Looking into the Future: The VHMPID for ALICE

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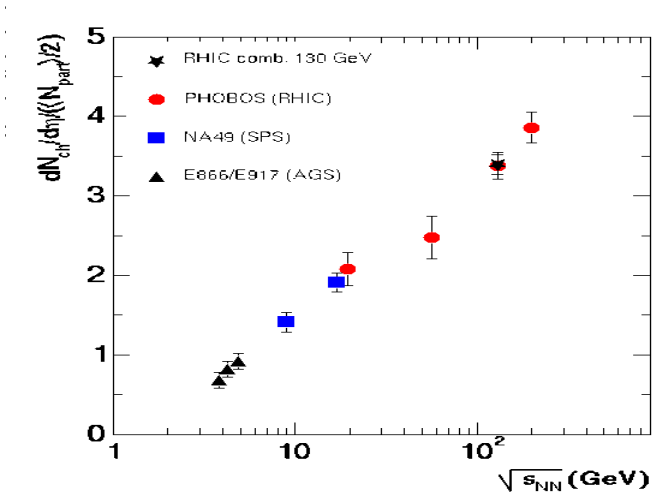
ICN

Outline

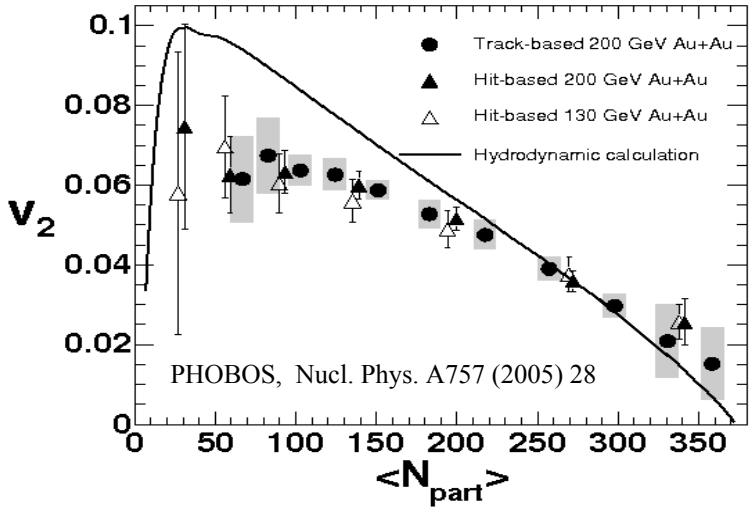
1. Background to the Very High Momentum Particle Identification Detector (VHMPID)
2. Detector Characteristics and Simulation
3. Physics possibilities (work in progress)
4. Project Status and Plans

The reference: RHIC

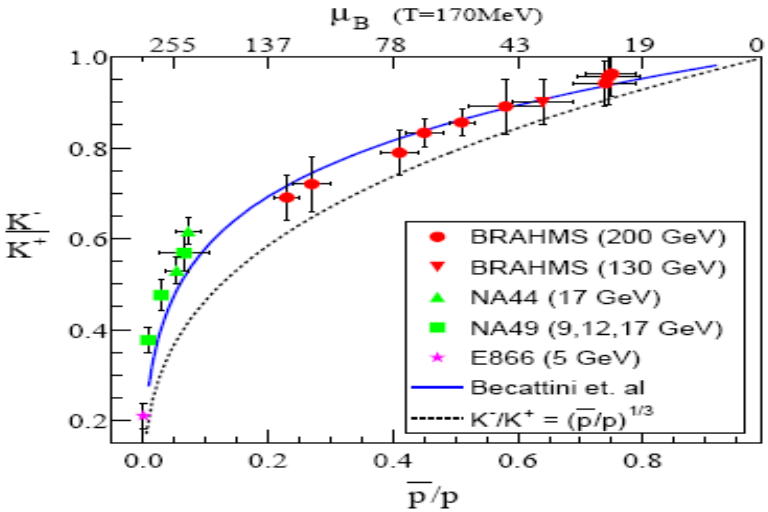
High energy density



Elliptic Flow

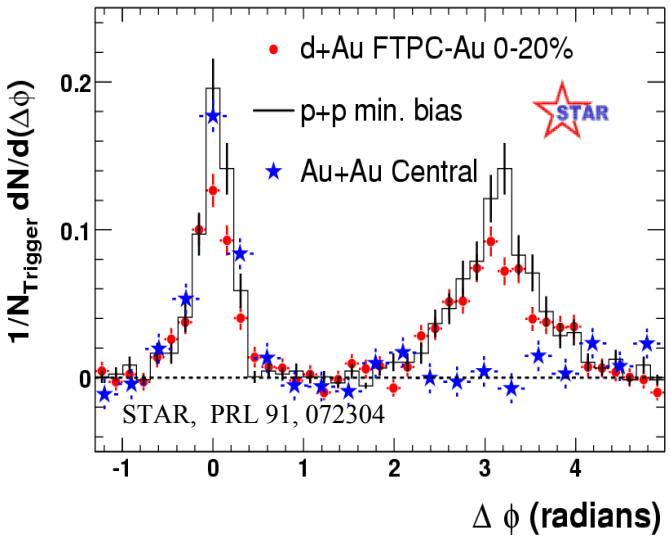


Applicability of thermodynamics

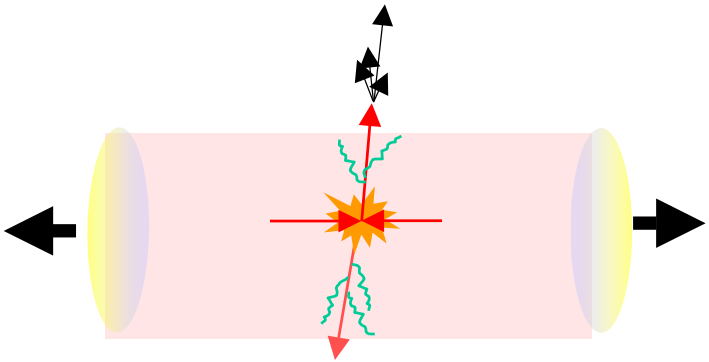


BRAHMS, Nucl. Phys. A757 (2005) 1-27

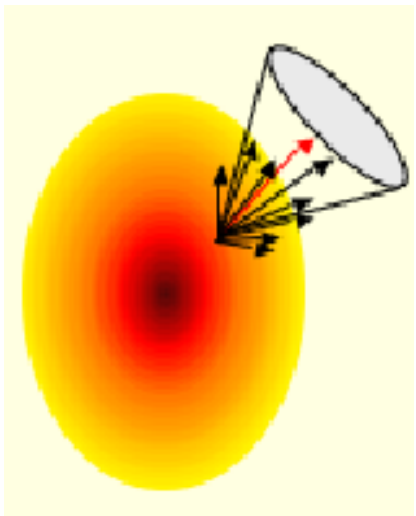
Jet Suppression

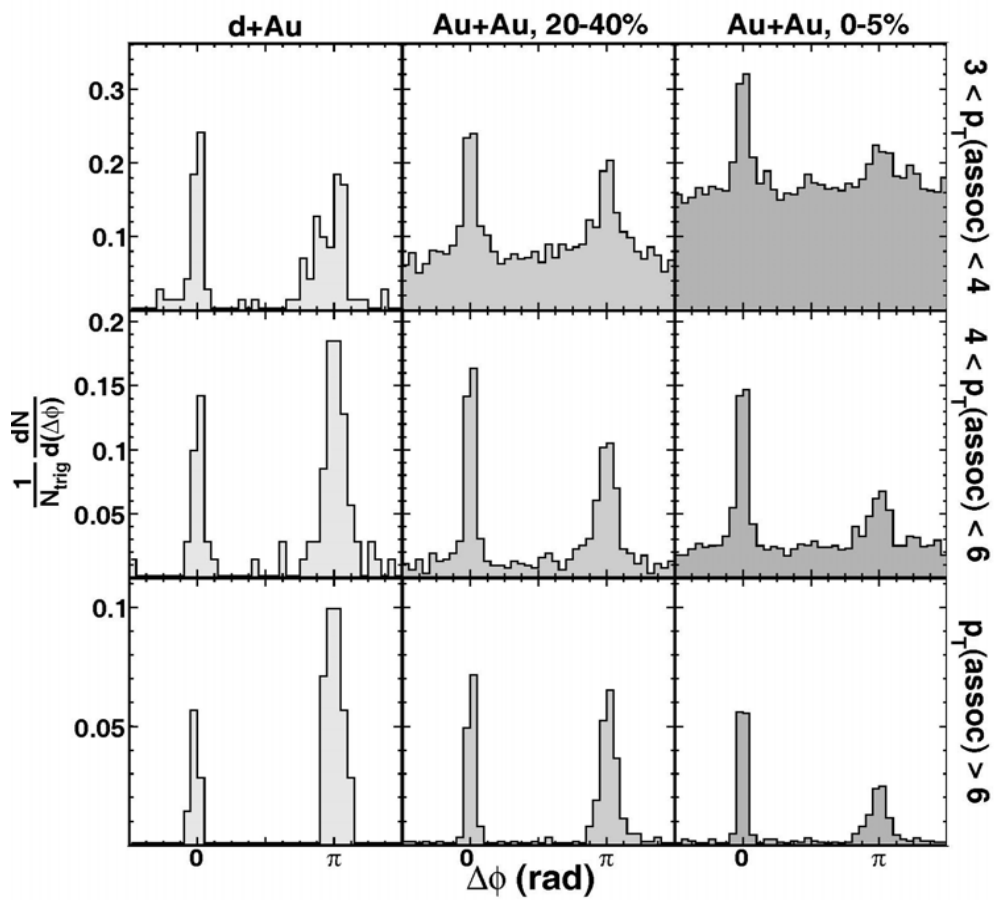


Jet Suppression



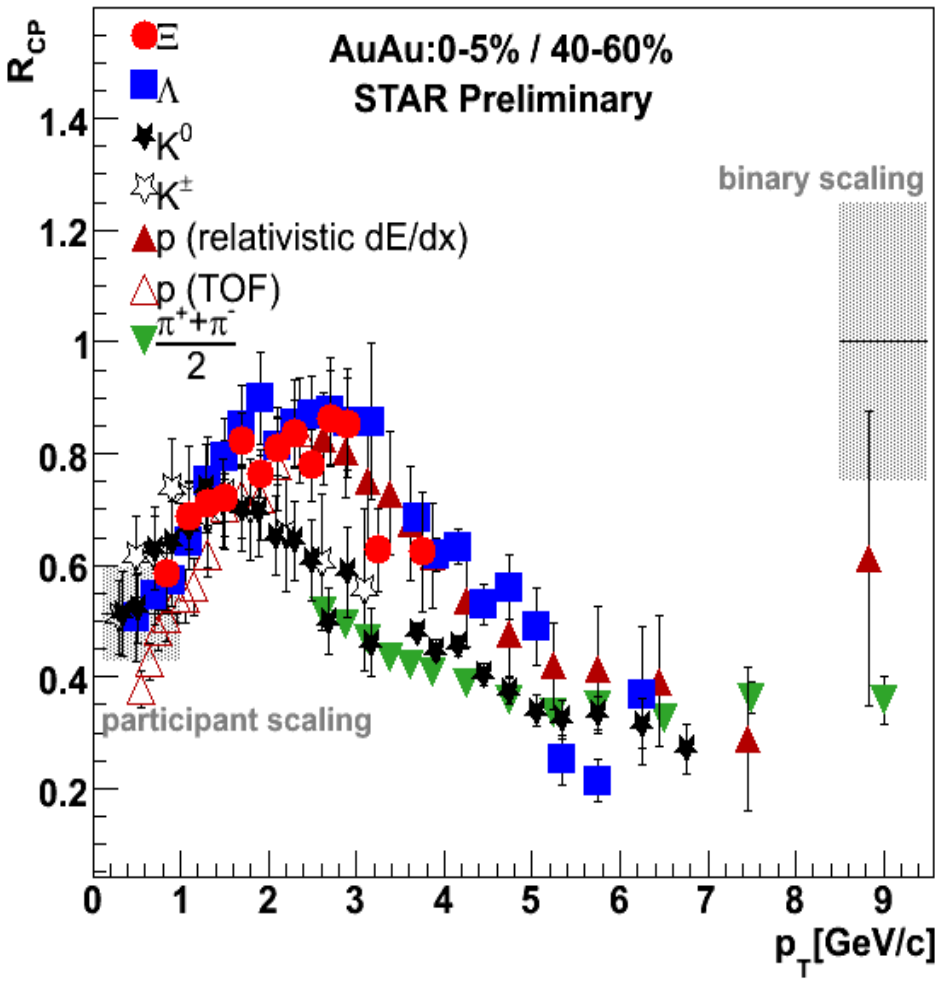
Yield suppression → partonic energy loss in medium generated in collision





Jet energy loss deposited in generated medium

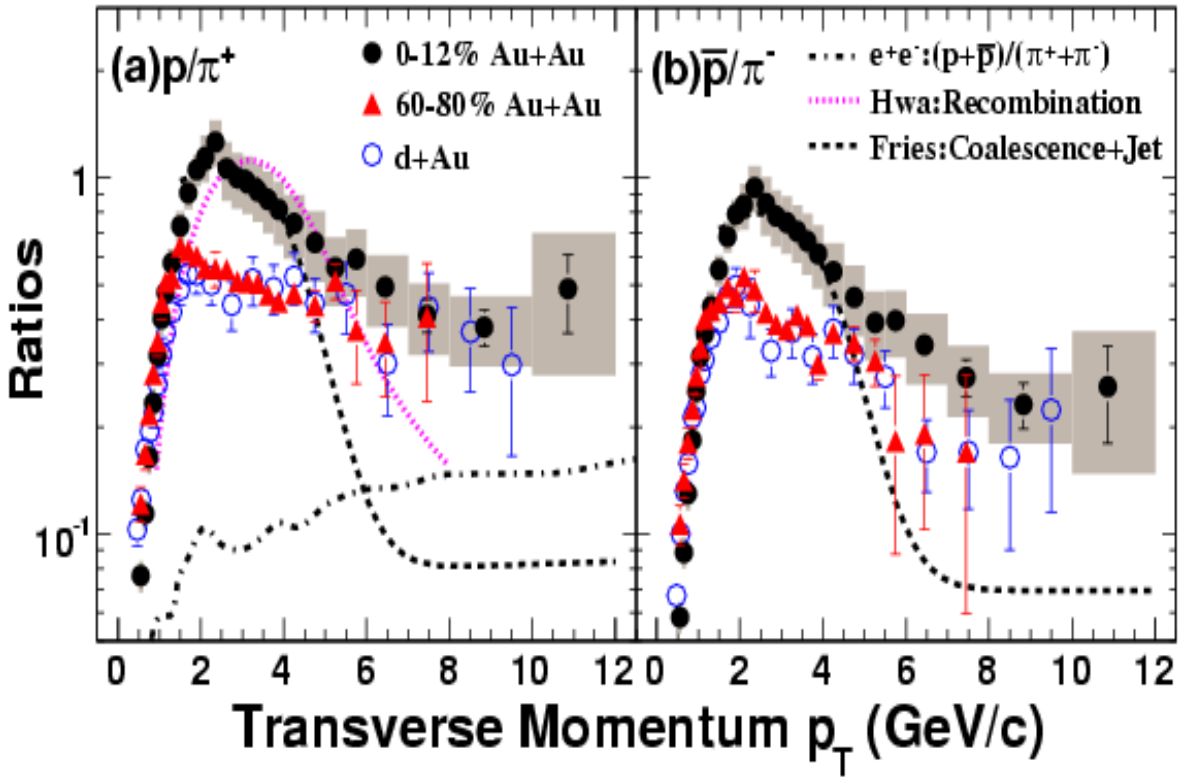
Baryon/Meson Anomaly at intermediate p_T



- R_C is the N_{BIN} scaled central to peripheral yield ratio
- At intermediate p_T baryon to meson splitting independent of the strangeness content
- At high p_T all particles have similar R_{CP} and appear to show similar suppression

Baryon/Meson Puzzle at RHIC

STAR, PRL 97 (152301) 2006



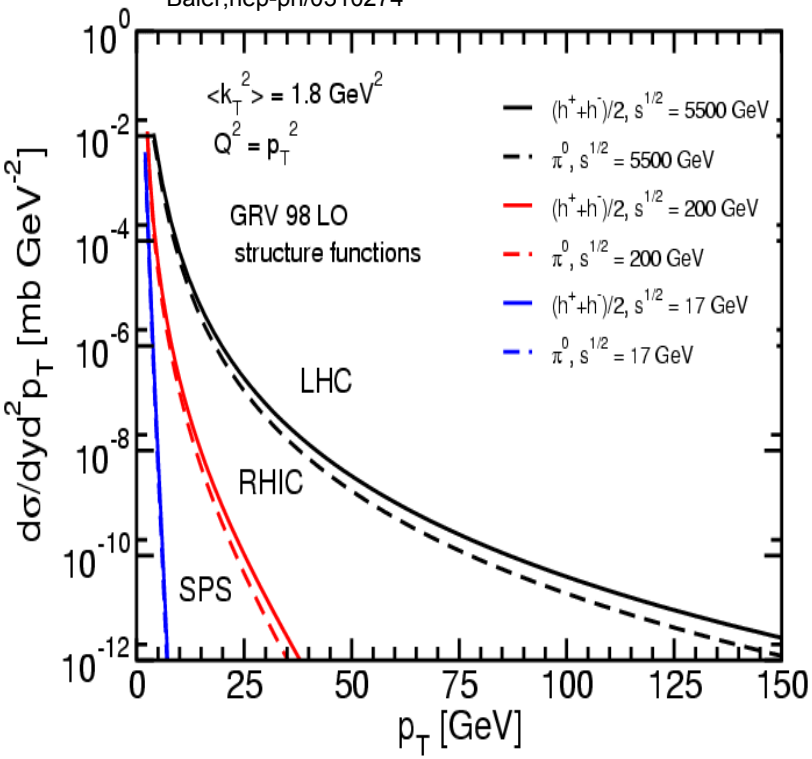
- Large enhancement of baryon to meson ratio in A+A collisions
- Reaches max. at pT ~ 3 GeV/c
- Jet fragmentation not the dominant source of hadronization

  p+p: $p/\pi \sim 0.2$
  Au+Au: $p/\pi \sim 1$

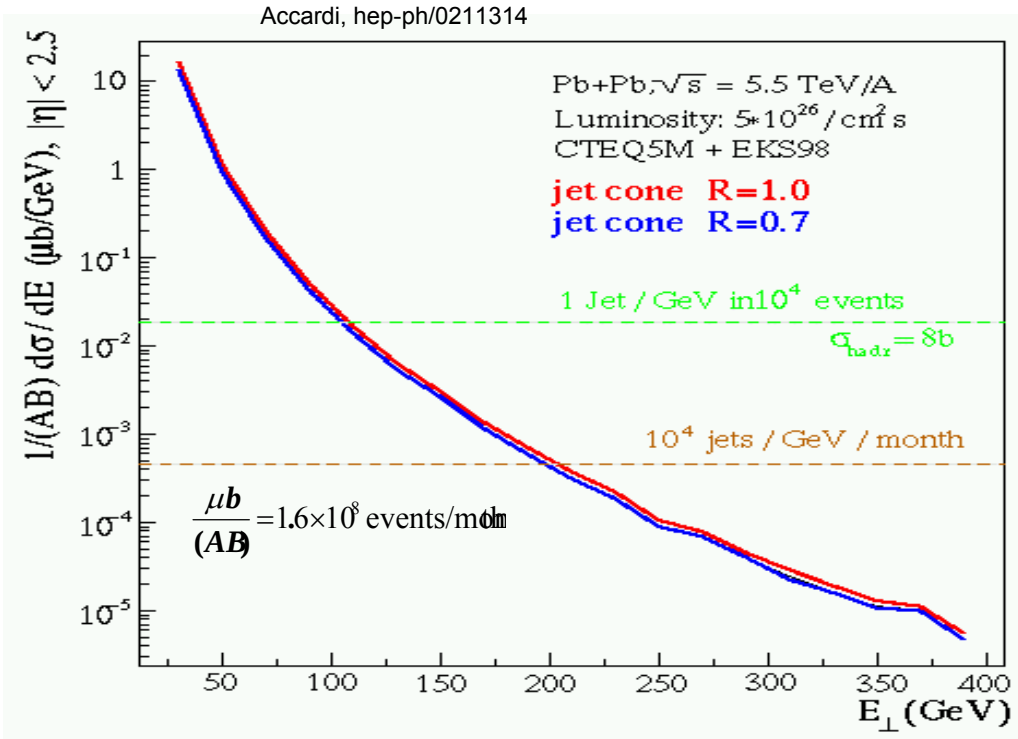
- Flow effects? Recombination?

From RHIC to LHC

Baier,hep-ph/0310274



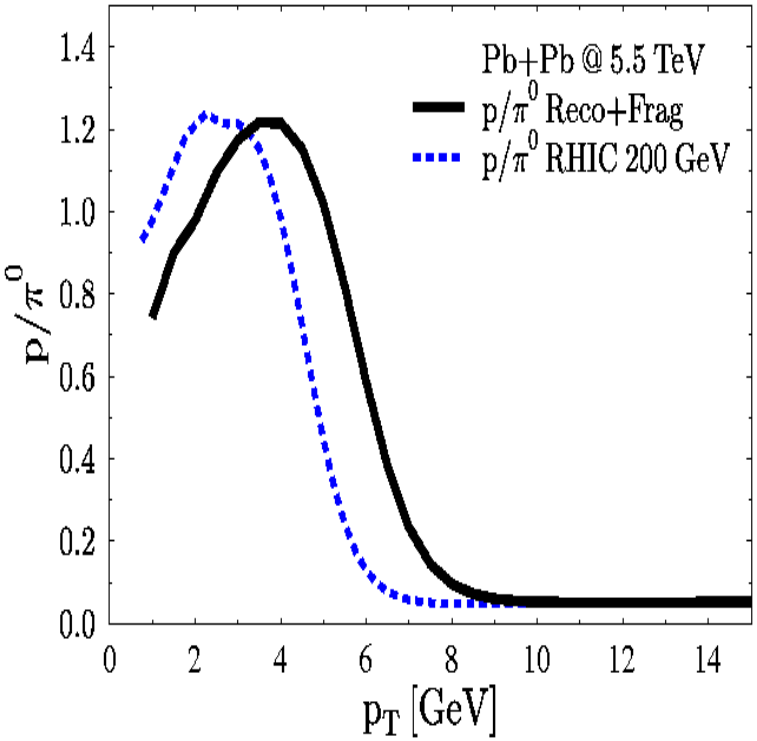
Accardi, hep-ph/0211314



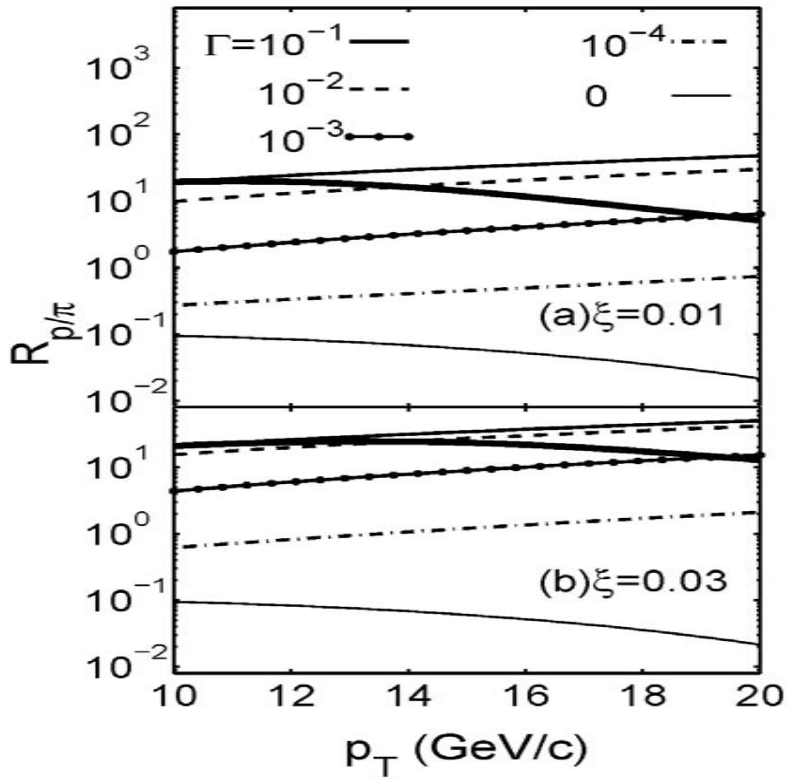
- Factor 28 increase in energy to $\sqrt{s_{NN}}$=5.5 TeV
- High Luminosity
- Large Cross sections
  - High p_T particles
  - Jets, which are now directly identifiable

Baryon/Meson Ratio at the LHC

Fries and Mueller, EJP C34, S279 (2004)



R.C. Hwa and C.B. Yang, PRL 97, 042301 (2006)



- LHC vs RHIC: amplitude of baryon/meson ratio similar, but pushed to larger p_T.
- Probing baryon/meson differences at the LHC implies particle identification over a large p_T range (10 – 30 GeV/c)

ξ: suppression factor

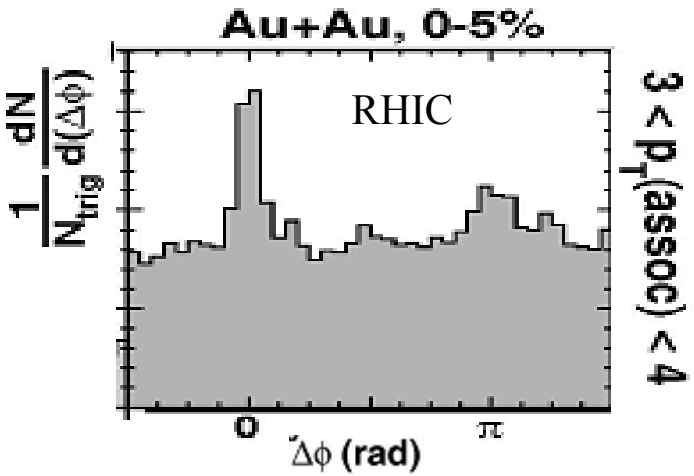
$\xi_{RHIC} = 0.07$

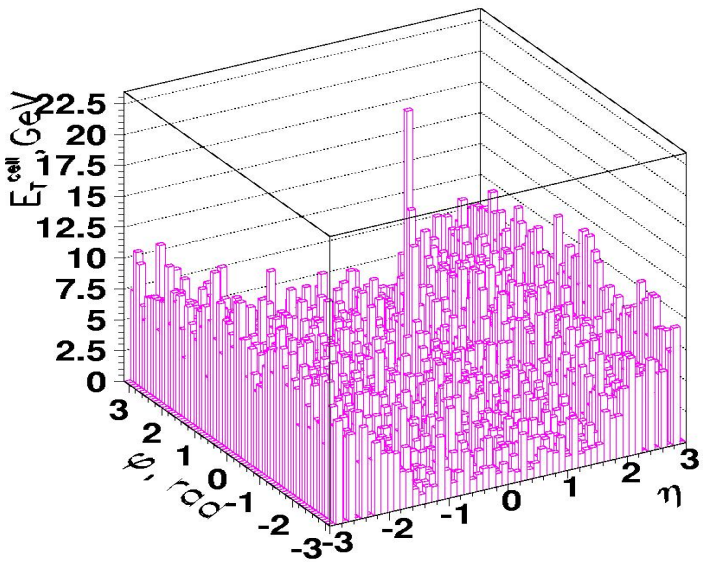
$\xi_{LHC} = 0.01\text{-}0.03$

Γ: overlap factor of shower partons from neighbouring jets

Challenges for Jet Physics at the LHC

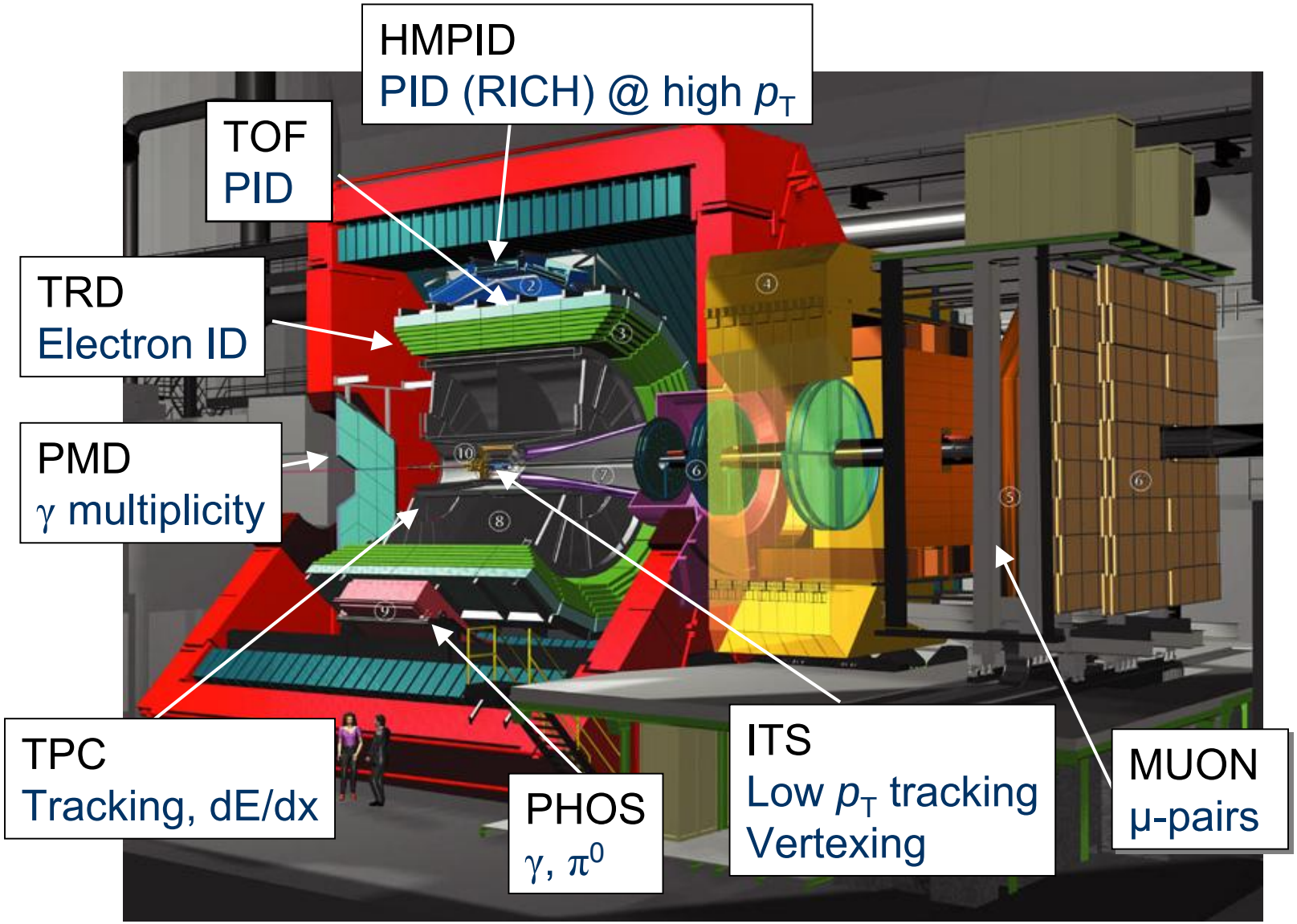
- Higher production rates, and the hardening of the spectra may represent a challenge for study of intermediate energy jets.
- I may be difficult to separate the leading hadron and the hadrons from the “radiated” energy.
  - Low *signal to background* in this region maybe a challenge
- The jet correlation studies will require tracking and acuarate PID capabilities (track-by-track)



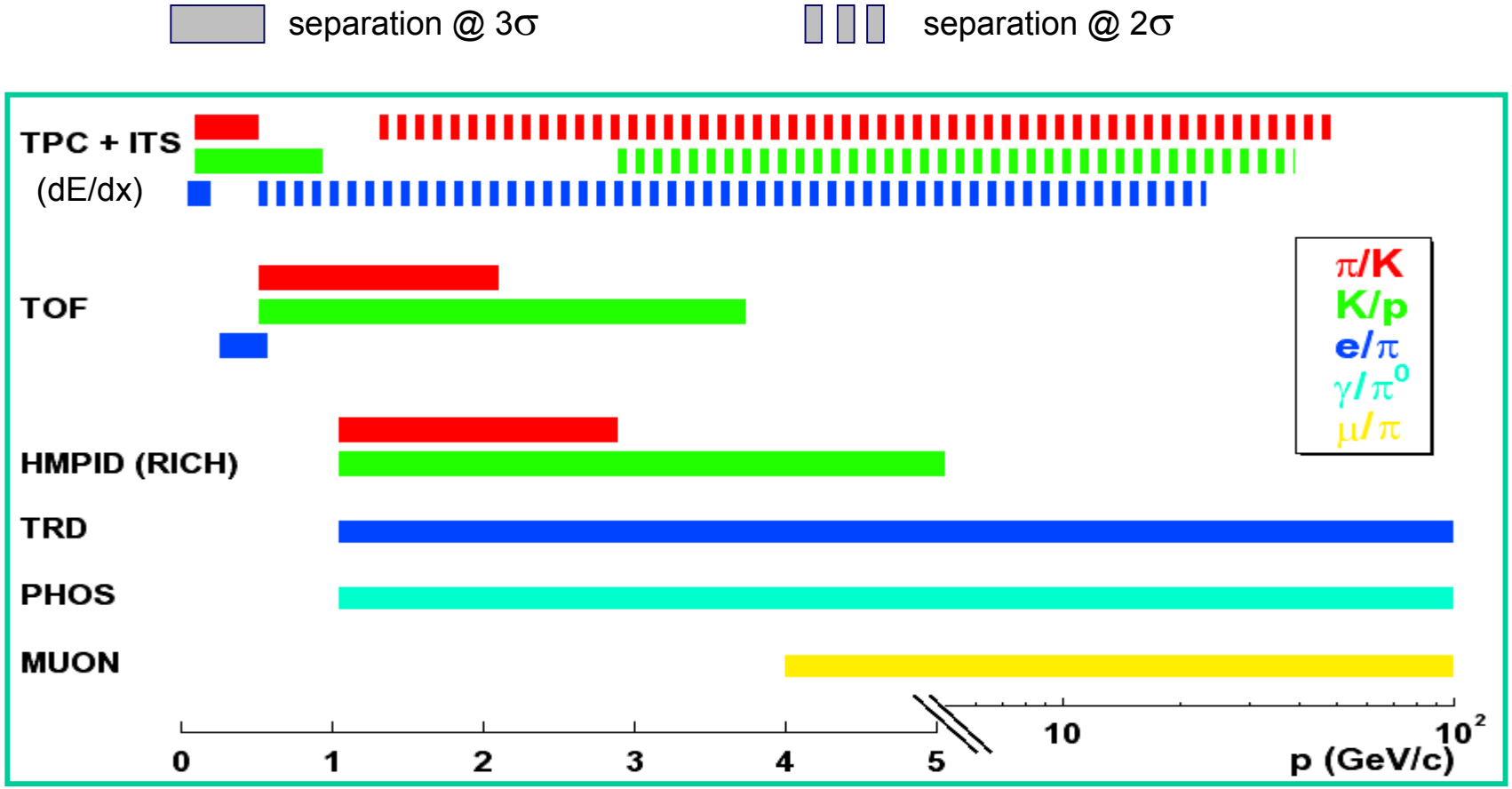


Jet superimposed on 5 TeV Pb + Pb background

A Large Hadron Collider Experiment - ALICE



ALICE PID



- Existing gap between low and high p_T ALICE for detailed (> 3 σ) particle identification.
- Probing the hadronization mechanisms with ALICE suggests an upgrade for track-by-track PID in the momentum range of 10 – 30 GeV/c

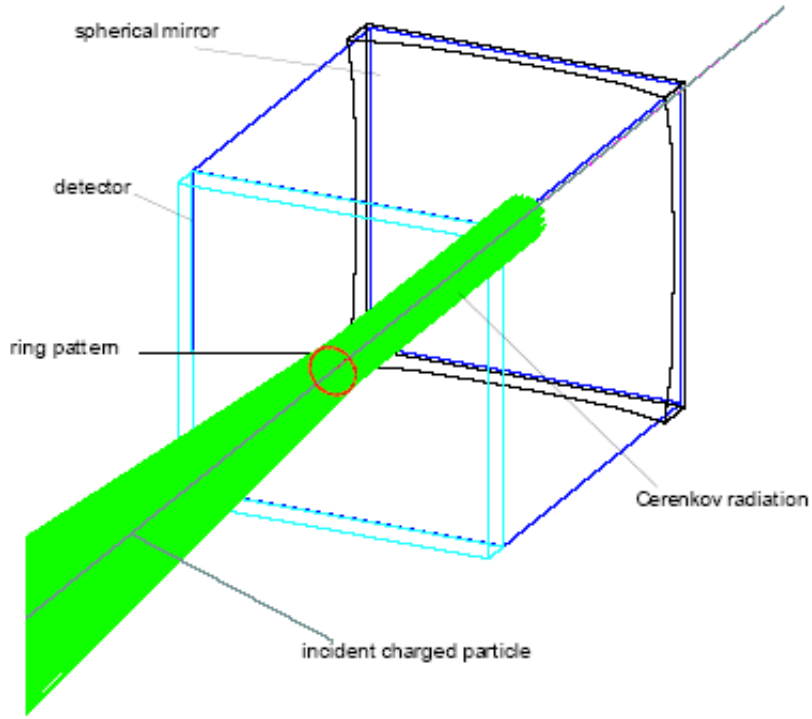
VHMPID

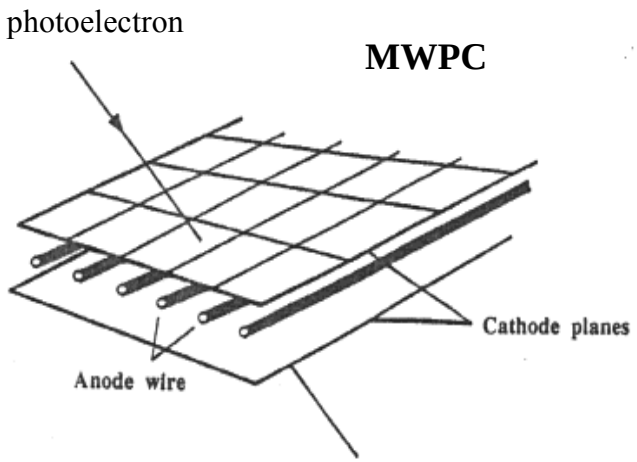
The challenge

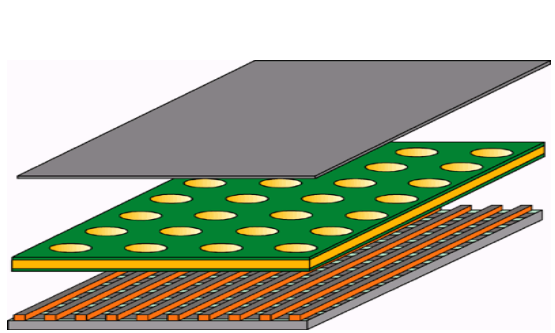
- Relatively small detector covering $\lesssim$5% of acceptance of ALICE's central barrel
- 0.5 T magnetic field
- PID in the range of 10 – 30 GeV
- Good separation resolution ($\gtrsim 3\sigma$)
- Enough granularity that allows the discrimination of background in a central HI collision

VHMPID Geometry

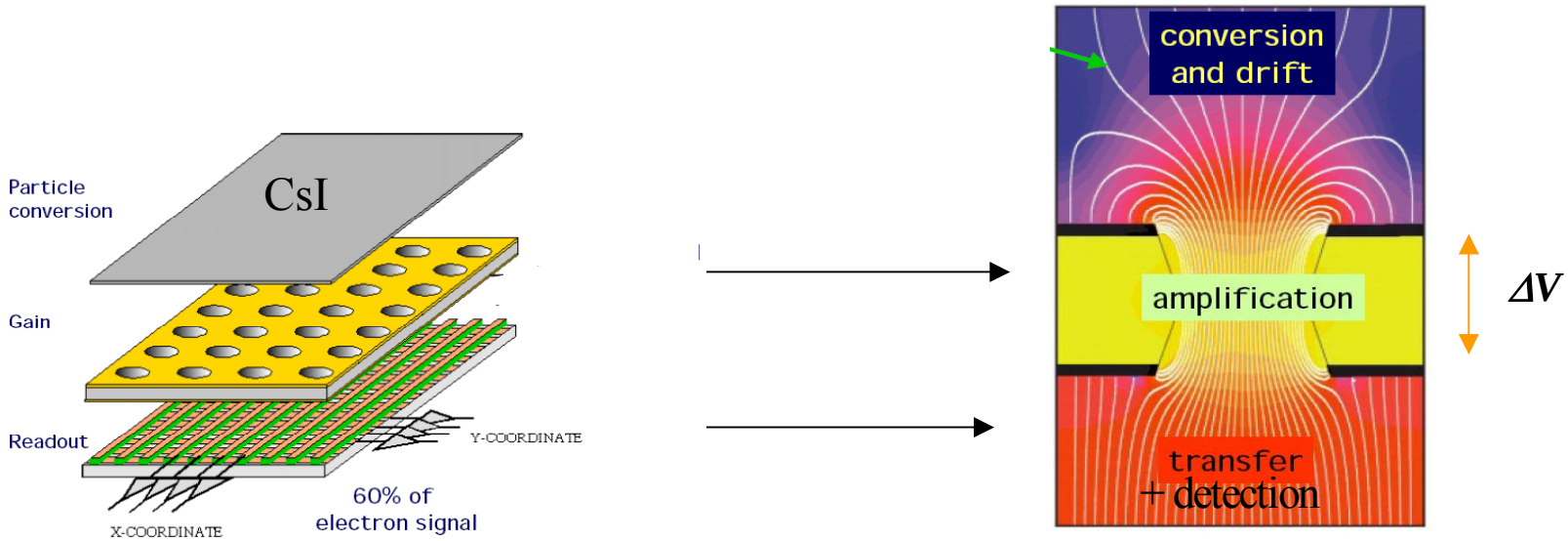
- C_5F_{12} gas radiator (n = 1.0015)
- Large area CsI photon-to-electron converter
- Position sensitive charged particle detector
  - Multi wire proportional chamber (MWPC)
  - Gas electron multiplier (GEM)







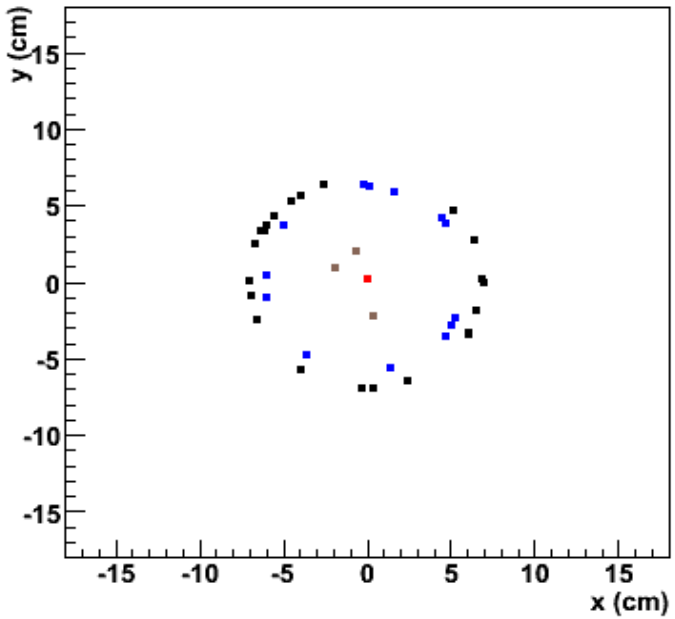
Gas Multiplier Detector



- Alternative to the MWPC
- Composite grid consisting of two metal layers separated by a thin insulator etched with a regular matrix of open channels (holes)
- The metal layers are kept at a suitable difference of potential, allowing the pre-amplification of the charge drift through the channels.
- GEM would improve the efficiency of the VHMPID, given the larger multiplication (gain)
- The sturdiness of the device when compared to a MWPC is also an advantage.

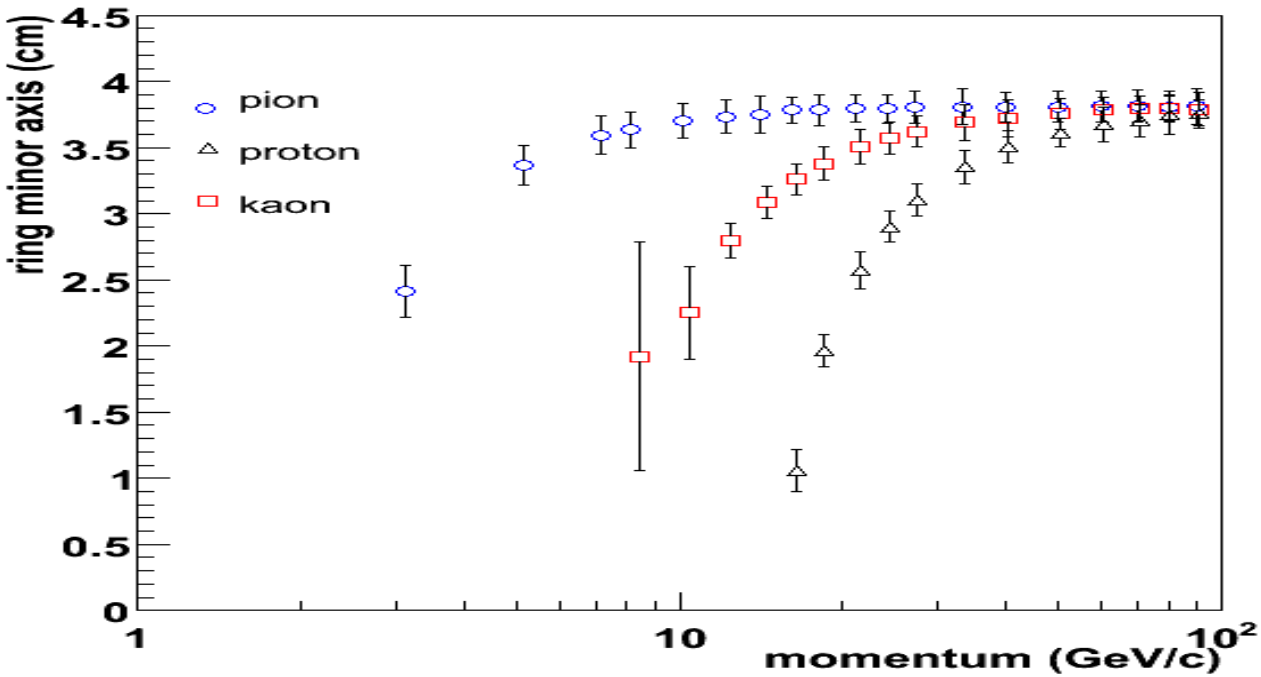
Simulation

- Based on GEANT 4
- The simulations include the CsI quantum efficiency, the gas transmittance and the optical characteristics of the proposed materials.
- Neither photoelectron conversion nor the response of the MWPC were included in the simulation at first stage



Photon hit position on the CsI photocathode. The rings are from one event of one incident 16 GeV/c pion (black), one kaon (blue) and one proton (brown).

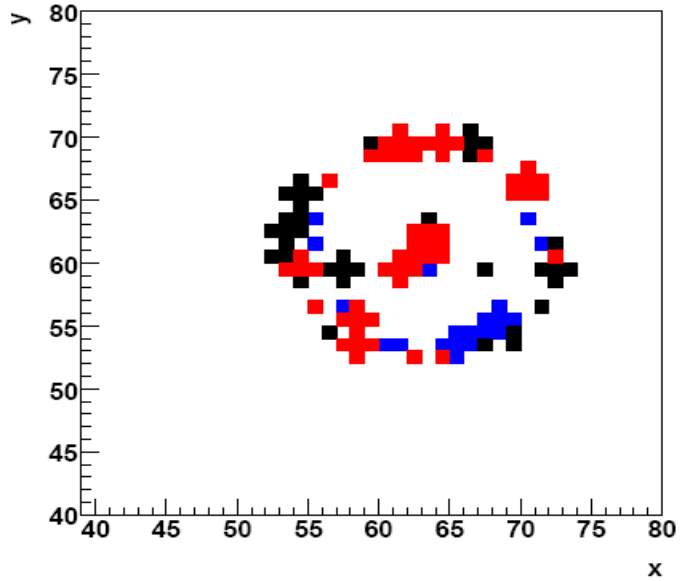
Simulations cont.



Identification momentum range		
Particle	With signal	Absence of signal
π	3–15 GeV/c	
k	9–15 GeV/c	
p	18-30 GeV/c	9–18 GeV/c

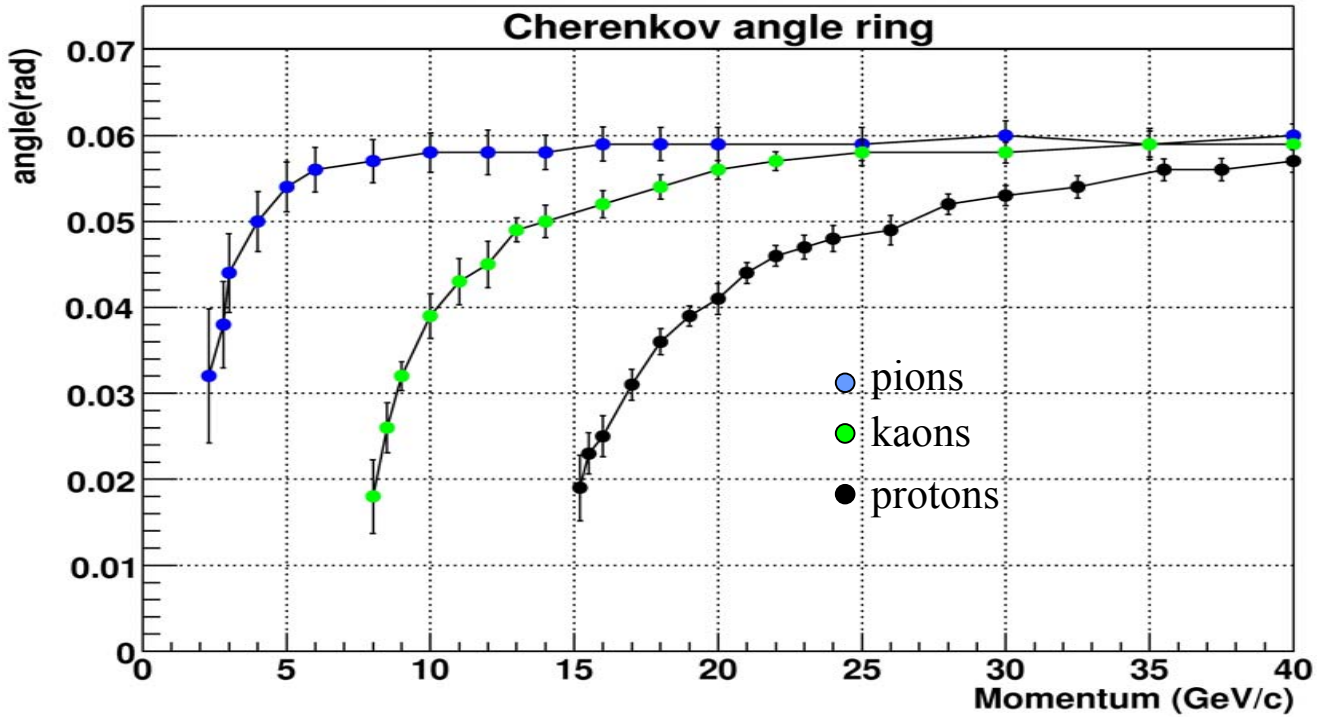
Simulation of Response of MWPC

- The response and pixel size of the MWPC's pads (8 x 8 mm^2) was included in the simulation
- The simulation was done with chambers of 122 x 120 pads corresponding to a surface of about 1 m^2
- Further parameters applied were those that reproduce satisfactorily the ALICE High Momentum Particle Identification Detector (HMPID) experimental results



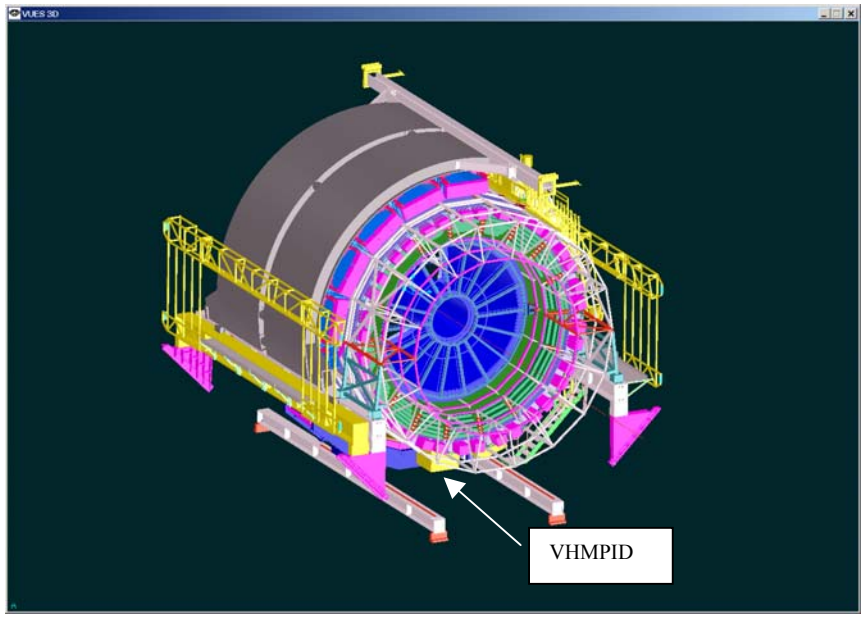
Ring image detected on MWPC. The rings are from one event of one incident 16 GeV/c pion (black), one kaon (blue) and one proton (red).

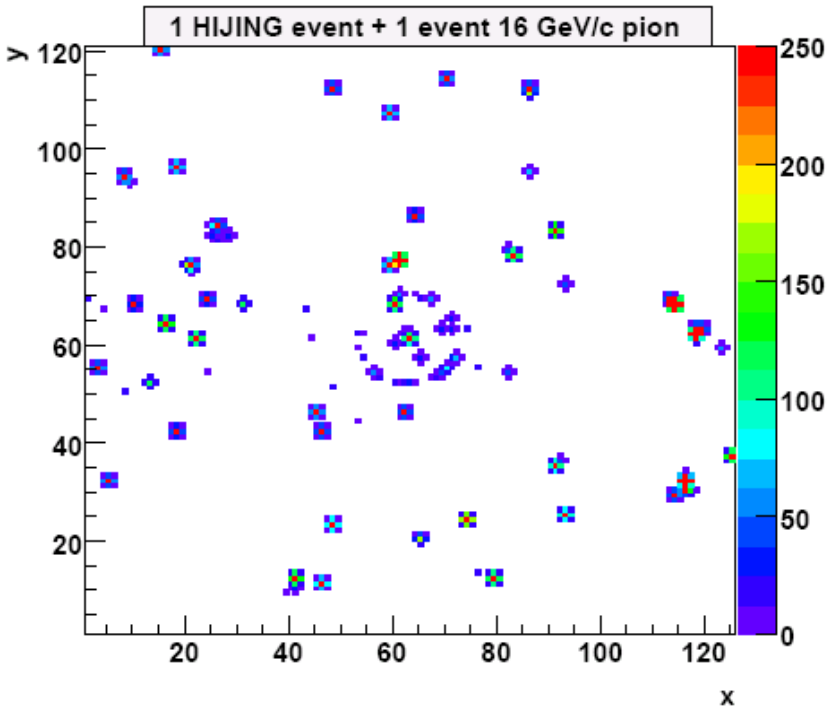
Simulation Cont.



- Cherenkov angle calculated for individual photos using patter recognition algorithm, assuming that the original particle track is known
- The points then are given by the average from the N photons from each ring $\theta_{Cherenkov} = \sum \theta_i / N$
- The design capabilities of the detector using full simulation plus reconstruction are confirmed

VHMPID Performance in Beam conditions



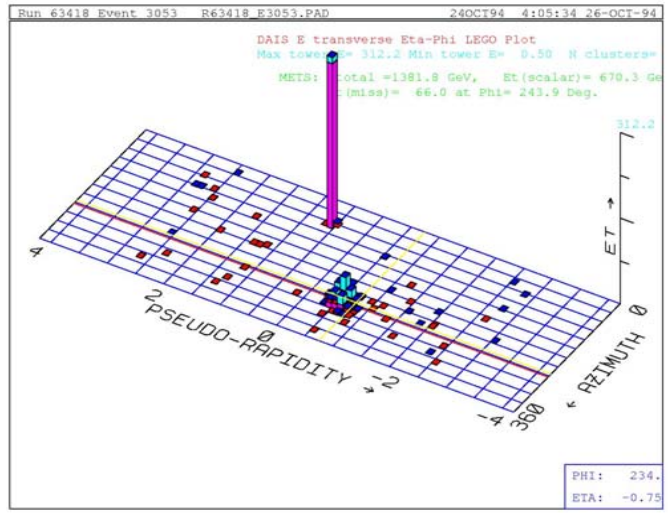


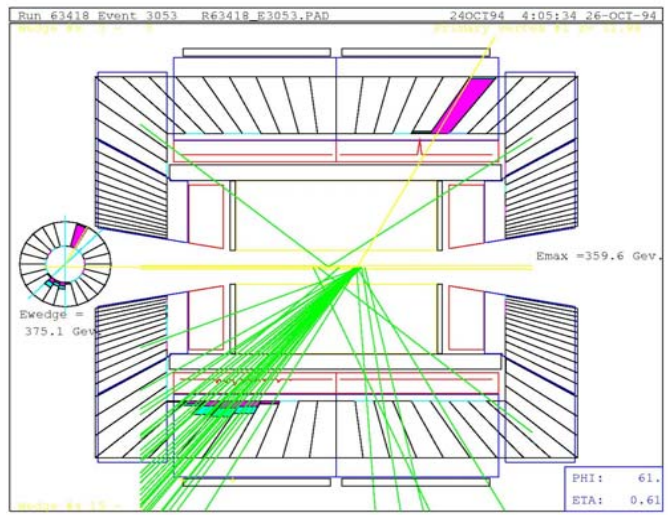
- The VHMPID detector is simulated at its proposed location with the ALICE detector.
- One pion track is embedded in a = 5.5 TeV Pb+Pb HIJING [20] event with a pessimistic charged particle multiplicity $dN_{ch}/dy \sim 4000$ at mid rapidity
- Pion trace is clearly detected in the MWPC above the background
- Note that the proposed location of the VHMPID is opposite to the EMCAL

Physics Possibilities (work in progress)

- The proposed location of the VHMPID, opposite to the EMCAL opens the possibility to use both detectors to measure gamma-jet events.
- Triggering with the gammas in the EMCAL
- Measuring the jet composition in the VHMPID
- Study then hadronization, for example: compare the jet multiplicity for proton-leading vs. pion-leading jets

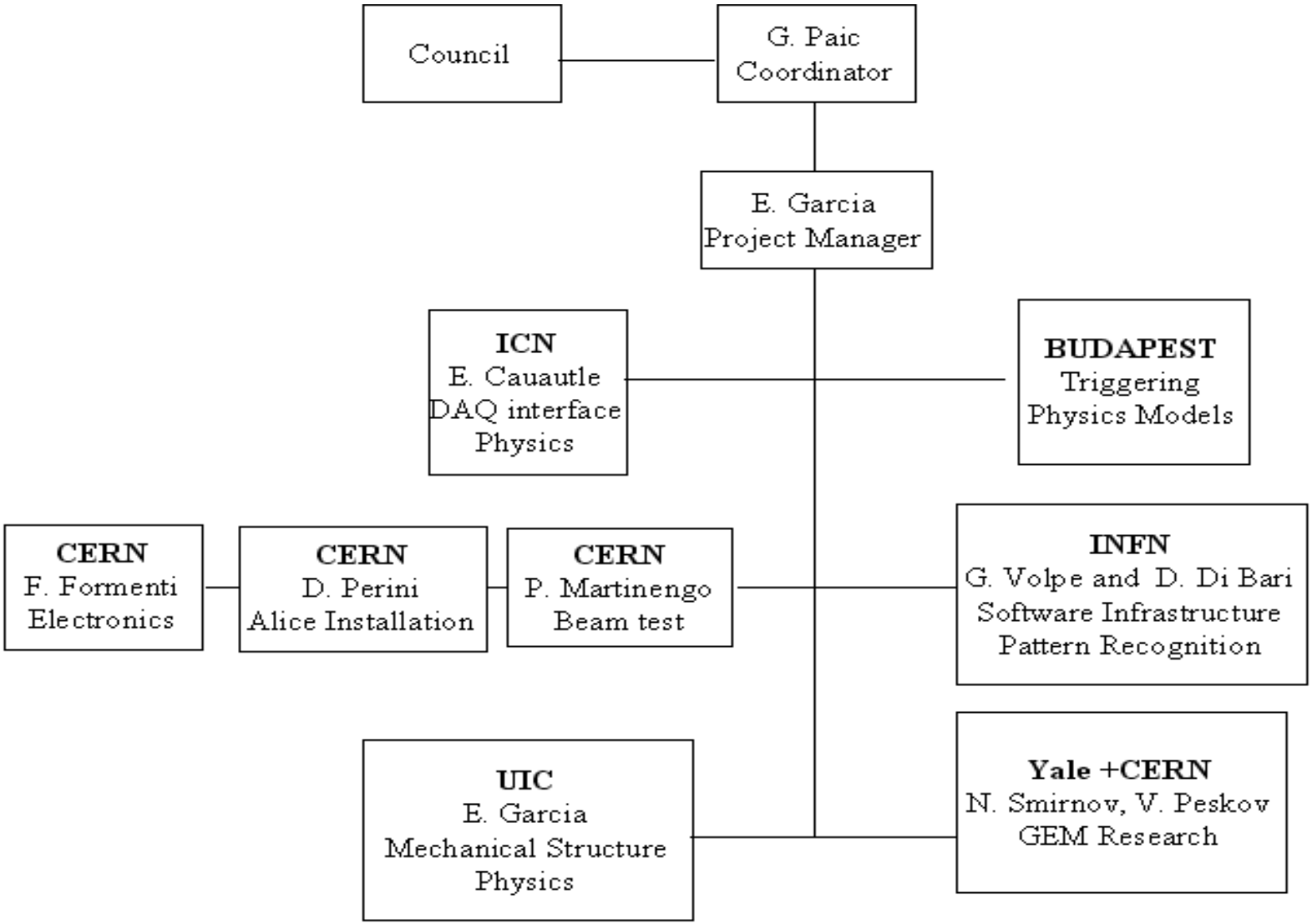
CDF event picture





Project Status

- Finalize simulations (physics studies) by the end of the year
- GEM test planned for this fall
- Finalize design by the end of the year
- Submit letter of intent to ALICE spring 2008
- Start construction of prototype summer 2008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