ALICE Status

F Antinori

43rd ALICE RRB, 25 October 2017

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- Collaboration news
- News from Point 2
- Computing update
- Physics update
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- Conclusions

Collaboration news

ALICE Institute News

- PINSTECH, Islamabad, Pakistan
  (associate member, team leader: Sohail Ahmad JANJUA)

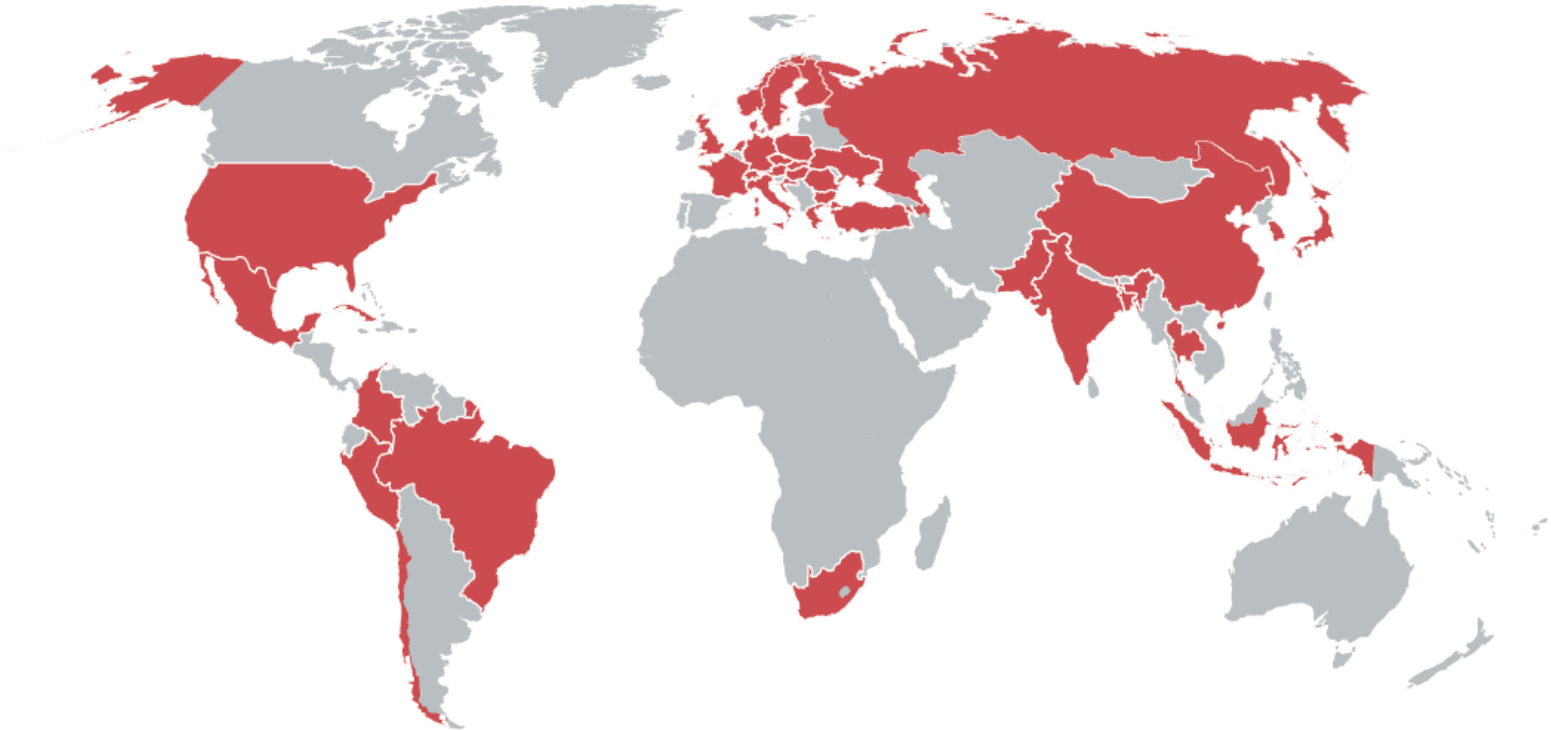
- AGH University of Science and Technology, Cracow, Poland
  (associate member, team leader: Marian BUBAK)

- Santiago de Compostela and CIEMAT, Spain: participation ended in August

- ongoing discussions with several groups (Chile, China, India, Kazakhstan, Malaysia)

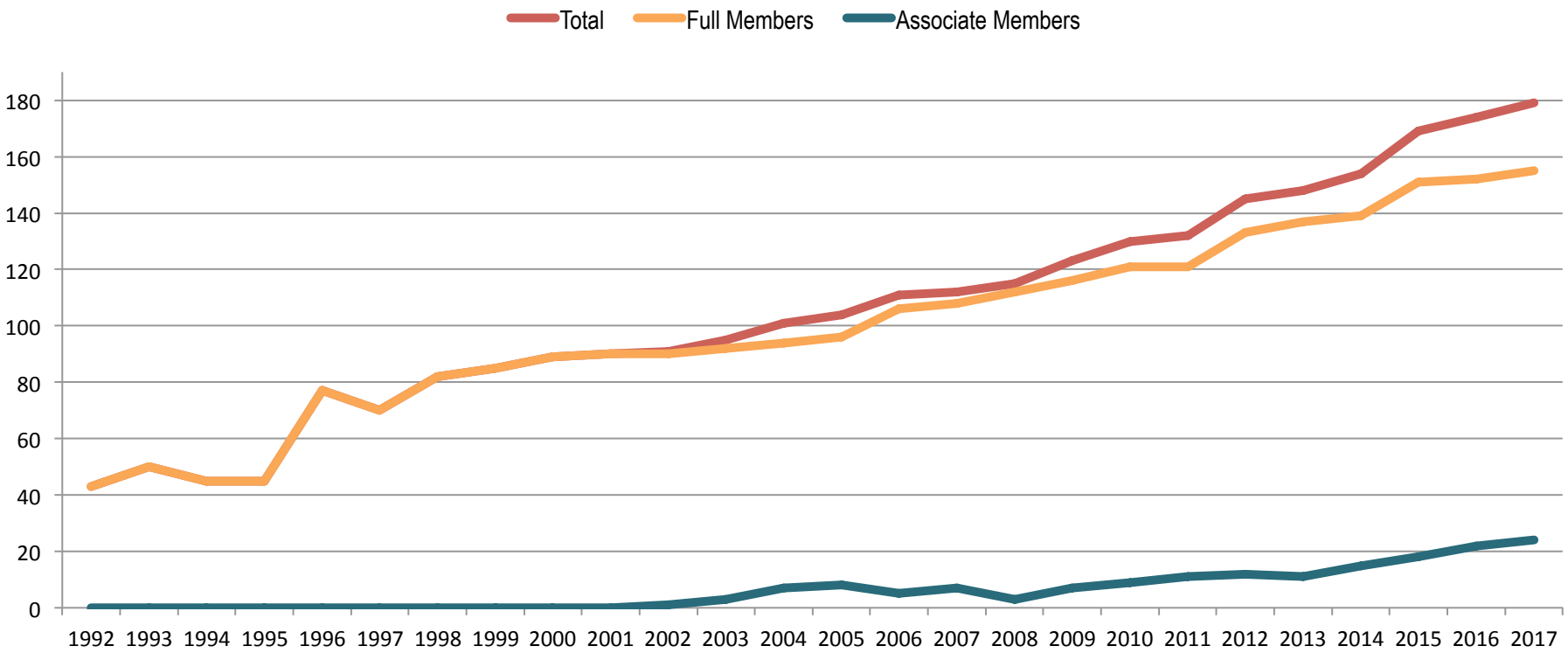
Participating Institutes (1992-2017)

178 Institutes – 41 Countries



Source: Alice Collaboration data base, October 2017

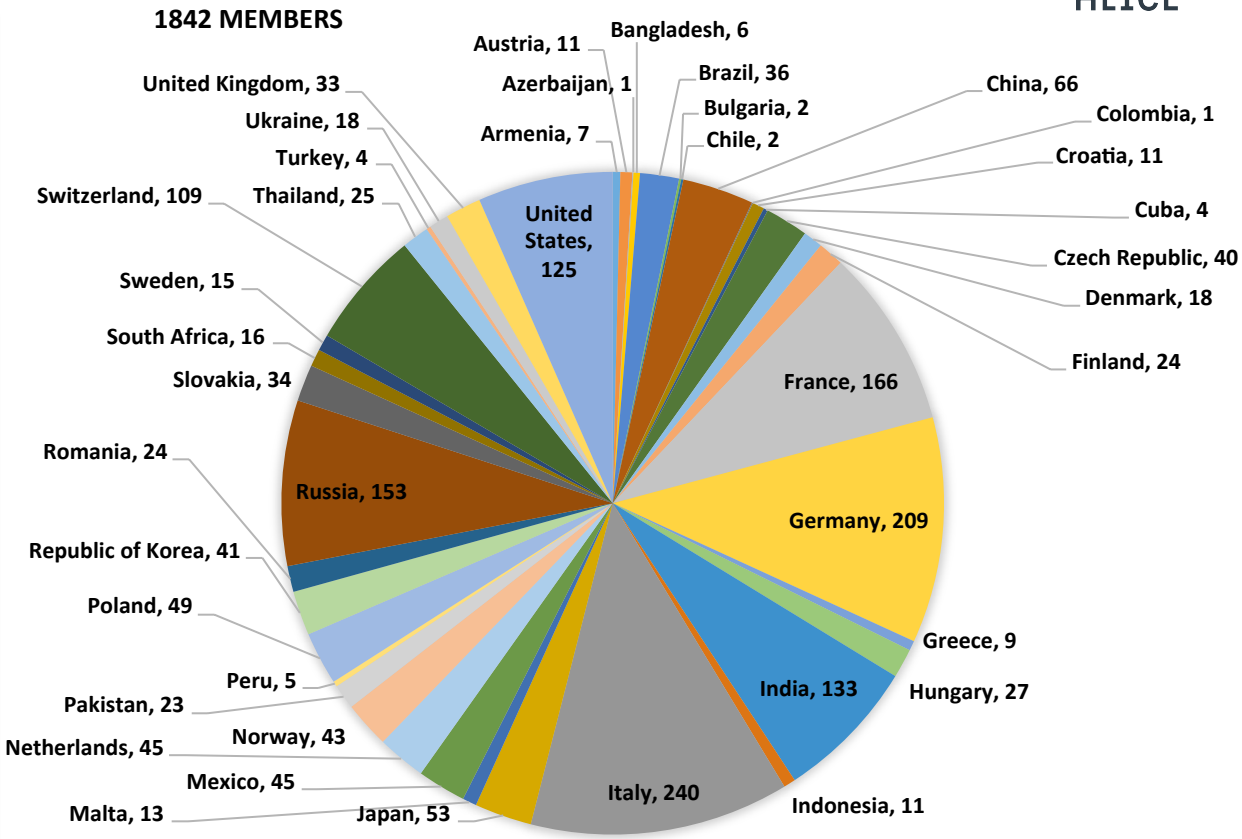
Participating Institutes (1992-2017)



The ALICE Collaboration

History of the ALICE Experiment:

- 1990-1996 Design
- 1992-2002 R&D
- 2000-2010 Construction
- 2002-2007 Installation
- 2008 -> Commissioning
- 4 TP addenda along the way:
  - 1996 Muon spectrometer
  - 1999 TRD
  - 2006 EMCAL
  - 2007 DCAL
- 2012 LoI for the Upgrade
- 2012-2014 R&D
- 2014-2016 Procurement/Fabrication
- 2016-2017 Integration, pre-commissioning
- 2018-2019 Installation, commissioning
- 2019-2020 Full deployment of DAQ/HLT



Source: Alice Collaboration data base, October 2017

New appointments

- Editorial Board Co-chair: David Dobrigkeit Chinellato (Campinas, Brazil)
- Deputy Run Coordinator: Kristjan Gulbrandsen (Copenhagen, Danemark)
- Conference Committee member: Lee Barnby (Derby, United Kingdom)
- Conference Committee member: Panos Christakoglou (Nikhef, The Netherlands)
- Junior Representatives: Erin Gauger (Austin, USA), Jeremy Wilkinson (Bologna, Italy)

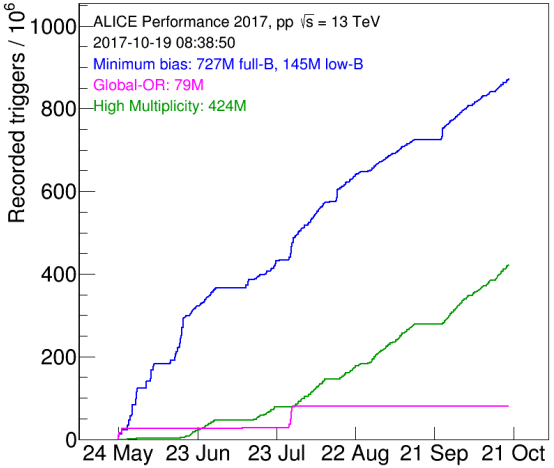
PWG Conveners

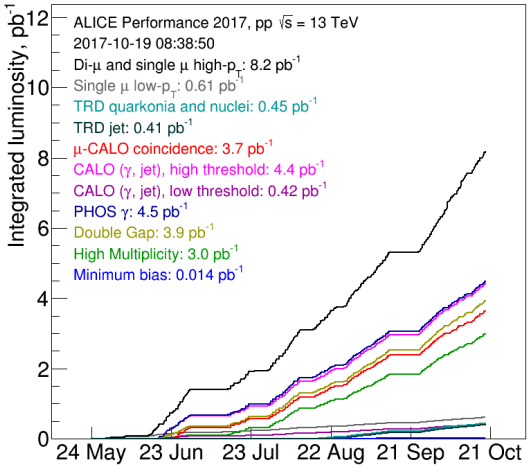
- Minimum Bias and MC generators: Paolo Bartalini (Wuhan, China)
- Jets: Tatsuya Chujo (Tsukuba, Japan)
- Jets: Leticia Cunqueiro (Oak Ridge National Laboratory, USA)
- Heavy Flavours: Alessandro Grelli (Nikhef, The Netherlands)
- Correlations and Fluctuations: Ilya Selyuzhenkov (GSI, Germany)

News from Point 2

Data taking in 2017

- nominal running conditions:
  - β* = 10 m
  - μ = 1-2%, leveled at target lumi ~2.6Hz/μbarn
- rich trigger menu
  - calos, muons, TRD, diffractive, hi-mult, min-bias, …
- 18 sub-detectors included in data-taking
- data-taking efficiency >92%
- on track for statistics goals for 2017
- special data-taking conditions
  - low-B data-taking in the central barrel (done)
  - data-taking at very low-μ (~ 0.1%) (done)
    - including Zero Degree Calorimeters
  - Xe-Xe test (done)
  - pp reference run at 5 TeV (→ November)

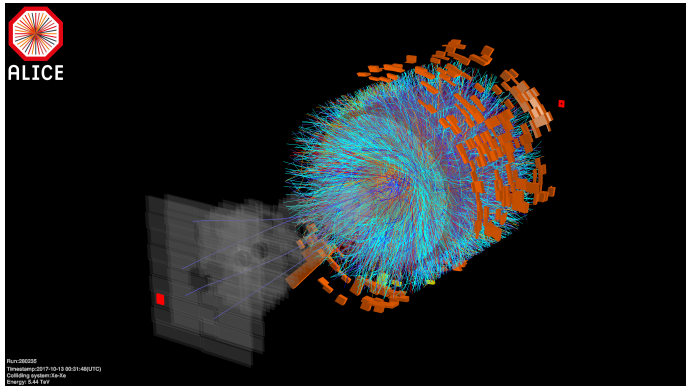


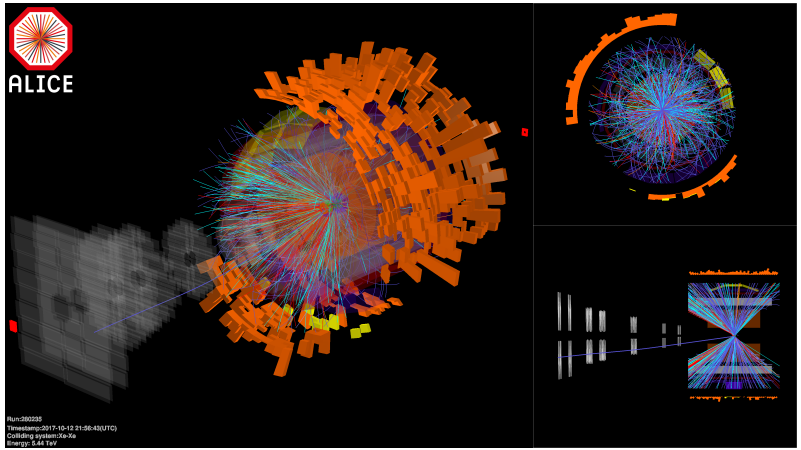


Data taking in 2017

Xenon-Xenon run

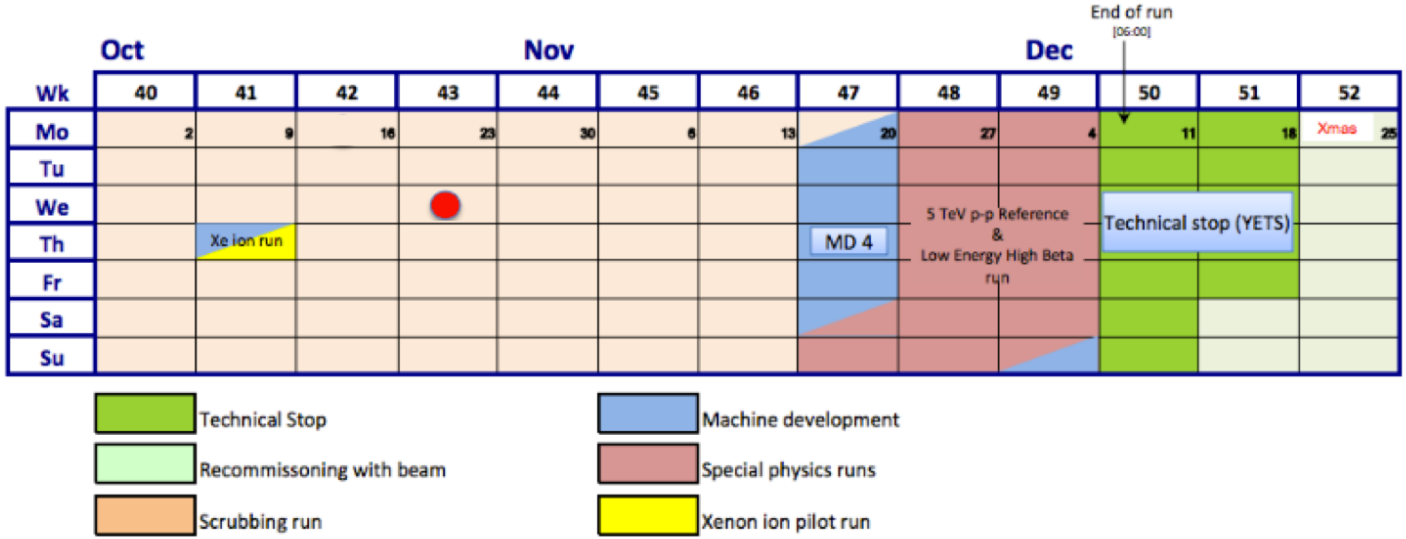
- Xe-Xe at 5.44 TeV
- Solenoid at half B-field (0.2 T)
- Solenoid/Dipole +,+ polarity
- β* used 10 m
- Fill 6294 (9h of set-up and loss maps)
- Fill 6295 (6h of Stable Beam)
  - 2x colliding bunches in IP2 compared to IP1/5/8
  - Initial peak luminosity: 2.5×10^{25} s^{-1} cm^{-2}
  - Hadronic interaction rate: ~80 Hz
- 97.4% efficiency, 1.7M min-bias events





Data taking in 2017

Next schedule



4 weeks of 13 TeV high lumi running remain.

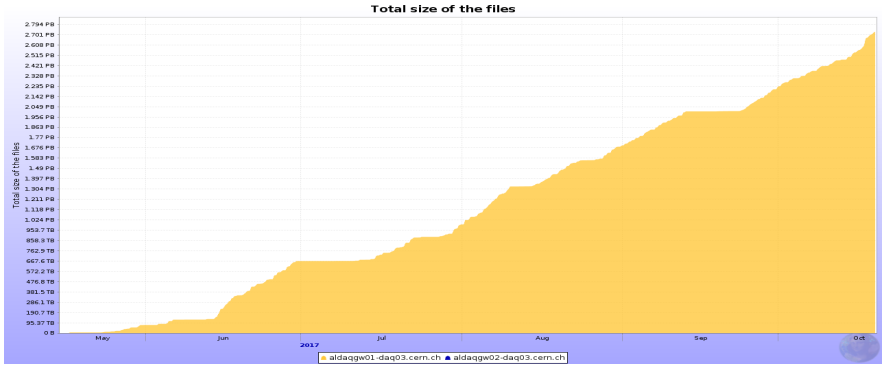
Plan to schedule 3 shifts of commissioning of 900 GeV high β* optics

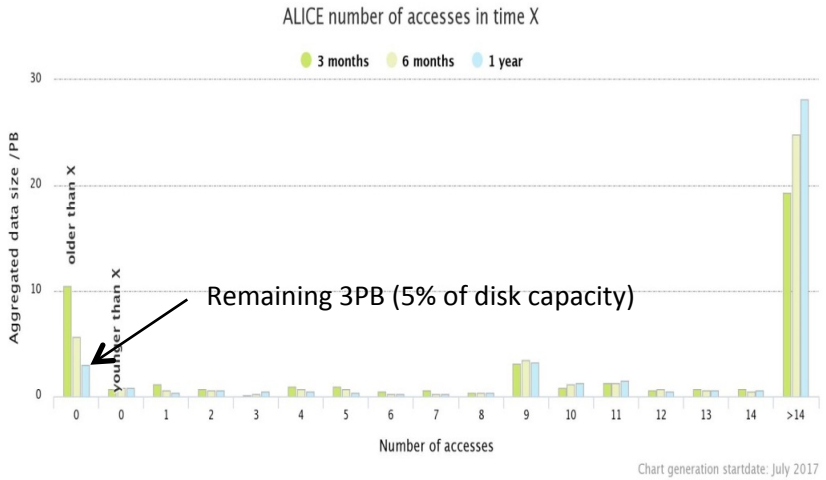
5 TeV pp reference: 870M events (6.7 days of data-taking, β*= 10 m)

Computing update

Data taking and processing

- 3.2 PB RAW data collected and replicated
- full calibration and reconstruction of all periods completed
- Improvement in HLT compression algorithm + new TPC gas resulted in reduced RAW pp data size and saved 7PB in tapes





- Cleanup of unpopular data on disk
  - 7.5PB removed,
  - ~3PB (5% of total) remains
  - reduced disk requirements in 2018
- revised and lowered request for 2019

2018 computing request

Apr-17

Resource	Site	2018 request	2019 request	Growth
CPU [kHS06]	T0	350	534	34.46%
	T1	306	501	38.92%
	T2	438	635	31.02%
Disk [PB]	T0	27	33.6	19.64%
	T1	32.2	39.9	19.30%
	T2	41	51	19.61%
Tape [PB]	T0	55	55	0.00%
	T1	41	49.5	17.17%

- Most of the pledged resources for 2017 installed resources on T0 and T1 for 2018 almost fully pledged
- T2 situation improved but still around -20%
- **Fulfillment of reduced request, in particular T2 disk, is necessary to allow ALICE continuous operation**

- Reduction in tape request (reduced event size)
- Reduction in disk request (disk cleanup)
- CPU request reevaluated based on improvements in reconstruction performance

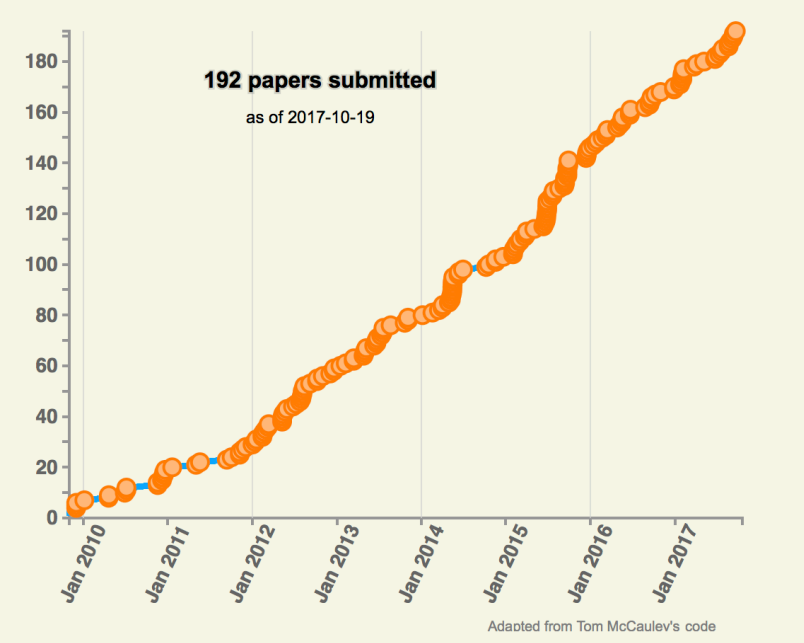
Oct-17

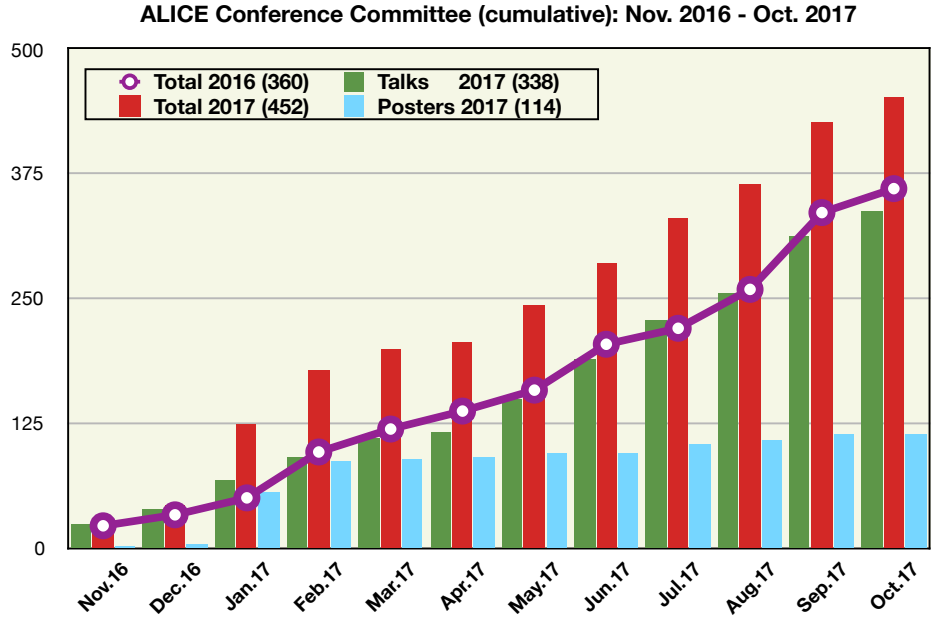
Resource	Site	2018 request	2019 request	Growth
CPU [kHS06]	T0	350	430	18.60%
	T1	307	375	18.13%
	T2	398	475	16.21%
Disk [PB]	T0	26.2	30.7	14.66%
	T1	30.5	35.8	14.80%
	T2	35.1	39.7	11.59%
Tape [PB]	T0	49.1	49.1	0.00%
	T1	40.9	40.9	0.00%

Physics update

Physics output

- going strong!
  - 192 papers on arXiv
  - several hundred conference presentations each year





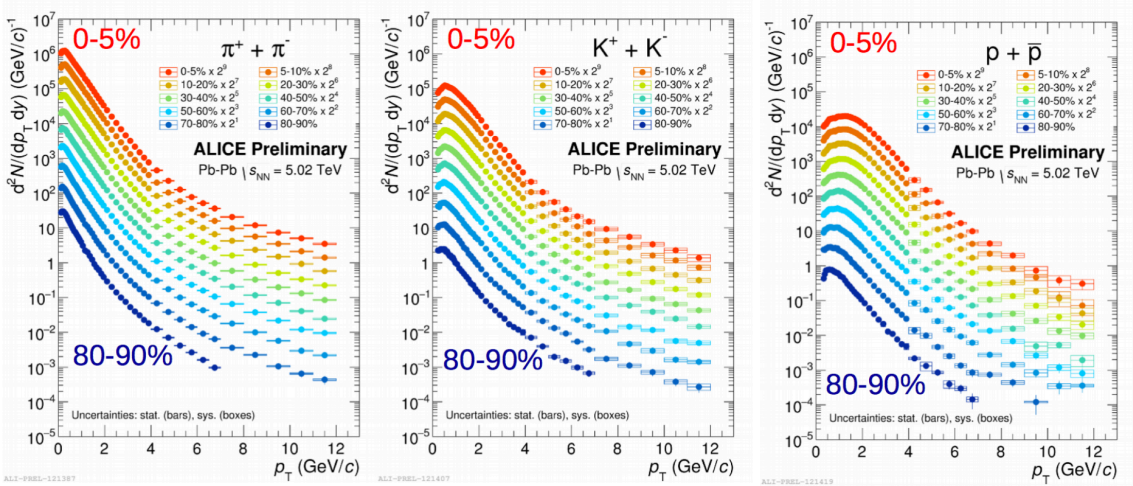
Some recent physics results…

At April RRB…

A Large Ion Collider Experiment

Identified particle production

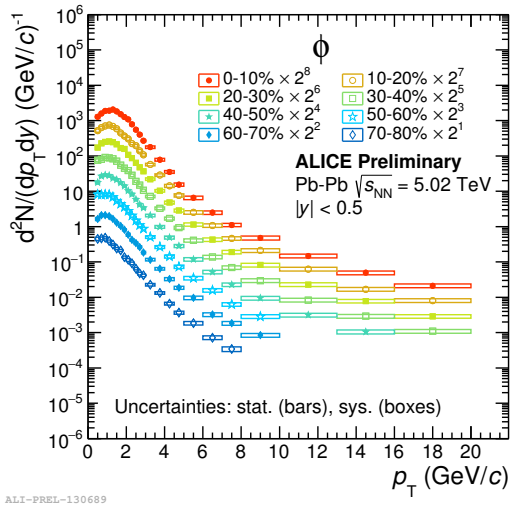
- textbook-quality Run 2 data!

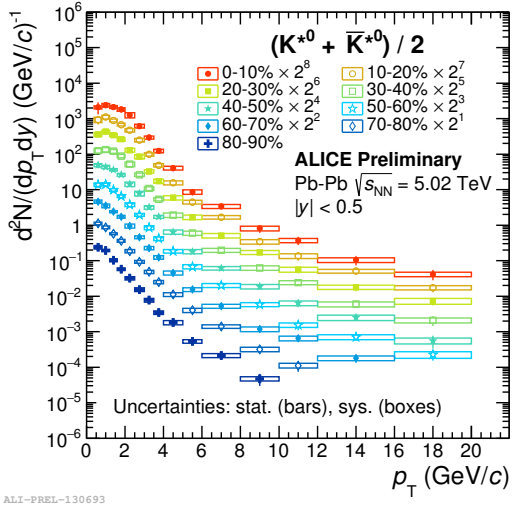


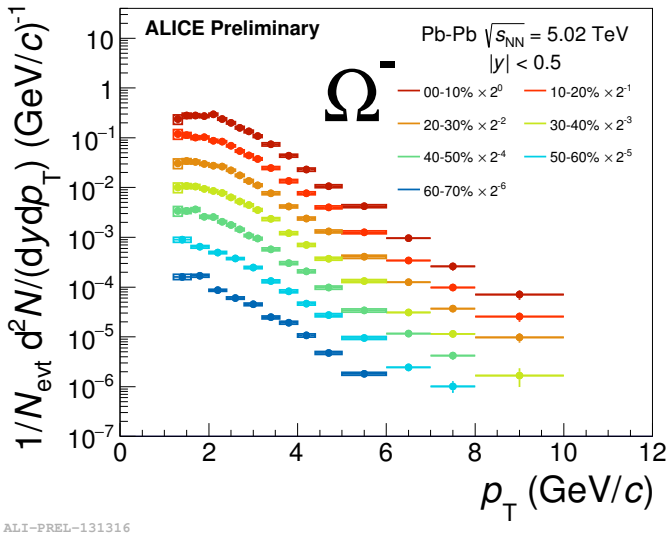
→ QGP hadronisation, collective expansion, freeze-out, …

… now: more and more species

Resonances, hyperons,…



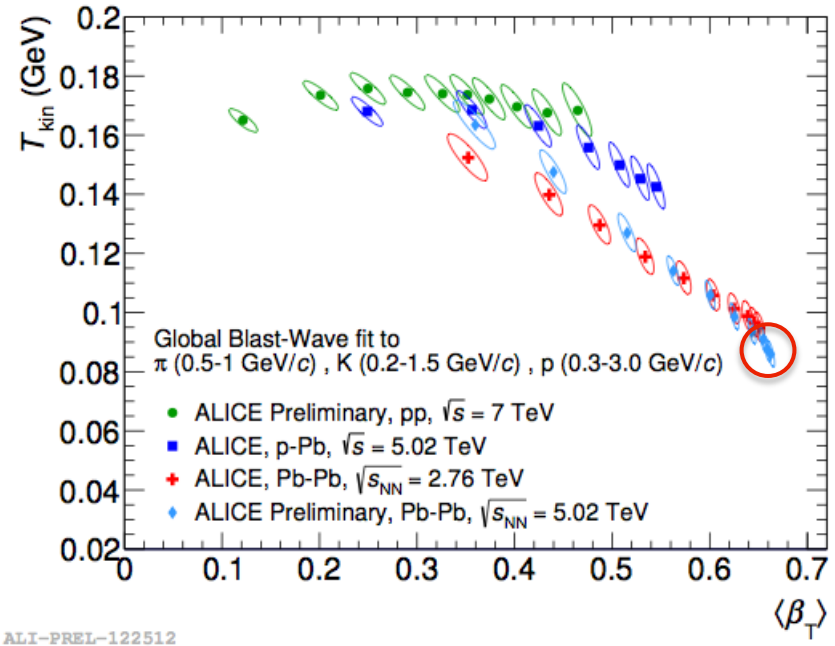




→ QGP hadronisation, radial expansion, freeze-out, …

Radial Flow

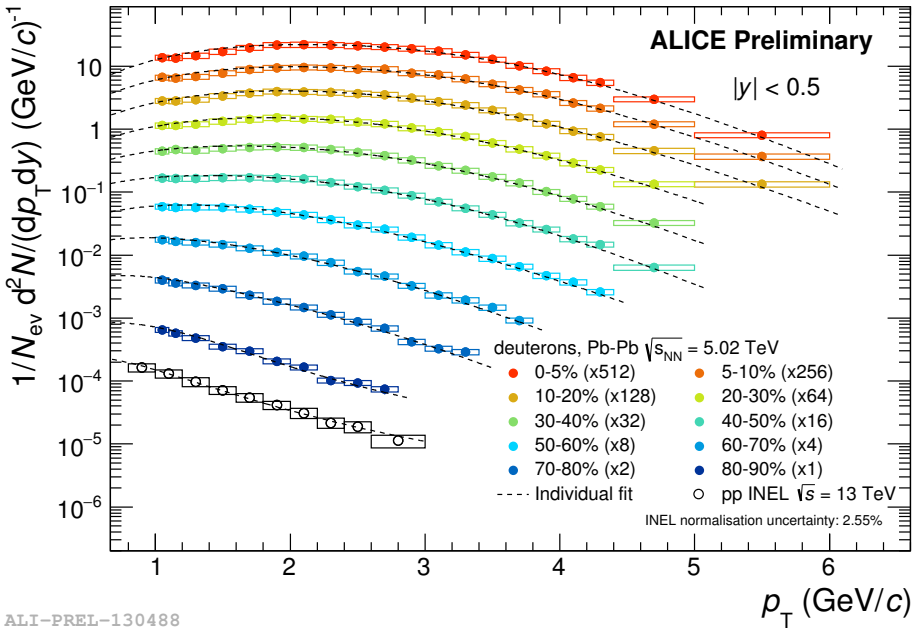
"Blast-Wave" fits to hadron spectra



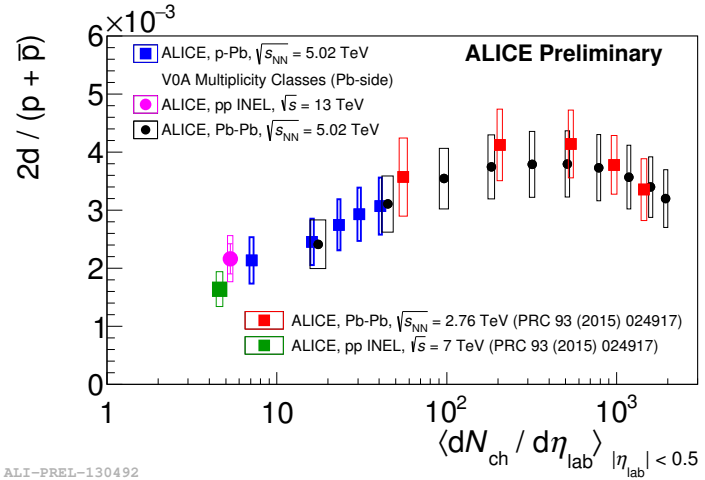
- model of radial expansion
  mass dependence → kinetic parameters
  - T_{kin}: kinetic freeze-out temperature
  - β_T: radial flow velocity
- Run 2 (5.02 TeV)
  - ~ 2/3 c (largest β_T ever observed)

Deuterons

ALICE-PUBLIC-2017-006



ALI-PREL-130488



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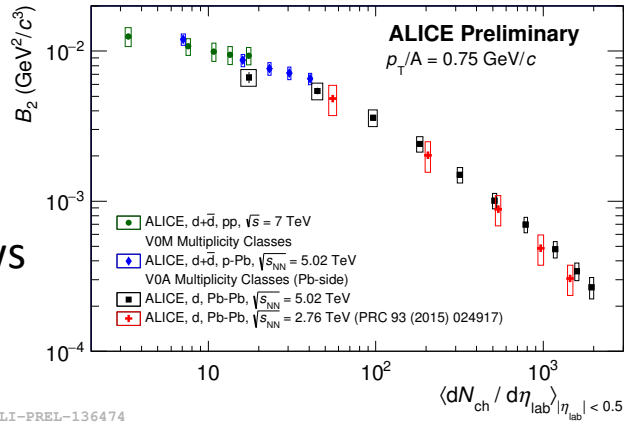


ALI-PREL-136474

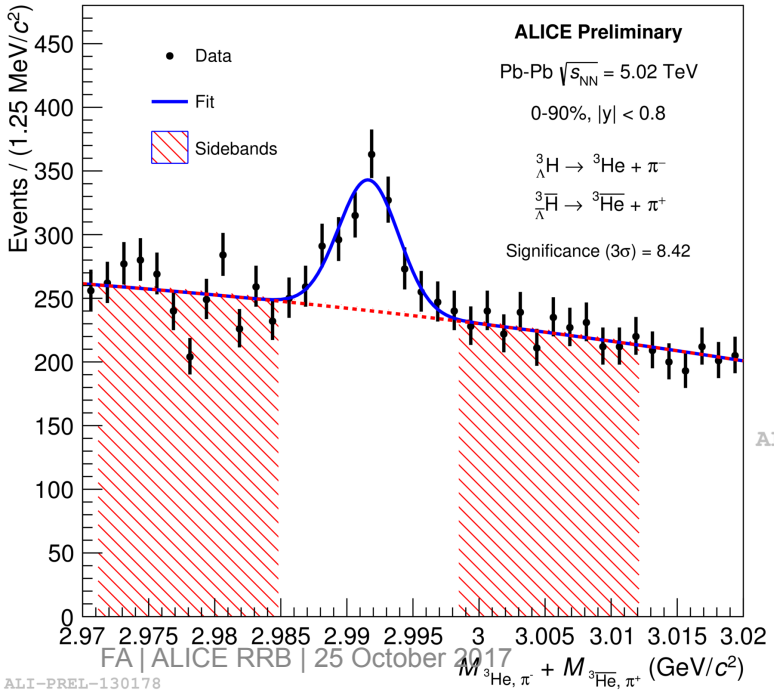
Coalescence probability decreases as system size grows

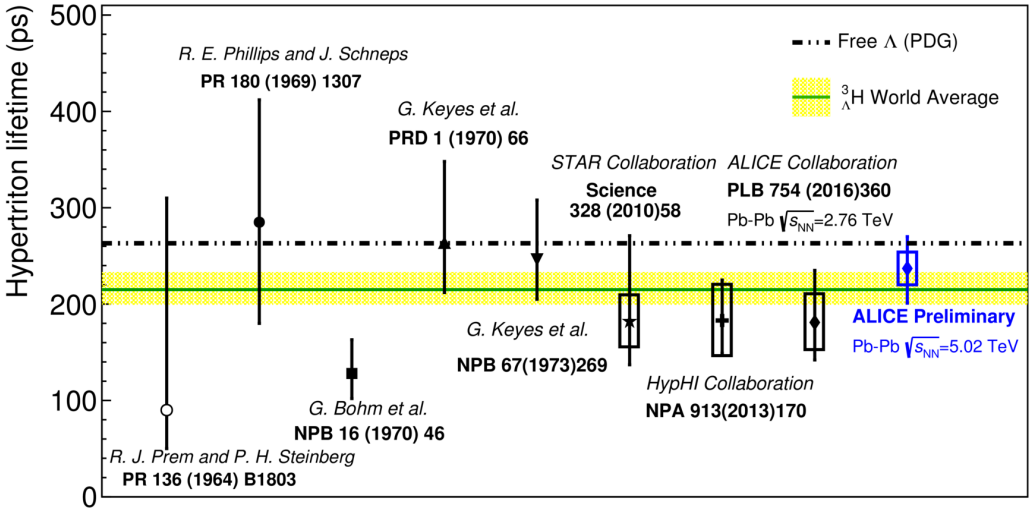
(+ light nuclei in pp arXiv:1709.08522)

Hypertriton lifetime

$^{3}_{\Lambda}$H: pnΛ bound state

$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$



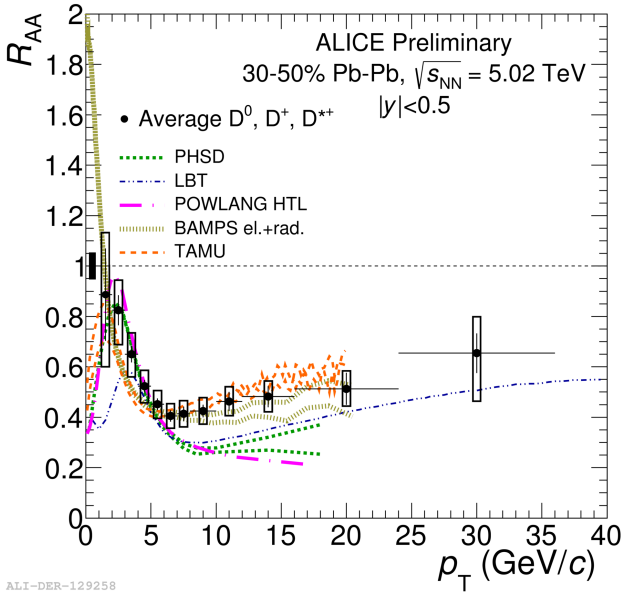


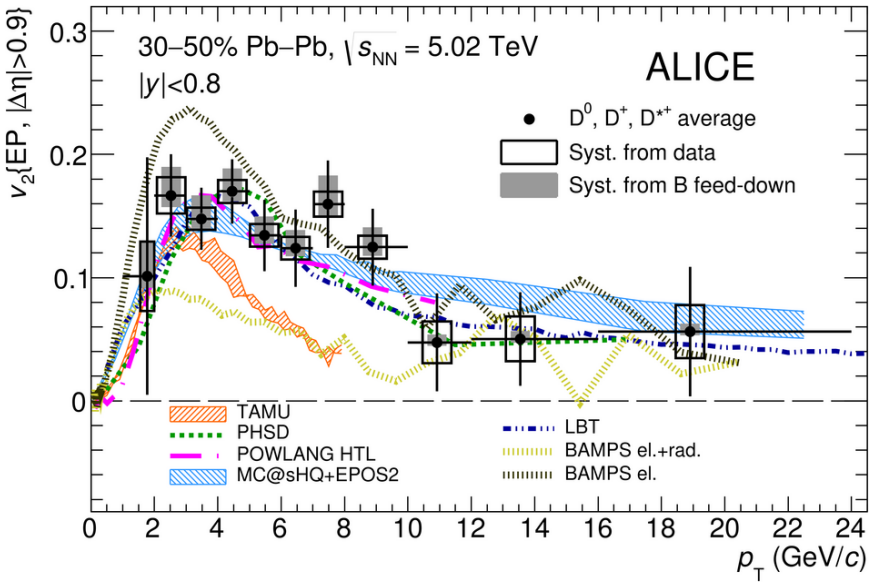
ALI-PREL-130195

Consistent with world data and with free Λ lifetime

ALI-PREL-130178

Charm: constraining the QGP transport properties

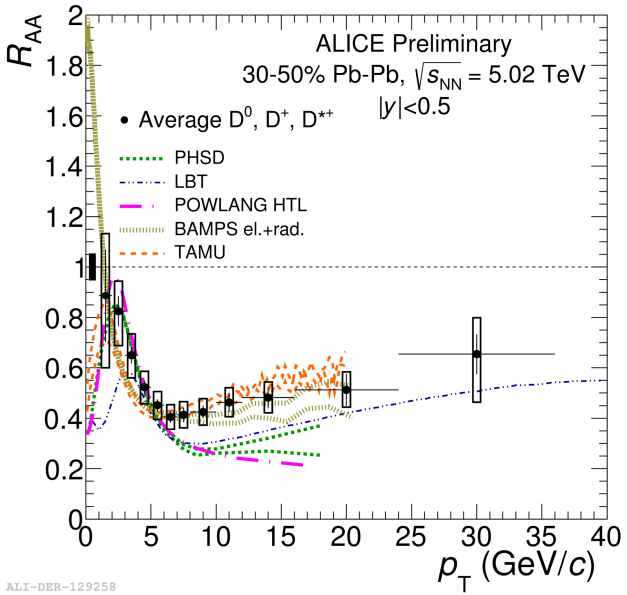




R_{AA}: AA / (N_{coll} * pp)

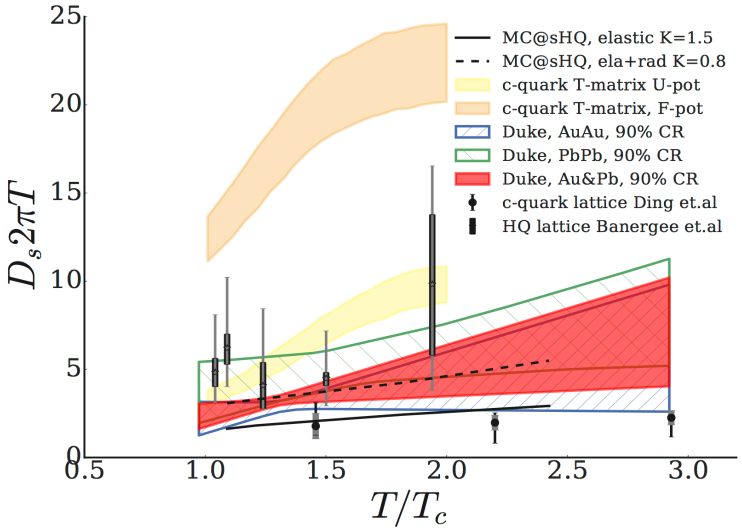
- powerful constraint from combination of R_{AA} and v_2
  → sensitivity to charm diffusion coefficient

Charm: constraining the QGP transport properties



R_{AA}: AA / (N_{coll} * pp)

e.g.: T dependence of diffusion coefficient from Run 1 ALICE data



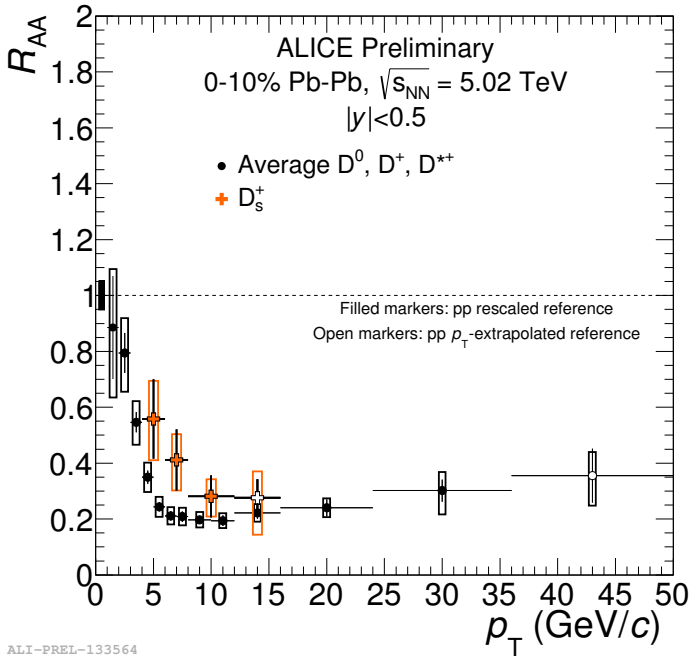
Duke group, arXiv:1704.07800

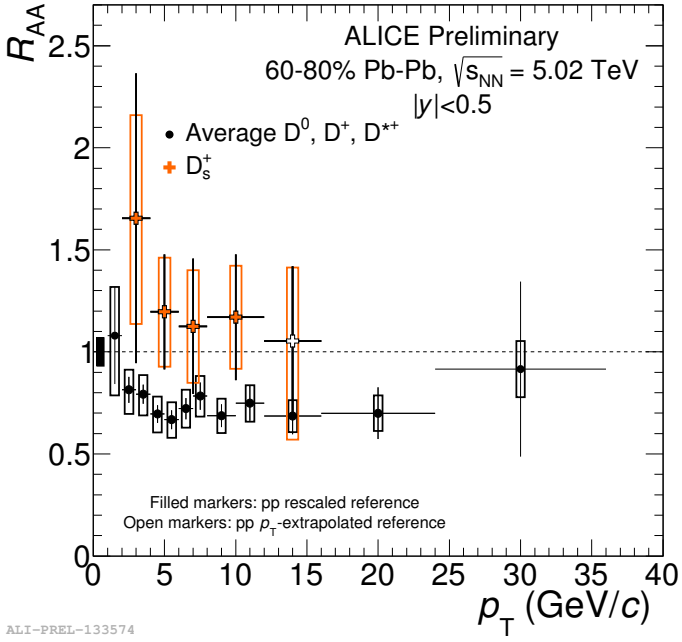
- powerful constraint from combination of R_{AA} and v_2
  → sensitivity to charm diffusion coefficient

The D_s

D and D_s

ALICE-PUBLIC-2017-003

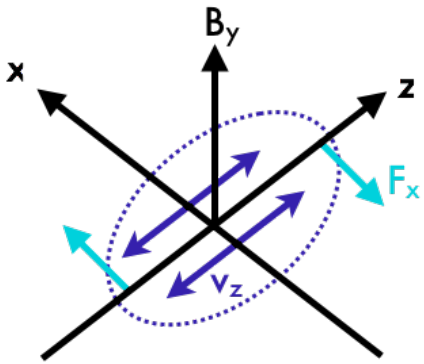




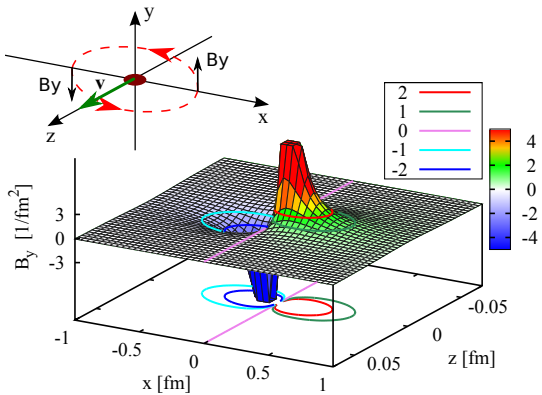
- hint of lower suppression for D_s → strangeness enhancement?

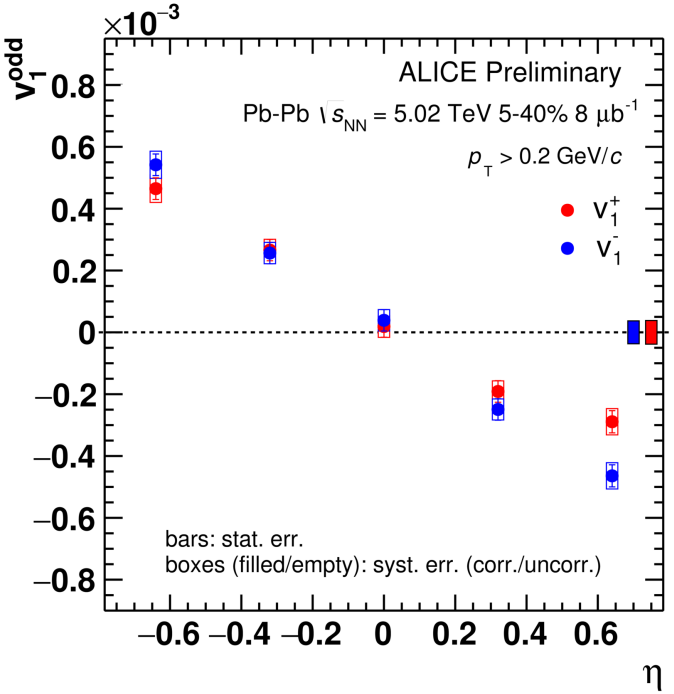
Magnetic fields in Pb-Pb collisions

- huge B generated in nuclear collision
  - can be sustained in QGP
  - sensitivity to medium properties



$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$





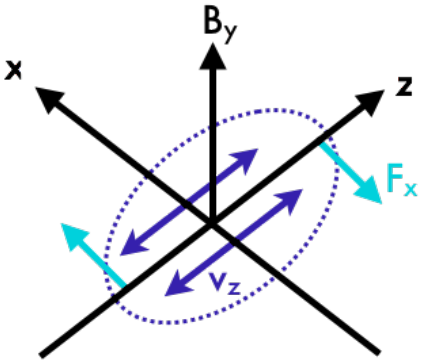
V. Voronyuk et al, Phys. Rev C83 (2011) 054911

ALI-PREL-129681

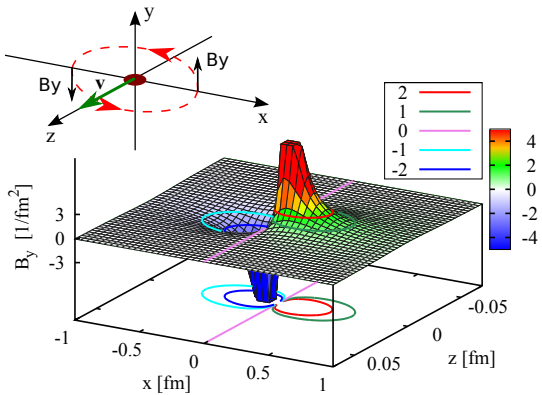
Hint of this effect observed in ALICE?

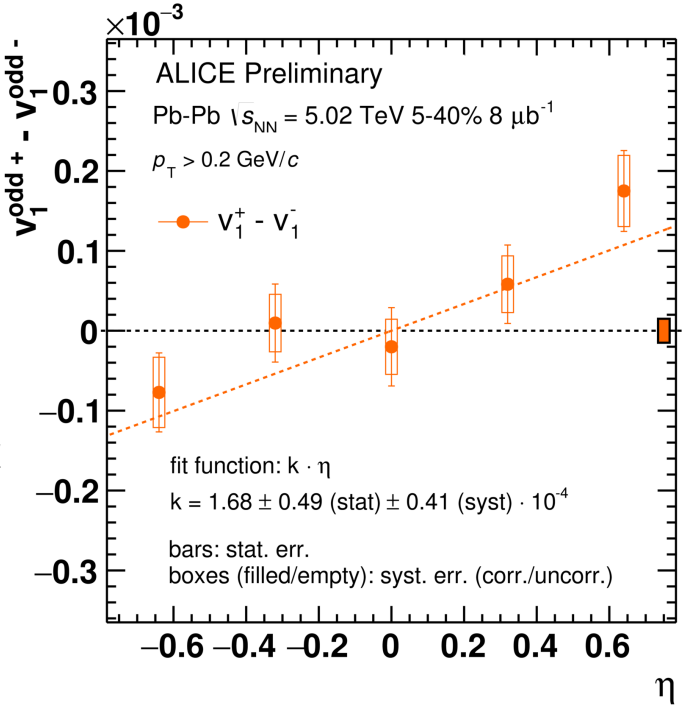
Magnetic fields in Pb-Pb collisions

- huge B generated in nuclear collision
  - can be sustained in QGP
  - sensitivity to medium properties



$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$





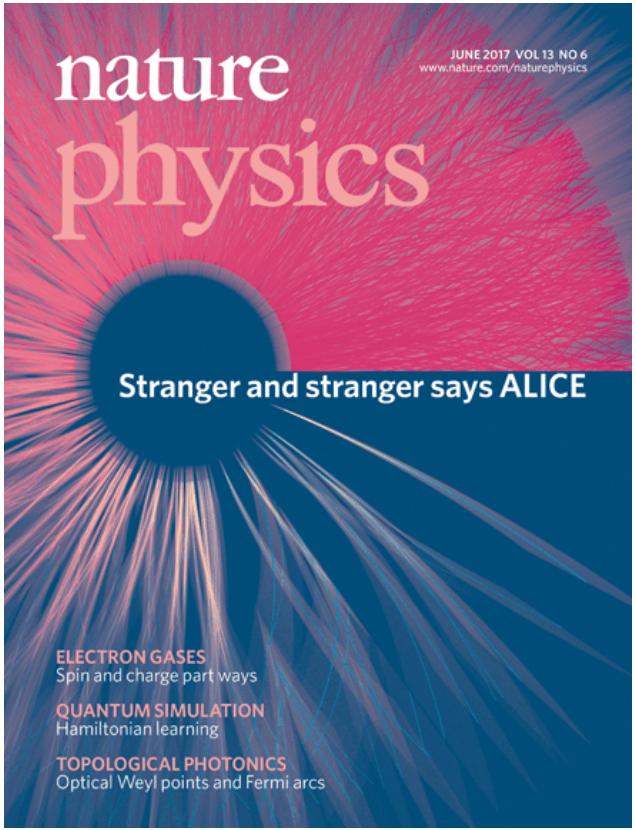
V. Voronyuk et al, Phys. Rev C83 (2011) 054911

ALI-PREL-129689

Hint of this effect observed in ALICE?

Strangeness enhancement

- reminder: Pb-Pb-like features in pp, p-Pb
  - indications of collective flow
    - two-particle correlations
    - identified particle spectra
  - strangeness enhancement
    - Nature Physics 13 (2017) 535



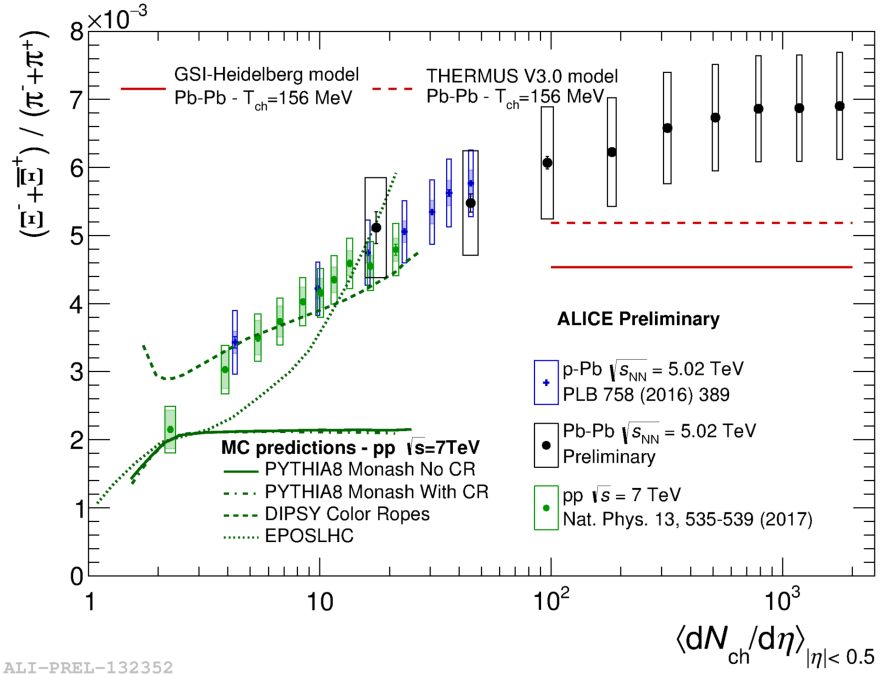
Strangeness enhancement

- reminder: Pb-Pb-like features in pp, p-Pb
  - indications of collective flow
    - two-particle correlations
    - identified particle spectra
  - strangeness enhancement
    - Nature Physics 13 (2017) 535
- now: Pb-Pb data at same energy (5 TeV)
  - smooth overlap with pp, p-Pb

→ enhancement only dependent on mult'y?

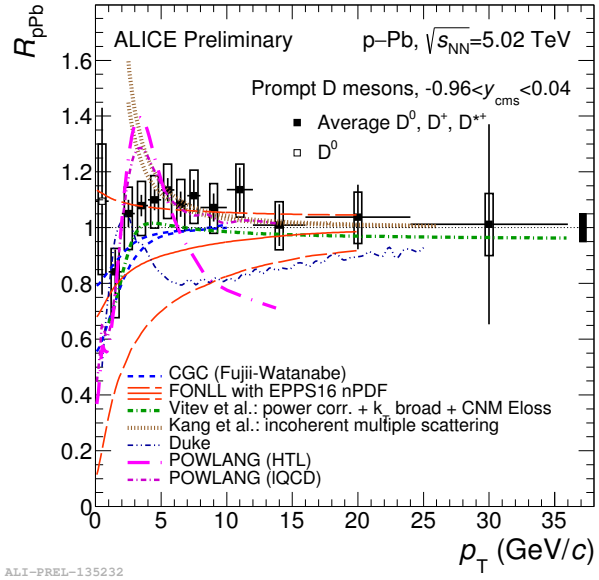
→ underlying mechanism?

→ pp event generators?



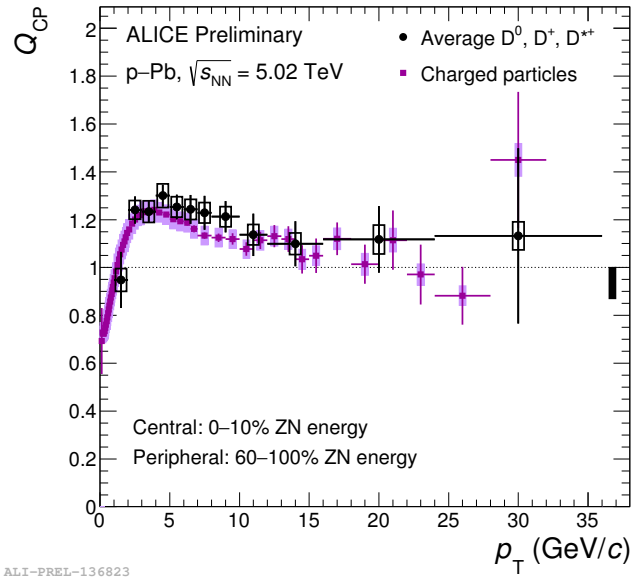
Charm in p-Pb: nuclear modification factors

p-Pb / A * pp



- no evidence of modifications
  - e.g. quenching

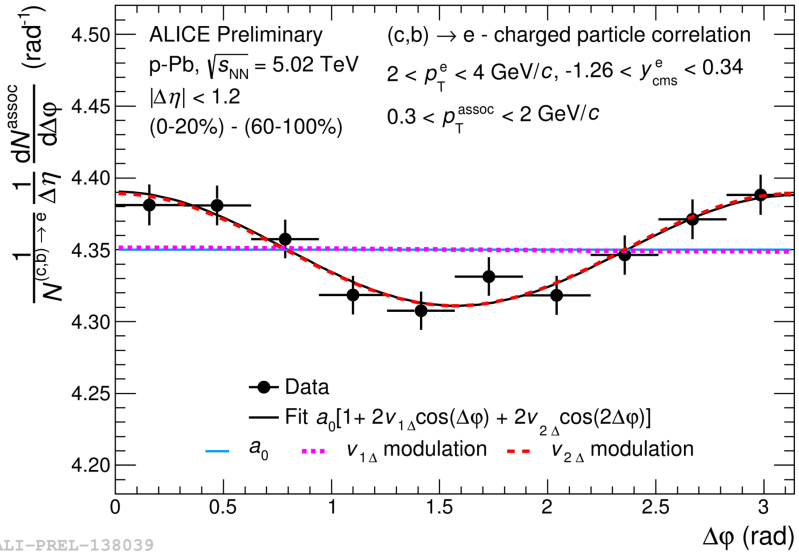
“central” / “peripheral”



- similar to charged particles
  → radial flow?

Collective effects for charm in p-Pb?

Heavy-flavour electron v_2

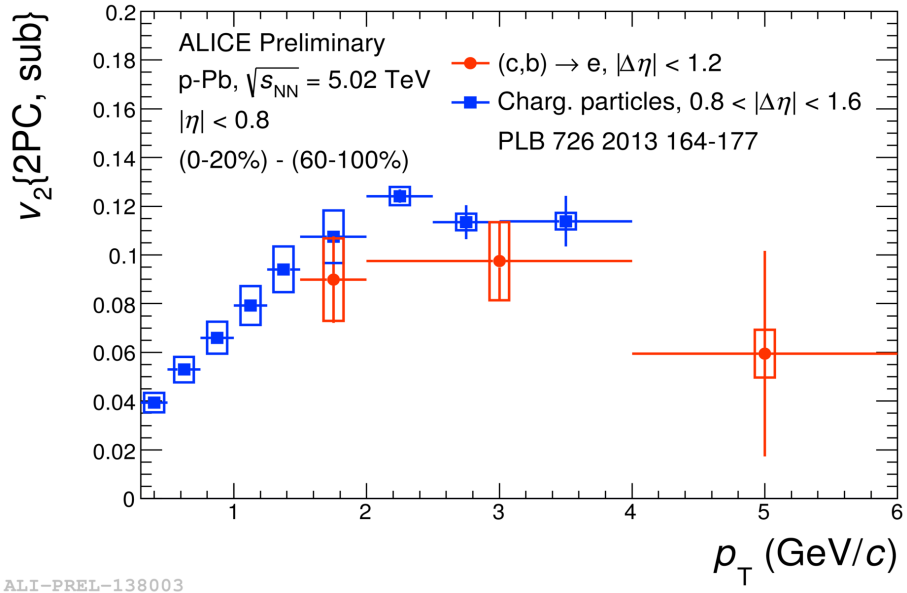


ALI-PREL-138039

- azimuthal modulation for HF electrons

Collective effects for charm in p-Pb?

Heavy-flavour electron v_2

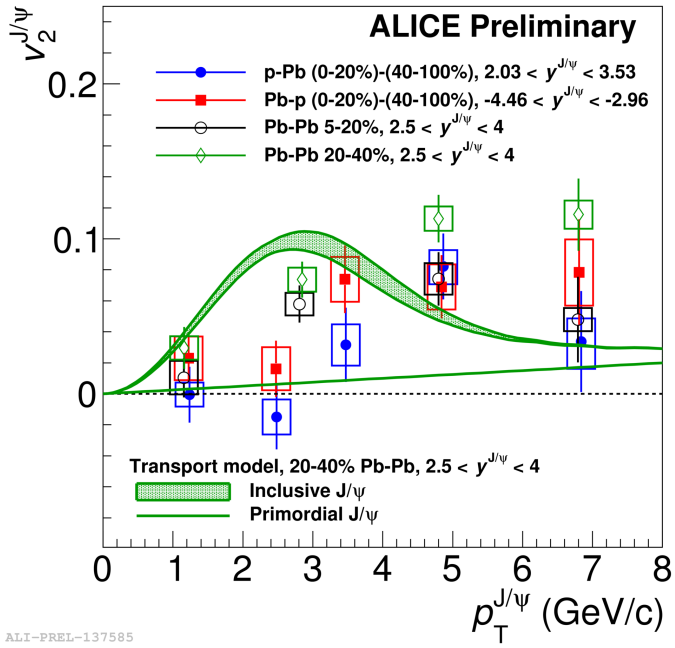


ALI-PREL-138003

- azimuthal modulation for HF electrons
- magnitude similar to charged hadrons
  - and Pb-Pb

Azimuthal asymmetry for J/ψ?

Correlate J/ψ in muon arm with charged particle in barrel



- p-going direction
- Pb-going direction
- Pb-Pb

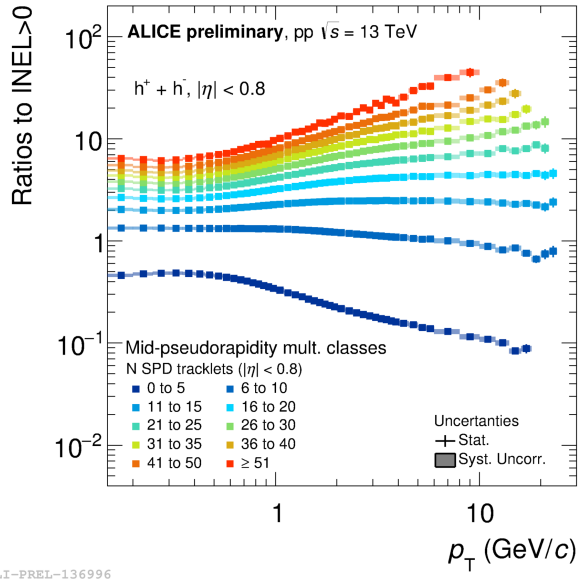
→ hint of non-zero v_2

arXiv:1709.06807

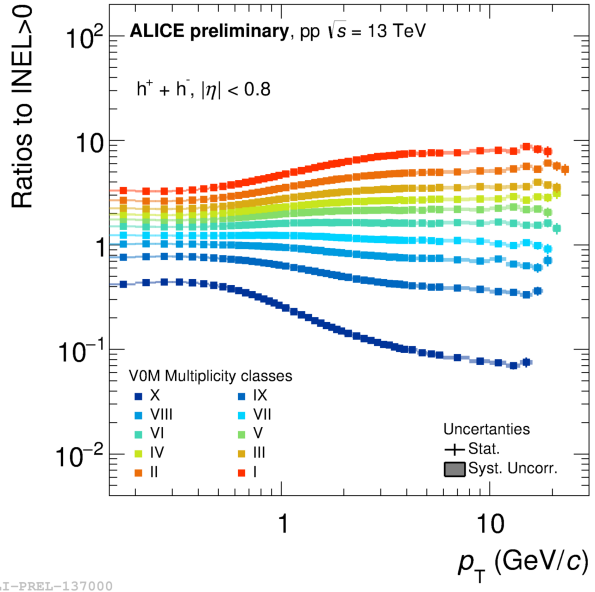
pp: multiplicity dependence of particle spectra

Ratio to minimum bias (inel > 0)

Multiplicity selection at mid-rapidity

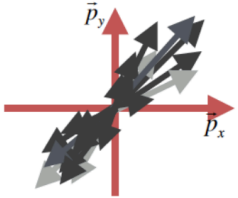


Multiplicity selection at forward rapidity

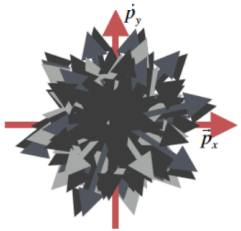


- correlation between inclusive multiplicity (low-p_T) and high-p_T particle production
  → MPIs + proton geometry

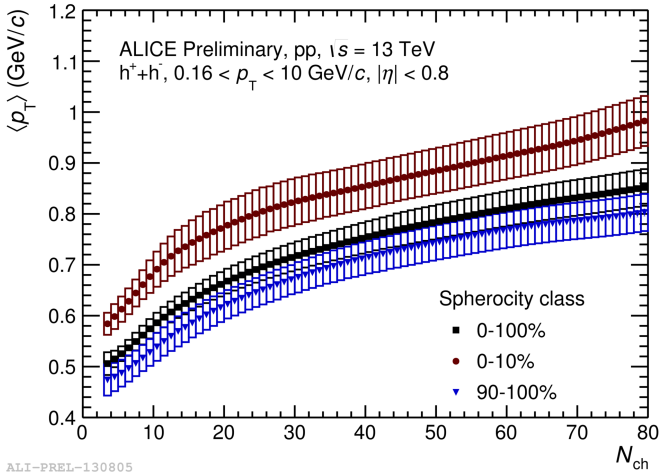
pp: particle spectra for jetty and isotropic events

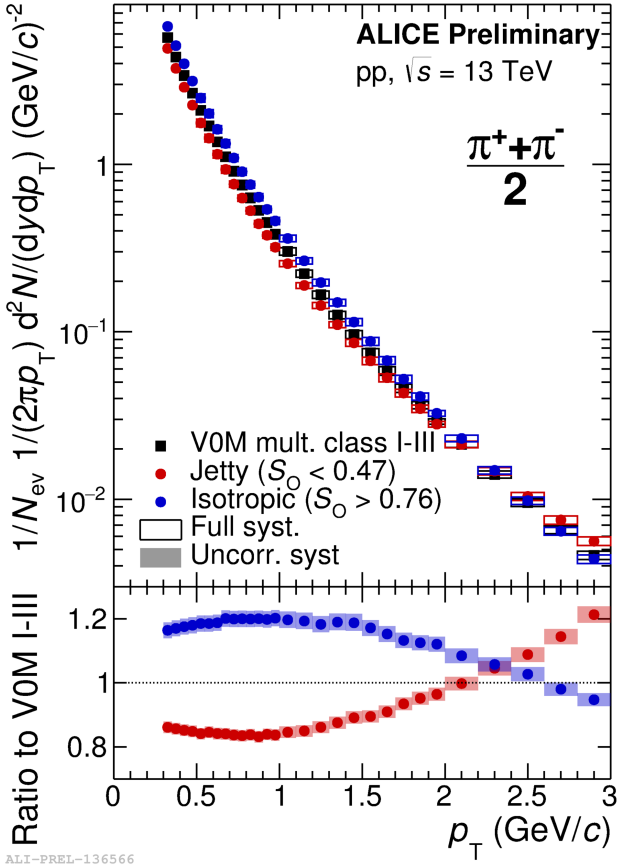


Jetty



Isotropic





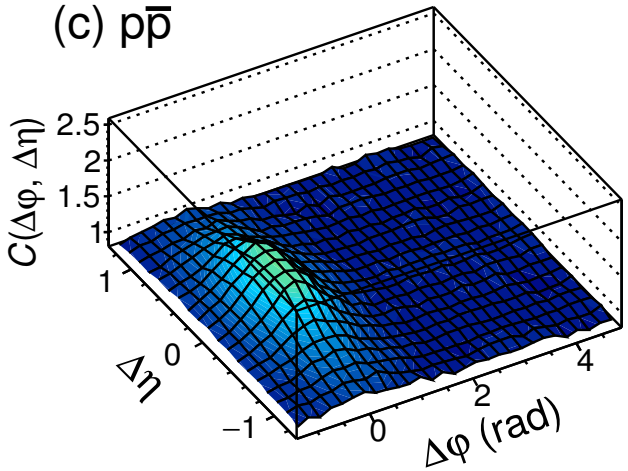
- in jetty events:
  - more particles at high p_T, fewer at low p_T

→ constrain MPI models

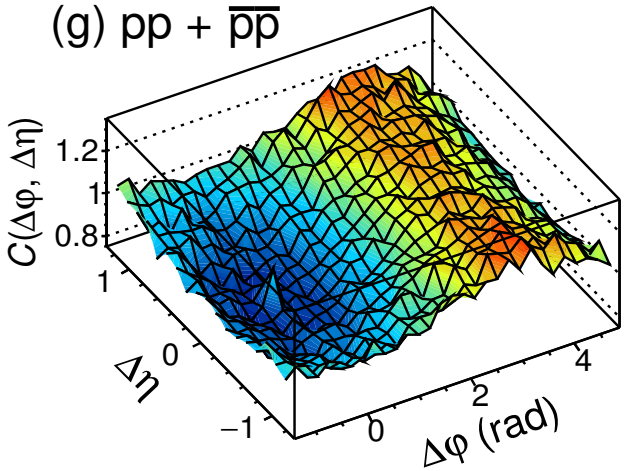
→ connected to p/π enhancement at intermediate p_T?

pp: proton-proton correlations

- close pp pairs enhanced



- close like-sign pairs suppressed

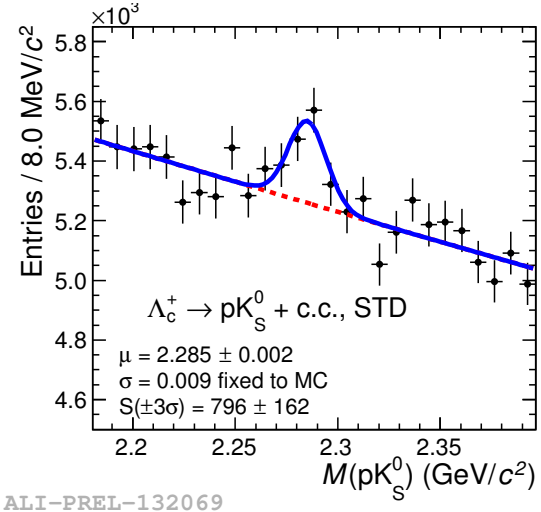


- baryon number conservation?
- not reproduced by PYTHIA tunes, PHOJET

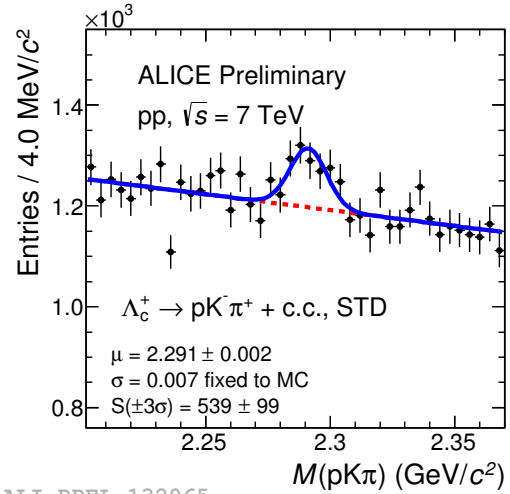
→ new window on baryon production mechanisms in pp

Charmed baryons in pp

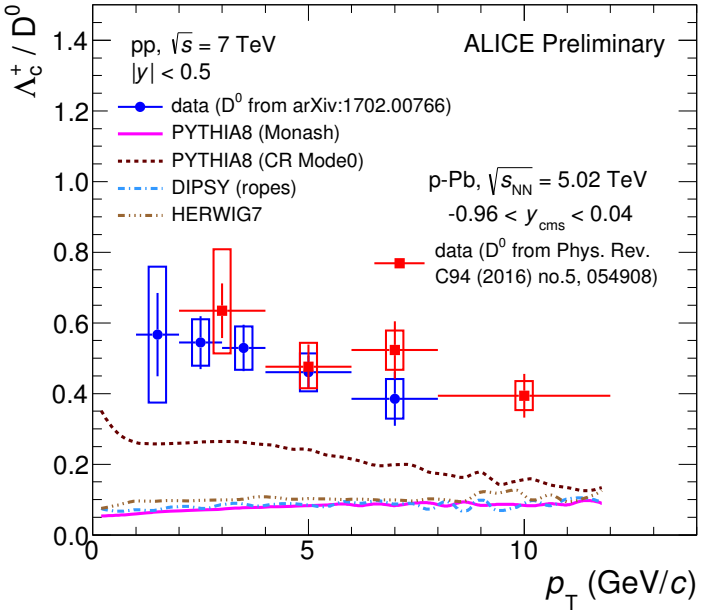
Λ_c



ALI-PREL-132069



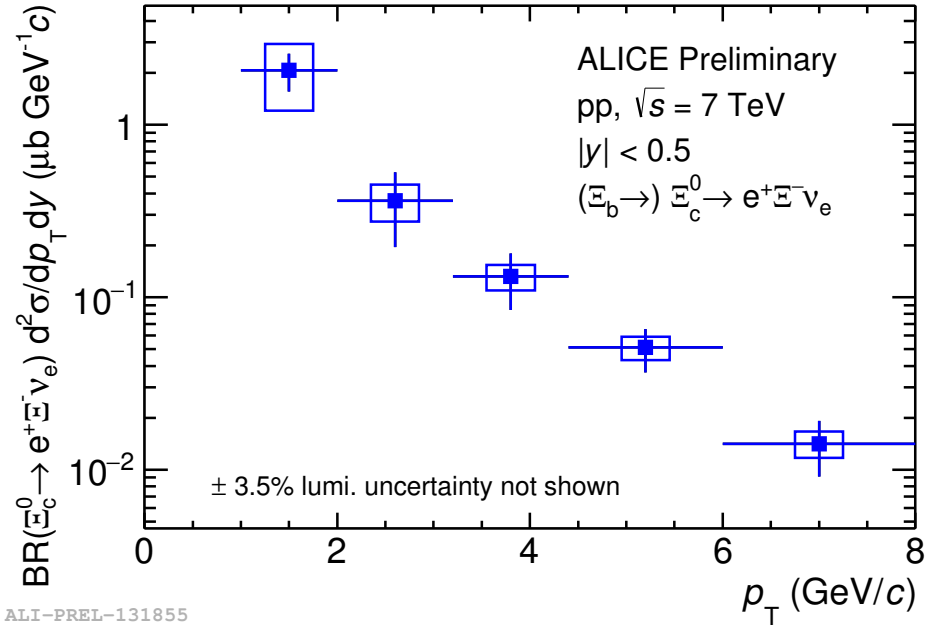
ALI-PREL-132065

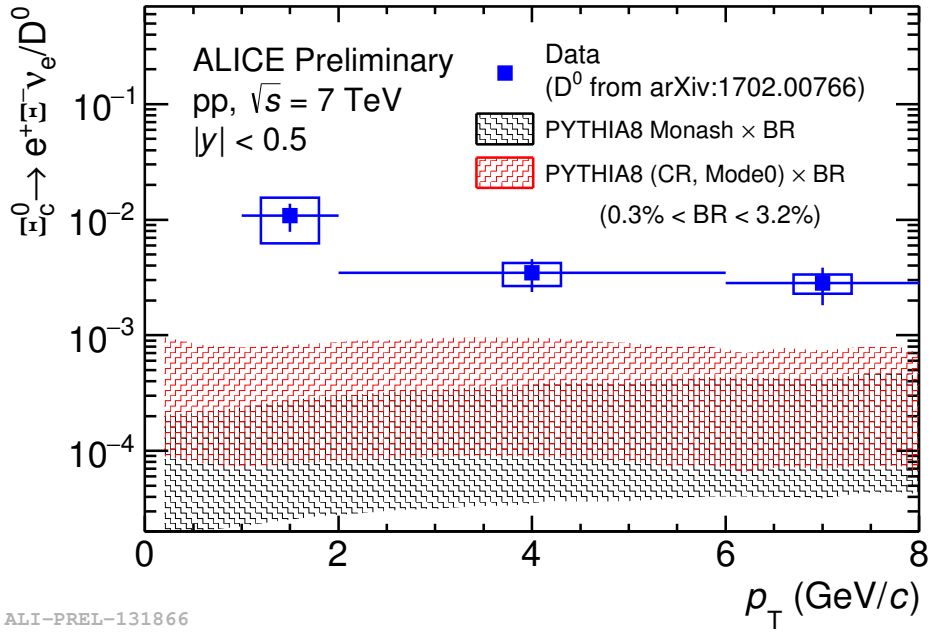


ALI-PREL-132125

Charmed baryons in pp

Ξ_c



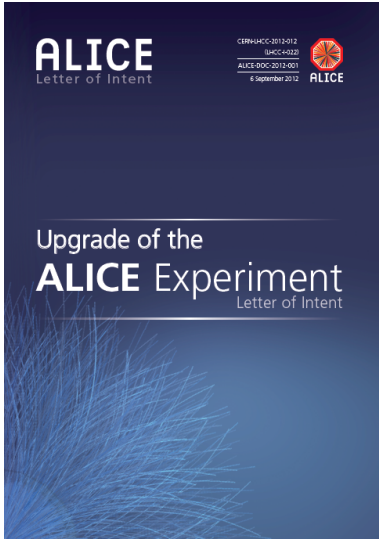


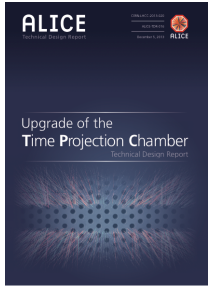
Update on upgrades

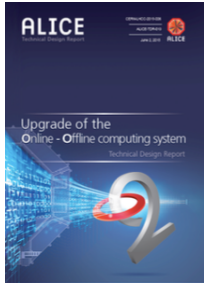
ALICE upgrades

Main physics goals

- study heavy quark interaction in QCD medium
  → heavy flavour dynamics and hadronisation at low p_T
- study charmonium regeneration in QGP
  → charmonium down to zero p_T
- chiral symmetry restoration and QGP radiation
  → vector mesons and virtual thermal photons (di-leptons)
- production of nuclei in QGP
  → high-precision measurement



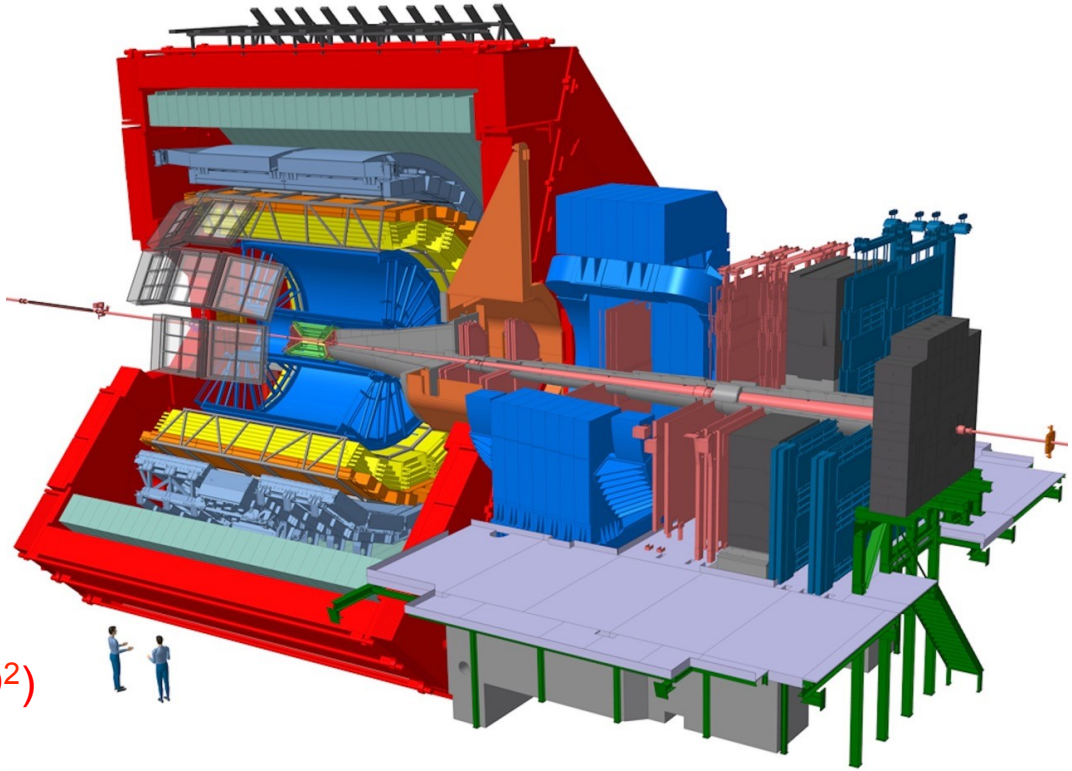




ALICE upgrades

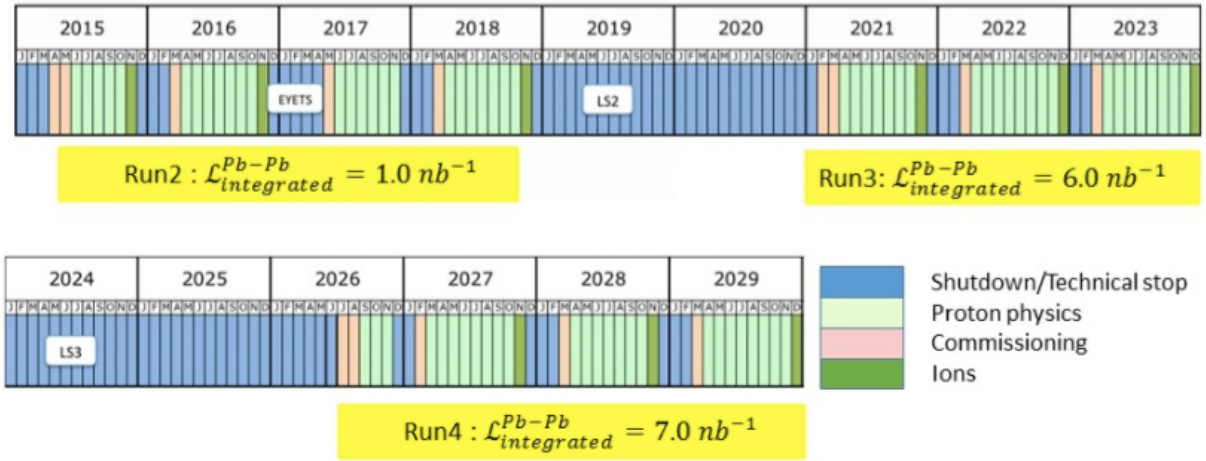
Layout

- New Inner Tracking System (ITS)
  - MAPS: improved resolution, less material, faster readout
- New Muon Forward Tracker (MFT)
  - vertex tracker at forward rapidity
- New TPC Readout Chambers
  - 4-GEM detectors
- New trigger detectors (FIT, AD)
  - + centrality, event plane
- Upgraded read-out for TOF, TRD, MUON, ZDC, EMCal, PHOS, integrated Online-Offline system (O^2)
  - record minimum-bias Pb-Pb data at 50 kHz (currently <1 kHz)



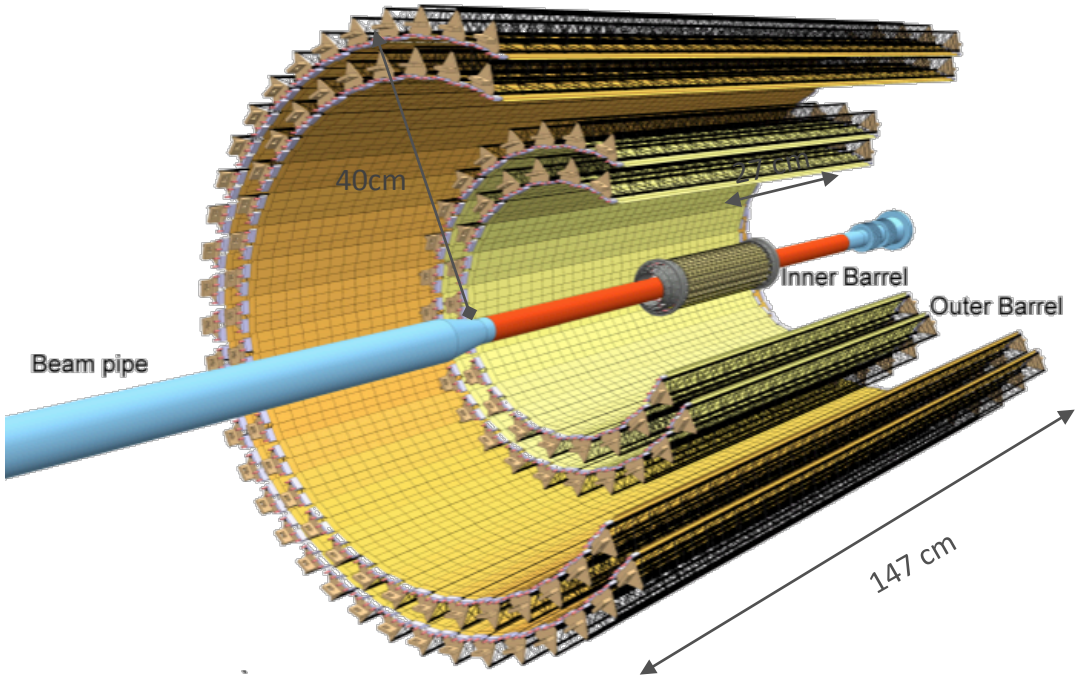
ALICE upgrades

Timeline



- LS2:
  - LHC injector upgrades, Pb-Pb rate → 50 kHz (now ~10 kHz)
  - ALICE upgrades
- Run 3 + Run 4:
  - experiments request > 10/nb (ALICE: 10/nb + 3/nb at 0.2 T)
  - in line with latest projections from machine group

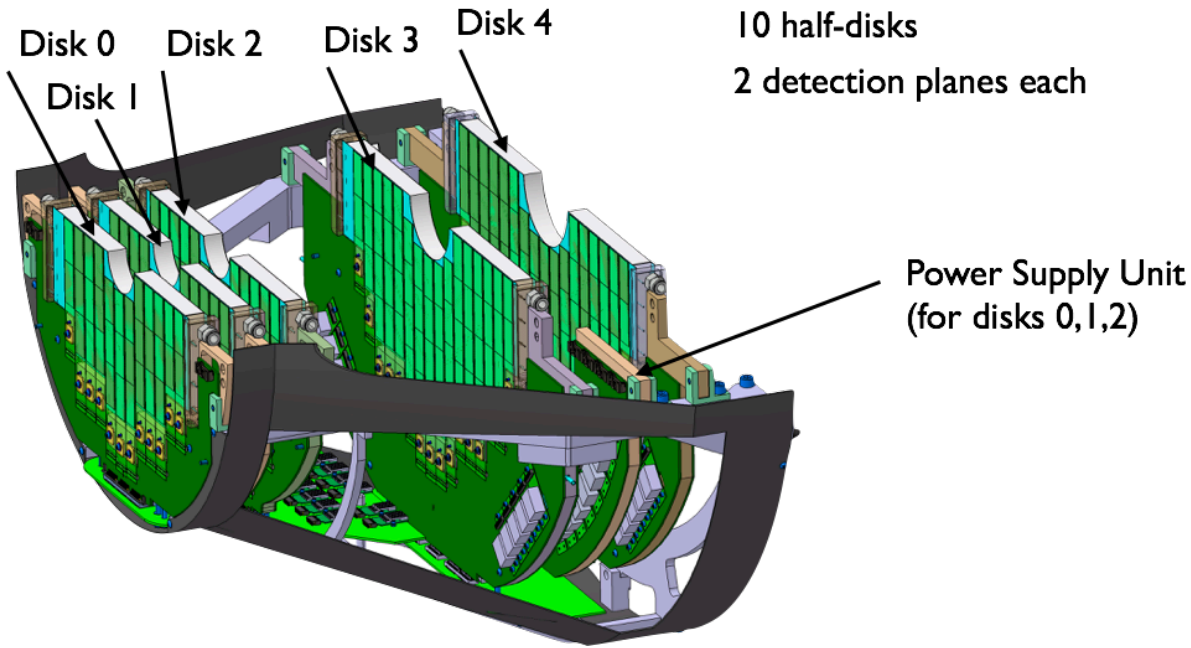
ITS Upgrade



Based on MAPS

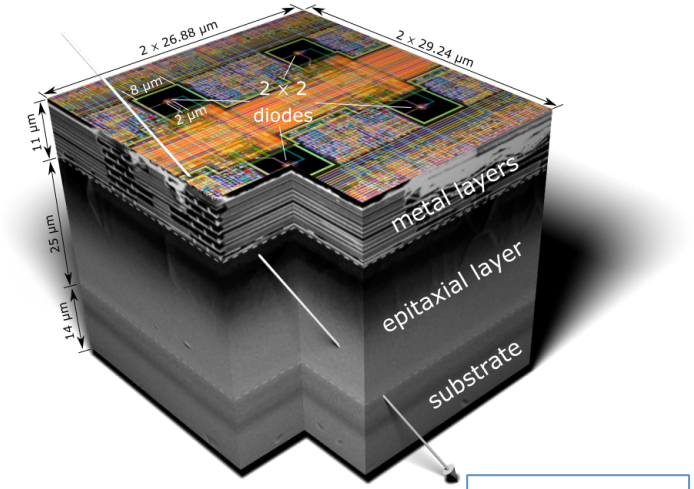
- 7-layer geometry (23 – 400mm), $|\eta| \leq 1.5$)
- 10 m^2 active silicon area (12.5 G-pixels)
- Pixel pitch 28 x 28 μm^2
- Spatial resolution ~5μm
- Power density < 40mW / cm^2
- Material thickness: ~0.3% / layer (IB)
- Max particle rate: 100 MHz / cm^2

New Muon Forward Tracker



- new Si pixel tracker
  - same technology as ITS
- in front of muon absorber
  - $2.35 < \eta < 3.6$
- 280 ladders
  - 2 to 5 sensors each
- 928 pixel sensors (0.4 m^2)
  - ~ 5% of ITS surface

Production of Monolithic Pixel Chip

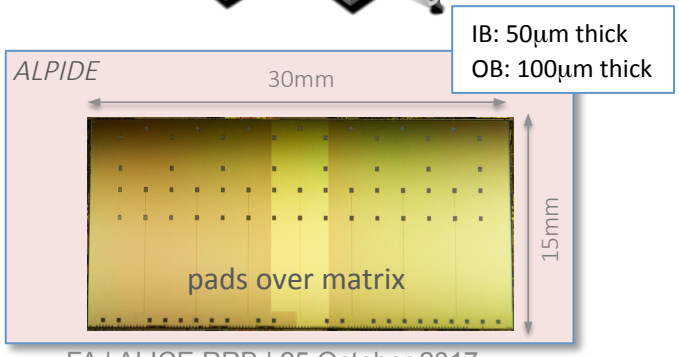


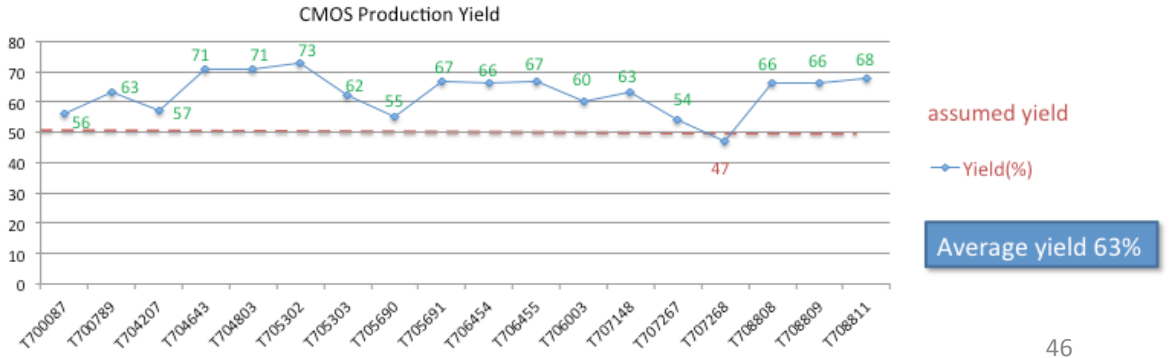
Production Status	Nr. wafers	Nr. chips
delivered	560	24840

Full production: 1200 wafers

Production proceeds smoothly
Throughput ⇨ > 100 wafers/month

⇨ Production will continue till Feb 2018





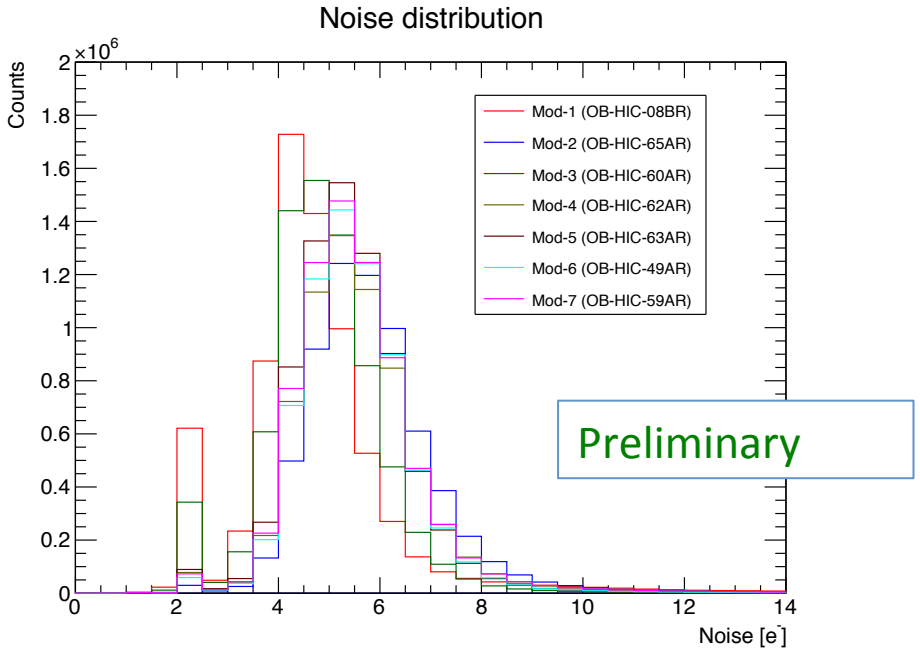
Module and Stave Pre-series

Performance of first full staves (stave-0 and stave-1)

51 Million pixel

Each half-stave is an independent system (power and readout)

Noise figure same as for standalone chip

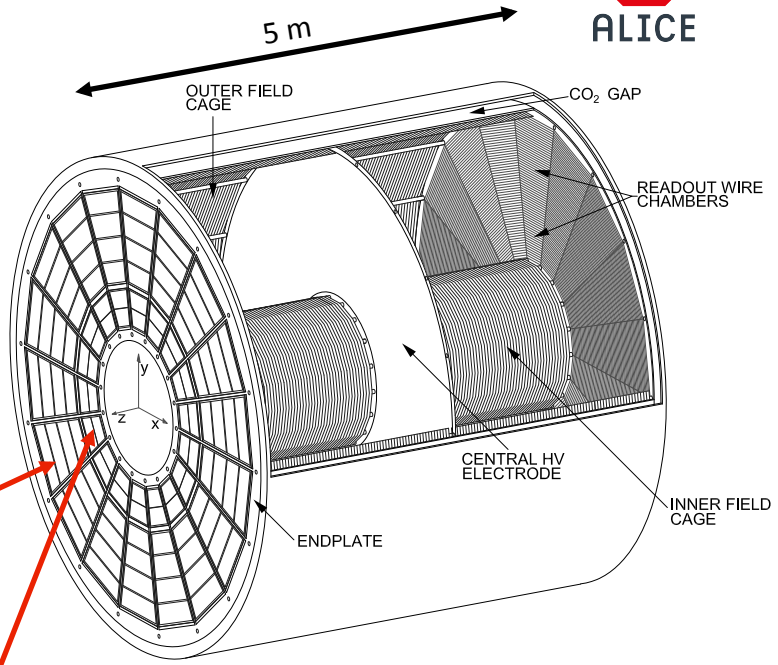


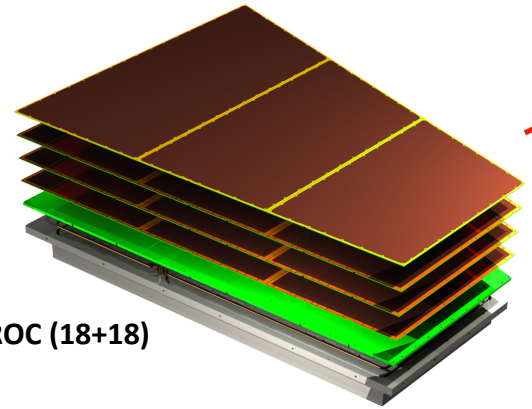
Preliminary

TPC Upgrade

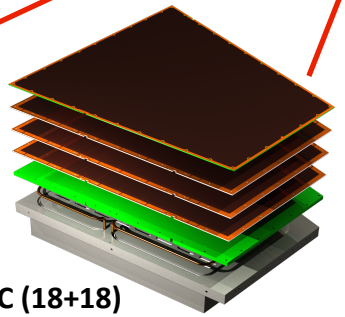
- Goal: replace existing MWPC-based Readout Chambers and Front-End Electronics in LS2 to allow **continuous readout** of Pb-Pb collisions at 50 kHz in RUN3 and 4

- Technical solution: **4-layer GEM** detectors

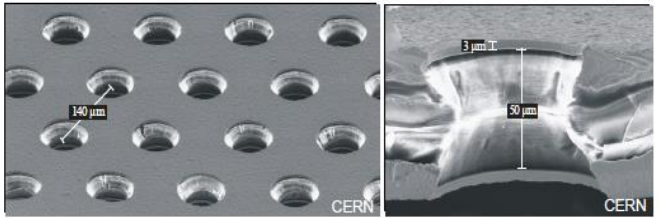




OROC (18+18)



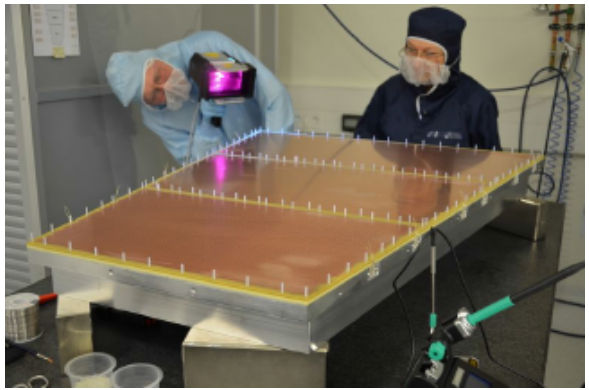
IROC (18+18)

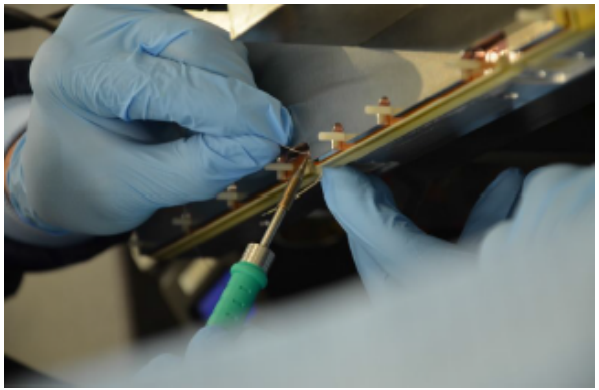


Electron microscope photograph of a GEM foil

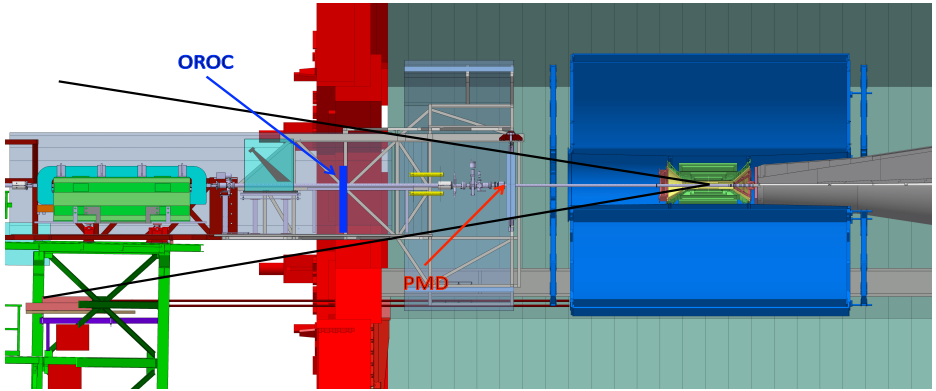
GEM and Readout Chamber production

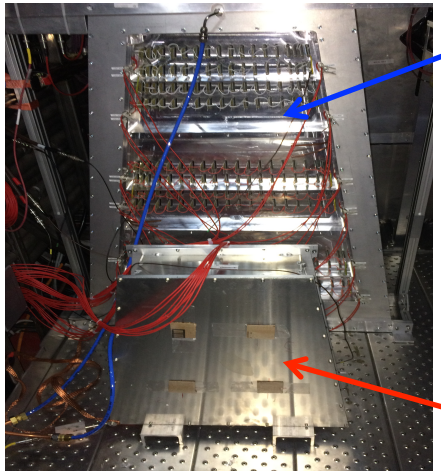
- almost **50% of GEM foils** produced in CERN PCB workshop (total 720)
- RO Chamber assembly ongoing, **first 5 final chambers** completed and tested
- **completion** of Readout Chamber production in **August 2018**



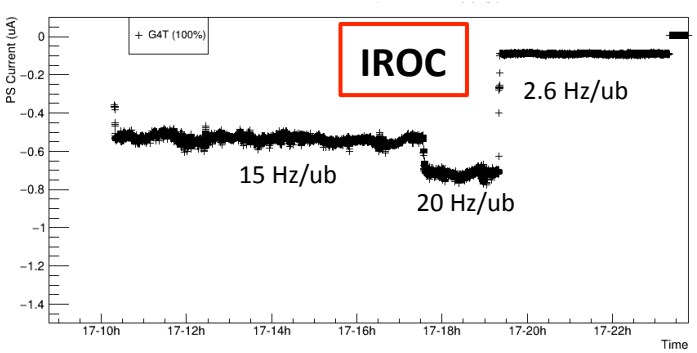


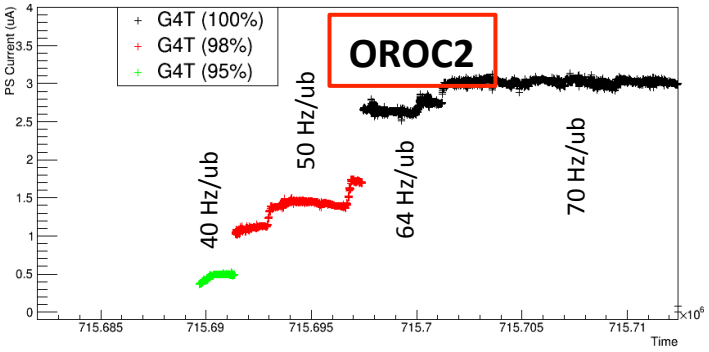
ROC tests at P2





- IROC and OROC in cavern at P2 (pp up to 70 Hz/μb)
- 100‘s hrs stable operation

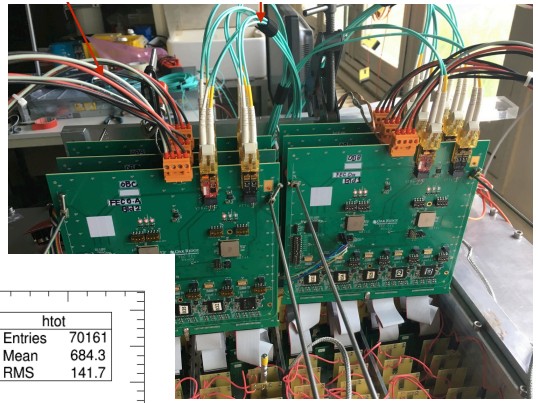


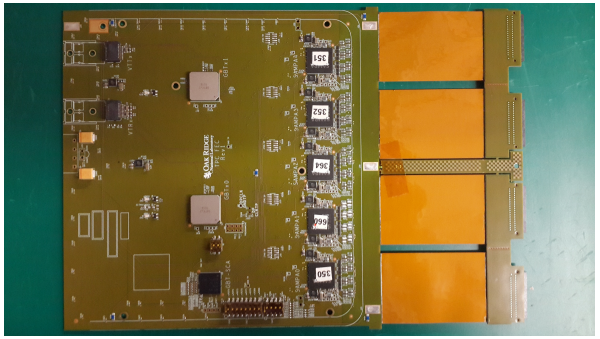


Front-End Electronics

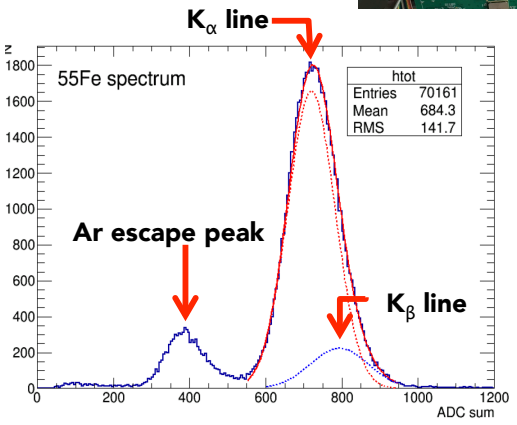
- New Front-End Electronics with SAMPA ASIC for **continuous data readout**
- SAMPA + FEC + IROC system test shows **very good noise behavior** in the lab and at the PS beam

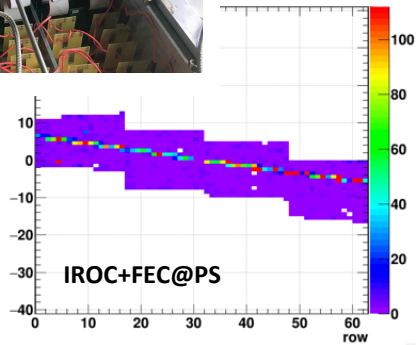
6 Front-End Cards mounted on IROC



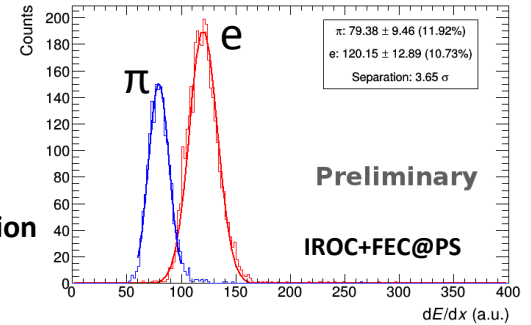


FEC Rev1



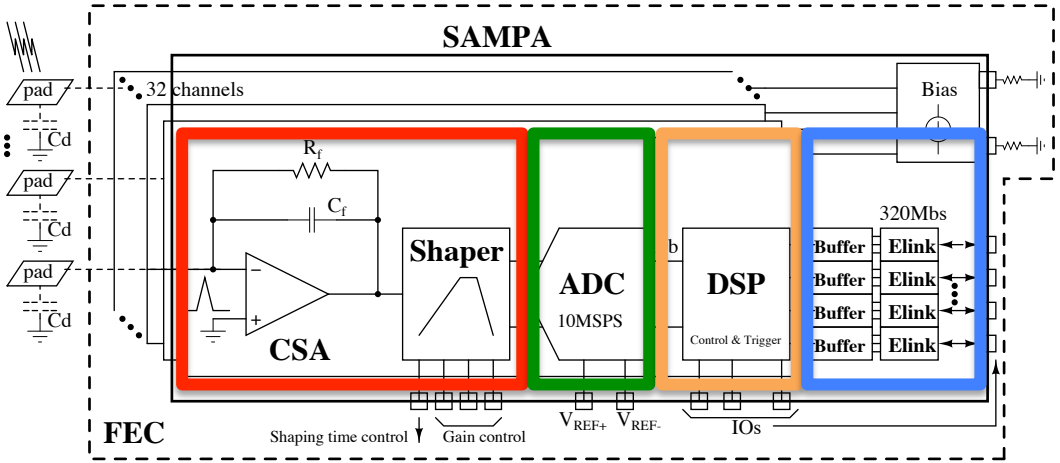


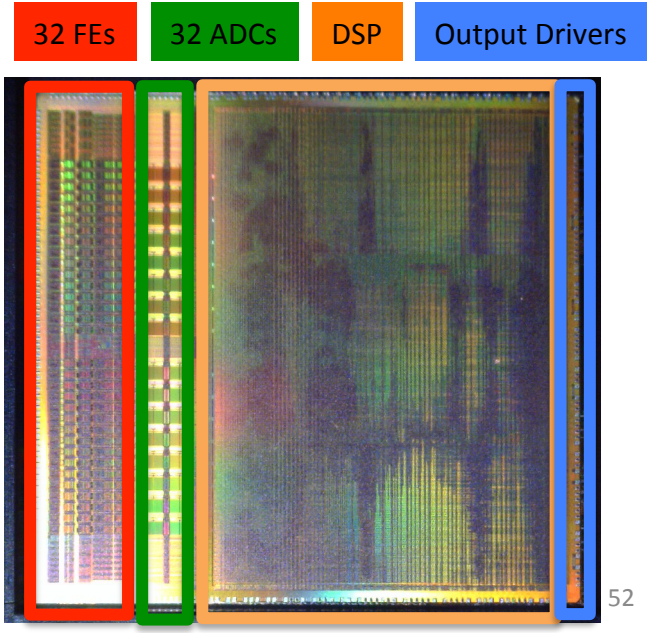
e-π separation at 1 GeV/c



Front-End Electronics

- SAMPA v3
  - delivery at CERN on 19/10
  - ADC: performance improvement
  - Bandgap: performance improvement
  - Digital: single event latchup sensitivity improvement
- SAMPA v4
  - delivery at CERN expected today!
  - In addition to V3, high input rate improvement





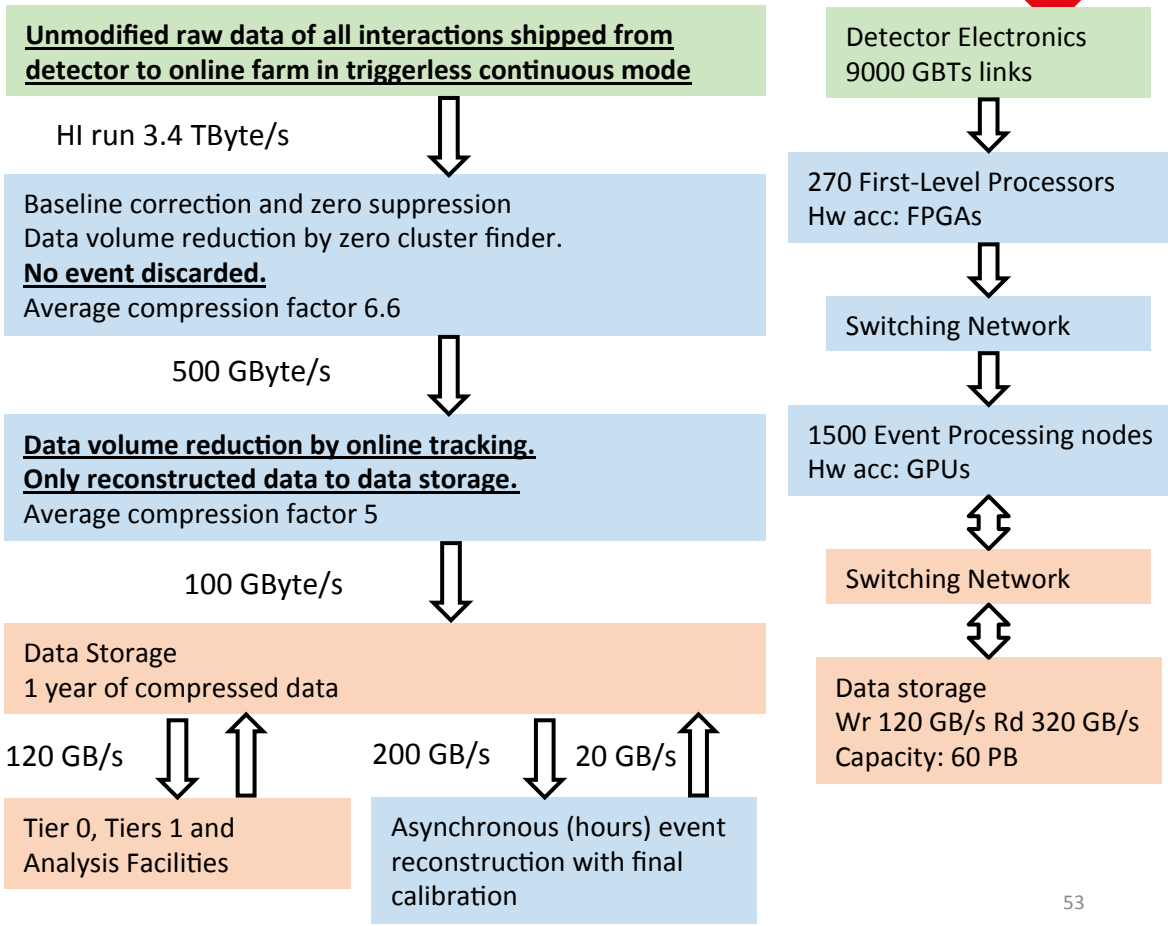
O^2 System

Requirements

1. LHC min bias Pb-Pb at 50 kHz
2. very small signal over background
   → triggering not possible
3. support for continuous read-out

New computing system

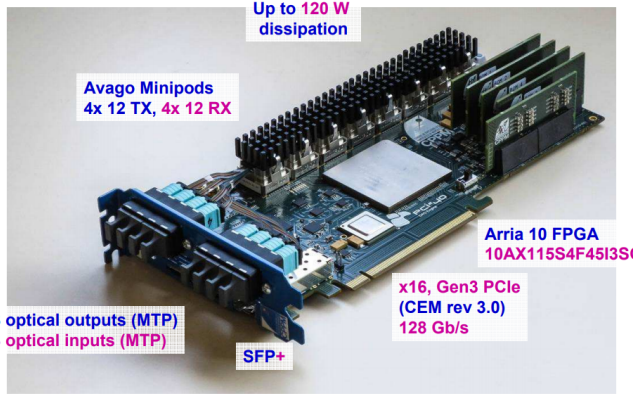
➔ read-out the data of all interactions
➔ compress data intelligently
   → online reconstruction
➔ common online-offline computing system
   → O^2

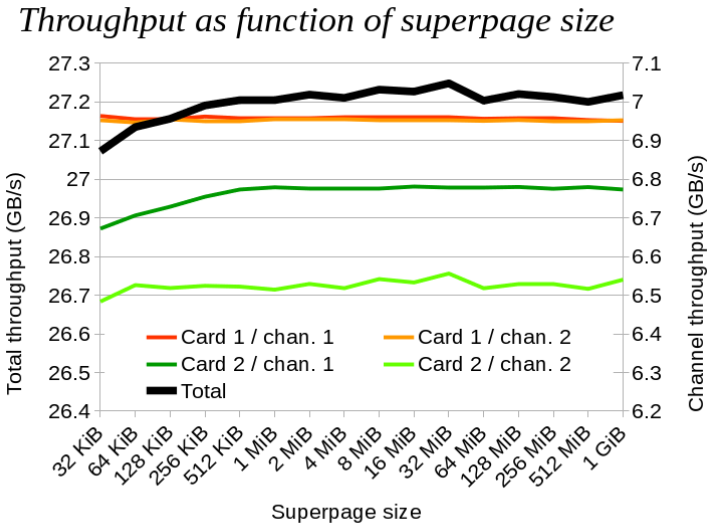


O^2 Software and Firmware Detector read-out

- Performance test with 1 FLP and 2 CRUs each with two channels PCIe Gen3 x 8
- Measured channel throughput 6.50 - 6.95 GB/s out of a maximum of 7.8 GB/s
- Total bandwidth of 27 GB/s (20 GB/s is needed for the TPC without data compression)

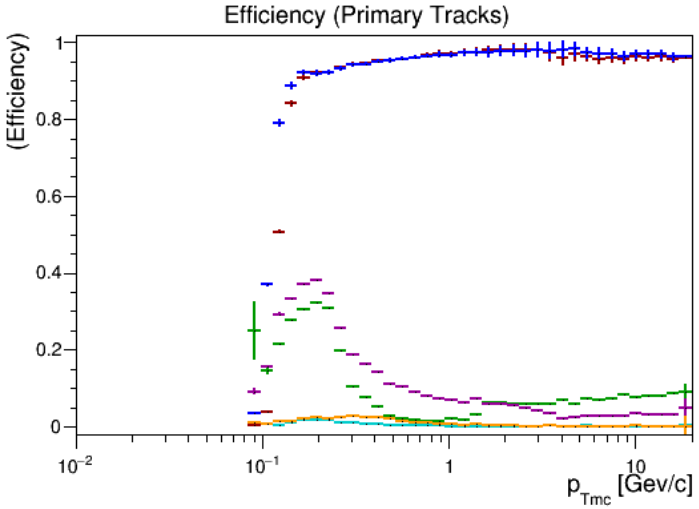
- First detector readout test with GBT and CRU performed with the ITS Read-out Unit
- Test in progress with the TPC FEC

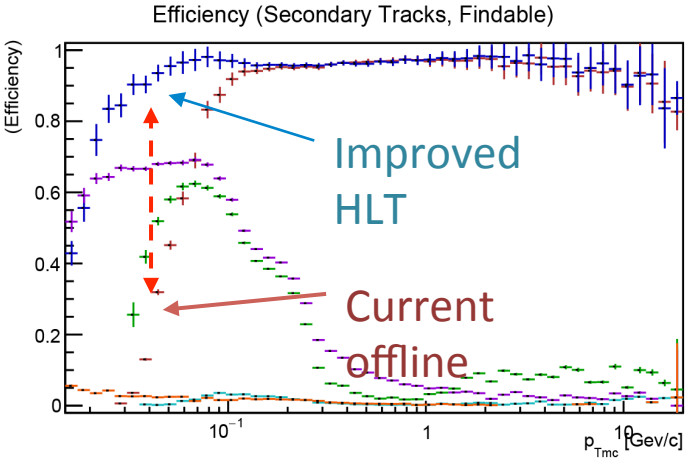




O^2 Software
Tracking and Data Compression

- TPC tracking
  - HLT TPC tracking code adapted to the O^2 framework including many improvements
  - Efficiency already equivalent to that of current reconstruction (or better at low p_T)
  - More development under way to improve resolutions, particularly in Pb-Pb
- TPC data compression : target factor ~20 wrt TPC zero-suppressed data
  - Requires good efficiency for secondary tracks
  - Thanks to a better noise suppression and some format optimization the current compression was improved by 40% (5.18 → 7.28).
  - With improved data representation and compression the reduction factor is now at 9.1
  - The remaining factor ~2 is being pursued with two approaches to discard clusters part of unusable tracks



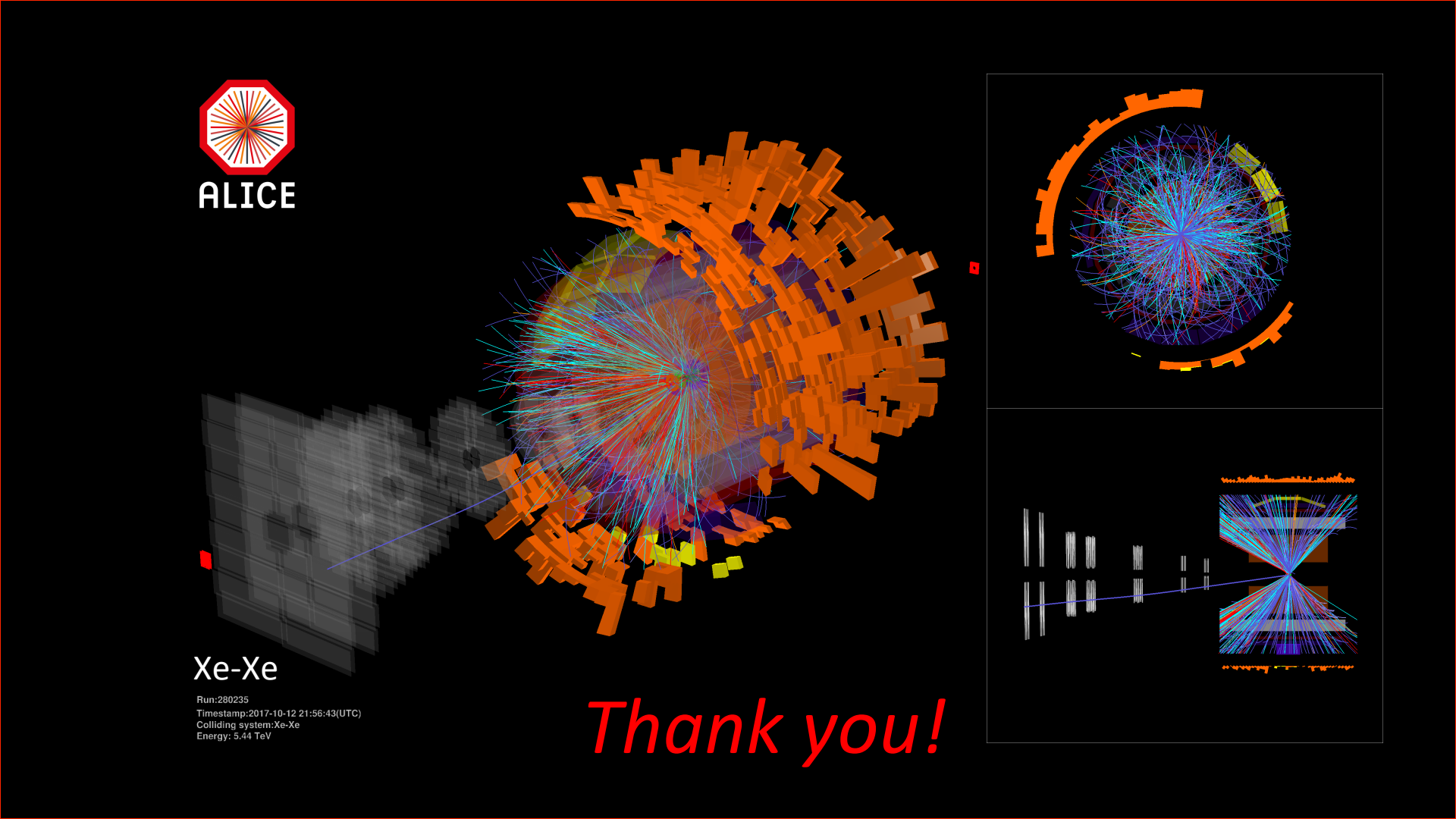


Conclusions

- Run 2 data collection proceeds smoothly

- physics harvest continues!
  - new insights on QGP properties
    - expansion, hadronisation
    - response to initial geometry
    - transport of heavy quarks
    - response to magnetic field
  - new insights on collective effects in small systems
    - systematics of strangeness enhancement
    - indications of collective effects for D, J/ψ
  - new measurements in pp collisions
    - multiplicity and event-shape dependence of p_T spectra (→ MPIs)
    - proton pair correlations
    - heavy flavour production

- all upgrade projects have entered construction phase
  - proceeding according to plans
  - little more than one year to go to LS2!!!


ALICE
Xe-Xe
Run:280235
Timestamp:2017-10-12 21:56:43(UTC)
Colliding system:Xe-Xe
Energy: 5.44 TeV
Thank you!