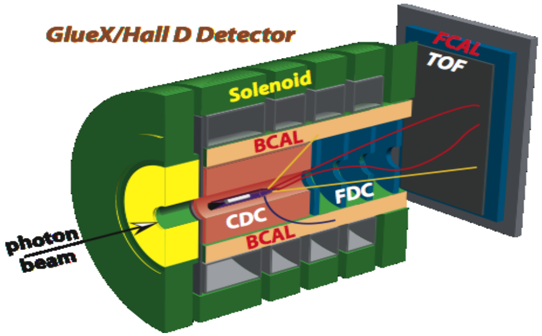


Status of the Beamline Simulation

A.Somov Jefferson Lab

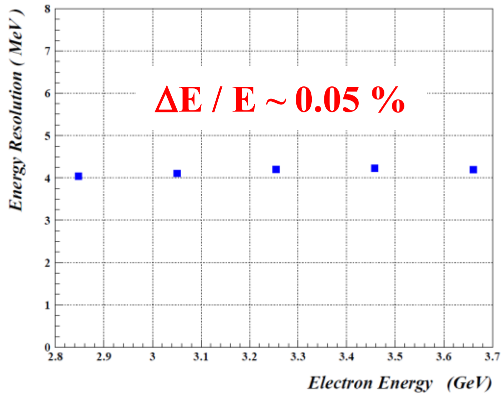
Collaboration Meeting, May 11, 2010

Simulation Overview

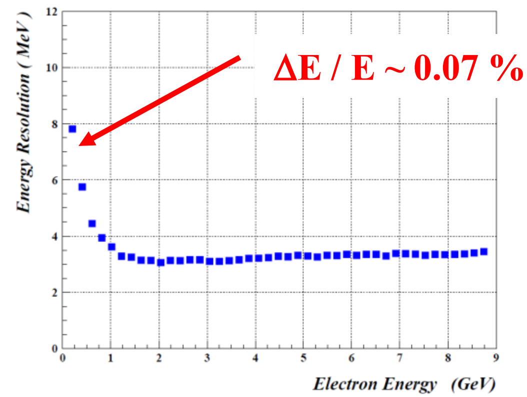
- Tagger magnet simulation
  - **Energy resolution and rate of microscope counters of the narrow magnet**
  - **Check the magnetic field map of the narrow magnet produced with TOSCA**
- Pair Spectrometer Simulation
  - **End-point energy calibration**
  - **PS alternative readout**

Summary on the Simulation of 6 cm Narrower Magnet

Microscope counters



Fixed-Array Hodoscopes



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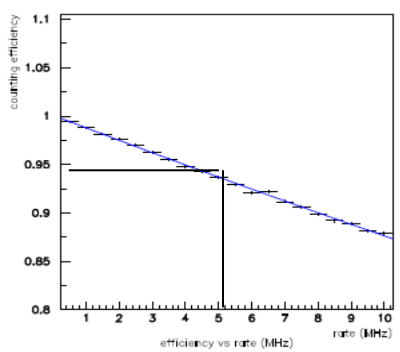
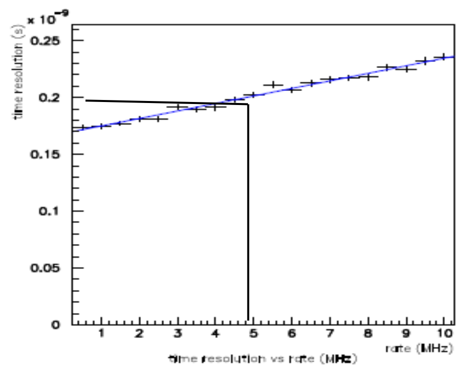
Resolutions due to the finite counter sizes are not included in these plots: σ (microscope) ~ 2.8 MeV σ (fixed-array) ~ 8.7 MeV

Counting efficiency versus rate



RMS time resolution versus rate



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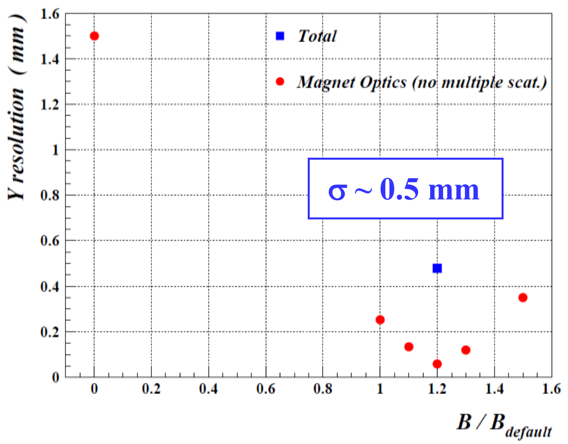
- **At the counter rate of 5 MHz the counting efficiency is close to 95% and the timing resolution is about 200 ps**
- **The expected rate in the microscope counters per energy bin is about 3.8 MHz**

Summary on the Simulation of 6 cm Narrower Magnet

Microscope counters



Uncertainties due to the multiple scattering:

- **0.32 mm multiple scattering of electrons in the diamond crystal**
- **0.38 mm scattering in the VC exit window and fixed-array counters**

➢ New magnetic field map for the narrow magnet generated with TOSCA (Yang)

- **Check position of electrons on the focal plane**
- **Check position of full-energy electrons at the Beam Position Monitors (z = 26 m)**

➢ **The technical drawings with the new focal plane will be updated shortly (Bill Crahen is working on them)**

To be done

➢ Implement the new magnetic field map produced with ANSYS to the Geant simulation (work in progress)

➢ Update Geant geometry (to be done)

➢ Study methods for the tagger calibration (work in progress)

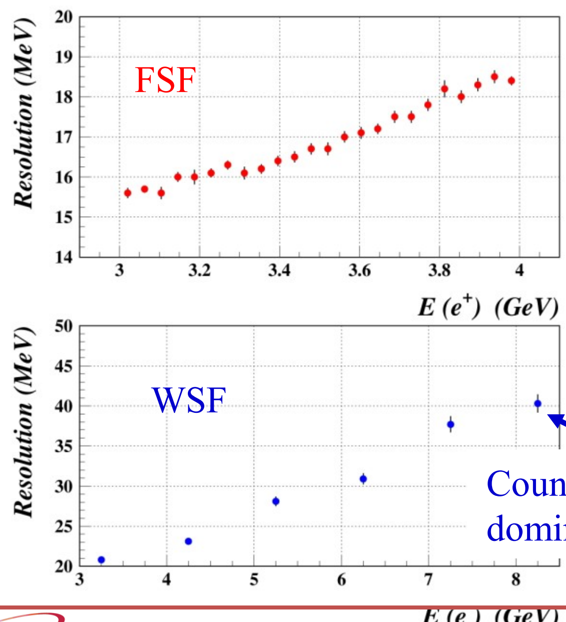
- calibrate energy using pair spectrometer (do we need to map the tagger field ?)

Simulation of the Pair Spectrometer

➢ **Recent Pair Spectrometer geometry:**

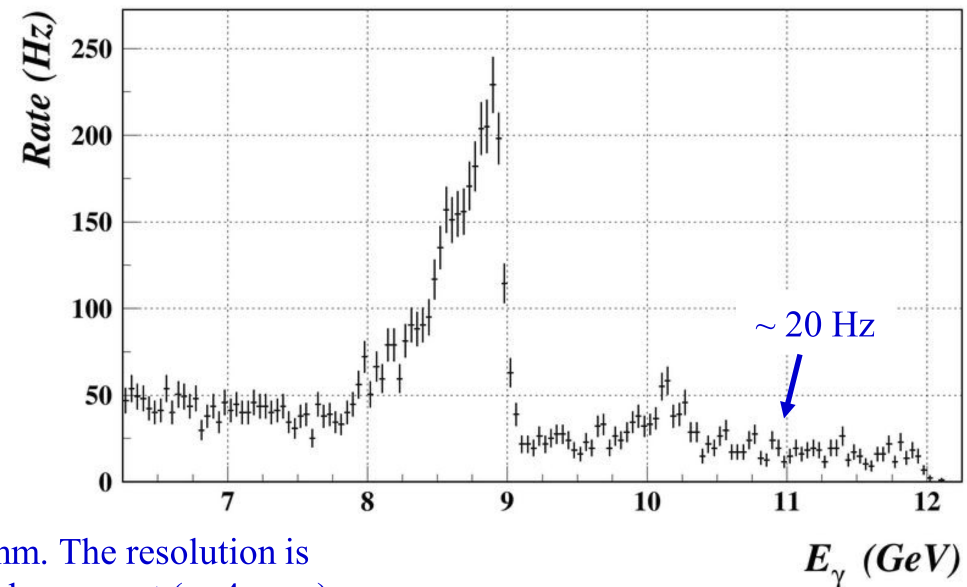
- 2 m long dipole magnet with the nominal operation field of 1.6 T
- 1.5 m long vacuum chamber
- 24 FSF counters covering the range 3 - 4 GeV
  - bin size 41.7 MeV, $\sigma(E)$ = 12 MeV
- 8 WSF counters positioned ar 3.25 GeV, … , 8.25
  - $\sigma(E)$ = 17 MeV

Counter resolution obtained with the Geant simulation (converter thickness $5x10^{-3}$ X_0)



Counter width 2 mm. The resolution is dominated by the beam spot (~ 4 mm)

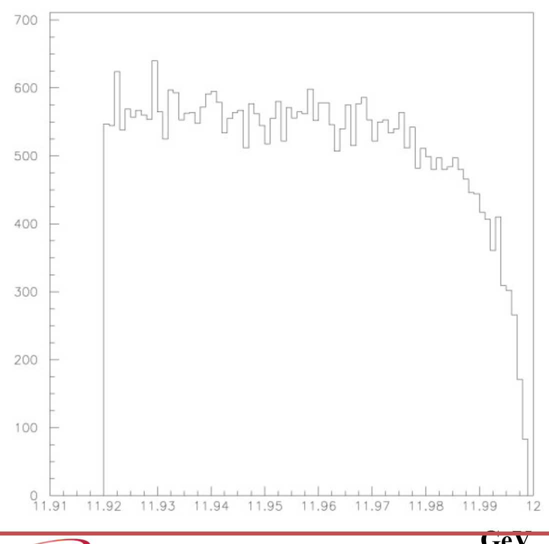
Photon energy measured at high luminosity (Al converter with the thickness $5x10^{-3}$ X_0)



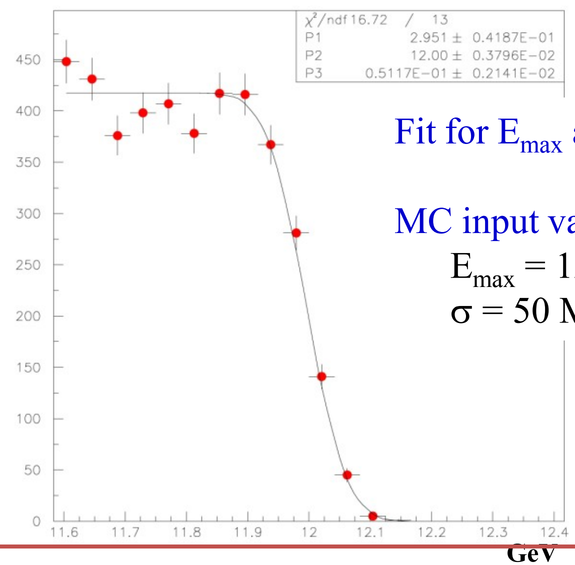
PS End-Point Energy Calibration

- We can calibrate the pair spectrometer by fitting the measured photon spectrum at the end-point region
- The tagger hodoscopes can subsequently be calibrated using the Pair Spectrometer
  - required precision on the realative end-point energy measurement ~10^{-3} (12 MeV)
- We need parameterization of the bremsshtrahlung energy in the end-point region – under study
- Use Toy MC to estimate accuracy of the energy measurements. Generate MC samples using the beamgen energy shape and the energy resolution of 50 MeV. Fit for E_{max} and $\sigma(E)$. Preliminary results:
  - taking the calibration data for 5 – 10 min (for low luminosity runs) will provide the precision on the energy measurement better than 10^{-3}
  - main uncertainties come from the energy bin size, which is 41 MeV (to be studied in detail). Use additional WSF counter between 7.25 GeV and 8.25 GeV.

The end-point energy distribution for incoherent Bremsstrahlung predicted by beamgen generator



Toy MC. Energy distribution at the end-point



Fit for E_{max} and σ

MC input values:

E_{max} = 12 GeV

σ = 50 MeV

PS: Summary on the Default Instrumentation

- The current instrumentation of the Pair Spectrometer with the FSF and WSF counters seems to be the simple and reliable design.

  - the PS rate should be sufficient for the precise monitoring of the photon flux
  - good precision in the online/offline determination of the photon polarization
  - the PS counters covering the energy region close to the end-point can be calibrated by fitting the end-point energy spectrum (we have to study the theoretical uncertainties in the shape of the end-point spectrum); we will probably need to add additional WSF counter(s) in the energy range between 7.25 GeV and 8.25 GeV

Some disadvantages:

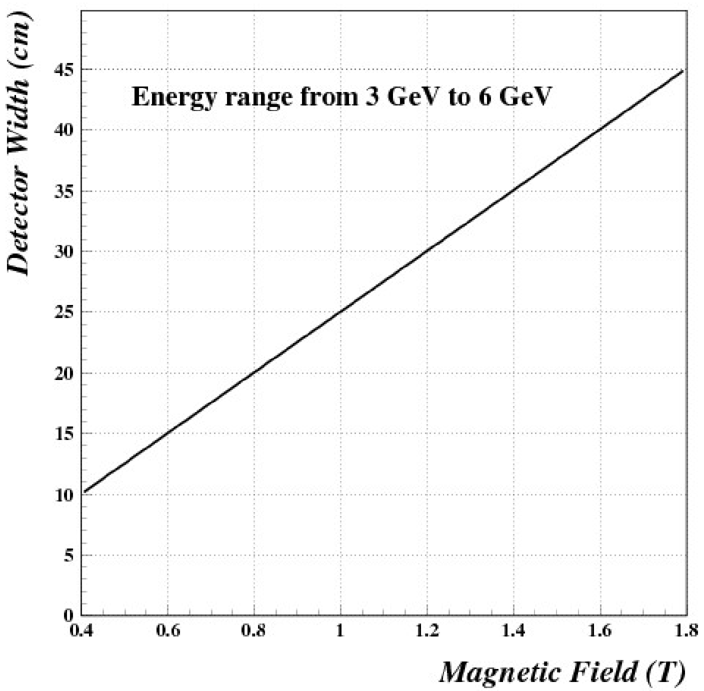
- small acceptance of about 0.1% (and the size of the counter positioned closest to the beamline). We need a procedure to calibrate the acceptance of each WSF counters
- small rate when operating with the wire target

- **Consider the feasibility of using Microstrip detectors as an additional PS instrumentation**

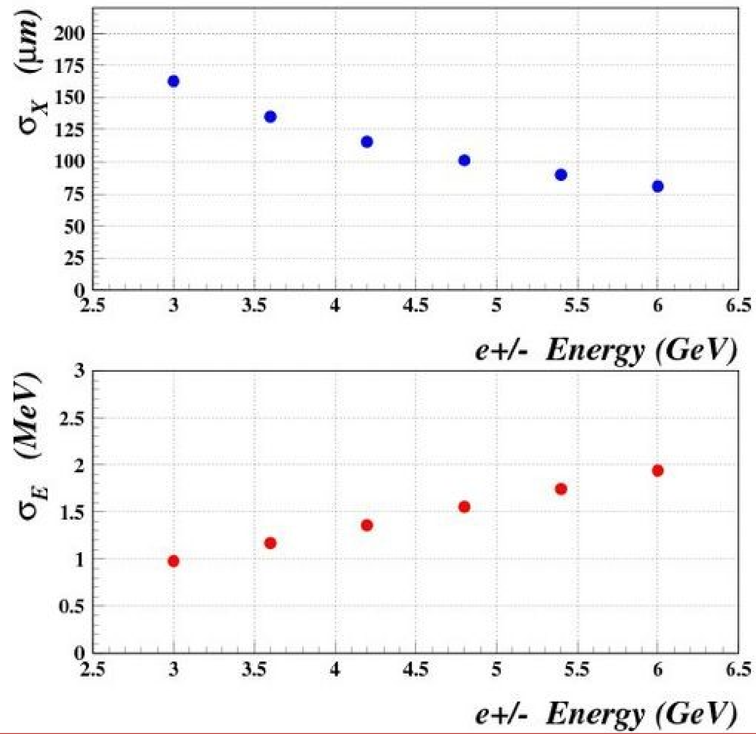
Using Microstrip Detectors for the PS

- **Consider symmetric design of the Microstrip detectors:**
  each arm covers the energy range between 3 GeV – 6 GeV
- **The detectors should be about 25 – 30 cm wide when operating the magnet at 1 – 1.2 T**

The detector width and position from the beamline as a function of the B-field



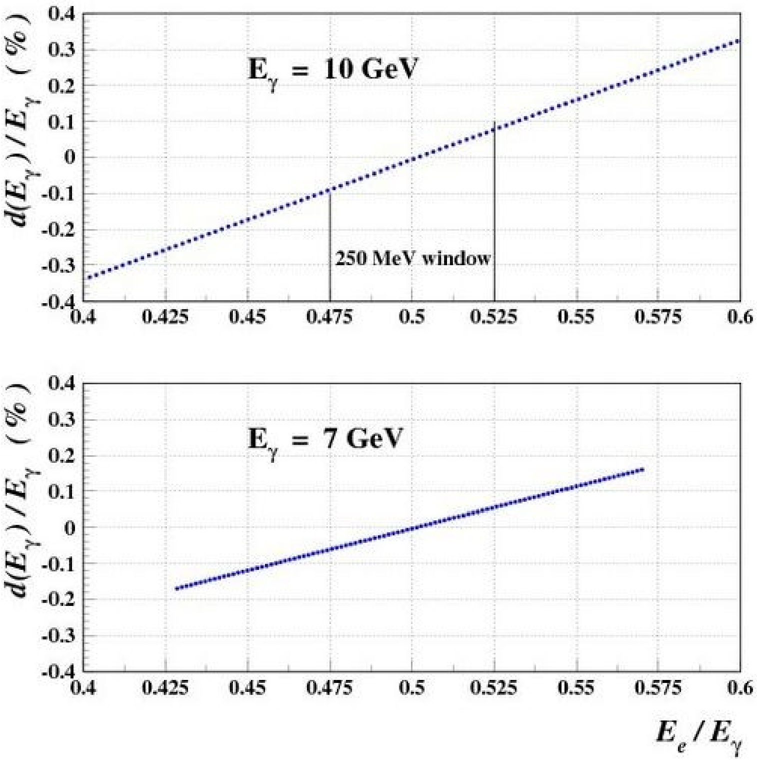
Contribution from the multiple scattering (10^{-4} X_0 thick converter)



Using Microstrip Detectors for the PS

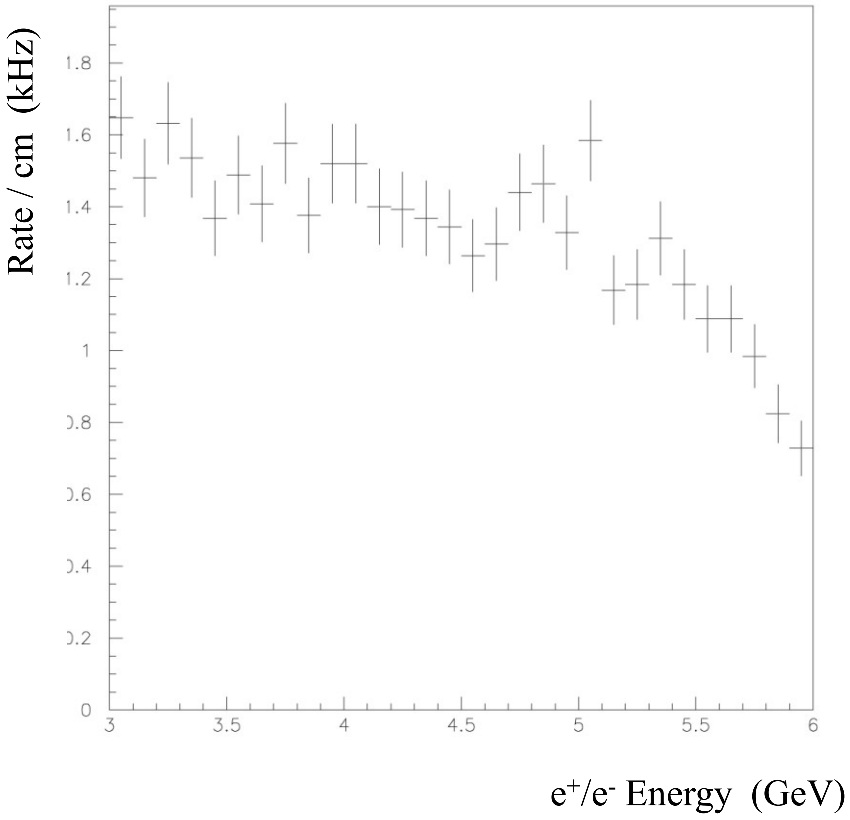
- **Microstrips provide some 'redundant' measurements which can be used to control systematic errors**

Impact of the beam profile distribution and beam motion on the energy resolution.
Relative shift of measured photon energy for the beam displacement of dx = 2.5 mm.
The magnetic field is set to 1 T.



Using Microstrip Detectors for the PS

Rate per cm (counter width 30 cm, 10^{-3} X_0 thick converter)



Total rate in the energy range between 3 GeV- 6 GeV is about 44 kHz

Summary

- The simulation of the narrow tagger dipole magnet is completed.
- The future plans are:
  - Implement ANSYS magnetic field map to the Geant simulation
  - Update Geant geometry of the narrow magnet and the vaccum chamber
  - Study calibration procedure of the tagger hodoscopes

  - Complete the studies of the Pair Spectrometer calibration using the end-point energy (and the feasibility of calibration of the tagger hodoscopes using the Pair Spectrometer)
  - Produce the magnetic field map of the Pair Spectrometer magnet using ANSYS and implement the map to the Geant simulation
  - Study the feasibility of using the microstrip detectors as an additional Pair Spectrometer instrumentation