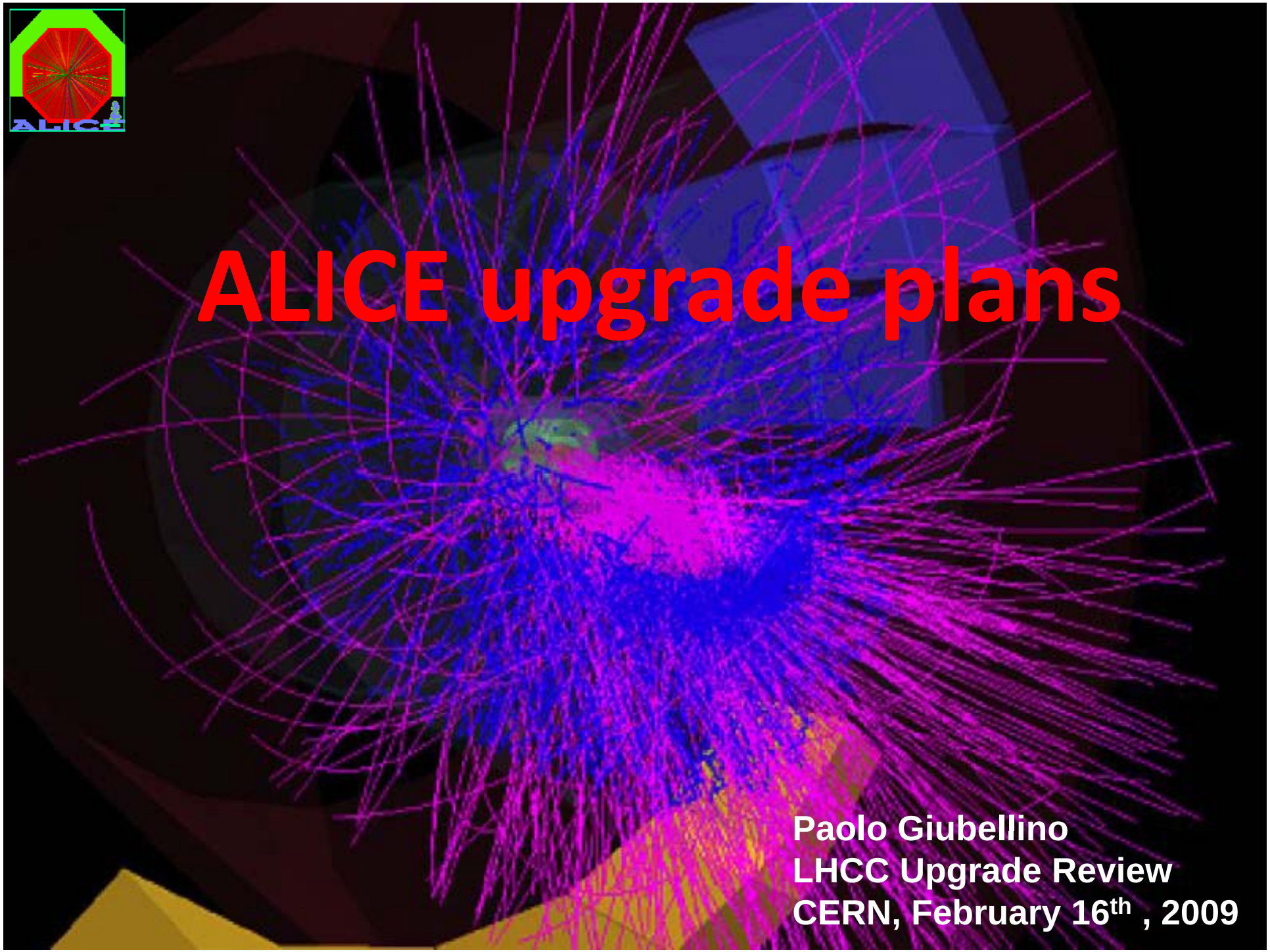


ALICE upgrade plans

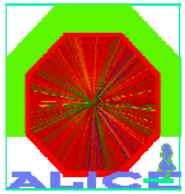
Paolo Giubellino

LHCC Upgrade Review

CERN, February 16th , 2009

Overview

- **ALICE has been designed primarily for Heavy Ion Physics. The Detector has therefore been optimized for (PbPb) luminosities of the order of 10^{27}**
- **pp Physics in ALICE is "minimum bias", low-luminosity**
  - **primary** motivation is the collection of comparison data as a tool to understand the Heavy-Ion ones
  - in addition several interesting measurements have been identified, for which the specificities of ALICE (low-p_T cutoff, PID) make it complementary to the other experiments => e.g. see figure
- **The optimal luminosity for ALICE during proton running is from 10^{29} (optimize pileup in TPC) to 10^{31} for low cross-section observables**



- Therefore **ALICE plans for the future are only very indirectly linked to the LHC high luminosity upgrade**
  - Some of the limitations to the maximum PbPb luminosity (which does limit the ALICE Physics reach in Heavy Ions in some areas) could be improved by the SLHC luminosity upgrade: most important, the necessary improvements in the collimation system would be instrumental to an increase in PbPb luminosity.
- The only ALICE requirement is to be able to take at least a few weeks of low luminosity pp running every year before the ion running for detector commissioning

ALICE programme I

- **First 5 years**: full exploitation of present ALICE detector (not necessarily in this order)
  - Need to explore a multi-variable space, not only in *statistics* but also in *beam type and energy*:
  - First pp run
  - 1 yr (10^6s) Pb-Pb at low Luminosity (initially ~1/20th design, i.e. L~5x10^{25} $cm^{-2}s^{-1}$)
  - 2 yrs Pb-Pb at nominal L~10^{27}, targeting integrated L~1nb^{-1} (as from LHCC recommendations)
    - Might take 3 years depending on L and on number of experiments sharing the beam
  - 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.)
    - Further comparison data will be needed with the addition of new detectors

ALICE programme II

- **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**.
- **In the past, HI Physics has been generous with surprises, so a detailed plan will have to wait at least for the analysis of the first PbPb data.**
- **Both the SPS and the RHIC programs had similar lifespans (RHIC has already 9 years of running and plans for 2-3 more, followed by a luminosity upgrade)**

Upgrades (ongoing)

- A **program to upgrade some elements of ALICE is already ongoing**
- In fact ALICE has evolved considerably from its Technical Proposal, largely because of the new data from RHIC, which are also at the base of some of the future upgrade ideas. In particular
  - the TRD has been approved much later than the other central detectors, and it is expected to be complete by 2009/2010
  - a new EMCAL calorimeter (very important for jet-quenching) has been added recently
    - US project, with French and Italian involvement.
    - 2 SM installed this year (maybe 3) out of 11
    - to be completed by 2010/2011

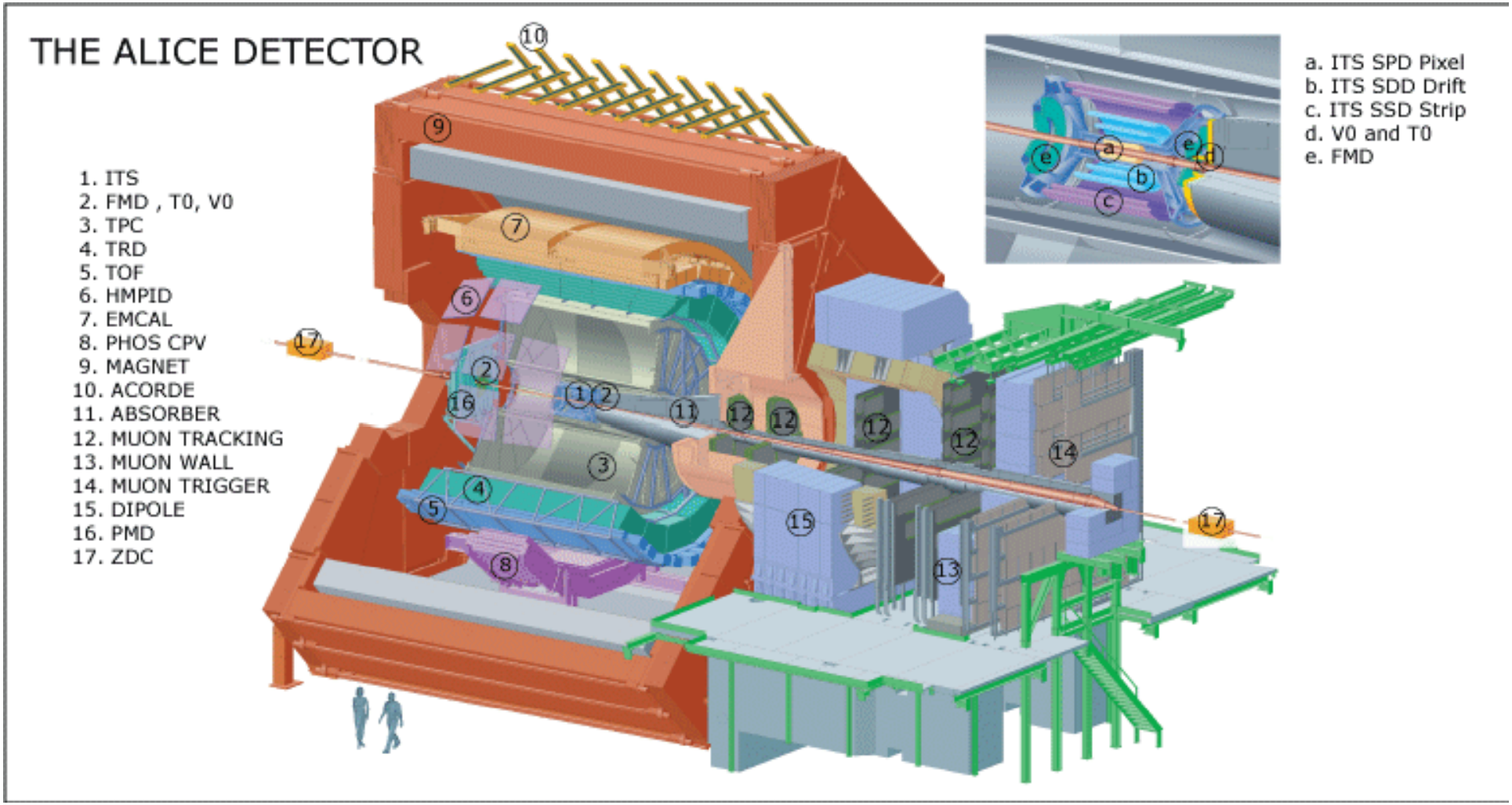
Upgrades (future)

Upgrade ideas for > 2010

- Vertex upgrade:
  - 2nd generation vertex detector (closer to beams)
  - → heavy flavour baryons, fully reconstructed B, …
- Forward upgrades:
  - new detectors for forward physics (tracking & calorimetry)
  - → low-x in pA, AA
- Particle id upgrade:
  - extend to p_T range for track-by-track identification to O(20) GeV/c
  - → new physics interest, based on RHIC results
- Calorimetry upgrade:
  - extend EMCAL to opposite ϕ
  - → Improve γ-Jet acceptance, dijets
- High rate upgrade:
  - increase rate capability of TPC (faster gas, increased r/o speed)
  - → rare hard probes (Υ, γ-jet, …)
- DAQ & HLT upgrades:
  - → more sophisticated and selective triggers

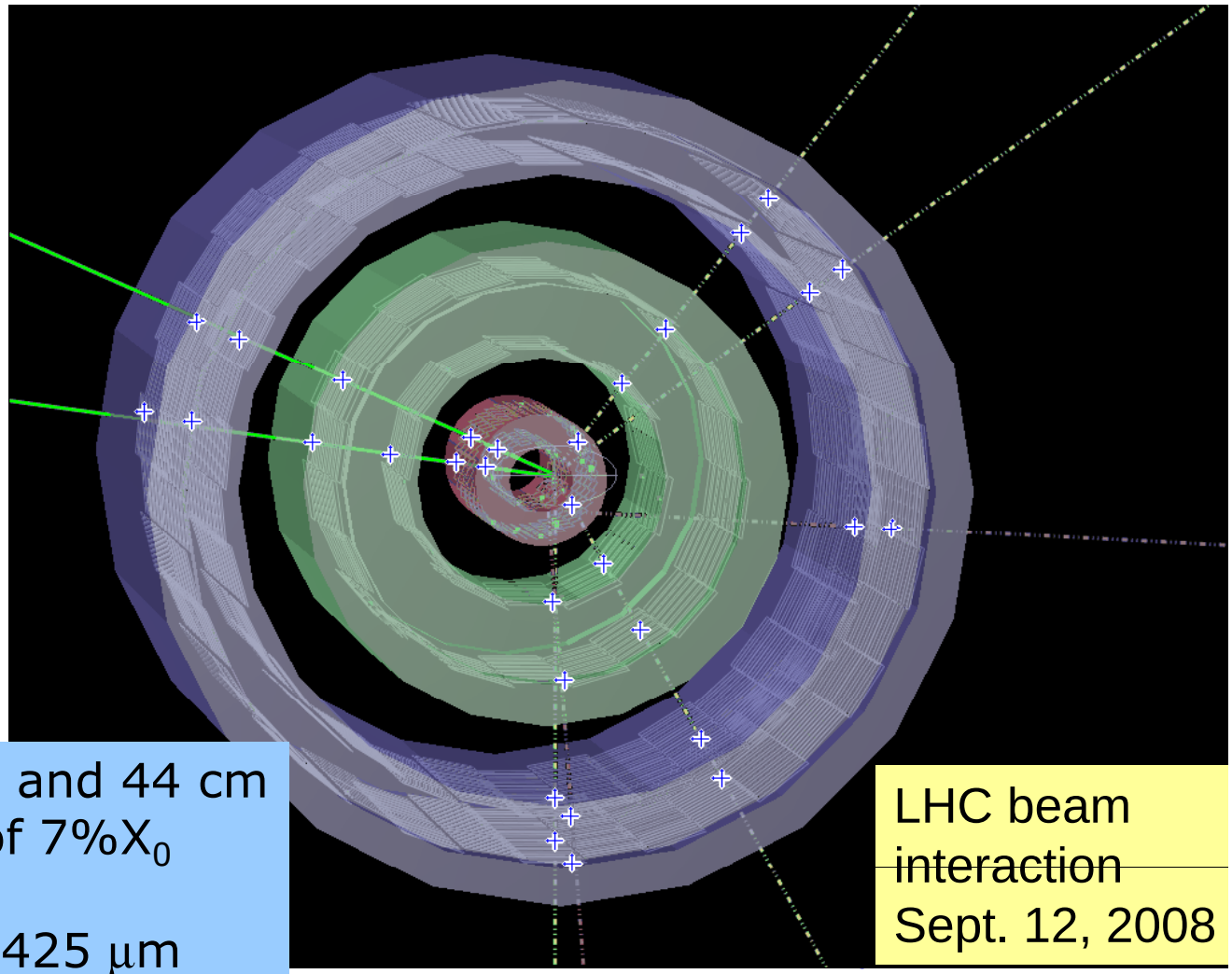
Require changes in the beampipe and therefore are correlated

ALICE


THE ALICE DETECTOR
1. ITS
2. FMD , T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCAL
8. PHOS CPV
9. MAGNET
10. ACORDE
11. ABSORBER
12. MUON TRACKING
13. MUON WALL
14. MUON TRIGGER
15. DIPOLE
16. PMD
17. ZDC
a. ITS SPD Pixel
b. ITS SDD Drift
c. ITS SSD Strip
d. V0 and T0
e. FMD

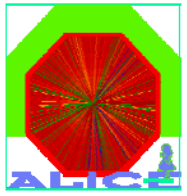
Inner Tracking System upgrade

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



LHC beam interaction
Sept. 12, 2008

Radii: 4, 7, 15, 24, 39, and 44 cm
Total material budget of 7%X_0 (normal incidence)
Pixel size 50 μm times 425 μm
Beam pipe radius 2.98 cm

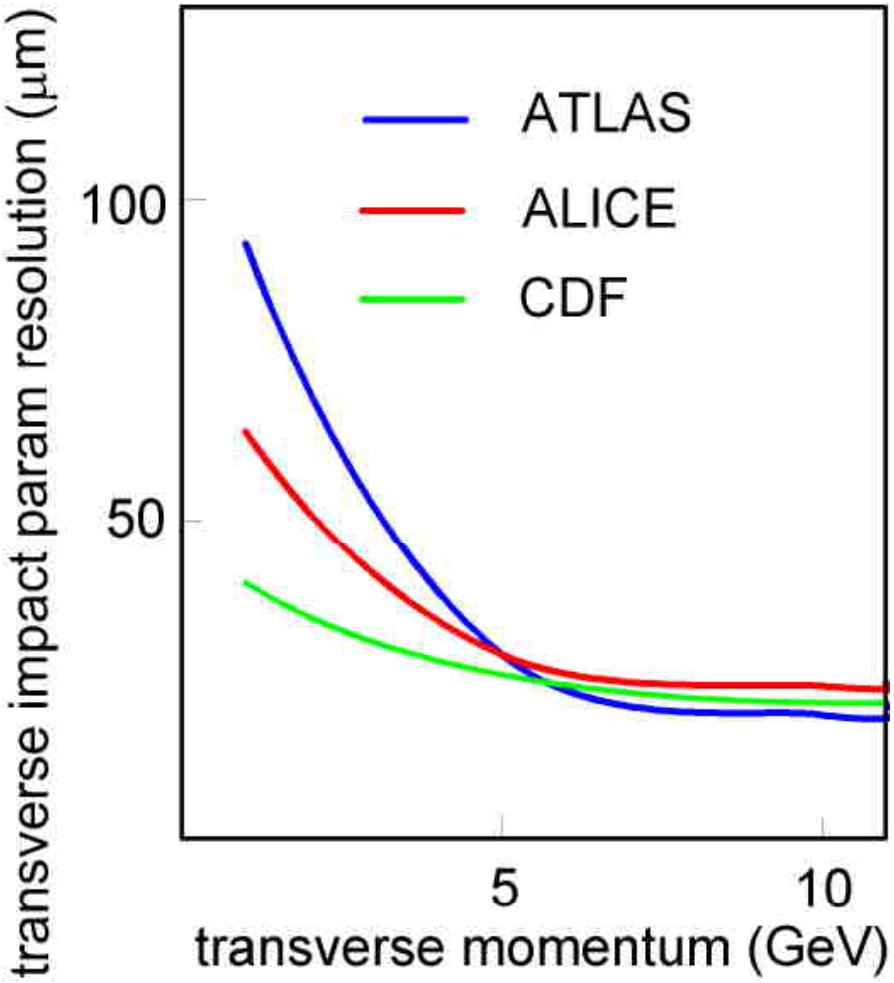


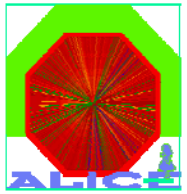
Inner Tracking System upgrade

- 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?
- Replace (at least) the two innermost (pixel) layers
  - Design:
    - key design parameters:
      - material budget (including power dissipation!)
      - space resolution
    - > investigating concept options for R&D



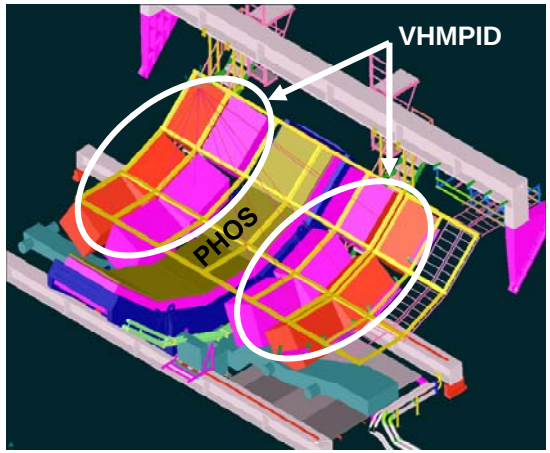


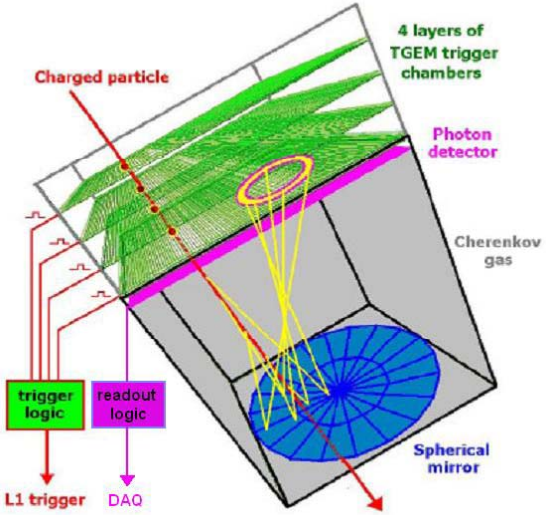
Particle Identification upgrade

- Expand ALICE power of analysis of Jet fragmentation function
- Identifying particles at high P_T (above 10 GeV/c) is useful to study the flavour dependence of jet fragmentation as well as the gluon/quark origin of the jet.
- Identifying the 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.
- Goal: achieve π and K identification up to 14 GeV/c with single radiator, up to O(20 GeV/c) with double radiator, and p identification up to 26 GeV/c (35 with double radiator) *on a track-by-track basis*

VHMPID

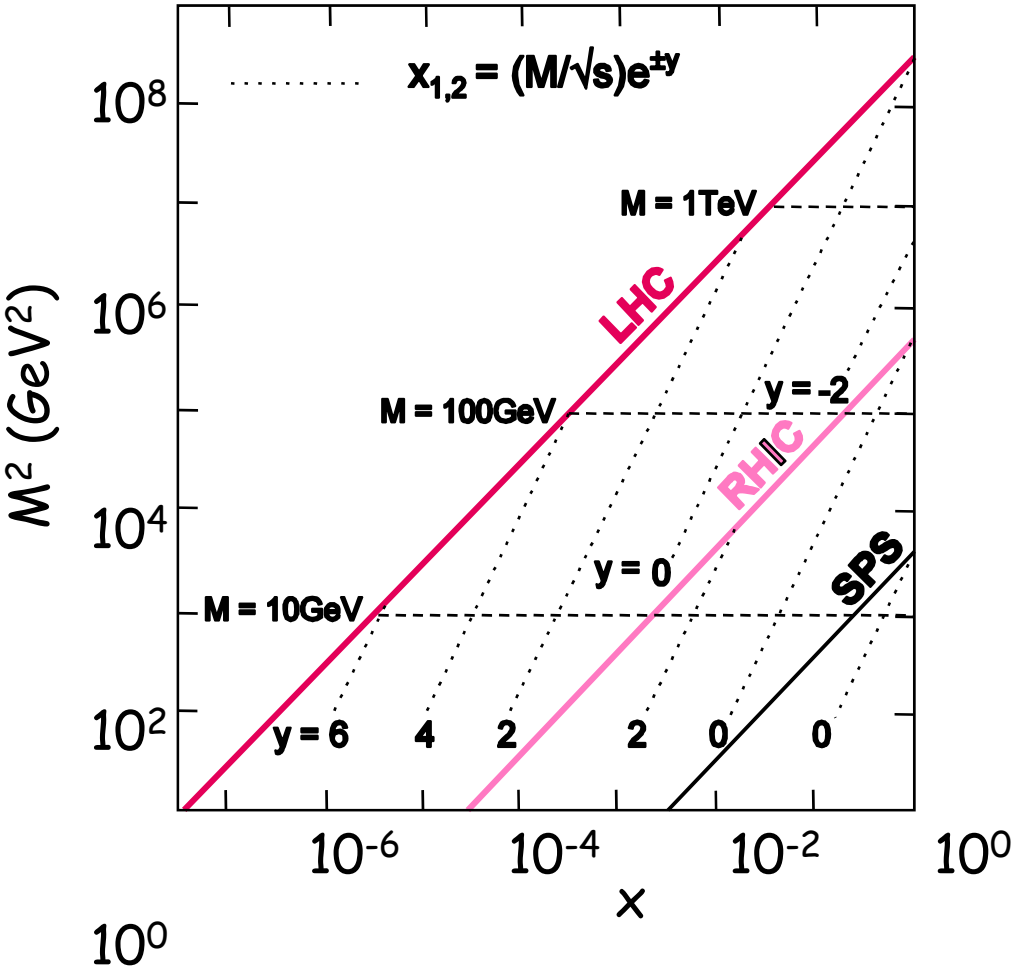
Would be located on both sides of PHOS, below space frame (10% of TPC acceptance)
RICH-like detector with mirrors, Gas radiator (C_4F_{10}? Double radiator $CF_4 – C_4F_{10}$?)
maximum length ~80cm;



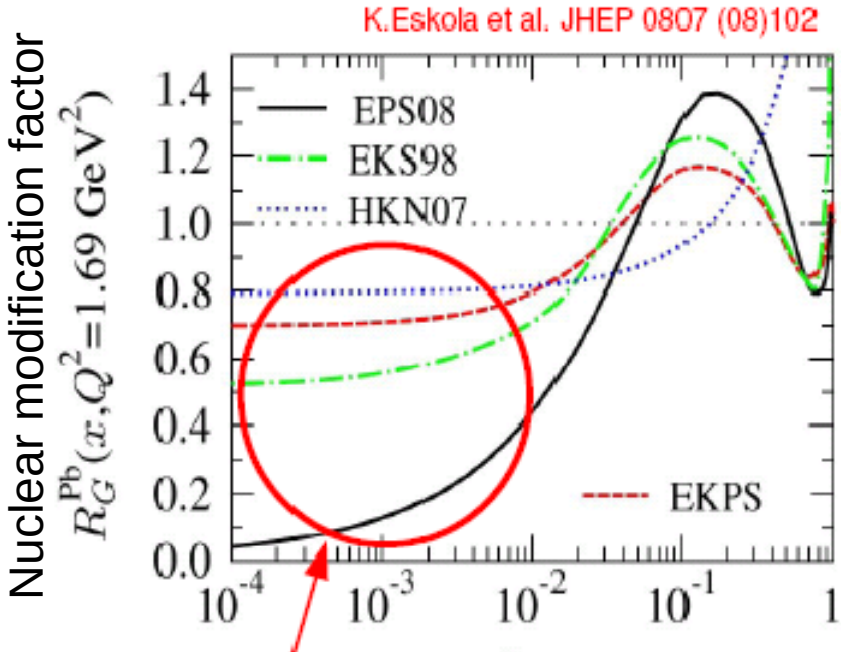


- Photon detector:
  - MWPC with CsI photon converter and pad readout (current HMPID technology)
  - Resistive Thick GEM (≥2 layers) with CsI photon converter (promising preliminary results).
- Dedicated trigger logic to select high p_T
  - use of TRD detector
  - 4 layer GEMs detector with algorithm selecting high p_T particles (new trigger detector)
  - use of EMCAL detector, opposite w.r. to beam line, triggering on high energy jets.

Forward physics at ALICE



Fully exploit the opportunity offered by the LHC to access the small-x region by going to forward rapidities (at the moment accessible only in the muon channel)



Strong effects expected at large rapidities for gluon PDF

-> shadowing

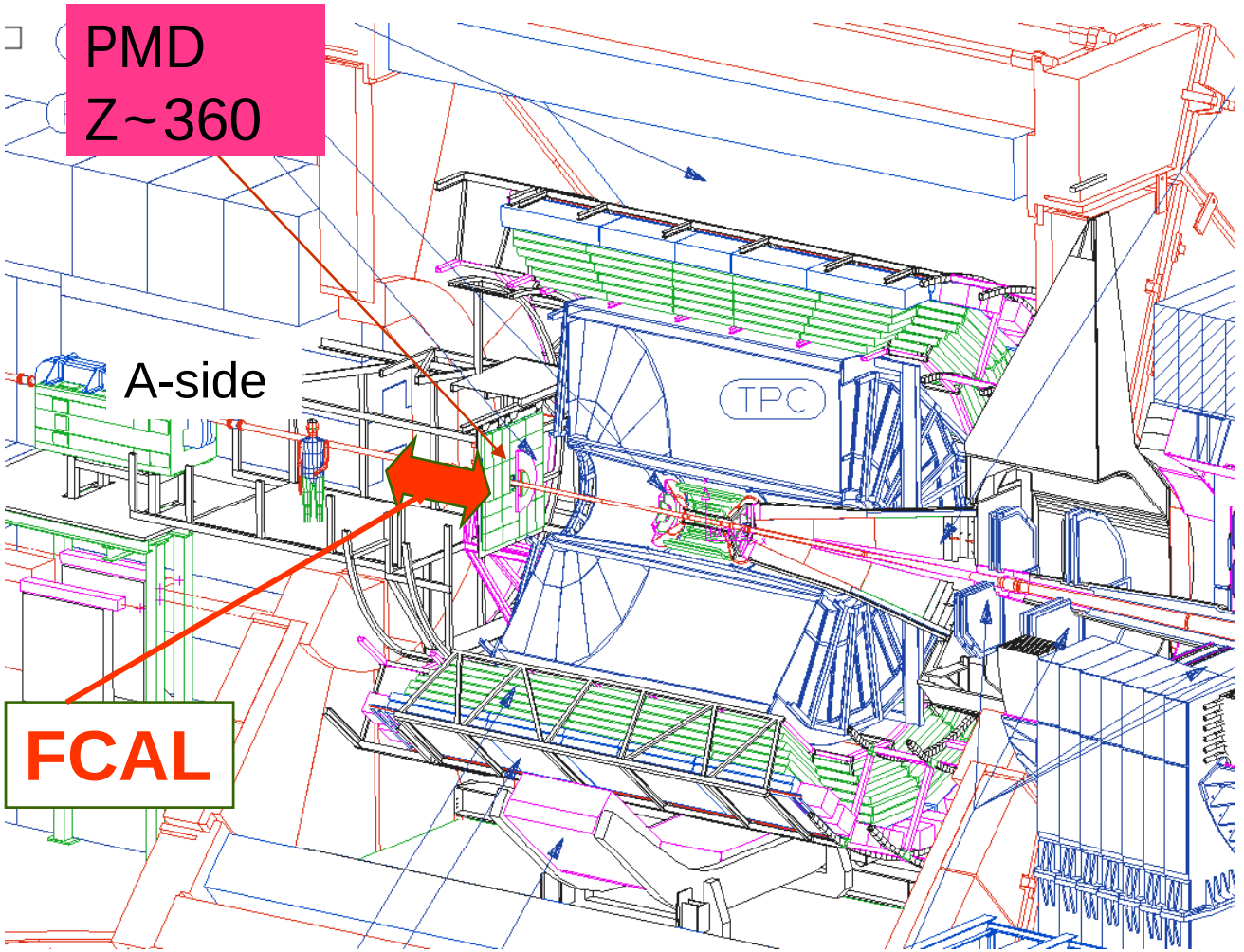
-> gluon saturation

FEMCAL in ALICE "near location"

- **Reconstruction of π^0 over a wide pt-range (1 GeV/c – 50 GeV/c)**
- **Forward jets (20 GeV < Et < 100 GeV)**

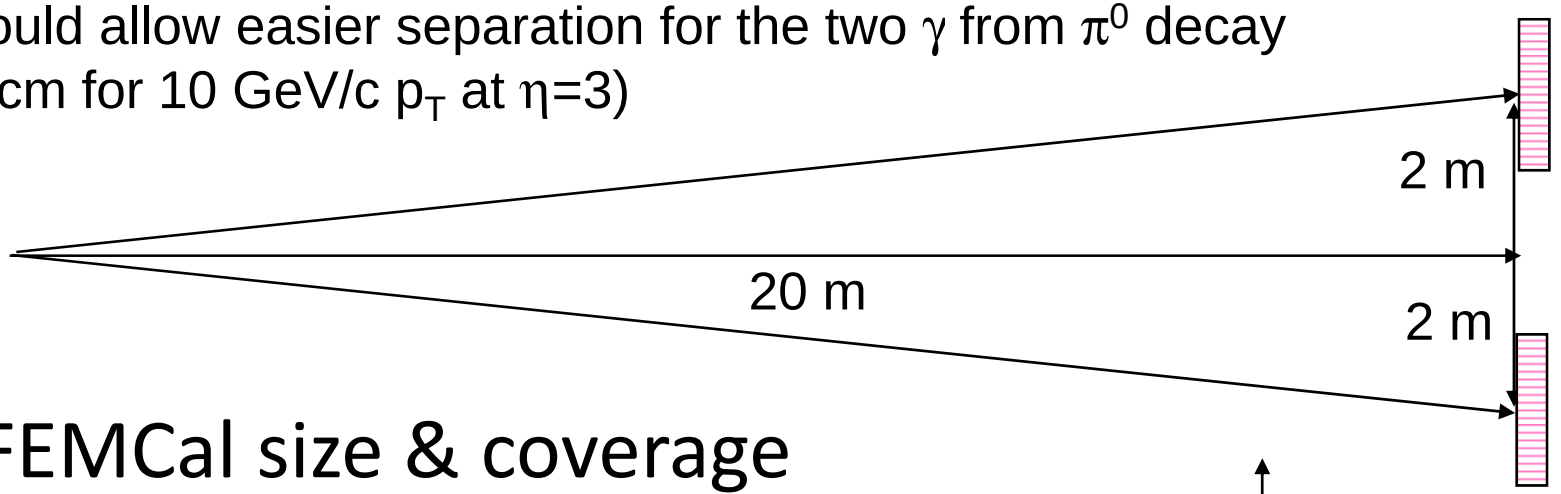
- Location on the A-side of ALICE
- Distance from Vertex: 360 cm
- η-Coverage: 2.3 to 4.0

- **Highly segmented (also longitudinally) EM-calorimeter with small Moliere radius (Si-W?) (large background from secondary particles)**

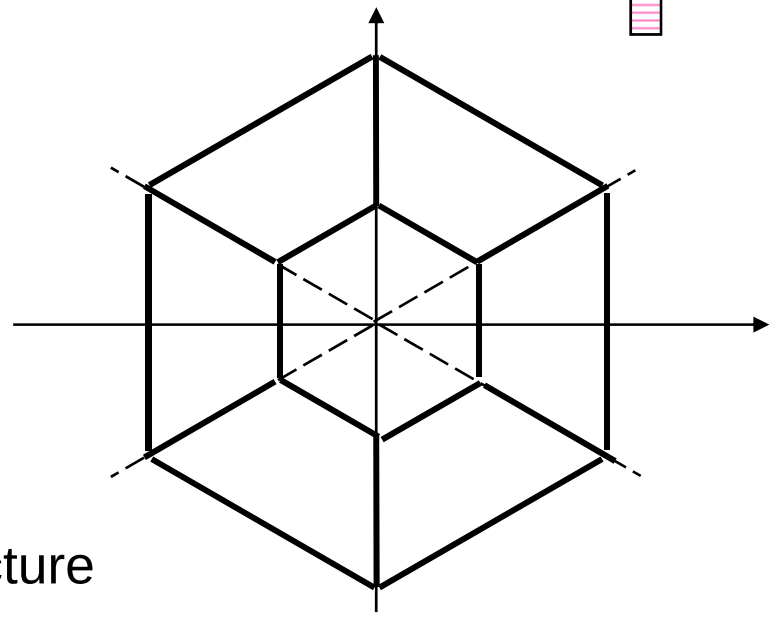


FEMCAL in ALICE "far location"

Would allow easier separation for the two γ from π^0 decay
(5 cm for 10 GeV/c p_T at η=3)



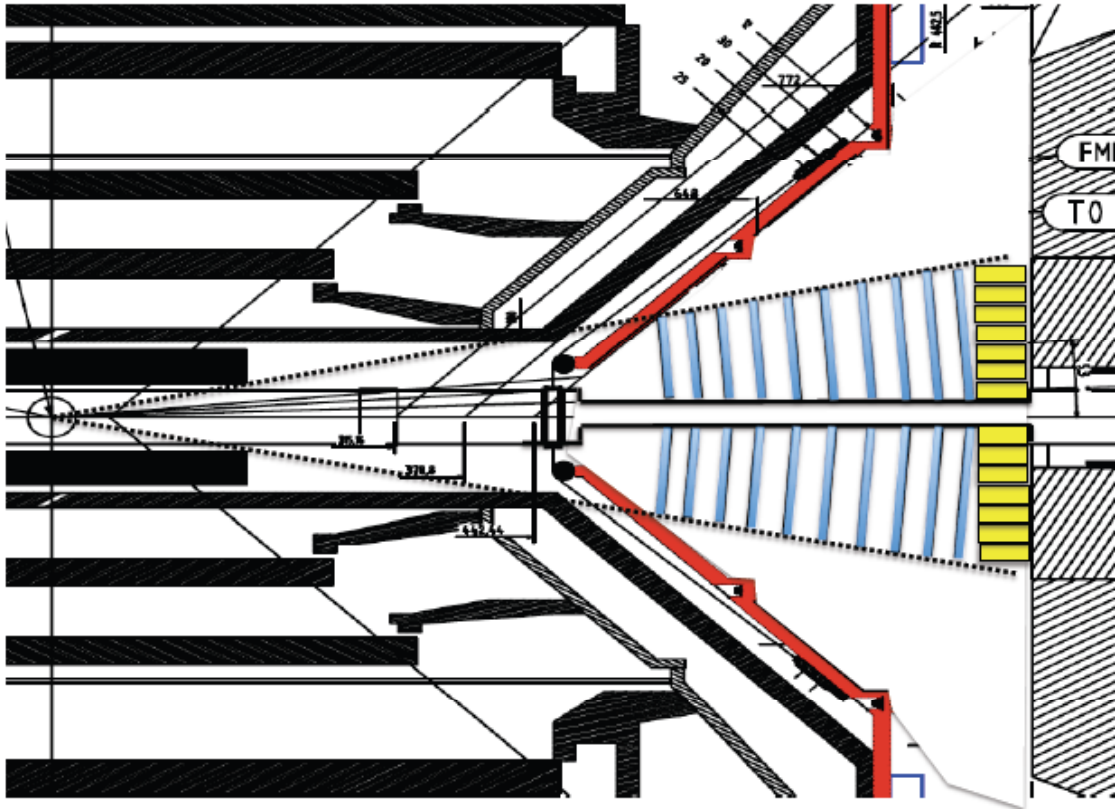
- FEMCal size & coverage
  - L = 20 m
  - ΔR = 2 m
  - R_{min} = 1.2 m R_{max} = 3.2 m
  - η = 3.5 -- - η = 2.5



Easier detector but bigger impact on infrastructure

Backward tracking

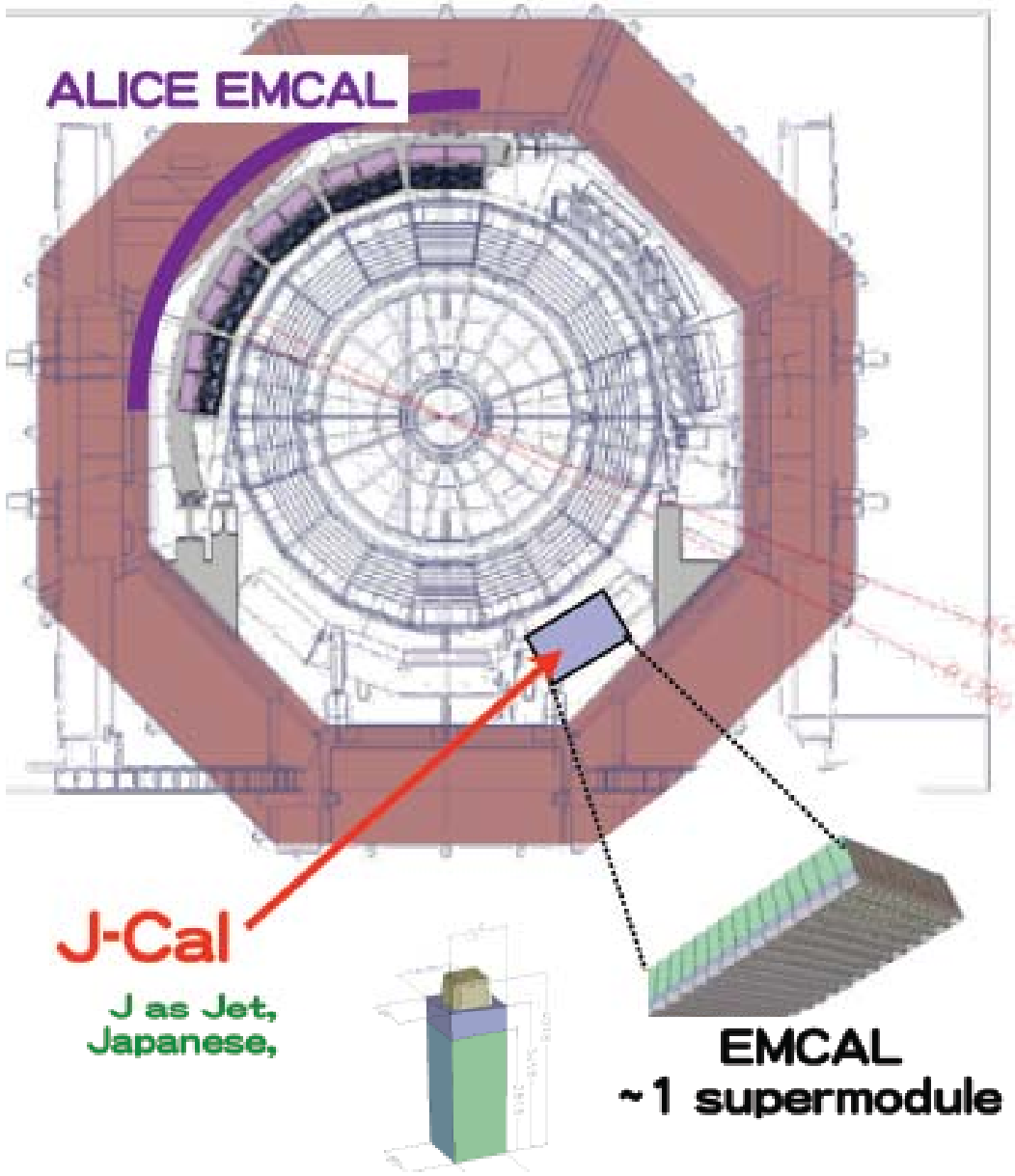
(still in early conceptual phase)



- Si tracker upstream of muon absorber (à la NA60)
  - charm vs K, π decays
  - reduce combinatiorial (ψ', …)
  - J/ ψ from B
- Presently under study:
  - matching to muon tracks, tracking performance

J-Cal

- Additional supermodule(s) opposite to EMCal
- Increase acceptance for γ–jet (low-cost alternative to increasing the PHOS acceptance)
- back-to-back jets



DAQ/HLT upgrade

- Problem of obsolescence of elements essential to the current architecture (PCI 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
- In the meantime, collaborate to the development of future fast links
- Adapt progressively to the increasing needs in data transfer and processing speed while maintaining the system: evolutionary approach

Heavy Ion Luminosity increase

- LHC Pb design Luminosity
  - design L = 10^{27} cm^{-2} s^{-1}, <L> ~ 0.3 – 0.5 L_{max} (depends also on # expts)
  - ALICE assumption: integrated L/year(10^6s) ~ 0.5 nb^{-1}
  - design L close to several LHC limitations => **could be optimistic !!!**
- Examples for statistics limited Signals
  - Y suppressions:
    - order 7000 Y, 1000 Y'' per standard year in ALICE
    - NA60: order 10^5 or more J/ψ !!!
  - γ-jet correlations ('golden channel' to study jet quenching)
    - order 1000 γ-jet events/year with p_t > 30 GeV
    - need order 10^4 for fragmentation functions at high z (most sensitive to quenching)

3 – 4 years running at 4-5 x design L would give the needed order of magnitude increase in statistics !!

HI Luminosity increase'

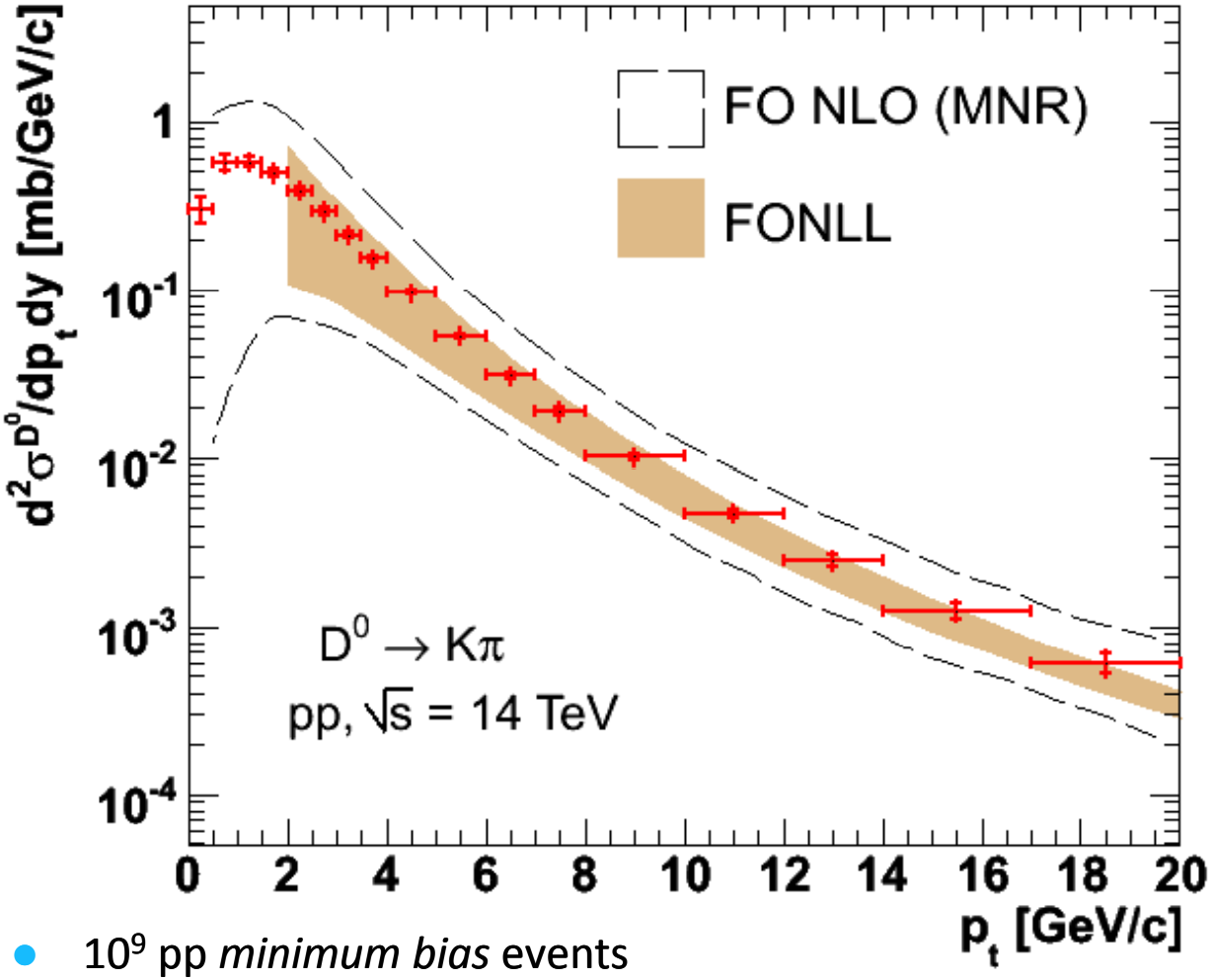
- Only minor detector modifications would be necessary to benefit from L increase to 5×10^{27}
  - current limitation is TPC (pile-up, possibly space charge)
  - TPC designed for up to $dN_{ch}/dy = 8000$, expectation is more like 2000 – 4000
  - significant rate increase possible (faster gas, accept pile-up for high p_t physics)
  - muon spectrometer needs no modifications

Plans

- Activity ongoing in several working groups, at very different stages of advancement
  - The VHMPID collaboration proposal fairly advanced
  - Others working on simulation and/or in the definition of R&D needs
- P.G. Charged by the ALICE Management Board to coordinate upgrade-related activites
- First general “kickoff meeting” at the next Alice Week, end of March 2009
  - Aim at
    - an overview of current and planned activites
    - Definition of timescales and procedures

$D^0 \rightarrow K^- \pi^+$

- **Differential cross section for D0 production in pp as measured by ALICE**



- Bars: systematic and statistical errors
- Band: theoretical uncertainty

- 10^9 pp *minimum bias* events

back