

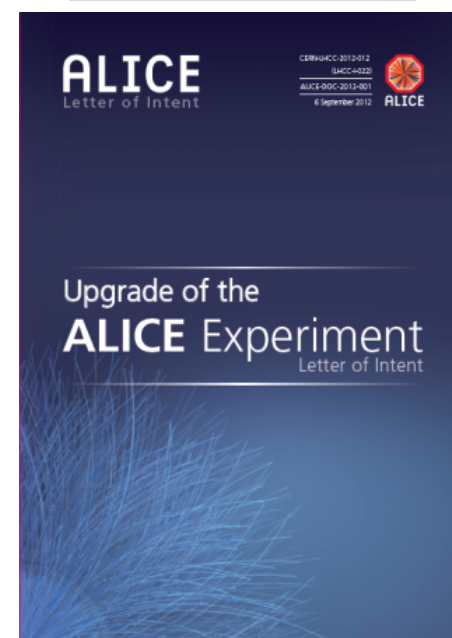
Heavy Ion Physics: ALICE Experiment/Plans

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- Brief goal overview
- The ALICE detector now
- ALICE LS2 Upgrade Strategy: TPC, ITS, O², ...
- Summary/Outlook

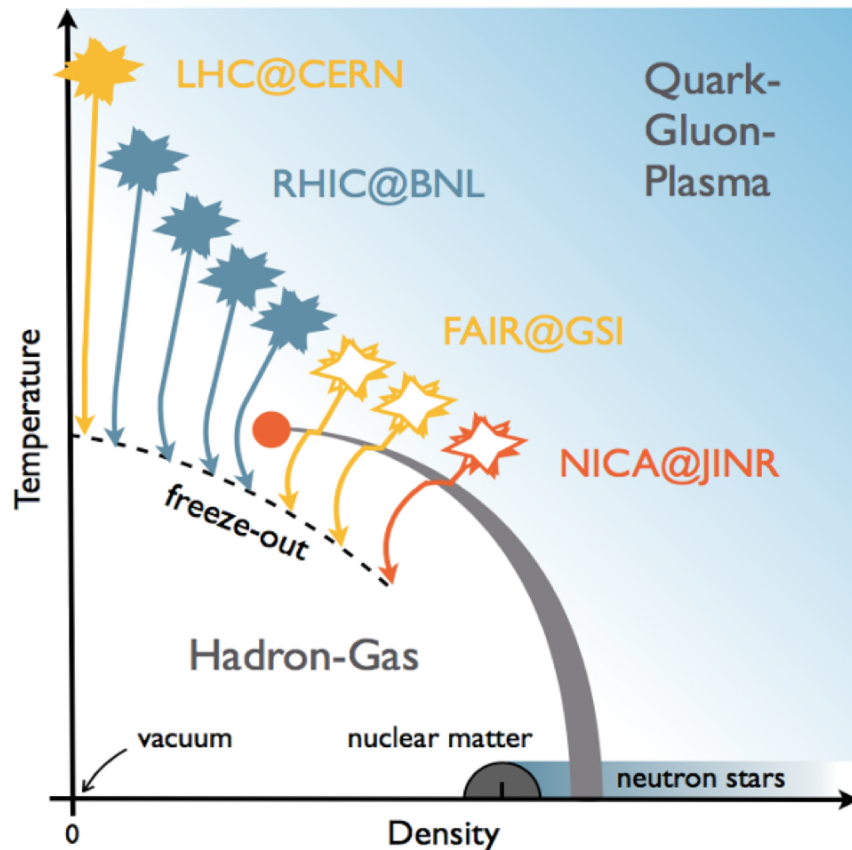
ALICE upgrade
Letter of Intent



CERN-LHCC-2012-12

ALICE primary goal : Quark Gluon Plasma (QGP)

QGP study via heavy ion collisions at the LHC: $\epsilon_0 \sim 10-40 \text{ GeV}/\text{fm}^3$



QGP probes

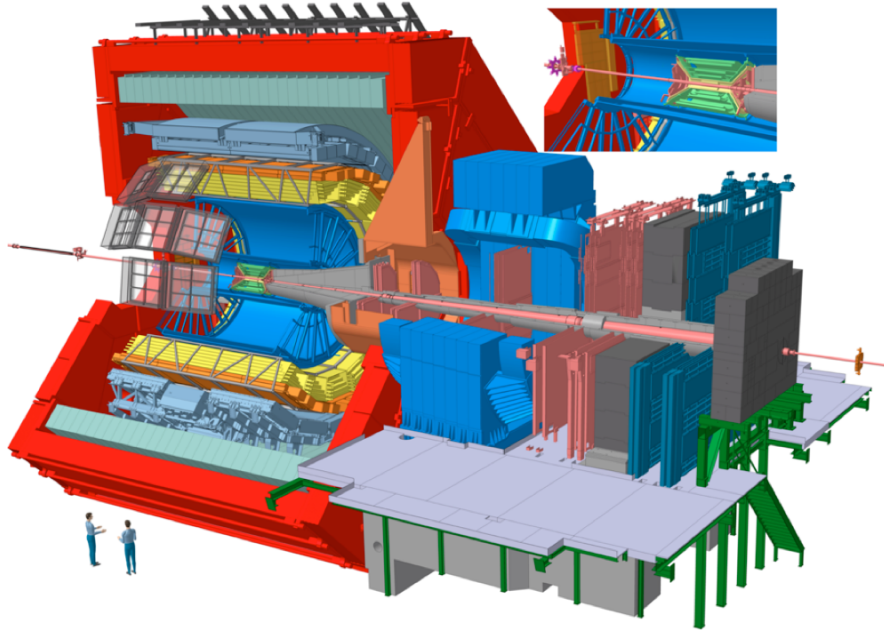
- Global observables
- Light hadrons
- Strange hadrons
- Quarkonia
- Open heavy flavours
- Electromagnetic probes
- Jets and high p_T hadrons
- Hypernuclei, anti-nuclei

NuPECC Long Range Plan 2017

<http://www.nupecc.org/lrp2016/Documents/lrp2017.pdf>

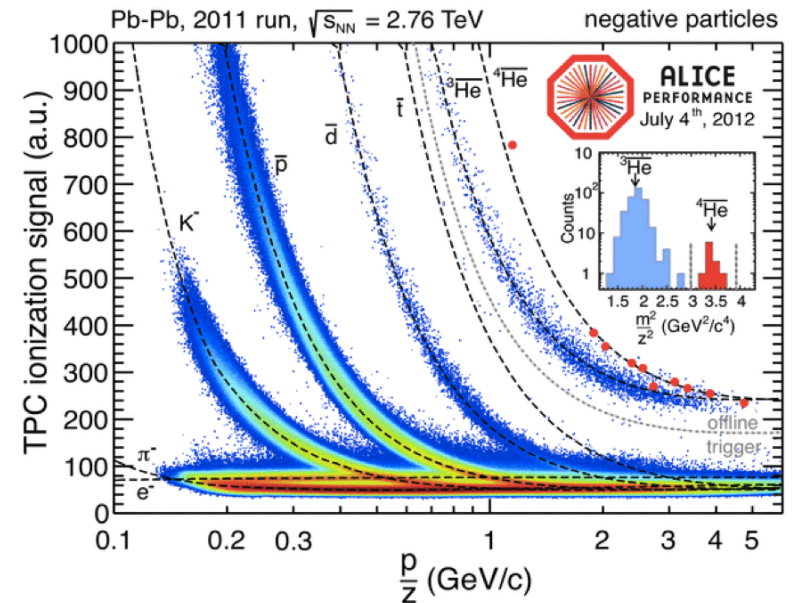
As a function of rapidity, transverse momentum, azimuthal angle, centrality, centre of mass energy, reaction plane, fluctuations, small systems (pp and pA), correlations ...

ALICE Detector (Run1 and Run2, 2009-2018)

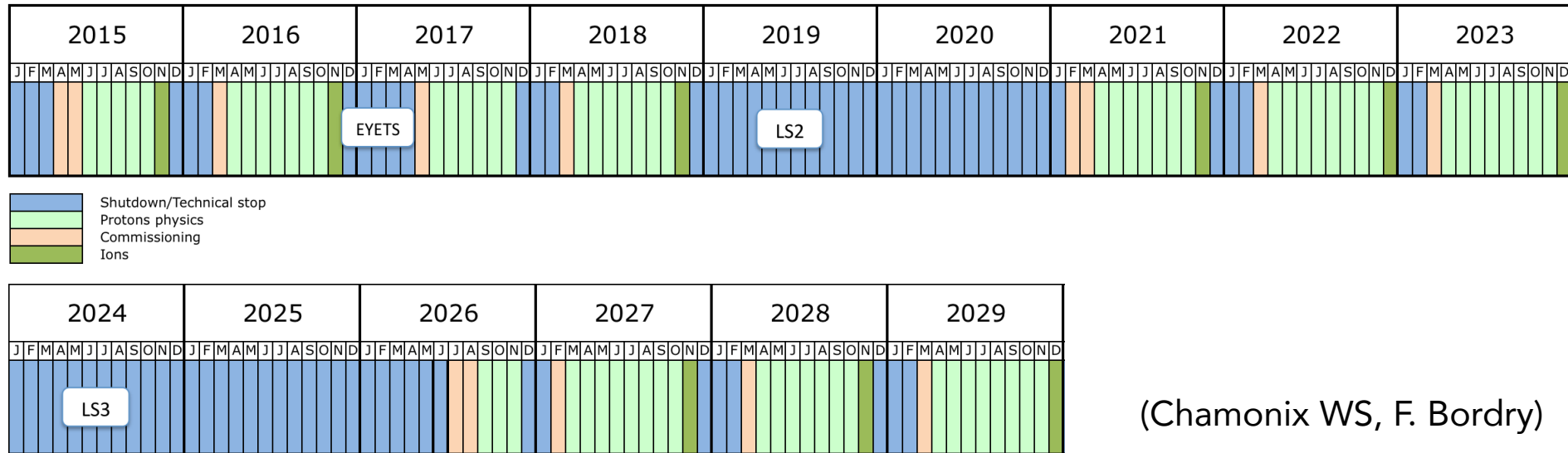


JINST 3 (2008) S08002
J. Mod. Phys. A 29 (2014) 1430044

- 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



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

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

Global observables.....

Light hadrons.....

Strange hadrons.....

Quarkonia.....

Open heavy flavours.....

Electromagnetic probes.....

Jet and high p_T hadrons.....

Hypernuclei, anti-nuclei.....

Better
significance

New observable
studies possible

PbPb MinBias 50 kHz

New read-out electronics

New TPC GEM chambers

New DAQ, reconstruction,
analysis system

Inner tracker (ITS) upgrade

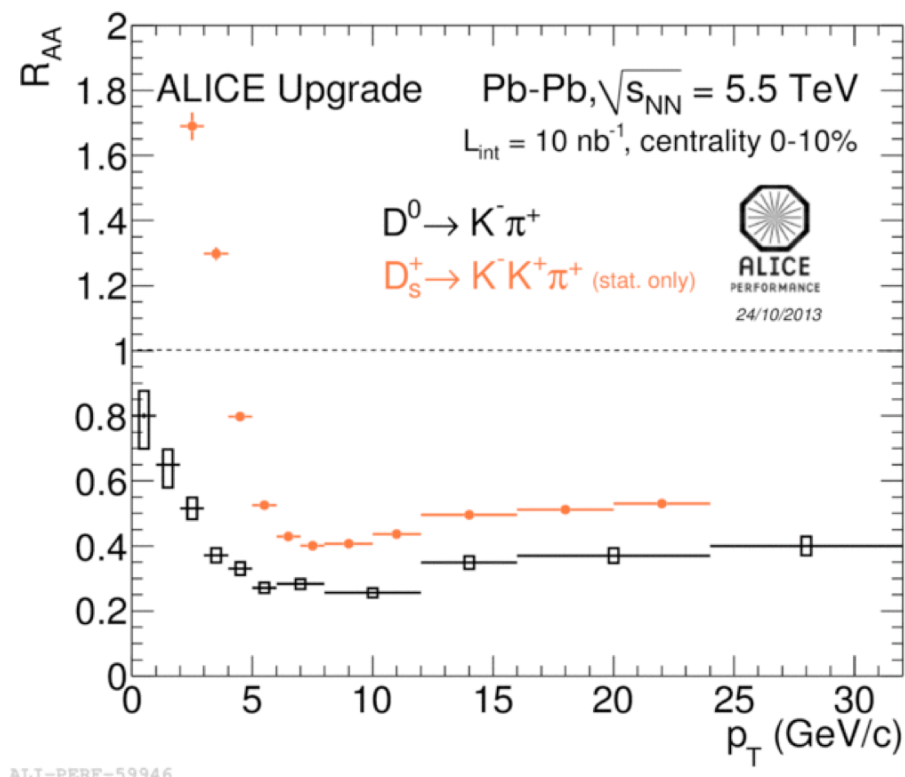
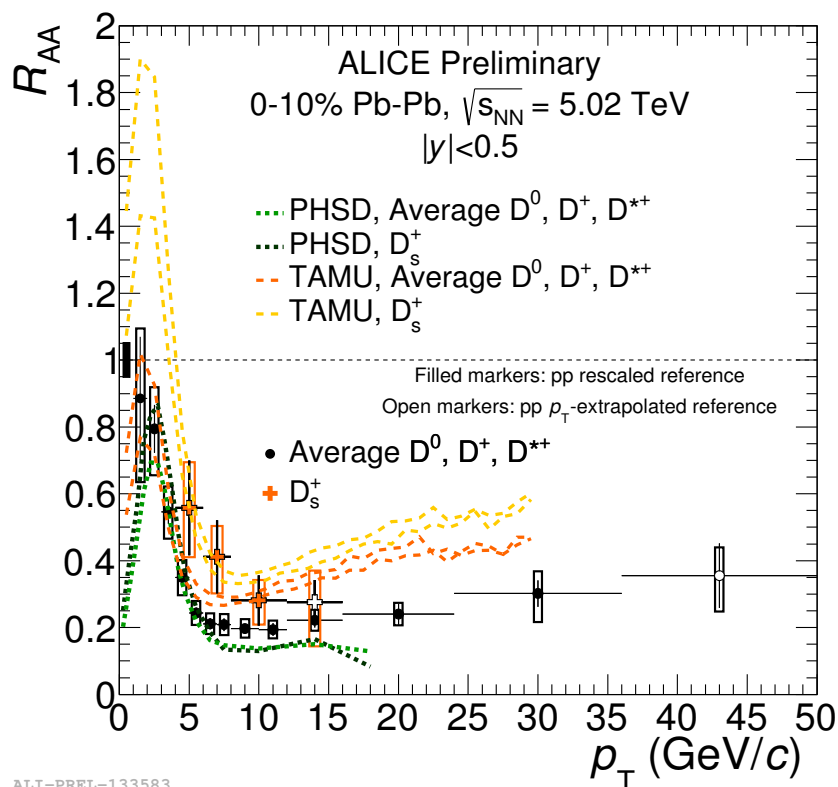
New forward tracker (MFT-)

New forward calo (2024)?

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

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)

(FIT)

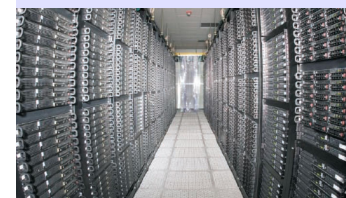
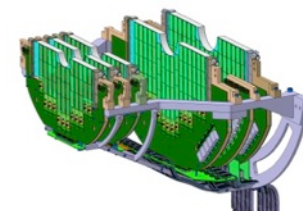
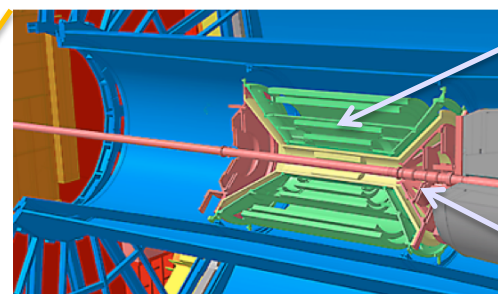
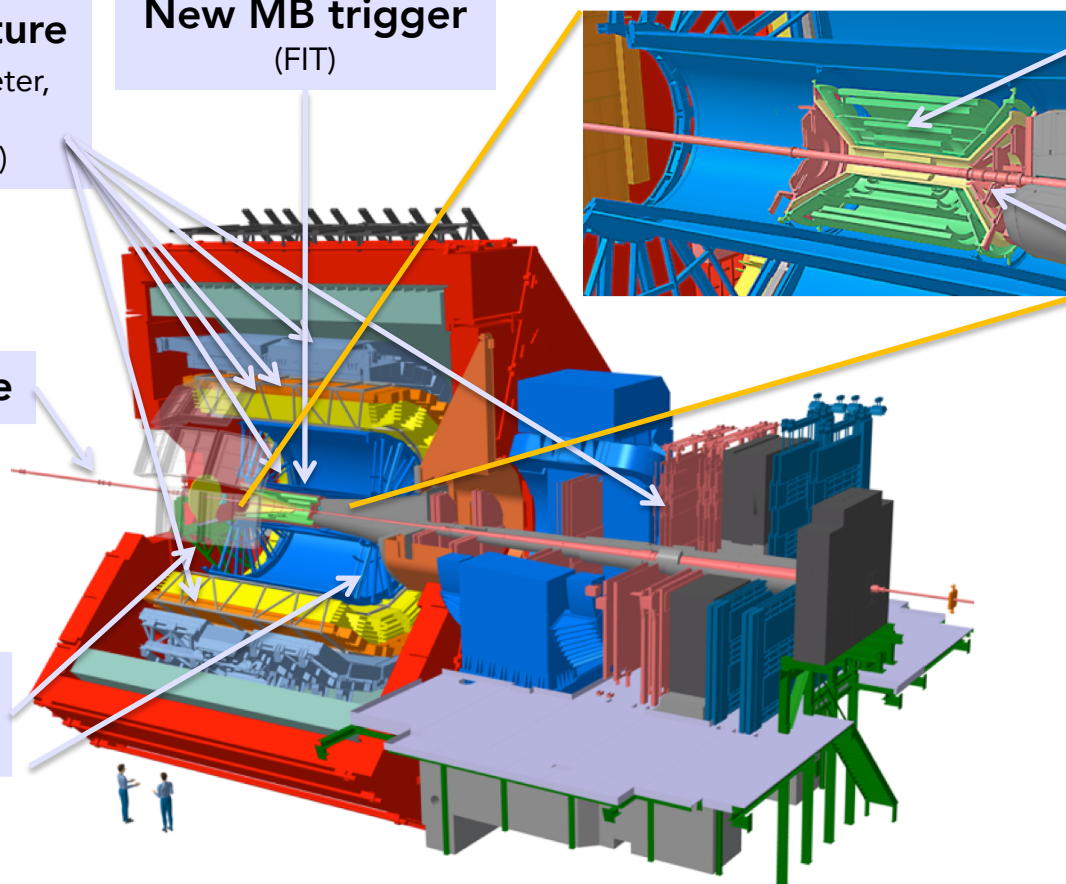
New Inner Tracking System

New Muon Forward Tracker

New Be beam-pipe

New TPC GEM-based chambers

Computing O²



- 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 (O²)
- ALICE upgrade Lol and its addendum
 - CERN-LHCC-2012-012 (LoI)
 - CERN-LHCC-2013-014 (addendum)



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(?)
- Most recent meeting March 6:

<https://indico.cern.ch/event/698005/>

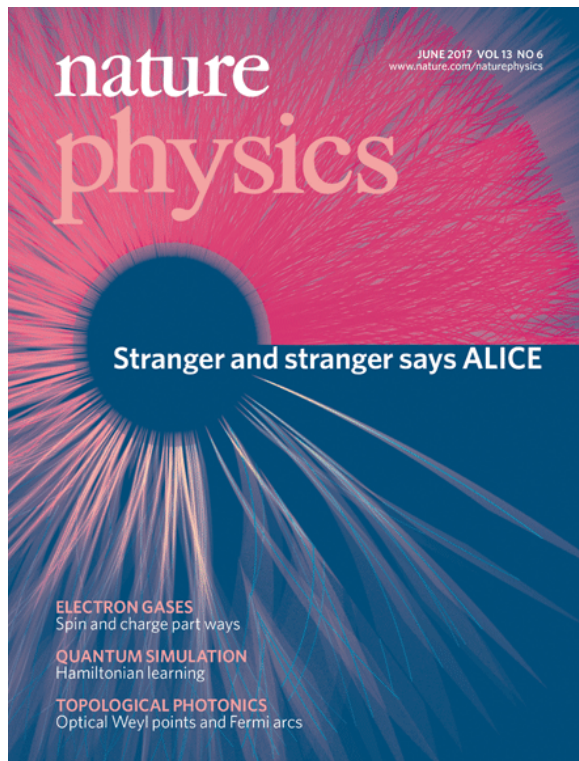
HL-LHC Physics Workshops:

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: Fall 2018 - YR close-to-ready

- 3 Seniors
 - Anders Oskarsson (retiring Nov 2018), David Silvermyr, Peter Christiansen
 - Also Evert Stenlund (emeritus) + now advertising for new BUL
- 1 Postdoc
 - Tuva Richert (VR international postdoc, with NBI)
- 3 Ph.D. Students (+ 3 master students)
 - Jonatan Adolfsson, Martin Ljunggren*, Vytautas Vislavicius*
 - Now hiring new PhD students to replace finishing students*, and e.g. work on new KAW project
- Activities
 - Group: ALICE
 - Individuals also work on detector R&D for: ILC (TPC), nnbar experiment at ESS, ESSvSB + approached re. collaborations at other facilities (electron-Ion Collider, s/ePHENIX, FAIR/CBM,...): have more opportunities than we can pursue...



Traditional large system physics:

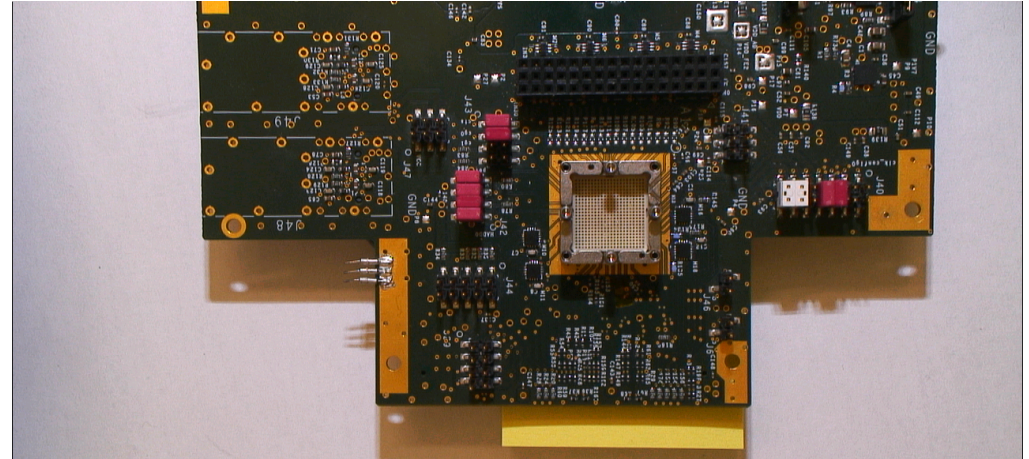
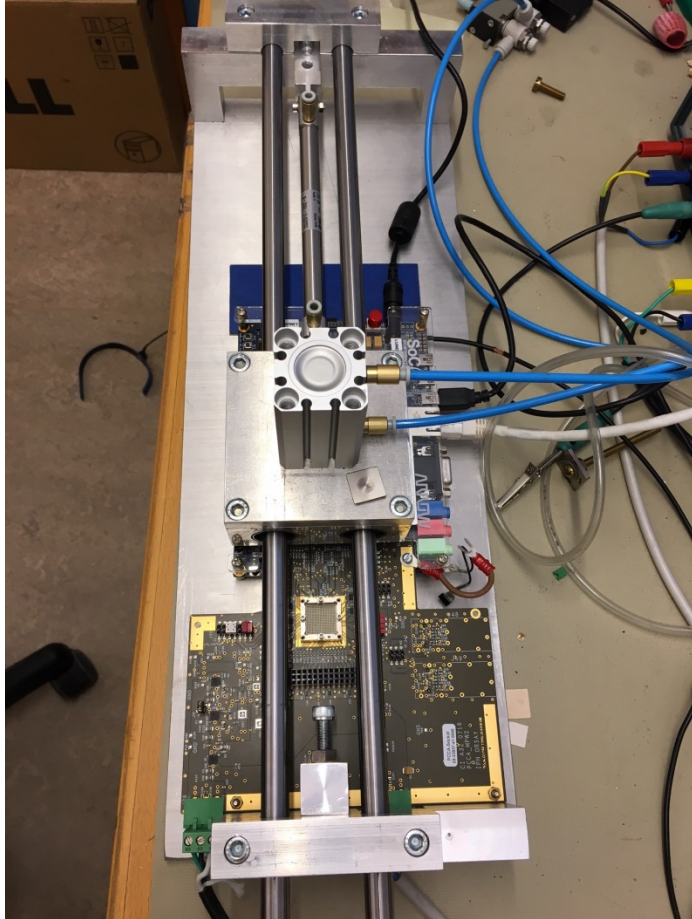
- jet quenching (LU),
- flow/collectivity (LU),
- quarkonia.

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 (2017), with Peter C. and Leif Lönnblad as co-PIs to pursue this further

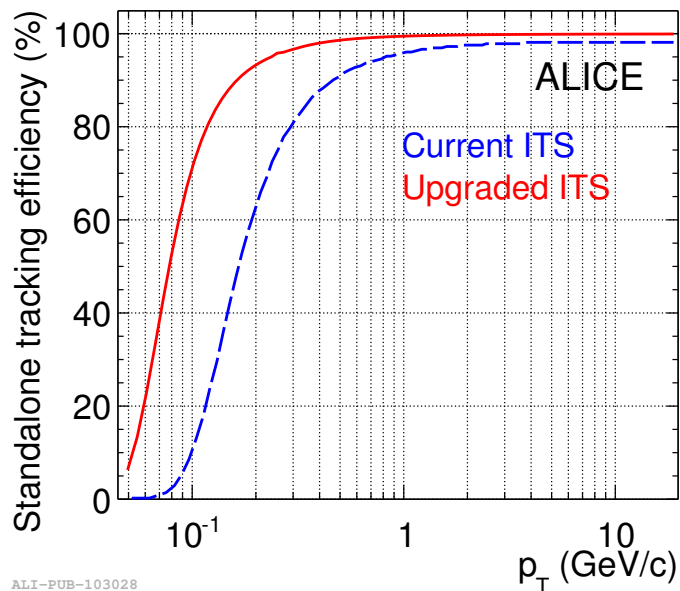


Main current hardware activity (DS et al.):

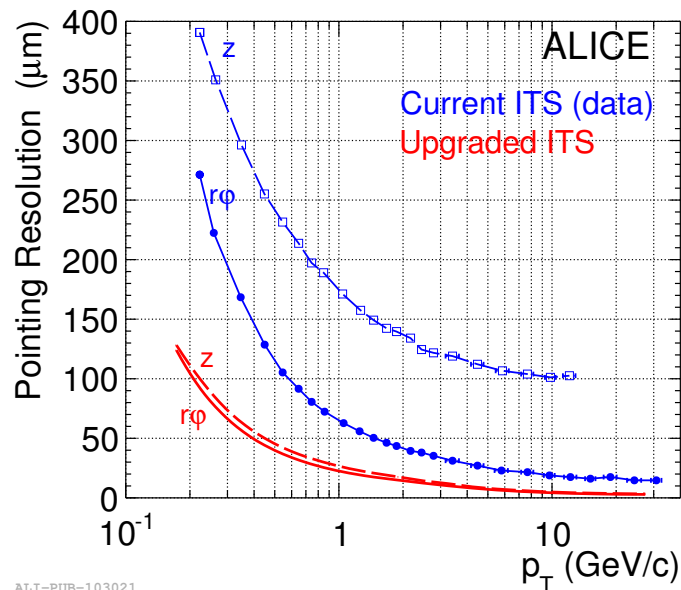
- Development and testing of new TPC readout electronics, incl. SAMPA chip
- Robotic mass test of SAMPA readout chips – approx. 30k + 60k chips for ALICE TPC + MCH LS2 upgrades to be tested in 2018-2019
- Robot choreography video:
<https://www.youtube.com/watch?v=bMKY0eO7XQw>

- 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).

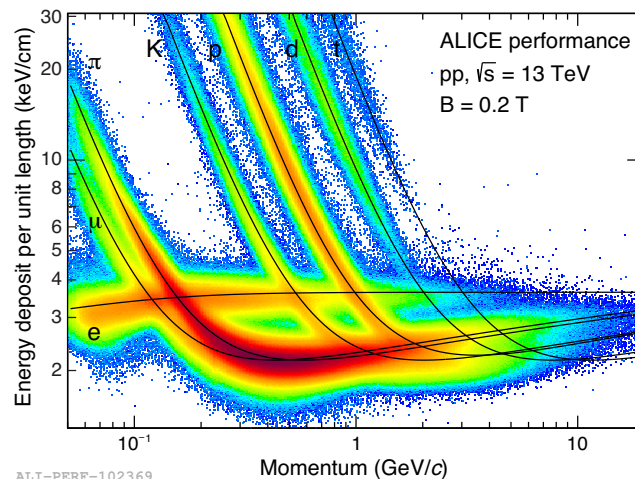
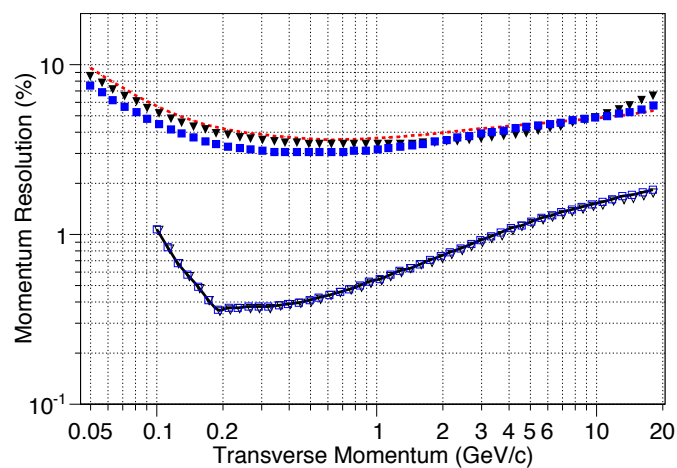
ALICE tracking performances (central barrel)



ALI-PUB-103028



ALI-PUB-103021



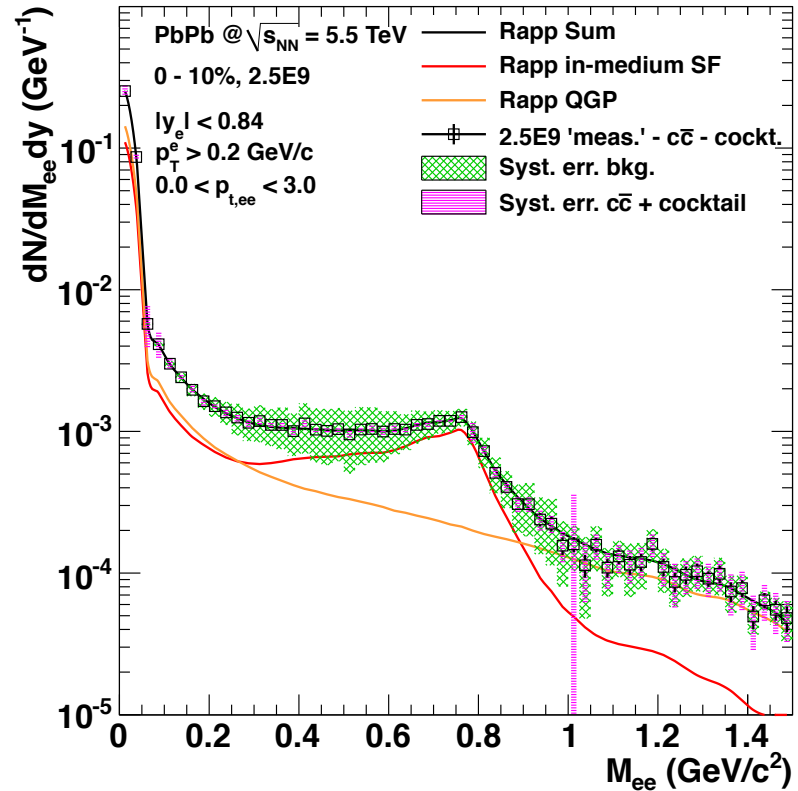
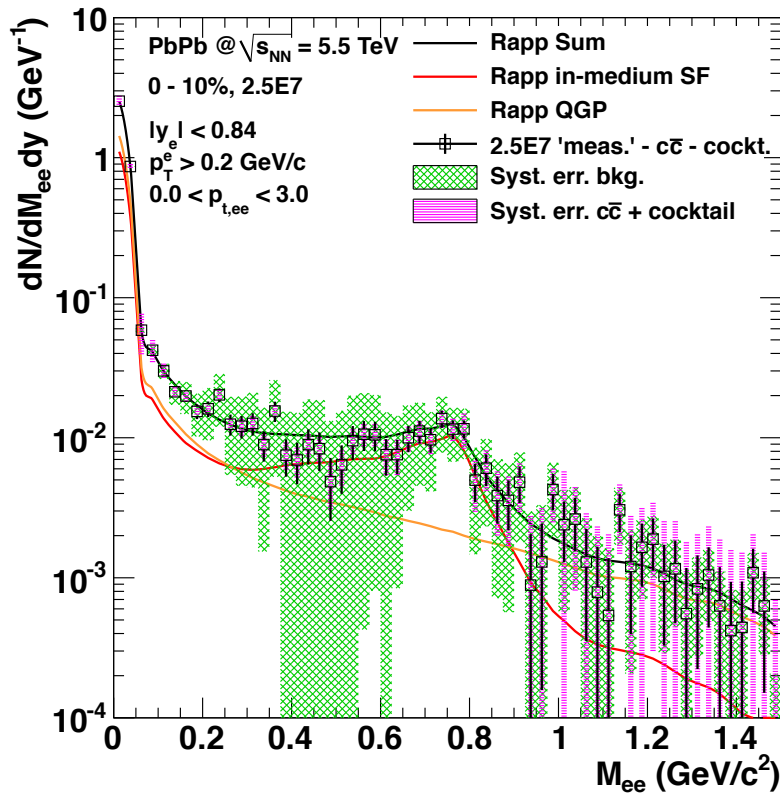
ALI-PERF-102369

Improved efficiency and resolution (mostly at low p_T)



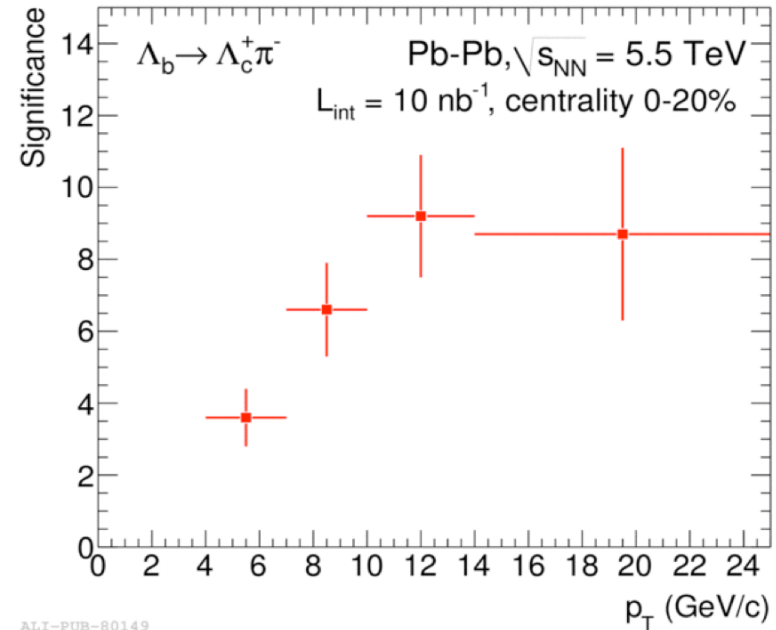
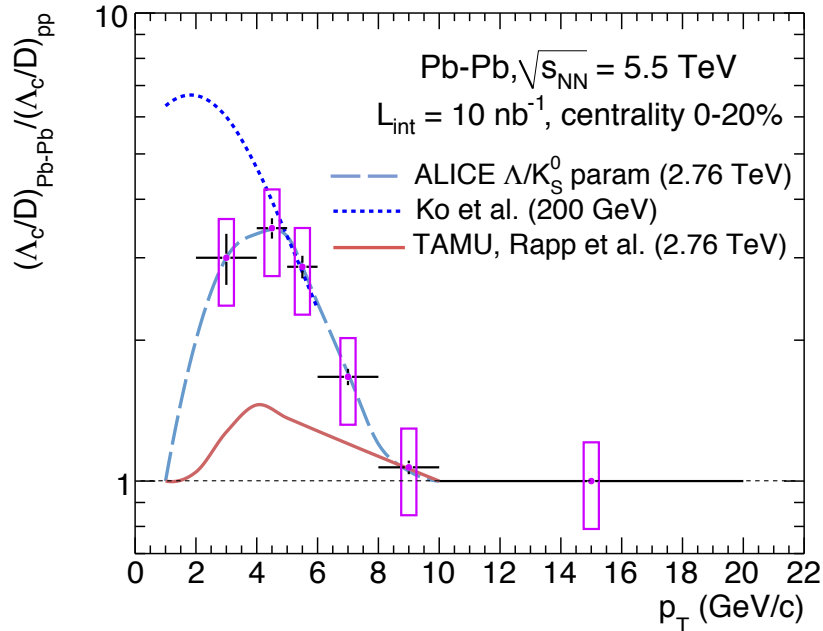
Keeping unchanged PID performances

Low Mass dielectrons $|\eta| < 0.9$



Drastic reduction of systematic error on background estimation

Charmed and Beauty baryons $|\eta| < 0.9$



ALI-PUB-80149

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>