Luminosity Measurement in OLYMPUS Experiment

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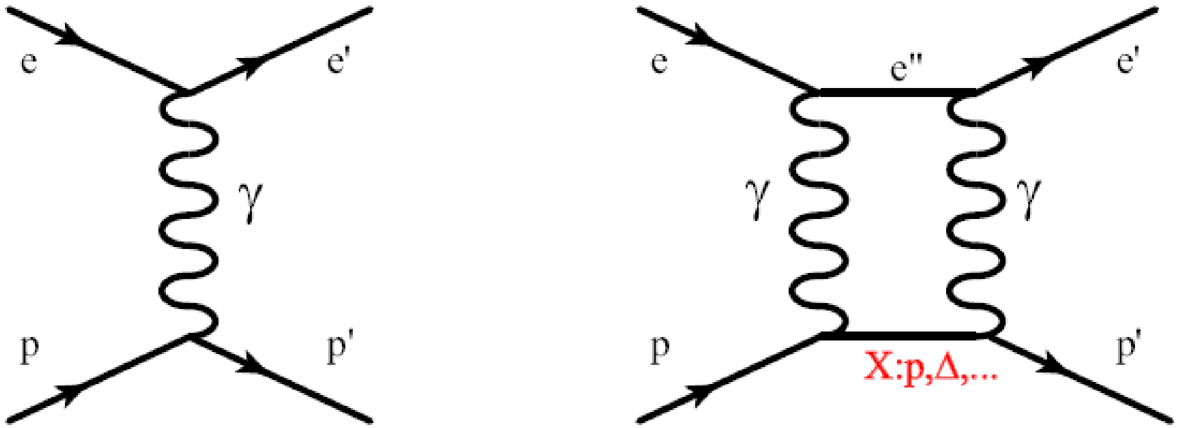
On behalf of OLYMPUS collaboration

OLYMPUS

Two photons exchange (TPE)



2γ exchange $\rightarrow$
measure $\sigma_{e^+p}/\sigma_{e^-p}$

$$\frac{\sigma_{e+}}{\sigma_{e-}} \cong \frac{|M_{Born}|^2 + 2e_e e_p M_{Born}\mathrm{Re}(M^*_{2\gamma}) + 2e_e e_p \mathrm{Re}(M_{e-bremstr} M^*_{p-bremstr})}{|M_{Born}|^2 - 2e_e e_p M_{Born}\mathrm{Re}(M^*_{2\gamma}) - 2e_e e_p \mathrm{Re}(M_{e-bremstr} M^*_{p-bremstr})}$$

Expected effect small ~ few percent
Need to precise (better then 1% !) luminosity measurement

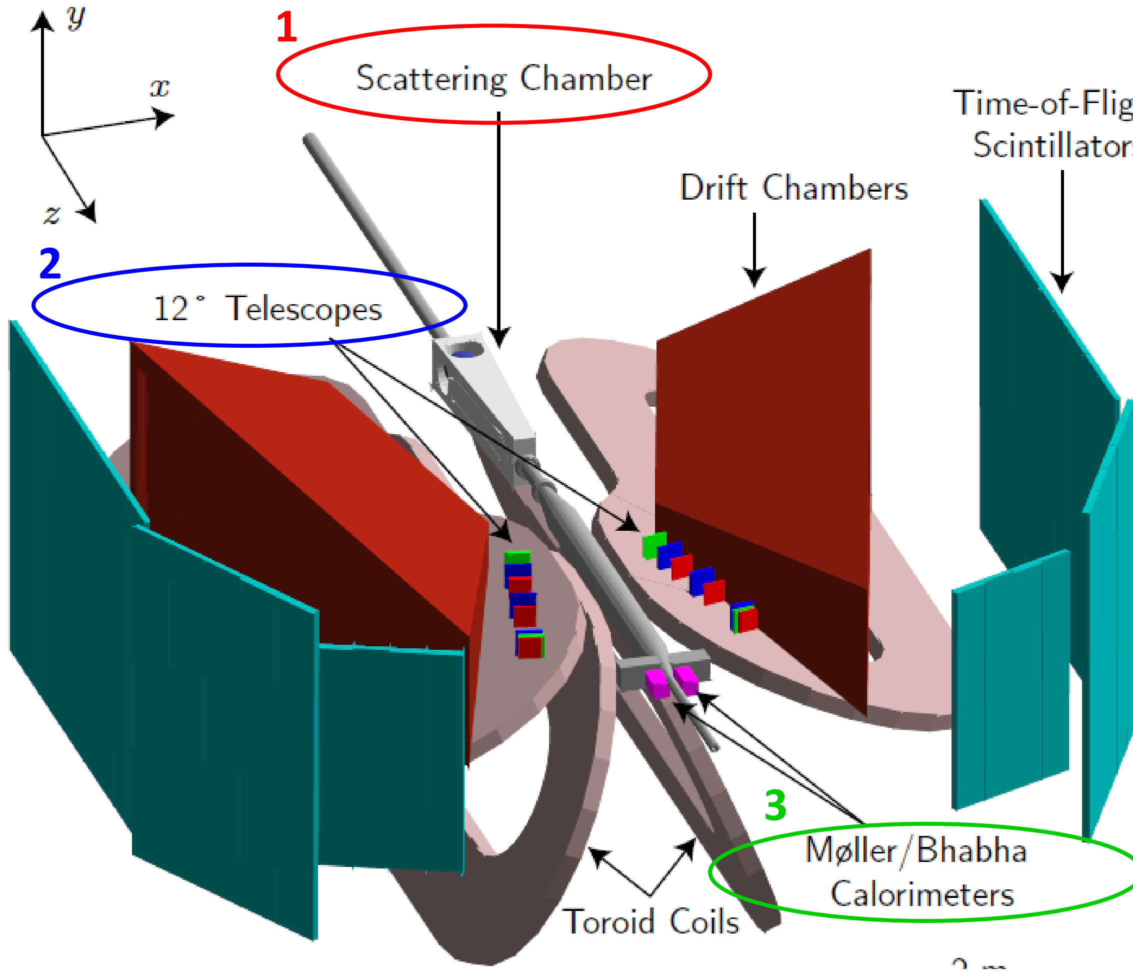
Luminosity measurement in OLYMPUS

Three system to measure luminosity

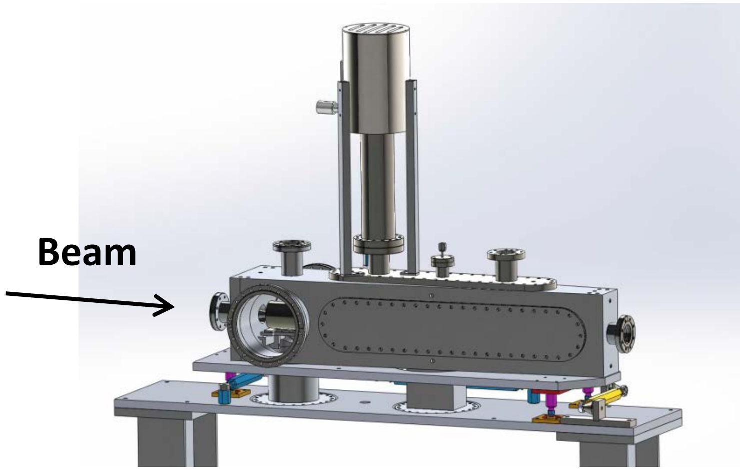
1. Slow Control (online monitor)
   $\text{SCLumi} = I_{beam} \cdot \rho_{targ} \cdot \Delta t$

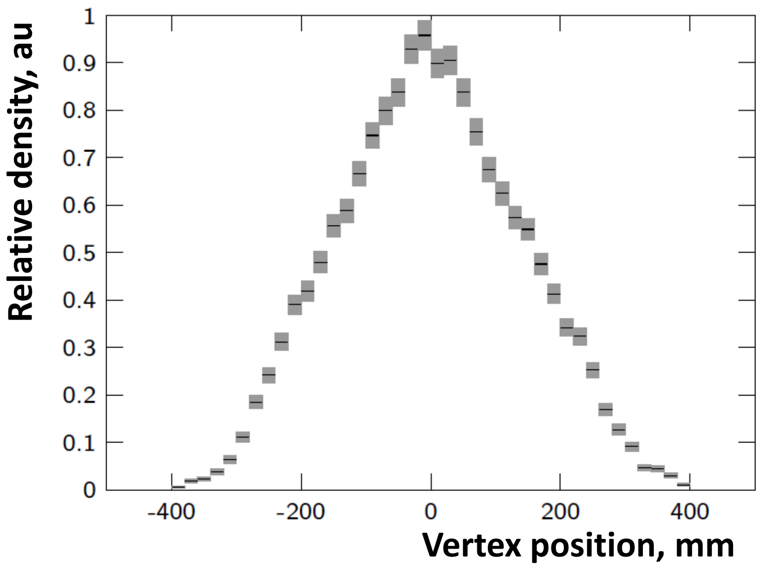
2. 12^0 monitors
   ep elastic scattering @ 12 degree

3. Symmetric Møller/Bhabha monitor
   Based on known cross-section of
   Møller/Bhabha scattering



Target Chamber and Slow Control luminosity





Slow control monitor

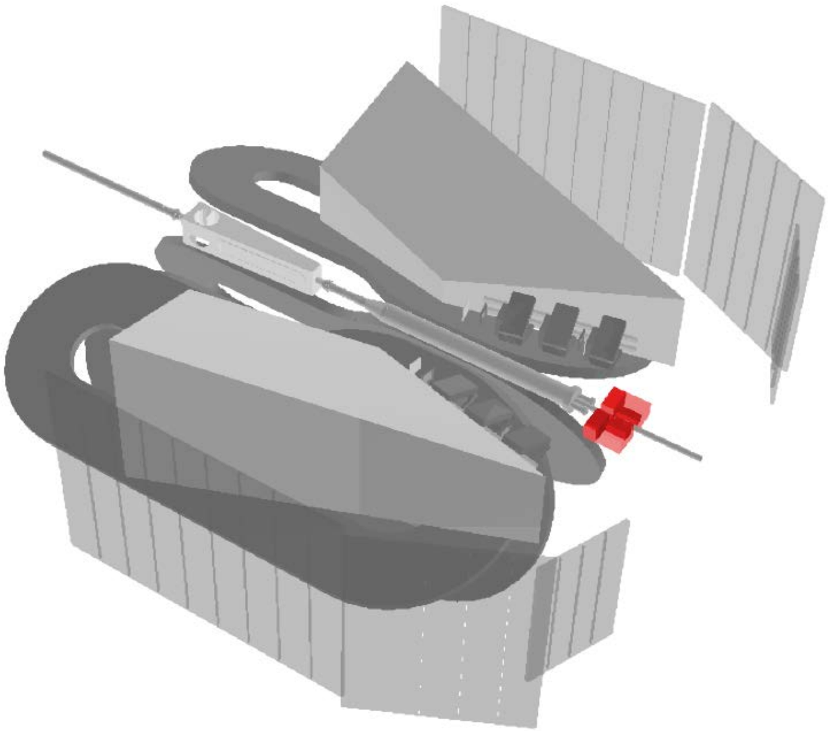
$$\text{SCLumi} = I_{beam} \cdot \rho_{targ} \cdot \Delta t$$

+ Simple system, no additional hardware
+ Online monitoring
+ Direct luminosity measurement
+ No geometry sensitivity
– Possible systematic error ~ 15% (relative on time uncertainty ~ few percent)

ρ_{targ} main source of systematic error, calculated using gas flow and target temperature

Symmetric Møller/Bhabha monitor

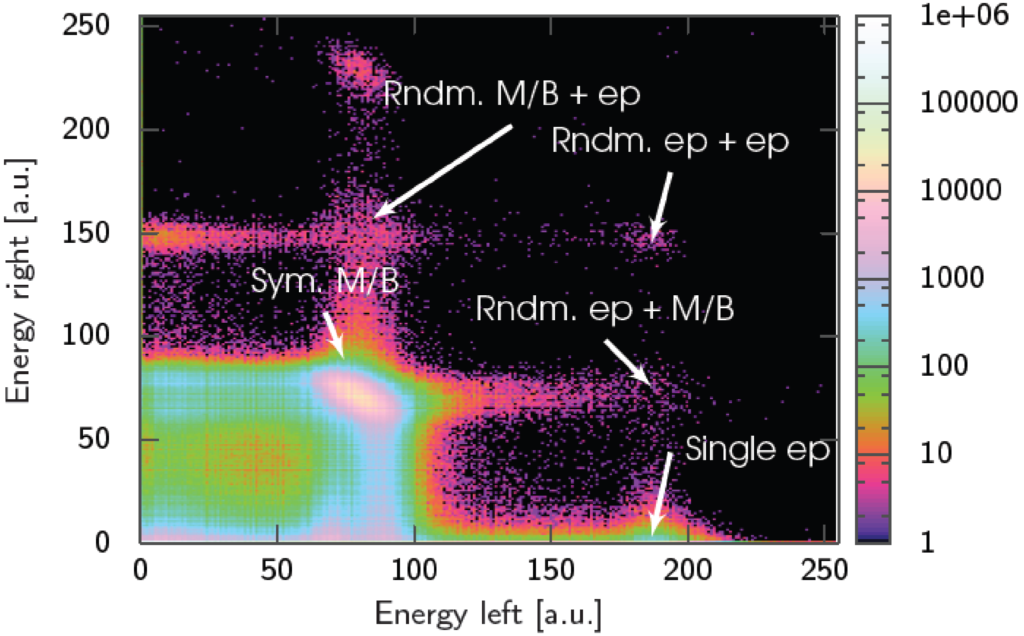
- Møller/Bhabha scattering at symmetric angle (1.3 deg @ 2.0 GeV)
- Known cross section (e^-e^-, e^+e^-+ annihilation) used to determine luminosity

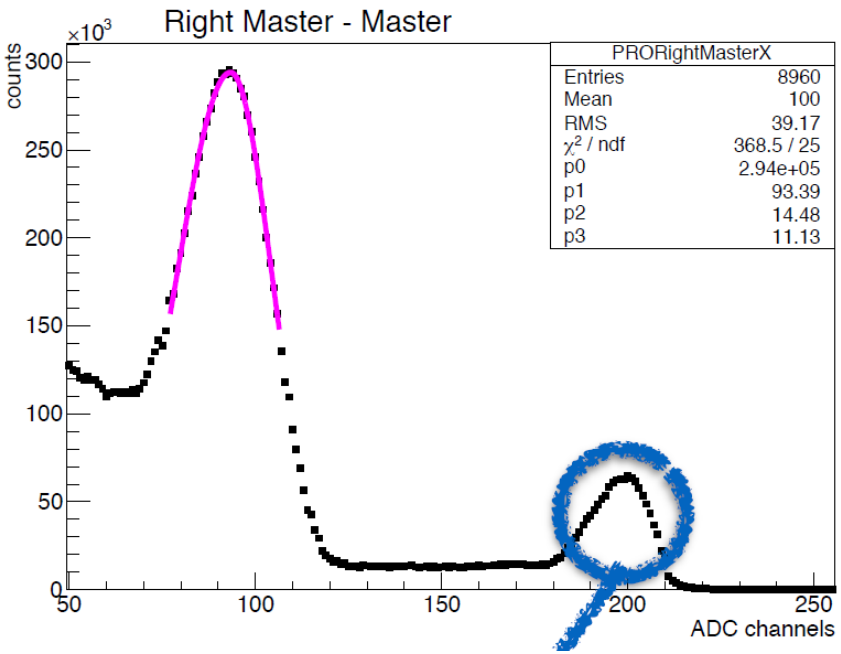


- Left and right blocks
- Each block contains 3x3 crystals PbF_2
- Each block more then 15 radiation length long
- Fast response PMTs 20 ns

\+ Very good statistics (high counting rate)
\+ Independent from ep process
\+ Independent trigger
\+ Not sensitive to magnet field
\- Very sensitive to geometry and misalignment

Møller/Bhabha monitor operating





Also able to measure elastic scattering @ 1.3 deg, additional redundancy

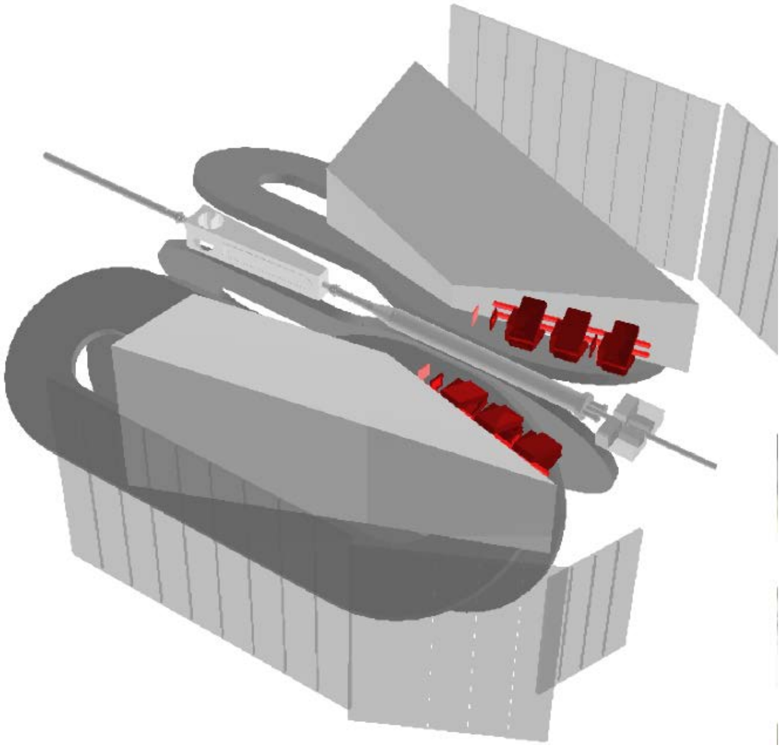
$$Lumi(e^+, e^-) = \frac{N_{concidence}}{\sigma_{MC(e^+e^-, e^-e^-)}}$$

$$\sigma_{MC(e^+e^-, e^-e^-)} = \int_{acceptance} \frac{d\sigma_{(e^+e^-, e^-e^-)}}{d\Omega} d\Omega$$

calculated using Møller/Bhabha + annihilation generator

12 degree monitor

- Known ep elastic cross section (without 2γ exchange) can be used to provide luminosity measurement
- expected effect of two photon exchange @ 12 deg much less 1 %

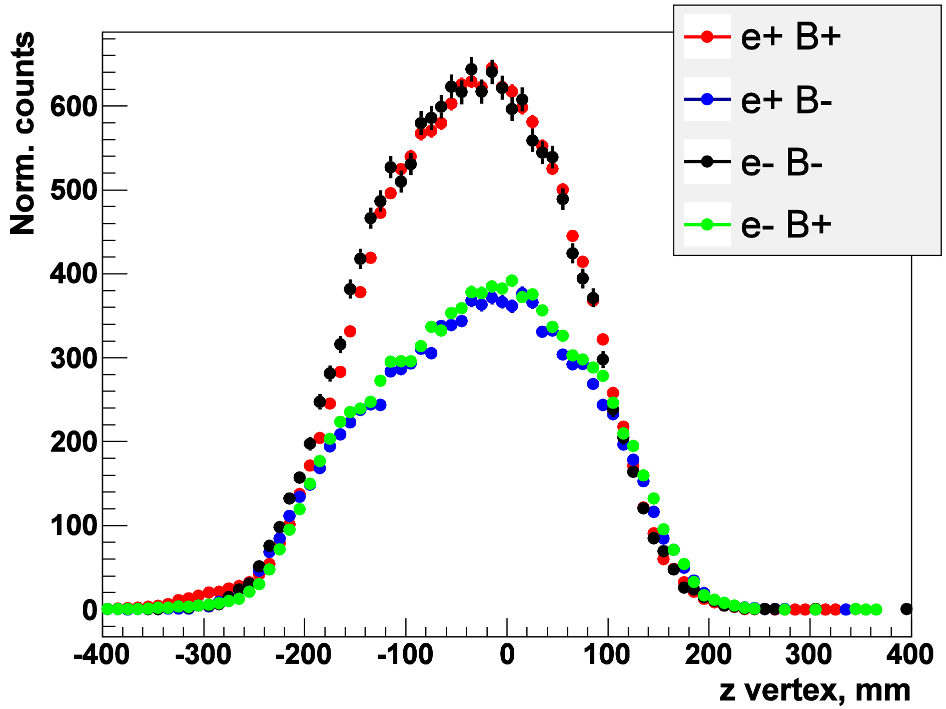


- 6 MWPCs (3 left & 3 right) with resolution ~0.3 mm
- 6 GEMs (3 left & 3 right) with resolution ~0.07 mm
- Measuring ep elastic scattering @ 12 deg in coincidence with recoil proton

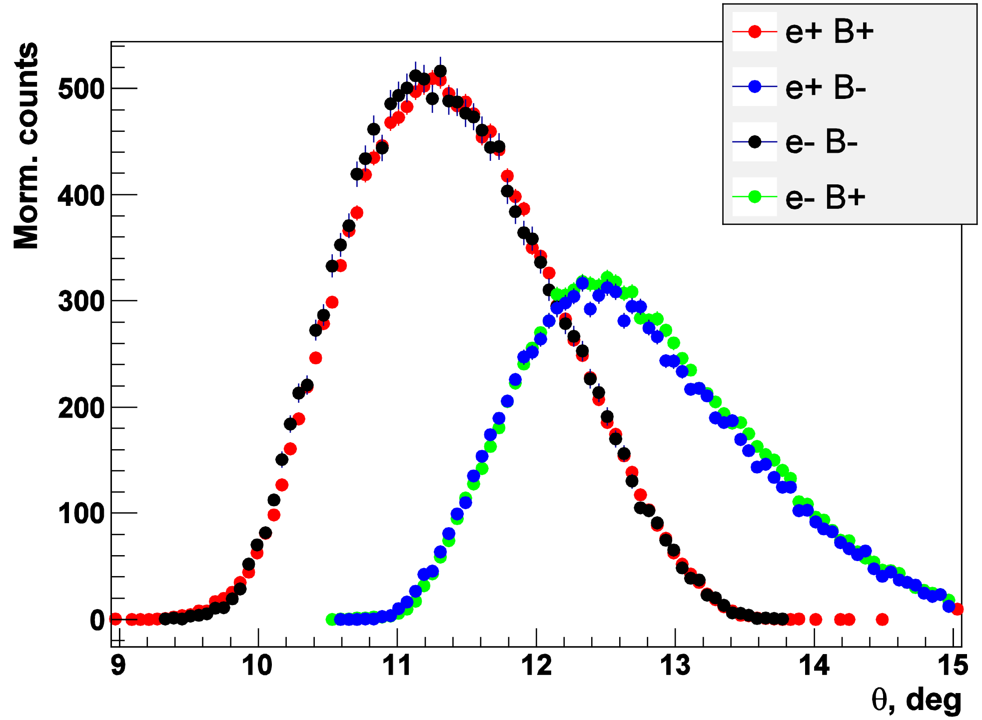
+ Good statistics (high counting rate)
+ Redundancy (left/right, GEMS/MWPC)
+ Two magnet field polarity
- Based on same ep scattering
- Use recoil proton from main detector
- Poor momentum resolution

Performance of 12 deg monitor

Vertex reconstruction



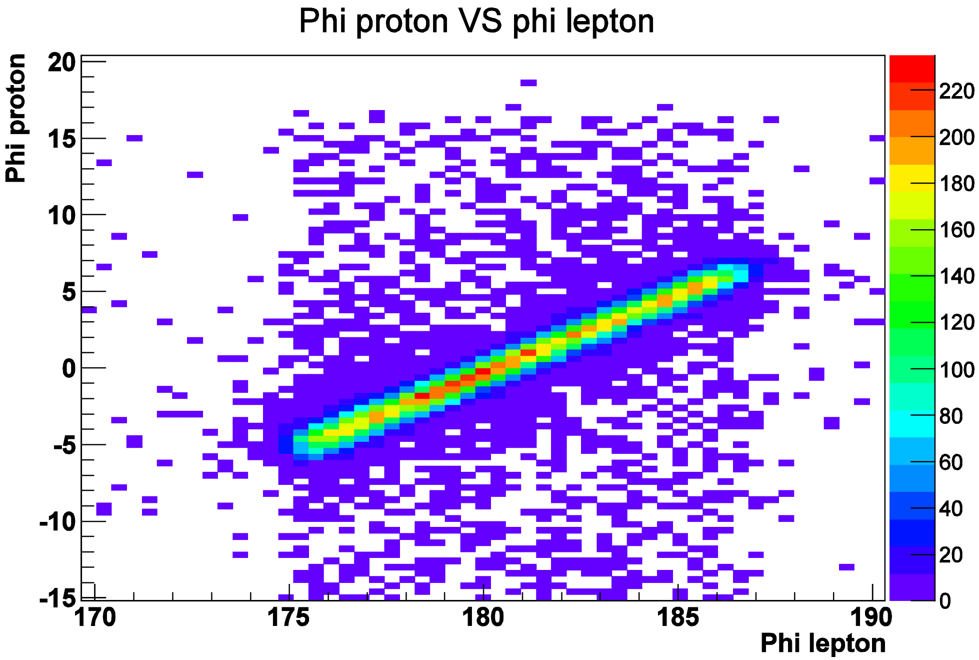
Scattered angle reconstruction

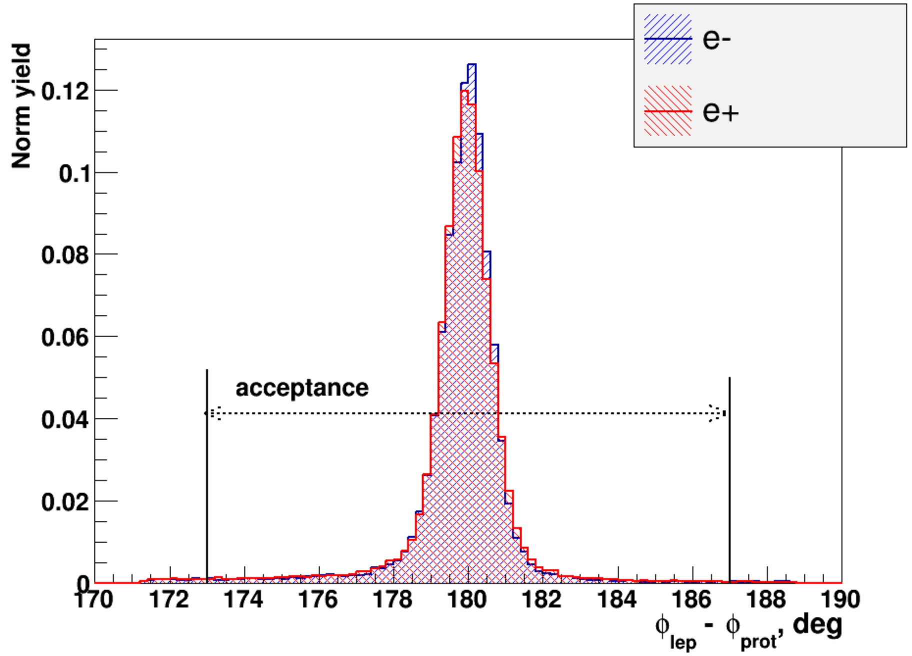


Same acceptance if change beam charge and magnet field polarity

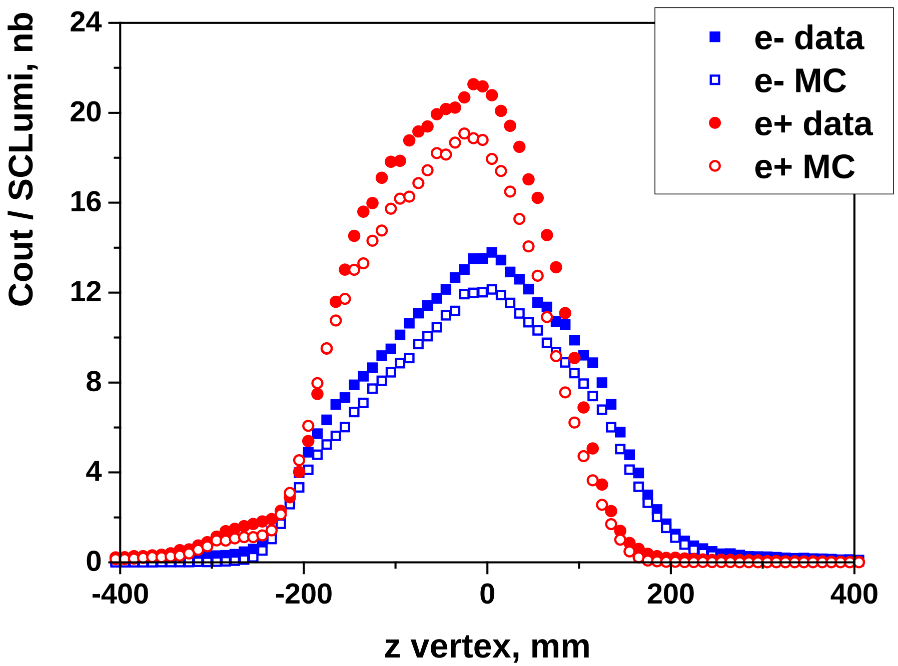
Performance of 12 deg monitor

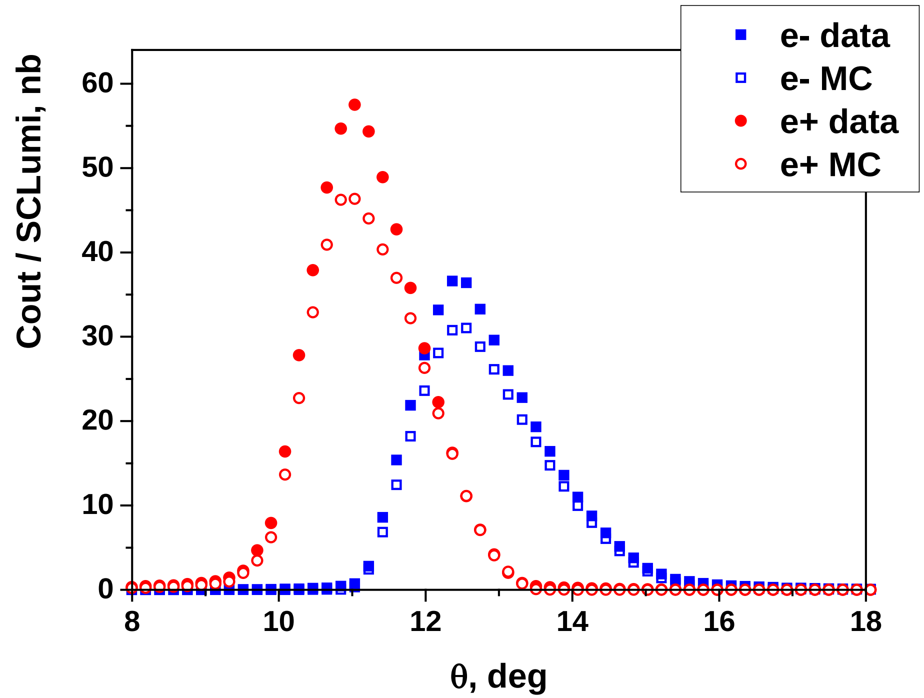
Complanarity used to select elastic events





Simulation





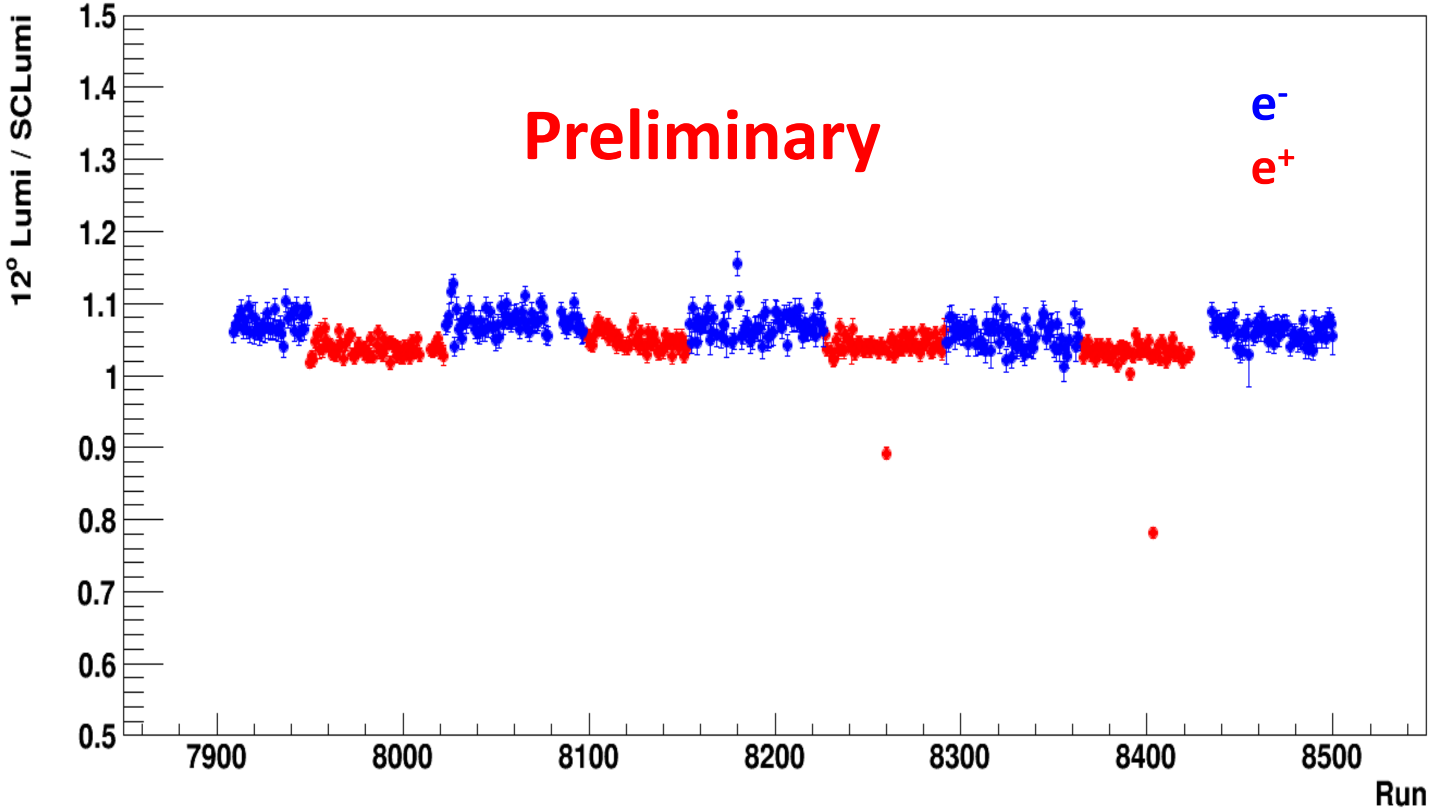
$$Lumi(e^+, e^-) = \frac{N_{tracks}}{\sigma_{MC(e^+p, e^-p)}}$$

$$\sigma_{MC(e^+p, e^-p)} = \int_{acceptance} \frac{d\sigma_{(e^+p, e^-p)}}{d\Omega} d\Omega$$

Calculated using special developed generator with internal and external bremsstrahlung included

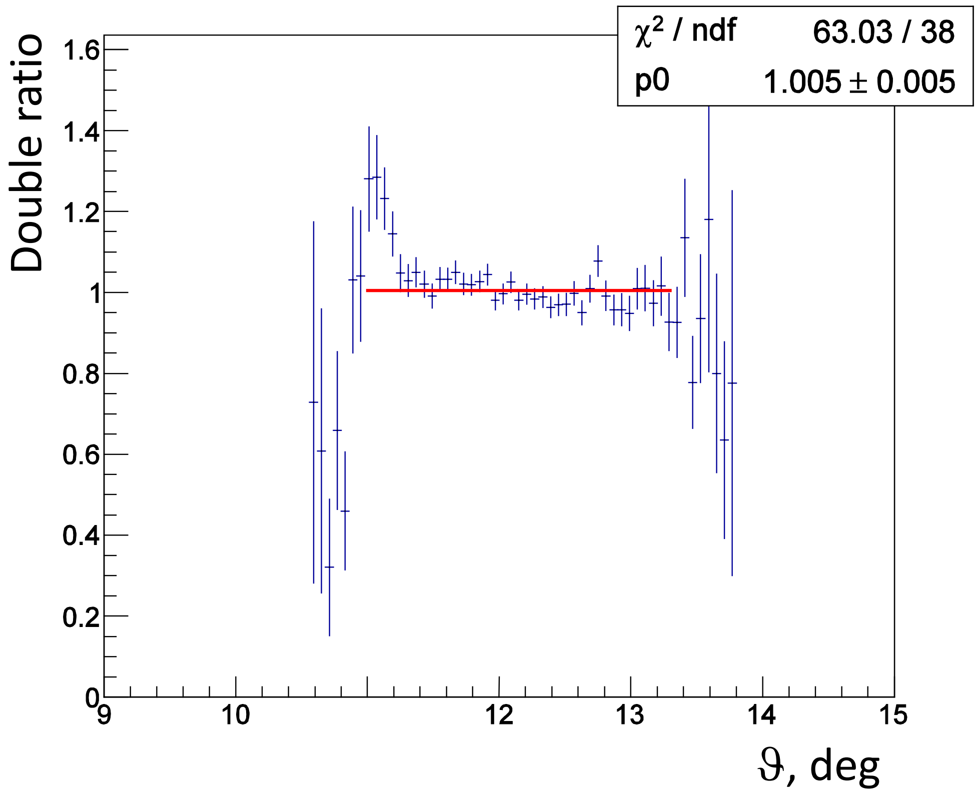
Ratio of luminosities

Ratio of 12 deg monitor luminosity over Slow Control monitor luminosity



12 deg monitor double ratio

Preliminary



$$\left. \frac{N_{tr}(e^+, B^+)/SCLumi}{N_{tr}(e^-, B^+)/SCLumi} \middle/ \frac{N_{tr}(e^+, B^-)/SCLumi}{N_{tr}(e^-, B^-)/SCLumi} \right. \cong 1$$

- **Acceptance correction and any (stable) systematic shifts are cancelled in double ratio**
- **Annihilation of scattered positrons are not canceled (small effect)**
- **MonteCarlo needed only to estimate annihilation effect**

Summary and Outlook

- **Accumulated data enough to determine luminosity with statistical error << 1%**
- **Preliminary result shows reasonable agreement between monitors**
- **Data analyse ongoing**

- *Cross check 12 degree monitor with negative magnet field*
- *Study all possible systematic effect and reduce systematic uncertainty*
- *Using double ratio look for any effect of TPE at small angles*