PRODUCTION OF LIGHT NUCLEI AT HIGH p_T IN PbPb/pp AND EXOTIC SPECTROSCOPY

AD POLOSA
SAPIENZA UNIVERSITY

W/ A. ESPOSITO, A. GUERRIERI, L. MALANI, F. PICCININI
A. PILLONI, V. RADUER.

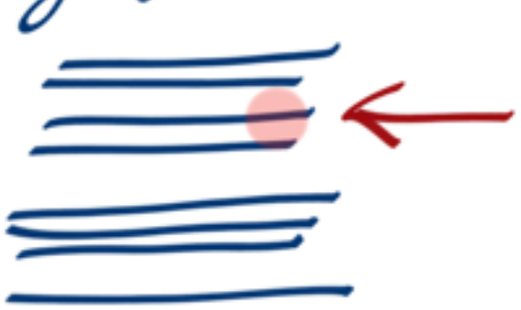
X(2) SPECTROSCOPY

THE '+' APPROACH

look for mesons w/ masses

$m_1 + m_2 \geq m$

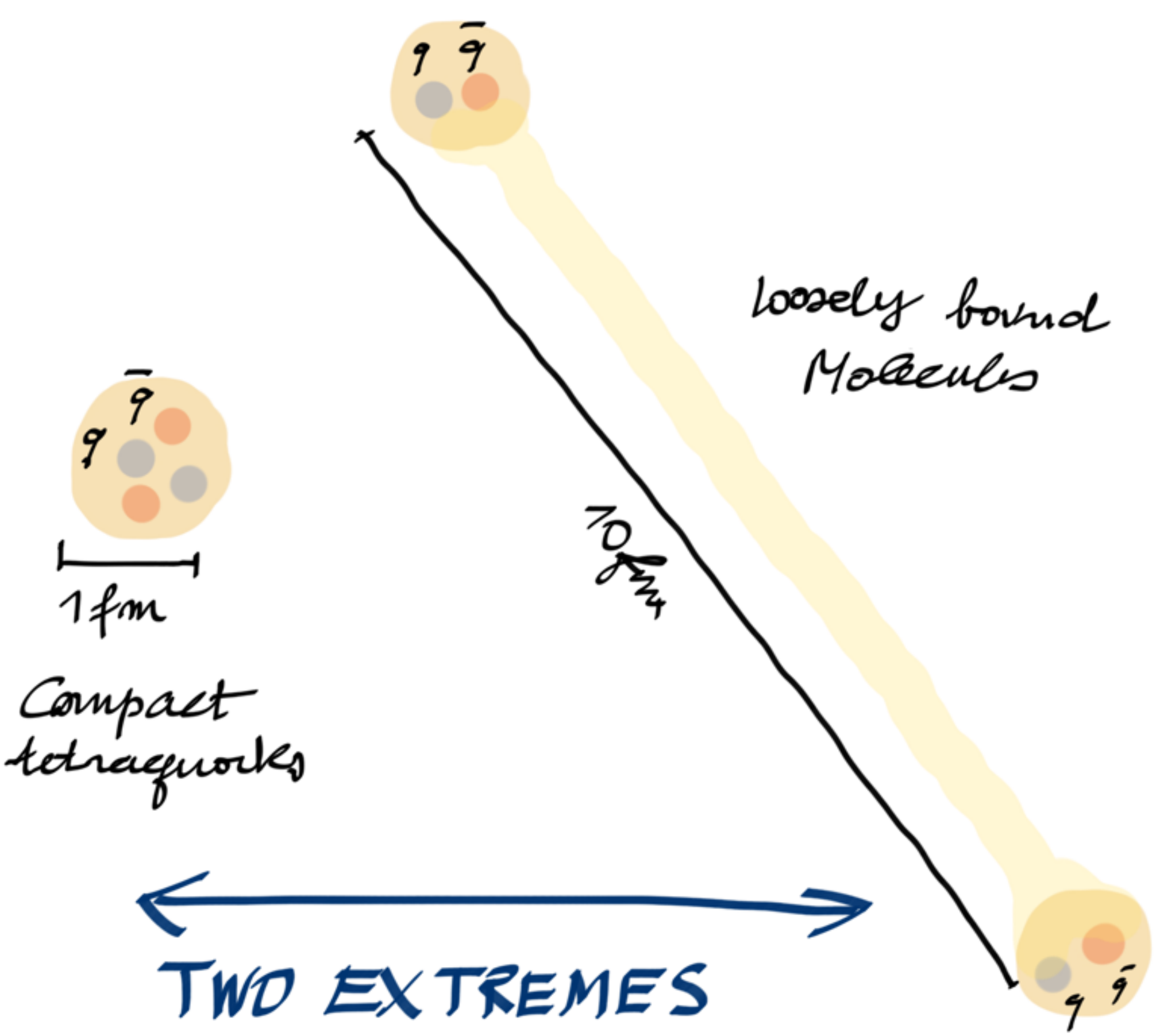
loosely or deeply bound molecules

PDB → 

THE '⊕' APPROACH

work with quarks, diquarks and symmetries

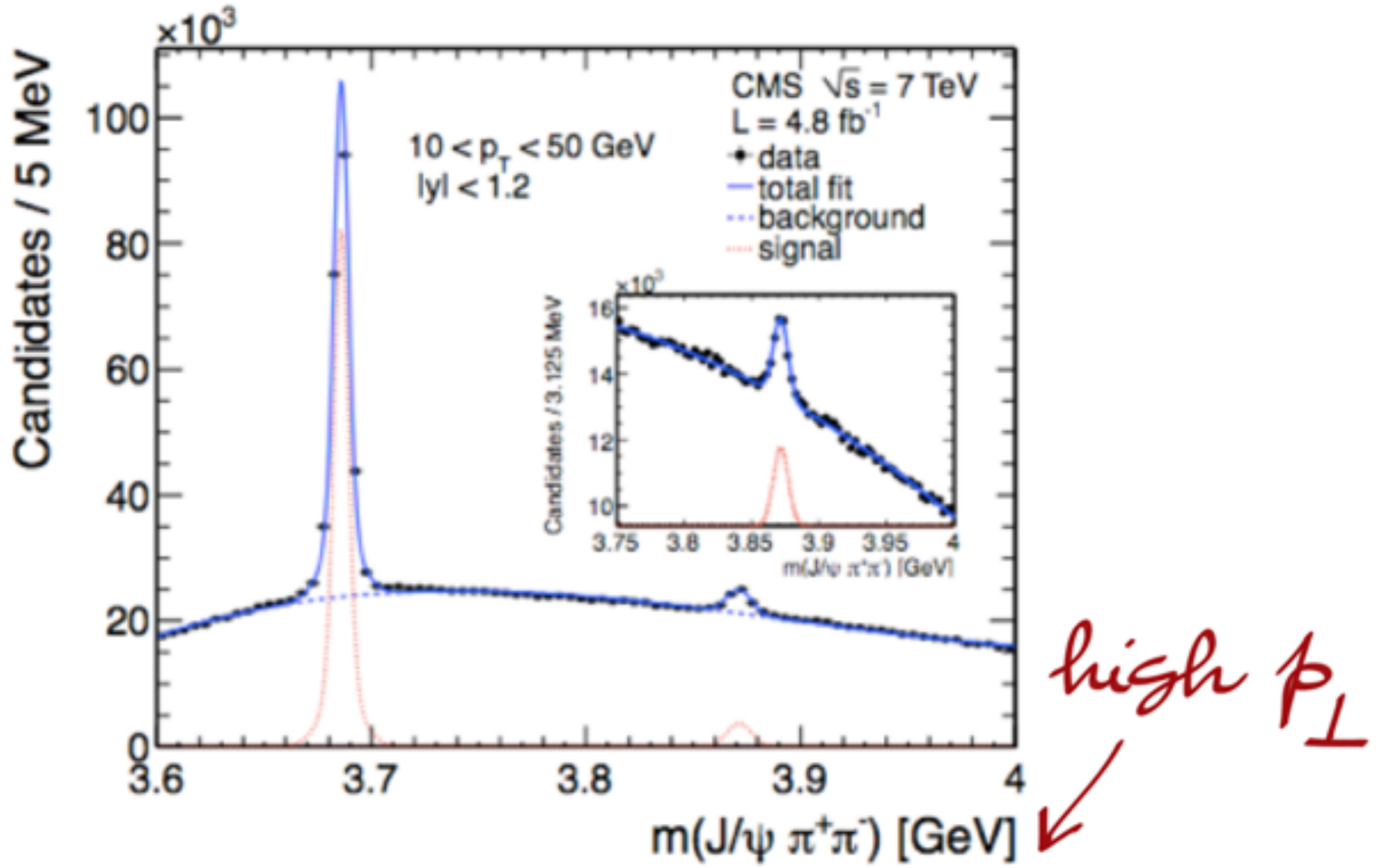
$X \in \underline{8}$ of SU(3) ?


q q̄
q q̄
1 fm
Compact tetraquarks
loosely bound Molecules
TWO EXTREMES
q q̄

X(3872) @ CMS

Confirming CDF results : $\sigma \approx 30 \div 50$ nb

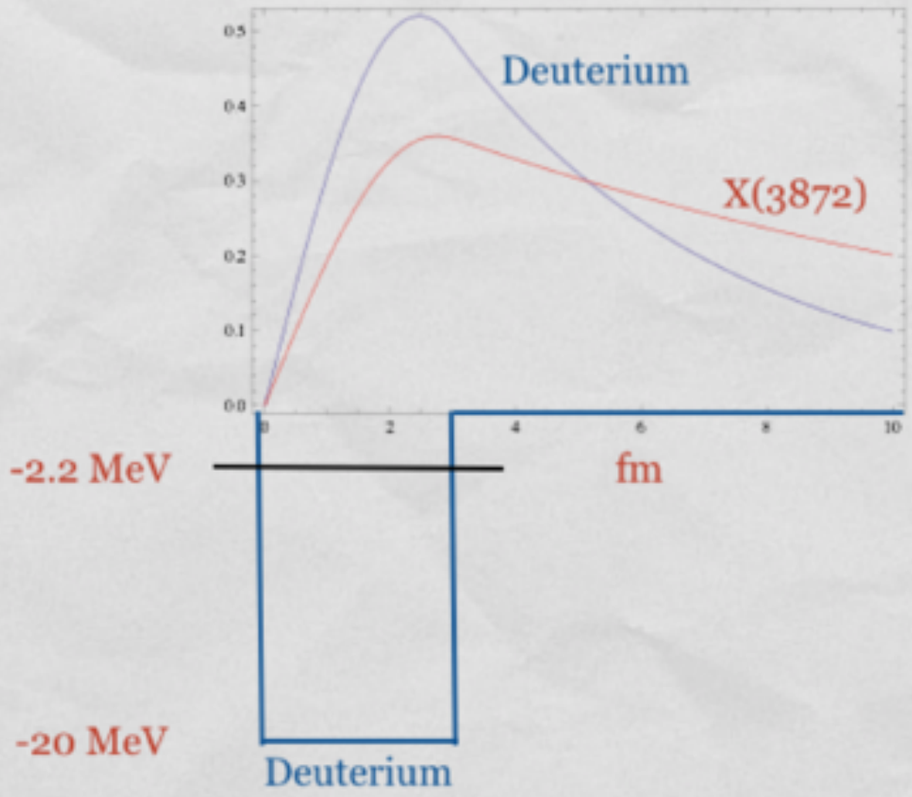
4 Measurement of the cross section ratio



high $p_\perp$

Figure 1: The $J/\psi\pi^+\pi^-$ invariant-mass spectrum for $10 < p_T < 50$ GeV and $|y| < 1.2$. The lines represent the signal-plus-background fits (solid), the background-only (dashed), and the signal-only (dotted) components. The inset shows an enlargement of the X(3872) mass region.

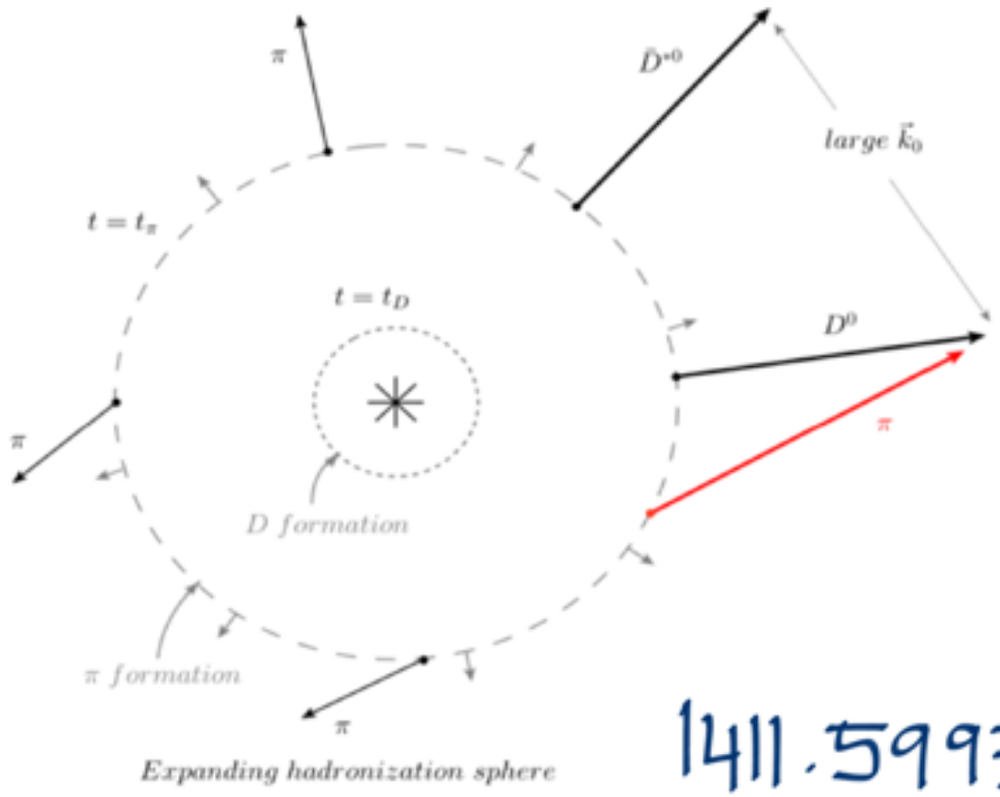
IS THE X(3872) SOME SORT OF DD* DEUTERON?



$$k_{\rm rel} = \sqrt{2\mu\langle T\rangle^2_\psi} \approx \begin{cases} 80 \text{ MeV} & \text{for deuterium} \\ 50 \text{ MeV} & \text{for } X; \quad U_0 \approx -7 \text{ MeV} \quad \mathcal{E}_b \approx -0.14 \text{ MeV} \end{cases}$$

$$\frac{\hbar^2}{2\mu r_0^2} - \frac{g^2}{4\pi}\frac{e^{-\frac{m_\pi c}{\hbar} r_0}}{r_0} = \mathcal{E}_b = 0.14 \text{ MeV} \Rightarrow r_0 \approx 12 \text{ fm}$$

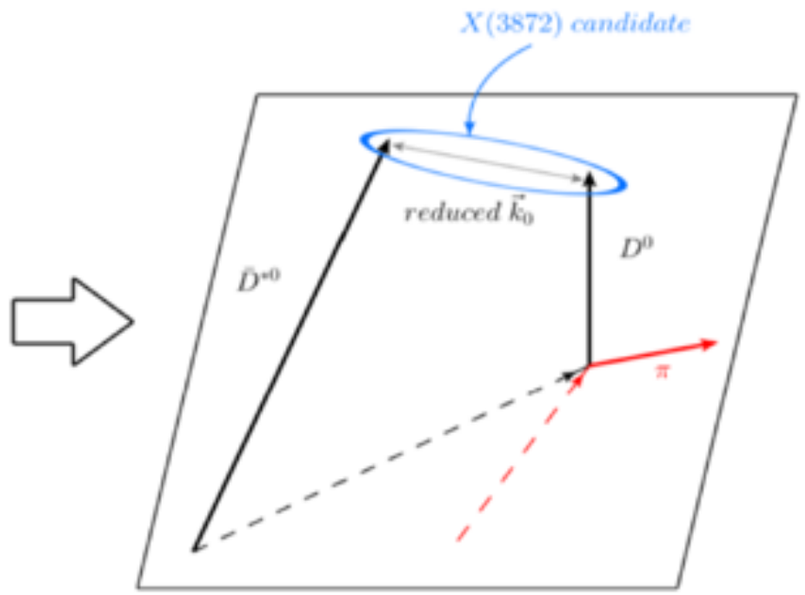
RESCATTERING?



Expanding hadronization sphere

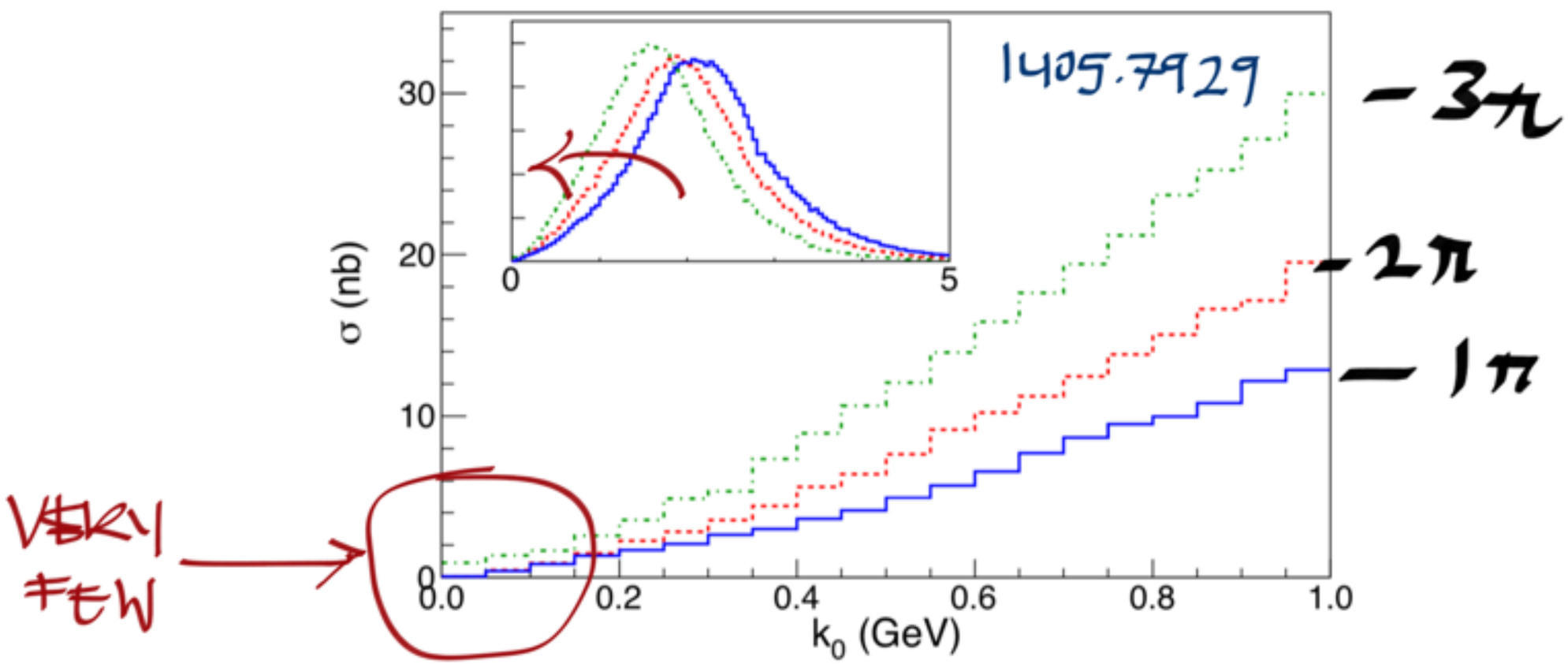
(a)

1411.5997

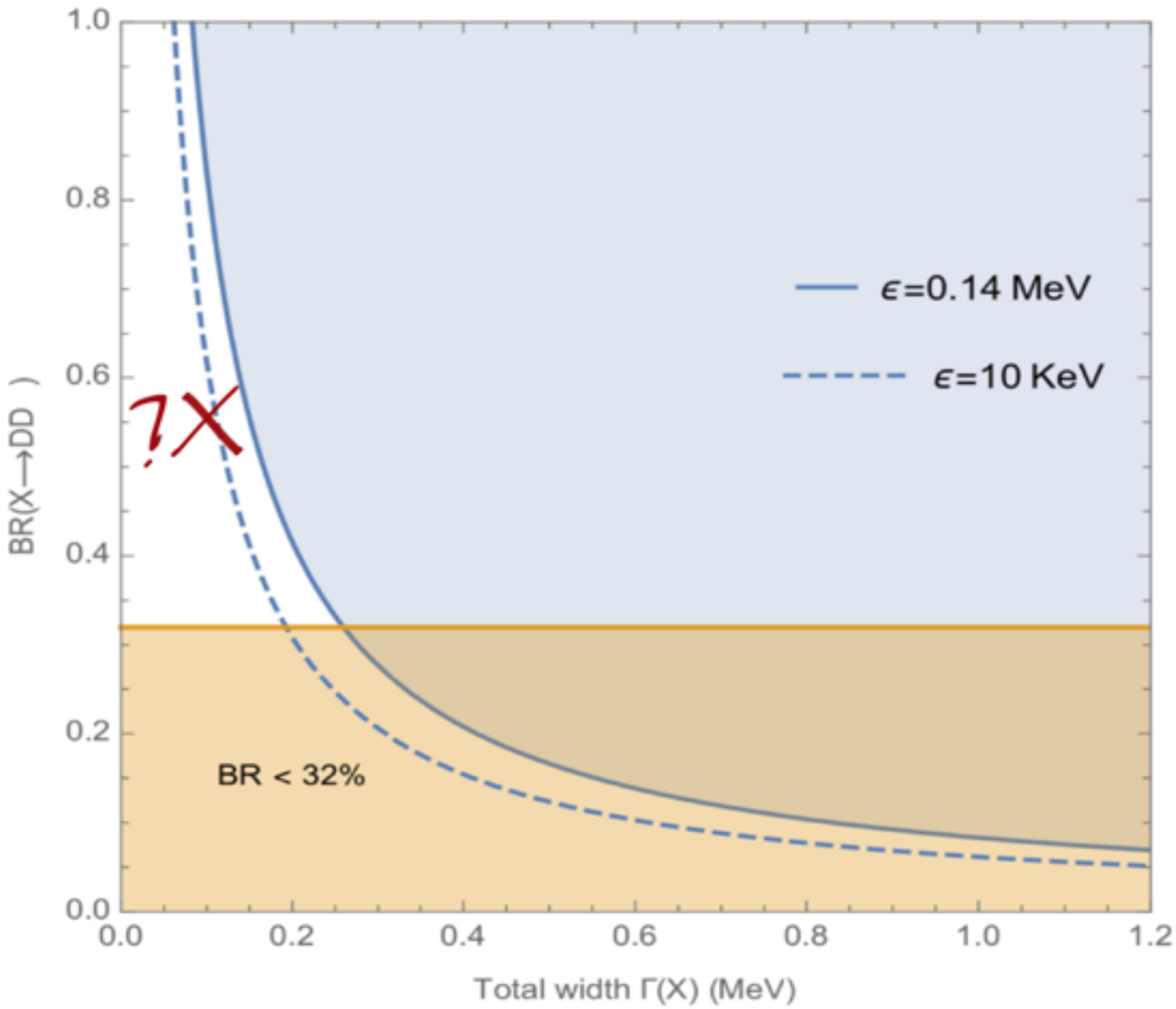


Plane $\pi - D$ rescattering

(b)

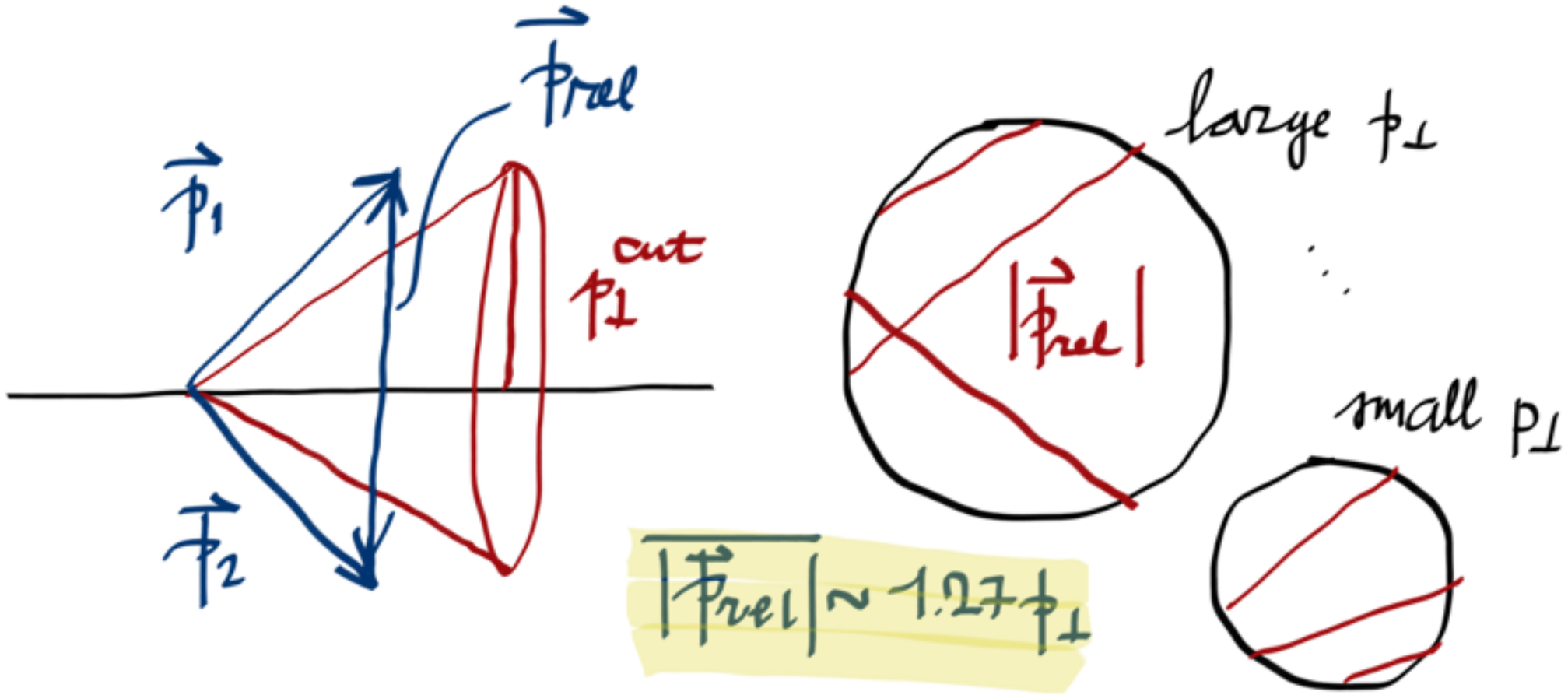


FINE TUNED X



PLB746 (2015) 248

HIGH $p_\perp$

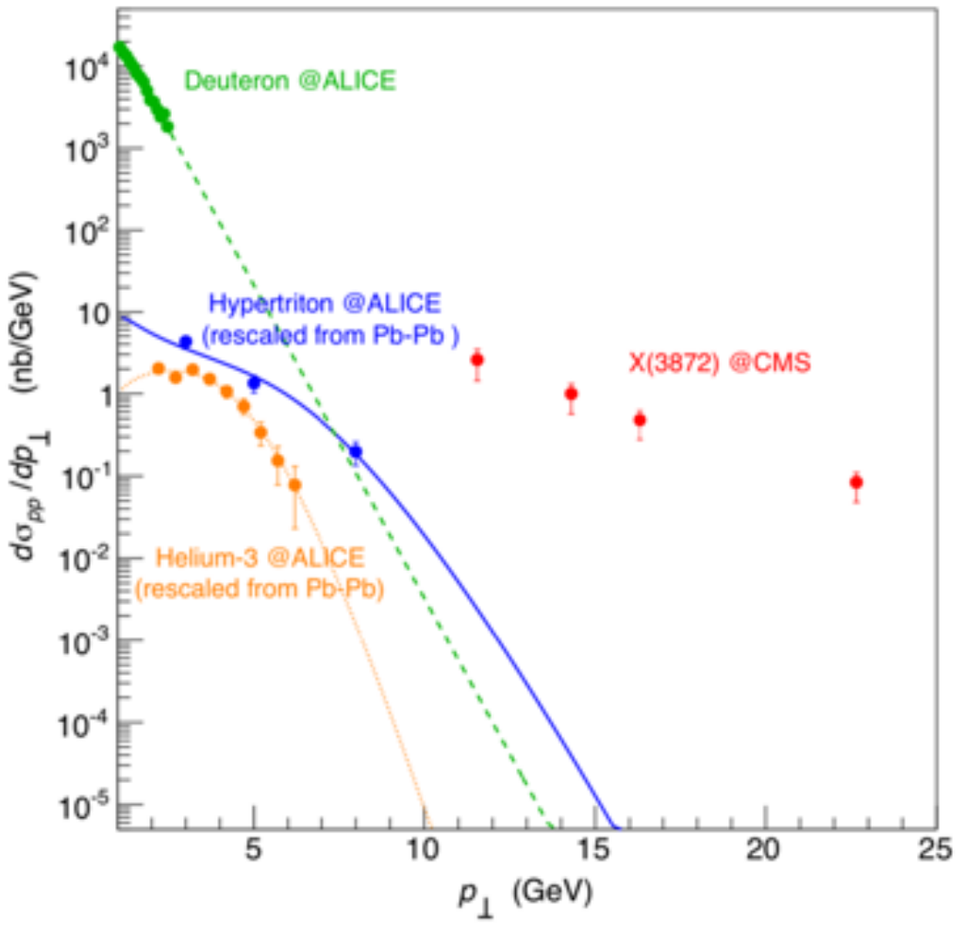


$$\mathcal{E}_B(X) \lesssim 140 \text{ KeV} \qquad \mathcal{E}_B({}^3_{\hat{}}H) \simeq 100 \text{ KeV}$$

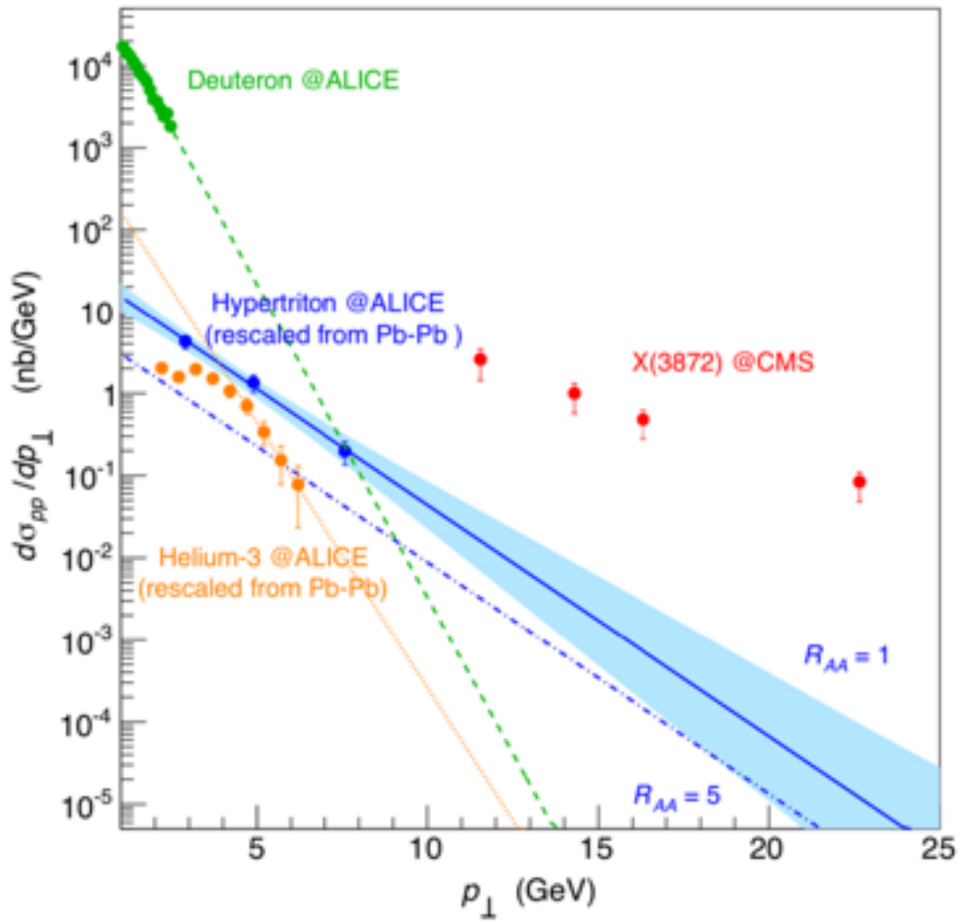
$$\Gamma(X) \lesssim 1.2 \text{ MeV}$$

HYPERTRITON & X(3872)

FROM ALICE PAPS. 1506.08453 & 1506.08951



'BLAST WAVE'



'EXP FIT'

$^{3}_{\Lambda}H$ | FALLS SHORT BY ORDERS OF MAGNITUDE

QUESTIONS

1. Integrated luminosity?
   ($\simeq 100\ mb^{-1}$)
2. CROSS SECTION OF $^{3}_{\Lambda}H$?
   ($\approx 100 mb$??)
3. From PbPb → pp just Glauber, or medium effects are known to be strong?
4. p_T slope of $^{3}_{\Lambda}H$ wrt ^{3}He?

OUR APPROACH

$$R_{AA} = \frac{\left(\frac{1}{N_e}\frac{d^2N(\pi\,{}^4\mathrm{He})}{dp_T\,dy}\right)^{0\text{-}10\%}}{N_C^{0\text{-}10\%}\left(\frac{1}{N_e}\frac{d^2N(\pi\,{}^4\mathrm{He})}{dp_T\,dy}\right)_{pp}}$$

assume ~ 1

Use that $\mathcal{L}_e\,\sigma_{pp}^{inel} = N_e$ (here 20_{+6} evts)

$$\left.\frac{d^2\sigma(\pi\,{}^4\mathrm{He})}{dp_T\,dy}\right|_{pp} = \frac{\sigma_{pp}^{inel}}{N_C^{0\text{-}10\%}}\left(\frac{1}{N_e}\frac{d^2N(\pi\,{}^4\mathrm{He})}{dp_T\,dy}\right)^{0\text{-}10\%}$$

MEASURED

$\Rightarrow R_{AA} = 1$

SOME NUMBERS

1. $\sigma_{pp}^{inel} = 73\,mb$ @ 7 TeV

2. $N_e = 20_{+6}$ $^{3}_{\Lambda}H$ in $0 \div 10$ %.

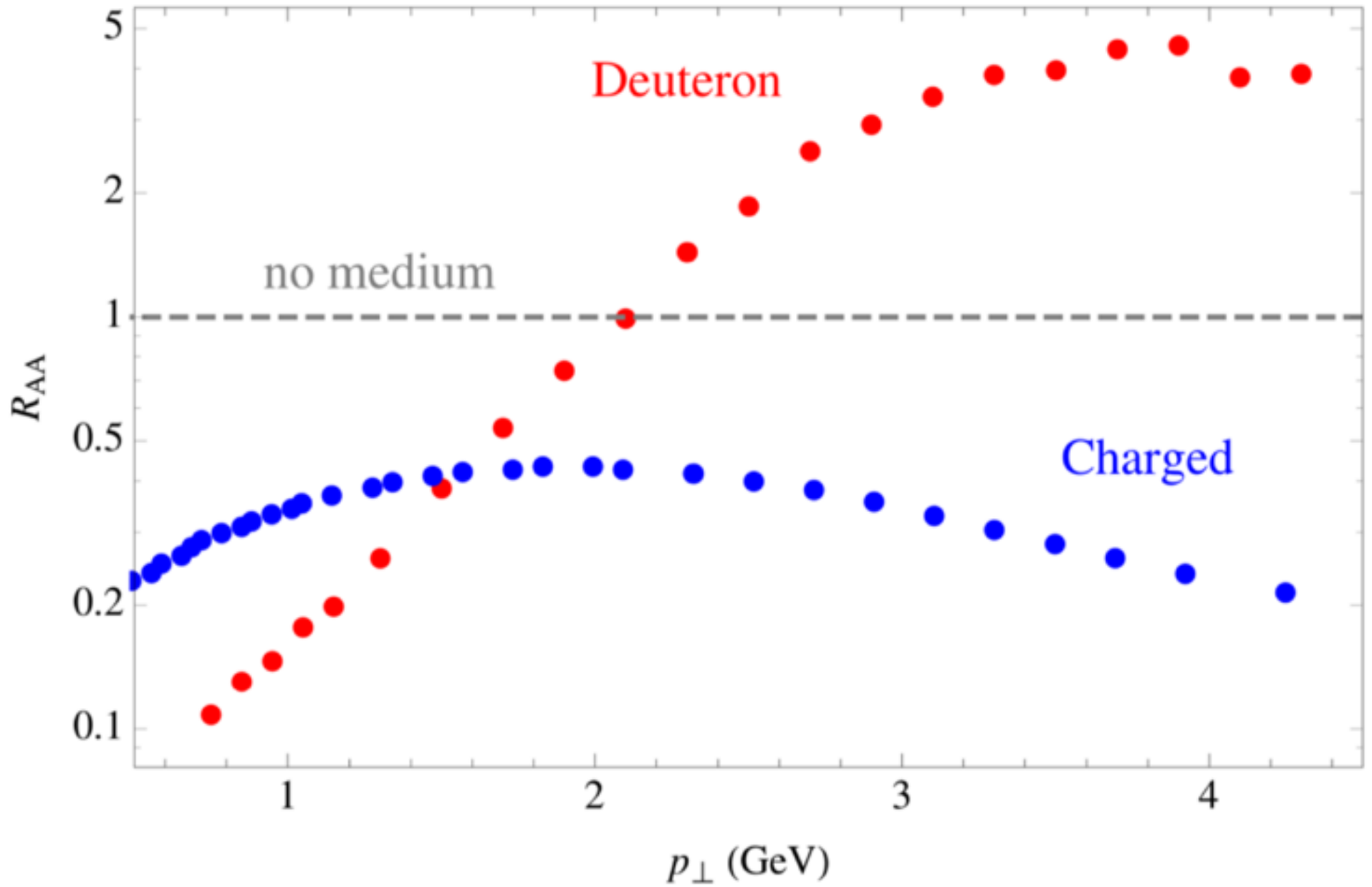
3. $B(^{3}_{\Lambda}H \to \pi\, ^{3}He) \approx 25$ %.

   As divide in the previous formula.

4. $N_c^{0-10\%} = 1518$

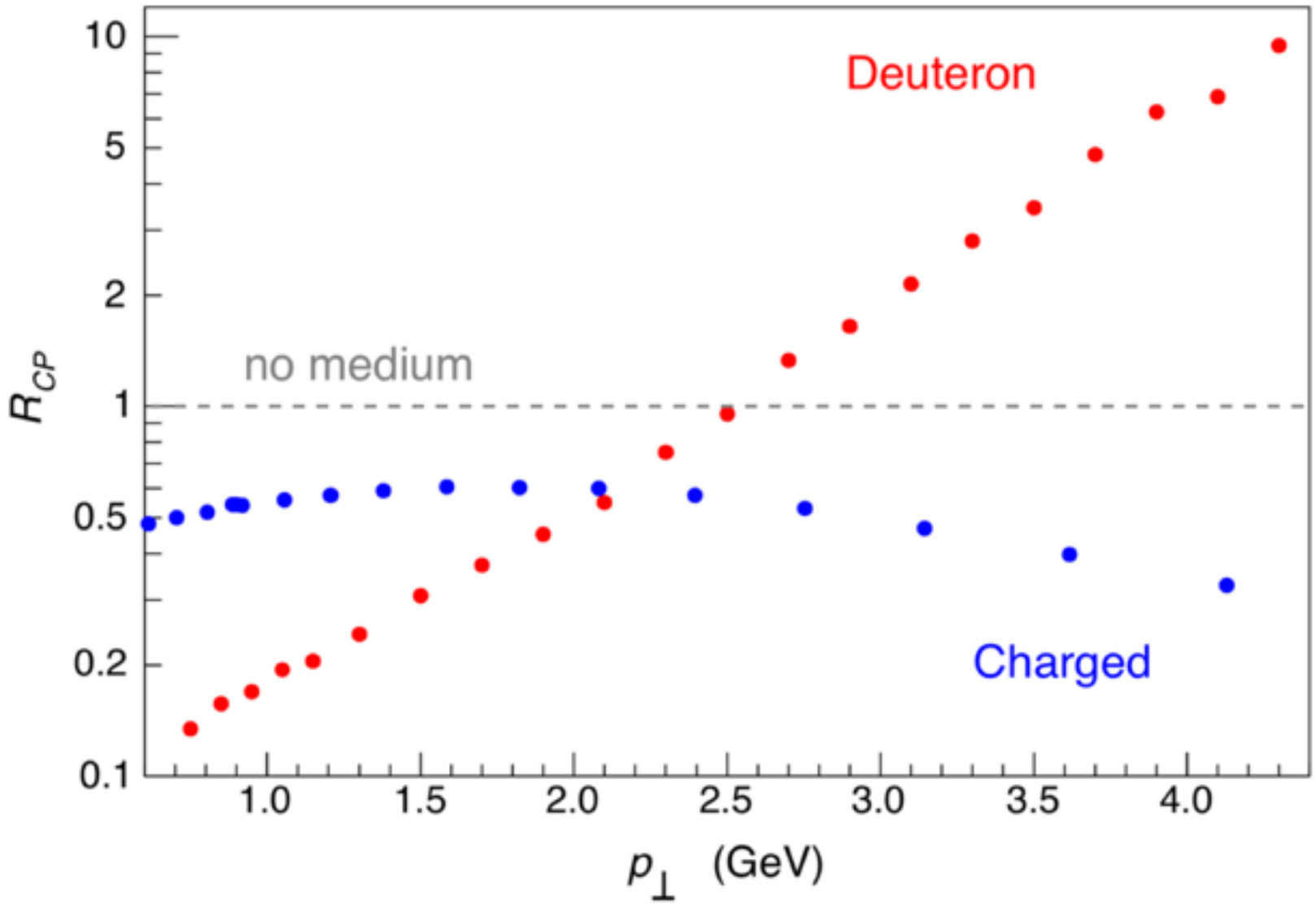
   $N_c^{0-20\%} = 1226$

R_{AA} FOR ^3_1H ?



Expected to be higher for $^3_1\hat{H}$?

R_{CP} FOR DEUTERON



A NOTE ON THE PENTA QUARK

LHCb $\Lambda_b \to (J/\psi p) K^-$

$$\mathbb{P} = \left(\frac{3}{2}^-, \frac{5}{2}^+\right)$$

Parity flip $\to \ell = 1$

lower state $\bar{c}[cu]_1[ud]_1$, $\ell = 0$

higher " $\bar{c}[cu]_1[ud]_0$, $\ell = 1$

Wigner-Eckart $\langle \mathbb{P} M | H_w(\Delta I = 0, \Delta S = -1) | \Lambda_b \rangle$

$8 \otimes 8 \supset 8$

$10 \otimes 8 \supset 8$

$3 \otimes \bar{3}$

EXPECTATIONS

$\Sigma_b^-(6049) \to \phi(J/4\,\Sigma^-)$

$\uparrow 10$

$b[ss]_1 \Rightarrow 6$

Λ_c ...

Wilczek on Nature:

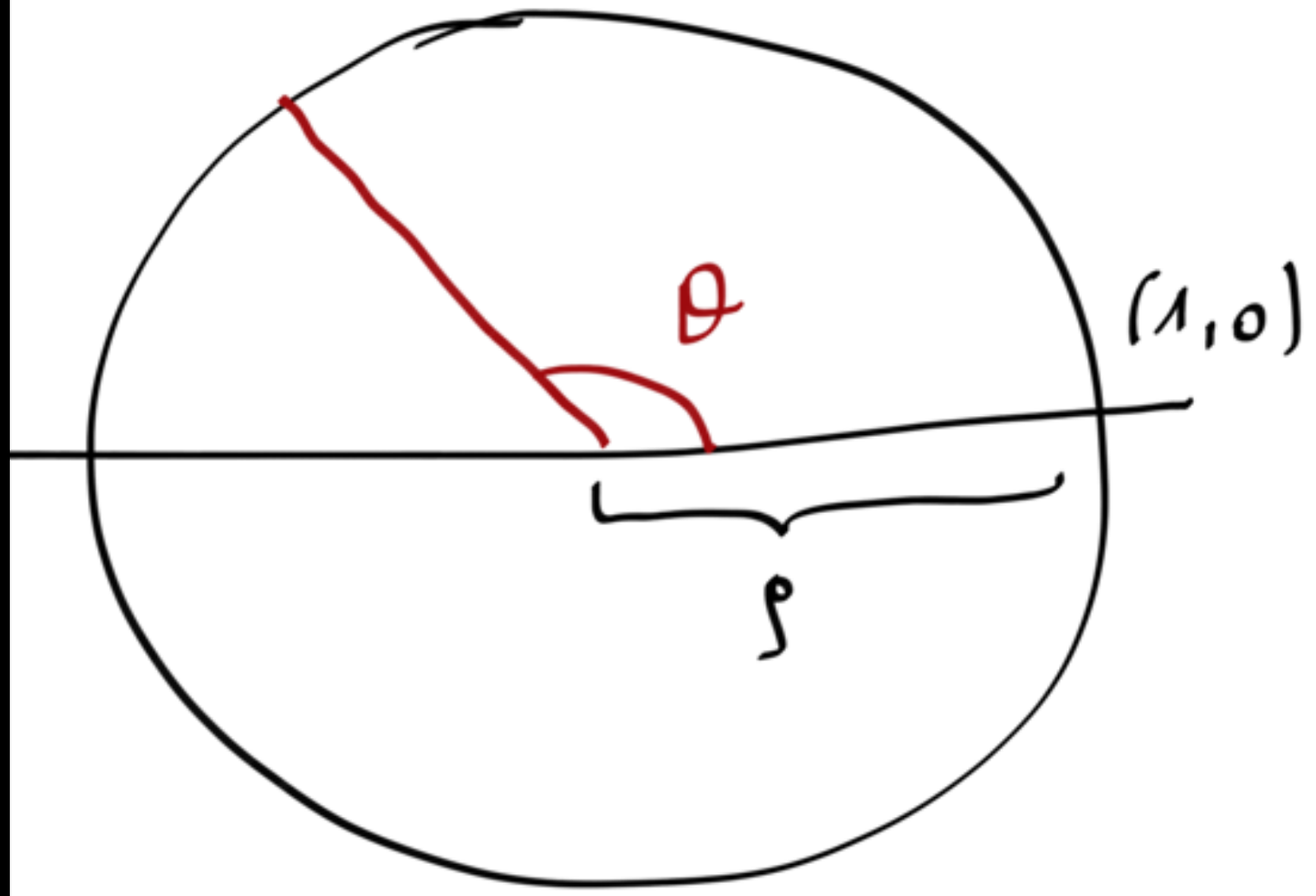
"... the most exciting discovery in QCD I could imagine."

"... the message is that diquarks are a useful organizing principle within hadrons"

CONCLUSIONS

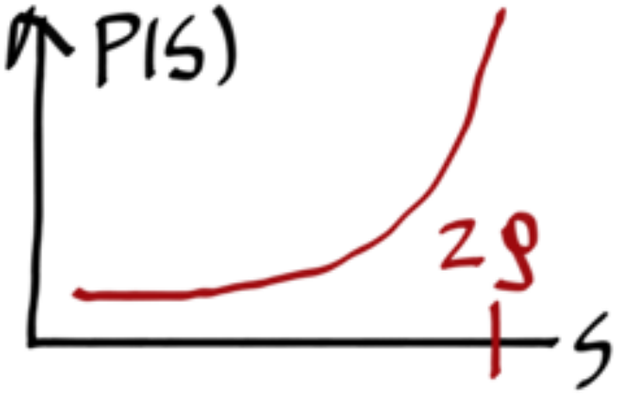
1. ALICE should look for the X and provide a p_T spectrum - (pp & Pb Pb)
2. (Anti) Deuteron at higher p_T ?
3. Hypertriton in p-p ?

ALICE CAN PROVIDE CRUCIAL INFORMATION TO SOLVE LONSTANDING PUZZLES IN EXOTIC SPECTROSCOPY.



$$P(s) = \frac{P(\theta)}{\left|\frac{ds}{d\theta}\right|} =$$

$$= \frac{1/\pi}{\sqrt{1-(s/2)^2}}$$



$$s(\theta) = \sqrt{2-2\cos\theta} = \sqrt{2}\sqrt{2}\sin\frac{x}{2} = 2\sin\frac{\theta}{2} \to 2\rho\,\lambda\left(\frac{\theta}{2}\right)$$

$$\tau = \frac{\int_0^\pi s(\theta)\,d\theta}{\int_0^\pi d\theta} = \rho\frac{4}{\pi} = \boxed{1{,}27\,\rho}$$