Lund ALICE Summary

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Lund University

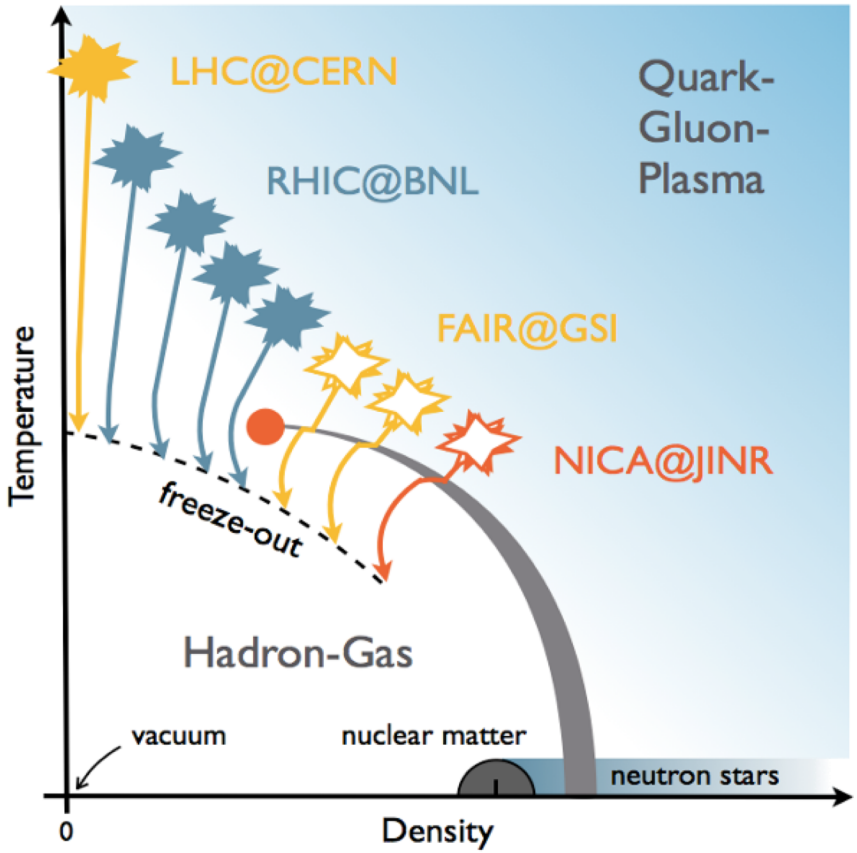
Particle Days 2018

Lund Heavy-Ion Group

- 3 Seniors
  - Anders Oskarsson (retiring Nov 2018), David Silvermyr, Peter Christiansen
    Also Evert Stenlund (emeritus) + new BUL (decision soon)
- 1 Postdoc
  - Tuva Richert (VR international postdoc, with NBI)
- 3+1 Ph.D. Students (+ 3 master students)
  - Jonatan Adolfsson (from July 2016), Adrian Nassirpour (from March 2018), Omar Vazquez Rueda (from May 2018), Oliver Matonoha (Nov 2018) - Vytautas Vislavicius finished Mar 2018
- Activities
  - Group: ALICE
  - Individuals also work on detector R&D for: ILC (TPC), nnbar experiment at ESS, ESS**ν**SB + approached re. collaborations at other facilities (electron-Ion Collider, s/ePHENIX, FAIR/CBM,…): have more opportunities than we can pursue...

ALICE primary goal : Quark Gluon Plasma (QGP)

QGP study via heavy ion collisions at the LHC: ε_0~10-40 GeV/fm^3



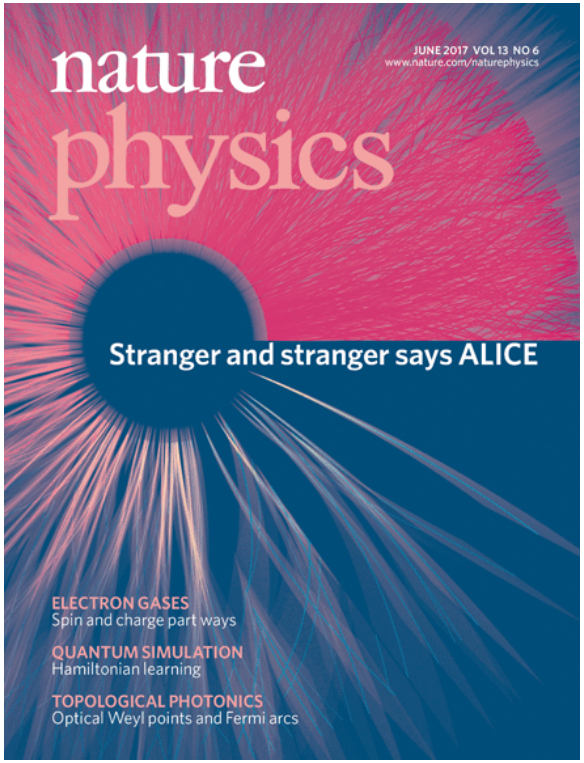
NuPECC Long Range Plan 2017
http://www.nupecc.org/lrp2016/Documents/lrp2017.pdf

QGP probes

- Global observables
- Light hadrons
- Strange hadrons
- Quarkonia
- Open heavy flavours
- Electromagnetic probes
- Jets and high p_T hadrons
- Hypernuclei, anti-nuclei

As a function of rapidity, transverse momentum, azimuthal angle, centrality, centre of mass energy, reaction plane, fluctuations, small systems (pp and pA), correlations …

Lund Group Activities: Analysis



Traditional large system physics:
- jet quenching (LU),
- flow/collectivity (LU),
- quarkonia.

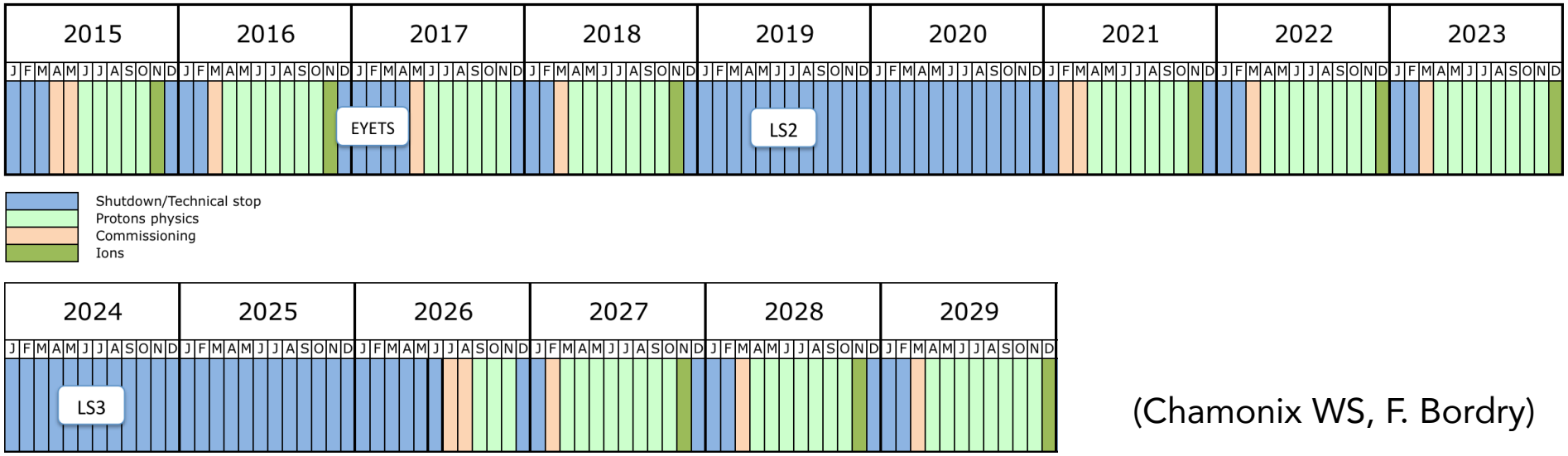
New small system physics:
- strangeness enhancement (LU),
- flow in small systems (LU).

- Collectivity in small systems challenges two paradigms at once!
  1. How far down in systems size does the "SM of heavy ions" remain?
  2. Can the standard tools for min bias pp remain standard?

C. Bierlich

KAW grant (CLASH), with Peter C. and Leif Lönnblad as co-PIs to pursue this further

The LHC roadmap (with heavy ion runs)

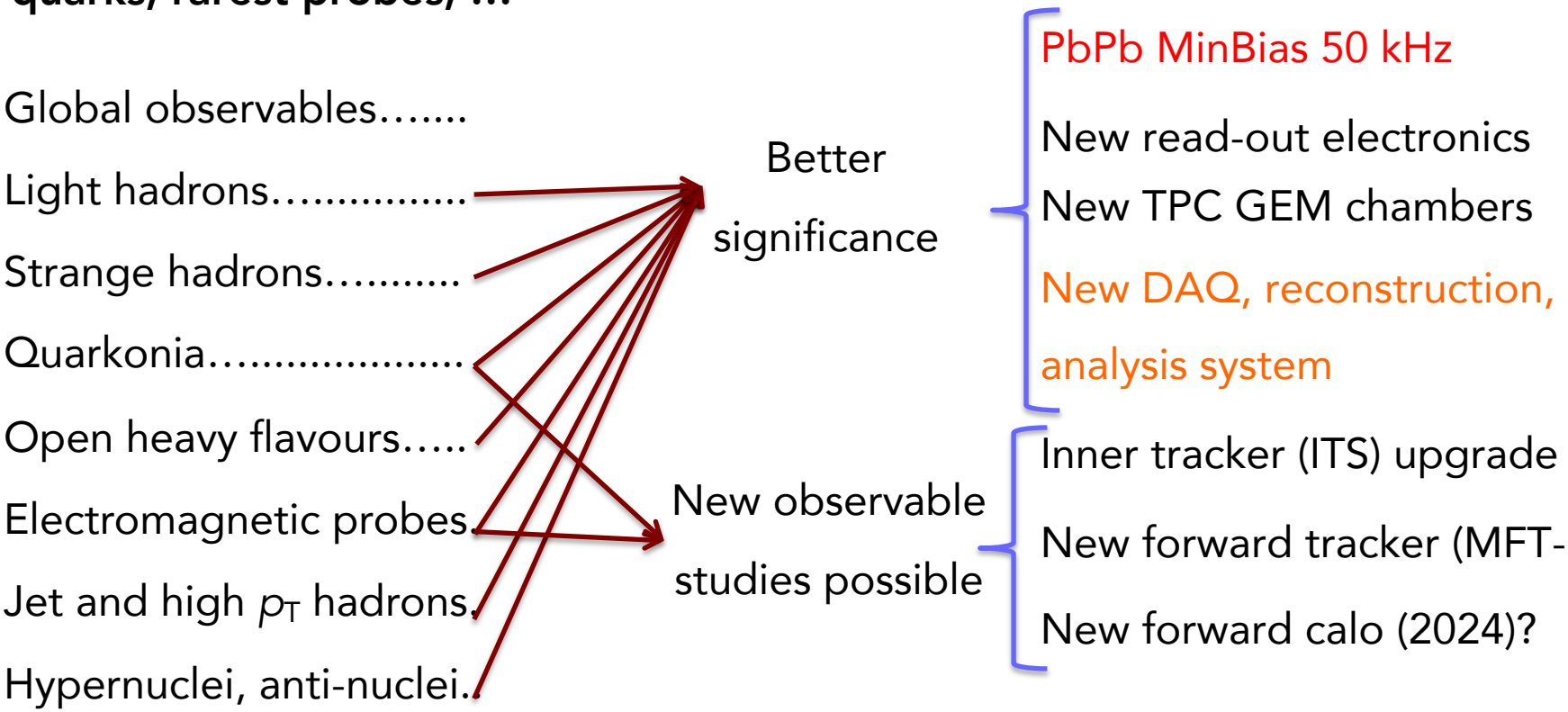


(Chamonix WS, F. Bordry)

- 10-fold higher luminosity in Pb-Pb collisions at the highest centre of mass energy (5.5 TeV) from Run3
- All 4 experiments will take part in the LHC heavy ion runs
- Also reference pp and pPb runs, and lighter ion runs (Ar or Xe, as in 2017) foreseen

ALICE strategy for Run3 and Run4 2021-2029

Higher sensitivity to low signal/background observables, low p_T heavy quarks, rarest probes, …

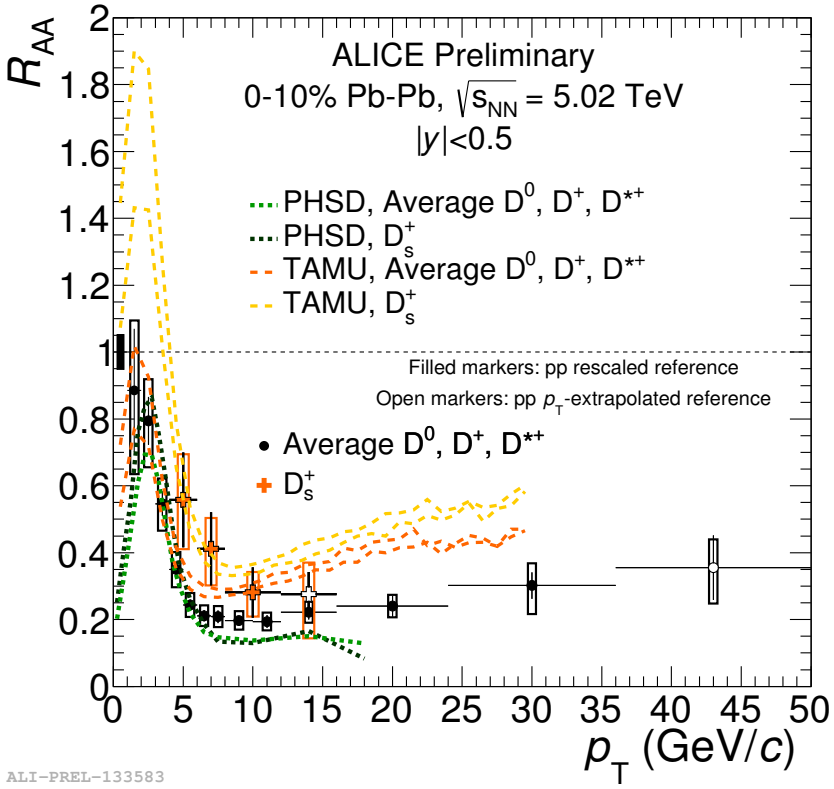


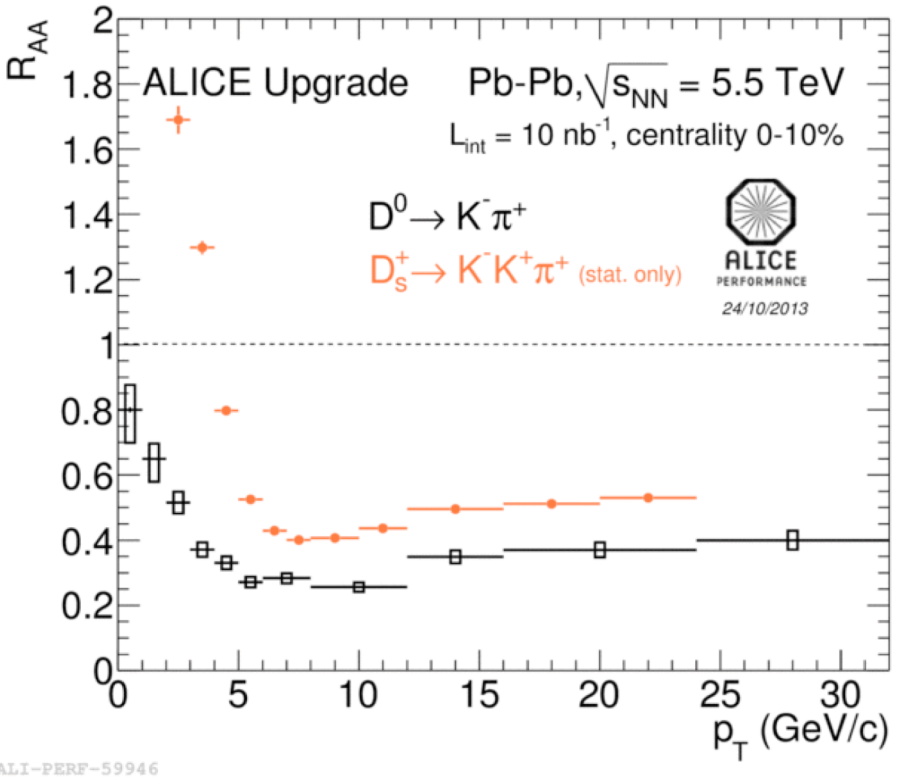
100-fold larger sensitivity than Run1 and Run2 (reading out ~300 Hz PbPb)

Low signal over background: hardware trigger filtering nearly impossible at low p_T

Physics Performance of the Upgraded ALICE

Example: Nuclear Modification Factor (R_{AA}) for Charmed D^0,D^{+-}, D_S mesons





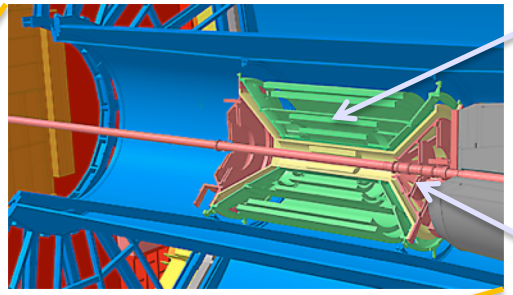
Improvement of the statistical significance on the suppression pattern

ALICE Detector Upgrade (LS2)

Increase of luminosity (50kHz IR) and improve vertexing and tracking at low p_T

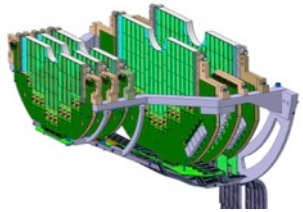
New RO architecture
(TPC, Muon Spectrometer, TRD, TOF, PHOS, EMCAL/DCAL, ZDC)

New MB trigger
(FIT)

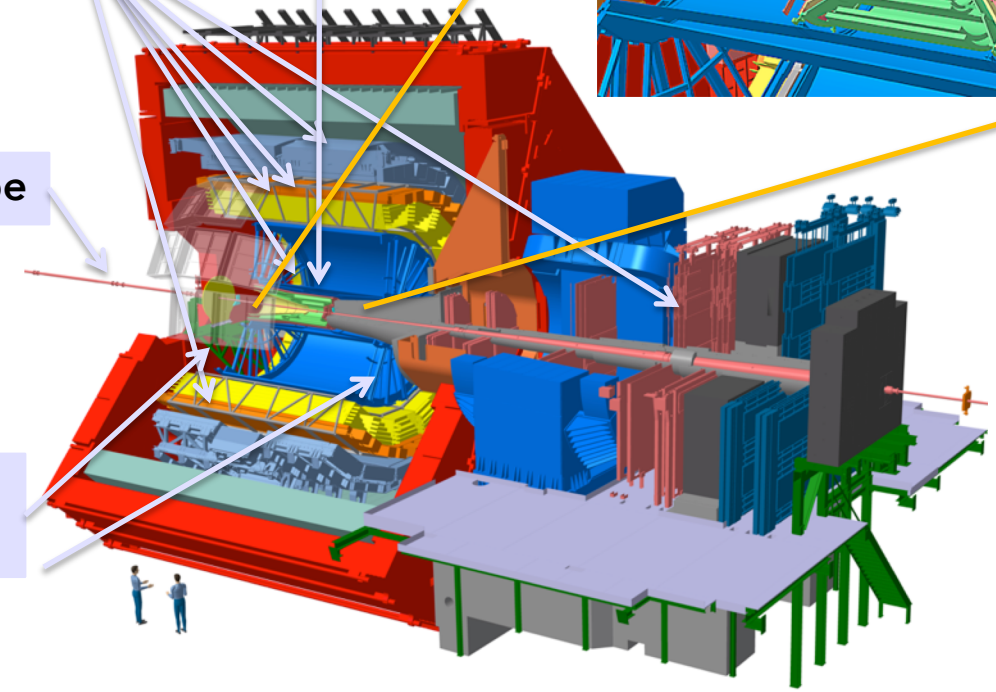


New Inner Tracking System

New Muon Forward Tracker

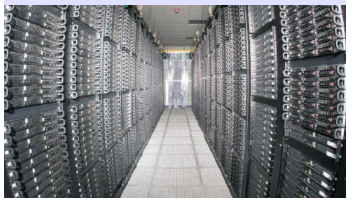


New Be beam-pipe



New TPC GEM-based chambers

Computing O^2



TPC Upgrade Project

Production overview:

- 40 IROC and 40 OROCs by Oct 2018
- Production of 640 GEM foils finished

(including spares)

All chambers thoroughly qualified in terms of:

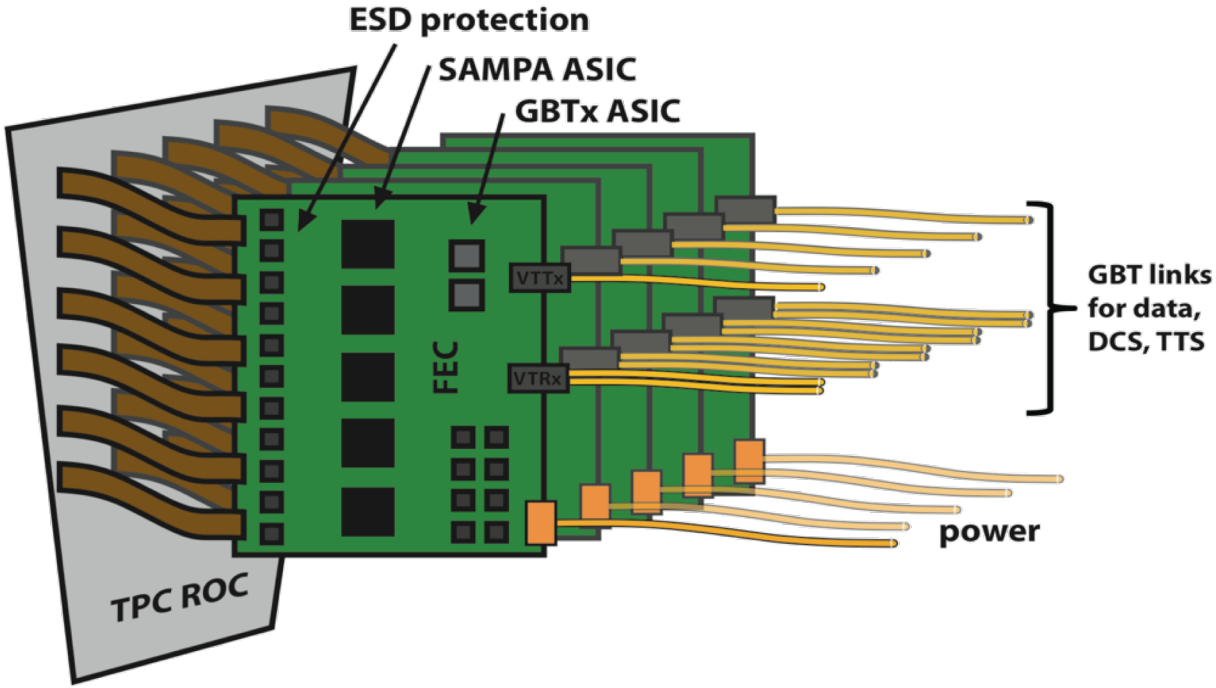
- – Gas tightness
- – Gain and ion backflow uniformity
- – Stability (long-term irradiation with X-rays)

Selected chambers tested at the LHC
Carried out at several sites in Europe and the US

Lund involved in simulations and readout electronics from project start

Readout electronics : SAMPA

On the Front-End Card (FEC):
New FE ASIC SAMPA (130 nm TSMC CMOS):
– Positive or negative input, 32ch
– Programmable conversion gains and peaking times
– Readout modes: triggered or continuous
– Digital Signal Processing (can be bypassed)



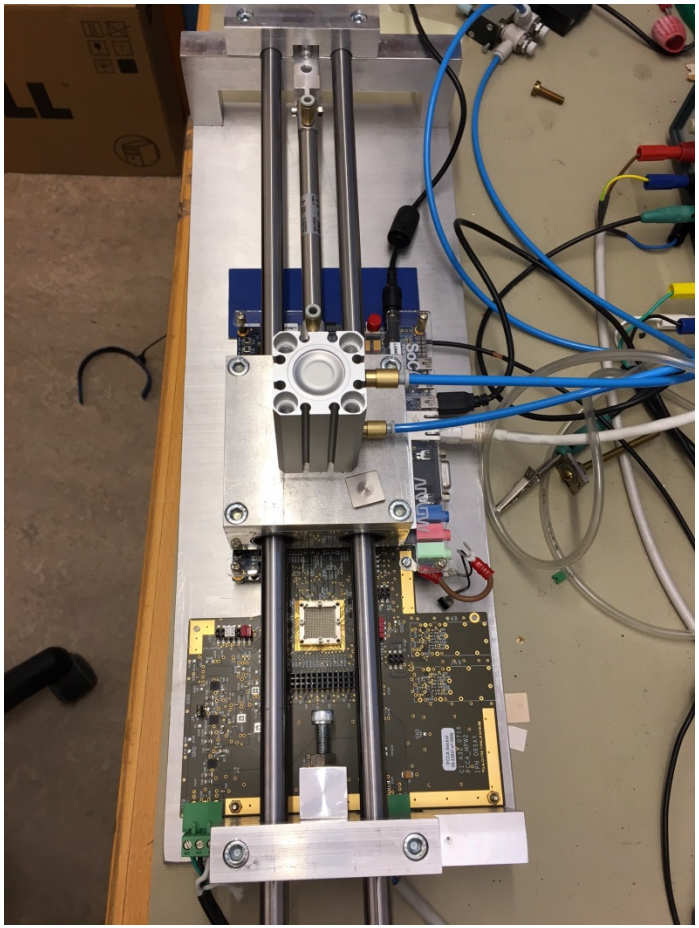
Lund:
Physicist input to chip designers

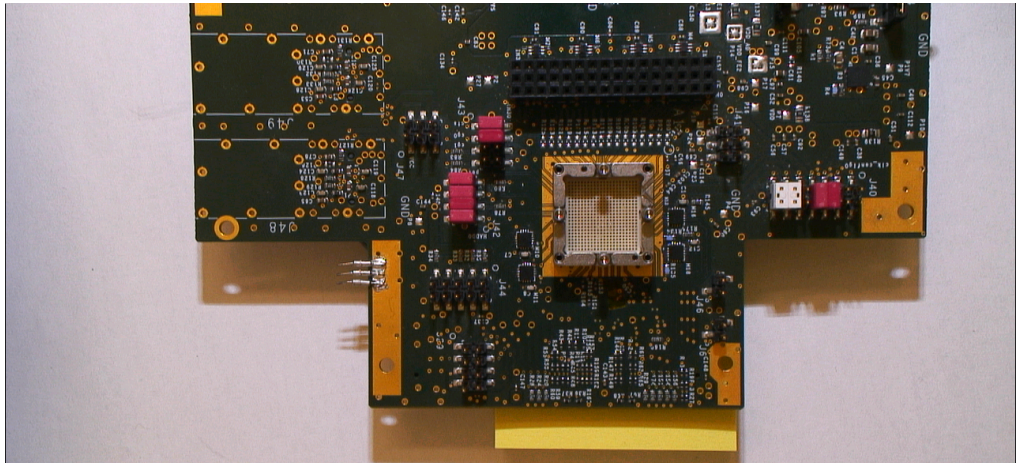
Testing and characterization of V1-V4 (2016-2018)

From oscilloscope level to DCS, DAQ & Analysis

FEE for systems beam tests

Lund Group Activities: Hardware





Main current hardware activity (AO, DS, LÖ, JA, ..):

- Development and testing of new TPC readout electronics, incl. SAMPA chip
- Robotic mass test of SAMPA readout chips – approx. 30k + 60k chips for ALICE TPC + MCH LS2 upgrades ongoing (2018 – early 2019)
- Robot (clean room in basement) testing video: https://youtu.be/3tnqPbMWzqQ

Summary/Outlook

- Factor 10 increase of the Pb-Pb integrated luminosity is planned by the LHC for Run3 and Run4. *(Heavy Ion running may continue also in Run5?)*
- Major ALICE upgrade during LS2 (2019-2020) to take advantage of the luminosity increase.
- 100 times more sensitive detector to study rare probes at low p_T (e.g. open heavy flavour and quarkonium) in pp, p-Pb, Pb-Pb collisions for Run3 and Run4. *(More performance plots in Backup section)*

- Lund heavily involved in TPC upgrade, in particular readout electronics. Will also test SAMPA chips for Muon Chamber readout upgrade.
- Lund group also lead ongoing analyses, in particular investigating smaller systems (e.g. p-Pb, and pp in QGP domain).

Backup

(High Luminosity - LHC Yellow Report)

Working Groups:

1. QCD, EW and top quark physics
2. Higgs and EWSB
3. BSM
4. Flavour
5. Heavy Ions

WG 5:

- Participation from all 4 experiments
- Asked to consider Heavy-Ion & ALICE operations possibly also in Run5(?)

Town meeting Relativistic Heavy Ion Physics (LHC, RHIC, FAIR, NICA,..) :
Oct 24 : https://indico.cern.ch/event/746182/

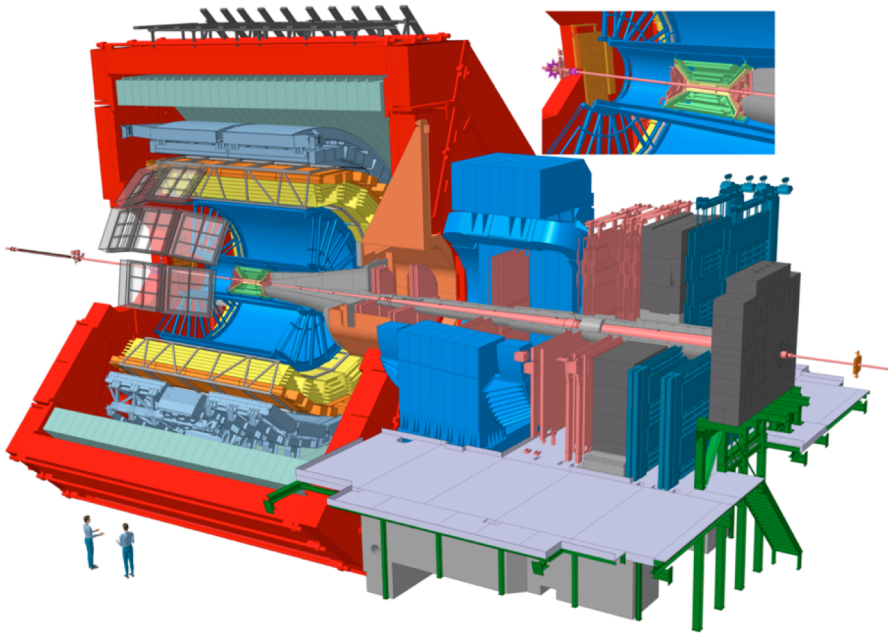
HL-LHC Physics Workshops:
1st WS: 30 Oct – 1 Nov 2017: https://indico.cern.ch/event/647676/
2nd WS: 18-20 June 2018: https://indico.cern.ch/event/686494/
3rd WS: 30-31 Oct : https://indico.cern.ch/event/758181/

SAMPA characteristics

SAMPA requirements:

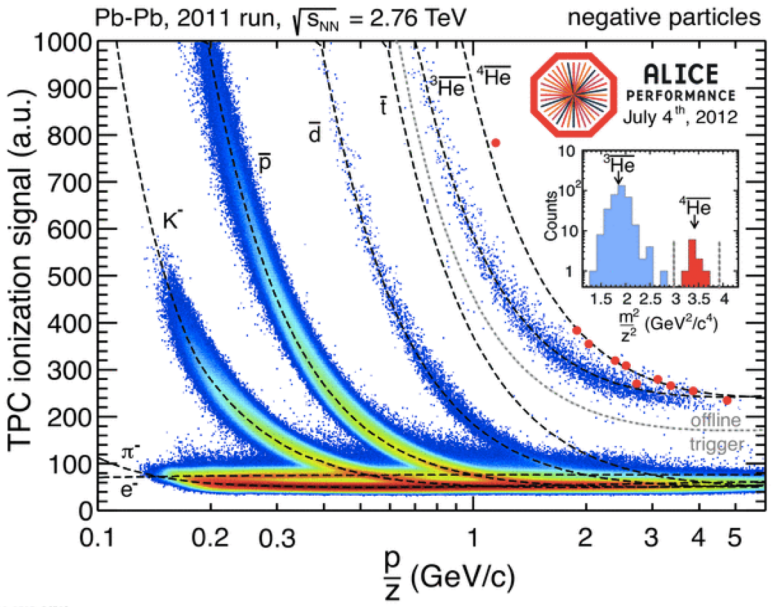
- Signal-to-noise ratio: 20:1 for IROC and 30:1 for OROC
- System noise (ENC): 670 e
- Conversion gain: 20 mV/fC
- Shaper peaking time: 160 ns
- Preamplifier saturation limit: > 10 nA
- ADC: 10 bit (ENOB>9.2), 5 MSPS

ALICE Detector (Run1 and Run2, 2009-2018)



JINST 3 (2008) S08002
J. Mod. Phys. A 29 (2014) 1430044

- Excellent (low p_T) tracking performances
- Excellent particle identification at mid-rapidity
- Good secondary vertexing reconstruction
- Electromagnetic calorimeters
- Muon spectrometer at 2.5<y<4
- Minimum Bias Trigger and centrality measurement



Letters of Intent and Technical Design Reports

- ALICE TDR for LS2 Upgrades
  - CERN-LHCC-2013-019 (System upgrade)
  - CERN LHCC-2013-013 (TPC Upgrade)
  - CERN-LHCC-2013-023 (ITS Upgrade)
  - CERN-LHCC-2015-001 (MFT)
  - CERN-LHCC-2015-006 (O^2)
- ALICE upgrade LoI and its addendum
  - CERN-LHCC-2012-012 (LoI)
  - CERN-LHCC-2013-014 (addendum)

High Luminosity - LHC Yellow Report

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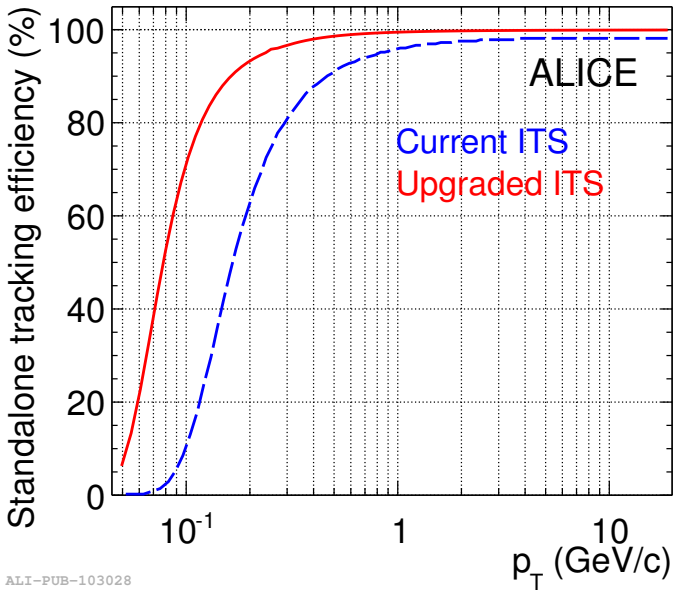
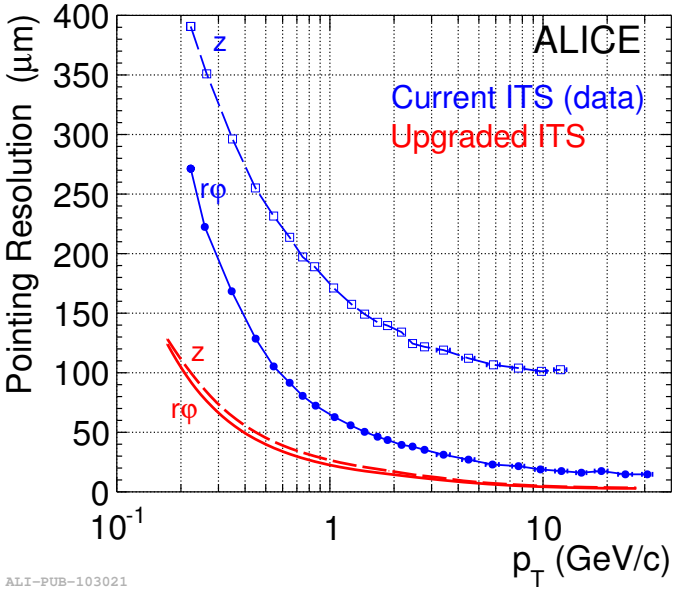
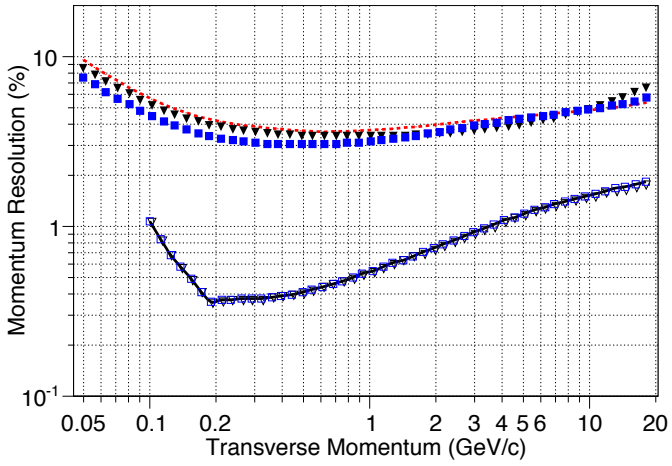
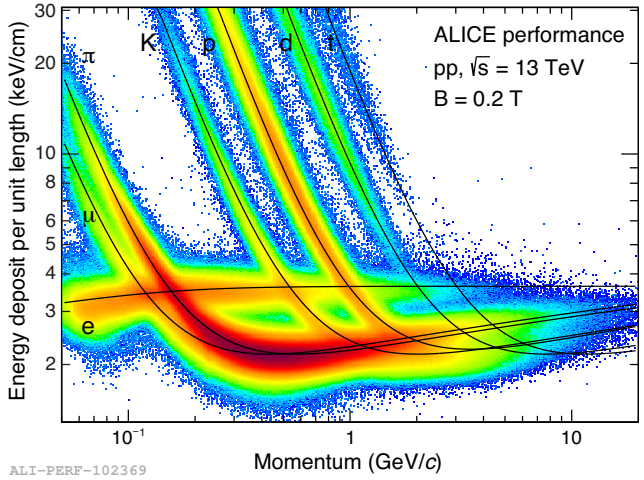
ALICE tracking performances (central barrel)





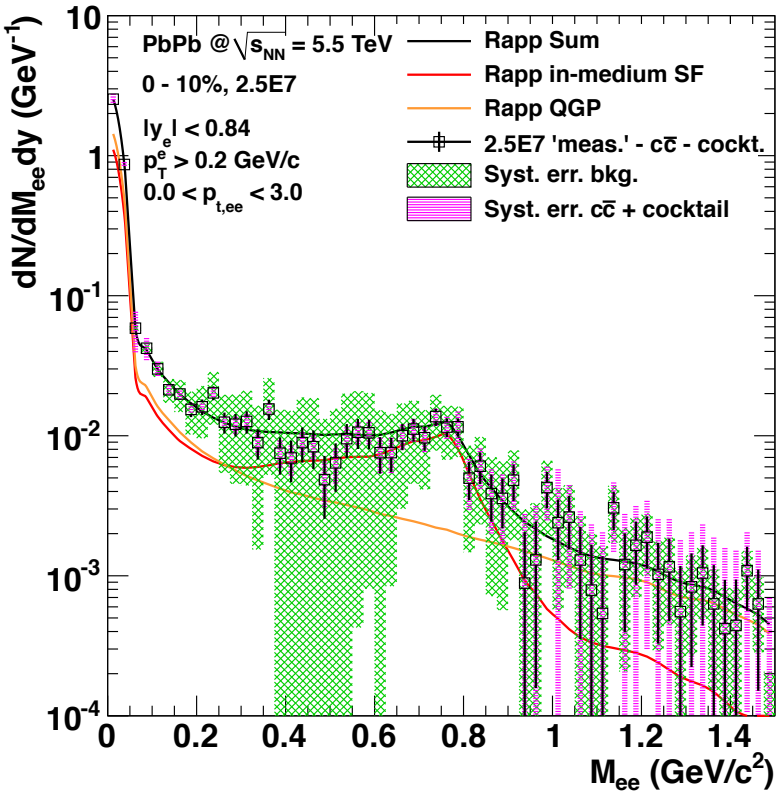


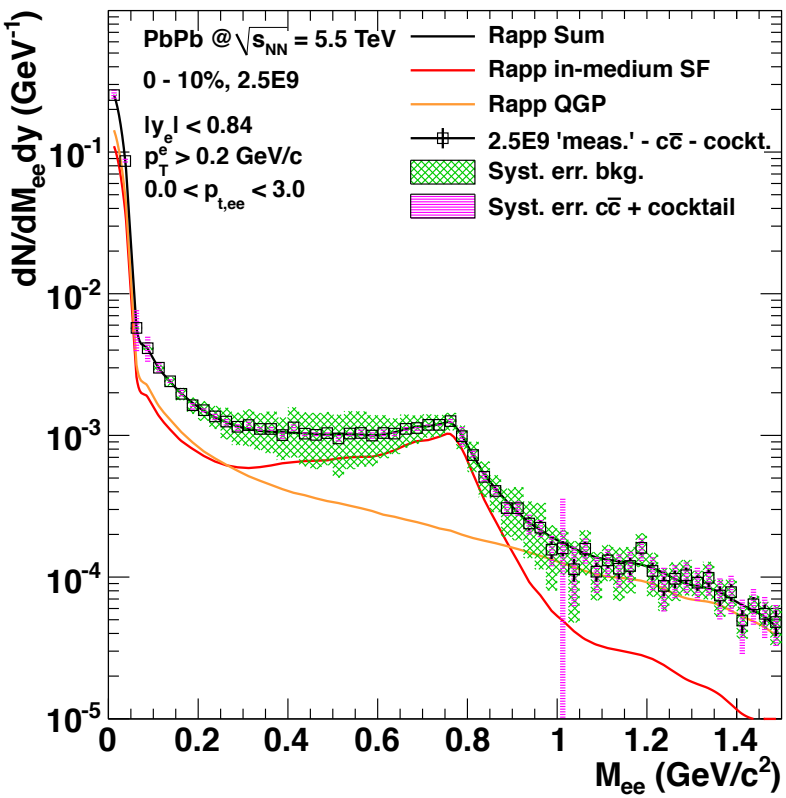


Improved efficiency and resolution (mostly at low p_T)

Keeping unchanged PID performances

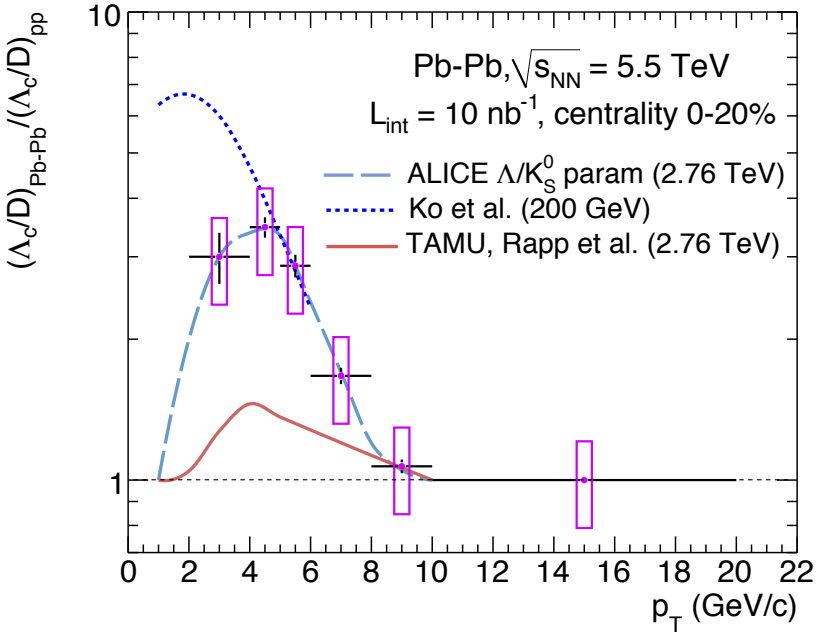
Low Mass dielectrons |η|<0.9

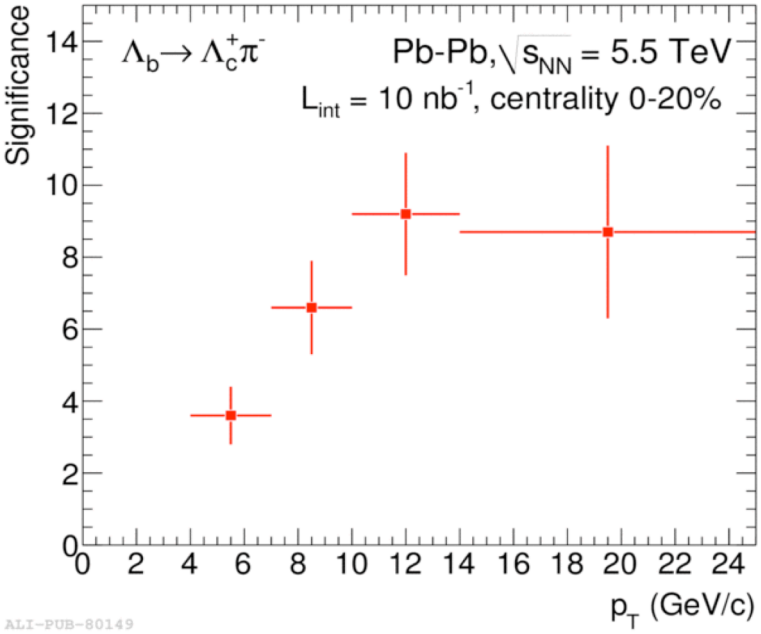




Drastic reduction of systematic error on background estimation

Charmed and Beauty baryons |η|<0.9





New observables in Pb-Pb: baryon production in the charm and beauty sector!

For the moment, only observed in pp and p-Pb collisions: https://arxiv.org/abs/1712.09581