Reconstruction of neutral π^0,η and the quest of direct photons in CERES

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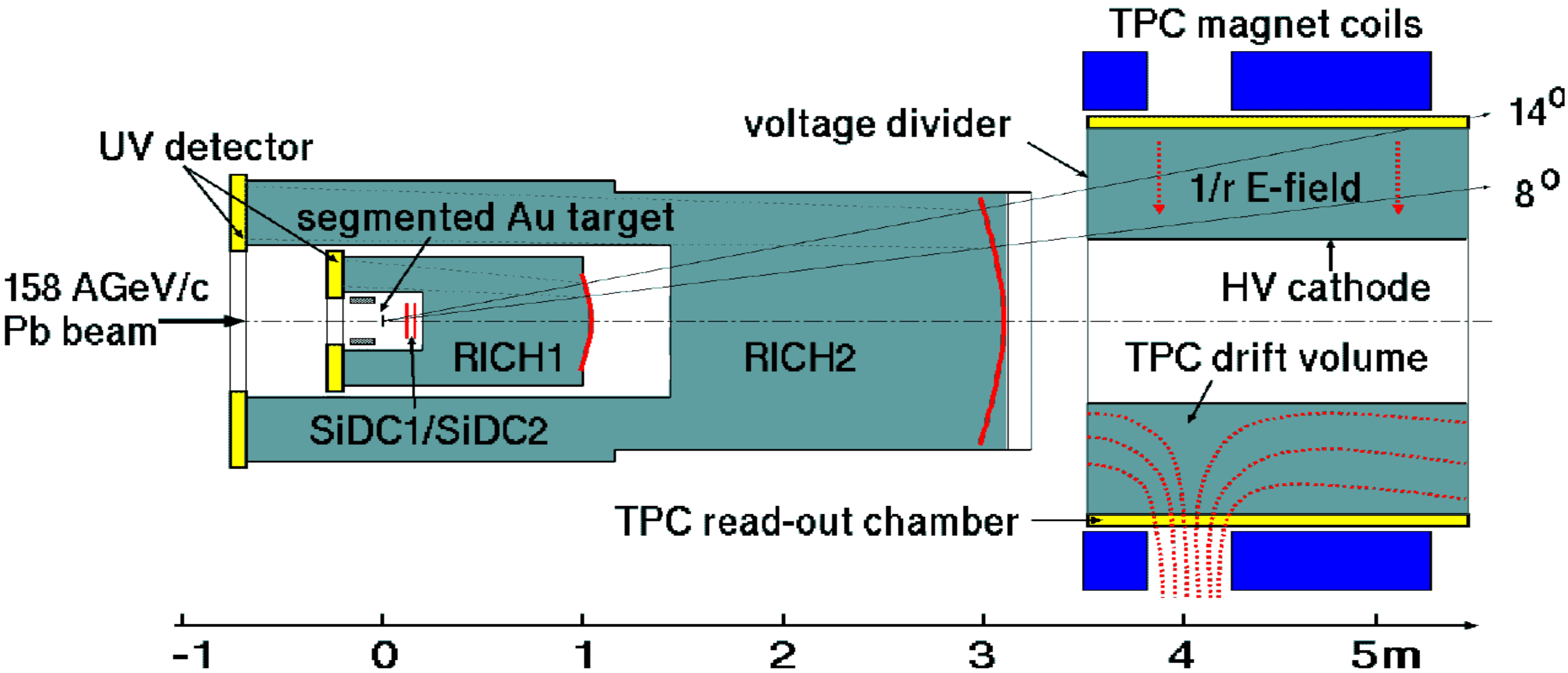
Outline

- Motivation.
- NA45/CERES experimental setup with TPC.
- Feasibility of π^0 and η detection in CERES.
- Study of π^0 and η acceptance in CERES.
- Expected number of π^0 and η after analysis.
- Analysis scheme.
- dE/dx Particle Identification with the TPC.
- The π^0 mass distribution.
- Observation of Direct Photons.
- Experimental Signatures of QGP at Alice.

Motivation

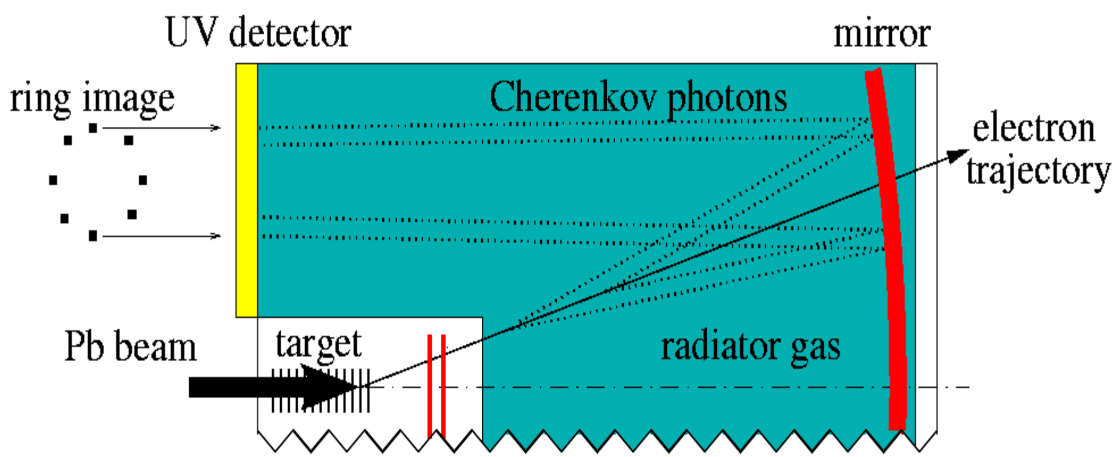
- One of the main sources of systematics errors in the measurement of the dilepton at CERES comes from the fact that the η/π^0 ratio is not measured with a good accuracy at SPS energies.
- In heavy ion collisions, the decay $\pi^0 \rightarrow \gamma\gamma$ is the dominant mechanism that produces photons. The π^0 mesons were detected by calculating the invariant mass of photon pairs.
- Prepare the tools for the same type of π^0, η and γ analysis for proton and heavy ion collisions at LHC.

NA45/CERES experiment setup



- SiDC1+2: Vertex reconstruction.
- RICH1+2: Electron ID .
- **TPC:** momentum of charged particles, particle ID.

NA45/CERES experiment setup

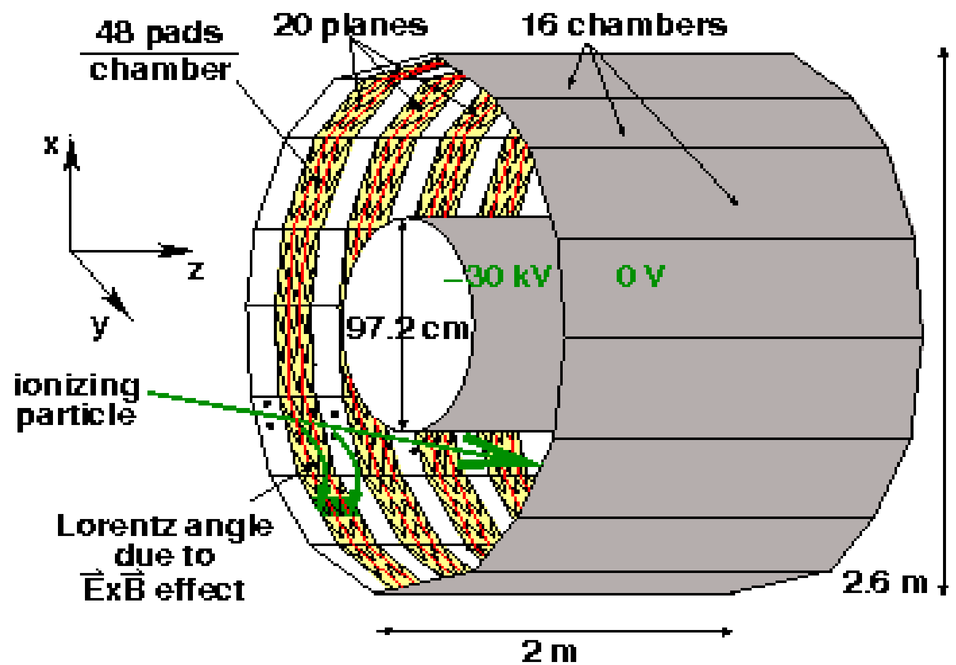


Principle of The RICH detectors

- Cherenkov photons are emitted under constant angle to the trajectory of a particle, if its velocity exceeds the velocity of light in the radiator gas.
- The photons are focused by a mirror onto a ring at the surface of a position-sensitive photon detector.

The CERES TPC

- A charged particle passing the active volume of the TPC ionizes the gas along its trajectory.
- The electrons drift towards the anode wires on the readout chambers.



Feasibility of π^0 and η detection in CERES

- γ detection through conversions in RICH 2 mirror

  - $\pi^0 \longrightarrow \gamma\,\gamma$
    - Mass of the mother Particle = 0.135 (GeV)
    - The BR : 0.98789

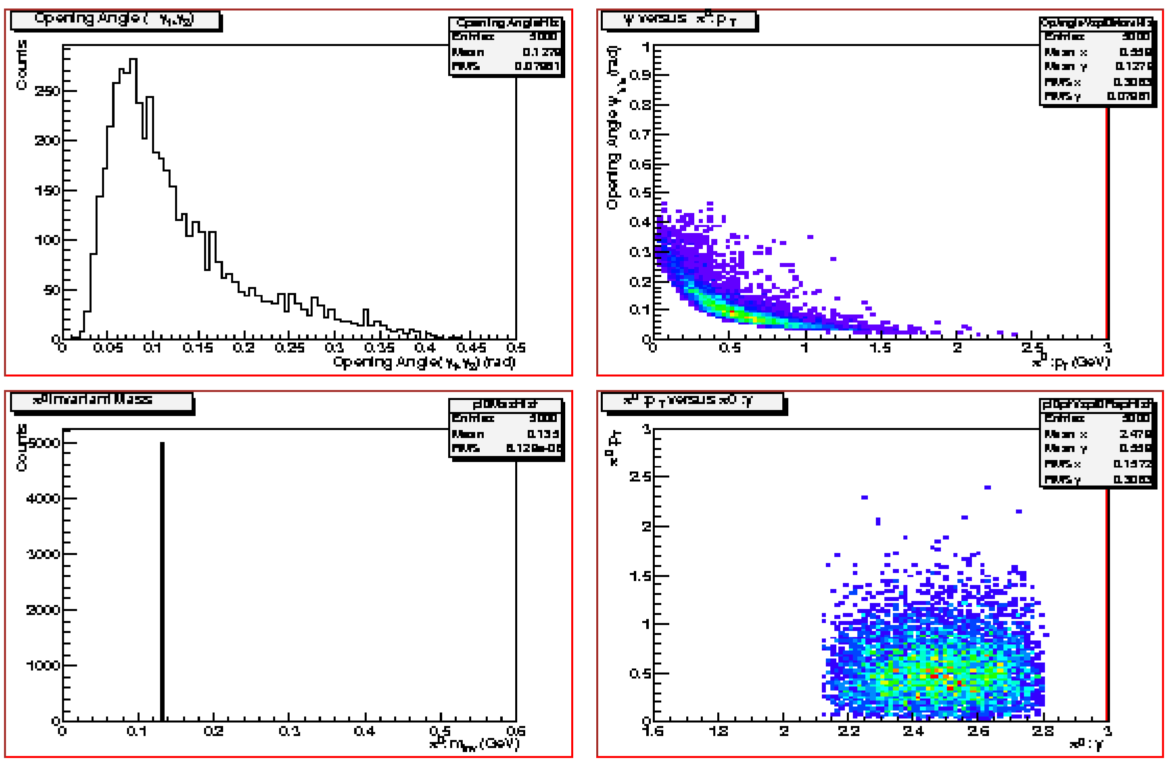
  - $\eta \longrightarrow \gamma\,\gamma$
    - Mass of the mother Particle = 0.547(GeV)
    - The BR : 0.3943

and each $\gamma \longrightarrow e^+ e^-$ **(conversion in RICH 2 mirror)**

Study of π^0 acceptance in CERES

$\pi^0 \longrightarrow \gamma\,\gamma$

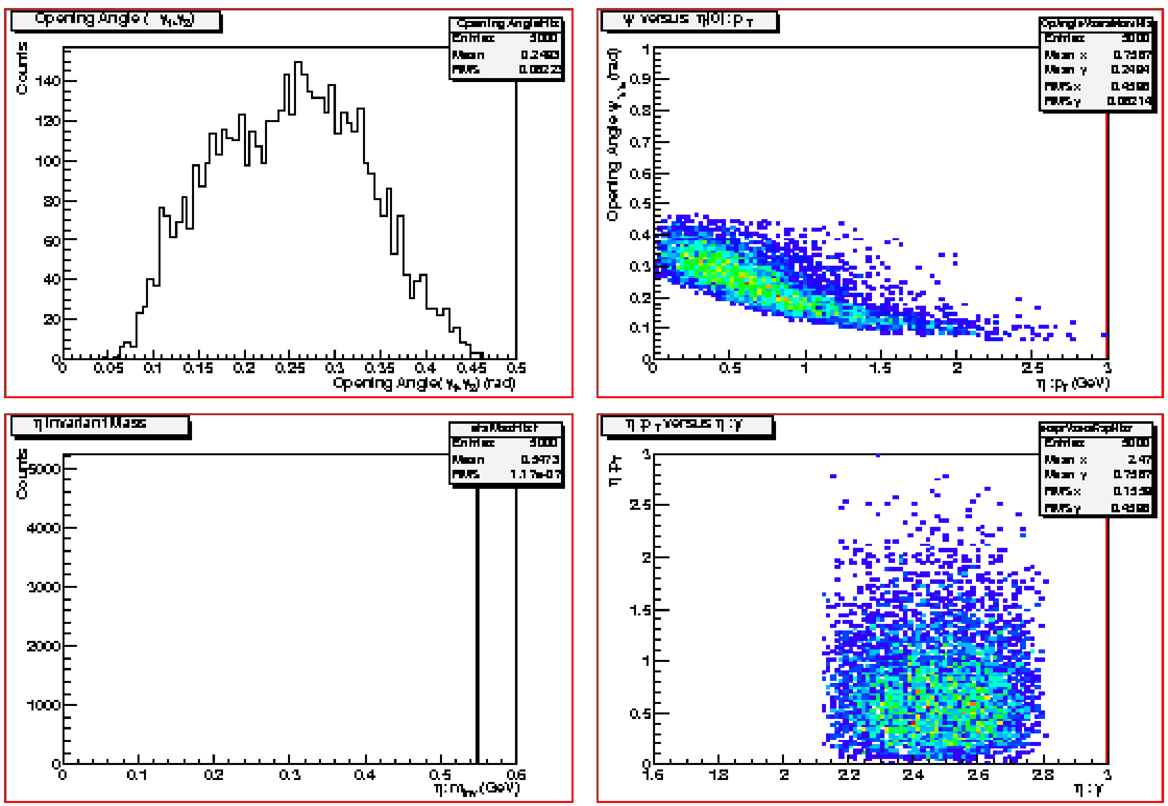
- $dN/dP_t = C_1 \,.P_t \exp\,(\,-m_t / T\,)$
  - Temp (π^0) : 0.17(GeV)
  - Number of decays: 66506
  - Decays in the detector : 5000
  - Acceptance :0.075



Study of η acceptance in CERES

$\eta \longrightarrow \gamma\,\gamma$

- $dN/dP_t = C_2\, P_t \exp(-m_t / T)$
  - Temp (η) : 0.24 (GeV)
  - Number of decays: 116279
  - Decays in the detector : 5000
  - Acceptance :0.043



Expected number of π^0 and η after analysis

- BR x 500 π^0/ event x acceptance x N event x efficiency

  ⇒ 0.98798 x 500 x 0.075 x 30 x 10^6 x efficiency

  ⇒ 1.1 x 10^9 x efficiency = 1.8 x 10^6 π^0

  if we take the efficiency ≈ $(0.04)^2$ from the radiation length

- $\eta / \pi^0 = 0.0857$ → The thermal model of P. Braun-Muzinger, J.Stachel, I.Heppe. Phys.Lett. B465 (1999) 15-20

- BR x 42 η/ event x acceptance x N event x efficiency

  ⇒ 0.39 x 42 x 0.043 x 30 x 10^6 x efficiency

  ⇒ 21.1 x 10^6 x efficiency = 3.4 x 10^4 η

  if we take the efficiency ≈ $(0.04)^2$ from the radiation length

Analysis scheme

- Tracking
- Electron identification
- Pairing ($e+e- \rightarrow \gamma$)
- Identification of γ conversions
- Pairing γ-γ
- Invariant mass in the same event
- Mixed event and background substraction
- Invariant mass of π^0 as function of pt and y
- Efficiency correction
- Transverse momentum spectrum of π^0 (η)

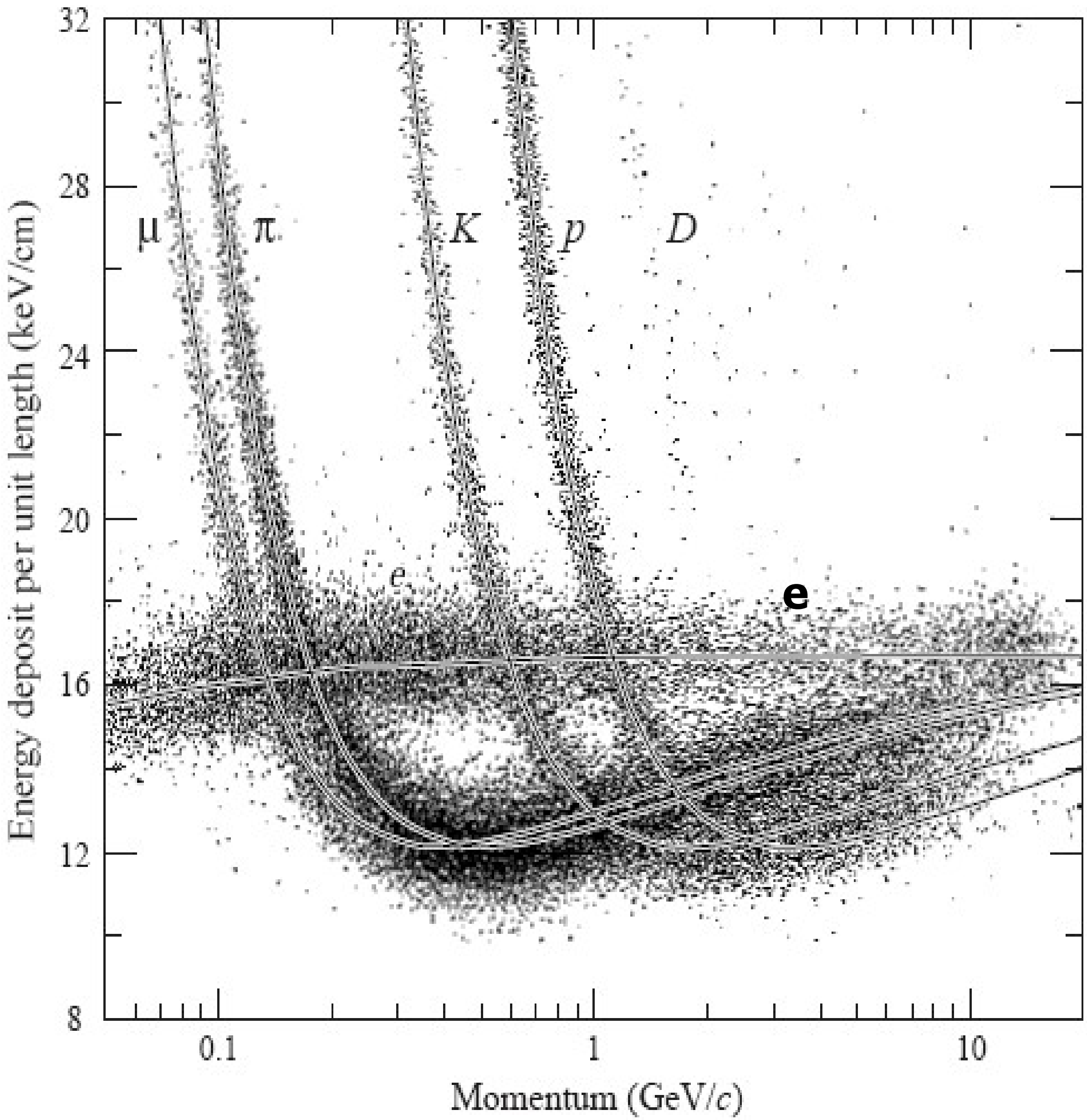
dE/dx Particle Identification with the TPC

- Charged particles lose energy while traversing matter.
- The energy loss per unit distance along a track, dEdx, in the TPC gas is described by the Bethe-Bloch function:

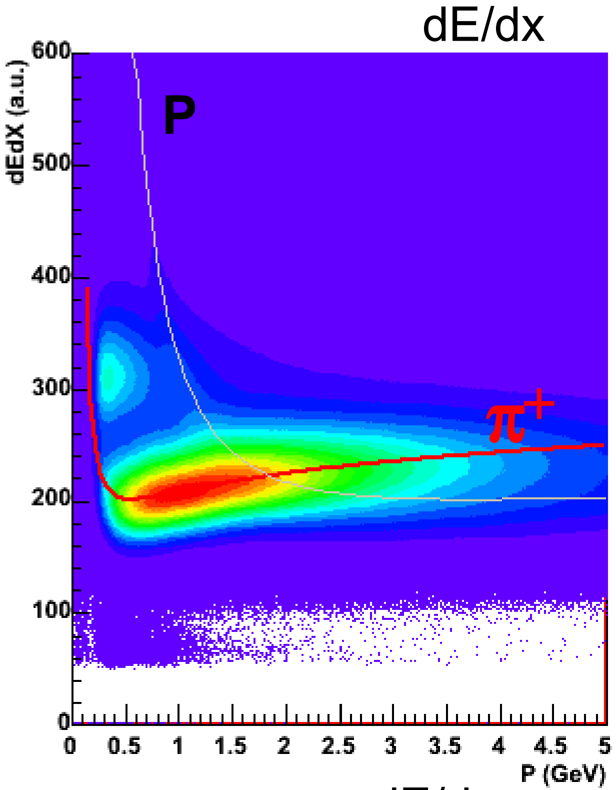
$$-dE/dx = Kq^2 \frac{Z}{A} \frac{1}{\beta^2} \left(\frac{1}{2} ln \frac{2m_e c^2 \beta^2 \gamma^2 T_{max}}{I^2} - \beta^2 - \frac{\delta}{2} \right)$$

- The knowledge of both a predicted dEdx value (Bethe-Bloch function) and the resolution of dEdx provides a powerful tool for particle identification.
- With both, a known fraction of a certain particle band can be sacrificed in order to eliminate other particles.

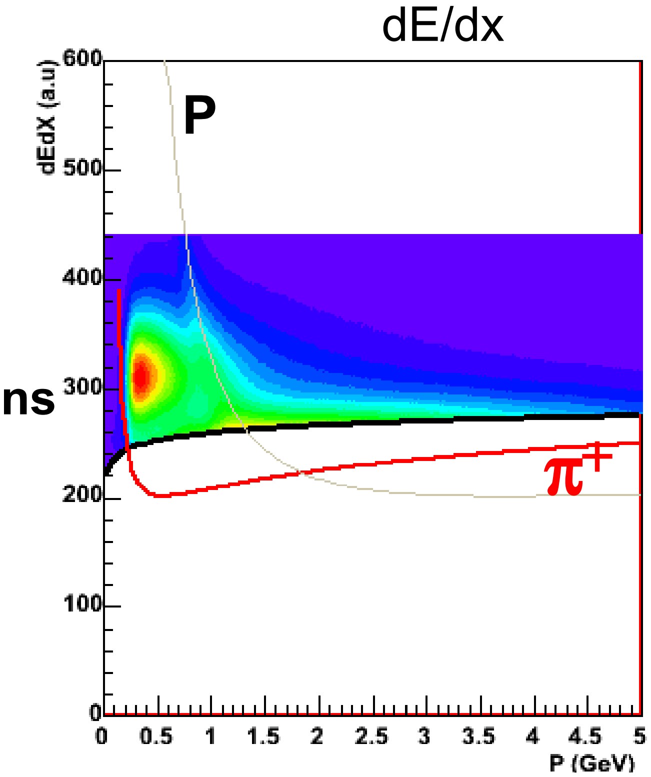
Ionisation variation with particle type

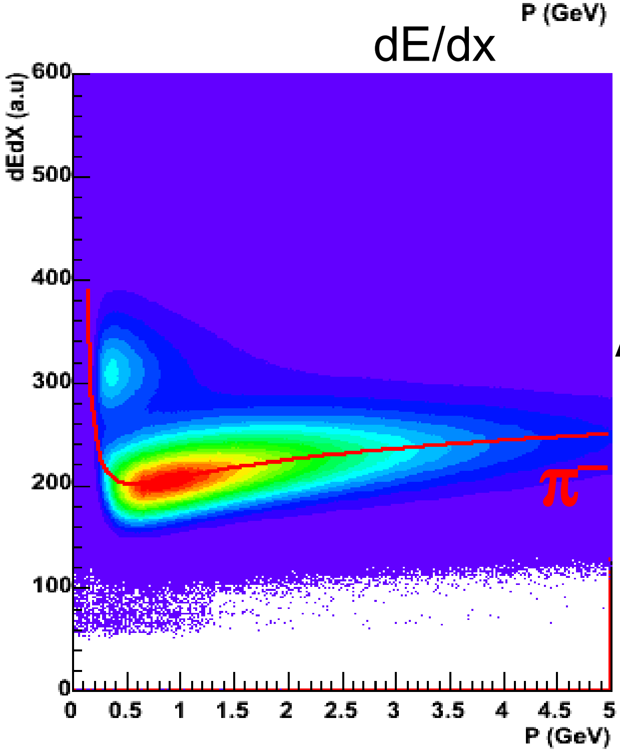


- $P = m\gamma v = m\gamma\beta c$
- variation in *dE/dx* is useful for particle ID
- variation is most pronounced in low energy falling part of curve
- if you measured *P* and *dE/dx* you can determine the particle mass and thus its "name"

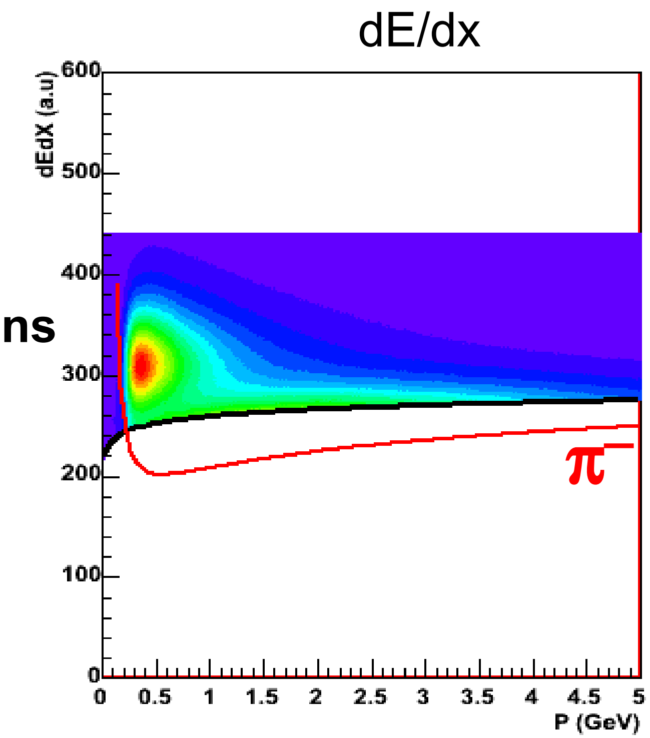


All positive particles → **positrons (e+)**





All negative particles → **electrons (e-)**



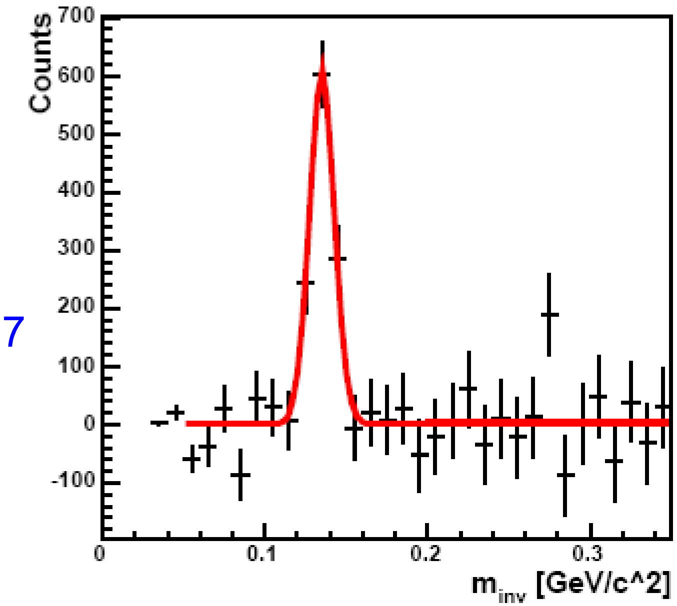
The π^0 mass distribution

- CERES (since 2 weeks ago) :

1.25<pt<1.50 GeV/c

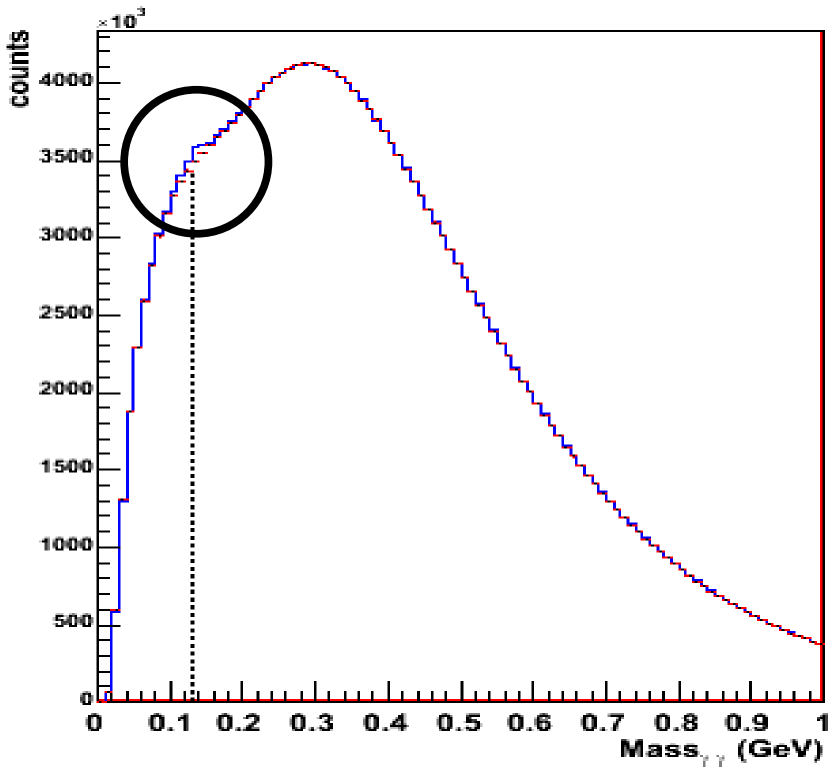
2.2<y<2.3

# of events = 1.1405e+7



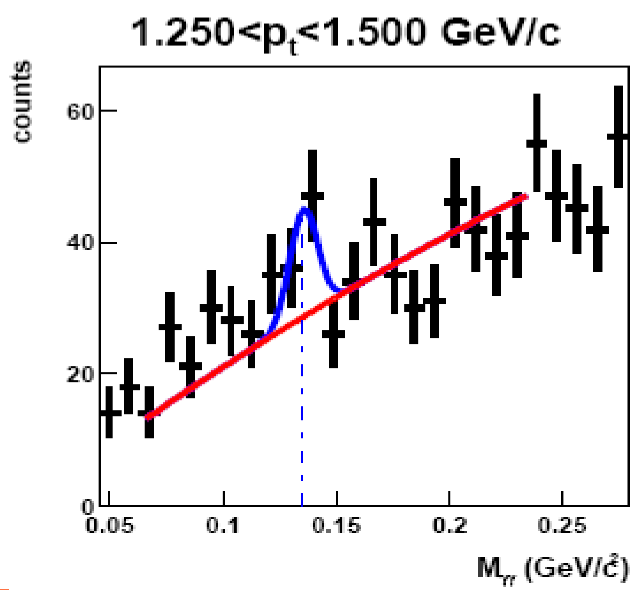
mixed event normalized (C*B)

same event (S)



The π^0 mass in two photons

- STAR (2002):

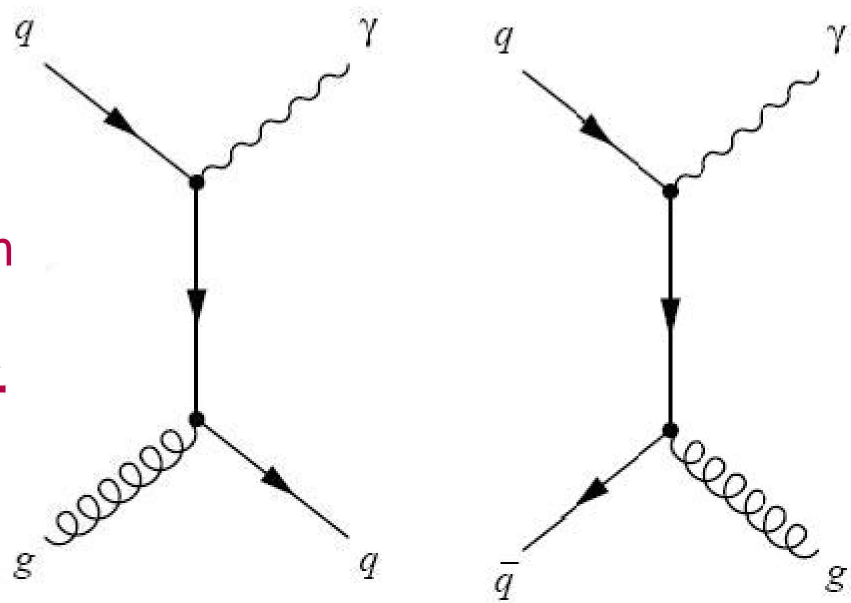


Direct Photons

- Photons in heavy ions collisions are mainly produced by the decay of hadrons.
- the examination of direct photons provides a tool to study the different stages of a heavy ion collision, especially the formation of a QGP.

Feynman graphs of the main production processes for direct photons

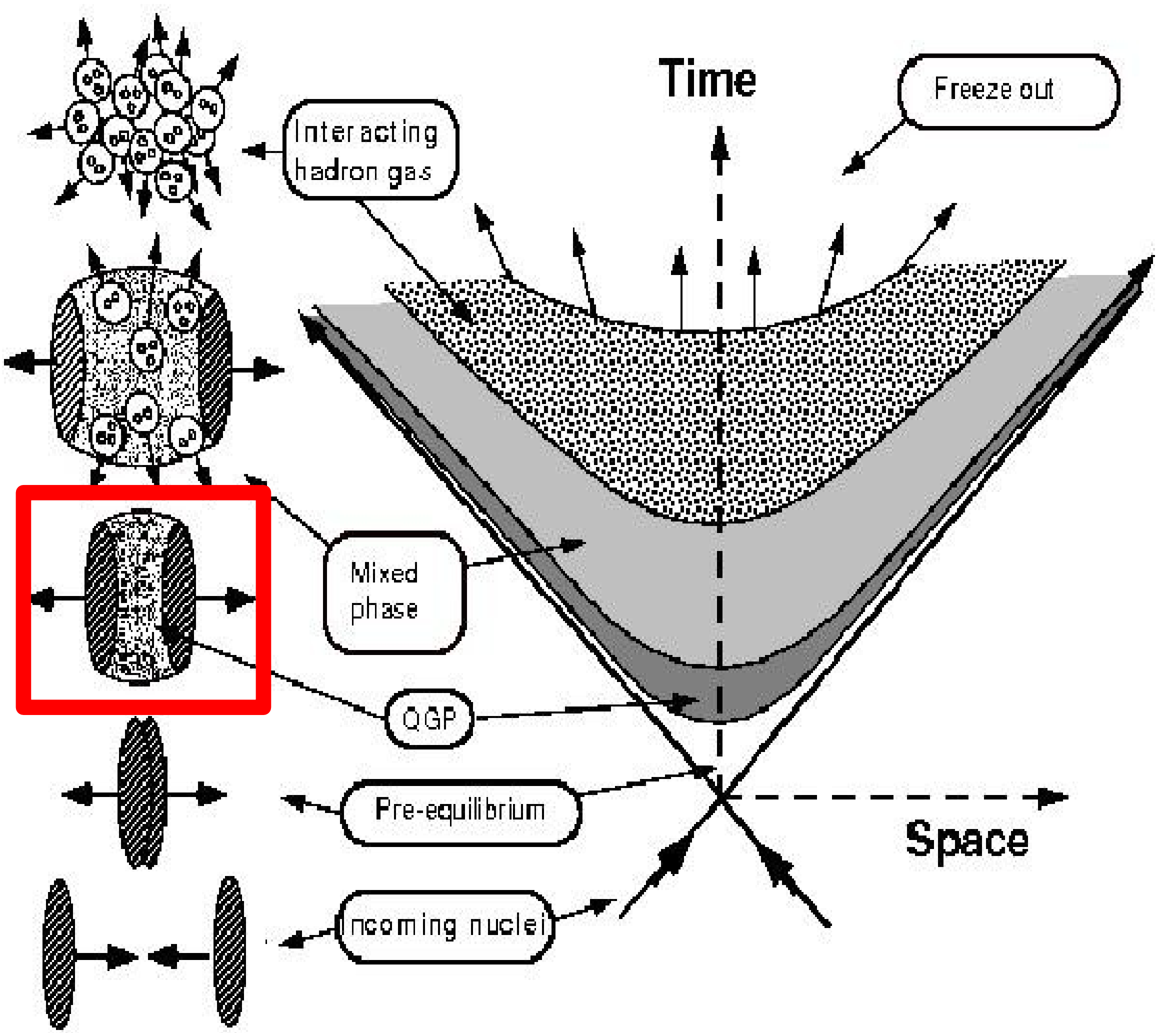
Photons produced by quark- gluon compton scattering or quark-antiquark annihilation of order $\alpha_s\alpha$, are called ***direct photons***.



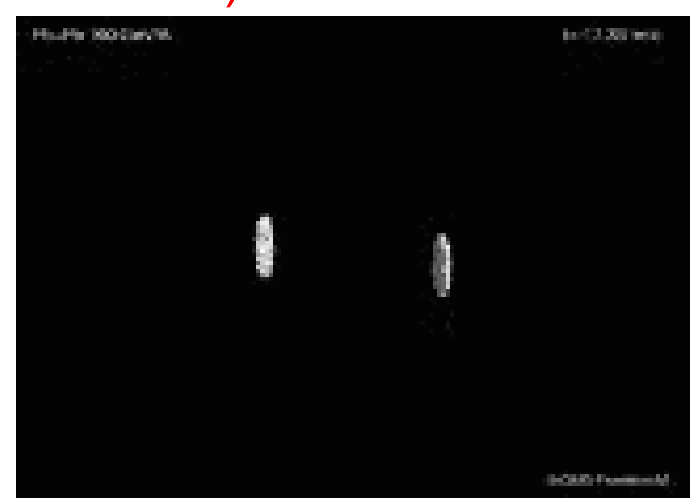
- **Photons** : - from the hot and dense medium (direct photon),

  - from decay of neutral hadrons.

Observation of Direct Photons



- One measure photons Directly using calorimeter, this method is applied by WA98.
- Another way is to identify photons by their conversion into $e^+ e^-$ pairs was done by CERES.
  (using 96 setup but is was not successful) .



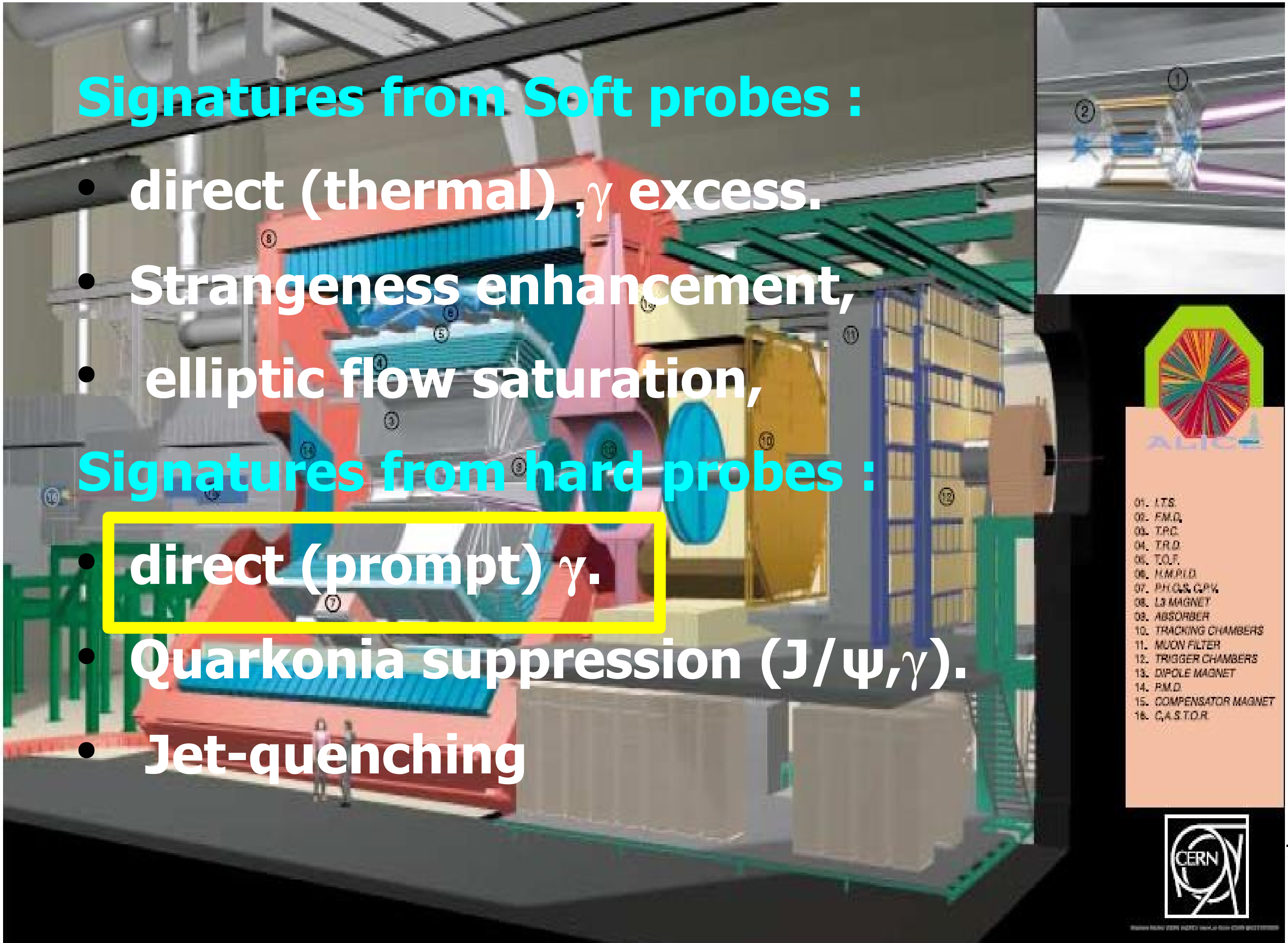
Alice and Experimental Signatures

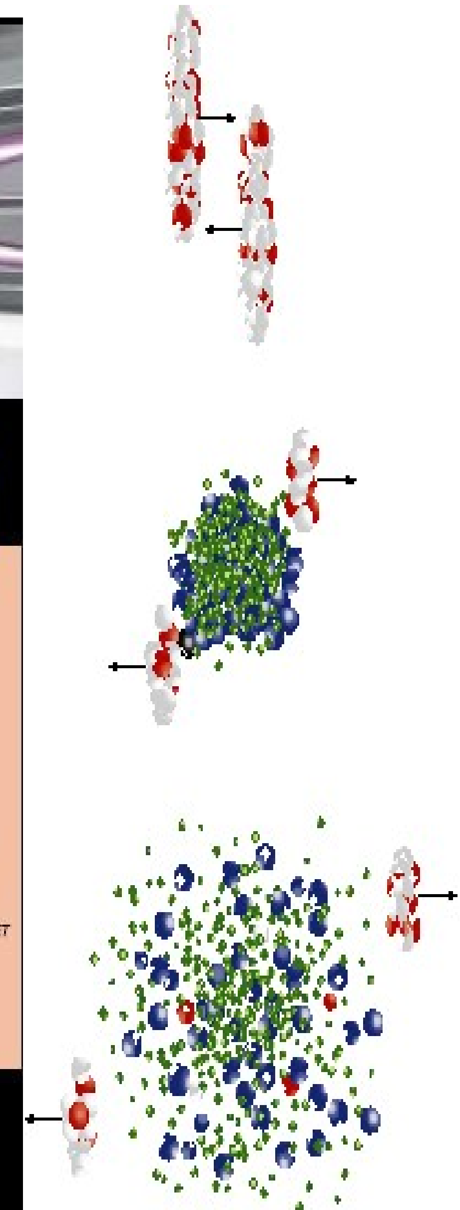
Signatures from Soft probes :

- **direct (thermal) ,γ excess.**
- **Strangeness enhancement,**
- **elliptic flow saturation,**

Signatures from hard probes :

- **direct (prompt) γ.**
- **Quarkonia suppression (J/ψ,γ).**
- **Jet-quenching**





Summary

- Ongoing analyses for π^0 and η.
- If there is enough data for π^0 and η mesons, we can study direct photons via the conversion method.
- If LHC data comes early enough one can possibly even apply the prepared analysis routines to first data.

Thanks!