Quinto convegno nazionale sulla fisica di ALICE
Trieste, 12 – 14 Settembre 2009

VHMPID detector in the ALICE experiment at LHC

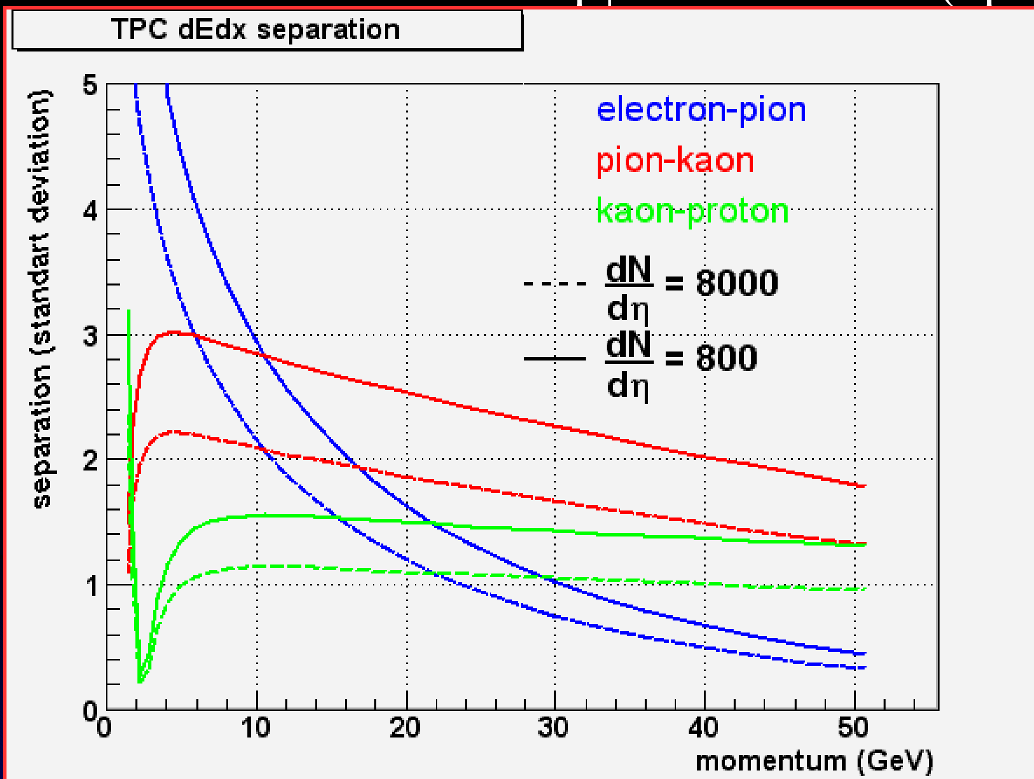
Giacomo Volpe

Università di Bari, Dipartimento Interateneo di Fisica “M. Merlin”
INFN, Sezione di Bari

ALICE experiment

ALICE has a unique capability, among the LHC experiments, of charged particle identification, due to the exploiting of different types of detectors:

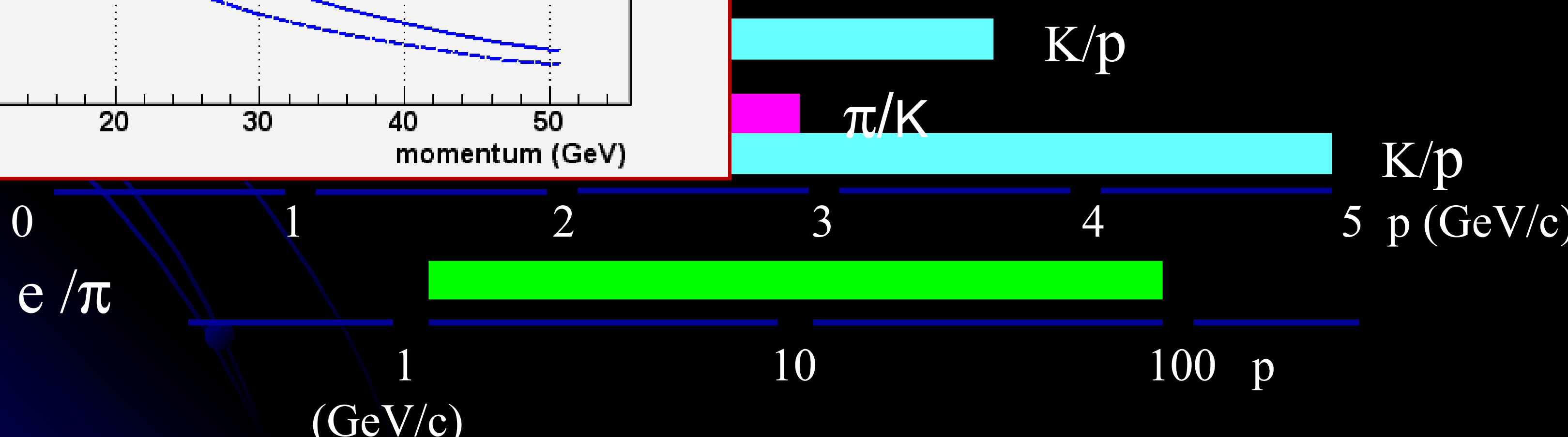
- ITS + TPC : low p_T identification (up to p = 600 MeV/c).



TPC performs statistical identification in the relativistic rise region

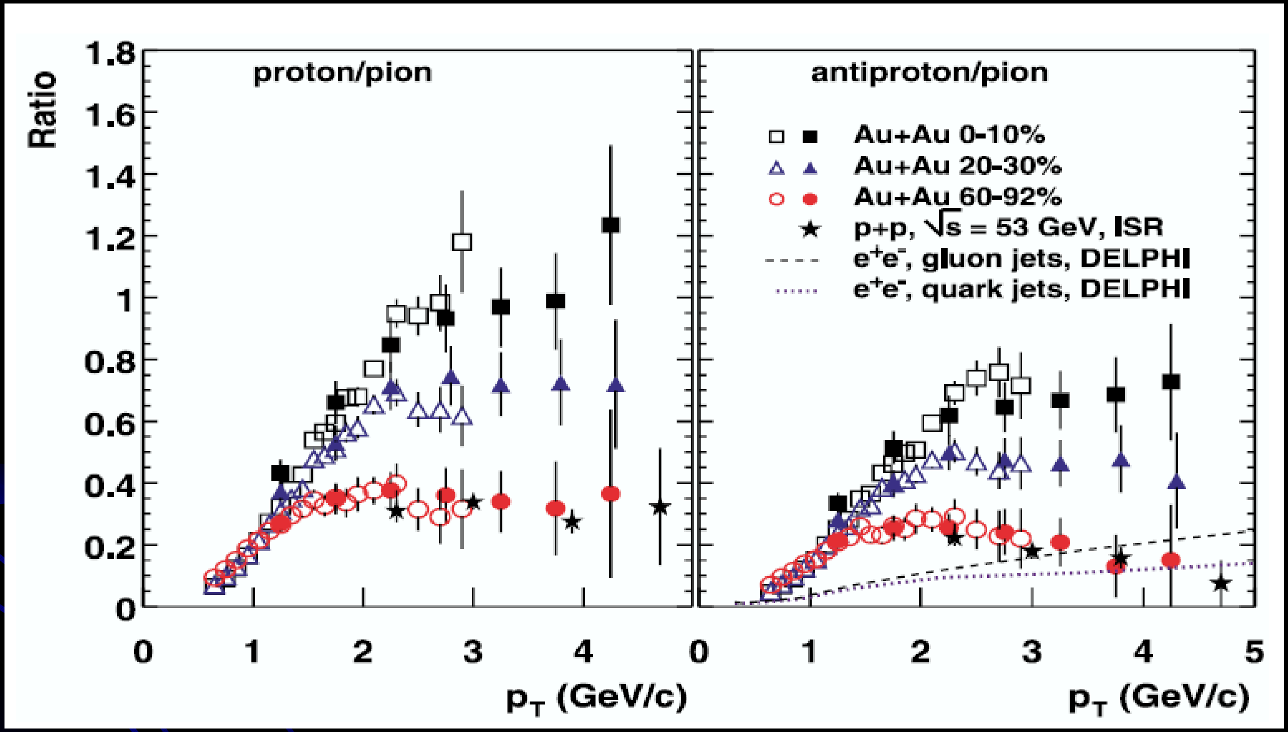
(RICH)

TRD



ALICE PID upgrade

RICH results: At RHIC has been observed a large enhancement of baryons and antibaryons relative to pions at intermediate $p_T \approx 2$ - 5 GeV/c, while the neutral pions and inclusive charged hadrons are strongly suppressed at those p_T.



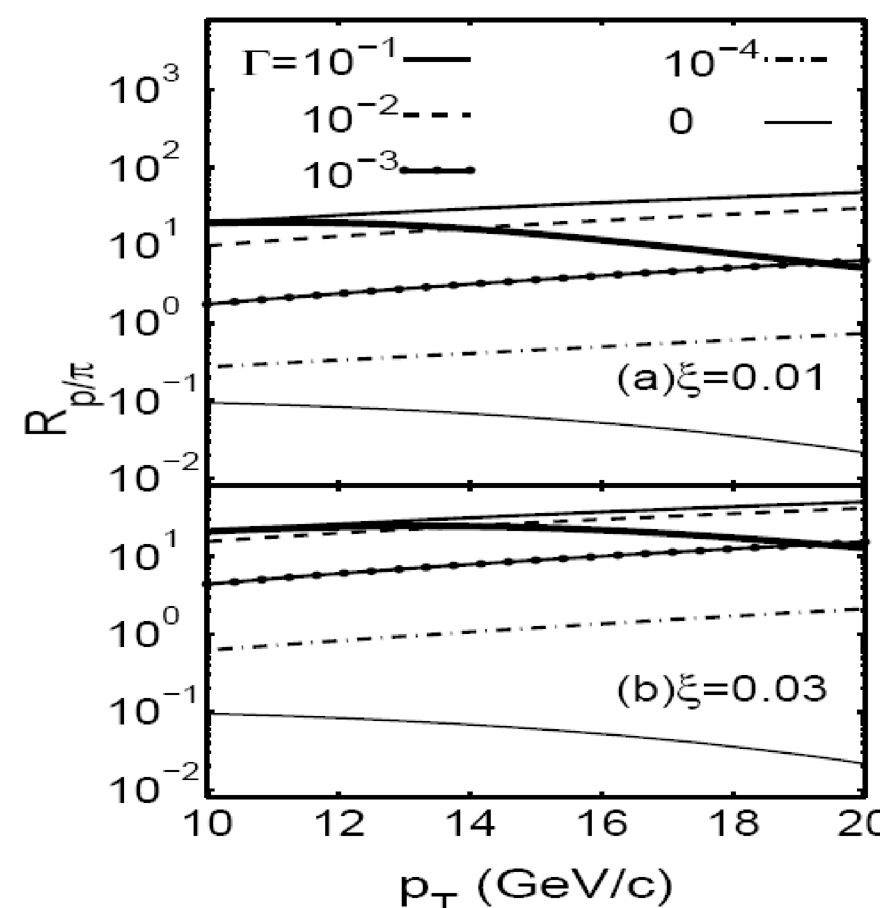
• The key issue is to understand what is the mechanism of the hadronization and the influence of this mechanism on the spectra of baryons and mesons.

ALICE PID upgrade

• The baryon puzzle observed at RICH can be interpreted with the “partons recombination” or “coalescence” mechanism.

• In the recombination scenario quark-antiquark pair close in the phase space can form a meson at hadronization, while three (anti)quark can form an (anti)baryon.

At LHC where the density of jets is very high, a new phenomenon originates where the recombination of shower partons in neighboring jets can make a significant contribution. It is foreseen that the baryon enhancement will be present in a momentum range higher than at RHIC, $p_T = 10 \div 20$ GeV/c. (ref. Rudolph C. Hwa, C. B. Yang, arXiv:nucl-th/0603053 v2, 21 Jun 2006)



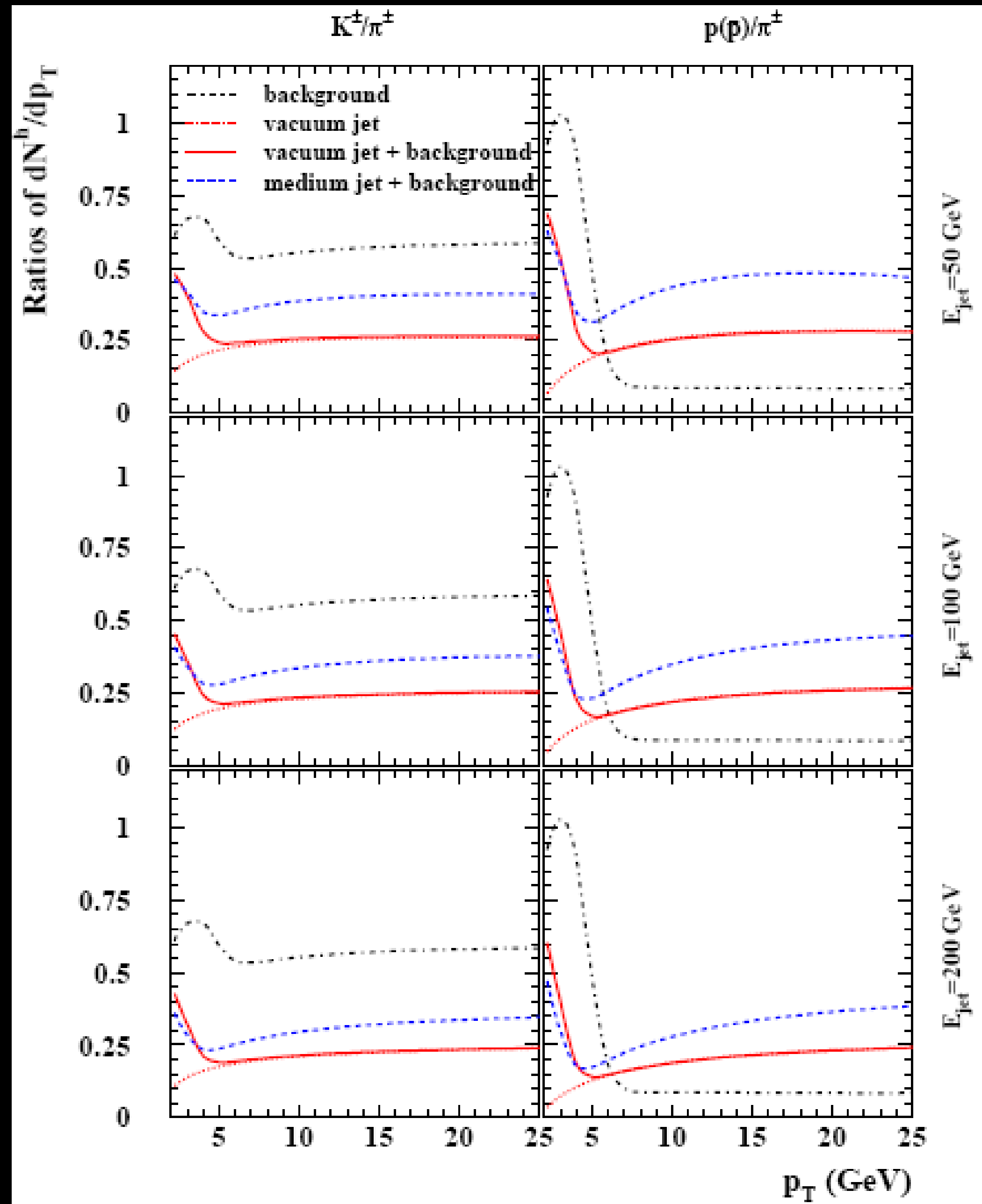
ALICE PID upgrade

Other authors using different arguments foresee also change in meson-baryon ratio for $p_T > 10$ GeV/c.

Jet quenching can leave signatures not only in the longitudinal and transverse jet energy and multiplicity distributions, but also in the hadrochemical composition of the

jet fragments.

S. Sapeta and U. A. Wiedemann, arXiv:0707.3494 [hep-ph], July 2007.



ALICE PID upgrade
track-by-track vs statistical identification

• One may imagine that the topology of events with high p_t protons will be distinct from the topology of the usual jet.

• One may study special aspects like the conservation of the baryonic number measuring the pbar-p correlations in the same side jet;

• The kaon identification may be also interesting in jet hadrochemistry as shown by Sapeta and Wiedeman;

• The track by track may be also interesting as a bench mark for the statistical identification.

VHMPID

- ALICE-HMPID collaboration is studying the possibility to built a new detector to identify charged particles with momentum p > 10 GeV/c → VHMPID (Very High Momentum Particle Identification Detector).
- Energy loss or Time of Flight measurements don't allow to identify track-by-track in such momentum range.
- Since the given space in the ALICE detector and the physics requirements it seems inevitable to use gas Cherenkov counters.
- To use a gas Cherenkov detector in a magnetic field environment brings about the following key problems: the choice of radiator gas, the photon detection and the detector geometry.
- A combination of a gas with low value of refractive index, with the proven concept of large area CsI photocathodes, has been considered.
- Depending on the particle momentum values, with VHMPID will be possible to have PID by means pattern recognition method or by threshold counters technique.

Primary objectives of the VHMPID

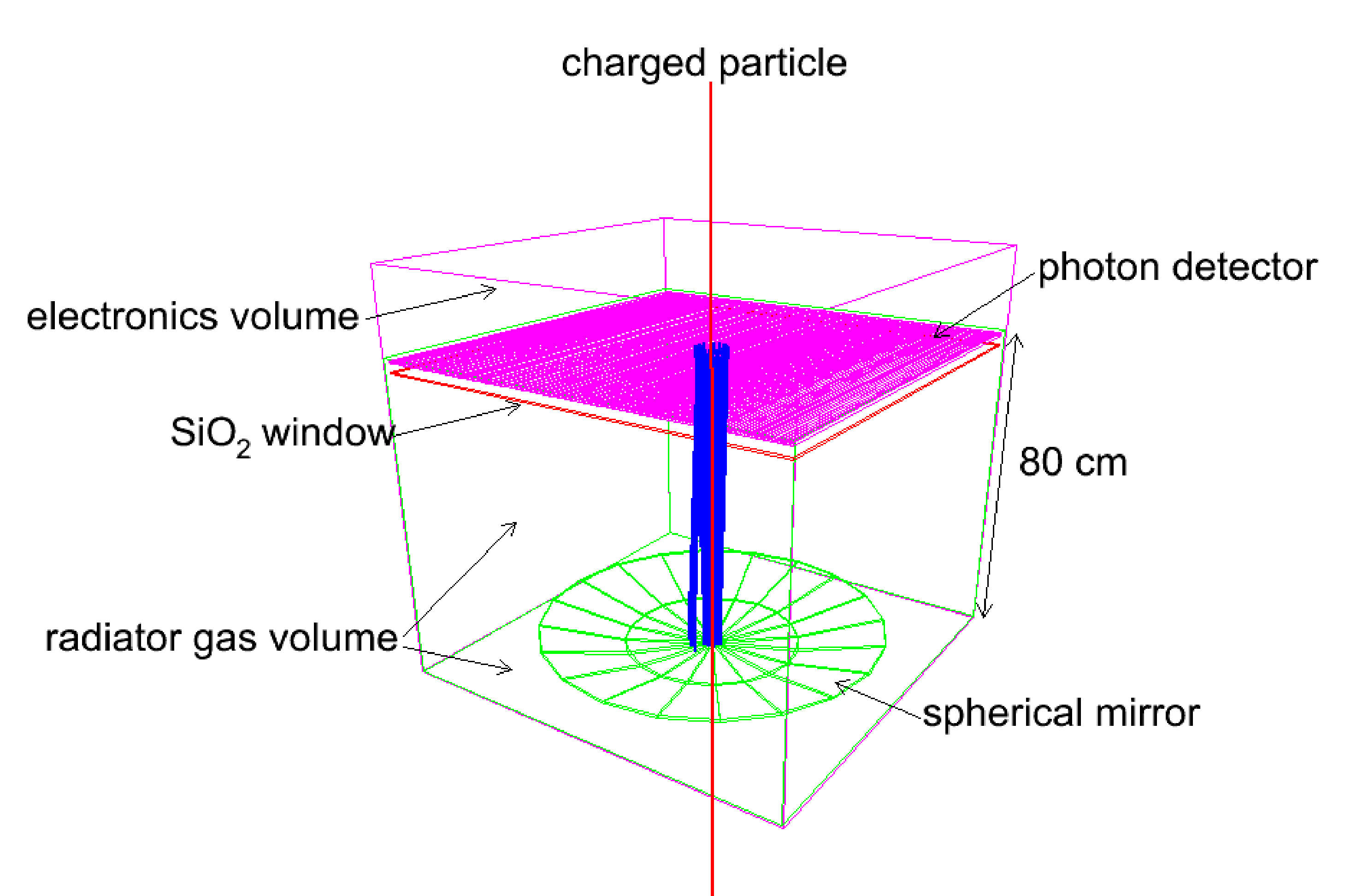
- Measurement of jets and identified jet fragmentation functions on a track-by-track basis for charged hadrons (pions, kaons and protons)

- Measurements of jet structure (momentum and flavor correlations) to study the medium modifications

- Special jet features (baryonic number balance) and possible enhancements of proton yields (modification of hadronization)

Studied setup

The focusing properties of a spherical mirror of radius R = 160 cm, are exploited. The photons emitted in the radiator are focused in a plane that is located at R/2 from the mirror center, where the photon detector is placed.



VHMPID

Radiator gas

• CF_4 (n ≈ 1.0005, γ_{th} ≈ 31.6) has the drawback to produce scintillation photons (N_{ph} ≈ 1200/MeV), that increase the background.

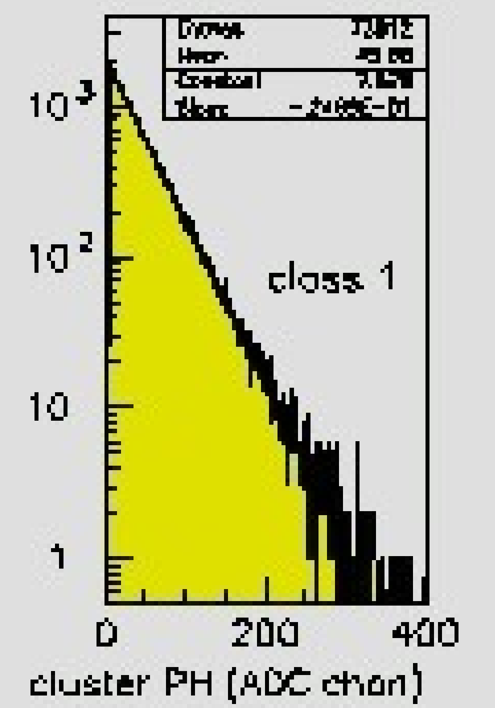
• C_5F_{12} (n ≈ 1.002, γ_{th} ≈ 15.84) has boiling point T_b = 28° C at 1 atm, implying a difficult use of it in ALICE setup, where the internal temperature could be more or less the same (heating plant is needed).

• C_4F_{10} (n ≈ 1.0014, γ_{th} ≈ 18.9) has been chosen.

Photon detector

• Pad-segmented CsI photocathode is combined with a MWPC with the same structure and characteristic of that used in the HMPID detector.

• The gas used is CH_4, the pads size is 0.8×0.84 cm^2 (wire pitch 4.2 mm), and the average single electron pulse height is of 34 ADC channels (1 ADC = 0.17 fC ≈ 1000 e^-) at 2050 V.

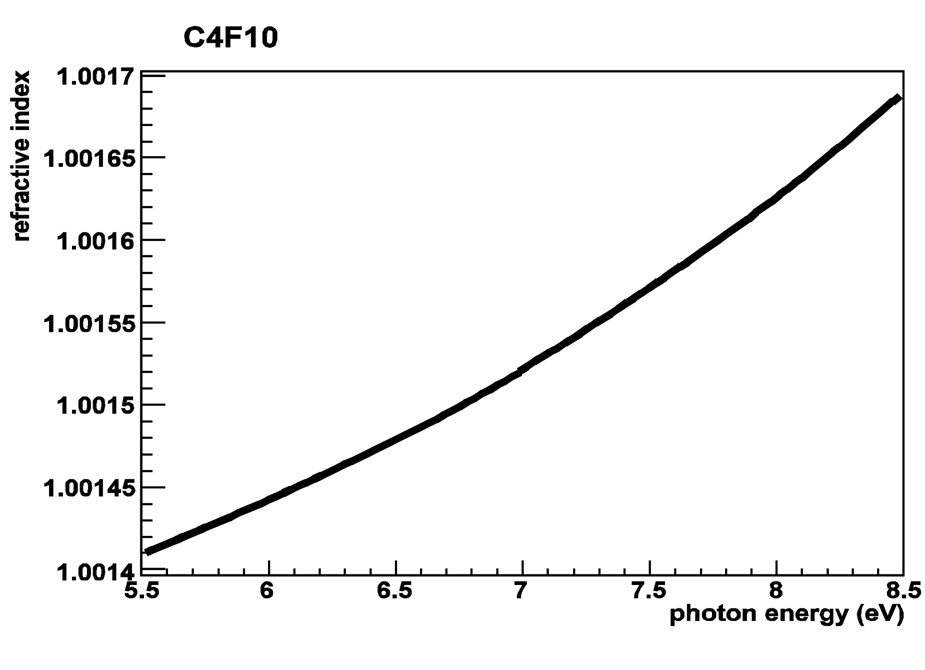


• The chamber is separated from the radiator by a SiO_2 window (4 mm of thickness).

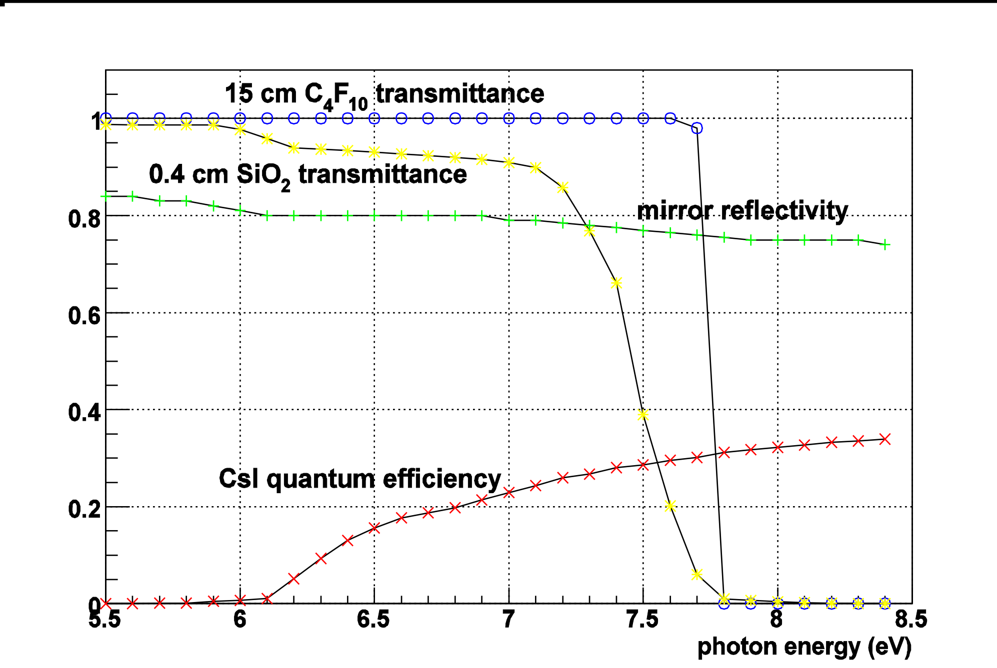
VHMPID

The simulation has been executed using AliRoot, the official simulation framework of the ALICE experiment.

C_4F_{10} refractive index as a function of photon energy



Material photon transmittances and CsI photocathode quantum efficiency

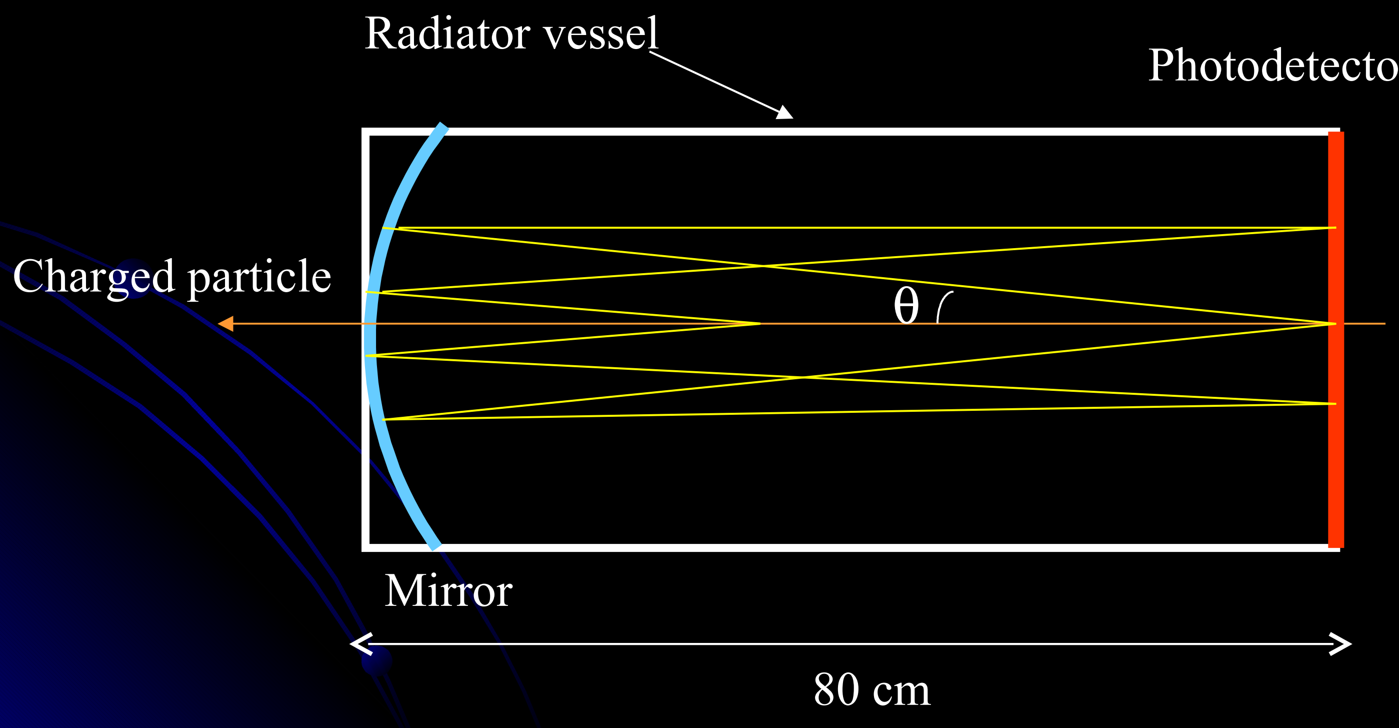


Study of the detector response: focusing setup

• In the case of focusing setup the determination of Cherenkov emission angle is possible.

• Pattern recognition algorithm is needed to retrieve the emission angle.

• A back-tracing algorithm has been implemented to retrieve the Cherenkov emission angle. It calculates the angle starting from the photon hit point coordinates, on the photon detector.



Background subtraction algorithm
Hough transform method

• The Hough Transform Method (HTM) is an efficient implementation of a generalized *template matching* strategy for detecting complex patterns in binary images.

• In the case of the Cherenkov pattern recognition, the starting point of the analysis is a bidimensional map with the impact point (x_p, y_p) of the charged particles, hitting the detector plane with known incidence angles (θ_p, φ_p), and the coordinates (x, y) of hits due to both Cherenkov photons and background sources.

• A "Hough counting space" is constructed for each charged particle, according to the following transform:

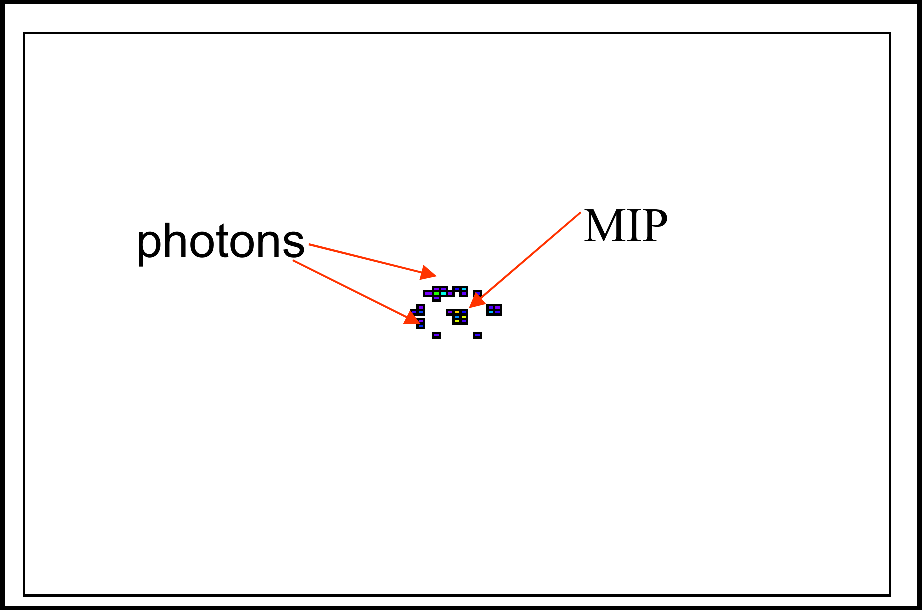
$$(x, y) \rightarrow ((x_p, y_p, \theta_p, \varphi_p)\ ,\ \eta c)$$

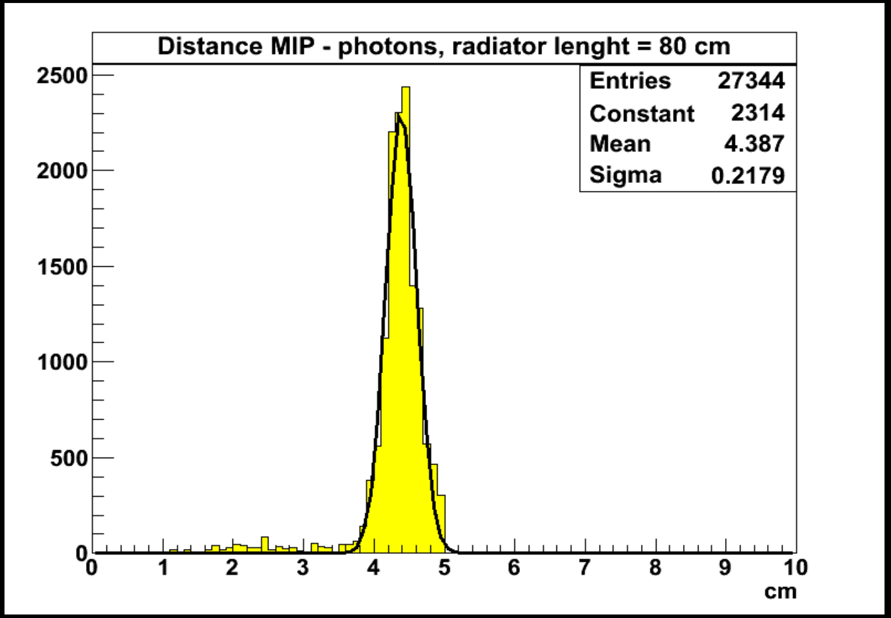
• (x_p, y_p, θ_p, φ_p) is provided by the tracking of the charged particle, so the transform will reduce the problem to a solution in a one-dimensional mapping space.

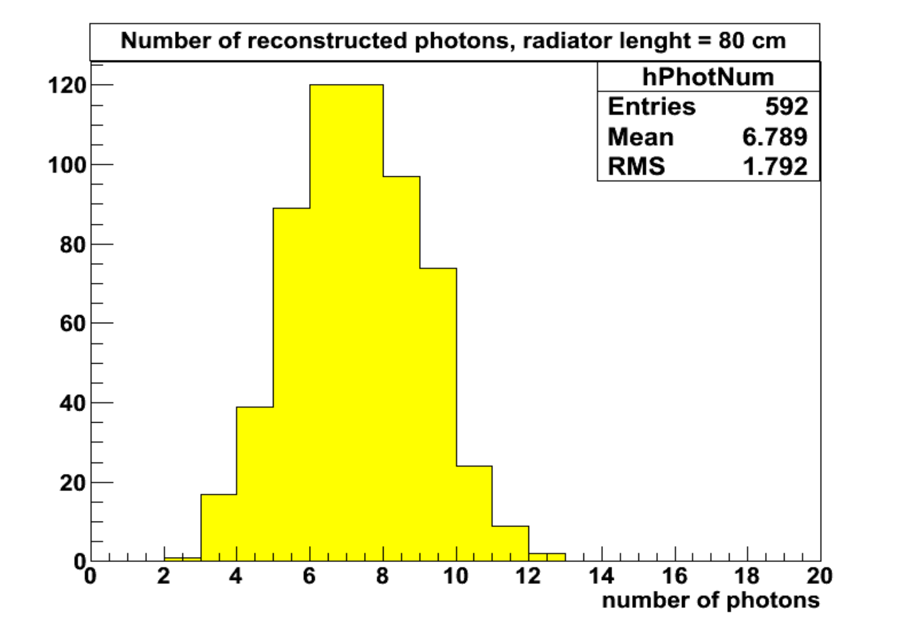
• A η_c bin with a certain width is defined.

• The Cherenkov angle θ_c of the particle is provided by the average of the η_c values that fall in the bin with the largest number of entries.

VHMPID performances

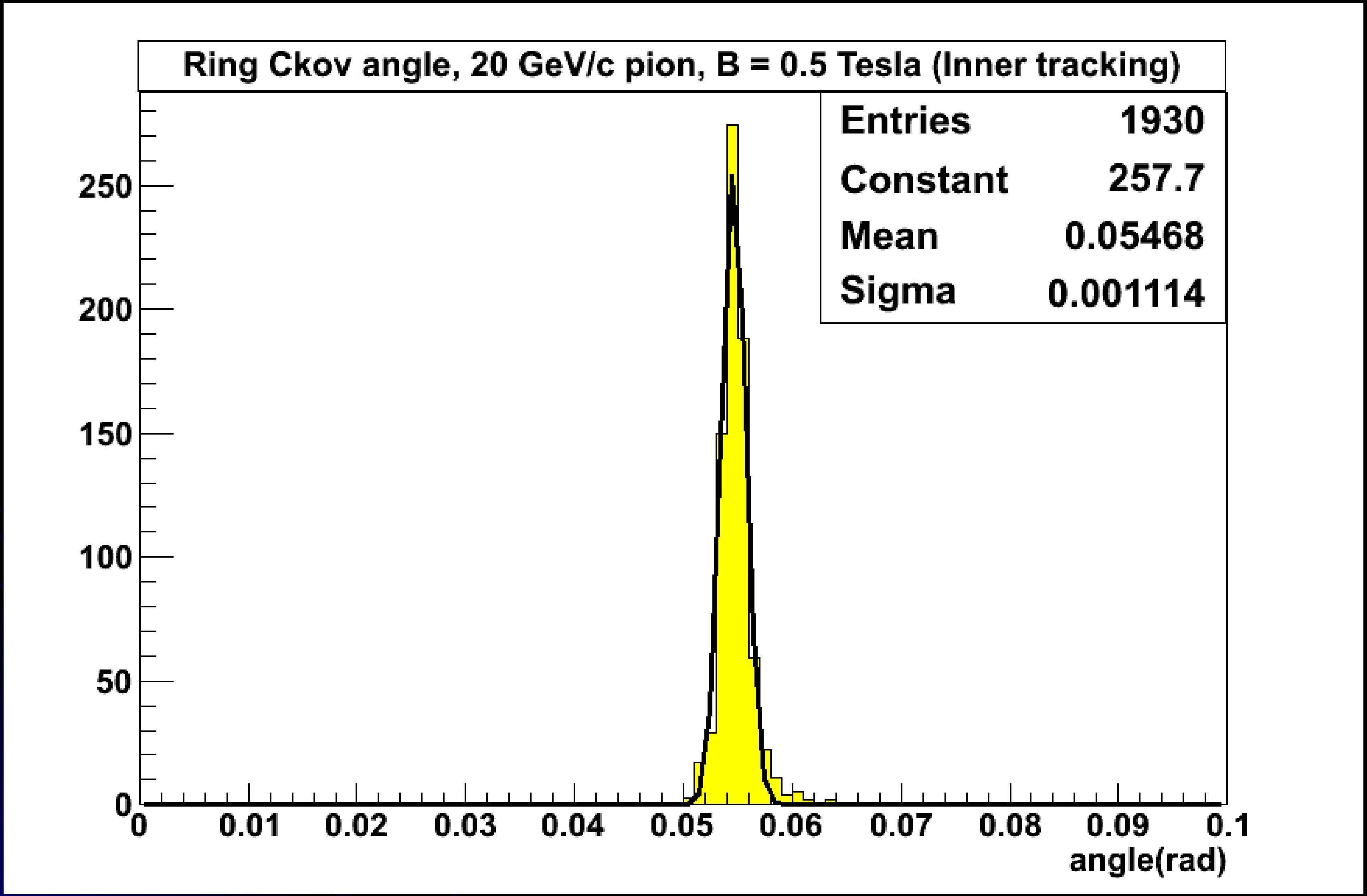




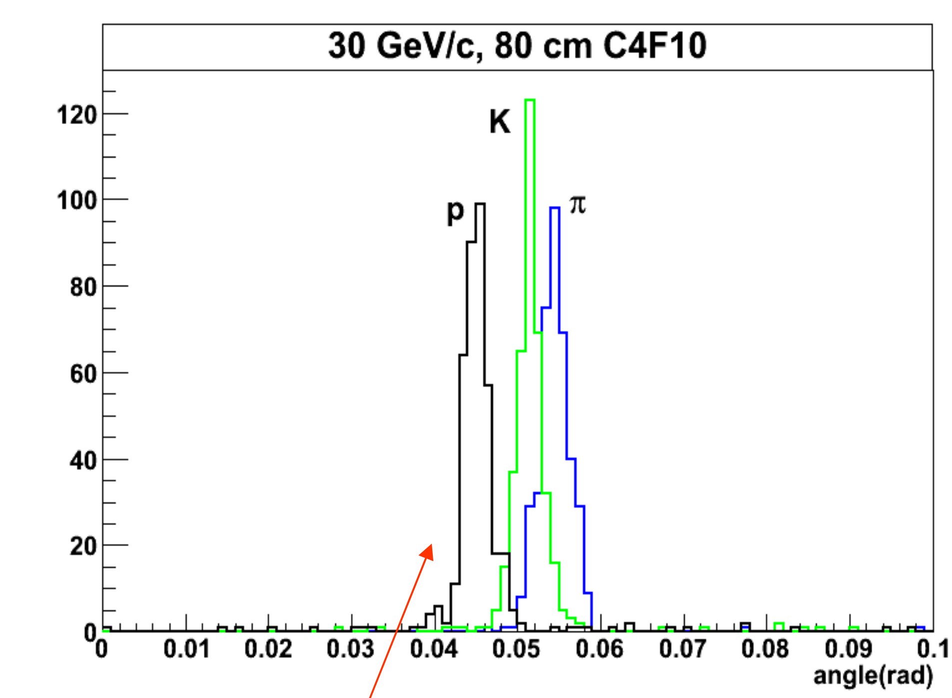


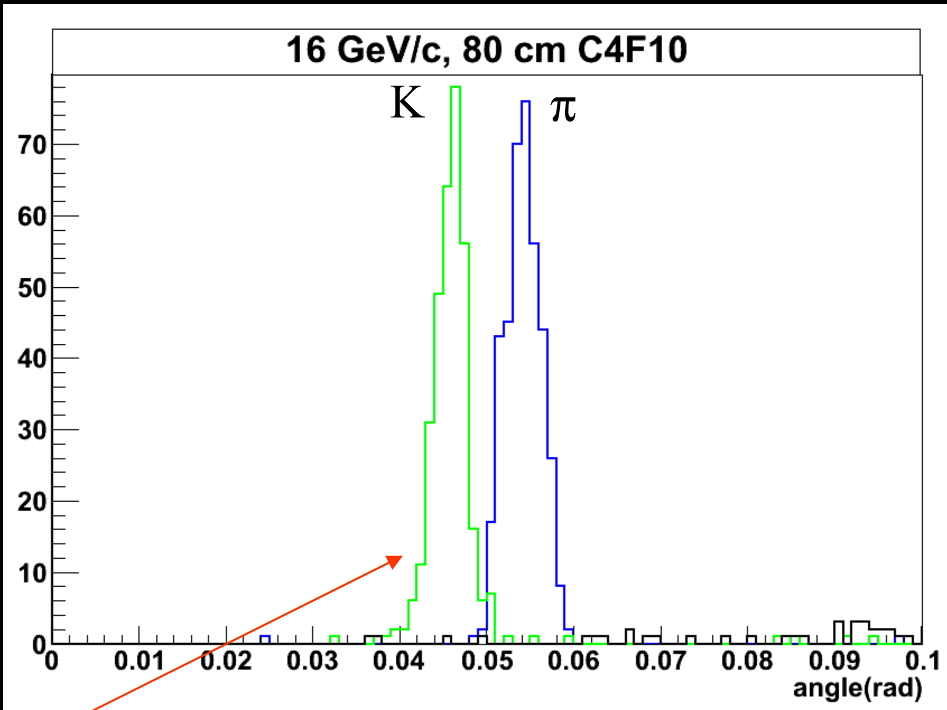
Pion at saturation

VHMPID performances



VHMPID performances



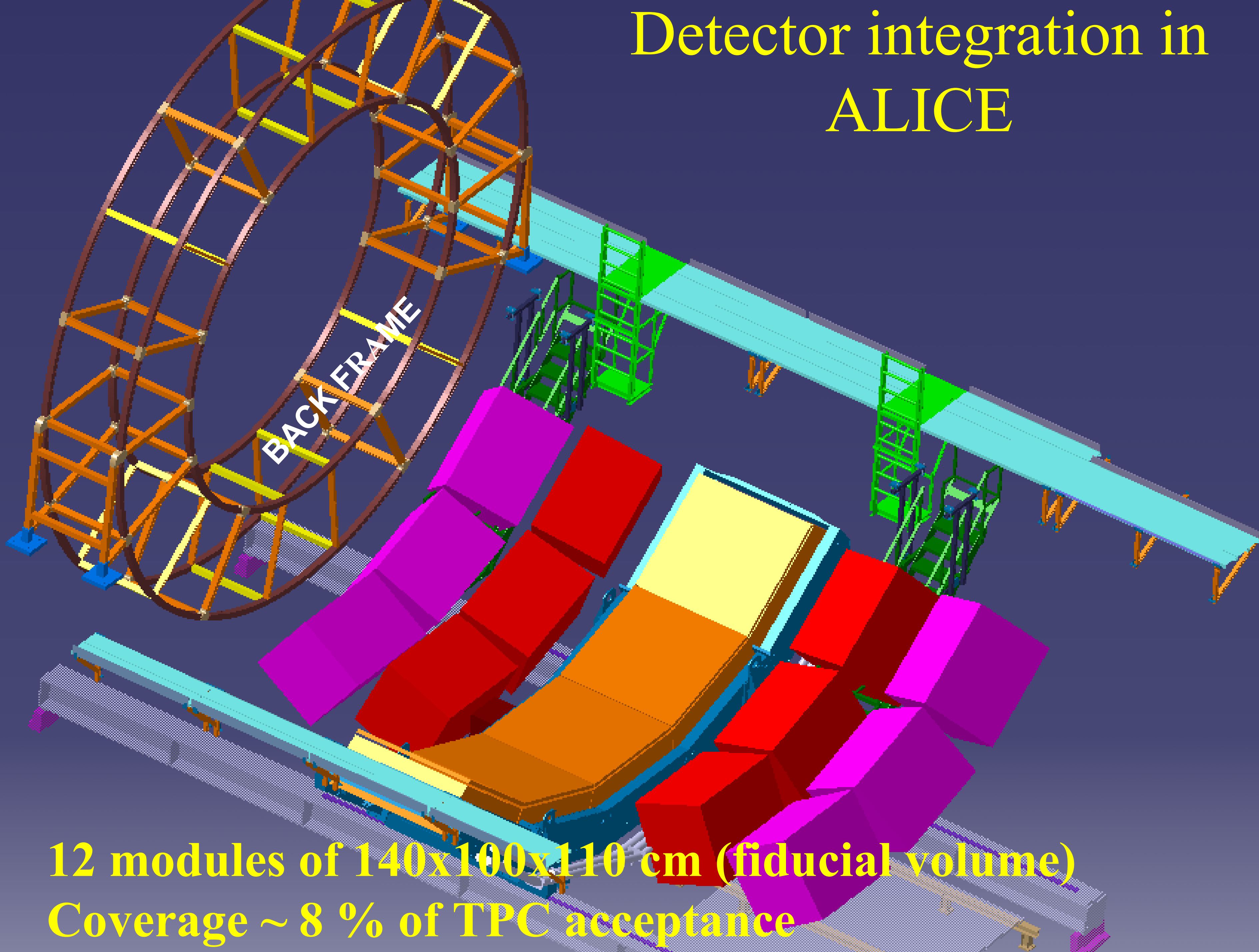


Background given by
HIJING Pb-Pb collision

3 σ separation

	Signal (GeV/c)	Absence of signal (GeV/c)
p	4-16	
K	11-16	
p	18-30	11-18

Detector integration in ALICE



12 modules of 140x100x110 cm (fiducial volume)

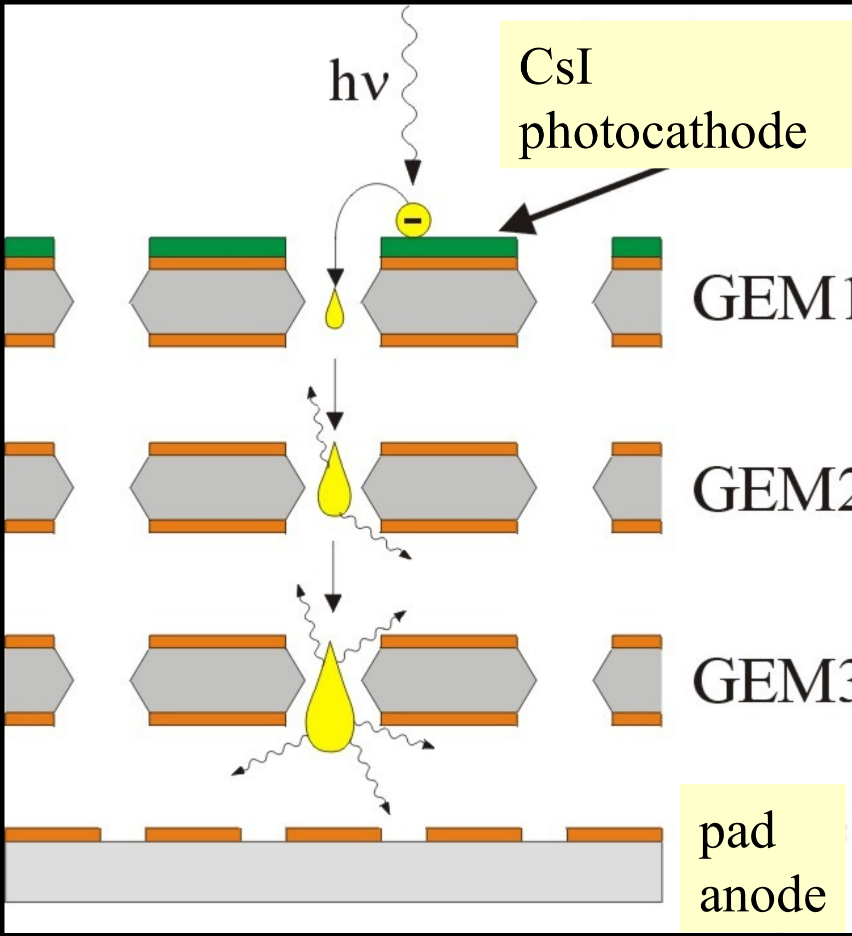
Coverage ~ 8 % of TPC acceptance

R&D on TGEM based CsI photodetector

Use Thick-GEM with CsI coating for single photon detection.

Main features:

- Stable operation at high gas gain ~ 10^6, improved single e^- detection efficiency;
- Reduction of secondary effects (photon feedback);
- Intrinsic higher localization resolution;
- Faster and simpler detector assembly wrt MWPC, lighter materials;
- Not flammable gas mixture.



Triggering

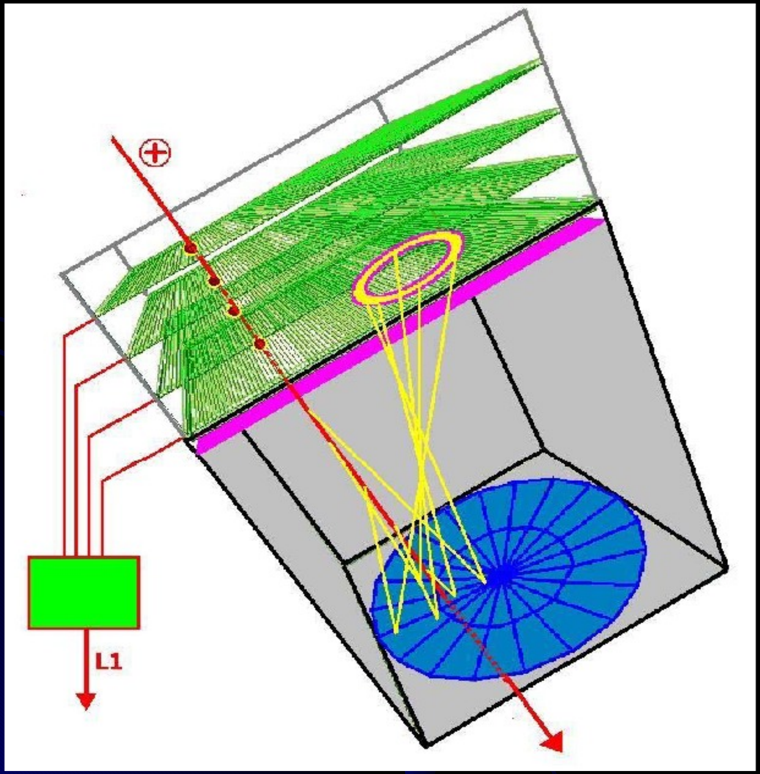
- Triggering is an important ingredient of the physics aspect.
    - Rough estimate of the number of high p_t particles

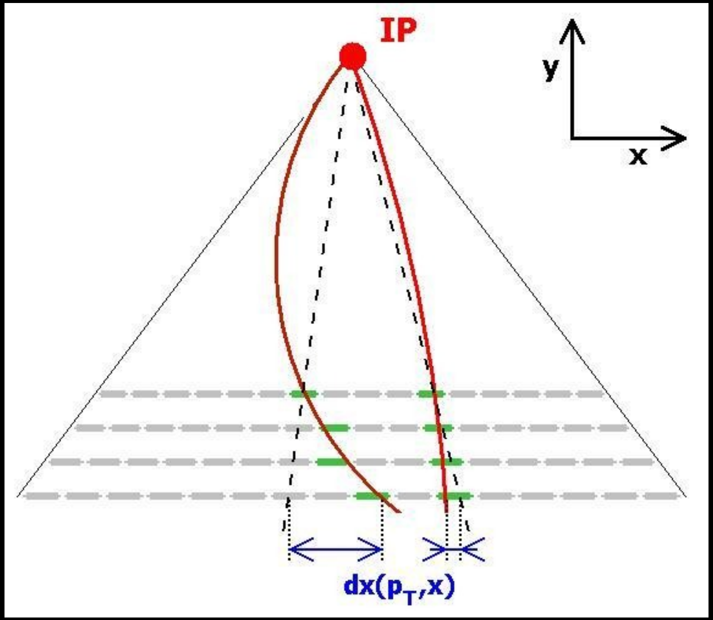
- Two possible ways to trigger
    - using TRD trigger;

    - using a dedicated trigger

Triggering: R&D on dedicated trigger

- Expected decrease of charged hadron yield above 10 GeV/c requires a dedicated trigger
- Besides the TRD options, a High p_t Trigger Detector (HPTD) is under study





Stack of four TGEM segmented in 50x2 mm strips in front of (or behind) VHMPID, tracking algorithm selecting high p_T particles at L1

Conclusions and Outlook

- A lot of work has been done, but further studies are still needed to define:
  - mirror shape;
  - radiator length;
  - geometry;
  - triggering option;
  - installation details.

- The possibility to install in the near future (2011/2012 shutdown?), only one VHMPID module has been taken into account.

- A single VHMPID module in an early phase would be of help with:
  - participate in pp running;
  - testing the concept and construction details;
  - Good opportunity to tune the TPC PID leading to decision on building a full VHMPID.