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# Depolarisation Effects at the ILC Damping Ring

*Cockcroft Institute*

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on behalf of

heLiCal collaboration



# heLiCal

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# Introduction

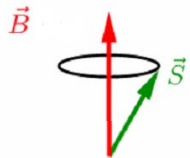
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- A high intensity polarised  $e^+$  beam is essential for realising the total physics potential of the ILC  
<http://www.ippp.dur.ac.uk/~gudrid/source/>
- Two lattices had been already studied: old OCS 6km and TESLA 17 km
- Loss of polarisation in 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

$$\vec{P} = \langle \vec{S} \rangle_{bunch}$$

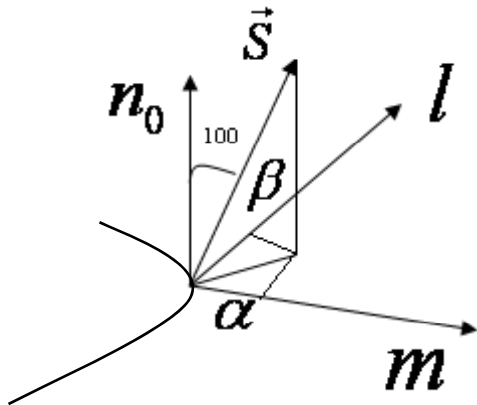
SPIN PRECESSION ( THOMAS-BARGMANN-MICHEL-TELEGDI)



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

Synchrotron Radiation

⇒ SPIN DIFFUSION in Damping ring



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

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

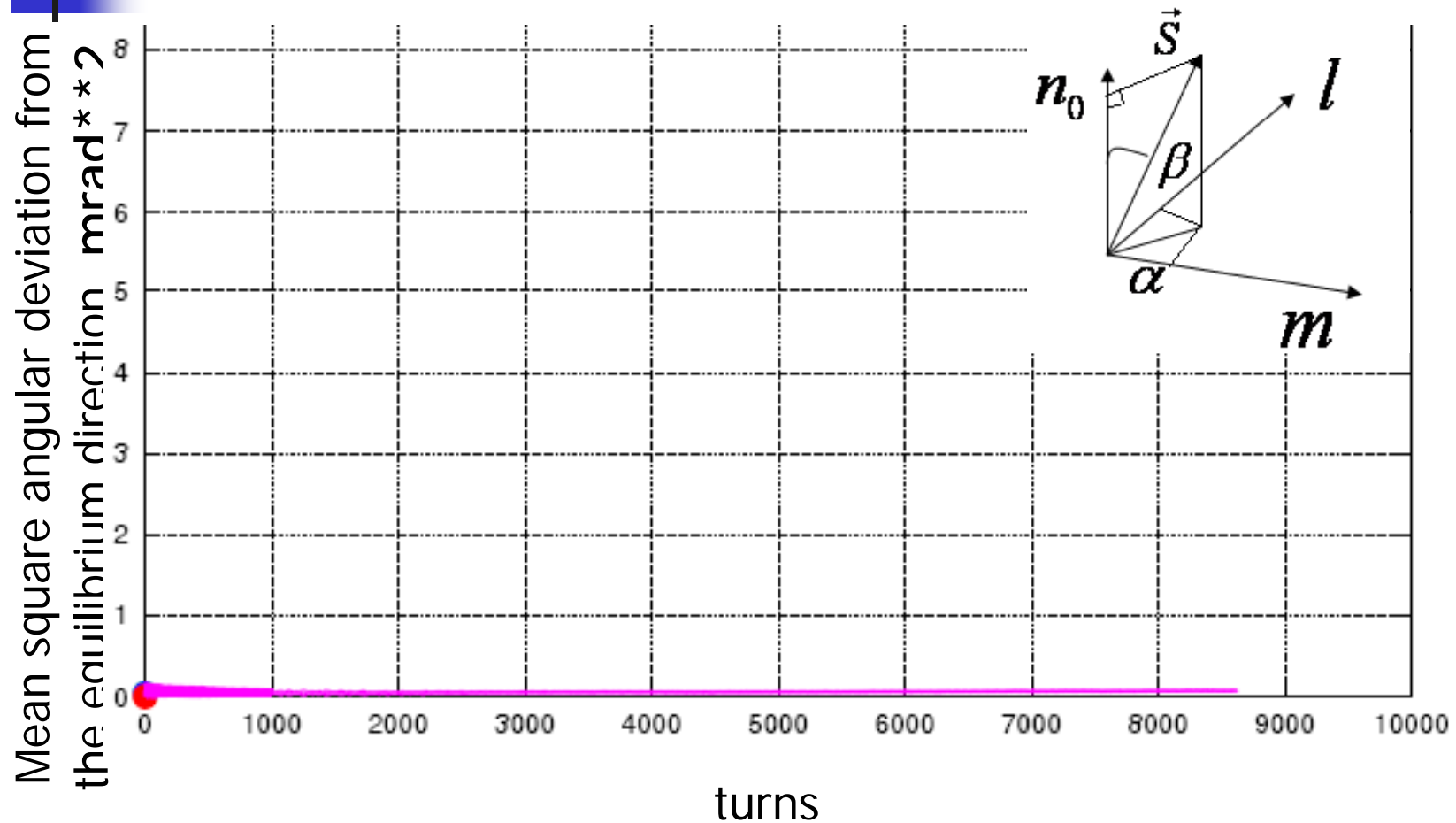


# Computer Simulation

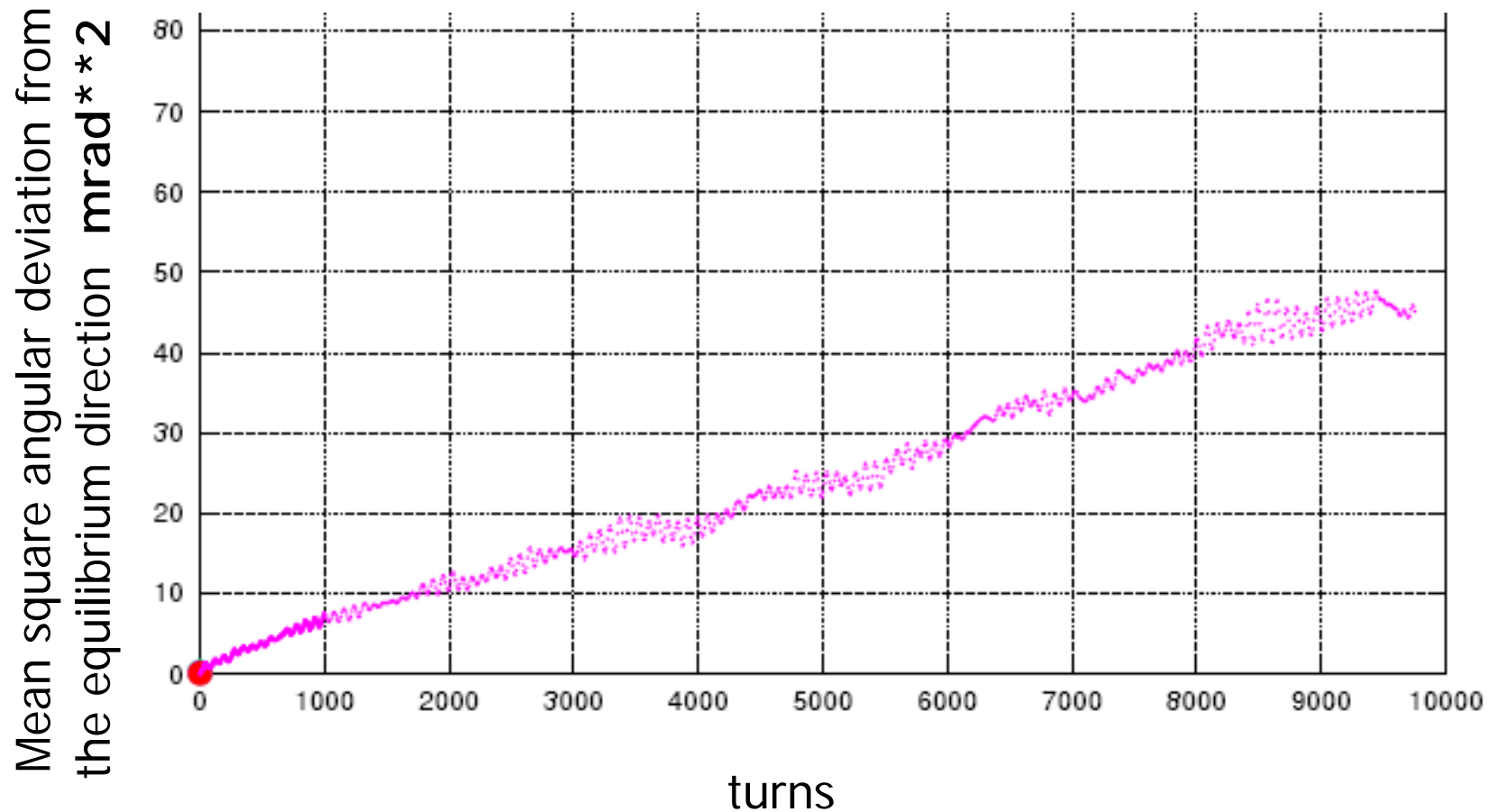
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- Misalignments were introduced: 1/3mm, 1/3 mrad
- **SLICKTRACK**: Monte-Carlo simulation of the effects of synchrotron radiation, i.e. evolution of the spin distribution over a few damping times including full 3-D spin motion
- **NO significant depolarising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

# OCS6 Spin Diffusion at 5 GeV: electrons

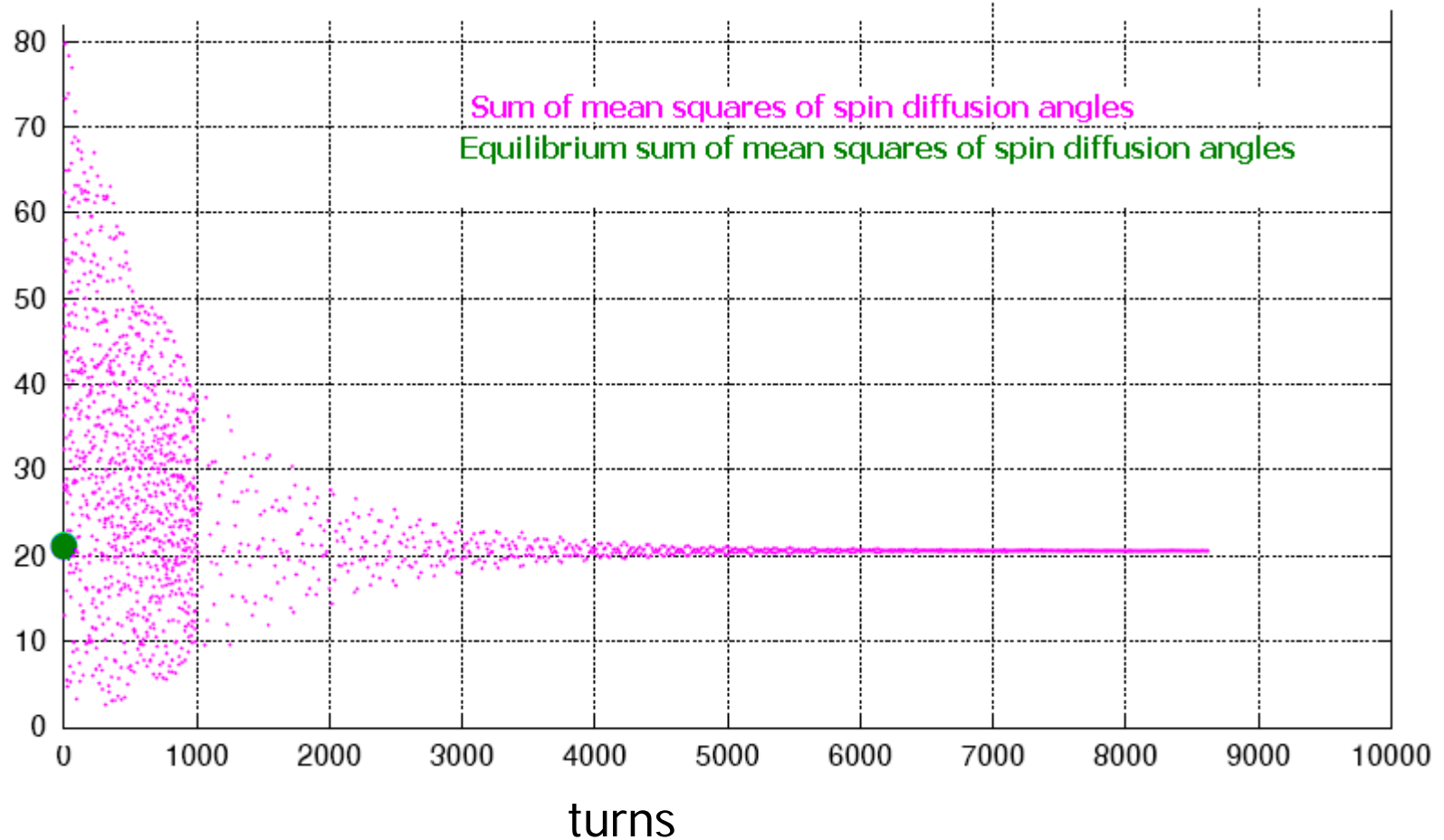


# OCS6 Spin Diffusion at 4.8 GeV



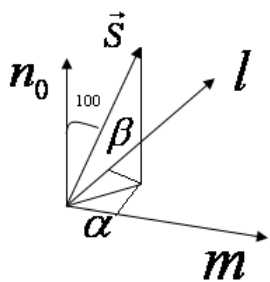
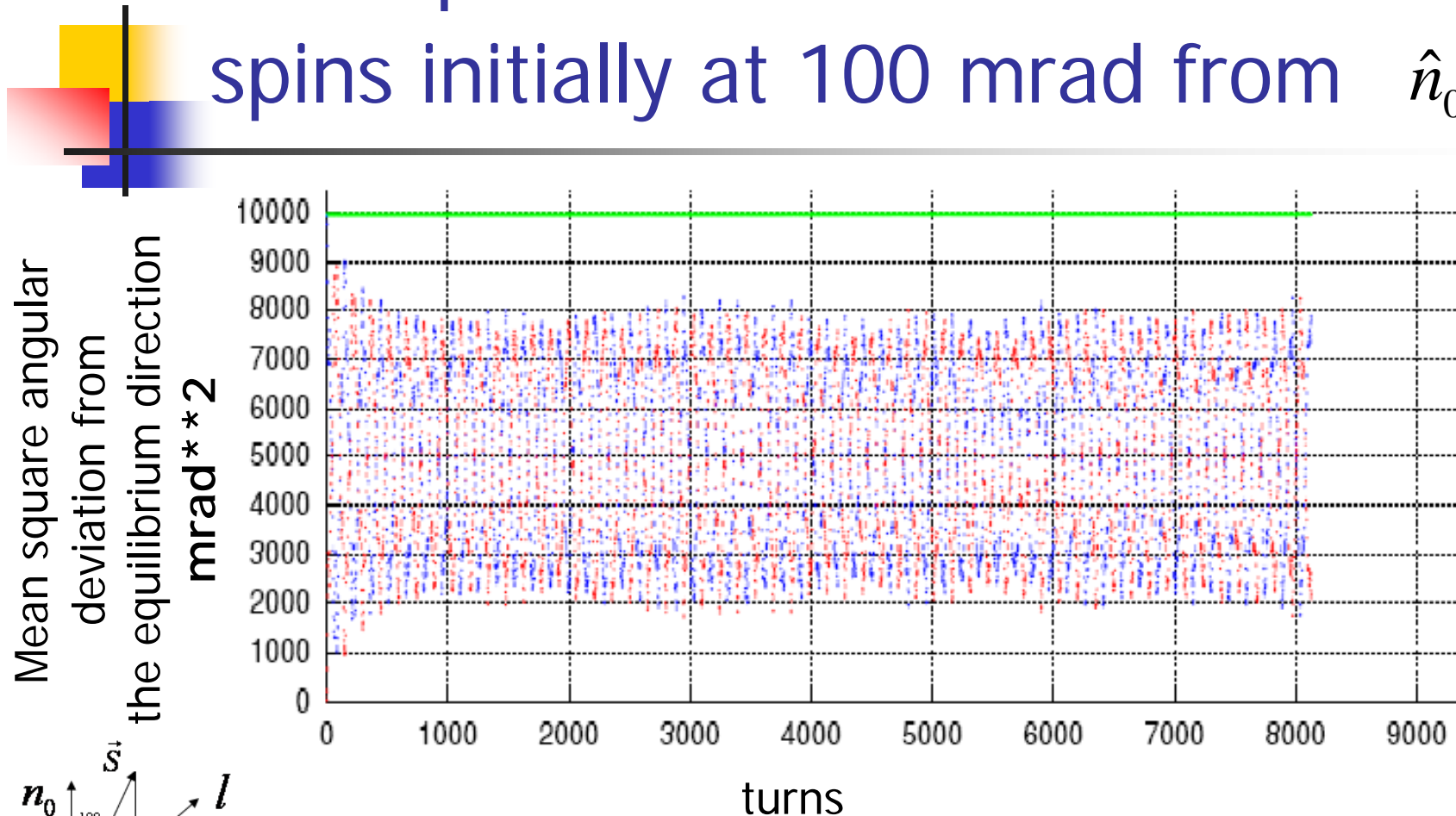
# OCS6 Spin Diffusion at 5 GeV: positrons

Mean square angular deviation from  
the equilibrium direction  $\text{mrad}^2$





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



No full decoherence of horizontal components of spins

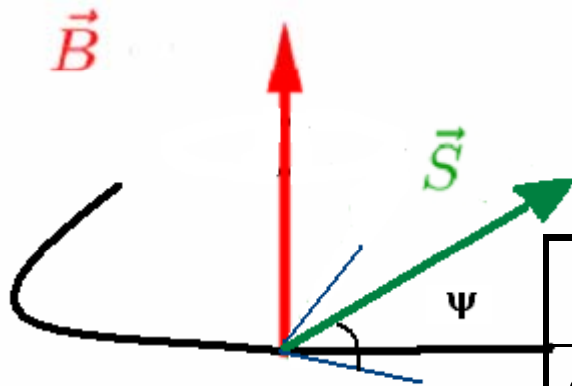
Longitudinal polarisation can survive DR

See [http://www.desy.de/~mpybar/psdump/bloom19\\_update.pdf](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  $\psi$  distribution reaches equilibrium!

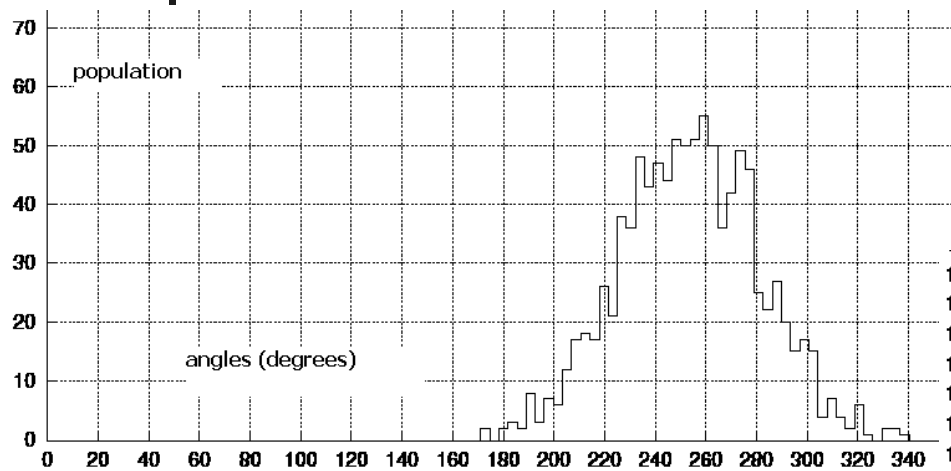
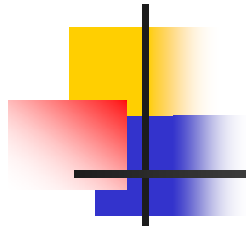


$$\sigma_{\psi}(\infty) = a\gamma\sigma_{\delta} / Q_s$$

	$Q_s$	$\sigma_{\delta}$	$\sigma_{\psi}(\infty)$	SLICKTRACK
OCS	0.037	$1.29 \times 10^{-3}$	$25.4^{\circ}$	$27.64^{\circ}$
OCS6	0.0958	$1.28 \times 10^{-3}$	$9.81^{\circ}$	$9.06^{\circ}$

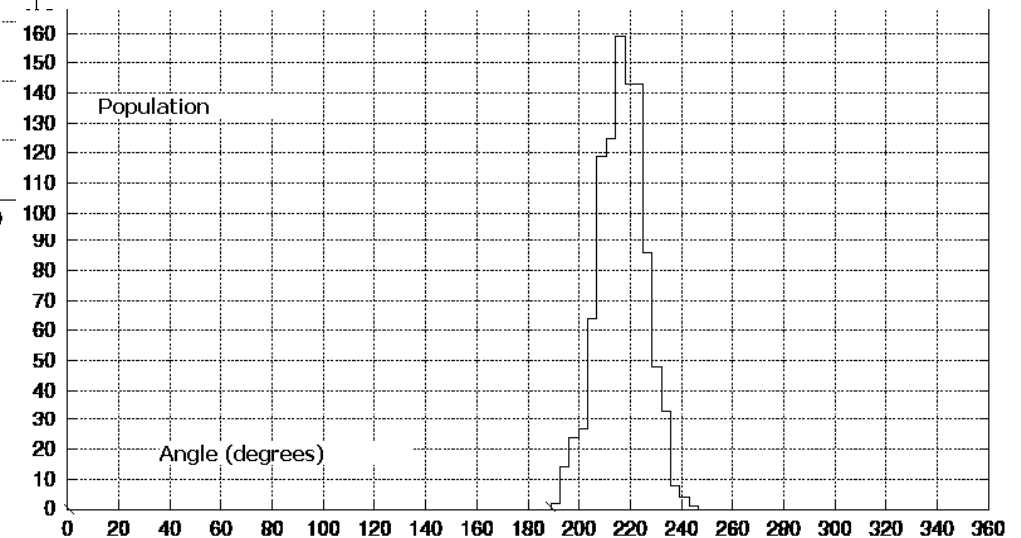
Slicktrack modelling assumes very small energy spread of starting distribution  
 $\sqrt{2}$  Factor for beams injected with "natural" energy spread

# Distribution of the spin projections on horizontal plane



Old OCS lattice

New OCS6





# Conclusions and Plans

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- 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 ( $n_0, m, l$ )”

