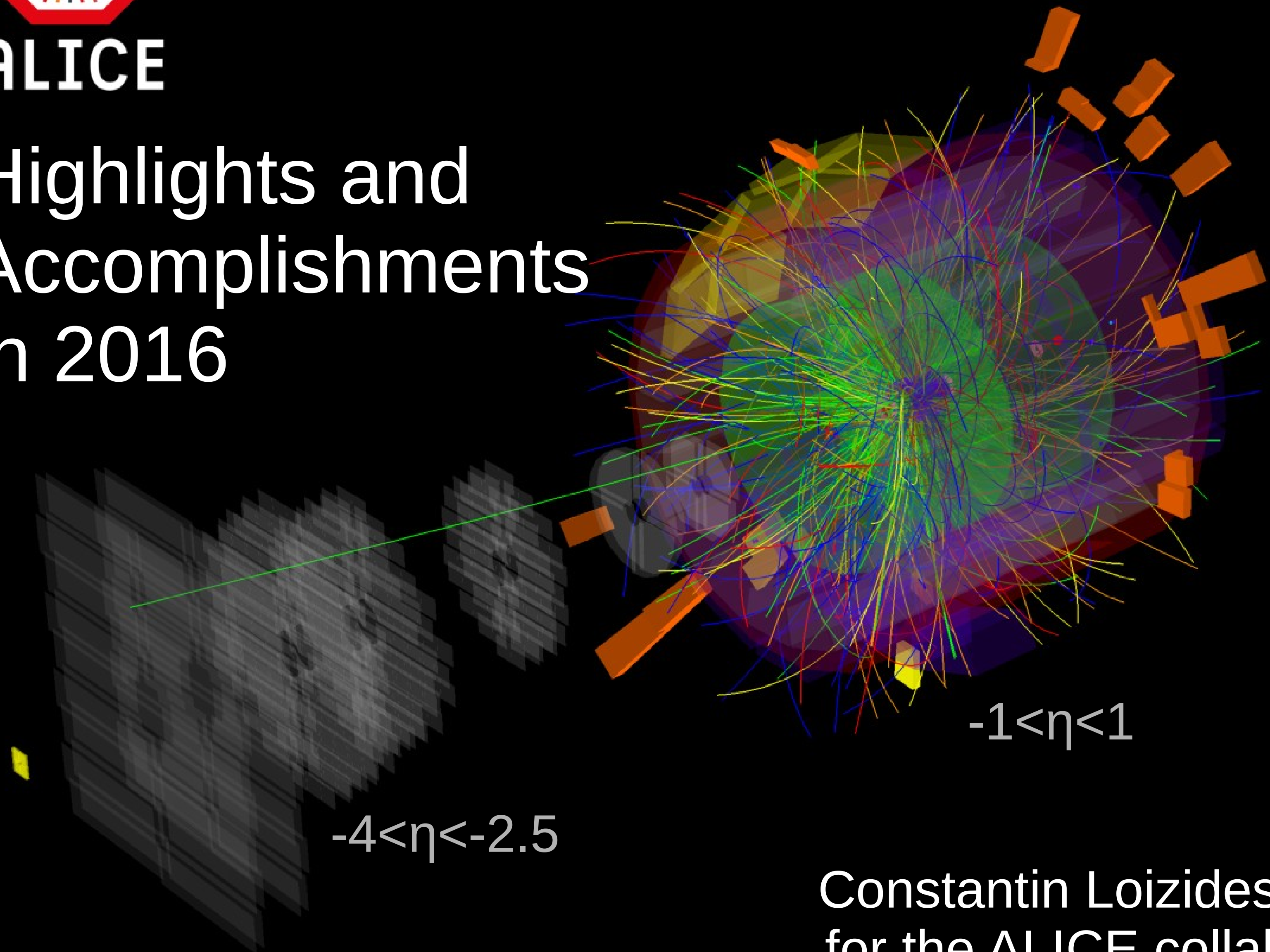
ALICE

Highlights and Accomplishments in 2016



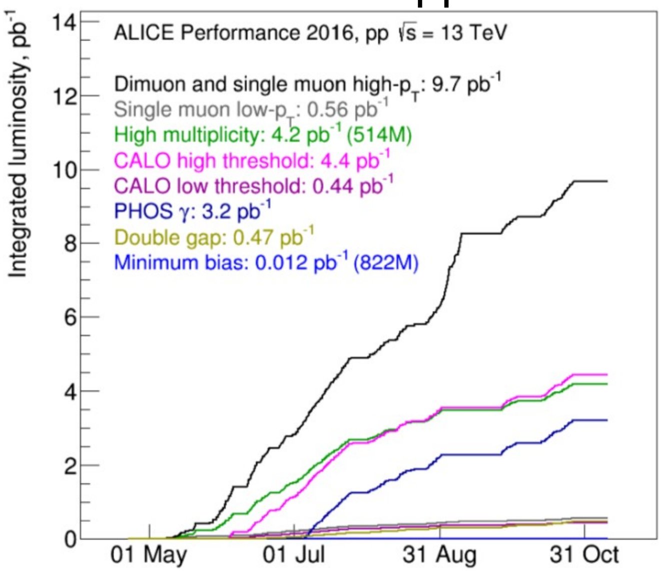
Constantin Loizides (LBNL)
for the ALICE collaboration

16 Dec 2016, Council meeting

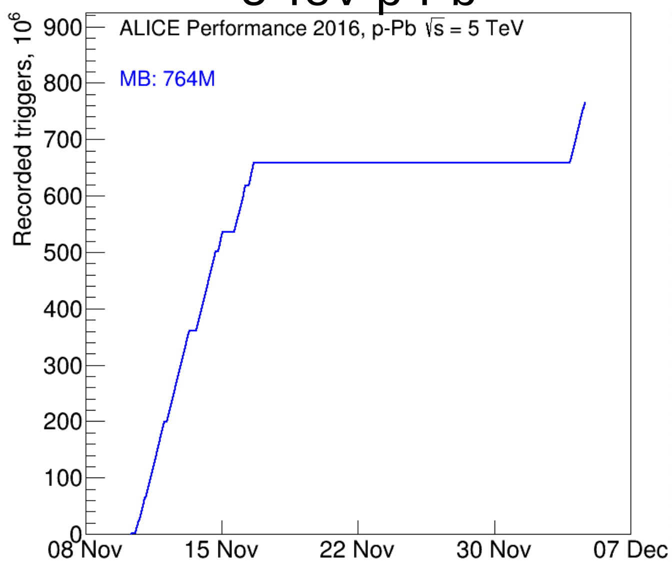
Run:265338
Timestamp:2016-11-11 02:02:08(UTC)
Colliding system:p-Pb
Energy: 5.02 TeV

2 LHC Run-2 datasets

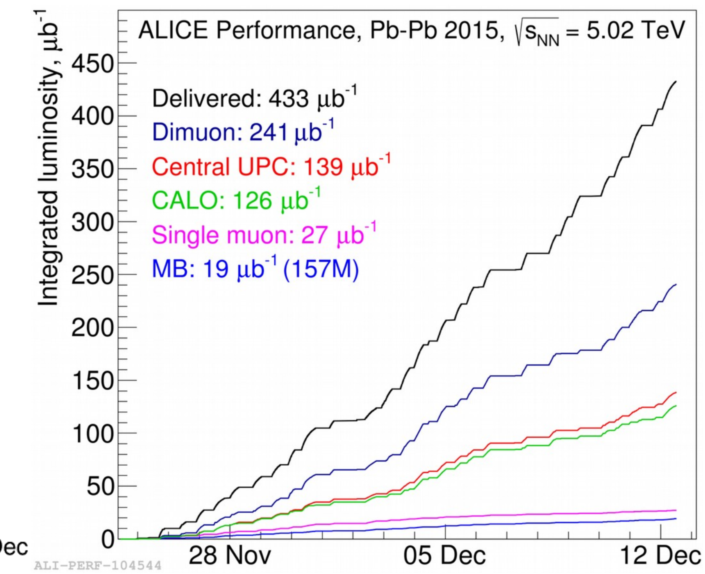
13 TeV pp



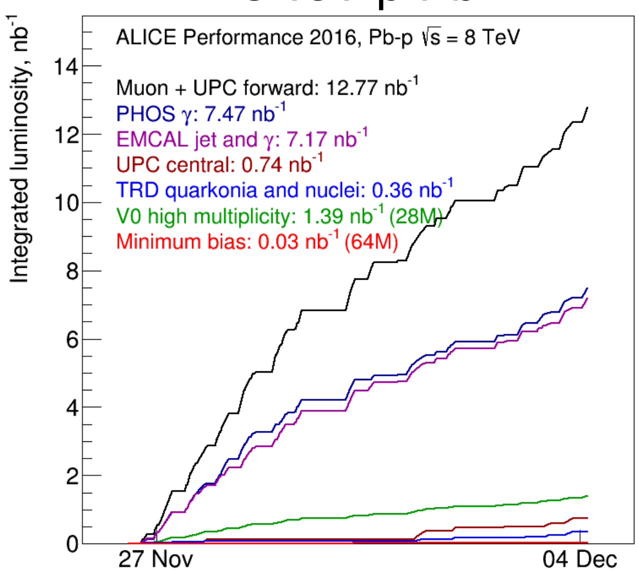
5 TeV p-Pb



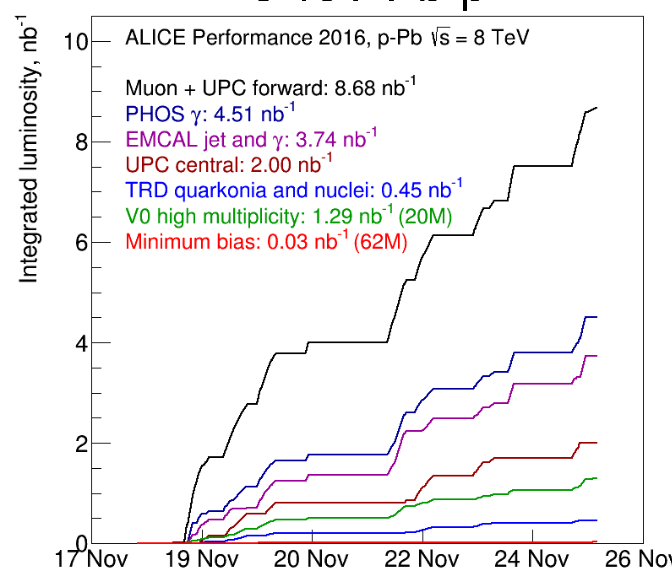
5 TeV Pb-Pb



8 TeV p-Pb



8 TeV Pb-p



- Versatile and challenging trigger mix
- Extremely stable operations
  - Thanks to CERN accelerator teams
  - ALICE efficiency > 90%

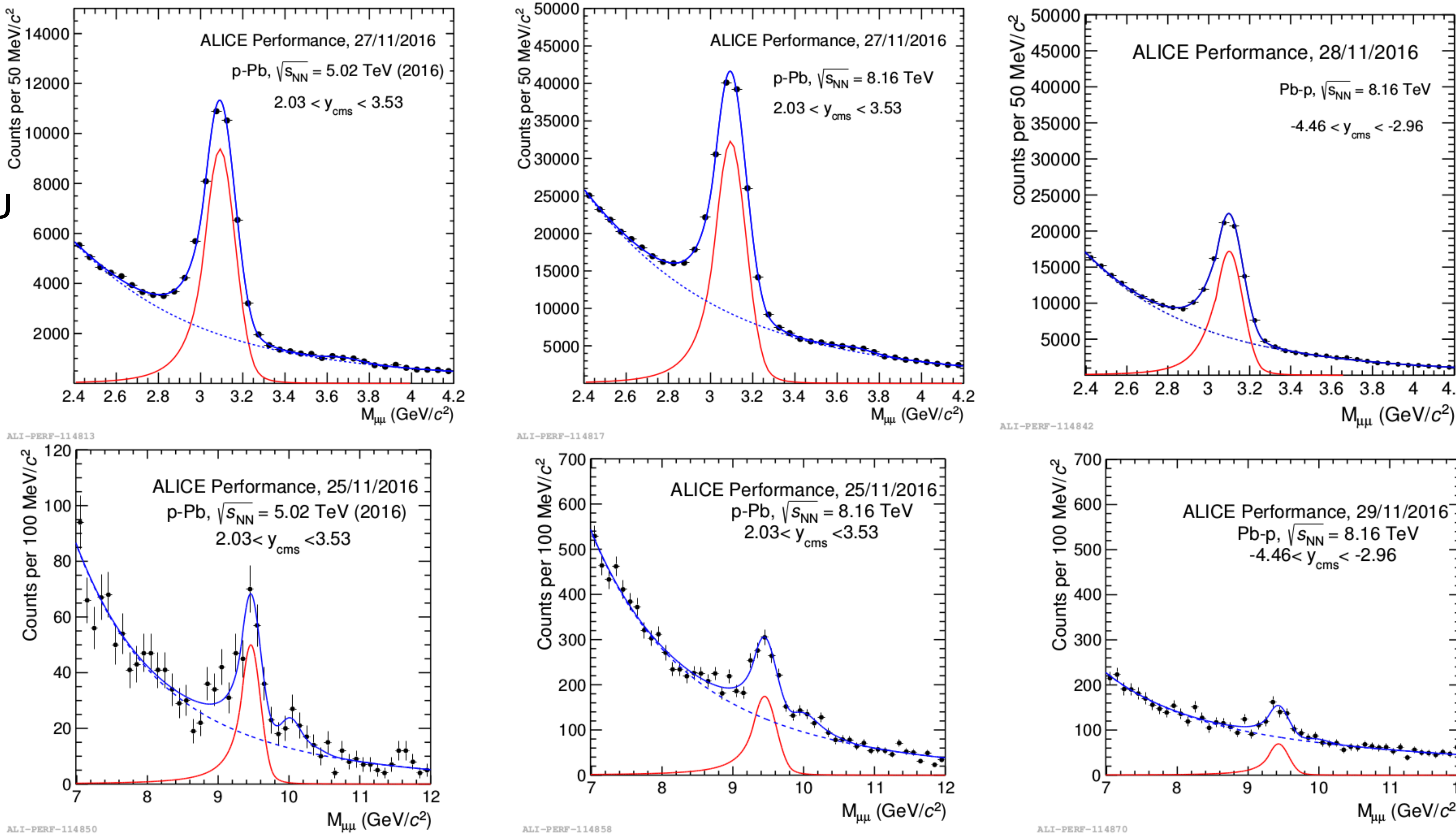
Datasets taken end of 2015 and 2016 are 7-8x larger than those from Run-1

3 Performance (from fast muon/calo reco)

p–Pb, 5.02 TeV | **p–Pb, 8.16 TeV** | **Pb–p, 8.16 TeV**

J/ψ

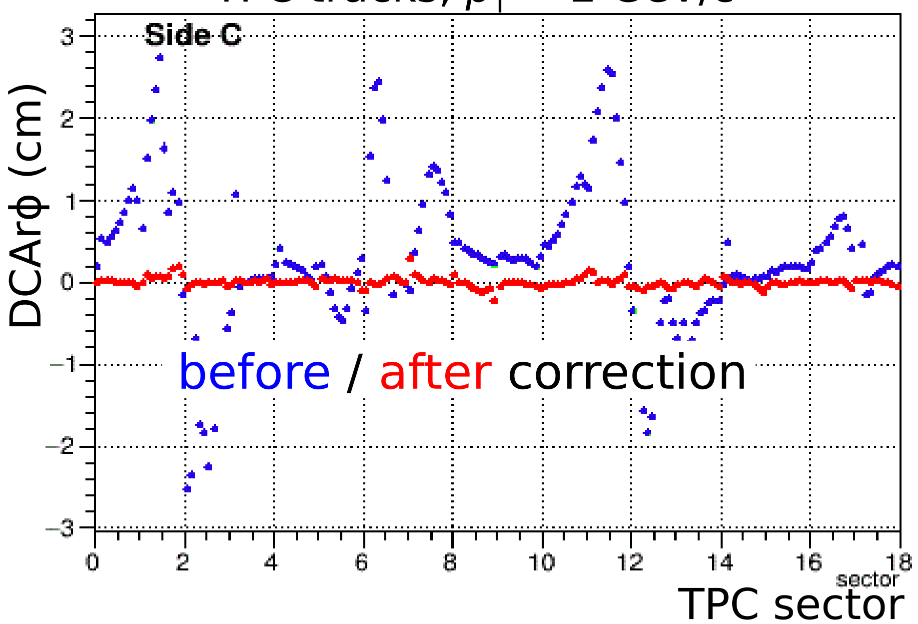
Υ



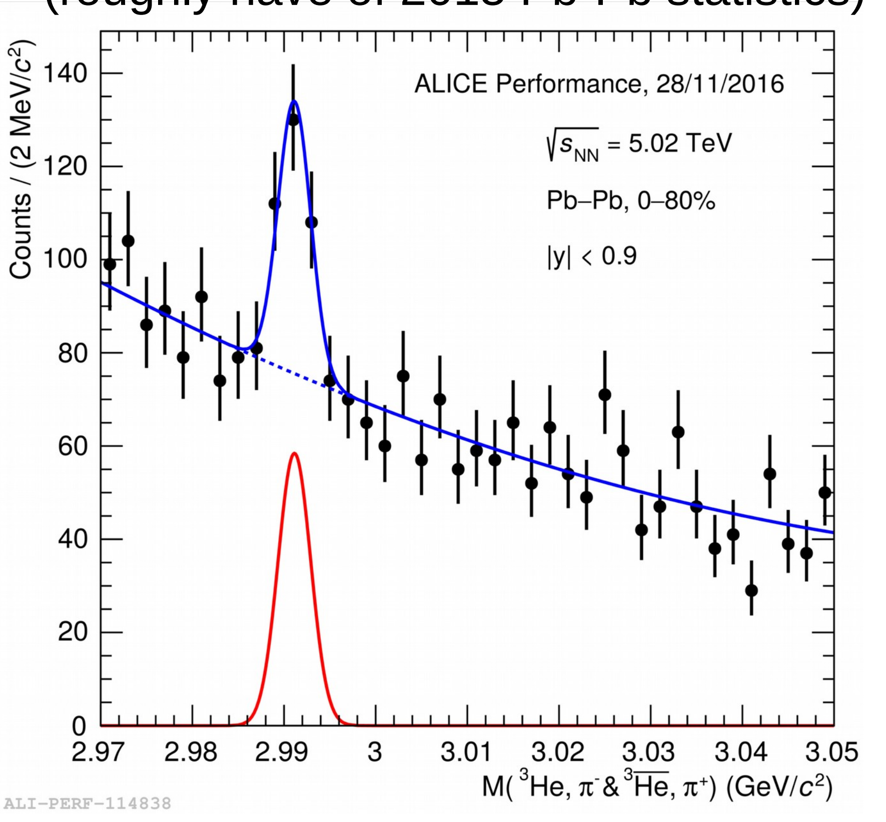
4 TPC space-charge distortion calibration

Pb-Pb 2015, IR = 4.7kHz

DCArφ vs TPC sector
TPC tracks, p_T > 2 GeV/c



Example: Hypertriton production
(roughly have of 2015 Pb-Pb statistics)

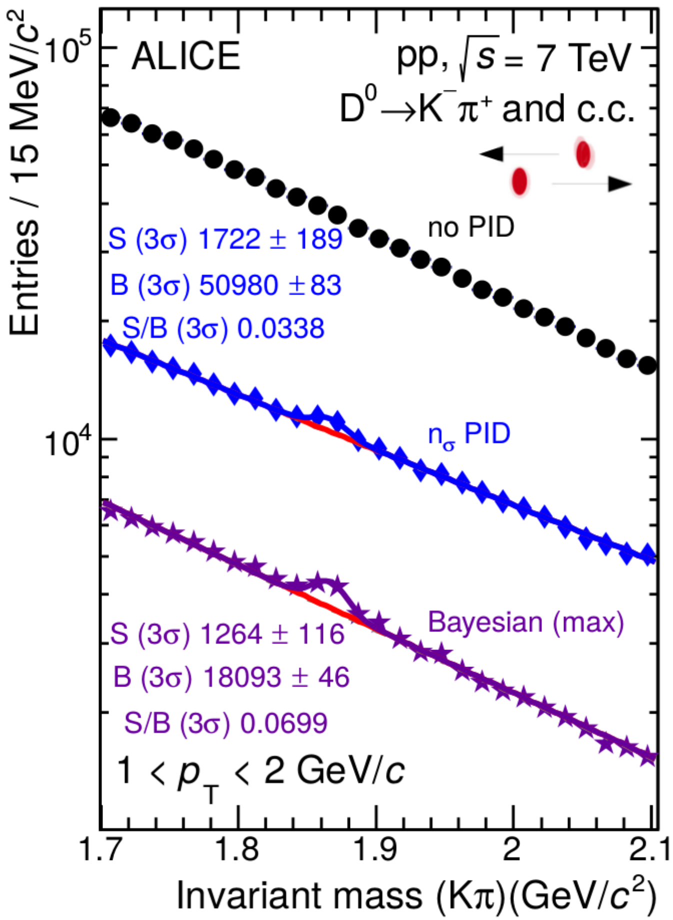


- Large space point distortions in Run2 located in edges of a few inner chambers (visible eg. in DCA distributions)
- Implemented time-dependent calibration scheme using inner (ITS) and outer (TRD+TOF) detectors
- Scheme originally foreseen for RUN3

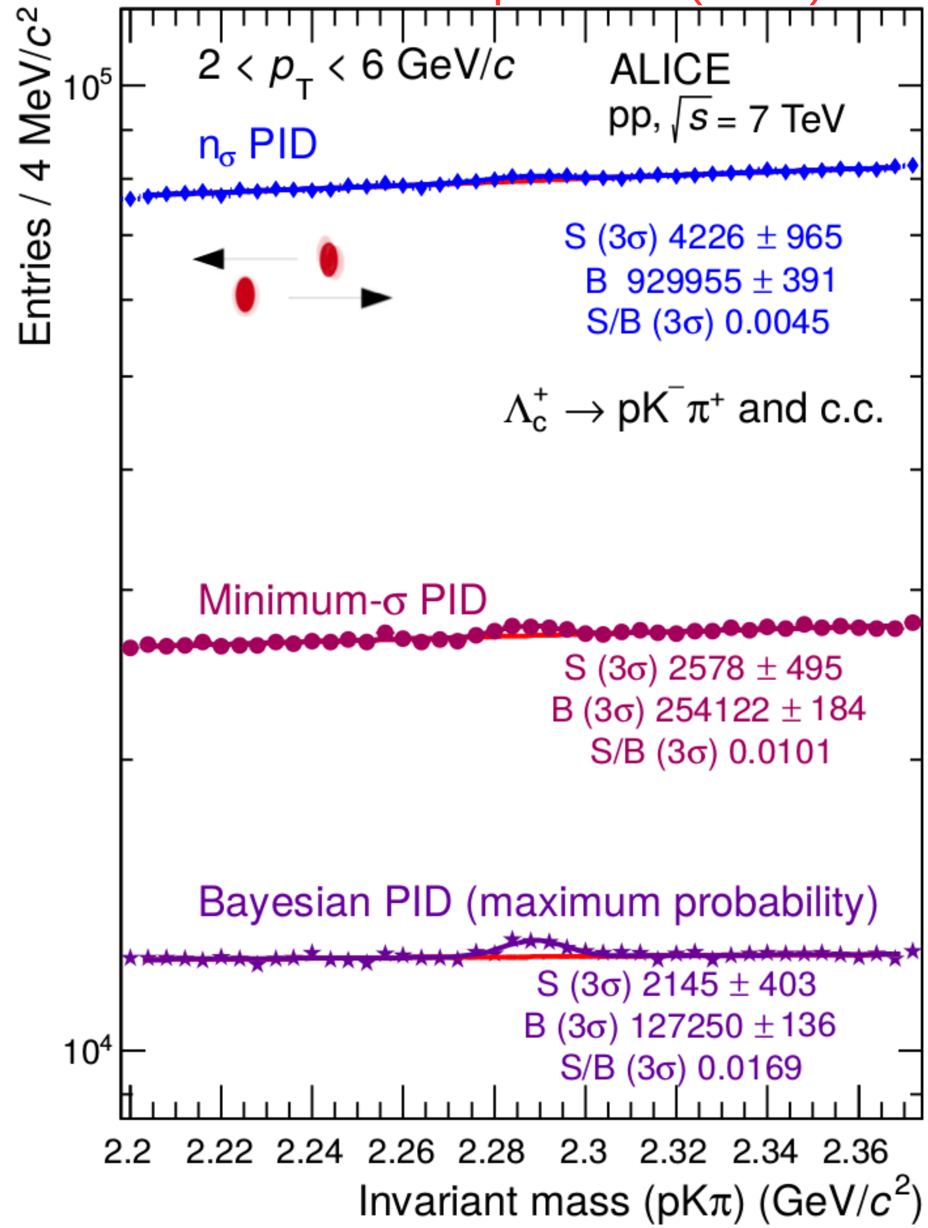
Intense effort over ~12 months resulted in effective calibration scheme!

5 Bayesian PID

- Generalized approach for usage of combined PID of various detectors
  - Standard approach “nSigma-cuts”
- Proof-of-concept for D-mesons

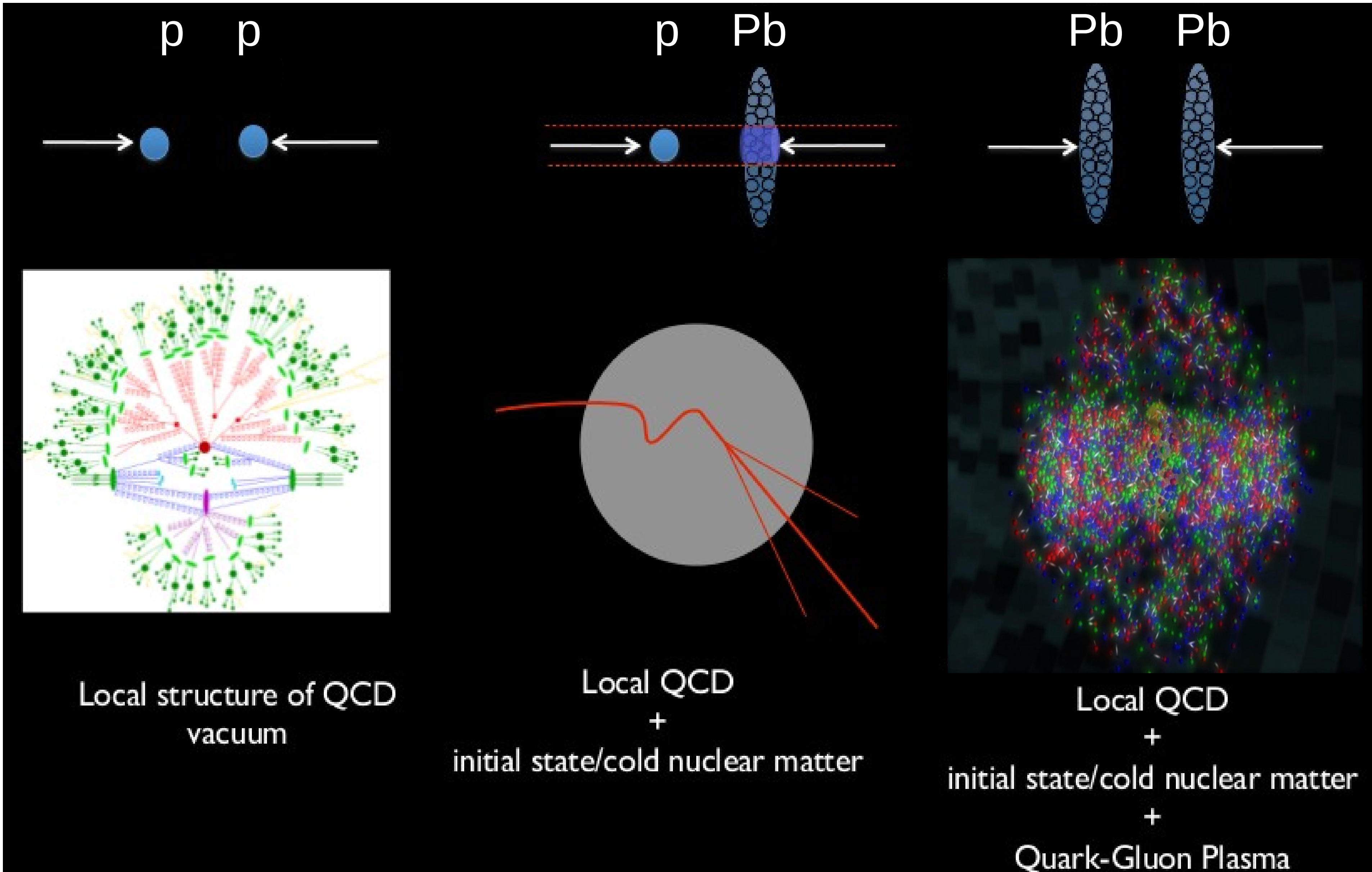


EPJplus 131 (2016) 168



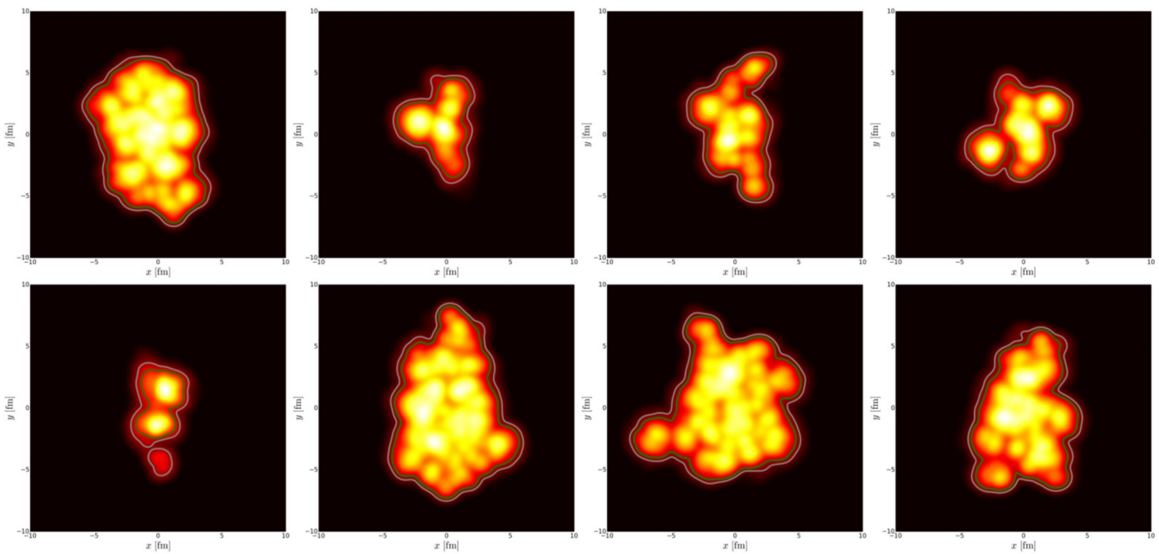
- Allows access to probes with worse S/B
  - $\Lambda c \rightarrow pK\pi$

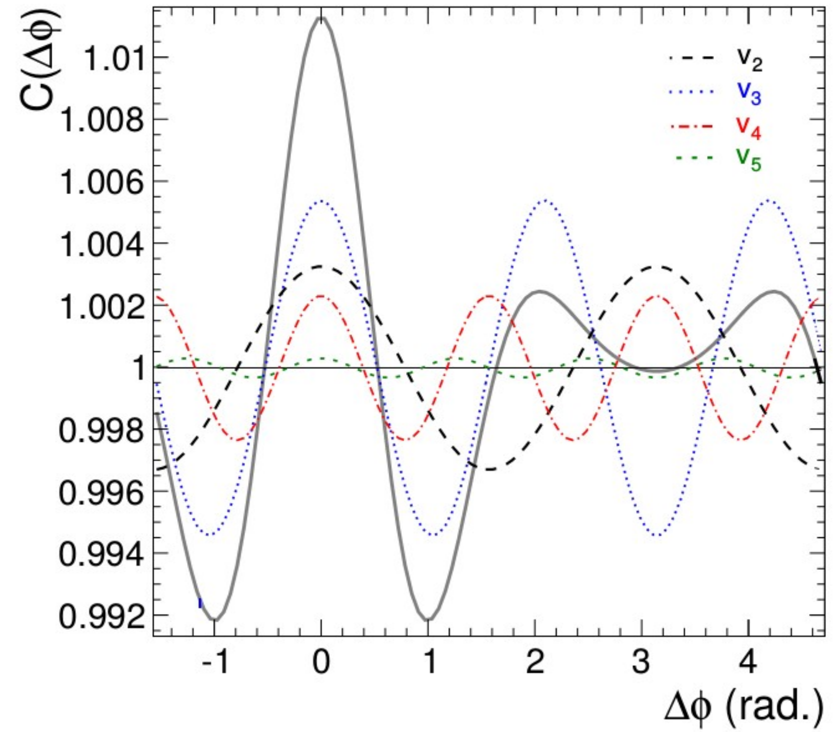
6 Scientific approach



7 Initial and final anisotropy

Temperature profiles in transverse plane
from hydrodynamical calculation (H. Niemi)





Initial spatial anisotropy
Eccentricity

→

Momentum space anisotropy
Flow

$$\epsilon_n e^{-in\varphi_n}$$

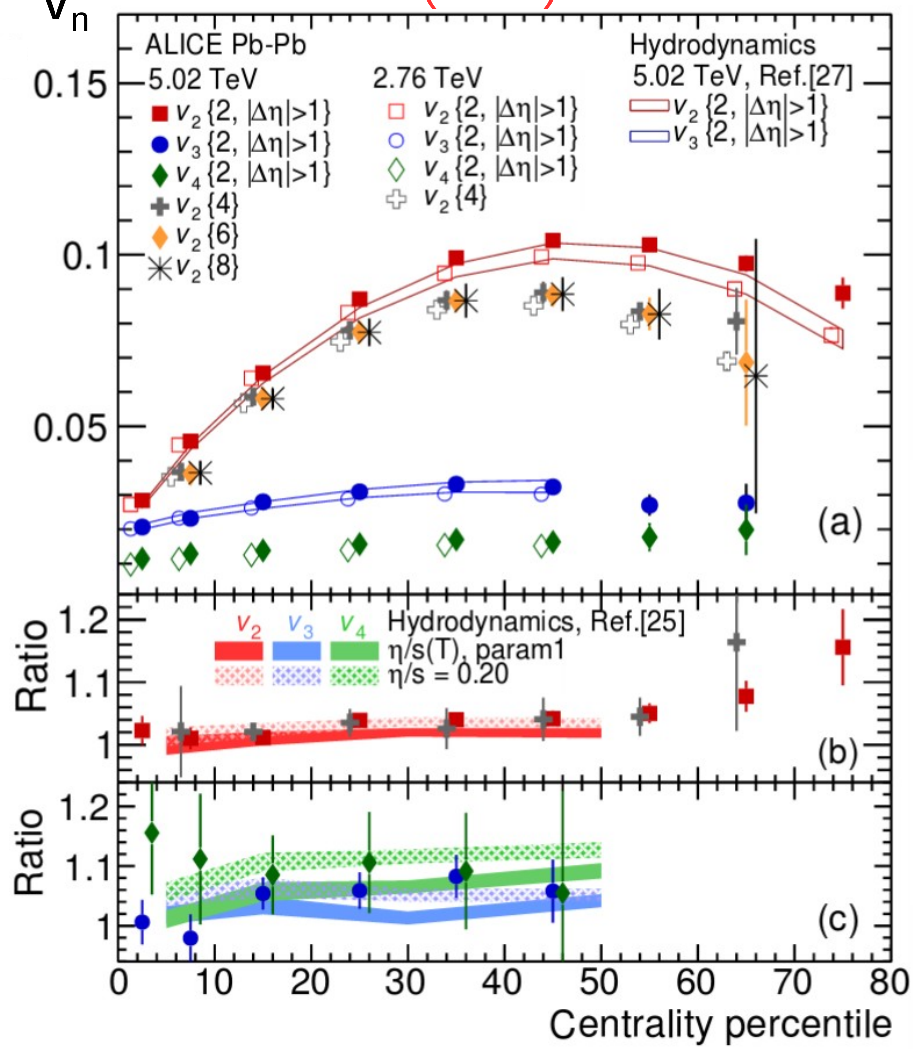
$$v_n = \langle \cos(2\varphi - 2\psi_n) \rangle$$

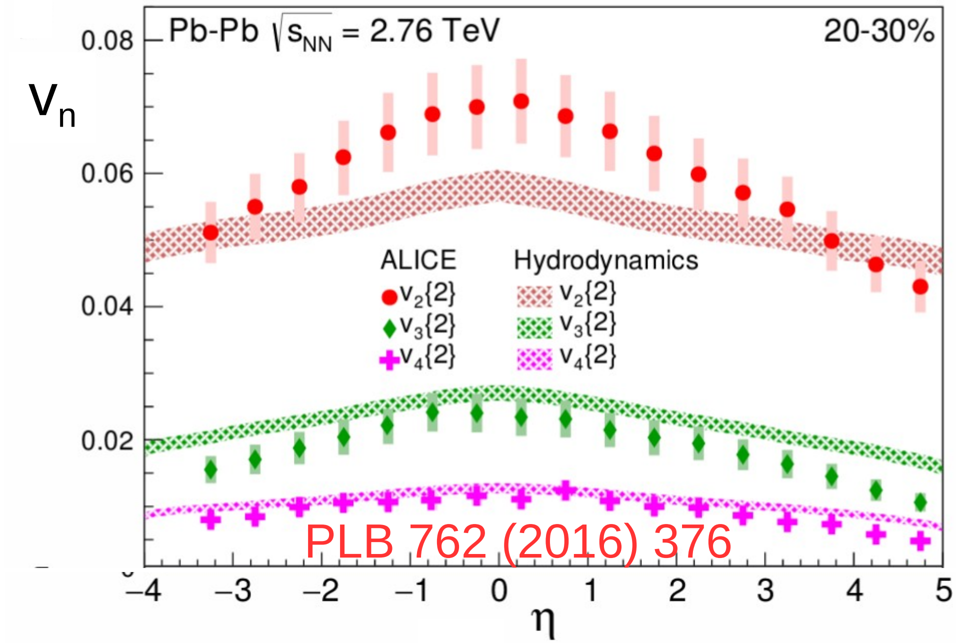
KSS bound

$$\eta/s > 1/4\pi \sim 0.08$$

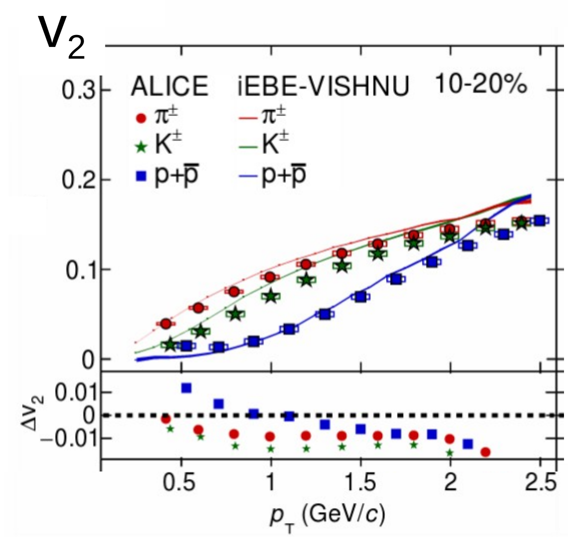
8 Latest "flow" results

PRL 116 (2016) 132302

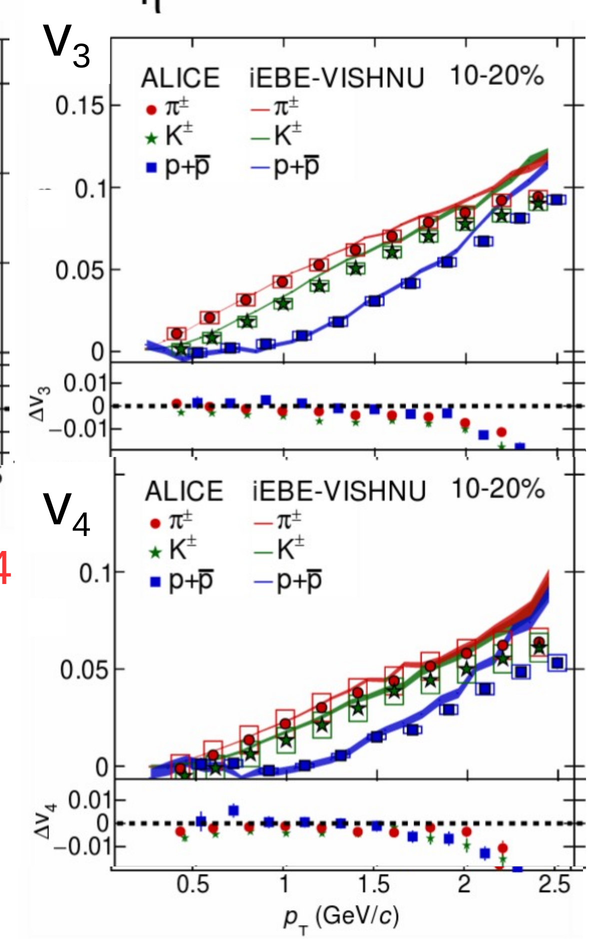




PLB 762 (2016) 376



JHEP 1609 (2016) 164

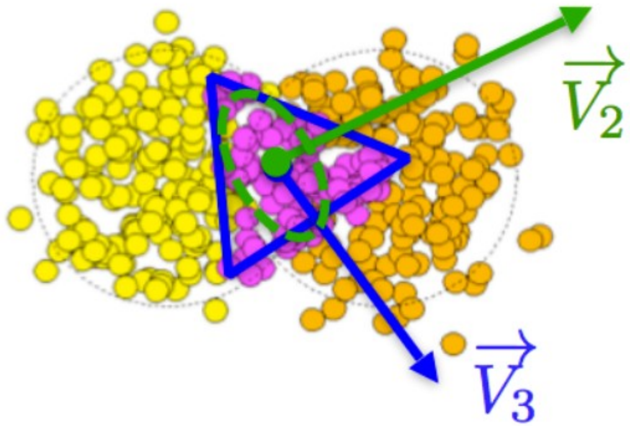


Wealth of new data for precision comparisons with hydro calculations and extraction of <η/s>

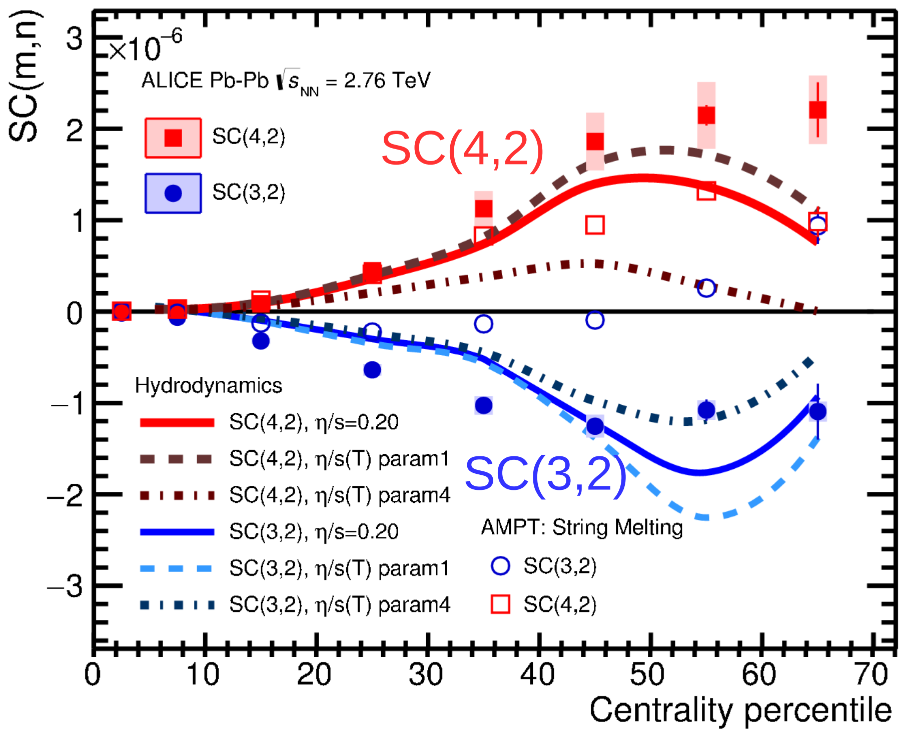
Correlation of anisotropic harmonics

- Measure relation between v_m and v_n via "Symmetric 2-harmonic 4-particle Correlations"

$$SC(m,n) = \langle v_m^2 v_n^2 \rangle - \langle v_m^2 \rangle \langle v_m^2 \rangle$$



- If SC(m,n)≠0 → (anti)-correlation
- Insensitive to
  - Non-flow effects
  - Inter-correlations of various symmetry plane angles



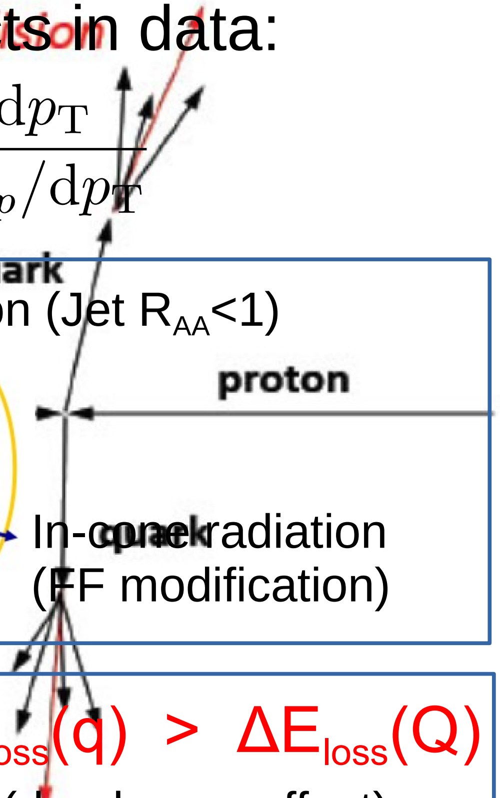
SC measurements are sensitive to the temperature dependence of η/s and initial conditions

PRL 117 (2016) 182301

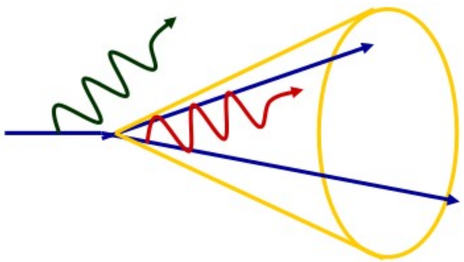
10 Jet quenching

Search for effects in data:

$$R_{\mathrm{AA}} = \frac{\mathrm{d}N_{AA}/\mathrm{d}p_{\mathrm{T}}}{N_{\mathrm{coll}}\,\mathrm{d}N_{pp}/\mathrm{d}p_{\mathrm{T}}}$$



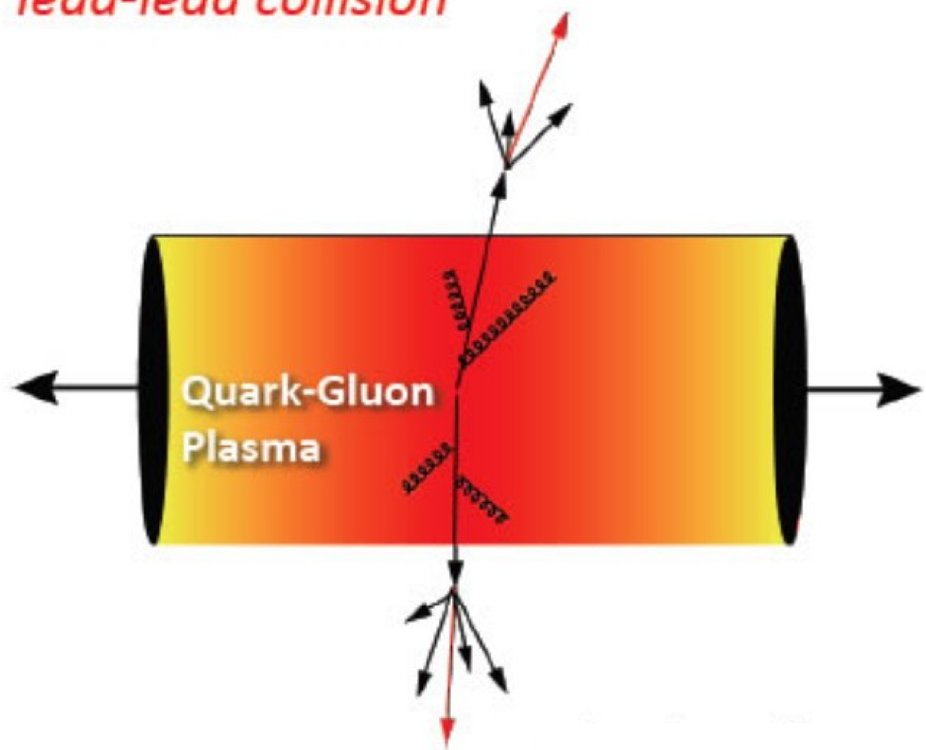
Out-of-cone radiation (Jet R_{AA}<1)



In-cone radiation (FF modification)

$\Delta E_{loss}(g) > \Delta E_{loss}(q) > \Delta E_{loss}(Q)$

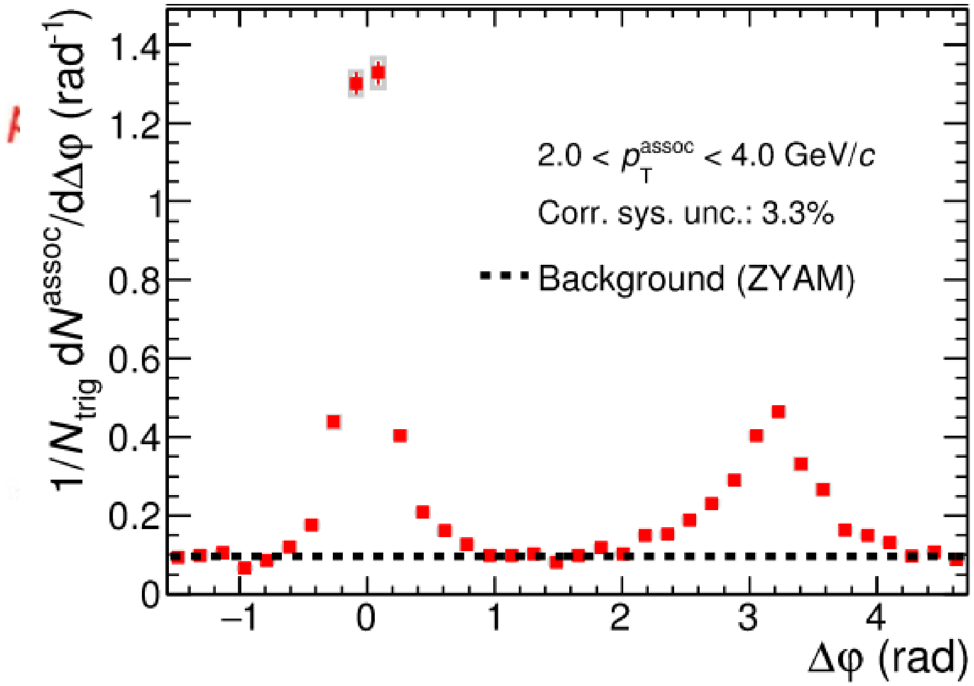
(color factor) (dead-cone effect)

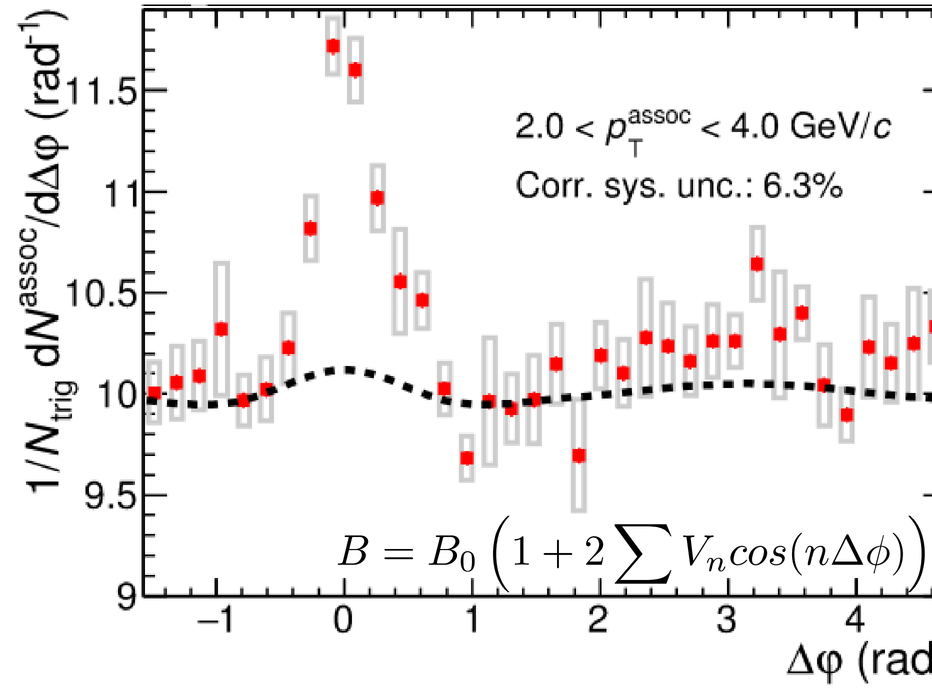


Compared to pp (vacuum) parton evolution in QGP affected by presence of many color charges which induce collisional and radiative energy loss:

→ Expected to change the inner structure, angular distribution and rate of jets

11 Jets via two particle correlations



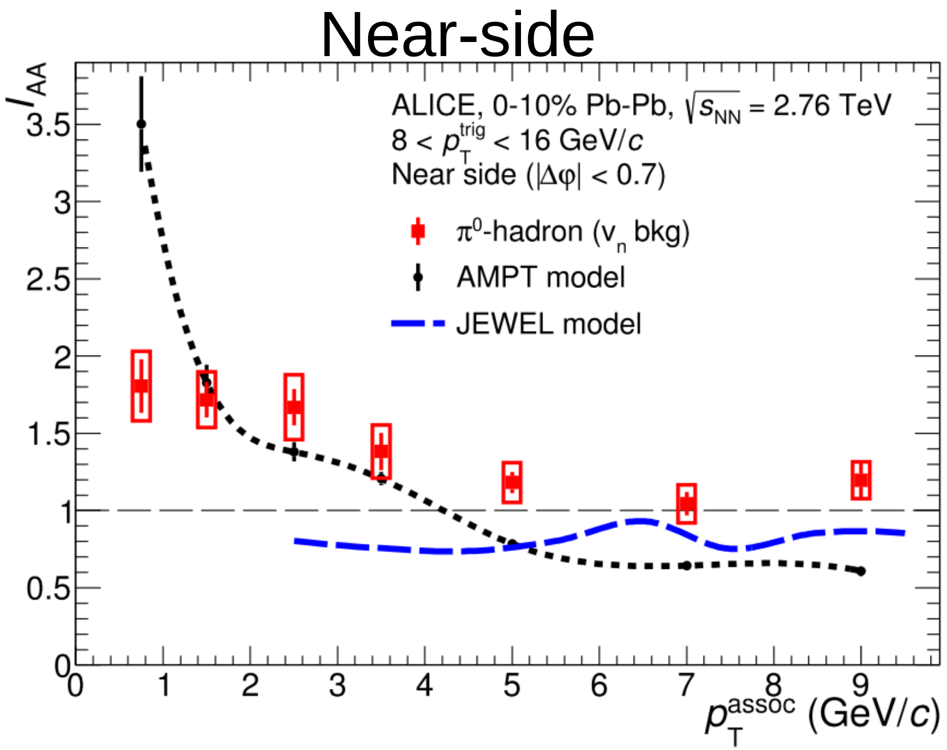


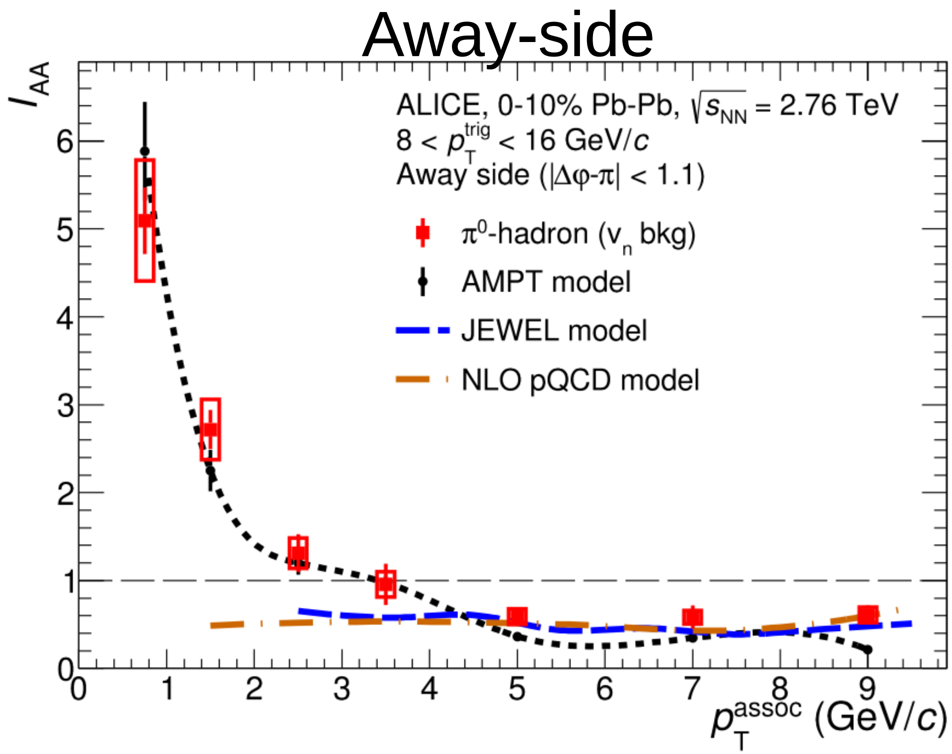
- Neutral pions as trigger particles
  - Measure associated charged hadron per-trigger yield J=Y-B
  - Compare to pp on <u>near-side</u> and <u>away-side</u> via

$$I_{\mathrm{AA}} = \frac{\int J_{\mathrm{AA}} \mathrm{d}\Delta\Phi}{\int J_{\mathrm{pp}} \mathrm{d}\Delta\Phi}$$

12 Per-trigger yield modification

PLB 763 (2016) 238-250



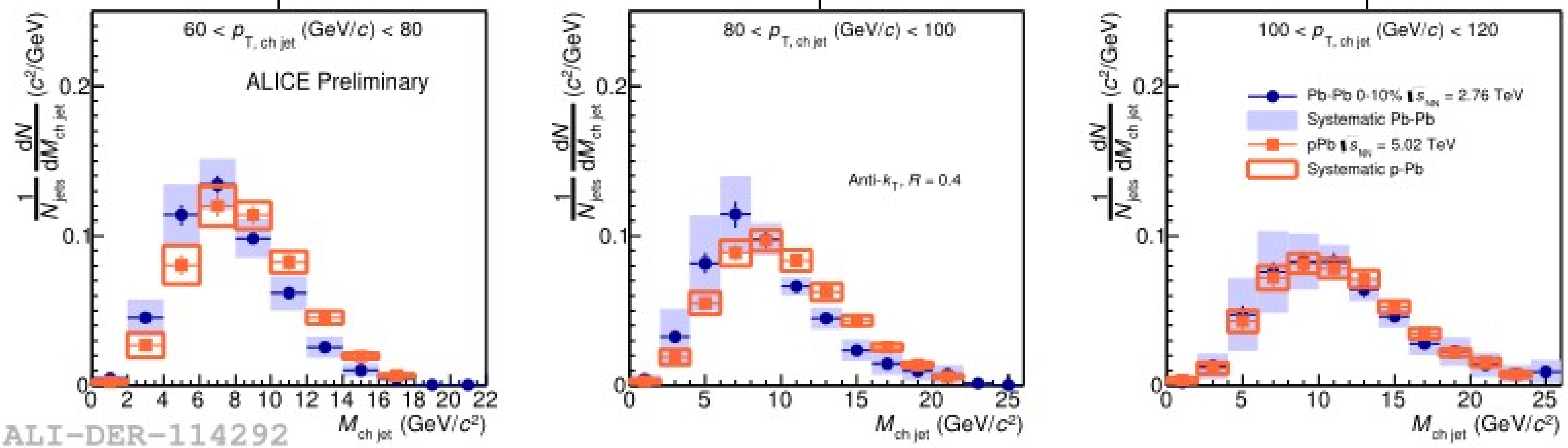


- Neutral pions as trigger particles
  - Measure associated charged hadron per-trigger yield J=Y-B
  - Compare to pp on near-side and away-side via $I_{\mathrm{AA}} = \frac{\int J_{\mathrm{AA}} \mathrm{d}\Delta\Phi}{\int J_{\mathrm{pp}} \mathrm{d}\Delta\Phi}$
- Enhancement at low p_T, and suppression on away-side for high p_T
  - Suppression well described by parton-energy loss calculations
  - Enhancement in AMPT from jet-medium interactions (but predicts suppression NS at high p_T)

13 Jet shapes: jet mass

New result for Hard Probes conference; to be submitted soon

$60 < p_T^{jet} < 80$ $80 < p_T^{jet} < 100$ $100 < p_T^{jet} < 120$



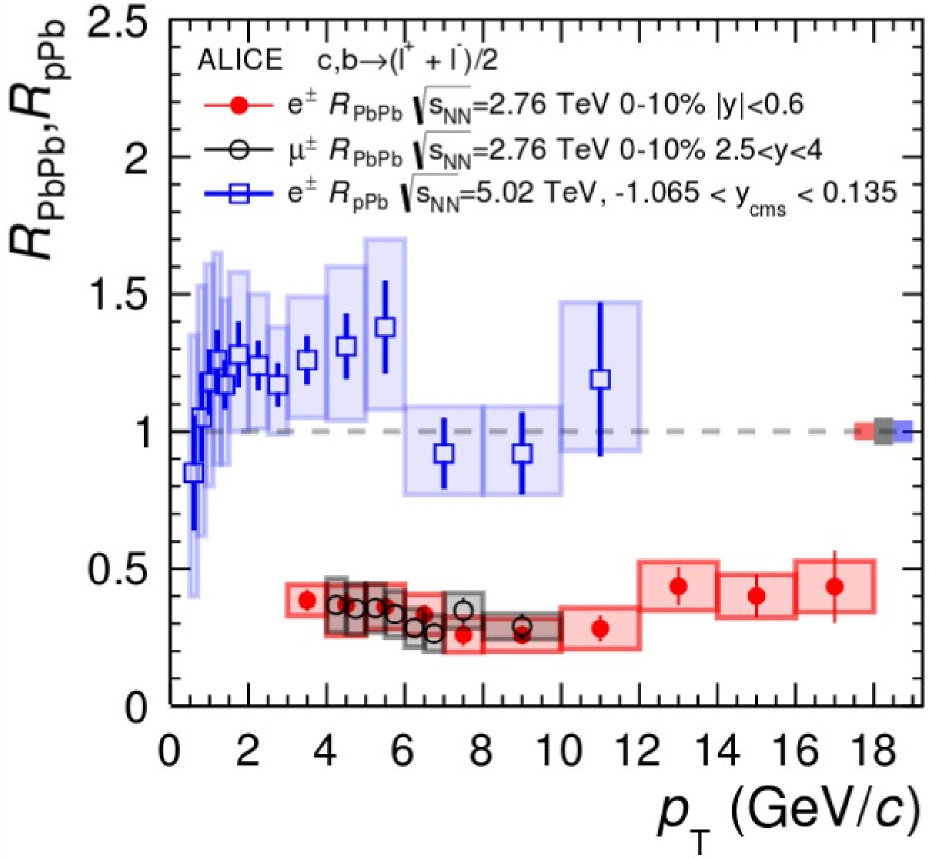
Interactions between jet and QGP cause changes in the jet structure

Expect relation between jet mass and virtuality of the partons, sensitive to the mechanism for energy loss

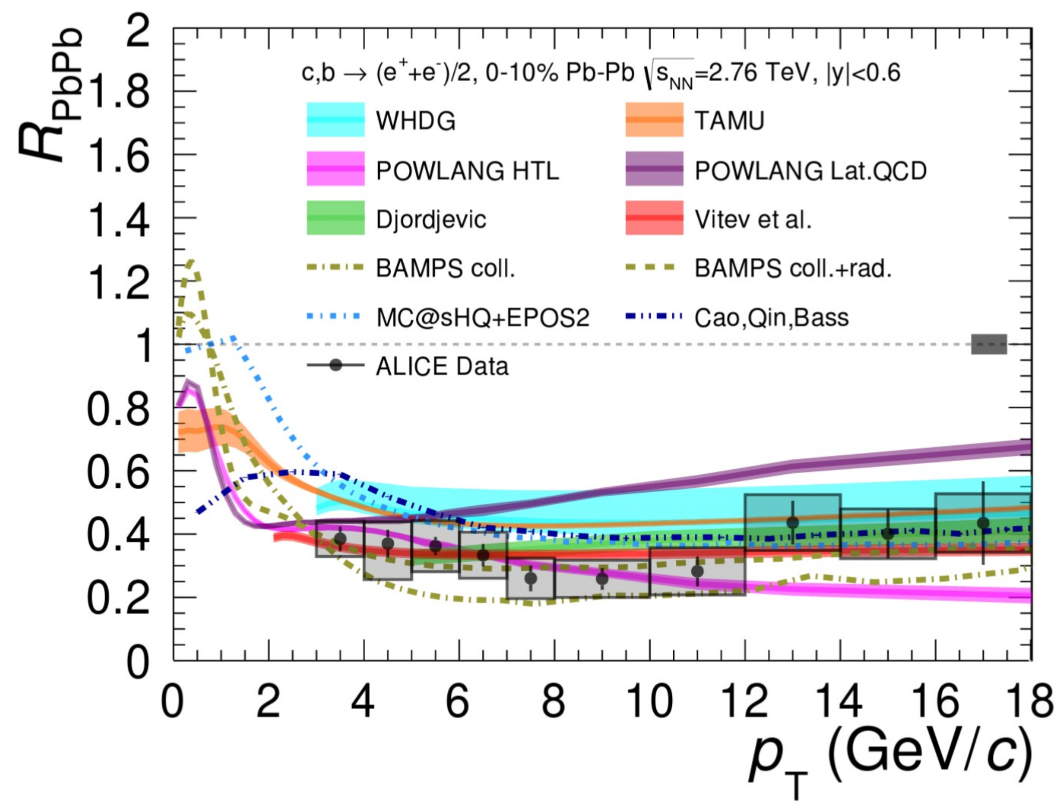
14 Heavy-quark energy loss

$$R_{\mathrm{AA}} = \frac{\mathrm{d}N_{AA}/\mathrm{d}p_{\mathrm{T}}}{N_{\mathrm{coll}}\,\mathrm{d}N_{pp}/\mathrm{d}p_{\mathrm{T}}}$$

via the measurement of decay electrons from charm and beauty hadrons



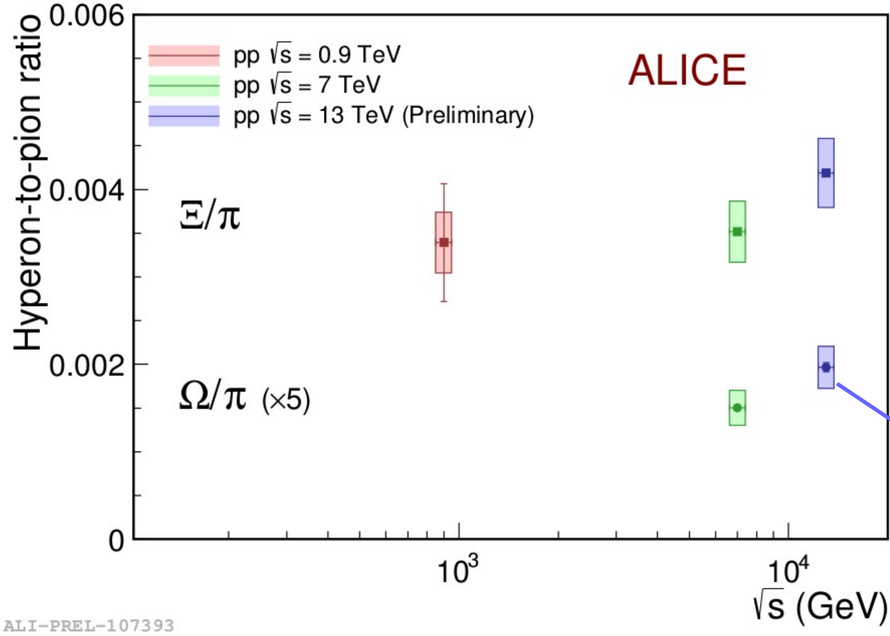
arXiv:1609.07104

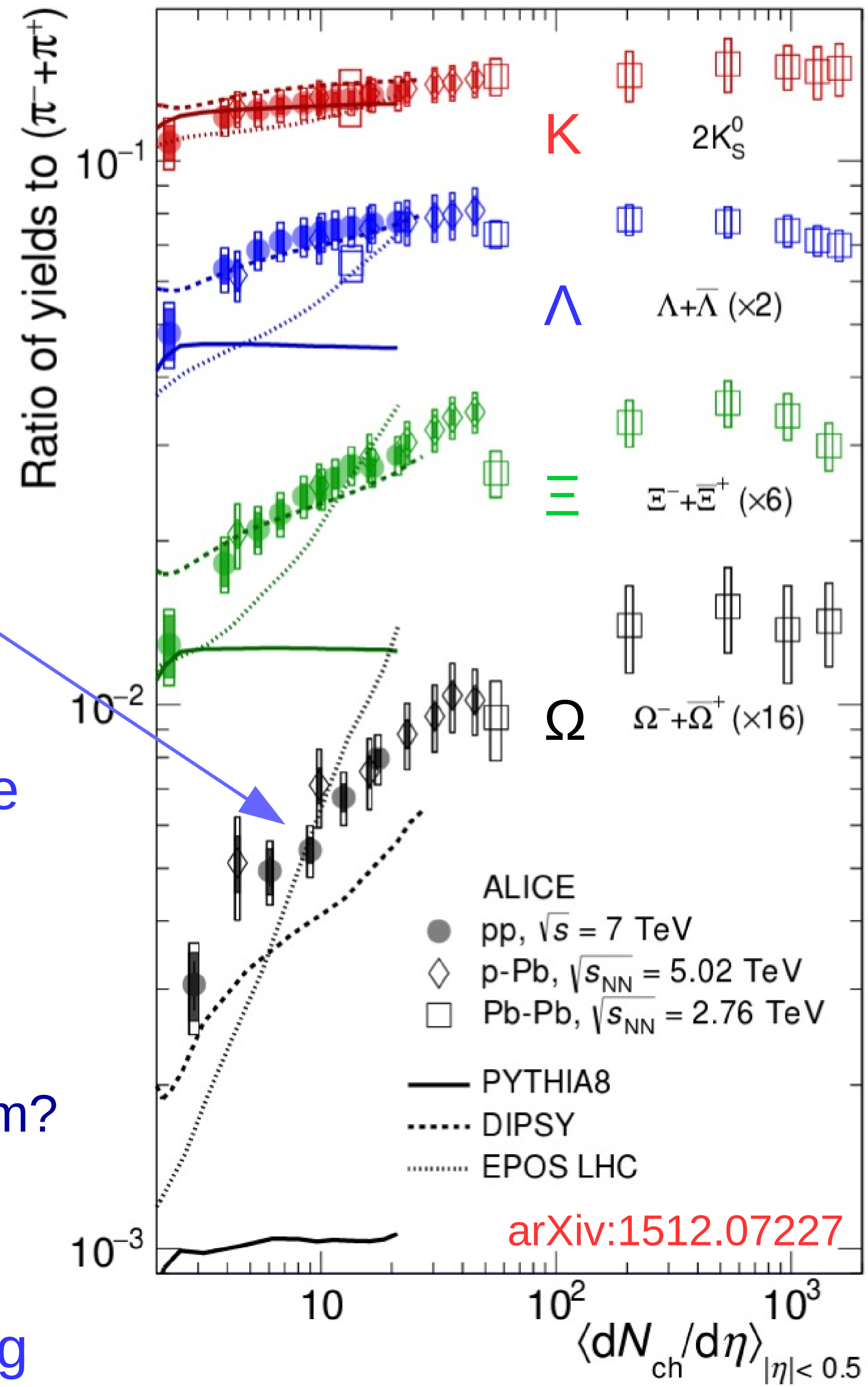


Strong suppression of electrons originating from heavy-flavor decays observed in central Pb-Pb collisions, unlike in p-Pb.

Constrain theoretical models (with D-meson R_{PbPb}&elliptic flow)
→ Extraction of heavy-quark transport coefficients

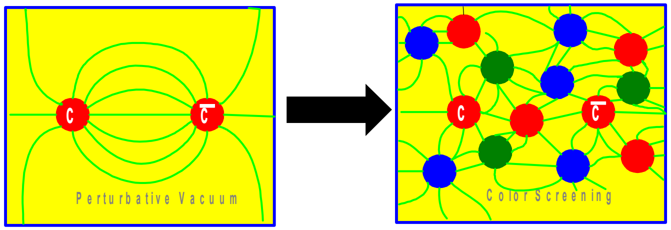
Strangeness enhancement

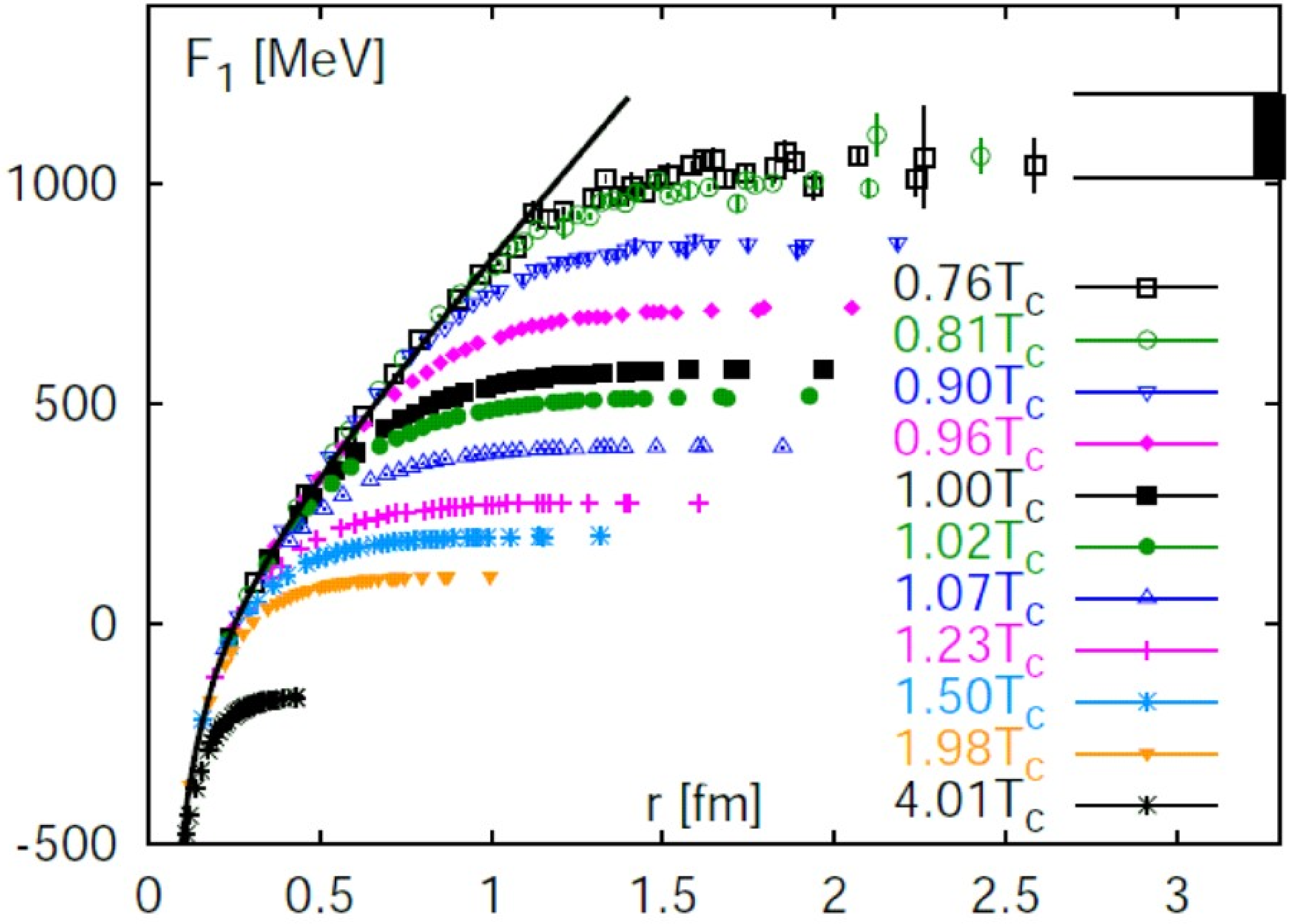




- Values in pp (and p-Pb) reach those from Pb-Pb
- Grand-canonical statistical description works well in Pb-Pb
  - Same mechanism in smaller system?
  - String hadronization models do not describe the data
- Follow-up studies at 13 TeV ongoing

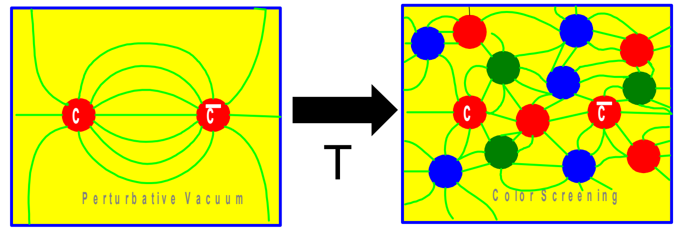
16 Charmonia

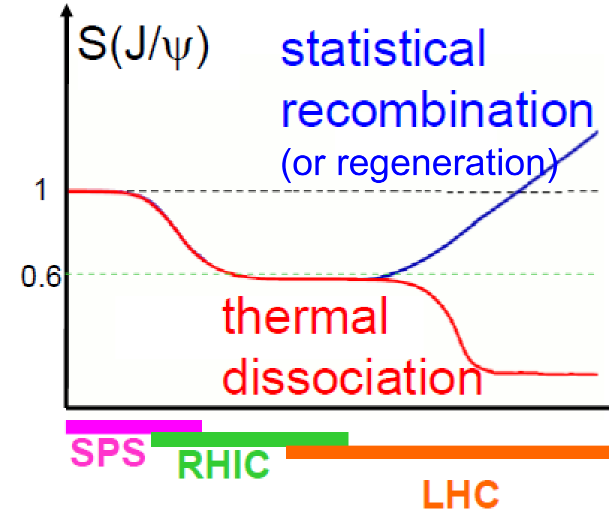




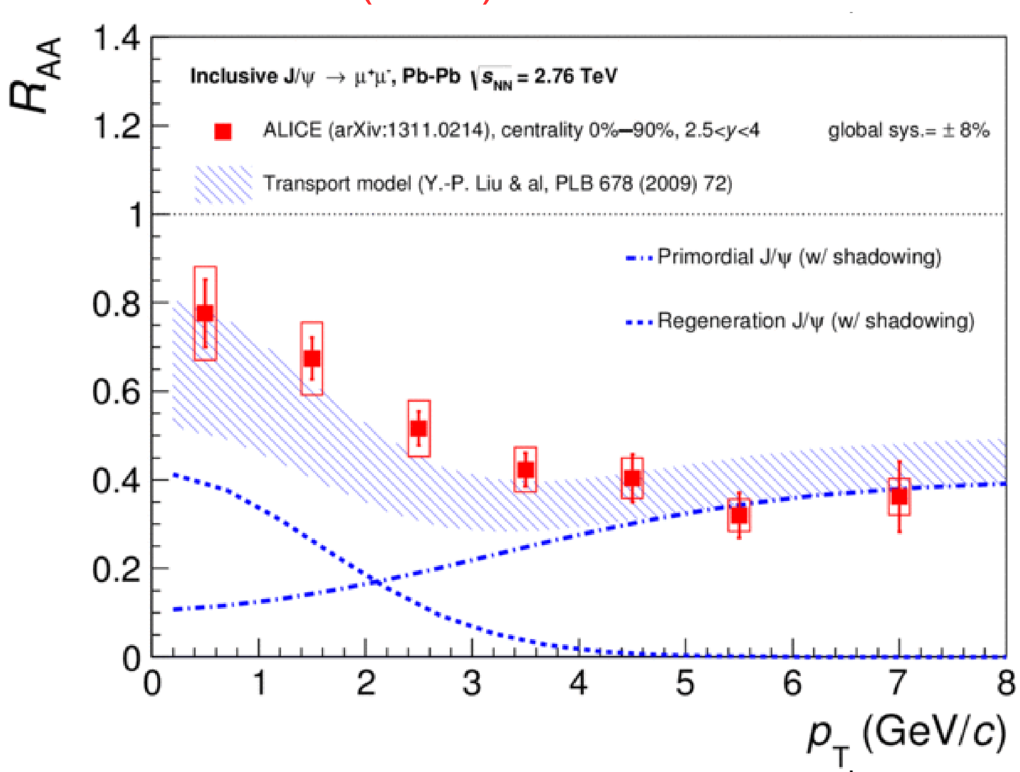
Debye screening of $Q\overline{Q}$ potential at large T

17 Charmonia

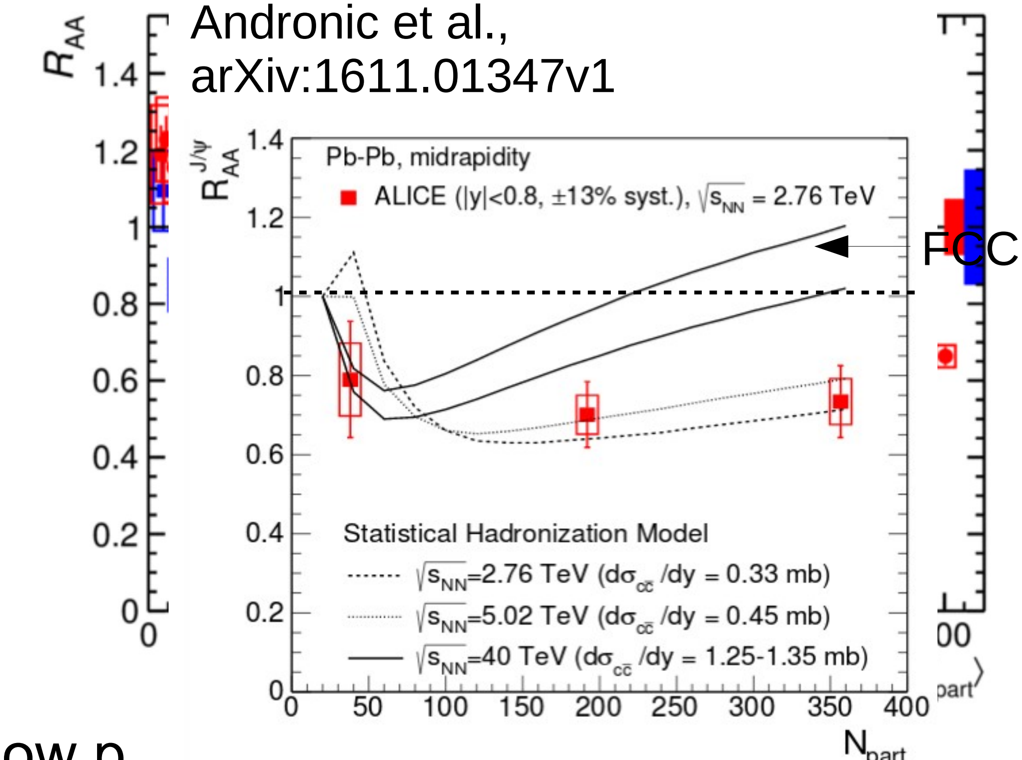




PLB 734 (2014) 314-327



Andronic et al., arXiv:1611.01347v1



Increase of J/psi yield in particular at low p_T
(consistent with regeneration calculation)

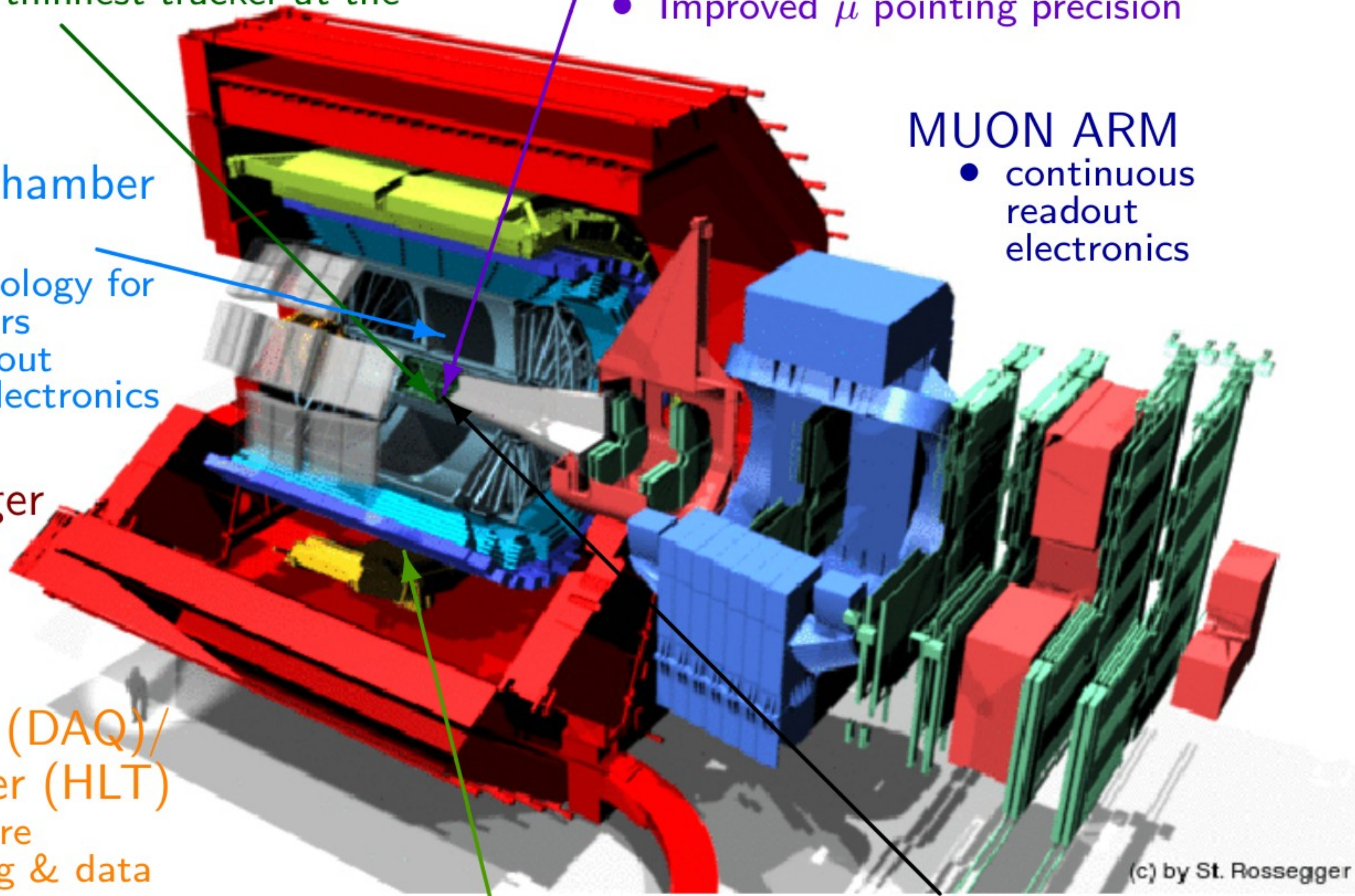
18 ALICE upgrade program (for Run 3) ...

New Inner Tracking System (ITS)

- improved pointing precision
- less material → thinnest tracker at the LHC

Muon Forward Tracker (MFT)

- new Si tracker
- Improved μ pointing precision



MUON ARM

- continuous readout electronics

Time Projection Chamber (TPC)

- new GEM technology for readout chambers
- continuous readout
- faster readout electronics

New Central Trigger Processor (CTP)

Data Acquisition (DAQ)/ High Level Trigger (HLT)

- new architecture
- on line tracking & data compression
- 50kHz Pbb event rate

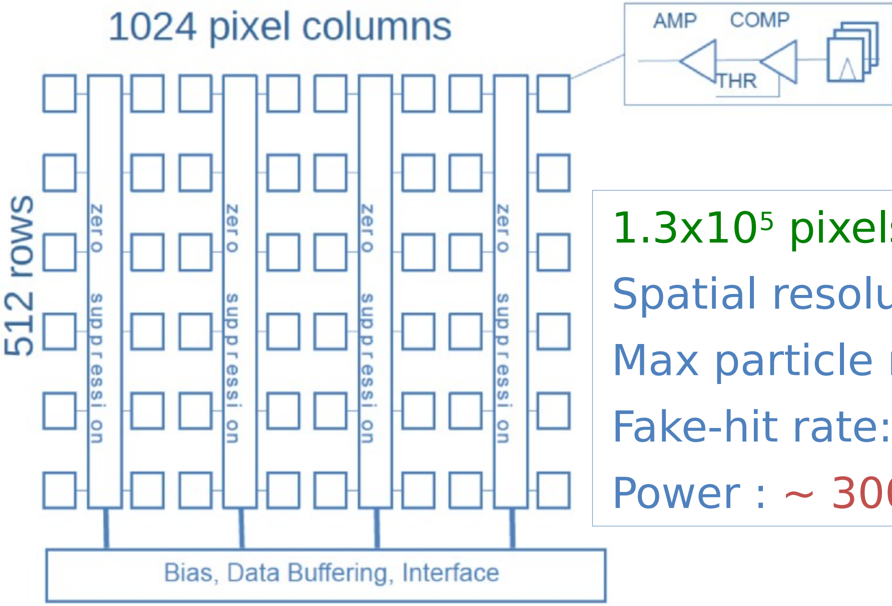
TOF, TRD, ZDC

- Faster readout

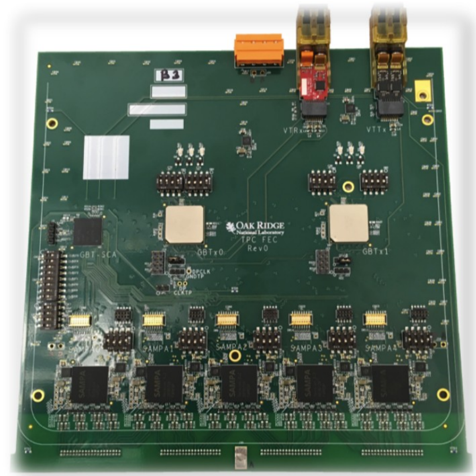
New Trigger Detectors (FIT)

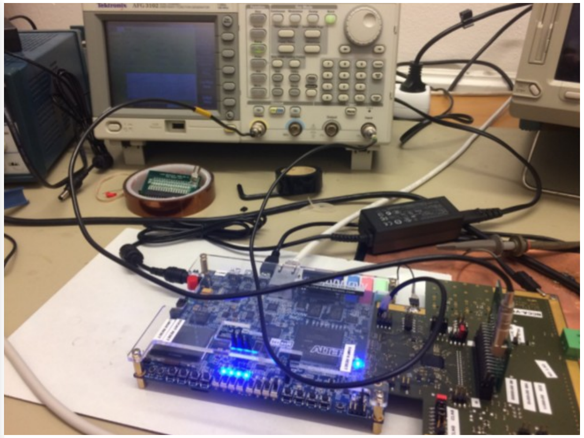
→ technical design reports in CDS

ALPIDE sensor ready for production



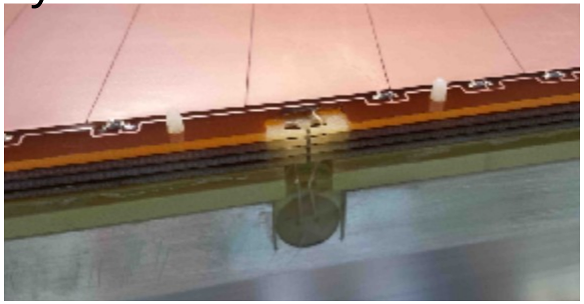
1.3x10^5 pixels/cm
Spatial resolution
Max particle rate: 100 MHz / cm^2
Fake-hit rate: < 10^{-10} pixel / event
Power : ~ 300 nW /pixel





- SAMPA MPW2 chips being tested to confirm TPC specs
- First FEC Rev0 prototypes being tested

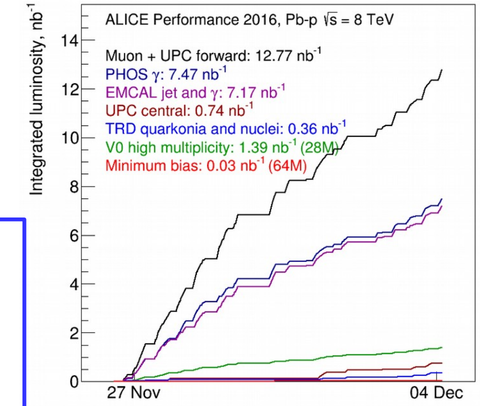
First final-design TPC OROC assembly at NIPNE Bucharest

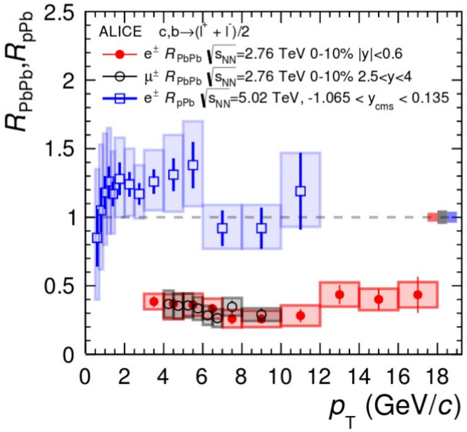


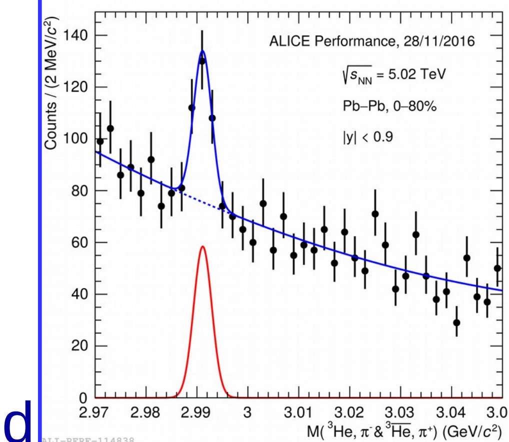
- Preproduction almost completed (2 IROC + 2 OROC)
- Comprehensive tests in lab and beam
- Start of mass production in 2017

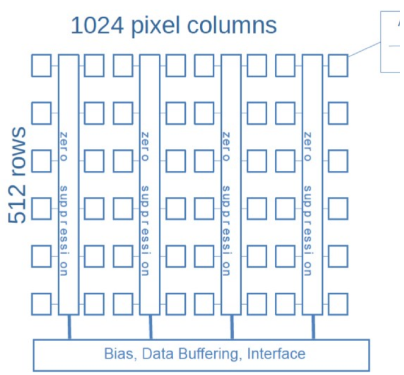
20 Summary

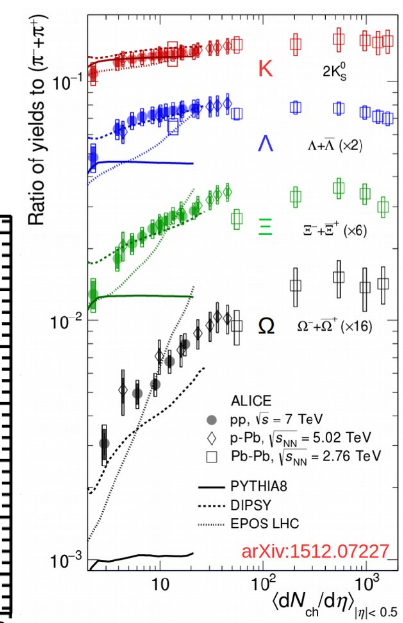
- Extremely successful data taking
  - Thanks to the over-performing LHC
- TPC SCD calibration in production
- Numerous physics results
  - For all, see http://aliceinfo.cern.ch/ArtSubmission/submitted
  - Many more in the pipeline, stay tuned
- Ambitious upgrade in full swing

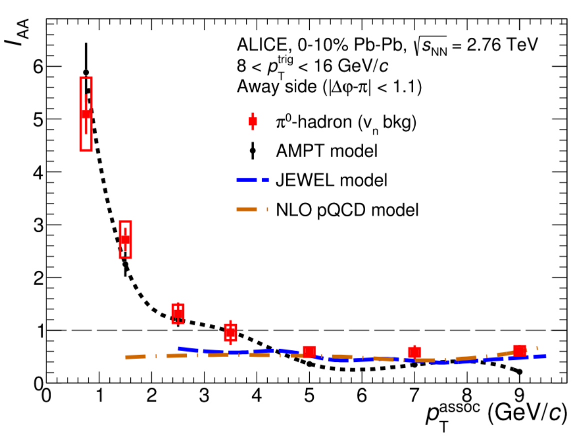


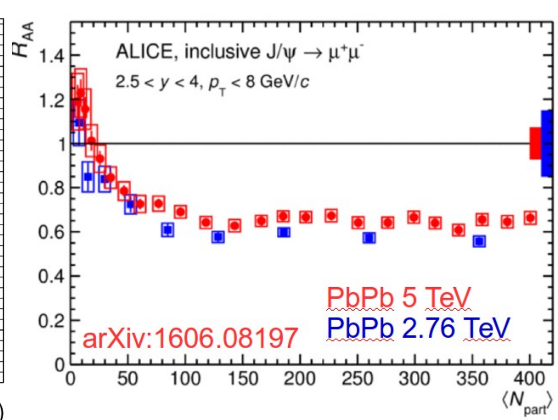


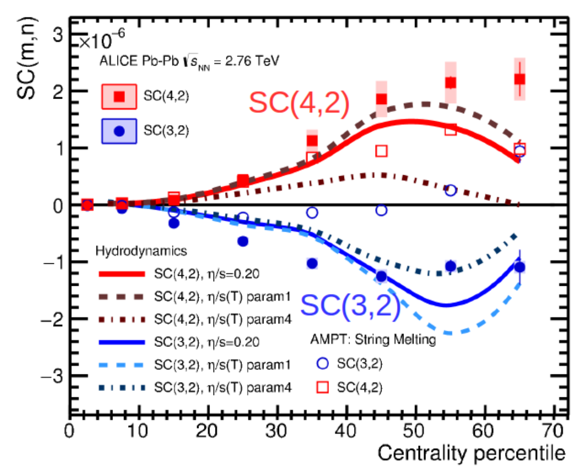






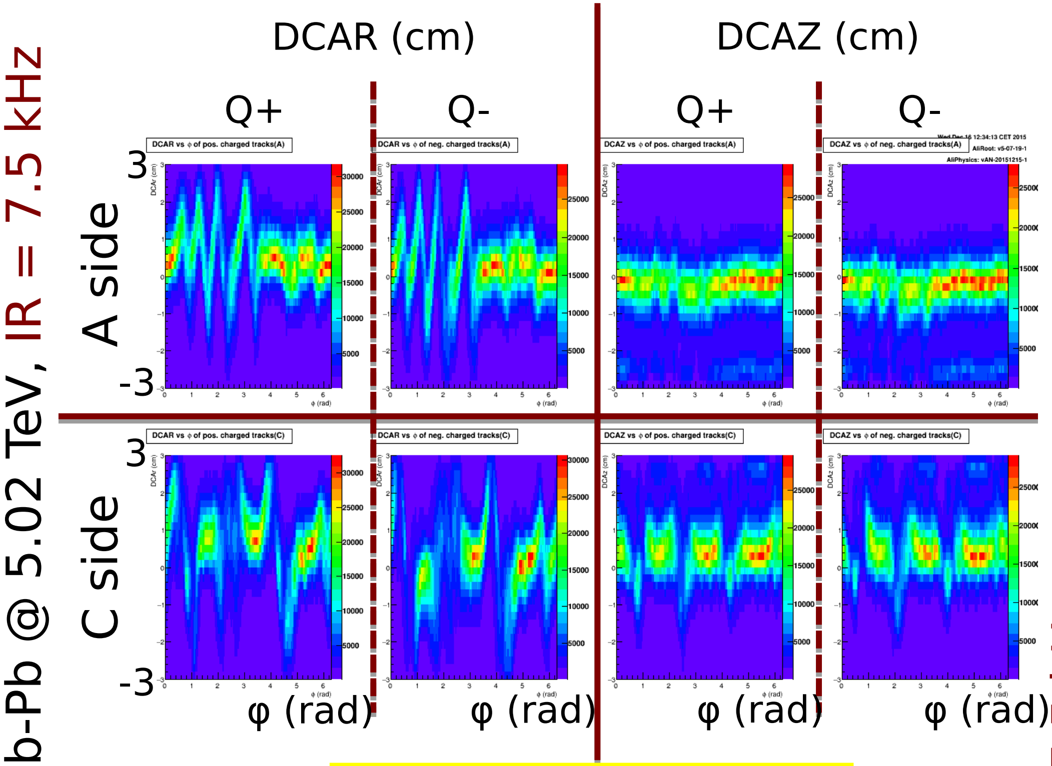






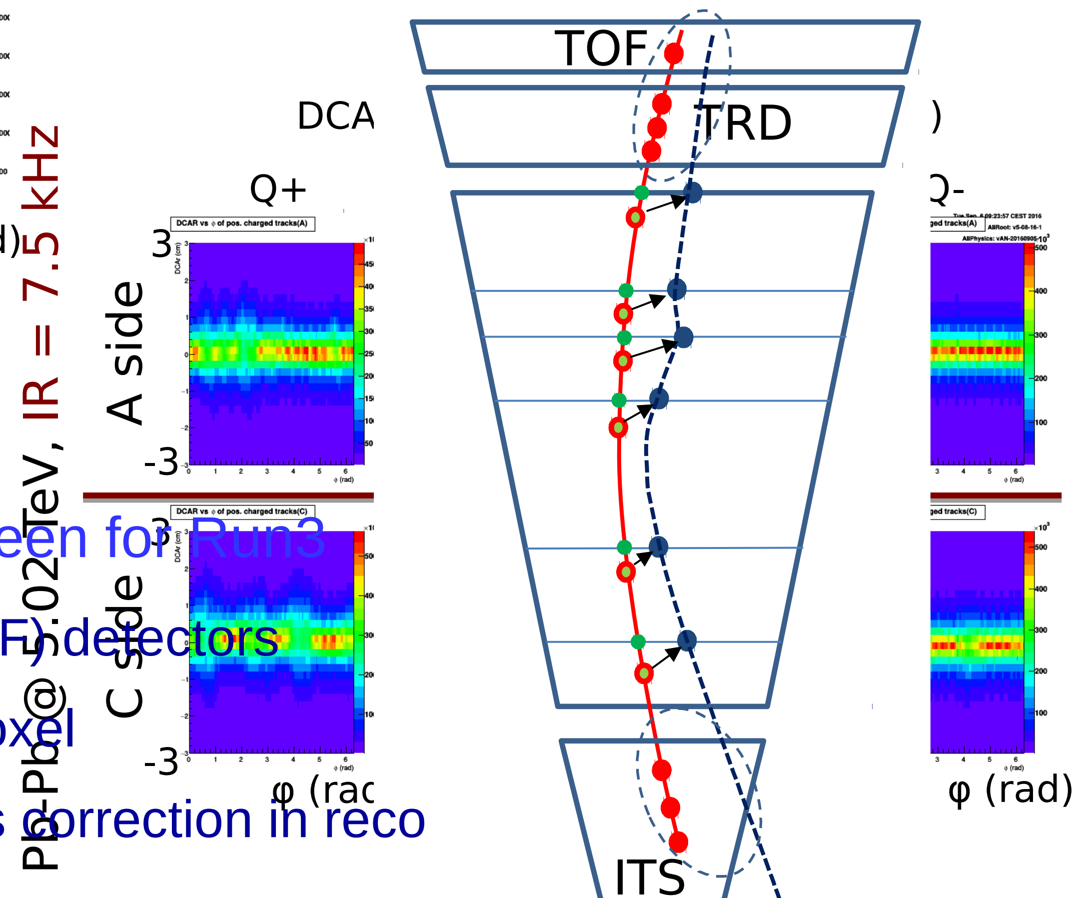
21 Extra

22 TPC Space point distortions



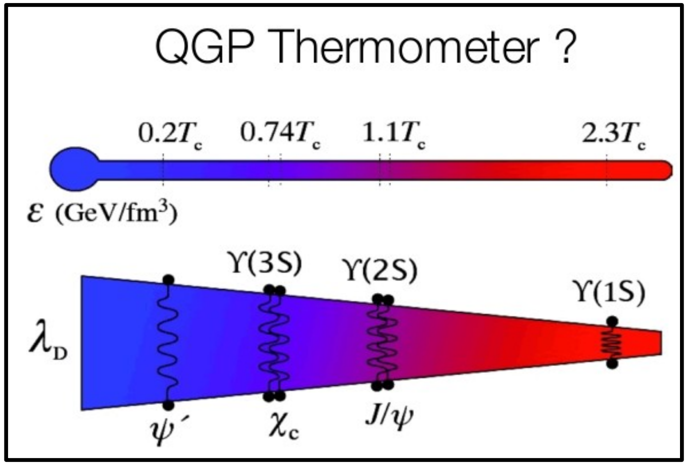
Before calibration

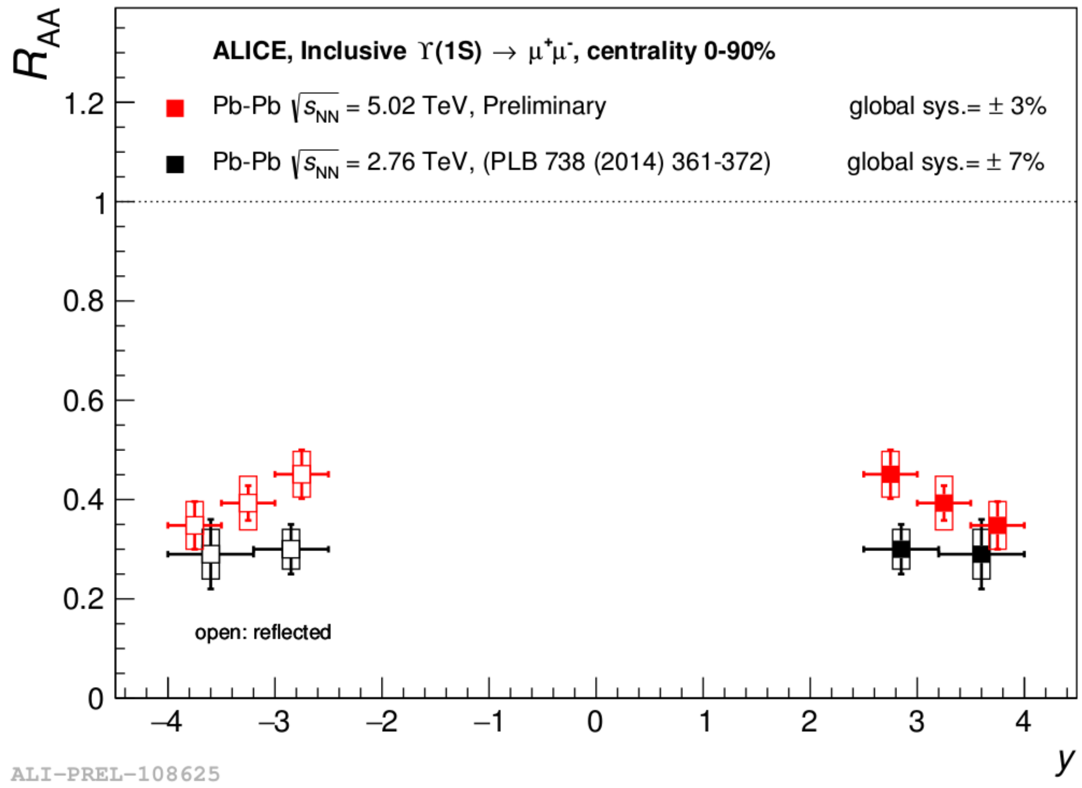
- Large space point distortions in Run2 (eg. in DCA distributions)
  - Charge originating from edges of a few inner chambers
  - Due to drifting columns of ions
  - Prop. to interaction rate



- Time dependent calibration as foreseen for Run3
  - Use inner (ITS) and outer (TRD+TOF) detectors
  - 3D distortion vector for each TPC voxel
  - Smoothed parameterization used as correction in reco

23 Upsilon regeneration?

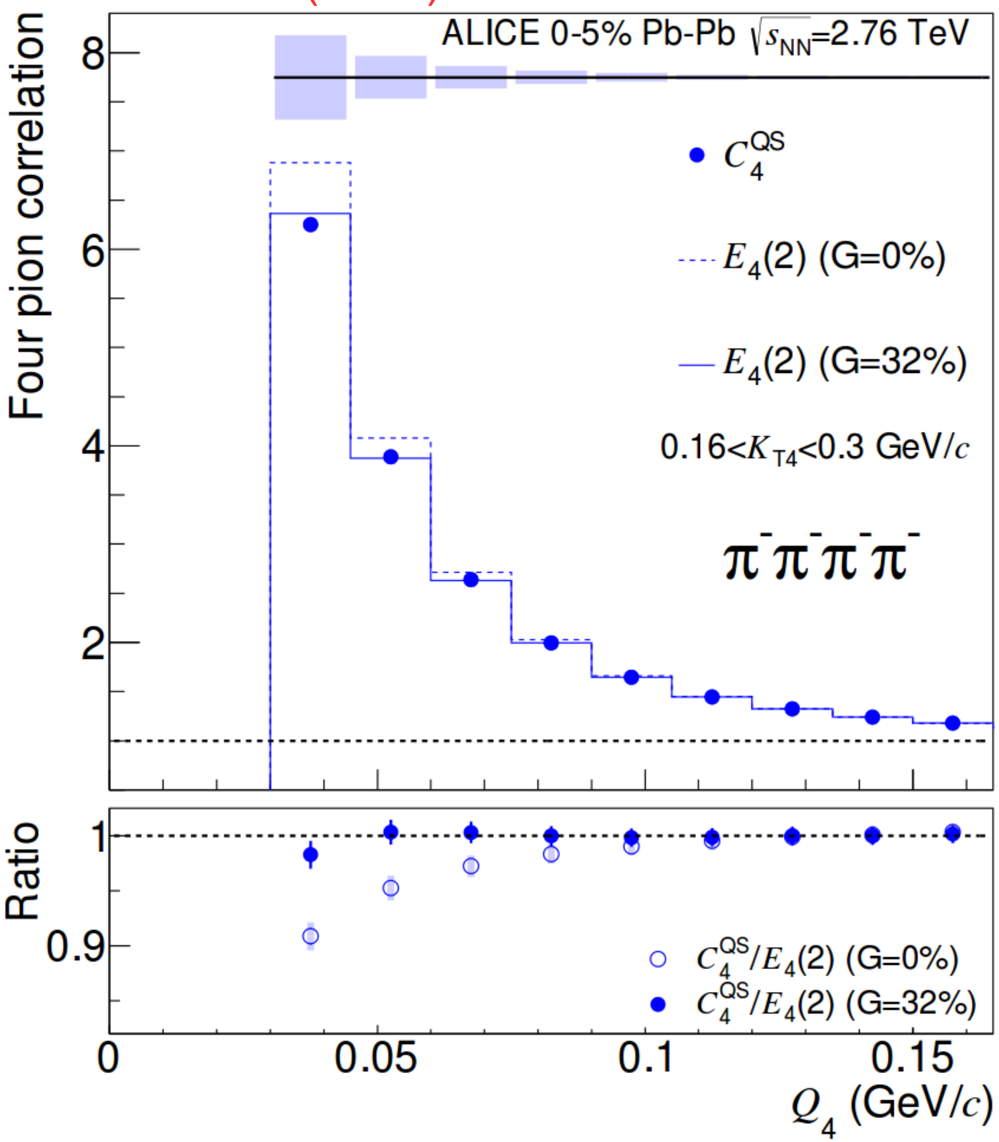




Expected from sequential melting would be lower Raa at higher energy,
However the opposite trend is seen
(even if not a large effect considering uncertainties)
Do we see (re)-generation in QGP or at phase boundary even for Upsilons?

Four pion correlation (Pb-Pb)

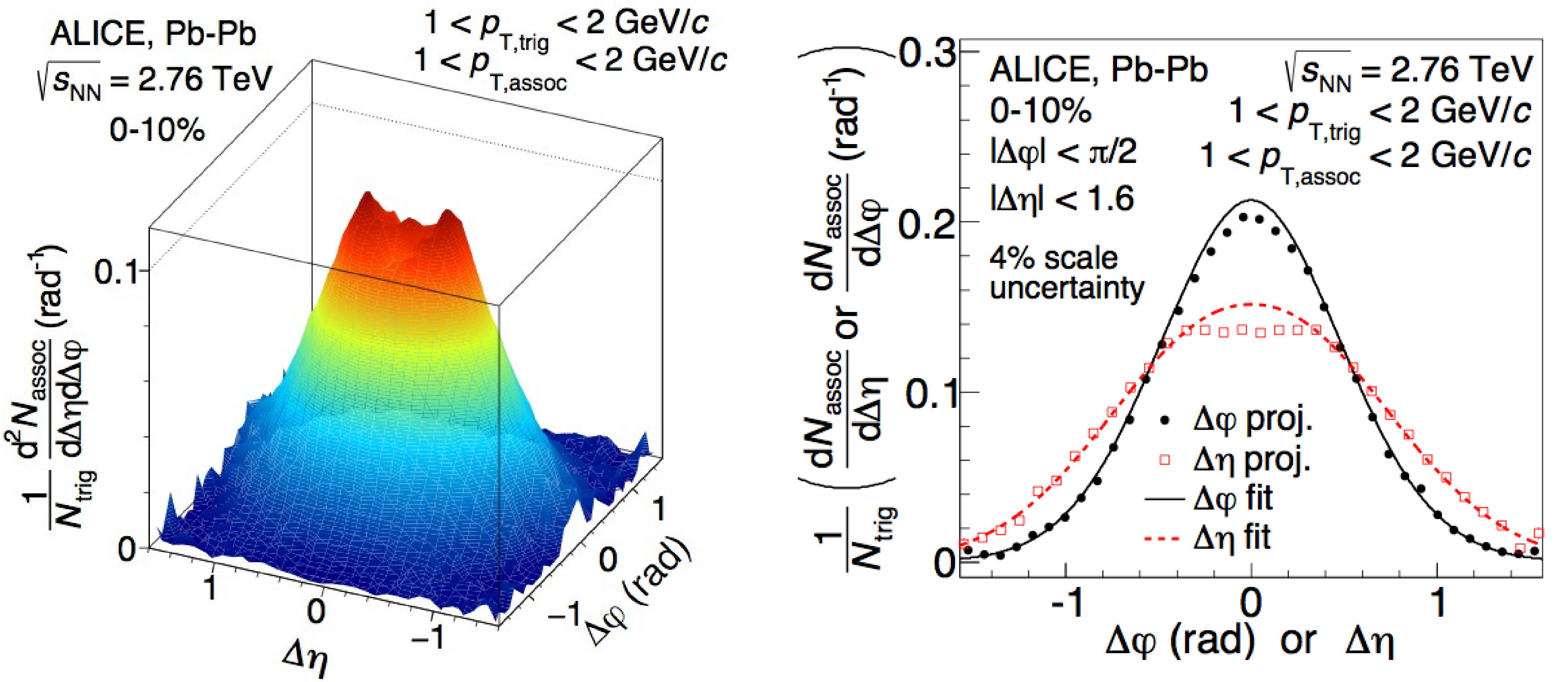
PRC 93 (2016) 054908



- Discrepancy of quantum optics calculation with measured 4-pion correlation
- Possible explanations
  - Quantum coherence
    - G=33%±9%
    - Fails to explain 3-pion correlation
    - Present also at high kT
  - Coulomb repulsion
    - Asymptotic limit used
    - If genuine multibody relevant, deviations up to 20% can explain effect

25 Jet-like dihadron correlation

arXiv:1609.06667



Asymmetry of near side jet peak: broader in η than in φ

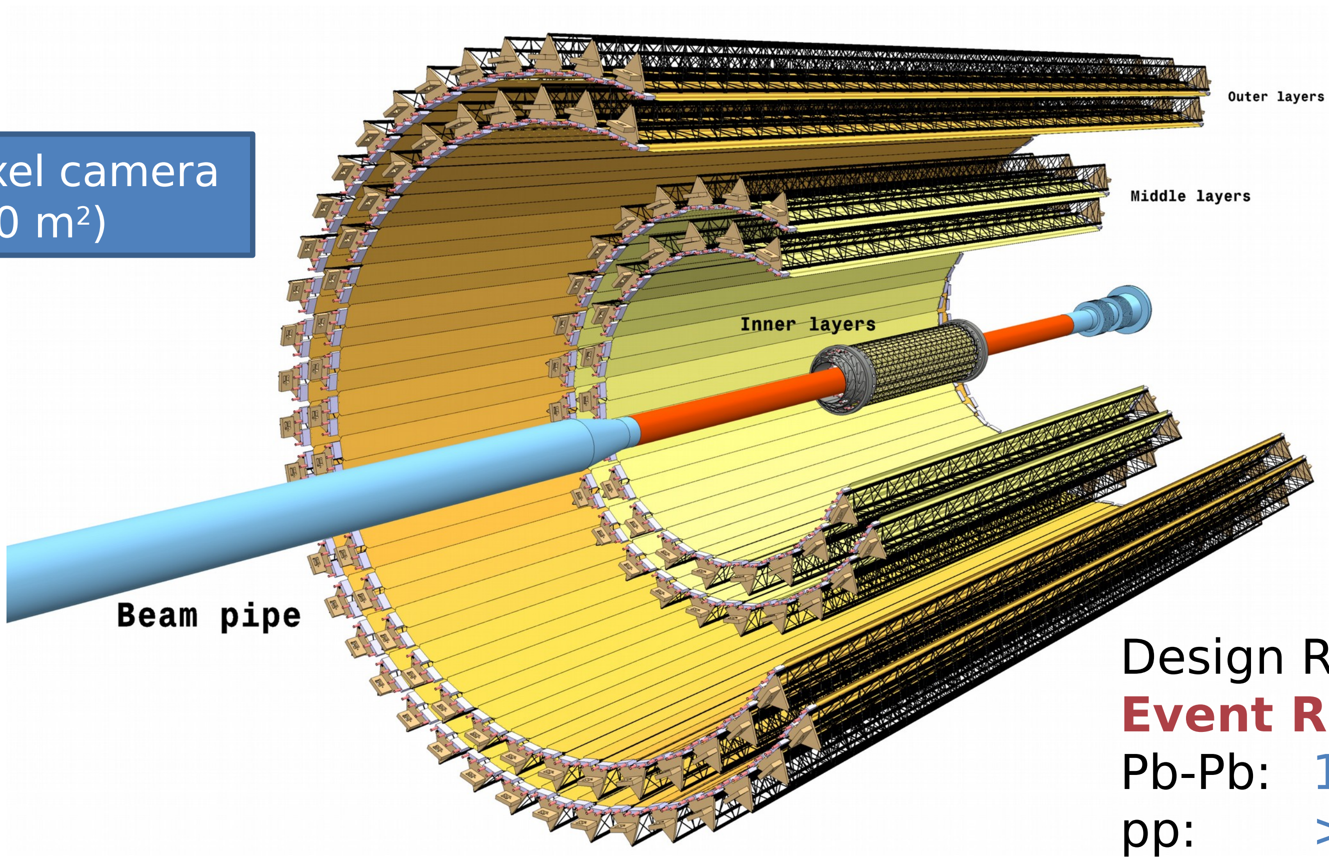
→ Possibly due to coupling to longitudinal flow; interplay between hard and soft physics

ALICE upgrade program

- Motivation: Focus on high-precision measurements of rare probes at low p_T
  - can not be selected with hardware trigger
  - need to record large sample of events
- Target: Pb-Pb recorded luminosity: ≥ 10 nb^{-1}
  - gain in statistics: factor 100 for selected probes!
  - plus pp and pA data
- Strategy:
  - read out all Pb-Pb interactions at a maximum rate of 50 kHz with a minimum-bias trigger or continuously (TPC)
  - perform online data reduction

27 New ITS layout

12.5 G-pixel camera
(~10 m²)



Design Requirements
Event Readout Rate
Pb-Pb: 100 kHz
pp: > 400 kHz

7-layer barrel geometry based on **CMOS Pixel Sensors**
r coverage: 23 – 400 mm

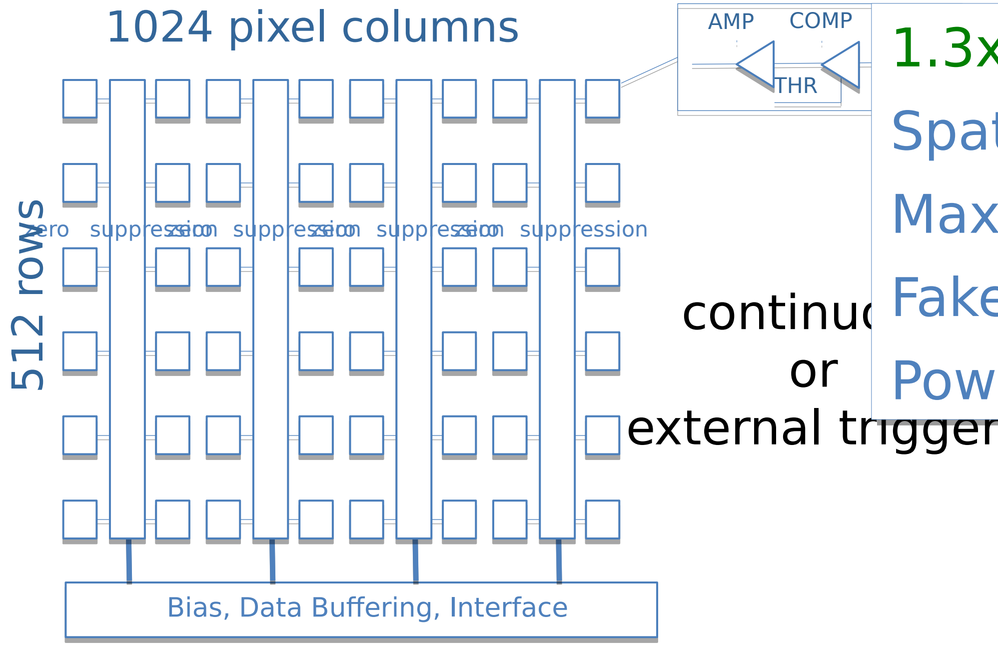
η coverage: $|\eta| \leq 1.22$
for tracks from 90% most luminous region

3 Inner Barrel layers (**IB**)

4 Outer Barrel layers (**OB**)

Material /layer : 0.3% X_0 (IB), 1% X_0 (OB)

28 ALPIDE sensor ready for production



1.3x10⁵ pixels/cm² O(30x30x30 μm³)

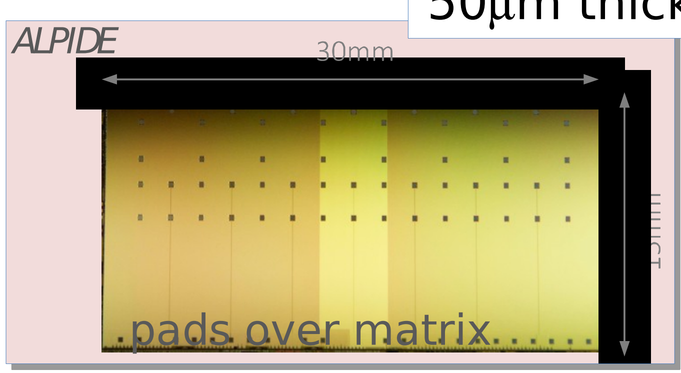
Spatial resolution: ~ 5 μm (3-D)

Max particle rate: 100 MHz / cm²

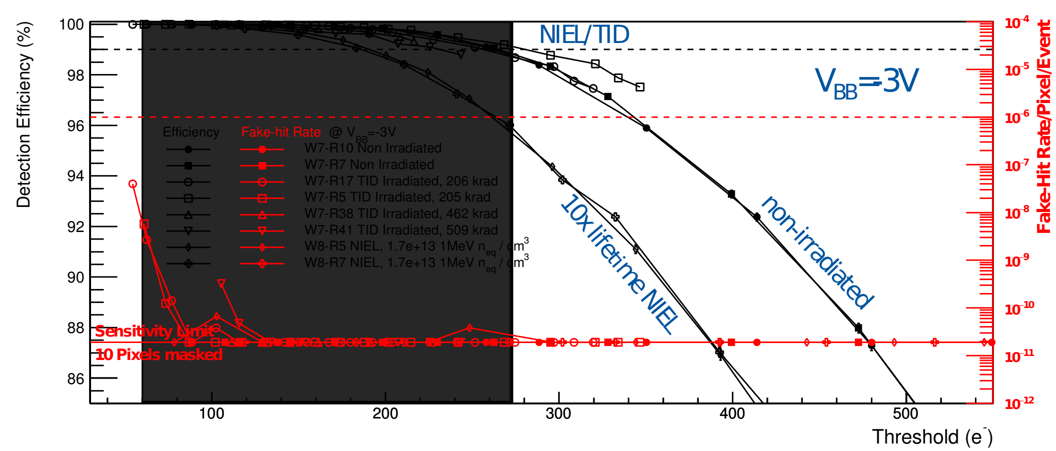
Fake-hit rate: < 10⁻¹⁰ pixel / event

Power : ~ 300 nW /pixel

50μm thick



Detection Efficiency & Fake Hit Rate



29 The ALICE detector