Machine-Detector Interface Status Report

Hongbo Zhu

On behalf of the MDI subgroup

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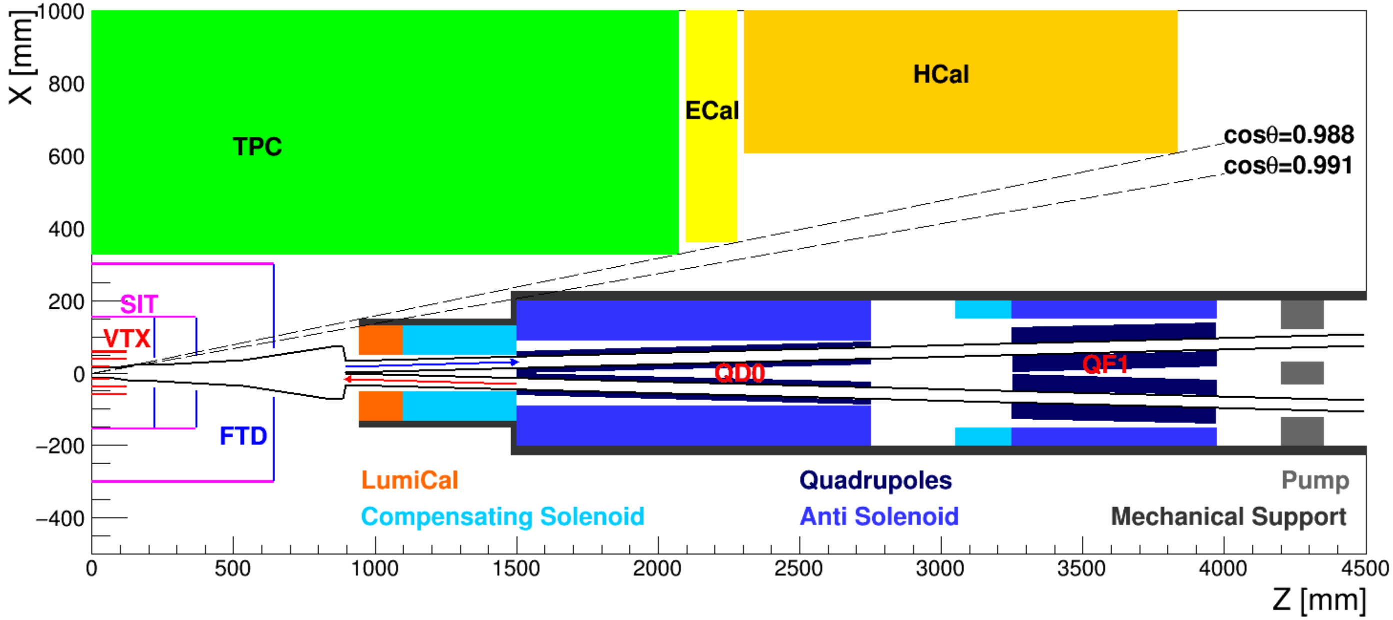
Outline

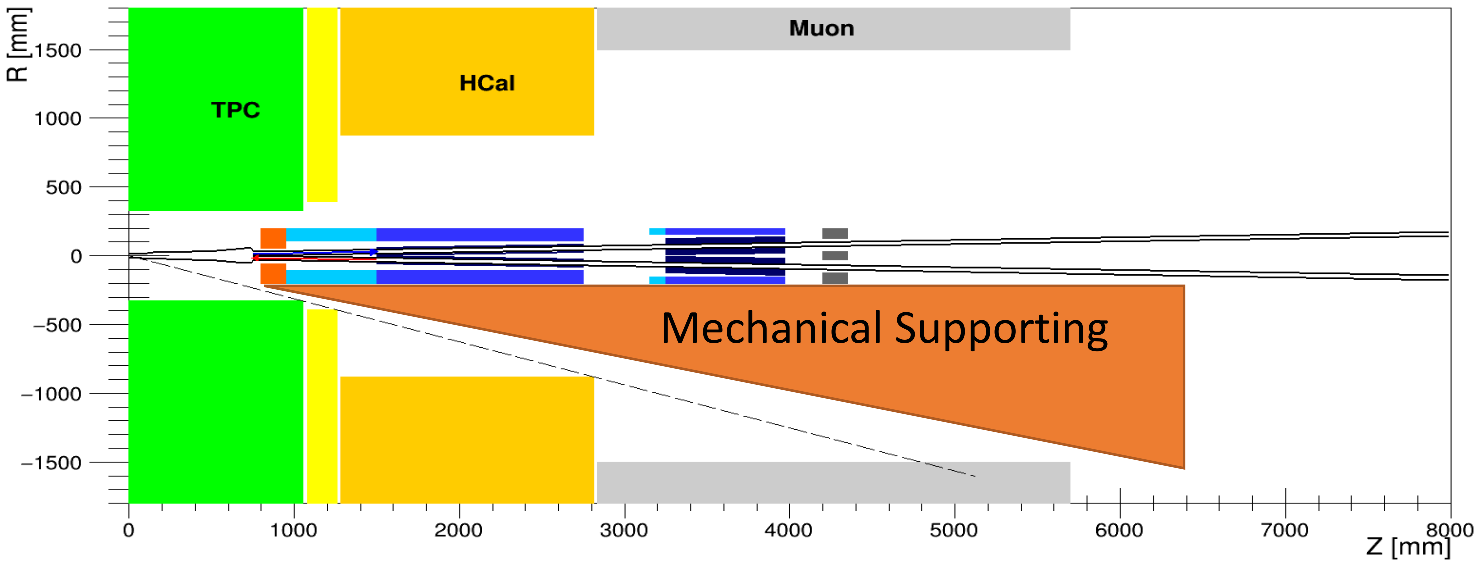
- Interaction region design
- Radiation backgrounds
- Quadrupole and solenoid designs
- Outlook

Interaction Region Design



- Shorter TPC to reduce the impacts of showers introduced by the forward machine elements
- Cone-shaped forward region design to give space for the mechanical support (next slide)
- Weaker solenoid field to shrink the compensating magnet
- Extremely limited space for the luminosity calorimeter

Mechanical Support



- Required space for the mechanical supporting structure: 150 - 300 mrad
- Supporting point ~6 m away from the IP
- Feasibility studies on-going:
  - Stress, deformation and vibration

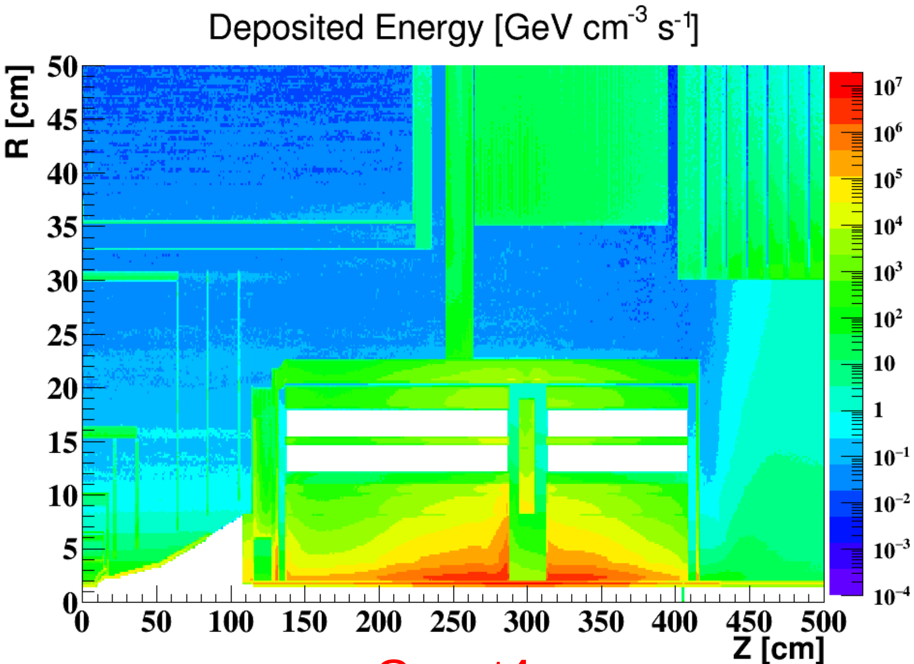
ELEMENT	WEIGHT (kg)
LumiCal	130
QD0 (Including solenoids)	900
QF1	600
Pump	20

Background without Shielding

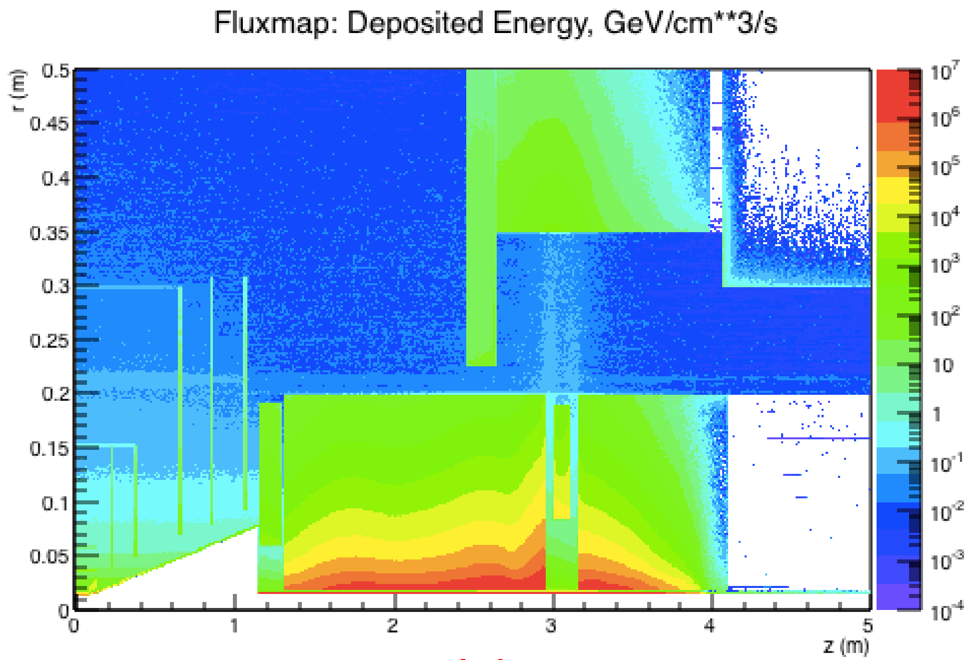
Source	Simulation Tool	Sub-Type	Particle Flux at VTX $[\mathrm{cm}^{-2}\mathrm{BX}^{-1}]$	Particle Energy [GeV]	Priority
Synchrotron Radiation	Geant4; BDSIM	Dipole	$\sim 10^{10}$	~ 0.001	★★★
		Quadrupole	$\sim 10^{6}$	~ 0.007	
Beam Lost Particles	BBBrem; SAD	Radiative Bhabha	~ 10	~ 120	★★
		Beam Gas Scattering	↑	↑	
Beamstrahlung	Guinea-Pig++; PYTHIA6	Pairs	$\sim 10^{-2}$	~ 0.05	★
		Hadrons	$\sim 10^{-5}$	~ 2	

- Software framework to study all beam induced backgrounds fully implemented and well maintained
- Background levels for the single ring design evaluated
- Next step: background levels for the (partial)-double ring

Geant4 vs Fluka: Energy Deposition



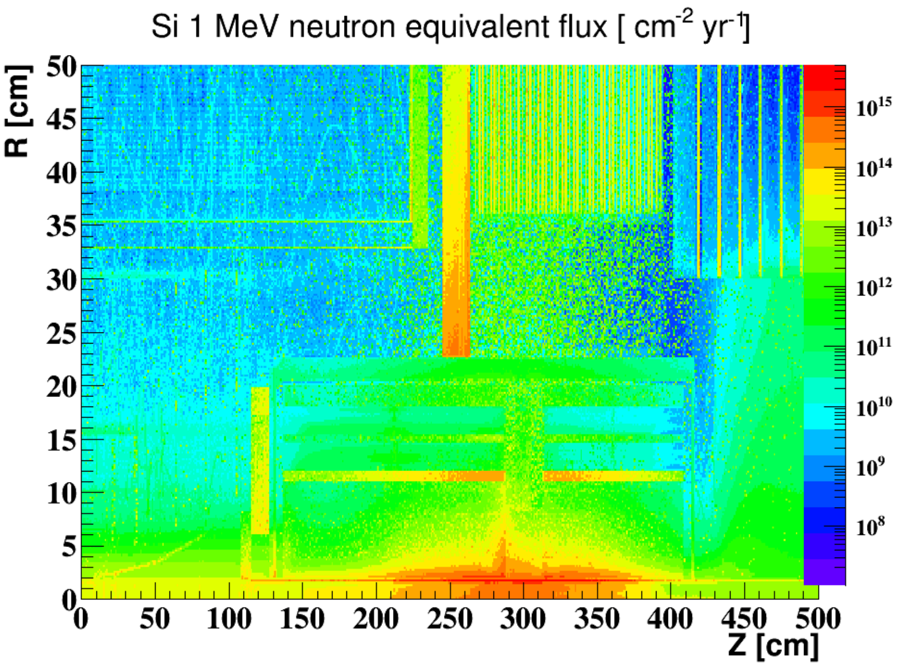
Geant4

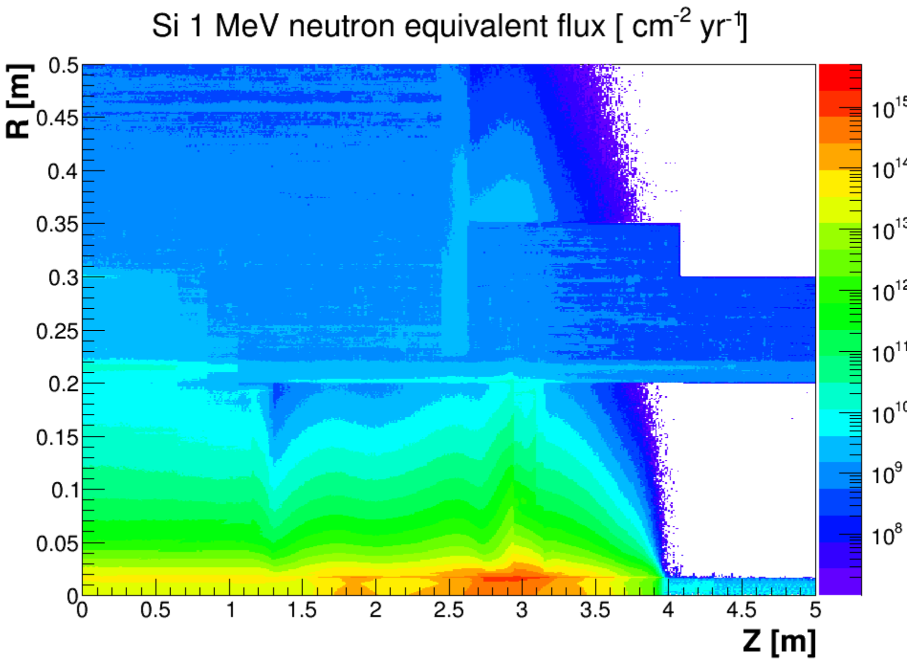


Fluka

- Radiation backgrounds evaluated with both Geant4 and Fluka → almost consistent results
- Implemented geometries still slightly different → *to be harmonized*

Geant4 vs Fluka: NIEL





Geant4 Fluka

- Noticeable difference of the NIEL distributions (1 MeV neutron equivalent) out of Geant4 and Fluka → *to be investigated*

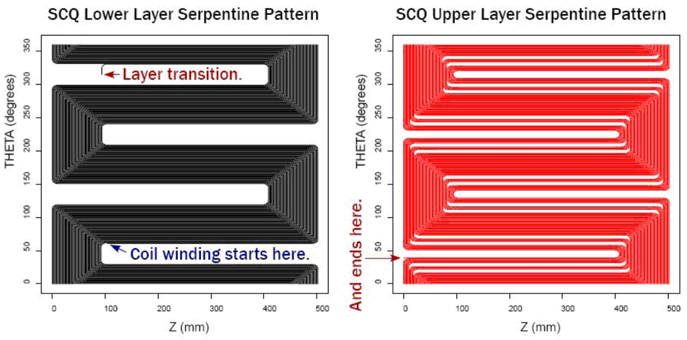
QD0 Design Progress

- Compact and high gradient quadrupole magnets for (partial)-double ring design

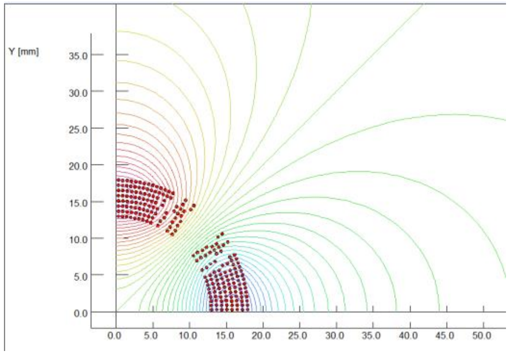
Field gradient (T/m)	Magnet length	Field harmonics	Coil inner radius (mm)
200	1.3	$B_n/B_2 < 5.0\times10^{-4}$ @ r=8 mm	12.5

- Minimum distance between two aperture centerlines ~45mm (coil inner radius of 12.5mm) → extremely tight radial space
- Serpentine winding coil using direct winding selected to achieve high efficiency and high compactness (experience from BEPCII)
- Serpentine coil adopted for BEPCII, J-PARC, ATF2, Super-KEKB, ILC baseline design, etc.

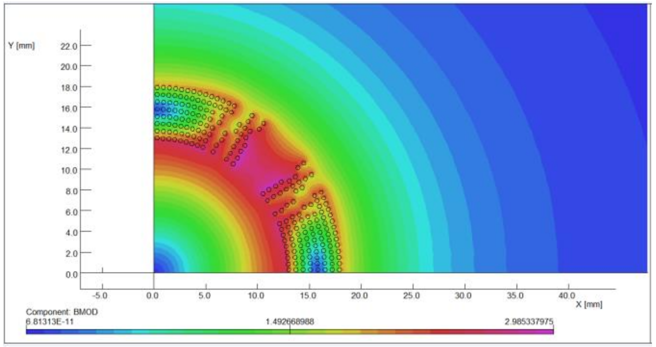
QD0 Design Progress cont.



Planar view of Serpentine winding



2D flux lines

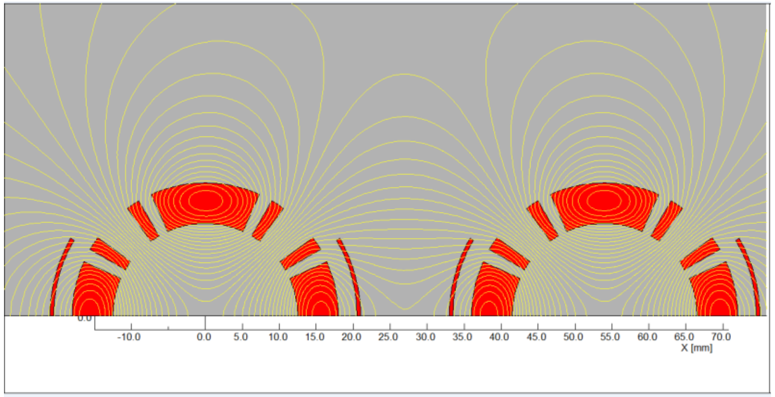


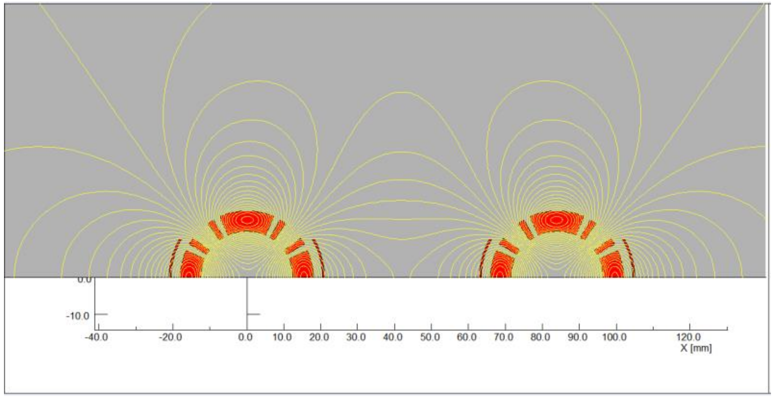
Magnetic flux density distribution

- QD0: small-aperture and long iron-free magnet
- Coils to be made of 0.5 mm round NbTi-Cu conductor using the direct winding technology.
- In total eight Serpentine coil layers (collar not needed)
- 110 coil turns per pole with excitation current of 340A.
- 2D magnetic field calculated: field quality in each aperture satisfying after optimisation

Field Cross Talk

- Significant field cross talk due to the small distance between the two magnets → additional layer of shield coil outside of the quadrupole to improve the field quality (multipole field reduced to below 5×10^{-4})





QD0 main design parameters

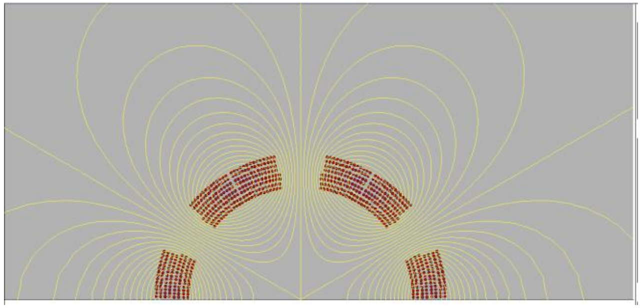
Magnet name	QD0
Field gradient (T/m)	200
Magnetic length (m)	1.3
Coil turns per pole	110
Excitation current (A)	340
Coil layers	8
Conductor size (mm)	NbTi-Cu Conductor, ∅ 0.5mm
Stored energy (KJ)	6.0
Inductance (H)	0.11
Peak field in coil (T)	3
Coil inner diameter (mm)	25
Coil out diameter (mm)	44
Coil mechanical length (mm)	1350

Sextupole Magnet Design

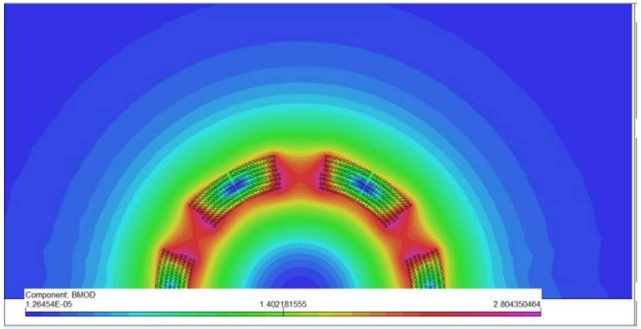
- Requirements:

Strength (T/m^2)	Magnet length	Field harmonics	Coil inner radius (mm)
12800	0.3	$B_n/B_2 < 5.0\times10^{-3}$ @ r=12 mm	18

- Eight Serpentine coil layers, 104 coil turns per pole



2D flux lines

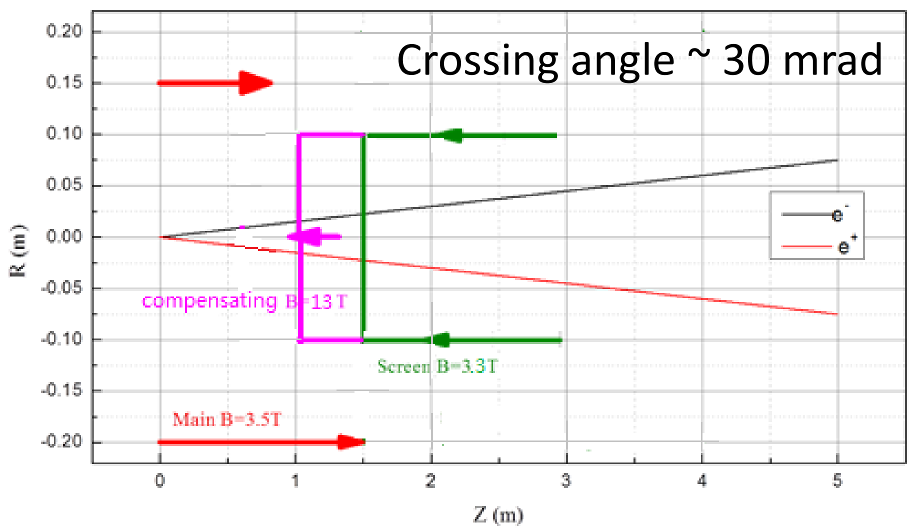


Magnetic flux density distribution

Sextupole main parameters

Magnet name	Sextupole magnet
Field strength (T/m^2)	12800
Magnetic length (m)	0.3
Coil turns per pole	104
Excitation current (A)	300
Coil layers	8
Conductor size (mm)	NbTi-Cu Conductor, ∅ 0.5mm
Stored energy (J)	750
Inductance (H)	0.017
Peak field in coil (T)	2.9
Coil inner diameter (mm)	36
Coil out diameter (mm)	50
Coil mechanical length (mm)	350

Compensating/Screening Solenoids



- To minimize the effects of the longitudinal detector solenoid field on the accelerator beam
- Integral longitudinal field generated by the detector solenoid and solenoid coils should cancel out.
- **Screening solenoid** (outside of QD0): the longitudinal field inside the quadrupole bore should be 0.

Compensation conditions:

*B*_main**L*_main+*B*_comp**L*_comp=0

*L** = *L*_main +*L*_comp = 1.5m

- **Compensating solenoid options** (before QD0):
  - 1m long, center field: 5.2T (NbTi) → 0.7m long, center field: 7.4T (NbTi) → 0.4m long, center field: 13T (Nb3Sn)

Outlook

- Expect to receive the first “workable” lattice design for the partial double ring design
- Revise the interaction region design (layout, collimators, mechanical support, etc.)
- Re-evaluate the radiation backgrounds