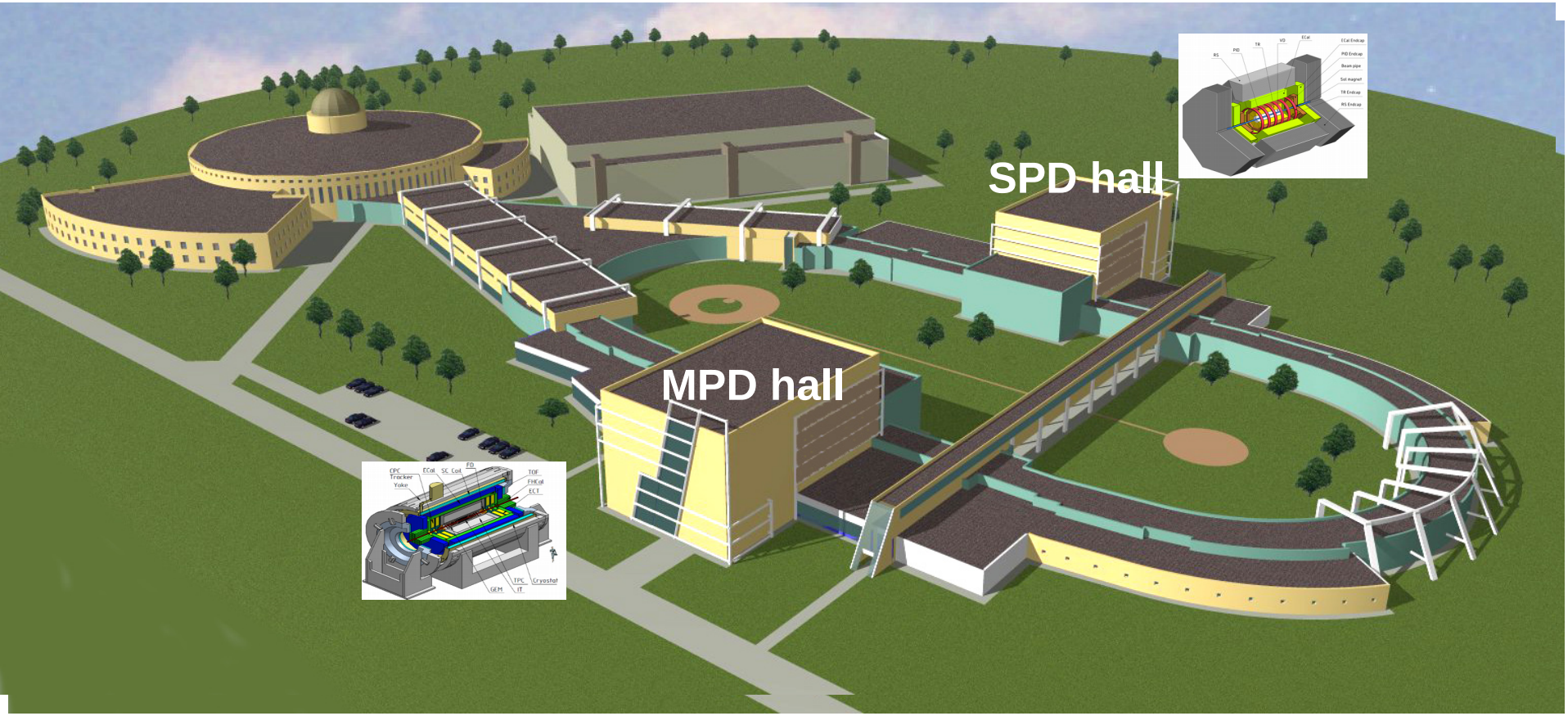
SPD concept

V.Ladygin for

SPD Collaboration

Status report
15 September 2020

NICA complex



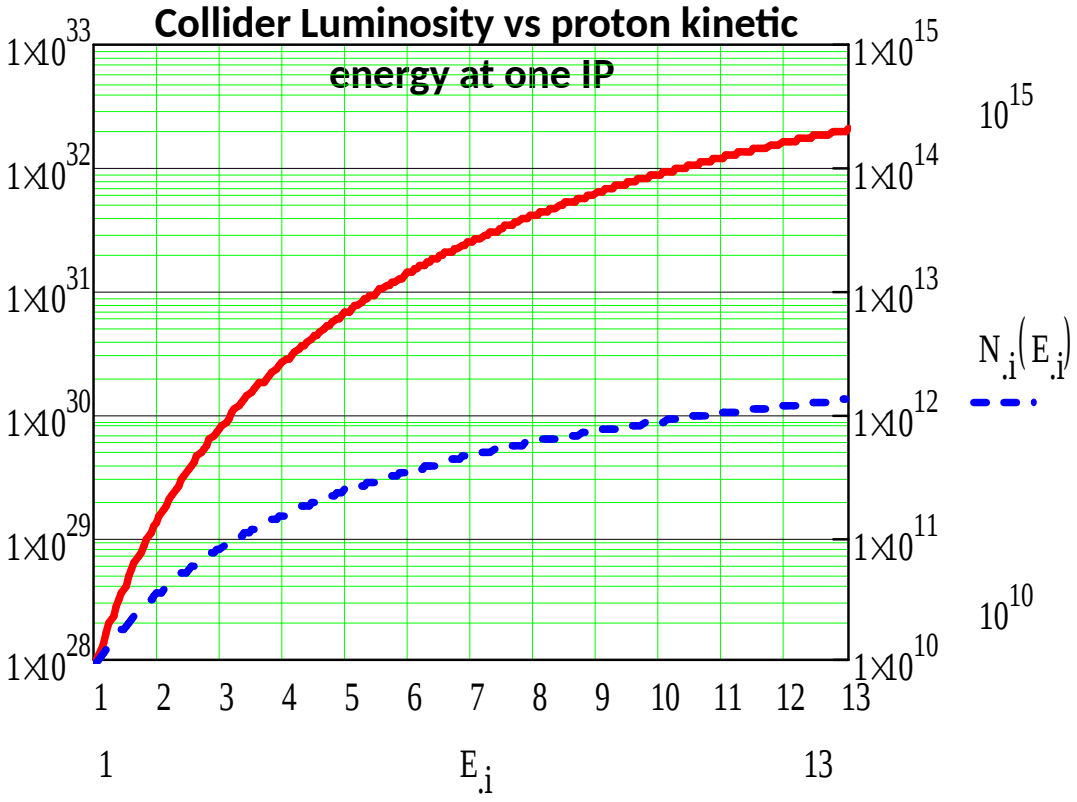
energy range for Au^{79+} $\sqrt{S_{NN}}$ = **4 – 11 GeV**

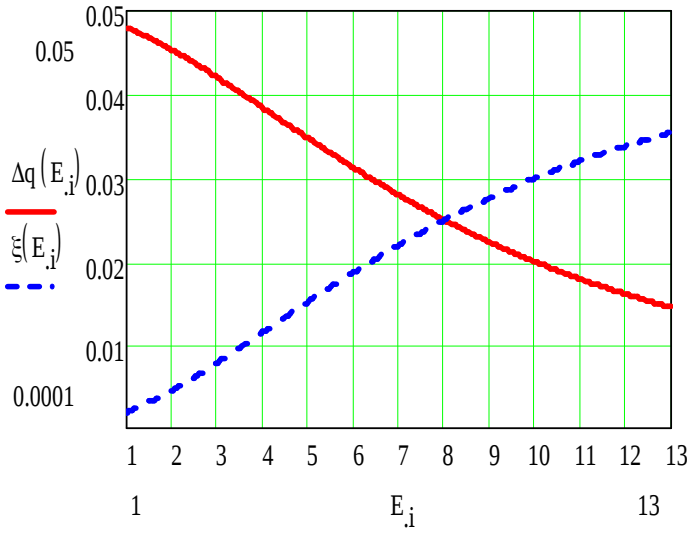
max. $\sqrt{S}$ *for polarized* **p**, *GeV* = **27 GeV**

Luminosity of pp Collider

Collider parameters

Parameter	Value
β^* , m	0.6
σ_s , m	0.6
$\varepsilon_{x,y}$, $\pi \cdot$ mm $\cdot$ mrad	1.1
N_{IP}	2
E_i , GeV	1.0 – 12.5
$\sqrt{s}$, GeV	3.86 – 26.86



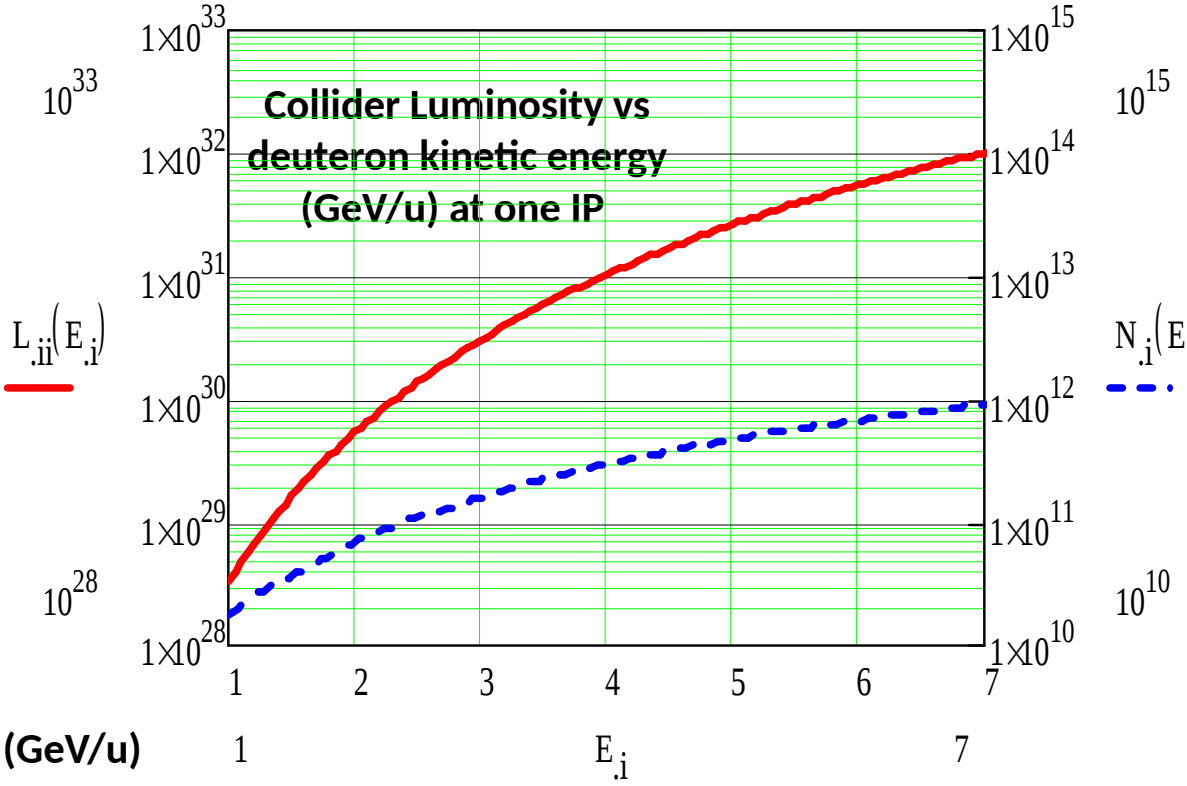


I.N.Meshkov, Phys.Part.Nucl. 50 (2019) 663-682.

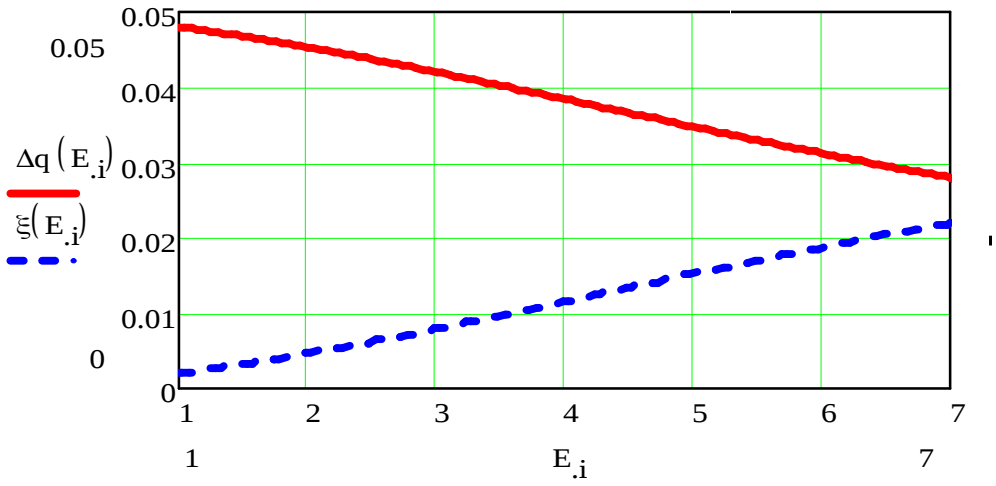
Luminosity of dd Collider

Collider parameters

Parameter	Value
β^* , m	0.6
σ_s , m	0.6
$\varepsilon_{x,y}$, $\pi \cdot$ mm $\cdot$ mrad	1.1
N_{IP}	2
E_i , GeV/u	1.0 – 6.5
$\sqrt{s}$, GeV/u	3.86 – 14.86



Betatron tune shifts vs deuteron energy (GeV/u)



I.N.Meshkov, Phys.Part.Nucl. 50 (2019) 663-682.

Major physics goals

1. Gluon content of the nucleon via the measurements of the prompt photons, charmonia and open charm production.

2. Spin and polarization effects in inclusive and exclusive hadron production.

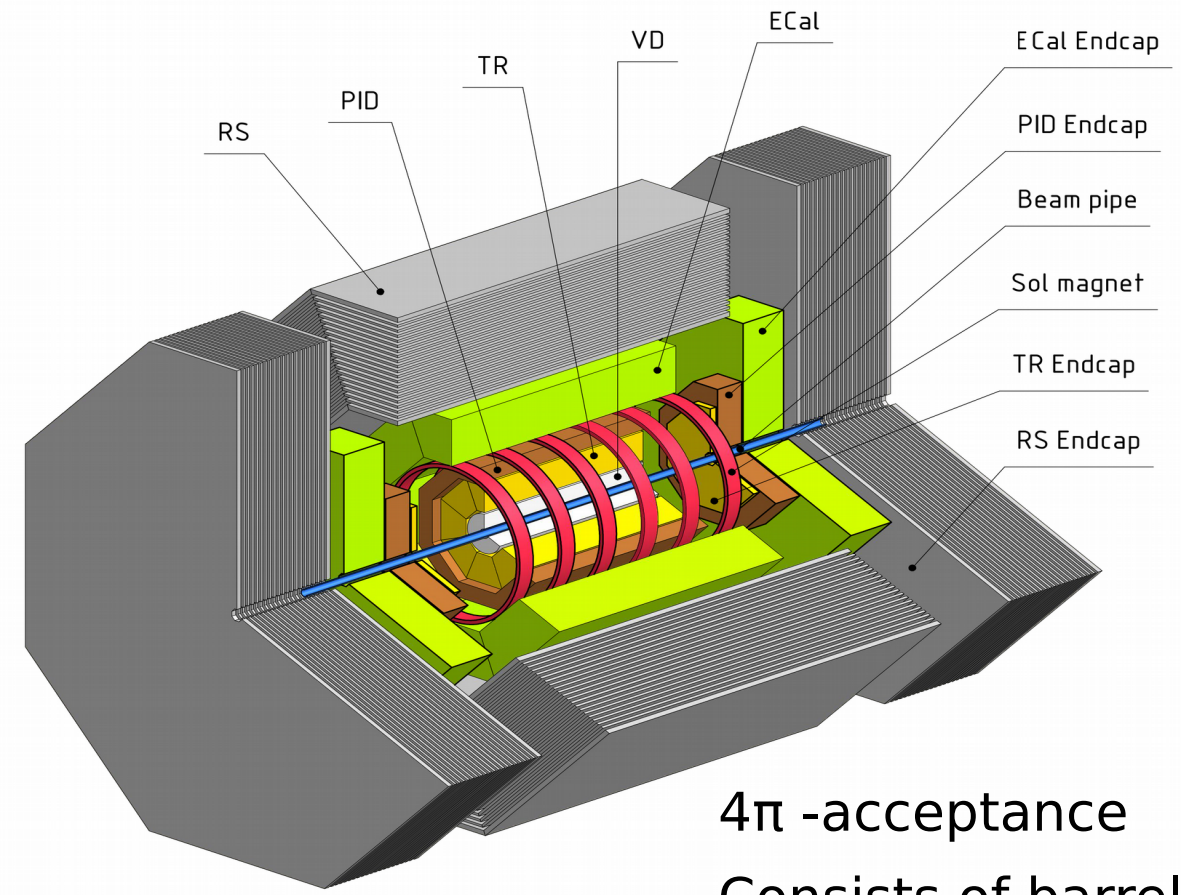
3. Spin observables in elastic pp- and pd- and dd- scattering.

4. Study of light nuclei (up to Ca) collisions.

……..

The details are given in the talk of A.Guskov

SPD systems



4π -acceptance

Consists of barrel and 2 endcups

Total mass: 1200 tons

Magnetic Superconducting System

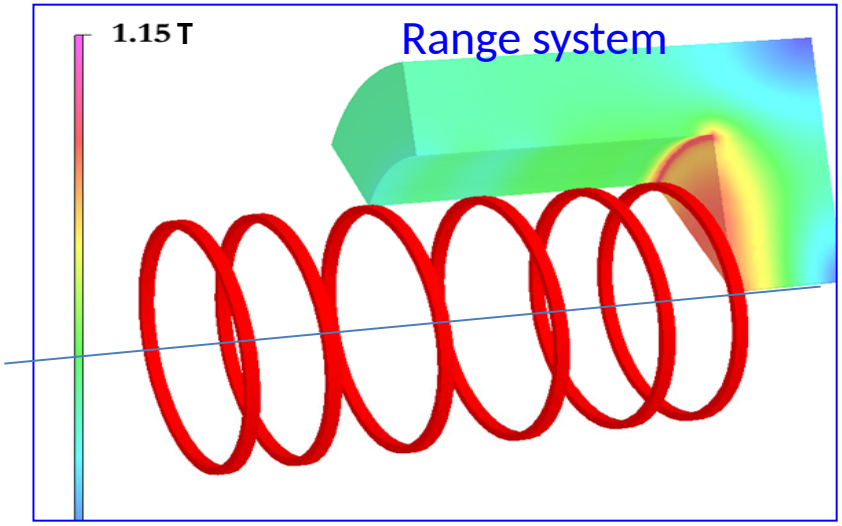
BASIC CRITERIA for choice

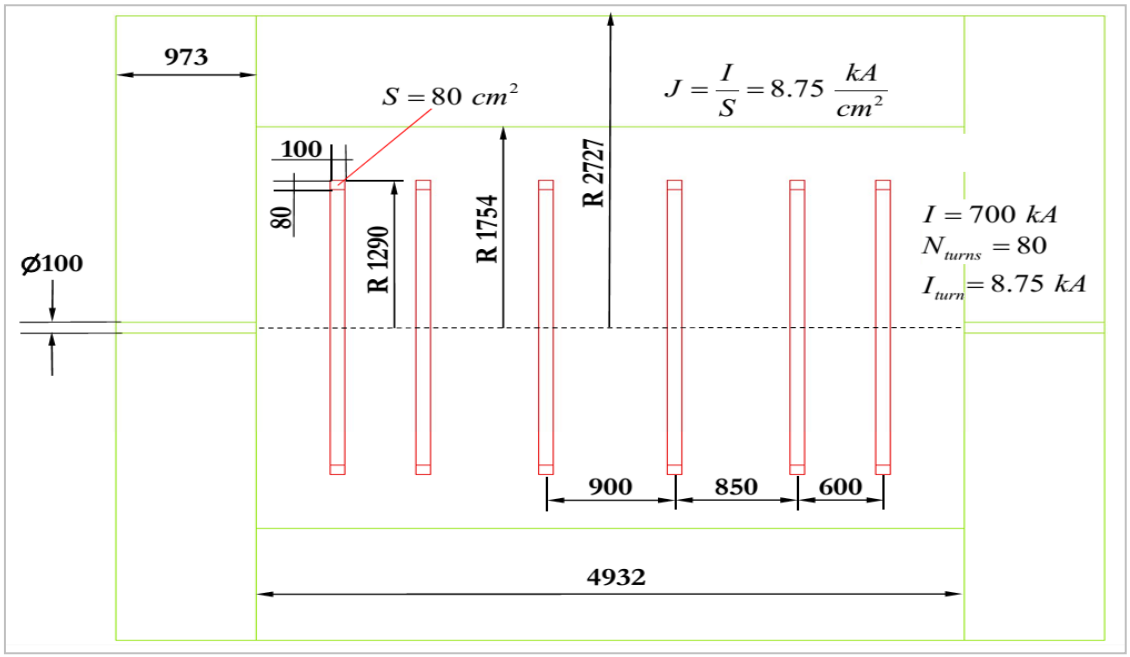
- universality
- minimization the MS material inside SPD
- field integral of 1 T•m along a track
- minimization of the SPD weight and sizes

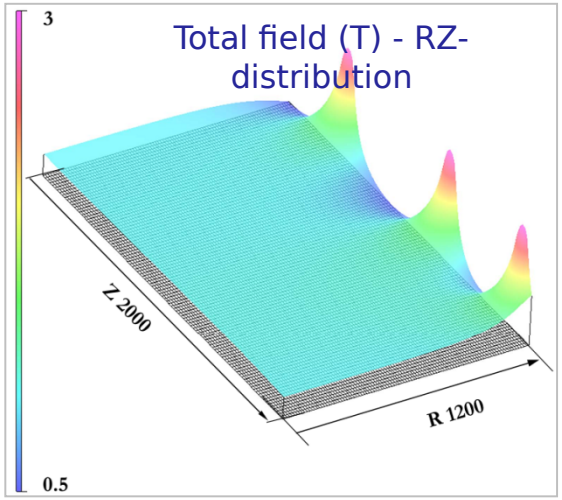
Considered options:

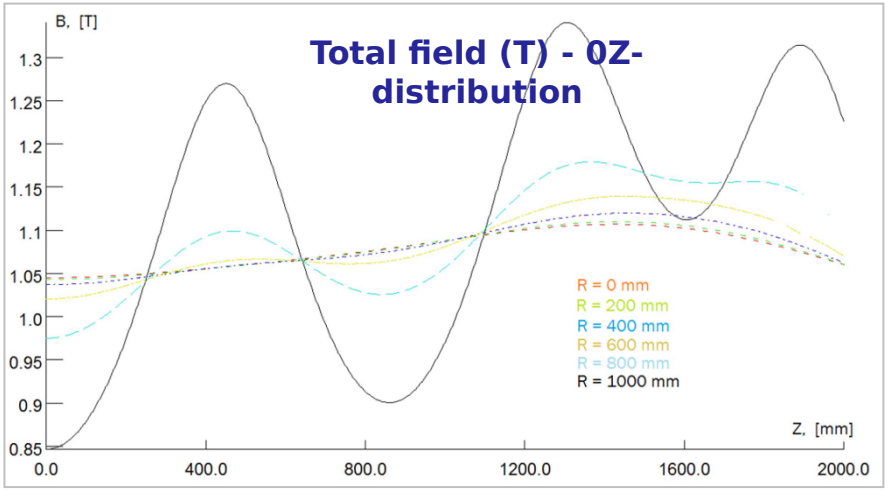
- Solenoid (placed outside ECal);
- Toroid (inside ECal): **1) *barrel part,* 2) *barrel+2 end parts*, 3) *warm coils,* 4) *superconducting coils;***
- 4 separate coils inside the ECal;
- Combination of the toroid and 2 pairs of the coils inside the ECal.

6-coils – chosen one:





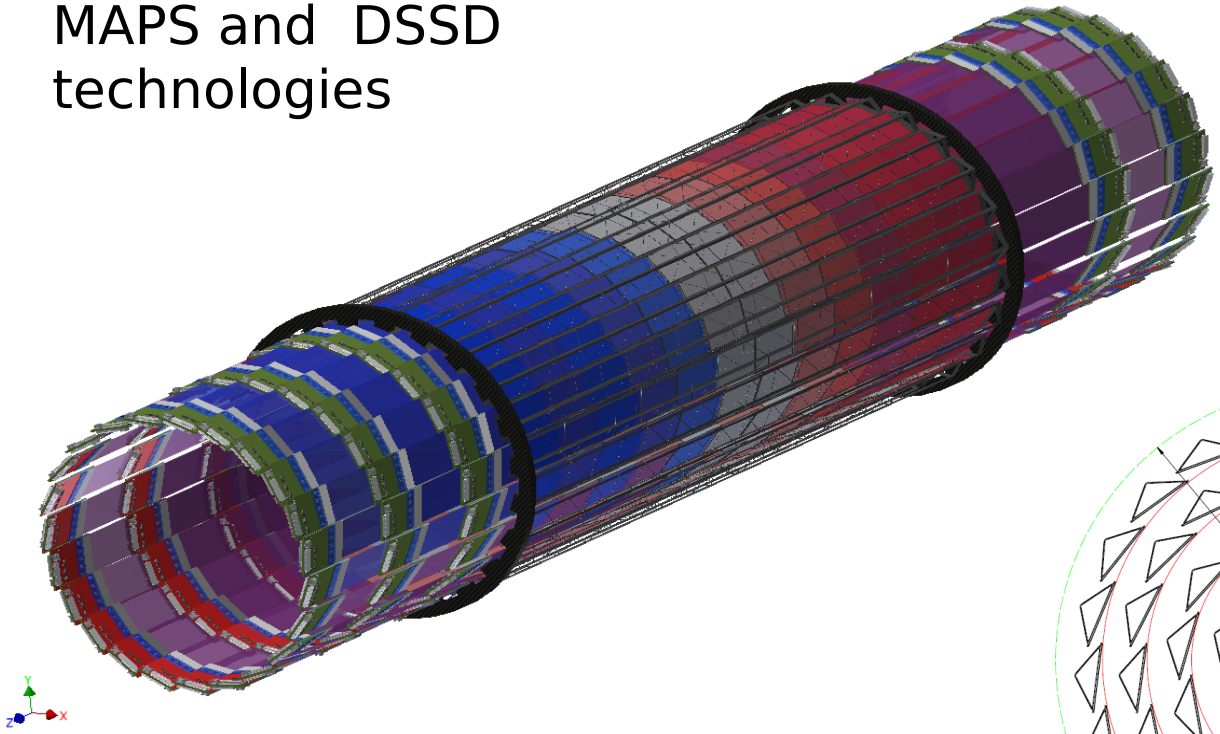




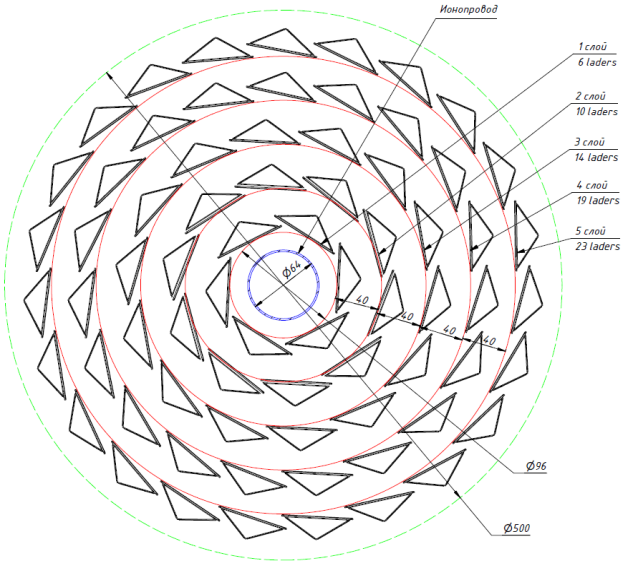
- SC coils minimize material inside SPD; - 1T on the axis is reached at 800 kA·turn;
- Further optimization of distances between coils will provide better field uniformity;
- Cost saving factor can be reached also.

Vertex Detector (Inner Tracker)

VD is based on the MAPS and DSSD technologies



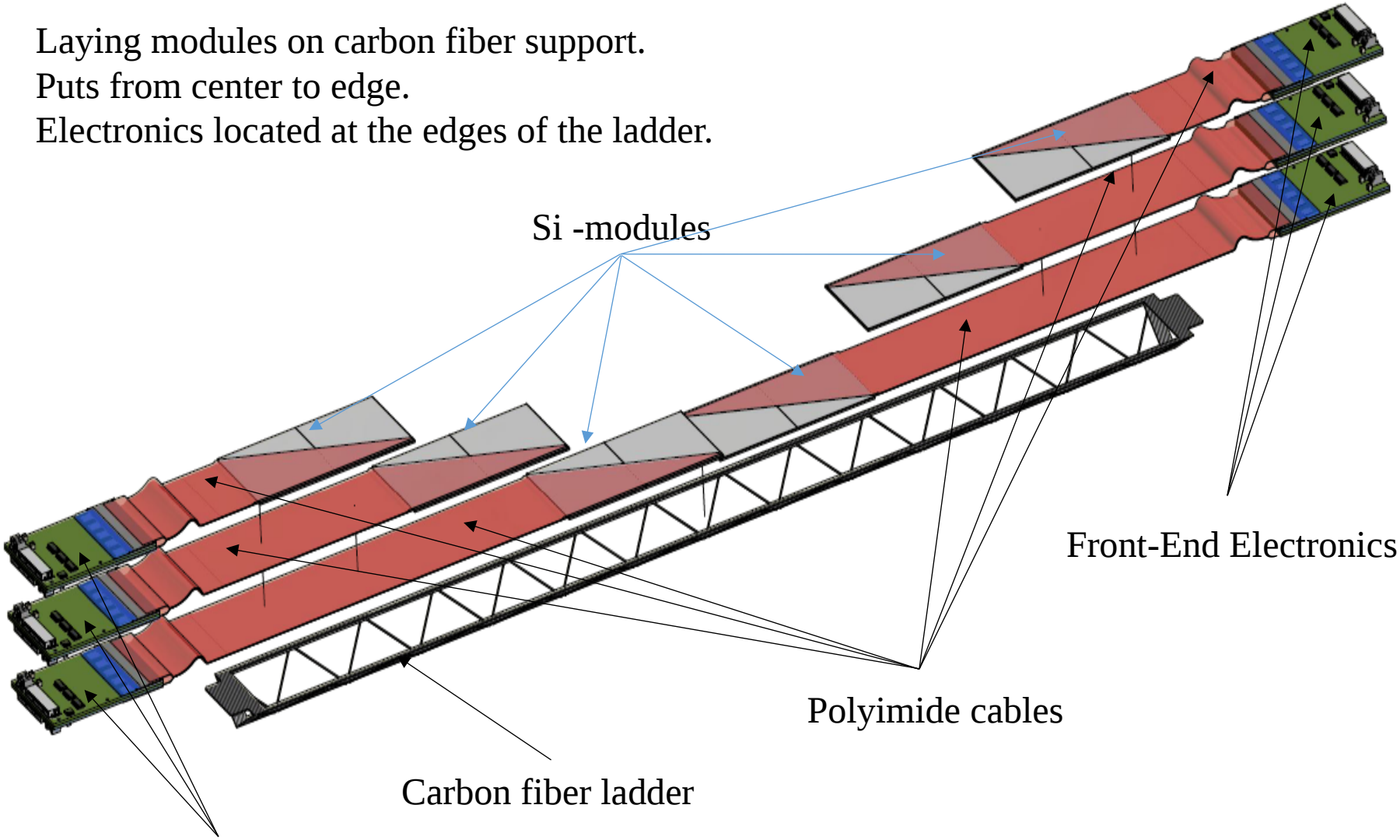
3D view of Vertex Detector with silicon sensors, signal cables and FEE boards



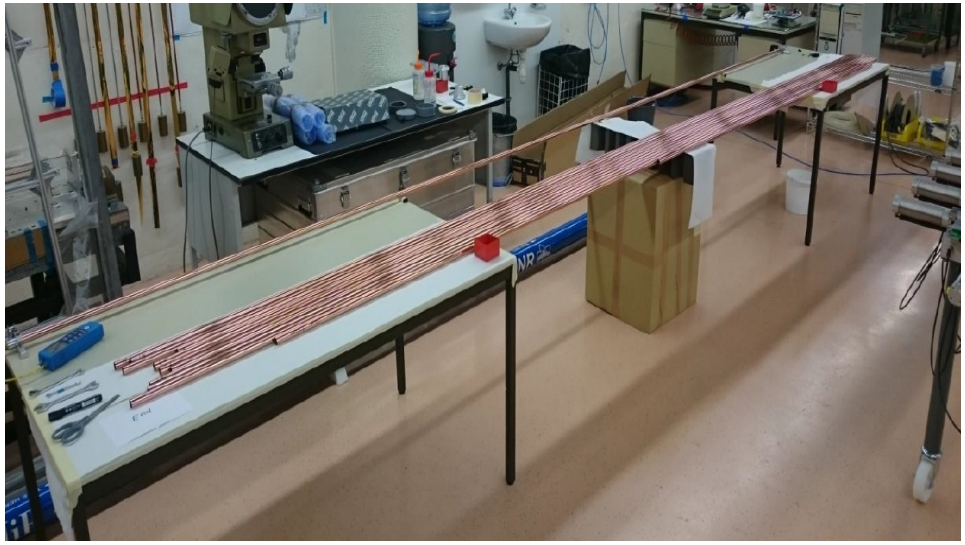
View across the beam pipe

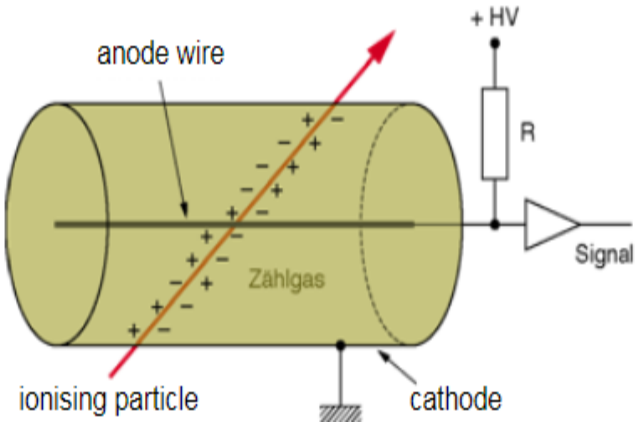
View of carbon fiber ladder with DSSD-modules

Laying modules on carbon fiber support.
Puts from center to edge.
Electronics located at the edges of the ladder.



Central Tracker





Minimum material on the particle tracks (X_0 ~ 0.1);

Time (~ 100 ns) and spatial resolution (~100 μm);

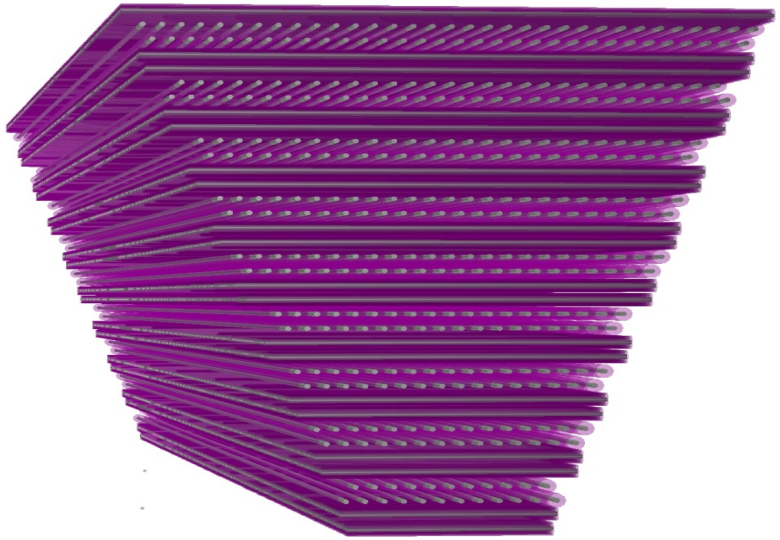
Expected particle rates (DAQ rates) ~ MHz.

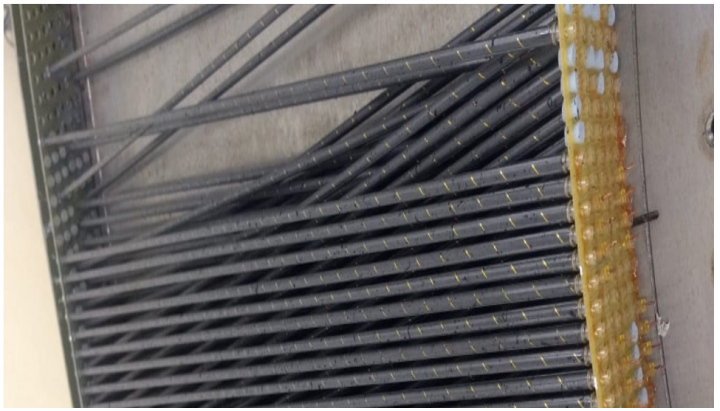
Technology is developed also at JINR

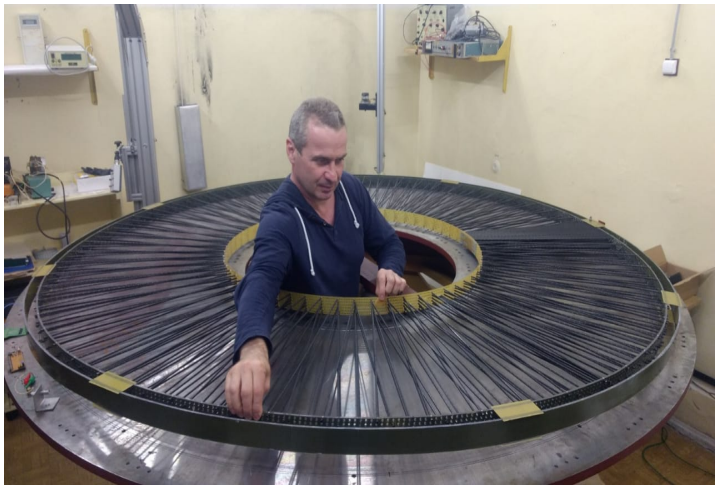
Contribution to ATLAS, COMPASS, NA64, home experiments

Production workshop is available

Central Tracker







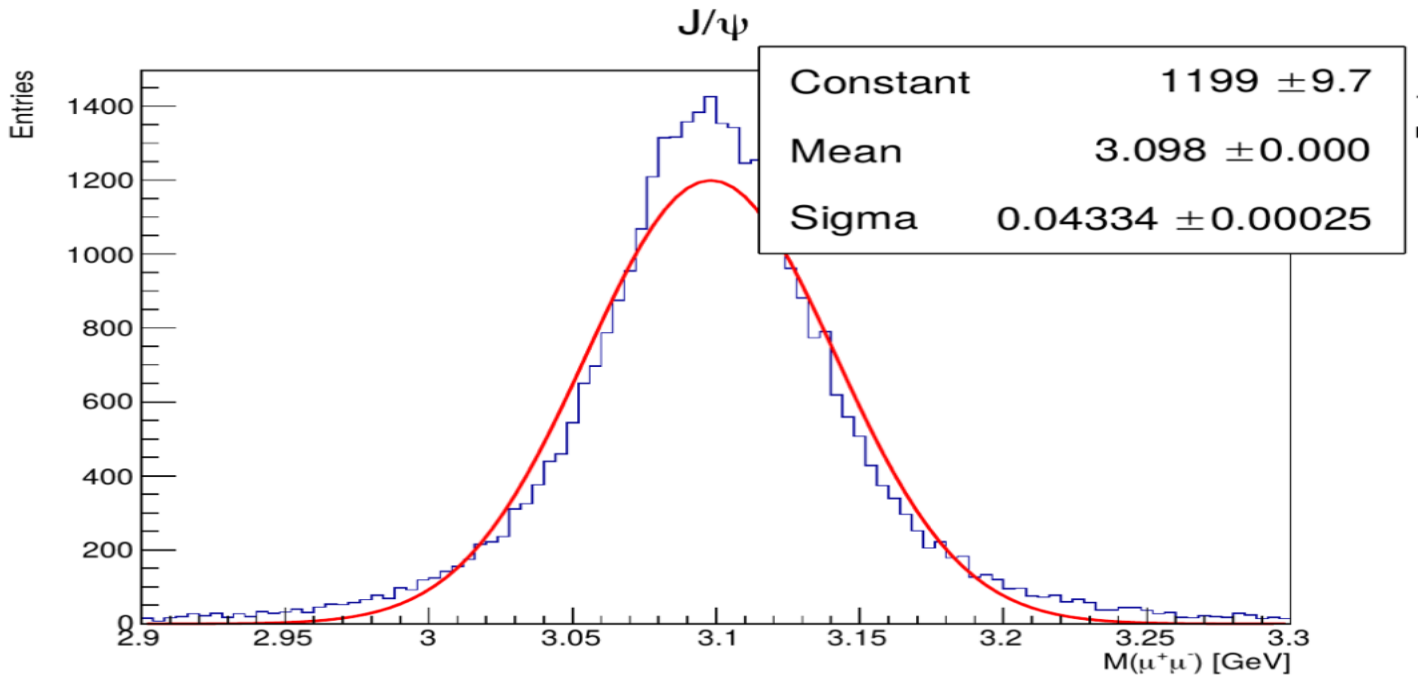
24 XY(optional UV) wedge-shaped straws stations

Straw tube with 10mm diameter, in the center a 30mkm diameter gold-plated tungsten wire

Precision measurement ~150 mkm

The number of layers and the number of straws are discussed.

J/Ψ mass resolution



Combined tracking:

VD: 5 silicon layers

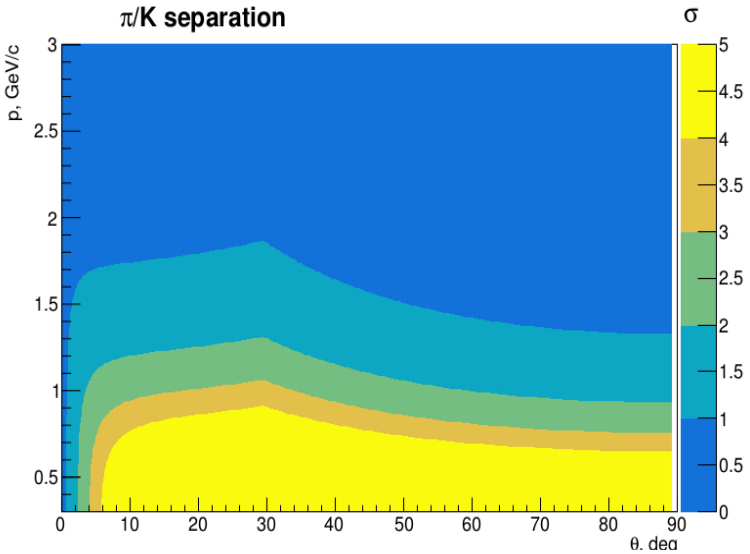
of 300 μm thickness each;

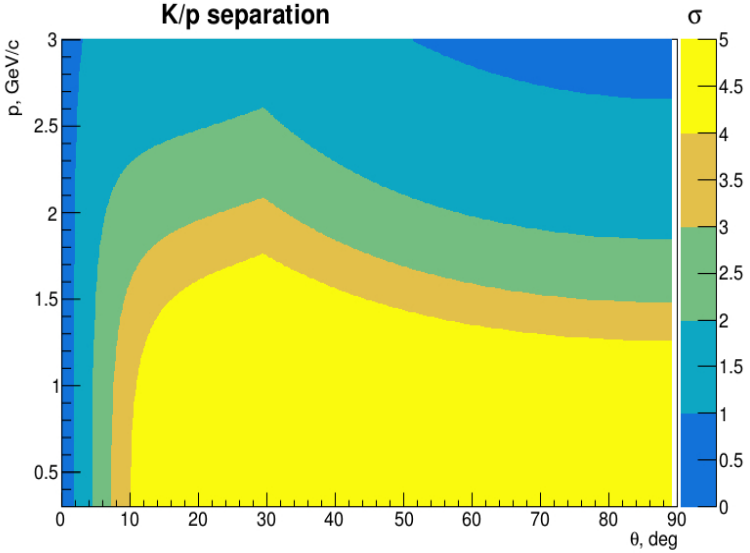
TR: 24 straw-tube

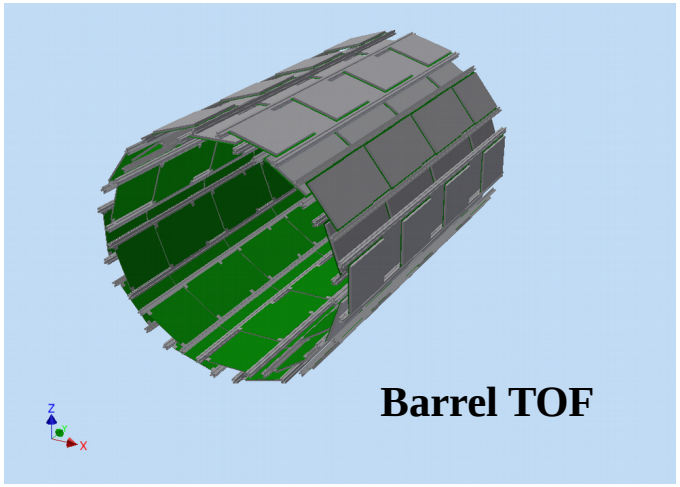
layers, two planes of

1 cm thickness in each

Particle IDentification system (TOF)





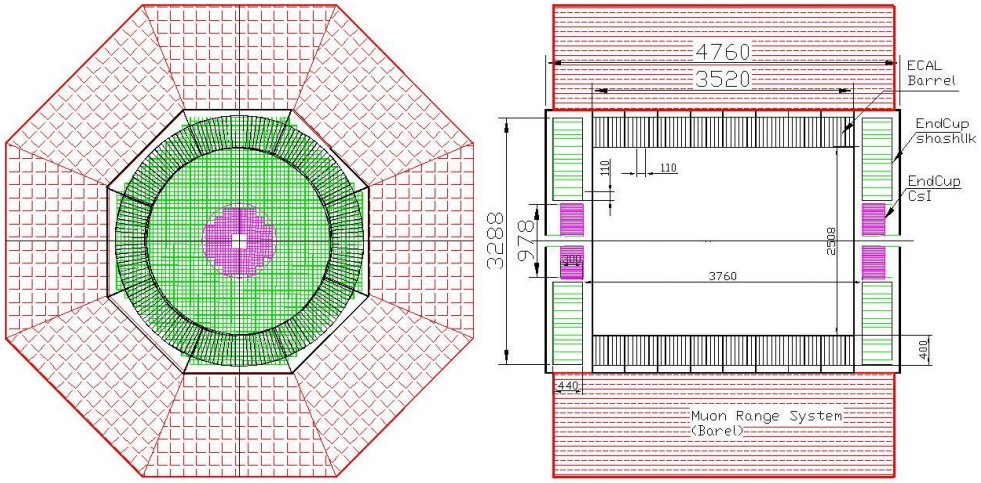


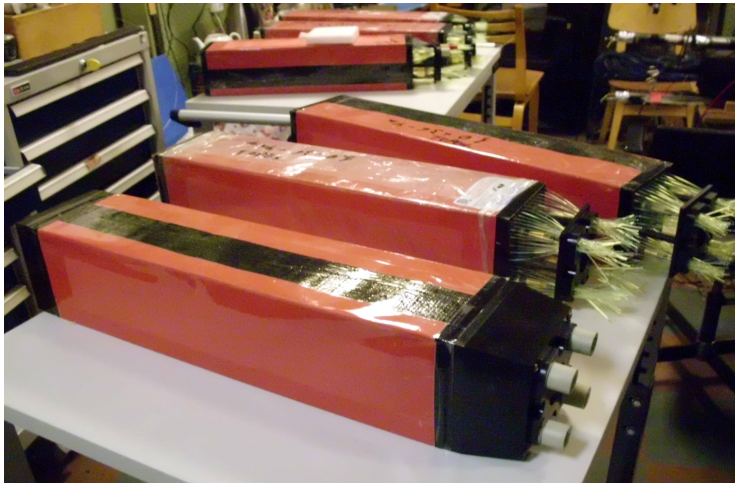
PID system using TOF is based on RPC (about 80 ps time resolution).

Good K/p and π/p separation up to 2.5 GeV/c and 1.2 GeV/c, respectively.

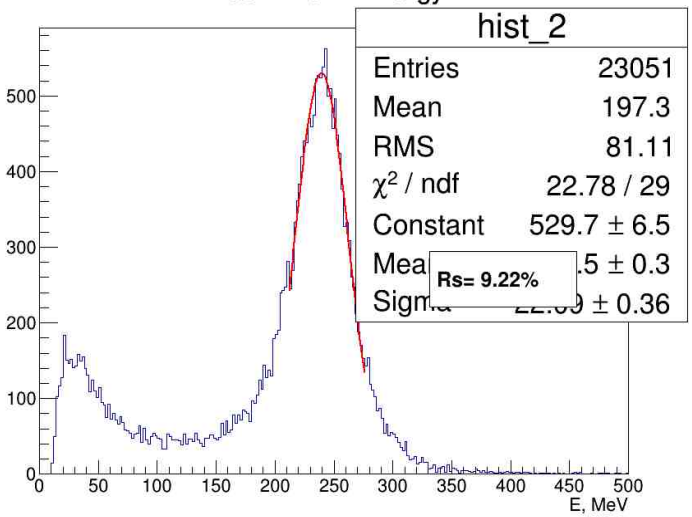
DIRC/aerogel option is also under consideration.

Electomagnetic Calorimeter





Sum ECAL Energy



Photon energy range 0.1 - 10 GeV.

Due to space limitations the total length of the ECAL module should be less than 50 cm.

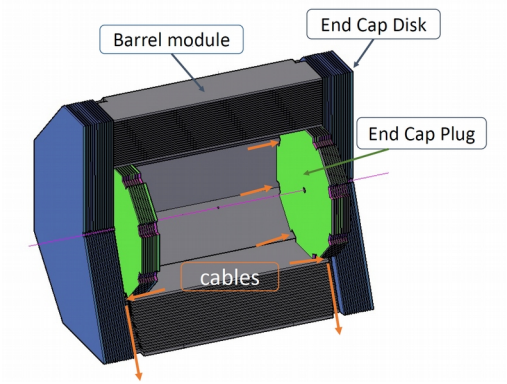
Required energy resolution <5.0%/√E (GeV) and energy threshold below 100 MeV.

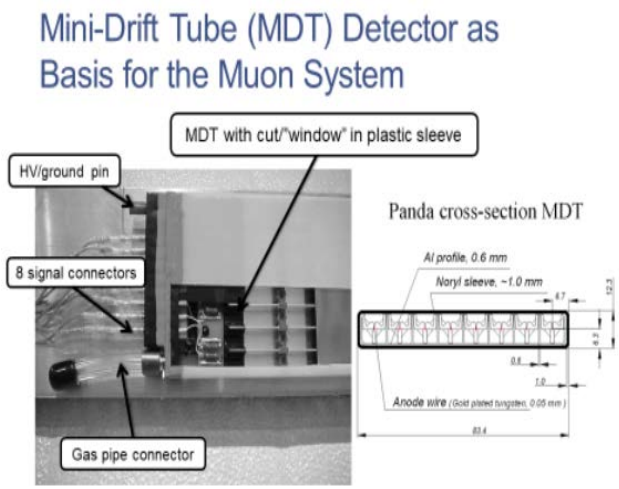
Design is "shashlyk" and crystal.

Projective geometry.

Cosmic test results (MIP)

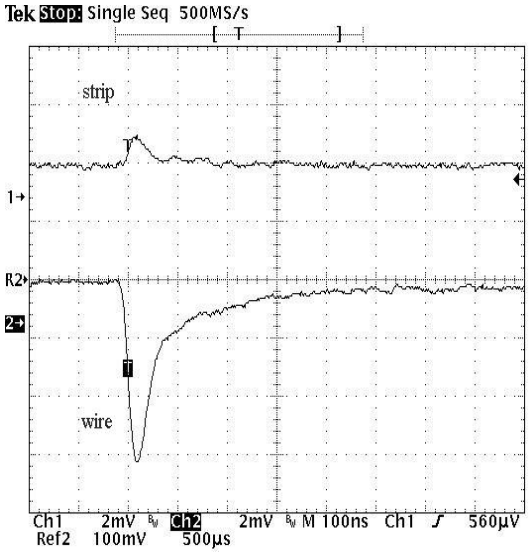
Range (Muon) System

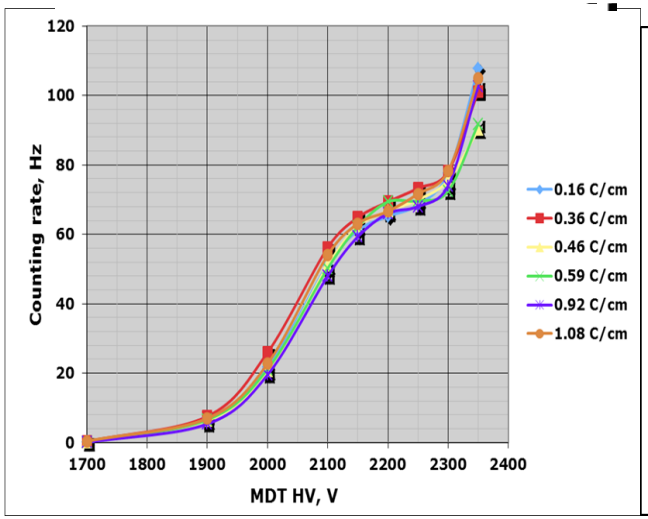


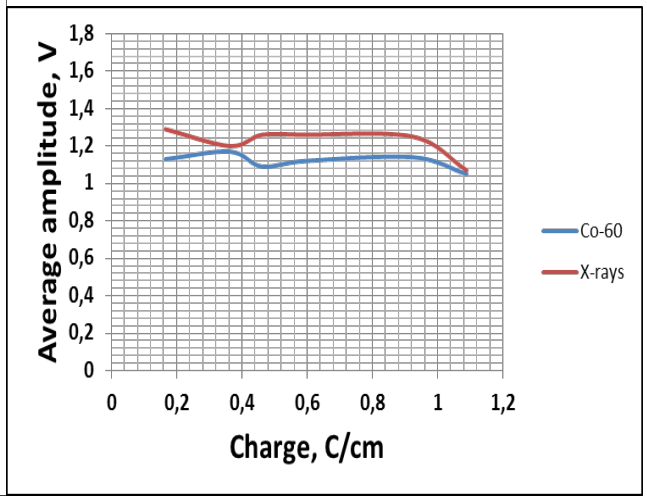


*) MDT detectors represent modification of well-known Iarocci streamer tubes (plastic conductive cathode is replaces by aluminum, and proportional mode of signal is used instead of streamer one).

*) MDTs were used at high quantities in the D0/FNAL and COMPASS/CERN experiments, and also accepted for the Muon System at PANDA/FAIR project

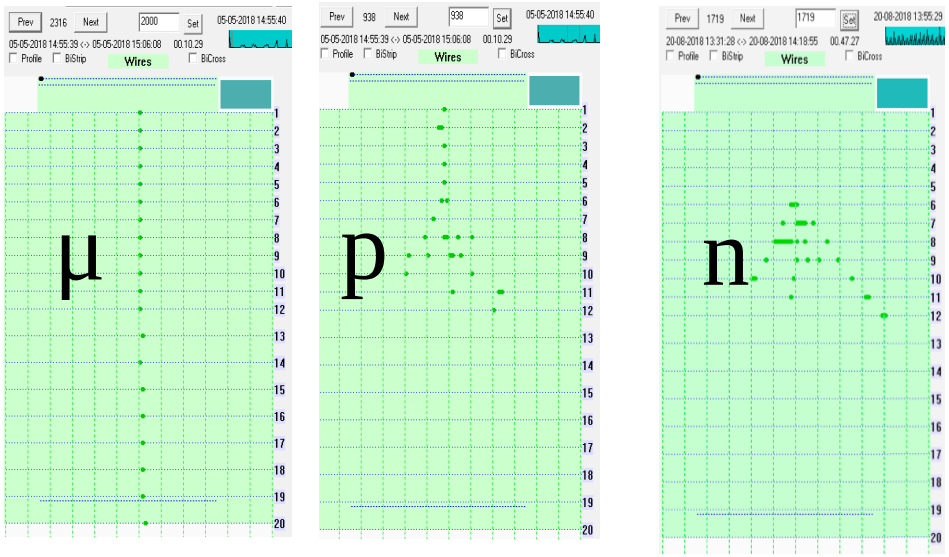




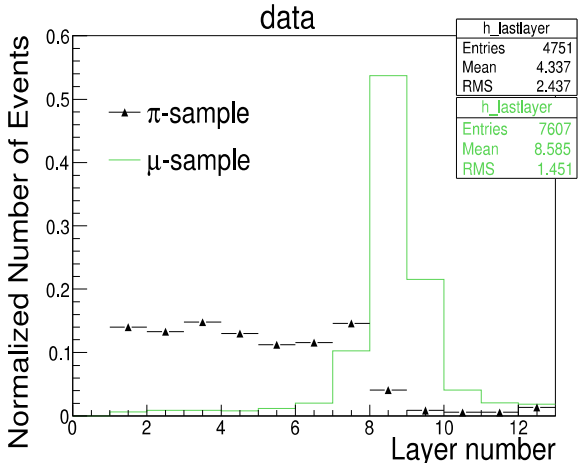


Range System for PID

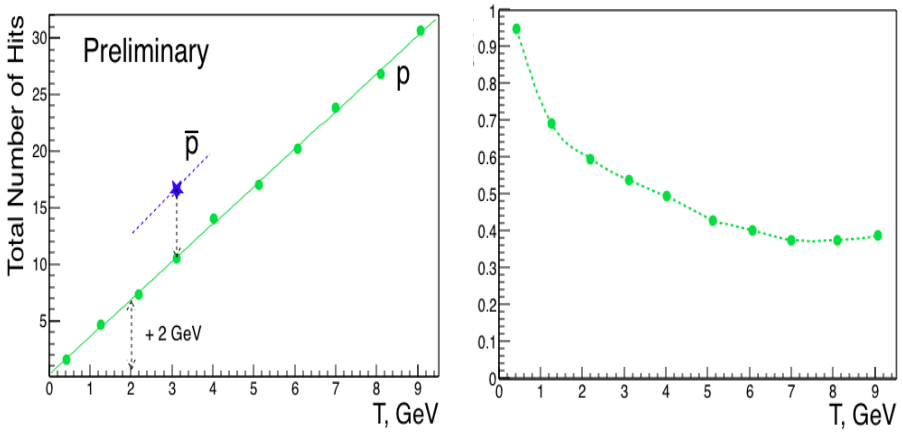
Event examples at 5 GeV/c



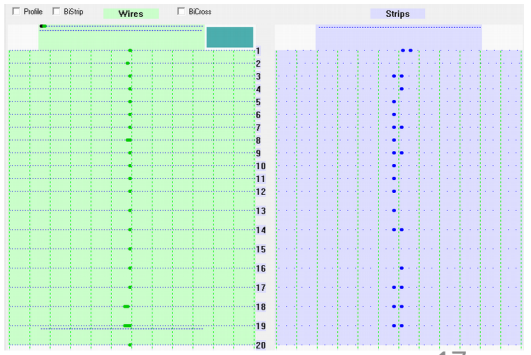
Pion/muon separation at 0.5 GeV/c (~20%)



Energy calibration for protons (response and resolution) with antiproton signal

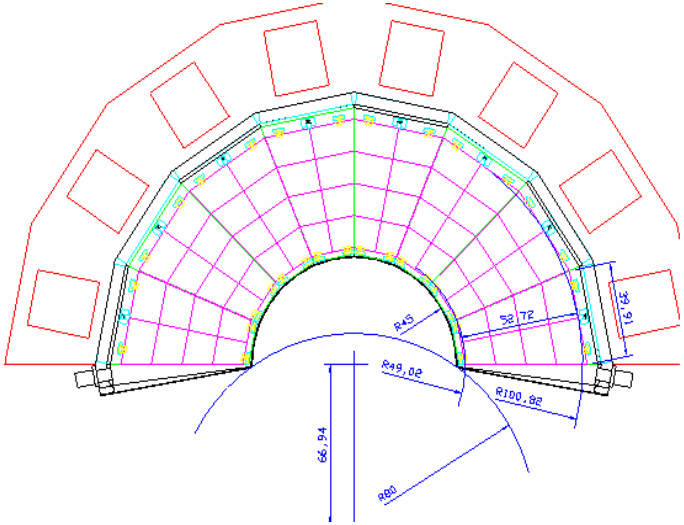


Two-coordinate readout (wires/left and strips/right



Beam-Beam Counter for local polarimetry

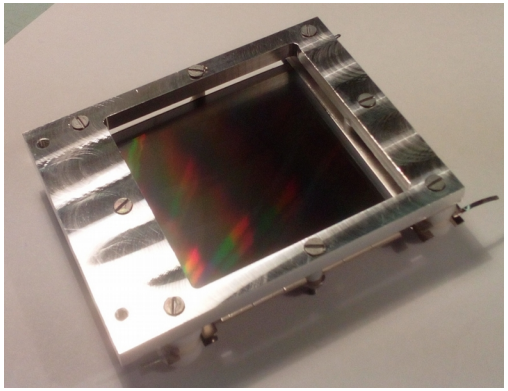
Purpose is the permanent monitoring of the beam polarization using the azimutal asymmetry of the inclusive charged particles yield.



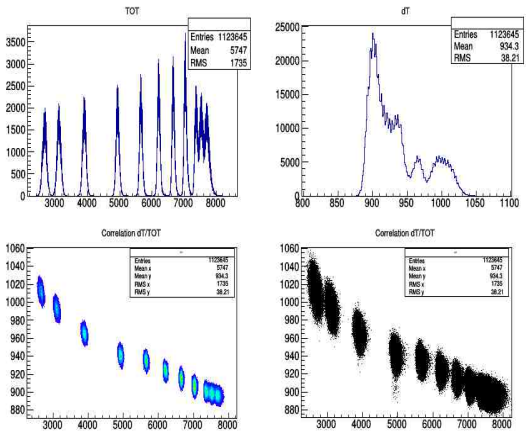
Concept:

inner part – microchannel plates (MCP) based detectors

outer part - high granularity scintillator tiles with SIPM readout

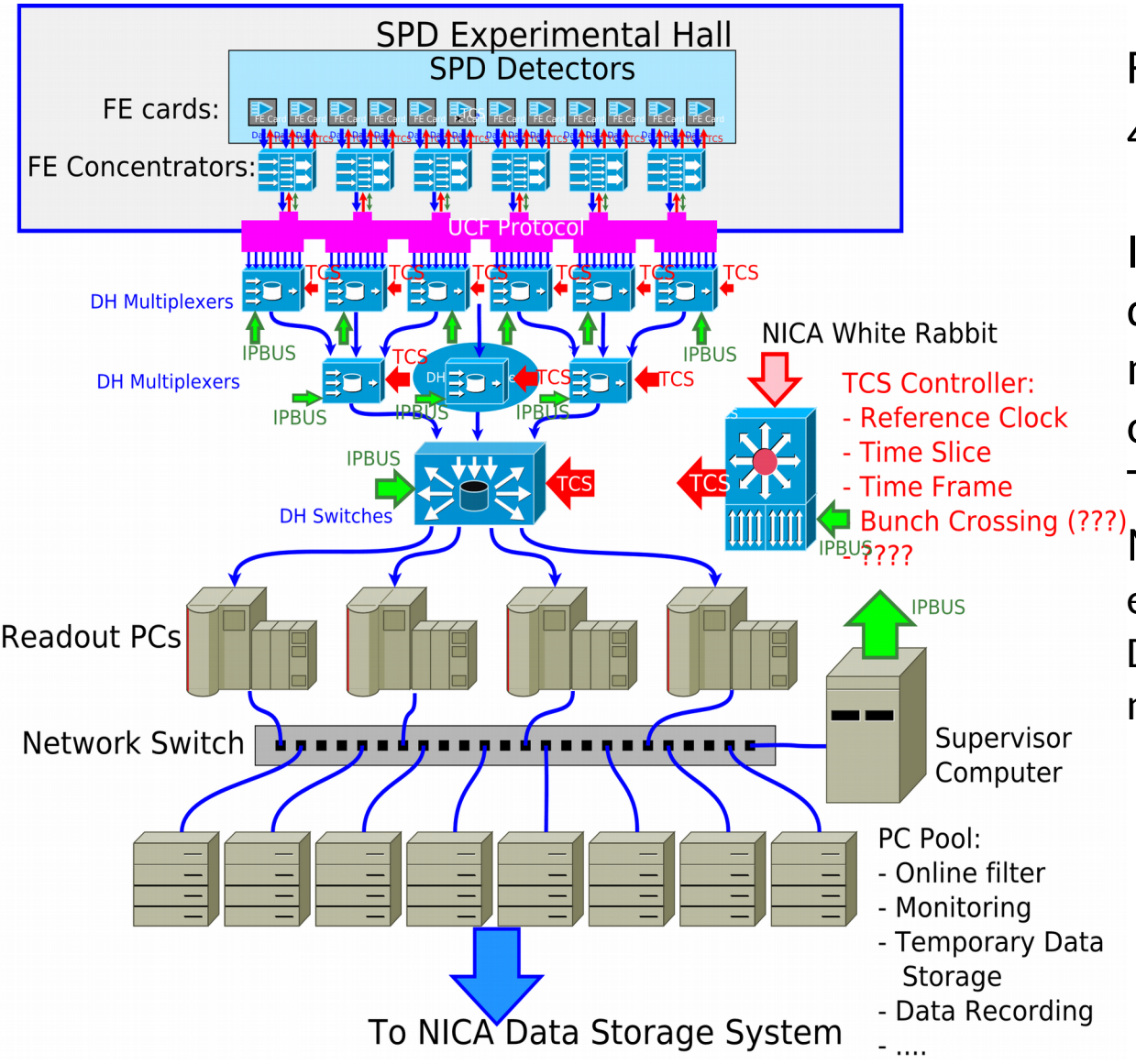


Front side of MCP prototype



FEE with TOT function studies for scintillator detector prototype

Free-streaming DAQ

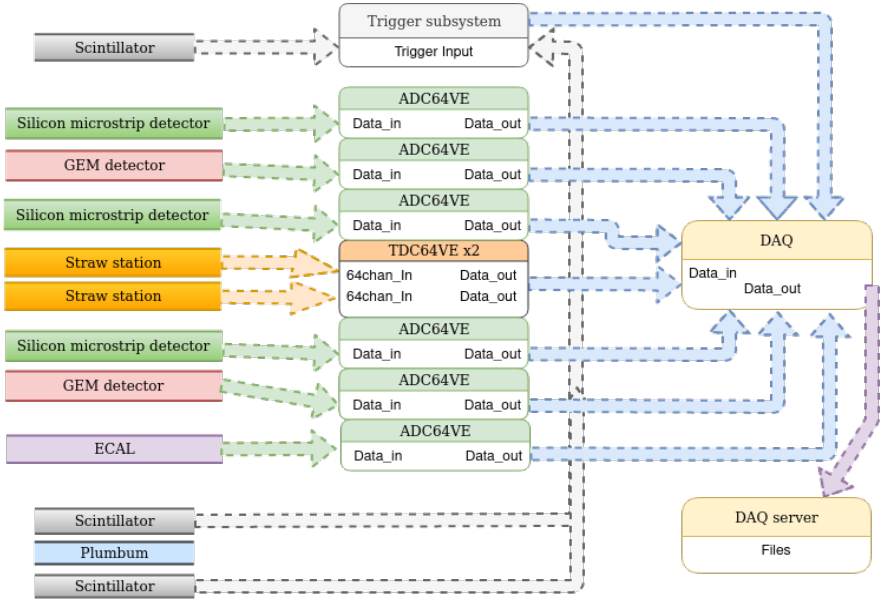


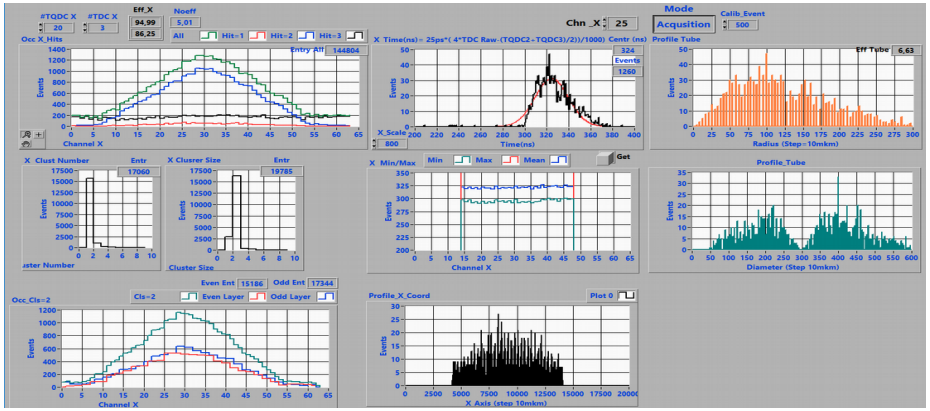
Free-streaming DAQ up to 4 MHz rate (20 Gbybes/s).

In DAQ of SPD the ideas developed for the modernized DAQ of COMPASS by the Technische Universität of München (TUM) team will be employed. This concept of SPD DAQ can be used with minor modifications.

The details are given in the talk of A.Zhemchugov

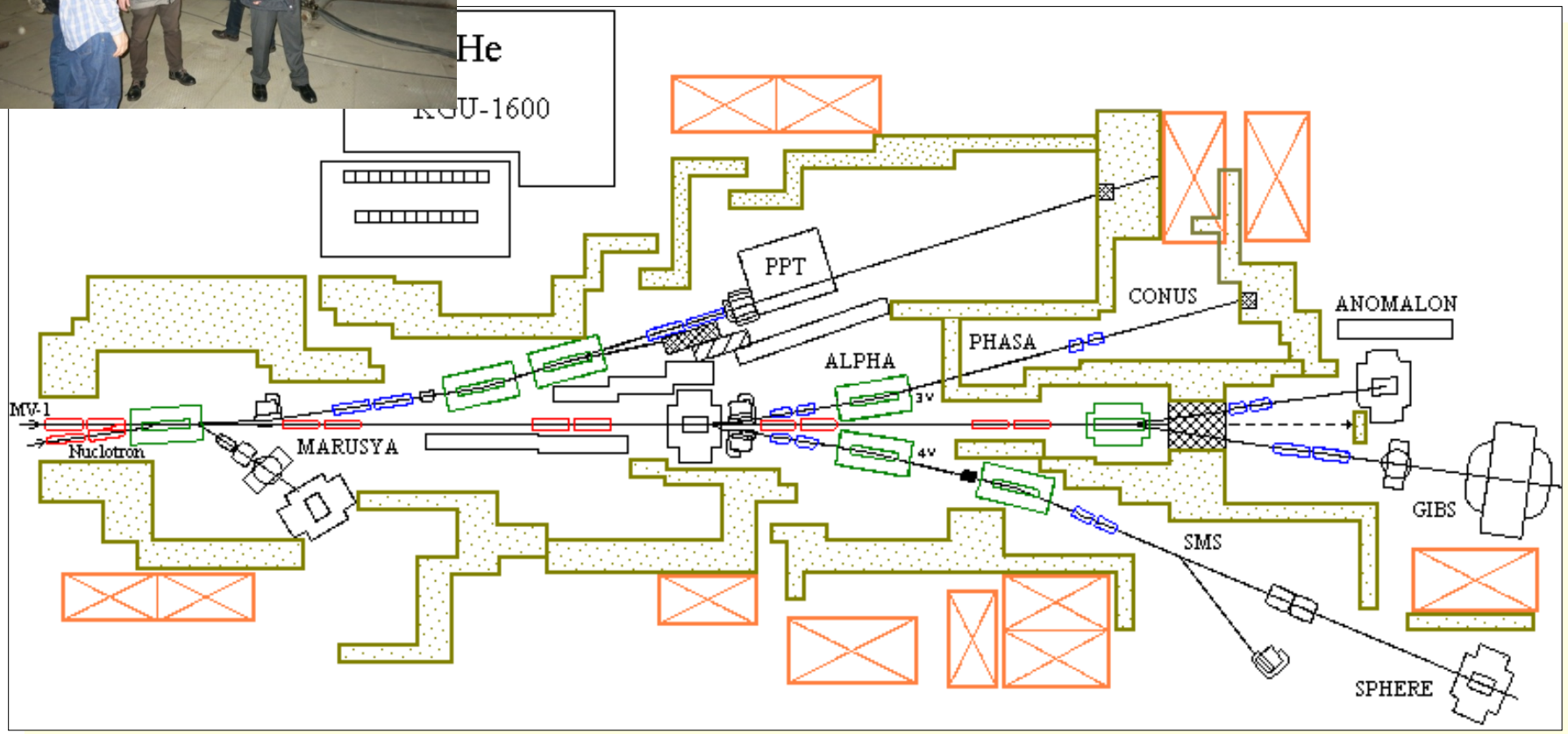
Detector combined test at cosmic muons (mini-SPD)





The details are given in the talk of A.Baldin

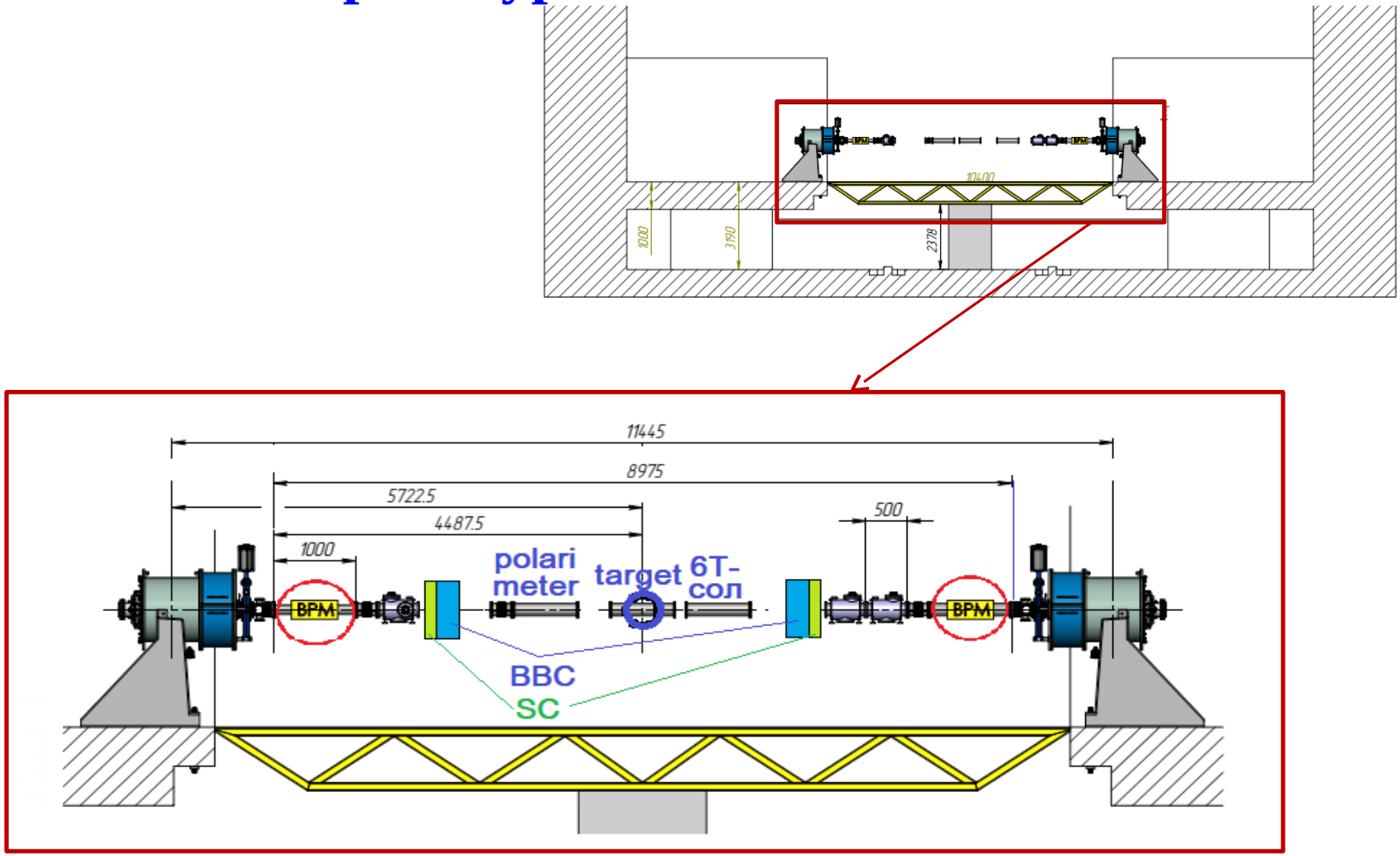
SPD test zone at Nuclotron: “MARUSYA”+”Polarimeter” setups



The Goal is to test of the detector prototypes, DAQ, slow control and Data analysis algorithms – 2021y.

The details are given in the talk of A.Baldin

Detector prototypes tests at SPD collider zone



Prototypes of BBC and other detectors can be tested during first beams at NICA.

Conclusions

SPD will provide a unique opportunily for the study of the spin and polarization effects in hadron and electromagnetic reaction channels ***not available at other facilities.***

The concept of the detector is under development.

The R&D was started.

The SPD test facilities (mini-SPD, SPD test zone at Nuclotron etc.) are under preparation.

Thank you !

Backup slides

SPD magnetic system

½ model symmetry

$$B^{(z)}(x,y,0)=0.$$

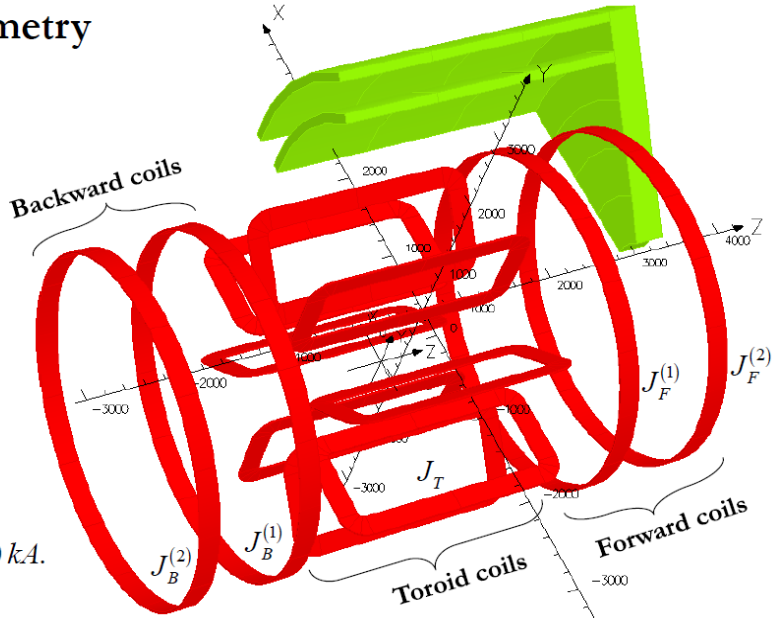
$$J_T = 40\frac{A}{mm^2},$$

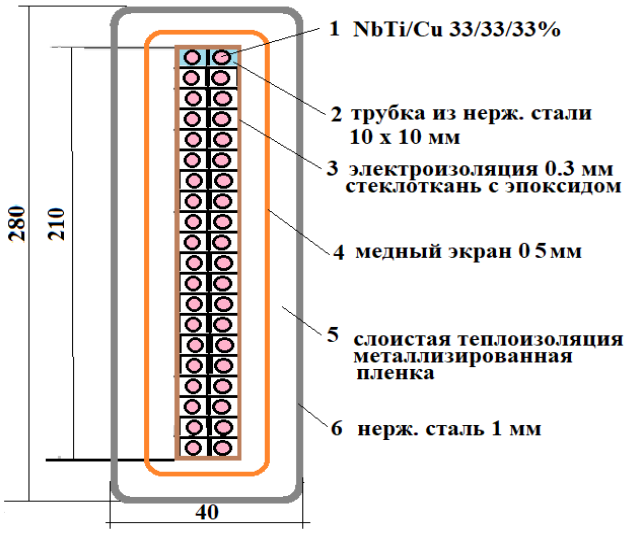
$$J_{B\backslash F}^{(1,2)} = \mp 80\frac{A}{mm^2},$$

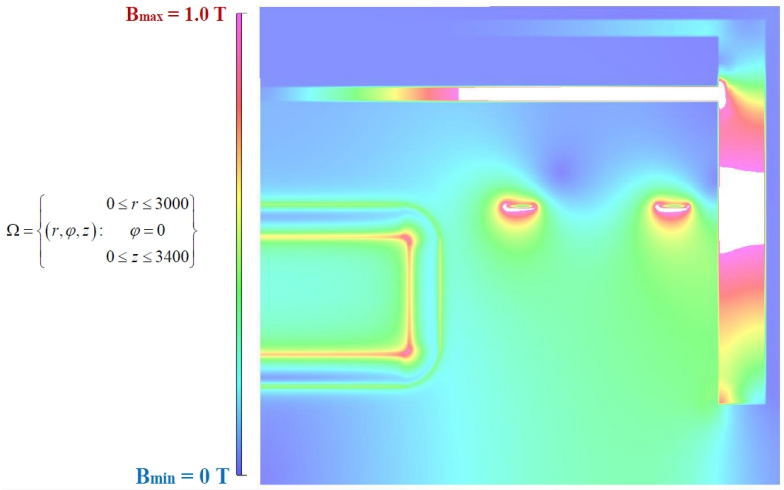
$$S = 200\times 20\,mm^2,$$

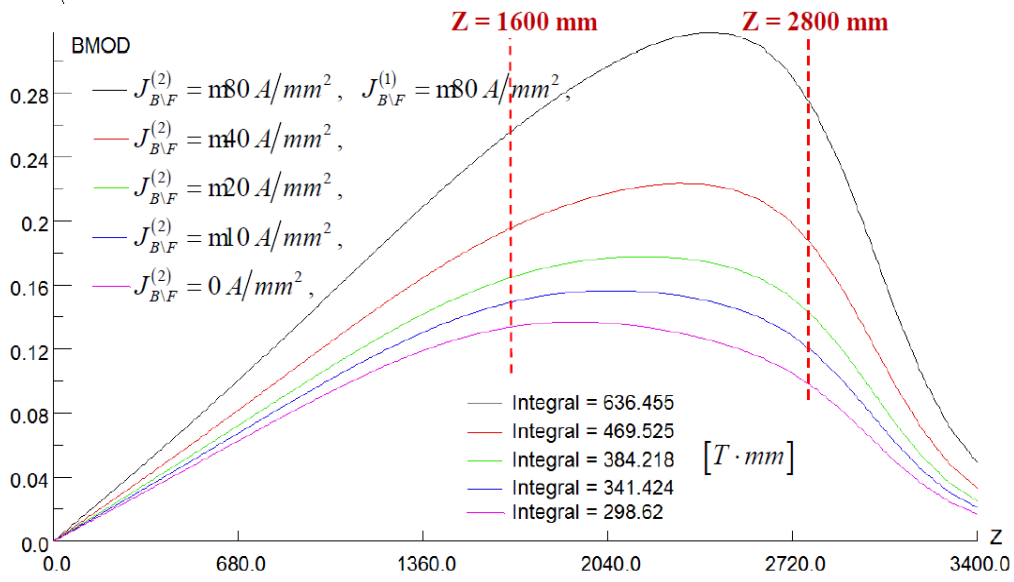
$$I_T = J_T\cdot S = 160\,kA,$$

$$I_{B\backslash F} = J_{B\backslash F}\cdot S = \mp 320\,kA.$$

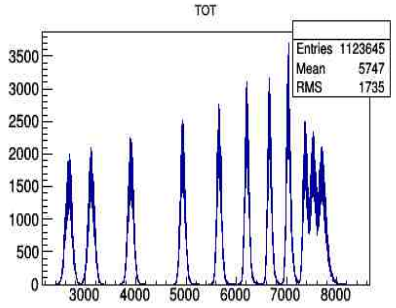


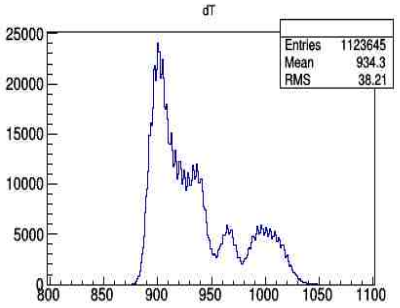


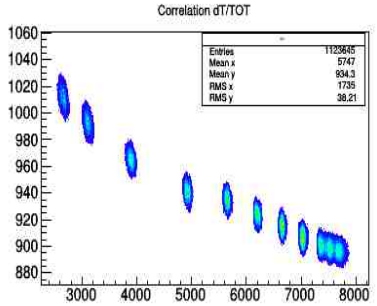


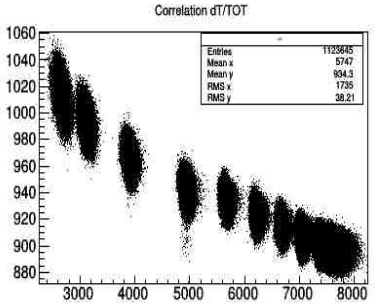


FEE for scintillator part of BBC









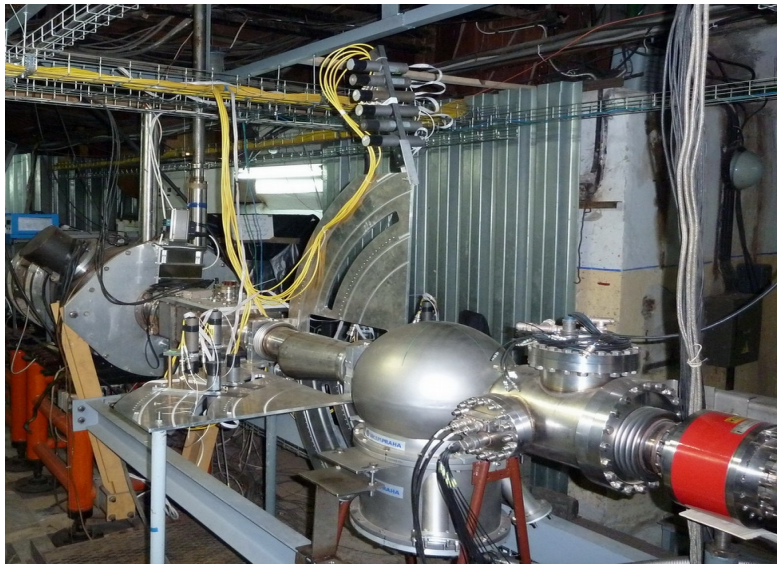
-Prototype of the FEE with TOT function for Hamamatsu S12572-010P SiPM has been tested using LED at the testbench equipped at LHEP.

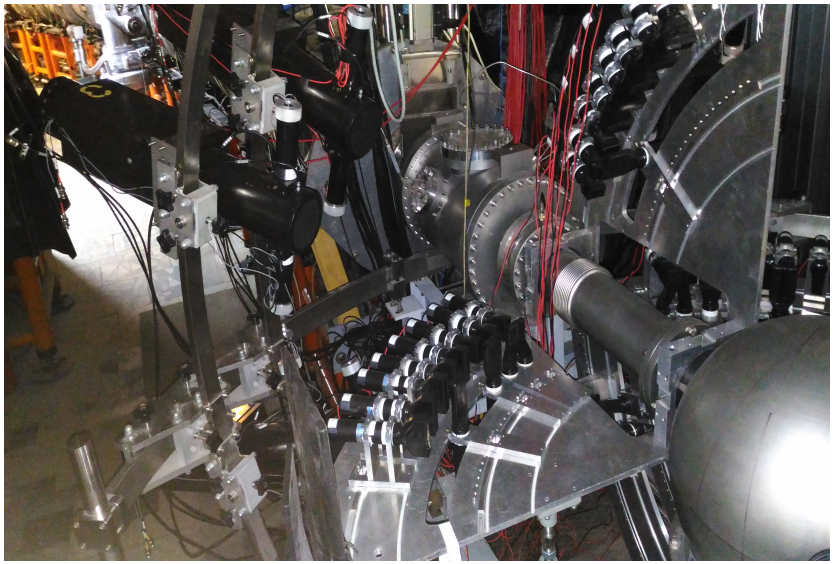
-TOT function (signal width vs amplitude) can be parameterized by the polinomians.

Studies were stopped due to COVID-19.

27

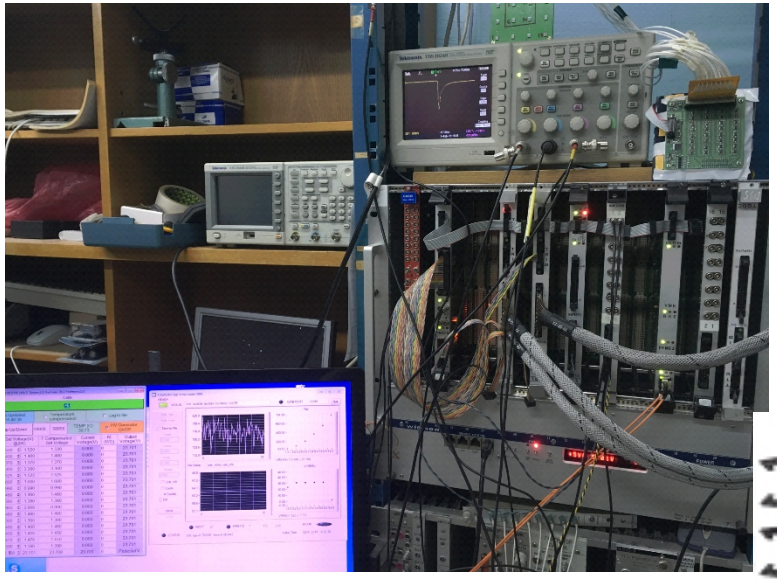
Internal target at Nuclotron



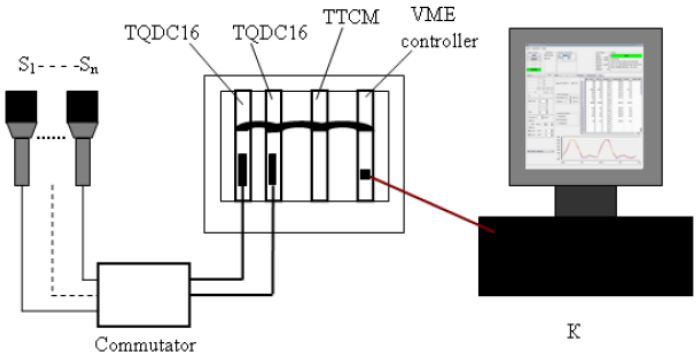


1. MCP part of BBC – different options of FEE
2. Scintillation part of BBC – together with proton/deuteron ITS polarimeter.
3. Part of the tests free (almost)!

Outer part of BBC: testbench



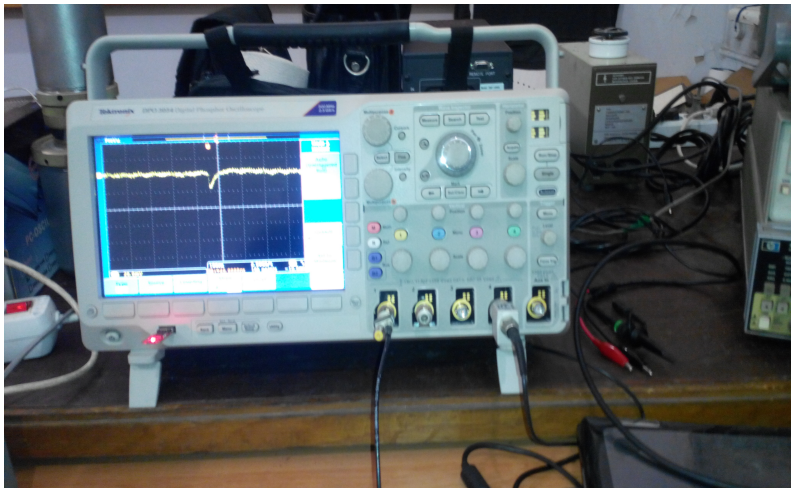
Ch.	Set Voltage(V) @20C		T Compensated Set Voltage	Current Voltage(V)	Kt (V/C)	Output Voltage(V)
0	1.356	1.356	1.356	1.356	0	73.646
1	1.239	1.239	1.239	1.239	0	73.763
2	1.247	1.247	1.247	1.247	0	73.755
3	1.648	1.648	1.648	1.648	0	73.354
4	1.351	1.351	1.351	1.351	0	73.651
5	1.125	1.125	1.125	1.125	0	73.877
6	1.399	1.399	1.399	1.399	0	73.603
7	1.323	1.323	1.323	1.323	0	73.679
8	1.341	1.341	1.341	1.341	0	73.661
9	1.224	1.224	1.224	1.224	0	73.778
10	1.297	1.297	1.297	1.297	0	73.705
11	1.348	1.348	1.348	1.348	0	73.654
12	1.608	1.608	1.608	1.608	0	73.394
13	1.315	1.315	1.315	1.315	0	73.687
14	1.225	1.225	1.225	1.225	0	73.777
15	1.299	1.299	1.299	1.299	0	73.703
Ped	75.000	75.002	74.998	75.002	0	Pedestal V

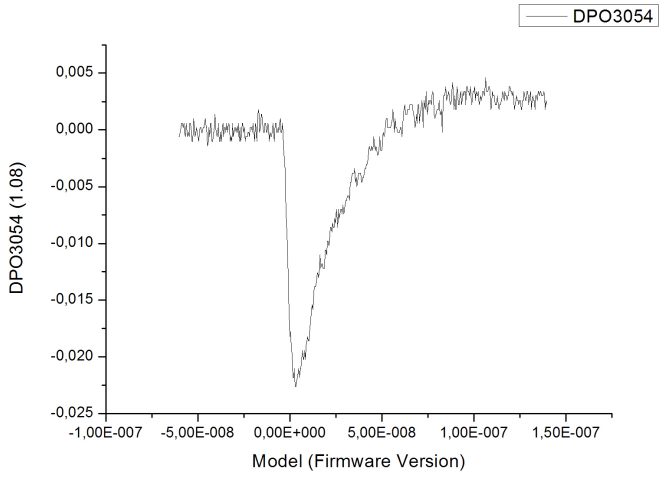


TQDC16 or TDC32(64)

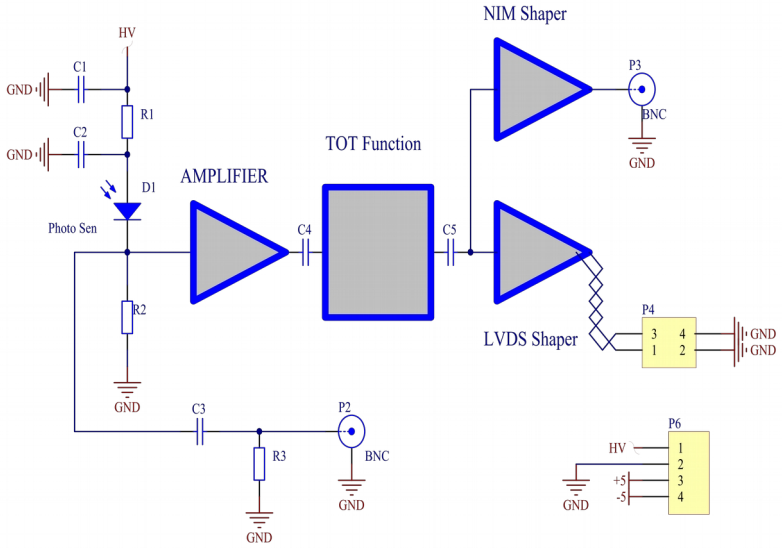
The VME based data acquisition system was developed and used for the data taking from scintillation detectors.

Status of the amplifier with ToT

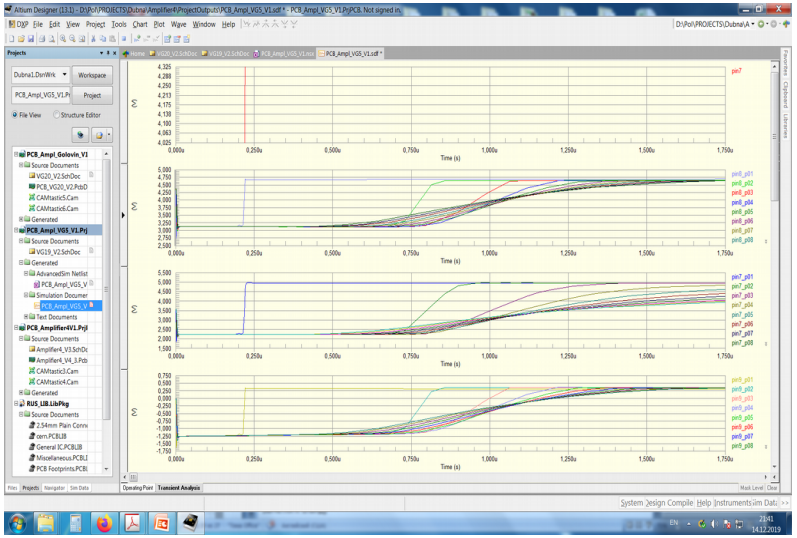




FEE for scintillator part of BBC



Scheme of the TOT amplifier (ITEP)



Simulation of the amplifier for large signal amplitudes

-Prototype of the front-end electronics with TOT function for Hamamatsu S12572-010P SiPM has been developed.

-Prototype of the bias voltage system has been developed.

FEE with TOT function allows to use standard TDC (with leading and trailing edges).

31