SPD Magnetic System

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JINR, Dubna, June 22.06.2020

OUTLINE

- Introduction: previous versions 2018-2019
- Current status of the setup composition
- Scheme of the MS
- Magnetic field calculations
- Summary
- Near future tasks

previous versions 2018-2019 (1)

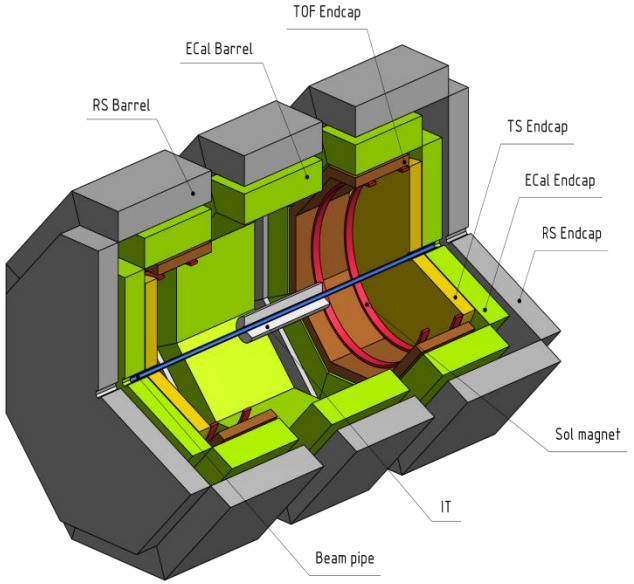
Spin Physics at NICA Workshop, Prague, 09-13 July, 2018

BASIC CRITERIA

- universality
- minimal influence on beam particles spin
- minimization the MS material inside SPD
- field integral of (1-2) T·m along the track
- minimization of the SPD weight and sizes

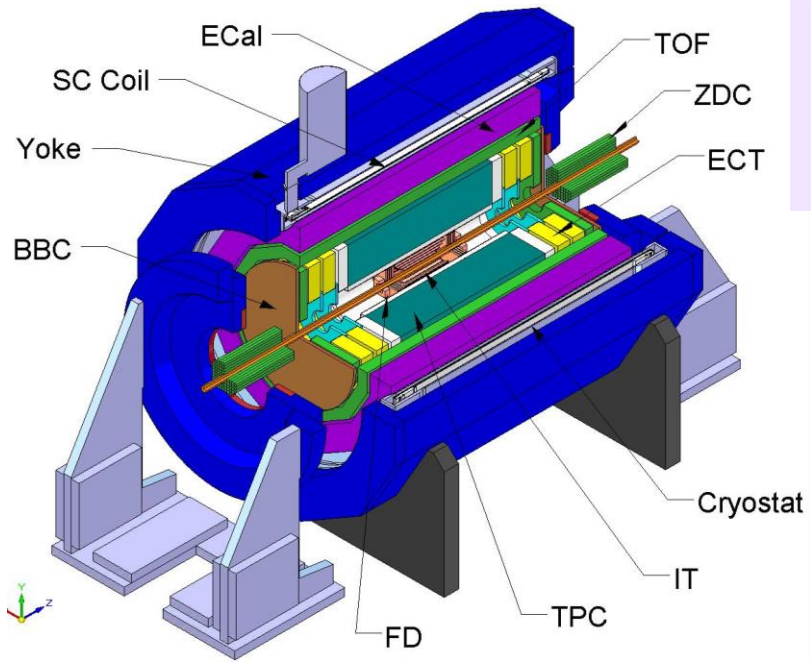
Seven options were discussed:

- 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.



previous versions 2018-2019 (2)

MPD setup

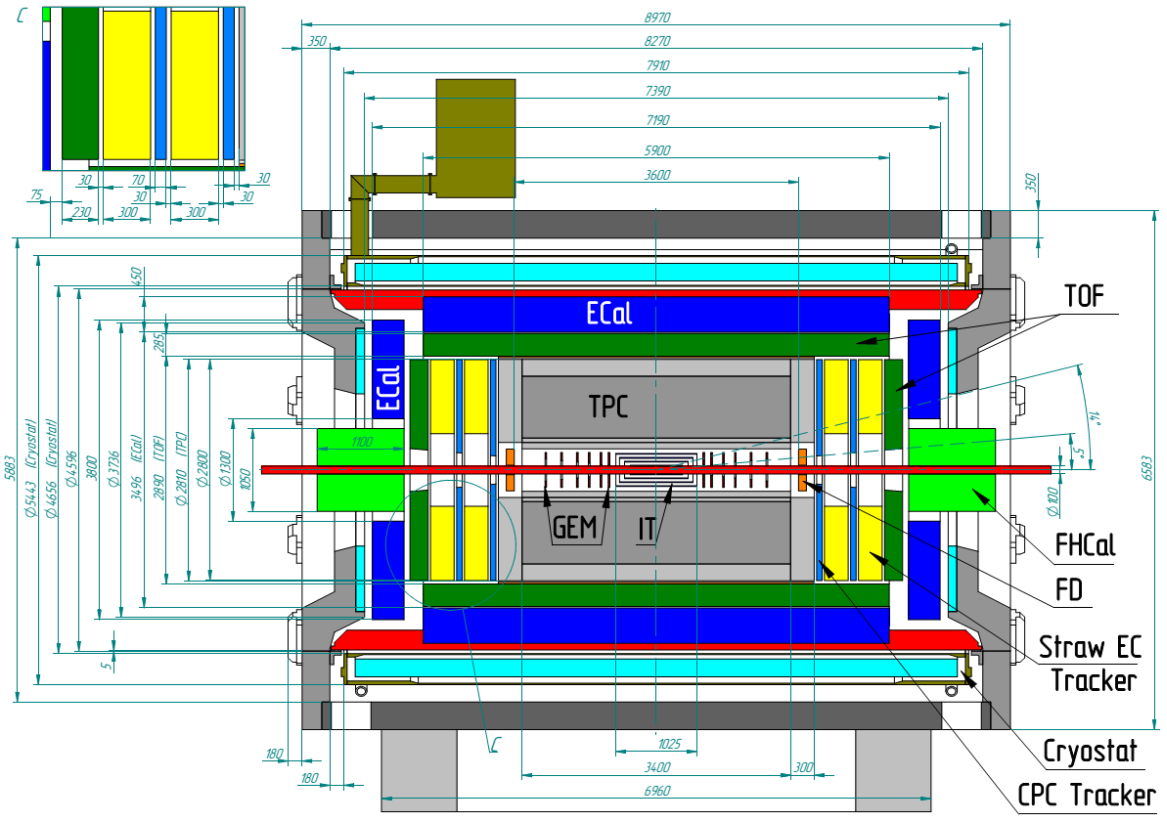


SC solenoid out of detectors,

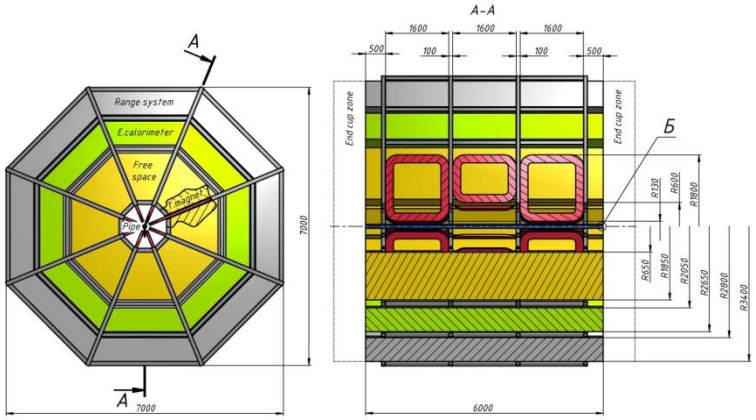
- Bmax = 0.66T;
- Cryostat: length – 8270 mm
  outer diam. – 5963 mm
- Trim coils (warm)

previous versions 2018-2019 (2a)

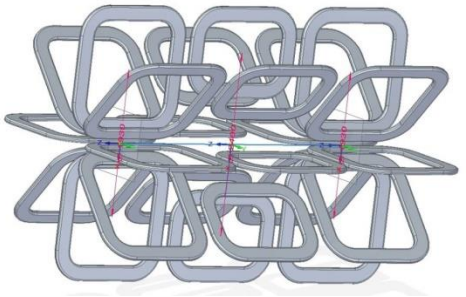
MPD setup



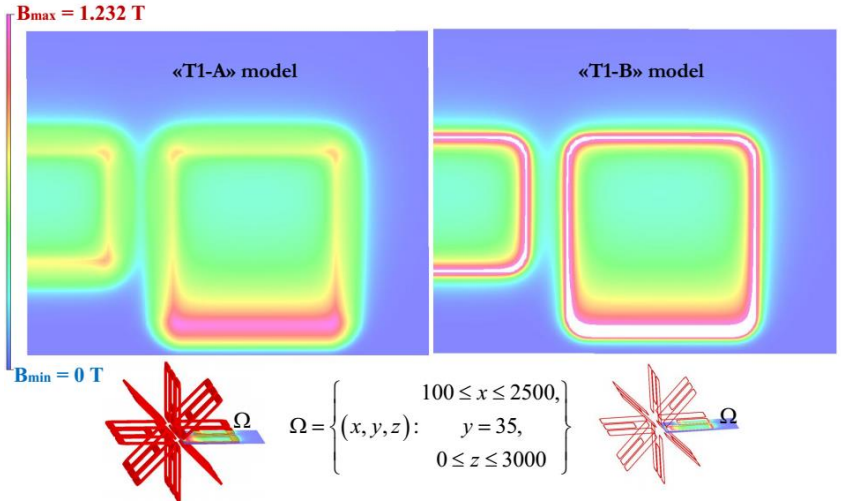
Toroidal Magnetic System

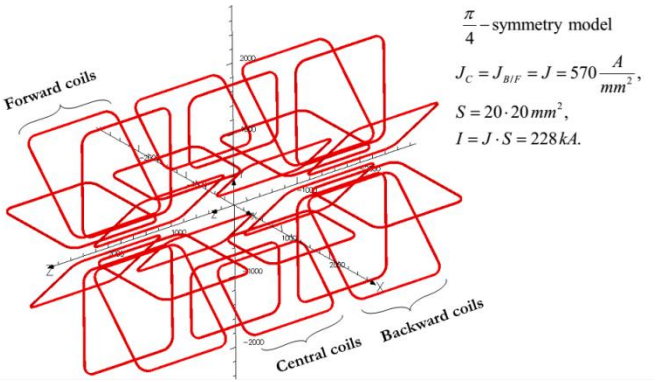


Normal conducting option



Superconducting option



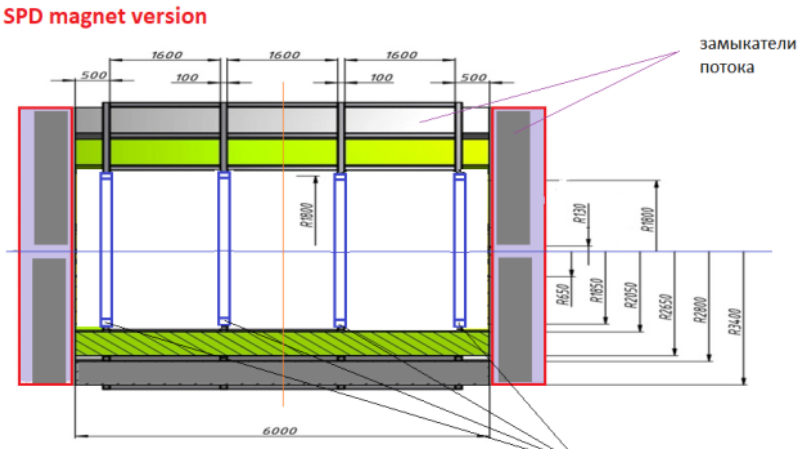


Nonlinear 3D - field map was obtained for both

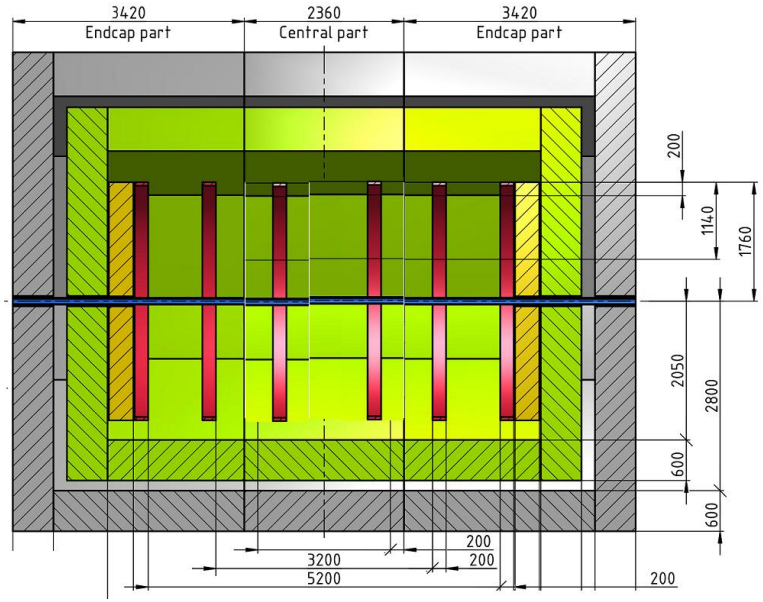
Technical complexity is high. Material budget? Nevertheless …

Separate Solenoid Coils

4 coils, Feb. 2018



6 coils, Sept. 2018



Combined: Toroid+ Coils

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

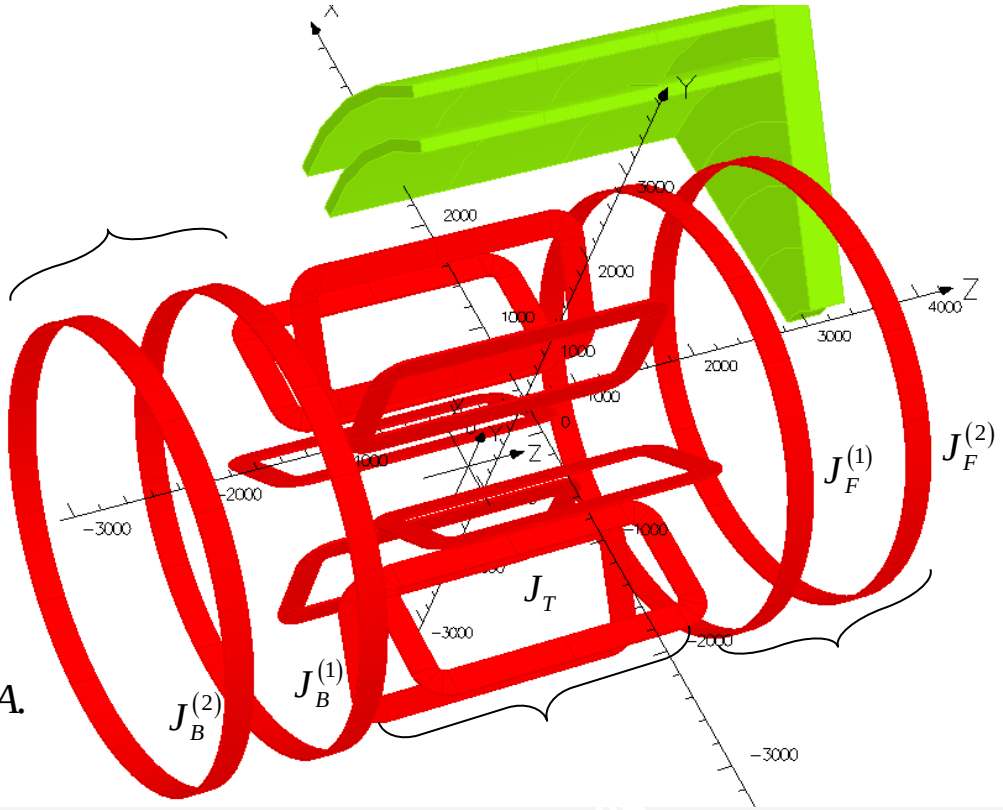
$$J_T = 40\frac{A}{mm^2},$$

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

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

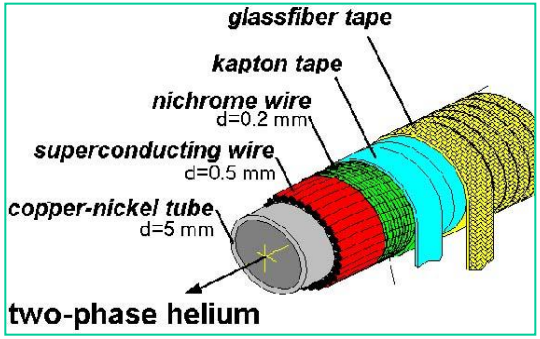
$$I_T = J_T \cdot S = 160\, kA,$$

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



SPD MS: Nuclotron/ITER technology

Dubna hollow SC cable



- OPERATING TEMPERATURE - 4.5 K
- COLD MASS WEIGHT - 80 t
- COOLDOWN TIME – 85 h
- PERIMETER - 251.5 m
- 96 DIPOLES: B = 2 T, 1. 4 m
- 64 QUADRUPOLES: 31 T/m, 0.4 m

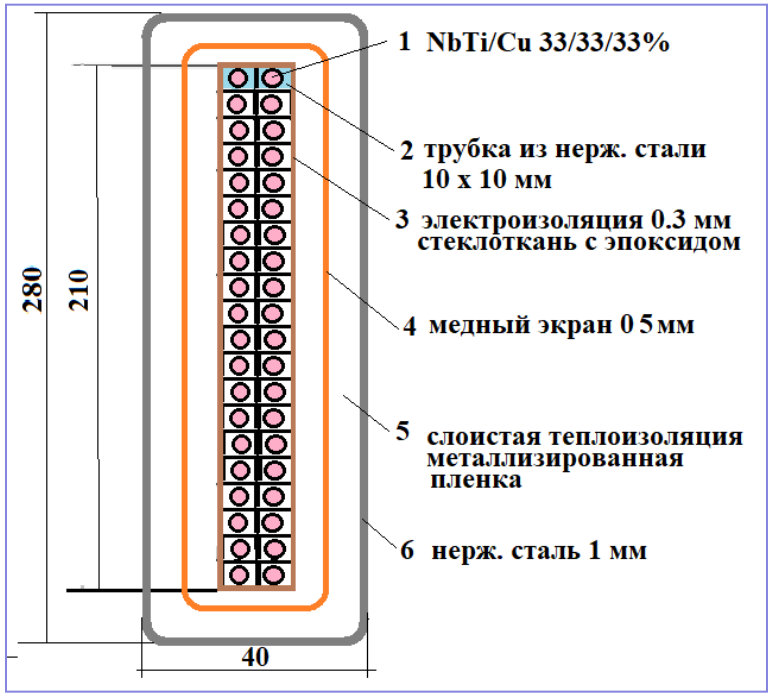
NICA booster magnets

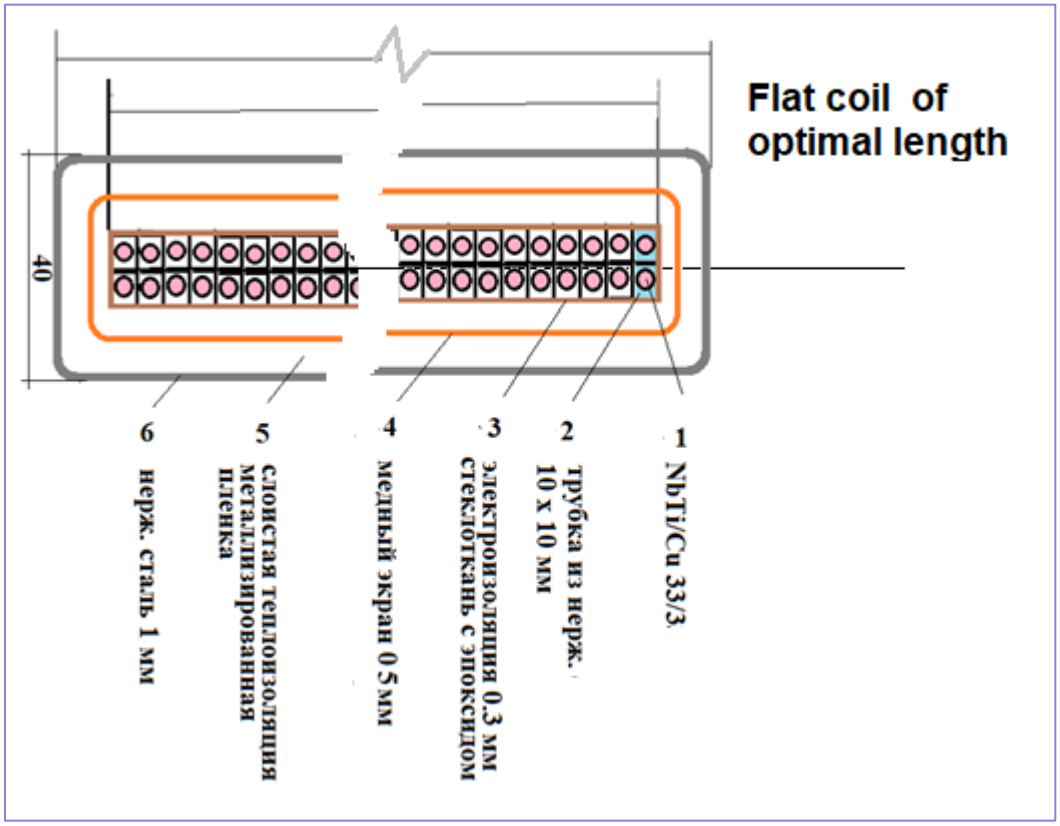
Operating current – 10 kA
Critical current -17 kA

We have unique technology and technological base for manufacturing SPD MS model coils at the LHEP.

CICC for ITER

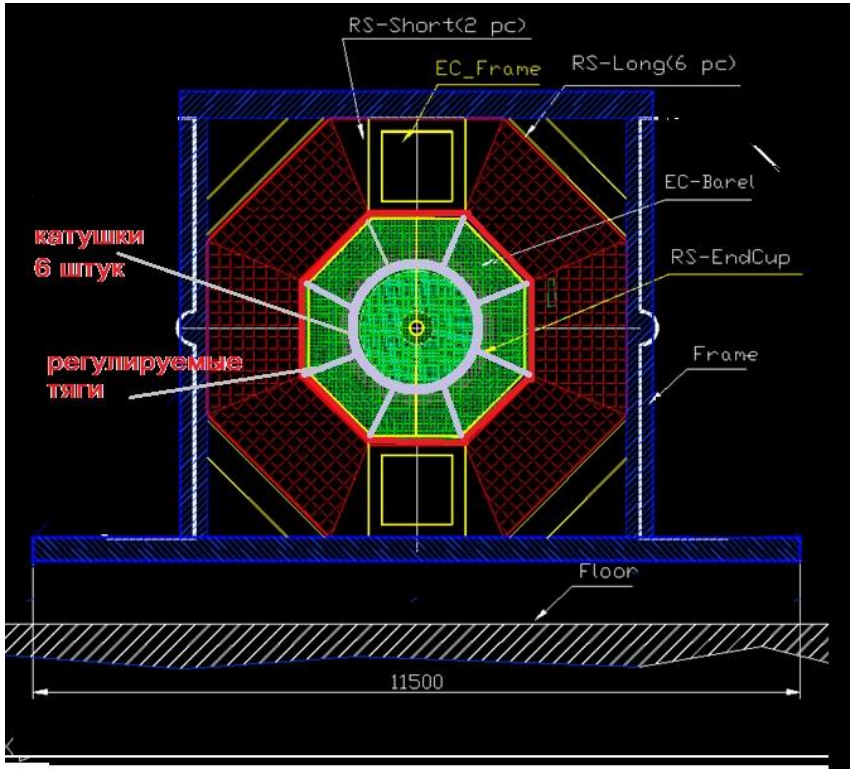
SPD MS: Nuclotron technology

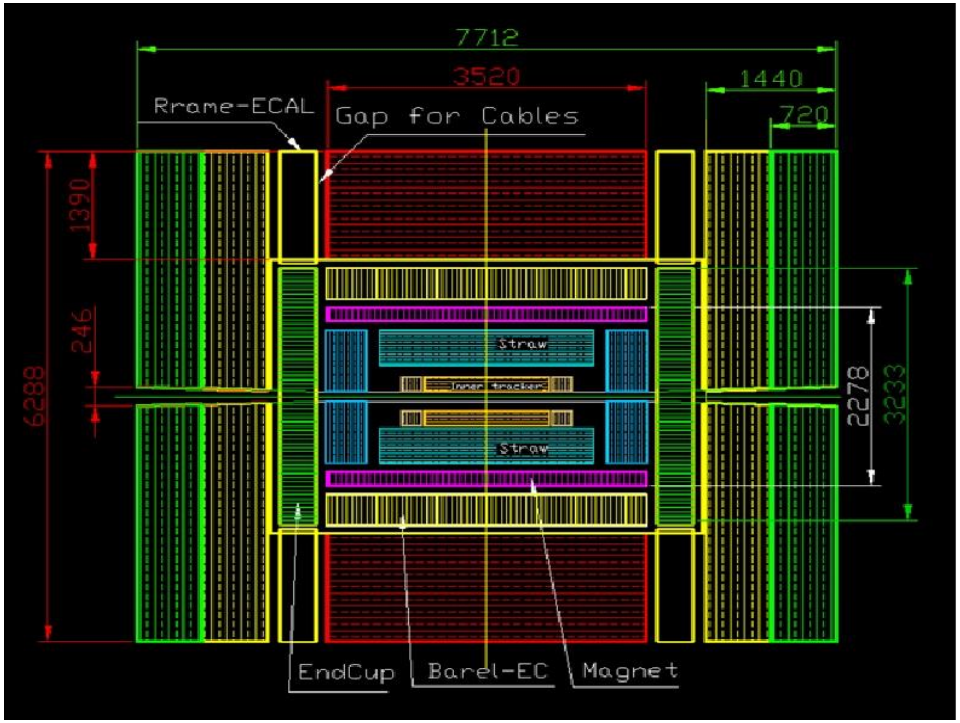




We have unique technology and technological base for manufacturing SPD MS coils at the LHEP that could save the expenses.

Updated setup composition

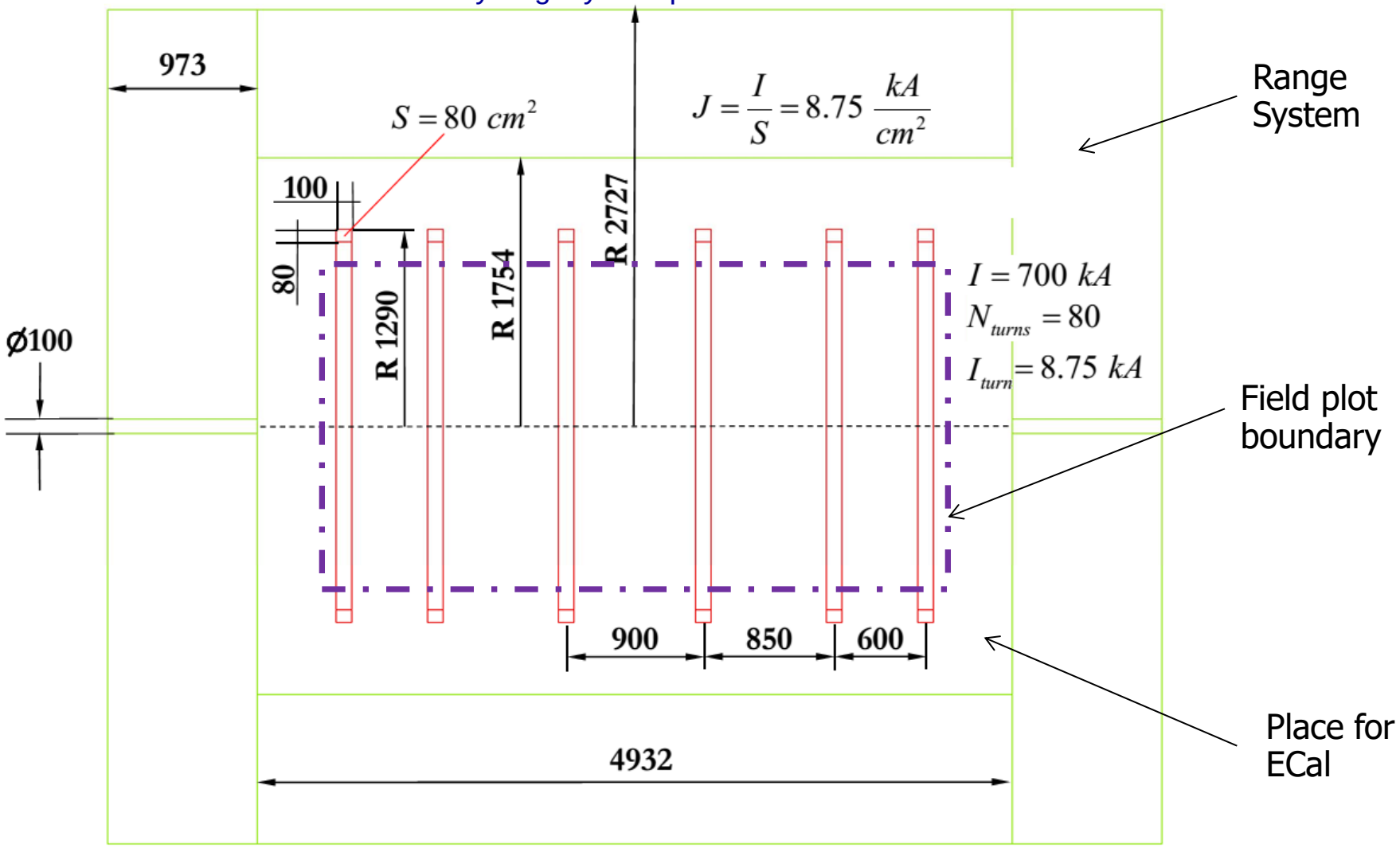




O.Gavrischyuk version, May 2020

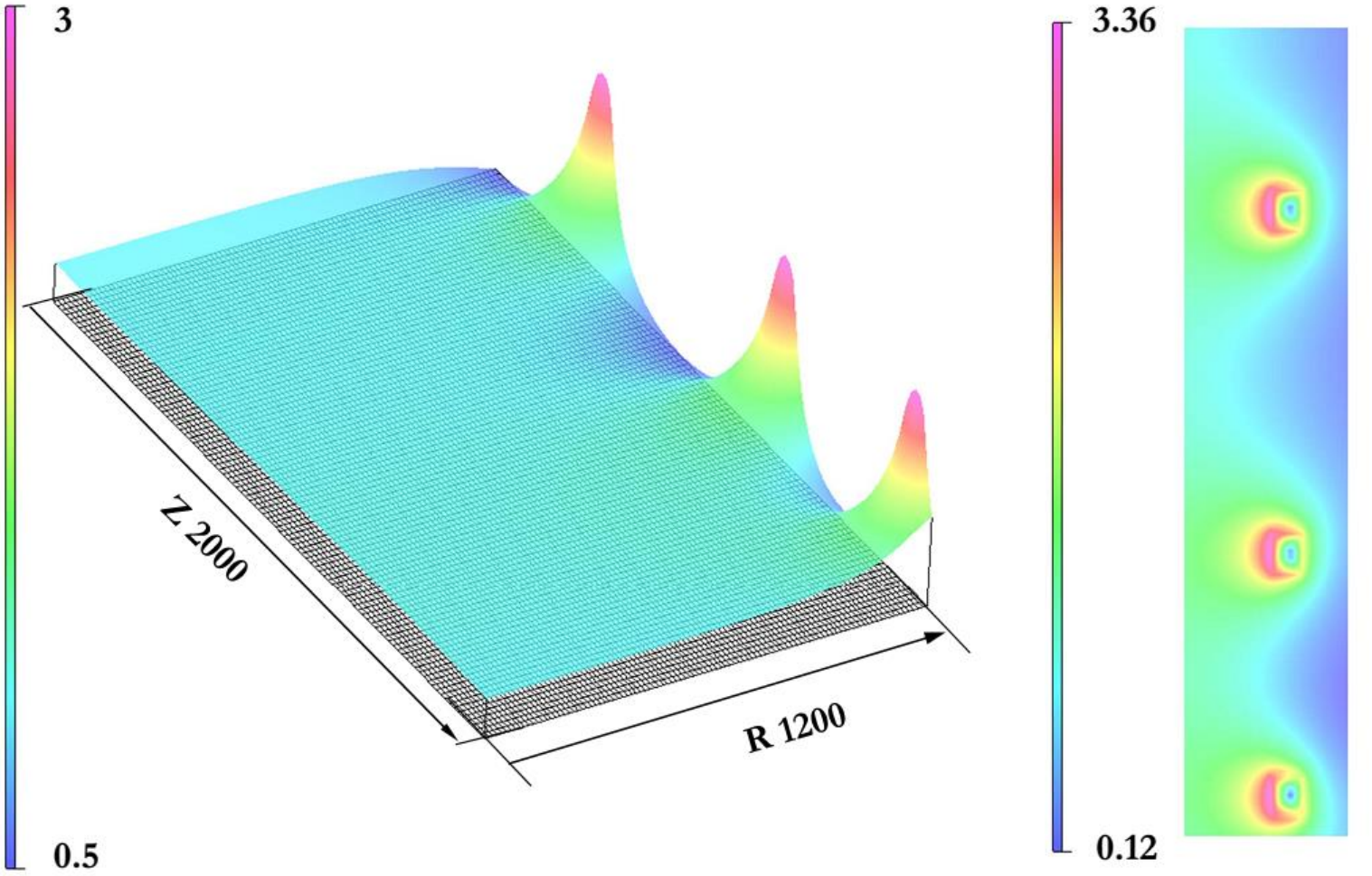
Scheme of the new MS

The model and further calculations by Eugeny Perepelkin

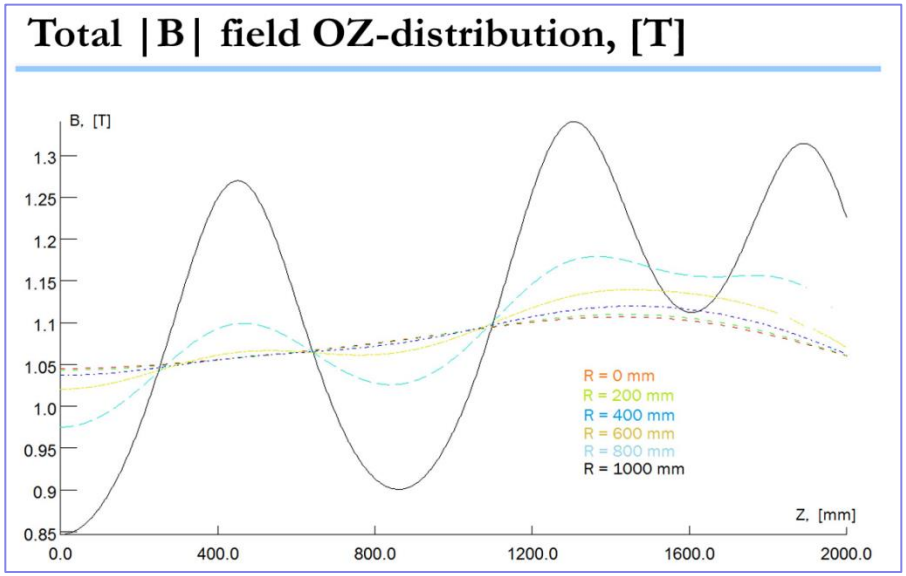


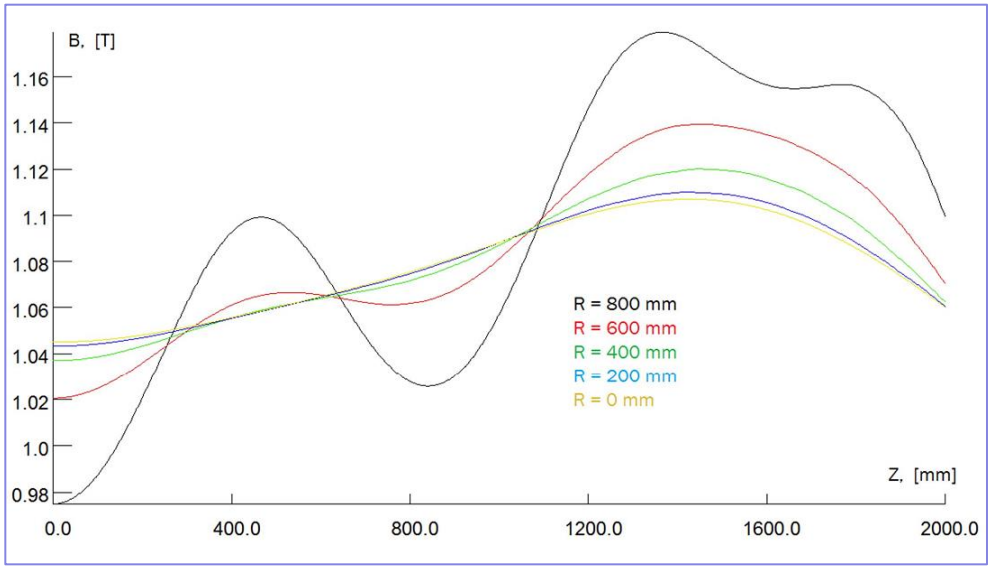
Results of calculations (1)

Total |B| field RZ-distribution, [T]

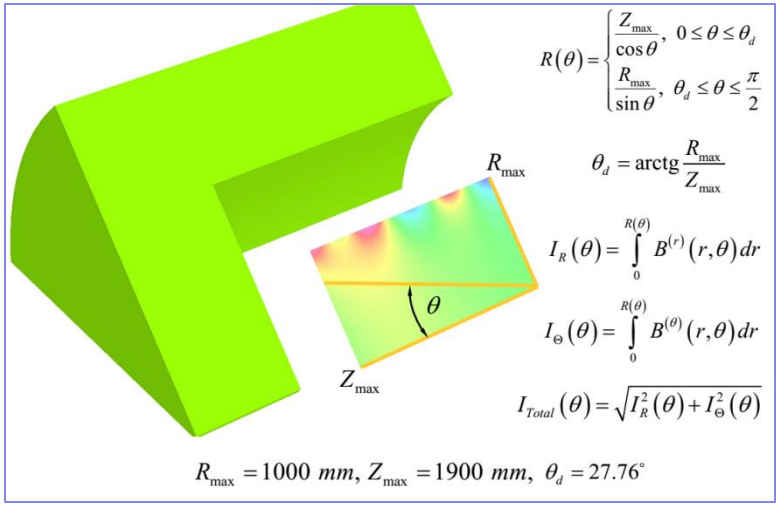


Results of calculations (2)





Results of calculations (3)



$$R(\theta)=\begin{cases}\frac{Z_{max}}{\cos\theta}, & 0\le\theta\le\theta_d\\ \frac{R_{max}}{\sin\theta}, & \theta_d\le\theta\le\frac{\pi}{2}\end{cases}$$

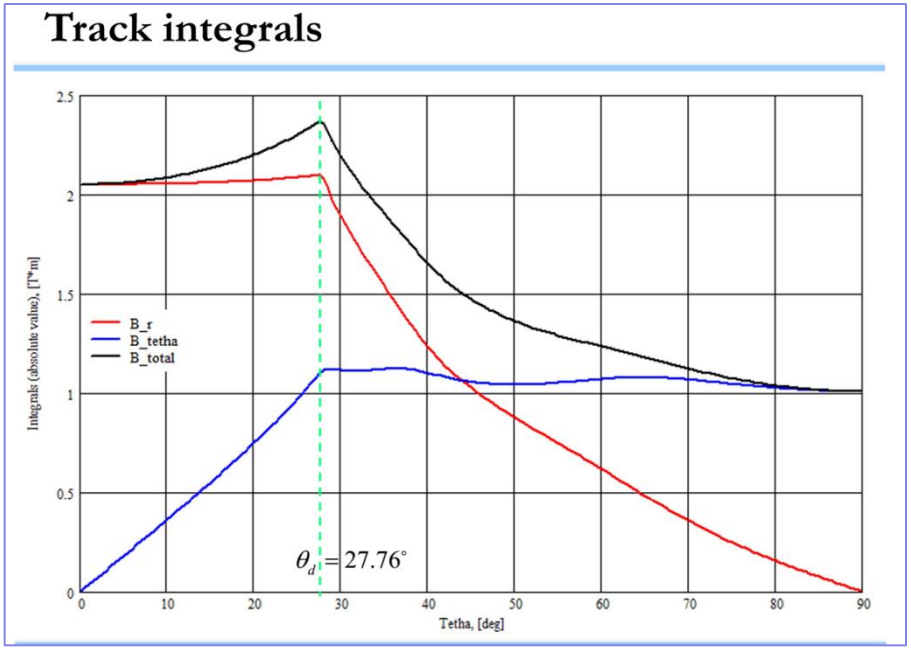
$$\theta_d=\operatorname{arctg}\frac{R_{max}}{Z_{max}}$$

$$I_R(\theta)=\int_0^{R(\theta)}B^{(r)}(r,\theta)\,dr$$

$$I_\Theta(\theta)=\int_0^{R(\theta)}B^{(\theta)}(r,\theta)\,dr$$

$$I_{Total}(\theta)=\sqrt{I_R^2(\theta)+I_\Theta^2(\theta)}$$

$R_{max}=1000\ mm,\ Z_{max}=1900\ mm,\ \theta_d=27.76^\circ$



Summary & Near Future Tasks

- The first set of 3D calculations taken new sizes of the 6 coil MS SPD was performed;
- The field data can be rescaled to other level linearly.

- Optimization of the coil positions and coil cross sections will be continued;
- Preparation of technical design including integration of the coil system into the SPD is considered as the next important step.
-

THANK YOU
FOR YOUR ATTENTION

Requirements to the facility in polarized mode

- **polarized and non-polarized p-; d–collisions**
- **p↑p↑(p)** at $\sqrt{s_{pp}}$ **= 12 ÷ 27 GeV** (5 ÷ 12.6 GeV kinetic energy)
- **d↑d↑(d)** at $\sqrt{s_{NN}}$ **= 4 ÷ 13 GeV** (2 ÷ 5.5 GeV/u kinetic energy)
- $L_{average} \approx 1 \cdot 10E32\ cm^{-2}s^{-1}$ (at $\sqrt{s_{pp}} \geq 27$ GeV)
- sufficient lifetime and degree of polarization
- longitudinal and transverse polarization in MPD/SPD
- asymmetric collision mode, **pd**, should be possible

A.Kovalenko, Baldin seminar, Dubna, September 2016

NICA collider scheme within the straights