Polarization Working Group

News from

- **heLiCal group**
- **'Polarization' workshops at Daresbury and at Zeuthen**
- **Optimization of baseline design**
- **Summary**

In short……

- **heLiCal group**
  - **survived**
  - **good progress for helical undulator: see Jims talk yesterday**

    - The 4m full scale cryomodule is in the final stages of manufacture
    - It will be completed this summer
    - The vertical magnet tests for the first ever 1.75m undulator are excellent

  - **good progress for target wheel: see Leos talk yesterday**

    - Operation of wheel in magnetic field ~May to Jul 08
    - Long-term operation of wheel to monitor stability ~Aug 08
    - Additional investigations using aluminium wheel or modifying conductivity of wheel rim also possible.
      - Very unlikely due to lack of funding.
    - Experiment complete by Nov 08.

Progress, cont.

- **UK@newsline:**

In short......

- **heLiCal group**
  - good progress in physics updates
  - spintracking and theory
- **Very successful workshop on polarization models@Daresbury**
- **Good progress at sources workshop@Zeuthen**
- **Good ideas at workshop of polarimetry and energy measurement @ Zeuthen**
  - write-up for GDE under work

Physics updates

- **Physics for polarized e- and e+**
  - comprehensive overview given in 'POWER' report
  - hep-ph/0507011, now in press as Physics reports
  - see also executive summary at

    www.ippp.dur.ac.uk/~gudrid/source/
- **Code updates:**
  - Alexanders Mikhailichenko program 'KONN' for tracking undulator e+ from source up to acceleration
  - ennables systematic studies of undulator parameters
  - Tony's (many thanks to Tony!) updated version of CAIN
  - included polarization (full BW and initial+final states)

ICFA Parameter Group

- 'Scope Document no.1' (2003) and 'no.2' (2006): 'baseline
  - 'full luminosity of 2 x $10^{34}cm^{-2}s^{-1}$'
  - 'beam energy stability and precision below tenth of percent level.'
  - 'Machine interface must allow measurements of beam energy and diff. lumi spectrum with similar accuracy.'
  - 'electron beams with polarisation of at least 80% within whole energy range.'
- Options:
  - 'e^+ polarisation ~50% in whole energy range wo sign. loss of lumi...., Reversal of helicity ... between bunch crossings.'
  - GigaZ: e^+ polarisation+frequent flips essential; energy stability+calibration accuracy below tenth of percent level.'

Physics requirements

- **Needed accuracy**
  - **for most physics studies $\Delta P/P=0.5\%$ (0.25%) sufficient; for precision measurements $\Delta P/P<0.1\%$ required**
- **Since polarization@IP = lumi-weighted polarization ≠ polarization@polarimeter**

→ ***Analysis of possible depolarization effects***

- **major component in beam-beam interaction:**
  - **spin precession (T-BMT)**
  - **spin-flip (Sokolov-Ternov) processes**
- **In the following: status report for deriving a method to calculate T-BMT in strong fields**

Spin precession

- **T-BMT equation:**

$$\frac{dS}{dt} = -\frac{e}{m\gamma}\left[(\gamma a+1)\boldsymbol{B}_T + (a+1)\boldsymbol{B}_L - \gamma(a+\frac{1}{\gamma+1})\beta \boldsymbol{e}_v \times \frac{\boldsymbol{E}}{c}\right] \times \boldsymbol{S},$$

  - **'a' is anomalous magnetic moment of electron a=(g-2) / 2=$\alpha/2\pi$ + ...**
  - **higher-order effect, radiative corrections to eeγ–vertex**
  - **experimentally measured up to accuracy of 10^{-11}**

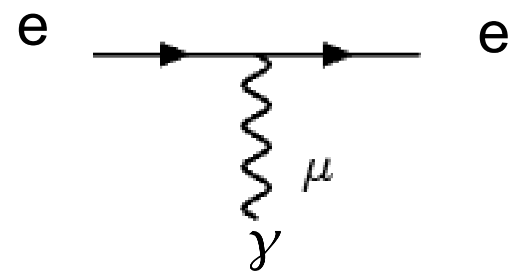
- **So far: used medthod in CAIN and Guinea-Pig**

Due to strong fields (beamstrahlung):

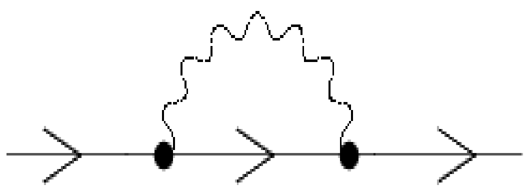
  - **' a' expressed as function of field in a medium**
  - **excellent work of V. Baier, V. Katkov**
  - **several approximations and assumptions have been made**

Anomalous magn. moment of e

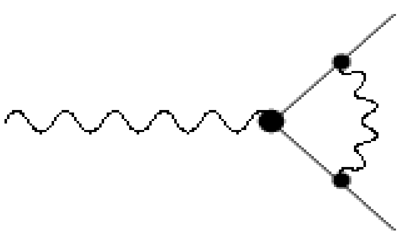
- **Contributions to the QED vertex**



at 1-loop order:



'self-energies
~mass corrections'



'vertex correction'
~decisive for an. magn. moment

vertex has impact on a, but has not been used in current method

Alternative to derive a in beam-beam

- **derive H in external field**
  - remember H-atom: spin-orbit term (l*s), interaction terms (B*s,B*l)
  - often A^2-terms neglected, important for strong fields (laser)
- **use Furry representation**
  - use explicit fermion operator in external field
  - 'usual' Feynman rules in perturbation theory
  - explicit fields in beam-beam zone required
  - straight forward.....but mathematically rather complex
- **status: not yet final results, but hopefully at EPAC08**
  - in collaboration with T. Hartin, also on ST-effect

Further news from workshops

- **1. @Cockcroft: Polarization models at LC**
  - excellent cross talk between machine+theory people
  - triggered further questions on QED in beam environment
  - suggestion of having a 'QED' workshop (maybe at Durham) to discuss the different approaches, estimates and used models
  - of course, such things are 'generic' LC items ....

Positron source @ Zeuthen

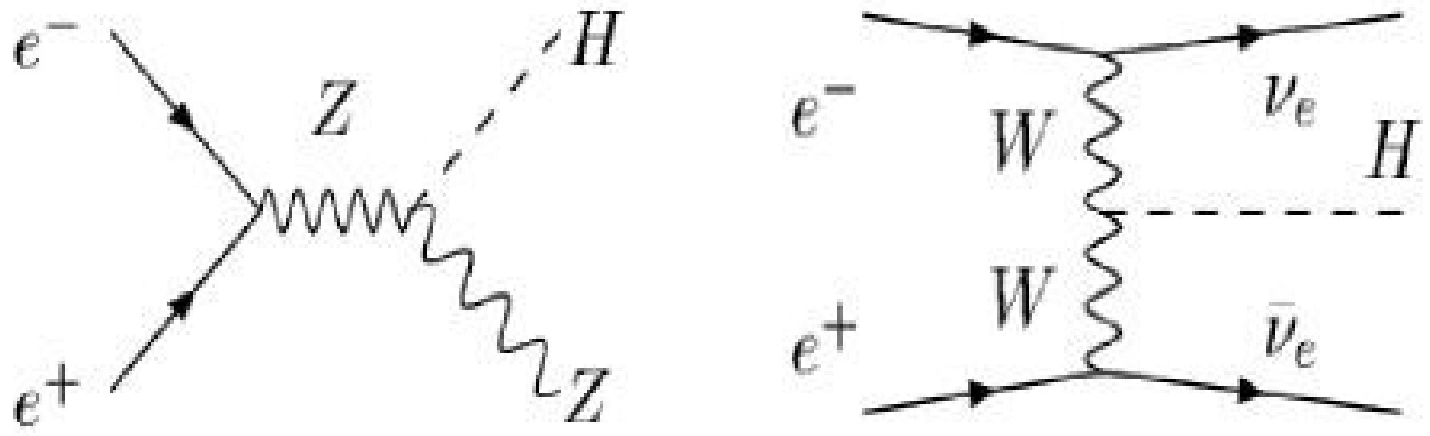
- **Shy concerns**
  - **excellent: Marc and Nick attended the meeting**
  - **important topic: costs**
  - **however, one should keep in mind that we need best ILC physics performance in order to be competitive to an LHC (SLHC?) from 2015 onwards.......**
- **all ILC physics should be seen on basis of possible LHC results!**

Determination of Higgs properties

- Expectations at the LHC:
  - Higgs mass: up to Δm_H =100-200 MeV
  - Higgs couplings: 15%-40% (with some model assumptions)
  - Higgs spin: challenging
- Expectations at the ILC:
  - at top threshold ($\sqrt{s}$=350 GeV) and at $\sqrt{s}$=500 GeV up to Δm_H=50 MeV !
  - absolute couplings: 1-5 %
  - Establishing of ew sym. breaking: triple Higgs couplings at 500 GeV up to 22%
  - Higgs spin: clear access via threshold scan
  - non-Standard Higgs properties: CP-properties
  - disentangling of light SUSY Higgs and SM Higgs via precision measurements of couplings

Higgs couplings

- Couplings determination: high rates and lumi needed



→ measurement of couplings in Higgs-strahlungs process at $\sqrt{s}$=350 GeV

→ beam polarization (80%,0) ⟶ (80%, 60%): improvement by about 30%

→ triple Higgs couplings: e.g. in HHZ at $\sqrt{s}$=500 up to 22% (unpolarized beams)

→ estimate: further gain of 30%-50% precision if both beams polarized

Optimization of ILC baseline

- **ILC baseline uses helical undulator**
  - even without any changes (since spin rotators and OMD collimator included): small polarization available 'for free'
  - about 30%
  - new simulations: if bunch compressor used, capture efficiency can be increased by factor 2 and polarization raises up to 45%!
- **Two choices:**
  - either flipping of helicity is required (either via solenoids, slow but ok for beginning or via kickers upstream DR)
  - or destroy polarization completely
- **Having LHC results in mind...... little efforts to exploit pol. e+ more useful**

Polarimetry+Energy workshop

- **Important topic: are both up- and downstream polarimeters required?**
  - **accuracy of <0.5% required**
  - **both polarimeters are complementary,....., needed**
- **Downstream:**
  - **access to depolarization**
- **Upstream:**
  - **higher counting rate, better time granularity**
- **Studies and executive summary for GDE under work for justifying both polarimeters**
  - **we need both!**

Physics @ calibration in push-pull

Baseline ILC includes Z-pole operation for detector calibration, but not for physics data. However, there are good arguments to use a modest (pre-GigaZ) Z-pole data sample, including calibration data, for

1. Polarimeter calibration. Can check luminosity-weighted polarization extrapolated from polarimeters with a physics-based measurement using the Blondel scheme from an A_{LR} measurement. (Can also check the A_{LR} result obtained against the SLD measurement.)
2. Energy spectrometer calibration. Z-pole mass determination from an energy scan can check the calibration. This was an important check at SLD and resulted in a small correction to the energy measurements.
3. Physics measurements. ILC luminosity at Z-pole should be $\sim 8 \cdot 10^{32} cm^{-2} s^{-1}$, which is ~40 times larger than at LEP and ~400 times larger than at SLC. Z-pole calibration data could be used to improve A_{LR} and many other Z-pole measurements. If this is successful, then a dedicated Z-pole run of at least a week will be desirable. And will be good preparation to evaluate capability for Giga-Z. Excellent polarimetry, energy and luminosity measurements will be needed for such a program.

➢ **strong motivation exists to include Z-pole operation for physics in ILC baseline!**

Use of Z-calibration data

- **Minimal changes to the baseline:**
  - **need 2 independent polarimeters**
  - **and 2 independent energy spectrometetrs during calibration**
  - **flipping kickers desirable**
  - **whether flipping via solenoid is sufficient is still under discussion**
- **But expectations:**

  The z-pole luminosity should be 7-8E32 (at 90 GeV CM), in comparison with nominal 2E34 at 500GeV CM. In one day of calibration data a factor 10 more zees will be produced than in the 100 days of SLD/SLC data taking.

  The z-pole calibration data at the ILC can result in a factor 5 or 6 smaller error on A_{lr} than achieved by SLD.
- **Specific short paper for research director under work**

Conclusion

- Polarization business exciting (cannot be stopped by Mason!)
- Undulator+target prototypes under active work at Daresbury and RAL
- Progress in theoretical description of depolarization effects
- Required: balance between cost and reduction of physics
  - ILC has to face possible LHC/SLHC results ....
  - physics requirements of parameter group should be fulfilled
  - frequent cross-talk between machine and physics people absolutely required
- Use of pol. e+ with 45% already with slightly changed baseline
- Use of Z-calibration data during push-pull with minor efforts