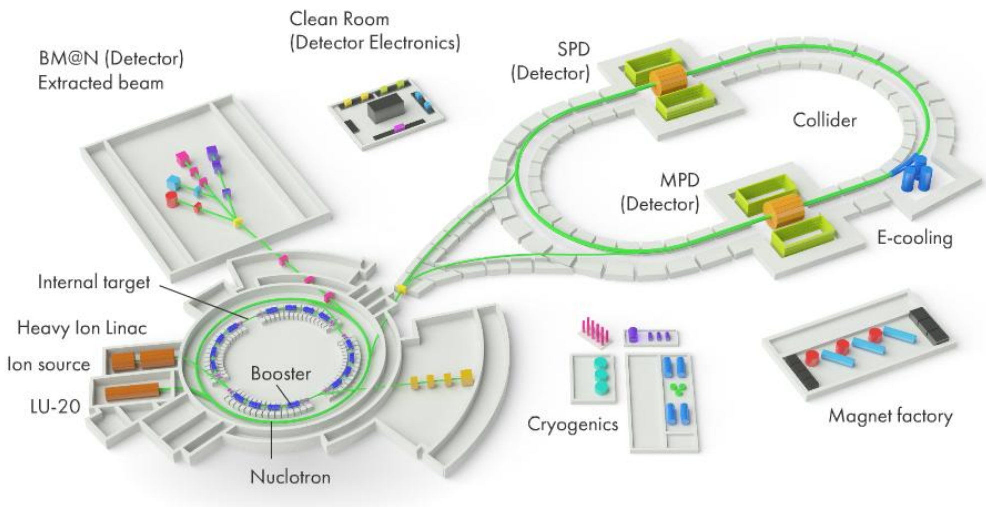
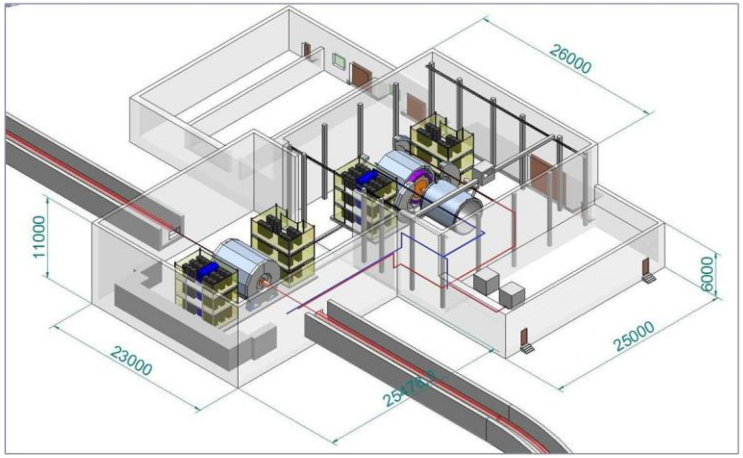
Preliminary design of the SPD





Requirements for the SPD

- close to 4π geometrical acceptance;
- high-precision (~50 µm) and fast vertex detector;
- high-precision (~100 µm) and fast overall tracker,
- good particle ID capabilities;
- efficient muon range system,
- good electromagnetic calorimeter,
- low material budget over the track paths,
- trigger and DAQ system able to cope with event rates at luminosity of 10^{32} $(cm.s)^{-1}$,
- modularity and easy access to detector elements, that makes possible further reconfiguration and upgrade of the facility.

Requirements for the SPD

Tracking detectors:

- Vertex detector - several coordinate silicon layers with resolution of the order of 50 µm;

- central and end track detectors - several groups of layers of straw tubes;

- In addition, you can use the space between the coils of the toroidal a magnet for drift chambers. Track resolution ~ 100 µm.

Trigger detectors:

- signals from the electromagnetic calorimeter;

- scintillation plates.

It is necessary to organize different types of triggers.

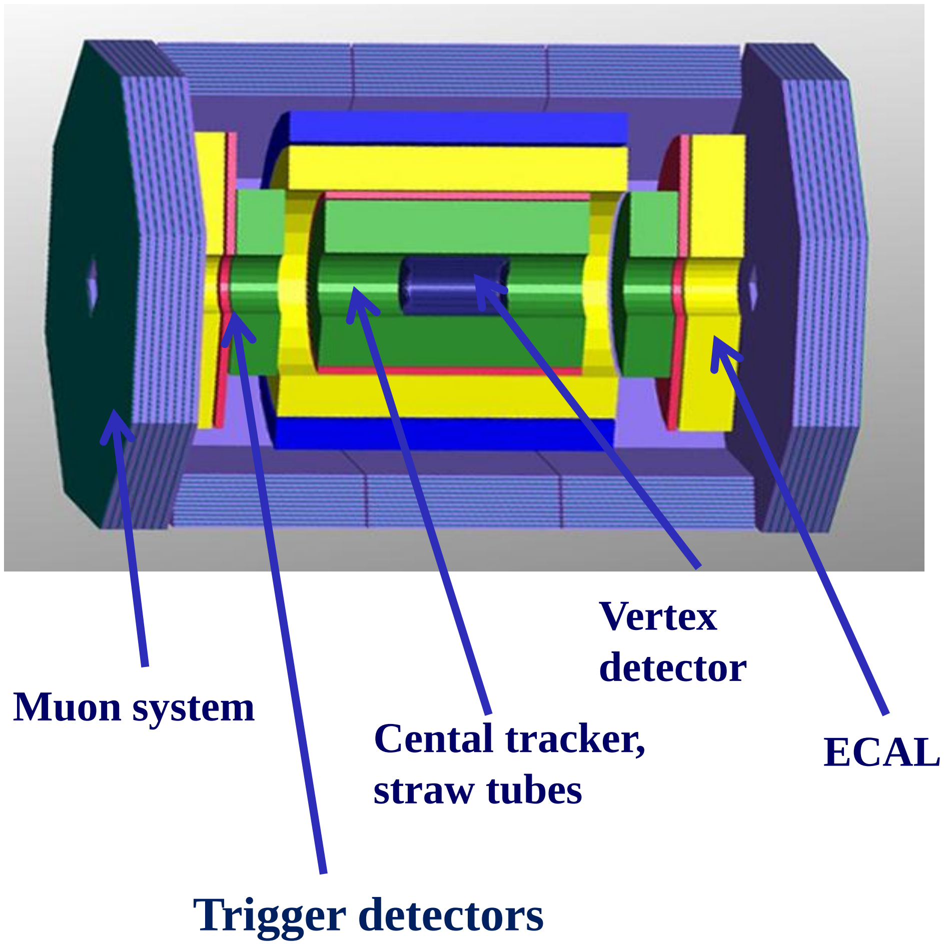
PID detectors:

- Time-of-flight system from - RPC planes ??;

- electromagnetic calorimeter;

- muon system (RS).

Preliminary SPD design

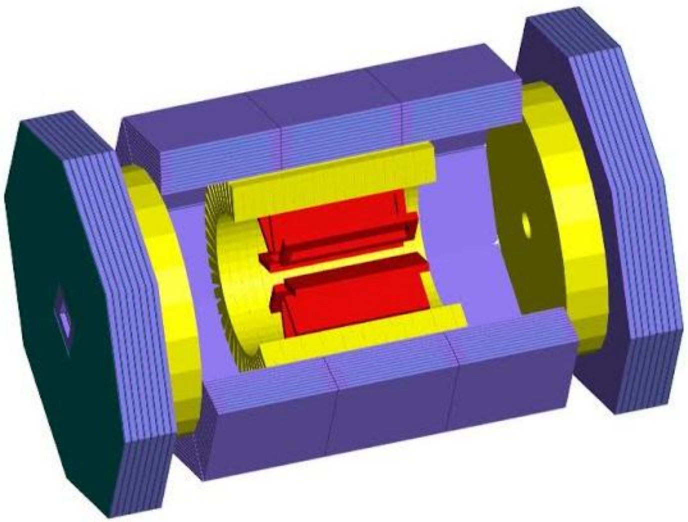


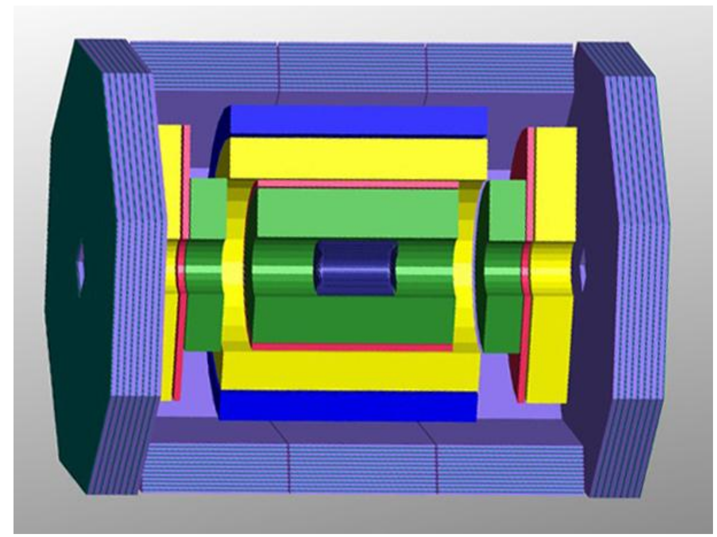
Proposed scheme of the SPD:

- Torroid/Solenoid magnet system
- Silicon detectors
- Drift chambers
- EM Calorimeter
- Muon system
- Trigger System
- EndCup detectors with RS, tracking system and EMC

SPD sizes: ~ 8 m along beams
~ 7 m in diameter

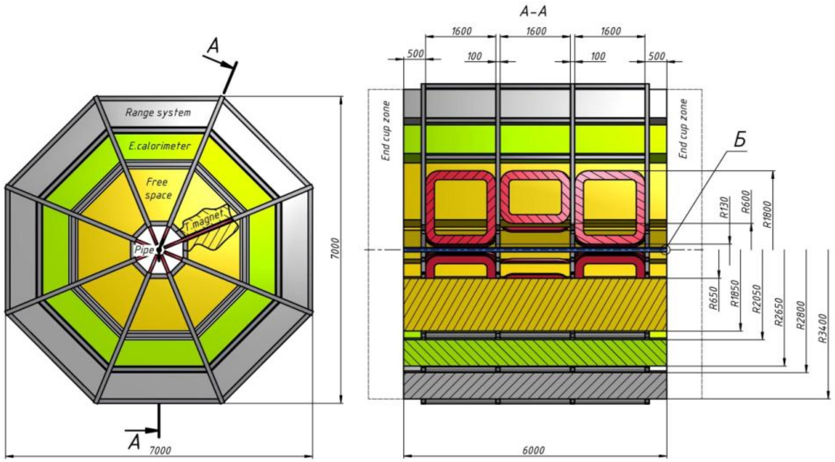
Preliminary SPD design





The most urgent task:
toroidal or solenoidal magnet?

Preliminary SPD design



<u>Toroid</u>

It may consist of 8 superconducting coils symmetrically placed around the beam axis. Preliminary studies show that the use of superconducting coils.

<u>Disadvantages:</u>

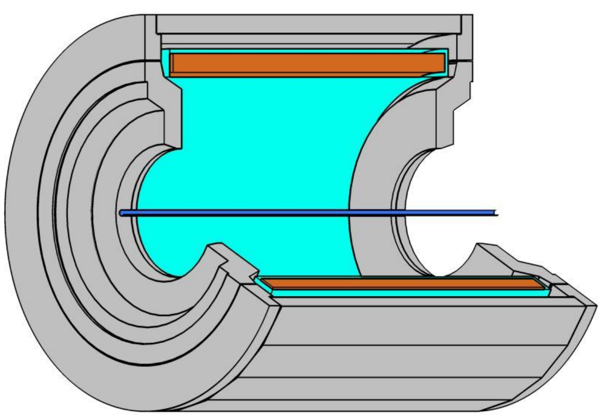
A high non- uniformity field

Lost acceptance

<u>Advantages:</u>

No field in beam pipe.

Compact spectrometer



<u>Solenoid:</u>

The maximum magnetic field of ~1T over a length of about 5 m and a diameter of 4 m. The field homogeneity is foreseen to be better than 1% over the volume of the vertex detector and central tracker.

<u>Disadvantages:</u>

Need to have the special magnetic shield for transverse polarized beams. Soleniod influence on beam polarization.

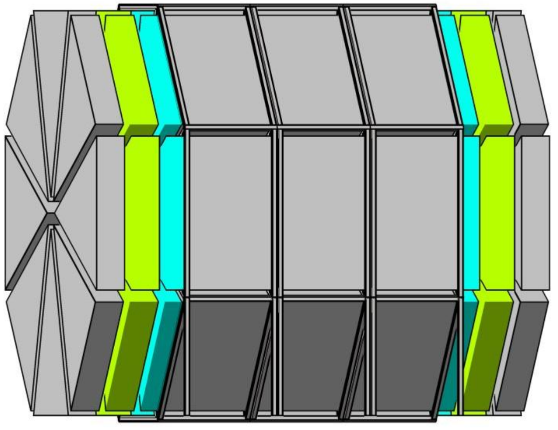
<u>Advantages:</u>

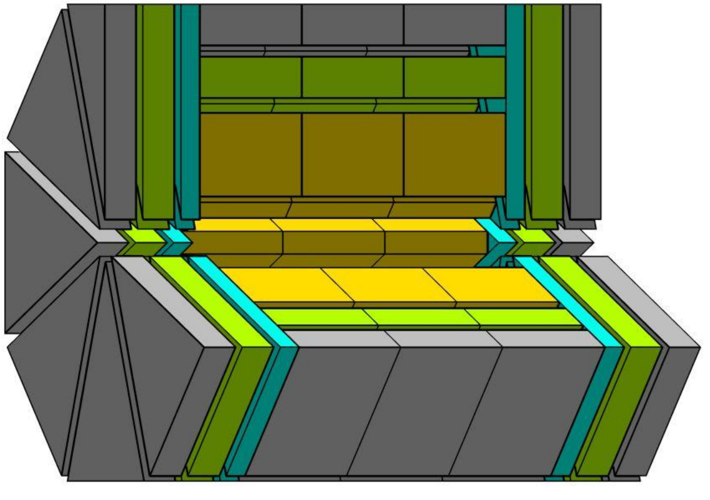
Acceptance

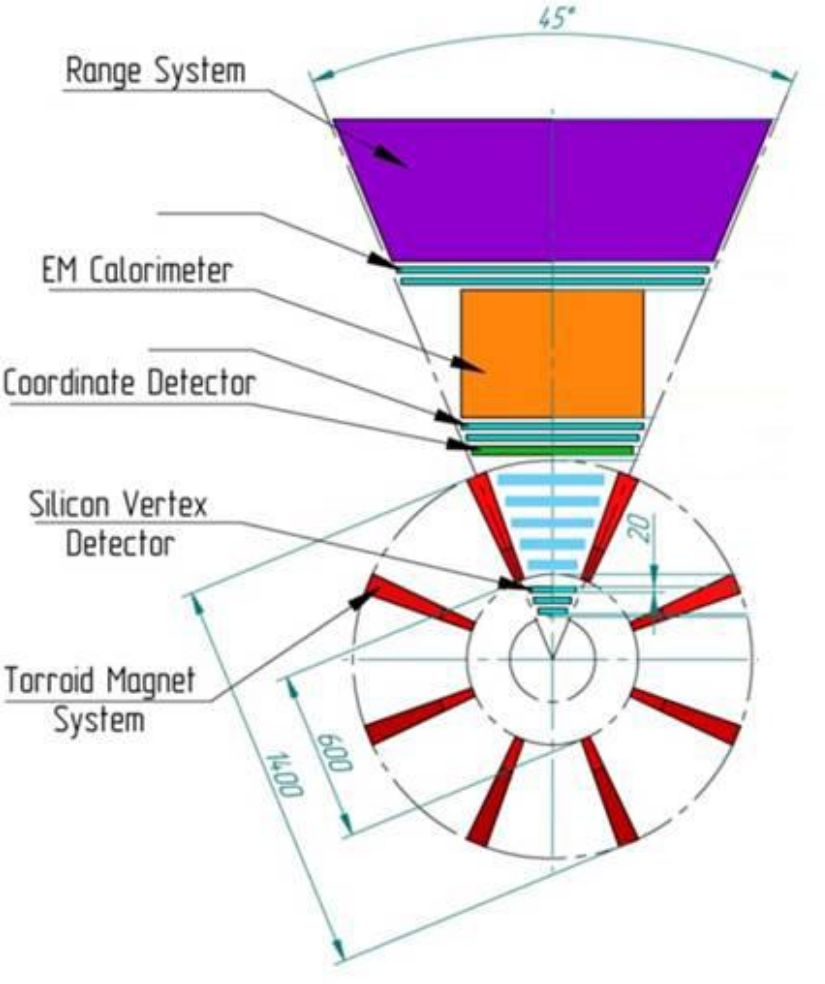
Uniformity of field

Possible layout of the SPD.

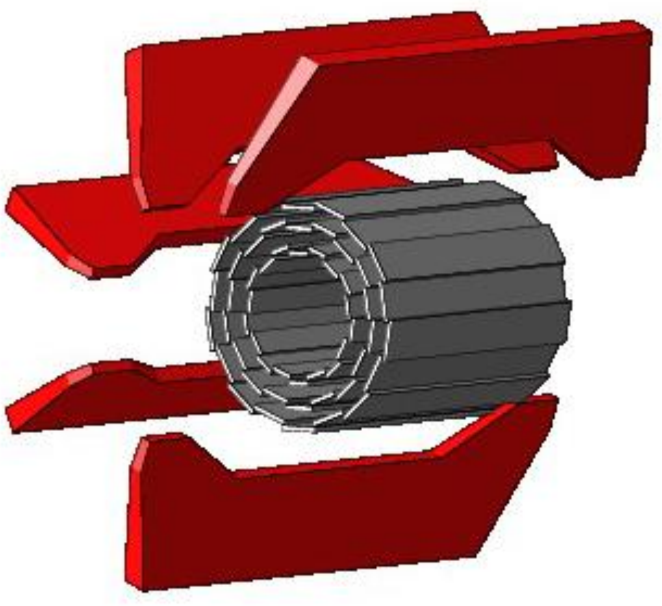
The setup can consist of 5 main parts: a 3 barrels and two endcaps.







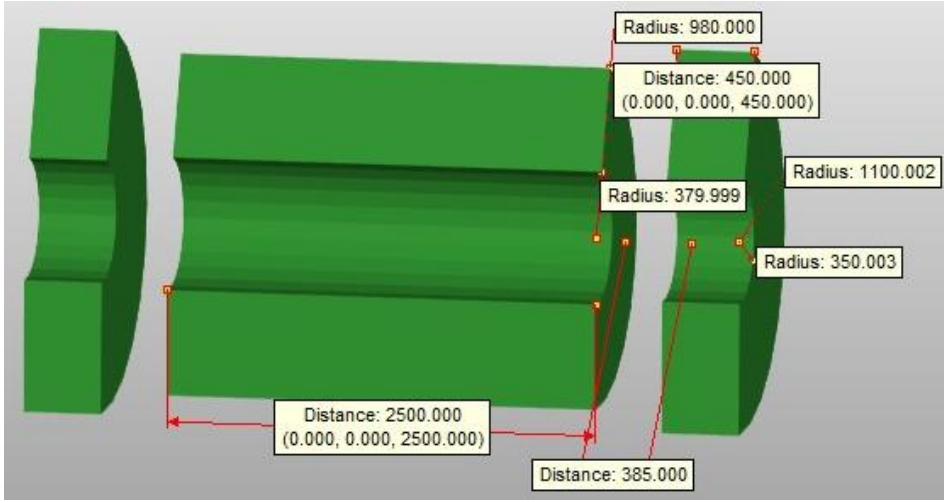
Possible layout of the SPD. Vertex

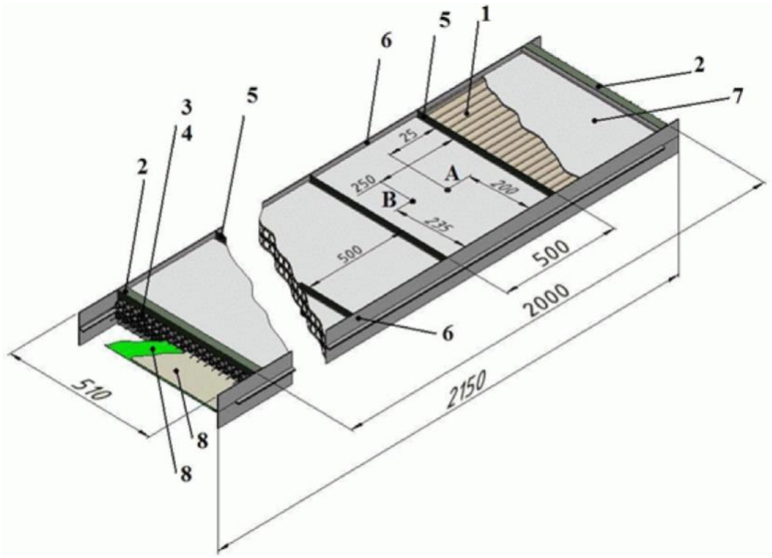


Silicon Microvertex Detector

The most obvious technology for the vertex detector (VD) is a silicon one.
It is approved for the MPD VD.
Outside the beam pipe.
Several layers of double -sided silicon strips can provide a precise vertex reconstruction and tracking of the particles before they reach the general SPD tracking system.
The design should use a small number of silicon layers to minimize the radiation length of the material. With a pitch of 50-100 μm it is possible to reach the spatial resolution of 30 μm. Such a spatial resolution would provide 50 μm for precision of the vertex reconstruction.
This permits to reject the secondary decay vertexes.

Possible layout of the SPD. Straw





The straw tubes can be selected to be the main detector of SPD Tracking System. This choice is based to the following properties of the staws tubes:

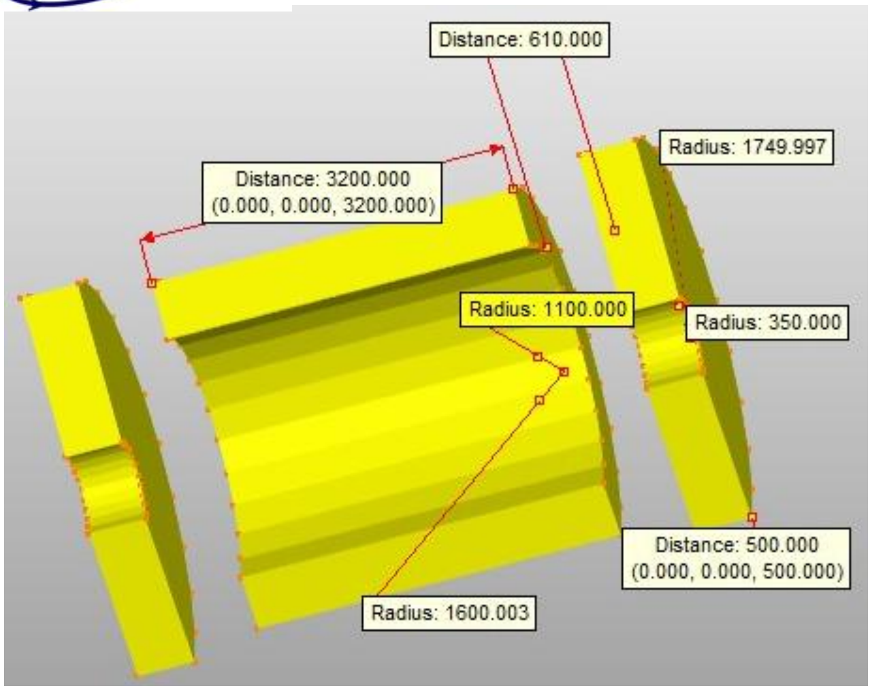
-the minimun of material for the tracks of the secondary particles (X_0 ~ 0.1);

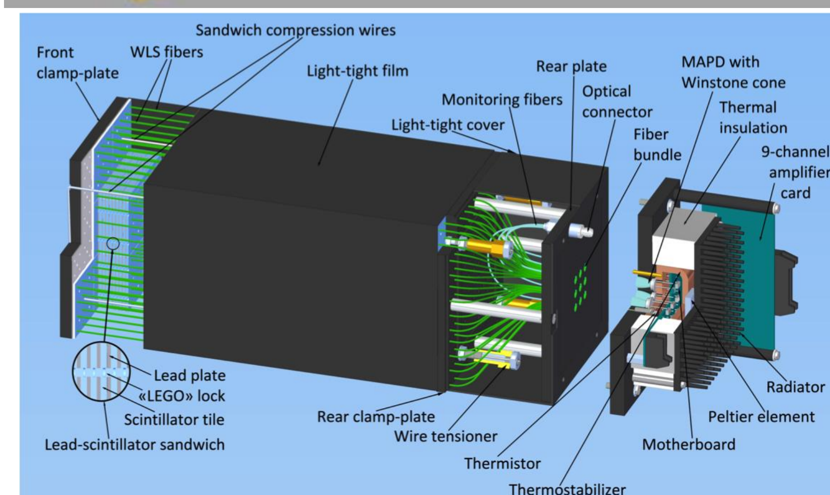
- the time (~ 200-300 ns) and spatial (track resolution ~ 100 μm);
- expected particle rates (DAQ rates ~ 100 Khz);
- the developed production sites (also in JINR,Dubna).

The one the main point of straw system development is the requiremets of the minimization of material budget. To meet this requirement it is planned to use the thin-walled tubes.

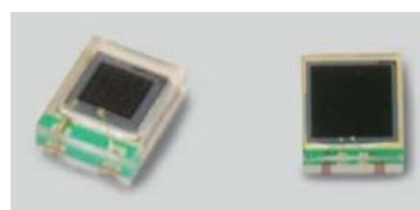
- V.A.Baranov et al, Instrum.Exp.Tech. 55 (2012) 26-28
- Bazylev S.N. et al., JINR Preprint P13-2010-60
- Davkov K.I. et al., JINR Preprint P13-2012-93
- NA-62 Collaboration, Technical Design Document, NA62-10-07, December 2010

Possible layout of the SPD. ECAL.



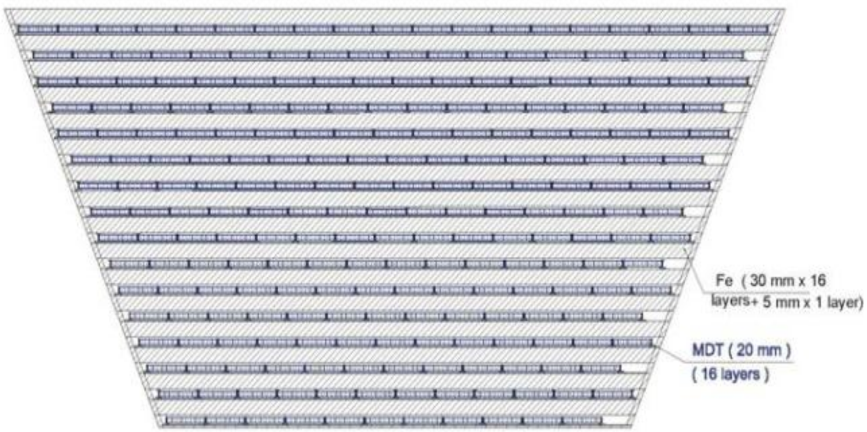


Photon energy range 0.1- 10GeV.
Taking into account the space limitation in the barrel region, the total length of module of the ECAL should be less than 50 cm.
The required energy resolution
<10.0%/√E (GeV).
The latest version of the electromagnetic calorimeter (ECAL) modules, developed at JINR for the COMPASS-II experiment at CERN, can be good candidates for ECAL at SPD. These "shashlyk" type of modules utilise new photon detectors Avalanche Multichannel Photon Detectors (AMPD).AMPD can work in the strong magnetic Field (in case solenoid magnet).



Surface mount type Custom made

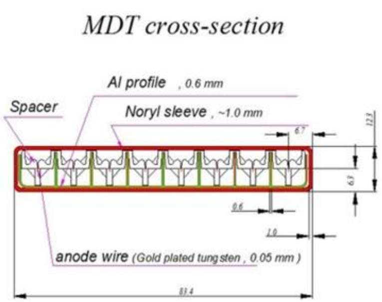
Possible layout of the SPD. Range system.



The system of MDT layers with Fe layers called by Range System (RS) is used in SPD as muon detector and main element of Particle Identification System.

It can provide the clean (>95%) muon identification for muon momenta greater than 1 GeV.

The combination of responses from EM calorimeter and RS can be used for the identification of pions and protons in the wide energy range.
RS provides good coordinate accuracy.

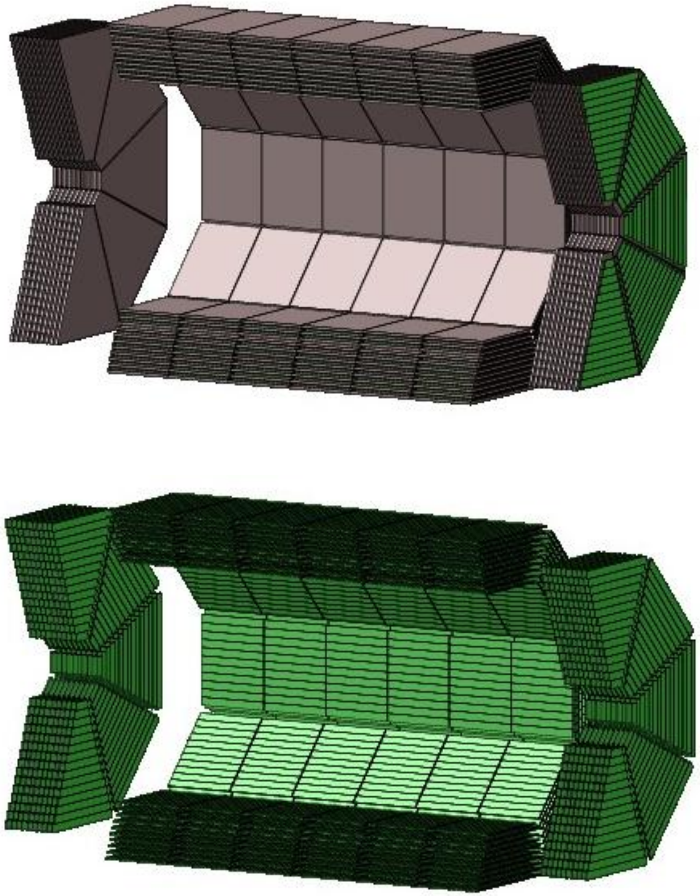


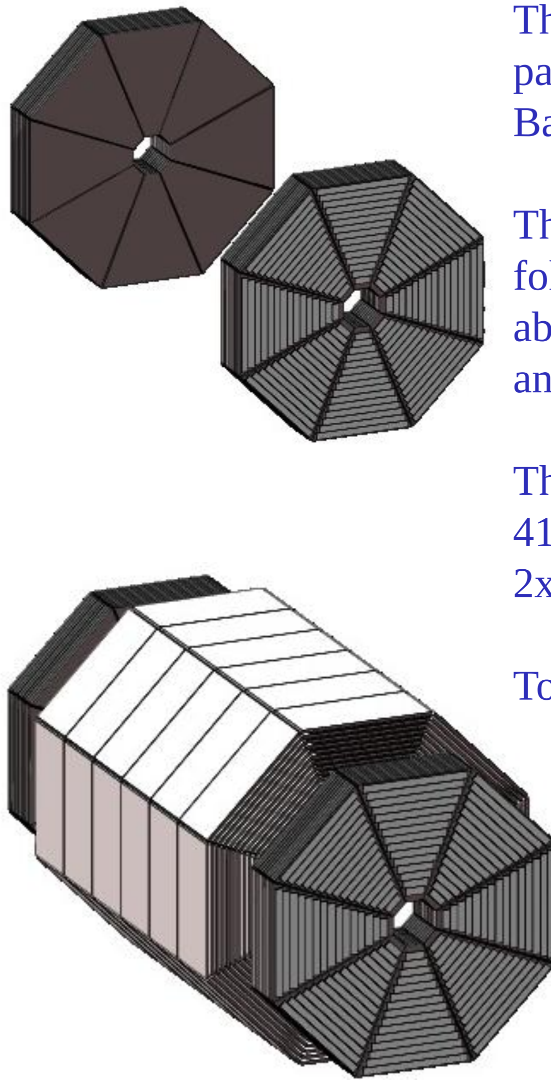
Plots are from " Muon TDR for PANDA ", PANDA Collab., November 2011

V.Abazov et al., Instrum.Exp.Tech.53:648-652,2010, Prib.Tekh.Eksp.5:32-36,2010.

DLNP group, leader G.Alexeev

Possible layout of the SPD. Range system.





The Range System consists of two parts:
Barrel and two End caps.

The preliminary sizes of RS are as follows:
about 6.8 m along beam line
and 3.7 m in diameter.

The RS designed with consists of 4140 MDT units for barell,
2x1200 units for End-caps.

Total: 6540 ch.

Possible layout of the SPD. Trigger and DAQ

Trigger logic could have two-level structure.

Dedicated hardware processors may be used at Level 1 which receives signals from the scintillation hodoscopes, Beam-Beam-Counter , EM calorimeter and the Range System. Using FPGA technology and look-up memories it is possible to organize flexible and efficient triggering.

Local and total energy deposit in the calorimeter, multiplicity in the hodoscopes and information from the range system provide primary event selection.

At Level 2 more time consuming operations could be done. These include search for tracks in the Drift Chambers and the Range System, check of track matching with EM calorimeter hits etc.

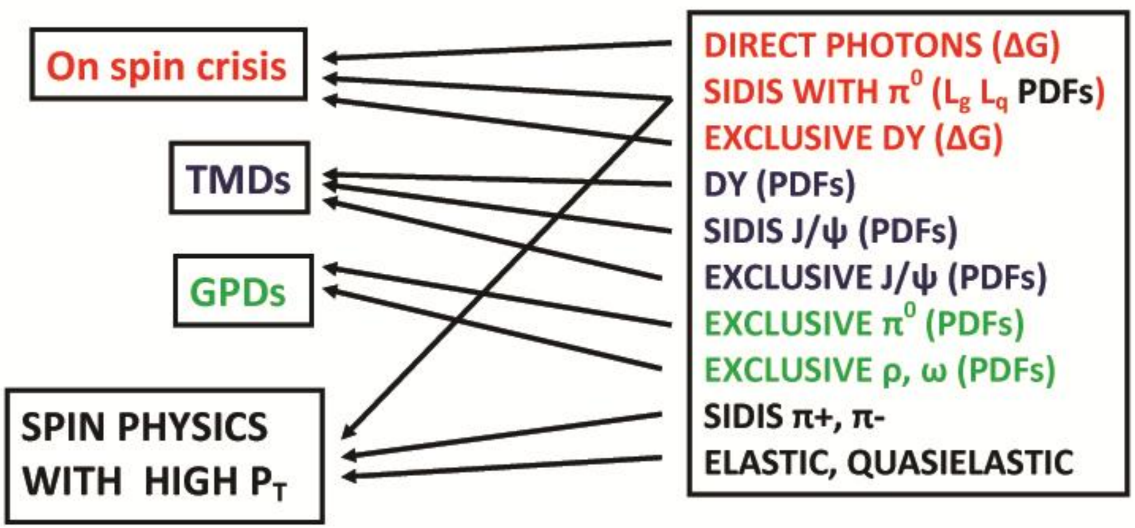
Information from the silicon detectors could also be employed (if needed) at this stage. Simulations of physics processes with use of real geometry, detector granularity and resolutions are planned in order to develop trigger scheme and selection algorithms.

CONCLUSIONS.

The project on NICA Spin studies is under preparation at 2nd interaction point of the collider. (http://spd.jinr.ru)

The purpose of proposed measurements is the study of the nucleon spin structure with high intensity polarized light nuclear beams.

- high collision proton (deuteron) energy up to $\sqrt{s} \sim 26(12)$ GeV
- the average luminosity up to 10^{31}-10^{32} cm²/s
- both proton and deuteron beams can be effectively polarized.

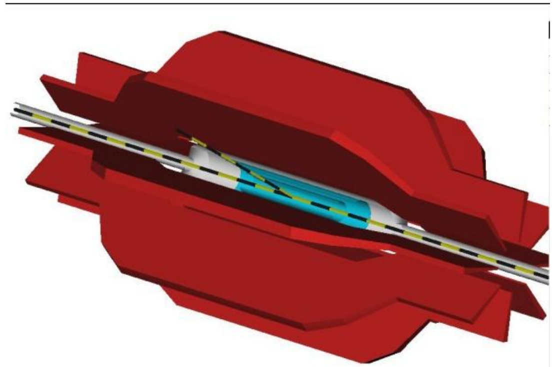


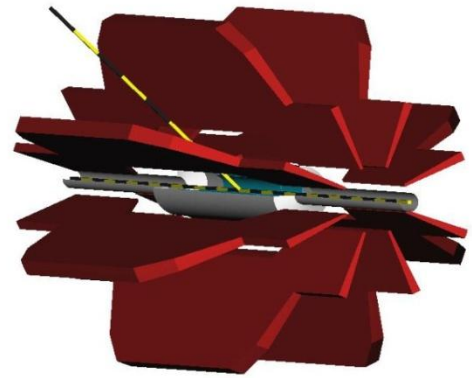
Backup slides

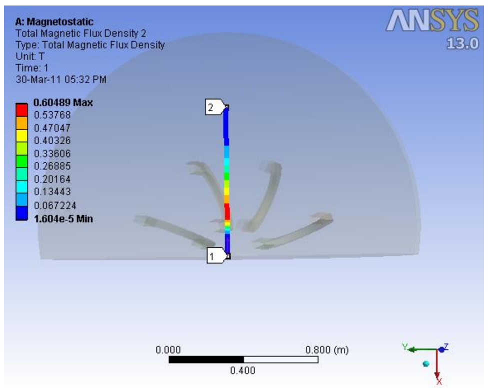
SPD EXPERIMENT AT NICA.

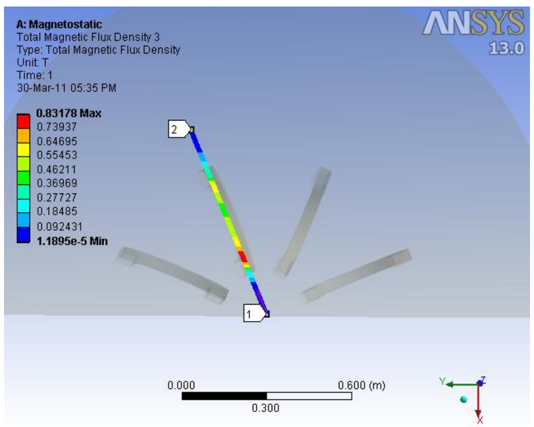
SPD.Torrid magnet.

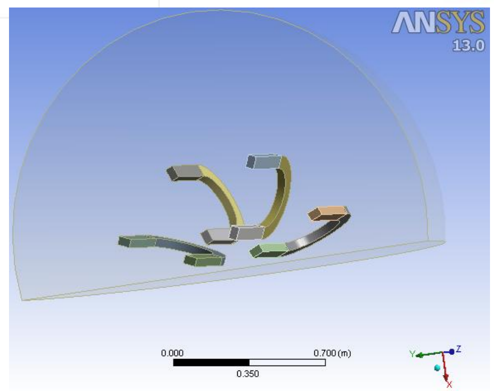
- 8 coils
- ~100 x 40 cm coils
- average integrated field: ~ 0.8 - 1.0 Tm
- acceptance ~ 80 %

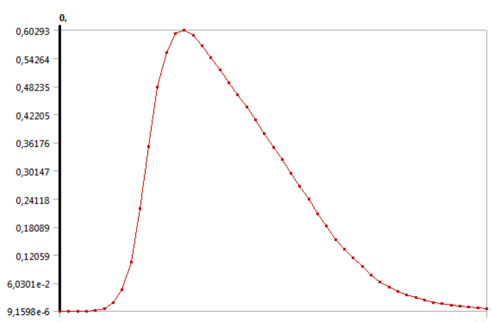


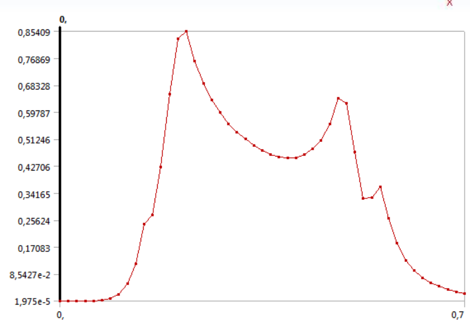


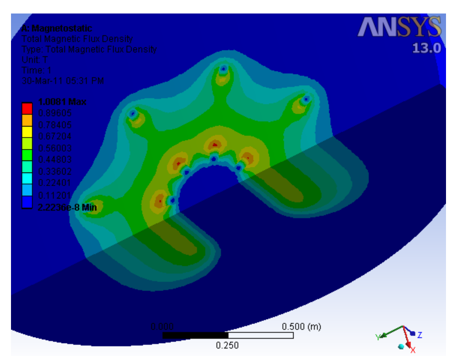








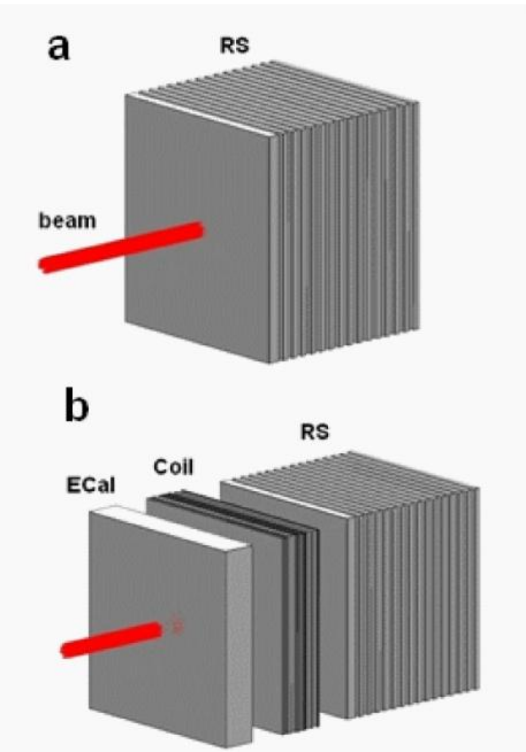


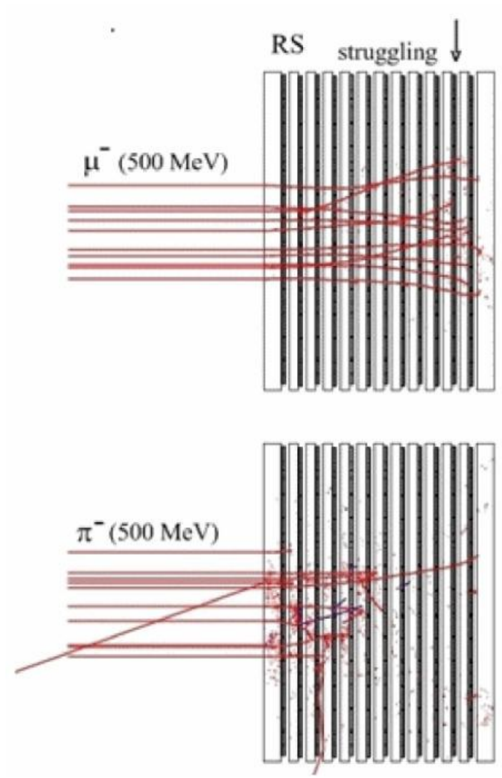


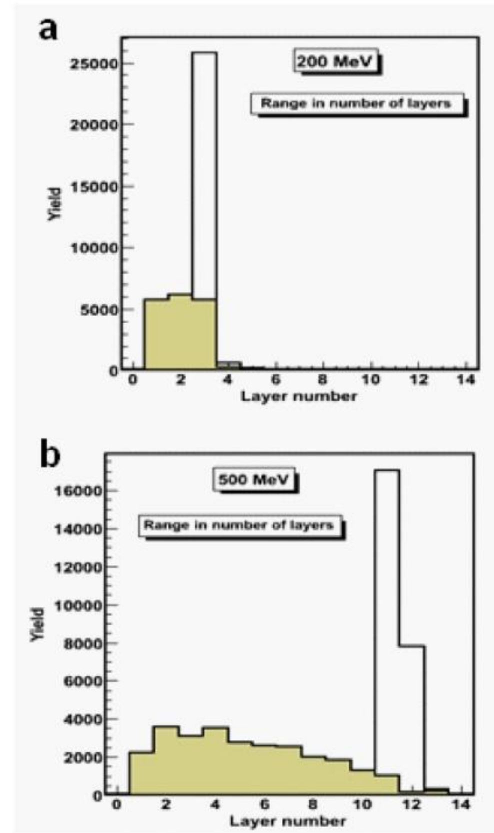
Done by Pivin R.

SPD EXPERIMENT AT NICA.

SPD.Range System.



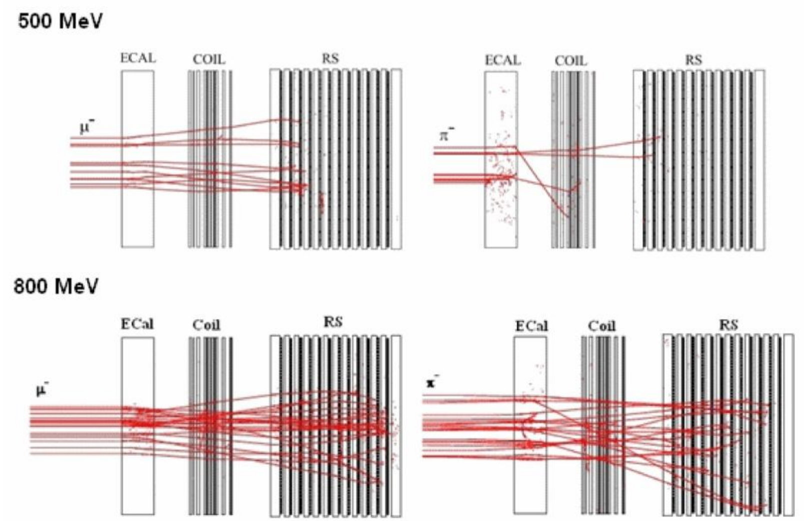


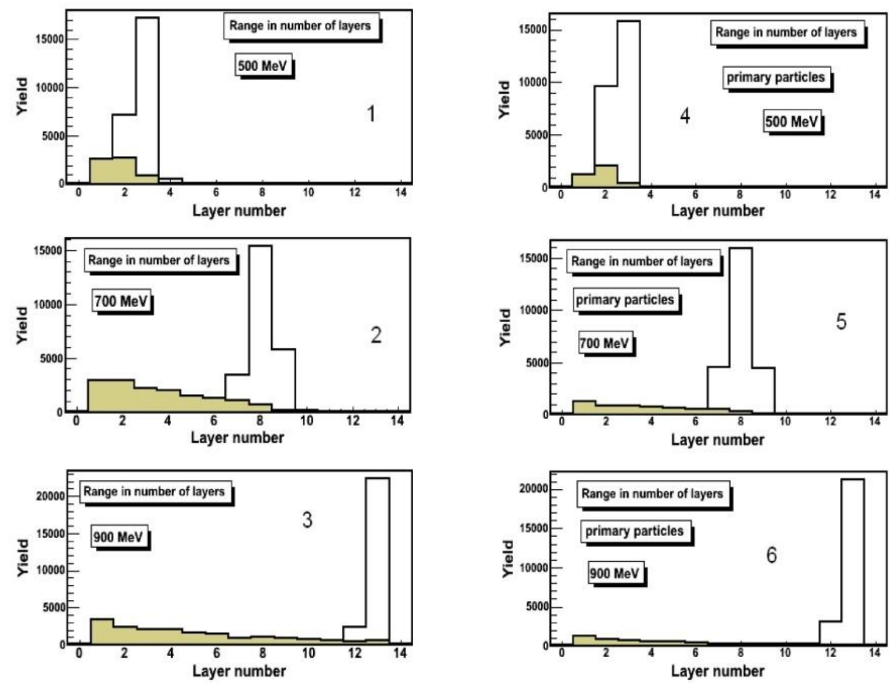


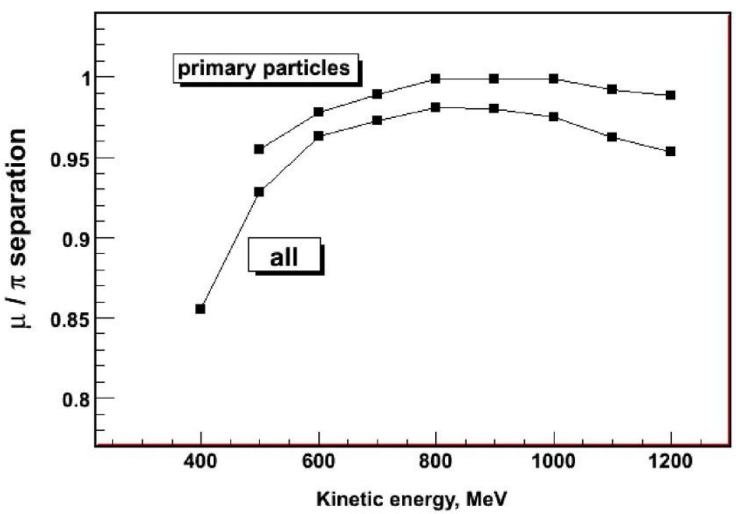
Plots are from " Muon TDR for PANDA ", PANDA Collab., November 2011

SPD EXPERIMENT AT NICA.

SPD.Range System.





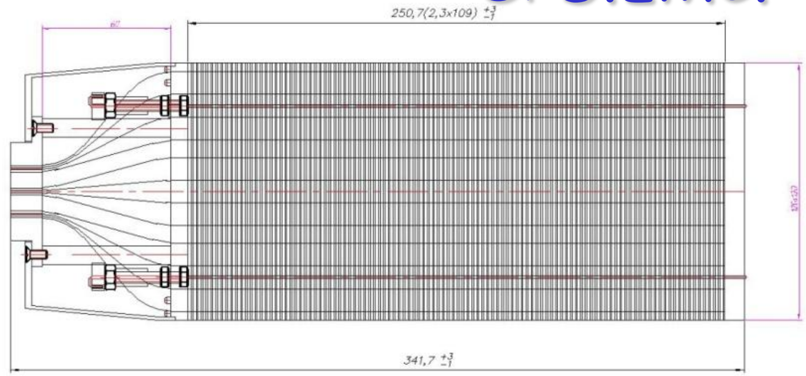


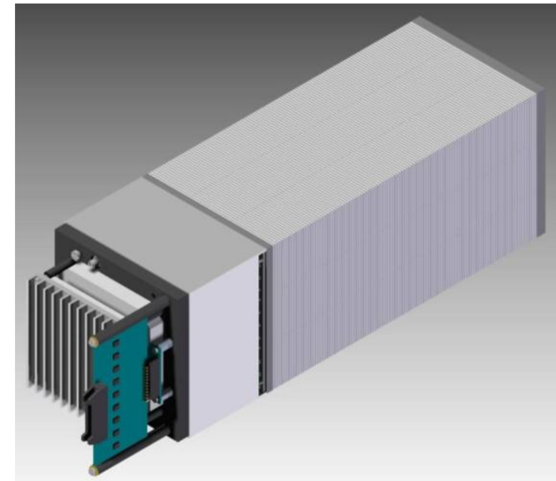
Estimated μ/π for E>1 GeV is more than 96%

Plots are from " Muon TDR for PANDA ", PANDA Collab., November 2011

SPD EXPERIMENT AT NICA.

SPD.EMC.





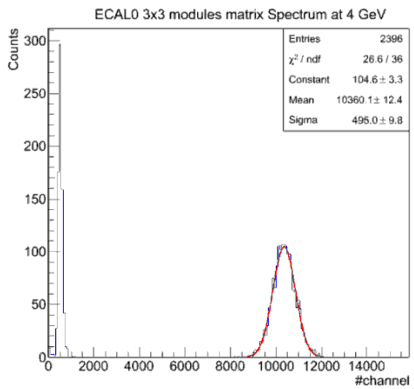
Technology	Shashlyk
Scintillator	Polystyrene Kharkov
Absorber	Lead
Number of layers	109
Sc / Pb plates thickness, mm	1.5/0.8
Pb/Sc plates dimension, cm	12.0x12.0
Moliere radius, cm	3.5
Radiation length, cm	1,64
Number of tower	9
Fiber	BICRON BCF91AMC d=1.2 mm
Number of fibers per tower	16
Diam. of bundle, mm	6.5
Light guide	Winston cone glued to photodetector
Photodetector	MAPD -Zecotek
Total thickness, cm	25.2(~ 15 X0)
ADC	MSADC

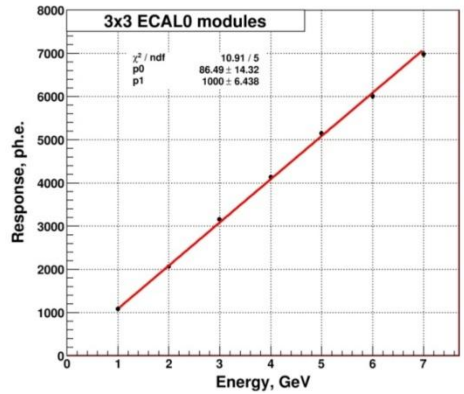
<u>Module</u>:

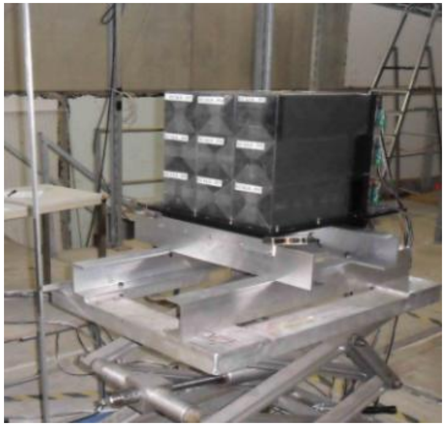
- size is 12x12 cm^2
- 9 cells, size is 4x4 cm^2
- 9 MSADC channels
- Temperature stabilization system (Peltier element, electronics)
- 9 Amplifiers
- 9 light collection system
- Control system (LED, Laser)
- Power supply

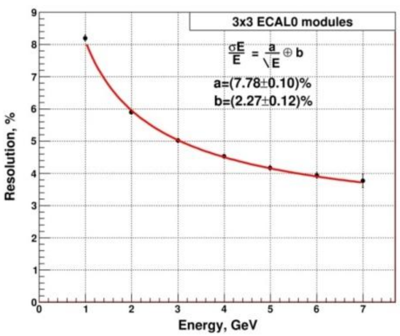
SPIN PHYSICS AT NICA.

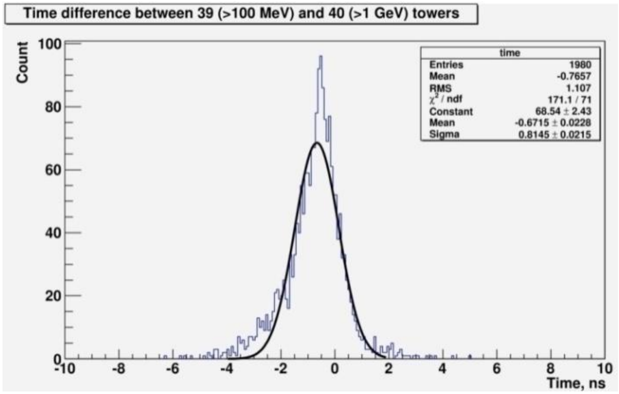
SPD.EMC. R&D results.

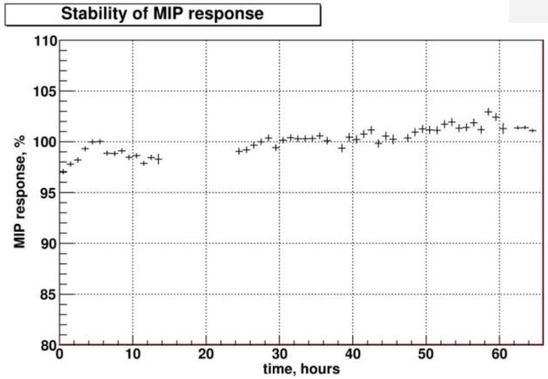












ECAL0 for COMPASS-II as EMC prototype for SPD

Tests in 2007-2011 at PS-T9 and COMPASS beams.

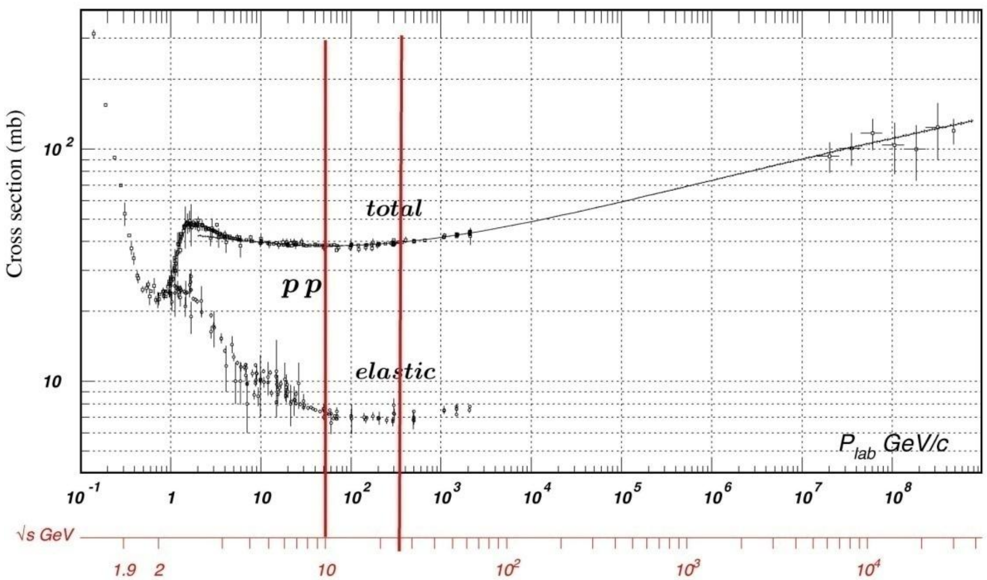
Module production in ISMA, Kharkov

MAPDs from Zicotek

Assembling and testing in JINR

SPIN PHYSICS AT NICA.

SPD. Trigger system.



For NICA kinematical conditions and planned values of luminosity (about 2 10^{30} sm^{-2} s^{-1}) the rates of pp events is equal to 80 K per second (with elastic processes contribution – about 15 K).

Charged particles	*13.5*
Neutral particles	*22.5*
π+	4.6
π -	3.9
π0	4.8
K+	0.4
K -	0.3
K0	0.7

The main task of the trigger system is to provide separation of the following reactions:

- with two muons (or electrons/positrons) in the final states;
- with various types of hadrons (π+/-, K, p, …);
- with photons (π^0, ω, η..);
- elastic reactions.

Different triggers will run in parallel in order to collect simultaneously data for several physics processes and for calibration as well.

SPIN PHYSICS AT NICA.

SPD.MC studies.

Simulation of MMT-DY in SPD

- for pp beams with E=12.6 GeV;
- pure MMT-DY events;
- PYTHIA generator was used;
- VC, DC, EMC,RS have to be fired.