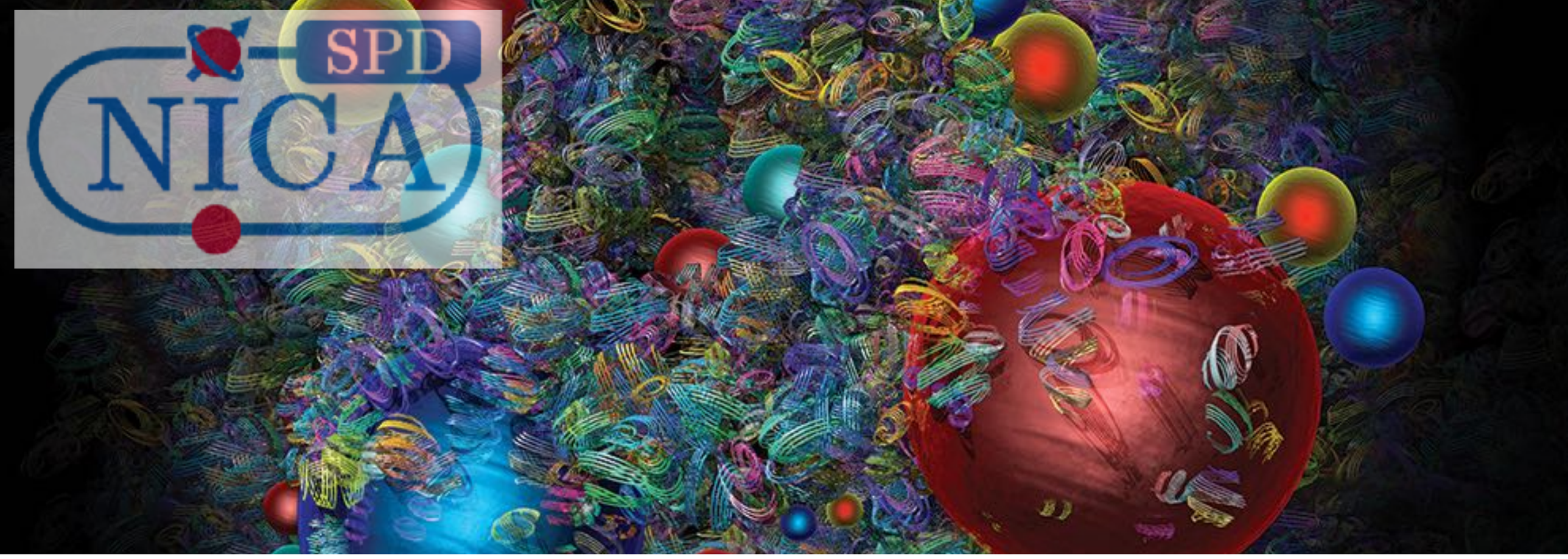


SPD EXPERIMENT AT NICA COLLIDER

Alexey Guskov (JINR) on behalf of the SPD collaboration

Alexey.Guskov@cern.ch

TWENTIETH LOMONOSOV
CONFERENCE August, 19-25, 2021
ON ELEMENTARY PARTICLE PHYSICS
MOSCOW STATE UNIVERSITY

SPD AT NICA

NICA - Nuclotron-based Ion Collider fAcility

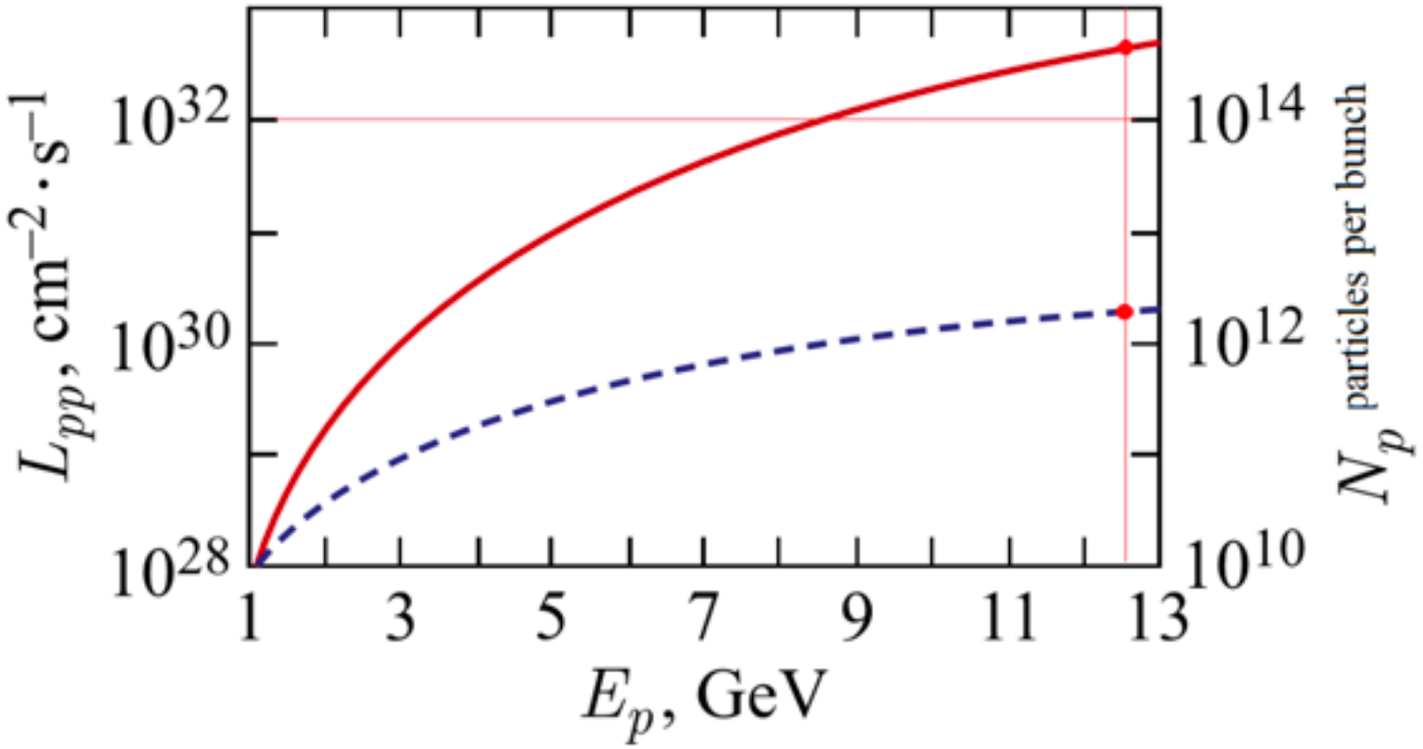
$p^{\uparrow}p^{\uparrow} : \sqrt{s} \leq 27\ GeV$

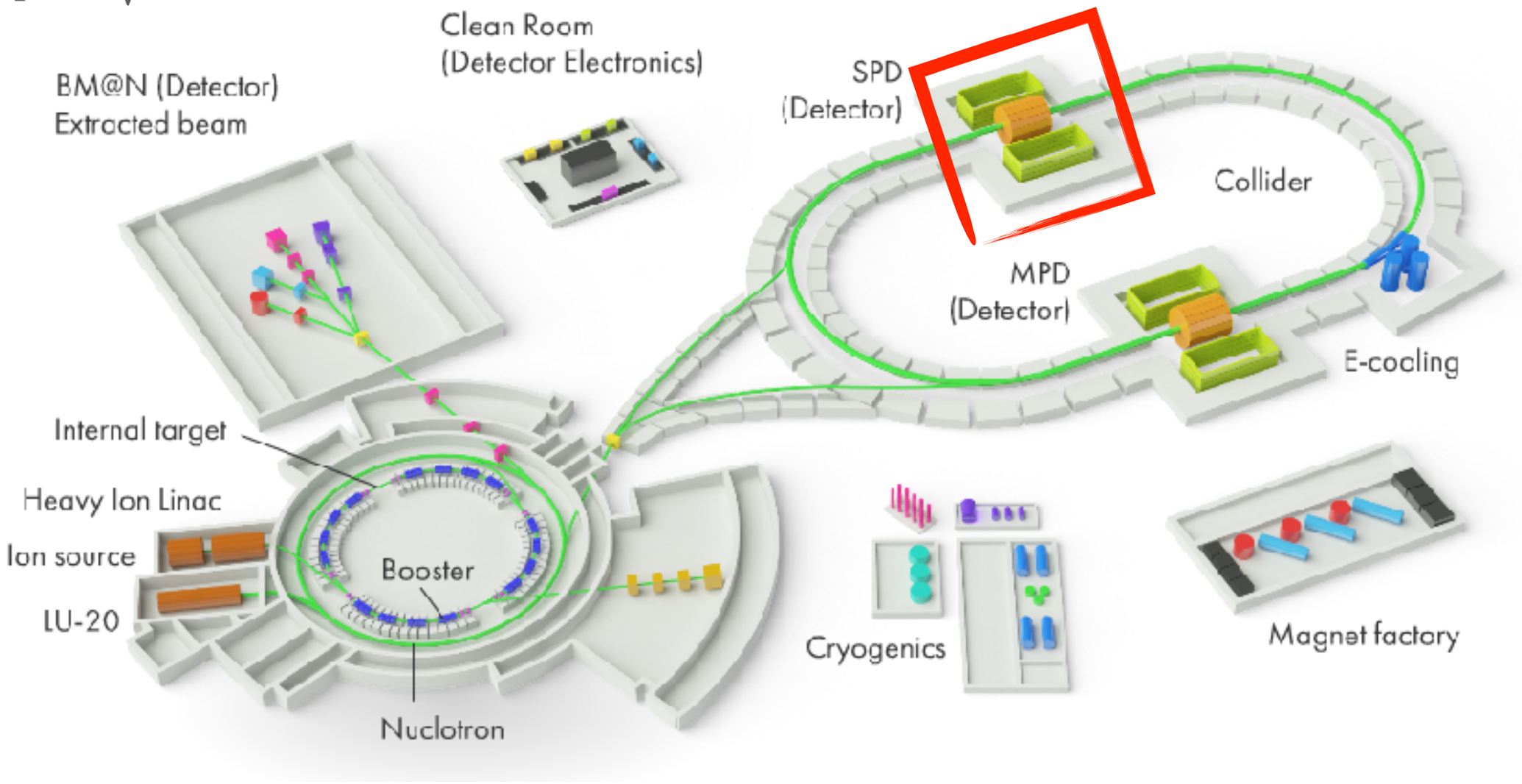
$d^{\uparrow}d^{\uparrow} : \sqrt{s} \leq 13.5\ GeV$

$d^{\uparrow}p^{\uparrow} : \sqrt{s} \leq 19\ GeV$

U, L, T

|P|>70%



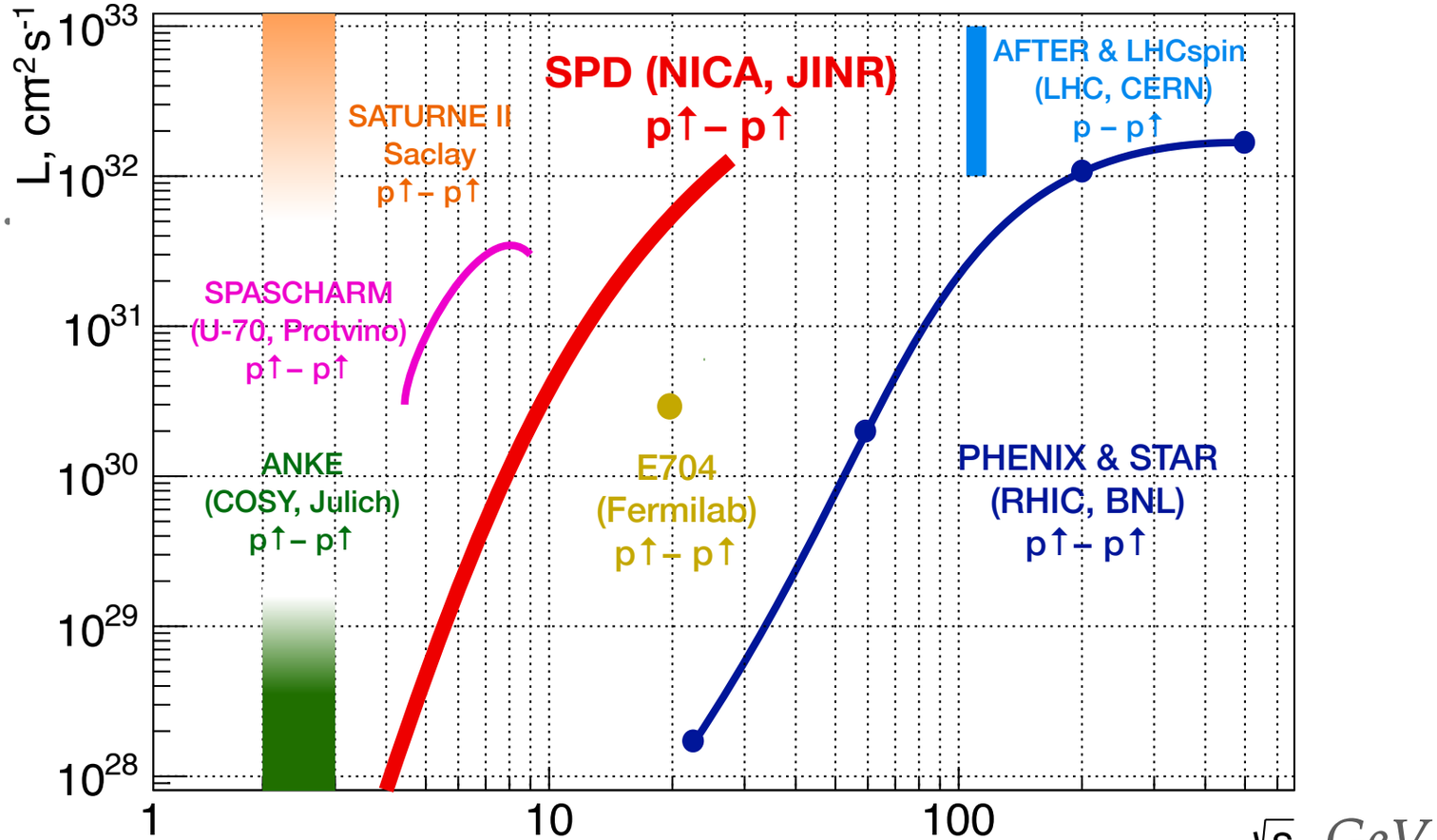


503 m


MPD
SPD

SPD – VS OTHERS

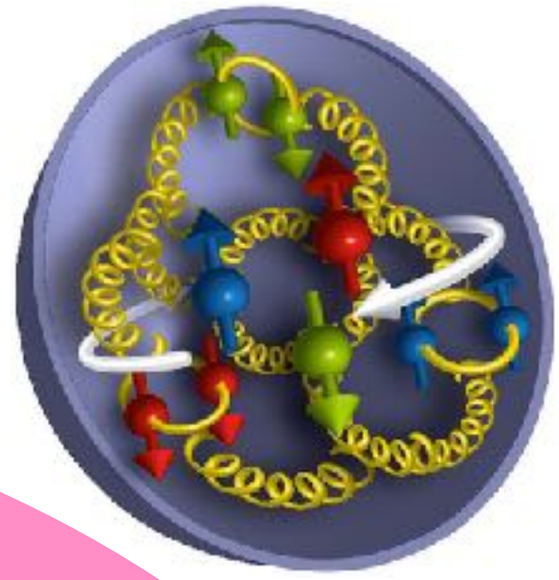
In the $p^{\uparrow}p^{\uparrow}$ mode:



Experimental facility	SPD @NICA	RHIC	EIC	AFTER @LHC	LHCspin
Scientific center	JINR	BNL	BNL	CERN	CERN
Operation mode	collider	collider	collider	fixed target	fixed target
Colliding particles & polarization	$p^{\uparrow}$-$p^{\uparrow}$ $d^{\uparrow}$-$d^{\uparrow}$ $p^{\uparrow}$-d, p-$d^{\uparrow}$	$p^{\uparrow}$-$p^{\uparrow}$	$e^{\uparrow}$-$p^{\uparrow}$, $d^{\uparrow}$, ^{3}He$^{\uparrow}$	p-$p^{\uparrow}$, $d^{\uparrow}$	p-$p^{\uparrow}$
Center-of-mass energy $\sqrt{s_{NN}}$, GeV	≤27 (p-p) ≤13.5 (d-d) ≤19 (p-d)	63, 200, 500	20-140 (ep)	115	115
Max. luminosity, 10^{32} cm^{-2} s^{-1}	~1 (p-p) ~0.1 (d-d)	2	1000	up to ~10 (p-p)	4.7
Physics run	>2025	running	>2030	>2025	>2025

In the $d^{\uparrow}d^{\uparrow}$ mode we are unique

CONCEPT OF THE SPD PHYSICS PROGRAM



SPD - a universal facility for comprehensive study of gluon content in proton and deuteron at large x

$\Delta g(x)$

Charmonia

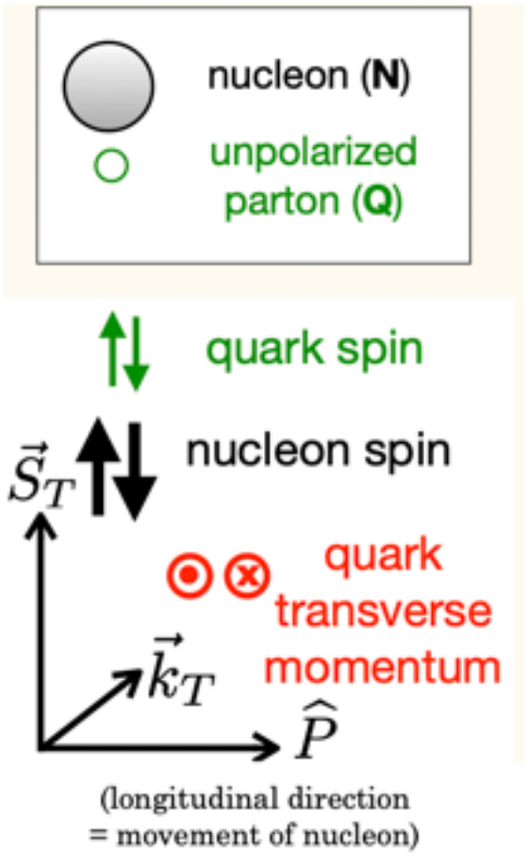
Prompt photons

Open charm

Other spin-related phenomena

Other physics

POLARIZED PARTONIC STRUCTURE



N \ Q	U	L	T
U	f_1 number density		$h_1^\perp$ Boer-Mulders
L		g_1 helicity	$h_{1L}^\perp$ worm-gear
T	$f_{1T}^\perp$ Sivers	$g_{1T}^\perp$ worm-gear	h_1 transversity; $h_{1T}^\perp$ pretzelosity

PARTONIC STRUCTURE OF PROTON AND DEUTERON

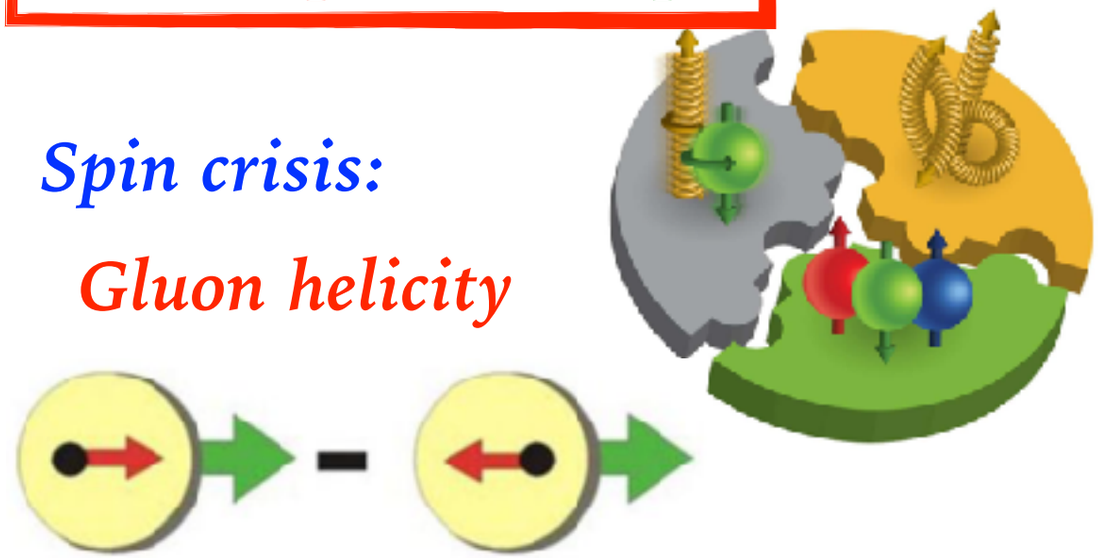
Prog.Part.Nucl.Phys. 119 (2021) 103858
arXiv:2011.15005

$\sigma(x_F,p_T)$ $A_{LL}(x_F,p_T)$

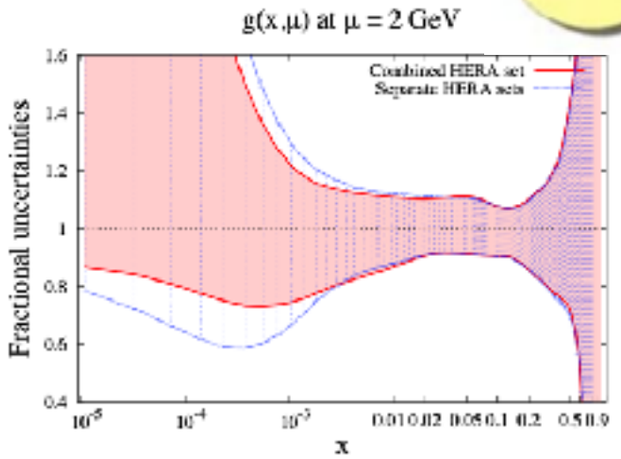
$A_{TT}(x_F,p_T)$ $A_N(x_F,p_T)$

Spin crisis:

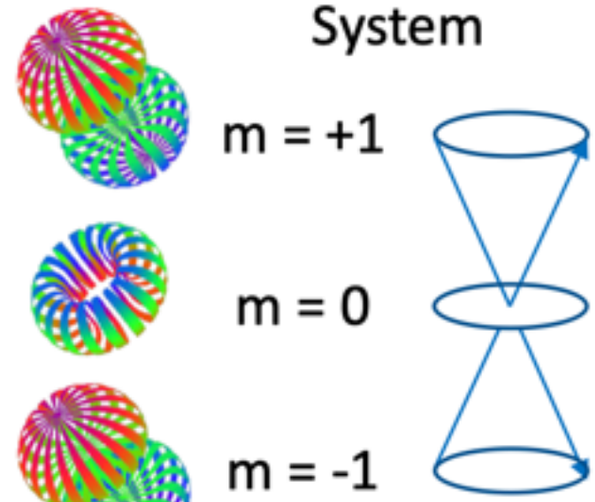
Gluon helicity



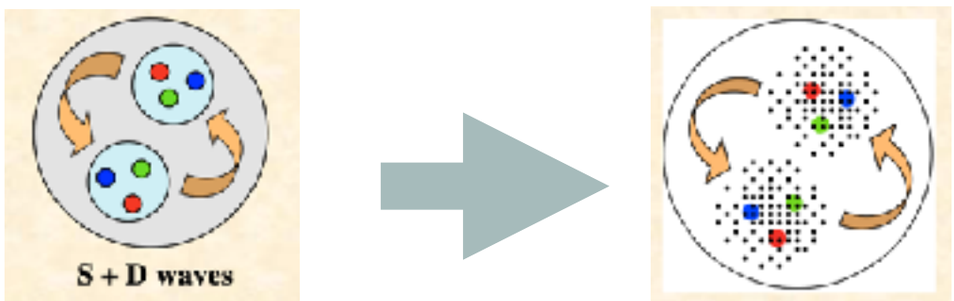
Unpolarized gluons in proton and deuteron at high x:



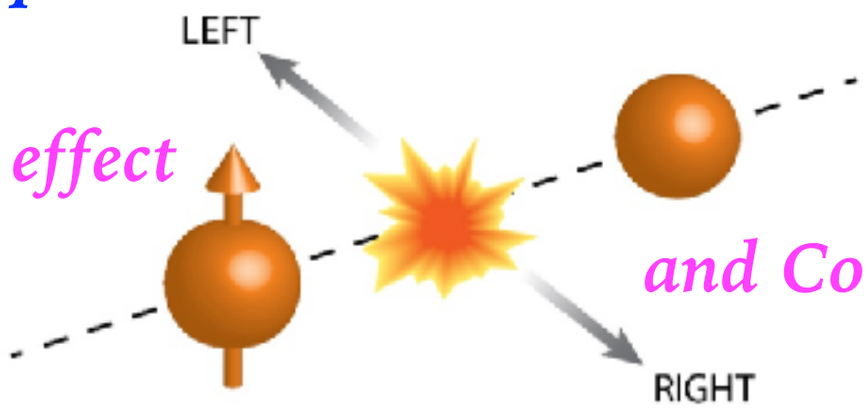
Tensor structure of deuteron:



Nonbaryonic content of deuteron:



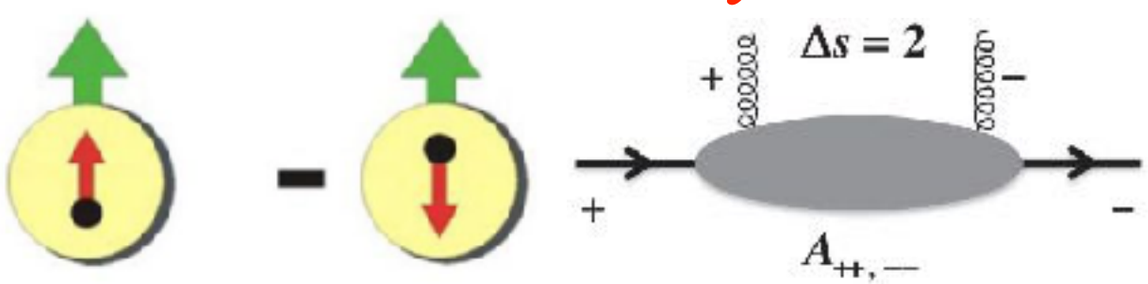
Gluon and quark TMD PDFs:



Sivers effect

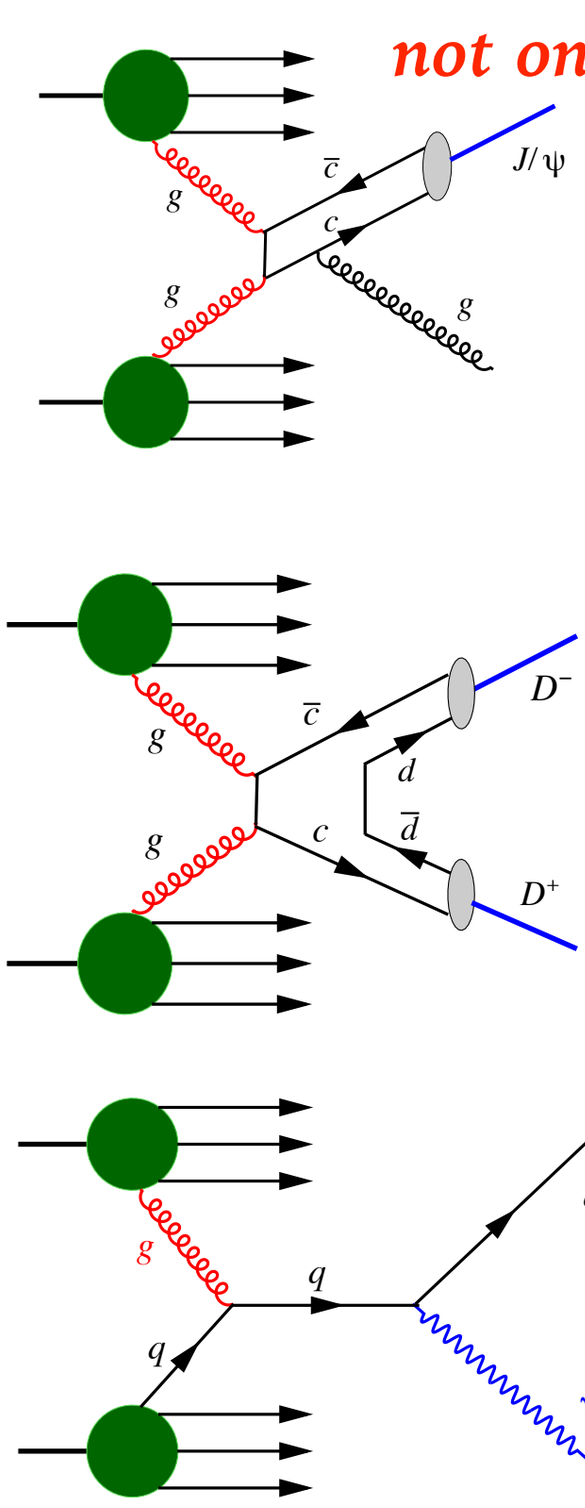
and Collins effect

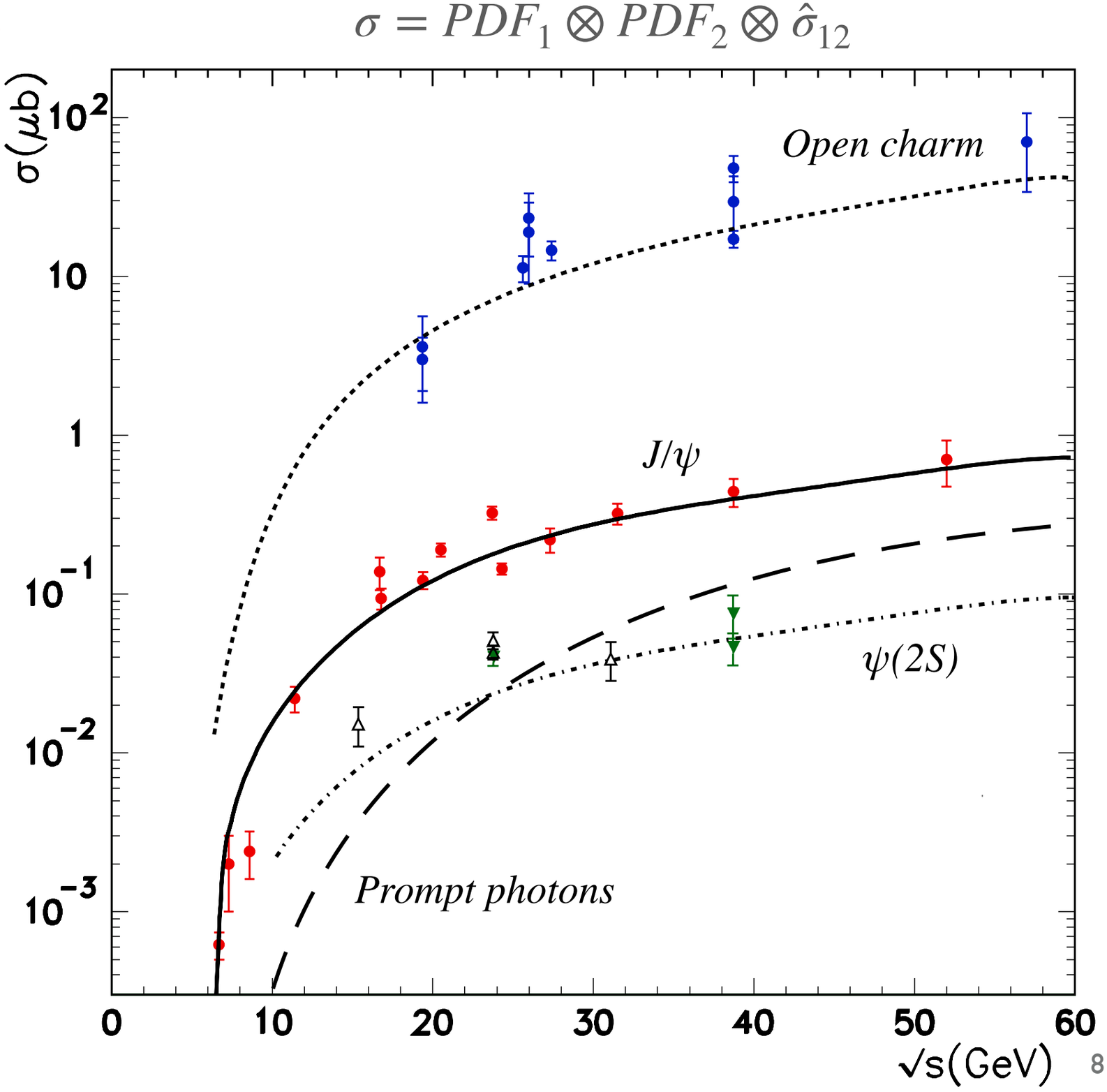
Gluon transversity



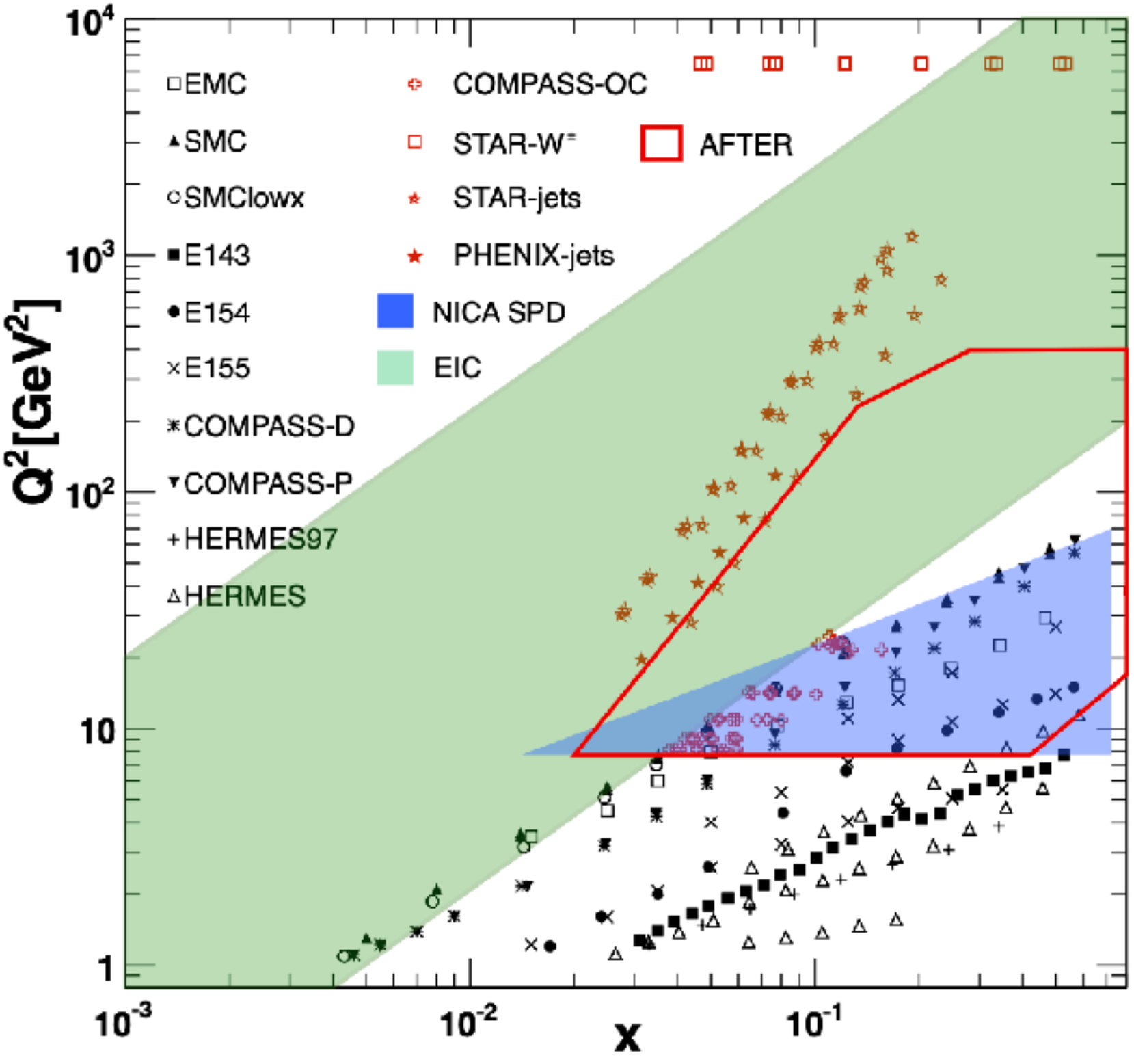
- *spin-dependent fragmentation functions*

GLUON PROBES AT SPD





CINEMATIC RANGE



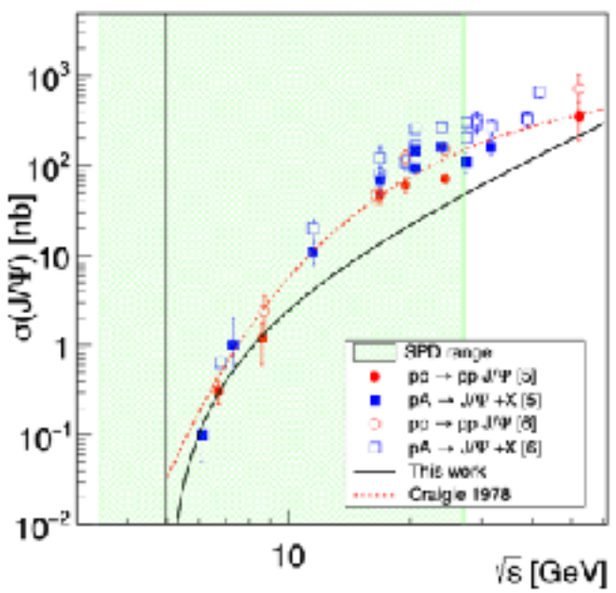
arXiv:2102.08477

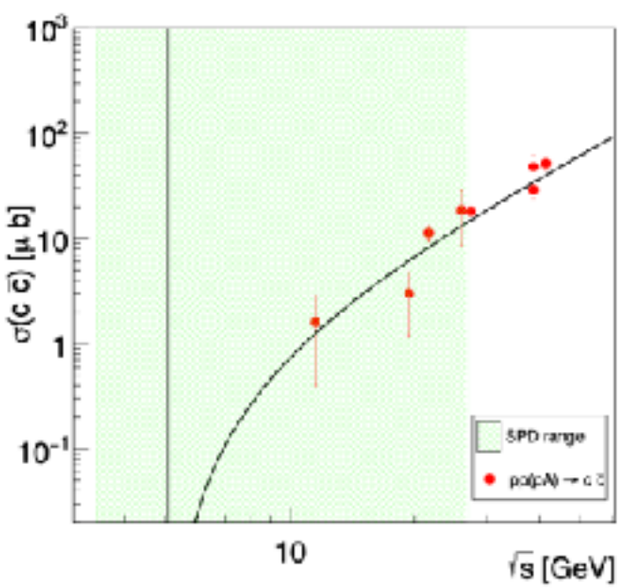
PHYSICS OF THE FIRST STAGE OF SPD RUNNING

Non-perturbative QCD — *Perturbative QCD*

$\sqrt{s}$

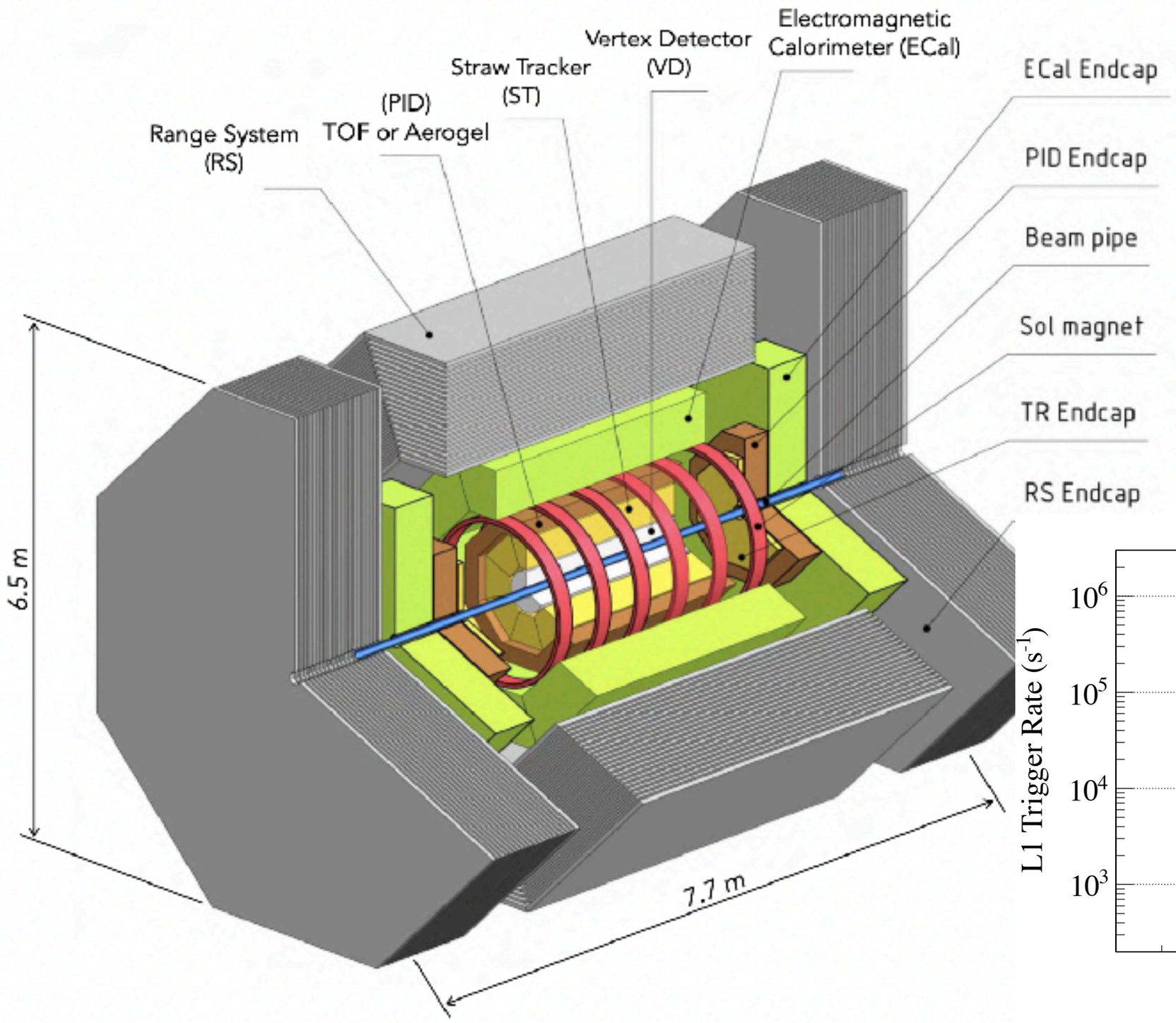
- Spin effects in p-p, p-d and d-d elastic scattering
- Spin effects in hyperons production
- Multiquark correlations $pp \to (6q)^* \to N\,N\,Mesons,$
- Dibaryon resonances
- Physics of light and intermediate nuclei collision
- Exclusive reactions
- Hypernucei $dd \to K^+\,K^+\,{}^{4}_{\Lambda\Lambda}\mathrm{n},$
- Open charm and charmonia near threshold



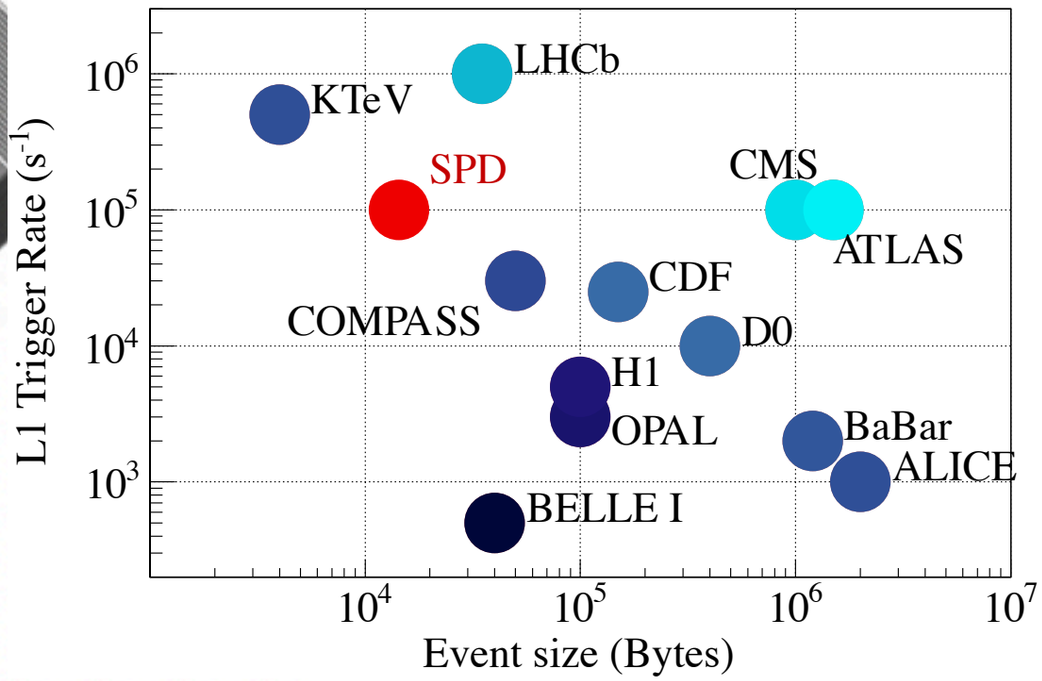


- Auxiliary measurements for astrophysics
- …

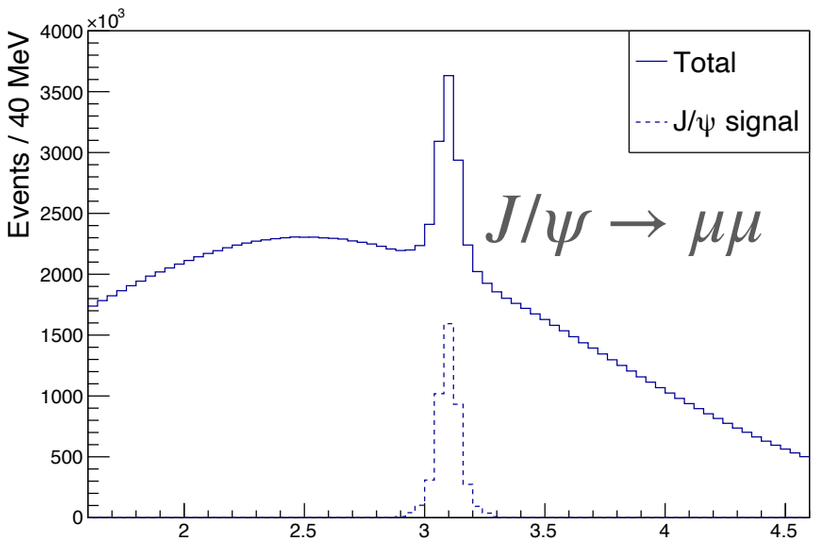
SPD DETECTOR

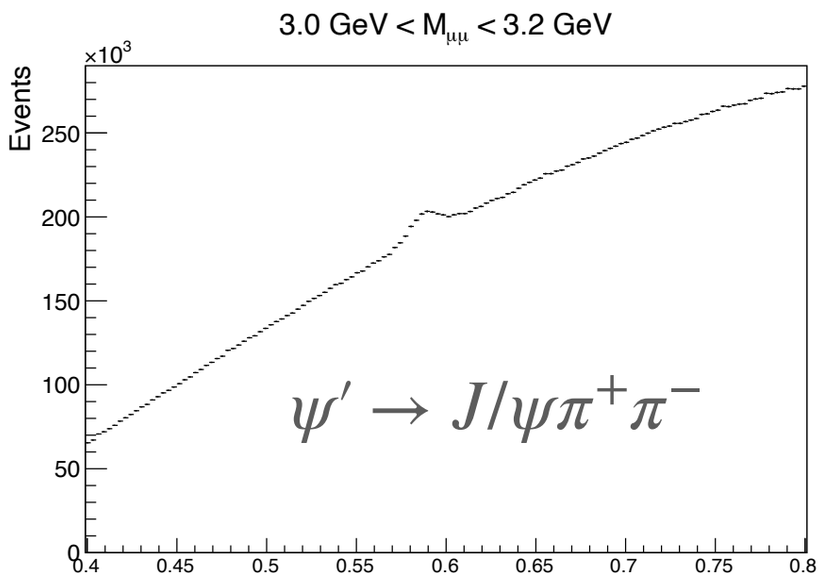


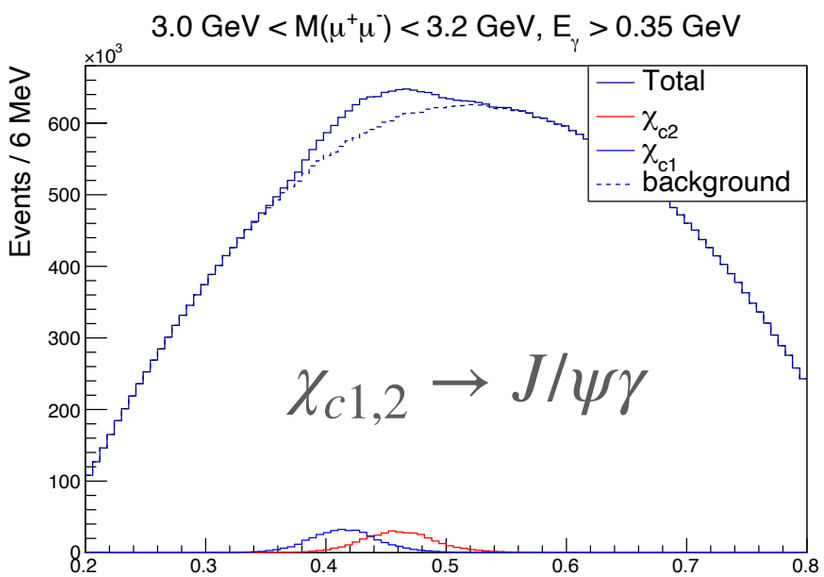
No hardware triggers to avoid possible bias!

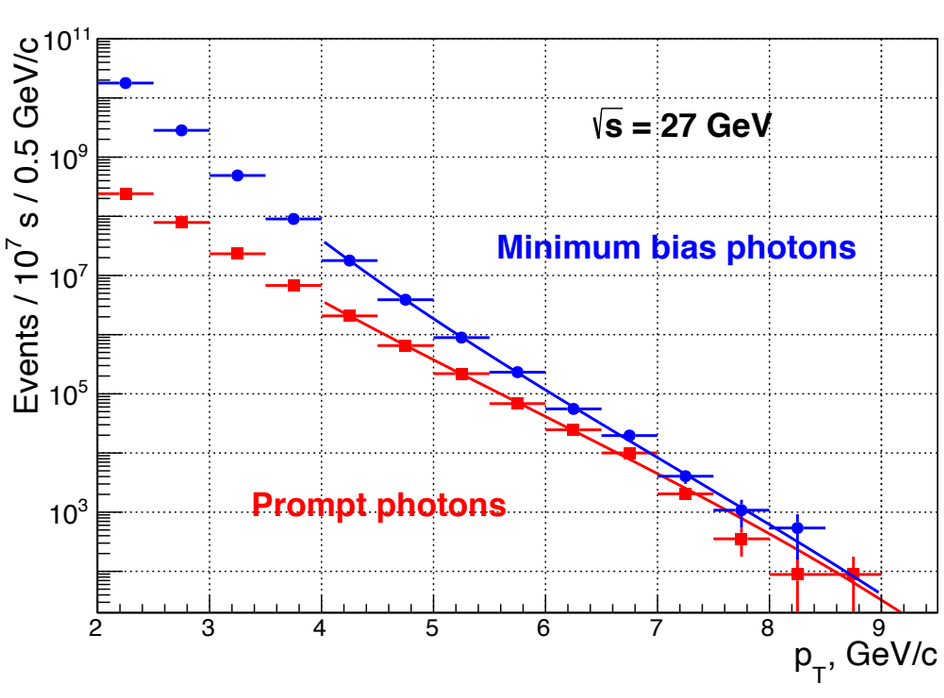


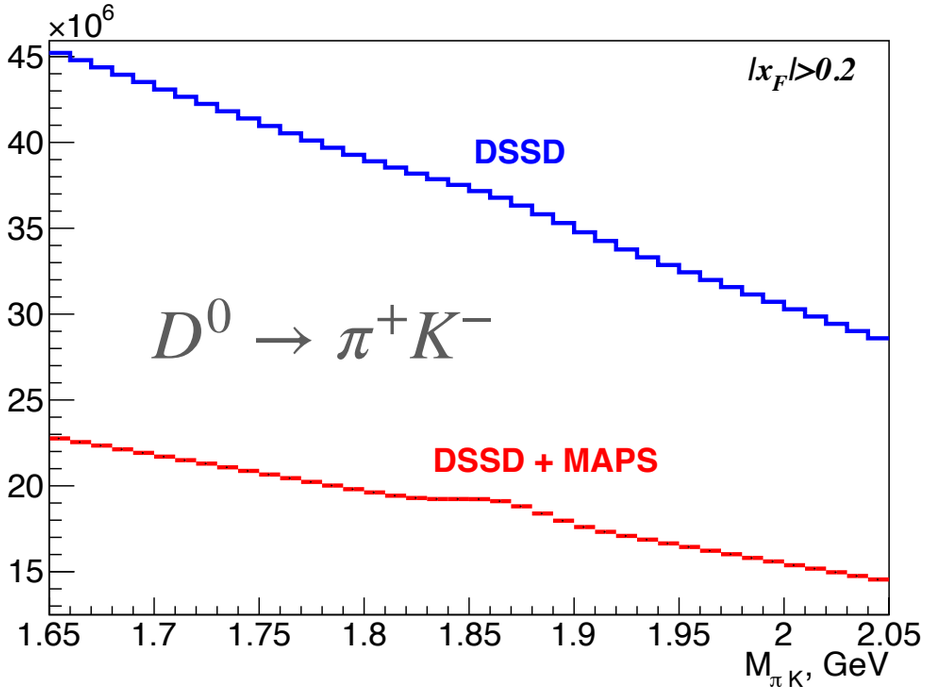
PHYSICS PERFORMANCE: GLUON PROBES (1 YEAR=10^7 S)











SPD INTERNATIONAL COLLABORATION

32 institutes from 14 states, ~300 members

The SPD international collaboration is forming actively

SPD CDR was issued in the beginning of 2021: arXiv:2102.00442

*CDR in now under expertise of the international **Detector Advisory Committee***

First version of the SPD TDR should be presented in 2022

SUMMARY

- The **Spin Physics Detector** at the NICA collider is a universal facility for comprehensive study of polarized and unpolarized **gluon content of proton and deuteron**; in polarized high-luminosity **p-p** and **d-d** collisions at $\sqrt{s} \leq 27\ GeV$
- Complementing main probes such as **charmonia** (J/ψ and higher states), **open charm** and **prompt photons** will be used for that;
- SPD can contribute significantly to investigation of
  - gluon helicity;
  - gluon-induced TMD effects (Sivers and Boer-Mulders);
  - unpolarized gluon PDFs at high-x in proton and deuteron;
  - gluon transversity in deuteron.
  - …
- **The SPD gluon physics program is complementary to the other intentions to study the gluon content of nuclei (RHIC, AFTER, EIC) and mesons (COMPASS++/AMBER, EIC).**
- SPD CDR could be found at arXiv:2102.00442 for more details.
- More information could be found at http://spd.jinr.ru