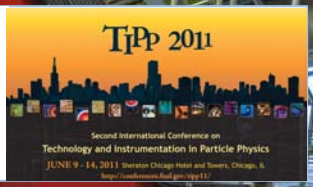
*TIPP 2011 – 2nd International Conference on Technology and Instrumentation in Particle Physics*




# Upgrade of the ALICE Detector

Petra Riedler/CERN

Photo: Mona Schweizer

# Overview



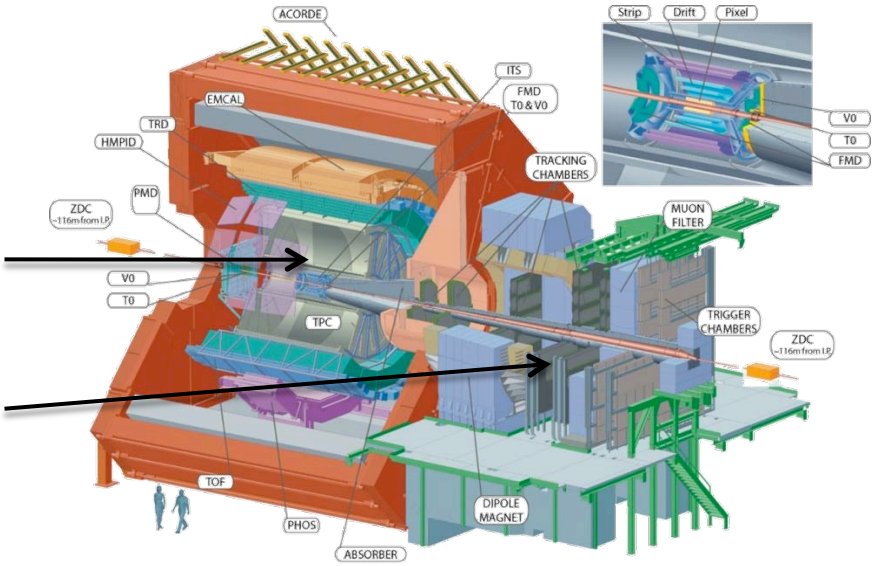
- The ALICE Experiment
- ALICE Upgrade
  - Selected list of proposals
    - FOrward CALorimeter - FOCAL
    - Very High Momentum Particle Identification – VHMPID
    - Muon Flavour Tracker –MFT
    - Upgraded Inner Tracking System – ITS
- Summary

# The ALICE Experiment



- Dedicated heavy ion (HI) experiment at LHC to study strongly interacting matter at extreme energy densities
- Data taking during HI and pp collisions (comparison data for HI physics)
- Two main parts:
  - barrel ($|\eta|<0.9$), B = 0.5 T
  - forward muon spectrometer

    $-4<\eta<-2.5$, dipole B=0.5 T

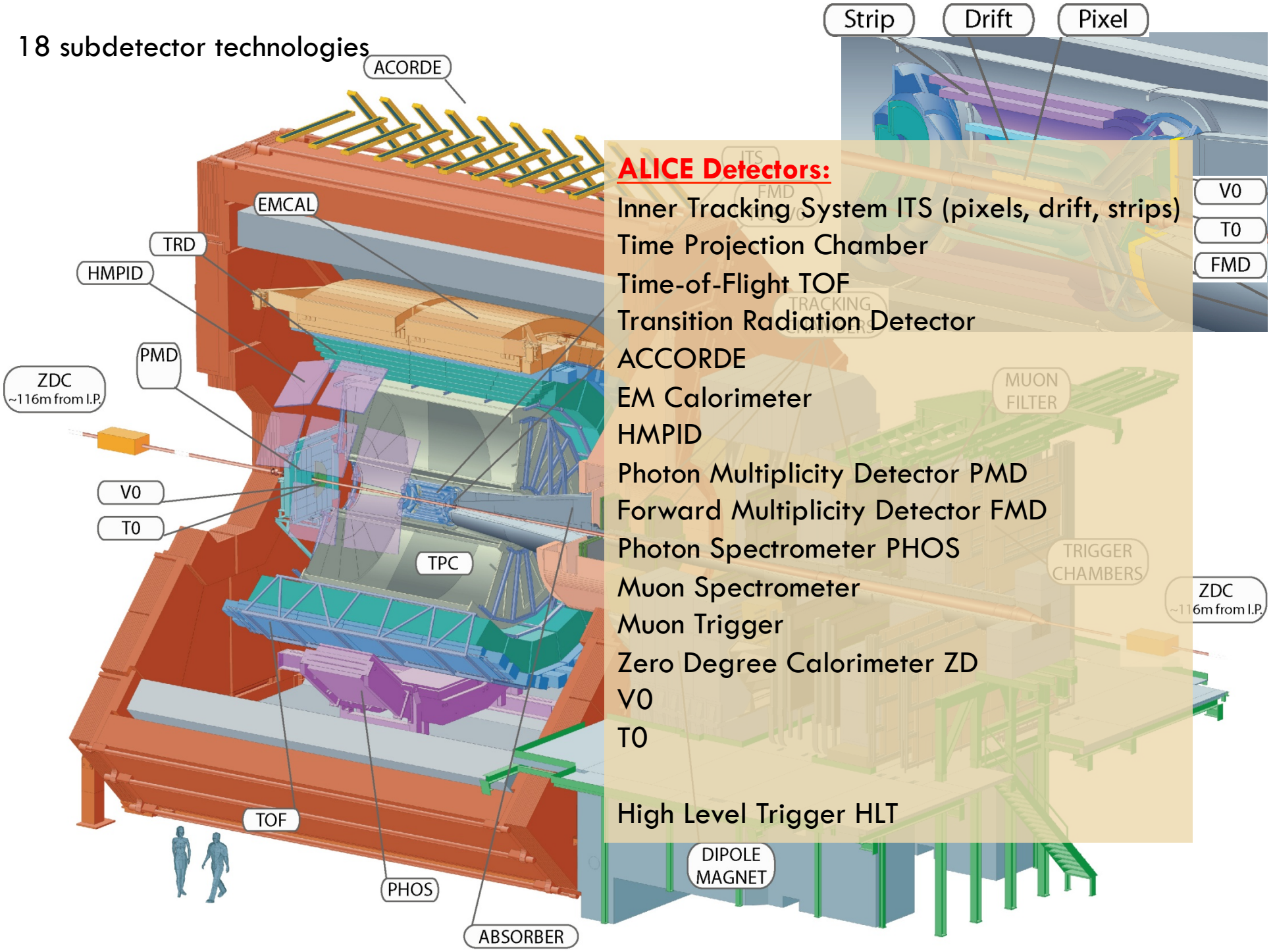


# The ALICE Experiment



- Optimized for Pb-Pb running (interaction rate ~ 10kHz)
- Radiation in innermost layers ~ few $10^{13}$ $n_{eq}$, few Mrad
- **Distinct features of ALICE:**
  - Designed to cover wide momentum range, from soft (down to 100 MeV/c) to hard (>200 GeV/c) physics
  - Low $p_T$ cut-off (~100 MeV/c) due to magnetic field and low material budget
  - Very good tracking and PID
  - Dedicated di-electron and di-muon detection
  - High resolution calorimeter for direct photons

18 subdetector technologies




**ALICE Detectors:**

Inner Tracking System ITS (pixels, drift, strips)
Time Projection Chamber
Time-of-Flight TOF
Transition Radiation Detector
ACCORDE
EM Calorimeter
HMPID
Photon Multiplicity Detector PMD
Forward Multiplicity Detector FMD
Photon Spectrometer PHOS
Muon Spectrometer
Muon Trigger
Zero Degree Calorimeter ZD
V0
T0

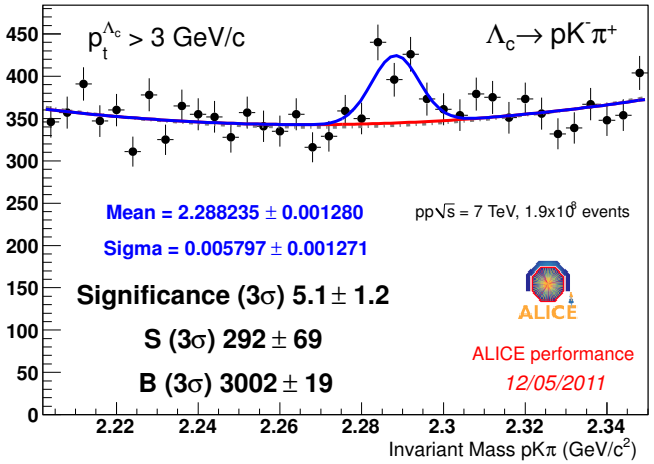
High Level Trigger HLT

# ALICE Upgrade



- Address open physics issues, which cannot be tackled with the current setup
  - Increase coverage and
  - Enhance measurement capabilities

$\Lambda_c$ in pp @ $\sqrt{s}$ = 7 TeV




- **Some of the open physics topics to address:**
  - Heavy flavour production
  - Hadronization
  - Small-x structure of nuclei and protons
  - Large range rapidity correlations

# ALICE Upgrade Schedule



- Upgrade plans defined by Pb-Pb results from first HI runs. However, long LHC shutdowns determine access to the experiment.
- **Timeline:**
  - Expression of Interest (spring 2011) for various proposals (see following slides)
  - Workshop on the physics of upgrades in ALICE, July 12+13, 2011 – close interaction with theorists
  - Call for Letters of Intent (autumn 2011)
  - Preliminary decision on approval of upgrade projects by end 2011
  - Most upgrades scheduled for LHC shutdown 2017/18

# ALICE Upgrade Proposals

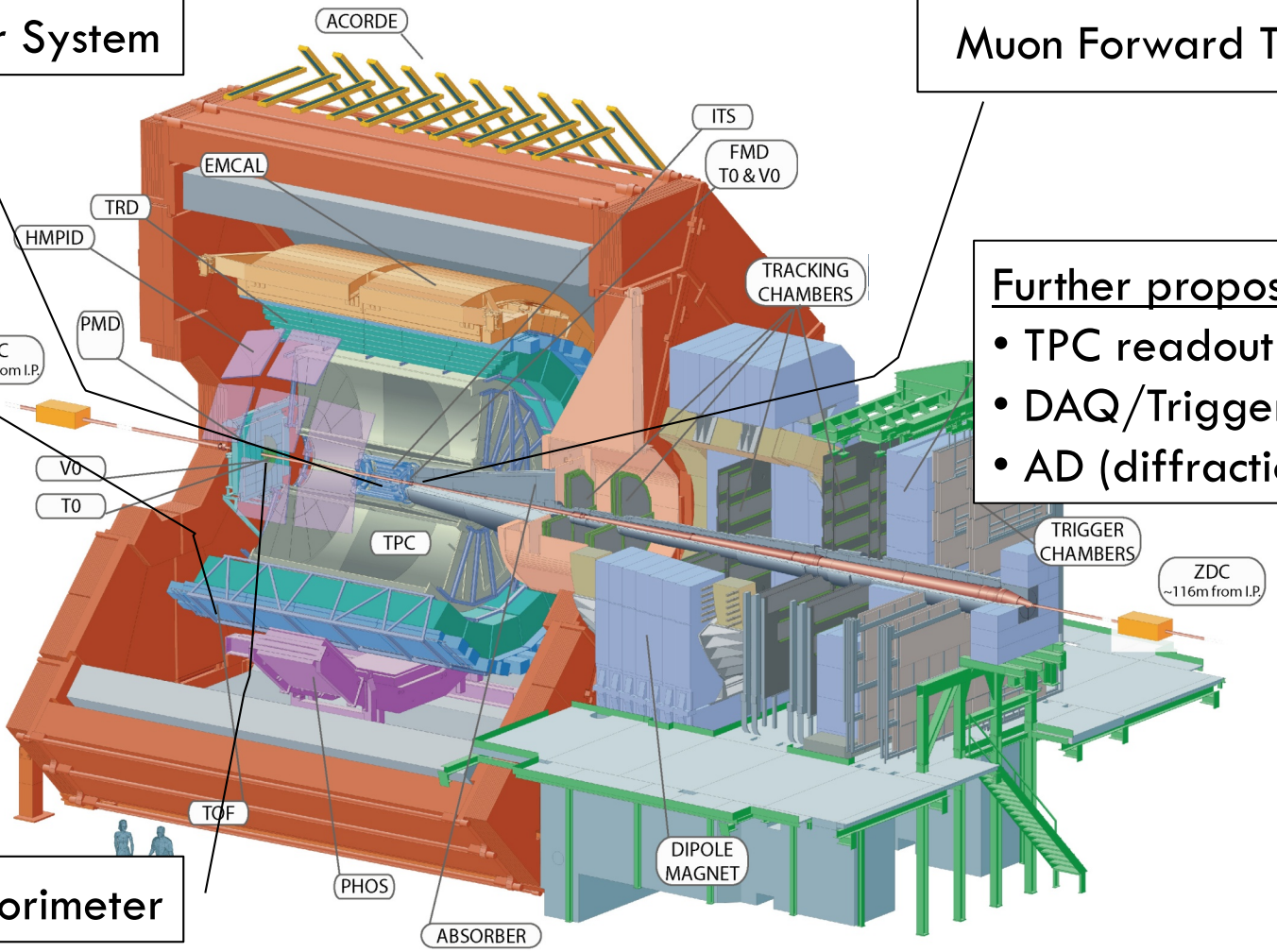


Inner Tracker System

VHMPID

Forward Calorimeter

Muon Forward Tracker




**Further proposals:**

- TPC readout upgrade
- DAQ/Trigger
- AD (diffraction)

# ALICE Upgrade Proposals

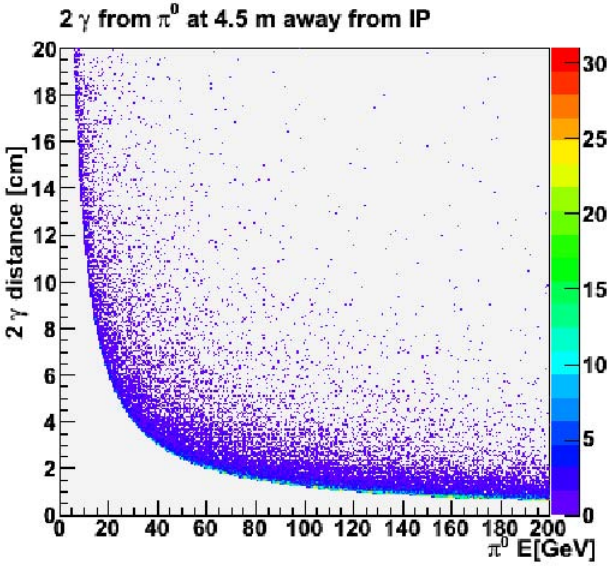


- Vertex (ITS & MFT) upgrade:
  - heavy flavour baryons, charm coverage at low pT, b-tagging for muons, measurement of exclusive B-decays
- Forward EM calorimeter (FOCAL):
  - low-x in pA, AA, photon/pion discrimination
- Particle ID upgrade (VHMPID):
  - extend to $p_T$ range for track-by-track identification to O(20) GeV/c
- TPC readout upgrade:
  - increase rate capability of TPC (faster gas, increased r/o speed)
- DAQ & HLT upgrades:
  - more sophisticated and selective triggers

# FOCAL



- Large rapidity coverage
  - $2.5 < \eta < 4.5$
- EM calorimeter for photons, neutral mesons ($\pi^0$,$\eta$), maybe $e^+e^-$
- Requirements:
  - $\pi^0/\gamma$ discrimination at high momentum (~200 GeV/c)
  - High granularity to cope with particle density in Pb-Pb
- ~350 cm from IP

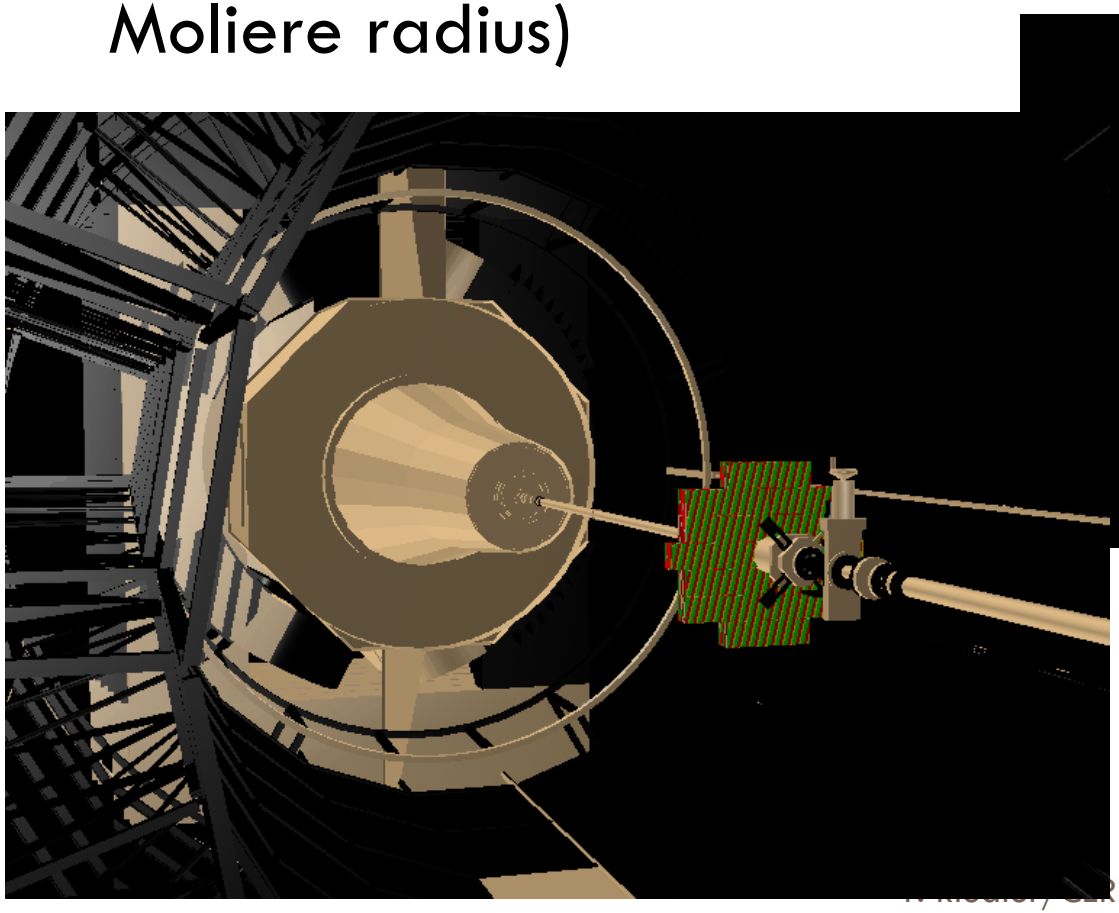


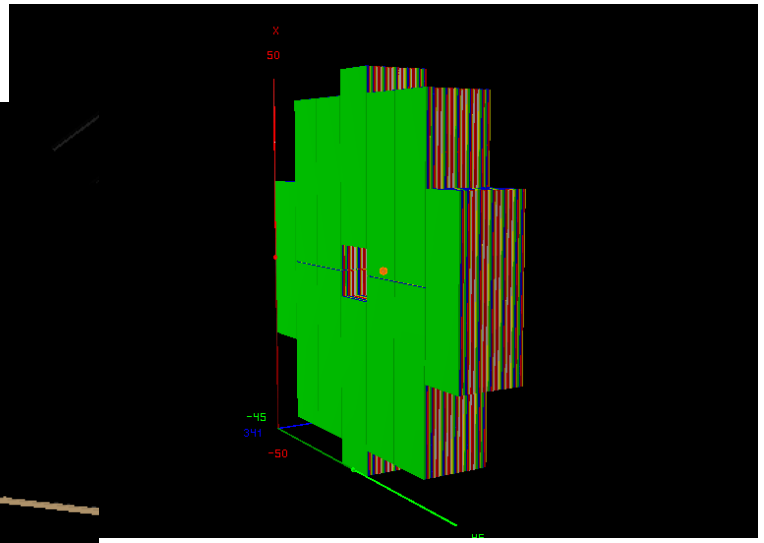

Two-photon distance D(2γ) from $\pi^0$ → 2γ decay at 4.5m from interaction point: Minimum D(2γ) = 0.6 cm for 200 GeV $\pi^0$

# FOCAL Technology



- Preferred material Si+W (small segmentation, small Moliere radius)



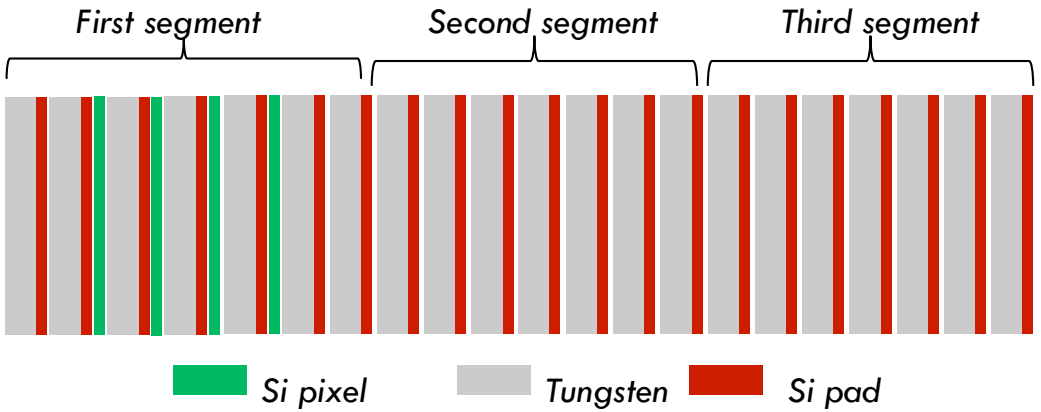


Outer radius: ~ 80 cm
Area: ~2 $m^2$
Depth: ~20 cm

# FOCAL Technology



- Detailed layout to be defined
- Approximately 21 layers along z
- W thickness: 3.5 cm
- Silicon technology options:
  - Si pads (~1 cm x 1 cm or smaller), 300 um thick, dedicated ASICs
  - Pixels (monolithic, ITS upgrade) at 2, 3, 4, 5 $X_0$

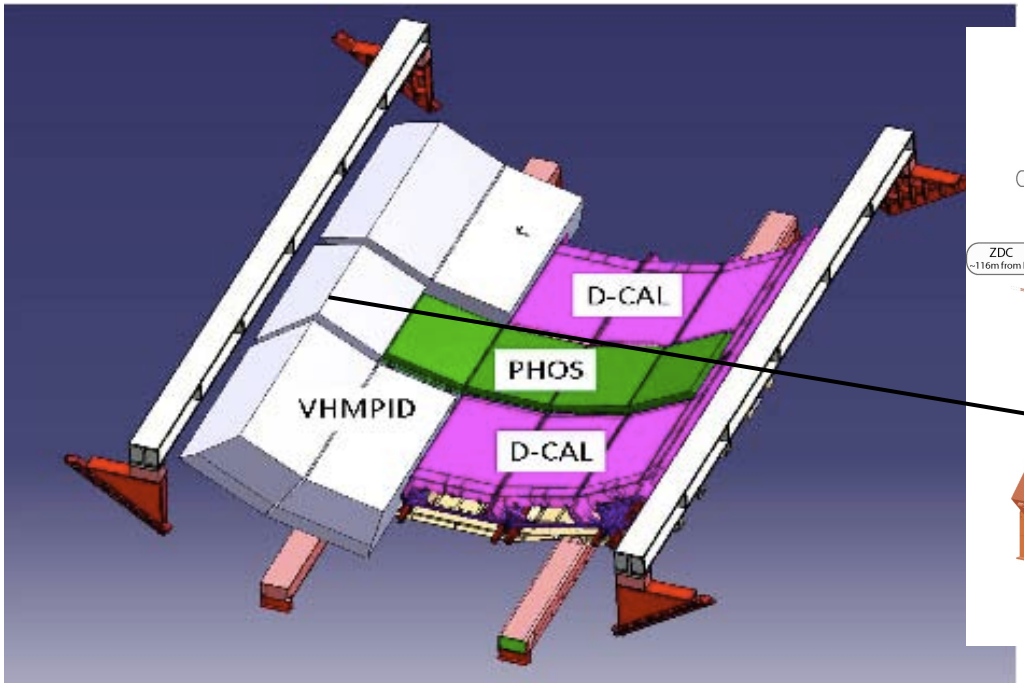


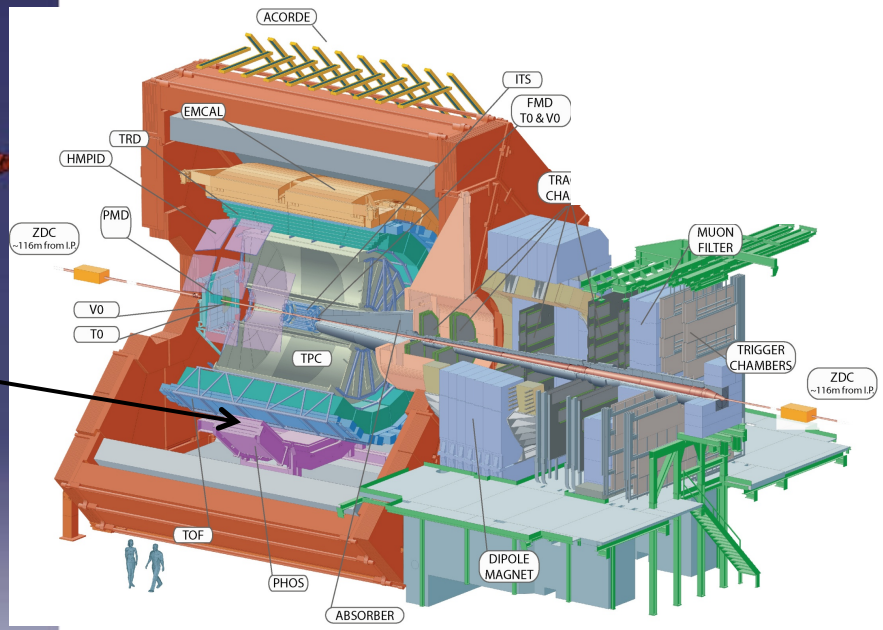

Example of a layout

# VHMPID



- Identify pions, kaons and protons on a track-by-track basis in the range from 10-25 GeV/c

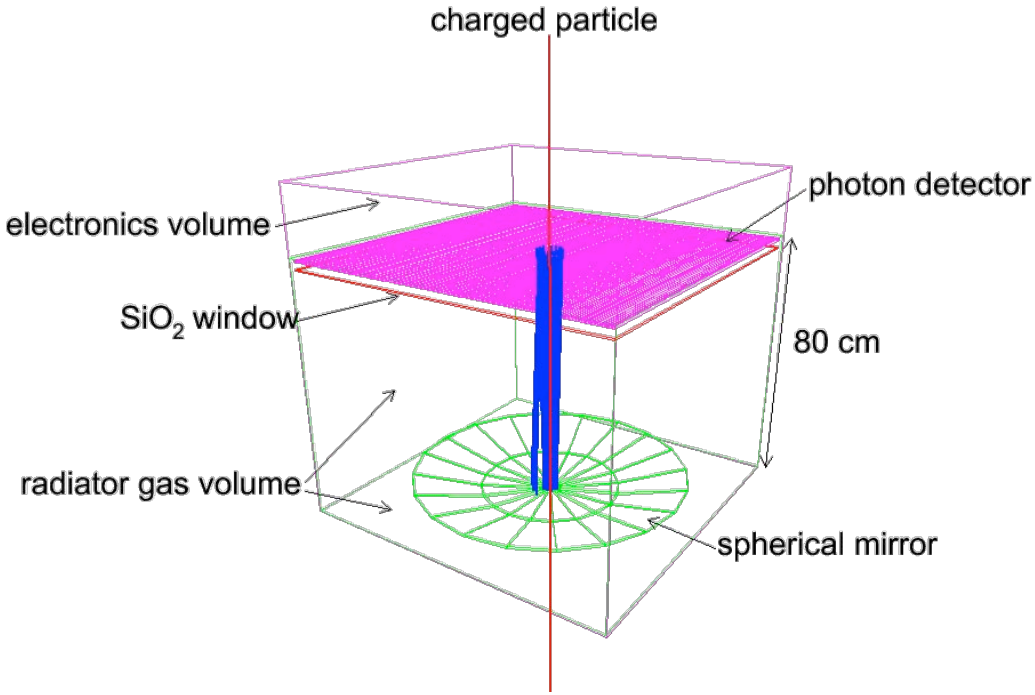


# VHMPID Technology



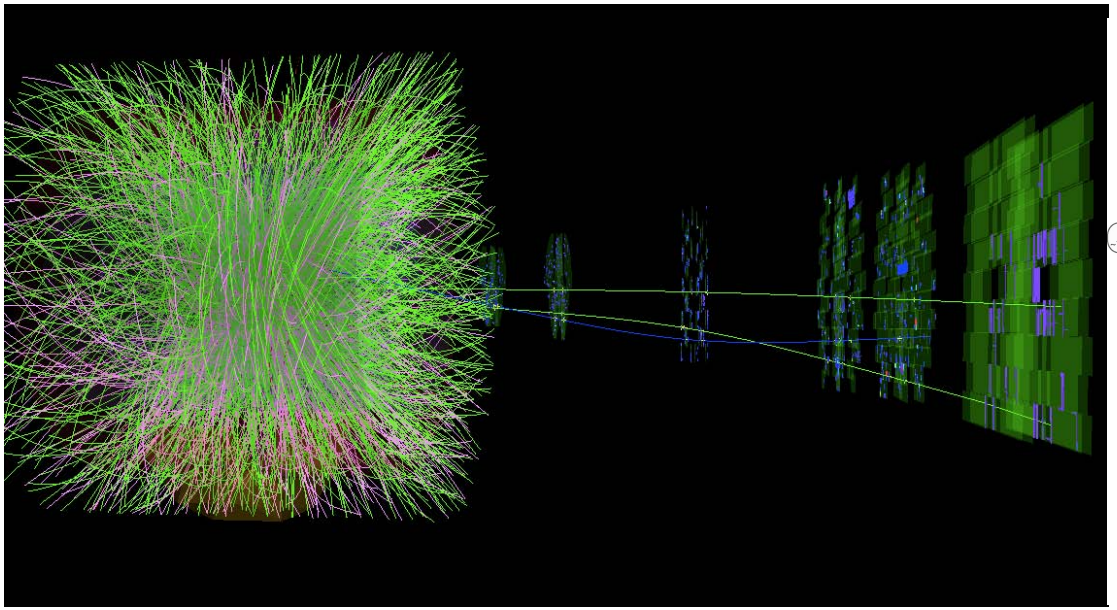
- **Focusing RICH** with sperical (or parabolic) mirrors
- C4F10 **radiator** (~100 cm), alternative aerogel
- **Photon detector:** MPWC operated with $CH_4$ using CsI photocathode, alternative with thick GEM and CsI coating
- **Readout:** GASSIPLEX (current HMPID frontend)

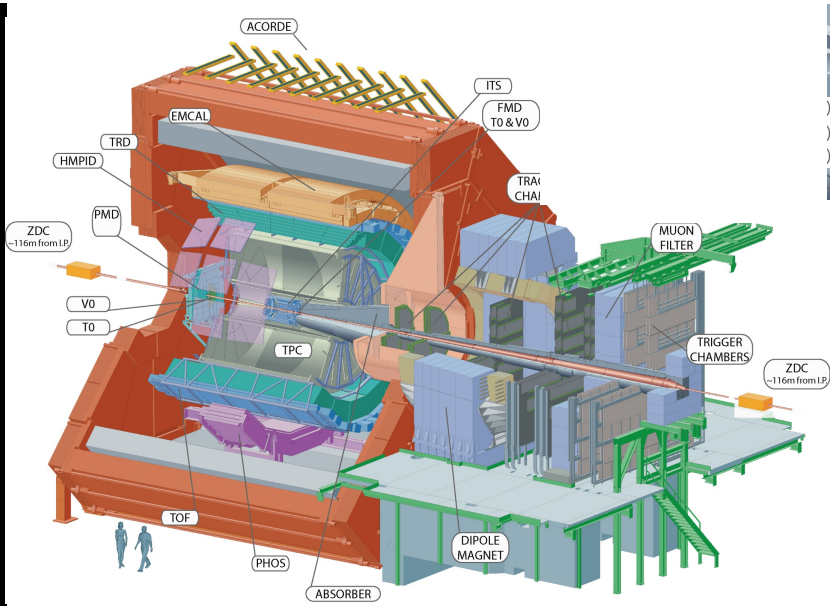


# MFT



- Complement muon arm with tracking in front of absorber
- Determine muon origin accurately
  - Silicon tracking station before the front-absorber





# MFT



- Requires modification of the beampipe and integration with the ITS
- Technology under discussion, e.g. possible use of monolithic silicon pixel detectors (ITS upgrade)

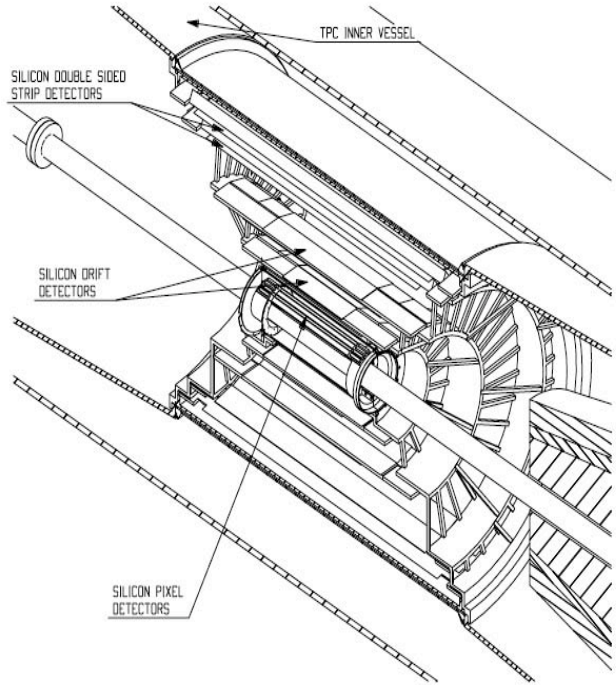
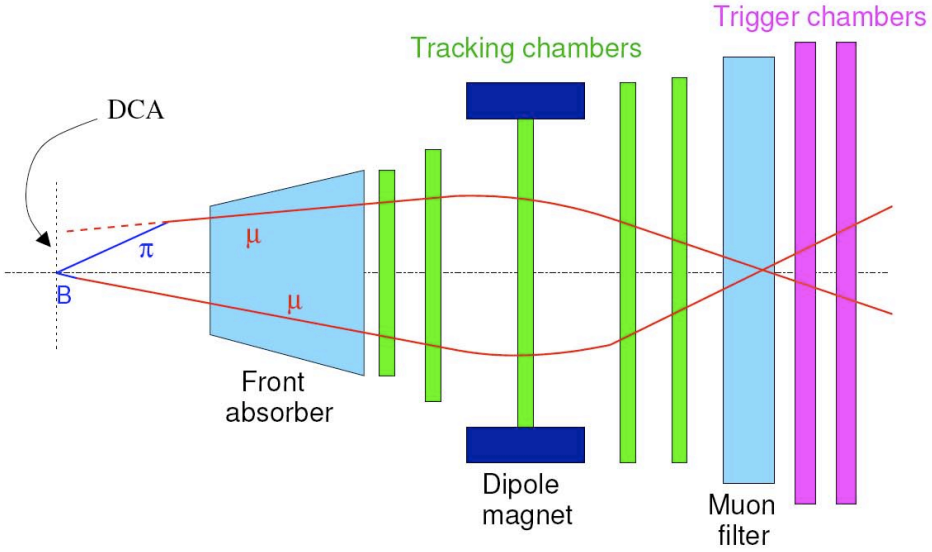



**Figure 2.1:** General view of the Inner Tracking System.

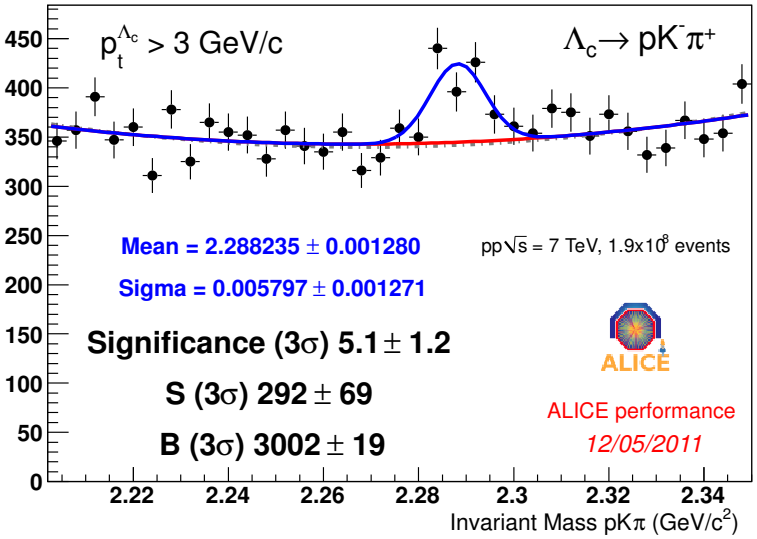



P. Riedler/CERN TIPP 2011 Conference

# ITS Upgrade



- Currently 6 silicon layers (pixel, drift, strips), 3.9<r<43 cm, total material budget 7% $X_0$
- Improve impact parameter resolution by factor 2-3 to access new physics, e.g. charmed baryons




$\Lambda_c$ in pp @ $\sqrt{s}$ = 7 TeV

| | | |
|---|---|---|
| $\Lambda_c^+(udc)$ | $m \approx 2285$ MeV | $c\tau \approx 60\,\mu m$ |
| $\Xi_c^+(usc)$ | $m \approx 2466$ MeV | $c\tau \approx 132\,\mu m$ |
| $\Xi_c^0(dsc)$ | $m \approx 2472$ MeV | $c\tau \approx 34\,\mu m$ |
| $\Omega_c^0(ssc)$ | $m \approx 2698$ MeV | $c\tau \approx 21\,\mu m$ |

# ITS Upgrade

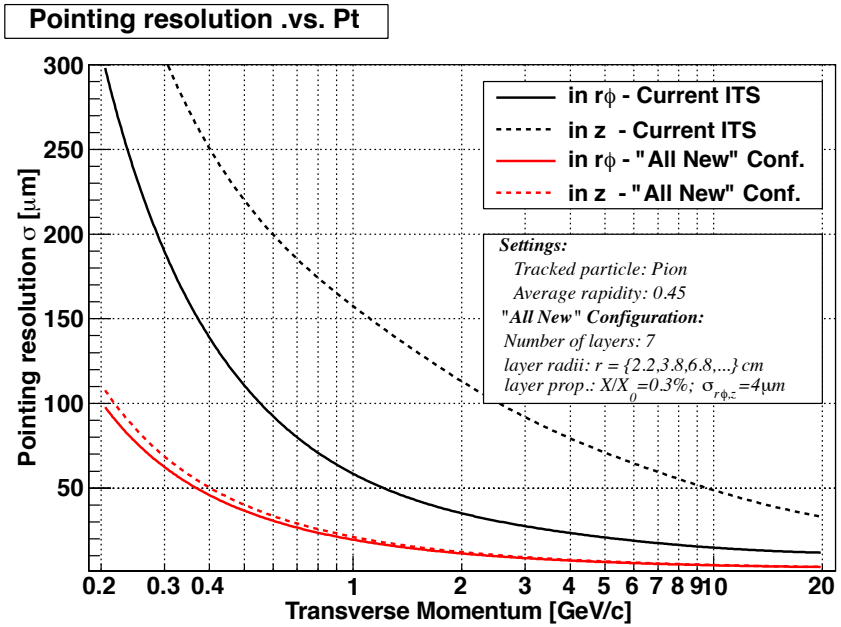


- **Technical goals:**
  - Reduce beampipe parameter and place **Layer 0** at ~ 20-22 mm radius
  - **Material budget** (innermost layers) to 0.3-0.5% $X_0$
  - Reduce **pixel size** to 20-30 um in r-phi (possibly z)
  - 3 pixel layers followed by 3-4 strip layers
  - **Trigger capability** (L2 ~ 100us): topological trigger, fast-OR and fastSUM at L0/L1(1.2 us/7.7 us)
  - **Increased acceptance** ($|\eta| > 0.9$)

# ITS Upgrade



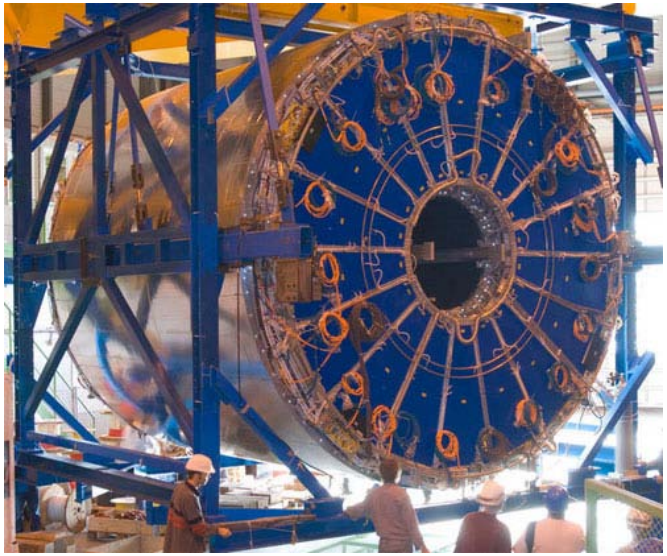
- Pixel technologies under study:
  - Hybrid pixels:
    - 100 um sensor + 50 um ASIC
    - 30 um x 100 um pixels
  - Monolithic pixels:
    - 50 um ASIC
    - 20 um x 20 um pixels
  - Requirements:
    - Readout time < 50 us
    - radiation tolerant (2 Mrad, 2 $10^{13}$ $n_{eq}$)
    - Low power design (250 mW/$cm^2$)



# Further Proposals



- Increase **TPC** high rate capability (change gas mixture, upgrade readout electronics)
- **DAQ/Trigger** update (replace components, allow for further and more complex triggers)

# Summary



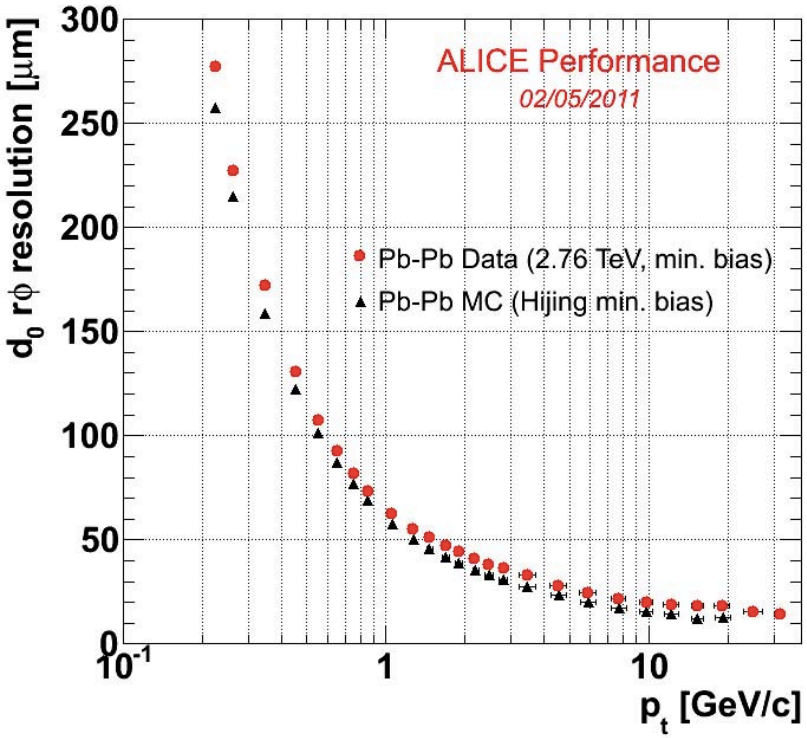
- ALICE is successfully taking data in pp and HI runs
- An upgrade will allow to address new physics topics.
- Several upgrade proposals have been submitted and the LOIs are being prepared for autumn 2011.
- We are looking forward to meeting the technical challenges and to encounter the new physics opportunities lying ahead.

# Backup Slides

# ITS Tracking Performance



- Charm: precise measurement of D mesons down to $p_T \sim 1$
  - ➔ not at all trivial in PbPb with current setup
- $\Lambda_c$: beyond capabilities of current setup in HI collisions




A. Dainese