ALICE upgrade plans

Jean-Pierre Revol

LHCC upgrade session

CERN, September 23, 2008

- **ALICE upgrade not linked to LHC high luminosity upgrade**; Concerning possible PbPb luminosity improvement, see later.

- **Large uncertainty in the PbPb multiplicity environment** and while there is clear indication from RHIC of what should be initially measured (Flow, jets, Baryon/meson, High p_T flavours), **there have always been surprises in the past** (RHIC) – even in pp with high multiplicity trigger there could be new issues.

- **Final strategic choices for the ALICE upgrade programme can only be made when the first pp and PbPb data have been analyzed**.

  ⇒ importance to ALICE to have the first heavy ion run as early as possible!

- However, **some elements of the upgrade programme are already identified**, because they are based on:
  - evolution of physics issues since the time of design of the detector (15 years!) (e.g. baryon production @ RHIC);
  - improvement of technologies and already acquired experience with silicon detectors;
  - removal of some LHC machine constraints, in particular on our tracker design (**input needed from LHC machine group**).

- **First 5 years**: full exploitation of present ALICE detector:
  - First pp run
  - 1 yr (10^6s) Pb-Pb at low Luminosity (initially ~1/20th design, i.e. L~5x10^{25} cm^{-2}s^{-1})
  - 1-2 yrs Pb-Pb at nominal L~10^{27}, targeting integrated L~0.5-1nb^{-1} but <L> ~ ⅓ or ½ of L_{max} and depends on sharing among experiments
  - 1 yr p-A (initial state interaction effects)
  - 1 yr low mass A-A (system size dependence)
  - Continuous running with p-p (comparison data and some genuine pp physics: charm, baryon, high multiplicity, etc.)

Following 5 years:

- Programme and priorities to be decided based on results from the first 5 years:
  - Lower energies (energy dependence, thresholds, pp at 5.5 TeV);
  - Additional AA and pA combinations;
  - Increased statistics for PbPb.

- **LHC schedule assumptions** (until last week):

  « First pp collisions before the end of 2008? »
  « First PbPb collisions before the end of 2009? »

  [September 2010 Next Quark Matter conference, Annecy (co-sponsored by CERN)]

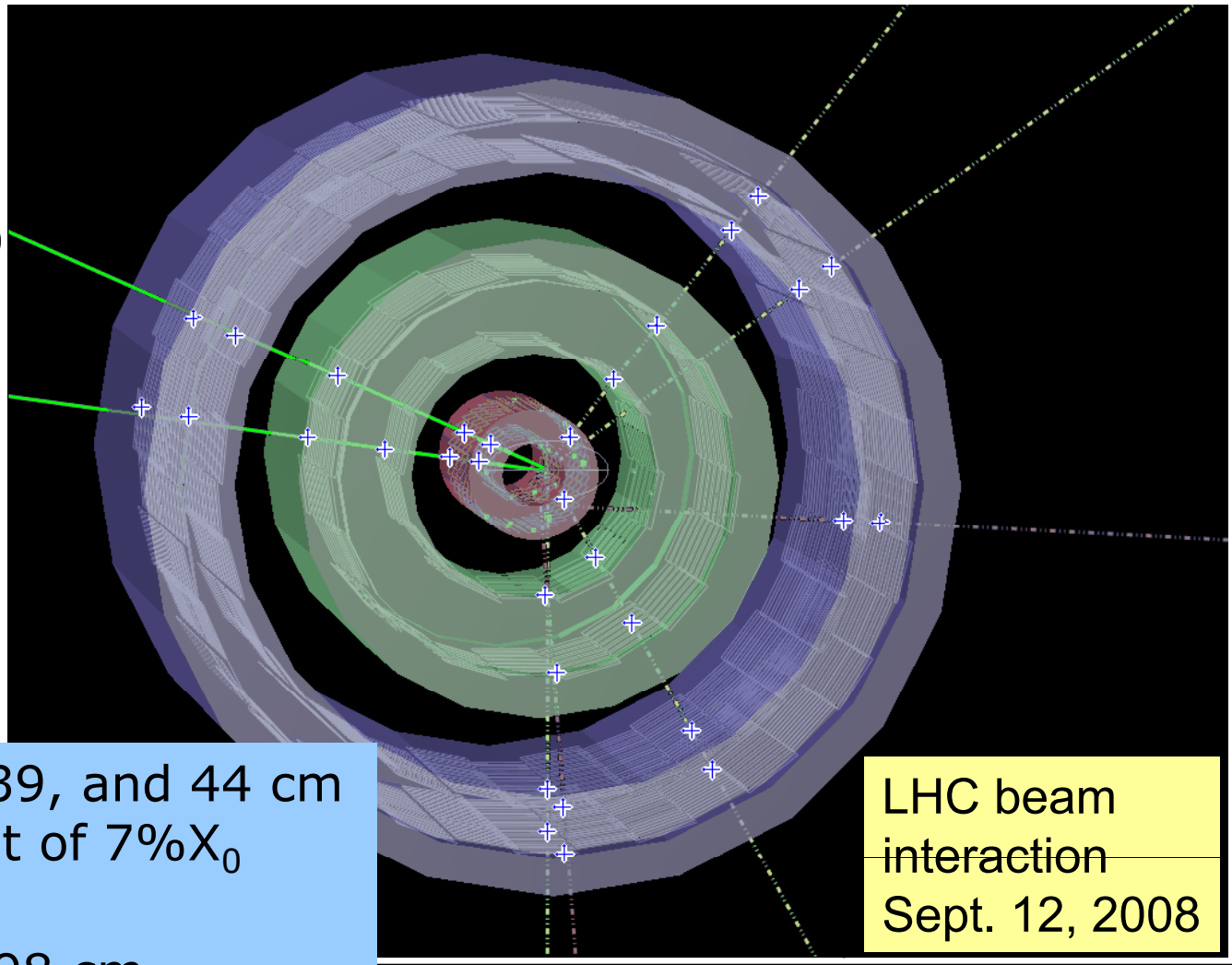
- 2008-2011 Detector Completion (TRD, PHOS, EmCal, PMD), data taking/analysis; some maintenance.

Scenario

- 2009-2011 Detector R&D and definition of upgrade plan (requires significant simulation effort, not possible so far)
- 2010-2011 Decision on upgrade, funding approval, etc.
- 2011-2014 Construction of new detectors
- 2013-15 Installation of upgraded detectors

Inner Tracking System upgrade

- Present 6 detector layers based on three silicon technologies:
  - SPD (pixels)
  - SDD (Si Drift)
  - SSD (Si strips)
- Unique level-zero trigger (fast OR)

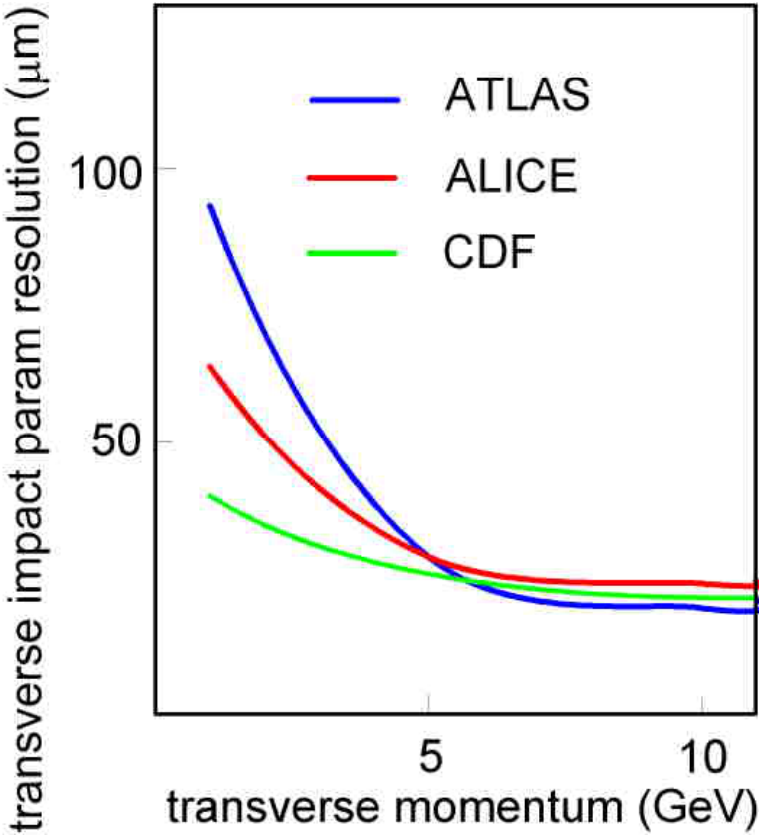


Radii: 4, 7, 15, 24, 39, and 44 cm
Total material budget of 7%X_0 (normal incidence)
Beam pipe radius 2.98 cm

- Improving the impact parameter resolution by a factor 2 or better will:
  - Increase sensitivity to charm by factor 100;
  - Give access to charmed baryons (baryon/meson ratio in charm sector – main issue is understanding of recombination);
  - Allow study of exclusive B decays;
  - Allows first measurement of total B production cross section down to zero P_T ;
  - Improve flavour tagging.

Inner Tracking System upgrade

- Thinnest and smallest beam pipe (à la CDF):
  - Present radius of 2.9 cm reduced to ~1.3 cm?
  - Wall thickness from present Be 800 μm to 400 μm?
  - Or, first layer inside beam pipe?
- Choose pixel technology:
  - thinnest (≤200μm + 150μm);
  - higher granularity (≤150μmx425μm)
  - higher readout frequency (Present 10 MHz, does not allow to trigger on each p bunch crossing).
  - Signal/noise; power consumption;
  - Trigger capability; Cost (bonding?) (radiation tolerance not an issue for ALICE– improves as pixels become thinner)



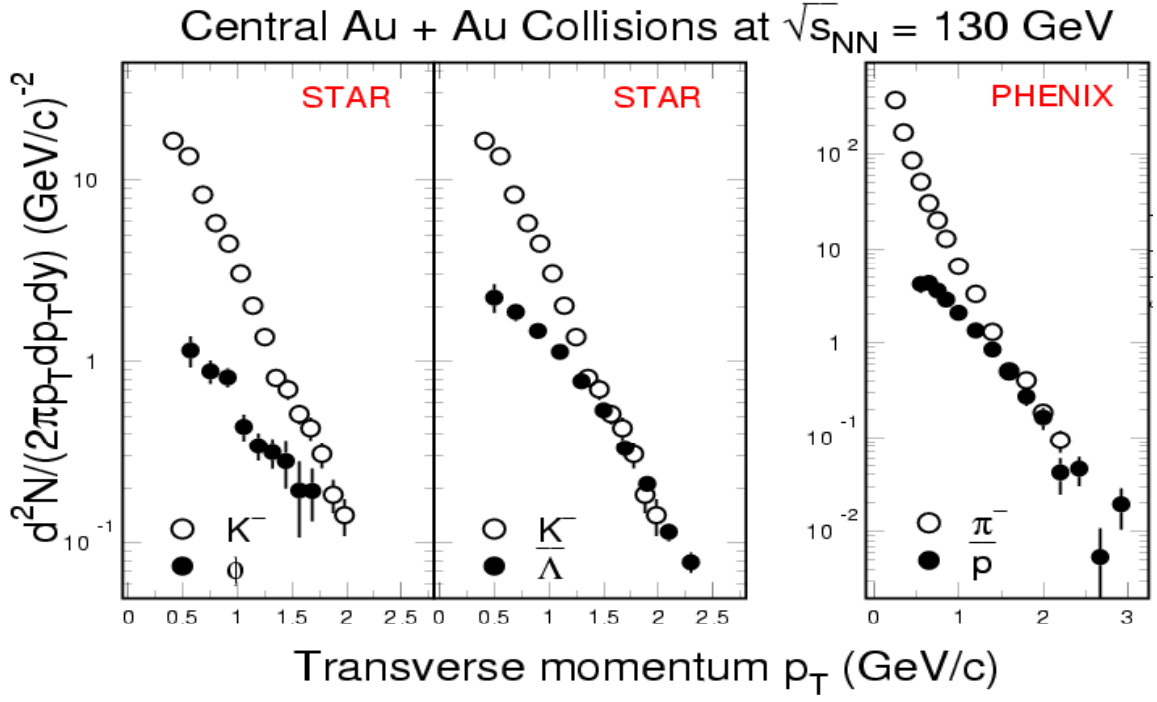
- Strategy:
  - Assess present SDD and SSD performance, to pick solution from pixel only solution (à la CMS) to mixed pixel + SSD or/and SDD?
  - Momentum analysis from ITS?
  - When we have measured the multiplicity in PbPb collisions then we can optimize number of layers, pseudorapidity coverage, etc. (simulation effort).

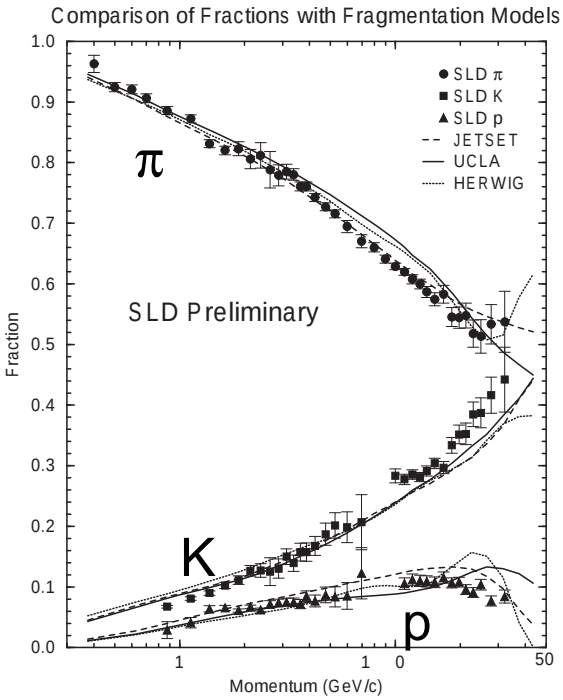
DAQ upgrade

- Problem of obsolescence of elements essential to the current architecture, namely the PC I/O bus. Supply becomes limited, and can be a problem in the medium-term.
- A transition to a new I/O bus can be implemented gradually, but it requires upfront a new interface card DDL-PC:
  - Project of the order of a couple of years for one good engineer full-time
    - development phase
    - 500 DDL cards to replace (of the order of half a million CHF) Part of it financed from normal DAQ maintenance budget as PC replacement is anyway necessary.
  - CERN-PH's plan for detector upgrades for LHC has a high-speed optical link (***VERSATILE LINK***) of high generality. If successful, it could suit us. One ALICE person contributing.

Particle Identification upgrade

- At the time of design of present HMPID (proximity focusing Ring Imaging Cherenkov Detector), PID up to 5 GeV/c thought more than sufficient. RHIC has shown the need to go beyond 10 GeV/c to understand the interplay between recombination and fragmentation.



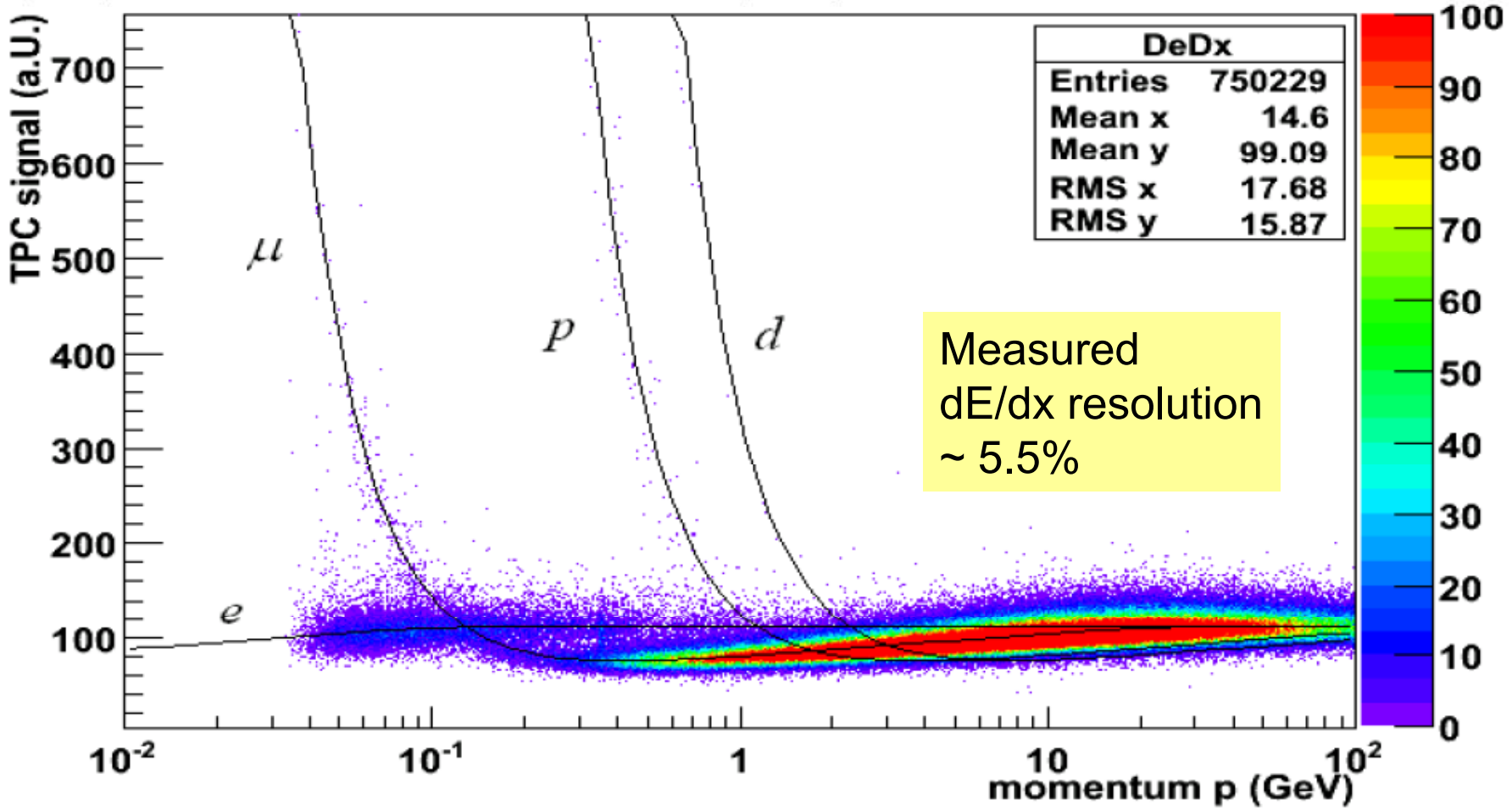


Particle Identification upgrade

- Identified particles at high P_T is necessary to study the flavour dependence of jet fragmentation as well as the gluon/quark origin of the jet.
- Identifying jet type is important as for instance, the quenching which probes the QGP medium is sensitive to the type of jet.
- In pp, need to improve understanding of flavour dependence of multiparticle production.
- However, for a strategic choice of a new PID technology, we need to assess the performance of the TPC.

PID calibration with cosmics data (1)

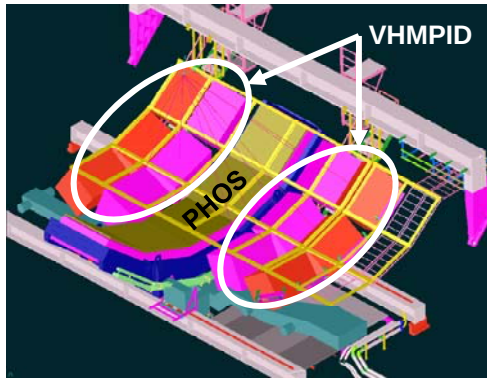
5,000,000 cosmic events from June 2008, simple Kr calibration



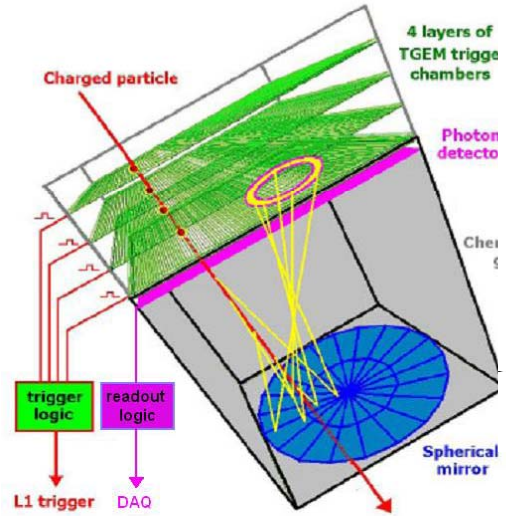
very basic cut (> 50 clusters) to not remove statistics at low p

❑ Detector assembly layout

- ✉ Would be located on both sides of PHOS, below space frame;
- ✉ RICH-like detector with mirrors, Gas radiator (C4F10?) maximum length ~80cm;

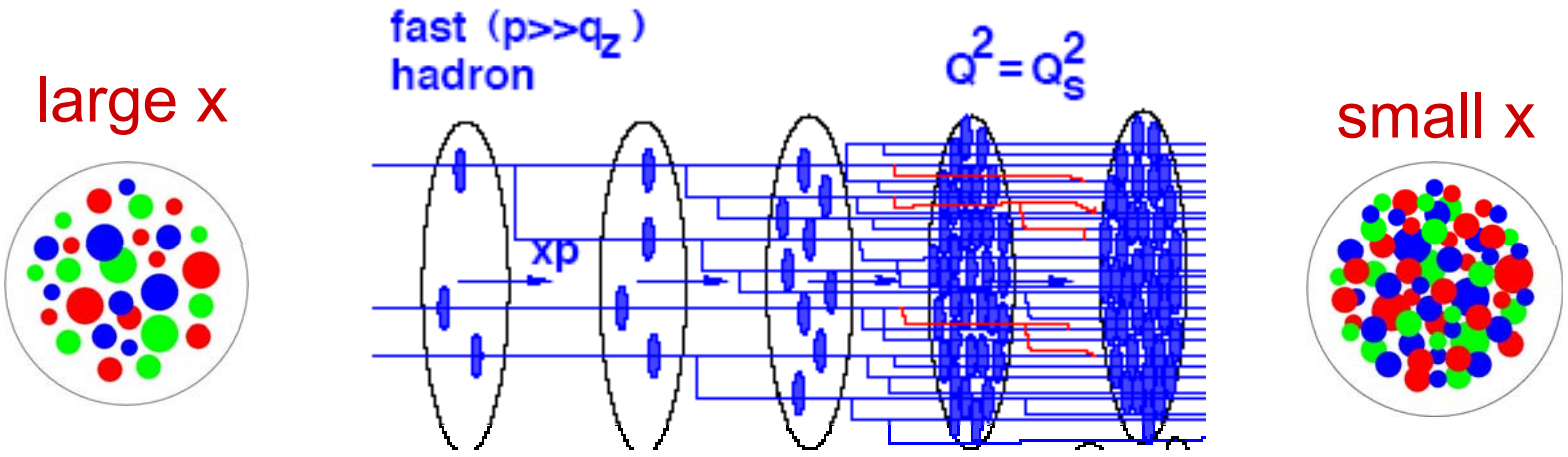


- ➢ Photon detector:
  - MWPC with CsI photon converter and pad readout (current HMPID technology);
  - Resistive Thick GEM (≥2 layers) with CsI photon converter (promising preliminary results).



- ➢ Dedicated trigger logic to select high p_T
  - use of TRD detector;
  - 4 layer GEMs detector with algorithm selecting high p_T particles (new trigger detector);
  - use of EMCAL detector, opposite to beam line, triggering on high energy jets.

- Preliminary discussions on **Forward calorimetry:**
  - Neutral meson (π^0, η) production at forward rapidities, for low x physics (Colour Glass Condensate), more generally the issue of parton saturation.



PbPb luminosity upgrade

- Rare physics items, (e.g. γ-jet correlations, Y , and a number of hard signals) require an improvement of statistics by a factor 10, to go beyond current proposal:
  - We understand that a factor 4 to 5 improvement is conceivable from beam collision peak luminosity increase, and luminosity lifetime increase;
  - An additional factor will come from the detector efficiency improvement.

- If it is confirmed that PbPb multiplicities are much lower than 8000 particles per unit of rapidity, then TPC and foreseen upgrades can cope with this (not a strong constraint).

Conclusion

- We will continue R&D on extending PID capabilities to higher p_T, and we will start soon R&D on ITS upgrade, DAQ upgrade (inevitable), and possibly forward calorimetry.

- Computing development (upgrade?) will have to follow the developments of detectors and DAQ.

- **Finalizing the ALICE upgrade plan** requires first pp and PbPb data analysis.