Siberian design of QD0

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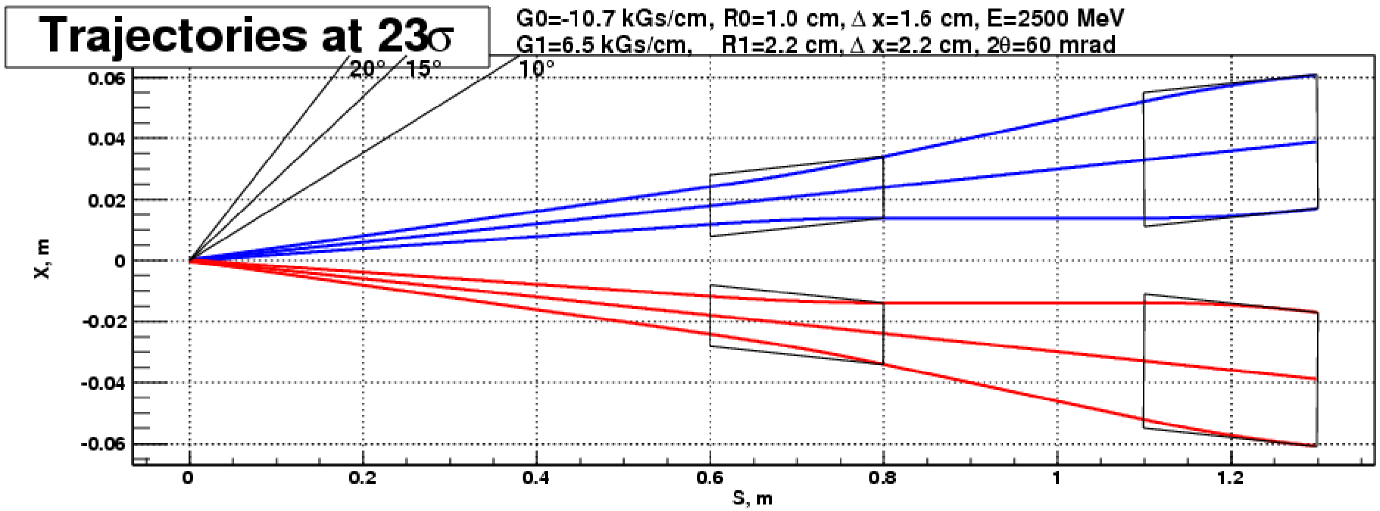
C-Tau IR design parameters

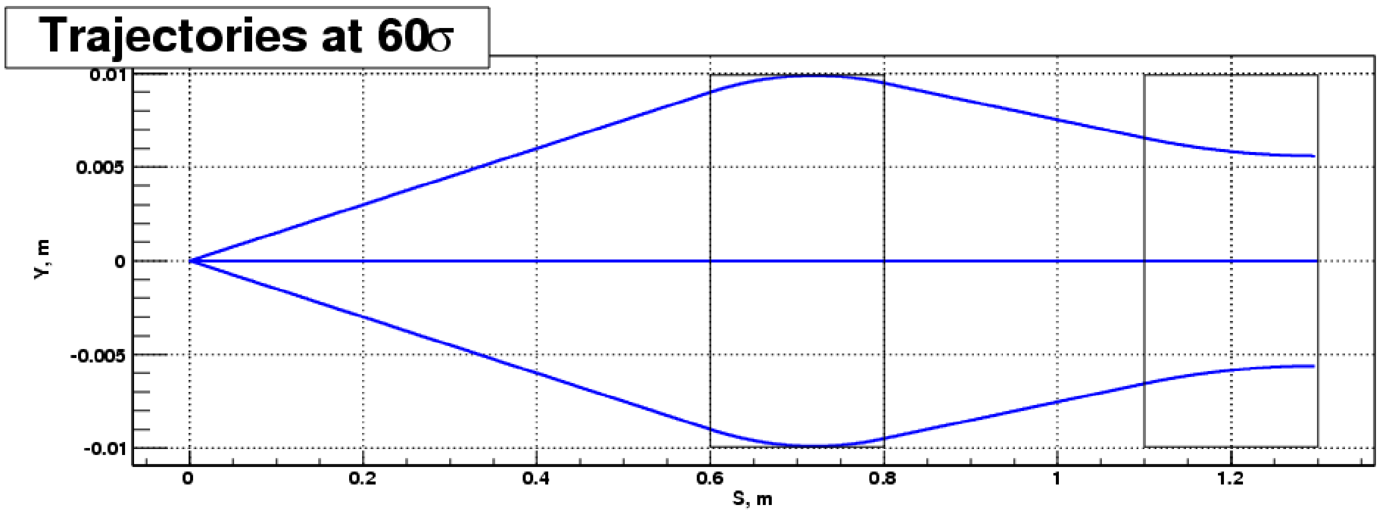
- Crossing angle is ±30 mrad
- Vacuum chamber in SC lenses is at nitrogen temperature
- Soft upstream bending magnets and no SR at IP
- We have 23σ in X and 60σ in Y in first lens

C-Tau IR Parameters

					Units	Comments
Energy	**1.0**	**1.5**	**2.0**	**2.5**	**GeV**	
Rigidity	3.336	5.003	6.671	8.339	T·m	
Circumference	766.6				m	
Revolution frequency	391.068				kHz	
Rovolution time	2.557				us	
Tunes						
Horizontal	47.54	47.54	47.54	47.54		
Vertical	30.57	30.57	30.57	30.57		
Synchrotron	$6.92 \cdot 10^{-3}$	$1.04 \cdot 10^{-2}$	$9.34 \cdot 10^{-3}$	$8.18 \cdot 10^{-3}$		
Beam						
Coupling	0.5				%	
Emittance	8.06	8.27	7.99	7.96	nm·rad	
Energy spread	$1.009 \cdot 10^{-3}$	$9.953 \cdot 10^{-4}$	$8.435 \cdot 10^{-4}$	$7.378 \cdot 10^{-4}$		
Beam length	1.60	1.06	1.00	1.00	cm	
Current						
Number of particles	$7 \cdot 10^{10}$					
Beam current	4.386				mA	
Total number of particles	$2.73 \cdot 10^{13}$					
Total current	1.71				A	
IP parameters						
Crossing angle	60				mrad	
Horizontal beta	4				cm	
Vertical beta	800				um	
Horizontal sigma	17.89				um	
Vertical sigma	0.179				um	
Piwinski angle	26.91	18.50	16.82	16.82	rad	
Luminosity						
Beam	$1.61 \cdot 10^{32}$	$2.43 \cdot 10^{32}$	$2.57 \cdot 10^{32}$	$2.57 \cdot 10^{32}$	$cm^{-2} \cdot s^{-1}$	with hourglass
Total	$0.63 \cdot 10^{35}$	$0.95 \cdot 10^{35}$	$1.00 \cdot 10^{35}$	$1.00 \cdot 10^{35}$	$cm^{-2} \cdot s^{-1}$	with hourglass
Admittance						
Horizontal	**$4.49 \cdot 10^{-4}$**				**cm·rad**	**by QF1 R=2.2 cm**
Vertical	**$1.84 \cdot 10^{-5}$**				**cm·rad**	**by QD0 R=1 cm**

C-Tau IR Design

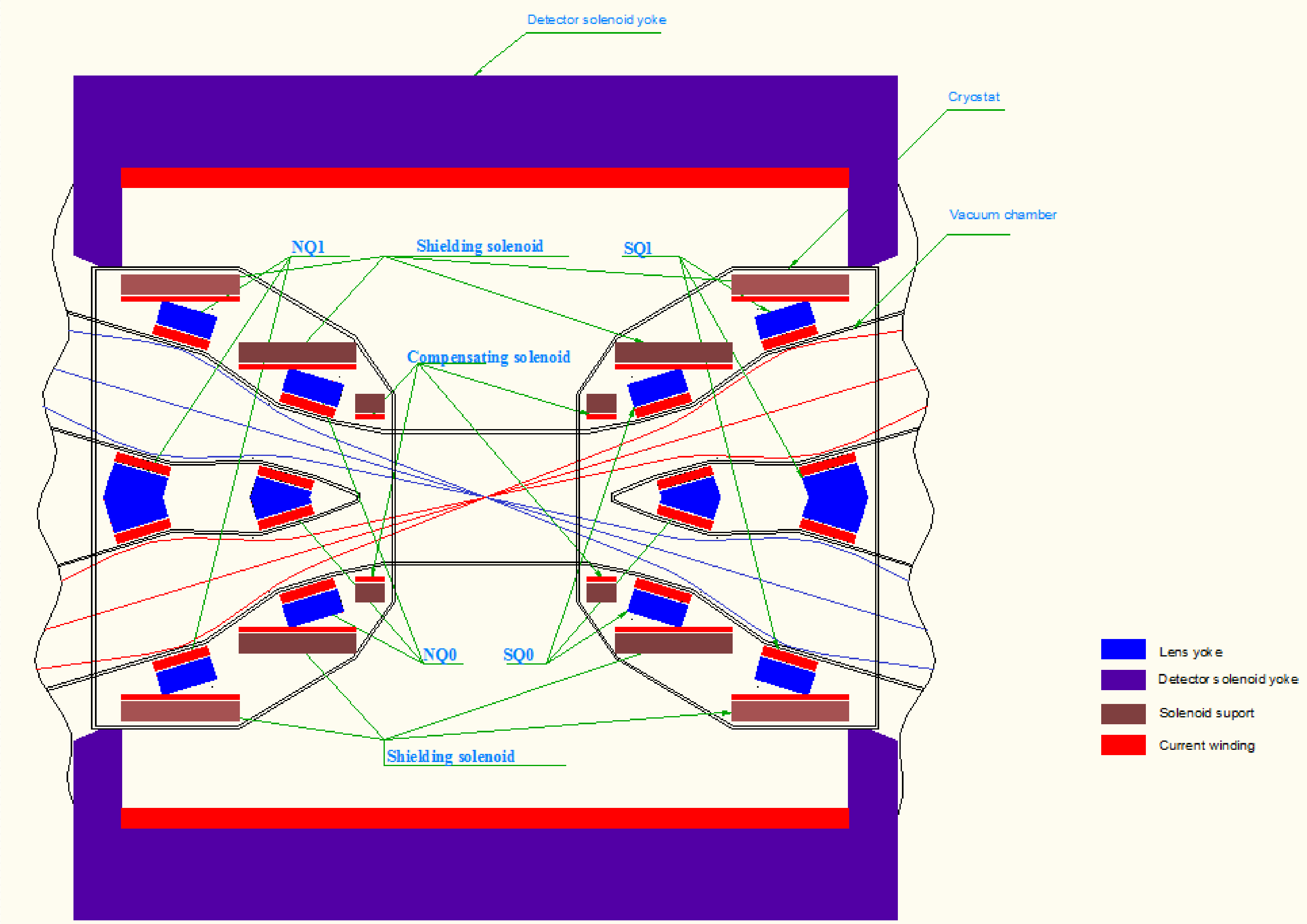




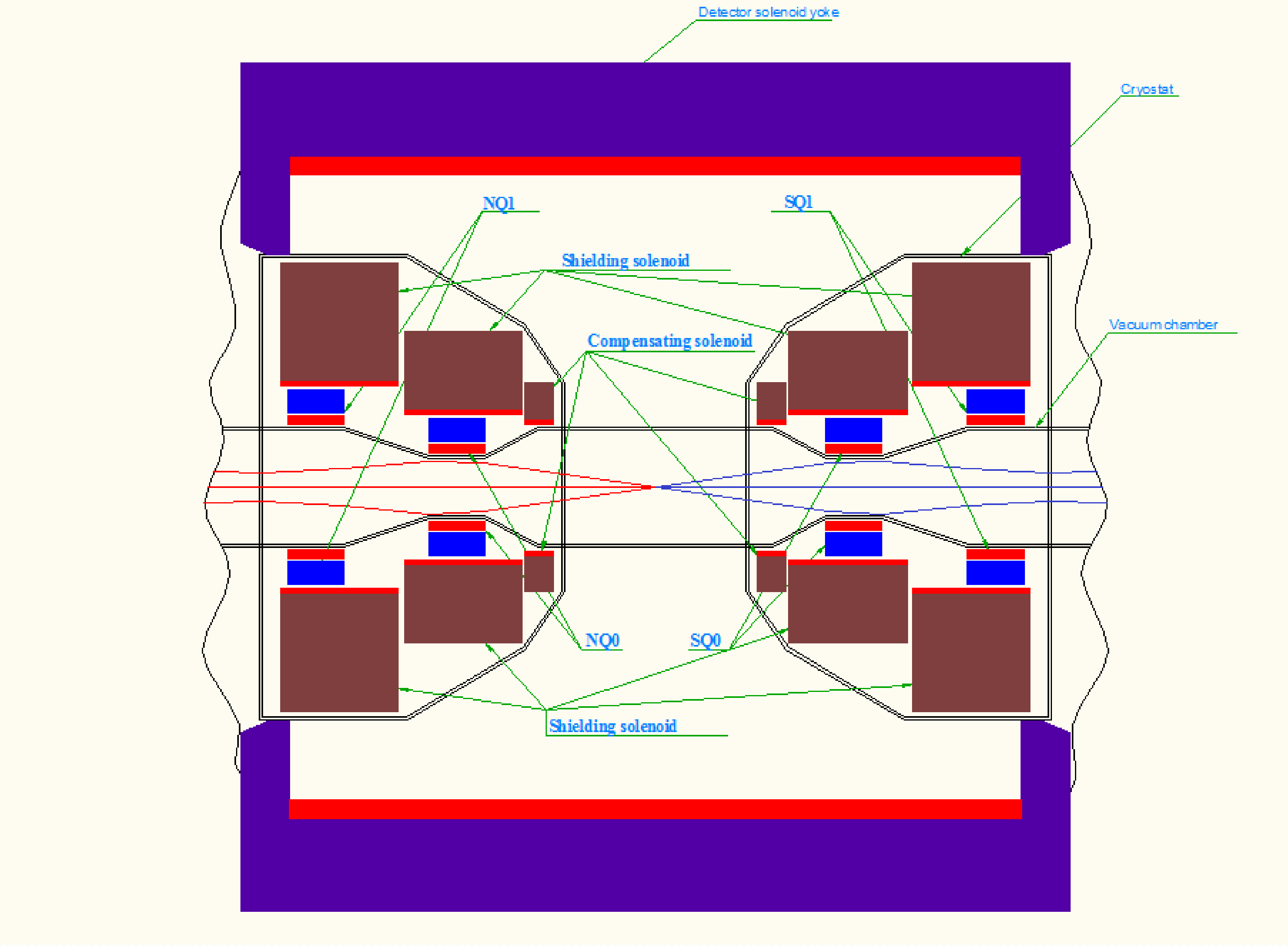
C-Tau IR Parameters

	Effective length, mm	Azimut, см	Longitudinal field (kGs), or Gradient (kGs/cm)	Aperture radius, mm	ΔB/B or ΔG/G	Type
Interaction point	~ 0.600 mm	0 cm	10 kGs	R = 40 mm	<1%	Interaction point
SC0	~ 100 mm	45 cm	-45 kGs	R = 45 mm	<1%	Superconducting solenoid
SSH1	~ 350-600 mm	55 cm	-10 kGs	-	<1%	Superconducting solenoid
SEQ0 (NEQ0)	**200 mm**	**60 cm**	**-10.7 kGs/cm**	**R = 10 mm**	***$1 - 5 \cdot 10^{-4}$***	**Superconducting double aperture quadrupole lens**
SSH2	~ 700-900 mm	85 cm	-10 kGs	-	<1%	Superconducting double aperture quadrupole lens
SEQ1 (NEQ1)	**200 mm**	**110 cm**	**6.5 kGs/cm**	**R = 22 mm**	***$1 - 5 \cdot 10^{-4}$***	**Superconducting double aperture quadrupole lens**

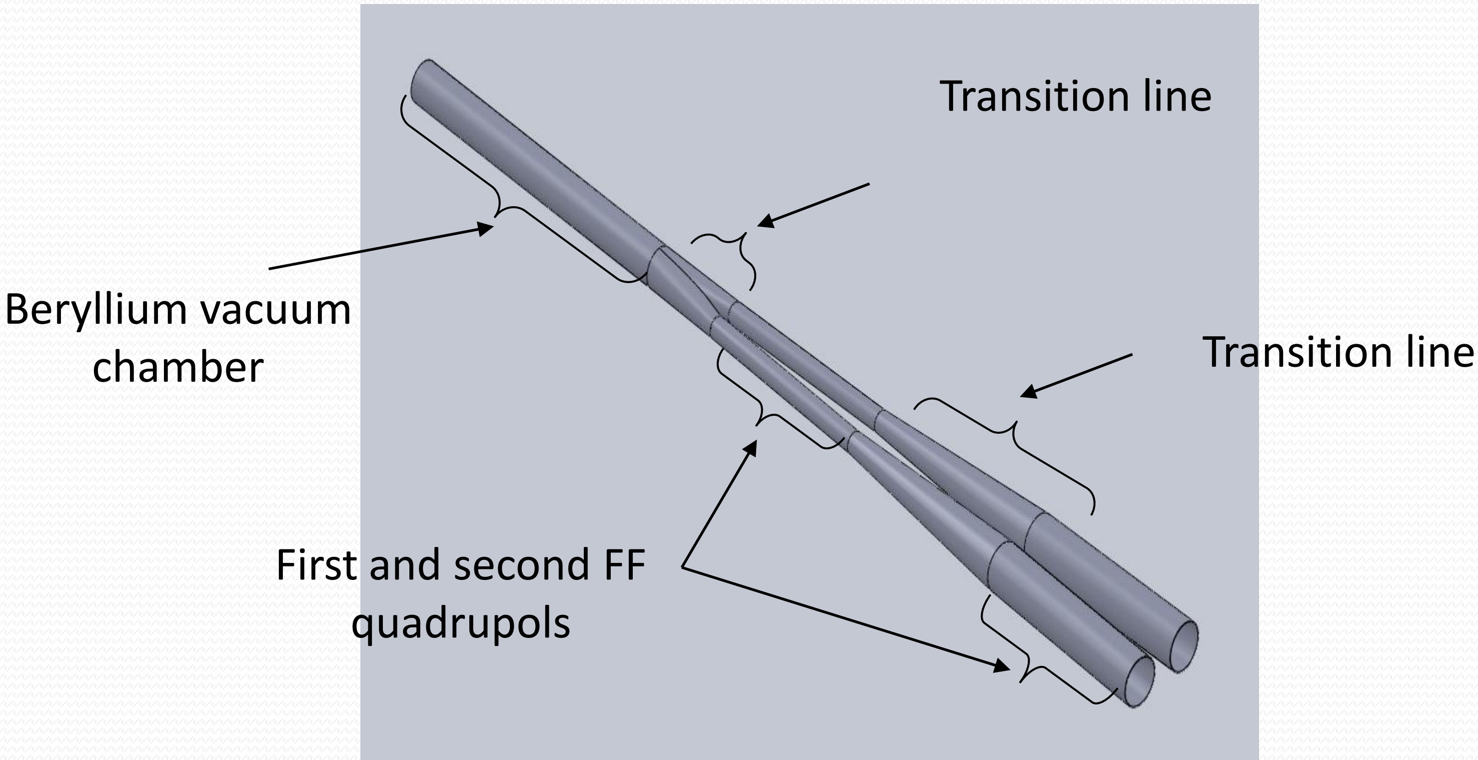
C-Tau IR layout in horizontal plane



IR layout in vertical plane

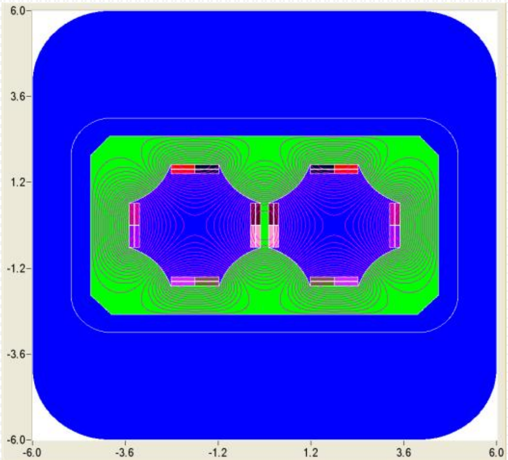


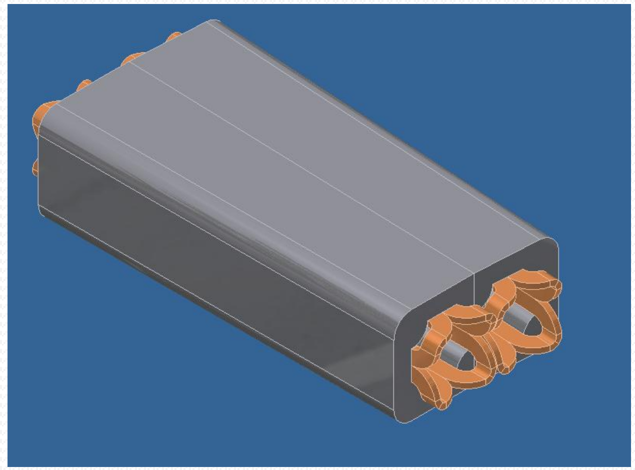
C-Tau IR vacuum chamber



Vacuum chamber in interaction point

Calculation of magnetic field





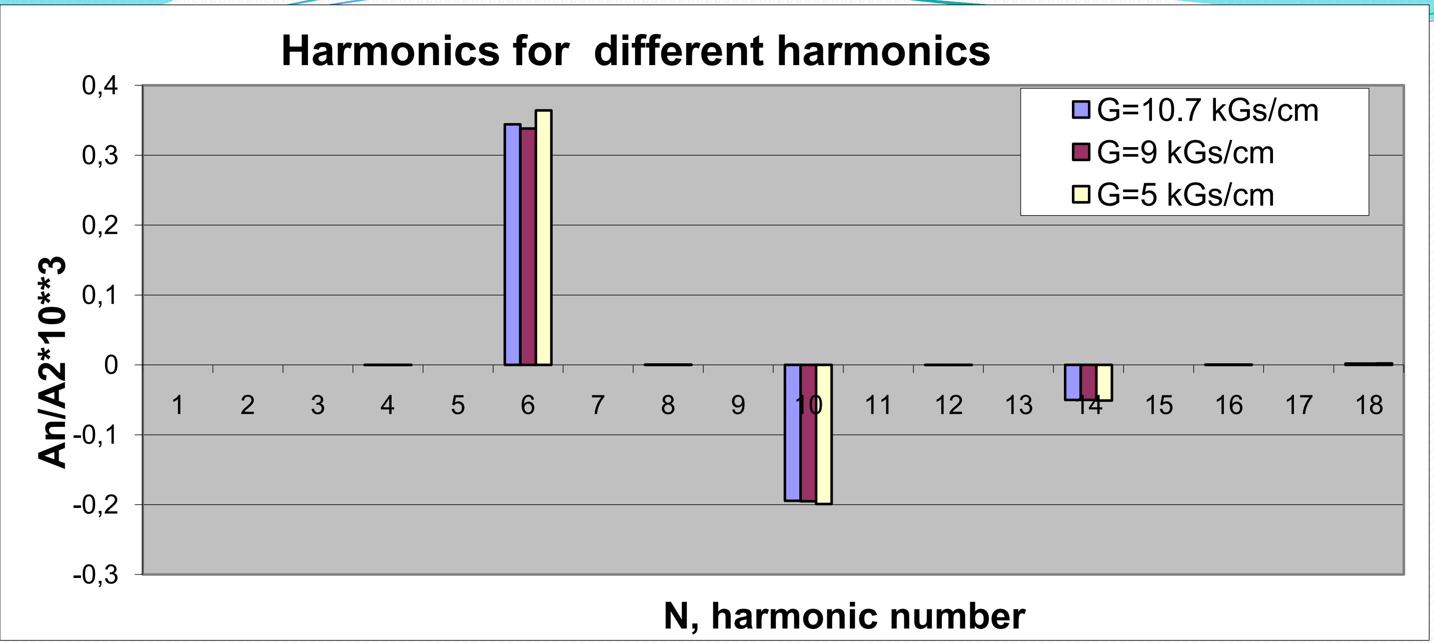
QD0 calculations in MERMAID

- All 2D and 3D calculations were made by MERMAID
- There is no yoke saturation at 11 kGs/cm (vanadium permendure)
- There are still no requirements on harmonic content
- 3D calculations give $\Delta G/G$ $\pm 10^{-3}$ without chamfers
- Chamfers are not optimized

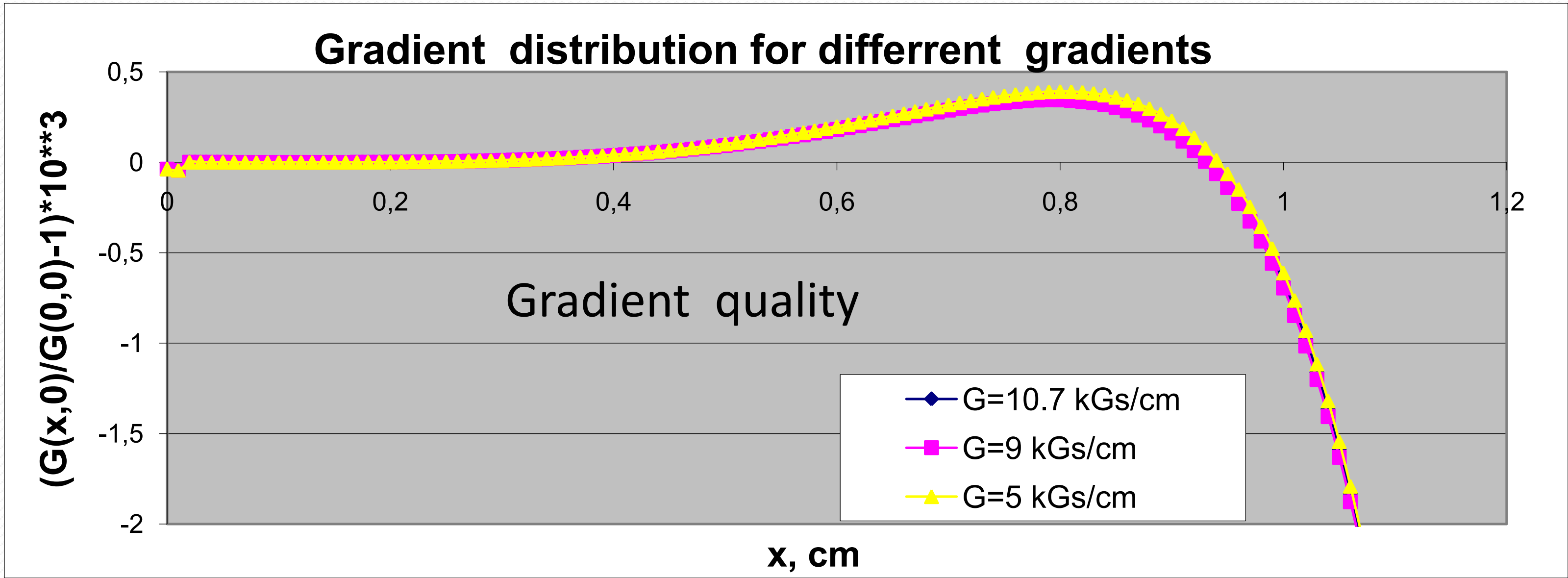
Harmonics of QD0 for different gradients at R = 1 cm

N	an	an	an
2	-10.97	-9.08	-5.32
6	-0.0038	-0.0031	-0.0019
10	0.0021	0.0018	0.0011
14	0.0006	0.00046	0.00027
18	-2.2E-05	-1.8E-05	-1.1E-05

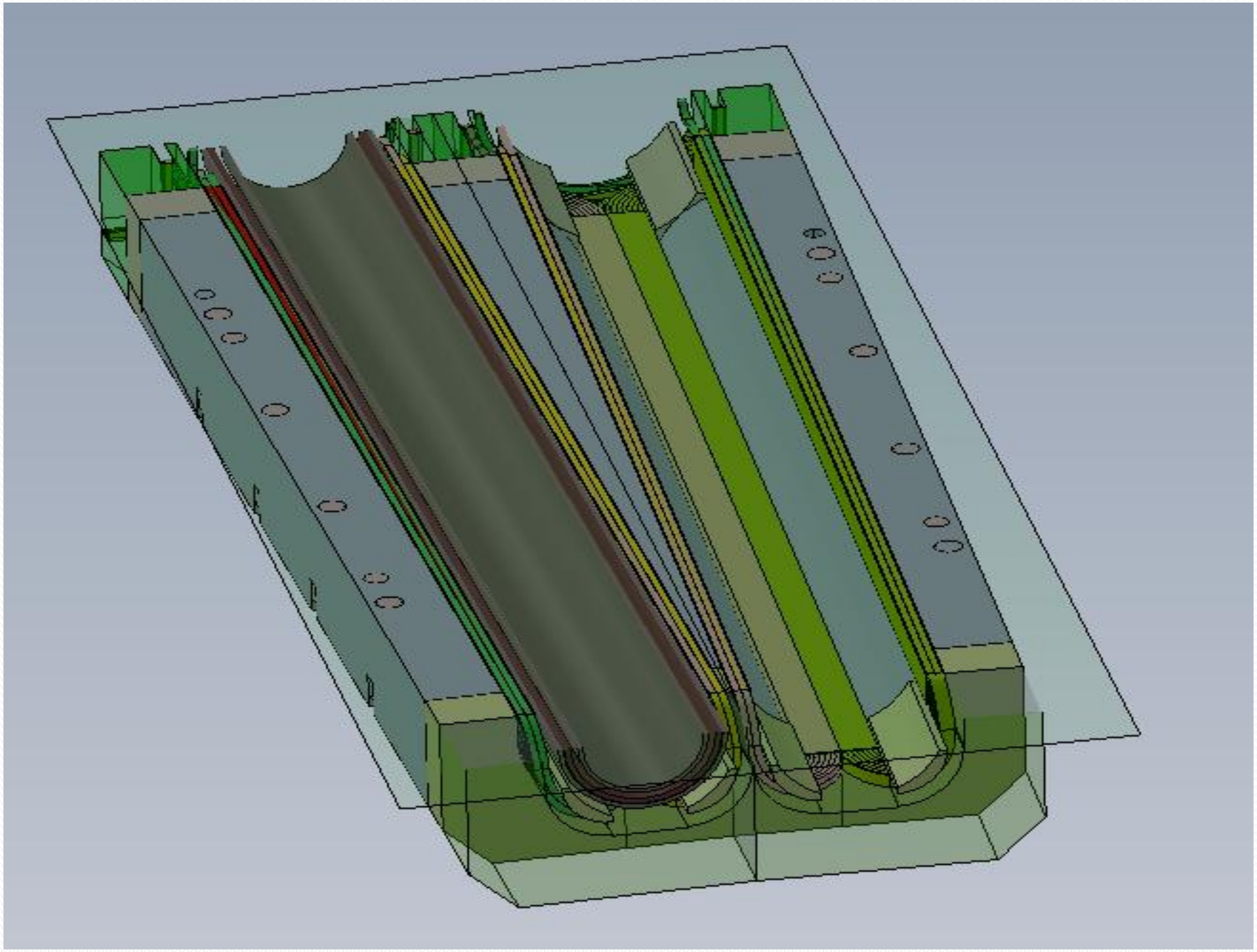
QD0 gradient



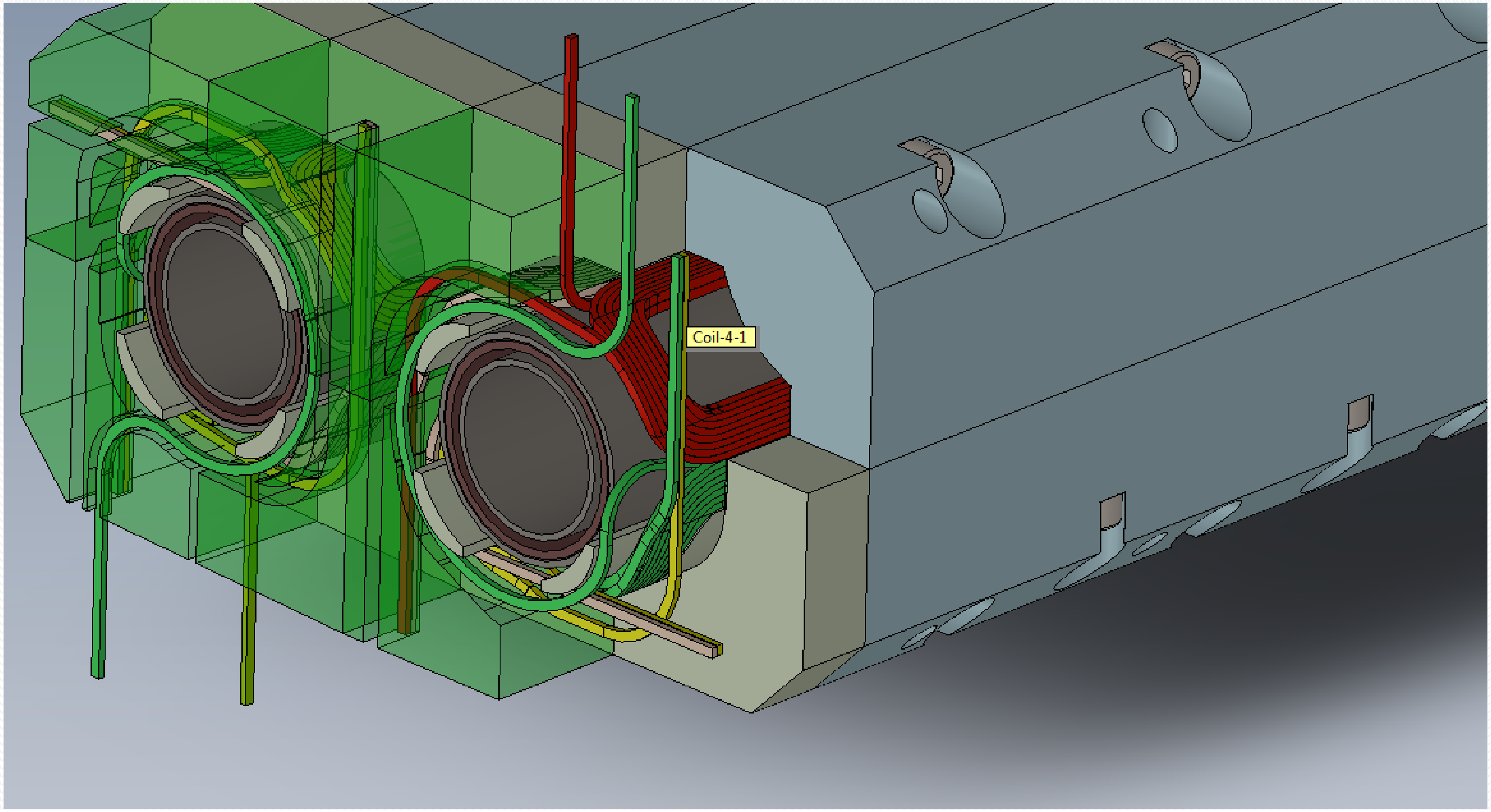
QD0 harmonics for different energy



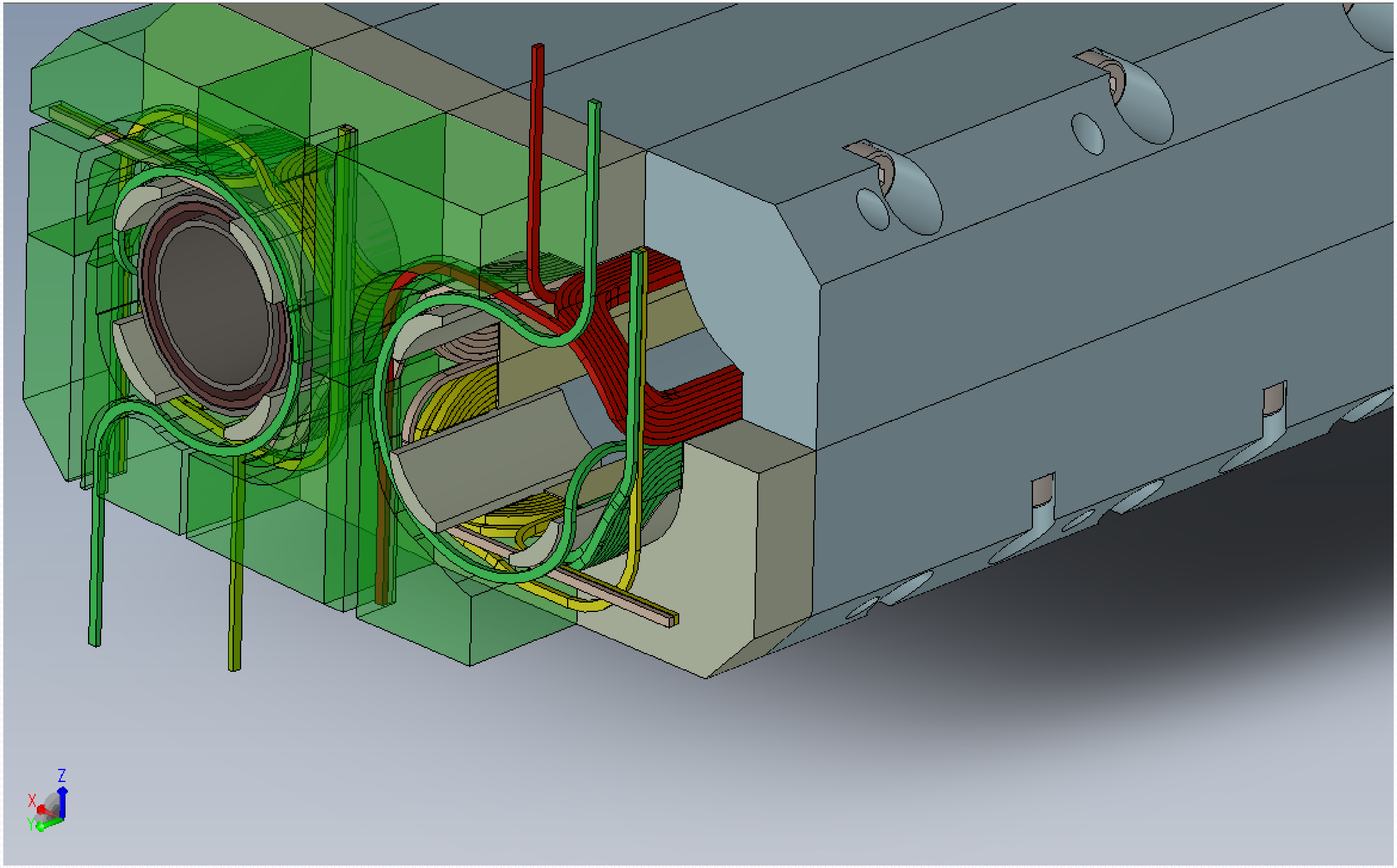
3D model of QD0



3D model of QD0



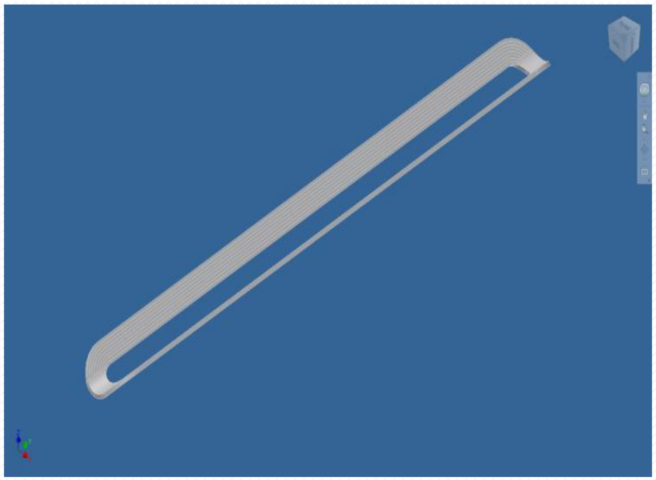
3D model of QD0



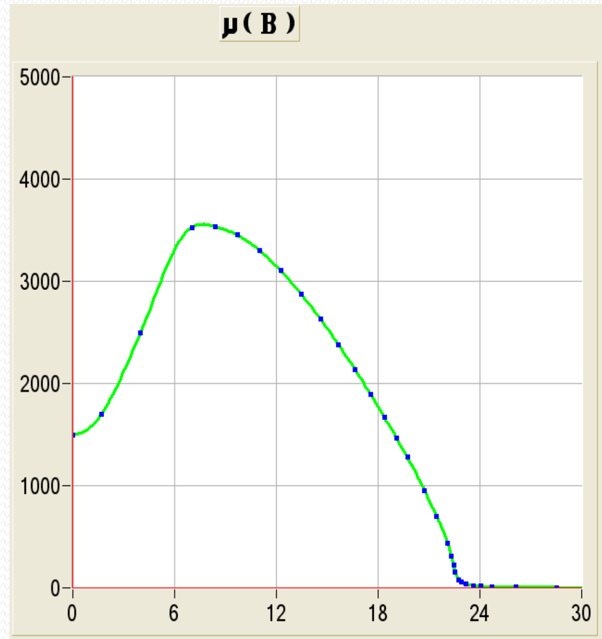
Status on the end of August

- Design of the SC quadrupole is in the final stage
- We have Vanadium Permendur for manufacturing of the lens
- For start we have round SC wire with Ø 0.9 mm
- Oxford Instruments sent us 2 km of rectangular wire (minimum length we can order)
- We are ready to manufacture the winding tool, to start making the protype

Some information on materials



Superconducting coil



Spline

B	μ	μH'
0.000	1500.00	1.00
2.727	2017.42	0.51
5.455	3110.34	0.30
8.182	3545.62	1.10
10.909	3315.85	1.45
13.636	2841.54	1.99
16.364	2207.15	2.90
19.091	1464.02	4.86
21.818	566.38	18.00
24.545	12.25	12.21
27.273	5.77	5.77
30.000	4.03	4.03

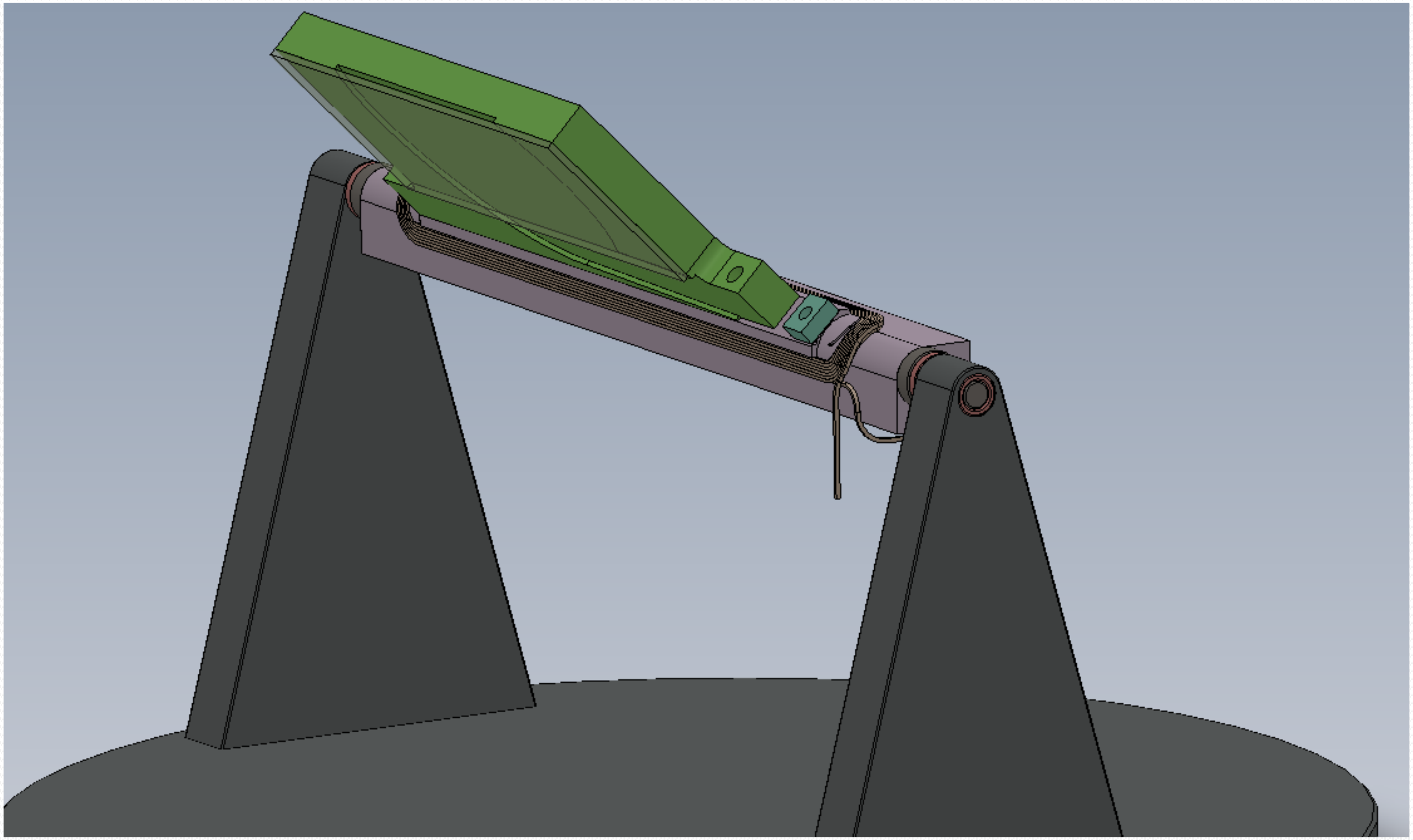
Cu/Sc Ratio (nom)	Bare Size (mm)	Ins. Size (mm)	RRR	Ic Amps (min)	Length (m)	Spool ID
1.35:1	1.20x0.75	1.28x0.83	>70	510@7T	2,730	917
1.35:1	1.00x0.60	Bare	>70	443@6T		908

OXFORD INSTRUMENTS NbTi rectangular superconductor

Saturation curve for Annealed Vanadium Permendur, MARMAID

- **Maximum current at 2.5 GeV is 720 A**
- **Maximum field in yoke at 2.5 GeV is 2 T**

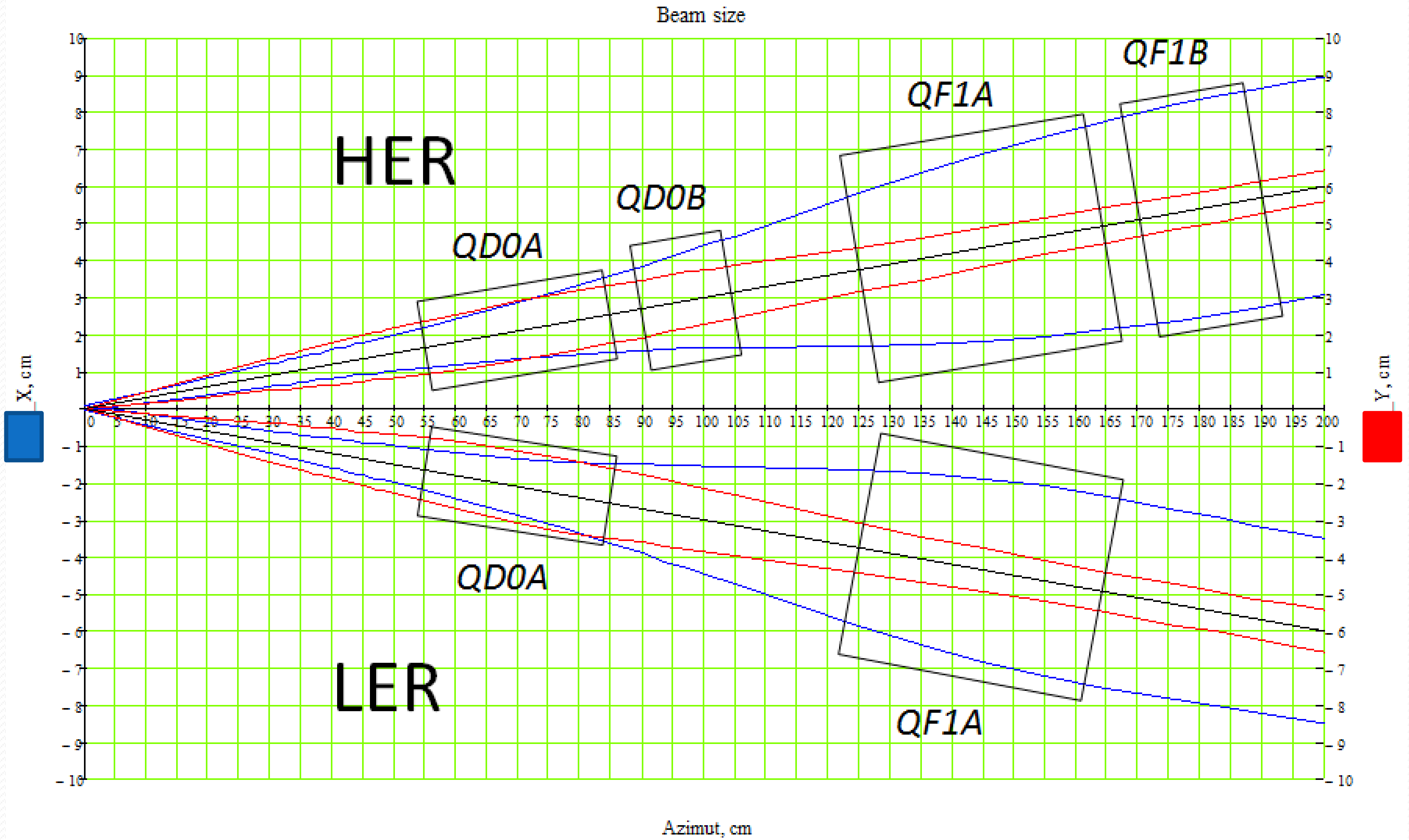
Winding tool



Ready for manufacturing

Application of Siberian QD0 to SuperB

SuperB parameters from M. Sullivan



30 sigma for x & 100 sigma for y

SuperB parameters from M. Sullivan

Half cross angle 30 mrad

Name	S, cm	L_{eff}, cm	G_HER, kGs/cm	G_LER, kGs/cm	R, mm	dR, mm	dH, mm
QD0A	**55**	**30**	**-9,57**	**-9,55**	**10,73**	**4,53**	**18,11**
QD0B	*90*	*15*	*-7,07*	-	*15,84*	*24,46*	*29,37*
QF1A	**125**	**40**	**4,08**	**4,07**	**28,17**	**8,95**	**41,72**
QF1B	*170*	*25*	*3,81*	-	*29,51*	*49,22*	*55,42*

Half cross angle 33 mrad

Name	S, cm	L_{eff}, cm	G_HER, kGs/cm	G_LER, kGs/cm	R, mm	dR, mm	dH, mm
QD0A	**55**	**30**	**-9,57**	**-9,55**	**10,73**	**6,34**	**19,92**
QD0B	*90*	*15*	*-7,07*	-	*15,84*	*30,34*	*32,31*
QF1A	**125**	**40**	**4,08**	**4,07**	**28,17**	**13,12**	**45,89**
QF1B	*170*	*25*	*3,81*	-	*29,51*	*60,30*	*60,96*

dR – place for the cryogenics

dH - distance between detector axes and beam trajectory in the beginning of the lens

Conclusion

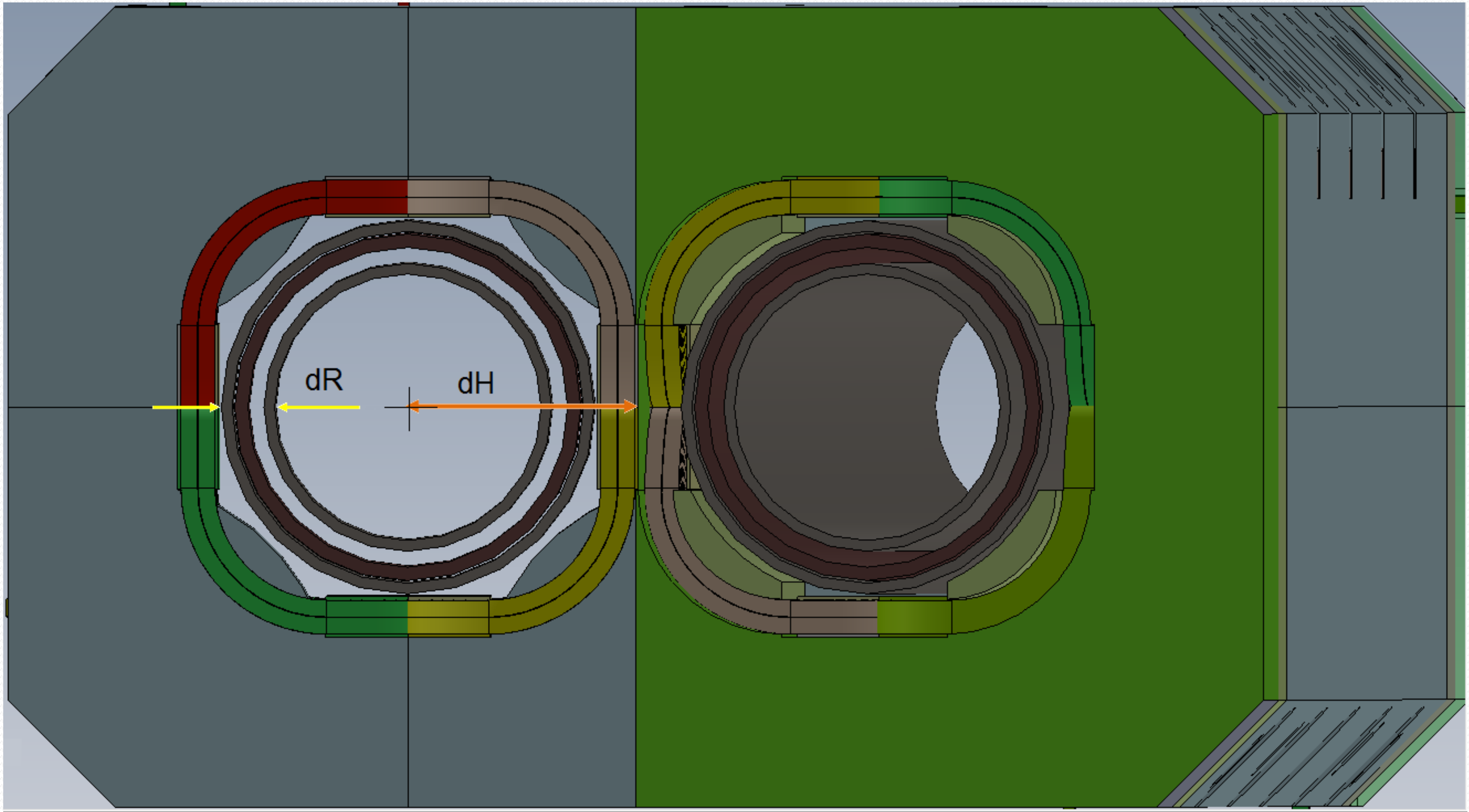
- Design of the FF quadrupole is finished
- It can be applied to SuperB FF
- We can start manufacturing of wending tool

If calculated tolerances is suitable for accelerators structure

- We will start manufacturing of quadrupole prototype in December
- First results from magnetic measurements will be available in the end of the spring

Thanks

Double aperture quadrupole



Raimondi vs. Nosochkov vs. Bogomyagkov