Short remark on helicity reversal

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ILC Positron Source Group Meeting, DESY Zeuthen

Outline

- Strong physics case for running ILC after years of LHC operation
- polarized positrons will broaden the ILC physics potential

Current status: $P_{e+} \approx 30\%$ (or even more, see Andriy's talk yesterday)

- ➢ use the ≥30% for physics
  remember: first NLC and TESLA physics studies were done with $P_{e-} = 60\%$, $P_{e+} = 40\%$!!
- ➢ need fast helicity reversal

RDR: Running Strategy

Physics between 200 GeV and 500 GeV

Luminosity: Year 1-4: $L_{int} = 500\ fb^{-1}$

1. year	10%:		$L_{int} \approx 50\ fb^{-1}$
2. year	30%:	+ $100\ fb^{-1}$	$L_{int} \approx 150\ fb^{-1}$
3. Year	60%:	+ $150\ fb^{-1}$	$L_{int} \approx 300\ fb^{-1}$
4. year	100%:	+ $200\ fb^{-1}$	$L_{int} \approx 500\ fb^{-1}$

➔ ee→HZ	at 350 GeV (mH≈120 GeV)	few 10^4
ee→ tt	at 350 GeV	10^5
ee → qq (μμ)	at 500 GeV	$5 \cdot 10^5$ ($1 \cdot 10^5$)
ee → WW	at 500 GeV	10^6

➔ statistical uncertainties at per-mille level !!

Uncertainties: $$\Delta\sigma \propto \frac{1}{\sqrt{N}} \oplus \frac{\Delta L}{L} \oplus \frac{\Delta P}{P} \longrightarrow O(10^{-3})$$

s-channel cross sections with pol e+ beams

Can perform independent measurements (s-channel vector exch.)

$$\sigma_{++} = \sigma_u \left[1 - P_{e^+} P_{e-} + A_{LR}\left(+P_{e^+} - P_{e-}\right)\right]$$

$$\sigma_{--} = \sigma_u \left[1 - P_{e^+} P_{e-} + A_{LR}\left(-P_{e^+} + P_{e-}\right)\right]$$

=0 (SM) if both beams 100% polarized

$$\sigma_{-+} = \sigma_u \left[1 + P_{e^+} P_{e-} + A_{LR}\left(-P_{e^+} - P_{e-}\right)\right]$$

$$\sigma_{+-} = \sigma_u \left[1 + P_{e^+} P_{e-} + A_{LR}\left(+P_{e^+} + P_{e-}\right)\right]$$

Standard Model
s-channel

SLC: $P_{e+,} = 0$

$$\sigma_{-} = \sigma_u \left[1 + A_{LR}\left(-P_{e-}\right)\right]$$

$$\sigma_{+} = \sigma_u \left[1 + A_{LR}\left(+P_{e-}\right)\right]$$

ILC with e+ polarization ➔ Cross section enhancement ~$(1+P_{e-}P_{e+})$
For (80%, ~30%) → 25% gain in luminosity

s-channel asymmetries with pol e+ beams

Can perform 4 independent measurements (s-channel vector exch.)

$$\sigma_{++} = \sigma_u \left[1 - P_{e^+} P_{e-} + A_{LR}\left(+P_{e^+} - P_{e-}\right)\right]$$
$$\sigma_{--} = \sigma_u \left[1 - P_{e^+} P_{e-} + A_{LR}\left(-P_{e^+} + P_{e-}\right)\right]$$

=0 (SM) if both beams 100% polarized

$$\sigma_{-+} = \sigma_u \left[1 + P_{e^+} P_{e-} + A_{LR}\left(-P_{e^+} - P_{e-}\right)\right]$$
$$\sigma_{+-} = \sigma_u \left[1 + P_{e^+} P_{e-} + A_{LR}\left(+P_{e^+} + P_{e-}\right)\right]$$

Standard Model
s-channel

SLC: σ_{-0} and σ_{+0} used for A_{LR} measurement

$$A_{LR} = \frac{\sigma_- - \sigma_+}{\sigma_- + \sigma_+} \cdot \frac{1}{P_{e^-}}$$

ILC:

$$A_{LR} = \frac{\sigma_{-+} - \sigma_{+-}}{\sigma_{-+} + \sigma_{+-}} \cdot \frac{1 + P_{e^-} P_{e^+}}{P_{e^-} + P_{e^+}}$$
$$= \frac{\sigma_{-+} - \sigma_{+-}}{\sigma_{-+} + \sigma_{+-}} \cdot \frac{1}{P_{eff}}$$

Error propagation:

➔ $$\frac{\Delta P_{eff}}{P_{eff}} < \frac{\Delta P_e}{P_e}$$

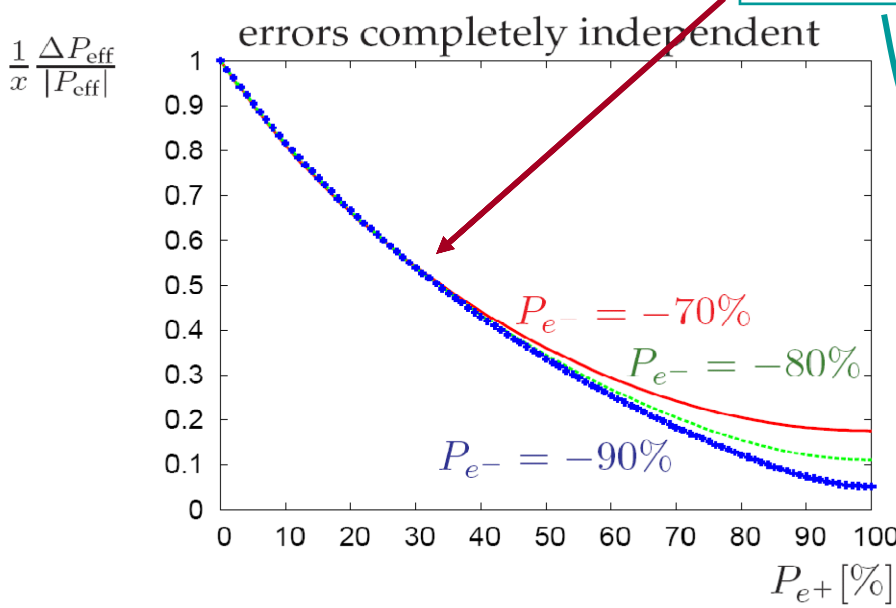
Δ P_{eff}

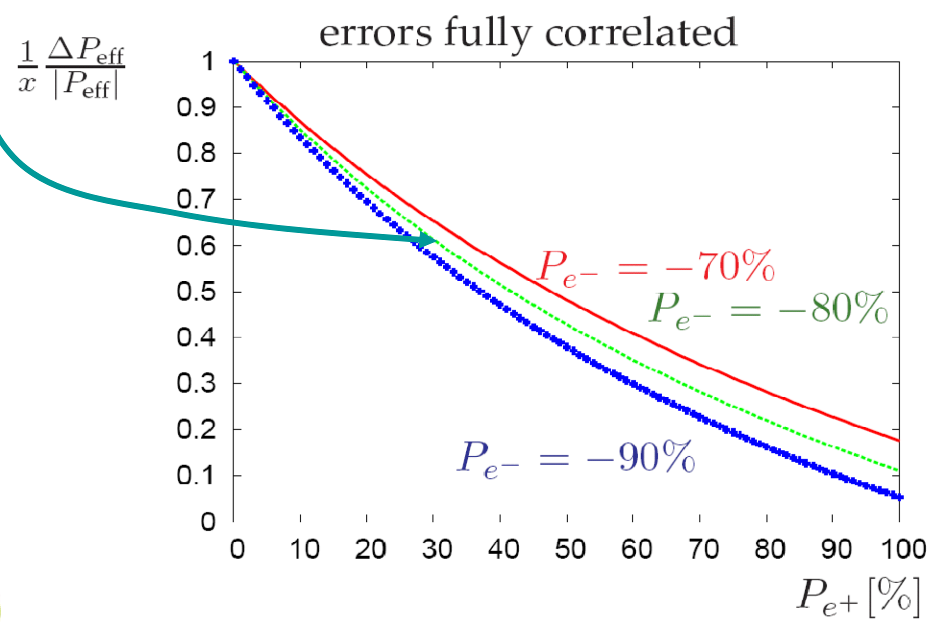
- Decrease of error on $P_{eff}=(P_{e-} + P_{e+})/(1+P_{e-} P_{e+})$

$$\frac{\Delta P_{eff}}{P_{eff}} = x \frac{\sqrt{\left(1-P_{e^+}^2\right)^2 P_{e^-}^2 + \left(1-P_{e^-}^2\right)^2 P_{e^+}^2}}{\left(P_{e^+}+P_{e^-}\right)\left(1+P_{e^+}P_{e^-}\right)}$$

$$x \equiv \frac{\Delta P_{e^-}}{P_{e^-}} = \frac{\Delta P_{e^+}}{P_{e^+}}$$

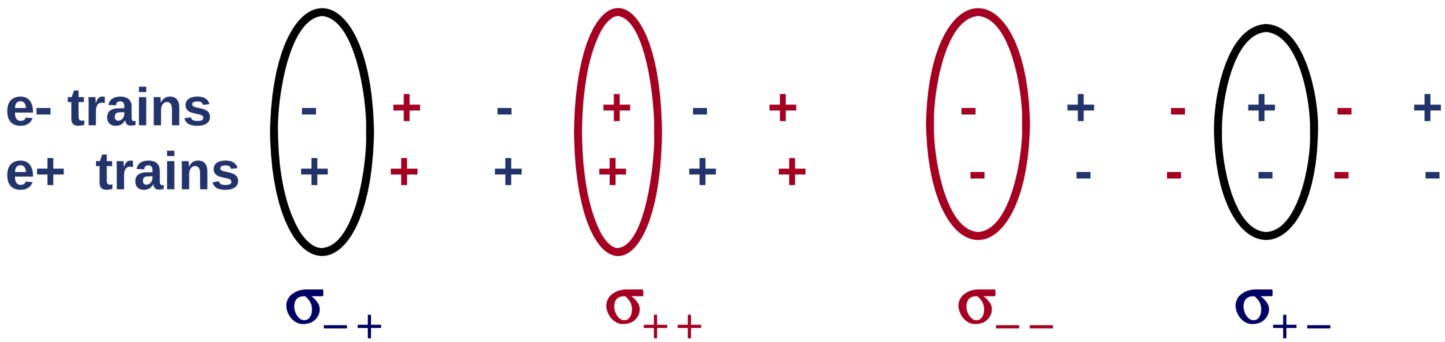
30%: Improvement by factor 2 (1.5)





e+ Helicity Reversal

e+ helicity flip less frequent than e- helicity reversal ?!



50% spent to ‘inefficient’ helicity pairing σ_{--} and σ_{++}

➔ gain due to xs enhancement for J=1 processes with e+ pol is lost

Improvement of ΔP_{eff} remains

But:
- systematic errors have to be known and small
- time dependent intensity/polarisation tolerances should be small
- $P_{e-} \cdot P_{e+}$ ⇔ need to understand correlations

No reversal could be worse than no e+ polarization!!

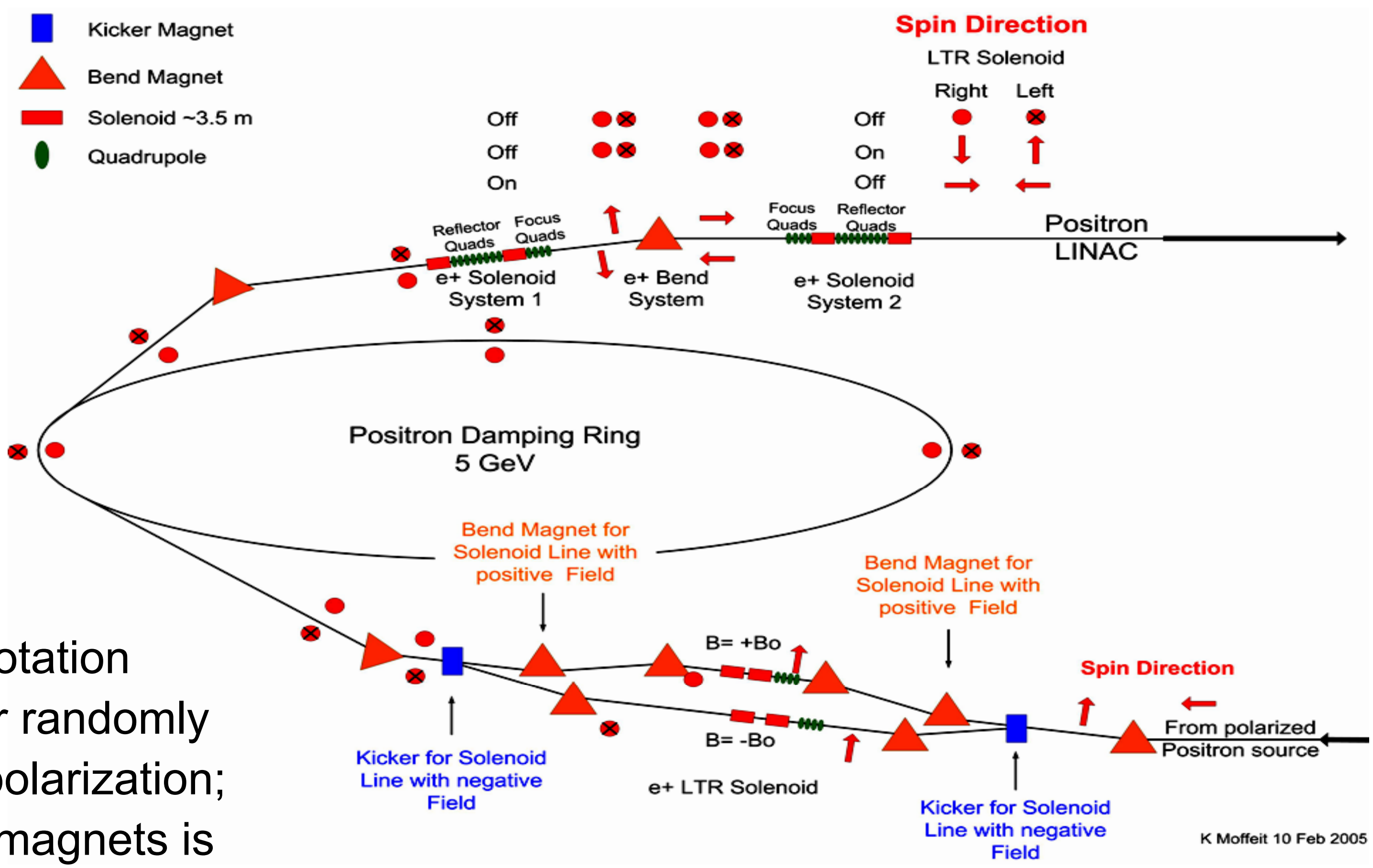
no reversal → no effective polarization, P_{eff}
→ larger uncertainty of polarization
(syst. effects, error propagation)

Even if Pe+ = 0 you must have a high energy polarimeter
(…PRECISION !!…)

Small polarization → no physics gain but more complicated measurement / analysis → less precision

Design proposals exist

K. Moffeit et al., SLAC-TN-05-045 → fast reversal before DR (5 GeV)



parallel spin rotation beam lines for randomly selecting e+ polarization; pair of kicker magnets is turned on between pulse-trains

Design proposals exist

New proposal: K. Moffeit, M. Woods

- Fast reversal at ~125 MeV
- Sent to Sendai Meeting
- See Ken’s talk in joint session with E/P Workshop

Summary

ILC undulator based source → polarized positrons (≥30%)

we must include this in further studies and should try to find cost effective solutions to keep e+ polarization for physics

consequences for design:

- **e+ polarization has to be taken into account**
- **e+ polarization has to be measured (in any case)**
- **helicity has to be reversable**

Helicity reversal frequency:

desired:

- **same flip frequency as for electrons should be possible**
- **independent flip**
- **Impact on machine looks small**

→ well prepared for LHC physics results

Details of polarization must be considered in collaboration with polarization at IP (measurement, stability, etc.)

→ See also Workshop on Energy and Polarization Measurement at IP