Testbeam data and simulations for ALICE TRD

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- Setup and main results
- Simulations procedure
- Data vs. simulations: dE/dx, TR
- Outlook

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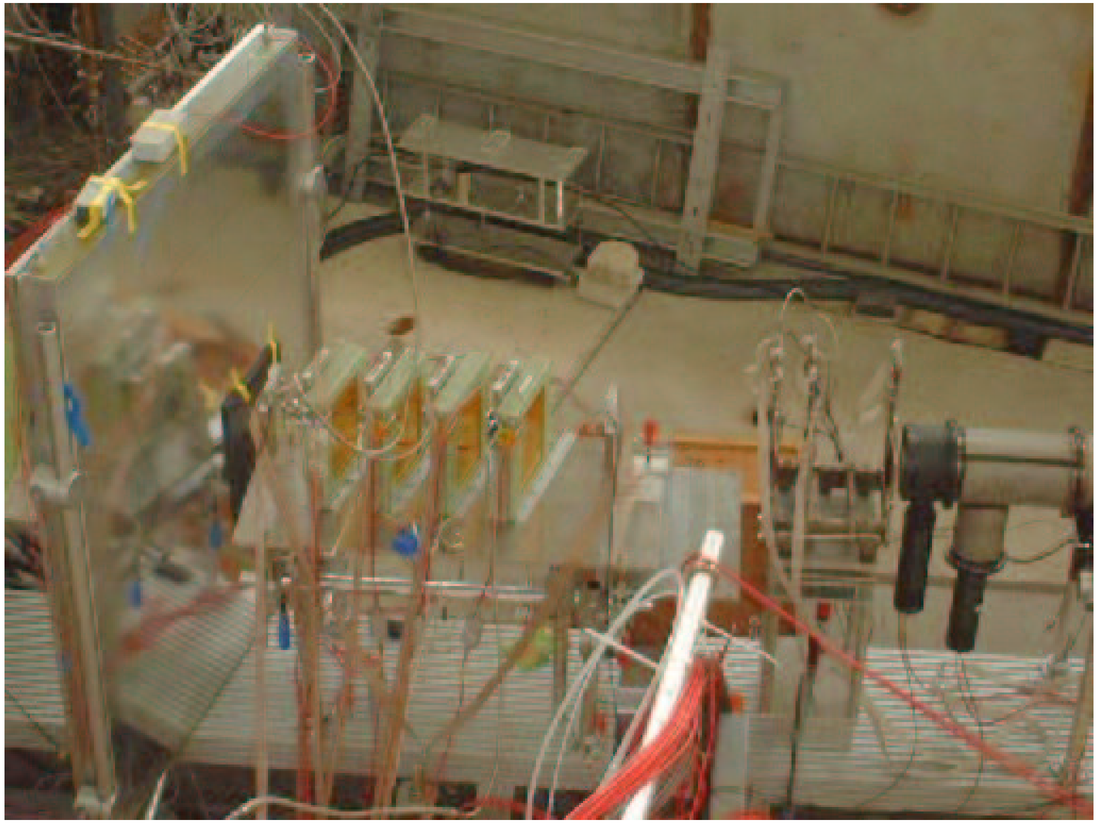
ALICE TRD Phase II: reference results (CERN '02)

Equipment:

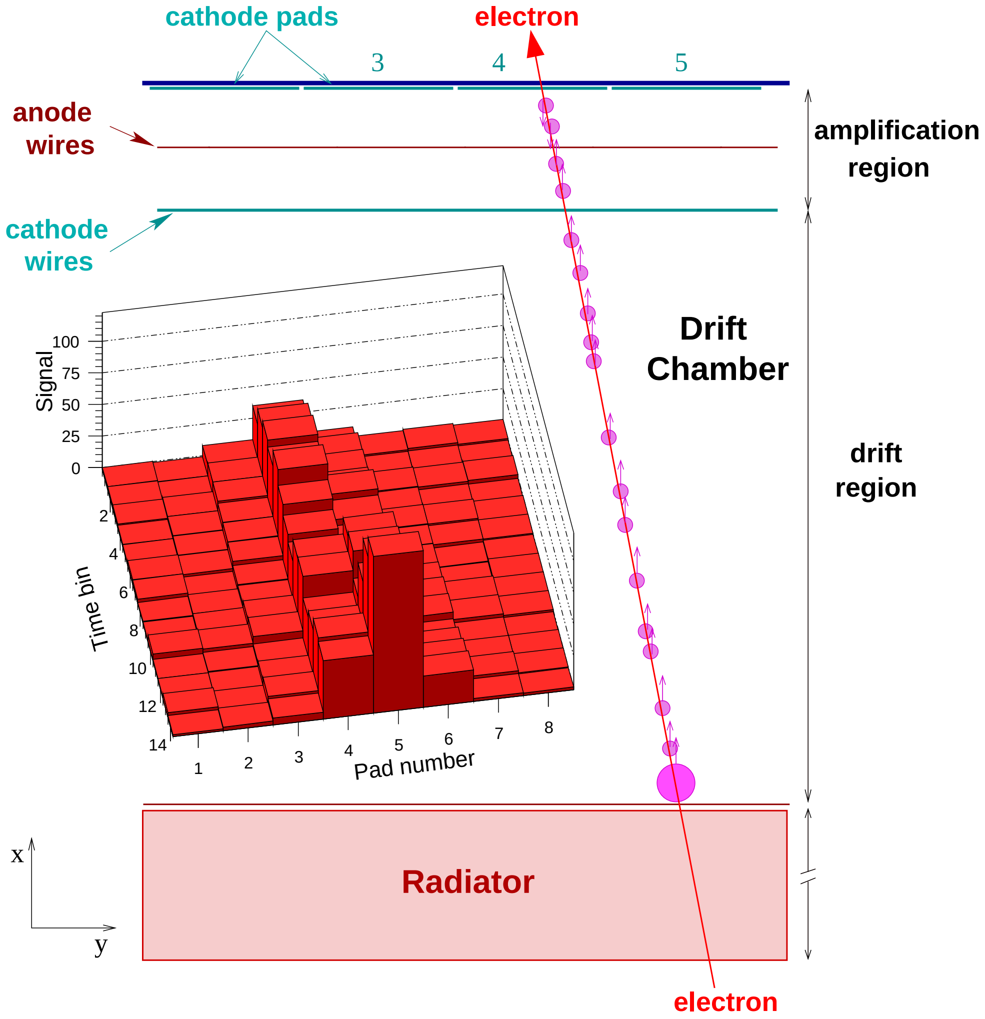
- 4 small-size prototypes + real-size prototype
- PASA v.2 (ASIC, quasi-final)
- Fully-functional gas system
- Improved beam diagnostics (Dubna)

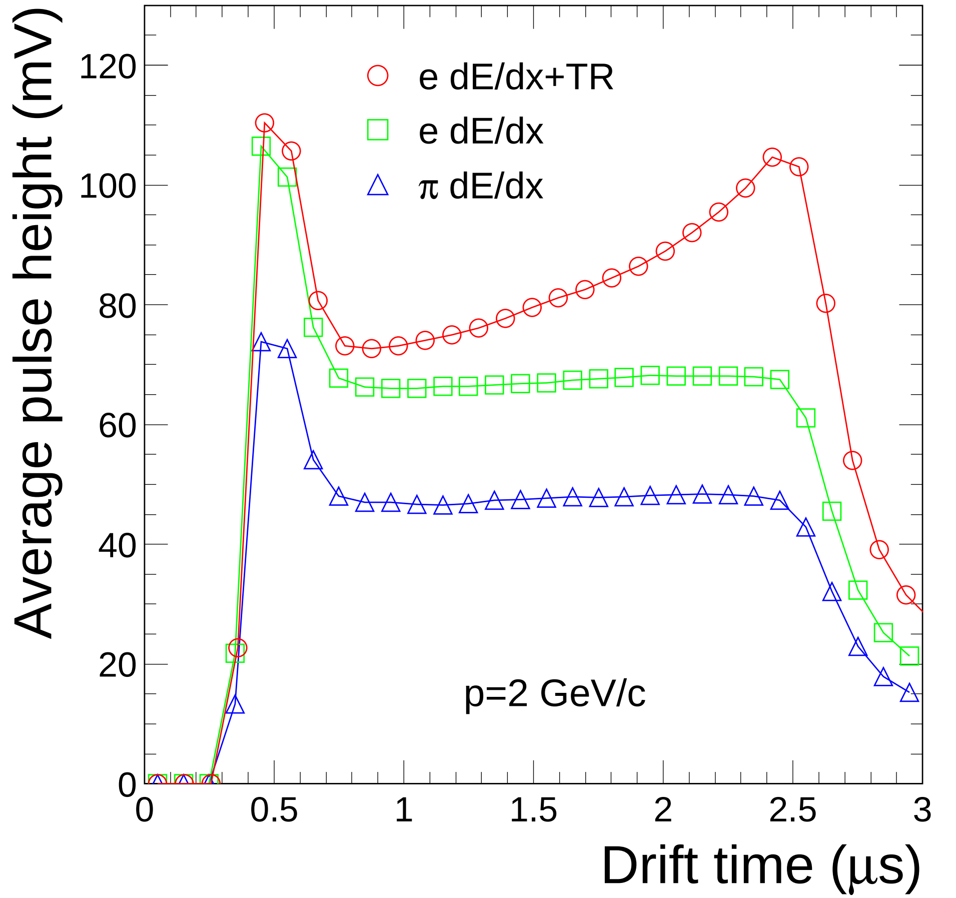


Results:

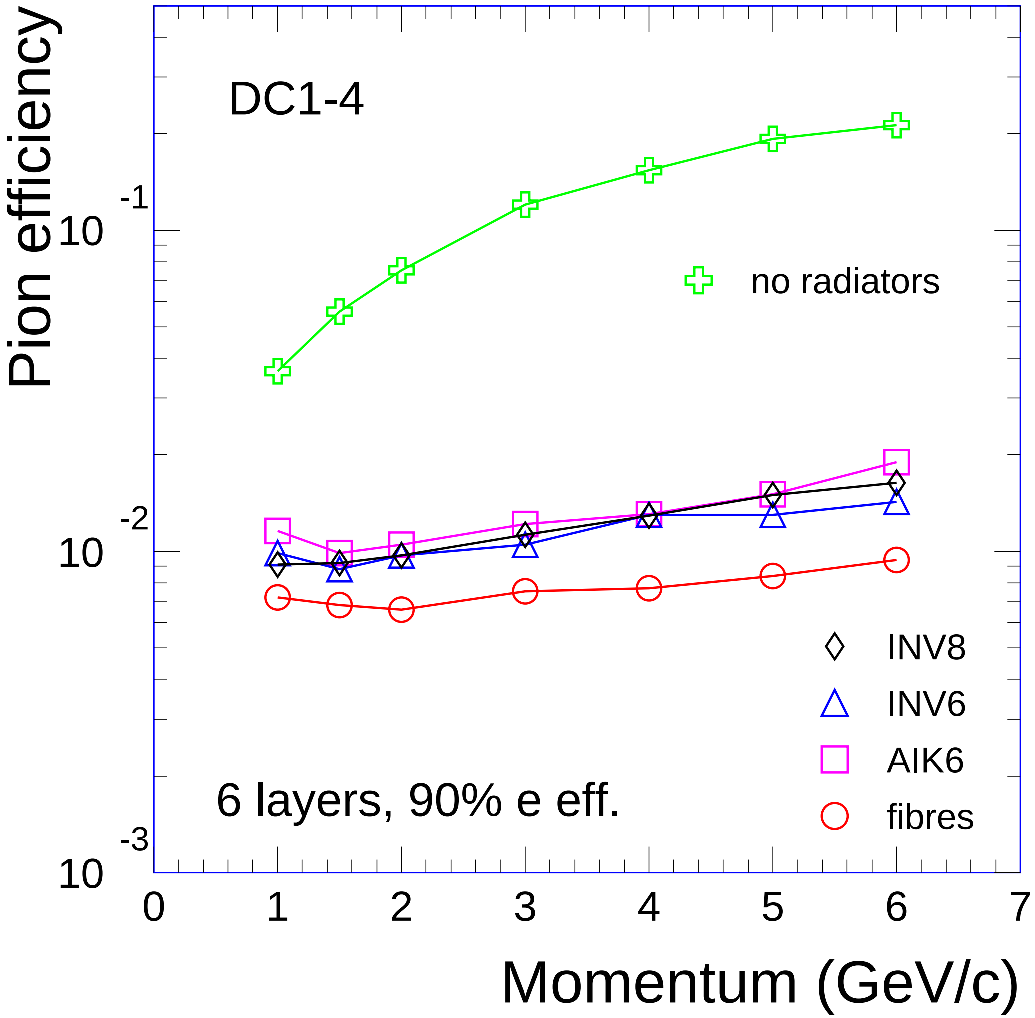
- Pion rejection - radiator and multi-layer performance
- Position resolution (B$\leq$0.56 T)
- TR spectrum

ALICE TRD – What do we measure





Radiator performance



- Likelihood on total charge averaged over four detectors
- Measured for 4 layers, simulated for 6 layers
- Pion rejection of 100 achieved (need improvement for deterioration in real life)
- Performance not critical on radiator manufacturer choice (3 sandwiches, final design, different C-fibre coating)

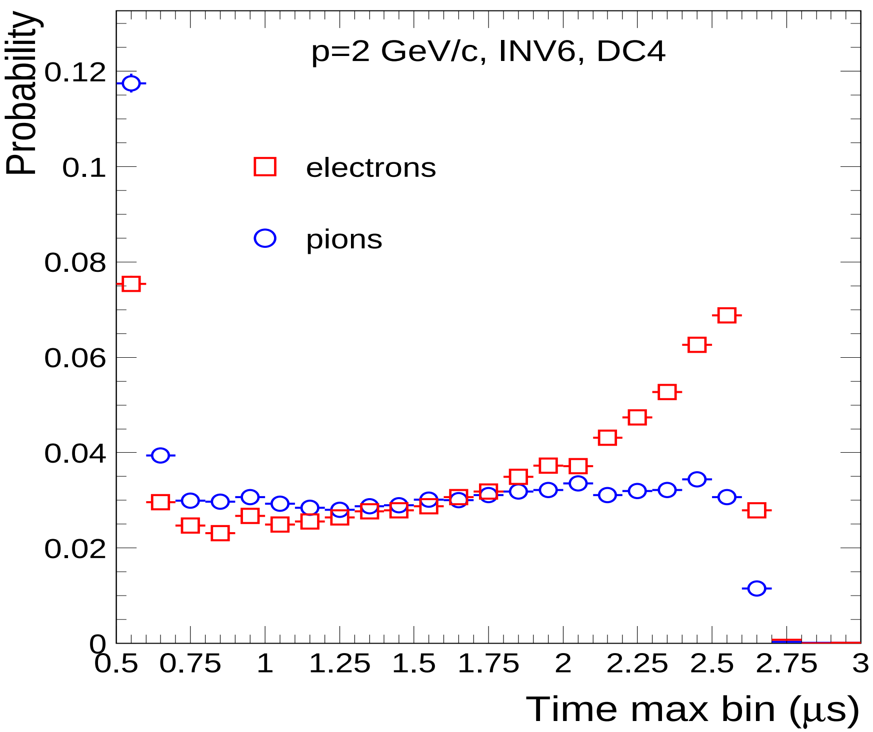
π rejection: exploiting the time information

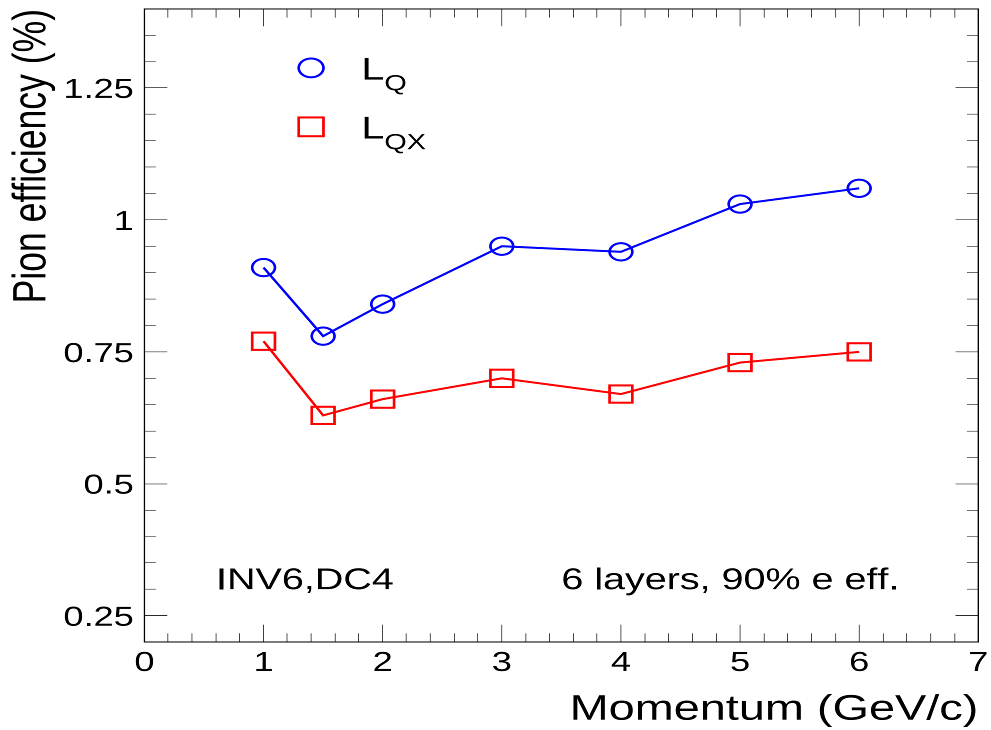
- $L_Q : P_{e,\pi} = \prod_{i=1}^{N} P(Q_i|e,\pi)$

  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

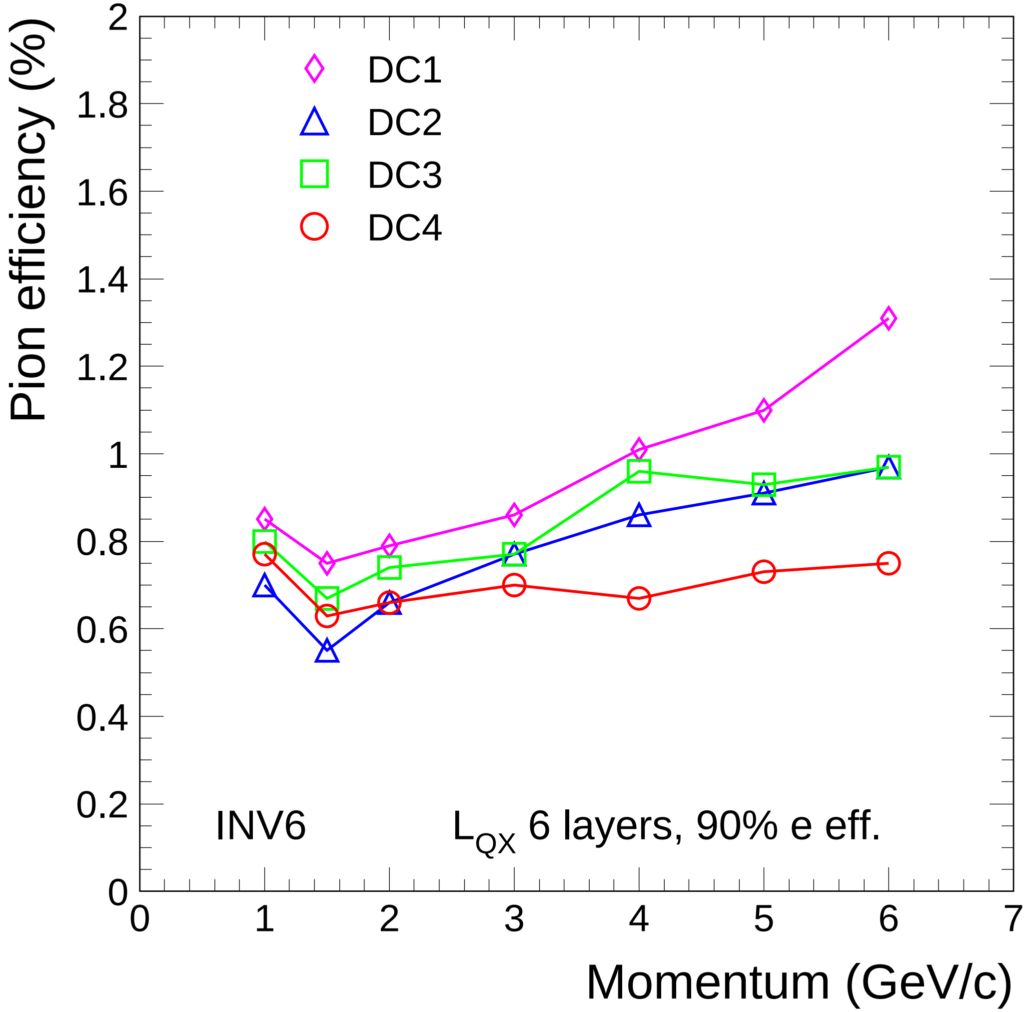




- L_{QX}: sizeable improvement, but not yet a factor 2
- It is just a first step to use differential information
- Further improvements possible: Q for each time bin (provided correlations are properly handled, NN?)

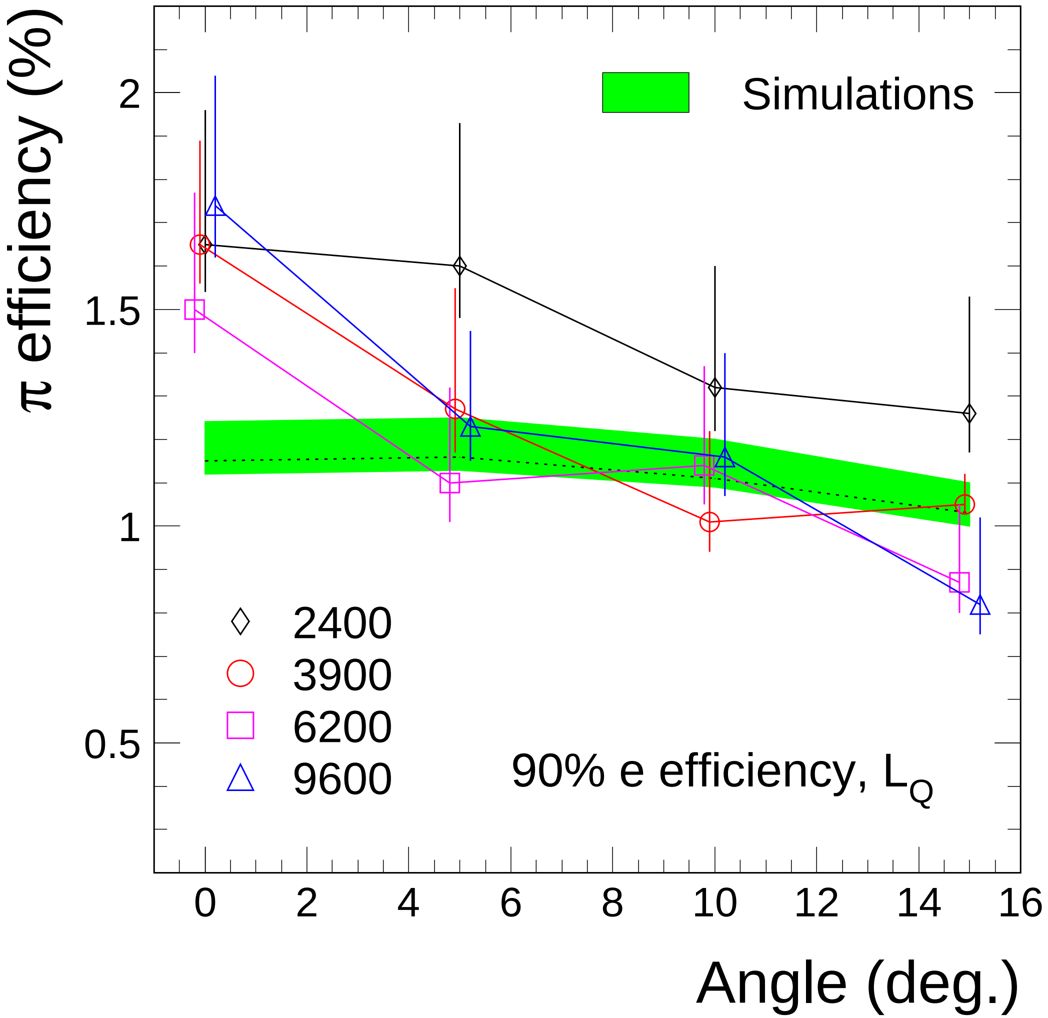
Pion rejection: layer dependence

bidimensional likelihood, L_{QX}



- On average deeper layer means better pion rejection
- TR buildup vs. Bremsstrahlung ?
- Pure fibres: less pronounced dependence
  → no TR responsibility ?
- Under further investigation (simulations)

Pion rejection: dependence on incident angle



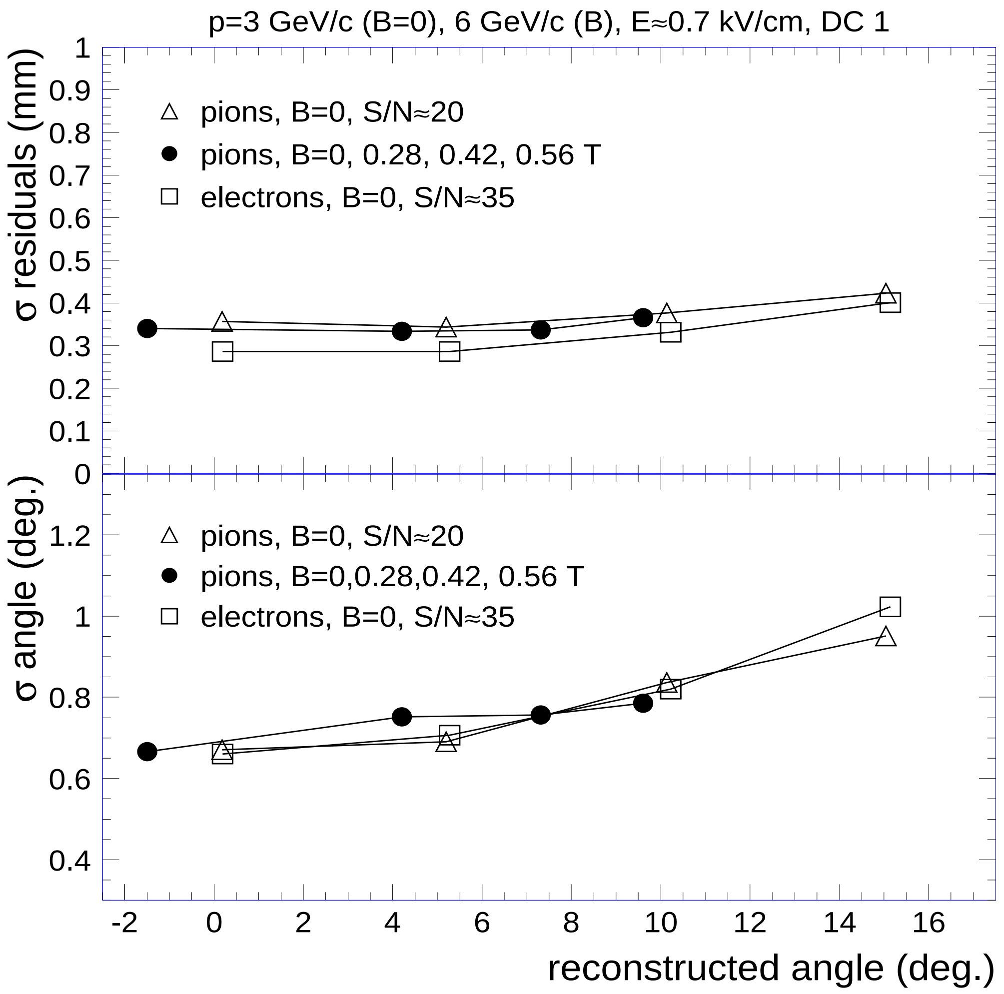
Likelihood on total charge averaged over four detectors, extrapolated for 6 layers

Simulations do NOT include space charge effects

- Performance affected at normal incidence (0°) due to space charge
- Not easy to correct → work at lowest gas gain (compromise with S/N)
- It is a very local effect (1-2° around normal)
- Normal incidence is rare in ALICE TRD

Position resolution

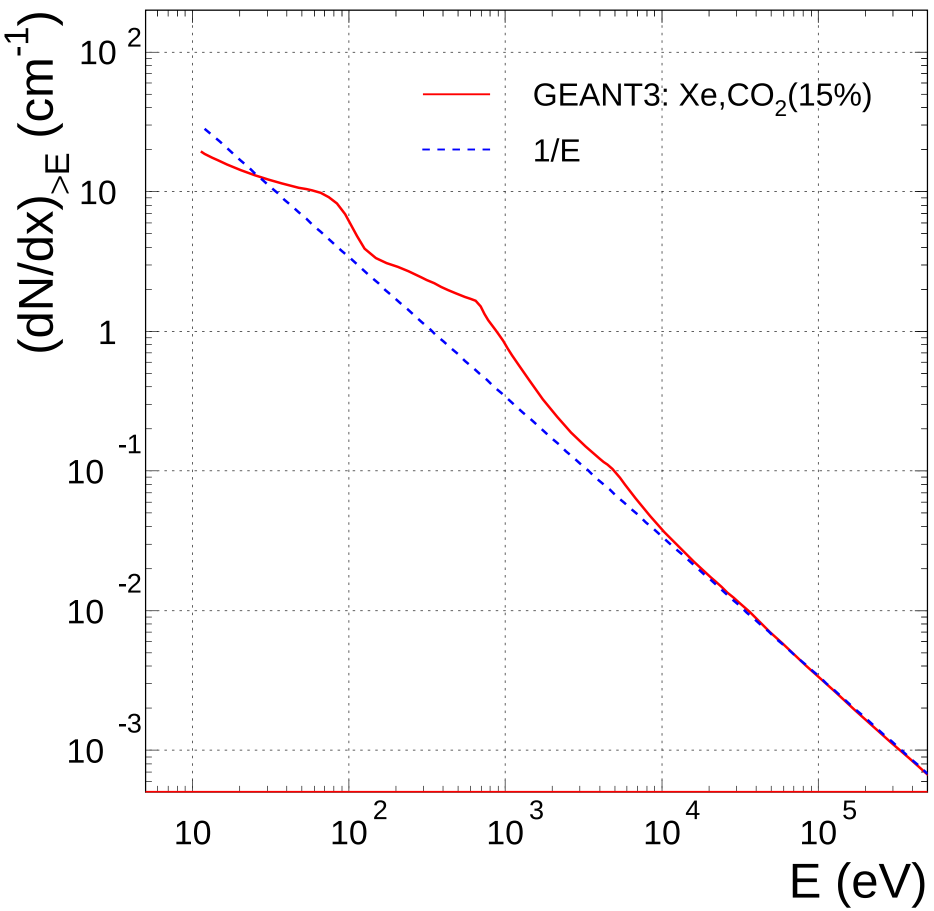
small-size prototypes, B-field (angle=Lorentz)



- Electrons: same resolution as pions (larger S/N)
- Point and angle resolution are within specs
- Same resolutions with or without B-field
- Lorentz angles as expected (GARFIELD)
- Real-size prototype has similar resolution

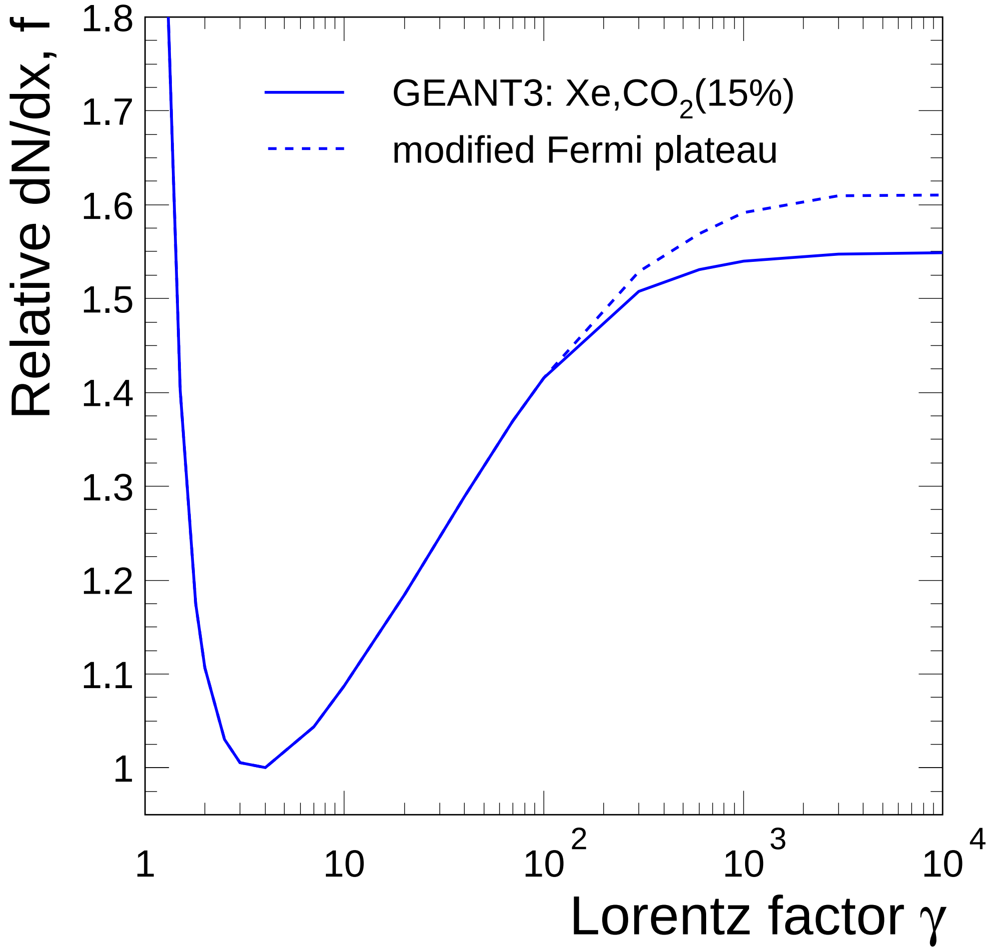
dE/dx calculations: inputs

Spectrum of energy transfer



N=19.3 /cm (Ermilova: 48)

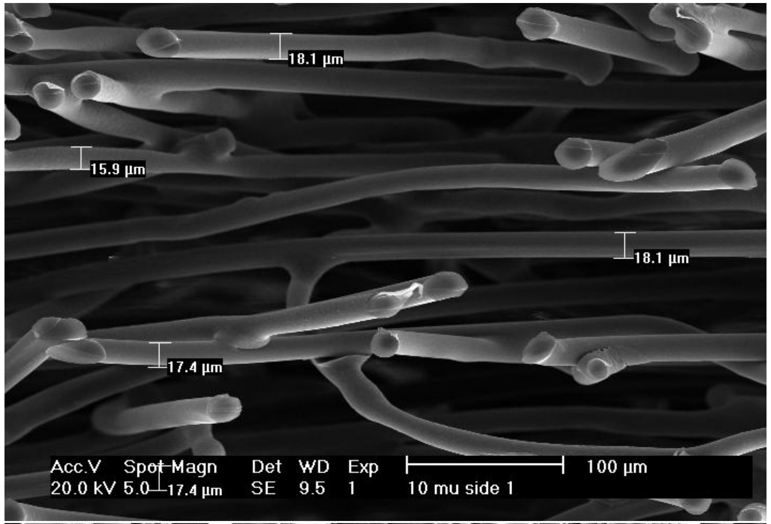
Relativistic rise

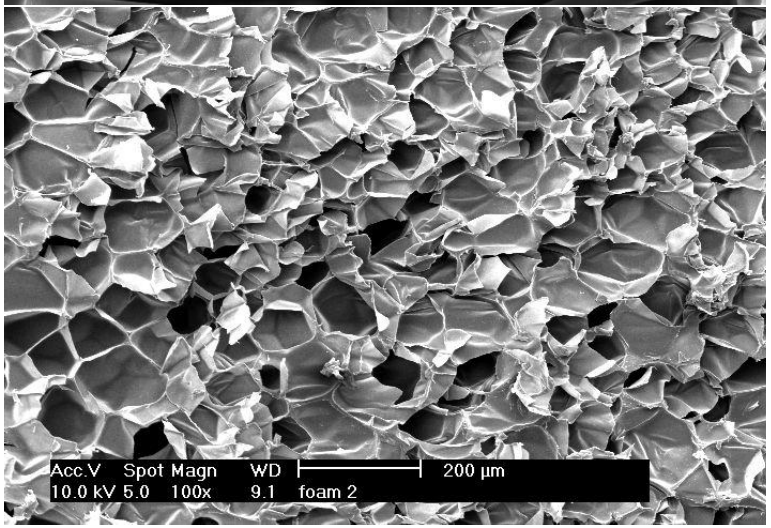


Fermi pl.: 1.55 (Ermilova: 1.36)

TR calculation: regular radiator

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





where:

$$\rho_i = \omega d_1/2c(\gamma^{-2}+\xi_1^2), \quad \sigma = \sigma_1+\sigma_2 \quad (\text{one} \quad \text{foil}+\text{gap}),$$

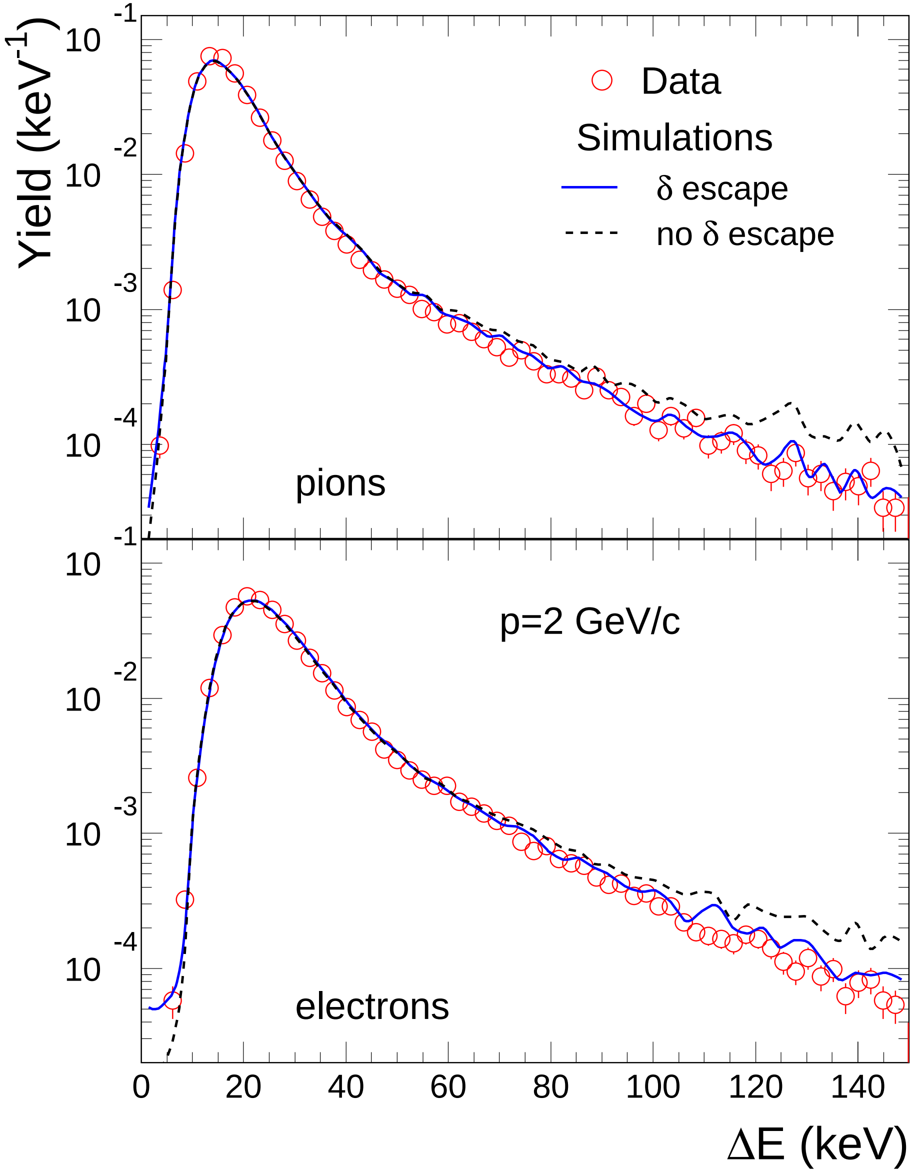
$$\theta_n = \frac{2\pi n - (\rho_1+\kappa\rho_2)}{1+\kappa} > 0, \quad \kappa = d_2/d_1$$

Approximate formula (10%, we checked it!)

includes absorption
→ TR yield at the exit of radiator

C.W. Fabjan and W. Struczinkski, Phys. Lett. B 57, 483 (1975)

dE/dx: spectral shape



3.7 cm Xe,CO_2(15%) 15° incidence

δ-rays tracked above E=10 keV

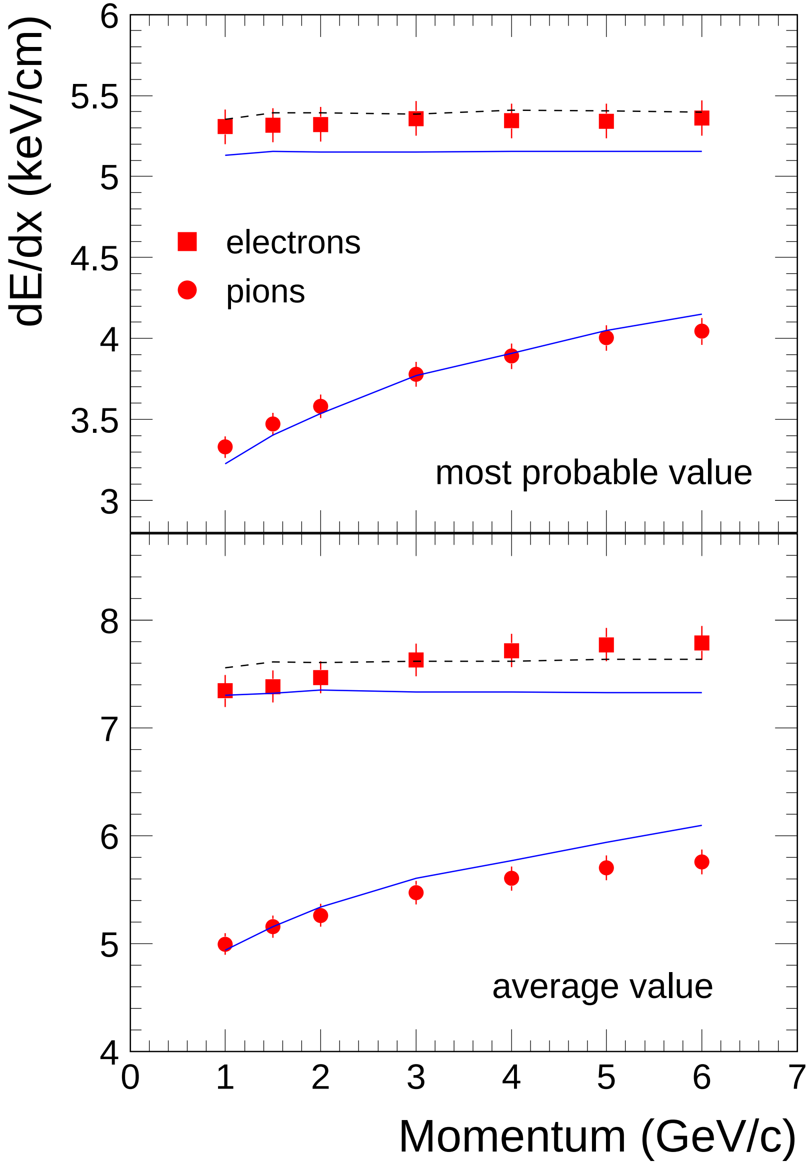
Range:

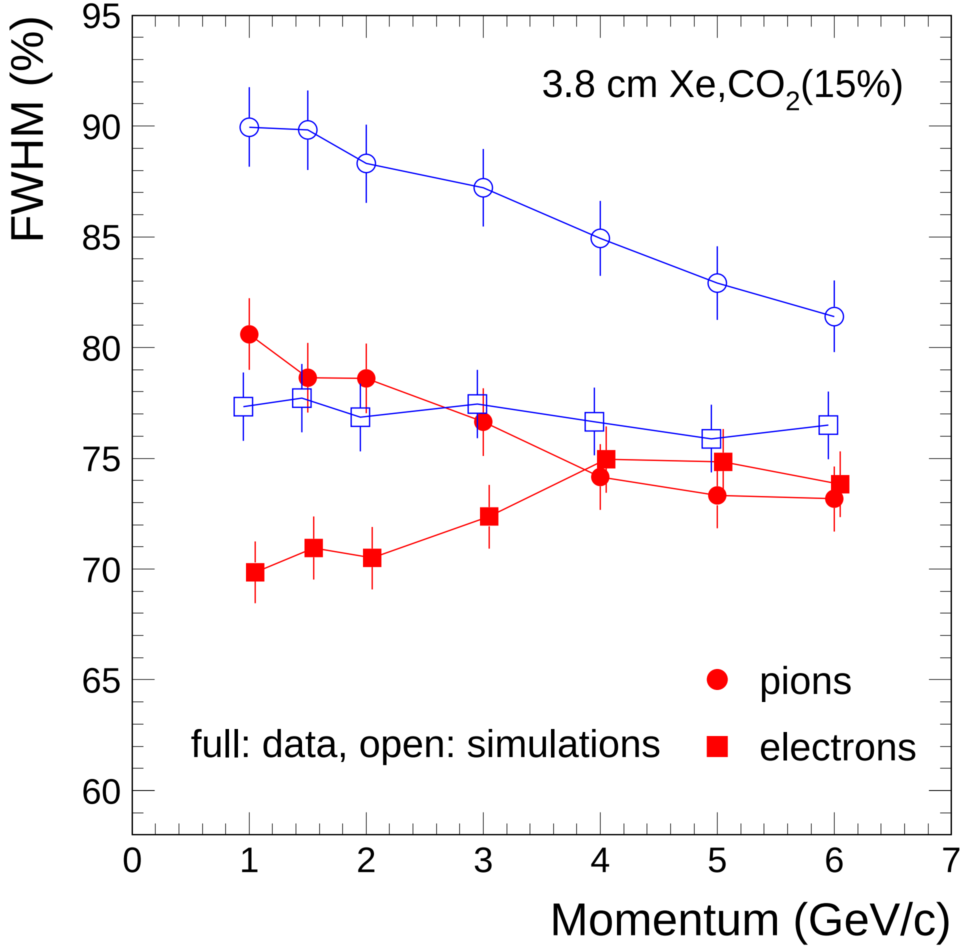
$$R(E) = AE\left(1 - \frac{B}{1+CE}\right)$$

A=5.37·10^{-4} gcm^{-2}keV^{-1}, B=0.9815, C=3.123·10^{-3} keV^{-1}

▷ affect the tails of the distributions

dE/dx: means and widths

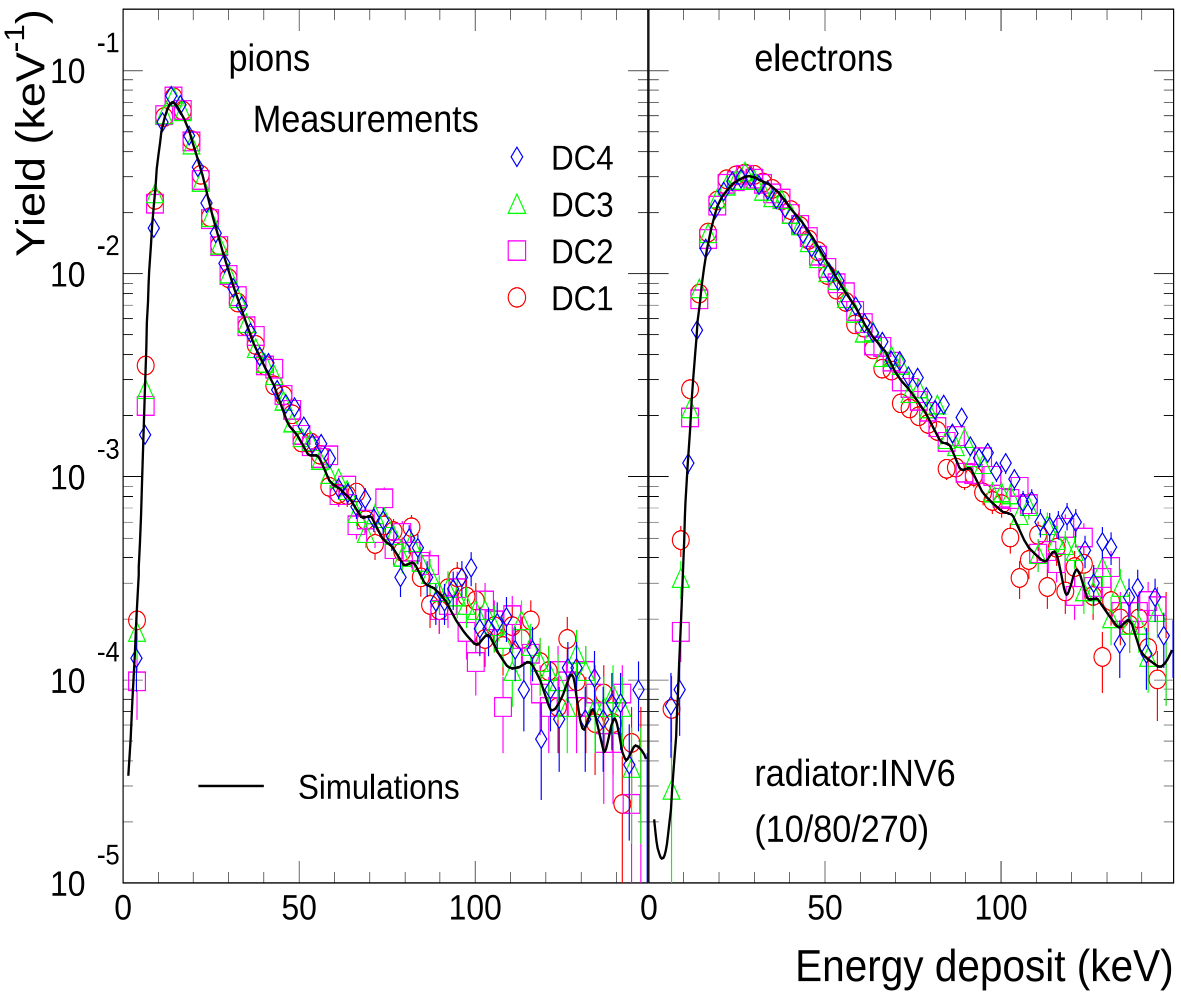




▷ the means are reproduced nicely

▷ FWHMs larger for calculations (N?)

Charge spectra with radiator



Data:

INV6 sandwich:

8 fibre mats, 5 mm each (in 34 mm)
$2\times$ 6 mm Rohacell
$2\times$ 100 μm C-fibre

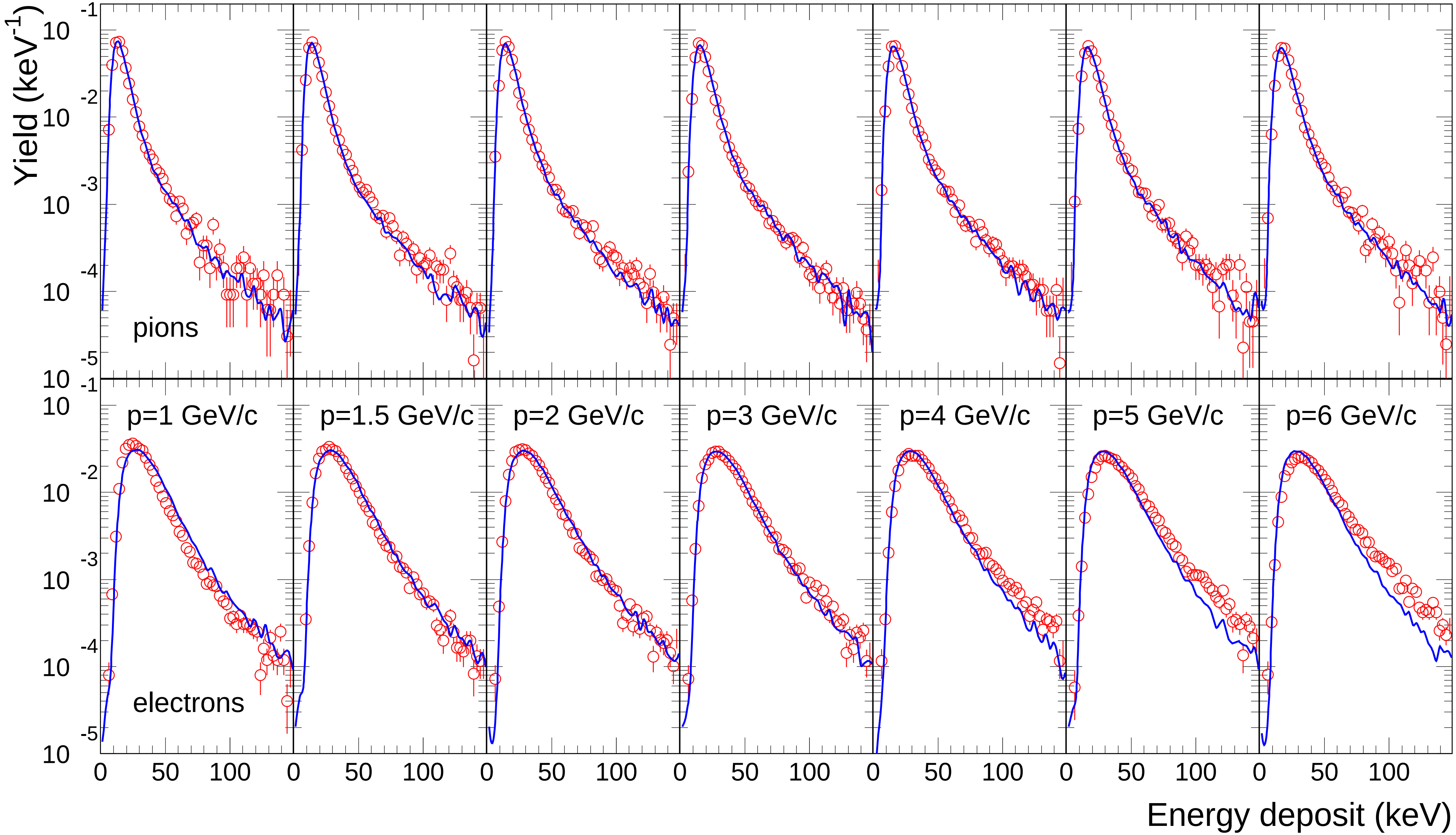
Simulations:

regular radiator:

d1=10 μm
d2=80 μm
Nf=270

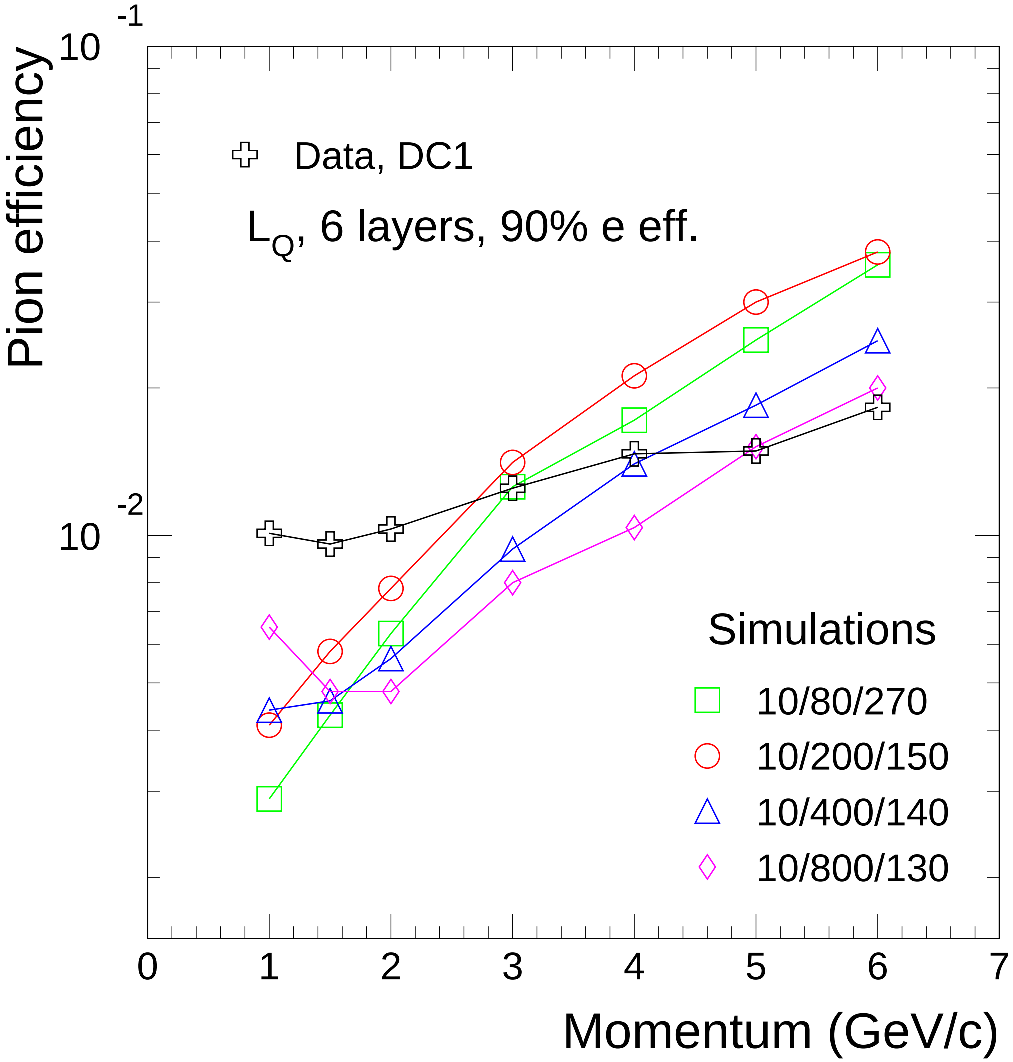
▷ Tuned parametrization gives a good description of the total TR yield

More charge spectra



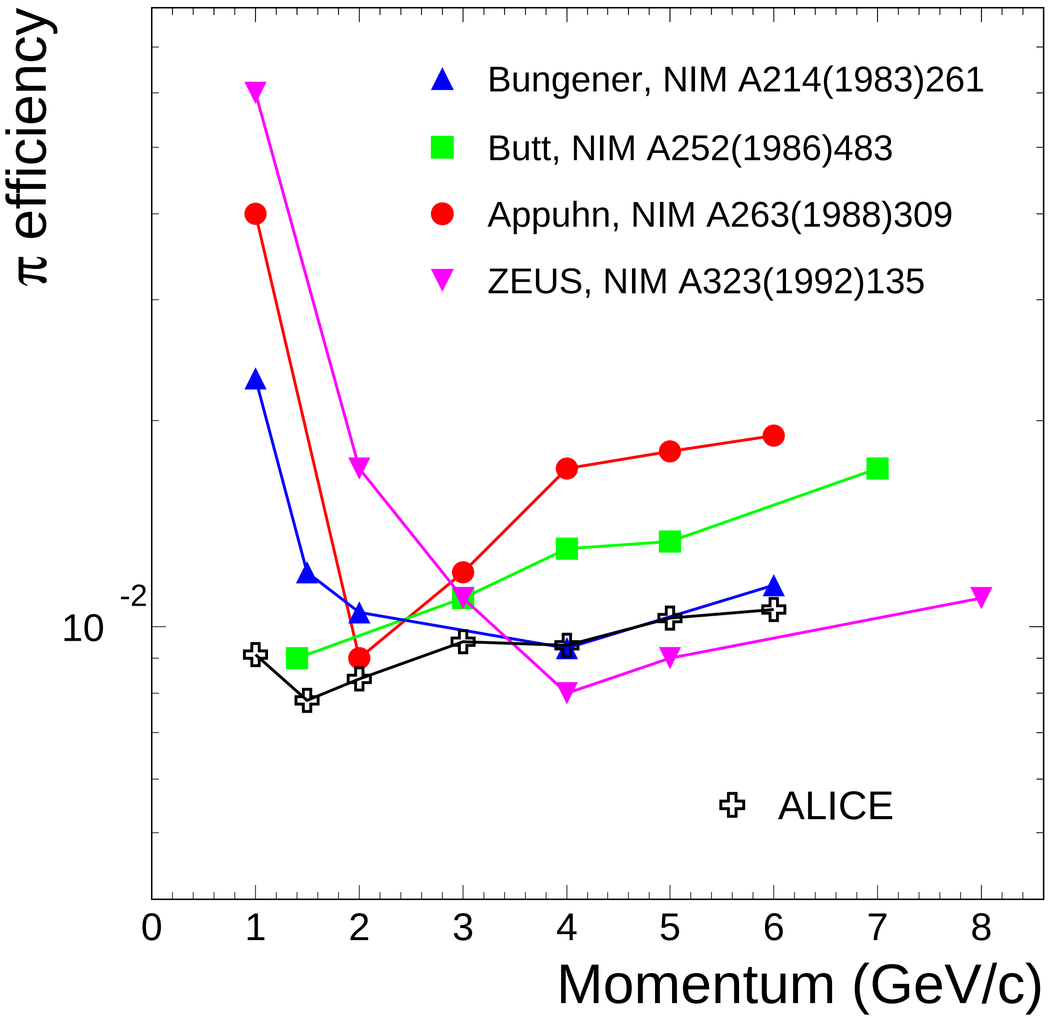
▷ Calculations fail to reproduce measured spectra consistently

e/π identification



- Calculations fail to reproduce measured momentum-dependent rejection (in the explored range of parameters, $d2$)
- Similar behaviour vs. $d1$
- Bremsstrahlung contribution ?

e/π identification: ALICE vs. others

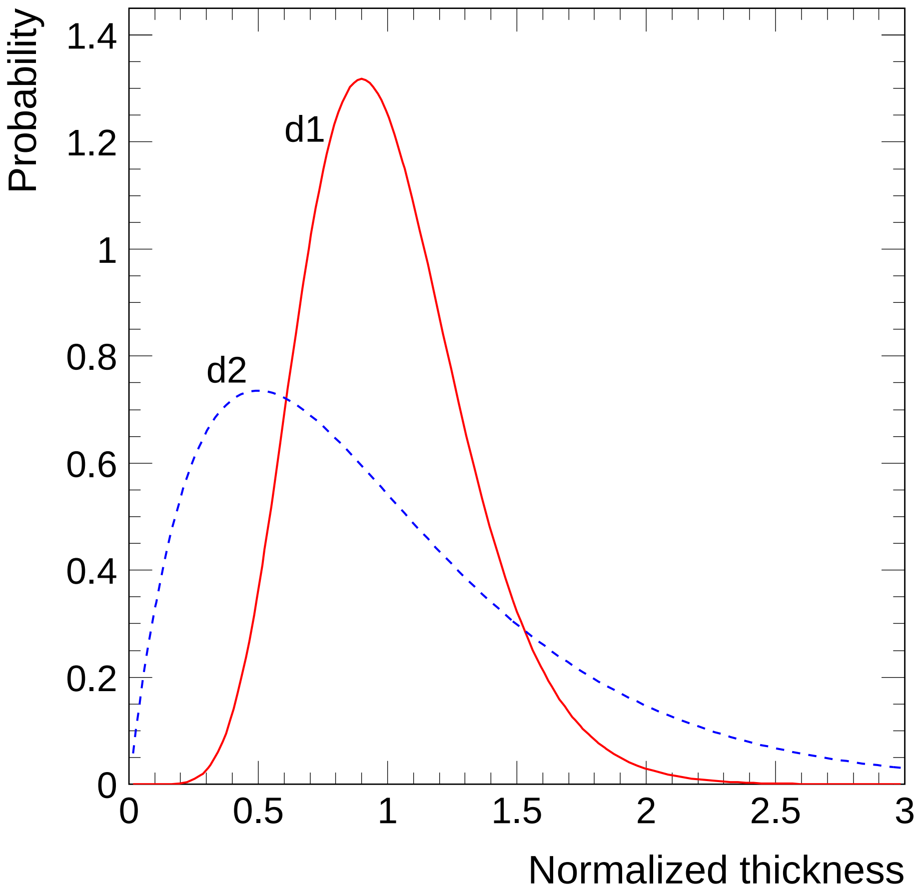


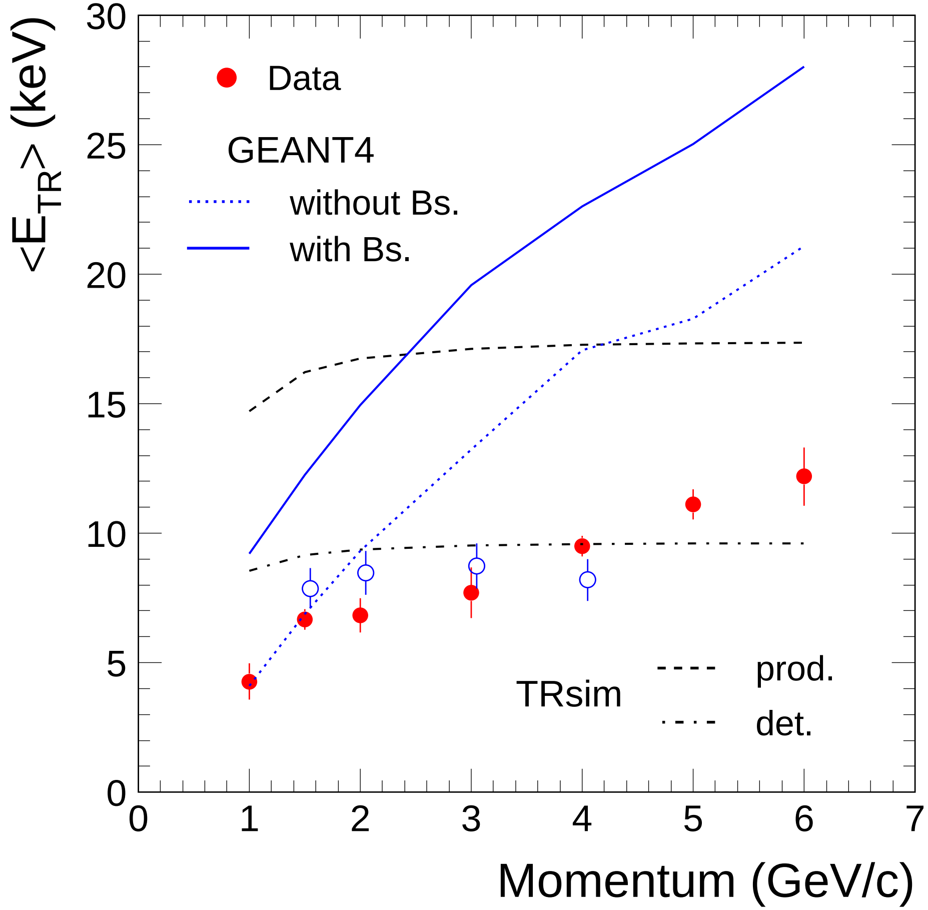
- Something outrageous with our data ?
  not really...
- Similar momentum dependences for p>3 GeV/c
- Low momentum is very sensitive to radiator configuration

Summary and outlook

- ALICE TRD required performance established in prototype tests (e/π separation and tracking)
- dE/dx OK in simulations (a modified Fermi plateau is needed to explain electron data)
- Measured momentum dependence of TR production is not easy to get in simulations (Bremsstrahlung?)
- "more work is needed..."
  (irregular radiator, GEANT4)

Outlook: GEANT4, irregular radiator





▷ GEANT4 looks promising (good chance to describe data)

▷ Bremsstrahlung contributes significantly ... P.Malzacher, K. Schwarz