Anti-Solenoid and Anti-DID

A view from the detectors (mostly ILD…)

Karsten Buesser
IDT-WG2 DR/BDS/Dump Meeting
27.10.2020

Detector Integrated Dipole DID

Paper from B. Parker and A. Seryi: PR ST 8, 041001 (2005)

- At this time ILC had still 20 mrad crossing angle

Conclusion:

Compensation of the effects of a detector solenoid on the vertical beam orbit in a linear collider

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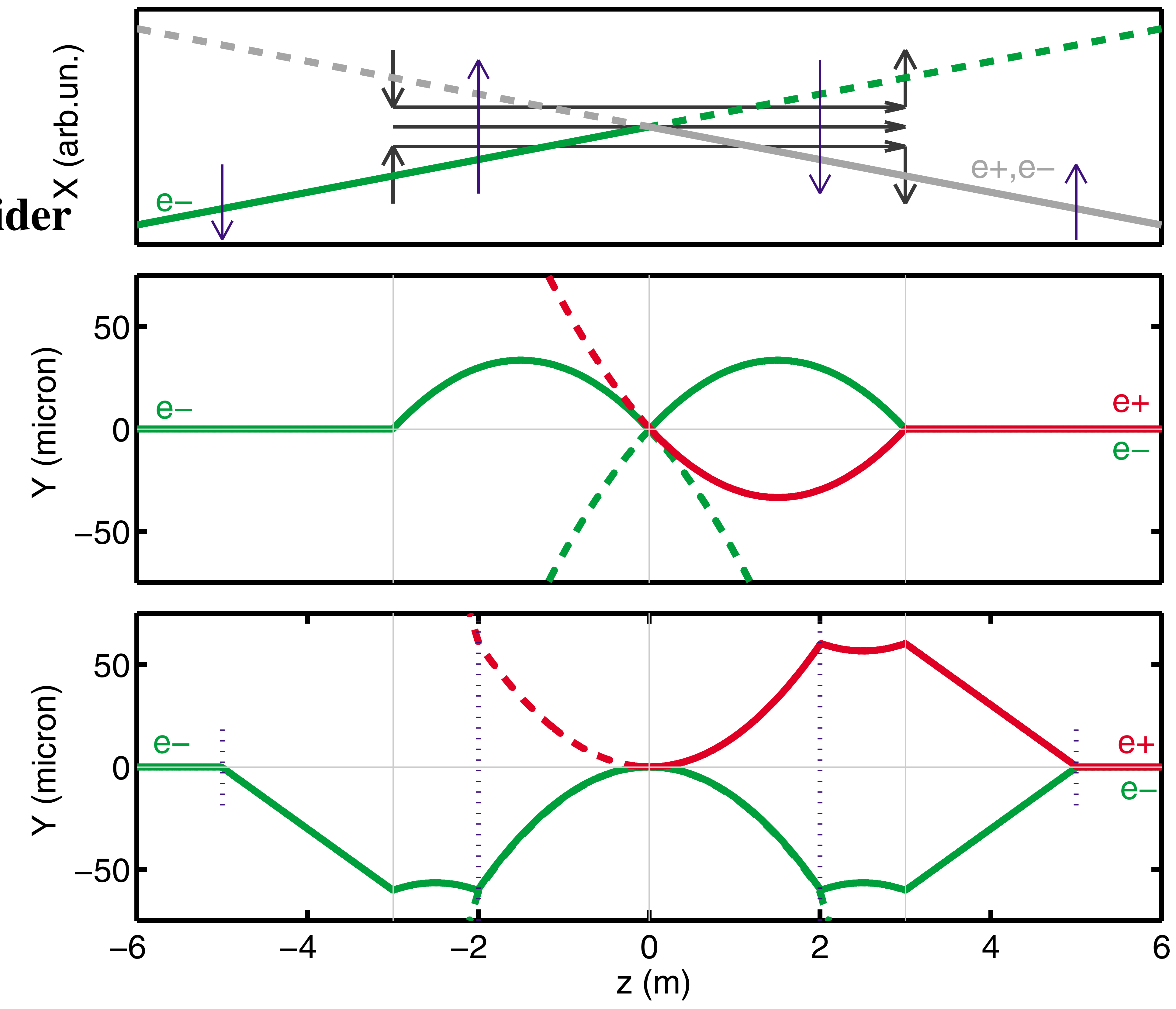
(Received 19 January 2005; published 1 April 2005)

This paper presents a method for compensating the vertical orbit change through the interaction region that arises when the beam enters the linear collider detector solenoid at a crossing angle. Such compensation is required because any deviation of the vertical orbit causes degradation of the beam size due to synchrotron radiation, and also because the nonzero total vertical angle causes rotation of the polarization vector of the bunch. Compensation is necessary to preserve the luminosity or to guarantee knowledge of the polarization at the interaction point. The most effective compensation is done locally with a special dipole coil arrangement incorporated into the detector (detector integrated dipole). The compensation is effective for both e^+e^- and e^-e^- beams, and the technique is compatible with transverse-coupling compensation either by the standard method, using skew quadrupoles, or by a more effective method using weak antisolenoids.



From DID to Anti-DID

Parker/Seryi reacted quickly to the Snowmass discussions on detector backgrounds: SLAC-PUB-11662

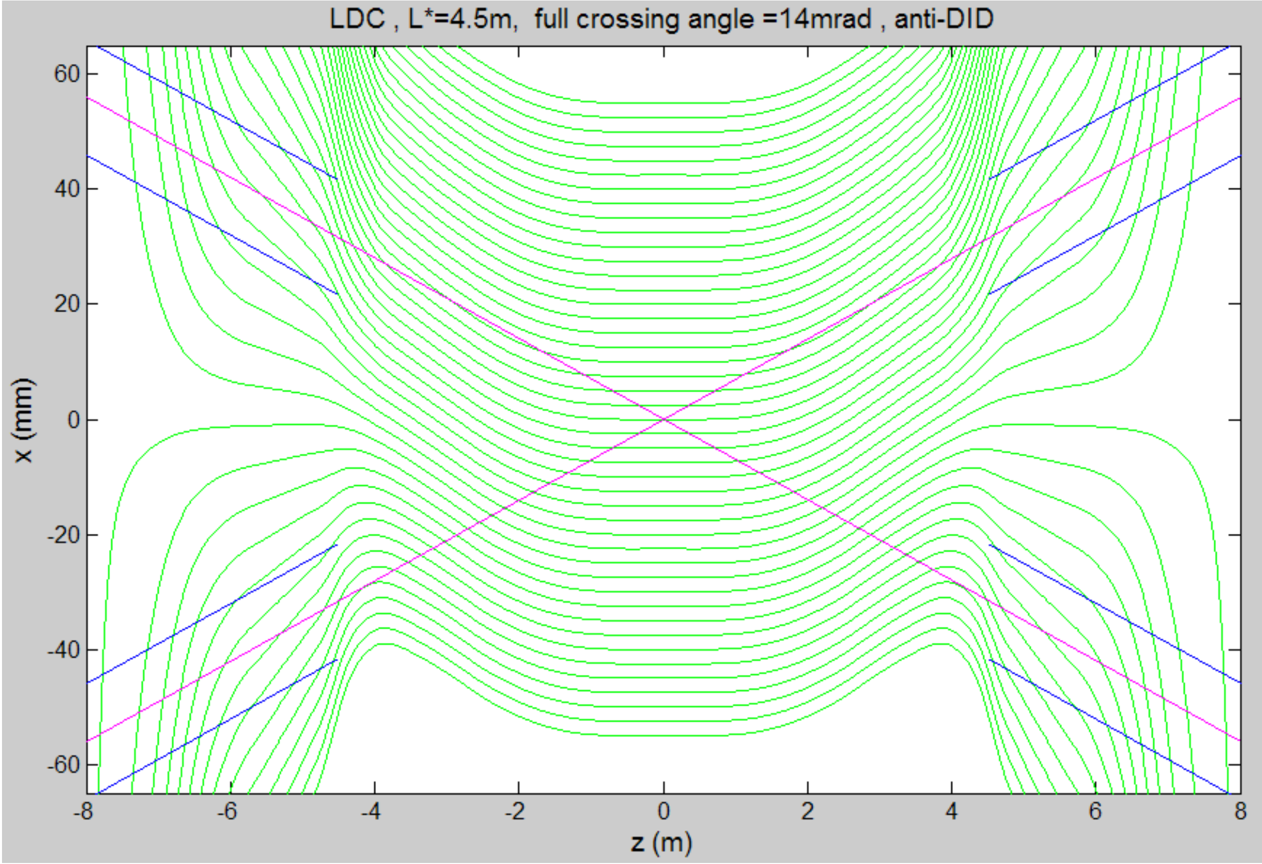
Crossing angle was reduced to 14mrad

- SR effects were strongly reduced
- beam angle could be corrected with other magnets in the final focus

Changing the polarity of the DID to Anti-DID turns the device from a „machine requirement“ to a „nice-to have for the detectors“

Significant reduction of energy deposited on BeamCal

- Interesting for searches for BSM physics



IR OPTIMIZATION, DID AND ANTI-DID*

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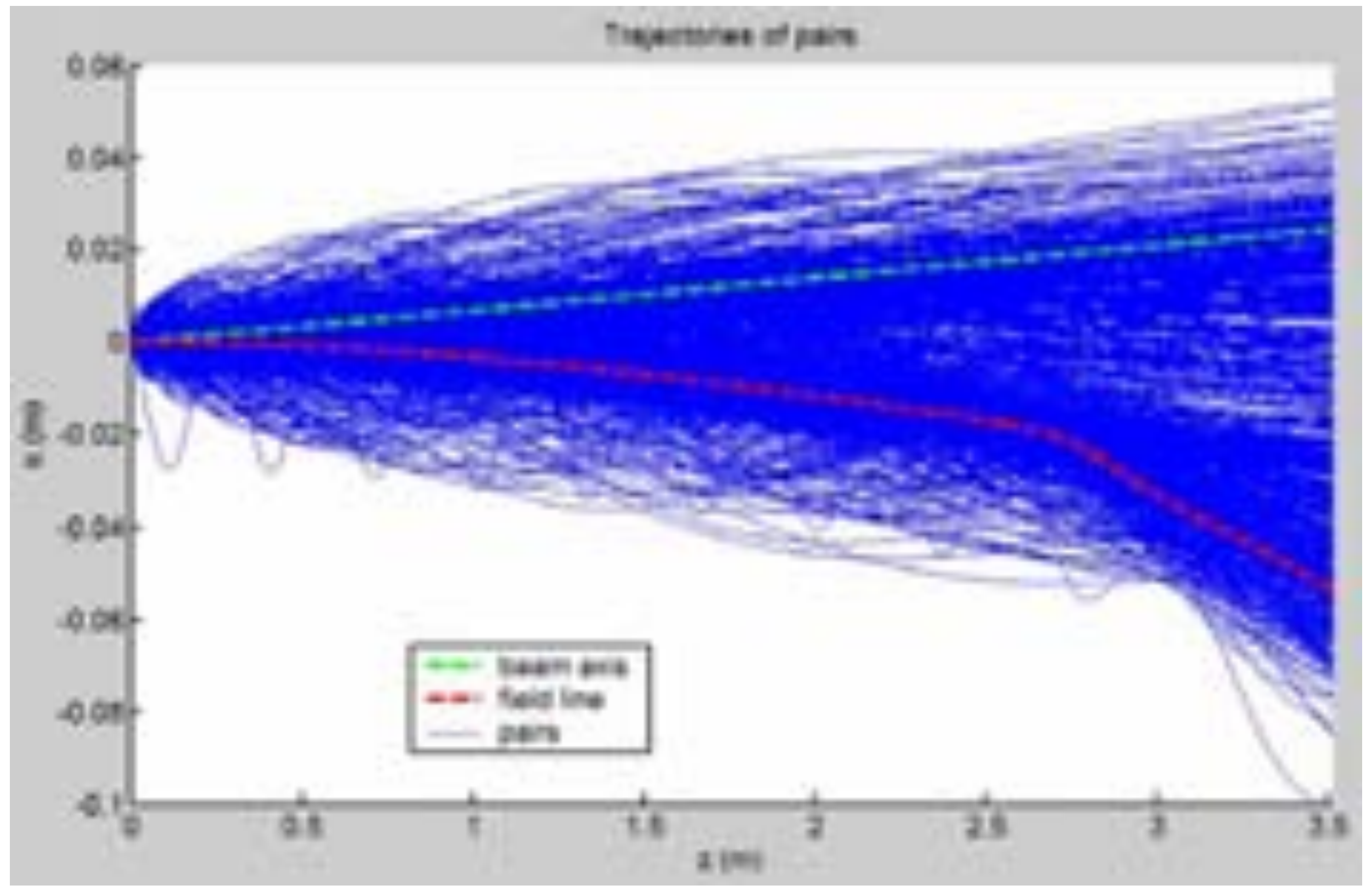
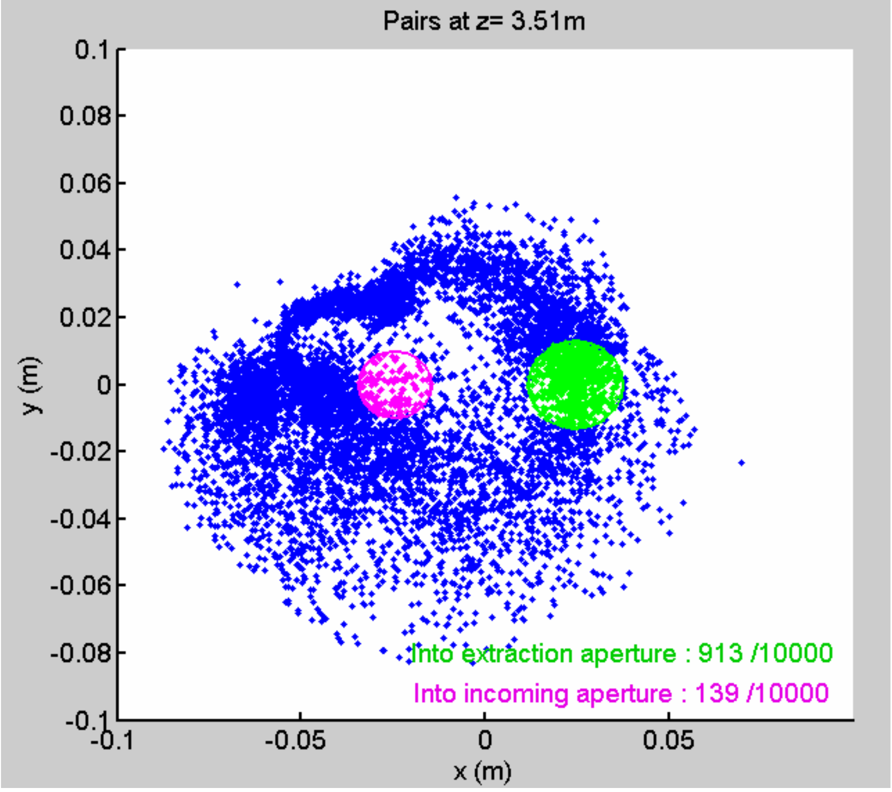
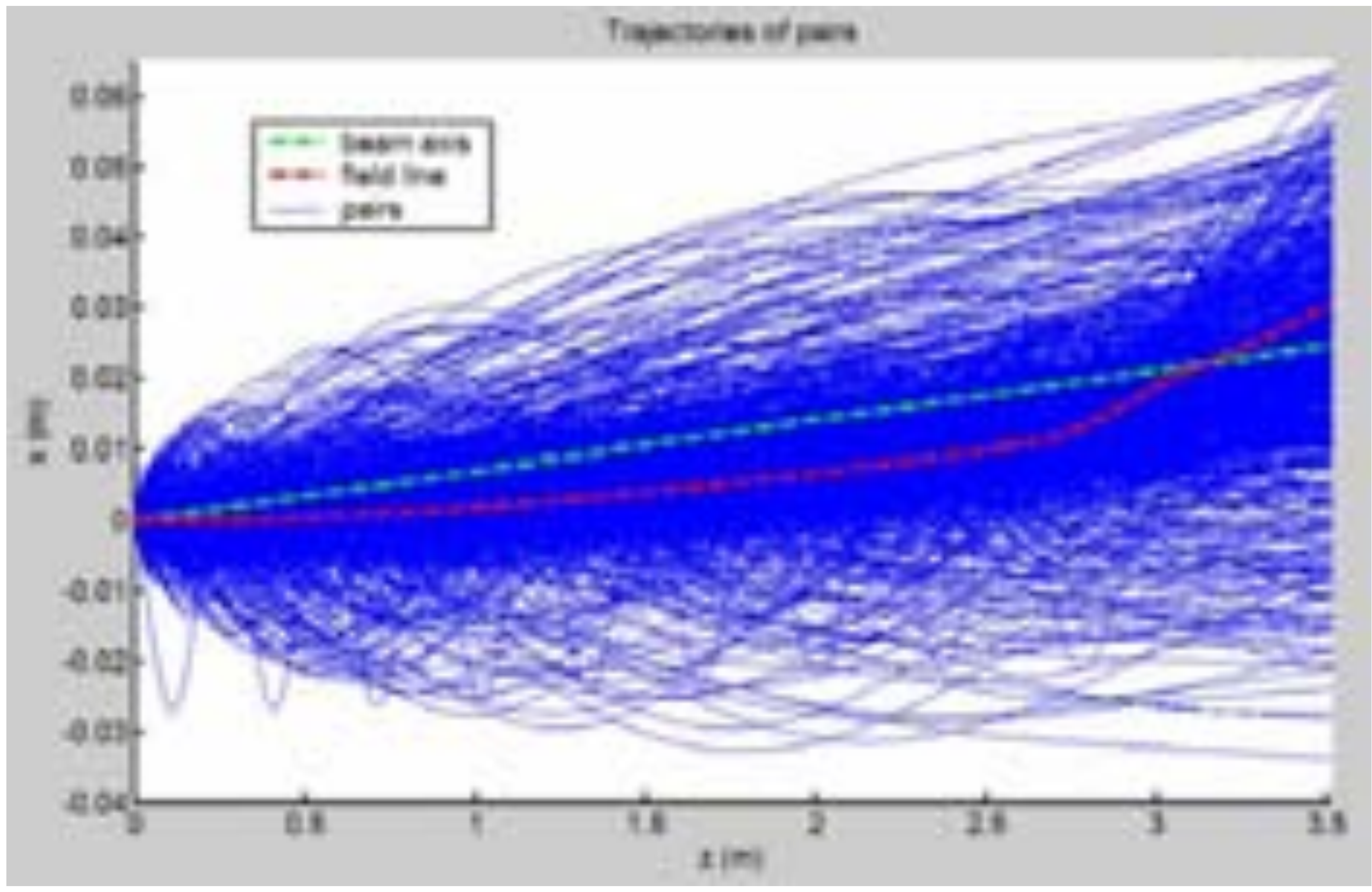
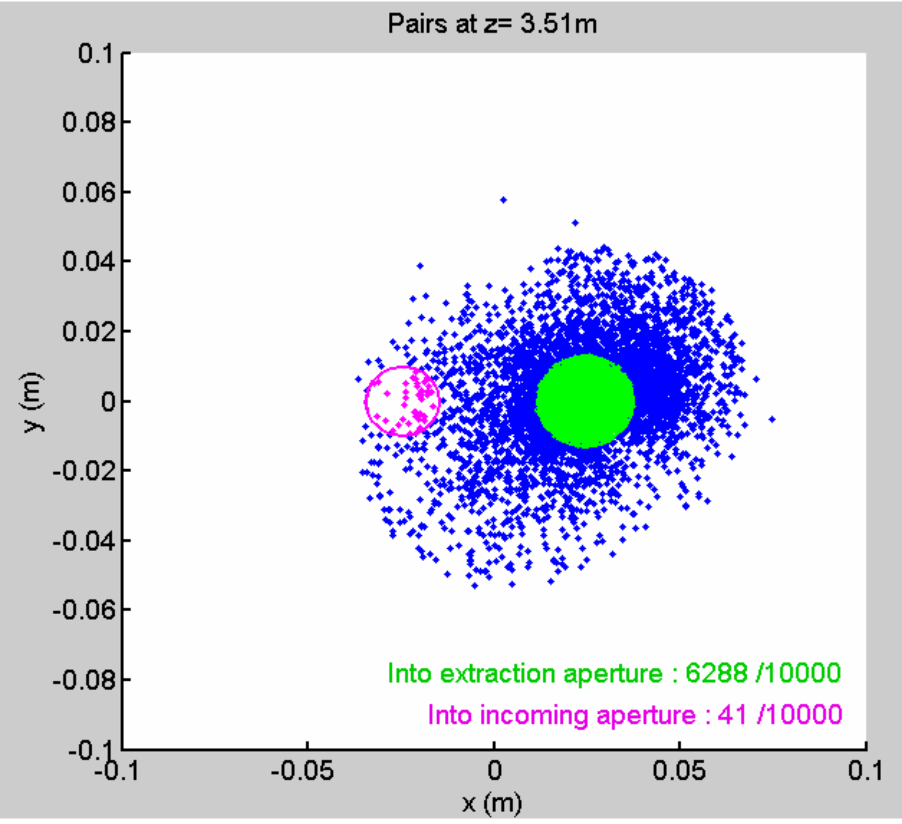






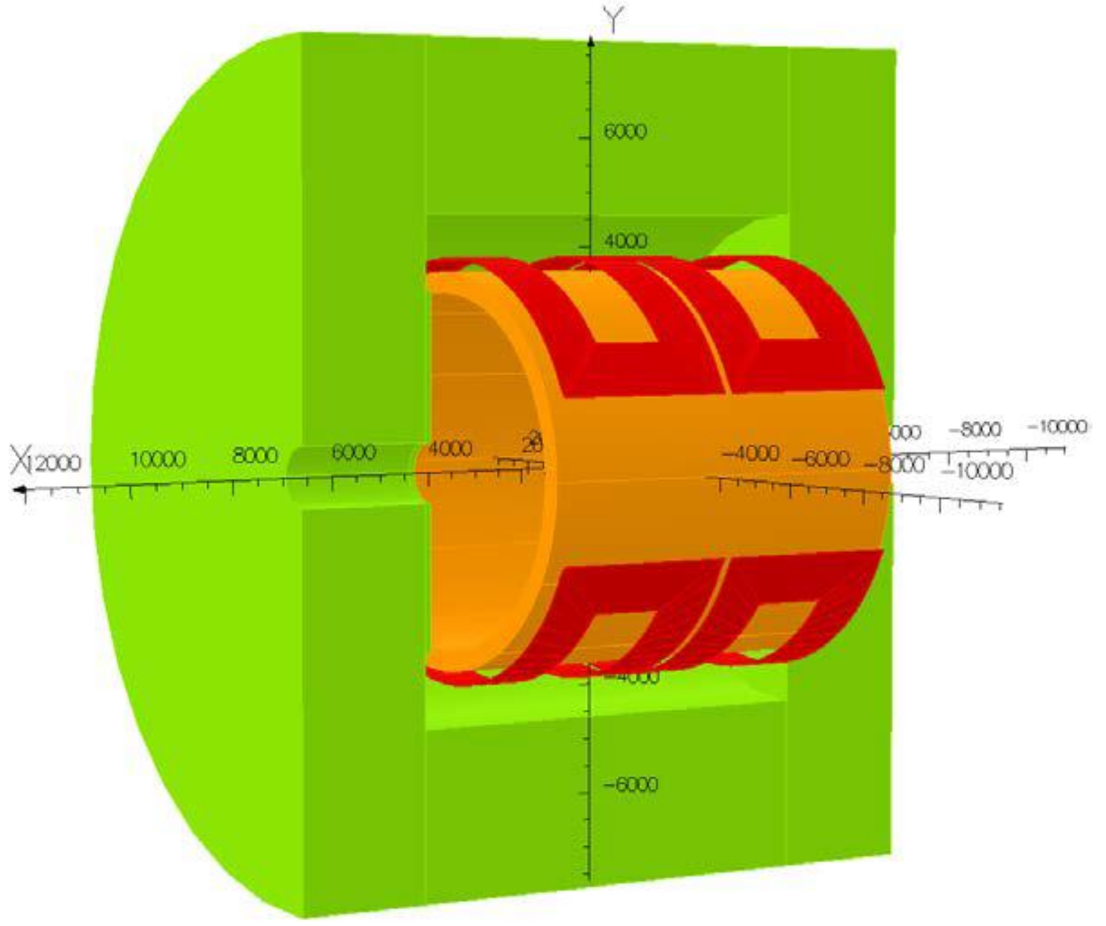


Field Studies (Toshiba)

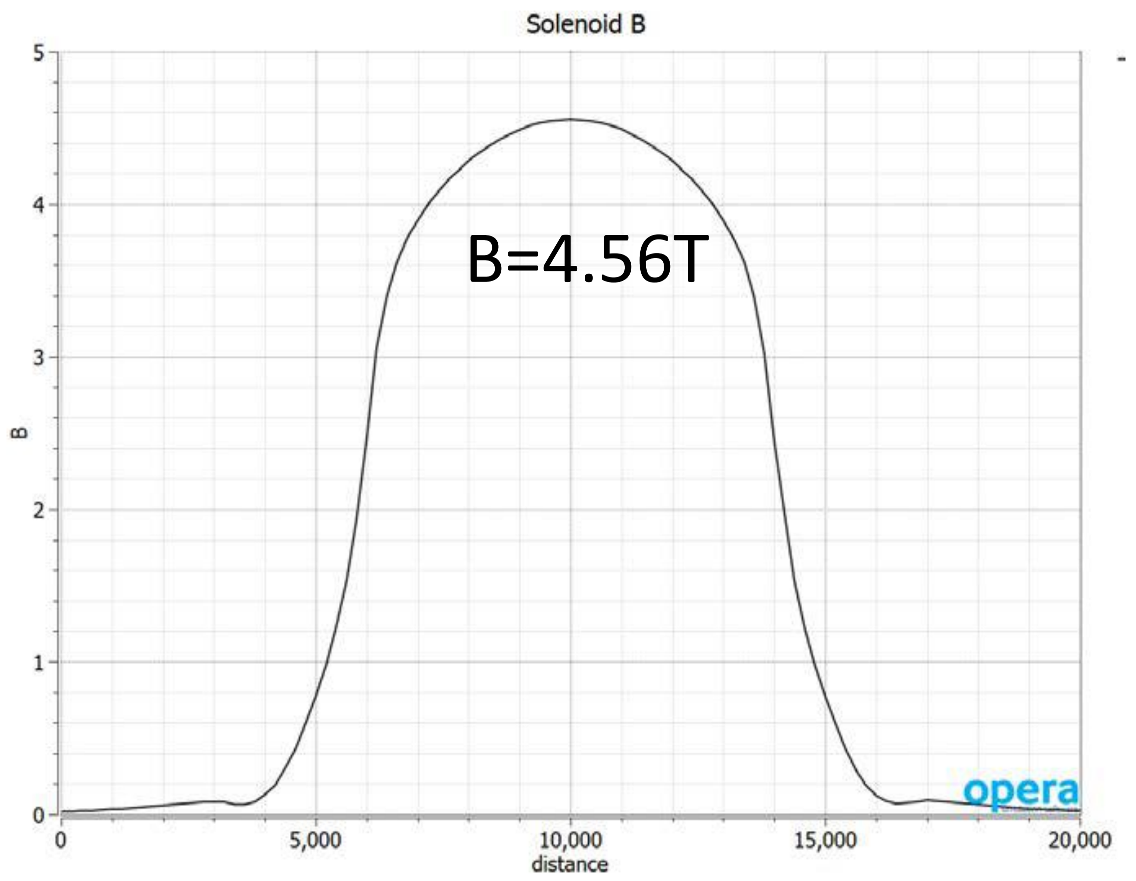
Y. Makida (09/2017)

Design Study by Toshiba Solenoid Field

I.R. (mm)29.7	3215	Axial turn #	40
O. R. (mm)	3570	Radial turn #	11
L (mm)	7350	Total turn #	440
Conductor axial W (mm)	61.3	Current (kA)	22.5
Conductor radial W (mm)	32.3	Current Density (A/mm^2)	11.4
		Ampere Turn (MAt)	29.7

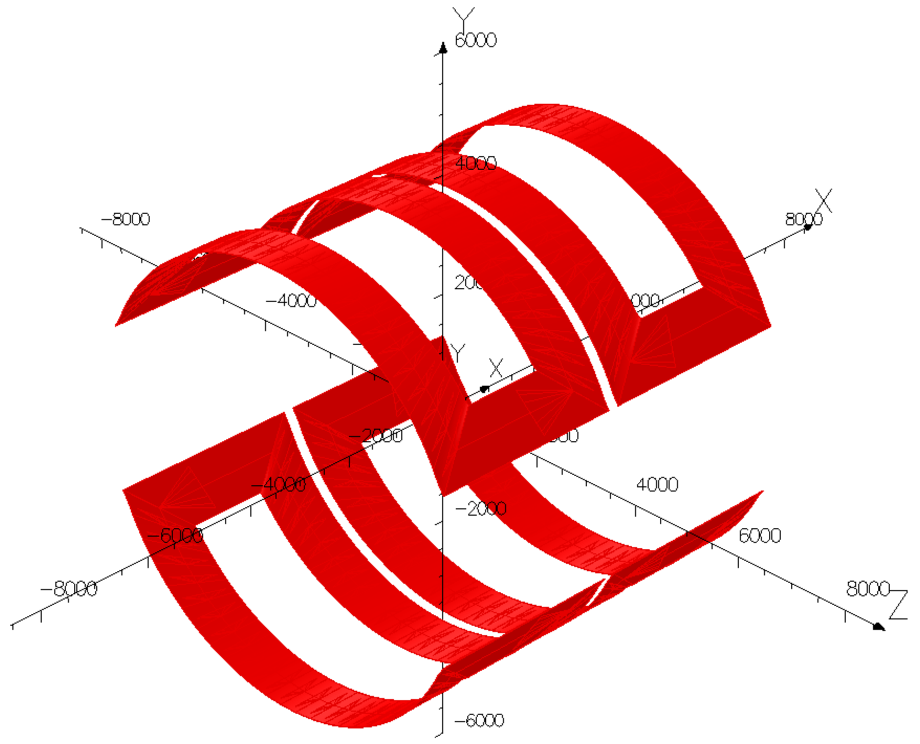


Sored Energy 2.16GJ

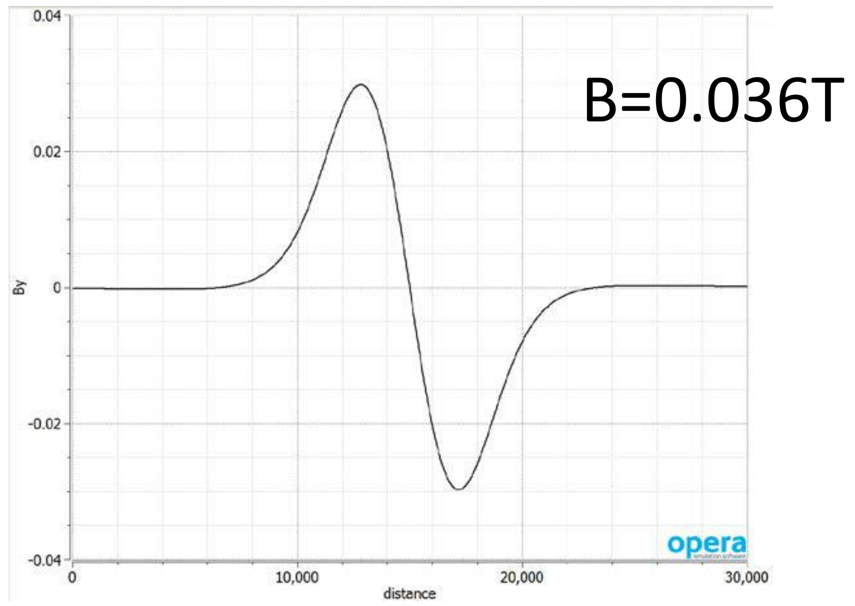


Design Study by Toshiba Anti-DID

I.R. @ Curve (mm)	3760	Straight region elevation angle (degree)	30
O. R. @ Curve(mm)	3768	Radial turn #	150
L @ straight (mm)	1200	Thickness turn #	2
Winding W (mm)	1000	Total turn #	300
Winding Thickness (mm)	8	Current (A)	1067
Conductor Width (mm)	6.67	Current Density (A/mm^2)	40
Conductor Thickness (mm)	4	Ampere Turn (MAt)	0.32



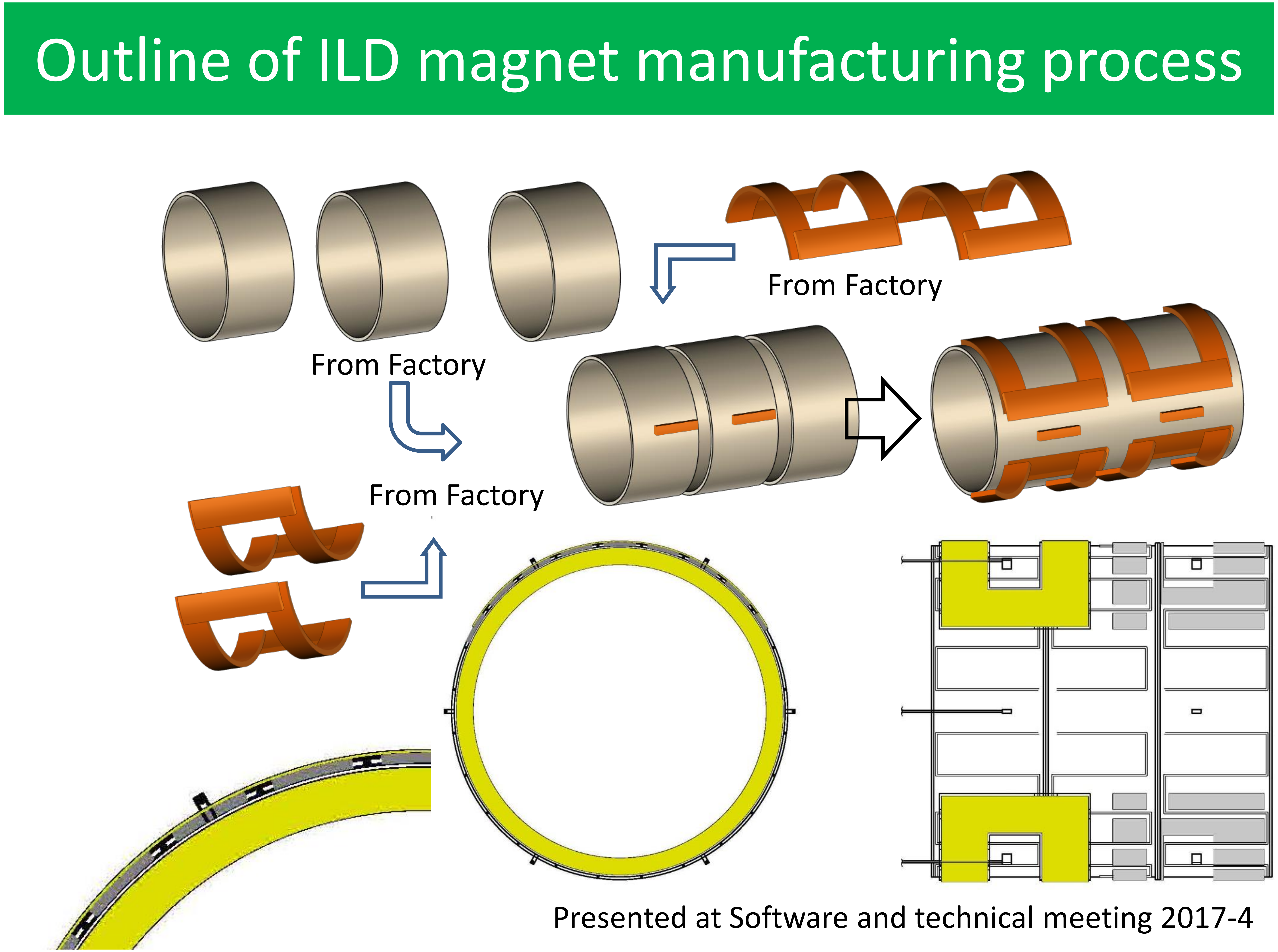
Sored Energy 0.179GJ



Solenoid Assembly

Y. Makida (10/2018)

- Result from industry studies with Toshiba and Hitachi
- Assembly of complete magnet (solenoid and Anti-DID) on surface
- Lowering CMS-style to underground area



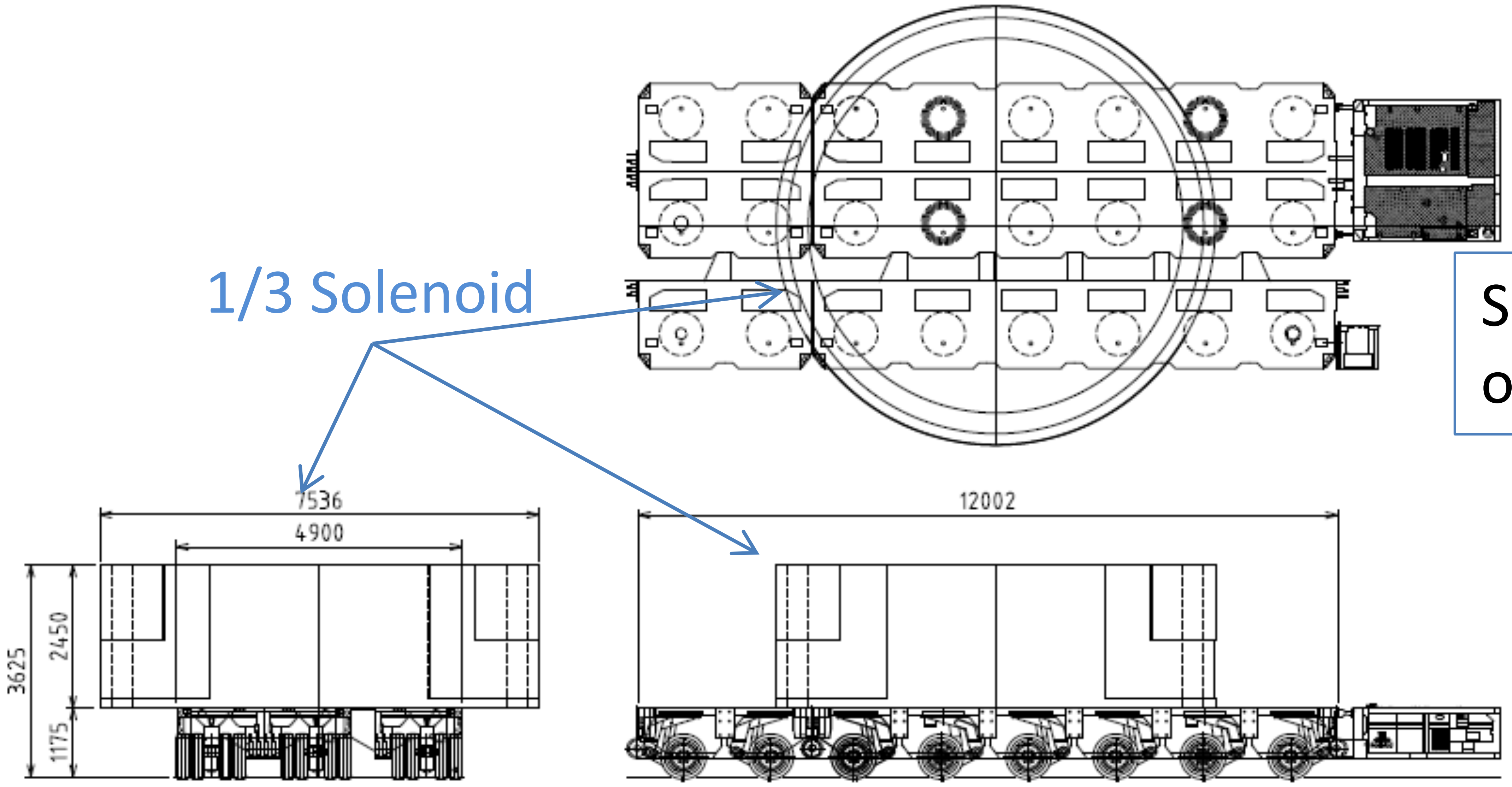
Magnet Transport

Transportation Proposal by Toshiba

Y. Makida (10/2018)

- Study from Toshiba
- Magnet elements to be transported from manufacture to ILC site

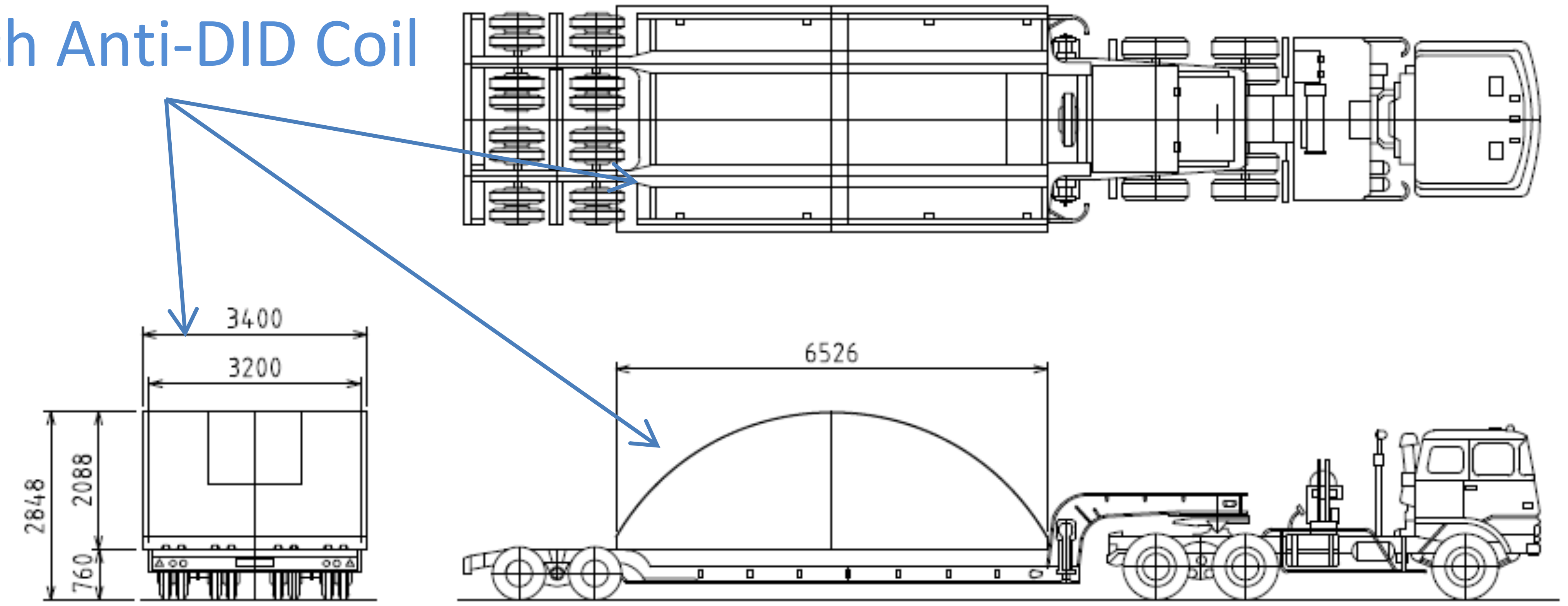
1/3 Solenoid



Special permission on public roads

Solenoid Transportation by “**JUMBO CARRIER**”

Each Anti-DID Coil



Anti-DID Transportation by low-floor trailer

- From view point of transportation from factory to ILC site, solenoid and anti-DID size are considered.
- Anti-DID is smaller and simpler, which meet the field requirement.
- Anti-DID coils are wound in a factory and are set on solenoid in an assembly build on-site.

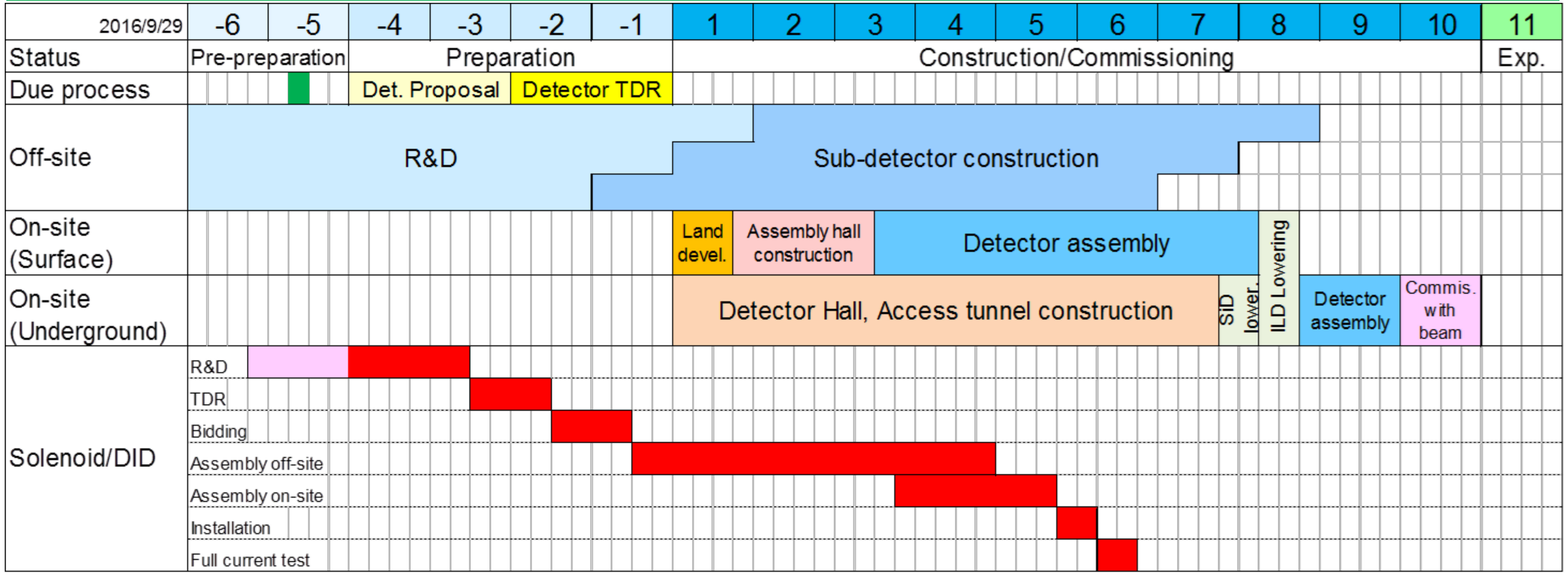
Solenoid Construction Timeline

Y. Makida (10/2019):

- Pre-preparation:
  - 2y
- Preparation:
  - 4y
- Construction:
  - 5y
- Installation/Commissioning:
  - 1y

- TOTAL:
  - ~11y

Solenoid Manufacture Time Line



R&D subjects before TDR

① Conductor Design
- Manufacturable dimension
- AL stabilizer material

② Technological components
- Internal multilayer winding
- Aluminum pipe welding
- Conductor joint

Assembly off-site (in Factories)

① 3 solenoid coil units (**C**old **M**ass)

② 4 anti-DID coils

③ Several **R**adiation **S**hield units

④ Several **V**acuum **V**essel units

Assembly on-site

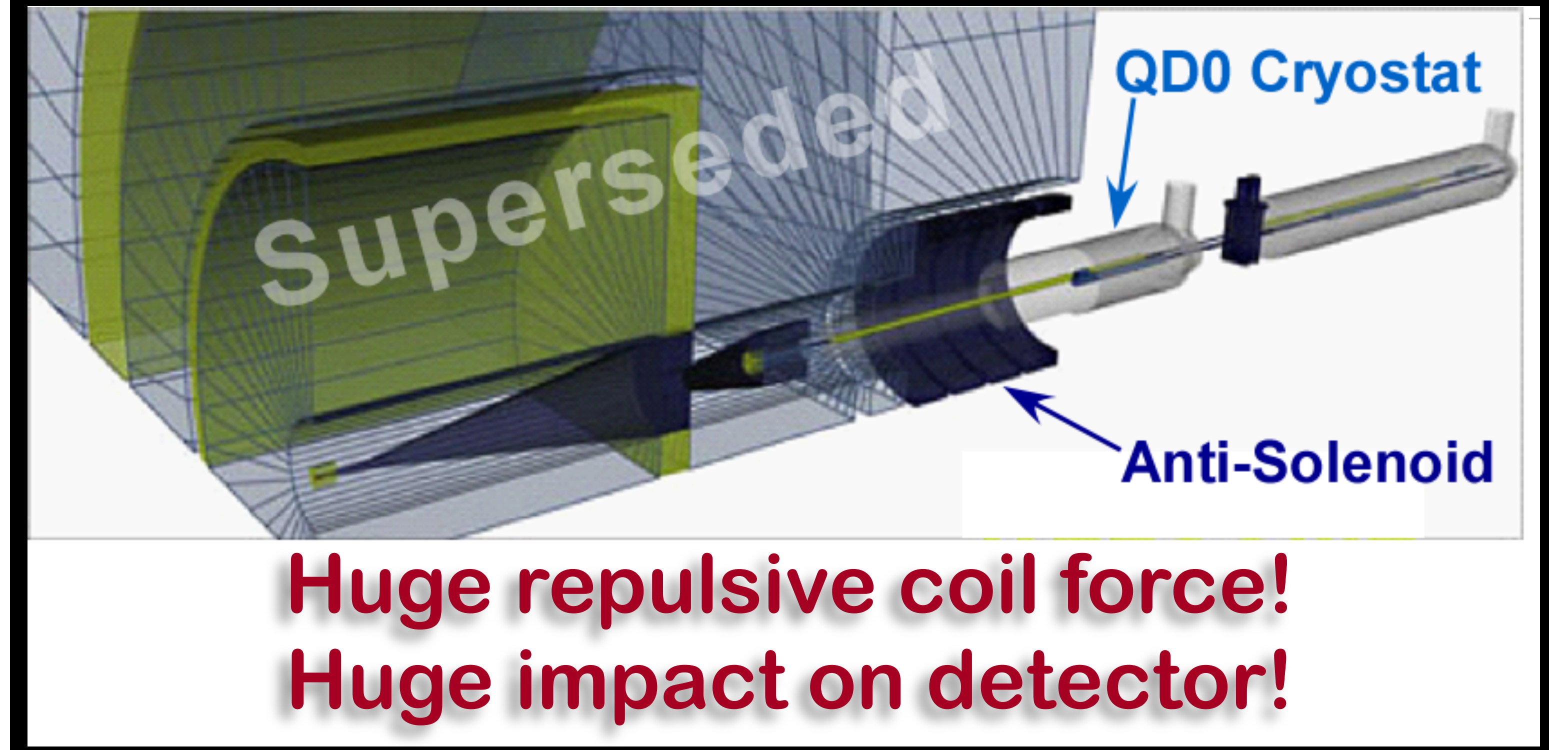
① Completion CM, inner & outer RS and inner & outer VV

② Composition CM, RS , VV and Yoke

Anti-Solenoid

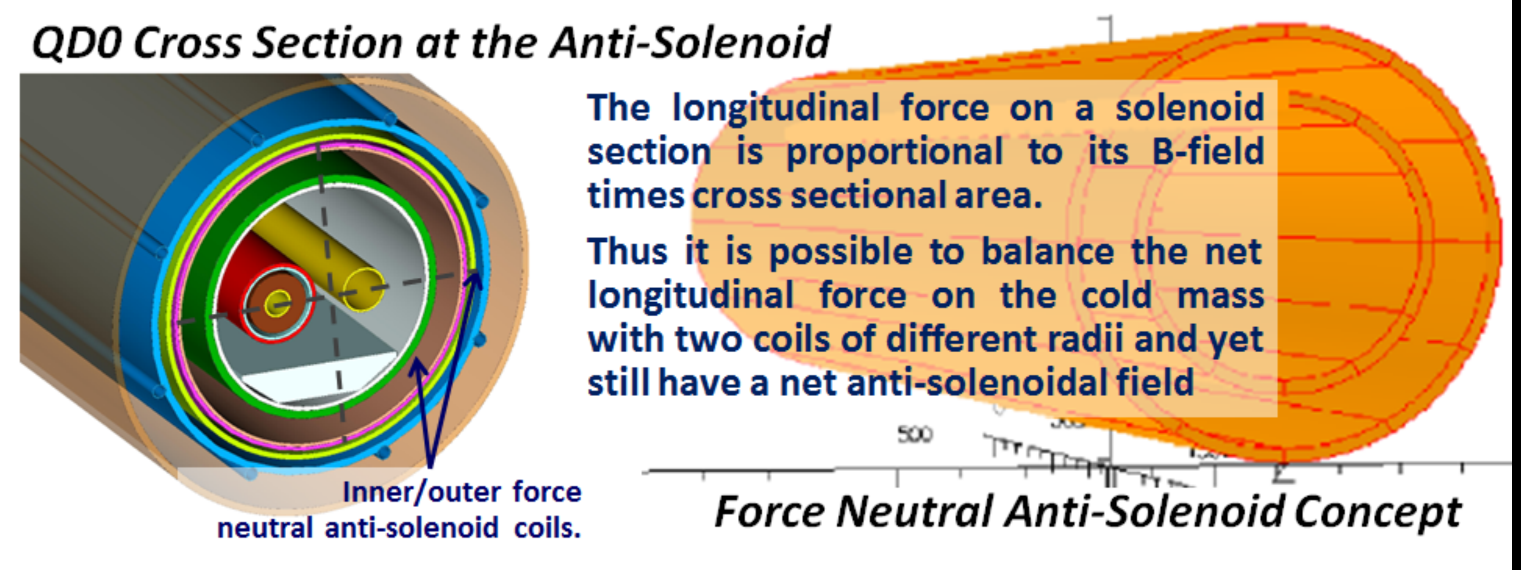
B. Parker (09/2016):

A Short Anti-Solenoid Design History Review

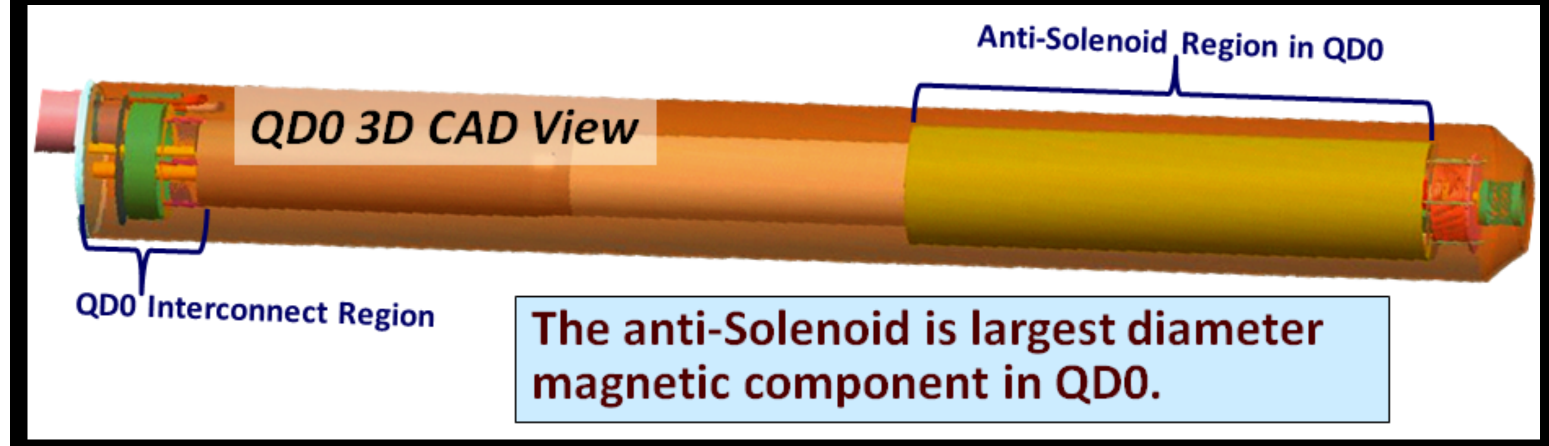


The accelerator physics formalism and first ILC specific designs for the anti-solenoid (AS) were presented by Y. Nosochkov & A. Seryi†.

But a 62 ton AS longitudinal coil force can not reasonably be accommodated in the QD0 cryostat; the AS had to be integrated with the detector (i.e. major field and design impacts).



For the ILC RDR/TDR we developed a force neutral AS concept where two solenoids of different radii but opposite polarity are used to largely cancel the longitudinal force yet maintain a net field at the beam position.



The efficiency of the two coil, force neutral AS configuration improves as the radial separation between the inner and outer coils increases. The size of the outer AS coil then becomes the determining factor (followed by the QD0 interconnect size) for setting the QD0 cryostat radial envelope.

†Yuri Nosochkov and Andrei Seryi, "Compensation of detector solenoid effects on the beam size in a linear collider," Rev. Mod. Phys. 8(2) , February 2005.

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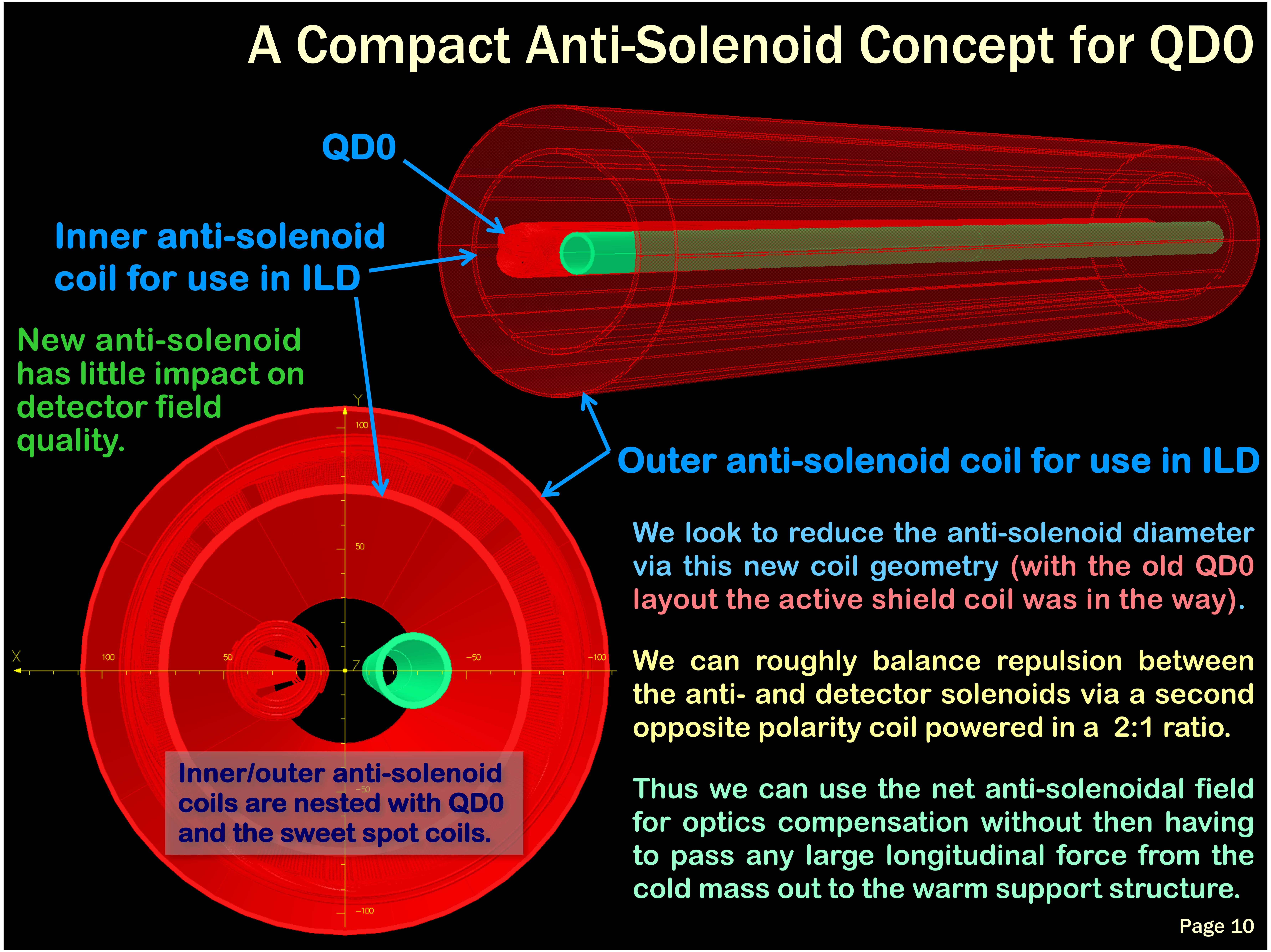
Anti-Solenoid

Compact AS concept

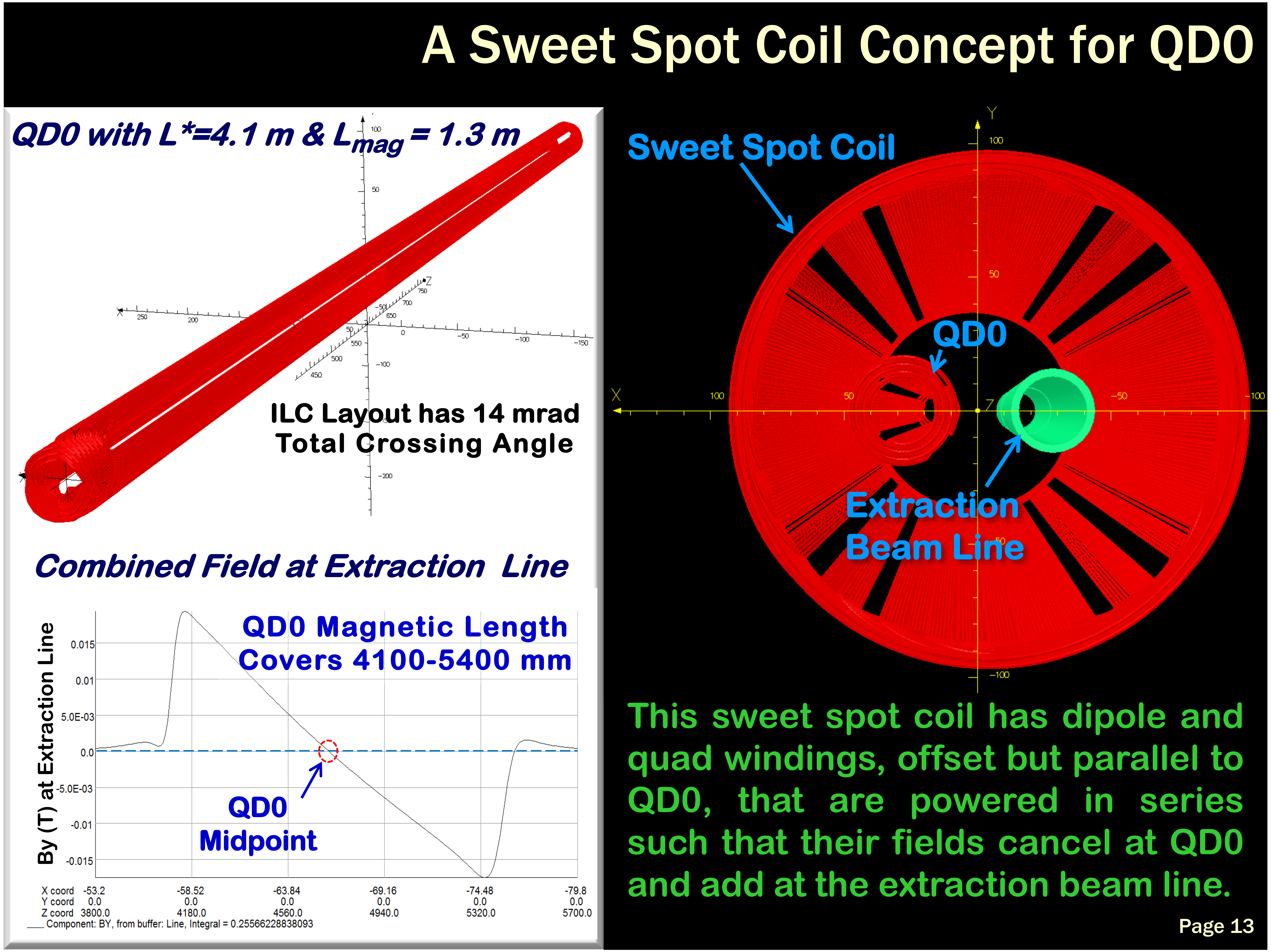
- Two-coil design



Anti-Solenoid

Sweet-spot coil

- compact system for QD0 extraction beam line



Discussion

Anti-DID

- A useful „nice-to-have“ feature for the detectors
- Could be an additional tuning-knob for background suppression
- Engineering studies have been done to some extent
- In the end probably a cost-benefit issue to be decided by the detector collaborations
- R&D is required before detector TDR can be written, is in the domain of the detector concepts

Anti-Solenoid

- Compact BNL design seems feasible
- Space requirements for complete QD0 package are relevant for the detectors
  - forward region instrumentation, hermeticity

QD0 package including anti-solenoids is critical for the MDI

- A lot of R&D work remains to be done, at least on the detector side
  - engineering design of QD0 support, alignment, assembly, maintenance access
  - vibration issues
- R&D on QD0 magnet package itself seems to be an obvious task for the BDS WG
- At this time, R&D work is budget-limited