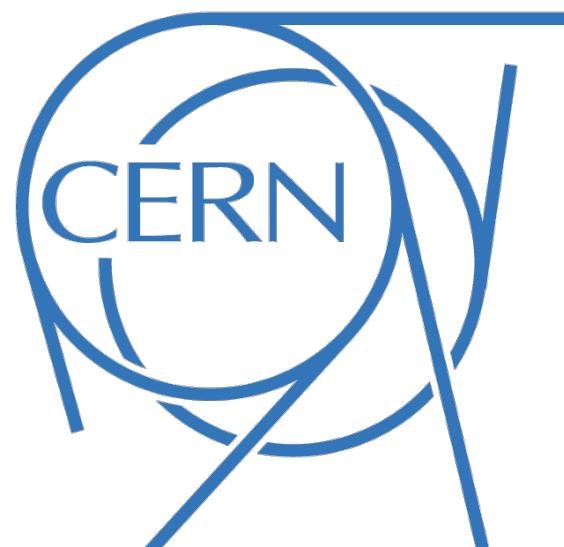


ALICE Status Report

Leticia Cunqueiro (CERN)
for the ALICE Collaboration

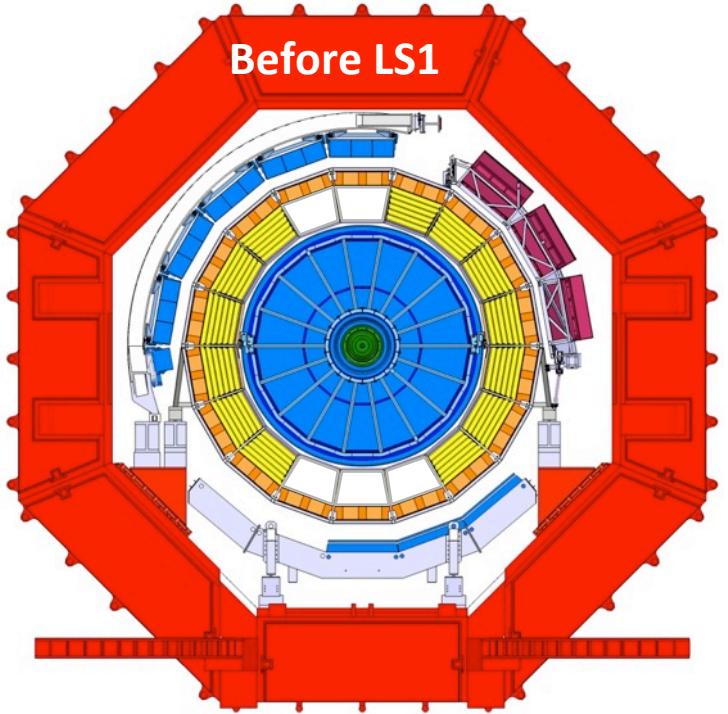


119th LHCC meeting
24-09-2014

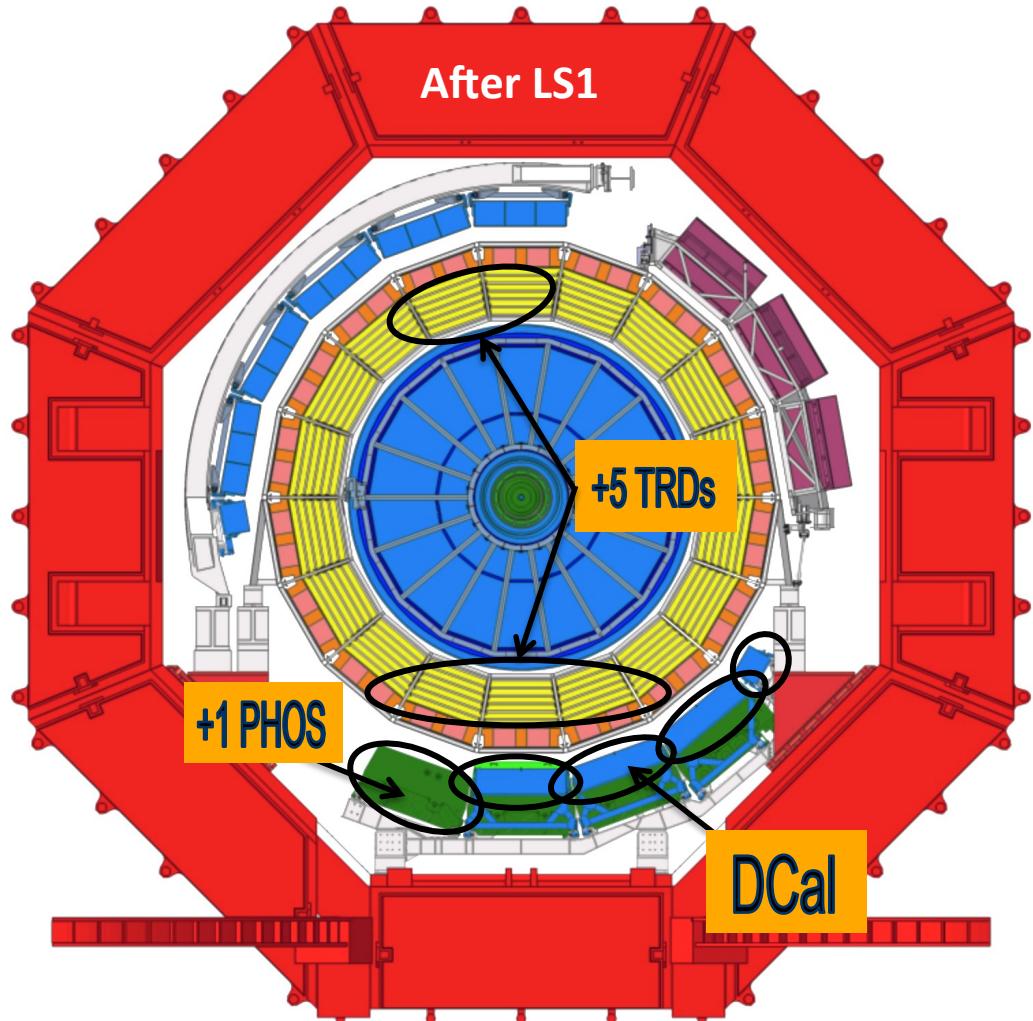


Selection of recently published and new preliminary results

ALICE LS1 activities: Detector Status



Before LS1



LS1 plan:

- Complete TRD detector (+5 SMs)
- Install DCal (8 SMs), including new support structure
- Extend PHOS (+1 SM)
- Install CPV
- Install AD detector

ALICE LS1 activities: DCal, PHOS and CPV status

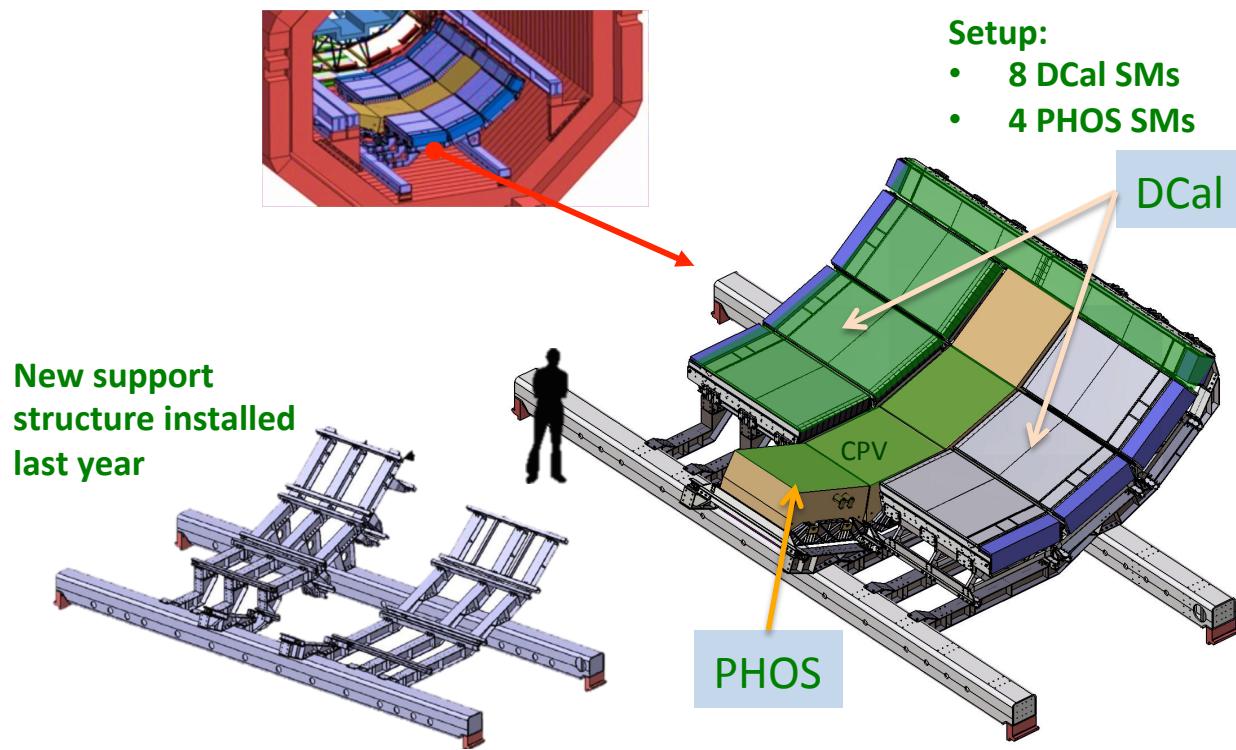
Readout + trigger upgrade and consolidation of the EMCAL/DCAL/PHOS system.



DCal installation



PHOS installation



New support structure installed last year

Setup:

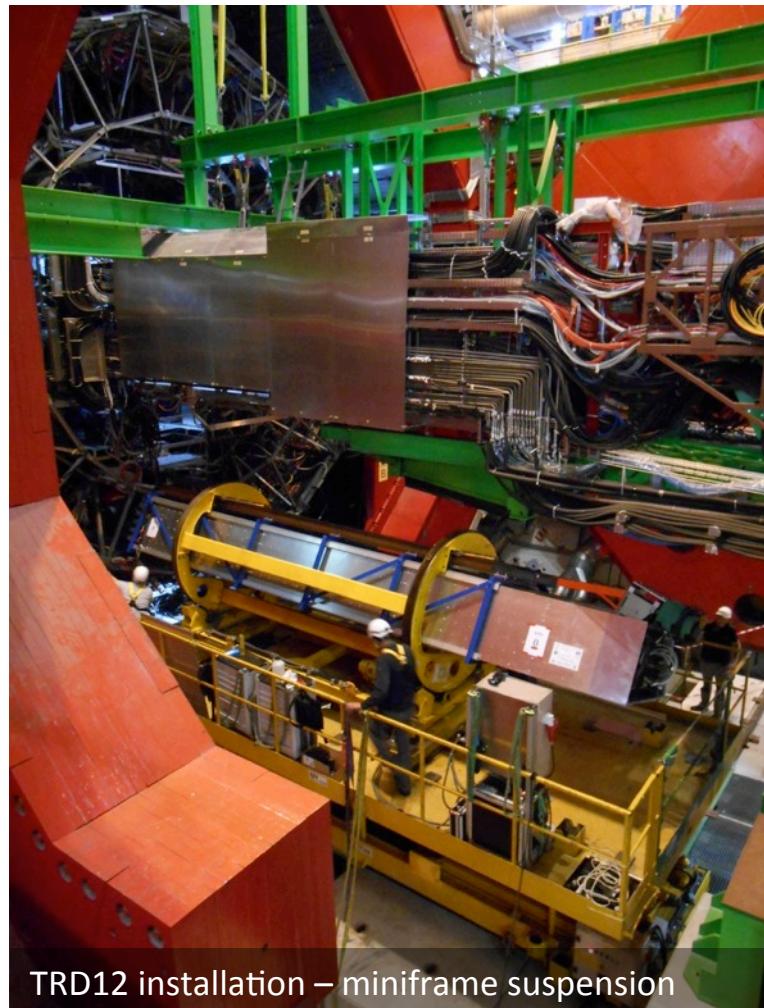
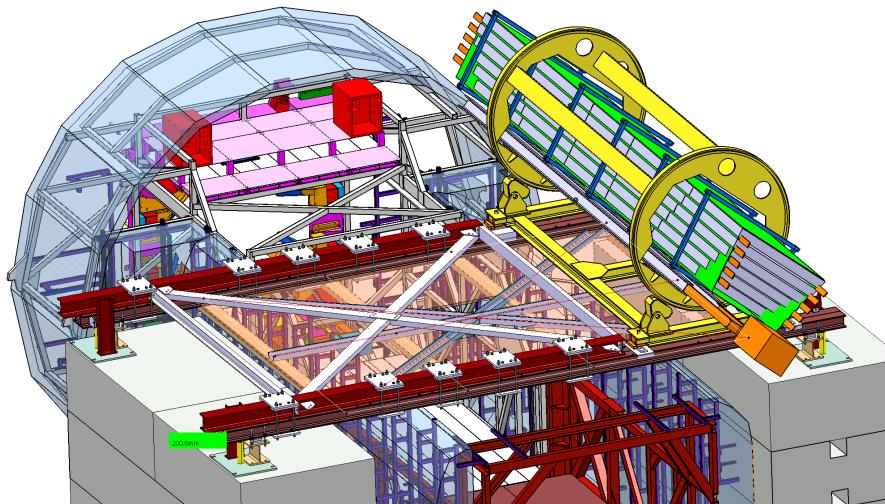
- 8 DCal SMs
- 4 PHOS SMs

Present status (w38):

- 5/8 DCal modules installed and connected to services
 - 3/4 PHOS modules installed, connections ongoing
 - 1/1 CPV module installed and connected
- plan to complete installation by beginning of November ↫

ALICE LS1 activities: TRD completion

- Three bottom sectors (12-13-14) have been installed in May → challenging installation, we had to suspend the ‘miniframe’
- Remaining sectors will be installed just before closing the L3 doors



TRD12 installation – miniframe suspension

ALICE LS1 activities and Re-commisioning schedule

- Installation of extended calorimetry and TRD completion
- Integration in progress after major upgrades of DAQ/HLT
- Numerous consolidation efforts for infrastructure
- Increase operational efficiency:
 - faster DAQ sequences
 - detector in-run auto-recovery procedures in case of front end hickups or trips
 - augmented central trigger system capabilities (double number trigger classes, sub-L0 logic, automatic setting of time sharing for triggers in different systems)
 - fully redesigned shifter interfaces and status displays
 - New Run Control Center environment operational



ALICE LS1 activities and Re-commisioning schedule

Week	System	Activity
37	CTP	<i>Install CTP2 board at p2 (no LM logic)</i>
38	CTP, LHC_IF, BEAM, DCS	<i>LHC RF ramps for DRY RUN4</i>
39	New CDH: ACO, ITS, TOF...	<i>Global Runs</i>
40	TPC, TOF, ACO, TRD? with CDHv3	<i>Start COSMIC/0 data taking (L3 B=0)</i>
41	CTP	<i>Development of LM functionality in CTP2 board</i>
42	All with CDHv3	<i>Technical (fast/full/PAR) and COSMIC/0</i>
43	EMCAL, DCAL, PHOS CDHv3	<i>Join Global Runs</i>
44	All with CDHv3	<i>Technical (fast/full/PAR) and COSMIC/0</i>
45	CTP, DAQ, ECS, V0, T0, TRD	<i>Deploy LM logic, re-test online chain with LM</i>
46	V0	<i>V0 FEE to new LM-position</i>
47	TPC	<i>RCU2 II gen proto installation (2 sectors)</i>
48	TPC, DAQ, HLT	<i>Commission mixed RCU1/RCU2 mode</i>
49	ALL	<i>Technical (fast/full/PAR) and Cosmic Runs</i>

ce

ALICE LS1 activities and Re-commisioning schedule

Week	System	Activity
37	CTP	<i>Install CTP2 board at p2 (no LM logic)</i>
38	CTP, LHC_IF, BEAM, DCS	<i>LHC RF ramps for DRY RUN4</i>
39	New CDH: ACO, ITS, TOF...	<i>Global Runs</i>
40	TPC, TOF, ACO, TRD? with CDHv3	<i>Start COSMIC/0 data taking (L3 B=0)</i>

ON SCHEDULE!

45	CTP, DAQ, ECS, V0, TO, TRD	<i>Deploy LIVI logic, re-test online chain with LIVI</i>
46	V0	<i>V0 FEE to new LM-position</i>
47	TPC	<i>RCU2 II gen proto installation (2 sectors)</i>
48	TPC, DAQ, HLT	<i>Commission mixed RCU1/RCU2 mode</i>
49	ALL	<i>Technical (fast/full/PAR) and Cosmic Runs</i>

New Physics results

Submitted papers since last LHCC

1. Multi-particle azimuthal correlations in p-Pb and Pb-Pb collisions at the LHC
[arXiv:1406.2474](#)

2. Production of $\Sigma(1385)^{\pm}$ and $\Xi(1530)^0$ in proton-proton collisions at $\sqrt{s}=7$ TeV
[arXiv:1406.3206](#)

3. Multiplicity dependence of jet-like two-particle correlations in p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV with ALICE at LHC
[arXiv:1406.5463](#)

4. Exclusive J/ ψ photoproduction off protons in ultra-peripheral p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV
[arXiv:1406.7819](#)

5. Event-by-event mean p_T fluctuations in pp and Pb-Pb collisions at the LHC
[arXiv:1407.5530](#)

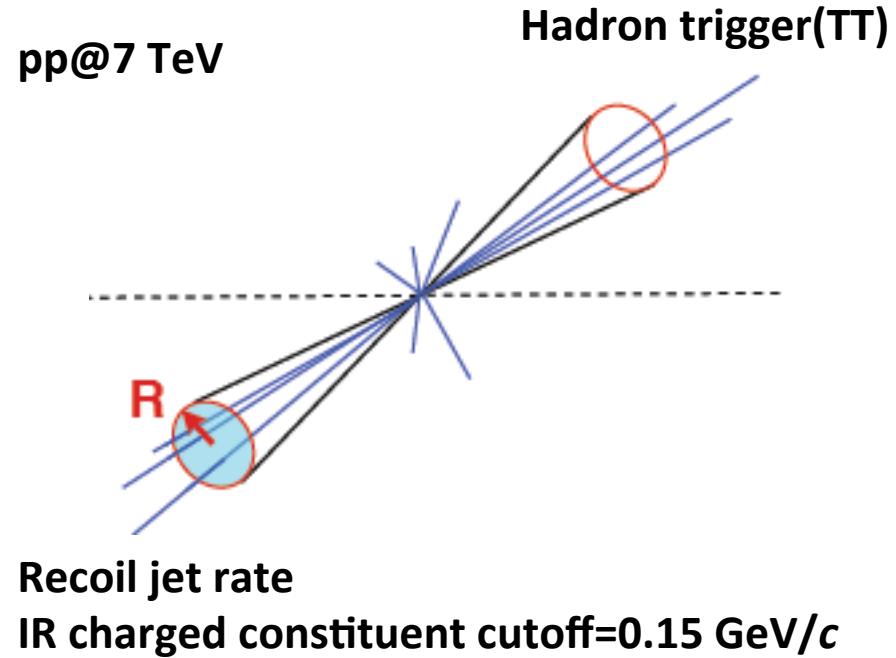
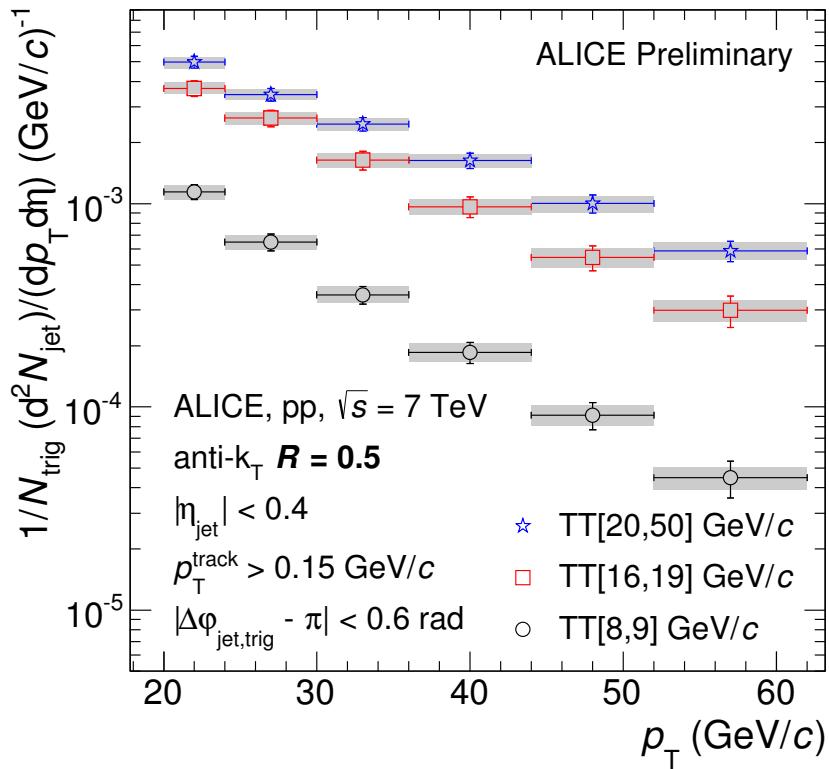
6. Performance of the ALICE experiment at the CERN LHC
[arXive:1402.4476](#)

Published papers since last LHCC

1. Transverse momentum dependence of inclusive primary charged-particle production in p-Pb collisions at $\sqrt{s}=5.02$ TeV
[Eur.Phys.J.C 74 \(2014\) 3054](#)
2. Measurement of quarkonium production at forward rapidity in pp collisions at $\sqrt{s}=7$ TeV
[Eur.Phys.J.C 74 \(2014\) 2974](#)
3. Production of charged pions, kaons and protons at large transverse momenta in pp and Pb-Pb collisions at $\sqrt{s}_{NN}=2.76$ TeV
[PLB 736 \(2014\) 196-207](#)
4. Centrality, rapidity and transverse momentum dependence of J/ ψ suppression in Pb-Pb collisions at $\sqrt{s}_{NN}=2.76$ TeV
[PLB 743 \(2014\) 314-327](#)
5. Azimuthal anisotropy of D-meson production in Pb-Pb collisions at $\sqrt{s}_{NN}=2.76$ TeV
[Phys.Rev.C 90,034904](#)
6. Beauty production in pp collisions at $\sqrt{s}=2.76$ TeV measured via semi-electronic decays
[PLB](#)

pQCD results in pp and p-Pb collisions

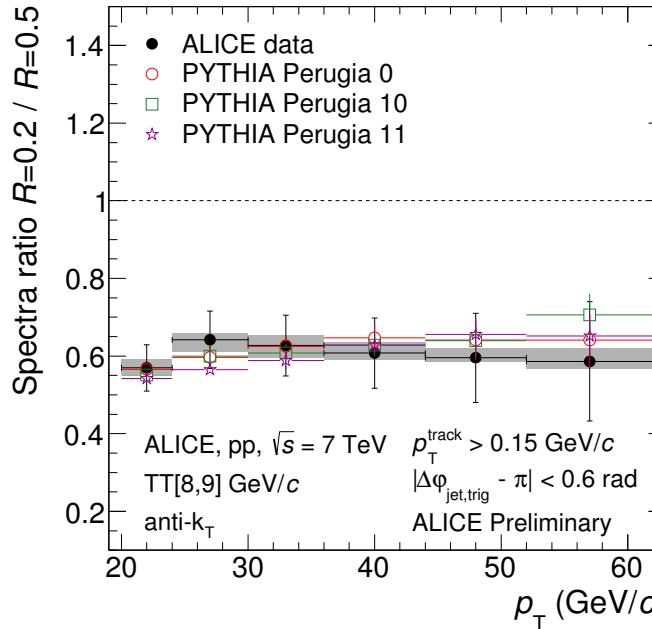
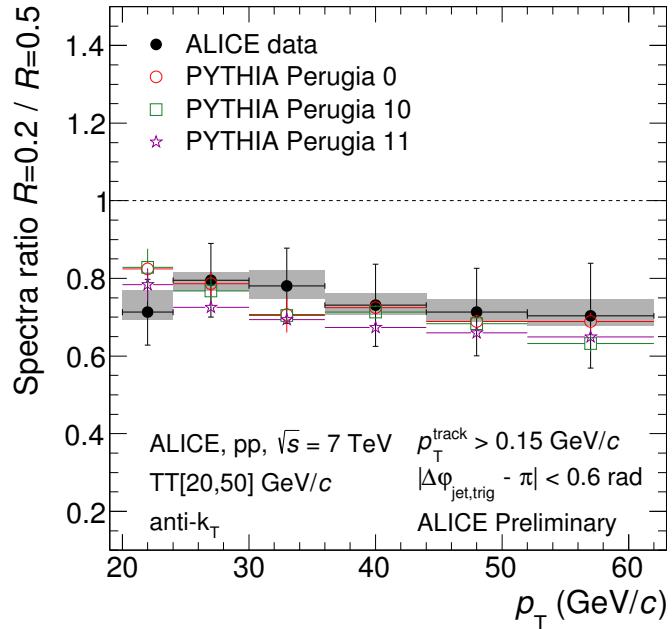
pQCD results: semiinclusive recoil jet yields



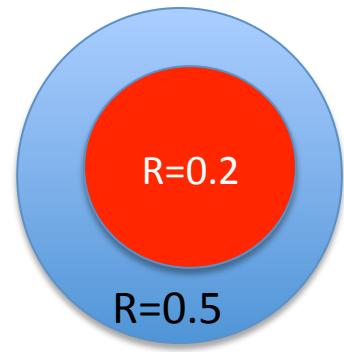
- Measurement of the per trigger charged jet yields recoiling from a high p_T trigger hadron
- Evolution of the recoil yield with the trigger hadron p_T :
increase p_T ->probe higher Q^2 processes->harder recoil yield

Important reference for similar measurements in Pb-Pb to probe quenching

pQCD results: semiinclusive recoil jet yields



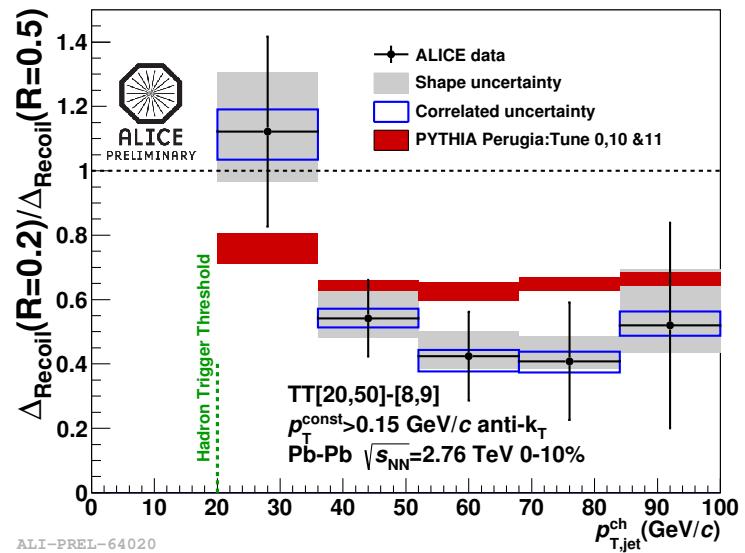
pp@7 TeV



Ratio of jet yields measured with different jet resolution R

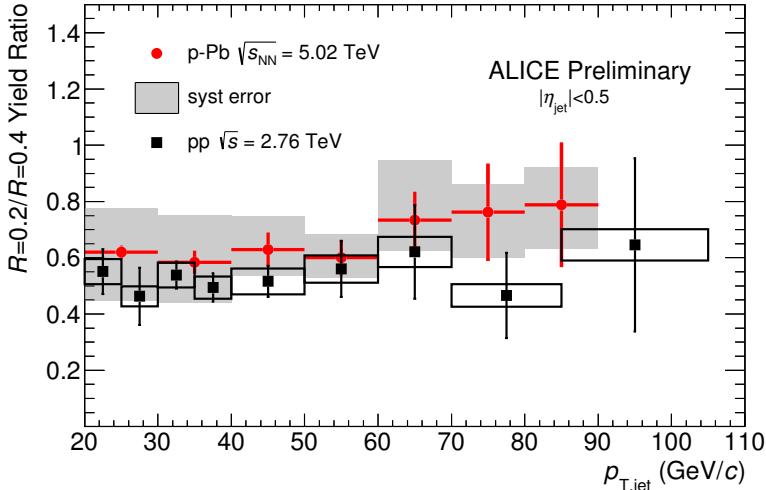
→ indirect measurements of transverse energy profile of the jet

Important reference for similar measurements in Pb-Pb to quantify jet quenching



pQCD results: jet structure in p-Pb

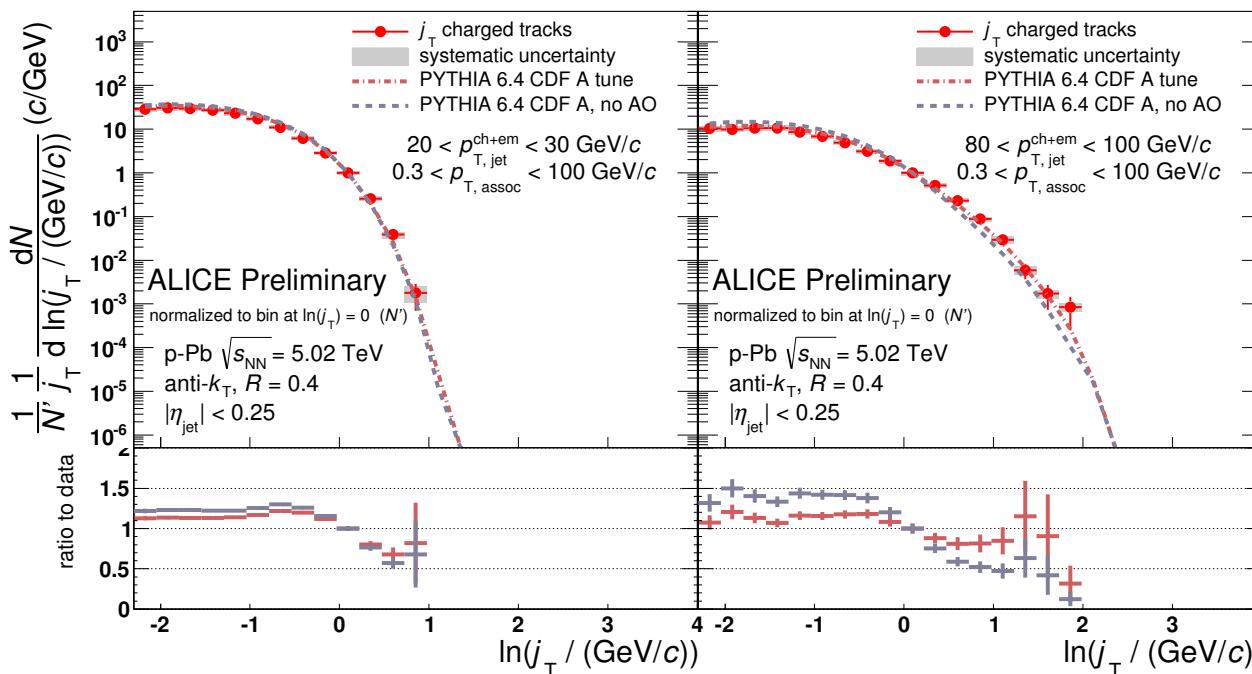
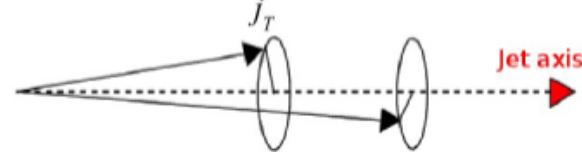
Inclusive charged jets



ALI-PREL-75744

No intra-jet broadening in p-Pb compared to pp

j_T = momentum component of charged constituents of jet



Observable sensitive to the ordering variable of the shower

ALI-DER-85290

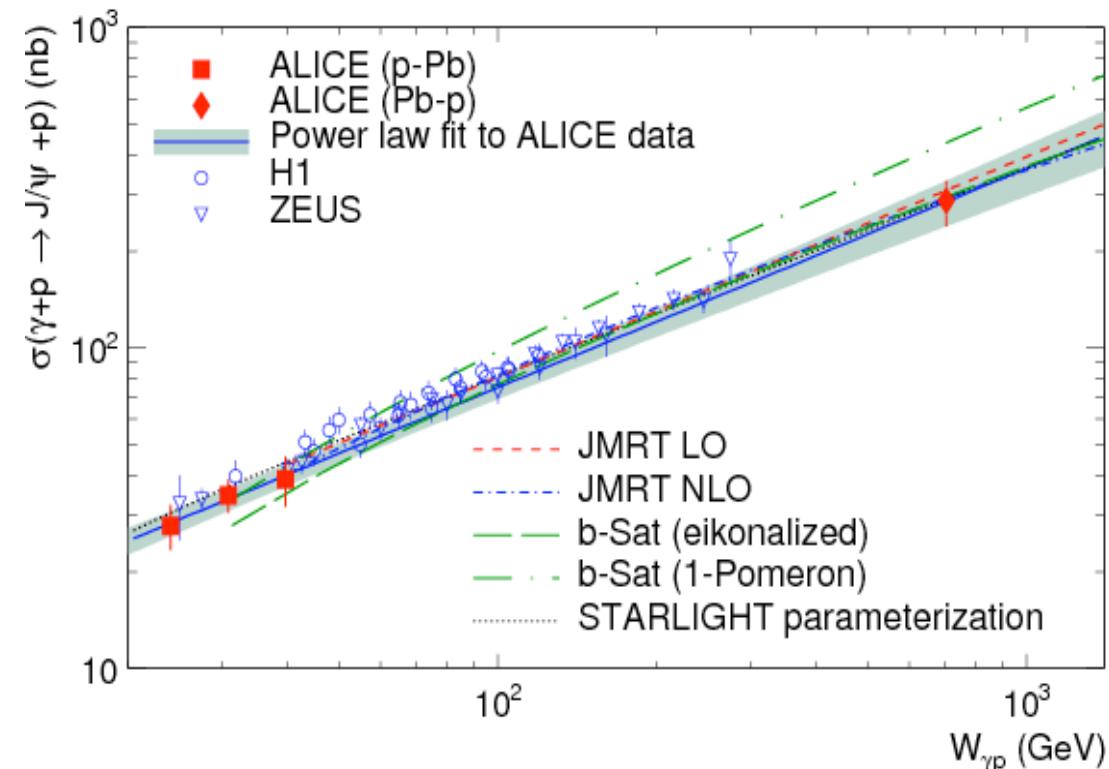
pQCD results: exclusive photoproduction of J/ ψ

- Cross section of the process $\gamma + p \rightarrow J/\psi + p$ proportional to the square of the gluon PDF
- Mass of charm quark sets the scale for pQCD
- Pb ion acts as a source of photons, **structure of the proton probed**

p-Pb@5.02 TeV

Kinematic range extended

	HERA	ALICE
γp CME	20-300 GeV	25-700 GeV
x_{BJ}	$2 \times 10^{-2} - 1 \times 10^{-4}$	$1.6 \times 10^{-2} - 1.9 \times 10^{-5}$



No evidence for change of regime

Same parametrical description of the cross section at HERA and LHC



no change in the evolution of the gluon PDF

Multiparticle correlations in pp, p-Pb and Pb-Pb collisions

Multiparticle correlations in pp, p-Pb and Pb-Pb

Study contributions to multiple-particle correlations in different systems

- Address their global (flow-like) or few-particle (non-flow) origin
- Collectivity in small systems like p-Pb or pp at high multiplicities?

-Flow contribution:

Initial spatial anisotropies in the initial state can translate to momentum anisotropies in the final state ->azimuthal flow

-Non-flow contribution:

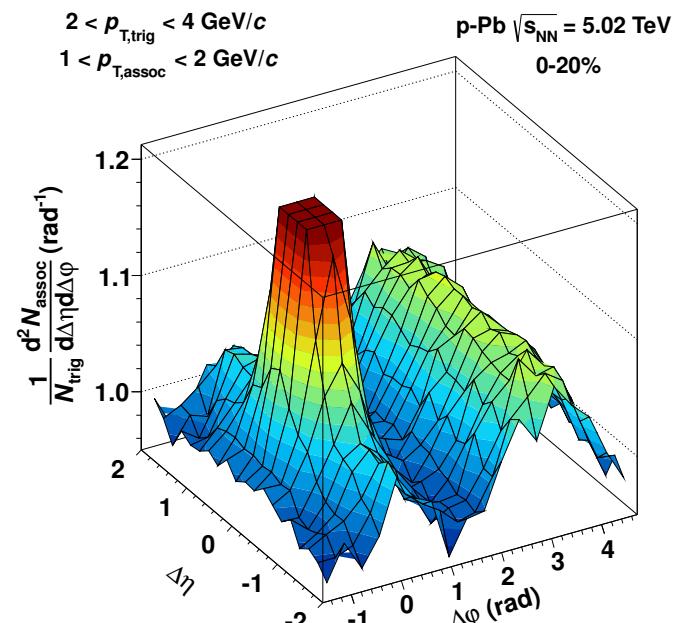
Quantum statistics, Femtoscopy

Conservation laws

(important for identified particle correlations)

Jets

Resonances, photon conversions

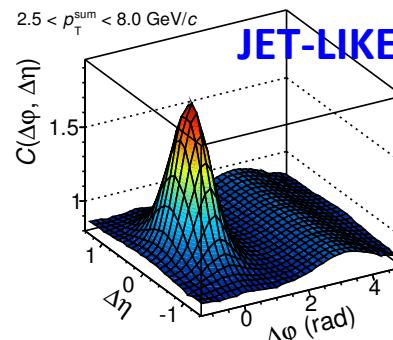
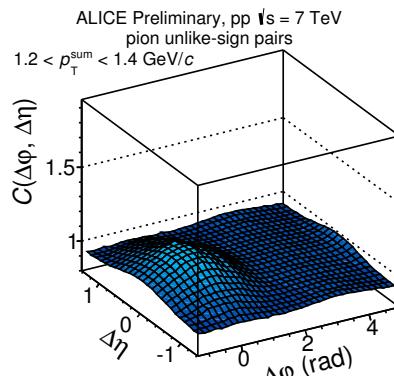
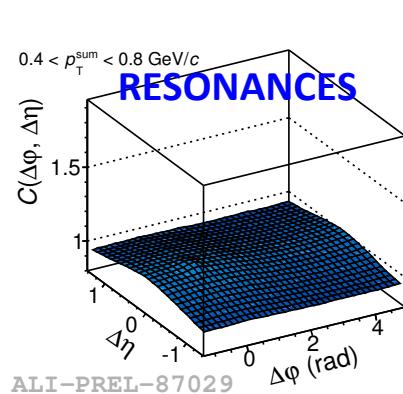


ALICE-PUBLIC-46644

PLB 726 (2013) 164-177

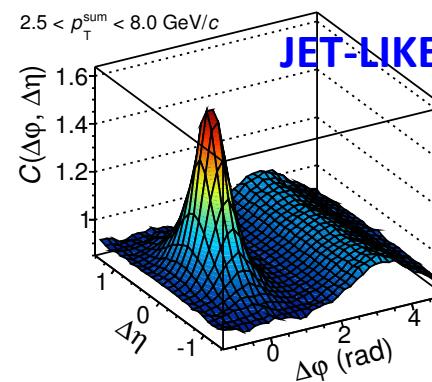
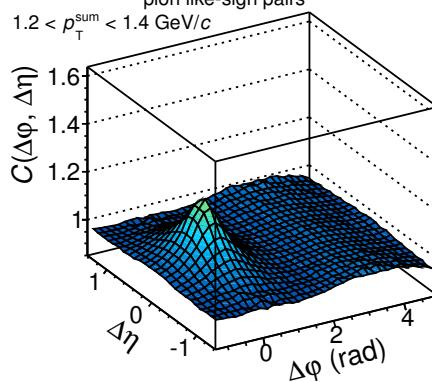
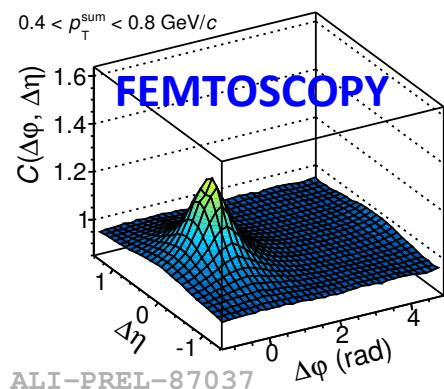
Multiparticle correlations in pp: identified hadrons

pp@7 TeV



2-particle angular correlations for PIONS

Unlike-sign

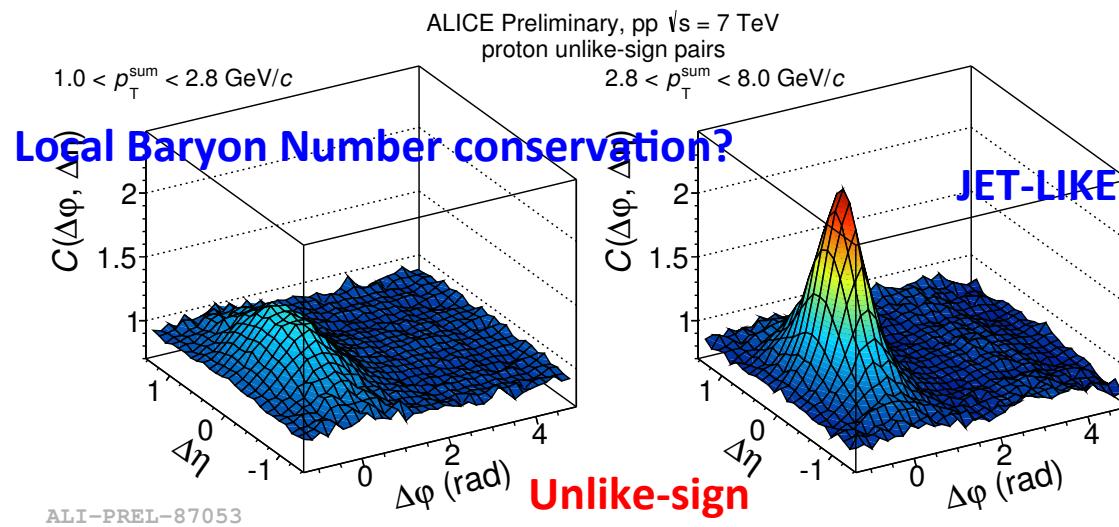


p_T increases ->jet-like peaks

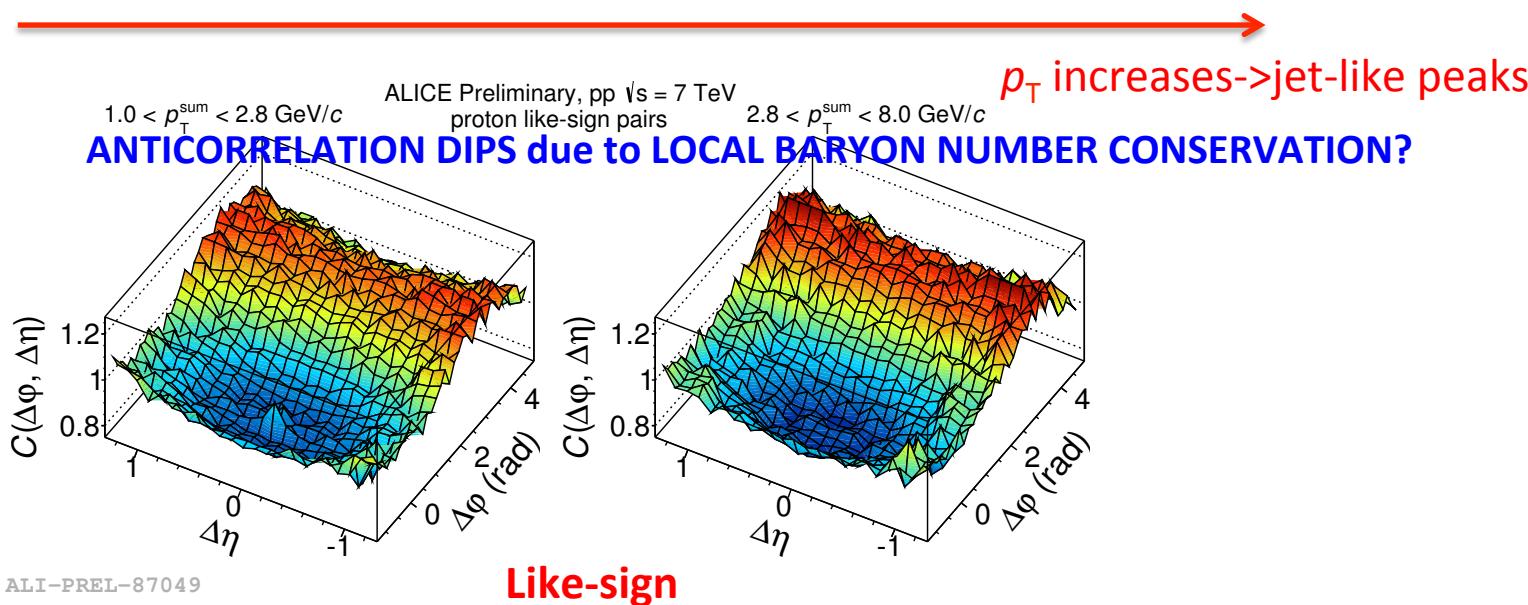
Like-sign

Multiparticle correlations in pp: identified hadrons

pp@7TeV

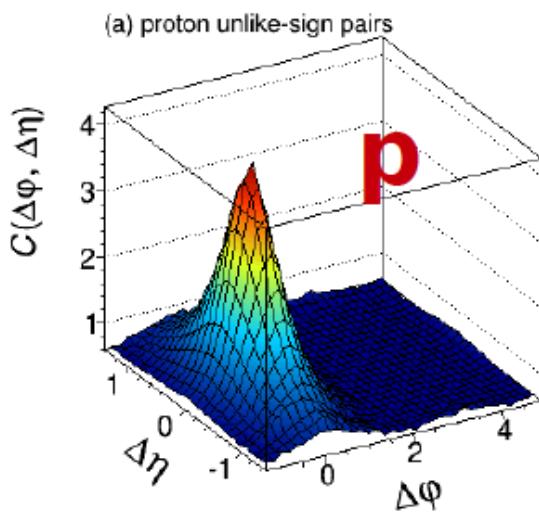


2-particle angular correlations for **PROTONS**

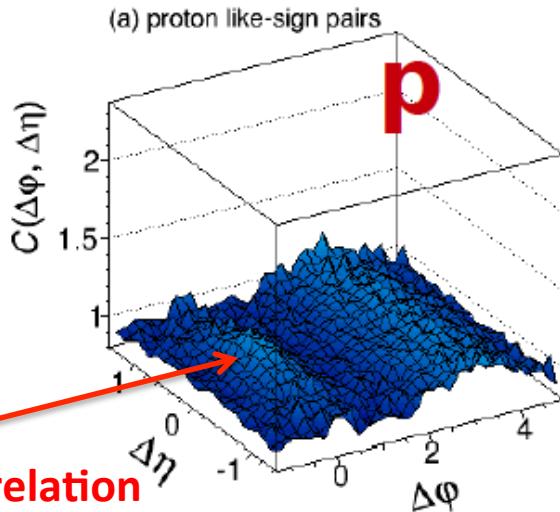


Multiparticle correlations in pp: identified hadrons

PYTHIA@7 TeV



Much stronger 2-proton correlation in PYTHIA Perugia0 (and PHOJET) than in data



Provide constraints to baryon production mechanisms in MC:

- Popcorn
- Color Reconnection

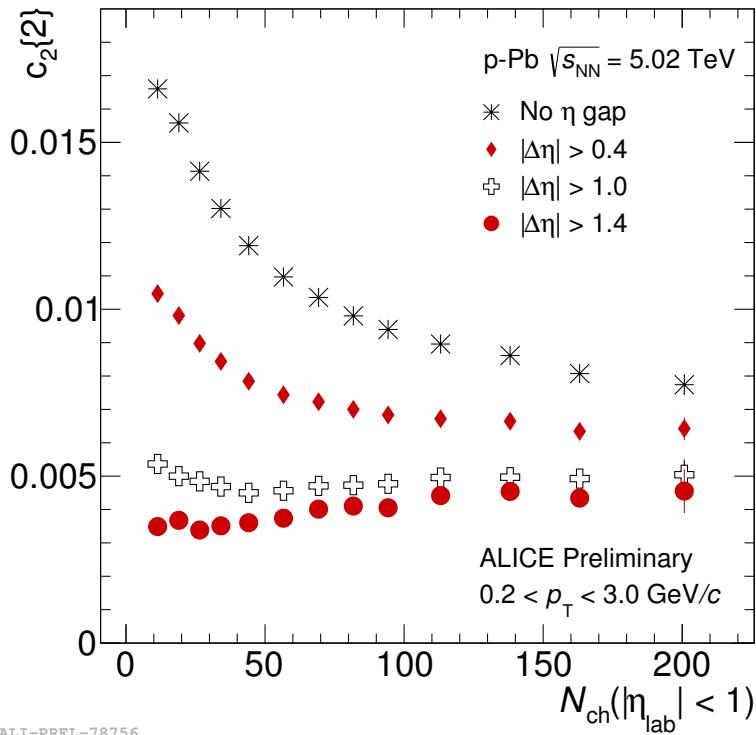
...

No anticorrelation

Multiparticle correlations in p-Pb and Pb-Pb: cumulants

Cumulants: genuine multiparticle correlation, not reducible to lower order correlations

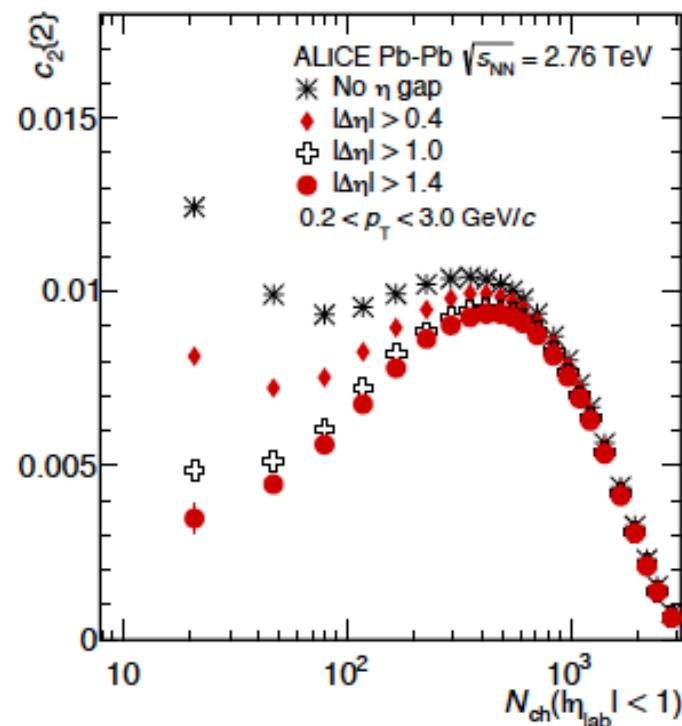
p-Pb



ALI-PREL-78756

Increase $\Delta\eta$: reduce correlations from jets and resonances
 $c_2\{2\}$ increases with multiplicity, not expected if non-flow effects dominate

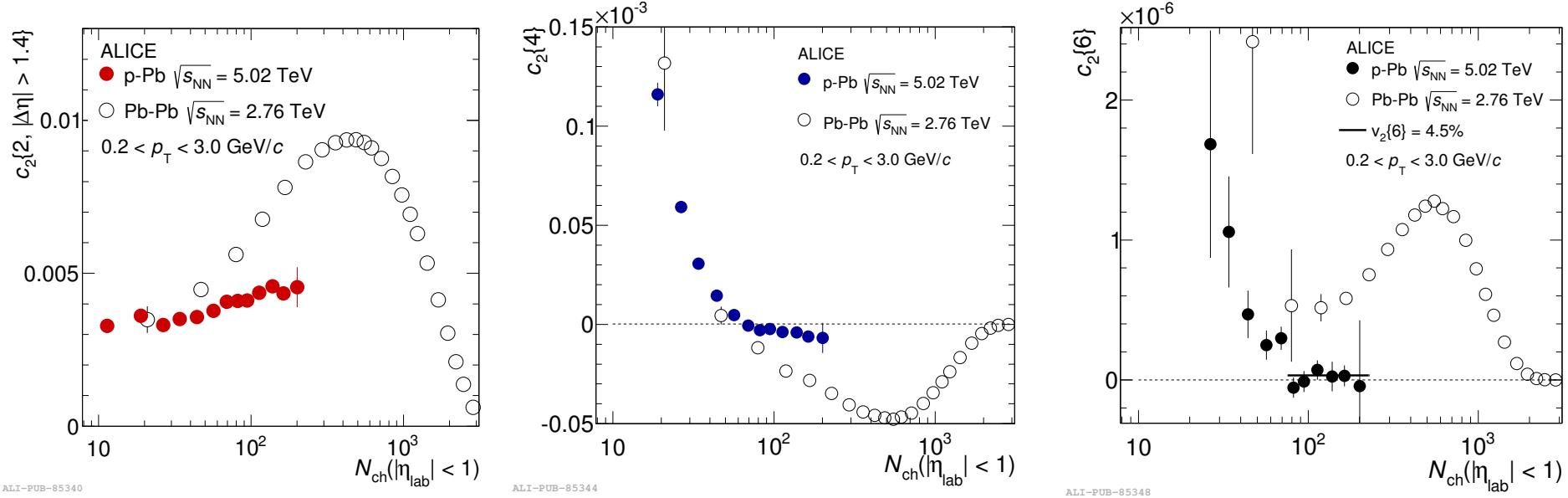
Pb-Pb



$c_2\{2\}$ is reduced with centrality at high multiplicity, as initial anisotropies decrease
 $c_2\{2\}$ strongly depends on rapidity gap at low multiplicity->non-flow dominates

Multiparticle correlations in p-Pb and Pb-Pb: cumulants

Cumulants: genuine multiparticle correlation, not reducible to lower order correlations

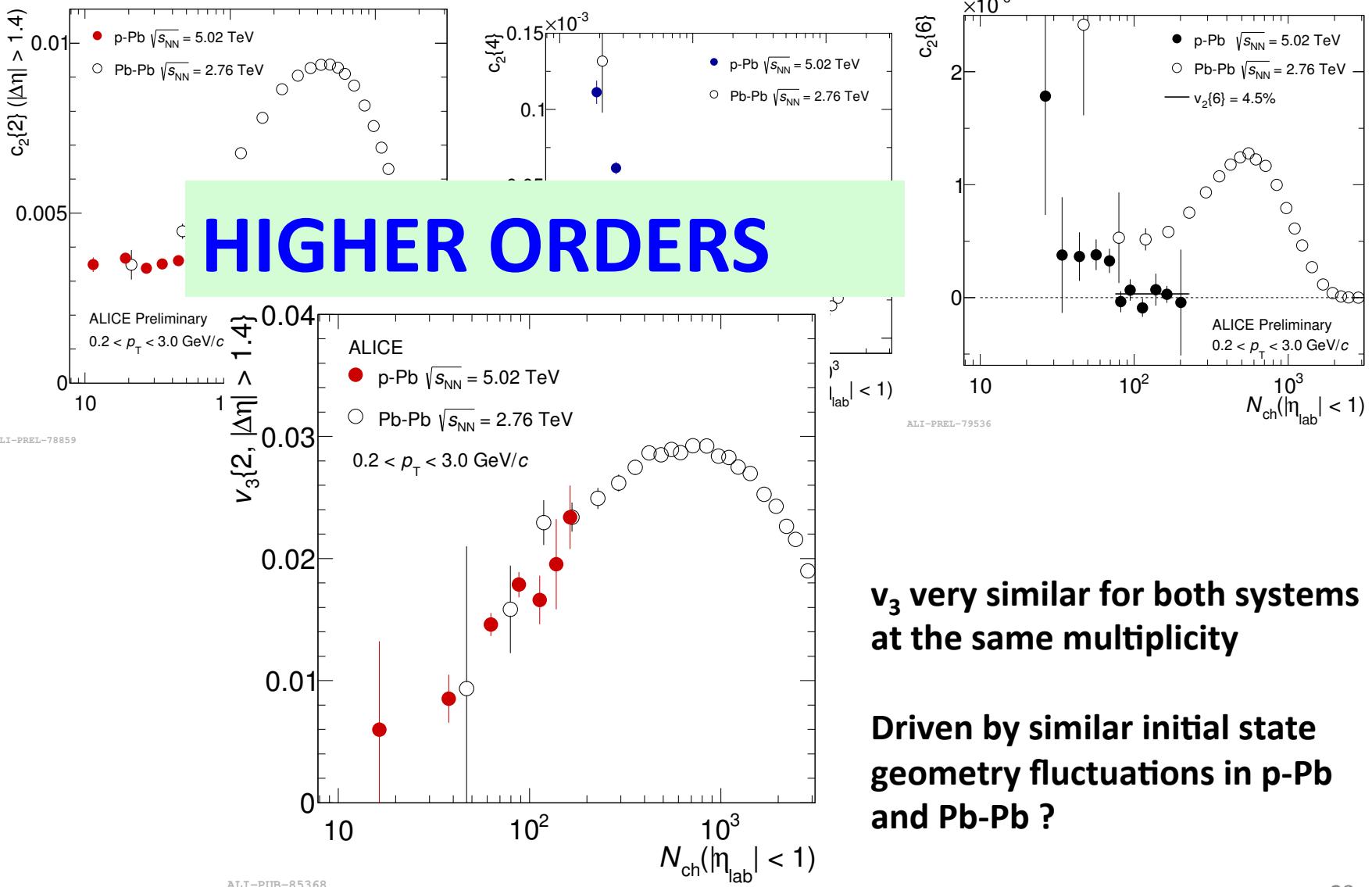


Correlations in p-Pb between 2,4 or 6 particles
signs of collective behaviour in p-Pb?

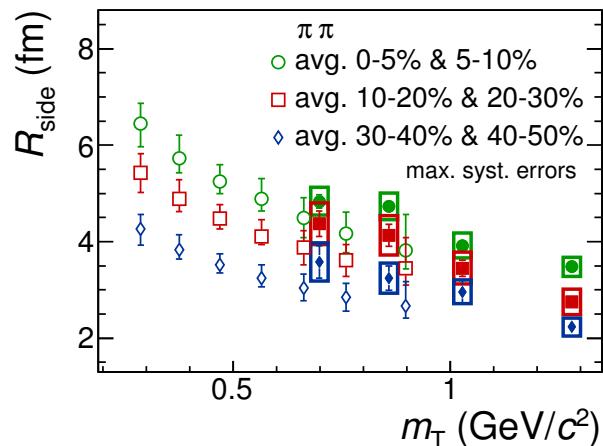
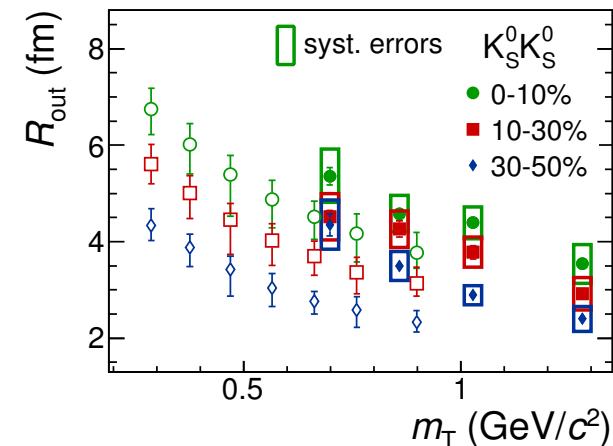
Similar qualitative picture between p-Pb and Pb-Pb
Same multiplicity, higher eccentricity in Pb-Pb

Multiparticle correlations in p-Pb and Pb-Pb: cumulants

Cumulants: genuine multiparticle correlation, not reducible to lower order correlations

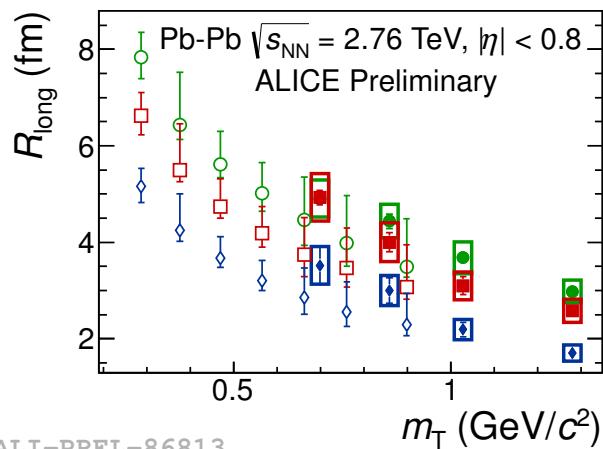


Multiparticle correlations in Pb-Pb: 3D femtoscopic radii, centrality and mass dependence

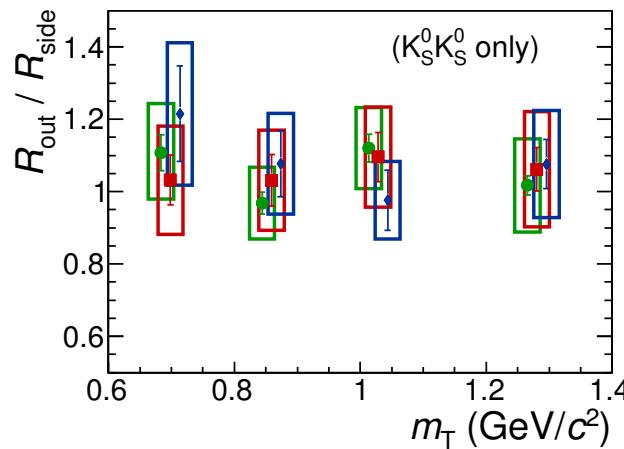


Pb-Pb@2.76TeV

Full symb.-> K_S^0
Open symb.-> π

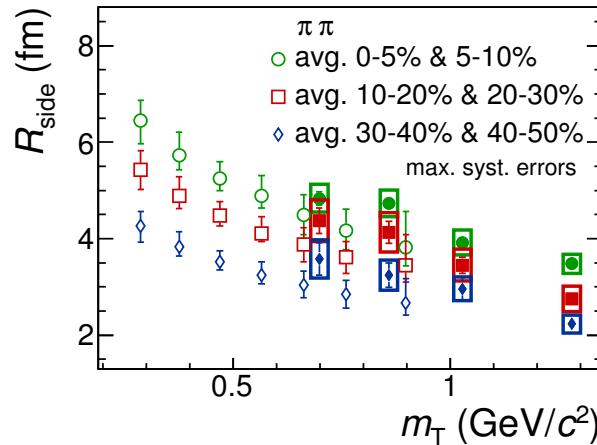
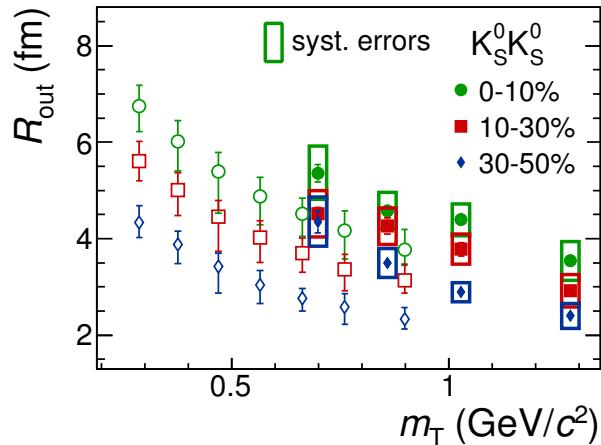


ALI-PREL-86813



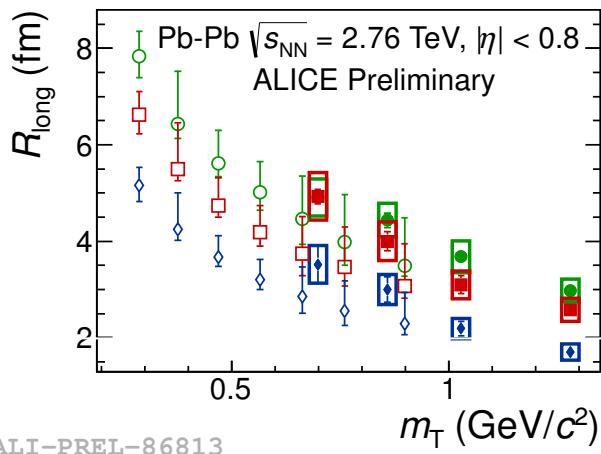
Use 2-particle quantum interferometry to measure
the size and shape of the homogeneity region at freezout

Multiparticle correlations in Pb-Pb: 3D femtoscopic radii, centrality and mass dependence

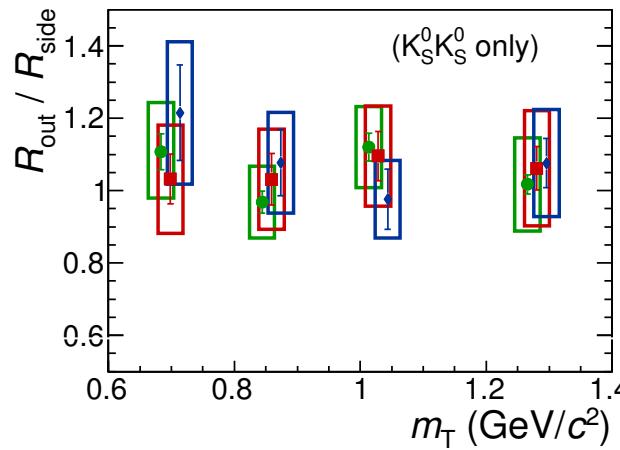


Pb-Pb@2.76TeV

Full symb.-> K_S^0
Open symb.-> π

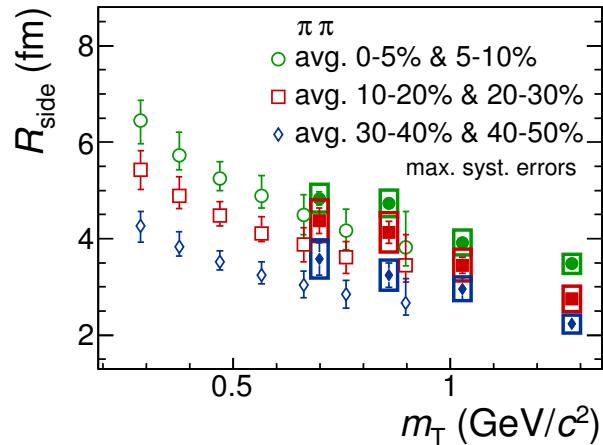
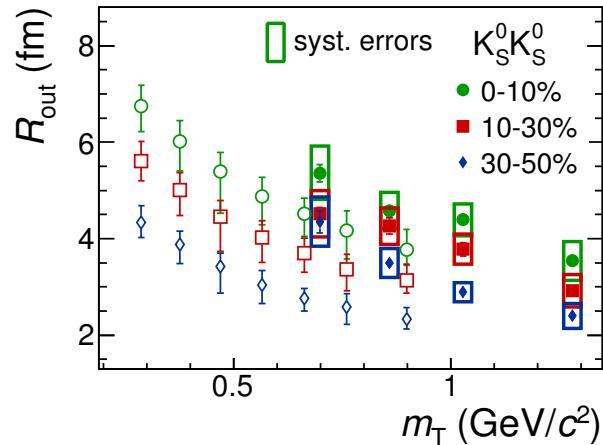


ALI-PREL-86813



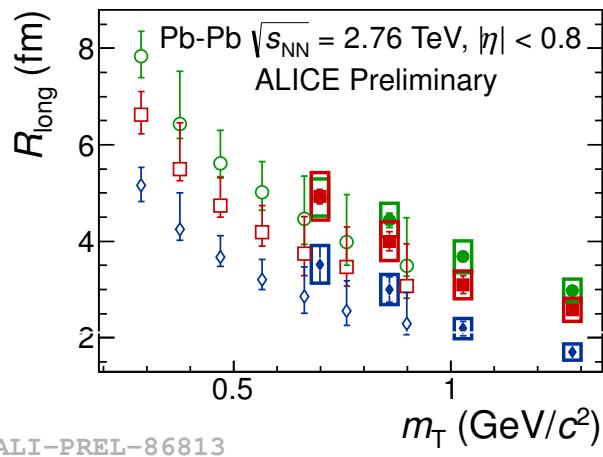
- Source size decreases with k_T (indication of collective radial flow)
- Kaons: less feed-down from resonances
look at earlier stages of the collision

Multiparticle correlations in Pb-Pb: 3D femtoscopic radii, centrality and mass dependence

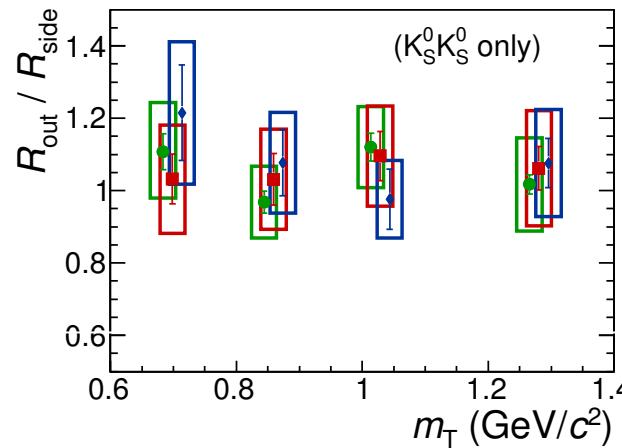


Pb-Pb@2.76TeV

Full symb.-> K_S^0
Open symb.-> π



ALI-PREL-86813

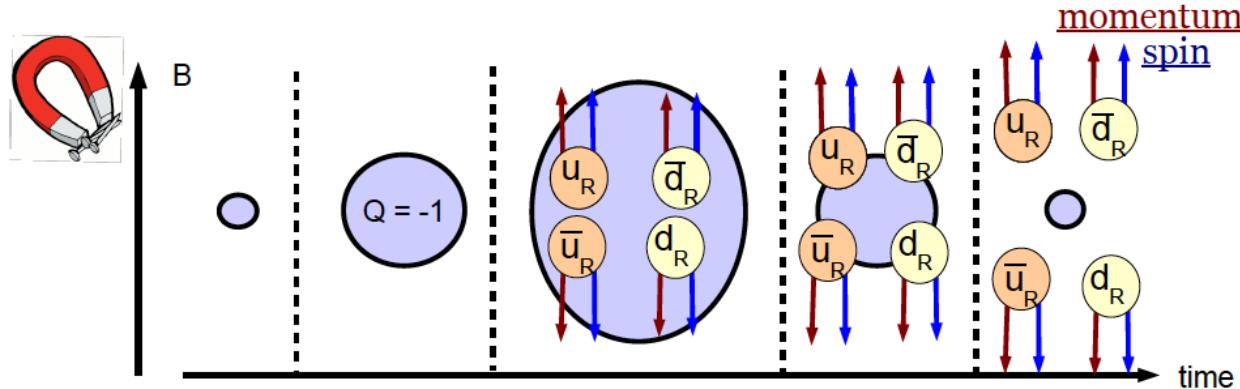


- Decreasing source size with decreasing system size (smaller initial volume)
- m_T scaling broken for R_{out} (FSI?)

Charge Separation and Chiral Magnetic Effect

$eB \sim 10^{18}$ Gauss in Heavy Ion Collisions
created by nucleon spectators

Pb-Pb@2.76TeV



Topological charge:
metastable
domains where parity
symmetry
is locally violated

$Q < -1$: Positively charged particles move parallel to magnetic field,
negatively charged antiparallel

Strong B field

+

Chiral symmetry restoration

+

Excess of left(right)-handed quarks

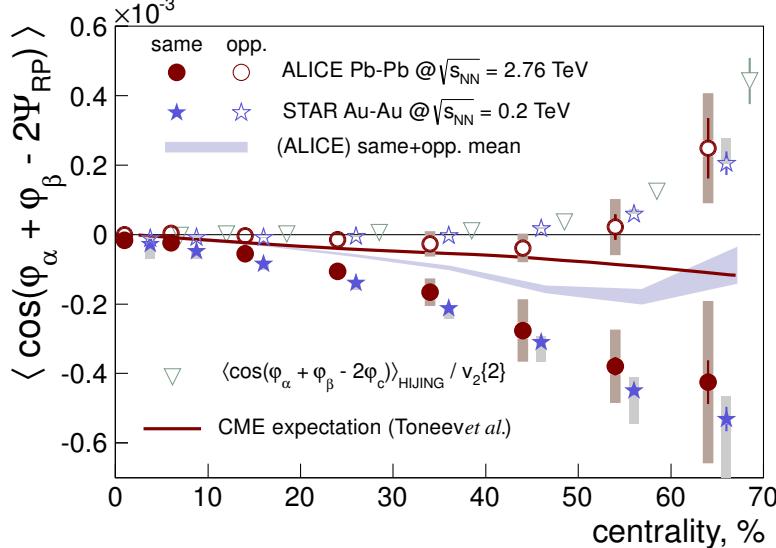
Chiral Magnetic Effect in Heavy Ions:

Preferential same-charge particle emission
along the system's angular momentum:
separation of charges in two hemispheres
separated by reaction plane

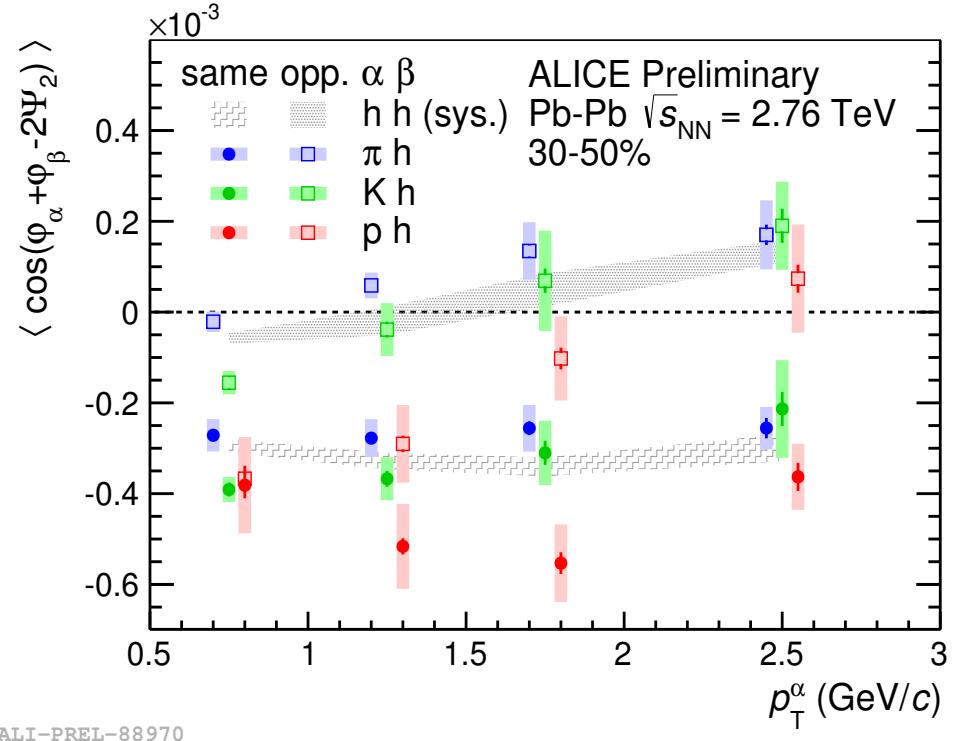
Charge Separation and Chiral Magnetic Effect

Pb-Pb@2.76TeV

2 particle correlator with the RP: $\langle \cos(\varphi_\alpha + \varphi_\beta - 2\Psi_{EP}) \rangle$



PRL 110, 012301 (2013)



-Clear charge separation with decreasing centrality

- opposite sign ~ 0
- same-sign- \rightarrow dominated by background? Local Charge Conservation +Flow ?

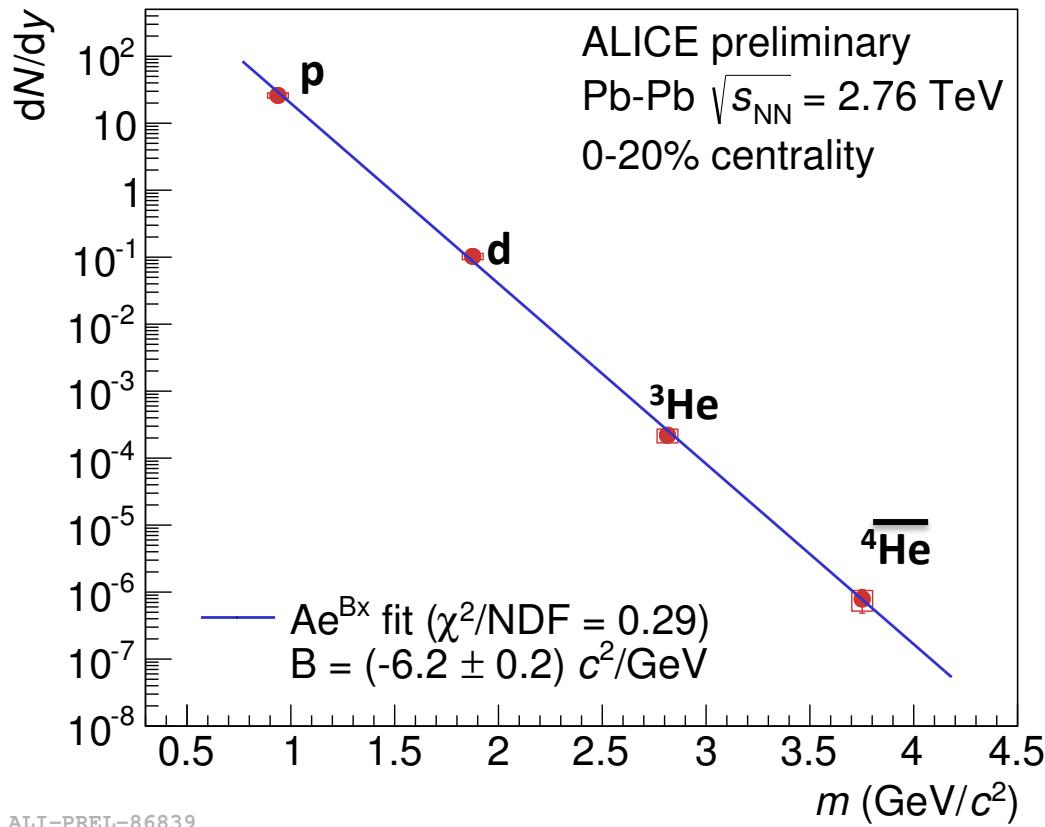
Y.Hori et al arXiv:1208.0603 [nucl-th]

-More differential measurements to constrain background:

- 1 identified particle, correlation vs the identified particle p_T

Observation and Measurement of ${}^4\overline{\text{He}}$

Pb-Pb@2.76TeV



From strongly bound protons to lightly bond ${}^4\overline{\text{He}} \rightarrow$ all lie on same curve
compatible with production in thermal equilibrium



RUN2 Planning

Year	System	E [TeV]	Lumi [$\text{cm}^{-2}\text{s}^{-1}$]	R [kHz]	LL	Weeks	Trig	Time
2015	pp 50ns	13	$10^{29} - 10^{32}$	10-600	YES	3	MIX	<i>pp</i>
	pp	13	$5 \times 10^{29} - 3 \times 10^{30}$	50-300	YES	13.5	MIX	<i>pp</i>
	PbPb	5.1	10^{27}	8	YES	4	MB	<i>HI</i>
	pp-ref	5.1	$10^{29} - 2 \times 10^{30} (*)$	10-200	YES	1+	MIX	<i>pp</i>
2016	pp	13	10^{31}	500	YES	22+2	MIX	<i>pp</i>
	pPb	5.1	10^{28}	10-20	YES	4	MB	<i>HI</i>
	pp-ref	5.1	$10^{29} - 2 \times 10^{30} (*)$	10-200	YES	0.4	MIX	<i>pp</i>
2017/8	pp	13	10^{31}	500	YES	22+2+N	MIX	<i>pp</i>
	PbPb	5.1	10^{27}	8	YES	4	MB	<i>HI</i>
	pp-ref	5.1	-	-	-	0.4	MIX	<i>pp</i>
					LS2 (1/7/18 → 18 months)			

(*) preliminary

$10\text{d} = 15 \text{ pb}^{-1}$ pp-ref $\approx 0.5 \text{ nb}^{-1} [3-4 \times 10^4 \times \int L dt (\text{PbPb})]$

The ALICE upgrade

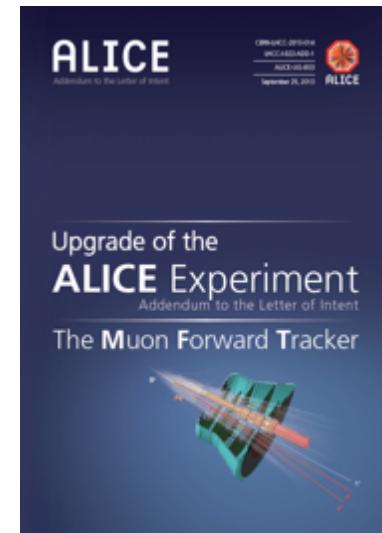
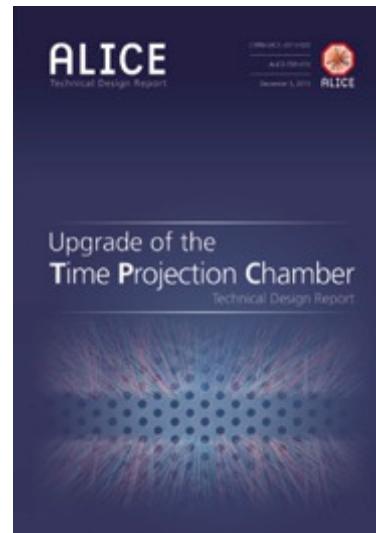
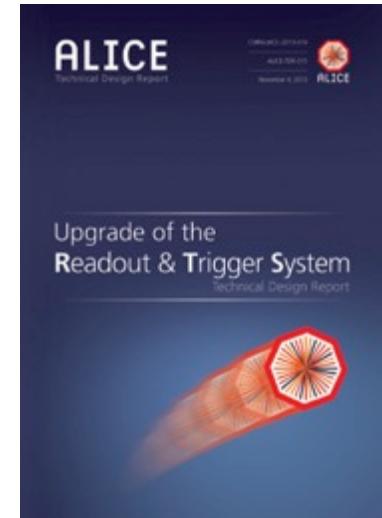
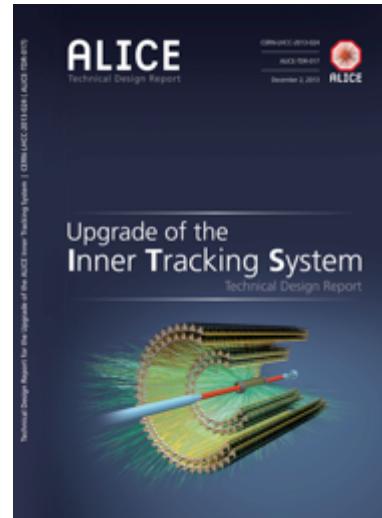
Run3+4 (after LS2)

- **Focus on rare probes:** study their coupling to the hot QCD medium and their (medium-modified) fragmentation/hadronization process:
 - Precision studies of charm and beauty mesons and baryons and quarkonia at low p_T
 - Low mass lepton pairs and thermal photons
 - Υ -jet and dijets with particle identificaton in a large kinematic range
 - Heavy nuclear states
 - **Low transverse momentum observables:**
 - Not possible to trigger, large statistics needed
 - Target:
 - *PbPb recorded luminosity: $>= 10 \text{ nb}^{-1} \rightarrow 8 \times 10^{10}$ events
 - *pp(5 TeV) recorded luminosity: $>= 6 \text{ pb}^{-1} \rightarrow 1.4 \times 10^{11}$ events
- Gain factor 100 over the statistics of the approved program**
- Operate ALICE at a high rate (->50 kHz Pb-Pb continuous)**

ALICE LS2 Scope

The approved LS2 upgrade is detailed in
5 Technical Design Reports

- ITS
- Readout and Trigger System
- TPC (under review)
- MFT (Nov. 2014)
- Online Offline System (Jun. 2015)



SUMMARY

ALICE continues to produce results...

Main recent highlights:

-**Hard probes:** mainly pp references for jet quenching measurements in Pb-Pb

-**Soft probes:** Multiparticle correlation in pp,p-Pb and Pb-Pb

-Quantum conservation laws and baryon production in pp

-Signatures for collectivity in small systems like pPb or pp at high multiplicities

-Femtoscopic radii and particle species dependence

-Charge separation and Chiral Magnetic Effect?

-Light nuclei

→ ALICE experiment on schedule for RUN2
completed TRD, calorimetry, new DAQ/HLT, new readout

→ ALICE LS2 upgrade in progress ->access to rare probes,
quantification of transport properties of the medium

BACKUP

The LS2 ALICE upgrades

New Inner Tracking System (ITS)

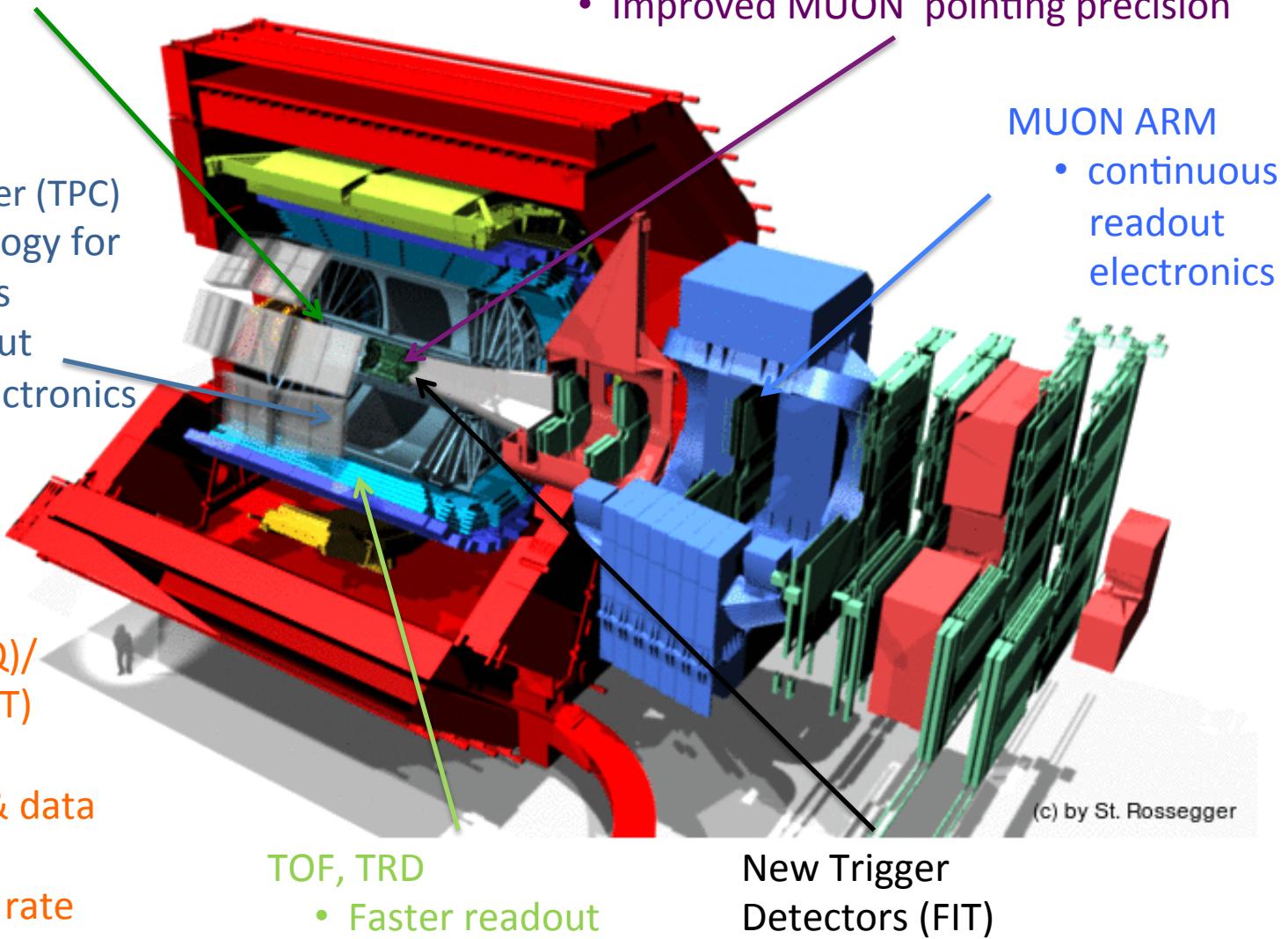
- improved pointing precision
- less material -> thinnest tracker at the LHC

Muon Forward Tracker (MFT)

- new Si tracker
- Improved MUON pointing precision

Time Projection Chamber (TPC)

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



- Faster readout

- New Trigger Detectors (FIT)

ALICE LS1 activities: consolidation work



UPS upgrade:

- UPS power increased (X5) from **160kVA** to **800kVA**
- Replacement of old units (from LEP times)
- Consolidation of electrical network



Rework of LV cables (TRD-TPC-TOF):

- Repair **400** LV (300mm²) cables whose insulation got badly damaged
- Installation new supports, re-routing of cables and test

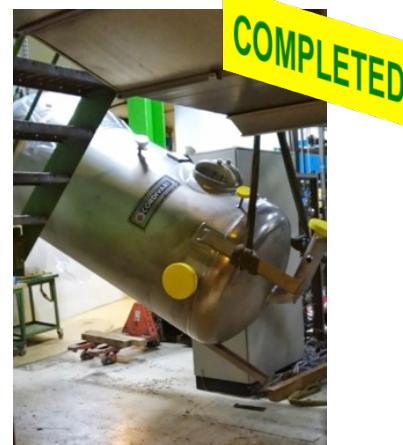
Chilled water upgrade:

- Increase of **60%** cooling power
- Installation of **5** chillers
new pumps and heat exchangers



Replacement cooling tanks:

Replacement of TRD and TPC cooling tanks with bigger ones



L3 ventilation upgrade:

- Increase air flow inside the L3 magnet by **60%**
- Replacement of the PX24 and SUX2 ducts (**80m**)



Multiparticle correlations in pPb and PbPb Analysis Methods

Two particle angular correlation
is generically constructed as:

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{pair}}}{d\Delta\eta d\Delta\phi} = B(0, 0) \times \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$

$$S(\Delta\eta, \Delta\phi) = \frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{same}}}{d\Delta\eta d\Delta\phi}$$
$$B(\Delta\eta, \Delta\phi) = \frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{mix}}}{d\Delta\eta d\Delta\phi}$$

Particle cumulants:

For given harmonic n

$$\langle 2 \rangle = \langle e^{in(\phi_1 - \phi_2)} \rangle$$

$$c_n\{2\} = \langle \langle 2 \rangle \rangle$$

$$\langle 4 \rangle = \langle e^{in(\phi_1 + \phi_2 - \phi_3 - \phi_4)} \rangle$$

$$c_n\{4\} = \langle \langle 4 \rangle \rangle - 2\langle \langle 2 \rangle \rangle^2$$

$$\langle 6 \rangle = \langle e^{in(\phi_1 + \phi_2 + \phi_3 - \phi_4 - \phi_5 - \phi_6)} \rangle$$

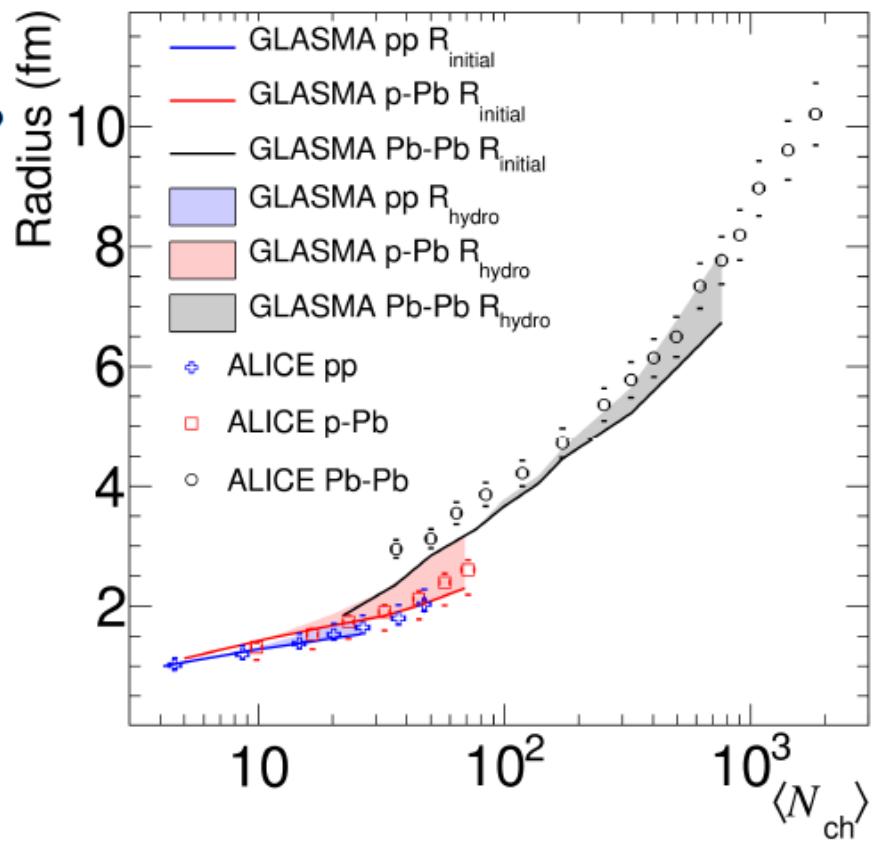
$$c_n\{6\} = \langle \langle 6 \rangle \rangle - 9\langle \langle 4 \rangle \rangle \langle \langle 2 \rangle \rangle + 12\langle \langle 2 \rangle \rangle^3$$

Cumulants subtract lower order correlations (where non-flow might contribute)

In absence of non-flow, $c_n\{2\} = \langle v_n^2 \rangle$, we need to measure RP Ψ_n

Femtoscopic radii and dynamical models

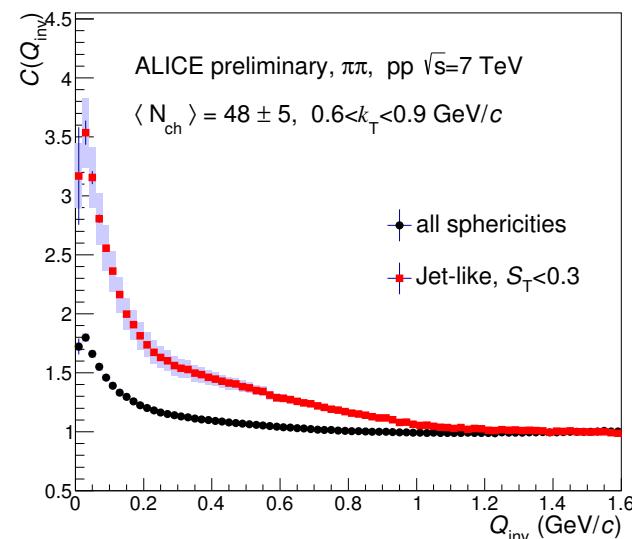
- Femtoscopic radius:
size of source at freeze-out
- Why measure the source radius?
→ initial conditions alone
 - vs
hydrodynamic evolution
- p-Pb similar to pp
- p-Pb reproduced by GLASMA model with
 - initial conditions from saturation
 - hydrodynamic evolution in p-Pb



Multiparticle correlations in pp: jet-like background

pp@7TeV

Correlation identical pions



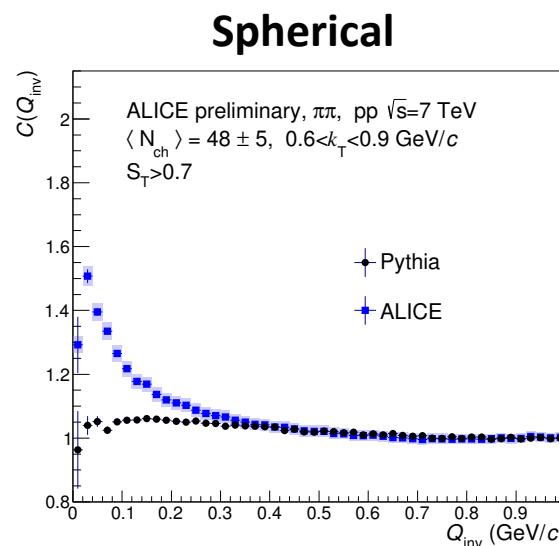
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Possibility to remove jet-like background from the 2-particle correlation and extend the k_T reach of femtoscopic radii

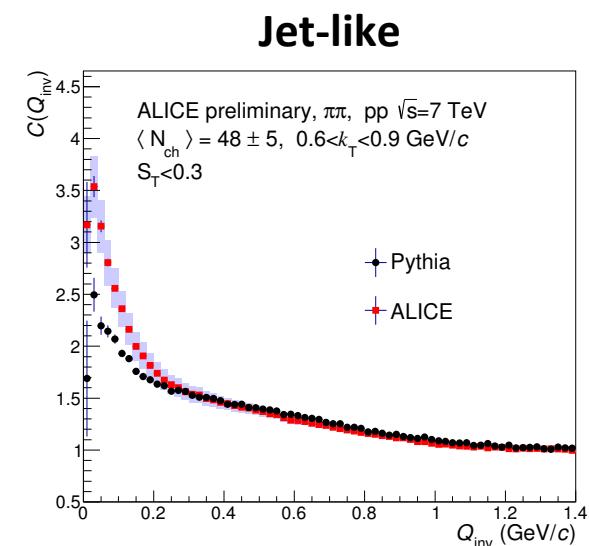
Use **event shapes** to select different **event topologies**:
transverse sphericity S_T

$$S_{xy}^L = \frac{1}{\sum_i p_{Ti}} \sum_i \frac{1}{p_{Ti}} \begin{pmatrix} p_{xi}^2 & p_{xi} p_{yi} \\ p_{yi} p_{xi} & p_{yi}^2 \end{pmatrix}$$

$$S_T = \frac{2\lambda_2}{\lambda_1 + \lambda_2} \Rightarrow S_T = \begin{cases} \approx 0 & \text{Jet-like} \\ \approx 1 & \text{Spherical} \end{cases}$$



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ALI-PREL-87829

