Status of NICA project

V. Kekelidze,

Joint Institute for Nuclear Research (JINR)

NICA days in Warsaw

October 21, 2019, Warsaw

Joint Institute for Nuclear Research today

18 Member States *(incl. **5** from **EU**)*:

Azerbaijan
Armenia
Belarus
Bulgaria
Cuba
Czech Republic
Vietnam
Georgia
Kazakhstan
DPRK
Moldova
Mongolia
Poland
Russia
Romania
Slovakia
Uzbekistan
Ukraine

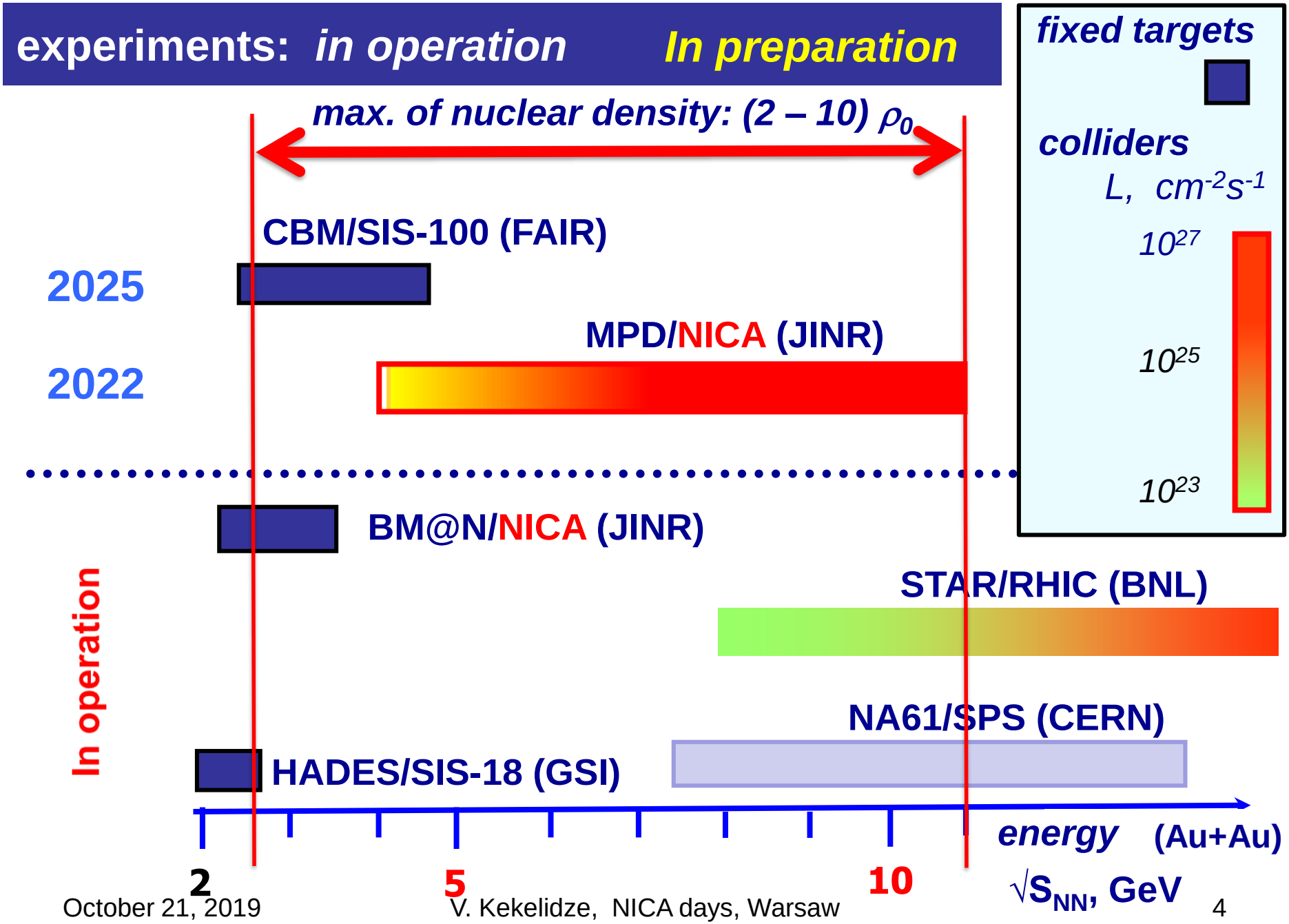
6 Associate Members (*incl. **3** from **EU):***
Hungary, Germany, Egypt, Italy, Serbia, RSA

Main goals:

- to study hot and dense nuclear matter:
  - *how quarks are clustering hadrons (protons, neutrons tec.)?*
  - *whether there is a first-order phase transition ?*
  - *whether there is a critical end-point?*
- to study nucleon spin structure:
  - *how the spin of proton / neutron is composed?*
- to provide infrastructure for applied researches

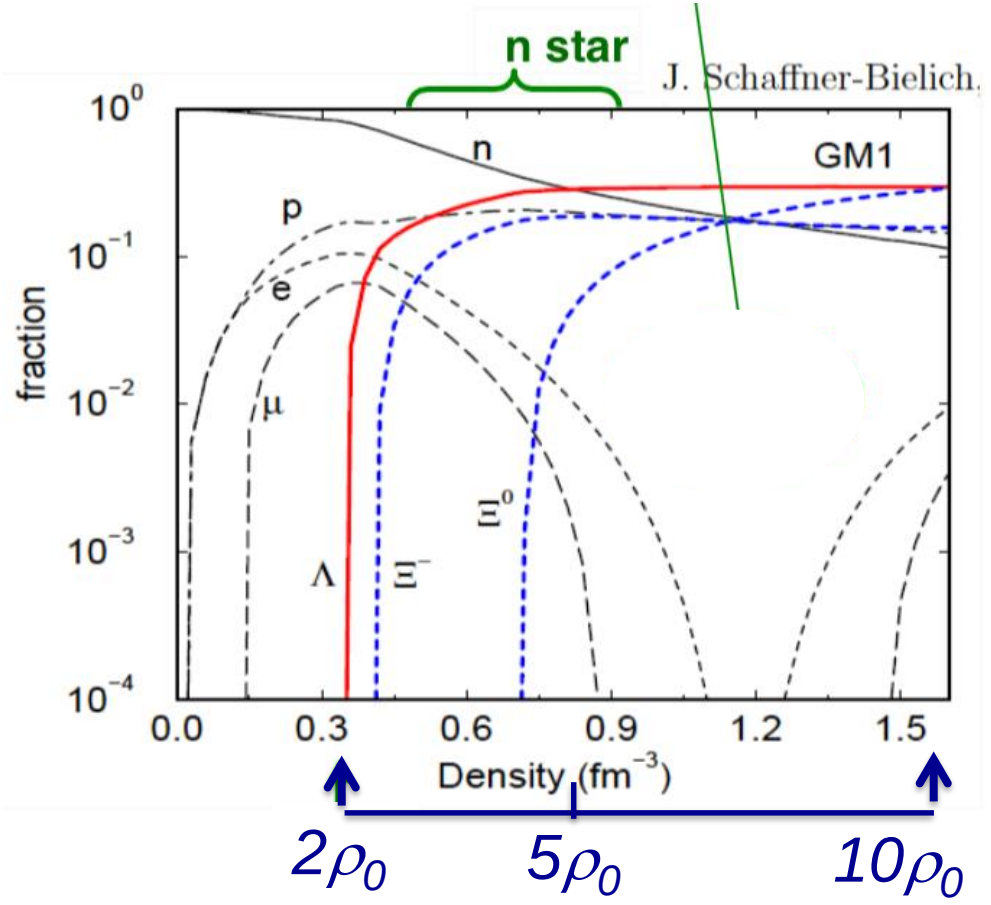
- *essential upgrade of existing accelerator complex*
- *construction of **Collider** to provide collisions of*
  - *ion species from **p** to **Au** at energy range $\sqrt{S_{NN}}$= **4** - **11** GeV*
  - *polarized **p** u **d** up to energy $\sqrt{S}$ =**27** GeV (p)*
- *construction of **3** detectors: **Baryonic Matter @ Nuclotron (BM@N)**,*

  Multi Purpose Detector (MPD)** and **Spin Physics Detector (SPD)

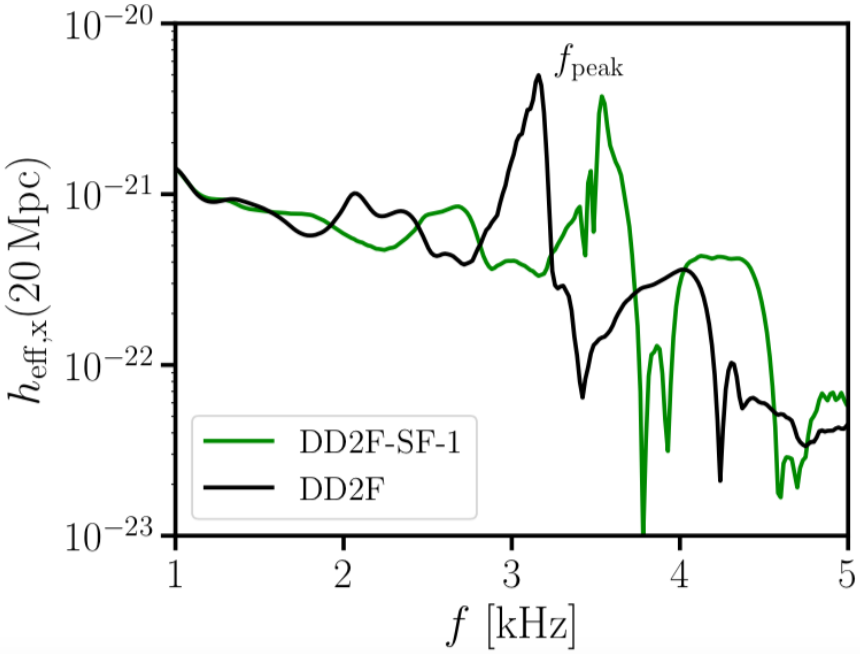

experiments: in operation
In preparation
max. of nuclear density: (2 – 10) ρ0
fixed targets
colliders
L, cm-2s-1
10^27
10^25
10^23
CBM/SIS-100 (FAIR)
2025
MPD/NICA (JINR)
2022
BM@N/NICA (JINR)
In operation
STAR/RHIC (BNL)
NA61/SPS (CERN)
HADES/SIS-18 (GSI)
energy (Au+Au)
2
5
10
√SNN, GeV

Similarity of Stellar Objects & Heavy Ion Collisions

appearance of strangeness changes EOS, depends on strangeness-nucleon interaction



1st OPT:
gravitational waves from mergers



Bauswein et. al.,
arXiv:1809.01116

Complex objects

BM@N: data taking started in 2018

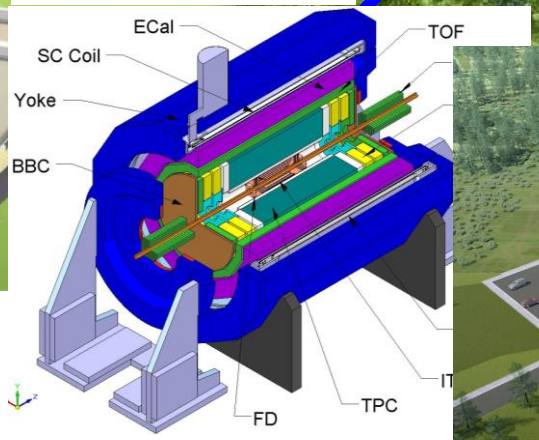
SPD TDR - 2021

Collider - 2022

applied research infrastructure- 2021

Booster- 2020

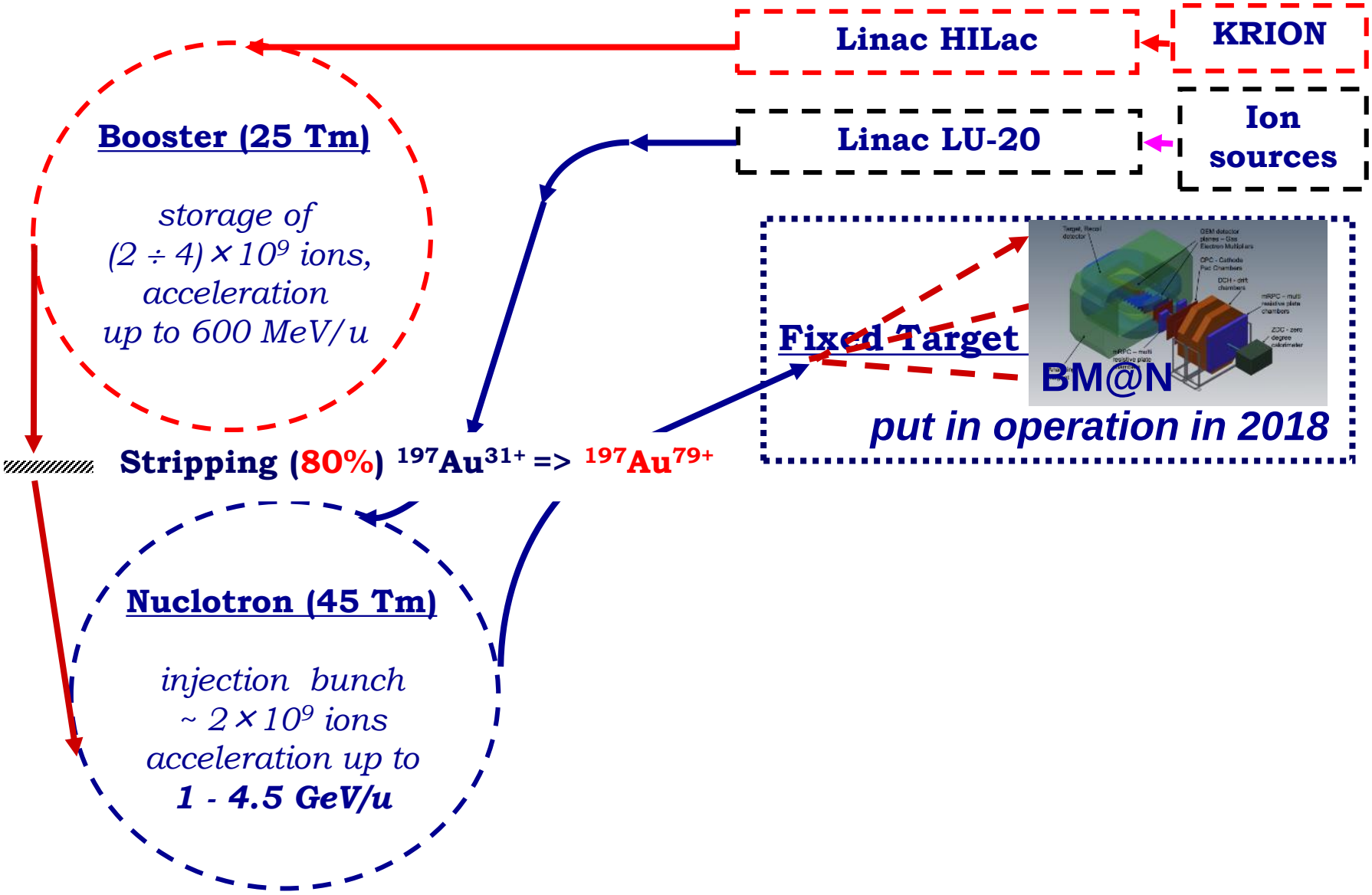
MPD - 2021



NICA Center - 2021

Nuclotron (c=251,5 m)

Structure of the Accelerator Complex

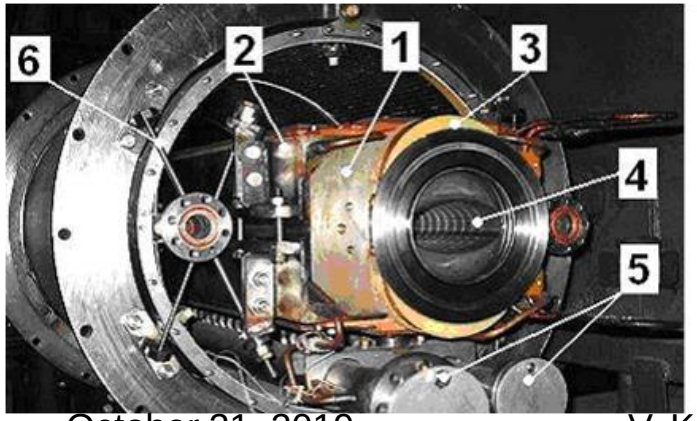


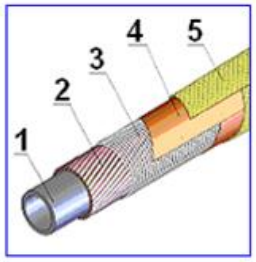
Nuclotron - *put in operation in* ***1993***

Type	SC synchrotron
particles	**↑p,↑d, nuclei**
max. energy, GeV/u	**13** (↑**p**); **6.5** (↑**d**) **5.3** (**Au**)
injection energy, MeV/u	5 (↑p,↑d) 570-685 (Au)
magnetic rigidity, T m	25 – 43.25
circumference, m	251.52
vacuum, Torr	10^{-9}
*intensity, **Au** /pulse*	**1 10^9**

*modernized in **2010-2015***

technology of fast cycling SC magnets "**Nuclotron type**"



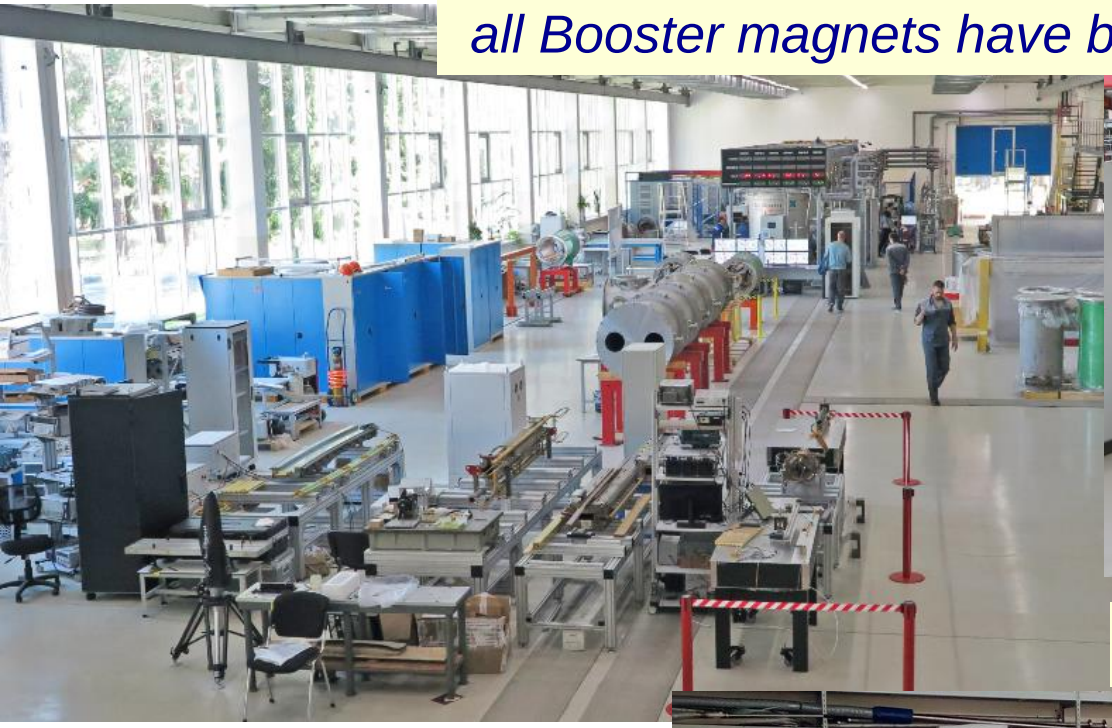


SC cable
1 - cupronickel tube
2 - NbTi composite wire
3 - nichrome wire
4,5- isolation

*cooling by two-phase **He** flow at **4,5** K;*
*peak current – **12** kA*

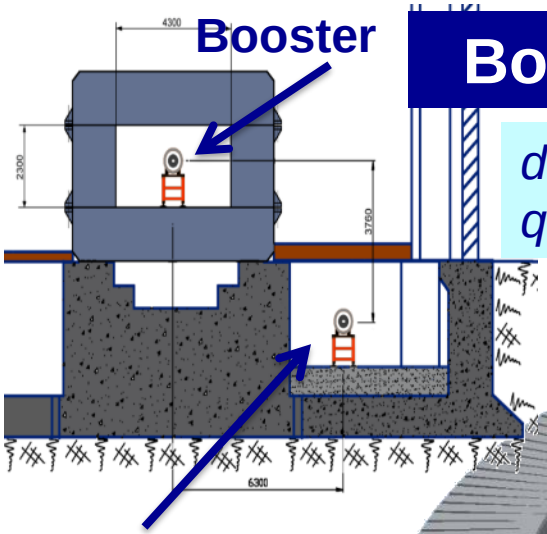
Technological line for production, tests and certification of SC magnets for NICA and FAIR was put in operation in 2016

all Booster magnets have been produced and tested

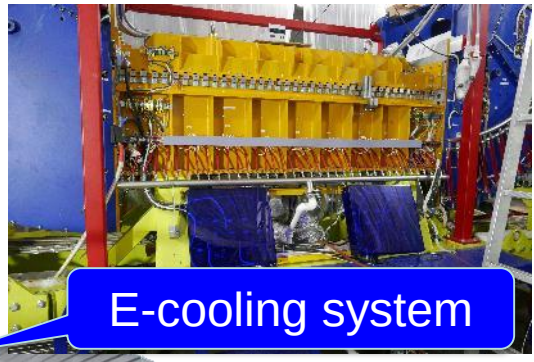


Collider magnets - in production

Booster: *assembly since 2018*



dipoles – 40
quadrupoles - 48



injection

Feed box

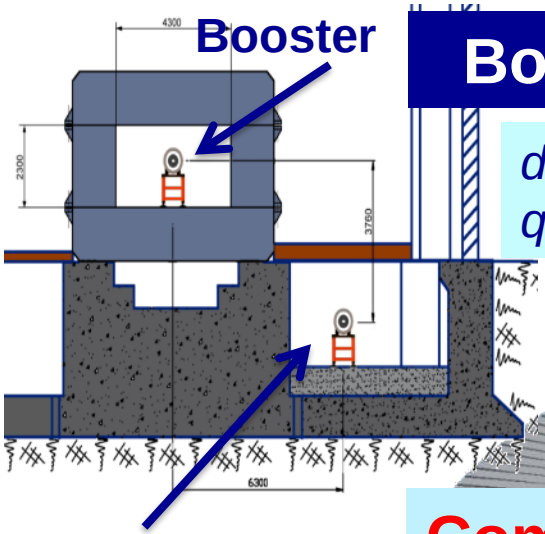
Power supply

extraction

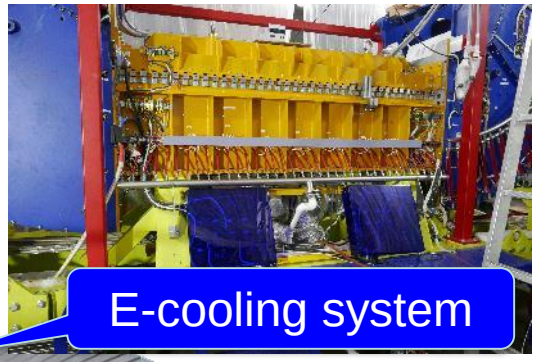
Accelerating station

Nuclotron

Booster: *assembly since 2018*



dipoles – 40
quadrupoles - 48



injection

Commissioning in 2019 - 2020

Feed box

	value
ion species	A/Z ≤ 3
max. energy, MeV/u	**600**
injection energy, MeV/u	3.2
magnetic rigidity, T m	1.6 – 25.0
circumference, m	210.96
vacuum, Tor	10^{-11}
*intensity, **Au** /p*	1.5 10^{9}
RF region,MHz	0.5 -2.53

ower
upply

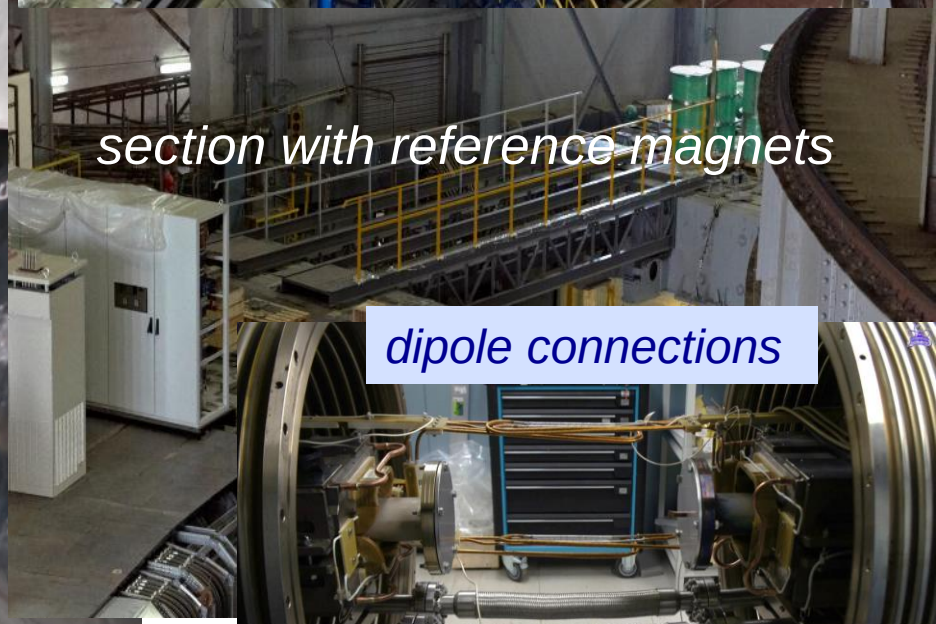
extraction

Nuclotron


Injection channel


power supply system


dipoles in the tunnel


section with reference magnets

dipole connections

Structure of the Accelerator Complex

Linac HILac

KRION

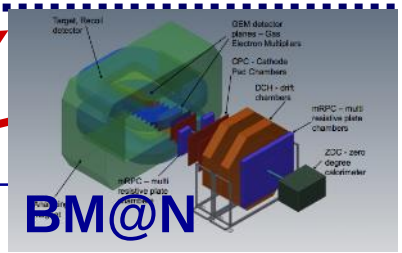
Linac LU-20

Ion sources

Booster (25 Tm)

storage of
$(2 \div 4) \times 10^9$ ions,
acceleration
up to 600 MeV/u

Fixed Target



BM@N

put in operation in 2018

Stripping (80%) $^{197}Au^{31+}$ => $^{197}Au^{79+}$

Nuclotron (45 Tm)

injection bunch
~ 2×10^9 ions
acceleration up to
1 - 4.5 GeV/u

Two SC collider rings

IP-2

$\sqrt{S_{NN}}$ = 4 – 11 GeV (Au+Au)

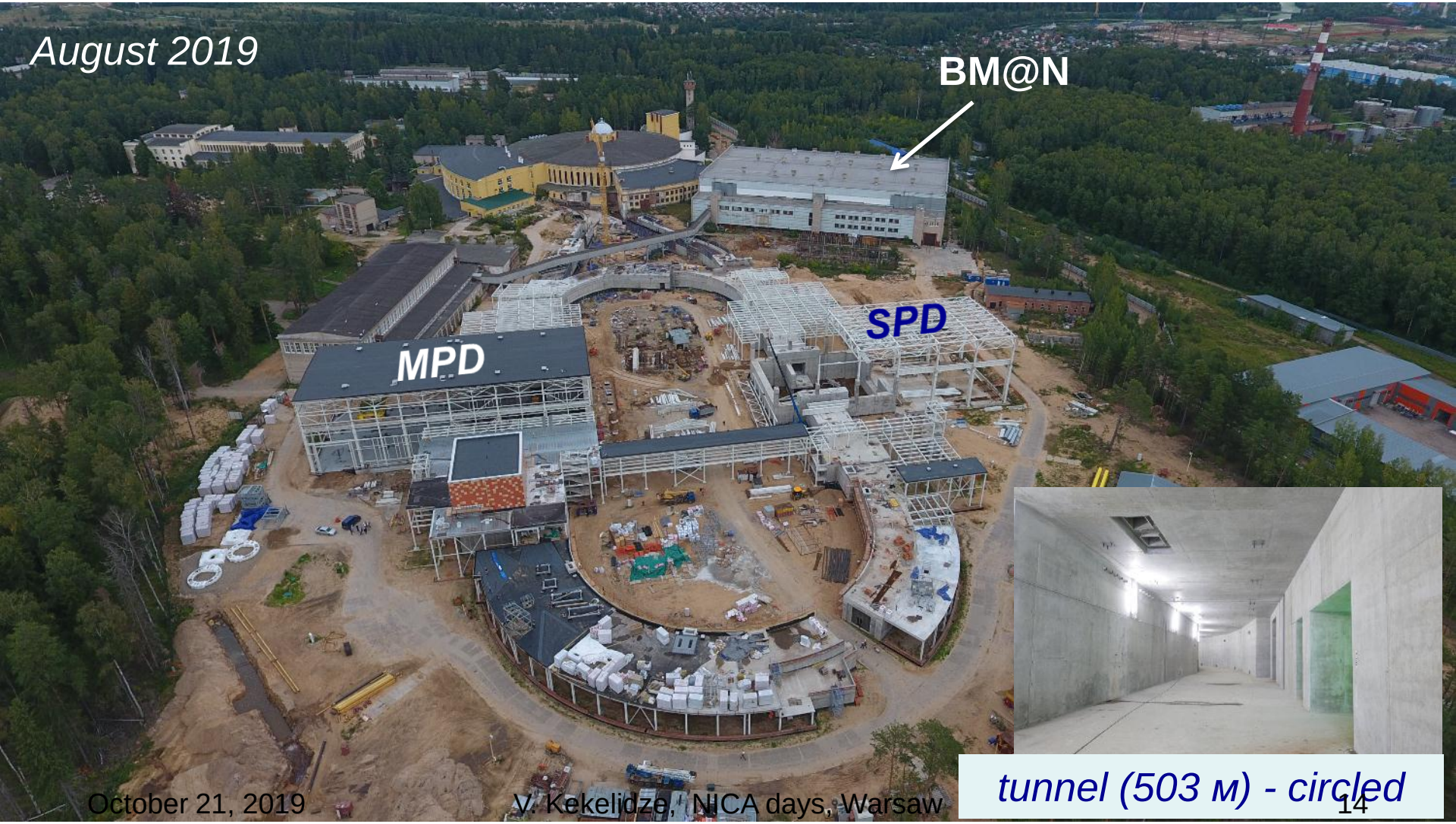
L = 1 x 10^{27} cm^{-2} s^{-1}

~ 2 x 22 injection cycles
22 bunches per ring

IP-1

Construction of the Collider building

*Completion in December **2020***



tunnel (503 м) - circled

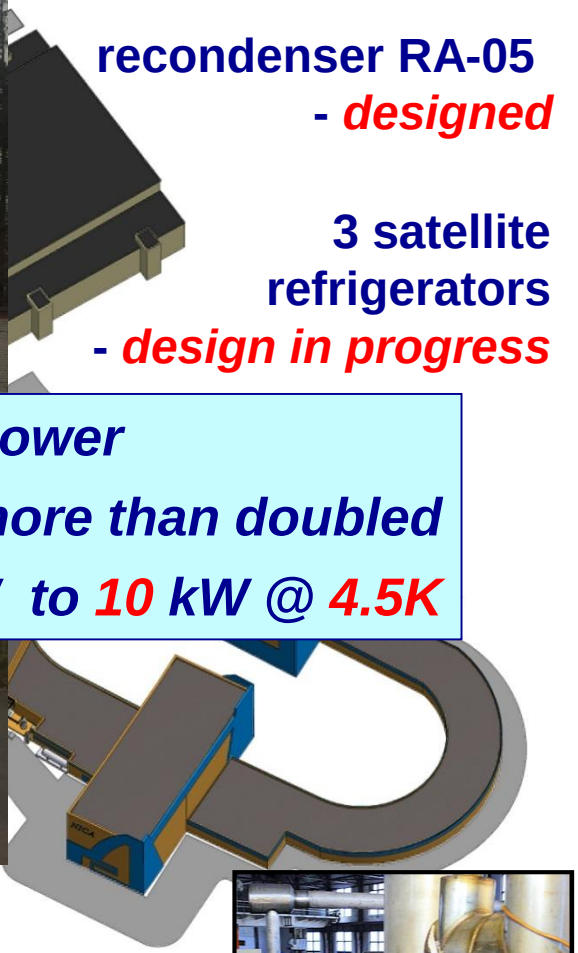
Cryogenics at NICA

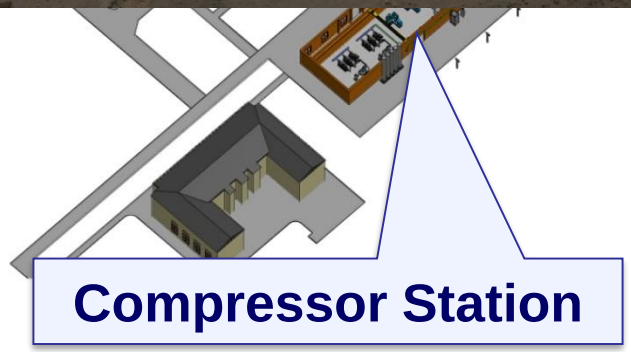
to be completed in 2020

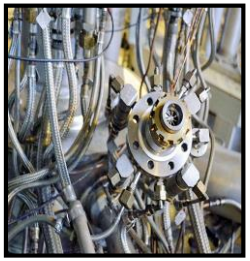
recondenser RA-05
- *designed*

3 satellite refrigerators
- *design in progress*

the cooling power will be more than doubled from 4 kW to 10 kW @ 4.5K







Main Power Substation (110 kV)

reconstruction in progress

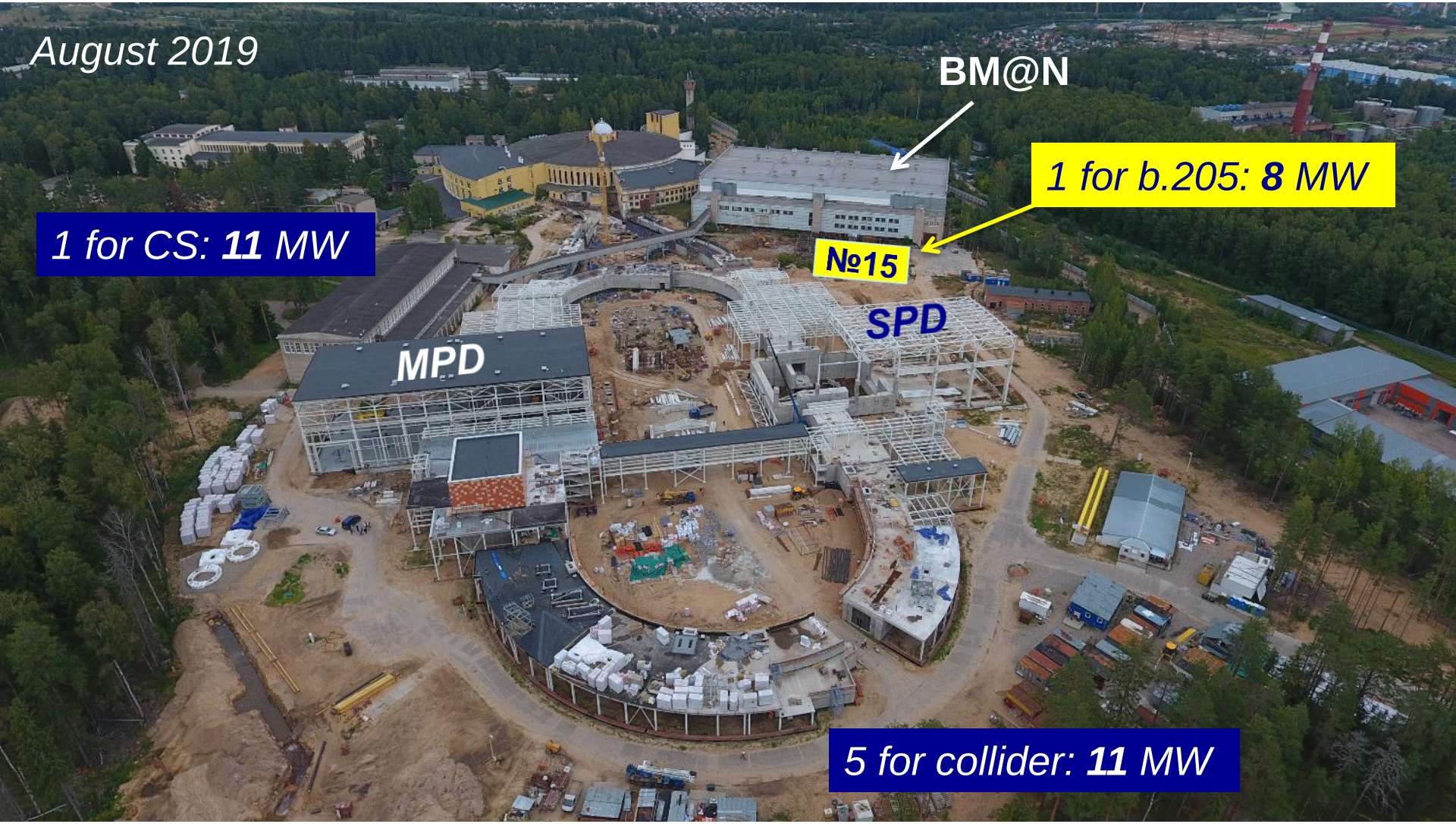
Two transformers 2 x 40 MW *(II category of reliability)*

total transformer power will be available

40.8 MW

	consumer	Power, MW
1	Booster	**1.6**
2	Collider	**11.0**
3	Compressor Station (CS)	**7.6**
4	Computer Claster	**1.0**
5	Nuclotron	**1.4**
6	Channels in bld. 205	**1.6**
7	SC magnet workshop	**1.1**
8	Lab infrastructure	**4.4**
9	East Boiler Room	**0.8**
10	NICA Center	**1.8**
11	external	**8.5**
	Total	**40.8**

Substations 6 kV



New Computer cluster
- *was put in operation on September 19, 2019*

- ***3000*** *cores,*
  will be upgraded to ***5000****;*
- ***3,5****+****3,5*** *PB store memory*

The kick-off meeting of MPD and BM@N Collaborations

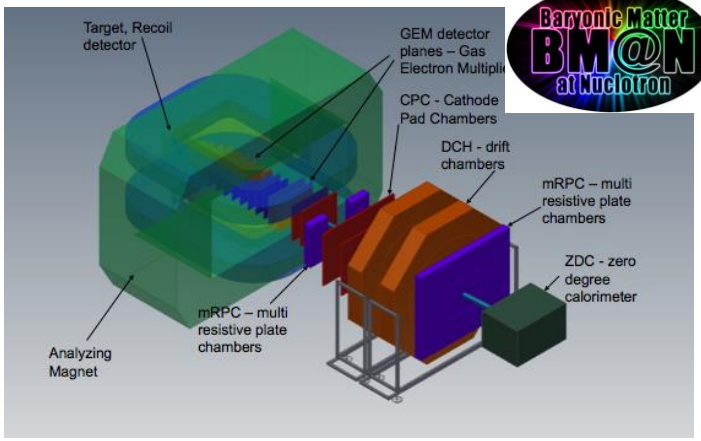
took place in Dubna on 11-13 April, 2018

https://indico.jinr.ru/conferenceDisplay.py?ovw=True&confId=385

***Two** Institutional **B**oards **(IB)** were formed for both collaborations:*
***18** members for **BM@N**, and **27** members for **MPD**.*
*The **bylaws** have been **adopted** and signed by the **IB's.***

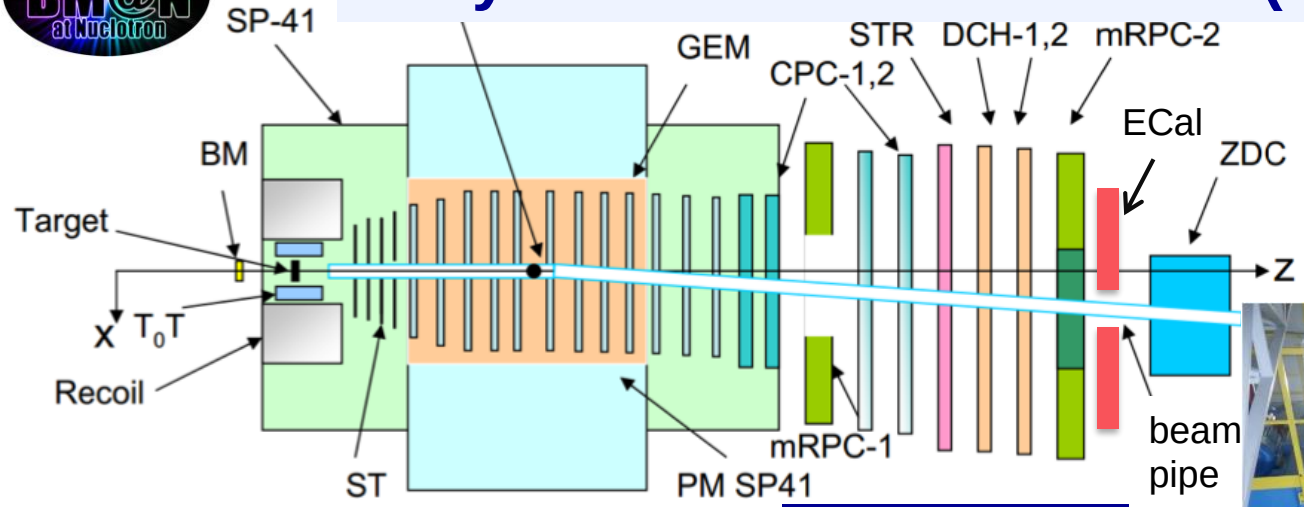
Baryonic Matter at Nuclotron

***Collaboration: 11** Countries, **21** Institutions, **234** participants*



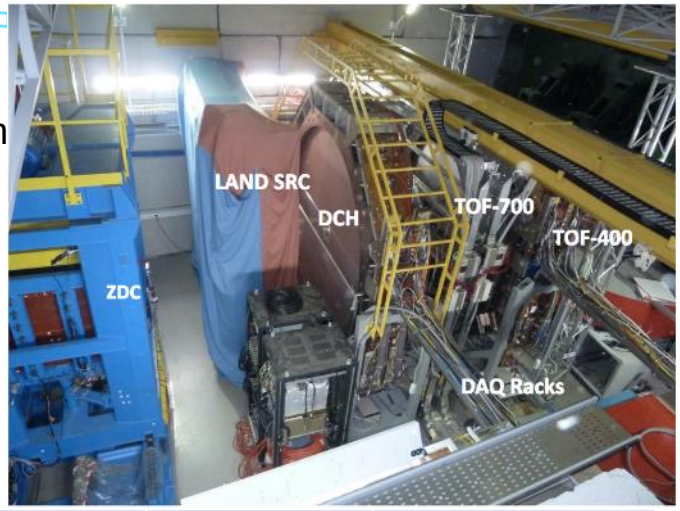
- *University of Plovdiv, **Bulgaria;***
- *Institute of High Energy Physics, **China;***
- *Shanghai Institute of Nuclear and Applied Physics, CFS**, China;***
- *Tsinghua University, Beijing, **China;***
- *Nuclear Physics Institute, **Czech Rep.;***
- *CEA, Saclay, **France;***
- *Tubingen University, **Germany;***
- *TU Darmstadt & GSI, **Germany;***
- *Tel Aviv University**, Israel;***
- ***Joint Institute for Nuclear Research;***
- *Almaty Institute of Physics & Technology, **Kazakhstan;***
- *Institute of Applied Physics, Chisinev, **Moldova;***
- *Warsaw University of Technology, **Poland;***
- *University of Wroclaw, **Poland**;*
- *Institute of Nuclear Research RAS, Moscow, **Russia;***
- *NRC Kurchatov Institute, Moscow, **Russia;***
- *Institute of Theoretical & Experimental Physics, NRC KI, Moscow, **Russia;***
- *Moscow Engineer and Physics Institute**, Russia;***
- *Skobeltsin Institute of Nuclear Physics, MSU, **Russia;***
- *Moscow Institute of Physics and Technology, Moscow, **Russia**;*
- *Massachusetts Institute of Technology, Cambridge, **USA.***

Baryonic Matter at Nuclotron (BM@N)

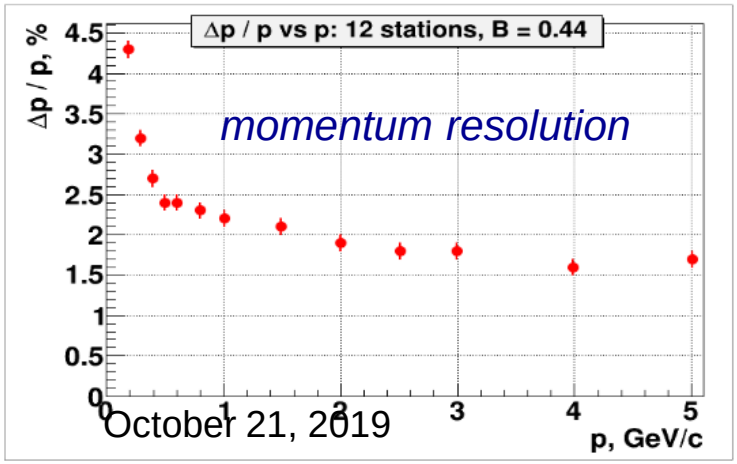


schematic view

time resolution:
- *T0 ~43 ps*
- *ToF-700 ~65 ps*
- *ToF-400 ~53 ps*



GEM: 163 x 45 cm²



plans

year	2017	2020	2021 +
beam	C, Ar/Kr	Au	Au, p
intensity, Hz	0,5M	1M	10M
trig. rate, Hz	10k	20k	50k
central tracker	10 GEM half pl.	8 GEM full pl.	12 GEM or 8+2Si
stage	0	1	2

Baryonic Matter at Nuclotron (BM@N)

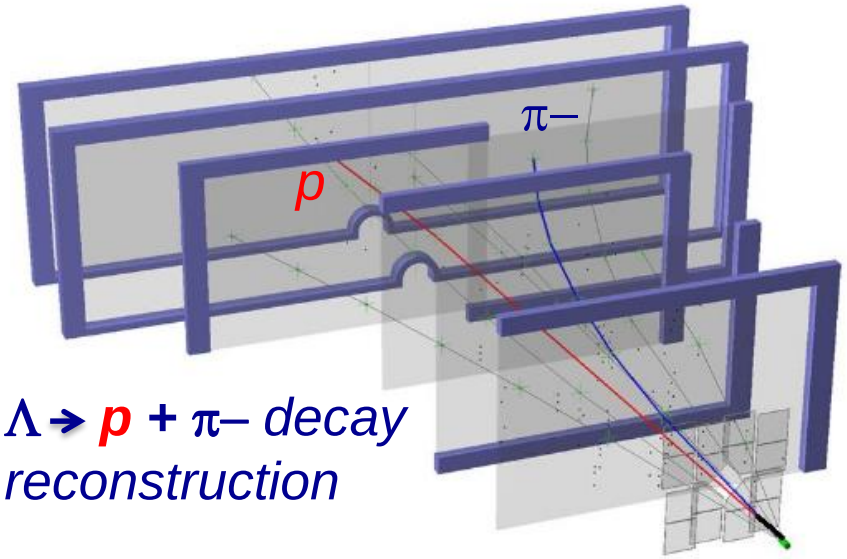
SP-41

milestone I (stage 0 of BM@N) :

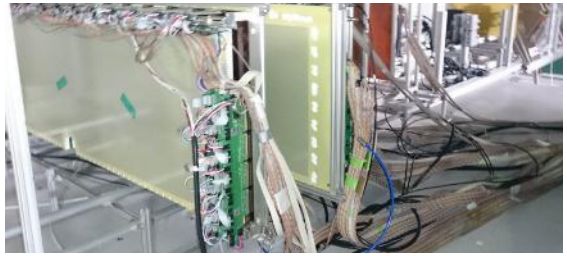
the first run: ***March 22 – April 3, 2018***:

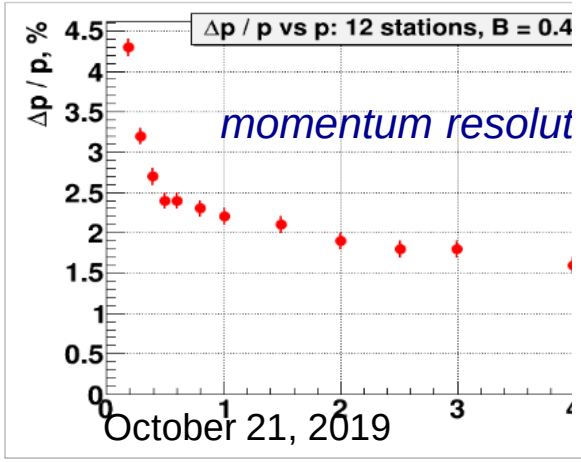
targets: ***C, Al, Cu, Sn, Pb;***

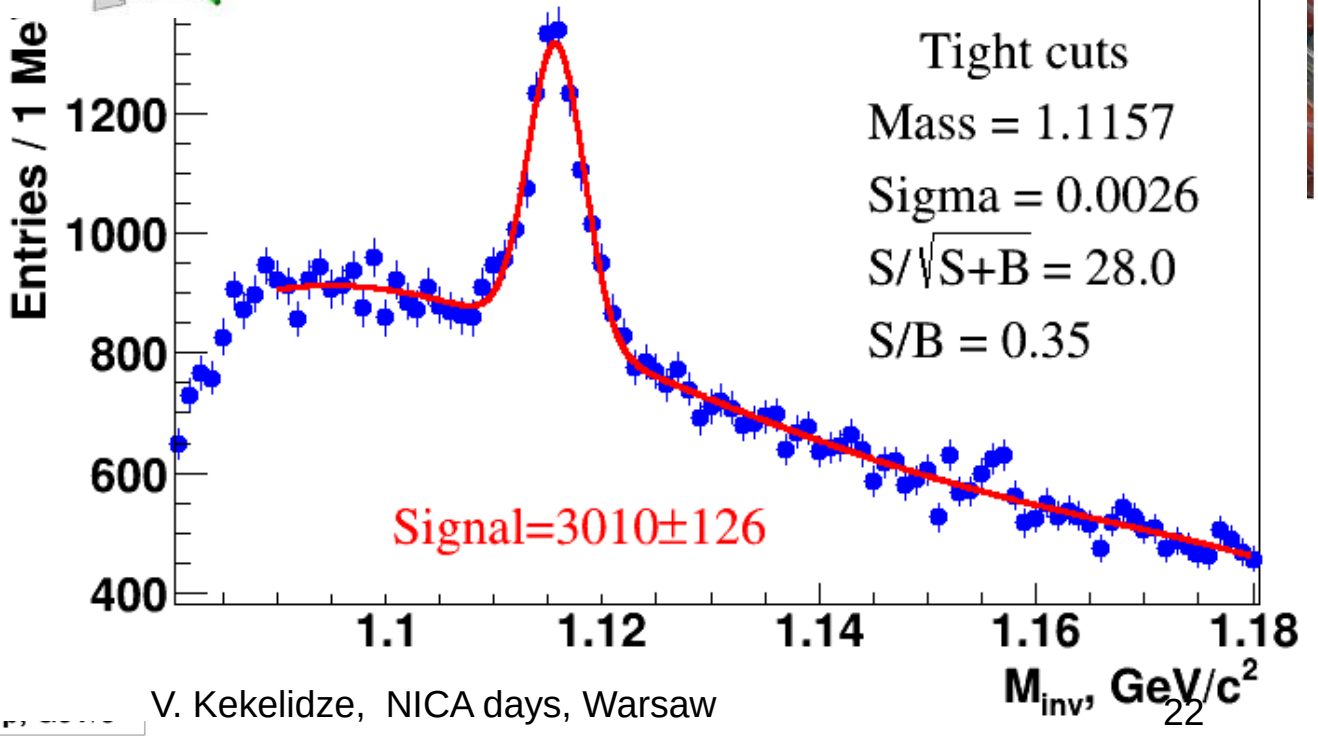
	beams	*statistics*
$^{12}C^{6+}$	***4,0 -4,5 AGeV***	***20 M events***
$^{40}Ar^{16+}$	***3,2 AGeV***	***130 M events***
$^{84}Kr^{26+}$	***2,3 AGeV***	***50 M events***



$\Lambda \rightarrow p + \pi-$ *decay reconstruction*



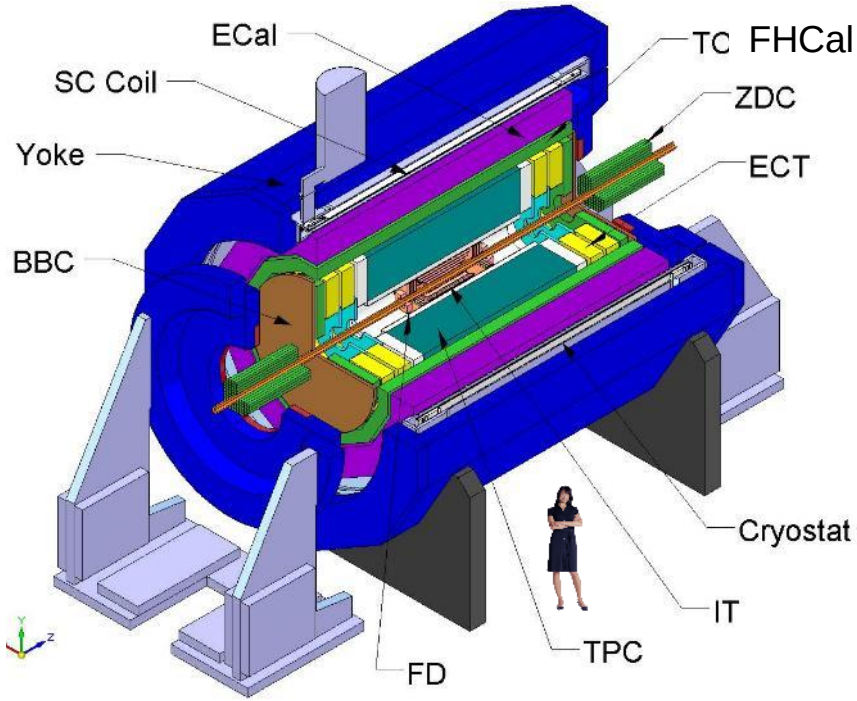




MPD Collaboration:

*spokesperson – **A. Kisiel WUT, Poland***

***10** Countries, **38** Institutes, ~ **500** participants*

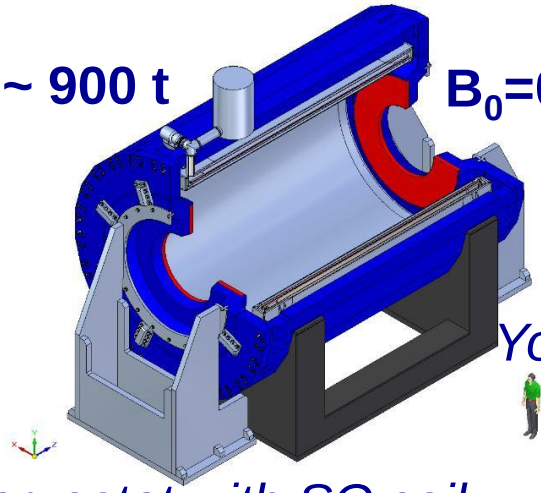


*Baku State University, NNRC, **Azerbaijan**;*
*University of Plovdiv, **Bulgaria;***
*University Tecnica Federico Santa Maria, Valparaiso, **Chili**;*
*Tsinghua University, Beijing, **China**;*
*USTC, Hefei, **China**;*
*Huizhou University, Huizhou, **China**;*
*Institute of Nuclear and Applied Physics, CAS, Shanghai, **China**;*
*Central China Normal University, **China**;*
*Shandong University, Shandong, **China**;*

*IHEP, Beijing, **China**;*
*University of South China, **China**;*
*Palacky University, Olomouc, **Czech Republic**;*
*NPI CAS, Rez, **Czech Republic**;*
*Tbilisi State University, Tbilisi, **Georgia**;*
*Tubingen University, Tubingen, **Germany**;*
*Tel Aviv University, Tel Aviv, **Israel**;*
Joint Institute for Nuclear Research;
*IPT, Almaty, **Kazakhstan**;*
***Consortium of 5 Universities**, **Mexico**;*
*Institute of Applied Physics, Chisinev, **Moldova**;*
*WUT, Warsaw, **Poland**;*
*NCN, Otwock – Swierk, **Poland**;*
*UW, Wroclaw, **Poland**;*
*Jan Kochanowski University, Kielce, **Poland**;*
*INR RAS, Moscow, **Russia**;*
*MEPhI, Moscow, **Russia**;*
*PNPI, Gatchina**, Russia**;*
*INP MSU, Moscow, **Russia;***
*KI NRS, Moscow, **Russia**;*
*SPSU - Dept. of NP, **Russia;***
*St. Petersburg, **Russia**;*
*SPSU – Dept. of HEP, St. Petersburg, **Russia**;*
*North Ossetia State University, Vladikavkaz, **Russia**;*

MPD major systems – *in production*

SC Solenoid



~ 900 t

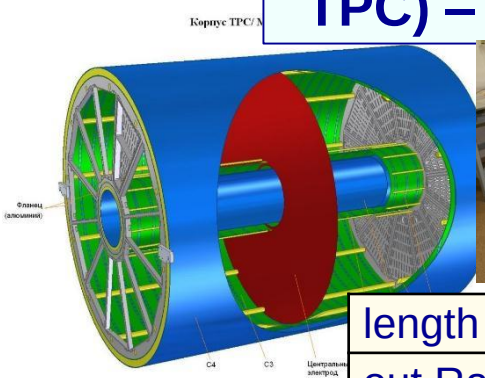
B_0=0.5 T

Yoke – produced & delivered

cryostat with SC coil

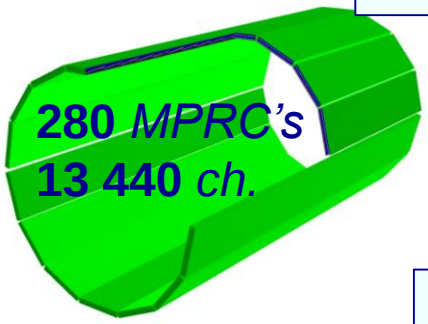
- ready for cold tests

TPC) – basic tracker



length	*340 см*
out Radii	*140 см*
N chan.	***95 232***

TOF system



280 *MPRC's*

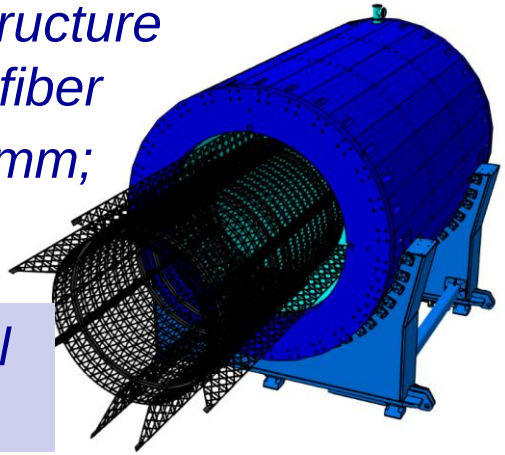
13 440 *ch.*

Integration

support structure of carbon fiber

sagite ~ ***5*** *mm;*

0,13 X_0



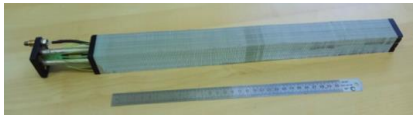
ECal *barrel*

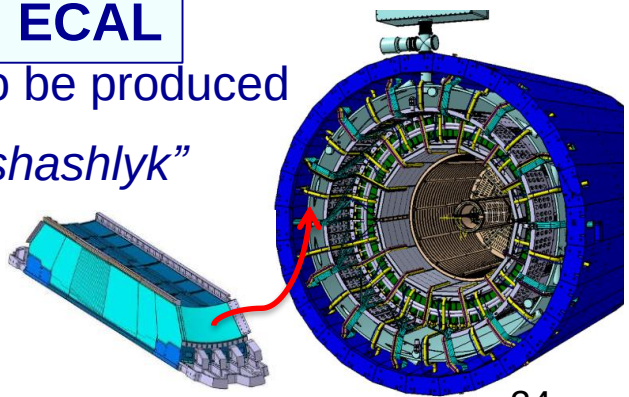
~ ***100*** *t*

ECAL

~ **43 000** modules to be produced

a module: Pb+Sc "shashlyk" type Ecal

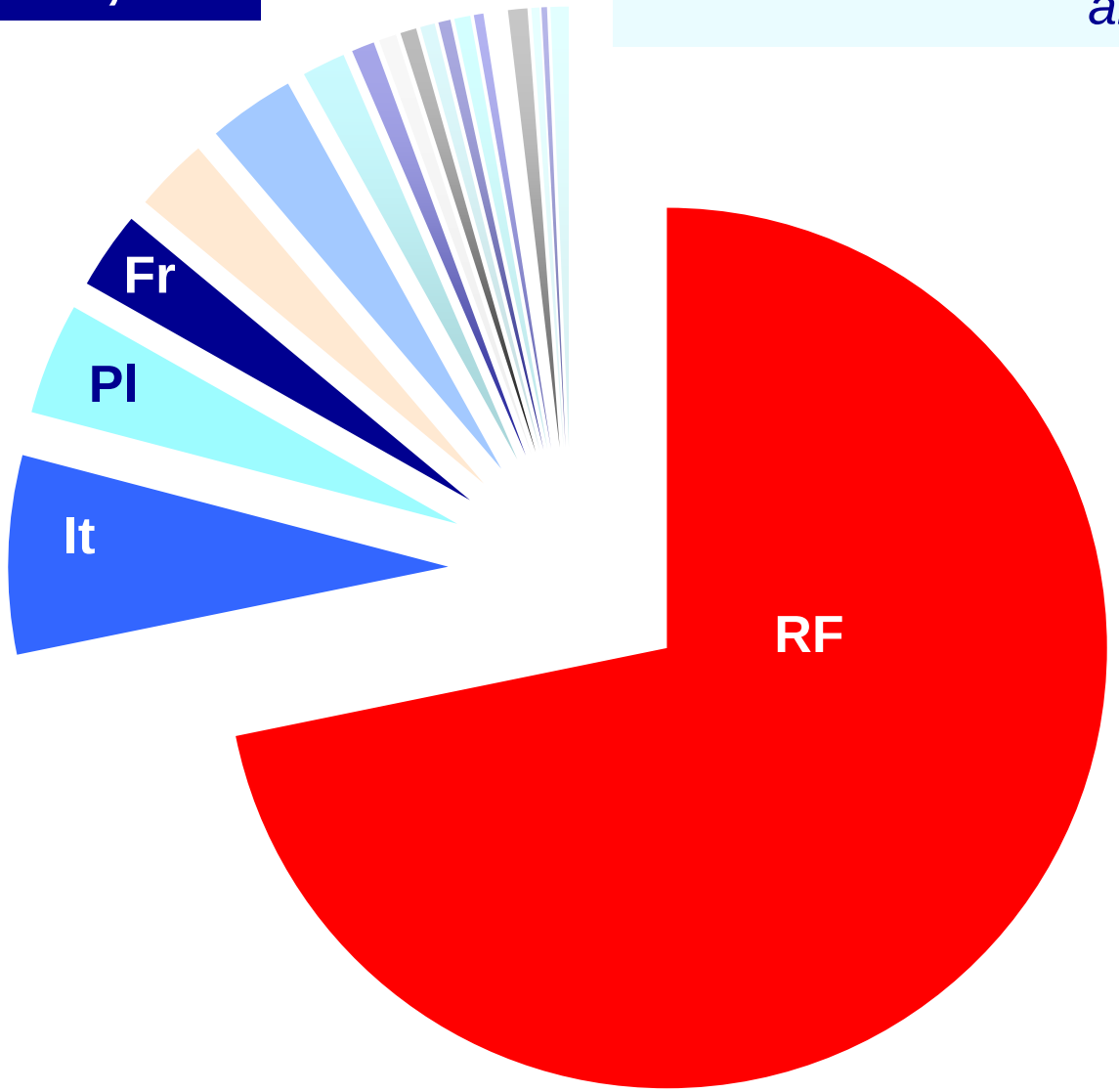




Industrial returns *(purchases by country)*

$ 205,4 M

*Total: **32** countries, incl. **8** member-states and **3** associated countries*

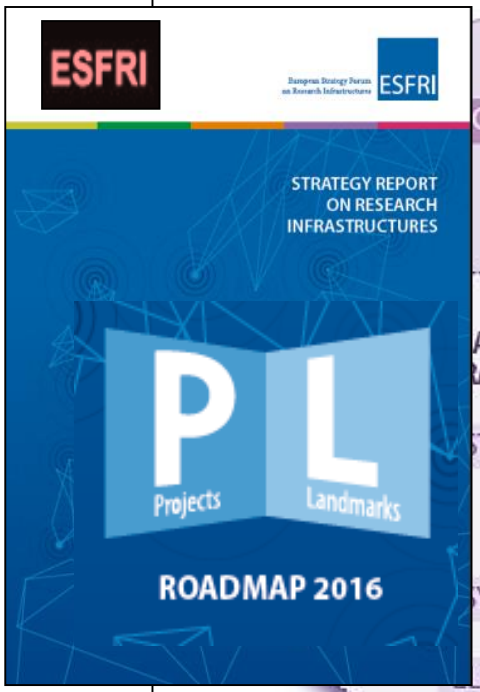


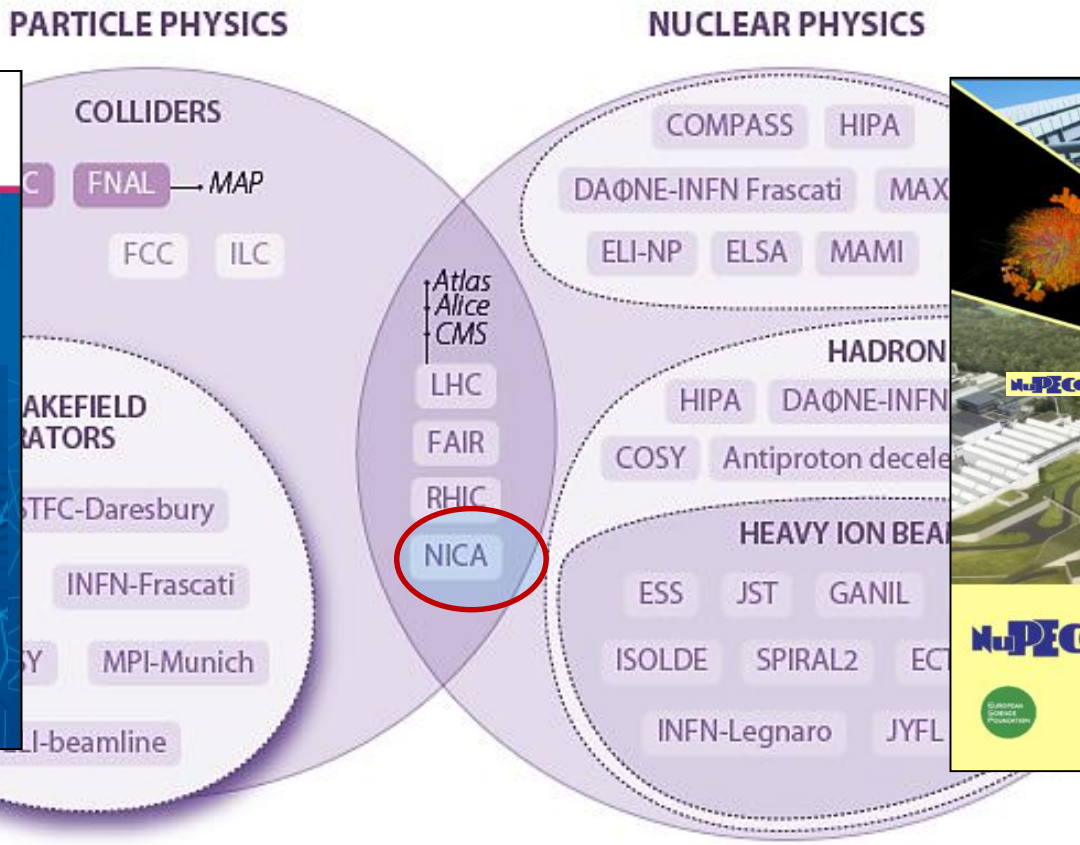
- Russian Federation
- Italy
- Poland
- France
- Czech Republic
- Germany
- Switzerland
- Norway
- China
- USA
- Sweden
- Jupan
- Belarus
- Korea
- Slovakia
- Slovenia
- Austria
- Ukraine
- other 13 countries

BARYONIC MATTER DENSITY FRONTIER

NICA is included in the ESFRI ROADMAP-2016 and in the NuPECC Long Range Plan 2017 - Perspectives in Nuclear Physics

Main Research Infrastructures in Particle and Nuclear Physics





Representatives of Poland at JINR with Polish students undergoing graduate practice within the NICA project in 2019

Concluding remarks

- **Construction of the NICA accelerator Complex,**
  both BM@N & MPD detectors
  and infrastructure development
  are going close to schedule

- **Both Collaborations MPD & BM@N**
  with the active participation of Polish groups
  have potential to obtain new precision data
  in less explored field of research - high baryonic density

“To know that we know what we know, and to know that we do not know what we do not know, that is true knowledge.”

N. Copernicus