First steps to Polarisation

2 March 2010

Recall experience at LEP above 46 GeV — it is very difficult and the reasons are well understood.

See the talk at Divonne, September 2008

Self polarization / depolarization.

- Electrons in storage rings can become spin POLARIZED due to emission of synchrotron radiation: Sokolov–Ternov effect (1964).

- The a flat ring the polarization is perpendicular to the machine plane.

- The maximum value is then $P_{st} = 92.4\%$.

- Sync. radn. also excites orbit motion. This leads to DEPOLARIZATION!

- The attainable polarization results from a balance between polarization and depolarization.

$$P_\infty \approx P_{st} \frac{1}{1 + (\frac{\tau_{dep}}{\tau_{st}})^{-1}}$$

- Depolarization is worst at RESONANCES:

$$\nu_s = k_0 + k_1 Q_1 + k_2 Q_2 + k_3 Q_3$$

At high energy the synchrotron sideband resonances take control:

$$\text{Strength scale :} \qquad \xi = (\frac{a\gamma\ \sigma_\delta}{Q_s})^2$$

- Overall, roughly at each energy:

$$\tau_{dep}^{-1} \ \propto \ (\text{a polynomial in } \gamma^{2N}) \times \tau_{st}^{-1}$$

- For longitudinal polarization the polarization vector must be rotated into the longitudinal direction before an IP and back to the vertical afterwards ===> spin rotators.

- Depolarization can be strongly enhanced by misalignments, regions where the polarization vector is horizontal between spin rotators etc, etc.....

The parameters at HERA are perfect: $\tau_{\rm pol} \leq 30$ min and $\xi \approx 1$ is still no disaster.

LEP: 46 GeV 1993. R. Assmann et al. reached 57 percent by tuning the orbit for many hours: $\tau_{\rm pol} \leq 300$ min and $\xi = O(1)$

The good news: at 70 GeV $\tau_{\rm pol} \approx\leq 36$ min (scales like γ^{-5}).

The bad news: depolarization is relatively much stronger than at 46 GeV.

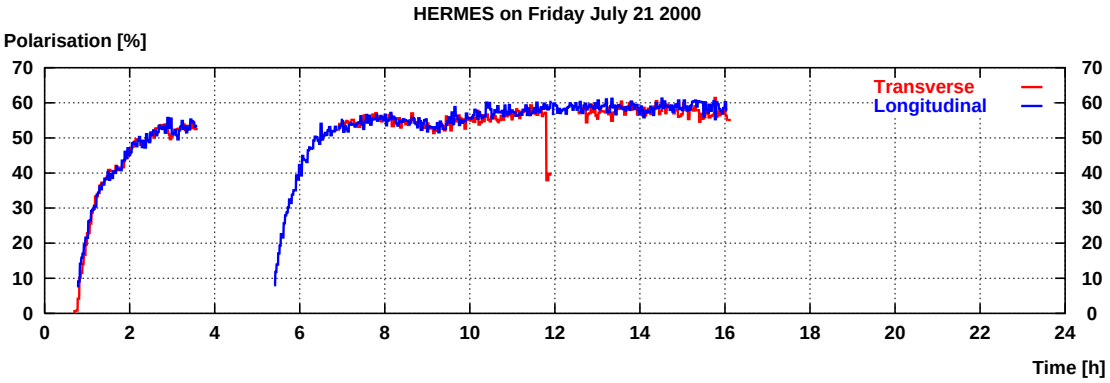

Figure 1: HERA-I with one pair of rotators (before HERA-II)

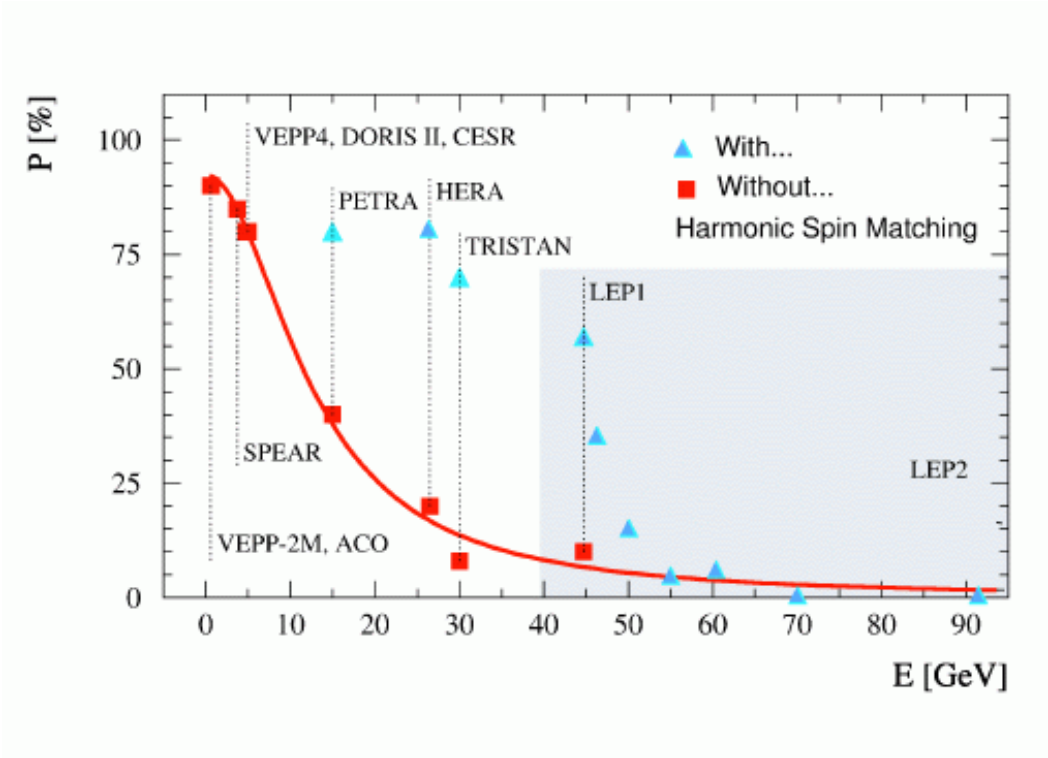

Figure 2: LEP: 46 GeV 1993. R. Assmann et al., SPIN2000, Osaka, Japan

The way forward

Plan for polarization from the start! Polarization can never be an after thought!

Begin NOW with intense careful study based on experience to investigate tricks.

- Need very good alignment – better than at LEP.
- Siberian Snakes to suppress the effect of energy spread and synchrotron motion on spin motion?
  These are essential in proton rings to suppress depolarising resonances during acceleration (e.g., RHIC).
  But in electron rings they kill the S-T effect if the synchrotron radiation is evenly distributed around the ring!!!
- Can an arrangement be found based on a correct snake layout combined with uneven synchrotron radiation from super bends?
- Is there substance in the claim of Derbenev and Kondratenko that their formalism is too pessimistic at very high energy?

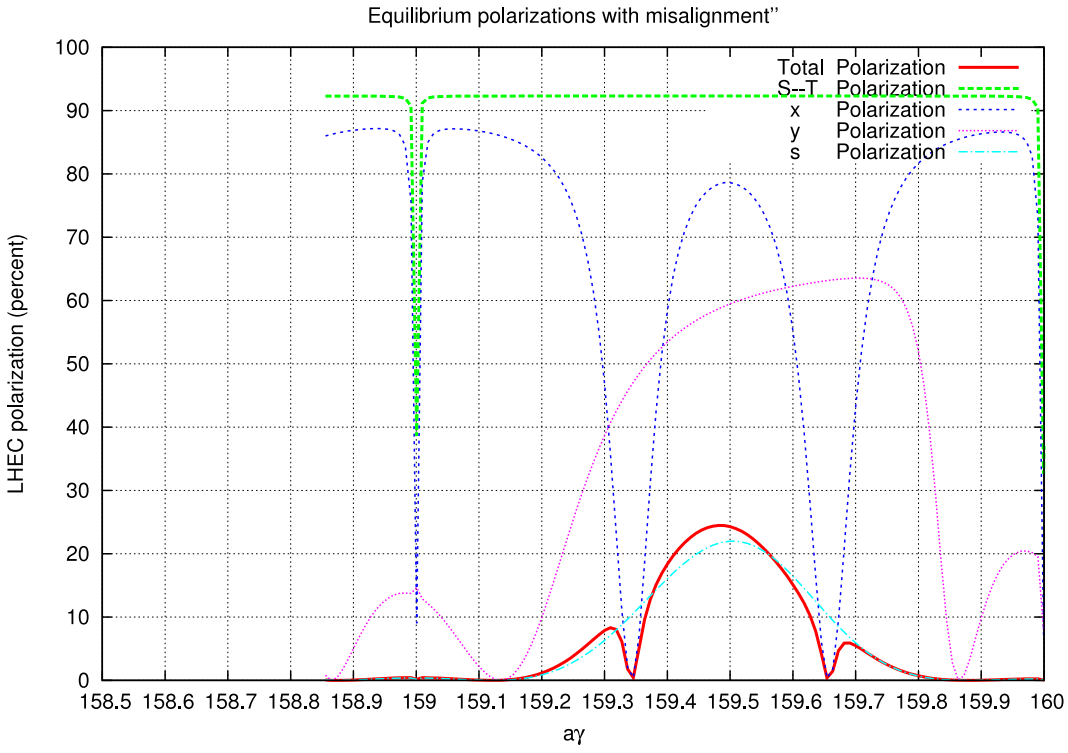

Figure 3: LHeC optic created by Alexander Kling, DESY