SPIN2021

Matsue, Japan

24th International Spin Symposium

October 18 -22, 2021

In memory of

A.V.Efremov

A.D. Kovalenko

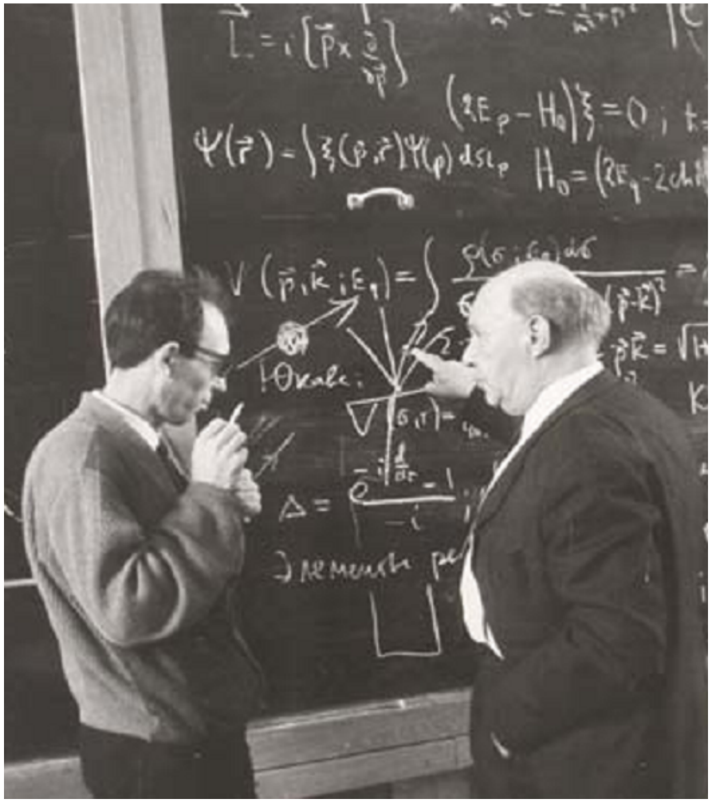
Spin Physics Detector at NICA

V.P. Ladygin on behalf of SPD collaboration

24-th International Spin Symposium (SPIN2021)

18-22 October 2021, Matsue, Japan

Anatoly Efremov

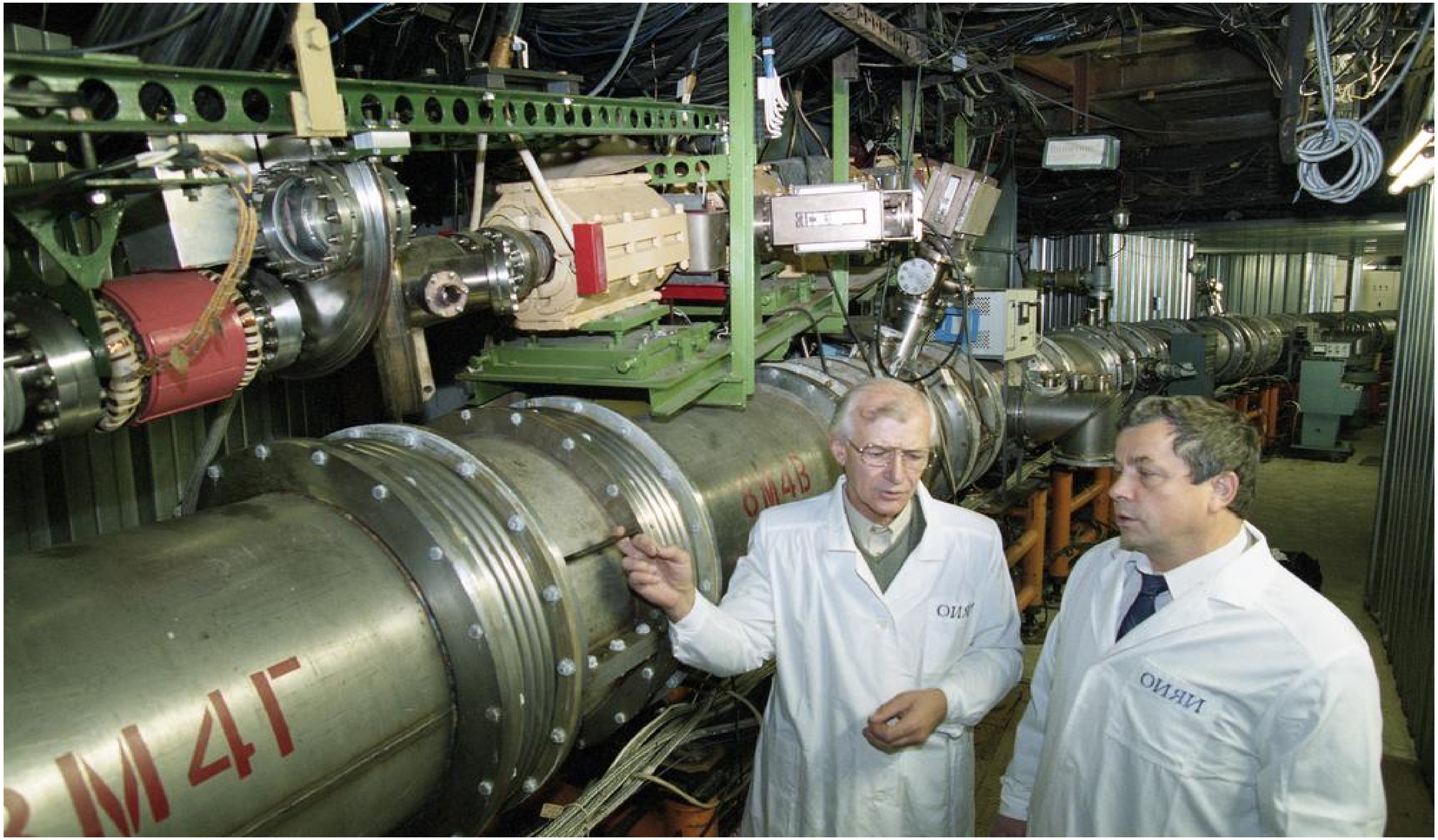


Brilliant physicist: quantum field theory, spin effects in QCD, T-odd effects, axial anomaly, cumulative and EMC effects description, meson spin alignment in HIC, handedness etc.

Member of International SPIN Committee, Organizer of Dubna SPIN Conferences series.

Large contribution to SPD physics program.

Alexander Kovalenko



Chief of Nuclotron until 2007

Leadership contribution to spin techniques development for NICA

Large contribution to SPD concept

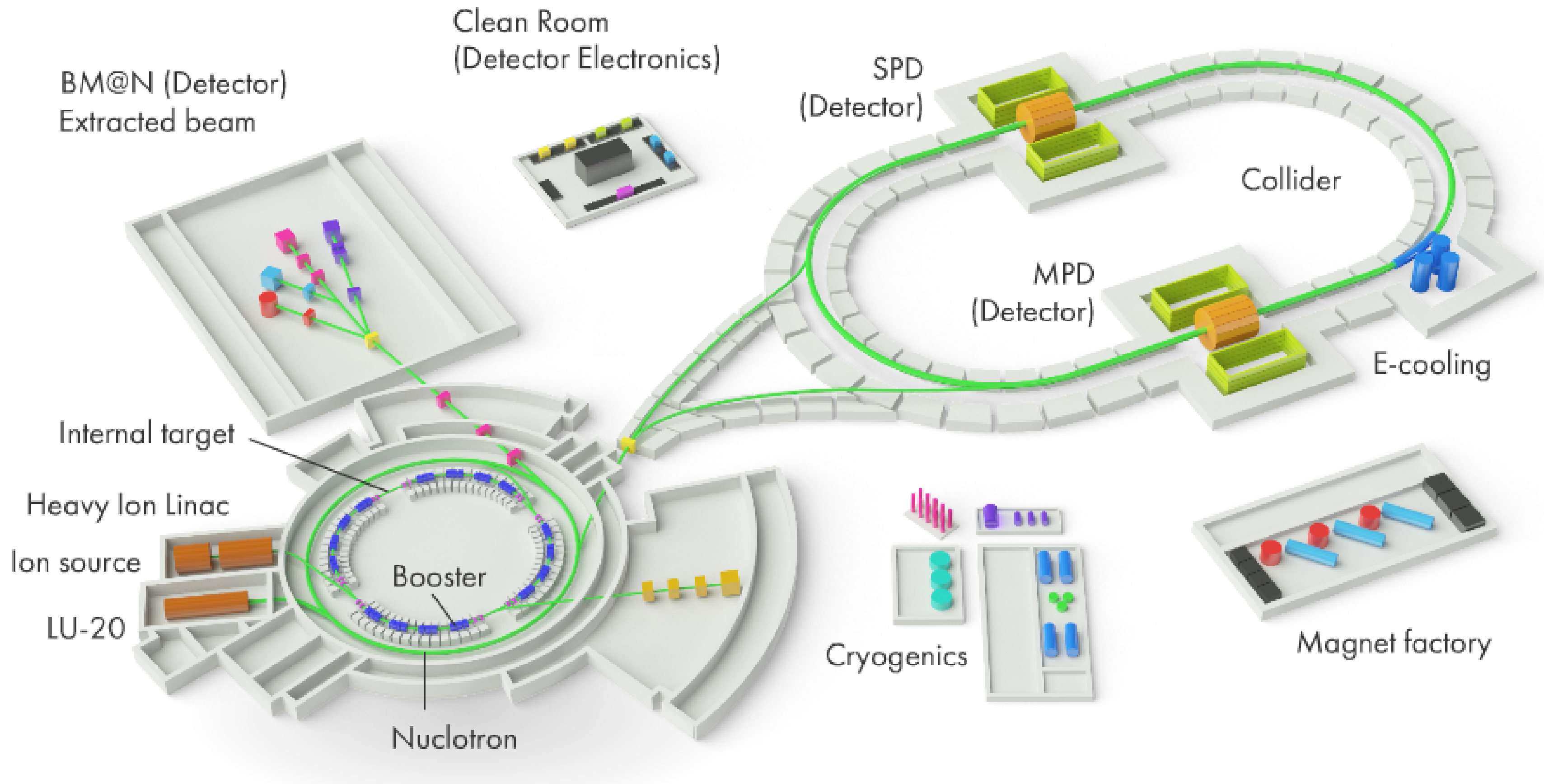
SPD collaboration

Armenia
Belarus
Chile
China
Cuba
Czechia
Egypt
France
Italy
Poland
Russia
Serbia
South Africa
Ukraine

33 laboratories and individual contributors from 14 countries

∼ 300 participants

SPD at NICA


Clean Room
(Detector Electronics)
BM@N (Detector)
Extracted beam
SPD
(Detector)
Collider
MPD
(Detector)
E-cooling
Internal target
Heavy Ion Linac
Ion source
Booster
LU-20
Nuclotron
Cryogenics
Magnet factory

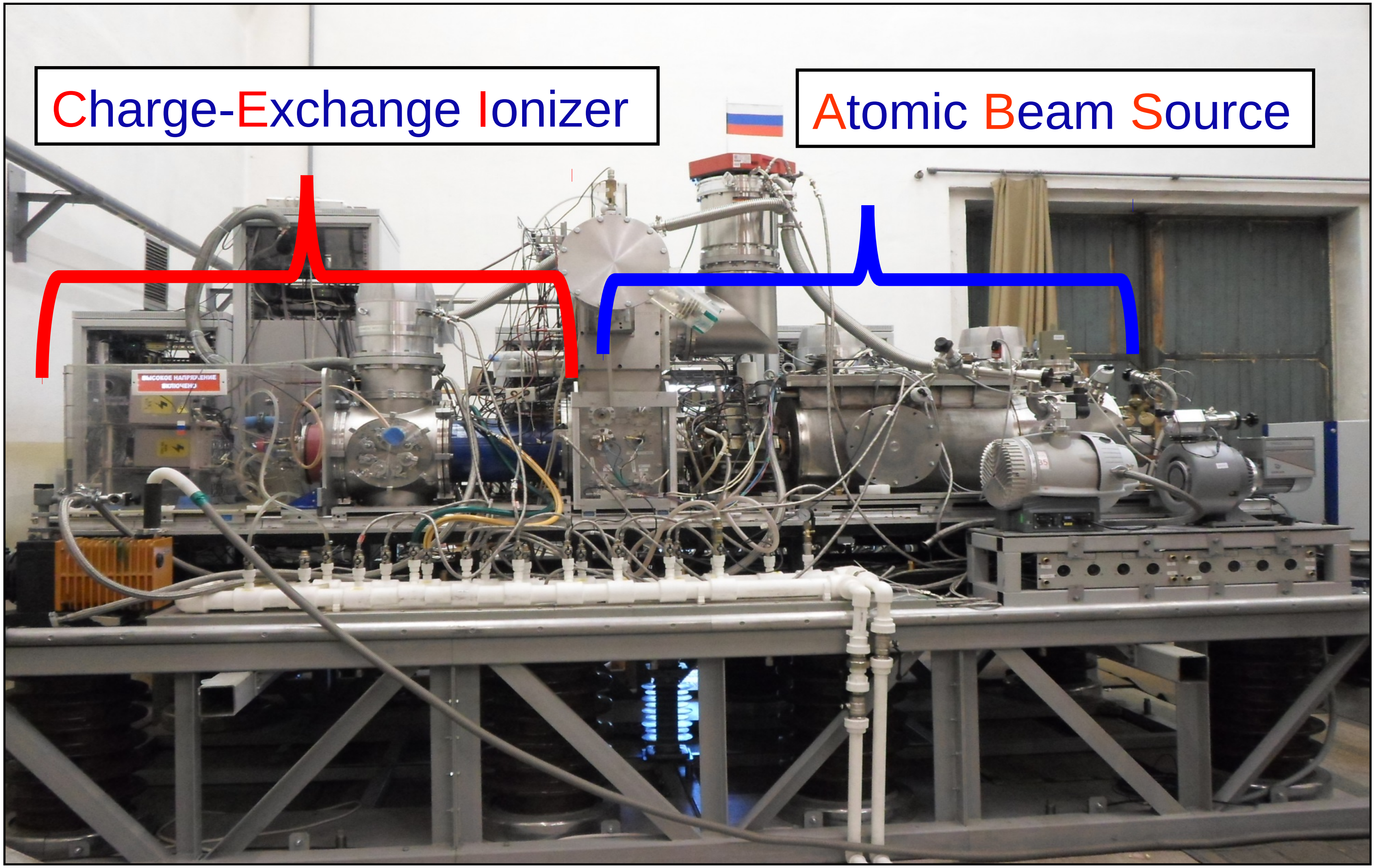
SPD at NICA in 2021

Requirements to polarized beam facility

- polarized and nonpolarized pp- , dd–collisions
- p↑p↑(p) at $\sqrt{s}_{pp} = 12 \div 27$ GeV (5 ÷ 12.6 GeV kinetic energy)
- d↑d↑(d) at $\sqrt{s}_{NN} = 4 \div 13$ GeV (2 ÷ 5.5 GeV/u kinetic energy)
  - $L_{av} \approx 10^{+32}$ cm^{-2}s^{-1} (at $\sqrt{s}_{pp} \geq 27$ GeV)
- sufficient lifetime and polarization degree (few hours, 70%)
- longitudinal and transverse polarization in MPD and SPD
- pd- collision mode should be available

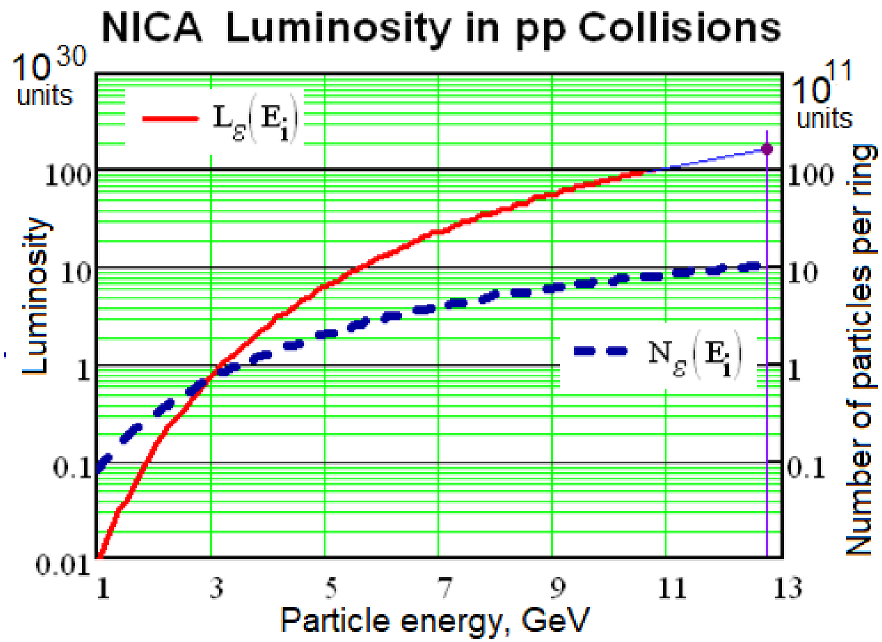
The facility operation in pp – mode at $\sqrt{s}_{pp}$ = 27 GeV reaching average luminosity of 10^{+32} cm^{-2}·s^{-1} remains the first priority task for coming years.

New Source of Polarized Ions



Put into operation in 2016-2017 with deuterons (test with protons)

NICA pp-collisions luminosity



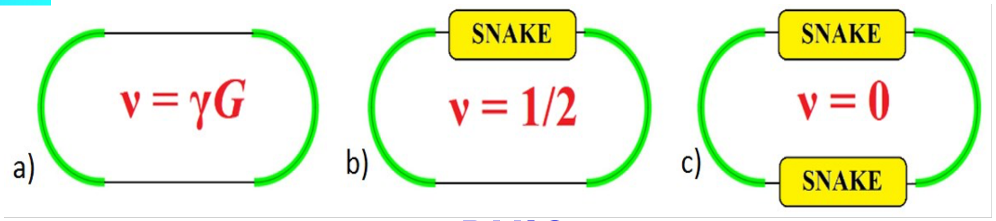
Parameter	beam energy	
	2.0 GeV	7.2 Gev
Nuclotron Dipole Field Ramp up, T/s	0.6	0.6
Nuclotron Dipole Field Ramp down, T/s	1.0	1.0
Magnet field flat top duration, s	0.5	0.5
Total useful cycle duration, s	1.62	4.02
Dipole Magnetic Field	0.42	1.22
Acceleration time, s	1.67	1.67
Number of accelerated protons per pulse	$7\cdot10^{10}$	$7\cdot10^{10}$
Number of cycles to store $2\cdot10^{13}$ particles	2x285	2x285
Collider filling time at cycle duration, s	923.4	2291
Preparation of the beam in the collider (cooling, bunching emittance formation), s	100	100
Magnetic field ramp in the collider, T/s	0.06	0.06
Acceleration time from E_i to 12.6 GeV	~ 27	~ 13
Luminosity life time (30% polarization degradation due to spin resonances), s	5400	5400
Beam deceleration up to the new injection	~ 1.7	~0.8
Total cycle duration, s **Working part, %**	6450 ~ 83	7803 ~ 70

❑ IP parameters: **β** = 35 cm, bunch length **σ** = 60 cm
bunch number – 22, collider perimeter **C** = 503 m

Lpeak ≈ $1.8\cdot10^{+32}$ $cm^{-2}\cdot s^{-1}$ → Lav ≈ ($10^{+32}cm^{-2}\cdot s^{-1}$)

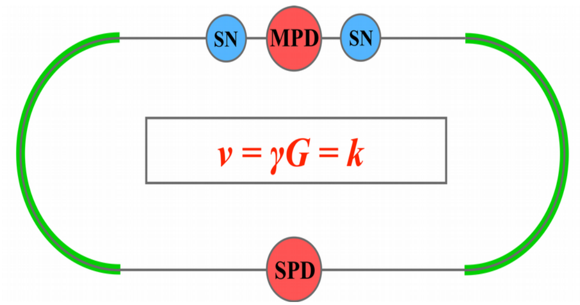
- The tests on polarized p-beam injection, storage, electron cooling can be started at ~2 GeV energy level from the beginning of the collider operation. The intensity of $5\bullet10^{+8}$ ppp can be provided;
- The LILAC could be put into operation not earlier than in 2023-24.

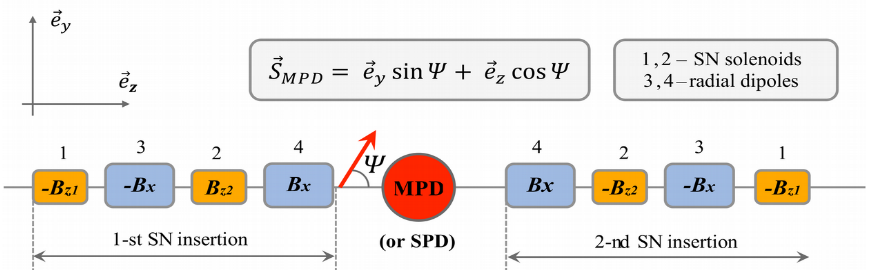
Spin manipulation at NICA



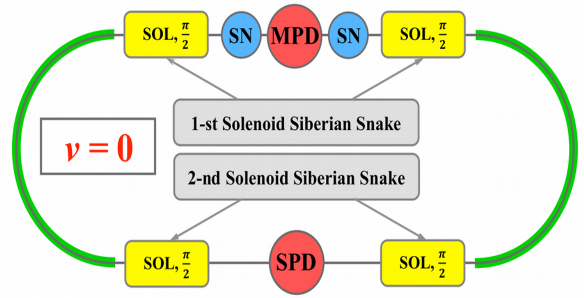
RHIC

HE-?





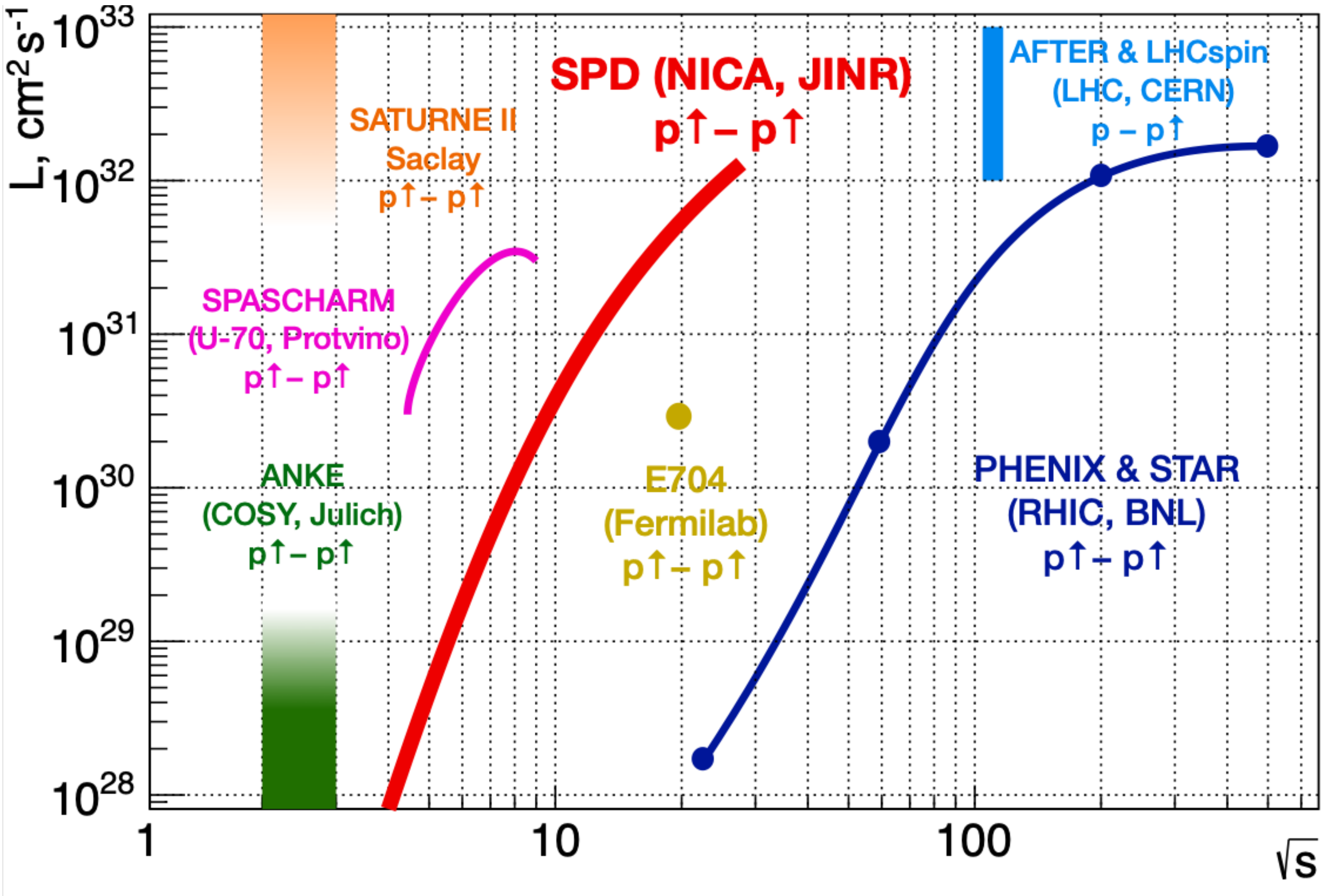
LE



Spin transparent (ST) mode with ν=0 is very well suited to the SPD physics tasks

A.M.Kondratenko, Yu.N.Filatov et al.

SPD and World polarized pp- facilities



Polarized dd-collisions are only at SPD!

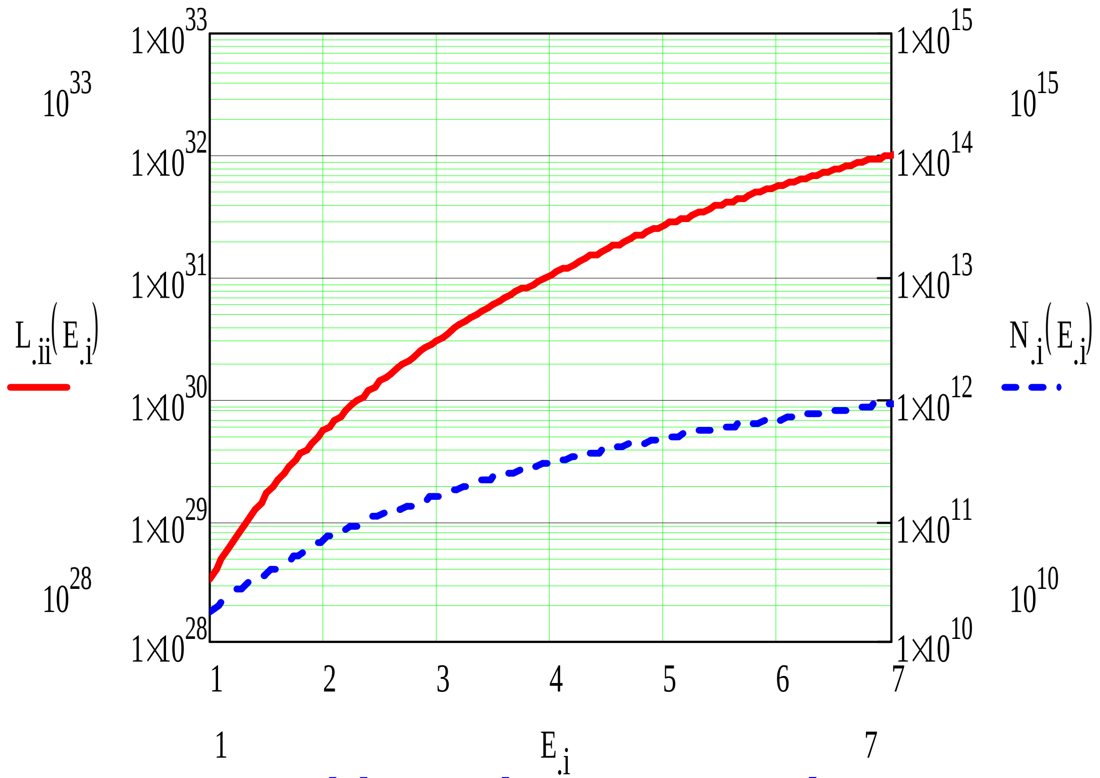
NICA dd-collisions luminosity

Collider parameters

Parameter	Value
β^* , m	0.6
σ_s , m	0.6
$\varepsilon_{x,y}$, $\pi \cdot$ mm $\cdot$ mrad	1.1
N_{IP}	2
E_i , GeV/u	1.0 – 6.5
$\sqrt{s}$, GeV/u	3.86 – 14.86

Polarized dd-collisions are unique → new physics!

Collider Luminosity vs deuteron kinetic energy (GeV/u) at one IP



I.N.Meshkov, Phys.Part.Nucl. 50 (2019) 663-682.

Scientific mission of SPD

-Contribute to the world effort in understanding the strong interaction using unpolarized and polarized *pp, pd* and *dd* collisions at $\sqrt{s_{pp}}$ =27 GeV.

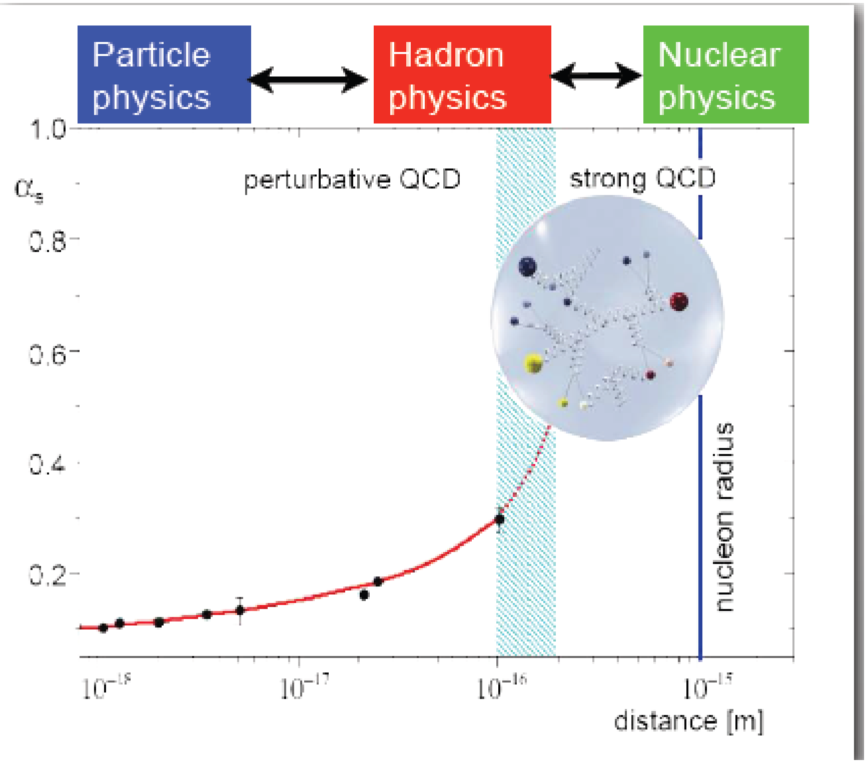
-Origin of the hadron mass: the Higgs mechanism accounts for some percent of the hadron mass: gluon dynamics

-Multiquark states

-Structure of the nucleon (charge, magnetic, spin distributions) and of light nuclei

-Open questions in light nuclei structure - spin observables

-Observables in ion-ion collisions (up to Ca-Ca system)



Gluon physics at SPD

Prog.Part.Nucl.Phys. 119 (2021) 103858

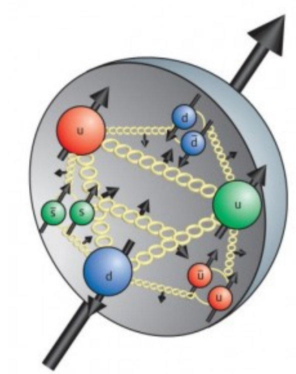
arXiv:2011.15005

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

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

Contact: Alexey.Guskov@cern.ch

Nucleon SPIN at SPD

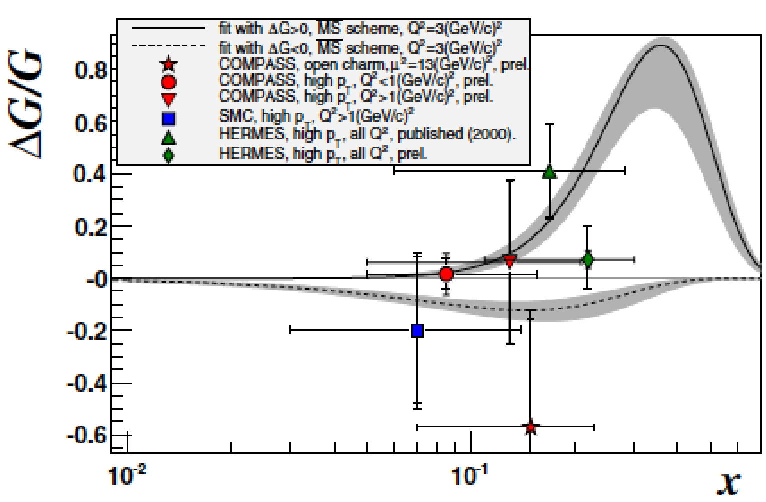


S = 1/2 (measured: ~ 1/4)

½ ΔΣ + ΔG + L

Quarks Gluons orbital momentum

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

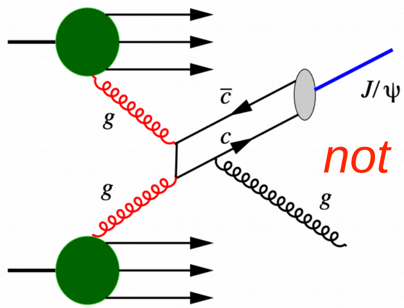


Gluon content of proton and deuteron: Transverse Momentum-Dependent PDFs

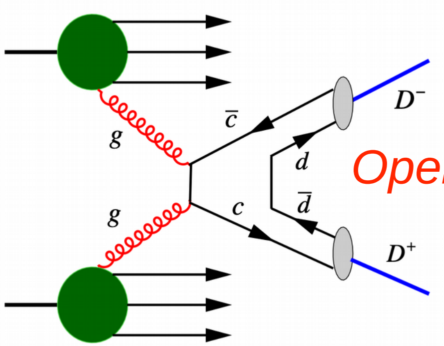
GLUONS	*unpolarized*	*circular*	*linear*
U	f_1^g		$h_1^{\perp g}$
L		g_{1L}^g	$h_{1L}^{\perp g}$
T	$f_{1T}^{\perp g}$	g_{1T}^g	$\boxed{h_{1T}^g}$, $h_{1T}^{\perp g}$

in deuteron only

Gluon probes at SPD

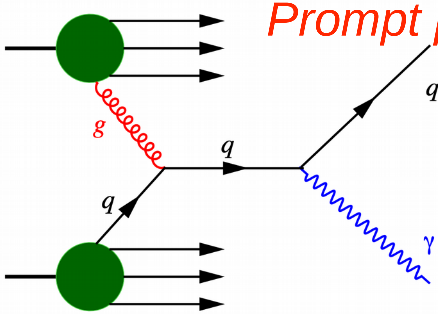


not only J/ψ!

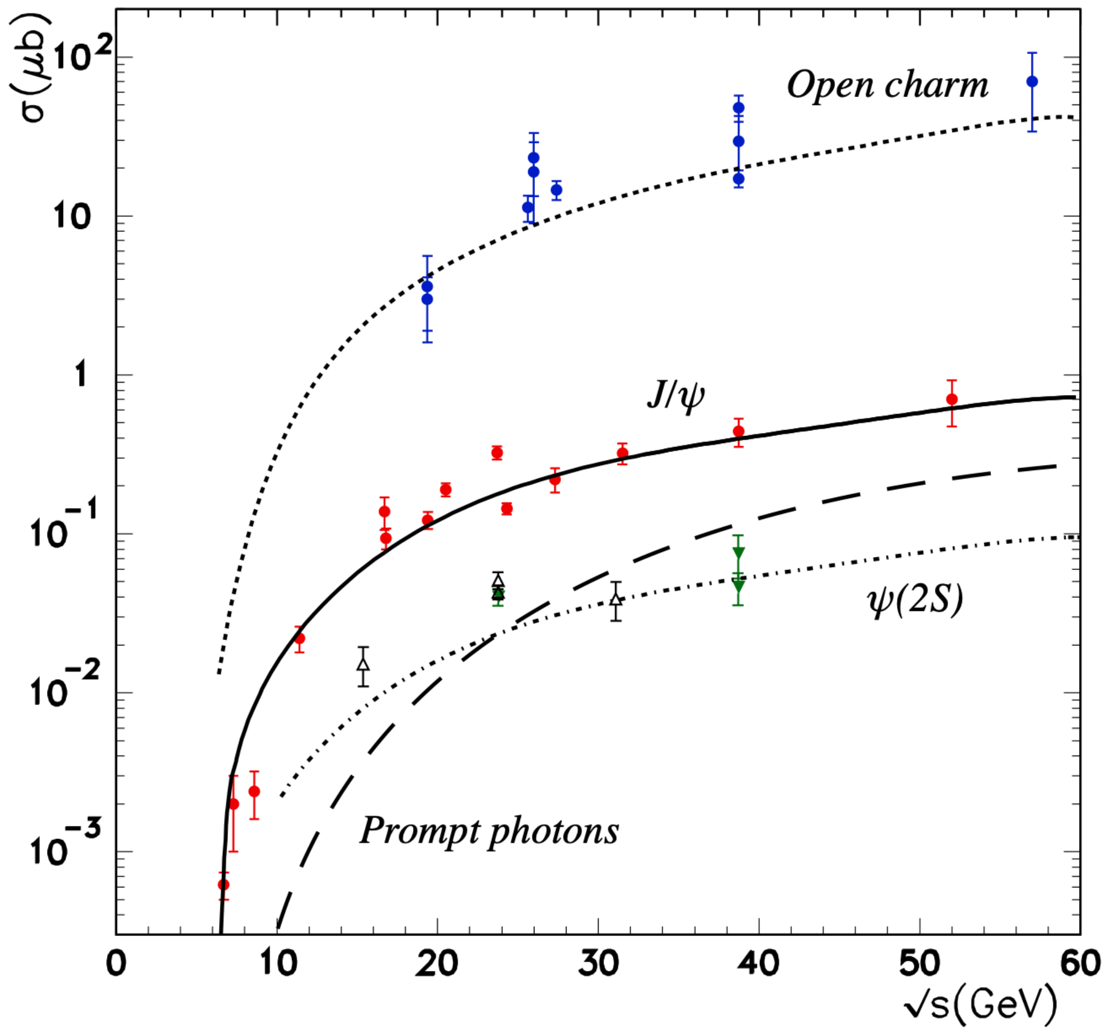


Open charm

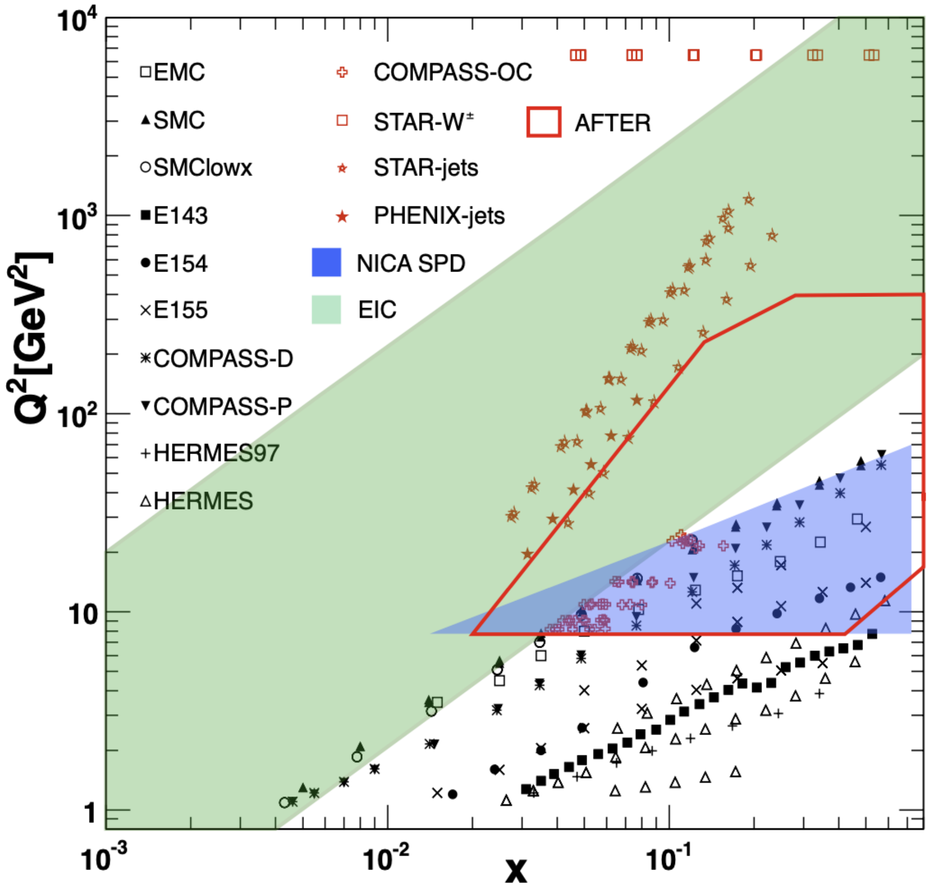
Prompt photons



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



SPD kinematical range



Contribute to the world effort in understanding gluon dynamics

Investigate polarized elementary reactions, elastic and inelastic vector, strange, charmed meson production

Beam energies:

$p\uparrow p\uparrow(\sqrt{s_{pp}}) = 12 \div \geq 27$ GeV ($5 \div \geq 12.6$ GeV of proton kinetic energy),

$d\uparrow d\uparrow(\sqrt{s_{NN}}) = 4 \div \geq 13.8$ GeV ($2 \div \geq 5.9$ GeV/u of ion kinetic energy).

SPD first stage physics

To be published in Part.Nucl.Phys.

arXiv:2102.08477

Prepared for Physics of Elementary Particles and Atomic Nuclei. Theory

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*[7,8], *E. Kokoulina*[5,9], *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*[18], *P.Yu. Shatunov*[10,11], *Yu.M. Shatunov*[10,11], *O.V. Selyugin*[14], *M. Strikman*[19], *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]

Contact: Yuri Uzikov;
Uzikov@jinr.ru

SPD first stage physics

Spin amplitudes of NN elastic scattering

Di-quarks dynamics

Vector meson production (strange, charm...) :

spin-isospin effects, backward emission…

Deuteron short range spin structure

Scaling properties of spin observables

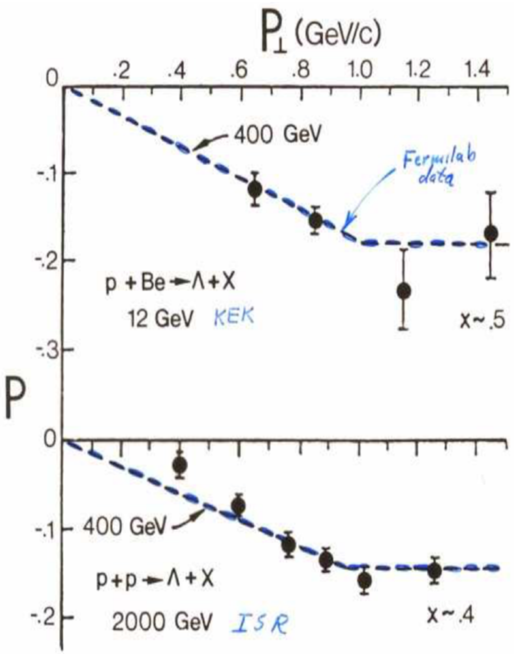
Diffractive and hard scattering

Heavy ion collisions

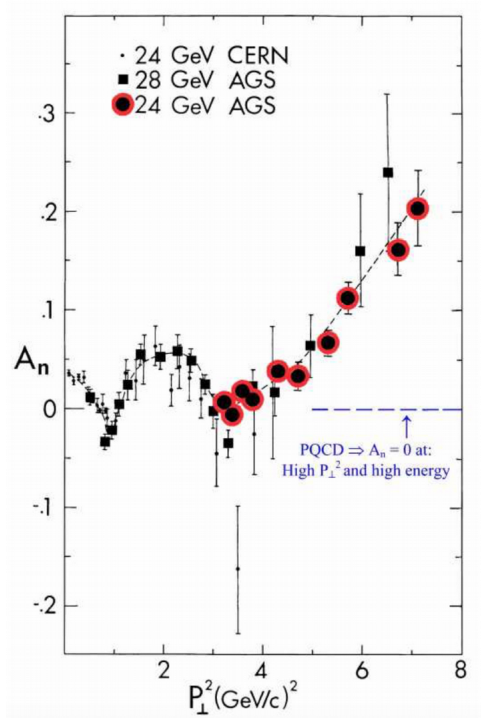
…..

Spin effects at large transfer momenta

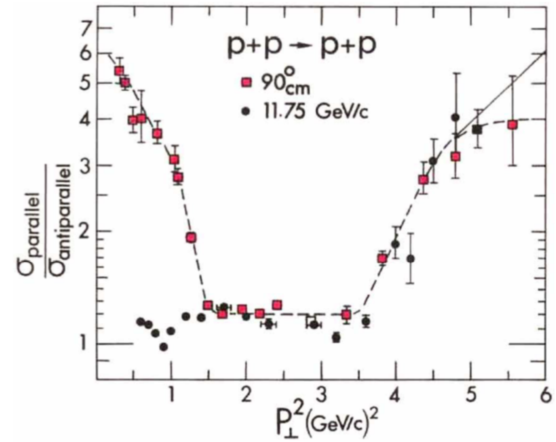
Hyperon polarization



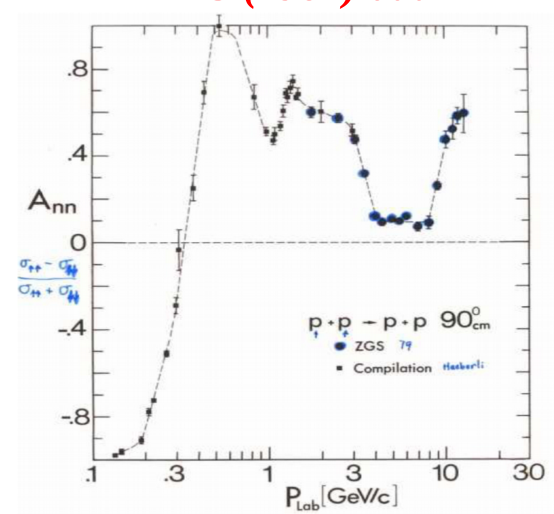
PRL 51 (1983) 2025



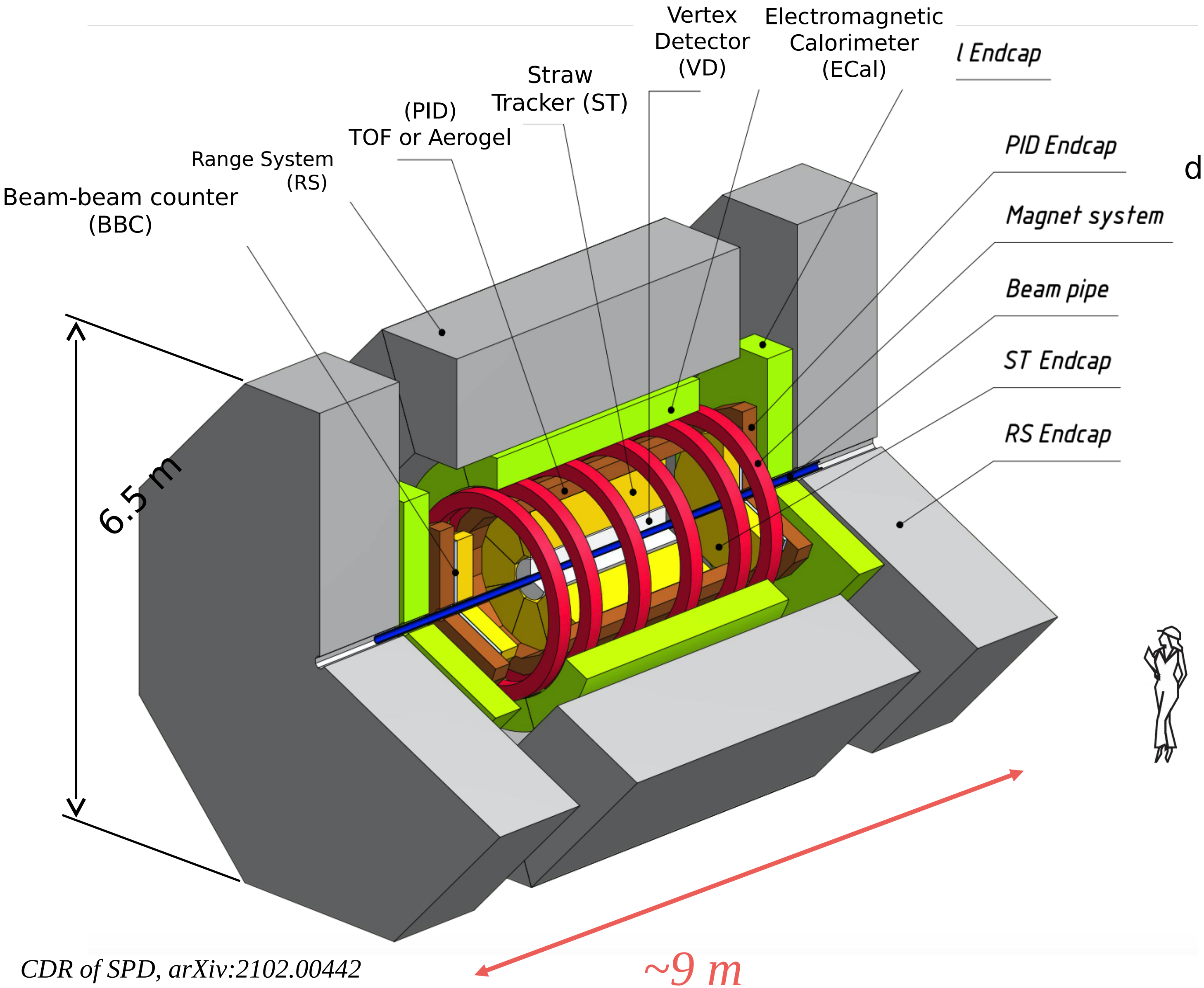
Large angle *pp* scattering



PRD 23 (1981) 600



Layout of SPD



Size of the detector is limited by its weight <1200 ton

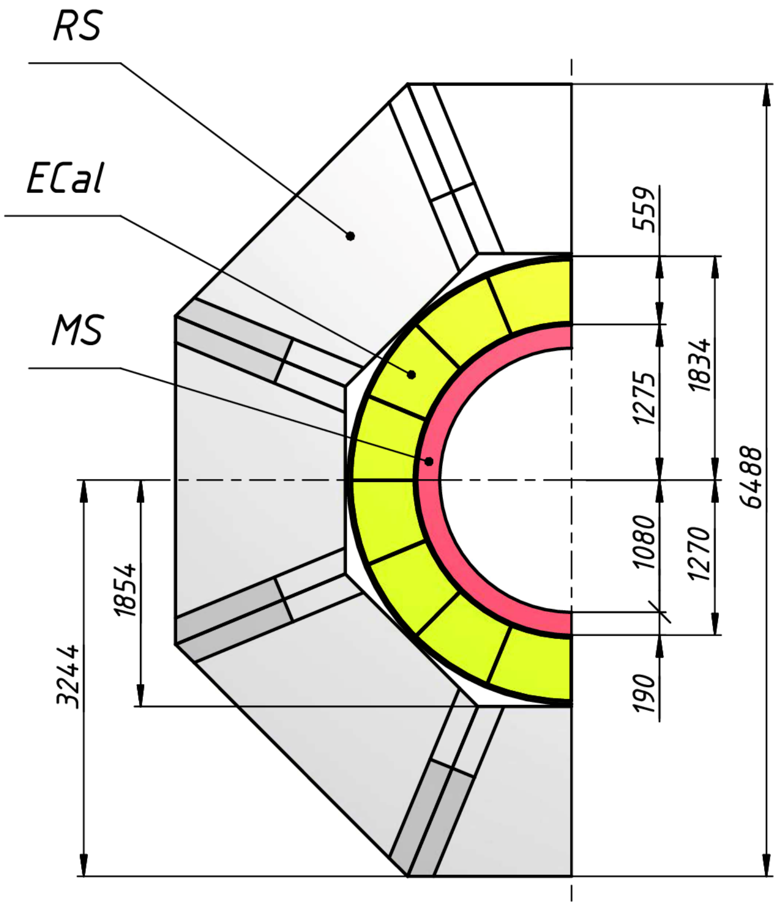
MF at the axis is ~1T

Collision rate ~4 MHz using triggerless DAQ

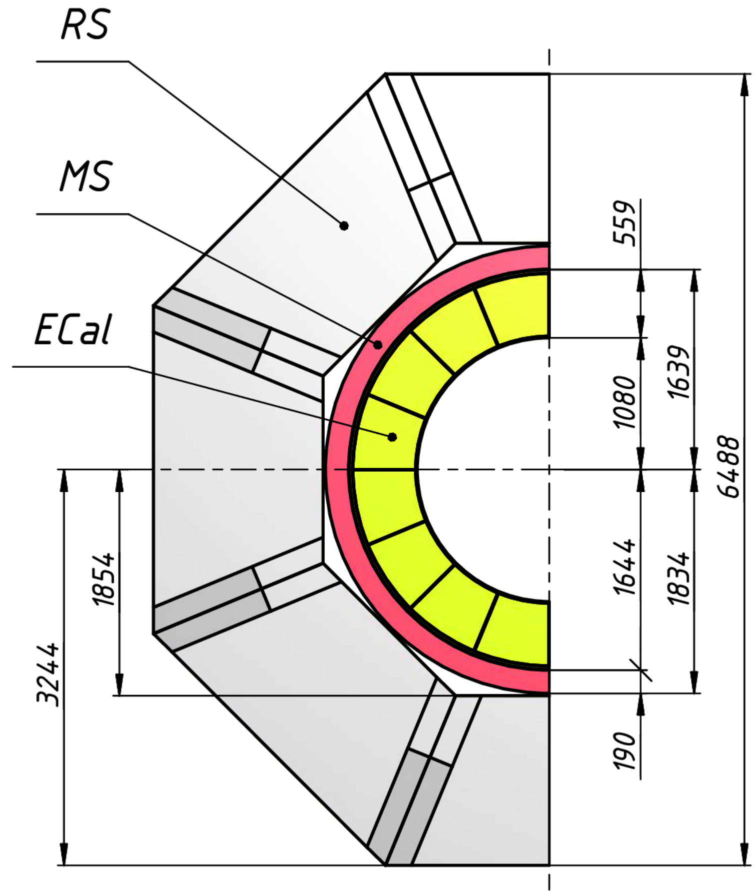
CDR of SPD, arXiv:2102.00442

SC magnet system options

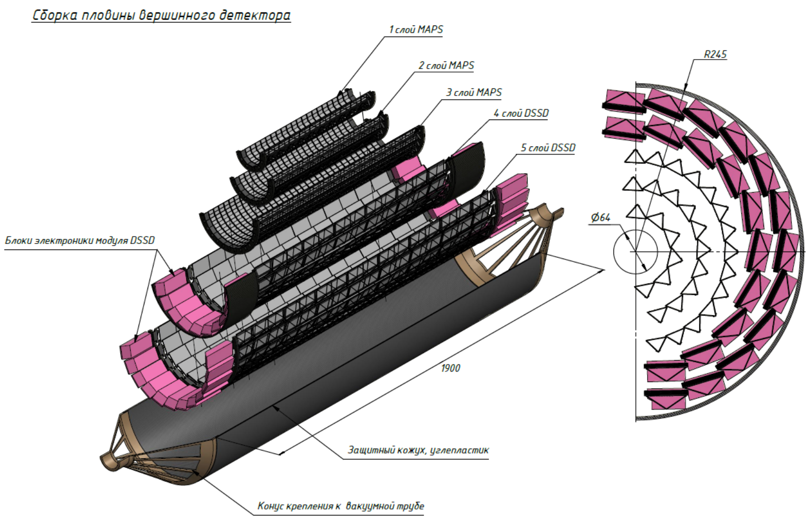
CDR version
6 separated coils inside ECal



Option under development
A single cryostat with several coils

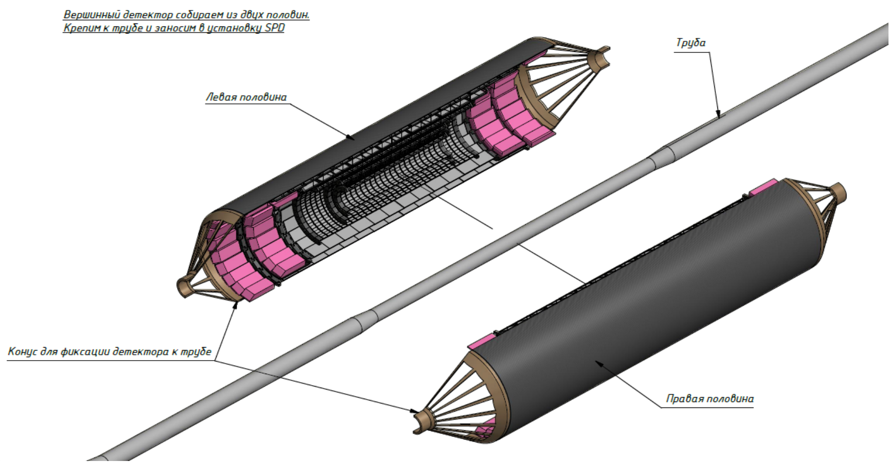


Vertex Detector (VD)



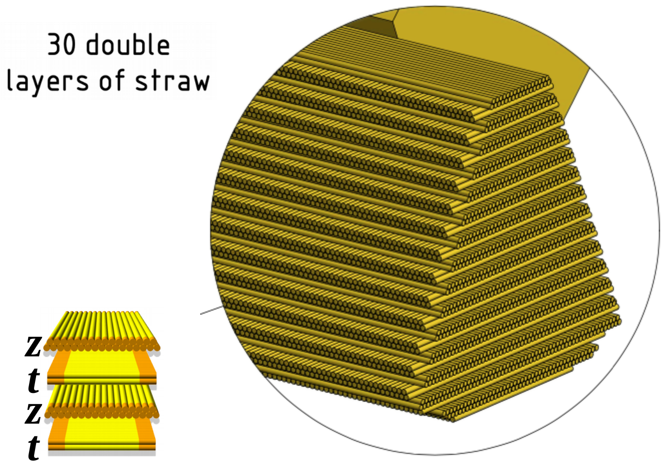
- **Inner tracking system of SPD: barrel + endcaps**
- **Reconstruction of D meson decay vertices**
- **5 layers = 2 DSSD + 3 MAPS**
- **Double Side Silicone Strip (DSSD), 300 μm thickness, strip pitch 95 μm - 281 μm**
- **Monolithic Active Pixel Sensors (MAPS) designed and produced for ALICE, pixel size 29 μm × 27 μm**

- **Low material budget**
- **As close as possible to the beam pipe 5<R<25 cm**
- **Spatial resolution < 100 μm**
- **Use of MAPS improves the signal-to-background ratio of D meson peak by a factor of 3**

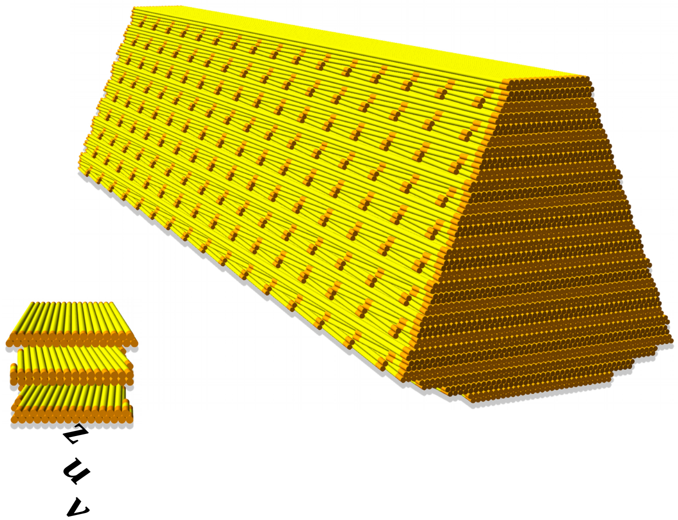


Straw Tracker (ST)

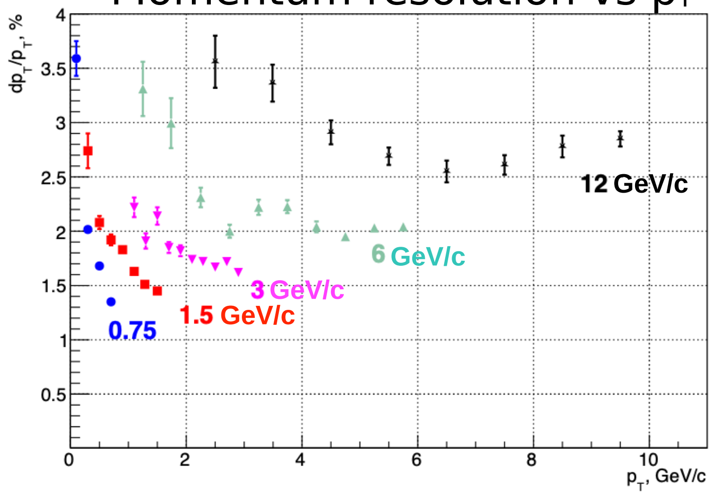
CDR version



Layers 10x(ZUV)



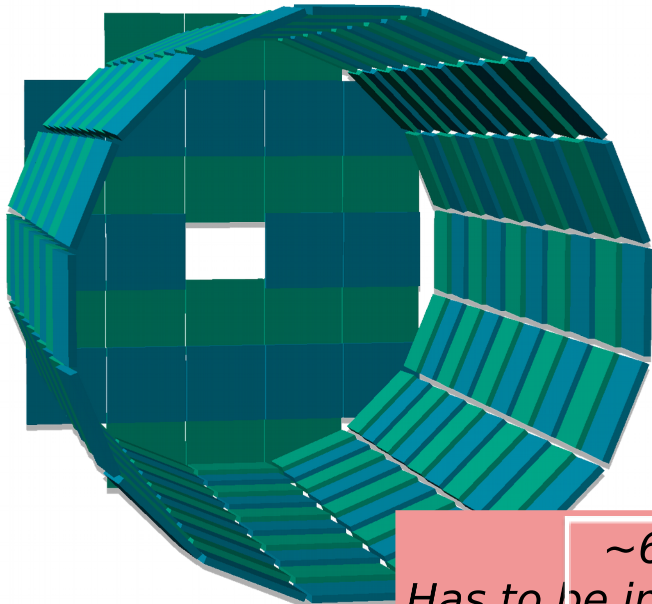
Momentum resolution vs p_T



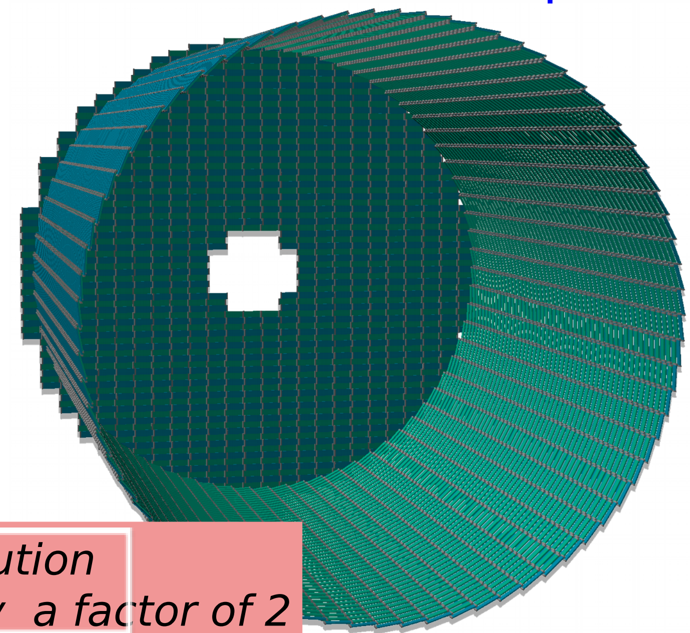
- Majority of tubes should be oriented ⊥ to the bending plane
- Number of channels can be reduced by a factor of 3
- Less dead space due to covers & electronics

PID: Time-of-Flight (TOF)

mRPC option

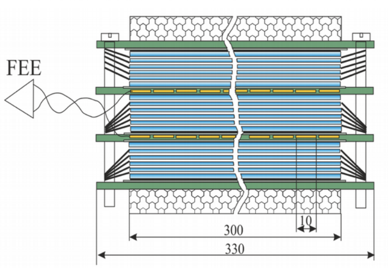


Plastic scintillator option

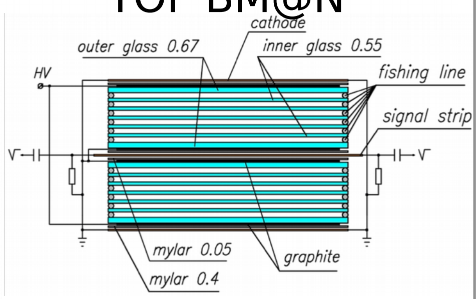


~60 ps resolution
Has to be improved by a factor of 2

TOF MPD

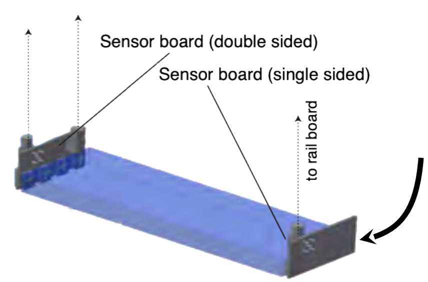


TOF BM@N



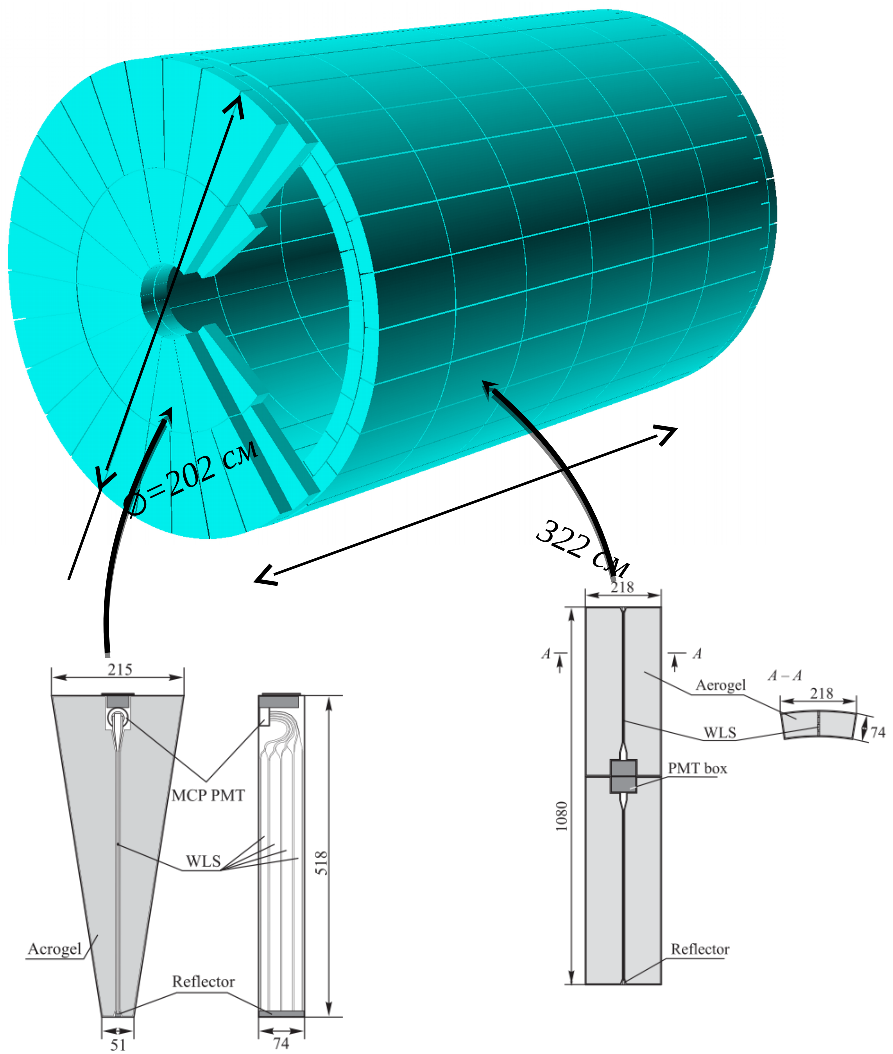
MPD NICA TDR TOF, Nov 2018, Rev 3.0

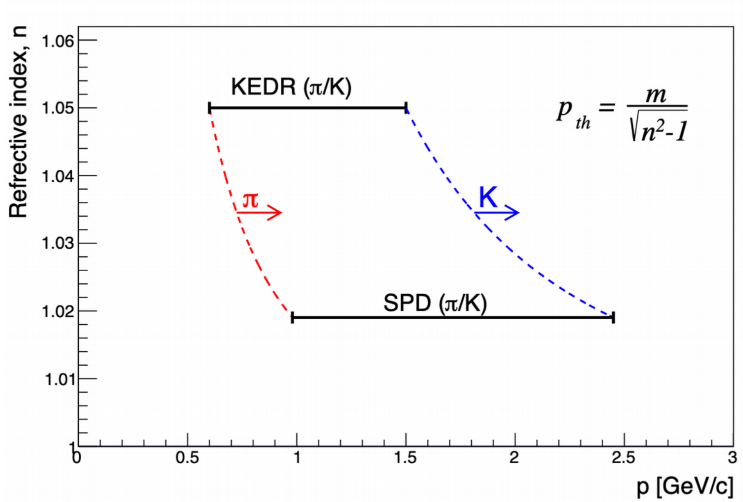
Inspired by the TOF of PANDA



TDR for the PANDA Barrel TOF, July 4, 2018

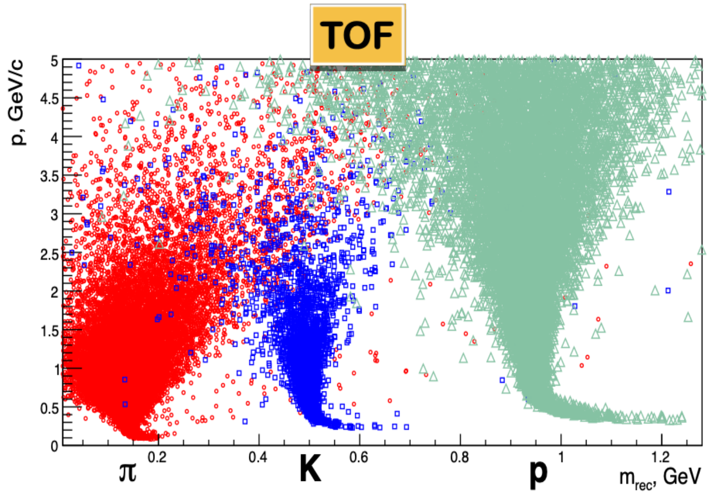
Aerogel counters for PID

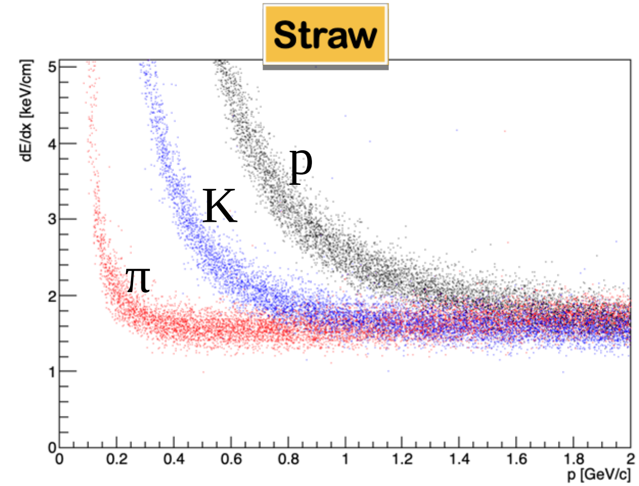




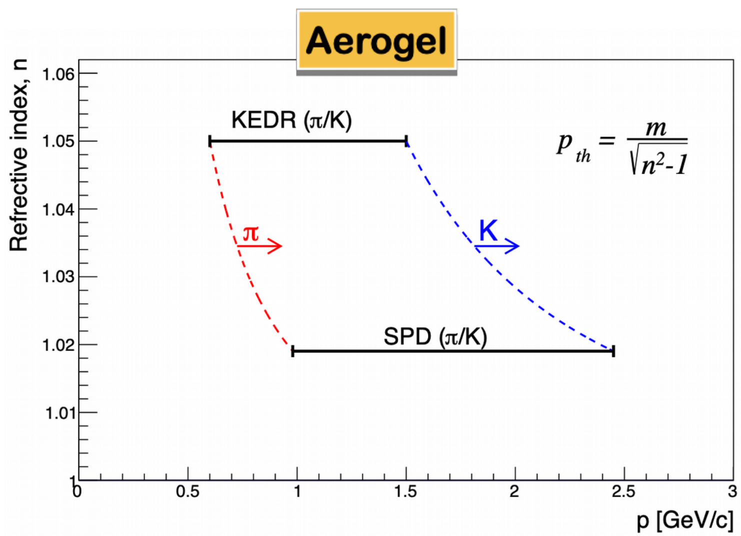
- **Identification based on Cherenkov light radiation**
- **Range of π/K separation is a function of refractive index *n***
- **The design follow closely the one of KEDR (Novosibirsk)**
- **Low light yield ~6 p.e.**
- **Can be used only in endcaps since there is more space and it is a region of higher momentum particles**

PID analysis in SPD (π, K, p)





π/K separation

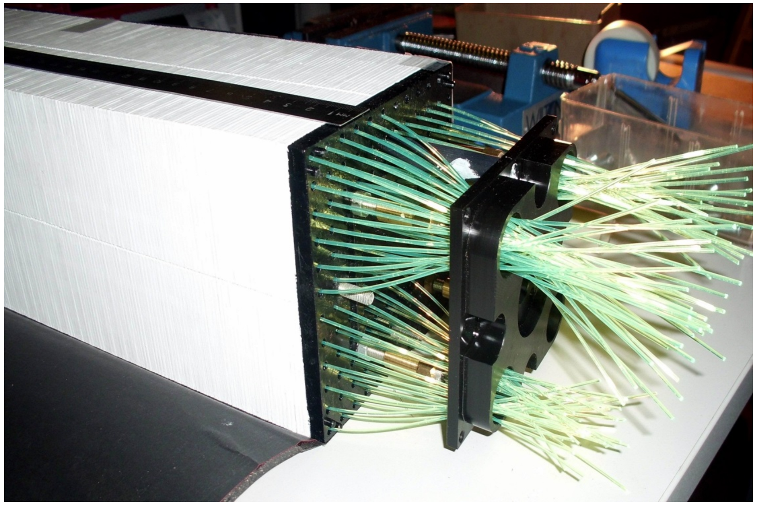


-Short tracks (R<1m) to be identified by straw up to 0.7 GeV/c

-Long tracks (R>1m) to be identified by straw+TOF up to 1.5 GeV/c

-tracks with p>1.5 GeV/c to be identified by aerogel

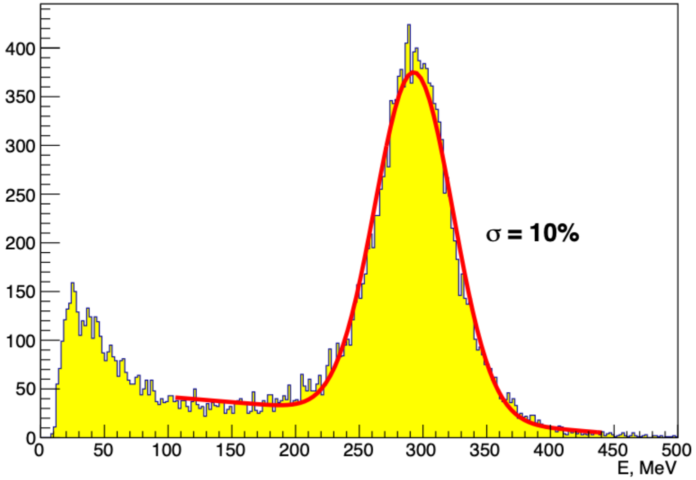
Electromagnetic Calorimeter (ECal)



- Purpose: detection of prompt photons and photons from π^0, η and χ_c decays
- Identification of electrons and positrons
- Number of radiation lengths $18.6X_0$
- Total weight is 40t (barrel)+2×14t (endcap) = 68t
- Support structure will be made of carbon composite materials
- Total number of channels is ~30k

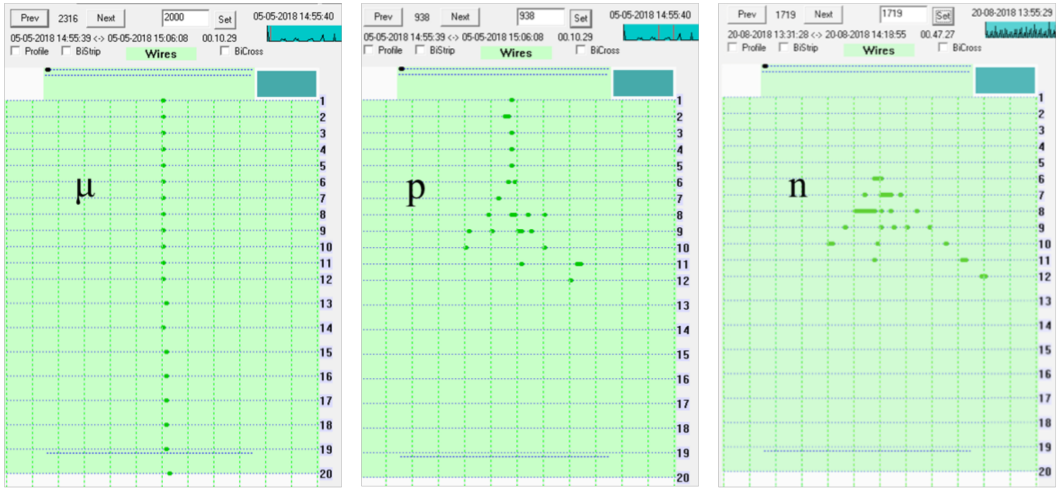
- 200 layers of lead (0.5 mm) and scintillator (1.5mm)
- Size of one sandwich: $4 \times 4 \times 40\ cm^3$
- Moliere radius is ~2.4 cm
- 36 fibers of one cell transmit light to $6\times6\ mm^2$ SiPM
- Energy resolution is ~5% / √E
- Low energy threshold is ~50 MeV
- Time resolution is ~0.5 ns

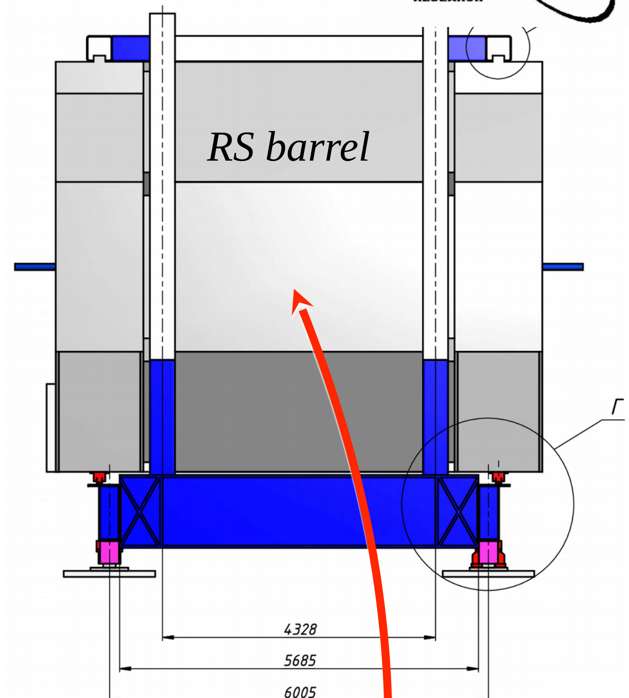
Energy deposition of one cell for MIP



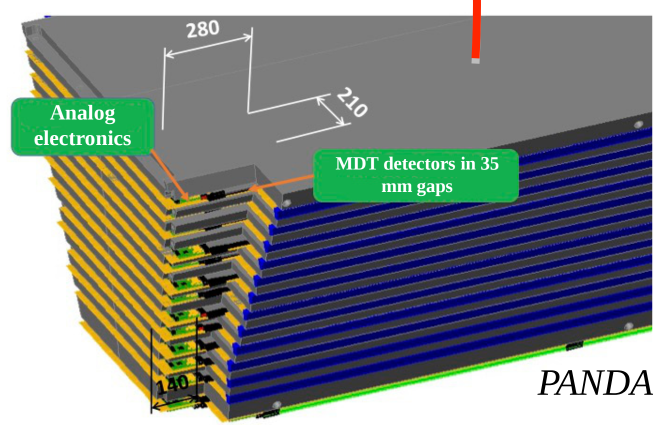
Range System (RS)

Results of beam tests of RS prototype (10 ton, 4k ch) at CERN



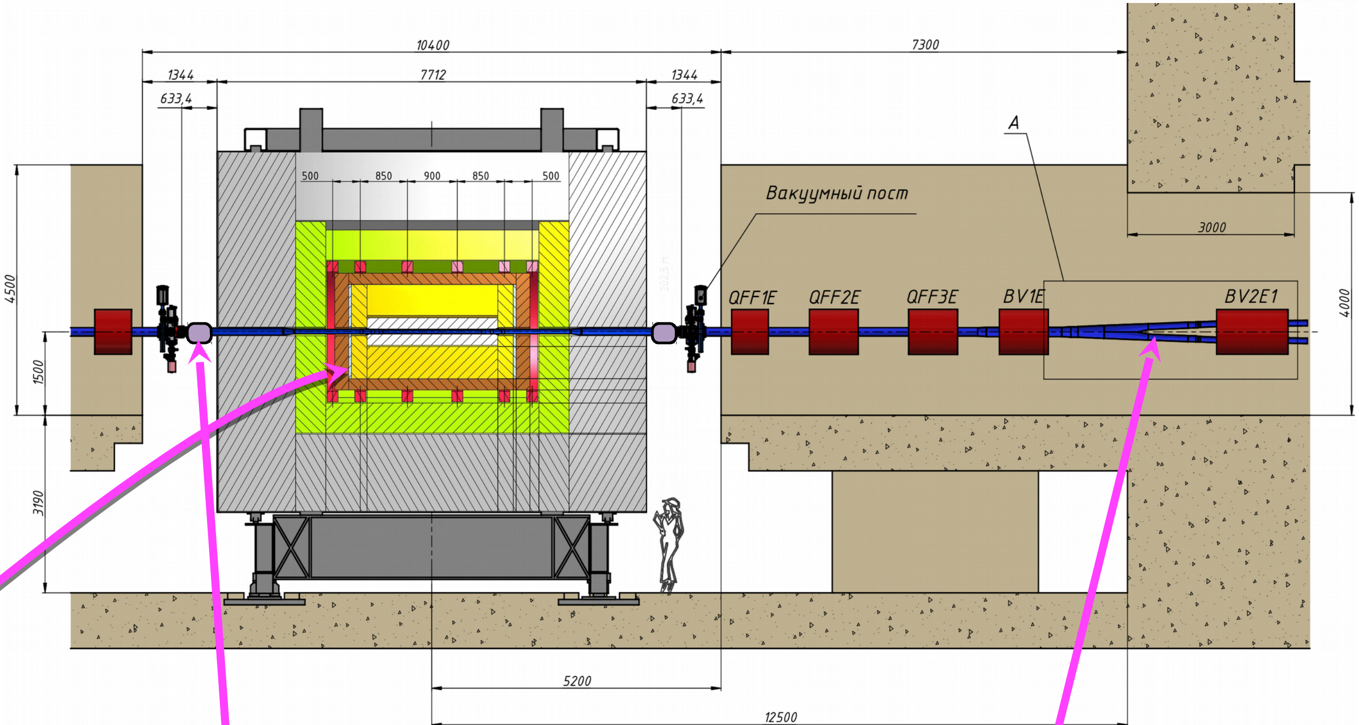


- Purposes: μ identification, rough hadron calorimetry
- 20 layers of Fe (3-6 cm) interleaved with gaps for Mini Drift Tube (MDT) detectors
- Total mass ~800 t, at least $4\lambda_I$
- The design will follow closely the one of PANDA
- MDT provide 2 coordinate readout (~100 kch)
- Al extruded comb-like 8-cell profile with anode wires + external electrodes (strips) perpendicular to the wires

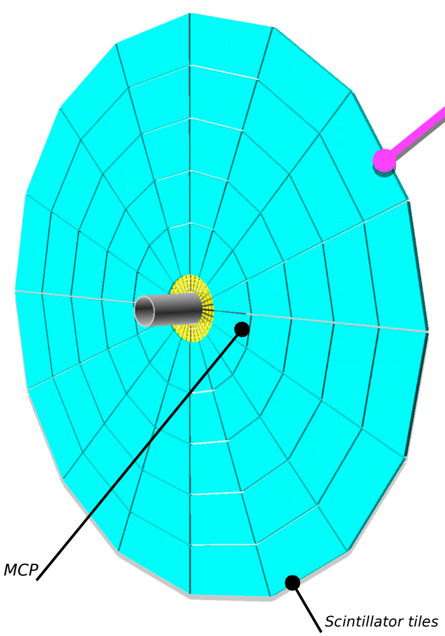


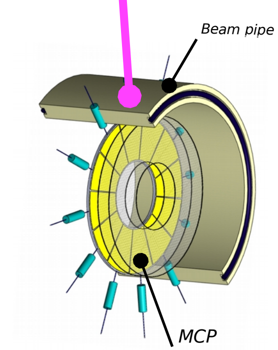
Detectors for local polarimetry and luminosity control

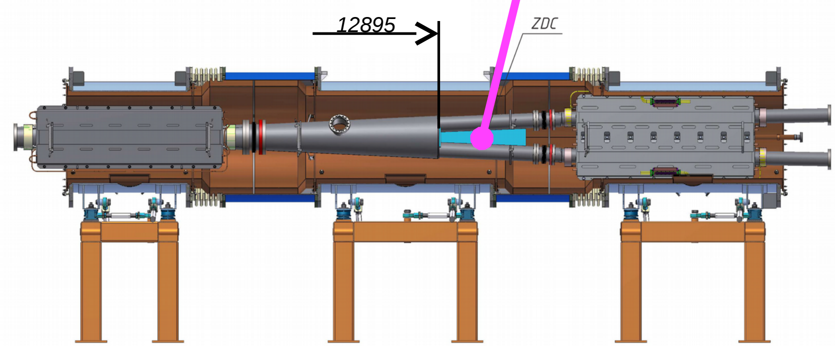
- **BBC (MCP+SciTil) at *z=±1.4m***
- **MCP at *z=±3.9m***
- **ZDC at *z=±12.9m***



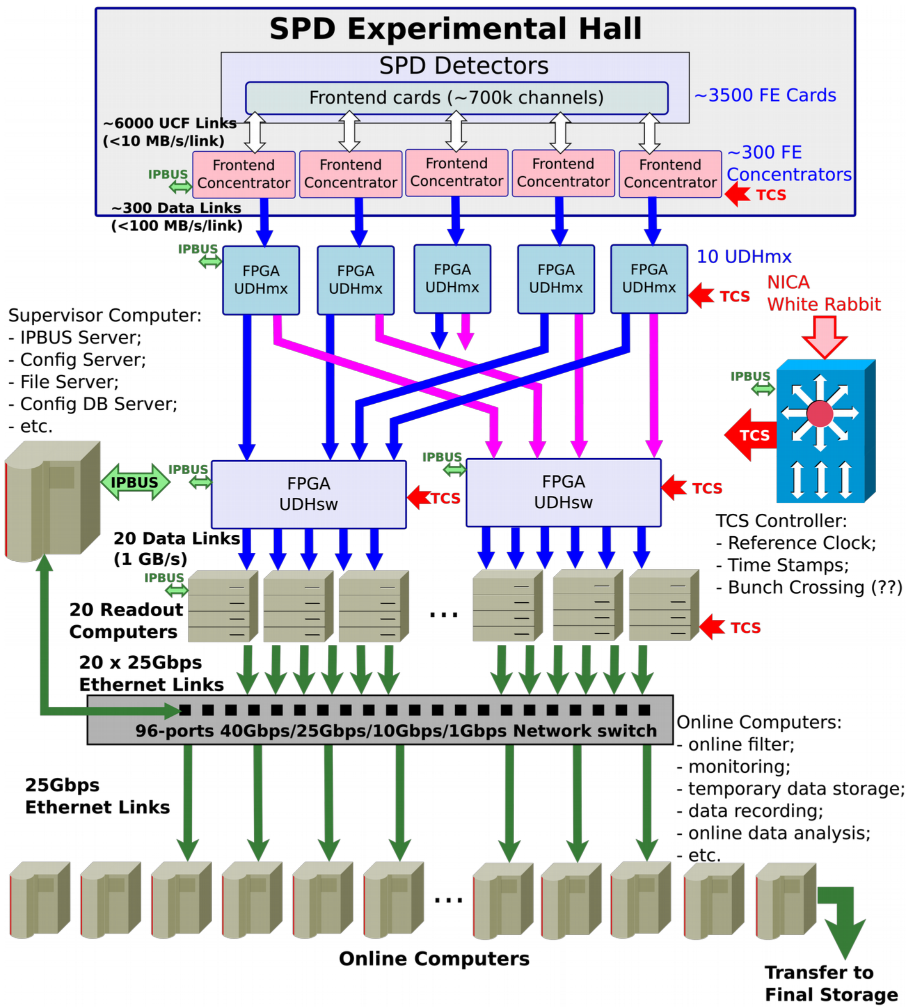
Beam-Beam Counter (BBC)



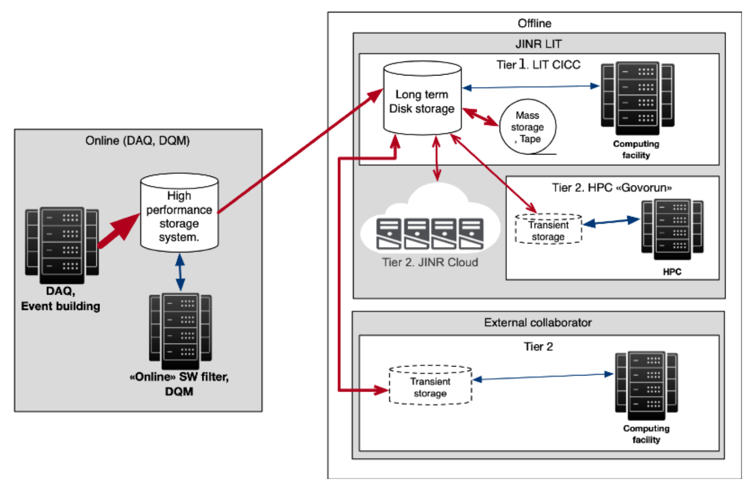




Data Acquisition System (DAQ)

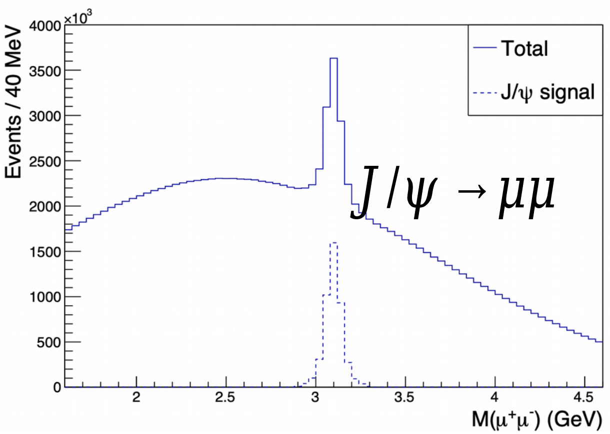


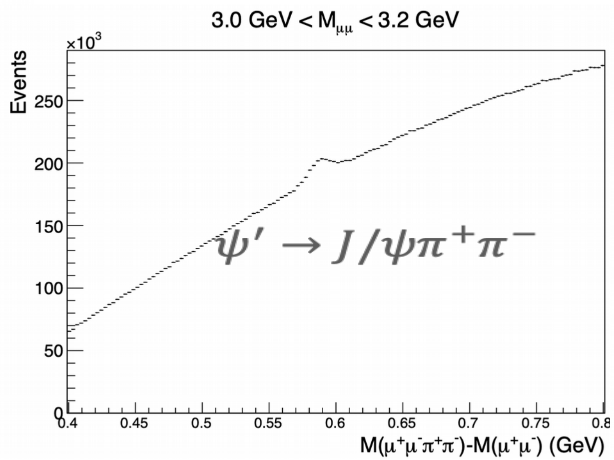
- Bunch crossing every 76 ns → crossing rate 12.5 MHz
- At maximum luminosity of 10^{32} $cm^{-2}s^{-1}$ the interaction rate is 4 MHz
- No hardware trigger to avoid possible biases
- Raw data stream 20 GB/s or 200 PB/year
- Online filter to reduce data by oder of magnitude ~10 PB/year

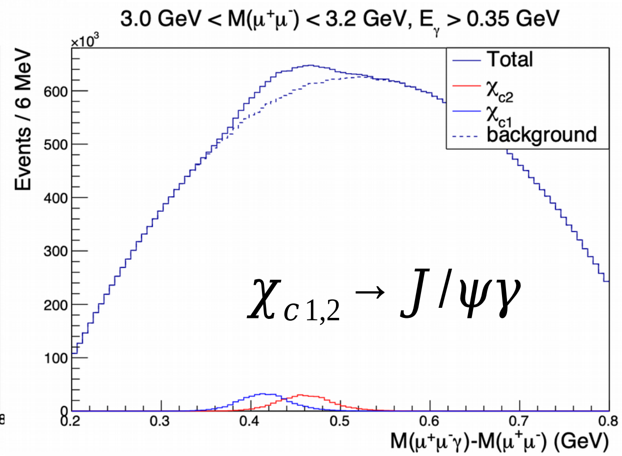


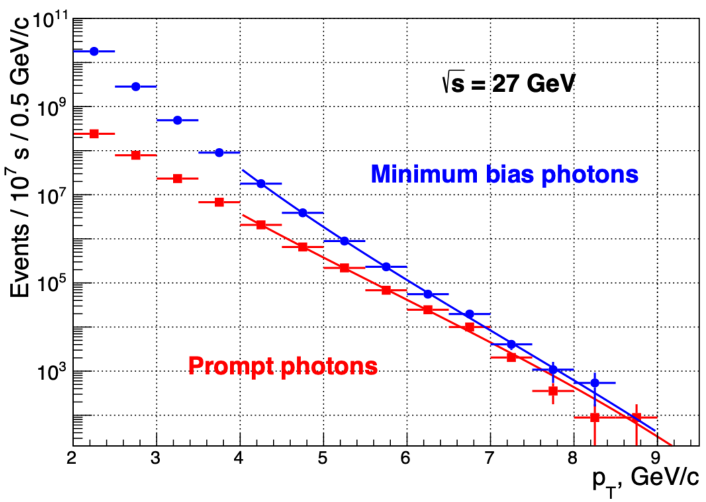
	CPU [cores]	Disk [PB]	Tape [PB]
Online filter	6000	2	none
Offline computing	30000	5	9 per year

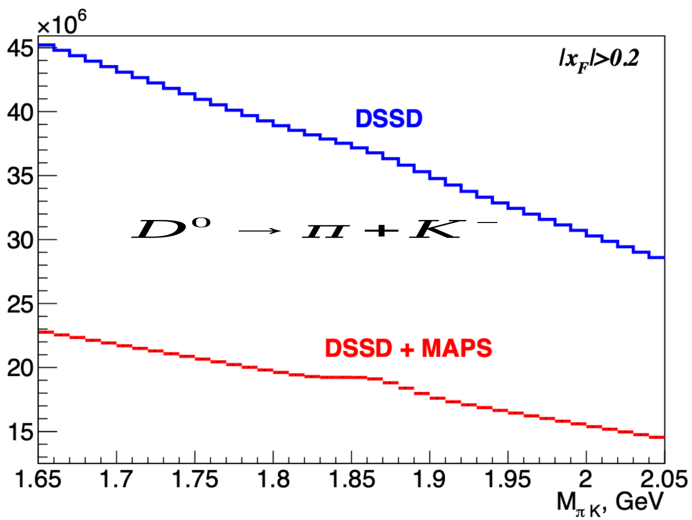
Physics performance for gluonic probes











(1y=10^7s)

Conclusions

SPD (Spin Physics Detector) at the JINR-NICA collider - a multipurpose 4π detector for QCD studies with polarized proton and deuteron beams at $\sqrt{s}$ up to 27 GeV.

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

SPD – unique facility for polarized deuteron collisions

A strong tradition for polarized beams and targets exists at JINR-DUBNA, where unique polarized proton, neutron and deuteron beams are available in the GeV range.

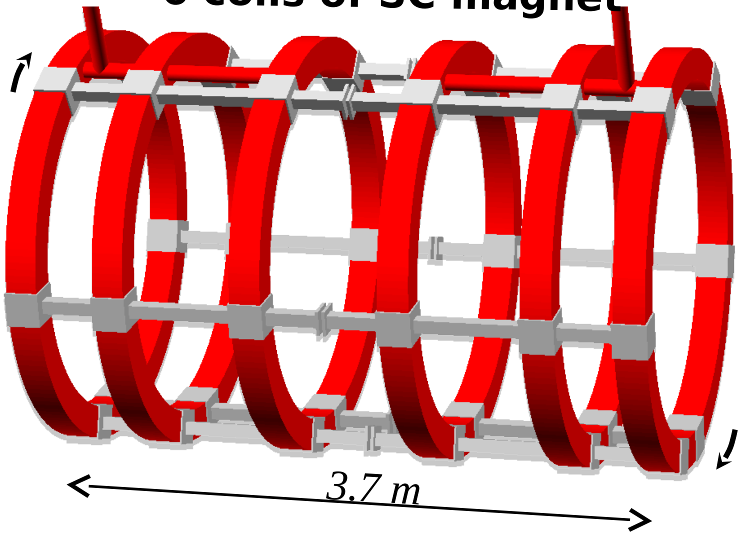
SPD is open for new ideas and collaborators.

Thank you for the attention!

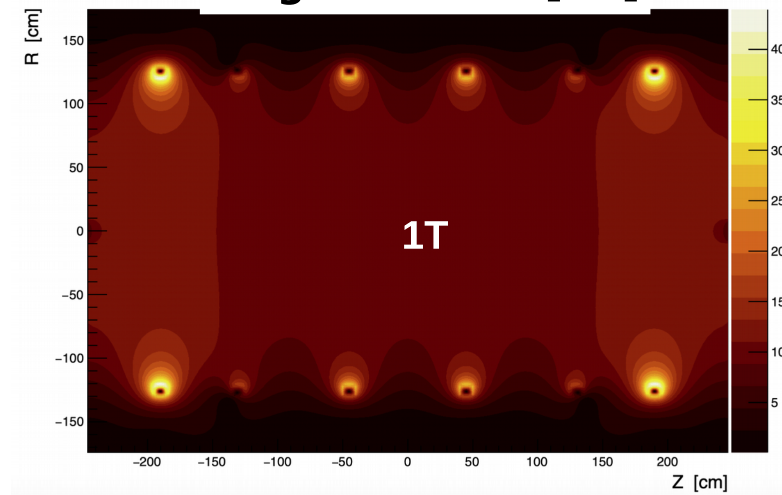
Backup

Superconducting magnetic system of SPD

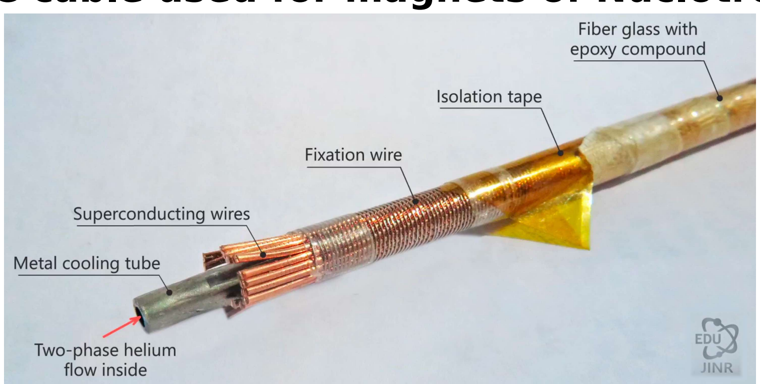
6 coils of SC magnet



Magnetic field [kG]



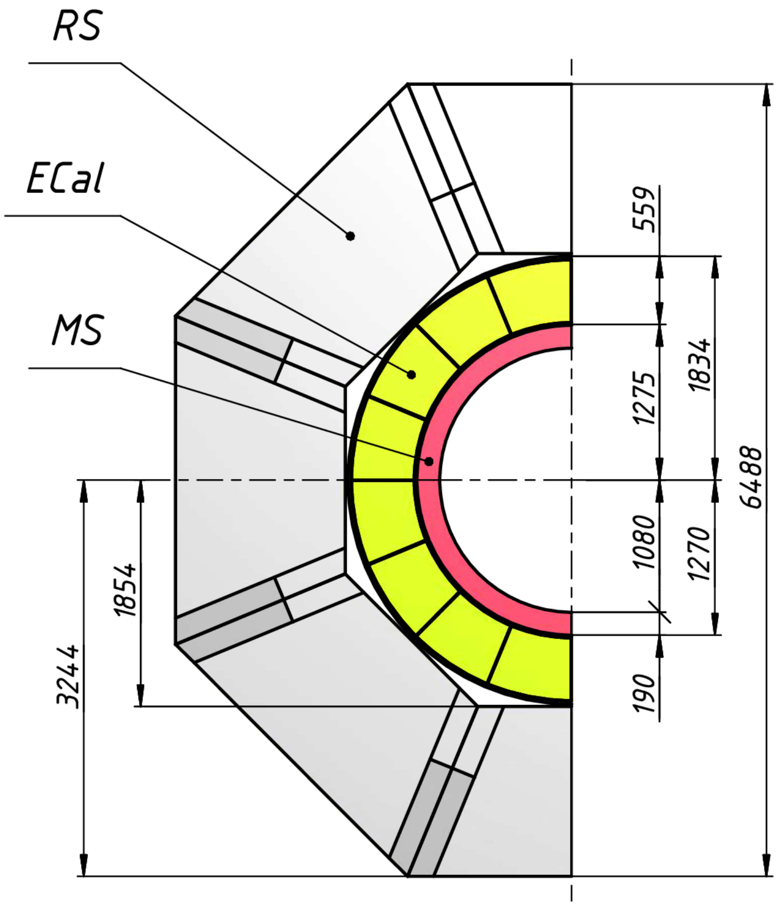
SC cable used for magnets of Nuclotron

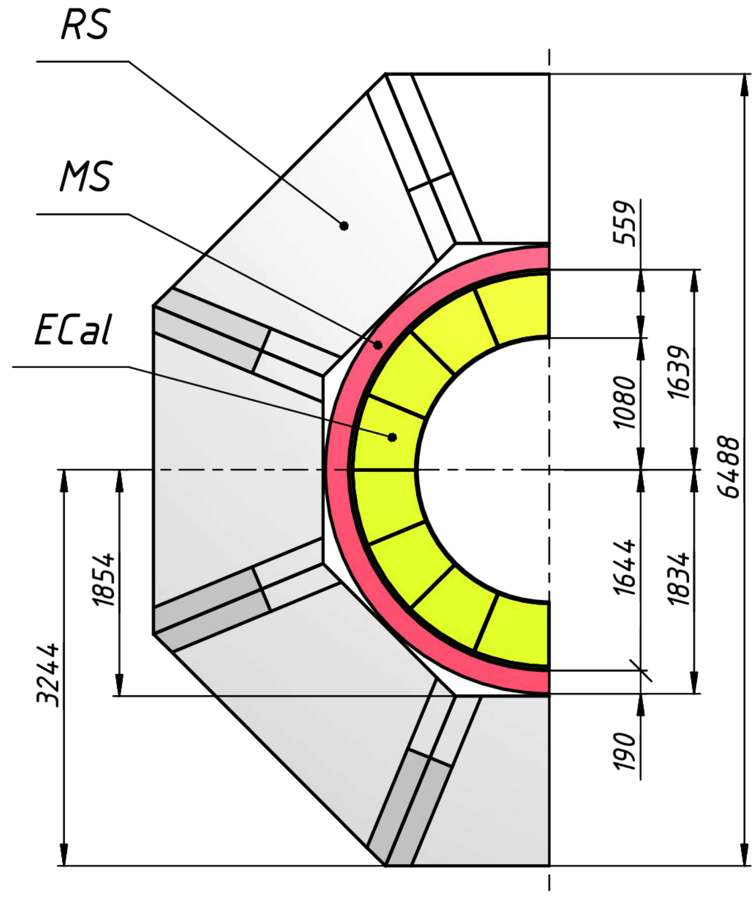


- **6 isolated superconductive coils**
- **Minimization of total amount of material**
- **Every coil consists of 60 turns of NbTi/CuNi cable with the 10 kA current**
- **Total current: 60×10 kA = 600 kA·turn**
- **The same cable as used in Nuclotron magnets: hollow superconductor with the helium flows inside (~4 K)**
- **Similar cryogenic system as the one of Nuclotron**

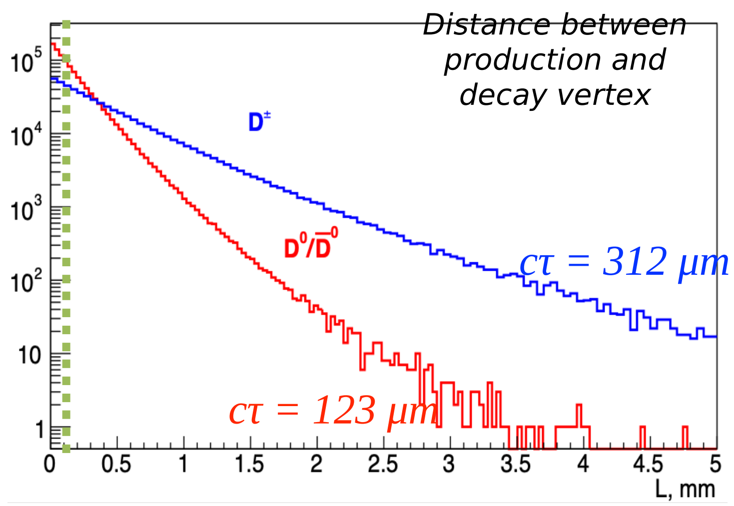
SC magnet system options

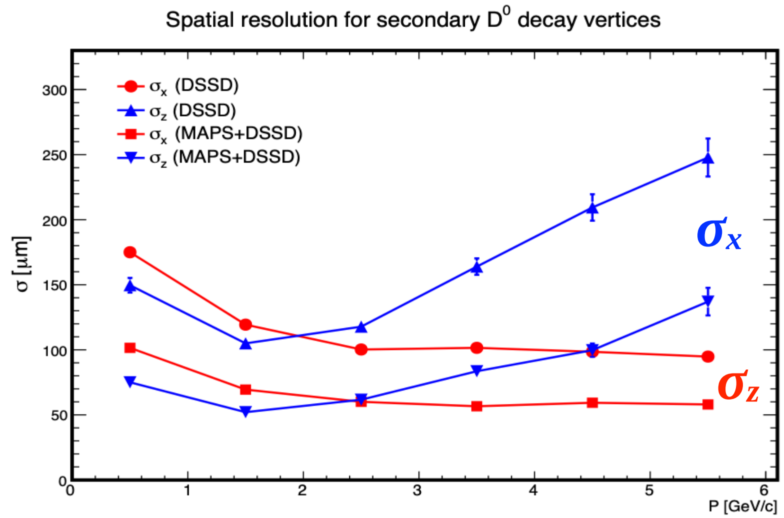
CDR version (**obsolete**) 6 separated coils inside ECa	Option under development A single cryostat with several coils

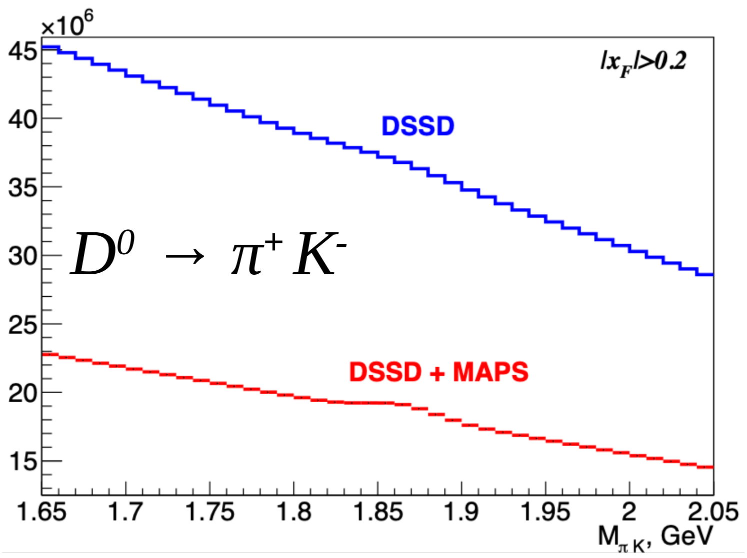


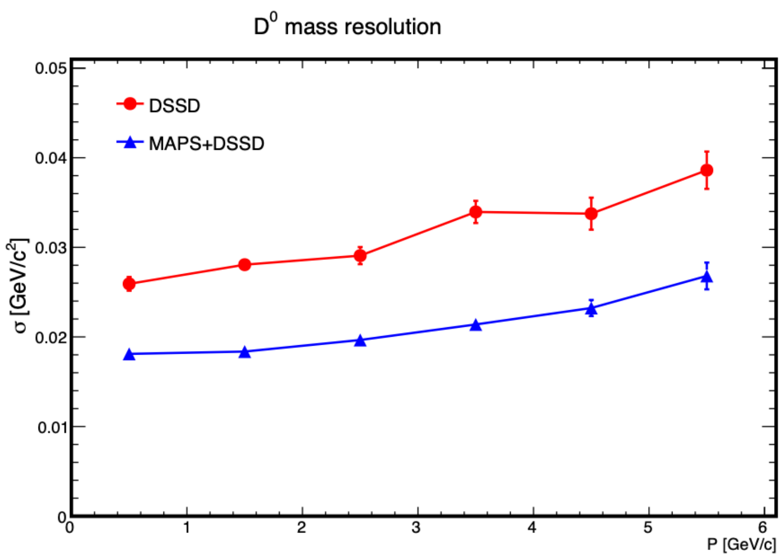


MC study:
DSSD compared to MAPS+DSSD









Polarized beams at the LHEP

- d↑- was accelerated in 1986 (Synchrophasotron); Nuclotron - in 2002. Spin resonance at 5.6 GeV/u. • p↑- was first obtained in 2017. The first test was performed after analysis of the spin resonances.

NUCLOTRON

6 AGeV SC SYNCHROTRON

CIRCUMFERENCE – 250 m

MAGNETIC FIELD – 2 T

THE FIELD RAMP – 1 T/s

ONE-TURN INJECTION

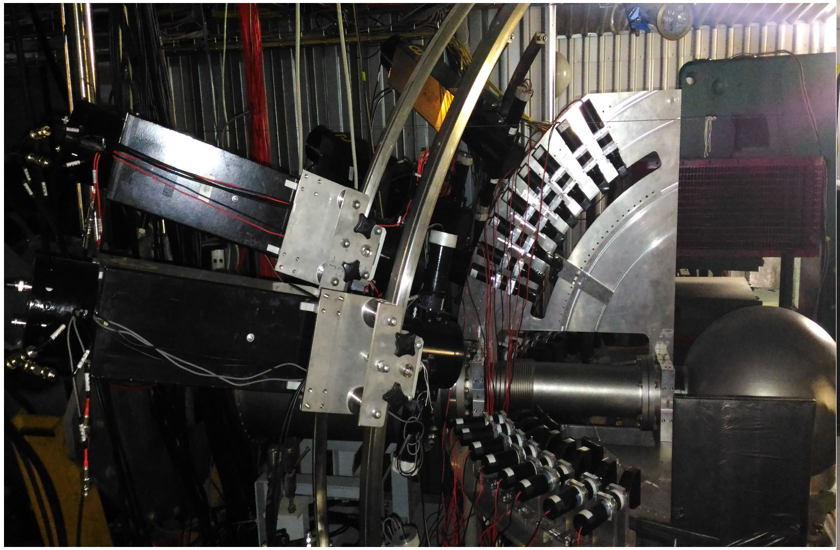
INJECTION ENERGY 5 MeV/u

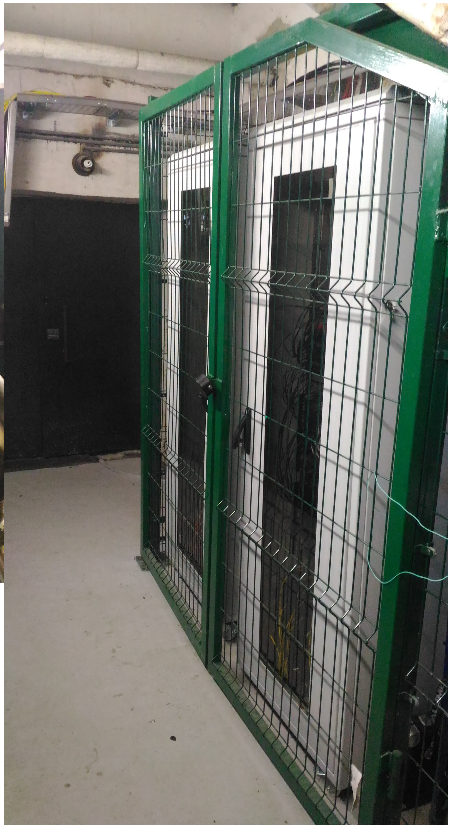
- Ion source SPI was used.

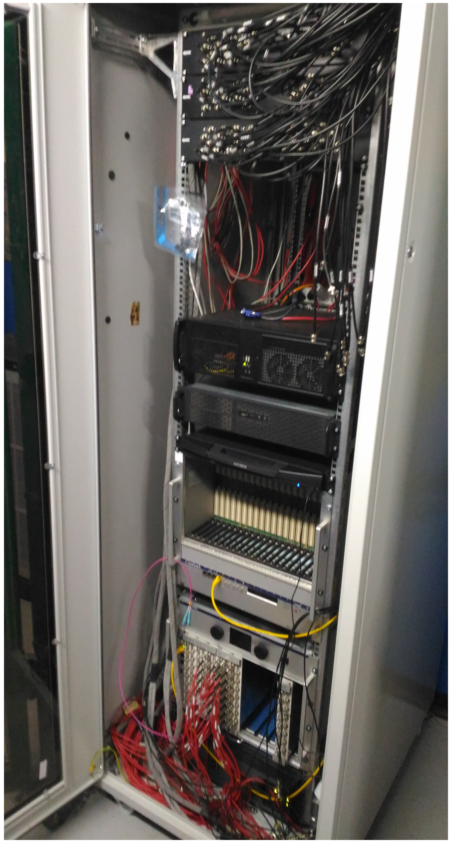
RFQ input–up to 3mA, t≈100 mks;
Particle number - 1.5•10e11 for 8 mks;
The spin modes (p_z,p_{zz}): (0,0), (0,-2), (2/3,0) and (-1/3,+1) were adjusted;
Polarization degree - 70-75 %

The RFQ, put limit for proton energy - 5 MeV at the linac LU-20 output (instead of 20 MeV). The new proton and light ion linac “LILAC” is now manufacturing . The LILAC output energy is 12 MeV.

Upgrade of the Delta-LNS (DSS) setup at ITS at Nuclotron

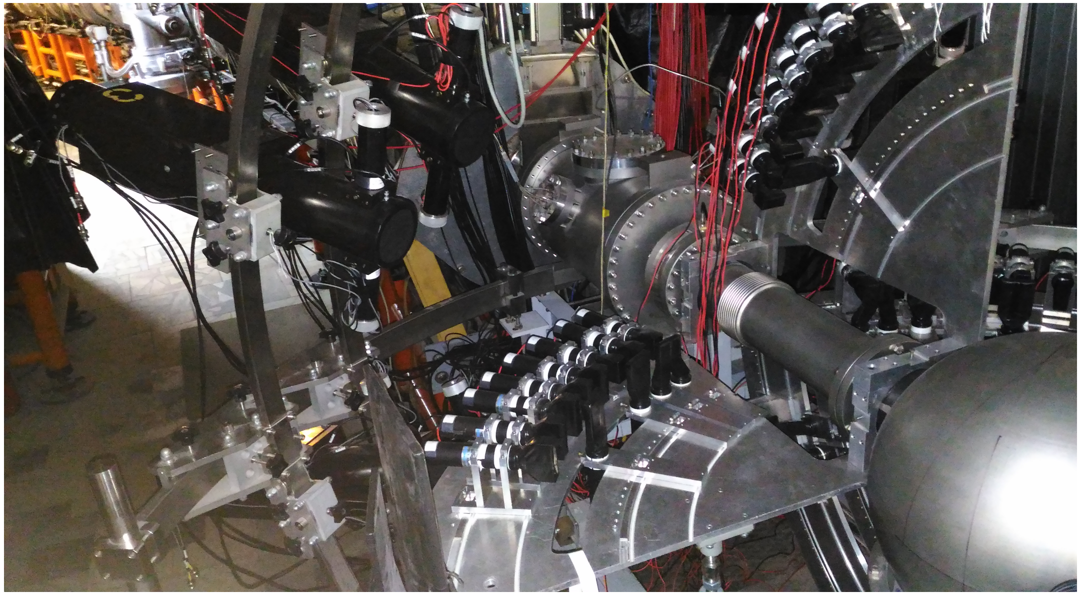






New infrastructure, cabling
New HV system (Mpod)
New VME DAQ
40 counters for dp-elastic scattering studies
8 dE-E detectors for dp -breakup studies

Setup to study dp- elastic scattering at ITS at Nuclotron



- Deuterons and protons in coincidences using scintillation counters
- Internal beam and thin CH_2 target (C for background estimation)
- Permanent polarization measurement at 270 MeV (between each energy).
- Analyzing powers measurement at 400-1800 MeV
- The data were taken for three spin modes of SPI: unpolarized, “2-6” and “3-5” $(p_z,p_{zz}) = (0,0)$, $(1/3,1)$ and $(1/3,-1)$.
- Typical values of the polarization was 70-75% from the ideal values.

Polarized protons at Nuclotron.

Injection of 5 MeV protons into Nuclotron ring.
Acceleration up to 500 MeV- no serious depolarization resonances.

Unpolarized protons: I~$1.5 \cdot 10^8$ ppp
Polarized protons: I~$2\text{-}3 \cdot 10^7$ ppp

IPol=1 P=-1 (WFT 1→3)
IPol=2 P=0 (unpolarized)
IPol=3 P=-1 (WFT 1→3)

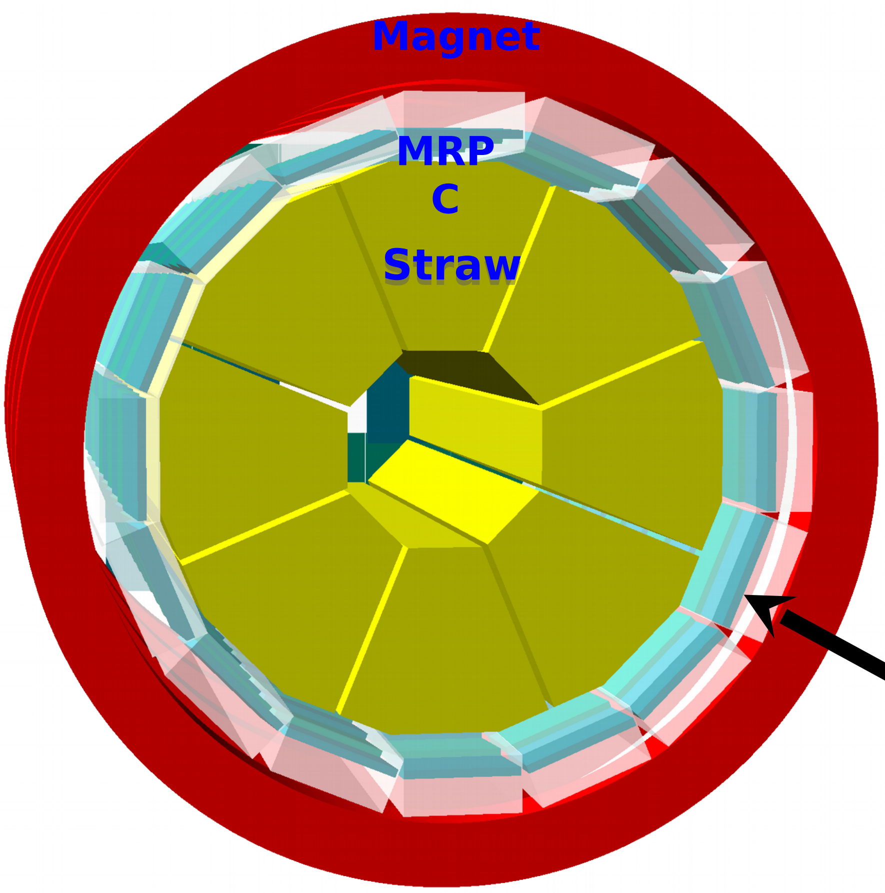
beam 2/3 of time.

Having the asymmetries for 6 angles (55^0-85^0 in the cms) we obtained the averaged value of the proton beam polarization

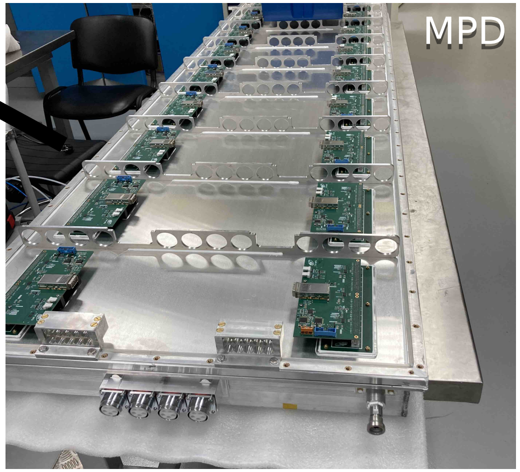
Unpolarized protons: P=+0.056±0.021
Polarized protons: P=+0.367 ±0.015

Need to produce new detection system for protons.

MRPC option for TOF/SPD



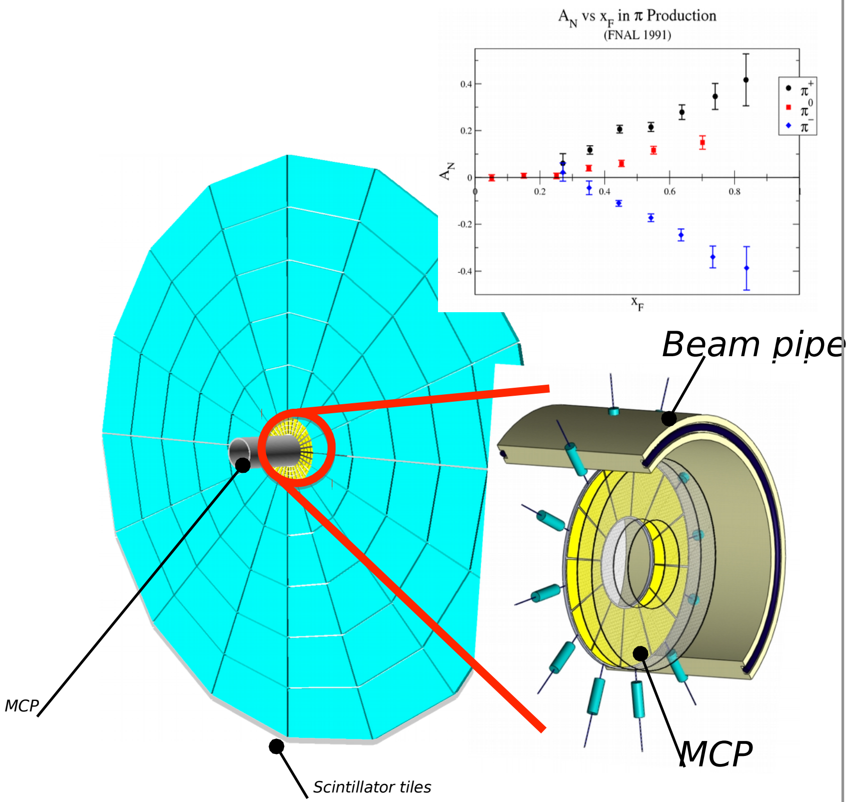
- TOF module of MPD is 17cm thick radially, no space for another PID detector
  - We should consider our own housing
- To be removable, the diameter of the TOF endcap must be smaller than the one of the magnet coil
  - Either large dead regions or conflict with coils
- 3 MRPC chambers were ordered in IHEP Protvino
  - 40 cm × 34 cm in size
  - New customised FEE based on discrete circuit CFD approach (8ch)
  - NINO based FEE ‘a la BM@N’ ~80ch



Local polarimetry and luminosity control

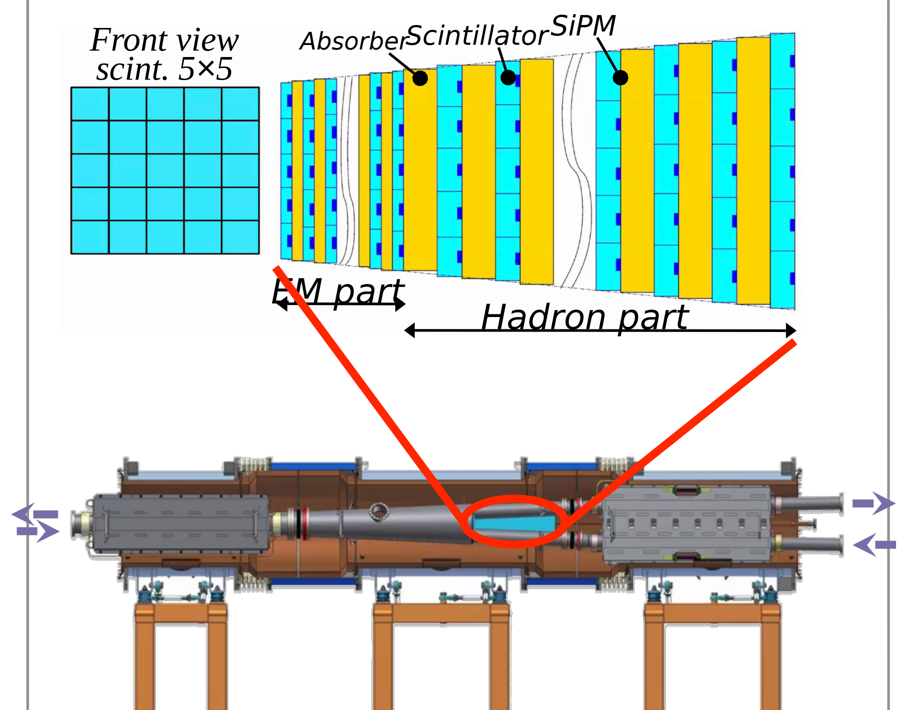
Beam Beam Counter (BBC)

- **BBC consists of inner and outer parts**
- **Inner part: Micro-Channel Plates (MCP) located in the vacuum of the beam pipe. Excellent σ_t**
- **Outer part: plastic scintillator tiles with SiPM readout. Time resolution ~0.5 ns**

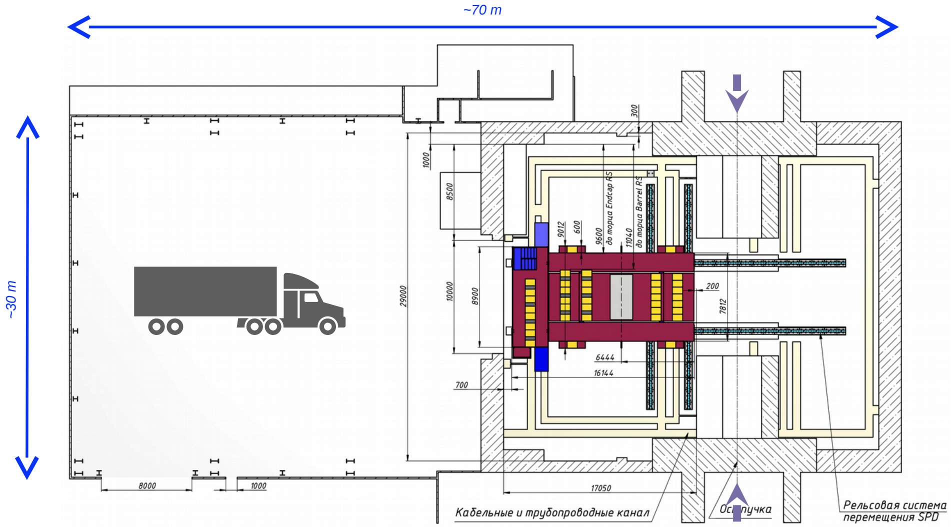


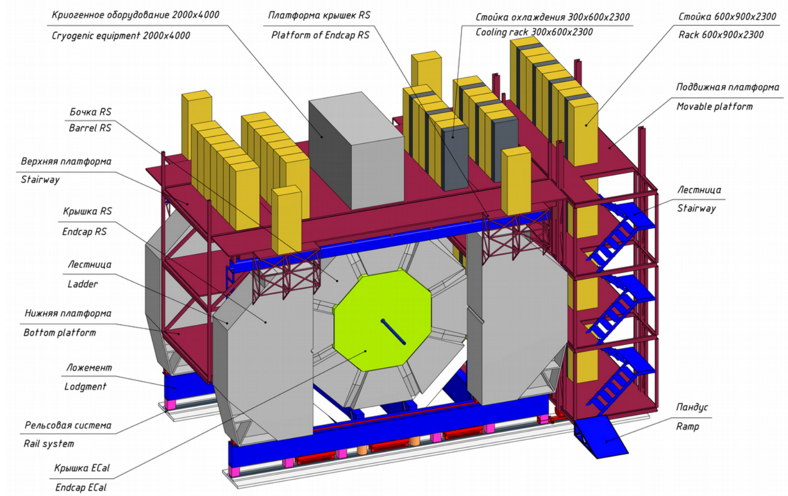
Zero Degree Calorimeter (ZDC)

- **ZDC will be integrated in the cryostat placed between two vertically deflecting magnets, 13m from IP**
- **Sampling calorimeter with fine segmentation, 5x5 matrix**
- **SiPM light readout, about 1000 channels, σ_t = 0.15ns**
- **Readout based on electronics designed for the DANSS neutrino experiment at Kaliniskaya NPP**

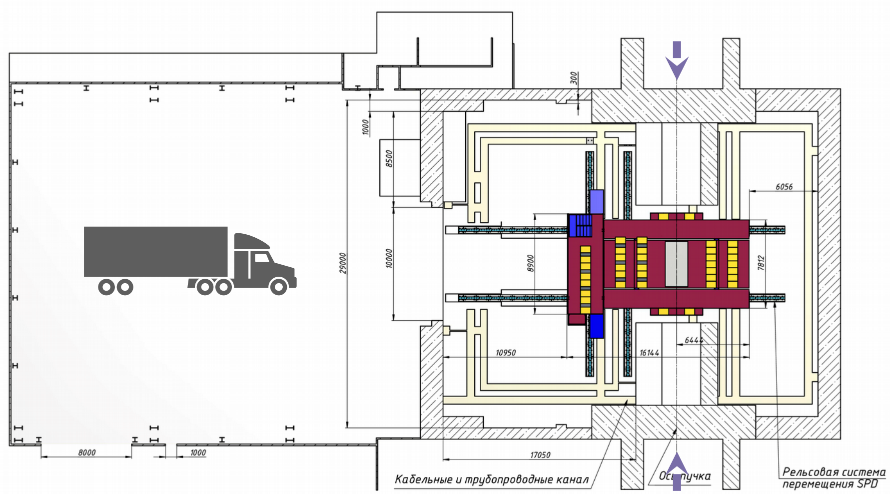


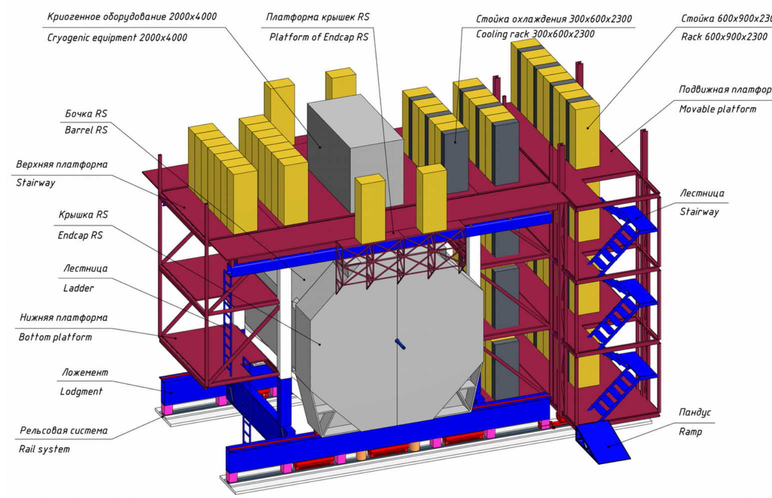
Assembling position



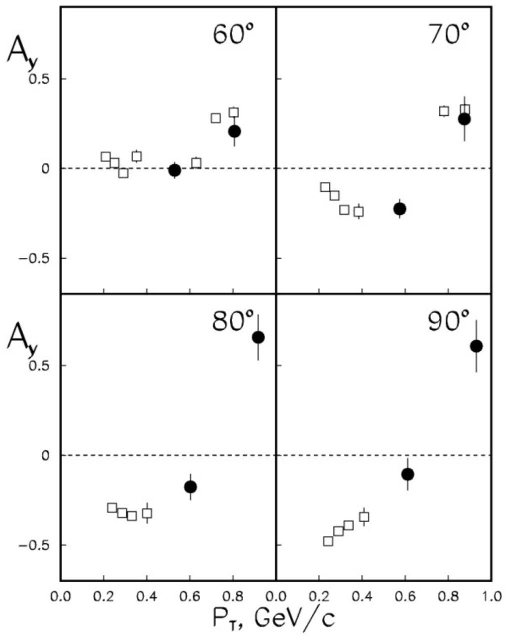


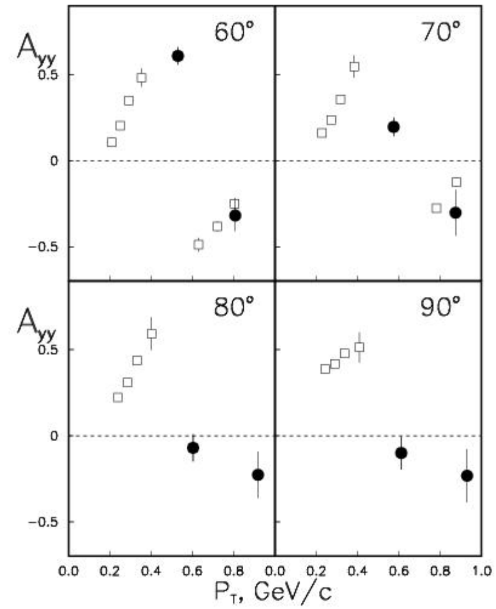
Beam position





Energy dependence of the dp-elastic scattering analyzing powers at fixed scattering angles in the c.m.s.





- **Full symbols are the data obtained at JINR**
- **Open symbols are the data obtained at RIKEN, Saclay and ANL**
- **The study of the energy dependence of the analyzing powers in dp- elastic scattering at large p_T is one of the tools to study spin effects in cold dense matter**

World facilities for gluonic structure

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-$d^\uparrow$	$p^\uparrow$-$p^\uparrow$	$e^\uparrow$-$p^\uparrow$, $d^\uparrow$, $^3\mathrm{He}^\uparrow$	p-$p^\uparrow$, $d^\uparrow$	p-$p^\uparrow$
Center-of-mass energy $\sqrt{s_{NN}}$, GeV	$\leq$27 (p-p) $\leq$13.5 (d-d) $\leq$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

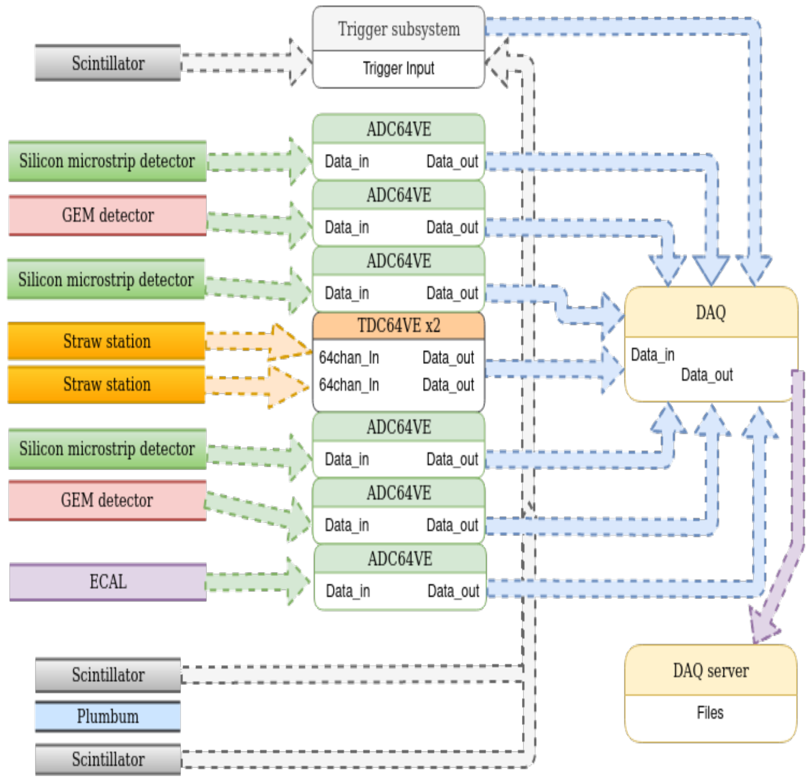
Rates for the main SPD probes

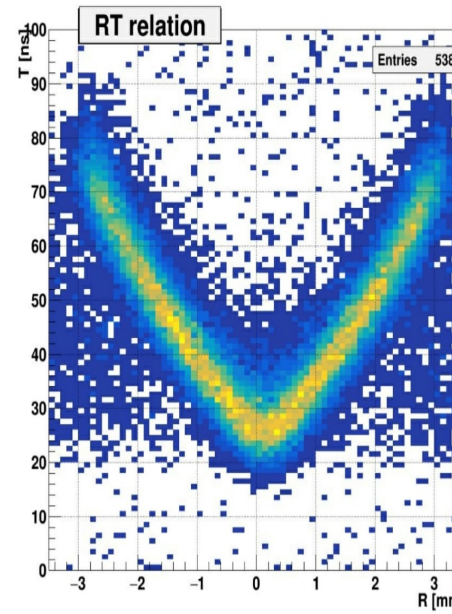
Probe	$\sigma_{27\,\text{GeV}}$, nb ($\times$BF)	$\sigma_{13.5\,\text{GeV}}$, nb ($\times$BF)	$N_{27\,\text{GeV}}$, 10^6	$N_{13.5\,\text{GeV}}$ 10^6
Prompt-γ ($p_T > 3$ GeV/c)	35	2	35	0.2
J/ψ	200	60		
$\rightarrow \mu^+\mu^-$	12	3.6	12	0.36
$\psi(2S)$	25	5		
$\rightarrow J/\psi\pi^+\pi^- \rightarrow \mu^+\mu^-\pi^+\pi^-$	0.5	0.1	0.5	0.01
$\rightarrow \mu^+\mu^-$	0.2	0.04	0.2	0.004
$\chi_{c1} + \chi_{c2}$	200			
$\rightarrow \gamma J/\psi \rightarrow \gamma\mu^+\mu^-$	2.4		2.4	
η_c	400			
$\rightarrow p\bar{p}$	0.6		0.6	
Open charm: $D\overline{D}$ pairs	14000	1300		
Single D-mesons				
$D^+ \rightarrow K^-2\pi^+$ ($D^- \rightarrow K^+2\pi^-$)	520	48	520	4.8
$D^0 \rightarrow K^-\pi^+$ ($\overline{D}^0 \rightarrow K^+\pi^-$)	360	33	360	3.3

MiniSPD cosmic rays test facility

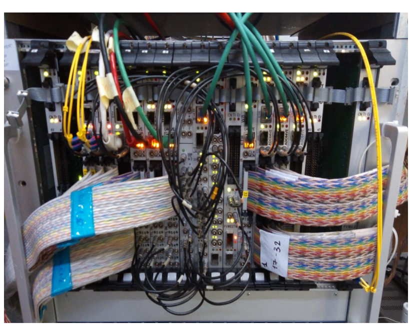
Straw+Vertex+ GEM+ Calorimeter(?)

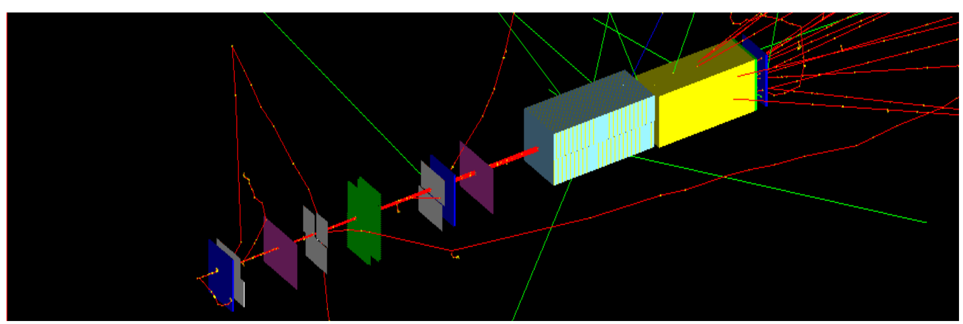
DAQ BM&N and MPD



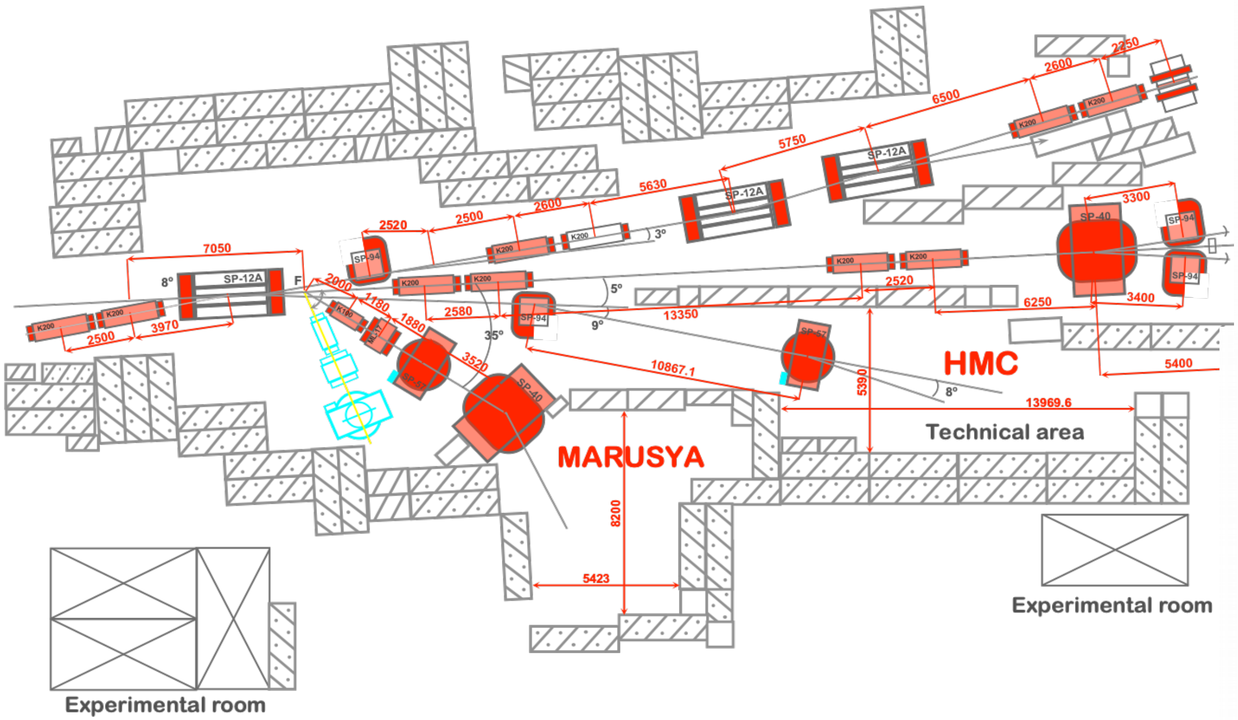


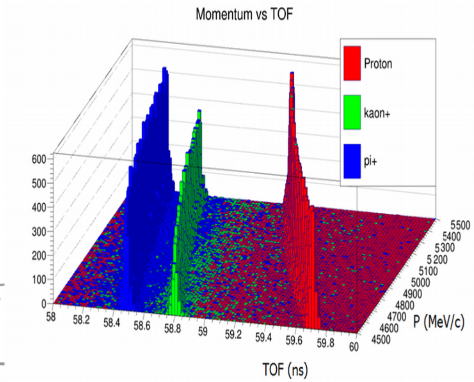
Spatial resolution 180mkm

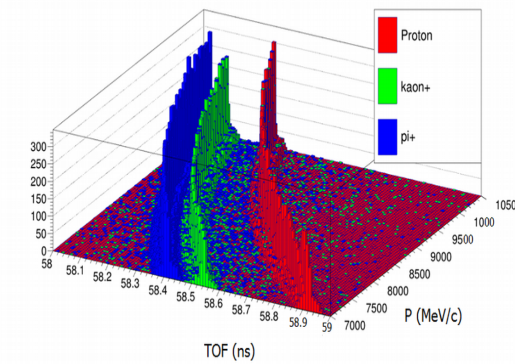




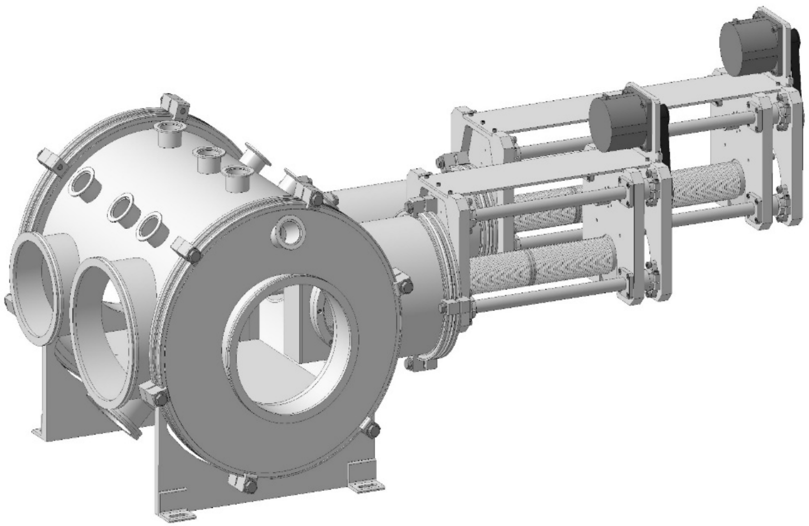
Beam test area of SPD at Nuclotron







Beam test area of SPD at Nuclotron



2 target stations,
2 spectrometers with PID
gas, DAQ, DCS (TANGO, WinCC)

Invite BM@N with their needs and contribution

P, MeV/c	d	p,n	$\pi^{\pm}$	K^{+}	K^{-}	$\mu^{\pm}$	$e^{\pm}$
400	10^3	10^5	10^5	10^3	10^2	10^3	10^3
800	10^3	10^4	10^4	10^3	10^2	10^3	10^3
1500	10^2	10^4	10^4	10^3	10^2	10^2	10^2
2000	10^4	10^5	10^4	10^3	10^2	10^2	10^2
7000	10^4	10^6	10^3	10^3	10^2	10^2	10^2