Magnetic field asymmetry studies of the PITZ gun main solenoid

Alexey Bulygin
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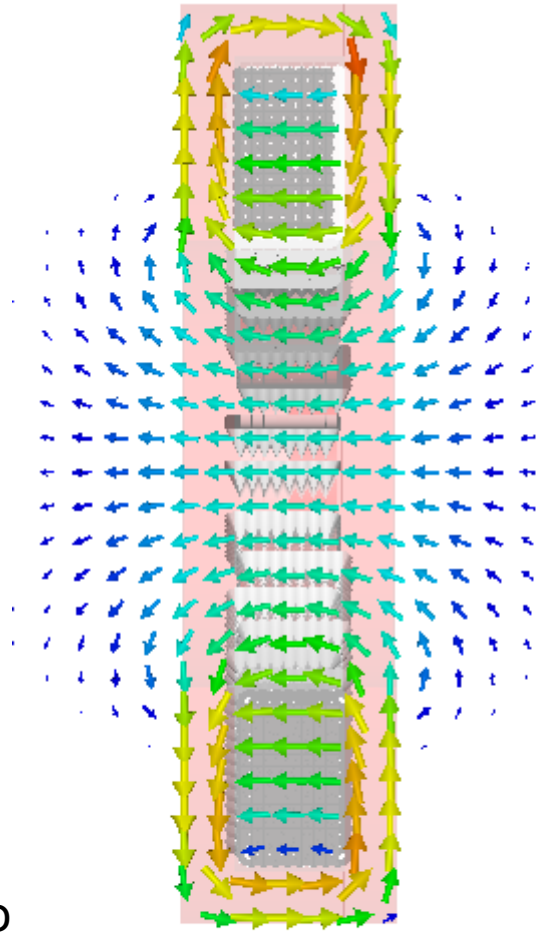
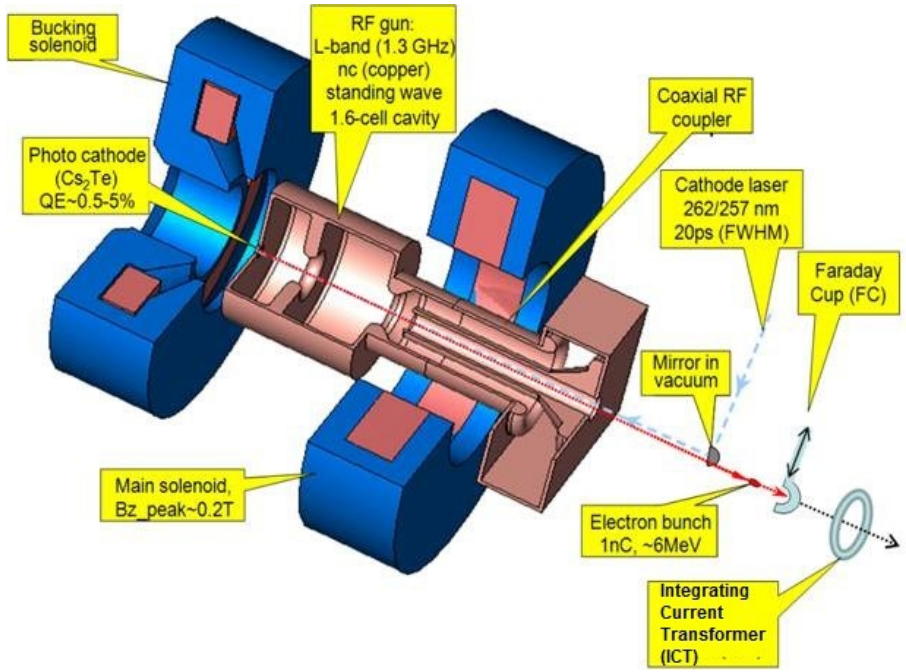
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

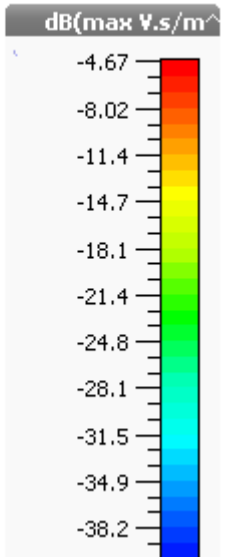
PITZ facility/ RF-gun/ Solenoid

- The heart of the PITZ facility is the RF photoelectron gun
- The gun cavity is surrounded by pair of solenoids.
- The main tasks of solenoids are focusing purposes and compensation space charge forces (emittance growth compensation).

1. **The main solenoid** has maximum magnetic field 0.3 T at 500 A current
2. **The bucking solenoid** current is set so, that the parameter magnetic field at the cathode is 0 T. **But** it can work up to 300 A, and produce maximum magnetic field 0,16 T

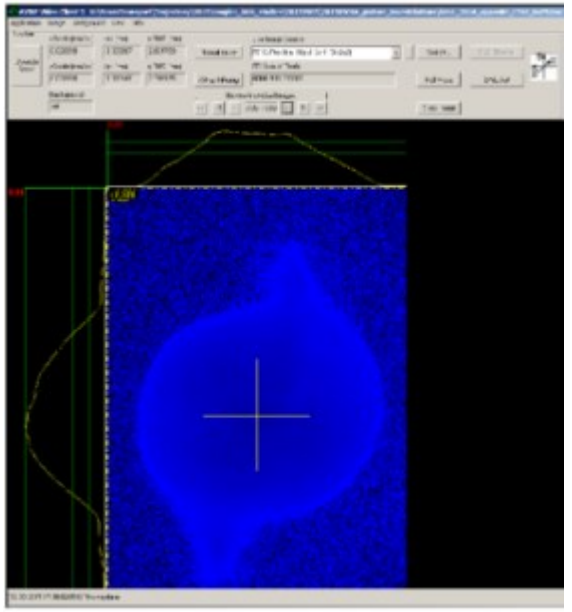






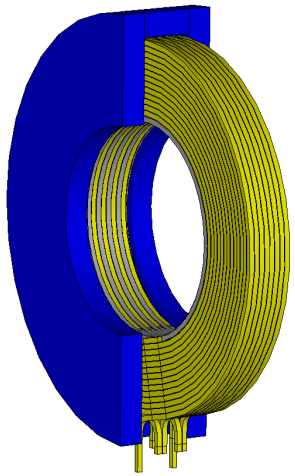
Motivation/ Asymmetries

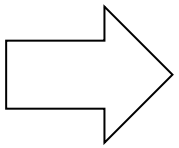
- During the PITZ operation there was always observed asymmetrical shape of the beam. Investigation of the **beam asymmetry source** showed that it is located in **the gun region** [2].The Larmour angle experiment showed that the source is located in the region of **coaxial coupler to the full cell transition**.
- The magnetic field asymmetry may come from asymmetrical parts of the main solenoid geometry. The solenoid geometry was splited to parts symmetrical and asymmetrical parts. There are following asymmetrical parts: **transitions, connectors and the hole in the shield**.

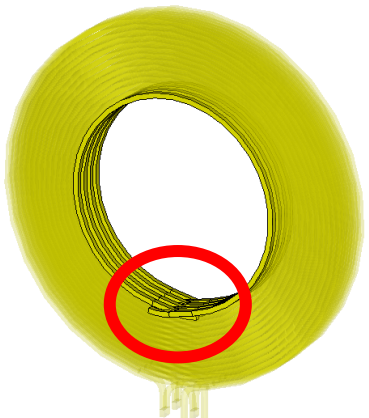


Beam transverse profile at High1.Scr.1 at I_{main} = 361A

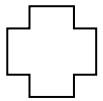
The main goal of this project is an investigation of field asymmetry contribution that comes from different solenoid parts.

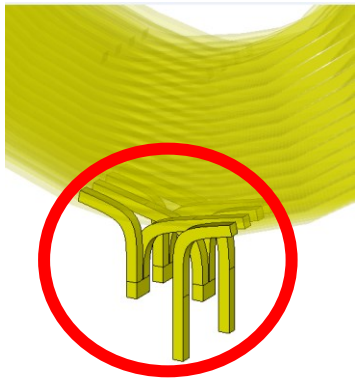




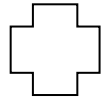


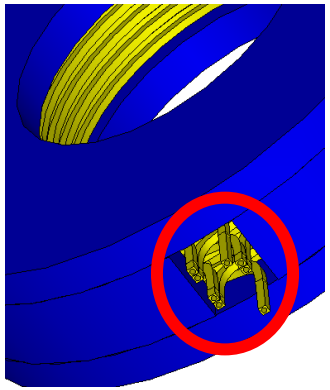
Transitions





Connectors





Hole in the shield.

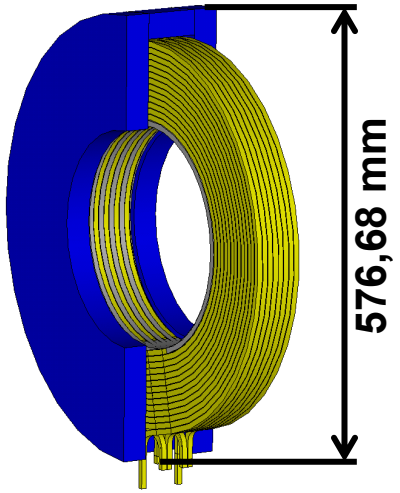
CST: Simulation and Meshing

Mesh with bigger number of cells:

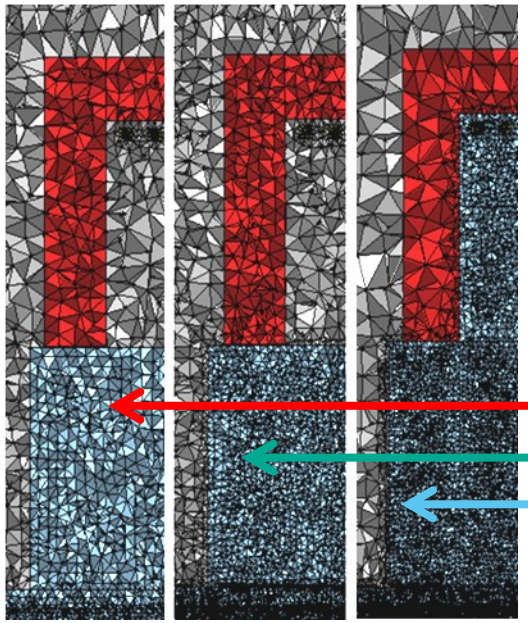
+ result will be more precise

- large number of points leads special requirements for computing devices (endless increase number of points => not enough memory)

Answer is a Balance!



3D - model in CST



Tetrahedral mesh

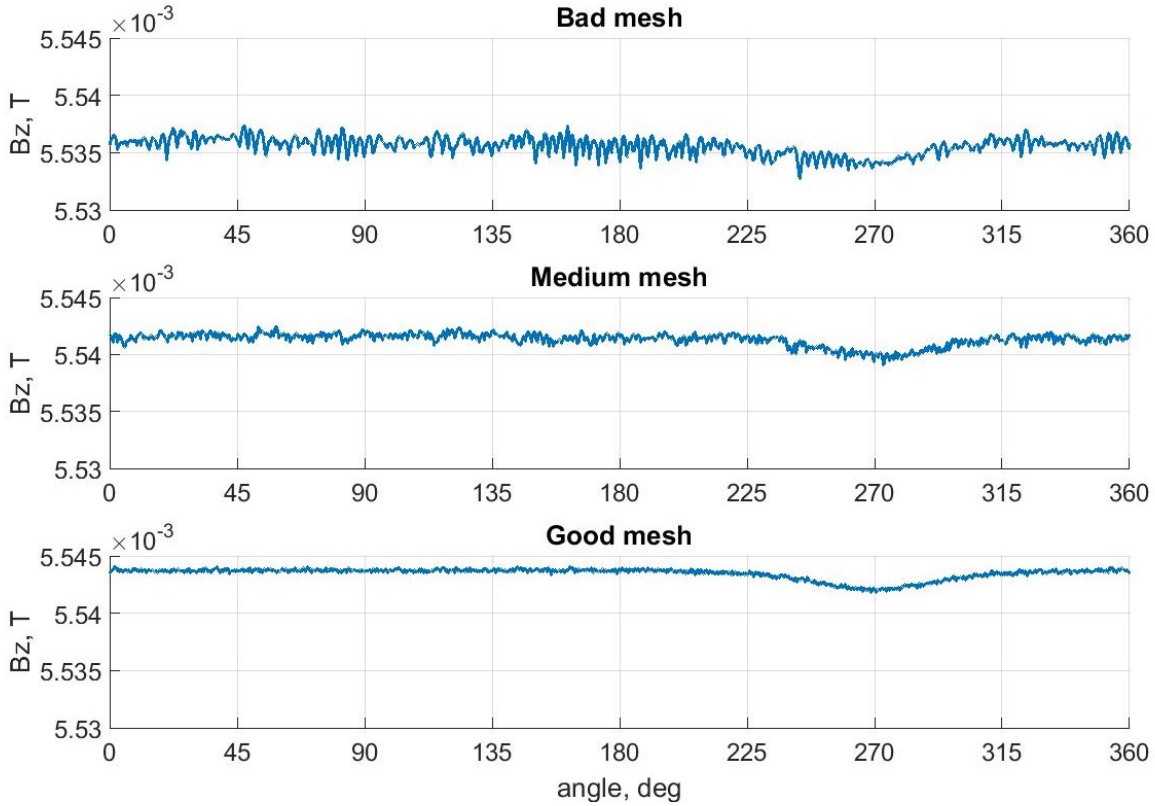
2,2M cells
5,6M cells
9M cells

Red – iron
Grey - background
Blue - vacuum

The model with different mesh

CST and simulation

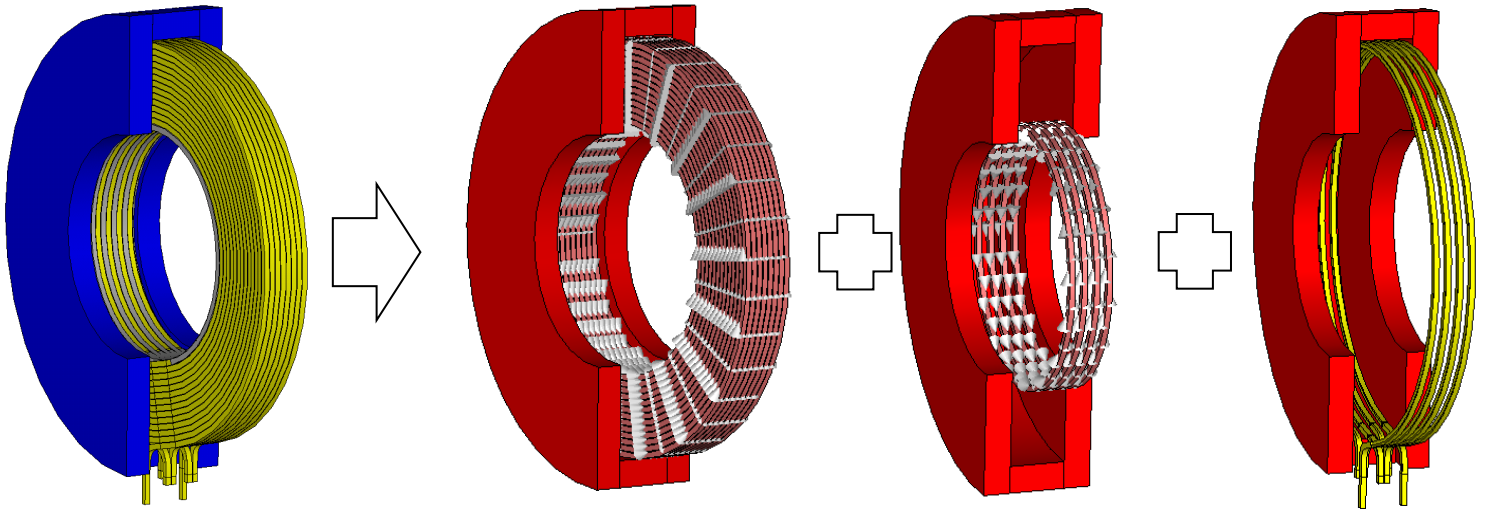
- CST (Computer Simulation Technology) is a special tool for 3D electromagnetic simulations. MS-solver (Magneto-Static solver) is used for simulations made according to initial solenoid design.
- The full 3D-model has all asymmetries.
- The solenoid central hole size is ~140 mm, but beam size is ~1 mm.



Plots for one model with different mesh

Split / Projections

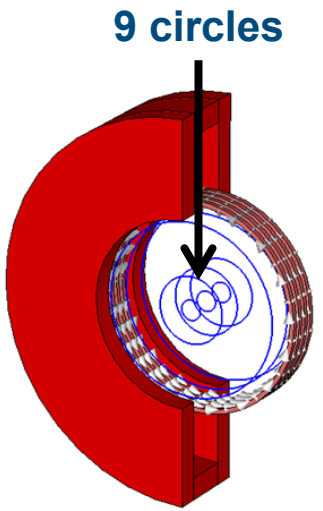
Splitting model for three parts



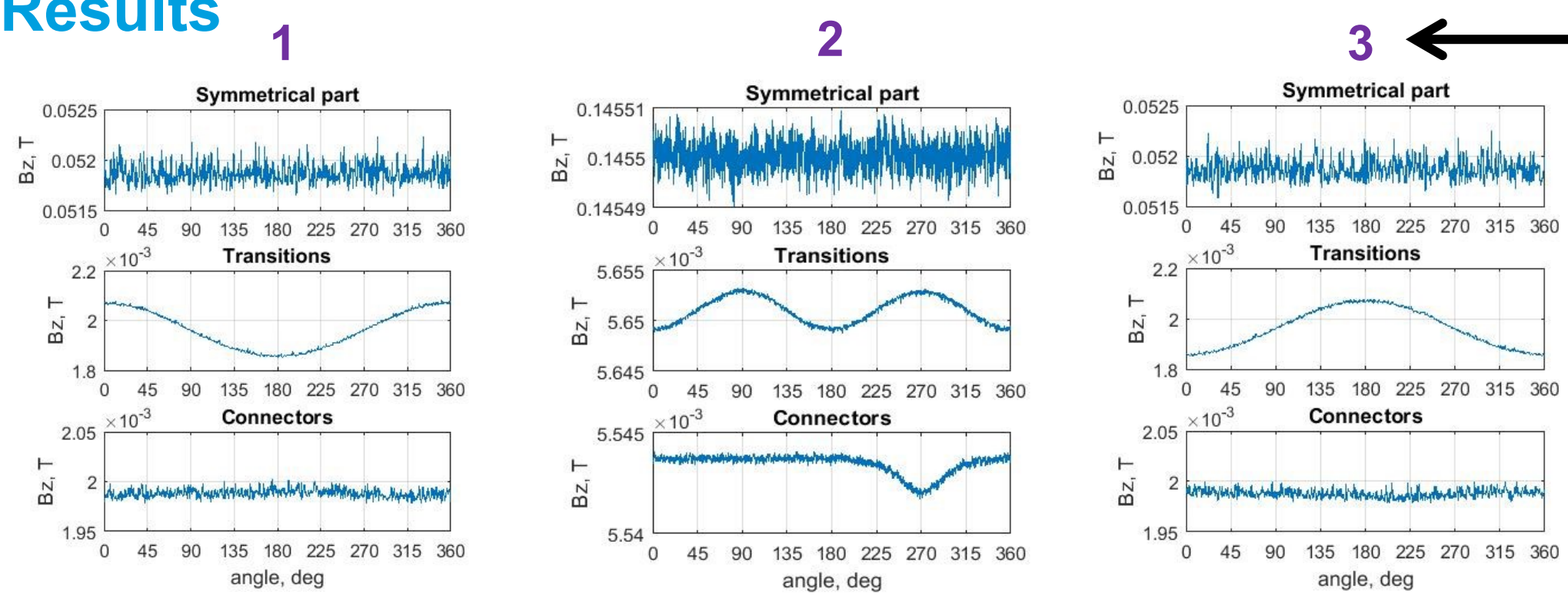
- Symmetrical model for obtaining symmetrical magnetic field. Changed windings for equally numbers of round coils (108) with the same dimensions
- Transitions to unite rows in the central part. Changed to rotated coils.
- Connectors to unite external part. Connectors are similar for initial model.

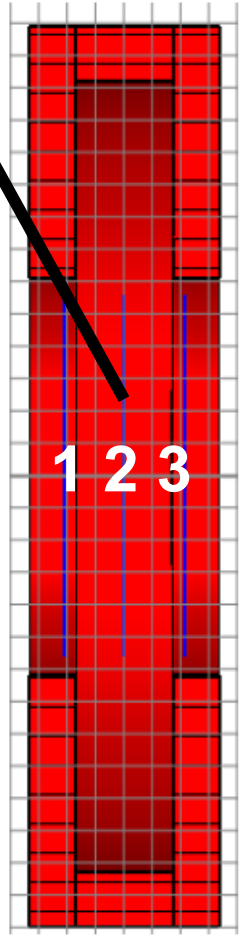
Field projections

- There are 9 circles.
- They have three different radii in three different points.
- More points on curves - more accurate result (better mesh).
- 2nd point - in the middle of the solenoid
- 1st and 3rd – on equally distance from center of the structure



Results





1. **Symmetrical model:** constant values of the field vs. angle (with noise) on all plots for. Magnetic field is symmetrical and homogenous inside the structure.

2. **Connectors:** 1st, 3rd plots- symmetrical magnetic field, on 2nd plot- decrease in the place, there is asymmetry (hole) in the structure. This data show, that connectors in combination with hole produce field distortions exactly at this angle.

3. **Transitions:** 1st, 3rd plots - clear dipole components of the magnetic field. The 2nd plot - clear quadrupole component.

Conclusion

- The main solenoid for PITZ RF gun was considered and simulated.

1. The simulated model has different asymmetries inside the structure (transitions in the middle, connectors on outer level and the hole in the shield).
2. These asymmetries influence on the asymmetry of the magnetic field.
3. Complicated structure was split for three models: 4 transitions, connectors and symmetrical part with coils instead wires.
4. Right choice of the mesh.

- Three different positions with three circles with different radius.

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Outlook

- Next steps are to investigate field asymmetry at the geometrical center of the solenoid, where the beam motion takes place
- Later the field might be taken for particle tracking simulation
- Use the obtain results for field asymmetry modeling by a simple structure (for example, combination of quadrupoles) so that it can be implemented to another simulation codes like ASTRA

Thank you

Acknowledgements

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Contact

DESY. Deutsches Elektronen-Synchrotron

www.desy.de

Alexey Bulygin
PITZ
a.m.bulygin@gmail.com