The status of E166

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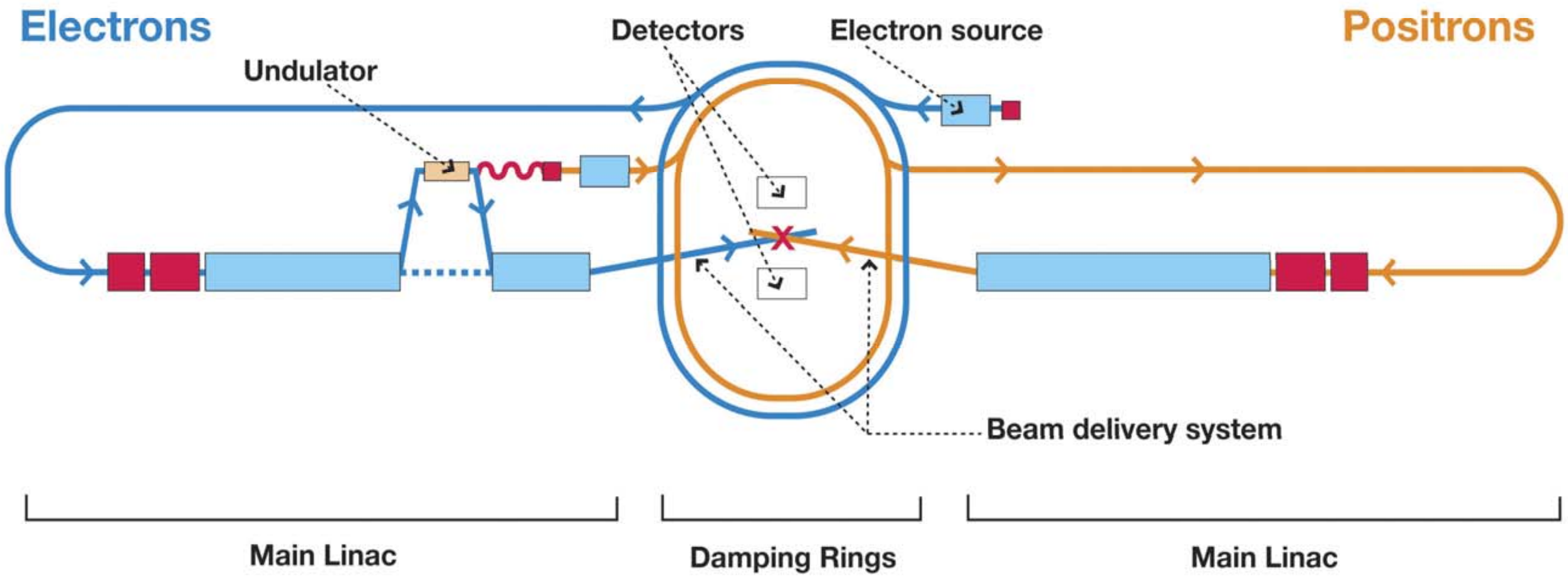
Outline

- E166 scheme
- The helical undulator
- Compton transmission polarimetry
- Setup
- Analysis, Simulation, Results

The International Linear Collider (ILC)

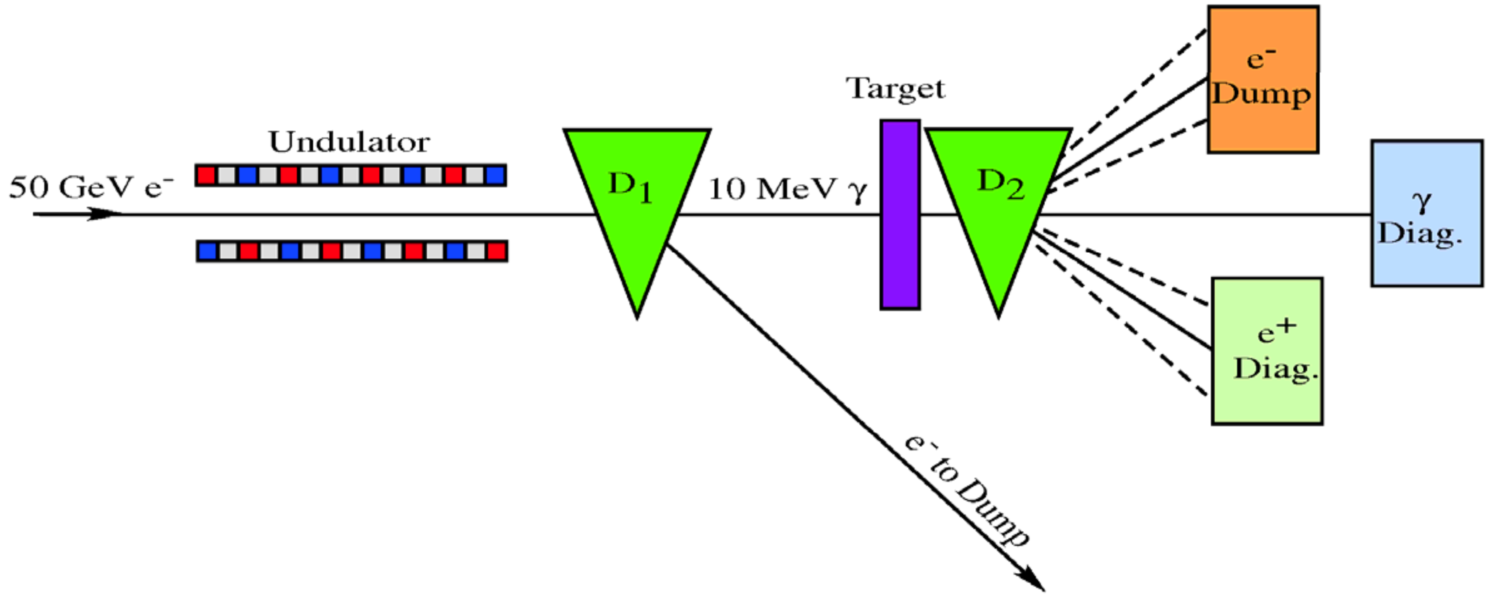
- Center of mass energy: 500 GeV
- Luminosity: $L= 2{\cdot}10^{34}\ cm^{-2}s^{-1}$
- Length: ~ 31 km
- Polarized beams: $P(e^-) > 80\%$, $P(e^+) \sim 30\%(60\%^\dagger)$ †upgrade
- Polarization of both beams is advantageous f. SM- and non-SM-physics (eff. luminosity, signal/background in SM processes …)

→ http://www.ippp.dur.ac.uk/~gudrid/source/



E166

Task: proof the possibility, to produce polarized positrons using a helical undulator !

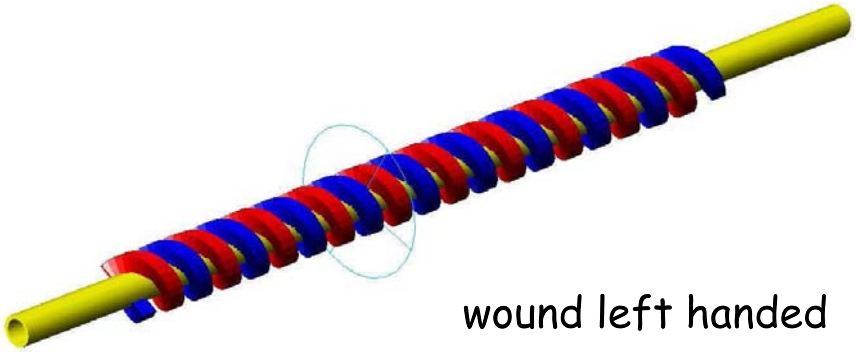


- 1 m long helical undulator produces circular polarized photons
- conversion of circularly polarized photons to longitudinally polarized positrons in thin W-target
- measurement of polarization of photons and positrons by Photon transmission method
- main parts: undulator, production target, spectrometer, e+/γ diagnostics

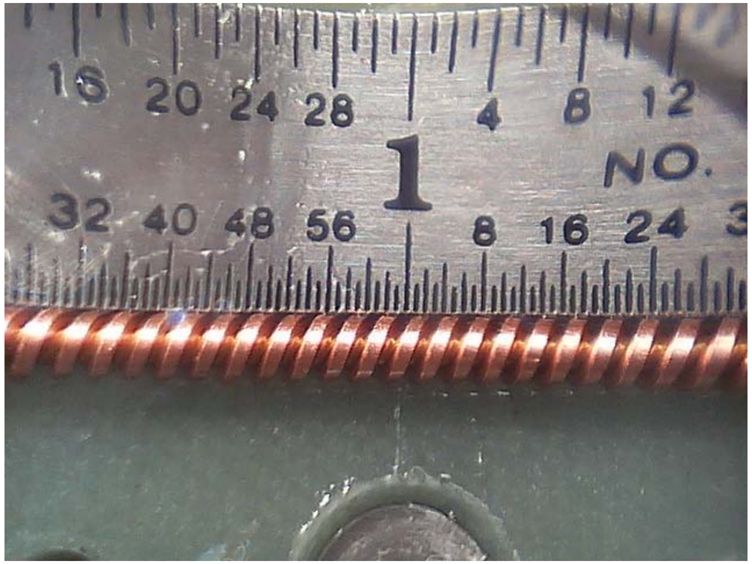
The E166 Undulator

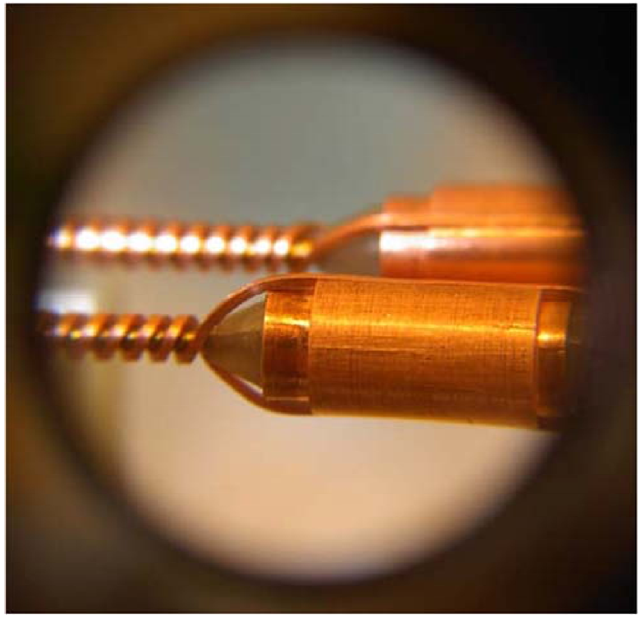
Design parameter:

- length 1m
- period 2.54 mm
- aperture 0.889 mm
- on axis field 0.71 T
- K 0.19
- E_γ (1^{st} harmonic) 7.8 MeV @ E_{beam}= 46.6 GeV



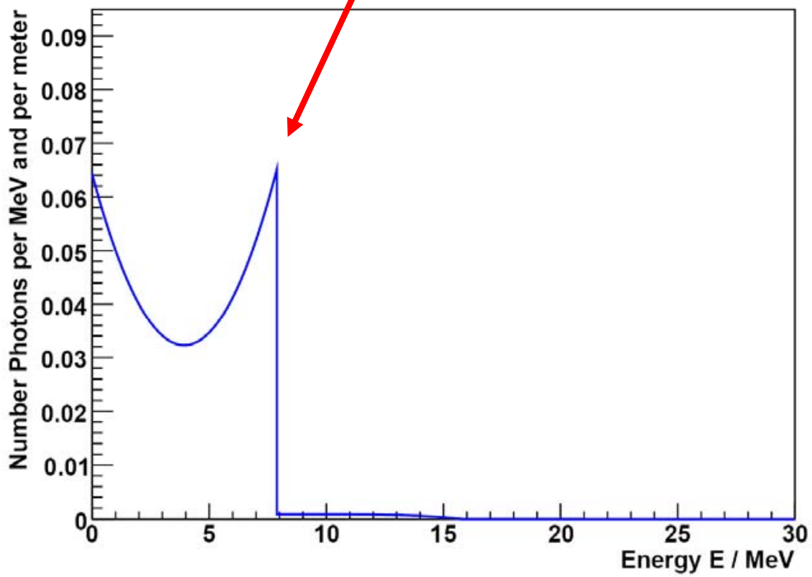
wound left handed



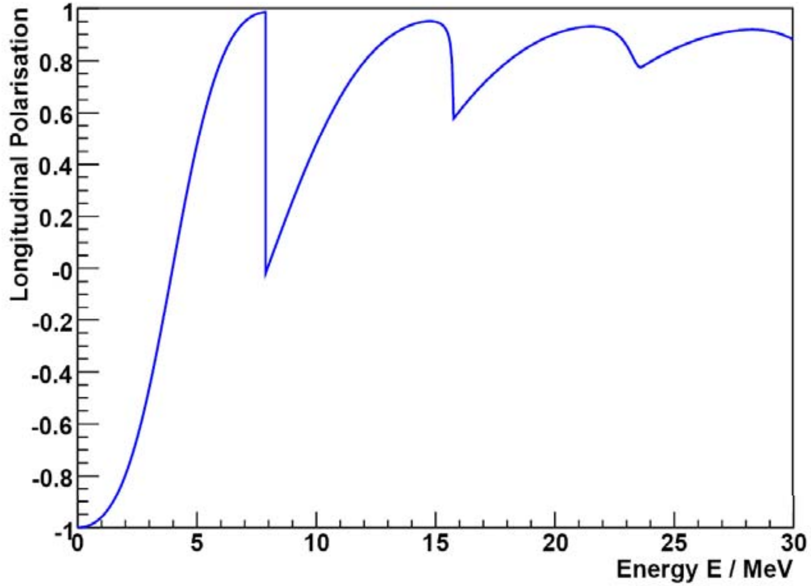


Photon Energy and Polarization (K~0.17)

E_{cutoff} (1st harmonic) : 7.8 MeV



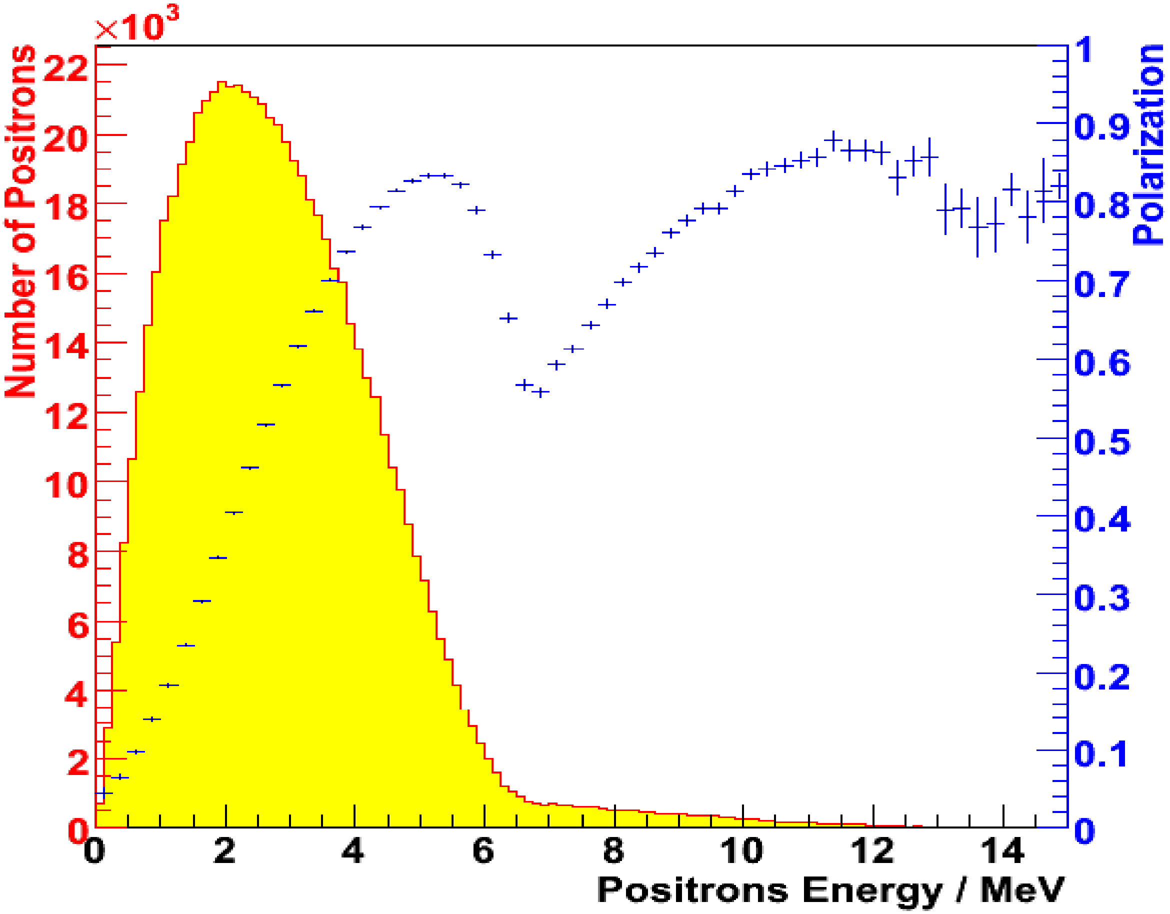
Undulator Photon energy spectrum



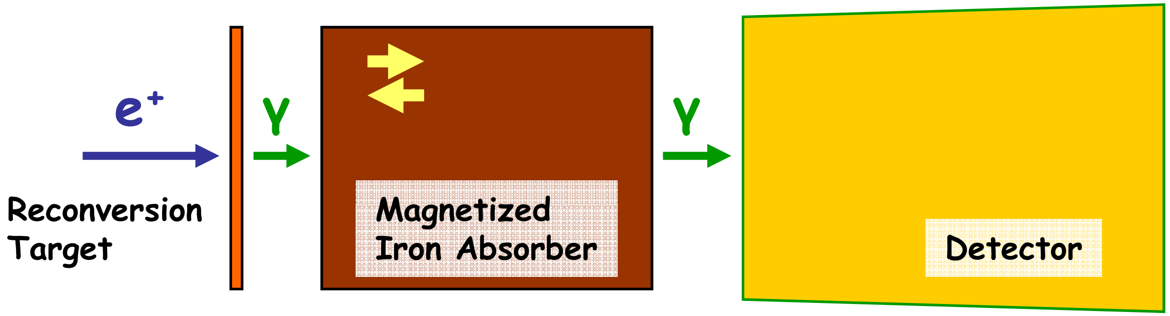
Undulator Photon degree of polarization

Expected Positron Spectrum and Polarization

positron generation in a 0.5 X_0 W-target for undulator design parameters:



Compton Transmission Polarimetry



$$\sigma_{tot} = \sigma_{phot} + \sigma_{comp} + \sigma_{pair} \quad \text{with} \quad \sigma_{comp} = \sigma_0 + P_\gamma P_e \sigma_{pol}$$

Transmission

$$T^{\pm}(L) = e^{-nL\sigma} = e^{-nL(\sigma_{phot} + \sigma_{pair} + \sigma_0)} e^{\pm nLP_\gamma P_e \sigma_{pol}}$$

Asymmetry

$$\delta(L) = \frac{T^+ - T^-}{T^+ + T^-} \approx nLP_e P_\gamma \sigma_{pol}$$

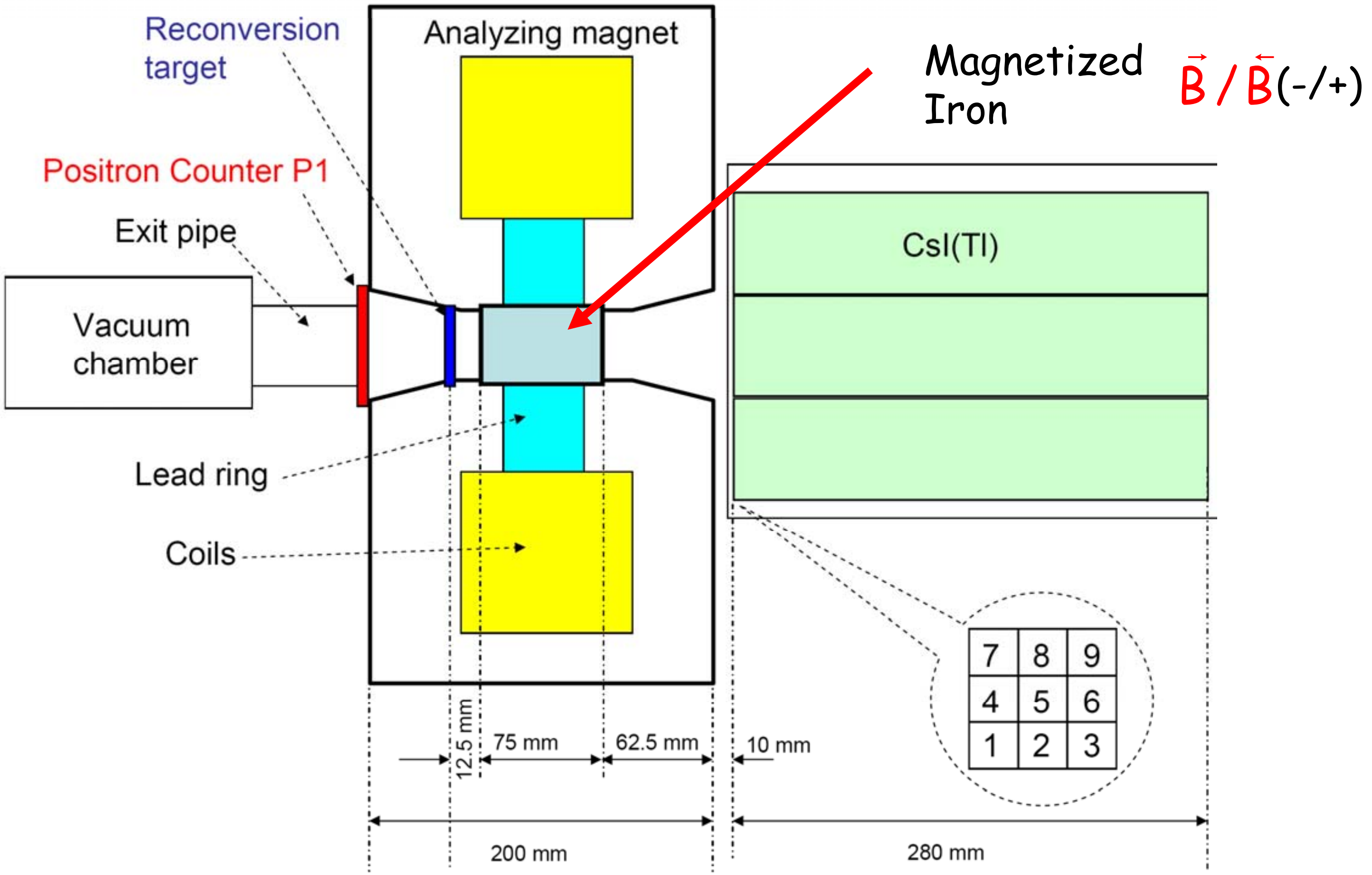
Photon Polarisation

$$P_\gamma = \frac{\delta}{nL\sigma_{pol} P_e} = \frac{\delta}{A_\gamma P_e}$$

$P_e(Fe) = 6.9 \pm 0.2$ %

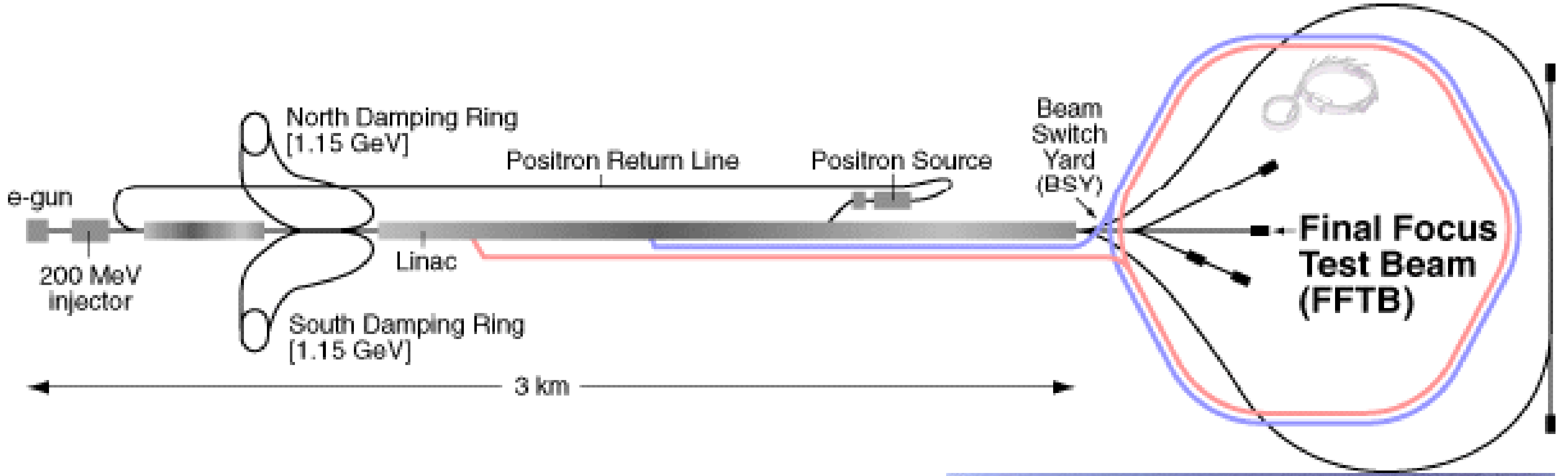
Analyzing Power
(via Simulation)

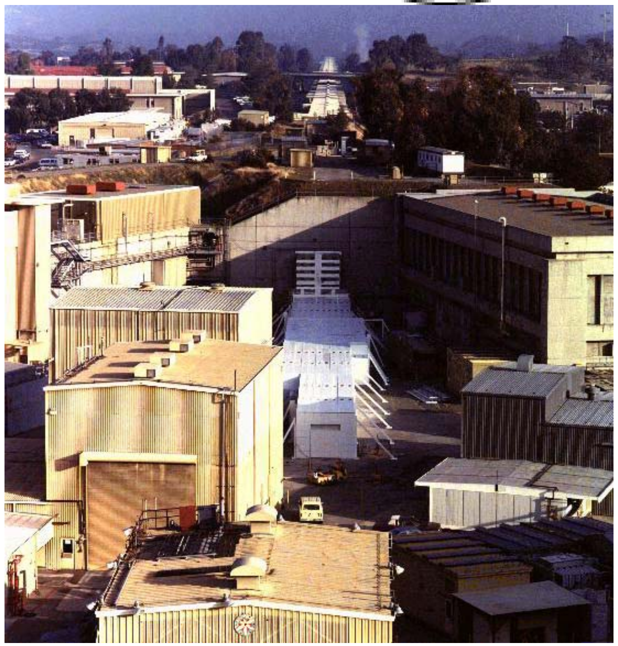
The E166 Polarimeter



Measure $E_{dep}(-)$ and $E_{dep}(+)$ -> Asymetry = $\frac{E_{dep}(-) - E_{dep}(+)}{E_{dep}(-) + E_{dep}(+)}$

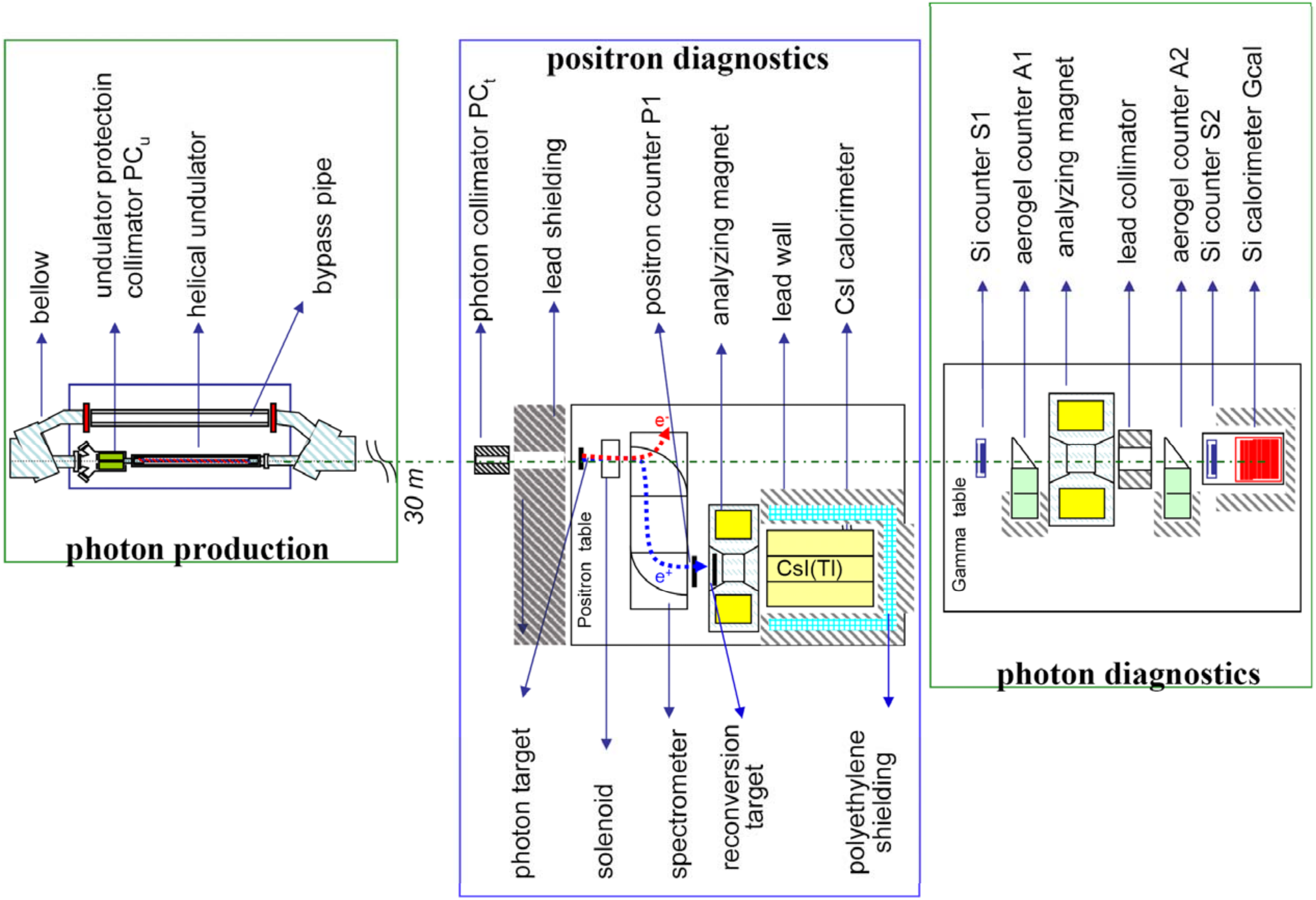
E-166 in the FFTB



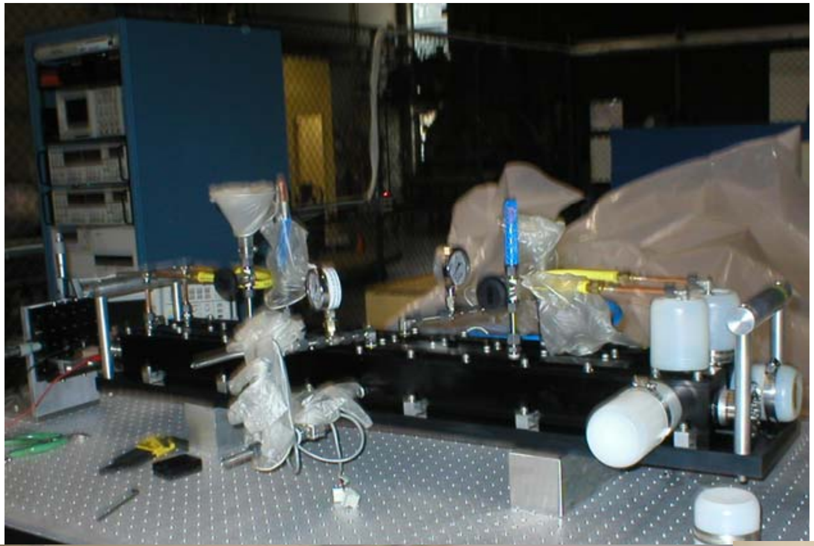


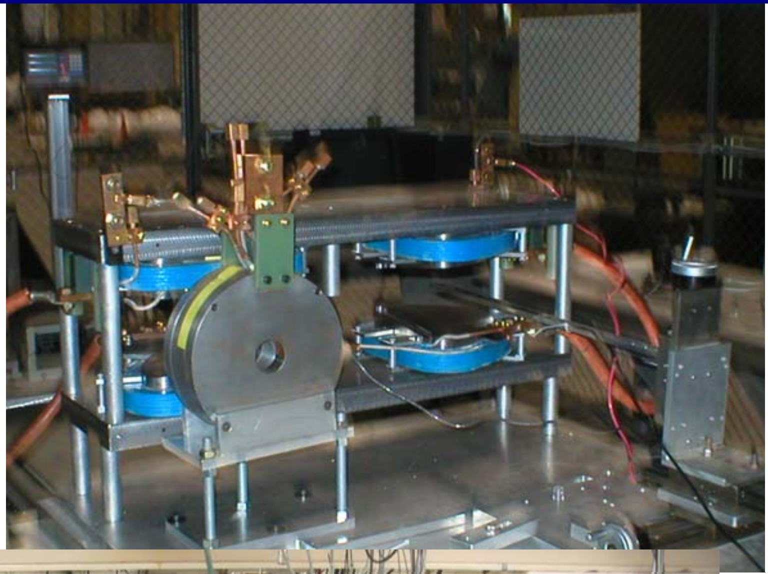
- beam energy E_{beam} = 46.6 GeV
- electrons/pulse N_{e-} ~10^{10}
- beam size σ = 40 μm
- rep. rate 10 Hz

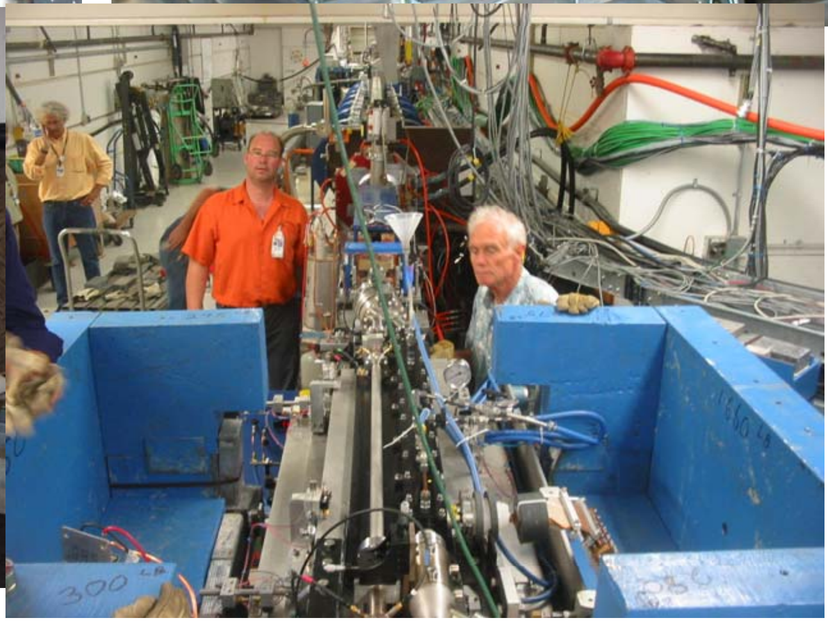
Details of the setup



The setup

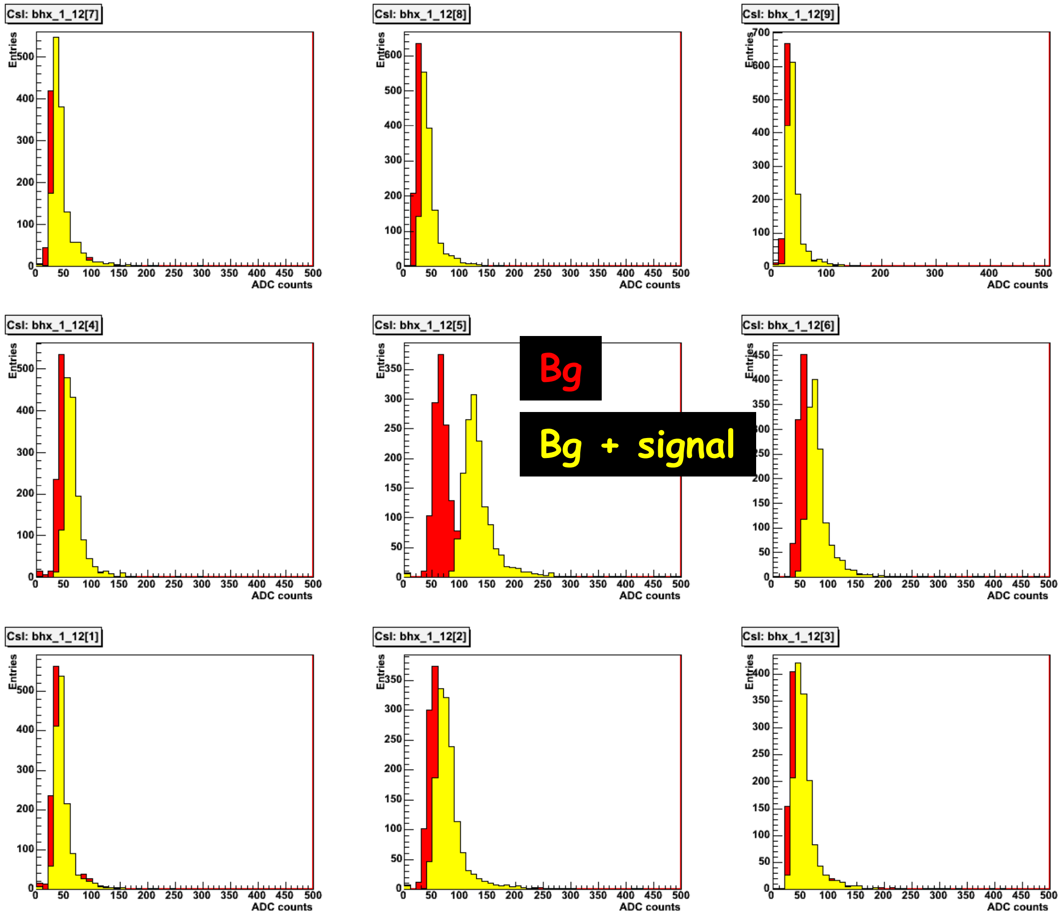






Positron data analysis

- 2 run periods (june and september 2005)
- 6 spectrometer settings (6 e^+ energy points)
- > 8 million triggers
- ~ 3000 cycles



Analysis steps:

- background subtraction
- normalization of the energy deposition
- cyclepairing
- asymmetry determination

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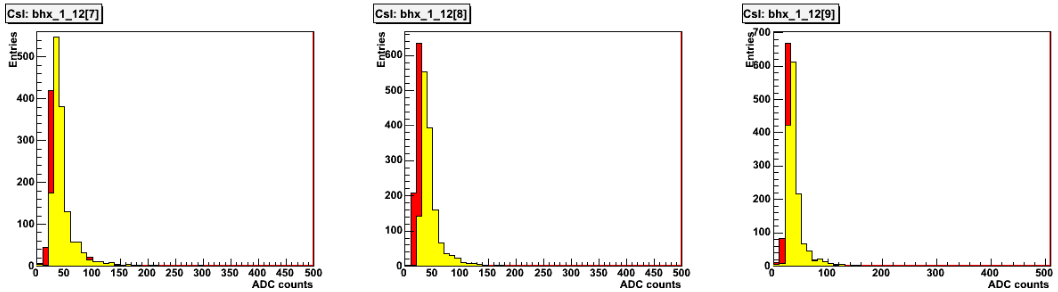

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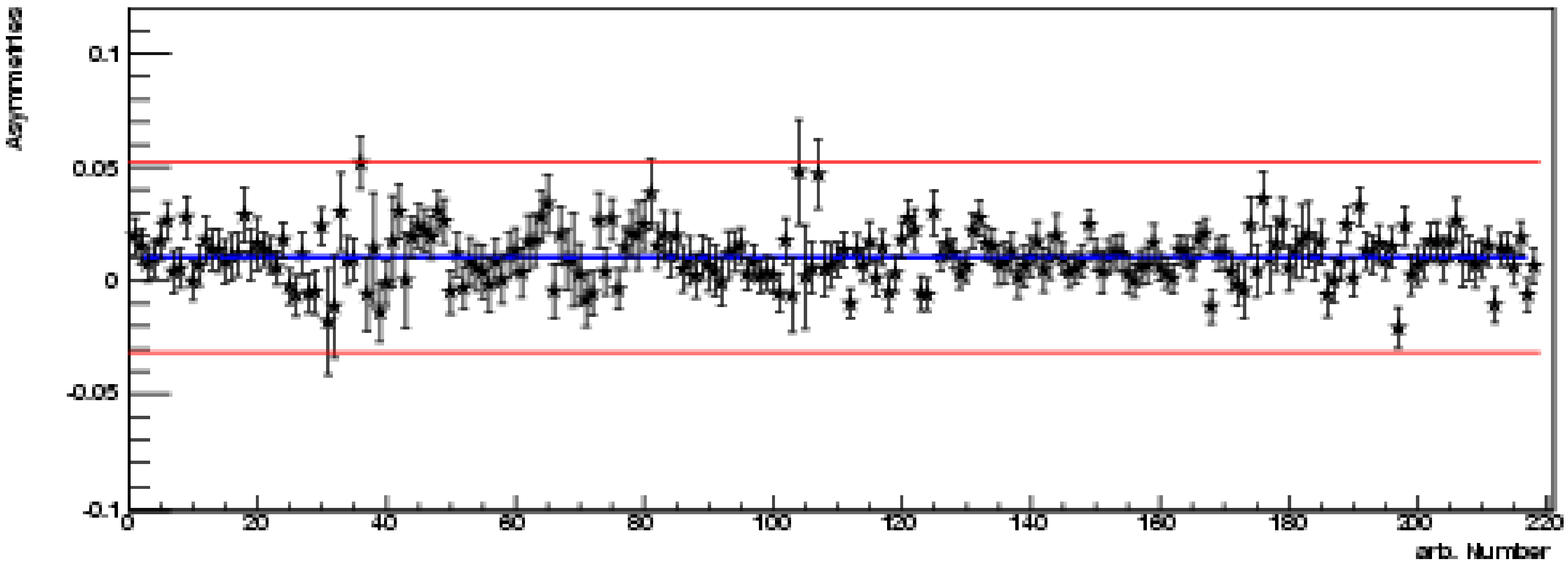
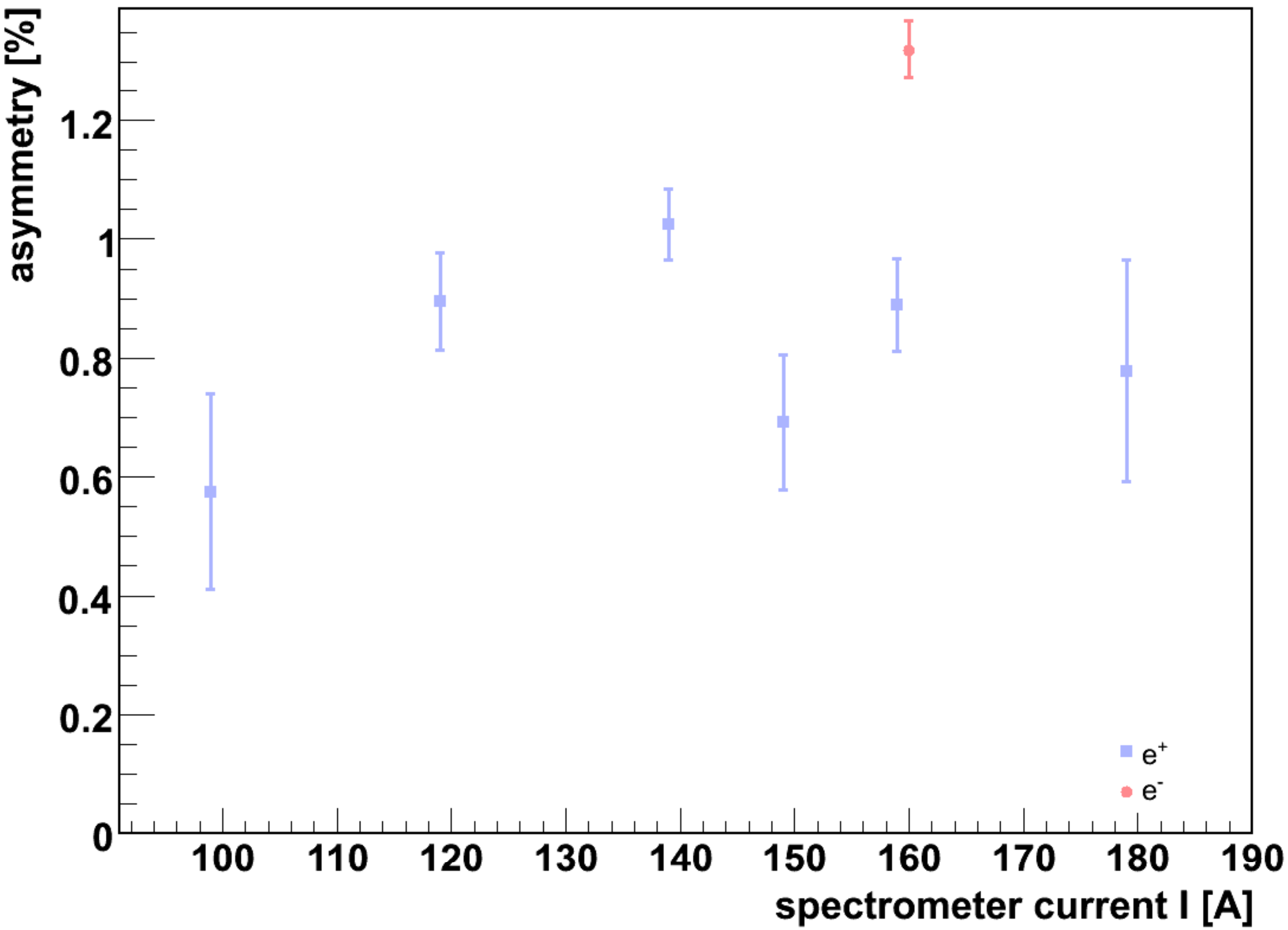


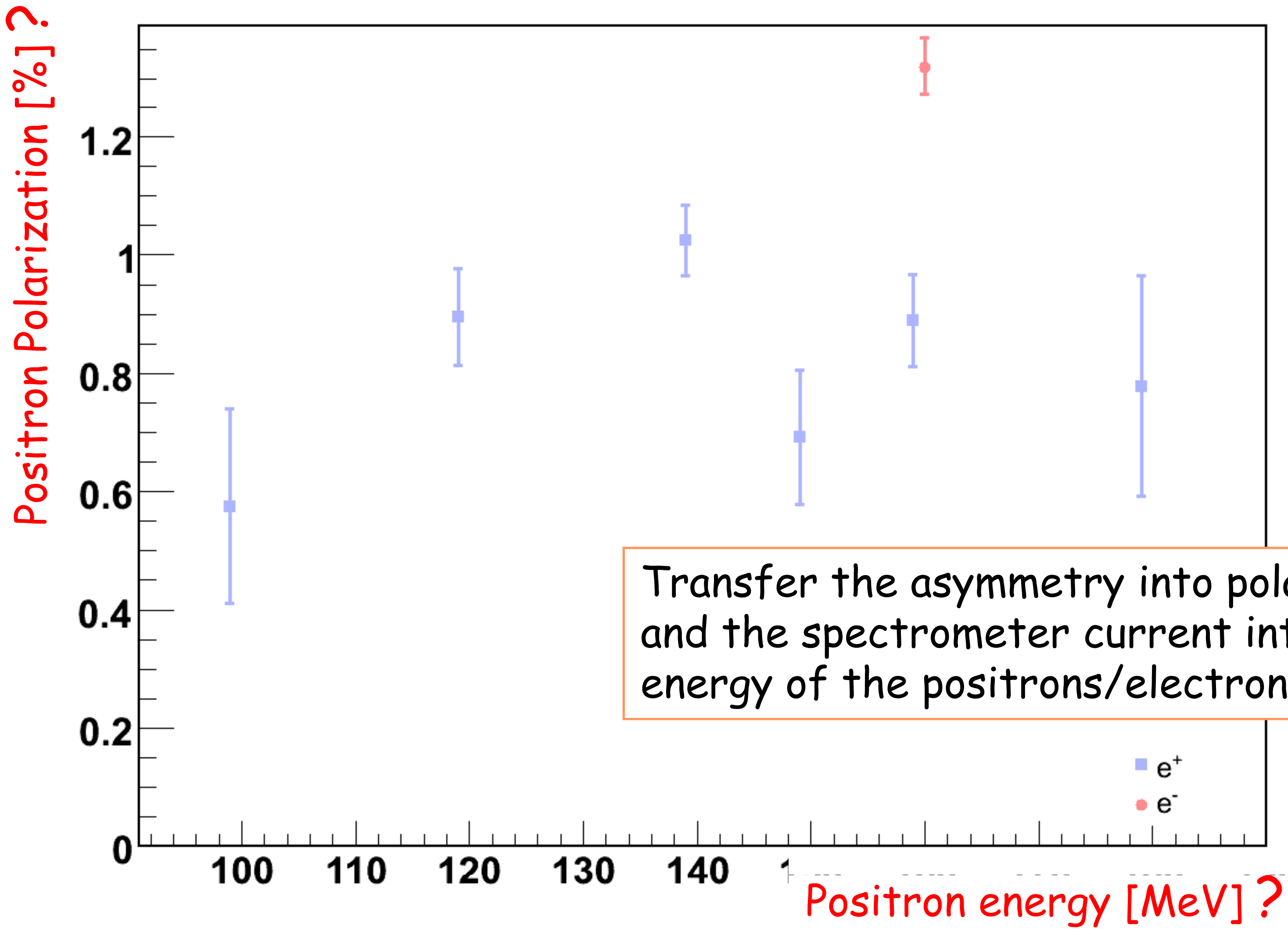
Asymmetries

I_{spec} [A]	$E_{tot}(e^{\pm})$ [MeV]	$A^{fit} \pm \Delta A^{fit}$ [%]	χ^2/n_f
100	4.59	0.575 ± 0.164	166.4 / 203
120	5.36	0.895 ± 0.081	167.9 / 184
140(1)	6.07	1.089 ± 0.096	404.1 / 276
140(2)	6.07	1.024 ± 0.060	274.9 / 217
140(1+2)	6.07	1.037 ± 0.051	628.2 / 490
150	6.41	0.692 ± 0.113	33.9 / 49
160(e+)	6.72	0.889 ± 0.077	257.9 / 166
160(e−)	6.72	1.320 ± 0.046	167.2 / 144
180	7.35	0.778 ± 0.186	59.8 / 63
180(ff)	7.35	0.914 ± 0.129	174.2 / 101
180(both)	7.35	0.883 ± 0.106	225.8 / 164

Asymmetries

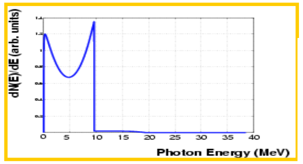


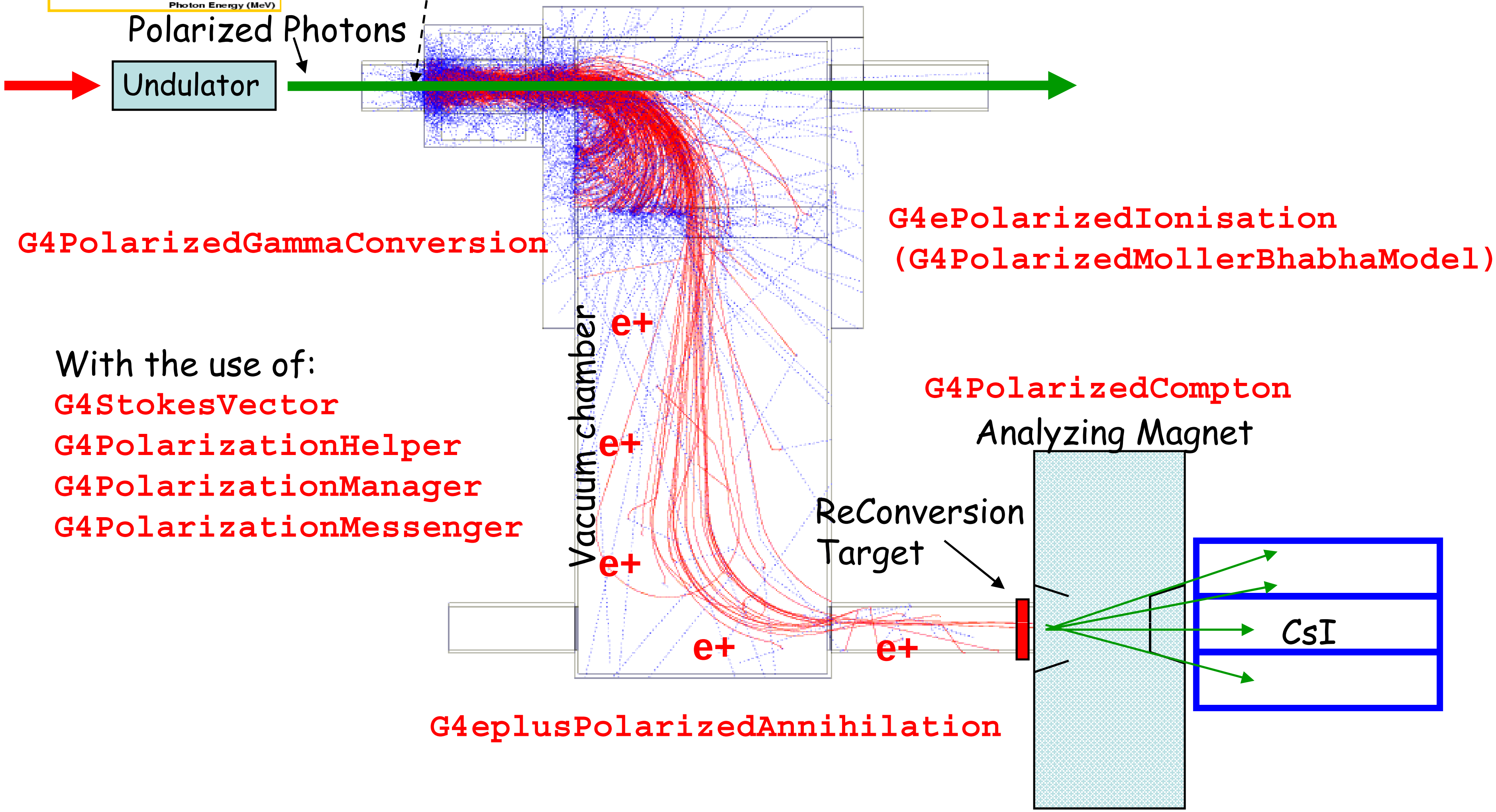
Asymmetries



Transfer the asymmetry into polarization and the spectrometer current into energy of the positrons/electrons

Polarization dependent processes in GEANT4



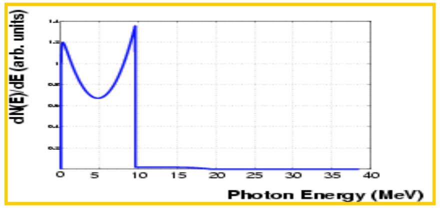


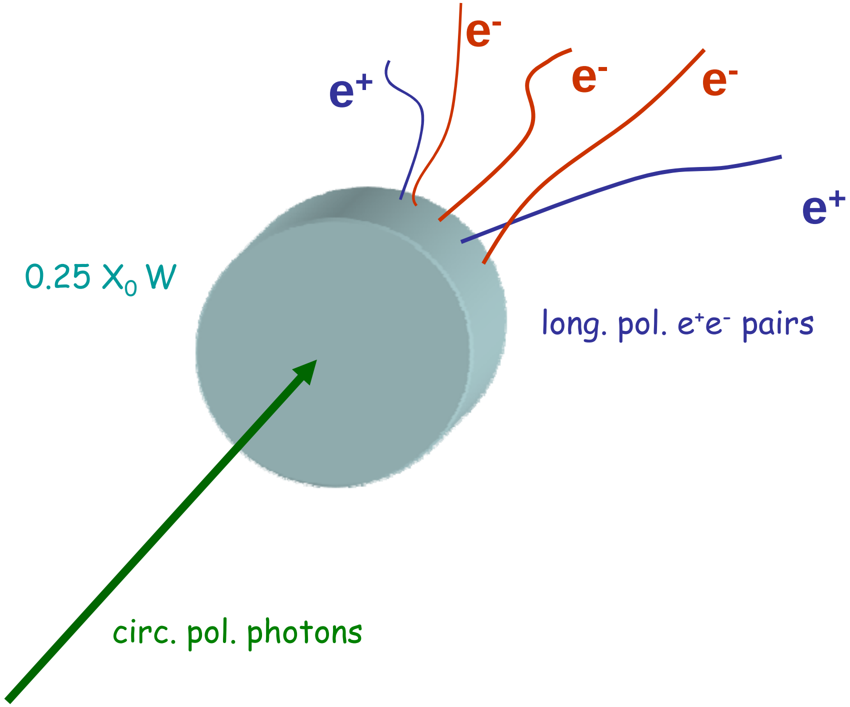
With the use of:

- G4StokesVector
- G4PolarizationHelper
- G4PolarizationManager
- G4PolarizationMessenger

Positron production Target

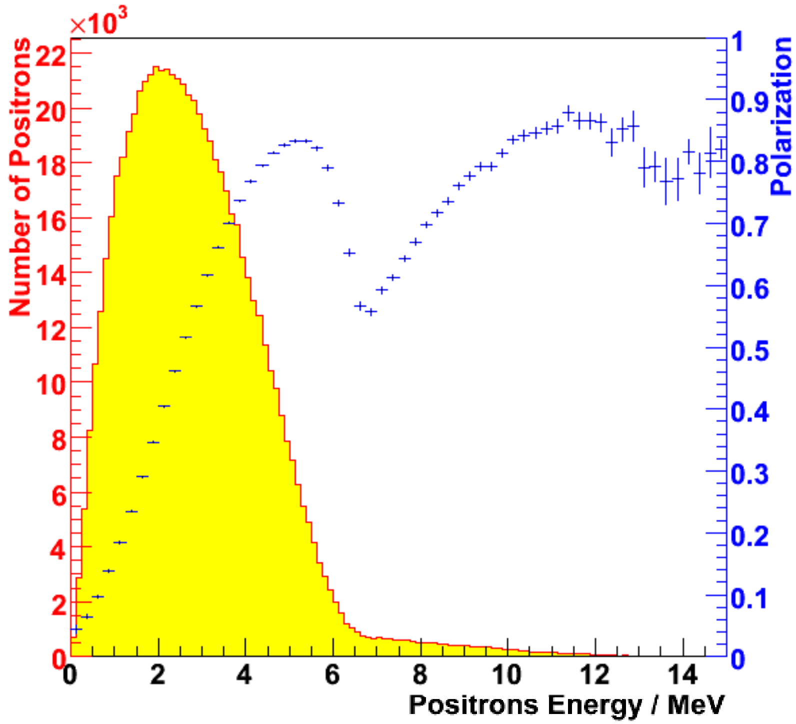
Input: undulator spectrum





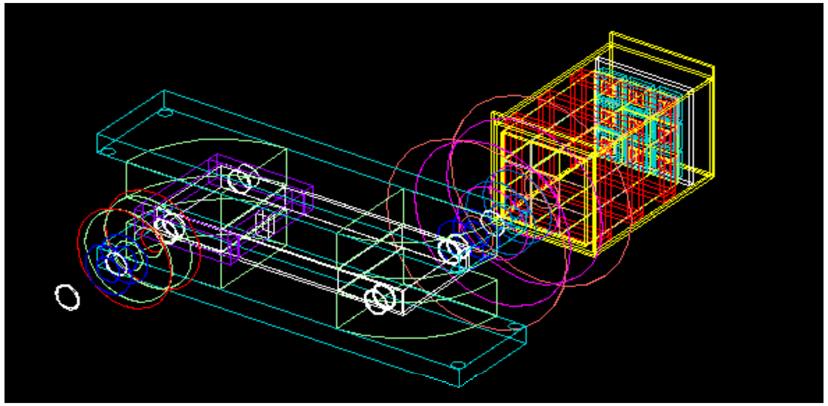
Polarization Transfer:
G4PolarizedGammaConversion

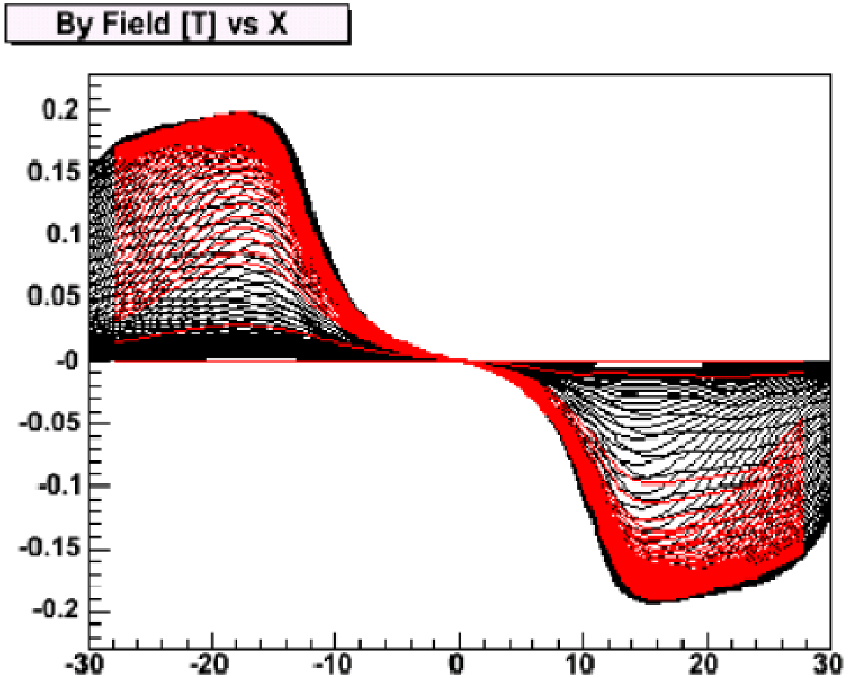
High energetic positrons
carry high degree of polarization

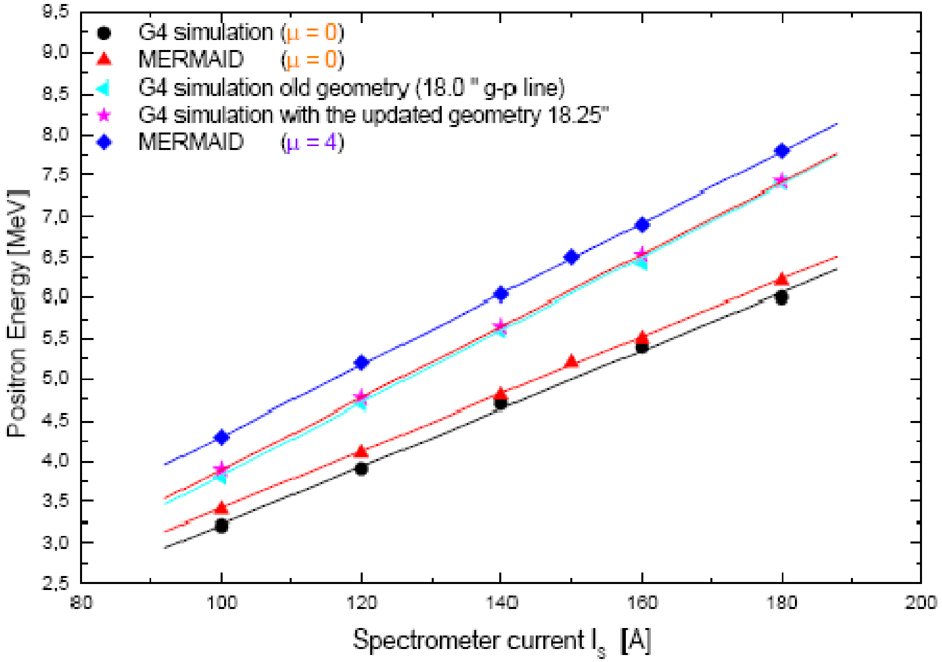


Spectrometer calibration

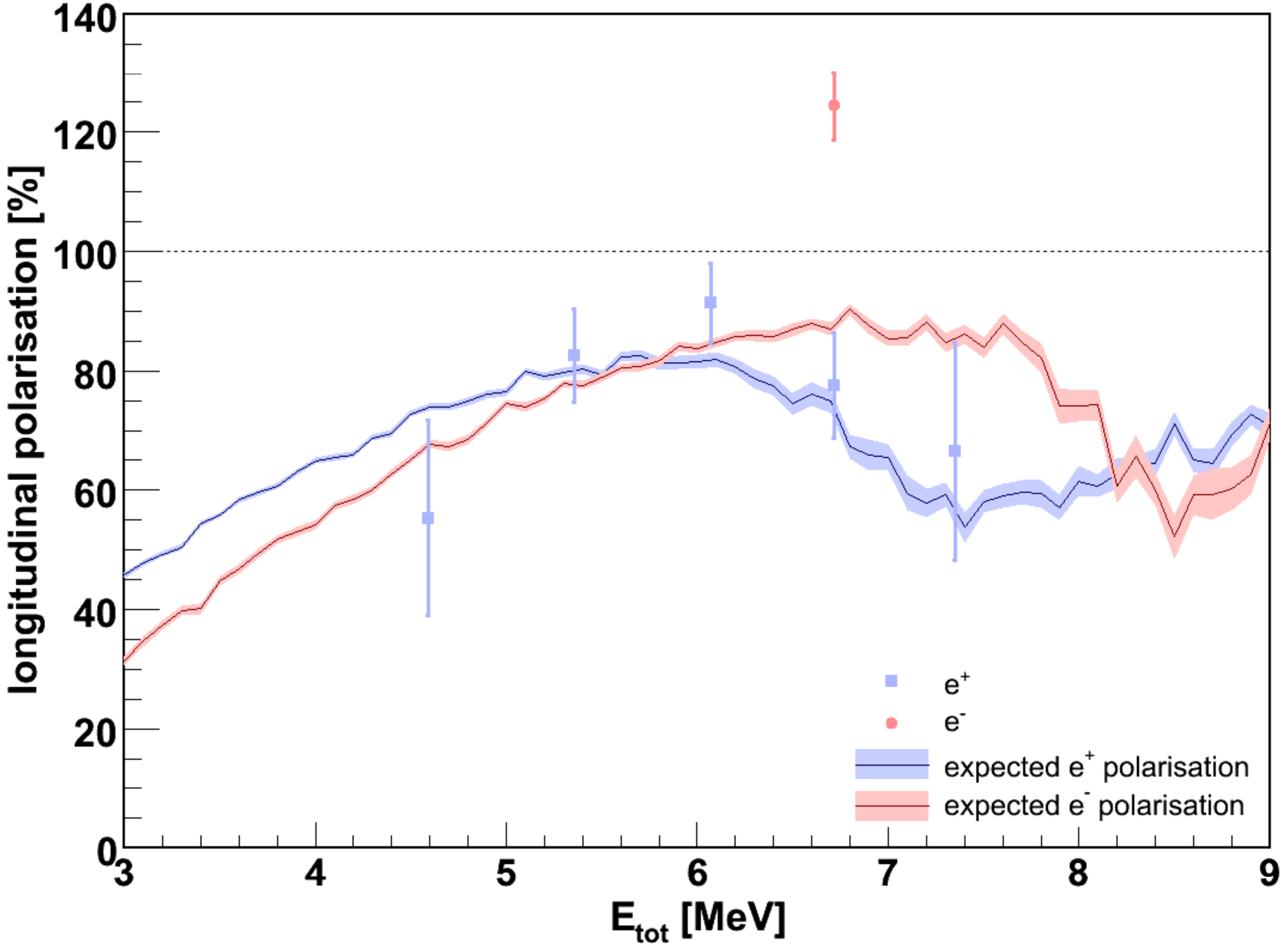
Calculated and measured field map were the input for the G4 Simulation



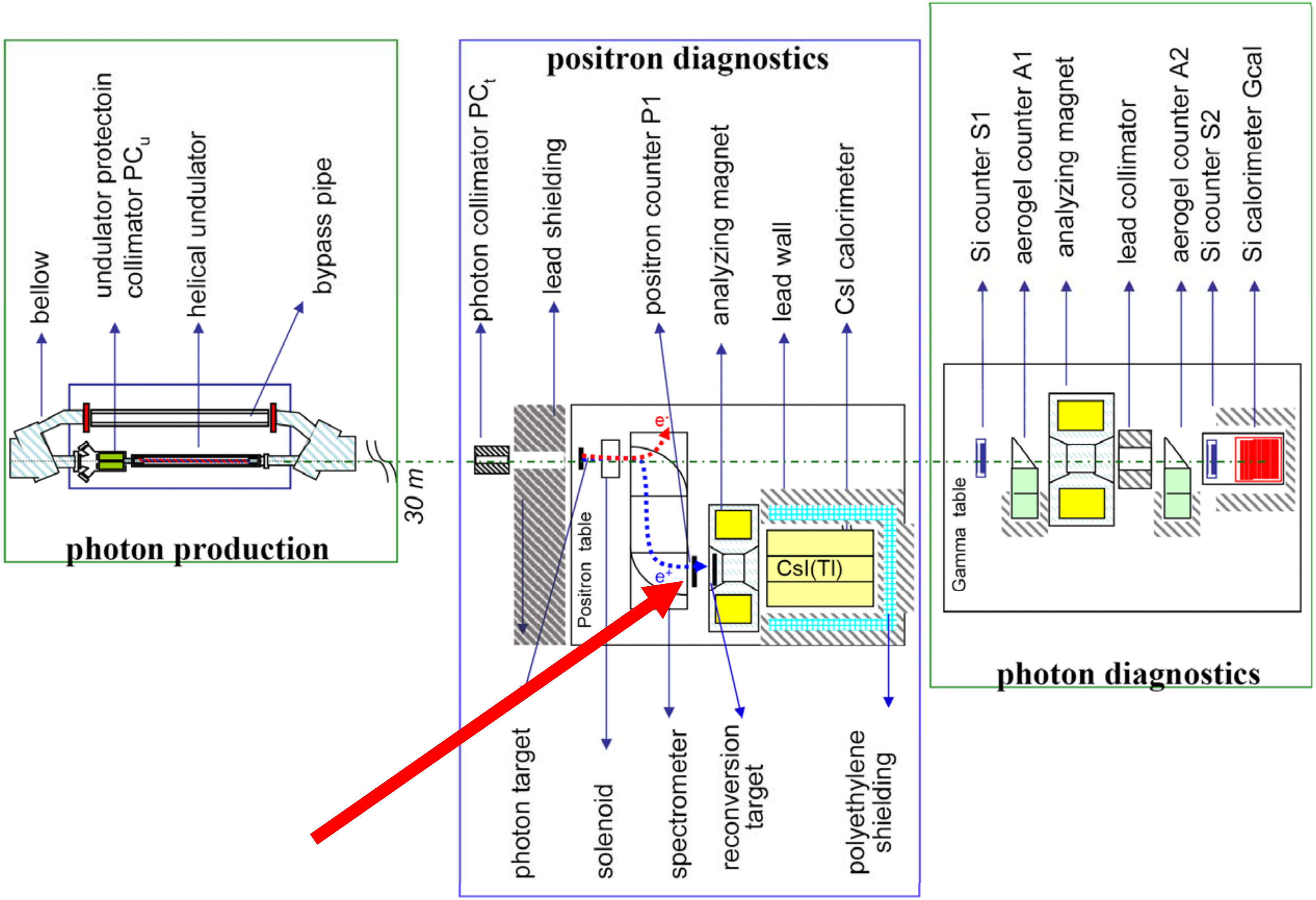




Polarization



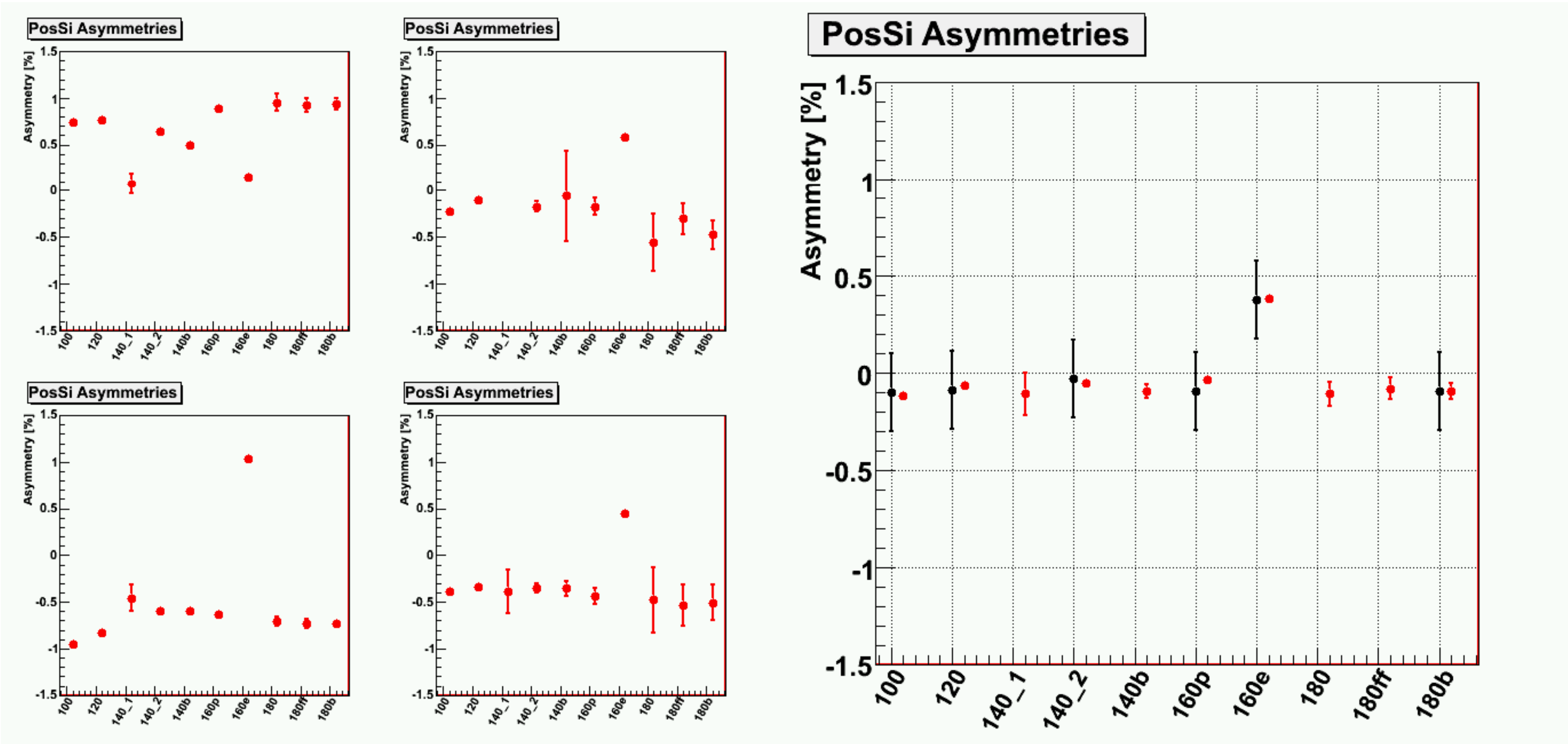
P1 counter (PosSi)



P1 asymmetries

	Zeuthen										Tennessee	
	Possi segments								Sum of all P1 segments			
	TL		TR		BL		BR					
	A	ΔA	A	ΔA	A	ΔA	A	ΔA	A	ΔA	A	ΔA
s100	0.735	0.022	-0.230	0.038	-0.946	0.017	-0.393	0.038	-0.115	0.017	-0.101	0.2
s120	0.768	0.022	-0.103	0.040	-0.826	0.027	-0.342	0.047	-0.066	0.020	-0.088	0.2
s140(1)	0.079	0.111	3.017	2.726	-0.459	0.144	-0.382	0.233	-0.107	0.110		
s140(2)	0.643	0.026	-0.174	0.054	-0.601	0.018	-0.351	0.050	-0.055	0.019	-0.029	0.2
s140(1+2)	0.496	0.041	-0.056	0.488	-0.599	0.038	-0.357	0.080	-0.095	0.034		
s160(e^+)	0.892	0.042	-0.174	0.090	-0.633	0.021	-0.438	0.088	-0.035	0.023	-0.096	0.2
s160el	0.149	0.020	0.579	0.043	1.030	0.049	0.449	0.040	0.382	0.022	0.379	0.2
s180	0.951	0.091	-0.558	0.303	-0.711	0.050	-0.480	0.352	-0.108	0.063		
s180(f)f	0.920	0.075	-0.307	0.163	-0.731	0.053	-0.532	0.223	-0.081	0.055		
s180(both)	0.937	0.058	-0.478	0.151	-0.734	0.039	-0.507	0.191	-0.094	0.042	-0.092	0.2
150									-0.697	0.041		
	Asymmetries and errors in [%]											

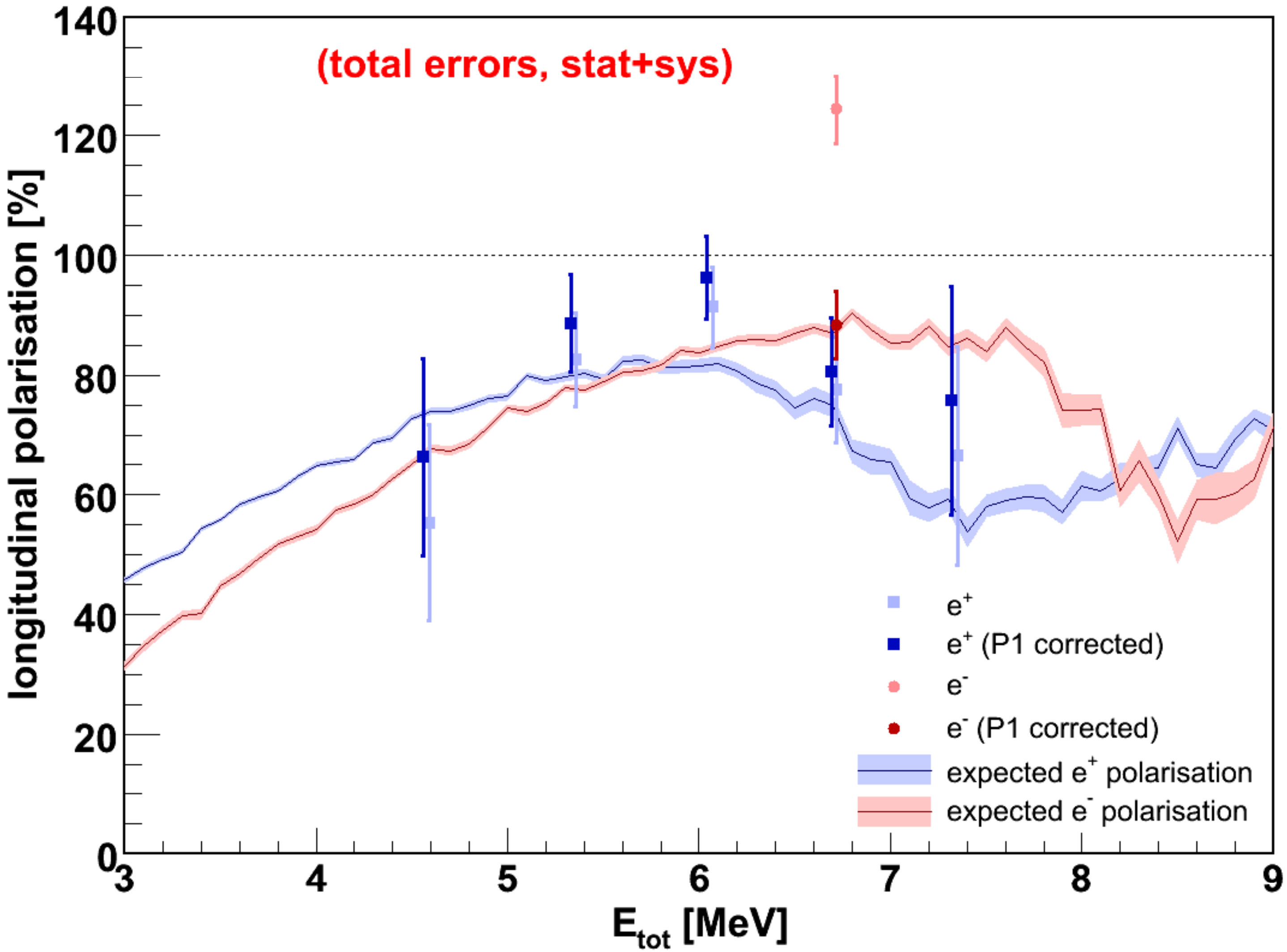
P1 asymmetries



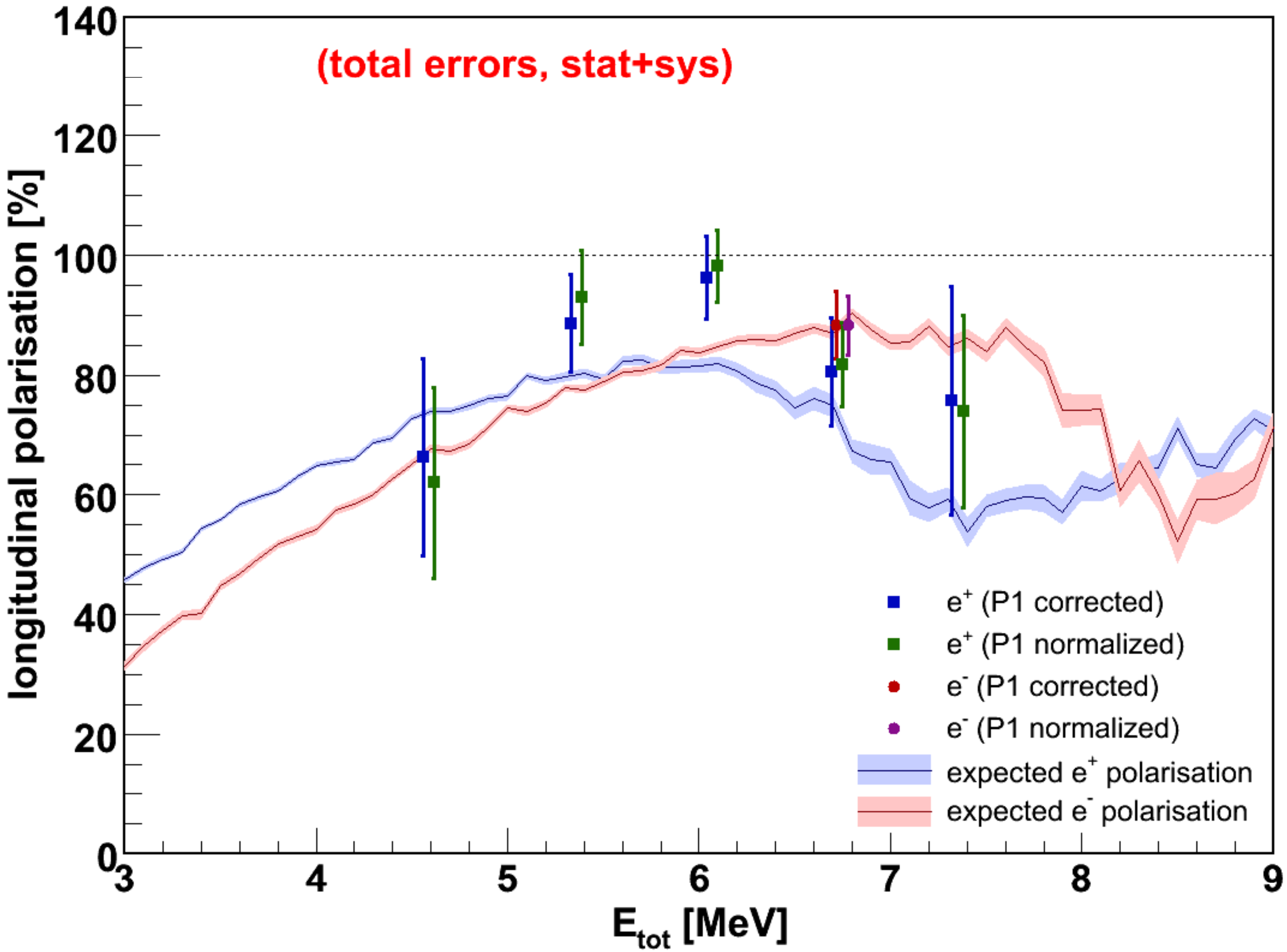
Polarization correction

									P(e-)	0.0694	0.0017	
	all values in [%]											
	Asym	dA	PossiAsym		corr.		anapower				Polarisation	
	asym	stat	PA	delta PA	A	dA			P	stat	Pcorr	stat
s100	0.575	0.164	-0.115	0.017	0.689	0.165	0.14980	0.00160	55.27	15.89	66.32	16.00
s120	0.895	0.081	-0.066	0.020	0.961	0.083	0.15630	0.00150	82.55	7.74	88.63	8.00
s140first	1.089	0.096	-0.107	0.110	1.197	0.145	0.16160	0.00140	97.13	8.89	106.72	13.26
s140second	1.024	0.060	-0.055	0.019	1.079	0.063	0.16160	0.00140	91.35	5.88	96.24	6.16
s140both	1.037	0.051	-0.095	0.034	1.132	0.061	0.16160	0.00140	92.43	5.15	100.90	6.06
s160pos	0.889	0.077	-0.035	0.023	0.923	0.080	0.16510	0.00130	77.56	7.01	80.58	7.30
s160el	1.320	0.046	0.382	0.022	0.938	0.051	0.15280	0.00140	124.43	5.41	88.41	5.39
s180	0.778	0.186	-0.108	0.063	0.886	0.196	0.16860	0.00130	66.47	15.95	75.69	16.85
s180ff	0.914	0.129	-0.081	0.055	0.995	0.140	0.16860	0.00130	78.08	11.21	85.03	12.19
s180both	0.883	0.106	-0.094	0.042	0.977	0.114	0.16860	0.00130	75.47	9.27	83.54	9.97
s150	0.692	0.113	-0.697	0.041	1.389	0.120	0.16335	0.00135	61.01	10.07	122.51	11.01

Corrected Polarization

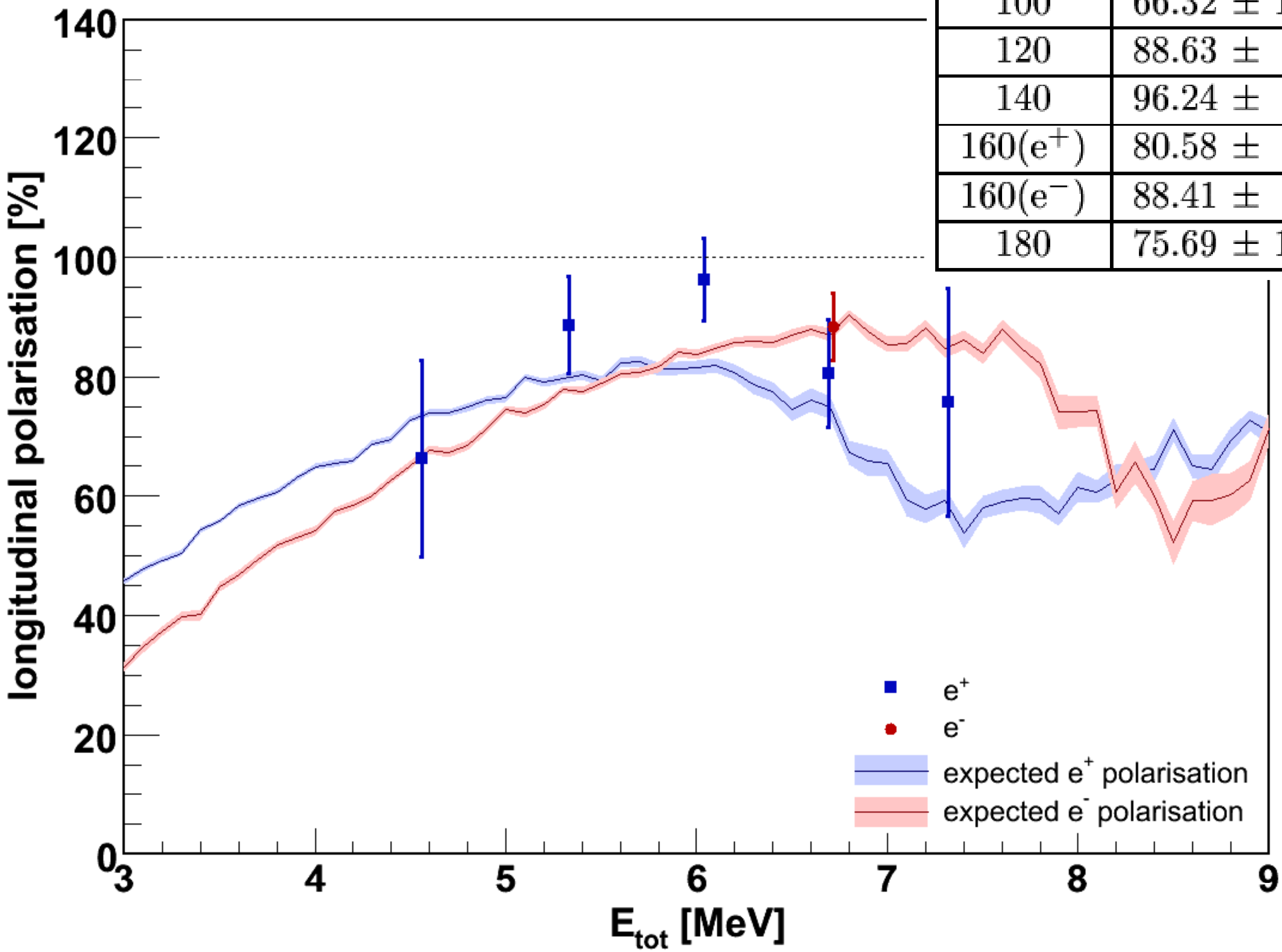


Correction vs. normalization (P1)



Corrected Polarization

I_{spec} [A]	$P \pm \Delta P_{stat} \pm \Delta P_{sys}$
100	66.32 ± 16.00 ± 4.31
120	88.63 ± 8.01 ± 2.60
140	96.24 ± 6.16 ± 4.09
160(e^+)	80.58 ± 7.31 ± 5.73
160(e^-)	88.41 ± 5.33 ± 2.90
180	75.69 ± 16.85 ± 9.08



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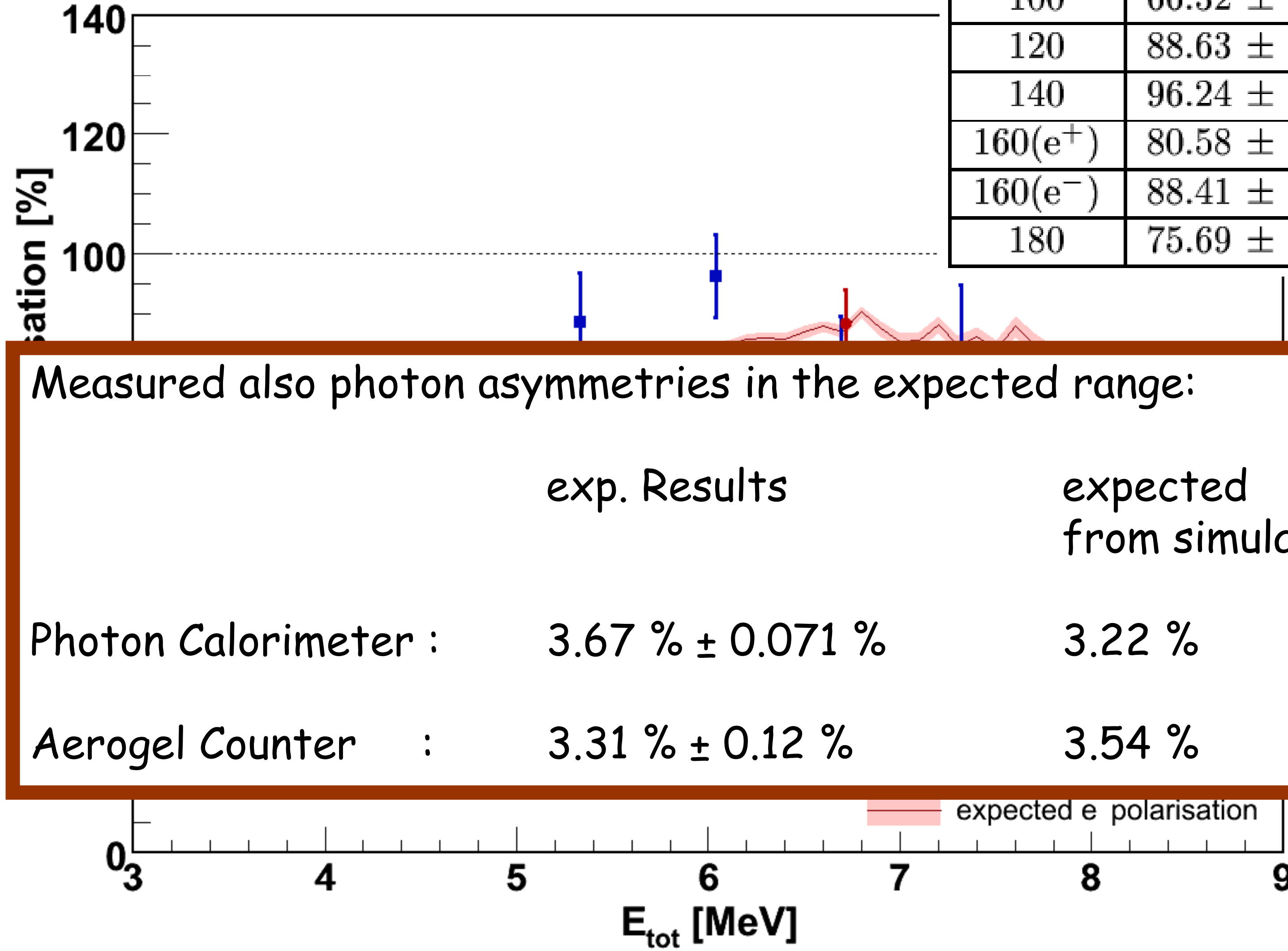
I_{spec} [A]	$P \pm \Delta P_{stat} \pm \Delta P_{sys}$
100	$66.32 \pm 16.00 \pm 4.31$
120	$88.63 \pm 8.01 \pm 2.60$
140	$96.24 \pm 6.16 \pm 4.09$
160(e^+)	$80.58 \pm 7.31 \pm 5.73$
160(e^-)	$88.41 \pm 5.33 \pm 2.90$
180	$75.69 \pm 16.85 \pm 9.08$



Measured also photon asymmetries in the expected range:

	exp. Results	expected from simulation
Photon Calorimeter :	3.67 % ± 0.071 %	3.22 %
Aerogel Counter :	3.31 % ± 0.12 %	3.54 %

Final remarks

- E-166 produced data with good quality and has shown, that the helical undulator works – polarized positrons have been measured

- Asymmetries -> polarization values are as expected

- The E166 simulation made polarized processes in GEANT4 necessary – they have been implemented

- (Interpretation of the data and) publication in progress