

# Electron polarisation in eRHIC

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## **Plan**

- Self polarisation/depolarisation/spin matching
- Calculations at first order.
- Beam-beam/thick beams.
- Summary.

## Spin motions

- Protons: largely deterministic — unless IBS.
- Electrons/positrons:  
If a photon causes a spin flip, what are the other  $\approx 10^{10}$  photons doing?  $\implies$

Stochastic/damped orbital motion due to synchrotron radiation  
+ inhomogeneous fields  
+ spin-orbit coupling via T-BMT  
 $\implies$  spin diffusion i.e. depolarisation!!

Self polarisation: Balance of poln. and depoln.  $\implies$

$$P_\infty \approx P_{BK} \frac{1}{1 + \left(\frac{\tau_{dep}}{\tau_{BK}}\right)^{-1}} \quad (P_{ST} \rightarrow P_{BK})$$

In any case:

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

$\implies$  Trouble at high energy!

## Spin-orbit resonances

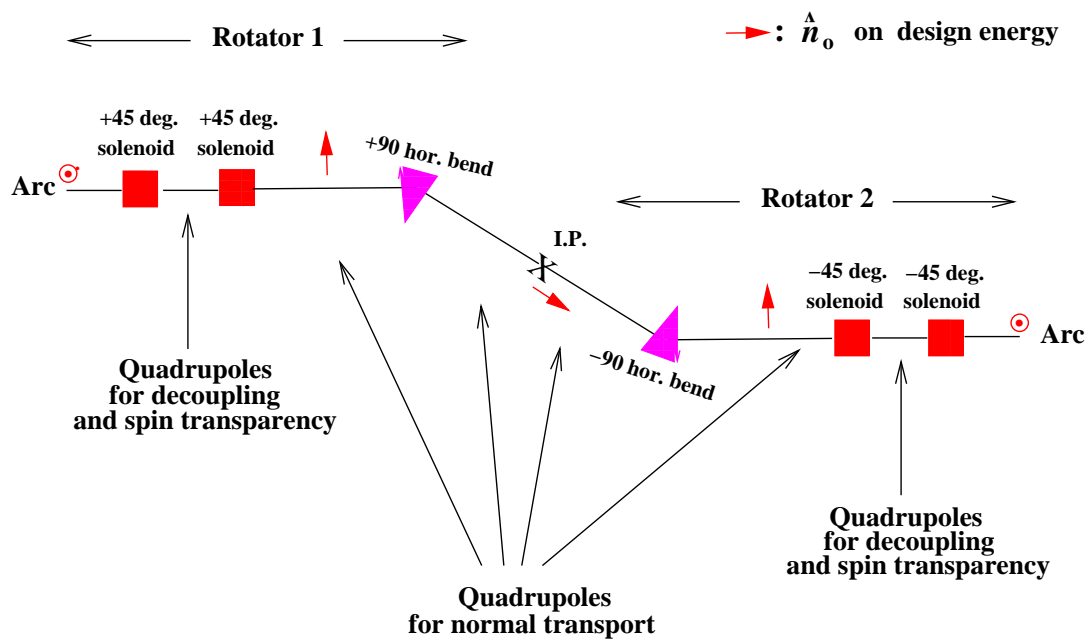
$$\nu_{\text{spin}} = k + k_I \nu_I + k_{II} \nu_{II} + k_{III} \nu_{III}$$

$\nu_{\text{spin}}$  : amplitude dependent spin tune  $\approx$  closed orbit spin tune = precessions /turn on CO

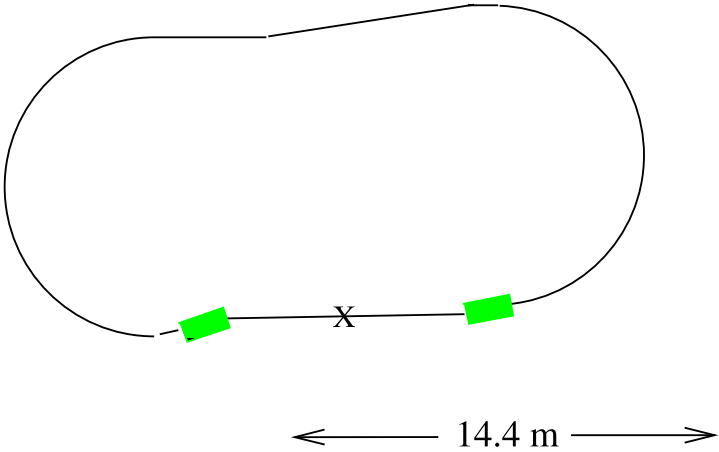
- Orbit “drives spins”  $\implies$  Resonant enhancement of spin diffusion.
- Resonance order:  $|k_I| + |k_{II}| + |k_{III}|$
- First order:  $|k_I| + |k_{II}| + |k_{III}| = 1$  e.g. SLIM like formalisms.
- Strongest beyond first order:  
synchrotron sidebands of first order parent betatron or synchrotron resonances


$$\nu_{\text{spin}} = k + k_i \nu_i + k_{III} \nu_{III}, \quad i = I, II \text{ or } III$$

### The solenoid spin rotators







# The basic eRHIC geometry for spin--exaggerated



**A rotator**  


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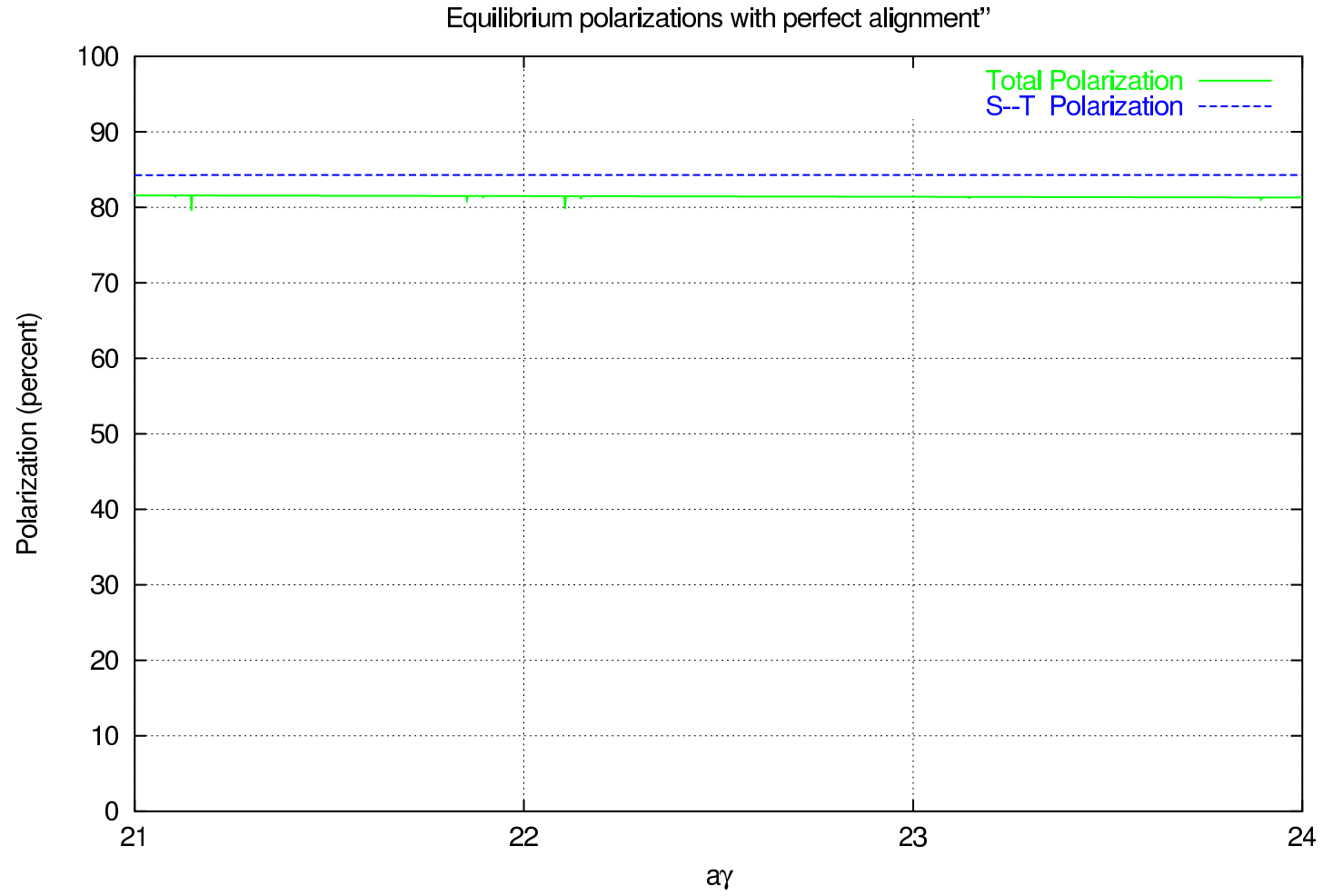
<b>Sol.</b>	<b>Quads.</b>	<b>Sol.</b>	<b>Hor. dipole</b>
			
26.7 Tm at 10 GeV	1 2 3 2 1	26.7 Tm at 10 GeV	

The  $4 \times 4$  transfer matrix for the transverse motion through a pair of solenoids:

$$\begin{pmatrix} 0 & -2r & 0 & 0 \\ 1/2r & 0 & 0 & 0 \\ 0 & 0 & 0 & 2r \\ 0 & 0 & -1/2r & 0 \end{pmatrix}$$

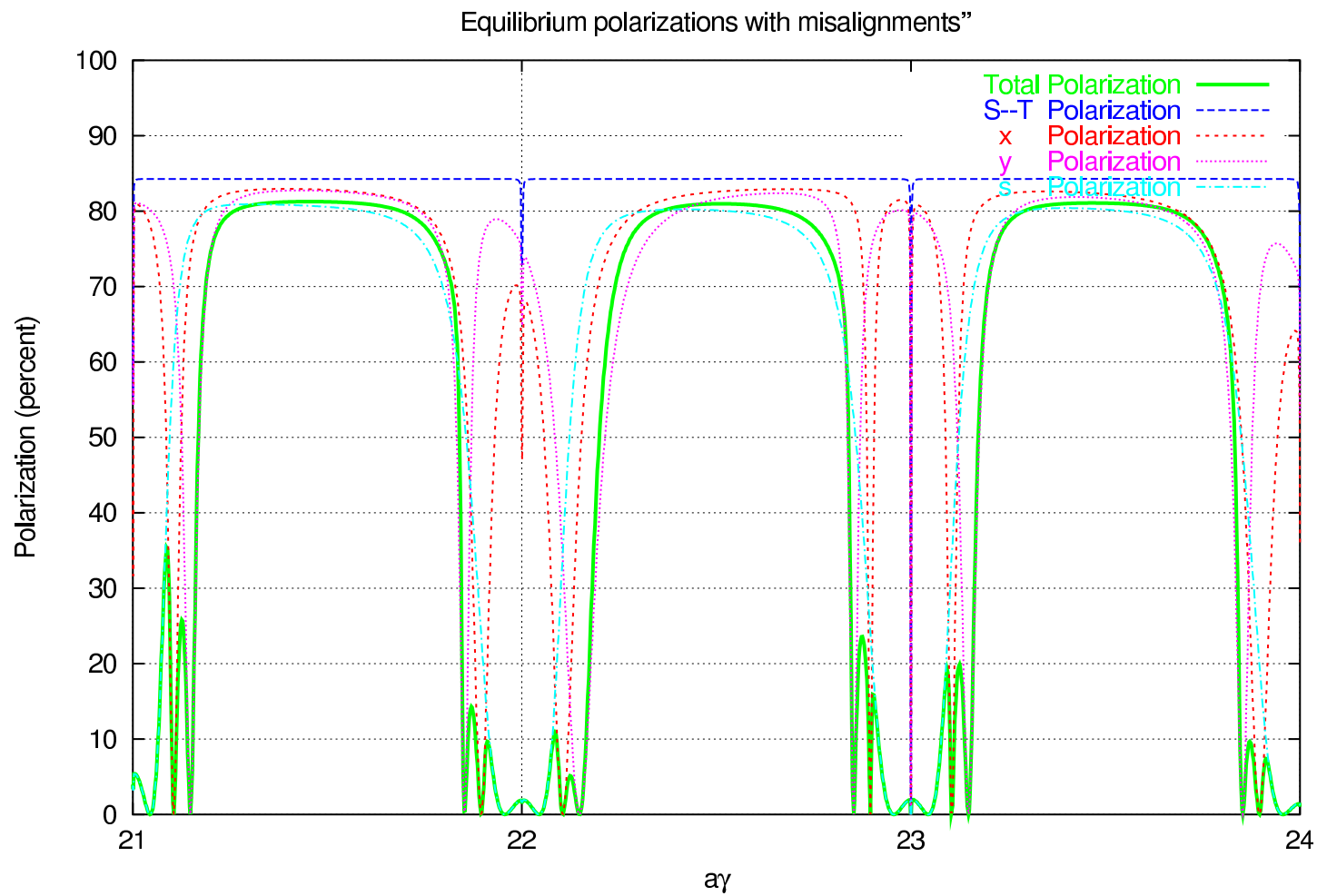
where  $r$  is the radius of orbit curvature in the longitudinal field.

Use 5 back-to-back symmetric quadrupoles.

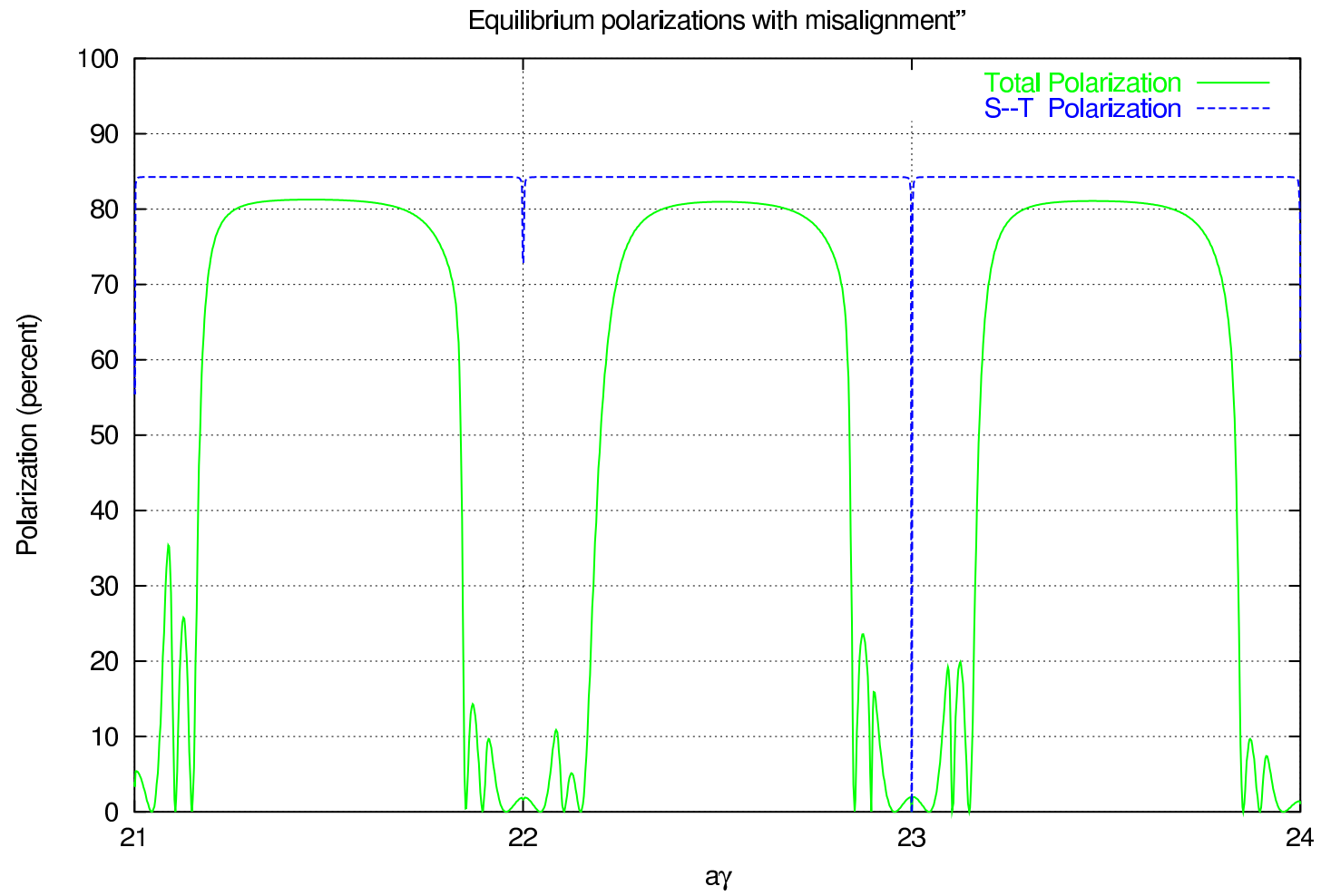




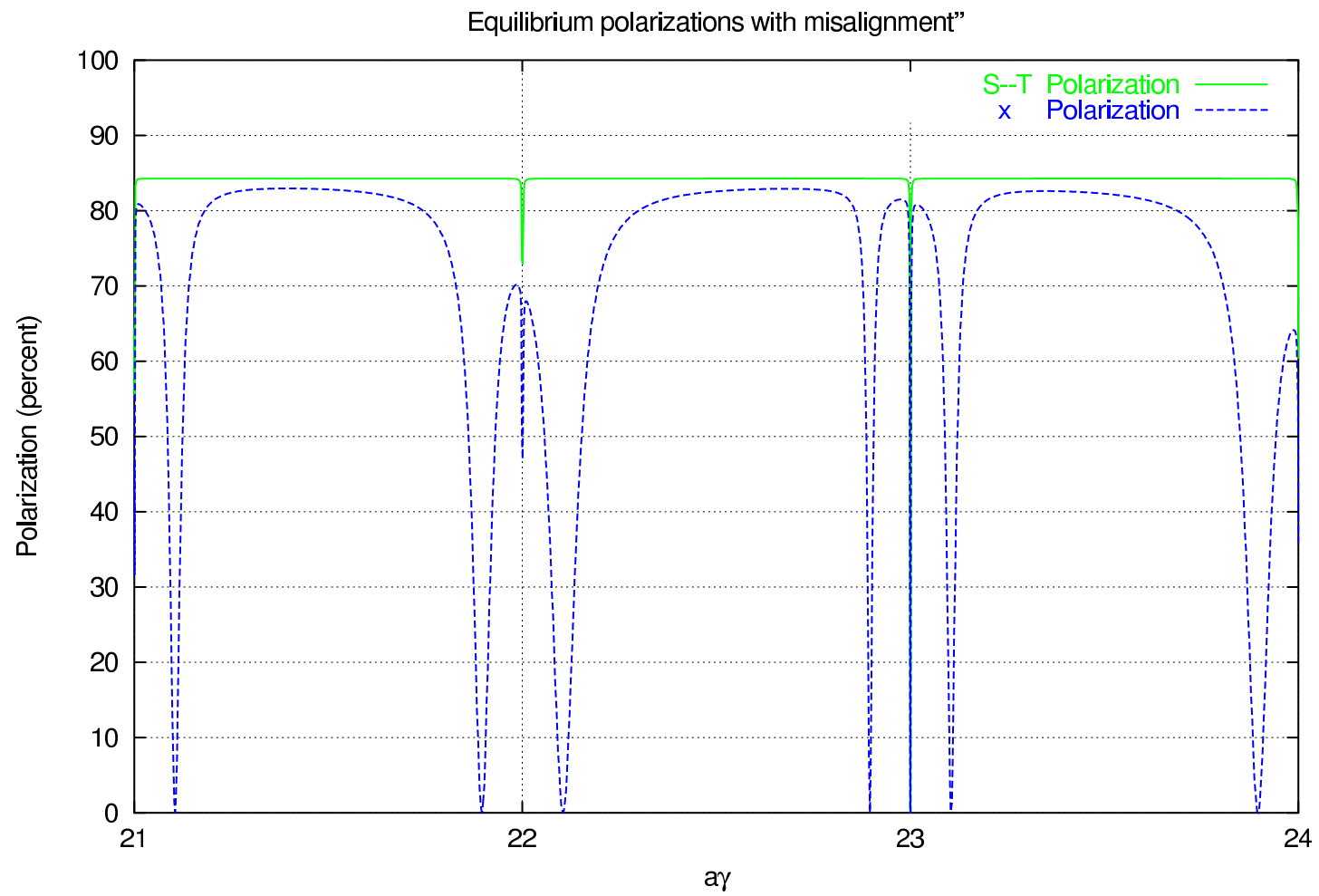
# All monitors on



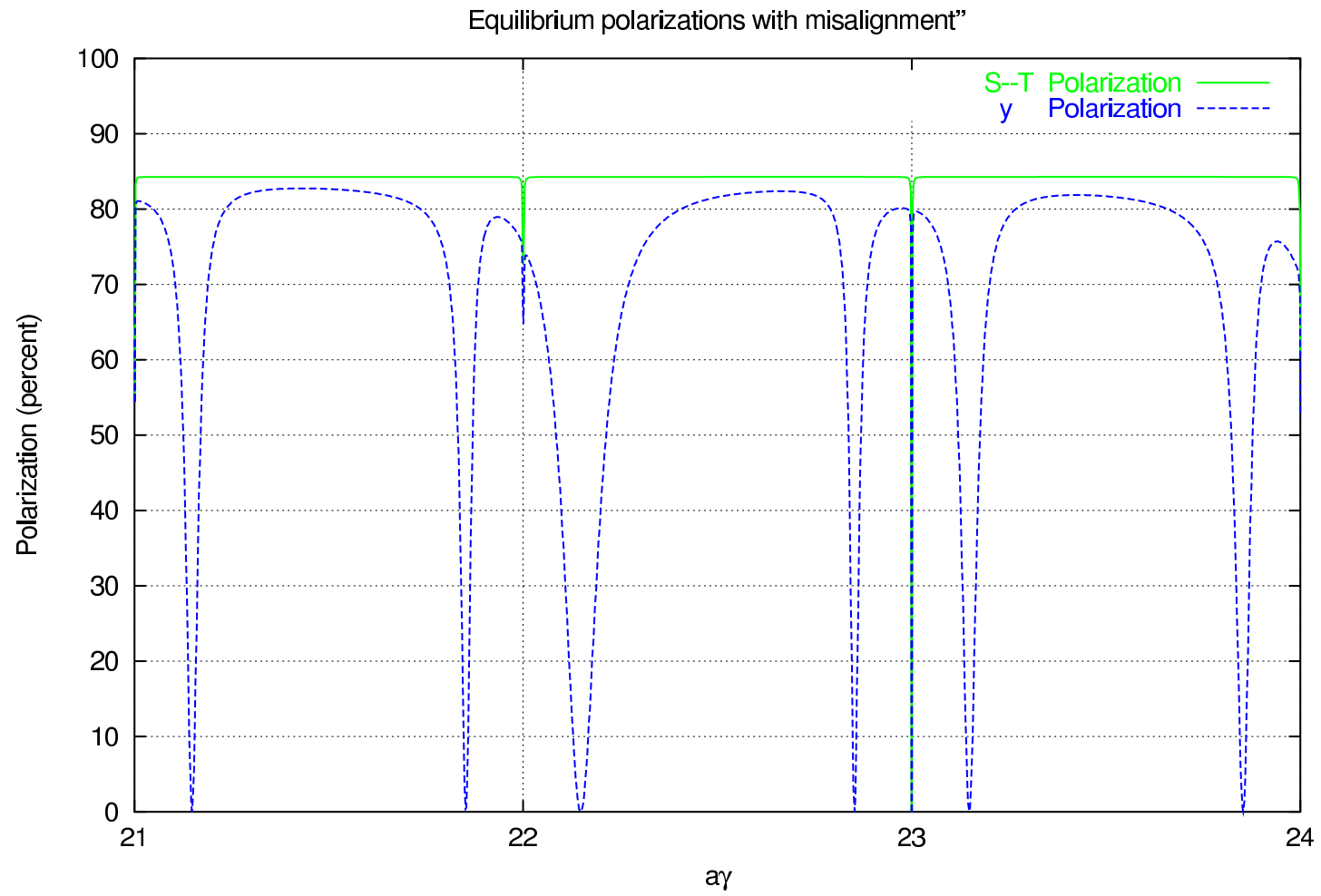
# All monitors on



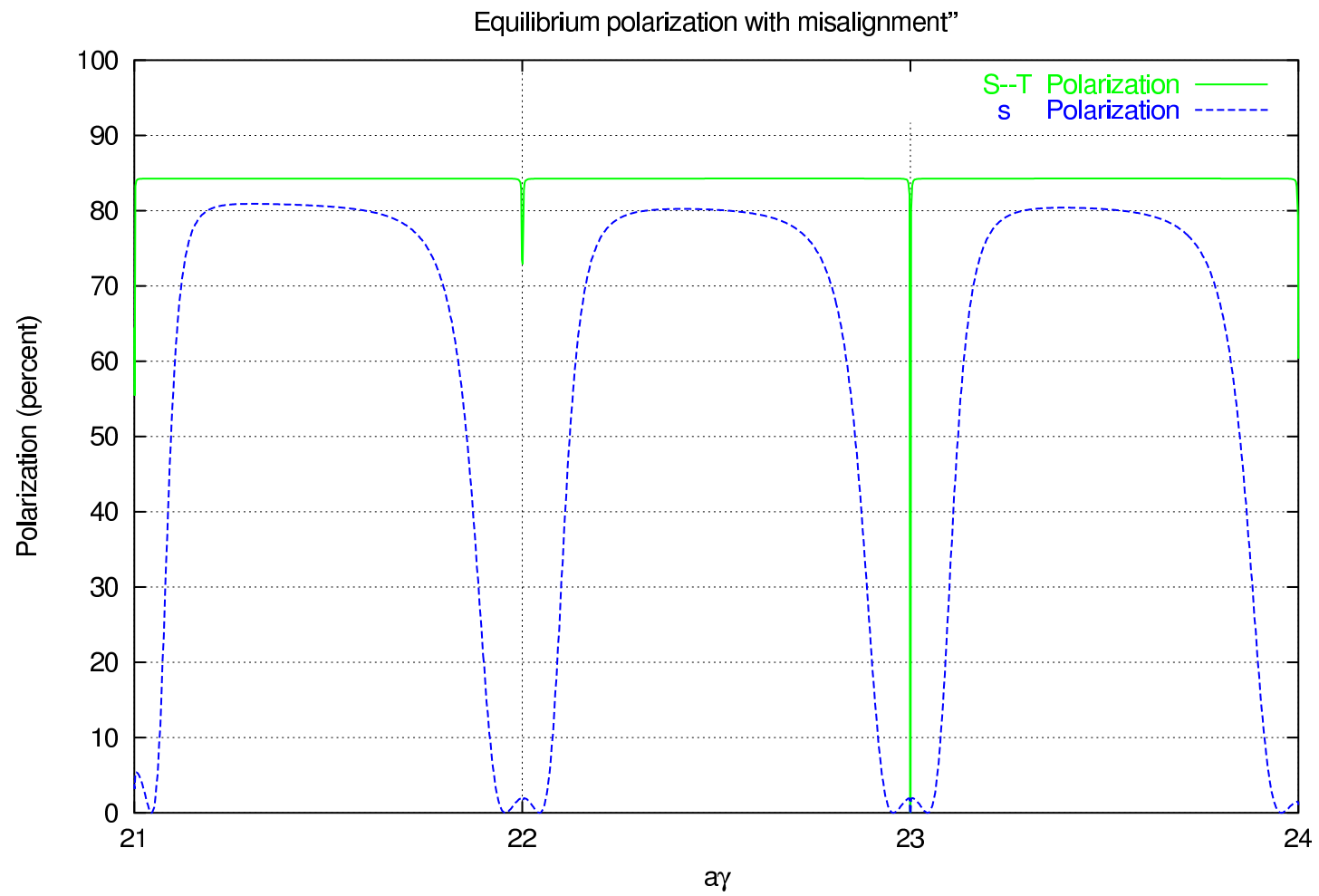
### All monitors on



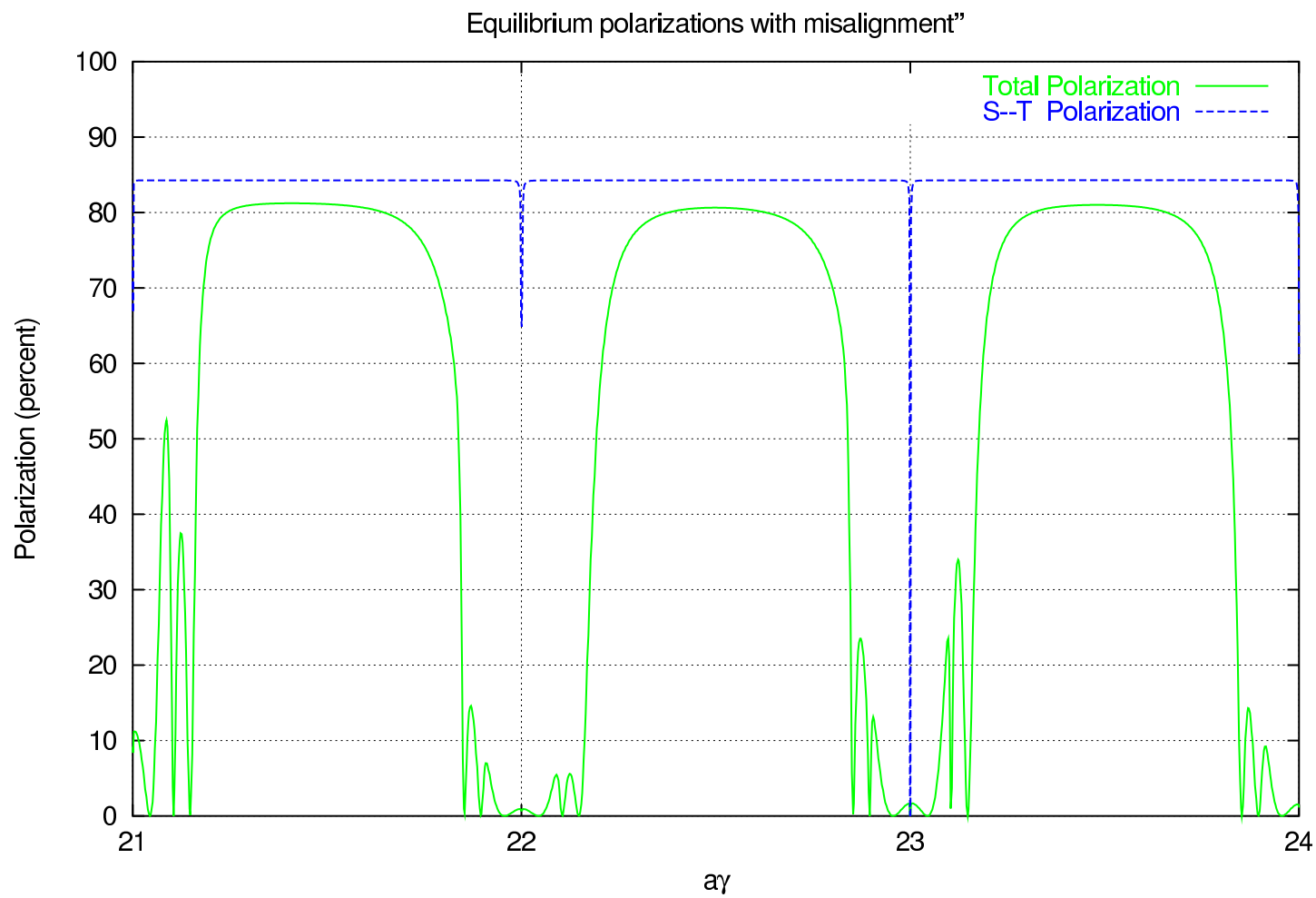
# All monitors on



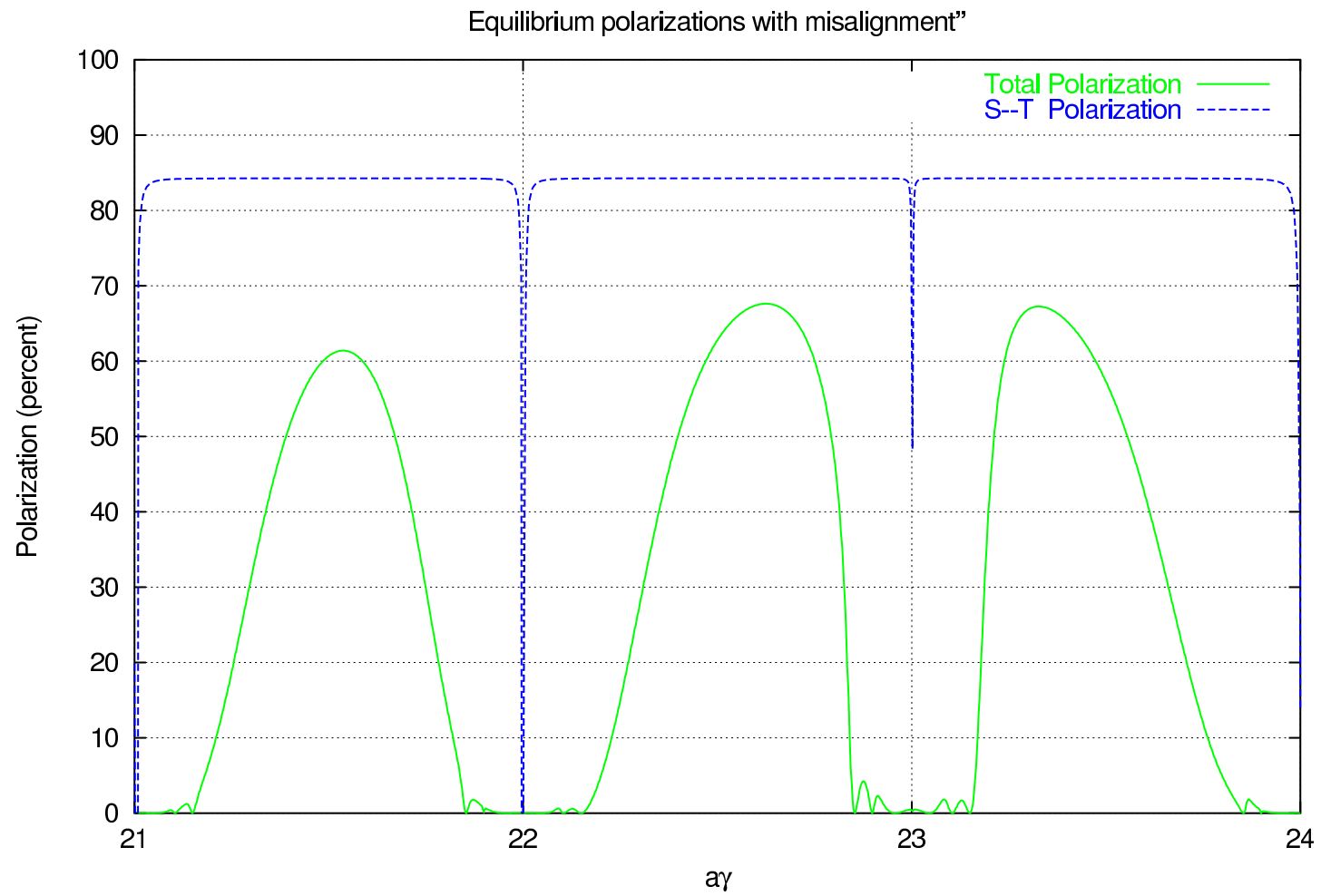
### All monitors on

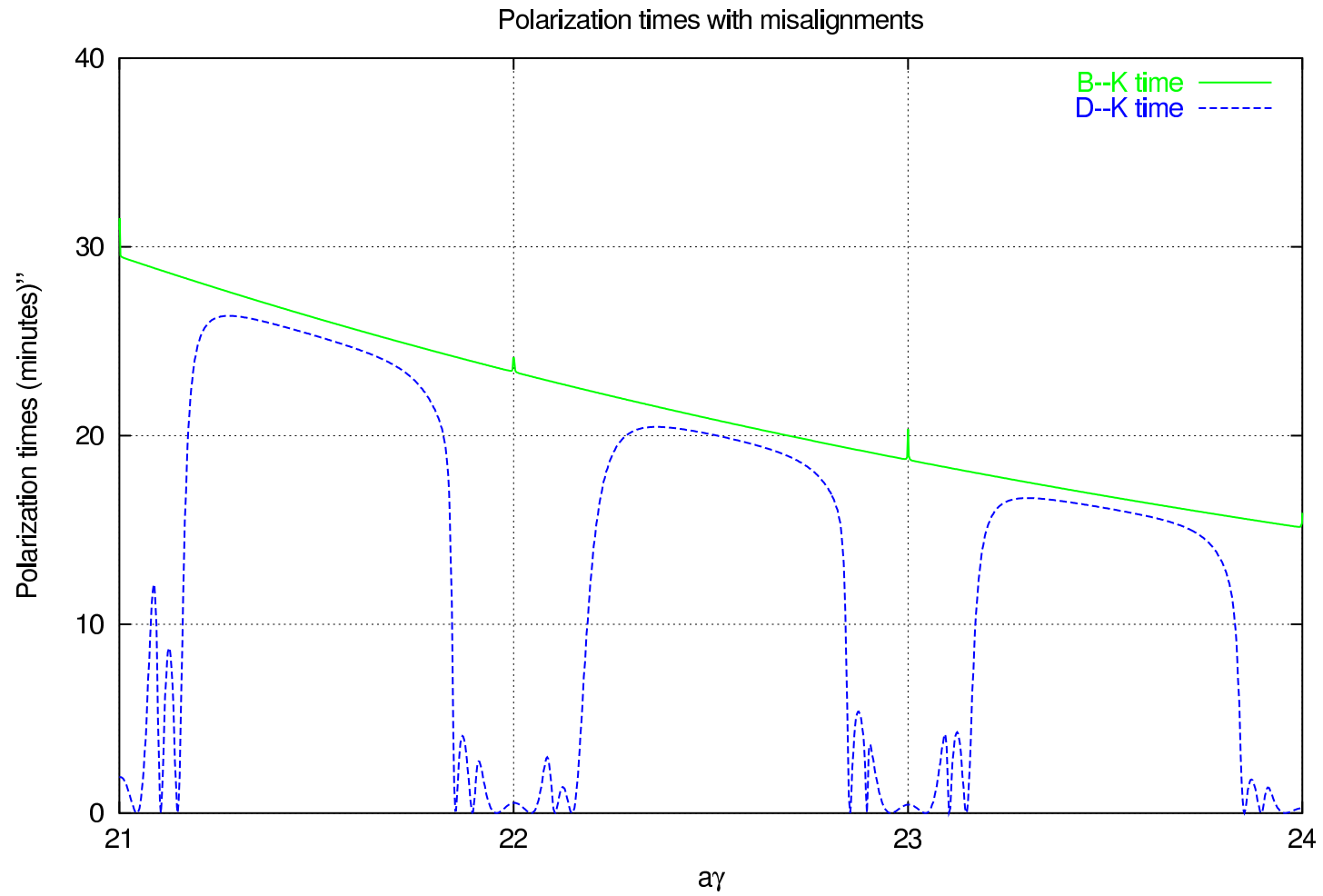


# 80 percent monitors on



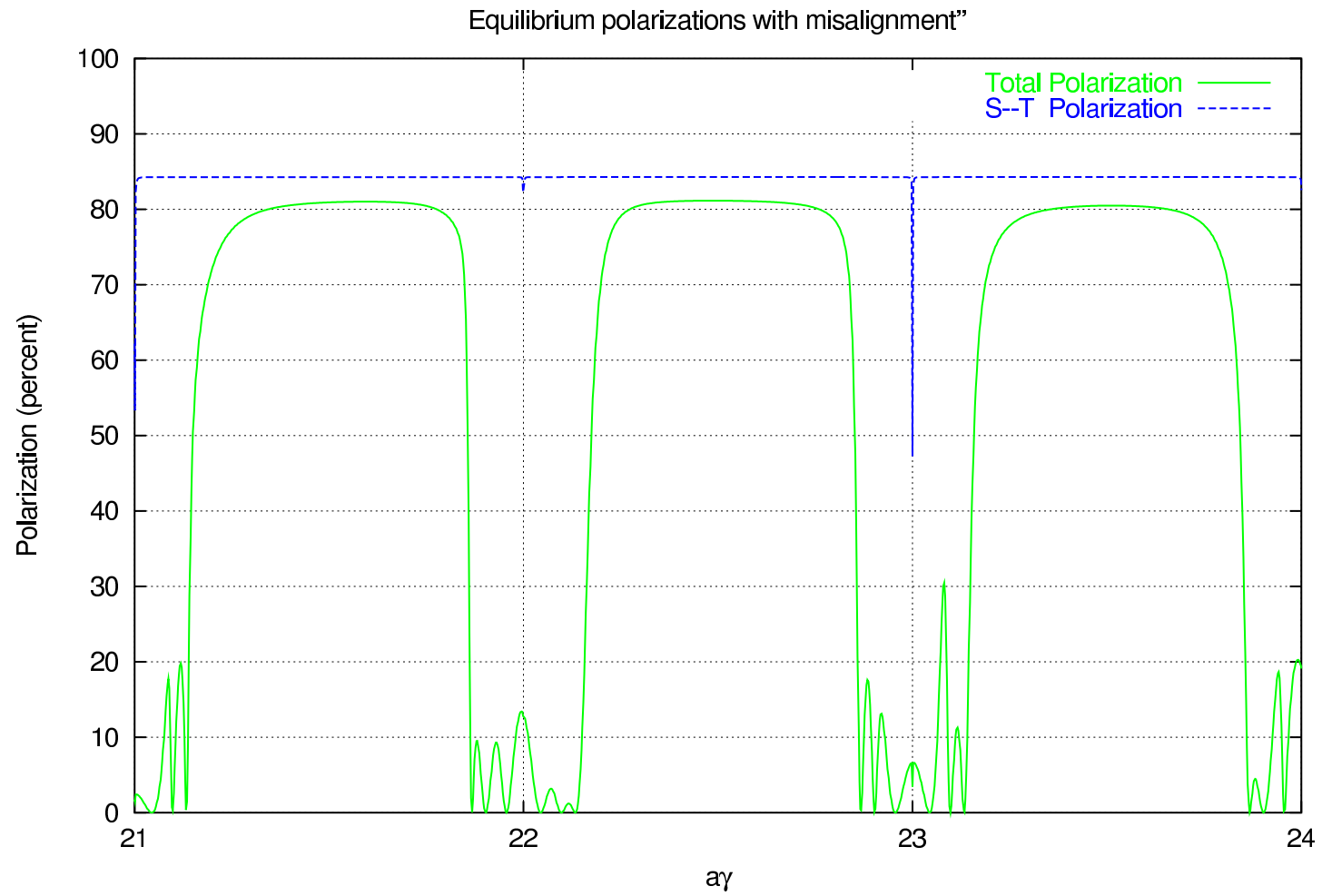
## 20 percent monitors on



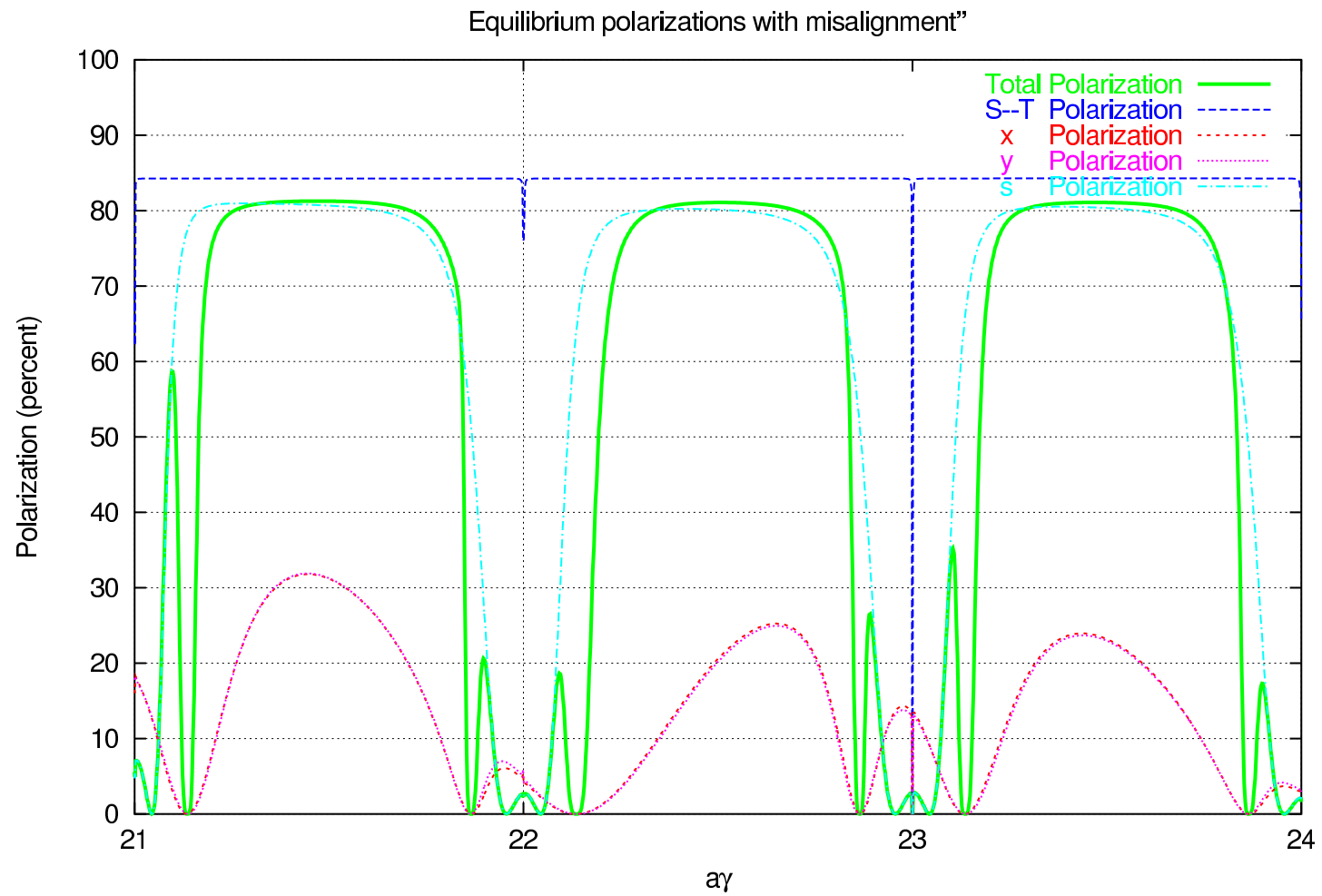




## All monitors on and about half of the “b–b”



## All monitors on, no “b–b”, near coupling resonance



## Summary

- First order calculations OK. Attention to alignment, monitoring and correction.
- Initial indications that beam-beam is not too troublesome.

## Next steps

- M-C spin diffusion simulations (in progress) – best way to get at higher order resonances.
- Generation of thick beams with polarisation.
- Include effects of detector fields.

We have longitudinal polarisation  $e^+$  at 3 IPs in HERA at  $3\times$  higher energy!