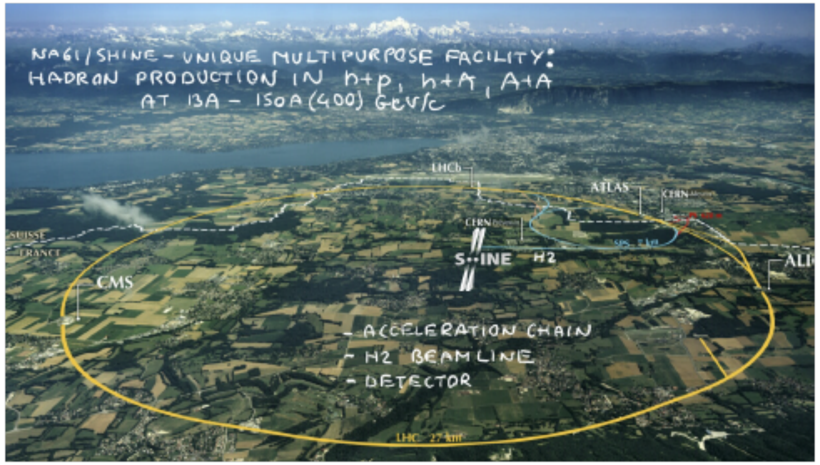
# Highlights from NA61/SHINE: proton intermittency analysis

**Daria Prokhorova for NA61/SHINE Collaboration**
Laboratory of Ultra-High Energy Physics, St. Petersburg State University

**ZIMÁNYI SCHOOL'18**
**WINTER WORKSHOP ON HEAVY ION PHYSICS**
6 December 2018

# NA61/SHINE Experiment

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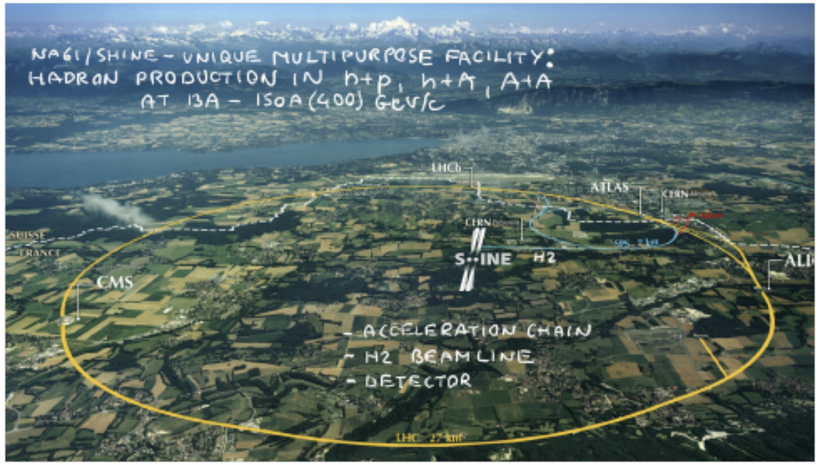


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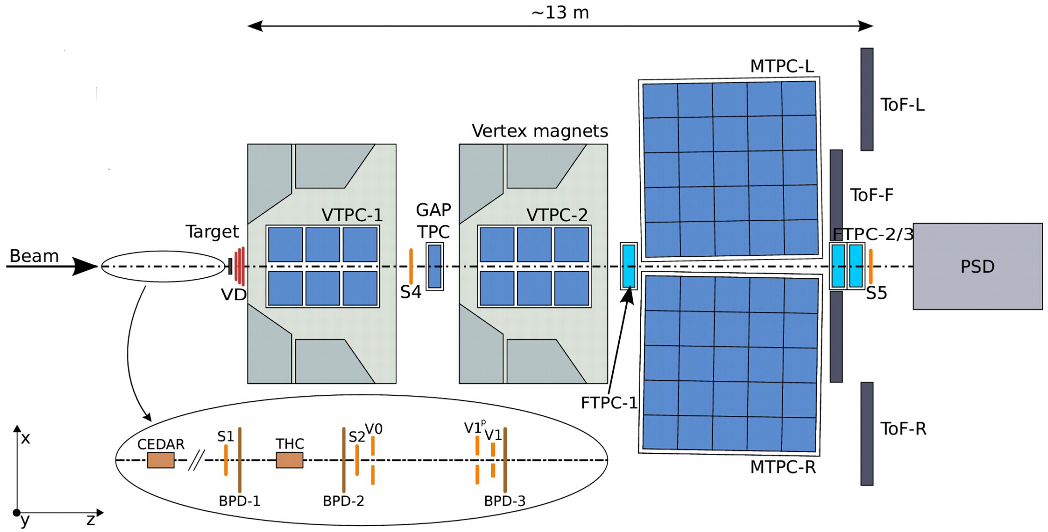


Schematic picture of the NA61/SHINE experiment NA61 JINST 9: 06005

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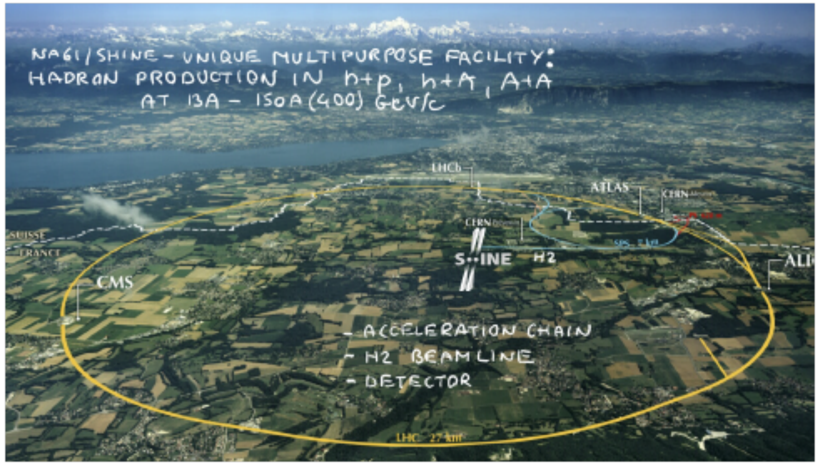


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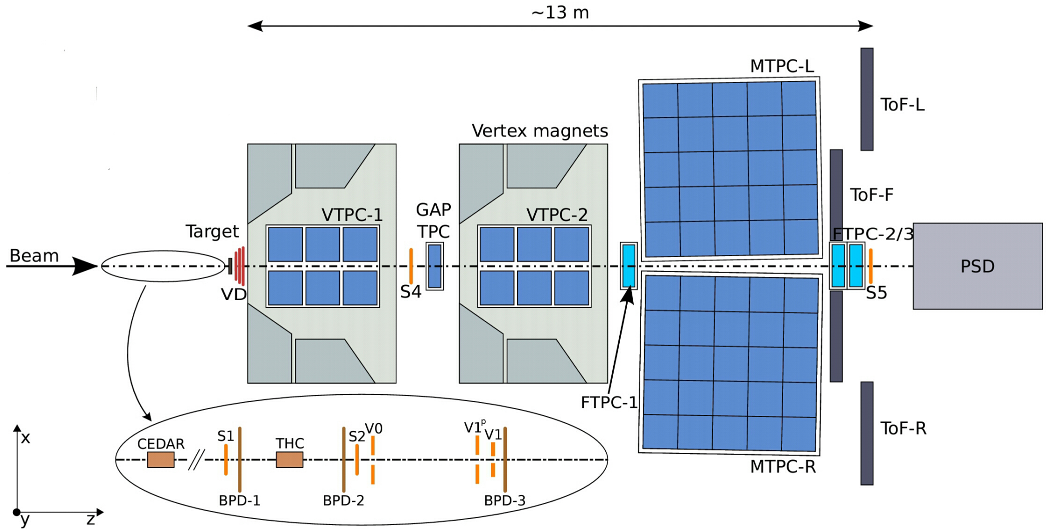


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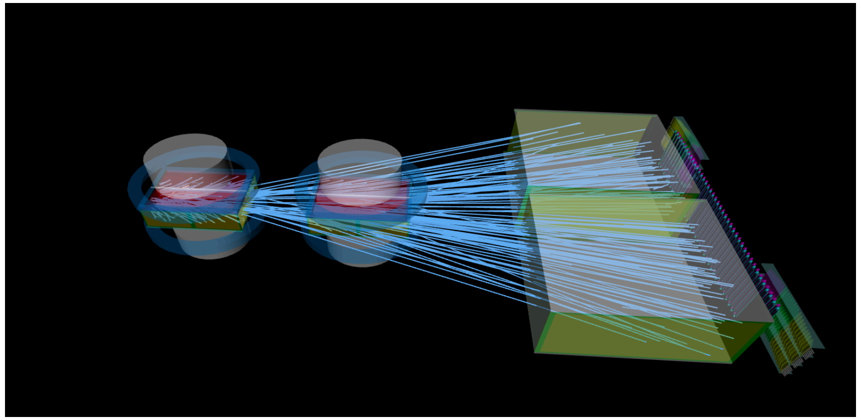

Event browser http://shine3d.web.cern.ch/shine3d/

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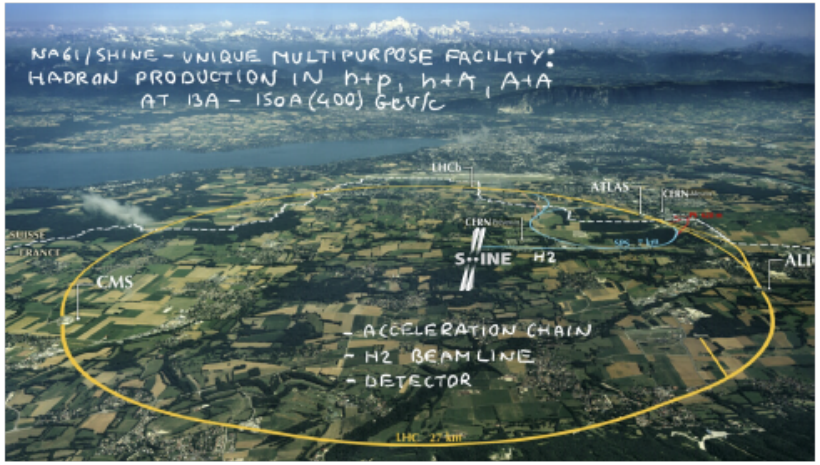


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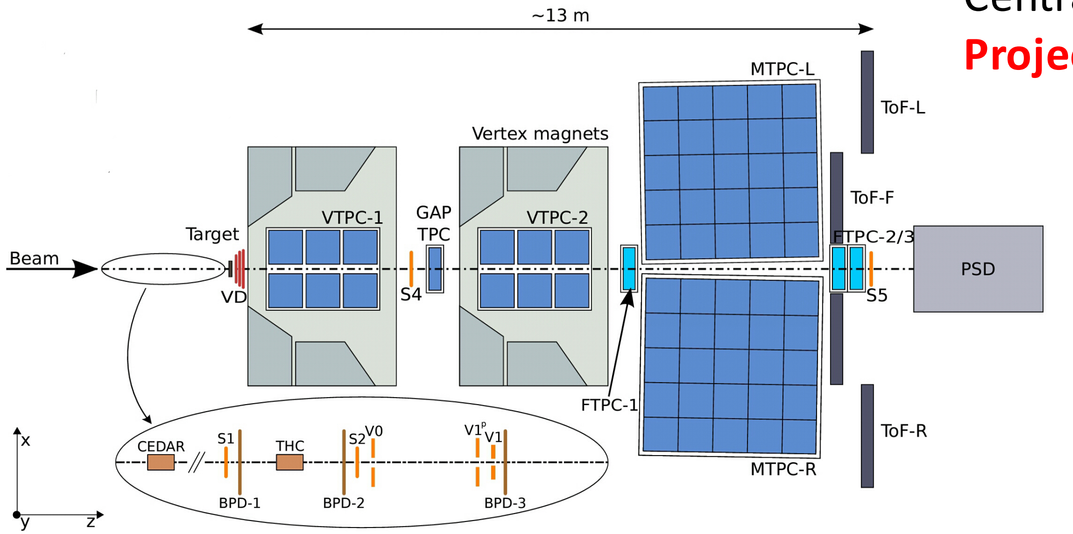
- Centrality selection in A+A collisions by measuring of forward energy with **Projectile Spectator Detector** (PSD)

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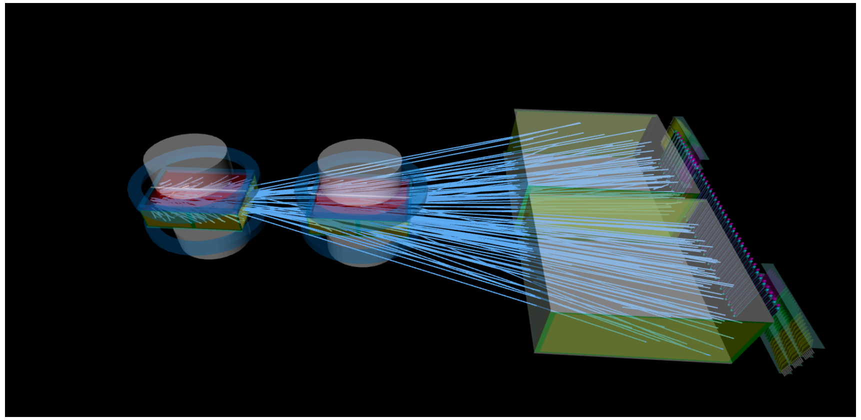

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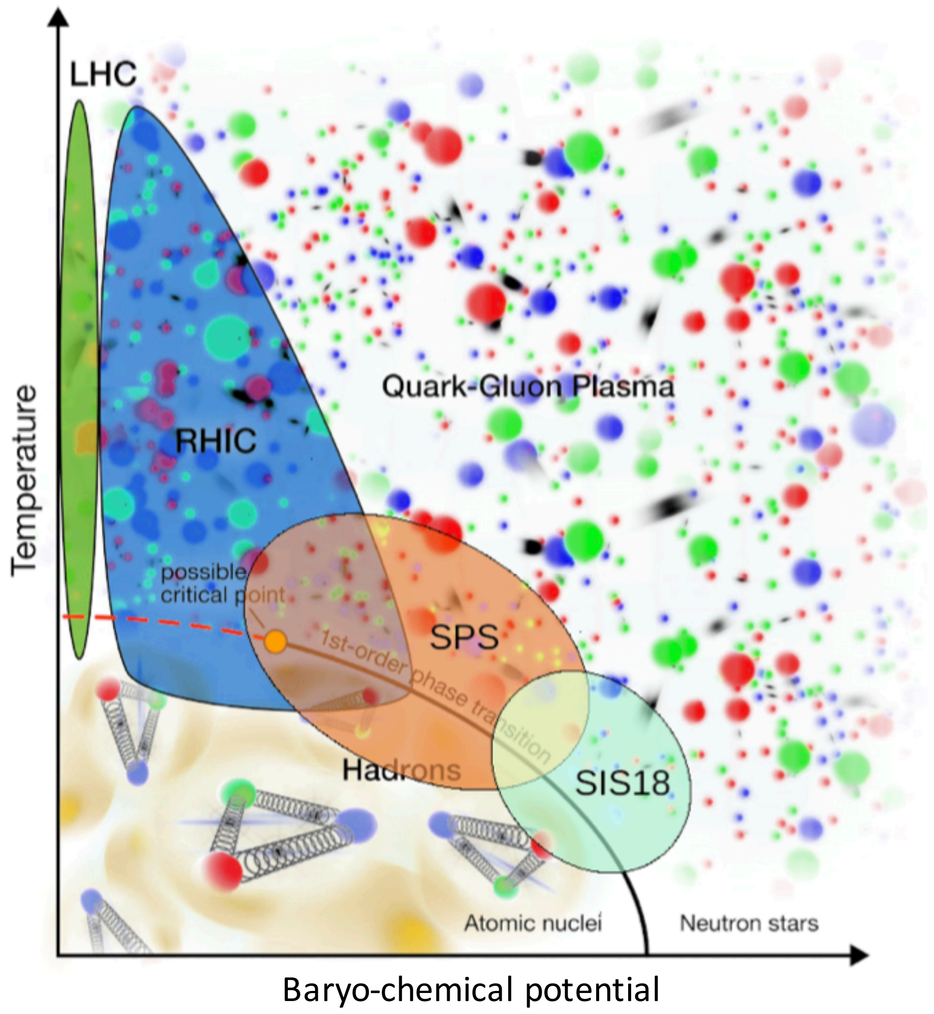


Sketch of the phase diagram of strongly interacting matter

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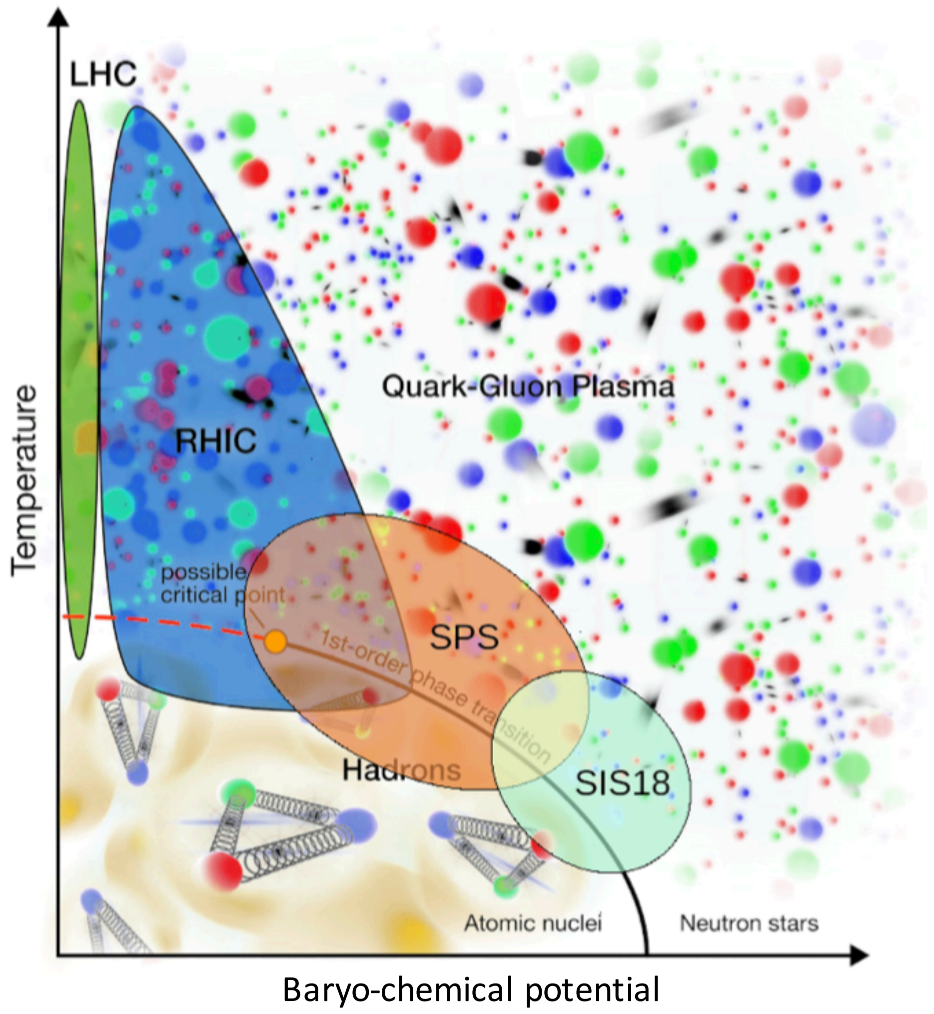


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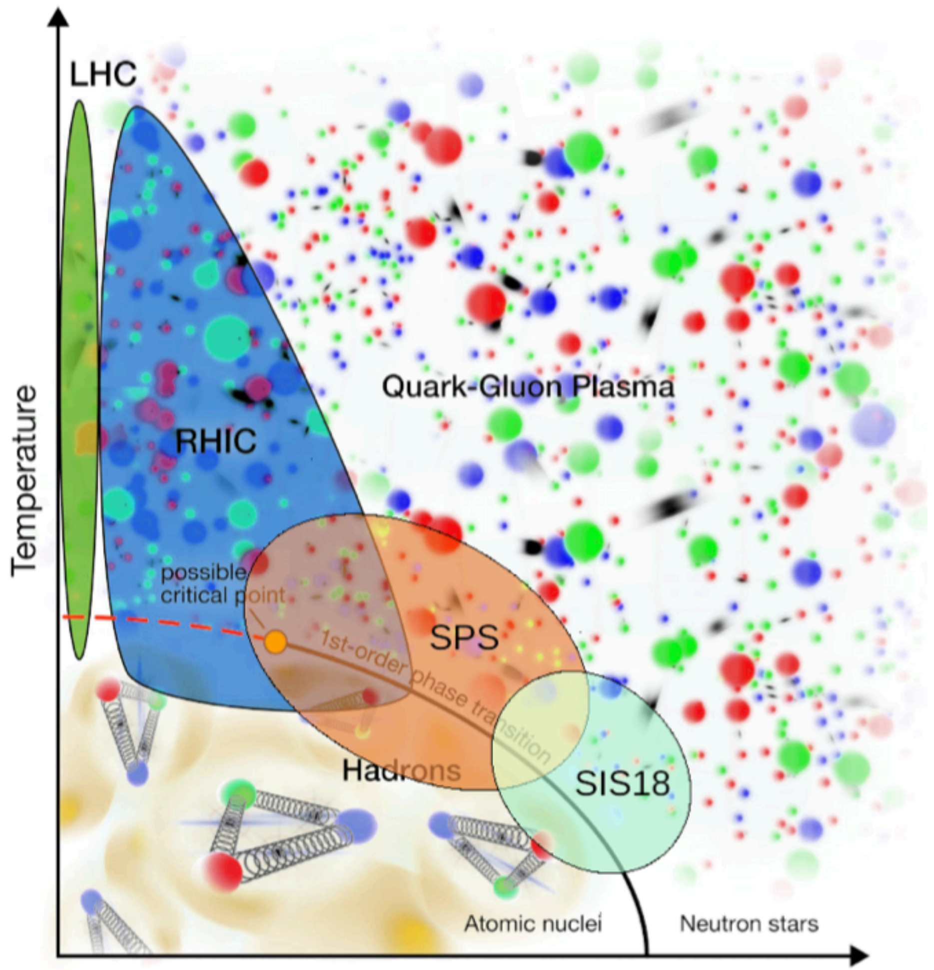


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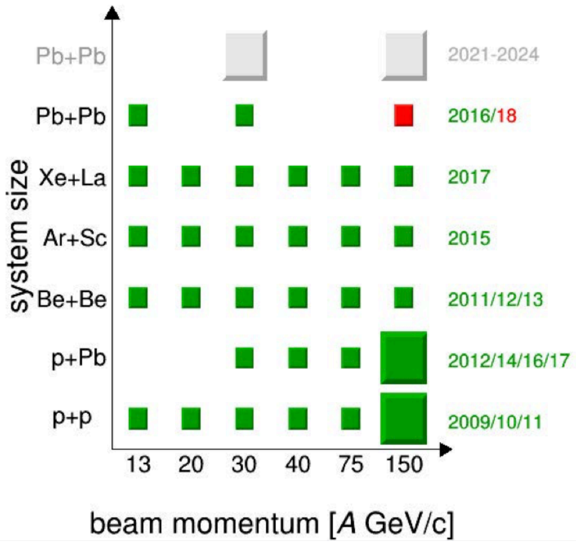


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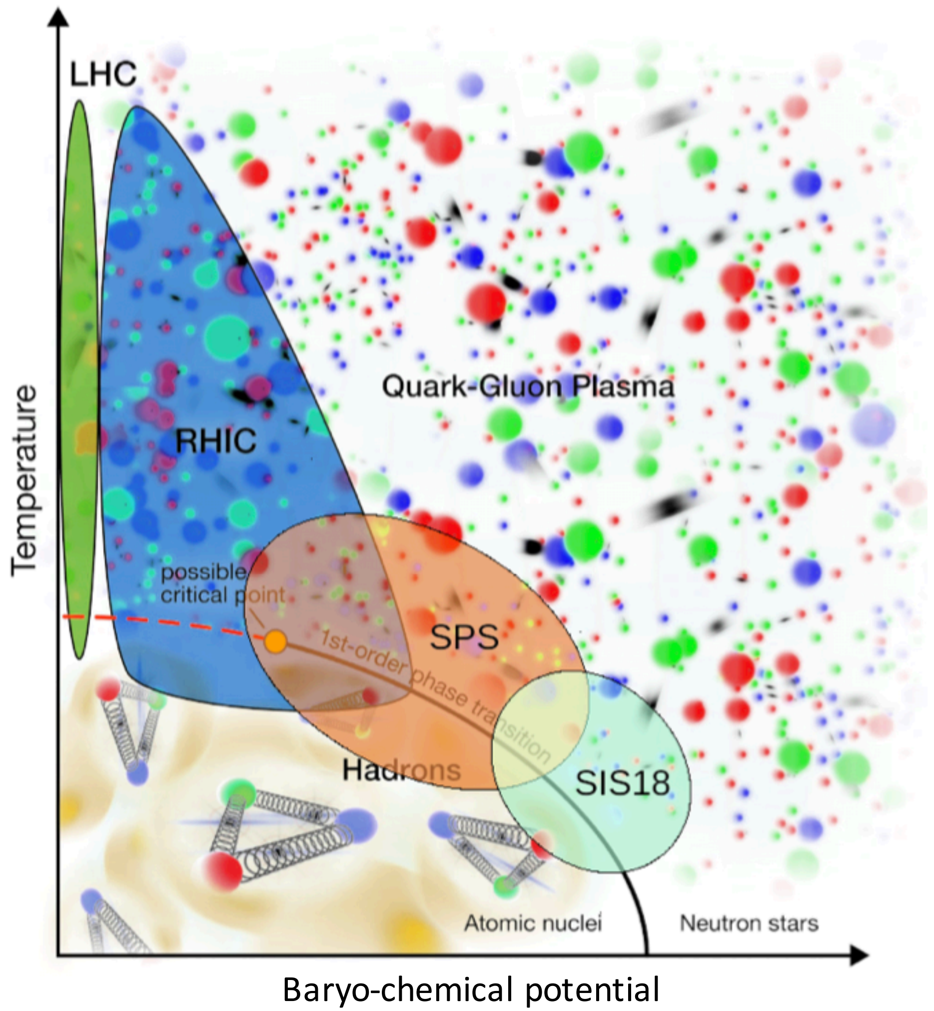


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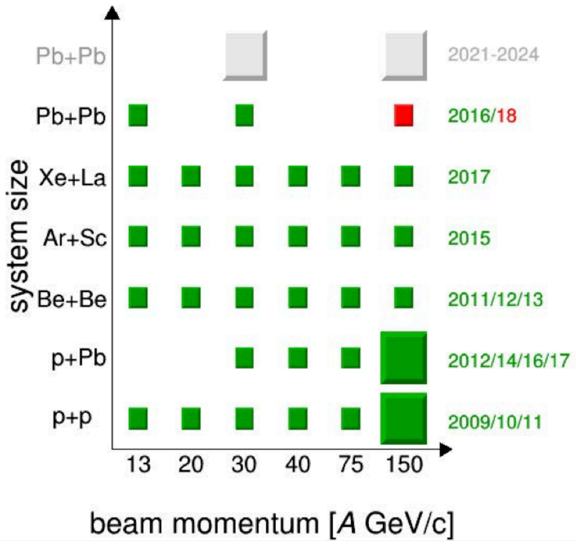


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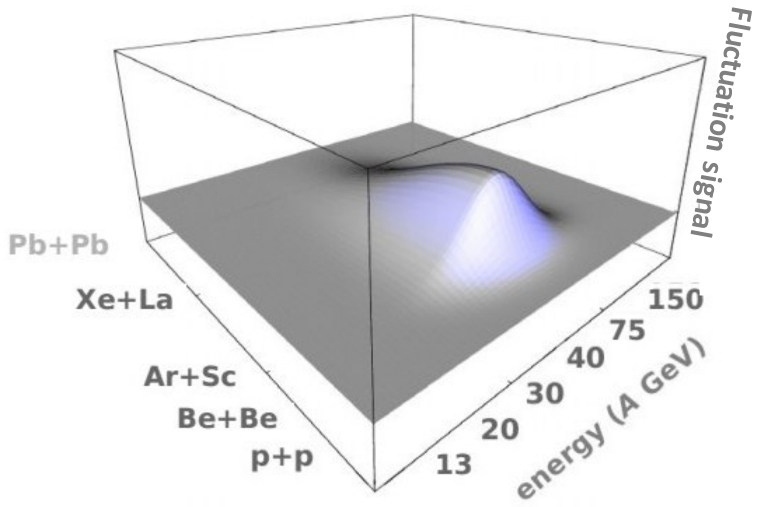
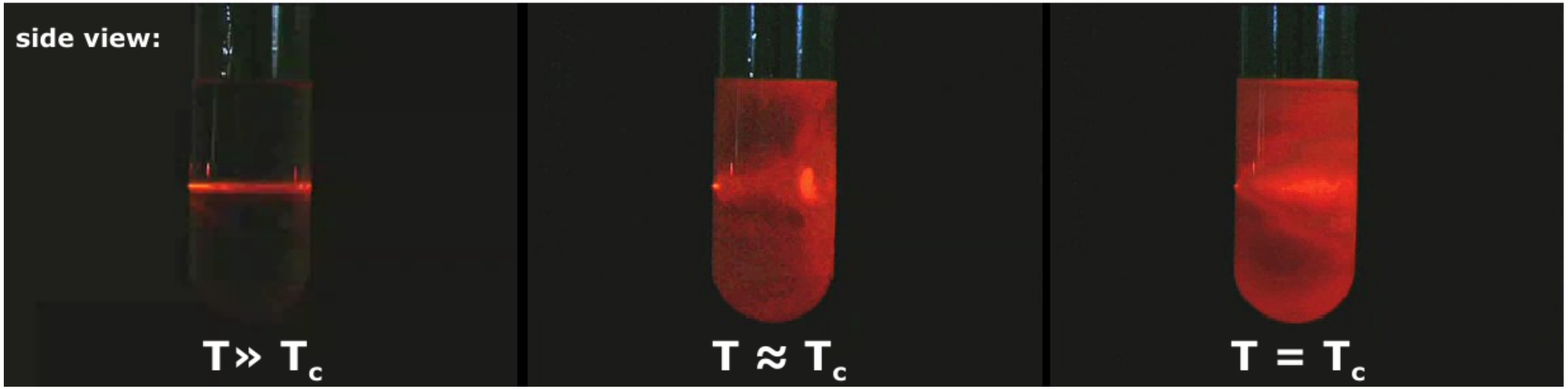



Sketch of the expected «critical hill»

# Critical behavior: back to school

Common knowledge: **critical opalescence**

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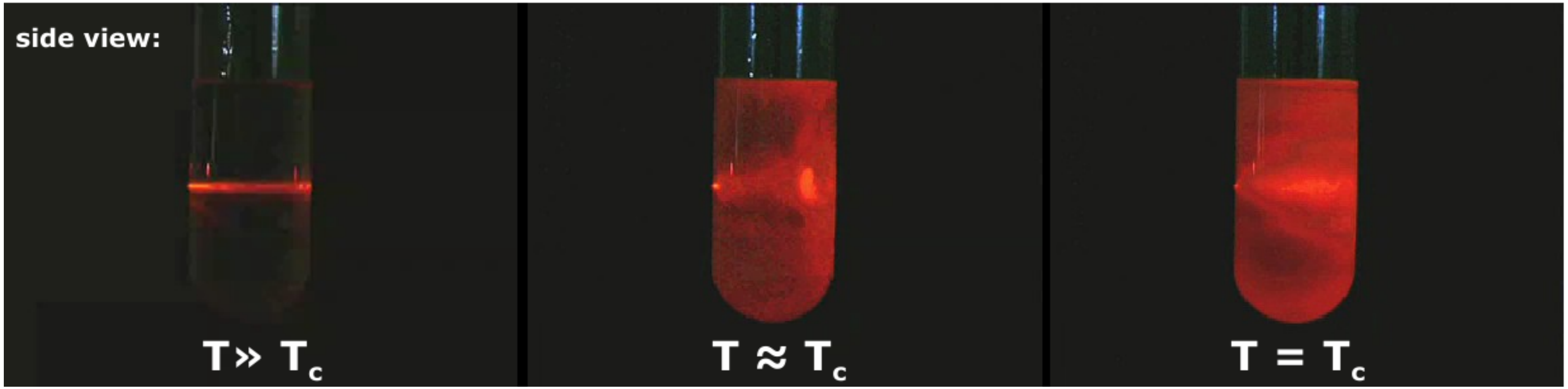


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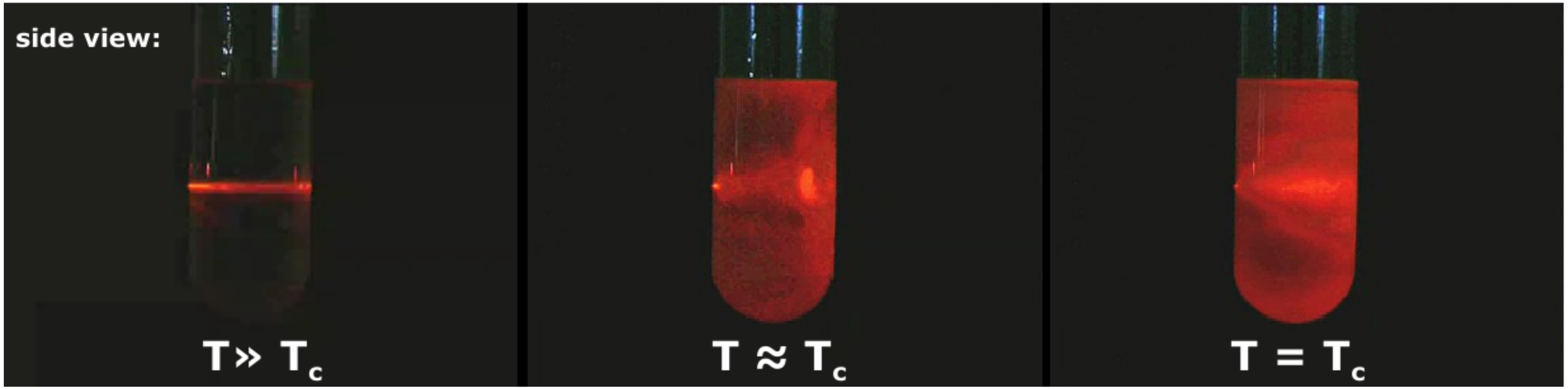


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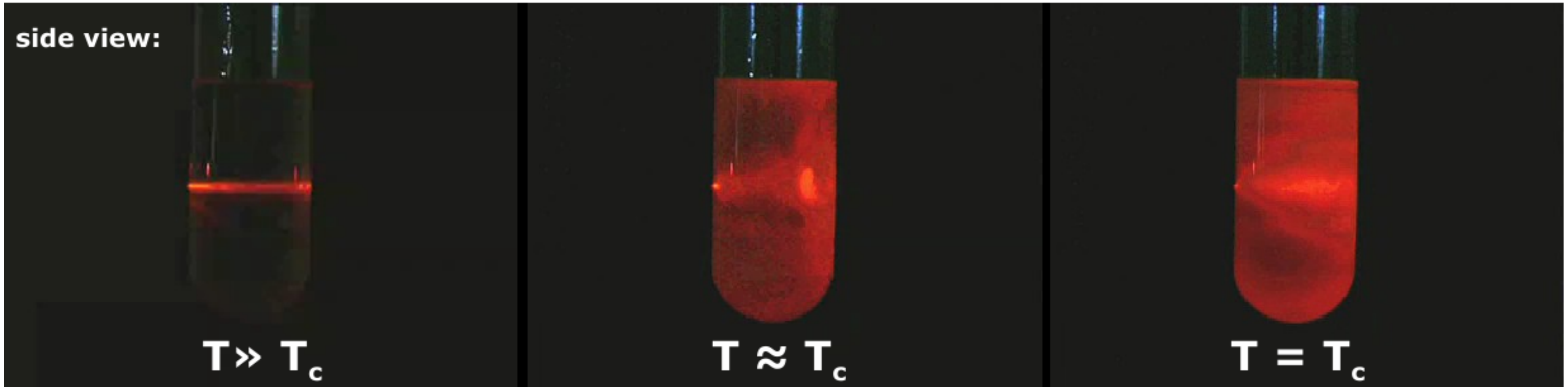


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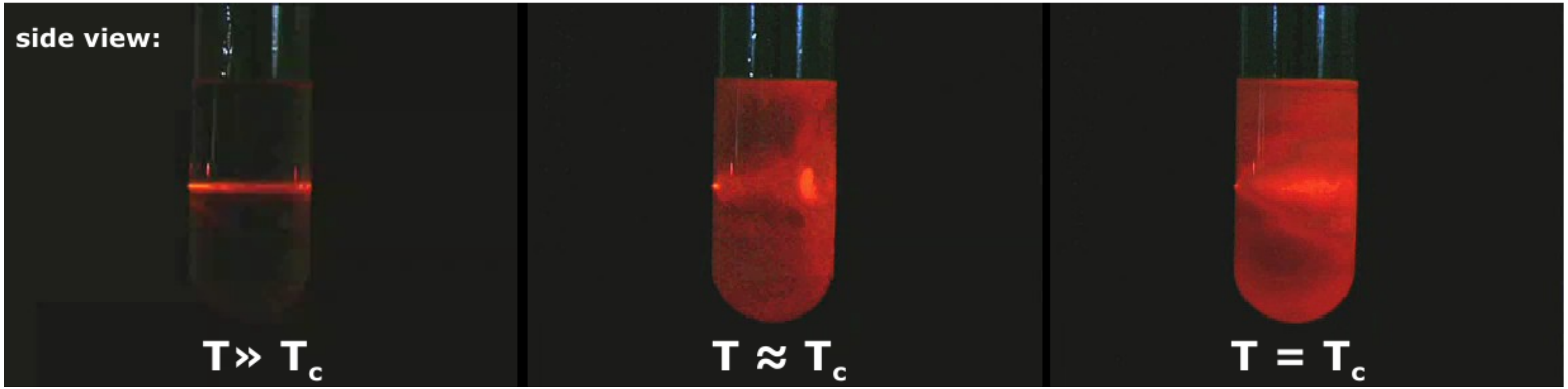


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Finally, we see a signature of a second order phase transitions and the **critical point is reached**

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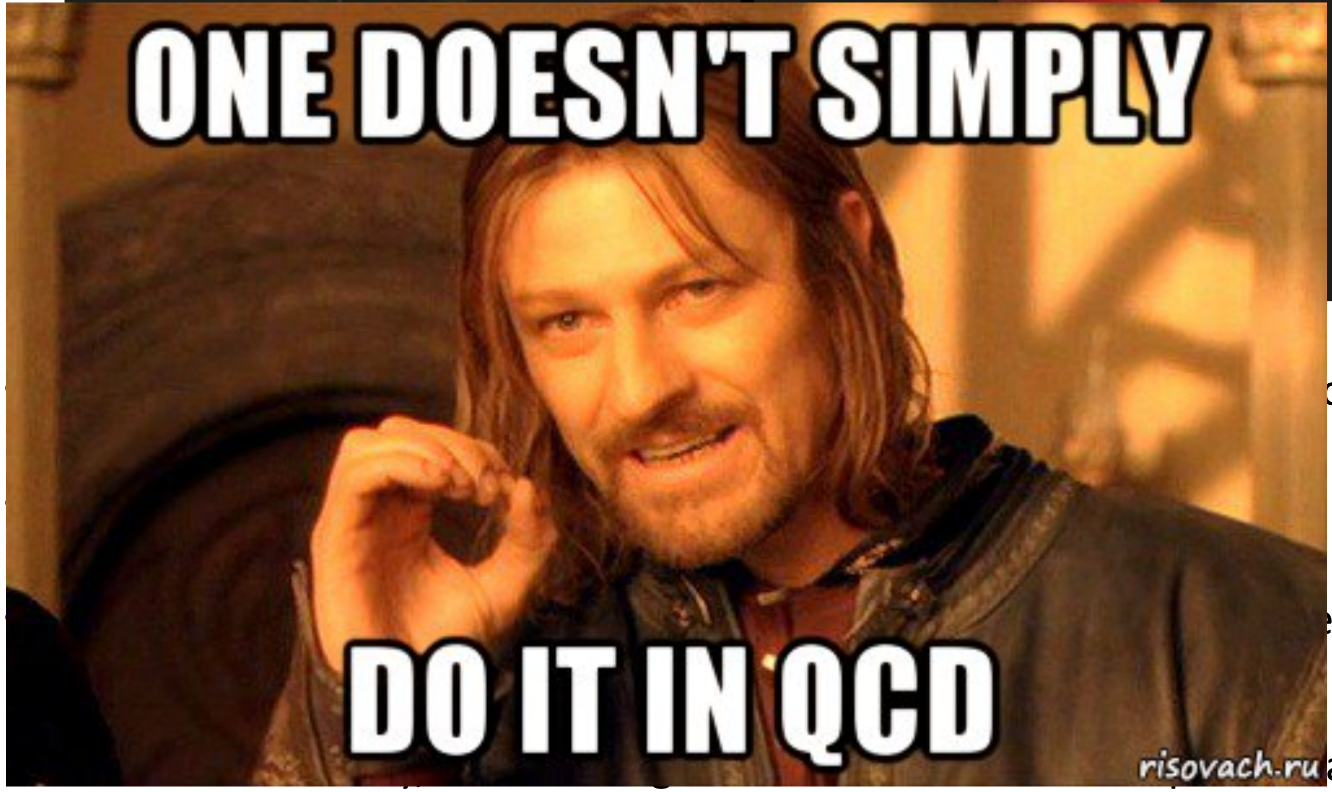


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**In this talk I will present:**

- theoretical aspects formulated by **Fotios Diakonos** at NA61/SHINE theory virtual meetings, can be found also at https://indico.cern.ch/event/760216/contributions/3154442/attachments/1722303/2781998/Diakonos_cpod2018v2.pdf

- experimental approach and results by **Nikolaos Davis** in collaboration with **Nikolaos Antoniou & Fotios Diakonos** for the NA61/SHINE collaboration based on NA61/SHINE and NA49 data with full information being available at: https://indico.cern.ch/event/760216/contributions/3153684/attachments/1721653/2779754/Davis_CPOD2018.pdf

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Our system has a finite size **L** → This introduces an additional length scale **L**, with exponent **p** describing the **scaling** of thermodynamic quantities for finite systems**:**

Q – any thermodynamic quantity
f – scaling function
$\xi_\infty$ - correlation length

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* [F.K. Diakonos, N.G. Antoniou and G. Mavromanolakis, PoS (CPOD2006) 010, Florence]

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**Intermittency ~ critical opalescence in heavy ion collisions ***

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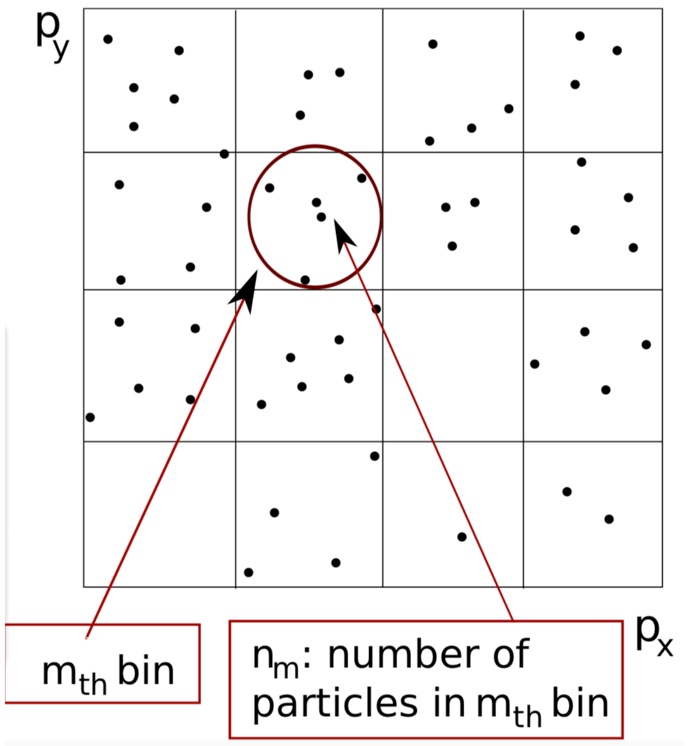
# Intermittency analysis: factorial moments

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[N. Davis, CPOD 2018 talk]

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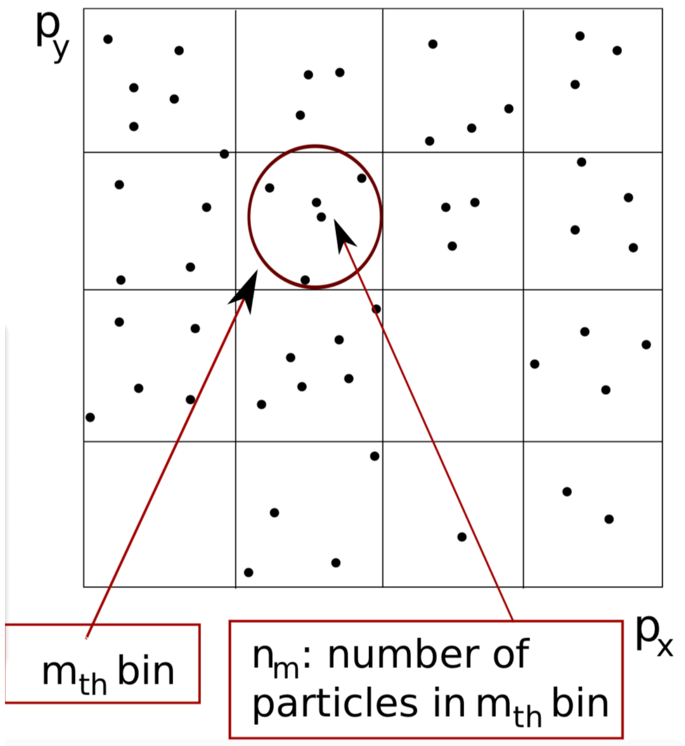


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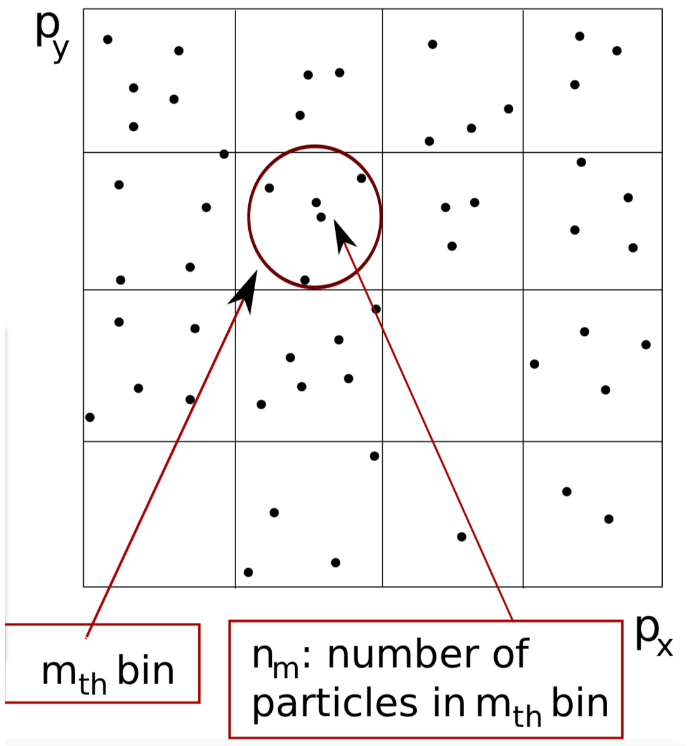


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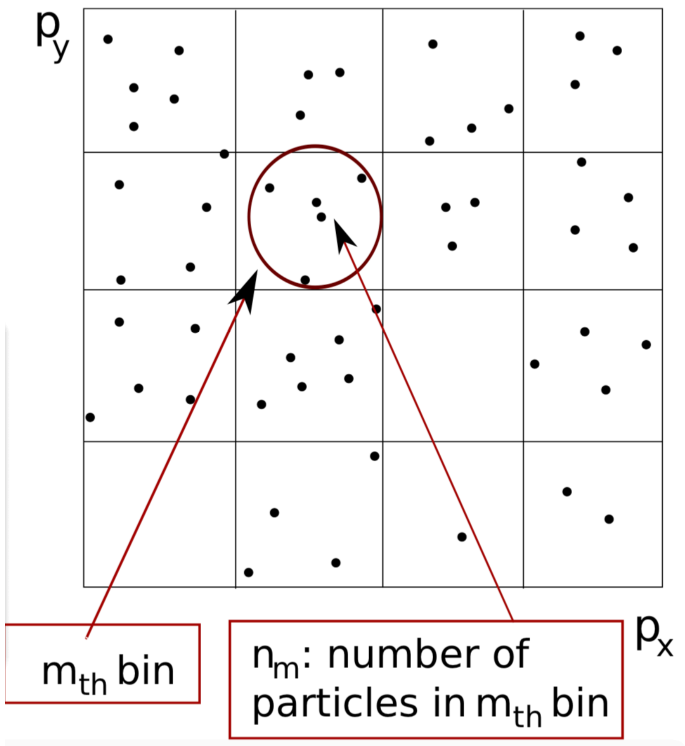


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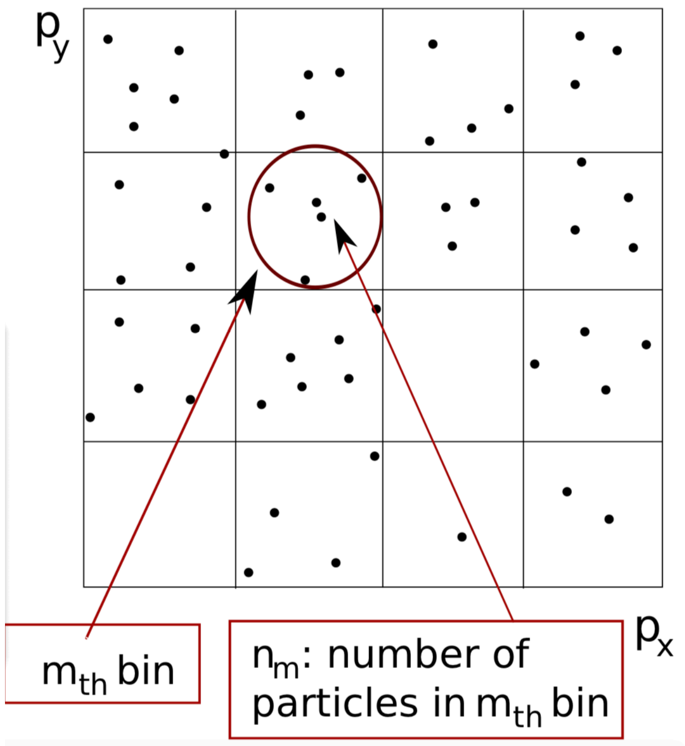


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- Calculate second factorial moments $\mathbf{F_2(M)}$ as a function of cell size ⇔ number of cells M

$$F_2(M) \equiv \frac{\left\langle \frac{1}{M^2} \sum_{i=1}^{M^2} n_i(n_i - 1) \right\rangle}{\left\langle \frac{1}{M^2} \sum_{i=1}^{M^2} n_i \right\rangle^2}$$

[N. Davis, CPOD 2018 talk]

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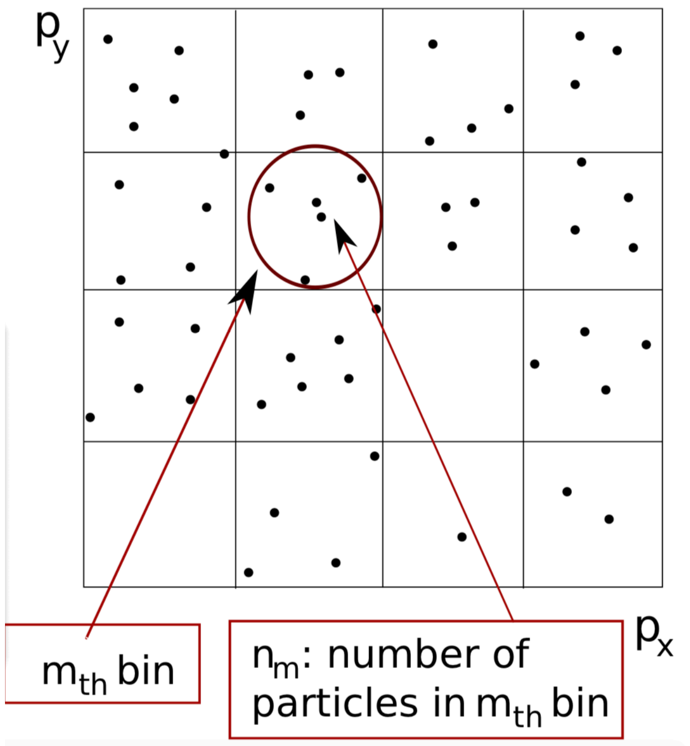


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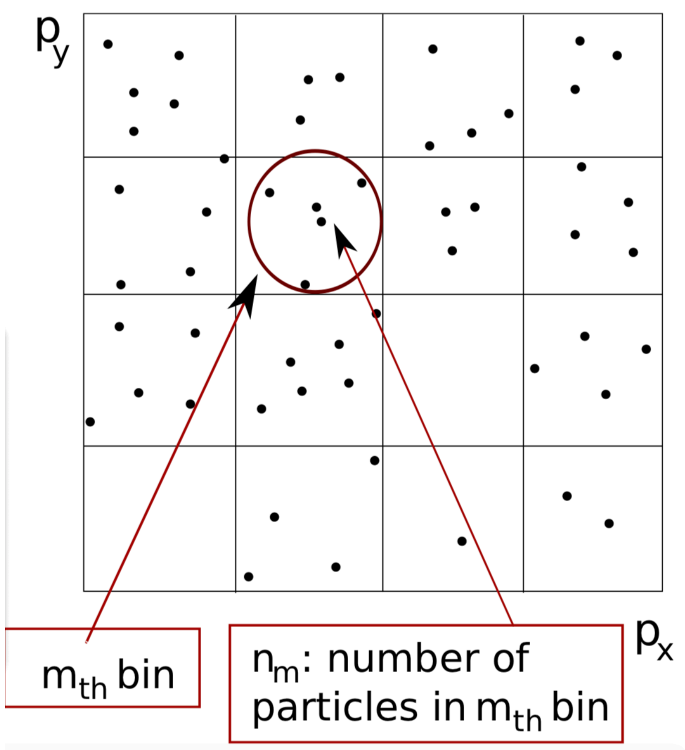


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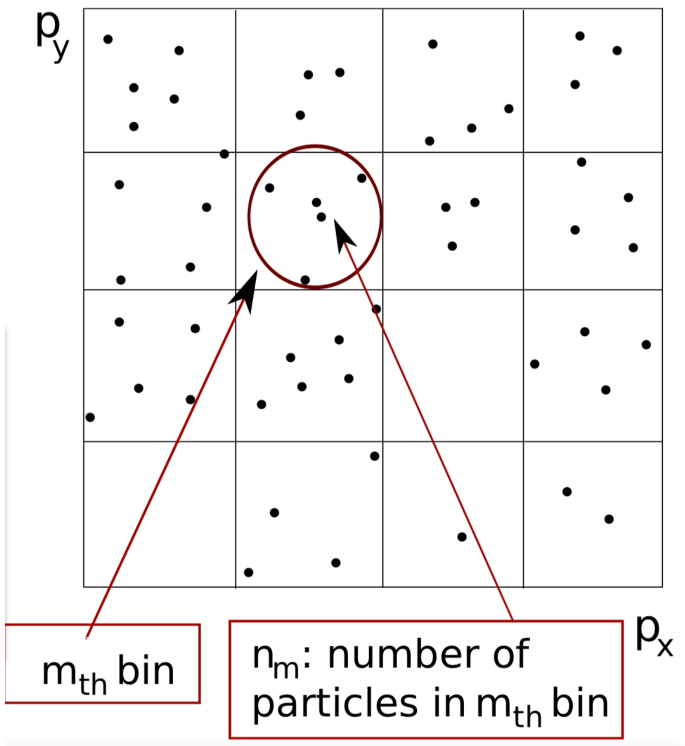


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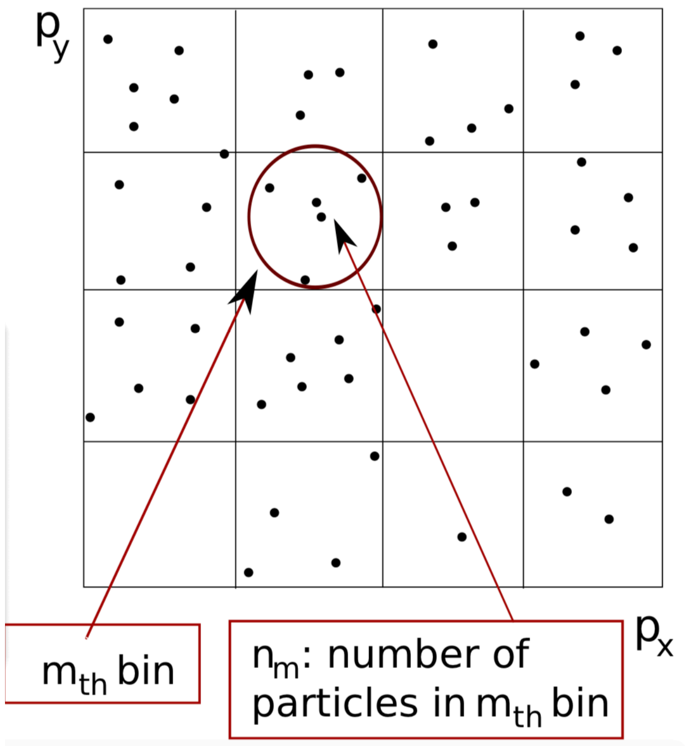


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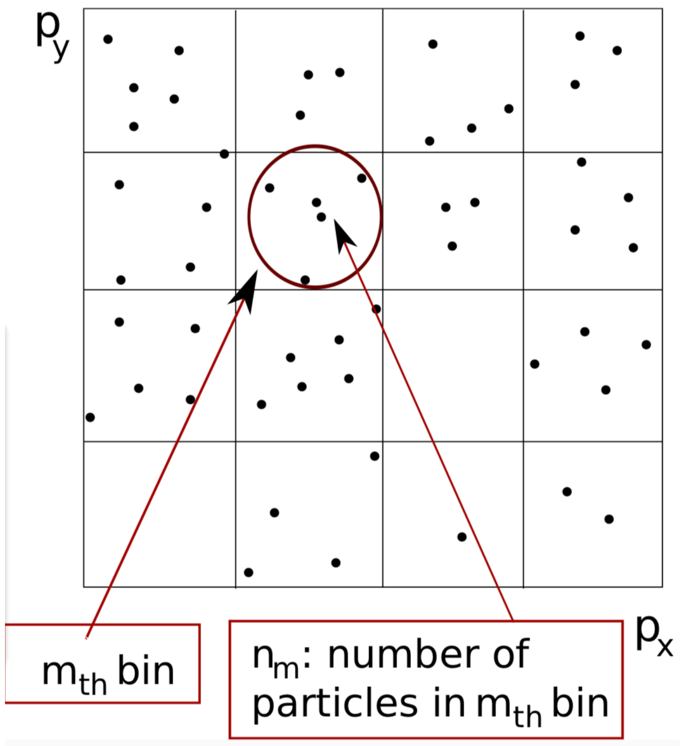


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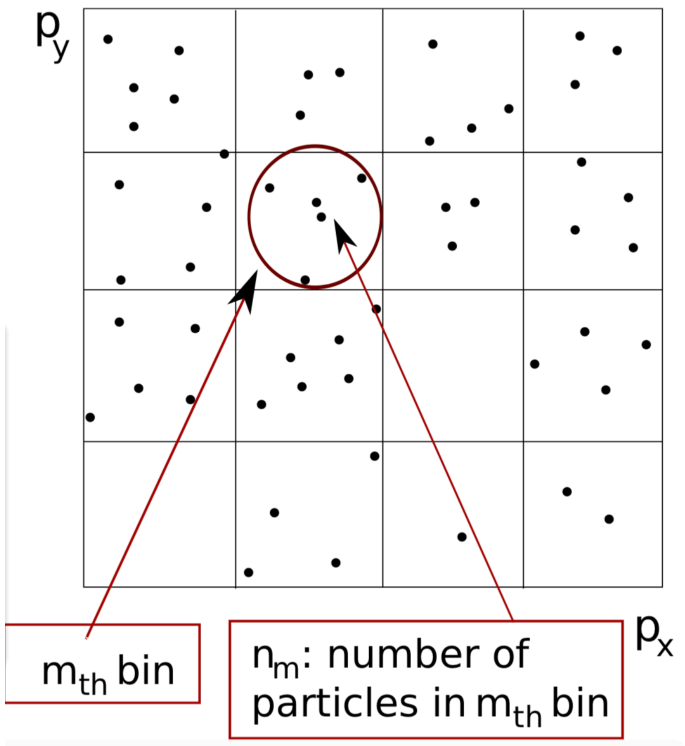


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⇐ **3d-Ising effective action**

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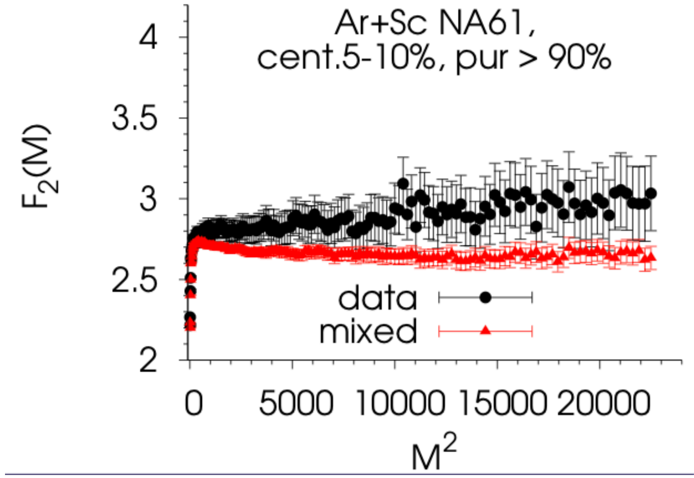
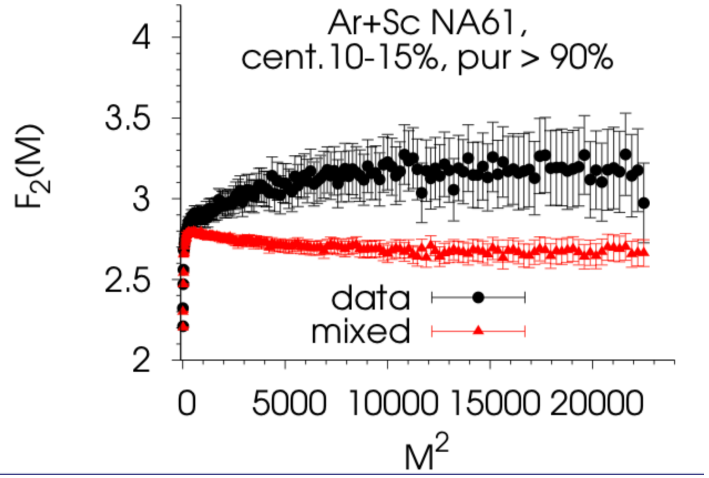
NA61/SHINE preliminary results

**Centrality 10-15%**

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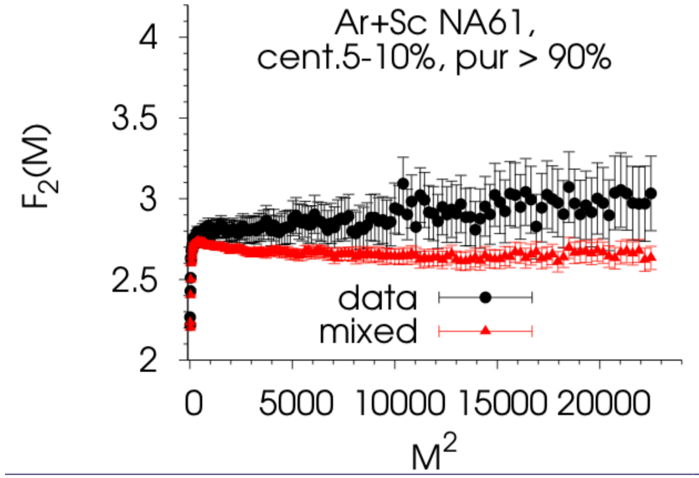


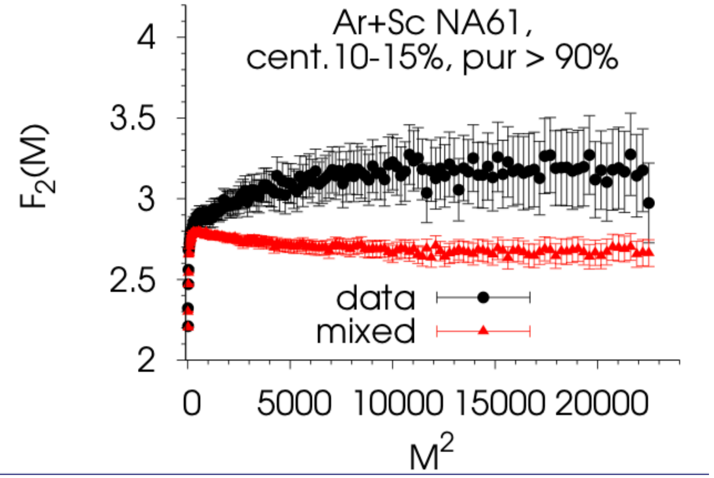


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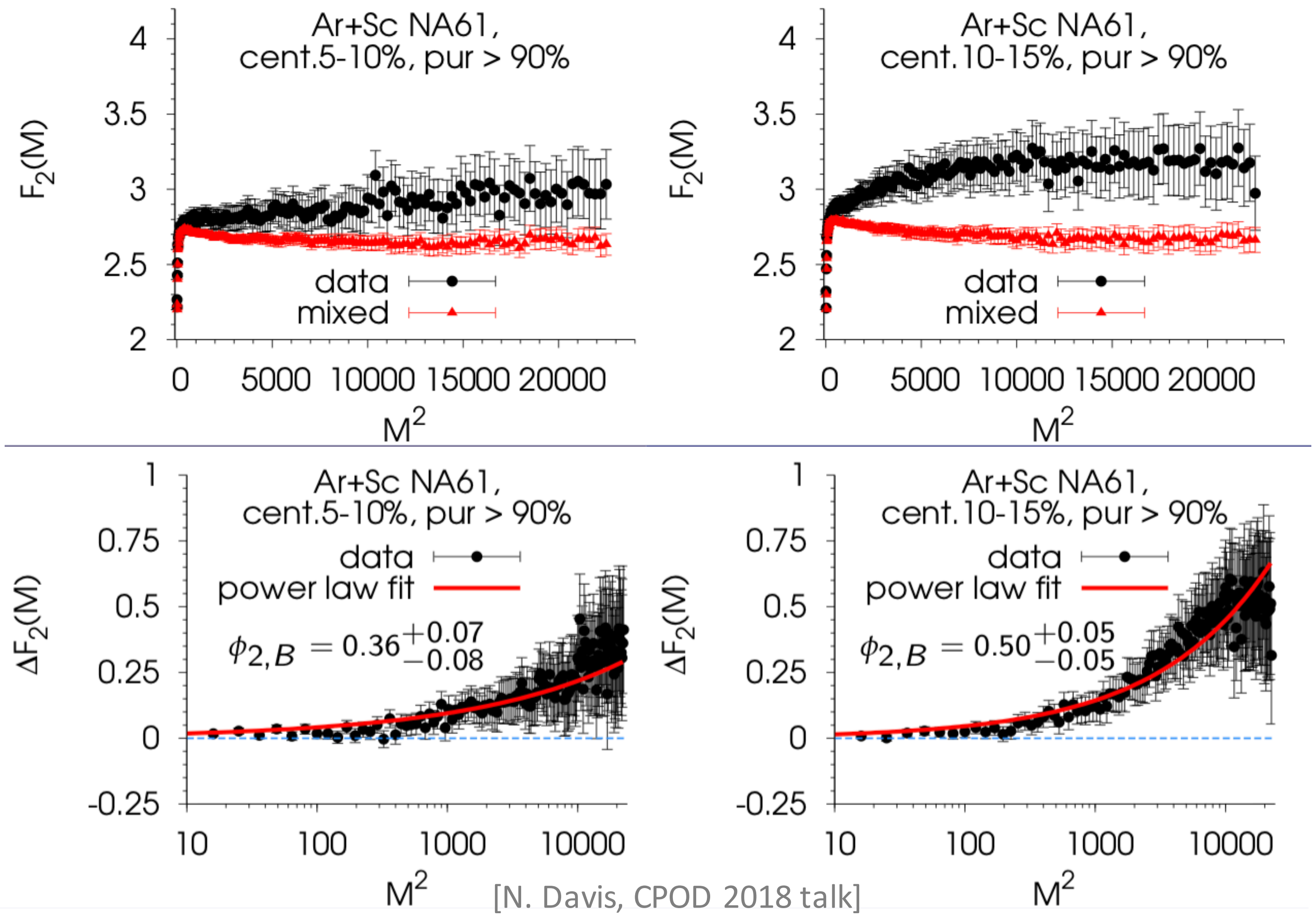


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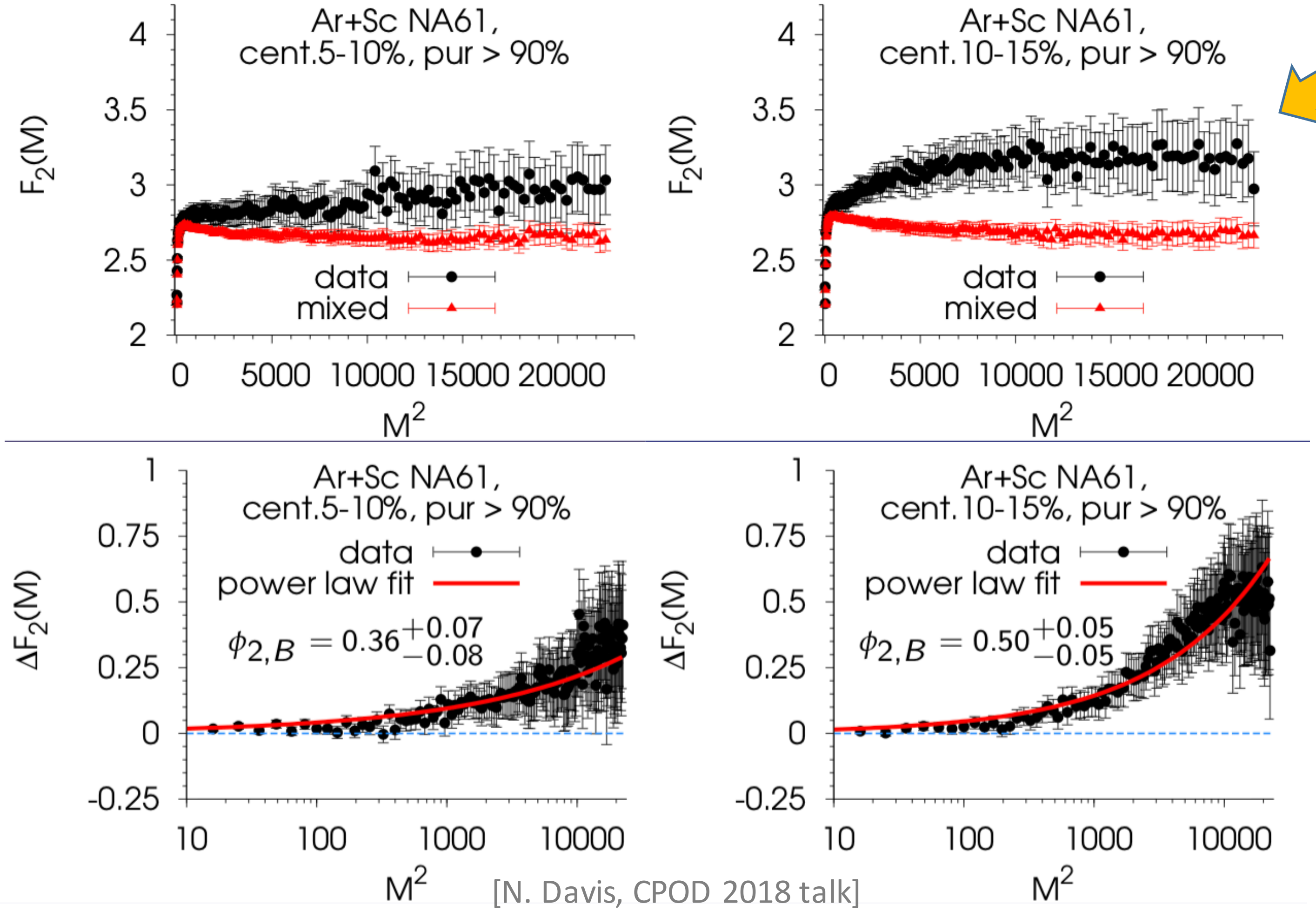


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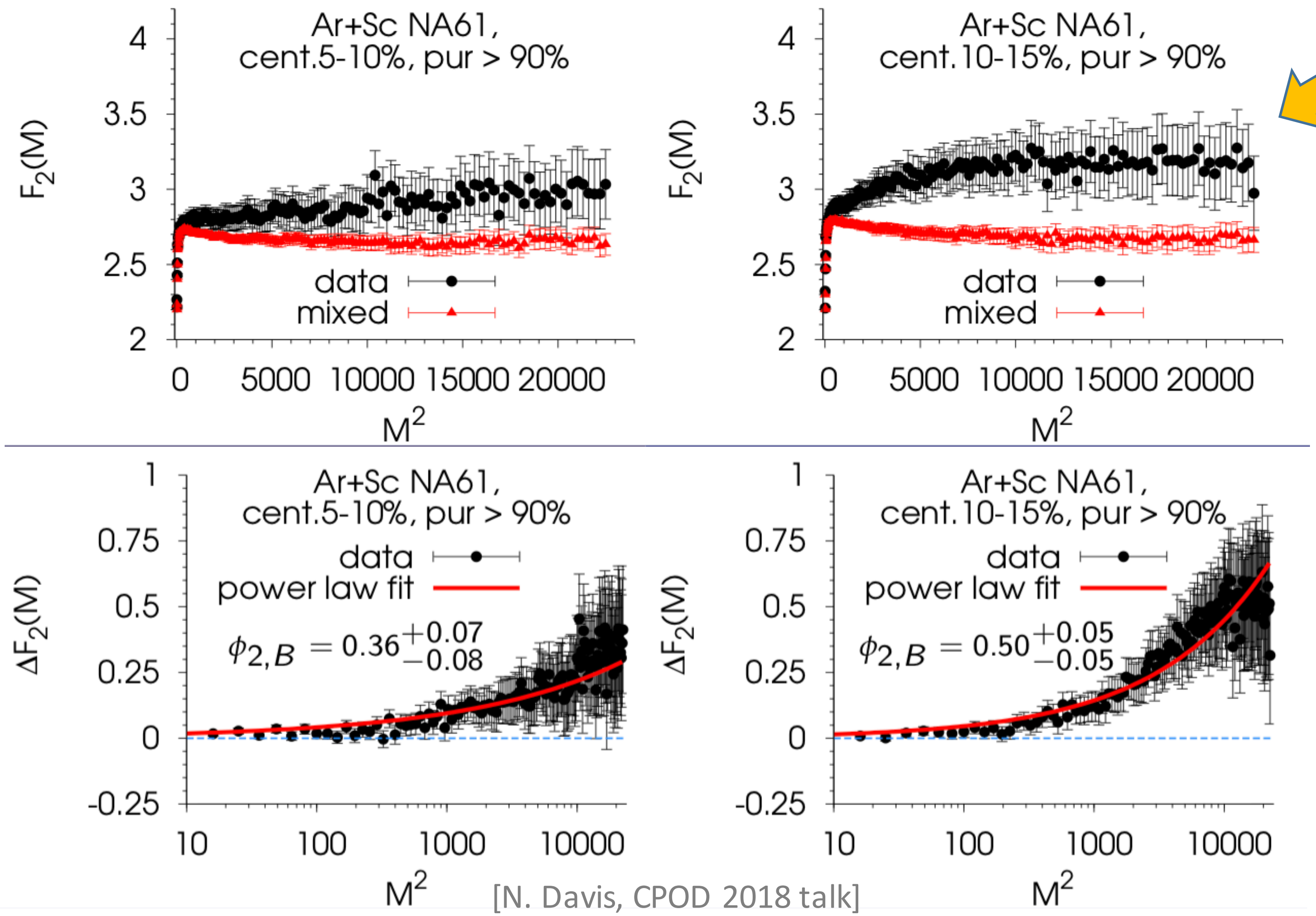


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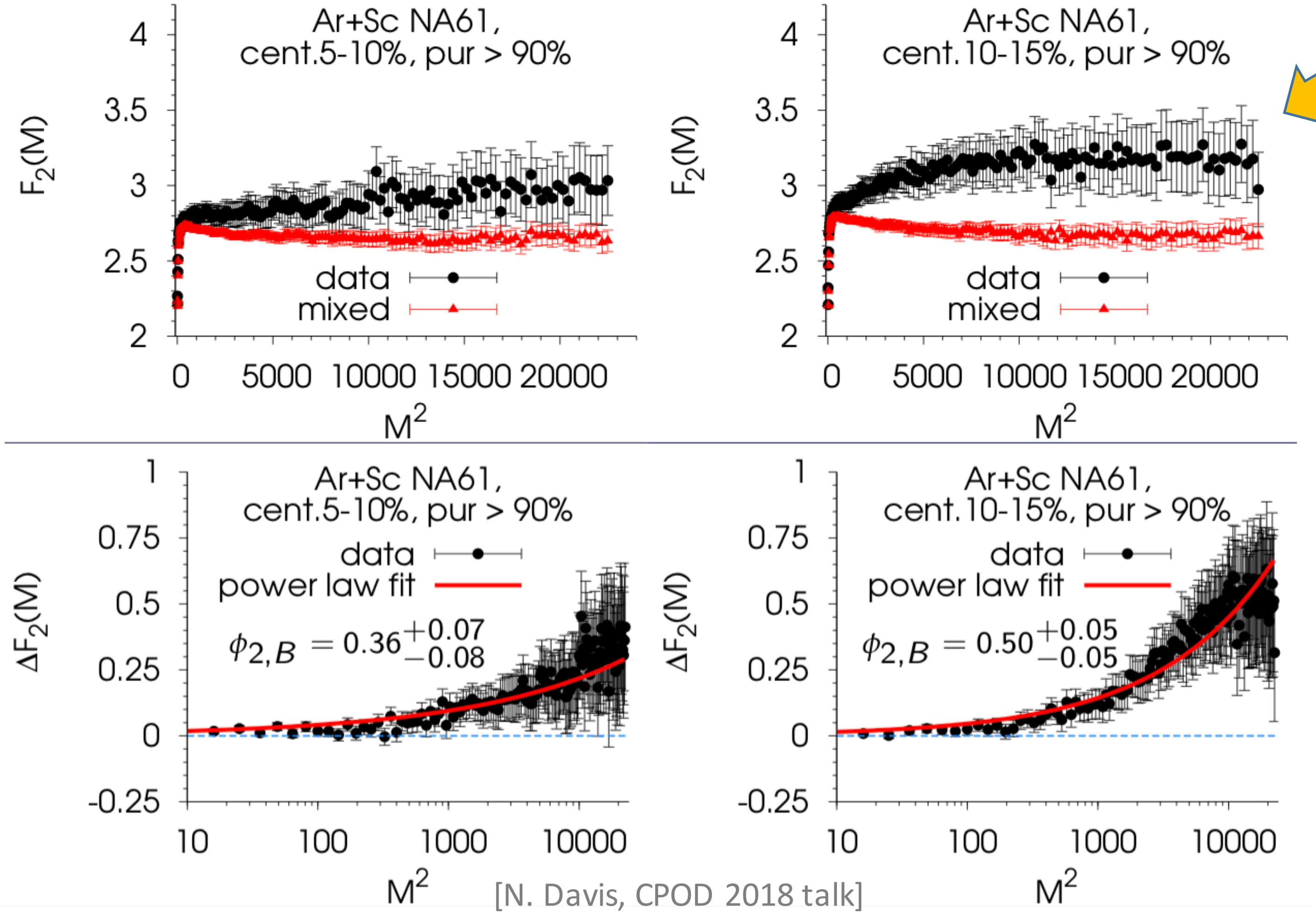


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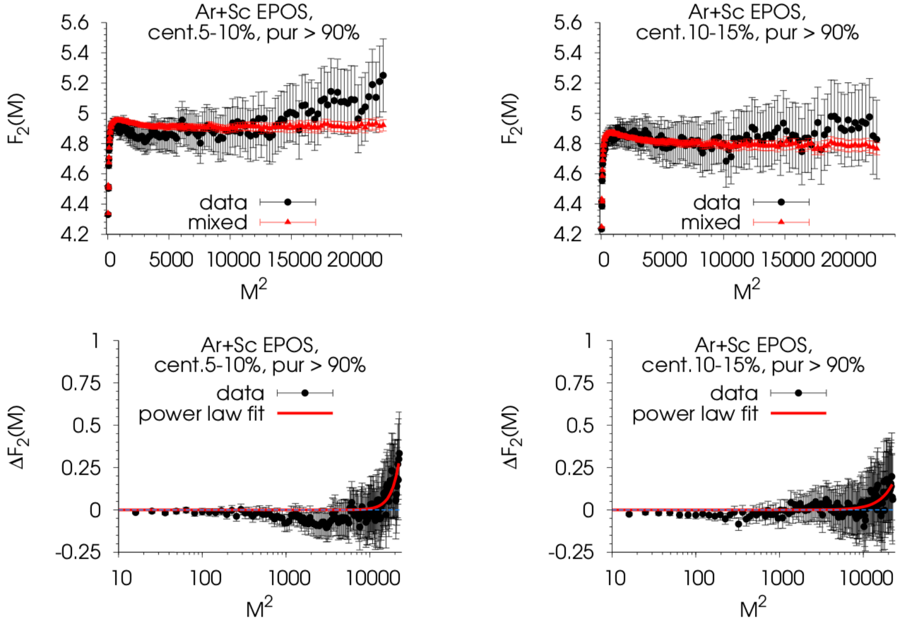


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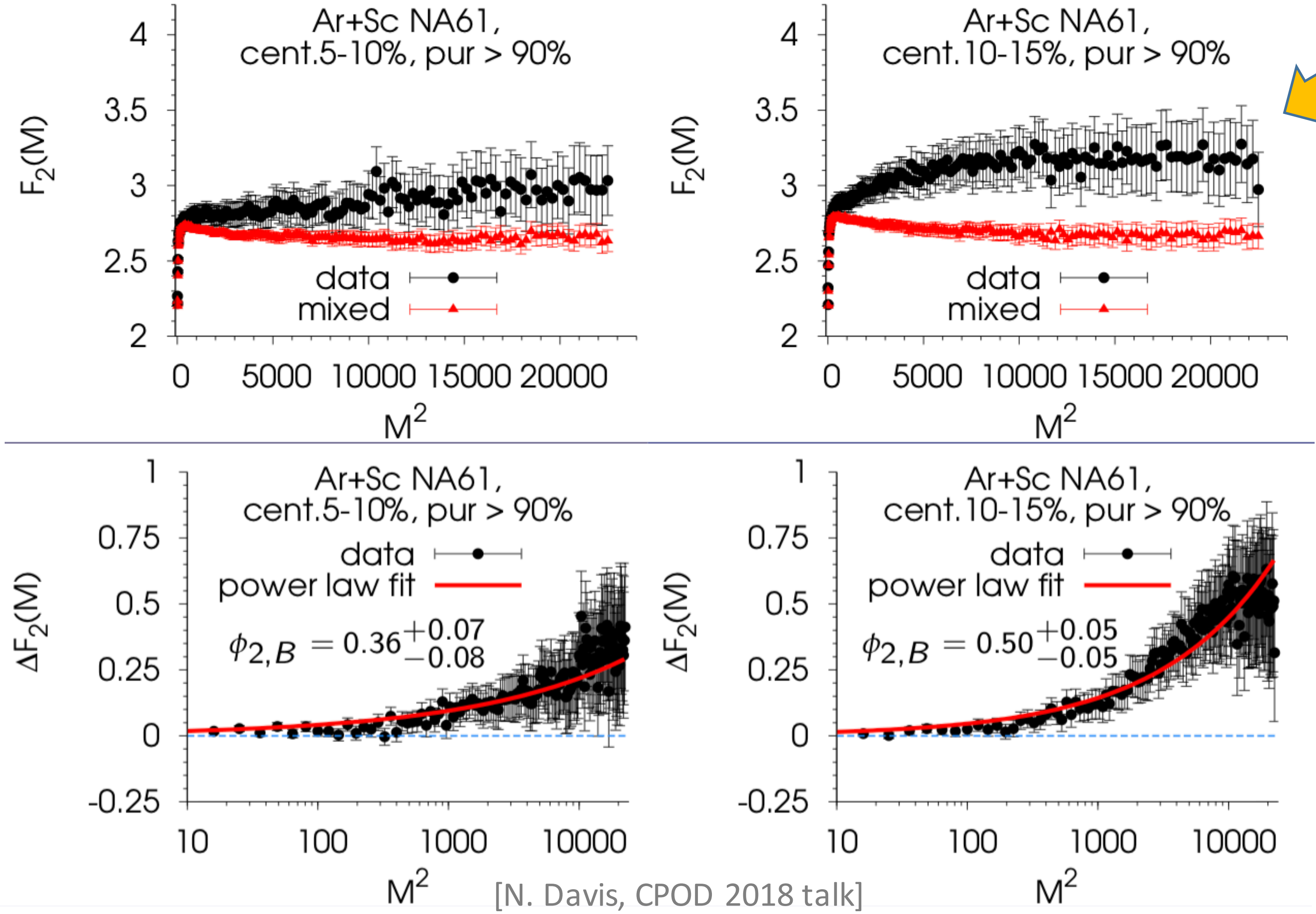


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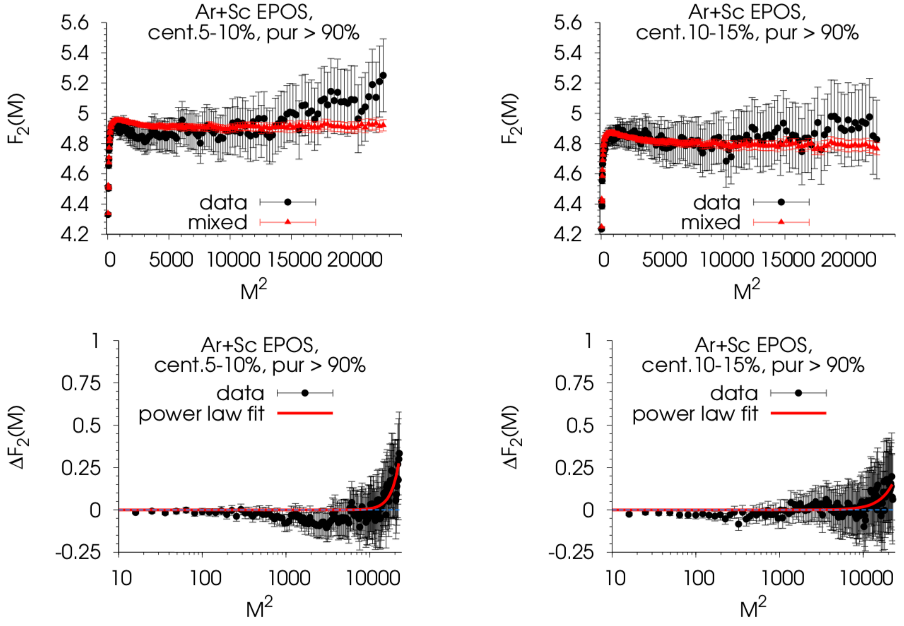
EPOS does not reproduce observed effect

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# Intermittency analysis: summary NA49 and NA61/SHINE

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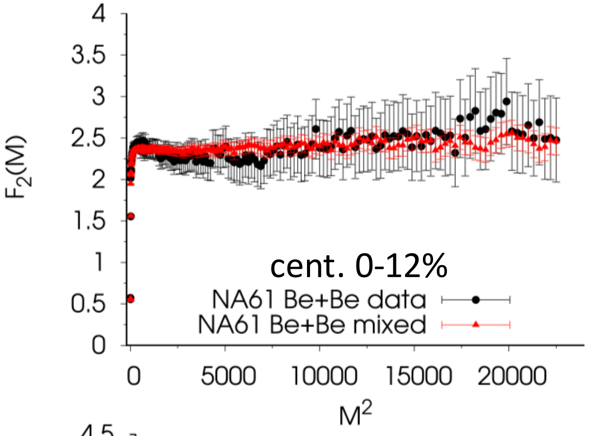


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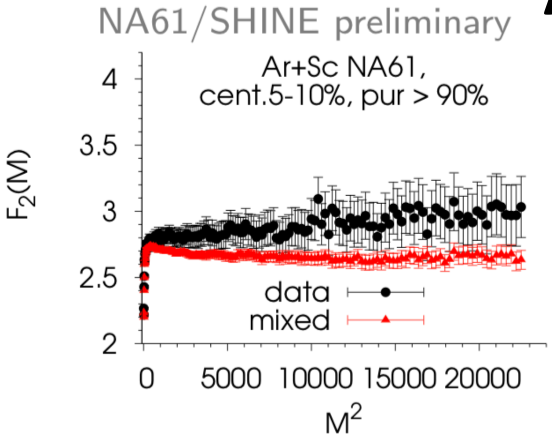
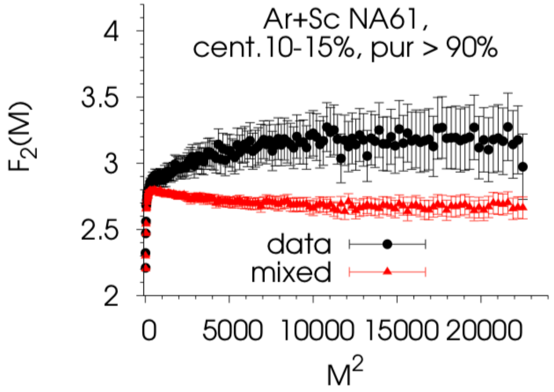
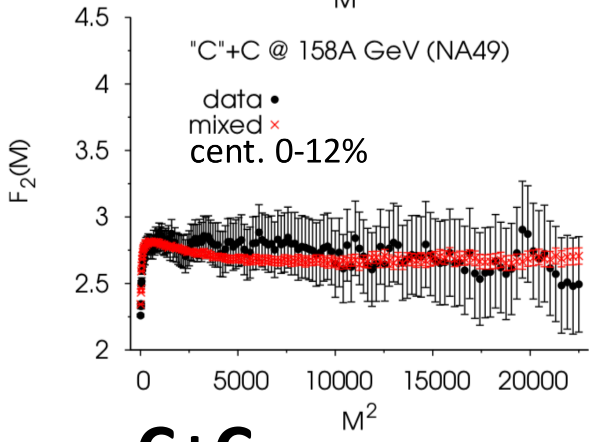
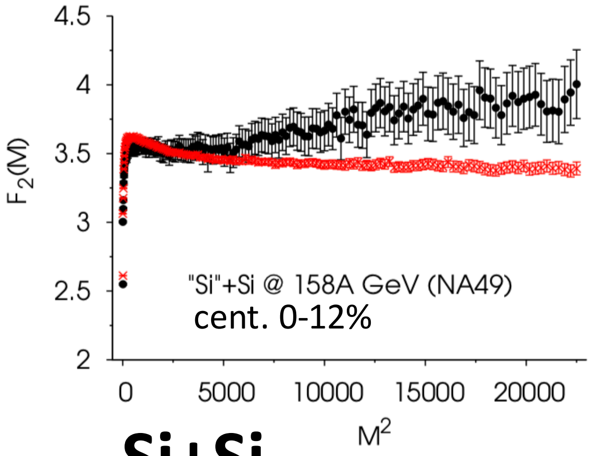


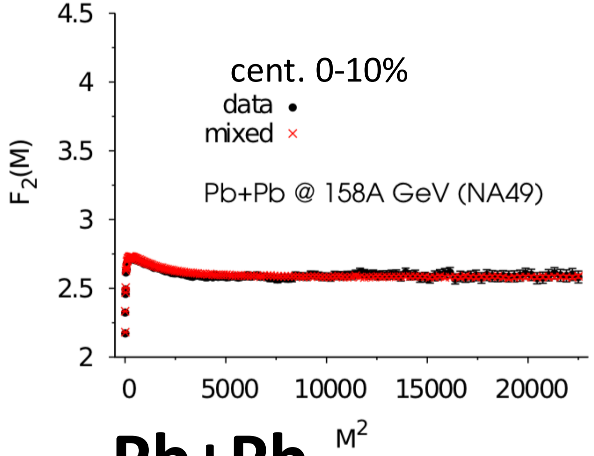




**C+C**




**Si+Si**



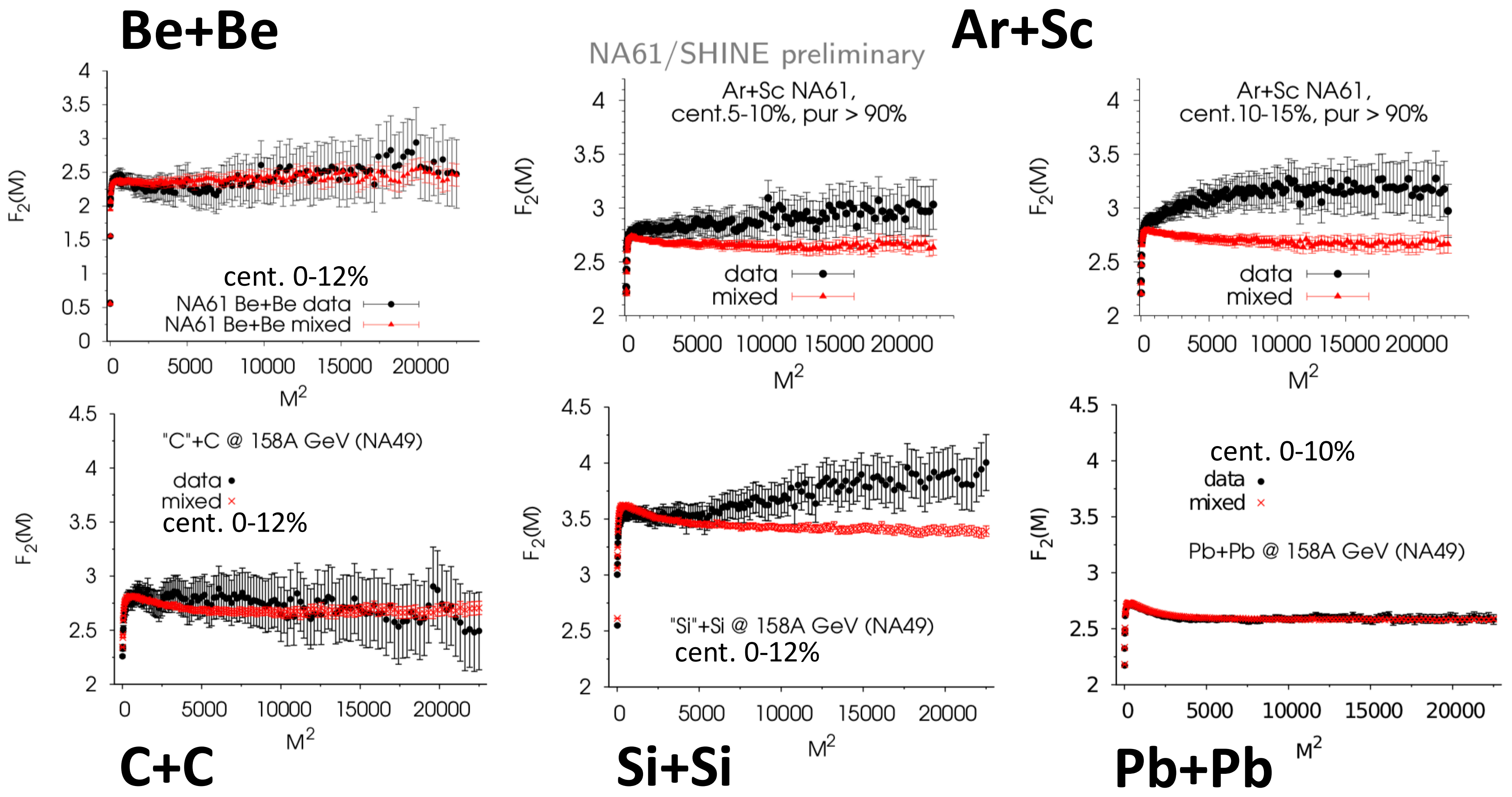

**Pb+Pb**

[N. Davis, CPOD 2018 talk]

# Intermittency analysis: summary NA49 and NA61/SHINE

**NA61/SHINE**

[Preliminary]




[N. Davis, CPOD 2018 talk]

# Intermittency analysis: summary NA49 and NA61/SHINE

**NA61/SHINE**

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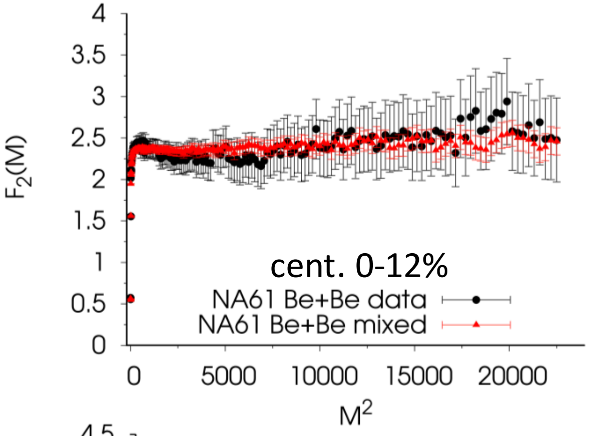
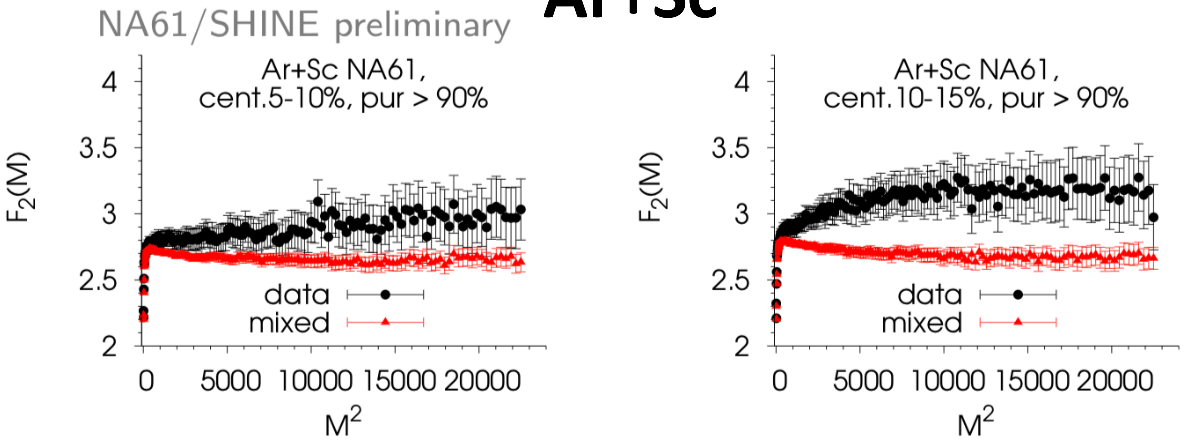
**Be+Be**

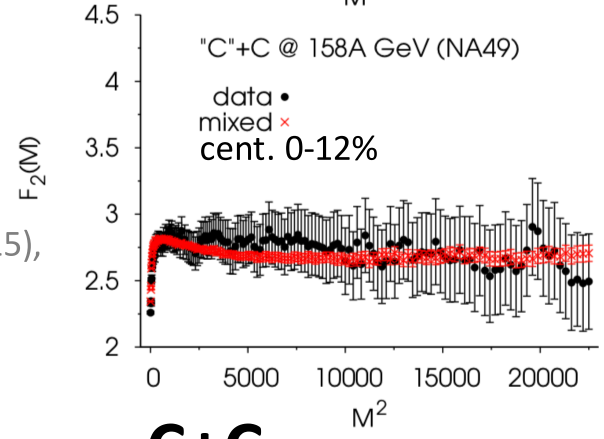



**Ar+Sc**




**NA49**

[T. Anticic et al., Eur. Phys. J. C 75:587 (2015), arXiv:1208.5292v5]

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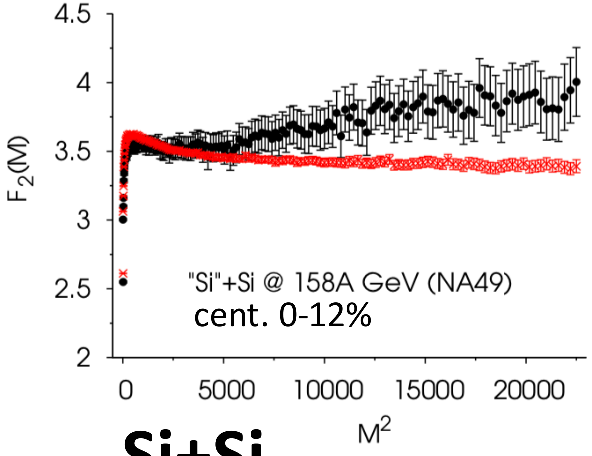


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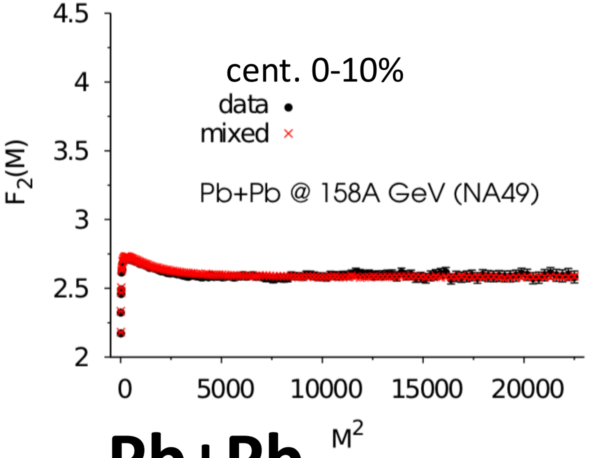


**Pb+Pb**

[N. Davis, CPOD 2018 talk]

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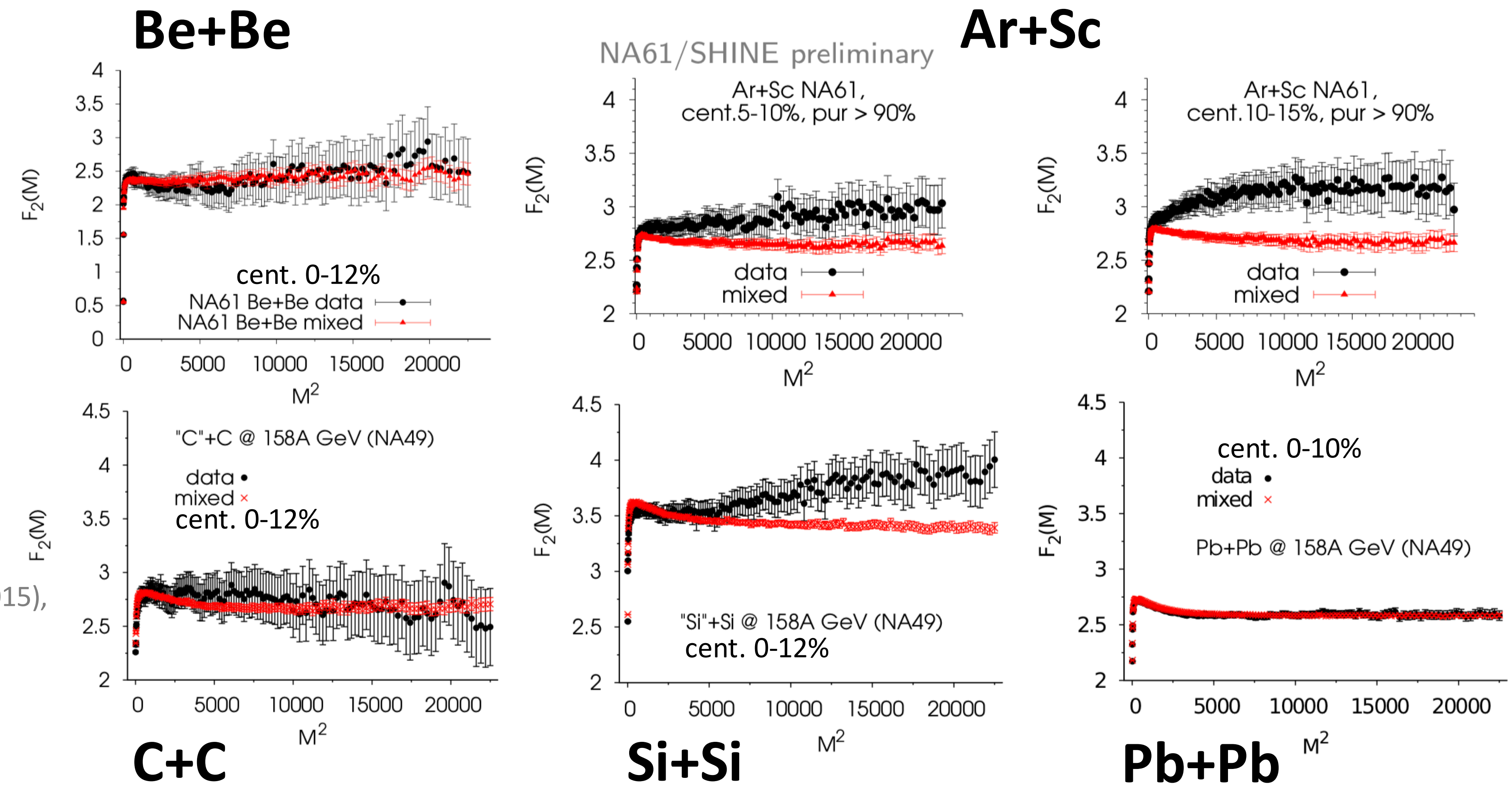


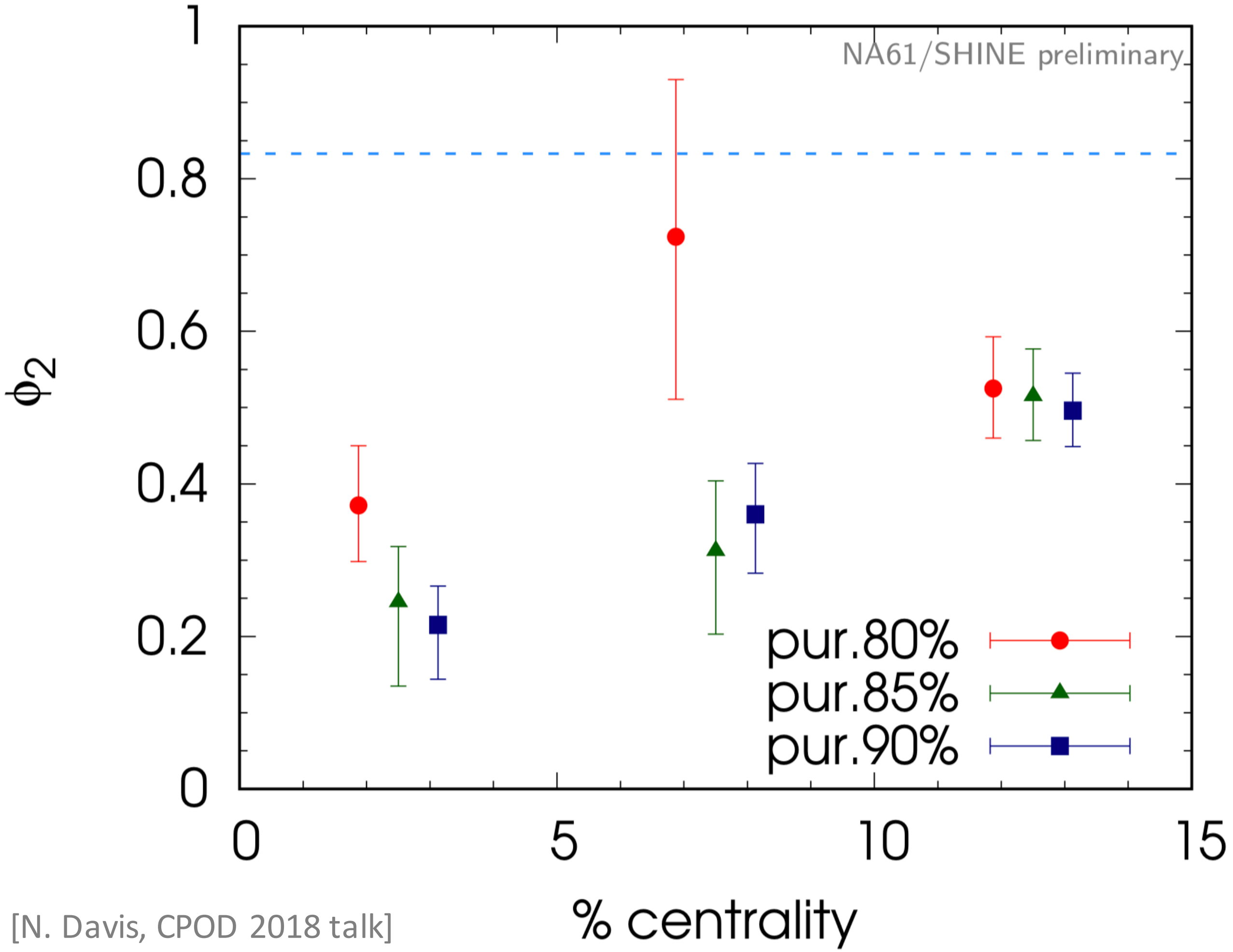

[N. Davis, CPOD 2018 talk]

What are the **intermittency indexes** for these systems?

# Intermittency index: NA61/SHINE

**Intermittency index** $\phi_2$ for Ar+Sc at 150*A* GeV/*c* (80, 85 and 90% purity selection for protons)

$$\mathcal{P}_p = p/(\pi + K + p + e)$$




[N. Davis, CPOD 2018 talk]

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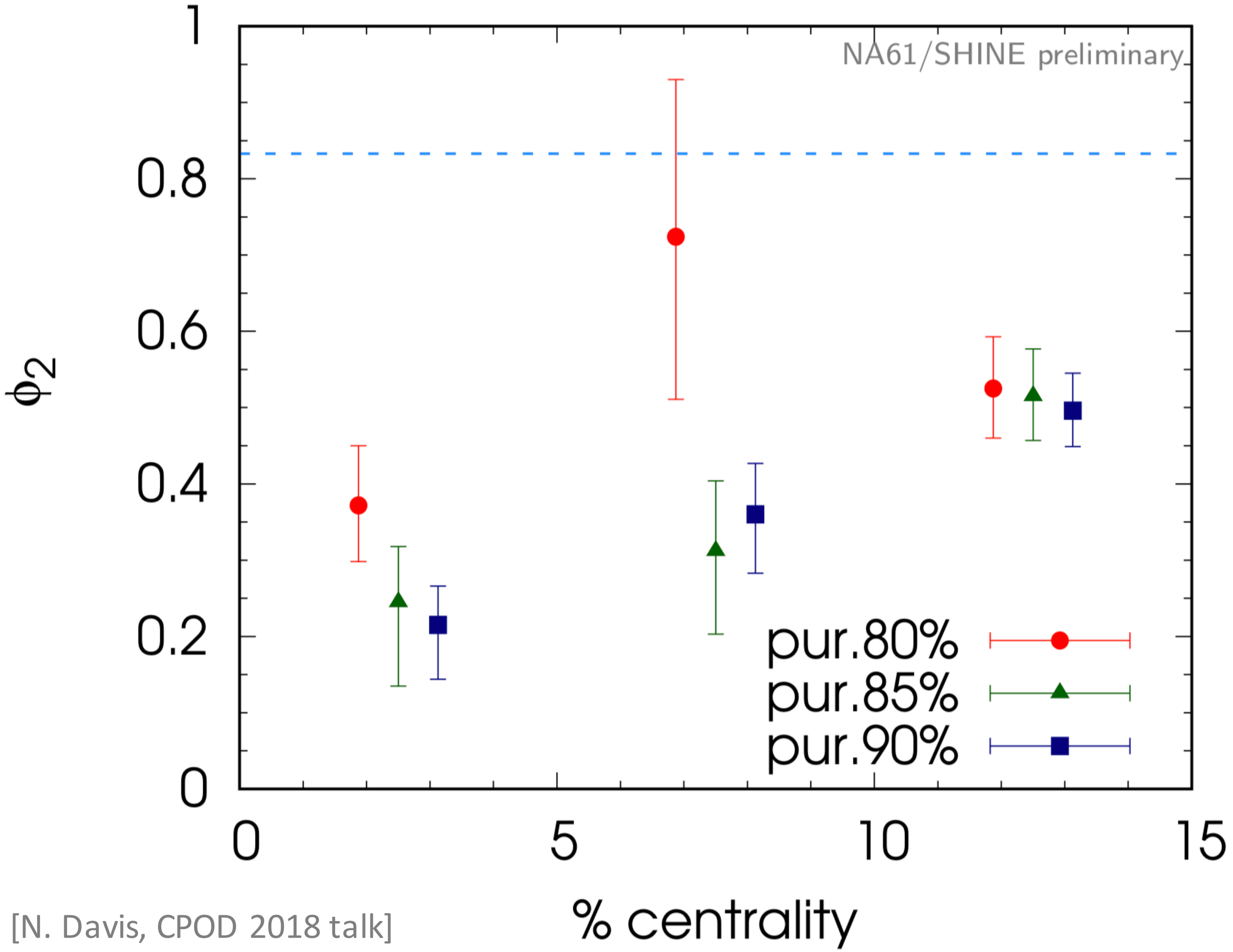


[N. Davis, CPOD 2018 talk]

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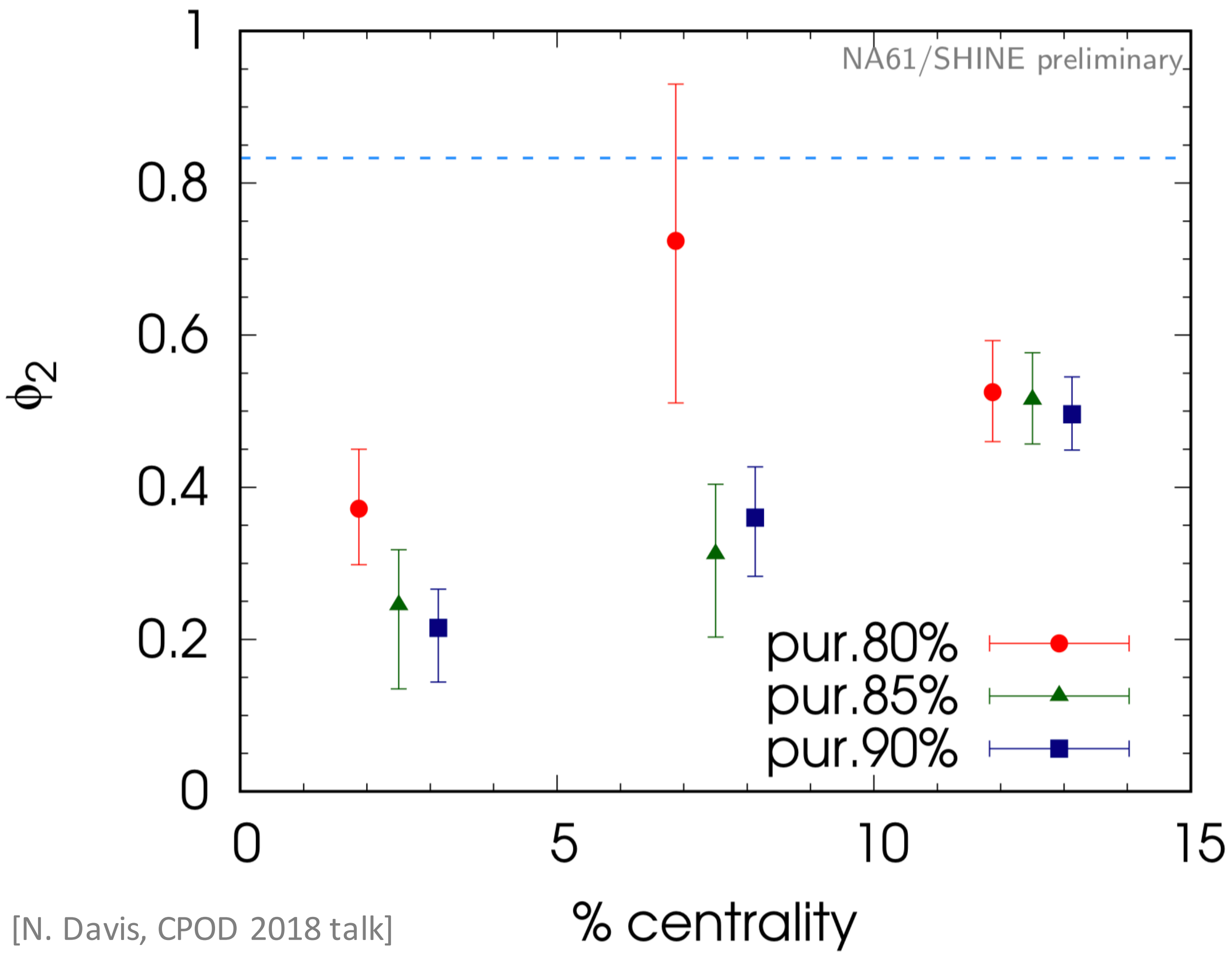


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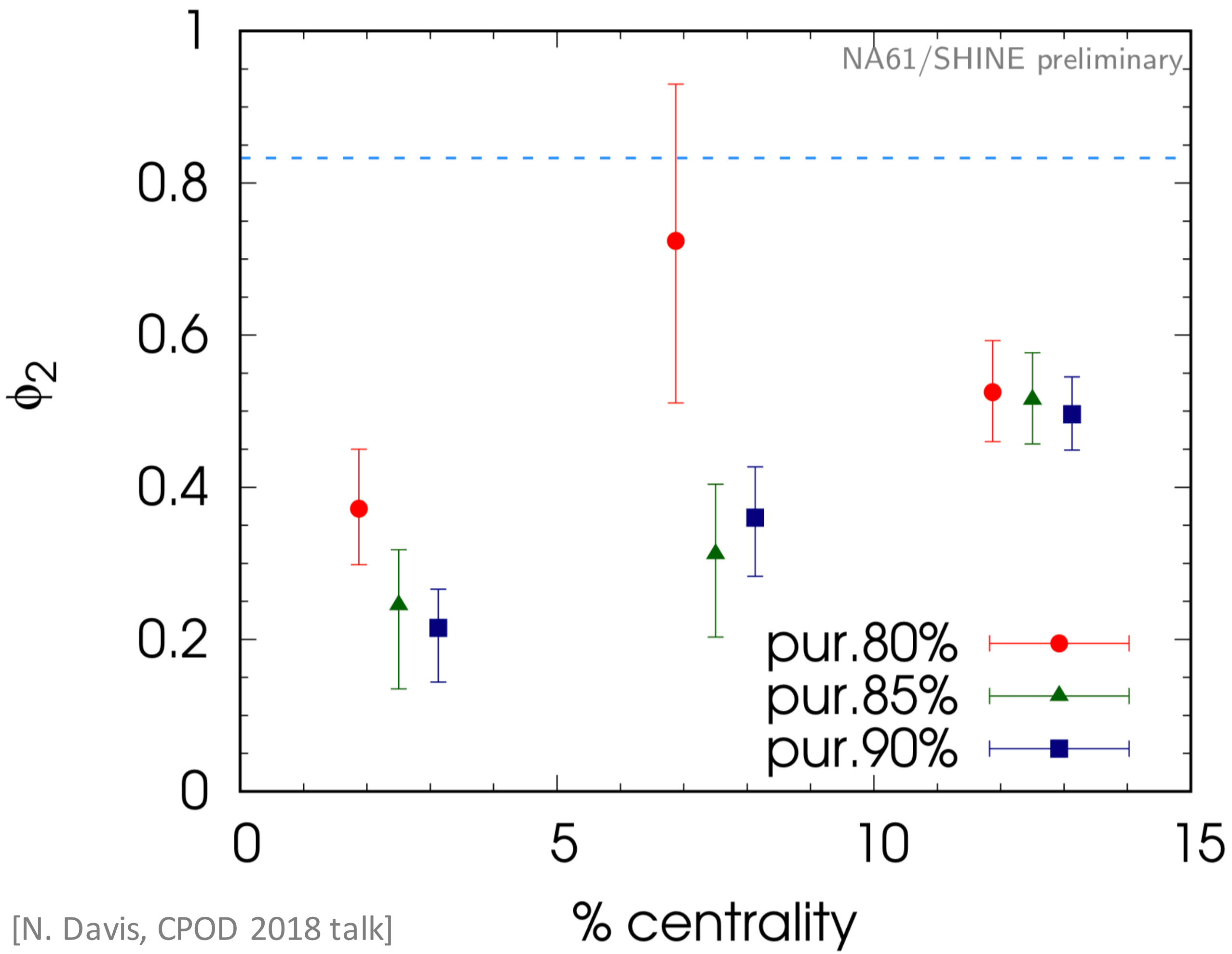


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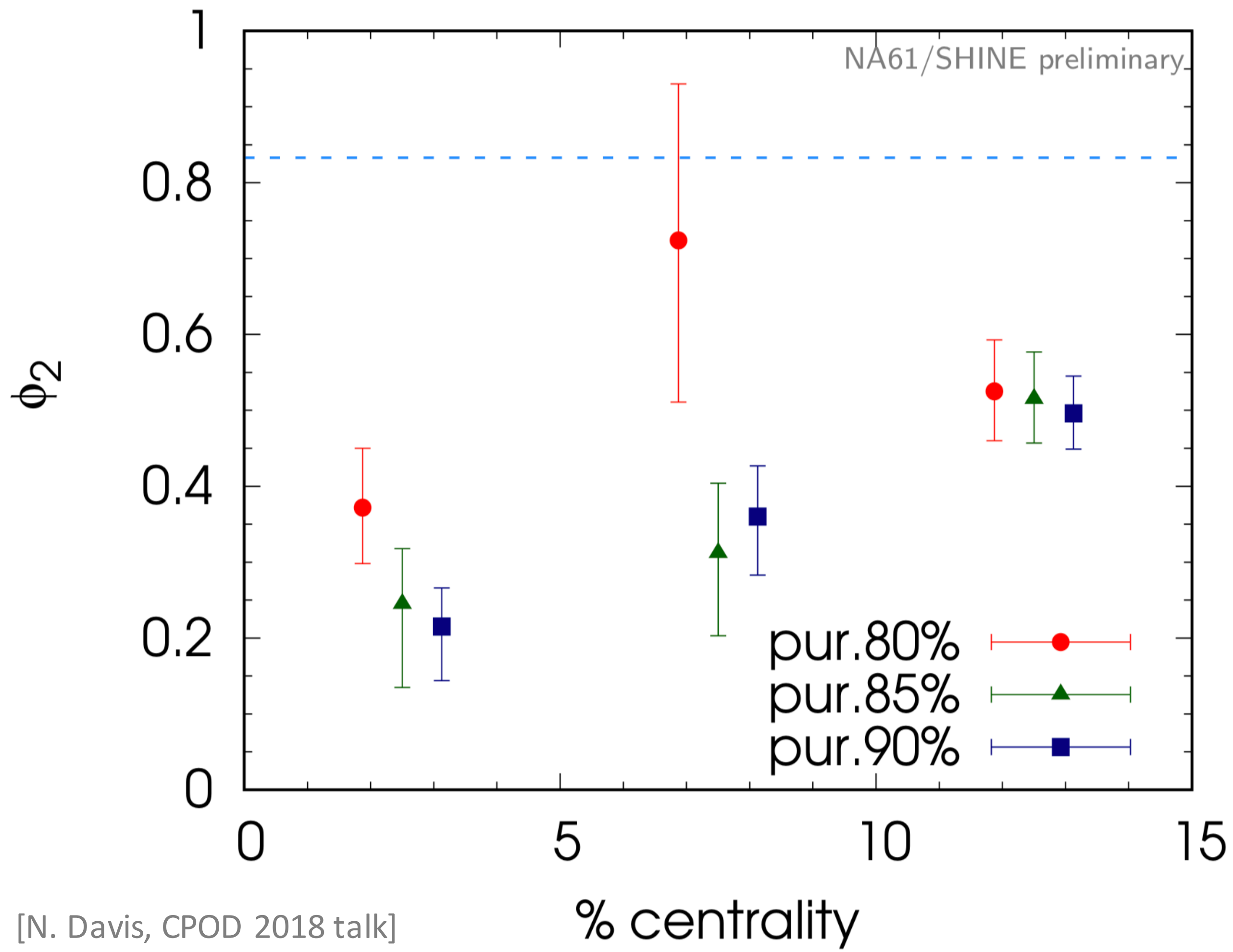


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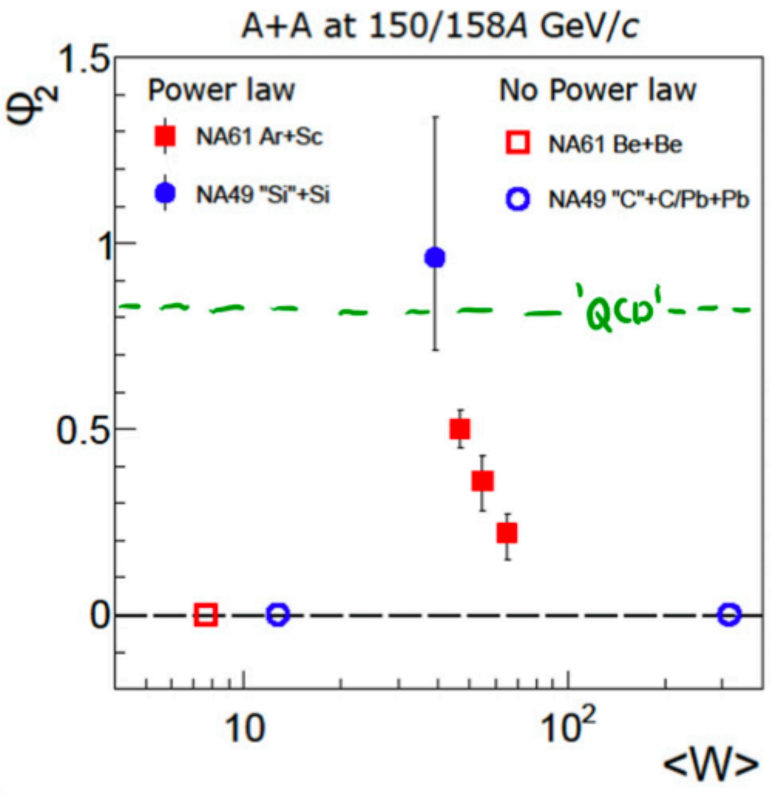


[M. Gazdzicki, indico.cern.ch]

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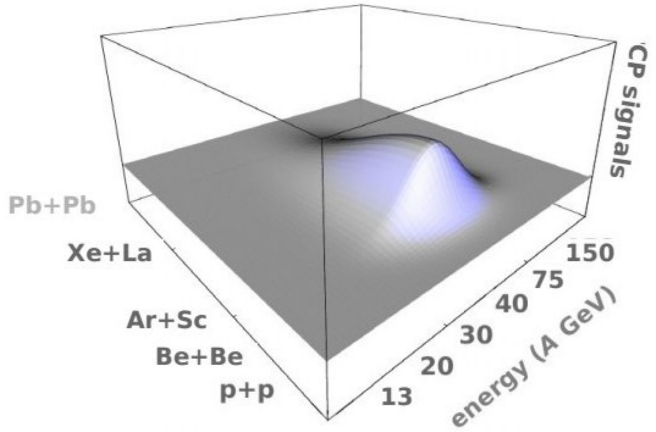

# Stay tuned and have a SHINY day!