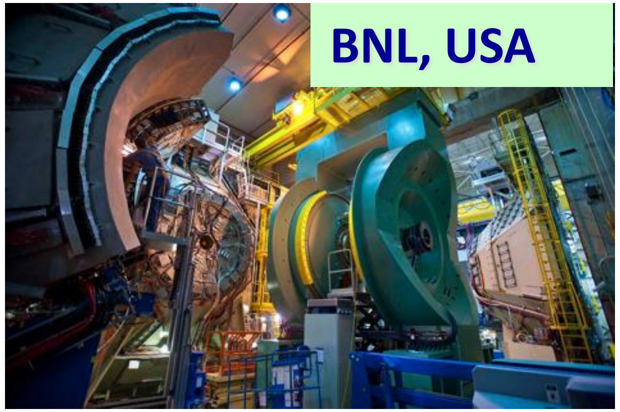
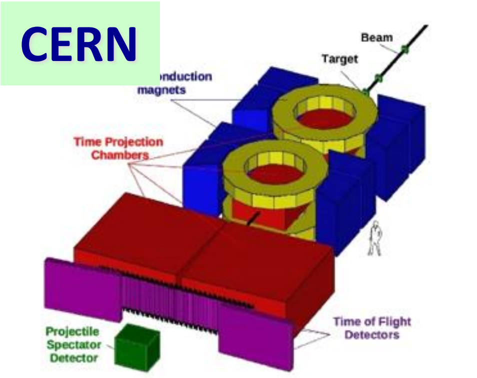
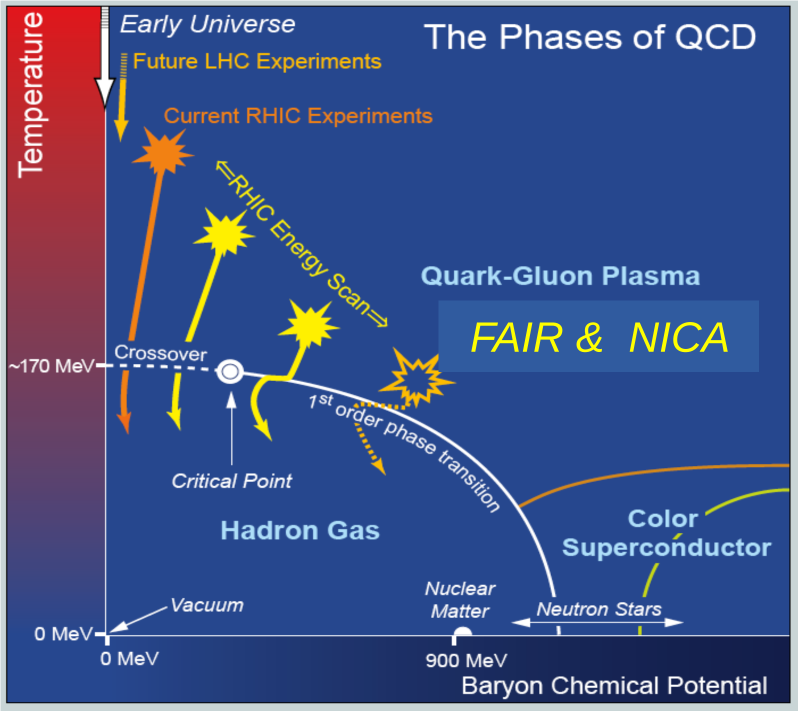
The Silicon Tracking Systems of NICA

Yuri Murin , VB LHEP JINR, Dubna, Russia

"Physics at CBM", June 21-23 2016, Sikkim, India







$\sqrt{s_{NN}}$ **~ 10 ГэВ**

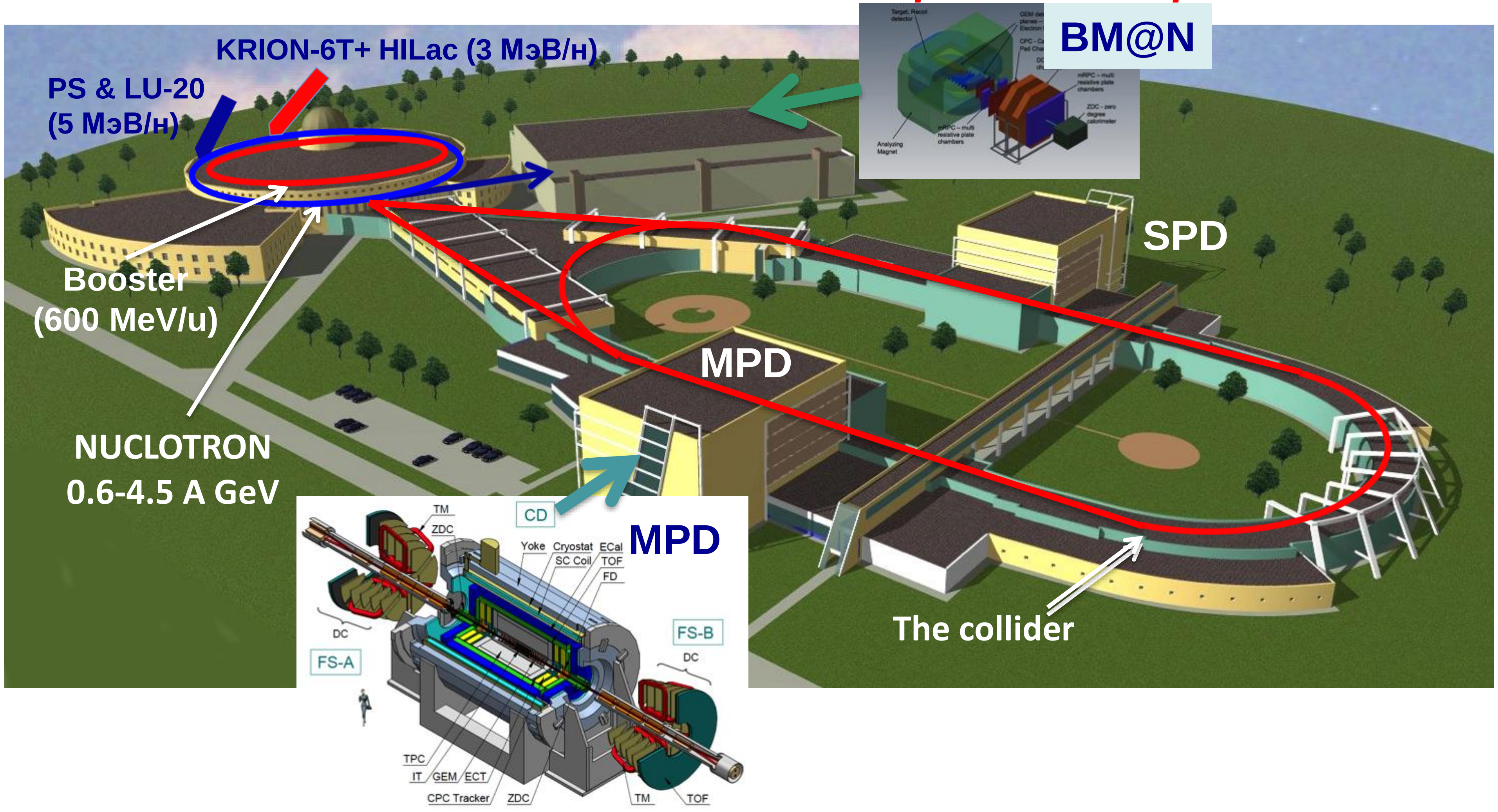
HI collisions energy domain of great expectations

- ✓ **FAIR** *(Darmstadt) – CBM stationary target experiment*
- ✓ **NICA** *(JINR, Dubna)* – **two types of experiment – Stationary target and collider**

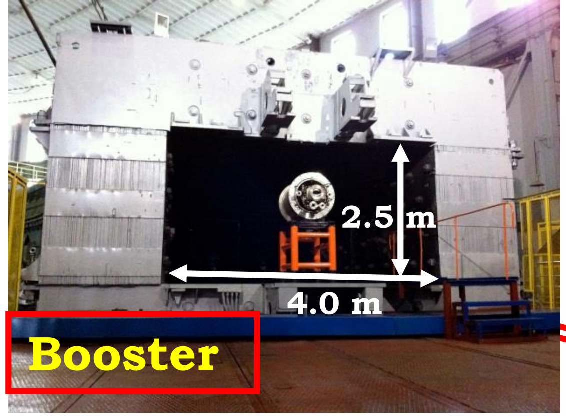
Mega-project «NICA»

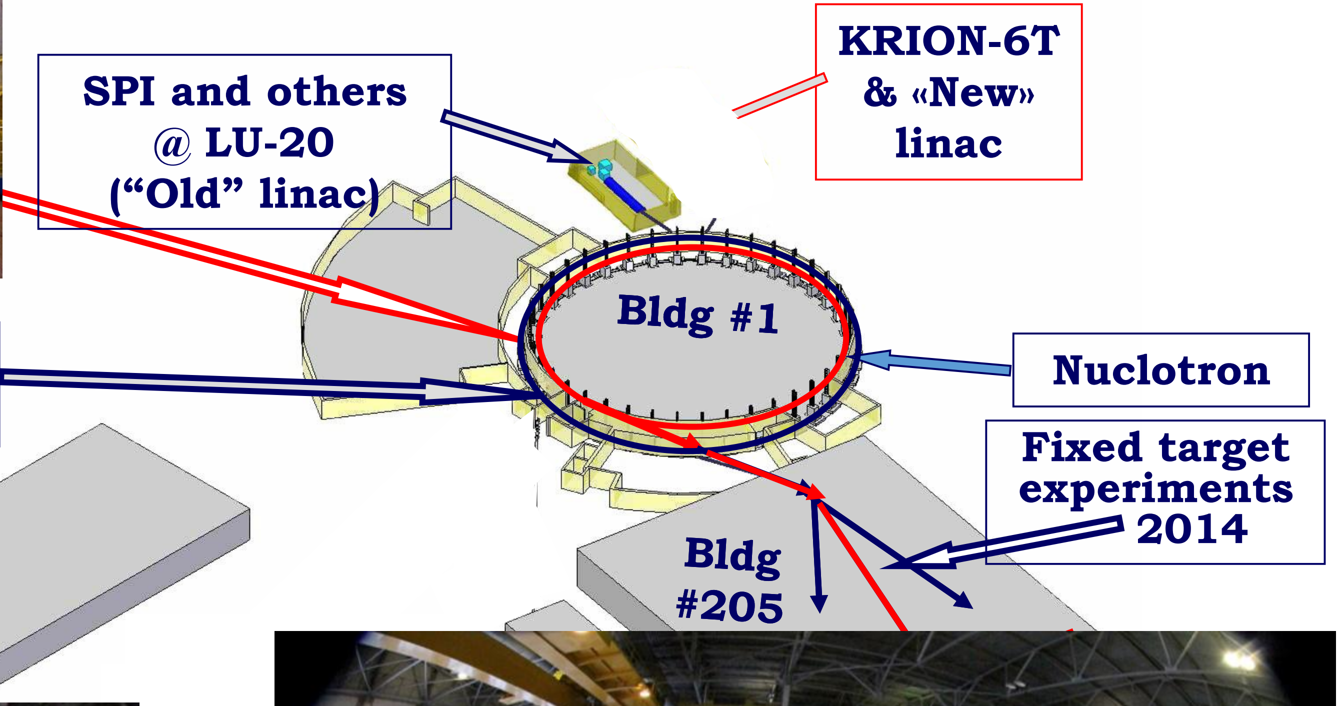
The setups at work

The planned setups



NICA – Stage I


2.5 m
4.0 m
Booster


SPI and others
@ LU-20
("Old" linac)
KRION-6T
& «New»
linac
Synchrophasotron
yoke
Bldg #1
Nuclotron
Fixed target
experiments
2014
Bldg
#205

Nuclotron Beams

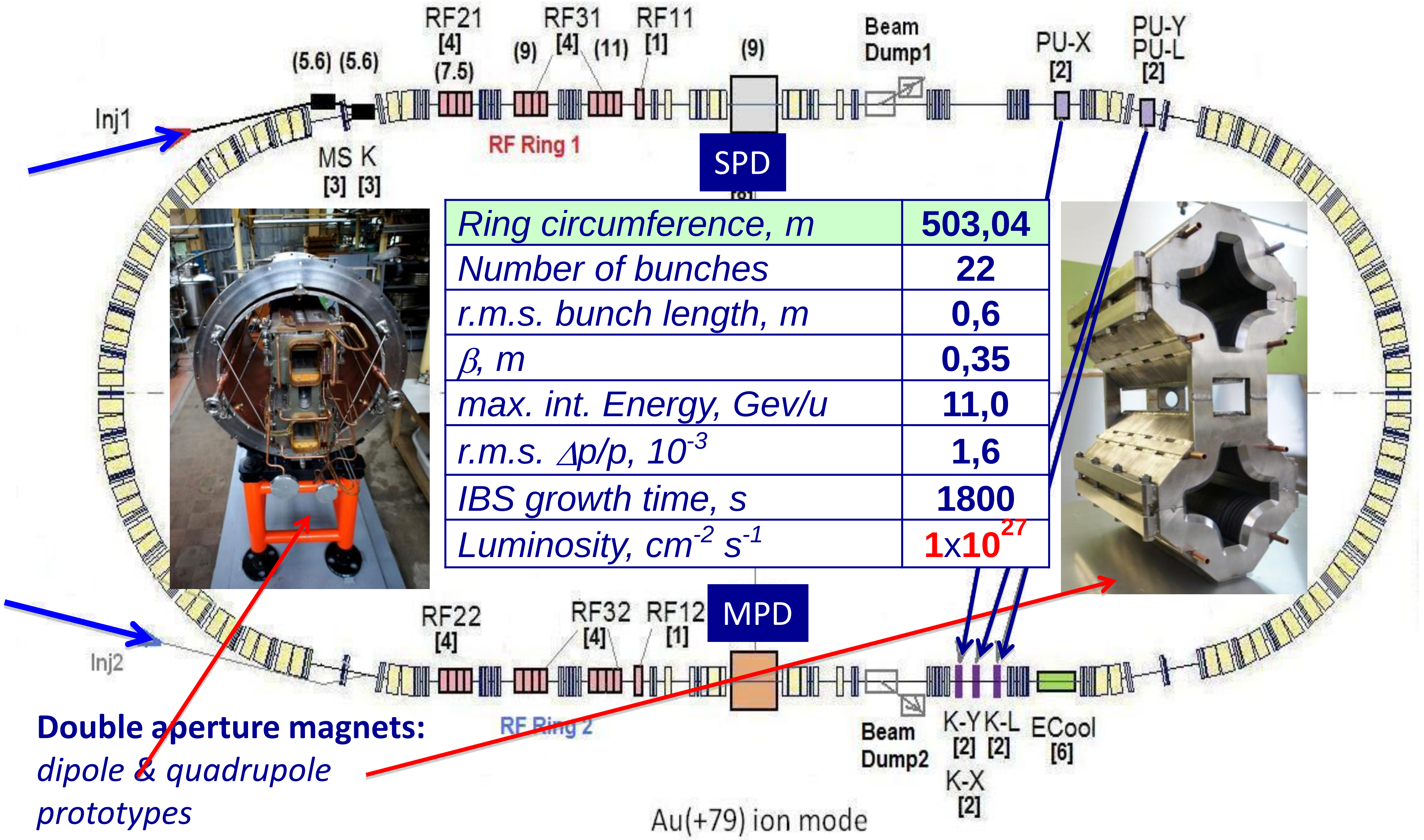
Leaders: *G.Trubnikov, I.Meshkov, A.Butenko*

Parameter	*Achieved*		*Project (2017 2019)*	
Magnetic field, T	2.0		2.0 (Bρ = 42.8 T·m)	
Field ramp, T/s	0.8		1.0	
Repetition period, s	8.0		5.0	
	Energy, GeV/u		Energy, GeV/u	Ions/ cycle
Light ions ⇒ d	5.6		6.0	$5 \cdot 10^{10}$
Heavy ions	*Without KRION-2*		*With KRION-6T & Booster*	
$^{40}Ar^{18+}$	3.5	$5 \cdot 10^{6}$	4.9	$1 \cdot 10^{8}$ $2 \cdot 10^{10}$
$^{56}Fe^{26+}$	2.5	$2 \cdot 10^{6}$	5.4	$1 \cdot 10^{8}$ $1 \cdot 10^{10}$
$^{124}Xe^{48/42+}$	1.5	$1 \cdot 10^{3}$	4.0	$1 \cdot 10^{7}$ $2 \cdot 10^{9}$
$^{197}Au^{79+}$	---	---	4.5	$1 \cdot 10^{7}$ $2 \cdot 10^{9}$
Polarized beams	*With Polaris*		*With SPI*	
p↑	---	---	11.9	$1 \cdot 10^{10}$ *)
d↑	2.0	$5 \cdot 10^{8}$	5.6	$1 \cdot 10^{10}$

**) With the Siberian snake*

The 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**
β, m	**0,35**
max. int. Energy, Gev/u	**11,0**
r.m.s. $\Delta p/p$, 10^{-3}	**1,6**
IBS growth time, s	**1800**
Luminosity, cm^{-2} s^{-1}	**1×10^{27}**

Double aperture magnets:
dipole & quadrupole prototypes

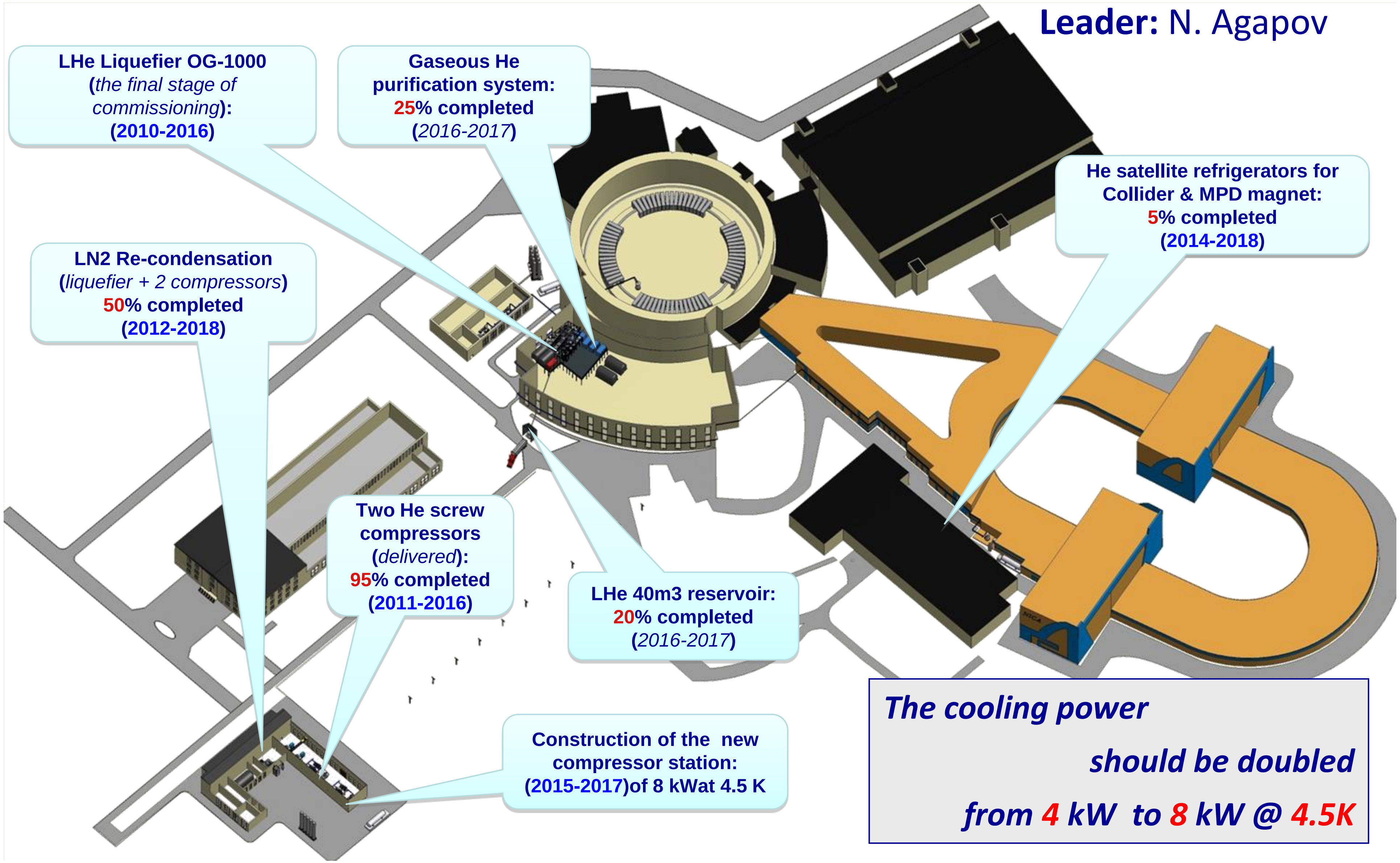
SC Magnets for Booster, Collider & SIS-100/FAIR workshop at VBLHEP JINR *(bld. 217)*

3 of 6 cryo-test benches are mounted

serial production of Booster magnets has started !

Development of the NICA Cryogenics

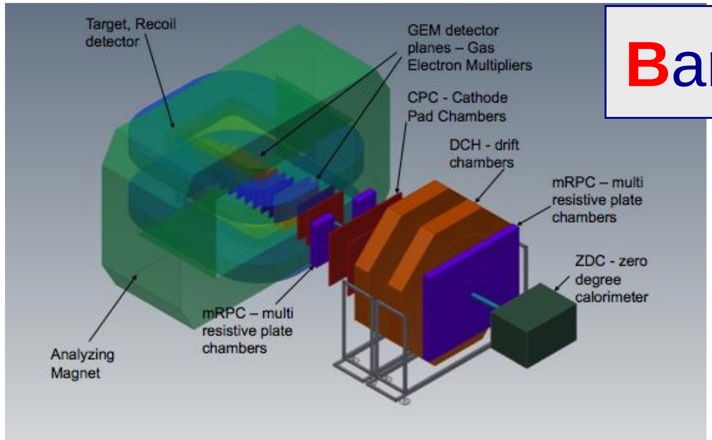
Leader: N. Agapov



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

NICA: 3 detectors

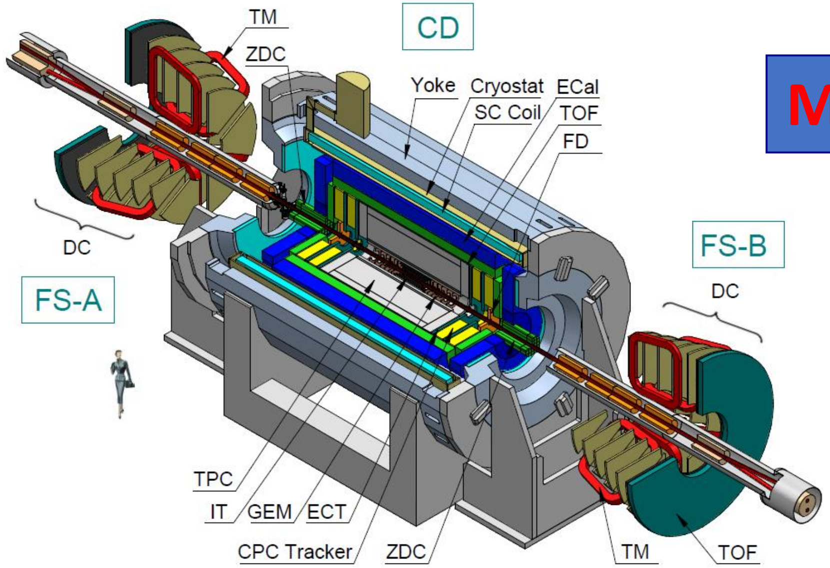
Leader: *V.Kekelidze*



Baryonic Matter at Nuclotron (BM@N)

the fixed target experiment at the Nuclotron

Stage I 2017



MultiPurpose Detector (MPD)

at the Collider

Stage I 2019

SPD (Spin Physics Detector) ***at the Collider***

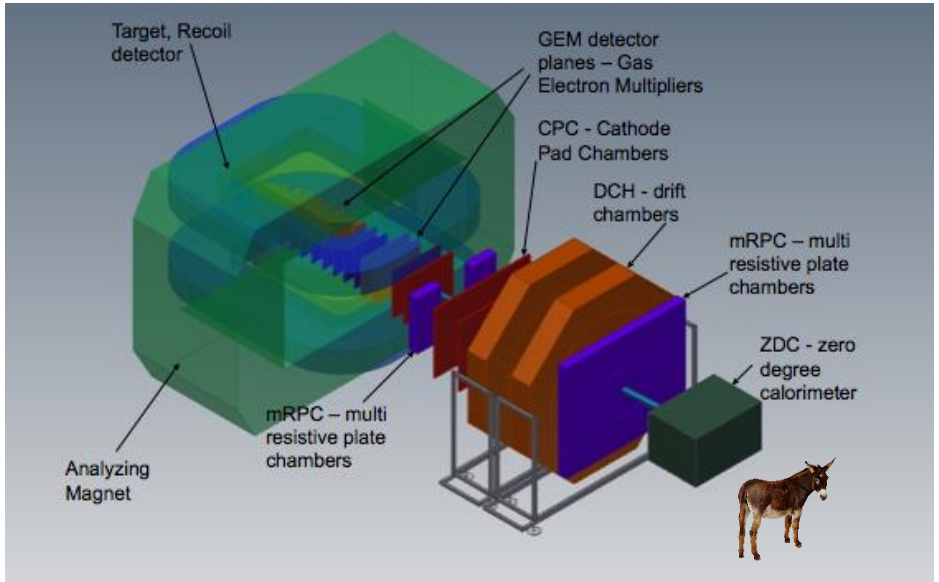
project is under preparation

BM@N: *the 1st stage*

Leaders: *V.Kekelidze, M.Kapishin*

Participants from:

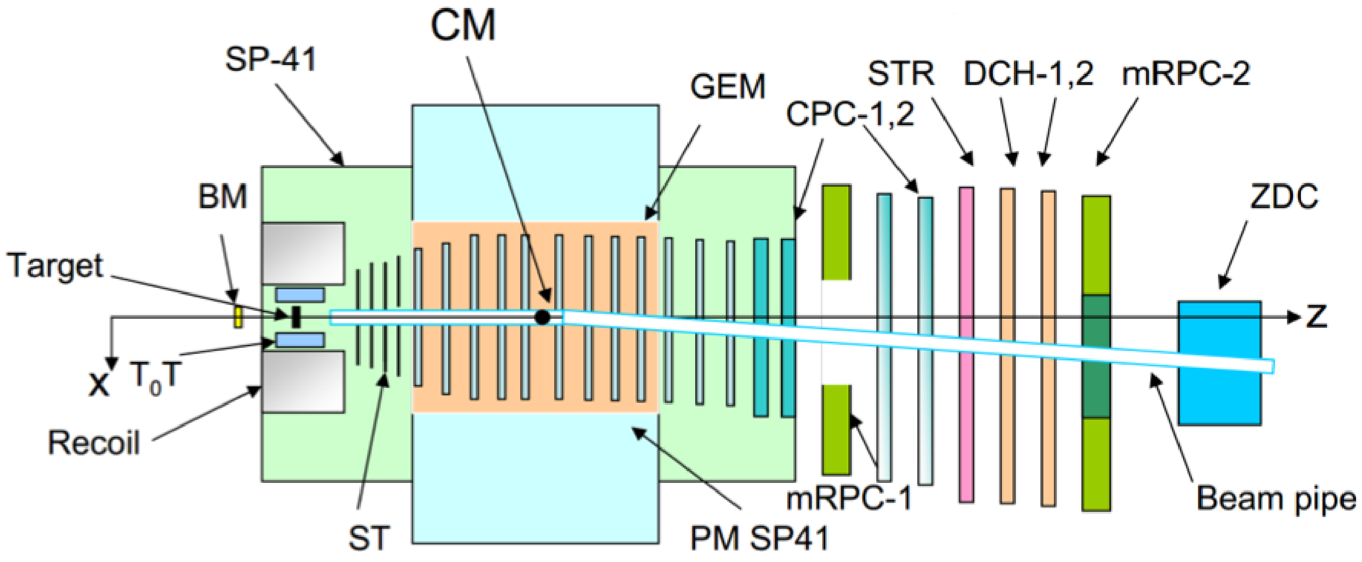
Russia: *INR, MEPhi, SINP, MSU, IHEP, S-Ptr Radium Inst.*
Bulgaria: *Plovdiv University;*
China: *Tsinghua University, Beijin;*
Poland: *Warsaw Tech.Uni.*
Israel: *Tel Aviv Uni.*
Germany: *Frankfurt Uni.*
+ expression of interest from CBM



Physics:

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

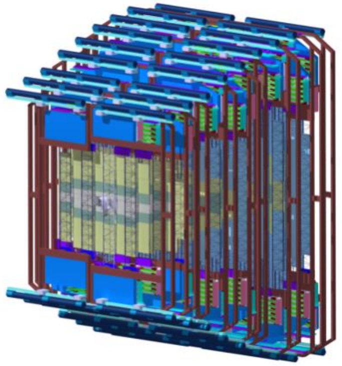
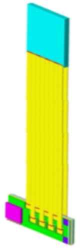
BM@N status and milestones



BM@N configuration

	DAQ	GEM *(CERN)*	ST	TOF	Outer tracker
•**2016, IV**:	*basic config.*	*6 half planes*	*1 small plane*	*half config.*	*DCH*
•**2017, III:**	complete	*10 h/pl.*	*2 s/pl.*	*basic*	*DCH*
•**2019, I:**	complete	*8-10 full pl.*	***4 CBM STS stations***	*complete*	*Straw+DCH*

BM@N STS comprises four first stations of CBM STS

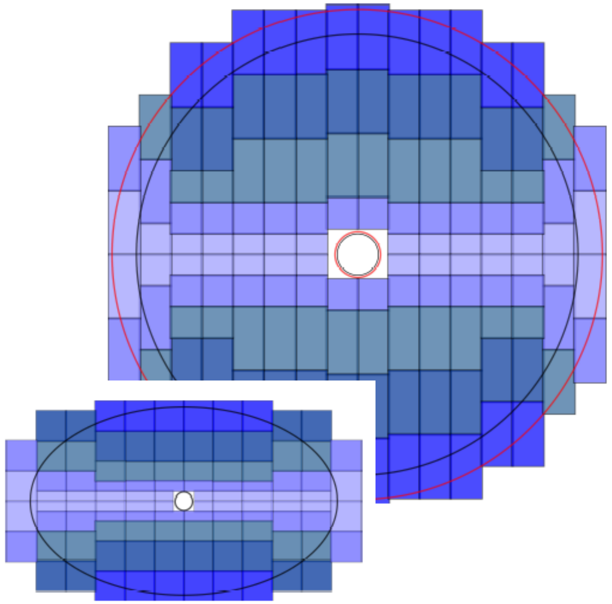



modules

ladders

CBM STS : 8 tracking stations

BM@N STS : 4 tracking stations

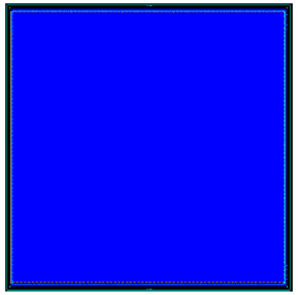


sensor:
0.3% X_0

r/o cables:
2×0.11% X_0

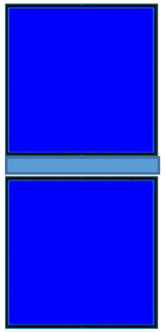
1220 sensors:

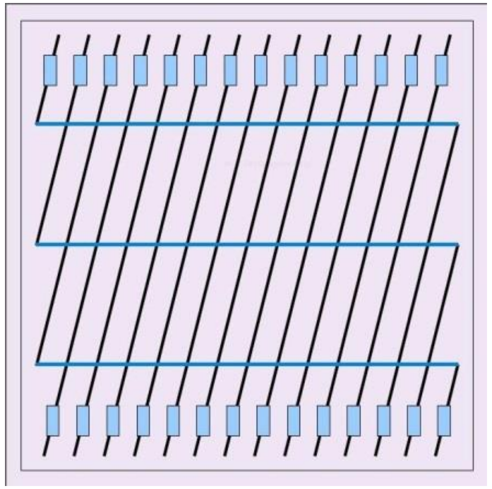
252 single /
324 daisy-pairs

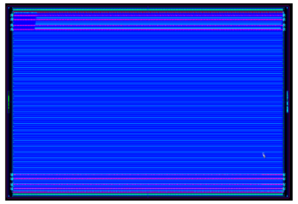


6.2 cm × 6.2 cm

900 / 220

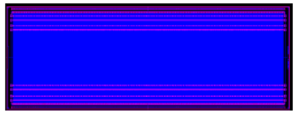






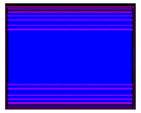
6.2 cm × 4.2 cm

260 / 216



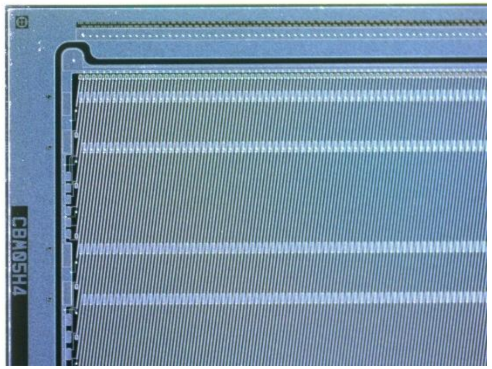
6.2 cm × 2.2 cm

60 / 60



3.2 cm × 2.2 cm

+ small number of “half” sensors



Double-sided-double-metalized sensors from Hamamatsu and CiS (pitch 58 um, stereo angle 7,5 degrees)

BM@N status and milestones

BM@N plan

technical runs with ***d, Li, C*** *beams*: **2016 – 2017;**

physics run **BM@N** *(I stage) with* ***Kr*** *int rate 20 kHz:* **IV q., 2017;**

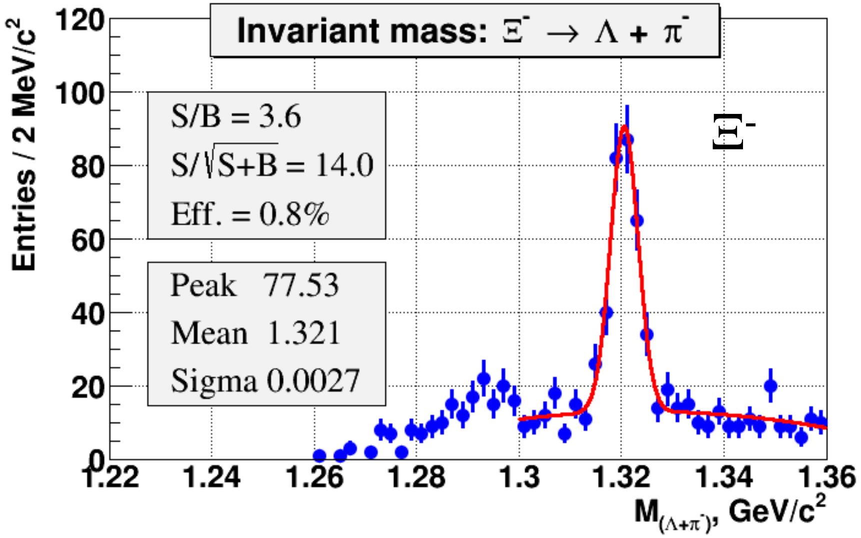
physics run **BM@N** *(II stage) with* ***Au*** *int rate 50 kHz:* **2019.**

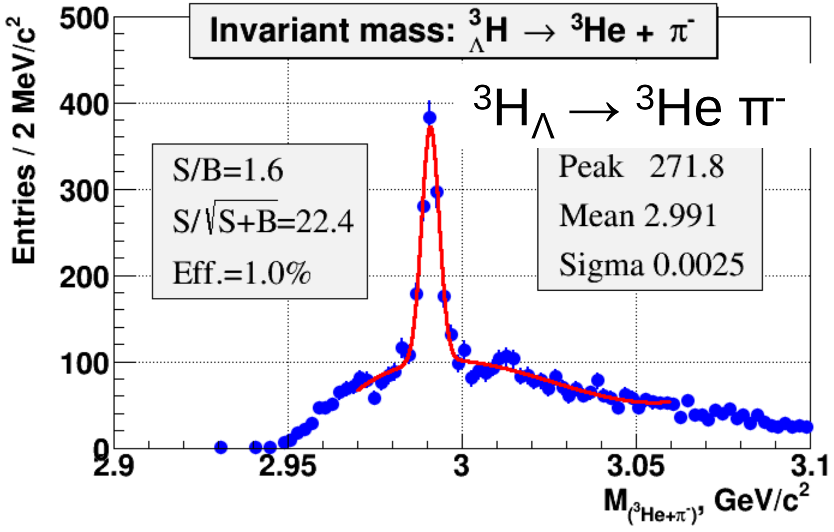
next technical run in 2016: *commissioning of GEM & Si inside magnet*

Simulation

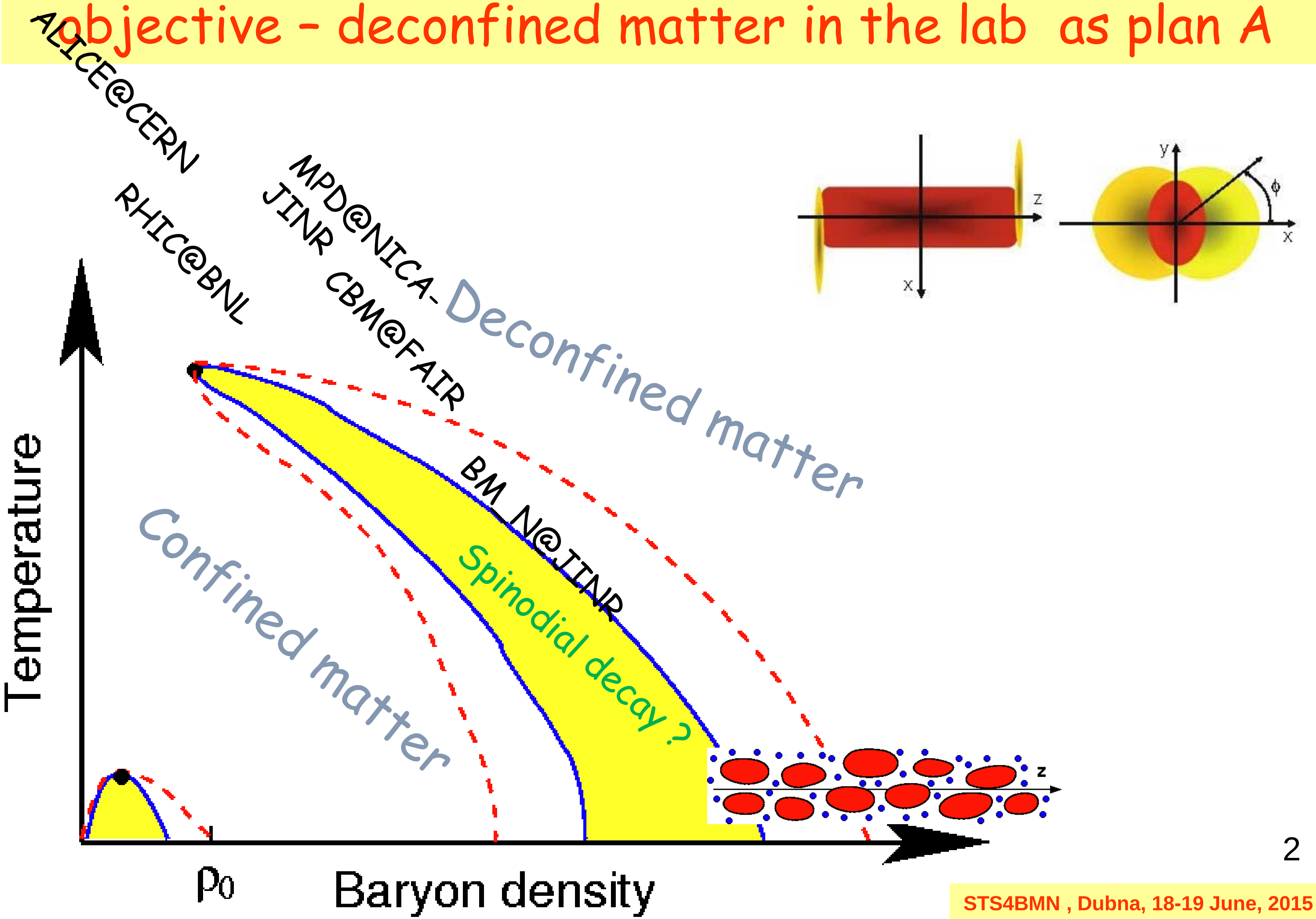
A.Zinchenko, V.Vasendina

UrQMD & DCM-QGSM, Au+Au, $E_{kin.}$ = 4.5A GeV, 2 ×10^6 events;





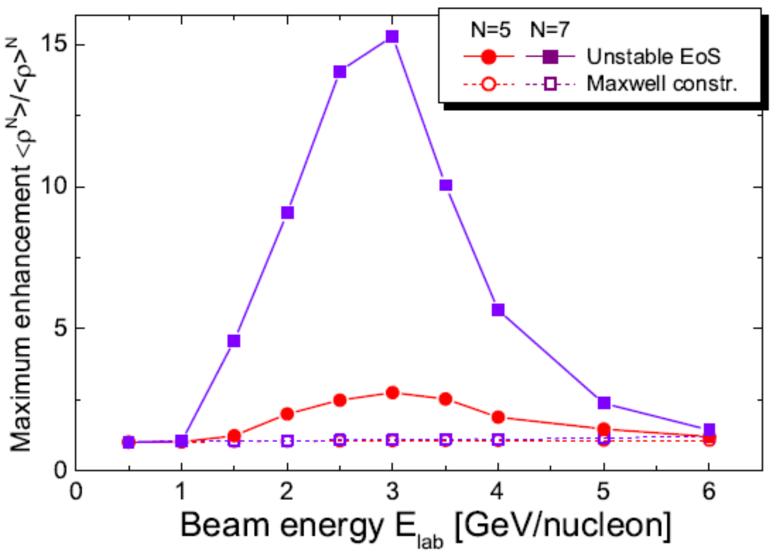
High and intermediate energy HI physics major objective – deconfined matter in the lab as plan A



Three ways to deconfinement

J.Steinheimer et al. J.of Physics: Conf.Ser., 599, 2015

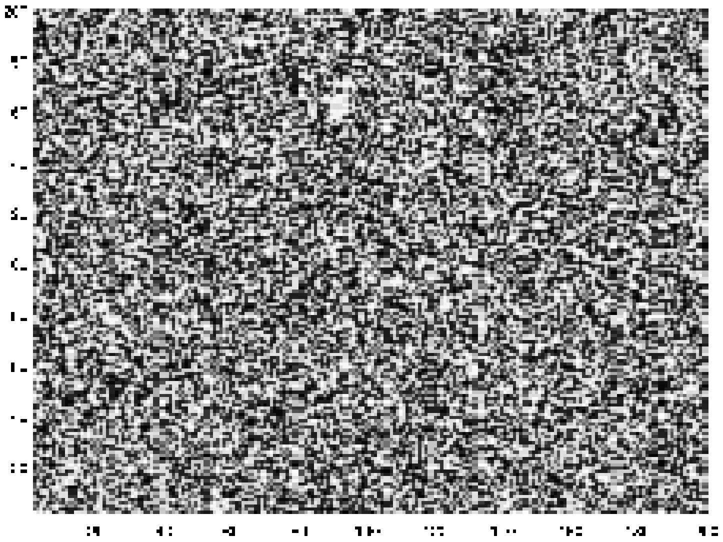
- through high energy density - no definite answer - result of the "crossover"



- "Pressing" (E≈30÷50AGeV) : Putting "the triple point" between the deconfined and confined worlds

- "formation of drops" (E≈3÷5AGeV) : th correlations within spinodial phase decomp (J.Randrup, LBL): Observable?
- (J.Aichelin, H.Gutbrod) direct producti subthreshold production of cascade particles!

Eprojectile > 3.7 AGeV : $p+p \rightarrow X^-K^+K^-p$
Eprojectile < 3.7 AGeV :
$p+p \rightarrow K^+Lp$: $LL \rightarrow X^-p$ - great sensitivity

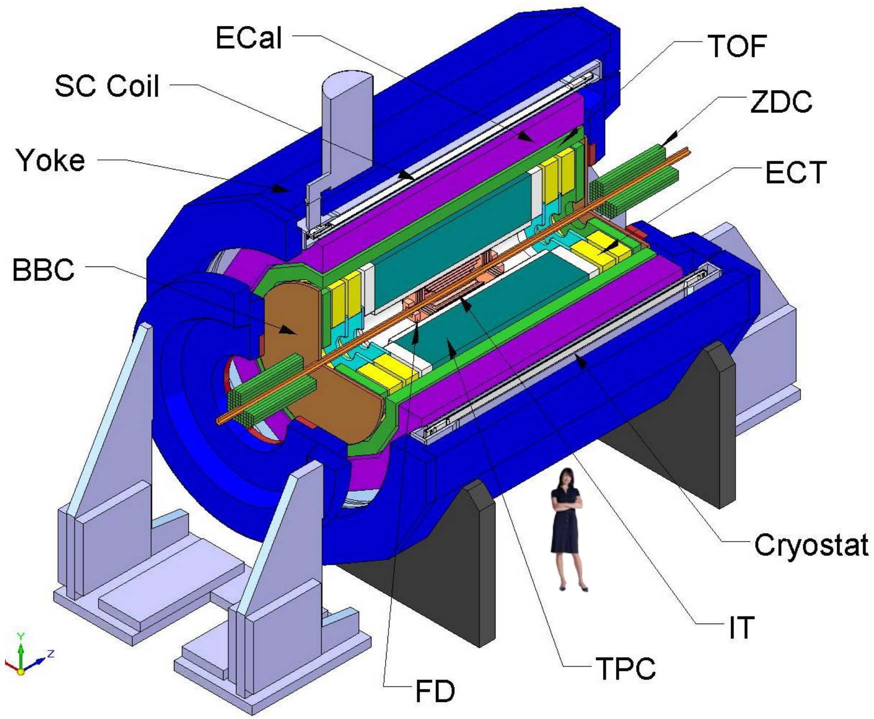


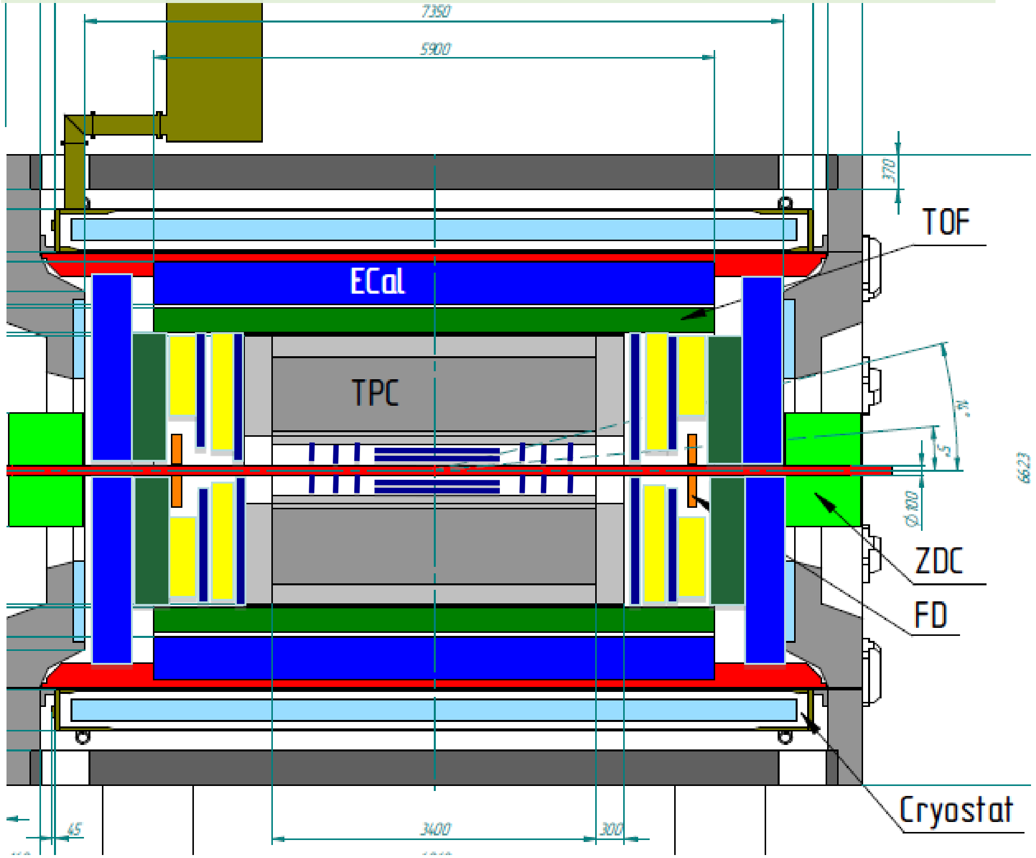
MPD detector for Heavy-Ion Collisions @ NICA

Tracking: up to |η|<2 (TPC)
PID: hadrons, e, γ (TOF, TPC, ECAL)
Event characterization:
centrality & event plane (ZDC)

Stage 1: TPC, TOF, ECAL, ZDC, FD

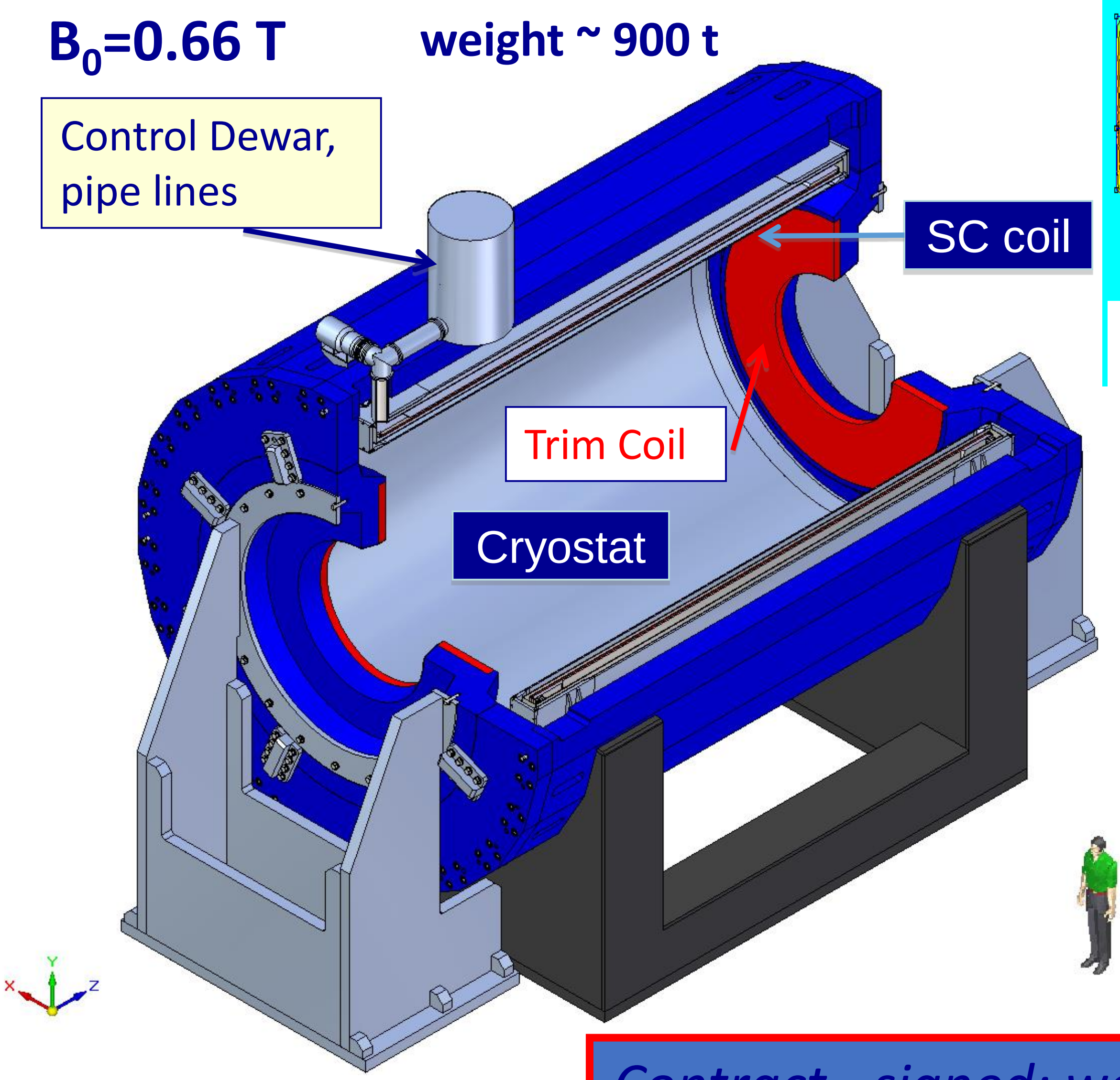
Stage 2: IT + Endcaps (tracker, TOF, ECAL)

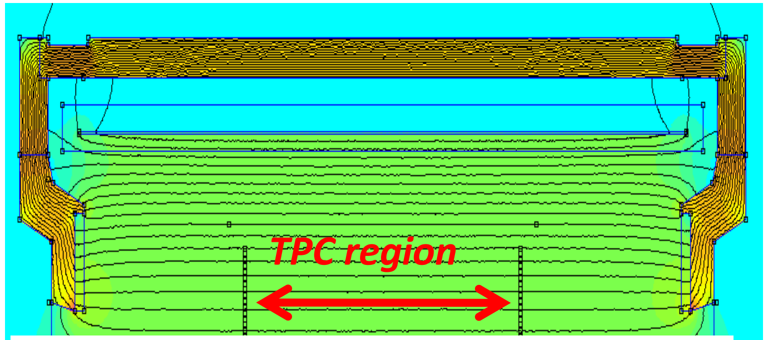




Status: *technical design and detector R&D – completed;*
Preparation for the mass production

MPD superconducting Solenoid





high level (~ 3x10^{-4}) of magnetic field homogeneity

ASG superconducting (Genova, Italy):

- *Cold Mass + Cryostat*
- *Vacuum System*
- *Trim Coils*
- *Control System*
- *PS*
- ***General responsibility***

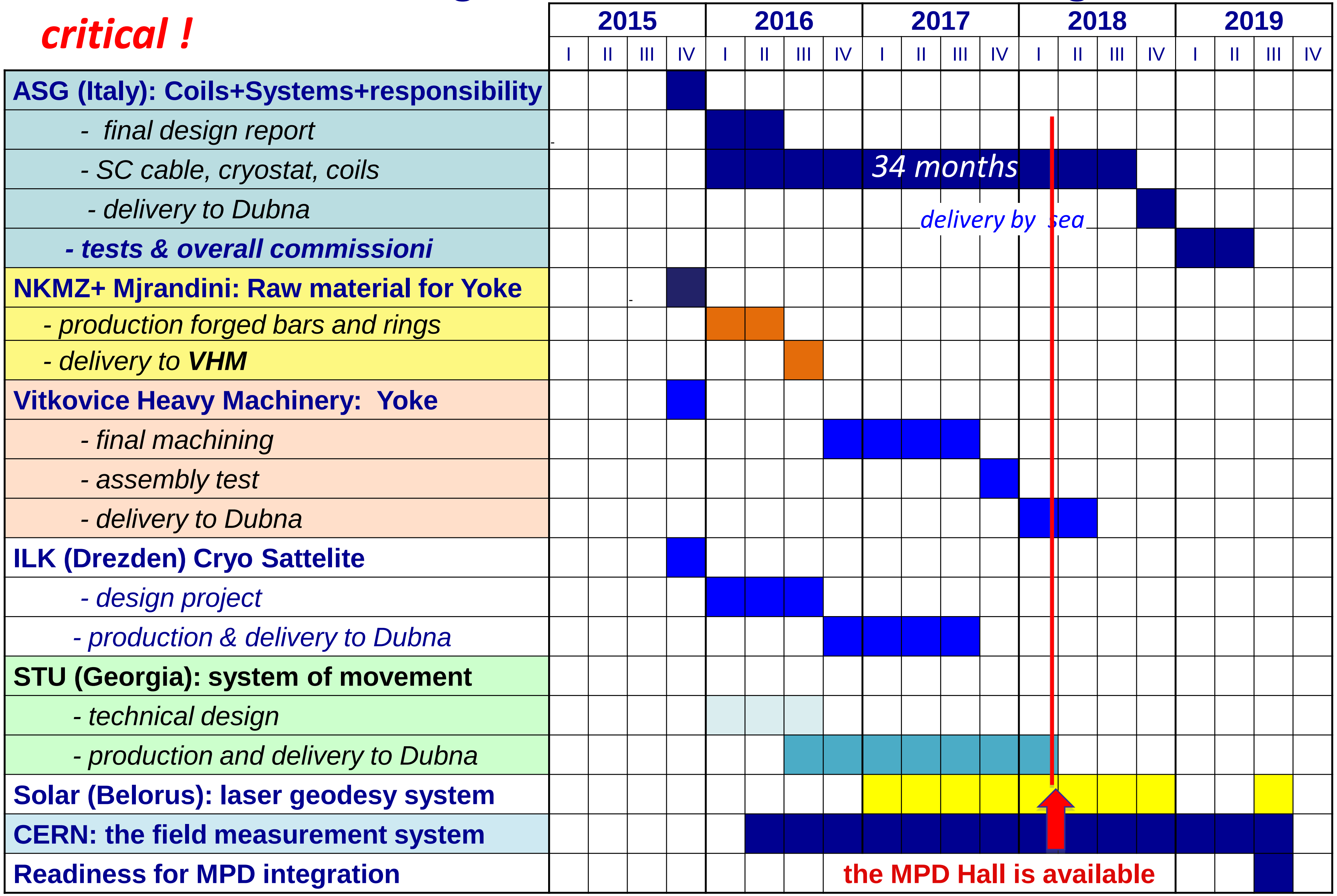
Contract - signed; works – in progress

Contract with ASG (Italy)

34 months; signed in Dec 2015

Schedule for MPD Magnet fabrication & commissioning

critical !



MAPS Inner Tracking System for ALICE LS2 Upgrade

J. Phys. G: Nucl. Part. Phys. **41** (2014) 087002 The ALICE Collaboration

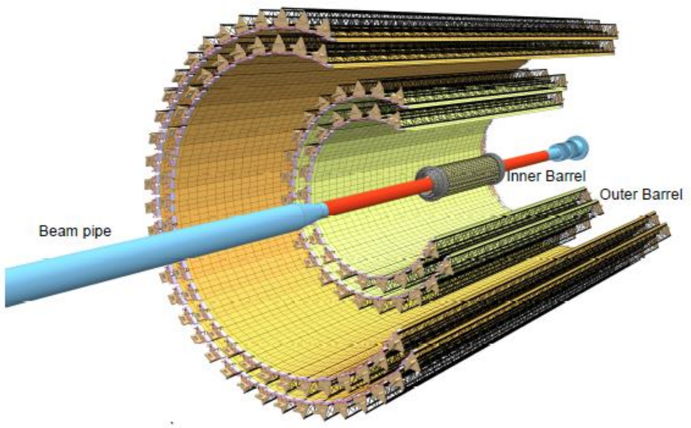


Figure 1.1: Layout of the new ITS detector.

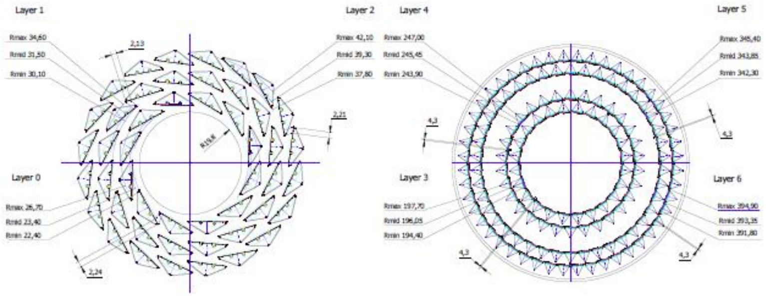
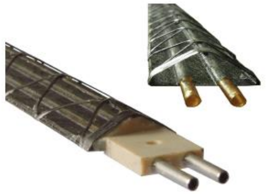


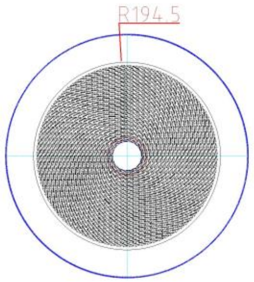
Figure 1.2: Schematic view of the cross section of the Inner Barrel (left) and Outer Barrel (right).

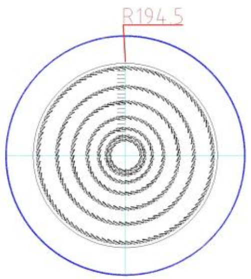
Table 1.1: Geometrical parameters of the upgraded ITS.

	Inner Barrel			Outer Barrel			
	Inner Layers			Middle Layers		Outer Layers	
	Layer 0	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
Radial position (min.) (mm)	22.4	30.1	37.8	194.4	243.9	342.3	391.8
Radial position (max.) (mm)	26.7	34.6	42.1	197.7	247.0	345.4	394.9
Length (sensitive area) (mm)	271	271	271	843	843	1475	1475
Pseudo-rapidity coverage[a]	±2.5	±2.3	±2.0	±1.5	±1.4	±1.4	±1.3
Active area (cm^2)	421	562	702	10 483	13 104	32 105	36 691
Pixel Chip dimensions (mm^2)				15 × 30			
Nr. Pixel Chips	108	144	180	2688	3360	8232	9408
Nr. Staves	12	16	20	24	30	42	48
Staves overlap in $r\phi$ (mm)	2.23	2.22	2.30	4.3	4.3	4.3	4.3
Gap between chips in z (μm)				100			
Chip dead area in $r\phi$ (mm)				2			
Pixel size (μm^2)		(20 – 30) × (20 – 30)			(20 – 50) × (20 – 50)		

[a] The pseudorapidity coverage of the detector layers refers to tracks originating from a collision at the nominal interaction point ($z = 0$).

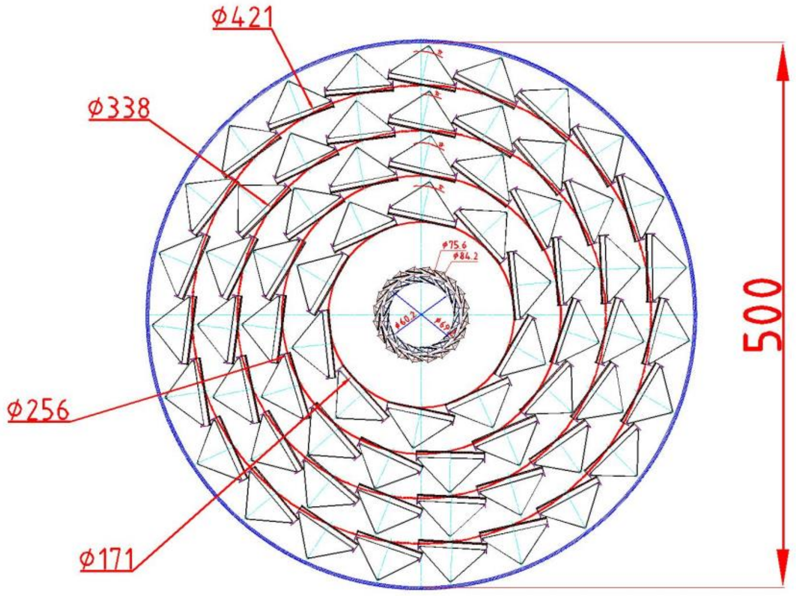


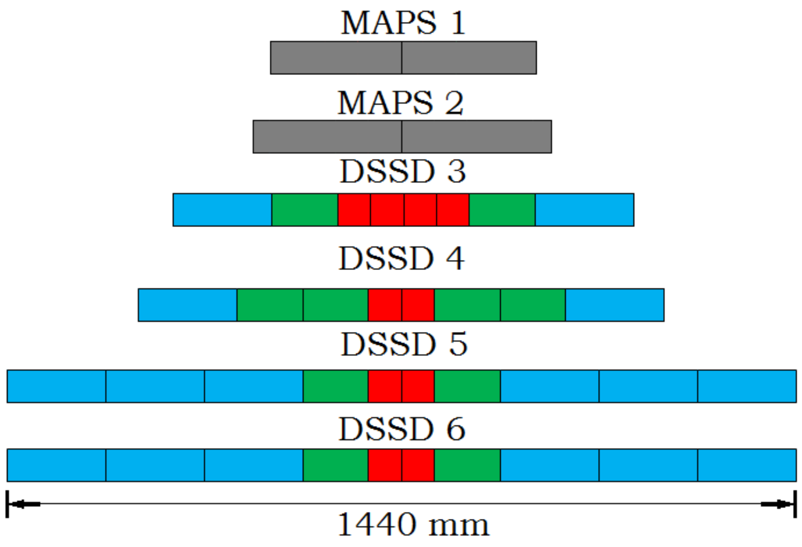




Leader: *Luciano Musa*

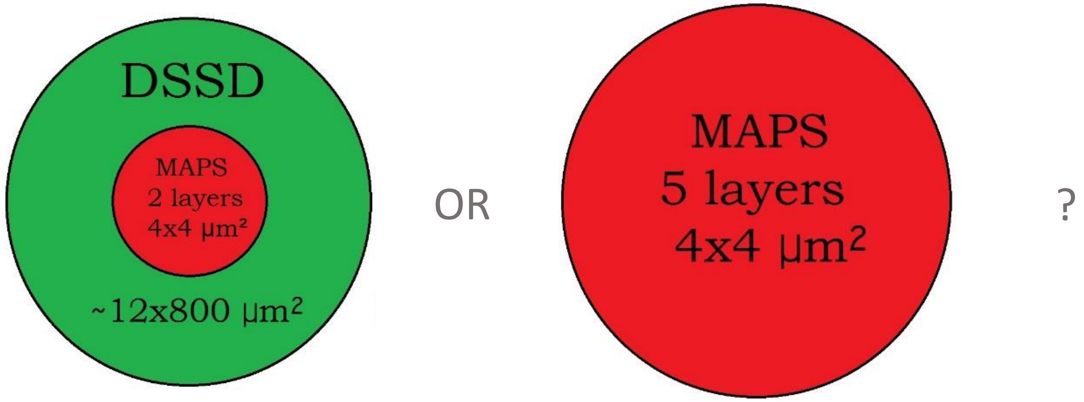
MAPS-DSSD or MAPS only? An attempt to keep synergy with CBM





MAPS budget: 0.3% X_0

DSSD budget: 0.3% - 1.2 %X_0



2 layers of ALICE ITS MAPS inner layers of double length

4 layers of DSSD with readout through long (up to 100 cm) (a call for ASIC development)

MAPS-DSS ITS MPD

Layer	Type	r, cm*	+-z	Area, m**2	Ladders	Det/Lad	Tot. Channels	Legend
1	MAPS	32,0	27,1	0,0562	16	9	93,6 M	2-d ALICE ITS-2
2	MAPS	39,0	27,1	0,0702	20	9	117,0 M	3-d ALICE ITS-2
3	DSSD	85,5	60,0	0,720	10	20	205 K (**)	2-d MPD ITS-1
4	DSSD	128,0	66,0	1,190	15	22	338 K (**)	3-d MPD ITS-1
5	DSSD	169,0	100,9	1,642	19	24	467 K (**)	4-h MPD ITS-1
6	DSSD	210,0	100,9	1,987	23	24	565 K (**)	6-d MPD ITS-1
TOT				4,812			212 M	

MPD-ITS Layout

*) measured from the beam line to the center of the active area
**) every second strip read-out

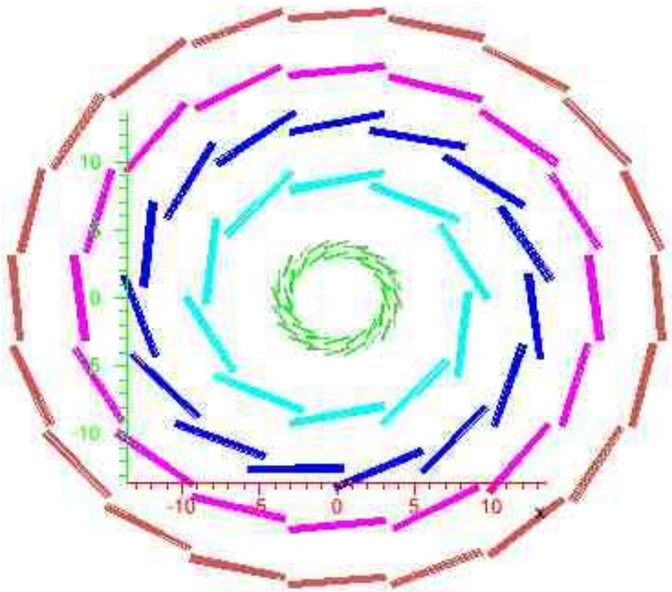
Sensor Layers Description

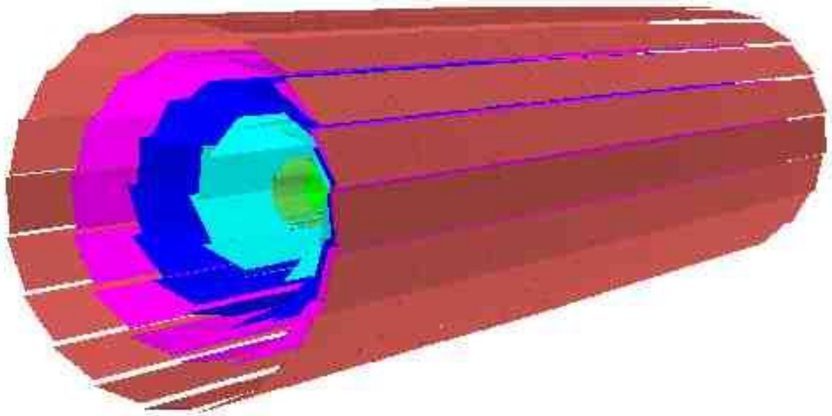
MAPS: 15x30 mm^2, 2 mm dead area at long edge is hidden in a turbine

Sensor: 20x30 um pixels, thickness – 50 um.

CBM DSSD: 62x62 mm^2, 1 mm dead area around active area is hidden in a tile along the ladder (z) and in a turbine in (r-φ)

MPD ITS Geometrical Model (V.P.Kondratyev, SPbSU, SpB)

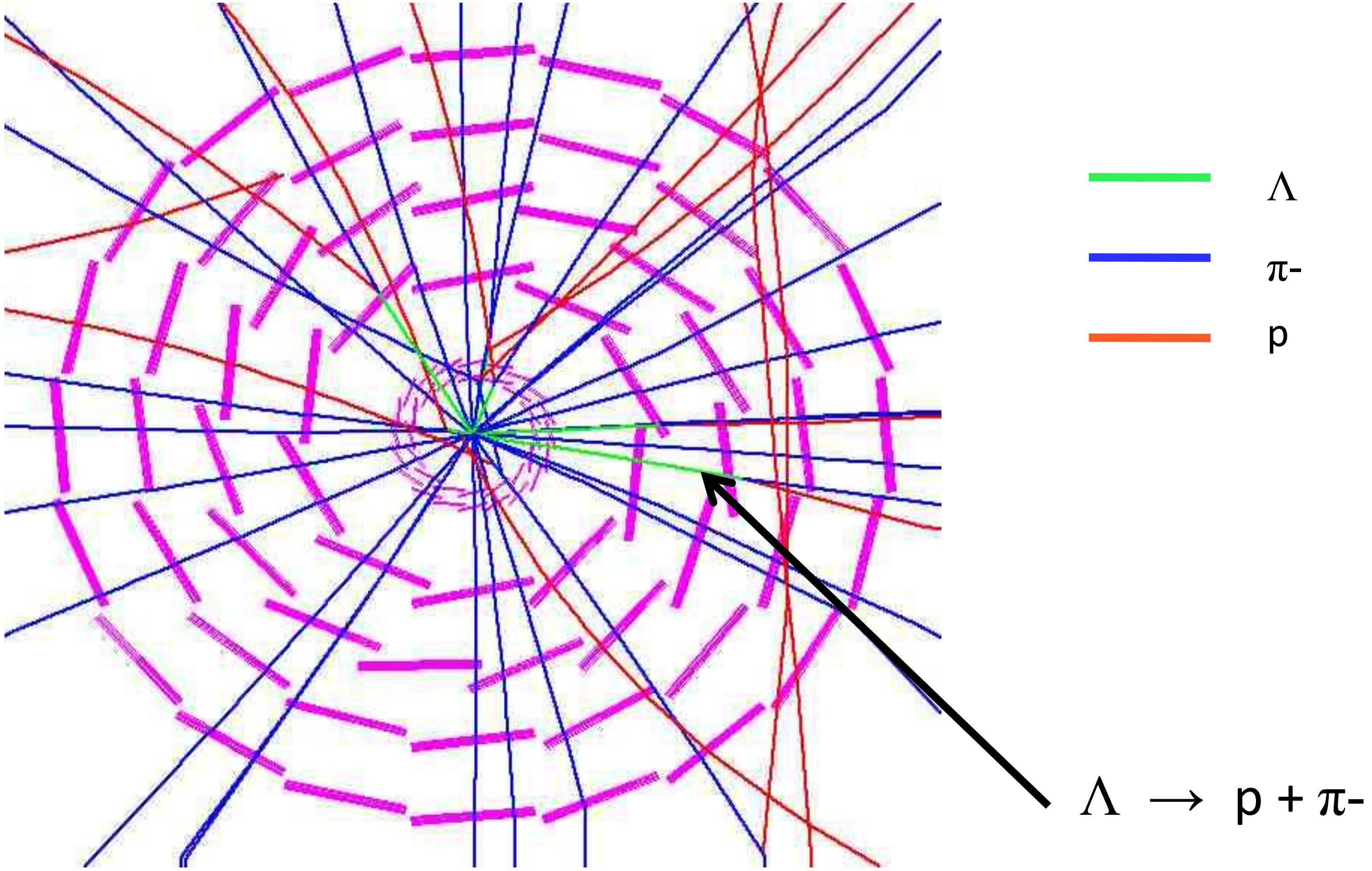




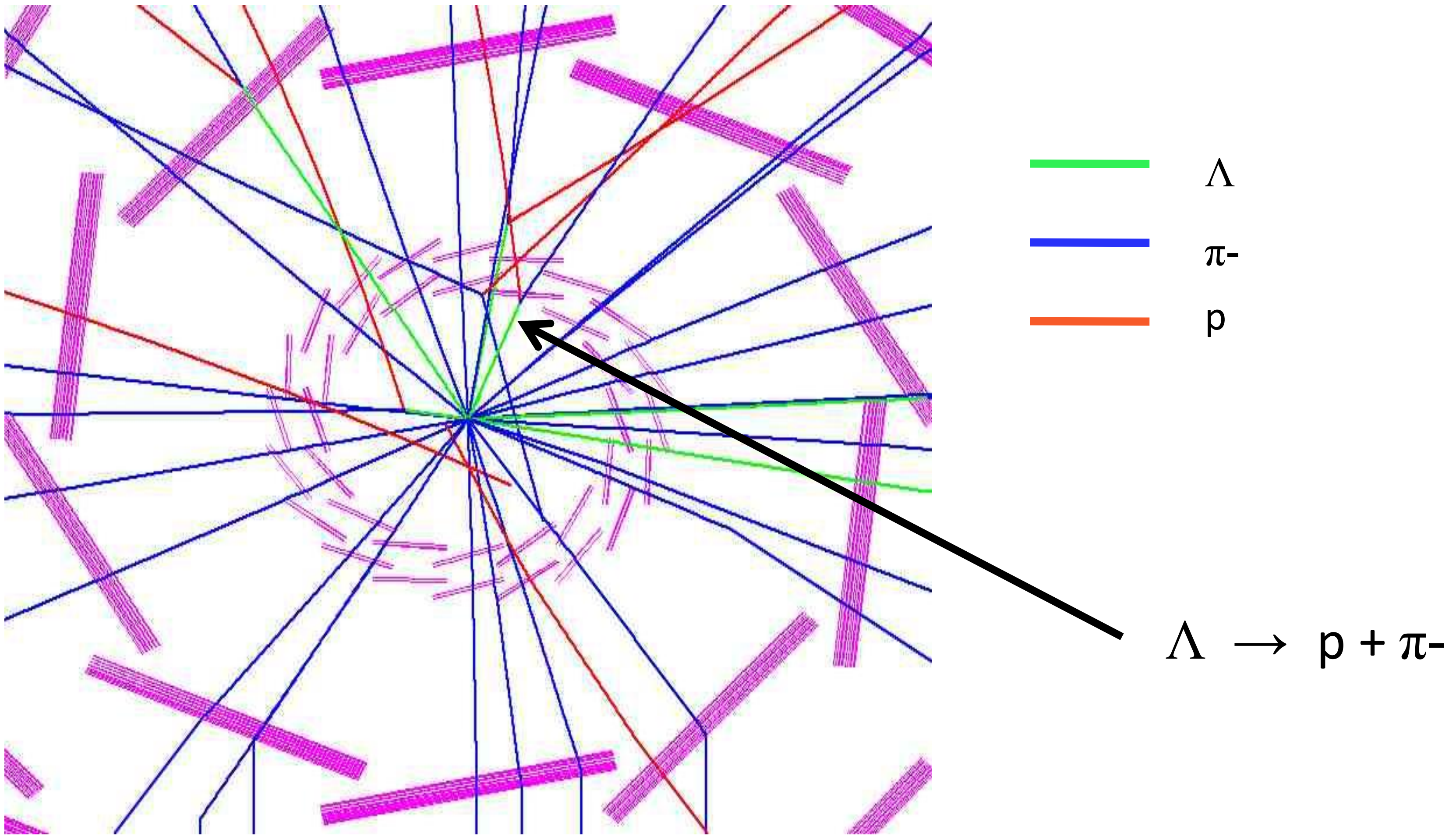
ITS comprises six layers of position sensitive Si sensors as follows

1) 2 Inner Layers of Monolithic Active Pixel Sensors (MAPS)
2) 4 Outer Layers of Double-Sided Silicon Detectors (DSSD)

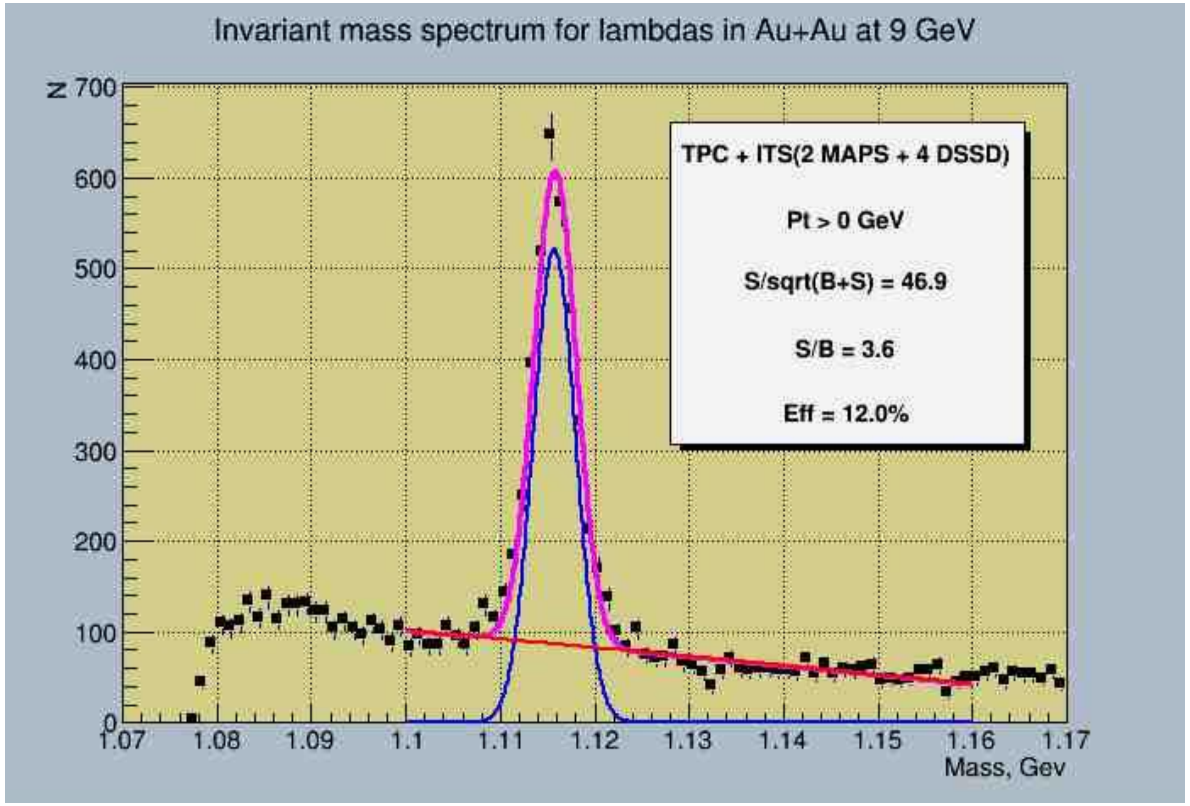
Long-range Λ-hyperons in central √S=10 GeV Au+Au collisions

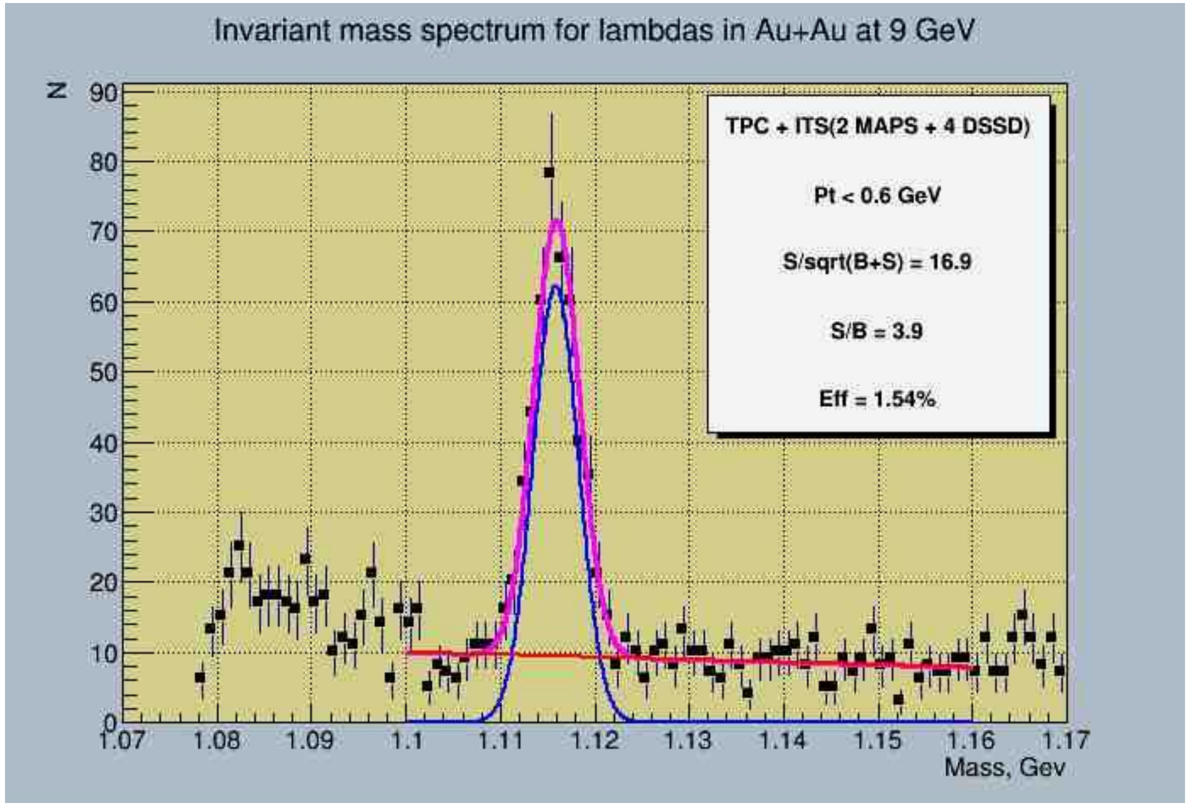


Short-range Λ-hyperons in central √S=10 GeV Au+Au collisions



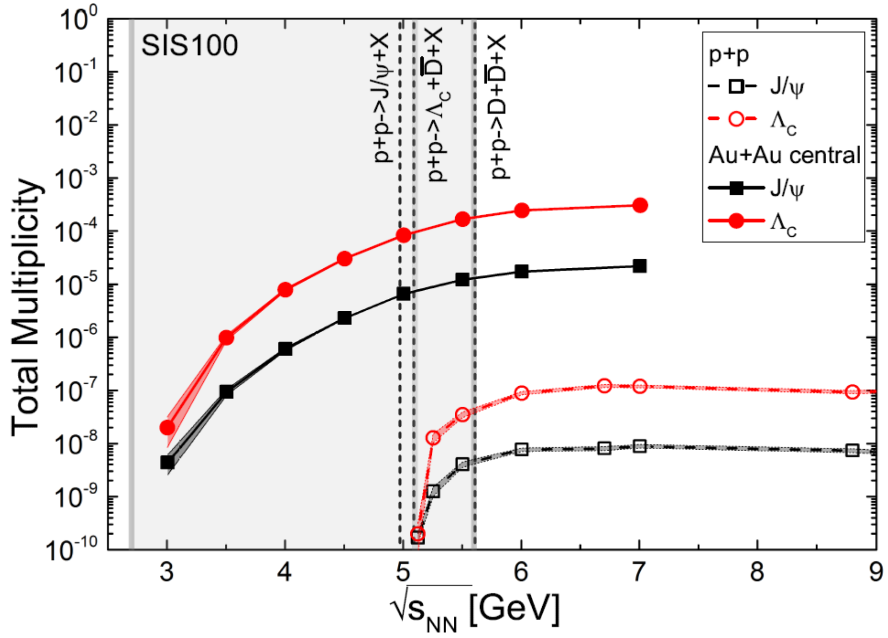
Λ-hyperon invariant mass spectrum $p_t > 0$ and $p_t > 0.6$ GeV/c



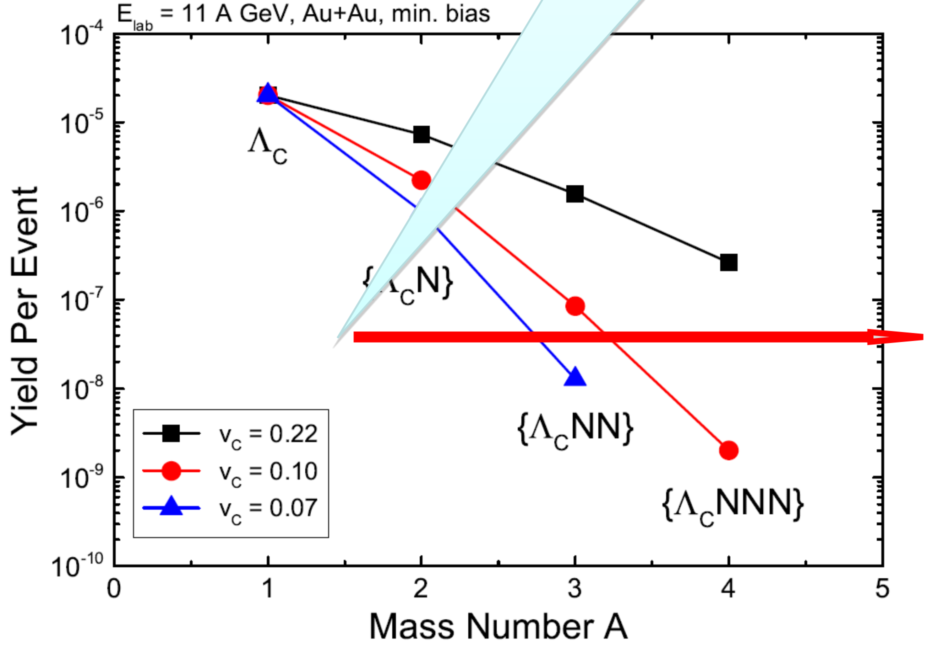


Super-nuclei hunt at NICA

J.Steinheimer et al. arXiV:1605.034039, May 11, 2016



Sensitivity to super-nuclei decays at maximum INICA uminosity of Au-Au Collisions

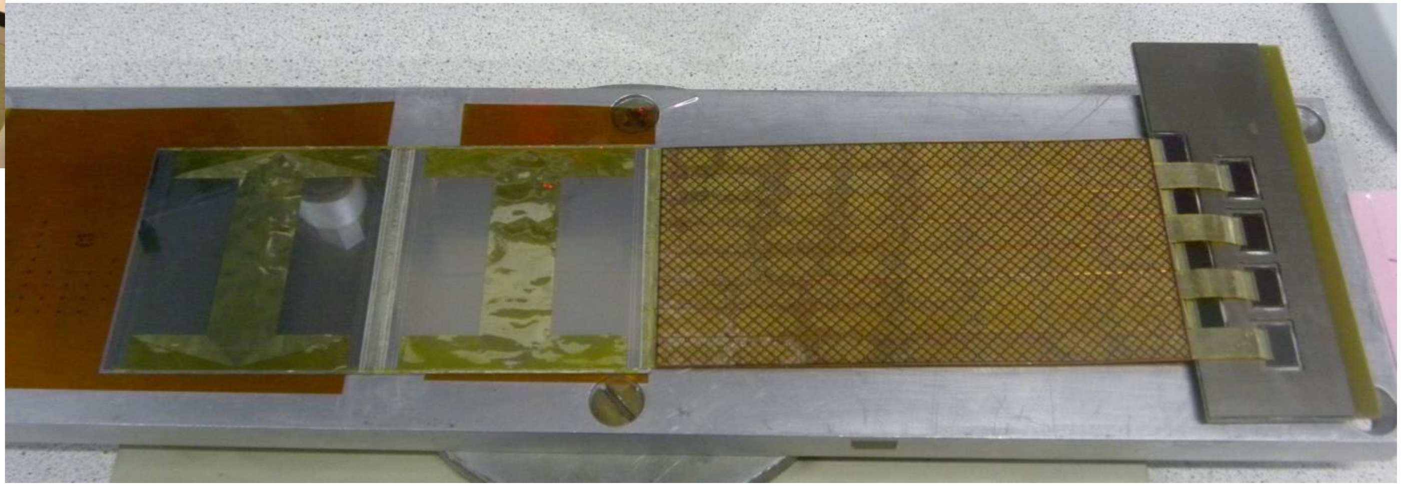


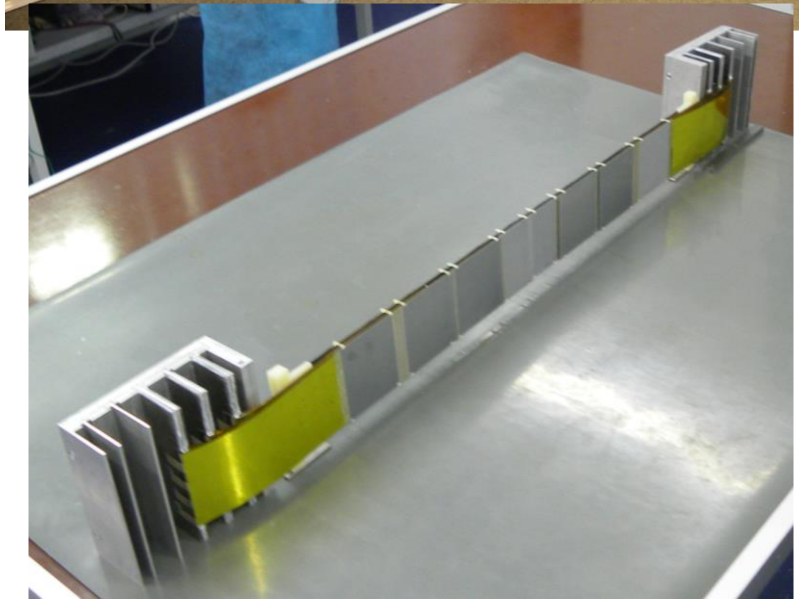
Process	Threshold Energy [GeV]
$p + p \to p + p + J/\psi$	4.973
$p + p \to N + \Lambda_c + \overline{D}$	5.096
$p + p \to N + N + D + \overline{D}$	5.611

GSI-JINR project on infrastructure develpoment

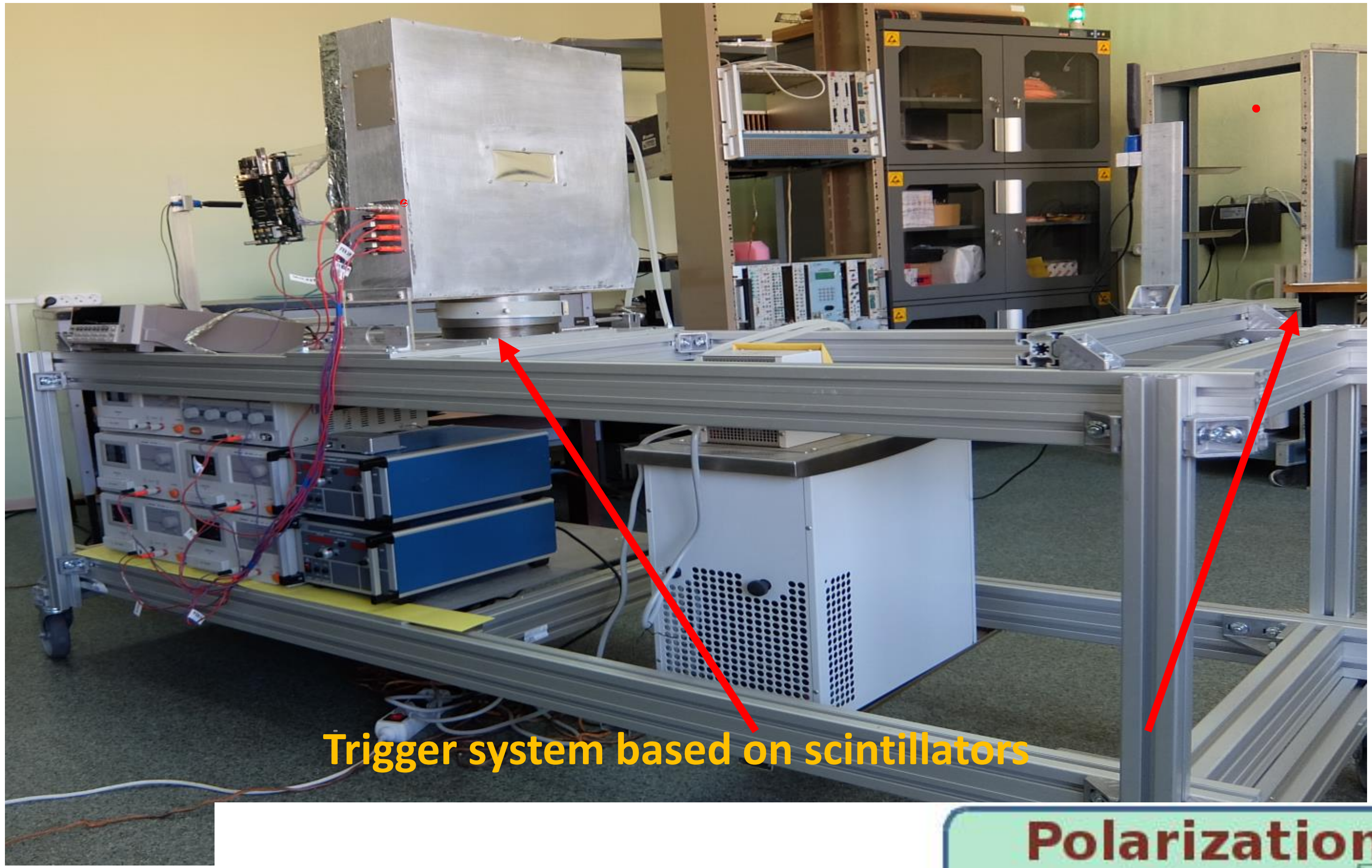
Our guests

The first shift and items manufactured





Perspectives for the in-beam tests at Nuclotron

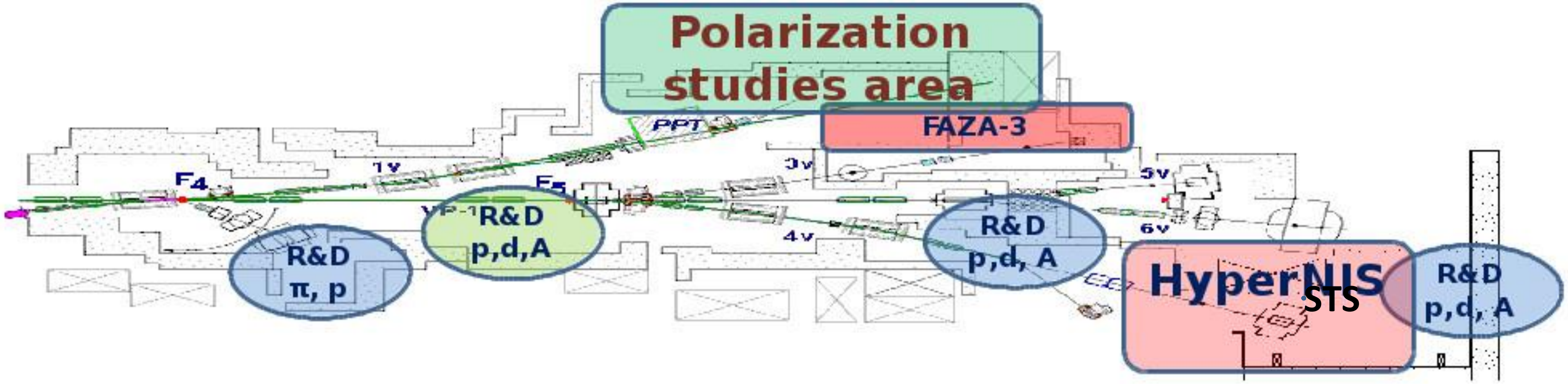


Remotly controled:

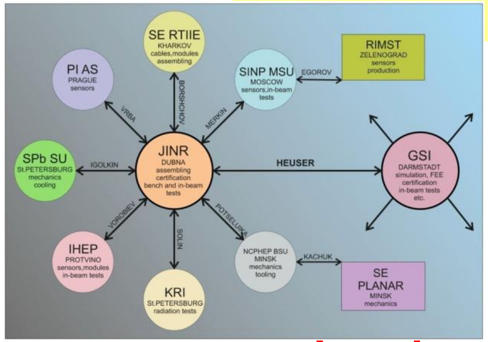
Low voltage power suppliers:
AKTAKOM APS 3320L

High voltage power supplier:
Keythley 6487

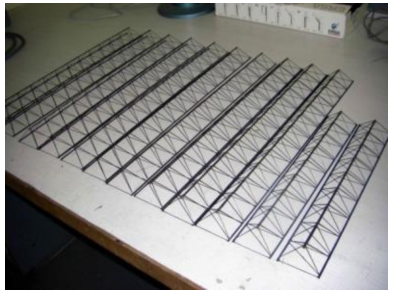
Water cooler
Lauda Alpha ra8



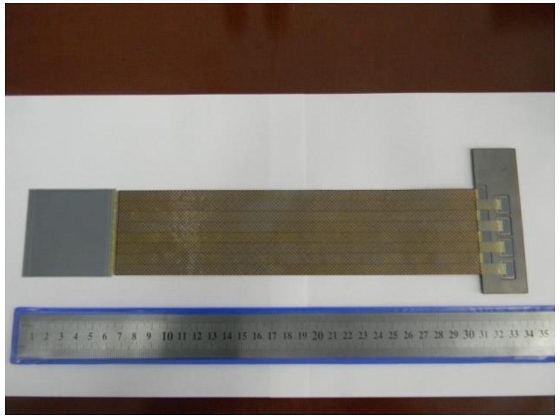
Chronology of Achievements



Organization of STS Consortium of teams in JINR-member countries (2008-2013)



Technological advance in Ultra-light (14 g/m) carbon Fiber Mechanics by Igolkin (2008-13)



Technological advance in the highest assembling density of module circuits based on TAB-bonding technology by Borshchov team sensor and cable design (2012-14)

Module assembly laboratory as a joint JINR-GSI effort (2014-15)

Welcome to NICA !

Thanks to G.Trubnikov , V.Kekelidze and J.Heuser for slides and the the audience for attention!