

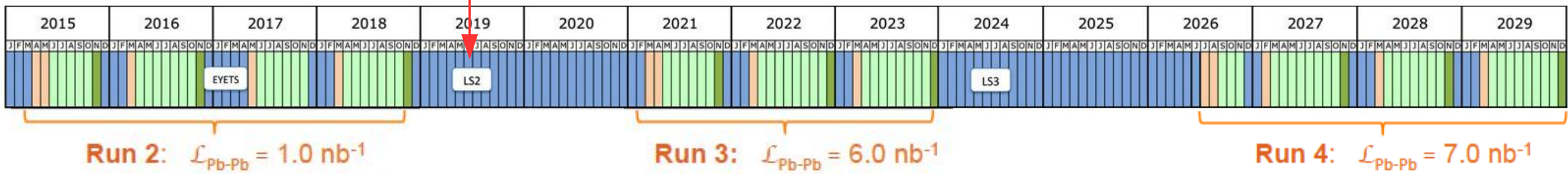
ALICE

ALICE status report

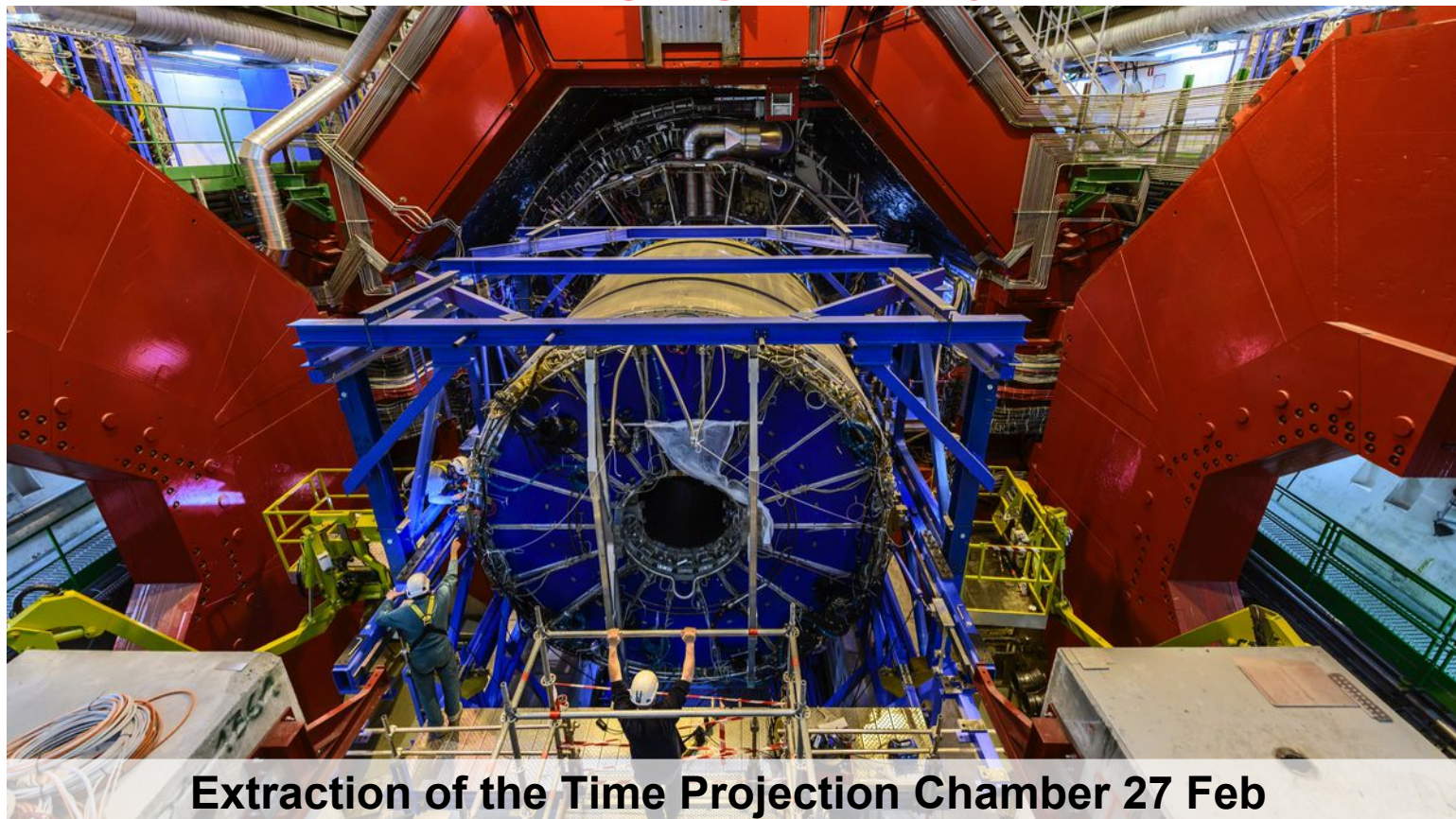
Raphaëlle Bailhache
Goethe University Frankfurt
on behalf of the ALICE Collaboration

Towards LHC Run 3

We are here



Long Shutdown 2 (LS2): a lot of LS2 activities on going to be ready for Run 3

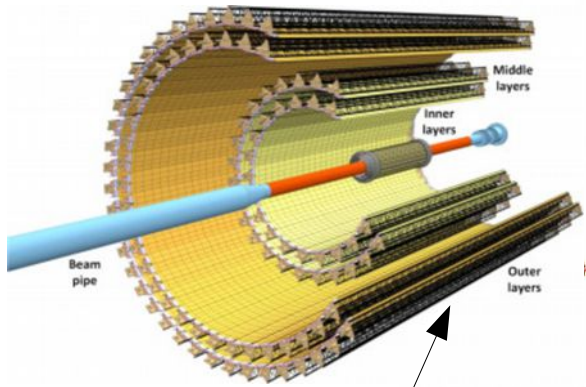


Extraction of the Time Projection Chamber 27 Feb

Goal

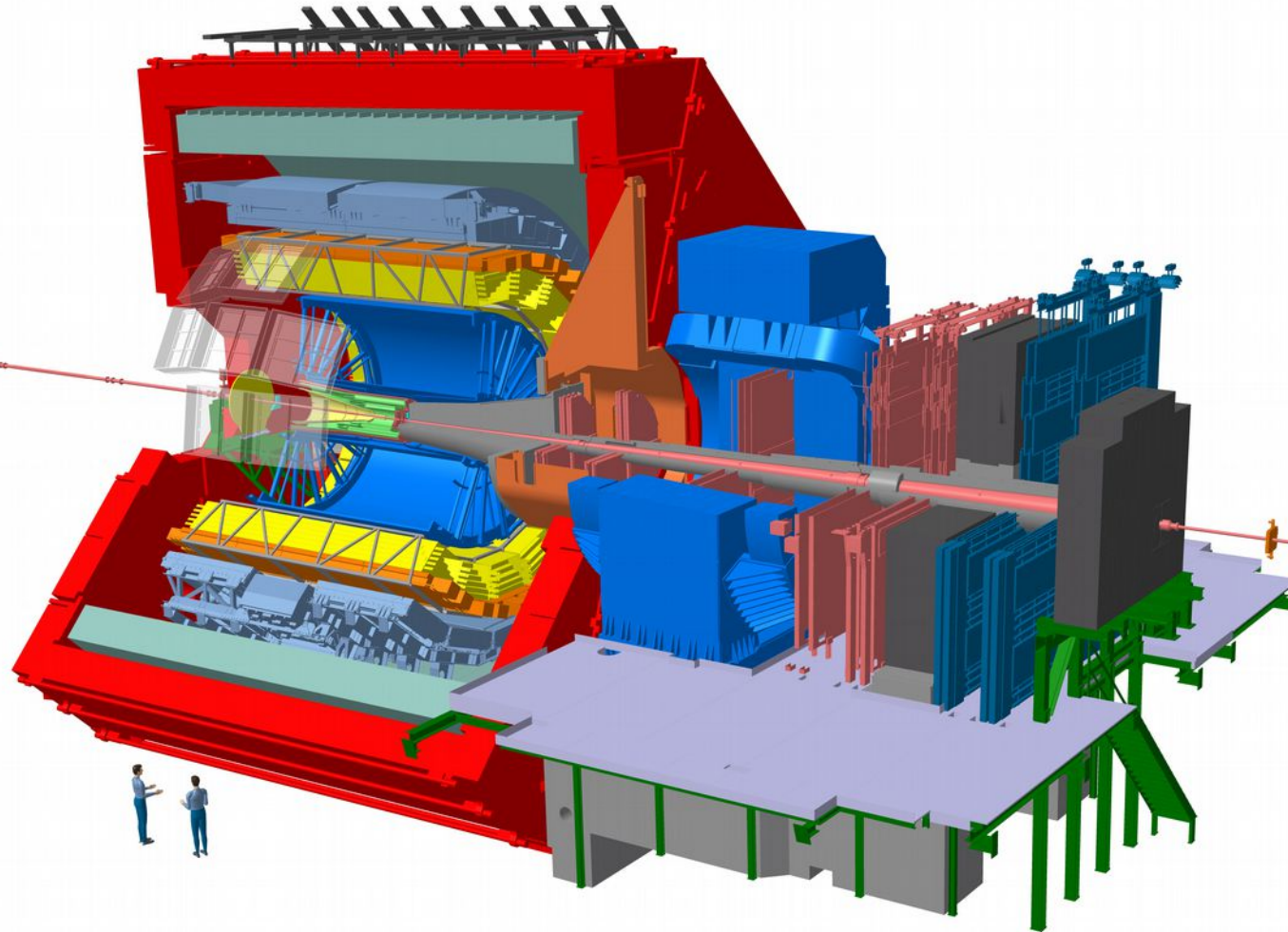
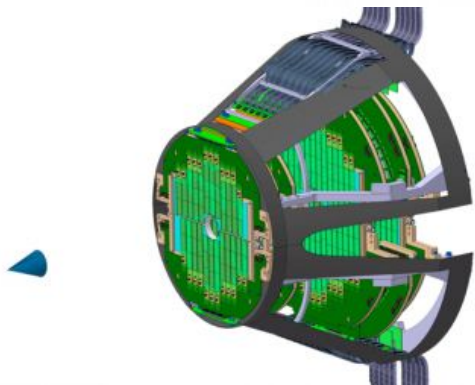
Operation at high interaction rates (50 kHz for Pb-Pb collisions, Run 2 was 8kHz)
 Continuous (i.e. untriggered) read-out for core detectors

Inner Tracking System

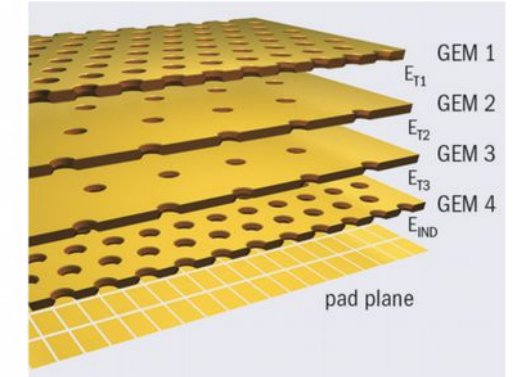


Both based on Monolithic Active Pixel Sensors

Muon Forward Tracker

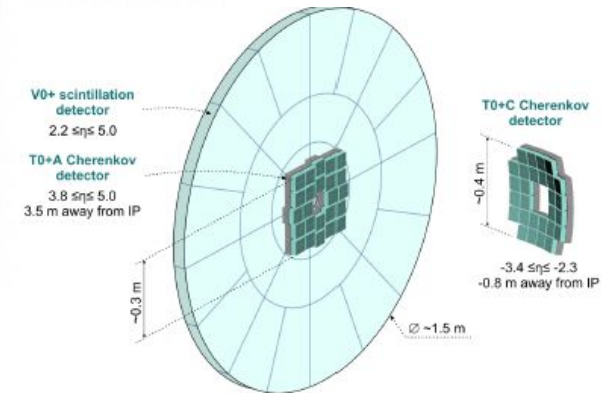


Time Projection Chamber



GEM readout chambers

Forward Interaction Trigger

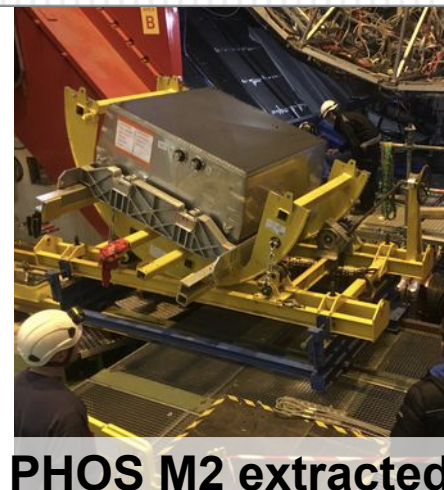
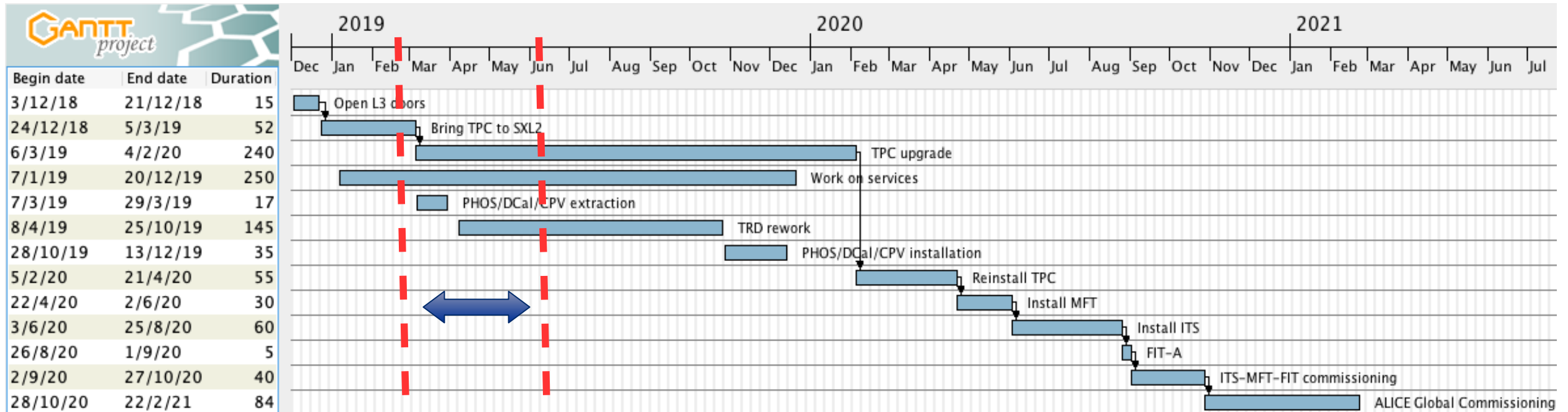


To replace the V0 and T0 detector

- + improved readout for calorimeters, TOF, TRD, Muon arm, ZDC
- + new Central trigger Processor
- + new DAQ and Online-Offline System (O₂)

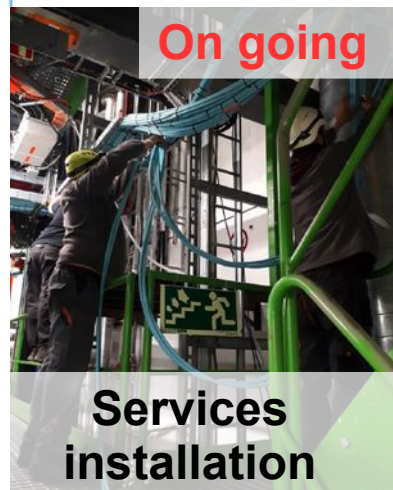
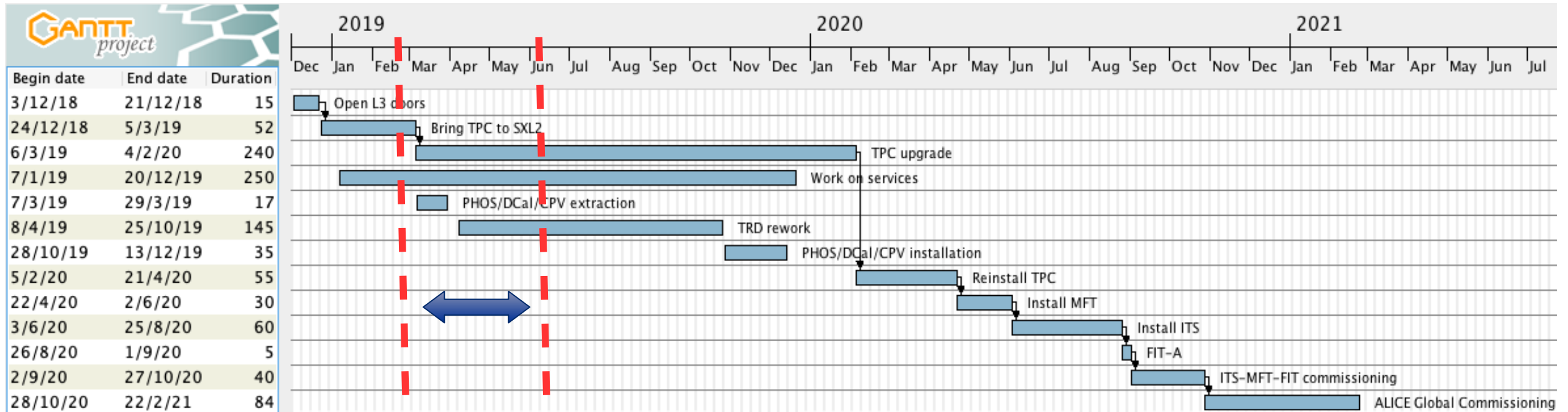
LS2 plan: update since last LHCC meeting

- Time Projection Chamber (TPC) extraction
- Services installation
- Muon Identifier Front-End Card upgrade
- Transition Radiation Detector (TRD) and Photon Spectrometer (PHOS) rework



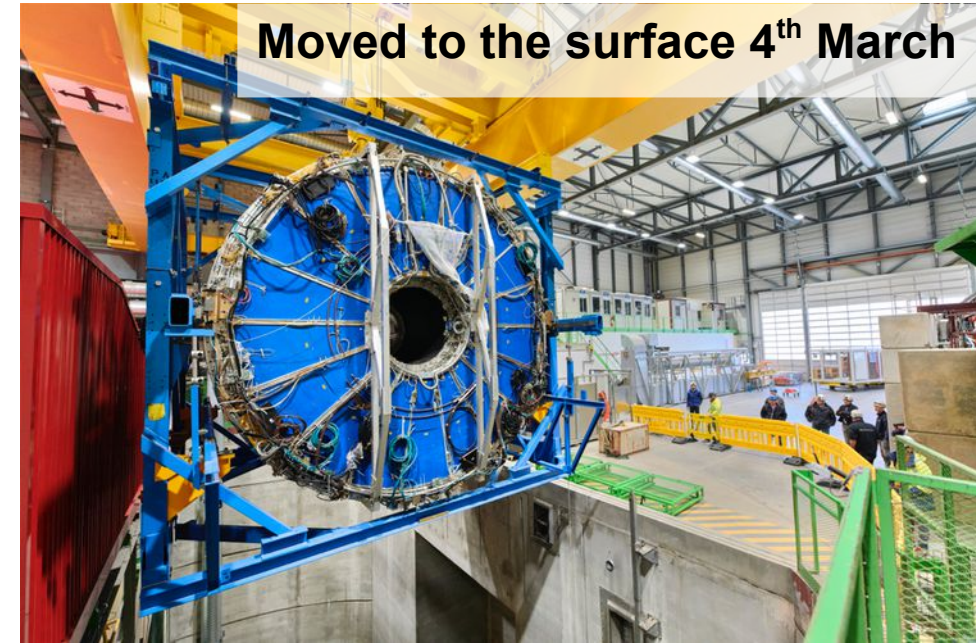
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Time Projection Chamber extraction

Moved to the surface 4th March



- TPC extracted from the cavern and transported to the SXL2 hall on 04,05th March
- Tightness test positive
- All services (electronics, cables...) removed

Arrived in the SXL2 hall 5th March



Removed services 19th March



Moved to the SXL2 hall 5th March



Time Projection Chamber in the cleanroom

- **TPC** moved to the cleanroom on 5th April
- Field cage X-ray irradiation - positive
- **Multi-wire proportional Chamber (MWPC) removal on A-side accomplished**
- TPC Field Cage adaptation for operation in RUN 3 and 4 **ongoing**
- **Next step: install GEM chambers**

Moved to the cleanroom 5th April

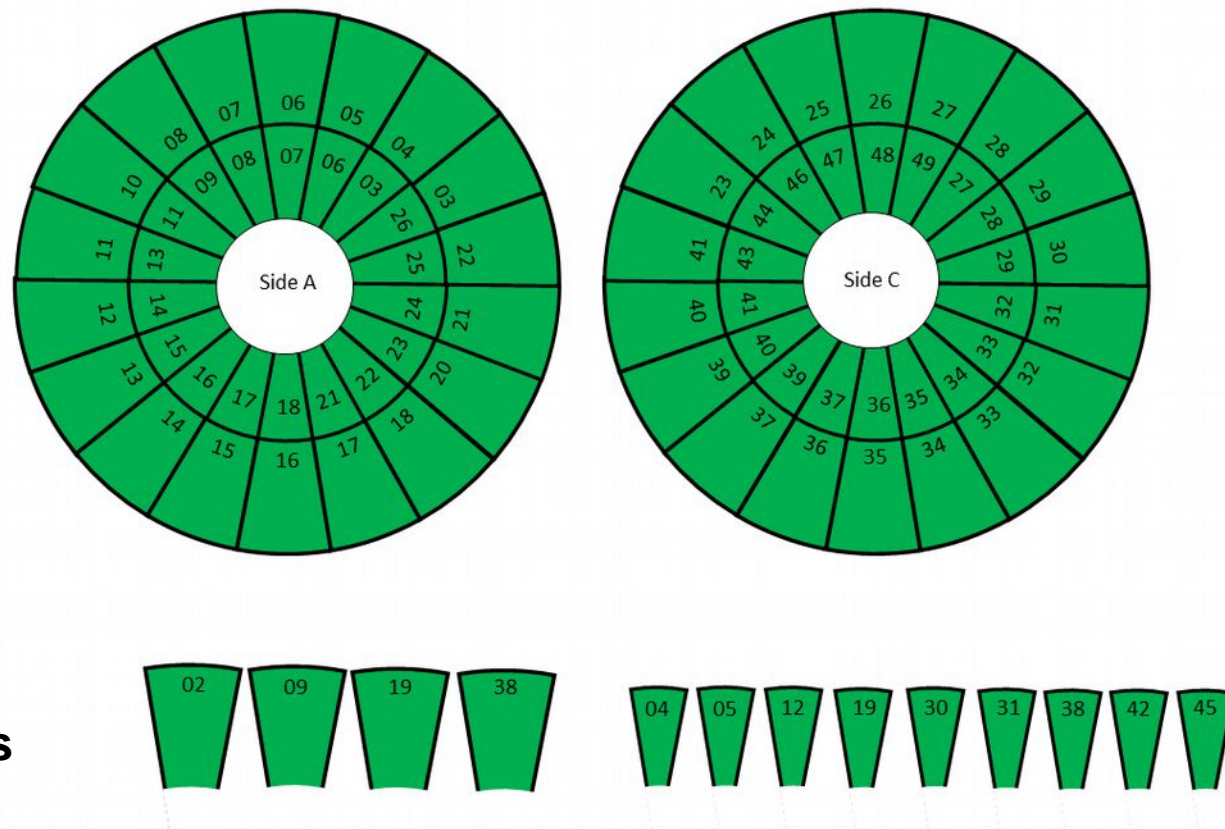


Multi-wire proportional chamber (MWPC) removal



New readout chamber status

- **Readout chamber production (ROC with GEM) accomplished**
- All ROCs successfully passed full irradiation tests at LHC and/or GIF++
- All ROCs stored in the TPC cleanroom, ready for installation



spare ROCs



Time Projection Chamber upgrade timeline



Remove wire chambers

Install GEM chambers

Survey, sealing, P test

Install new Front-End Cards

TPC ready for transportation

10 May (A-side)
11 Jul (C-side)

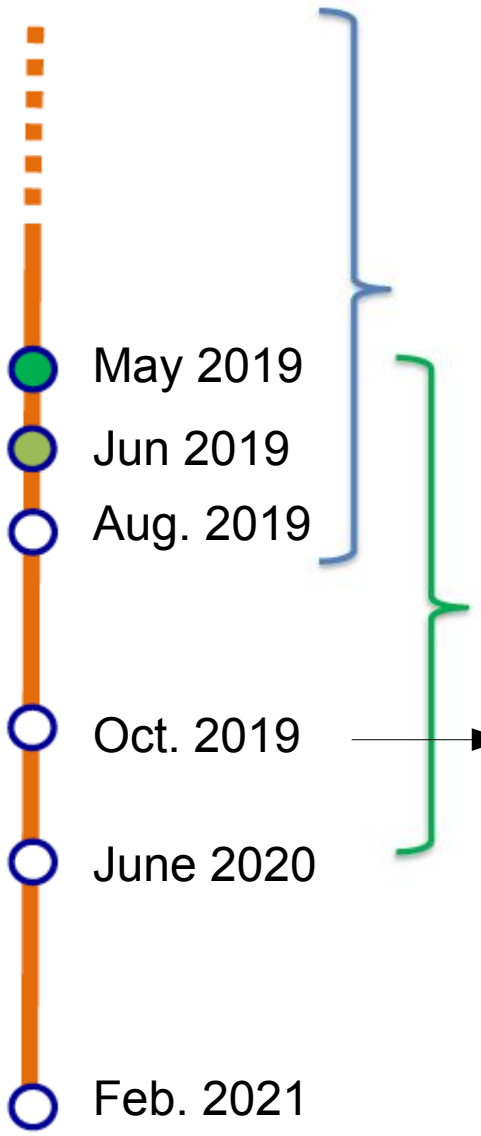
27 May (A)
24 Jul (C)

17 Jun (A)
12 Aug (C)

27 Sep (A)
14 Oct (C)

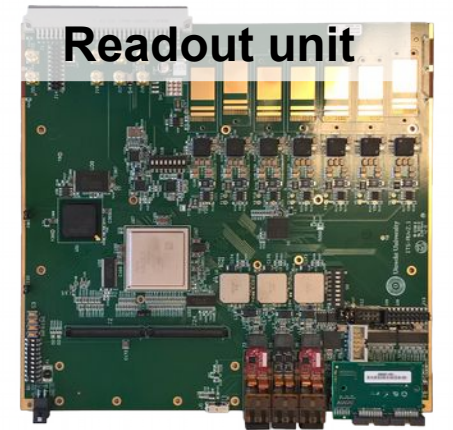
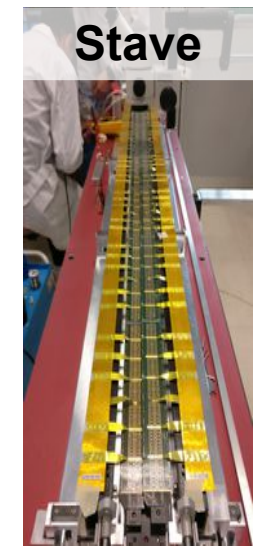
4 Feb '20

Inner Tracking System upgrade timeline



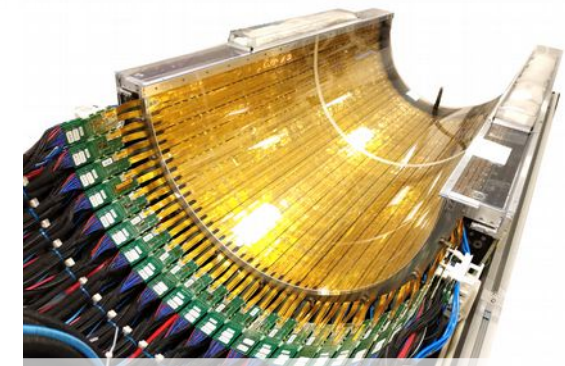
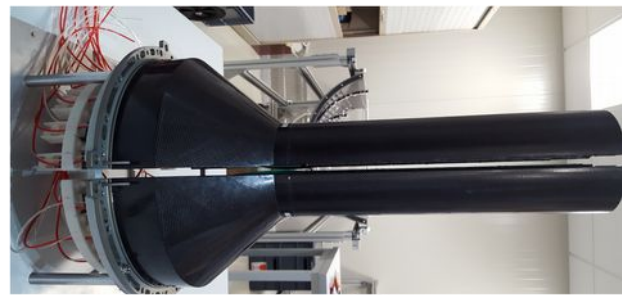
Detector Construction and Assembly

- **Module production: completed!** (May 2019)
- **Electronics production: done!**
→ testing till end of July 2019
- **Stave production: 85% done**
→ continues till Aug. 2019



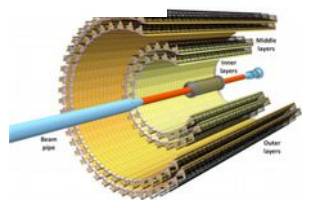
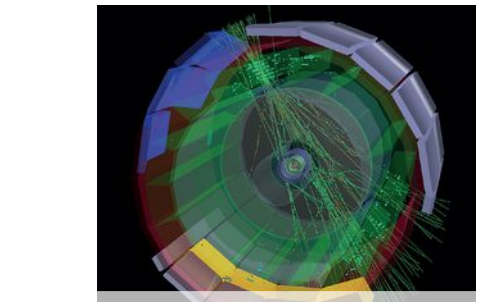
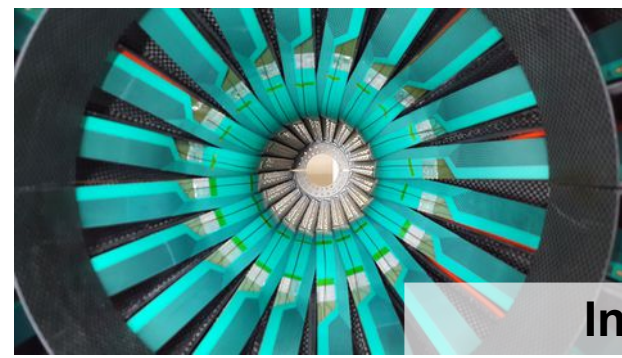
Commissioning on ground with final services ongoing (operation 24/7)

OB stave Assembly End: > 50% done



Installation

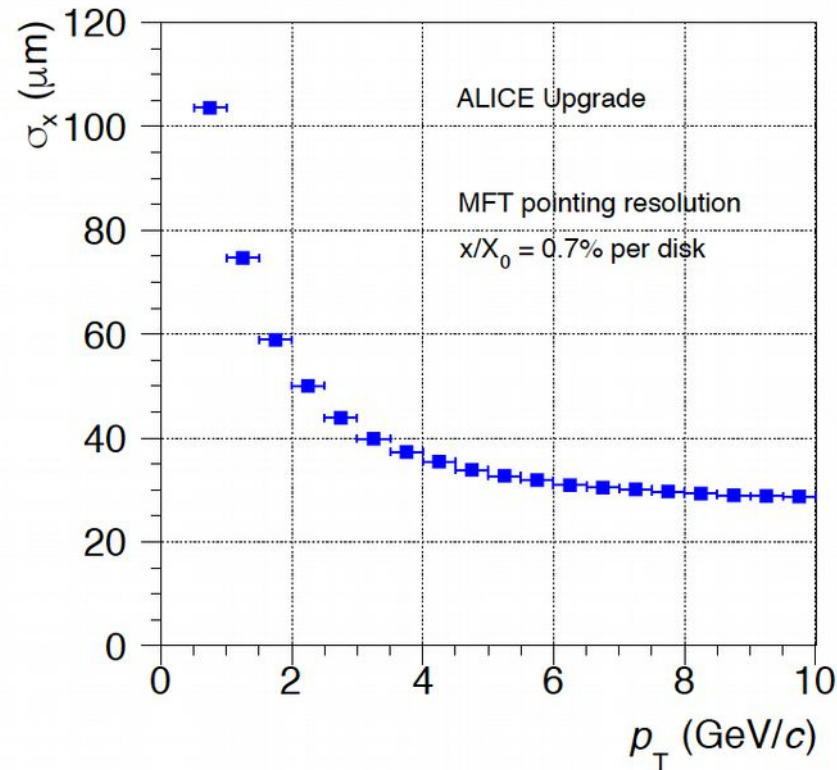
6-month Global Commissioning



The Muon Forward Tracker in a nutshell

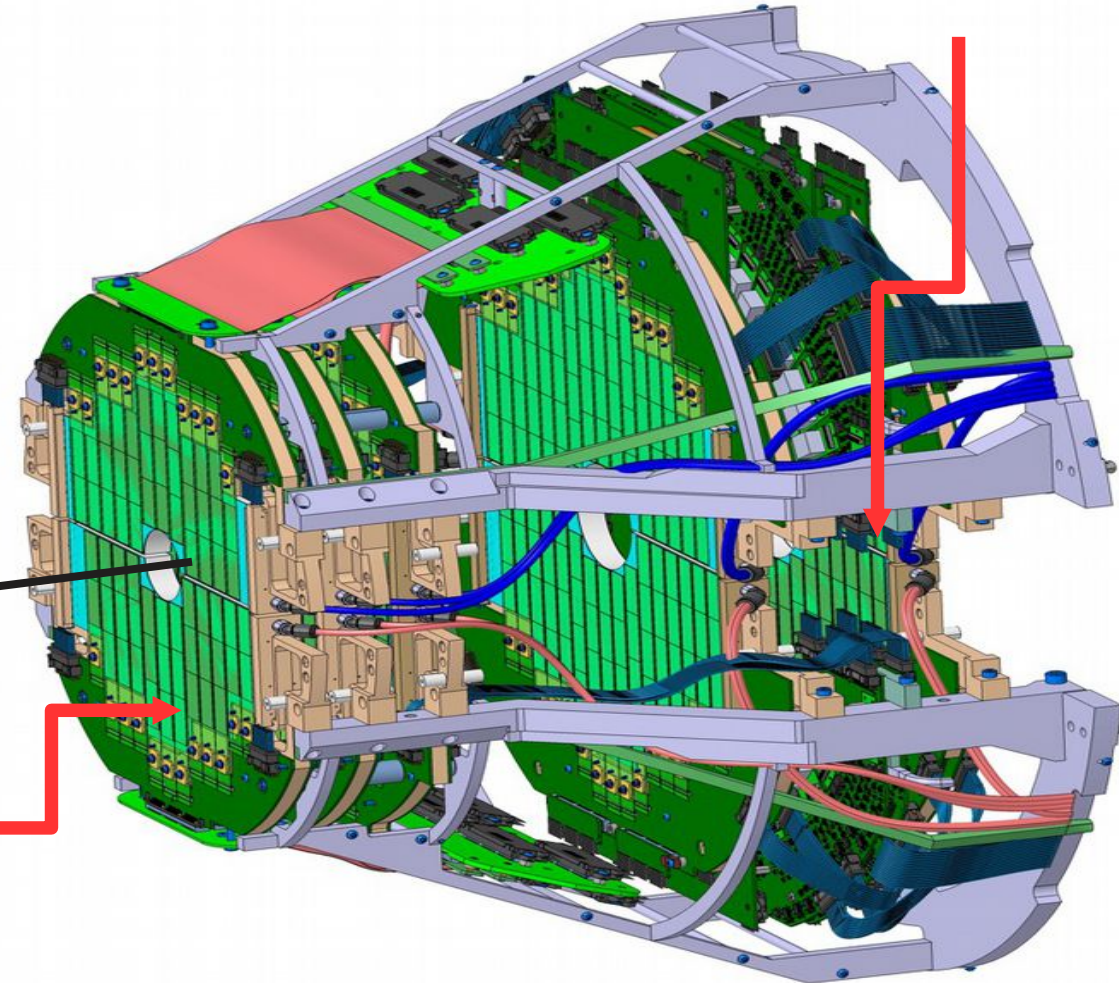
- $-3.6 < \eta < -2.45$
- **936 ALPIDE Silicon pixel sensors** (0.4 m^2) on 280 ladders of 2 to 5 sensors
- Sensor size = $15 \times 30 \text{ mm}^2$; Pixel pitch = $29 \times 27 \text{ }\mu\text{m}^2$
- 5 Disks with 2 detection planes each
- ALPIDE chips thinned down to $50 \text{ }\mu\text{m}$
- **X/X_0 per disk = 0.7%**

Disk 4
($z = -77 \text{ cm}$)



$z=0$
IP

Disk 0
($z = -46 \text{ cm}$)



MFT pointing resolution $< 100 \mu\text{m}$ at $1 \text{ GeV}/c$

Muon Forward Tracker status

- **Support barrels** delivered and insertion tests successful
- **Good ladder production** throughput (10 ladders /week) and yield (92% gold and silver grades)
- **Disk supports and heat exchanger** production being finalized
- **Ladder gluing on disk ongoing**
- Surface commissioning lab @ CERN **being prepared** for detector installation

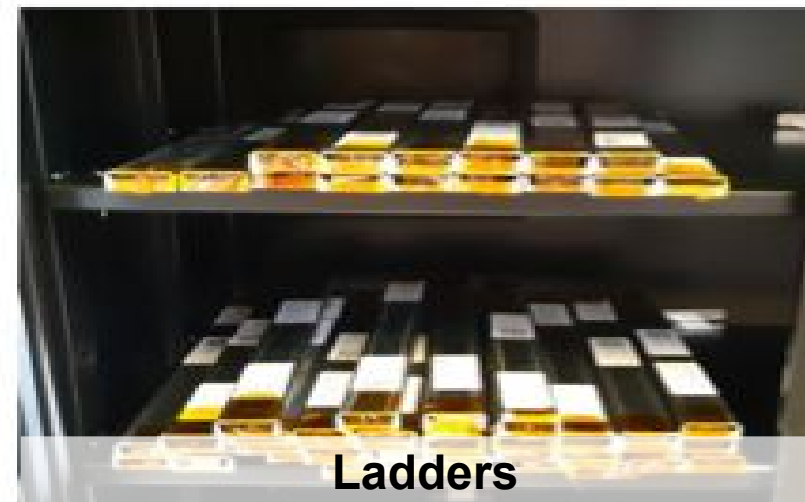
Disk fully equipped with ladders



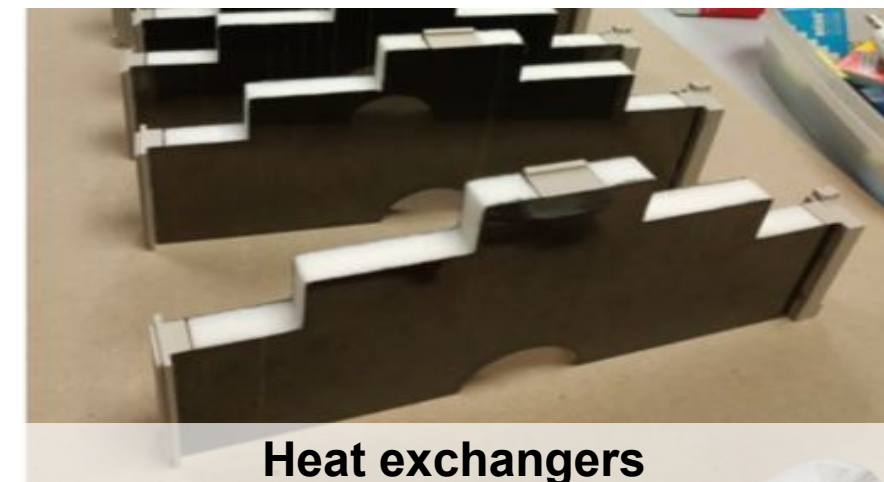
Mechanical disk fully equipped



Support barrels



Ladders



Heat exchangers

New ALICE publications since last LHCC



- Isolated direct photon cross section measurement in pp collisions at $\sqrt{s}=7$ TeV, submitted to EPJC, arXiv:1906.01371
- Low-energy Kp scattering with femtoscopy in pp collisions at the LHC, submitted to PRL, arXiv:1905.13470
- Production of muons from heavy-flavour hadron decays in pp collisions at $\sqrt{s}=5.02$ TeV, submitted to JHEP, arXiv:1905.07207
- Inclusive J/psi production at mid-rapidity in pp collisions at $\sqrt{s}=5.02$ TeV, submitted to JHEP, arXiv:1905.07211
- Charged-particle production as a function of multiplicity and transverse sphericity, submitted to EPJC, arXiv:1905.07208
- Measurement of charged jet cross section in pp collisions at $\sqrt{s}=5.02$ TeV, submitted to PRD, arXiv:1905.02536
- Measurement of charm jets tagged with D^0 mesons in pp collisions at $\sqrt{s}=7$ TeV, submitted to JHEP, arXiv:1905.02510



- Study the Λ - Λ interaction with femtoscopy correlations in pp and p-Pb collisions, submitted to PLB, arXiv:1905.07209
- First observation of an attractive interaction between a proton and a multi-strange baryon, submitted to PRL, arXiv:1904.12198
- One-dimensional charged kaon femtoscopy in p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV, submitted to PRC, arXiv:1903.12310



- Exploration of jet substructure using iterative declustering in pp and Pb-Pb collisions, submitted to PLB, arXiv:1905.02512
- Measurement of jet radial profiles in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, submitted to PLB, arXiv:1904.13118
- Coherent J/psi photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV, submitted to PLB, arXiv:1904.06272
- Measurement of $p\bar{\Lambda}\oplus p\bar{\Lambda}$ & $\Lambda\bar{\Lambda}$ interactions with femtosopic correlations in Pb-Pb collisions, submitted to PRC, arXiv:1903.06149
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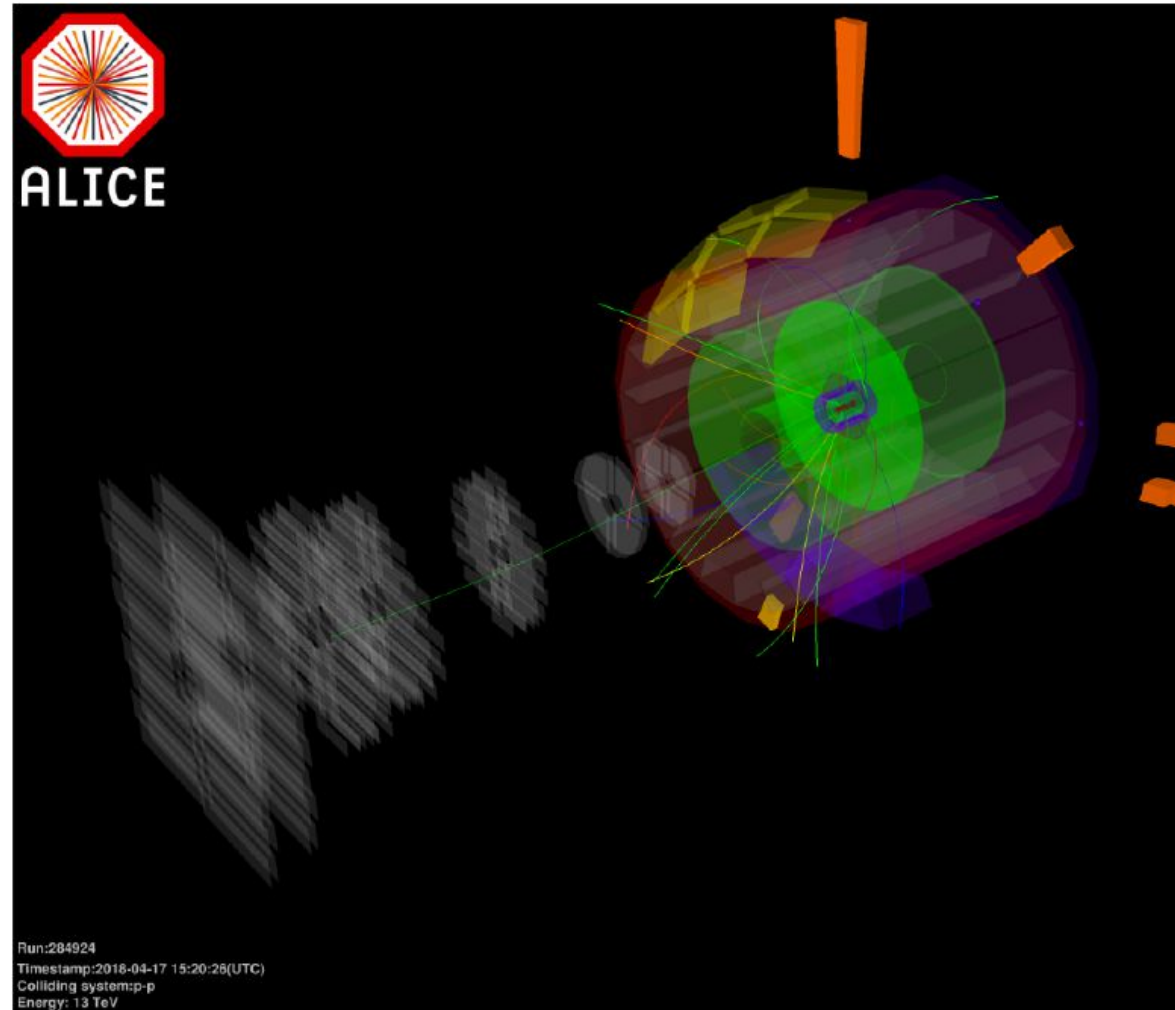


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First publication with 2018 Pb-Pb data

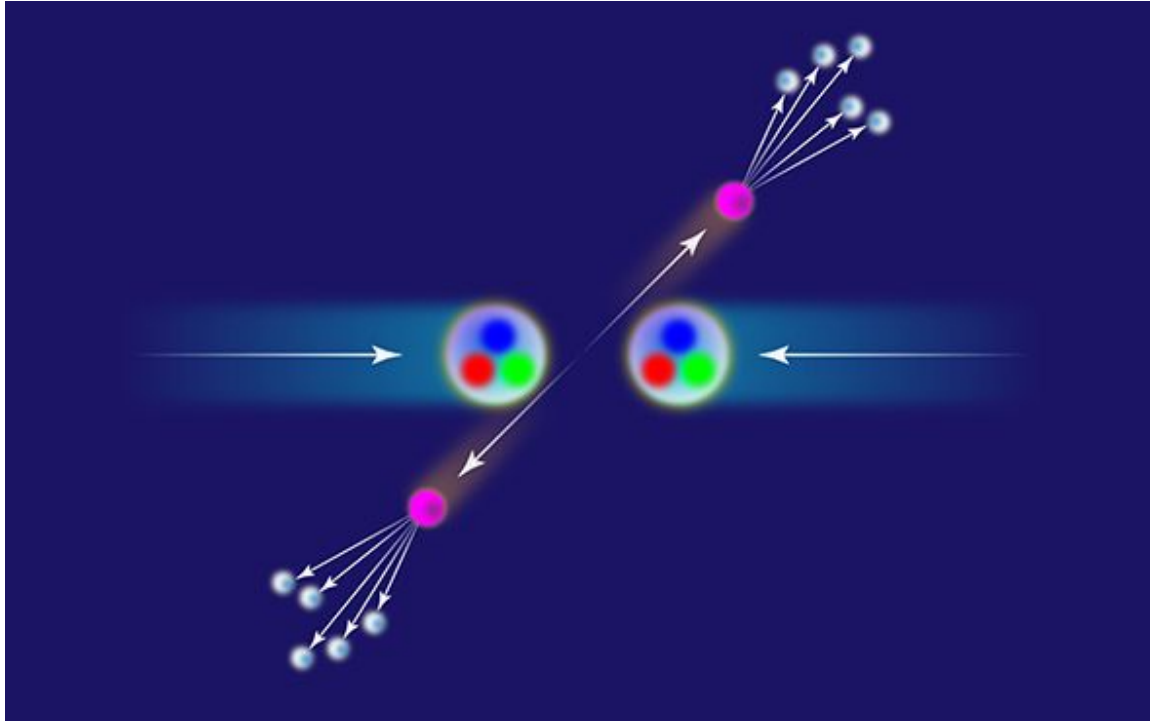
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Recent results in pp collisions



Jet measurements at low p_T in vacuum

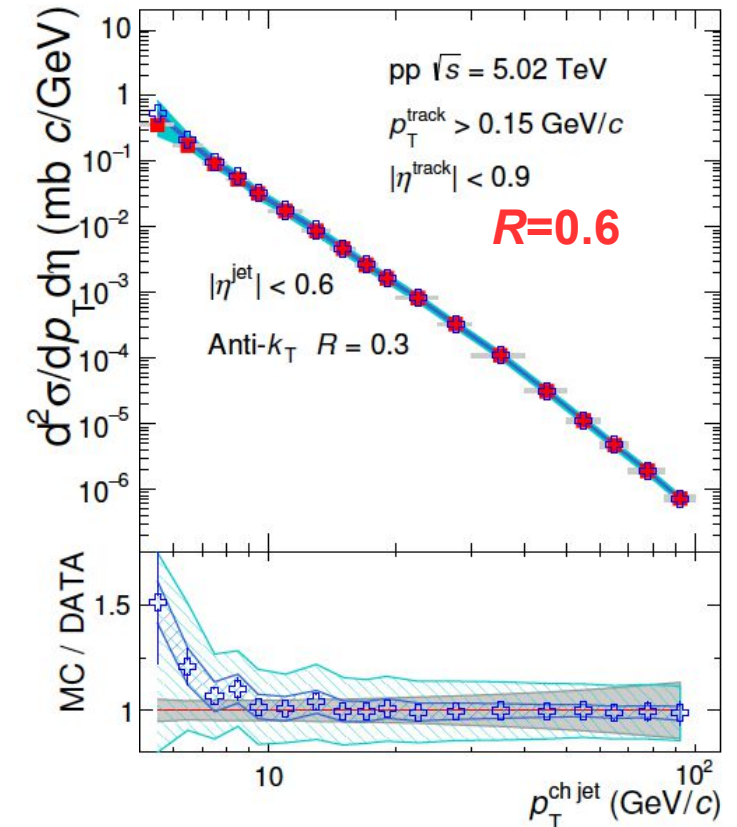
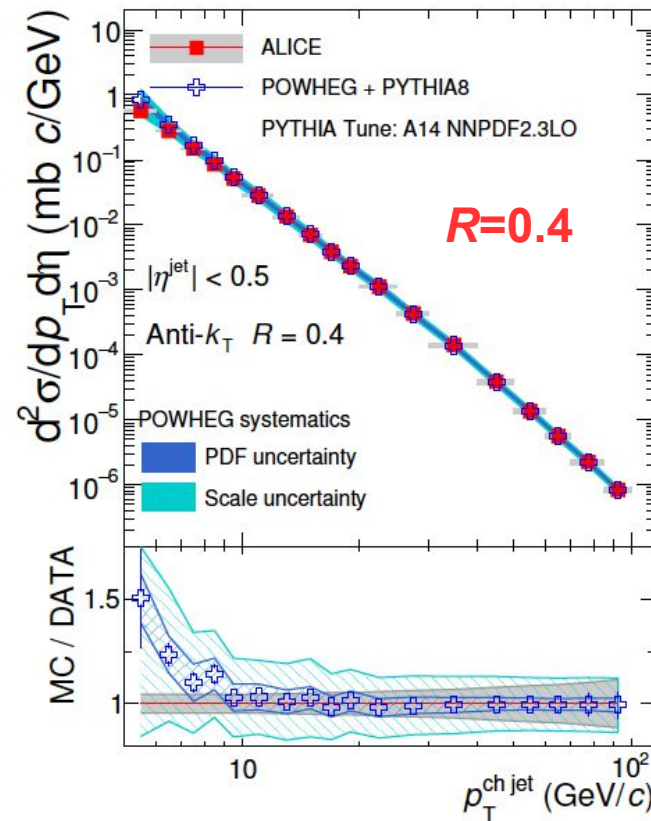
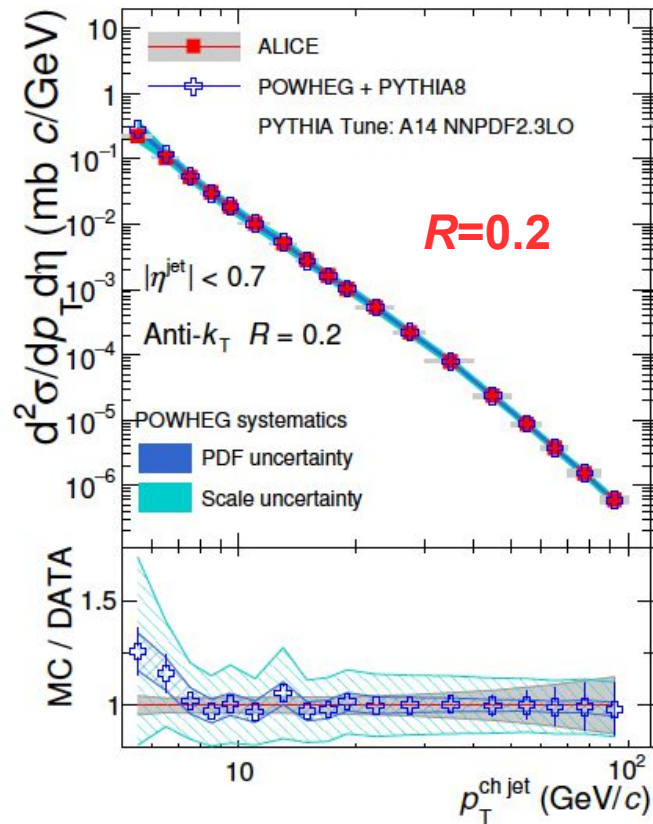


- **Jet measurement from low to high p_T :**
 - Unique opportunity to constrain non-perturbative and perturbative effects with ALICE
 - **Measurement as a function of jet radius R :**
 - Investigate the jet shape
 - **More differential measurements possible with new data:**
 - Probe the heavy-quark fragmentation function
- **Understand jets in vacuum**
(fragmentation function and parton distribution function)
- **Crucial reference for Pb-Pb studies**
(particularly at low p_T)

Charged jets in pp collisions at 5.02 TeV

- **Probe charged jet production:**
 - in a wide p_T range ($5 < p_T < 100$ GeV/c) from the non-perturbative to the perturbative region
 - in a wide range of jet radii ($0.2 < R < 0.6$)
- **Compare to LO (PYTHIA) and NLO (POWHEG + PYTHIA8) calculations :**
 - better agreement with NLO
 - large theoretical uncertainties at low p_T

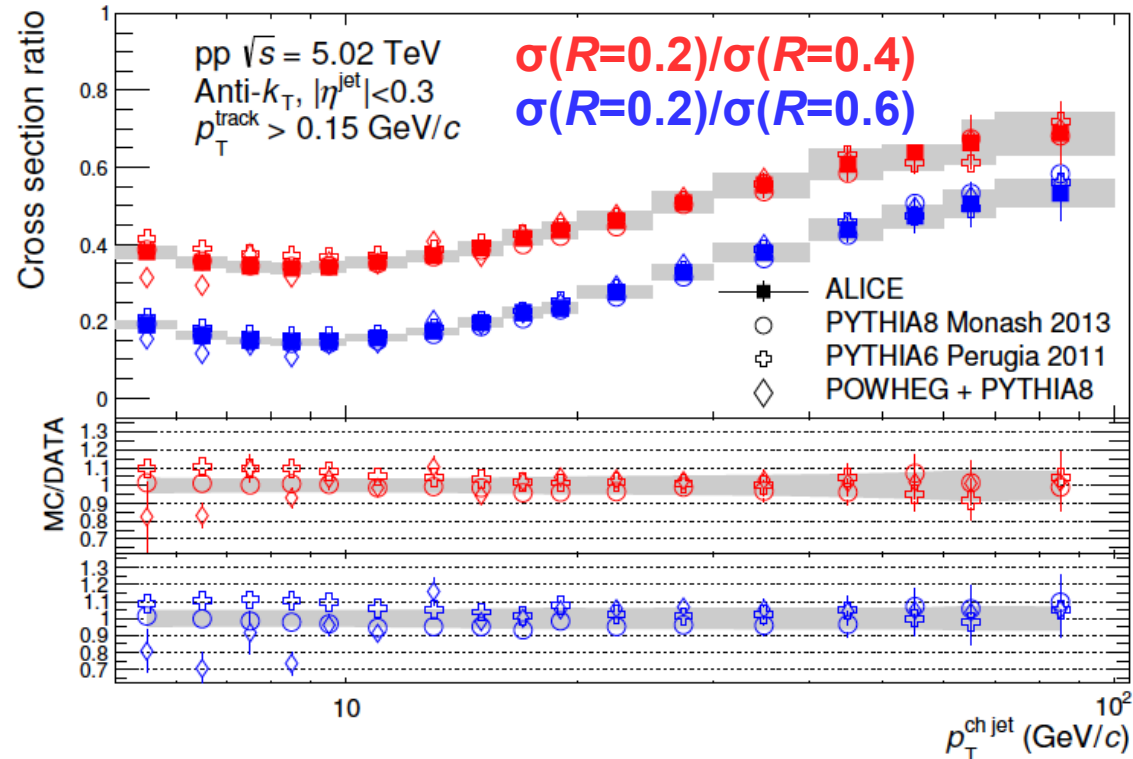
New paper arXiv:1905.02536



Charged jets in pp collisions at 5.02 TeV

- **Probe charged jet production:**
 - in a wide p_T range ($5 < p_T < 100$ GeV/c) **from the non-perturbative to the perturbative region**
 - in a wide range of jet radii ($0.2 < R < 0.6$)
- **Cross section ratios:**
 - correlated uncertainties cancel in the ratio
 - increase with p_T and saturate at high $p_T \rightarrow$ **jet collimation larger at high p_T**

New paper arXiv:1905.02536

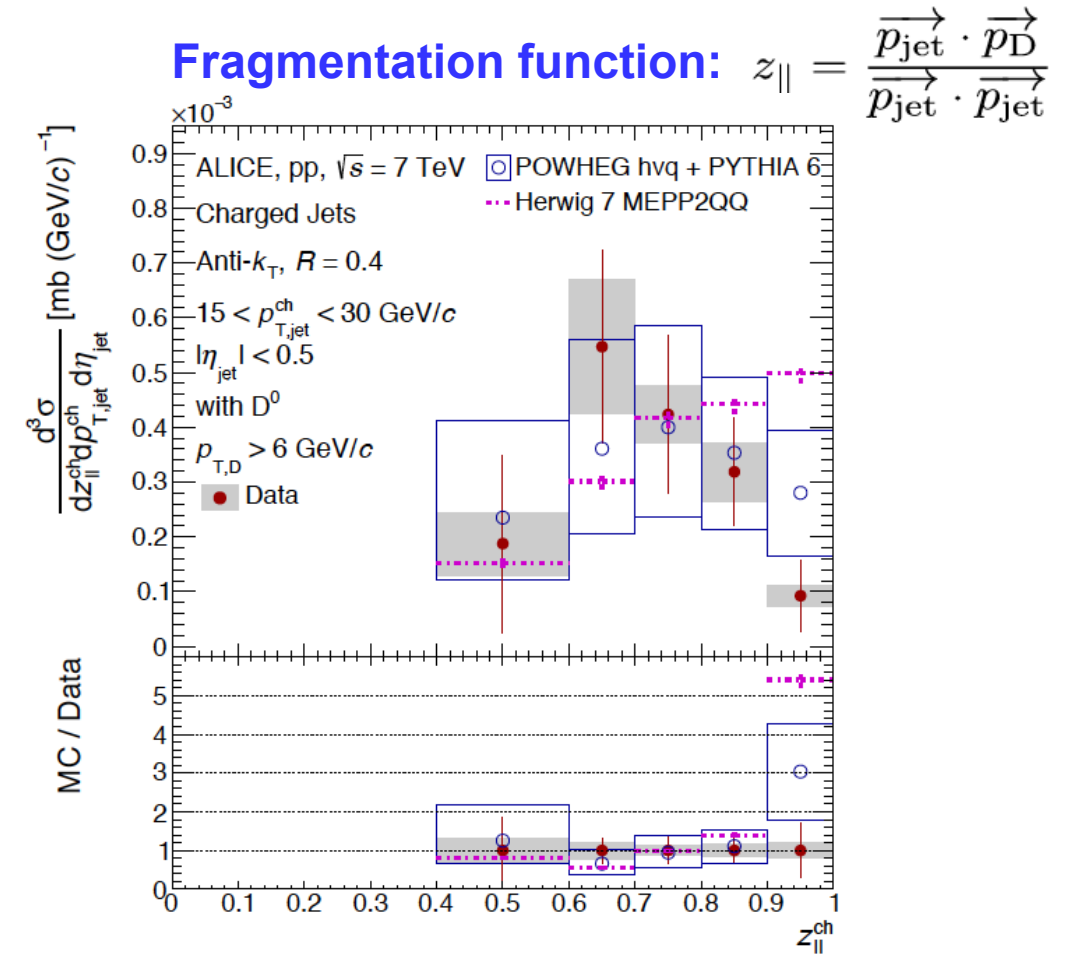
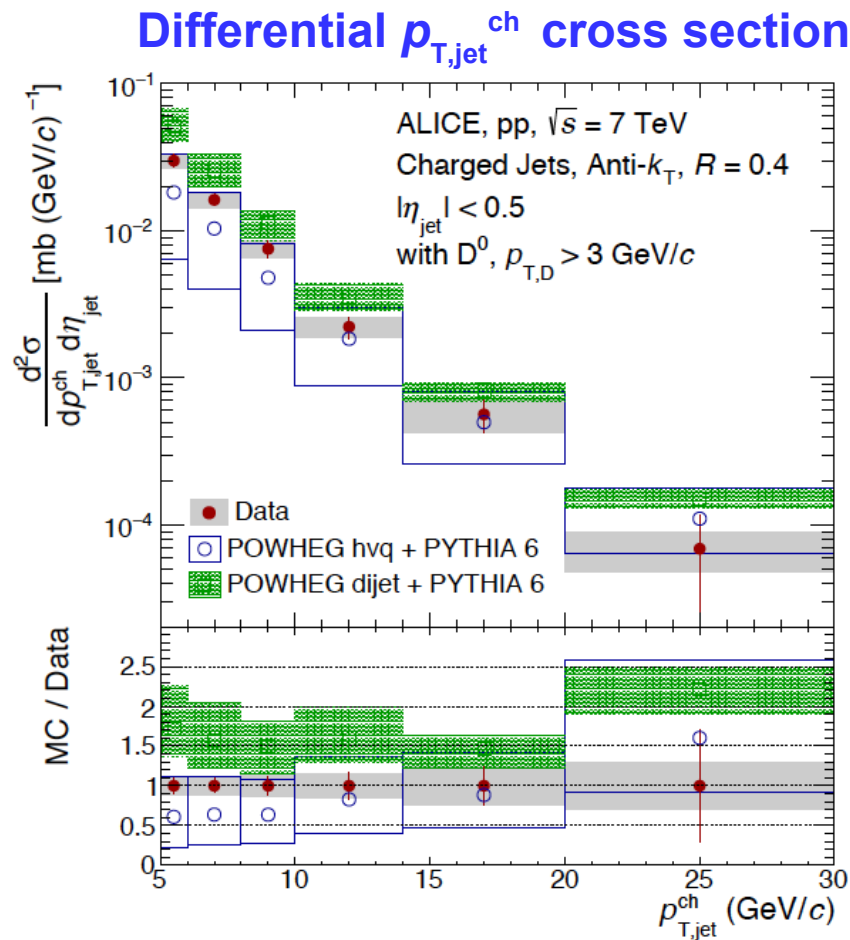


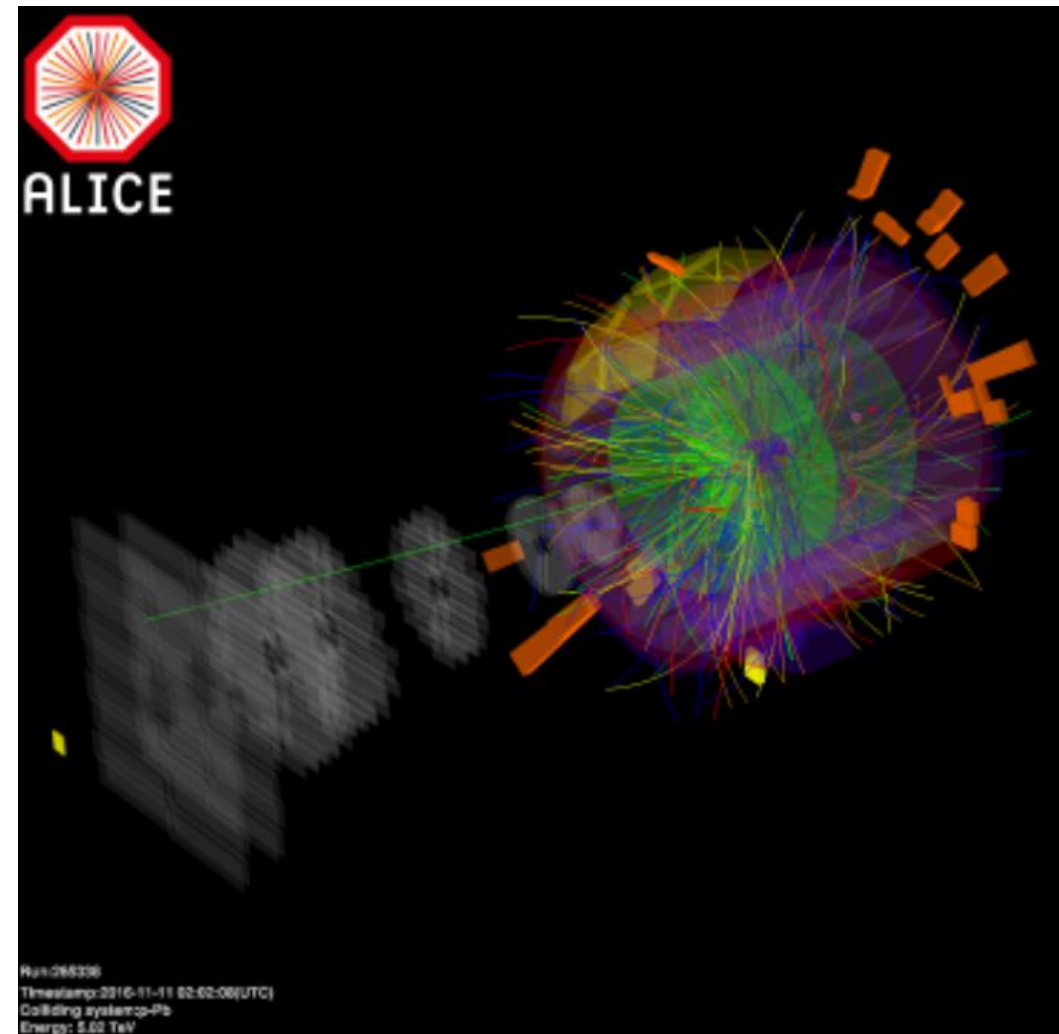
New preliminaries:
 Similar study for full jets in pp at 13 TeV

Heavy-flavour jets in pp collisions at 7 TeV

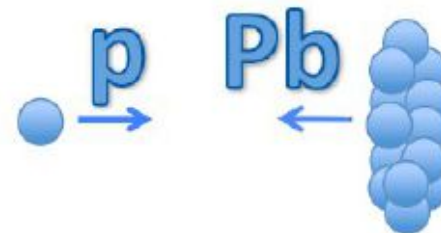
- Measure **charged jets containing a prompt D^0**
- **Cross section in good agreement with POWHEG hvq + PYTHIA 6**
- $z_{||}$ = momentum fraction carried by the D meson
 → **Hint for a softer fragmentation function in data wrt to theory ? More data needed**

New paper arXiv:1905.02510





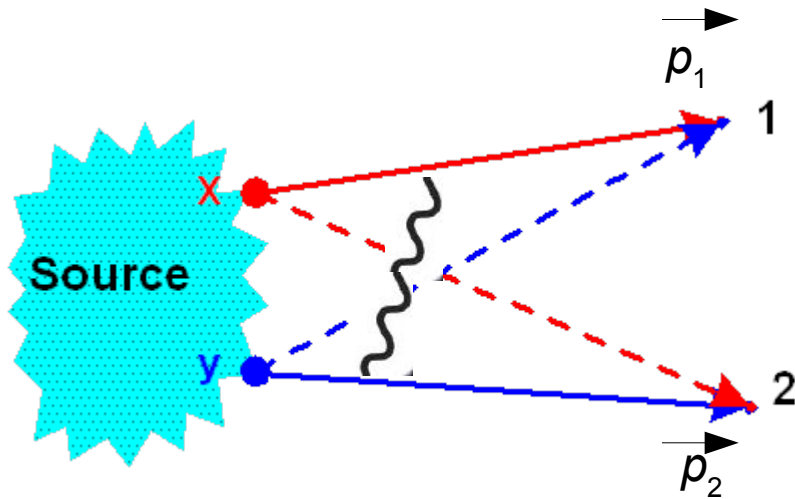
Recent results in p-Pb collisions



Measure the system size

Traditional Hanbury-Brown-Twiss (HBT) measurement:

- Use **two identical boson momentum correlation** to **estimate the system size at kinematical freeze-out**



$$C(\vec{p}_1, \vec{p}_2) = \frac{P(\vec{p}_1, \vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}$$

$$C(\vec{q}) = \int S(\vec{r}) |\Psi(\vec{q}, \vec{r})|^2 d^3r$$

Measured correlation

Source size/shape unknown

Two-particle wave functions
Interaction known

q : relative momentum

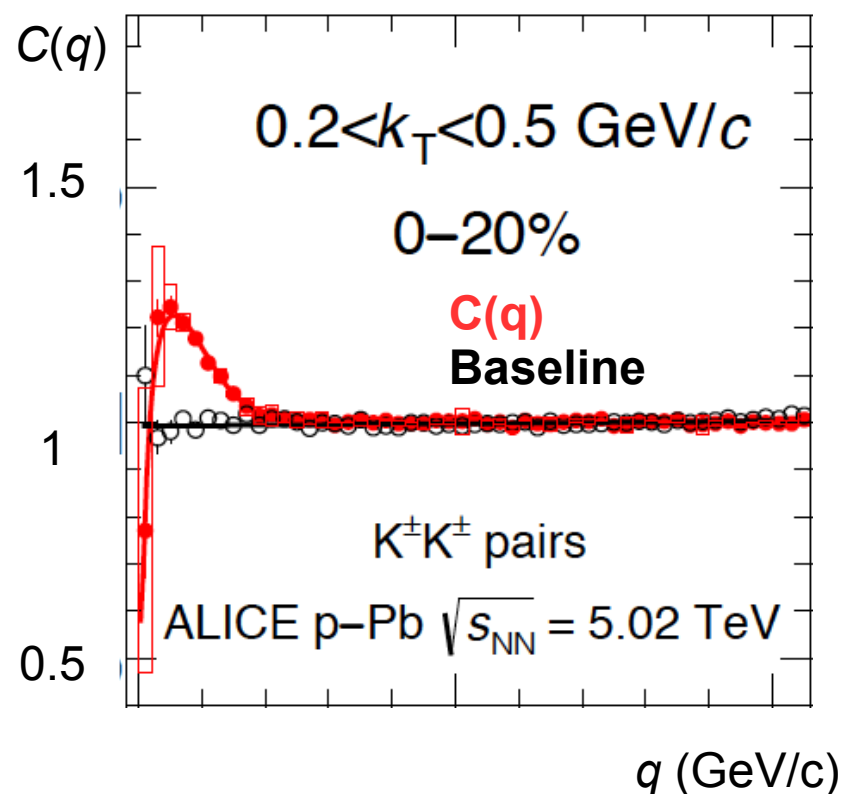
r : relative distance between the points of emission of the two bosons

- **Interaction between two identical bosons given by:**
 - Quantum statistics (Bose-Einstein correlation)
 - Electromagnetic interaction (Coulomb interaction)
 - Strong interaction

Measure the system size

New paper arXiv:1903.121310

$K^\pm K^\pm$ correlation function
in 0-20% central p-Pb collisions



Fit $C(q)$ to extract the source radius
as a function of centrality
and k_T (pair transverse momentum)

Traditional Hanbury-Brown-Twiss (HBT) measurement:

- Use two identical boson momentum correlation (here $K^\pm K^\pm$) to estimate the system size at kinematical freeze-out

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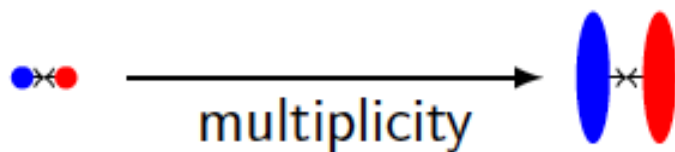
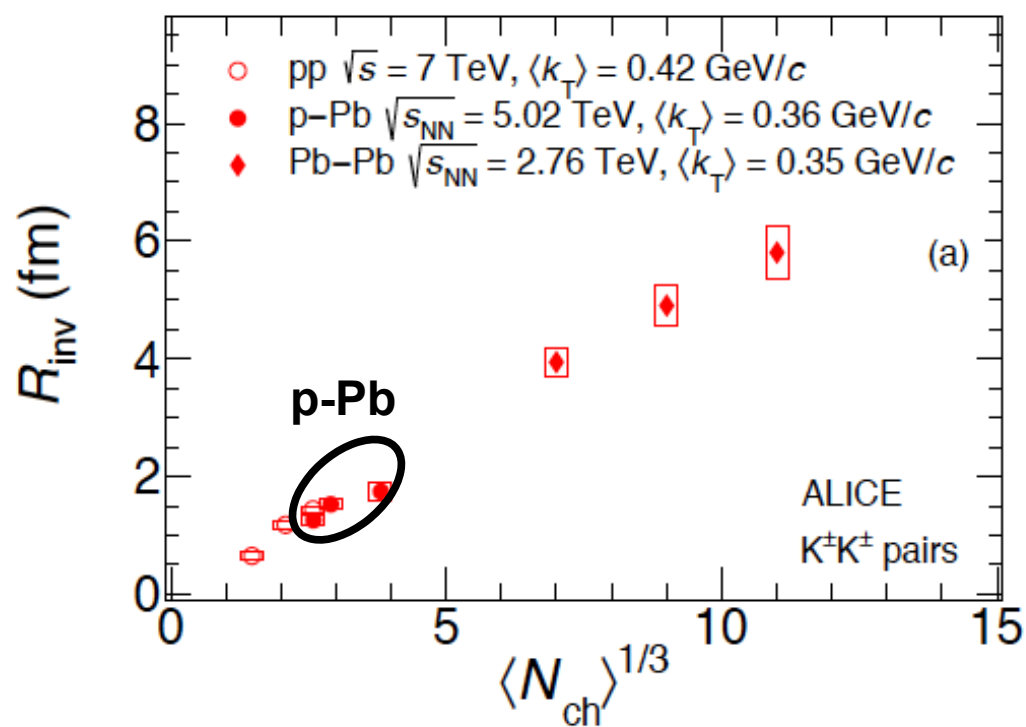
r : relative distance between the points of emission of the two kaons

- Interaction between two identical bosons given by:
 - Quantum statistics (Bose-Einstein correlation)
 - Electromagnetic interaction (Coulomb interaction)
 - Strong interaction (negligible for $K^\pm K^\pm$)

Measure the system size

New paper arXiv:1903.121310

Source Radius as a function of multiplicity in pp, p-Pb and Pb-Pb



More results:
New preliminary for K^+K^- in Pb-Pb

Traditional Hanbury-Brown-Twiss (HBT) measurement:

- Use two identical boson momentum correlation (here $K^\pm K^\pm$) to estimate the system size at kinematical freeze-out

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$$c(\vec{q}) = \int S(\vec{r}) |\Psi(\vec{q}, \vec{r})|^2 d^3r$$

Measured correlation

Source size/shape unknown

Two-particle wave functions
Interaction known

q : relative momentum

r : relative distance between the points of emission of the two kaons



- Compare source radius R_{inv} in pp, p-Pb and Pb-Pb collisions

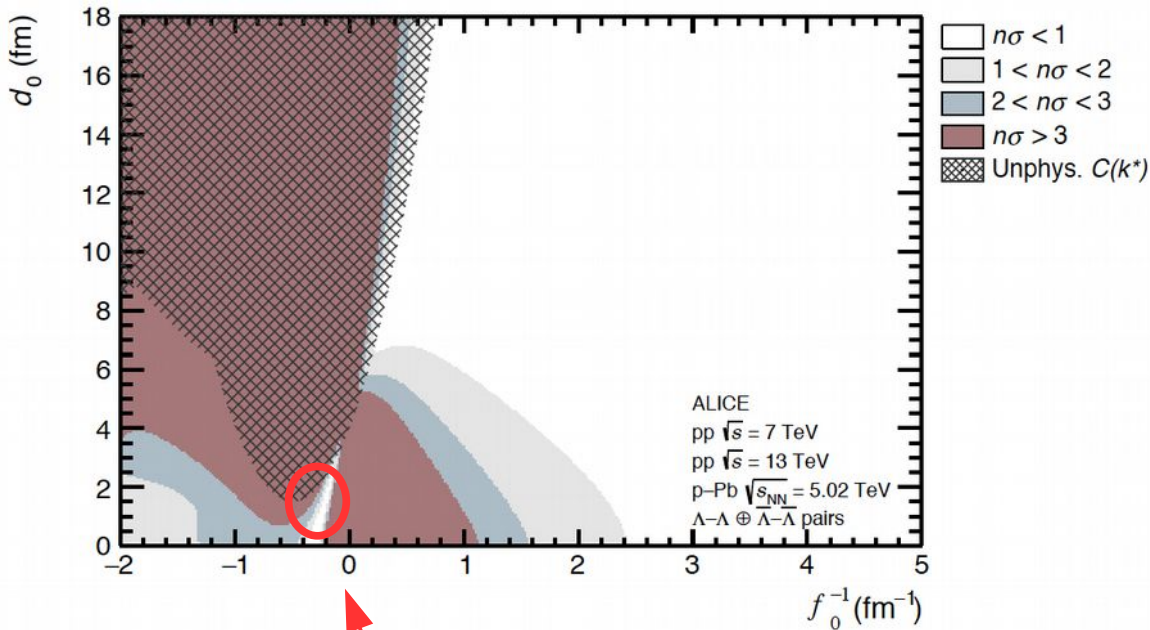
Observe:

- Increase of radii with multiplicity in all systems (also pp and p-Pb)
- Same radii in pp and p-Pb at similar multiplicities
→ Similar dynamics of the source in pp and p-Pb

Study baryon-(anti)baryon interactions

New paper arXiv:1905.07209

Exclusion plot
for the Λ - Λ scattering parameters



Narrow allowed region
compatible with a bound state

- Use Λ - Λ momentum correlation to measure their interaction

$$C(\vec{p}_1, \vec{p}_2) = \frac{P(\vec{p}_1, \vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}$$

$$C(\vec{q}) = \int S(\vec{r}) |\Psi(\vec{q}, \vec{r})|^2 d^3r$$

Measured correlation

Source size/shape known from pp

Two-particle wave functions
Interaction unknown

q : relative momentum

r : relative distance between the points of emission of the two kaons

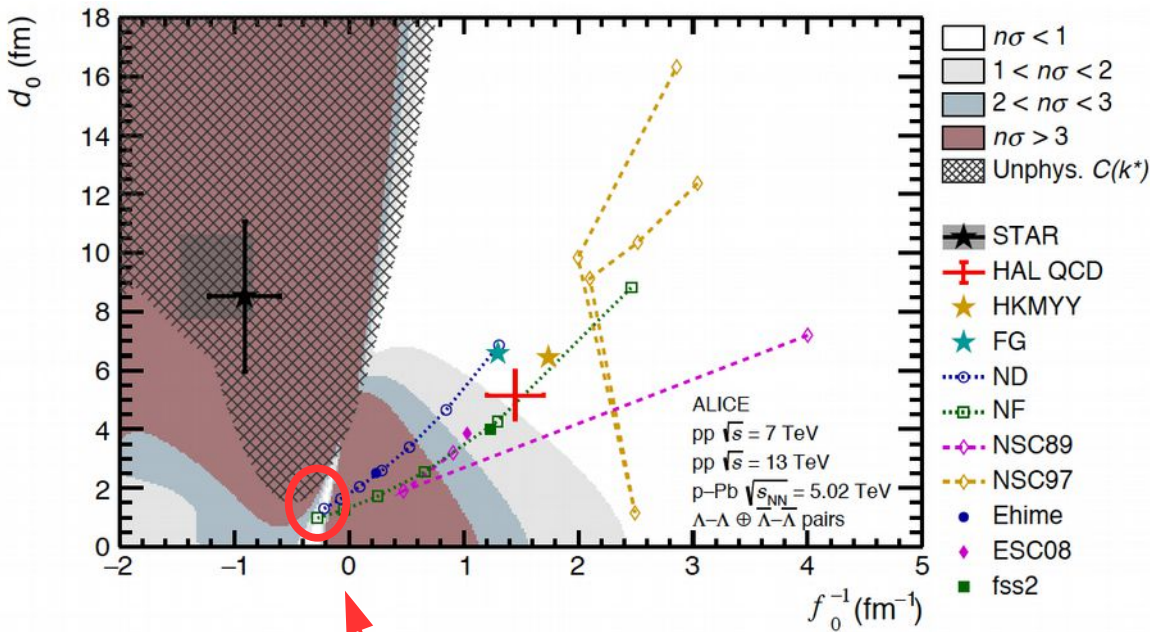
- Determine the scattering parameters (f_0^{-1}, d_0) defining the interaction which can describe the measured $C(q)$ using the Lednicky model:
 - Scattering length: f_0
 - Effective range: d_0

Study baryon-(anti)baryon interactions

New paper arXiv:1905.07209

- Use Λ - Λ momentum correlation to **measure their interaction**

Exclusion plot for the Λ - Λ scattering parameters



Narrow allowed region compatible with a bound state

More results:

first ever measured Λ - Λ interaction arXiv:1903.06149

first observation of attractive p - Ξ arXiv:1904.12198

new preliminaries for p - p , p - Ξ^- , p - Σ^0 , p - Ω^-

$$C(\vec{p}_1, \vec{p}_2) = \frac{P(\vec{p}_1, \vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}$$

$$c(\vec{q}) = \int S(\vec{r}) |\Psi(\vec{q}, \vec{r})|^2 d^3r$$

Measured correlation

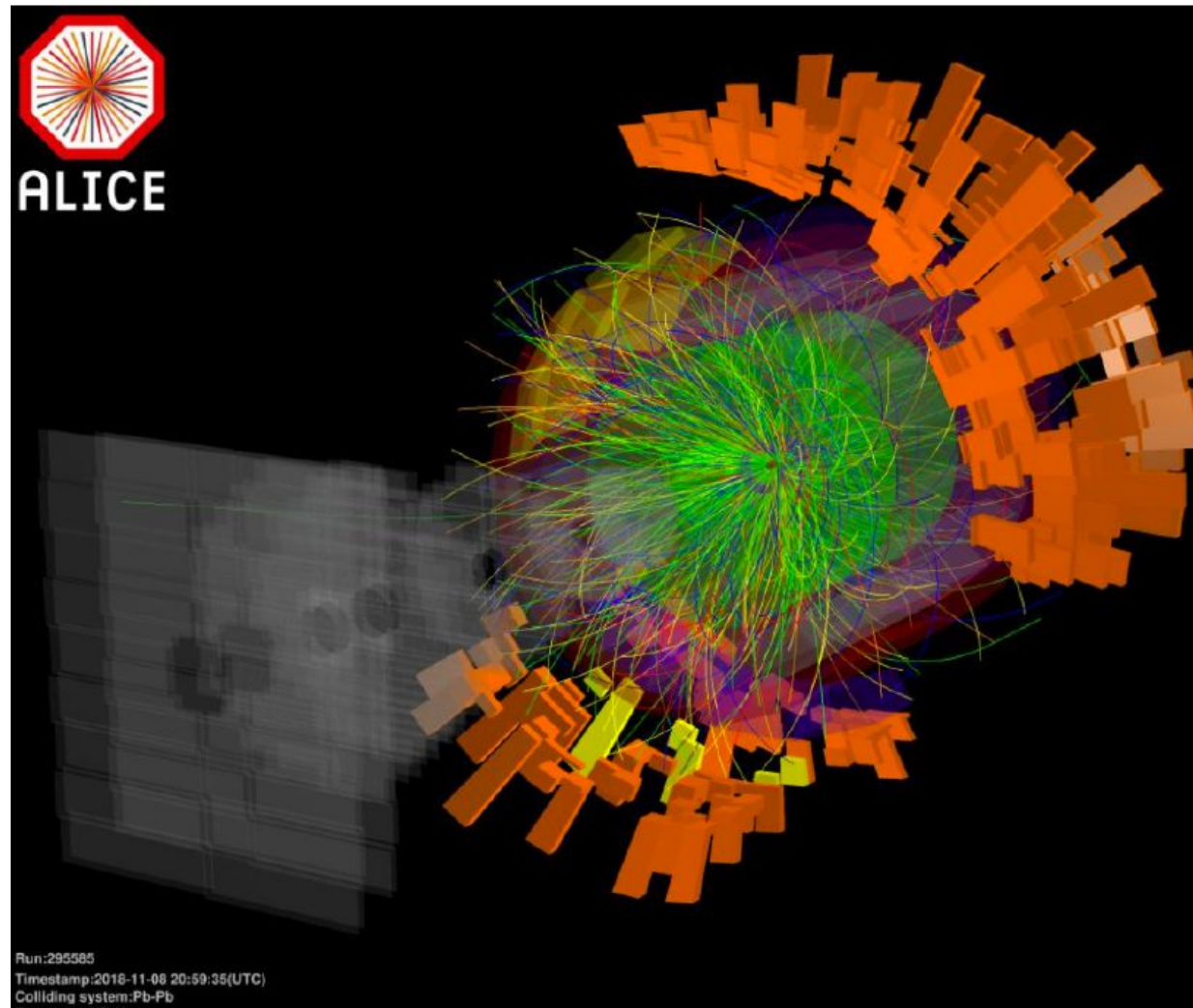
Source size/shape known from pp

Two-particle wave functions Interaction unknown

q : relative momentum

r : relative distance between the points of emission of the two kaons

- New constraints on a possible Λ - Λ bound state**
→ Important inputs for neutron-rich matter studies

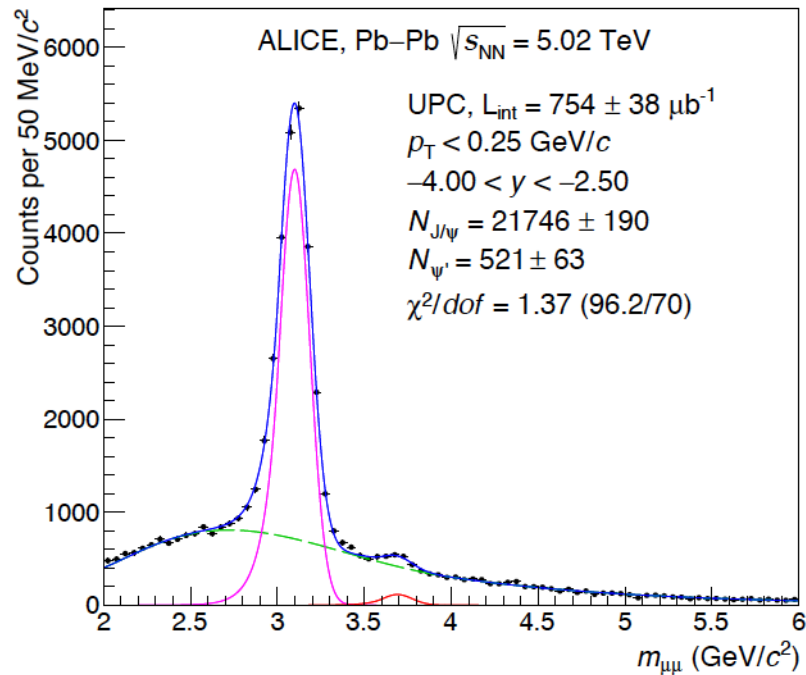


Recent results in Pb-Pb collisions compared to pp, p-Pb, Xe-Xe collisions



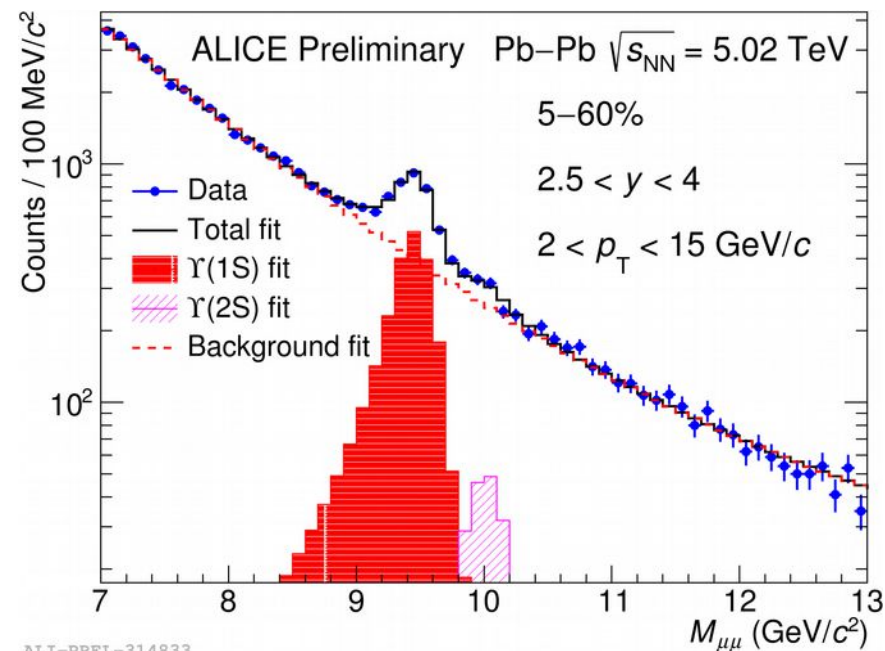
Pb-Pb run 2018

J/ψ in ultra-peripheral Pb-Pb collisions



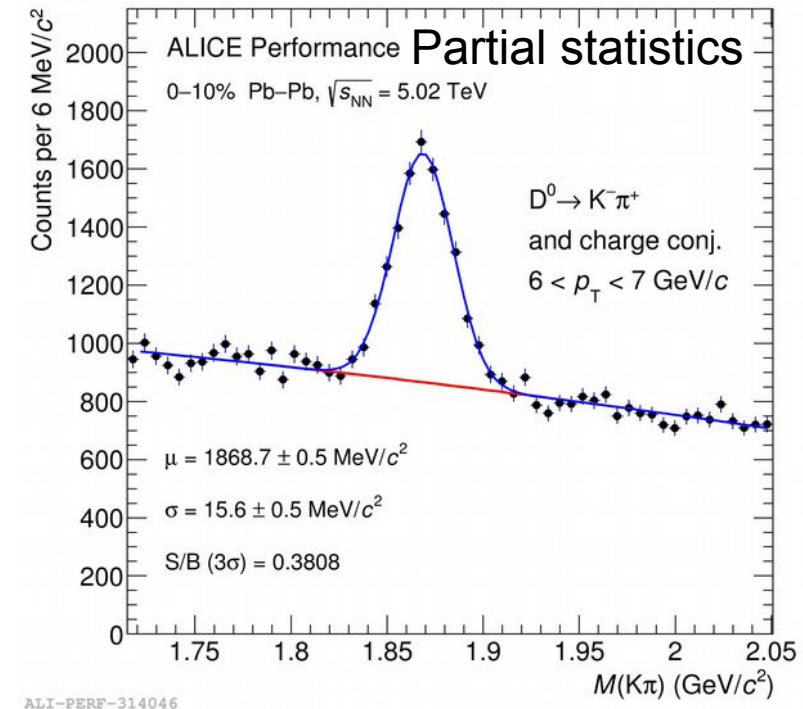
First paper submitted
including 2018 data
arXiv:1904.06272

γ in 5-60% central Pb-Pb collisions



First preliminary results
including 2018 data

D⁰ in 0-10% central Pb-Pb collisions

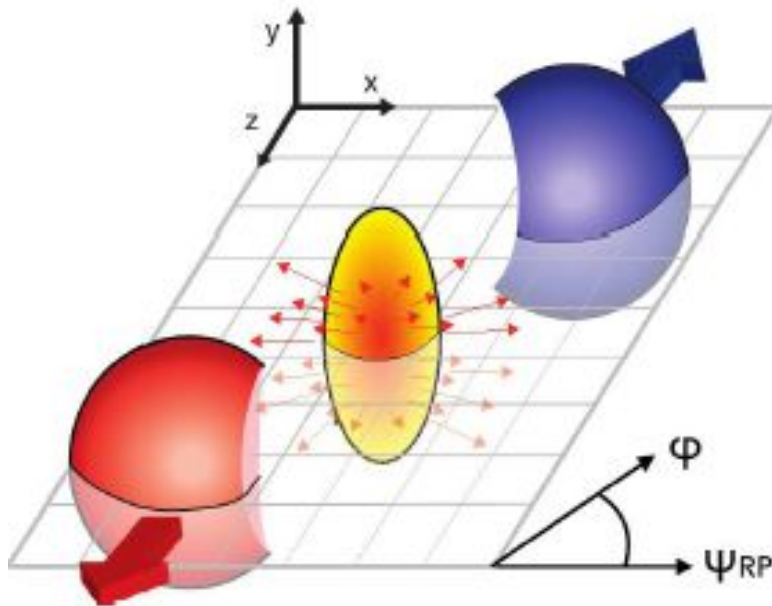


More results for
Summer conferences

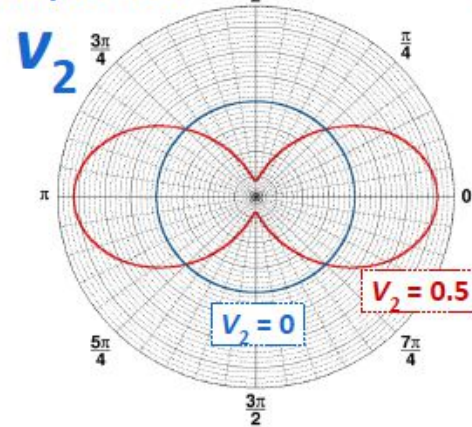
Anisotropic expansion of the medium

- **Spatial anisotropies** convert to **momentum anisotropies** in strongly interacting systems, in a way **depending on the medium's properties**:
→ **anisotropic flow**
- **Quantified in terms of Fourier coefficients**:

$$E \frac{d^3N}{d^3p} = \frac{1}{2\pi p_T dp_T dy} \left(1 + 2 \sum_{n=1}^{\infty} v_n \cos[(\varphi - \Psi_n)] \right)$$

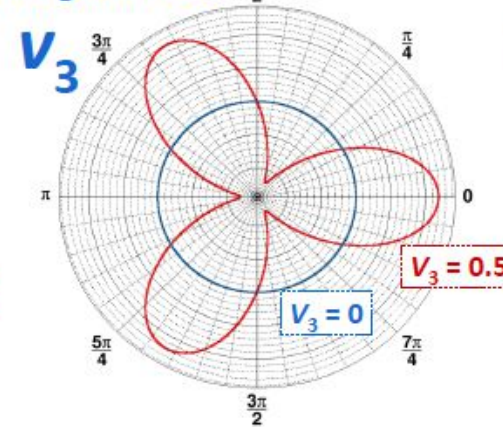


Elliptic flow

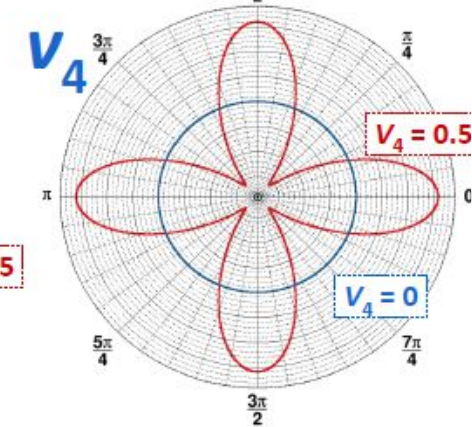


Driven by overlap geometry

Triangular flow



Mostly driven by fluctuations

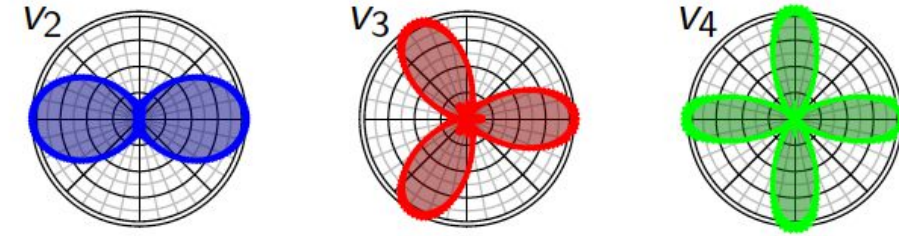
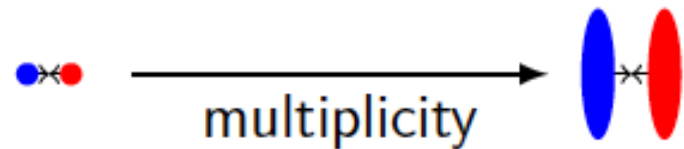
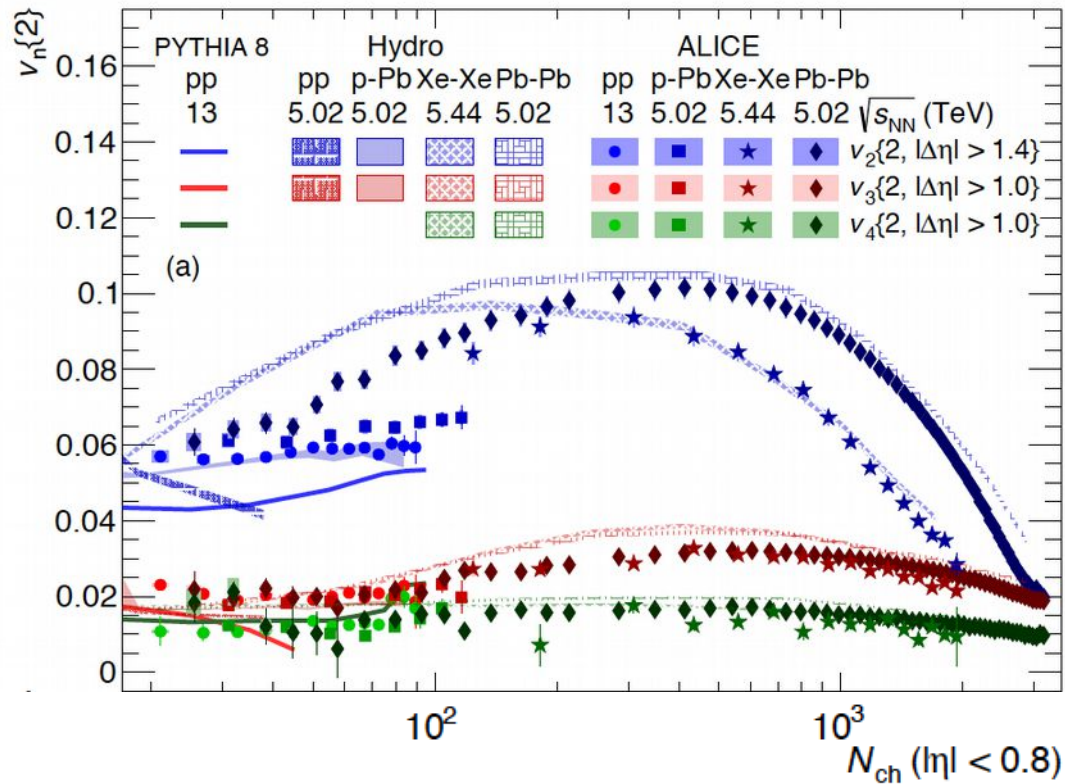


→ Related to **pressure gradients & shear viscosity to entropy ratio (η/s)** in particular v_2

Anisotropic flow of charged particles

New paper arXiv:1903.01790

v_n as a function of multiplicity
in pp, p-Pb, Xe-Xe and Pb-Pb



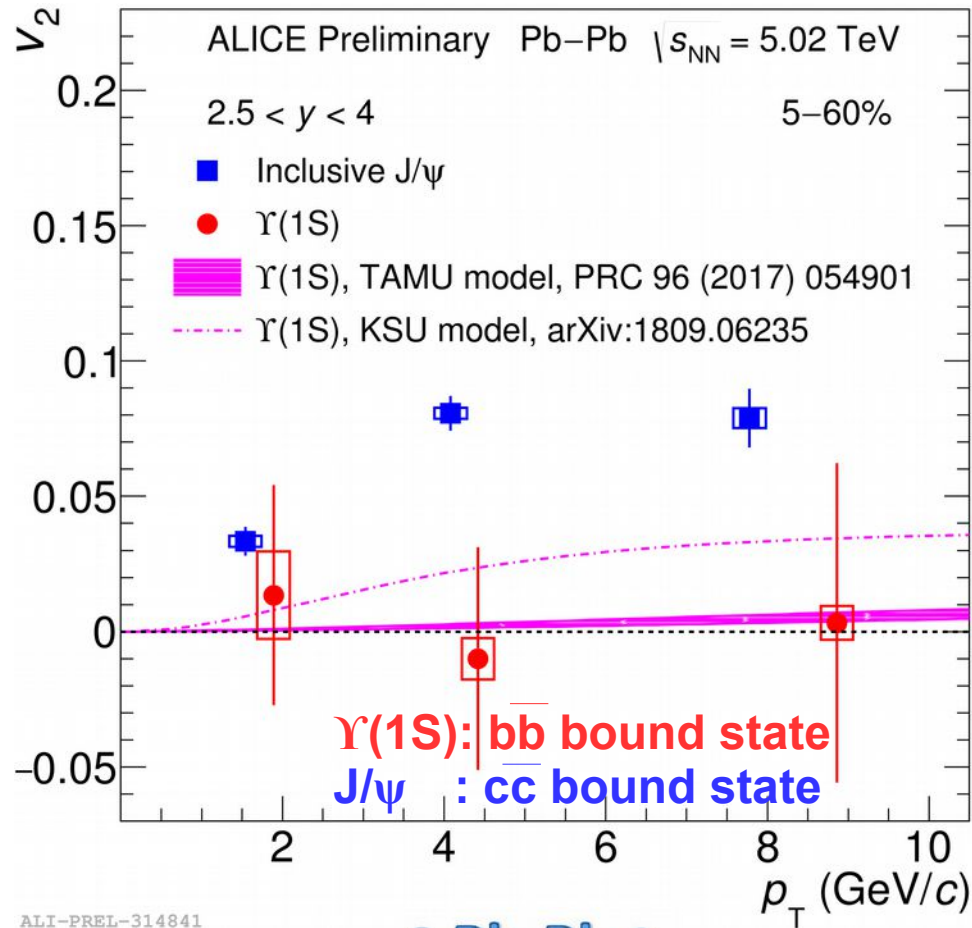
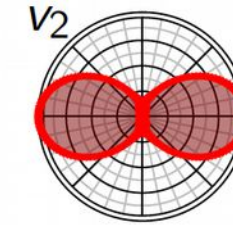
- Compare v_2, v_3, v_4 in pp, p-Pb, Xe-Xe and Pb-Pb using charged-particle multiplicity
- Finite v_n in pp and p-Pb: $v_2 > v_3 > v_4$
Similar values as peripheral Pb-Pb, Xe-Xe
- Different geometry at a given multiplicity in different systems:
 v_2 does not scale with multiplicity

High precision data
Different systems → explore effect of geometry

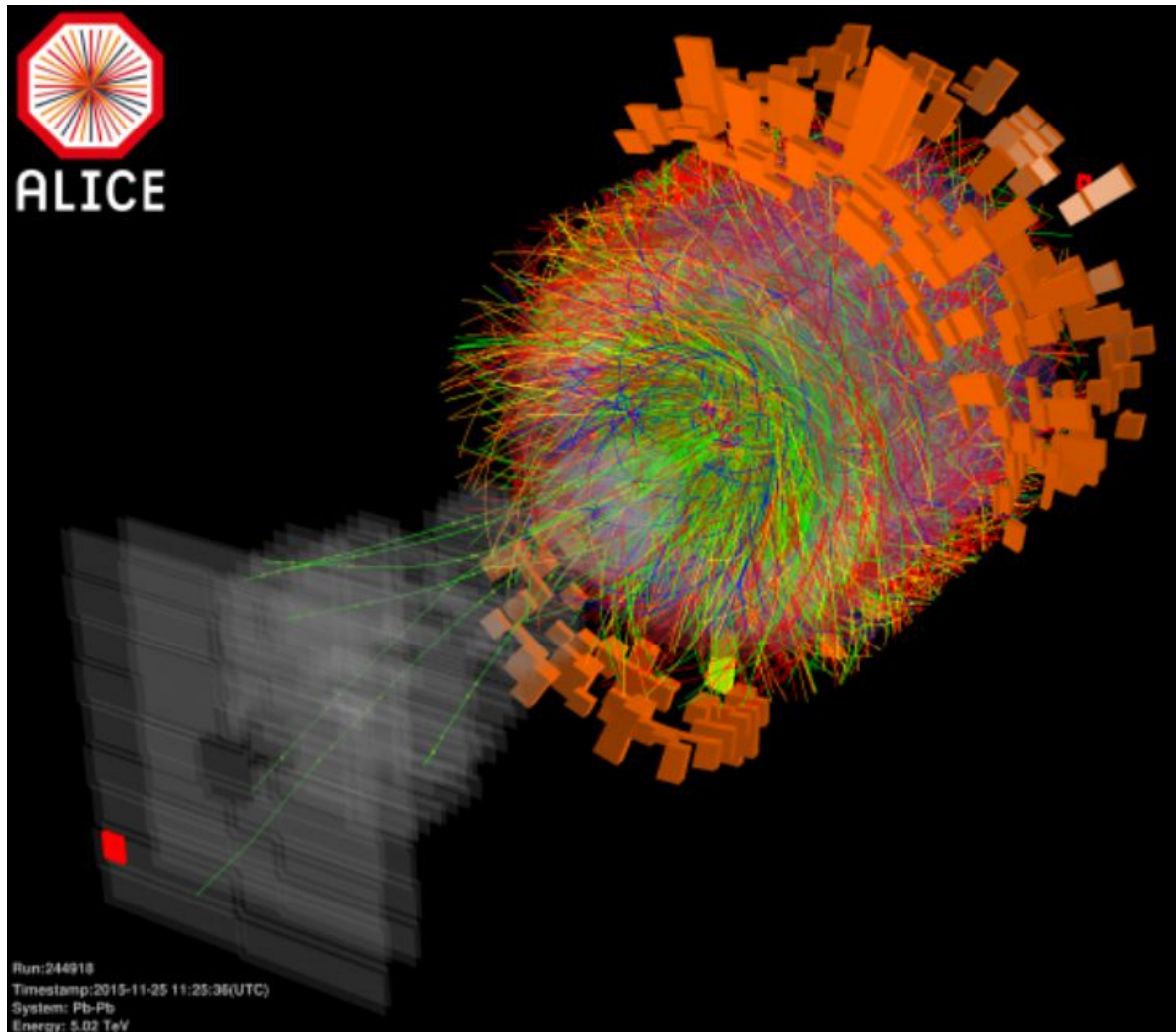
Υ anisotropy in Pb-Pb collisions at 5 TeV (2018!)

New preliminary

with
2018 data



- First measurement of v_2 for $\Upsilon(1S)$: **consistent with 0**
- $v_2(\Upsilon) < v_2(J/\psi)$: 2.6σ effect in $2 < p_T < 15$ GeV/c
 → in line with expectations: small contribution from coalescence



Pb-Pb collisions: a photon-Pb and photon-photon collision factory

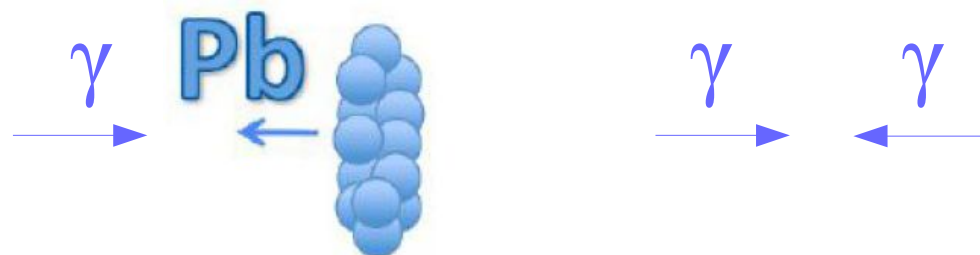
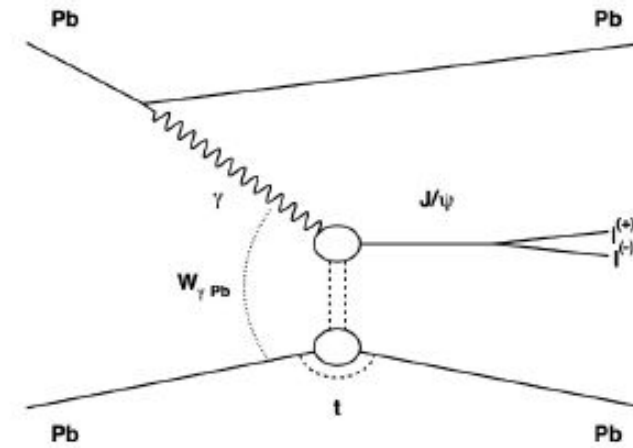
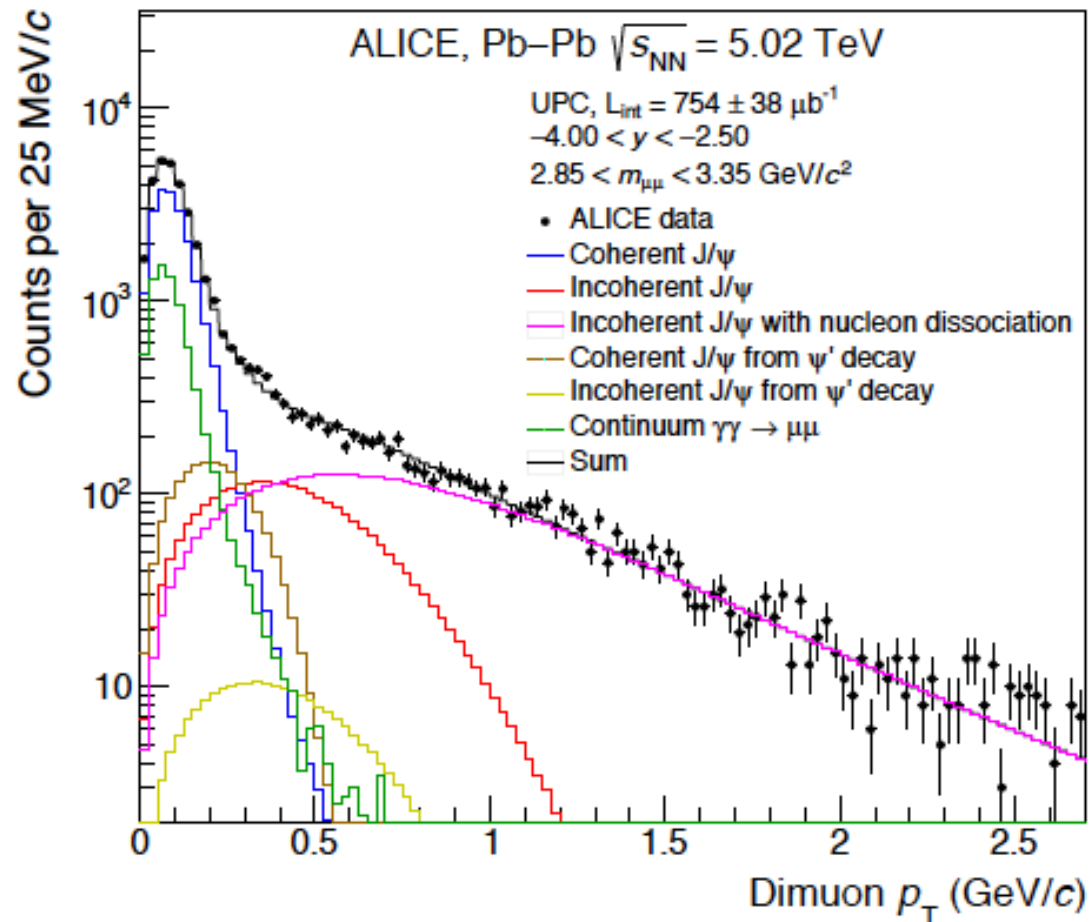


Photo-production of J/ψ in ultra-peripheral Pb-Pb collisions

New paper arXiv:1904.06272

with
2018 data

p_T spectrum of $J/\psi \rightarrow \mu^+ \mu^-$



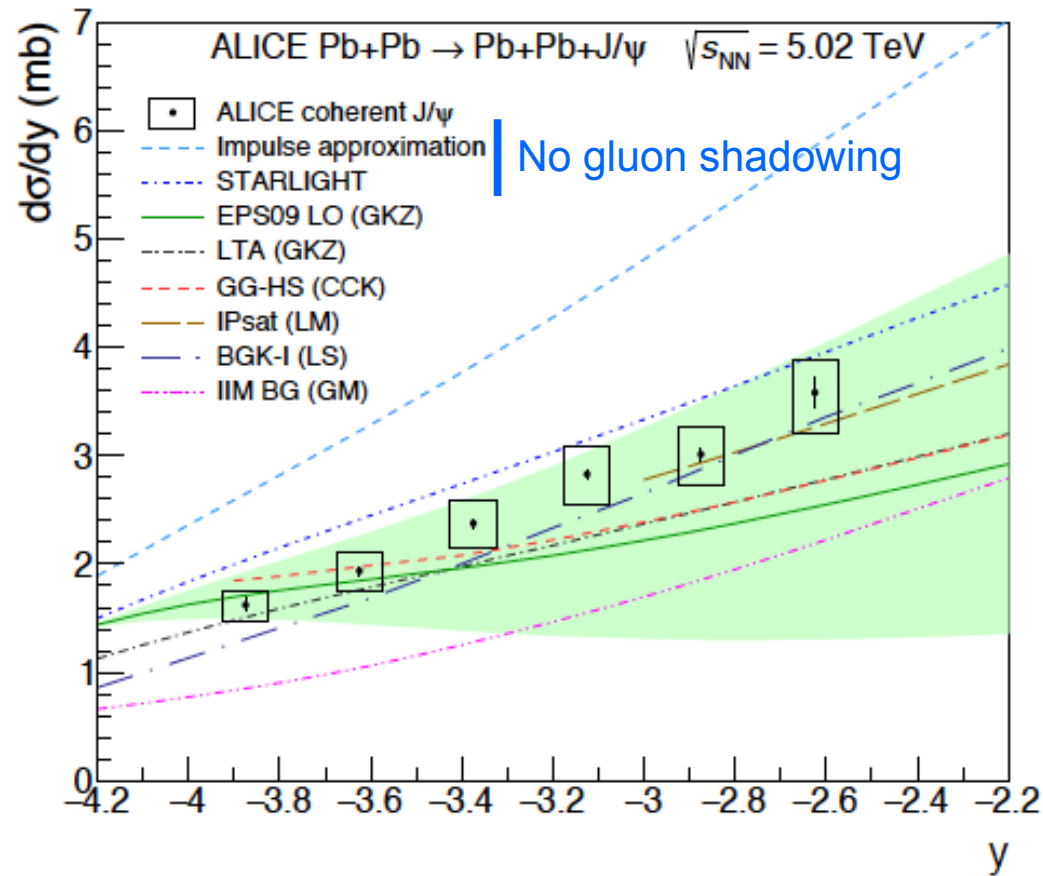
- **Select UPC with $b > 2 \cdot R_{Pb}$:**
 Hadronic interactions strongly suppressed
 Electromagnetic interactions dominant
- **Extract coherent J/ψ using p_T spectrum:**
 - **Coherent J/ψ**
 - Photon couples coherently to all nucleons
 - $\langle p_T \rangle \sim 1/R_{Pb} \sim 60 \text{ MeV}/c$
 - **Non-coherent J/ψ**
 - Photon couples to a single nucleon
 - $\langle p_T \rangle \sim 1/R_p \sim 500 \text{ MeV}/c$

Photo-production of J/ψ in ultra-peripheral Pb-Pb collisions

New paper arXiv:1904.06272

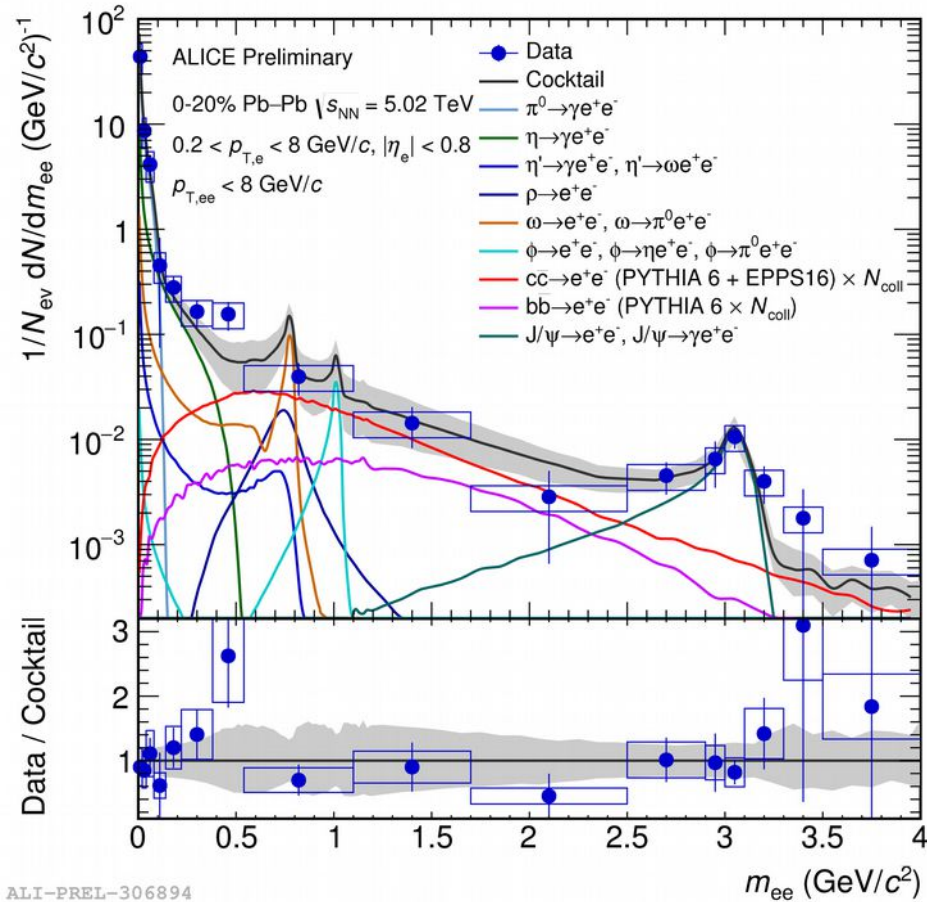
with
2018 data

Coherent J/ψ photoproduction



- **Coherent J/ψ photoproduction:**
precise rapidity dependence measurement
proportional to square of the gluon density in the target (Pb)
→ Study gluon nuclear shadowing
- **Compare data with different theoretical models:**
→ Results in agreement with moderate nuclear gluon shadowing
→ Constrain the gluon distributions in global PDF fits

Dielectron invariant mass spectrum in central Pb-Pb collisions at 5.02 TeV



Dielectrons come from various sources:

- Light-flavour mesons
- Heavy-flavour mesons
- Thermal radiation from the medium
- Photo-production

In central Pb-Pb collisions:

- m_{ee} spectrum in central Pb-Pb collisions fairly well described by hadronic cocktail with light-flavour and heavy-flavour mesons including cold-nuclear matter effects

analysis of 2018 Pb-Pb data on going to address thermal radiation and ρ line shape

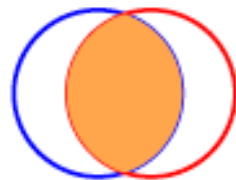
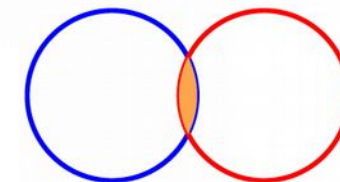
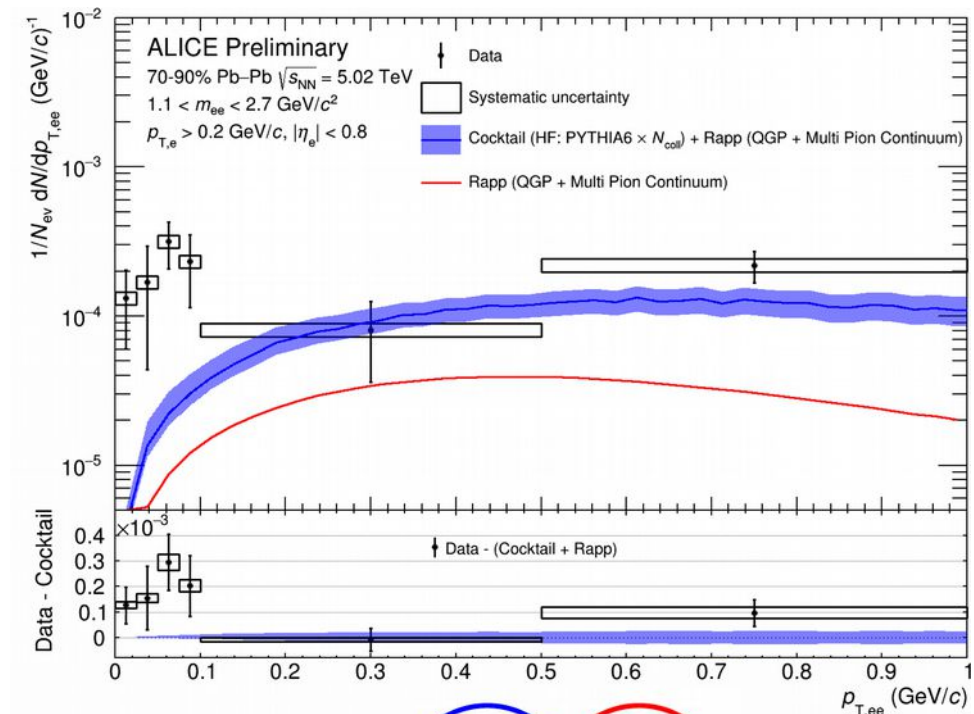
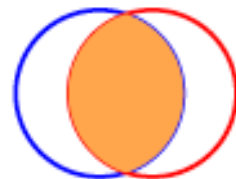
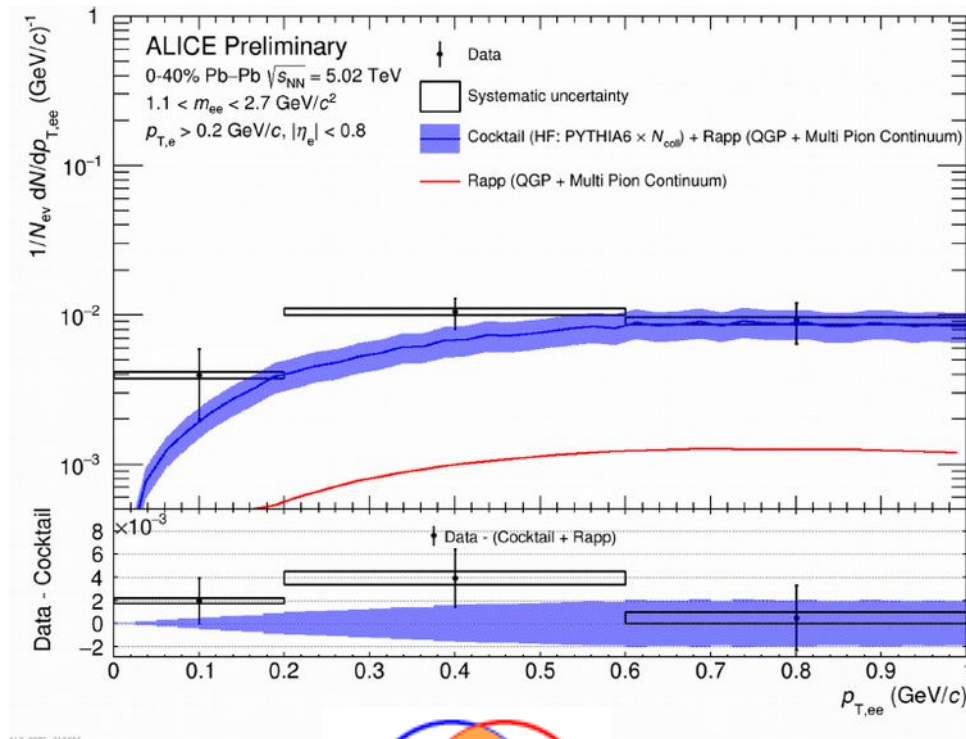


Photo-production of dielectrons in peripheral Pb-Pb collisions

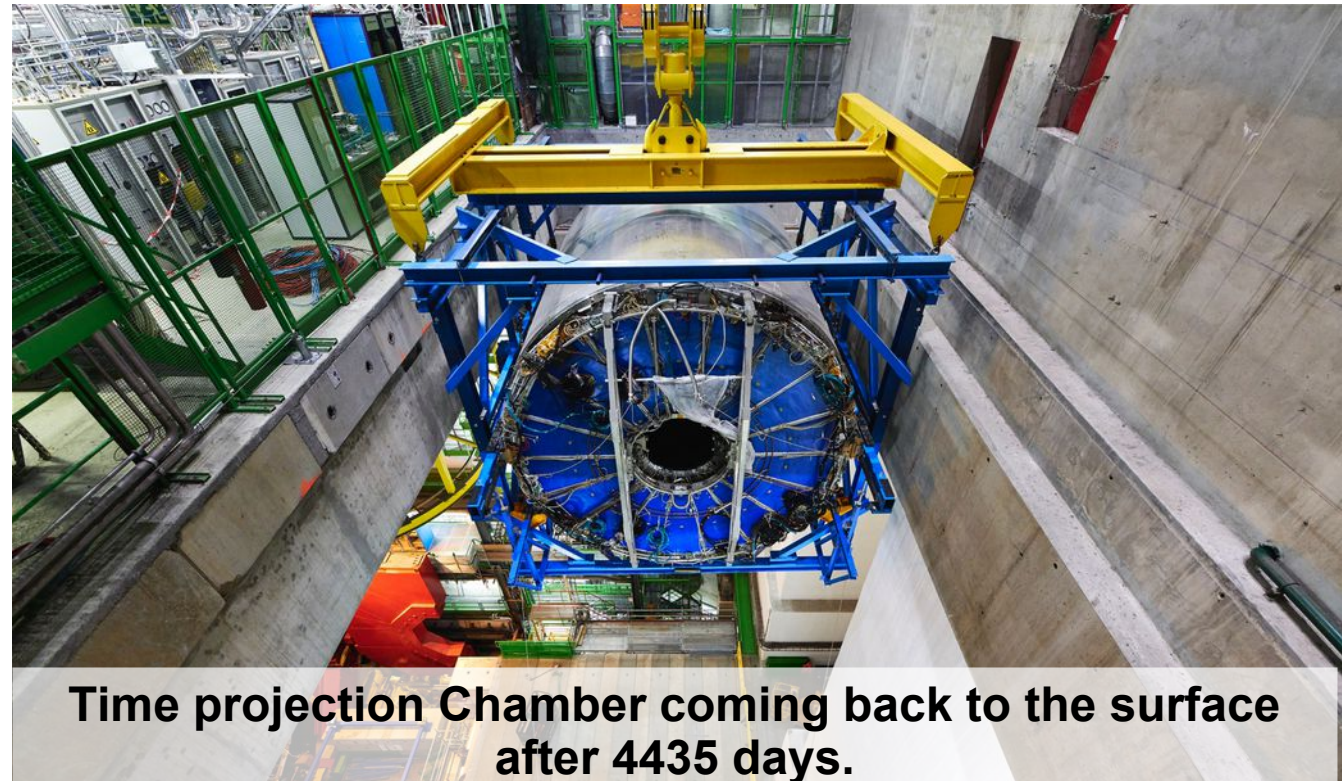
- **Excess observed at low $p_{T,ee}$ in peripheral Pb-Pb collisions**
 - No excess in 0-40% central Pb-Pb collisions
 - **3.6 σ excess in 70-90% central Pb-Pb collisions**
- **Similar excess observed at RHIC** by the STAR experiment
 Could be related to **initial photon annihilation processes $\gamma\gamma \rightarrow e^+e^-$**

New Preliminary

Dielectron $p_{T,ee}$ spectra



Summary

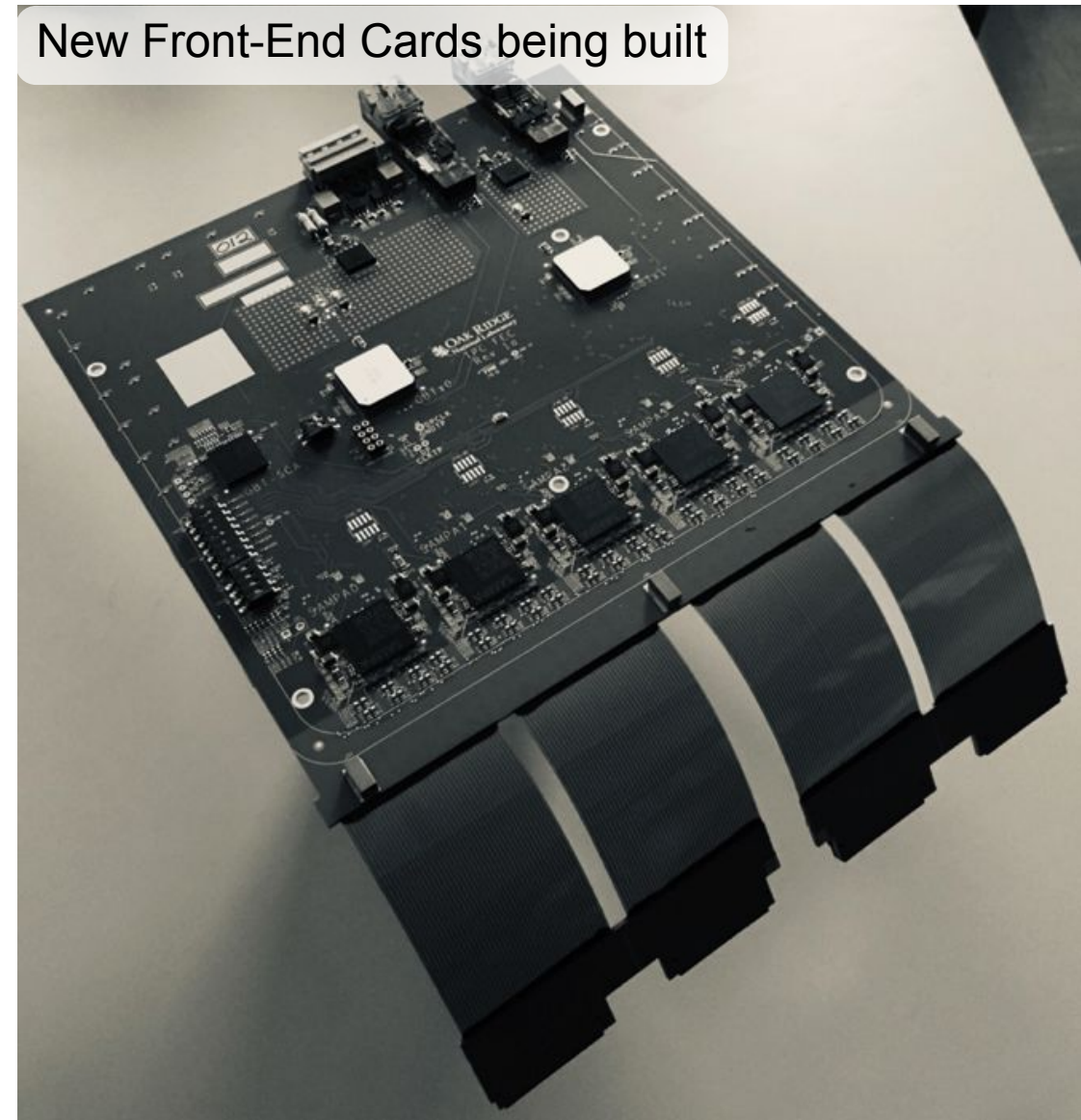


- **ALICE LS2 activities progressing well**
Time Projection Chamber extracted and TPC upgrade now on going
- **New results in particular in:**
 - Jets
 - Femtoscopy measurements in small system
 - Anisotropy of charged particles and $\Upsilon(1S)$ in heavy-ion collisions
 - Ultra-peripheral and peripheral Pb-Pb collisions
- **First results from 2018 Pb-Pb data**
Large number of new results prepared for summer conferences (next week: Strangeness in Quark Matter)

Back-up

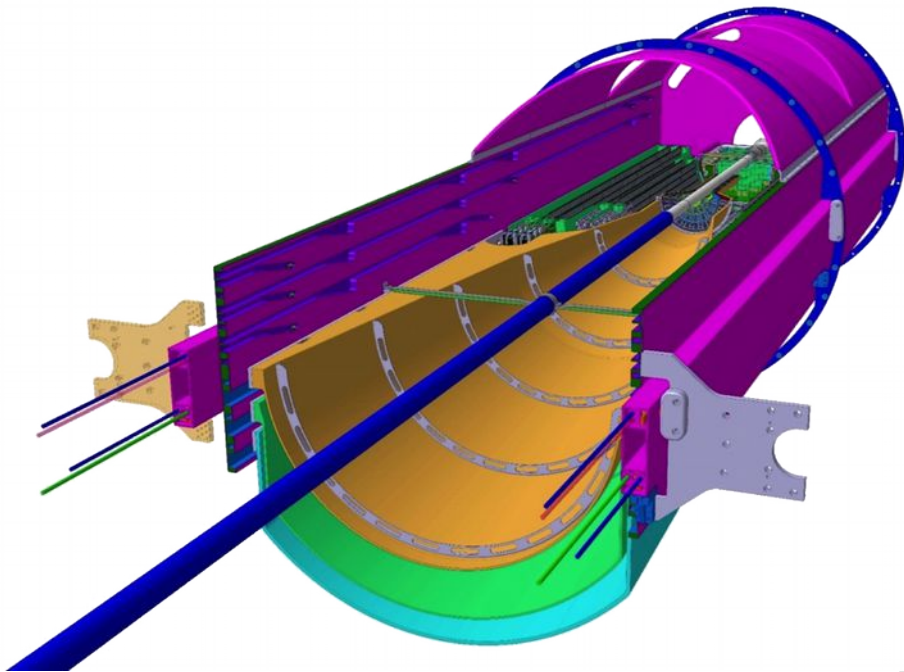
Front-End Card production progress

- ~3700 Front-End Cards (FEC) will be built
- FEC assembly and testing ongoing
- >900 assembled FECs functionally tested so far
- On track to complete **delivery to CERN in July**
- **Start of installation: end of September**

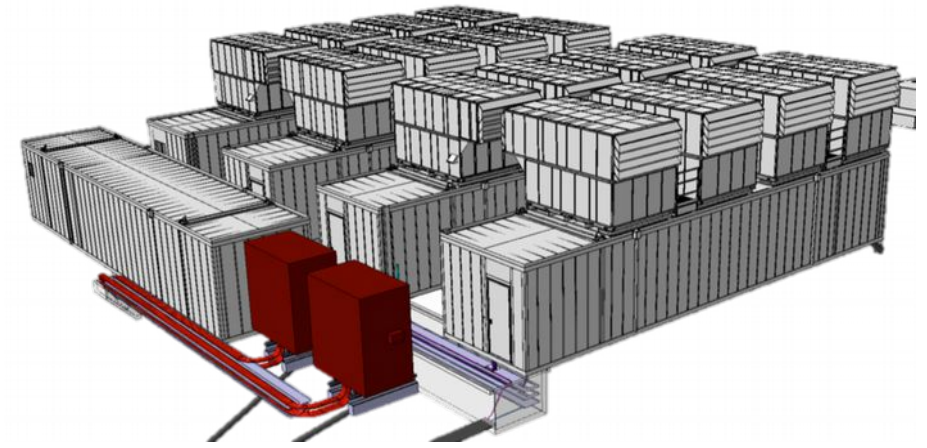


New beampipe status

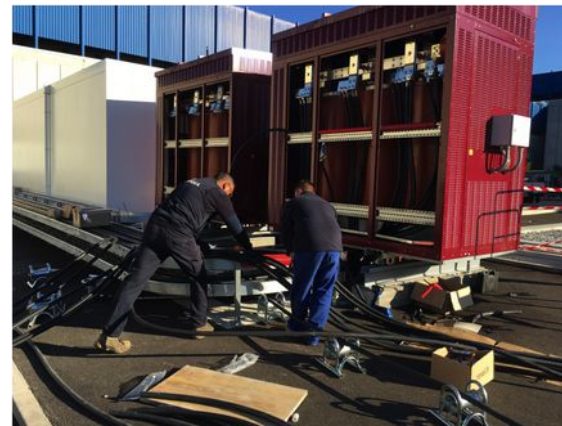
- New ALICE beampipe: **19mm radius, $X/X_0=0.22\%$**
- **1st chamber (for LS2 installation) received** at CERN mid-april
- 2nd chamber (spare) in production (expected delivery end of the year)
- **Foreseen installation in LS2: February 2020**



New Data Centre (CR0)



- **50% installed, completion by September 2019**
 - IT1-2 installed and accepted
 - IT3 will be installed on June 13th
 - IT4 will be installed on August 7th
- Electrical supply infrastructure
+ connection to primary cooling done before LS2



Datasets from Run 1 & 2

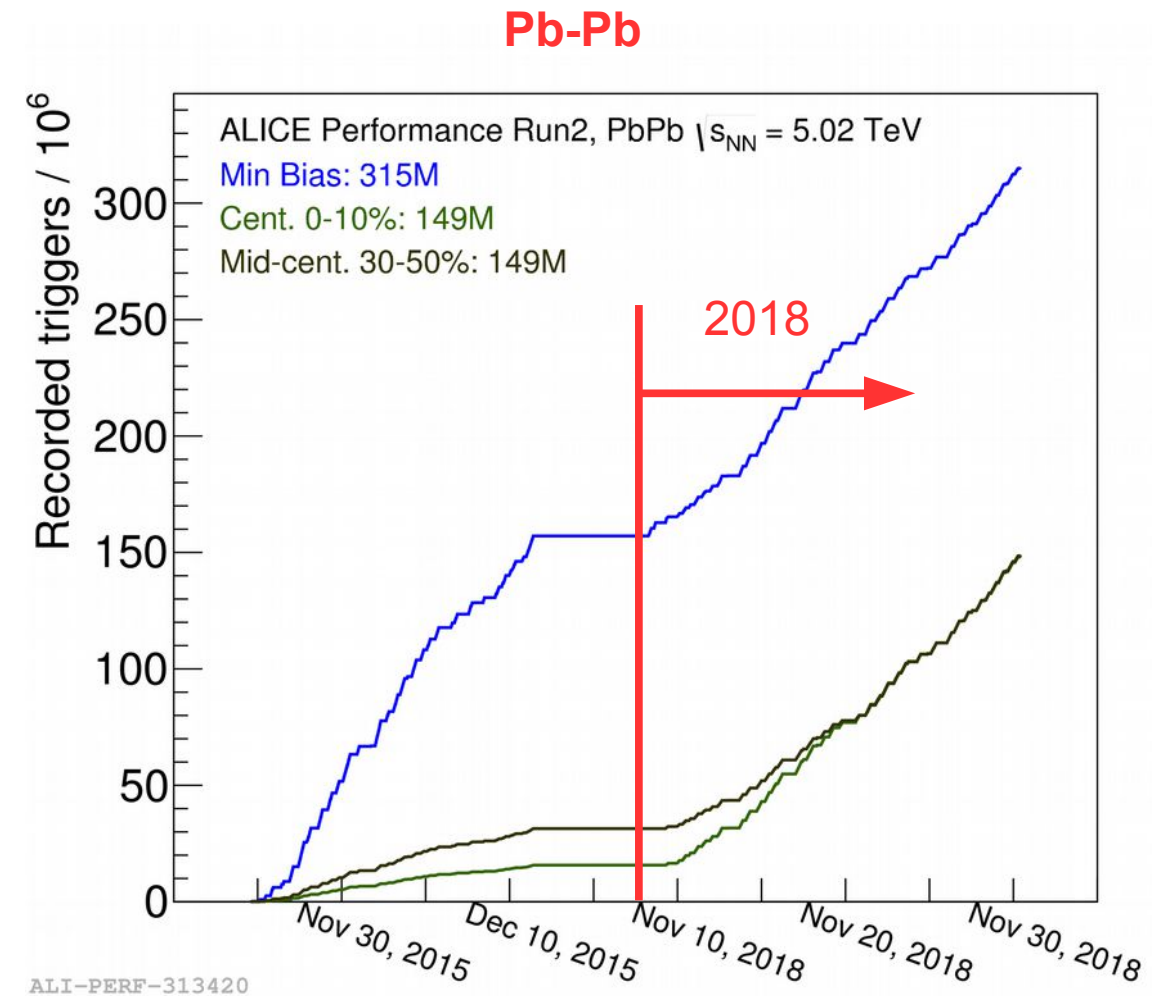
- **Run 2** data taking concluded

system	$\sqrt{s_{NN}}$ (TeV)	L_{int}
pp	0.9	$\sim 200 \mu\text{b}^{-1}$
	2.76	$\sim 100 \text{nb}^{-1}$
	5.02	$\sim 1.3 \text{pb}^{-1}$
	7	$\sim 1.5 \text{pb}^{-1}$
	8	$\sim 2.5 \text{pb}^{-1}$
	13	$\sim 25 \text{pb}^{-1}$
p-Pb	5.02	$\sim 15 + 3 \text{nb}^{-1}$
	8.16	$\sim 25 \text{nb}^{-1}$
Xe-Xe	5.44	$\sim 0.3 \mu\text{b}^{-1}$
Pb-Pb	2.76	$\sim 75 \mu\text{b}^{-1}$
	5.02	$\sim 0.25 + 1 \text{nb}^{-1}$

→ Study system and energy dependence with **Run 1** and **Run 2** data

- **2018 Pb-Pb data:**

- **Substantial increase in statistics (up to a factor 9 in central Pb-Pb)**
- **Fully calibrated reconstruction now available** also for central barrel
- Muon and calorimeter data reconstructed synchronous with data taking



Further triggers:
muon, EMCal/PHOS, UPC

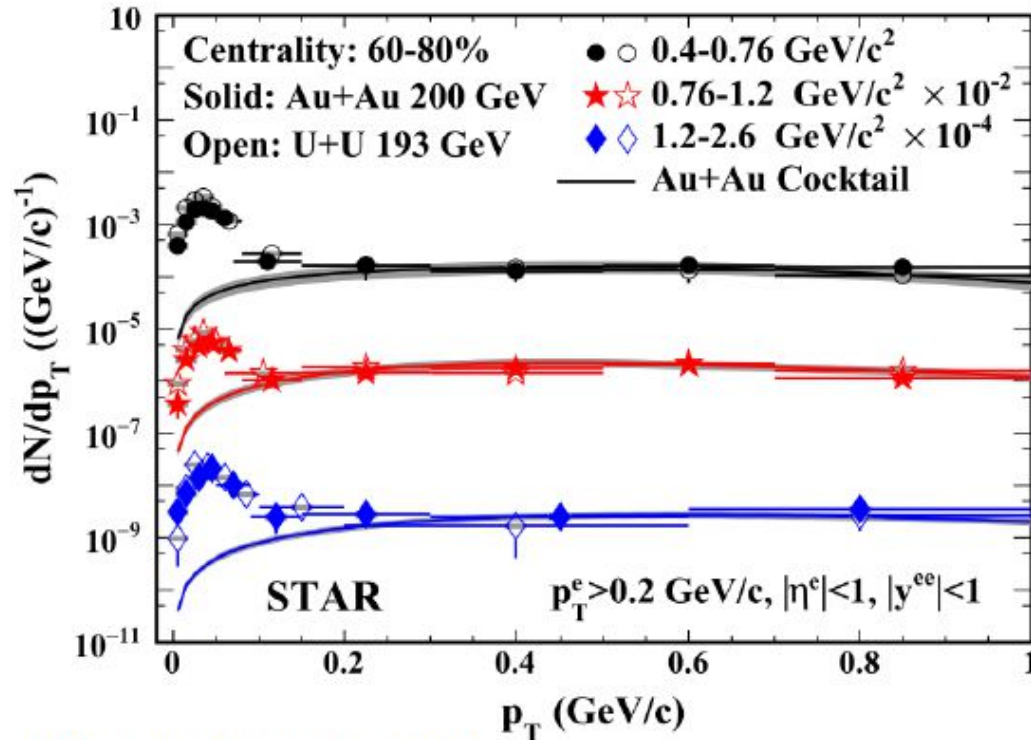
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New Preliminary

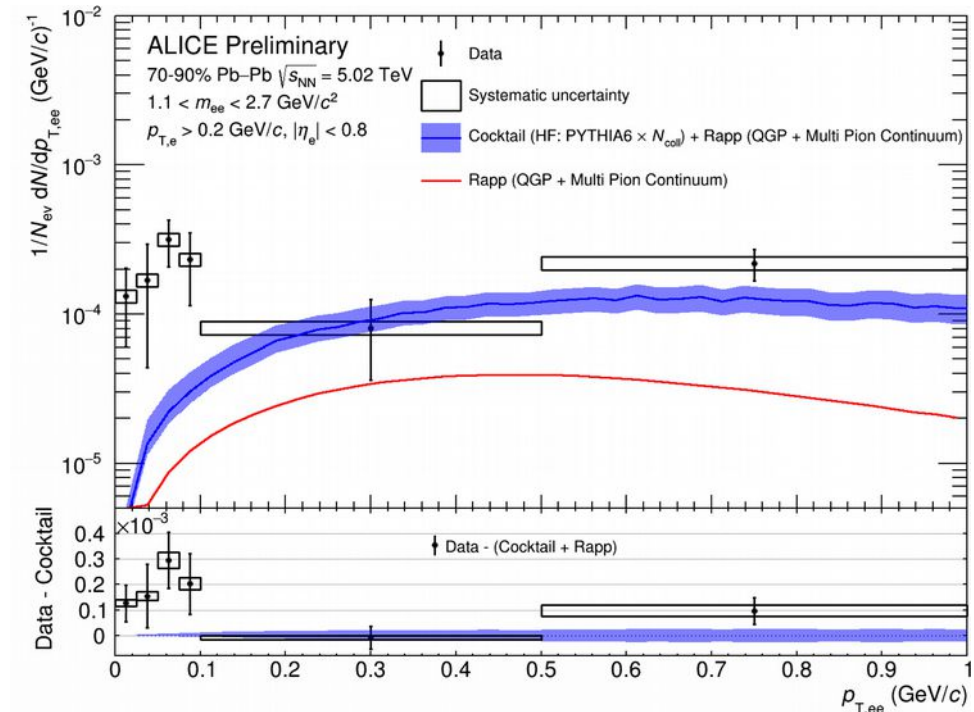
Dielectron $p_{T,ee}$ spectra

STAR at RHIC



STAR, Phys. Rev. Lett. 121, 132301

ALICE at the LHC

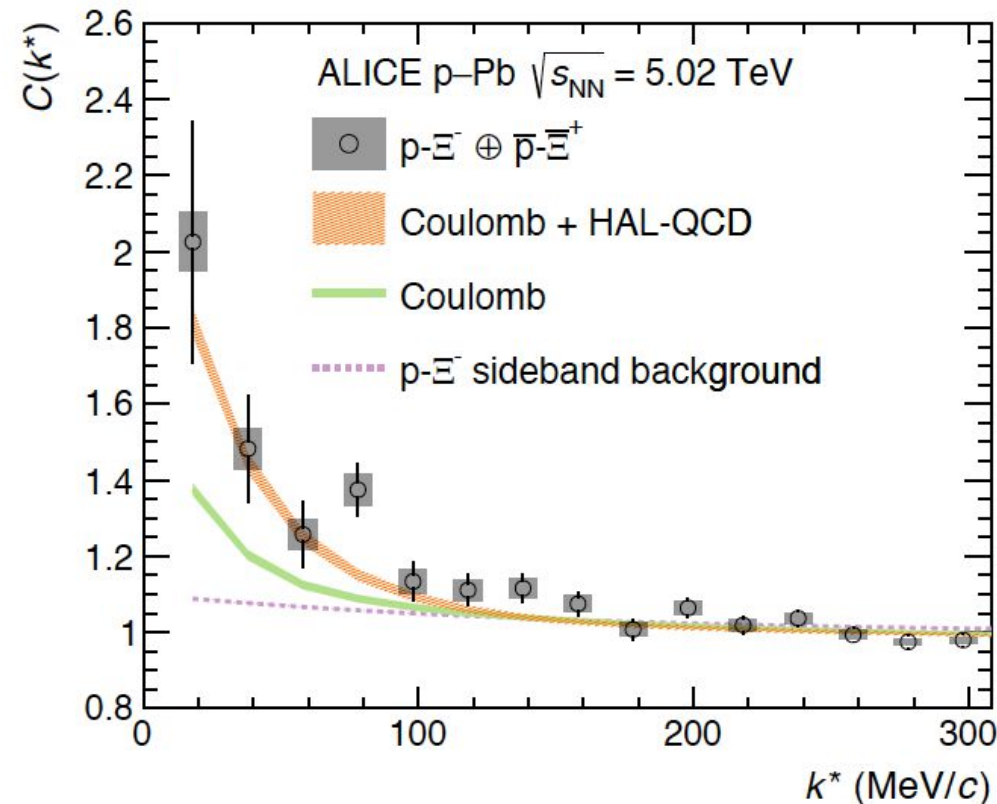


ALICE-PHOS-201604

Proton and multi-strange baryon interaction

New paper arXiv:1904.12198

kp- Ξ^- correlation function in p-Pb collisions at 5.02 TeV



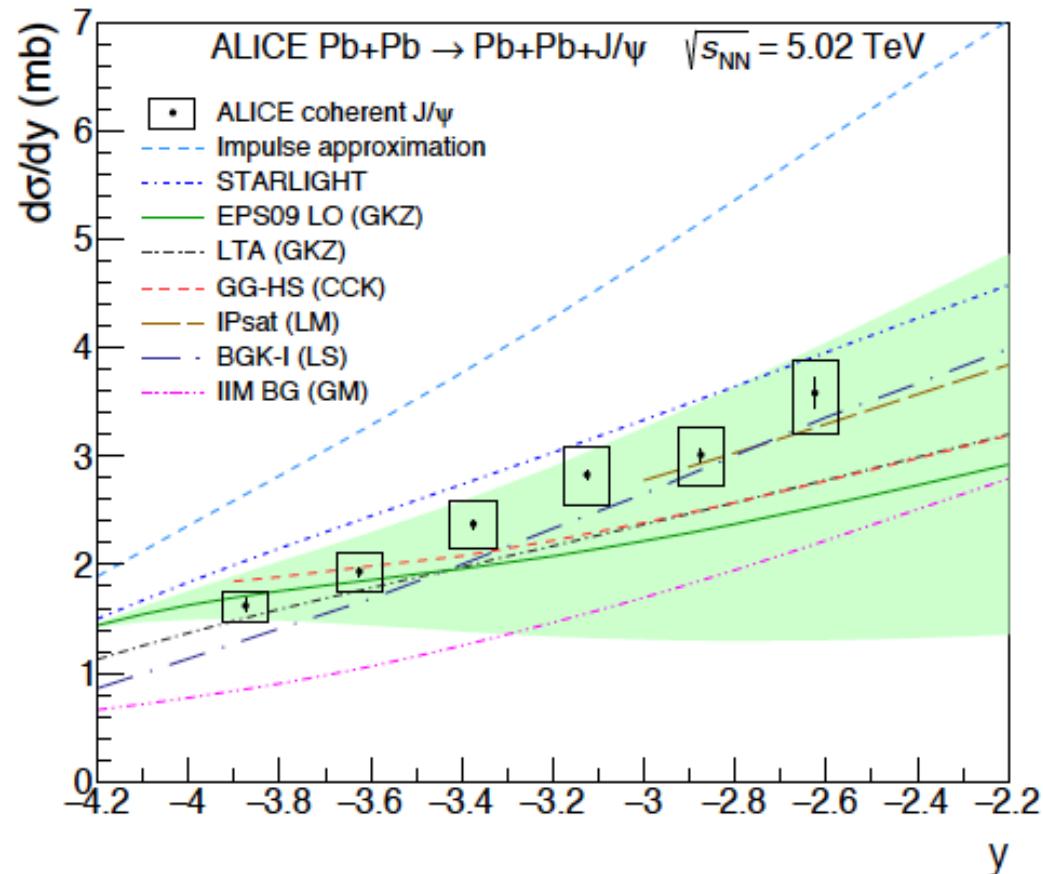
- **First observation of an attractive interaction between a proton and a multi-strange baryon ($\Xi^- = ssd$)**
- **Coulomb interaction** not enough to reproduce the data
→ Need **additional strong attractive interaction** computed with lattice QCD (HAL-QCD Collaboration)
- **Imply stiffer equation of state for neutron-rich matter including hyperons**

k^* = reduced relative momentum of the two particles

Photo-production of J/ψ in ultra-peripheral Pb-Pb collisions

New/First paper including 2018 data !
arXiv:1904.06272

Coherent J/ψ photoproduction



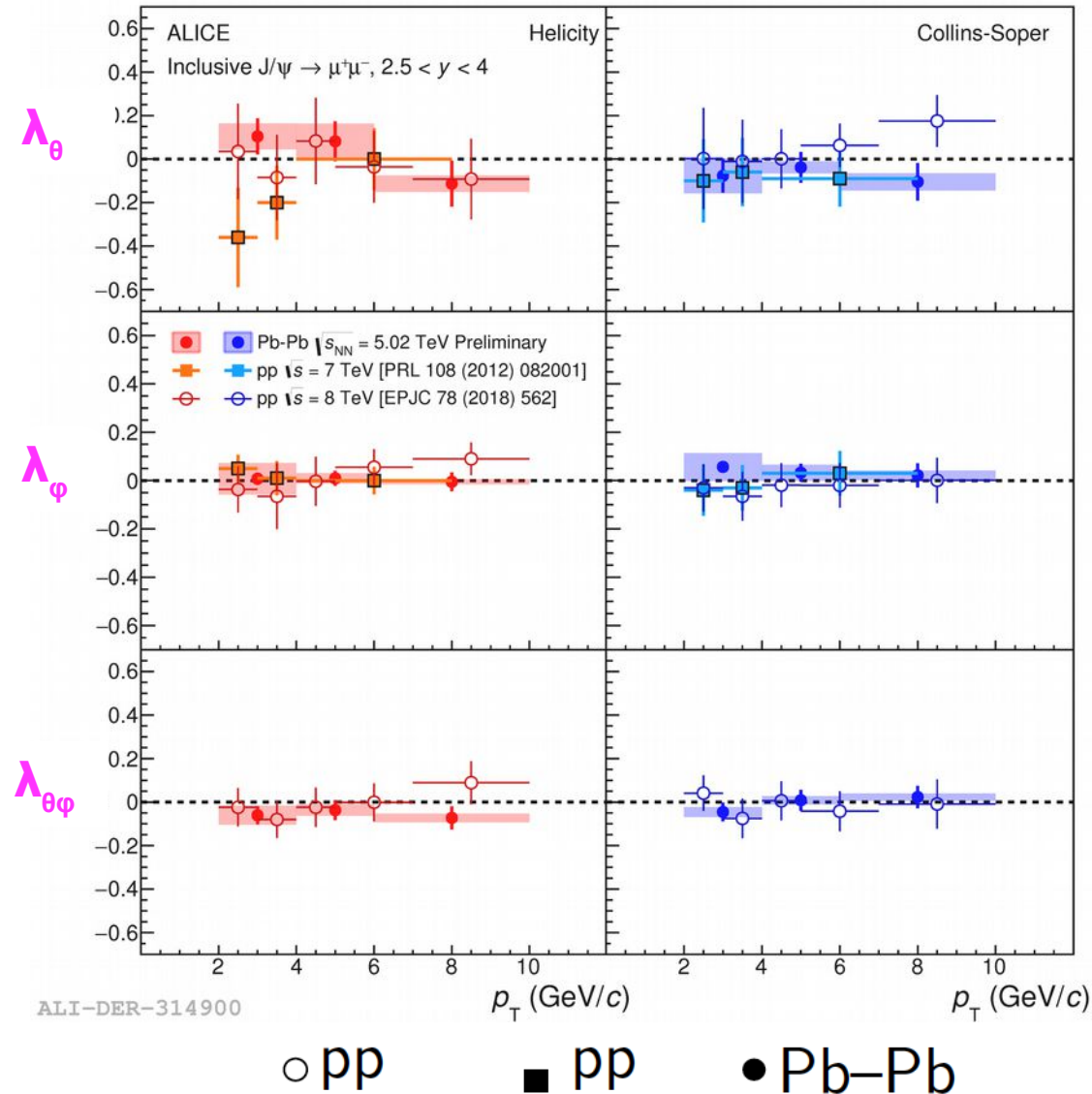
- **Coherent J/ψ photoproduction:**
proportional to square of the gluon density in the target (Pb)
Study gluon nuclear shadowing
- **Results in agreement with moderate nuclear gluon shadowing**

- **Impulse approximation: no nuclear effects**
- **STARLIGHT: VDM + Glauber,**
Klein, Nystrand et al:
Comput. Phys. Commun. 212 (2017) 258
- **EPS09 LO (GKZ): EPS09 shadowing**
Guzey, Kryshen, Zhalov, PRC93 (2016) 055206
- **LTA (GKZ): Leading Twist Approximation**
Guzey, Kryshen, Zhalov, PRC93 (2016) 055206
- **GM: Color dipole model + IIM CGC**
Goncalves, Machado et al.:
PRC 90 (2014) 015203, JPG 42 (2015) 105001
- **LM IPSat: Color dipole model + IPSat CGC**
T. Lappi, H. Mäntysaari, PRC 83 (2011) 065202;
87 (2013) 032201
- **CCK: hot-spot model + Glauber-Gribov:**
Cepila, Contreras, Krelina, PRC97 (2018) 024901
- **LS: Color dipole model + BGK-I CGC:**
Luszczak, Schafer: arXiv:1901.07989

J/ψ polarization in Pb-Pb collisions at 5 TeV

Reference frame: Helicity

Collins-Soper

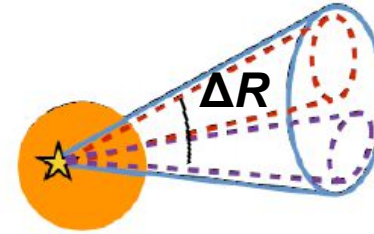


New preliminary in Pb-Pb

- Non-perturbative formation of J/ψ from $c\bar{c}$
- **Polarisation sensitive to production mechanisms:**
 - Transverse (LO NRQCD)
 - Longitudinal (NLO color singlet model)
- **pp results consistent with no polarisation** (feed-down from higher charmonium states)
- **First measurement of non-polarisation in Pb-Pb**
 - Probing interaction with and formation from medium
 - Feed-down changed in Pb-Pb:
 - Suggests no polarisation for J/ψ and $\psi(2S)$

Jet substructure

- Use iterative procedure to split jet into two subjets:
 - Remove pieces with momentum fraction z less than 0.1
 - Split remaining subjet into two prong structure
 - Study z_g and the opening angle ΔR

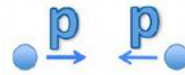
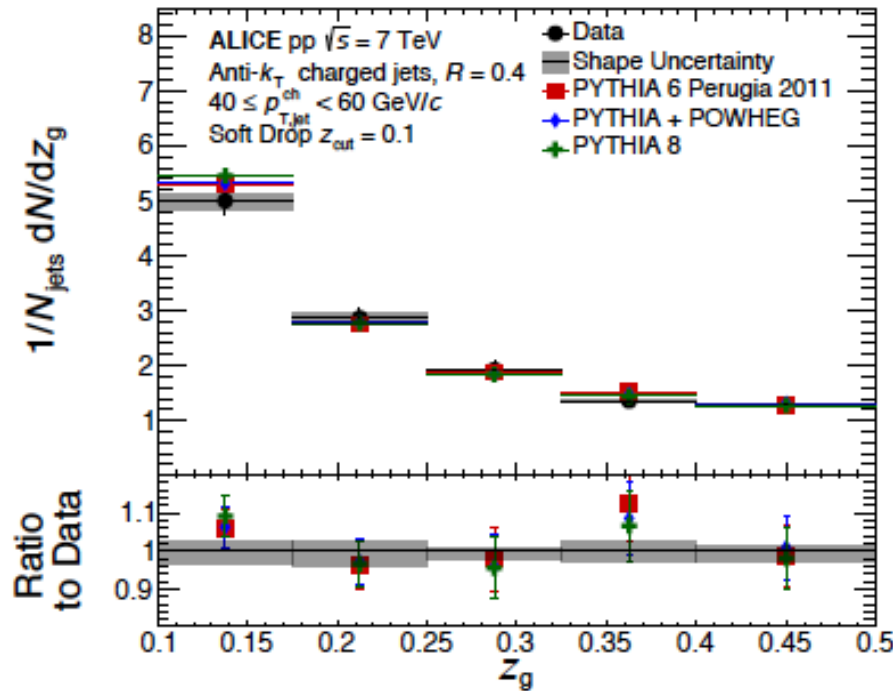


Sub-jet1 with z_g $z_g = \frac{\min(p_T^1, p_T^2)}{p_T^1 + p_T^2}$

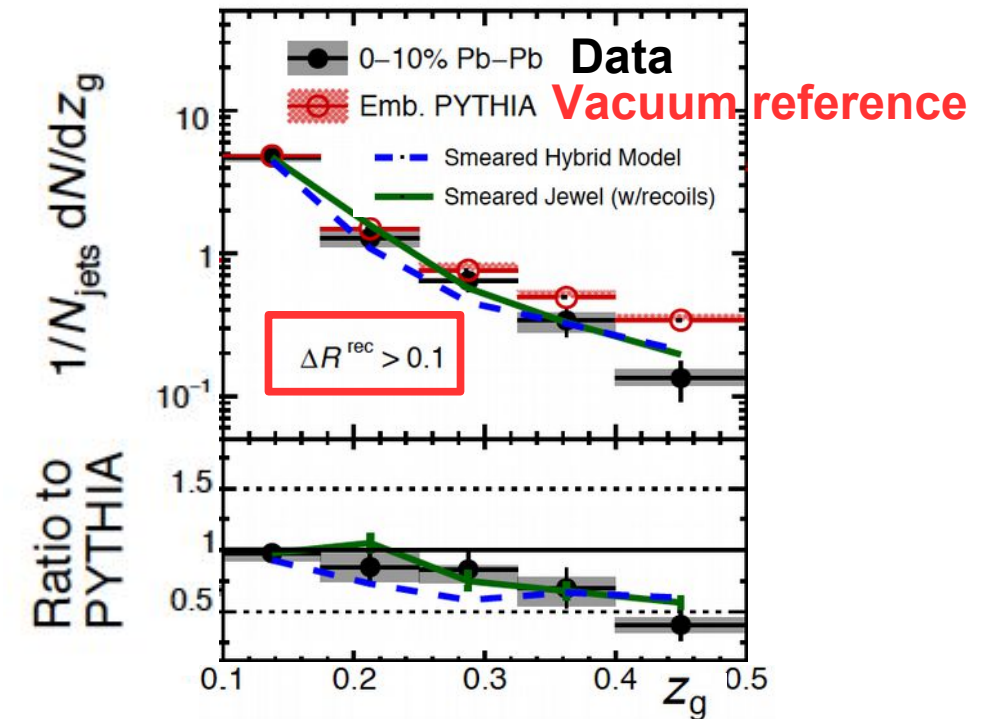
Sub-jet2 with $(1-z_g)$ $z_g > 0.1$

New paper arXiv: 1905.02512

pp collisions at 7 TeV



0-10% central Pb-Pb collisions at 2.76 TeV



Data reproduced by vacuum calculations expect for the number jets without splitting (smaller in data)

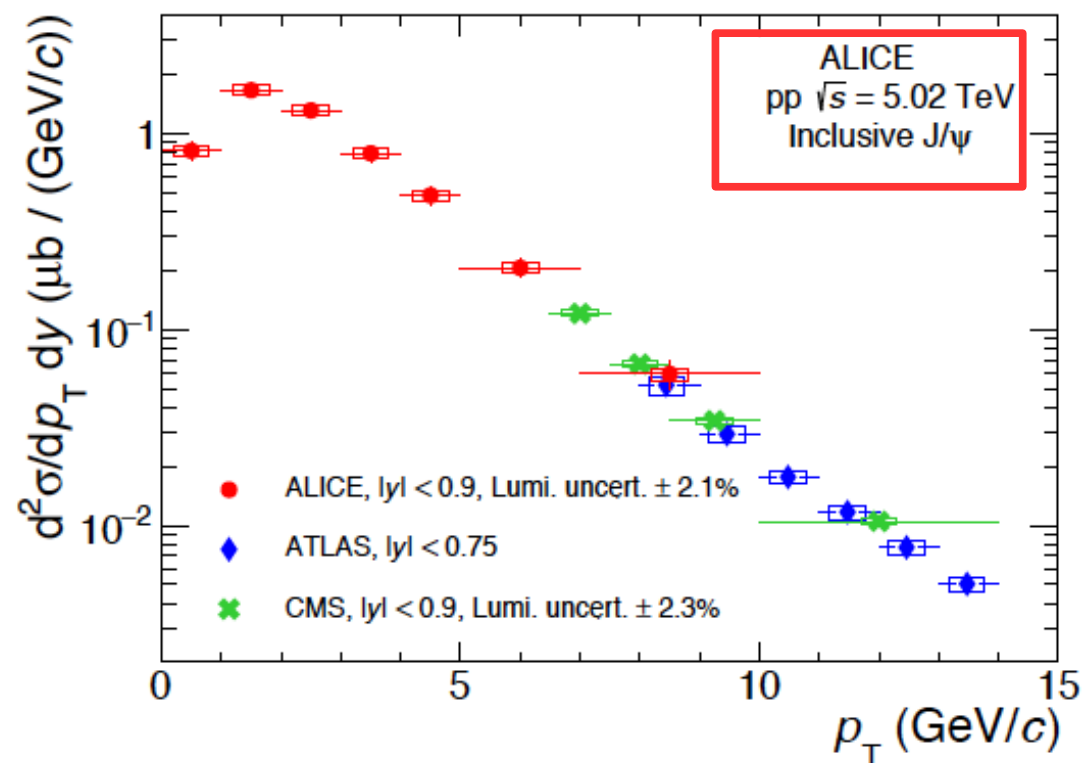
Suppression of symmetric splittings at large angles
 → formation times of the splitting, color coherence effects

Inclusive J/ψ at mid-rapidity in pp collisions at 5 TeV

- Measure **inclusive $J/\psi \rightarrow e^+e^-$ at mid-rapidity**
- **Extend to lower p_T ($p_T=0$)** the **ATLAS/CMS** measurements \rightarrow possible to extract $d\sigma/dy$
- Provide **strong constraint for state-of-the-art model calculations** (NRQCD (+CGC), CEM, CSM)

New paper arXiv:1905.07211

Differential p_T cross section



$d\sigma/dy$ as a function of \sqrt{s}

