## Physics case for polarized $e^+$ with $P(e^+) = 60\%$ and $30\%$[1]

- To exploit the effects of transversely polarized beams the polarization of both beams is required, otherwise all effects at leading order from transverse polarization vanish for $m_e \to 0$ (suppression by $m_e/\sqrt{s}$) .
- In processes, where only (axial-) vector interactions are contributing in $e^+e^-$ annihilation, the dependence on beam polarization of the cross section can be expressed via the unpolarized cross section, the left-right asymmetry $A_{\rm LR}$ and two polarization dependent factors, the effective polarization ($P_{\rm eff} = [P_{e^-} - P_{e^+}]/[1 - P_{e^-}P_{e^+}]$) and the effective luminosity ($\mathcal{L}_{\rm eff} = \frac{1}{2}[1 - P_{e^-}P_{e^+}]\mathcal{L}$ with $\mathcal{L}_{\rm eff}/\mathcal{L}$ reflecting the number of interacting particles). The ratio of colliding and interacting particles is given by $\frac{1}{2}$ for unpolarized positrons and can only be enhanced if $P_{e^+}$ is available.

[1] more details, see G. Moortgat-Pick et al., hep-ph/0507011; updated version and an executive summary accessible at www.ippp.dur.ac.uk/~gudrid/power

| $(P(e^-), P(e^+))$ | Effects for $P(e^-) \longrightarrow P(e^-)$ and $P(e^+)$ | Gain w.r.t. (80%,0%)& Requirement (90%,0) | (80%,60%) | (80%,30%) |
|---|---|---|---|---|
| **Statistics:** | | | | |
| $P_{\rm eff}$ | V,A processes | 90% | 95% | 94% |
| $\mathcal{L}_{\rm eff}/\mathcal{L}$ | # of interacting particles | – | $\times 1.5$ | $\times 1.2$ |
| $\Delta A_{LR}/A_{LR}$ | due to error propagation | 0 | $\times 3$ | $\times 2$ |
| **Standard Model:** | | | | |
| top threshold | Electroweak coupling measurement | 0 | $\times$ 3 | $\times$ 2 |
| $t\bar{q}$ | Limits for FCN top couplings improved | | $\times$ 1.8 | $\times$ 1.4 |
| CPV in $t\bar{t}$ | Azimuthal CP-odd asymmetries give access to S- and T-currents up to 10 TeV | – | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}$ | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}\times 0.8$ |
| $W^+W^-$ | TGC: error reduction of $\Delta\kappa_\gamma$, $\Delta\lambda_\gamma$, $\Delta\kappa_Z$, $\Delta\lambda_Z$ | ? | $\times 1.8$ | ? |
| | Specific TGC $\tilde{h}_+ = {\rm Im}(g_1^{\rm R} + \kappa^{\rm R})/\sqrt{2}$ | – | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}$ | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}\times ?$ |
| CPV in $\gamma Z$ | Anomalous TGC $\gamma\gamma Z$, $\gamma ZZ$ | – | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}$ | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}\times ?$ |
| $HZ$ | Separation: $HZ \leftrightarrow H\bar{\nu}\nu$ | ? | $\times 4$ | $\times$ 2 |
| | Suppression of $B = W^+\ell^-\nu$ | ? | $\times 1.7$ | ? |
| $t\bar{t}H$ | Top Yukawa coupling at $\sqrt{s} = 500$ GeV | ? | $\times 2.5$ | $\times 1.6$ |
| **Supersymmetry:** | | | | |
| $\tilde{e}^+\tilde{e}^-$ | Quantum numbers L, R and Yukawa | – | $P_{e^-}P_{e^+}$ | $P_{e^-}P_{e^+}\times 0.6$ |
| $\tilde{\mu}\tilde{\mu}$ | $S/B$, $B = WW \to \Delta m_{\tilde{\mu}_{\rm L,R}}$ in cont. | ? | $\times$5-7 | ? |
| $HA$, $m_A > 500$ GeV | Access to difficult parameter space | ? | $\times 1.6$ | ? |
| CPV in $\tilde{\chi}^0_i\tilde{\chi}^0_j$ | Direct CP-odd observables | – | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}$ | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}\times ?$ |
| RPV in $\tilde{\nu}_\tau \to \ell^+\ell^-$ | Test of spin: $S/B$, $S/\sqrt{B}$ | ? | $\times 10$ | ? |
| **Extra Dimensions:** | | | | |
| $G\gamma$ | Enhancement of $S/B$, $B = \gamma\nu\bar{\nu}$, | ? | $\times 3$ | ? |
| $e^+e^- \to f\bar{f}$ | Unique distinction ADD vs. RS | – | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}$ | $P^{\rm T}_{e^-}P^{\rm T}_{e^+}\times 0.5$ |
| **New gauge boson Z′ :** | | | | |
| $e^+e^- \to f\bar{f}$ | Measurement of $Z'$ couplings | ? | $\times 1.5$ | ? |
| **Contact interactions:** | | | | |
| $e^+e- \to e\bar{e}$ | Model independent bounds | – | $P_{e^-}P_{e^+}$ | $P_{e^-}P_{e^+}\times ?$ |
| **Precision measurements of the Standard Model at GigaZ:** | | | | |
| $Z$-pole | Improvement of $\Delta\sin^2\theta_W$ | ? | $\times$ 10 | $\times$5 (?) |
| | Improvement of Higgs bounds | ? | $\times 10$ | ? |
| | Constraints on CMSSM parameter space | ? | $\times 5$ | ? |

Summary table: the case of having both beams polarized is compared with the case of using only polarized electrons with $(|P_{e^-}|, |P_{e^+}|) = (80\%, 0\%)$; B (S) denotes background (signal); CPV (RPV) means CP (R-parity) violation, FCN means flavour changing courrents, TGC denotes triple gauge couplings. details see Polarization report and references therein.