$\vec{e}^-$ in Super*B*

Update (since MiniMac)

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with input from D.P. Barber, DESY

Introduction

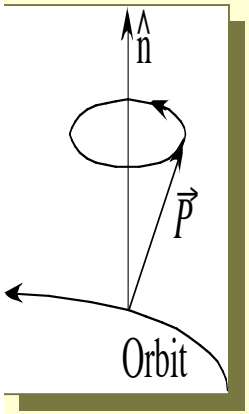
- Polarization build-up (Sokolov-Ternov) time for SuperB:
  - HER: $\gamma = 13700$ (7 GeV), $\rho = 110$ m, $R = 263$ m: 5...6 h
  - New situation: LER with 1400 m length LNF site
  - LER: $\gamma = 8220$ (4.2 GeV), $\rho = 40$ m, $R = 222$ m: 8...10 h ($\gamma^5/\rho^3 \approx 1.6$ times higher)

- > inject polarized electrons into either.
  - A polarized source of 15 nC/sec is needed to maintain beam current in the SuperB HER. Sources like this are available The SLC gun e.g. delivers 15 nC=10^{11} e^-/pulse at 120 Hz (≈2 μA). Polarization can be up to 90%.
  - Radiative (de-)polarization effect still applies:

$$\tau_p^{-1} = \frac{5\sqrt{3}}{8}\frac{\lambda_e}{2\pi} r_e c \gamma^5 \left\langle \frac{1 - \frac{2}{9}\left(\hat{n}\cdot\vec{s}\right) + \frac{11}{18}\vec{d}^{\,2}}{\rho^3} \right\rangle$$

$$\gamma \frac{d\hat{n}}{d\gamma}$$

Spin Rotation



- Polarization in the ring will normally be vertical. But needs to be longitudinal at the IP
  - => spin rotators needed before and after the IP to align $\vec{P}$ longitudinally & restore to vertical.
  - This is achieved with dipole fields (horizontal and vertical fields) and/or with solenoids
- The net rotation wanted is by 90° about the transverse horizontal axis
  - Most straightforward way is to use a solenoid (90° about longitudinal axis => radial polarization) followed by a horizontal dipole (90° or 270° about vertical axis => longitudinal polarization).

Comparison of Spin-Rotator Geometries

- Rotators can be symmetric or antisymmetric
  - antisymmetric: cancellation of spin angle variation with $\delta\gamma/\gamma$
    - well matched across energy band
  - symmetric: addition of spin angle errors
    - badly mismatched off energy
- Only optics solution for 270° (spin) dipoles in the HER
  - 17.1° bending of reference orbit
- P_{eq} for coasting beam

$$\overline{P} = P_{inj}\frac{\tau_{pol}}{\tau_{pol}+\tau_{beam}} + P_{eq}\frac{\tau_{beam}}{\tau_{pol}+\tau_{beam}}$$

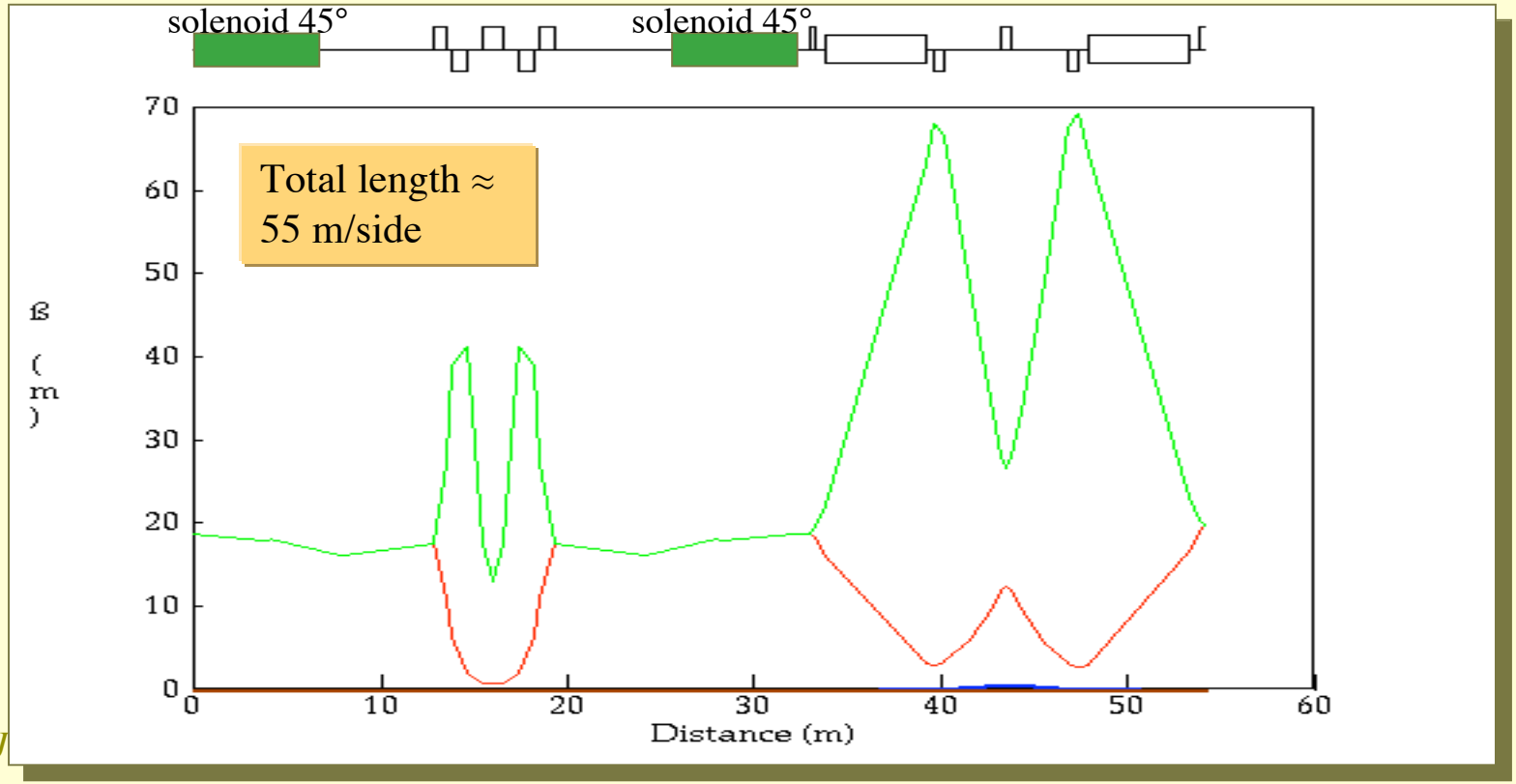
- Following results all normalized to 1800 m circumference
  - $P_{inj} = 0.9$, $\tau_{beam} = 60$ min.

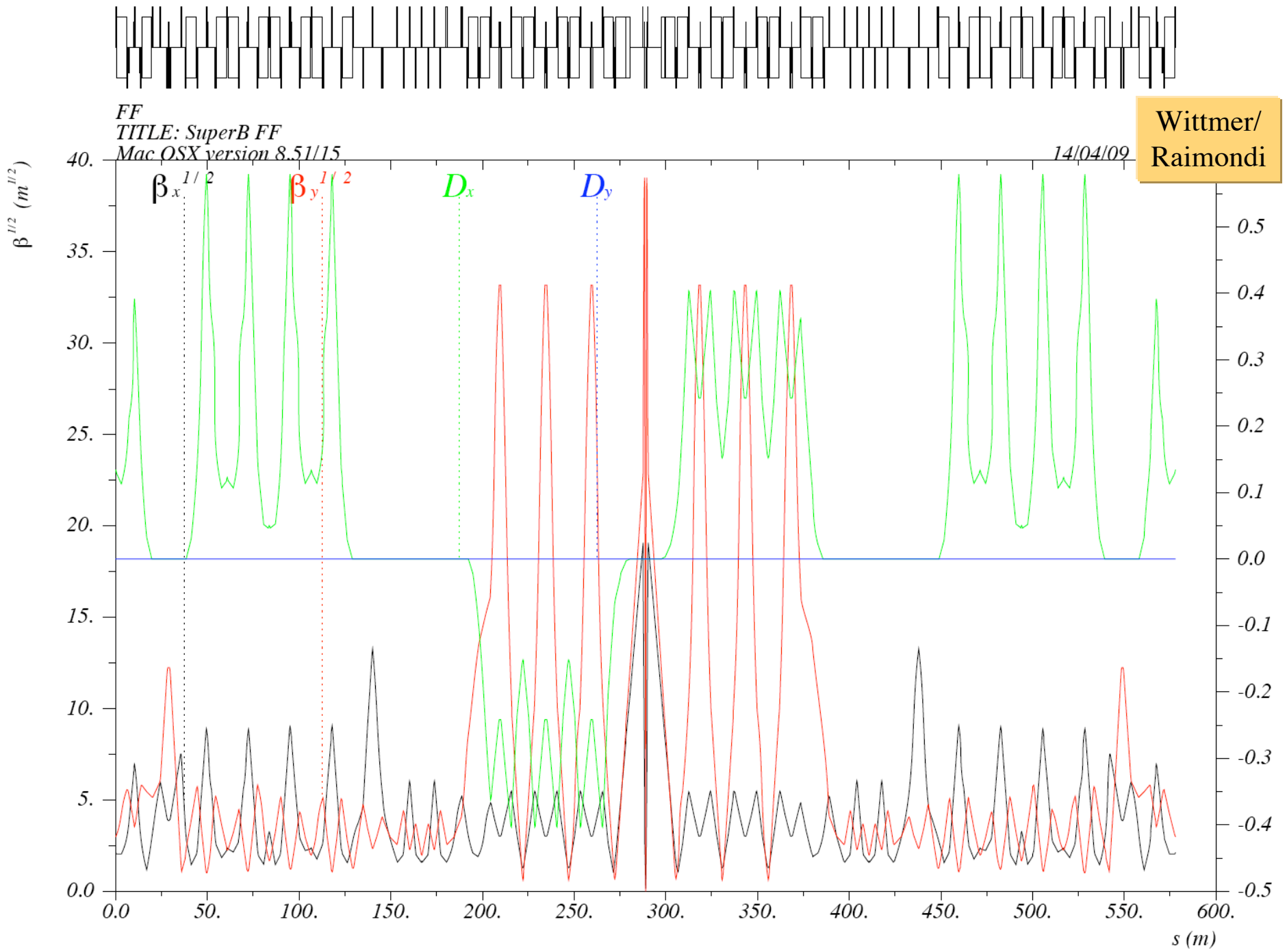
Solenoid Rotator

- $\Theta_{spin}=(1+G)*BL/(B\rho)$ => 36.6 Tm for 90° spin rotation
  - 2.5 T field => 14.66 m total length, 30E6 Amp turns
- Dipole: $\Theta_{spin}=(\gamma G)*BL/B\rho$ => 2.3 Tm, 5.7° orbit for 90° spin
- Zholents & Litvinenko have shown how to compensate the plane rotation of the solenoid by optics in between two 45° solenoids.

$G=(g-2)/2 \approx 0.0012$,

$\gamma G(7\ \text{GeV}) \approx 16$ for electrons




FF
TITLE: SuperB FF
Mac OSX version 8.51/15
14/04/09
Wittmer/
Raimondi
β x 1/2
β y 1/2
Dx
Dy
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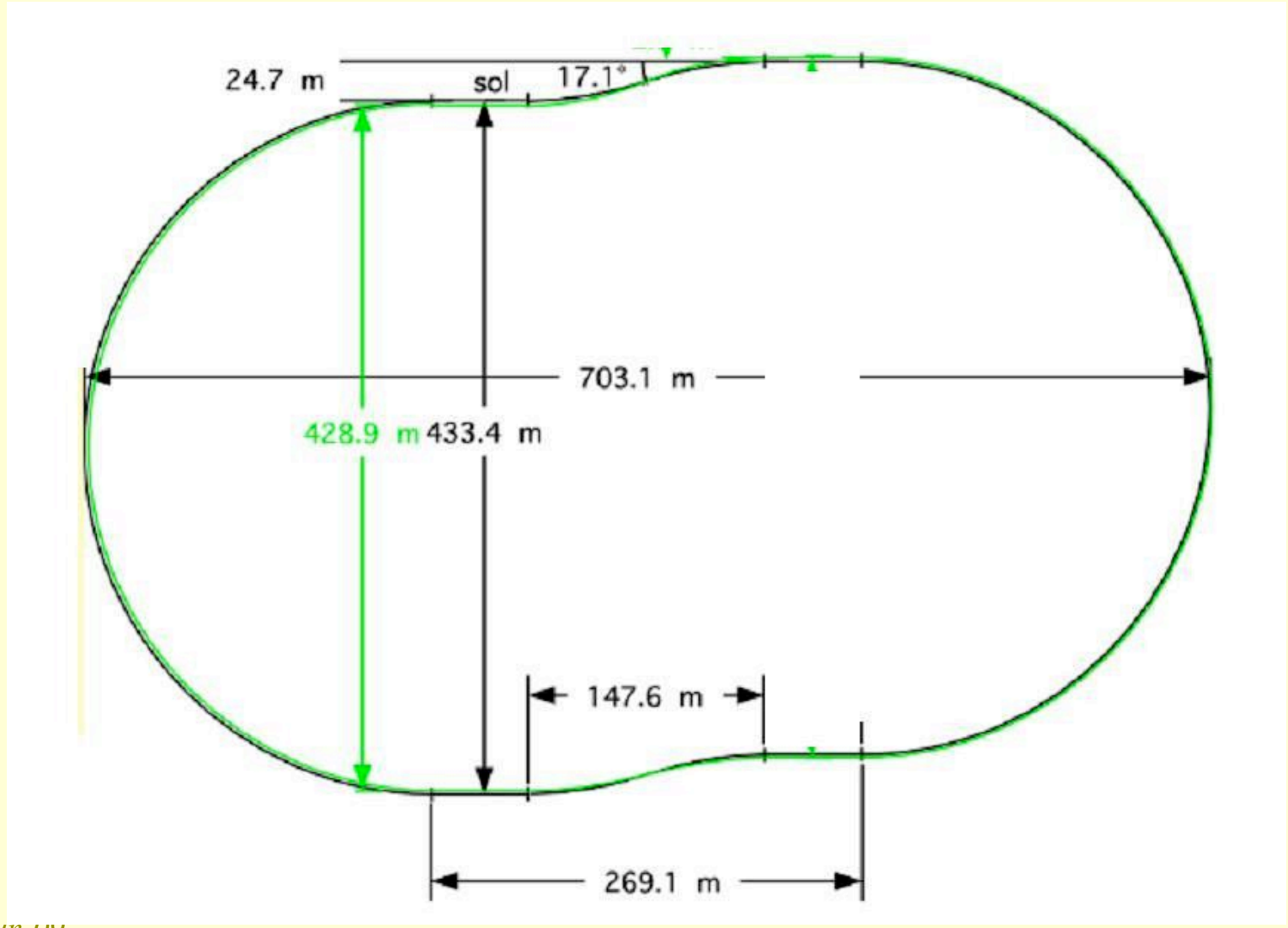
s (m)

HER Layout + matching LER

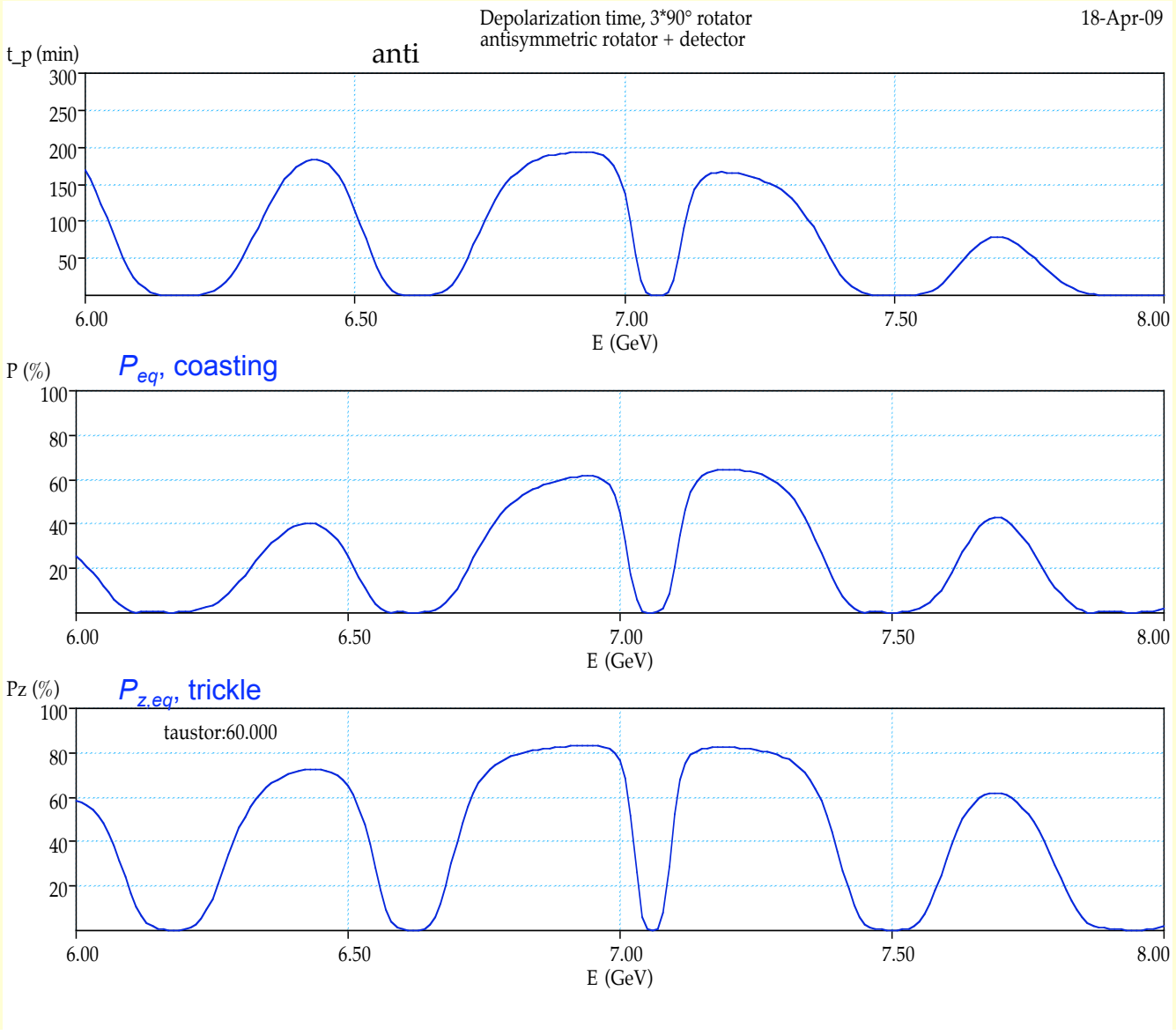


270° dipole, antisymmetric

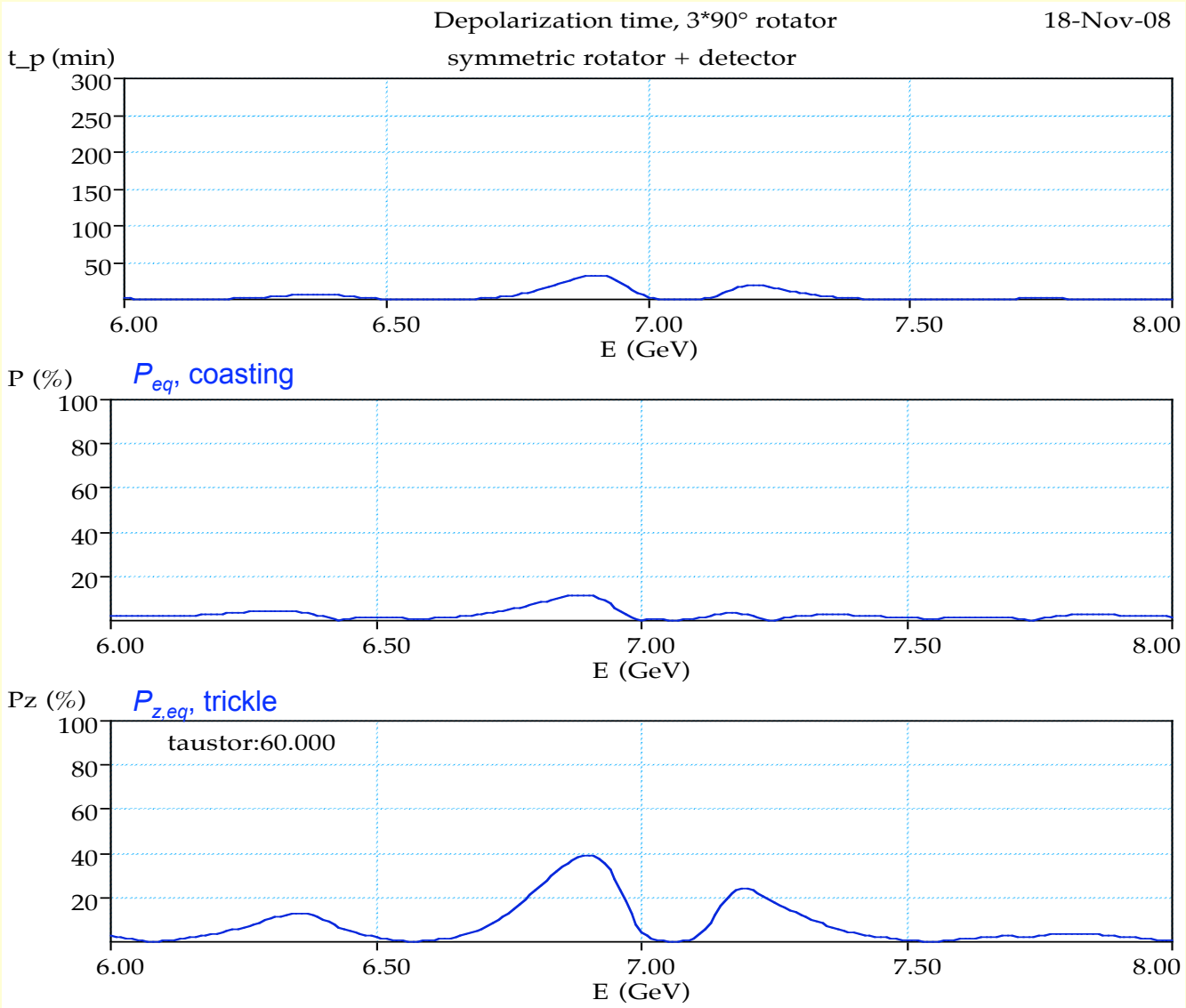
Evaluation of $\gamma\, dn/d\gamma$

incl. detector solenoid

no tr. or longitud. motion



270° dipole, symmetric

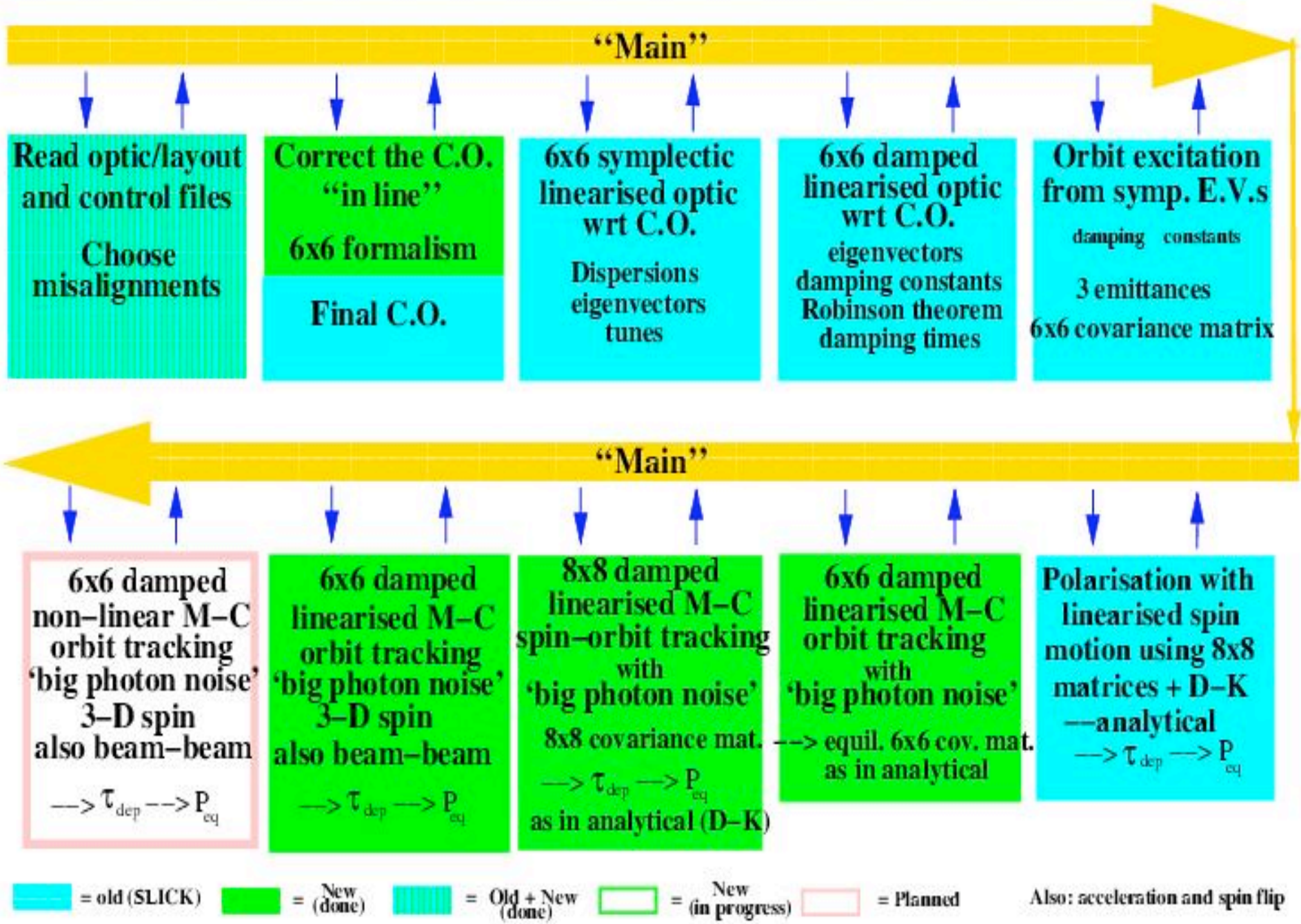


New Development

- Visited D. Barber @ DESY after MiniMac
- Code Slicktrack
  - thick-lens extension of SLIM code (A. Chao)
    - 1st-order orbit, 1st-order spin
    - misalignment & correction, 6-d
  - Monte-Carlo (tracking)
    - 1st-order orbit (for now), any order spin
  - Now running on Stanford Linux system
- Ran SuperB HER antisymmetric case (Wittmer's IR with rotator)
- Working on LNF LER

The structure of SLICKTRACK

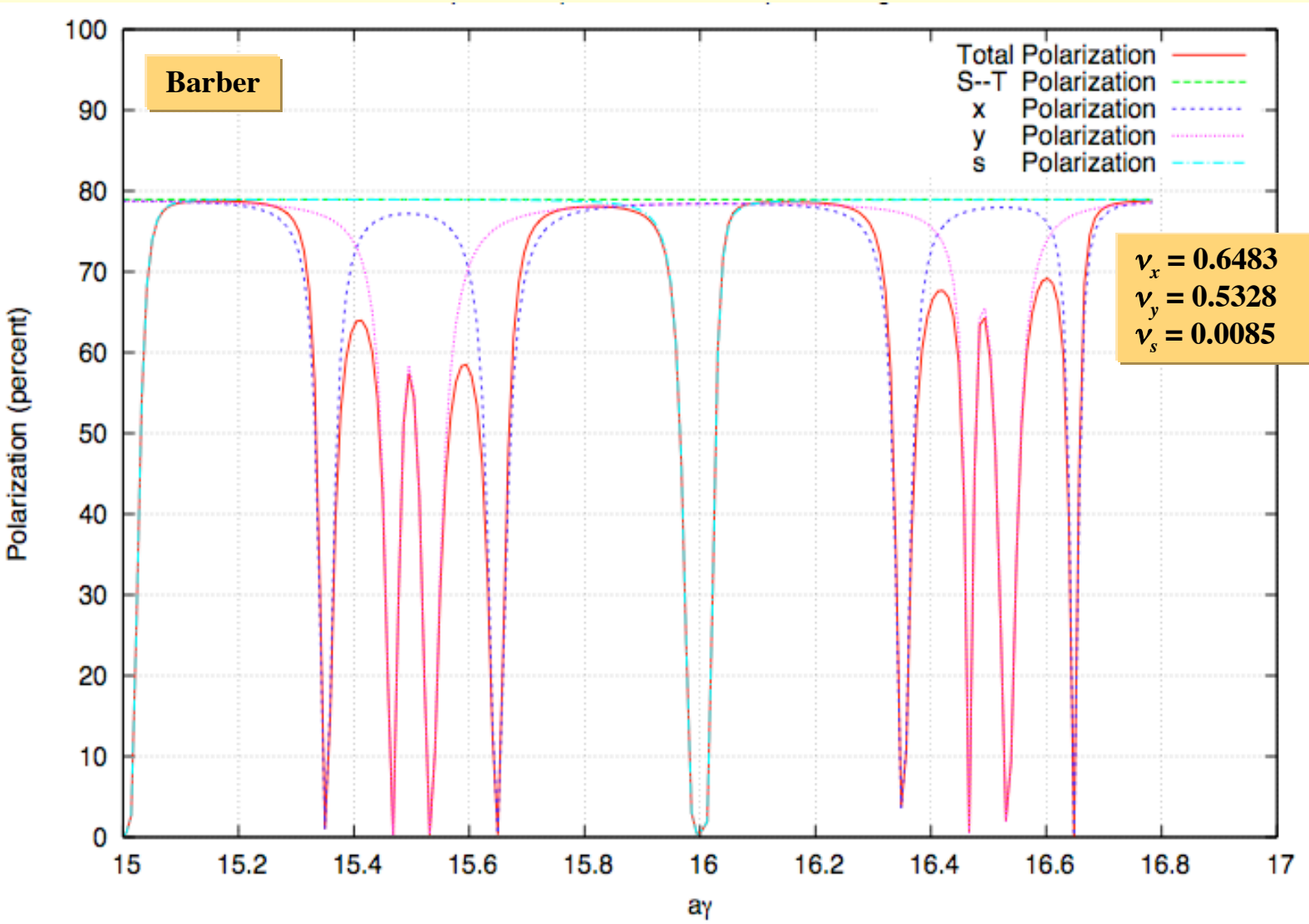
Barber



Equilibrium Polarization

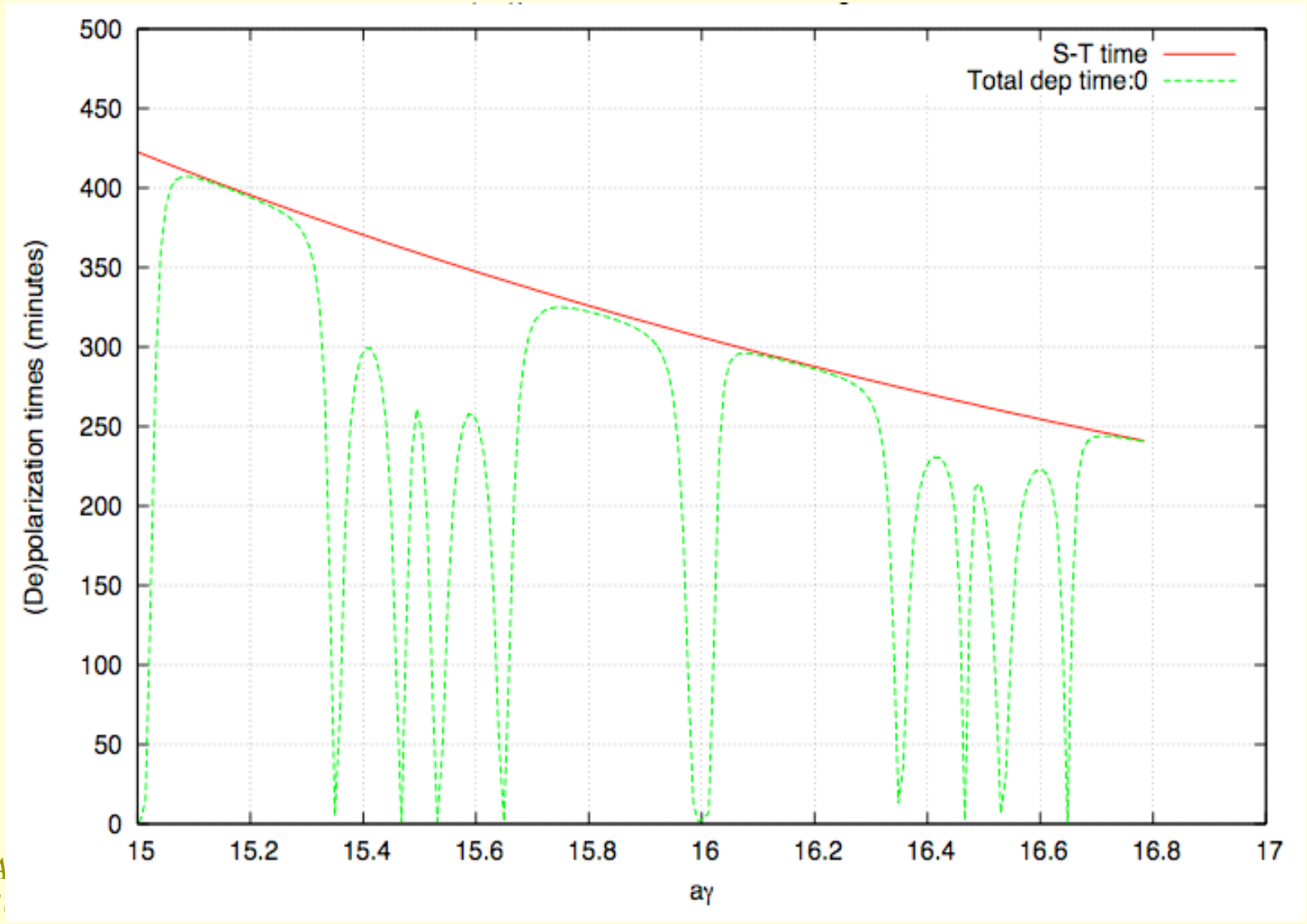
$\delta y = 50\ \mu m$
$\delta\phi = 200\ \mu r$
$\delta_{BPM} = 50\ \mu m$
no detector solenoid

Note the horiz. and vertical tune lines, as well as the dip at the integer (syn. osc.)



$\nu_x = 0.6483$
$\nu_y = 0.5328$
$\nu_s = 0.0085$

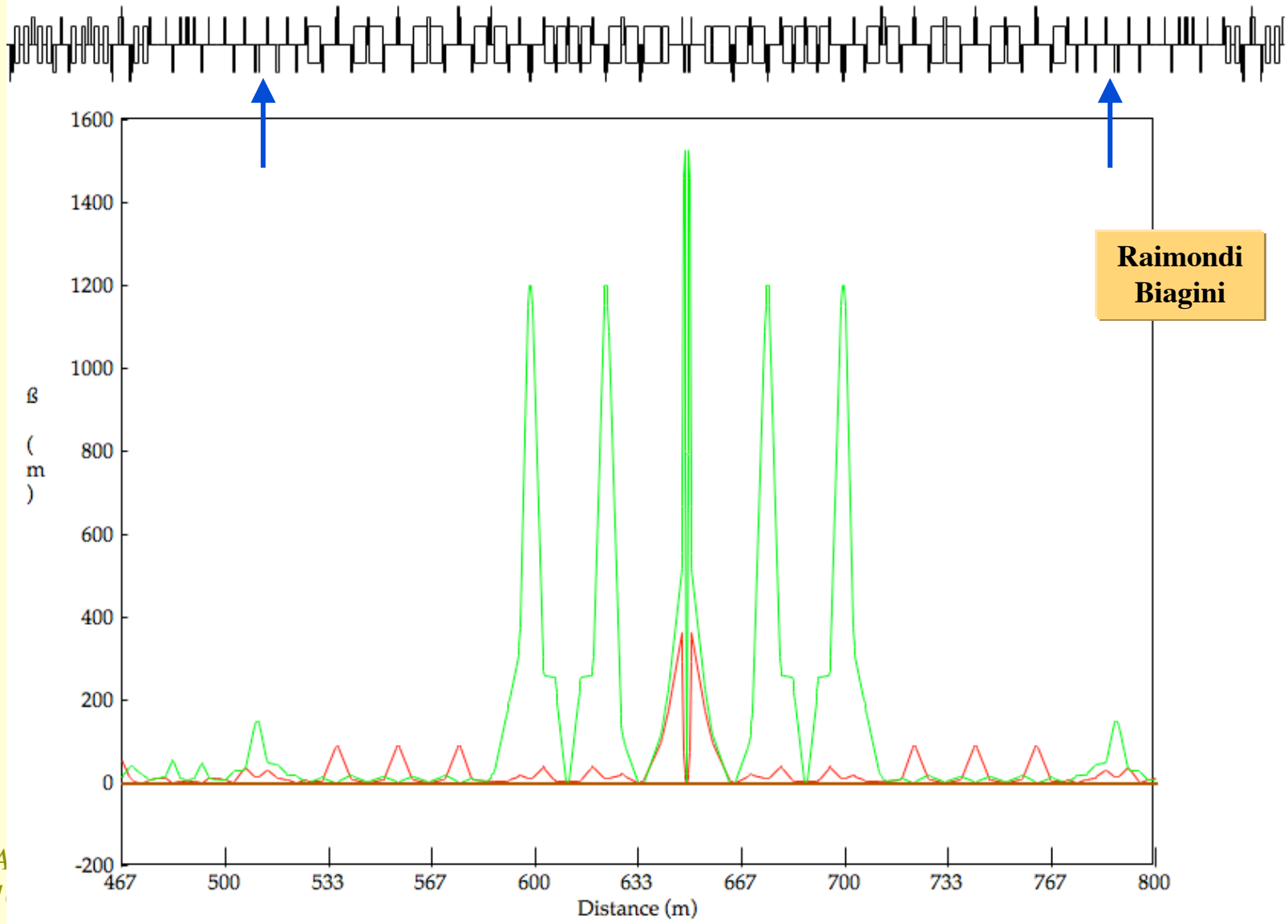
Settling Time



LNF LER

- Much shorter ring (1400 m *vs* > 1800 m)
  - can't fit antisymmetric rotator
- Lower spin tune (9.5 (4.2 Gev) vs 16 (7 GeV))
  - can use whole IR for 270° rotation
  - much easier optically…
- Investigate Pantaleo/Marica's lattice

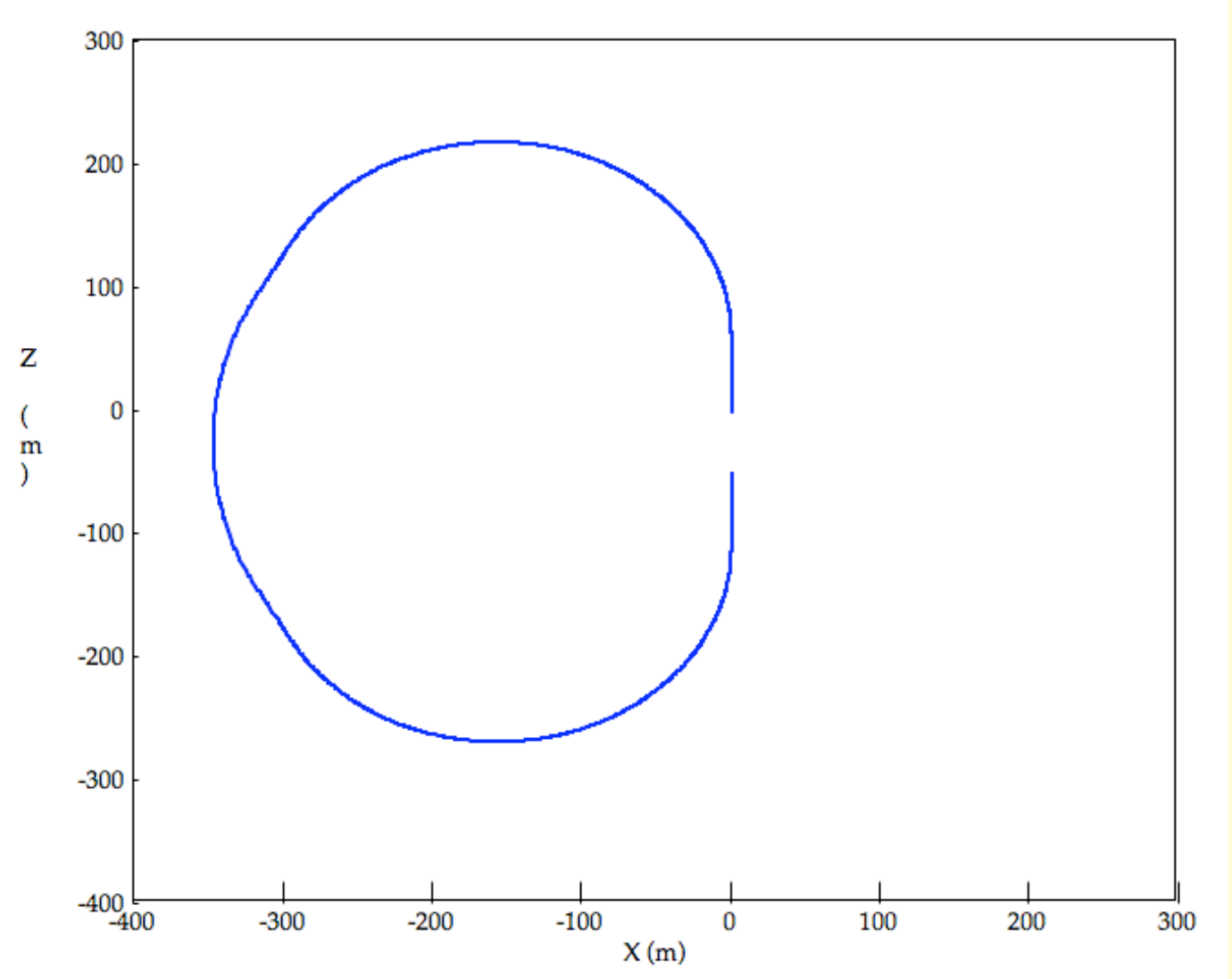
LER IR with Spin Rotators



Raimondi
Biagini

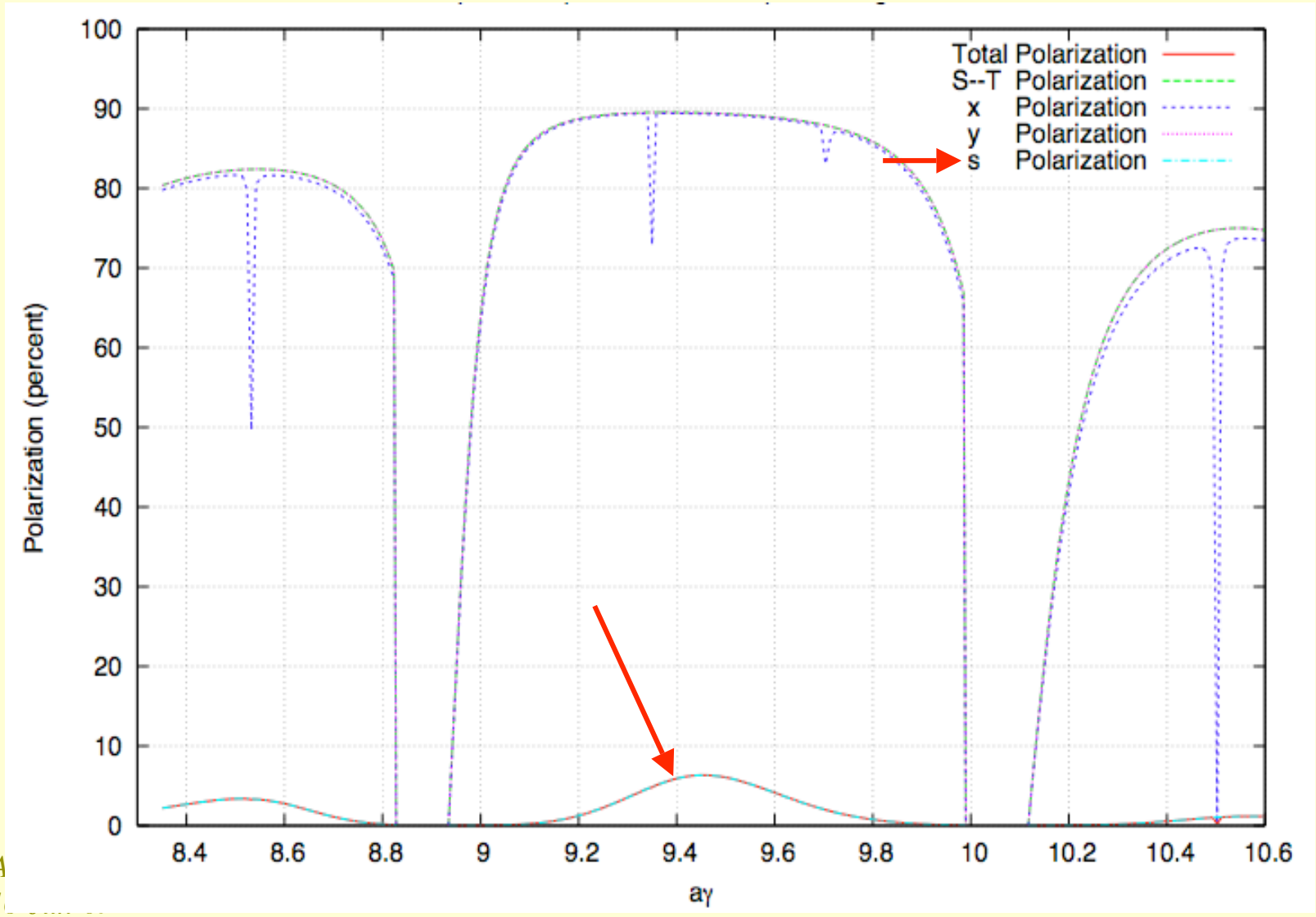
LNF LER Layout

The apparent gap is inconsequential for polarization estimates



Slicktrack Eq. Polarization

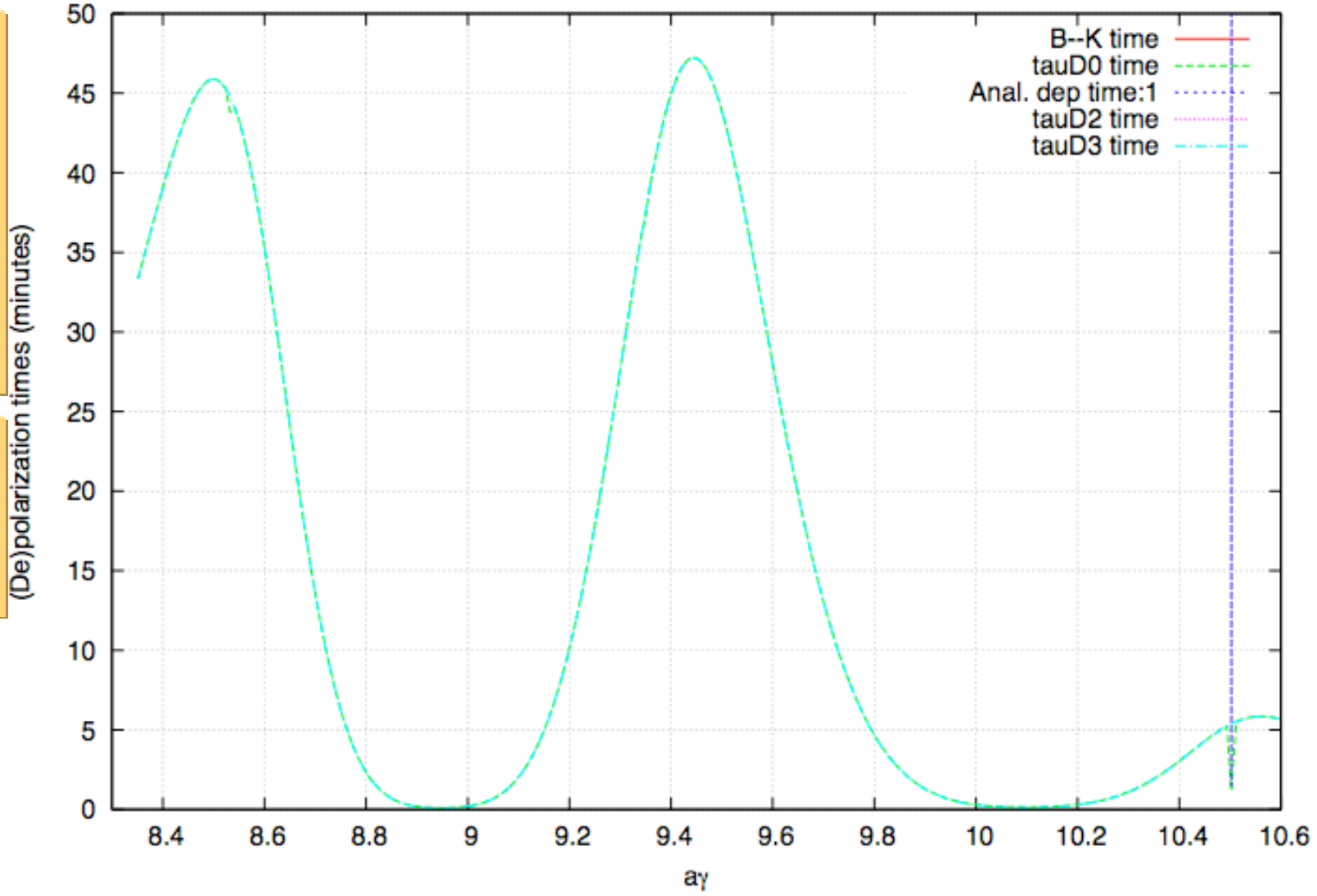
Strong longitudinal mismatch destroys polarization.



LER Polarization Settling Time

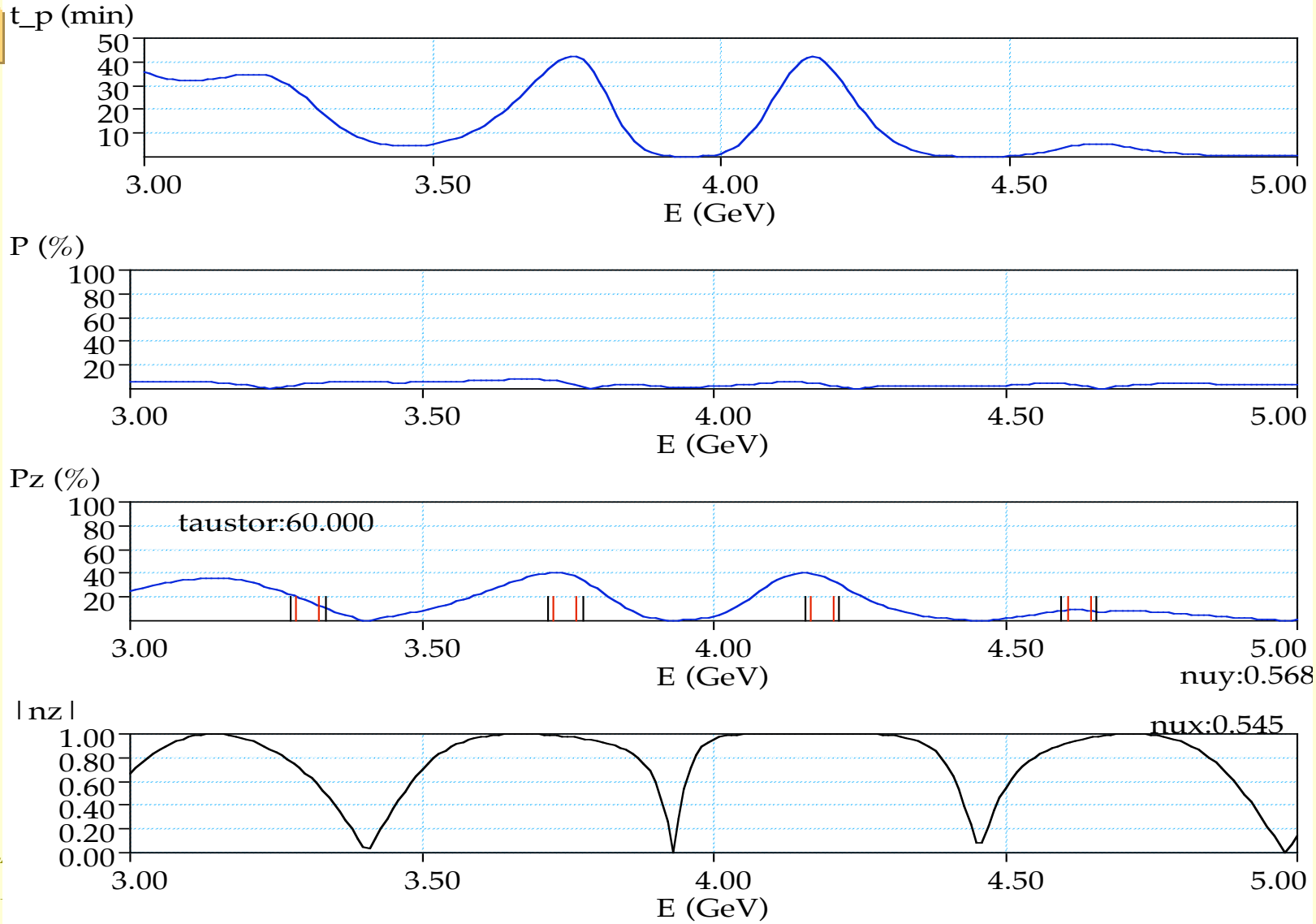
The settling time for polarization is about 45 min at best.
***P* will settle to a few % i.e. this is the depolarization time.**

Disclaimer: Optics in this Slicktrack run is not verified yet.



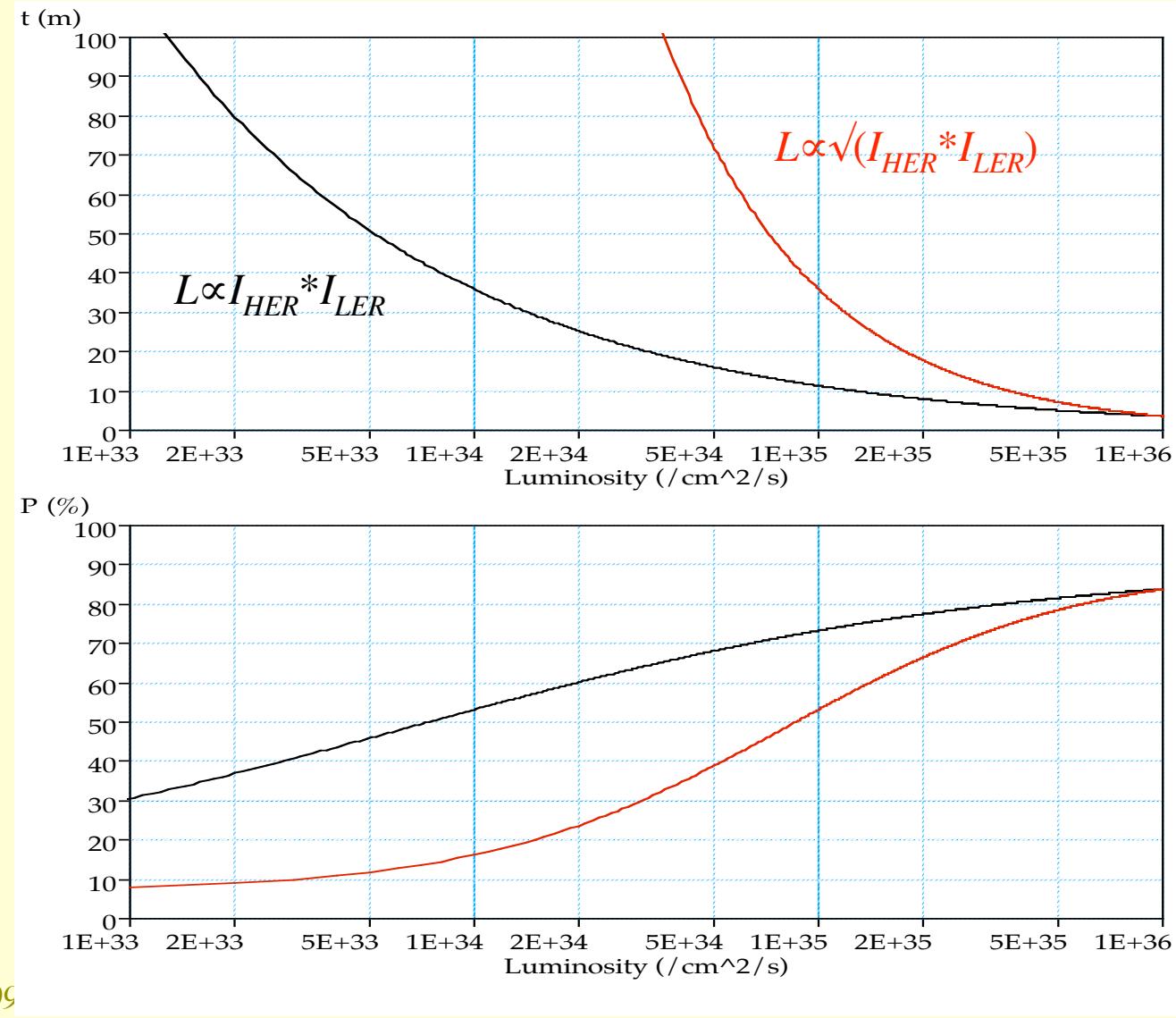
Compare to simple UW Code…

No so bad…



LER Life Time & Polarization *vs L*

These curves indicate beam lifetime & polarization vs luminosity with certain assumptions:
t_{pol} = 45 min
P_{inj} = 90%
P_{eq} = 7%
Touschek & lumi lifetime for LER beam



Summary

- Collaboration with DESY (Barber) established
  - Slicktrack now runs at Stanford
  - First look at both antisymm. HER and symmetric LNF LER
- Antisymmetric HER looks promising
  - need more work with Slicktrack incl higher-order MC
- Symmetric LER looks marginal
  - Correct treatment of betatron resonances & orbit will reduce polarization, by a tbd amount.
  - at this point cannot give a final word
- but models not yet detailed enough & LER needs verification
  - so results are *preliminary*

Next Steps

- Continue investigating the options
  - Can we improve spin matching in the LNF LER?
  - misalignment studies, spin matching
- Put detector solenoid & compensation into IR lattice, investigate its effect
- Start thinking about space for polarimetry
- Spin tracking & higher orders once we have a lattice that looks reasonable to 1^{st} order.
  - improve spin match
- Solenoid parameter optimization.
- It has been suggested to investigate snakes (again)
  - unlikely to succeed, $\gamma\, dn/d\gamma$ tends to get huge
  - but it is relatively simple to do…
- Beam-beam effect on P (relevant by HERA exp.)

End