Estimations of GASSOL capabilities in investigations of multinucleon transfer reactions

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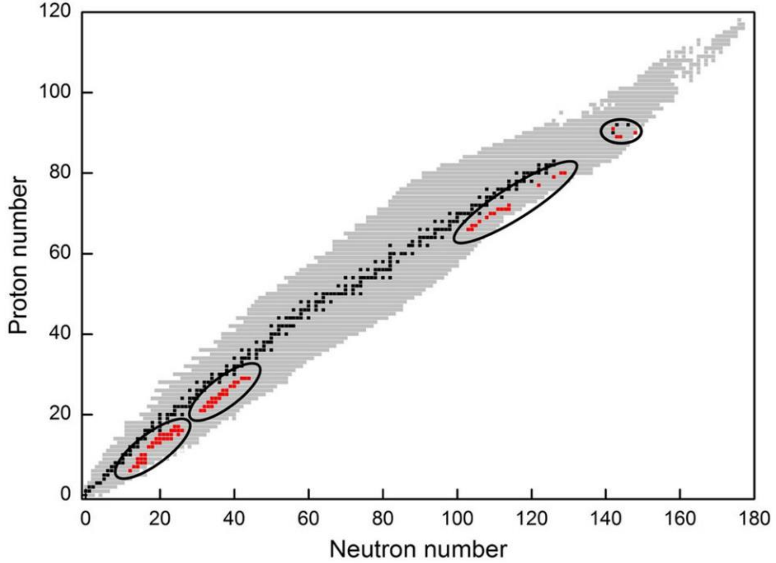
Multinucleon transfer reactions

- Projectile and target nucleus form molecule-like dinuclear system and exchange mass and energy
- MNT products with atomic numbers Z = (94 − 103) were observed
- A possible way to neutron rich and neutron deficient heavy and superheavy nuclei
- Products of MNT reaction have a very wide angle-energy distribution

Scheme of MNT reaction in CM system



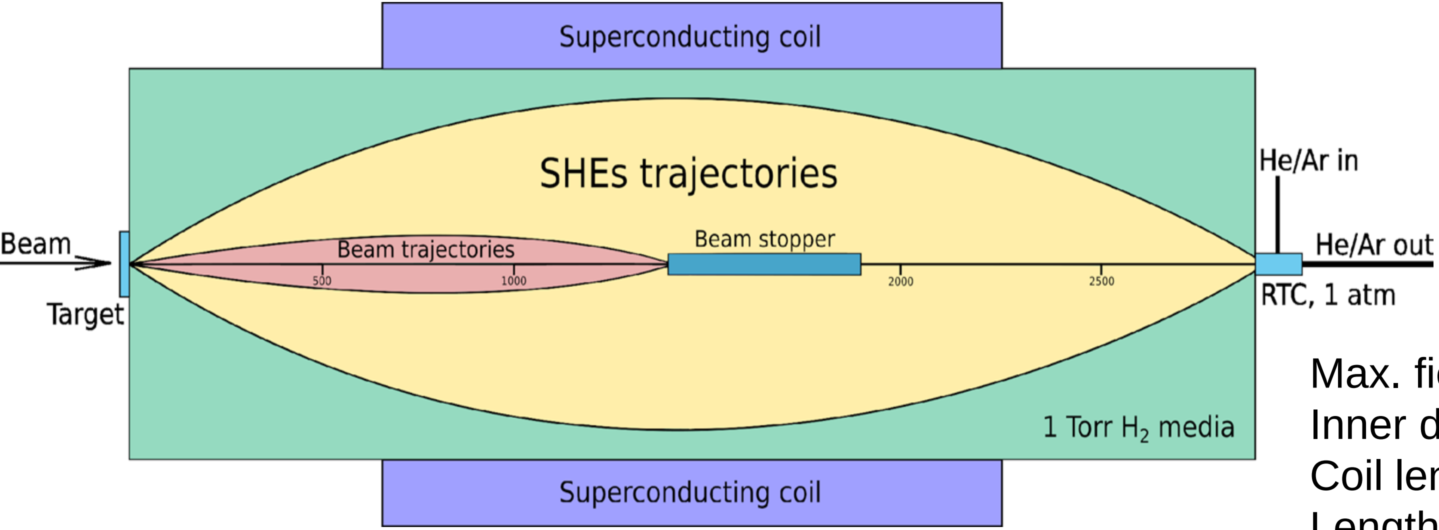
The 76 nuclides which were discovered in MNT reactions are marked in red

Solenoid GASSOL

- Currently is being designed in FLNR
- Main purpose – chemistry of superheavy elements

- Good angular acceptance
- In first approximation, works as focusing lens:

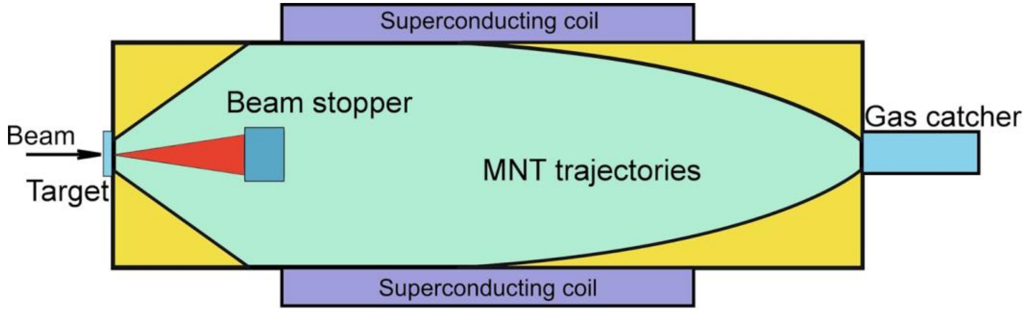
$$f \sim \frac{p^2}{q^2} \frac{1}{B_z^2 L}$$



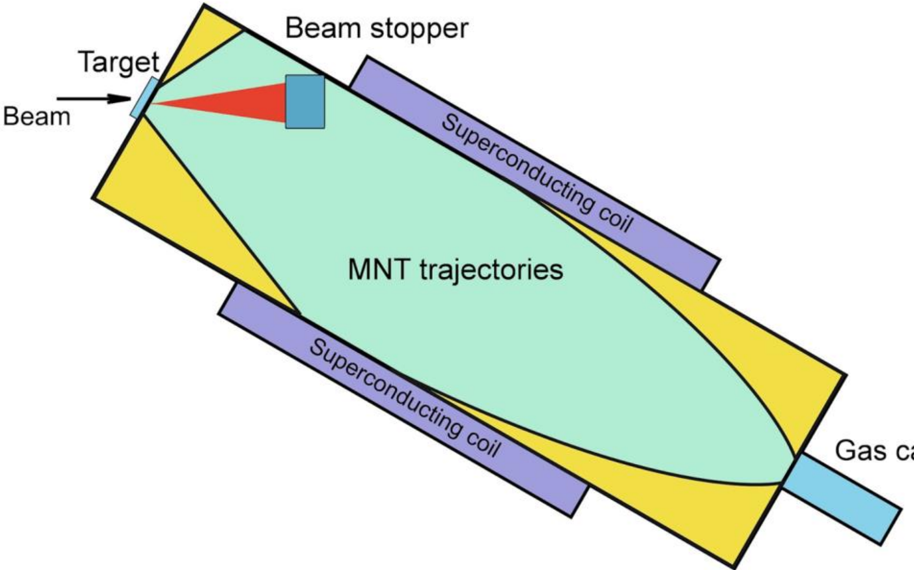
Max. field: 6.5 Tesla
Inner diameter: 308 mm
Coil length: 1500 mm
Length from target
to focal plane: 2920 mm

MNT reaction products in GASSOL

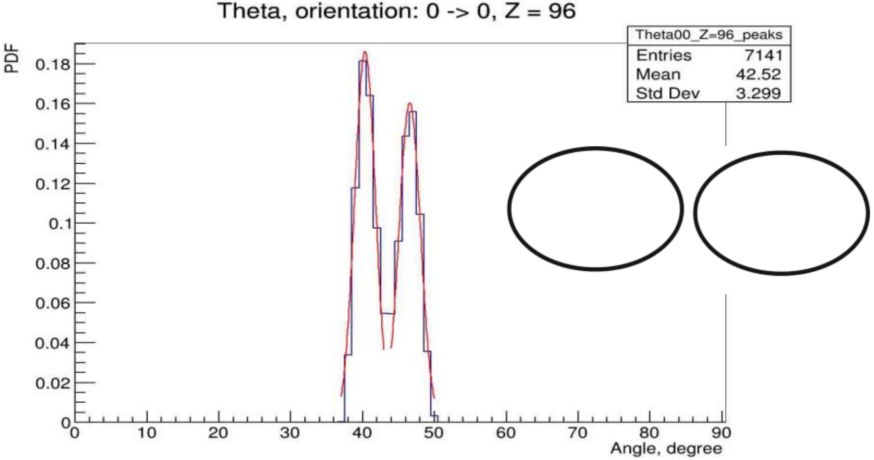
Idea is to look what transmission we can get for MNT reaction products in GASSOL!

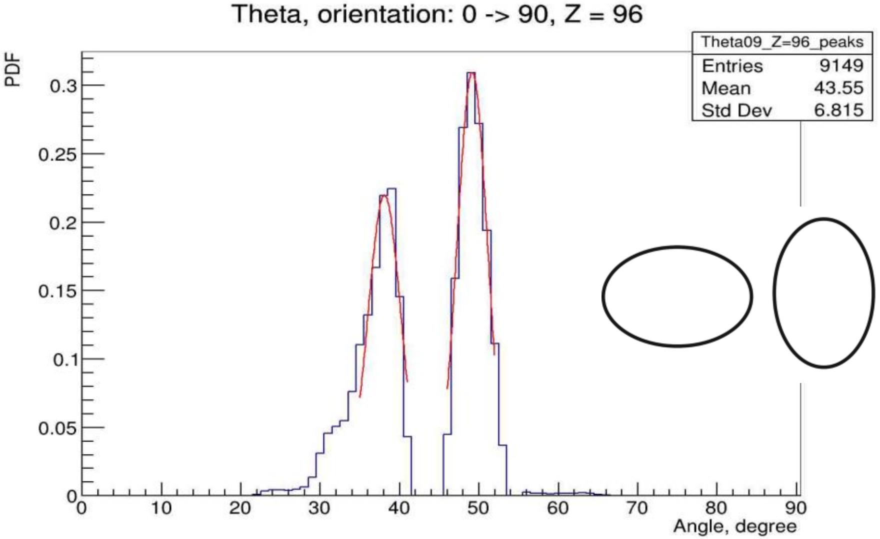


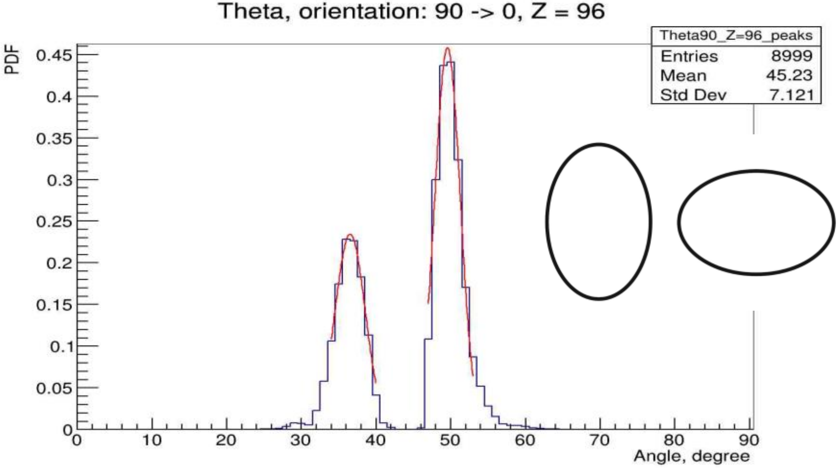
- GASSOL will be without gas
- Two configuration – collinear to beam axis and at different angles
- Reaction:
  6.75 MeV/amu $^{238}U + ^{238}U$
- Angle-energy distribution for MNT products is taken from dynamical model based on Langevin equations
- Product: Cm, all isotopes
- Focal plane: gas catcher, 10 cm diameter

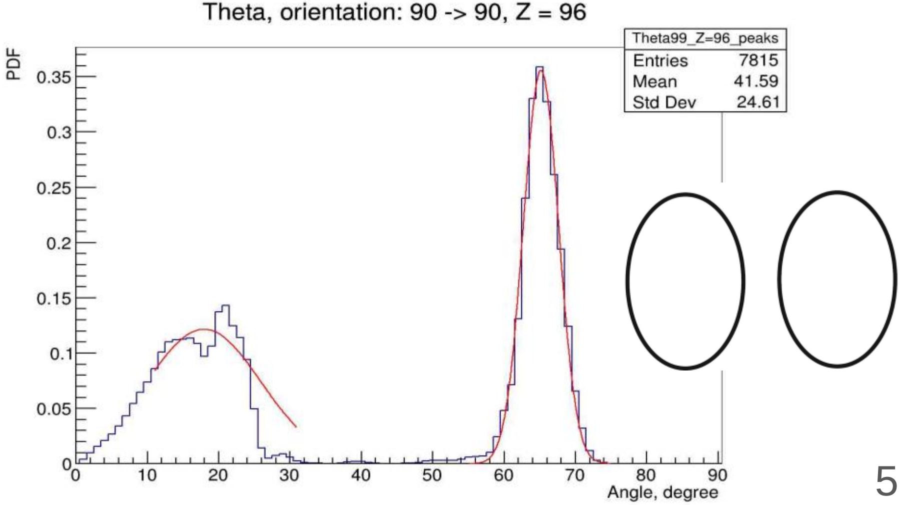


Calculated distributions



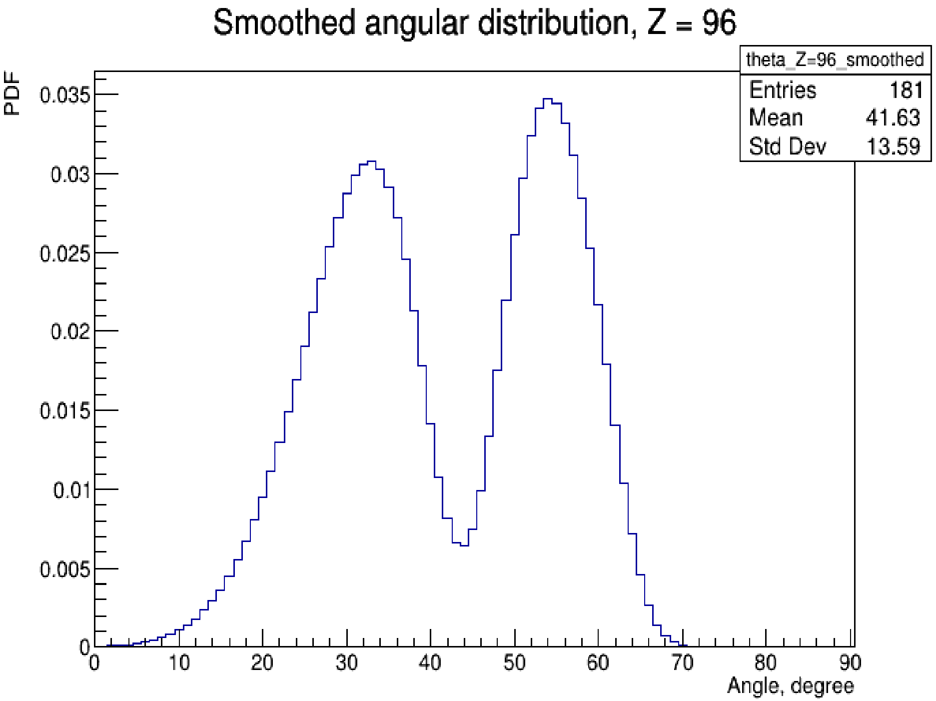


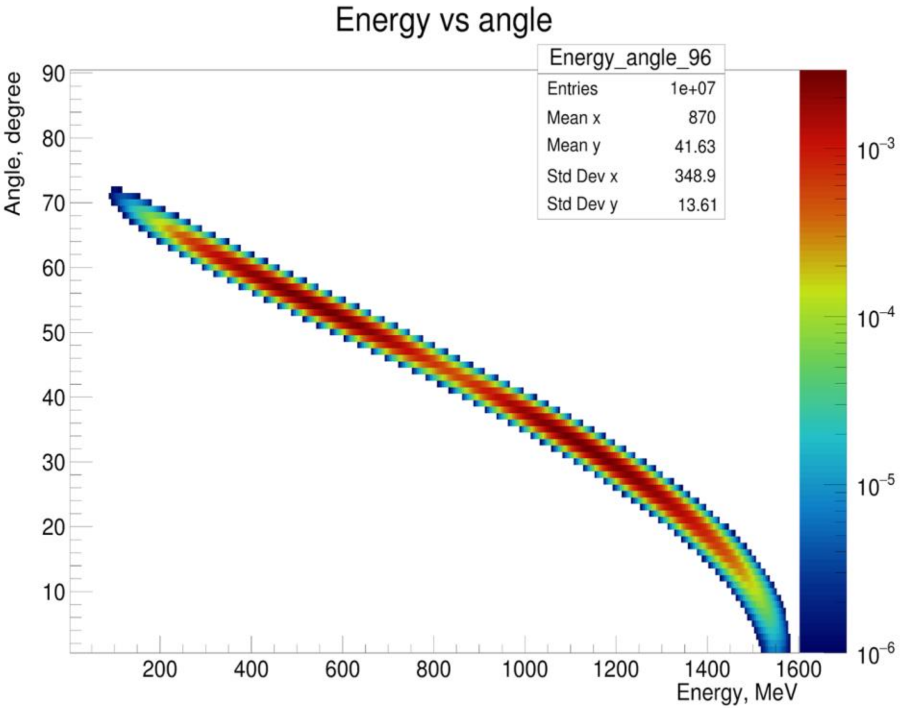




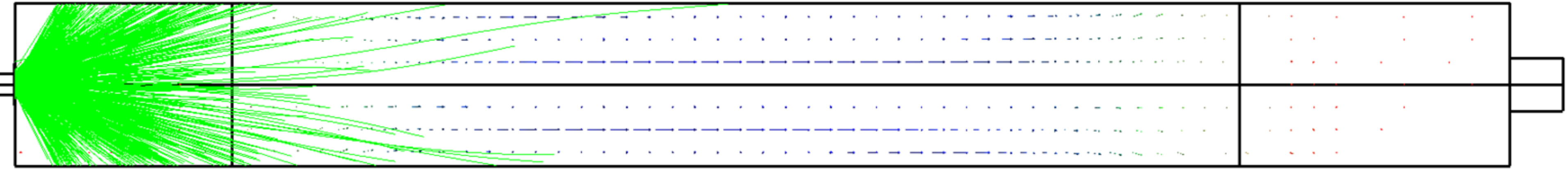
Averaged energy-angle distribution

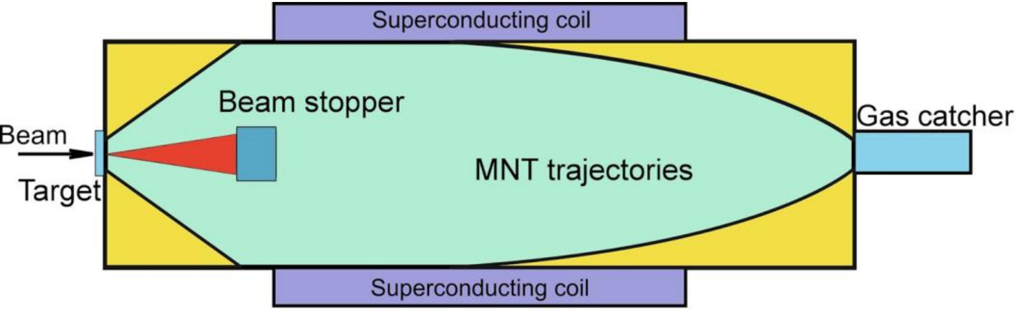
$$\langle\sigma(\theta)\rangle = \iint_0^{\pi/2} \sigma(\theta,\varphi_1,\varphi_2)\sin(\varphi_1)\sin(\varphi_2)\,d\varphi_1\,d\varphi_2$$





Collinear placement





- Very low transmission - about 0.2 % - most of the products are lost before they reach the field
- We can’t put target inside the solenoid - target should rotate
- Even if we could - beam separation problem!

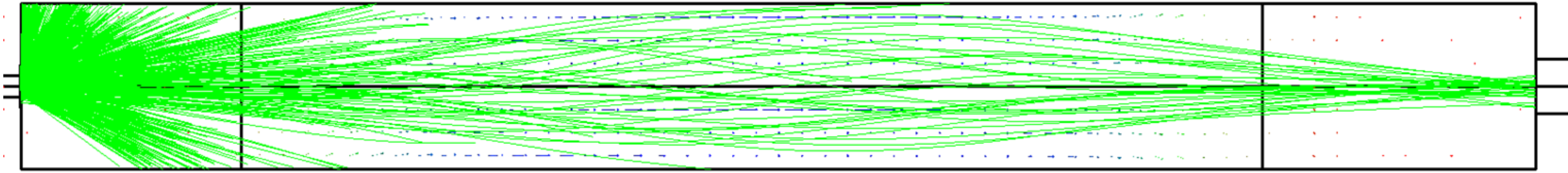
Beam separation problem:

- large intensity about 10^{13} pps
- unstable emittance
- large size - about 2-3 cm on a target
- has a magnetic rigidity close to MNT products - will be focused in gas catcher

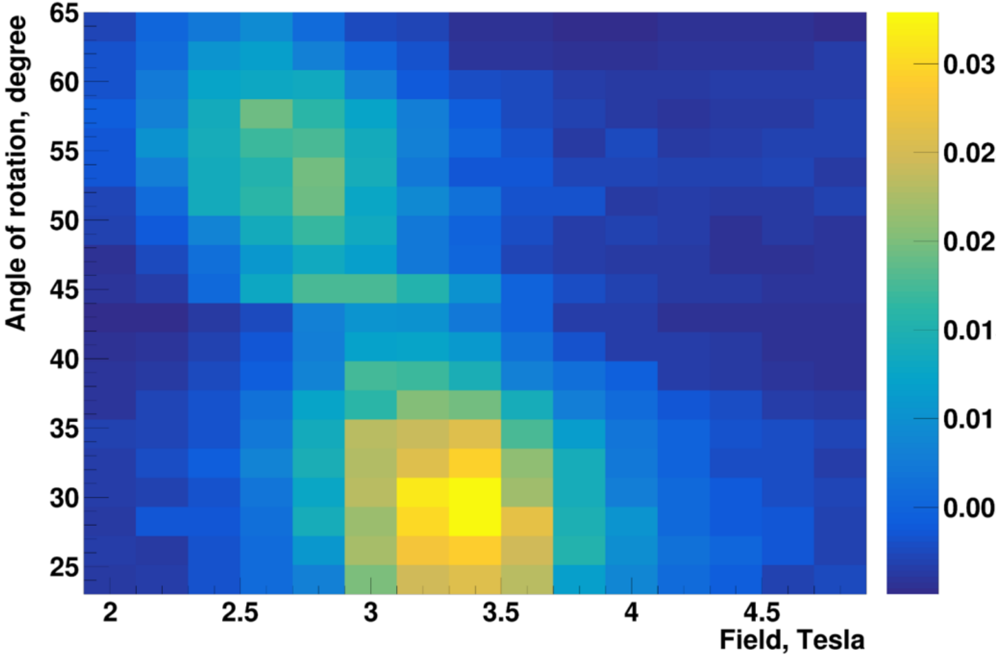
You need a very precise estimation of beam scattering!

All beam particles which miss stopper will be focused in a gas catcher!

Placements at different angles



- Transmission is about 3% - still quite low
- Beam separation problem is solved - good background conditions
- Optimal angle is about 30 degrees, optimal field about 3.4 Tesla



Conclusion

- Placement of a solenoid at some angle shows more potential - better background conditions
- Maximal field necessary is less than 4 Tesla
- Transmission is still quite low - about 3% - which does not justify the costs of GASSOL modification necessary for such experiment

From these results, requirements for a new solenoid:

- Large inner diameter - 700-1000 mm with coil length 1500 mm
- Maximum field about 4 Tesla
- Possibility to rotate from 60 to 0 degrees from the beam axis

Thank you for your attention!