The E166-Experiment

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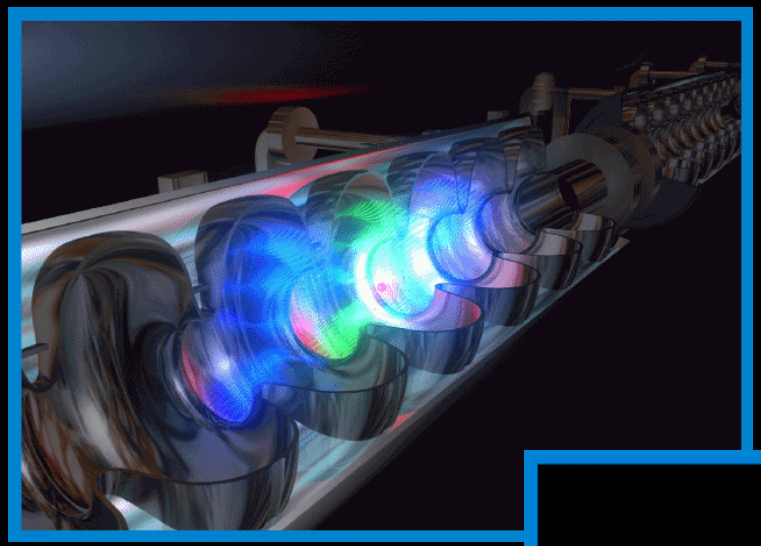
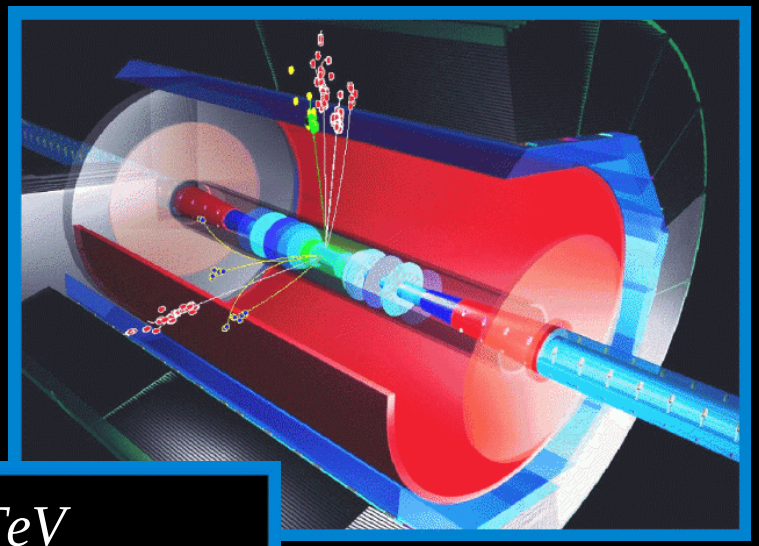
DESY Hamburg
E166 Kollaboration

Experiment to investigate the Production of Polarized Positrons at the ILC

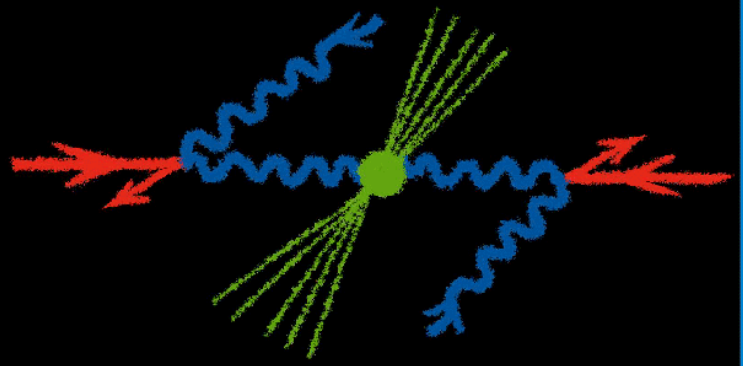
ILC Meeting DESY 7/1/05

E166 is an Experiment in the Frame of ILC Research and Development





$\sqrt{s} = 0.5\text{-}1\ TeV$



$\vec{e}^-$

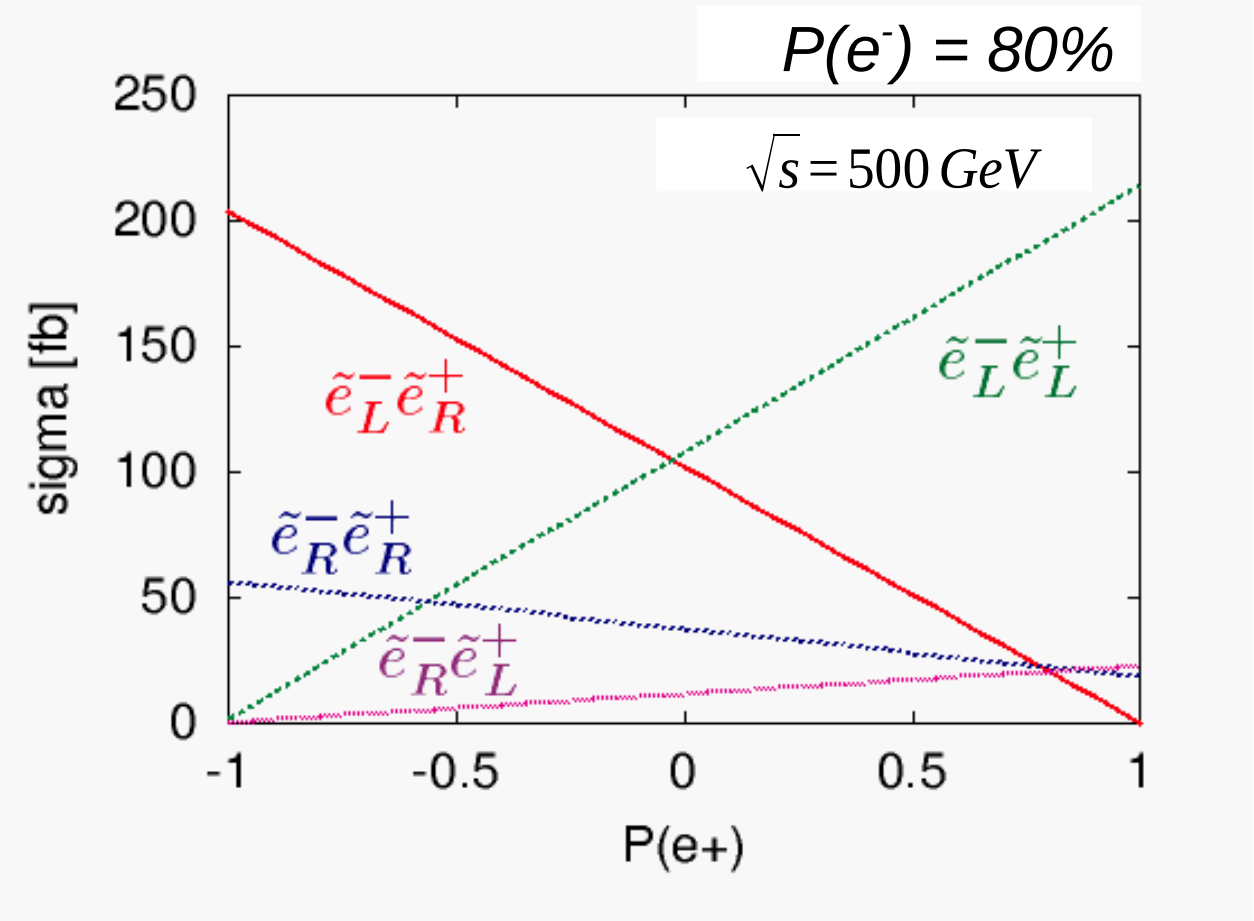
✔

Typical Value
80%

$\overleftarrow{e}^+$

?

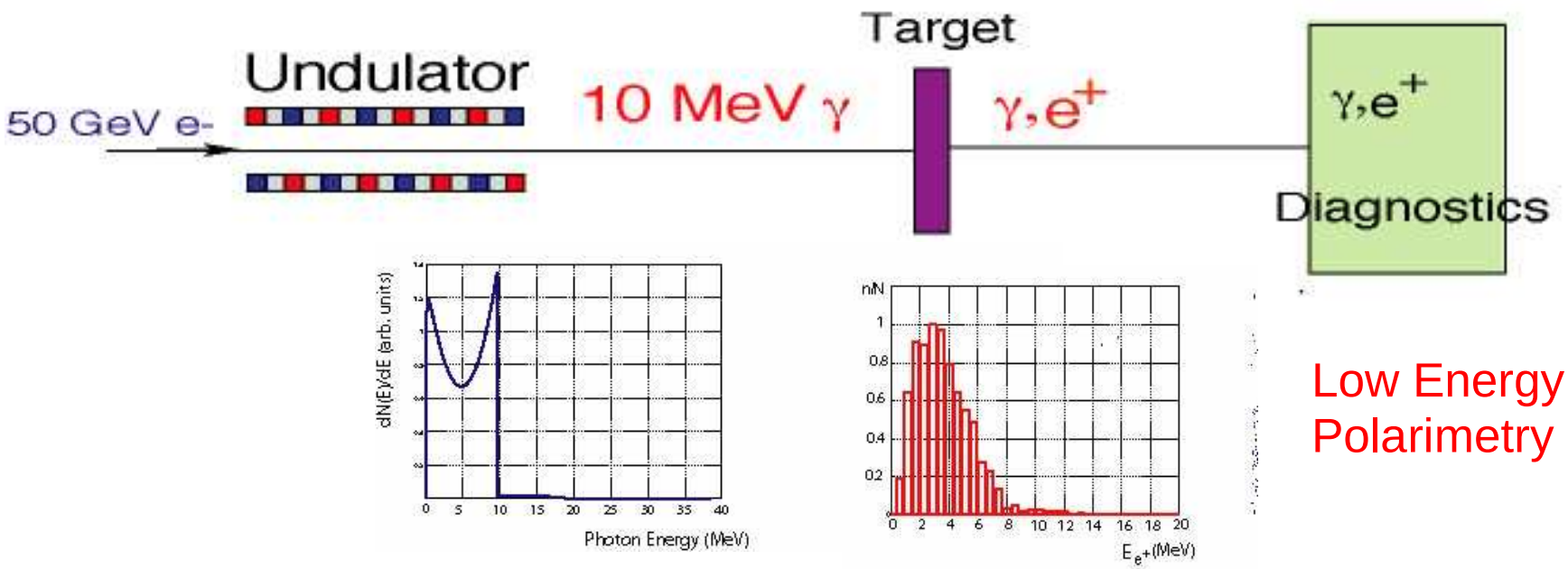
Physical Motivation – An Example



Separation of selektron-Pair in $e^+e^- \rightarrow$ *sfermions*

Study of chiral properties of SUSY-Particles

Principle of the E166-Experiment

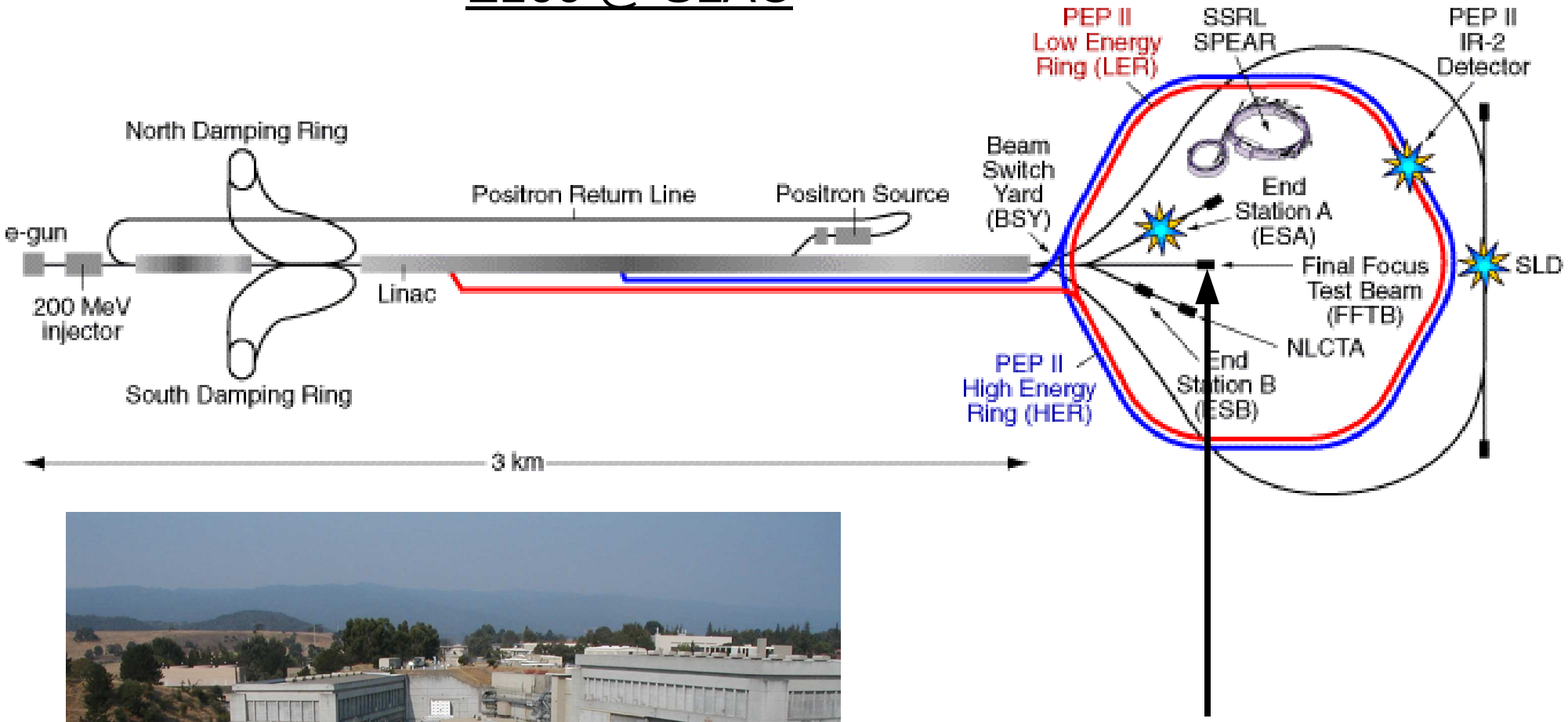


- **E-166 uses the 50 GeV SLAC-Beam in conjunction with a 1m long helical Undulator for the production of Polarized Photons.**

- **These photons are converted by a ~0.5 X_0 thick Absorber into Polarized Positrons (und Electrons).**

- **The Polarization of the Positrons (und Photons) is measured**

E166 @ SLAC



We are here !

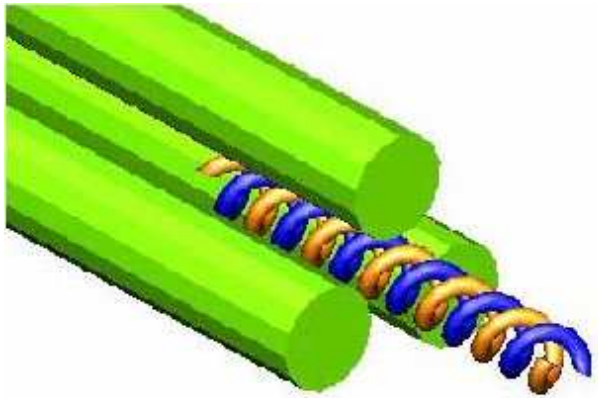
FFTB @ SLAC is unique facility to study pol. Positron production

E166 – Participating Institutes

Electron-Beamline (Linac)	SLAC
Undulator	Cornell
Positron-Beamline(Spectrometer)	Princeton/SLAC
Photon-BeamLine	SLAC
Polarimetry:	
Overall:	DESY
Magnetized Fe-Absorber	DESY
Cerenkov-Detectors	Princeton
Si-W-Calorimeter	Tenn./ S. Carolina
CsI-Calorimeter	DESY/Humboldt
DAQ	SLAC/Humboldt

Transatlantic Collaboration of ~50 People

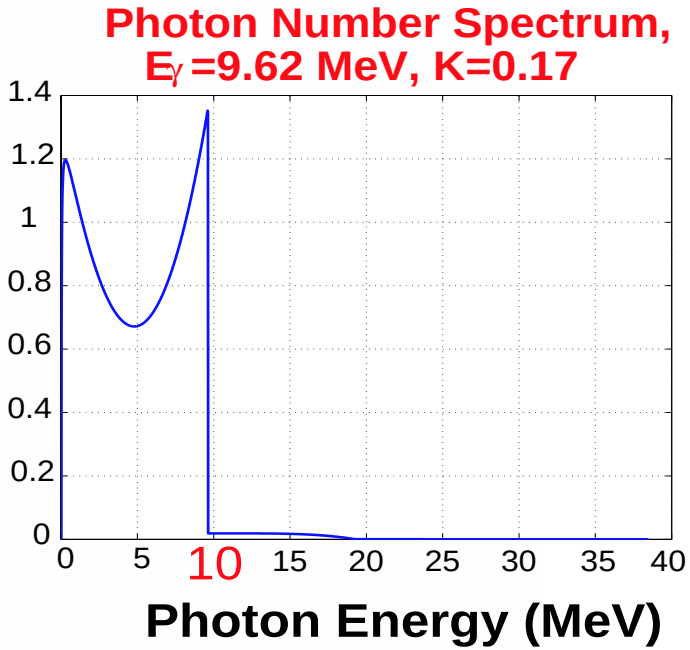
The helical Undulator Cornell University

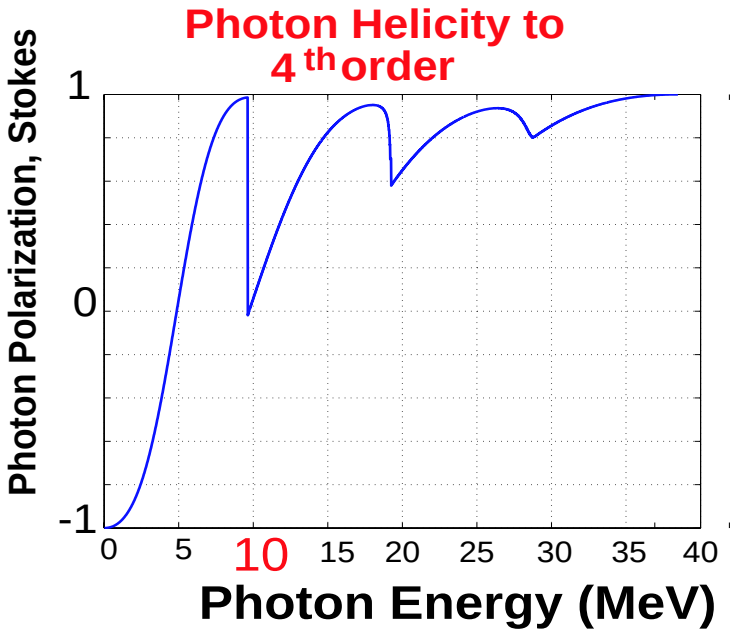


A.A. Michailichenko BINP 79-85 (1979))

Parameters

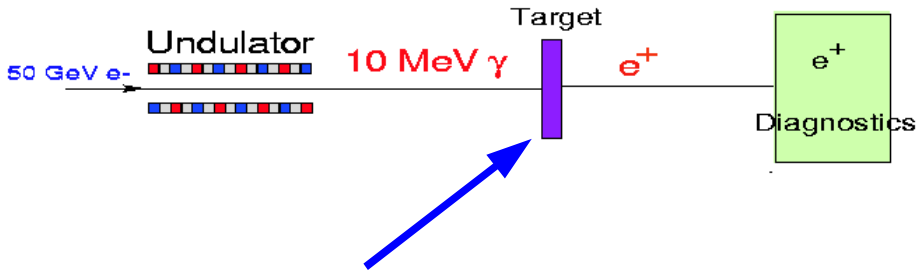
	E166	LC
e^--Injectionenergy [GeV]	50	~200
Undulatorperiod [mm]	2,4	~10
Undulatorparameter K	0.17	1
Inner Diameter [mm]	0.9	$< \lambda$
Undulatorlength [m]	1	~130





Creation of circular polarized Photons in Undulatorfield

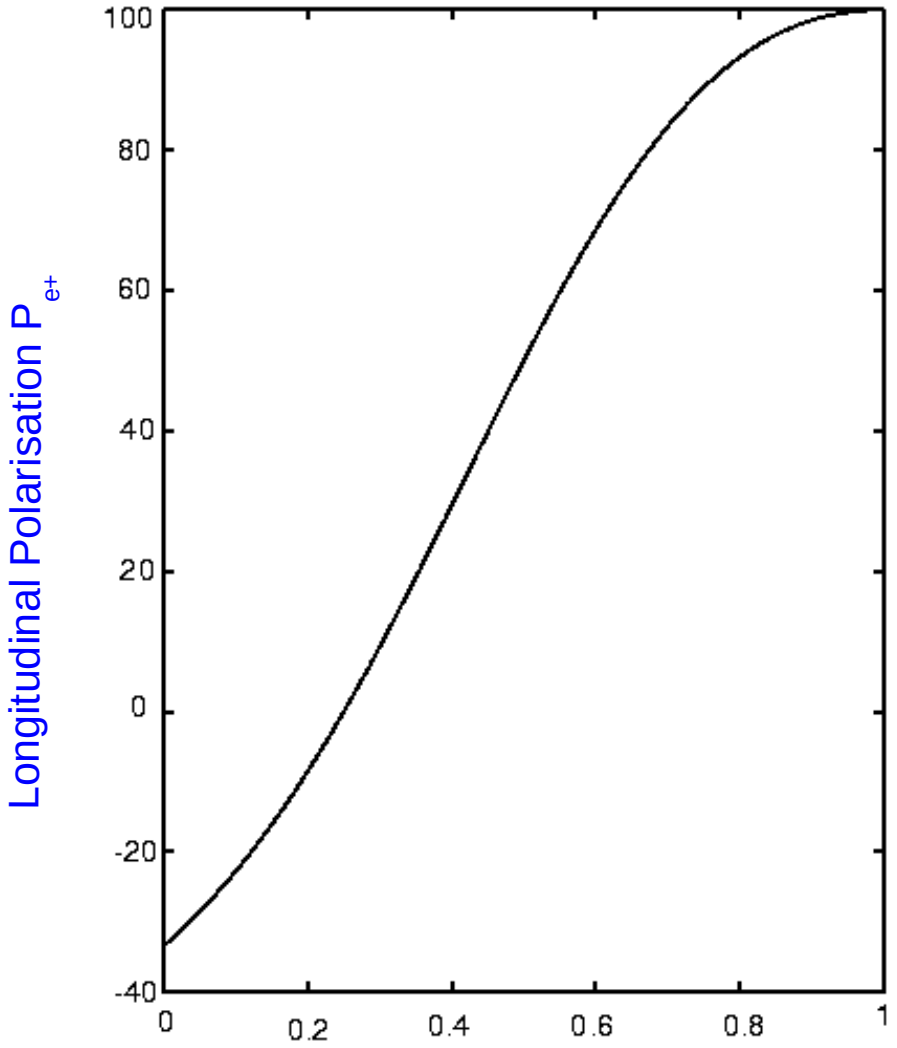
Polarizationstransfer: $\vec{\gamma} \rightarrow \vec{e^+}$



Circular Polarization of Photons is transferred into longitudinal Polarization of Positrons

Polarization of Positrons varies with their fractional Energy

E166 is first experimental study of Polarization Transfer in electromagnetic Cascades



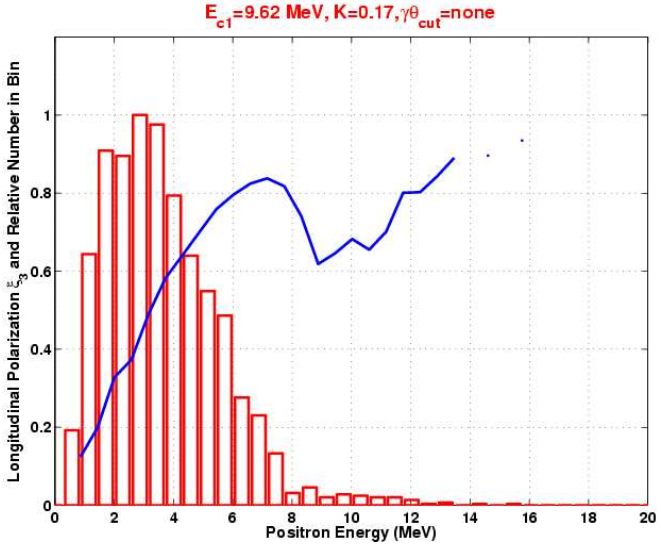
Olsen & Maximan 1959
Fronsdahl & Überall 1958

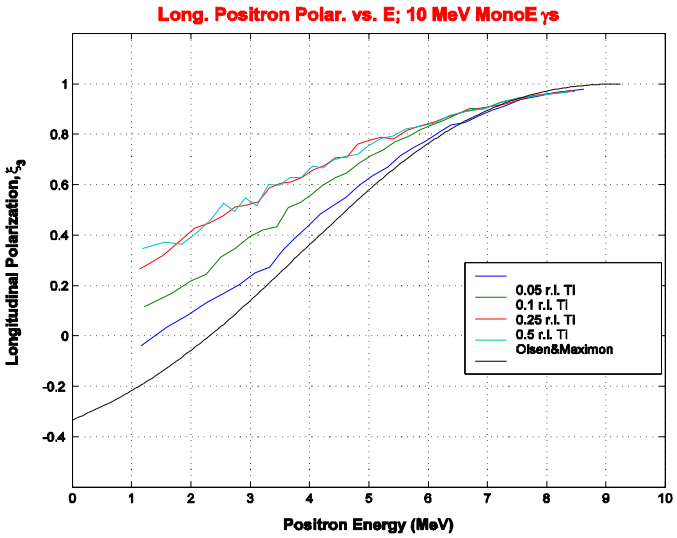
Polarized Positron Production in the FFTB

Polarized photons pair produce polarized positrons in a 0.5 r.l. thick target of Ti-alloy with a yield of about 0.5%.

Longitudinal polarization of the positrons is 54%, averaged over the full spectrum

Note: for 0.5 r.l. W converter, the yield is about 1% and the average polarization is 51%.

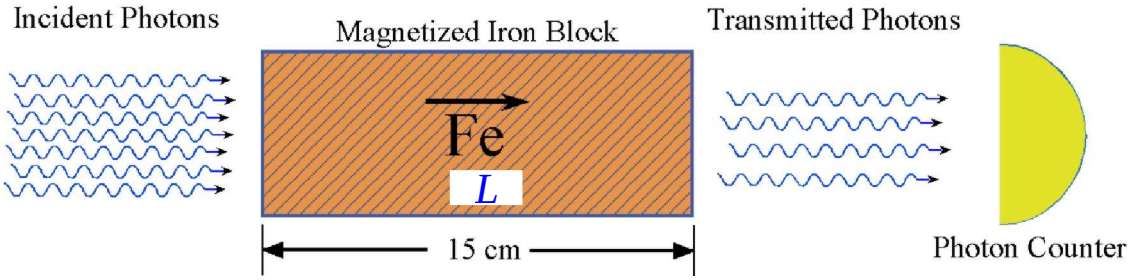


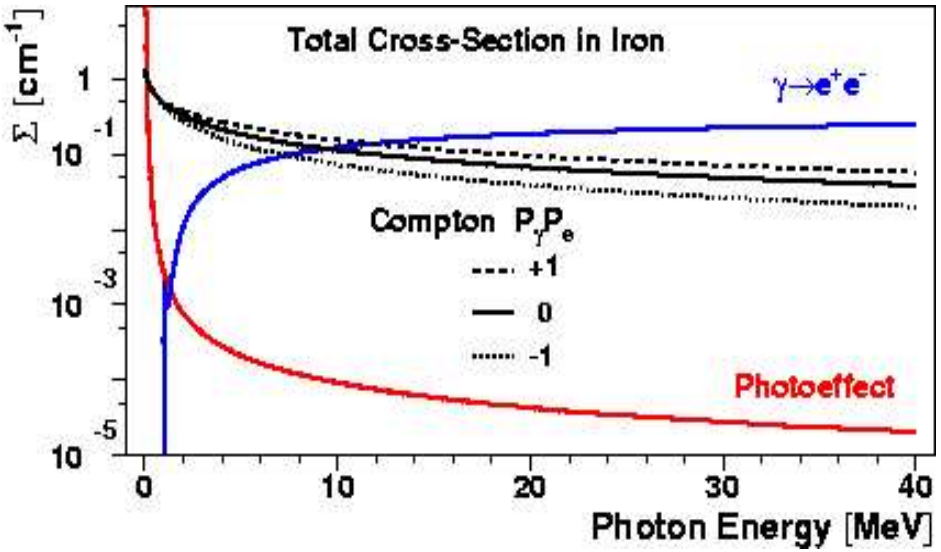


Transmission Polarimetry

Analyzer Iron

M. Goldhaber et al. Phys. Rev. 106 (1957) 826





$\sigma = \sigma_{phot.} + \sigma_{comp.} + \sigma_{pair}$

$\sigma_{comp.} = \sigma_0 + P_e P_p \sigma_p$

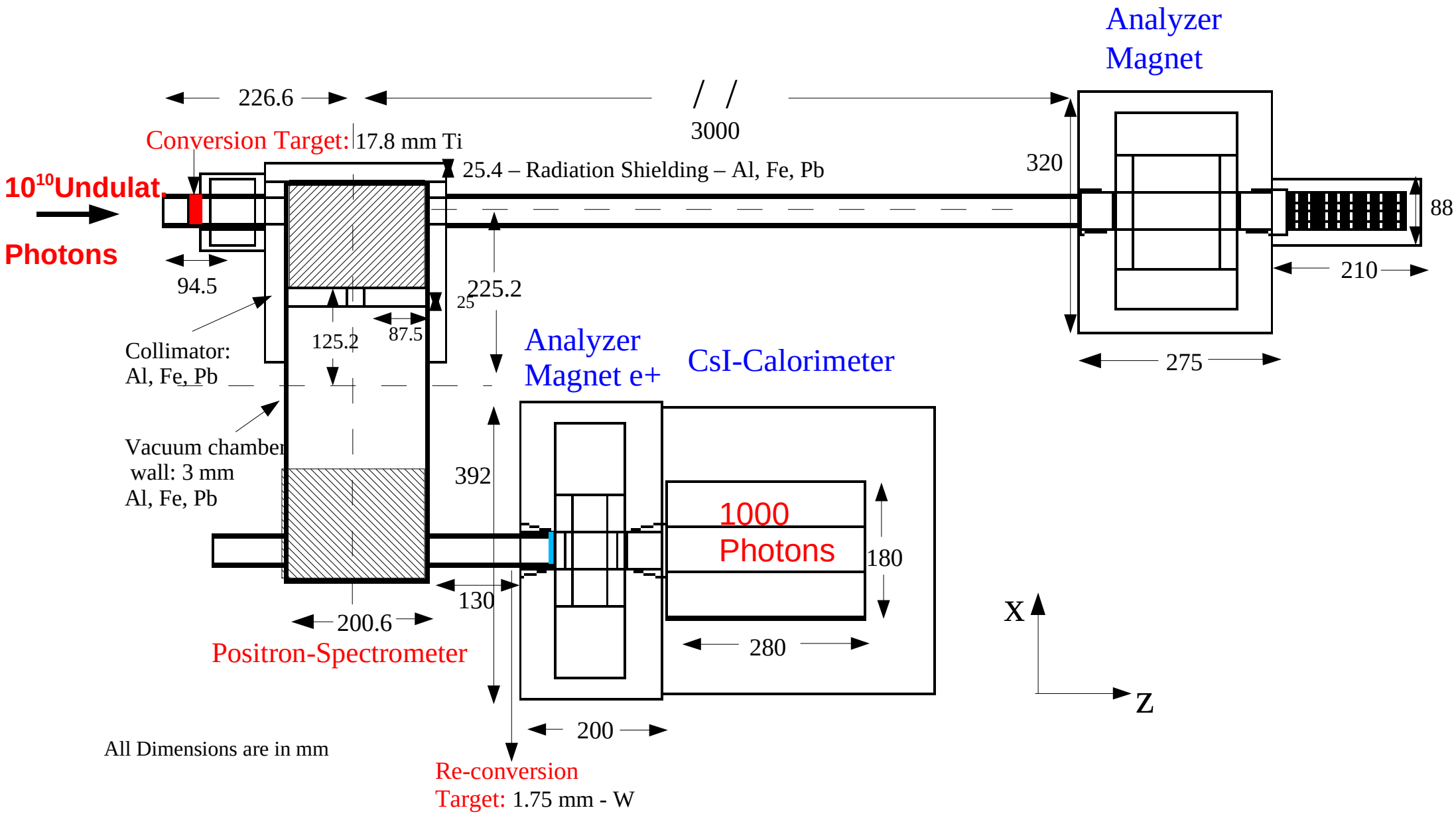
$$T^{\pm}(L) = e^{-nL\sigma} = e^{-nL(\sigma_0+\sigma_{phot}+\sigma_{pair})}\, e^{\pm nLP_eP_\gamma\sigma_P}$$

$$\delta(L) = \frac{T^+(L) - T^-(L)}{T^+(L) + T^-(L)} = \tanh(nLP_eP_\gamma\sigma_P) \approx nLP_eP_\gamma\sigma_P$$

Unpolarized Contributions cancel in Transmission-Asymmetry δ

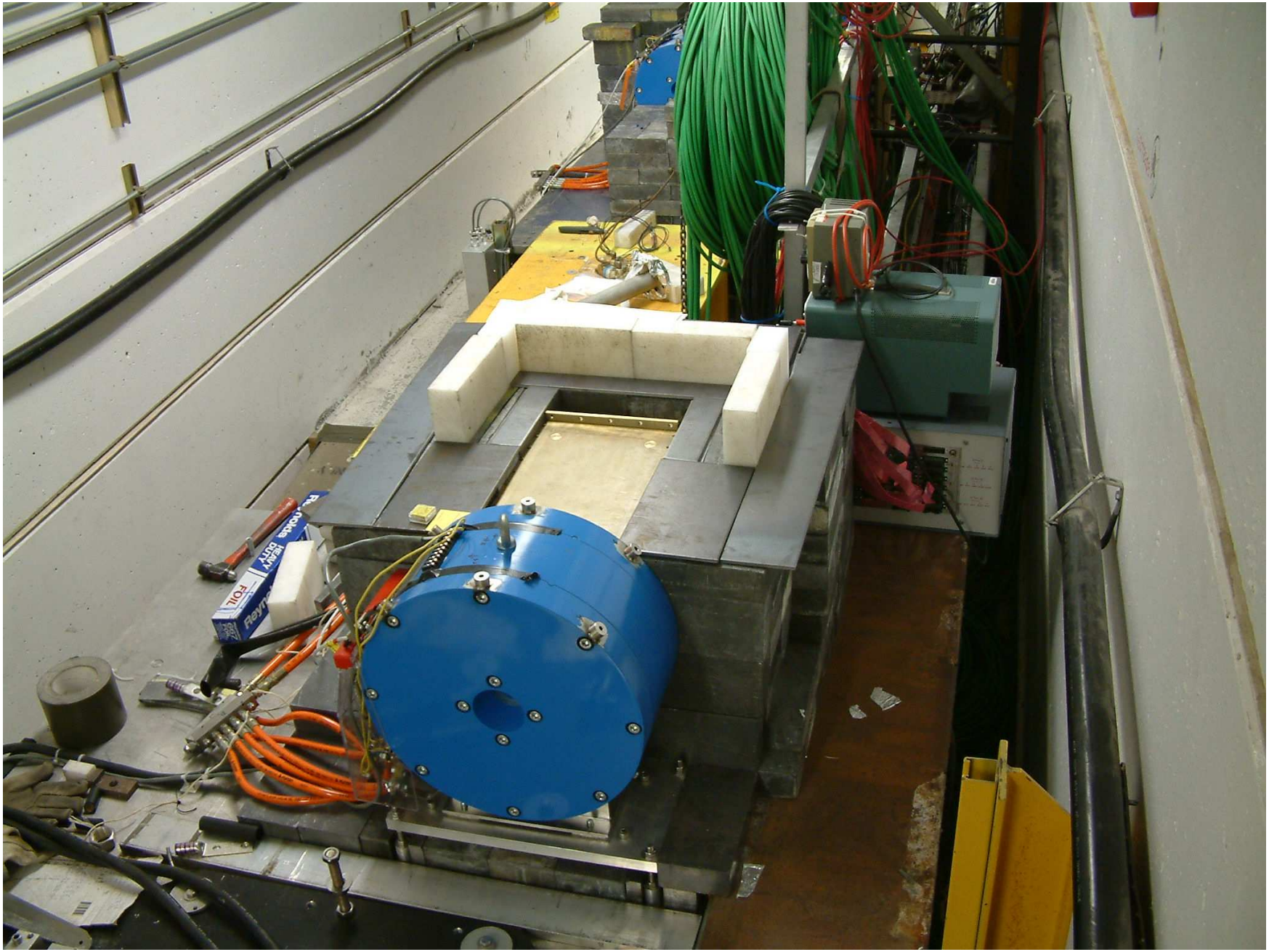
Measure: $P_{e+} = \dfrac{\delta}{P_{e-}A_{e+}}$ A_{e+} = Analyzing-Power

Schematic Overview of Polarimeter



E166 on the paper ...

... and in Reality



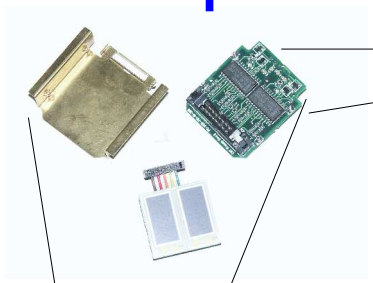
Picture by Erez Reinherz

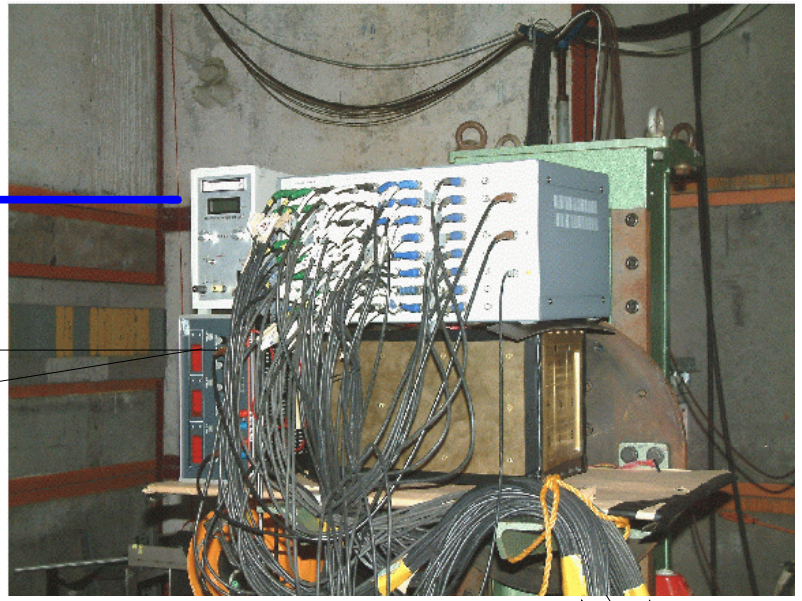
CsI Calorimeter

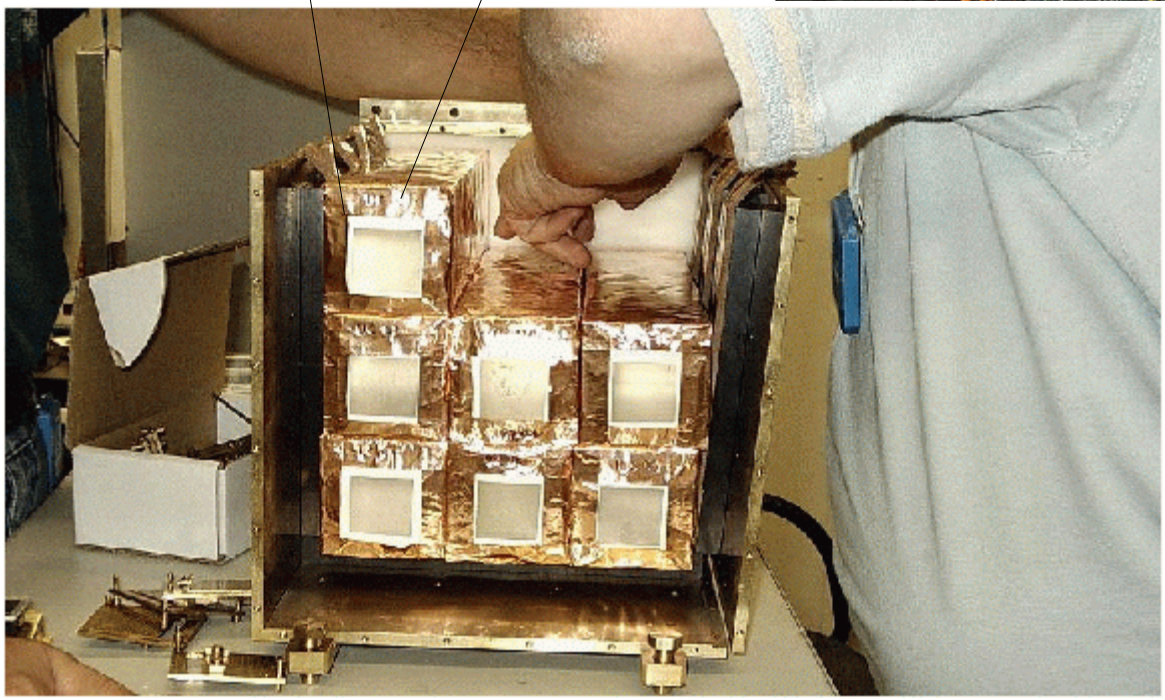
CsI Calorimeter built (mainly) by DESY Zeuthen and Humboldt University

Signal Flow

x32 gain
x1 gain





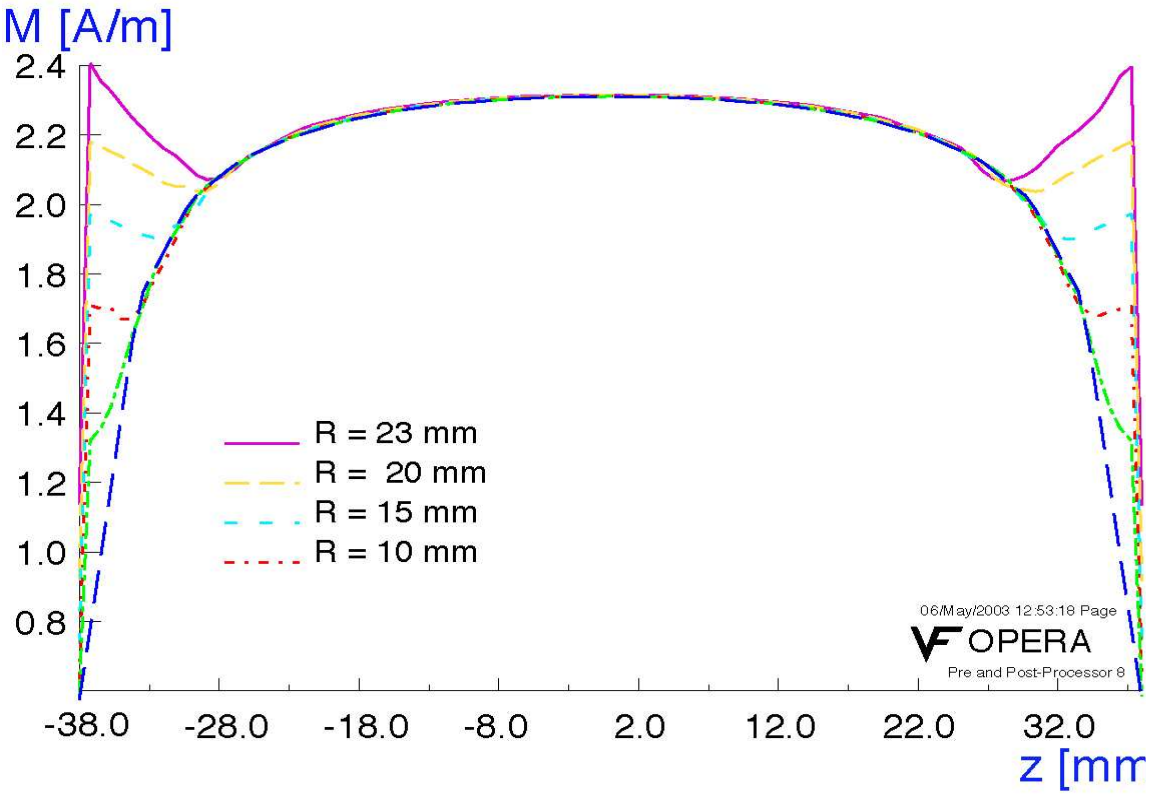


100 m

Differential Amplifier

CAEN V265 ADC
12/15 bit res.

Analyzer-Iron



Asymmetry: $\delta \sim P_{e^-}$ (see above)

Need to measure e^- Polarisation in Iron to determine γ - Polarisation

$$P_{e^-} = 2 \frac{g'-1}{g'} \cdot \frac{M}{n\mu_B}$$

$$Max.\ P_{e^-} = 2/26 \approx 0.07$$

$$\Delta P_{e^-}/P_{e^-} \approx 0.05$$

Error on e^- Polarization is dominated by knowledge of effective Magnetisaton M along the Photon Trajectory *z*

Active Volume

Positron-Analyzer-Iron: 50 mm dia. x 75 mm long

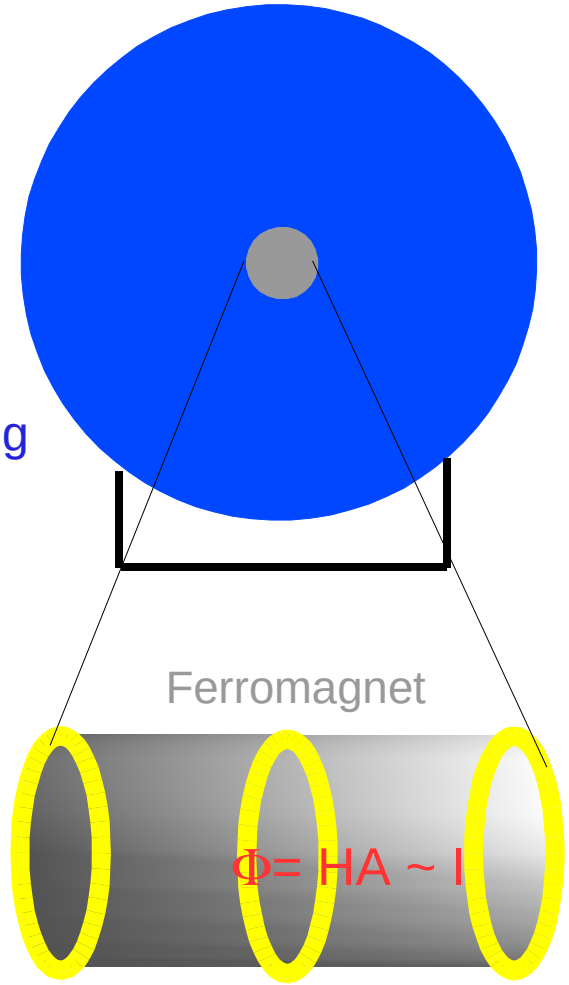
!

Analyzer Magnets and Measurement of M

Designed by P. Schüler, built by Efremenkov Institute St. Petersburg

Analyzer Magnet: -> Solenoidal Field

Iron
Yoke
+
Coil
Housing



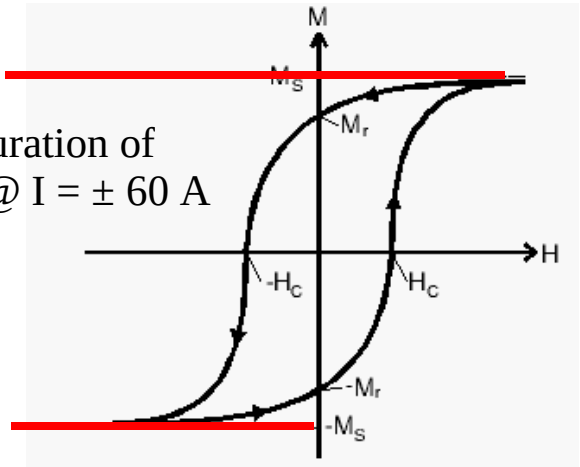
Three coils around
Analyzer Iron with
n windings => U_{ind}

Faraday's Law

$$U_{ind.} = \frac{d\Phi}{dt} = n\left(\frac{dM}{dt} + \frac{dB_o}{dt}\right)$$

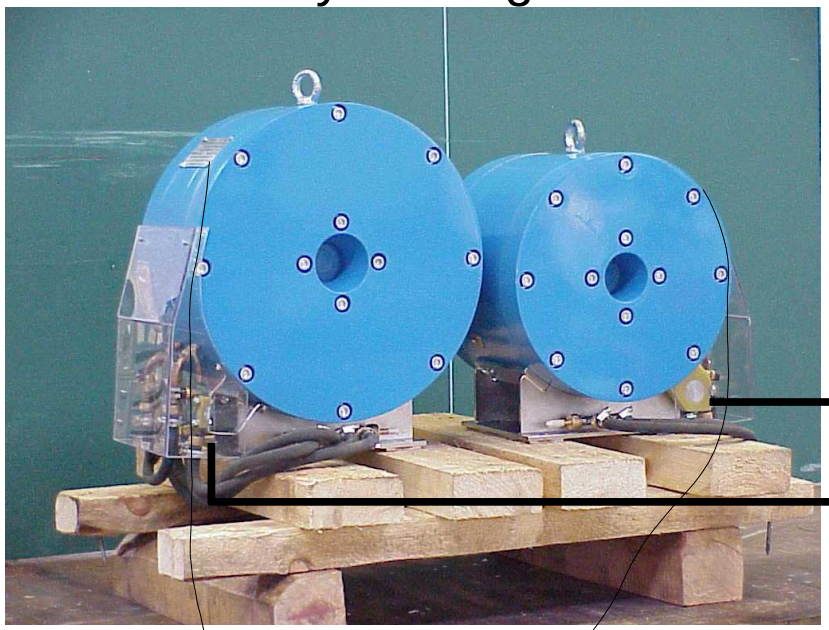
ϕ = Magnetic Flux
B_o = Magnetic Flux density in Vacuum
~ I_{magnet}

Saturation of
M @ I = ± 60 A



Magnet Operation and Readout

Analyzer Magnet



Magnet Ramp

$T_{ramp} \approx 1s$

Field reversion every 5 Minutes

SLAC Main Accel. Control
SCP
OpenVMS

E166 DAQ Menu

Wavefunction Generator

U_{ind}

ADC
ESD 8012

r/o of U_{ind}

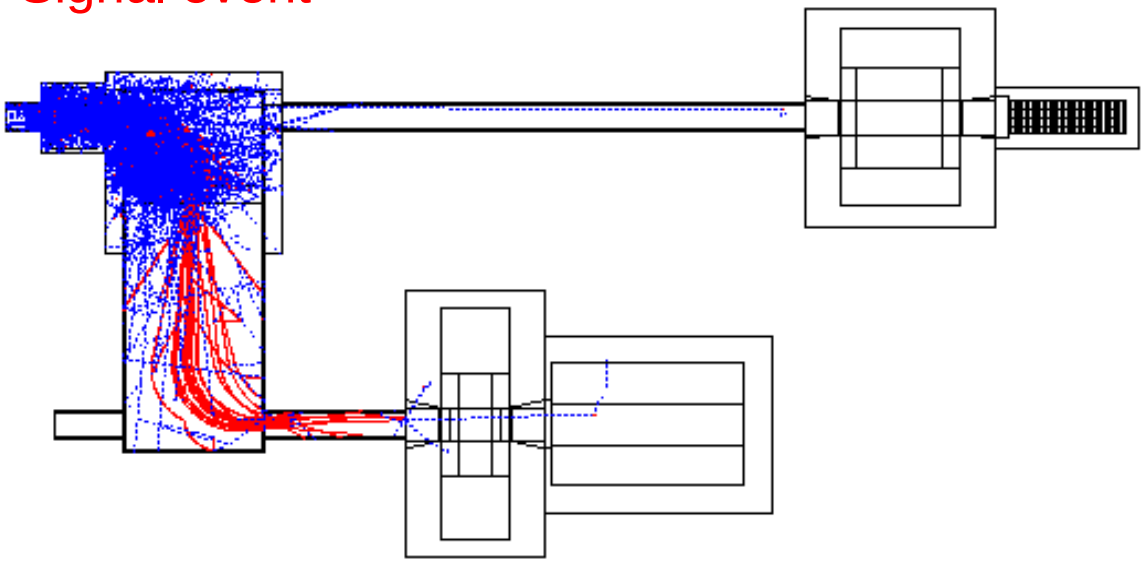
CAN Bus

Configure ADC

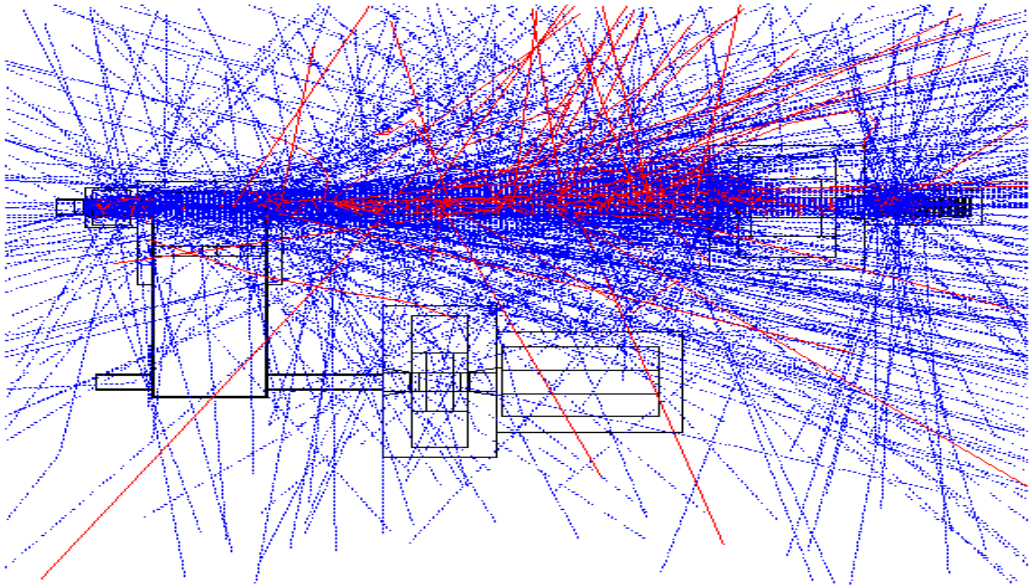
Clock for measurement of ϕ

Simulation of the Experiment

Signal event



Background Event



Employ GEANT3 (and GEANT4) simulations to investigate

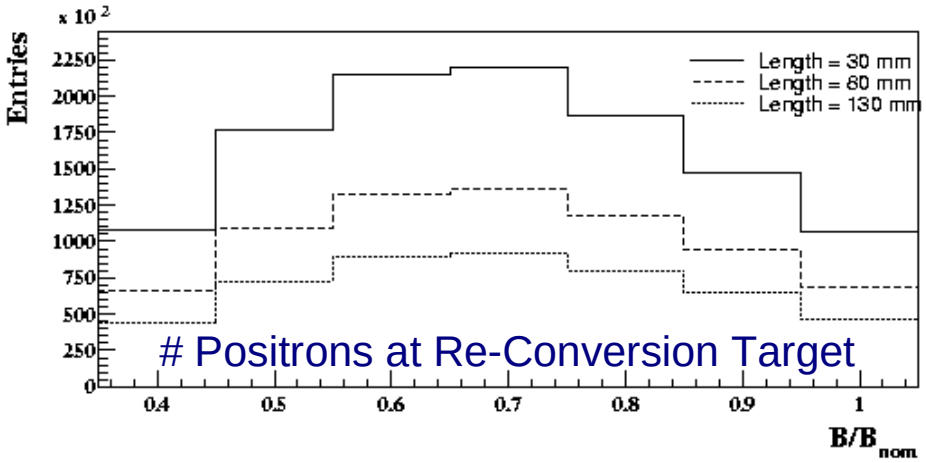
Efficiency of positron production

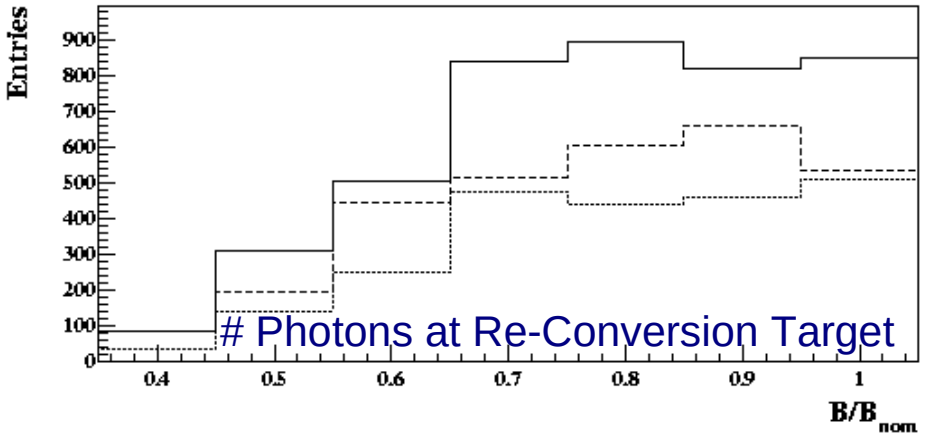
and

background from non signal photons

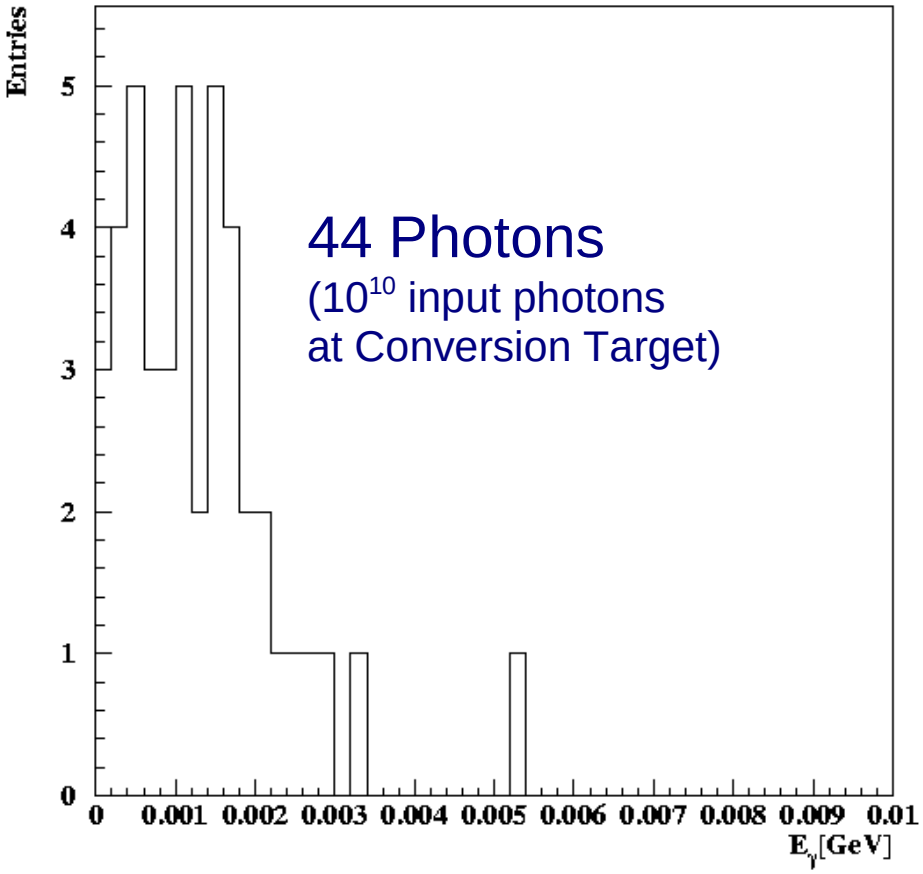
Simulation Studies Some Results

'Good' Positron/Photon Yield



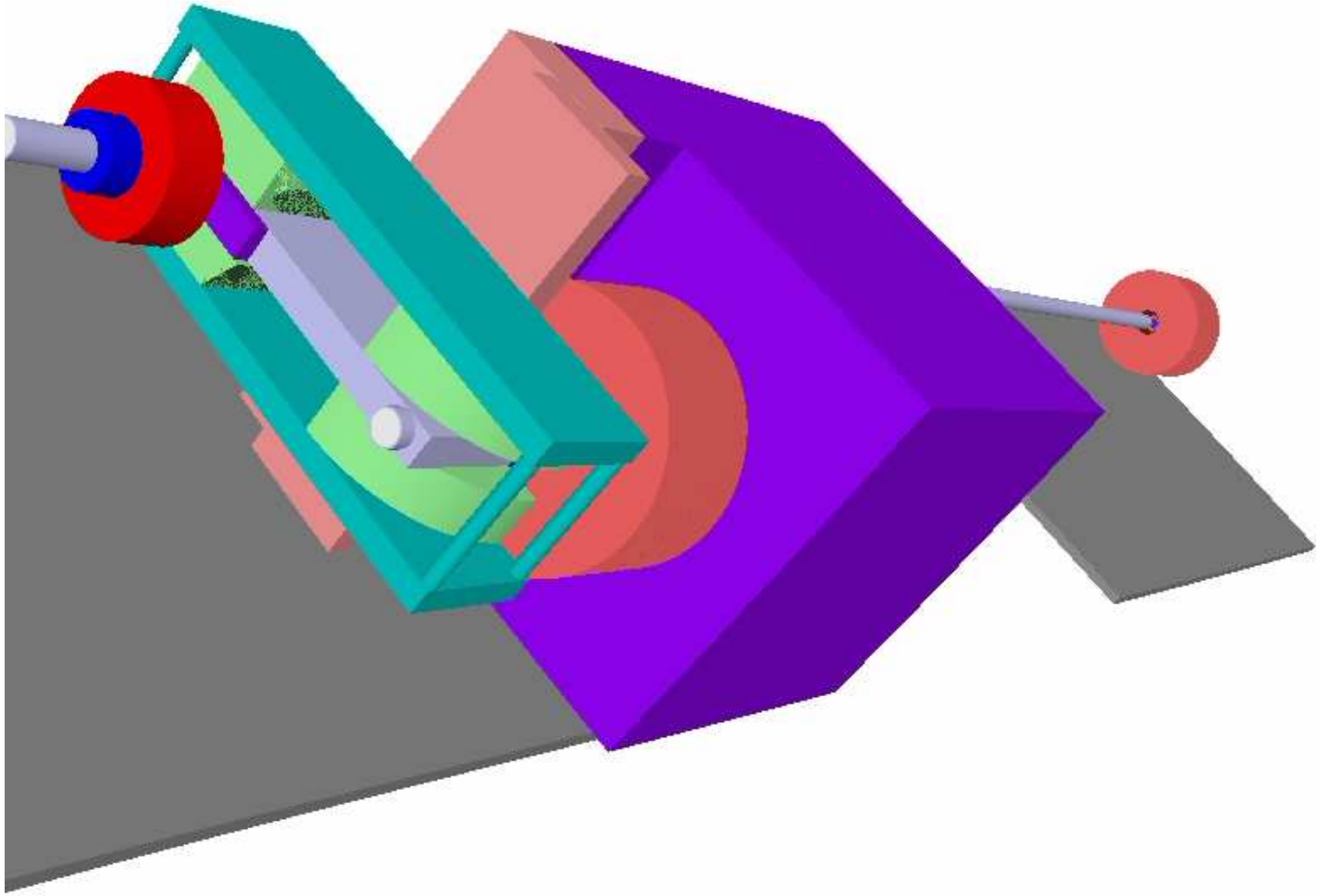


Background Photons in CsI after proper shielding



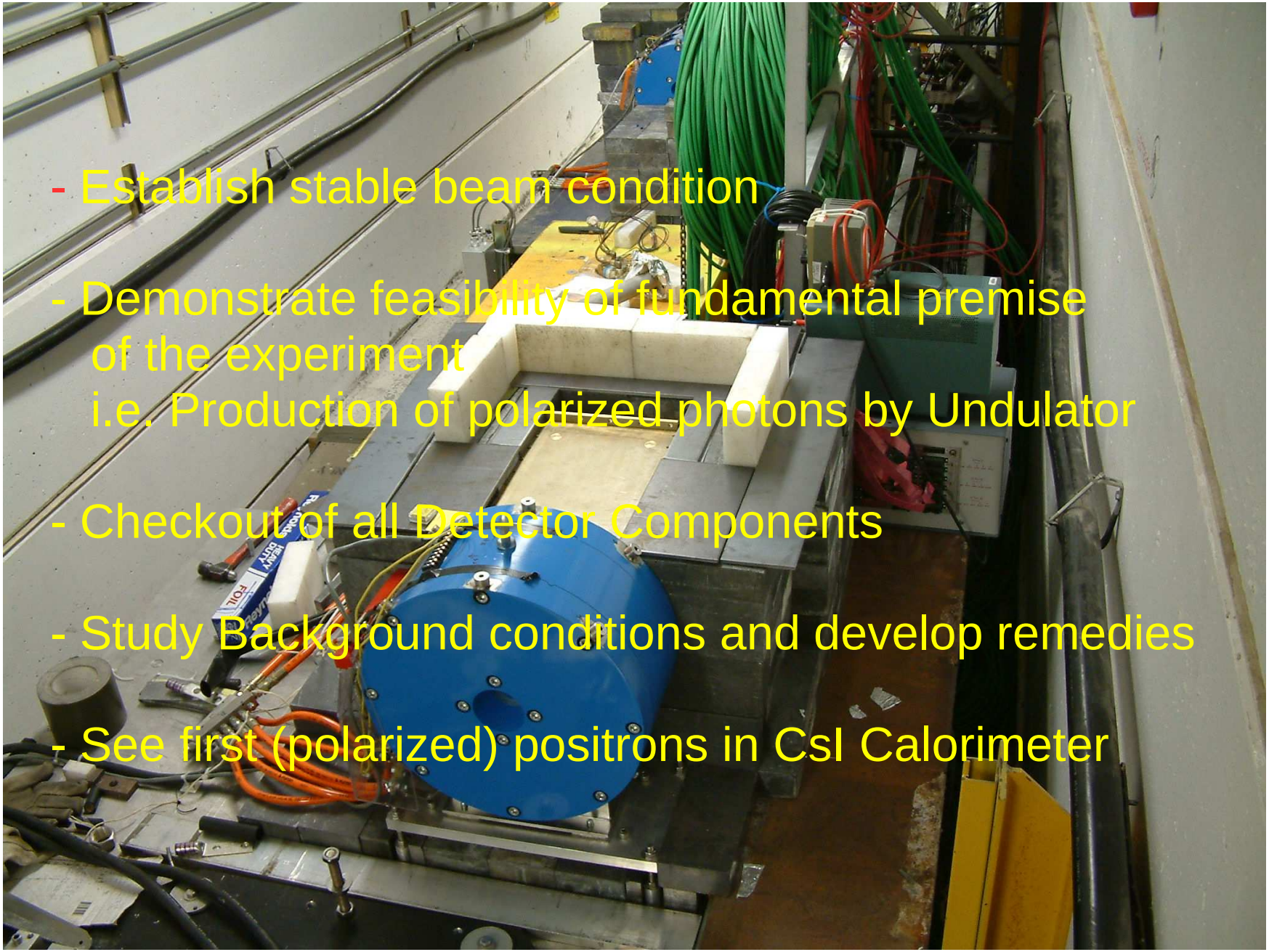
Simulation Studies to increase signal yield and background suppression

GEANT4 Implementation of E166 (K. Laihem, Zeuthen)



Efforts to implement long. Polarization into G4 are ongoing
(Part of Karims PhD thesis)
Simulation and data of E166 provide important input for realization of polarized positron production at the ILC

(Goals of) Running period in October



- Establish stable beam condition

- Demonstrate feasibility of fundamental premise of the experiment
  i.e. Production of polarized photons by Undulator

- Checkout of all Detector Components

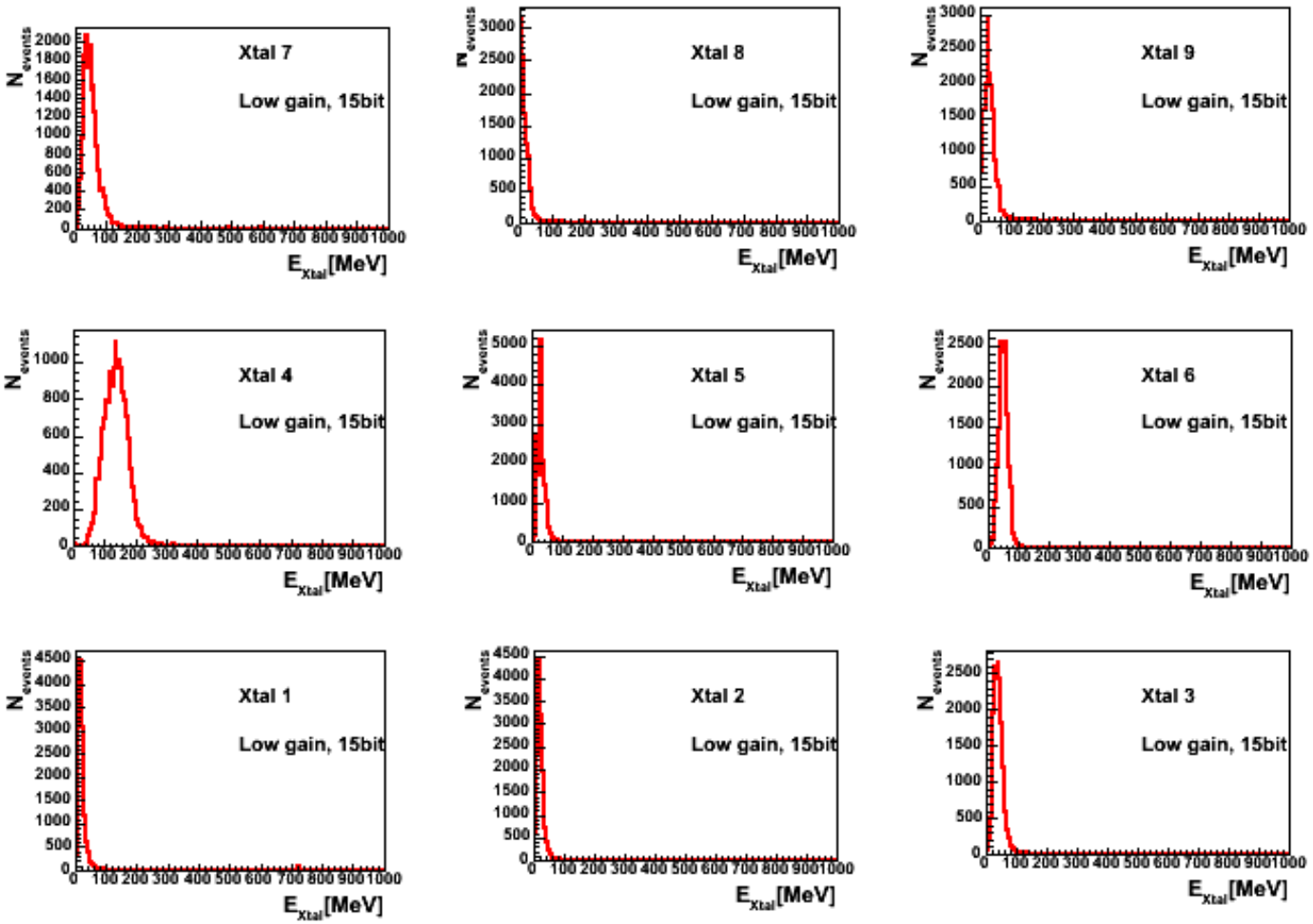
- Study Background conditions and develop remedies

- See first (polarized) positrons in CsI Calorimeter

Picture by Erez Reinherz

First Beam Spectra – Run 518 10/10/04

Goal: Bring beam to beam dump and first noise check



Small background < 100 MeV
(don't draw too optimistic conclusion)

SLAC 10/11 !

- On October 11th a very serious accident happened at SLAC

- Electrical Worker burned by electric arc while working on a 480 V power switch for the LINAC
  - burns to a second and third degree
  - situation of man is improving by still serious

- ... accident after a 'near miss' two weeks before
  - Steel plate fell out of crane in BaBar building (no one injured)

- Accident caused SLAC directorate to order a lab wide stand down to revise status of work-safety at SLAC

  - SLAC staff and visitors were adviced to cease any type of usual work and asked to create personal hazard analysis and participate in safety classes

- Stand down in parallel to a Type A investigation by US DOE

Current Situation @ SLAC

- Slow resumption of usual activities

  Need to comply with updated safety requirements

- DOE inspectors and external panels have finished evaluating safety situation

  - DOE report arrived by end of Nov
  - SLAC is working on corrective measures and launch the corresponding actions

- Very unlikely that there will be beam operation (SPEAR) before end of January

- No new time schedule for E166 so far

Conclusion

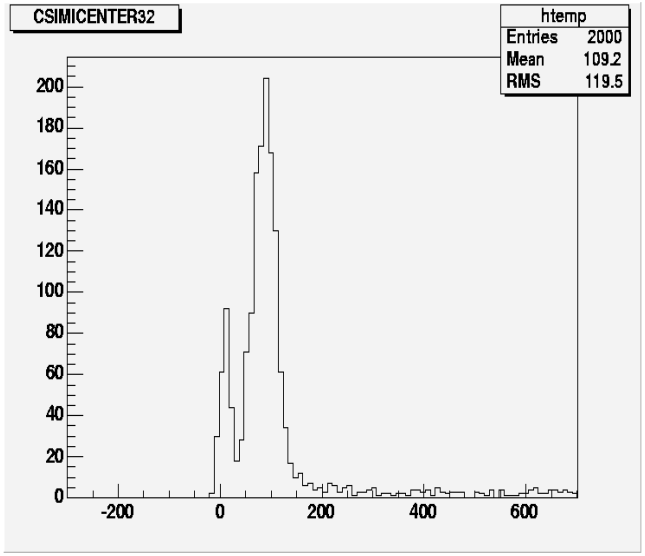
- E166 is a principle of proof experiment to demonstrate production of polarized positrons 'with' an helical undulator
  - Important and unique input for the realization at the ILC
  - Data and tuned simulation will allow for extrapolation to ILC parameters
- Most of the E166 detectors components installed and checked-out
  - (In particular) DESY components are installed at SLAC
- First beam data seen
- However ...
  - Vacuum chamber for spectrometer still under construction !!!
  - Serious alignment work still to be done
  - No undulator operation
  - No analyzer magnet ramp so far
- SLAC 10/11 accident stopped all research activities @SLAC

  Resumption of E166 data taking ???

Calibration Spectra – Source and Cosmics

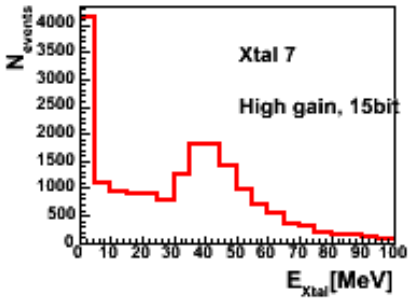
Calibration performed Achim and Erez – Raw Data Conversion by R.P.

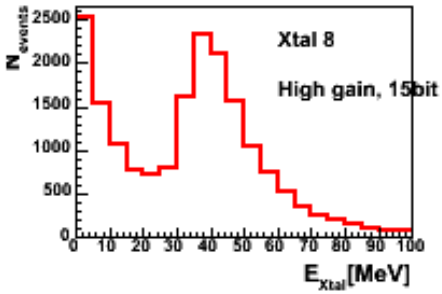
Th228 – 2.6 MeV line

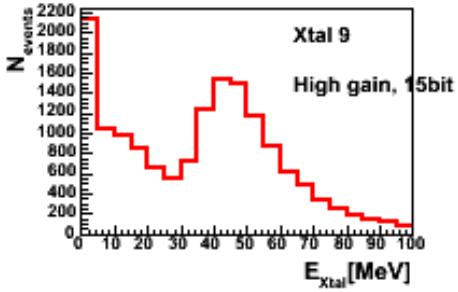


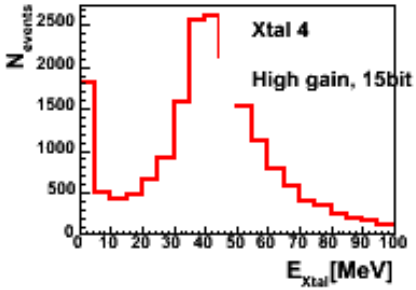
Source visible in all
9 Xtals

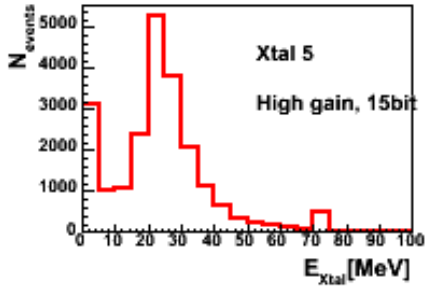
Cosmics

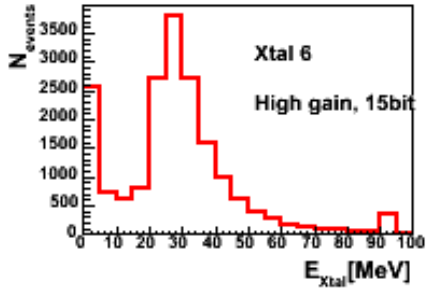


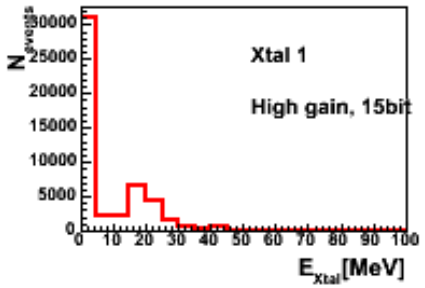


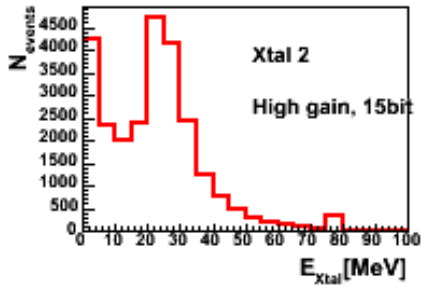


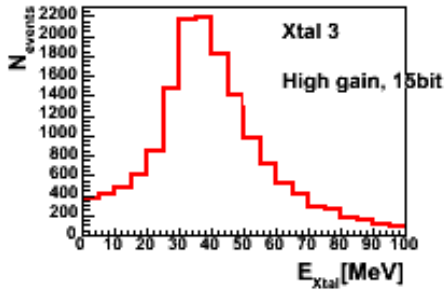












Calibration Data taken
All 9 Crystals are alive