Status and Perspectives of the NICA Project

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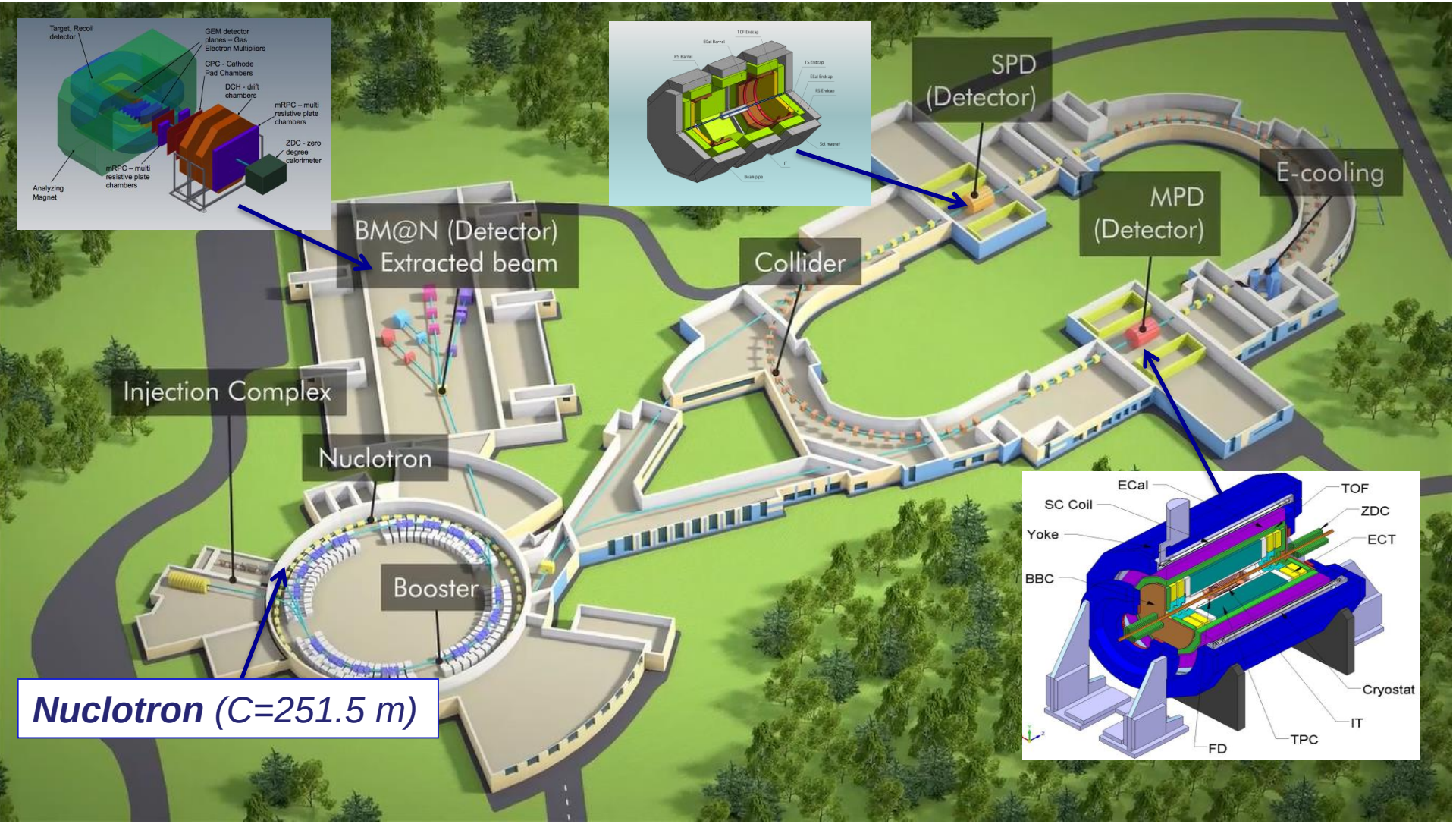
Main targets :

- *study hot and dense baryonic matter at the energy range of max baryonic density*
- *nucleon spin structure, polarization phenomena*

Main targets :

- *development of accelerator facility, construction of collider of relativistic ions (up to Au), polarized protons and deuterons with max energy up to* $\sqrt{S_{NN}}$ *= 11 GeV (*Au^{79+}*) and* $\sqrt{S_{NN}}$ *= 27 GeV (p)*

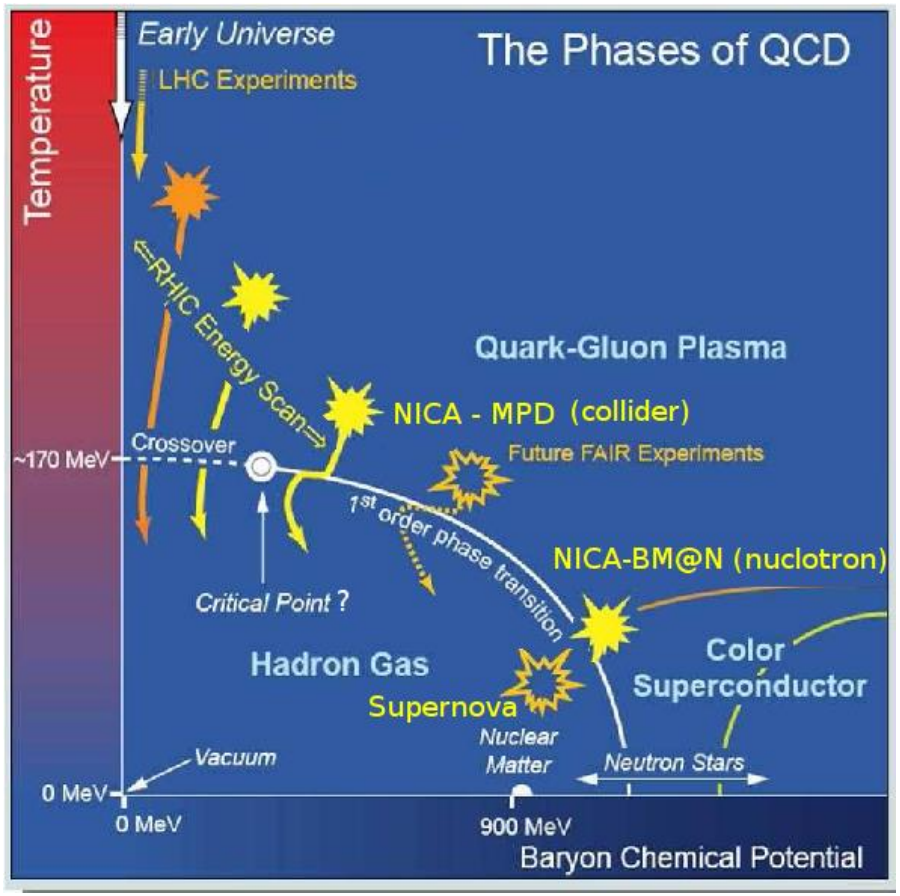
General Scheme the Facility



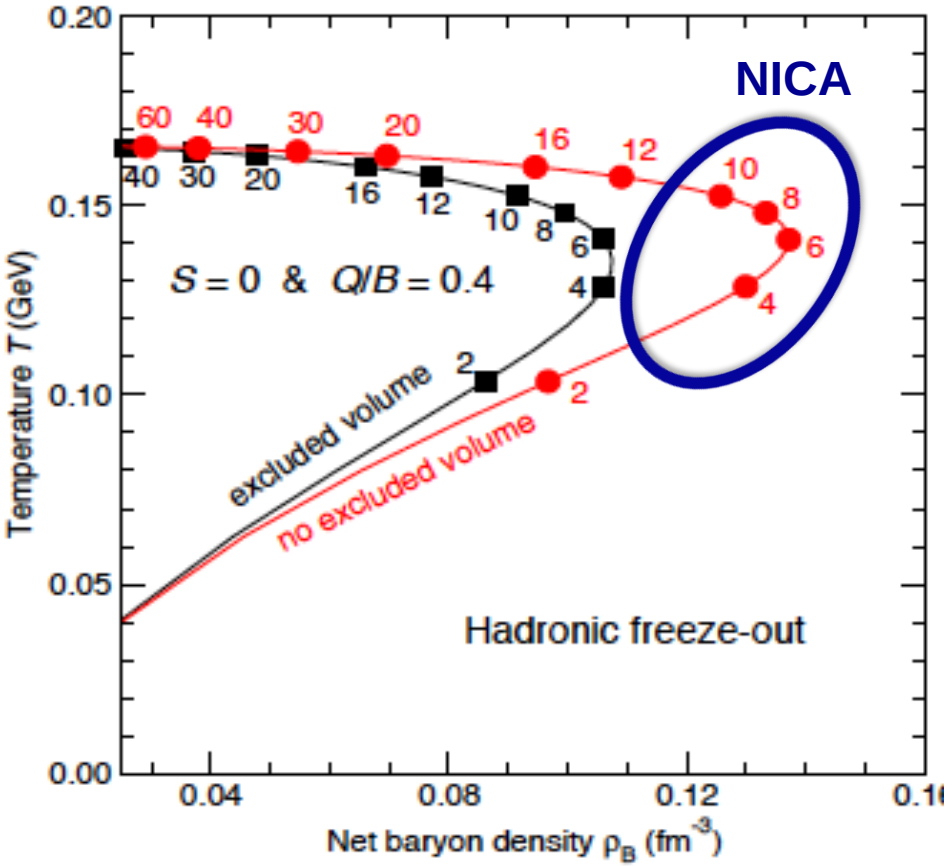
Nuclotron *(C=251.5 m)*

NICA Heavy Ion Research Targets

Exploring high-density baryonic matter: maximum freeze-out density

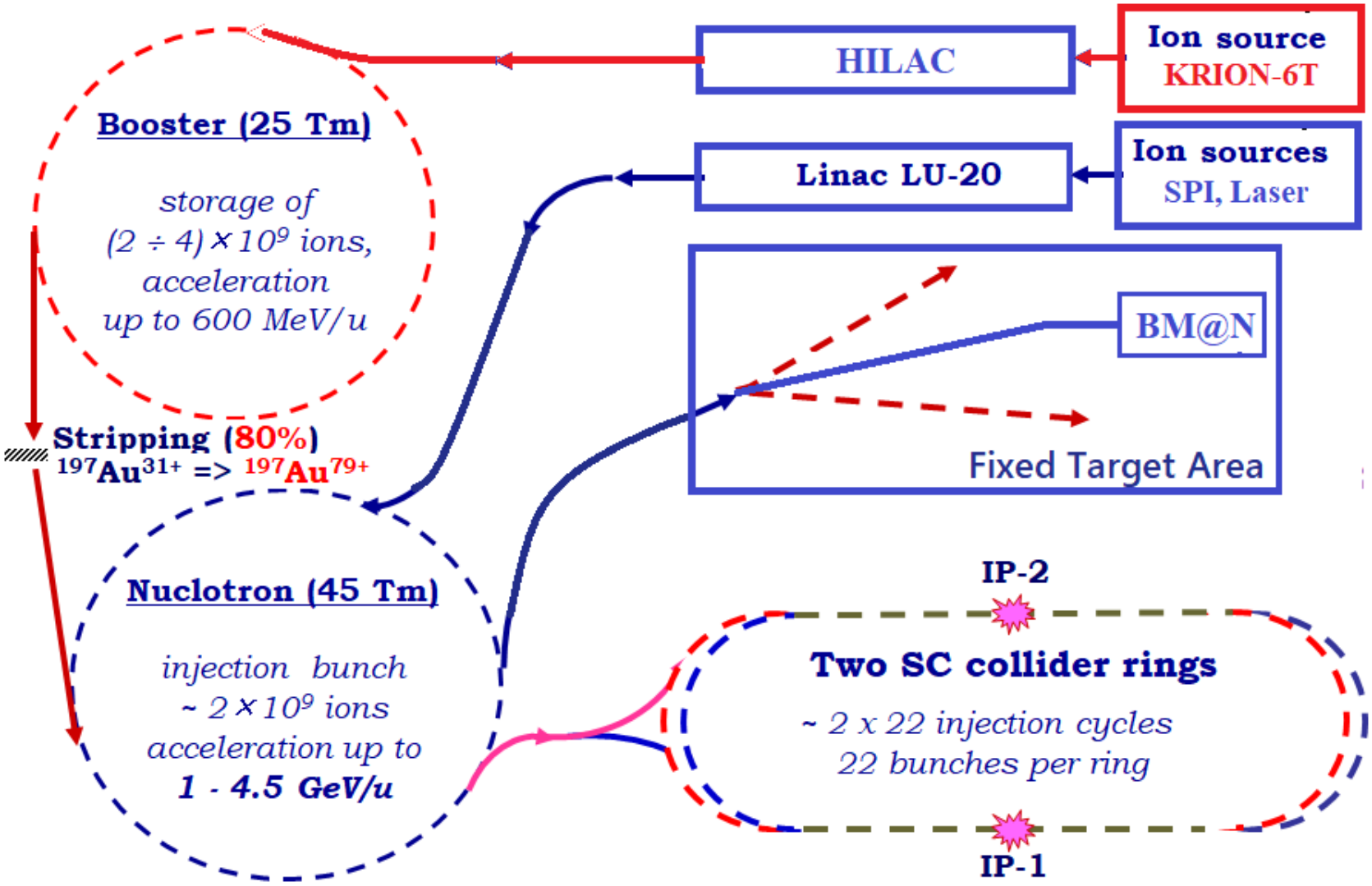


J. Randrup, J. Cleymans; NICA White Paper



NICA is well suited for exploring the transition between the hadronic and q-g phases at the highest baryon density. This is the top priority of the NICA program.

NICA Functional Scheme



Injection Complex: 4 ion sources

Source	KRION-6T	Laser	Douplasmatron	SPI
particles	Au^{31+}	up to Mg^{10+}	p, d, He^{2+}	↑p, ↑d
particle/cycle	~2.5 10^9	~10^{11}	p, d ~5 10^{12} He^{2+} ~10^{11}	5 10^{11}
repetition, Hz	10	0,5	1	0,2

Injection Complex: 2 Linacs

Linac	LU-20	HILAC
structure (section number)	RFQ + Alvarez type	RFQ + IH DTL(2)
*mass to charge ratio **A/Z***	From **1** to **3**	From **1** to **6**
injection energy, keV/amu	150 for A/Z 1-3	17
extraction energy, MeV/amu	**5** (A/Z = 1-3)	**3.24** (A/Z = 6)
input current, mA	up to 20	up to 10

LU-20:new front end (INR,ITEP, MEPHI)

commissioned: May '16

HILAC: "BEVATECH OHG"

commissioned: Oct. '16

Injection Complex: Nuclotron

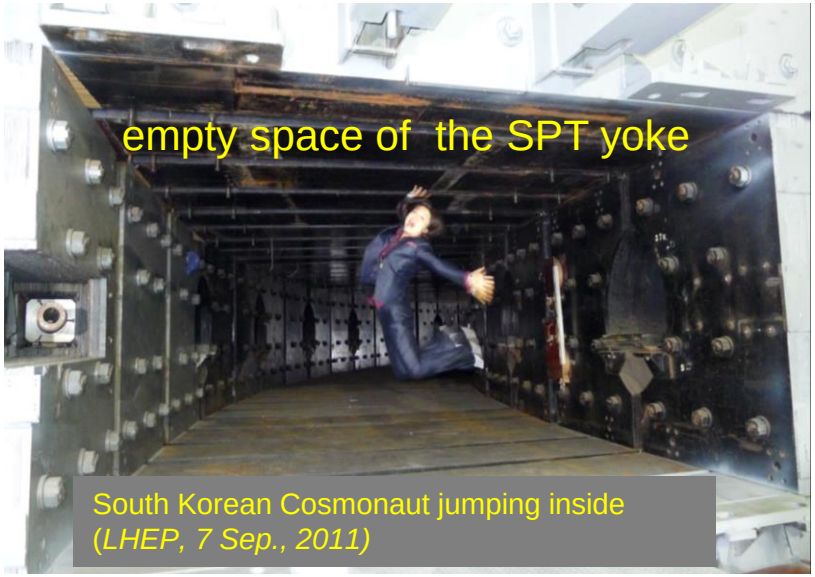
Parameter	**Nuclotron**
type	SC synchrotron
particles	p, d, (p, d polarized), nuclei
injection energy, MeV/u	5 (p, d) / 570-685 (Au)
max. kin. energy, GeV/u	12.1 (p); 5.6 (d); 4.4 (Au)
magnetic rigidity, T m	25 – 43.25
circumference, m	251.52
cycle at collider mode, s	1.5-4.2 (active); **5.0 (total)**
vacuum, Torr	10^{-9}
intensity, ppp: Au/proton.	$1 \cdot 10^{9}$ / $1 \cdot 10^{11}$
transition energy, GeV/u	7.0
RF range, MHz	0.6 -6.9 (p,d) 0.947 – 1.147 (nuclei)
spill at slow extraction, s	up to 10

commissioned: March 1993

modernized 2010-2015

Injection Complex: Booster

Parameter	**Booster**
type	SC-synchrotron
particles	ions A/Z $\leq$ 3
energy, MeV/u: inj. / max.	3.2 / 600
e - cooling energy, MeV	50
magnetic rigidity, T m	1.6 – 25.0
circumference, m	210.96
cycle for collider mode, s	5.0 (total)
vacuum, Pa	10^{-9}
*intensity, **Au** ions/pulse*	1.5 10^{9}
transition energy, GeV/u	3.25
RF range, MHz	0.5 -2.53
spill of slow extraction, s	up to 10

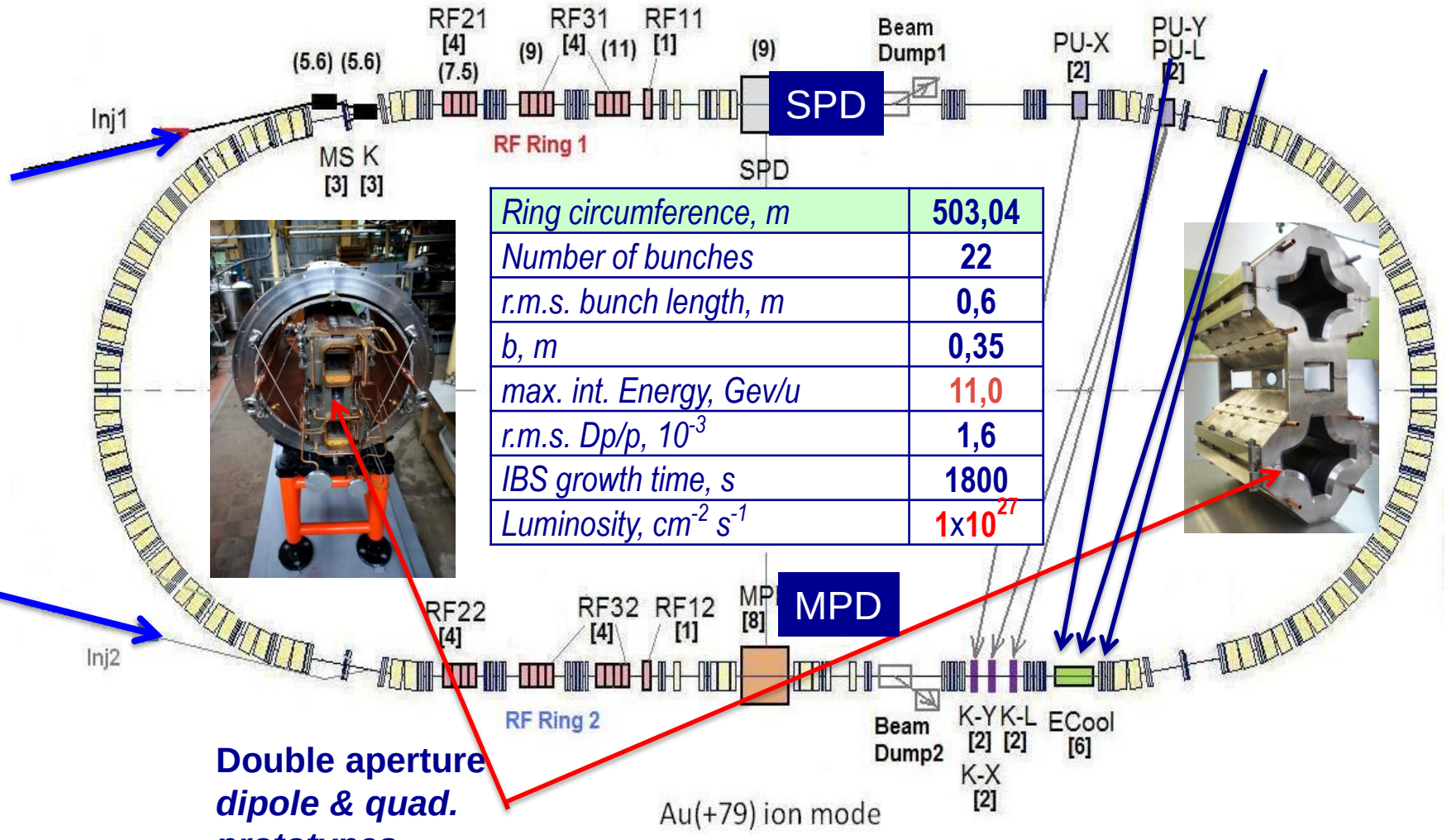


South Korean Cosmonaut jumping inside
(*LHEP, 7 Sep., 2011)*

Commissioning is scheduled for 2018-2019

NICA Collider

45 T*m, *4.5 GeV/u for* ***Au***$^{79+}$



Ring circumference, m	**503,04**
Number of bunches	**22**
r.m.s. bunch length, m	**0,6**
b, m	**0,35**
max. int. Energy, Gev/u	**11,0**
r.m.s. Dp/p, 10^{-3}	**1,6**
IBS growth time, s	**1800**
Luminosity, cm^{-2} s^{-1}	**1×10^{27}**

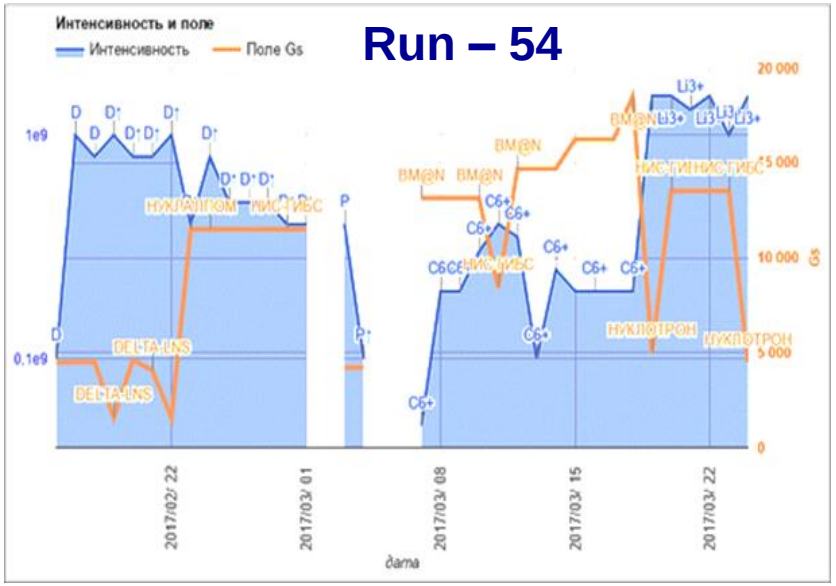
Double aperture dipole & quad. prototypes

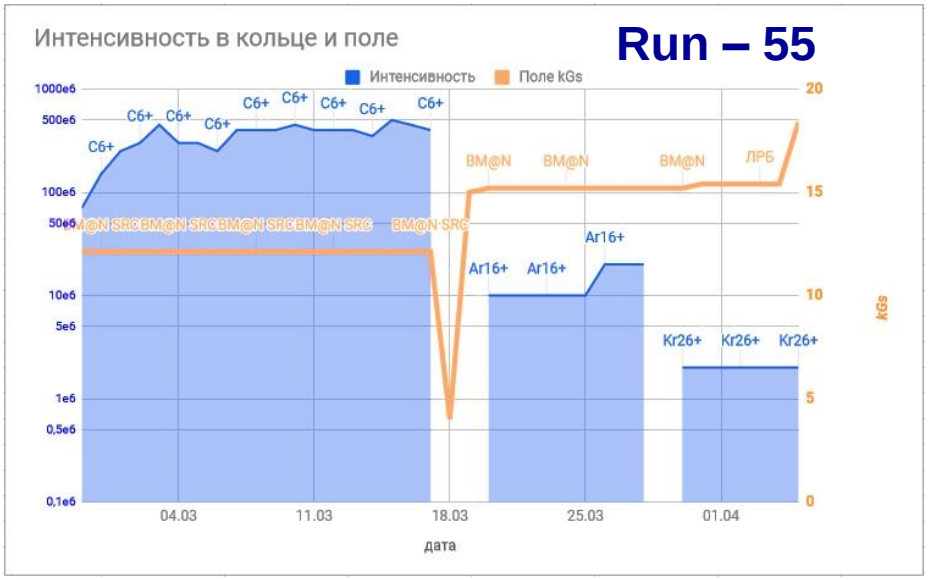
Current Operation of the Nuclotron Facility

Despite of the NICA design and construction, the Nuclotron was running for physics data taking, detectors test and accelerator tasks.

- **Run – 53 (**d⇑, Li) *October – December,* ***2016***
- **Run – 54 (**d⇑,p⇑), C *February – March,* ***2017***
- **Run – 55 (** C**,** Ar**,** Kr,) *February. – April,* ***2018***

Data from the Nuclotron duty book are presented below.





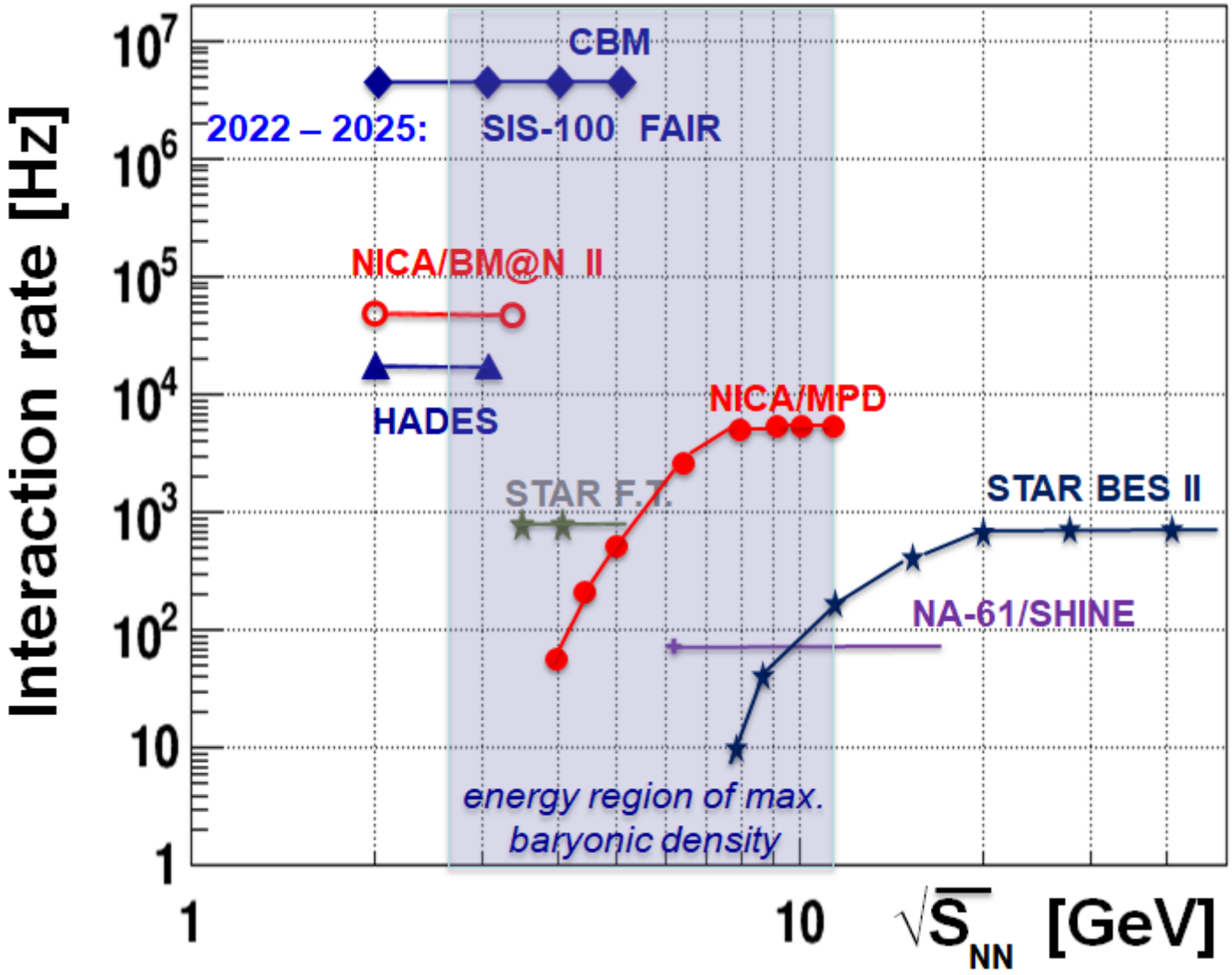
SC Magnet Assembling and Test Facility

Serial tests of Booster magnets close to completion, preparation to serial production of the Collider magnets is in progress. Quadrupole modules for the FAIR SIS100 synchrotron is also task for the facility.

NICA Cryogenic Facility

The cooling power will be doubled from 4 kW to 8 kW @ 4.5K

Physics, Capabilities and Set-ups

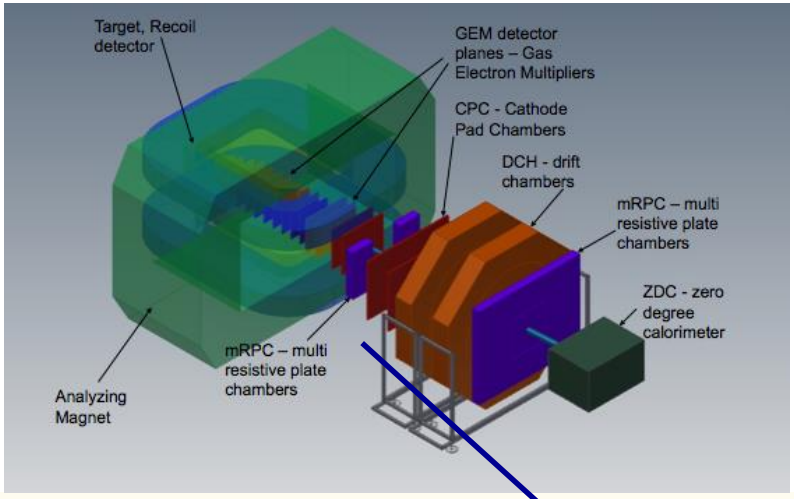


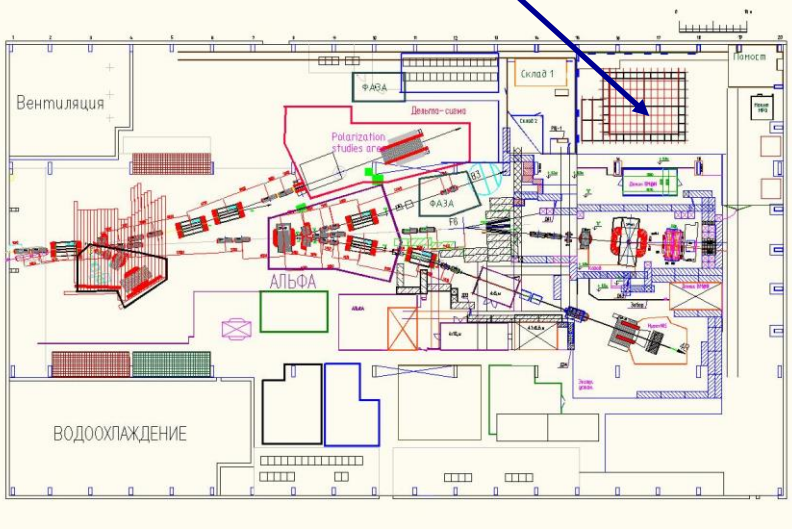
Baryonic Matter at Nuclotron (BM@N)

Physics data taken is started

Physics:

- ✓ *strange / multi-strange hyperon and*
- ✓*hypernuclei production at the threshold*
- ✓ *hadron femtoscopy*
- ✓ *short range correlations*
- ✓ *event-by event fluctuations*
- ✓ *in-medium modifications of strange*
- ✓*& vector mesons in dense nuclear matter*
- ✓ *electro-magnetic - probes, states decaying into γ, e (with ECAL)*





BM@N Collaboration:

Russia: *INR, MEPhi, SINP, MSU,IHEP, S-Ptr Radium Inst.*
Bulgaria: *Plovdiv University;*
China: *Tsinghua University, Beijin;*
Poland: *Warsaw Tech.Uni.*
Israel: *Tel Aviv Uni., Weitzman Inst.*
Germany: *Frankfurt Uni.; eoi GSI*
USA*: MIT*

BM@N operation plan

year	2016	2017 Feb.-Mar.	2017 Nov.-Dec.	2019	2020 + ..
beam	d (↑)	C, Ar	Kr	Au	Au, p
maximum intensity, Hz	1M	1M	1M	1M	10M
trig. rate, Hz	10k	10k	20k	20k	50k
central tracker	6 GEM half pl.	8 GEM half pl.	10 GEM half pl.	8 GEM full pl.	12 GEM or 8+2Si
expiment status	techn. run	techn. run	physics run	physics stage 1	physics stage 2

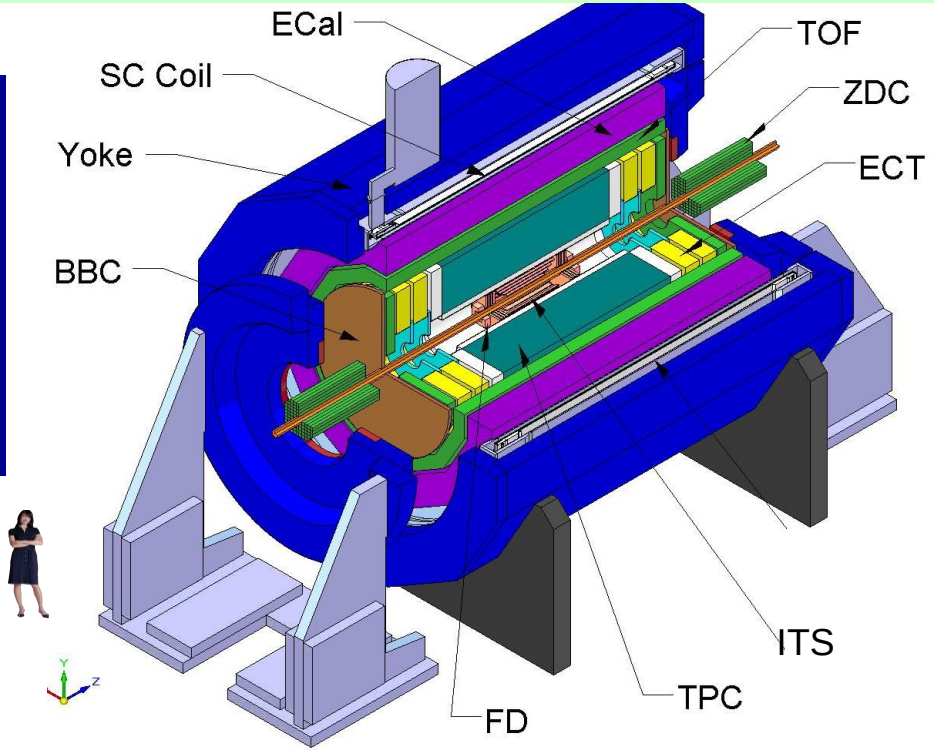
Was performed in Feb.- April 2018

beam: E_{kin} = 3.5, 4.0, 4.5 AGeV

MPD- Multi Purpose Detector at the Collider

Main target:

- study of hot and dense baryonic matter at the energy range of max net baryonic density



expression of interest:

- *CERN;*
- *DF, US, Mexico;*
- *ICN UNA; Mexico;*
- *DF, CIEA del I.P.N, Mexico;*
- *FCF-M UAS, Sinaloa, Mexico;*
- *FCF-MB UAP, Puebla, Mexico;*
- *PI Az.AS, Baku, Azerbaijan;*
- *ITEP, NC KI, Moscow, Russia;*
- *PNPI NC KI, Saint Petersburg, Russia;*
- *CPPT USTC, Hefei, China;*
- *SS, HU, Huzhou, Republic of South Africa.*

MPD Collaboration:

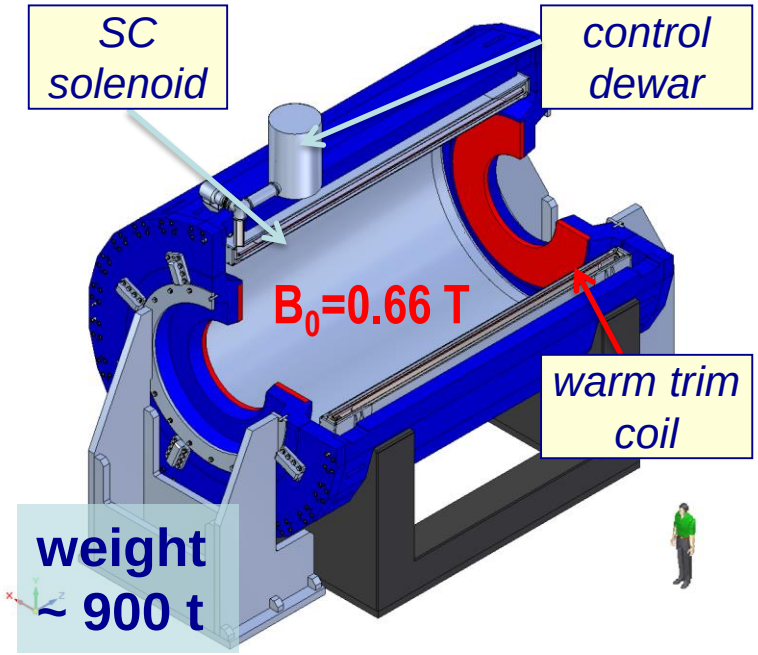
- *JINR, Dubna;*
- *Tsinghua University, Beijing, China;*
- *MEPhI, Moscow, Russia.*
- *INR, RAS, Moscow, Russia;*
- *PPC BSU, Minsk, Belarus;*
- *WUT, Warsaw, Poland;*

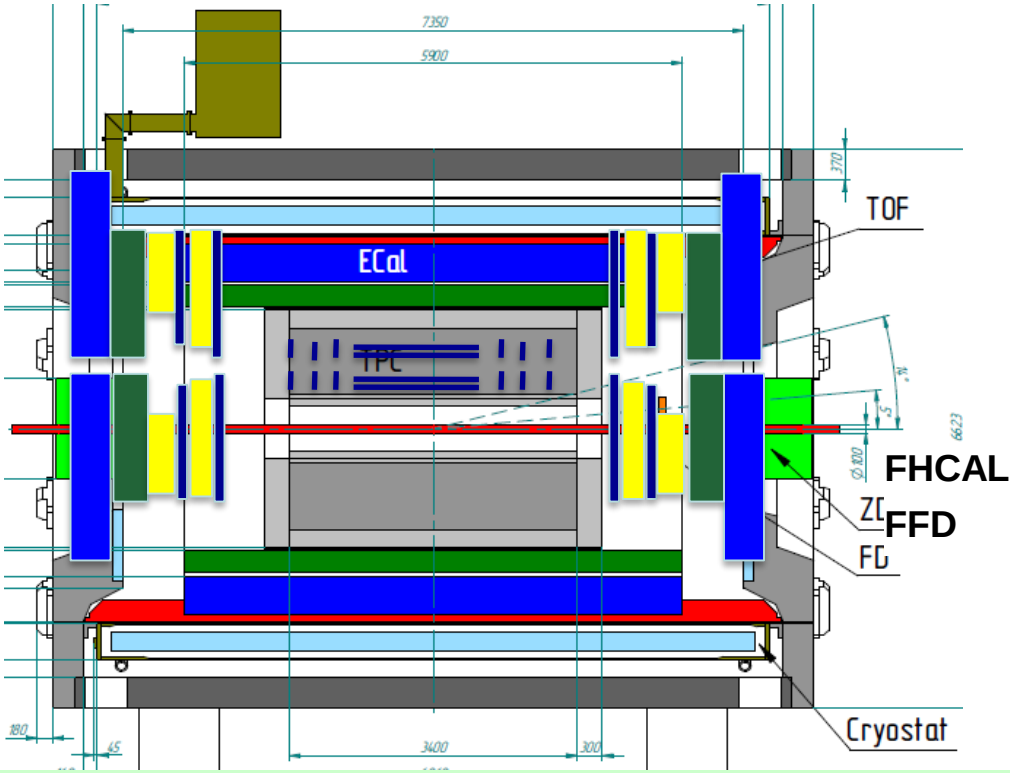
MPD - Multi Purpose Detector

Tracking: up to |η|<1.8 (TPC)
PID: hadrons, e, γ (TOF, TPC, ECAL)
Event characterization:
centrality & event plane (FHCAL)

Stage 1: **TPC, TOF, ECAL, FHCAL, FFD**

Stage 2: **ITs + Endcaps (tracker, TOF, ECAL)**





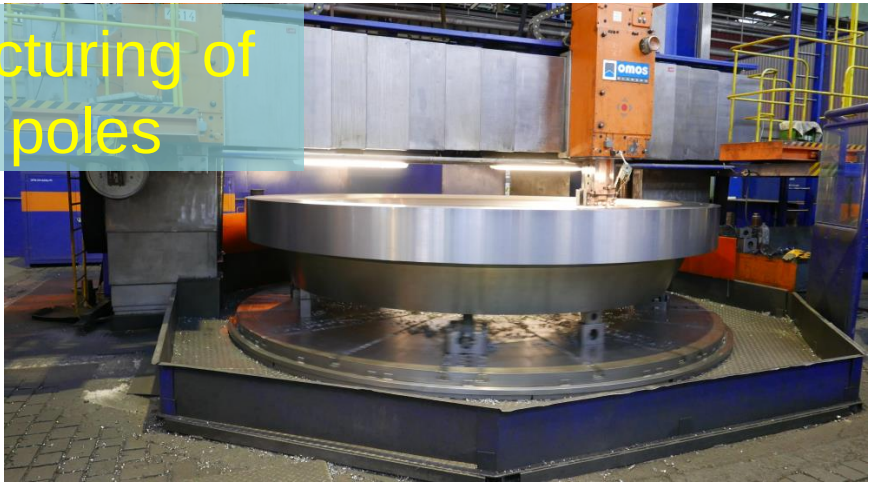
General contractor:
ASG Superconductors,
Genova, Italy

Status: *technical design – completed / close to completion; preparation for the mass production*

MPD – manufacturing stages (1)

2 Poles: Ø 4.5 m,
47 tons each

Manufacturing of
the end poles

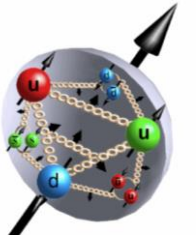


MPD – manufacturing stages (2)

Cradles are in progress: 1.47x4.15x7.68, m; 34 tons in total

MPD/SPD Equipment for the halls

Polarized Beams & Spin Research



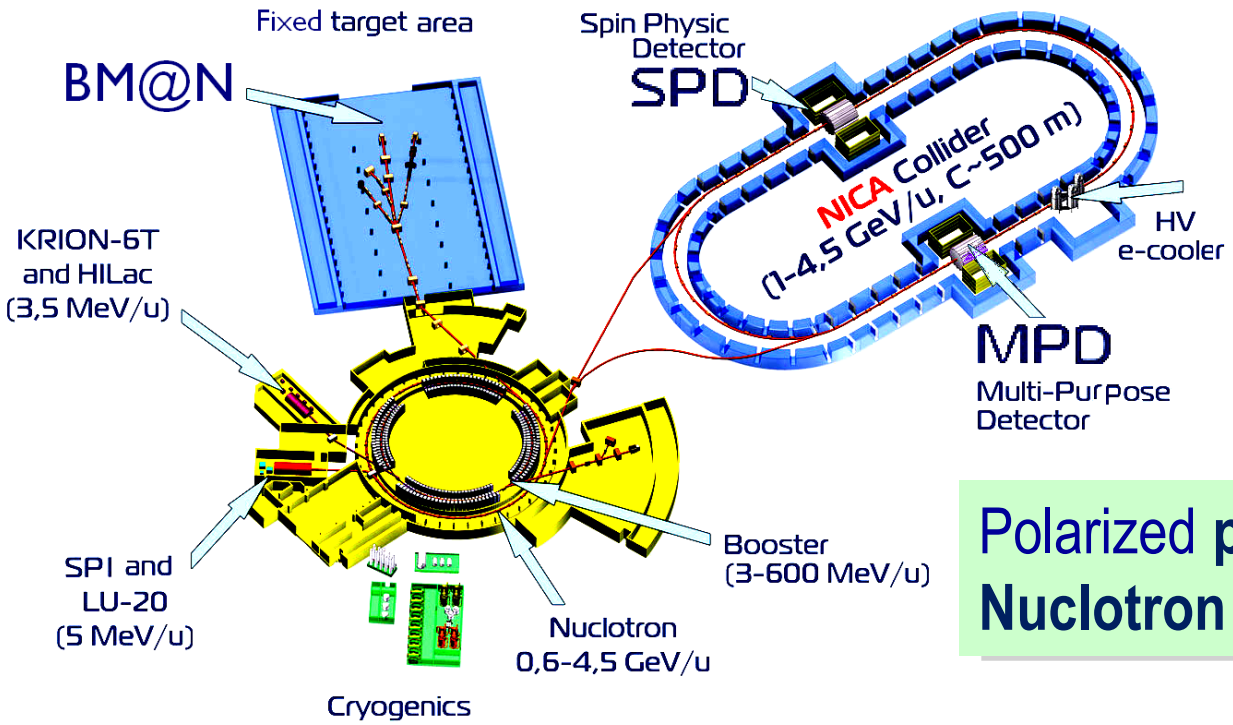
General remarks:

- Polarized deuteron and proton beams are available at our facility.
- Number of particles per pulse of 5e10 is attainable.
- “SPI”- polarized source can be easily connected to the linac.
- Important test was performed – injection of 5 MeV polarized proton beam into the Nuclotron, RF-capture and acceleration.

9 reports are presented at SPIN2018 connected with collaborative projects at Nuclotron beams and NICA design and development: V.Ladygin, N.Piskunov, V.Fimushkin, M.Kulikov, R.Tsenov, O.Teryaev, A.Kovalenko

NICA in Polarized Proton @ Deuteron Mode

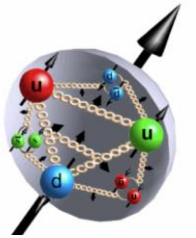
Polarized **dd**: SPI→ LU-20M → Nuclotron → **Collider**



Polarized **pp: SPI→ LU-20M → Nuclotron → Collider**

Polarized pd – collisions: both injection lines are needed

SPD – Current status



- SPD Project is in preparation.
- Renewed WG (leader Prof. R.Tsenov) was approved by the JINR Director.

- Presentation: “The SPD project for spin studies at the NICA accelerator complex” at SPIN2018 is scheduled for Wednesday, session A8 (16.40 – 18.40).

Civil Construction

Concluding Remarks

- NICA recognized as a part of European research infrastruct.
- NICA has a status of *mega-project* at RF level.
- The construction of BM@N, MPD and accelerator systems is going close to the schedule.
- SPD at the stage of the project preparation.
- Spin physics research program at fixed target is going.
- Spin physics proposed as a part of the JINR strategic plan.

- NICA is open for new participants.

Thank you for your attention!