Design of the "4th" detector

Calorimeter

1. dual-readout fiber - similar to RD52 modules today
2. BGO crystal dual-readout in front
3. projective

Magnetic field

1. dual-solenoid, from Alexander Mikhailichenko
2. 3.5T tracking field
3. second muon momentum measurement

Tracking

1. Ionization cluster timing and counting
2. KLOE-like drift chamber
3. nearly massless

New machines —> bring new detectors

FCCee (CERN) —> CERN group
(Gigi Rolandi, Mogens Dam)

ILC (Japan) —> KEK-SLAC-DESY++ groups

CEPC (China) —> Tsinghua, IHEP + INFNs
(Yuanning Gao, Manqi Ruan)

All three colliders are being worked on, and all three detector groups are active. What will happen? I do not know.

4th detector design

- pixel vertex detector (MAPS technology) with $\sigma_b \sim 10\mu m$

- drift chamber like KLOE: cluster timing and counting on 155 space points with 50μm resolution per point and 3% *dE/dx* resolution

- dual-readout calorimeter for *W,Z* decays to *qq*.

- dual or multiple solenoid flux return

Eight principles around which 4th was designed

- Each detector system is independent of other
- Particle identification is critical to physics and built in from the start
- Auxiliary or ancillary detectors should be unnecessary
- Use common technologies wherever possible
- An iron-free detector has many benefits to both machine and detector
- Watch every channel every nanosecond, as long as possible
- Relative absence of dead or inactive volumes
- Careful of engineering creep; test complete prototypes

Gross design: radial (*r*) extent of detector

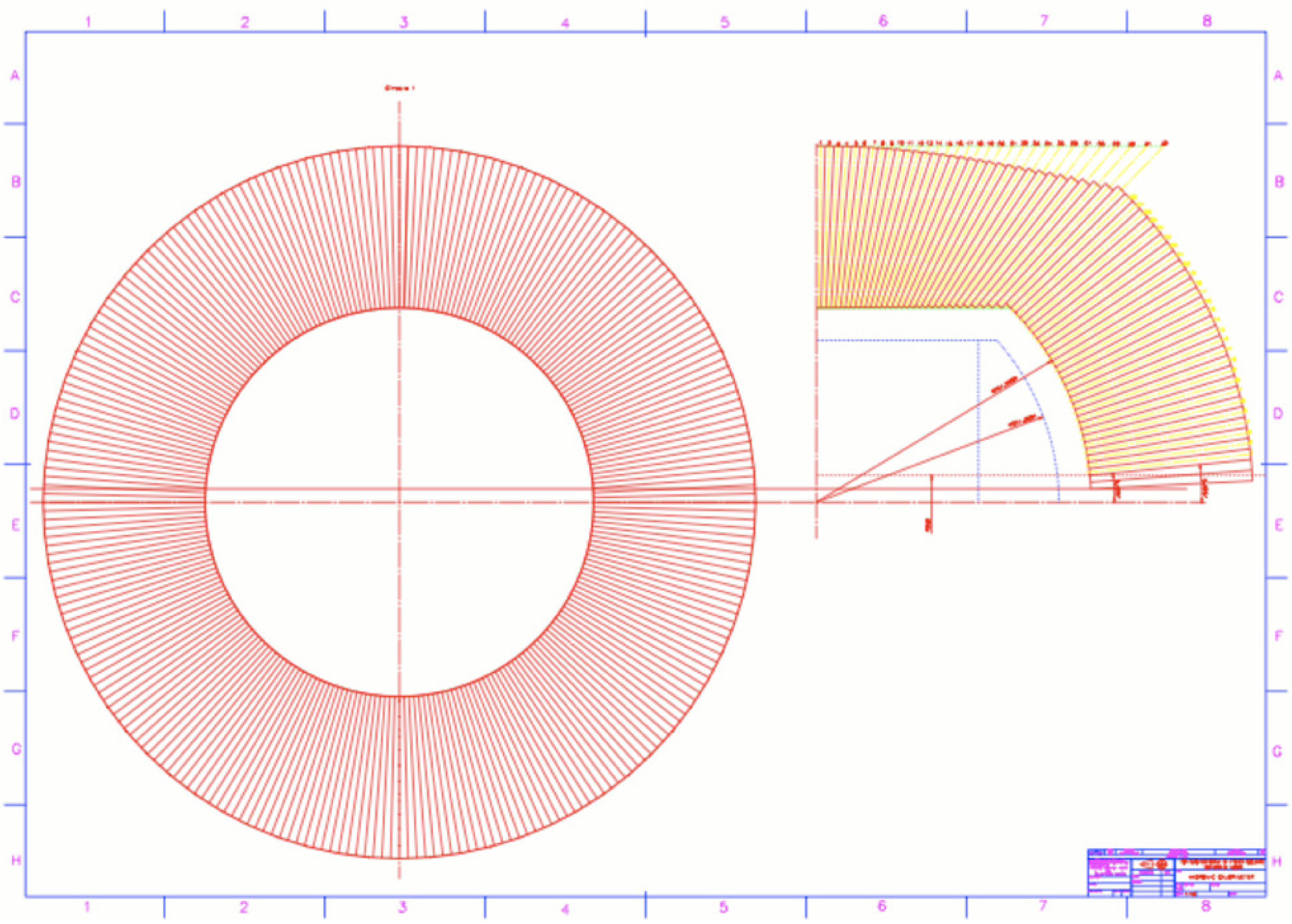
- important: calorimeter needs $10\lambda_{Int} \sim 2$m
- equally important: track length L, $\sigma/p \sim 1/L^2$ … L~1.5m
- inner radius of solenoid ~ 3.5m, and about 0.6m thick
- outer solenoid starts at 6m. Not critical for σ/p or current density

Gross design: axial (z) extent of detector

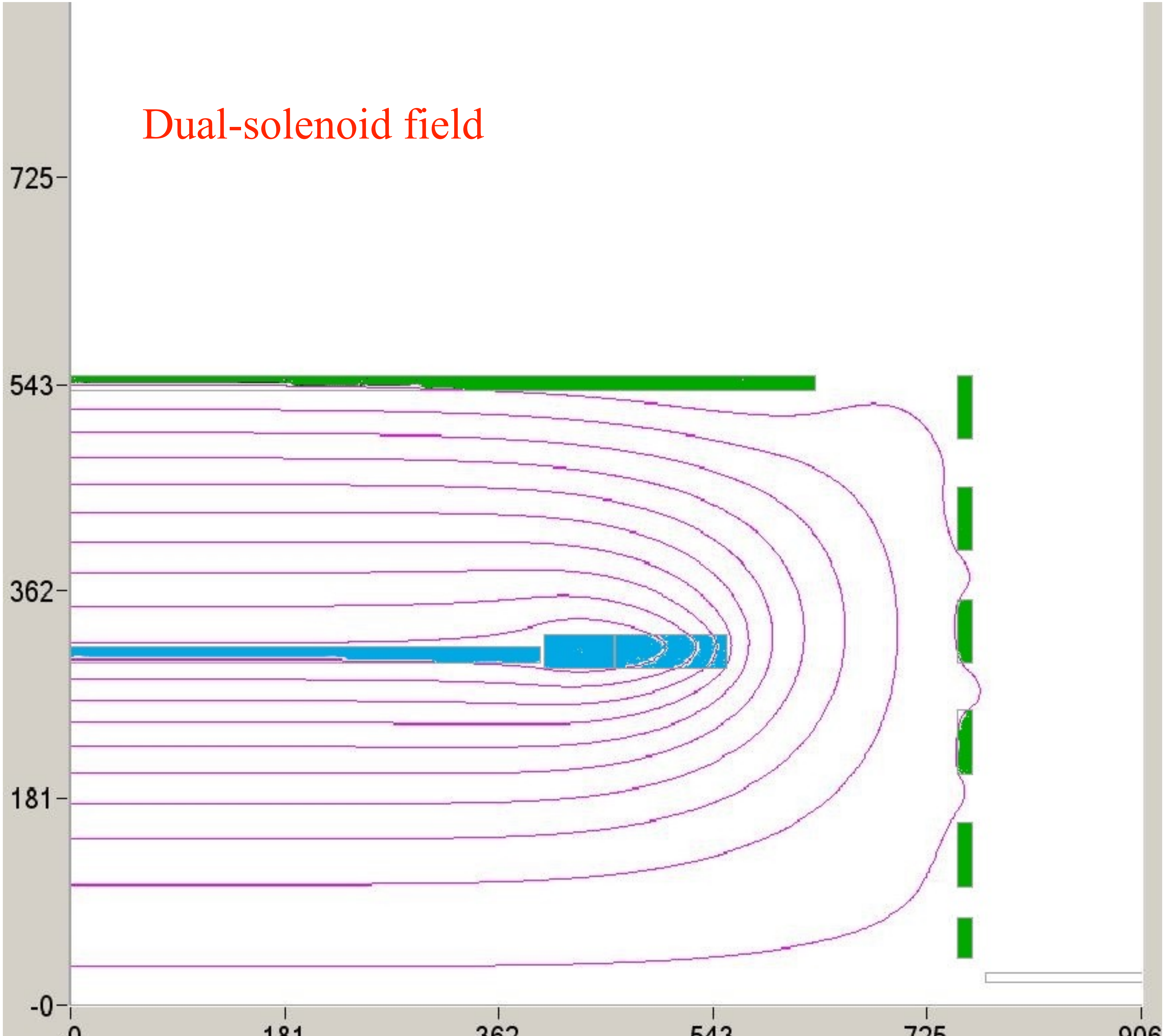
- the z extent is not important for the end coils of the dual-solenoid or for an axial muon spectrometer, or for the tracking (except for wire length in CLuCou). The cost is the volume of the calorimeter, so $z \sim 2$m is beginning of end cap calorimeter

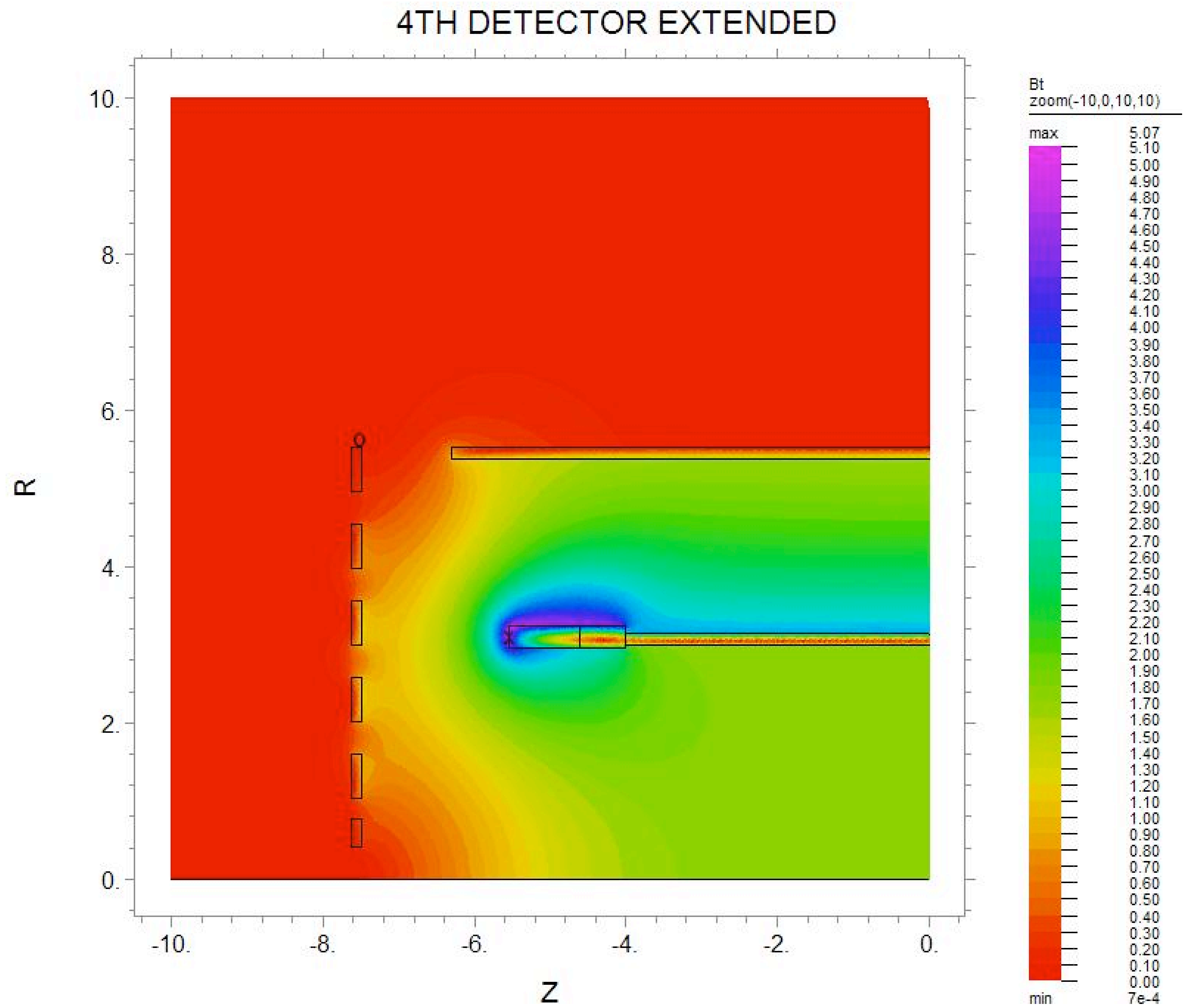
- the magnetic volume ends around $z \sim 7.5$m

Calorimeter geometry: projective



Dual-solenoid field




4TH DETECTOR EXTENDED
R
Z
10.
8.
6.
4.
2.
0.
-10.
-8.
-6.
-4.
-2.
0.
Bt
zoom(-10,0,10,10)
max
5.07
min
7e-4
5.10
5.00
4.90
4.80
4.70
4.60
4.50
4.40
4.30
4.20
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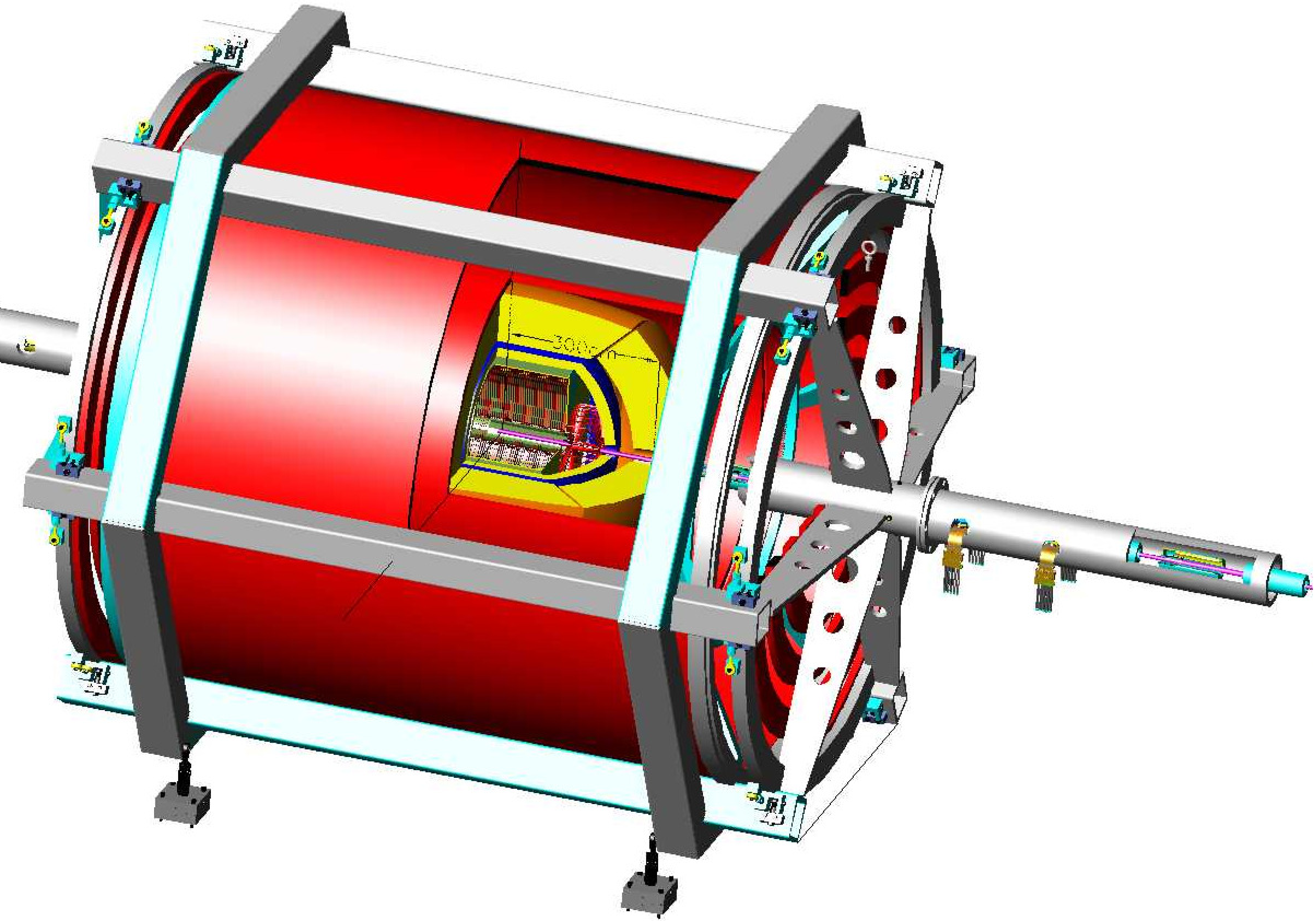

300

Benefits of iron-free detectors

- avoids huge internal forces on the iron ~ 25,000t. The dual solenoids are self stable

- avoids fringe fields

- annulus between solenoids can have detectors for muons and/or “exotics”

- detector is easily disassembled and quick repairs, or additions of new instruments, are possible in ~ one month.

- surveying and alignments are easier

- all elements of the machine lattice “final focus” are visible

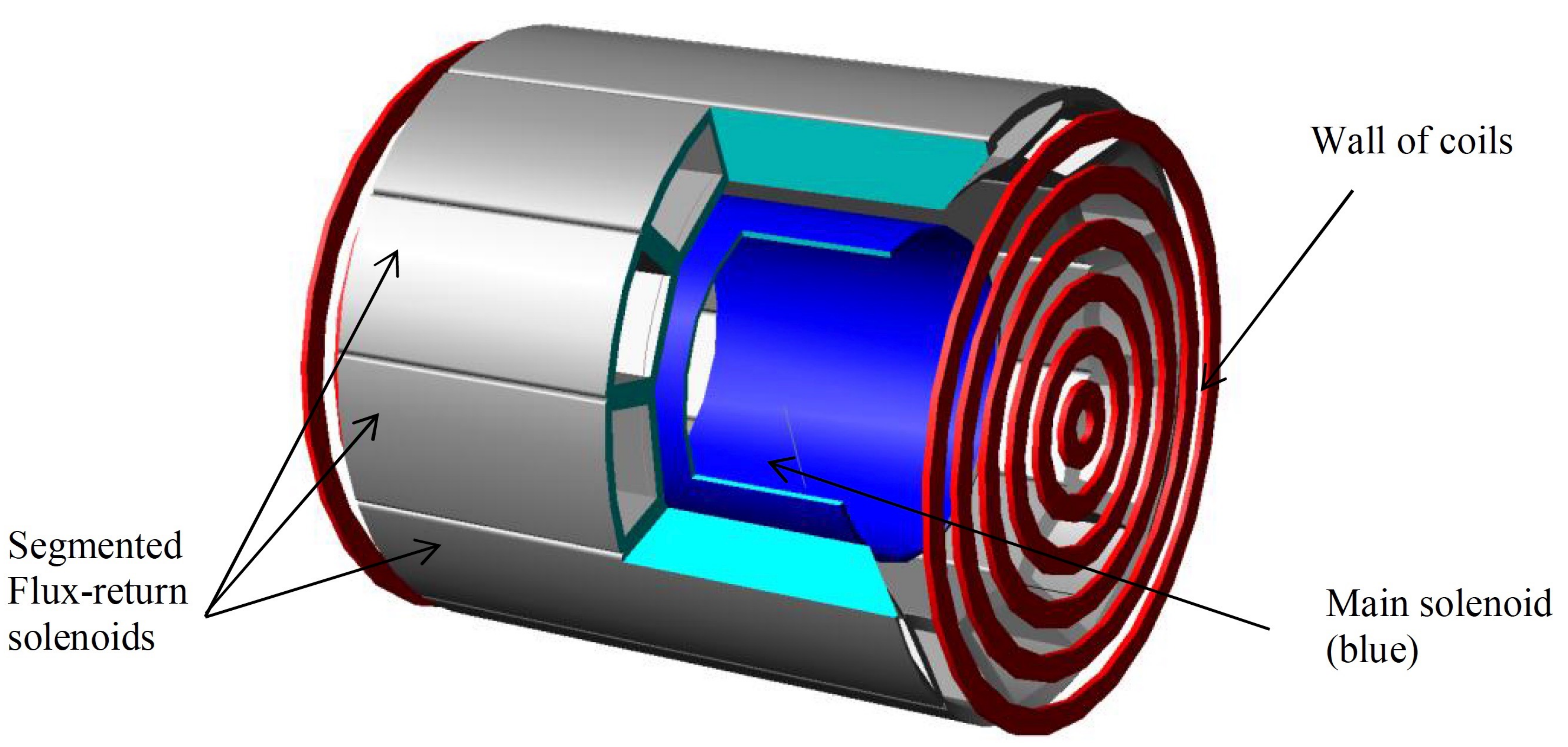
- absence of B-field forces on machine lattice elements

- $\gamma\gamma$ collisions with an installed laser are easier.

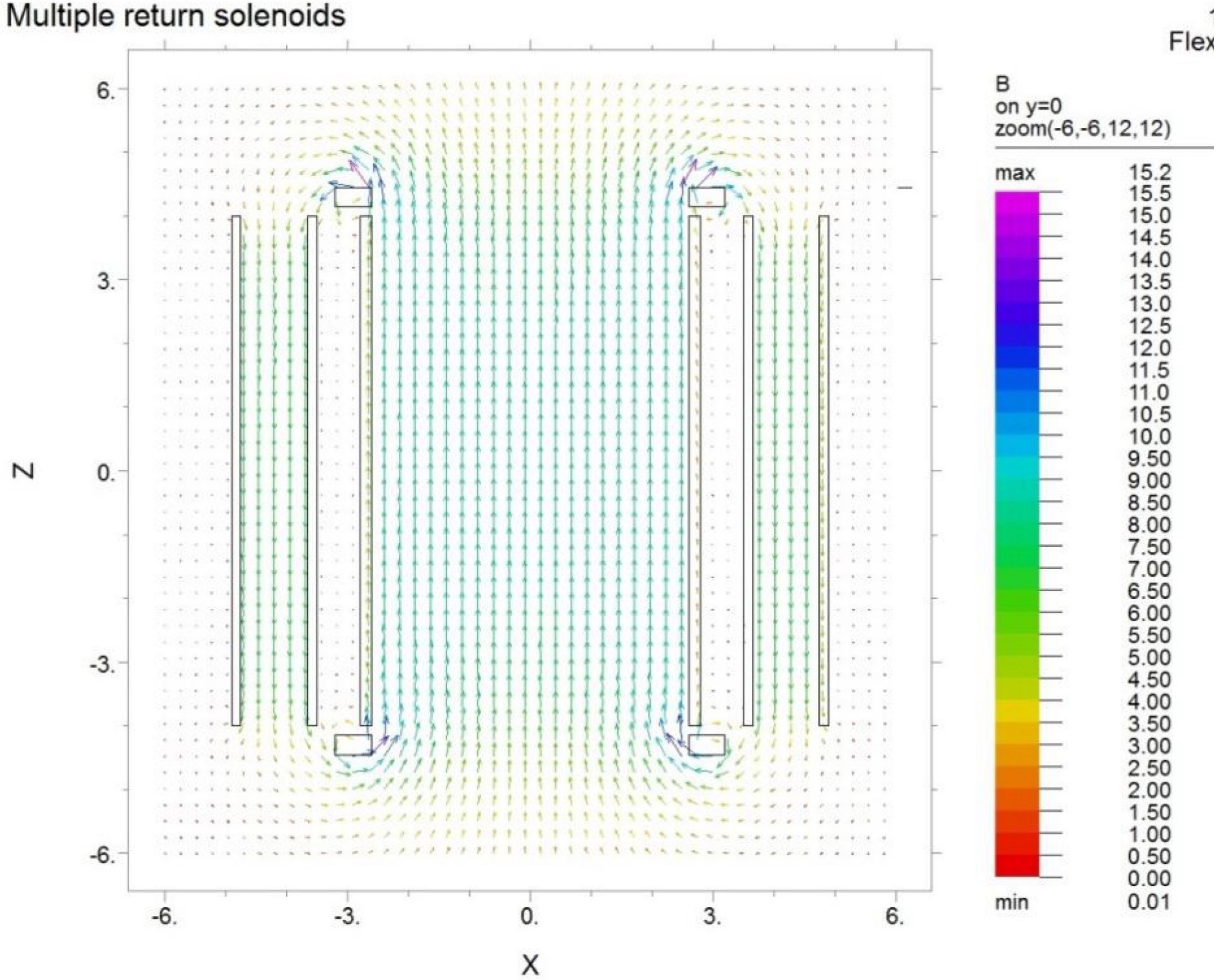
More benefits of iron-free detectors

- almost every problem in the IR becomes easier: crane capabilities, floor loading and deformation,
- B can be reversed, B —> -B, to cancel detector asymmetries in delicate quark asymmetry measurements
- the experiment can run at any field, e.g., 0 or 1T …
- 2nd muon momentum measurement reduces fake muons.
- easy alignment and survey allow fast installation and removal.

Multiple-solenoid flux return



Multiple return solenoids



Multiple solenoids

- lose the second muon momentum measurement
- no more space for additions in the annulus
- but, gain higher B-field at lower currents
- can make radius of solenoid larger for the same field and currents, and have more tracking and calorimetry. This might be a very important idea to pursue.