Recent results from ALICE experiment at LHC

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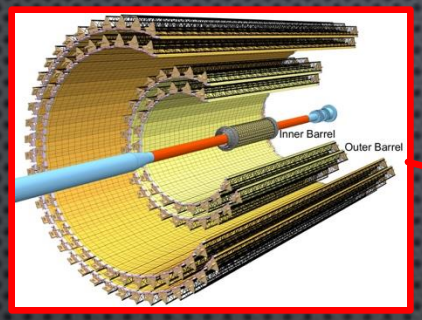
ALICE detector in Run 3

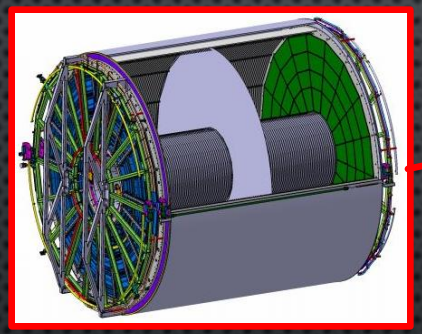
Inner Tracking System 2

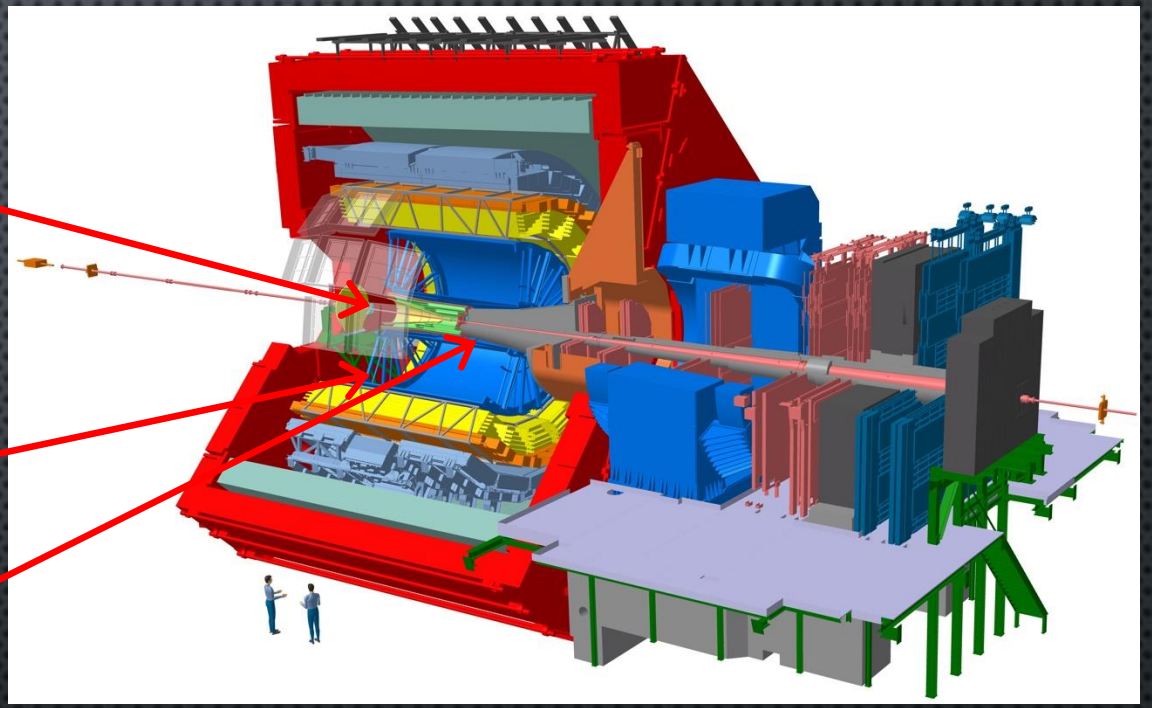
- State-of-art MAPS detector consisting of 7 layers



GEM-TPC

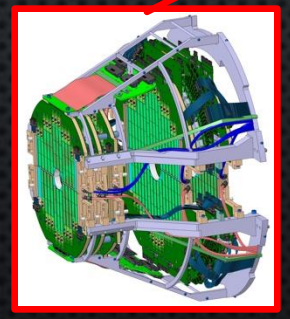
- GEM for signal amplification & suppression of ion back-flow w/o gating grid

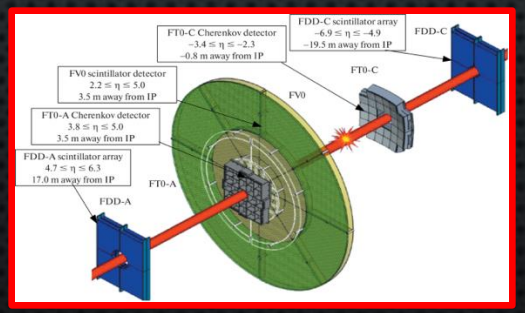




Muon Forward Tracker

- 5 disks w/ MAPS plane in both side for vertex measurement at forward





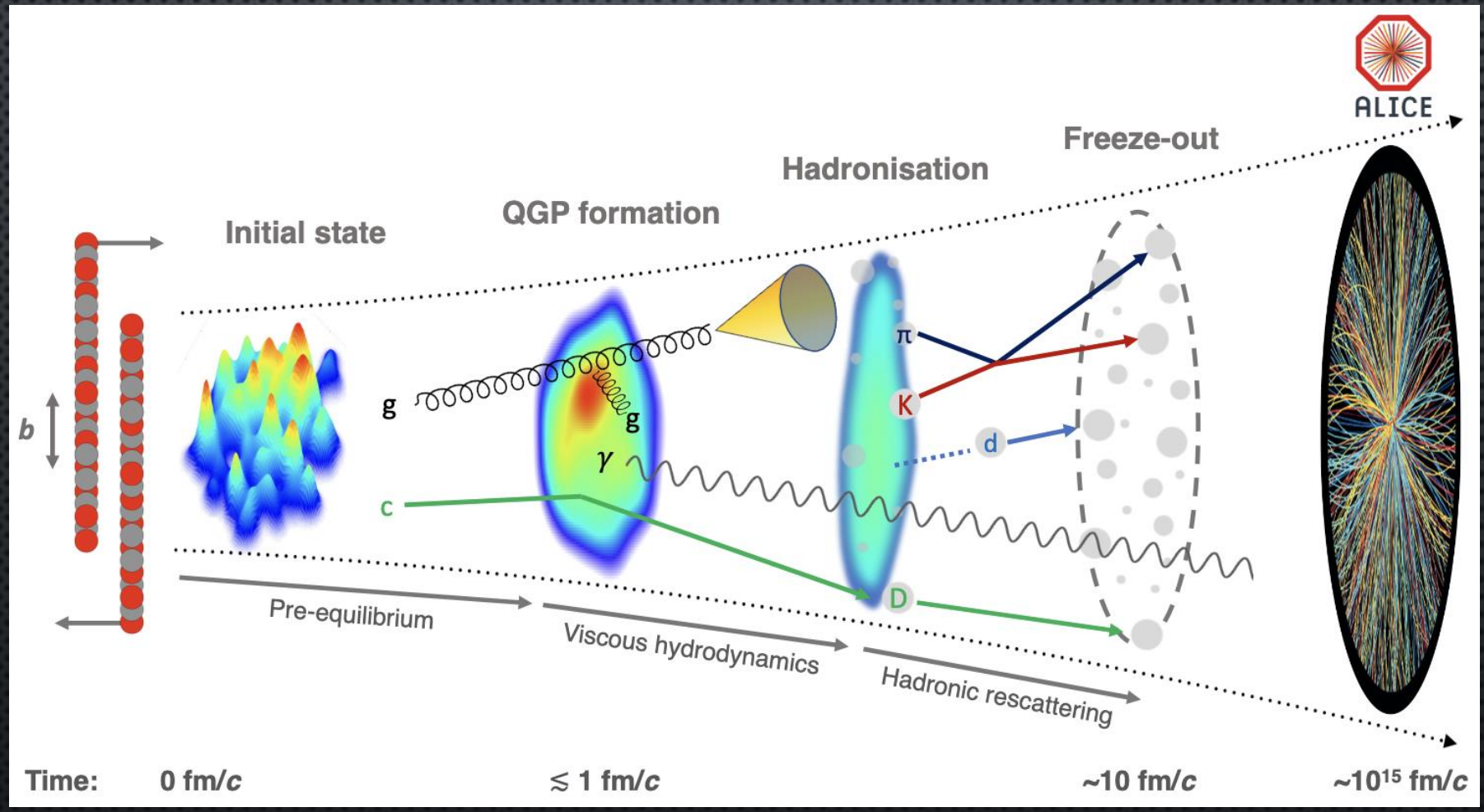
Fast Interaction Trigger

- Luminosity monitor & particle multiplicity measurement at forward

Online and Offline (O^2) control system

- Continuous readout w/ 500kHz for pp & 50kHz for Pb-Pb

High-energy Heavy Ion Collisions



- Primary physics target: Understanding of QCD matter in extreme condition and QGP-hadron phase transition
  - Offering unique measurements for connection to other hadron/nuclear topics

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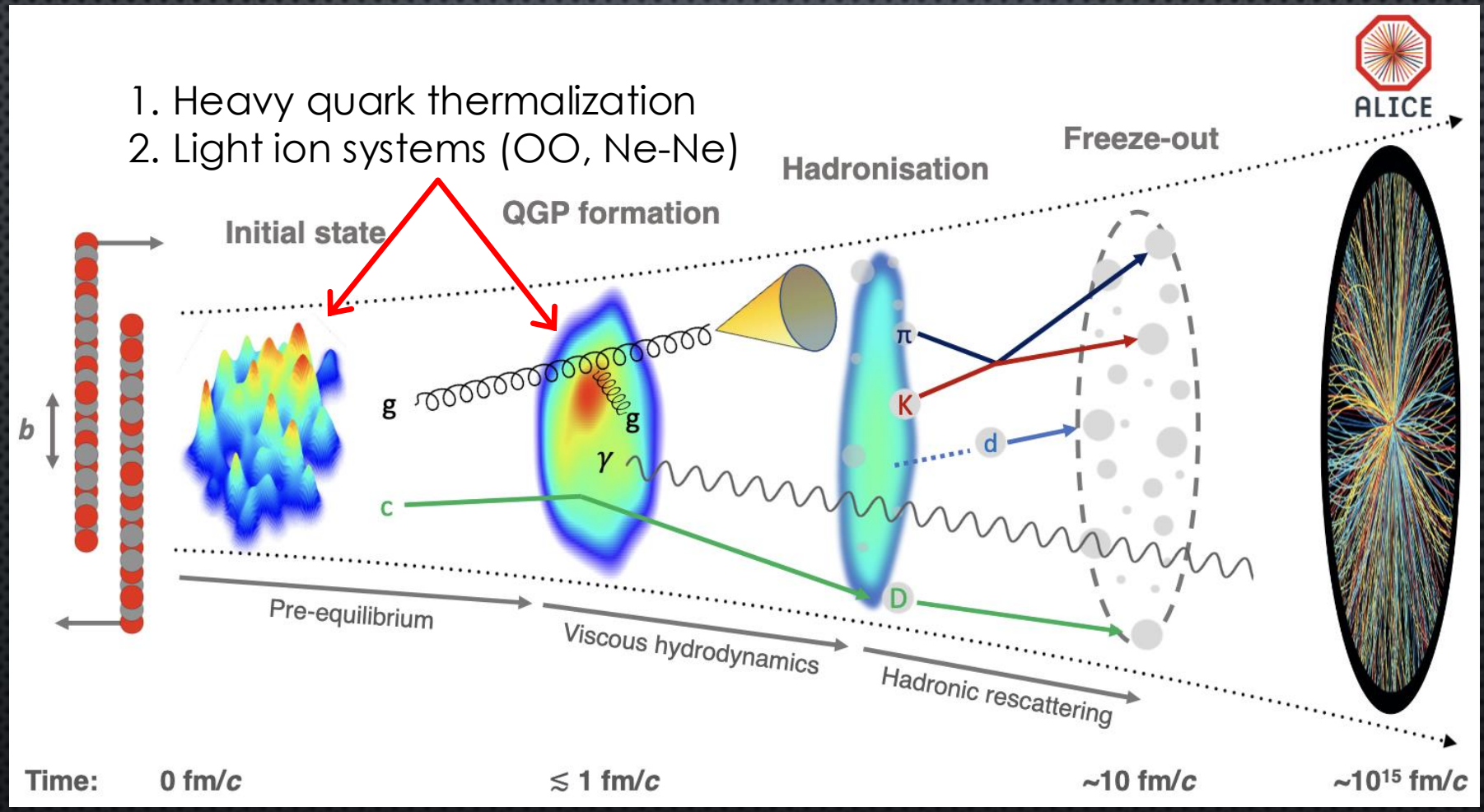

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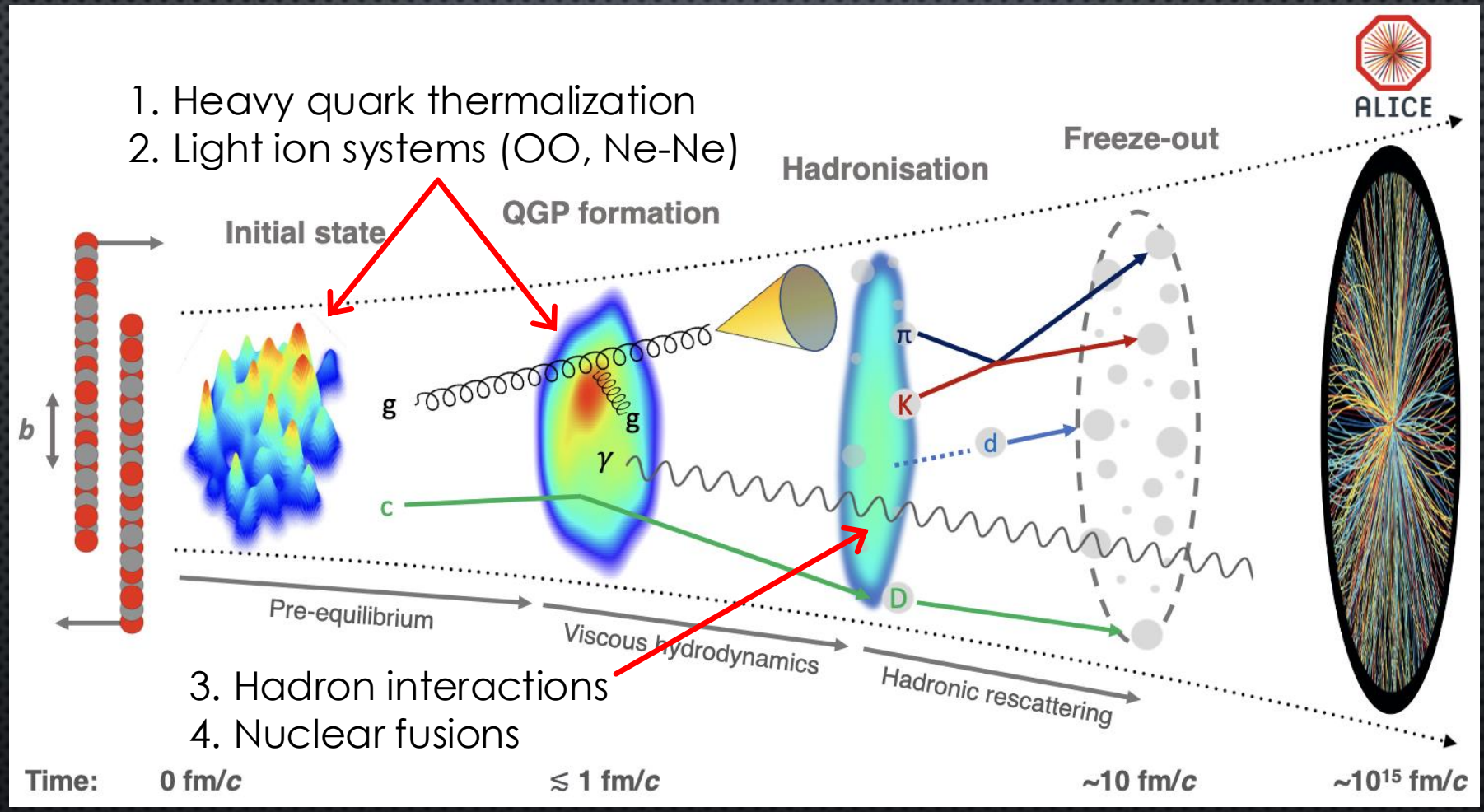

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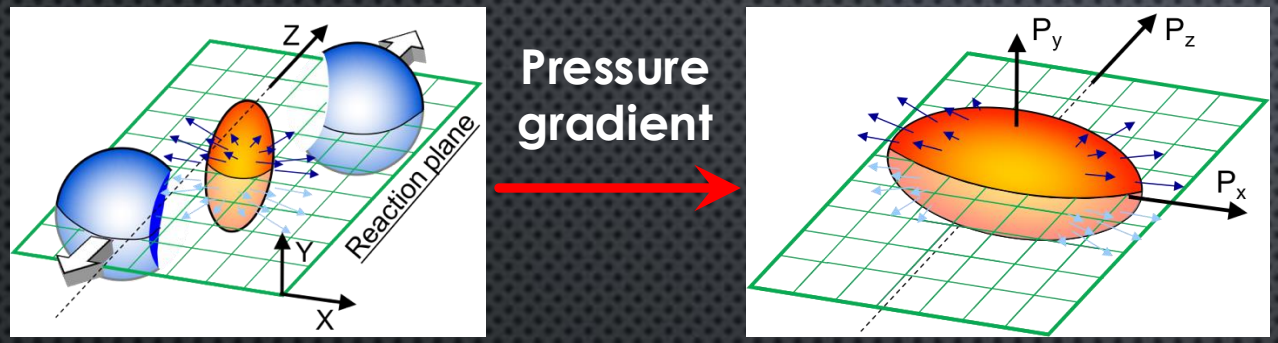
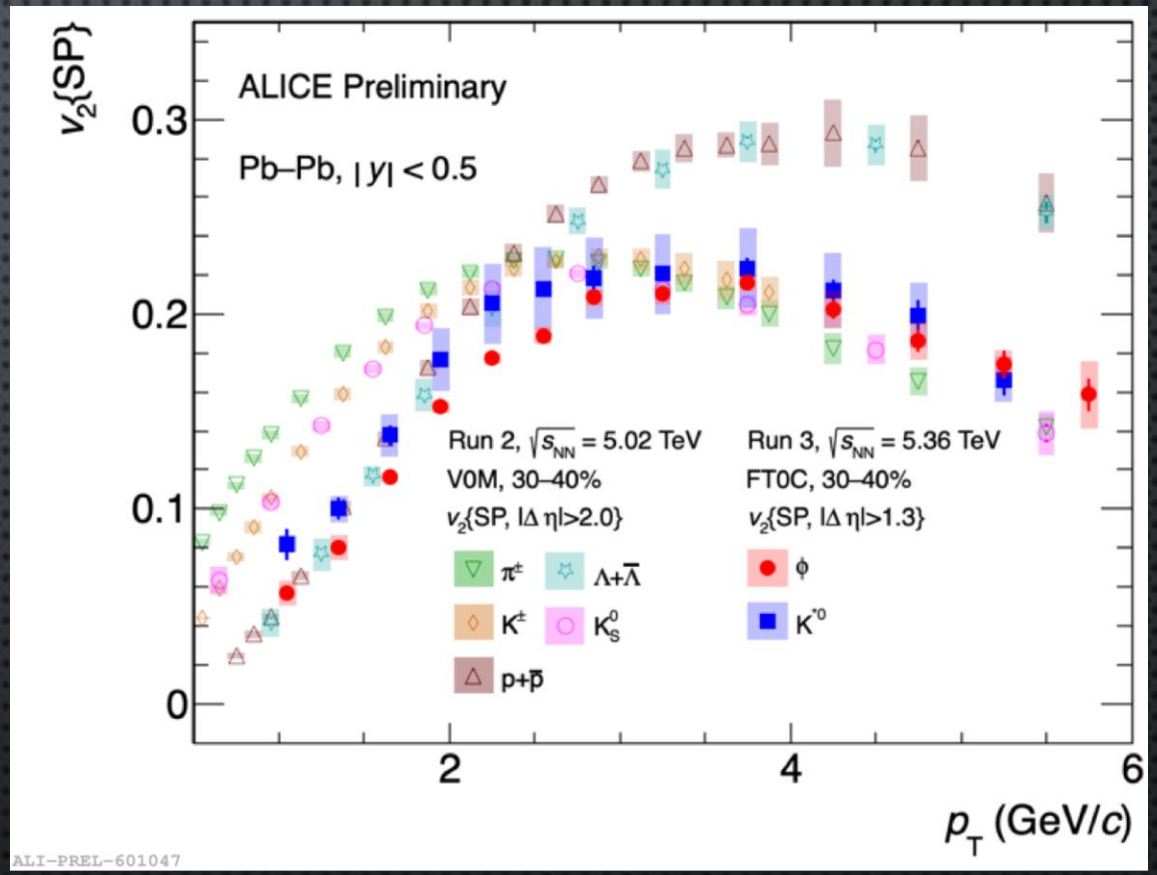
Collective motion - flow

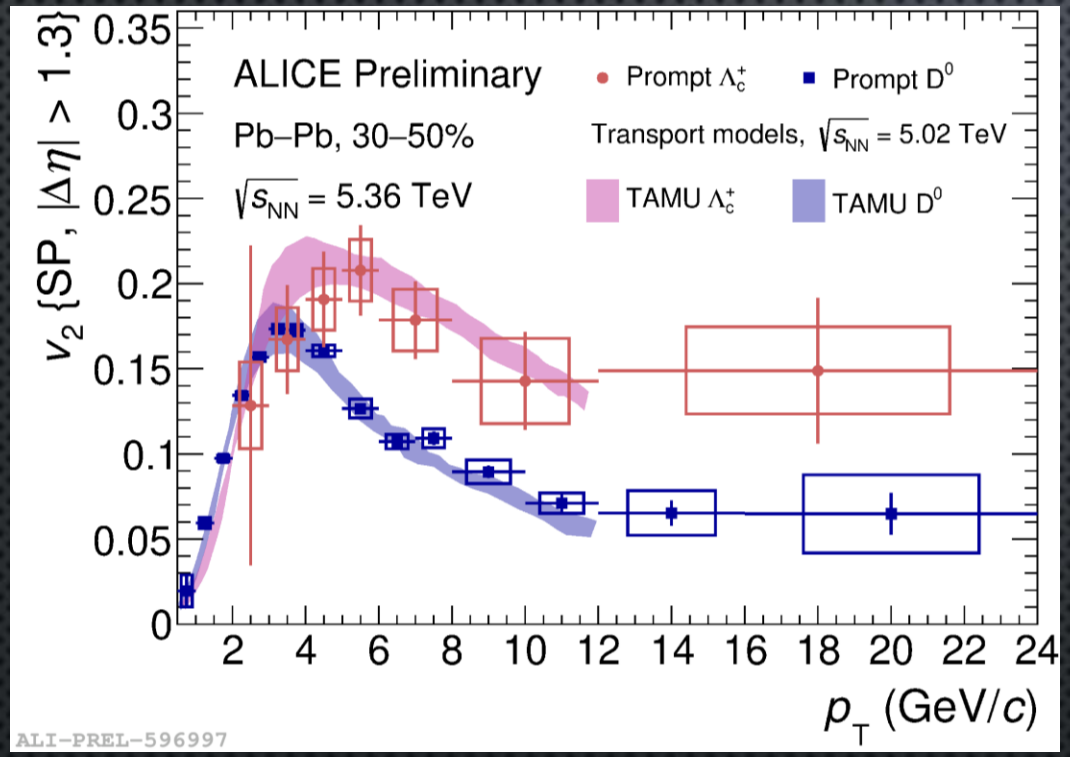


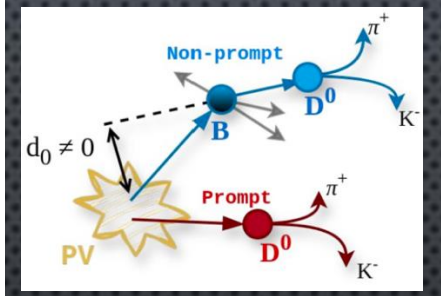


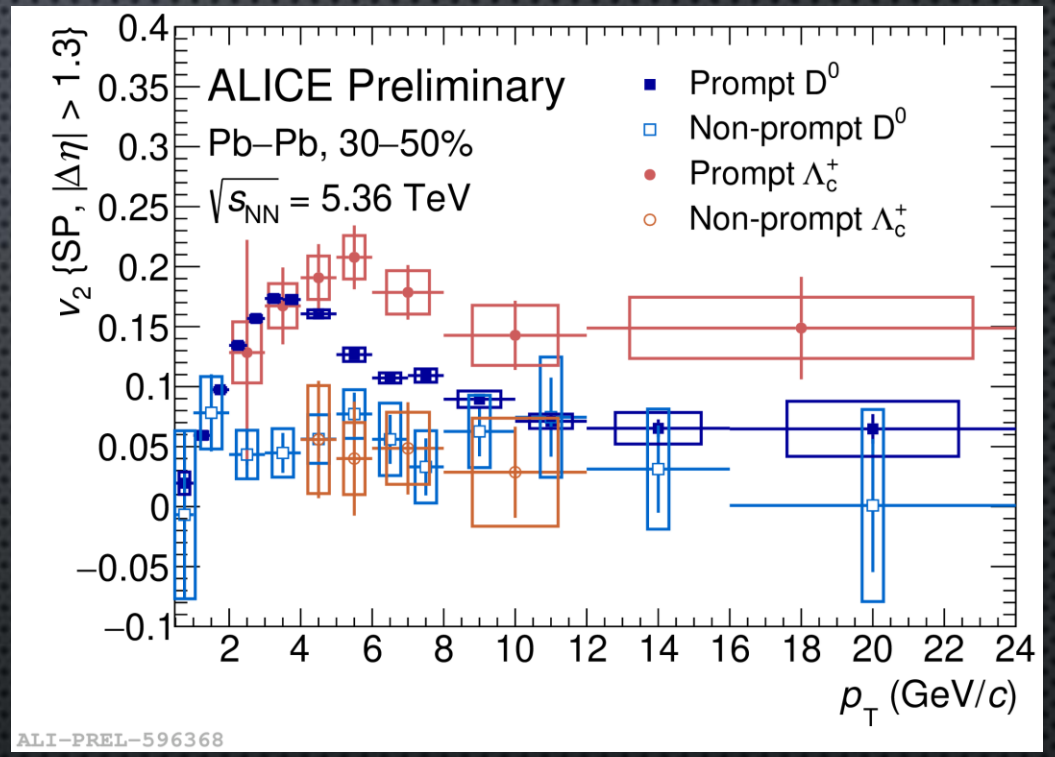
- Anisotropic flow
  - Conversion of initial spatial anisotropy to final momentum anisotropy by pressure gradient
  - Fourier decomposition w.r.t reaction plane
    - $\frac{dN}{d\varphi} \sim 1 + 2\sum_n v_n \cos n(\varphi - \psi_{RP})$

Low p_T : Mass ordering
→ Common flow velocity
High p_T : Meson/Baryon splitting
→ Quark coalescence at hadronization

Heavy quark flow – D^0 & Λ_c

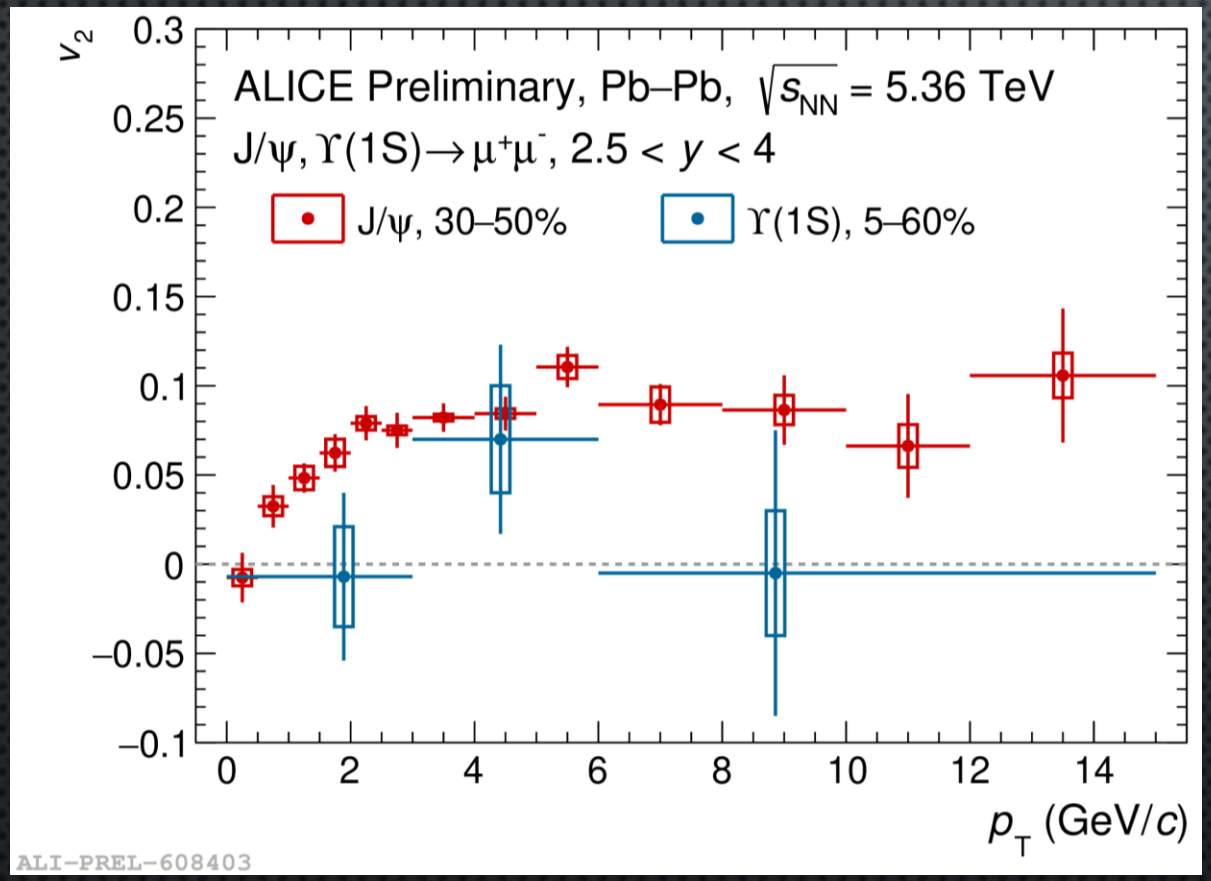


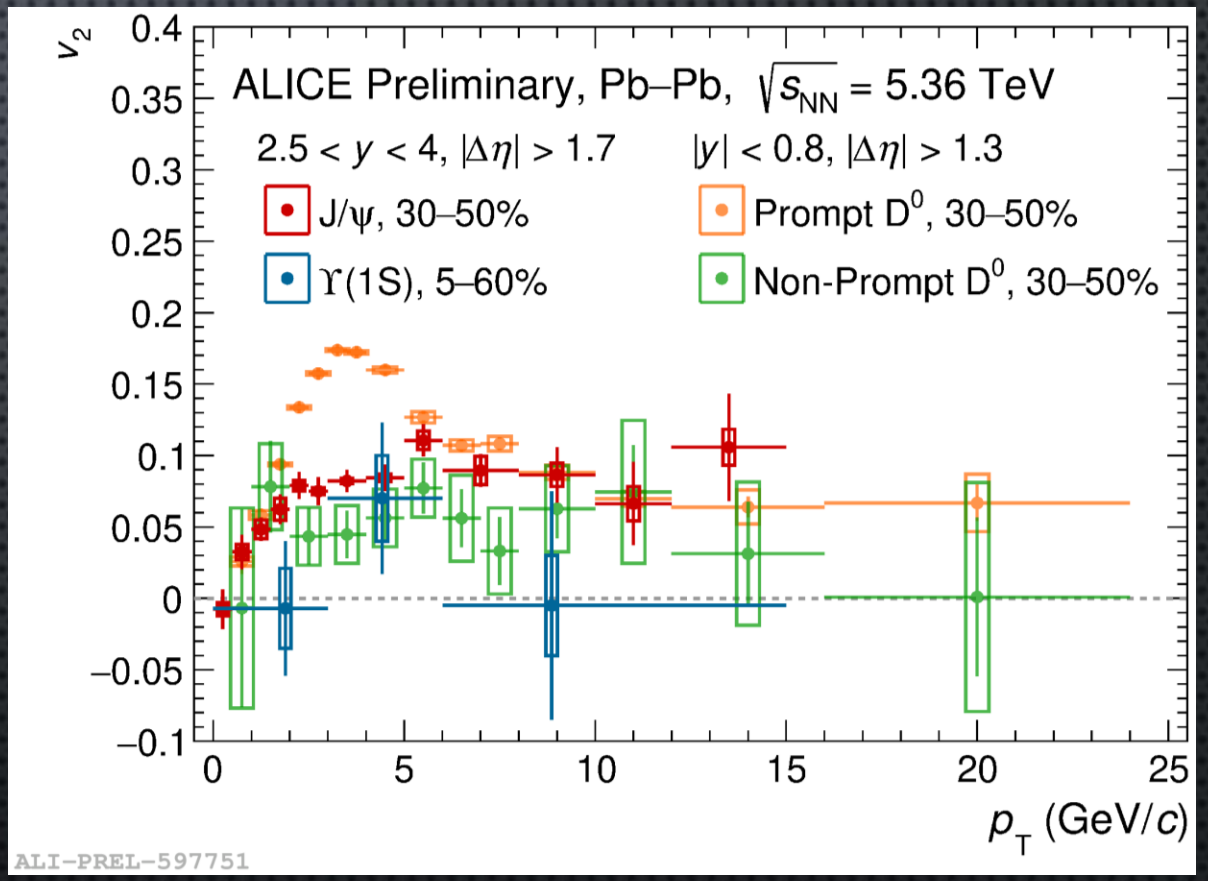




- Flow measurements for charmed hadrons w/ separation of prompt/non-prompt components
  - Large v_2 & meson/baryon splitting for charmed hadrons
    - ✓ Consistent with Hydro + coalescence model
  - Less flow for non-prompt charmed hadrons from b quark hadron decays

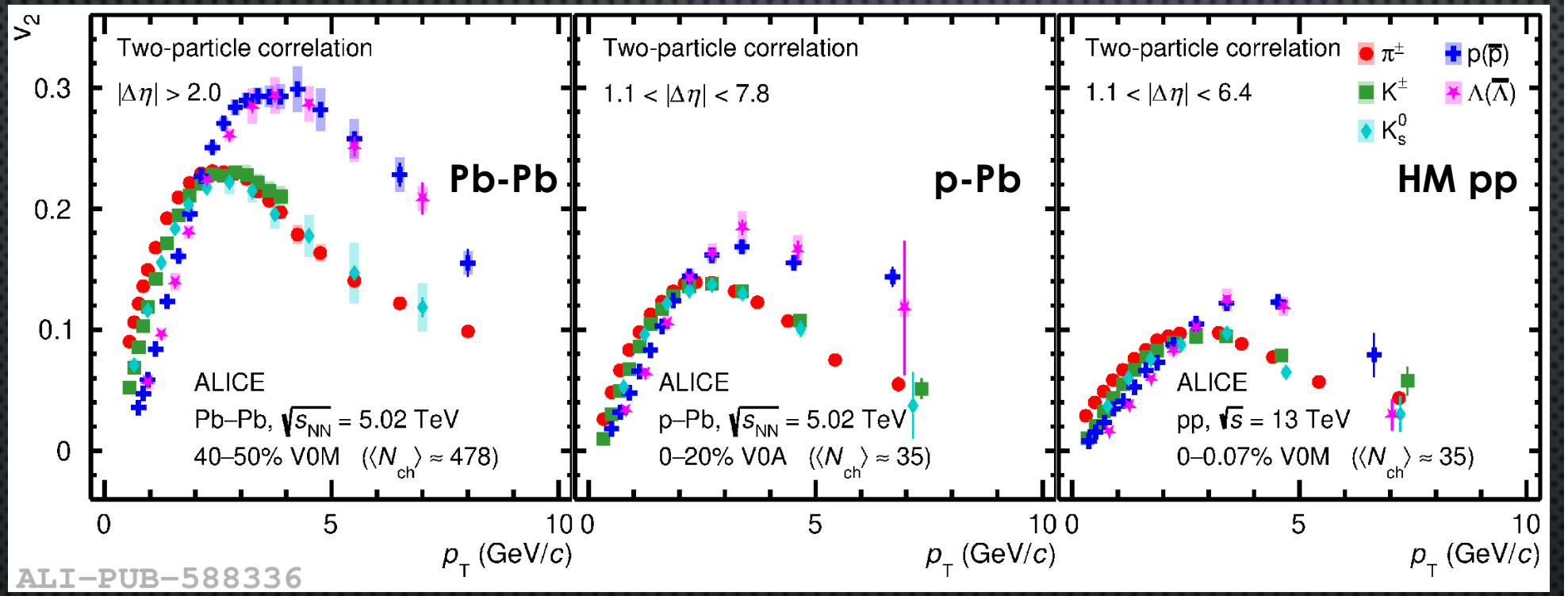
Heavy quark flow – J/ψ & Υ

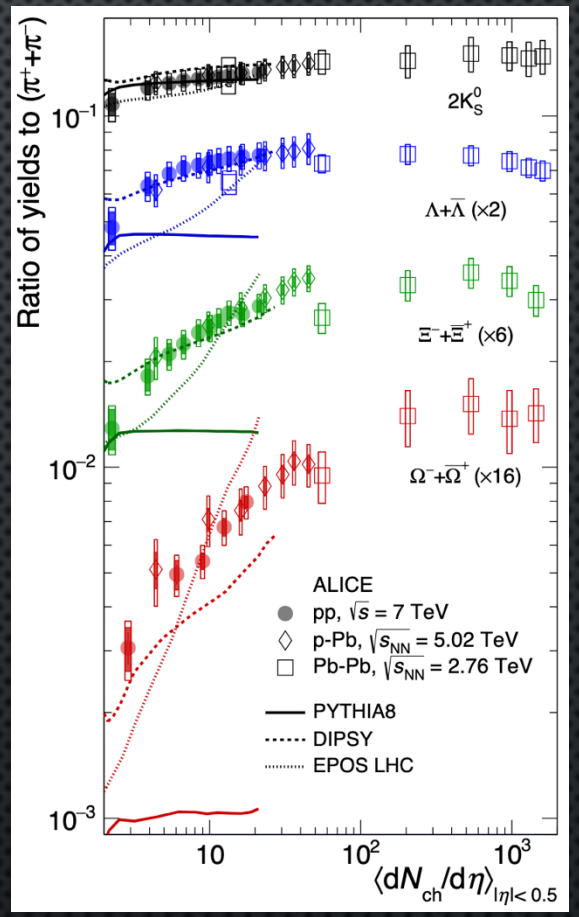




- Large v_2 for $J/\psi = c\bar{c}$ & zero v_2 for $\Upsilon(1S) = b\bar{b}$
  - Supporting charm quark thermalization in QGP

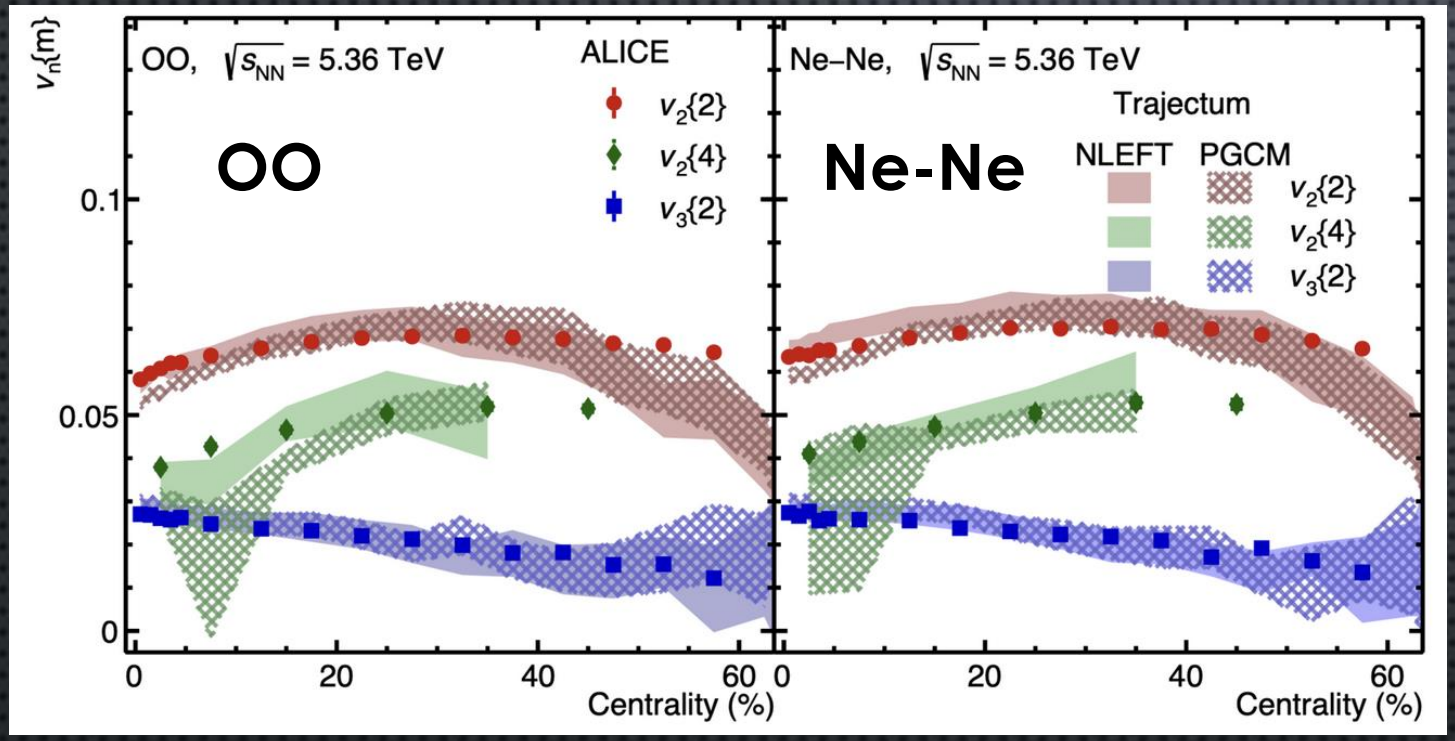
Light ions bridging from pp to AA

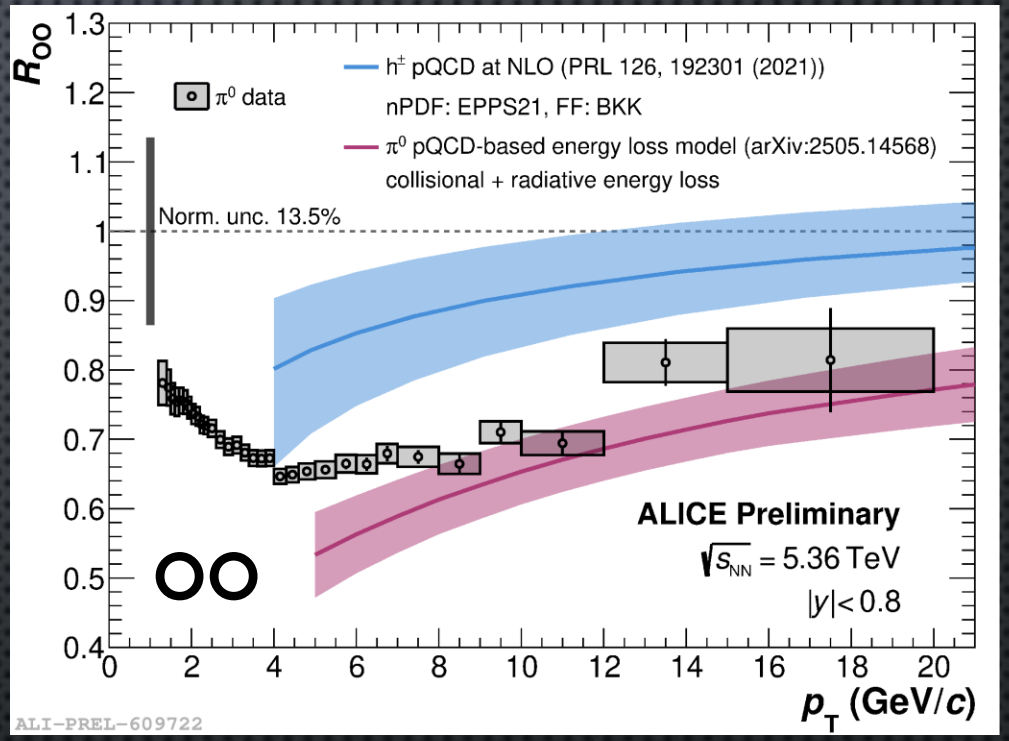




- Discovery of QGP-like signatures in small systems w/ high multiplicity
  - ✓ OO (MB) : Multiplicity comparable to p-Pb (0-10%) & Pb-Pb (75-80%)
- OO & Ne-Ne runs in July, 2025
  - 5.01 nb^{-1} (OO), 0.84 nb^{-1} (Ne-Ne)

Results in OO & Ne-Ne





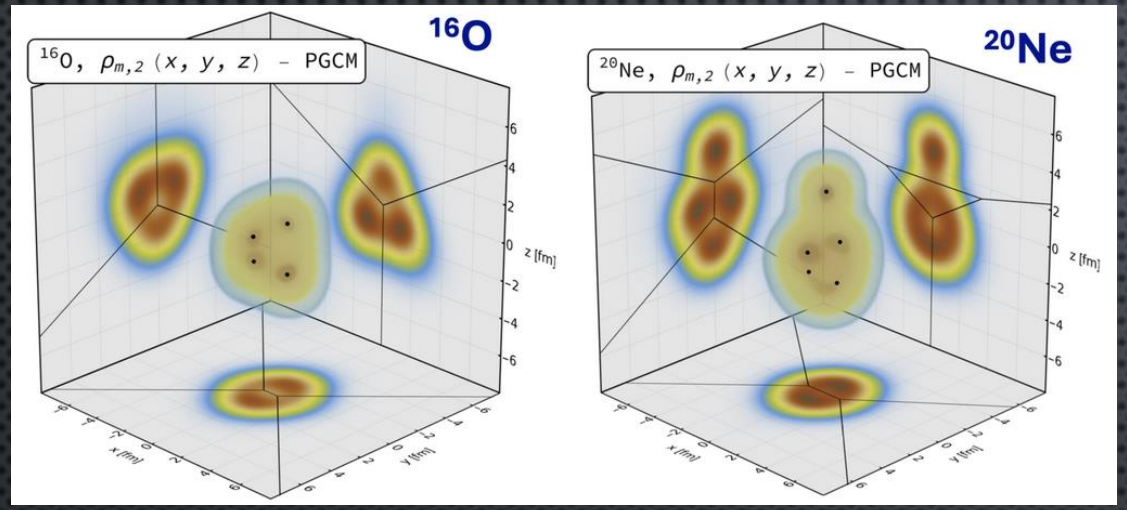
- Sizable v_2 and v_3 with weak centrality dependence
  - Well-described by hydrodynamic evolution w/ geometrical nuclear structure

- Significant suppression of π^0 R_{AA} in OO

$$R_{AA} = \frac{(dN/dp_T)_{AA}}{N_{coll} \cdot (dN/dp_T)_{pp}}$$

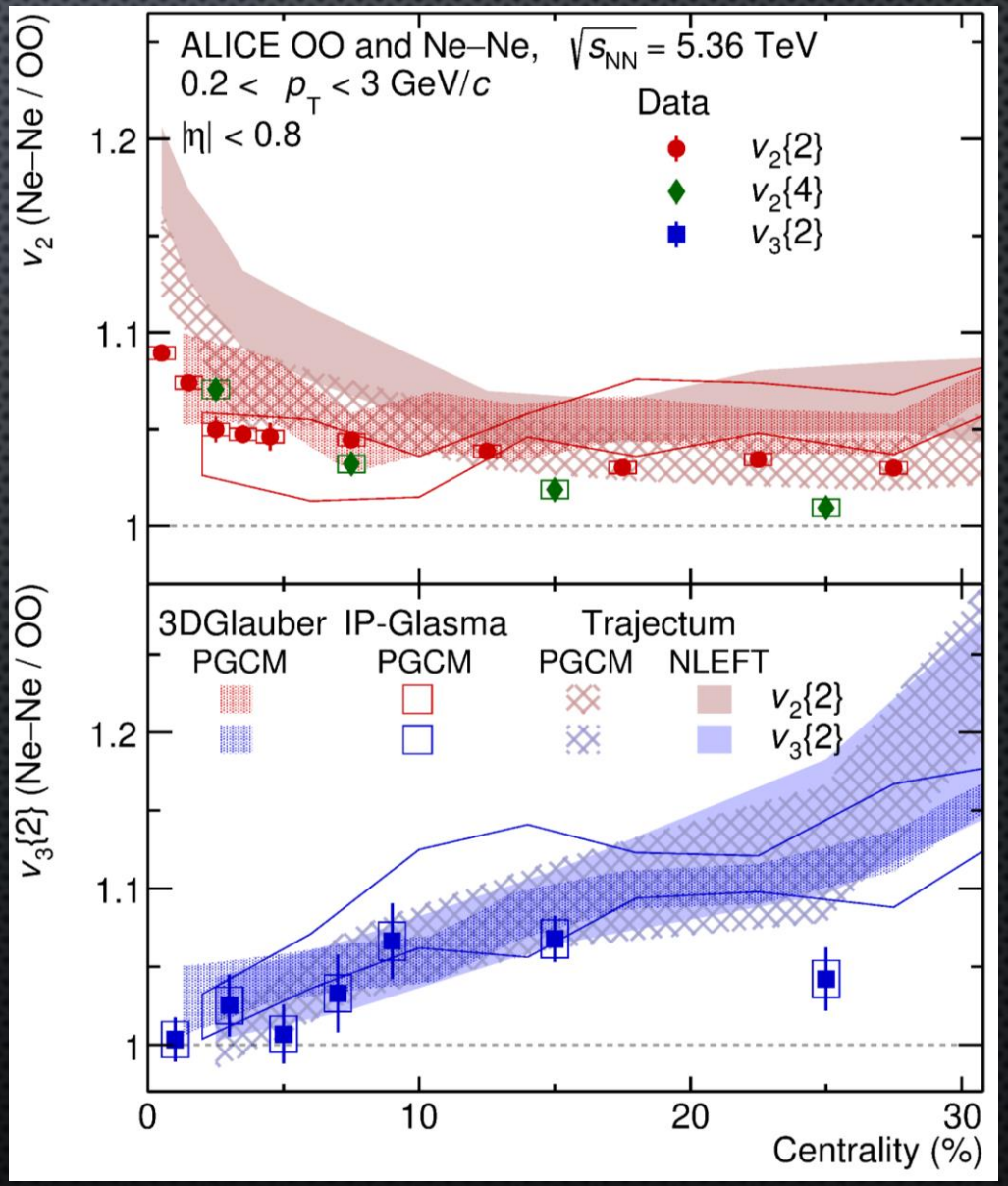
  - Similar trend w/ peripheral Pb-Pb
  - 2.4 σ deviation from CNM pQCD w/o energy loss

Nuclear deformation



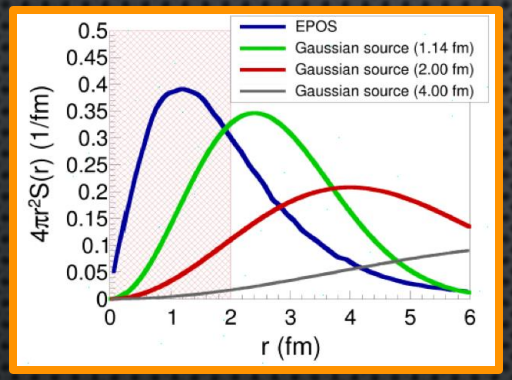
PRL 135, 012302 (2025)

- Ratio: Ne-Ne/OO
  - Reduction of final state effects
  - ✓ Trends in v_2 & v_3 explained by deformation of Ne
  - → Demonstration to probe nuclear deformation by azimuthal anisotropy

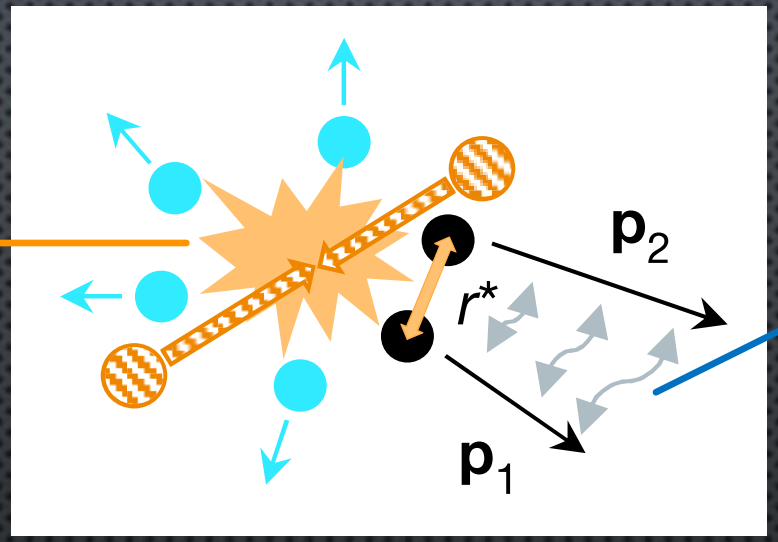


Femtoscopy

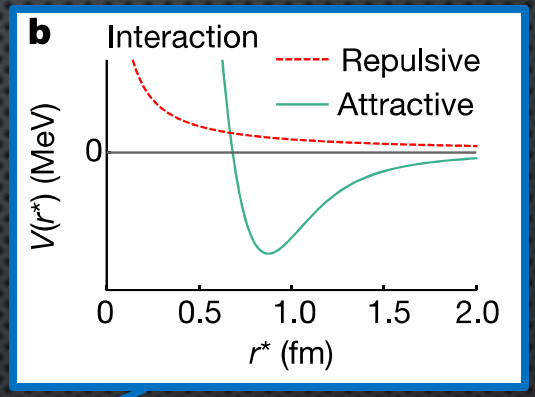
Source function



Gaussian source
- A-A: r~5fm
- pp: r~1fm



Potential between particles



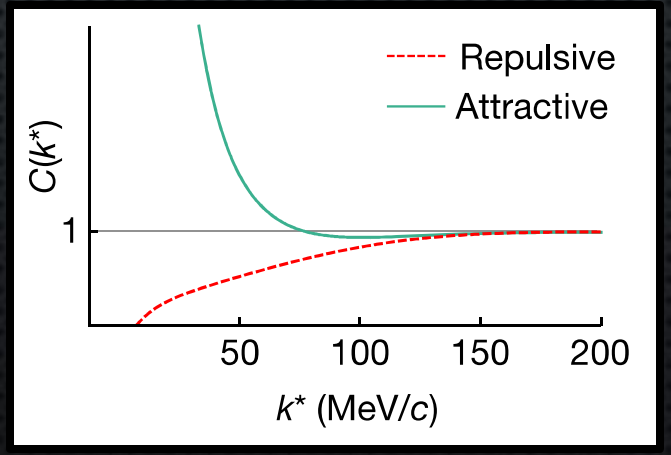
Schrödinger equation

$$C(k^*) = \int S(r^*)\,|\psi(\mathbf{k}^*, \mathbf{r}^*)|^2\, d^3r^* = \xi(k^*)\,\frac{N_{\text{same}}(k^*)}{N_{\text{mixed}}(k^*)}$$

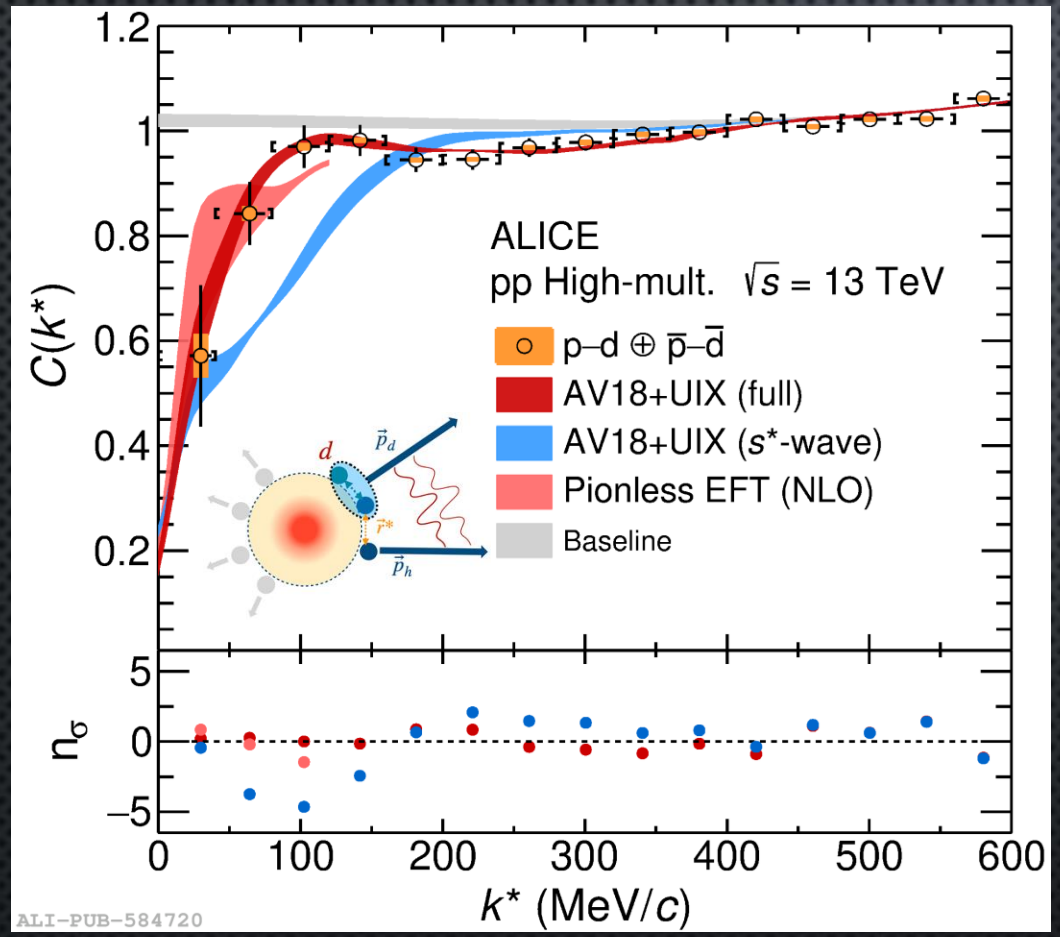
Koonin-Pratt formula in pair rest frame

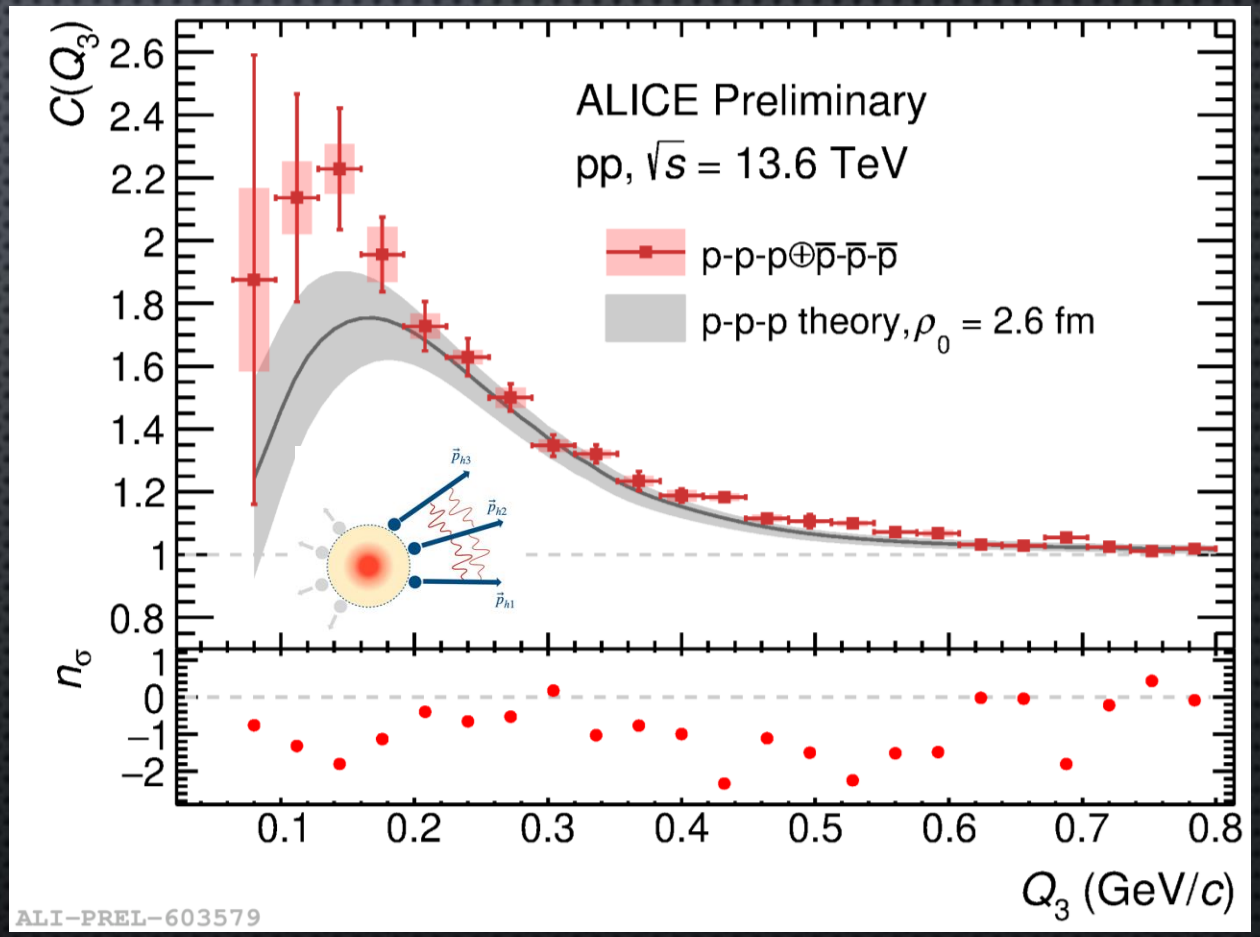
=

Resulting correlation function



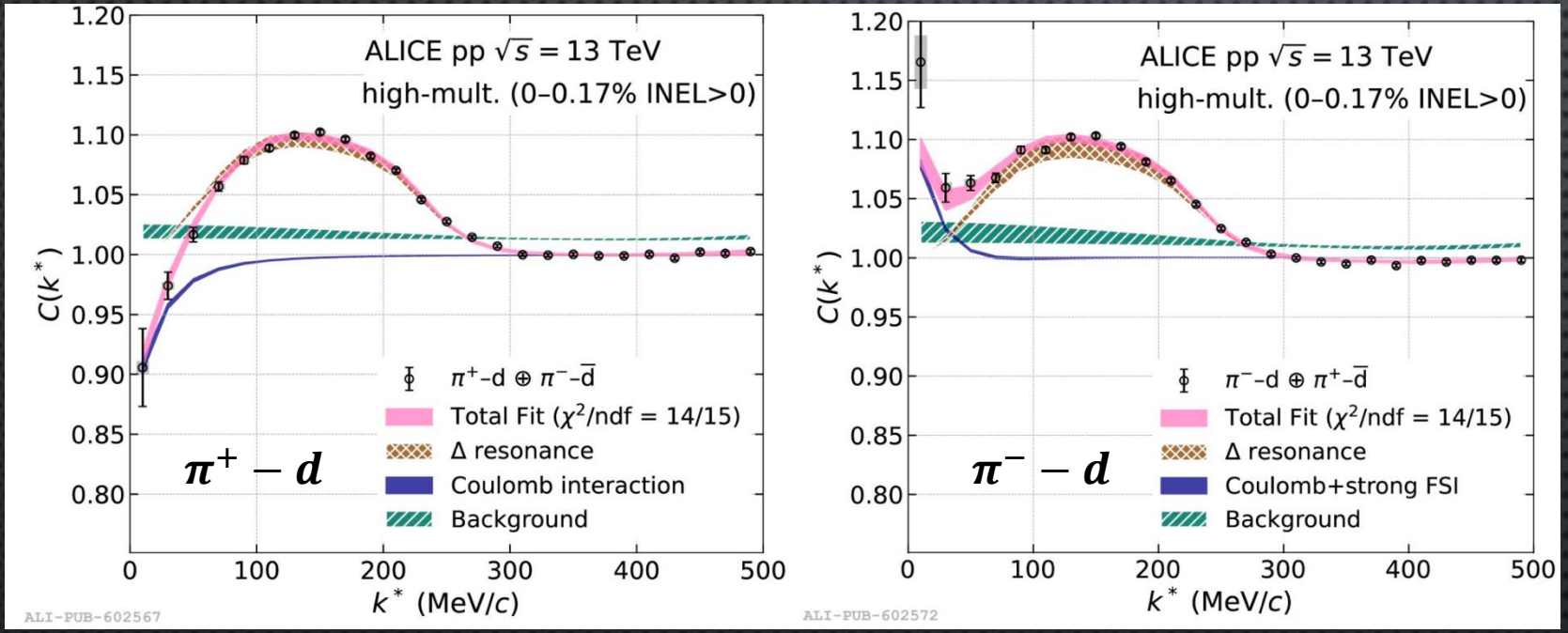
3-body interaction

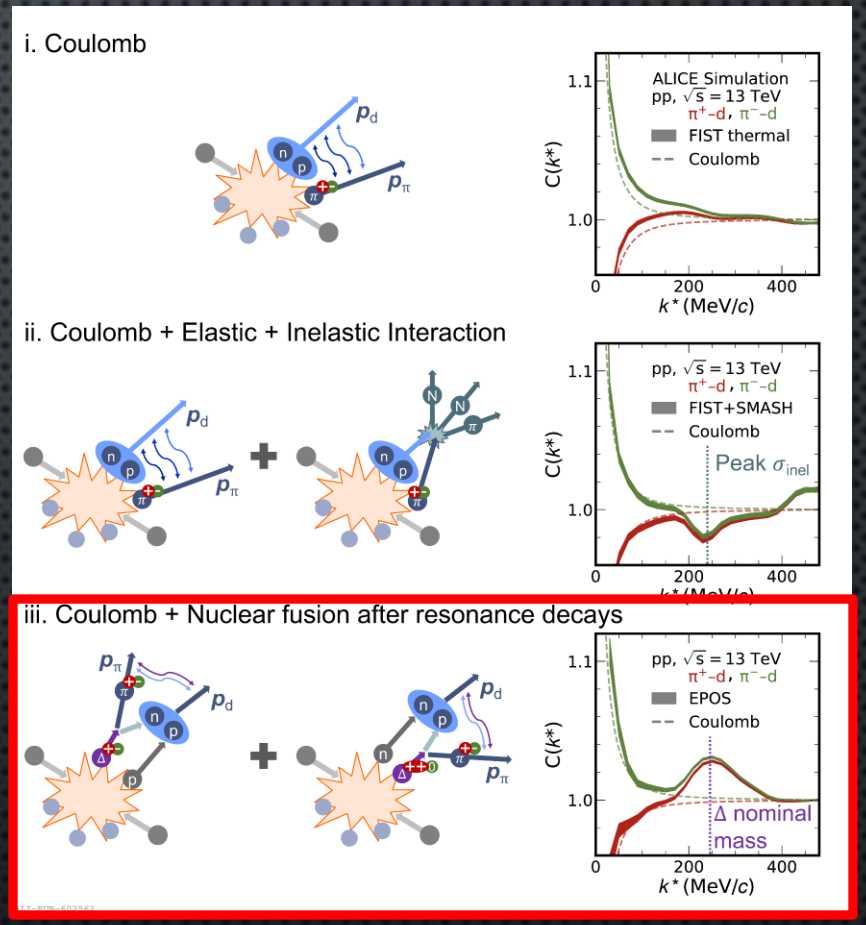




- Successful 3 particle correlation measurements w/ high statistic Run 3 data
  - ✓ Measured p-d & p-p-p correlations described by models considering 3 body interactions

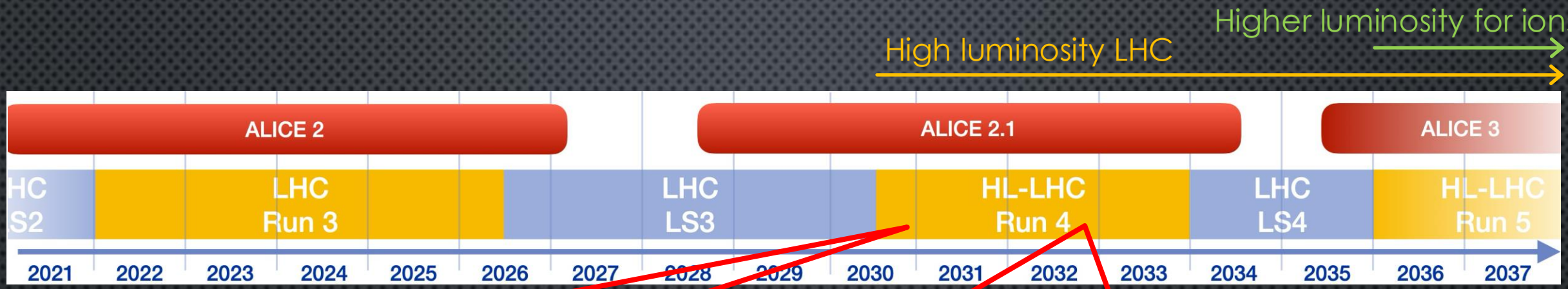
Deuteron production in HI



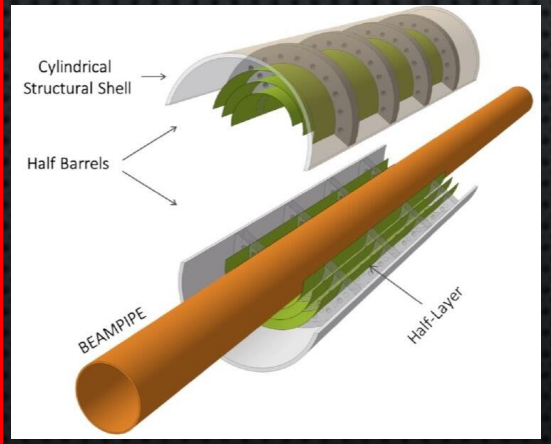


- Solving the mystery of loosely-bound deuteron production in hot medium
  - ✓ $\pi - d$ correlation revealing Δ resonance decay + nuclear fussion as dominant process for deuteron production

ALICE upgrade roadmap



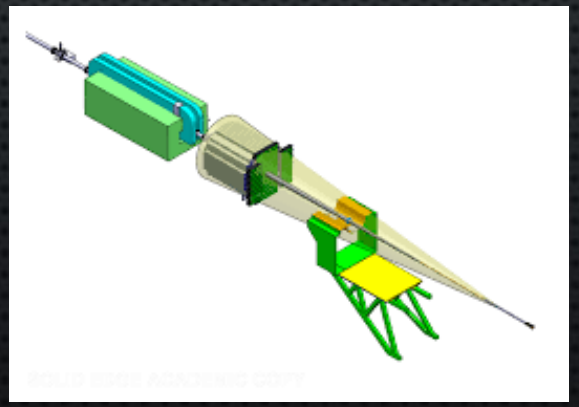
ITS3



- 3 cylindrical layers of new MAPS
  - ✓ 65nm-CMOS technology
  - ✓ 30 cm-wafer size & bendable

→ × 2 improvement in pointing resolution

Focal

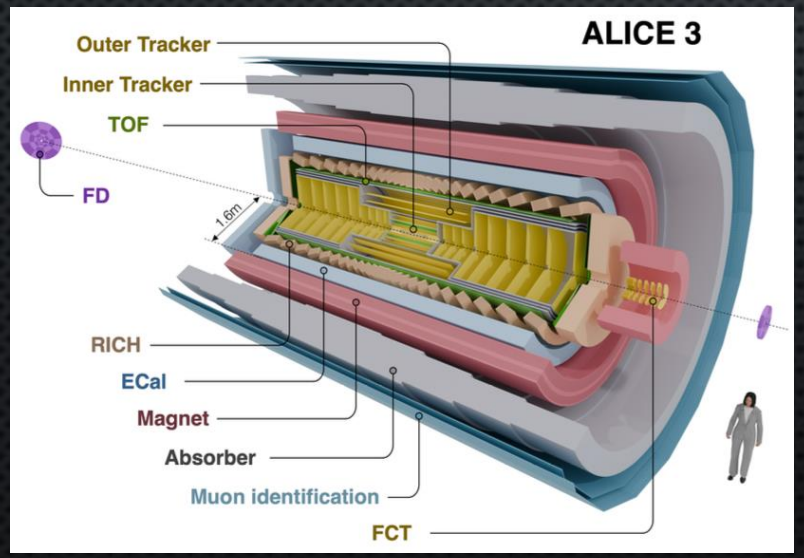


- EM + Hadron calorimeters
  - ✓ Sandwiched silicon layers
  - ✓ $3.4 < \eta < 5.8$

→ Probing gluon nPDF down to ~ 10^{-5}

ALICE upgrade roadmap

ALICE 3

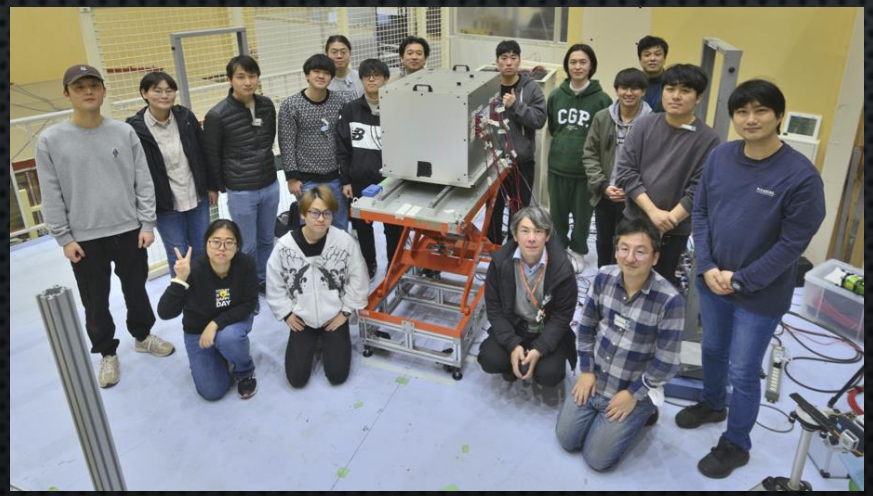


- Next-generation heavy ion experiment w/ innovative detector concept
  - ✓ Ultra-light all silicon tracker
  - ✓ Retractable vertex detector inside the beam pipe
  - ✓ Extensive PID for wide η & p_T
  - ✓ Wide η coverage
  - ✓ High rate capability

Summary

- Recent highlights from ALICE experiment
  - ✓More Run 3 results coming soon
- Pioneering detector R&D for future upgrades
  - ✓Friendly collaboration especially w/ Korean colleagues

1st beam test at KEK (2024/3)



2nd beam test at KEK (2024/12)

3rd beam test at KEK (2025/3)