Spin Physics Detector

Spin Physics Detector (SPD) at NICA Collider: Present Status and Outlooks

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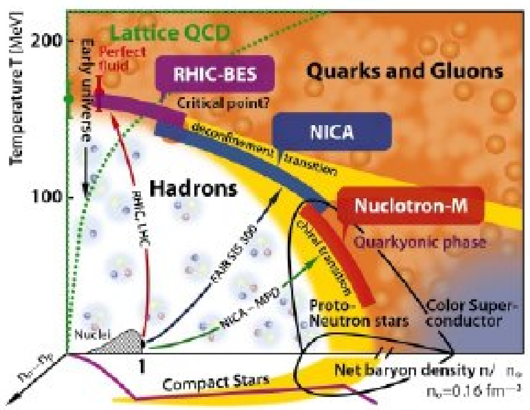
On behalf of the SPD Collaboration

NICA Accelerator Complex at JINR, Dubna

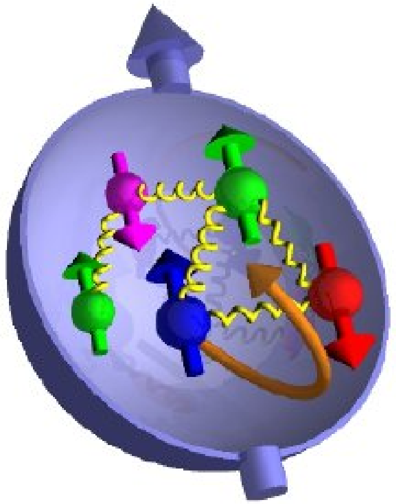
NICA facility at JINR, Dubna

NICA (Nuclotron-based Ion Collider fAcility)



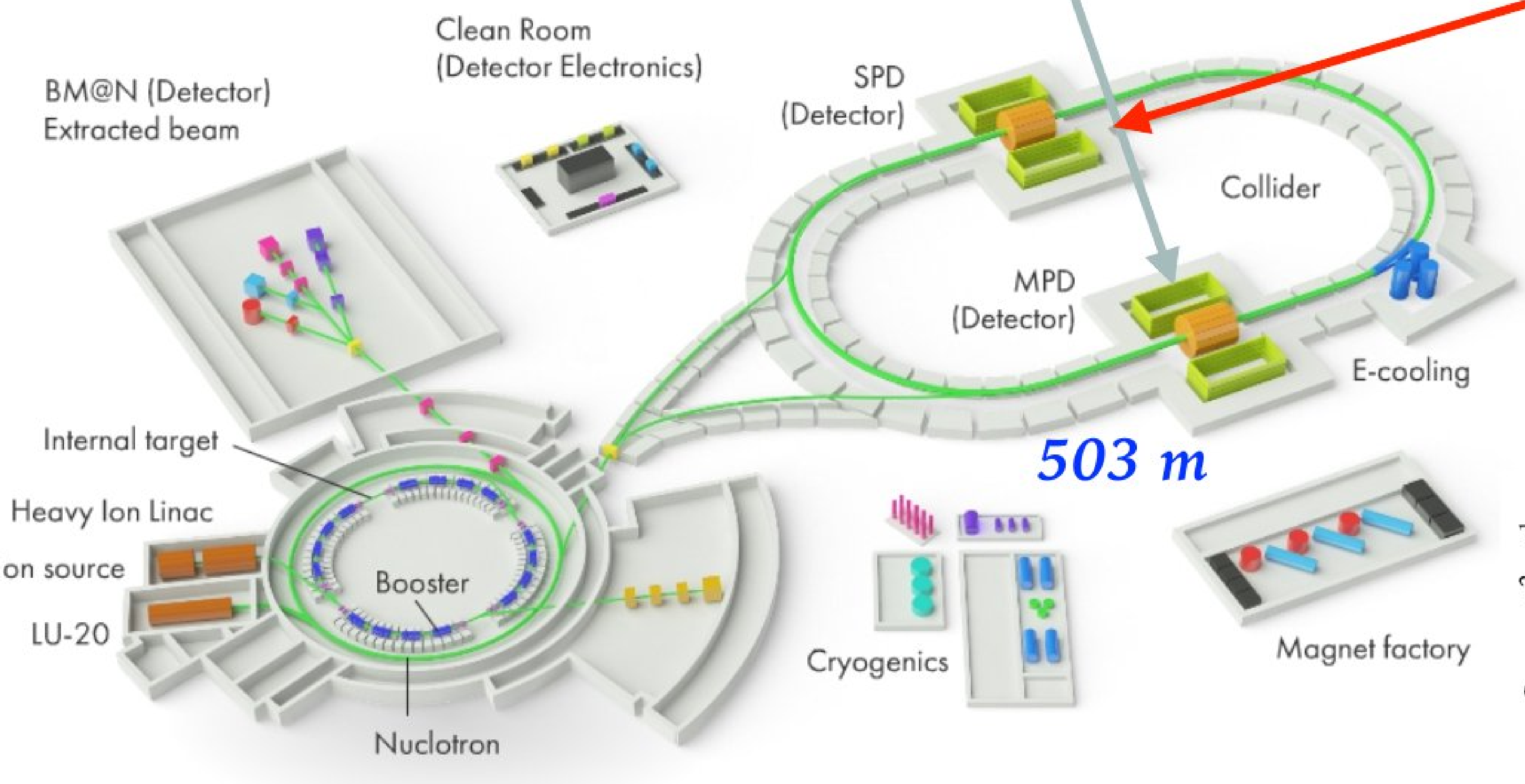
Stage 1

Hot hadronic matter in extremal conditions with heavy-ion beams



Stage 2

Proton and deuteron spin structure with polarized beams

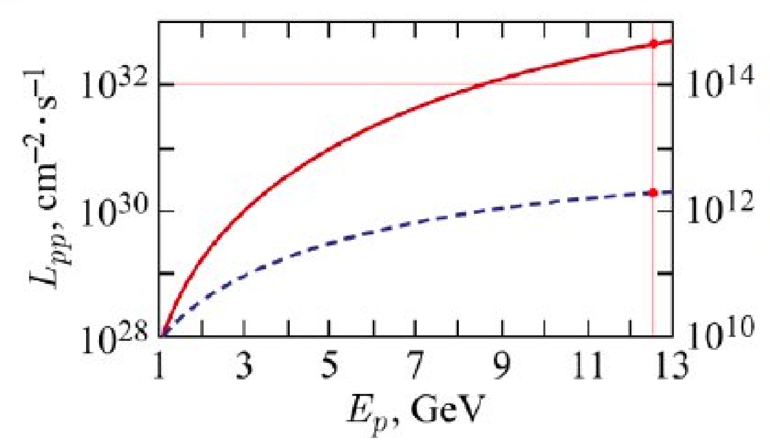


Polarized proton and deuteron beams:

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

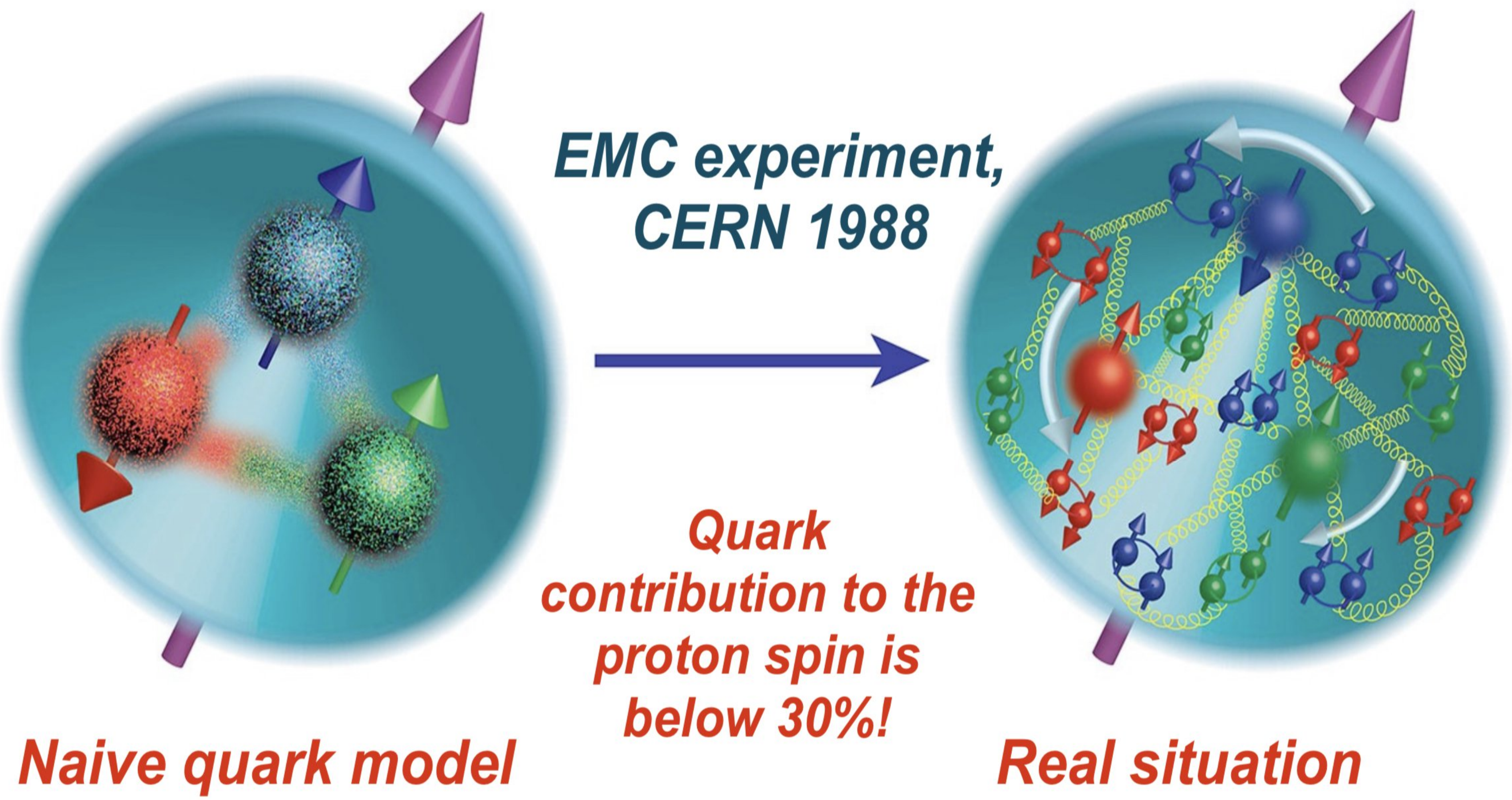
$d^{\uparrow}d^{\uparrow}: \sqrt{s} \leq 13.5$ GeV

U, L, T $|P| > 70\%$



SPD at NICA Collider

Spin Physics Detector (SPD):
polarized pp- and dd- collisions at high luminosity



SPD NICA experiment is aimed at studying the properties of strong interactions in the nonperturbative region, at measuring the proton and deuteron spin structures, and at the development of a three-dimensional picture of the nucleon.
SPD NICA is unique in its methodology, breadth of coverage and variety of tasks.

SPD Physics Primary Goals

► Spin Physics Detector (SPD) at NICA (http://spd.jinr.ru):
a universal setup for comprehensive study of
polarized and unpolarized gluon content of proton and deuteron
in polarized and unpolarized high-luminosity pp- and dd- collisions at $\sqrt{s} \leq 27$ GeV

► Complementing main probes: charmonia (J/Psi, higher states),
open charm and direct photons in inclusive and semi-inclusive modes

► SPD can reveal significant insights on:
- gluon helicity structure
- unpolarized gluon PDF at high x in proton and deuteron
- gluon transversity in deuteron

► Comprehensive physics program for the initial period of data taking
(can be performed even at reduced energy and luminosity)

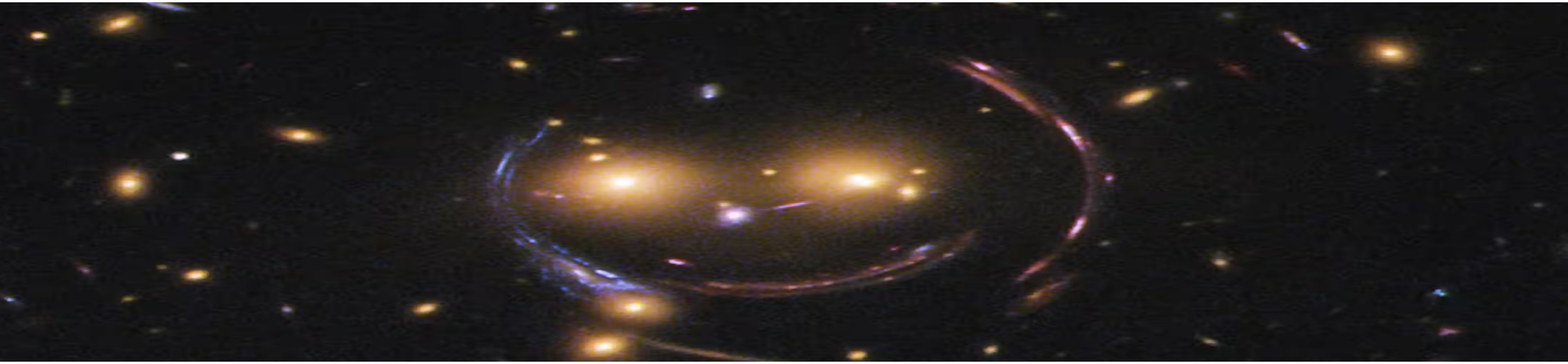
Why Nucleon Spin Physics?

Search for New Physics:

► Search for new particles and interactions beyond the Standard Model

► Search for new dynamics within the Standard Model

Why Nucleon Structure?



- proton mass -> the visible Universe mass

Electroweak Higgs boson provides:

u-, d- quark mass in p ~ 15 MeV ≃ 2% of the visible Universe mass

➥ **Quark-Gluon dynamics of nucleon structure provides:**

~ 98% of the mass of the visible Universe!

Why Spin?

Spin: pure quantum characteristics

spin: no classical analog

spin observables

-> hadron wave functions
-> process amplitudes

"proton spin crisis" :
quark model -> only 1/3 of proton spin

SPD Experiment Primary Goals

Spin Physics Detector (SPD) (http://spd.jinr.ru):
A Universal Detector at NICA Collider

➥ **SPD Primary Goals:**
understanding strong interactions using polarized and unpolarized pp- and dd- collisions $\sqrt{s} < 27$ GeV

- 3D structure of proton and deutron, in particular, PDF and TMD at large x

A. Arbuzov et al. ,Prog. Part. Nucl.Phys. 119 (2021) 103858 e-Print: 2011.15005 [hep-ex]

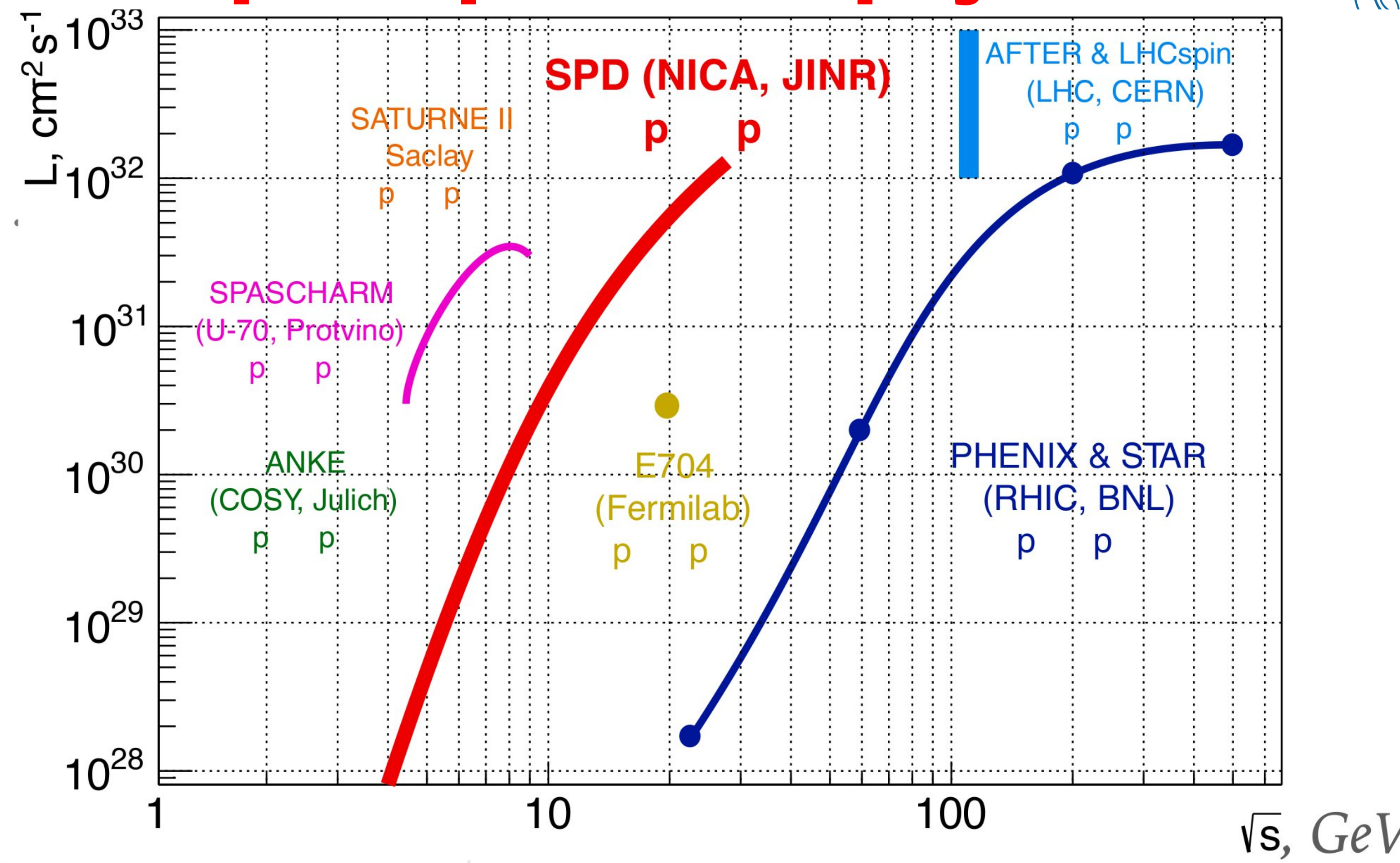
➥ **In addition, a wide research program for particular and nuclear physics in the initial 1st Stage of SPD operation is planned**

V.V. Abramov et al., Phys. Part. 52 (2021) 1044, e-Print: 2102.08477 [hep-ph]

TMD - Parton Distribution Function with longitudinal momentum
TMD - Transverse Momentum Distribution–
parton distribution with transverse momentum

SPD in World landscape of polarized physics

p↑ p↑-mode ➡

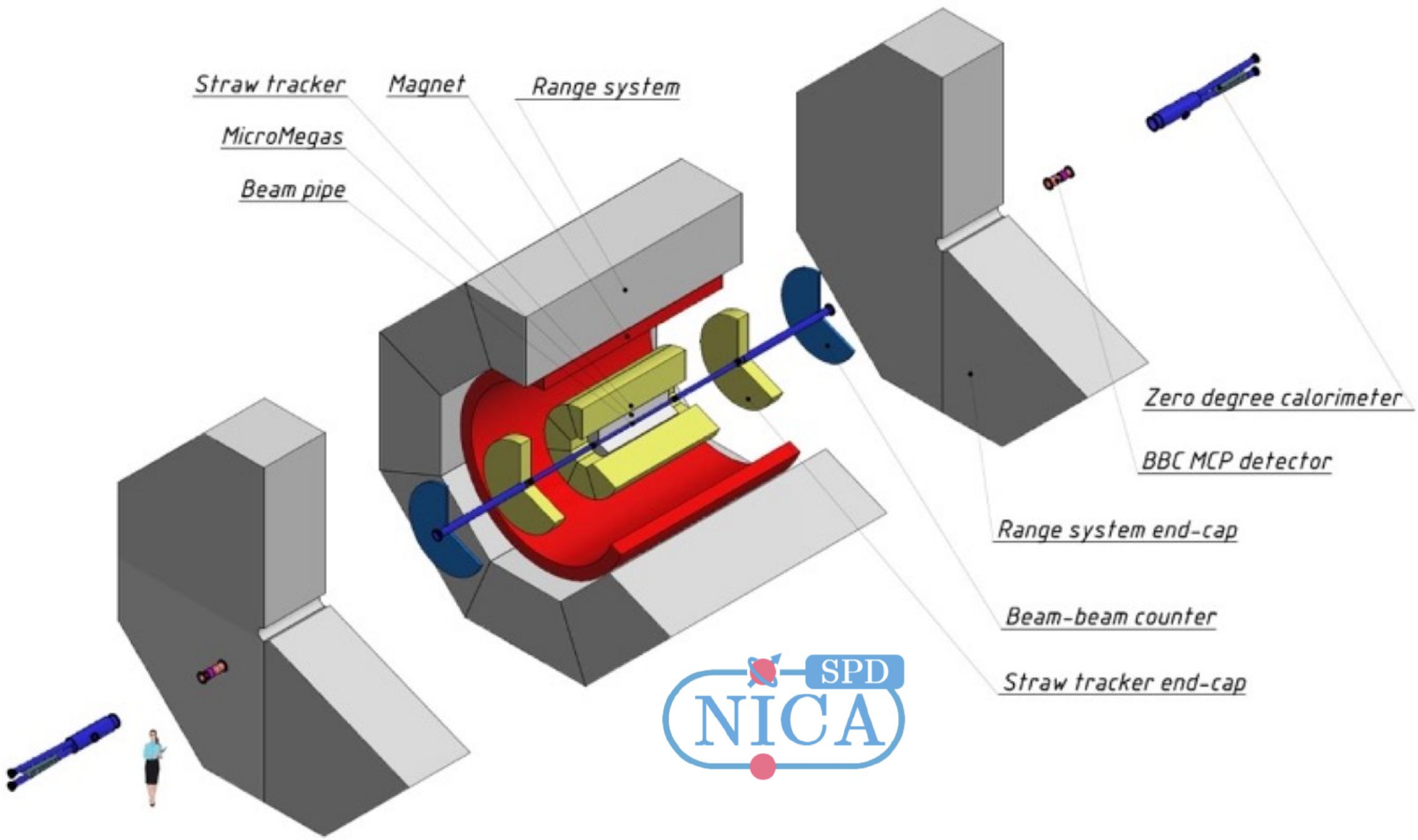


Experimental facility	SPD @NICA	RHIC	EIC	AFTER @LHC	LHCspin
Scientific center	JINR	BNL	BNL	CERN	CERN
Operation mode	collider	collider	collider	fixed target	fixed target
Colliding particles & polarization	$p^{\uparrow}$-$p^{\uparrow}$ $\boxed{d^{\uparrow}\text{-}d^{\uparrow}}$ $p^{\uparrow}$-d, p-$d^{\uparrow}$	$p^{\uparrow}$-$p^{\uparrow}$	$e^{\uparrow}$-$p^{\uparrow}$, $d^{\uparrow}$, ^{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

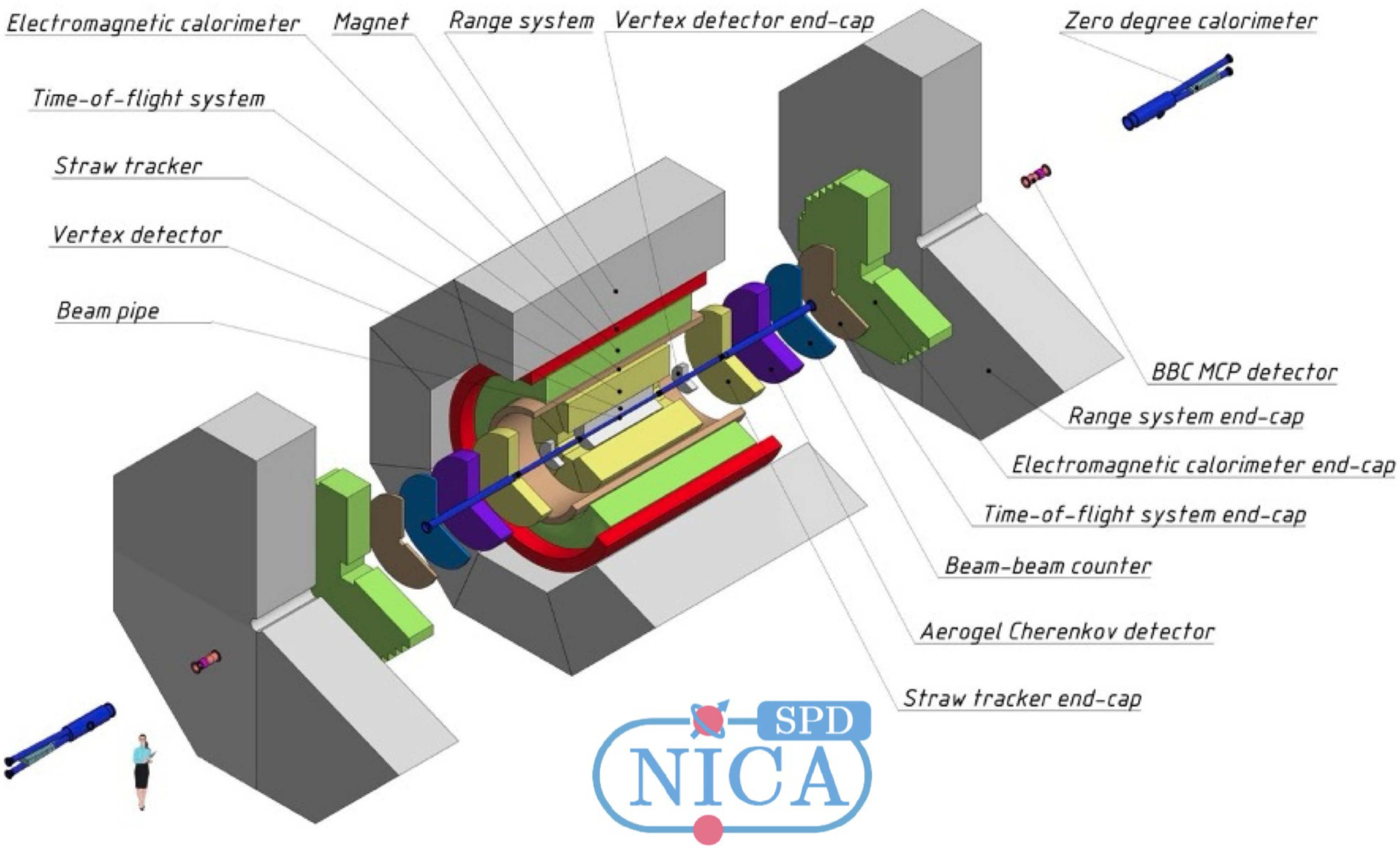
⬅ SPD is unique in d↑ d↑-mode!

SPD detector at the Phase I

	$p\uparrow p\uparrow$	$d\uparrow d\uparrow$	AA
	First phase		
$\sqrt{s_{NN}}$, GeV	< 9.4	< 4.5	< 4.5
L, 10^{30} cm^{-1}	< 10	< 1	< 0.001
	Second phase		
$\sqrt{s_{NN}}$, GeV	< 27	< 13.5	
L, 10^{30} cm^{-1}	< 100	< 10	



SPD detector at the Phase II



- Event rate at peak luminosity and energy 3M Hz
- Silicon vertex detector : MAPS/ DSSD
- Time of ight (TOF) for PID ($_t$ 50 ps), $/K$ separation upto 1.5 GeV/ c
- Electromagnetic calorimeter (ECAL) ($\frac{E}{E}$ = $\frac{5\%}{\sqrt{E}}$ +1 %)
- Aerogel counter in endcaps,exten GeV/ c separation upto 2.5

- Improved vertex detector for short lived particle decays
- TOF+A Gel for better PID
- ECAL for , e identification

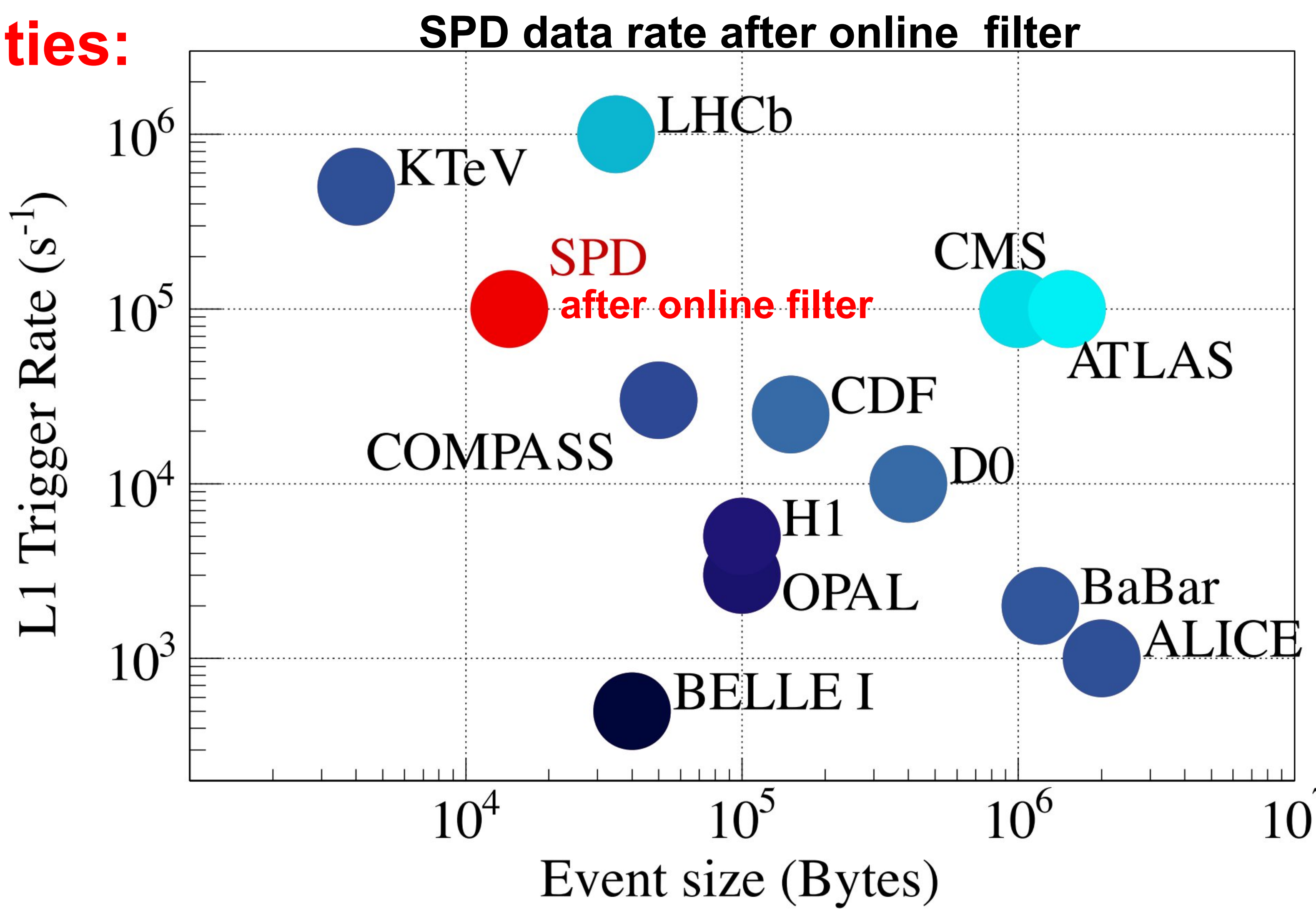
SPD detector data flow

No hardware trigger at the SPD detector to avoid a possible bias:
3 MHz event/s at 10^{32} cm^2/s design luminosity
20 GB/s ➡ 3 10^3 events/year ➡ 200 PB/year

The SPD setup is a medium scale detector in size,
but a large scale one in data rate!
Comparable in data rate with ATLAS and CMS at LHC

SPD Tier-1 Prototype Facilities:

- **NRC KI - PNPI, Gatchina**
- **SSU, Samara**



Towards SPD Grid Sites:
- **LIT JINR**
- **NRC KI – PNPI, Gatchina**
- **SSU, Samara**

SPD: Requested Computing Resources

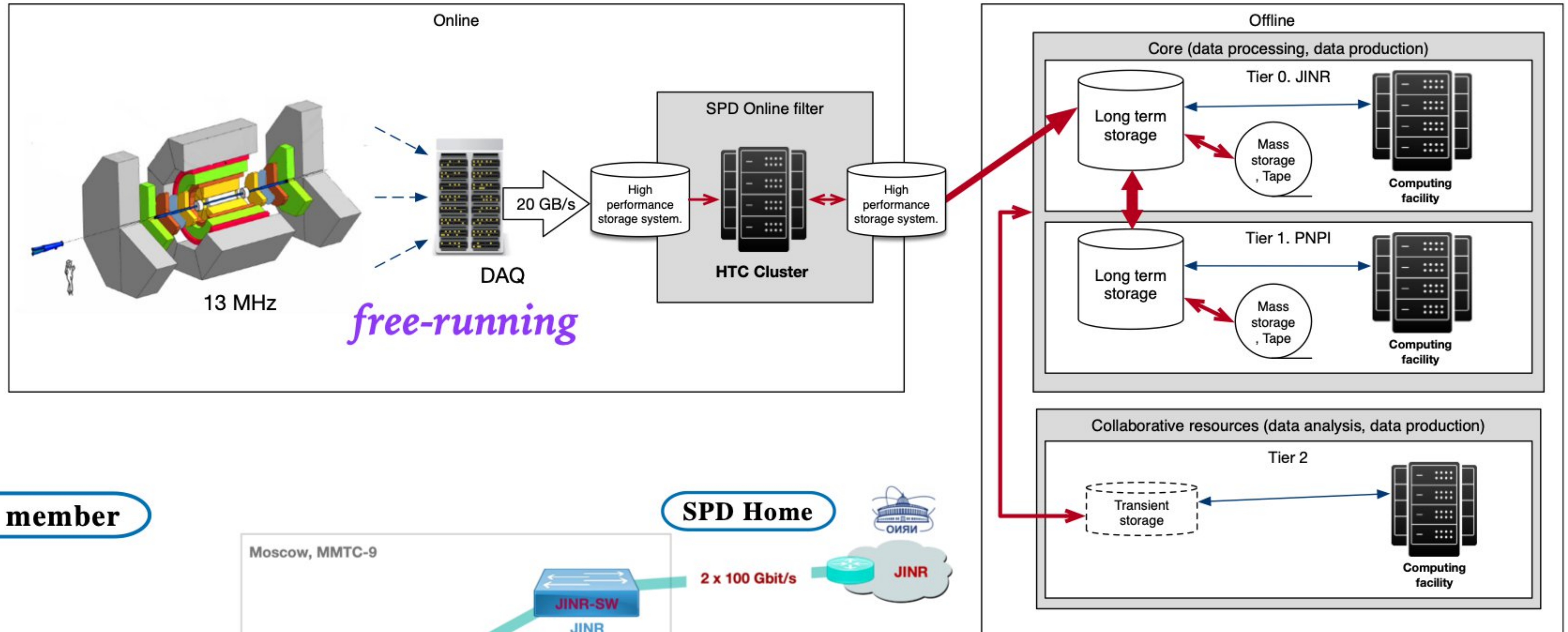
Considerations of SPD Tier-1
for the SPD 2nd Stage at NRC KI – PNPI, Gatchina

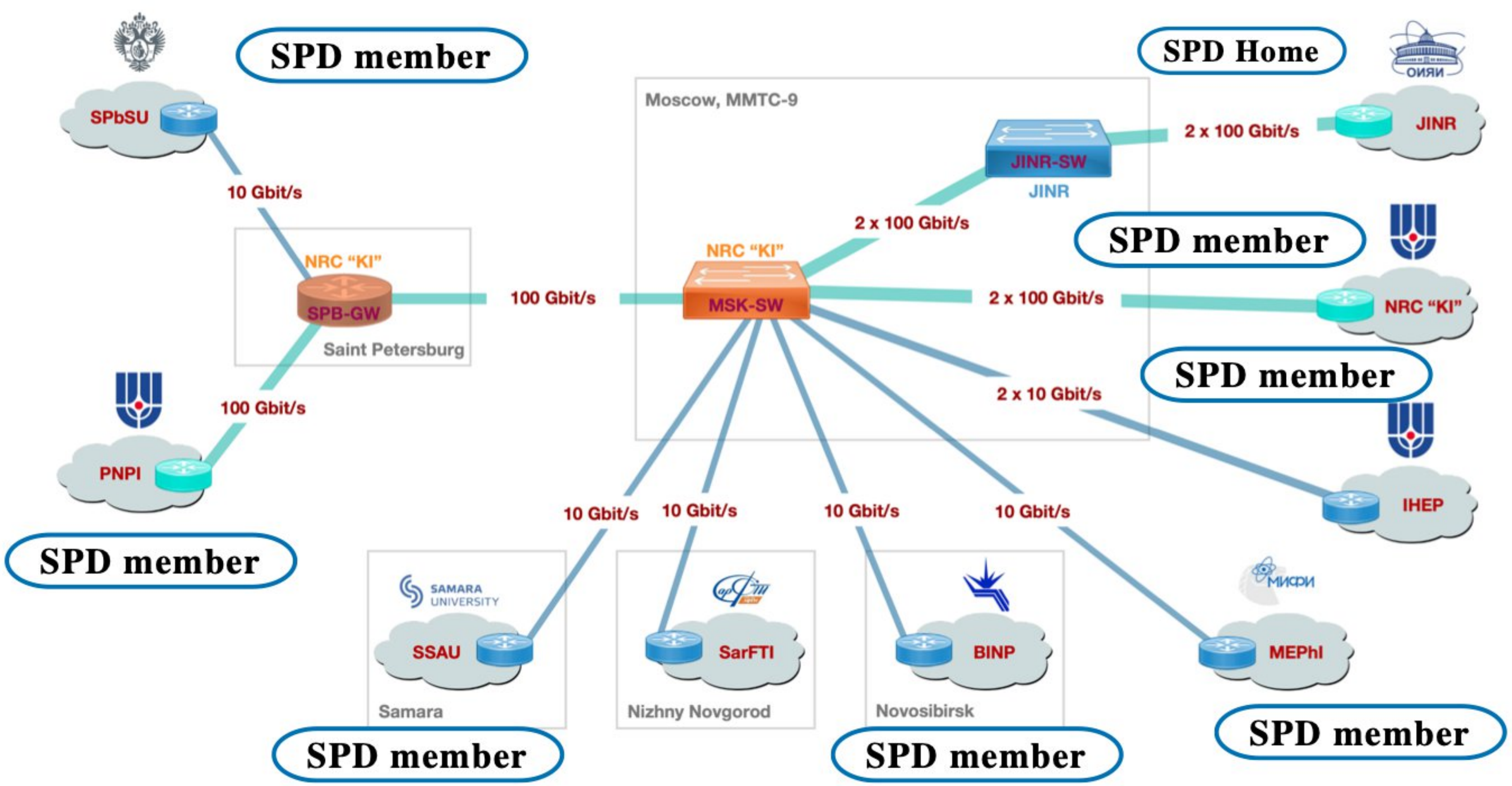
Computing resources	Distribution by year				
	1st year	2nd year	3rd year	4th year	5th year
Data storage (TB) - EOS - Tapes	1500 0	2000 2000	5000 10000	7000 14000	10000 20000
Tier 1 (CPU corehours)	17 520 000	43 800 000	87 600 000	131 140 000	175 200 000
Tier 2 (CPU corehours)	1 752 000	4 380 000	8 760 000	13 114 000	17 520 000
SC Govorun (CPU core hours)	1 752 000	4 380 000	8 760 000	8 760 000	8 760 000

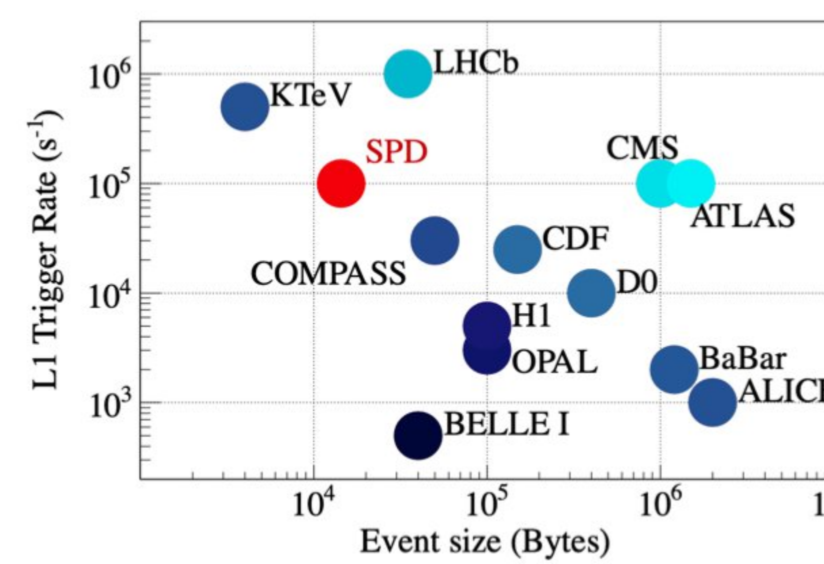
SPD GRID sites:
- LIT JINR
- NRC KI – PNPI, Gatchina (Sep 2021)
- SSU, Samara (Aug 2025)

SPD IT Infrastructure

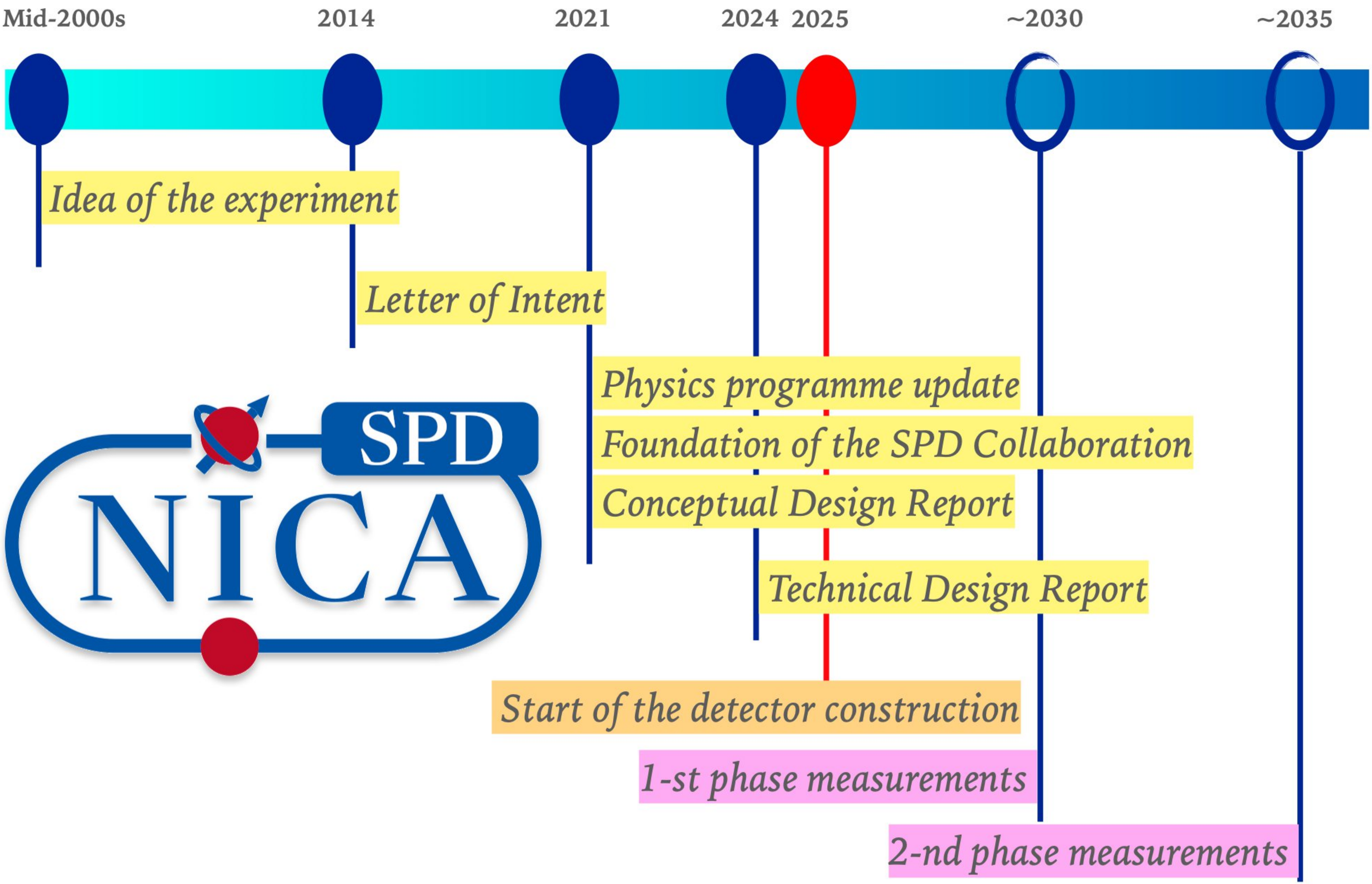
SPD Data Flow







SPD Collaboration: established in July 2021



SPD Collaboration: Organization

40 organizations from 15 countries   *> 400 participants*

Signed MoU (18):

NRC “Kurchatov Institute” - PNPI, Gatchina
Alikhanov National Science Laboratory (Yerevan Physics Institute), Yerevan
Samara National Research University, Samara
Peter the Great Saint Petersburg Polytechnic University, St. Petersburg
Saint Petersburg State University, St. Petersburg
Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow
Lebedev Institute of Physics RAS, Moscow
Institute for Nuclear Research RAS, Moscow
Institute of Nuclear Physics (INP RK), Almaty
Tomsk State University, Tomsk
National Research Nuclear University MEPhI, Moscow
Belgorod State University, Belgorod
Institute of Nuclear Problems, Belorussian State University, Minsk
Budker Institute of Nuclear Physics RAS, Novosibirsk
Higher Institute of Technologies and Applied Sciences, Havana
Higher School of Economics, Moscow
Stepanov Institute of Physics NAS, Minsk
I-Temba Labs (South Africa)
in signing: Univ. Cairo (Egypt)
New members: Shandong Univ. (China) and USTC (China)

SPD Co-Spokespersons:
A.V. Guskov (JINR) & V.T. Kim (NRC KI - PNPI)

CB Chair: A. Tumasyan (AANL, Yerevan)
Physics Coordinator: A. Datta (JINR)
Technical Coordinator: A. Korzenev (JINR)
Software Coordinator: D. Oleynik (JINR)

SPD Collaboration Meetings:
prior 2023: Dubna
2023: Dubna (April)
Samara (October)
2024: Almaty, Kazakhstan (May)
Dubna (November)
2025: Yerevan, Armenia (May)
Dubna (October)
2026: Tomsk (May)
Dubna (November)
2027: Quingdaio, China (May?)

SPD Physics highlights

► Spin Physics Detector (SPD) at NICA (http://spd.jinr.ru):
a universal setup for comprehensive study of
polarized and unpolarized gluon content of proton and deuteron
in polarized and unpolarized high-luminosity pp- and dd- collisions at $\sqrt{s} \leq 27$ GeV

► Complementing main probes: charmonia (J/Psi, higher states),
open charm and direct photons in inclusive and semi-inclusive modes

► SPD can reveal significant insights on:
- gluon helicity structure
- unpolarized gluon PDF at high x in proton and deuteron
- gluon transversity in deuteron

► Comprehensive physics program for the initial period of data taking
(can be performed even at reduced energy and luminosity)

SPD Physics:

Progress in Particle and Nuclear Physics
Volume 119, July 2021, 103858

Review

On the physics potential to study the gluon content of proton and deuteron at NICA SPD

ArXiv e-Print: 2011.15005 [hep-ex]

A. Arbuzov[a], A. Bacchetta[b, c], M. Butenschoen[d], F.G. Celiberto[b, c, e, f], U. D'Alesio[g, h], M. Deka[a], I. Denisenko[a], M.G. Echevarria[i], A. Efremov[a], N.Ya. Ivanov[a, j], A. Guskov[a, k], A. Karpishkov[l, a], Ya. Klopot[a, m], B.A. Kniehl[d], A. Kotzinian[j, o], S. Kumano[p], J.P. Lansberg[q], Keh-Fei Liu[r], F. Murgia[h], M. Nefedov[l], B. Parsamyan[a, n, o], C. Pisano[g, h], M. Radici[c], A. Rymbekova[a], V. Saleev[l, a], A. Shipilova[l, a], Qin-Tao Song[s], O. Teryaev[a]

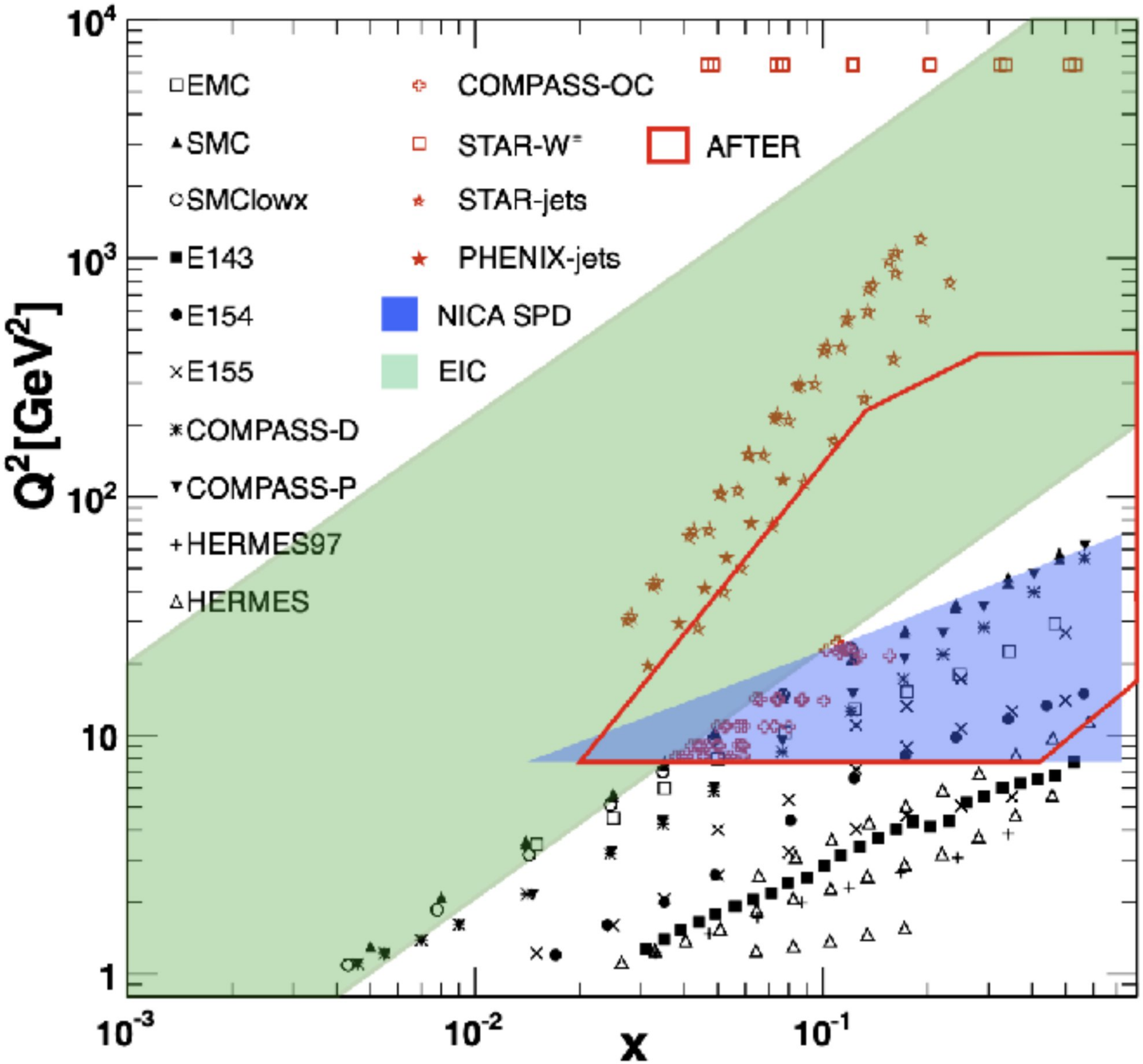
Possible studies at the first stage of the NICA collider operation with polarized and unpolarized proton and deuteron beams

V. V. Abramov[1], A. Aleshko[2], V. A. Baskov[3], E. Boos[2], V. Bunichev[2], O. D. Dalkarov[3], R. El-Kholy[4], A. Galoyan[5], A. V. Guskov[6], V. T. Kim[7, ←], E. Kokoulina[5, ↳], I. A. Koop[10, 11, 12], B. F. Kostenko[13], A. D. Kovalenko[5], V. P. Ladygin[5], A. B. Larionov[14, 15], A. I. L vov[3], A. I. Milstein[10, 11], V. A. Nikitin[5], N. N. Nikolaev[16, 26], A. S. Popov[10], V. V. Polyanskiy[3], J.-M. Richard[17], S. G. Salnikov[10], A. A. Shavrin[7, 1↵], P. Yu. Shatunov[10, 11], Yu. M. Shatunov[10, 11], O. V. Selyugin[14], M. Strikman[1↳], E. Tomasi-Gustafsson[20], V. V. Uzhinsky[13], Yu. N. Uzikov[6, 21, 22, ⋆], Qian Wang[23], Qiang Zhao[24, 25], A. V. Zelenov[7]

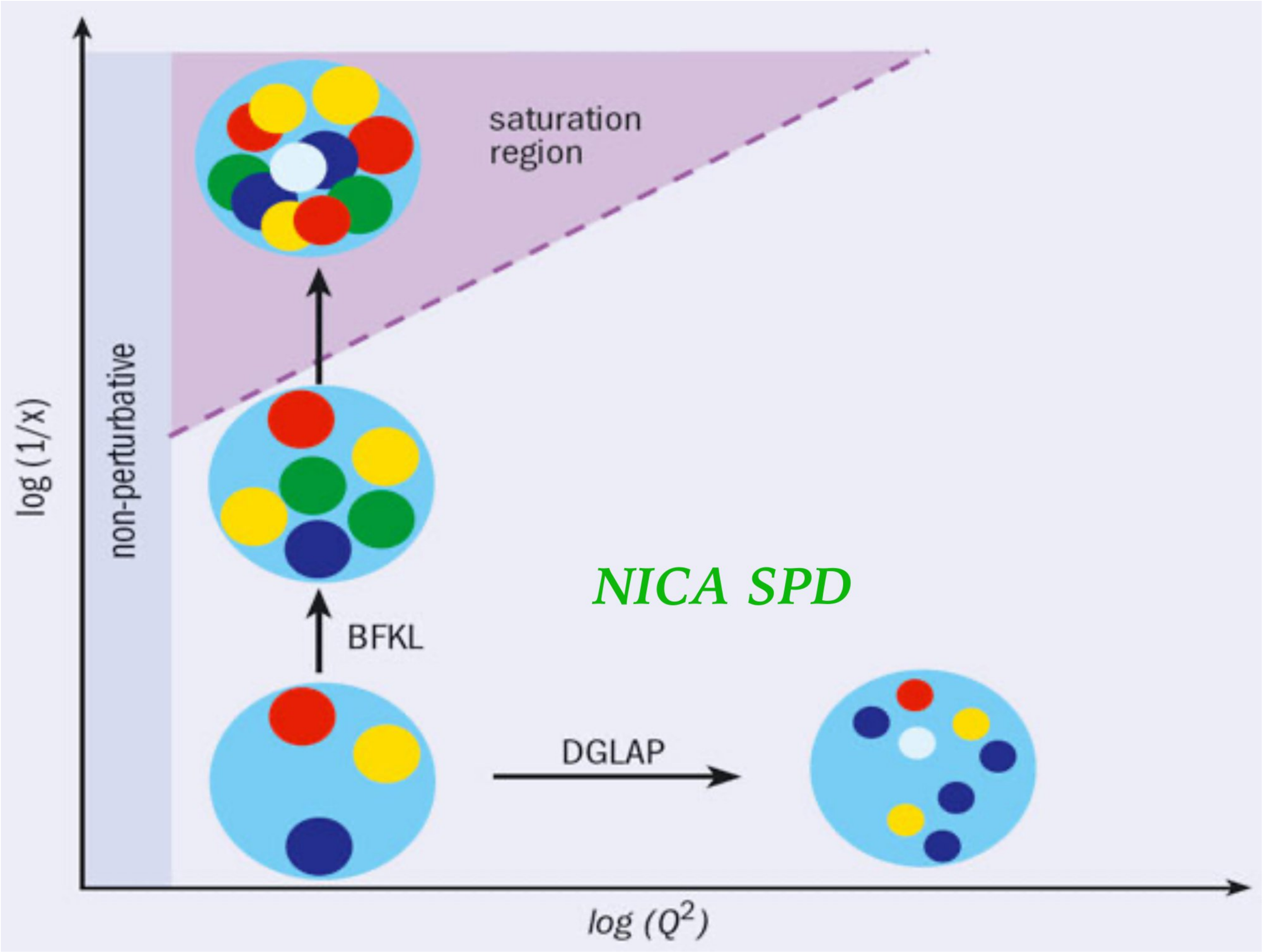
Phys. Part. Nucl. Vol.52, 2021, 1044

ArXiv e-Print: 2102.08477 [hep-ph]

PDF kinematic range



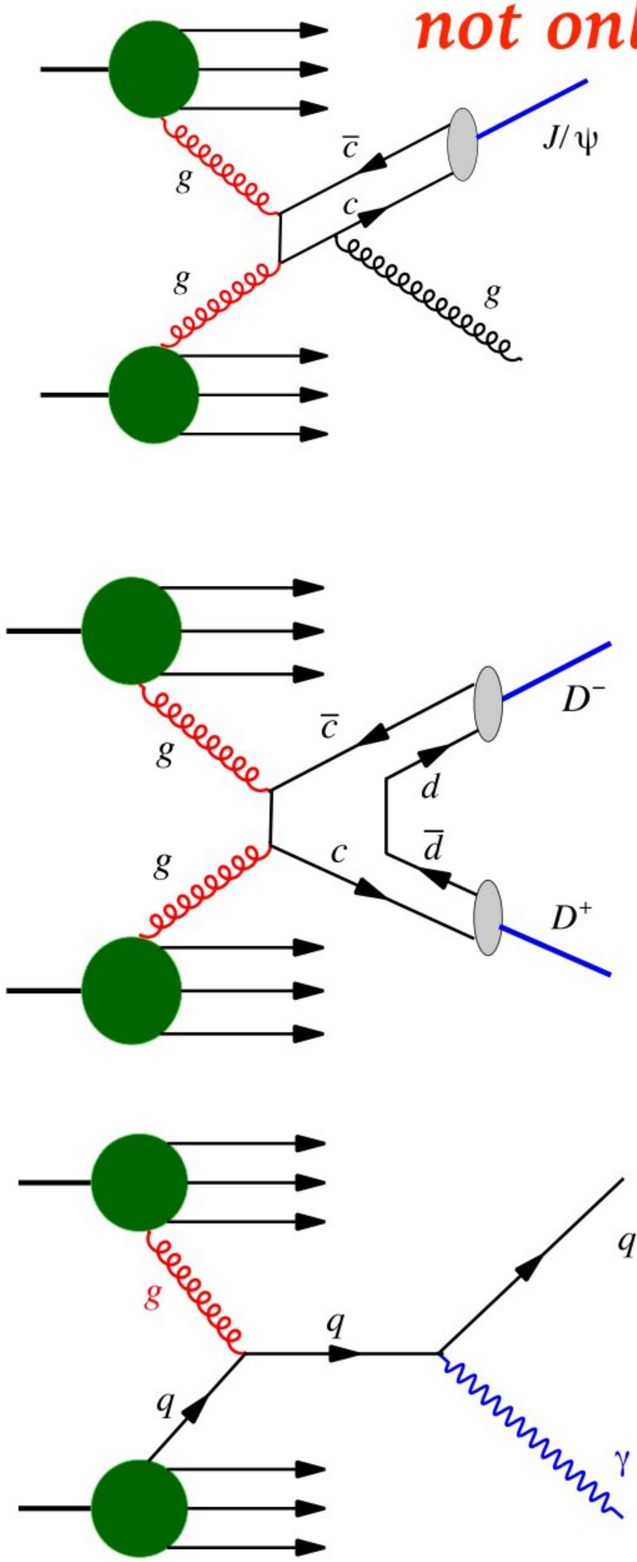
Dynamics kinematic range

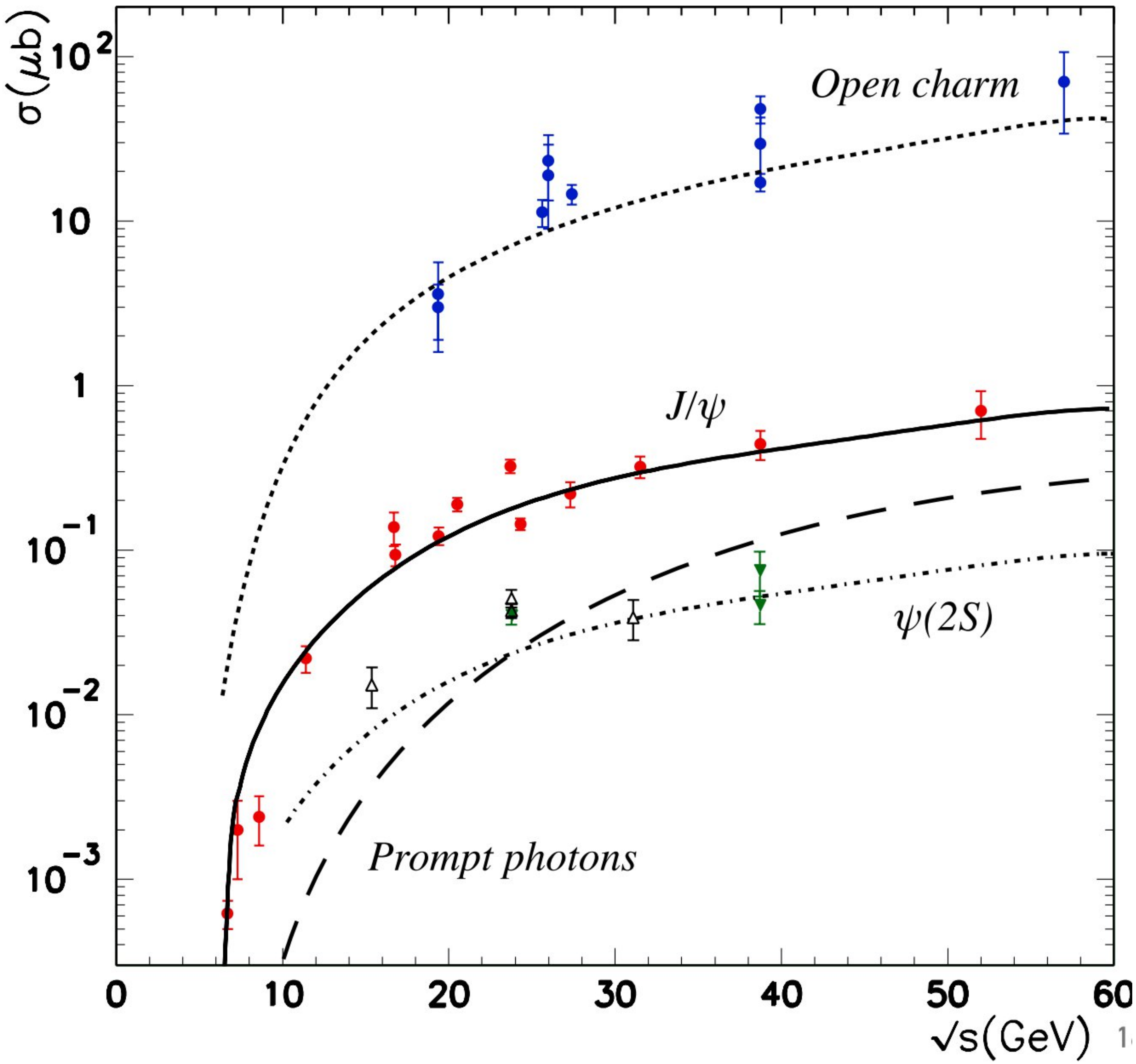


SPD Golden Probes for gluons: charmonia, open charm, direct photons

$$\sigma = PDF_1 \otimes PDF_2 \otimes \hat{\sigma}_{12}$$

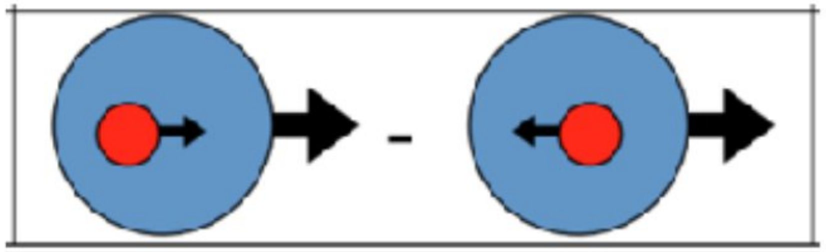
not only J/ψ!



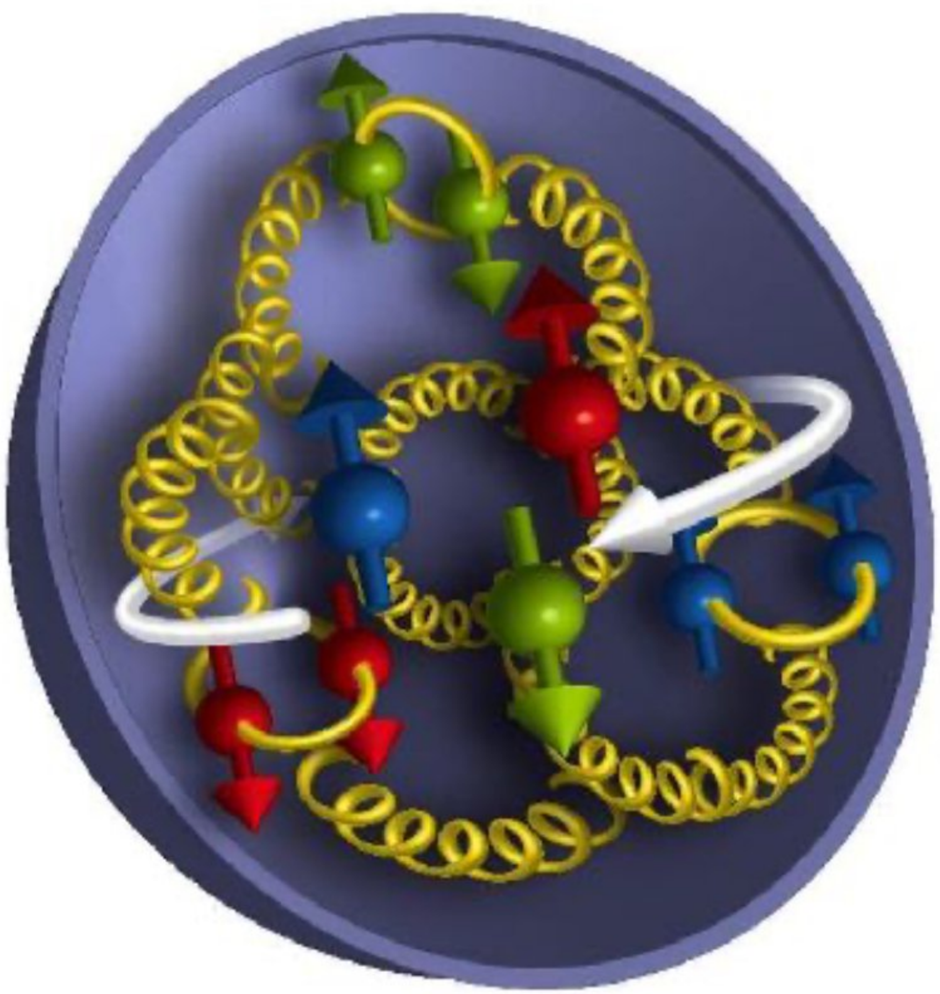


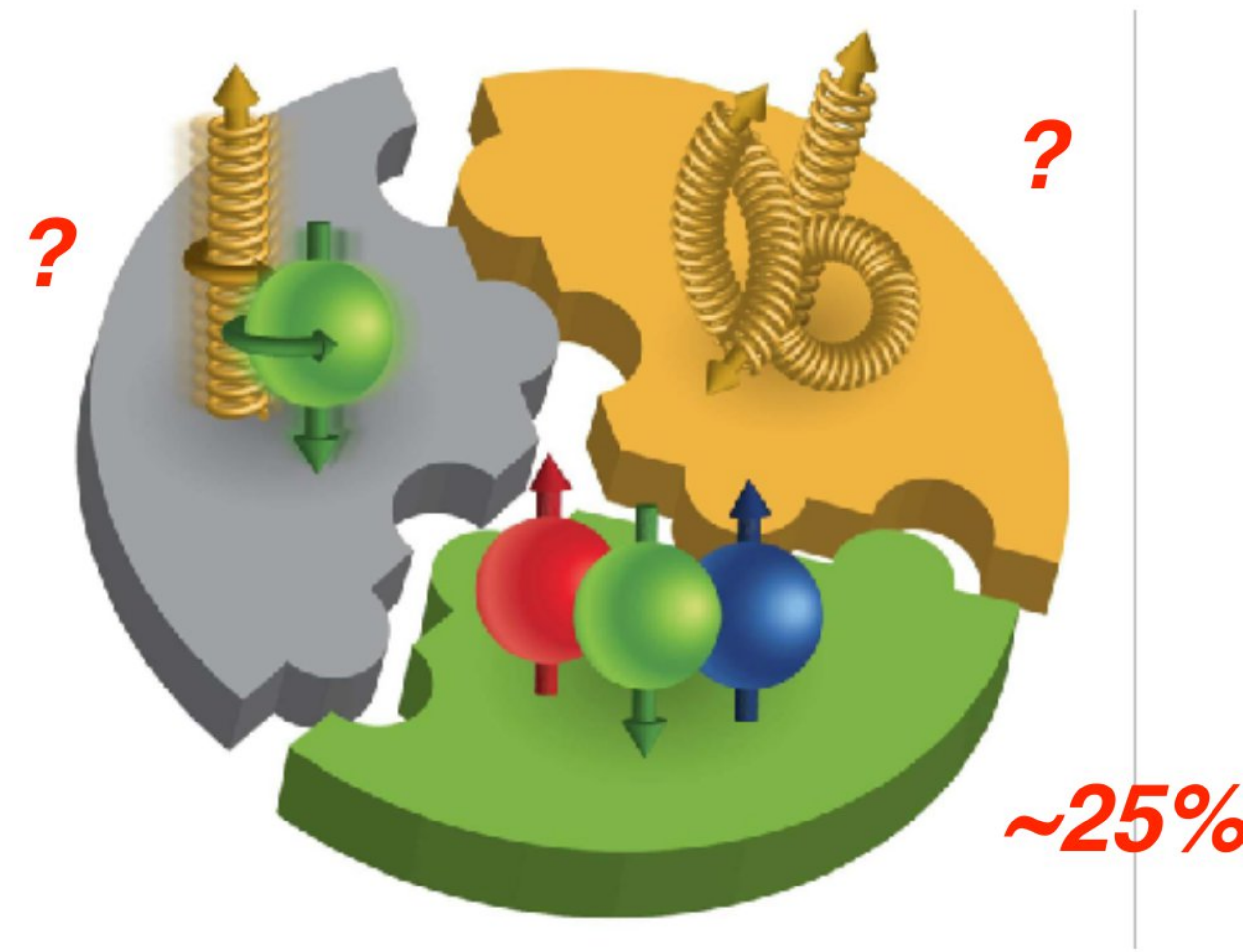
Helicity gluon PDF Δg(x): Proton Spin Crisis

g(x) :



$$\Delta G = \int_0^1 \Delta g(x) dx$$



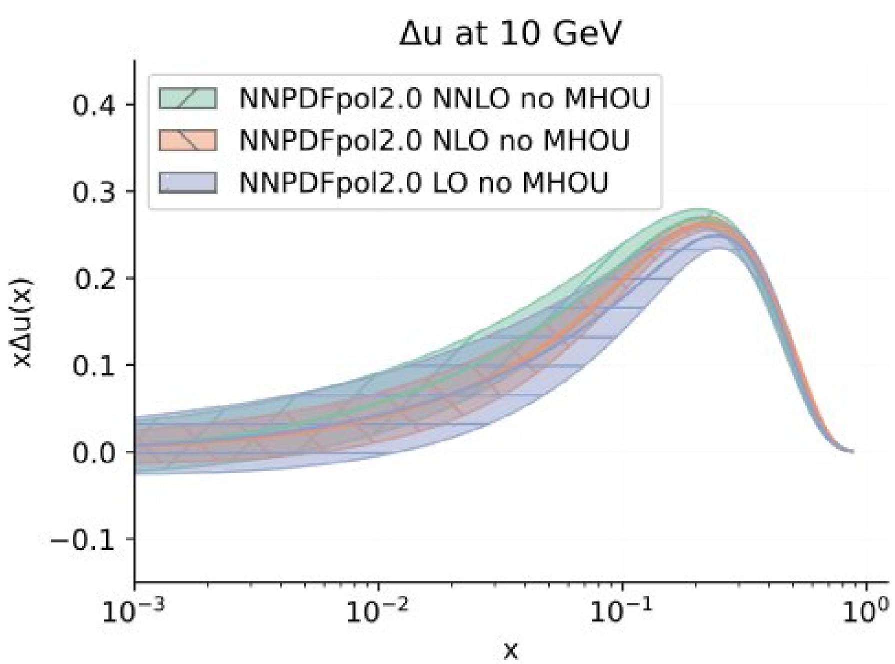


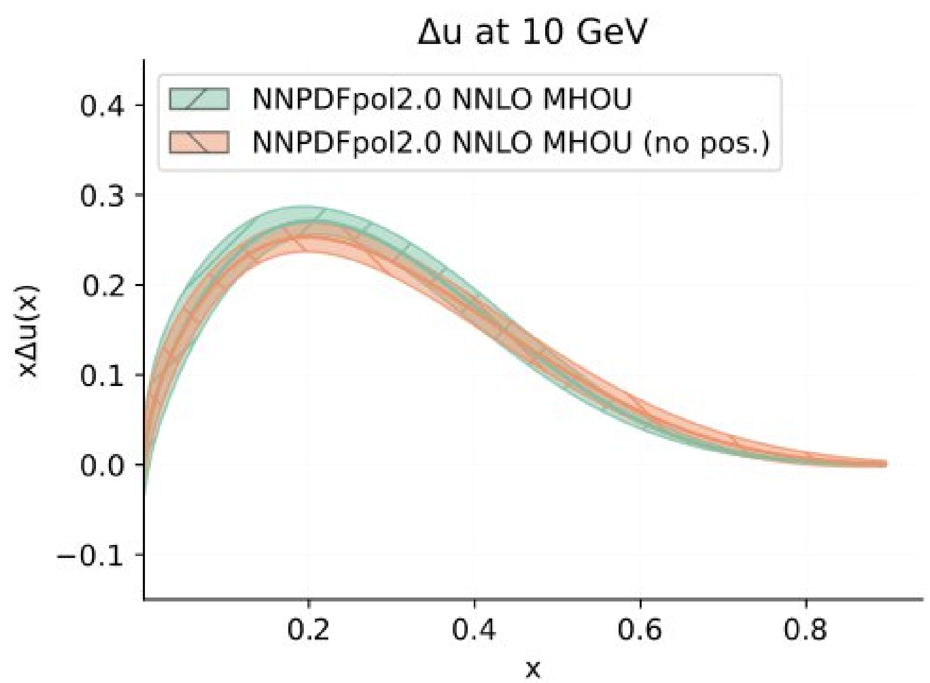
$$S_N = \tfrac{1}{2} = \tfrac{1}{2}\,\Delta\Sigma + \Delta G + L$$

EMC, SMC, COMPASS, HERMES
E142,E143,E154, E155

J. Ellis, R. Jaffe (1974), M. Ahmed, G. Ross (1976)
A. Efremov, O. Teryaev (1988,1990)
R. Carlitz, J. Collins, A. Mueller (1988)
S. Brodsky, J. Ellis, M. Karliner (1988) ....

NNPDF Coll.: NNPDFpol2.0
quark and gluon helicity PDFs of proton at NNLO

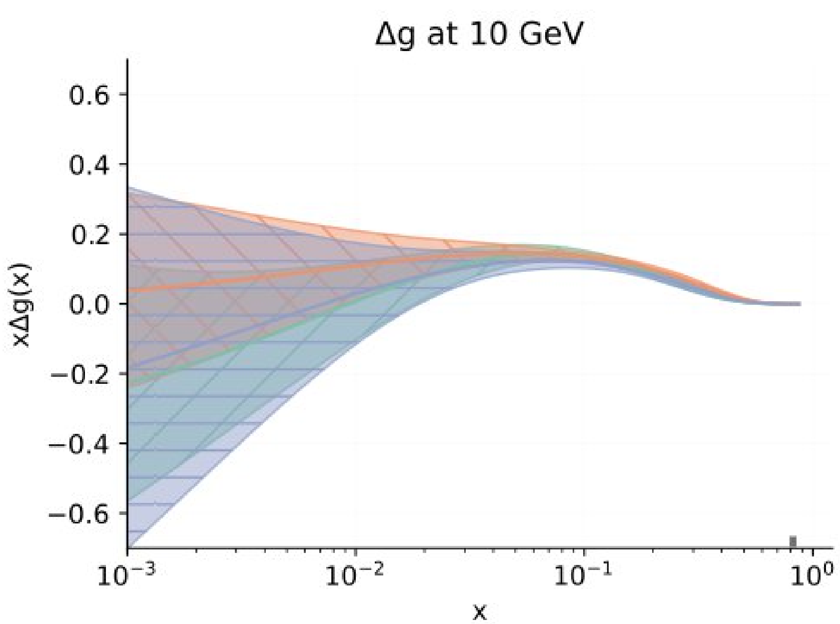


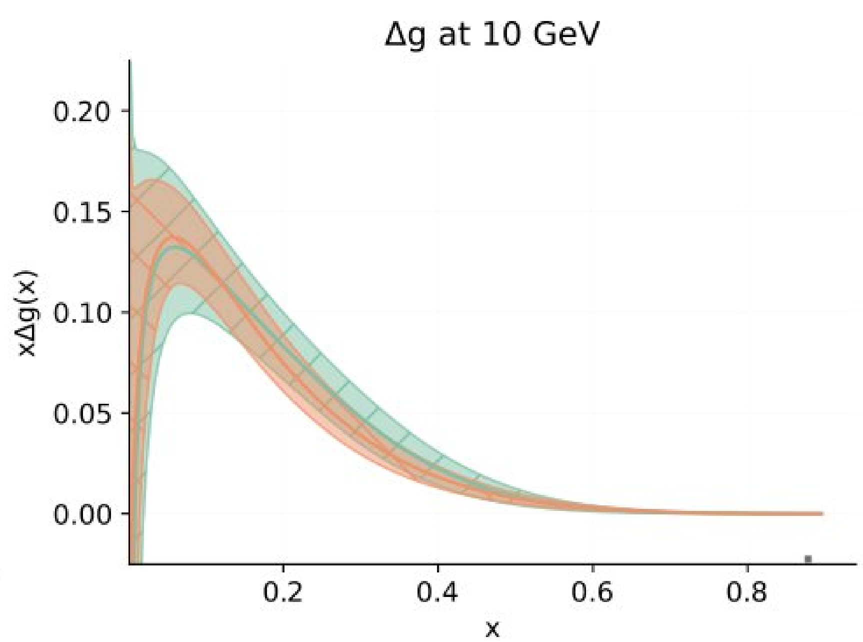


NNPDF Coll.: NNPDFpol 2.0
J. Cruz-Martinez et al. (2025)

Quark helicity PDF:
few percent level uncertainties
(right by MHOU)

Measured with high precision
at CERN, JLAB, DESY and BNL





Gluon helicity PDF:
still rather high uncertainties!
(right by MHOU)

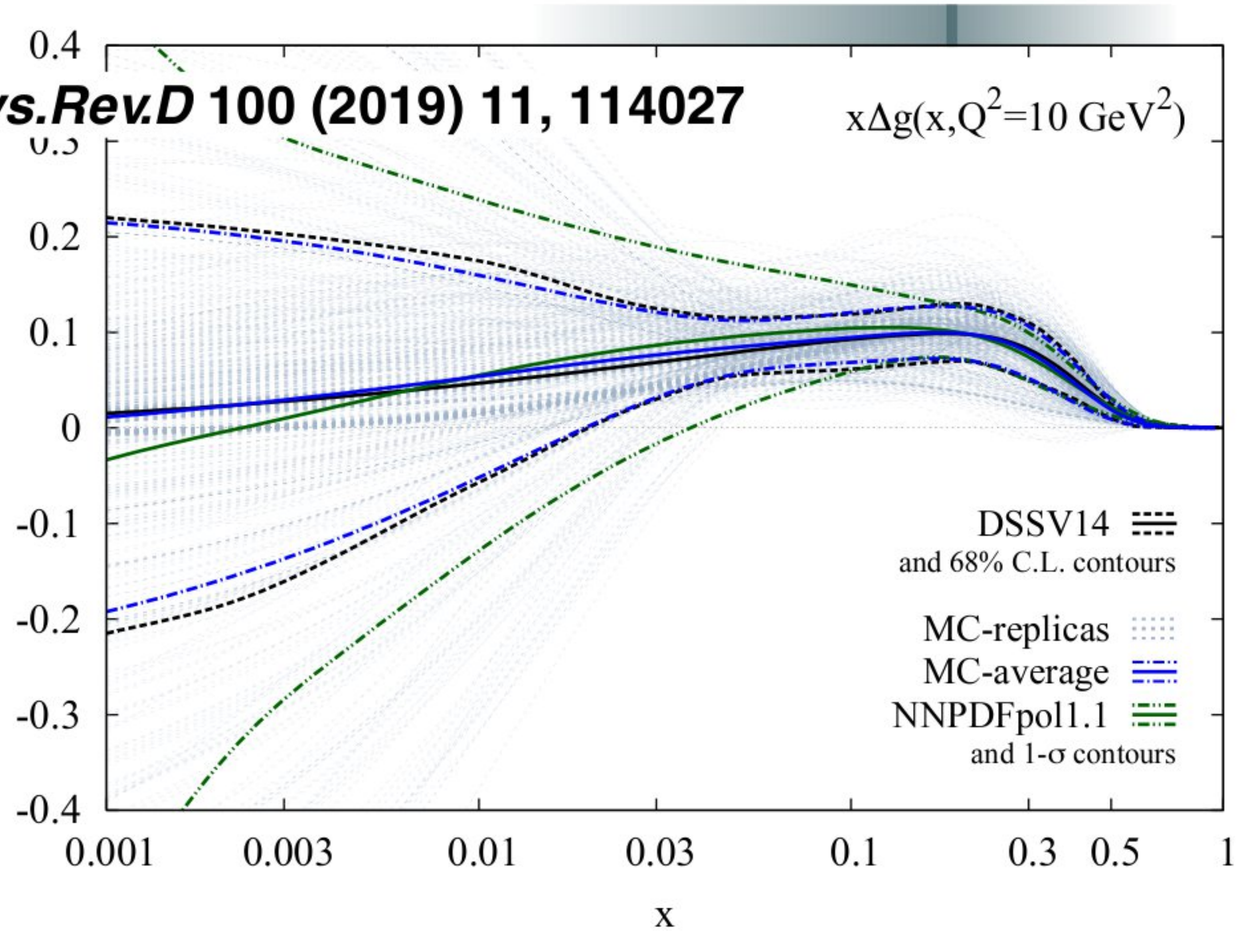
Hadron collisions have a better
sensitivity to measure it.

⬅ SPD NICA
has a good opportunity!

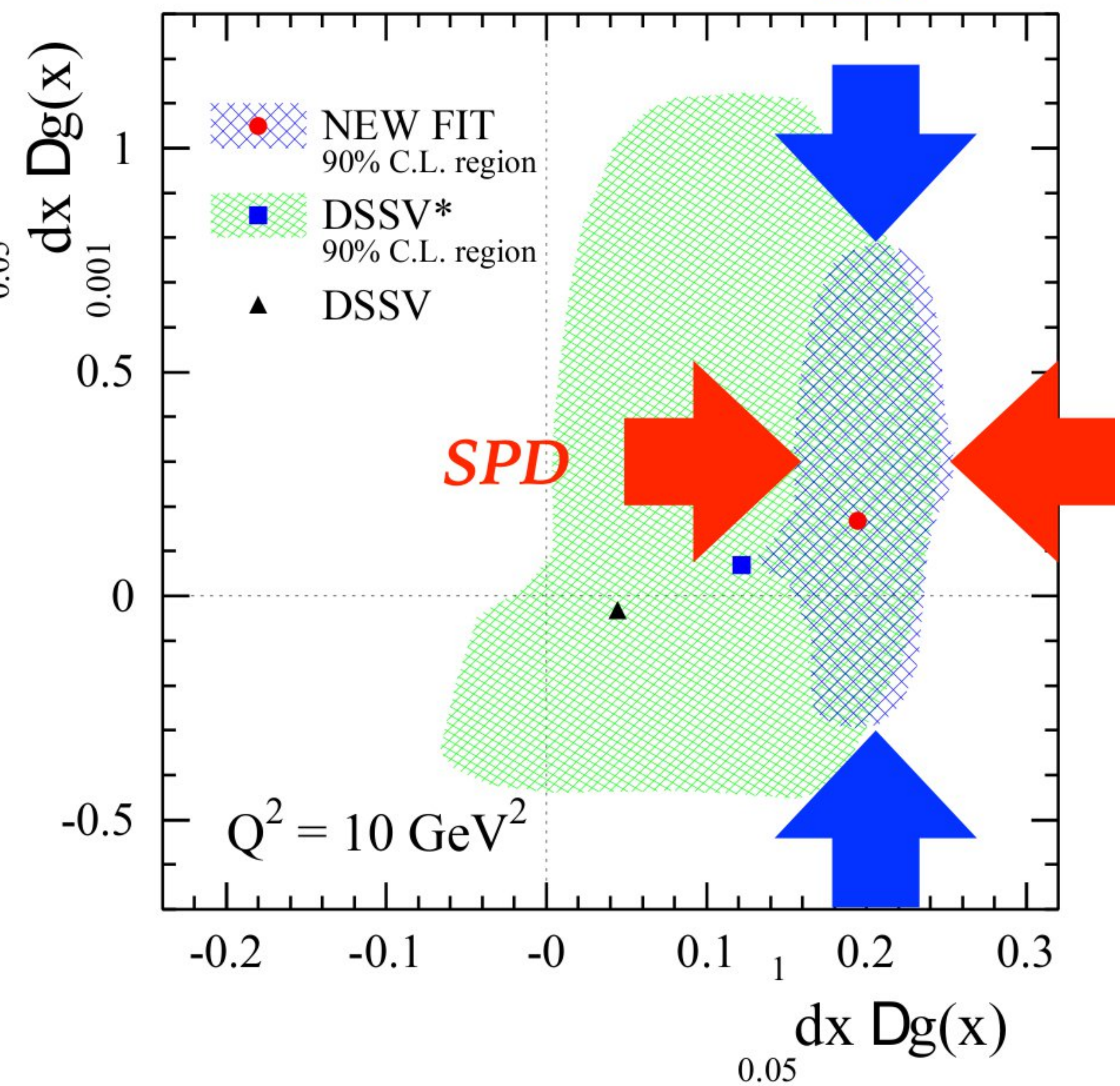
Helicity gluon PDF Δg(x):

accessible with SPD

Phys.Rev.D 100 (2019) 11, 114027



Phys.Rev.Lett. 113 (2014) 1, 012001

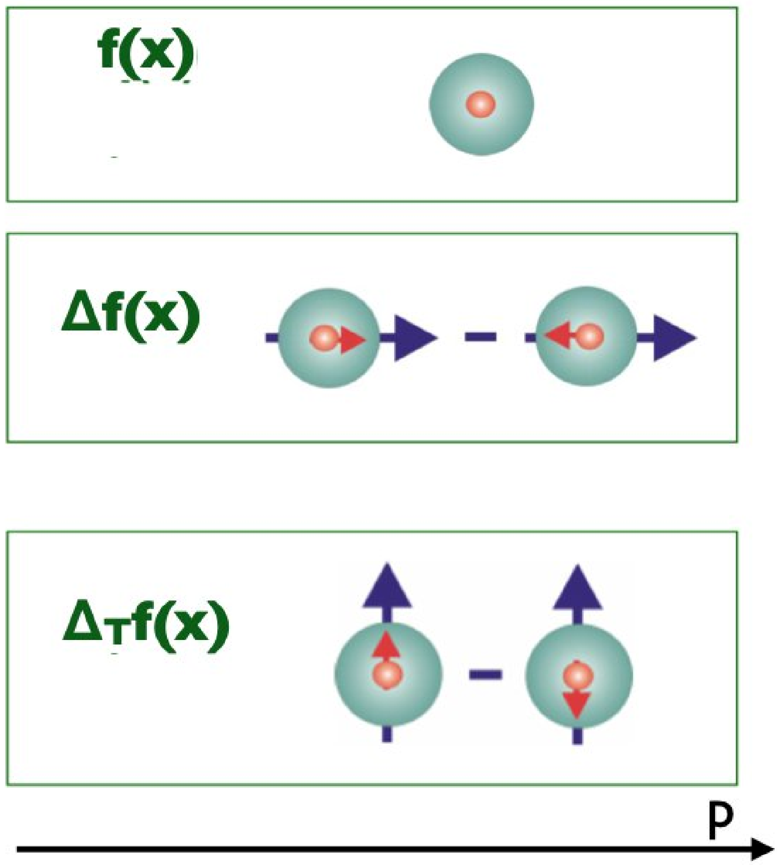


SPD could help to r educe uncertainty of G at large x

$$A_{LL} = \frac{\sigma^{++} \qquad \sigma^{+}}{\sigma^{++} + \sigma^{+}}$$

$$A_{LL}^{cc} \approx \frac{\Delta g(x_1)}{g(x_1)} \otimes \frac{\Delta g(x_2)}{g(x_2)} \otimes \hat{a}_{LL}^{gg\to ccX} \qquad A_{LL}^{\gamma} \approx \frac{\Delta g(x_1)}{g(x_1)} \otimes A_{1p}(x_2) \otimes \hat{a}_{LL}^{gq(q)\to\gamma q(q)} + (1 \leftrightarrow 2)\,.$$

Spin of proton



Unpolarized PDF

Helicity

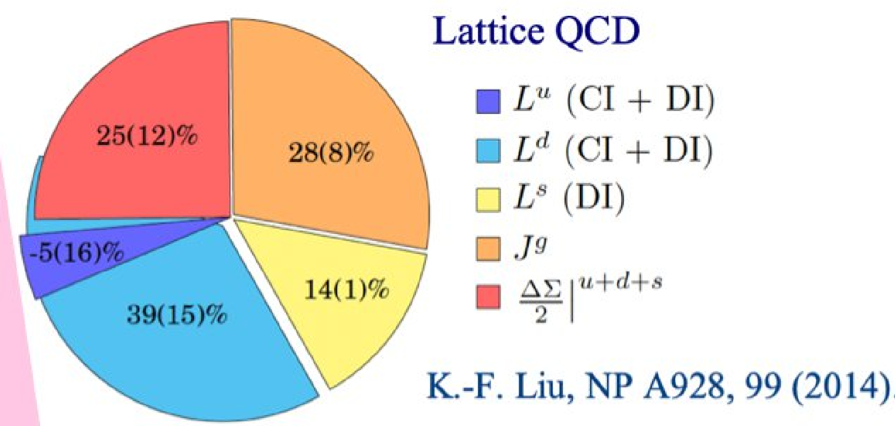
Transversity

~30%

$$J = \frac{1}{2}\Delta\Sigma + \Delta G + \boxed{L_q + L_g}$$

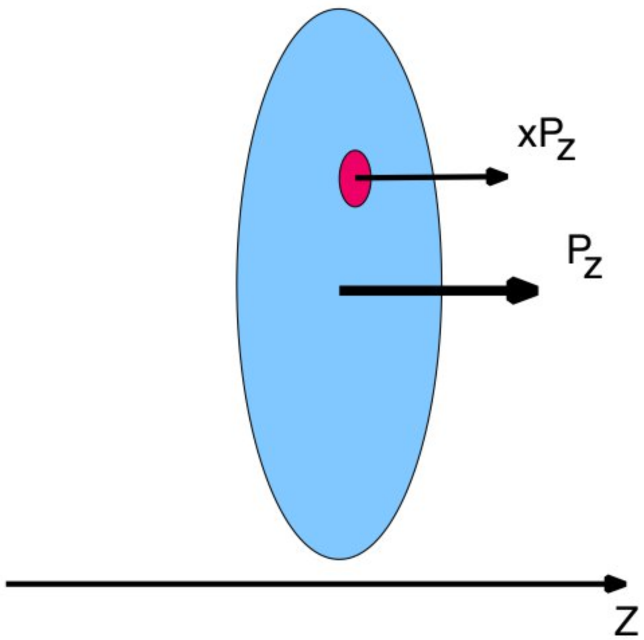
? ?

~10-20%



To access angular momenta info about 3D structure is needed!

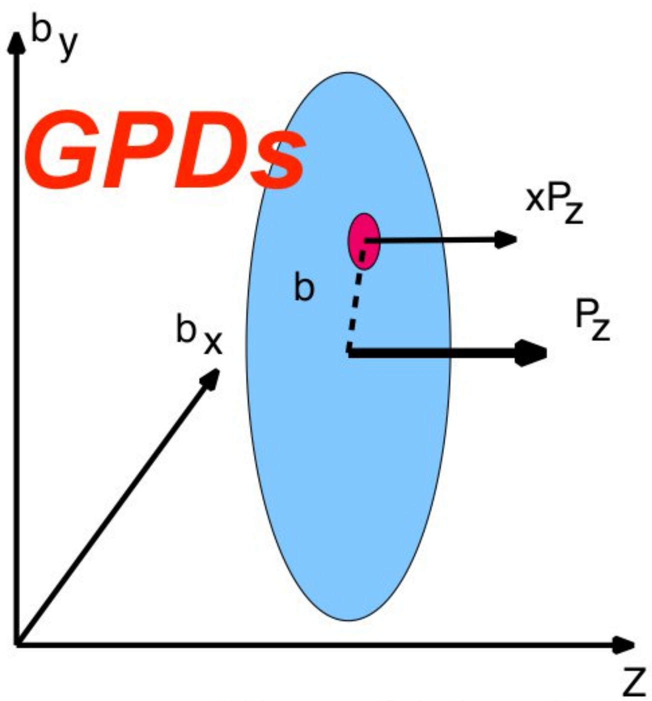
SPD: towards 3D-structure of nucleon



Collinear approximation

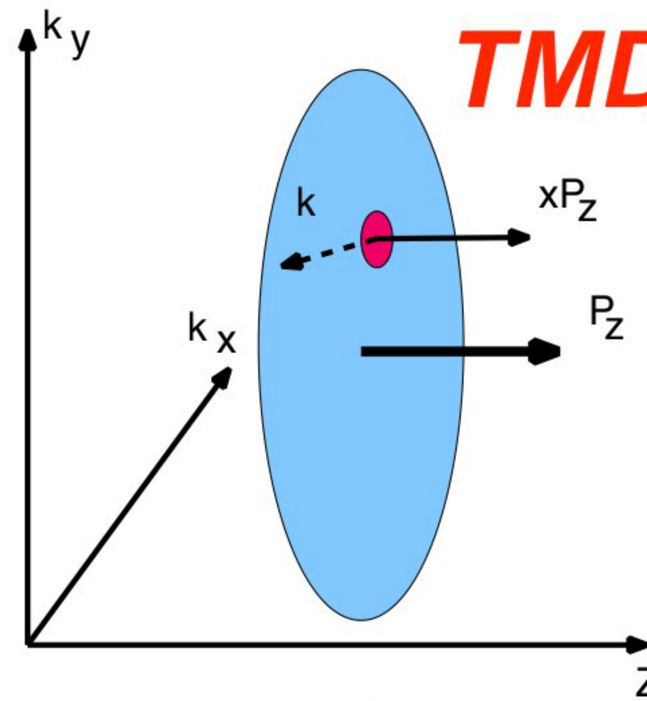
(common PDF)

GPDs

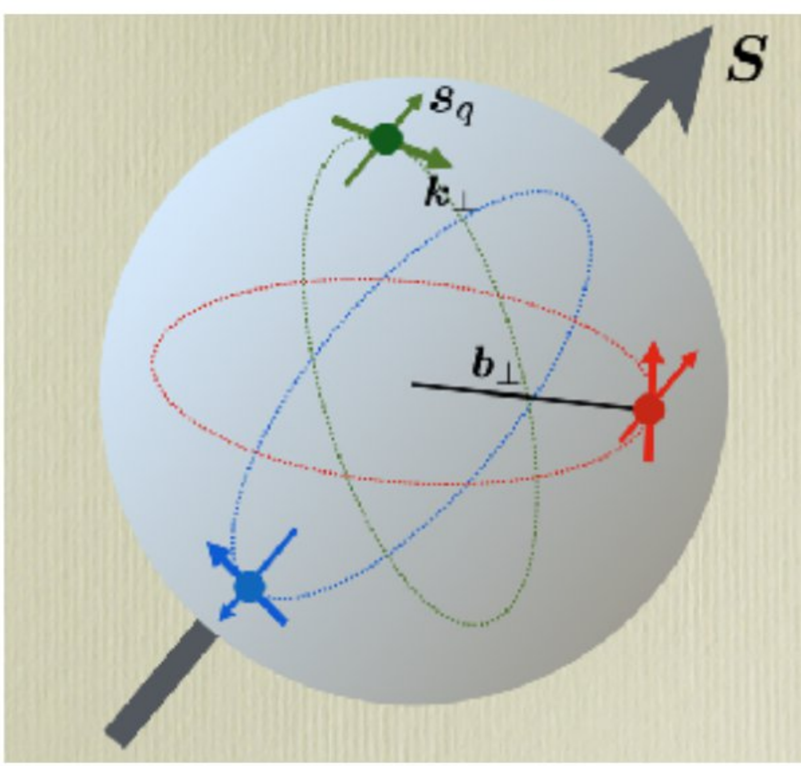


Generalized Parton Distributions

TMD PDFs



Transverse Momentum Dependent PDFs



13

3D structure of nucleon

connection to orbital moment

A. Bukhvostov, G. Frolov. L. Lipatov (1982,1983,1984)

A. Efremov, O. Teryaev (1982,1984)

TMD: quarks in polarized nucleon

Nucleon (N) with momentum P and spin polarization S=(U,L,T)

New information in quark TMD of nucleon: $\Phi^q(x, P, S)$

$\Phi^q(x, P, S)$ contains time-even functions:

$f^q(x, kT)$ ⬅ unpolarized quarks in unpolarized N ⬅ density

$g^g{}_L(x, kT)$ ⬅ L-polarized (chiral) quarks in L-polarized N ⬅ helicity

$g^g{}_T(x, kT)$ ⬅ L-polarized (chiral) quarks in T-polarized N ⬅ worm-gear

$h^q{}_T(x, kT)$ ⬅ T-polarized quarks in T-polarized N ⬅ pretzelocity

and time-odd functions (spin-orbital correlations):

$f^{\perp g}{}_L(x, kT)$ ⬅ unpolarized quarks in T-polarized N ⬅ Sivers f.

$h^{\perp q}{}_T(x, kT)$ ⬅ T-polarized quarks in unpolarized N ⬅ Boer-Mulders f.

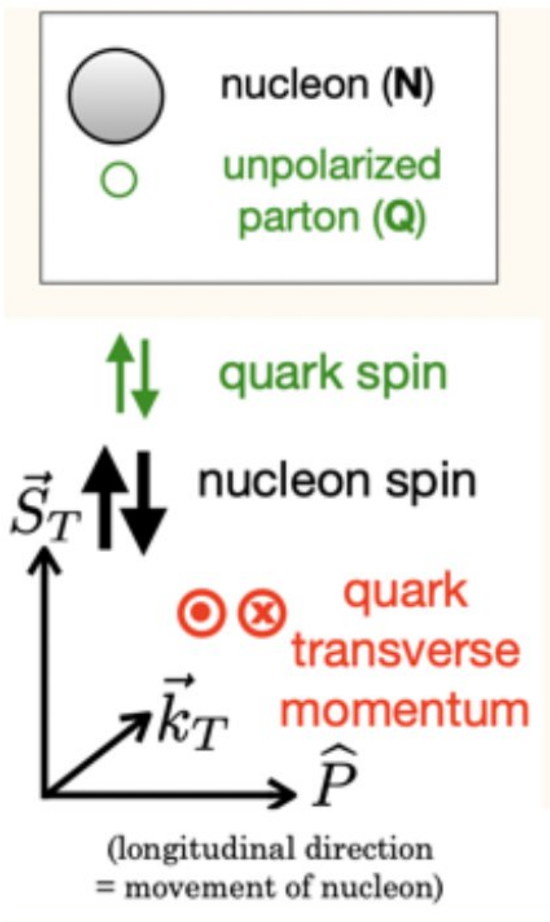
Integrated over kT quark TMDs:

$f^q(x) = q(x) = q_{L=+}(x) + q_{L=-}(x)$

$g^q{}_L(x) = \Delta q(x) = q_{L=+}(x) - q_{L=-}(x)$ ⬅ helicity (chirality)

$h^q{}_T(x) = \delta q(x) = q_{T=+}(x) - q_{T=-}(x)$ ⬅ transversity

TMDs: quarks in nucleon



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

Gluon TMD with SPD

Unpolarized gluons at high x in proton and deuteron

Gluon helicity

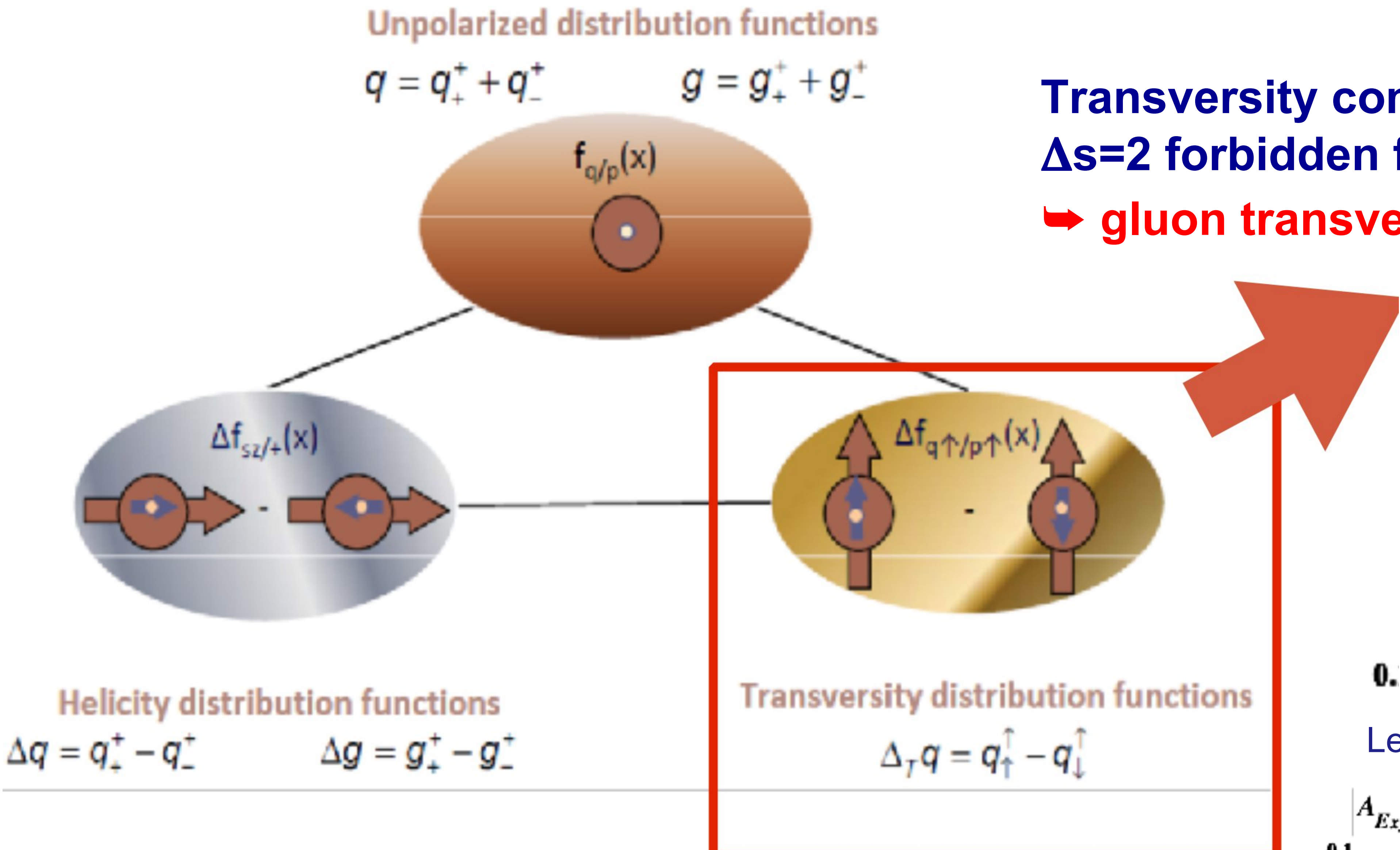
Gluon Boer-Mulders function

GLUONS	*unpolarized*	*circular*	*linear*
U	f_1^g		$h_1^{\perp g}$
L		g_{1L}^g	$h_{1L}^{\perp g}$
T	$f_{1T}^{\perp g}$	g_{1T}^g	$\boxed{h_{1T}^g,}$ $h_{1T}^{\perp g}$

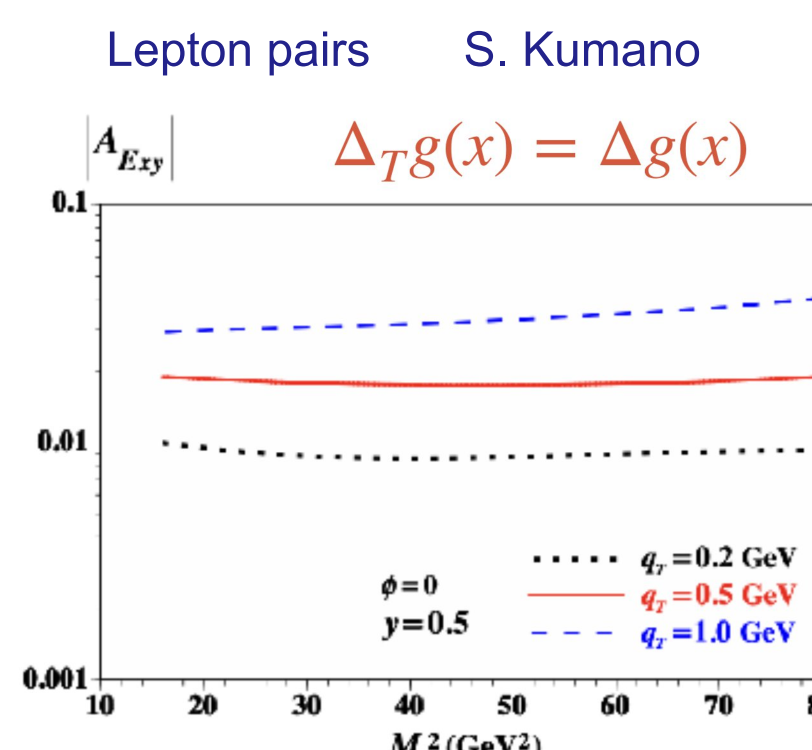
Gluon Sivers function

Gluon transversity in deuteron

Gluon transversity of deuteron



Transversity comes from spin-flip:
Δs=2 forbidden for spin-½ nucleon in LO
➥ gluon transversity in nucleon ≈ 0



SPD has a unique opportunity to measure
gluon transversity in deuteron for the first time!

To probe new non-nucleonic degrees of freedom (flucton) in deuteron!

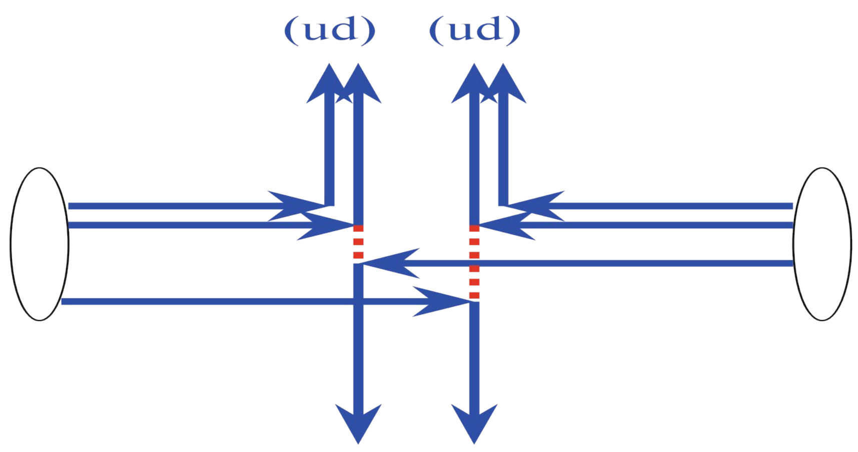
SPD Physics at the 1st Phase

V.V. Abramov et al., Phys. Part. Nucl. 52(2021) 1044, e-Print: 2102.08477 [hep-ph]

Comprehensive and rich physics program at the initial stage of SPD data taking:

- **Spin effects in pp-, pd- and dd- (quasi)elastic scattering**
- **Spin effects in hyperon production**
- **Search for exotic states (glueball, penta- and tetra- quarks)**
- **Multiquark correlations (fluctons, SRC) in deuteron and light nuclei**
- **Dibaryon resonances**
- **Open charm and charmonia production near threshold**
- **Large-pT hadron production to study diquark structure of proton**
- **Large-pT hadron production to study multiparton scattering (MPS)**
- **Antiproton production measurement for astrophysics and BSM search**
- **…**

SPD Physics at the 1st Stage: exotic states pentaquark, dihyperon, tetraquark, etc. production



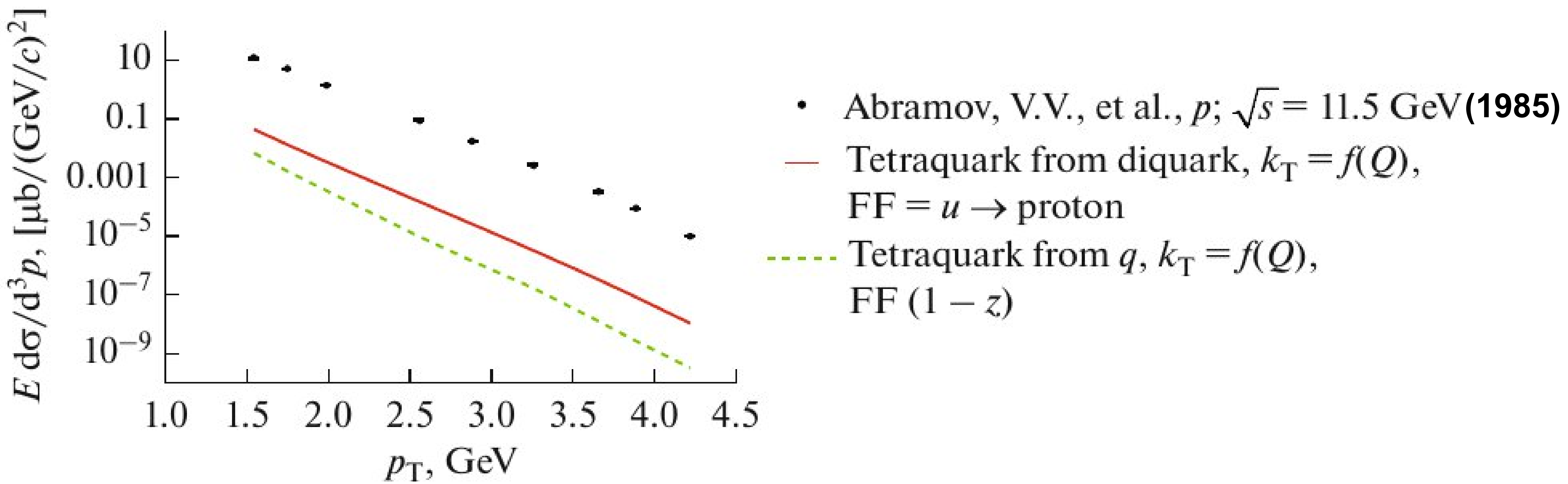
Diquarks:

- proton production scaling violation
  V.K. 1988
- exotic multiquark state production
  A. Efremov, V.K. 1987
  V. Abramov et al 2021

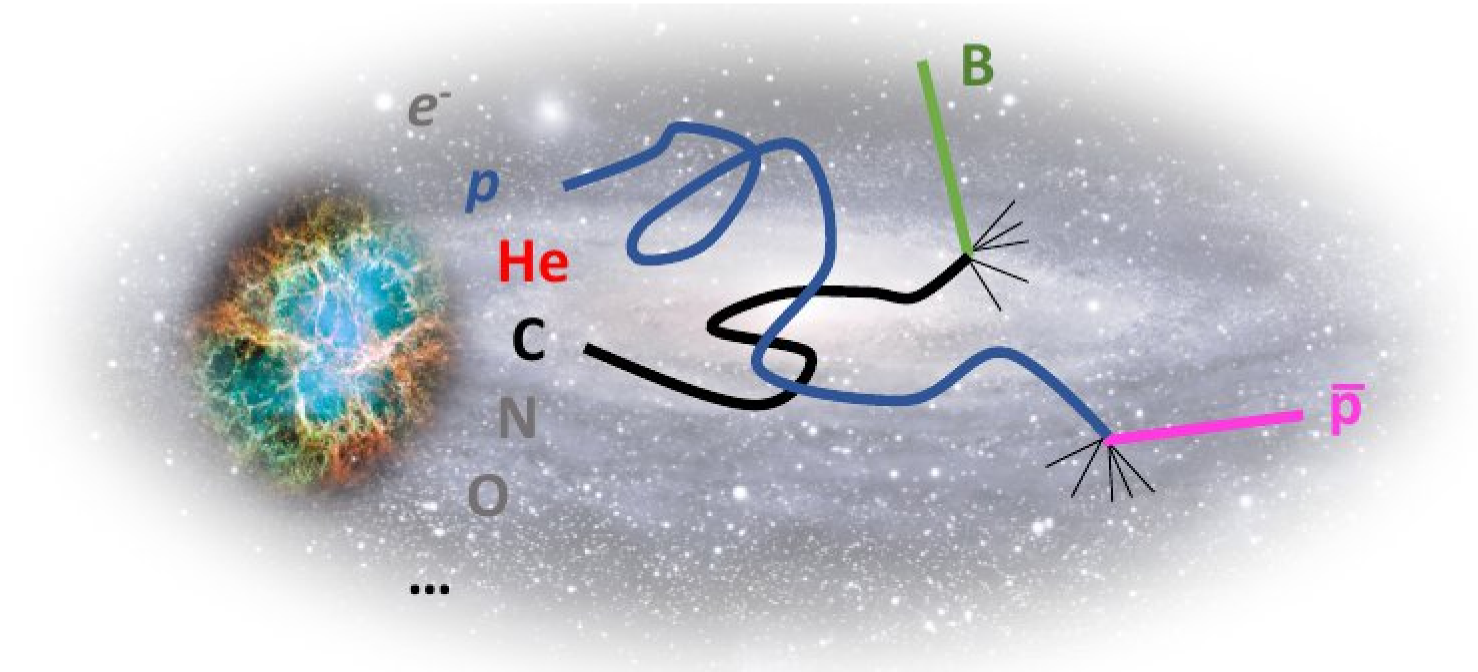
Diquarks:

tetraquark production a(980)⇒(ud)(ūđ)?: ~ up to 10% of large-pT proton production

V.K., A.V. Zelenov 2025



$$a_0(980) \to K^0\bar{K}^0 \to \pi^+\pi^-\pi^+\pi^- \qquad p_T(\pi) \sim 1/4\; p_T(a_0)$$



ASTROPHYSICS

AMS-02 in International Space Station

AMS-02 search for Dark Matter:
antiproton flux precision ~ 5%

Contemporary high energy physics experiments
antiproton production ~ 25%

Precision antiproton production measurements needed:
energy range 5 GeV < ECM < 100 GeV with precision ~ 5%

SPD now: main focus

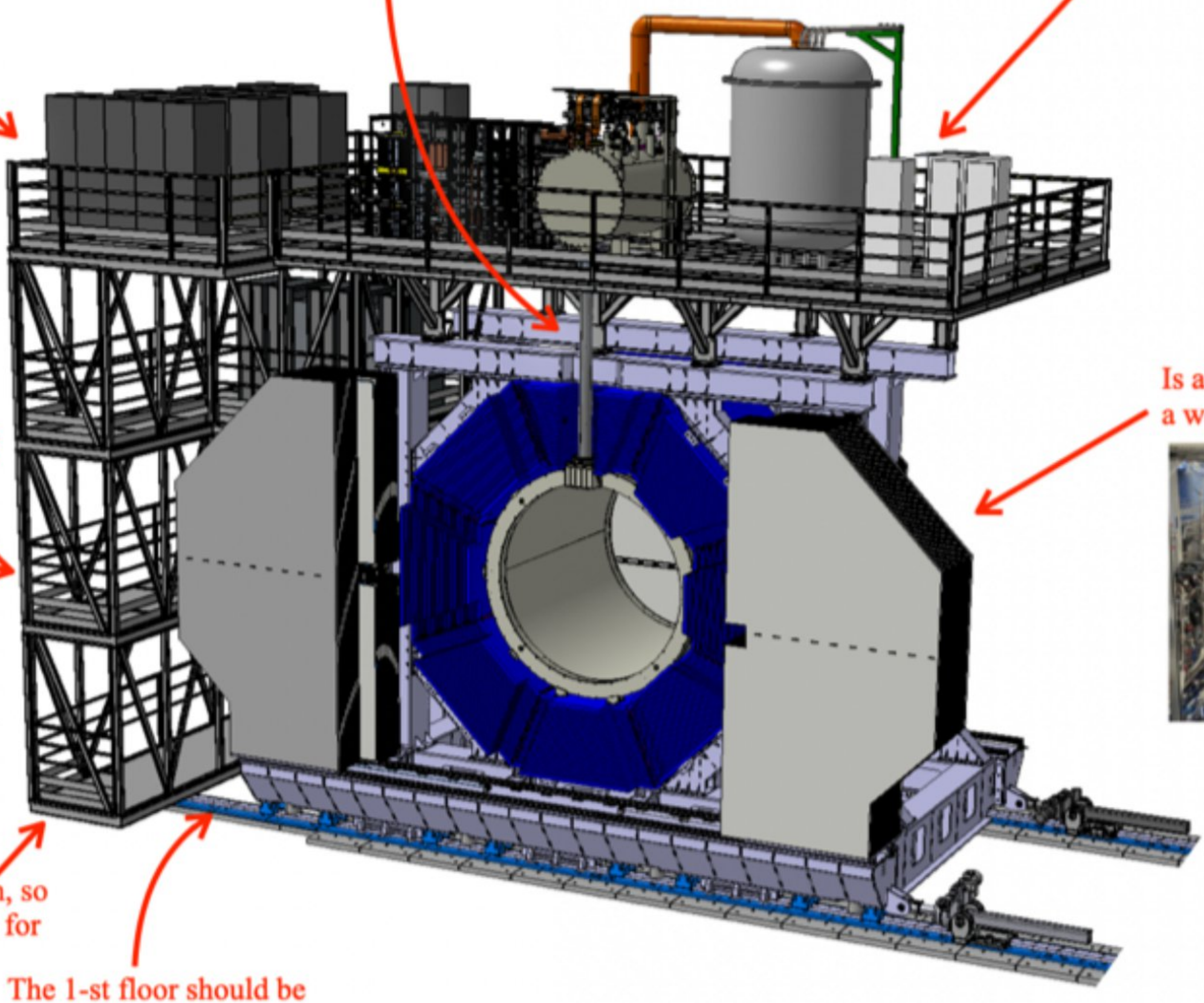
- Load-bearing structure of the Detector & Yoke
- Superconducting magnet (INP, Novosibirsk)
- Engineering infrastructure & communications
- The 1st Stage detectors: Trackers, Muon (RS), BBC, ZDC, part of ECAL -> to manufacture
- The 2nd Stage detectors: ToF, FARICH, Vertex detector -> R&D
- DAQ and computing infrastructure
- The 1st Phase Physics program -> Updating
- SPD Interaction Point at NICA -> BBC and ZDC installation

SPD: Platform for equipment

Will we use the attic floor?
The height is 1.8 m

The upper platform is entirely dedicated to cryogenic equipment

The area of 4th floor is 8.6 x 4.1 m^2



Is all this space dedicated to a water cooling system?

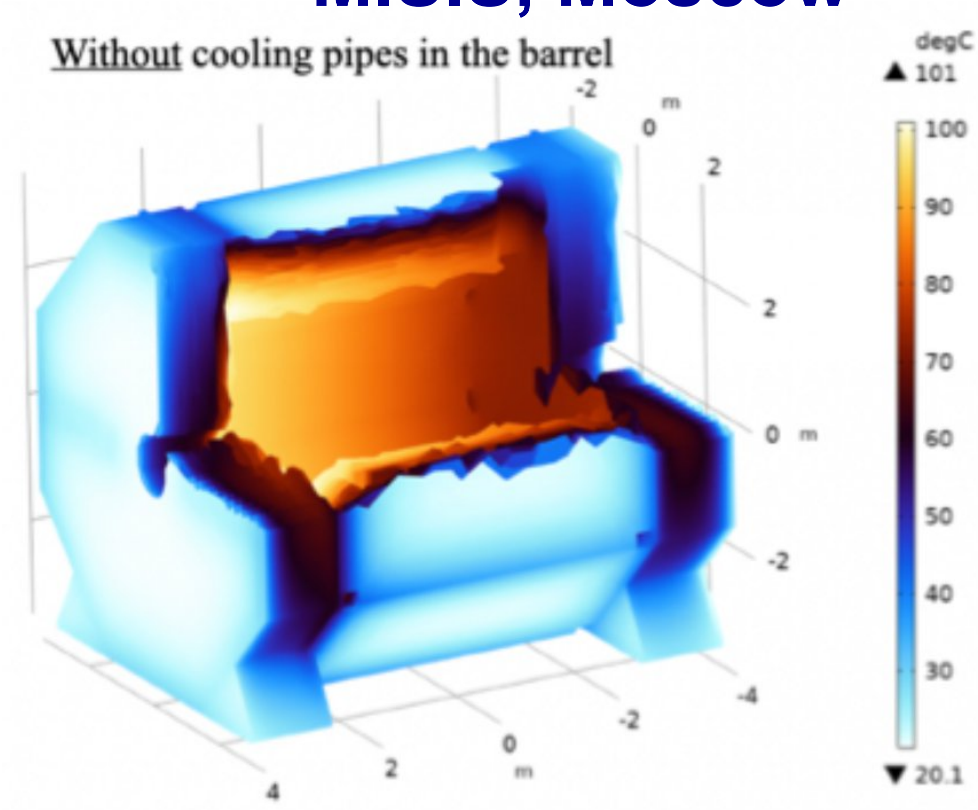
The floor is T-shaped.
The usable area for racks is only 4.8 x 4.8 m^2

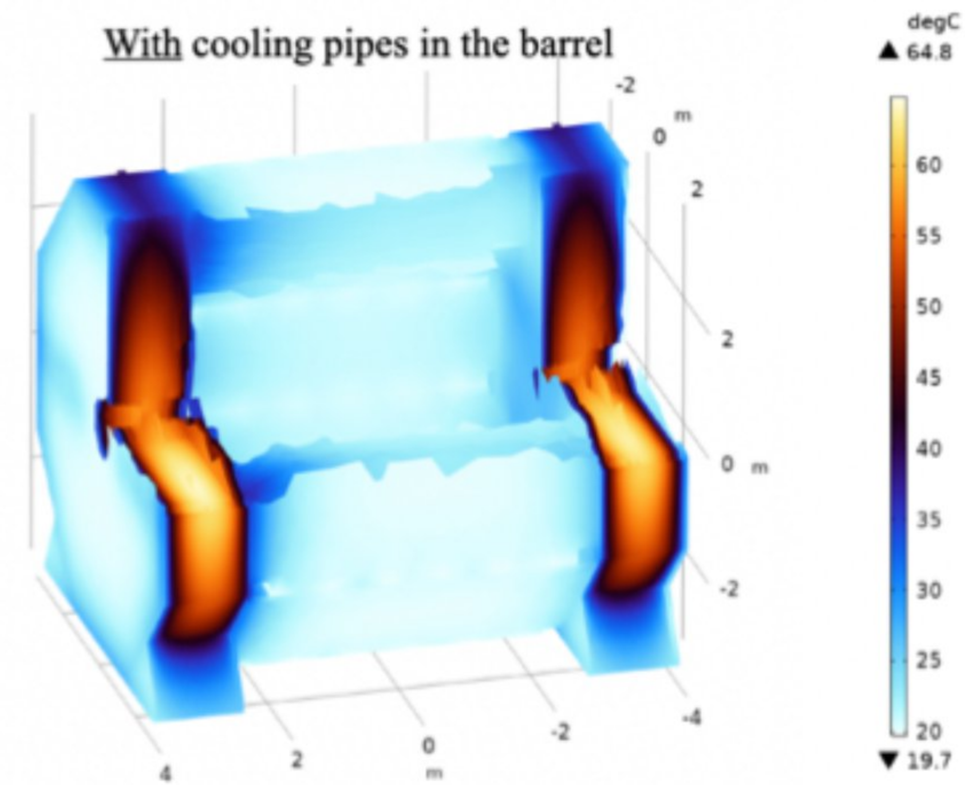
The width is only 1.7 m, so there is not much room for equipment

The 1-st floor should be a walk-through floor

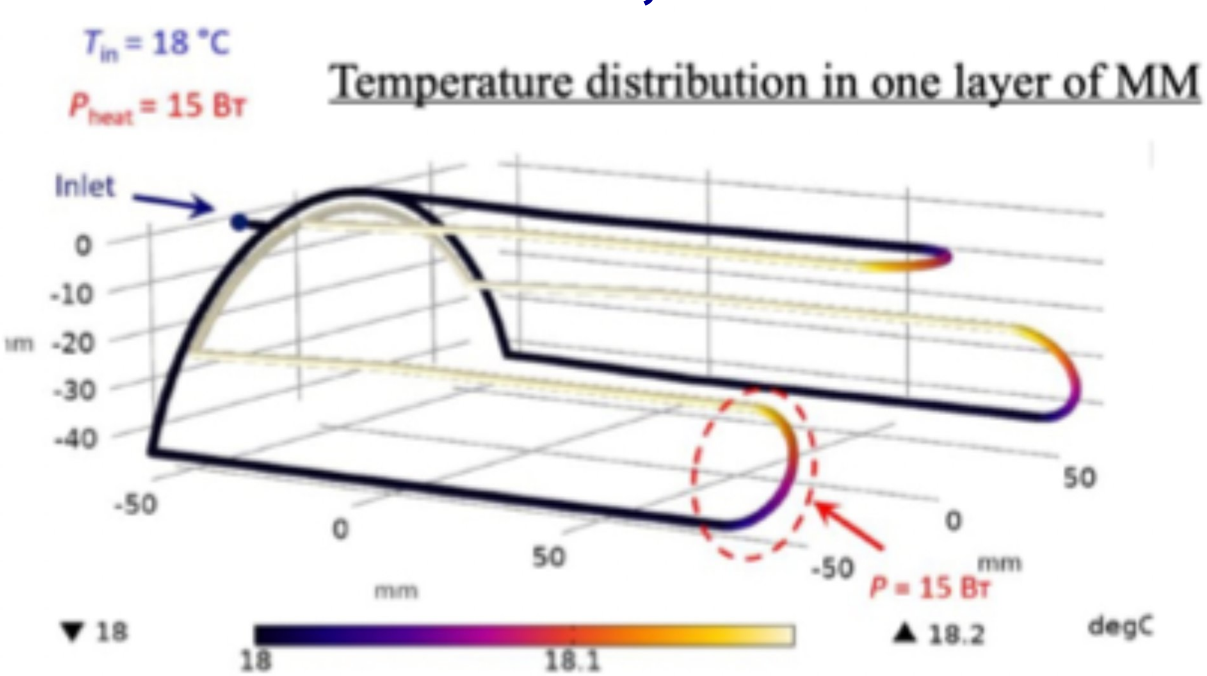
SPD: Thermal analysis

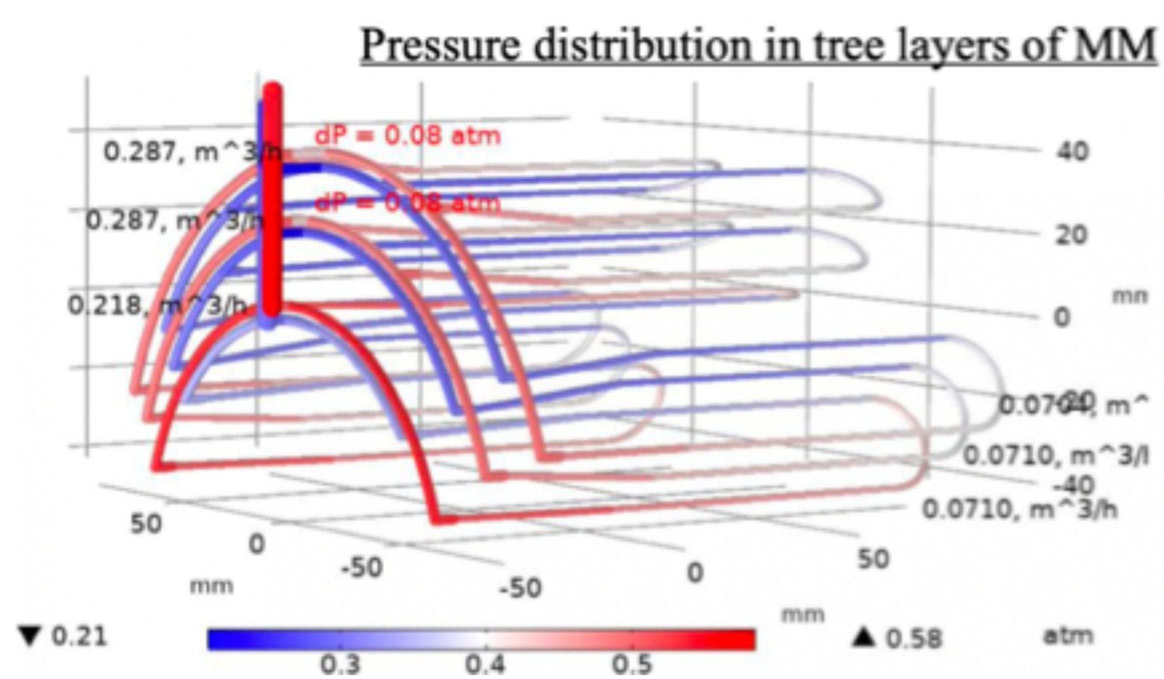
MISIS, Moscow

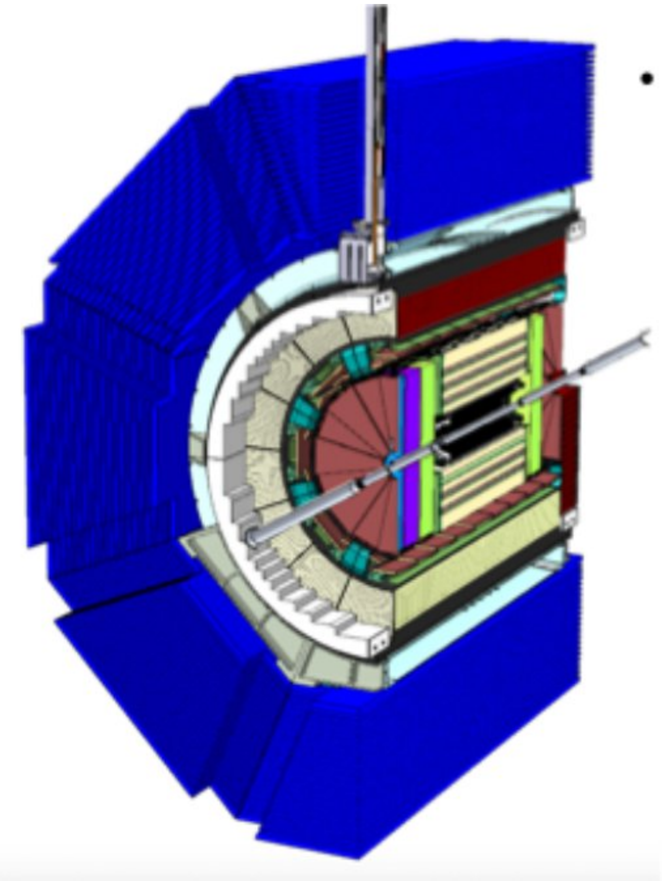




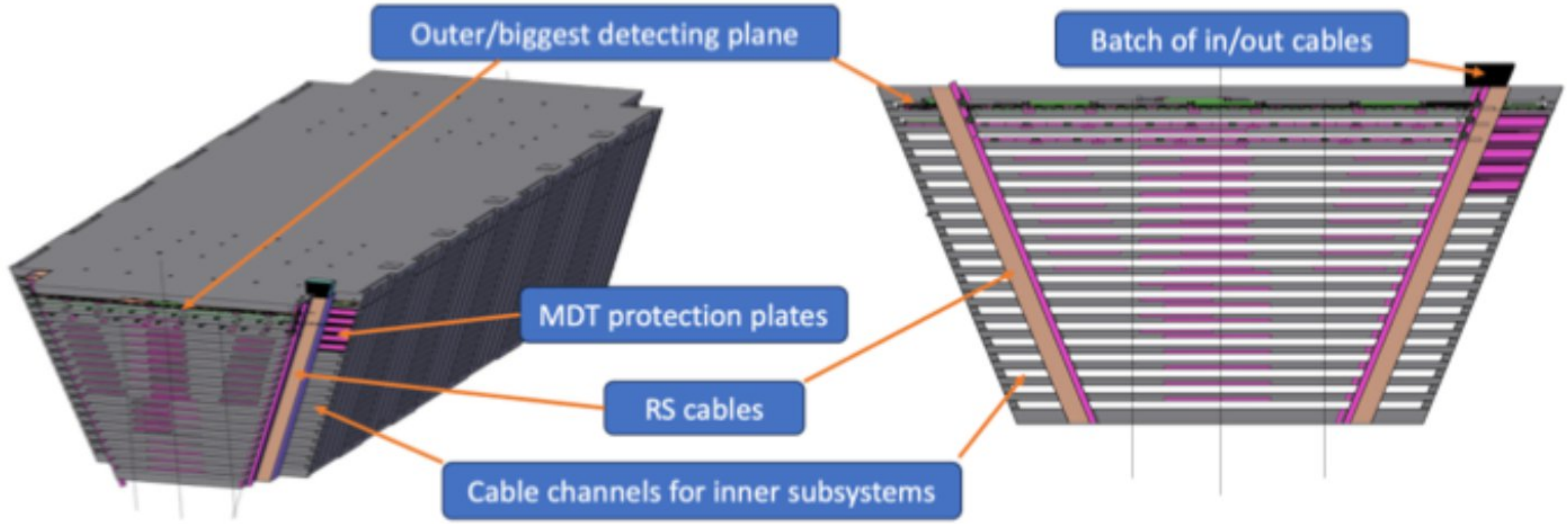
INP BSU, Minsk



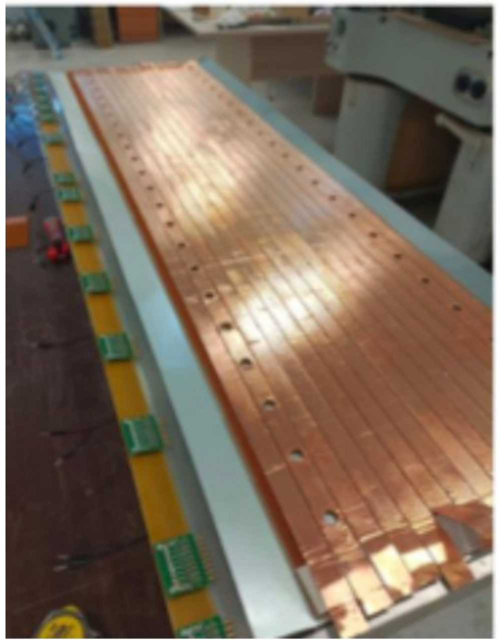


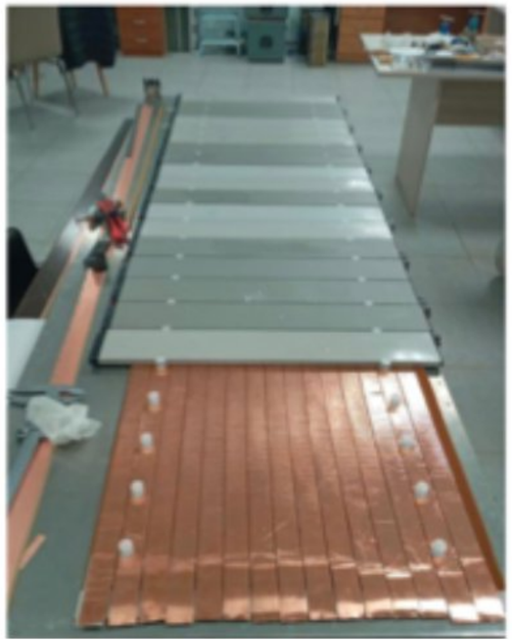


- Since the beginning of this year, the Design Bureau №2 of LHEP has been actively involved in the development of the detector's load-bearing structure. The work is coordinated with engineers from other groups

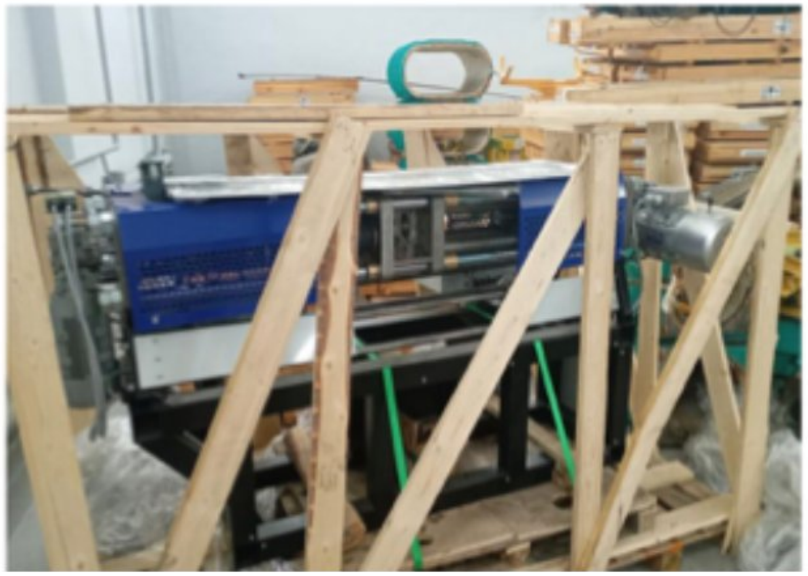


RS detector layer prototype





Injection molding machine for MDTs plastic details



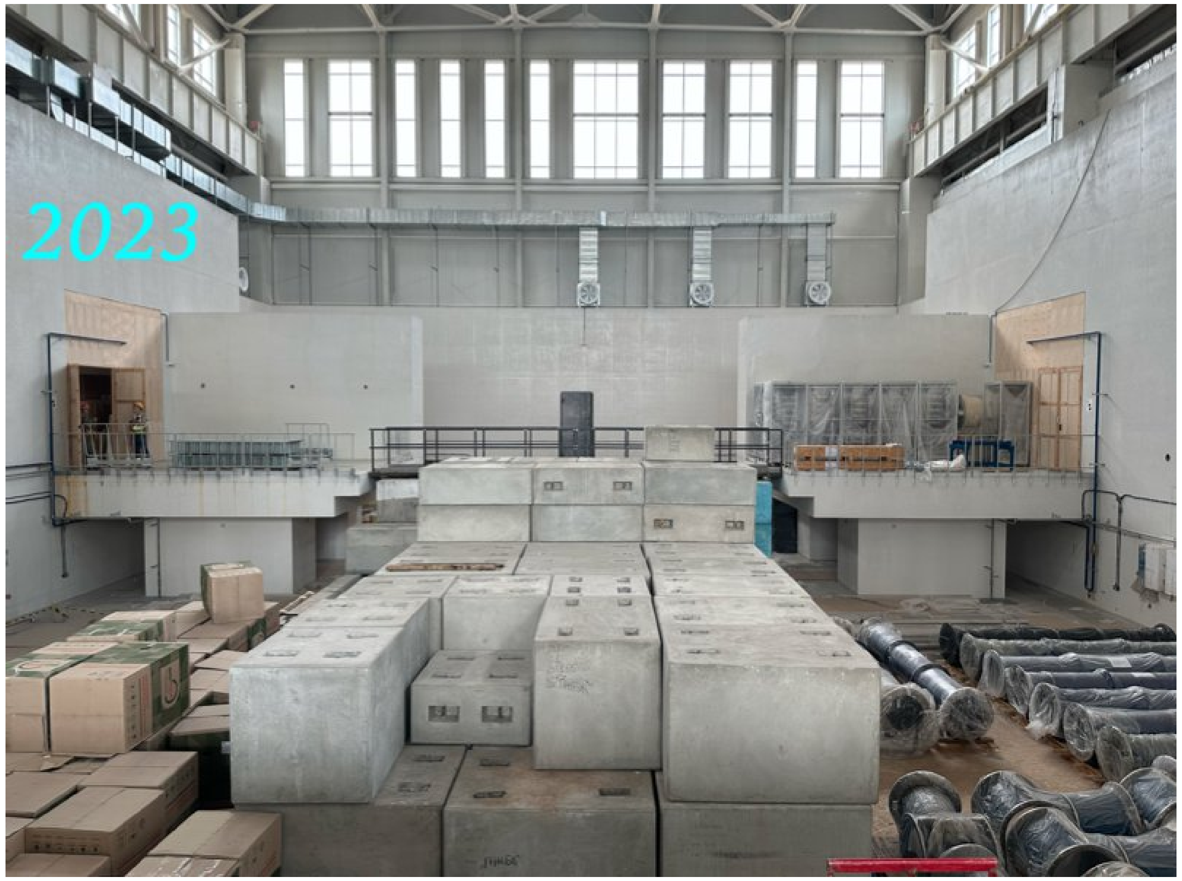
SPD R&D: Central Straw-Tracker

Groups: JINR (Dubna), NRC KI - PNPI (Gatchina) and INP RK (Almaty)
R&D: thin straw tubes with ASIC solution

- ► Straw R&D Test Stand for SPD/SHiP/Dune/DRD1 at SPS and PS (CERN)
  for definition of ASIC novel technology requirements
  Test Runs with ASIC: VMM3,VMM3a, Tiger
  - 2021 (1 Run), 2022 (3 Runs), 2023 (3 Runs), 2024-2026 (6 Runs SPS, 4 Runs PS)
  - most of the results included to the SPD TDR
  R&D Test Run at SC-1000 (1 GeV) NRC KI - PNPI, Gatchina in Fall 2025
- ► INP BSU, Minsk: new ASIC solution in progress

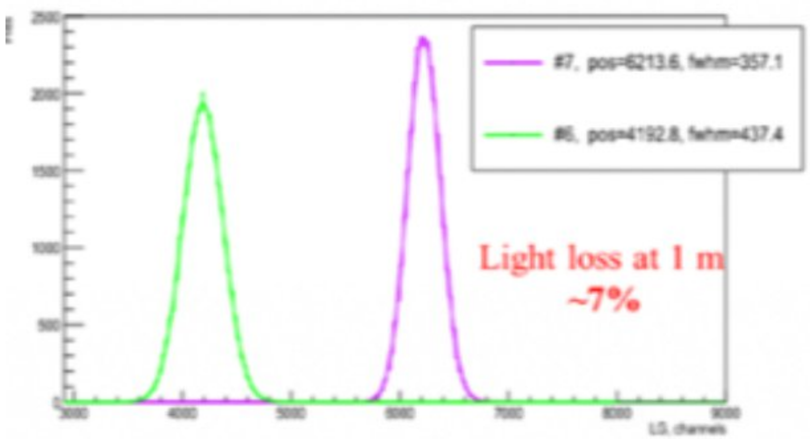
SPD SETUP: Prototyping

SPD Experimental Hall

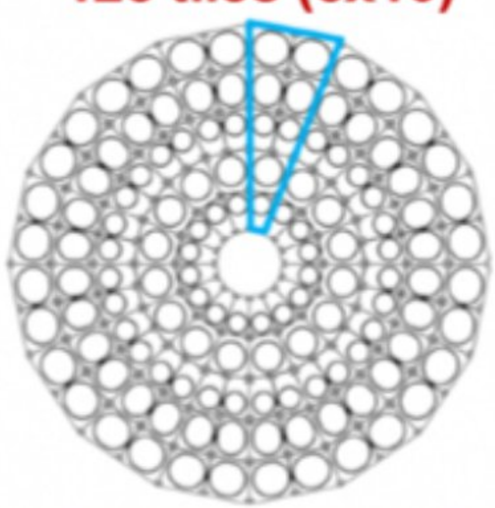


SPD Interaction Point: Beam-Beam Counter (BBC)

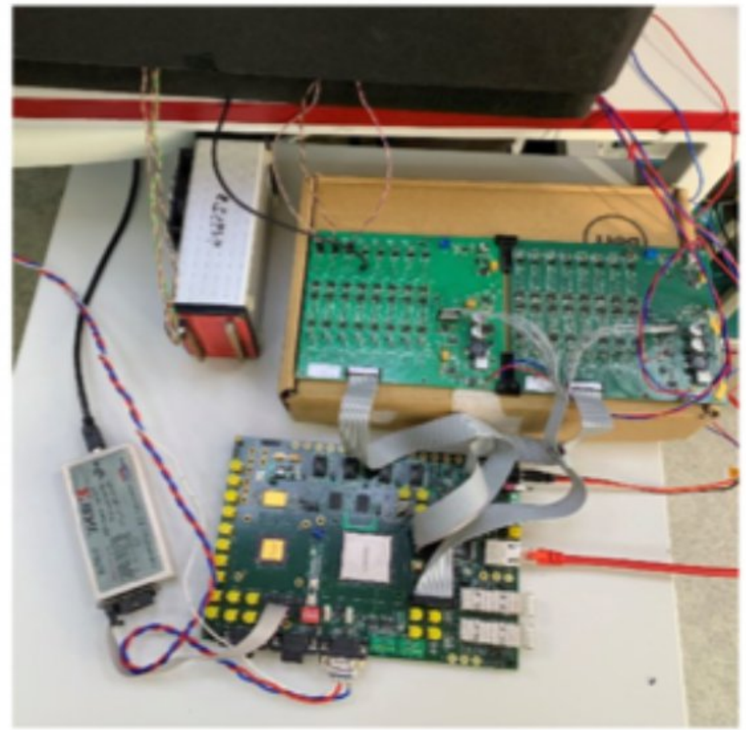
The optical cables prototype test



128 tiles (8x16)



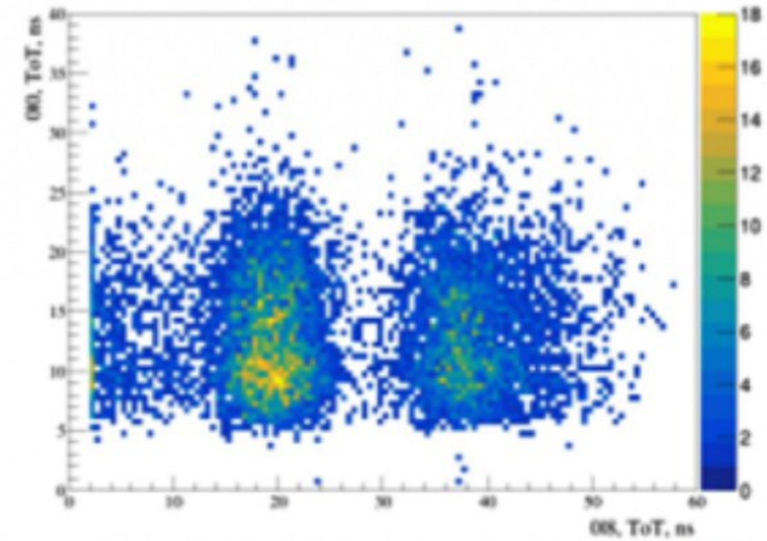
reduced prototype wheel (x2)
(at the 1-st stage)



FEE & Readout system:

CAEN FERS-5200 (1)	for Phase 0
NEW ELECTRONICS (2)	for Phase ≥1

(1)



(2)

- Tests of the new electronics showed reasonable results
- The upgraded version of FEE with FPGA KINTEX-7 based readout system are under development
- The cables prototype with clear fiber produced by Kuraray has been developed and tested

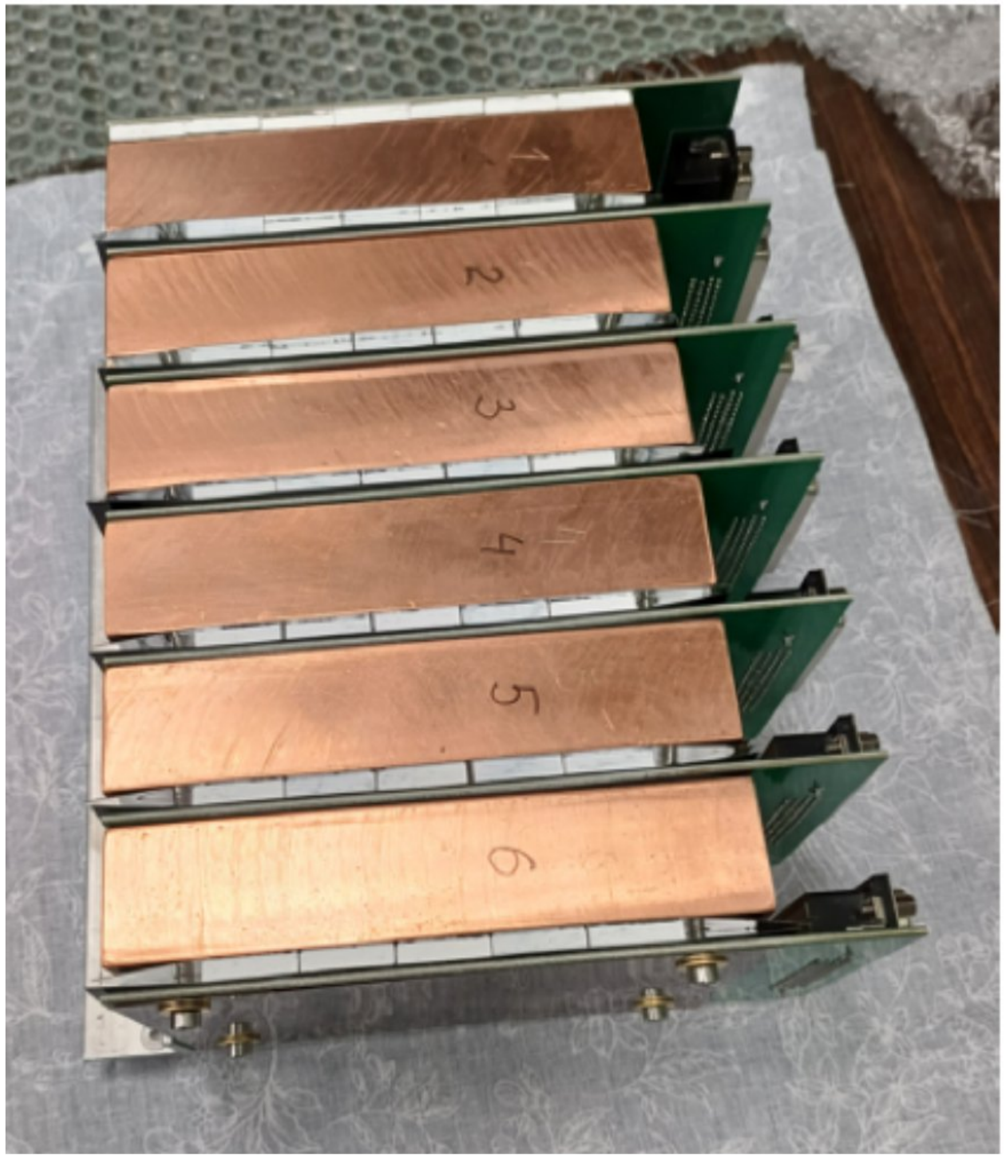
Plans:

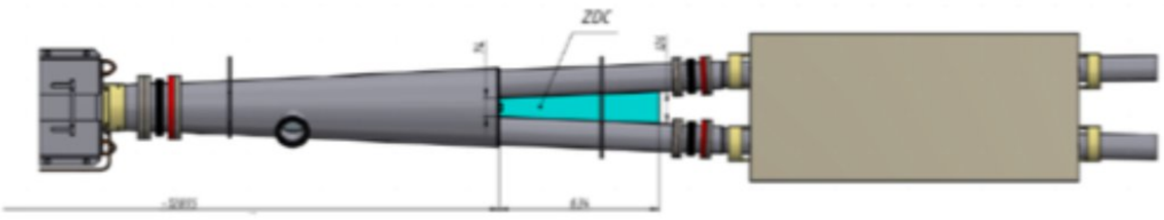
I. The R&D phase for **optical and transmission connectors,** as well as **methods of express sector checking** to be continued.

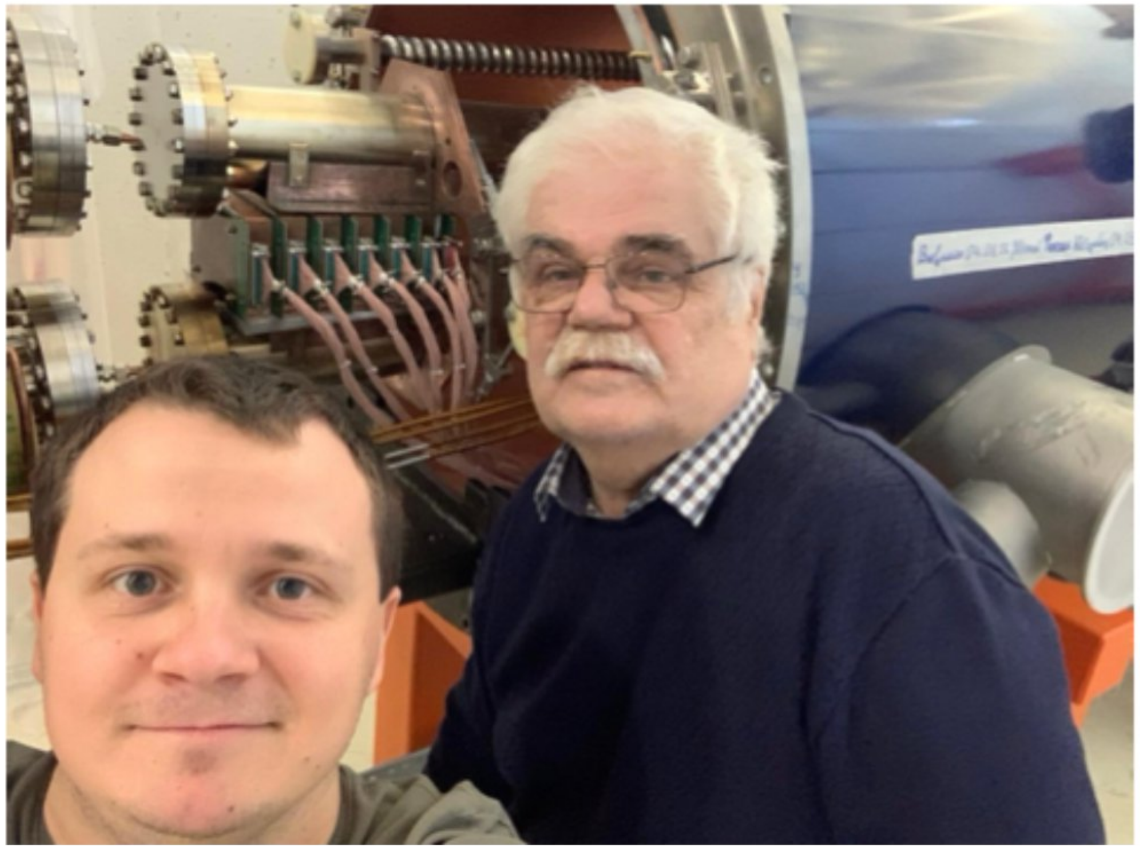
II. The manufacture of **reduced BBC wheels** (128 tiles each) for SPD Phase 0 is planned to the mid of 2025.

10

SPD Interaction Point: ZDC prototype installed







SPD Interaction Point:

- ► The 1st ZDC prototype is installed already
- ► The 2st ZDC prototype will be installed soon

SUMMARY

► **Spin Physics Detector (SPD) – a universal detector at NICA Collider:**
Detail study of polarized and unpolarized (gluon) structure of proton and deuteron in polarized pp- и dd- collisions at high luminosity up to √s < 27 GeV

► **Complementary probes: quarkonia (J/Psi and higher states), open charm and direct photons**

► **SPD should improve understanding of 3D-gluon structure:**
- **polarized gluon distributions**
- **unpolarized PDF and TMD at large x in proton and deuteron**
- **gluon transversity of deuteron**
- **… other spin-related phenomena**

► **SPD physics program is complementary to studies at COMPASS++/AMBER, RHIC, AFTER@LHC, LHC-spin, EIC**

► **Wide physics program at the SPD 1-Phase:**
- **search for exotic resonances (glueball, penta- and tetra- quarks), …**
- **multiquarks fluctons, short-range nucleon correlations …**

► **SPD TDR:** ***http://spd.jinr.ru approved by JINR PAC in June 2024, published in the new JINR journal Natural Science Review (2024) v.1, p. 1***

► **SPD Phase-1:** ***included to JINR 7-years plan for 2024-2030***

► **SPD: got all the approvals, got funding, construction of the Phase-1 SPD setup configuration is ongoing, installation started at SPD IP**

SPD: dynamically developing and in a good shape! Welcome to join for exploring new opportunities!