MultiPurpose Detector MPD
&
SpinPurpose Detector SPD
Status Report

XIX International Baldin Seminar on High Energy Physics Problem,
Dubna, Sep.29- Oct.4, 2008
V.Kekelidze

- *Physics motivation*
- *General approach to MPD concept*
- *Progress in MPD project preparation*
  - *software environment MPDROOT*
  - *activity of physics groups*
  - *End-Cap concept development*
  - *progress in R&D of detectors*
- *SPD start up*
- *Conclusions*

Introduction

New strategic course of the JINR in relativistic heavy ions & particle physics endorsed by the PAC is based on:

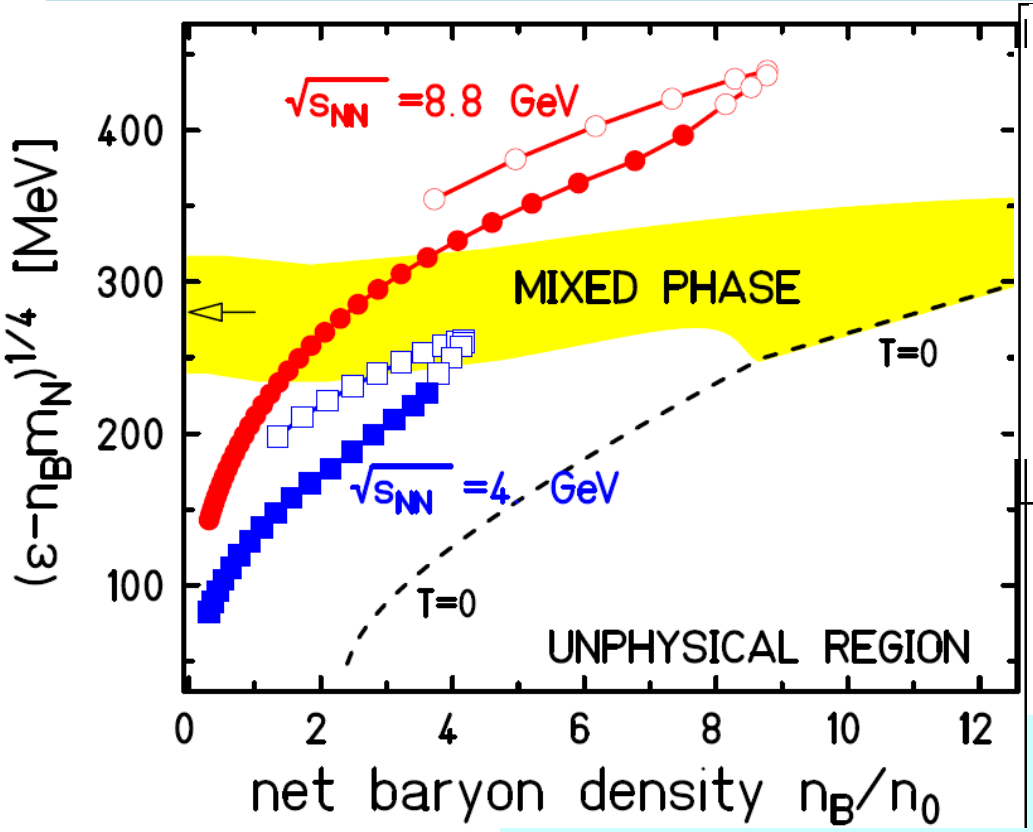
- **development of the home accelerator facility NICA**
  providing relativistic heavy ions & polarized beams
- **scientific programs at home & external accelerators including**
  a study of various phases of strongly interacting matter, urgent topics of particle physics and spin physics

Relativistic Heavy Ion Physics is a high priority task in many scientific centers (BNL, CERN, GSI, JINR,..) since last few decades

Theoretical motivation of relativistic heavy ion study at JINR is well founded in the works of:
A.Sissakian, A.Sorin, V.Toneev, G.Zinoviev etc & others.

Heavy Ion Physics at $\sqrt{s_{NN}}$ = 3-9 GeV

The phase diagram in terms of the reduced energy density
the trajectories are calculated with hybrid model



E_{lab}	$\sqrt{s}$ GeV/u	
5	3.60	NICA & CBM
10	4.73	
30	7.75	
80	12.42	RHIC (?)
158	17.36	NA49/61 (SPS)

steps:
0.3 fm/c & 0.5 fm/c

$\sqrt{s_{NN}}$ = 3-9 GeV is a most promising energy region to search for mixed phase & critical end-point

Basic facility NICA development plans

- 2008 -2009 NUCLOTRON

extracted beams (p, d, Li, C, …) & internal target
(d↑ beam) & polarized (//) proton target
Running period: 2 x~ 600 h/year (~1/2 R&D for machine)
efforts are making to extend

- 2010 -2013 NUCLOTRON-M *(the first stage of NICA)*

beams up to A ~ 200
~ 4 GeV/u (for Au)
extracted beams ~ 10^9 A/pulse
(↑ beam & polarized (//) internal target)

Project Leaders:

A.Sissakian, A.Sorin, A.Kovalenko, I.Meshkov, G.Trubnikov

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-1

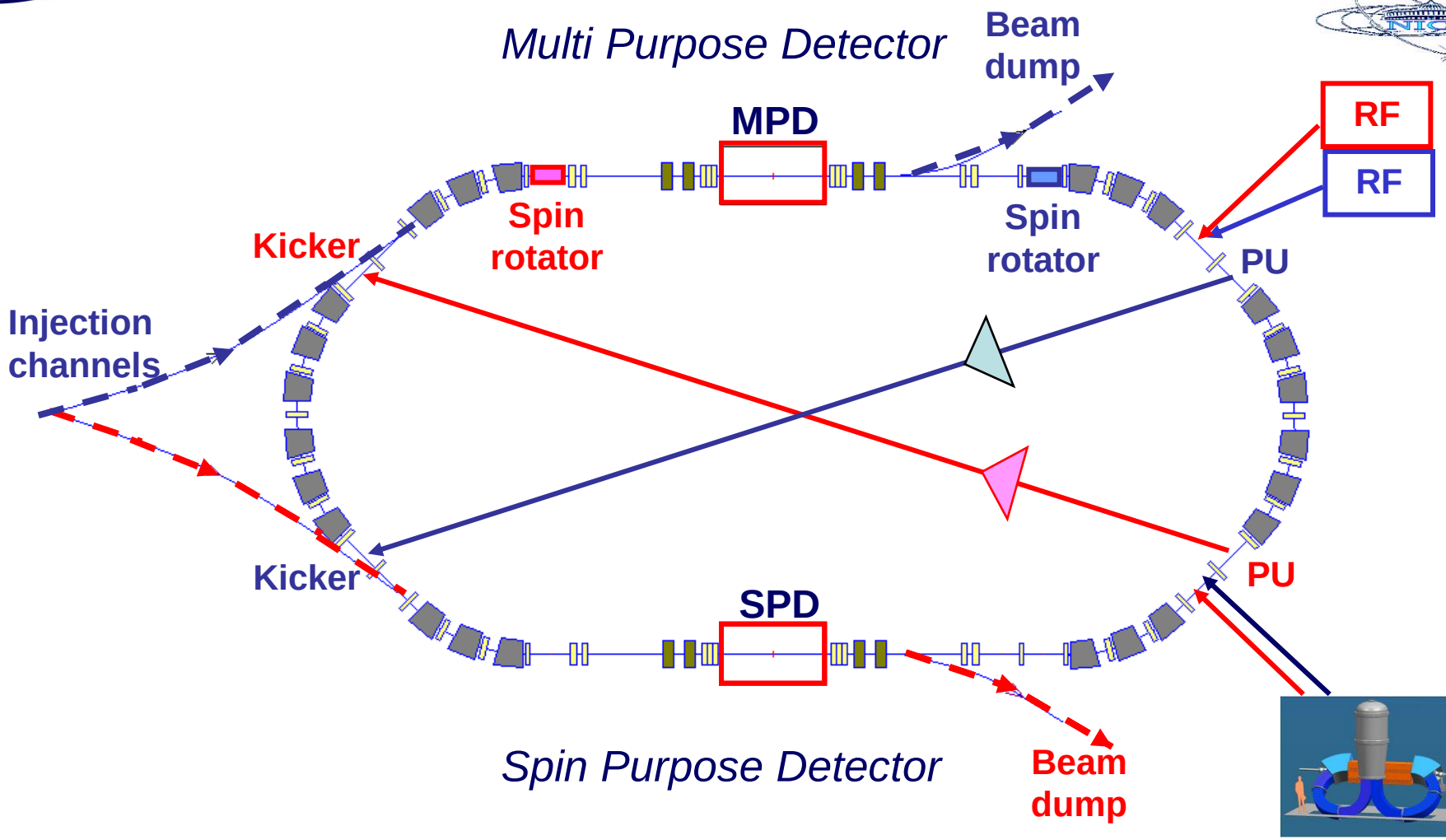
with at least two interaction points:

MPD - MultiPurpose Detector (to search for mixed phase)
SPD - Spin Purpose Detector in (d,p)↑ beams

Collider NICA *new* major parameters

Ring circumference, m	251
Interaction points	2
Beta function at interaction point β^*, m	0.5
Momentum spread (rms)	0.001
Bunch length, m	0.3
Particle number per bunch	10^9
Bunch number	17
Ion kinetic energy, E[GeV/u], min/max	1/3.5
Luminosity fro ions, L [$cm^{-2}s^{-1}$], average	10^{27}

Collider structure



Relativistic Heavy Ion Physics at Laboratory of High Energy Physics

FAZA at Nuclotron — *S.Avdeev, V.Karnaukhov*
effects of phase transition in thermal multifragmentation

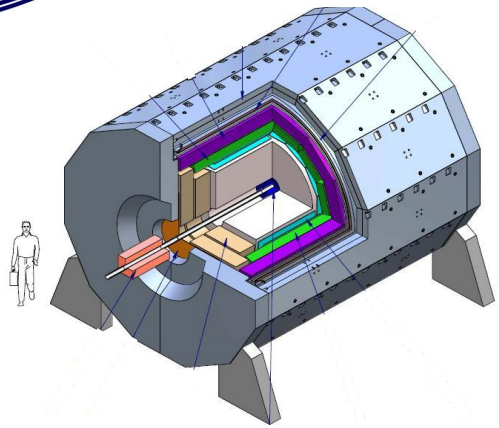
HADES & **CBM** — *A.Malakhov, Yu.Zanevsky, Yu.Murin*
at SIS 18, 100/300 **GSI**

NA49 -> **NA61** *at SPS* **CERN** — *G.Melkumov*

STAR *at RHIC* **BNL** — *R.Lednicky, Yu.Panebratcev*

ALICE *at LHC* **CERN** — *A.Vodopianov*

Relativistic Heavy Ion Physics at NICA



The MPD experiment is proposed

to study in-medium properties of hadrons,
& search for phase transition, mixed phase
& critical end-point

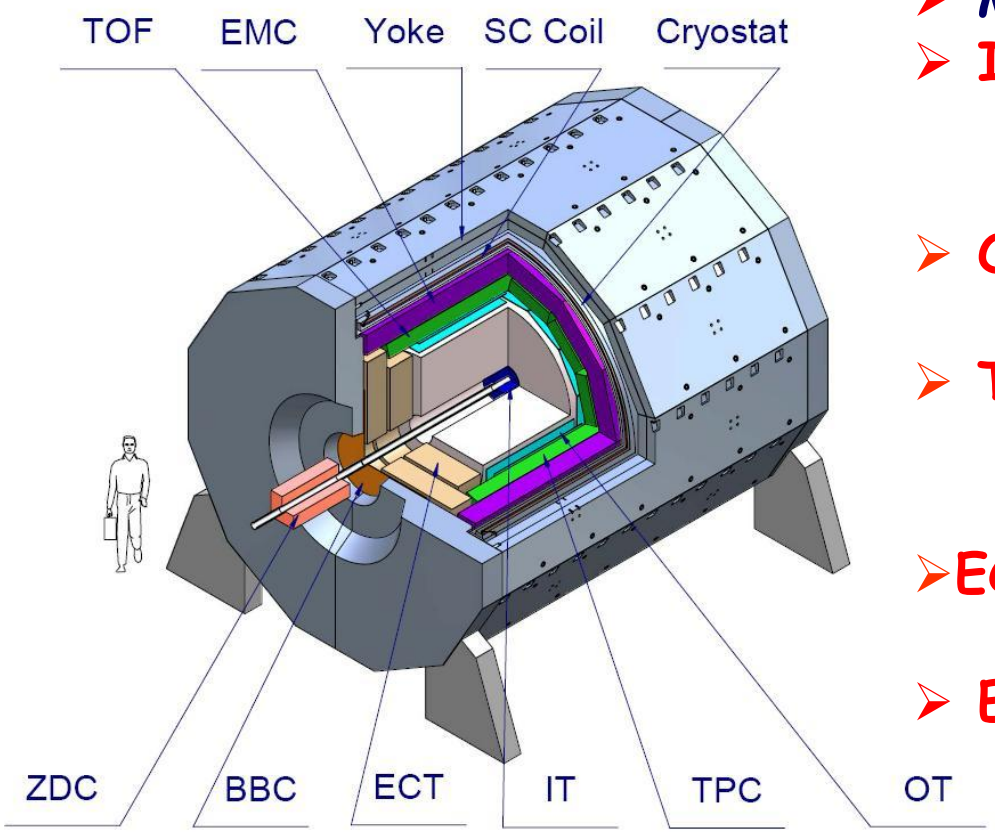
*in collisions of **heavy ion** (over atomic mass range A = **1-238**)*
*by scanning of the **energy region** $\sqrt{s_{NN}}$ = **1 - 9 GeV***

MPD project preparation foresees two stages:
- detector design & R&D targeting to detect light hadrons
(as probes of phase transition)
-consideration of possibilities with lepton probes

simultaneously permanent efforts are making
*to **organize the collaboration** & look for new ideas,*
preparation of the White Book

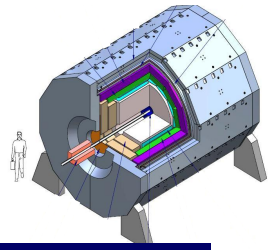
MPD – conceptual design

General View



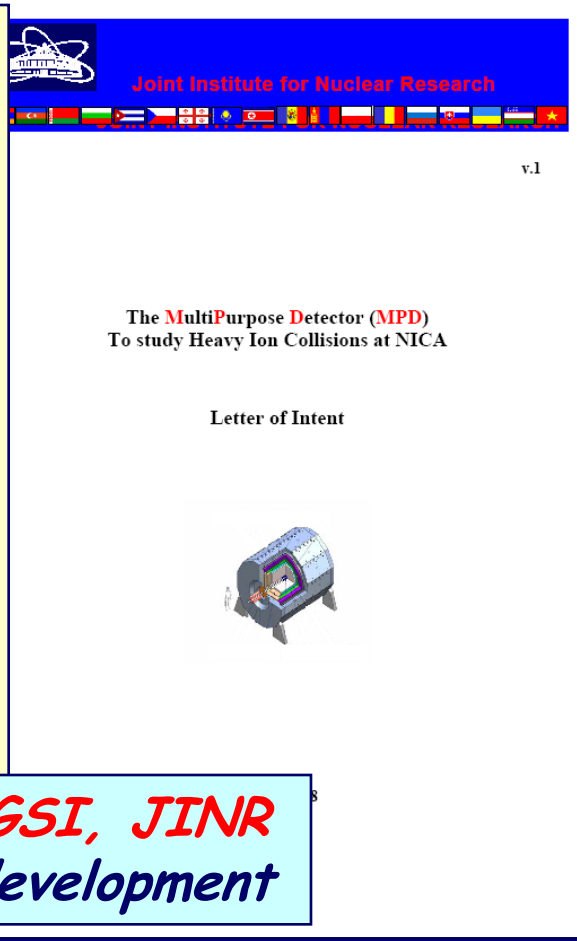
- **0.5T solenoid** *with closed yoke*
- **Major tracker** - ***TPC***
- **Inner Tracker** - *silicon strips for tracking close to the interaction region*
- **Outer Tracker** *straw barrel (optional)*
- **Time Of Flight** ***RPC*** *(+ start/stop sys.) for charged particle* ***ID***
- **ECAL** ***shashlyk type*** *- for* e, γ, π**0** *reconstruction*
- **End Cap Tracker** *to cover enlarged* η *region* ***- challenging task*** *for tracking in solenoidal field*

MPD Project Preparation



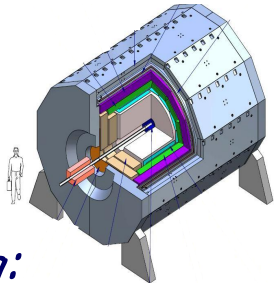
The MPD Collaboration

- 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 of Applied Physics, AS, **Moldova**



A consortium was organized involving GSI, JINR & other centers, for the IT module development

MPD experiment – first stage targets

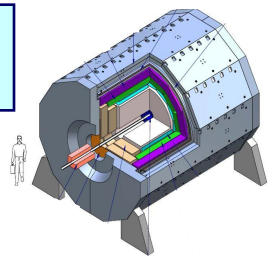


the effects to be studied with various ion interactions on energy & centrality scanning:

- ***Event-by-event fluctuation in hadron productions*** *(multiplicity, Pt etc.)*
- ***HBT correlations indicating the space-time size of the systems involving*** π, K, p, Λ *(possible changes close to the de-confinement point)*
- ***Multi-strange hyperon production: yield & spectra*** *(the probes of nuclear media phases)*
- ***Directed & elliptic flows for various hadrons***

- ***Leptonic probes - feasibility under study dedicated experiment under consideration***

Further Progress in Project Preparation



directions of activity

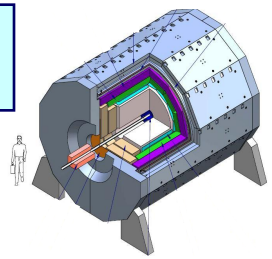
- ***development of theoretical models & corresponding generators***
  A.Sorin, V.Skokov, V.Toneev, I.Mandjavidze, J.Musulmanbekov et al.

- ***maintenance & development of software environment - MPDROOT***
  group of O.Rogachevsky

- ***Detector concept optimization for various physics tasks***
  - ***charged hadron production-*** *D.Arkhipkin et al.*
  - ***Λ, K^0 and hyperon production*** *A.Kechechyan, M.Tokarev et al.*
  - ***leptonic observables*** *A.Olchevsky, I.Tyapkin et. al.*
  - ***other groups*** *leaders to be identified*

- ***End-Cap concept development***
  O.Rogachevsky, V.Golovatyuk, A.Zinchenko, D.Arkhipkin, V.Peshekhonov, Yu.Kiryushin et al.

Further Progress in Project Preparation



directions of activity

- ***detector R&D*** ***progressing in many groups***

- ***beam test facility preparation plans*** ***– under discussion***
  E.Strokovsky, G.Trubnikov, A.Kovalenko

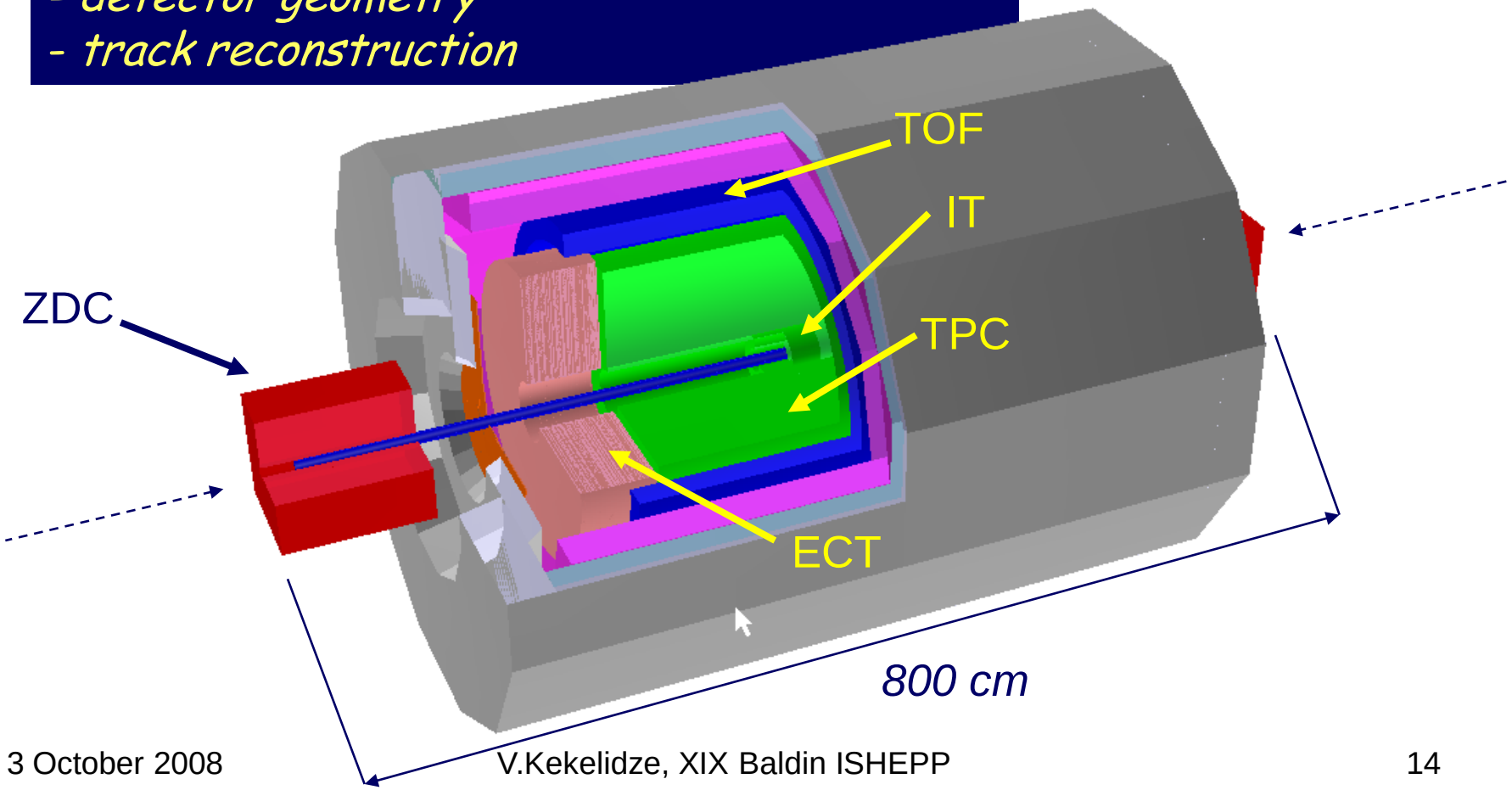
- ***IT infrastructure development*** *Yu. Potrebenikov et al.*
- ***management program & corresponding software preparation***
  Yu.Potrebenikov, D.Madigozhin, N.Molokanova

- ***MPD allocation (+ cost estimates), engineering & harness designs***
  Russian State Specialized Design Institute (Rossatom, Moscow)
  N.Agapov, A.Shabunov,V.Borisov

Progress in MPD Project Preparation

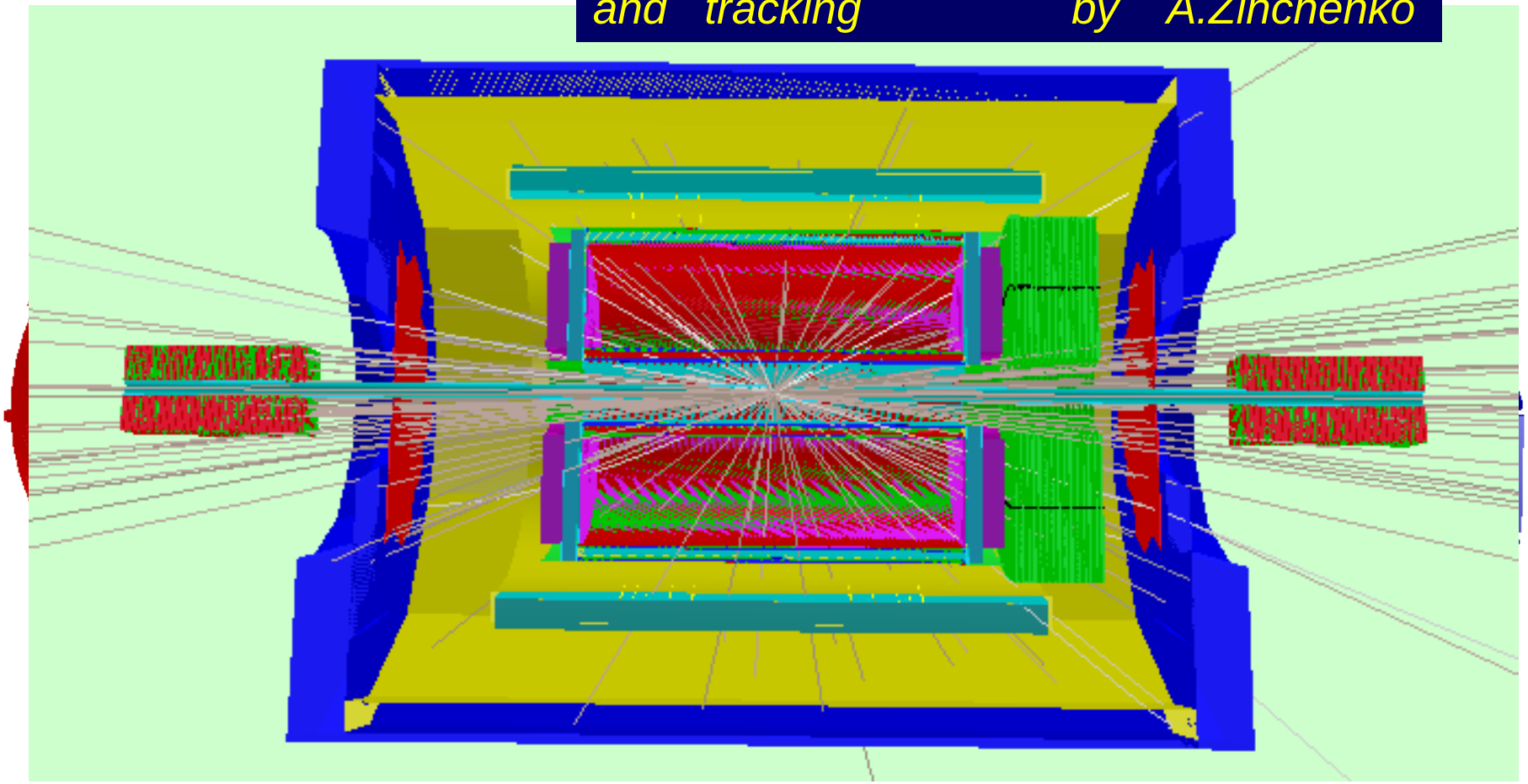
Development of the MPDROOT software:
- *general framework*
- *GEANT-4 based simulation*
- *detector geometry*
- *track reconstruction*

O.Rogachevsky's group

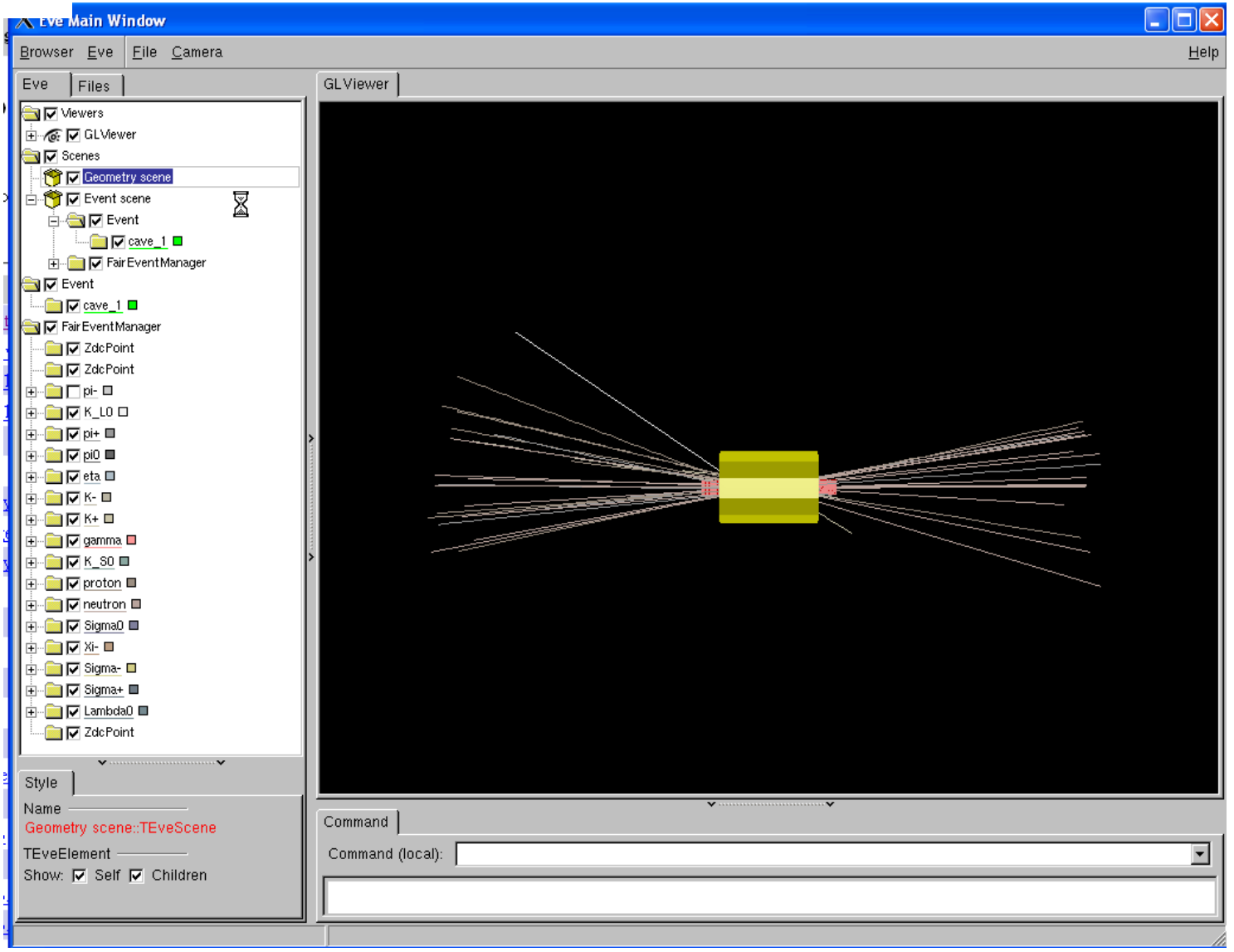


Detector geometry in MPDROOT

and tracking by A.Zinchenko



Event display (geometry + selected tracks)

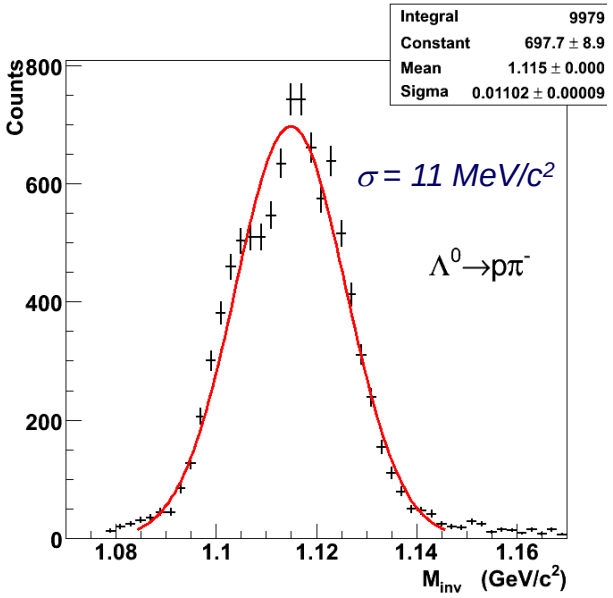


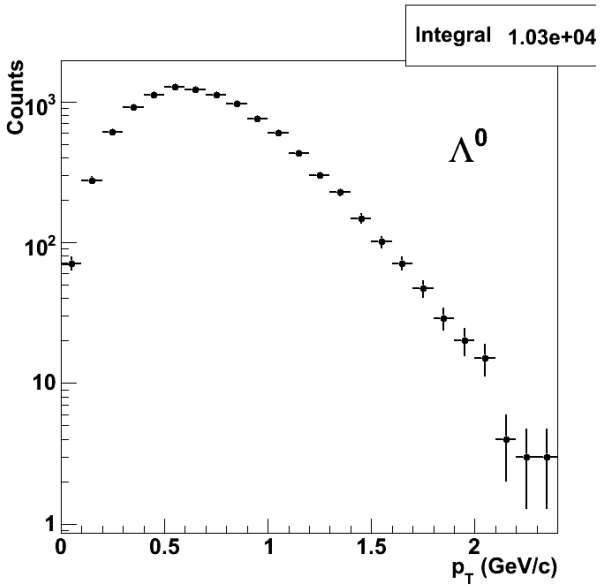
Physic tasks *first steps*

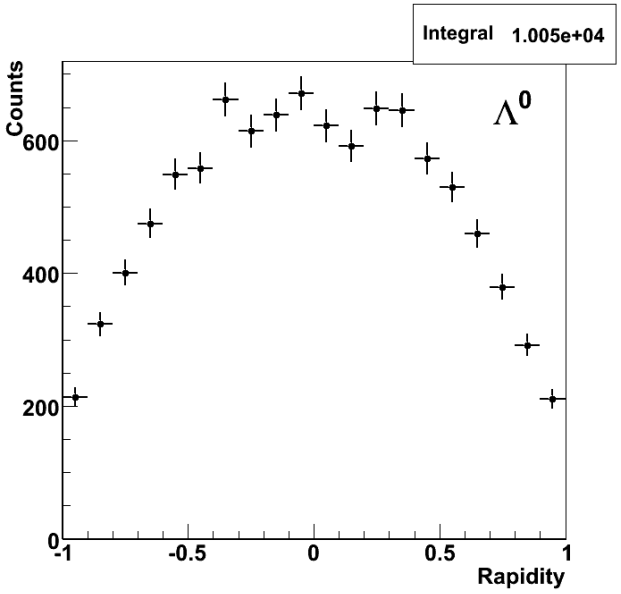
Lambda reconstruction *A. Kechechyan et al.*

generated & reconstructed 1000 decays in Au+Au at $\sqrt{s_{NN}}$ = *9 GeV*

mass resolution & spectra



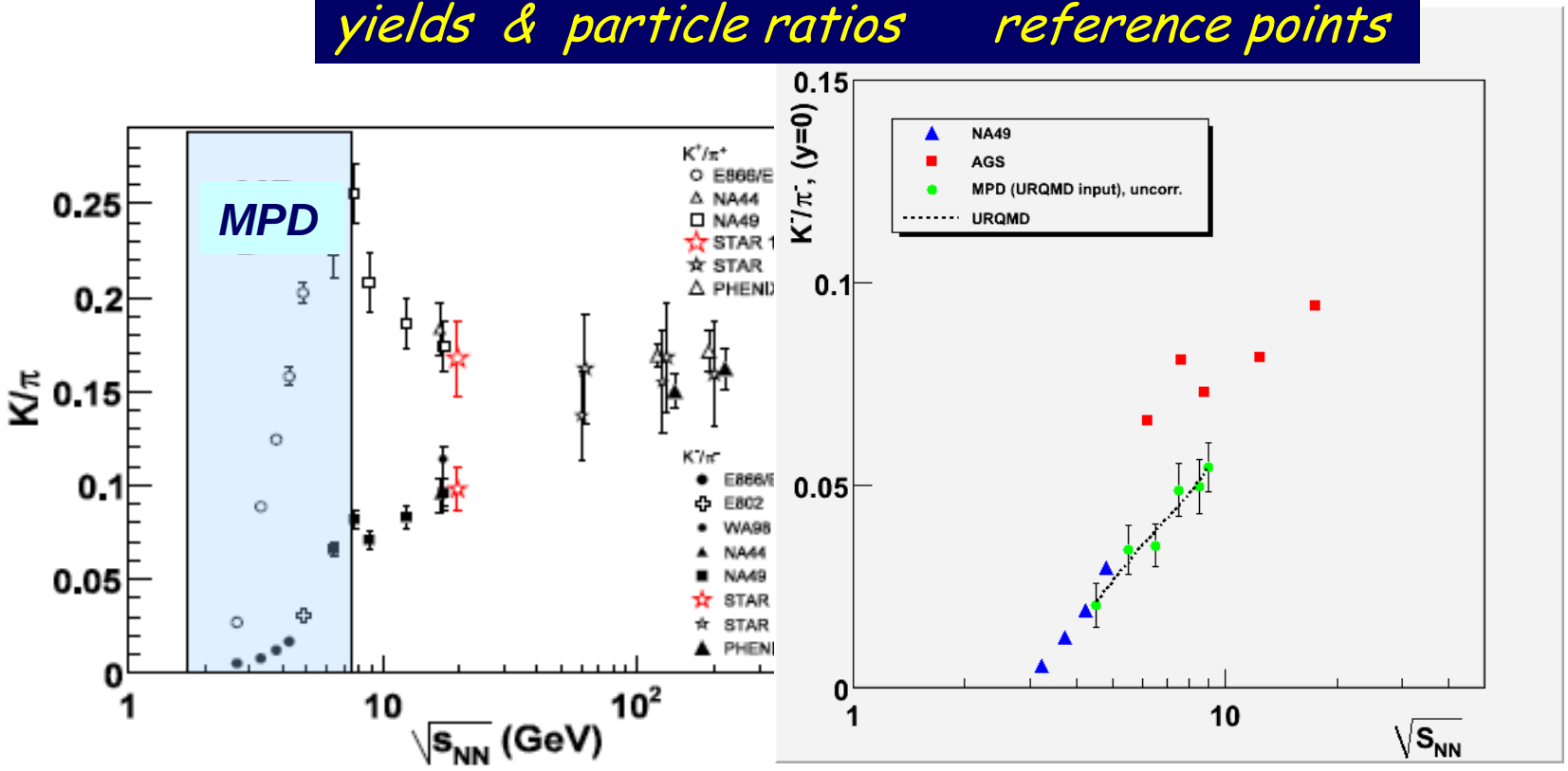




Physic tasks *first steps*

charged hadron production
K/π ratio *D. Arkhipkin et al.*

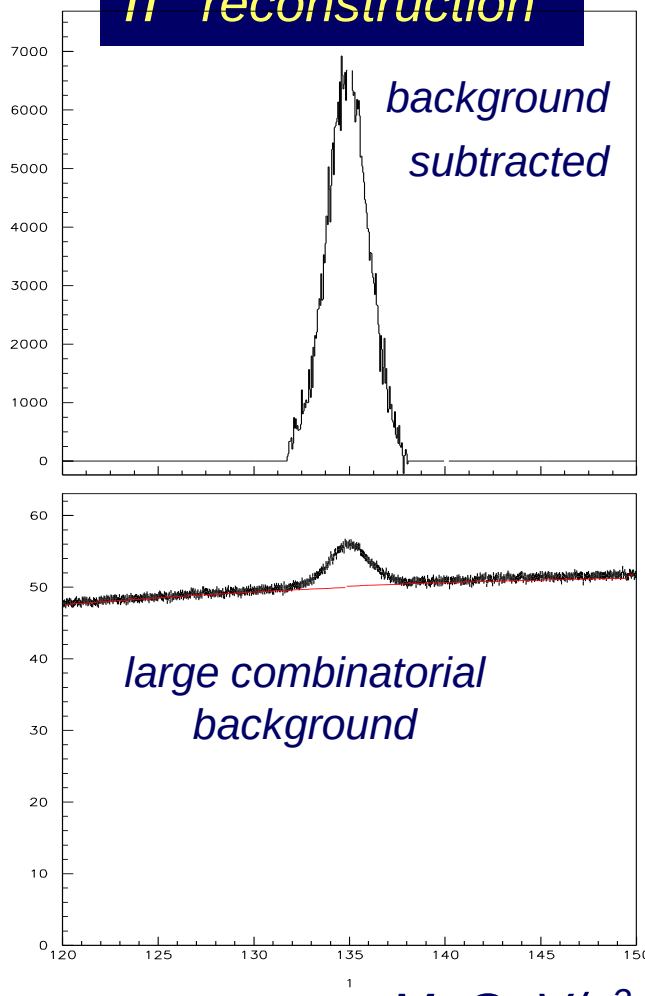
yields & particle ratios *reference points*



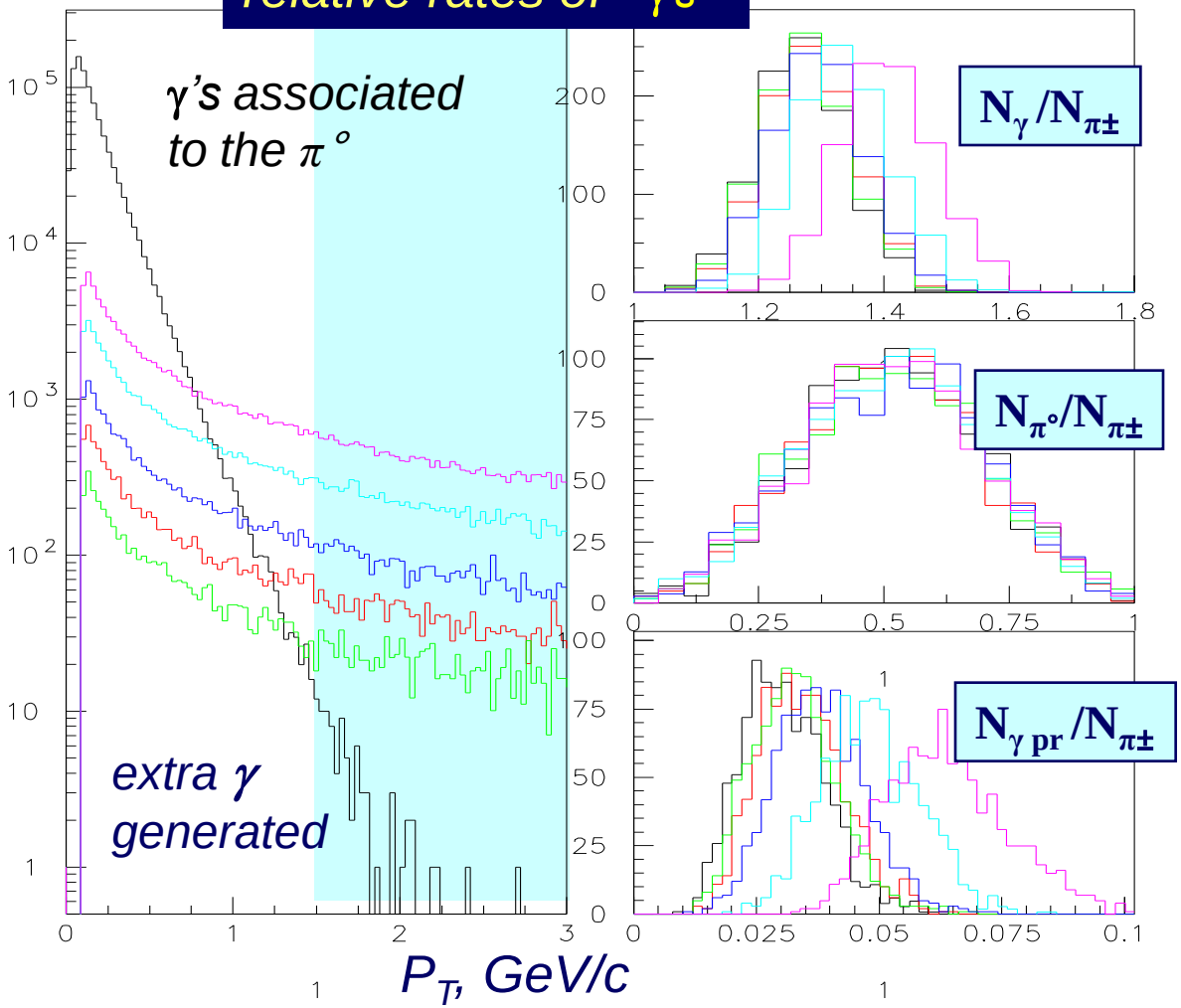
Physic tasks *first steps*

Electromagnetic observables *A.Olchevsky, I.Tyapkin, etc.*

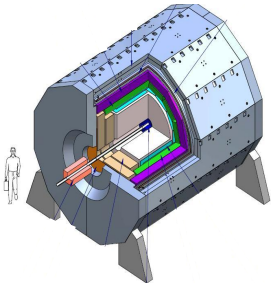
π° reconstruction



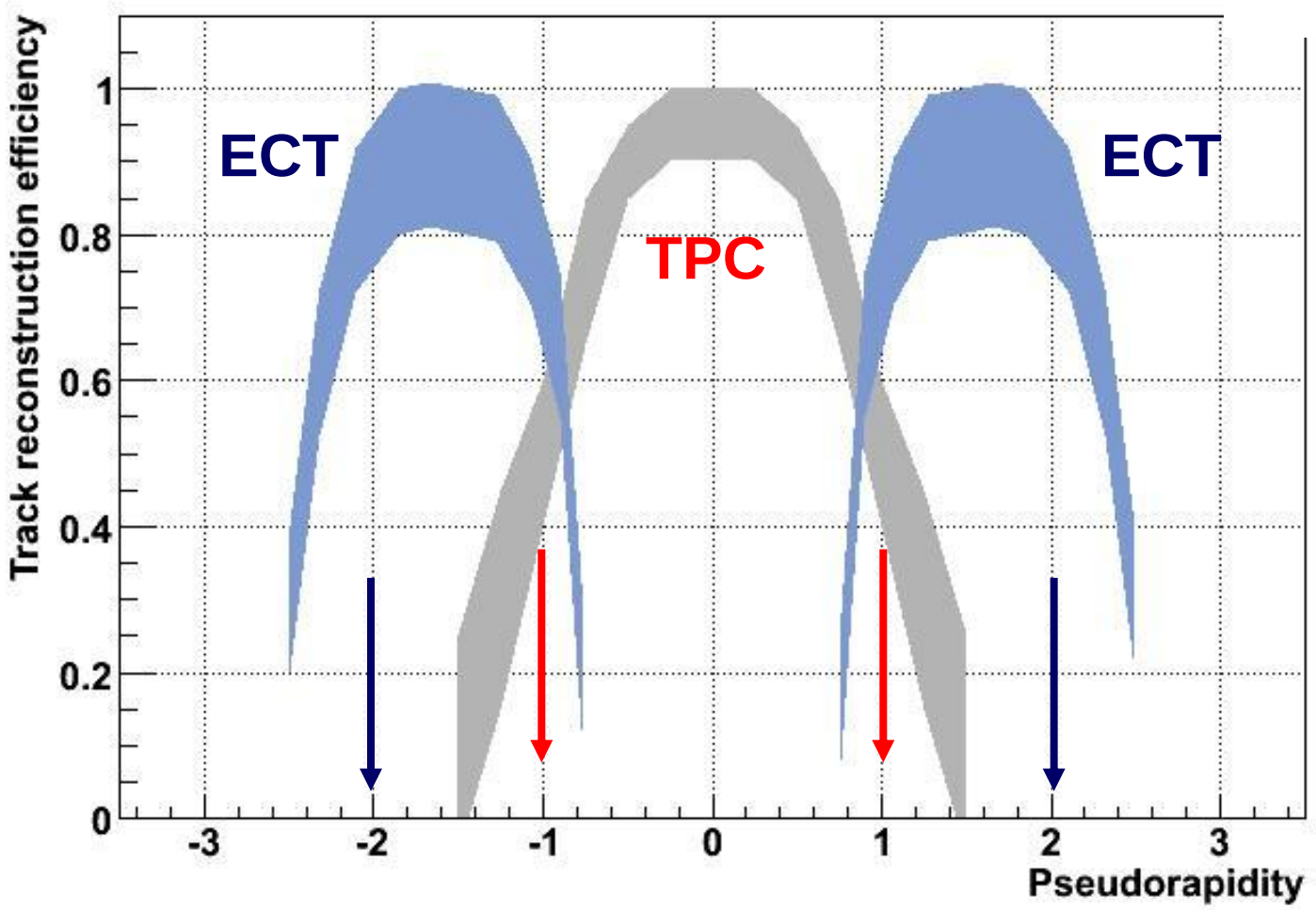
relative rates of γ's



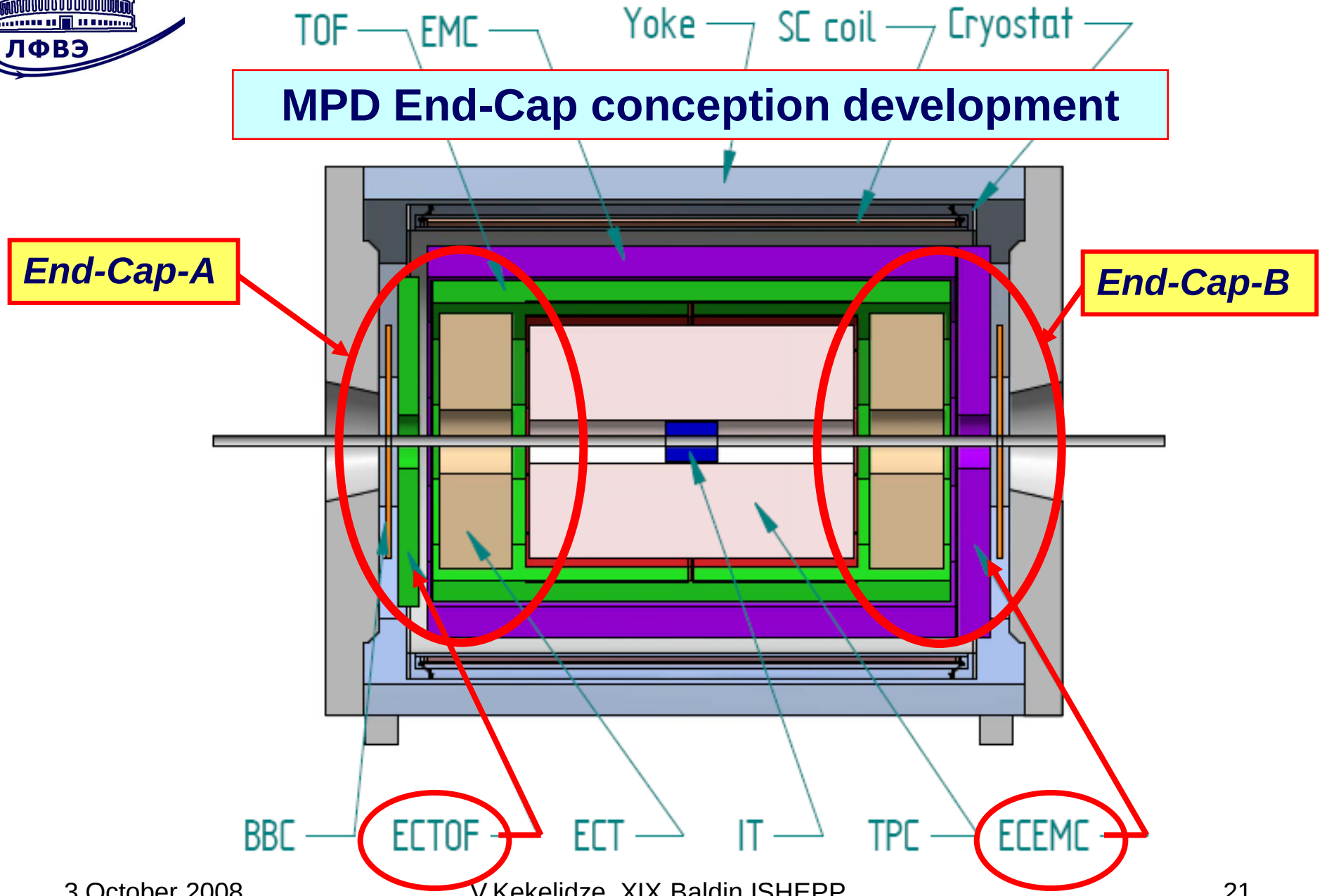
Typical track reconstruction efficiency



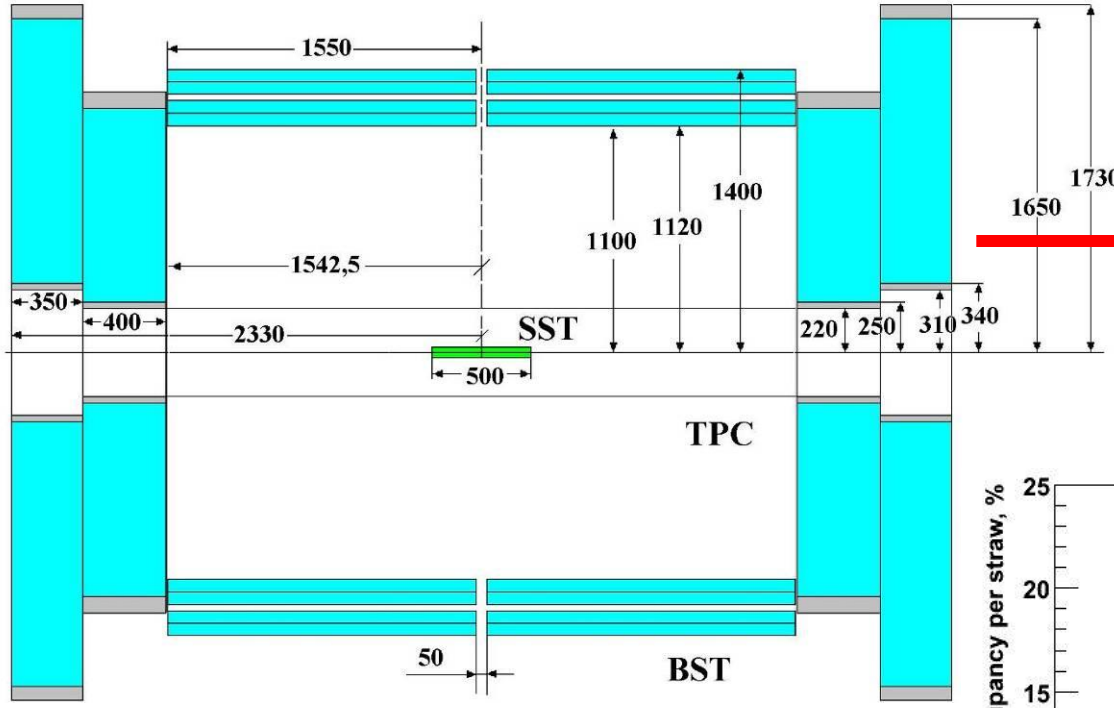
ECT complementary to TPC
to extend pseudorapidity range

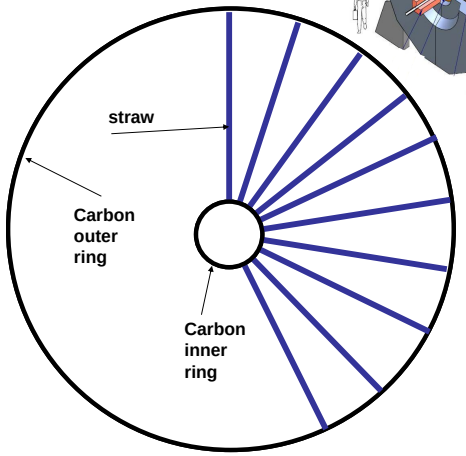


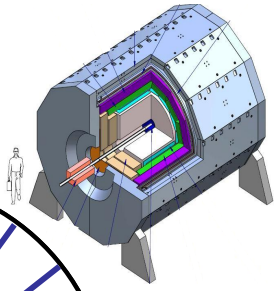
MPD End-Cap conception development

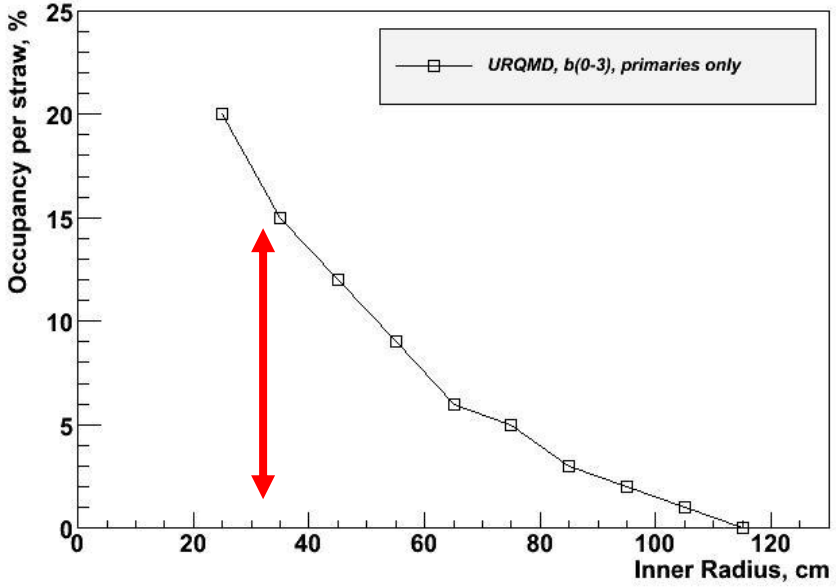


ECT straw wheels







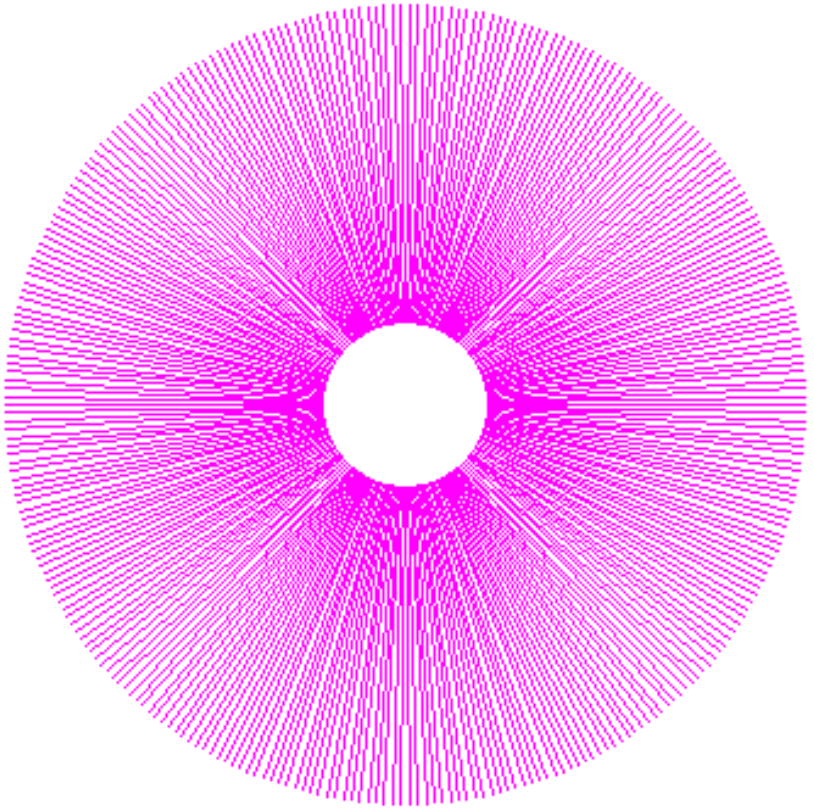


occupancy /straw < 15 %

Straw Tracker geometry (MPDROOT)

ST barrel

ECT - Straw Wheels (60 layers in total)



End-Cap concept development: ECT

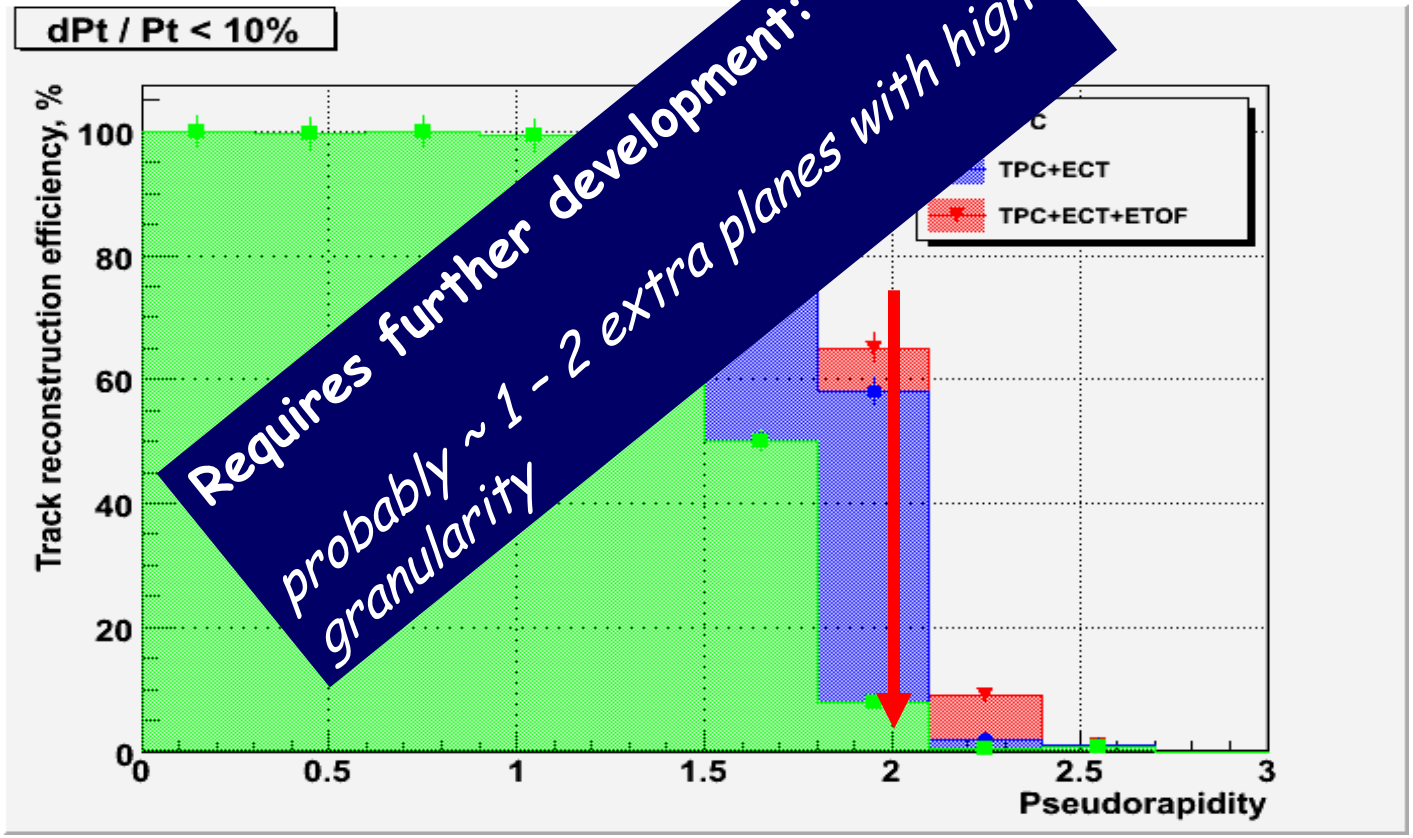
A.Zinchenko

to enlarge the acceptance over pseudo rapidity region

End-Cap elements have been added

- EC (Straw Wheels)

- [illegible] chambers)



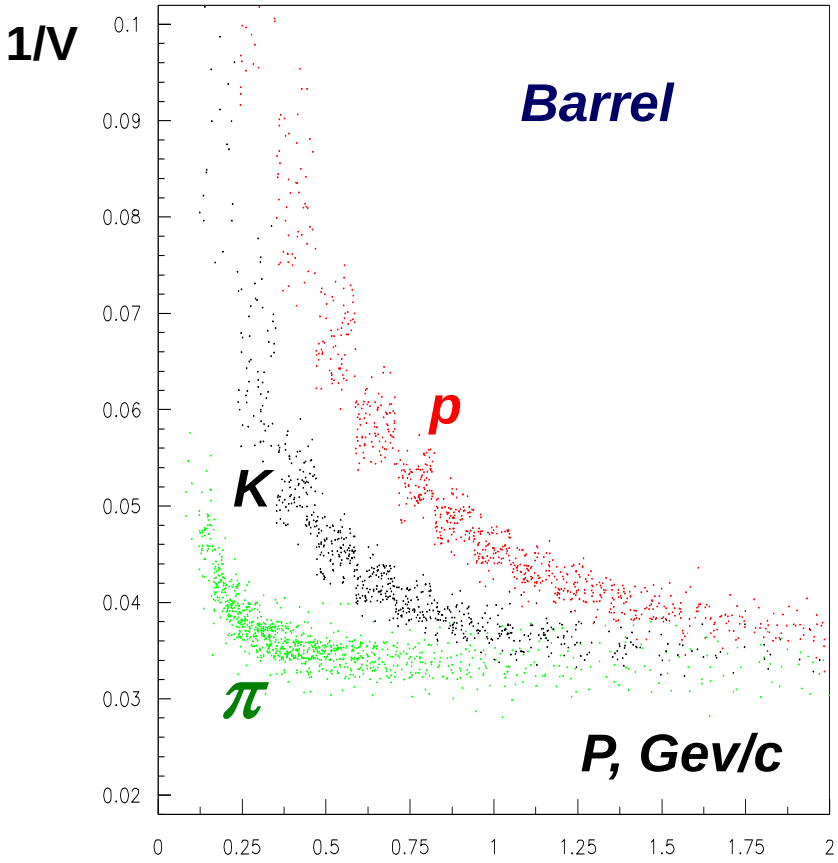
Requires further development:

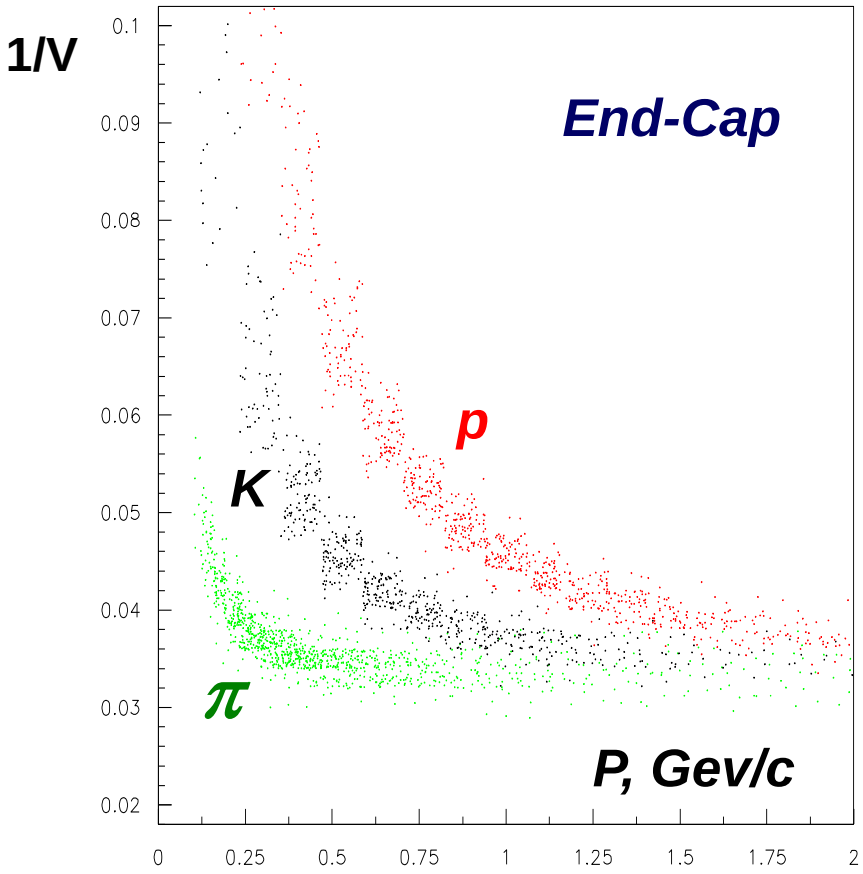
probably ~ 1 - 2 extra planes with high granularity

ECAL (shashlyk) potential possibilities

A.Olchevsky, I.Tyapkin, etc.

Energy resolution – *2.5% /√E ⇒ good π° identification*
Time resolution – *80ps /√E ⇒ TOF for charged particle id*
⇒ suppression of pile-up & electronic noise



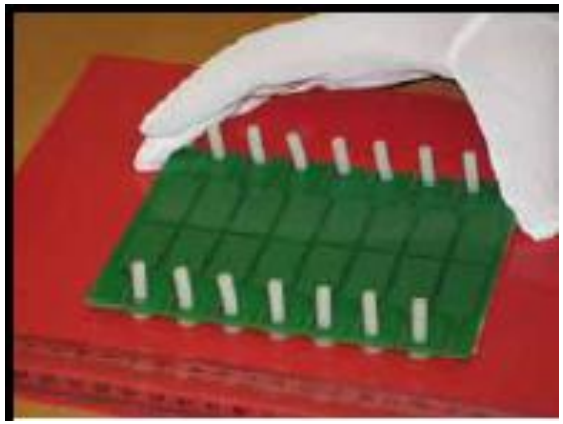


R&D progress in RPC modules for TOF

10-gap RPC module prototype assembling

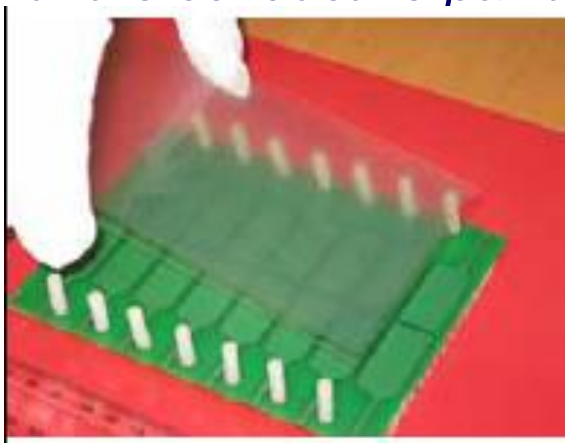
V.Golovatyuk's group

installation of the fish-line coiling on the external readout board



fish-line is using as a spacer

installation of the glass electrode with the conductive paint



assembled prototype with the fast preamp developed by ALICE on the base of NINO chip

R&D progress in Segmented Straw

tracking detectors achieve low occupancy & safer operation in harsh environments

V.Peshekhonov's group

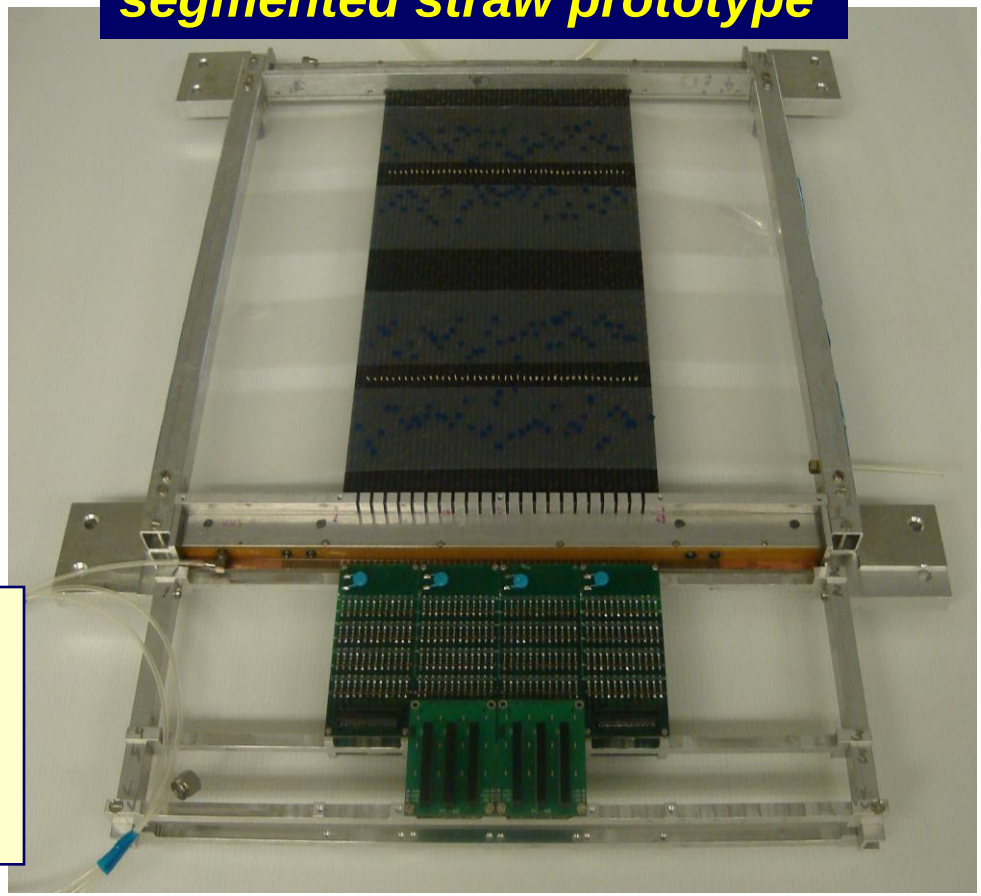
The prototype is developed for the beam testing with:

- *Double Layer Detector (anode high-voltage)*
- *FEE (low-noise amplifiers)*
- *DAQ (interface PCI-Express & 64-channels TDC)*

Double Layer Detector contains:

2x48 straws (∅ 4 mm; L = 40cm)
400 segments (L ~ 10cm/segment)
FEE density: FEE is 1 ch. / 1mm

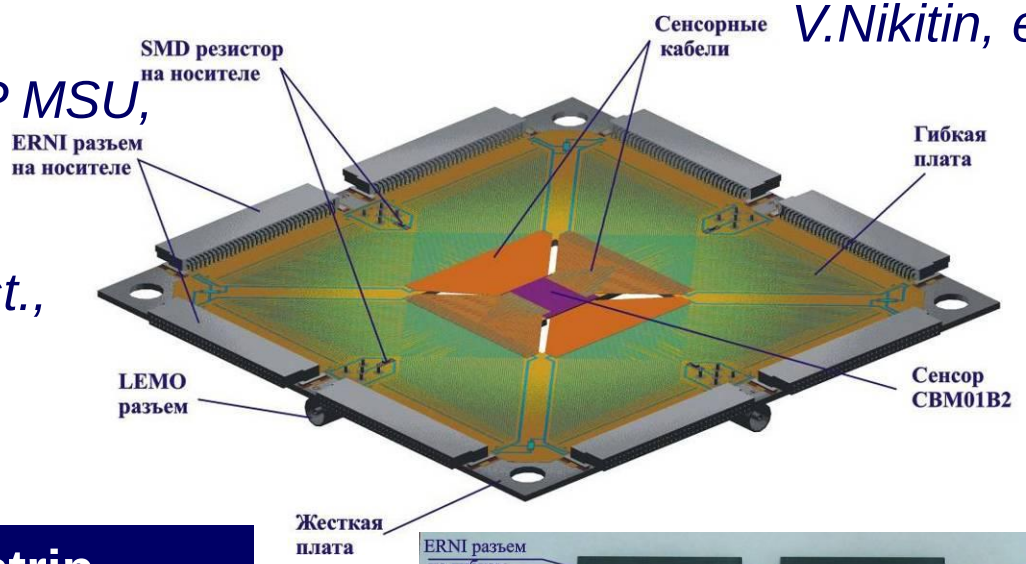
segmented straw prototype



R&D progress in IT

Yu.Murin, V.Nikitin, et al.

Consortium: *GSI, JINR, INP MSU, SESRTIIE (Kharkov), IHEP, Saint-Petersburg Uni., Saint-Petersburg Radium Inst., ITEP*



Double side silicon micro strip sensor *(15x15mm², 50um strips, 285 um thickness, 256 channels)* **mounted on a base plate with *super low mass cables* for PS & readout**

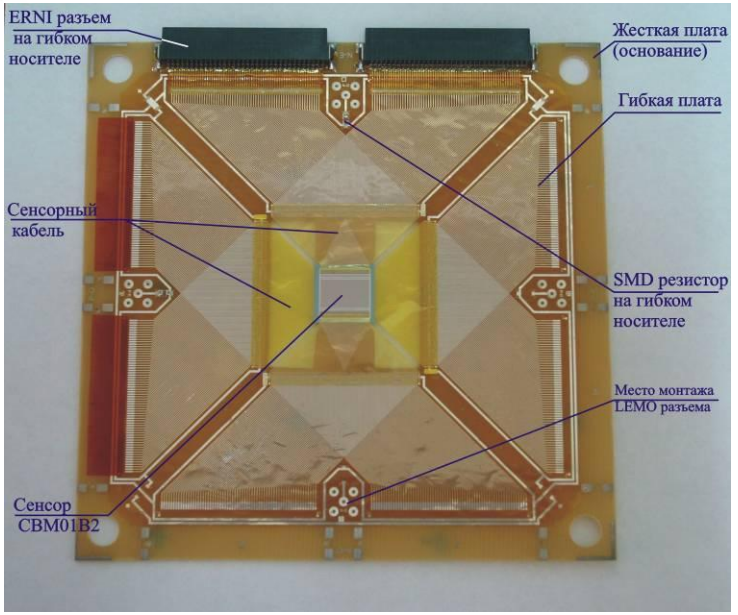
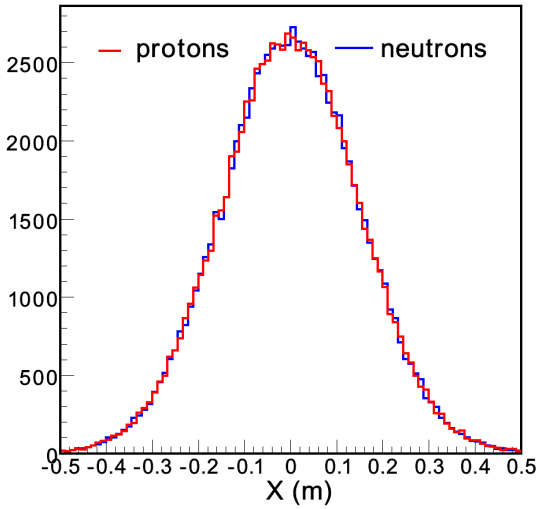


photo of the prototype produced in SESRTIIE (Kharkov)

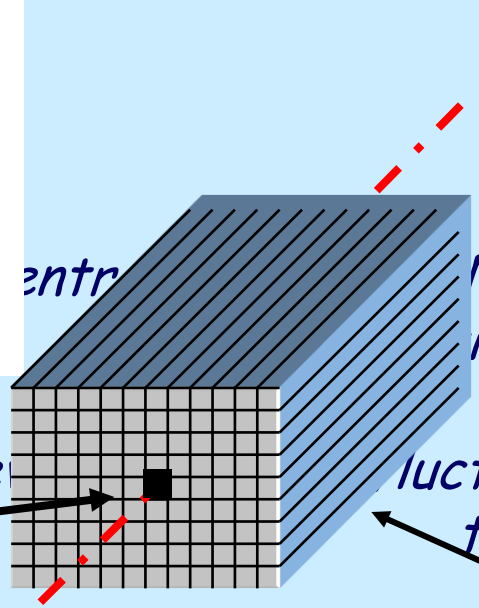
Zero Degree Calorimeter

A.Kurepin et al.
INR

X - horizontal direction



- compensated calorimeter (lead /scint.)



Beam hole

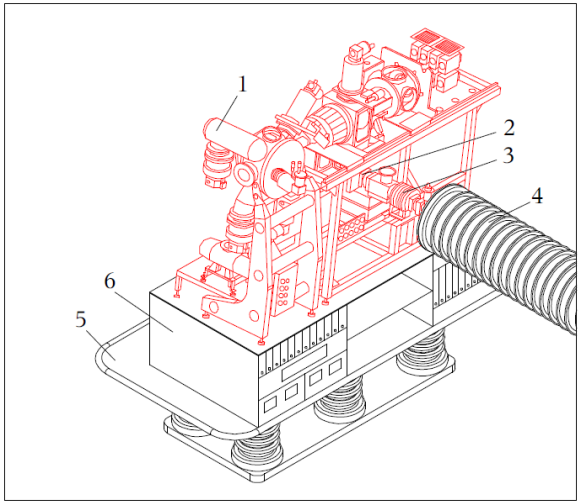
- measurement of e… …luctua… …to e…
- monitor of beam intensity by detecting the neutrons from electromagnetic dissociation

Full beam intensity.
Minimum 16 modules!

z

x

Spin Physics in LHEP



Source of Polarized Deuterons *(CIPIOS based)*
for Nuclotron-M / NICA complex
will provide ~ 10^{10} **d↑** */pulse from Nuclotron-M*

MPPT *(movable* **p↑⊥** *target) for f.t. experiments*

Spin physics of few nucleon system ***A.Kovalenko***

- **pp** *elastic scattering (analyzing powers & correlation coefficients)*
- *meson production in* **pp** *near the threshold*
- **pd** *(3-nucleon forces, analyzing powers & correlation coefficients)*

Nucleon Spin structure ***A.Nagaitsev, I.Savin O.Shevchenko***

- **COMPASS (SPS CERN), HERMES (Desy)**
- **SPD** *at* **NICA** *(pp, pd –polarized,* **$\sqrt{s} > 20$ GeV***)* ***LoI*** *in preparation*

Spin Physics at NICA

Working Group started preparation the spin physics program to operate with polarized pp, pD & DD beams.

Preliminary topics:

- *Matveev-Muradyan-Tavkhelidze-Drell-Yan (MMTDY) processes with L&T polarized p & D beams*
- *extraction of unknown (poor known) PDF*
- *PDFs from J/ψ production processes*
- *Spin effects in baryon, meson and photon productions*
- *Spin effects in various exclusive reactions*
- *Diffractive processes*
- *Cross sections, helicity amplitudes & double spin asymmetries (Krisch effect) in elastic reactions*
- *Spectroscopy of quarkoniums with any available decay modes*
- *Polarimetry*

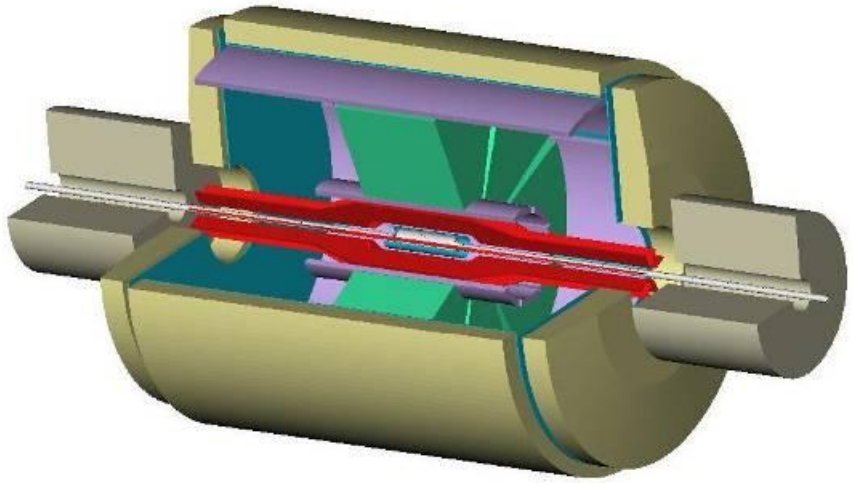
Conceptual design for Spin Purpose Detector (SPD)

preliminary

A.Nagaitsev, I.Savin, O.Shevchenko, etc.

Requirements to the detector :

- 4π geometry to enlarge MMTDY event statistics
- minimal X_0 – effective detection of lepton pairs
- good angular resolution
  – very important for azimuthal spin asymmetries measurements in the wide kinematical region

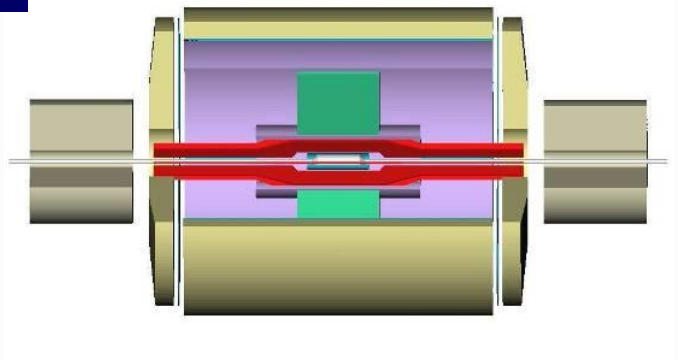


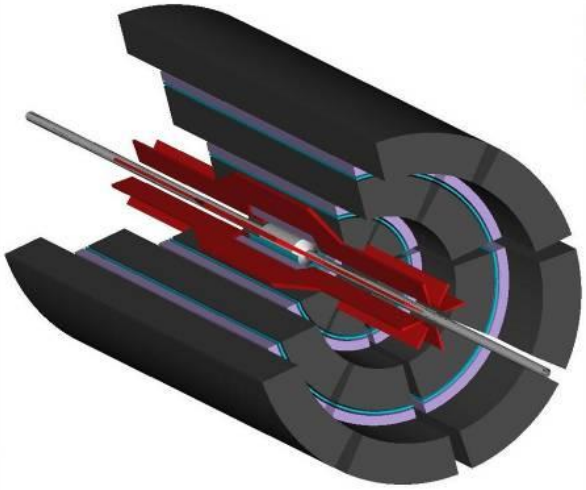
SPD conceptual design *preliminary*

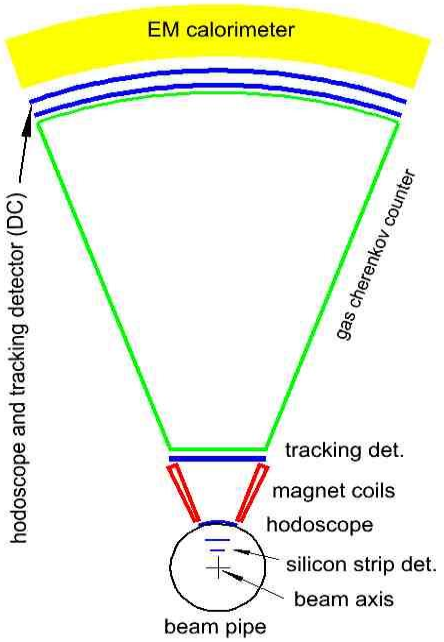
A.Nagaitsev, I.Savin, O.Shevchenko, etc.

Preliminary scheme ot the SPD

- toroid magnet system (∫Bdl ~ 0.4Tl m)
  minor influence on beam polarization
  transverse field matching the momentum
  no fringe field
- Silicon or MicroMega (inner tracking)
- Drift chambers or straw (for tracking)
- Cherenkov counter
  (for PID & trigger)
- EM calorimeter
- Trigger counters
- EndCap detectors







Conclusions

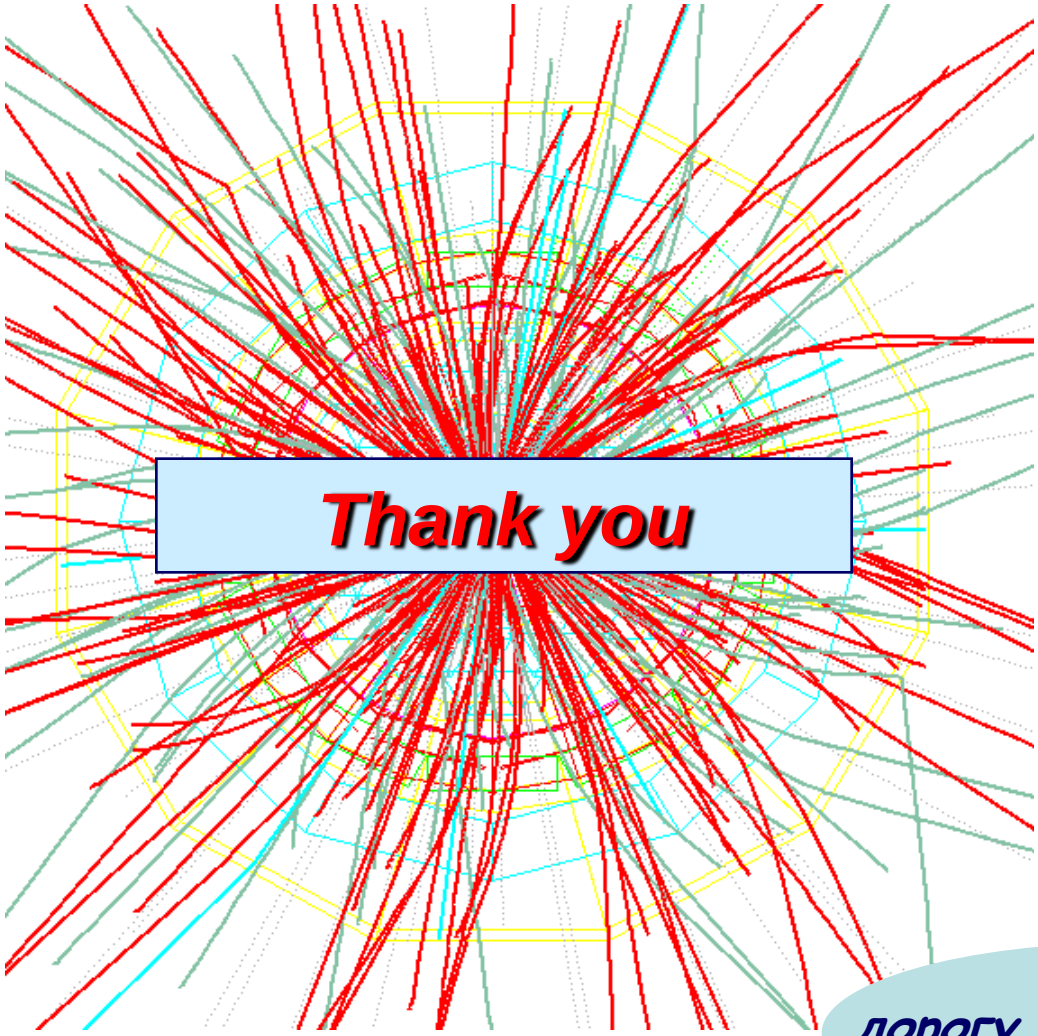
- *The strategic plans of JINR in HEP is targeting to the developments of home facility NICA/MPD & corresponding scientific program*
  It should provides good opportunity for the frontier experimental researches at JINR in the forthcoming decade

- *The first approach to MPD conceptual design is done*

- *A formation of appropriate groups is going on and the reparation of MPD project is progressing in different direction*

- Fur
- New
- Gen … bet …

…ned …l …arch …sian …ters



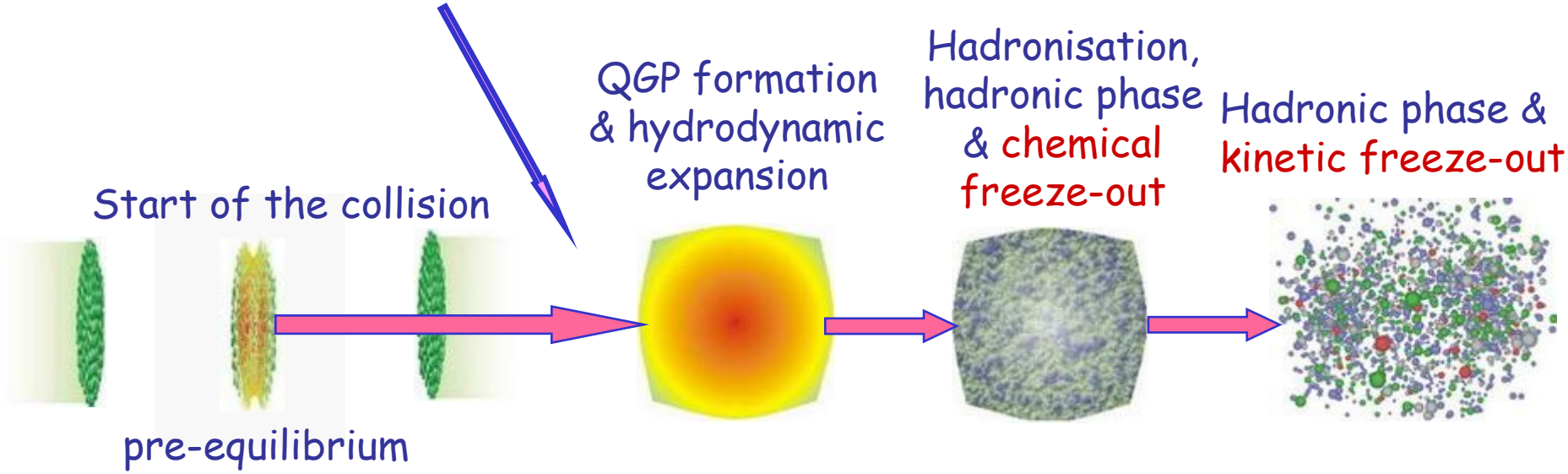
Thank you

дорогу осилит идущий

spare

Evolution diagram

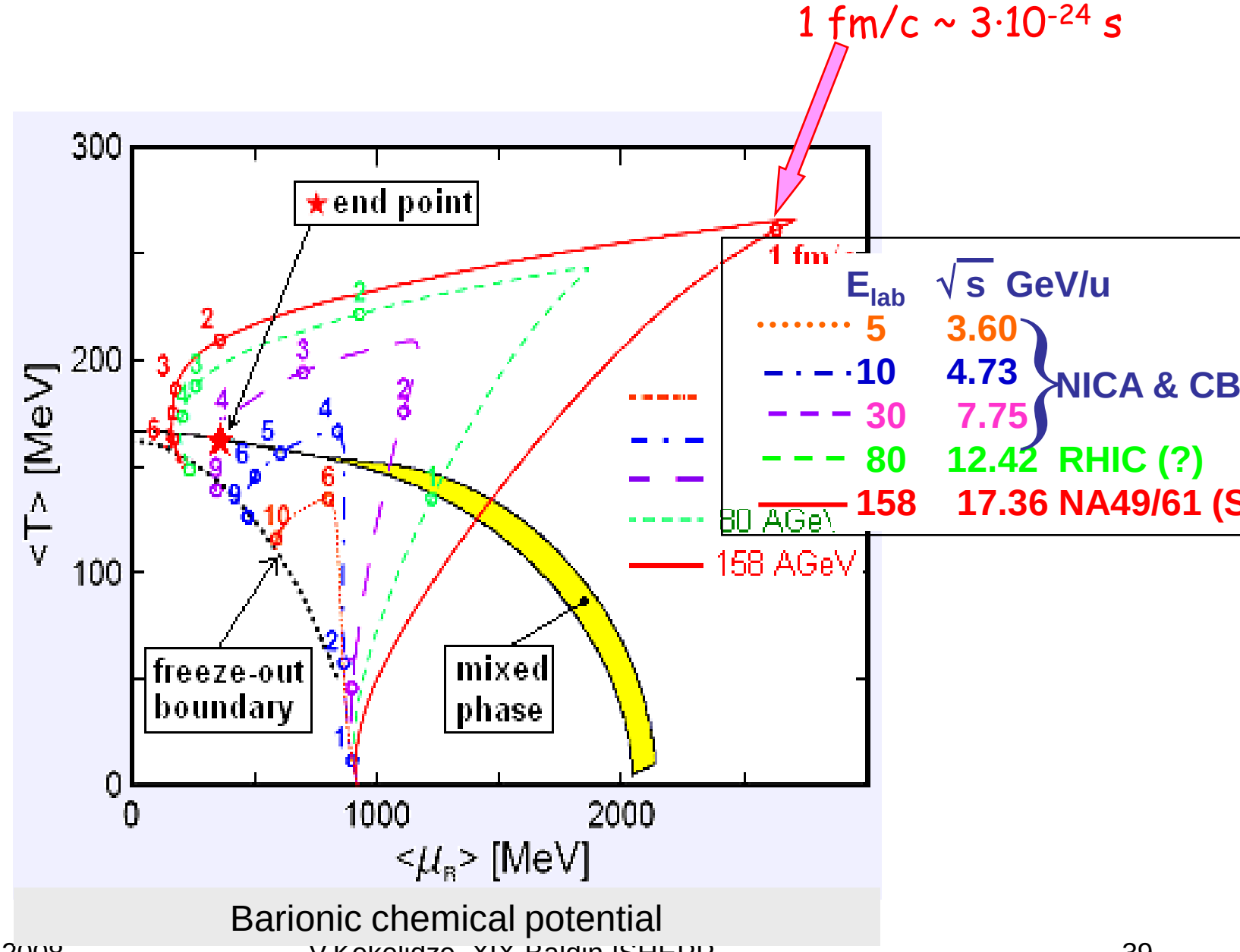
Mixed Phase? –
– a mixture of QGP & barionic matter!



"Chemical freeze-out" – finish of inelastic interactions;
"Kinetic freeze-out" – finish of elastic interactions.

*) freeze-out – here means "to get rid"

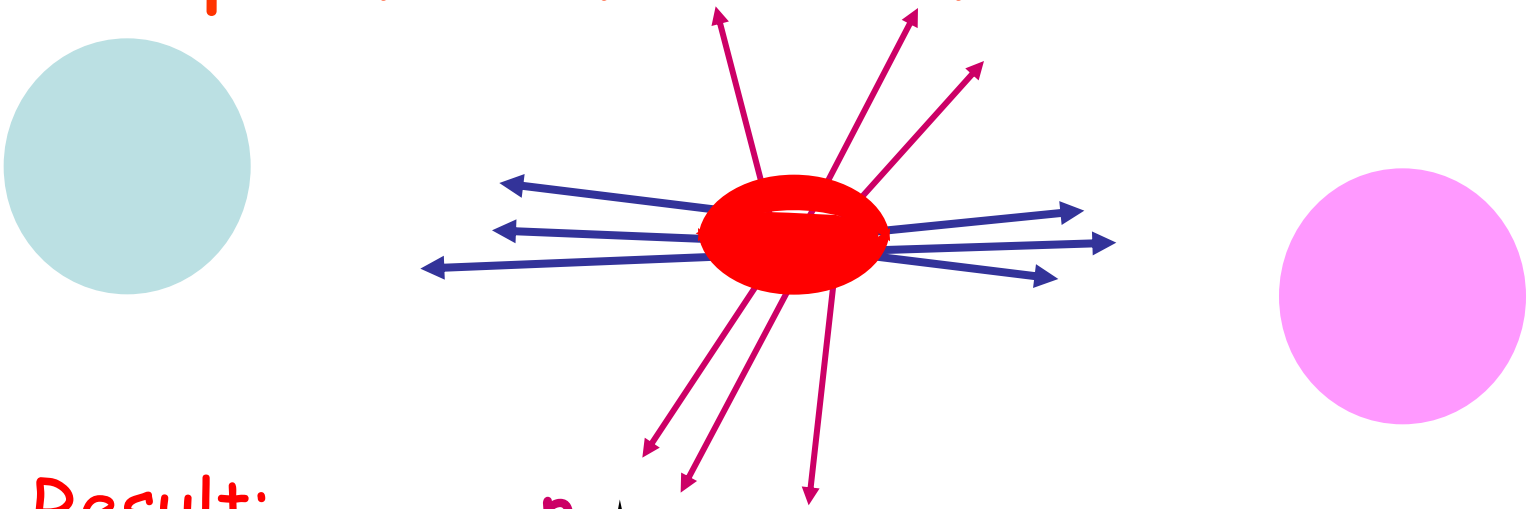
1. Search for mixed phase of strongly interacting matter



Barionic chemical potential

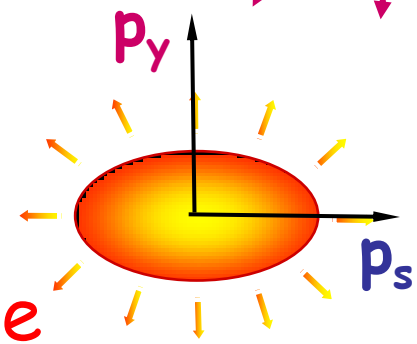
What to look for ?

Elliptic flow of central fireball matter



Result:

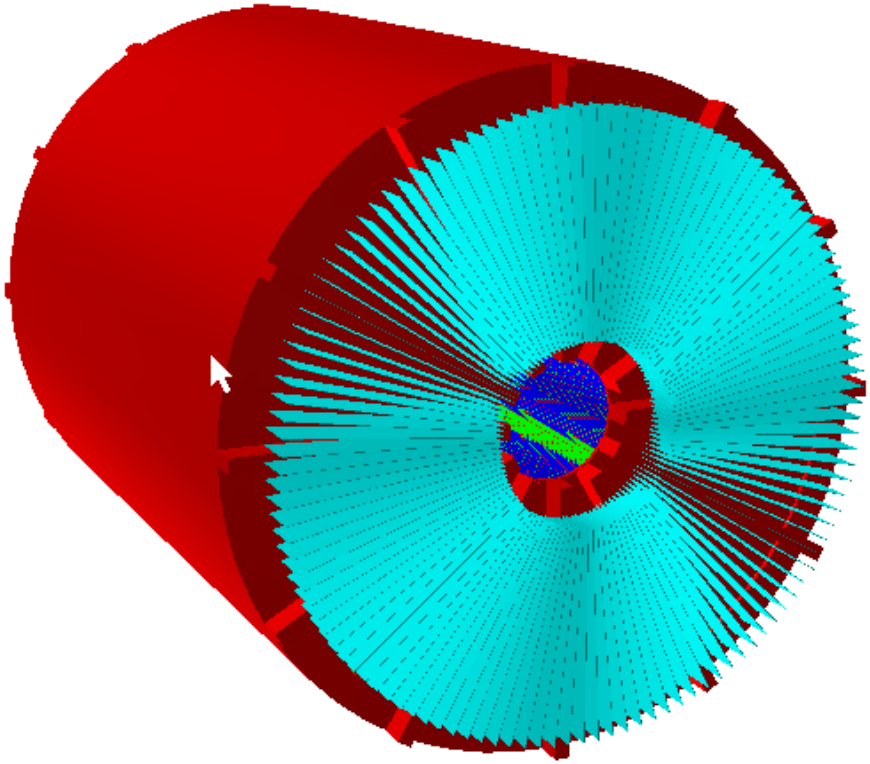
Anisotropy in momentum space

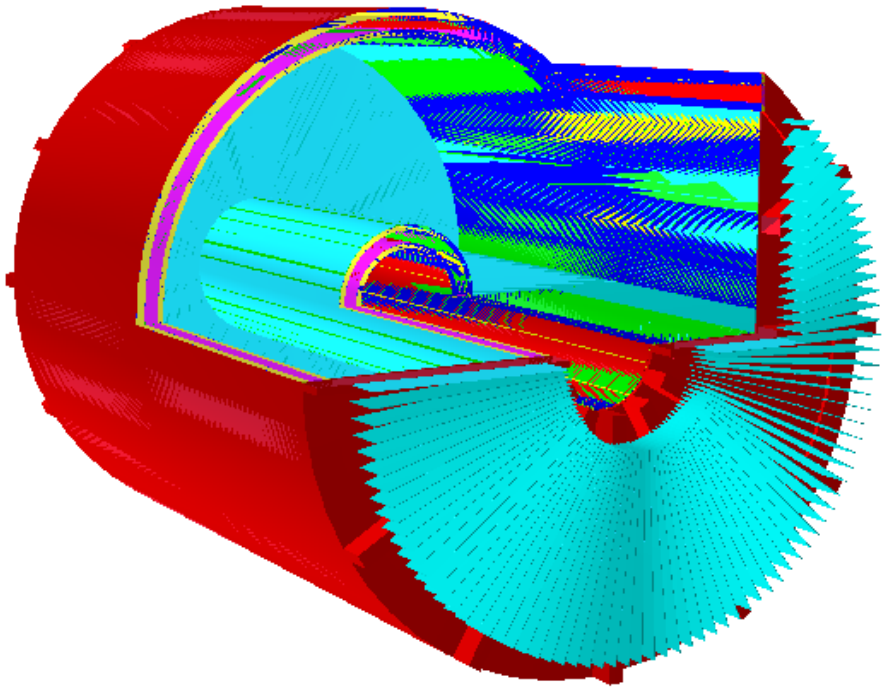


One has to measure the ellipticity parameter

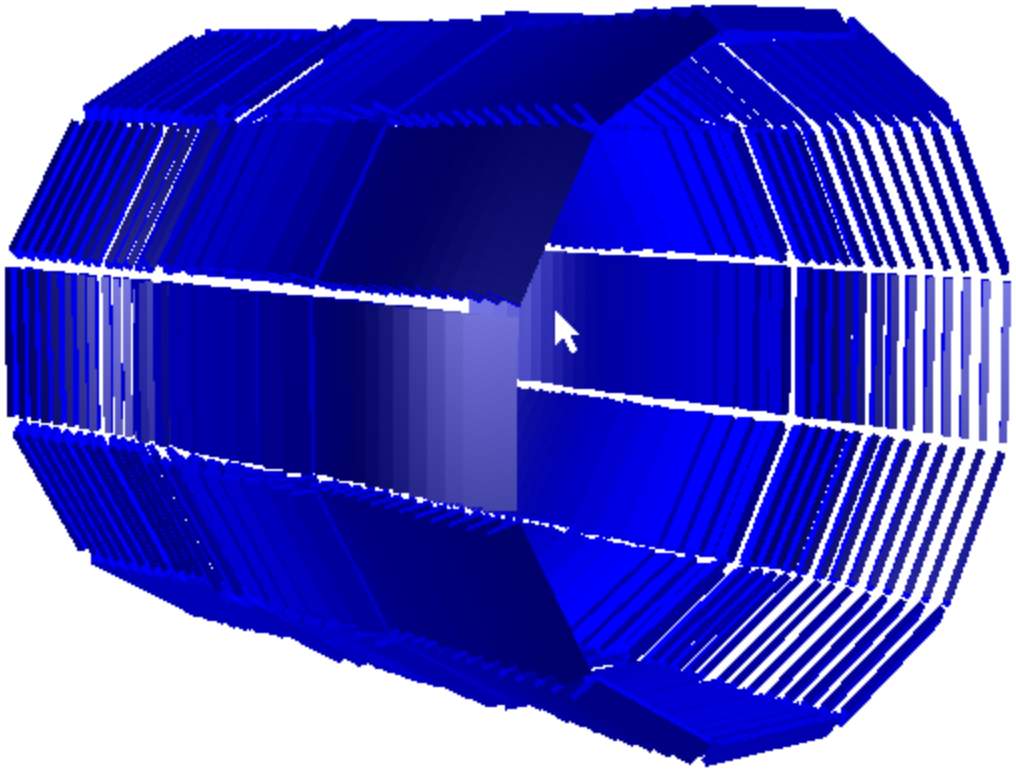
$$\chi(E_{total}) = \langle p_s \rangle / \langle p_y \rangle$$

TPC geometry (MPDROOT)

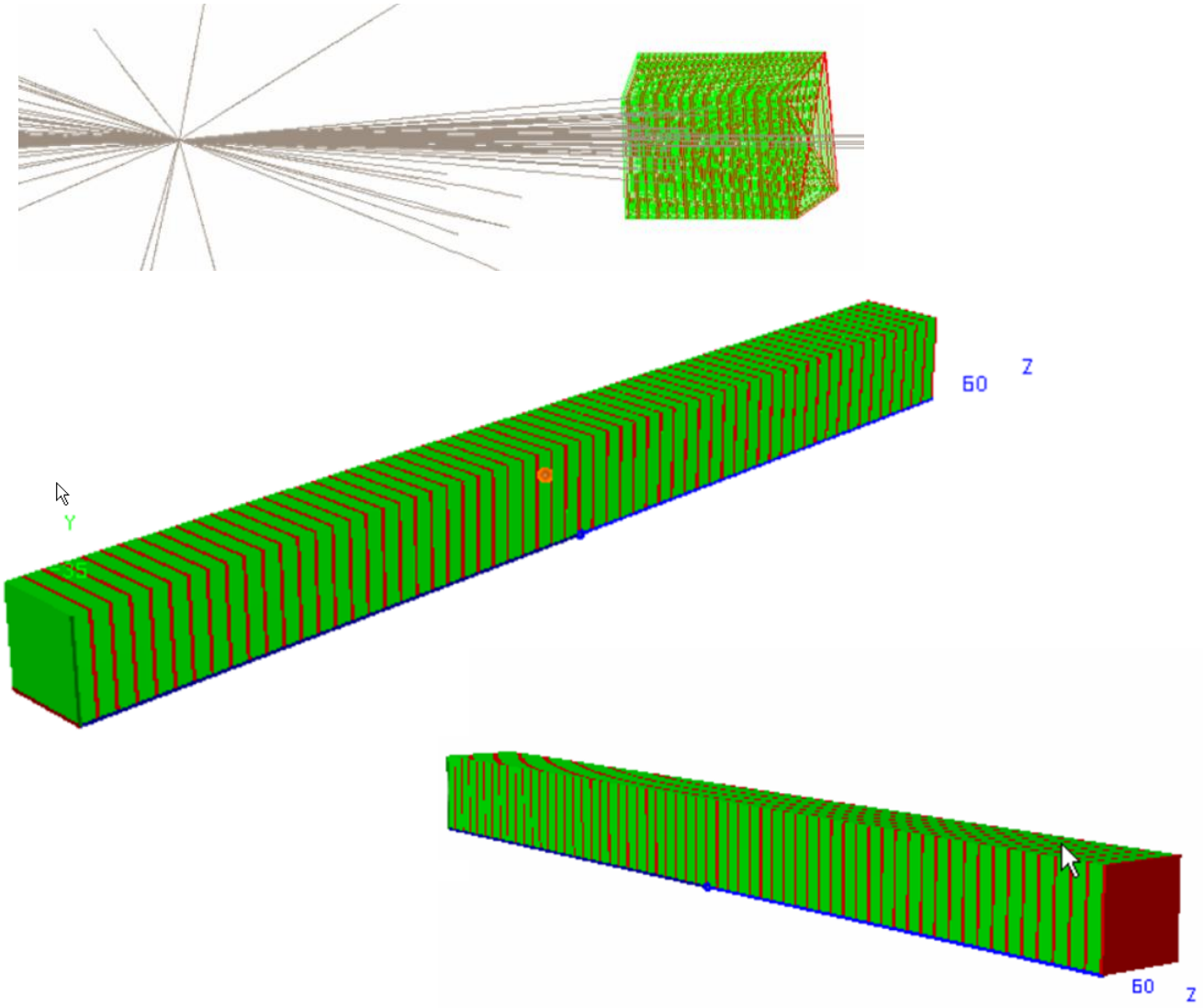




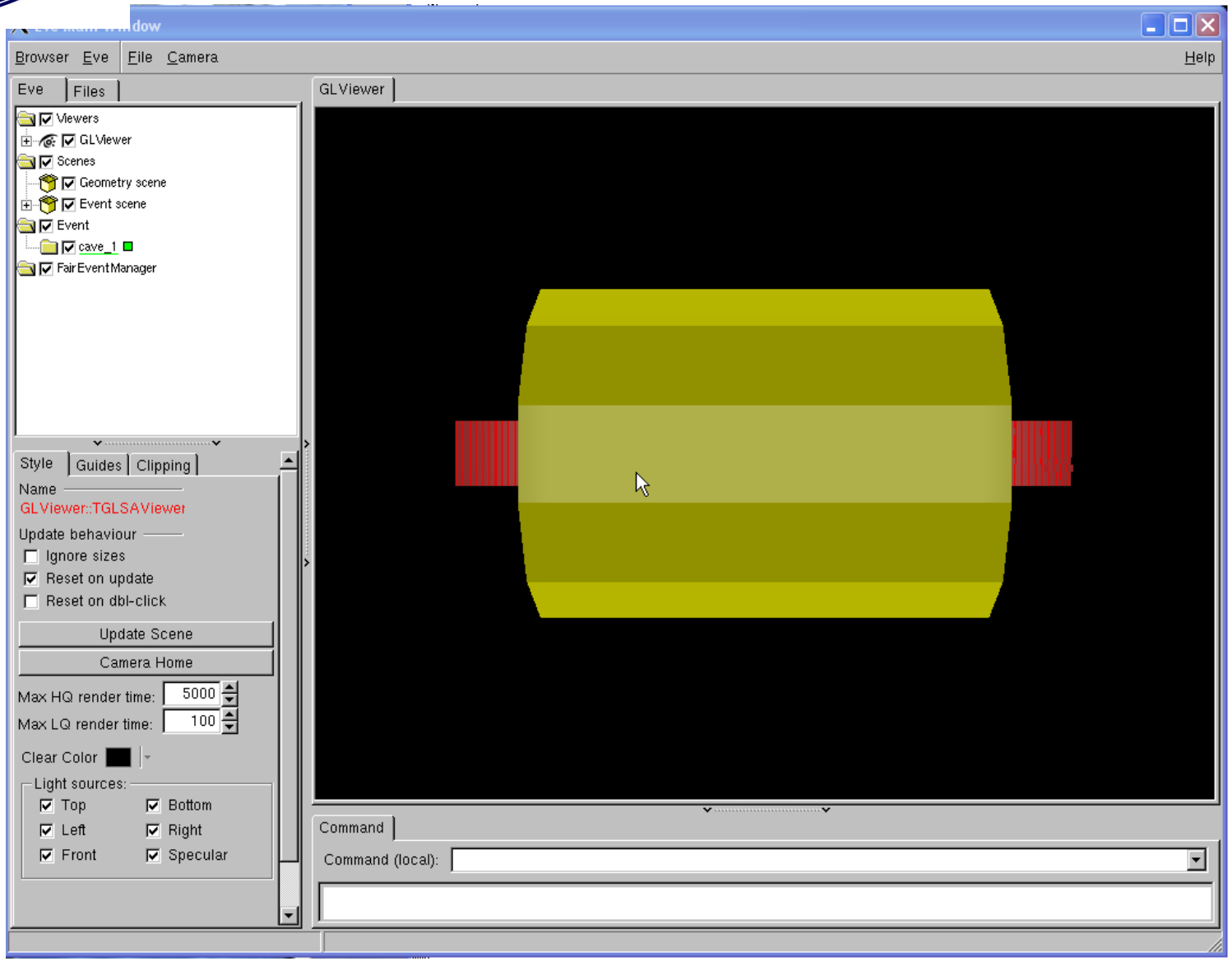
TOF (RPC based) geometry (MPDROOT)



ZDC geometry (MPDROOT)



Event display (geometry) under MPDROOT

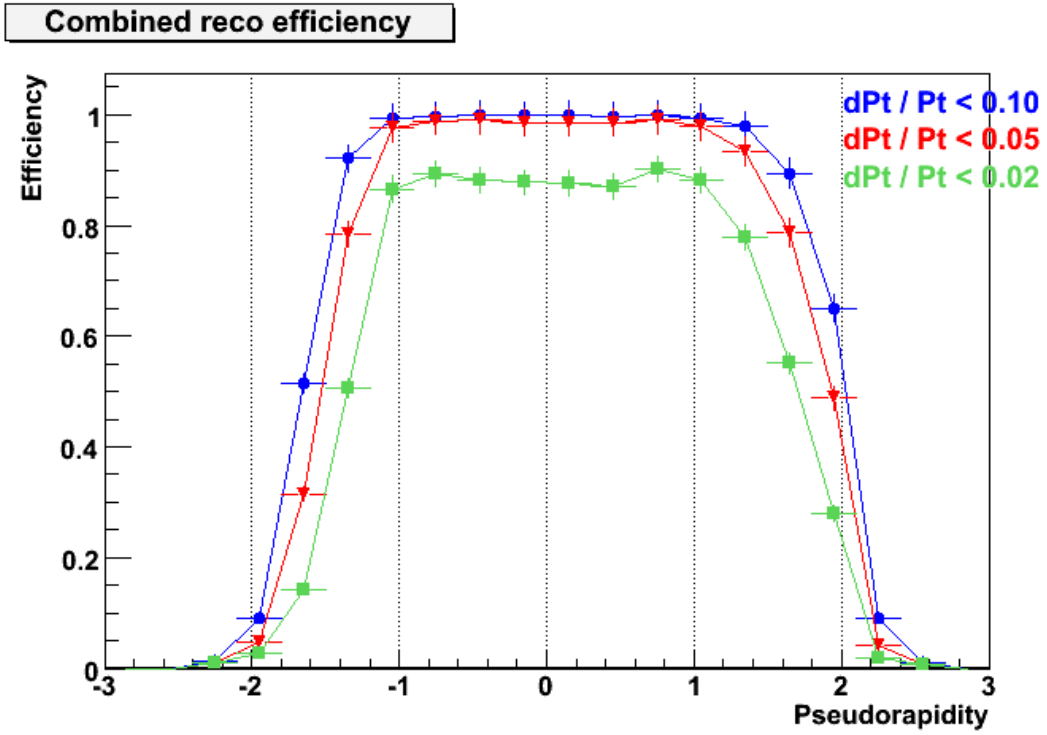


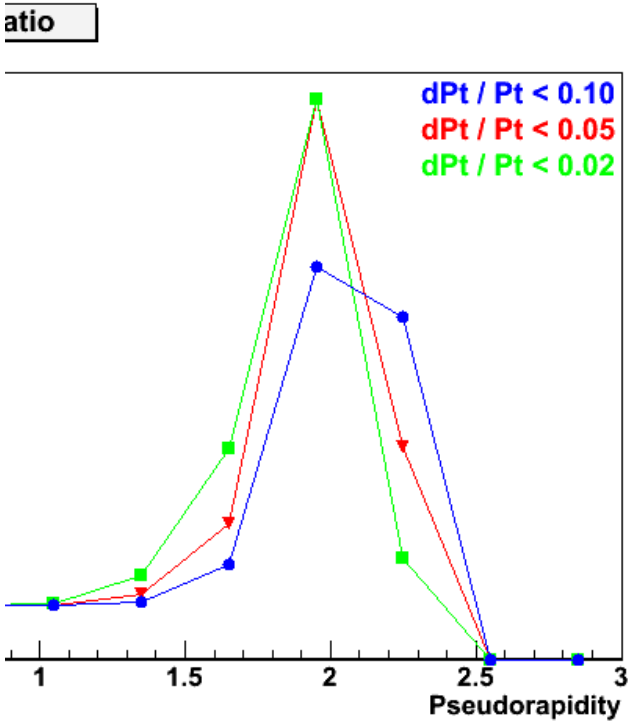
End-Cap concept development: ECT

Comparison of two versions of End-Cap tracking:

- **TPC alone**
- **TPC + ECT (Straw Wheels) + ETOF**

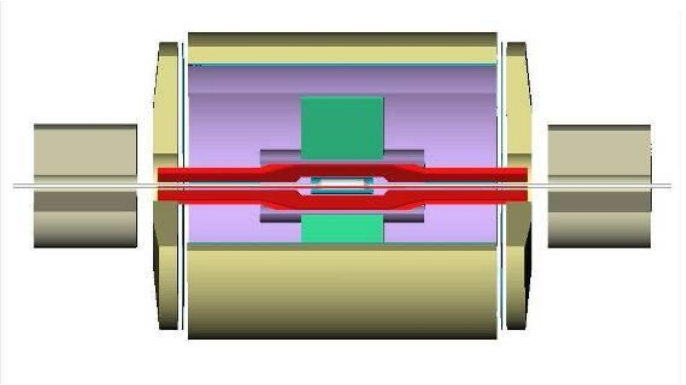
at various limits on momentum resolution

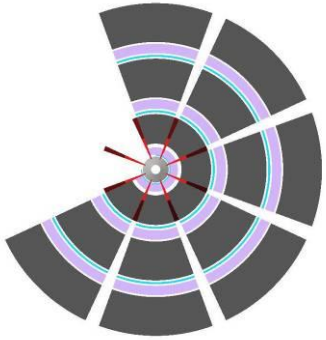


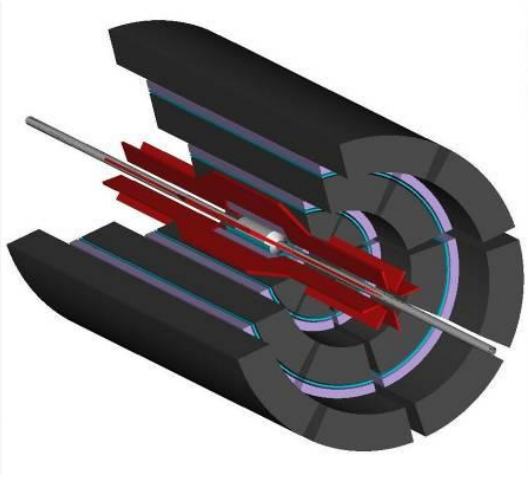


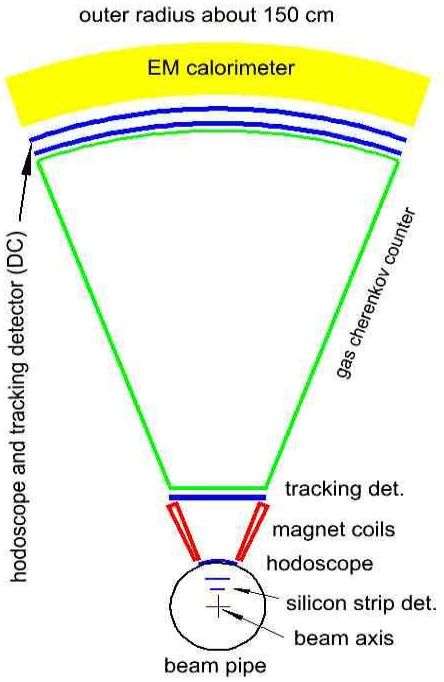
SPD main parts

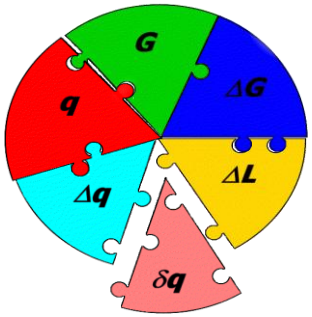
- toroid magnet system ($\int$Bdl ~ 0.4Tl m) minor influence on beam polarization transverse field matching the momentum no fringe field
- Silicon or MicroMega (inner tracking)
- Drift chambers or straw (for tracking)
- Cherenkov counter (for PID & trigger)
- EM calorimeter
- Trigger counters
- EndCap detectors











SPIN at NICA

Operation mode

Collider (pp,pd, p(d)A)
$\sqrt{s_{pp}}$ = (12+12) GeV/c

fix target (gaseuos)

with different combination of polarized p(d) & unpolarized p,d,A

Intermediate energy (fix target):

- **pp** *elastic scattering (analysing powers & correlation coefficients)*
- *meson production in* **pp** *near the threshold*
- **pd** *(3-nucleon forces, analysing powers & correlation coefficients)*

High energy (collider):

- *Transversity distribution (Drell-Yann & J/Ψ)*
- *Spin transfer to hyperons*

Competitiveness to other projects

COMPASS & J-PARK

-can not provide direct measurements
(both – beam & target to be polarized)

PAX

- plans to access transversity via measurement of double polarized asymmetry in Drell-Yan process with antiprotons
- problematic to get intensive polarized beam of antiprotons

RICH

- different kinematic region covering only small $x<10^{-3}$

Resources *(in k$)*

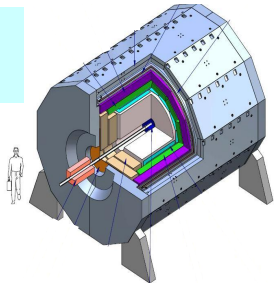
PROJECT		funding	2008	2009	2010
NICA/MPD (1065)	Nuclotron-M; MPD, R&D & II IP detector;	direct	661	1 000	
			1 710	2 181	
	Heavy Ion collider, MPD & II IP detector				10 000
non-nucleon degrees of freedom & spin effects in low nucleon systems (0941)		LHE budget	58	60	to be reconsidered or integrated with NICA/MPD research program
		non-budget	80	130	
physics at the Nuclotron, NA49 (0983)		LHE budget	94.3	100	
STAR (1066)		LHE budget	34.5*)	90	90
ALICE (0001)		LHE budget	81.5	85	85

**) Part related to the LHE budget only*

JINR budget direct grants , other direct sources & external sources

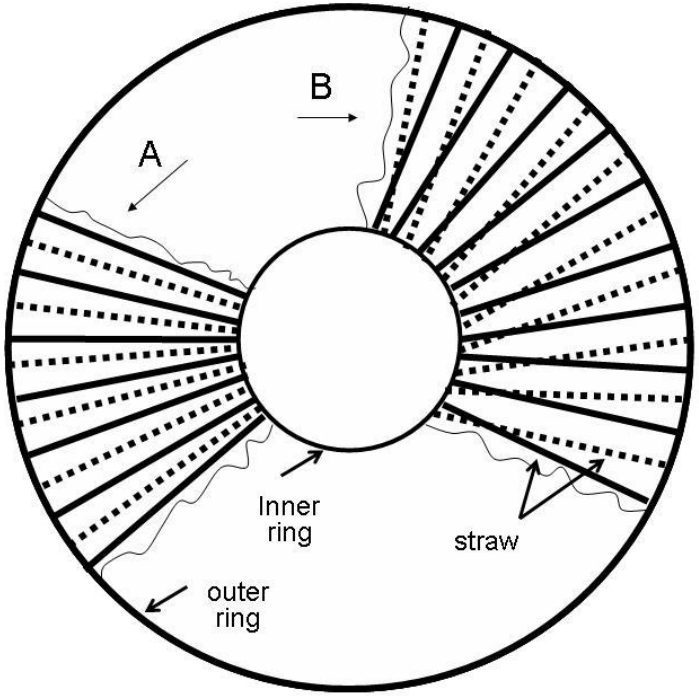
Obligations in IREN (have to be completed in 2008),
Activities within GSI-JINR & CERN-JINR Accelerator research programs
& corresponding R&D in accelerator physics are not included
participation in CBM (within the JINR-BMBF Agreement) – not included as well

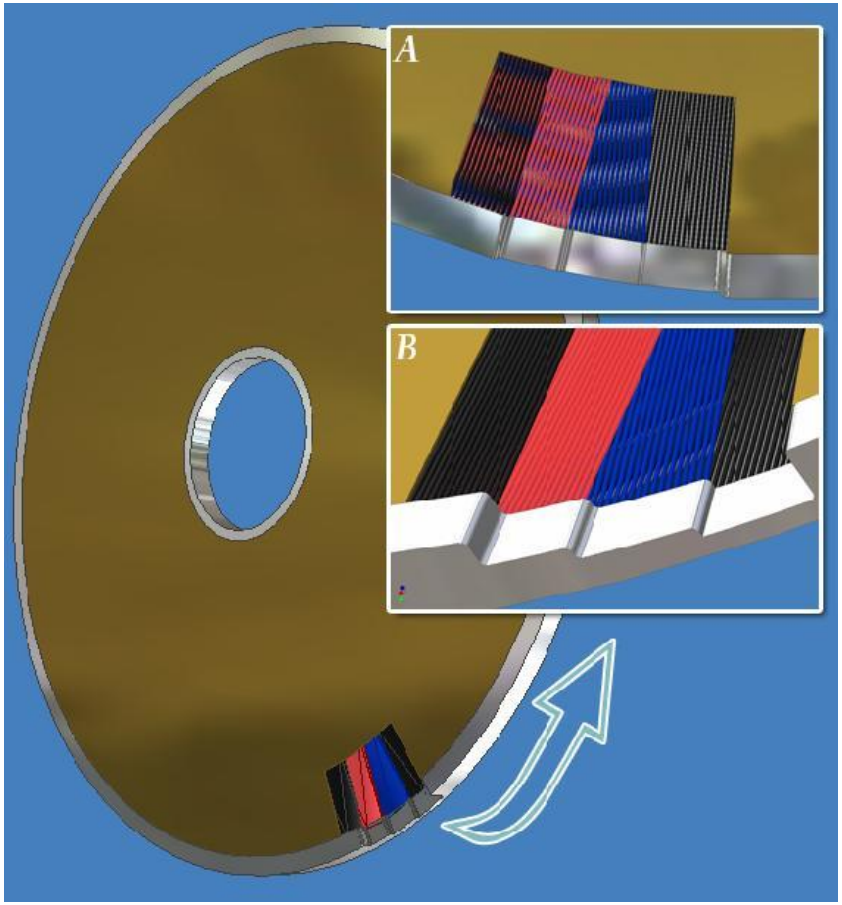
ECT straw wheel



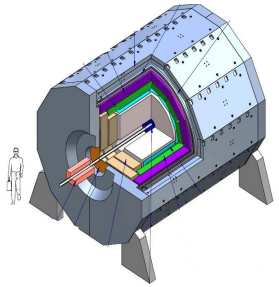
Stereo wheel construction:

each stereo wheel contains 4 layers of radial straws with different orientation

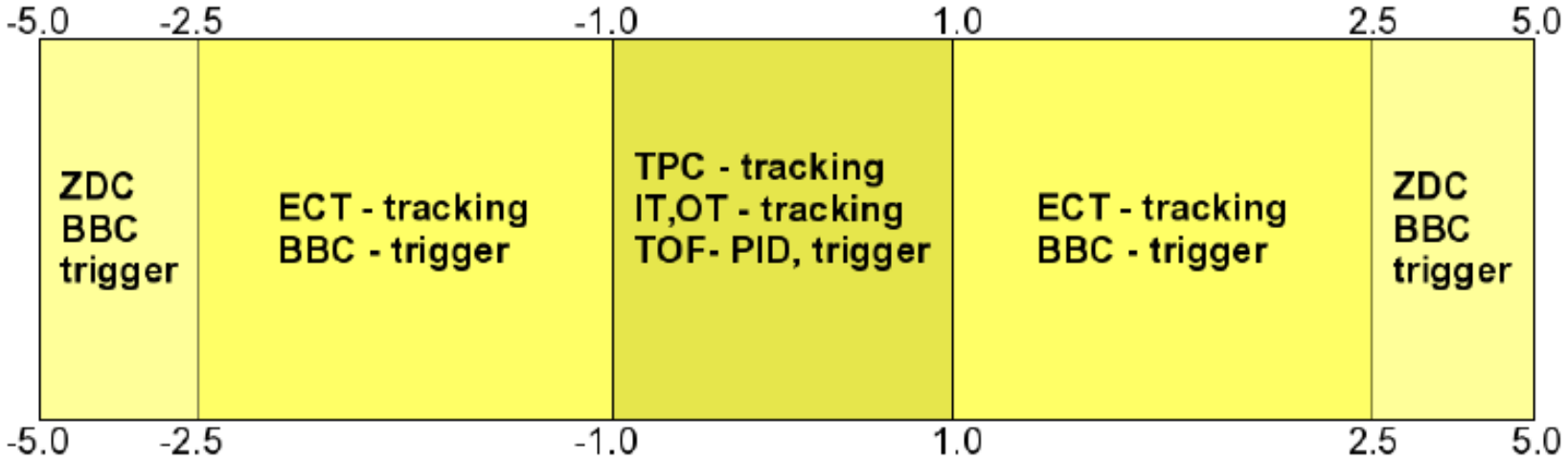




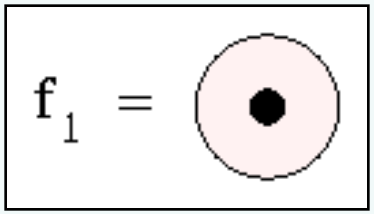
MPD – conceptual design

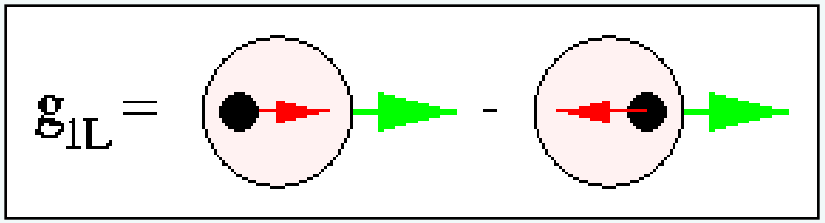


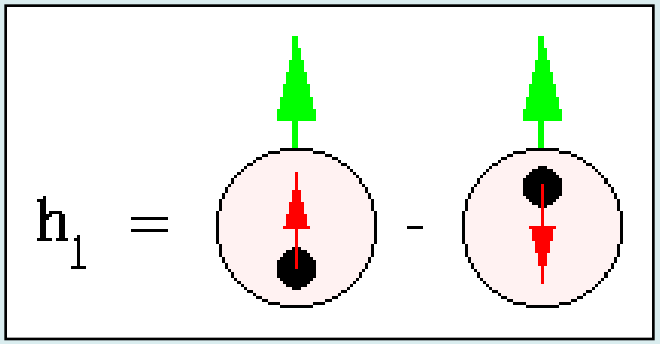
Towards 4π acceptance: to cover a wide pseudorapidity range



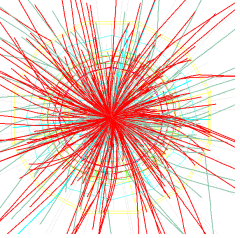
Leading Twist Distribution Functions

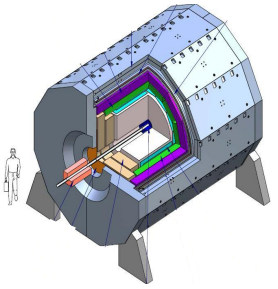
$f_1(x)$  *q(x) spin averaged (well known)*

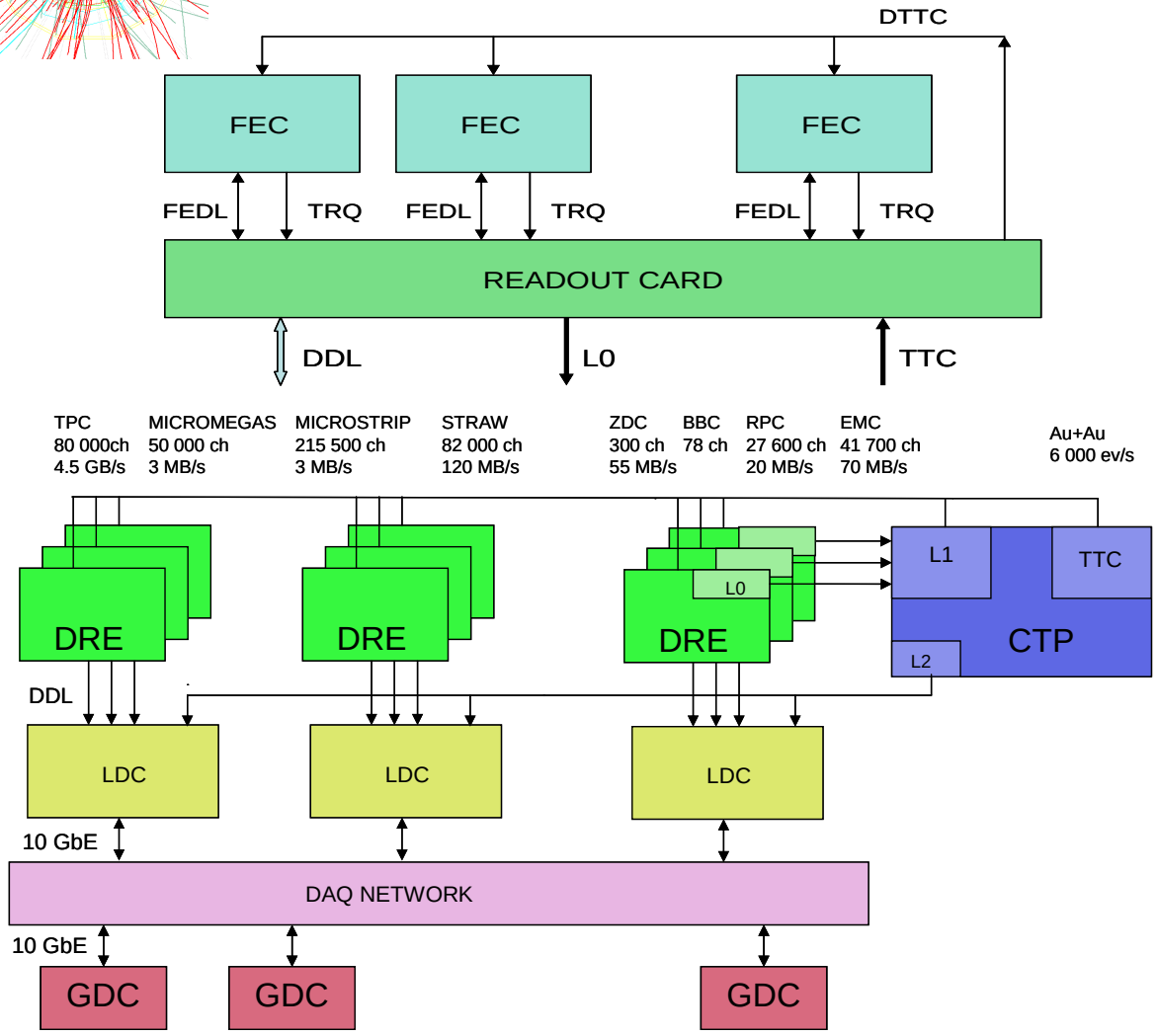
$g_1(x)$  *Δq(x) helicity diff. (known)*

$h_1(x)$  *δq(x) helicity flip (unknown)*

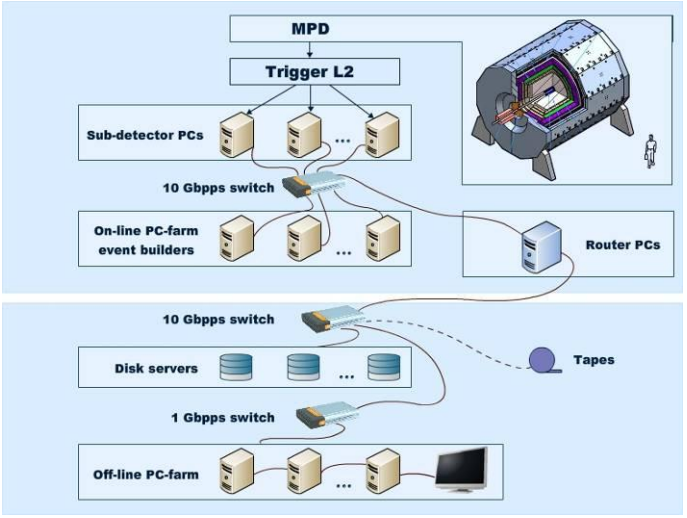
DAQ & Computing





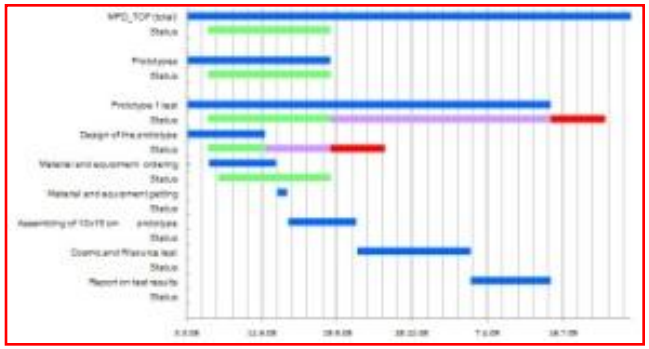


- *events* ~2 10^{10}
- *disk space* 10 000 TB
- *PC's* ~ 1800

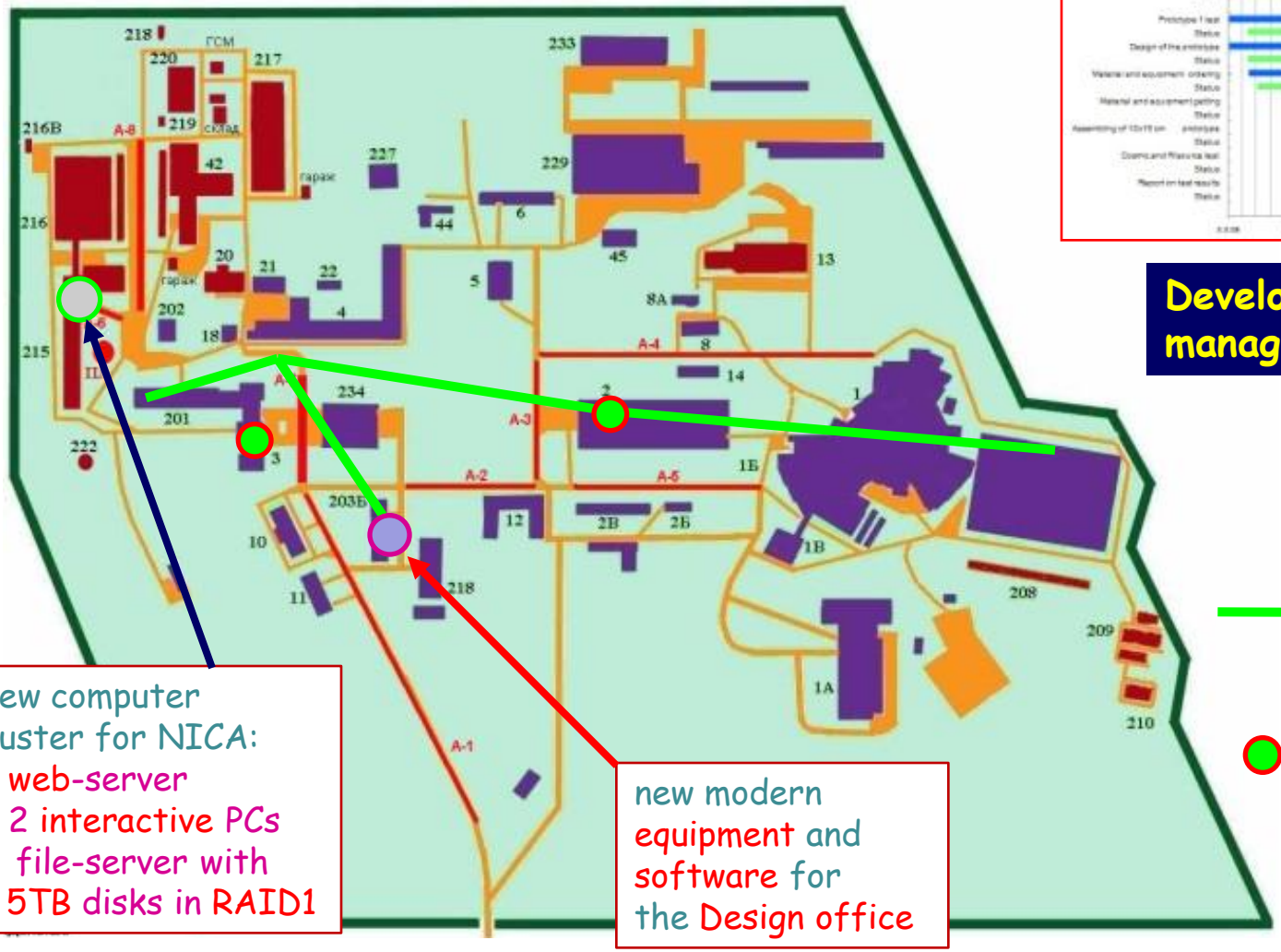


Development of IT Infrastructure

Group of Yu.Potrebenikov



Development of project management program



New computer cluster for NICA:
- web-server
- 2 interactive PCs
- file-server with 5TB disks in RAID1

new modern equipment and software for the Design office

new (repaired) Gbit optical link

- new switches

Veksler & Baldin Laboratory of High Energy Physics

is founded on May 4-th 2008 in accordance with the JINR Member States Plenipotentiary Representative Committee decision (27-28 Nov. 2007) by the JINR Director decree N 112 of February 19th, 2008

Strategic objectives of the Laboratory are

- *construction, development & maintenance of the JINR basic accelerator complex for relativistic heavy ions and polarized beams*
- *relevant researches in high energy heavy ion physics, spin physics & particle physics*