Double J/ψ production in pion-nucleon scattering at COMPASS

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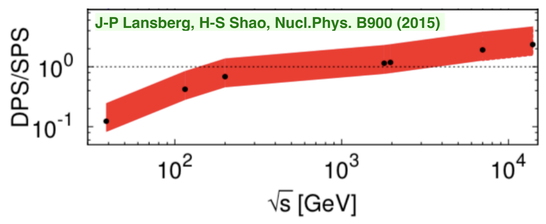
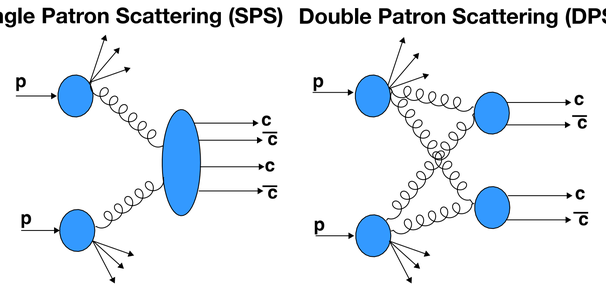
Double J/ψ production mechanisms

DPS & SPS



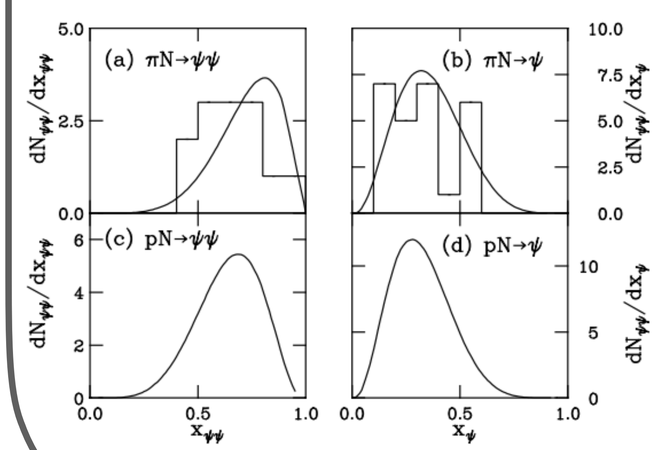
Single Patron Scattering (SPS) Double Patron Scattering (DPS)



The SPS mechanism is expected to be dominant at low center of mass energies, while the DPS mechanism plays the main role at high energies.

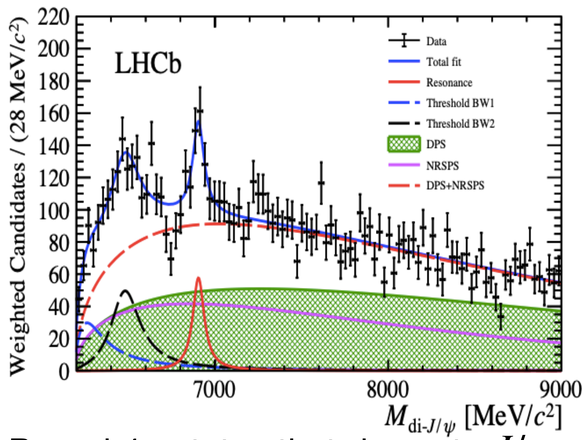
DPS was studied by a lot of experiments in different processes (also in double J/ψ production), but still there is a large uncertainty of DPS/SPS ratio.

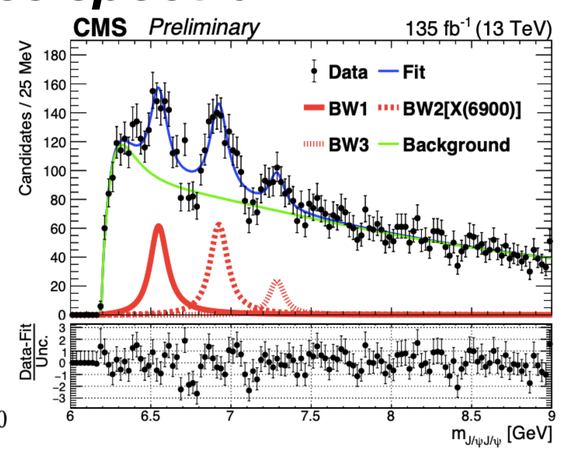
Intrinsic charm of pion (IC)



IC are valence-like $c\bar{c}$-pairs in the wave function of a hadron. The NA3 observed J/ψ pair events in 1982 in πN and pN collisions [1,2]. These data were explained as materialization of $|d\bar{u}c\bar{c}c\bar{c}\rangle$ Fock state, predicted by intrinsic charm of pion hypothesis [3]. Still the NA3 result is the only observation of J/ψ pair production in πN collisions.

J/ψ-pair mass spectrum





Bound 4c-states that decay to J/ψ pair were predicted in 1975 [4]. Only in 2020 the LHCb reported the X(6900) structure in the $M_{2J/\psi}$ spectrum with high statistical significance [5]:

$M[X(6900)] = 6905 \pm 11_{stat} \pm 7_{syst}$ MeV

In 2022 ATLAS and CMS confirmed the X(6900) peak in the $M_{2J/\psi}$ spectrum [6,7] and announced two more resonances:

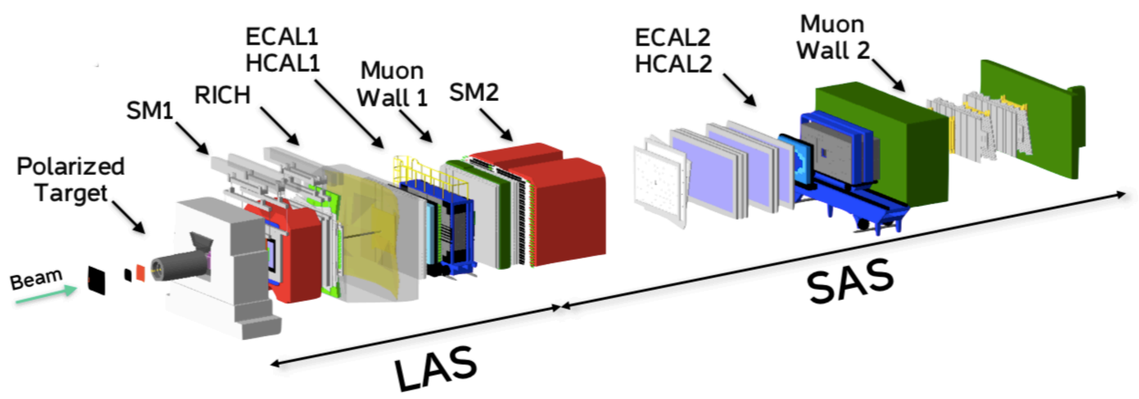
$M(X(6600)) = 6552 \pm 10_{stat} \pm 12_{syst}$ MeV

$M(X(7300)) = 7287 \pm 19_{stat} \pm 5_{syst}$ MeV.

The new measurement will allow:

- to estimate contributions of different production mechanisms into J/ψ pair production cross section;
- to test the hypothesis that IC dominates in J/ψ pair production at NA3 energies.

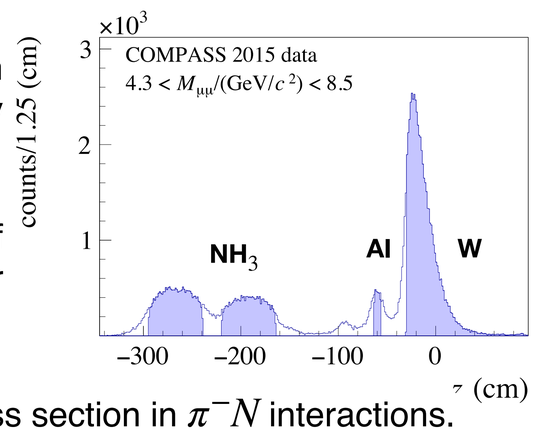
COMPASS experiment and results: PLB 838 (2023) 137702



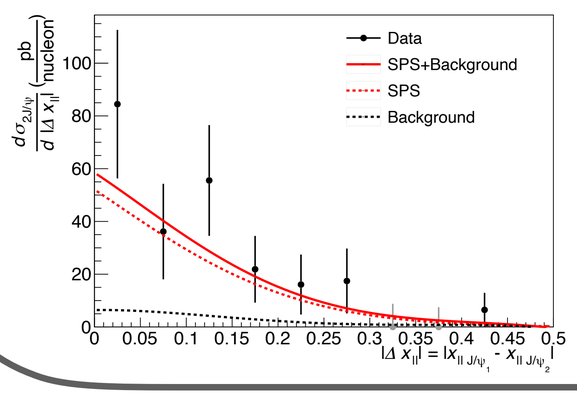
COMPASS is a high energy experiment which studies hadron structure and spectroscopy with high intensity pion and muon beams. The experiment is located at the M2 beam line of the Super Proton Synchrotron at CERN.

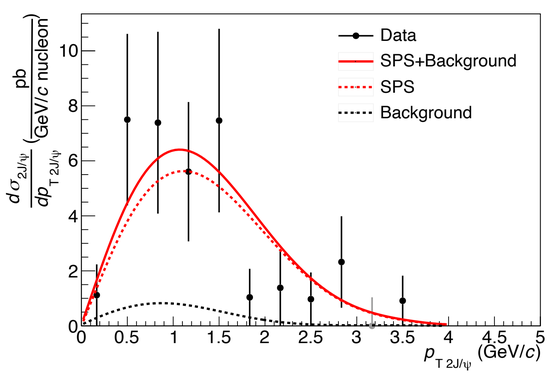
COMPASS uses a 190 GeV pion beam and NH3, Al, W targets to study production mechanisms of dimuon pairs.

COMPASS Drell-Yan data (two years of data taking) were used for the search for 2J/ψ events.

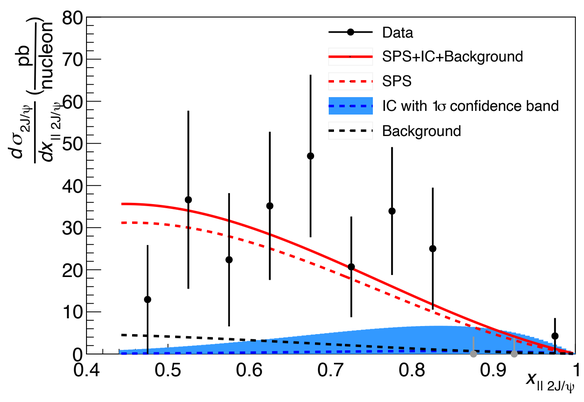


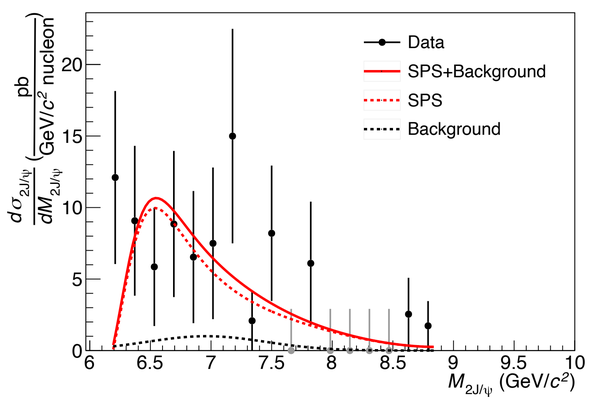
1) COMPASS has measured J/ψ pair cross section in $\pi^- N$ interactions. Differential cross sections as functions of $p_{T\ 2J/\psi}$, $x_{||\ 2J/\psi}$, $\Delta x_{||\ 2J/\psi}$ are obtained for NH_3 target.



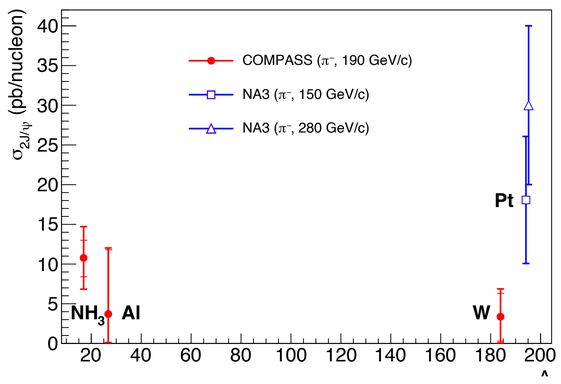


2) The COMPASS double J/ψ data are consistent with SPS production mechanism. An upper limit on IC production mechanism is established in $x_{||\ 2J/\psi} > 0.4$ region: $\sigma^{IC}_{2J/\psi}/\sigma_{2J/\psi} < 0.24$ $(CL = 90\%)$.





3) The distribution of J/ψ pair production cross section off different nuclear targets is obtained. Within uncertainties, no significant evidence of nuclear effects in J/ψ pair production is observed.



4) The double J/ψ mass spectrum does not contain any evident signal from exotic charmonium-like states observed by LHCb.

5) It is shown, that the interpretation of NA3 double J/ψ data (π^-, 150 and 280 GeV) using intrinsic charm of pion model is not correct. Kinematics of J/ψ pair events at COMPASS (π^-, 190 GeV) do not contradict to the SPS production mechanism.

References

[1] NA3 collaboration, Phys Lett B, v114, No6, 1982
[2] NA3 collaboration, Phys Lett B, v158, No1, 1985
[3] R.Vogt, S.Brodsky, Phys.Lett.B349, p.569-575, 1995
[4] Y. Iwasaki, Prog. Theor. Phys. V.54, 492 (1975)
[5] LHCb collaboration, Sci. Bull., V65, No23, p1983-1993, 2020
[6] ATLAS collaboration, arXiv:2304.08962v1, CERN-EP-2023-035
[7] CMS collaboration, CMS PAS BPH-21-003