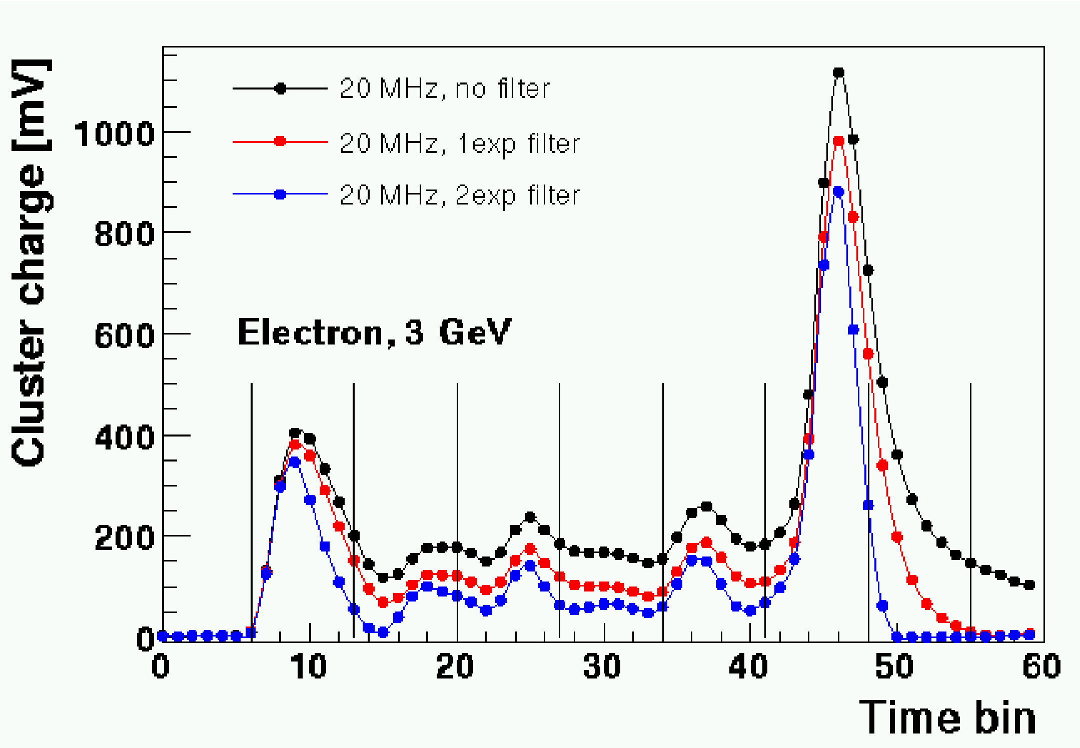
JetNet 3.0 (Lund)

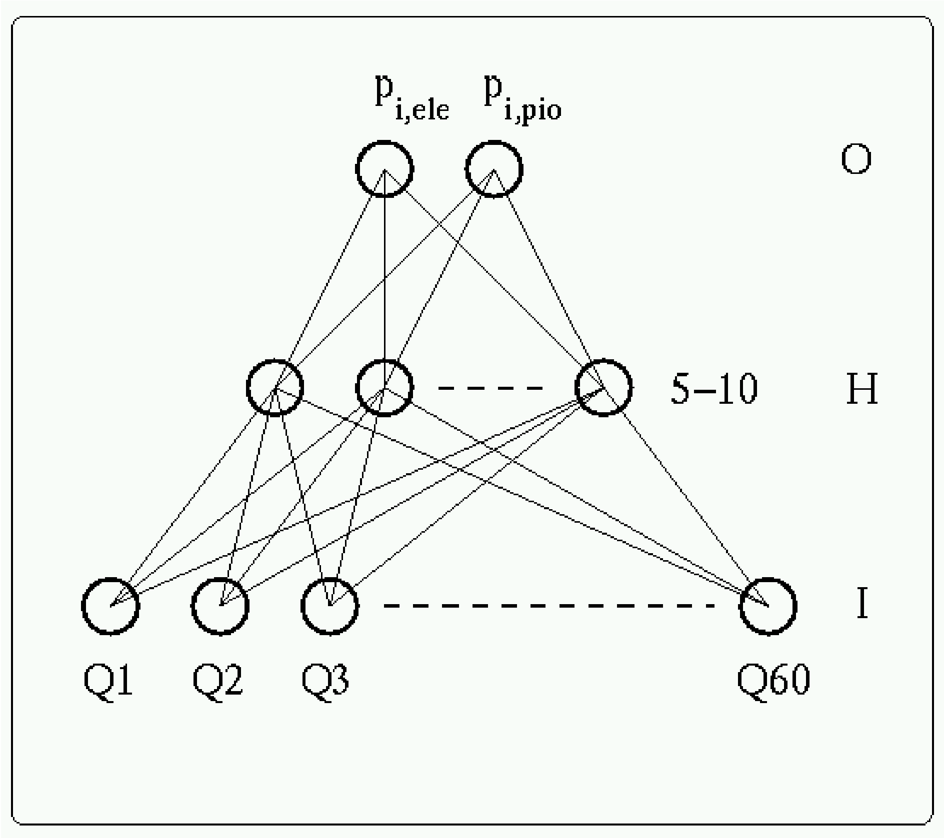
$$Q_i = \sum_1^n q_i^j \qquad i = 1 \ldots 6 \qquad n = 20, 40, 60$$

$P_{i,ele}$ and $P_{i,pio}$ used for likelihood L(6) or a second NN.

Correlations between the samples!

- Short drift time
- Electronic response
- Ion tails in the drift signal!

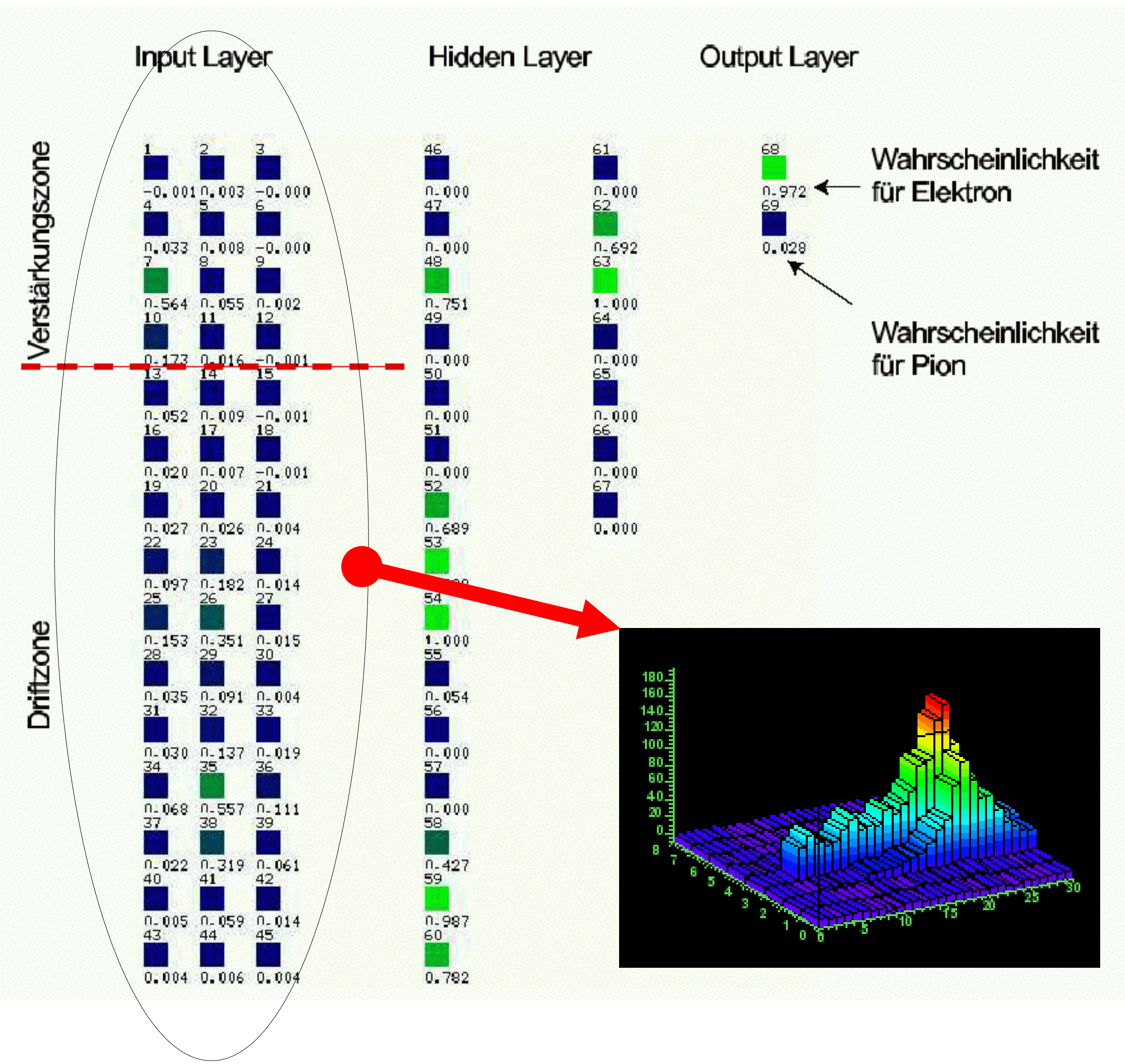


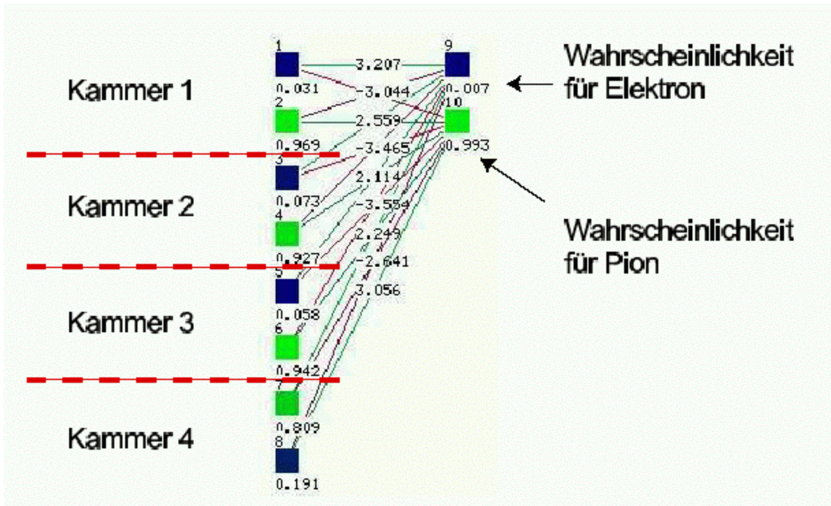


PID with Feed-Forward Neural Network (2)

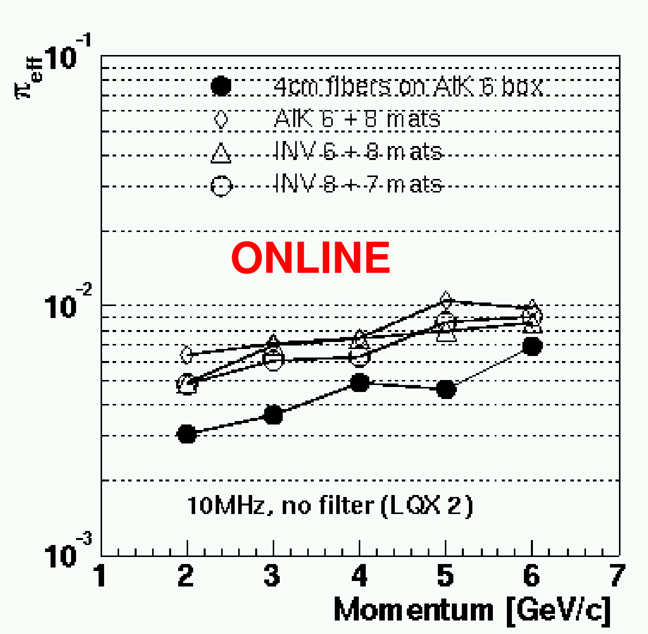
The Stuttgart neural Network Simulator (SNNS) - A. Wilk, Uni. Muenster, Diploma Thesis

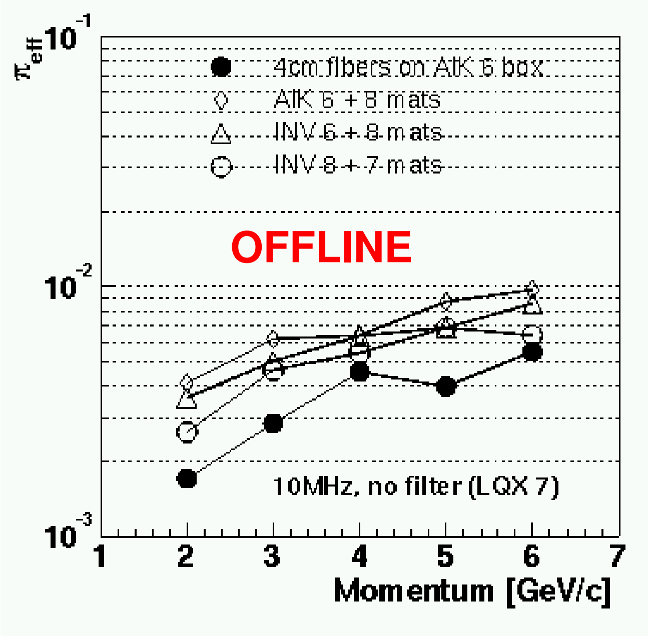
Use full cluster information (3-pads amplitude) in time direction.



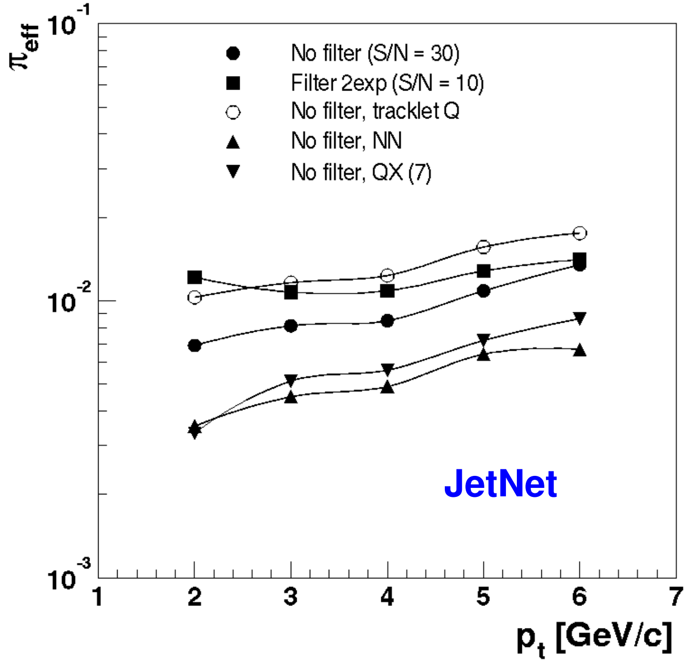


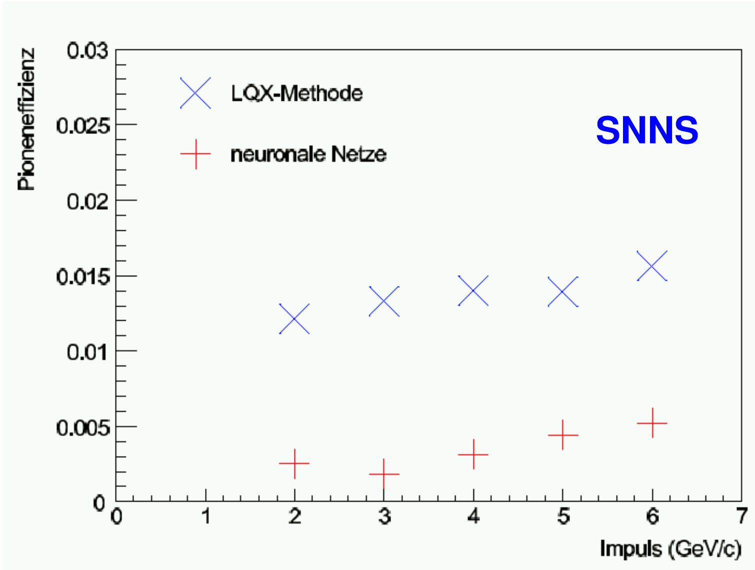
Results - momentum scan



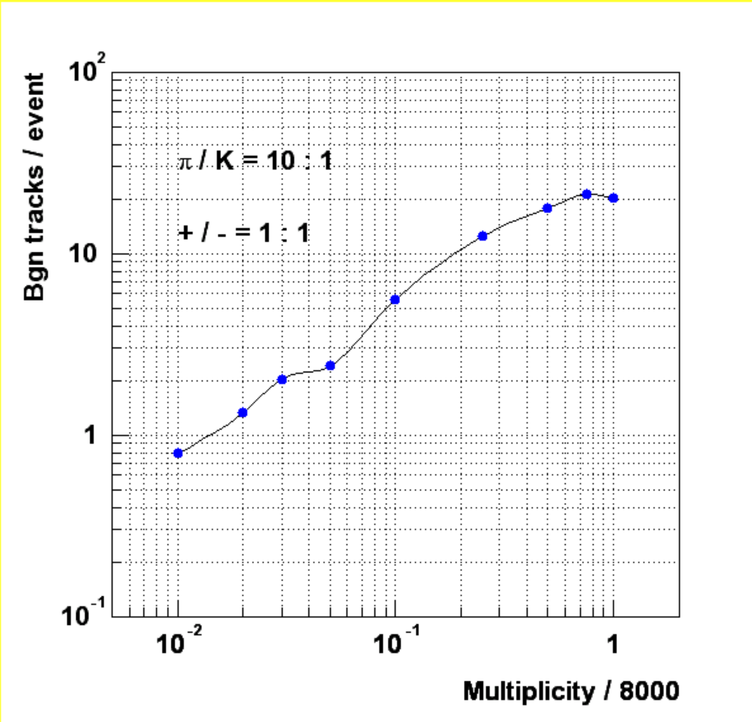


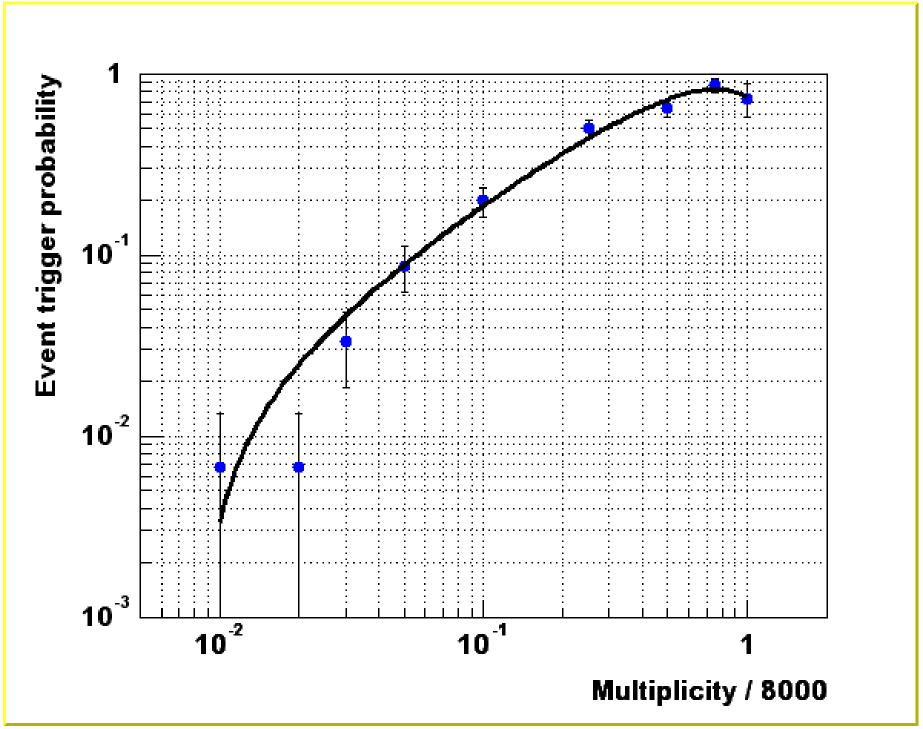
Comparison: LQ, LQX, LQN, NN

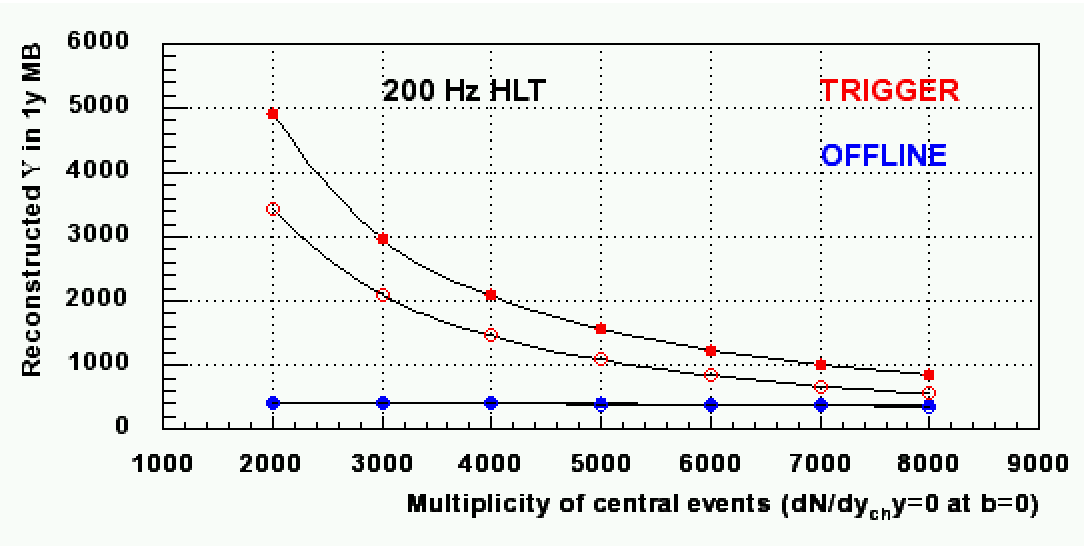




Evaluation of trigger rates







Conclusion, remarks on PID

AliRoot ?

- No good generator models for non-regular radiators...
- Use regular radiators, parametrize radiator geometry (N_{foils}, d_1, d_2) as function of momentum
- Essential input from measurements in beam (TR production)
- Promissing version of the code in PDC04

PID online ?

- LQ, maybe LQ2
- Fixed tracklet „word“ to contain position and PID information, internal LUT for probabilities
- First data with the FEE tracklet processor in Oct. 2004

PID offline ?

- Any method !

PID in the HLT ?

- NN would be nice to have...

Conclusions on e^+e^- trigger

Estimated from (micro-production) simulations:

- Online tracking efficiency and resolution
- Pion background
- Trigger rates (partial)
- Number of reconstructed Upsilon in MB and CEN10 events

Checked and tuned on beam test data:

- Tracking algorithm, PID
- Consistency with simulations (recent progress in the drift chamber description: geometry, gas properties, ...)

Expected from PDC04:

- Other electron sources (heavy mesons, Dalitz, secondary)
- Better understanding of the dependence on event multiplicity in the MB range