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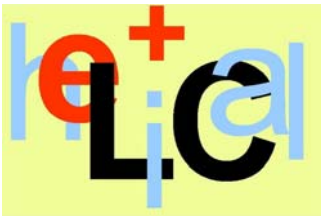
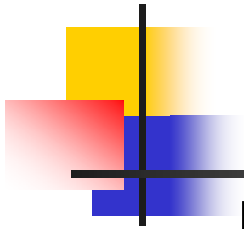


Depolarisation Effects at the ILC Damping Ring

Cockcroft Institute

L.I. Malysheva
on behalf of
heLiCal collaboration



heLiCal

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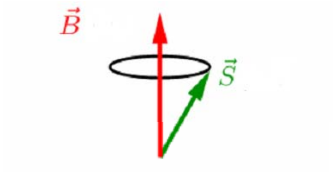
Introduction

- A high intensity polarised e^+ beam is essential for realising the total physics potential of the ILC
  http://www.ippp.dur.ac.uk/~gudrid/source/
- Two lattices had been already studied: old OCS 6km and TESLA 17 km
- Loss of polarisation in DR according to previous simulations was found to be negligible.
- Absence of full decoherence of the horizontal components of the spins was observed for the electron beams.

Spin behaviour in guide fields

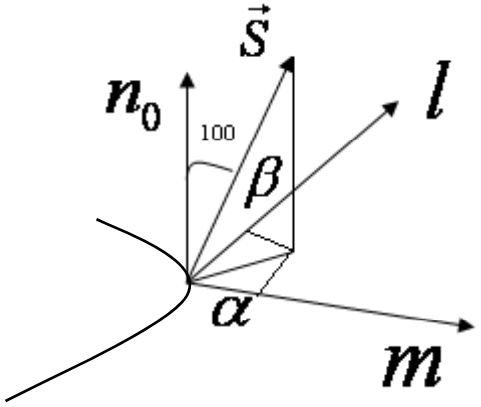
- $\vec{P} = \left\langle \vec{S} \right\rangle_{bunch}$

SPIN PRECESSION (THOMAS-BARGMANN-MICHEL-TELEGDI)



$$\frac{d\vec{S}}{ds} = \vec{\Omega} \times \vec{S}, \quad \text{where} \quad \vec{\Omega}(\vec{E}, \vec{B}, \gamma, \vec{v}) \Rightarrow \delta\theta_{spin} \propto \frac{(g-2)}{2} \gamma \delta\theta_{orbit}$$

Synchrotron Radiation $\Rightarrow$ SPIN DIFFUSION in Damping ring



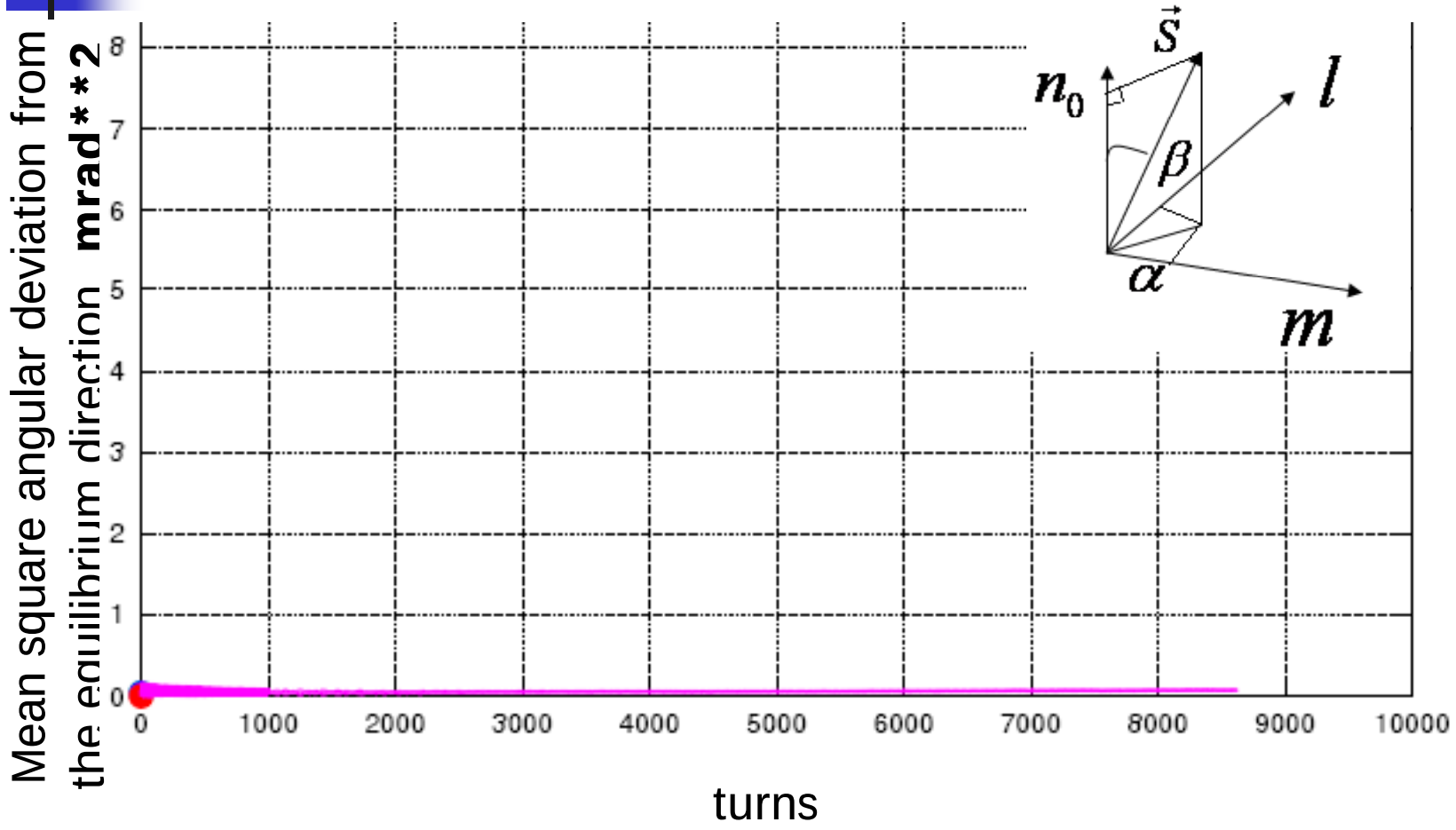
$$\vec{S} = \sqrt{1-\alpha^2-\beta^2}\,\hat{n}_0(s) + \alpha\hat{m}(s) + \beta\hat{l}(s)$$

$$\frac{dP}{dt} \approx -\frac{1}{2}\frac{d}{dt}\left\langle \alpha^2 + \beta^2 \right\rangle = -\frac{1}{2}\frac{d}{dt}(\sigma^2{}_\alpha + \sigma^2{}_\beta)$$

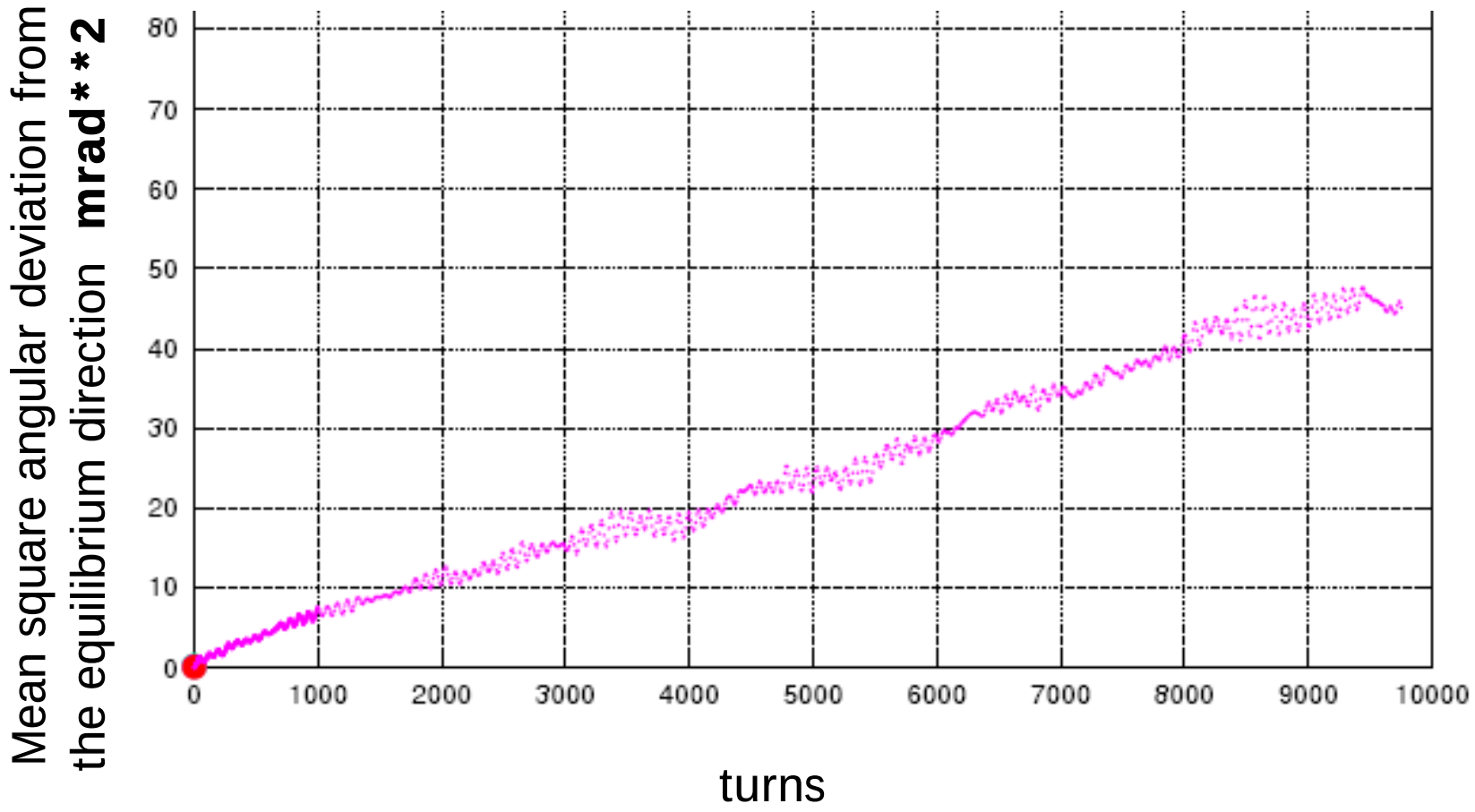
Computer Simulation

- Misalignments were introduced: 1/3mm, 1/3 mrad
- SLICKTRACK: Monte-Carlo simulation of the effects of synchrotron radiation, i.e. evolution of the spin distribution over a few damping times including full 3-D spin motion
- NO significant depolarising effects have been detected even for a positron beam with its large energy spread and transverse dimensions.

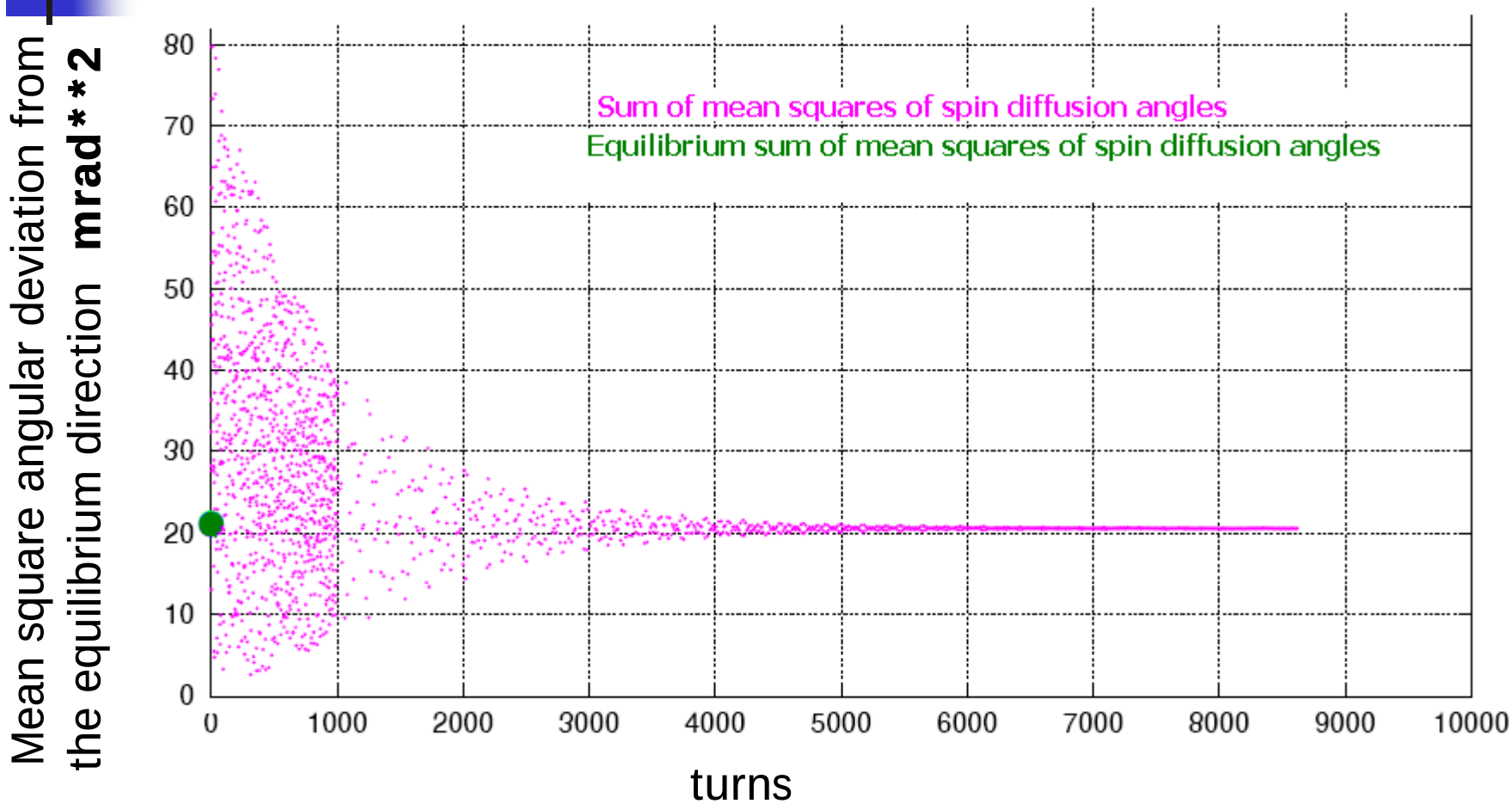
OCS6 Spin Diffusion at 5 GeV: electrons



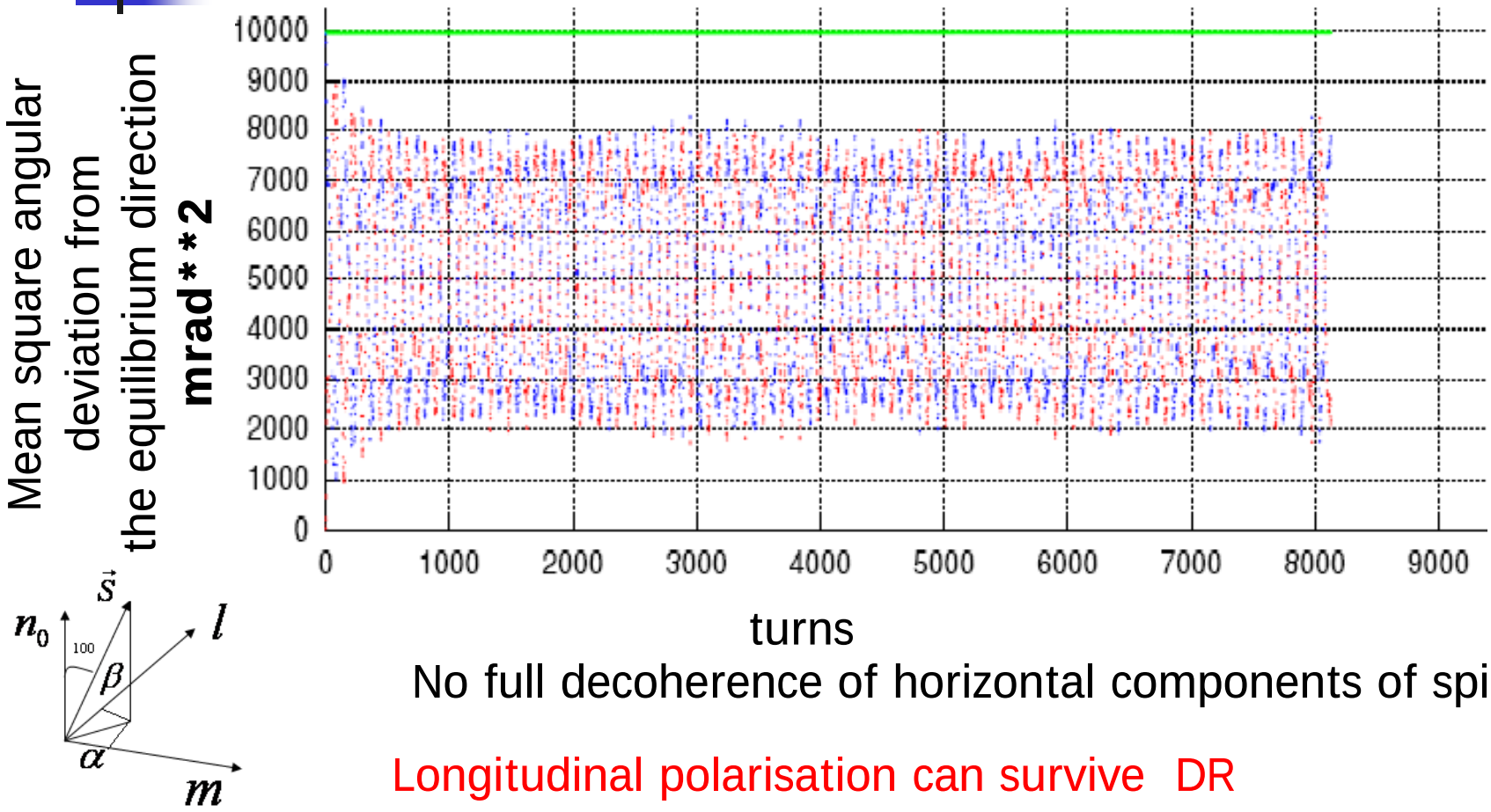
OCS6 Spin Diffusion at 4.8 GeV



OCS6 Spin Diffusion at 5 GeV: positrons



OCS Spin Diffusion at 5.066GeV for spins initially at 100 mrad from $\hat{n}_0$



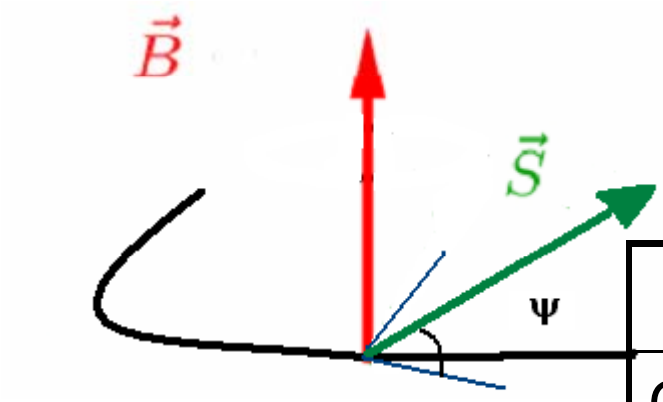
No full decoherence of horizontal components of spins

Longitudinal polarisation can survive DR

See http://www.desy.de/~mpybar/psdump/bloom19_update.pdf
and http://arxiv.org/physics/9709025

Simple analytical model

1. "Ideal" ring: perfectly aligned, no vertical bends, solenoids or skew quads
2. vertical emittance assumed to be zero
3. Only longitudinal motion, smooth optic



In a few synchrotron damping times the ψ distribution reaches equilibrium!

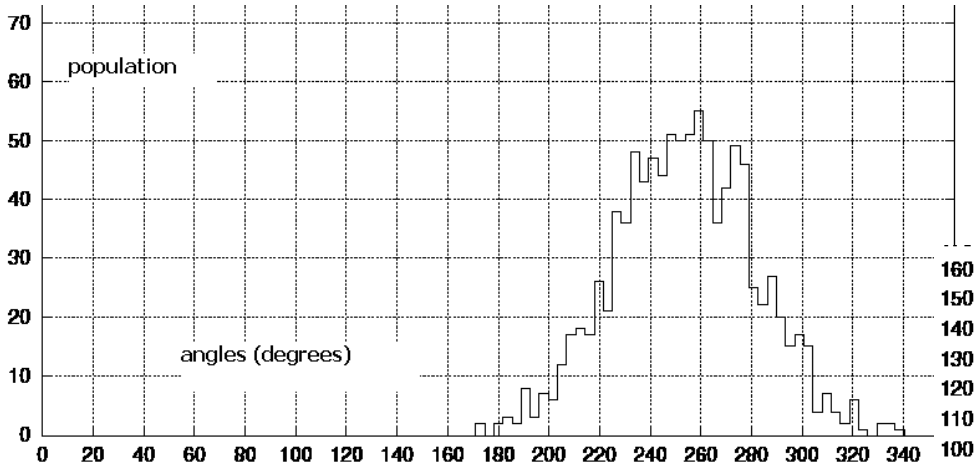
$$\sigma_\psi(\infty) = a\gamma\sigma_\delta / Q_s$$

	Q_s	σ_δ	$\sigma_\psi(\infty)$	SLICKTRACK
OCS	**0.037**	**1.29x10 $^{-3}$**	**25.4^0**	27.64 ^{0}
OCS6	**0.0958**	**1.28x10^{-3}**	**9.81^0**	**9.06 ^{0}**

Slicktrack modelling assumes very small energy spread of starting distribution

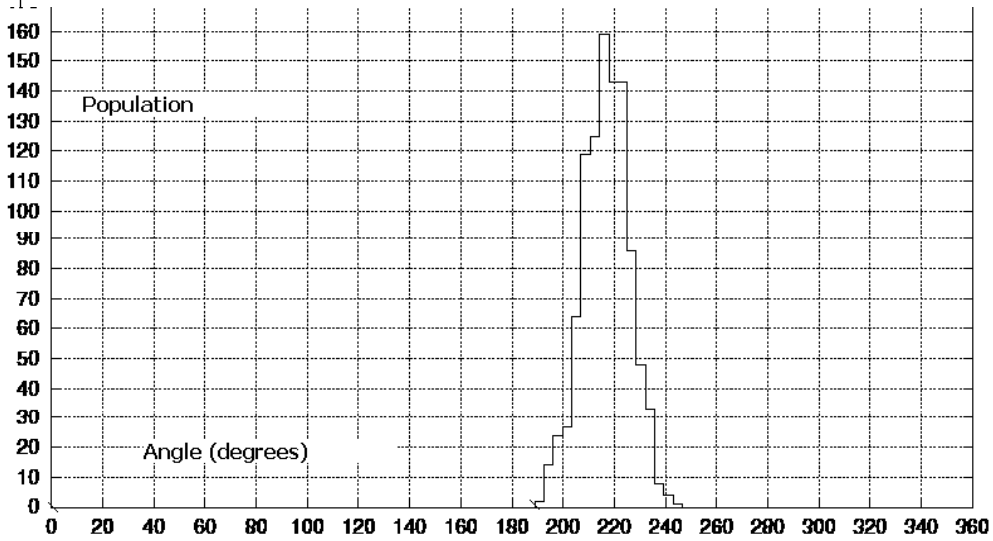
$\sqrt{2}$ Factor for beams injected with "natural" energy spread

Distribution of the spin projections on horizontal plane



Old OCS lattice

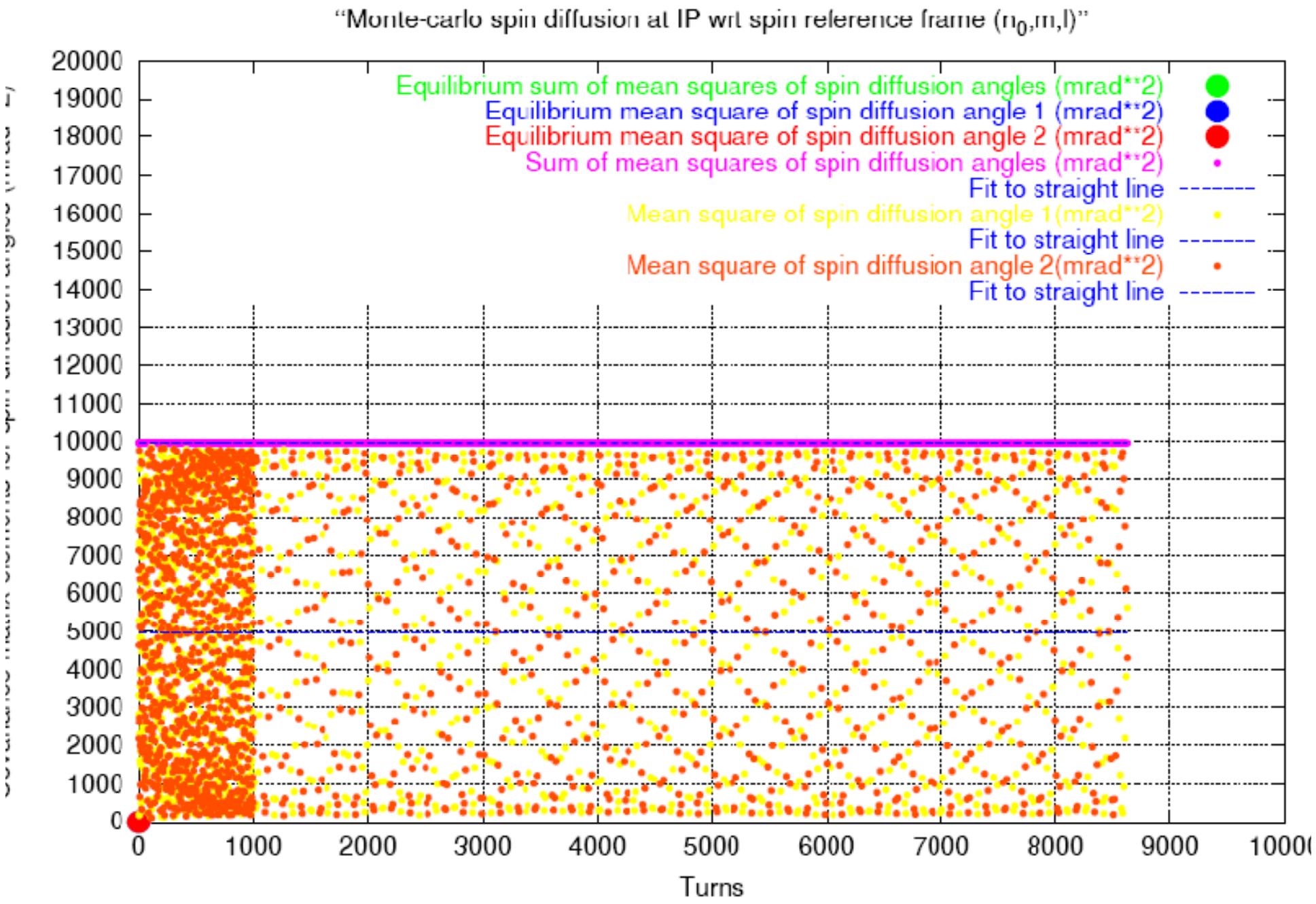
New OCS6



Conclusions and Plans

- Loss of polarisation in DR insignificant for new OCS6 lattice
- Depolarisation of positron beam with its large energy spread and transverse dimensions was estimated and found negligible
- The horizontal component of polarisation will survive in DR!

- We will maintain a rolling study to include extra effects as necessary as for
- Include non-linear optics (Collaboration with E. Forest to build spin into PTC and FPP codes)


"Monte-carlo spin diffusion at IP wrt spin reference frame (n_0,m,l)"
Equilibrium sum of mean squares of spin diffusion angles (mrad**2)
Equilibrium mean square of spin diffusion angle 1 (mrad**2)
Equilibrium mean square of spin diffusion angle 2 (mrad**2)
Sum of mean squares of spin diffusion angles (mrad**2)
Fit to straight line
Mean square of spin diffusion angle 1(mrad**2)
Fit to straight line
Mean square of spin diffusion angle 2(mrad**2)
Fit to straight line
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
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0
1000
2000
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8000
9000
Turns