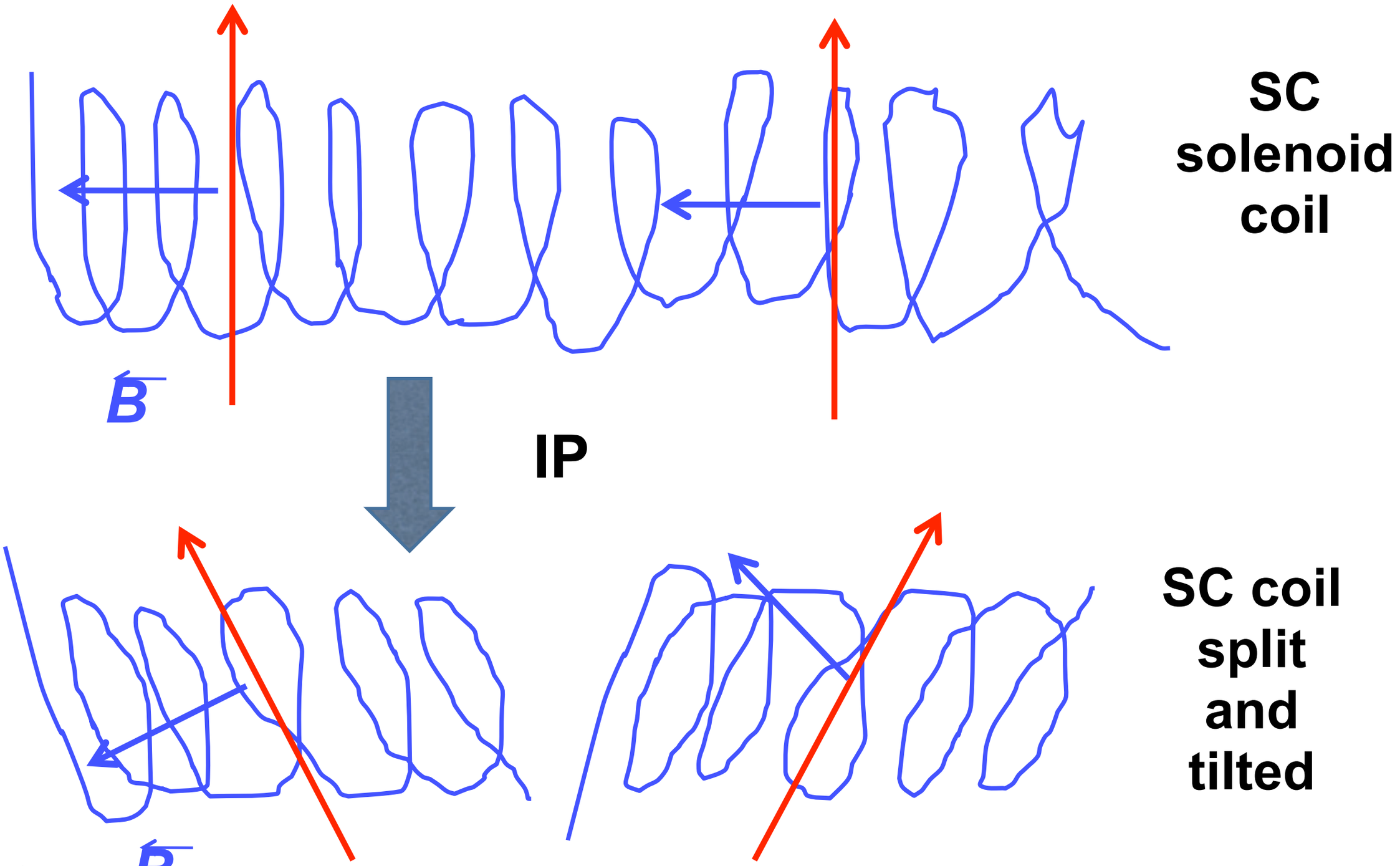
LHeC Detector Update

- Second Proton Beam
  - steering through IR in same beam pipe √
  (informal meeting on 5.October '10)
- Beam Separation Dipols
  - integrated in detector structure - where?
- SR Calculations
  - not finished
- Beam Pipe / Detector Dimensions
  - not fixed
- Forward Jet Measurement - Toroid
  - an option?
- Solenoid(s)
  - 1 or 2 magnets (2 magnets - no return yoke)?
  - physics case: best muon measurement possible
  - cost estimate needed
  - any drawbacks?

Beam Separation Dipols

detector integrated dipole

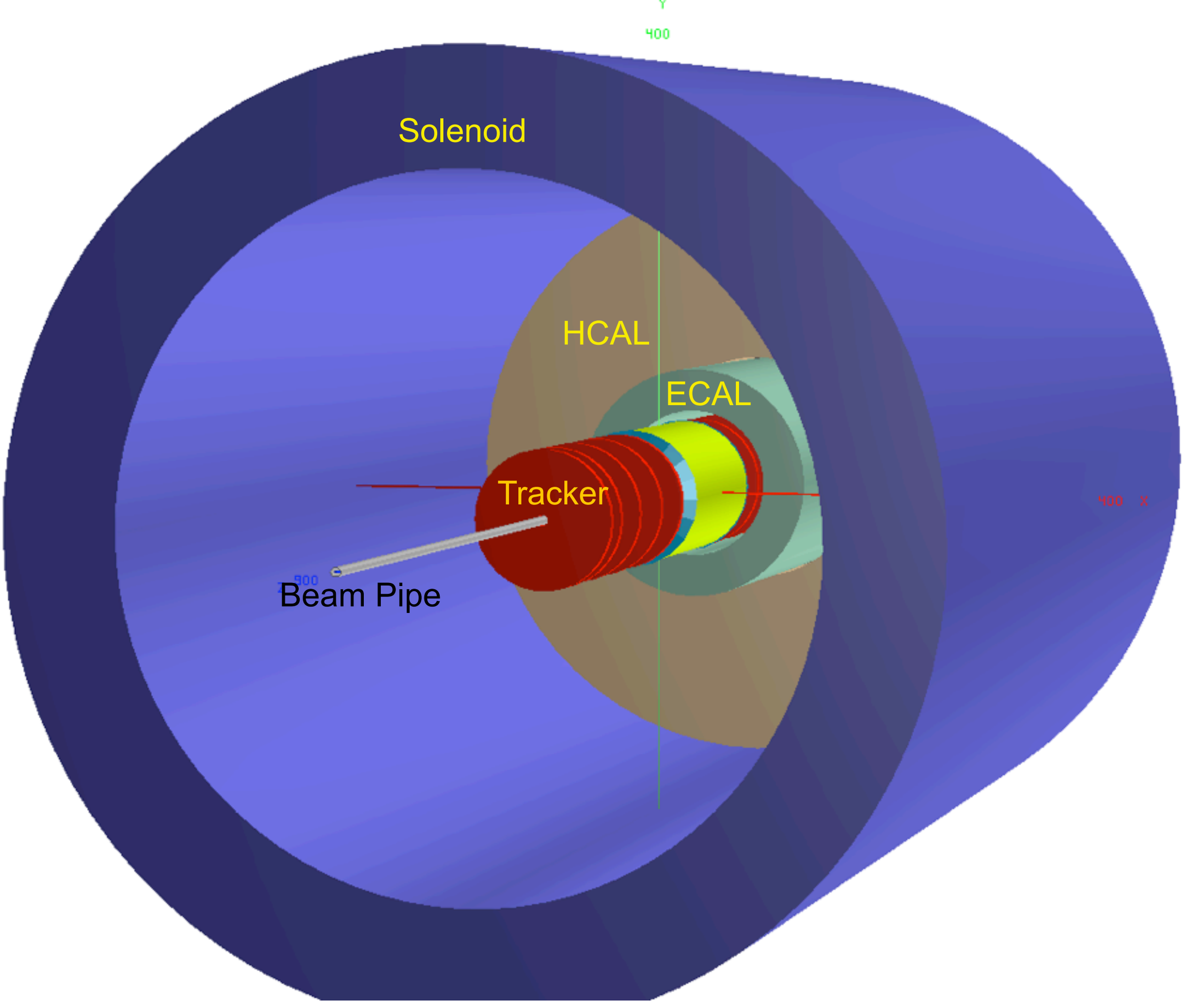


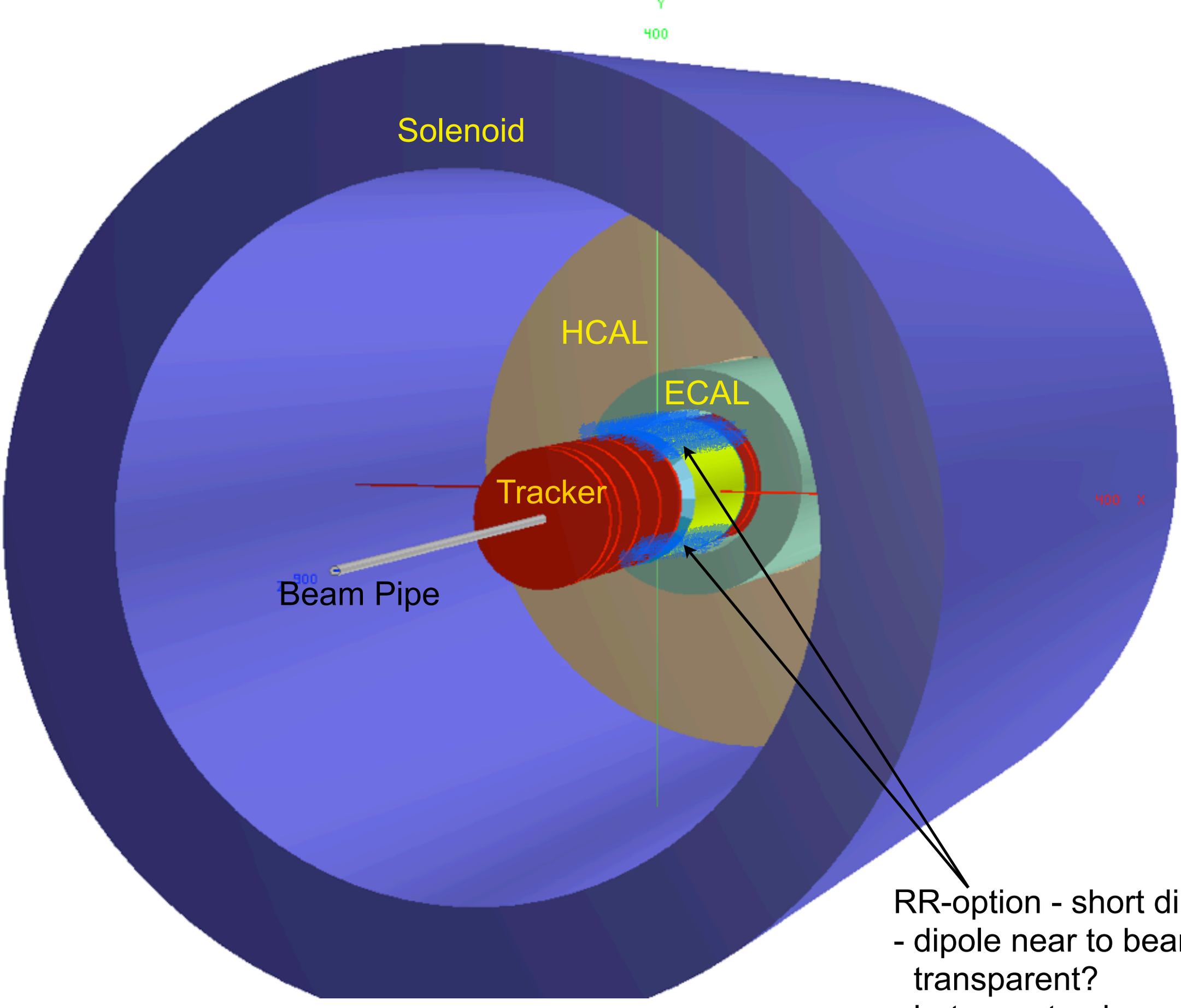
Rogelio Tomas, Frank Zimmermann

Special LHeC Meeting

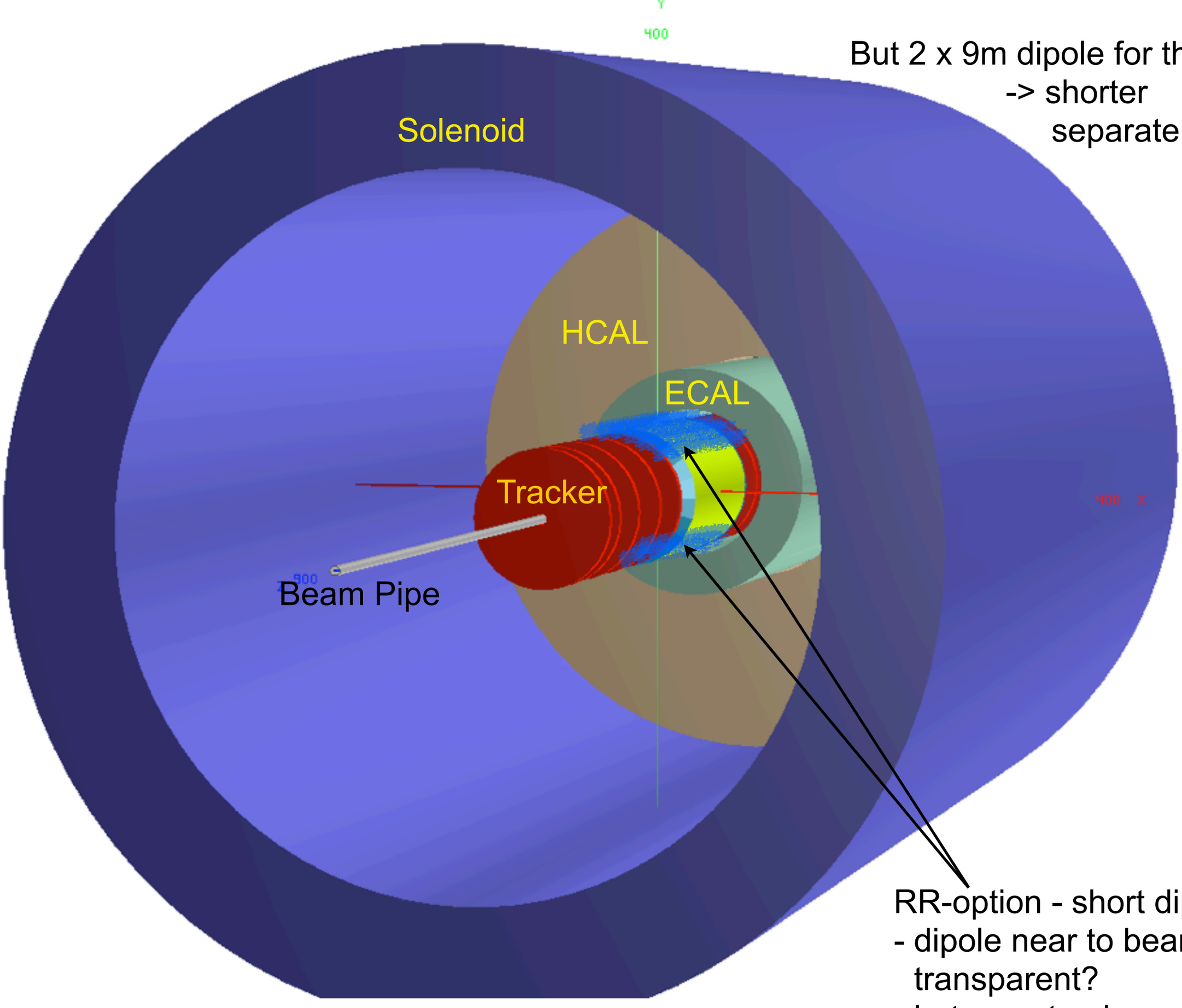
4 October 2010

Stephan Russenschuck, Simona Bettoni, Eugenio Paoloni


Solenoid
HCAL
ECAL
Tracker
Beam Pipe


Solenoid
HCAL
ECAL
Tracker
Beam Pipe
RR-option - short dipoles
- dipole near to beam pipe - transparent?
- between tracker + calorimeter

But 2 x 9m dipole for the LR option?
-> shorter
separate functionality

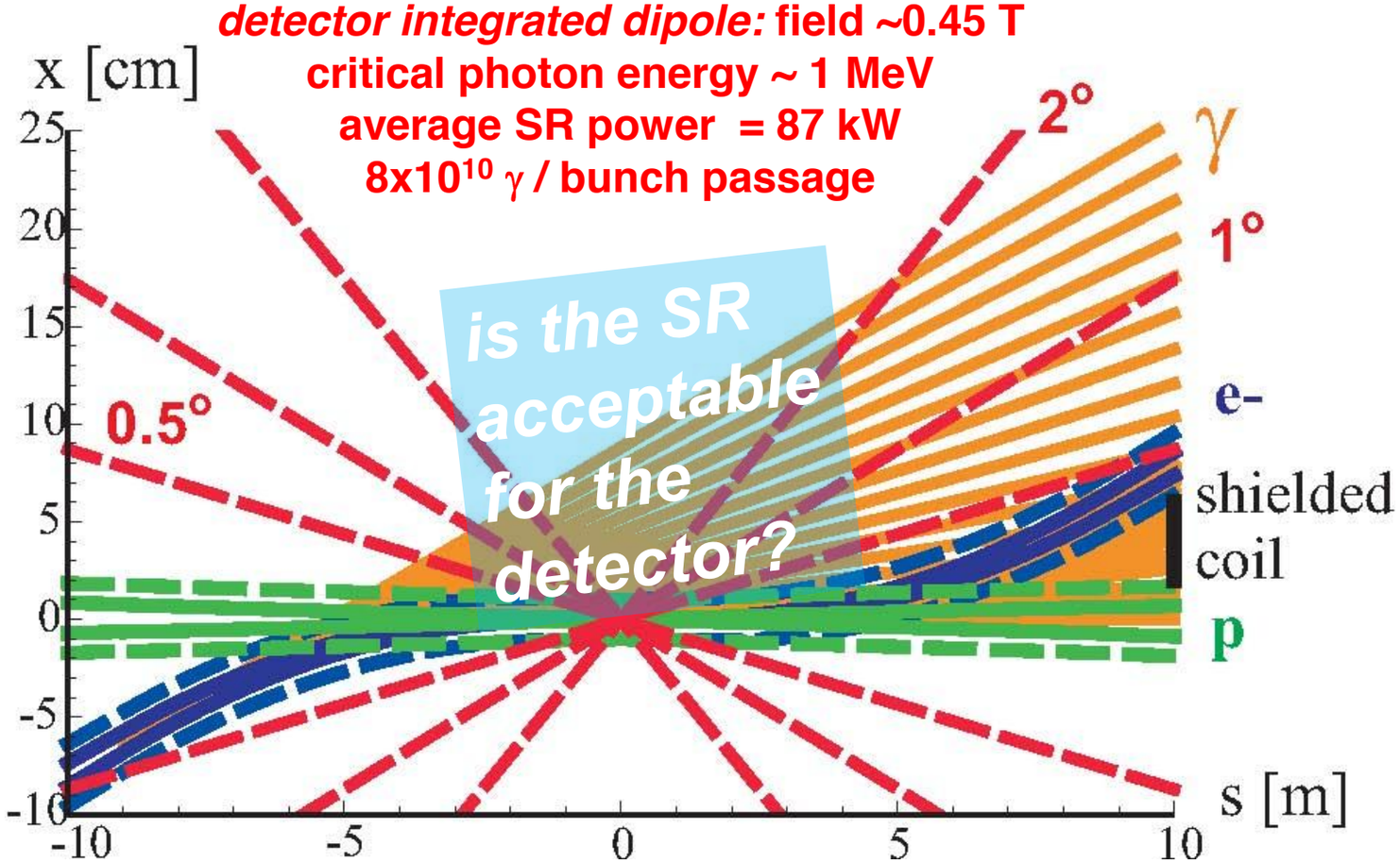


RR-option - short dipoles
- dipole near to beam pipe - transparent?
- between tracker + calorimeter

SR Calculations

IR layout w. head-on collision

LR - Design
M.Sullivan -
Elliptical Beam Pipe1:
inner-$\varnothing_x$ = 12cm
inner-$\varnothing_y$ = 5cm
outer-$\varnothing_x$ = 12.8cm
outer-$\varnothing_y$ = 5.8cm
➟ thickness: 0.4cm



Beam envelopes of 10σ (electrons) [solid blue] or 11σ (protons) [solid green], the same envelopes with an additional constant margin of 10 mm [dashed], the synchrotron radiation fan [orange], and the approximate location of the magnet coil between incoming protons and outgoing electron beam [black].

INTERACTION-REGION DESIGN OPTIONS FOR A LINAC-RING LHEC by F.Zimmermann et.al. submitted IPAC'10

Answer: SR problematic - to be checked

CLIC-LHeC Synergies & KEK Trip Report, Frank Zimmermann, CLIC Meeting 20 August 2010

SR Calculations

Current Activities

- RR Option:
  - Nathan Bernard (UCLA) - MadLab/GEANT4
    Rob Appleby (Uni Manch.) - dedicated software - fields (Velocity Verlet meth.) + (MC LEP inspired - H.Burkhardt)
- LR Option:
  - Emre Eroglu (Uludag Uni. - Fluka)
- First Results (RR) presented in August (N.B.)
- Essential: check of LR Option
- Incorporate the upstream sources
  (not starting from last p-quadrupole)

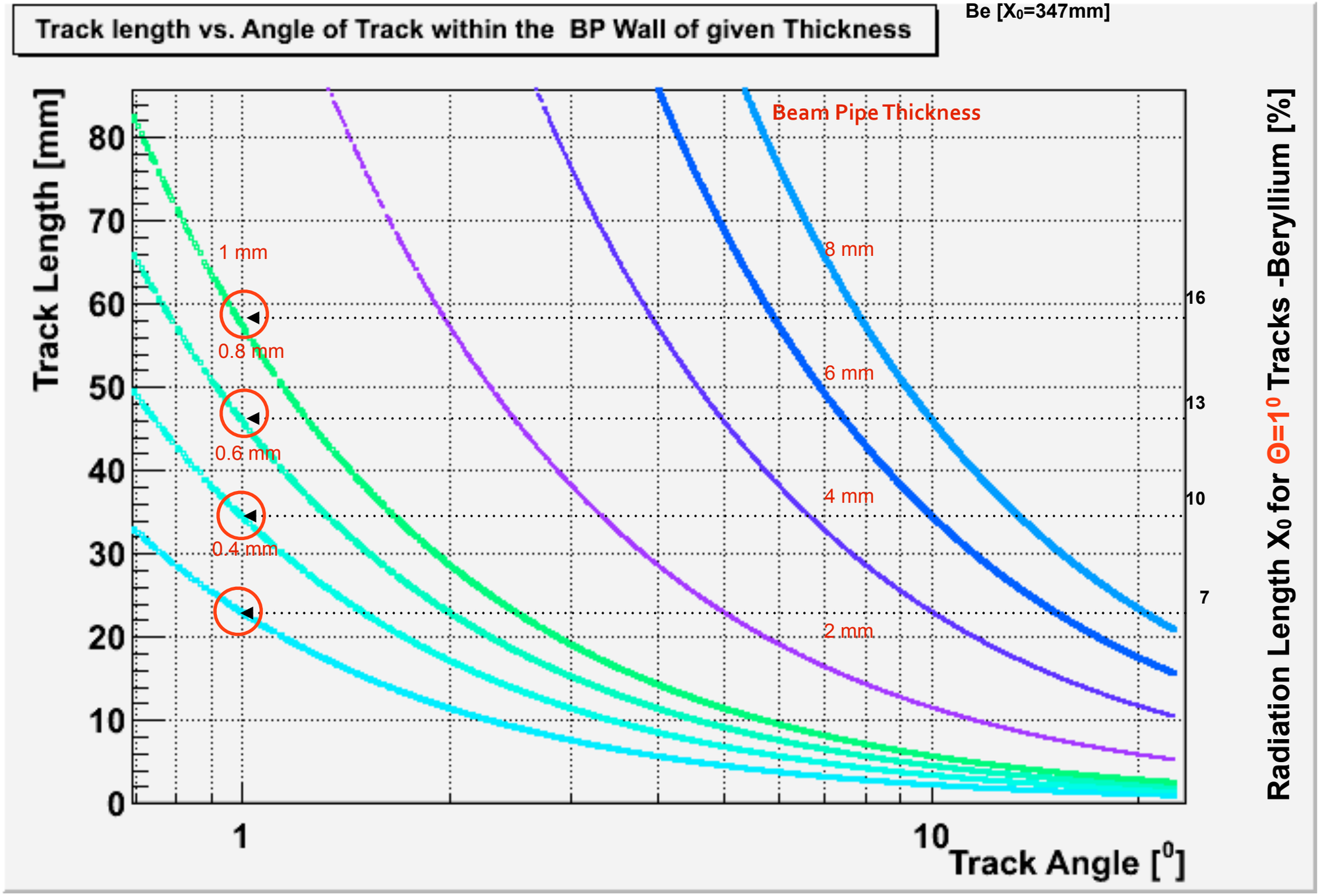
SR Characteristics using GEANT4 Simulations

Characteristic	Detector Dipole	No Detector Dipole
E [GeV]	60	60
I [mA]	100	100
Detector Dipole Length [m]	2.4	0
B [T]	0.024	0.028
$\theta_{Initial}$* [mrad]	3.6	3.8
$\theta_{Crossing}$* [mrad]	1.108	1.104
E_c [keV]	102.79	108.05
E_μ [keV]	31.65	33.27
E_σ [keV]	57.47	60.41
λ [m]	2.585	2.579
γ/e-	7.7025	8.2043
P [kW]	24.3756	27.2986
Separation** [mm]	49.067	49.795

*θ is the angle between the electron and proton momentum vectors

** The separation is the displacement between the proton and electron centroids at the absorber

Beam Pipe Wall Thickness

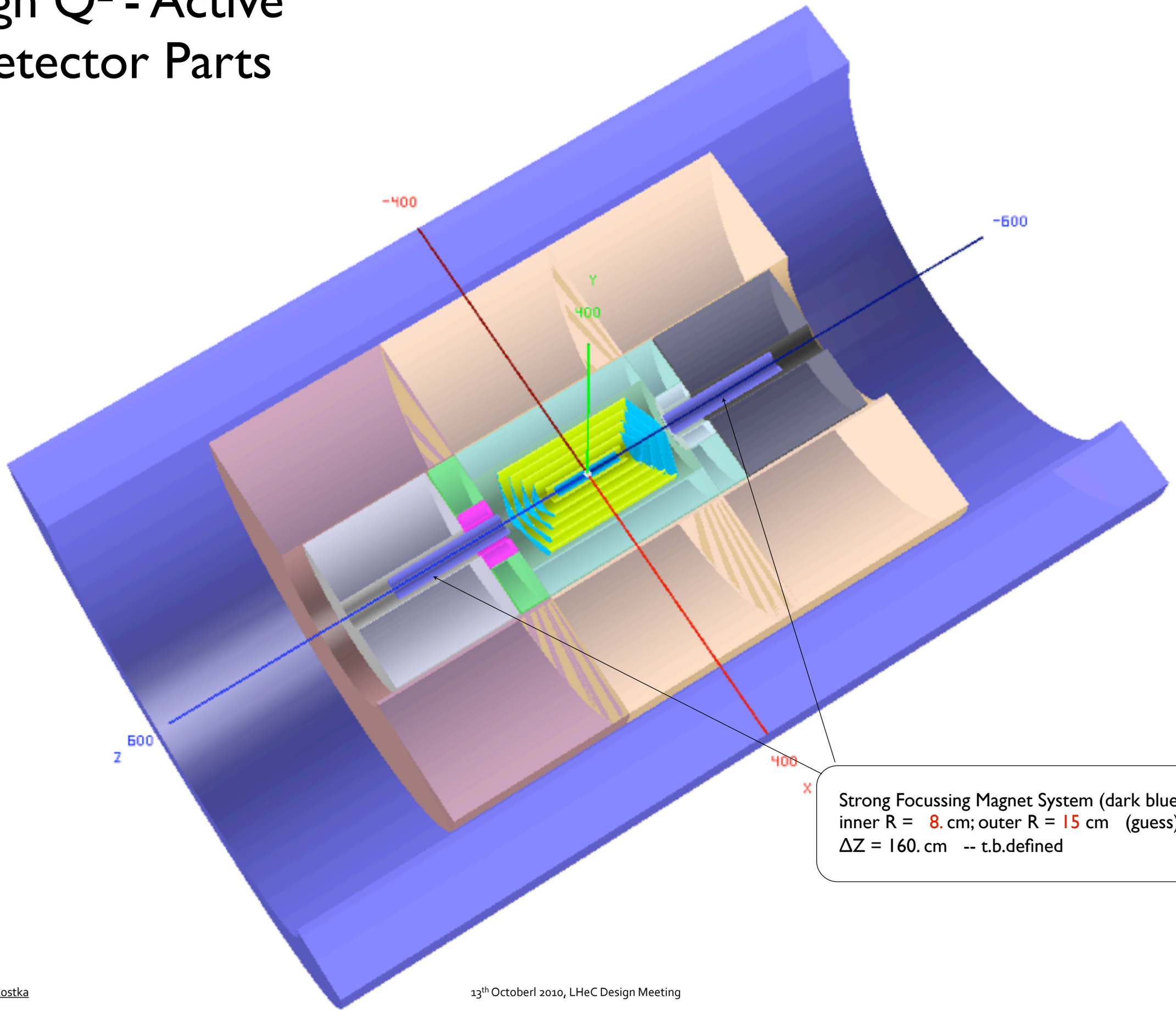


Detector Setup

Main Objectives 1

- Warm Calorimeter (contr. Uludag Univ.)
- Cold Calorimeter (H.Oberlack)
- dedicated forward calorimeter (Calice, DREAM)
- Tracking - lightweight - SiGas (pixel, strip, pad)
  Trigger capable
  TRD in front of backward calorimeter ($\gamma/\pi^0/e$)
  track segment definition (NikHEF)
- Tracking conventional - Si based (pixel, strip, pad)
  multiple scattering!
  few high accurate measuring points only - high costs

High Q^2 - Active Detector Parts



Strong Focussing Magnet System (dark blue)
inner R = 8. cm; outer R = 15 cm (guess)
ΔZ = 160. cm -- t.b.defined

Low Q^2 - Active Detector Parts 1

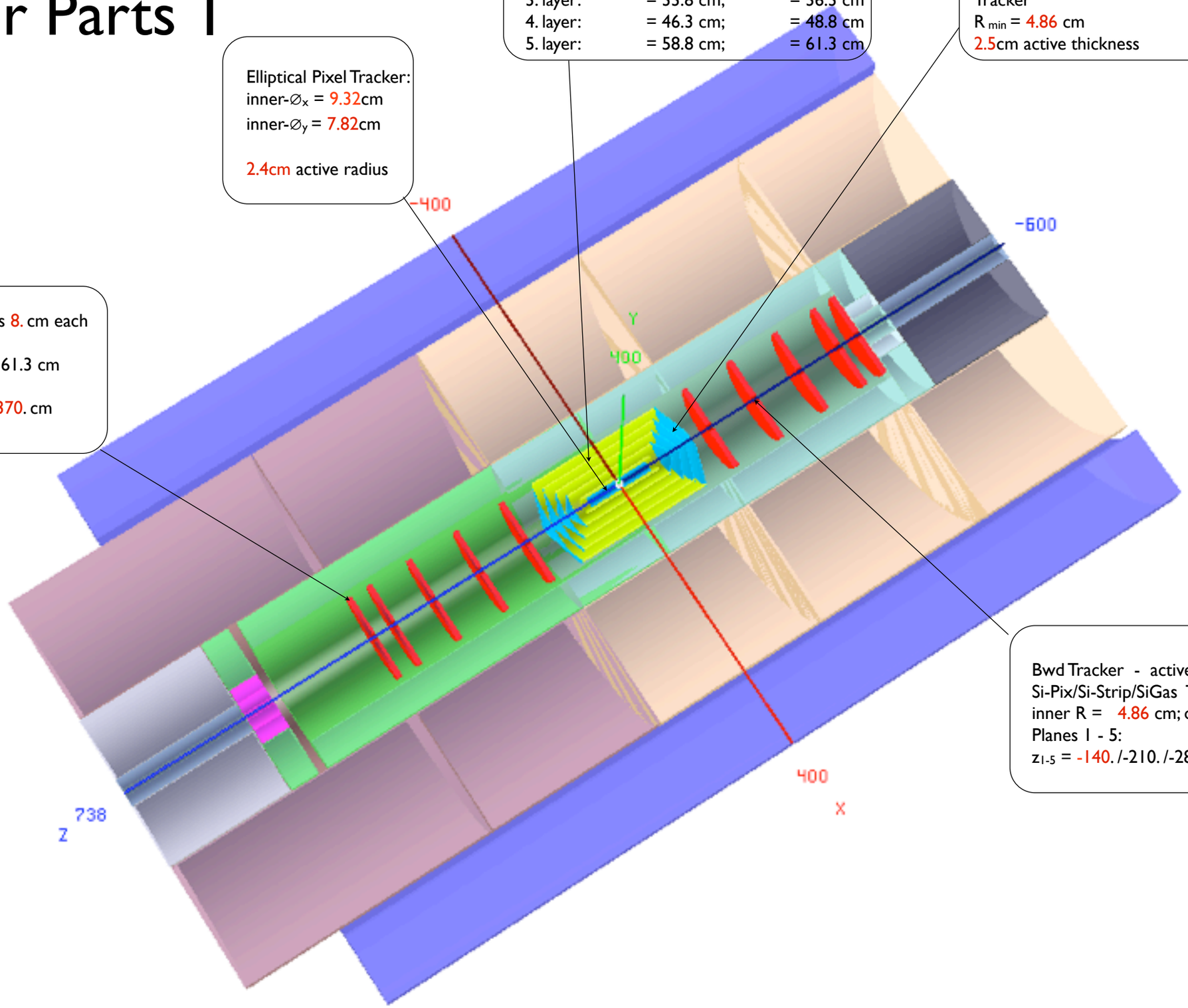
Barrel Tracker - active Radius 2.5cm each
Si-Pix/Si-Strip/SiGas Tracker:
1. layer: inner R = 8.8 cm; outer R = 11.3 cm
2. layer: = 21.3 cm; = 23.8 cm
3. layer: = 33.8 cm; = 36.3 cm
4. layer: = 46.3 cm; = 48.8 cm
5. layer: = 58.8 cm; = 61.3 cm

Elliptical Pixel Tracker:
inner-$\varnothing_x$ = 9.32cm
inner-$\varnothing_y$ = 7.82cm

2.4cm active radius

4 Cone structured fwd/bwd Si-pix/Si-strip/Si-gas Tracker
R_{min} = 4.86 cm
2.5cm active thickness

Fwd Tracker - active Thickness 8. cm each
Si-Pix/Si-Strip/SiGas Tracker:
inner R = 4.86 cm; outer R = 61.3 cm
Planes 1 - 5:
$z_{1\text{-}5}$ = 140. / 210. / 280. / 340. / 370. cm



Bwd Tracker - active Thickness 8. cm each
Si-Pix/Si-Strip/SiGas Tracker:
inner R = 4.86 cm; outer R = 61.3 cm
Planes 1 - 5:
$z_{1\text{-}5}$ = -140. /-210. /-280. /-340. /-370. cm

Low Q^2 - Active Detector Parts 2

Barrel Tracker - active Radius 2.5cm each
Si-Pix/Si-Strip/SiGas Tracker:
1. layer: inner R = 8.8 cm; outer R = 11.3 cm
2. layer: = 21.3 cm; = 23.8 cm
3. layer: = 33.8 cm; = 36.3 cm
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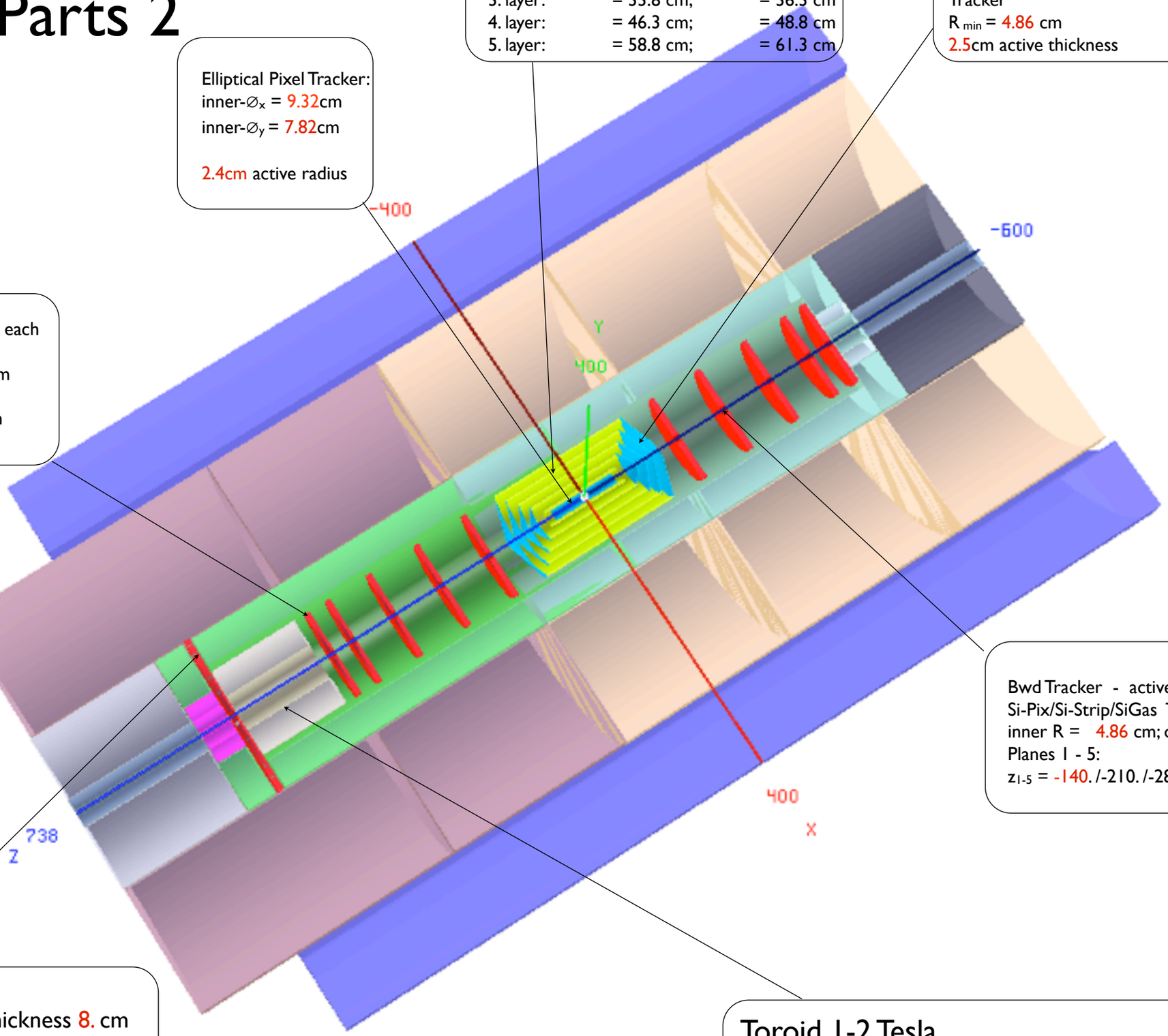

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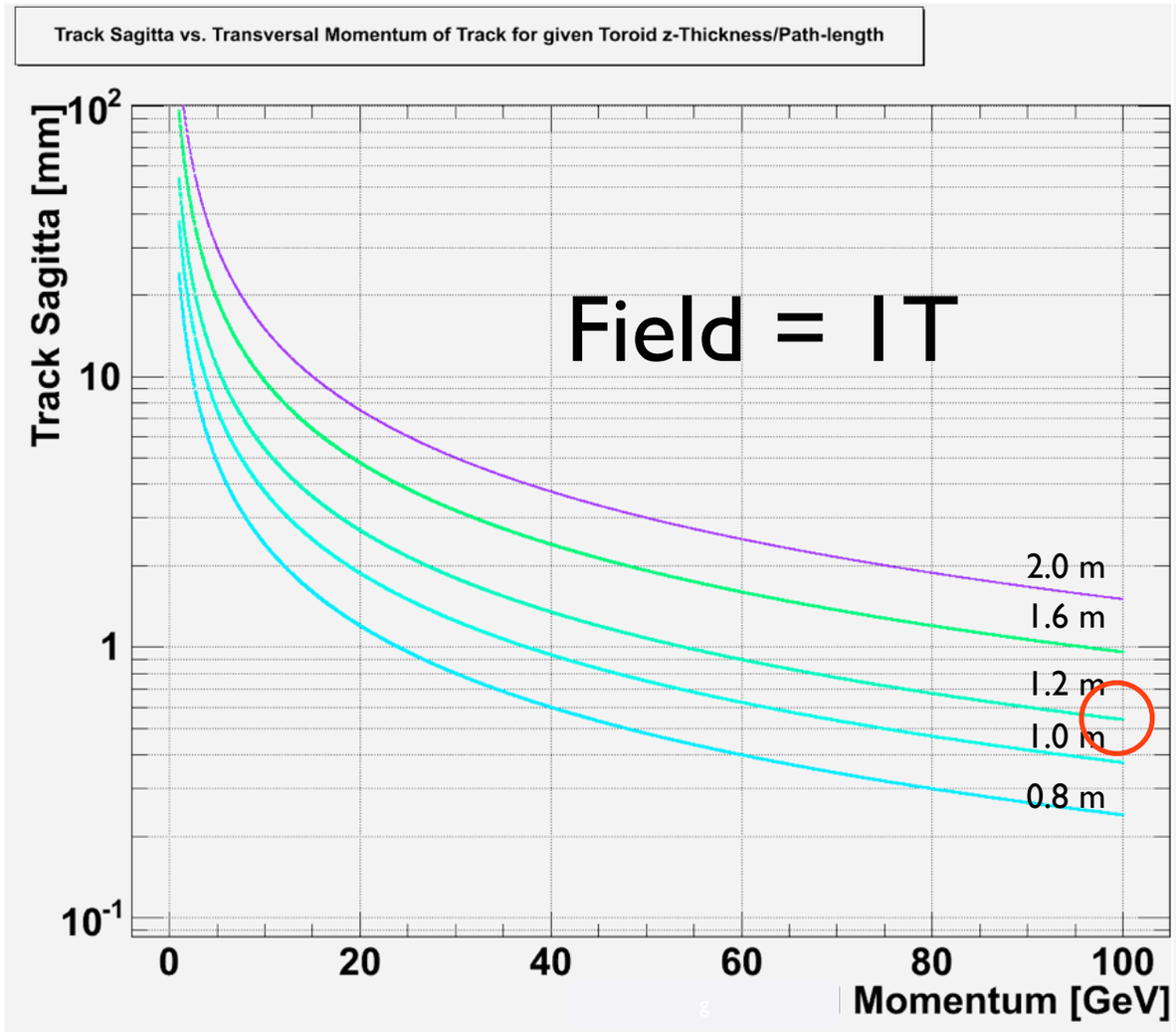
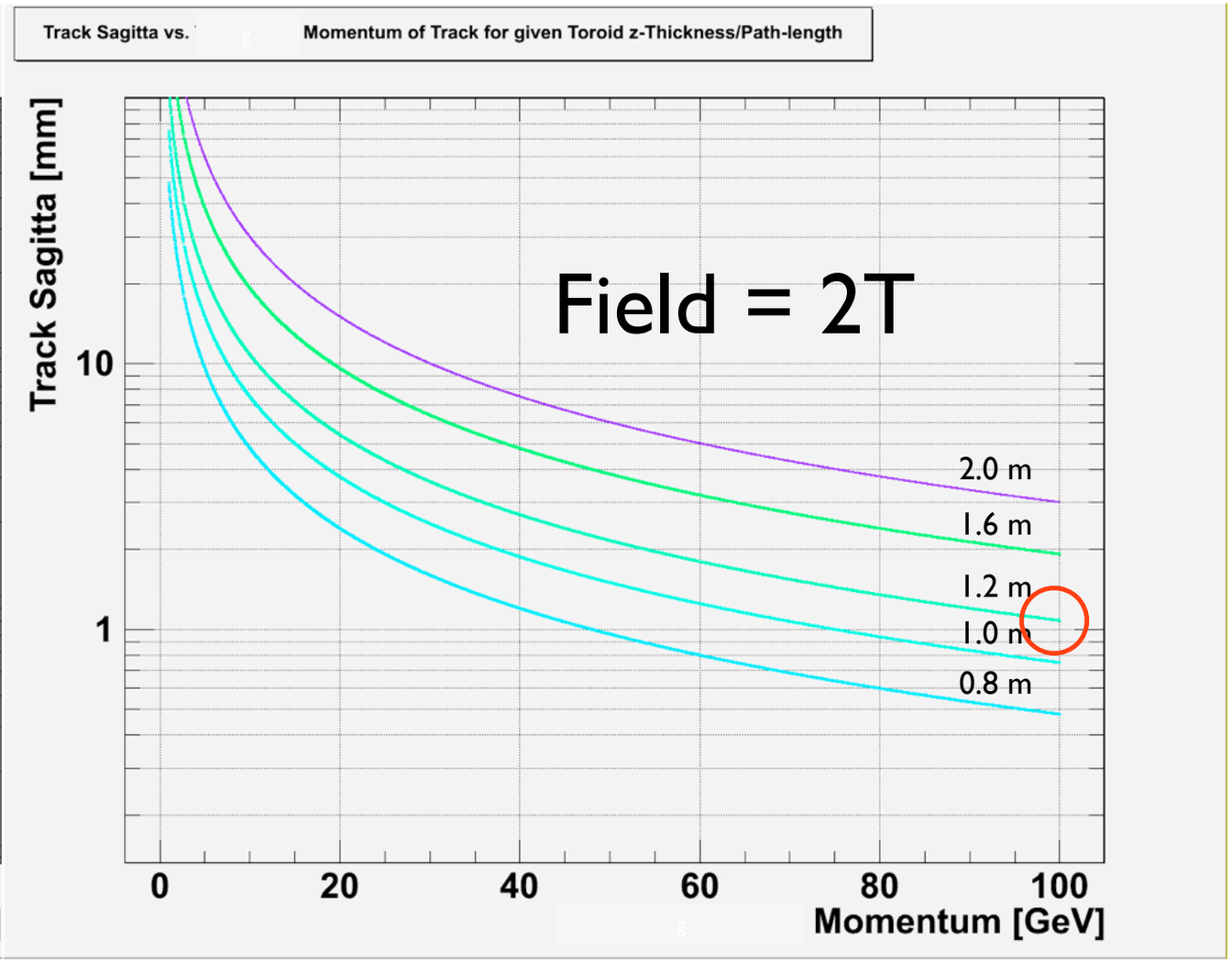
Fwd Tracker - active Thickness 8. cm
Si-Pix/Si-Strip/SiGas Tracker:
inner R = 20 cm; outer R = 62 cm

Toroid 1-2 Tesla
inner R = 20 cm; outer R = 62cm; Δz = 120cm
Better low angle jet measurement - option to be checked (transparent enough?)

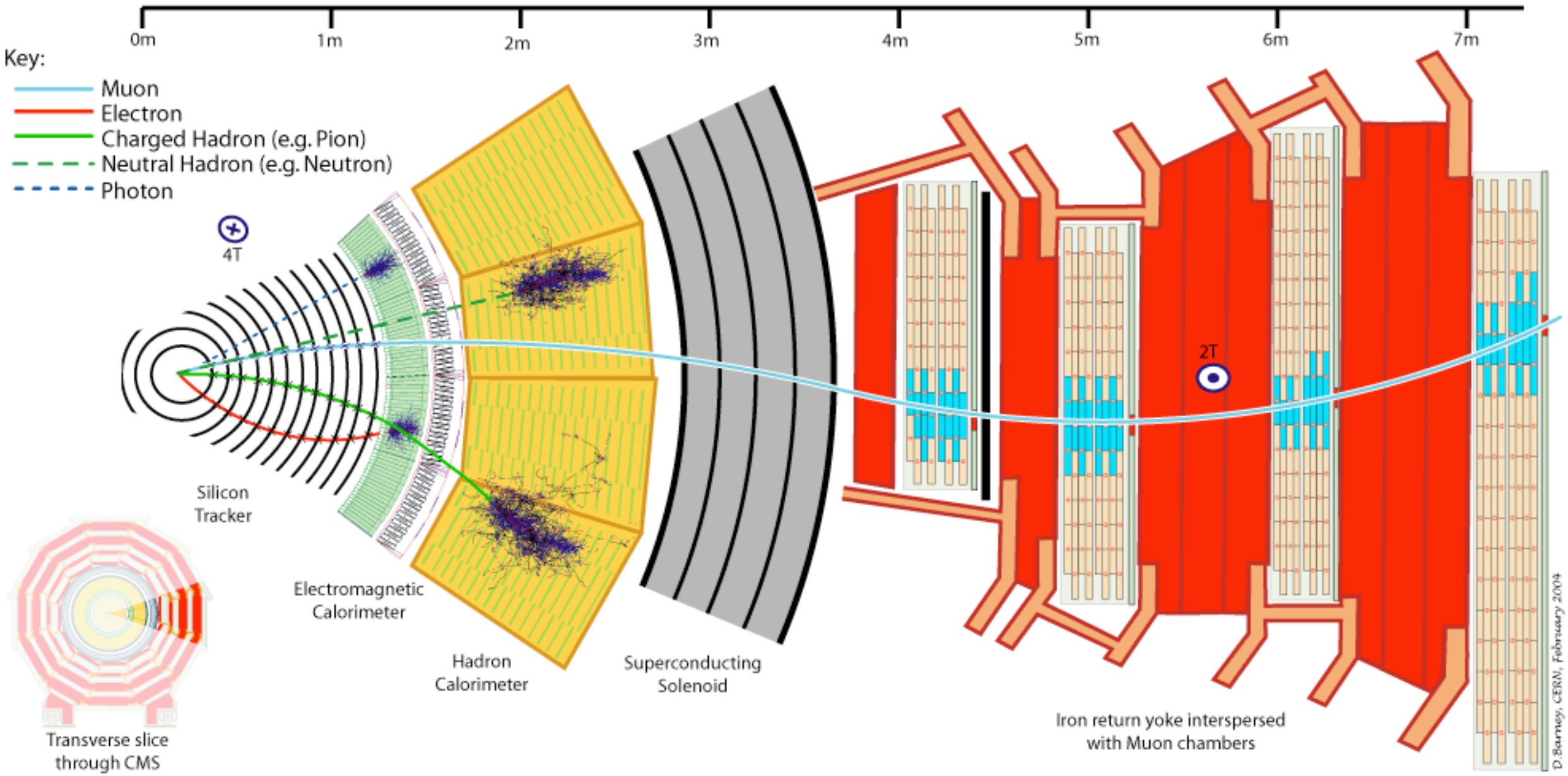
Fwd-Toroid z-Dimension = PathLength
Momentum - Field Strength



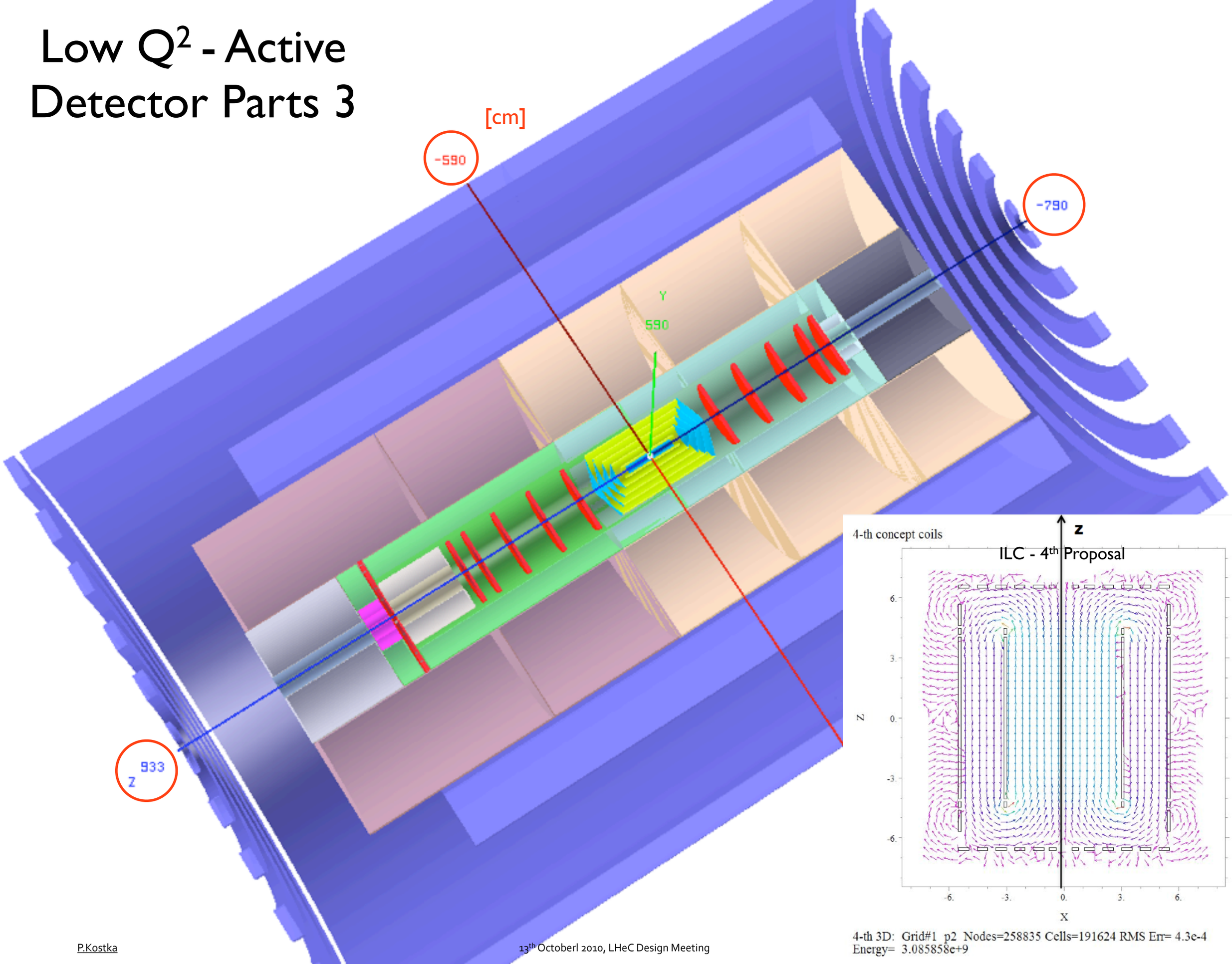


PathLength = 1.2 m used in figure before

CMS Detector Setup



Low Q^2 - Active Detector Parts 3



Detector Setup

Main Objectives 2

- Solenoid return yoke for 3.5T - needs ~10k tons steel ~3M$ (June '10) - ~5M$ (currently) + cost for extended muon tracking detector, mechanics etc.
- Second solenoid - closed field; either lower field both - adding to 3.5T;
  Or higher field in inner part = 3.5T + outer field
- CMS and ATLAS are not hermetic as well; radiation to be checked (Uludag Univ.)
- access easier and weight much less; support structure by both solenoids + external frame
- to be evaluated (H.Tenkate, A.Dudarev)
- ONE Detector Configuration Only would be a big step forward!

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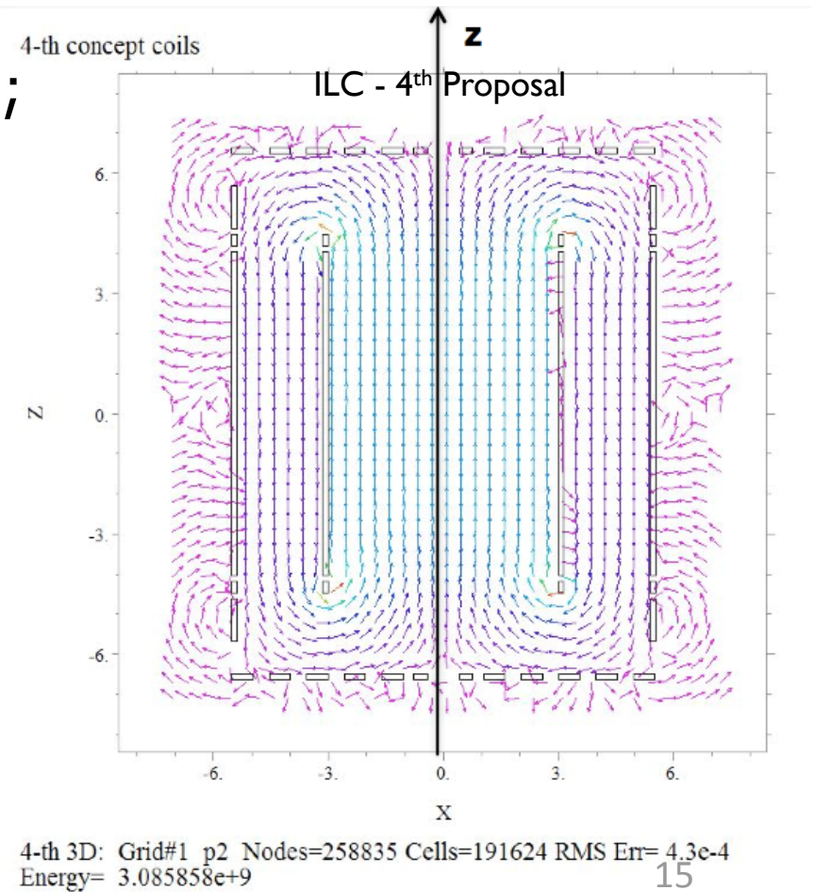

many things to do still

LHeC – general parameters

e- beam	RR	LR ERL	LR "p-140"
e- energy at IP[GeV]	60	60	140
luminosity [10^{32} cm^{-2}s^{-1}]	17.1	10.1	0.44
polarization [%]	5 - 40	90	90
bunch population [10^9]	26	2.0	1.6
e- bunch length [μm]	10000	300	300
bunch interval [ns]	25	50	50
transv. emit. $\gamma\varepsilon_{x,y}$ [mm]	0.58, 0.29	0.05	0.1
rms IP beam size $\sigma_{x,y}$ [μm]	30, 16	7	7
e- IP beta funct. $\beta^*_{x,y}$ [m]	0.18, 0.10	0.12	0.14
full crossing angle [mrad]	0.93	0	0
geometric reduction H_{hg}	0.77	0.91	0.94
repetition rate [Hz]	N/A	N/A	10
beam pulse length [ms]	N/A	N/A	5
ER efficiency	N/A	94%	N/A
average current [mA]	131	6.6	0.27
tot. wall plug power[MW]	100	100	100

p- beam	RR	LR
bunch pop. [10^{11}]	1.7	1.7
tr.emit.$\gamma\varepsilon_{x,y}$ [μm]	3.75	3.75
spot size $\sigma_{x,y}$ [μm]	30, 16	7
$\beta^*_{x,y}$ [m]	1.8,0.5	0.1$
bunch spacing [ns]	25	25

$ smaller LR *p*-β* value than for nominal LHC (0.55 m):
- reduced *l** (23 → 10 m)
- only one *p* beam squeezed
- new IR quads as for HL-LHC

B. Holzer,
M. Klein,
F. Zimmermann

CLIC-LHeC Synergies & KEK Trip Report, Frank Zimmermann, CLIC Meeting 20 August 2010