ZEUS Collaboration Meeting

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Luminosity Spectrometer for ZEUS

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- Overview
- Project Status
  - Hardware
  - Software
  - Calibration
  - Radiation Dose Studies
- Future Plans
- Summary

HERA Upgrade Schedule

Shutdown: September/00 (L$\simeq 2 \times 10^{31} cm^{-2} s^{-1}$)
Turn On: August/01 (L$\simeq 7.5 \times 10^{31} cm^{-2} s^{-1}$)

Required Luminosity Measurement Precision

- Diffraction Group: 3%
- Heavy Flavor Group: 1%
- Hadronic Final States: 2%
- Structure Functions and EW Group: 1-2%
- Exotics Group: 5%

Basic idea

How to measure luminosity?

- choose process with well known cross section

- measure the rate of such a process, $\mathcal{L} = \frac{Rate}{\sigma * A}$

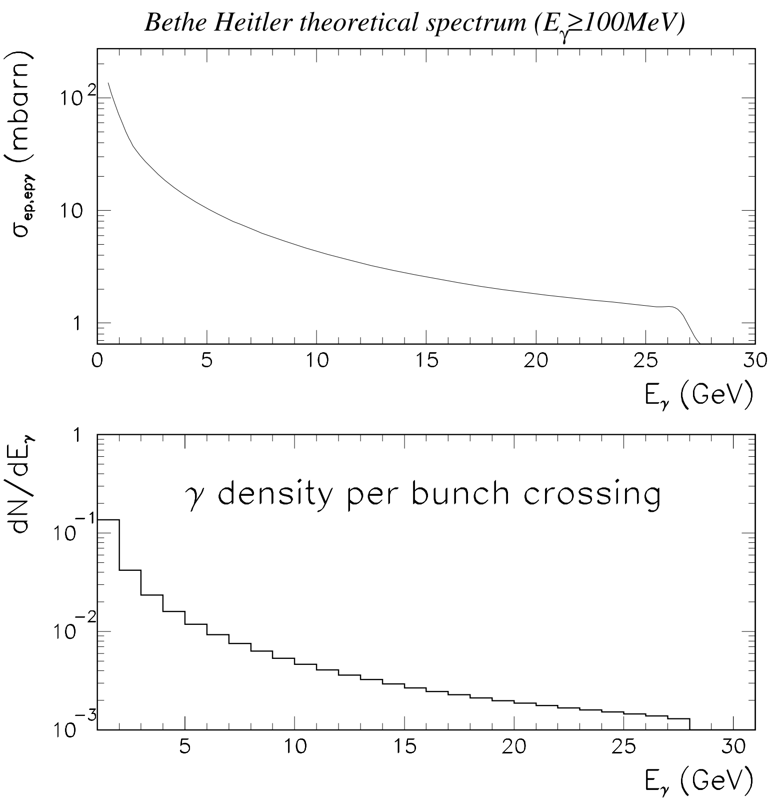
- at Hera such a process is Bremsstrahlung
  $e^{\pm}p \to e^{\pm}p\gamma$ with $\Delta\sigma/\sigma_{theory} \leq 0.5\%$

- measure emitted photons $\approx 100m$ downstream
  - Photon Calorimeter(Krakow) directly (pile-up, synchrotron radiation)
  - Spectrometer(Columbia) measure $e^{+}e^{-}$ pairs from photon conversion in the exit window (acceptance)

Bethe-Heitler

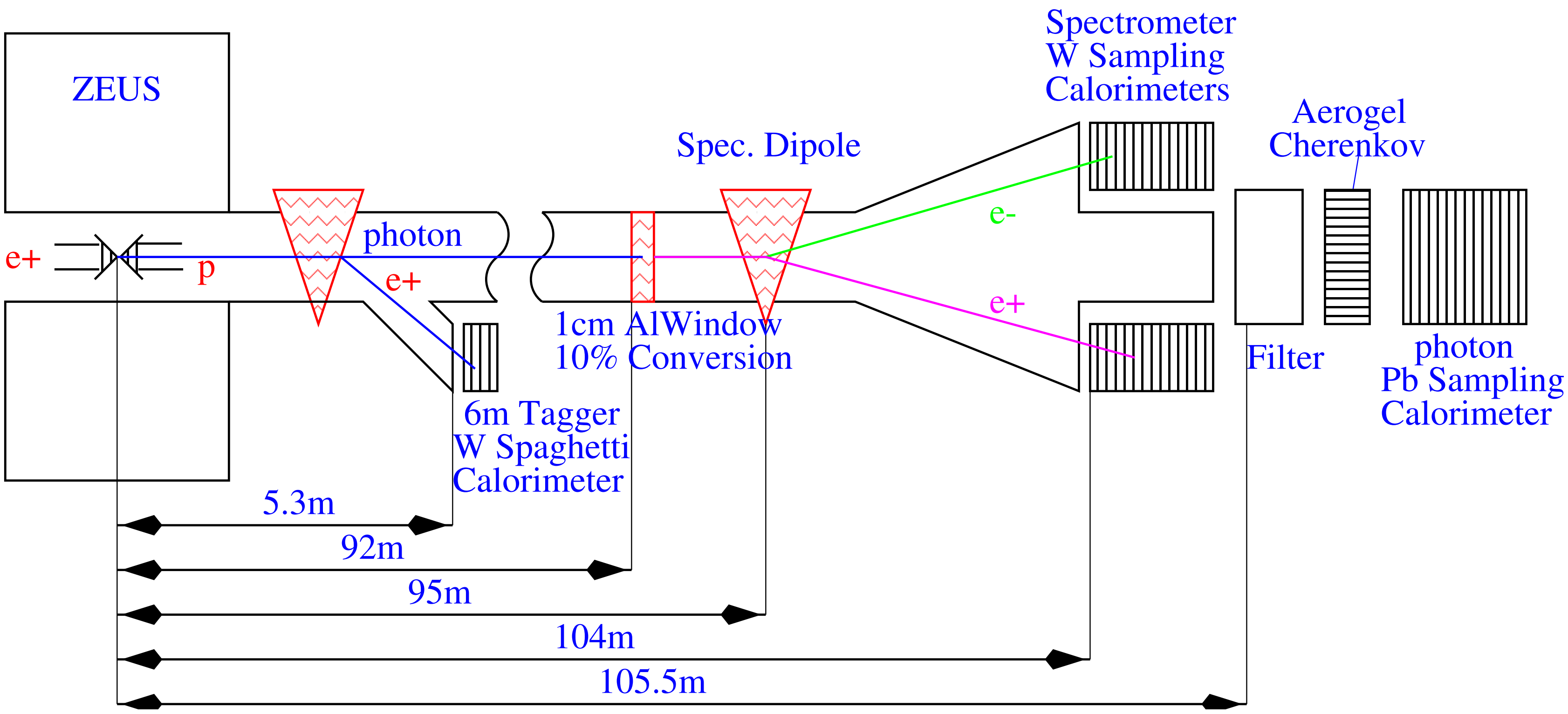
The cross-section for the process $ep \rightarrow ep\gamma$ is given by the Bethe-Heitler formula:

$$\frac{d\sigma}{dE_\gamma} = 4\alpha r_e^2 \frac{E_{e'}}{E_\gamma E_e}\left(\frac{E_e}{E_{e'}} + \frac{E_{e'}}{E_e} - \frac{2}{3}\right)\left(ln\frac{4E_p E_e E_{e'}}{M m E_\gamma} - \frac{1}{2}\right)$$

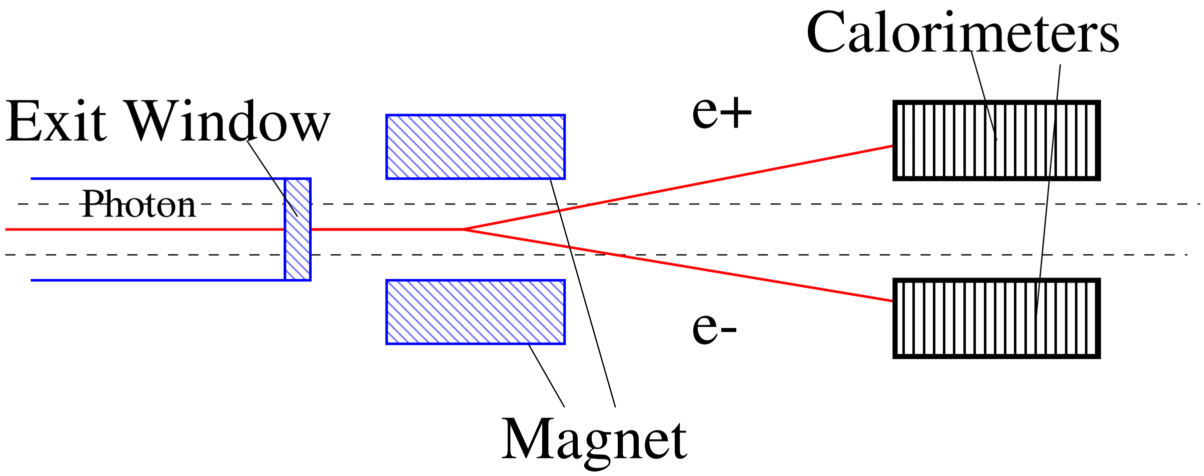


Cross-section (top plot) and photon density dN/dE_γ (bottom) for the process $ep \rightarrow ep\gamma$.

Calibrate using end point of photon spectrum.


ZEUS
e+
p
photon
e+
6m Tagger
W Spaghetti
Calorimeter
1cm AlWindow
10% Conversion
Spec. Dipole
Spectrometer
W Sampling
Calorimeters
e-
e+
Aerogel
Cherenkov
Filter
photon
Pb Sampling
Calorimeter
5.3m
92m
95m
104m
105.5m

Lumi Spectrometer Characteristics



- Small systematic errors due to pile-up. With acceptance $A \simeq 3\%$, the chances of confusion from a second photon are reduced by two orders of magnitude.

- Accurate knowledge of the acceptance ($\Delta A/A < 1\%$) in a window of width $\Delta E_\gamma \simeq 3GeV$, as determined with the use of the 6m tagger.

- No radiation damage issue due to synchrotron radiation.

- Small errors from energy scale uncertainty due to the good BPC resolution and clean spectrum end point.

- Good photon beam profile reconstruction at the exit window. Shifts of the profile mean values smaller than $\simeq 1mm$ can be measured every 10 seconds.

Hardware

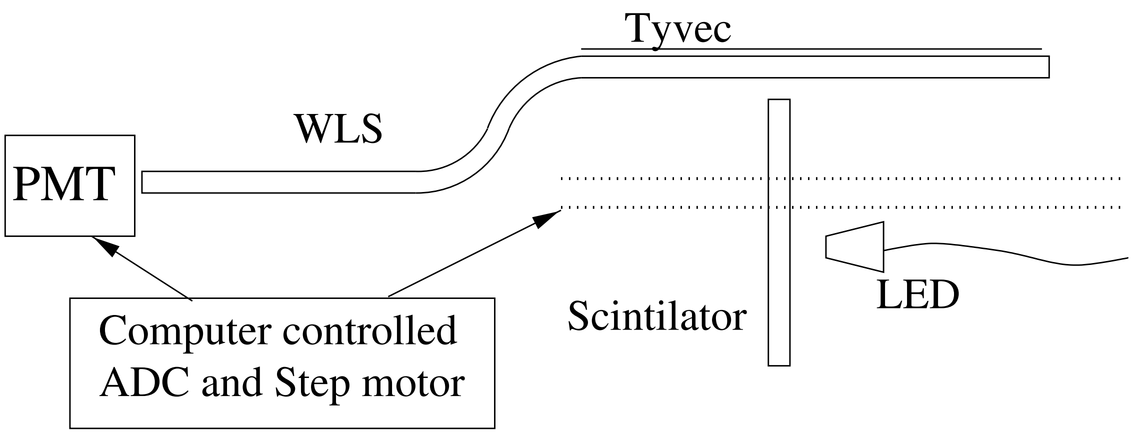
- **BPC South rebuilding**
  - BPC readout and support structure disassembled
  - Wave Length Shifter(WLS) replacement due to new geometry.
    - WLS produced and their ends alluminized
    - WLS were scanned for attenuation
    - A correcting reflective mask on Tyvek paper produced to lower uniformity over whole length of 16cm to less than 2%
    - introduced nonlinearity is well below 1%
  - All mechanical pieces ready for assembly.
  - We expect full assembly in few weeks.

- **Cobalt scans for BPCs and BPCn.**
  - No radiation damage or dead channels in BPCs.
  - BPCn analysis in progress (one dead channel already found).

Hardware II

- Dipole magnet + proton beam pipe shielding arrived
  - perform B field measurements
- PMT Tests:
  - 32 PMT's tested at Hamburg I during summer.
  - New test stand for testing the rest of PMT's (60) is setup.
- LED monitoring system is ready
- 1 month of test beam scheduled in January.
  (Use 2249A 10bit ADCs and CAMAC based DAQ with 500Hz (tested) throutput)

WLS scanning

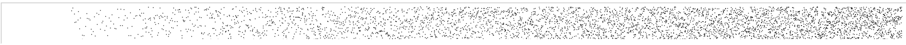


Schematics of experimental setup for WLS scanning.

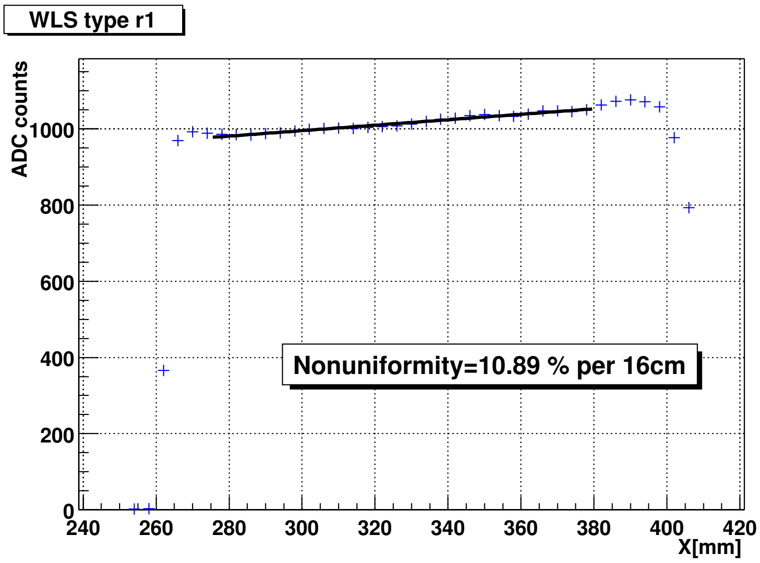
- Attenuation $\Rightarrow$ nonlinearity due to different shower depths
- Nonlinearity $\leq 1\%$ $\Rightarrow$ kepp nonuniformity $\leq 5\%$.
- We keep nonuniformity $\leq 2\%$ over length of WLS.
- We have lower range of energies in spectrometer acceptance.
- Introduced nonlinearity is negligible.

WLS scanning

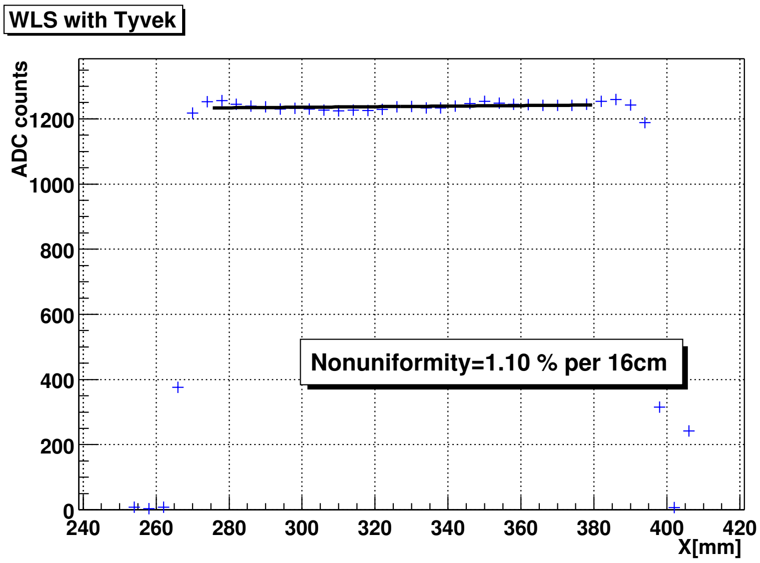
Example of Tyvek paper



Uniformity in Wavelength shifter



Uniformity in Wavelength shifter using correcting reflection mask



Software

- Full Stand-Alone Monte Carlo simulation in Geant3.21. Started to generate event database.

- "alpha" version of reconstruction program (C) ready. Histogramming and analysis based on ROOT.

- Reconstruction of coincidence energy and position at event rates $\approx 25kHz$ on $200MHz$ CPU with full energy correction algorithms.

- Preliminary MC studies of position and energy resolution of $\Delta X = 0.7mm$, $\frac{\Delta E}{E} = \frac{17\%}{\sqrt{E}}$ agree with previous studies

- DAQ: A "mock" data generator transforms GEANT output to actual raw data format. We use these data for DAQ throuput tests.

Radiation Dose Studies

There is $700W$ of synchrotron radiation (SR) hitting exit window. Spectrometer is not hit directly but we have two "hot" sources of radiation

- back scattered SR from lumi calorimeter
  - about 1%/sr is scattered
  - difficult to shield from the inner surface
  - new position of detectors and calorimeter filters increased in order to allow shielding from back and decrease radiation dose from inner surface to negligible levels
- compton scattered SR in the exit window
  - $\approx 30\%$ SR scattered in the window
  - assuming spectro acceptance and absorption in front tungsten layer we get $\approx 200Gy$ per month
- ambient radiation from HERA tunnel is expected to be low compared to "hot" sources

Radiation Dose Studies II

Decrease of signal due to expected radiation damage (Compton scattered only)

	month	year	5years
Scintillator	0.2%	2.1%	10.5%
WLS	0.06%	0.7%	3.5%

- we are at the limit of being safe

- run with radiation monitors to measure actual level of radiation

- What can we do?
  - **extra shielding** - reduces energy resolution and is not very efficient, b/c the hard component is absorbed slowly
  - **rebuild** the BPC stack after few years of running

Calibration

End point of photon spectrum at $E_e = 27.5 GeV$.

- Increase B field to achieve $\int BdL = 0.36Tm$
- Calibrate outer strips only for $y_{hit} \approx 3\sigma$.
  - We have $\approx 10kHz$ rates.
  - We need to know, which photons hit window at high y.
- Relative energy scale E^s_{scale}/E^n_{scale}
  Relative E-scale $\neq 1$ can be mimicked by photon beam shifts.

Special runs at $E_e = 12GeV$.

- Whole energy in single detector.
- No issue of relative energy scales.
- Only few strips calibrated. Run at different B fields?
- Special runs $\Rightarrow$ not often.

Hardware Upgrade

Proposal to use extra bar in front of the window.

- Will be used to define conversion position.
- Thick enough to convert detectable amount photons.
- Movable in vertical direction
  - Solve relative energy scale problem.
  - Measure position dependent acceptance.
  - Extend calibration to cover outer strips.

Feasibility under study

- Material.
- Dimensions.
- Cooling.
- Performance.

What next?

- Assemble BPC south.
- Finish and analyze Cobalt scans.
- Perform magnetic field measurements.
- Test the rest of PMT's.
- Get DAQ software for all components running.
- A November "system test" to test the PMT-FEE-RG213(150m)-"DAQ" chain, using an LED pulser, is planned.
- Proceed with studying calibration procedure.
- Possible hardware upgrade for calibration.
- Get ready for the test beam.

Summary

- Most of work on BPC south assembly done.
- Dipole magnet + proton beam pipe shielding ready.
- PMT tests done and new ones being started
- LED monitoring system ready
- Cobalt scans started.
- Software development in progress (reconstruction, Monte Carlo, DAQ).
- Radiation damage problems identified.
- Calibration problems identified.

As ussualy:

A lot of work has been done and
a lot of work still needs to be done.