Dedicated to the memory of
Alexei Sissakian

NICA / MPD - status & challenges

JINR accelerator facility to study DBM

V.Kekelidze at 108 SC JINR 23 September 2010

Introduction

The JINR Committee of Plenipotentiary (CP) approved the 7-y Plan for the development of JINR, based on concentration of resources for updating the accelerator & reactor base of the Institute

The CP also supported the efforts being taken towards integration of the JINR basic facilities into the common European research infrastructure

The project NICA/MPD
(Nuclotron based Ion Collider fAcility & Multi Purpose Detector)
aimed to study of hot & dense baryonic matter (DBM)
& spin physics with polarized protons & deutrons
- is the JINR flagship project in HEP

It was initiated & led by **A.N.Sissakian**

Introduction

- **the study of DBM could provide us with information on**

  -in-medium properties of hadrons

  & nuclear matter equation of state (EOS)

  -onset of deconfinement (OD) & chiral symmetry restoration (CSR),

  -phase transition, mixed phase & critical end-point (CEP)

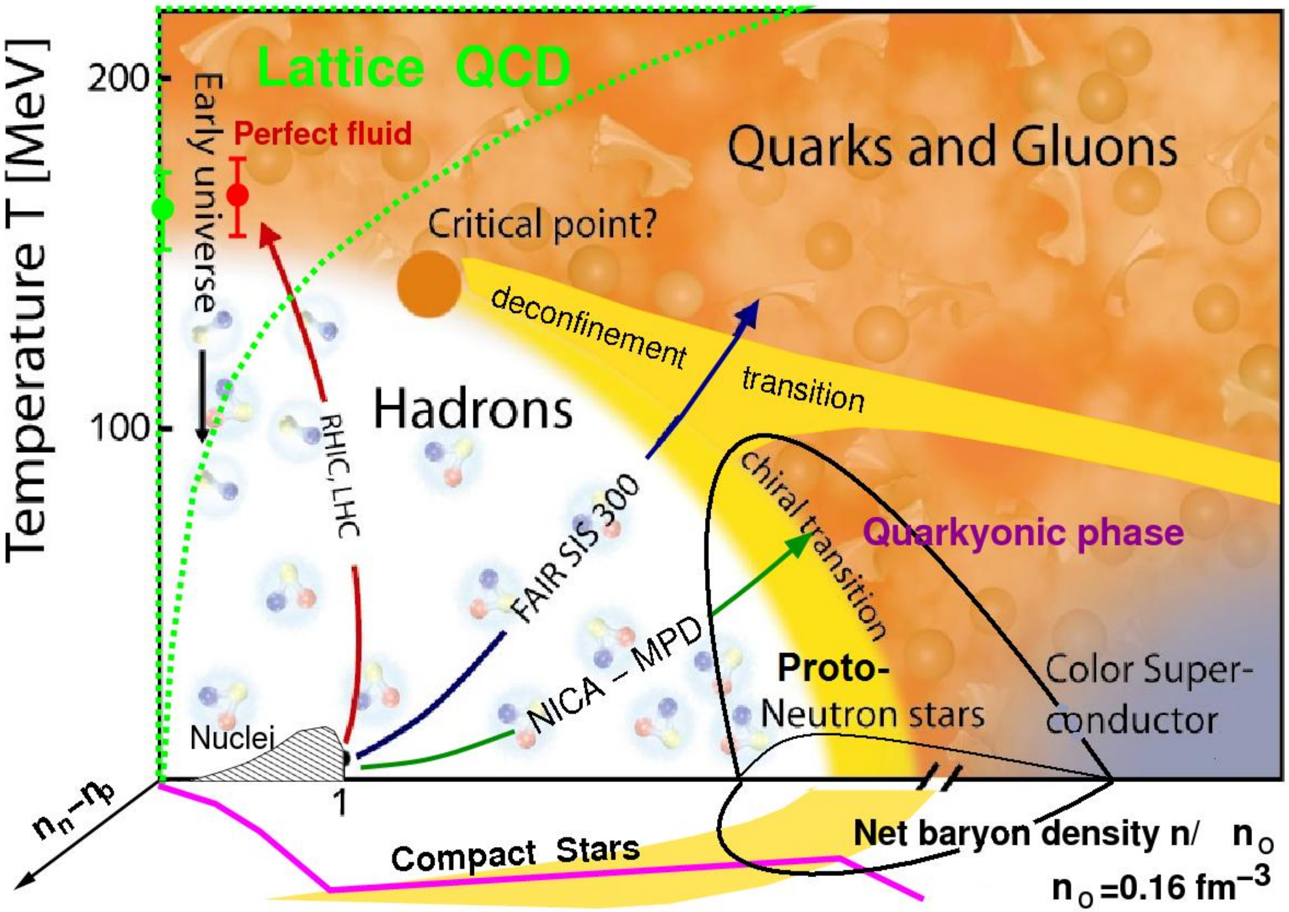
  -possible local parity violation in strong interaction (LPV)

- **the study of spin physics is aimed**
  - ***to shed light on the origin of spin***
  - ***to define the nucleon spin structure***

NICA/MPD physics

Creation of deconfined QGP state in HI collisions, study of fundamental properties of QCD in various regions of QCD PD

QCD phase diagram



Optimal energy region

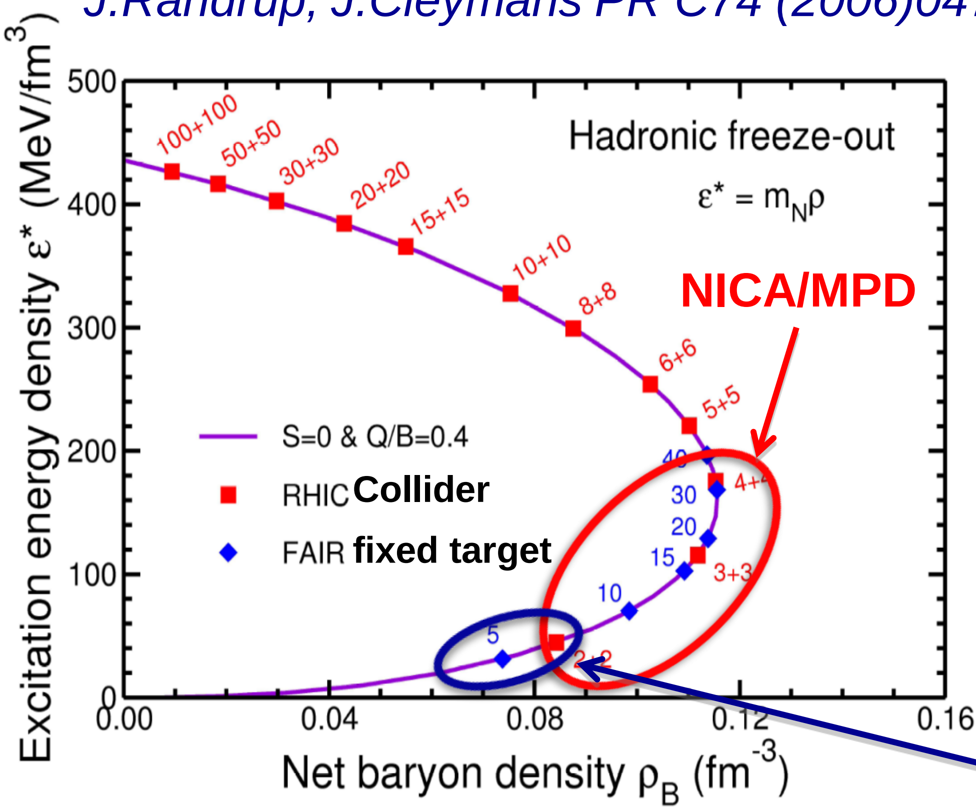
J.Cleymans, M. Gazdzicki, M. Gorenstein , J.Randrup, A.Sissakian, A.Sorin, V. Toneev, G. Zinovjev & others: **to reach the highest possible baryon density**

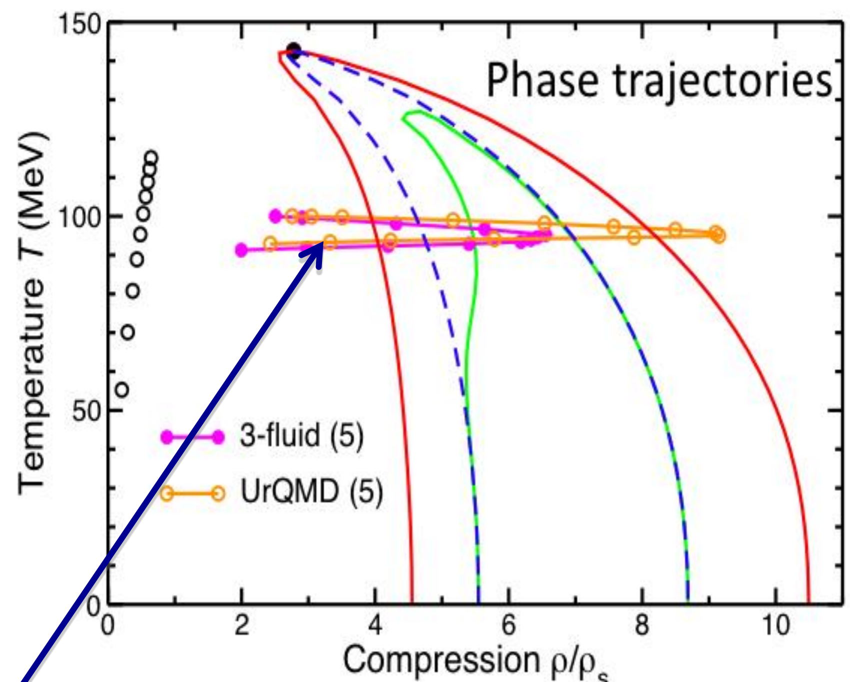
→ **heavy ion collision at $\sqrt{S_{NN}}$ = 4 - 11 GeV/u**

Baryon density in A+A collisions

J.Randrup, J.Cleymans PR C74 (2006)047901.

J.Randrup, CPOD2010





Nuclotron energies

Critical point and onset of deconfinement - CPOD-2010

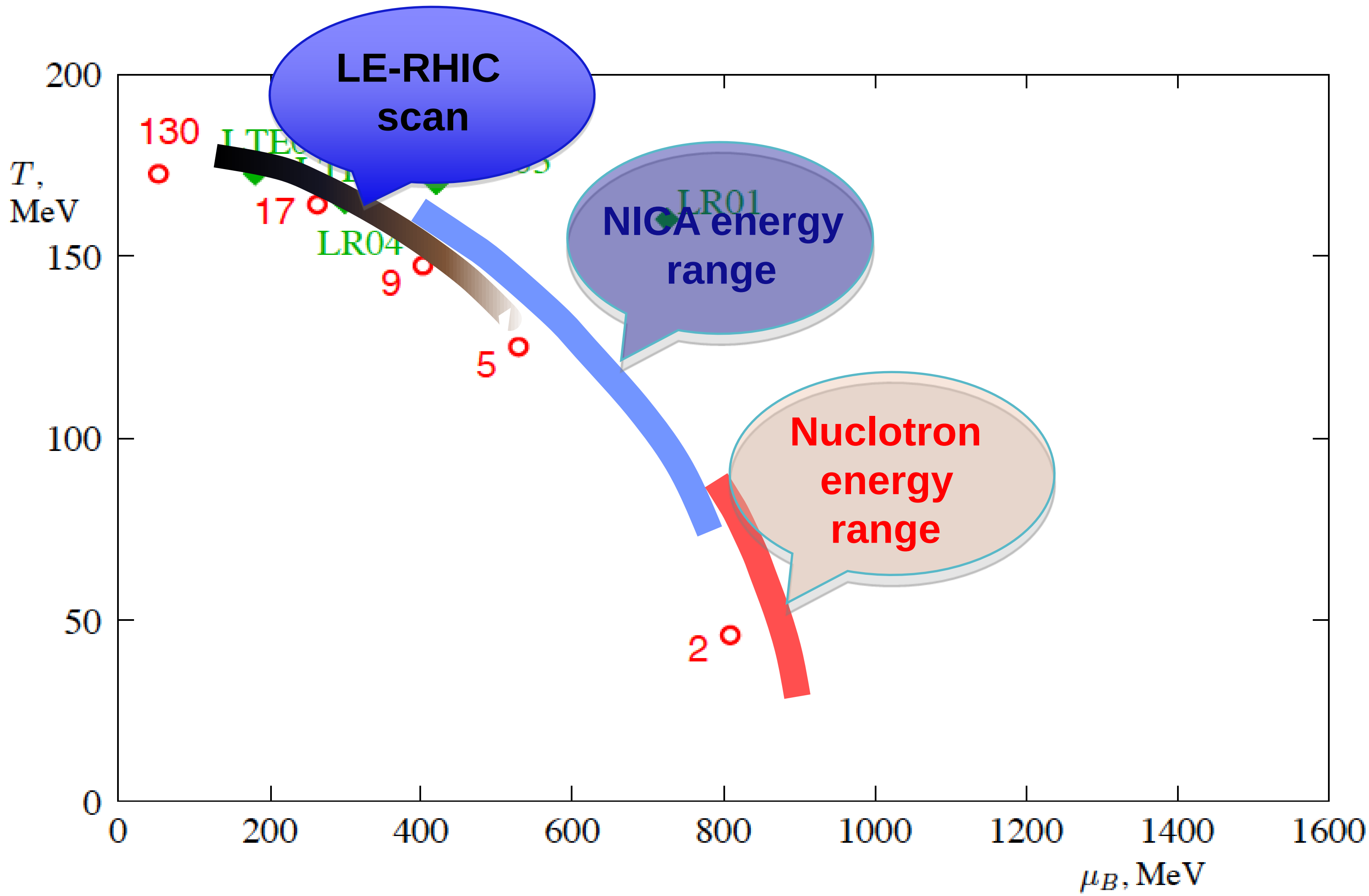
22-29 August, 2010, Dubna

- *very fruitful discussions on the **NICA/MPD** program have indicated a great interest of the community to **this project***
- *an importance of experiments at **Nuclotron** was emphasized*

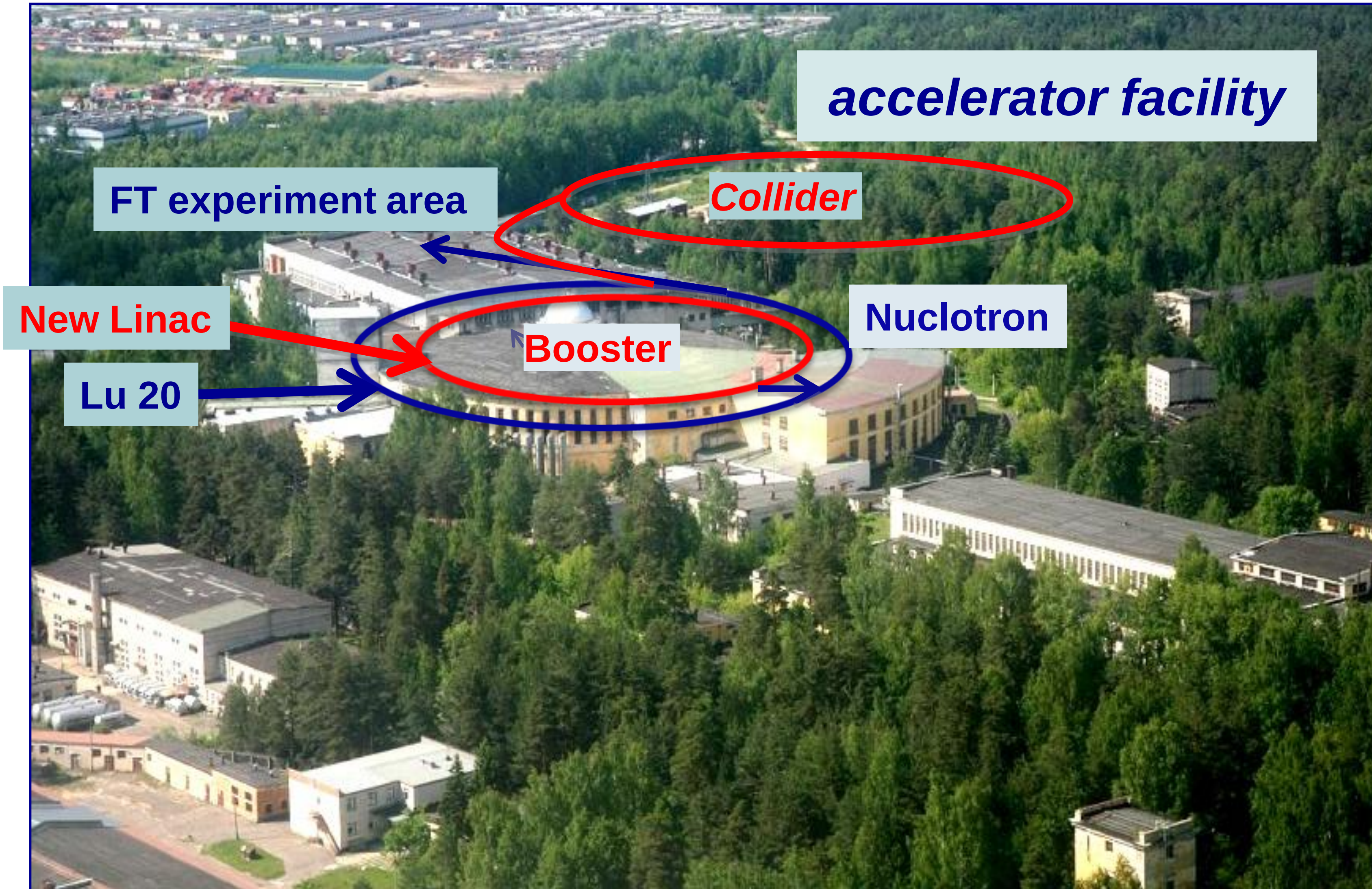
- *essential contribution to the **NICA White Book** (**114** authors,**19** countr.)*

Available energy regions

& its extension



Veksler & Baldin Laboratory of High Energy Physics



Nuclotron

- JINR HEP basic facility, *in operation since* **'93**
- based on the unique technology of **super-conducting fast cycling magnets** *developed in JINR*
- provides proton, **polarized** deuteron & **multi charged** ion beams

Parameter	design	obtained
Accelerated ions	1<Z<92	1<Z<42
Energy, GeV/amu	6,A/Z=2	5.2
Magnetic field, T	2.0	1.8
Inj. Ener. MeV/amu	5	5
Vacuum pressure,Torr	$1\cdot10^{-7}$	$2\cdot10^{-9}$
cold chamber	$1\cdot10^{-10}$	$1\cdot10^{-10}$
Repetition rate, (Hz)	0,5	0,2
Field ramp rate, (T/s)		
stand testing	4	2
in the ring	4,1	1,0

Nuclotron development plans:

- **Nuclotron-M** *(vac., PS, orbit corr.)* **2010**
- **Nuclotron-N** *(Krion-6, LU-20, RF)* **2012**
- **Nuclotron-N*** *(New Linac, Booster)* **2013**

Beam	Nuclotron beam intensity (particle per cycle)		
	Current	Ion source type	New ion source + booster **(2013)**
p	$3 \cdot 10^{10}$	Duoplasmotron	$5 \cdot 10^{12}$
d	$3 \cdot 10^{10}$	--- ,, ---	$5 \cdot 10^{12}$
^{4}He	$8 \cdot 10^{8}$	--- ,, ---	$1 \cdot 10^{12}$
d↑	$2 \cdot 10^{8}$	ABS (“Polaris”)	$1 \cdot 10^{10}$ *(SPI)*
^{7}Li	$8 \cdot 10^{8}$	Laser	$5 \cdot 10^{11}$
^{11,10}B	$1 \cdot 10^{9,8}$	--- ,, ---	
^{12}C	$1 \cdot 10^{9}$	--- ,, ---	$2 \cdot 10^{11}$
^{24}Mg	$2 \cdot 10^{7}$	--- ,, ---	
^{14}N	$1 \cdot 10^{7}$	ESIS (“Krion-2”)	$5 \cdot 10^{10}$
^{24}Ar	$1 \cdot 10^{9}$	--- ,, ---	$2 \cdot 10^{11}$
^{56}Fe	$2 \cdot 10^{6}$	--- ,, ---	$5 \cdot 10^{10}$
^{84}Kr	$1 \cdot 10^{4}$	--- ,, ---	$1 \cdot 10^{9}$
^{124}Xe	$1 \cdot 10^{4}$	--- ,, ---	$1 \cdot 10^{9}$
^{197}Au	-	--- ,, ---	$1 \cdot 10^{9}$

Heavy Ion Mode: Operation Regime & Parameters

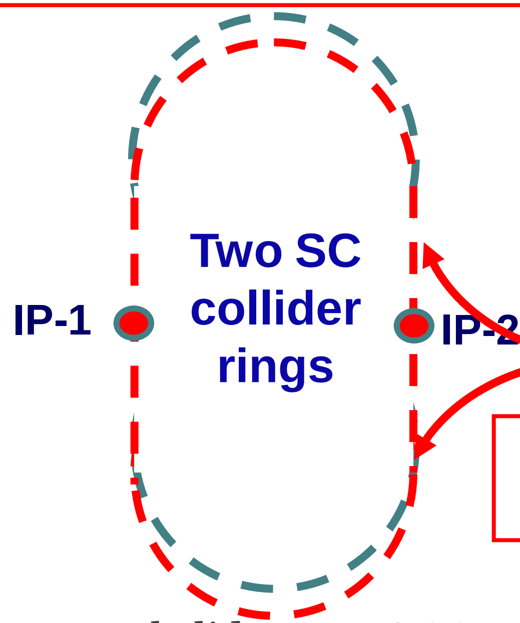
(preliminary)

Injector: 2×10⁹ ions/pulse of $^{197}Au^{32+}$ at 6.2 MeV/u

Collider (45 Tm)
Storage of
26 bunches by ~ 1x10⁹ ions per ring
at 1 - 4.5 GeV/u,
electron and/or stochastic cooling

Booster (25 Tm)
1(2-3) single-turn injection,
storage of 2□(4-6)×10⁹,
acceleration up to 100 MeV/u,
electron cooling, acceleration
up to 600 MeV/u

Stripping (80%) $^{197}Au^{32+}$ => $^{197}Au^{79+}$



2x26 injection cycles

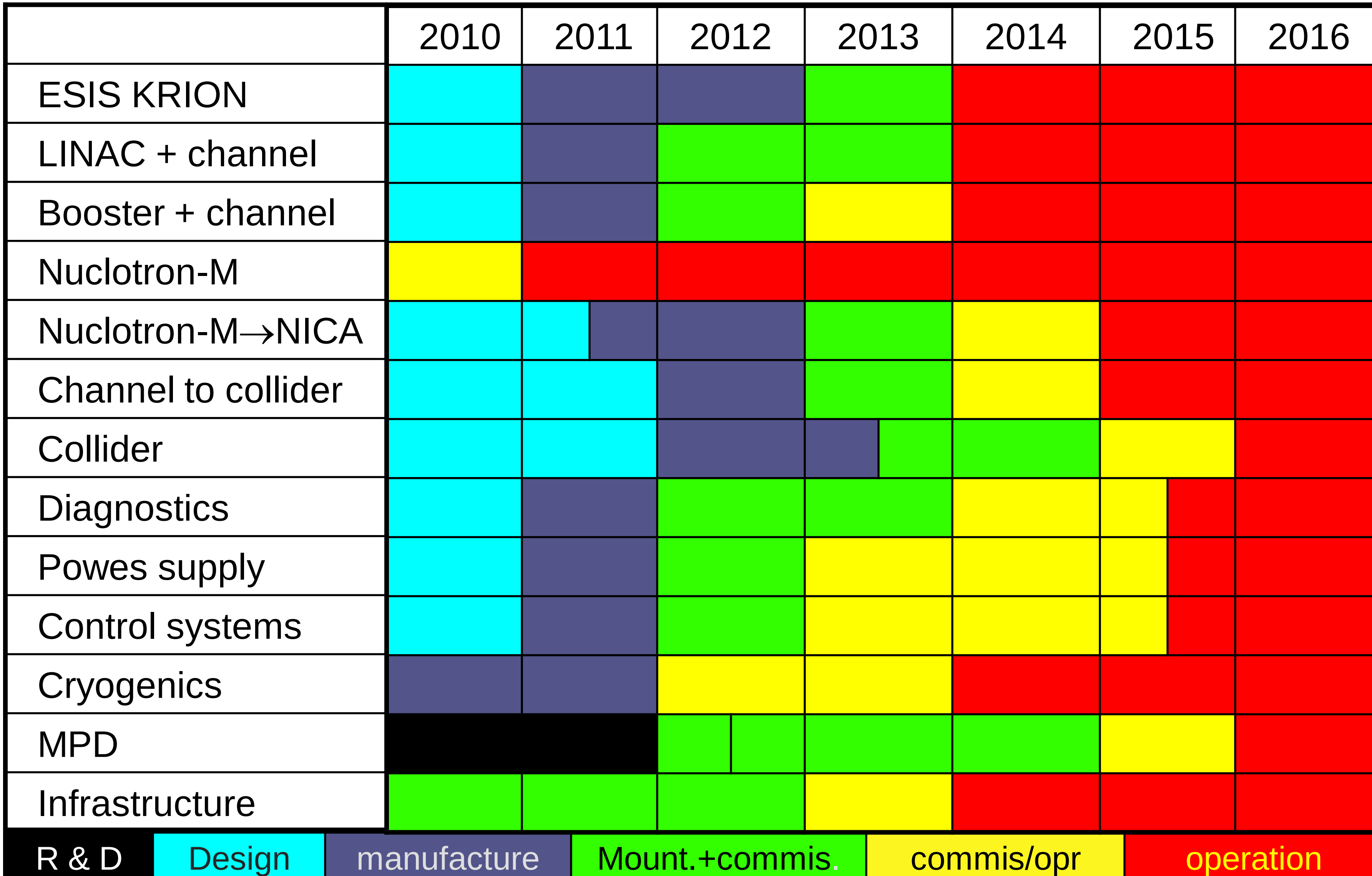
Nuclotron (45 Tm)
injection of one bunch
of 1.1×10⁹ ions,
acceleration up to
1 - 4.5 GeV/u max.

Collider–general parameters *(preliminary)*

Bρ max [T·m]	**45.0**
Ion kinetic energy (Au79+), [GeV/u]	**1.0 ÷ 4.56**
Dipole field (max), [T]	**2.0**
Free space at IP (for detector)	**9 m**
Beam crossing angle at IP	**0**
Vacuum, [Torr]	**10^{-11}**
Luminosity per one IP, $cm^{-2} \cdot s^{-1}$	**0.02÷5.0 ·10^27**

Structure & details of the storage rings
*- subject of consideration by the forthcoming **MAC**)*

NICA: works schedule



Accelerator expertise

ECFA members in Dubna,

11 October 2009

Machine advisory committee meetings:

- forthcoming meeting in
4-5 Octo

- previous meeting in Dub
Janu

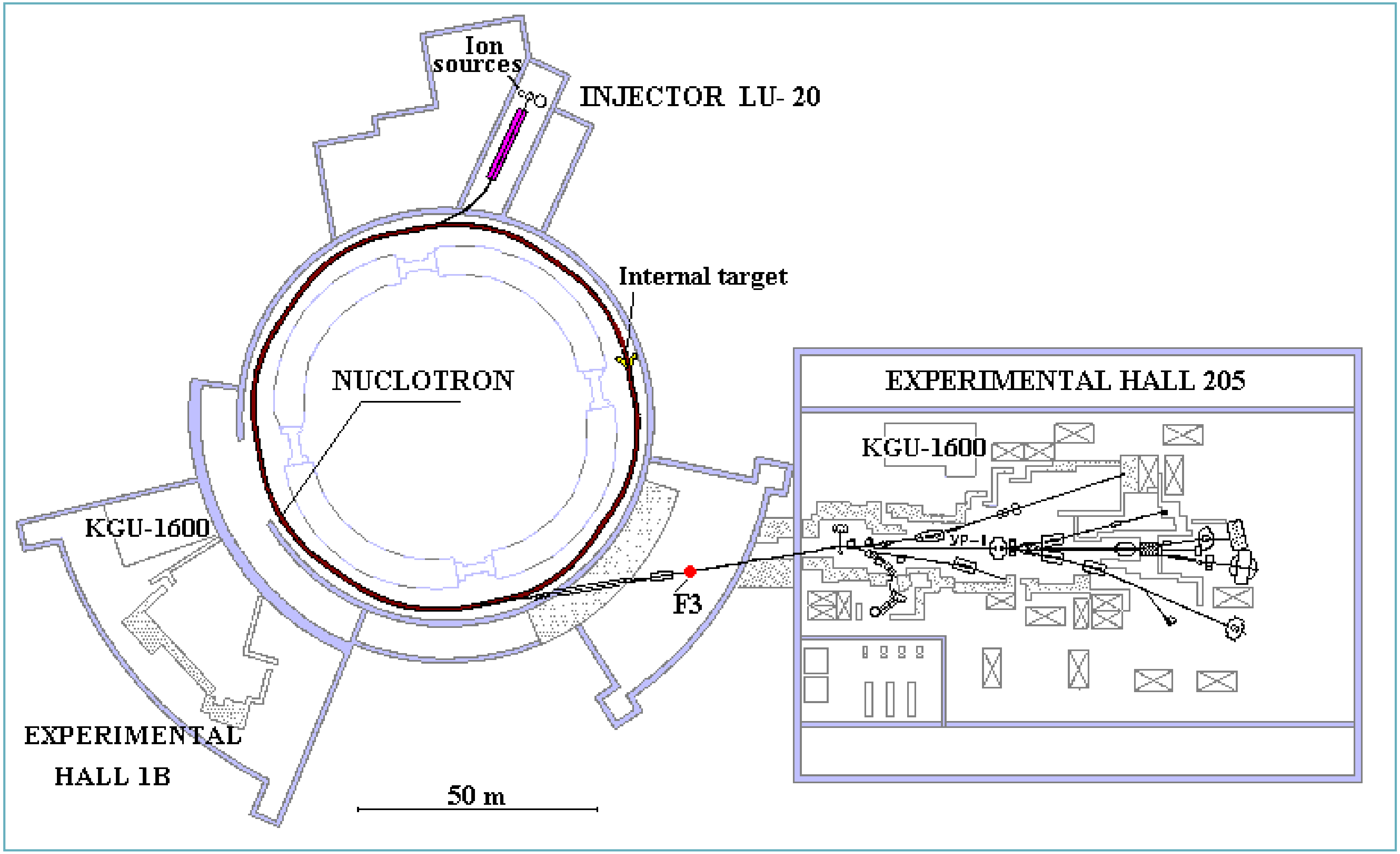
J

BINP

AL

ITEP

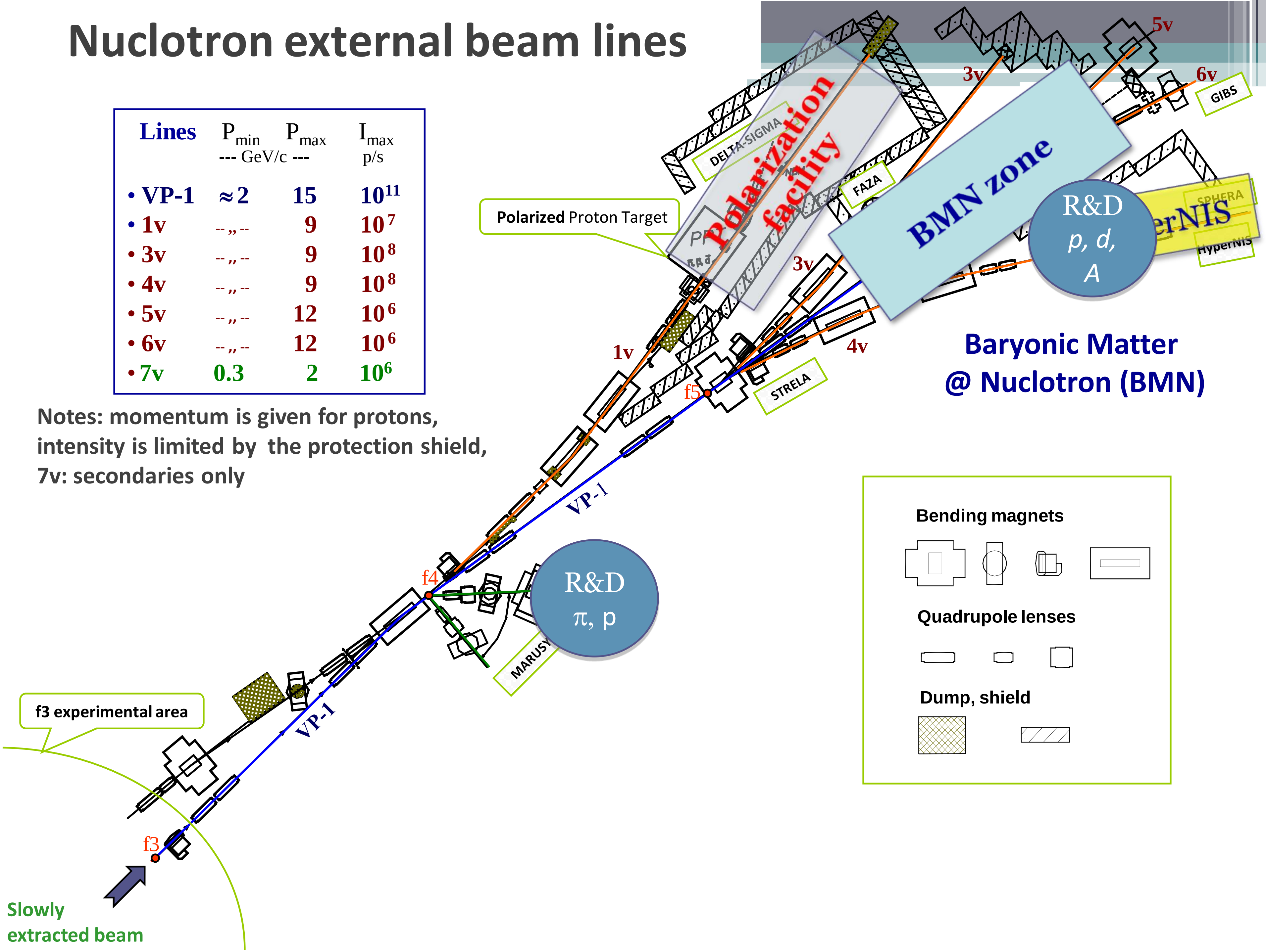
The plan of Nuclotron and experimental zones



Nuclotron external beam lines

Lines	P_{min}	P_{max}	I_{max}
	--- GeV/c ---		p/s
• VP-1	≈ 2	15	10^{11}
• 1v	-- „ --	9	10^{7}
• 3v	-- „ --	9	10^{8}
• 4v	-- „ --	9	10^{8}
• 5v	-- „ --	12	10^{6}
• 6v	-- „ --	12	10^{6}
• 7v	0.3	2	10^{6}

Notes: momentum is given for protons,
intensity is limited by the protection shield,
7v: secondaries only



Baryonic Matter @ Nuclotron (BMN)

***Schedule** (preliminary)*

- **Start of project preparation** **2010**
- **presentation for the consideration at PAC** **2011**
- **Experimental area preparation** **2012**
  major subdetector for the starting kit are prototyped & mounted
- **BMN starting kit commissioning** **2013**
- **Start of physics runs** **2014**

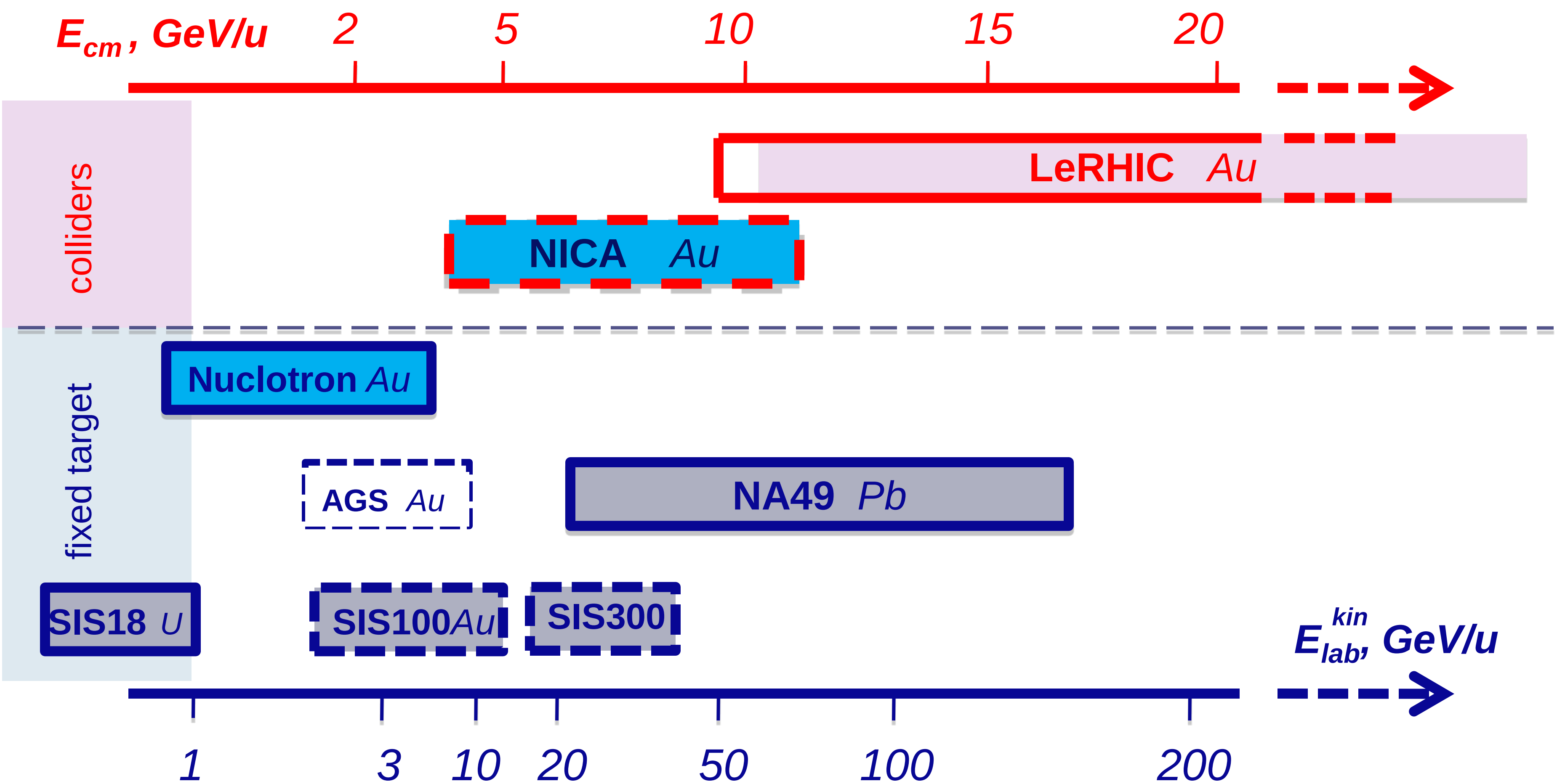
Fixed target experimental area

Should be properly developed in parallel with
Nuclotron upgrade & NICA collider construction

This is the high priority task, because it provides:

- **relevant experimental *program* in BM**, *(could be started in 2014)*
- **proper *monitoring* of Nuclotron performance & beam parameters**
- **highly required beams - *to test MPD various subsystems***
- **development of modern experimental *infrastructure,* organization necessary services, & training of corresponding *personal***
- **better *integration* of the JINR HEP facility into the common European research infrastructure**

Energy regions covered by present & future experiments



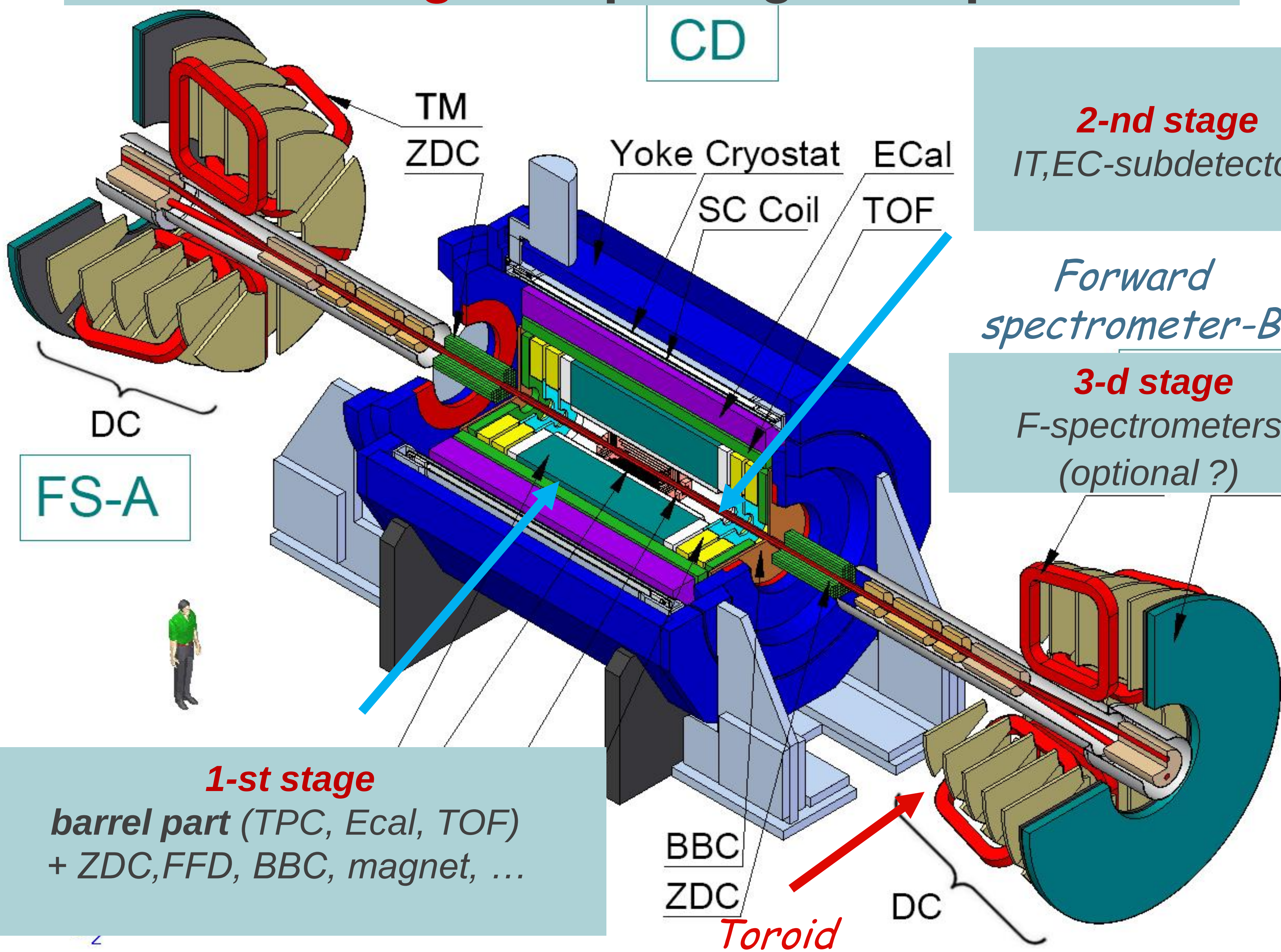
MPD

- ***Concept of*** **universal detector for collider experiments; a central part inserted into 0.5T superconducting solenoid *(D=5m, L=8m)***

- **Could be used for both studies: DBM & SP**

- **Three stages of putting in operation**

MPD: 3 stages of putting into operation



2-nd stage
IT,EC-subdetectors

3-d stage
F-spectrometers
(optional ?)

1-st stage
barrel part *(TPC, Ecal, TOF)*
+ ZDC,FFD, BBC, magnet, …

List of Tasks for MPD

.. To measure a large variety of signals at systematically changing collision parameters (energy, centrality, system size).
Reference data (i.e. p+p) will be taken at the same experimental conditions.

- **bulk observables (hadrons): 4π particle yields (OD, EOS)**
- **multi-strange hyperon production : yields & spectra (OD, EOS)**
- **electromagnetic probes (CSR, OD)**
- **azimuthal charged-particle correlations (LPV)**
- **event-by-event fluctuation in hadron productions (CEP)**
- **correlations involving π, K, p, Λ (OD)**
- **directed & elliptic flows for identified hadron species (EOS,OD)**
- **…….**

NICA White Paper (http://nica.jinr.ru)
Round Table materials (http://jinr.ru/theor/)

Timetable MPD

	Stage/Year	2009	2010	2011	2012	2013	2014	2015	2016
1	MPD Conceptual Design Report								
2	MPD TDR								
3	**R&D program**								
	TPC								
	TOF								
	ZDC								
	Si inner tracker								
	EMC								
	Straw Tracker								
	DAQ								
4	**Production and tests (the 1st stage detectors)**								
	Superconducting Magnet of MPD								
	TPC								
	EMC								
	ZDC								
	TOF barrel								
	Slow Control								
	DAQ								
	Installation& Commissioning								
	Si inner tracker								
5	**Production and tests (the 2nd stage detectors)**								
	TOF(EndCap)								
	Straw Tracker								
	DAQ								
	Slow Control								
	Installation								
6	**Production and tests (the 3rd stage, Forward Spectrometer)**								
	Toroidal Magnet construction								
	Coordinate detectors production								
	Coordinate detector testing								
	Installation& Commissioning								

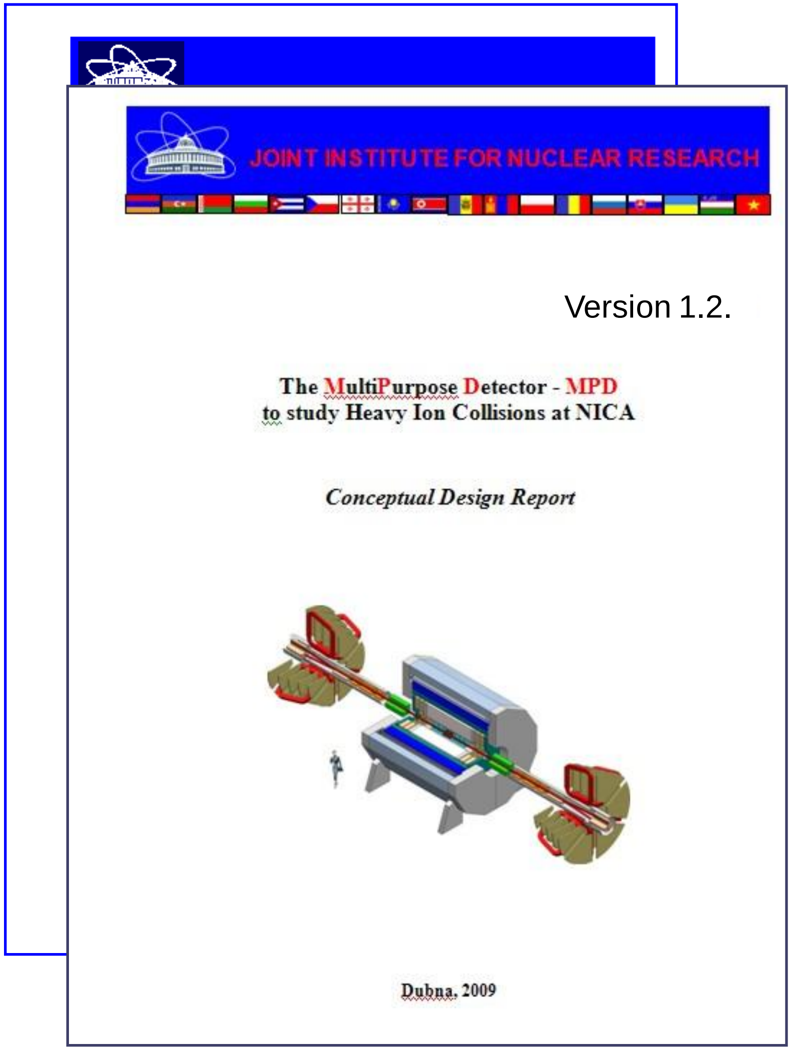
Status of MPD project & physics

- **MPD project (1st stage) was recommended for approval by PAC of PP in January 2010**

- **White Book**
  - the last version in August 2010 (>100 authors from>40 centers)

- **MPD CDR**
  - the first version -June 2009
  - the last v.1.2 - August 2010

- **MPD LoI - the first version in February 2008**



JOINT INSTITUTE FOR NUCLEAR RESEARCH

Version 1.2.

The MultiPurpose Detector - MPD
to study Heavy Ion Collisions at NICA

Conceptual Design Report

Dubna, 2009

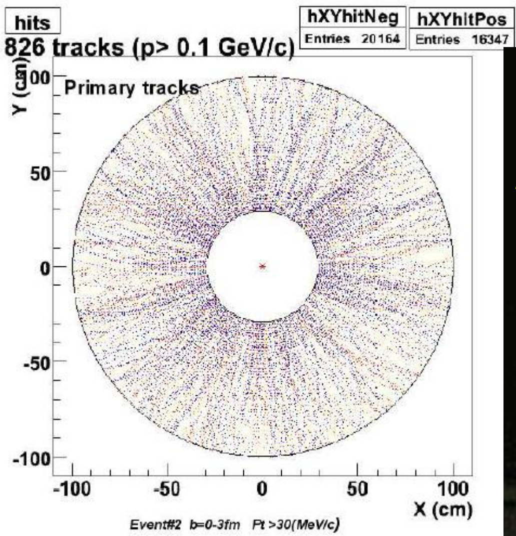
MPD working packages & corresponding groups

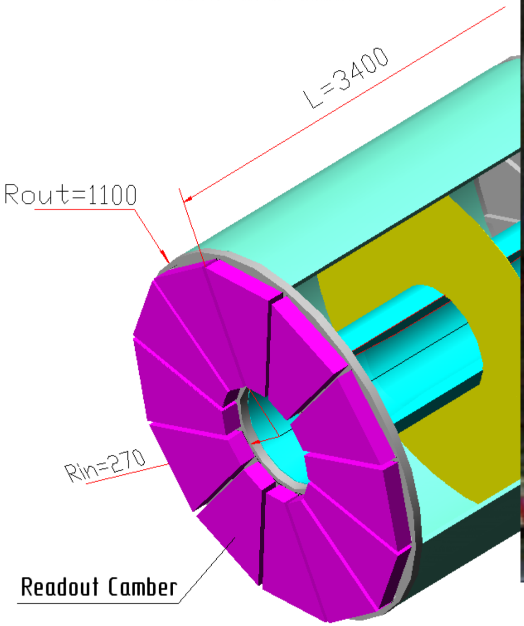
- Magnet
- TPC (+prototyping)
- ECal
- TOF
- ZCal
- FFD
- CPC
- Straw wheels

- EC DC
- IT
- DAQ
- Slow Control
- Infrastructure & Integration
- Soft ware
- Physics performance

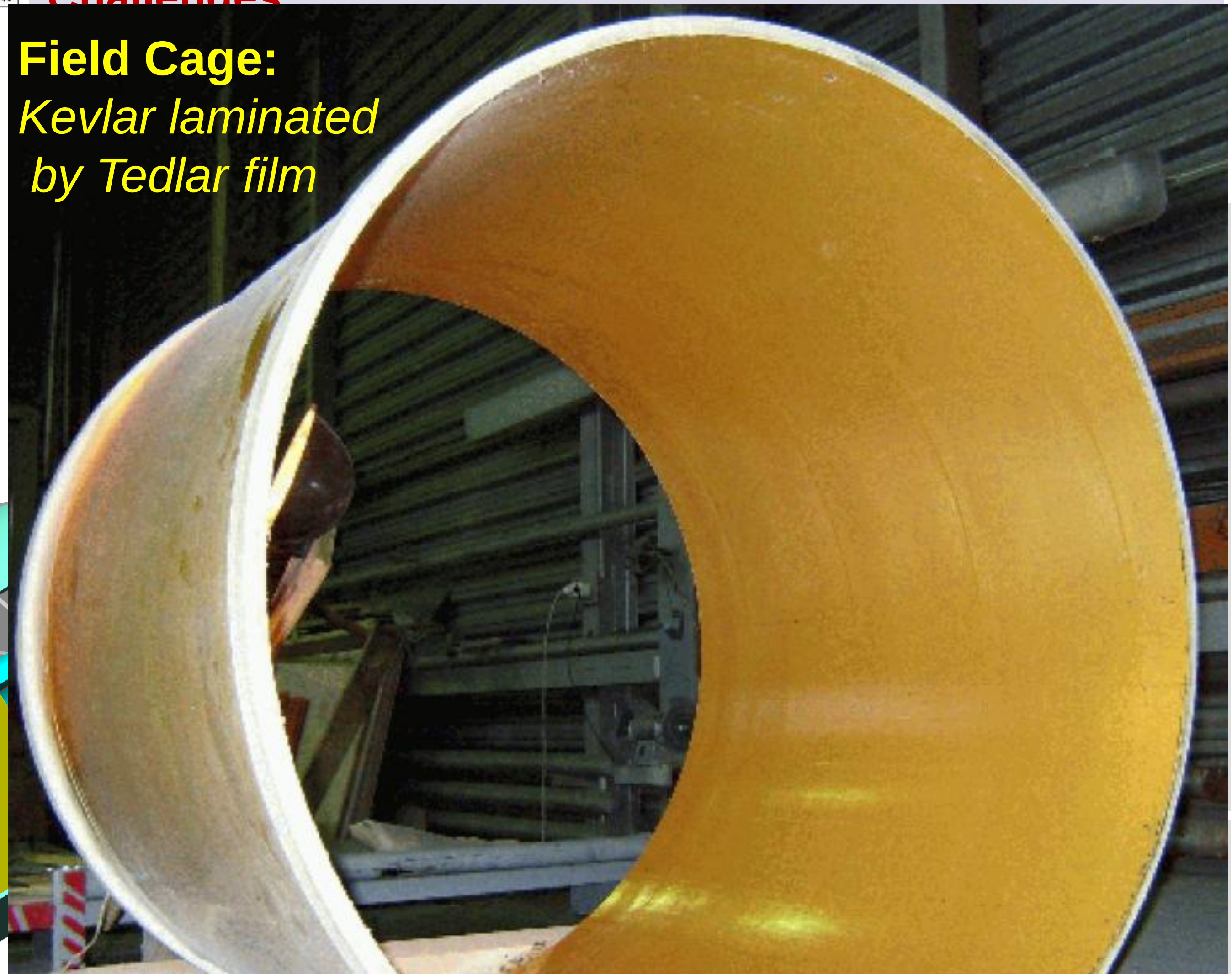
The CBM-MPD SSD consortium:
GSI - JINR - IHEP - … in IT silicon module development is well progressing

Time Projection Chamber (TPC)



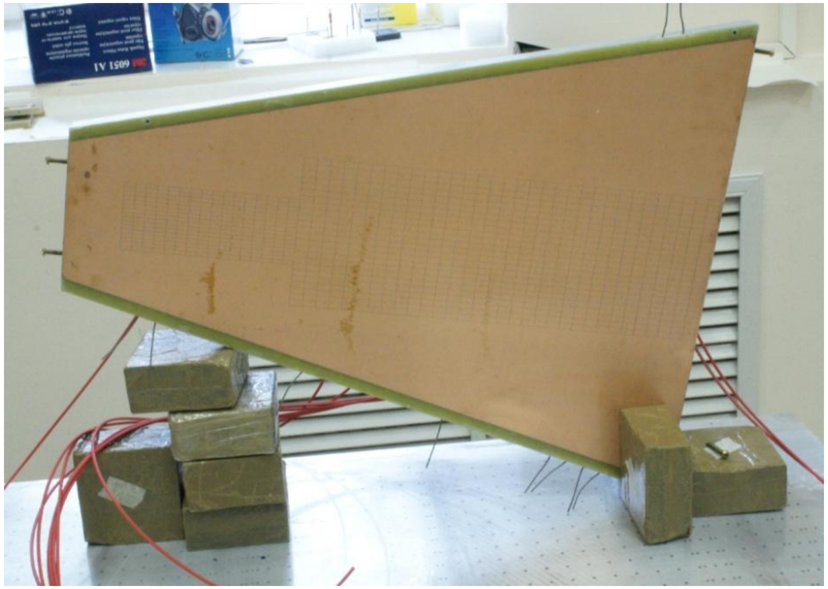


Challenges

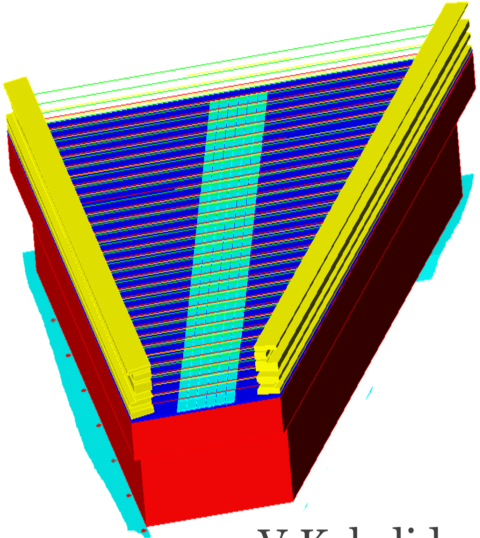


Mom. resolution $\Delta p/p < 3\%$ ($0.2<p<1$ GeV/c)
dE/dx resolution < 8%

TPC Readout Chamber



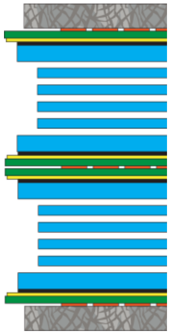
Pad Plane:
- *2 sets of 4x10 mm & 6x12mm pads*
- *256 channels of readout electronics*

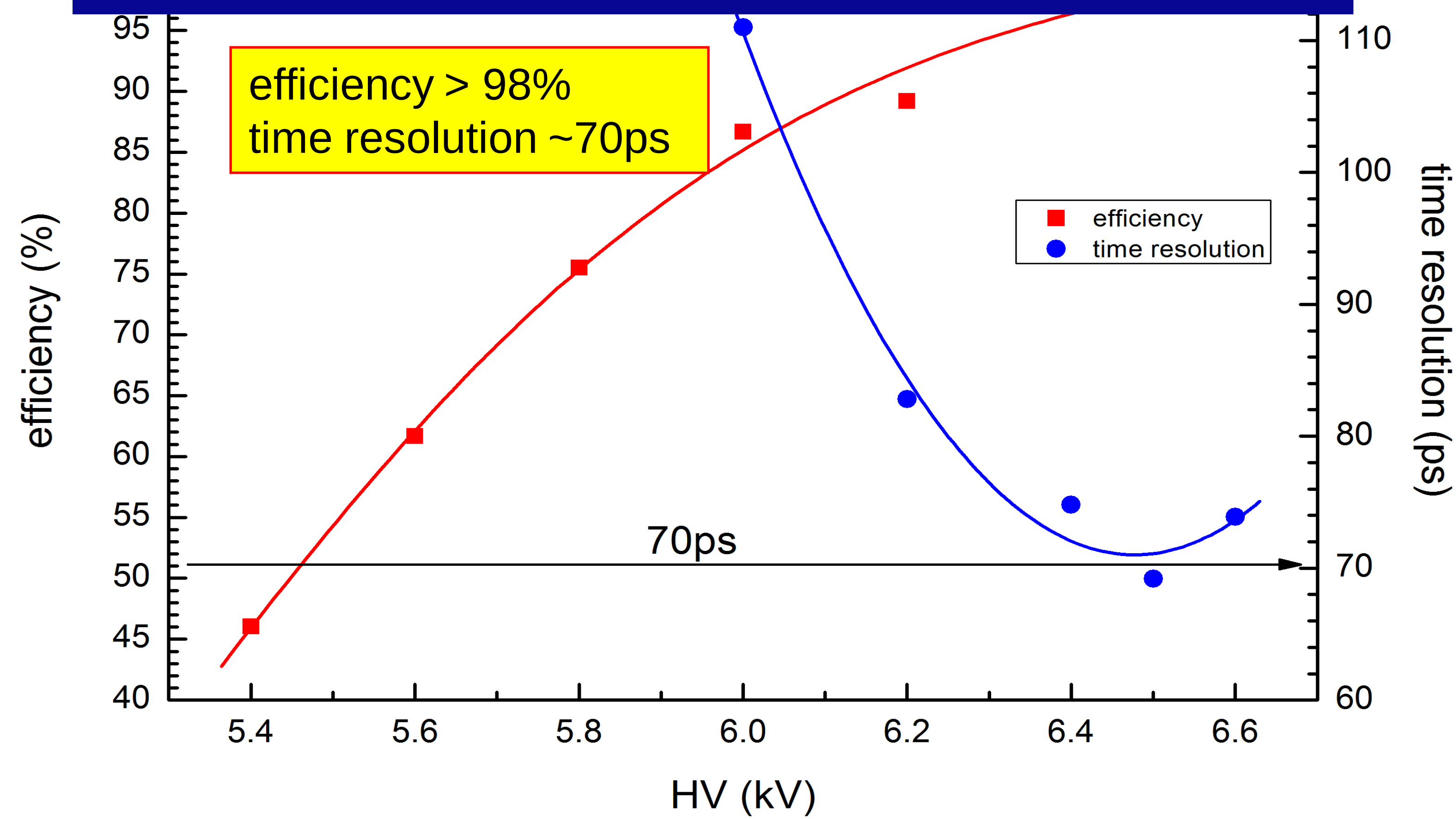


FEE :
- *Amplifier/Shaper – PCA16/ILC and PASA*
- *12 bits ADC – ADC12EU050*
- *FPGA VIRTEX5*

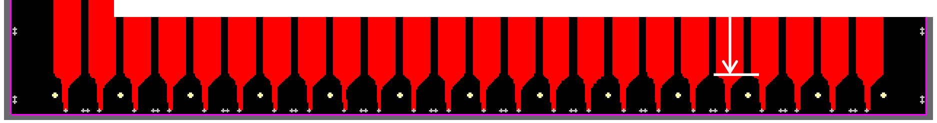
RPC prototype *(China group)*

Plan to continue optimization & tests at Nuclotron beam in Dec. 2010





by cosmic ray

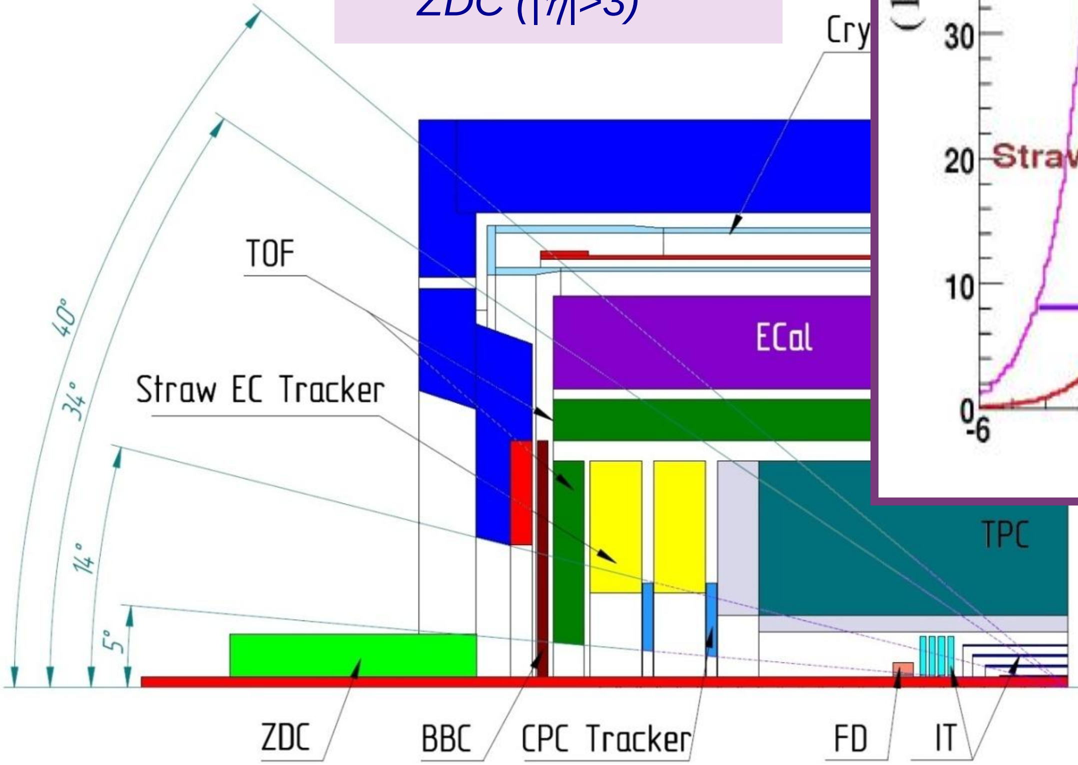


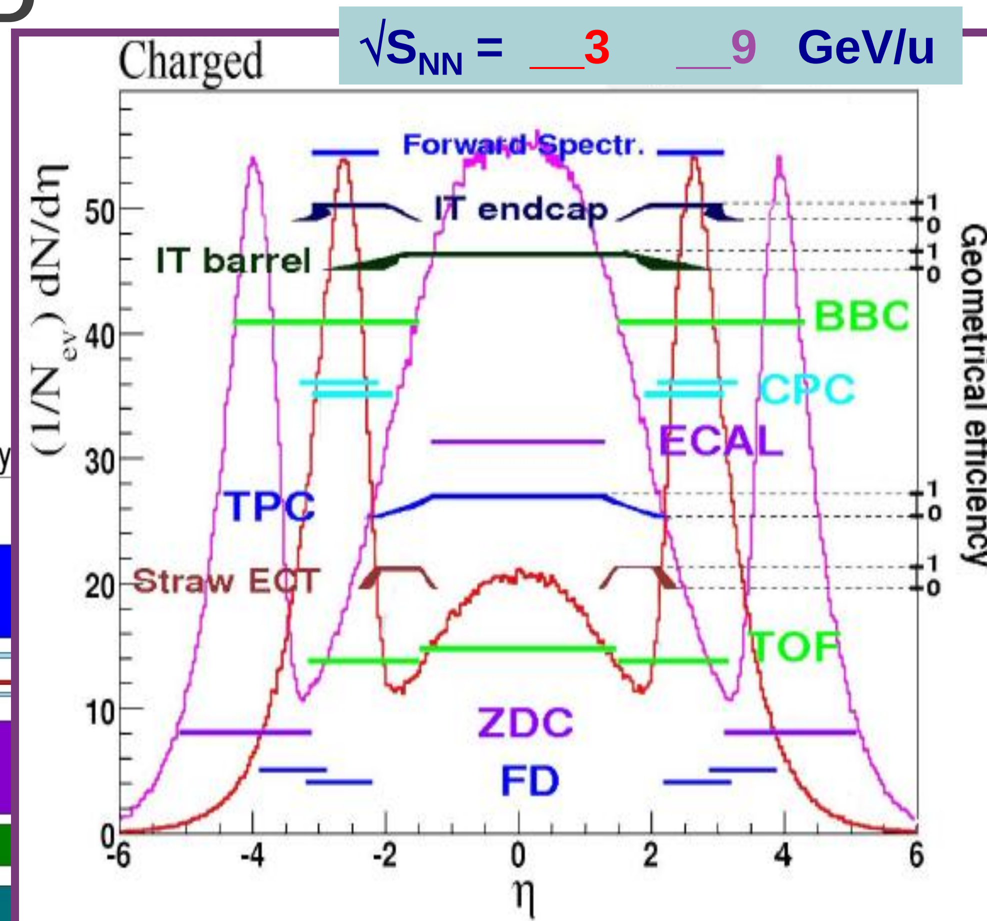
MPD performance for physics tasks

was evaluated using a powerful tool based on ***MPDRoot*** *including various physics generators, Detector simulation, event reconstruction & analysis*

Angle coverage of MPD

TPC ($|\eta|<2$)
ECAL ($|\eta|<1.2$)
FD ($2<|\eta|<4$)
TOF ($|\eta|<3$)
IT ($|\eta|<2.5$)
ZDC ($|\eta|>3$)





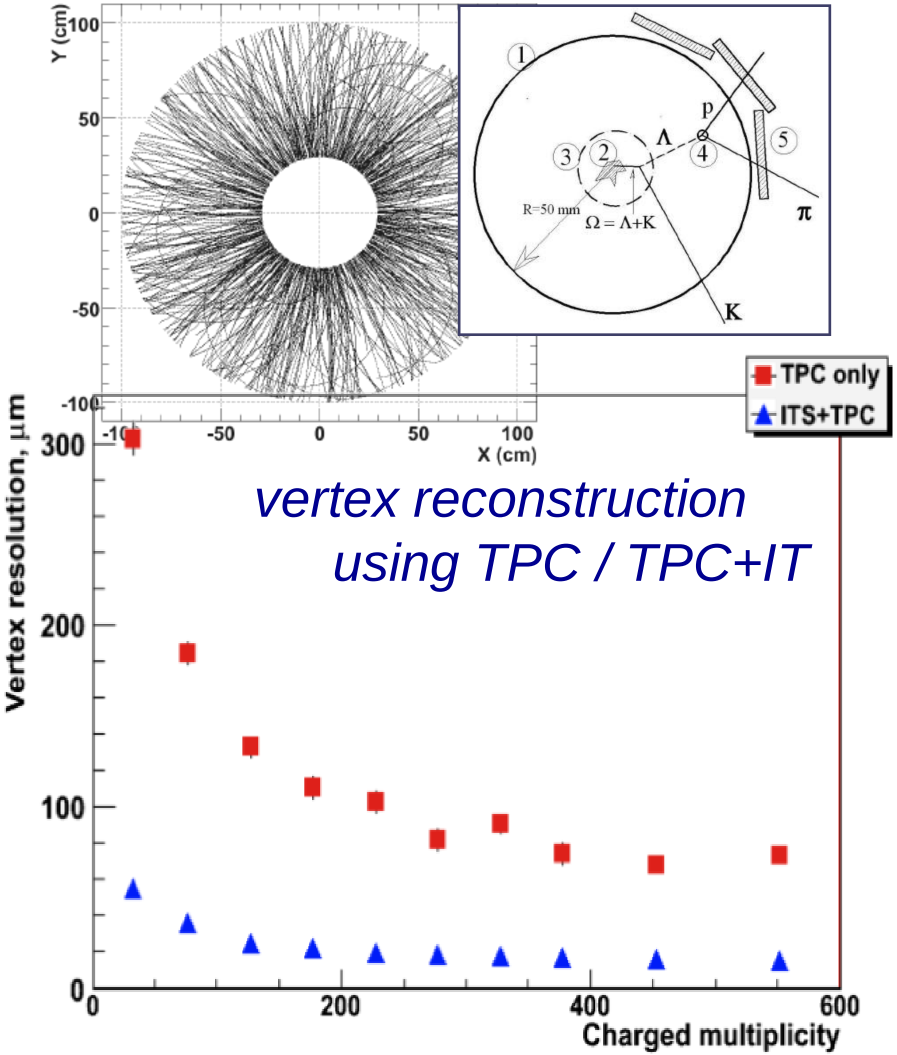
B = 0.5 T

Particle yields in Au+Au collisions $\sqrt{s_{NN}}$ = 7.1 GeV (10% central)

Luminosity L = $10^{27} cm^{-2}s^{-1}$
Event rate (central) 700 Hz

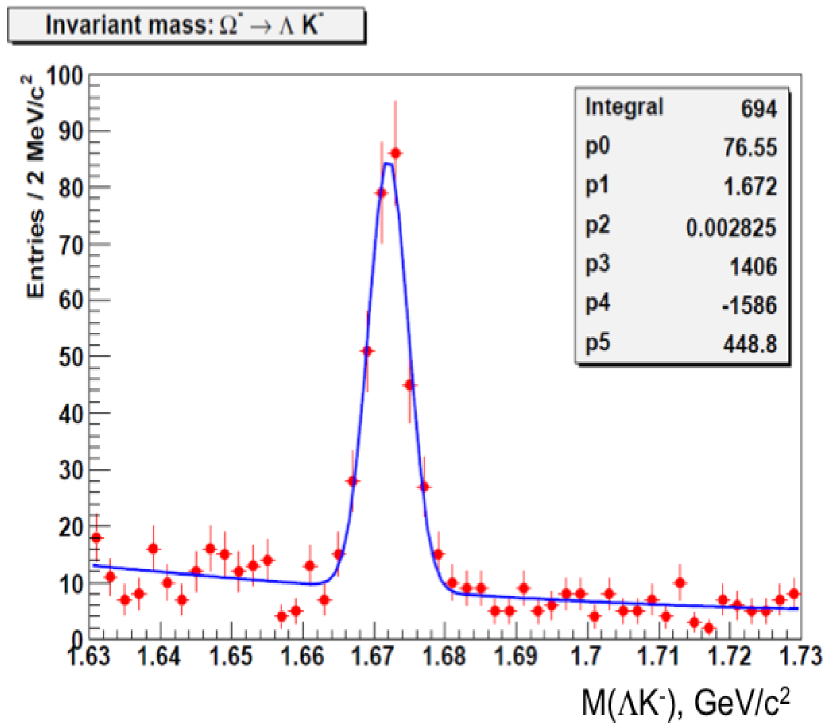
Particle (mass)	Multi-plicity	decay mode	yield (s^{-1})	yield 10w
K^+ (494)	55	--	$7.7 \cdot 10^3$	$4.6 \cdot 10^{10}$
K^- (494)	16	--	$2.2 \cdot 10^3$	$1.3 \cdot 10^{10}$
ρ (770)	23.6	e^+e^-	$1.6 \cdot 10^{-2}$	$9.4 \cdot 10^4$
ω (782)	14.2	e^+e^-	$1.4 \cdot 10^{-2}$	$8.6 \cdot 10^4$
φ (1020)	2.7	e^+e^-	$1.1 \cdot 10^{-2}$	$6.8 \cdot 10^4$
Ξ^- (1321)	2.4	$\Lambda\pi^-$	67	$4.0 \cdot 10^8$
Ω^- (1672)	0.16	ΛK^-	1.5	$9.2 \cdot 10^6$
D^0 (1864)	$7.5 \cdot 10^{-4}$	$K^+\pi^-$	$2.0 \cdot 10^{-4}$	1200
J/ψ (3097)	$3.8 \cdot 10^{-5}$	e^+e^-	$8.0 \cdot 10^{-5}$	480

Vertex & hyperon decay reconstructions



vertex reconstruction using TPC / TPC+IT

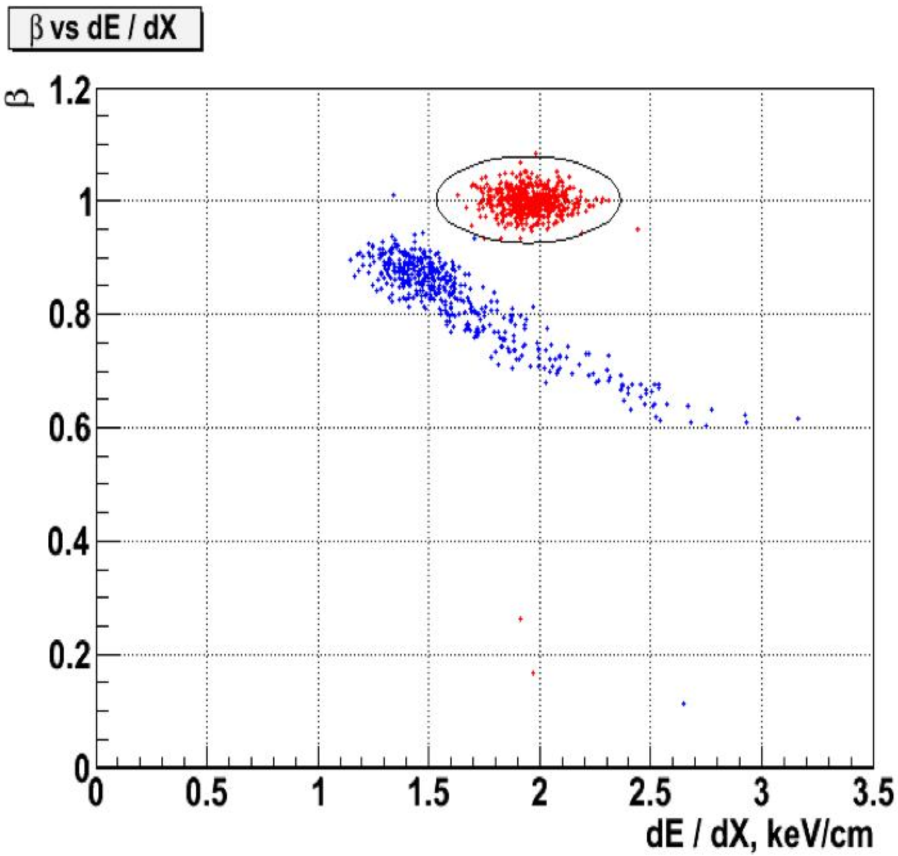
Ω^- -> ΛK^- *decay reconstruction (vertex + particle ID)*

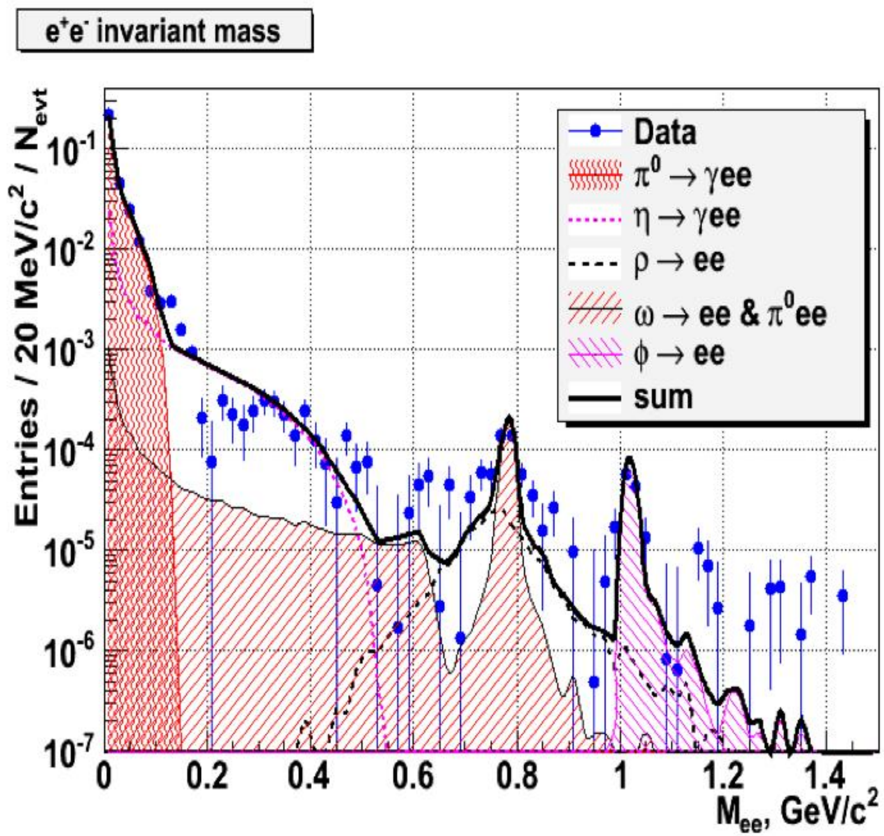


Lepton pairs *(e⁺e⁻)* reconstruction

Signal = (+-) - 2√(++)(--)

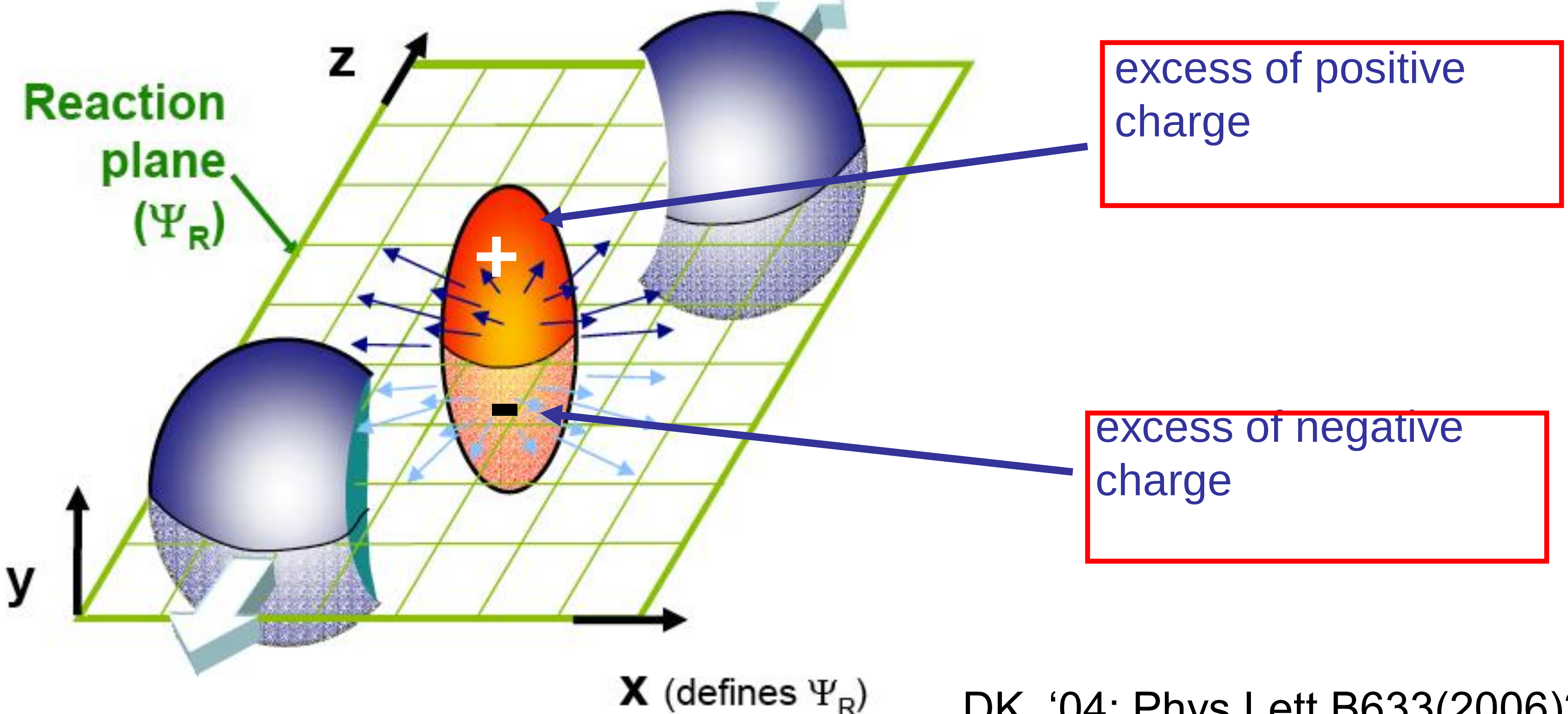
e / *π separation (using TPC + RPC)*





To be done:

estimate of ability to measure charge asymmetry w.r.t. reaction plane as a possible signature of strong P violation



DK, '04; Phys.Lett.B633(2006)260

Electric dipole moment of QCD matter!

Spin Physics (SPD)

NICA design allows to reach effectively polarized
- **protons up to $\sqrt{s}$ ~ 26 GeV with average L = 2 10^{30} cm^2/s**
- **deuterons up to $\sqrt{s}$ ~ 12 GeV with the average L= 10^{29} cm^2/s.**

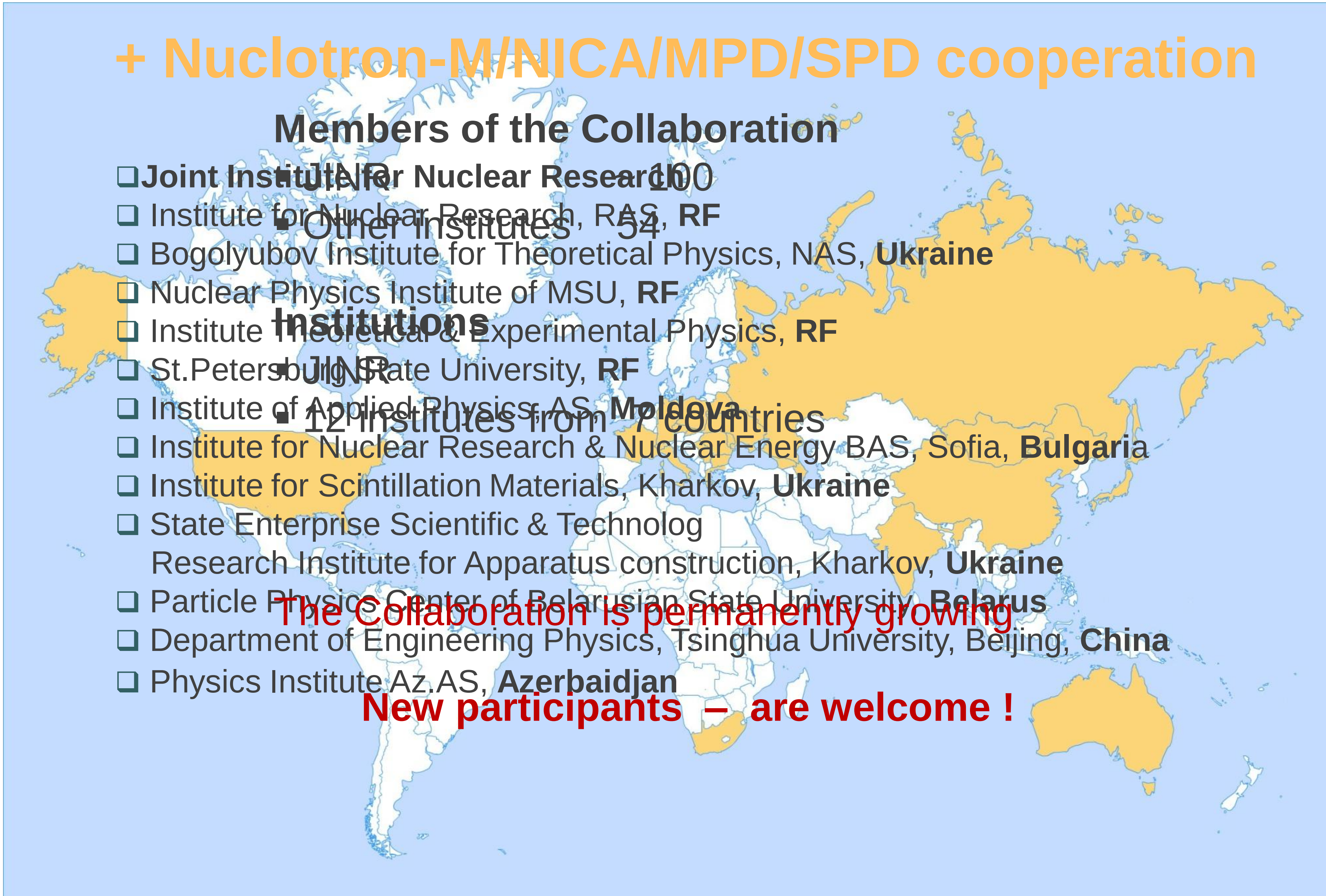
The SPD (Spin Physics Detector) program includes:
- **Drell-Yan / MMT processes,**
- **J/Ψ production processes,**
- **Spin effects in elastic *p↑p↑*, *p↑d* & *d↑d↑* scattering,**
- **Spin effects in inclusive high-pT reactions,**
- **Polarization effects in heavy ions collisions**

All these give unique possibilities to investigate "spin puzzle"
- one of the main tasks of the modern hadron physics

*The 1-st stage could be started already at **MPD***

essential extension of COMPASS (CERN SPS) program

MPD Collaboration



+ Nuclotron-M/NICA/MPD/SPD cooperation

- **Joint Institute for Nuclear Research**
- Institute for Nuclear Research, RAS, **RF**
- Bogolyubov Institute for Theoretical Physics, NAS, **Ukraine**
- Nuclear Physics Institute of MSU, **RF**
- Institute Theoretical & Experimental Physics, **RF**
- St.Petersburg State University, **RF**
- Institute of Applied Physics, AS, **Moldova**
- Institute for Nuclear Research & Nuclear Energy BAS, Sofia, **Bulgaria**
- Institute for Scintillation Materials, Kharkov, **Ukraine**
- State Enterprise Scientific & Technolog Research Institute for Apparatus construction, Kharkov, **Ukraine**
- Particle Physics Center of Belarusian State University, **Belarus**
- Department of Engineering Physics, Tsinghua University, Beijing, **China**
- Physics Institute Az.AS, **Azerbaidjan**

Members of the Collaboration

- JINR 100
- Other institutes 54

Institutions

- JINR
- 12 institutes from 7 countries

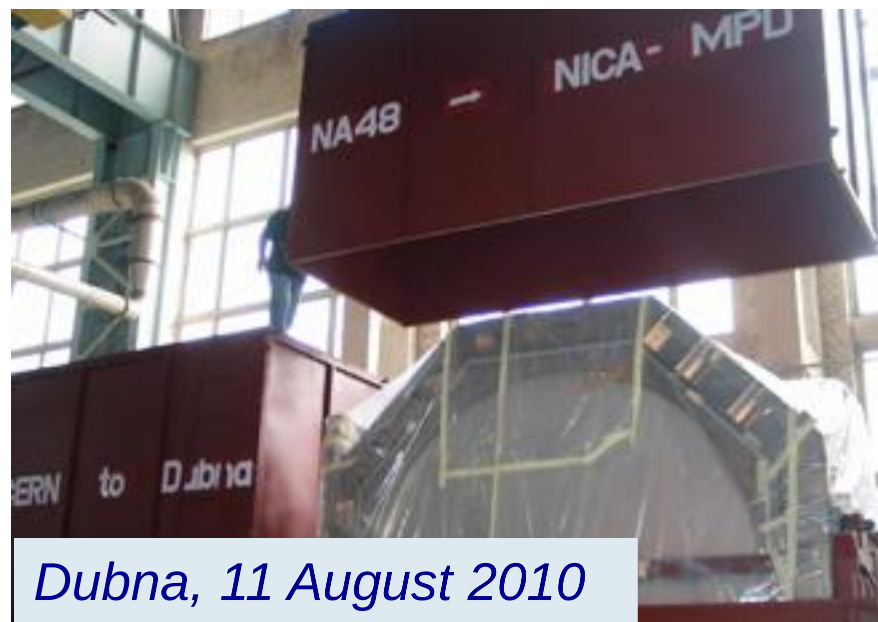
The Collaboration is permanently growing

New participants – are welcome !

CERN-JINR agreement

signed by two directors in Jan. 2010, opens the door for bilateral activity in LHC & NICA

The four big drift chambers of NA48 delivered to Dubna for MPD – good contribution to this agreement & good memory for Alexei Sissakian



Major milestones for 2011

- **launch the magnet production line** *(final assembly, test, QC & certification)*

  *required for **booster, collider, FAIR +….***

- **to complete Nuclotron-M & start Nuclotron-N**ica **project** *with beams required for both **NICA** & **BMN***

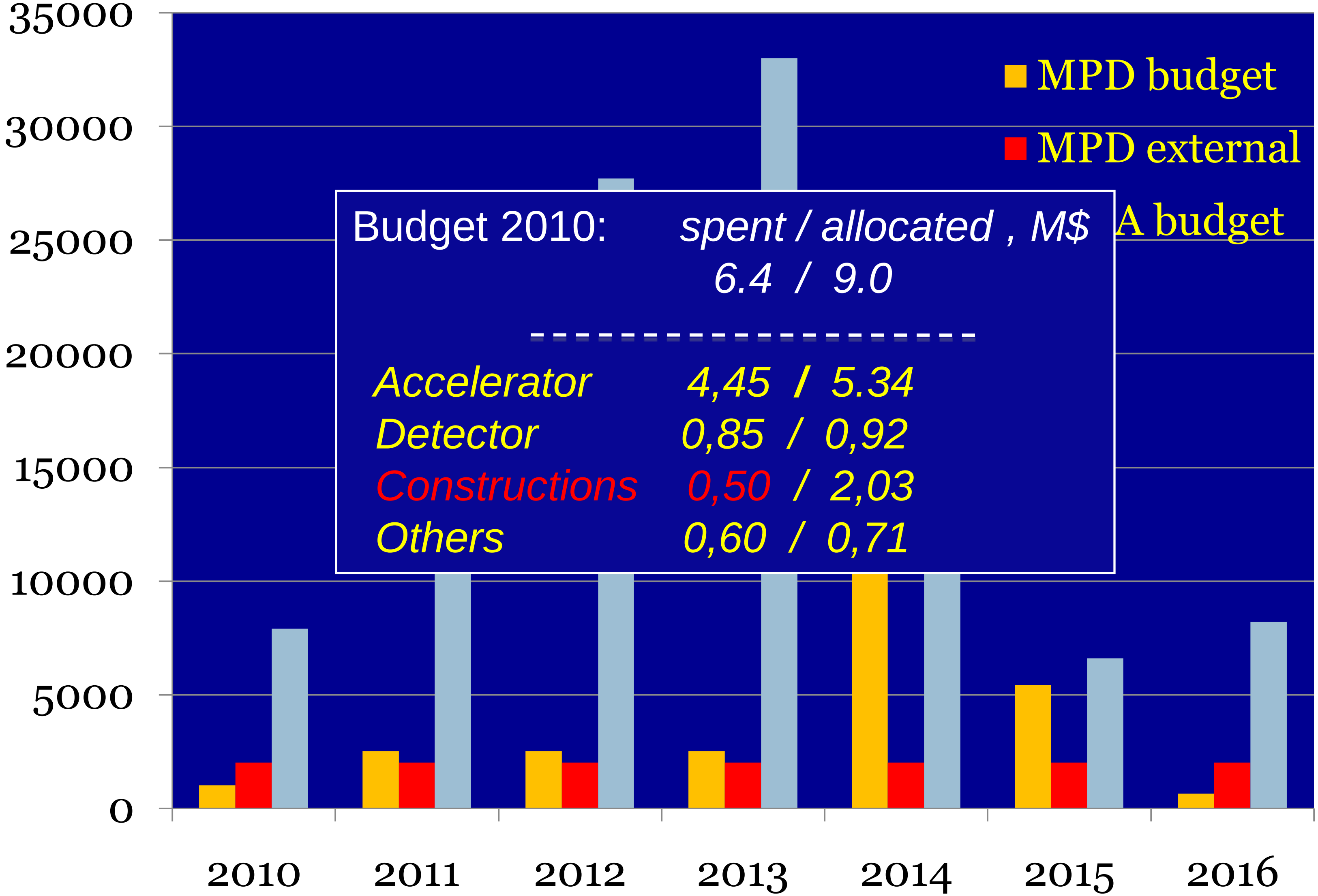
- **to approve project for collider civil engineering & start works on** *Collider layout design, & construction + infrastructure*

- **to complete design works on MPD solenoid,** *& launch a tender for the production*

- **development of fixed target area, & infrastructure upgrade** *(bld.205)*

- **to start the BMN project**

Resources for NICA & MPD, in k$



Budget 2010: *spent / allocated , M$*

6.4 / 9.0

- -

Accelerator	*4,45 / 5.34*
Detector	*0,85 / 0,92*
Constructions	*0,50 / 2,03*
Others	*0,60 / 0,71*

Summary

- **NICA/MPD** project to study hot & dense baryonic matter is *progressing well*
- The accelerator part is properly *supervised*
- The 1st stage **of MPD** conception *is completed,* & the project is *recommended for realization*
- The scientific program in DBM will be extended for low energy region by ***FT** facility* – ***BMN***
- External collaborations *are invited* to present proposals
- Project schedule & financing *are fulfilling*
- The **Collaboration around NICA/MPD** is growing

New members are welcome !

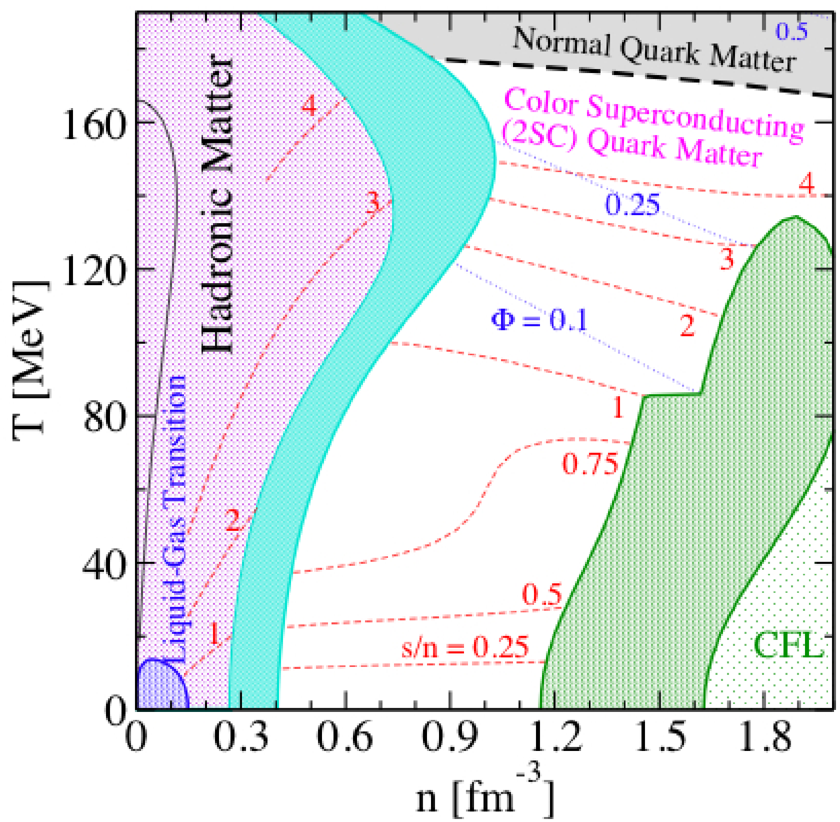
“…Why is there something rather than nothing?”

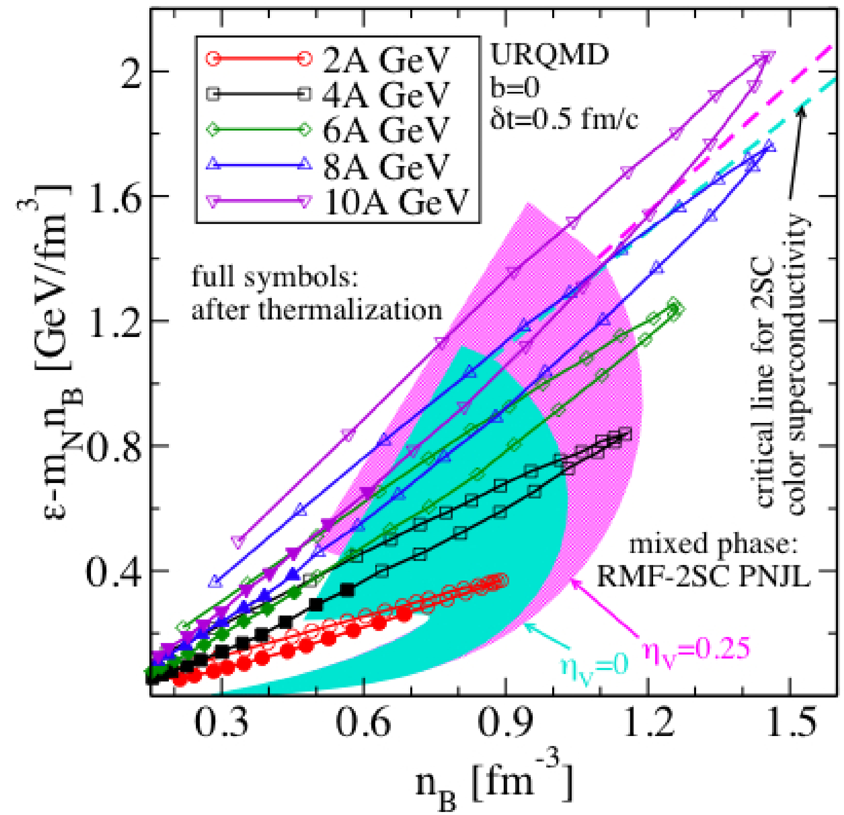
from the speech of
President of the French Republic
at the XXV ICHEP in Paris

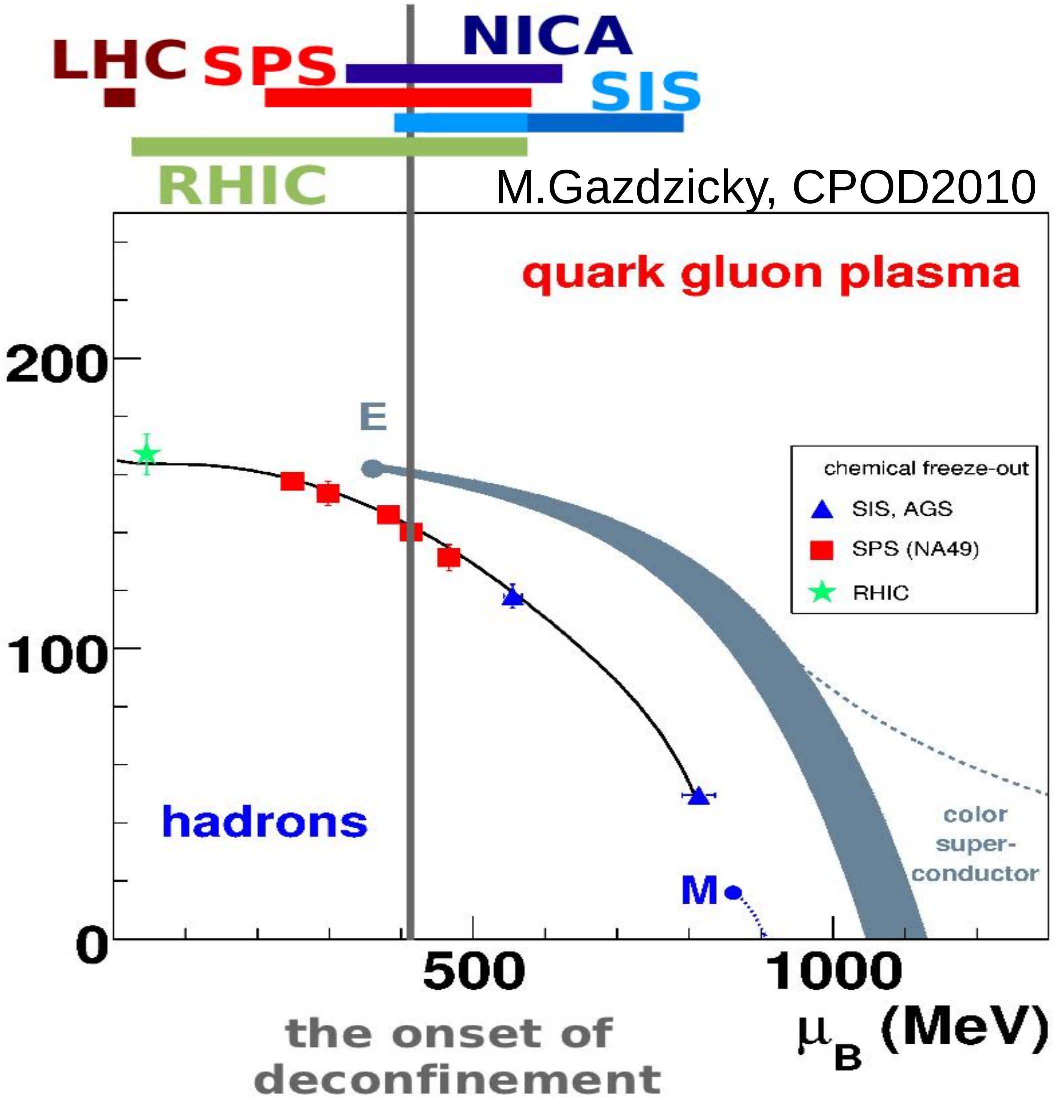
Thank you

Spares

D.Blaschke et.al. NICA White book






LHC
SPS
NICA
SIS
RHIC
M.Gazdzicky, CPOD2010
quark gluon plasma
E
chemical freeze-out
SIS, AGS
SPS (NA49)
RHIC
200
100
0
hadrons
color
super-
conductor
M
500
1000
the onset of
deconfinement
μ_B (MeV)

Extracted beam	Max T_{kin} , GeV/u	Max $\sqrt{S_{NN}}$, GeV/u
proton (Z/A=1)	11.0	5.0
deutron (Z/A=1/2)	5.1	3.6
Au (Z/A=0.4)	3.9	3.3

STAR Run10 Physics Programs

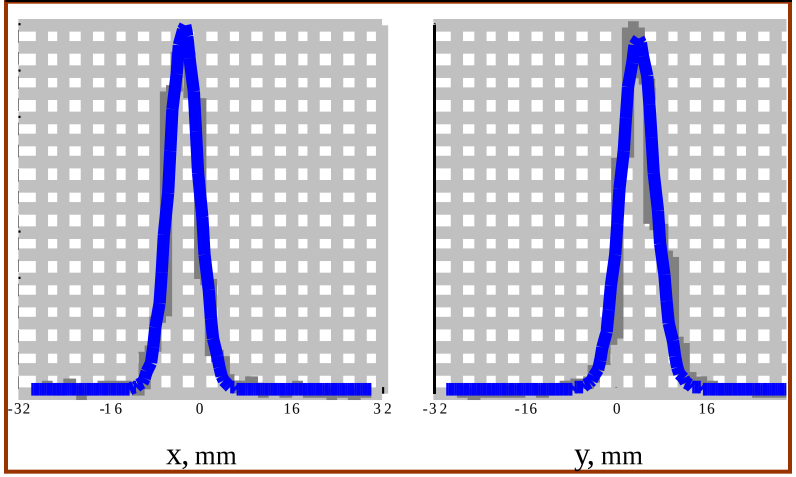
Beam Energy (GeV)	29 cryo-week	STAR BUR In days	Physics
200	11 1/2 - 3/18	56	
62.4	4 3/20 - 4/17	0	
39	1.5 4/8 – 4/21	5 (24M)	BES programs (1) QCD T_E (2) QCD phase boundary
27		15 (33M)	
18		16 (15M)	
11.5	2 6/7 - 21	19 (5M)	
7.7	4 4/21 – 5/31	56 (5M)	
5.5	0.5 6/2 - 5	5 (0.1M)	

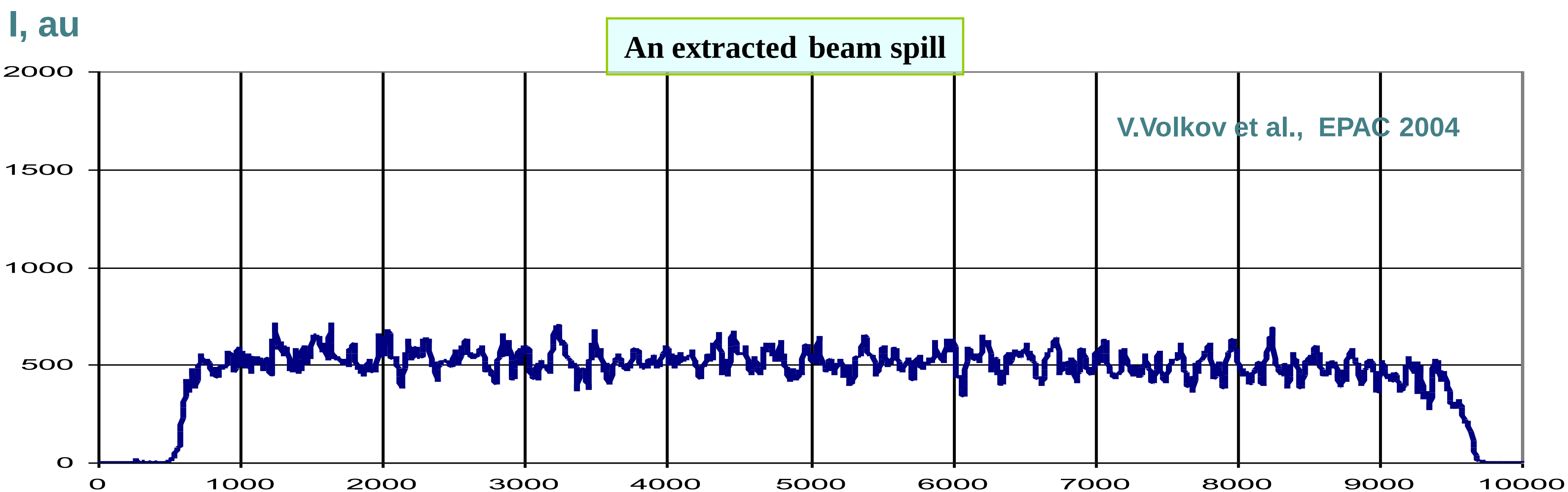
Weekly planning info: *http://www.c-ad.bnl.gov/esfd/RMEM_10/rhic_planning.htm*

Nuclotron slow extraction

Parameter	@	Units	Value
Momentum range	Z/A = 1/2	Gev/c/amu	0.6 – 6.8
Momentum spread, σ		%	0.04 – 0.08
Extraction time		sec	10
Beam emittance	P_{max}	mm·mr	2π
Beam size in a waist, σ	P_{max}	mm	≤ 1
Extraction efficiency		%	> 90
Beams	p, d, d↑, α, ^{6,7}Li, ^{10,11}B, ^{12}C, ^{14}N, ^{24}Mg, ^{56}Fe		

Beam profiles at the F_5 focus.
Deuterons, p_{beam} = 4.3 GeV/c, σ_x = 2.6 mm, σ_y = 3.0 mm

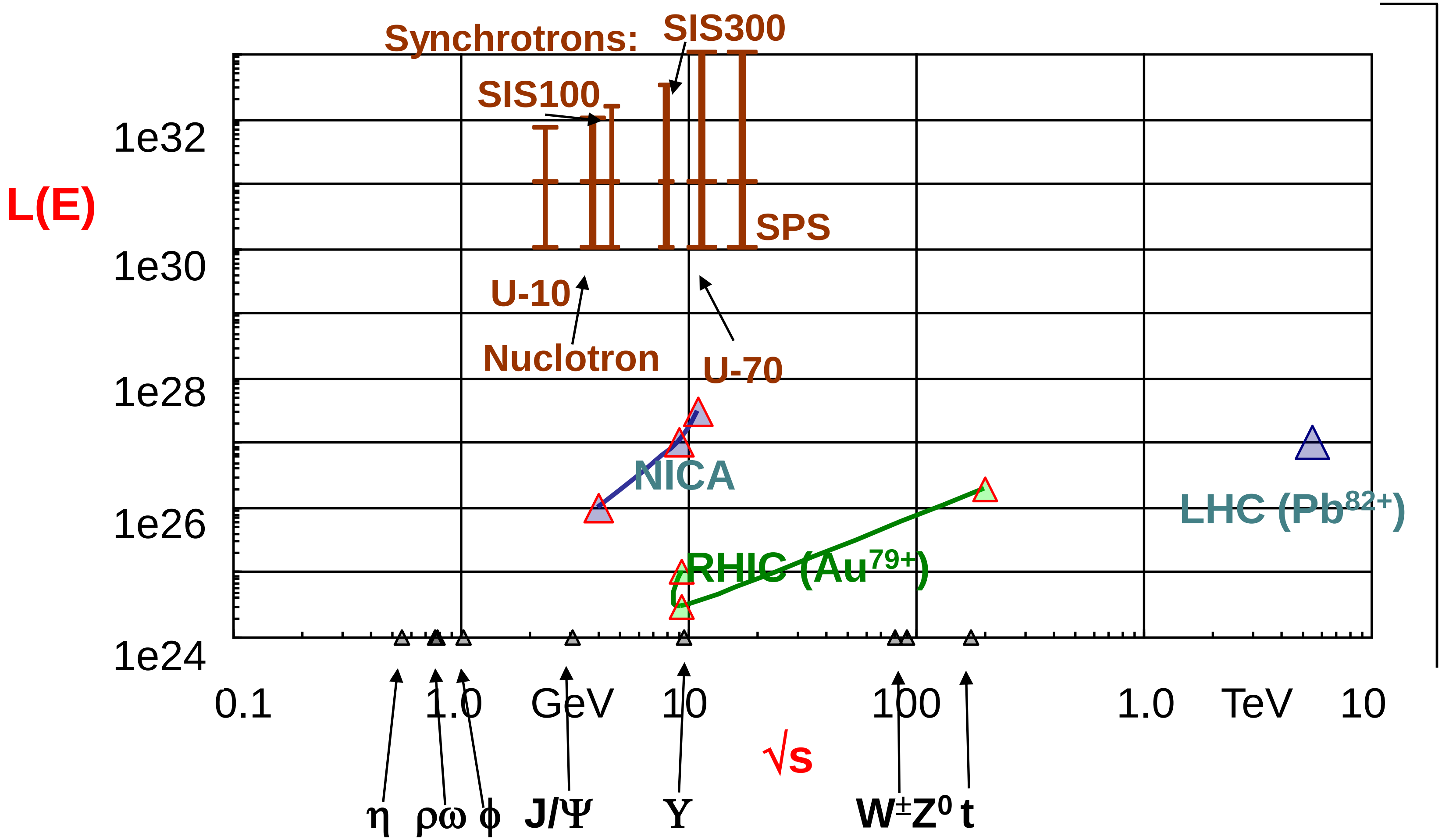


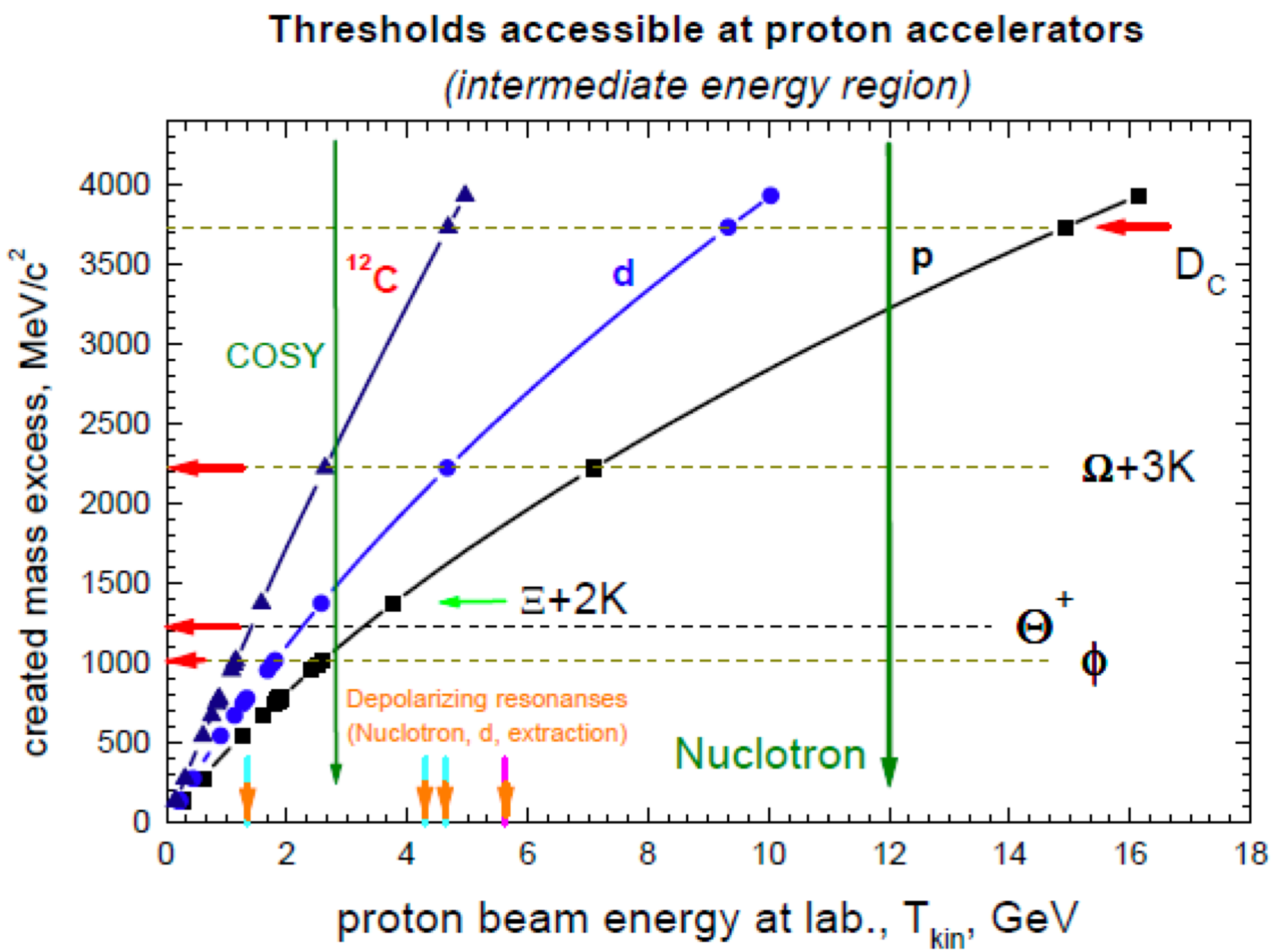


Slide from P.Rukoyatkin

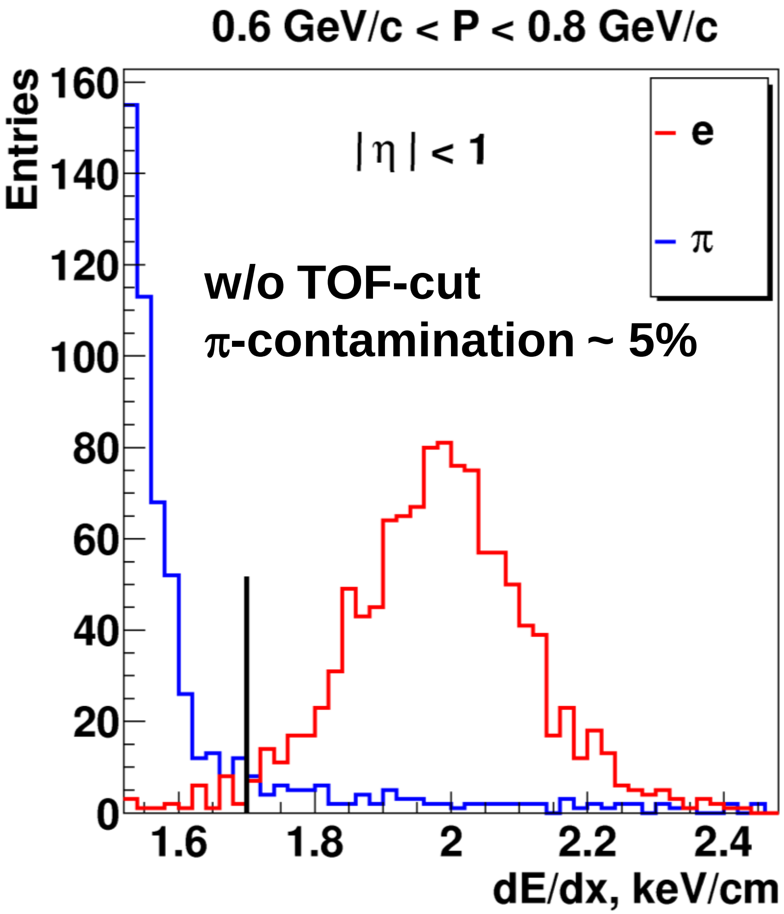
Relativistic Nuclear Physics

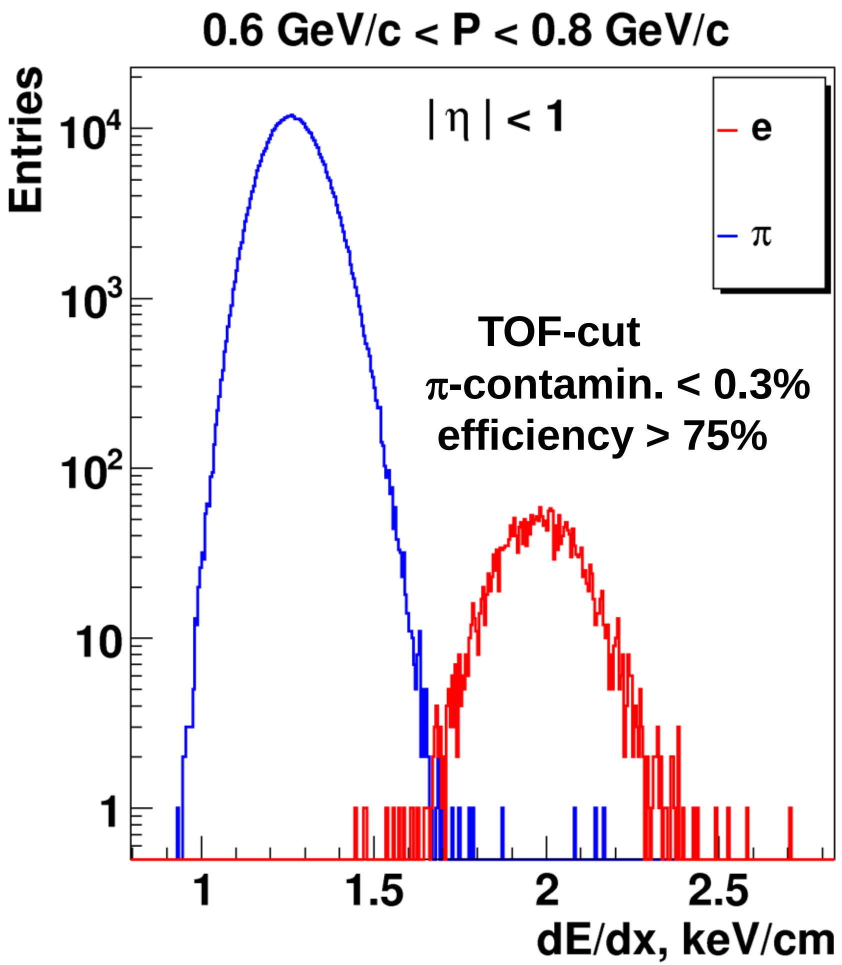
Colliders & Synchrotrons: Luminosity vs Energy (√s)




Thresholds accessible at proton accelerators
(intermediate energy region)
created mass excess, MeV/c²
proton beam energy at lab., T_kin, GeV
0
500
1000
1500
2000
2500
3000
3500
4000
0
2
4
6
8
10
12
14
16
18
¹²C
d
p
D_C
COSY
Ω+3K
Ξ+2K
Θ⁺
φ
Depolarizing resonanses
(Nuclotron, d, extraction)
Nuclotron

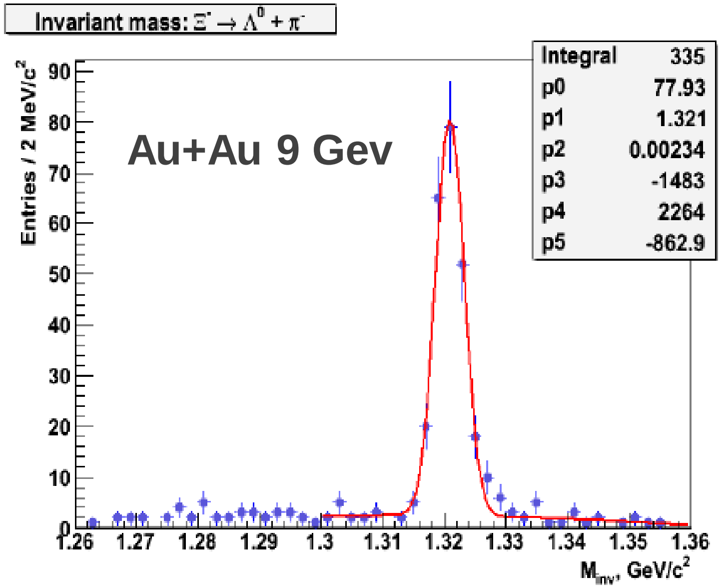
Electron identification





- ❑ Rejection of protons, kaons and most of pions by TOF
- ❑ π contamination in the e^{+-} sample < 0.3%
- ❑ ECAL provides extra suppression factor

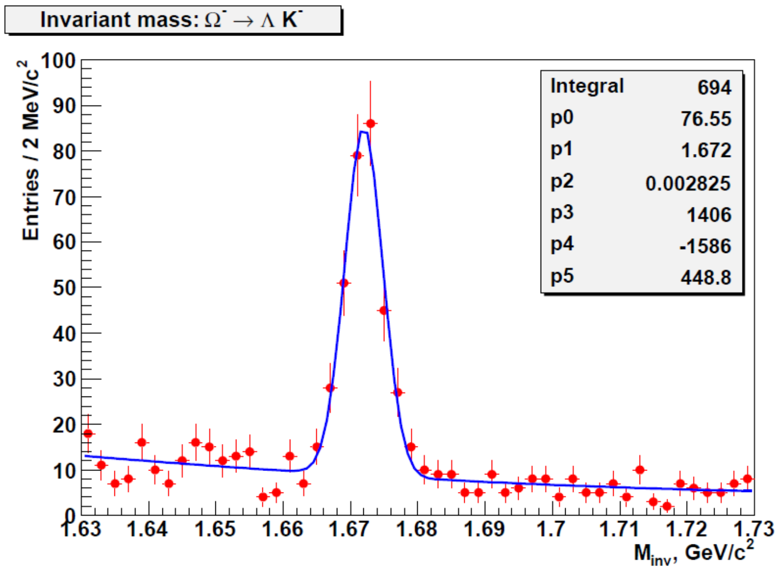
Hyperon reconstruction



Eff. ≈ 3.8%

S / B (±3σ) = 245 / 18 ≈ 13.7

S / √(S+B) ≈ 15.1



Eff. ≈ 2.1%

S / B (±3σ) = 286 / 59 ≈ 4.9

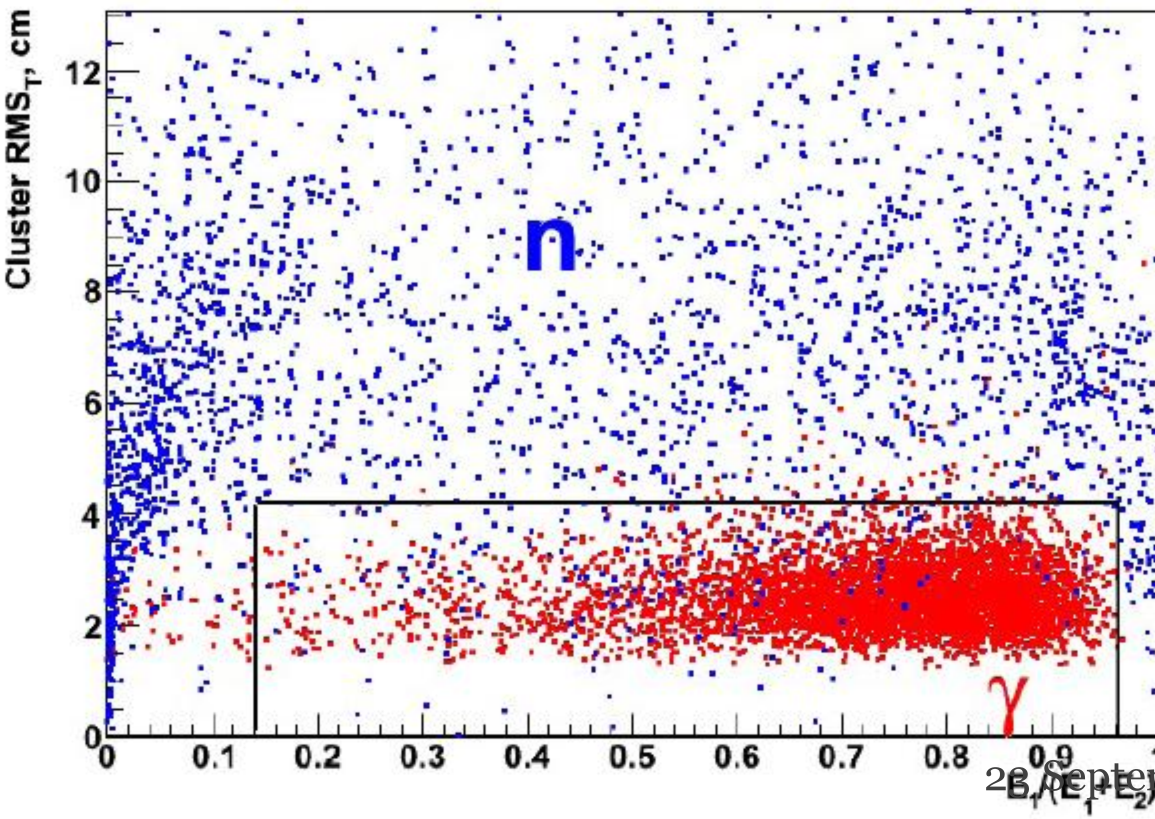
S / √(S+B) ≈ 15.4

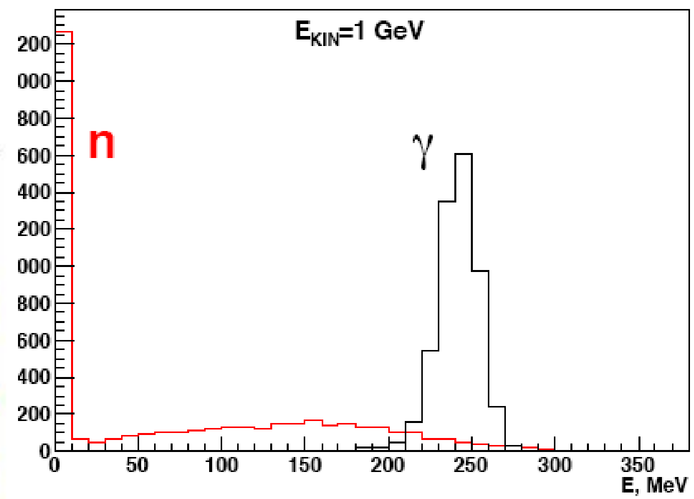
Excellent capabilities for hyperon measurements!

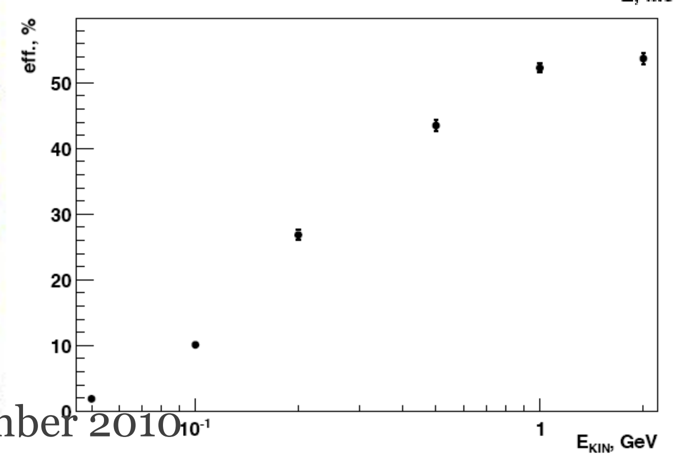
n/γ separation efficiency

by using information on X-Y(transverse) and Z (longitudinal) shapes of profiles of the cluster in the ECal

Efficiency of neutron identification - 95% with 3% admixture of photons





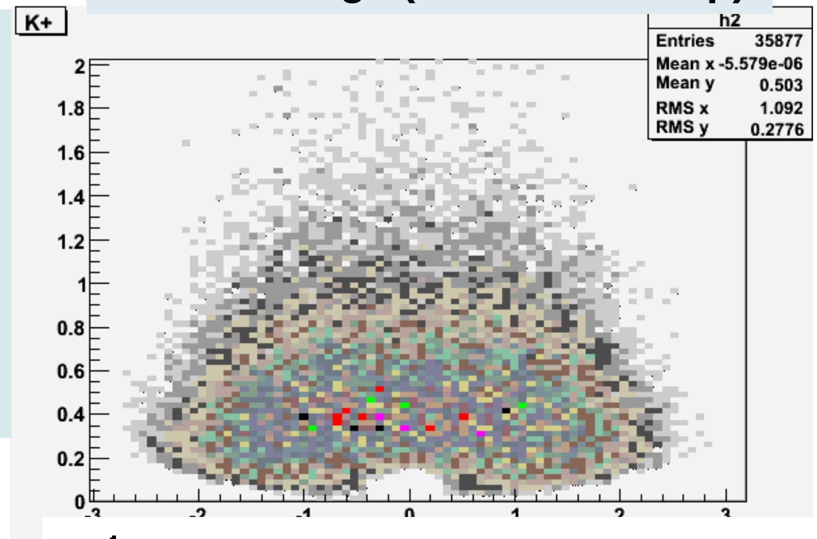


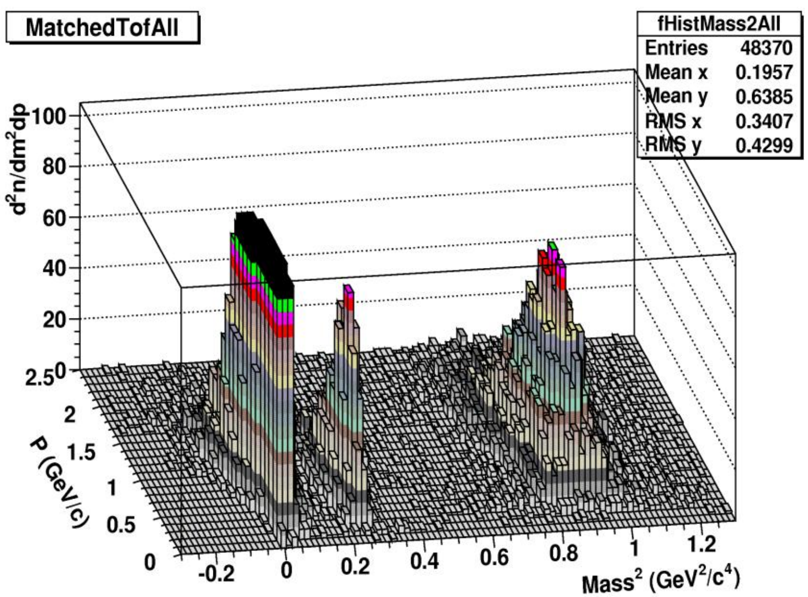
Beam	Nuclotron beam intensity (particle per cycle)				
	Current	Ion source type	Nuclotron-M (2010)	Nuclotron-N (2012)	New ion source + booster (2013)
p	$3\cdot10^{10}$	Duoplasmotron	$8\cdot10^{10}$	$5\cdot10^{11}$	$5\cdot10^{12}$
d	$3\cdot10^{10}$	--- „ ---	$8\cdot10^{10}$	$5\cdot10^{11}$	$5\cdot10^{12}$
^{4}He	$8\cdot10^{8}$	--- „ ---	$3\cdot10^{9}$	$3\cdot10^{10}$	$1\cdot10^{12}$
d↑	$2\cdot10^{8}$	ABS (“Polaris”)	$2\cdot10^{8}$	$1\cdot10^{10}$ *(SPI)*	$1\cdot10^{10}$ *(SPI)*
^{7}Li	$8\cdot10^{8}$	Laser	$5\cdot10^{9}$	$3\cdot10^{10}$	$5\cdot10^{11}$
$^{11,10}B$	$1\cdot10^{9,8}$	--- „ ---	$2\cdot10^{9,8}$	$2\cdot10^{10,9}$	
^{12}C	$1\cdot10^{9}$	--- „ ---	$3\cdot10^{9}$	$2\cdot10^{10}$	$2\cdot10^{11}$
^{24}Mg	$2\cdot10^{7}$	--- „ ---	$2\cdot10^{8}$	$1\cdot10^{9}$	
^{14}N	$1\cdot10^{7}$	ESIS (“Krion-2”)	$3\cdot10^{7}$	$3\cdot10^{8}$	$5\cdot10^{10}$
^{24}Ar	$1\cdot10^{9}$	--- „ ---	$3\cdot10^{9}$	$2\cdot10^{10}$	$2\cdot10^{11}$
^{56}Fe	$2\cdot10^{6}$	--- „ ---	$6\cdot10^{6}$	$1\cdot10^{8}$	$5\cdot10^{10}$
^{84}Kr	$1\cdot10^{4}$	--- „ ---	10^{5}	$1\cdot10^{7}$	$1\cdot10^{9}$
^{124}Xe	$1\cdot10^{4}$	--- „ ---	10^{5}	$1\cdot10^{7}$	$1\cdot10^{9}$
^{197}Au	-	--- „ ---		$1\cdot10^{7}$	$1\cdot10^{9}$

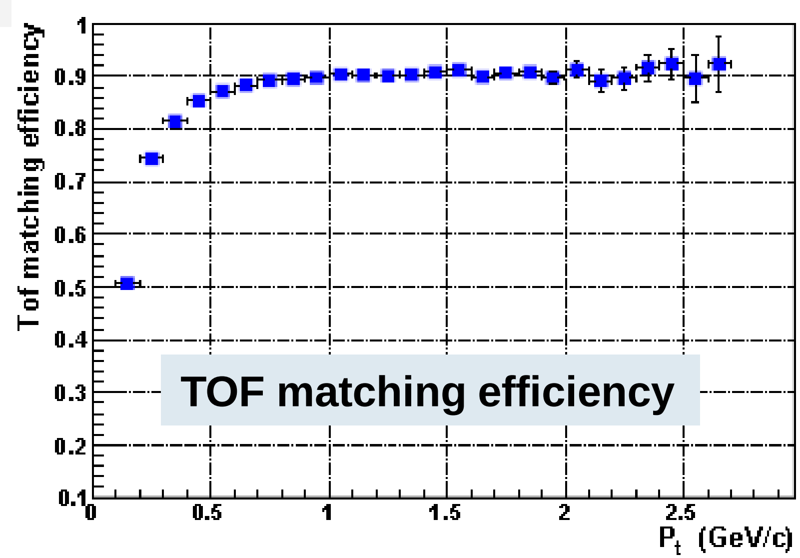
TOF performance study

- **Coverage:**
  $|\eta| < 1.4$, p_t=0.1-2 GeVc barrel
  $|\eta| < 2.6$, p_t=0.1-2 GeVc barrel+endcap
- **Matching eff.:** > 85% at p_t > 0.5 GeV/c
- **PID:** 2σ π/K ~ 1.7 GeV/c, (π,K)/p ~ 3 GeV/c

TOF coverage (barrel + endcap)







TOF matching efficiency

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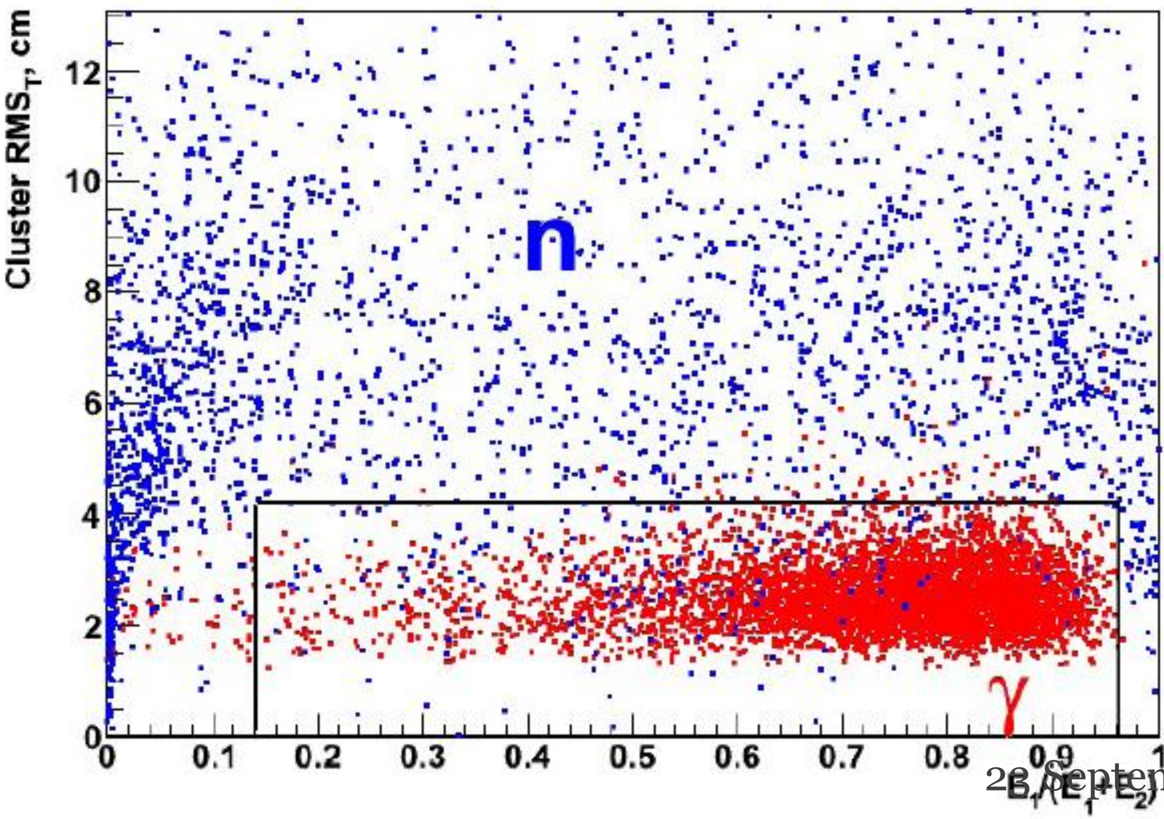
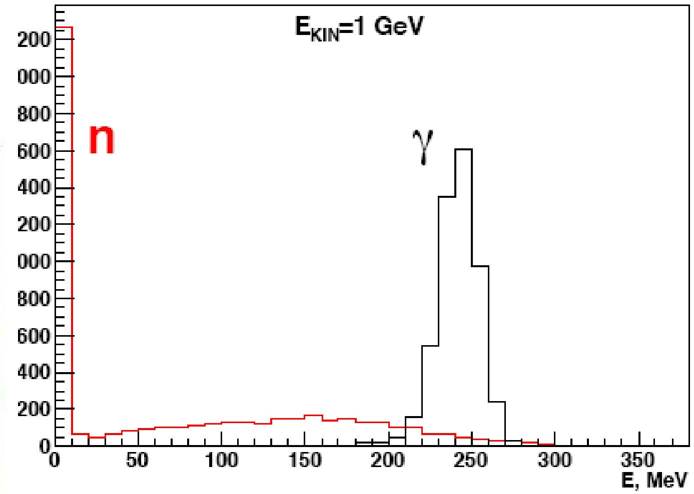
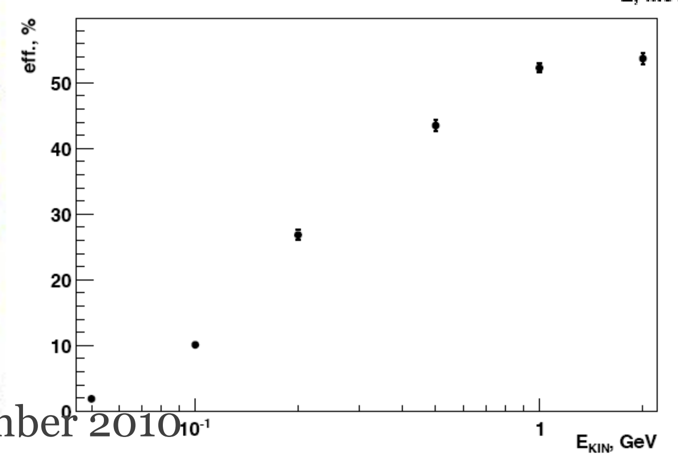
Efficiency of neutron identification - 95% with 3% admixture of photons



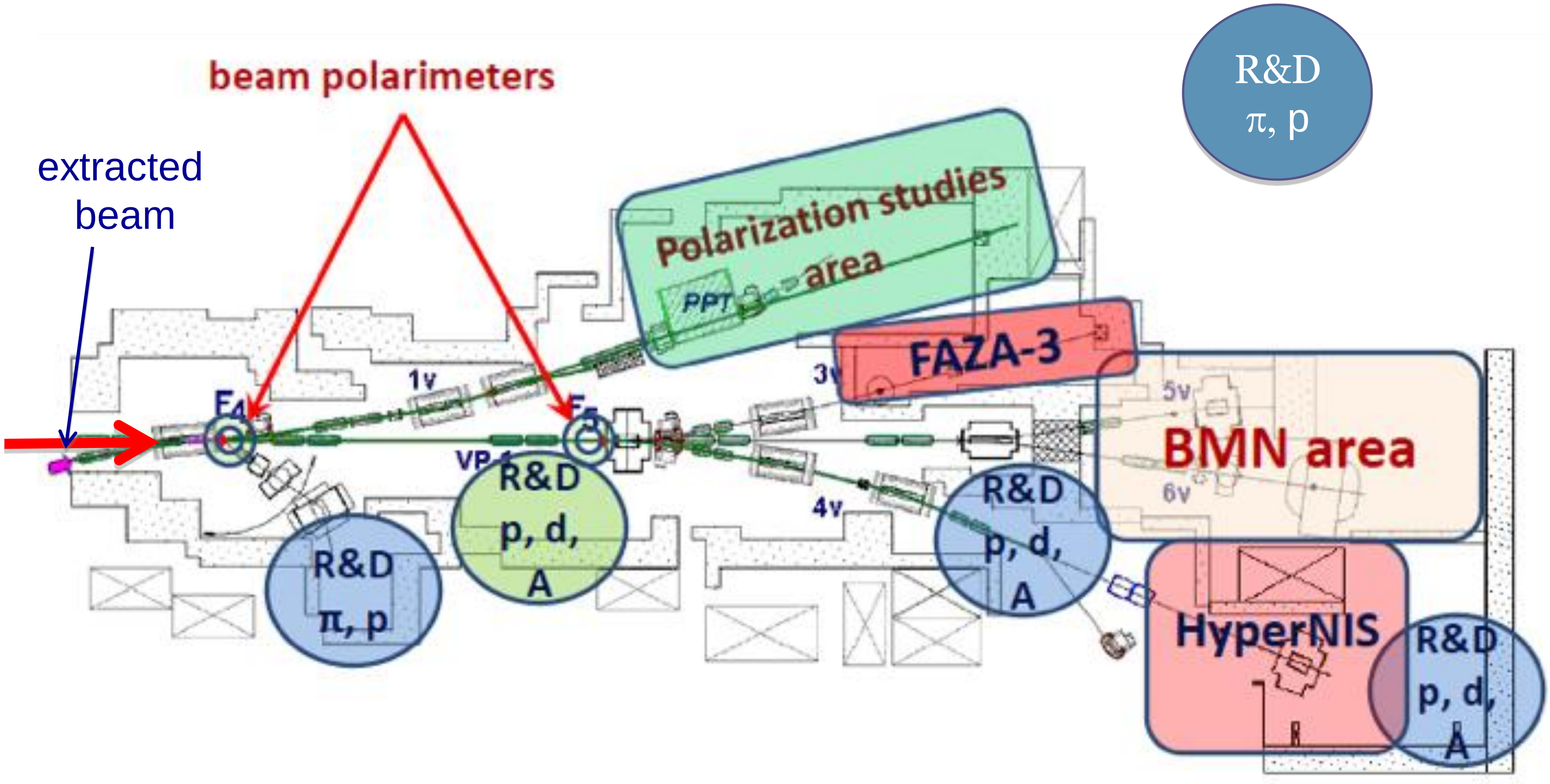




Nuclotron beam slow extraction

Parameter	Design	Obtained
Energy range, (GeV/amu)	0,2-6,0	0,2-2,2
Duration, (s) up to	10	10
Extraction efficiency, %		
at 0,2 GeV/amu	90	95
at 2,2 GeV/amu	95	95
Extraction angles, (mrad)		
horizontal	5	5
vertical	96±6	96±1
Nominal ES voltage, (kV)	200	140
Exploitation ES voltage, (kV)	up to 200	up to 120
LM supply current, (kA)	up to 6,3	6,3
Repetition rate, (Hz)	1,0	1,0

Fixed Target Experiment Area *(bld. 205)*



NICA operation regime & parameters

Injector: 2×10^9 ions/pulse of $^{197}Au^{32+}$
at energy of 6.2 MeV/u

Booster (25 Tm)
1(2-3) single-turn injection,
storage of 2 (4-6)×10⁹,
acceleration up to 100 MeV/u,
electron cooling,
acceleration
up to 600 MeV/u

Collider (45 Tm)
Storage of
32 bunches × $1 \cdot 10^9$ ions per ring
at 1÷4.5 GeV/u,
electron and/or stochastic cooling

Stripping (80%) $^{197}Au^{32+} \Rightarrow {}^{197}Au^{79+}$

IP-1

Two superconducting collider rings

IP-2

Nuclotron (45 Tm)
injection of one bunch
of 1.1×10^9 ions,
acceleration up to
1÷4.5 GeV/u max.

2 x 32 injection cycles (~ 6 min)

Option: stacking with BB and S-Cooling
~ 2 x 300 injection cycles (~ 1 h)

Bunch compression (RF phase jump)