First look at back-scattered Compton polarimeter-and-spectrometer

N. Muchnoi (BINP) A. Blondel (Geneva)
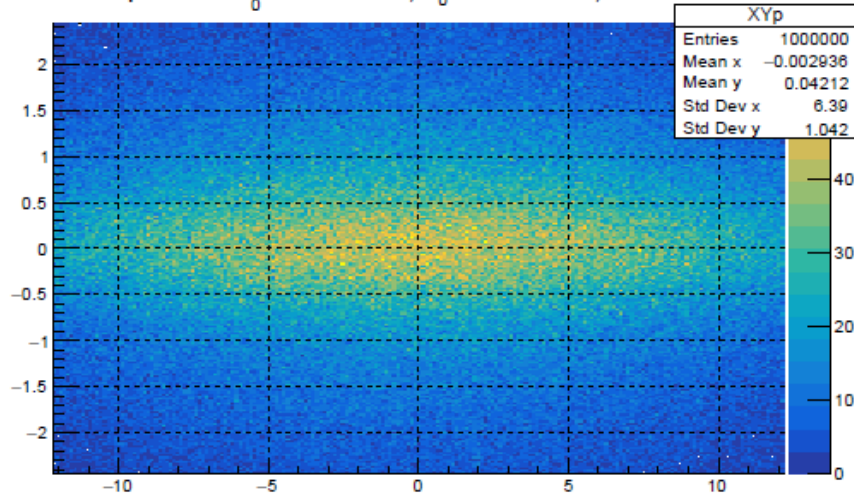
FCCee_z_208_nosol_4g.sad

The dispersion suppressor dipole (BDS):

```
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 BEND    BDS       =(L =24.119925292770883   ANGLE =.002134100603580931      E1 =.5     E2 =.5  )
```
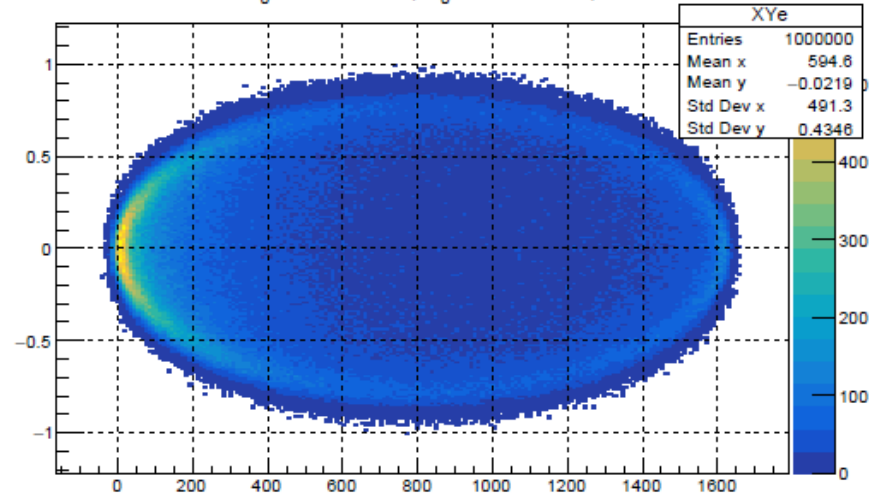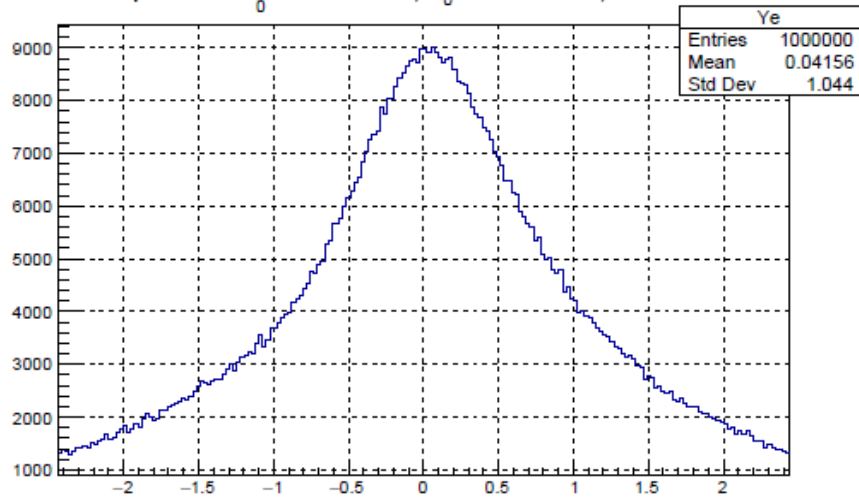
In units of $1/\gamma = m_e c^2/E_{beam}$

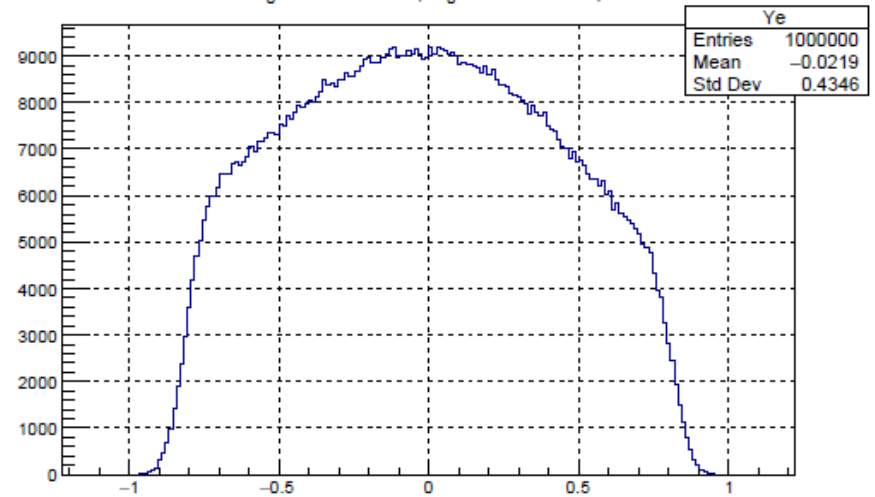photons $E_0 = 45.6$ GeV, $\lambda_0 = 532.0$ nm, $\kappa = 1.628$

XYp	
Entries	1000000
Mean x	−0.002936
Mean y	0.04212
Std Dev x	6.39
Std Dev y	1.042

electrons $E_0 = 45.6$ GeV, $\lambda_0 = 532.0$ nm, $\kappa = 1.628$

XYe	
Entries	1000000
Mean x	594.6
Mean y	−0.0219
Std Dev x	491.3
Std Dev y	0.4346

photons $E_0 = 45.6$ GeV, $\lambda_0 = 532.0$ nm, $\kappa = 1.628$

Ye	
Entries	1000000
Mean	0.04156
Std Dev	1.044

electrons $E_0 = 45.6$ GeV, $\lambda_0 = 532.0$ nm, $\kappa = 1.628$

Ye	
Entries	1000000
Mean	−0.0219
Std Dev	0.4346

0.083

$\kappa \sim 1.68$

$\kappa \sim 0.16$

$W = \dfrac{P\ [W]\ \sqrt{}}{0.7 \cdot 10^{11}\ [V}$

$E_{min} = $

$\sim B \qquad \kappa \cdot \theta_0$

E_{beam}

$\sim \dfrac{B}{E} \qquad \theta_0$

$\dfrac{160}{0.1}$

γ

30mm

40mm

90μ

3.5 mm

laser

laser

$\leftarrow 24m \rightarrow$

2μrad

40mm

$\dfrac{\Delta L}{L} \sim 10^{-6}$

e

τ

S_{max}

$\Delta P = \dfrac{\sigma}{\sqrt{2N}\ \delta^{max}} = \sqrt{\langle S^2 \rangle}\ \sigma_0^{-2}$

$\sqrt{2N}\ \delta^{max}$

http://laser-export.com/prod/527.html
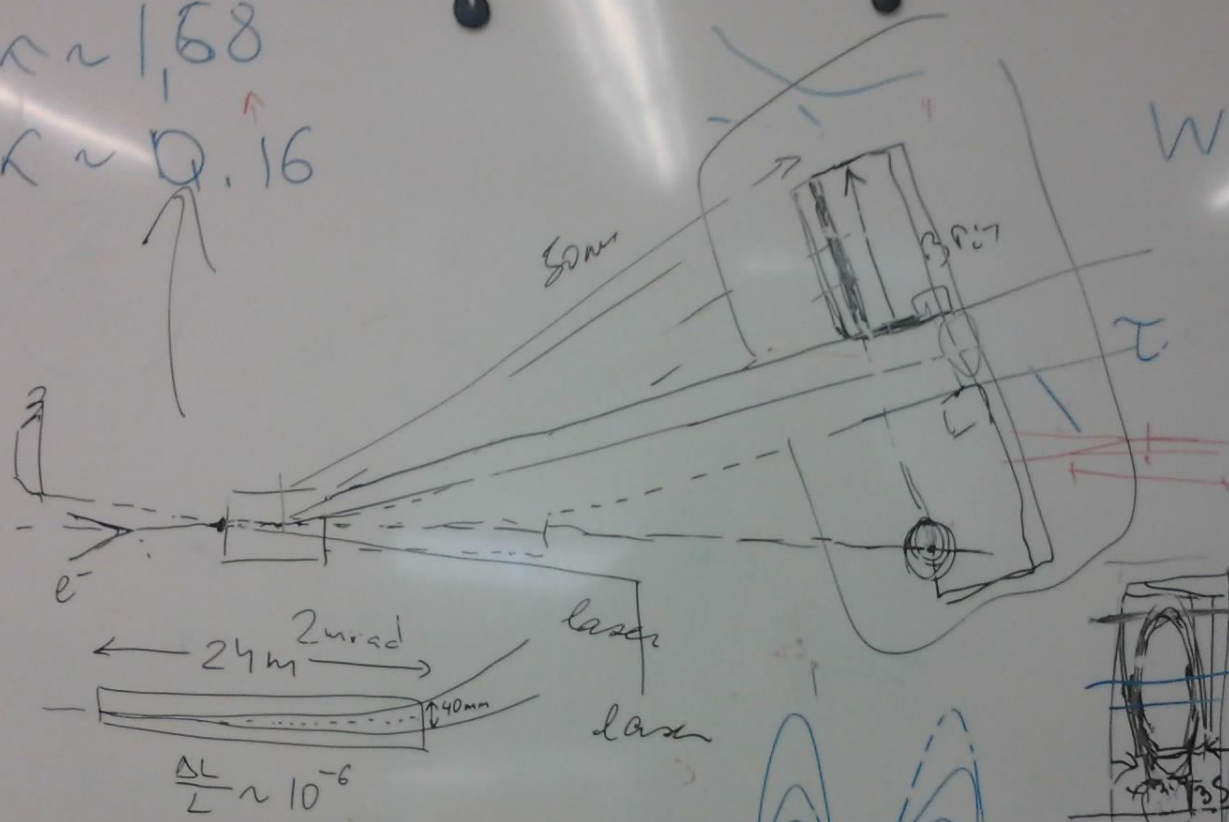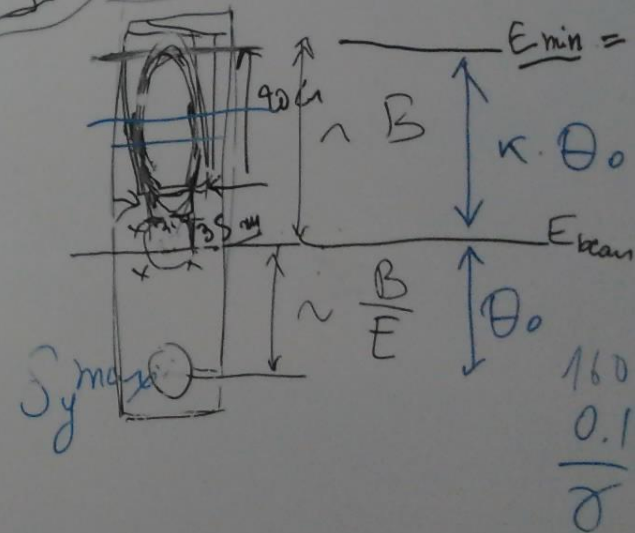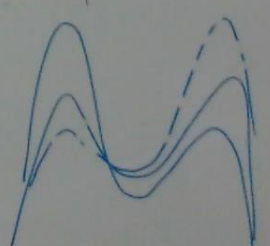
...Laser-compact Group specializes in research, development and manufacturing of **ultra-violet (UV), green and infrared (IR)** diode-pumped solid-state (DPSS) lasers....

ISO 9001:2008 certified

TECH-527

Application fields: materials micromachining, laser marking, photoacoustics, LIBS (laser-induced breakdown spectroscopy), DLIP (Direct Laser Interference Patterning), LIBD (laser-induced breakdown detection), OPO pumping, remote sensing, high technologies R&D, ablation.

Features:

- Active Q-switched mode of operation with nanosecond pulse duration
- High pulse energy and peak power
- Perfect beam quality
- High pulse-to-pulse stability
- Ultra-compact design
- Conductive cooling of laser head
- External / internal triggering, PC control via RS-232
- Fiber-coupling option is available on request

TECH-series datasheet

Parameter / Model	TECH-527			
	Basic	**Advanced**	**Express**	**Specific**
Wavelength, nm	527			
Mode of Operation	Q-switched, external/internal triggering			
Pulse Energy [1,2], µJ	250	500	500	1000
Max. Average Output Power, W	~0.25@1kHz ~0.5@4kHz	~ 2 @4 kHz	~ 0.5 @1kHz	~ 1 @1 kHz
Pulse Duration(FWHM)[1,2], ns	< 5		< 3	<12
Peak Power[1,2], kW	>50	> 100	> 165	>80

Range of Pulse Repetition Rate, kHz
  Ext. Triggering[3]
  Int. Triggering: through RS-232[4]
      without PC[5]
	single pulse - 4
	0.01 - 4
	1 ±0.01
		single pulse-4
		0.01 - 4
		4 ±0.01
			single pulse - 1
			0.01 - 1
			1 ±0.01	

Pulse-to-pulse Stability - StDev/Mean [1,2],%	<3		<2	
Long-term Stability, %/8 hrs	< 2			
Beam Quality	TEMoo, M^2<1.2			
Beam Diameter (1/e², at output aperture), mm	0.6 ±0.2		0.7 ±0.2	0.8 ±0.2
Beam Divergence (full angle,1/e²), mrad	< 3			
Polarization Linearity	> 100:1, vertical (< 5°)			

Laser Trigger to Sync Out Pulse[1,2,6] , ns (av. pulse energy > 80%)
  Delay (the value is within the range)
  Jitter
	300 ±250 *
	< 8 *			

Laser Emission to Sync Out Pulse[1,2,6] , ns (av. pulse energy > 80%)
  Delay
  Jitter
	< 50
	< 2			

Warm Up Time, min	< 10			
Remote Control of Laser Parameters via interface RS-232	ON/OFF, Ext./Int. Triggering, Pulse Rep. Rate, Pulse Energy			
Data rate via Interface RS-232, bit/s	4800			
Operation Voltage, V	24 ±10%			
Max. Current Consumption, A	< 6			
Power Consumption, W	15-70[7]	20-90[7]	15-70[7]	
Laser Head Heating Power, W	5-20[7]	5-30[7]	5-20[7]	
Operating Temp/Humidity Range °C	+15 to +35 °C / up to 80% non-condensing			
Shipping Temp/Humidity Range (In the manufacturer package)	-20 to +50 °C / up to 80% humidity at 25 °C			
Dimensions of Laser Head (LxWxH), mm	215 x 70 x 40			

Beam Height, mm	21.5
Weight of Laser Head, kg	1.2 ±0.1
Dimensions of PSU (LxWxH), w/o Fan Heat Sink[7], mm	max. 230 x 153 x 47
Weight of PSU w/o Fan Heat Sink , kg	1.9 ±0.1
Weight of Fan Heat Sink, kg	1.7 ±0.1
Fiber Cable Length, m	1.5 ±5%
Minimal long term bending Radius of Fiber Cable, mm	50
LH-PC Cable Length, m	1.5 ±5%
Laser Class	IV
Compliance	CE, RoHS
Drawing of Laser Head	
Drawing of Power Supply	
Drawing of Fan Heat Sink for PSU	

* **For Advanced, Express and Specific line:** Delay and jitter are specified for the case of triggering by the pulse with the certain duration determined by the manufacturer (typ. 200-230 Bµs for Advanced and 800-900 Bµs for Express, Specific). Counted from the fall edge of the trigger pulse. In case of triggering with rise edge, the delay is about 200-230 Bµs and 800-900 Bµs, respectively, and the jitter is approx. 2% of it.

[1] Measured at 1 kHz pulse repetition rate for Basic, Express and Specific line.

[2] Measured at 4 kHz pulse repetition rate for Advanced line.

[3] Triggering with external electric pulse generator; generator is not included in delivery set.

[4] Generation of periodical laser pulses using PC, step 0.01 kHz. Average energy may be changed by software from 10% up to maximum value.

[5] Generation of periodical laser pulses at fixed rep. rate; external generator and/or PC are not required.

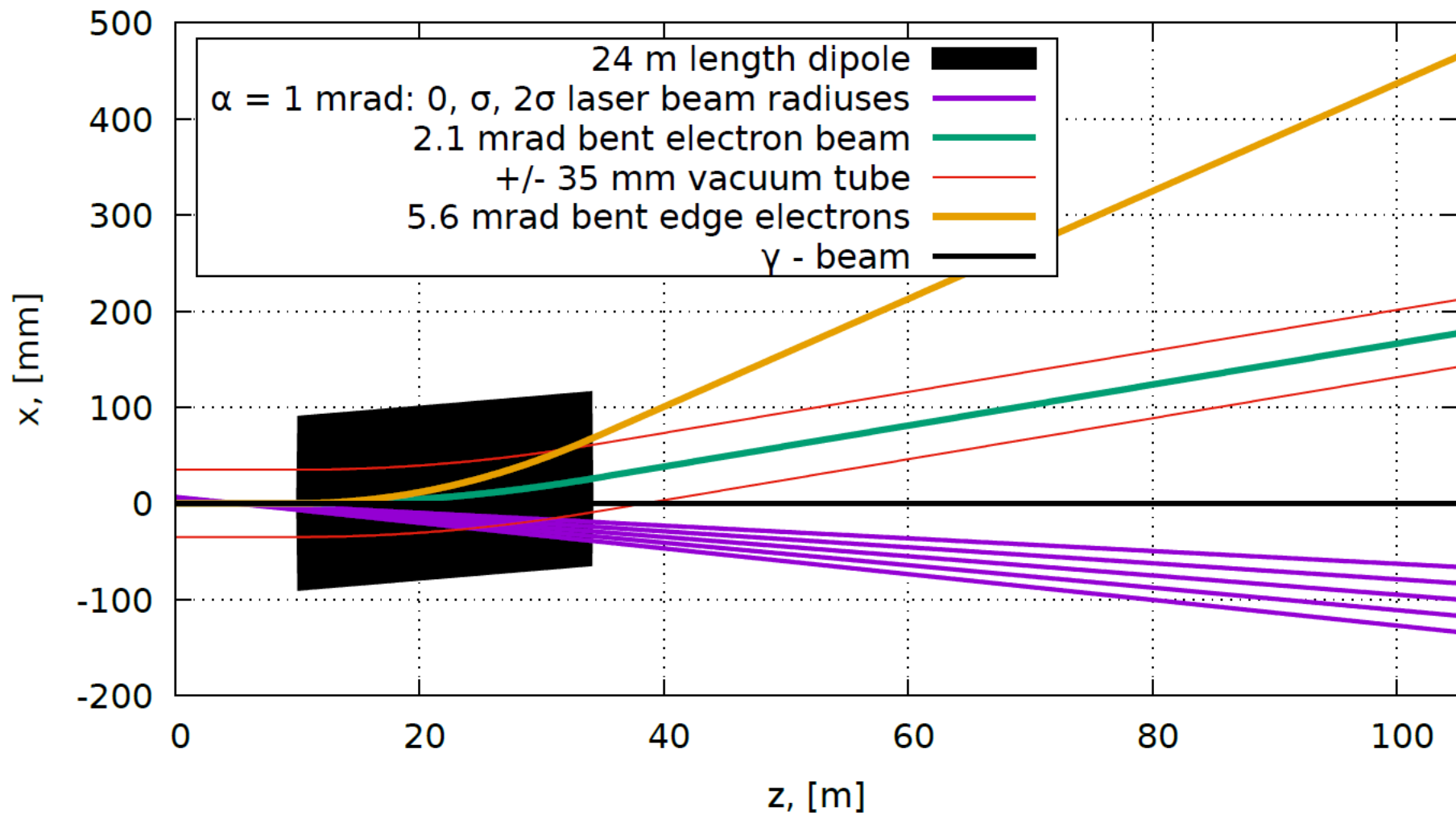[6] Sync Out signal is generated by pulse of laser light.

[7] Depending on pulse repetition rate. Fan Heat Sink to be attached depending on operation conditions and/or pulse repetition rate operation range.
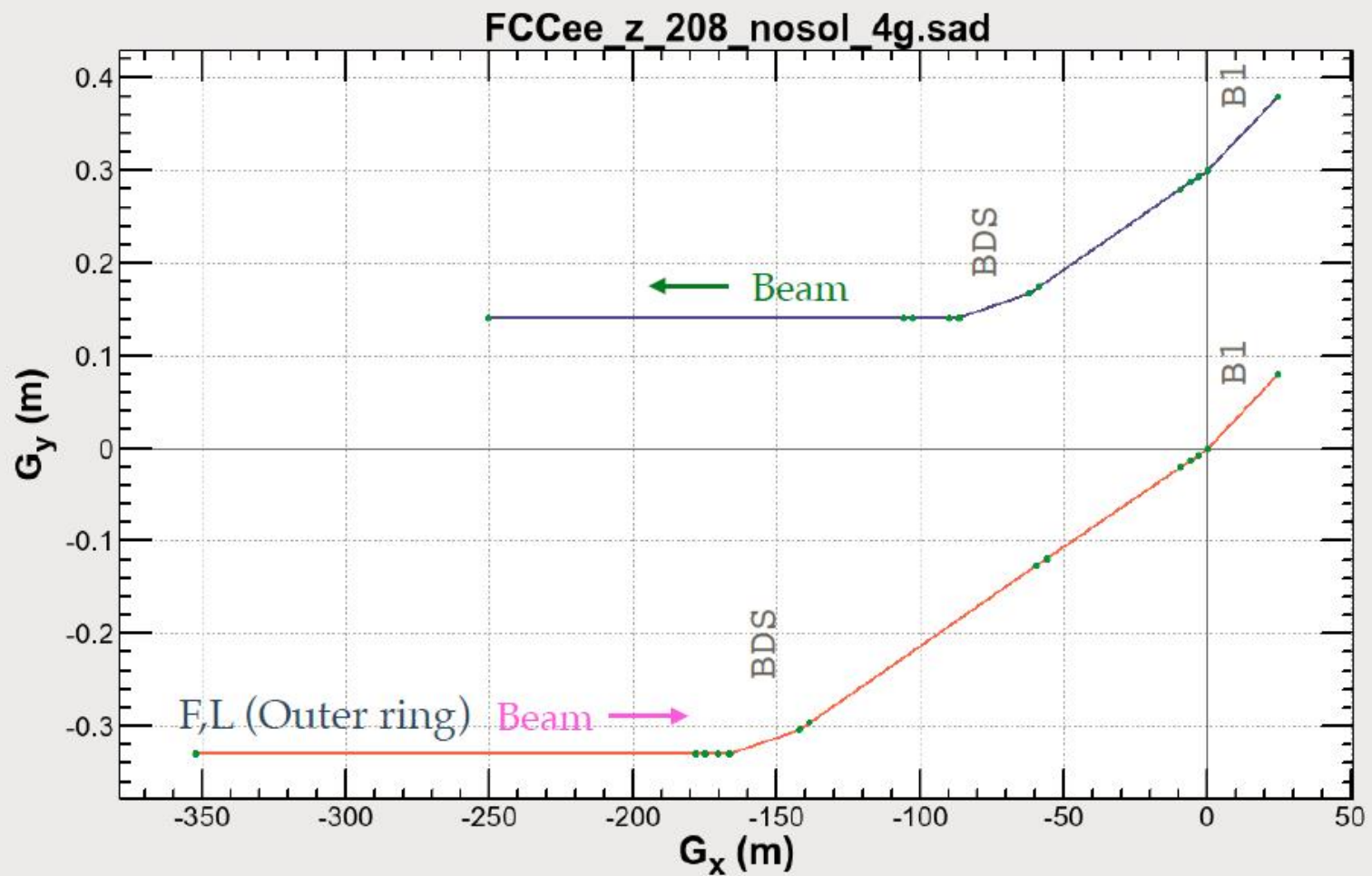
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The dispersion suppressor dipole (BDS):

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;
```

Laser polarimeter and energy spectrometer layout

Legend:
- 24 m length dipole
- $\alpha = 1$ mrad: 0, σ, 2σ laser beam radiuses
- 2.1 mrad bent electron beam
- +/- 35 mm vacuum tube
- 5.6 mrad bent edge electrons
- γ - beam

x-axis: z, [m]
y-axis: x, [mm]

FCCee_t_208_nosol_4g.sad
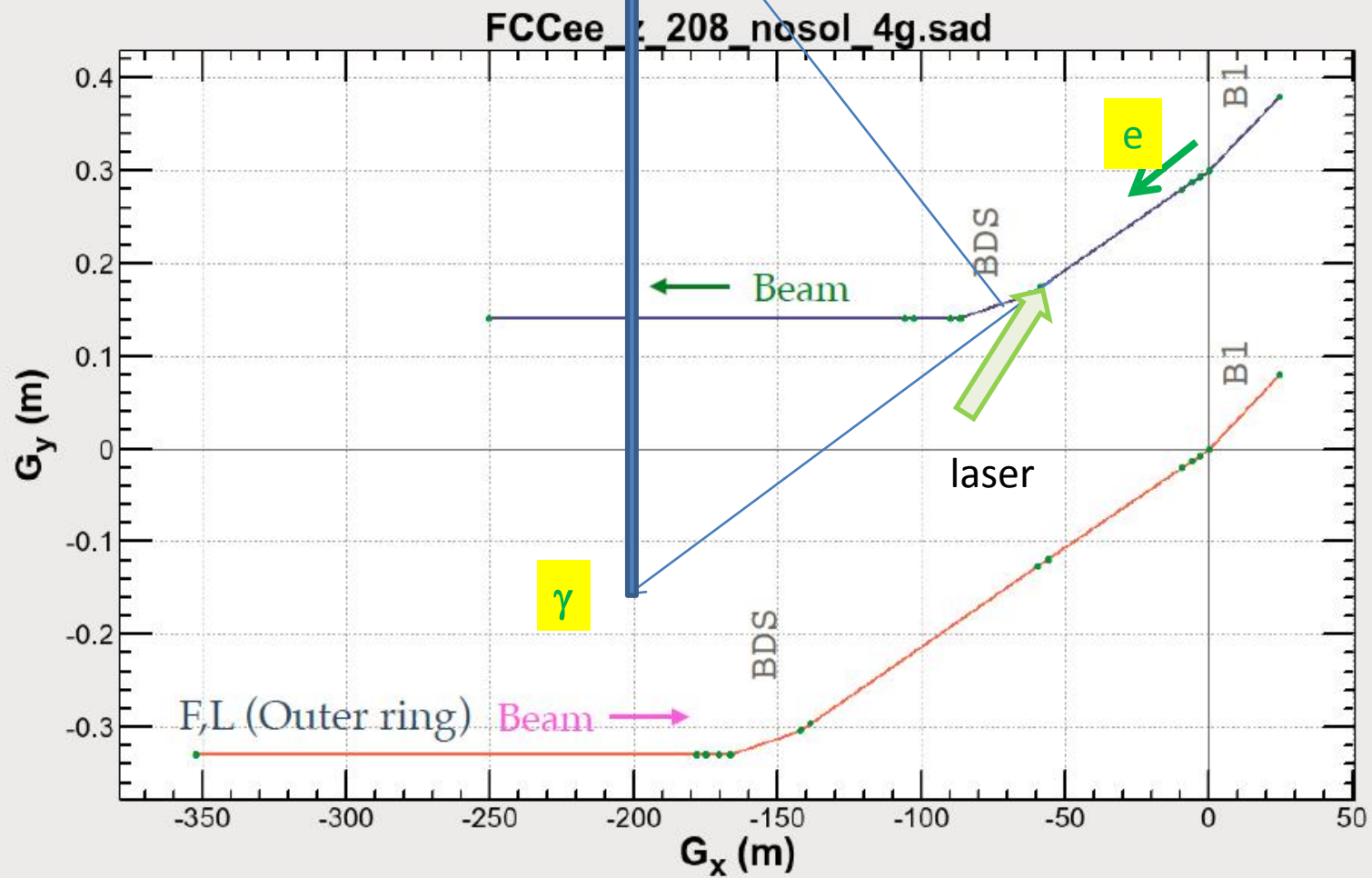
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Using the incoming beam and the dispersion suppressor dipole
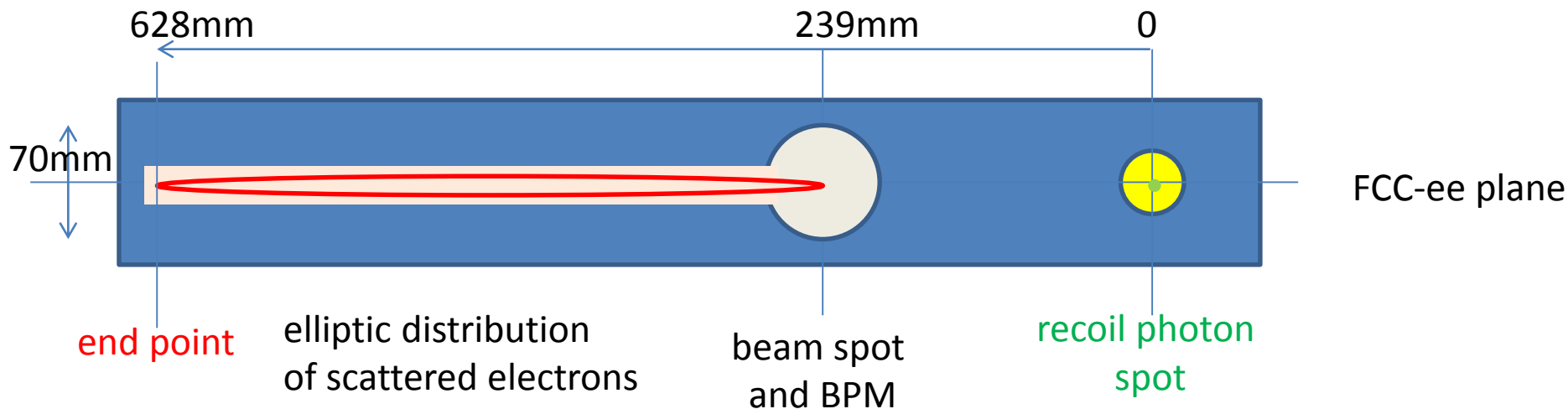with a lever-arm of **100m** from the end of the dipole, one finds
-- minimum compton scattering energy at 45.6 GeV is 17.354 GeV
-- distance from photon recoil to Emin electron is   0.628m

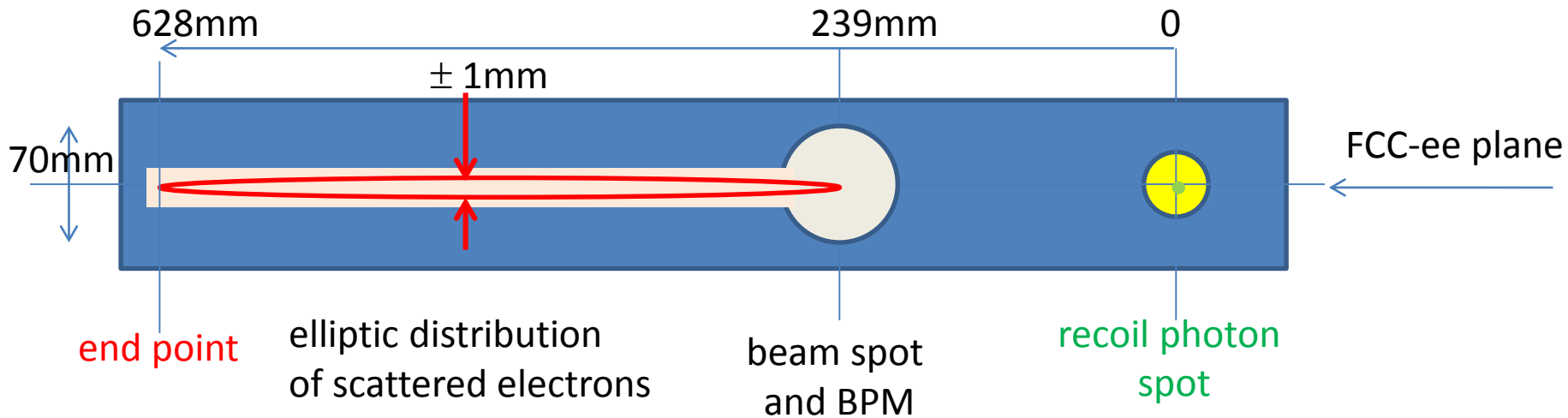|	laser (eV)	beam (GeV)	mc2(MeV)	B field	R	LM	theta	L	true beam
	2.33	45.6	0.511	0.013451	11300	24.119	0.002134	100	45.60005
nominal kappa = 4. E_laser.Ebeam_nom/mc2	1.627567296								
true kappa = 4. E_laser.Ebeam_true/mc2	1.627568924								
nominal Emin	17.35445561								
true Emin	17.35446221								
position of photons	0								
nominal position of beam (m)	0.239182573								
true position of beam (m)	0.239182334	2.39182E-07							
nominal position of min (m)	0.628468308								
true position of min (m)	0.628468069	2.39182E-07							

mouvement of beam and end point
is the same:
0.24microns for $\delta Eb/Eb = 10^{-6}$

polarimeter-spectrometer situated 100m from end of dipole.

628mm   239mm   0

70mm

FCC-ee plane

end point   elliptic distribution   beam spot   recoil photon
               of scattered electrons   and BPM   spot

polarimeter-spectrometer situated 100m from end of dipole.

628mm   239mm   0

± 1mm

70mm

FCC-ee plane

end point   elliptic distribution   beam spot   recoil photon
                   of scattered electrons   and BPM   spot

The end point moves by 0.24 microns over 628 mm (0.3 10^{-6})
These relative movements are perhaps visible using a silicon pixel array.
The absolute measurement in the underground conditions seems difficult.

Platina is supposed to be made of invar, insensitive to thermal expansion at level less
than 10^{-6} for the changes of temperature to be foreseen.

Synchrotron radiation from the ring should be shielded taking into account
the critical energy at W energies.
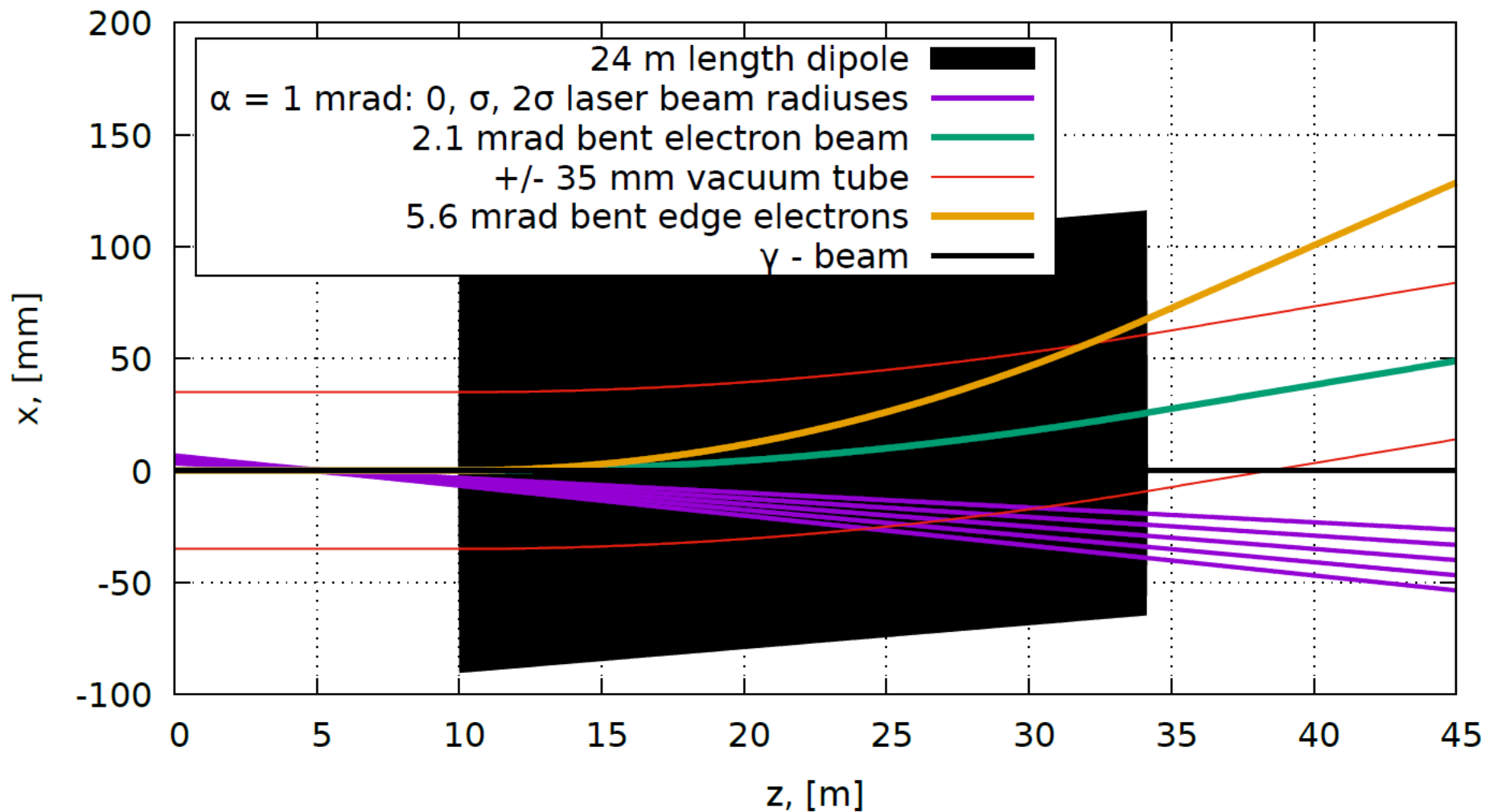
FCCee_z_208_nosol_4g.sad
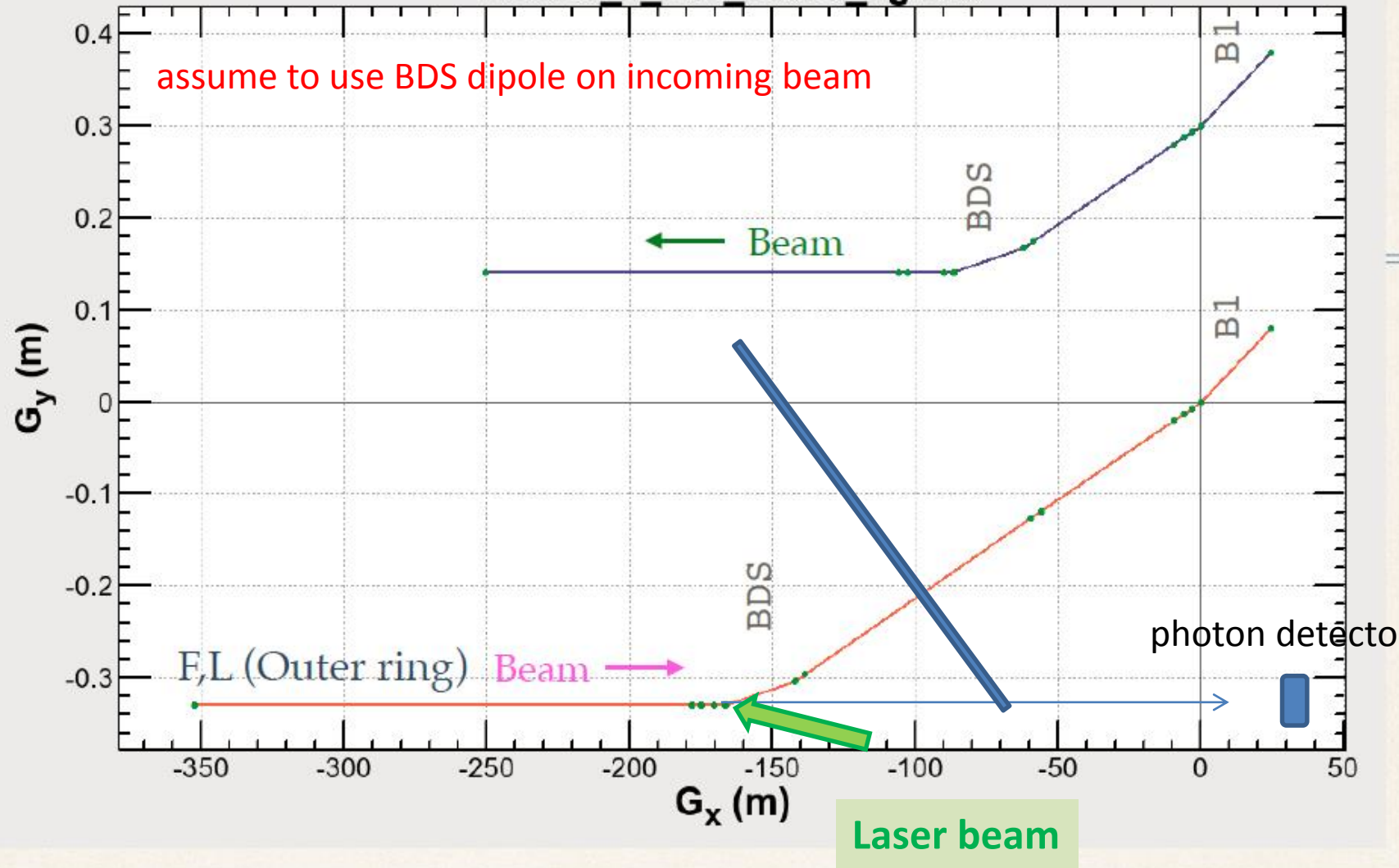
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x-axis: z, [m]
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Using the dispersion suppressor dipole and a lever-arm of **50m** from the end of the dipole, one finds
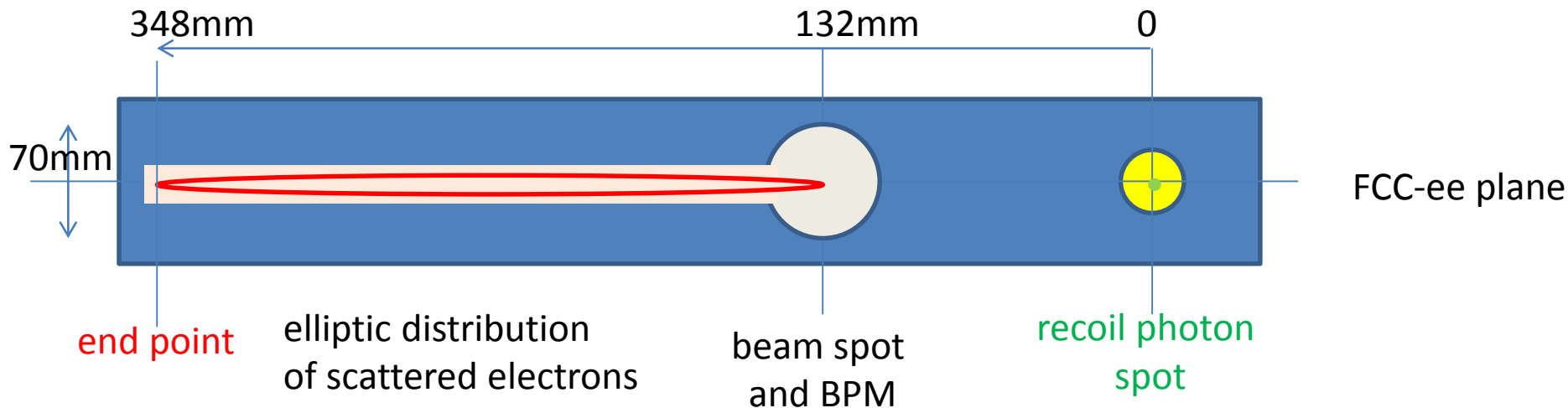-- minimum compton scattering energy at 45.6 GeV is 17.354 GeV
-- distance from photon recoil to Emin electron is   0.348m

	laser (eV)	beam (GeV)	mc2(MeV)	B field	R	LM	theta	L	true beam
	2.33	45.6	0.511	0.013451	11300	24.119	0.002134	50	45.60005
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true kappa = 4. E_laser.Ebeam_true/mc2	1.627568924								
nominal Emin	17.35445561								
true Emin	17.35446221								
position of photons	0								
nominal position of beam (m)	0.132461335								
true position of beam (m)	0.132461202	1.32461E-07							
nominal position of min (m)	0.348051071								
true position of min (m)	0.348050938	1.32461E-07							

mouvement of beam and end point is the same:

0.13microns for $\delta Eb/Eb = 10^{-6}$

polarimeter-spectrometer situated 100m from end of dipole.

end point

elliptic distribution
of scattered electrons

beam spot
and BPM

recoil photon
spot

FCC-ee plane

Conclusions to be drawn and written

We know we can make the backscattered compton detector
Adding a measurement of the scattered e+- adds information of beam energy.
Stability is necessary for relative measurements
➔ monitoring purposes, comparison of energy of pilot beam with inteacting beam

Absolute calibration is … challenging (to do it with respect to resonant depolarization)

Installation in ring requires another iteration with infrastructure team.