Production of J/ψ pairs in pion-nucleon scattering at COMPASS

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56th meeting of the PAC for Particle Physics
(poster session)

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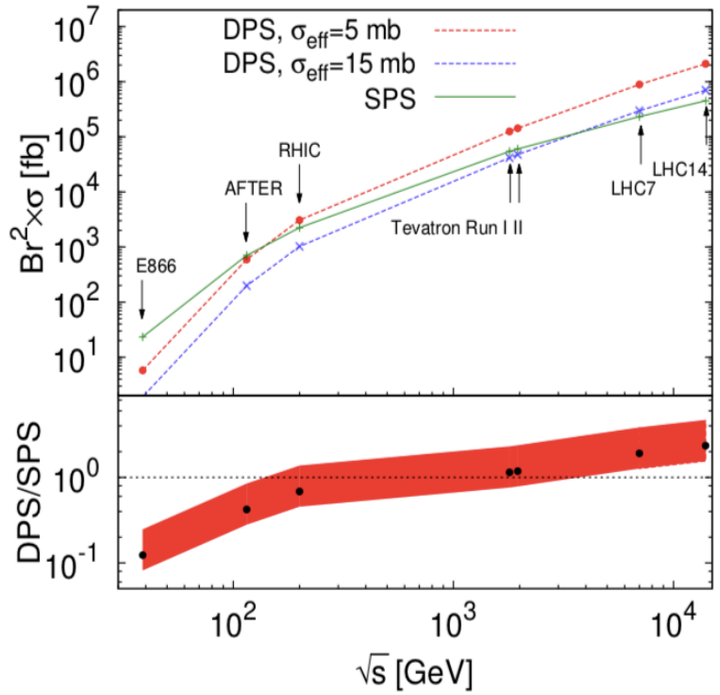
24.01.2022

J/ψ pair production mechanisms

Single and double parton scattering (SPS and DPS):

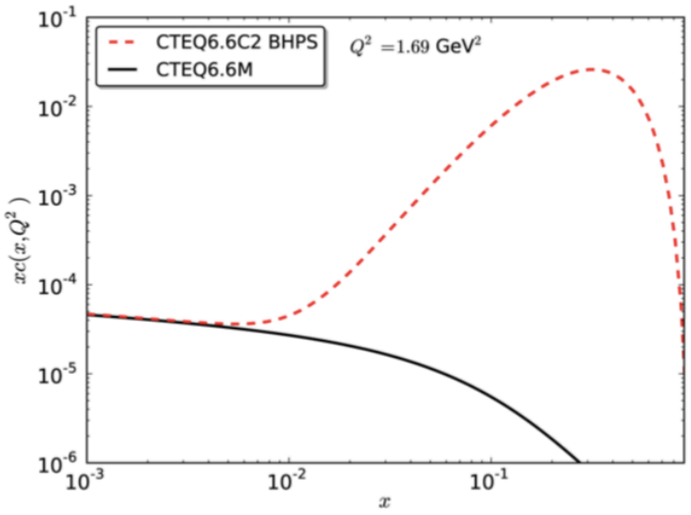
- Production of J/ψ pairs is one of the channels to study DPS at collider experiments;
- The DPS contribution becomes important at high $\sqrt{s}$ energies, while at $\sqrt{s} = 18.9$ GeV the DPS is expected not to exceed 8% of the SPS: **arXiv:1909.06195 [hep-ph]**

J.-P. Lansberg, H.-S. Shao
Nucl. Phys. B 900 (2015) 273



Intrinsic charm of hadron

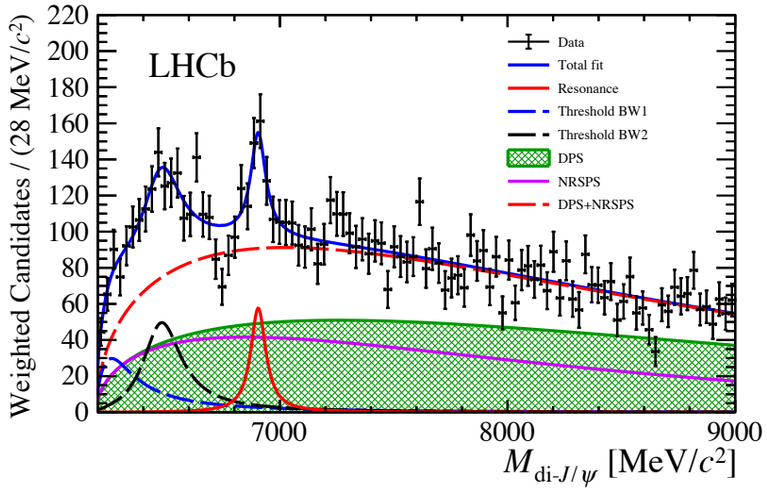
- The existence of non-perturbative (intrinsic) Fock component in a hadron with c-quarks is postulated in BHPS model: **S.J. Brodsky, Phys. Lett. B 93, 451 (1980).**
- In contrast to perturbative charm component, intrinsic charm mechanism contributes at high x.
- For the case of pion beam, production of J/ψ pairs could be interpreted as materialization of $|d\bar{u}c\bar{c}c\bar{c}\rangle$ Fock component of pion: **R Vogt, S.J. Brodsky, Phys. Lett. B, v349: 569-575, 1995.**



V.A. Bednyakov, G.I. Lykasov
Phys. Lett. B, 728, 602 (2014)

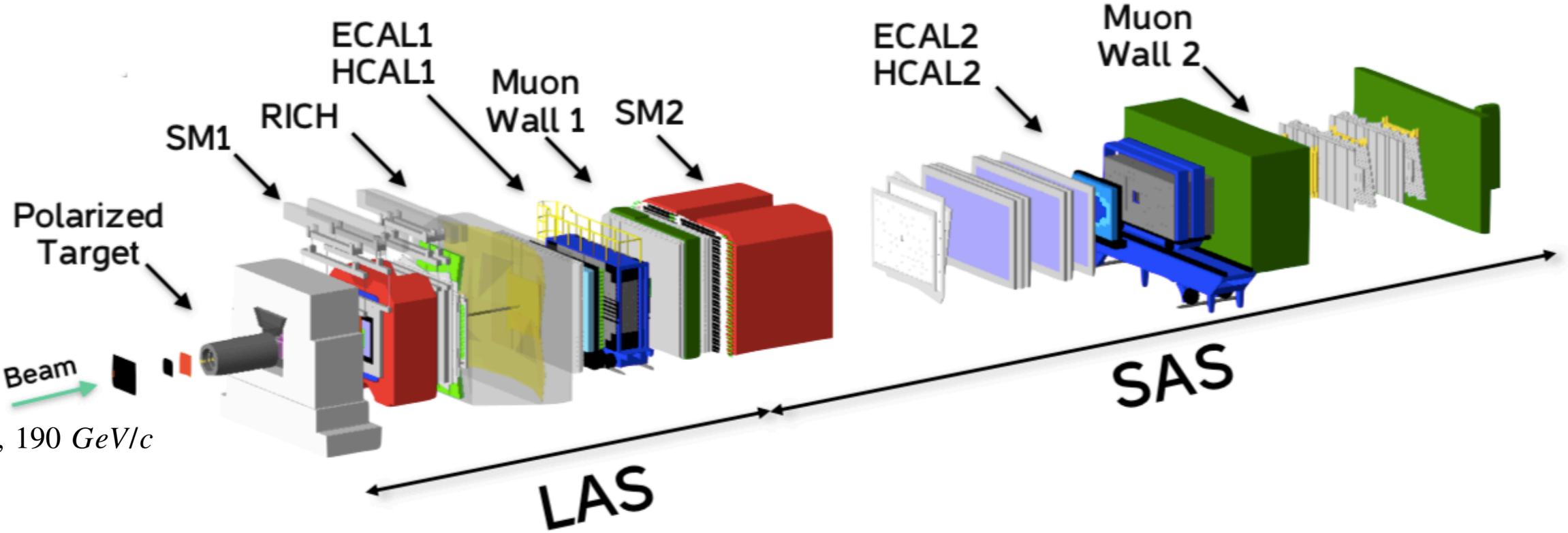
All charm tetraquarks

- A lot of theoretical models are developed since 1975.
- The first experimental evidence published by LHCb: **Sci. Bull., V65, №23, p1983-1993, 2020.**



COMPASS Drell-Yan setup

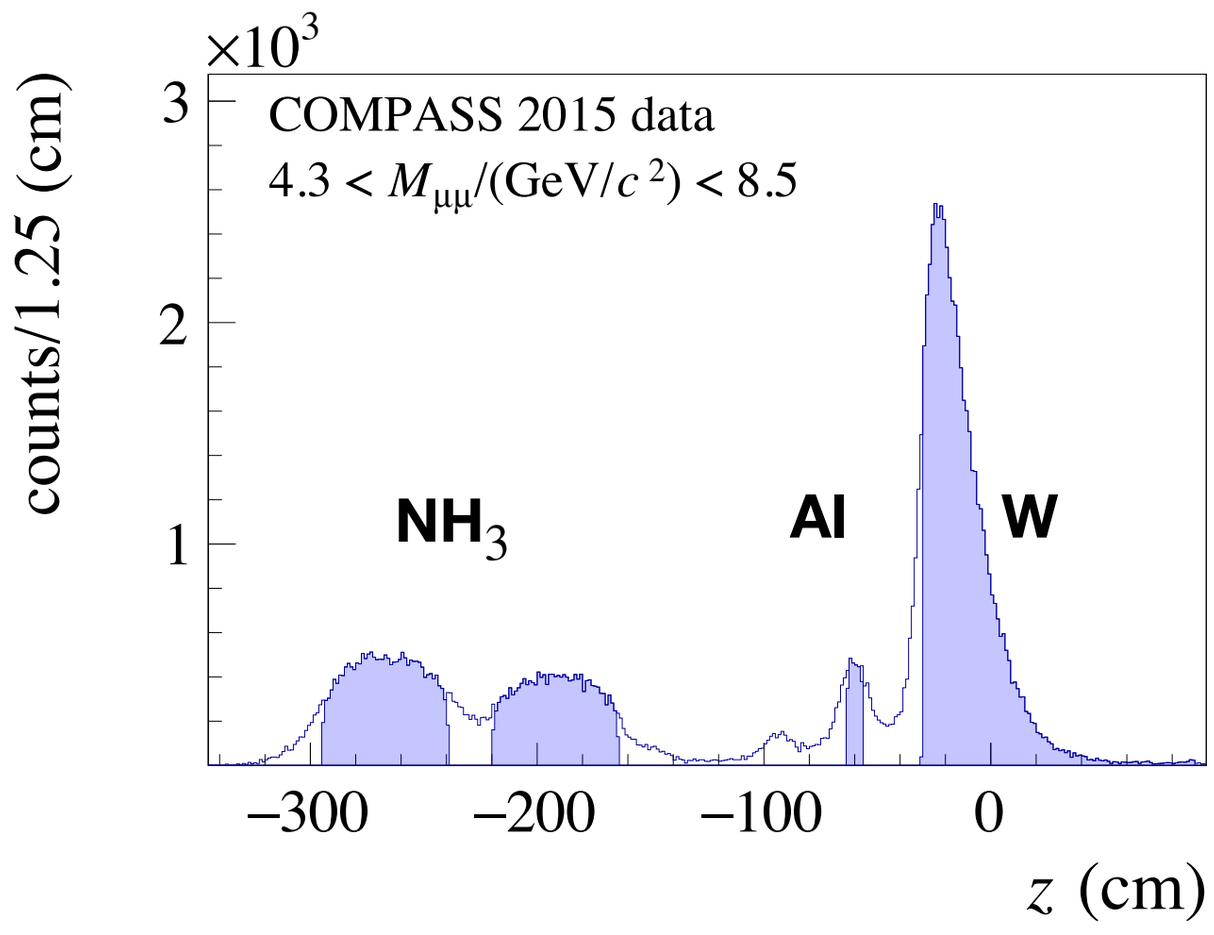
CERN, Super Proton Synchrotron, M2 beam line:



Polarized target: two 55 cm long cells filled with NH_3 immersed in LHe used in polarized DY studies.

Nuclear targets (Al and W):

- — aluminum (A ~ 27): 7cm length;
  — tungsten (beam plug, 120 cm, A ~ 184): first 10 cm used for the physics analyses.
- used to remove hadrons originating from target interactions or beam;



Double J/ψ data at COMPASS

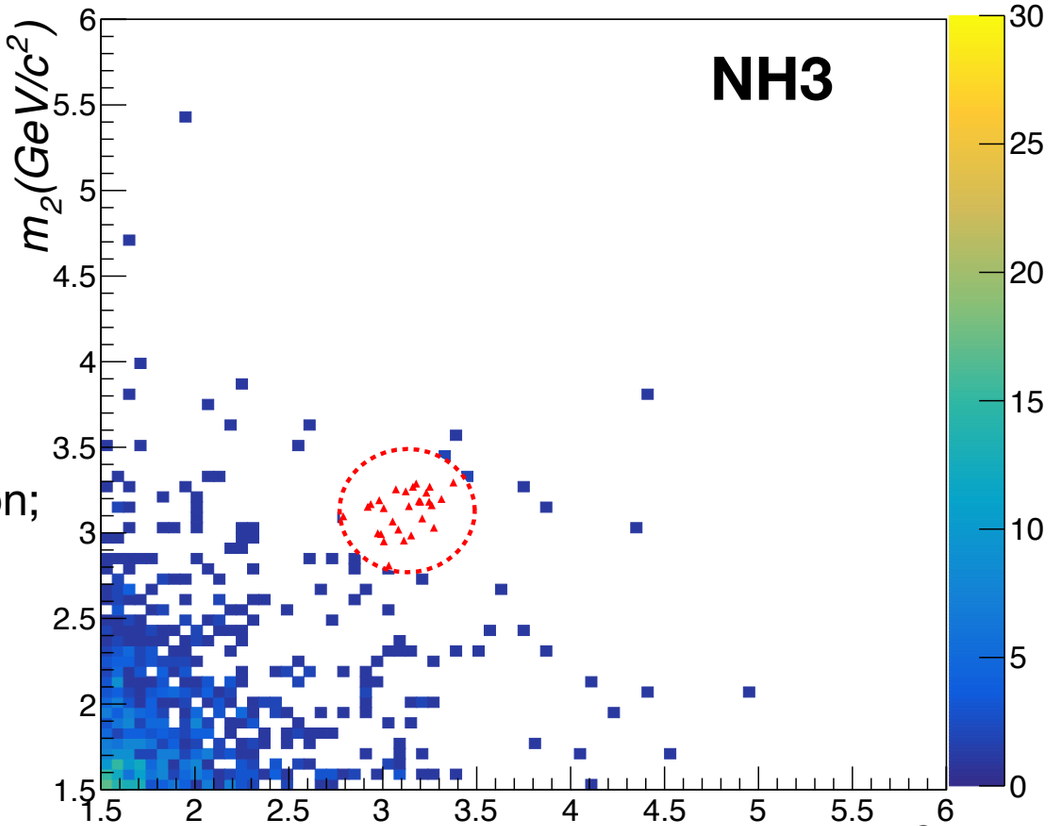
2015: ~4 months of data taking;
2018: ~5 months of data taking;

NH_3 target: 28 events

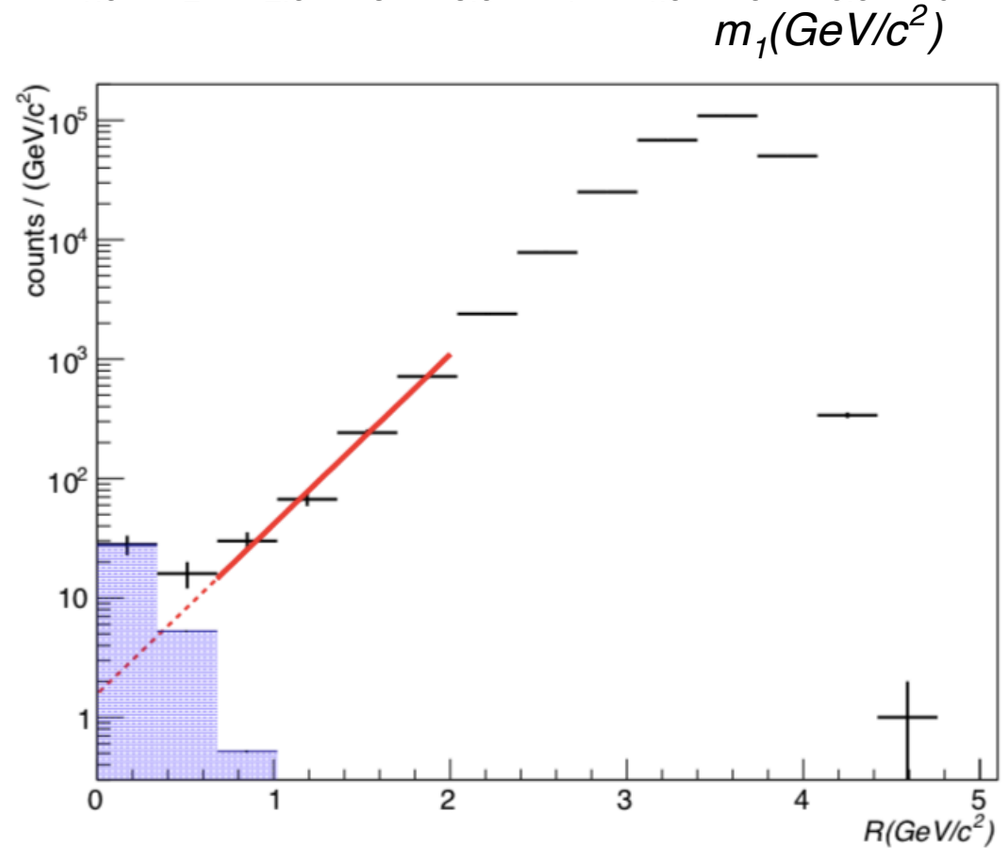
Al target: 2 events

W target: 13 events

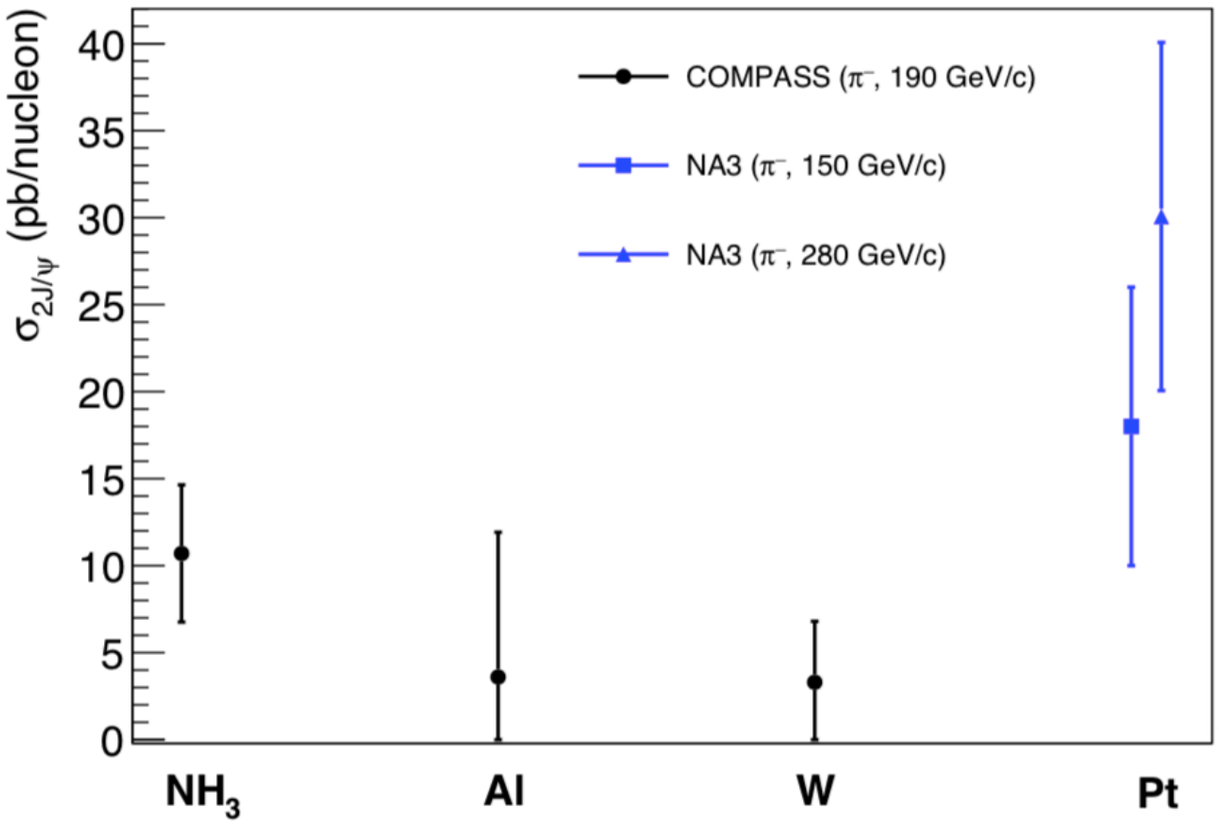
- large background contribution;
- used only for evaluation of production cross section;



An $R = \sqrt{(m_1 - M_{J/\psi})^2 + (m_2 - M_{J/\psi})^2}$ value was used for combinatorial background evaluation for each target. After the background contributions were subtracted, the number of double J/ψ signal events for NH_3, Al and W was estimated to be: 25.1 ± 0.5, 0.6± 0.4 and 4.5± 2.0, respectively.



COMPASS results



In the kinematic region $x_{F\ J/\psi} > 0$:

$$\frac{\sigma_{2J/\psi}}{\sigma_{J/\psi}} = (1.02 \pm 0.22_{stat} \pm 0.27_{syst}) \cdot 10^{-4}(NH_3)$$

$$\sigma^{NH3}_{2J/\psi} = 10.7 \pm 2.3_{stat} \pm 3.2_{syst}\ \frac{pb}{nucleon}$$

$$\sigma^{Al}_{2J/\psi} = 3.6 \pm 8.2_{stat} \pm 1.4_{syst}\ \frac{pb}{nucleon}$$

$$\sigma^{W}_{2J/\psi} = 3.3 \pm 3.0_{stat} \pm 1.8_{syst}\ \frac{pb}{nucleon}$$

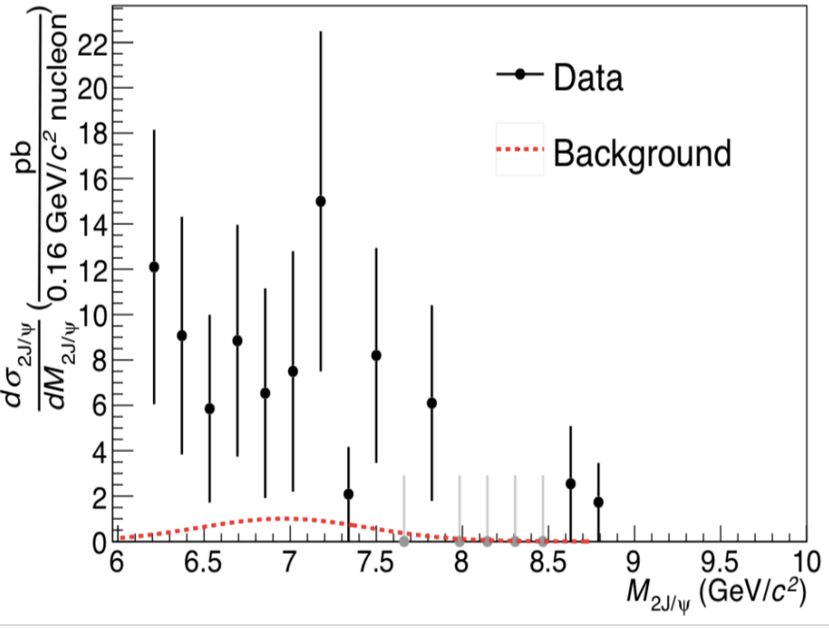
The NA3 double J/ψ results: **Phys. Lett. B, v114, No6,1982, Phys. Lett. B, v158, No1,1985**

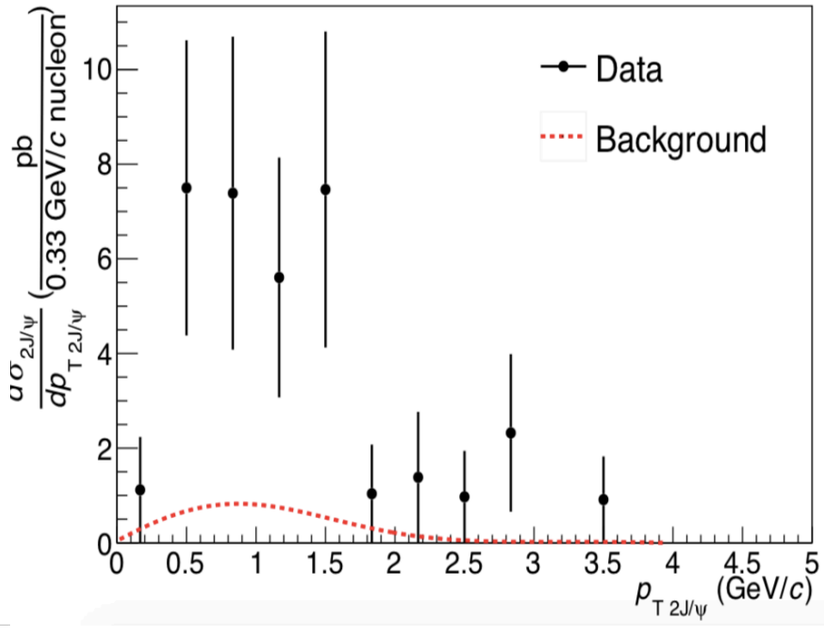
Main sources of systematics:

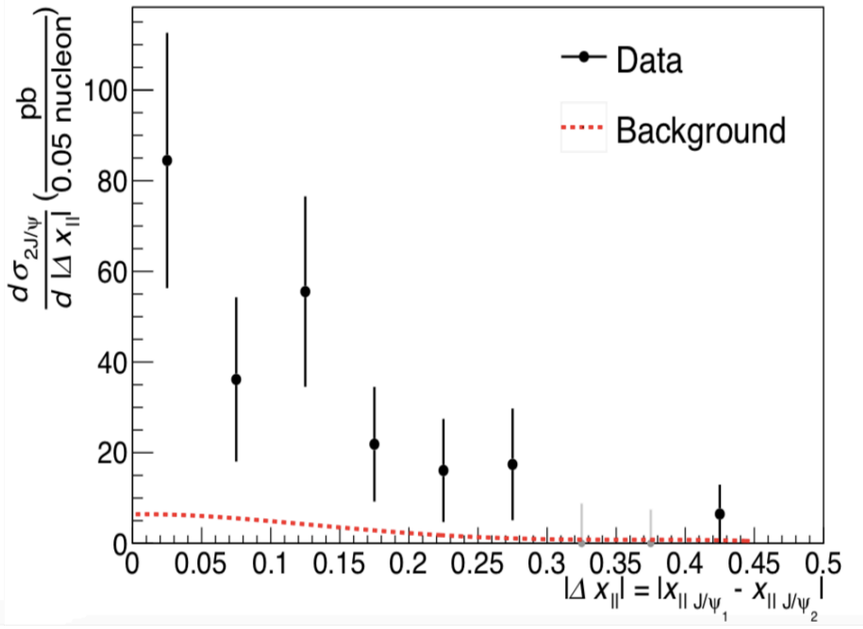
- uncertainty of $\sigma_{J/\psi}$
- background estimation
- acceptance of double J/ψ
- acceptance of single J/ψ
- uncertainty of the number of single J/ψ

- The COMPASS has searched for double J/ψ events produced in various targets and has estimated double J/ψ production cross-section. Within the uncertainties, no significant evidence of nuclear effects is observed.

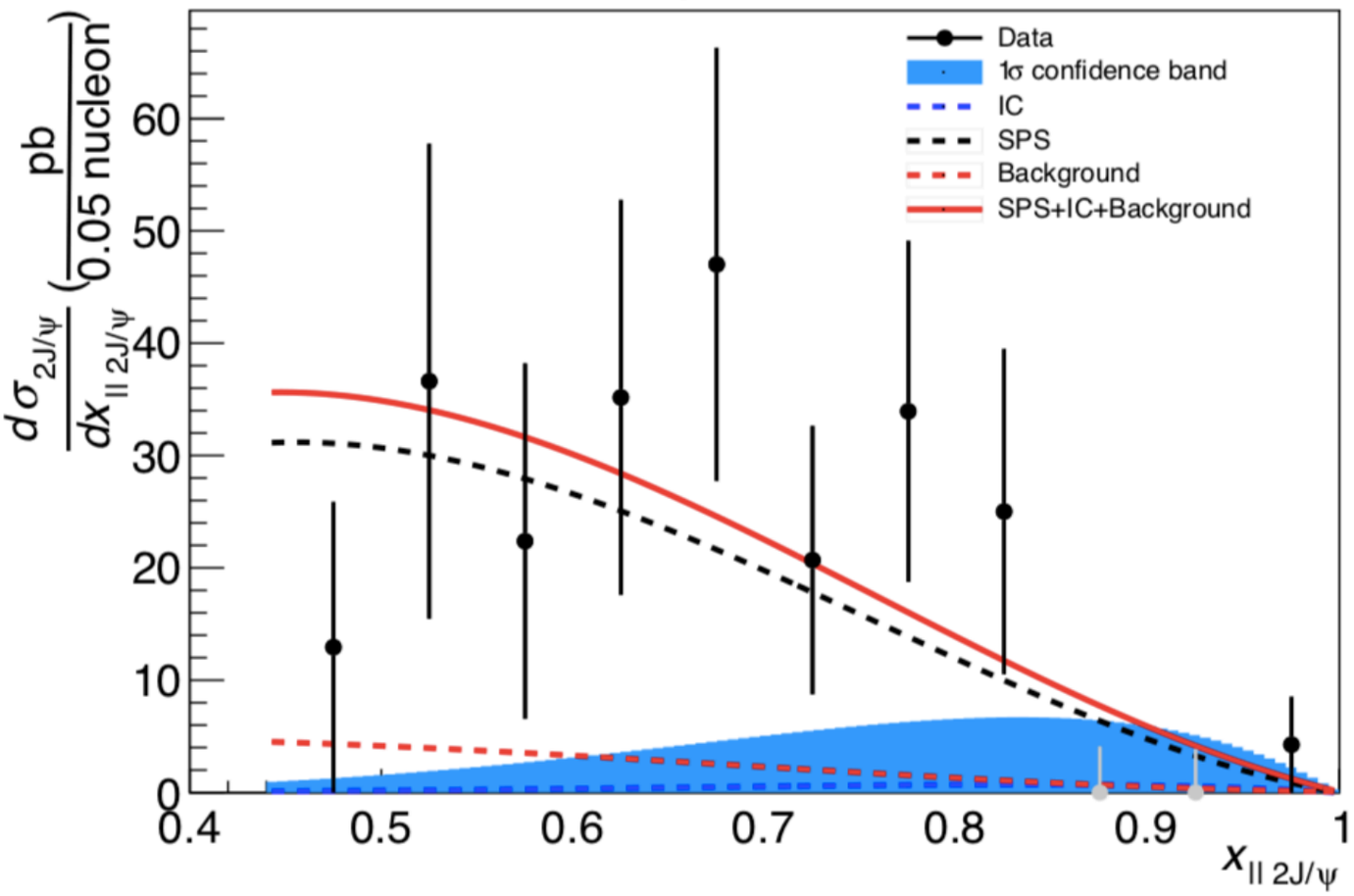
Differential cross section distributions:







- With the limited statistics of this measurement, no evidence of any resonant states decaying into two J/ψ was found.



- The upper limit on the production rate of double J/ψ from the intrinsic charm mechanism:
  $\sigma^{IC}_{2J/\psi}/\sigma^{SPS}_{2J/\psi} < 0.24\ (CL = 90\%)$.

- The obtained result for the differential cross section $d\sigma_{2J/\psi}/dx_{||\ 2J/\psi}$ is fully consistent with the SPS hypothesis which appears to be sufficient to describe the data.