126th LHCC session: ALICE status report

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Submitted Papers: 6 (since 125^{th} LHCC)

SMALL SYSTEMS	Centrality dependence of $\psi(2S)$ suppression in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, *arXiv:1603.02816*
	Measurement of azimuthal correlations of D mesons and charged particles in pp collisions at $\sqrt{s} = 7$ TeV and p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, *arXiv:1605.06963*
	D-meson production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and in pp collisions at $\sqrt{s} = 7$ TeV, *arXiv:1605.07569*
LARGE SYSTEMS	Measurement of transverse energy at midrapidity in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1603.04775*
	Correlated event-by-event fluctuations of flow harmonics in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1604.07663*
	Pseudorapidity dependence of the anisotropic flow of charged particles in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1605.02035*

Accepted Papers: 9 (since 125th LHCC)

SMALL SYSTEMS	Production of $K^{\star}(892)^0$ and $\phi(1020)$ in p-Pb collisionsat $\sqrt{s_{NN}} = 5.02$ TeV, *arXiv:1601.07868, accepted by EPJC*
	Multi-strange baryon production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, *arXiv:1512.06104, accepted by PLB*
	Centrality dependence of charged jet production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, *arXiv:1603.03402, accepted by EPJC*
	Particle identification in ALICE: a Bayesian approach *arXiv:1602.01392, EPJ+ (2016) 131*
LARGE SYSTEMS	Centrality Dependence of the Charged-Particle Multiplicity Density at Midrapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1512.06104, accepted by PRL*
	Multipion Bose-Einstein correlations in pp, p-Pb, and Pb-Pb collisions at the LHC, *arXiv:1512.08902, accepted by PRC*
	Charge-dependent flow and the search for the Chiral Magnetic Wave in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1512.05739, accepted by PRC*
	Measurement of an excess in the yield of J/psi at very low pt in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1509.08802, accepted by PRL*
	Differential studies of inclusive J/ψ and $\psi(2S)$ production at forward rapidity in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, *arXiv:1506.08804, accepted by JHEP*

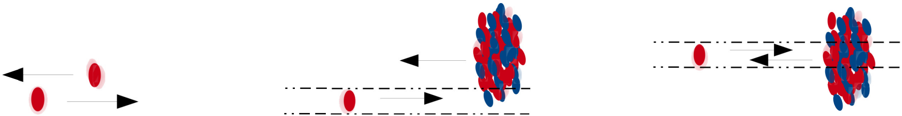
Published Papers: 8 (since 125th LHCC)

SMALL SYSTEMS	Inclusive quarkonium production at forward rapidity in pp collisions at $\sqrt{s} = 8$ TeV, *arXiv: 1509.08258, EPJ C76 (2016) no.4, 184*
	Forward-central two-particle correlations in p-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV, *arXiv:1506.08032, PLB 753(2016) 126-139*
LARGE SYSTEMS	Production of light nuclei and anti-nuclei in pp and Pb–Pb collisions at LHC energies, *arXiv:1506.08951, PRC 93 (2015) 024917*
	Centrality dependence of the nuclear modification factor of charged pions, kaons, and protons in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV, *arXiv:1506.07287, PRC 93 (2016) 034913*
	Measurement of D_s^+ production and nuclear modification factor in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV, *arXiv:1509.07287, JHEP 1603 (2016) 082*
	Transverse momentum dependence of D-meson production in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV, *arXiv:1509.06888, JHEP 1603 (2016) 081*
	Event shape engineering for inclusive spectra and elliptic flow in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV, *arXiv:1507.06194, PRC 93 (2016) 034916*
	Anisotropic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV *arXiv:1602.01119, PRL 116 (2016) 132302*

SMALL SYSTEMS (pp & p-Pb)

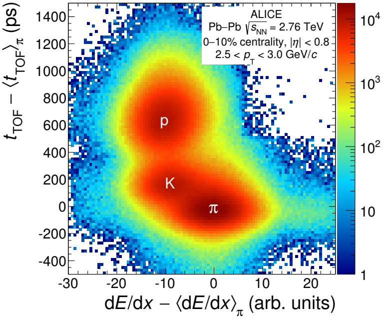
&

HARD PROBES



Bayesian Particle Identification in ALICE

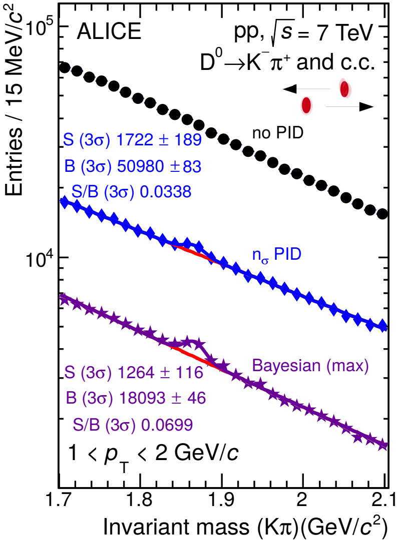
- Generalized approach for usage of full PID information in ALICE
  - Standard approach cuts in nσ to expected for each detector & species



arXiv:1602.01392

Bayesian Particle Identification in ALICE

- Generalized approach for usage of full PID information in ALICE
- Proof of Concept:
  D-meson extraction
  - Trade-off between between purity/ higher dependence on MC
    $\Rightarrow$ higher purity ideal for correlation analysis
  - Increase in S/B with respect to standard approach particularly at low p_T
  - Currently only TPC and TOF included in analysis, other PID detectors to come



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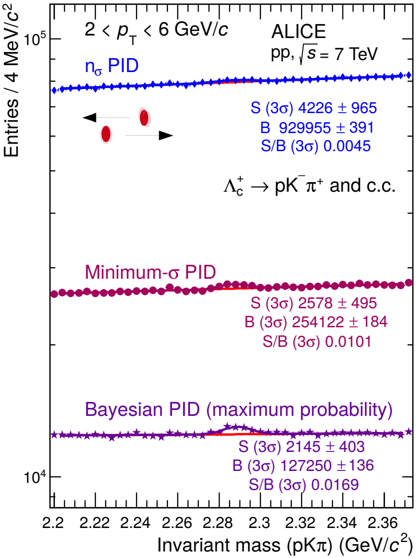
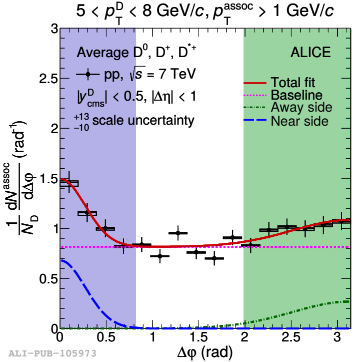
- Access to even rarer probes: $\Lambda_C \rightarrow pK\pi$

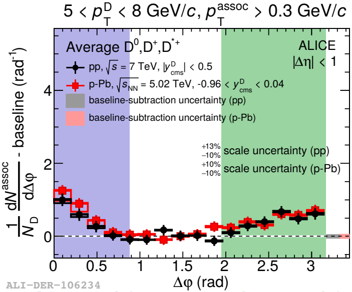


arXiv:1602.01392

D-h correlations in pp & p-Pb

- First measurement of D-h correlation functions at the LHC
- Provides information on:
  - Charm production & fragmentation process
  - Implementation of underlying event and help tuning MC generators
- Similar correlations functions for pp & p-Pb
  - ⇒ The current measurements shows no evidence for a possible v_2 in min bias p-Pb collisions
  - ⇒ Looking forward to p-Pb run this year





Near side **Away side**

arXiv:1605.06963

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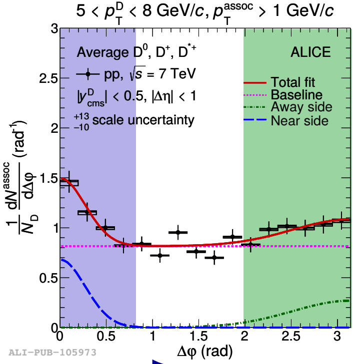
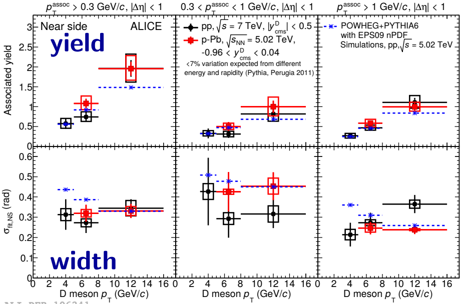
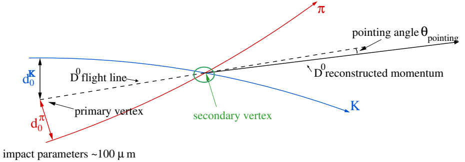


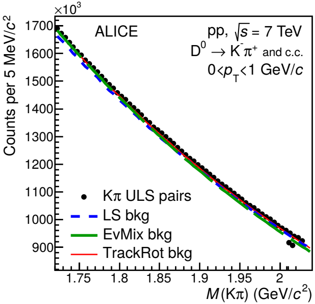


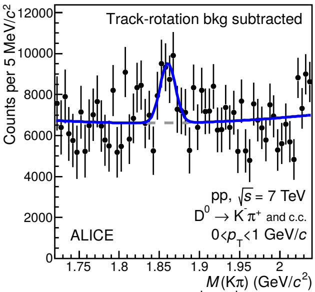
arXiv:1605.06963

D-mesons at low p_T in pp & pPb



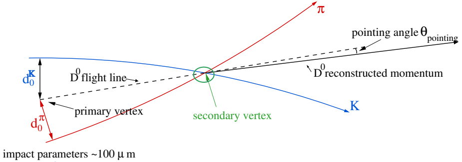
- First D^0 measurement by ALICE to $p_T = 0$
- Reconstruction w/o secondary vertex provides a more precise result at $p_T < 2$ GeV/c as separation between primary and secondary vertex at low p_T is smaller
  - Different systematics between the two methods
  - Smaller contribution from feed-down from B-mesons





arXiv:1605.07569

D-mesons at low p_{T} in pp & pPb

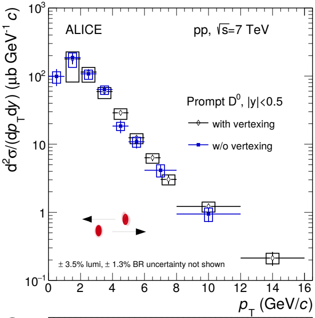


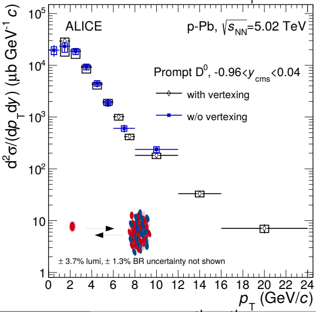
- First D^0 measurement by ALICE to $p_{\mathrm{T}} = 0$
- Reconstruction w/o secondary vertex provides a more precise result at $p_{\mathrm{T}} < 2\ \mathrm{GeV}/c$ as separation between primary and secondary vertex at low p_{T} is smaller
- $c\bar{c}$ cross sections for pp $\sqrt{s} = 7$ TeV & p-Pb $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV at mid rapidity determined with improved systematics

$$\sigma^{c\bar{c}}_{\mathrm{pp,\ 7TeV}} = 8.18 \pm 0.67(\mathrm{stat})\ ^{+0.90}_{-1.62}(\mathrm{syst})\ ^{+2.4}_{-0.36}(\mathrm{extr}) \pm 0.29(\mathrm{lum}) \pm 0.36(\mathrm{FF})\ \mathrm{mb}$$

$$R^{\mathrm{prompt\ D}^0}_{\mathrm{p\text{-}Pb,\ 5.02TeV}} = 0.89 \pm 0.11(\mathrm{stat})\ ^{+0.13}_{-0.18}(\mathrm{syst})$$

measured for $-0.96 < y_{cms} < 0.04$, $p_{\mathrm{T}} > 0$

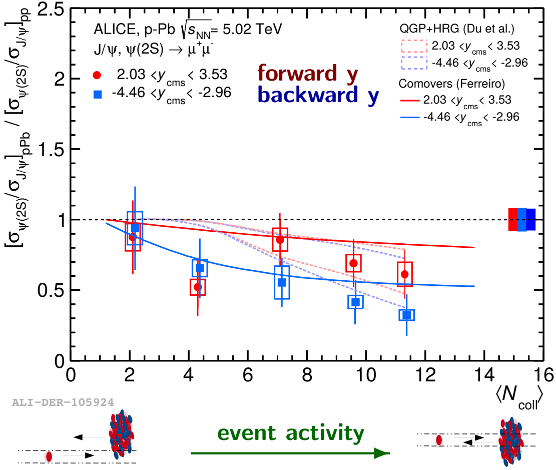




arXiv:1605.07569

ψ(2S) suppression in p-Pb vs. event activity

- Decreased ψ(2S) w.r.t J/ψ for central p-Pb collisions
  - ⇒ Stronger at backward y
  - ⇒ Cancellation of shadowing effects in double ratio
  - ⇒ Hint for final state effects



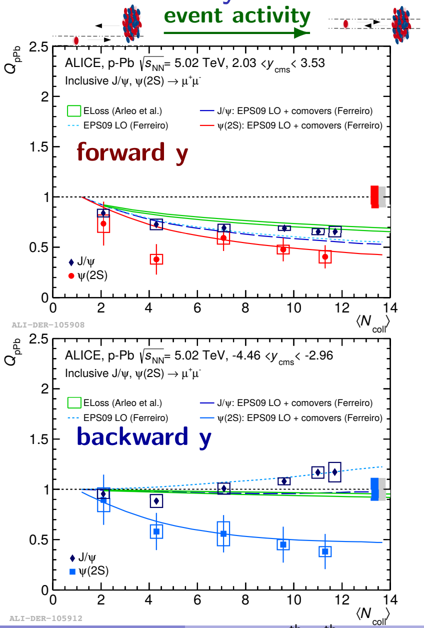
arXiv:1603.02816

$\psi(2S)$ suppression in p-Pb vs. event activity

- Decreased $\psi(2S)$ w.r.t J/ψ for central p-Pb collisions
  - $\Rightarrow$ Stronger at backward y
  - $\Rightarrow$ Cancellation of shadowing effects in double ratio
  - $\Rightarrow$ Hint for final state effects
- Different suppression pattern vs event activity for J/ψ and $\psi(2S)$
  - $\Rightarrow$ Shadowing could reproduce J/ψ results
  - $\Rightarrow$ Points to final state effects

$$Q_{\mathrm{pA}} = \frac{\frac{1}{N^{\mathrm{pA}}_{\mathrm{evt}}} dN^{\mathrm{pA}}/dp_{\mathrm{T}}}{\langle N^{\mathrm{Glauber}}_{\mathrm{coll}} \rangle \frac{1}{N^{\mathrm{pp}}_{\mathrm{evt}}} dN^{\mathrm{pp}}/dp_{\mathrm{T}}}$$

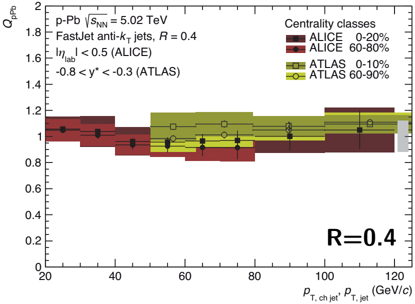
arXiv:1603.02816

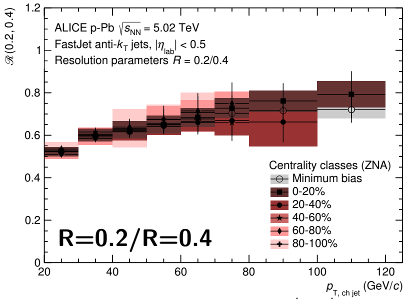


Jet production in p-Pb vs. event activity

- Nuclear modification factor $Q_{\mathrm{pPb}} \sim 1$ in all centrality classes
  - ⇒ Cold matter effects: shadowing and nuclear PDFs &
  - ⇒ Hot matter effects: energy loss

  are small for high p_{T} probes
- Measurements of full jet (ATLAS) and charged jet production at midrapidity fully consistent
- Ratio of jet production cross sections with R=0.2 and 0.4 in different centrality fully consistent with pPb min bias ratio and pp 7TeV
  - ⇒ No significant broadening of the jet seen at midrapidity





arXiv:1603.03402

LARGE SYSTEM (Pb–Pb)

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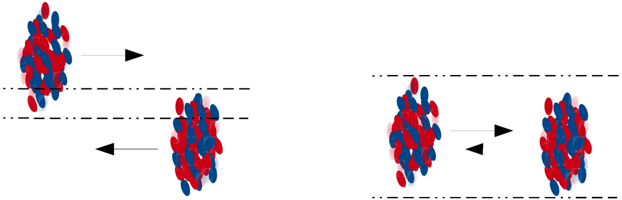
GLOBAL EVENT PROPERTIES



Transverse energy E_T vs. cent

- $\langle dE_T/d\eta \rangle / \langle dN_{ch}/d\eta \rangle$ flat vs. $\langle N_{part} \rangle$
- $\langle dE_T/d\eta \rangle / \langle dN_{ch}/d\eta \rangle$ rises much stronger than expected from extrapolation of low energy experiments
- Bjorken estimate for volume averaged energy density ϵ:

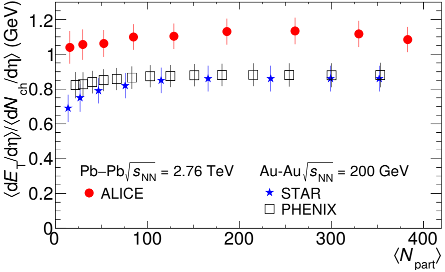
$$\epsilon\tau_0 = \frac{1}{Ac} J \left\langle \frac{dE_T}{d\eta} \right\rangle$$

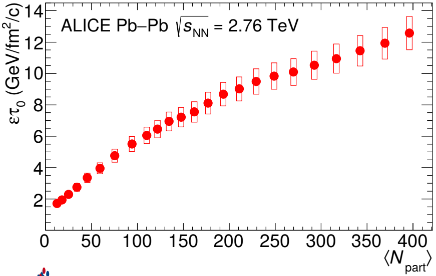
assuming (conservatively) $\tau_0 = 1$ fm$/c$:

⇒ Energy density ranges from 1.6 to 12.3 GeV/fm^3

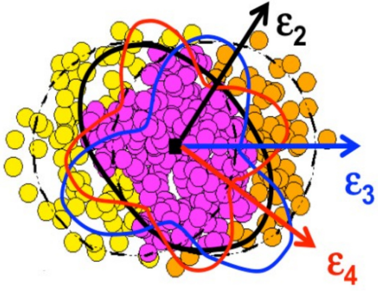
⇒ Core densities of up to 21 GeV/fm^3

arXiv:1603.04775



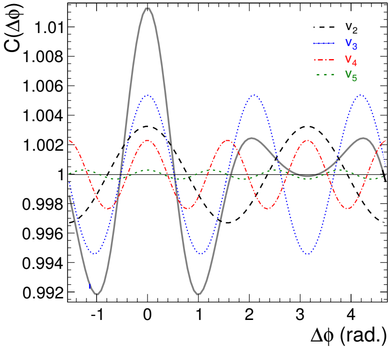


LARGE SYSTEM (Pb–Pb) & ANISOTROPIC FLOW

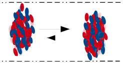


Alver, Roland (*arXiv:1003.0194*)

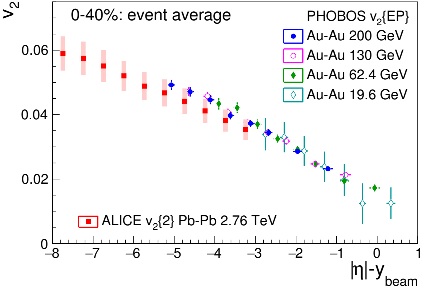
$\Rightarrow$

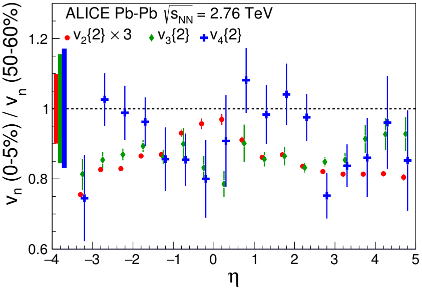


Anisotropic flow $v_n(\eta)$



- Extended longitudinal scaling observed by PHOBOS in Au-Au collisons holds up to LHC energy
- None of the harmonics show clear centrality dependence in the shape of $v_n(\eta)$ within uncertainties
- Small decrease of v_3/v_2 at high $|\eta|$
  $\Rightarrow$ viscous effects suppressing higher harmonics
- Small increase of v_4/v_2^2 at high $|\eta|$
  - $\Rightarrow$ Relatively larger contribution from v_2 at larger $|\eta|$
- $v_n/(\mathrm{d}N/\mathrm{d}\eta)$ vs η flat for all centralities, except v_2
  - $\Rightarrow$ v_3 & v_4 largely driven by local particle density in fixed centrality window





arXiv:1605.02035

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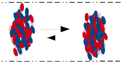

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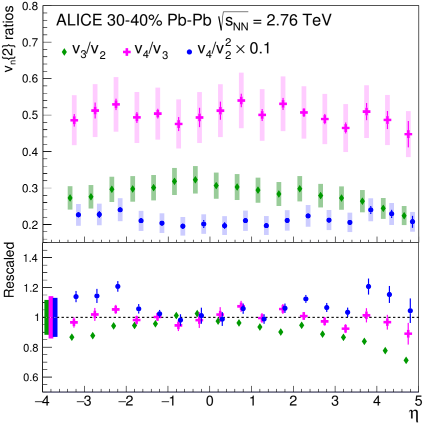
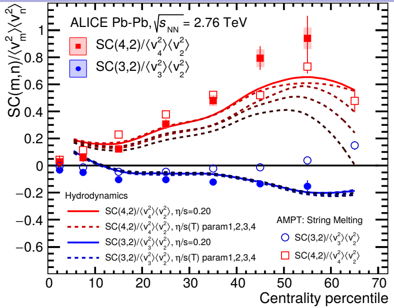


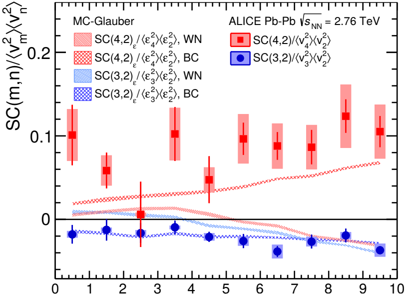
arXiv:1605.02035

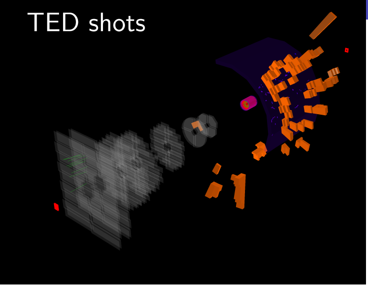
Event-by-Event fluctuations of flow harmonics

- Study correlation between v_m and v_n via Symmetric 2-harmonic 4-particle Cumulants
  $$SC(m,n) = \langle v_m^2 v_n^2 \rangle - \langle v_m^2 \rangle \langle v_n^2 \rangle$$
  insensitive to:
  - Inter-correlations of various symmetry planes & non flow effects
- Normalized $SC(m,n)/\langle v_m^2 \rangle \langle v_n^2 \rangle$ can be used to constrain temperature dependence of η/s (SC(4,2)) and initial conditions (SC(3,2))
- Anisotropies in central collisions mainly arise from fluctuations
  - ⇒ Discriminate between different initial conditions using both SC(3,2) & SC(4,2) in central events

arXiv:1604.07663







Overview of 2016 Operations

& News from RUN 2

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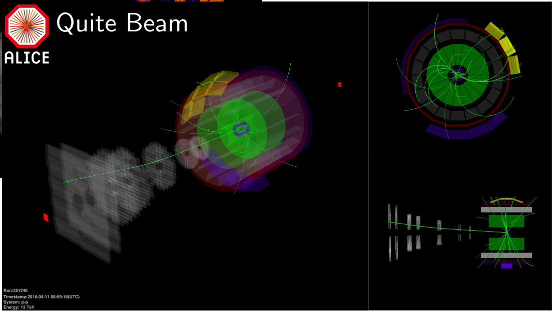

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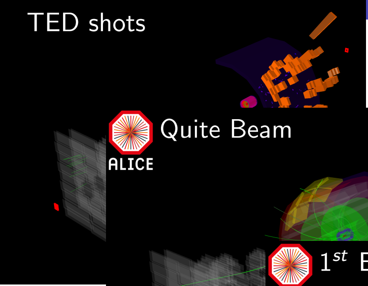

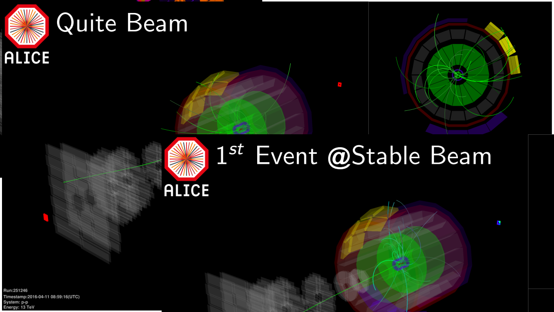

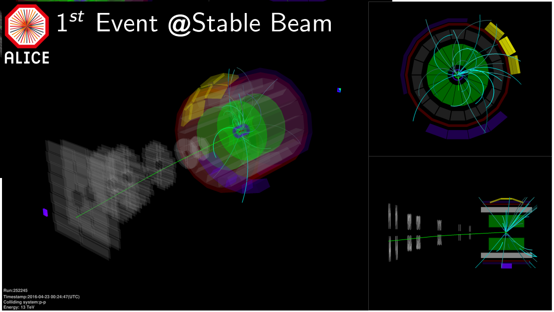

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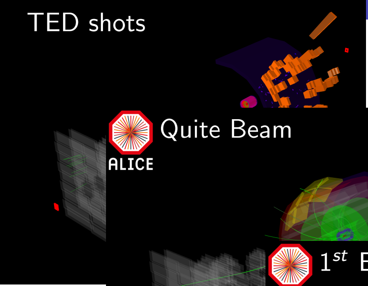
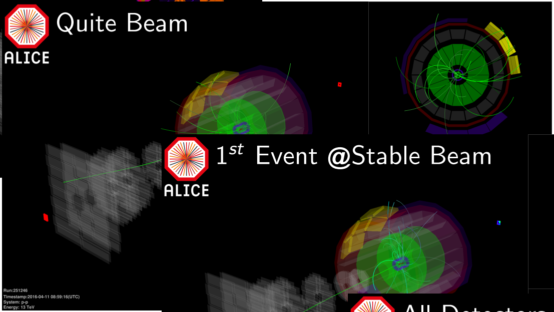
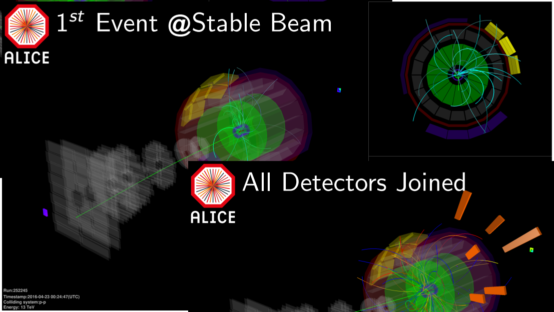
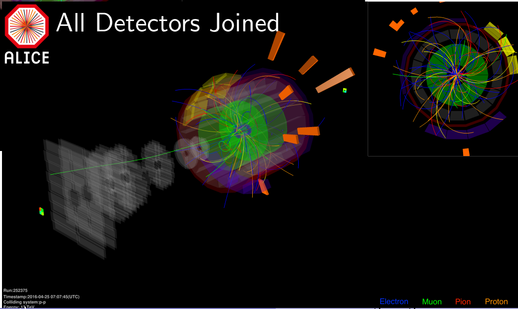
Overview of 2016 Operations



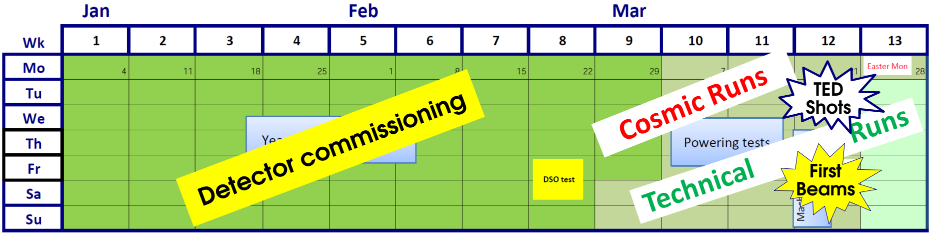




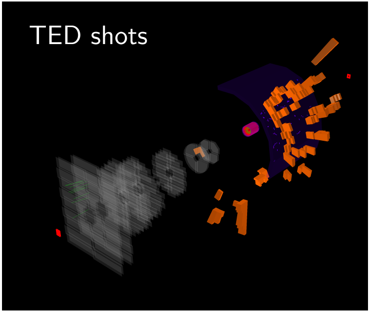


& News from RUN 2

Commissioning & Startup in 2016



- TPC RCU2 commissioning finished in time for stable beam
- Shots on TED (21^{st}-22^{nd} March) used for initial trigger alignment
- Finalized trigger alignment during quite beam period



Running Strategy for pp 2016

Default strategy

- μ: $\sim 1\%$
- Interaction rate: up to V0AND ~300 kHz (L=5Hz/μb) with 2500 colliding bunches
- Lifetime: ~50% in central barrel, ~80% in muon arm
- Foreseen integrated luminosity: 7.5pb^{-1} in central barrel, 12 pb^{-1} in muon arm

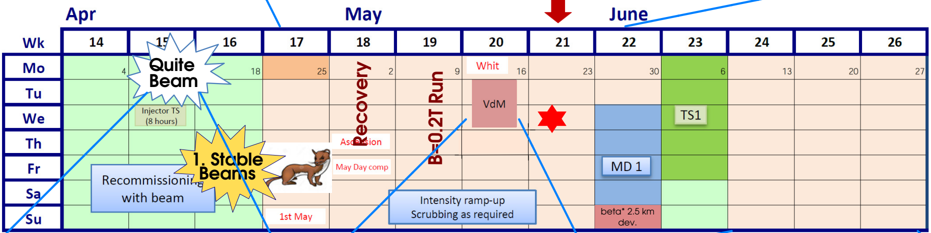
Trigger menu:

- Central barrel:
  - Minimum bias: 300 Hz (target ~900M), B=0.2T: ~150M
  - High multiplicity trigger: 80 Hz (target ~250M)
  - CALO (EMCAL/DCAL/PHOS) gamma and jet triggers: 60 Hz
  - Double-gap diffractive trigger: 30-50 Hz (downscaled)
  - ACORDE cosmic 4-fold coincidence interleaved with beam: <1 Hz
  -
- MUON arm:
  - Single muon low and high p_T: 10-20 Hz (downscaled) and 130 Hz
  - Dimuon low p_T: 30 Hz

Early Running in pp 2016

Ramp up scenario

- 3 b/beam (isolated bunches): → Global OR, μ=5%, IR=1kHz
- 12-48 b/beam: MB (VBAND) data taking with trains at μ=5%
- 72-600 b/beam: MB data with B=0.2T
- 72-1700 b/beam: MB+RARE data taking: keep constant μ 1% and gradually increase IR



Quite Beams

- Only Calorimeters & trigger detectors (ITS, V0, AD, T0)
- Mainly for trigger alignment

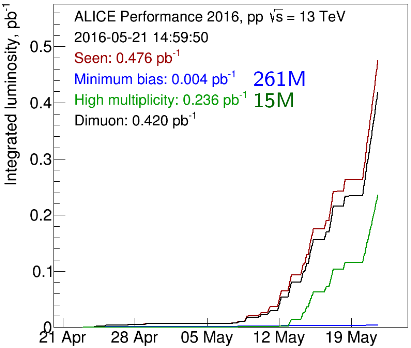
Trigger setup for vdM

- ATLAS+CMS+LHCb vdM: GlobalOR data taking with ZDC, μ=0.1-1%
- ALICE vdM: standard vdM scan setup (ADAND, VBAND, 0TVX)

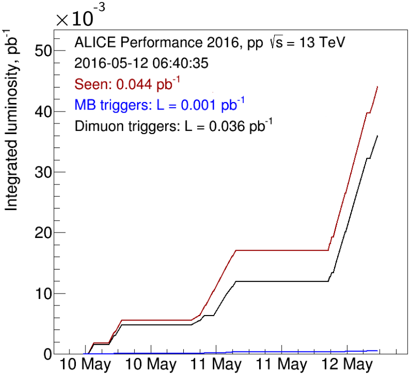
Trigger setup after ramp up

- IR=300kHz (or @IR=100kHz)
- Muon cluster decoupled (∼80% lifetime))
- Central cluster: MB(300Hz) + HM(80Hz) + CALO(60Hz) + DG(tests) + TRD

ALICE Performance 2016



B = 0.5T



B = 0.2T

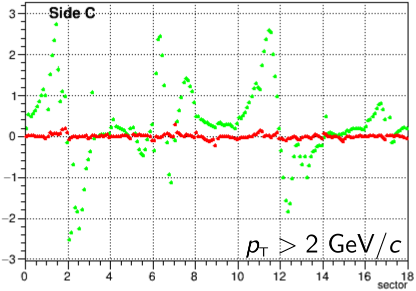
Special periods:

- 75M global OR triggers (V0 | AD |SPD) with isolated bunches
- 54M minimum bias triggers with reduced solenoid field B=0.2T (to be continued)
- 10M minimum bias at $\mu < 0.002$ with ZDC during ATLAS/CMS/LHCb vdM

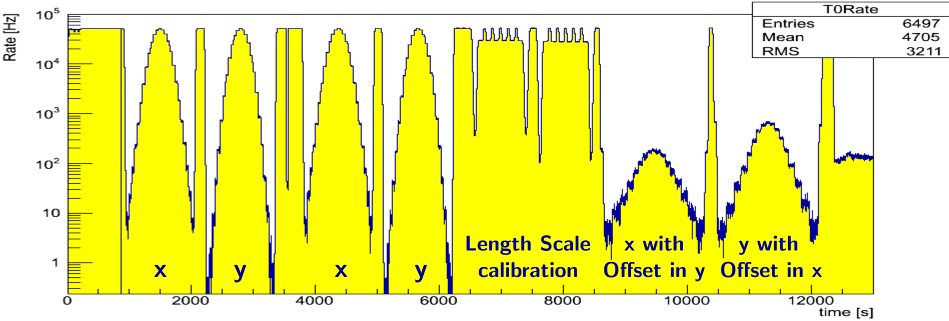
TPC Distortion Corrections

- Correction extraction procedure well established (was foreseen for RUN3)
  - New calibration allows to correct for up ∼10 cm distortions
  - Distortions fluctuations remain, accounted by increasing errors of affected clusters
- Study of distortions scaling with IR
  (caused major delay in starting the production)
  - Scaling is not precise enough to reliably extrapolate corrections from one run to another (in analysis grade production)
  - Very useful in initial reconstruction for calibration
- Pb-Pb 2015 production status
  - Low luminosity: finished in middle of May
  - High luminosity: running

TPC track DCA@vertex
(convolution of p_T and angular resolution)
Uncorrected Corrected



Van der Meer Scans in IP2



- $\beta^* = 19$ m
- Detectors: T0, V0, ITS, AD0
- Taking data with half crossing angle $= +160\ \mu$rad external in shadow of ATLAS and CMS vdM scan
- Successful scan within ~ 3.5 h
- Data taking efficiency 93%

The Future: ALICE Upgrade Program

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

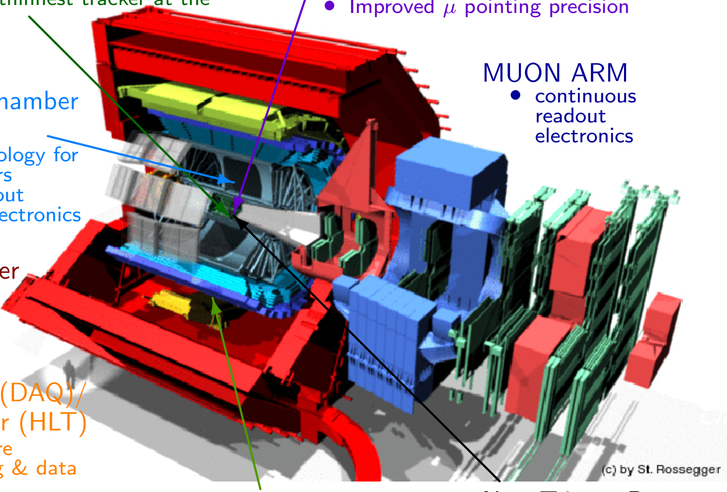
MUON ARM

- 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

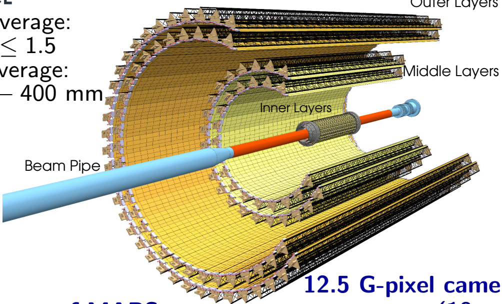
TOF, TRD, ZDC

- Faster readout

New Trigger Detectors (FIT)

Upgrade Progress: New ITS

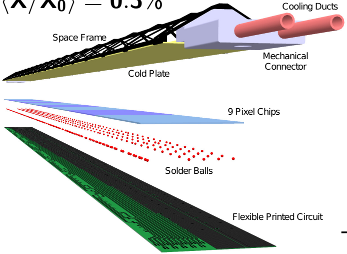
η coverage:
$|\eta| \leq 1.5$
r coverage:
$22 - 400$ mm

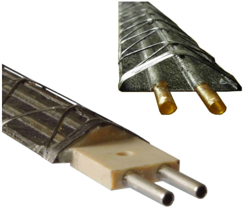


7 layers of MAPS

12.5 G-pixel camera (10 m^2)

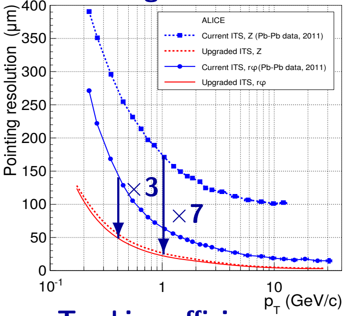
$\langle \mathbf{X/X_0} \rangle = \mathbf{0.3\%}$



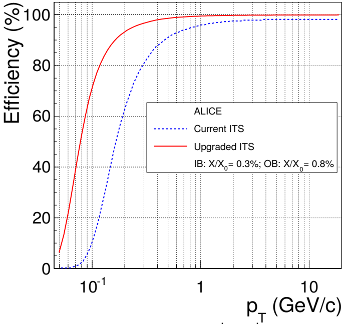


Total weight: 1.4 g

Pointing resolution



Tracking efficiency



Stave - Support Mechanics and Cooling

Inner Barrel

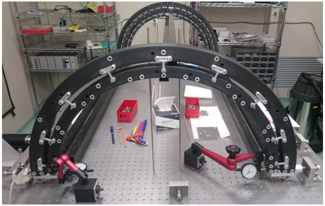
Production:
31 units produced

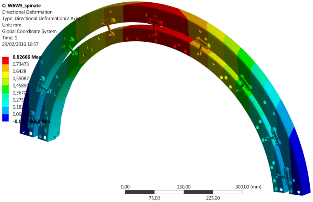
Outer Barrel

Production:
Spaceframe
21 units 1.4m (OL) produced
14 units 1m (ML) produced

Coldplate
23 units 1.5m (OL) produced
9 units 1m (ML) produced

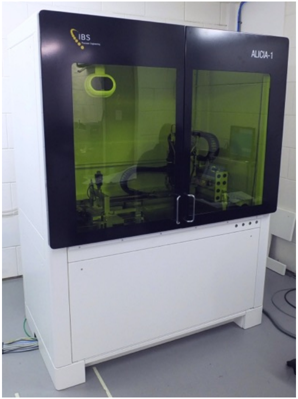
End-wheel prototypes





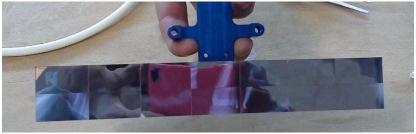
ITS Module & Stave Prototypes

Semi-automatic Module Assembly Machine

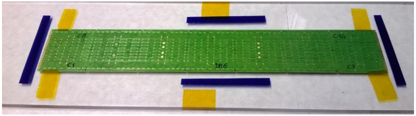


- Factory Acceptance Test successful (IBS Precision Mechanics – Netherlands)
- 1^{st} Delivery to CERN: May 2016, 5 more to come during the remainder of the year

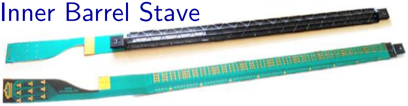
Outer Barrel HIC, pixel chip side



Outer Barrel HIC, FPC side

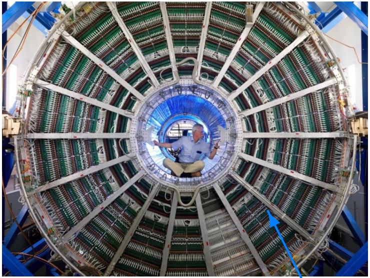


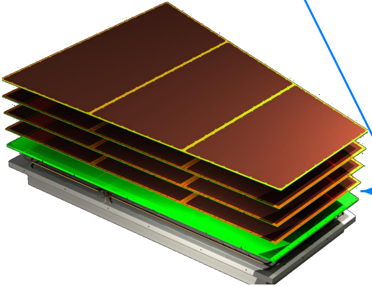
Inner Barrel Stave



- Successful construction of detector modules
- Noise thresholds as for single chip
- **Successful ITS stave engineering design review (May 3-4 2016)**

TPC Upgrade with GEMs





World Largest TPC ALICE key tracking and PID instrument 500 million pixels

To operate at the 50 kHz rate
⇒ no gating grid
⇒ need to minimize Ion Back Flow to keep space charge distortions at a tolerable level

Replace wire-chambers with quadruple-GEMs

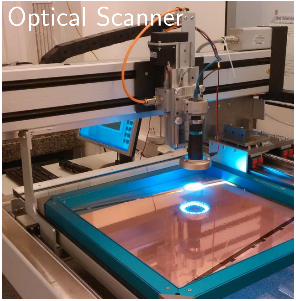
- 100 m^2 single-mask foils
- Limit Ion Back Flow into drift volume
- Maintain excellent $\mathrm{d}E/\mathrm{d}x$ resolution

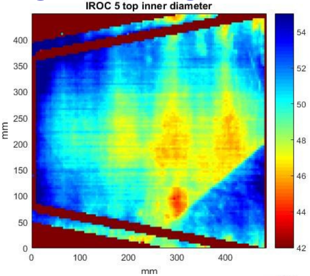
New readout electronics
Keep all other subsystems

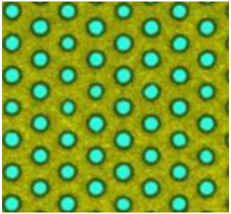
GEM and ROC EDR in November 2015
MoU sent to FA
Final decision on readout scheme taken

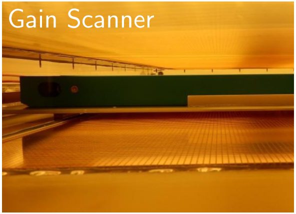
Preparing for Series Production

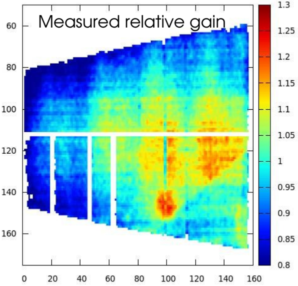
GEM QA: HD optical and gain scanning









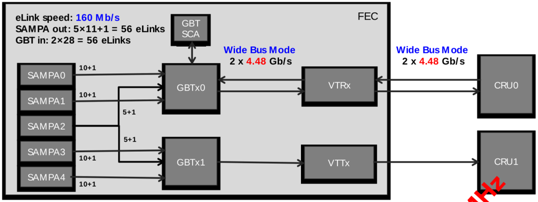


- Pre-production campaign ongoing (2 IROC + 2 OROC)
- QA and production procedures being established
- Start of mass production after PRR in August 2016

New TPC Readout Scheme

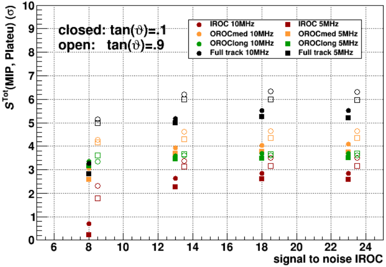
CRU

- Use direct readout mode of SAMPA without zero suppression and move signal processing functionality to CRU
  - ⇒ Reduce complexity of SAMPA and FEC
  - ⇒ Increase flexibility of signal treatment in CRU
- Reduce SAMPA ADC sampling frequency from 10 MHz to 5 MHz
  - ⇒ Reduce raw data volume by factor 2
  - ⇒ No significant performance loss



For 5 MHz

FEC schematic



Summary

- **6 paper submitted**, 9 accepted and 8 published
- Exploiting new techniques and the full detector capabilities
- New insights from hard probes in pp & p-Pb collisions from RUN1 data
  - ⇒ Hint for final state effects in central p-Pb collisions from $\psi(2S)$ production
  - ⇒ Looking forward to high statistics Run 2 data for these probes and other statistics hungry analyses!
- TPC distortions for RUN2 under control, data reconstruction ongoing
- Successful start up of pp 2016 data taking campaign
- Some key upgrade milestones have been passed, the ALICE upgrade is proceeding according to schedule