Upgrade of the ALICE Detector

Petra Riedler/CERN
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 (|η|<0.9), B = 0.5 T
  - forward muon spectrometer -4<η<-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
Address open physics issues, which cannot be tackled with the current setup

- Increase coverage and
- Enhance measurement capabilities

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

\[ \Lambda_c \text{ in } pp \at \sqrt{s} = 7 \text{ TeV} \]

\[ p_{t}^{\Lambda_c} > 3 \text{ GeV/c} \]

\[ \Lambda_c \rightarrow pK\pi^+ \]

Mean = 2.288235 ± 0.001280

Sigma = 0.005797 ± 0.001271

Significance (3\(\sigma\)) 5.1 ± 1.2

S (3\(\sigma\)) 292 ± 69

B (3\(\sigma\)) 3002 ± 19
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

Further proposals:
- TPC readout upgrade
- DAQ/Trigger
- AD (diffractive)
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 pT 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
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 ($\sim 200$ GeV/c)
- High granularity to cope with particle density in Pb-Pb
- $\sim 350$ cm from IP

Two-photon distance $D(2\gamma)$ from $\pi^0 \rightarrow 2\gamma$ decay at 4.5m from interaction point: Minimum $D(2\gamma) = 0.6$ cm for 200 GeV $\pi^0$
Preferred material Si+W (small segmentation, small Moliere radius)

Outer radius: ~ 80 cm
Area: ~2 m²
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 \( \times \) 1 cm or smaller), 300 um thick, dedicated ASICs
  - Pixels (monolithic, ITS upgrade) at 2, 3, 4, 5 \( X_0 \)

![Example of a layout](image)

P. Riedler/CERN  TIPP 2011 Conference
Identify pions, kaons and protons on a track-by-track basis in the range from 10-25 GeV/c
- **Focusing RICH** with spherical (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)
- Complement muon arm with tracking in front of absorber
- Determine muon origin accurately
  - Silicon tracking station before the front-absorber
- Requires modification of the beampipe and integration with the ITS
- Technology under discussion, e.g. possible use of monolithic silicon pixel detectors (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

$$\Lambda_c \rightarrow pK^+\pi^+$$

$\Lambda_c^+ (udc)$: $m \approx 2285$ MeV, $c\tau \approx 60 \mu m$

$\Xi^+_c (usc)$: $m \approx 2466$ MeV, $c\tau \approx 132 \mu m$

$\Xi^0_c (dsc)$: $m \approx 2472$ MeV, $c\tau \approx 34 \mu m$

$\Omega^0_c (ssc)$: $m \approx 2698$ MeV, $c\tau \approx 21 \mu m$

$\Lambda_c$ in pp @ $\sqrt{s} = 7$ TeV
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 ($|\eta| > 0.9$)
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/cm²)
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 $p_T \approx 1$
  - not at all trivial in PbPb with current setup
- $\Lambda_c$: beyond capabilities of current setup in HI collisions

A. Dainese