Luminosity Measurement at the OLYMPUS Experiment

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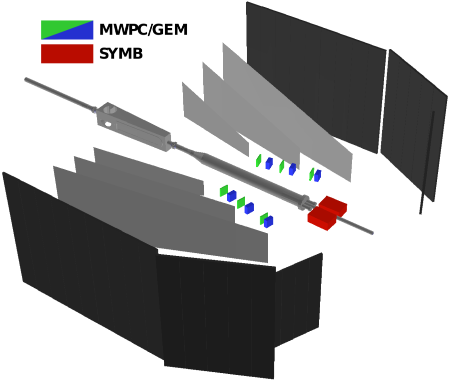
Outline

- Luminosity measurement
  - Slow Control
  - 12 degree monitor
  - Symmetric Møller/Bhabha monitor
- Summary

Luminosity measurement

3 independent systems were used:

- Slow Control, on the beam and target conditions
- 12 degree monitor (MWPCs and GEMs), lepton-proton elastic scattering
- Symmetric Møller/Bhabha monitor, electron-electron or positron-electron scattering



Slow Control

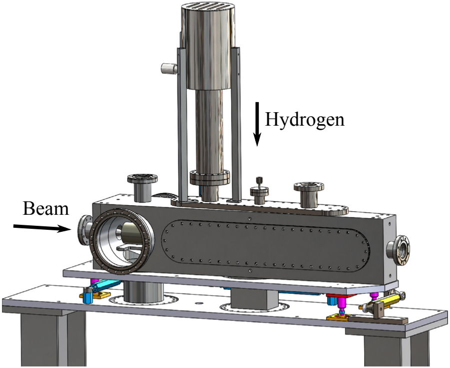
Luminosity measurement

$$\mathcal{L} = I \cdot \rho \cdot \Delta t$$

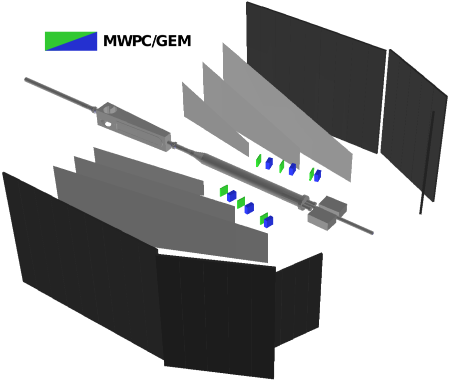
where I is the beam intensity, ρ is the target density, and Δt is the measurement time

disAdvantages

- Simple and reliable
- On-line luminosity measurement
- Geometry independent
- Absolute uncertainty ±15%, relative ±3%



12 degree monitor



- Detected lepton elastic scattering in the coincidence with a recoil proton
- At $\theta = 12^\circ$ two-photon contribution is expected to be small
- Consist of multi-wire proportional chamber (MWPCs) and gas electron multipliers (GEMs)

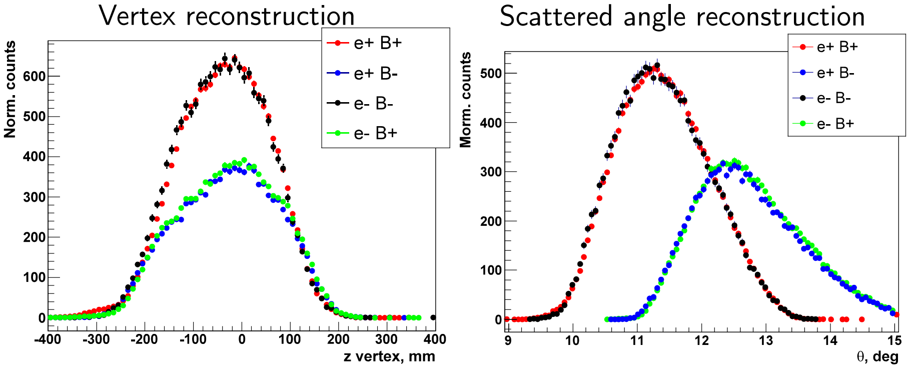
- 6 MWPCs with a spatial resolution of 0.3 *mm*
- 6 GEMs with a spatial resolution of 0.07 *mm*

12 degree monitor

disAdvantages

- Redundancy (6×MWPCs and 6×GEMs)
- Statistical precision of approximately %1 per hour
- Based on the same lepton-proton scattering
- Use recoil proton from the main detector
- Poor momentum resolution

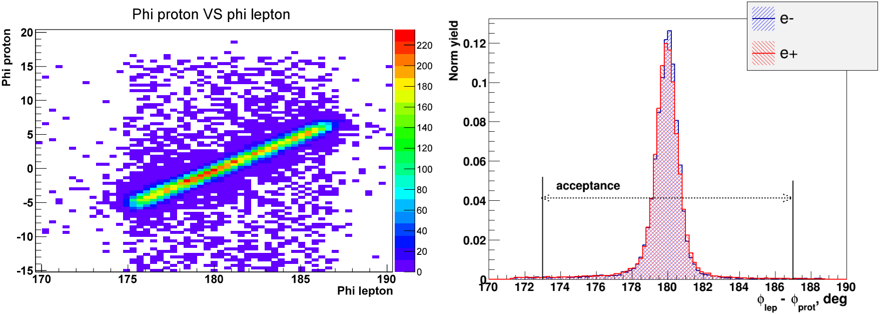
Performance of 12 degree monitor



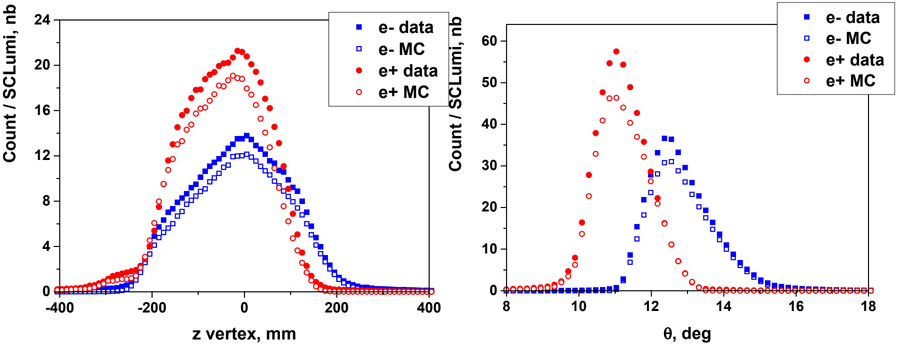
Acceptance doesn't dependent from the beam charge nor from the magnetic field polarity

Performance of 12 degree monitor

Lepton-proton coplanarity



Simulation of 12 degree monitor



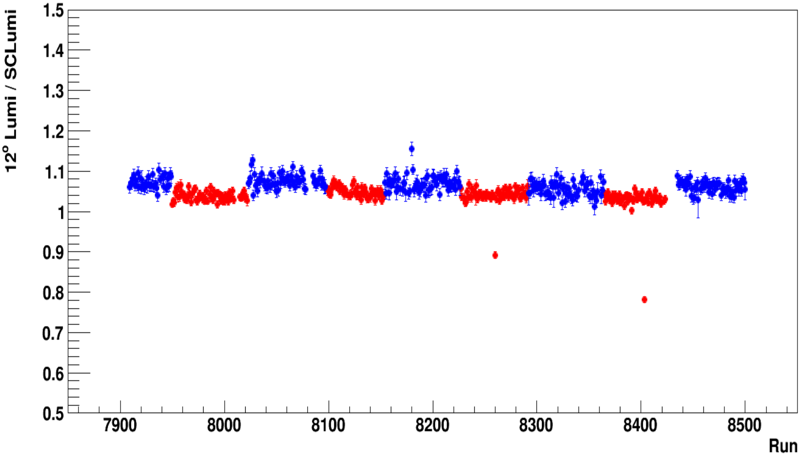
$$\mathcal{L}(e^{\pm}) = \frac{N_{tracks}}{\sigma_{MC}(e^{\pm}p)}$$

$$\sigma_{MC}(e^{\pm}p) = \int\limits_{acc} \frac{\sigma(e^{\pm}p)}{d\Omega} d\Omega$$

Luminosity was calculated using an event generator with internal and external bremsstrahlung included

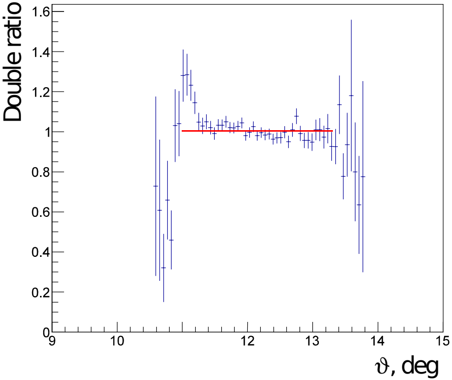
Performance of 12 degree monitor

Ratio of 12 degree monitor luminosity over Slow Control monitor luminosity



12 degree monitor double ratio (preliminary)

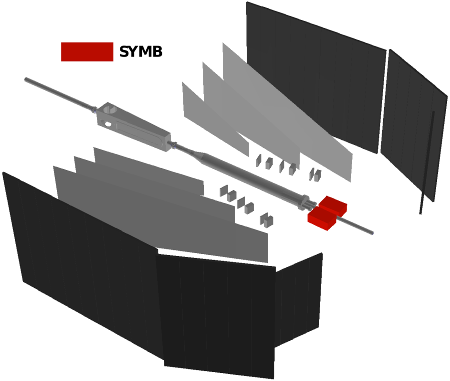
$$\frac{N(e^+,B^+)/SCLumi}{N(e^-,B^+)/SCLumi} \Big/ \frac{N(e^+,B^-)/SCLumi}{N(e^-,B^-)/SCLumi} \cong 1$$



- Acceptance correction and any stable systematic shifts are canceled
- Positron annihilation isn't canceled (small effect)
- Monte Carlo needed only to estimate annihilation effect

Symmetric Møller/Bhabha monitor

- Detected Møller/Bhabha scattering at the symmetric 1.29° angle



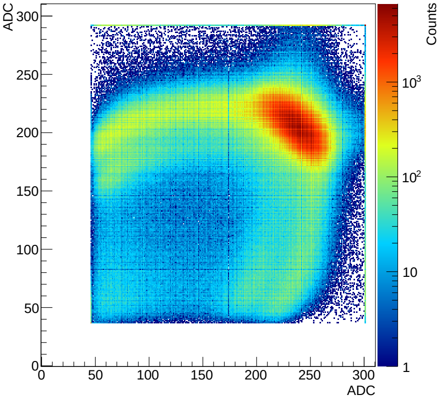
- Two monitors located symmetric to the beam pipe
- Each module consists of a 3x3 array of lead fluoride (PbF_2) crystals
- Each crystals is at least 15 radiation lengths long

Symmetric Møller/Bhabha monitor

disAdvantages

- Very high statistical precision
- Independent from $e^{\pm}p$ process
- Dead time free
- Very sensitive to geometry and misalignment

Coincidence mode of the SYMB



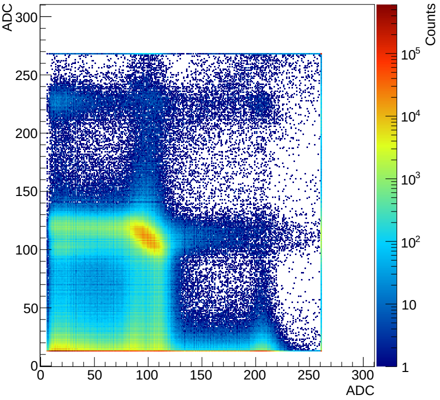
- Coincidence - signal of the central crystal of each detector has the highest amplitude
- Luminosity can be calculated using Møller, Bhabha, and annihilation event generators

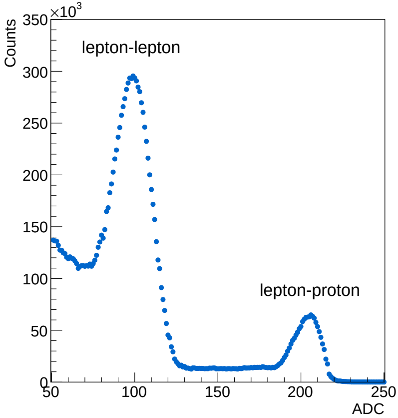
$$\mathcal{L}(e^{\pm}) = \frac{N_{coincidence}}{\sigma_{MC}(e^{\pm}e^{-})}$$

$$\sigma_{MC}(e^{\pm}e^{-}) = \int_{acc} \frac{\sigma(e^{\pm}e^{-})}{d\Omega} d\Omega$$

Master-slave mode of the SYMB

Master-slave - signal of the central crystal of at least one detector has the highest amplitude





Summary

- All luminosity monitors performed very well during the data taking
- Accumulated data should make possible measurement of the luminosity with a statistical error less then 1%
- Preliminary results show a reasonable agreement between all luminosity monitors
- Data analysis in progress