## Rotators: the T-BMT equation.

$$\frac{d\vec{S}}{ds} = \vec{\Omega} \times \vec{S}$$

- Dipole rotators: in transverse fields:

$$\delta\theta_{spin} = a\gamma \cdot \delta\theta_{orbit}$$

$a = (g-2)/2$ where $g$ is the electron $g$ factor.

At 27.5 GeV $a\gamma = 62.5$

===>Suitable for high energy

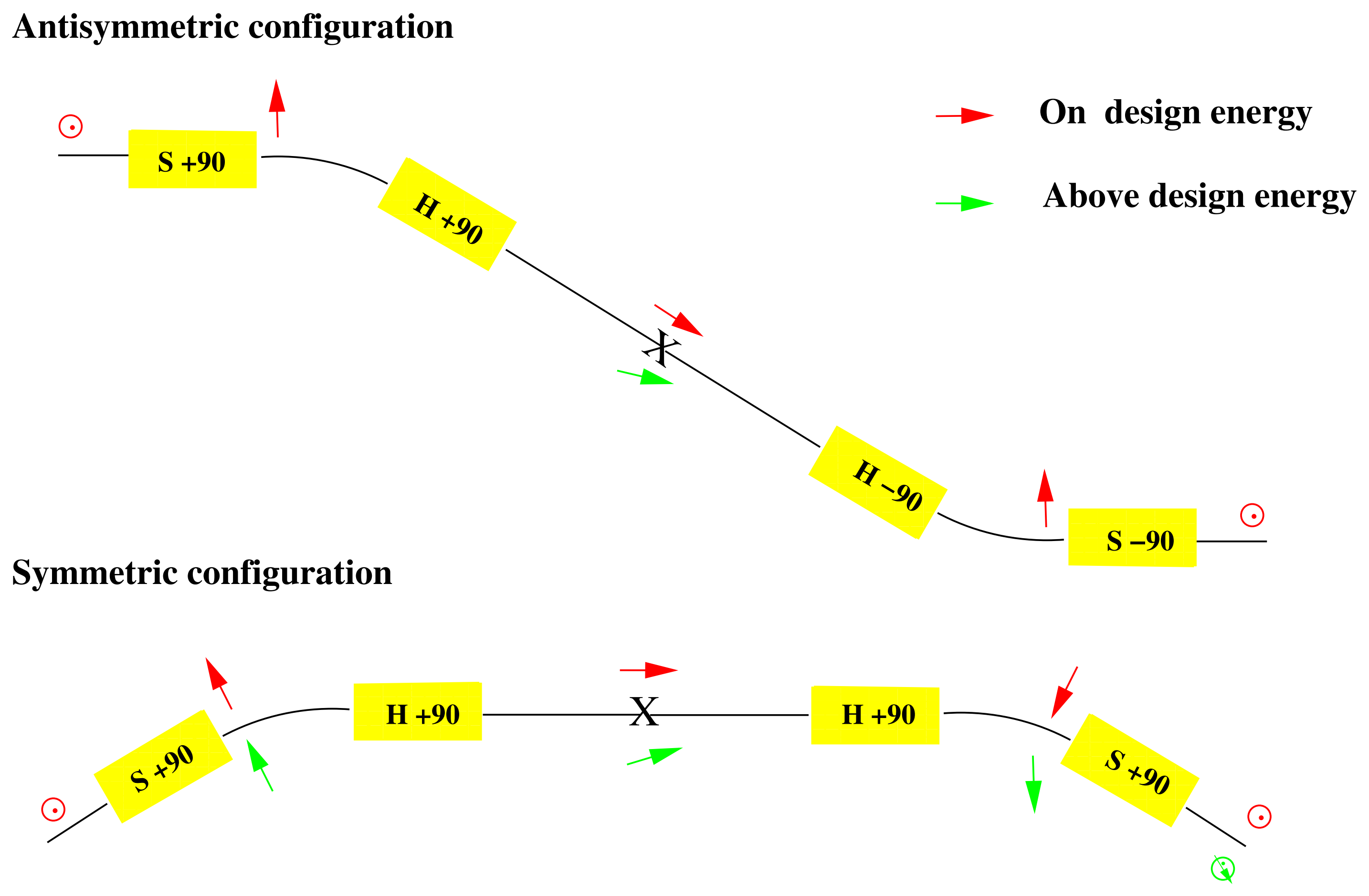
- Solenoid rotators:

$$\delta\theta_{spin} \propto \frac{B_{\mathrm{long}}}{E}$$

===>Only suitable for low energy.

. Also nontrivial spin–orbit coupling.

# Solenoid spin rotators (from above): best at low energy



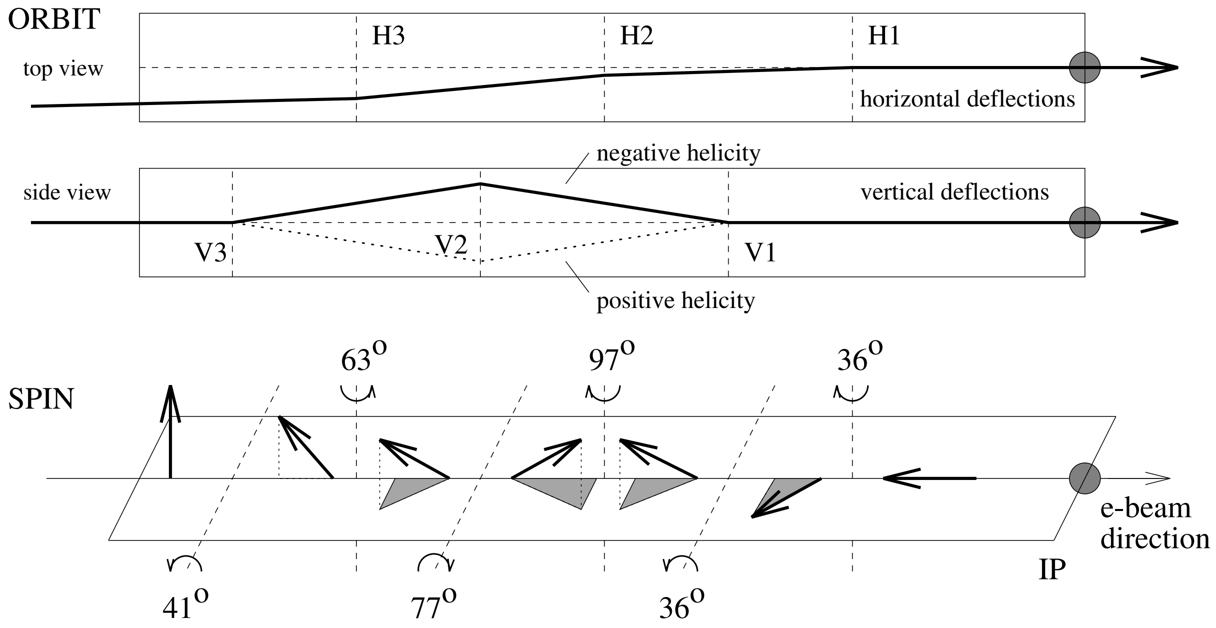

D.P. Barber et al.. Part. Acc. vol. 17 1985

## Dipole spin rotators

- need $\vec{P}_{meas} \parallel \vec{B}$ in most of ring to drive Sokolov–Ternov.
- The natural polarization is vertical.
- But need $\vec{P}_{meas}$ longitudinal at IP.
- ===> Rotate $\vec{P}_{meas}(\hat{n}_0)$
  - Vertical $\rightarrow$ longitudinal just before an IP.
  - Longitudinal $\rightarrow$ vertical just after an IP.
- Recall: $\delta\theta_{spin} = a\gamma \cdot \delta\theta_{orbit}$
  Finite rotations do not commute
  ===>Use string of interleaved vertical and horizontal bends.

  ===> For HERA: MiniRotator by Buon and Steffen.

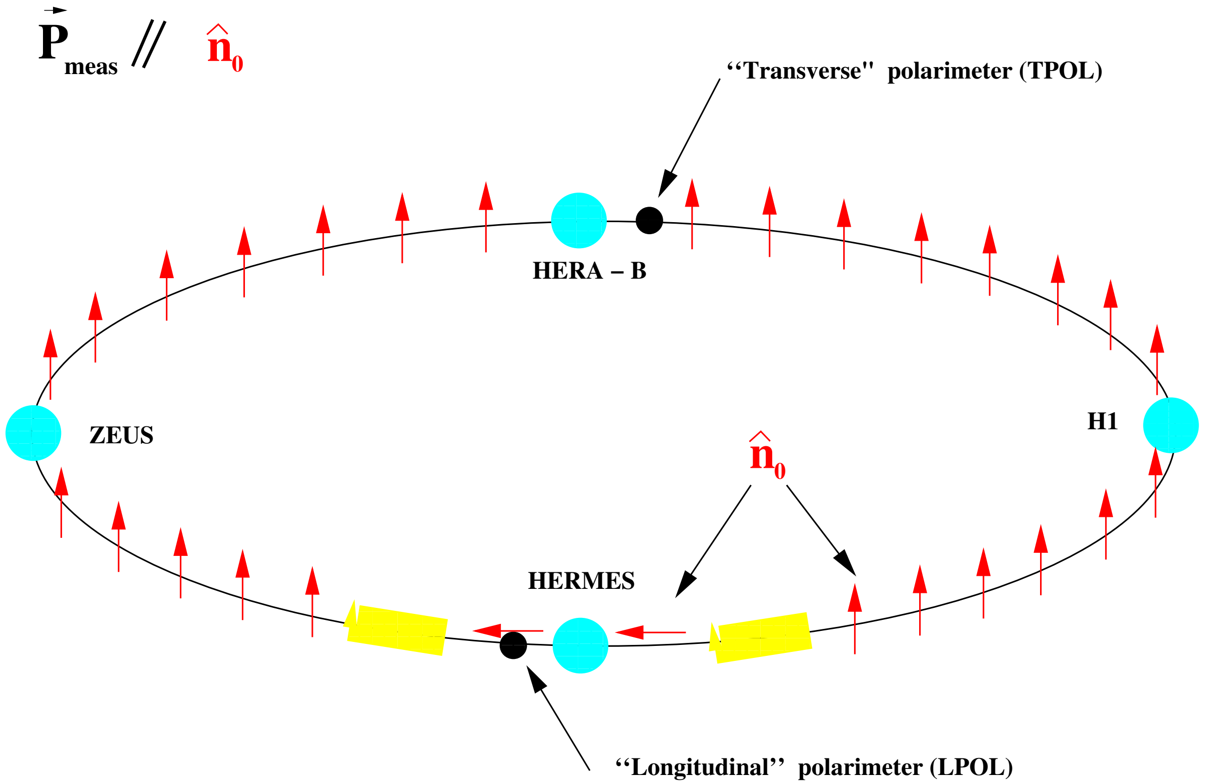
# HERA MiniRotator: Buon + Steffen




**56 m ("short") → no quads.**

**27 – 39 GeV, both helicities, variable geometry**

## HERA electron/positron ring 1994 –– 2000



## Chief features of the MiniRotator

- Length limited to 56 metre: no quads needed, but $\delta P \propto L^{-2}$,
- Variable energy: 27–39 GeV, variable geometry.
- Symmetric w.r.t. IP in hor. plane. Antisymmetric in vert. plane.
- Maximum polarization: $P_{39} > P_{27}, \quad P_{_{BK}}$ maximized.
- +ve and -ve helicity: reverse vertical bends.
- Ends fixed: middle section must me movable.
- Vertical orbit excursion small: 20 cm.
- Total vertical bend is zero.
- Total horizontal bend non–zero: include in arc to save space.
- Spin tune shift: $\delta\nu_{spin}$ small.