# Summary of the Polarisation Session

**10 November 2006, ECFA Workshop, Valencia**

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# Polarisation: Topics

- **Polarimetry at the IP**

- polarized **e+ source:**
  → GEANT4 with polarised processes:
  → E166 Status and results
  → target and radiation aspects

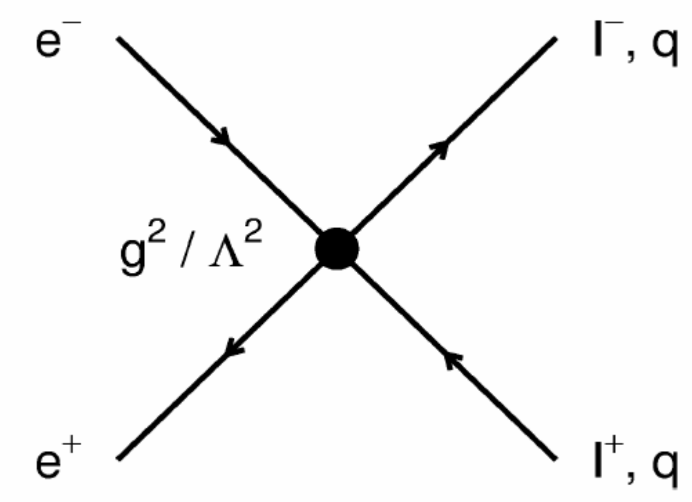
- **Physics studies:**
  Contactlike interactions
  radiative neutralino production

- **Undulator source → 30% e+ polarisation**
  can be kept with spin rotators:
  **Physics goal of $P_{e+}$ ~30**

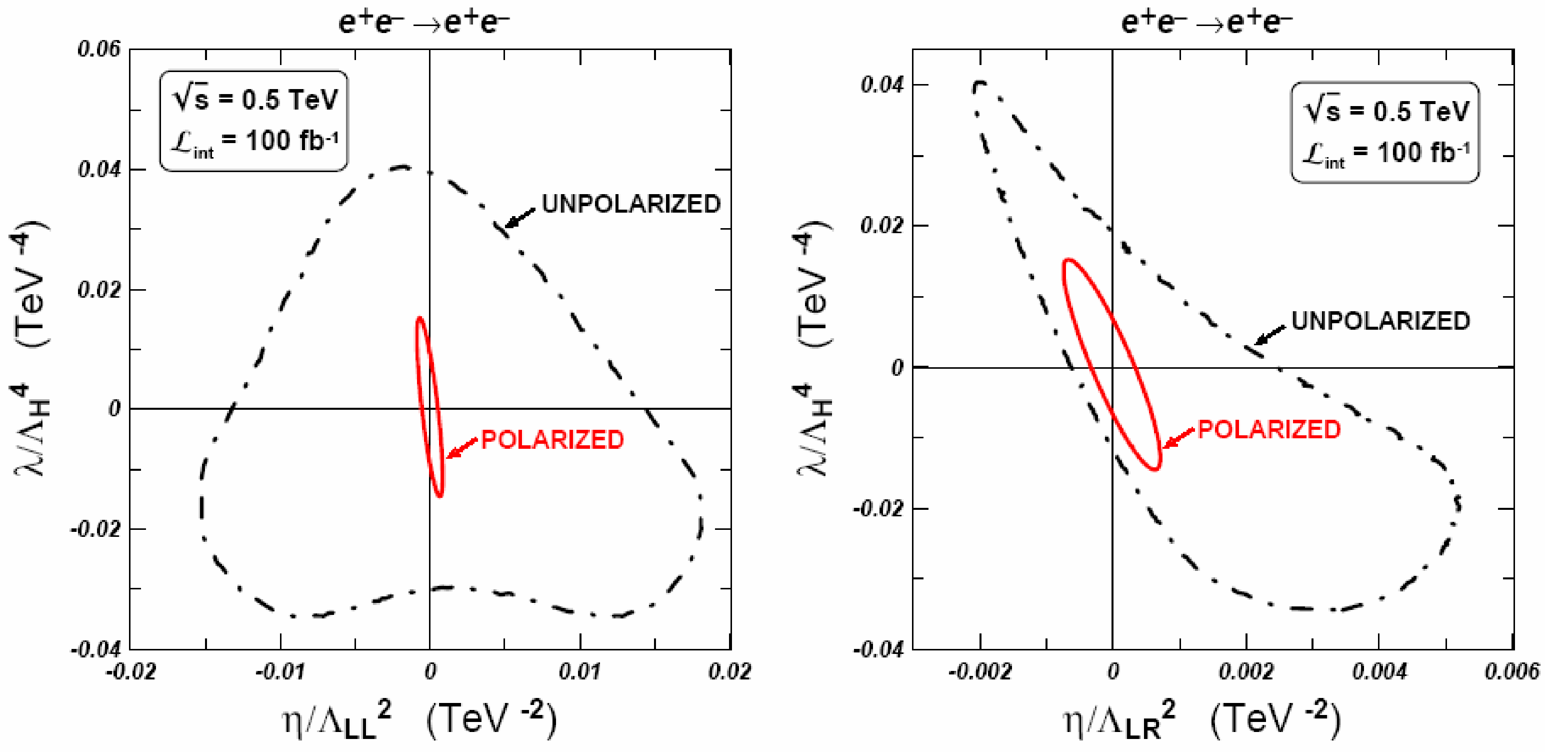
- Sensitivity to new physics ↔ deviations from predictions
- e+ polarisation enhances cross section → higher sensitivity ($N \sim [1+P_{e+}P_{e-}]$; smaller $\Delta P/P$)
- Identification of new physics

  e+ polarisation is essential → smaller region of confusion

$g/\Lambda$ → Z', leptoquarks, …

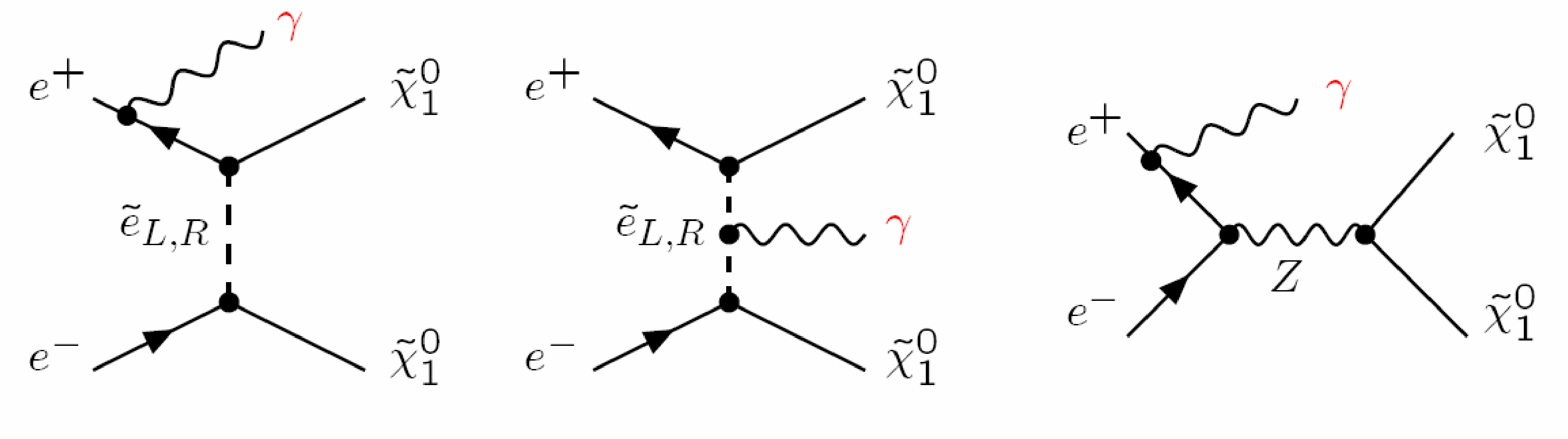


Two-dimensional projection of the 95% C.L. confusion region onto the planes $(\eta_{\rm LL}/\Lambda^2_{\rm LL},\ \lambda/\Lambda^4_H)$ (left panel) and $(\eta_{\rm LR}/\Lambda^2_{\rm LR}\ ,\ \lambda/\Lambda^4_H)$ (right panel) obtained from Bhabha scattering with unpolarized beams (dot-dashed curve) and with both beams polarized (solid curve).



# Olaf Kittel: Polarisation aspects in radiative neutralino production

$$e^+ + e^- \to \tilde{\chi}_1^0 + \tilde{\chi}_1^0 + \gamma$$




**Discovery of R-parity conserving SUSY particles:**

**indirect: missing energy**

**direct: pair production of neutralinos, charginos, sleptons**

**Process can be studied at ILC (not at LEP)**

## Significance $S$ for SPS 1a

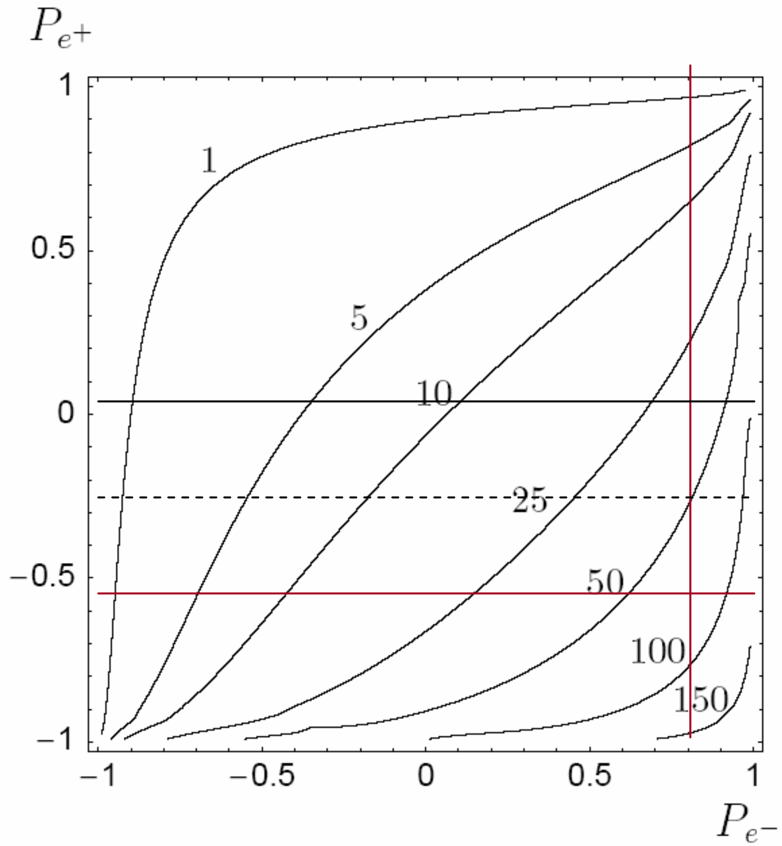
$$S = \frac{N_S}{\sqrt{N_S + N_B}} \quad \text{and} \quad N = \mathcal{L} \times \sigma$$

$$\Rightarrow S = \frac{\sigma}{\sqrt{\sigma + \sigma_B}} \sqrt{\mathcal{L}}$$

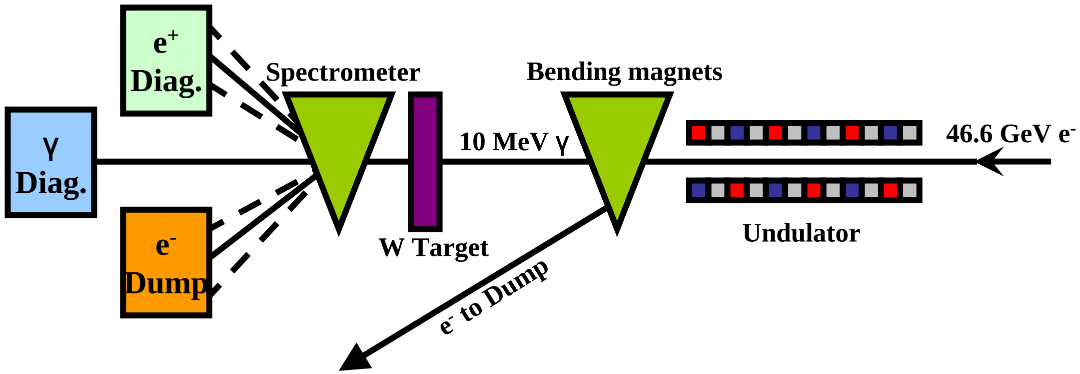
signal: $\sigma(e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \gamma) = 70$ fb

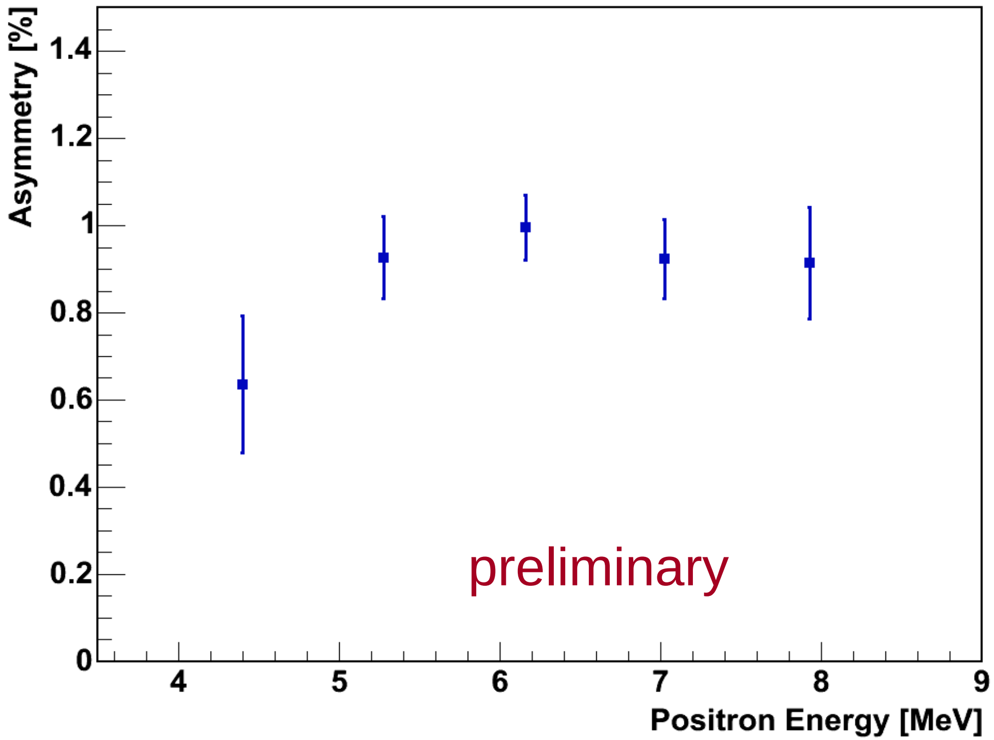
BG: $\sigma_B(e^+e^- \to \nu\bar{\nu}\gamma) = 330$ fb

$$\Rightarrow S = 80 \text{ and } \frac{N_S}{N_B} = \frac{1}{5}$$




These results should motivate detailed Monte Carlo studies!



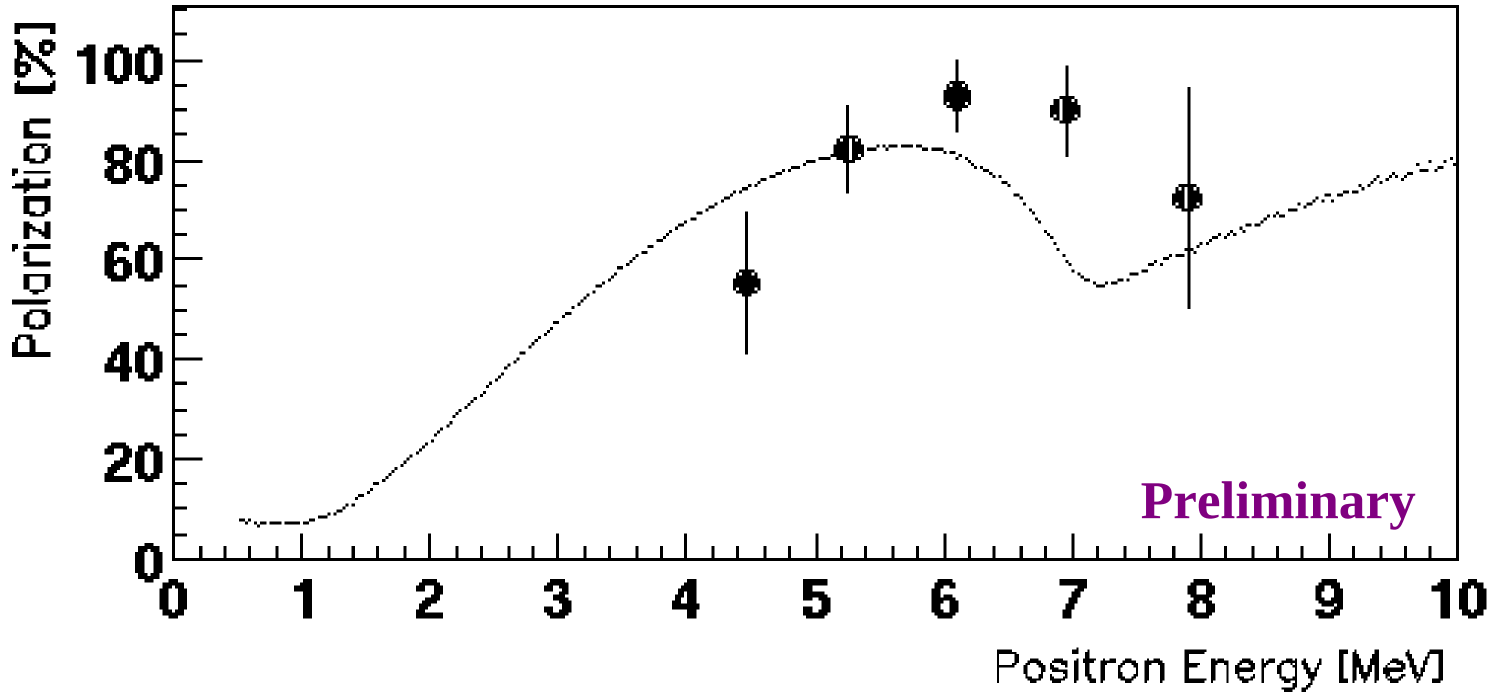




$$P_{e+} = \frac{Asy}{P_{e-} A_{e+}}$$

$$P_{e-} = 0.07$$

# Erez Reinherz-Aronis: Results from E166

- Analyzing power determined by simulations




- e+ polarisation between 50% and 90 % depending on e+ energy

# Andreas Schaelicke: Polarisation in GEANT4

- **Polarisation transfer**
  - in the E166 experiment
  - Target studies
- **Polarimetry at low energies**
- **Processes:**
  - Pair-production
  - Bremsstrahlung
  - Compton scattering
  - Moller/Bhabha scattering
  - Positron annihilation in flight

} QED

**Use matrix formalism → diff. xs, asymmetry, polarisation, depolarisation and polarisation transfer**

## Summary & Outlook

- New EM polarisation library
  - fits requirements for optimisation of ILC polarised positron source
  - general scheme based on Stokes vectors
  - focused on logitudinal and circular polarisation (in the moment)
  - describes polarisation transfer & asymmetry effects
  - included in Geant4 8.2 released in December
- Validation onging
  - independent calculation of polarised processes
  - comparison with EGS, and other software tools
  - data of the E166 experiment
- Future plans
  - continue in validation
  - work on efficiency optimisation
  - improve software framework (in cooparation with M.G.Pia)

G4 polarisation group:
R. Dollan, K. Laihem, T. Lohse, S. Riemann, A.S., A. Stahl, P. Starovoitov
in fruitful cooparation with V. Ivantchenko and M. Maire

# A. Ushakov: Radiation and Target Aspects

## Summary

UBS: undulator based source (150 GeV e-, Ti alloy)
CS: conventional source (6.2 GeV e-, W-Re target)

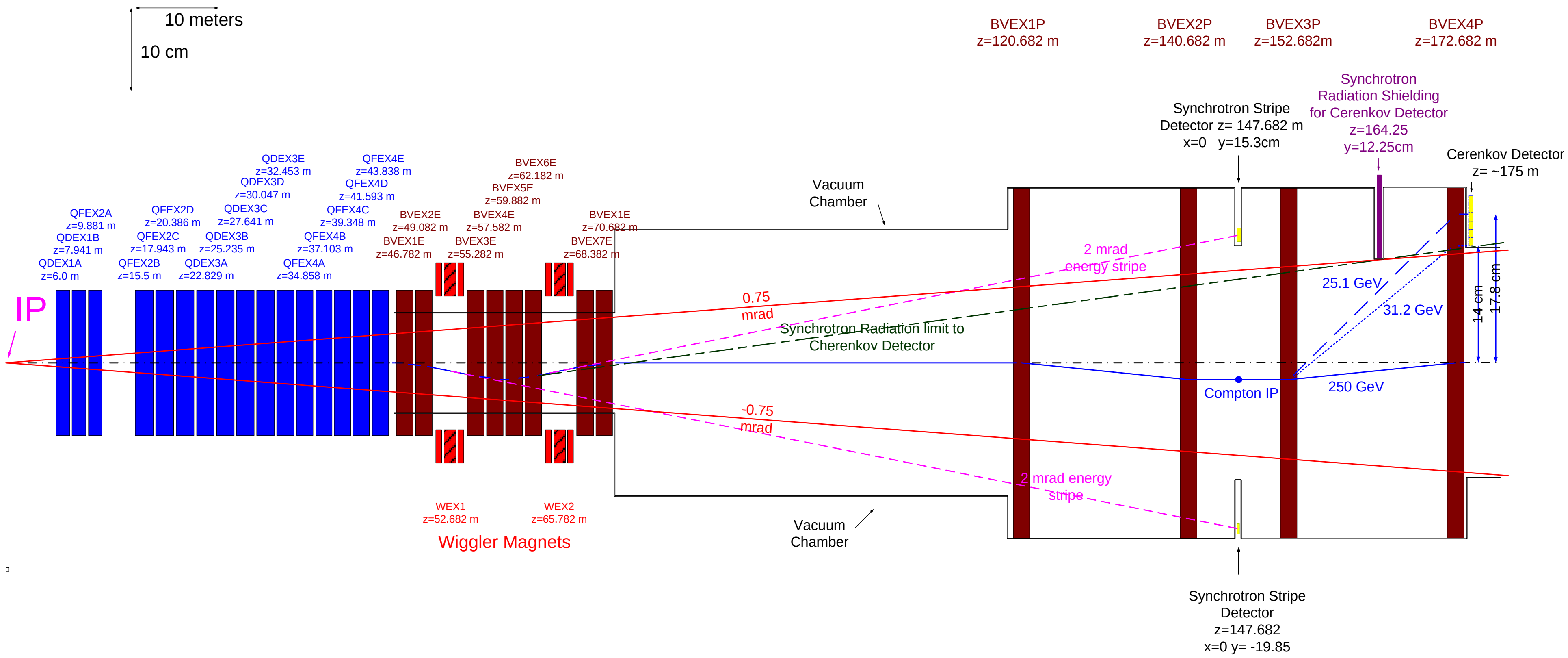
| Source type | UBS | CS |
|---|---|---|
| Total energy deposition, kW | 6.89 | 47.44 |
| Maximal energy deposition density, $kW/cm^3$ | 145.4 | 346.8 |
| Maximal dpa (by neutrons, after 5000h), $dpa/cm^3$ | 2.68 | 0.85 |
| Target activation after 5000 h, GBq | 3344 | 31302 |
| Dose rate after 1 week shutdown, mSv/h | 155.8 | 489.7 |

Simulations done with FLUKA, SPECTER

# Ken Moffeit et al.: Performance of 14 mrad Extraction Line at 500 GeV and 1 TeV

## Energy Chicane

## Polarimeter Chicane



# Ken Moffeit: Conclusions

0.5 TeV CMS

- Performance of Polarimeter Meets Goals

1 TeV CMS

- Performance of Polarimeter Meets Goals
- Large background from scattered synchrotron radiation photons at the Cherenkov Detector
- Concern about large beam losses for Low Power beam parameters

# Ken Moffeit: Conclusions

## 14 mrad extraction line 0.5 TeV CMS

•Core of beam within +-100microns has 48% of the beam.

•The polarization projection at the Compton IP is in good agreement with the luminosity weighted polarization at the e+e- interaction region. A precision measurement of +-0.25% will be possible.

•No beam losses from e+e- IR to Compton detector plane out of 17.6 million beam tracks for Normal ILC and Large-y beam parameter data sets. The Low Power beam parameter data set has losses of 1.1 * $10^{-4}$.

•The collimator at z=164.25 meters needs to be designed. It absorbs the synchrotron radiation above the 0.75 mrad beam stay clear allowing the Cherenkov detector to begin at y~14 cm. Background from scattered synchrotron radiation occurs at the Cherenkov detector and will require careful design of the collimation and shielding.

•Performance of Polarimeter Meets Goals

# Ken Moffeit: 14 mrad extraction line 1 TeV CMS

•Core of beam within +-100microns has 43% of the beam. The large-y and low power parameter data sets have a lower Compton luminosity by a factor 2.

•The polarization projection at the Compton IP is in good agreement with the luminosity weighted polarization at the e+e- interaction region. A precision measurement of +-0.25% will be possible.

•Beam losses of $1.8*10^{-5}$ occur between the e+e- IR and the Compton detector plane for the Normal ILC beam parameter data set. Beam losses are also small but not negligible for the Large-y beam parameter data set. There are large losses of 0.53% of the beam for the Low Power beam parameter data set that will require insertion of a new collimator between the e+e- IR and the Compton detector plane or an increase in the beam stay clear from 0.75 mrad.

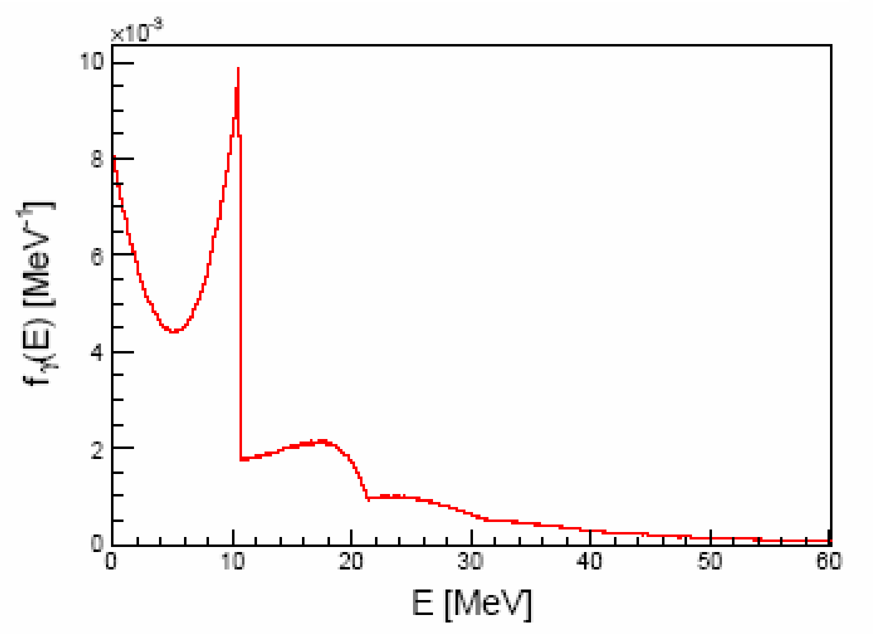
•The collimator at z=164.25 meters absorbs the synchrotron radiation above the 0.75 mrad beam stay clear allowing the Cherenkov detector to begin at y~14 cm. Background from scattered synchrotron radiation is very large at the Cherenkov detector and will require careful design of the collimation and shielding.

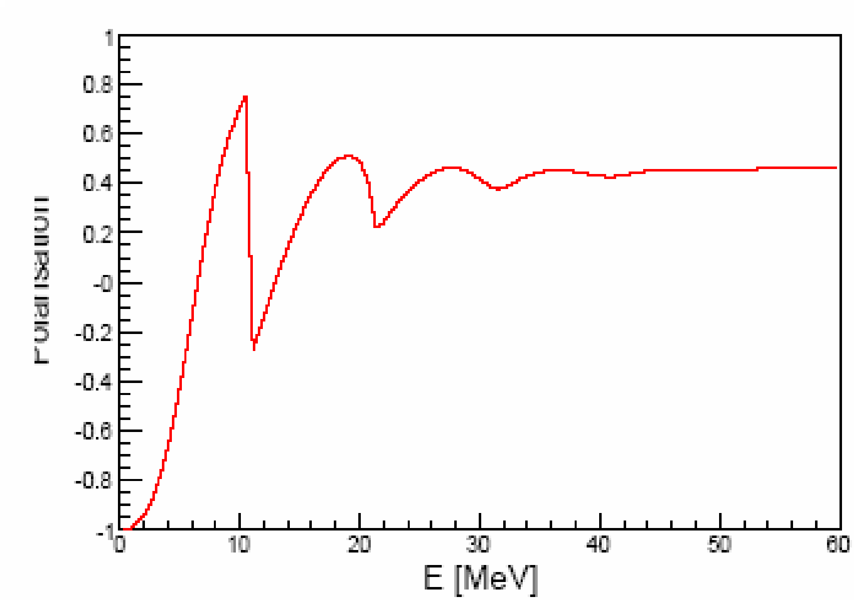
•Performance of Polarimeter Meets Goals
•Background from scattered synchrotron radiation photons at the Cherenkov Detector
•Concern about large beam losses for Low Power beam parameters

# Jenny List: Detector development for High Energy Polarimetry

- Polarimetry at the ILC is supposed to be at least a factor 2 more precise than what exists up to now
- activities up to now: design of chicane, laser, position in machine, backgrounds, spin transport...
- new effort just starting up: investigate Čerenkov detector
  - goal: make sure that necessary precision can be achieved
  - revisit design
  - test different types of photo detectors
  - detailed simulations
  - build prototype

## With the helical undulator e+ source we could have **both beams polarised**




avarage e+ polarisation:

≈30%

# Summary table of POWER report: Tab 4.1

- Comparison with (80%,0): estimated gain factor when

| Case | Effects for $P(e^-) \longrightarrow P(e^-)$ and $P(e^+)$ | Gain& Requirement — most (80%, 60%) | (80%, 30%) |
|---|---|---|---|
| **Standard Model:** | | | |
| top threshold | Electroweak coupling measurement | factor 3 | gain factor 2 |
| $t\bar{q}$ | Limits for FCN top couplings improved | factor 1.8 | gain factor 1.4 |
| CPV in $t\bar{t}$ | Azimuthal CP-odd asymmetries give | $P^{\mathrm{T}}_{e^-}P^{\mathrm{T}}_{e^+}$ required | $P^{T}_{e-}\ P^{T}_{e+}$ required |
| | access to S- and T-currents up to 10 TeV | | factor 1.3 worse |
| $W^+W^-$ | Enhancement of $\frac{S}{B}$, $\frac{S}{\sqrt{B}}$ | up to a factor 2 | |
| | TGC: error reduction of $\Delta\kappa_\gamma$, $\Delta\lambda_\gamma$, $\Delta\kappa_Z$, $\Delta\lambda_Z$ | factor 1.8 | |
| | Specific TGC $\tilde{h}_+ = \mathrm{Im}(g_1^{\mathrm{R}} + \kappa^{\mathrm{R}})/\sqrt{2}$ | $P^{\mathrm{T}}_{e^-}P^{\mathrm{T}}_{e^+}$ required | $P^{T}_{e-}\ P^{T}_{e+}$ required |
| CPV in $\gamma Z$ | Anomalous TGC $\gamma\gamma Z, \gamma ZZ$ | $P^{\mathrm{T}}_{e^-}P^{\mathrm{T}}_{e^+}$ required | |
| $HZ$ | Separation: $HZ \leftrightarrow H\bar{\nu}\nu$ | factor 4 | gain factor 2 |
| | Suppression of $B = W^+\ell^-\nu$ | factor 1.7 | |
| $t\bar{t}H$ | Top Yukawa coupling measurement at $\sqrt{s} = 500$ GeV | factor 2.5 | gain factor 1.6 |

# Summary table of POWER report: Tab 4.1

- Estimated gain factor when only $P(e+)=30\%$

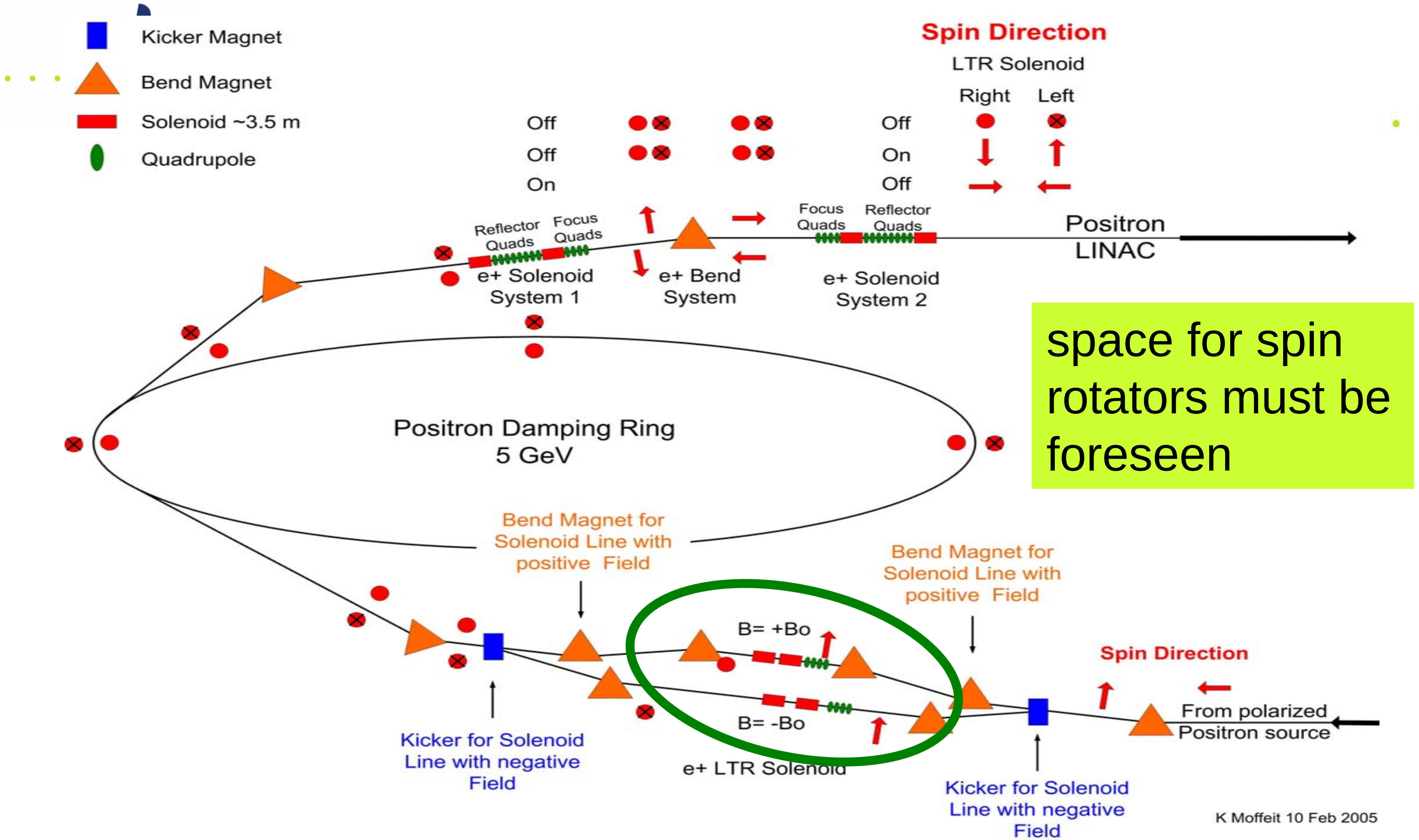
| Case | Effects for $P(e^-) \longrightarrow P(e^-)$ and $P(e^+)$ | Gain& Requirement |
|---|---|---|
| **Supersymmetry:** | | |
| $\tilde{e}^+\tilde{e}^-$ | Test of quantum numbers L, R | $P_{e^+}$ required |
| | and measurement of $e^\pm$ Yukawa couplings | |
| $\tilde{\mu}\tilde{\mu}$ | Enhancement of $S/B$, $B = WW$ | factor 5-7 |
| | $\Rightarrow m_{\tilde{\mu}_{L,R}}$ in the continuum | |
| $HA$, $m_A > 500$ GeV | Access to difficult parameter space | factor 1.6 |
| $\tilde{\chi}^+\tilde{\chi}^-$, $\tilde{\chi}^0\tilde{\chi}^0$ | Enhancement of $\frac{S}{B}$, $\frac{S}{\sqrt{B}}$ | factor 2–3 |
| | Separation between SUSY models, | |
| | 'model-independent' parameter determination | |
| CPV in $\tilde{\chi}^0_i\tilde{\chi}^0_j$ | Direct CP-odd observables | $P^T_{e^-} P^T_{e^+}$ required |
| RPV in $\tilde{\nu}_\tau \rightarrow \ell^+\ell^-$ | Enhancement of $S/B$, $S/\sqrt{B}$ | factor 10 with LL |
| | Test of spin quantum number | |

$P_{e+}$ required
factor <2 worse

**With (80%, 30%) we expect a gain up to 2 compared to (80% ; 0%)**

# Summary & Conclusion

- Group covers wide range of physics, production and measurement of e+ polarisation
- With an undulator also the e+ beam is polarized!
  ➔ we could have a polarized machine from the beginning!
- To explore the polarisation spin rotators before (LTR) and after the DR (RTL) are needed (see SLAC-TN-05-045, EUROTeV-Report-2005-024-1)
  (spin-flip: pulse-to-pulse ?!)
- Polarimetry of e- and e+ at the IP
- Physics goal of 30% e+ polarisation:
  remember: first TESLA studies were done also with a 60/40 option; already 30% polarisation help to suppress background processes estimated improvement: factor ~2
- details will be now considered




Layout of positron damping ring system showing the parallel spin rotation beam lines for randomly selecting positron polarization direction. A pair of kicker magnets is turned on between pulse-trains to deflect the beam to the spin rotation solenoids with negative B-field.

# Summary table of POWER report: Tab 4.1

- Estimated gain factor when only P(e+)=30%

| Case | Effects for $P(e^-) \longrightarrow P(e^-)$ and $P(e^+)$ | Gain& Requirement |
|---|---|---|
| **Extra Dimensions:** | | |
| $G\gamma$ | Enhancement of $S/B$, $B = \gamma\nu\bar{\nu}$, | factor 3 |
| $e^+e^- \to f\bar{f}$ | Distinction between ADD and RS models | $P^T_{e^-} P^T_{e^+}$ required |
| **New gauge boson Z′ :** | | |
| $e^+e^- \to f\bar{f}$ | Measurement of $Z'$ couplings | factor 1.5 |
| **Contact interactions:** | | |
| $e^+e- \to f\bar{f}$ | Model independent bounds | $P_{e^+}$ required |
| **Precision measurements of the Standard Model at GigaZ:** | | |
| $Z$-pole | Improvement of $\Delta \sin^2\theta_W$ | $\sim$ factor 10 |
| | Improvement of Higgs bounds | $\sim$ factor 10 |
| | Constraints on CMSSM parameter space | factor 5 |
| CPV in $Z \to b\bar{b}$ | Enhancement of sensitivity | factor 3 |

**To do !**