Summary of the Polarization Working Group

Conveners:
Tom Markievicz (SLAC), Sabine Riemann (DESY)

ECFA LC Workshop 2013, Hamburg
May 27-31, 2013

Topics

Precision measurement of polarization, collision effects:

Moritz Beckmann, Annika Vauth, Benedikt Vormwald, Burak Bilki, Tony Hartin

In situ energy measurement using $Z\gamma \rightarrow \mu\mu\gamma$

Graham Wilson

Joint session Polarization / Injector WG: Polarized Positrons

Andriy Ushakov, Wanming Liu, Friedrich Staufenbiel, Tsunehiko Omori

Beam polarization physics potential at the staged approach

Gudrid Moortgat-Pick

Precision polarimetry

Goal: ΔP/P = ±0.25

Analysing power: 0.2%
Laser helicity: 0.1%

ΔP/P contribution due to detector non-linearity must be <0.1%

→ Calibration is essential

B. Vormwald, J. List

- high-precision calibration system for the Compton polarimeter ⇔ correct detector non-linearity
- Achieved:

  non-linearity below 0.2% in the dynamic range of the polarimeter

A. Vauth, J. List

- Quartz detector as possible option for upstream polarimeter
- Self-calibration (?)
  - Large number of photo-electrons per Compton e-
  - resolution of single electron peaks possible
- Prototype tested at DESY, detailed analysis is still ongoing

Spin tracking

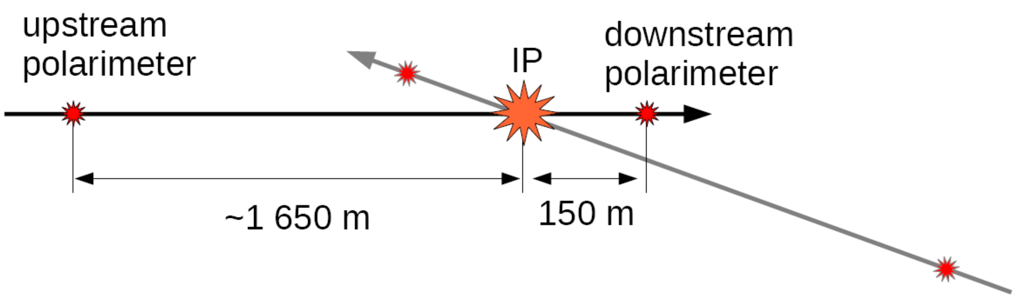
Goal: ΔP/P = ±0.25%

Analysing power: 0.2%

Laser helicity: 0.1%

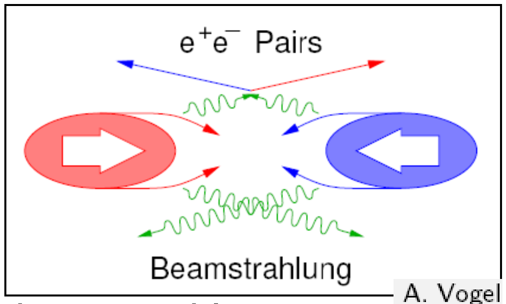
Detector linearity: 0.1%

+ spin transport through IP



M. Beckmann, T. Hartin, J. List

- beam collision effects and spin transport behind IP to downstream polarimeter

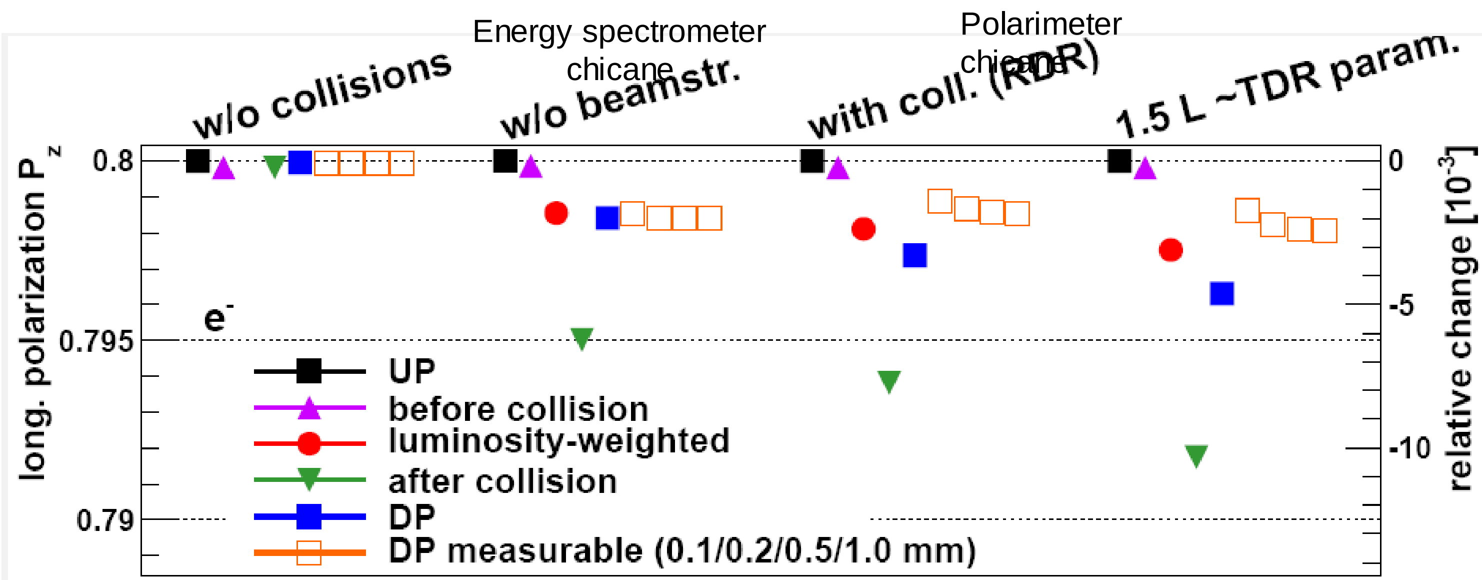


- T-BMT Spin precession and spin flip due to beamstrahlung
- Simulation with Guinea-Pig++
- Directly connected to transport simulation

Spin transport

M. Beckmann:

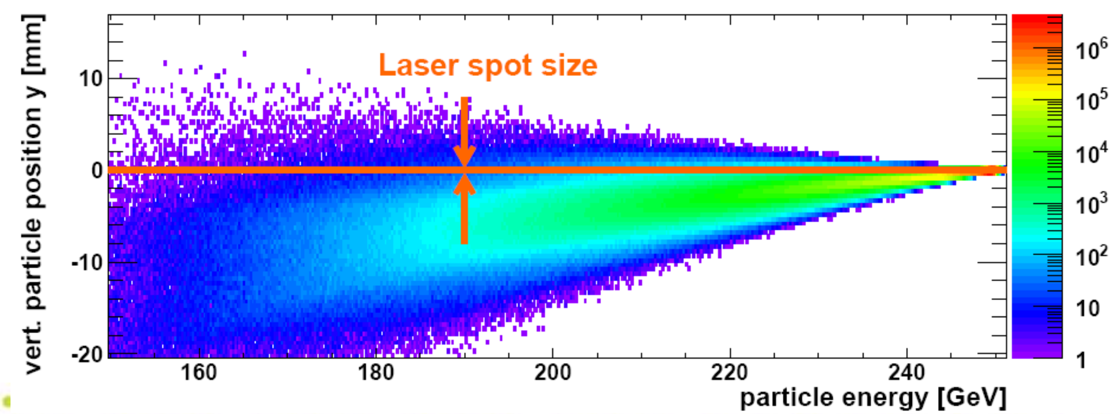
DP = downstream polarimeter



Beamstrahlung:

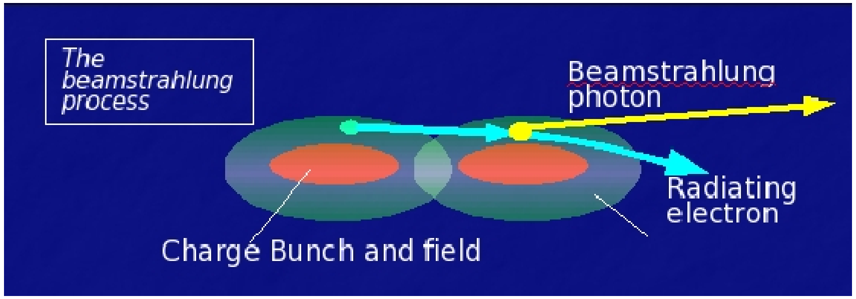
- Correlates energy loss and depol
- already difficult to measure P after collision assuming ideal conditions

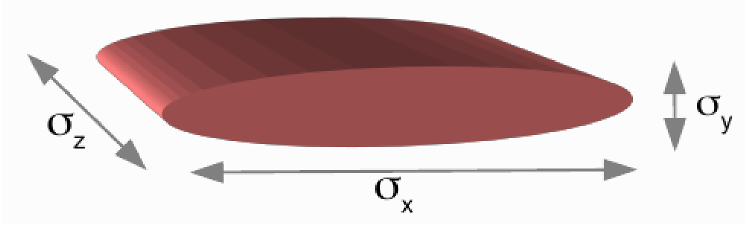
It is crucial to know laser spot size and position



Strong field effects

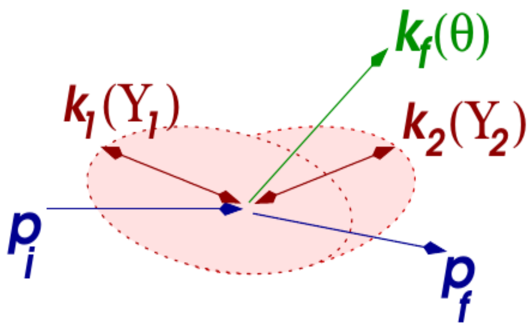
T. Hartin
G. Moortgat-P





$$\Upsilon = \frac{e}{m^3}|F_{\mu\nu}p^\nu| \equiv \frac{\text{field strength in rest frame}}{\text{Schwinger critical field}} \approx \frac{5}{6}\frac{N\,\gamma\,r_e^2}{\alpha(\sigma_x+\sigma_y)\sigma_z}$$

Y is a natural parameter indicating the scale of external fields. (ILC: Y≈0.24, CLIC: Y=4.9)



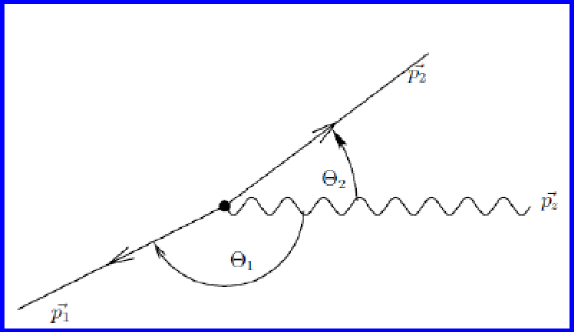
A more exact Beamstrahlung calculation

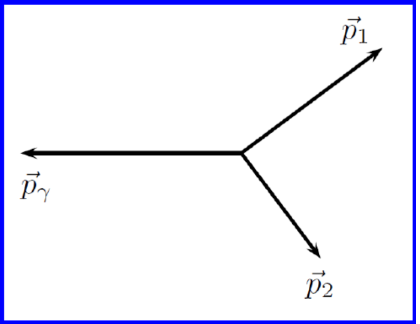
- CAIN, Guinea-Pig: e- interact with one bunch, no crossing angle
- New solutions for charged particles in two non-collinear crossed fields being developed

Y values vary independently throughout the bunch collisions

Investigating In-Situ √s Determination with μμ(γ)

G. Wilson





Precision measurements of Masses rely on knowledge of absolute Ecm scale and luminosity spectrum

Two methods:
A) Use angles only, measure m_{12} /√s.
Use known m_Z to reconstruct √s.
P) Use muon momenta.
Measure $E_1 + E_2 + p_{12}$.

- Use muon momenta measurements
- beam spread, ISR, FSR, beamstrahlung

→Prospects to determine absolute center-of mass energy scale (<10ppm)

Summary Table

(Statistical errors only …)

ECM (GeV)	L (inv fb)	Δ(√s)/√s Angles (ppm)	Δ(√s)/√s Momenta (ppm)	Ratio
250	250	64	4.0	16
350	350	65	5.7	11.3
500	500	70	10.2	6.9
1000	1000	93	26	3.6

< 10 ppm for 200 – 500 GeV CoM energy

Joint Session

Polarization / Injector WG

Polarized Positrons

Positron production @ ILC: helical undulator

- Circularly polarized photons → ILC e+ beam is polarized
- Intensity of e+ beam depends on length of undulator, and on energy of e- beam
- Degree of e+ polarization: depends on undulator parameters and beam energy

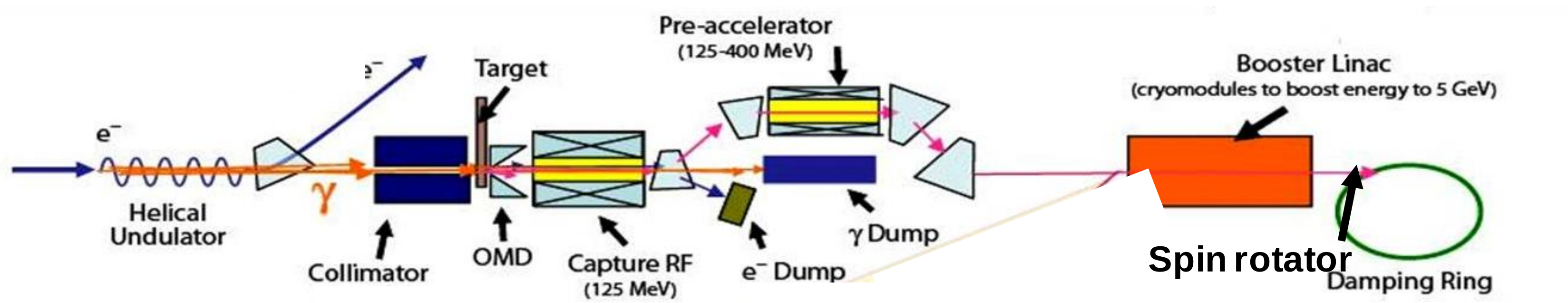
147m active length for Ecm = 500 GeV Pe+ ≈ 30%
147m active length for Ecm = 375 GeV Pe+ ≈ 30%
} TDR

New study of A. Ushakov:

231m active length for Ecm = 250 GeV Pe+ = 30%

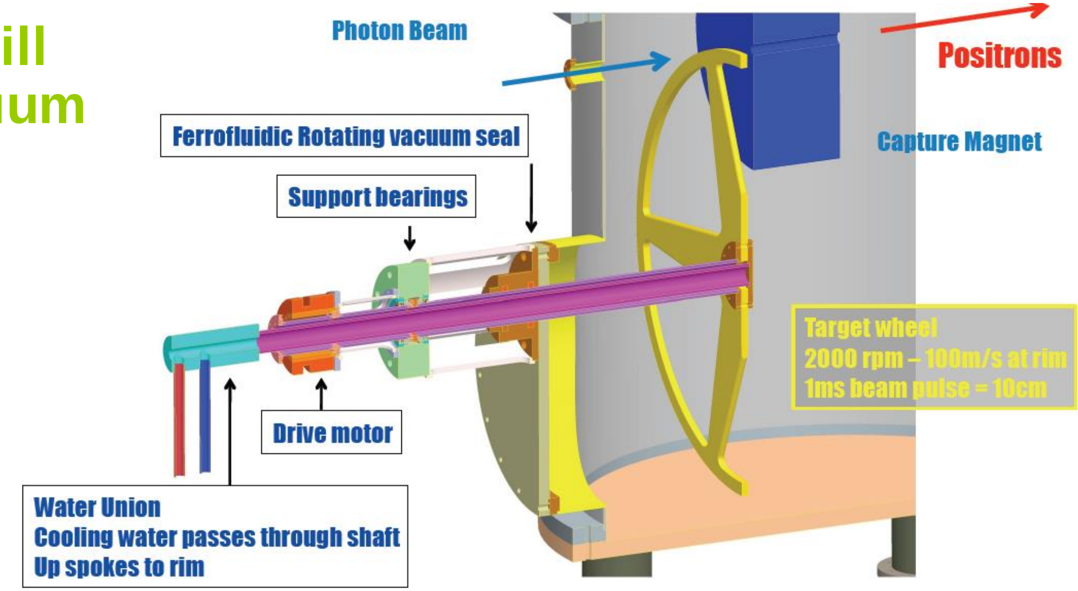
with normal 5Hz scheme and RDR undulator

- Degree of e+ polarization can be enhanced up to 40% to 60% by photon beam collimation
  - for more details see talks of W. Liu, F. Staufenbiel and A. Ushakov



Positron target:

- **High energy deposition in the target requires fast rotating target wheel**
- **Design exists, R&D still needed (rotating vacuum seal)**



? Backup solution?

- **Conventional e+ source (6GeV e- beam on W target) under consideration**

Details: see talks in injector WG sessions

→ **<u>unpolarized</u> source !!**

The LC physics offer

- **Staged approach:**
  - $\sqrt{s}$=240 GeV, Higgs mass, couplings
  - $\sqrt{s}$=350 GeV, Top mass, Higgs width, couplings
  - $\sqrt{s}$=500 GeV, Top Yukawa, trilinear Higgs coupling, …
  - ($\sqrt{s}$=91 GeV, `Precision frontier‘)
  - $\sqrt{s}$=1000 GeV, Precision physics at high energy
- **`New' features, impact on 'quality' (and quantity):**
  - Flexible energy (threshold scans)
  - Polarized e- and e+ beams

What has changed since Polarisationreport?

ECFA LC2013@Hamburg Gudrid Moortgat-Pick

All is still valid !

Summary of the summary

Precision measurements (P, E)

- Good progress made in
  - **Spin tracking and strong field effects studies**
  - **detector calibration and development for Compton polarimeter**

- precise 'in situ' $\sqrt{s}$ determination using $Z\gamma \rightarrow \mu\mu\gamma$

Joint session Polarization and e+ source group

- Undulator-based source ➔ e+ beam polarization > 30%,
  with photon collimator up to 60%
- ILC as Higgs factory:
  if full undulator length used, no 10Hz scheme necessary, P(e+) > 30%
- R&D for the positron target and capture device still needed

Physics case for e+ polarization is as strong as it ever was