Test of the ILC Compton beam energy measurement scheme at the VEPP-4M collider (pre-proposal)

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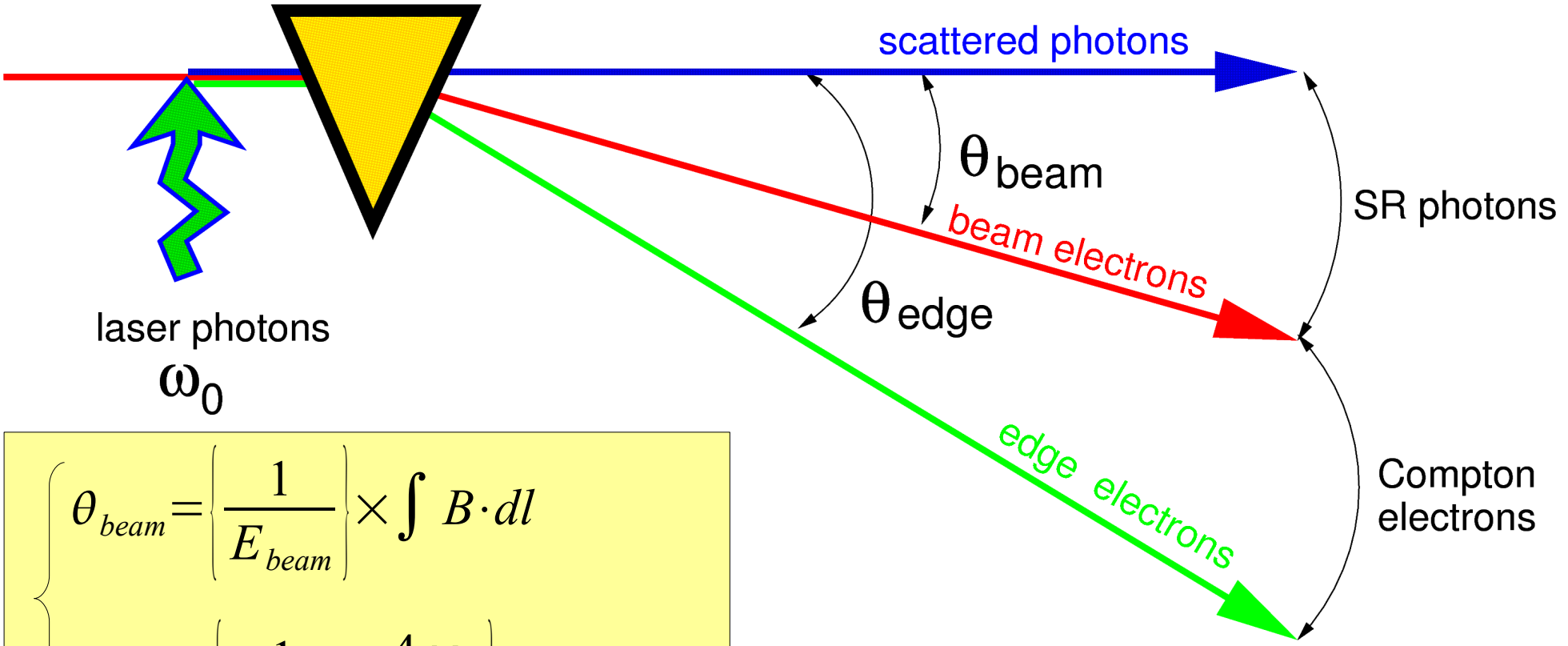
Original Idea



$$\begin{cases} \theta_{beam} = \left\{ \dfrac{1}{E_{beam}} \right\} \times \int B \cdot dl \\ \theta_{edge} = \left\{ \dfrac{1}{E_{beam}} + \dfrac{4\,\omega_0}{m^2} \right\} \times \int B \cdot dl \end{cases}$$

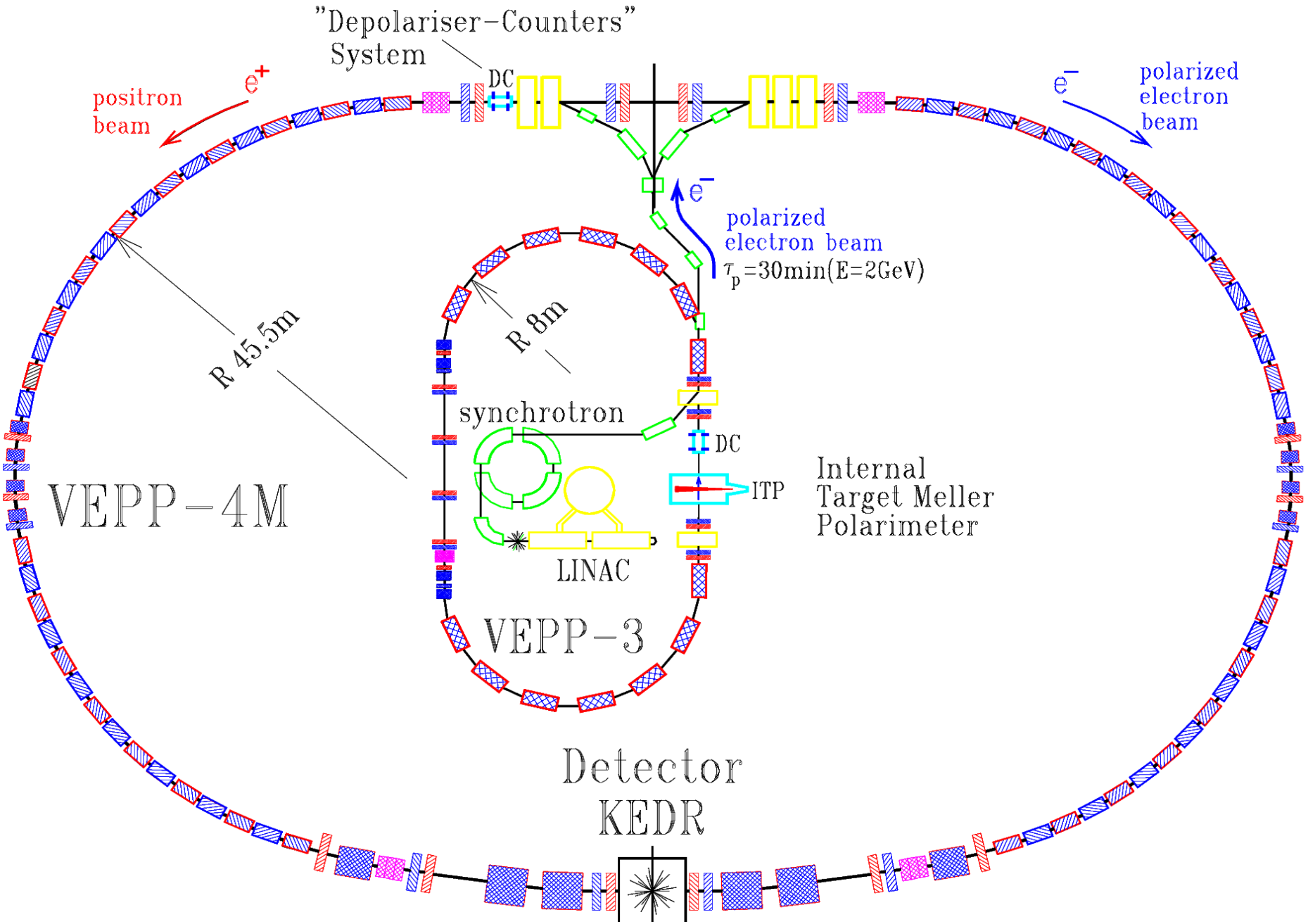
$$\theta_{edge} - \theta_{beam} = \frac{4\,\omega_0}{m^2} \times \int B \cdot dl$$

While this idea was suggested for the ILC beam energy measurement, cross-check with well-established techniques is important. The idea to perform a test at the VEPP-4M collider (BINP Novosibirsk) appeared due to:

1. Beam energy is known with ~10ppm accuracy by resonant depolarization technique

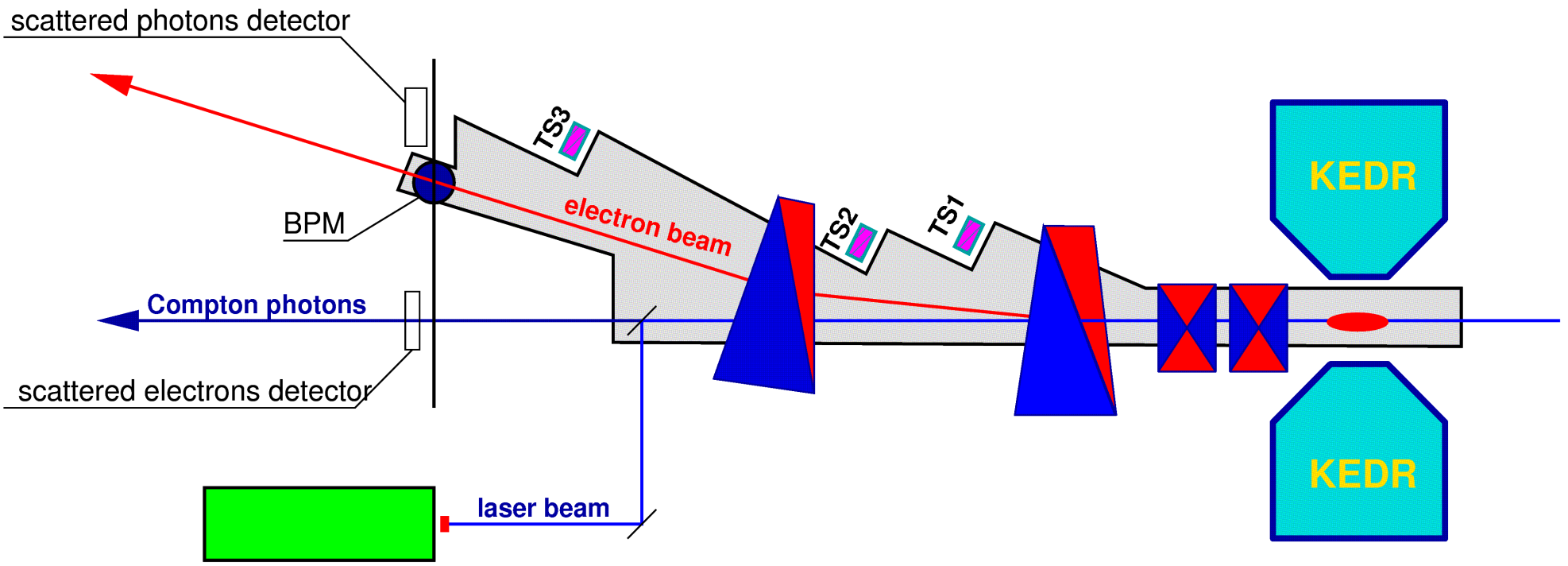
2. Existing registration system for scattering electrons allows required apparatus layout without modifications of vacuum chamber

VEPP-4M Collider at BINP



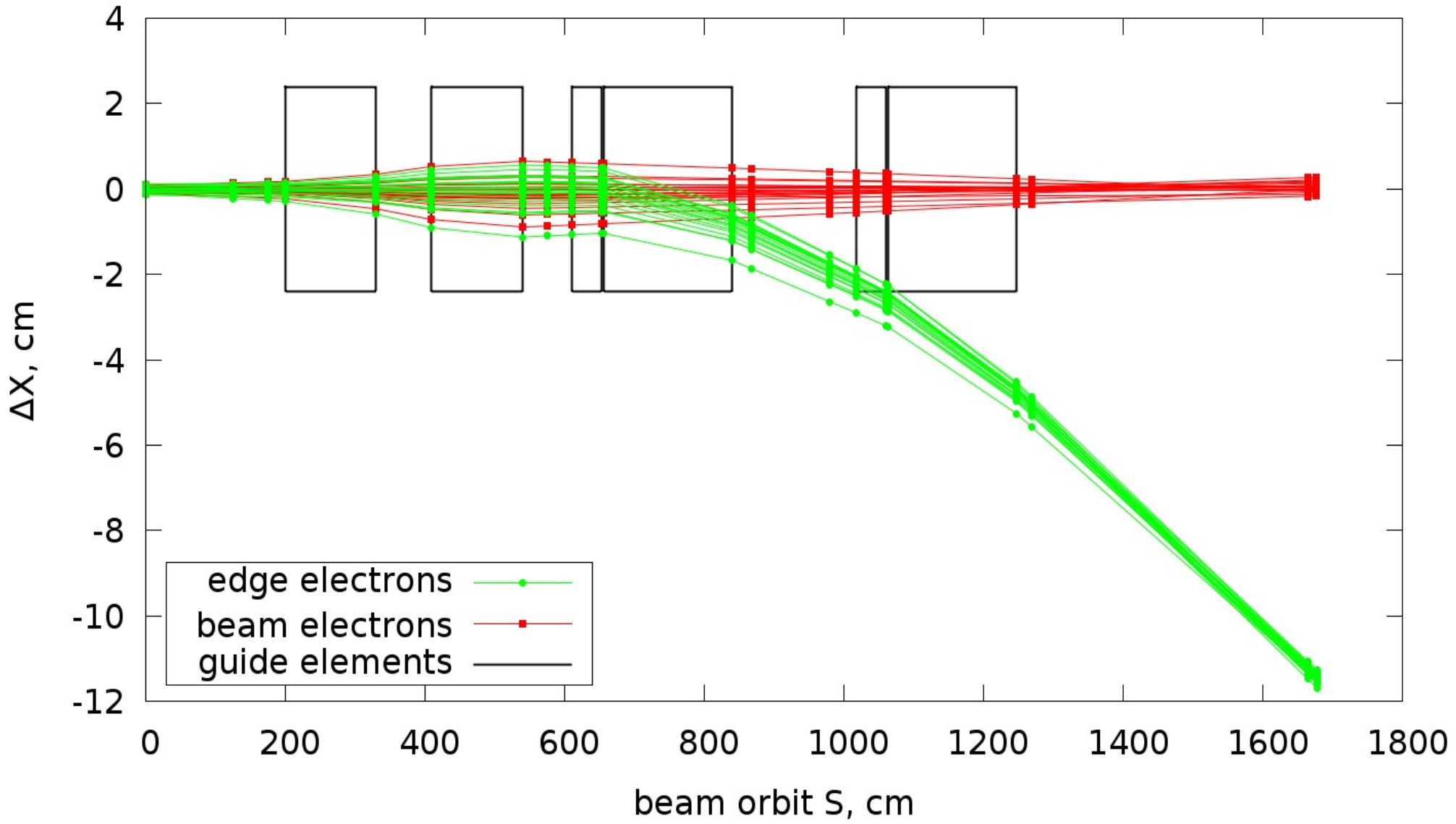
Accommodation: the ROKK-1M facility

(G.Kezerashvili, A.Milov and N.Muchnoi - NIM-B 145 1998)



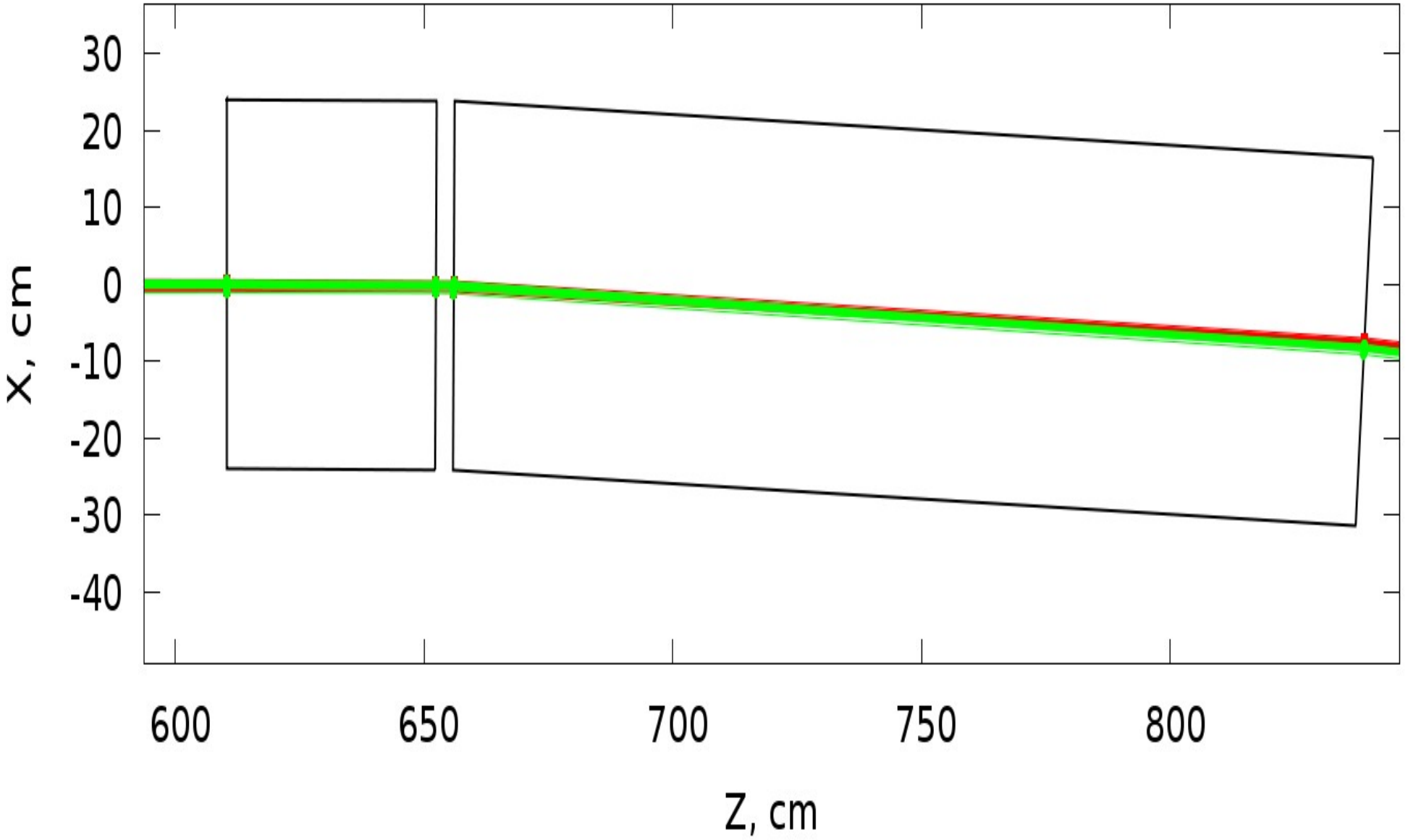
TS4 module covers the scattered electrons energies from 2% to 16% of E_{beam}

Tracking in S-ΔX coordinates

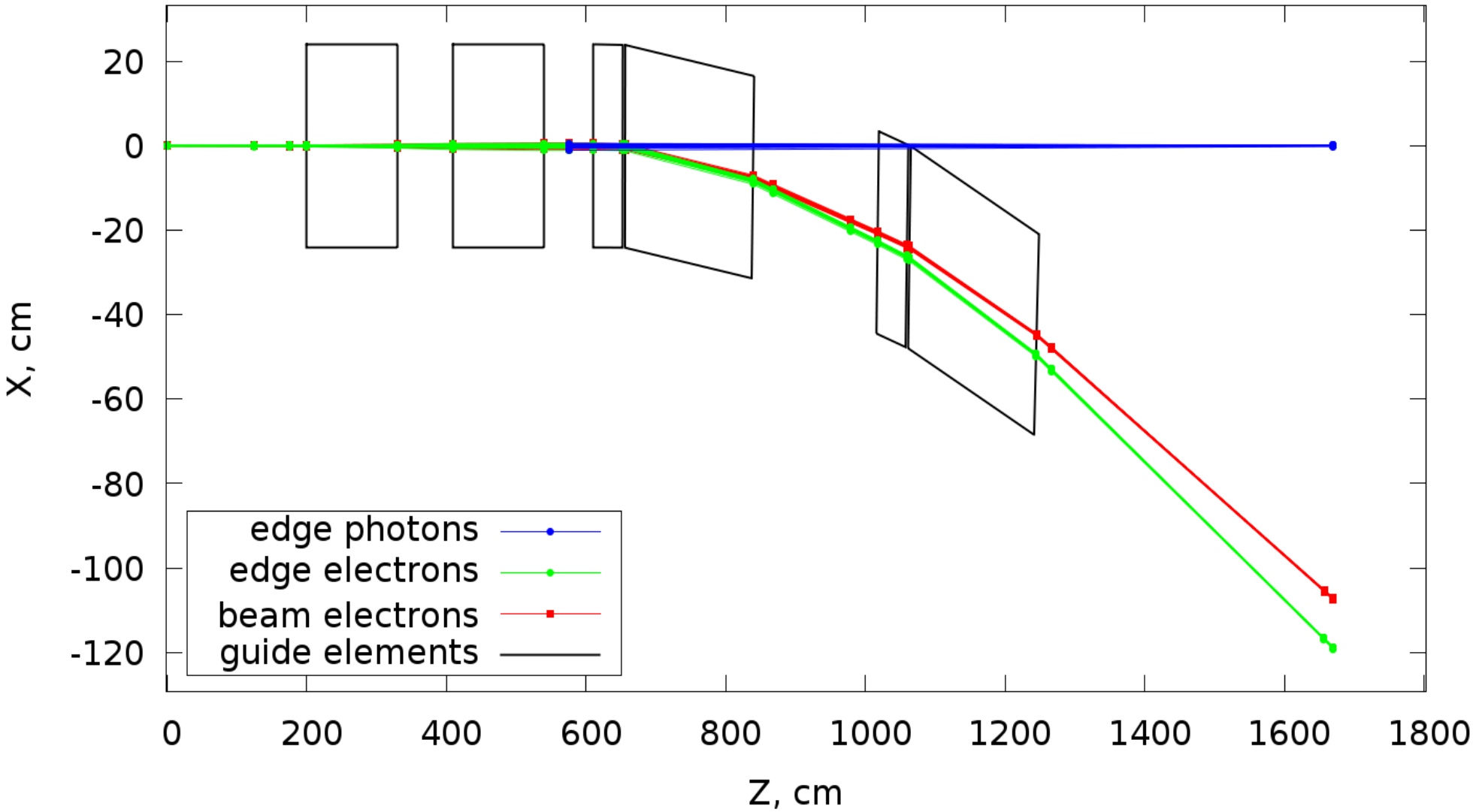


E_{beam} = 3 GeV, ω_0 = 2.33 eV

Sector-type pole shapes



Tracking in Z-X coordinates



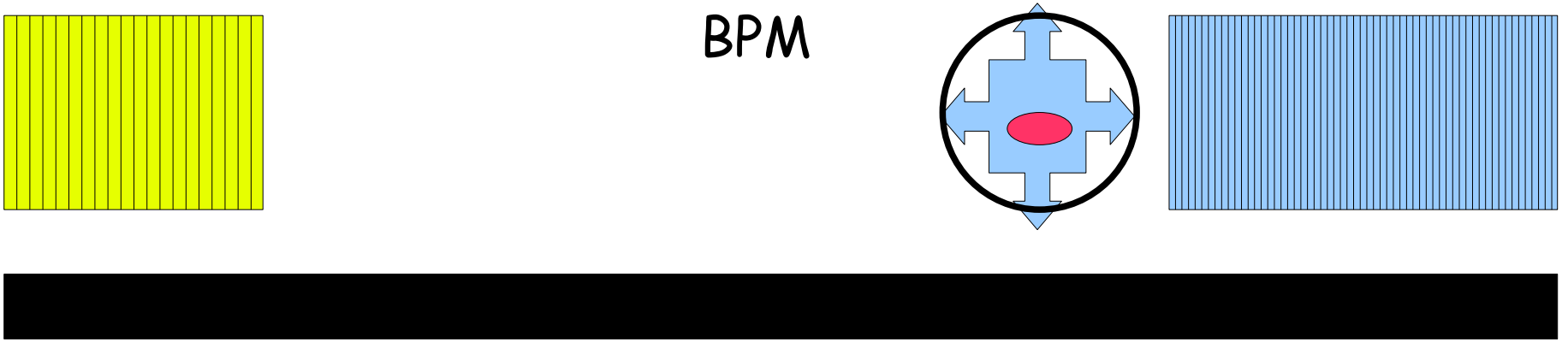
E_{beam} = 3 GeV, ω_0 = 2.33 eV

Detection plane

Photon detector

Beam pipe, beam, BPM

Scattered electrons detector



Compare main parameters

Quantity	ILC	VEPP-4M
Accelerator type	Linear	Storage ring
B-E coupling	Any B for any E	B ~ E
Beam Energy	50-500 GeV	1.5-5.5 GeV
Beam Bending Angle	~ 1 mrad	~ 150 mrad
ΔB/B by geometry	~ 1 ppm	~ 1000 ppm
ΔB/B by field	~ 10 ppm	~ 100 ppm
ΔE/E accuracy goal	~ 100 ppm	~ 100 ppm
Beam energy is known	~ 1000 ppm (?)	~ 10 ppm (!)

Tune the Approach:

$$\begin{cases} \theta_{beam} = B_{beam}\left\{\dfrac{1}{E_{beam}}\right\} \\ \theta_{edge} = B_{edge}\left\{\dfrac{1}{E_{beam}} + \dfrac{4\,\omega_0}{m^2}\right\} \end{cases}$$

$$\frac{\theta_{edge}}{\theta_{beam}} = \frac{B_{edge}}{B_{beam}}\left\{1 + \frac{4\,\omega_0\,E_{beam}}{m^2}\right\}$$

$$E_{beam} = \frac{m^2}{4\,\omega_0}\left\{\frac{\theta_{edge}}{\theta_{beam}} \times \frac{B_{beam}}{B_{edge}} - 1\right\}$$

Need to know:

$$R = \frac{\theta_{edge}}{\theta_{beam}} \times \frac{B_{beam}}{B_{edge}}$$

One can measure:

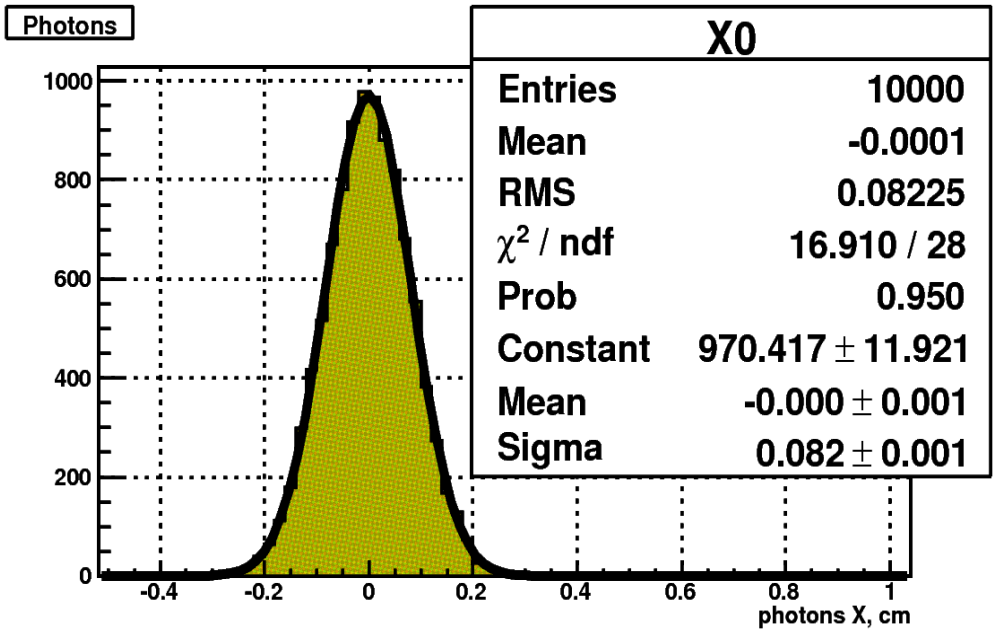
$$X = \left(\frac{X_{edge} - X_{beam}}{X_{beam} - X_0}\right)$$

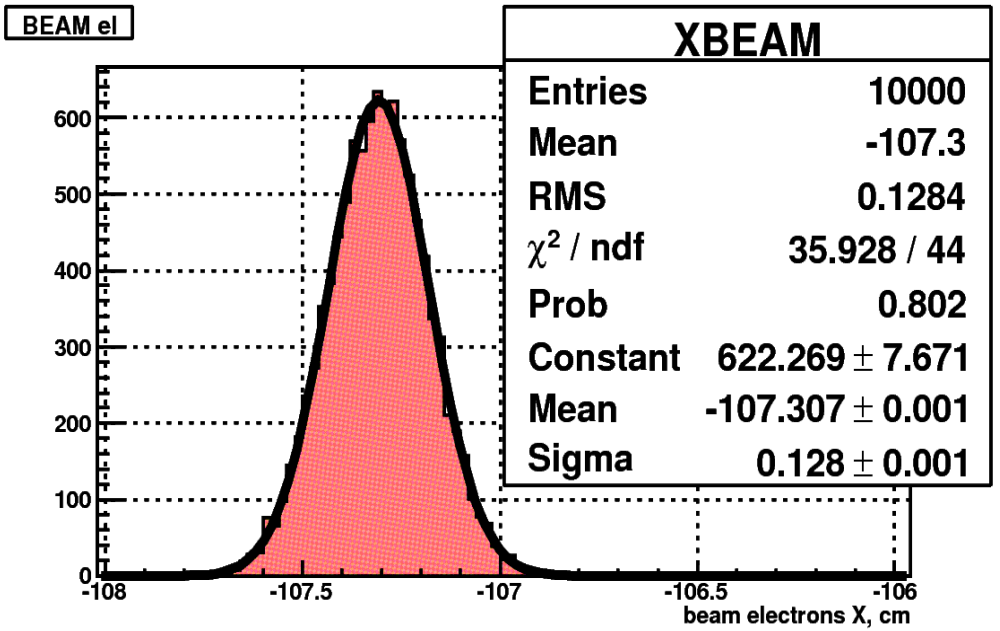
Sure that:

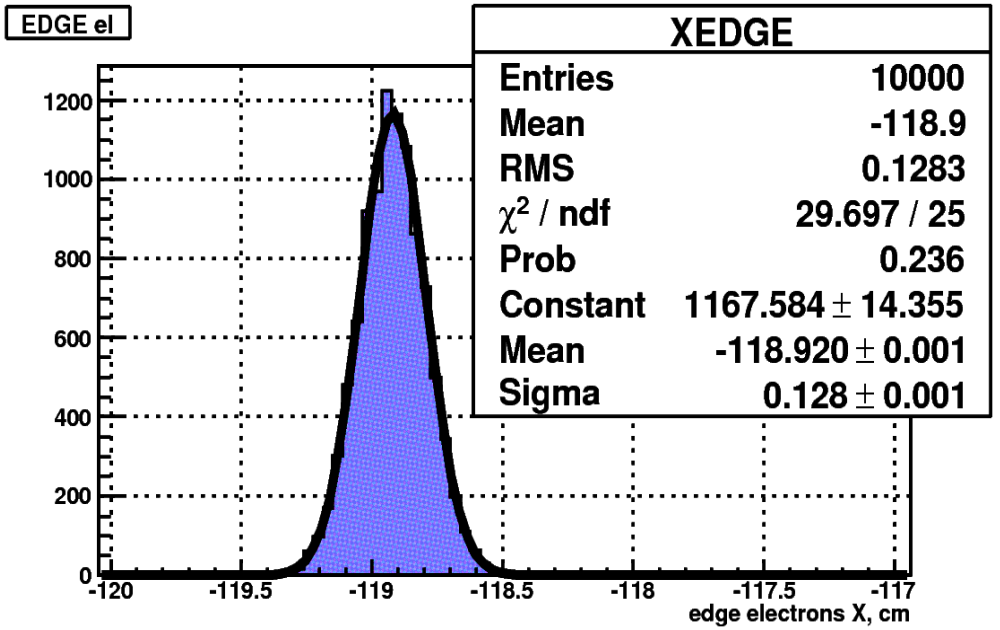
$$R = f(X);$$

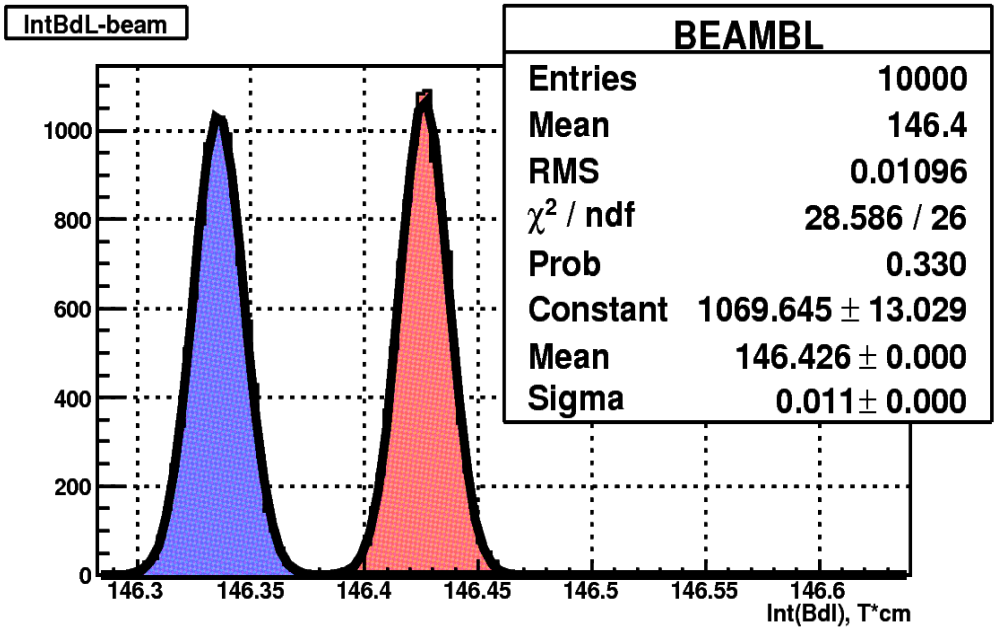
$$f(0) \equiv 1$$

Simulation results



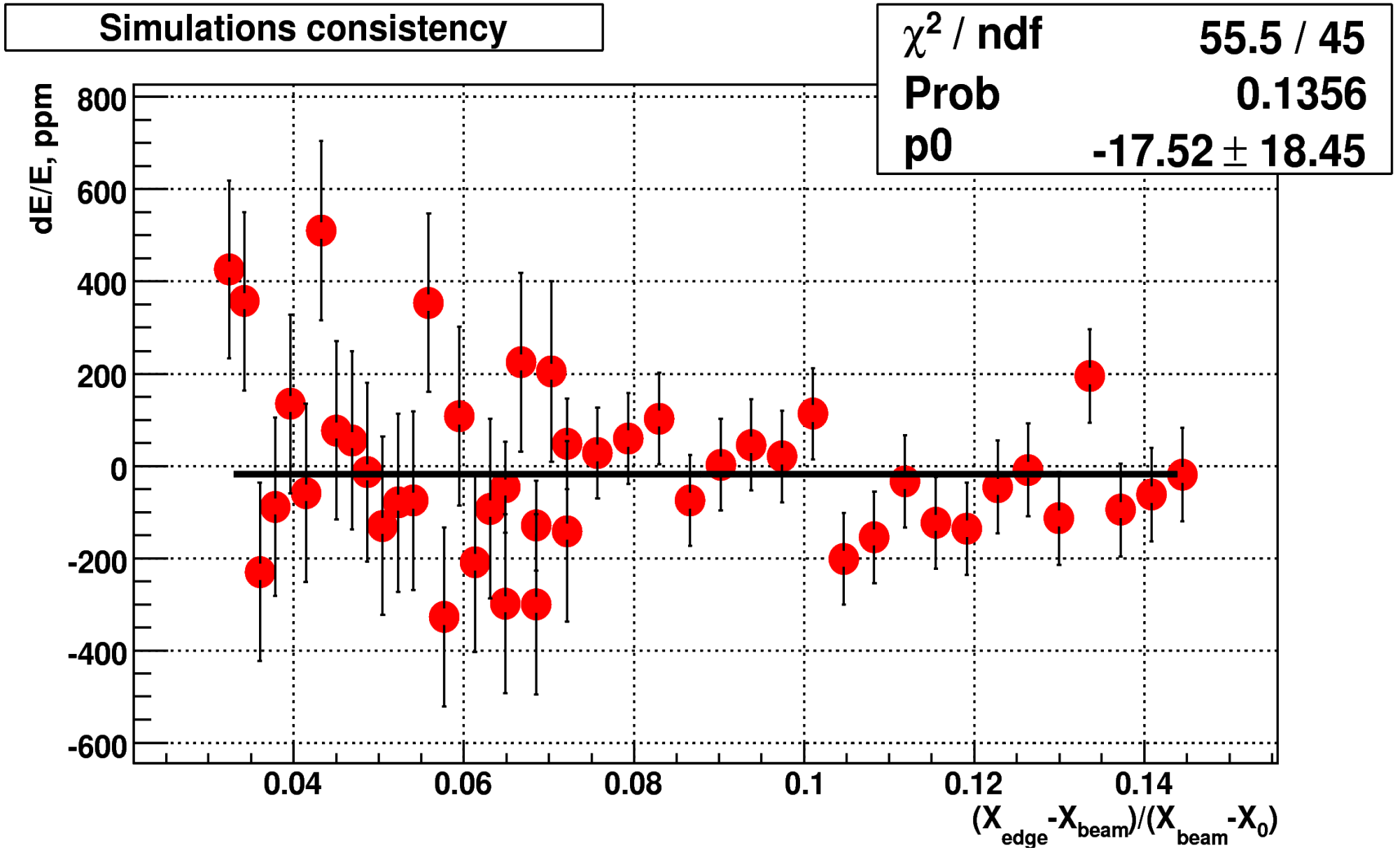






E_{beam} = 3 GeV, ω_0 = 2.33 eV

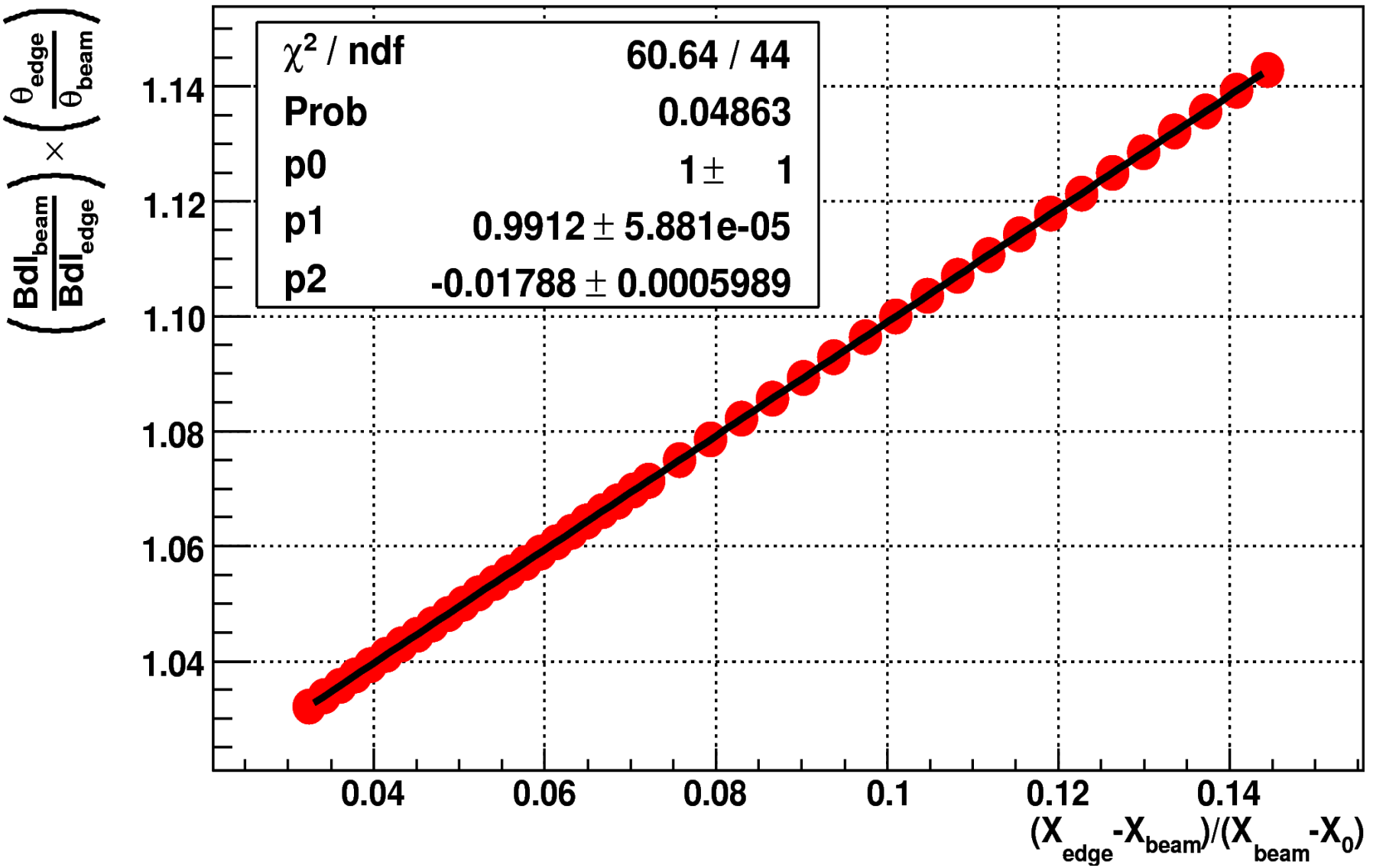
E_{beam} = 2-4 GeV, ω_0 = 1.165 eV and 2.33 eV, 10^5 edge e-



From simulations: θ_{beam} , θ_{edge} , $\int Bdl_{beam}$, $\int Bdl_{edge}$

E_{beam} = 2-4 GeV, ω_0 = 1.165 eV and 2.33 eV, 10^5 edge e-

B-field and θ corrections



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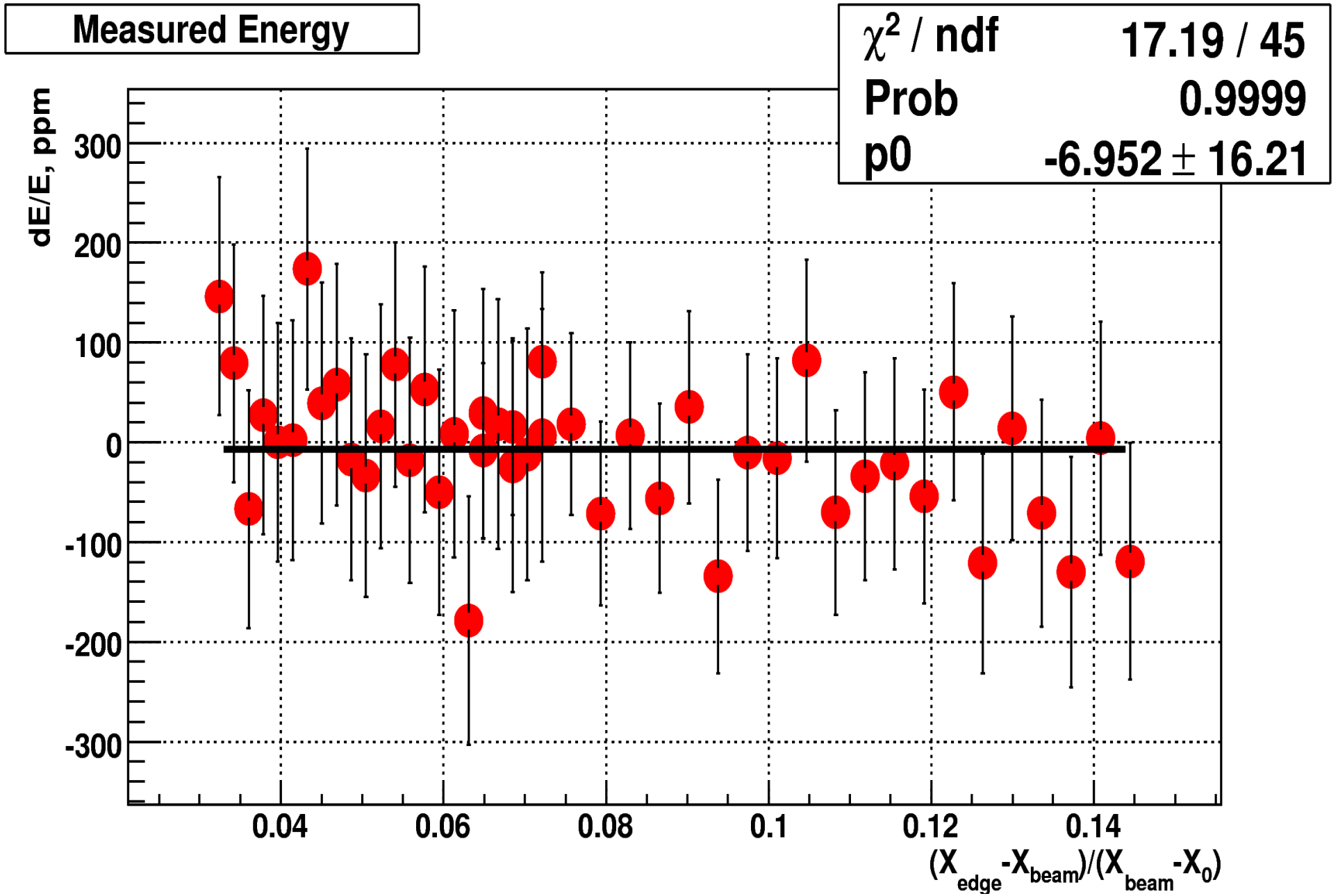

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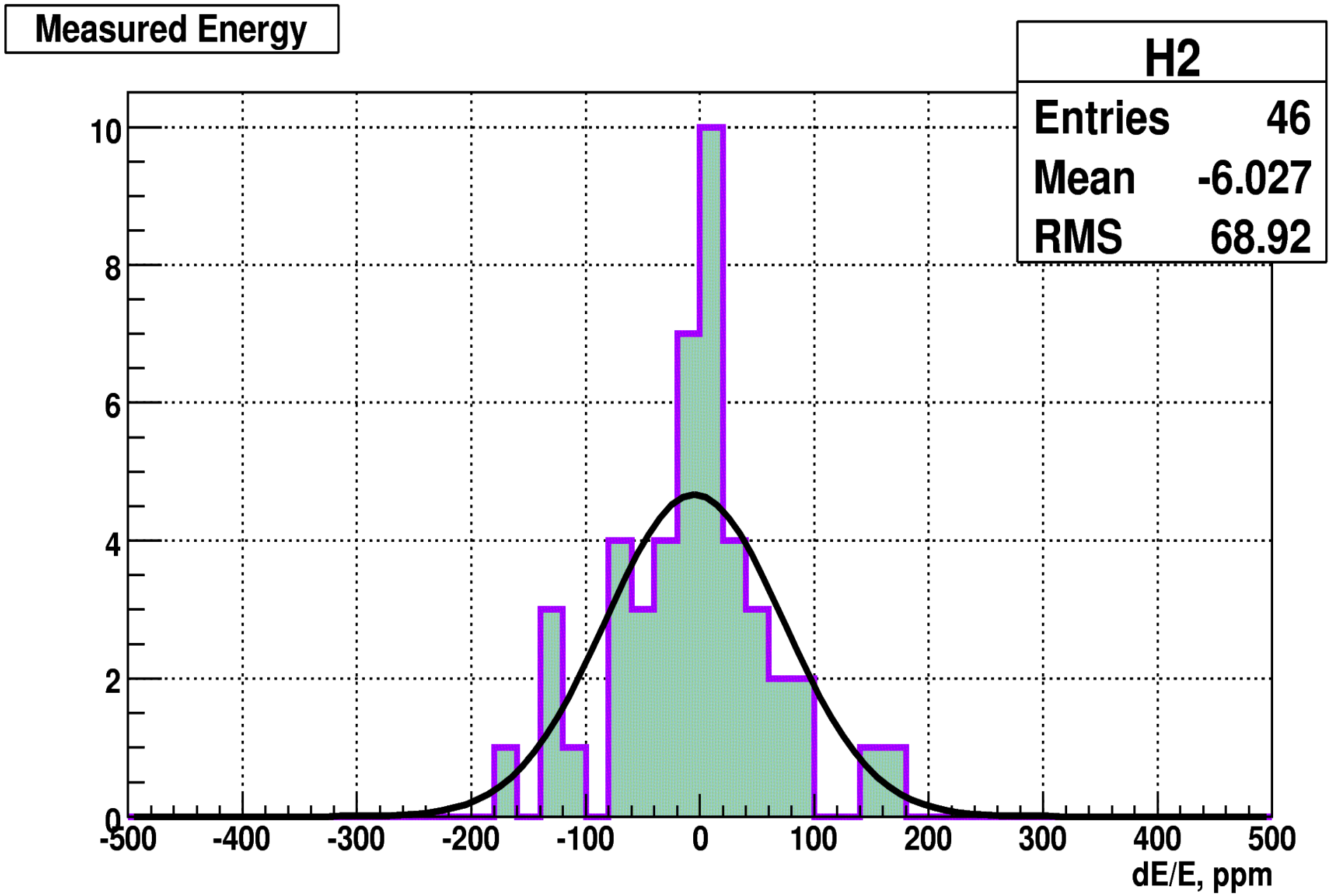
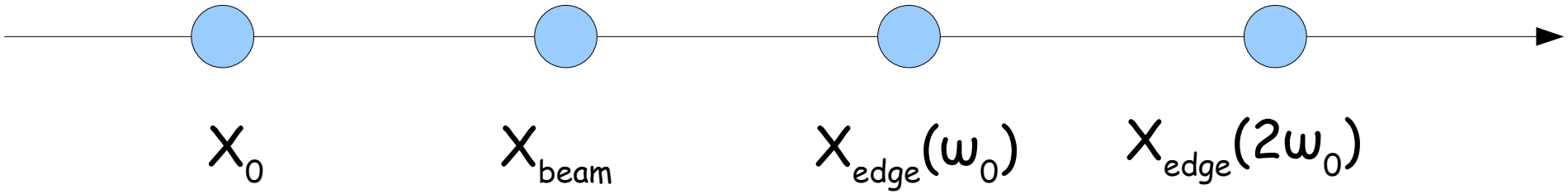


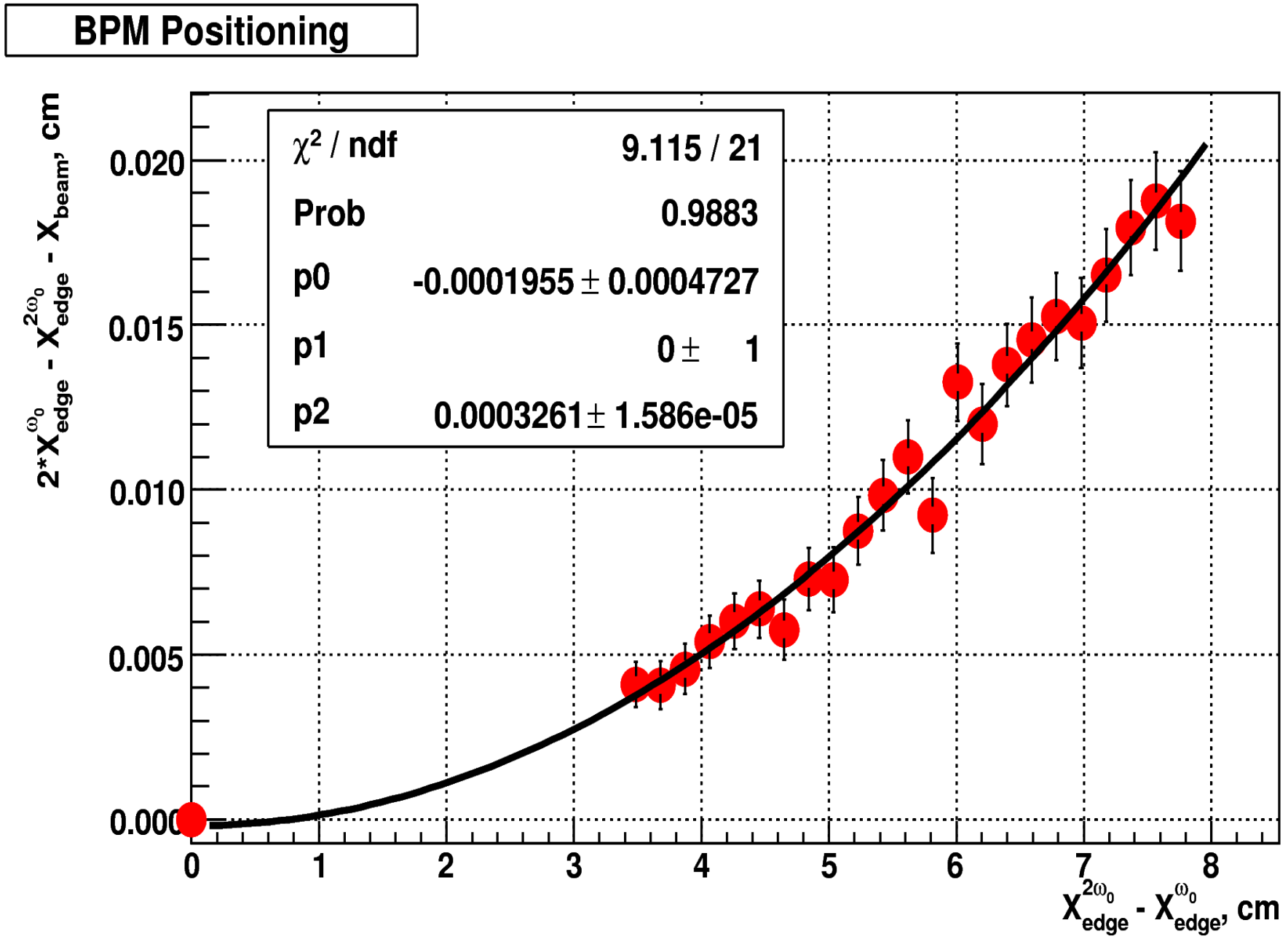
BPM signal to absolute beam position



$$X_{edge}(\omega_0) - X_{beam} = X_{edge}(۲\omega_0) - X_{edge}(\omega_0)$$

$$X_{beam} = 2X_{edge}(\omega_0) - X_{edge}(2\omega_0)$$

E_{beam} = 2-4 GeV, ω_0 = 1.165 eV and 2.33 eV, 10^5 edge e-



Test experiment allows to check the following issues:

- Beam energy measurement approach
- Performance of the photon and SE detectors
- Detectors alignment apparatus
- BPM signal absolute "positioning"