



Polarimetry at the Positron Source of the ILC

Sabine Riemann on behalf of the LEPOL group

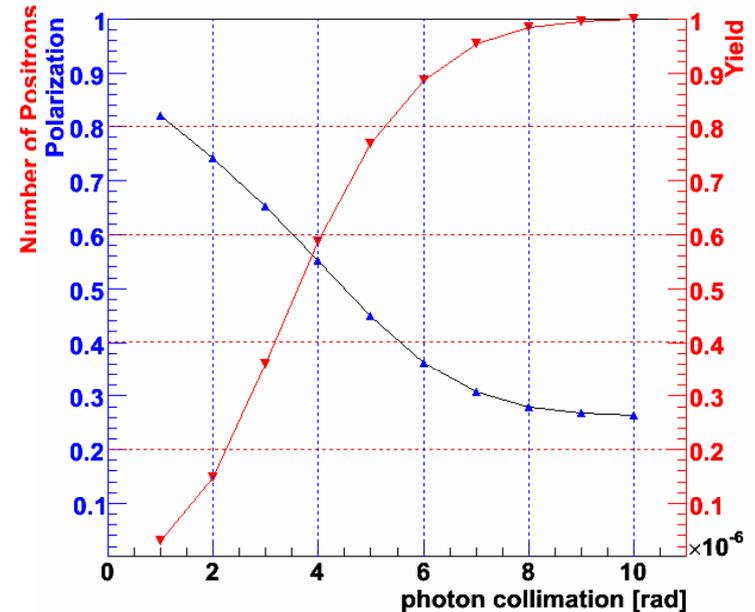
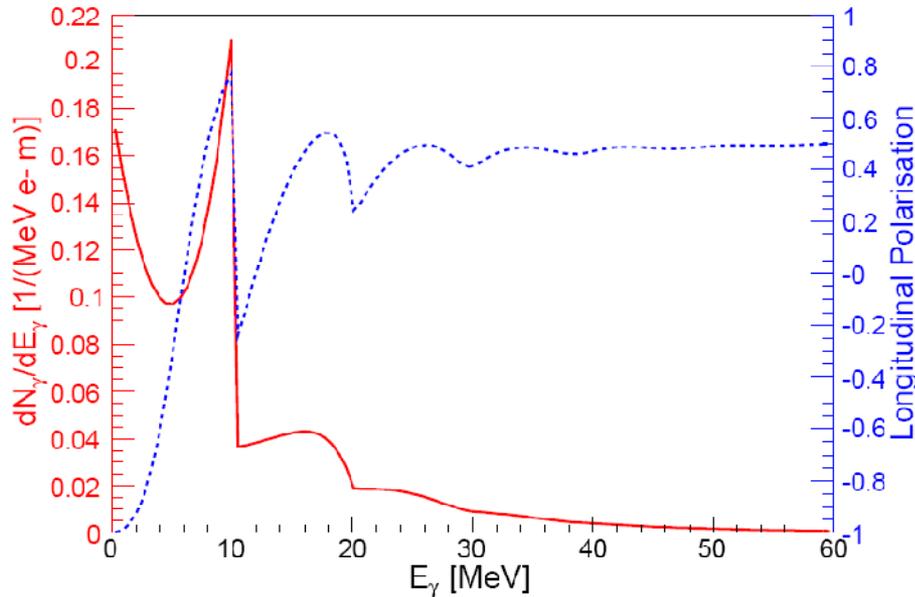
June 25, 2009

POSIPOL09, Lyon

A horizontal dotted line in a light yellow-green color runs across the bottom of the slide, mirroring the one at the top.

- ILC baseline: undulator → polarized PS
- e+ polarimetry at low energies (LEPOL)
 - Compton transmission polarimeter
 - Update of Bhabha polarimeter studies
 - Compton polarimetry after DR
- Summary

ILC baseline design: Average positron polarization >30 %



Polarimeter at the e+ source

- Optimization of e+ polarization and e+ intensity at the source
- Control of polarization transport (e- source \Leftrightarrow Mott polarimeter)



Polarimetry at positron source

Requirements for the method:

- Suitable for low energy range
- Suitable for large positron beam size
- Suitable for intense beam
- Fast, non-destructive
- Accuracy O(several %)

Conditions:

- Large beam size
- Energy: ≥ 125 MeV

Laser Compton Scattering

- High intensity Laser on low emittance beam
- High precision
- Only after Damping Rings

Bhabha/Møller scattering

- Thin magnetized Target
- Suitable for desired energy range

Compton Transmission

- Beam absorbed in thick target
- energy ~few tens MeV

Mott scattering

- Transverse polarized positrons, high background

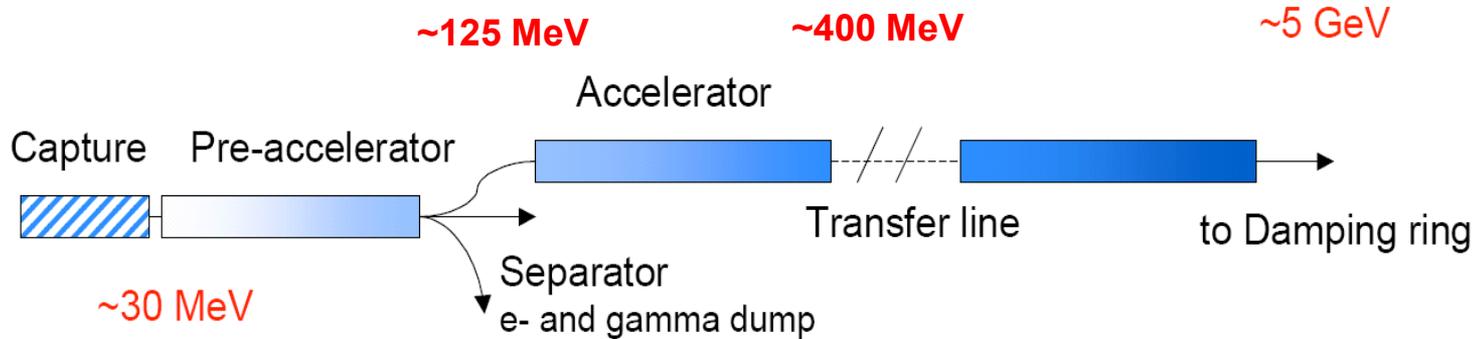
Synchrotron radiation

- Used at storage ring (VLEPP)
- Transverse polarization
- Low signal

ilc Polarimetry at the e⁺ source(LEPOL)

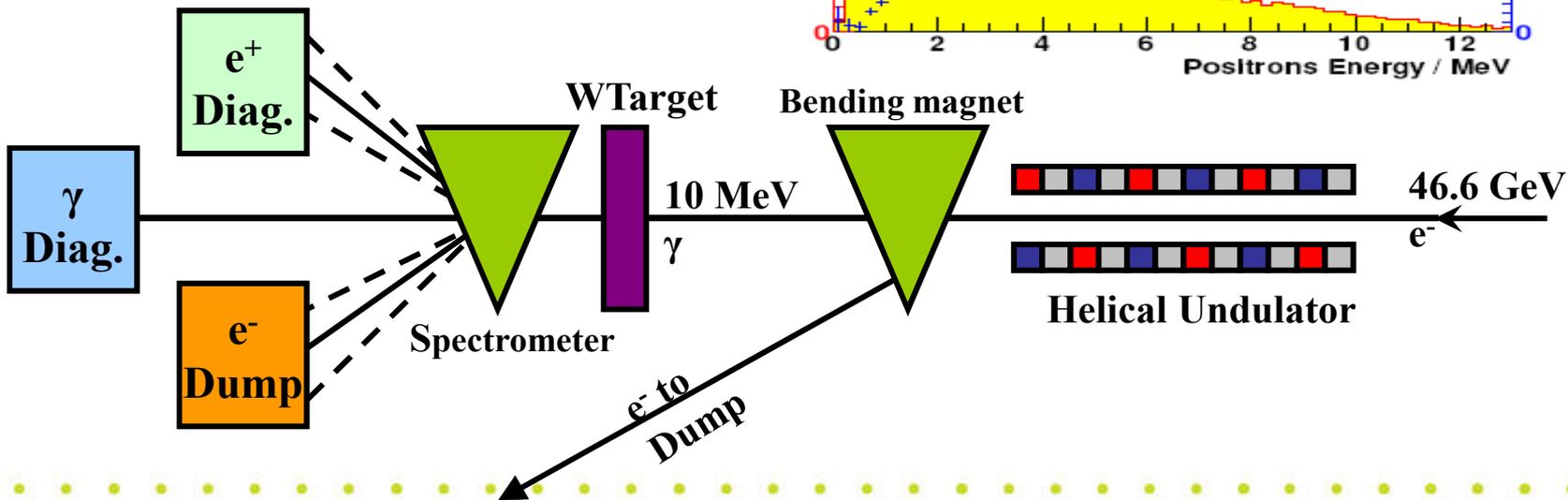
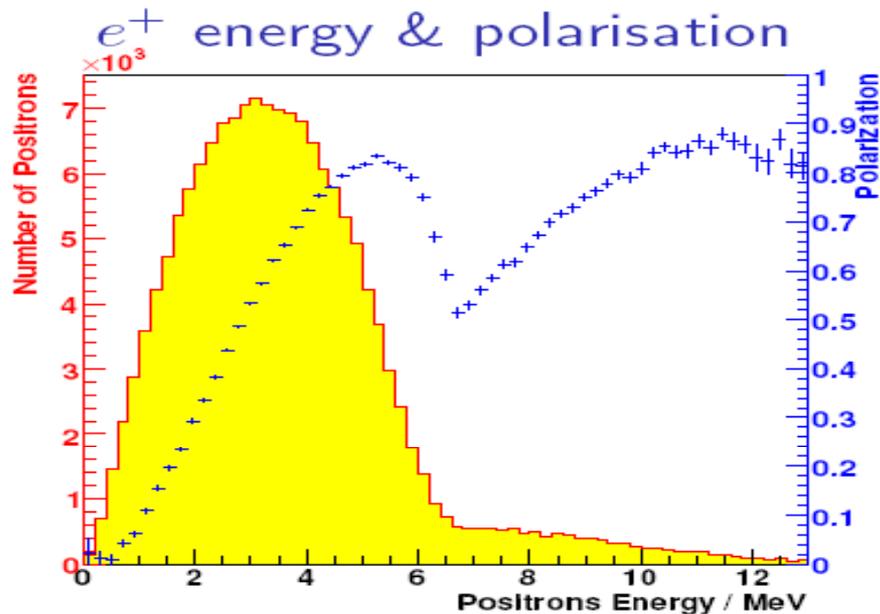
Considered options:

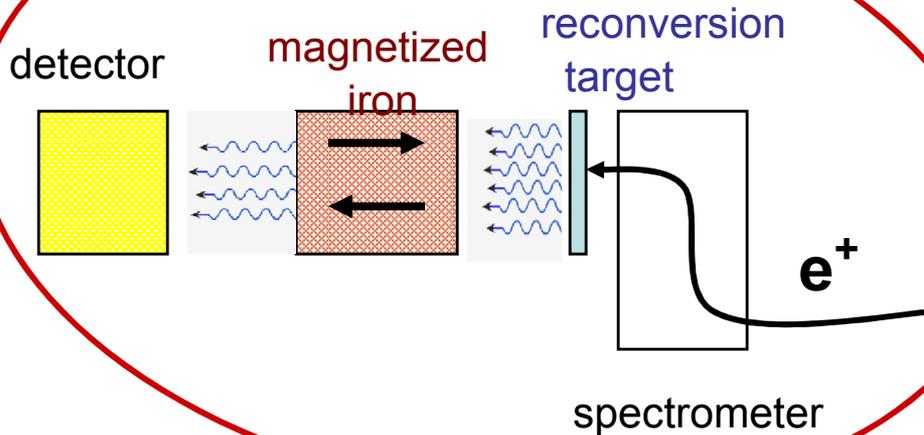
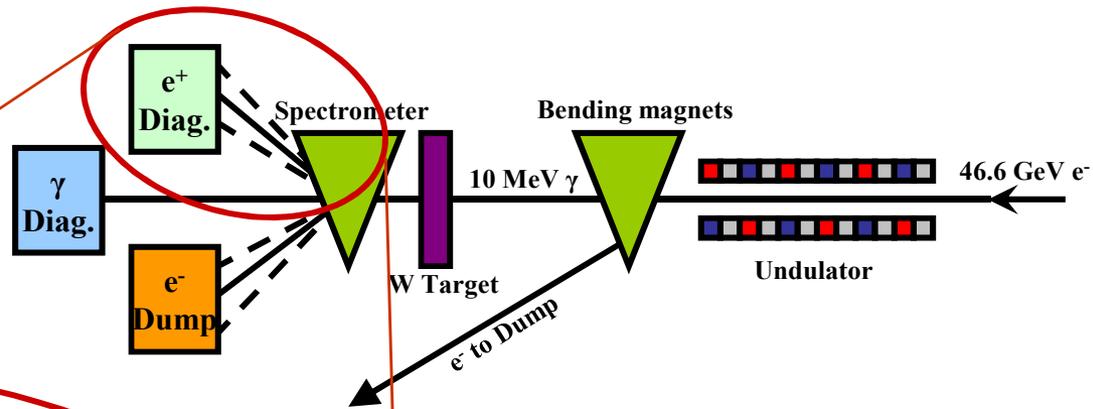
- Compton transmission (125 MeV)
- Bhabha polarimeter (400 MeV)
- Compton – after DR (beamsize!) (5 GeV)
- Simulations using Geant4 with polarized processes (see talk by Andreas Schaelicke)



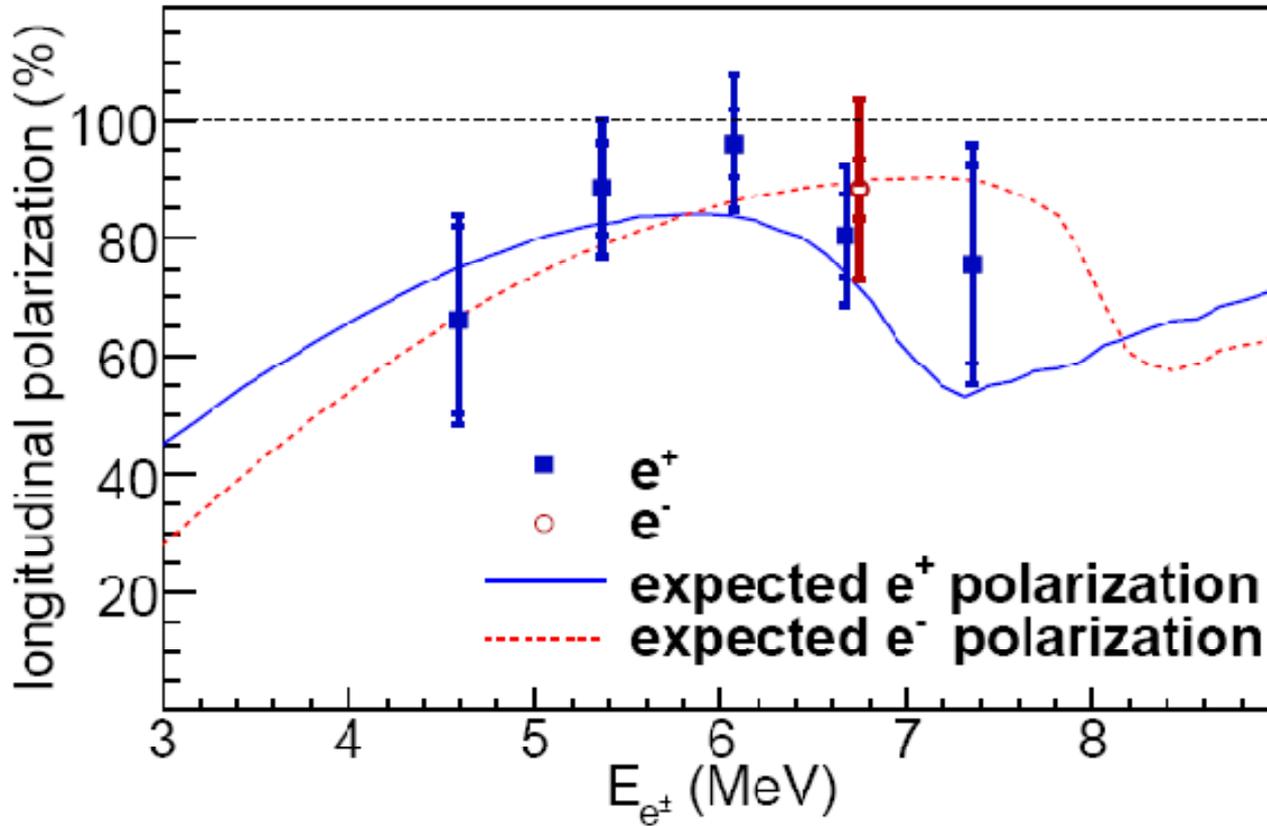
E166: prototype for polarized ILC e^+ source (undulator)

- **Diagnostics**
for e^+ , photons, e^-





- Reconversion of polarized e^+ to polarized photons
 - transmission of photons through iron depends on its magnetization
 - Measurement of transmission asymmetry for opposite (\rightarrow and \leftarrow) iron magnetization
- Method was also used at ATF**

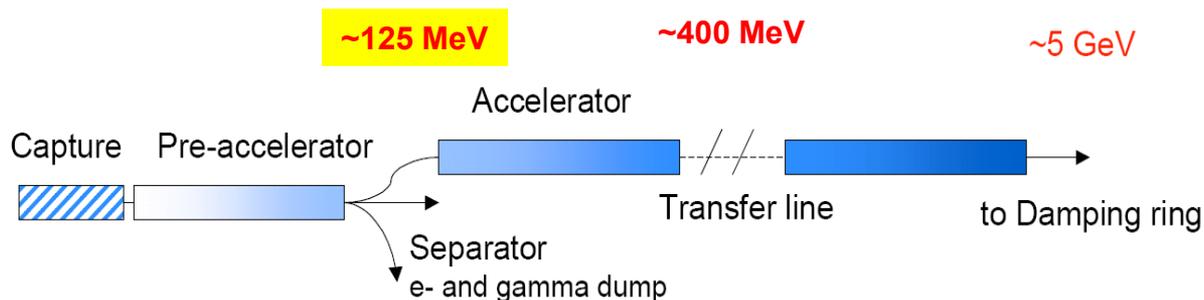


Good agreement
of measurement
and prediction

E166 results published in PRL 100:210801,2008
arXiv:0905.3066 [physics.ins-det]

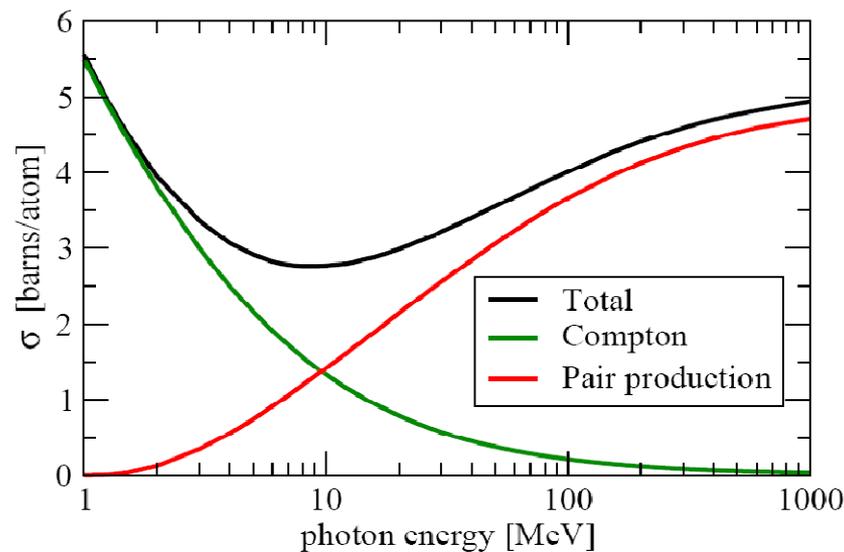
Application of Compton transmission polarimetry at ILC

- $E_{e^+} = 125 \text{ MeV}$



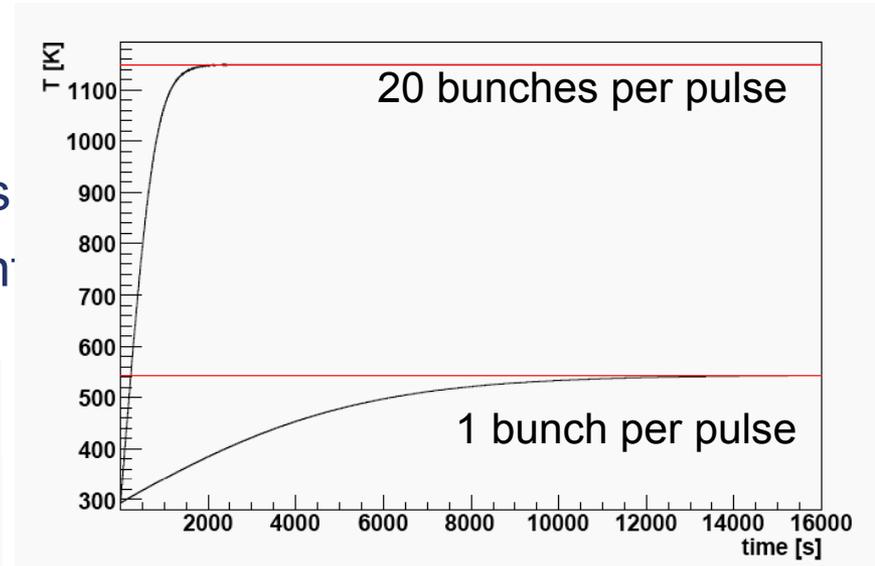
Disadvantages:

- Compton process is not dominating
- Method is destructive
→ only few bunches/pulse



- Target heating:
power deposition in target (W, $2X_0$)
and iron absorber → only few bunches
(1 bunch) for polarization measurement

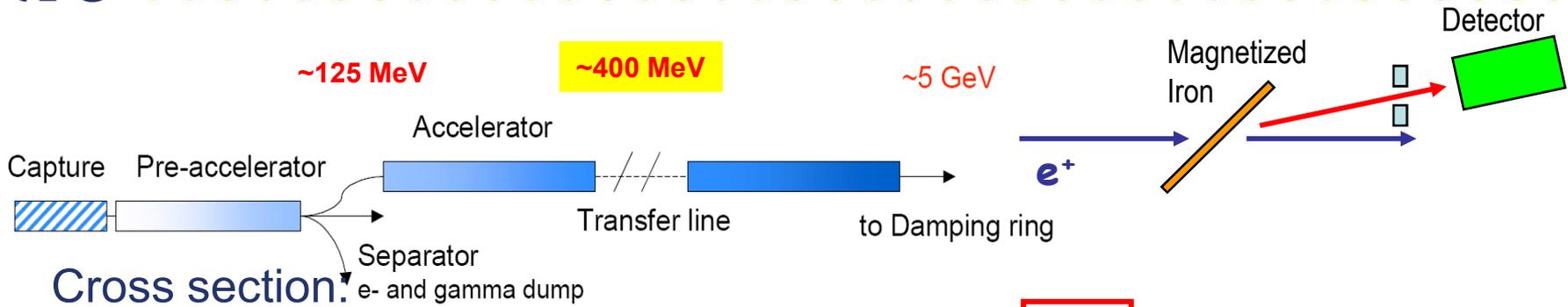
| | Positron beam energy [MeV] | material | thickness [X_0 / mm] | E_{dep} per e^+ [MeV/ $1e^+$] |
|----------|-------------------------------|----------|----------------------------|---------------------------------------|
| Target | 35 | W | 2.0 / 7.0 | 22.4 |
| Absorber | | Fe | 26.7 / 150 | 6.9 |
| Target | 125 | W | 2.0 / 7.0 | 38.1 |
| Absorber | | Fe | 26.7 / 150 | 61.6 |



- Precision:
Intense ILC beam → sufficient statistics,
precision <10% after few pulses

→ Compton transmission polarimetry is possible solution

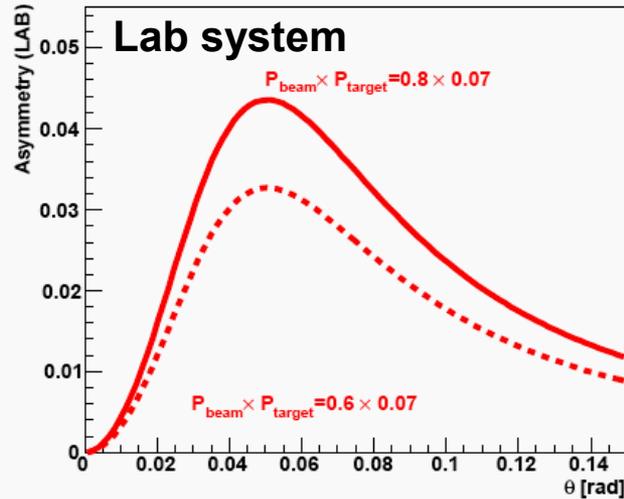
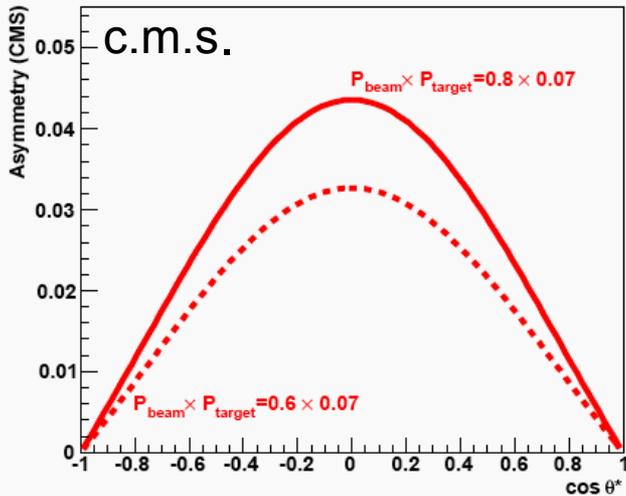
Bhabha Polarimetry



Cross section:

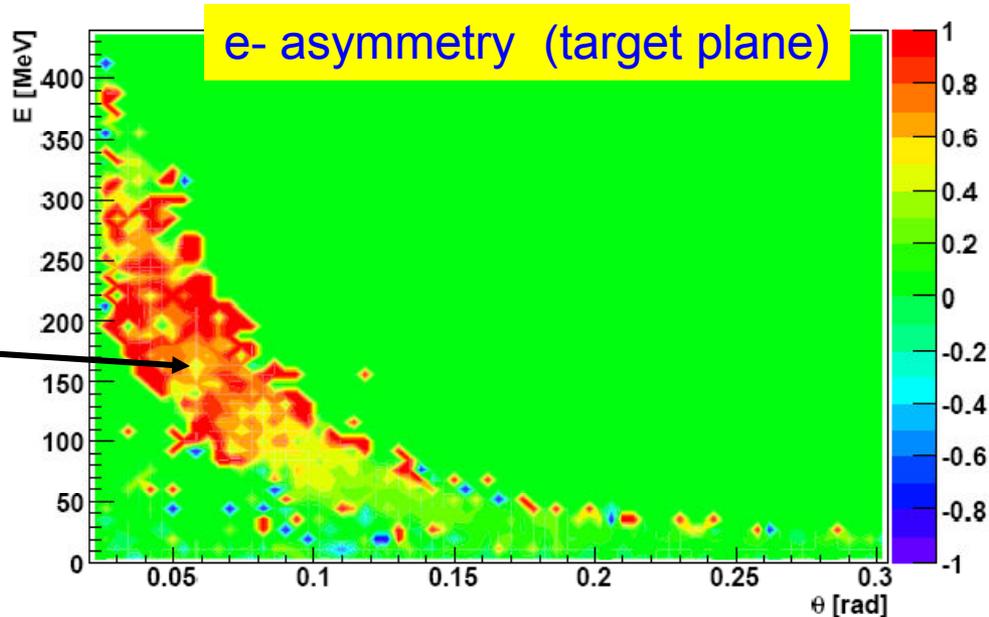
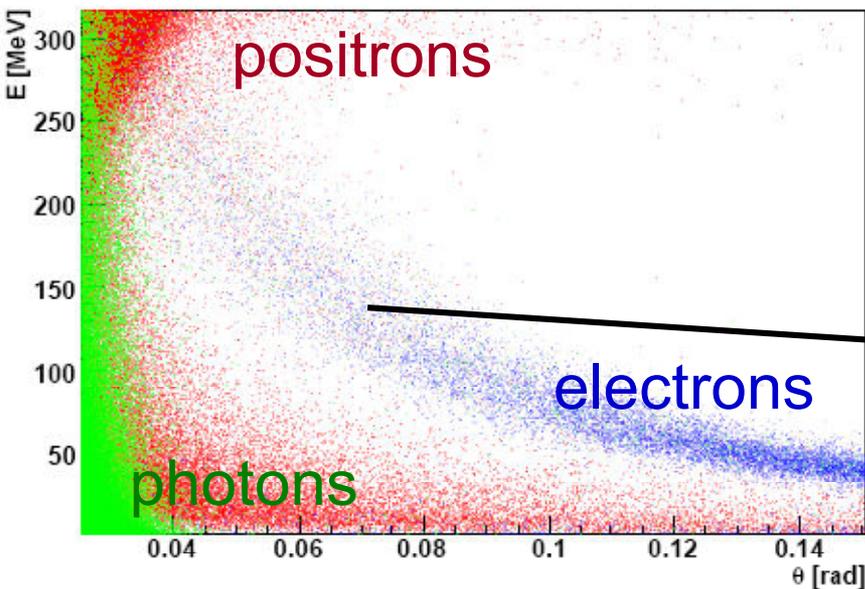
$$\frac{d\sigma}{d\Omega} = r_0^2 \frac{(1 + \cos \theta)^2}{16\gamma^2 \sin^4 \theta} \left[(9 + 6 \cos^2 \theta + \cos^4 \theta) - P_{e^+} P_{e^-} (7 - 6 \cos^2 \theta - \cos^4 \theta) \right]$$

- e+ and e- must be polarized



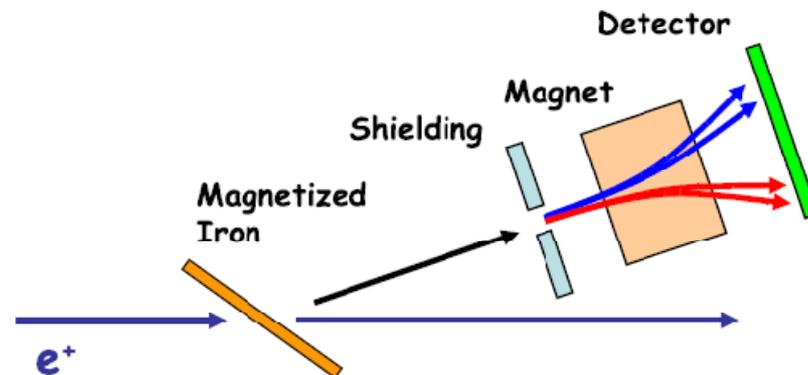
Example:
 $P_{e^+} = 80\%$,
 $P_{e^-} = 7\%$

$A_{\text{max}} \sim 4.4 \%$



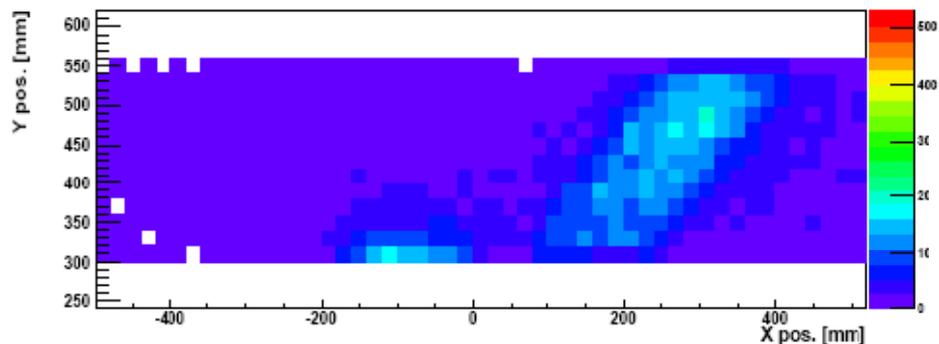
Selection of electrons and positrons:

- $0.05 < \theta < 0.09 \text{ rad}$ (mask)
- $100 \text{ MeV} < E < 300 \text{ MeV}$ (spectrometer)

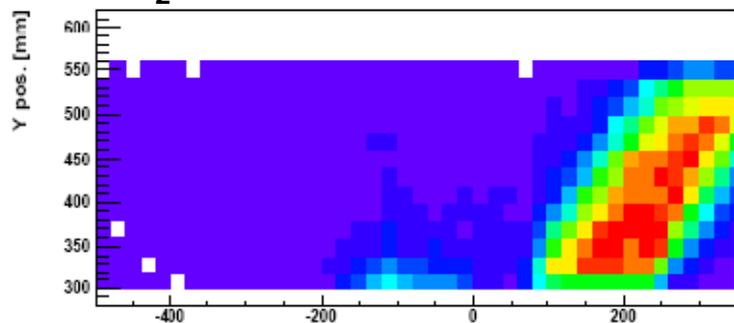


e⁻ distribution (detector plane)

$P_z = -100\%$



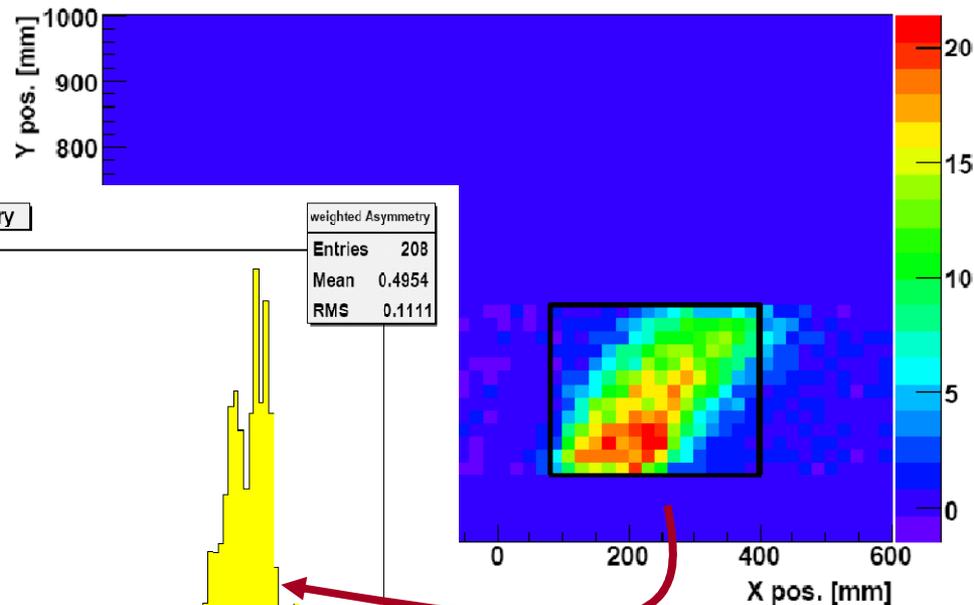
$P_z = +100\%$



- 30 μm magnetized Fe foil
- $E_{\text{beam}} = 400 \text{ MeV } (\pm 3.5\%)$
- Angular spread: 0.5°
- 100% e⁺ and e⁻ polarisation

e⁻ asymmetry \rightarrow e⁺ polarization

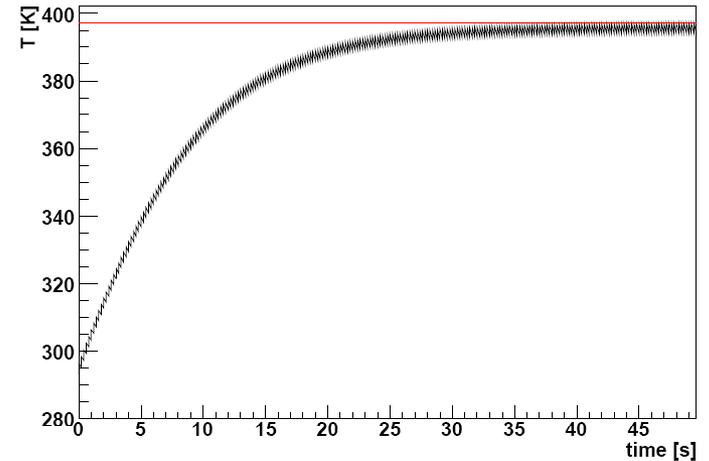
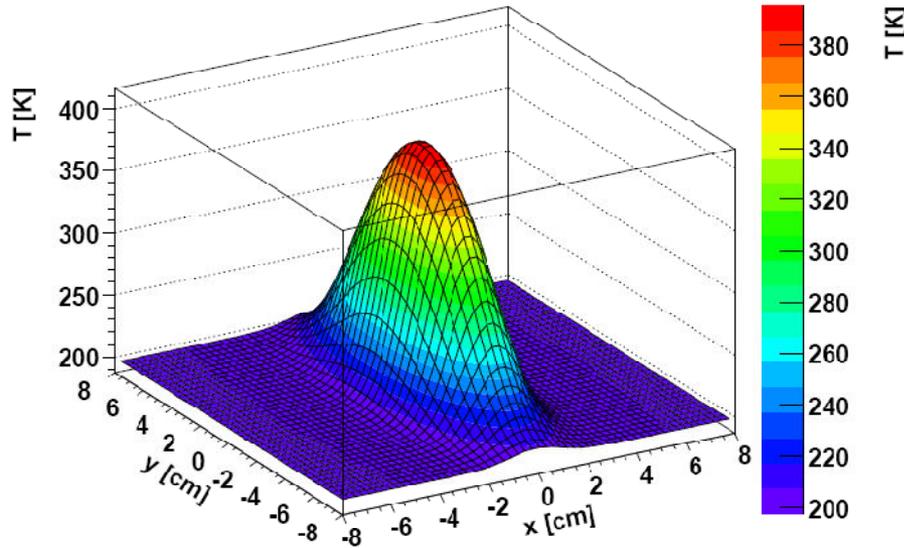
Significance



Bhabha target heating

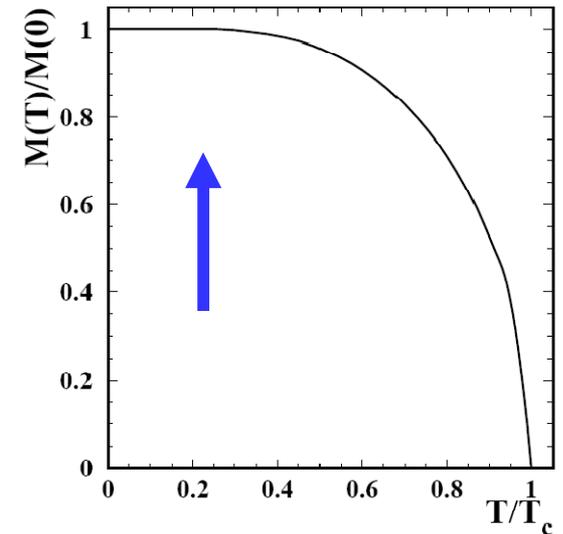
Peak temperature for iron foil (30 μ m)

time dependence



Magnetization of iron foil
depending on temperature
→ Only small reduction of P_{Fe}

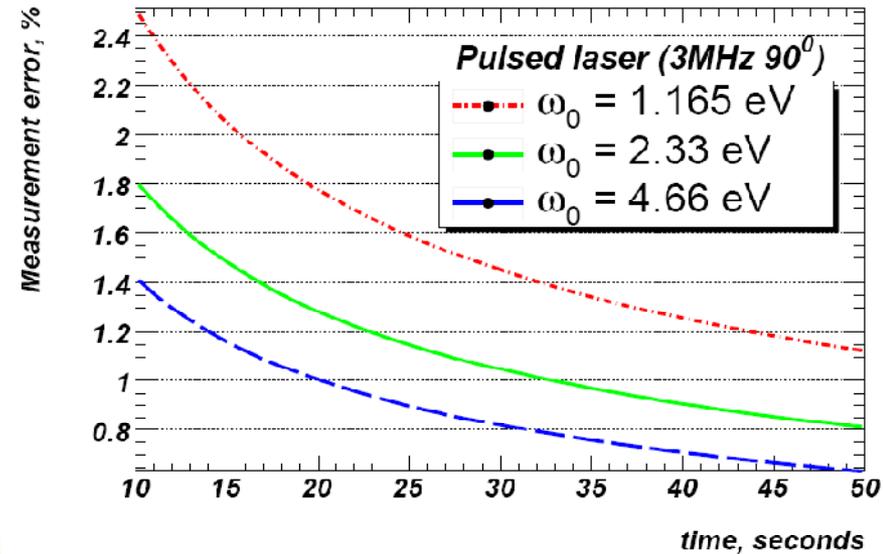
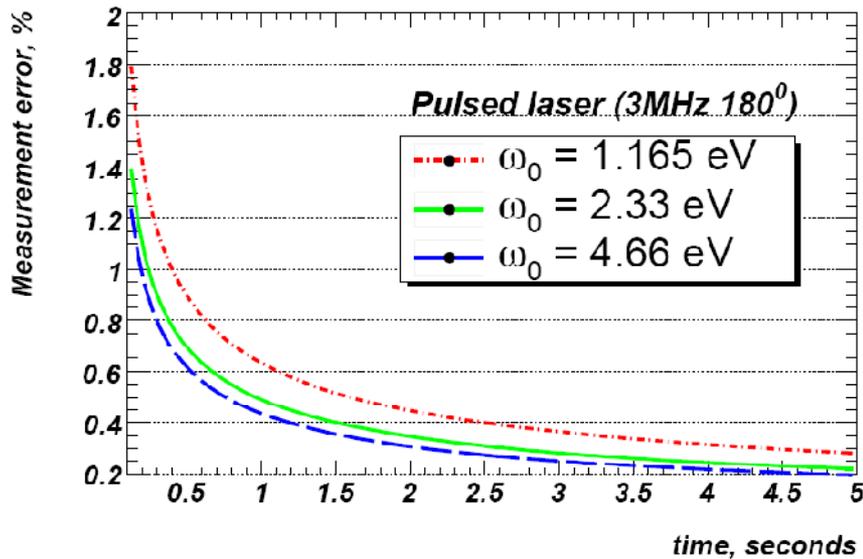
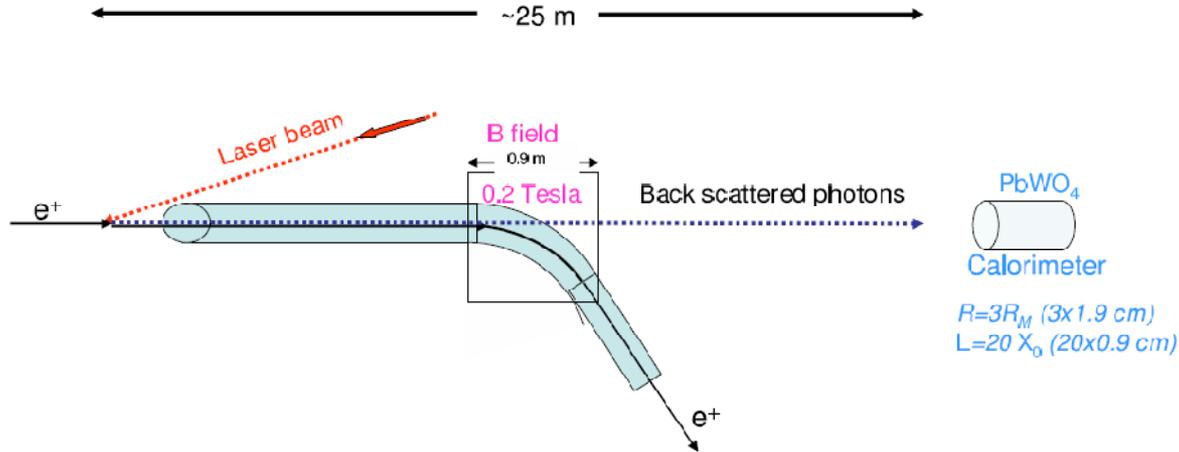
Emittance growth: 1.3% ($\sigma=1.0$ cm)
5.2% ($\sigma=0.5$ cm)



Only efficient for small beam sizes → after DR

- First considerations for (5 GeV)
 - see G. Alexander, P. Starovoitov, LC-M-2007-014
- Use laser or laser wire?
 - **Laser wire:**
 - $\pi/2$ crossing angle between e and γ
 - e beam size larger than laser beam waist
 - **Compton:**
 - $\sim\pi$ crossing angle between e and γ
 - small e beam size for high rate

Compton polarimeter @ 5 GeV



| Method | e+ Energy | | precision | |
|----------------------|---------------------|--|--|--|
| Compton transmission | 125 MeV | Destructive → use only few bunches per pulse | Stat: few %; Syst. will dominate | Prototype (E166) ILC design Simulations |
| Bhabha | 400 MeV | Almost non- destructive | Stat: few %; Syst. will dominate | ILC design Simulations |
| Compton | 5 GeV (after DR) | Non- destructive | Stat: few %; Syst. will dominate | ILC design simulations |



Remark: why polarized positrons?

- GigaZ (upgrade option, $P=60\%$)
 - Running at the Z resonance
 - 10^9 Z bosons
 - $\sin^2\theta_W$ with precision $1E-5$ (Blondel scheme)
- High energies
 - will reach precision of $\leq 0.5\%$ in the first years for WW, ffb \bar{r} , ttb \bar{r} processes (J=1)
 - with e $^+$ polarization
 - Increase of effective luminosity for J=1 processes
 - Reduction of error on effective polarization
 - Increase effective polarization
 - Resolution of new physics



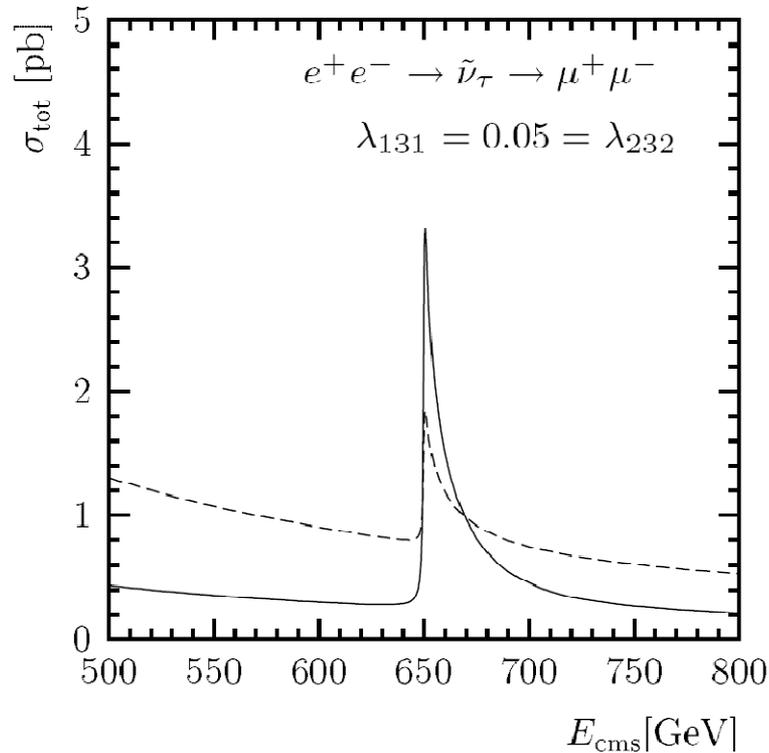
Summary

- Undulator based e^+ source is polarized
- Low energy polarimetry
 - **Detailed design depends on FLC design e^+ polarimeter**
 - **Considered options**
 - Compton transmission (few bunches, $E \approx 125$ MeV)
 - Bhabha (~ 400 MeV)
 - Compton (5 GeV, longitudinal polarization)
 - **Fast helicity flip to match the experimental precision for physics is also useful for polarization measurement at the e^+ source**
(control of syst. effects)
- Tools for design/performance studies
 - **G4 with polarization extension**

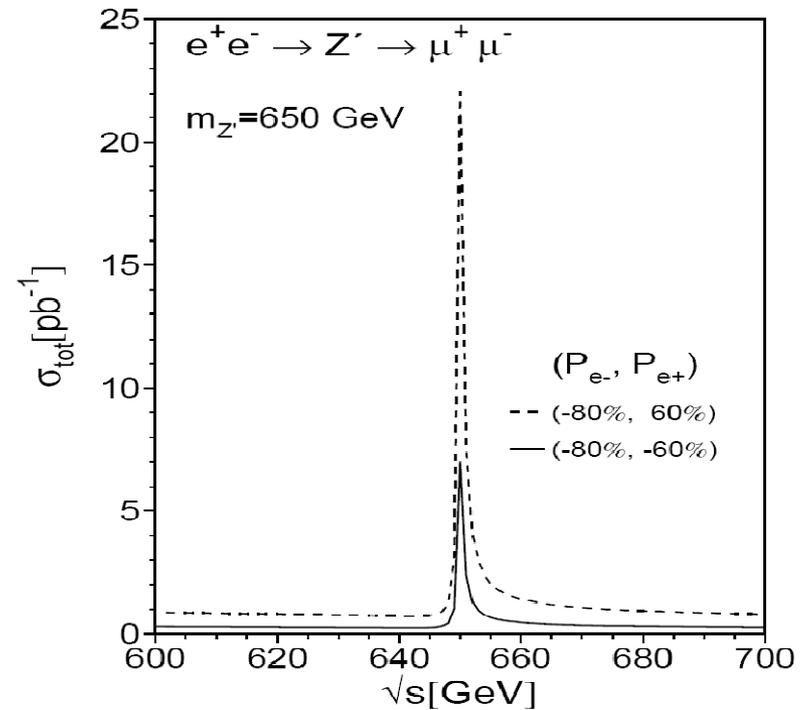


BACKUP

Enhance / suppress new physics effects \Leftrightarrow differentiate models



$J=0$ (*s-channel sneutrino*)



$J=1$ (Z')