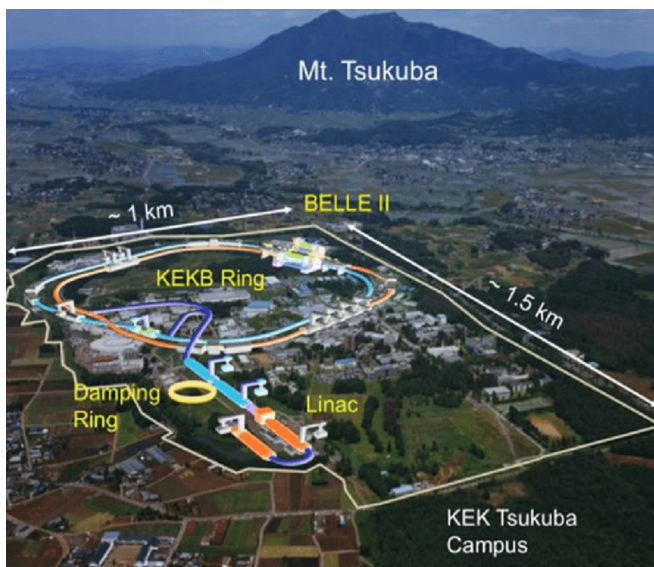# Transverse Polarization Studies
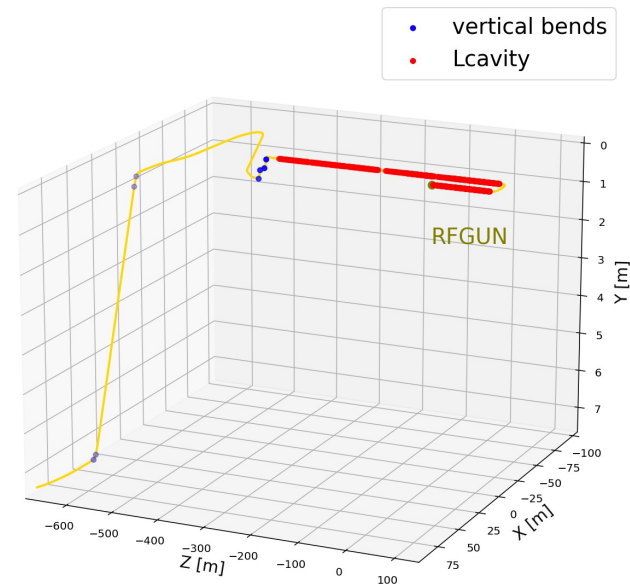
Michael Roney
Univ of Victoria

5 June 2023
B2GM Nagoya

KEK Injection Linac polarization BMAD studies
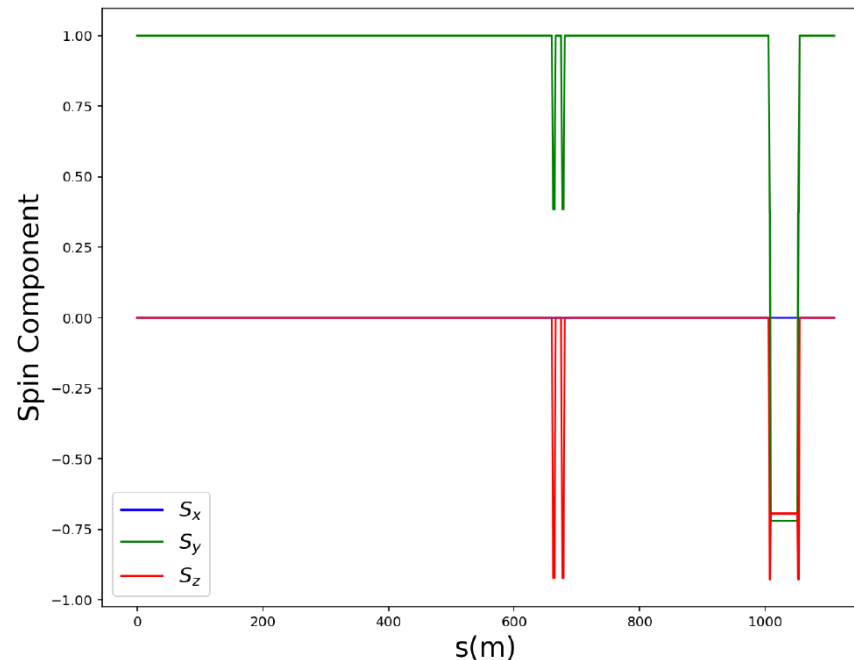
Y. Peng's (UVictoria)

KEK Linac

Need transversely polarized beam at the injection point of the e- storage ring (High Energy Ring -HER)

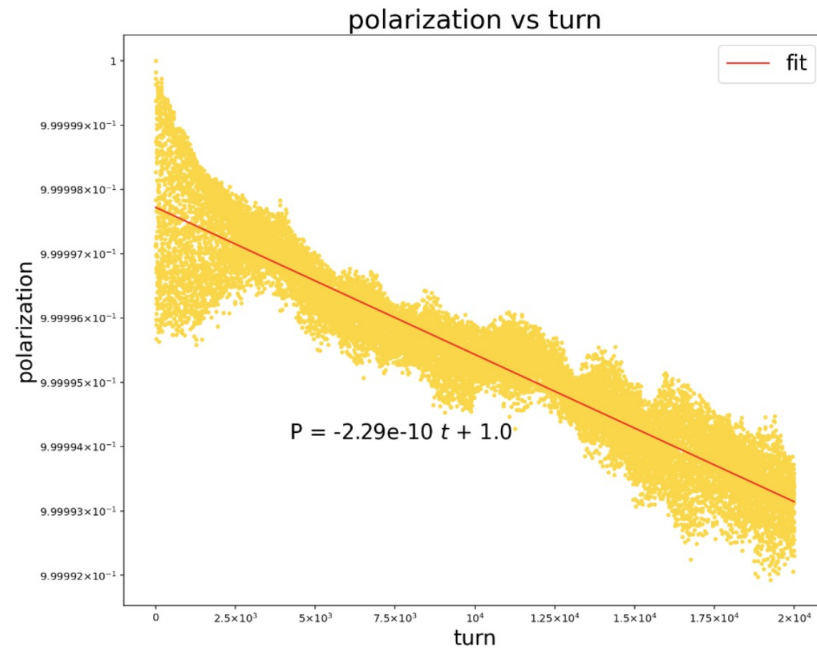# Spin motion in the KEK Injection Linac

Y. Peng's (UVictoria)

These spin tracking using BMAD show if the electron starts with vertical
 spin (0,1,0) at the source, after all the vertical beam motion,
it will end up with a vertical spin at the injection point, as desired.

3

Transverse polarization survival rate in HER

Y. Peng's (UVictoria)

- Tracking 100 particles for 20000 turns in the HER with BMAD
- This study estimates polarization lifetime > 10 hours

Touschek lifetime have been to study transverse polarization

From
Farah MAWAS
Aurélien MARTENS
Slides at Feb
Chiral Belle meeting

- Touschek described the lifetime of electrons in AdA ('accumulation ring') in 1963 (Bernardini et al., Phys. Rev. Lett 10 (1963) 407)

- Baier & Khoze, pointed out that Touschek lifetime is sensitive to polarization (At. Energ. 25 (1968) 440)

- It was then use in the VEPP-2M ring to measure depolarization (and thus beam energy): Derbenev Part. Acc. 8 (1978) 115

  - Measuring the counting rate of scattered electrons

- Ex: Allowed first precision mass measurement of J/Psi (3096.93+-0.09 MeV) then superseded in 1993 (E760)

- Continously improved at VEPP-4M (KEDR at VEPP-4M: 3096.900 ± 0.002 ± 0.006 MeV): Phys. Lett 96B (1980) 214; Blinov et al., proc. of EPAC (2002) 1954
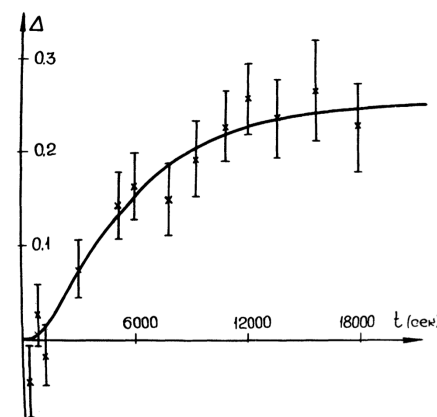

FIGURE 5 The jump in the counting rate during depolariza-tion versus time from the beginning of a polarization cycle.
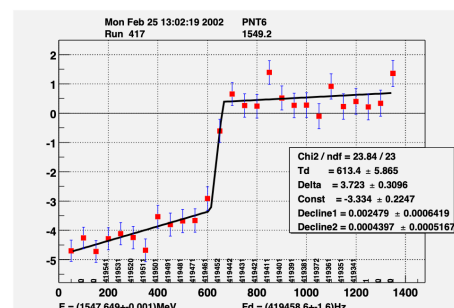

Figure 6: The jump ΔS during the scan of the depolarizer frequency. Abscissa is the time in seconds.

A slightly more modern use

From
Farah MAWAS
Aurélien MARTENS
Slides at Feb
Chiral Belle meeting

- Used at :
  - HIgS (DUKE): NIMA 614 (2010) 339
  - SOLEIL, NIMA 697 (2013) 1
  - Diamond Light Source, PRAB22 (2019) 122801
  - Based on expressions given in NIMA 554 (2005) 85
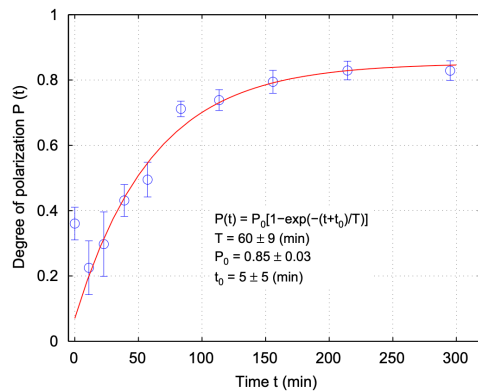 - Also proposed for FCCee: arXiv1909.12245

$$P(t) = P_0[1-\exp(-(t+t_0)/T)]$$
$$T = 60 \pm 9 \text{ (min)}$$
$$P_0 = 0.85 \pm 0.03$$
$$t_0 = 5 \pm 5 \text{ (min)}$$

Fig. 6. The build-up process of the electron beam polarization $P(t)$. The solid line is the exponential fit of the data. The fitting model as well as the fit results are also shown in the plot.
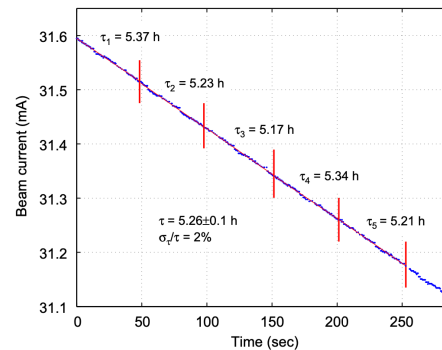

$$\tau_1 = 5.37 \text{ h}$$
$$\tau_2 = 5.23 \text{ h}$$
$$\tau_3 = 5.17 \text{ h}$$
$$\tau_4 = 5.34 \text{ h}$$
$$\tau = 5.26 \pm 0.1 \text{ h}$$
$$\sigma_\tau/\tau = 2\%$$
$$\tau_5 = 5.21 \text{ h}$$

Fig. 4. Illustration of beam lifetime determination around the current of 31 mA of the first run.

$$C(\epsilon) = \epsilon \int_\epsilon^\infty \frac{1}{u^2} \left\{ \left(\frac{u}{\epsilon}\right) - \frac{1}{2}\ln\left(\frac{u}{\epsilon}\right) - 1 \right\} e^{-u} \, \mathrm{d}u$$

$$F(\epsilon) = \frac{\epsilon}{2} \int_\epsilon^\infty \frac{1}{u^2} \ln\left(\frac{u}{\epsilon}\right) e^{-u} \, \mathrm{d}u$$

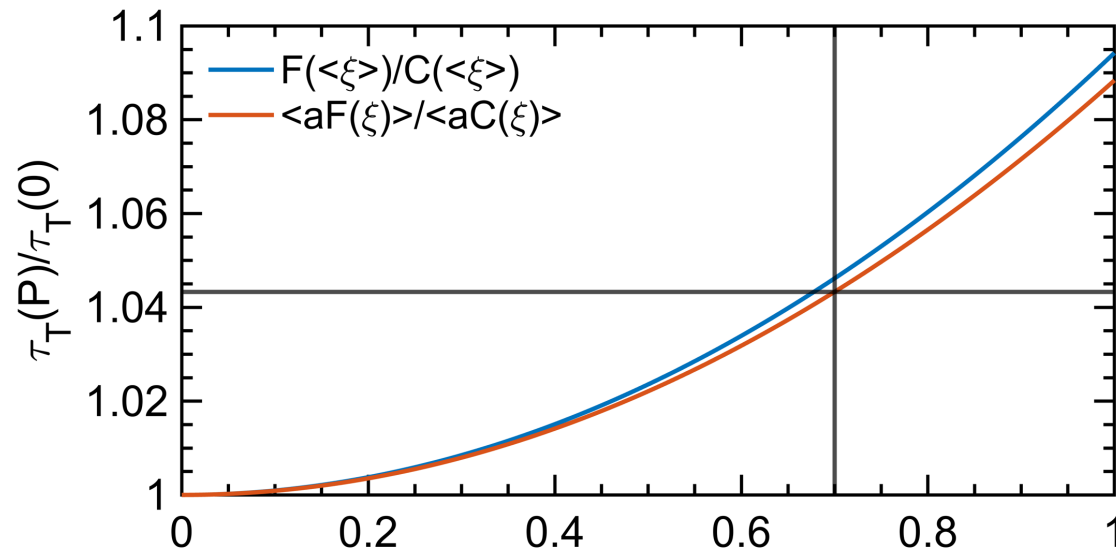$$\epsilon = \left(\frac{\Delta p_m/p_0}{\gamma \sigma_{x'}}\right)^2$$

$$a = \frac{\sqrt{\pi} c r_e^2}{\gamma^3 V \sigma_{x'} (\Delta p_m/p_0)^2}$$

$$P(t) \approx \sqrt{\frac{1}{A} \frac{I(t)\tau(P) - I_0\tau(0)}{I(t)\tau(P)}}$$

$$A = \frac{\langle aF(\epsilon) \rangle}{\langle aC(\epsilon) \rangle}$$

For SuperKEKB

- It is ~4% effect assuming (overall) momentum acceptance of 0.6%, and using her_2021-06-09_231636.388_MeasOpt

- This is likely observable in SuperKEKB

- May need to inject both polarized and unpolarized beams in the ring and measure bunch/bunch intensity with time to minimize systematics (feasbile according to Demin)

- Maybe F/C factor could be calibrated by comparing measurements with various momentum acceptances ? (linked to RF voltage ?)

Towards Transverse Polarized Beam Campaign

- Engage Background/MDI group to contribute to Touschek measurements in existing data & measure Touschek timetime
  - Can Paris group take lead on this?

- Determine timeline towards possibility of having a viable polarized source for such a focused study
  - Can Hiroshima group take lead on this?
  - Does Mitsuhiro Yoshida-san already have something close to being usable?
  - Engage KEK team – MakotoTobiyama-san, Mika Masuzawa-san, Mitsuhiro Yoshida-san

- Develop schedule for completing R&D and execution of studies

- Propose to Belle II a special run with transverse polarized beam injection with intention of measuring correlation between polarization and Touschek lifetime