A (fast) hypertriton experimental overview

Maximiliano Puccio (CERN)

Outline/Disclaimer

- Not a comprehensive review of the “Hypertriton lifetime puzzle”

➡*Personally I am not even sure there is a lifetime puzzle anymore*

- Hadronic-collider biased perspective
  - Most of the recent results were either at RHIC or LHC

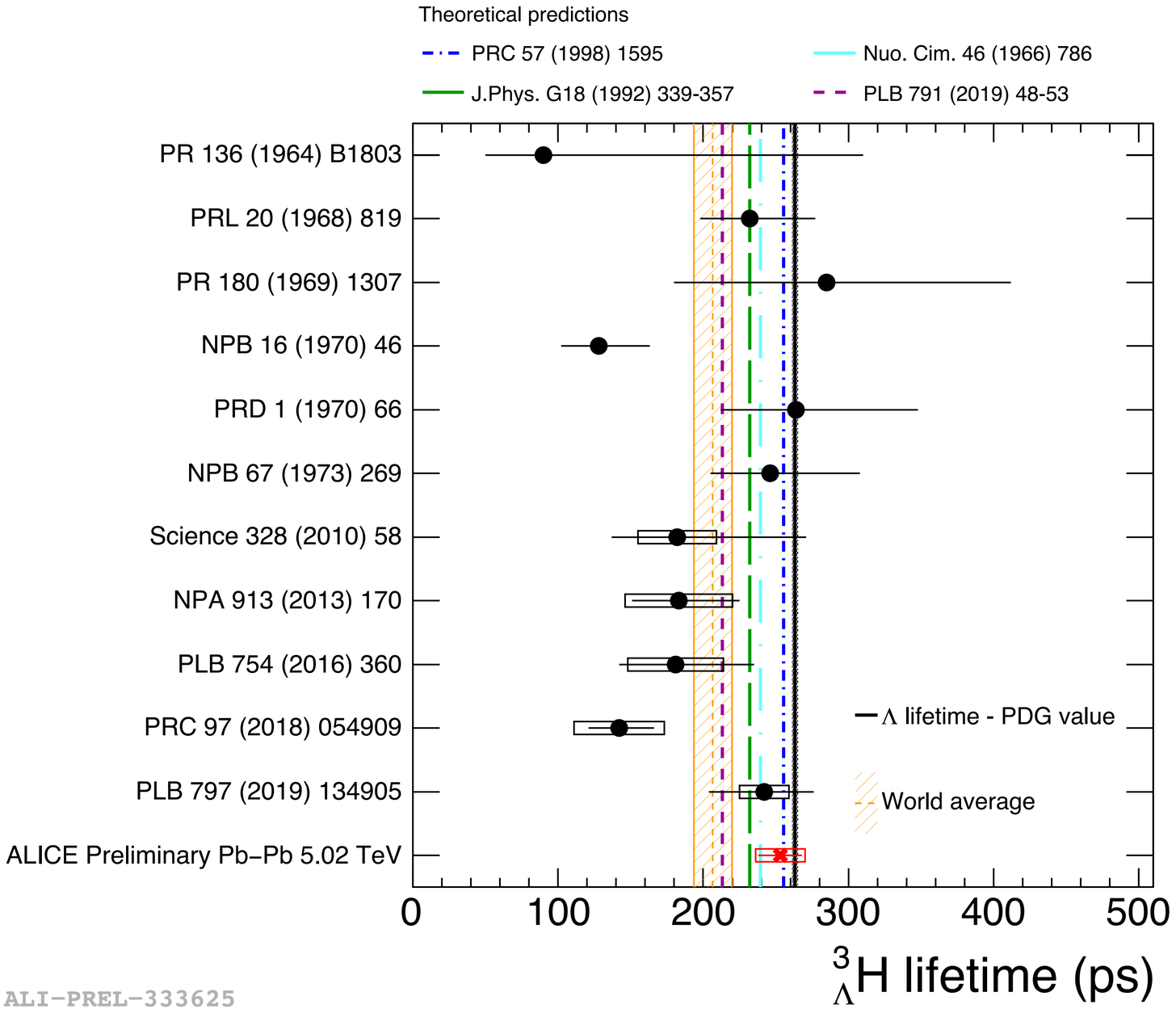
It is clear from all the discussions in these two days that if coalescence is the production mechanism:

Understanding the hypertriton structure

=

1/2 of understanding his production rate

Hyper triton lifetime



$^{3}_{\Lambda}$H as loosely bound object

- Kind of d-Λ state
- Theory expectations close to the free Λ lifetime

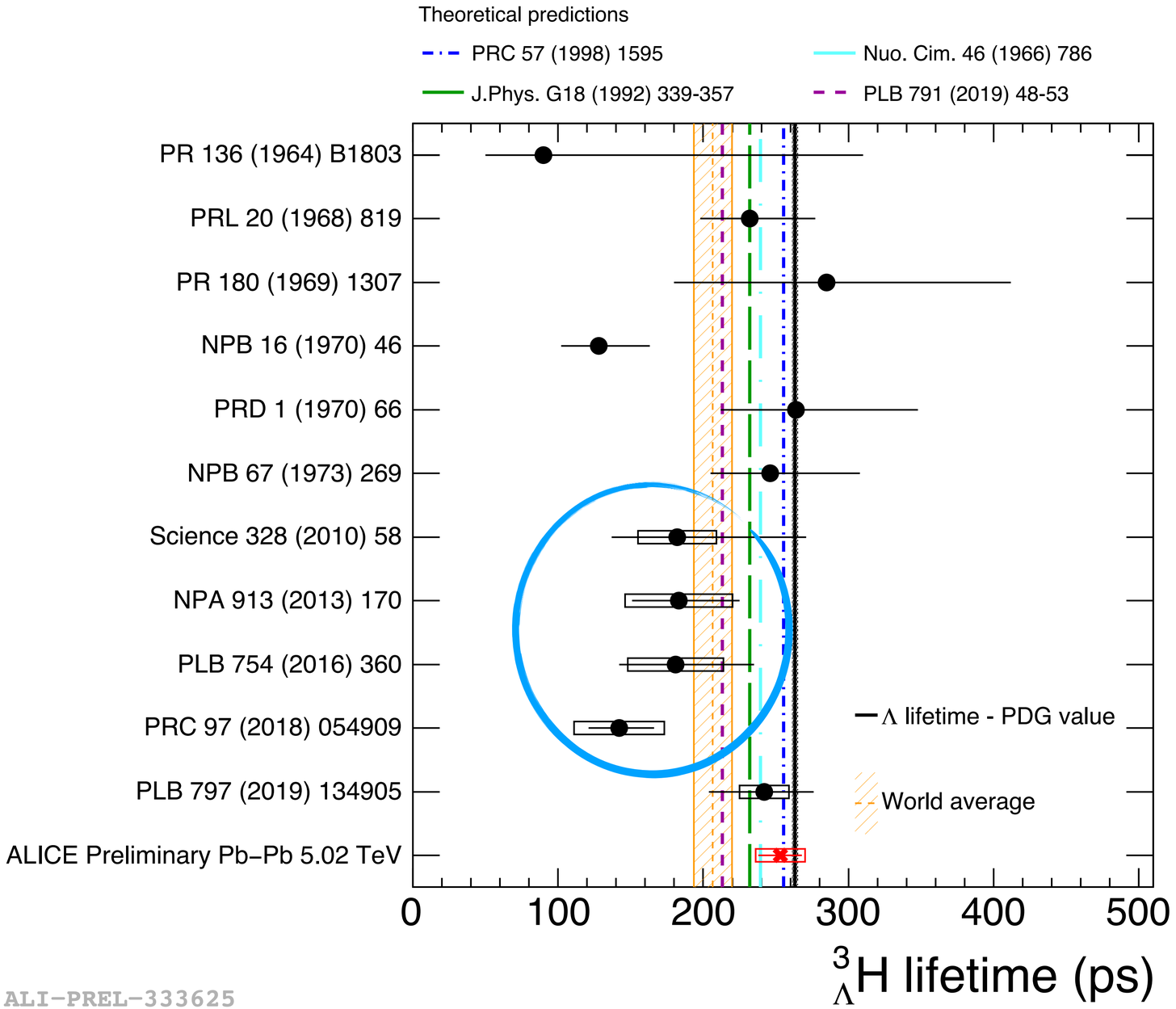
$^{3}_{\Lambda}$H lifetime from heavy ion experiments lower than Λ lifetime

- But still large uncertainty

Picture change with LHC Run2

- Lifetime compatible with Λ
- O(1%) uncertainties

Hyper triton lifetime



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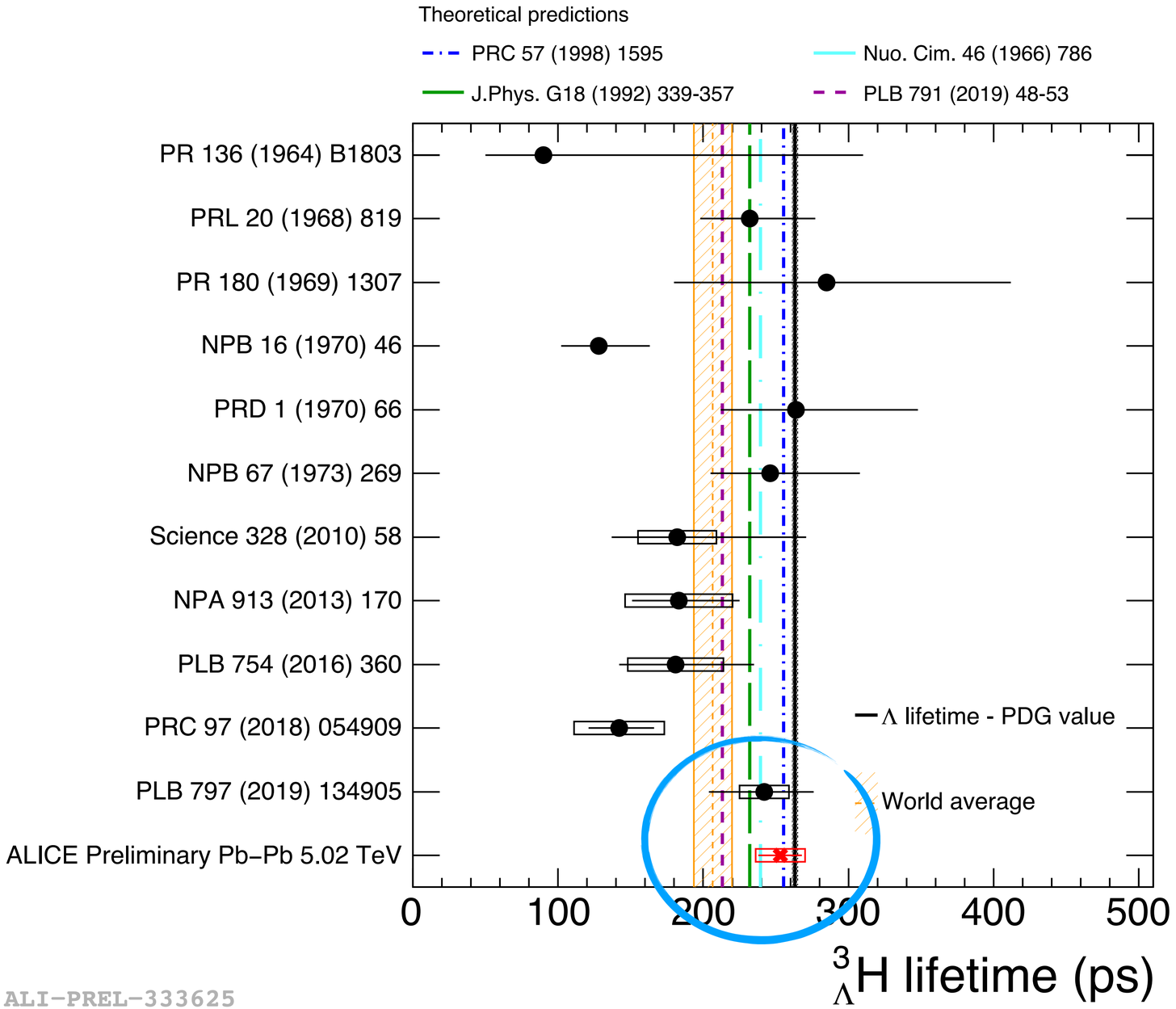

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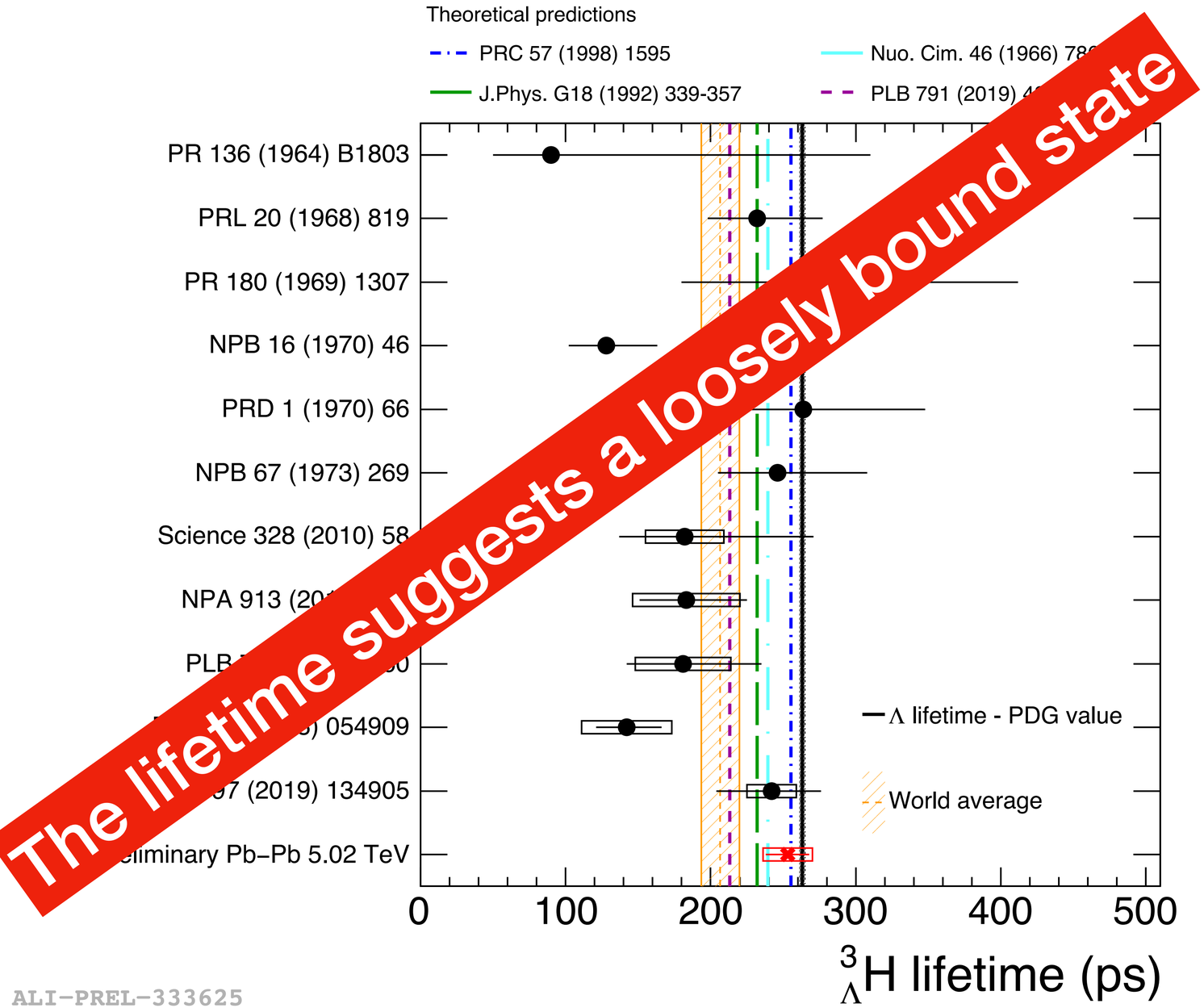

The lifetime suggests a loosely bound state

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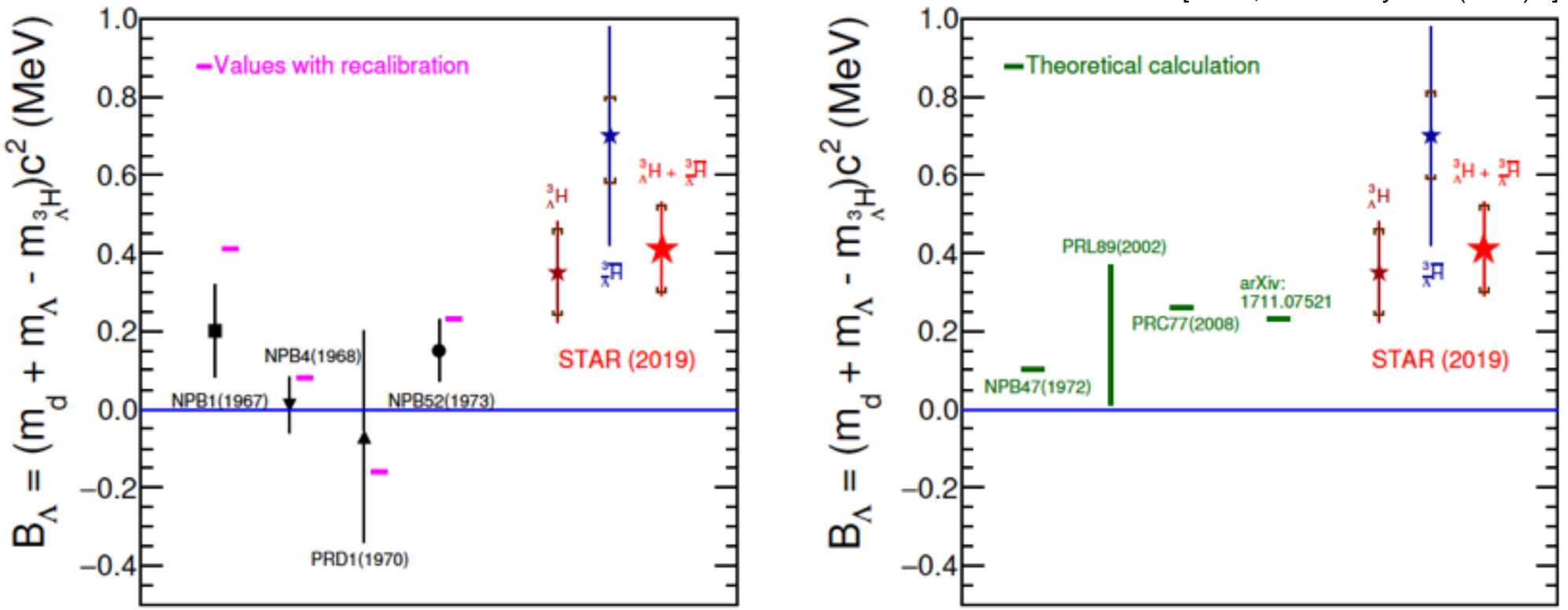
Direct measurement of the Λ binding energy

[*STAR, Nature Phys.* 16 (2020) 4]



Latest direct measurement of STAR: 0.41 ± 0.12(stat.) ± 0.11(syst.) MeV

- Debate in the community about the consistency of old emulsion data with modern measurements also for other hyper nuclei

Direct measurement of the Λ binding energy

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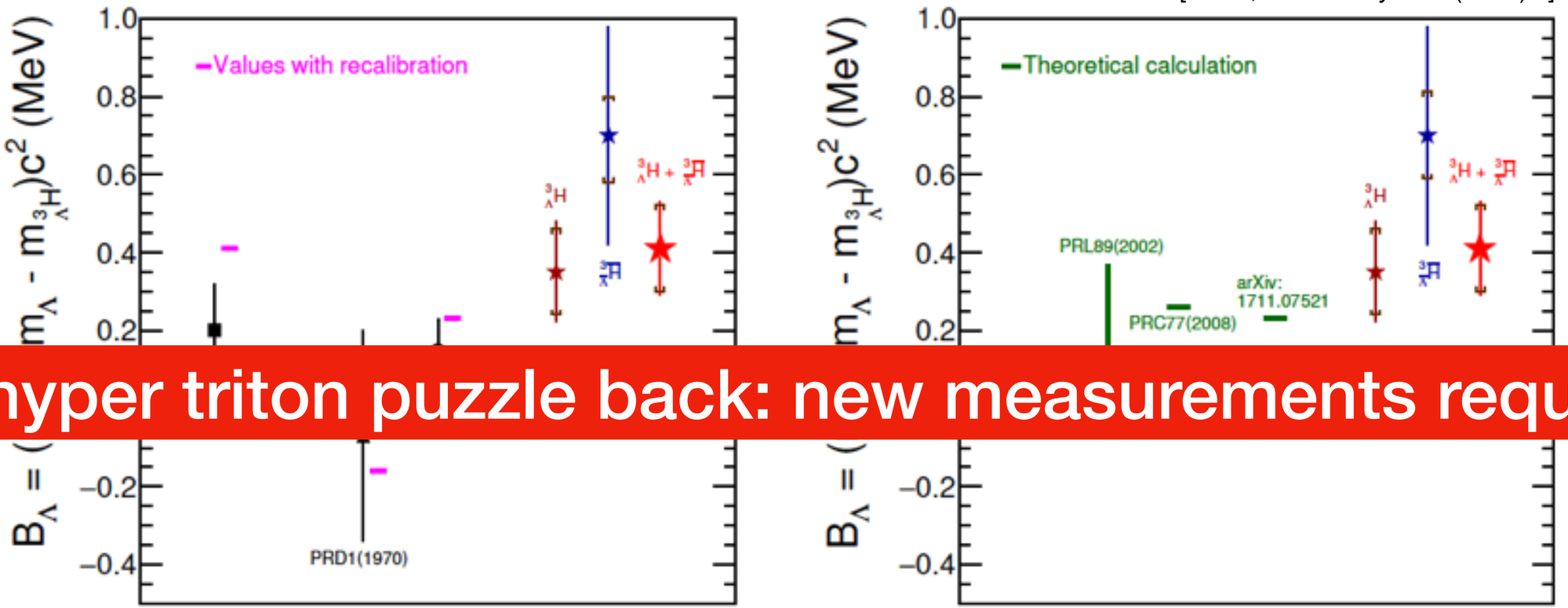

The hyper triton puzzle back: new measurements required

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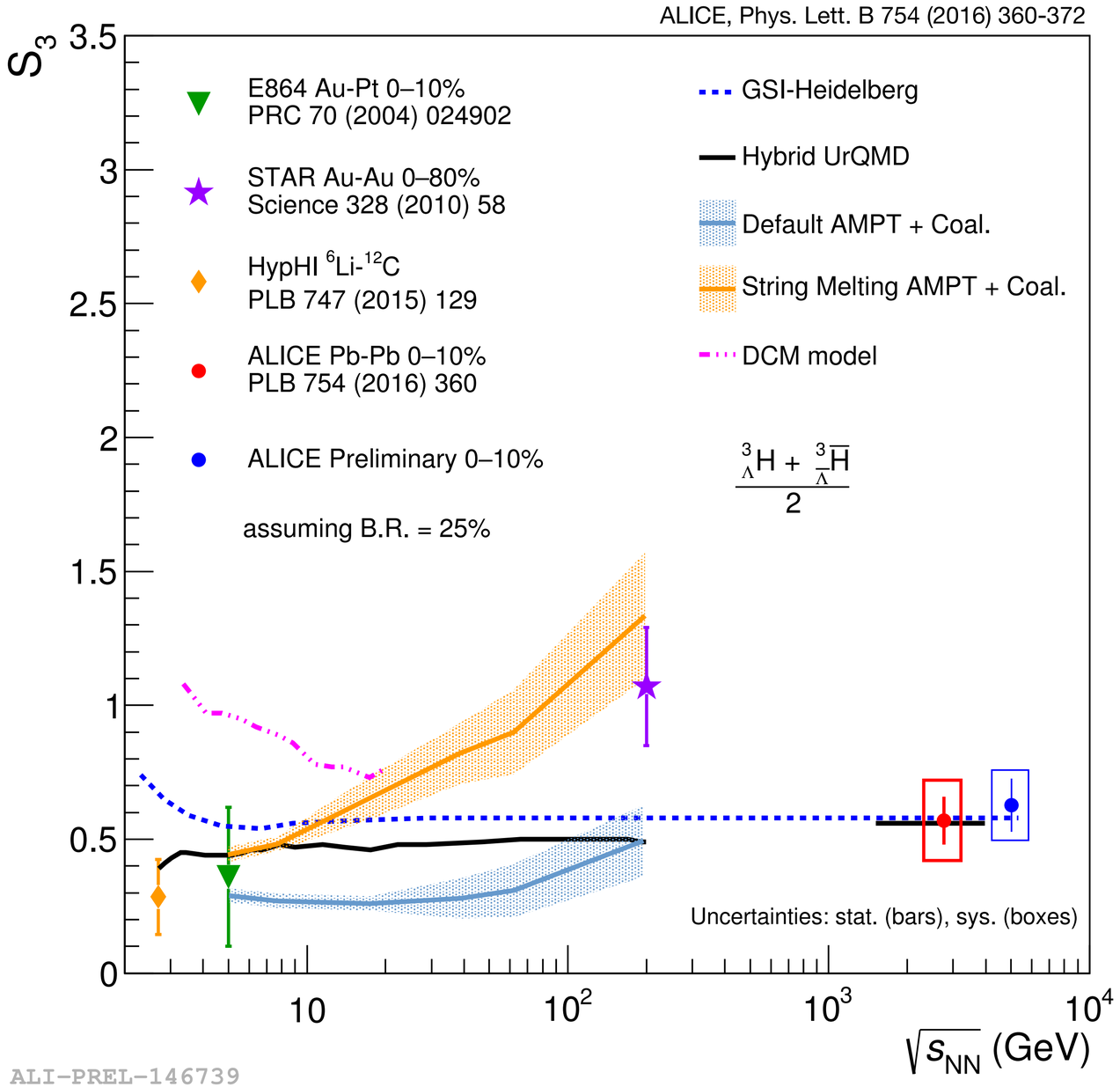
From structure to production



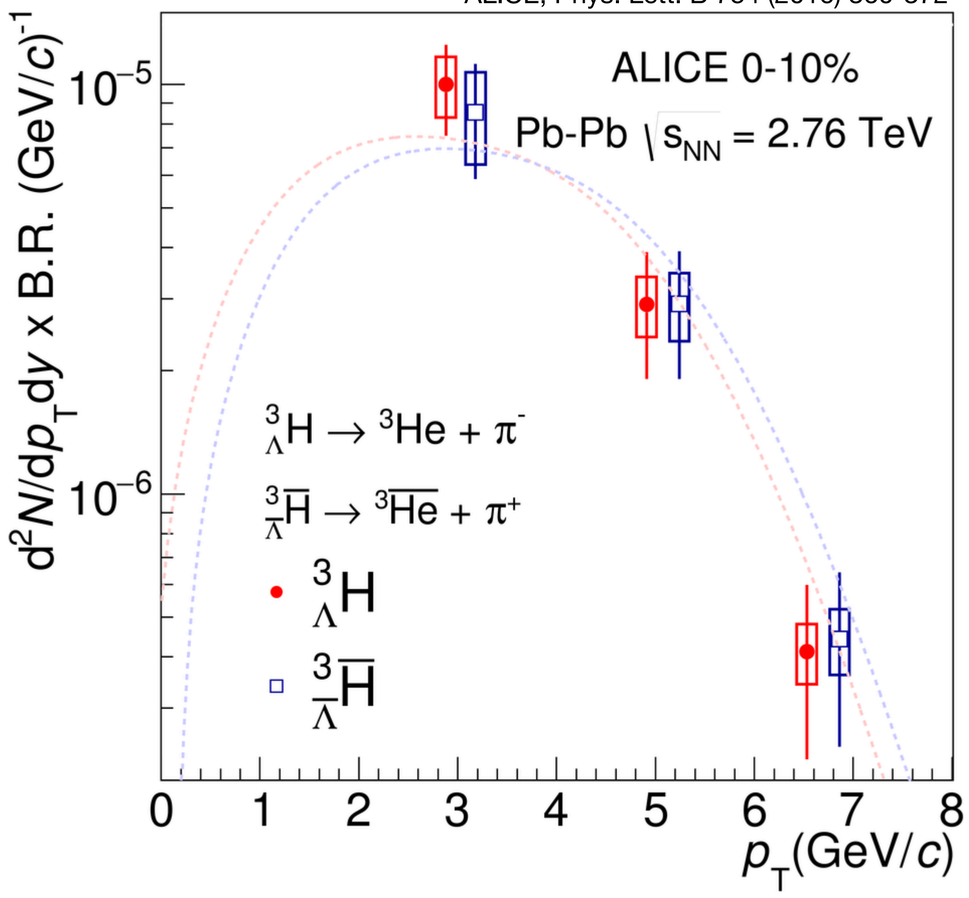
Direct model comparison using the S_3 parameter

$$S_3 = \frac{^3_\Lambda\mathrm{H} \,/\, ^3\mathrm{He}}{\Lambda \,/\, p}$$

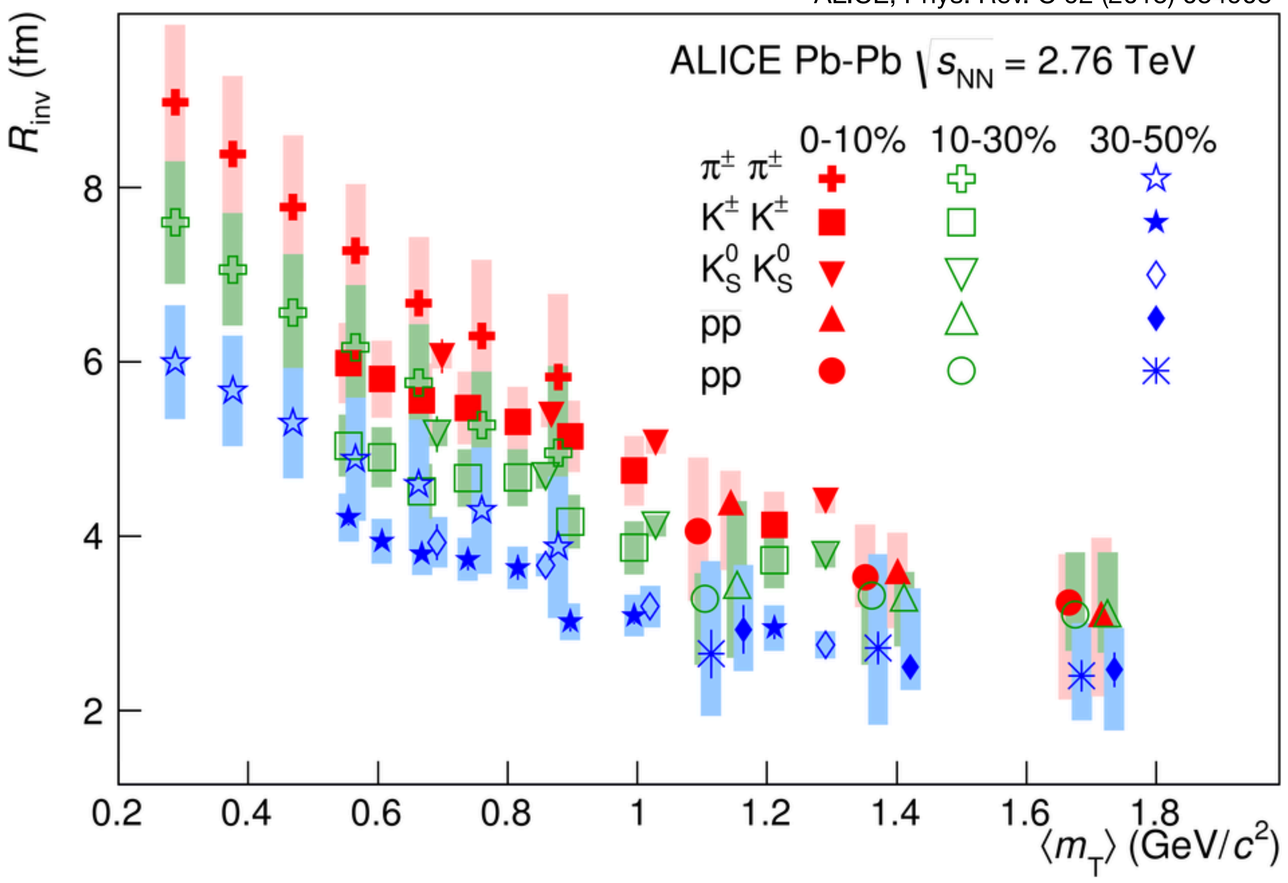
- Yields of (hyper-)nuclei agree with SHM predictions at *chemical* freeze-out.
- Final-state coalescence requires more detailed modelling: naive coalescence ($S_3 \approx 1$) does not describe data.

How to investigate coalescence

ALICE, Phys. Lett. B 754 (2016) 360-372



ALICE, Phys. Rev. C 92 (2015) 054908



- Coalescence predicted rates depends on the HBT radius
- Integrated S3 can be compared, but require modelling on the average radius
  - Comparison with p_T differential measurements

Coalescence at work

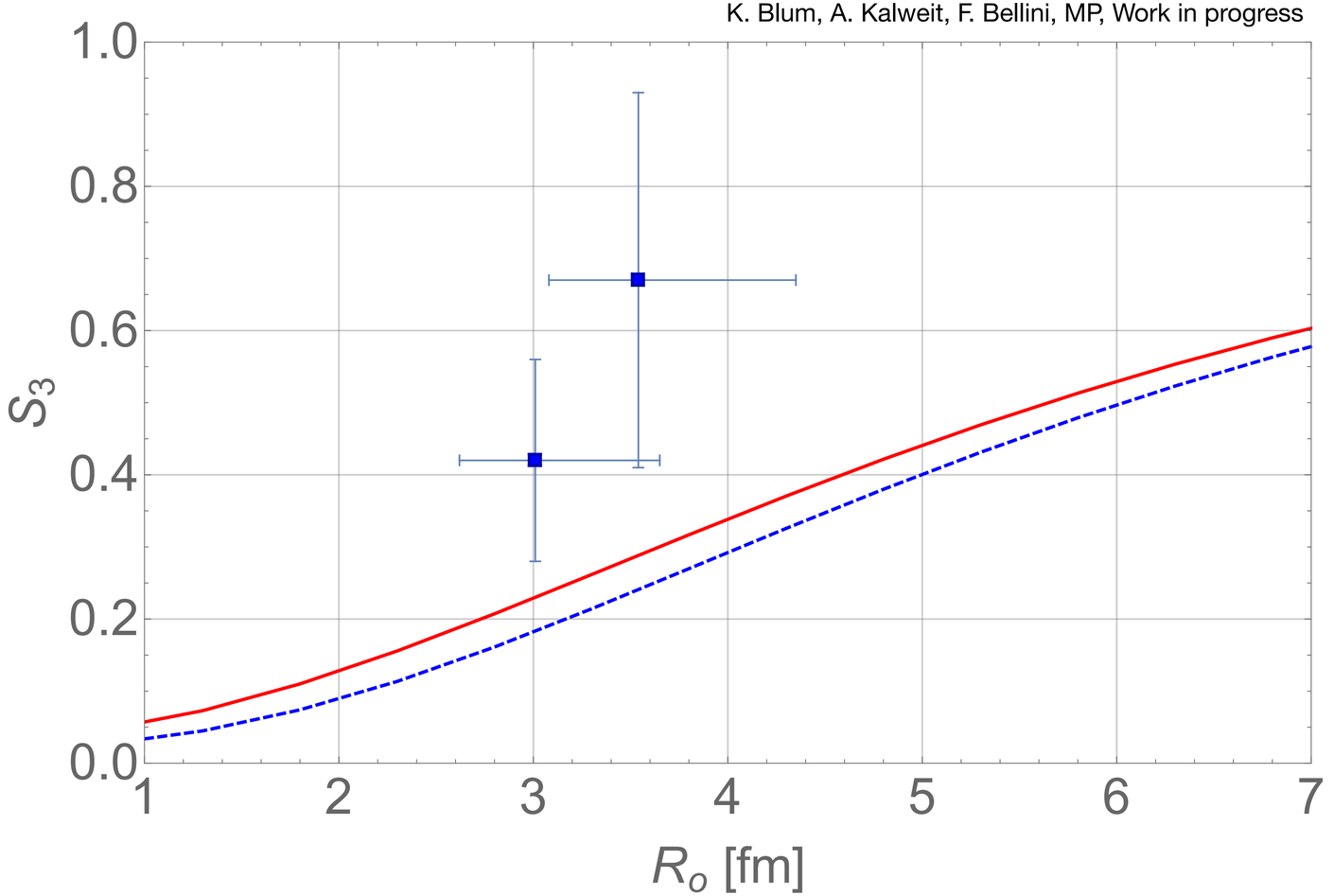
- Using ALICE data it is possible to map p_T, centrality in R
- Comparison with coalescence calculation

$$S_3 \approx \frac{\left(b_{\mathrm{He}}^2 + 2R_o^2\right)^3}{\left(b_{pn}^2 + 2R_o^2\right)^{\frac{3}{2}} \left(b_{\Lambda}^2 + 2R_o^2\right)^{\frac{3}{2}}}$$

Dashed line: ${}^{3}_{\Lambda}\mathrm{H}$ with unisotropic gaussian wave function

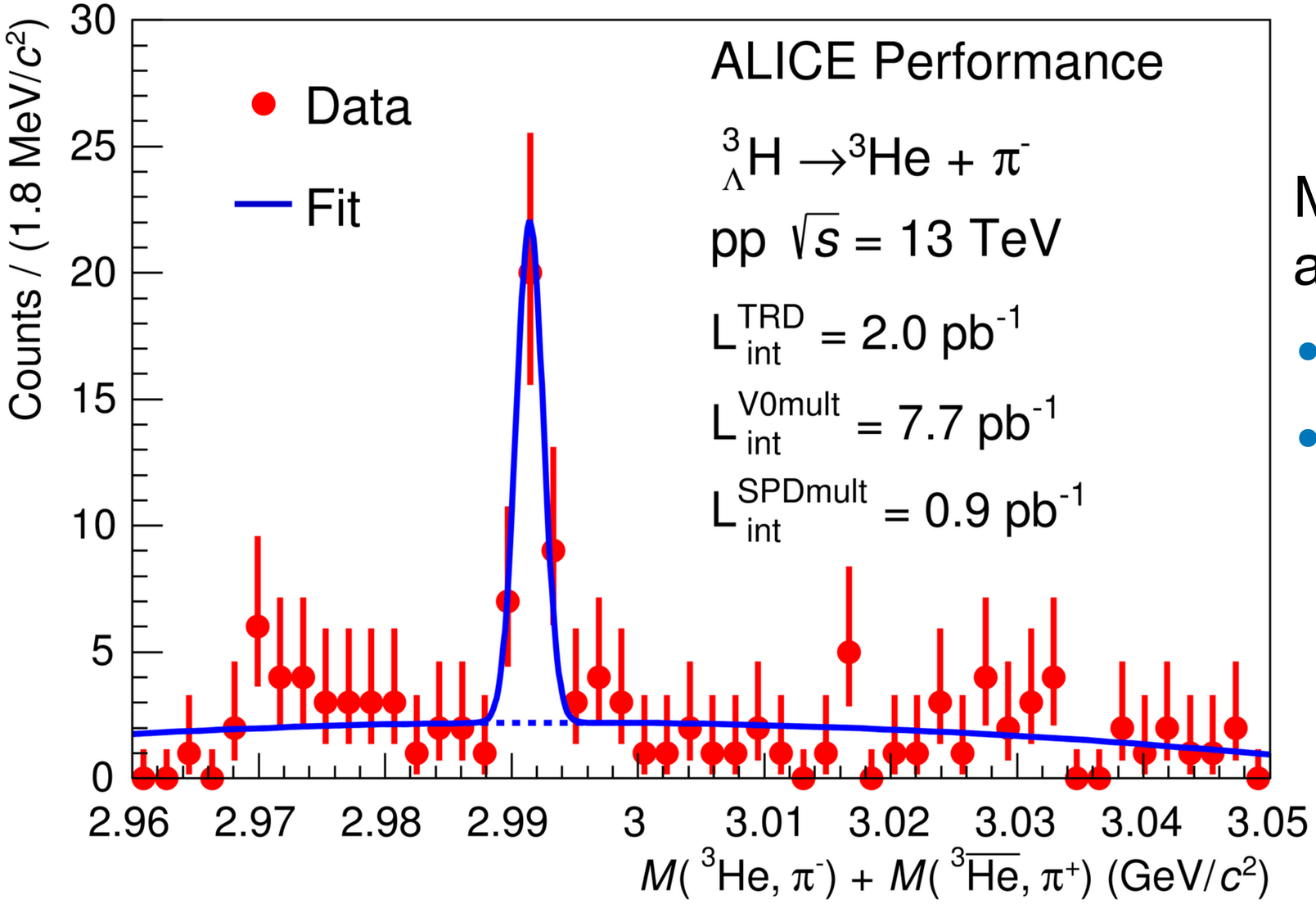
Solid line: realistic ${}^{3}_{\Lambda}\mathrm{H}$ wave function

K. Blum, A. Kalweit, F. Bellini, MP, Work in progress



$$S_3 = \frac{\mathcal{B}_{3\Lambda}}{\mathcal{B}_3} \approx \frac{\int d^3\mathbf{k}_d \int d^3\mathbf{k}_\Lambda \, \mathcal{F}_{\mathcal{H}}(\mathbf{k}_d, \mathbf{k}_\Lambda) \, e^{-R_o^2\left(\mathbf{k}_d^2 + \frac{3}{4}\mathbf{k}_\Lambda^2\right)}}{\int d^3\mathbf{k}_{pp} \int d^3\mathbf{k}_n \, \mathcal{F}_{\mathrm{He}}(\mathbf{k}_{pp}, \mathbf{k}_n) \, e^{-R_o^2\left(\mathbf{k}_{pp}^2 + \frac{3}{4}\mathbf{k}_n^2\right)}}$$

What about small systems?



Maybe ALICE already has the answer

- Few /pb give a good signal
- Does this already give us a hint of where we stand in SHM vs coalescence?

Personal view

Todo list for experimentalists:

- Have another precise measurement of the hyper triton line shape to confirm STAR findings
- Hypertriton in Pb-Pb: we know we can go to high p_T, but then we miss radius measurements
- Small systems: the last frontier
  - Any theory uncertainty cannot cover the orders of magnitude between SHM and coalescence