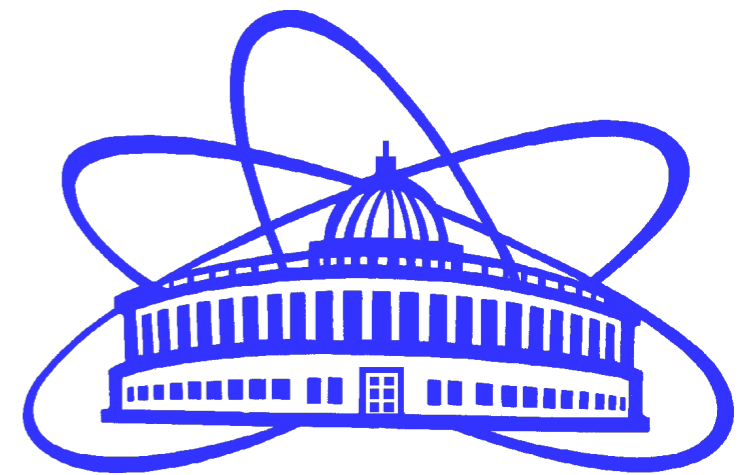


# Experience of using HELAC-Onia with pion beams

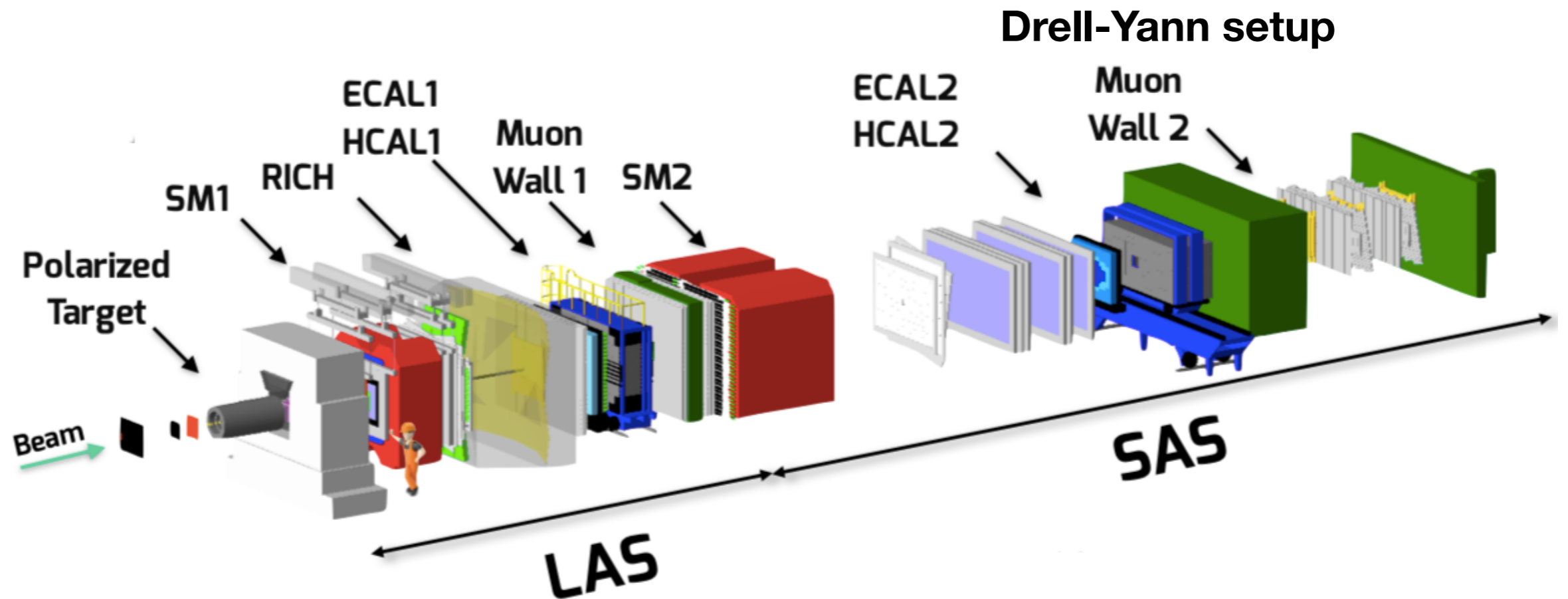
Andrei Gridin  
Joint Institute for Nuclear Research  
(Dubna, Russia)



**FTE@LHC & NLOAccess**  
*STRONG 2020 joint kick-off meeting*  
CERN, 7-8 November 2019



# COMPASS experiment @ CERN



$\pi^-$  beam with  $P = 190 \text{ GeV}/c$

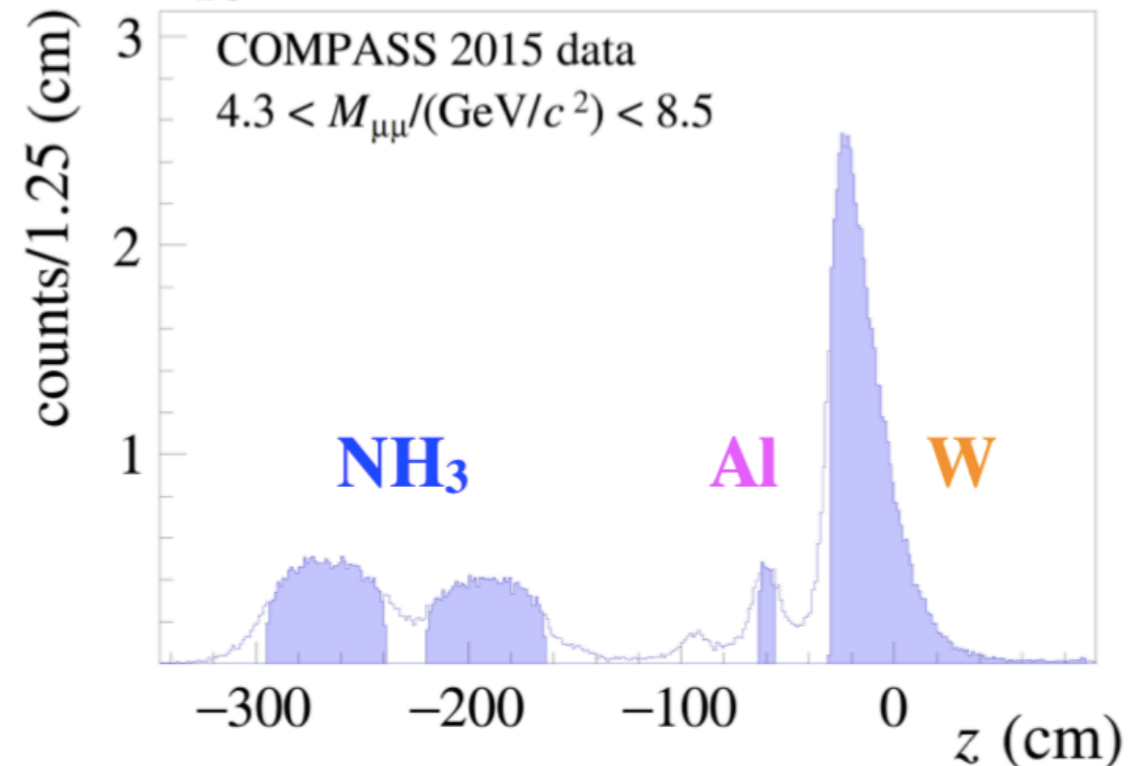
$\sqrt{s} = 19.7 \text{ GeV}$

Beam intensity:  $\approx 10^8 \text{ part/sec}$

High tracking power:  $\sim 350$  planes

Two years of Drell-Yann data taking (2015 + 2018)

3 nuclear targets:  $\text{NH}_3$ ,  $\text{Al}$ ,  $\text{W}$



# Production of $J/\psi J/\psi$ with pion beam

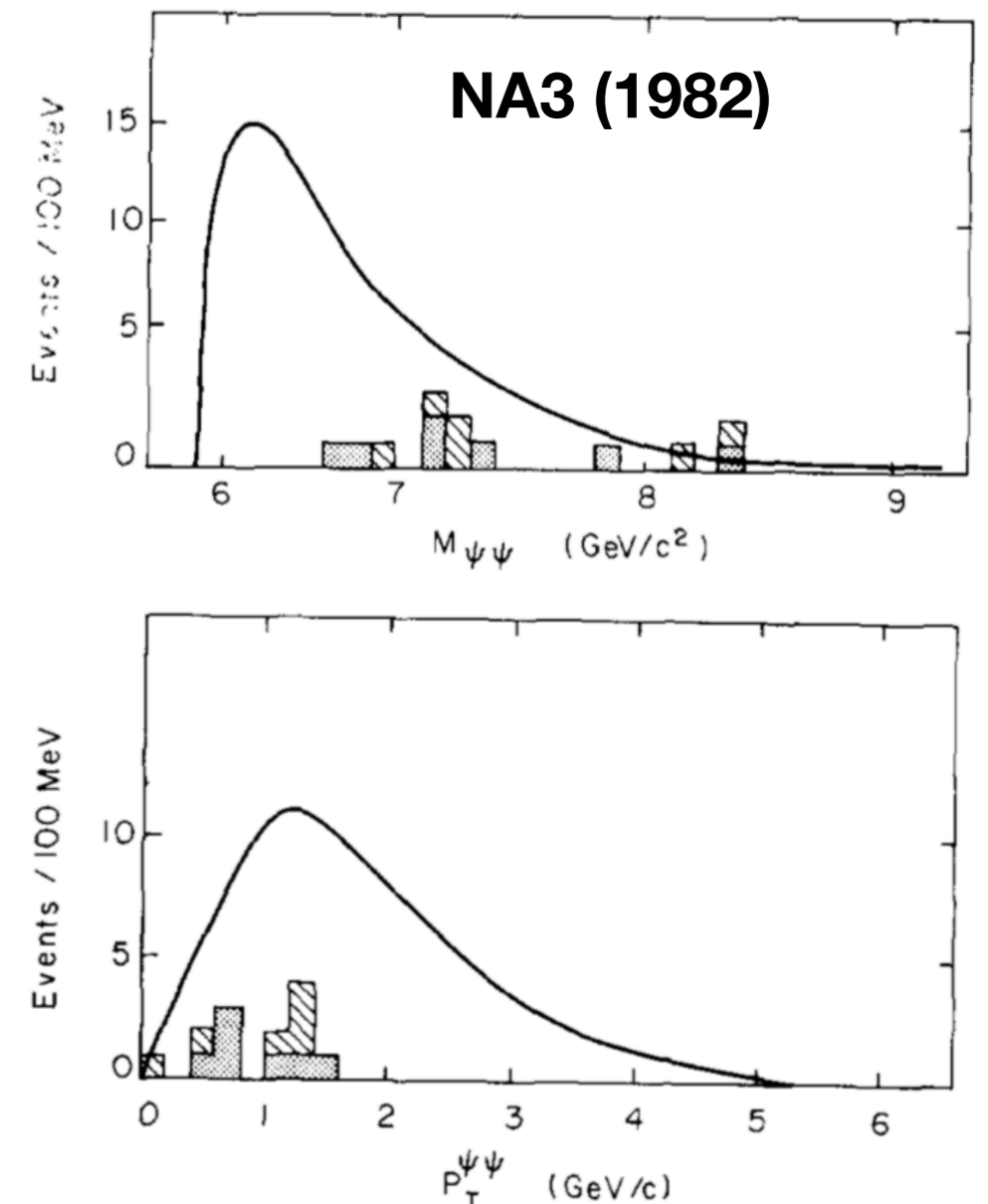
Phys Lett B, v114, No6

Only one measurement with pion beam performed by the NA3 in 1982:

- $\sigma_{2J/\psi}(150 \text{ GeV}/c) = 18 \pm 8 \text{ pb/nucleon}$
- $\sigma_{2J/\psi}(280 \text{ GeV}/c) = 30 \pm 10 \text{ pb/nucleon}$

Possible contribution from **SPS**, **DPS**, **Intrinsic charm** production mechanisms;

Not many generators of  $2J/\psi$ :  
Pythia8 (CS LO), HELAC-Onia (NRQCD NLO);



# Using HELAC-Onia with pion beams

Starting with v.2.4.0 Helac-Onia can use different PDFs for each beam:

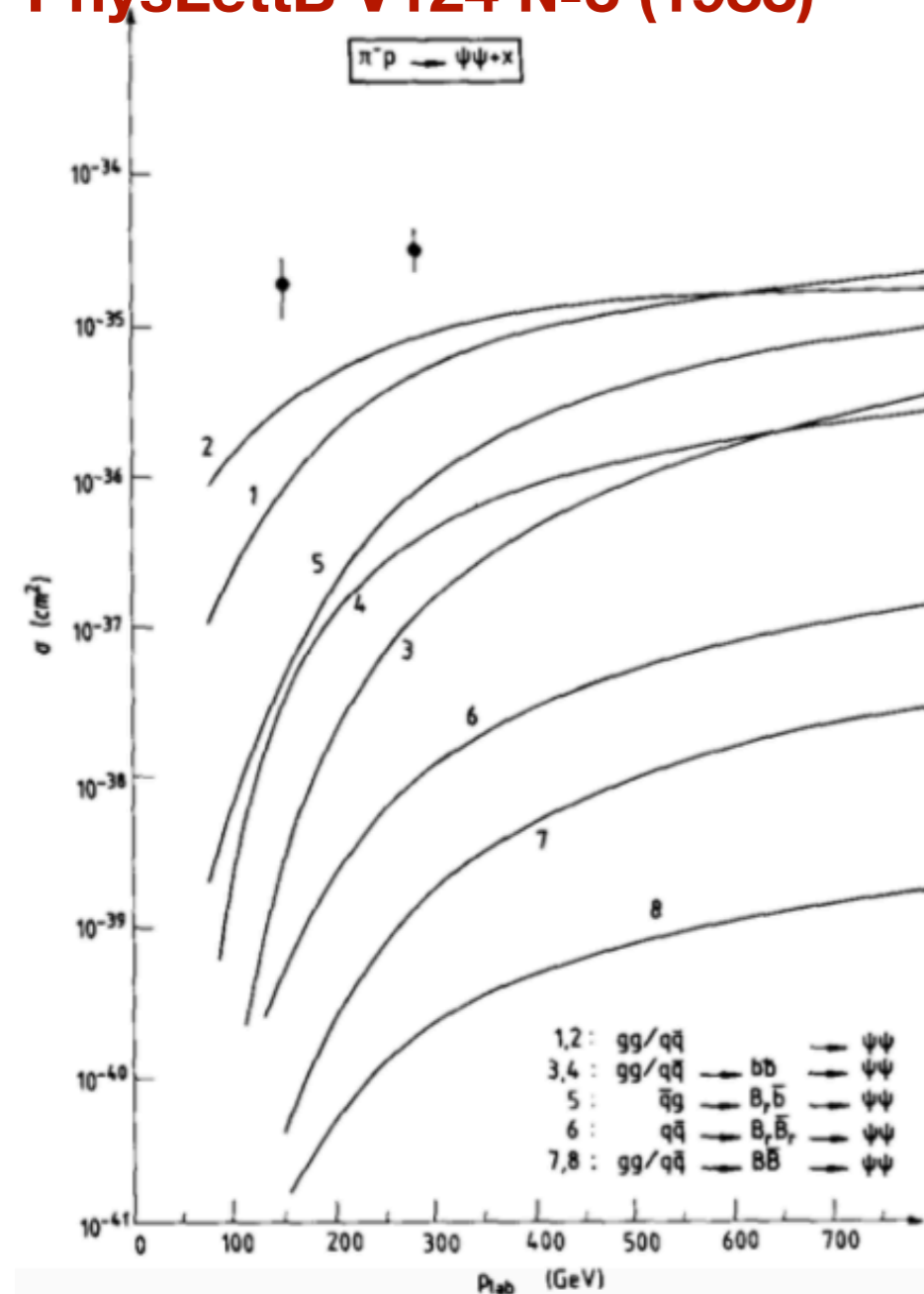
qqbar channel: generate  $p \bar{p} \rightarrow c\bar{c} \sim (3S11) c\bar{c} \sim (3S11)$

gg channel: generate  $g g \rightarrow c\bar{c} \sim (3S11) c\bar{c} \sim (3S11)$

**PhysLettB V124 N°3 (1983)**

- **GRVPI1**
- **E = 190 GeV/c**

- **Fixed target mode**
- **Nuclear PDFs**



**Cross sections from generators:**

$$\pi p \rightarrow 2J/\psi \text{ via } q\bar{q} : 1.42 \cdot 10^{-8} mb$$

$$\pi p \rightarrow 2J/\psi \text{ via } gg : 1.11 \cdot 10^{-9} mb$$

**Pythia8:**

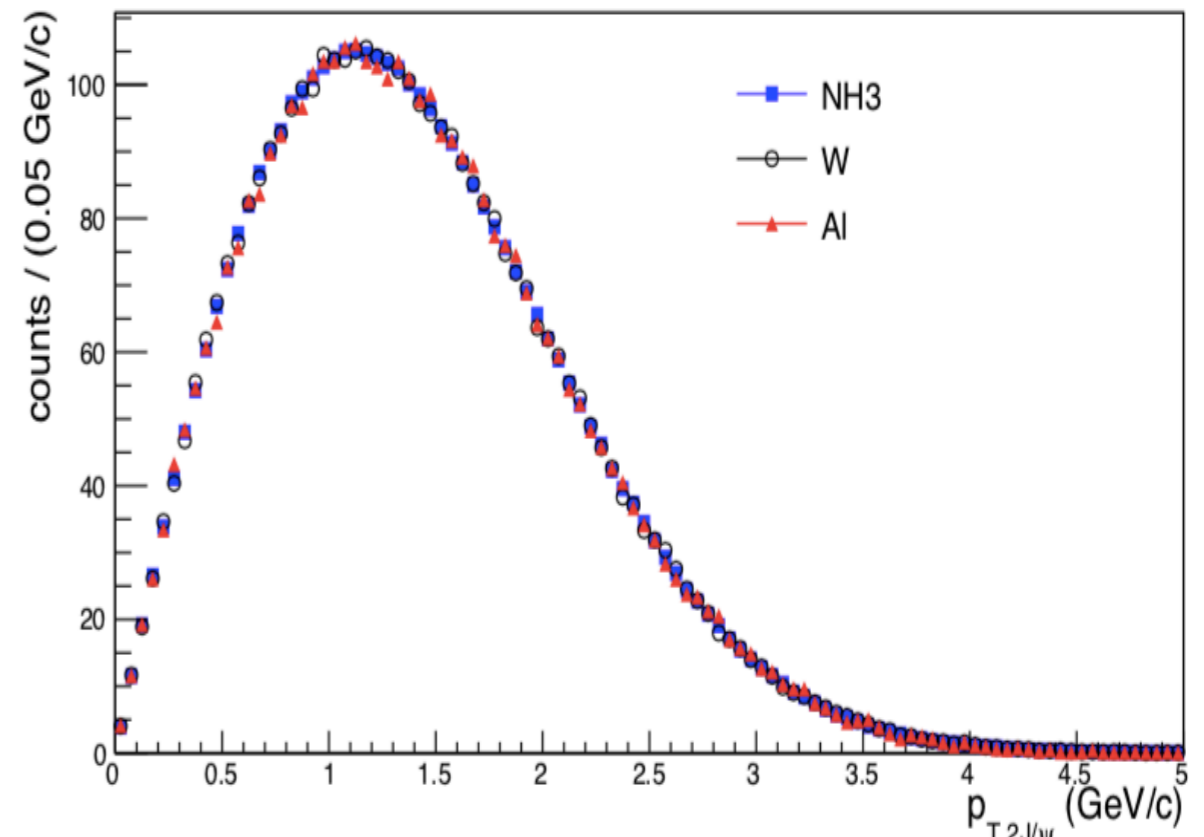
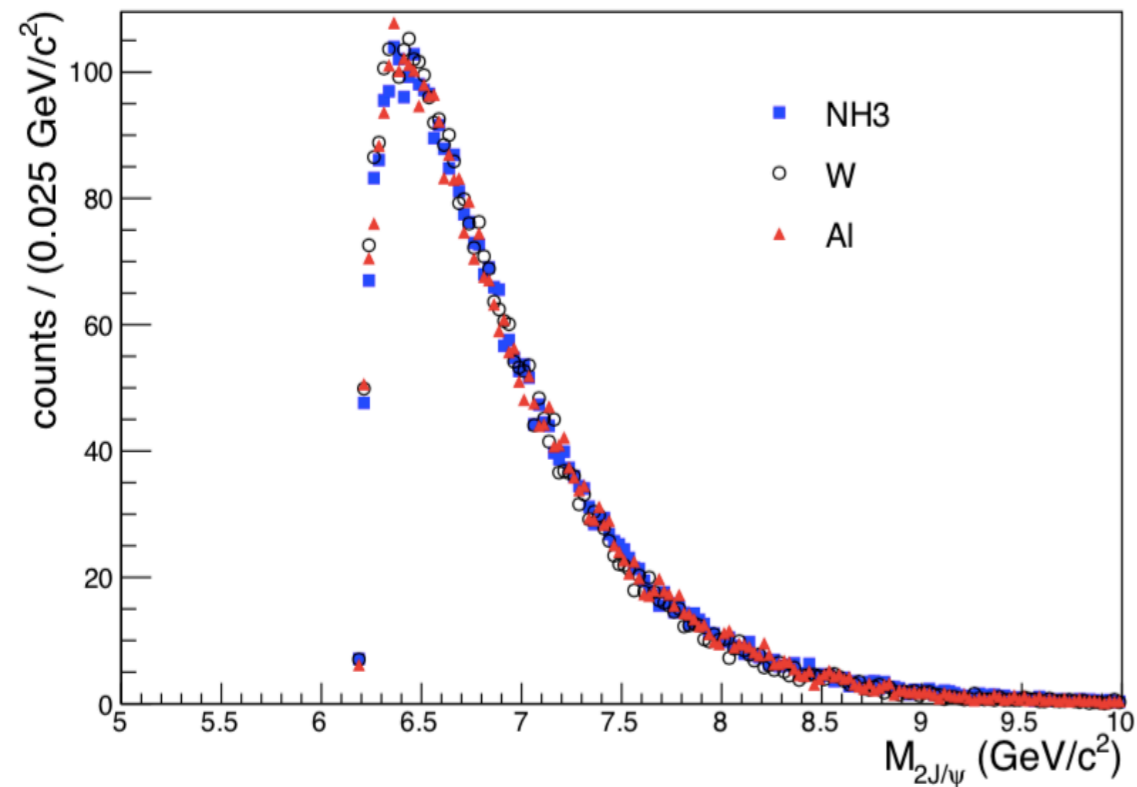
$$\pi p \rightarrow 2J/\psi \text{ via } q\bar{q} : 9.57 \cdot 10^{-11} mb$$

$$\pi p \rightarrow 2J/\psi \text{ via } gg : 3.32 \cdot 10^{-10} mb$$

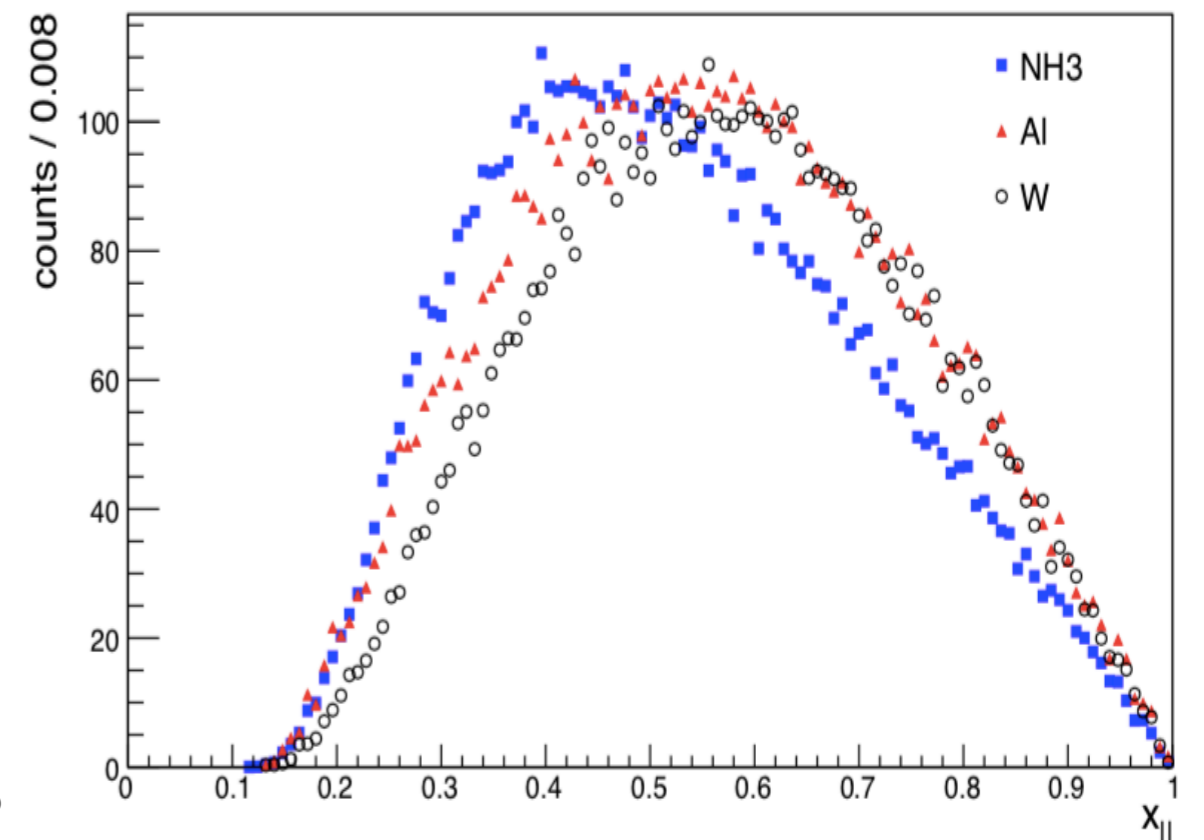
**HELAC-Onia:**

**HELAC-Onia gives untrustable  $2J/\psi$  cross section at COMPASS energies. But cross section ratios between qqbar and gg could be estimated by hand.**

# Using HELAC-Onia with different nuclear targets



An  $x_{||} = \frac{p_{Z2J/\psi}}{p_{beam}}$  variable  
could be used for  
comparison of  $2J/\psi$   
production mechanisms.



# Feed-down effect with pion beam

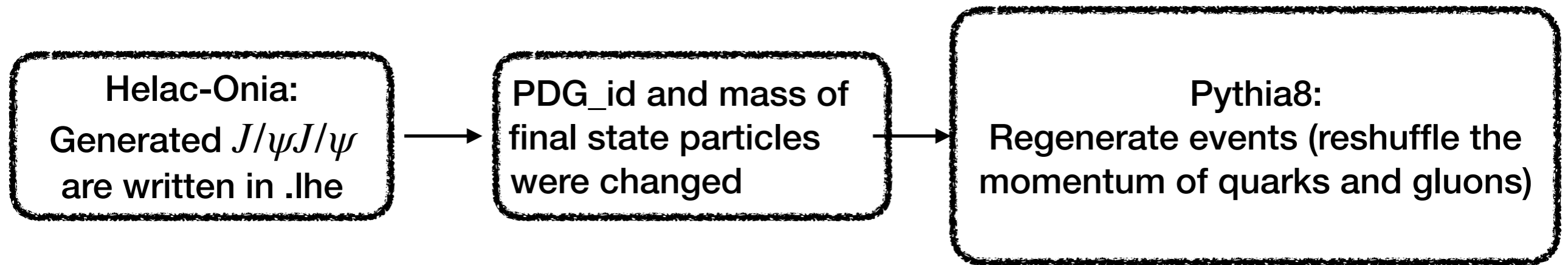
**Physical Review D, Vol 64, 094015**

State	Mass (GeV)	Decay mode (BR)	fraction
$J/\psi$	3.1	-	$0.57 \pm 0.3$
$\psi(2S)$	3.69	$J/\psi + X$ (61%)	$0.08 \pm 0.02$
$\chi_{1c}(1P)$	3.51	$J/\psi + \gamma$ (34 %)	$0.20 \pm 0.05$
$\chi_{2c}(1P)$	3.56	$J/\psi + \gamma$ (19%)	$0.15 \pm 0.04$

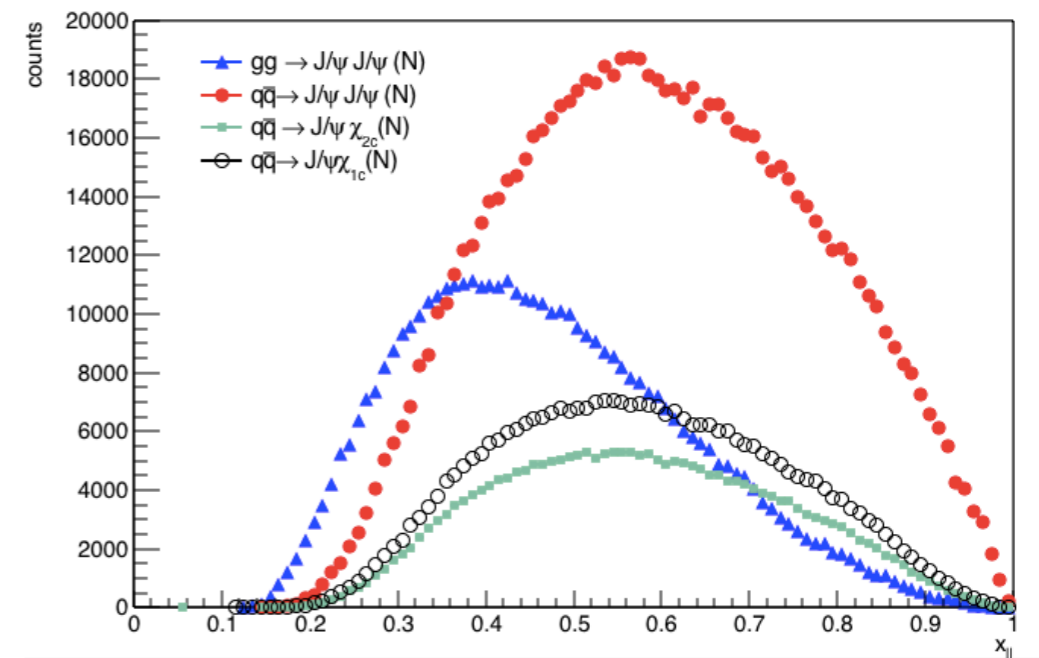
For the case of pion beam fractions of feed down components are known.

HELAC-Onia does not generate pairs of higher charmonium states (e.g.  $\psi(2S)\chi_{1c} \rightarrow J/\psi J/\psi$ ).

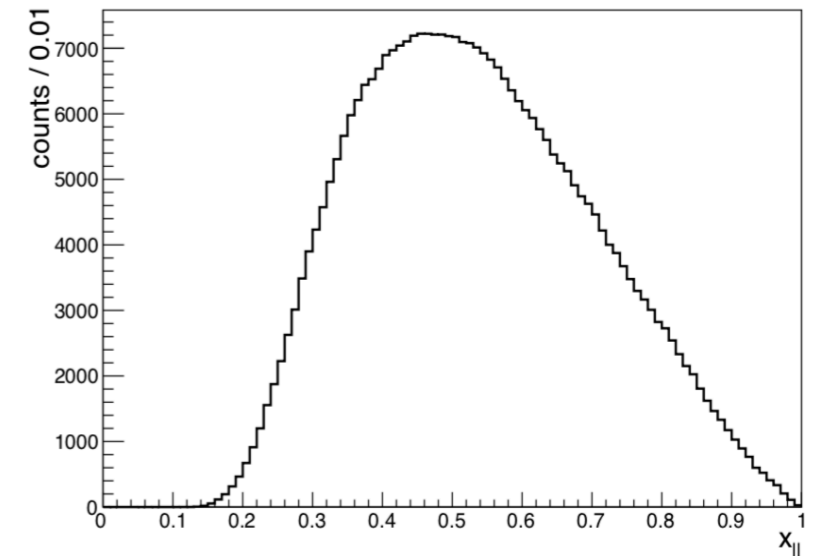
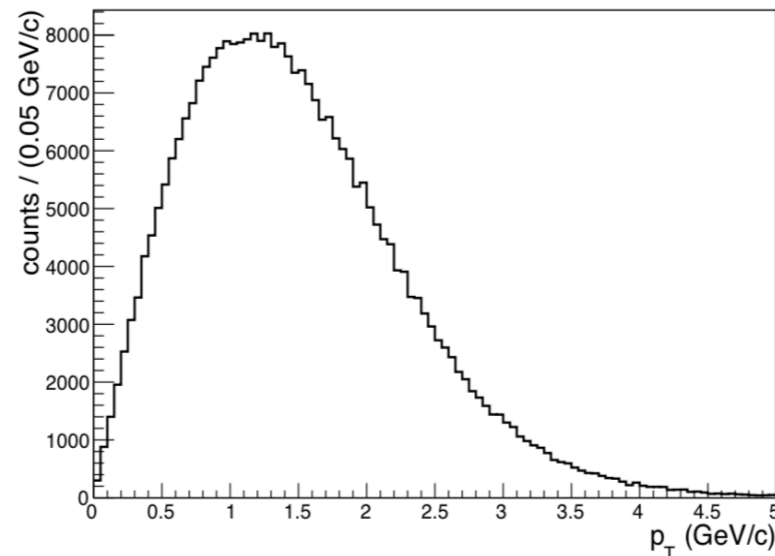
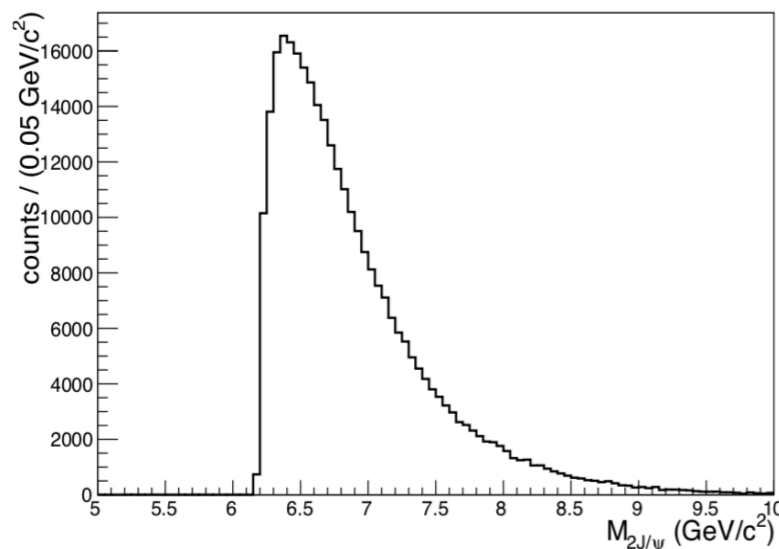
# Feed-down effect with pion beam



After all the generation chain one gets a set of good events with the needed state (e.g.  $J/\psi\psi(2S)$ ). All the laws of momentum and energy conservation are taken into account by Pythia8.



## Distributions with feed down effect:



# Conclusions

HELAC-Onia was already used by couple of experiments (D0, ATLAS, CMS, LHCb) and seems to be promising also for COMPASS.

There are many questions and ideas to HELAC-Onia developers (cross-sections, feed-down effect, usage of JAM pion PDF).