Update of Compton polarimeter

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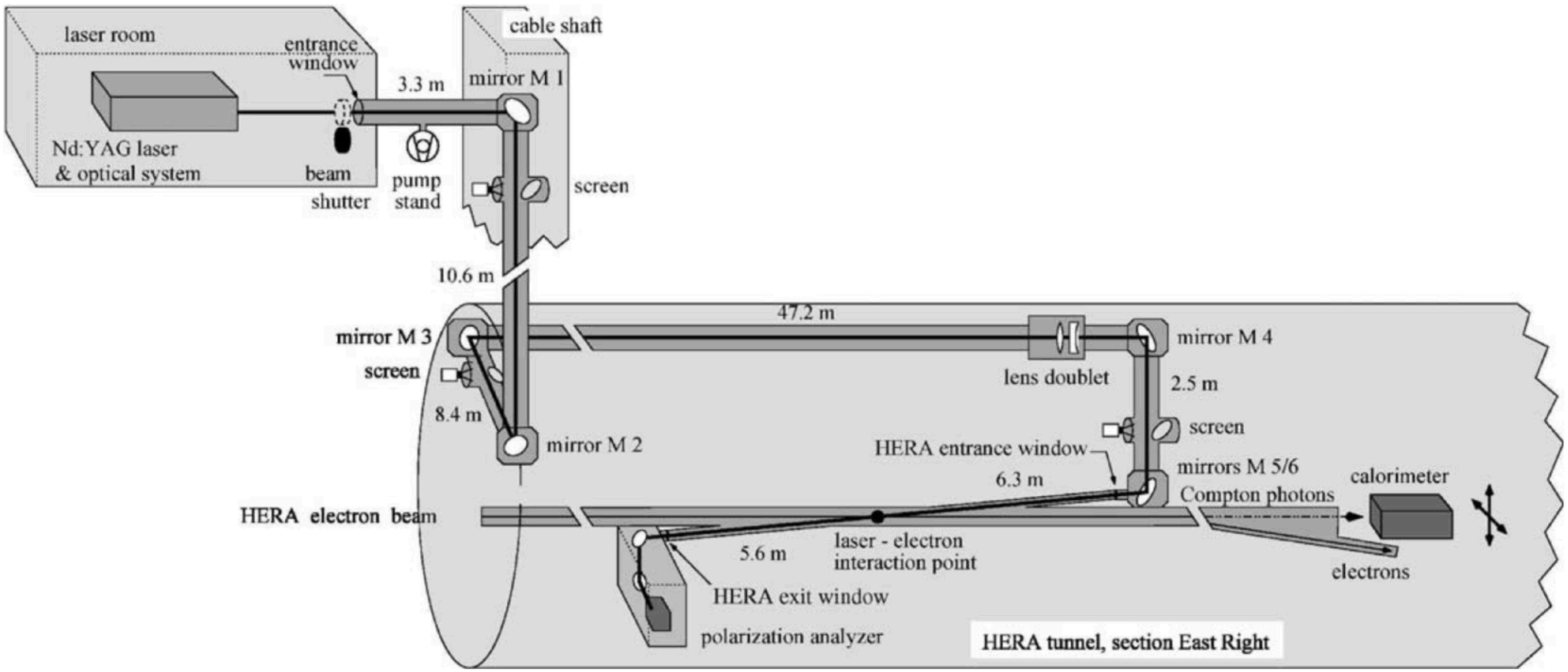
Electron polarimeter in HERA

Layout of the Longitudinal Polarimeter in the HERA East section.

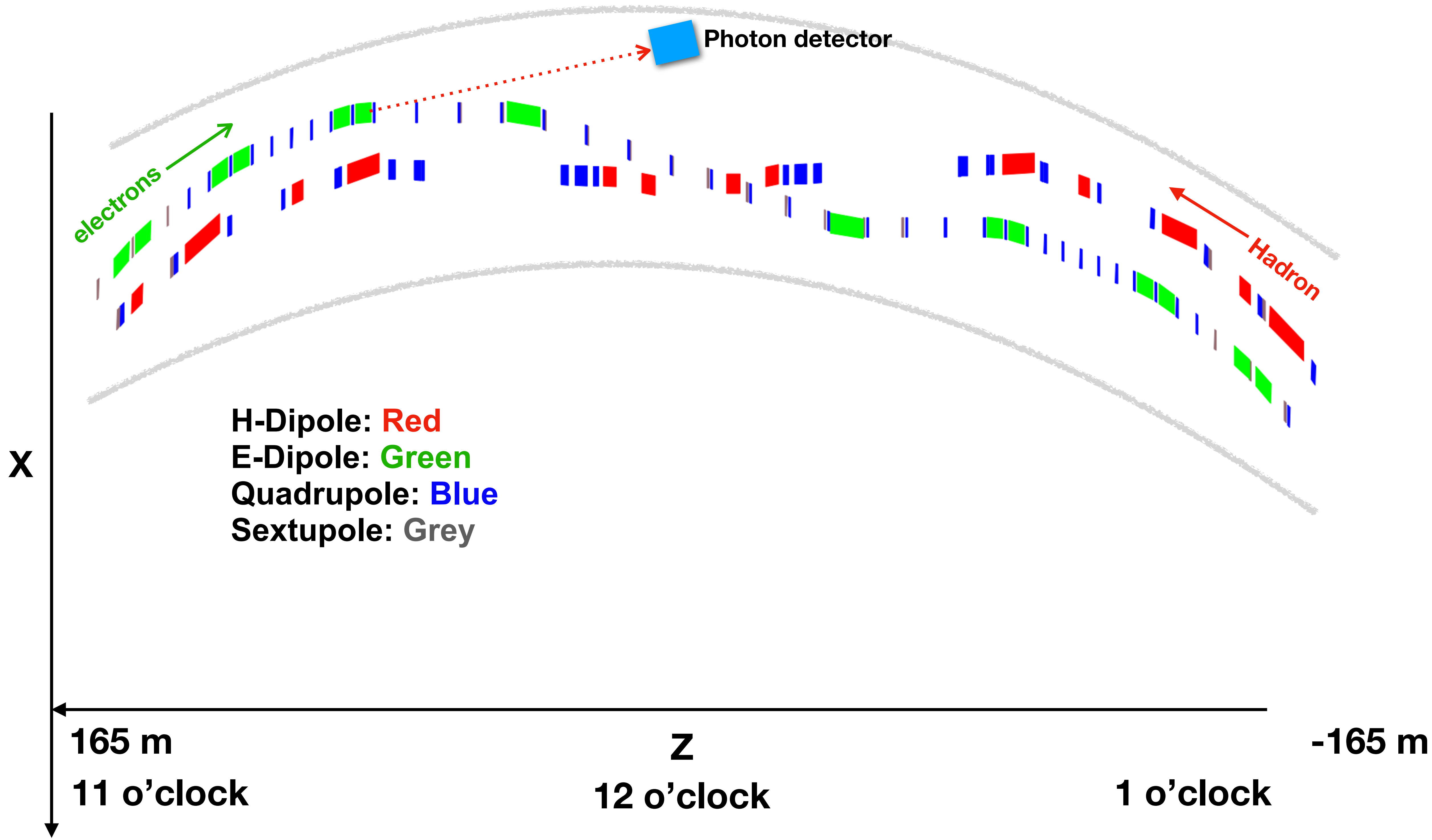


Beckmann M, Borissov A, Brauksiepe S, et al. The longitudinal polarimeter at HERA[J]. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2002, 479(2-3): 334-348.

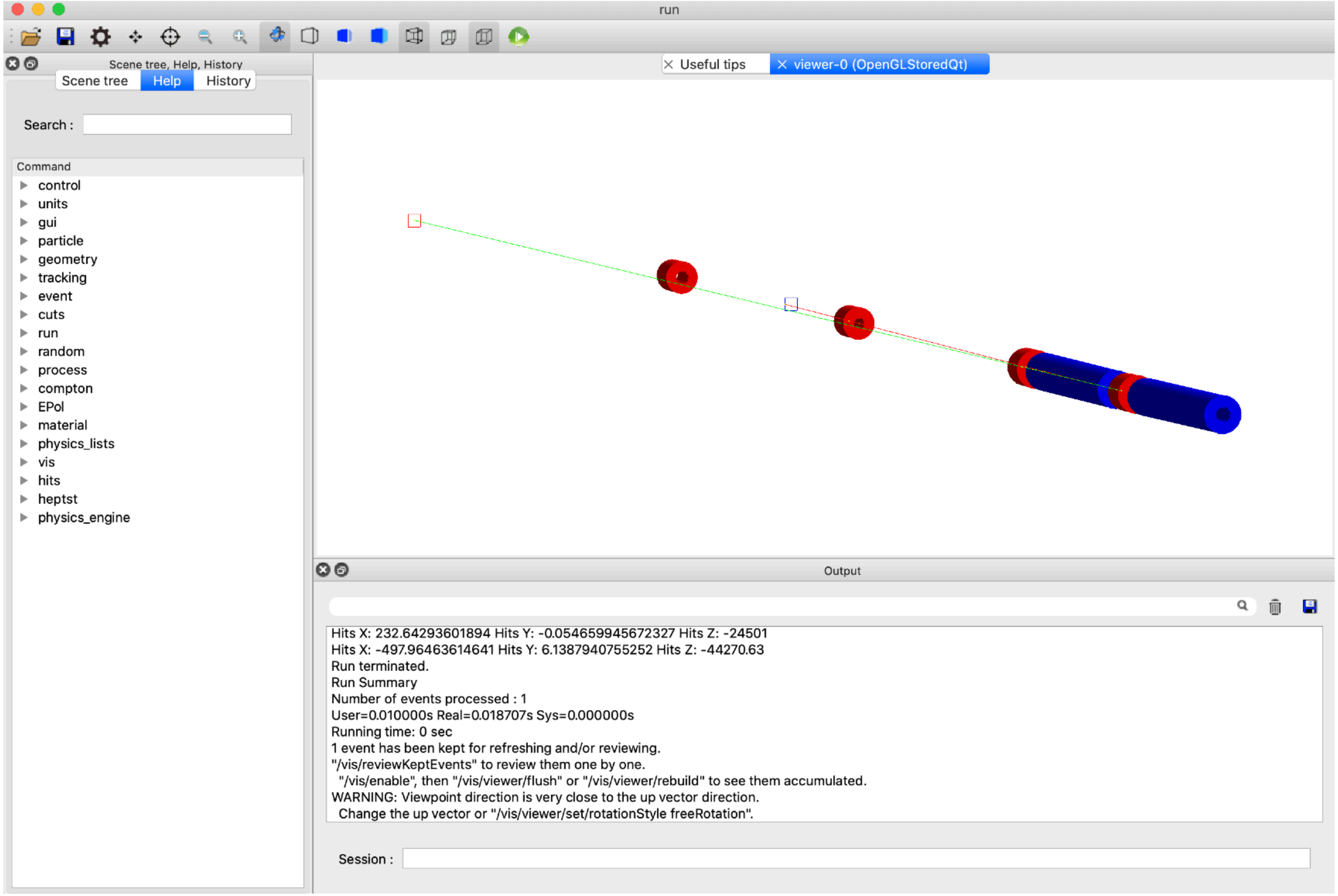
Requirements of electron polarimeter

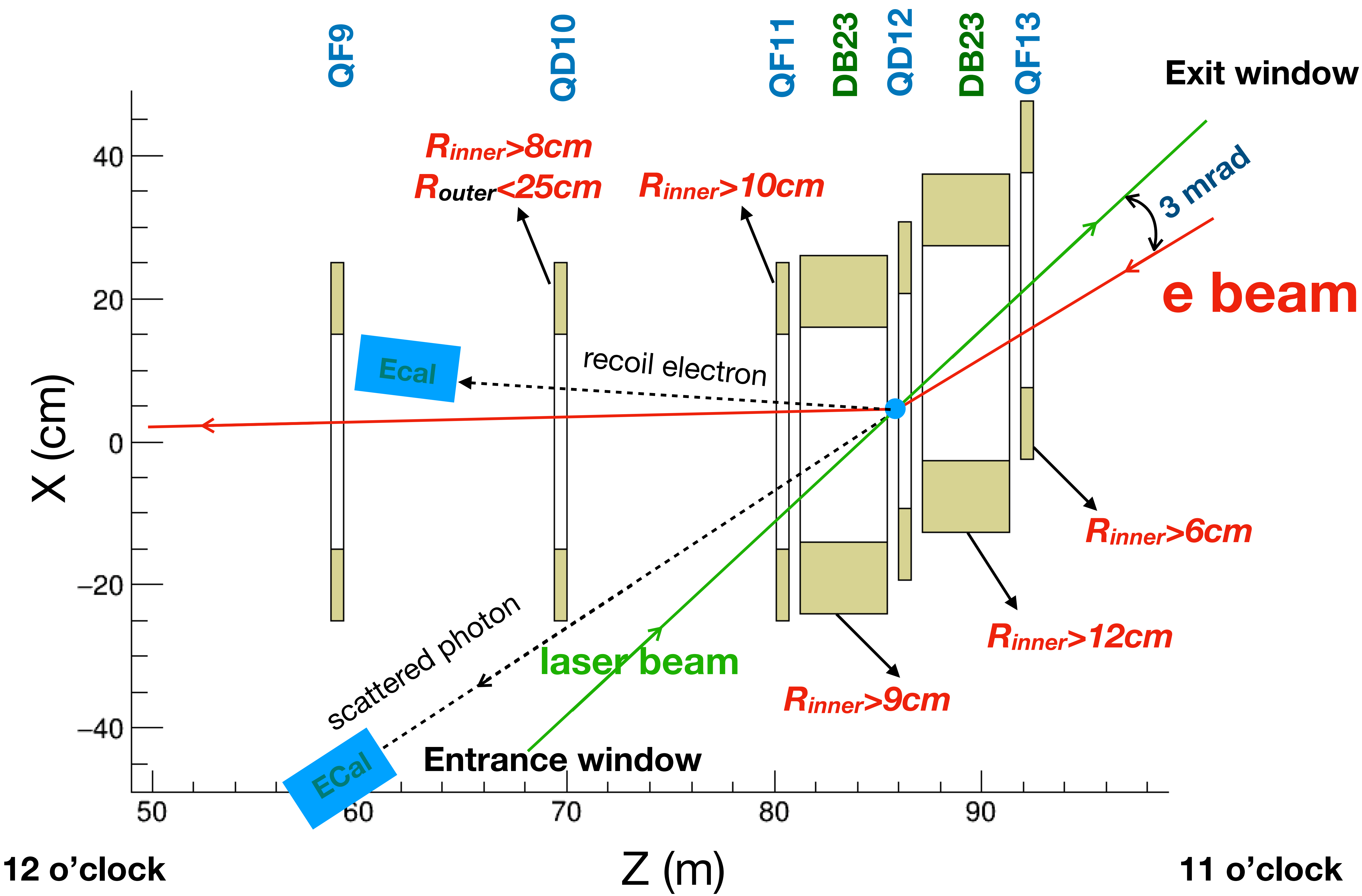
- Need to measure both longitudinal and transverse components;
  - The longitudinal polarization can be measured by measuring the asymmetry of the energy spectra measured with left and right helicities laser;
  - The transverse polarization can be measured by measuring the spatial asymmetry;
- Need to measure bunch-by-bunch polarization;
- Need to measure with high precision ~1%;

IR12 layout


Photon detector
electrons
Hadron
H-Dipole: Red
E-Dipole: Green
Quadrupole: Blue
Sextupole: Grey
X
Z
165 m
11 o'clock
12 o'clock
1 o'clock
-165 m

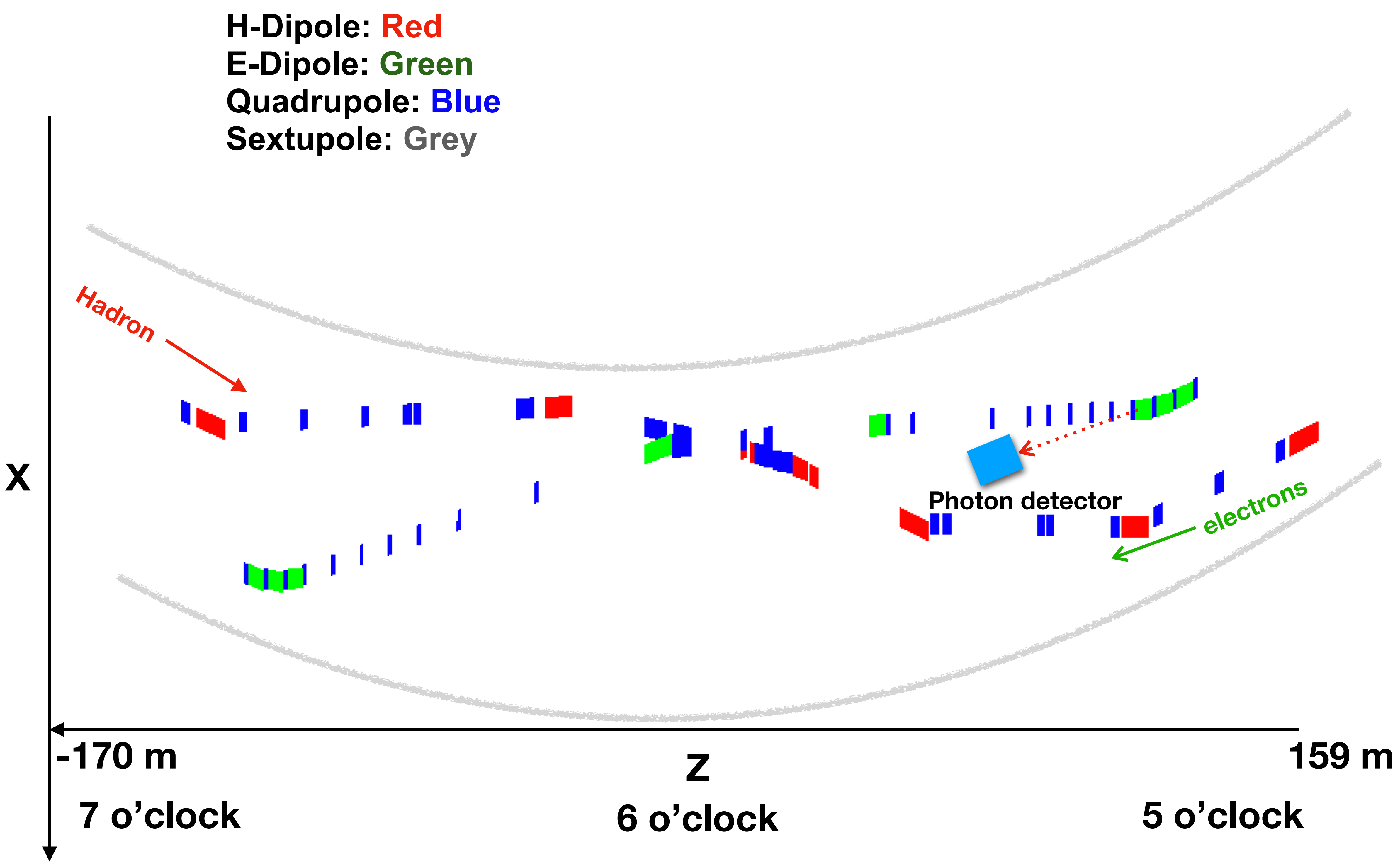
IR12 layout


run
Scene tree, Help, History
Scene tree
Help
History
Search :
Command
control
units
gui
particle
geometry
tracking
event
cuts
run
random
process
compton
EPol
material
physics_lists
vis
hits
heptst
physics_engine
Useful tips
viewer-0 (OpenGLStoredQt)
Output
Hits X: 232.64293601894 Hits Y: -0.054659945672327 Hits Z: -24501
Hits X: -497.96463614641 Hits Y: 6.1387940755252 Hits Z: -44270.63
Run terminated.
Run Summary
Number of events processed : 1
User=0.010000s Real=0.018707s Sys=0.000000s
Running time: 0 sec
1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them one by one.
"/vis/enable", then "/vis/viewer/flush" or "/vis/viewer/rebuild" to see them accumulated.
WARNING: Viewpoint direction is very close to the up vector direction.
Change the up vector or "/vis/viewer/set/rotationStyle freeRotation".
Session :

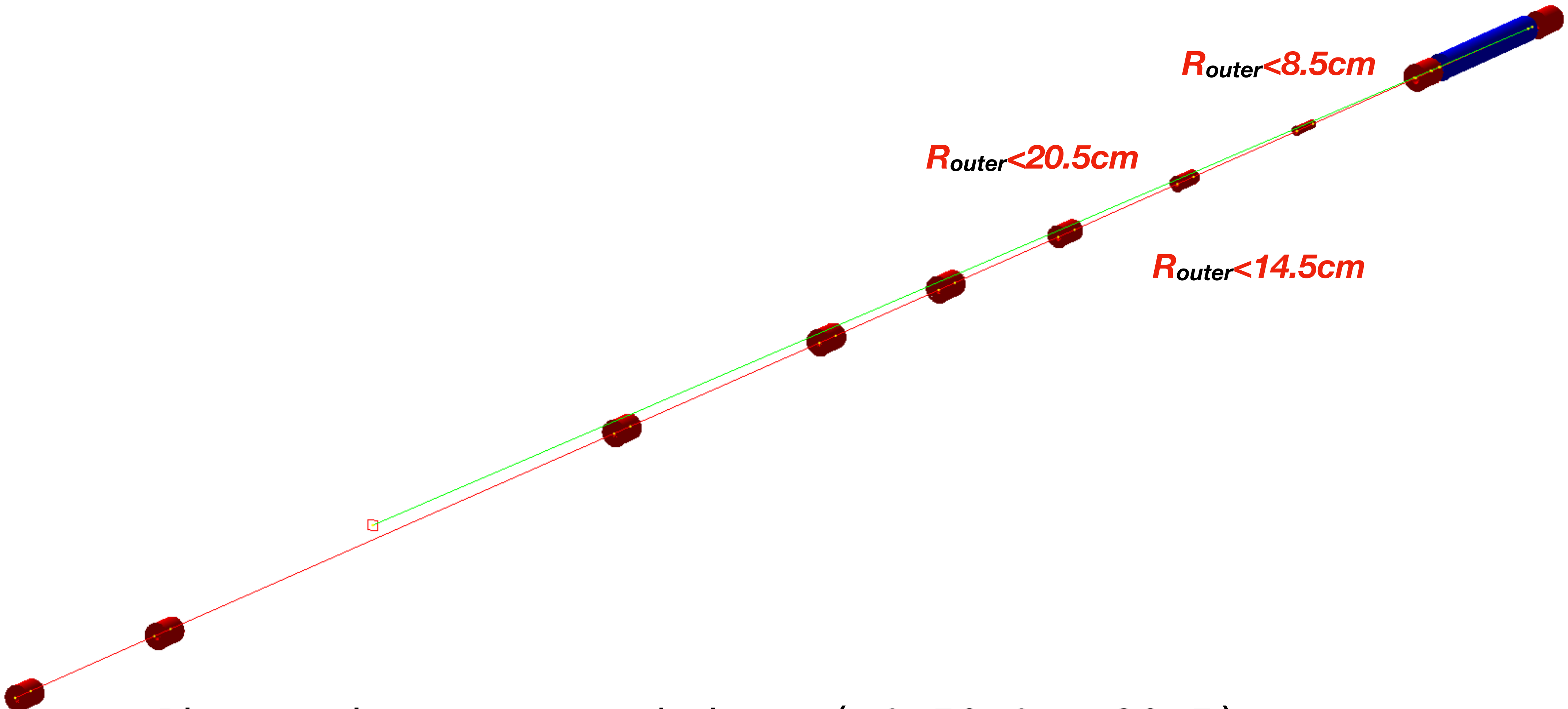


QF9
QD10
QF11
DB23
QD12
DB23
QF13
Exit window
Rinner>8cm
Router<25cm
Rinner>10cm
3 mrad
e beam
recoil electron
Ecal
Rinner>6cm
Rinner>12cm
Rinner>9cm
scattered photon
laser beam
ECal
Entrance window
X (cm)
Z (m)
12 o'clock
11 o'clock

New IR6 layout

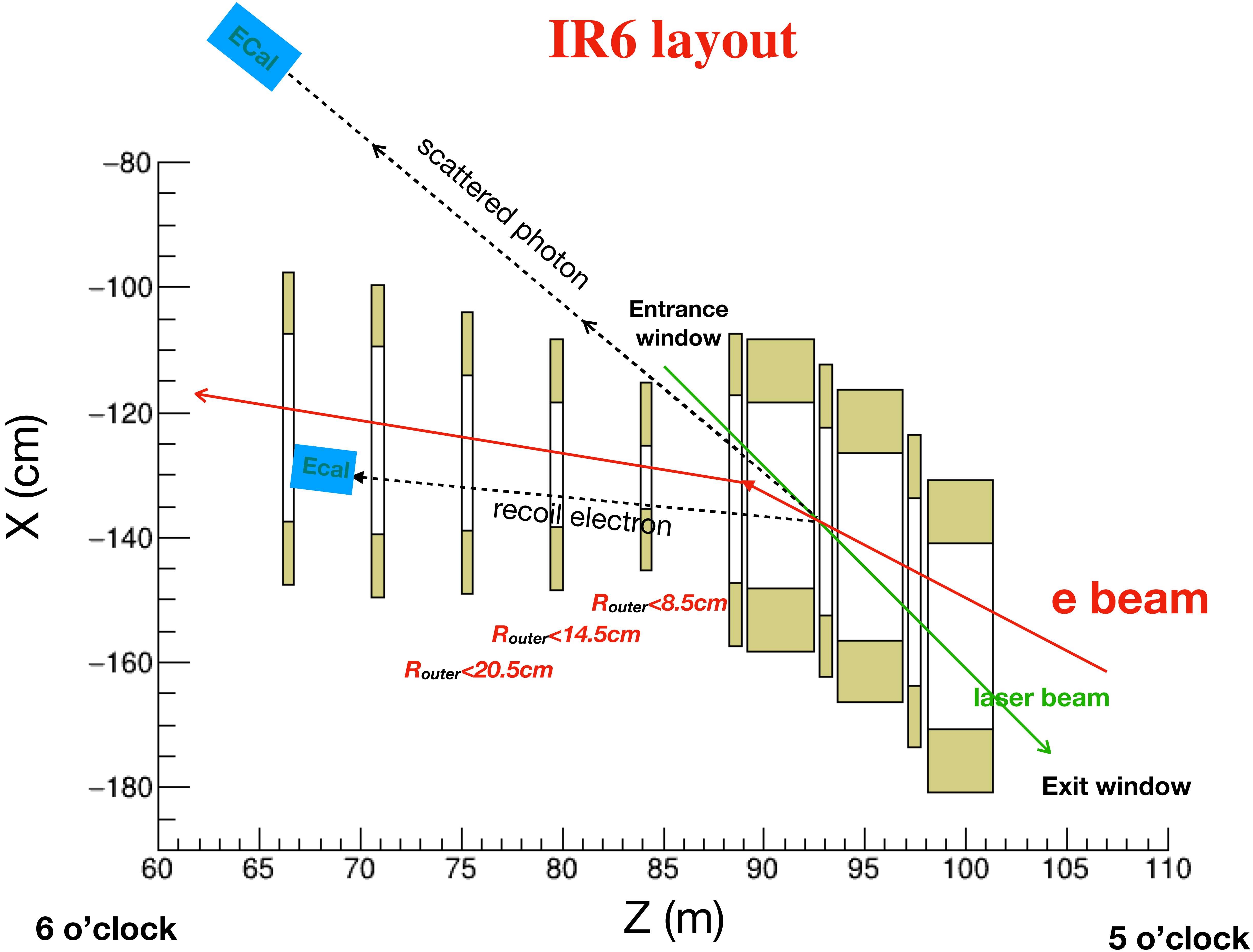


IR6 layout



Photon detector position: (-0.59,0, -39.5);
About 1 meter away from the hadron beam;
About 40 meters away from the interaction point;

IR6 layout



ECal
scattered photon
Entrance window
Ecal
recoil electron
e beam
laser beam
Exit window
Router<8.5cm
Router<14.5cm
Router<20.5cm
X (cm)
Z (m)
−80
−100
−120
−140
−160
−180
60
65
70
75
80
85
90
95
100
105
110
6 o’clock
5 o’clock

Transverse polarization

The distribution of the initial electrons would also produce a smearing of the Y distribution of the scattered photon; The height of the electron beam at a distance D from the IP is calculated in the following way:

$$\sigma_{e,y}(D) = \sqrt{\epsilon_y \beta_y(D)} = \sqrt{\epsilon_y}\sqrt{\beta_y(0) - 2\alpha_y(0)D + \gamma_y(0)D^2}$$

$$\gamma_y(0) = \frac{1 + \alpha_y^2(0)}{\beta_y(0)}$$

$$\epsilon_y = 2.0nm$$ **(Vertical emittance)**

Let's assume the distance between the Compton scattering IP and the photon detector is 40m. In the case of IP12, we have:

$$\beta_x = 14m; \alpha_x(0) = -1.577; \gamma_x(0) = 0.249m^{-1}$$

$$\beta_y = 54m; \alpha_y(0) = 0.0649; \gamma_x(0) = 0.0186m^{-1}$$

↓

$$\sigma_{e,y}(40) = 0.4mm \quad vs \quad \sigma_{e,x}(40) = 3.6mm$$

Species	proton	electron
Energy [GeV]	275	18
CM energy [GeV]	140.7	
Bunch intensity [10^{10}]	20.5	6.2
No. of bunches	290	
Beam current [A]	0.74	0.227
RMS norm. emit., h/v [μm]	4.6/0.75	845/72
RMS emittance, h/v [nm]	16/2.6	24/2.0
β^*, h/v [cm]]	90/4.0	59/5.0
IP RMS beam size, h/v [μm]	119/10	
K_x	11.8	
RMS $\Delta\theta$, h/v [μrad]	132/253	202/202
BB parameter, h/v [10^{-3}]	3/2	100/100
RMS long. emittance [10^{-3}, eV·sec]	36	
RMS bunch length [cm]	6	0.9
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9
Max. space charge	0.006	neglig.
Piwinski angle [rad]	5.6	0.8
Long. IBS time [h]	2.1	
Transv. IBS time [h]	2	
Hourglass factor H	0.86	
Luminosity [10^{33}cm^{-2}sec^{-1}]	1.65	

The horizontal smearing of the backscattered distribution is much larger than the vertical smearing, so we choose to measure the vertical component of the polarization.

Time Requirements

$$L = f_b N_e N_\gamma G$$

Geometric factor:

$$G = \frac{1+\beta cos\theta}{2\pi\sqrt{\sigma_y^2+\sigma_{\gamma y}^2}\sqrt{\sigma_x^2(\beta+cos\theta)^2+\sigma_{\gamma x}^2(1+\beta cos\theta)^2+(\sigma_z^2+\sigma_{\gamma z}^2)sin^2\theta}}$$

$f_b = 2.2852\times10^7; Ne = 6.2\times10^{10}; N_\gamma = 2.84974\times10^{12};$

$\sigma_{\gamma x} = 0.1mm; \sigma_{\gamma y} = 0.1mm; \sigma_{\gamma z} = 1.3mm;$

$\sigma_z = 10mm; \sigma_x = \sqrt{\epsilon_x\beta_x}, \beta_x = 14m; \beta_y = 54m;$

$\delta P_e \approx \frac{1}{A\sqrt{N}}; N = time * L * \sigma_{Compton} * 0.8 * f_b/290;$

$\theta = 3mrad; \sigma_{Compton} = 400mb;$

Laser power: 10W

Species	proton	electron
Energy [GeV]	275	18
CM energy [GeV]	140.7	
Bunch intensity [10^{10}]	20.5	6.2
No. of bunches	290	
Beam current [A]	0.74	0.227
RMS norm. emit., h/v [μm]	4.6/0.75	845/72
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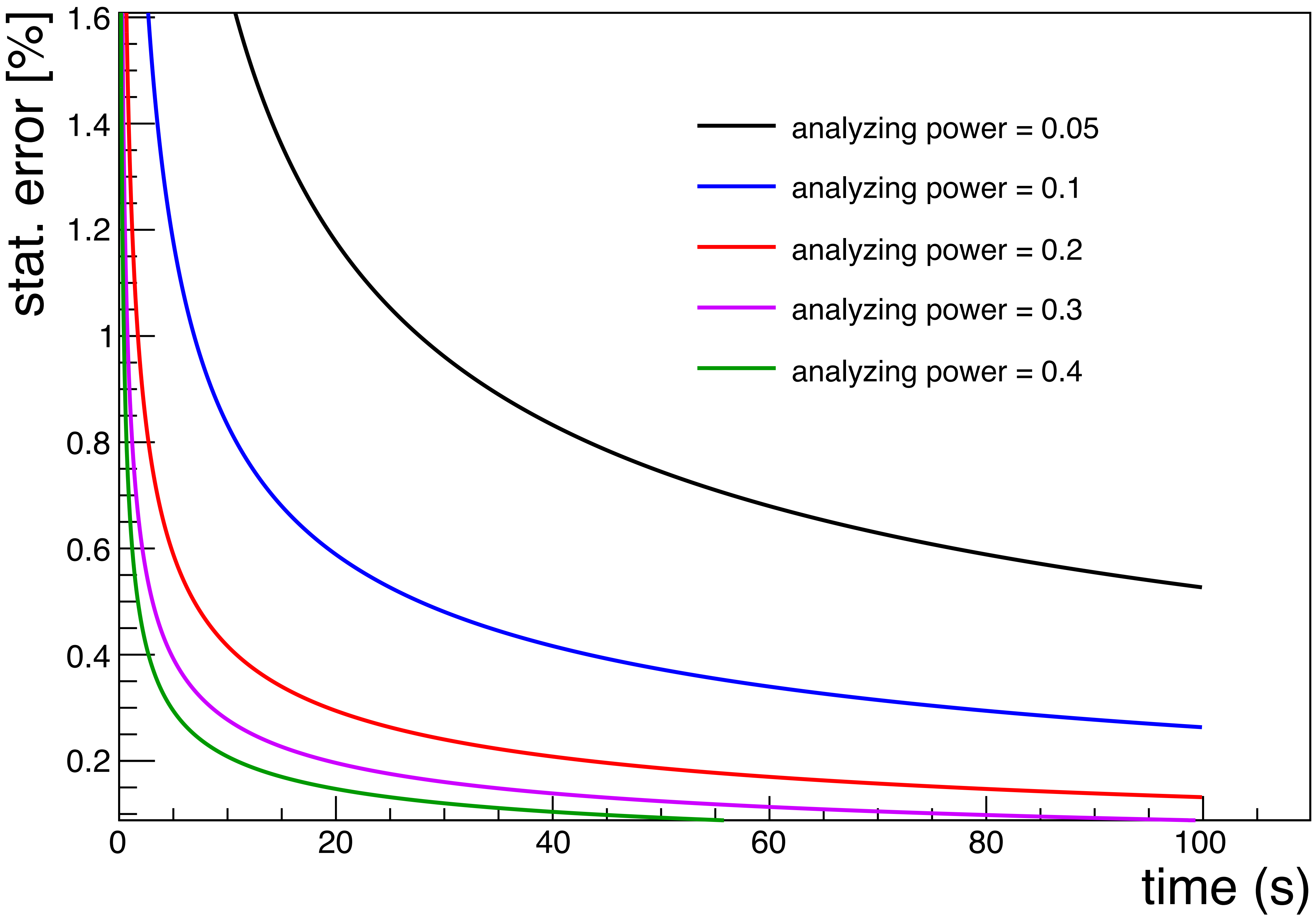
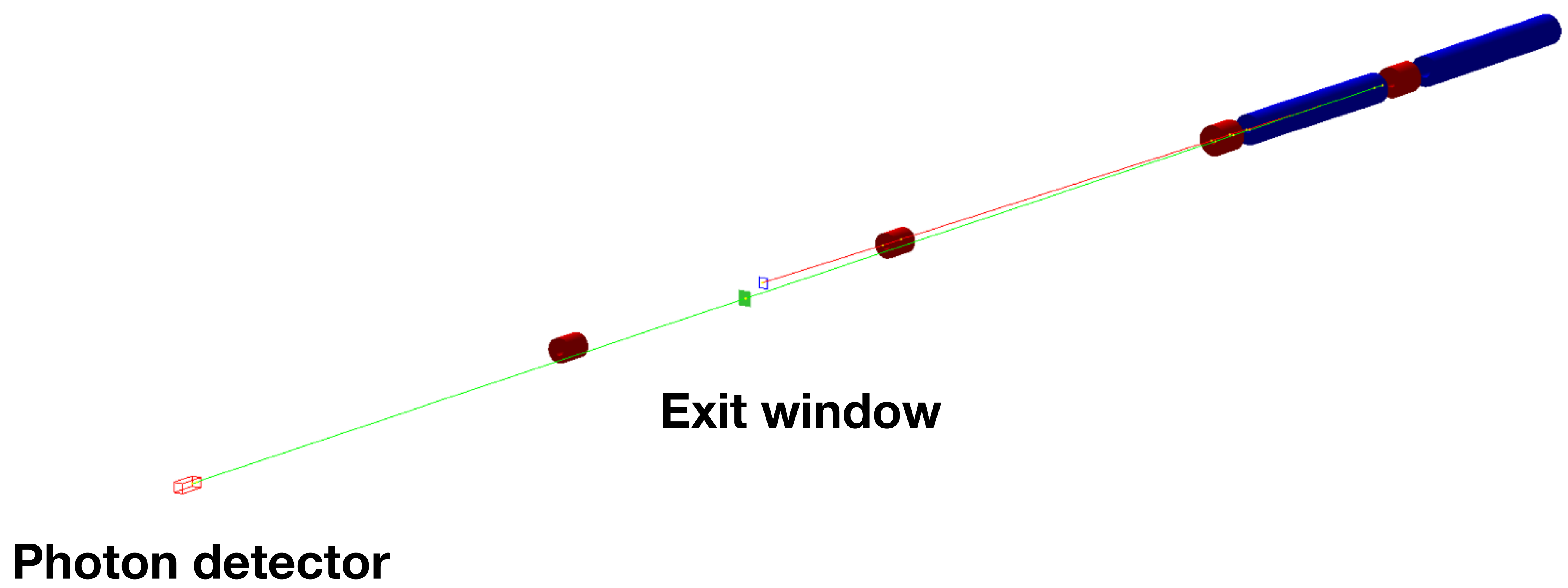
Time Requirements



Systematic Uncertainty



- Conversion of the Compton photons in the exit window (0.5 mm aluminum);
- 20m of the air between the exit window and the photon detector;
- Photon detector response;

Thanks.