Numerical computation of the Derbenev-Kondratenko depolarization rate using Zgoubi

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Why are we interested in numerical DK?

EIC requires high polarization (~80%) for both electron and ion beams.

Frequent re-injection of the electron beam is expensive.

Design studies demand simulations of multiple lattice configurations with a wide variety of errors.

T_{rev} ~10 μs ⇒ 1 min of real time ~ 6×10^6 turns!

Can we find a reliable means of quickly estimating the depolarization rate?

Derbenev-Kondratenko formula describes the equilibrium beam polarization

$$\tau_{\mathrm{DK}}^{-1} = \frac{5\sqrt{3}}{8}\frac{r_e \hbar \gamma^5}{m_e}\frac{1}{C}\oint \mathrm{d}s \left\langle \frac{1 - \frac{2}{9}(\hat{n}\cdot\hat{s})^2 + \frac{11}{18}\left(\frac{\partial \hat{n}}{\partial \delta}\right)^2}{|\rho(s)|^3} \right\rangle_s$$

$$\frac{1}{\tau_{\mathrm{DK}}} = \frac{1}{\tau_{\mathrm{ST}}} + \frac{1}{\tau_{\mathrm{dep}}}$$

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approximate using closed orbit value

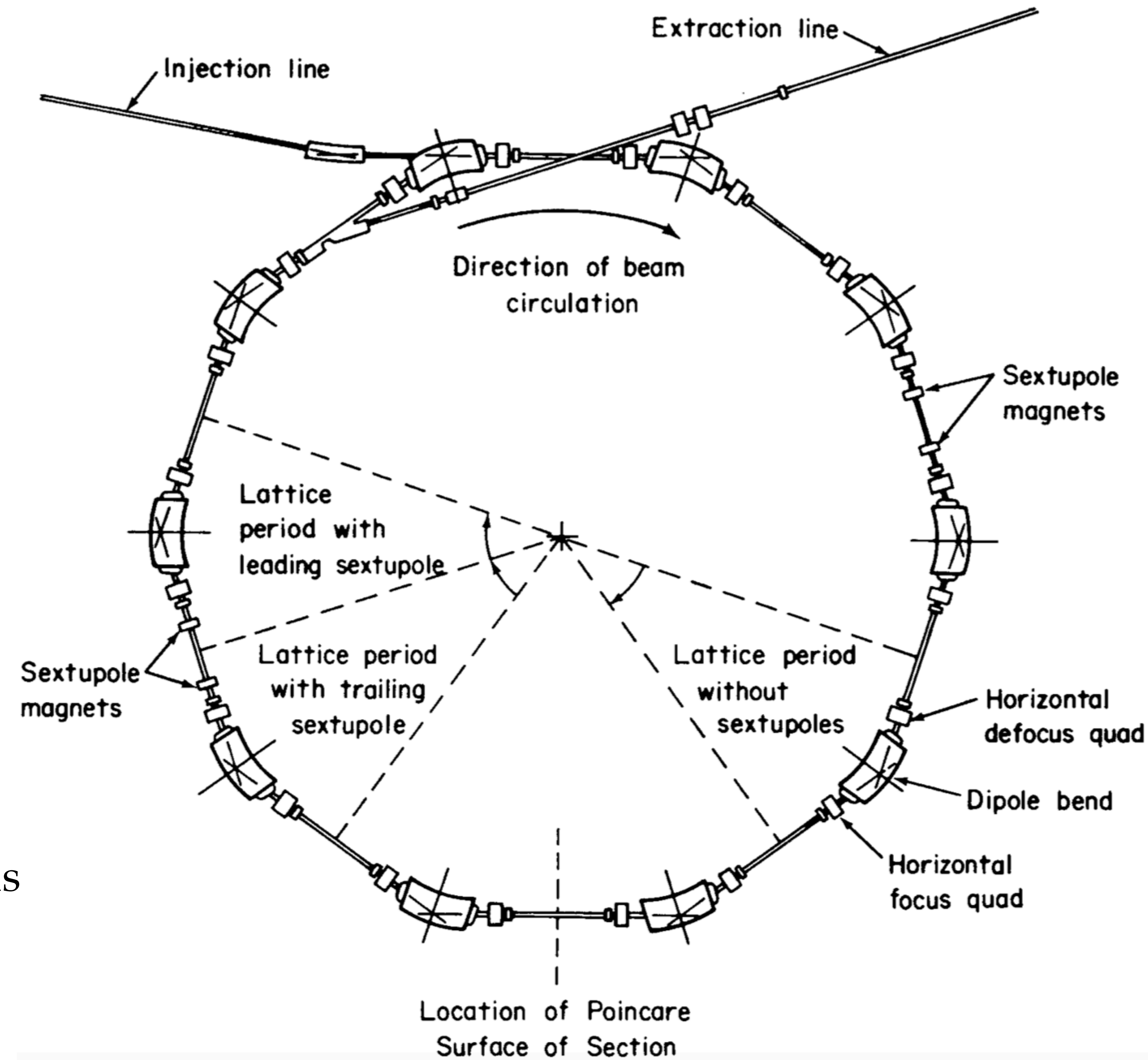
The *ePSR* is a useful testbed for benchmarking

$B\rho = 4.869$ T.m

$\Rightarrow$ 1.46 GeV electrons

γ ~2860

For electrons in this ring, synchrotron radiation leads to an energy loss of about 198 keV / turn.



See AJ Dragt, *Particle Accel.* 12:205 (1982)

Zgoubi can provide the data we need

Algorithm:

'FIT' the closed orbit with relative momentum deviations $(0, \pm\delta)$.

'FIT' the spin (n_0) with relative momentum deviations $(0, \pm\delta)$.

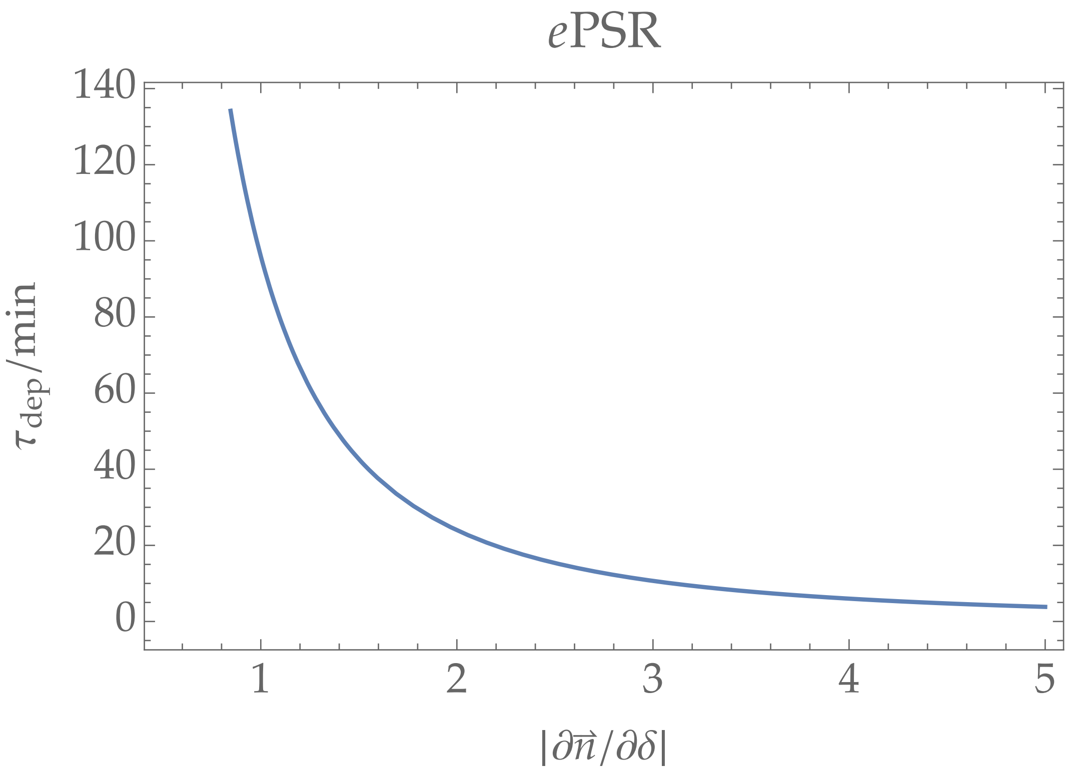
Track n_0 around the lattice and record values across each bend.

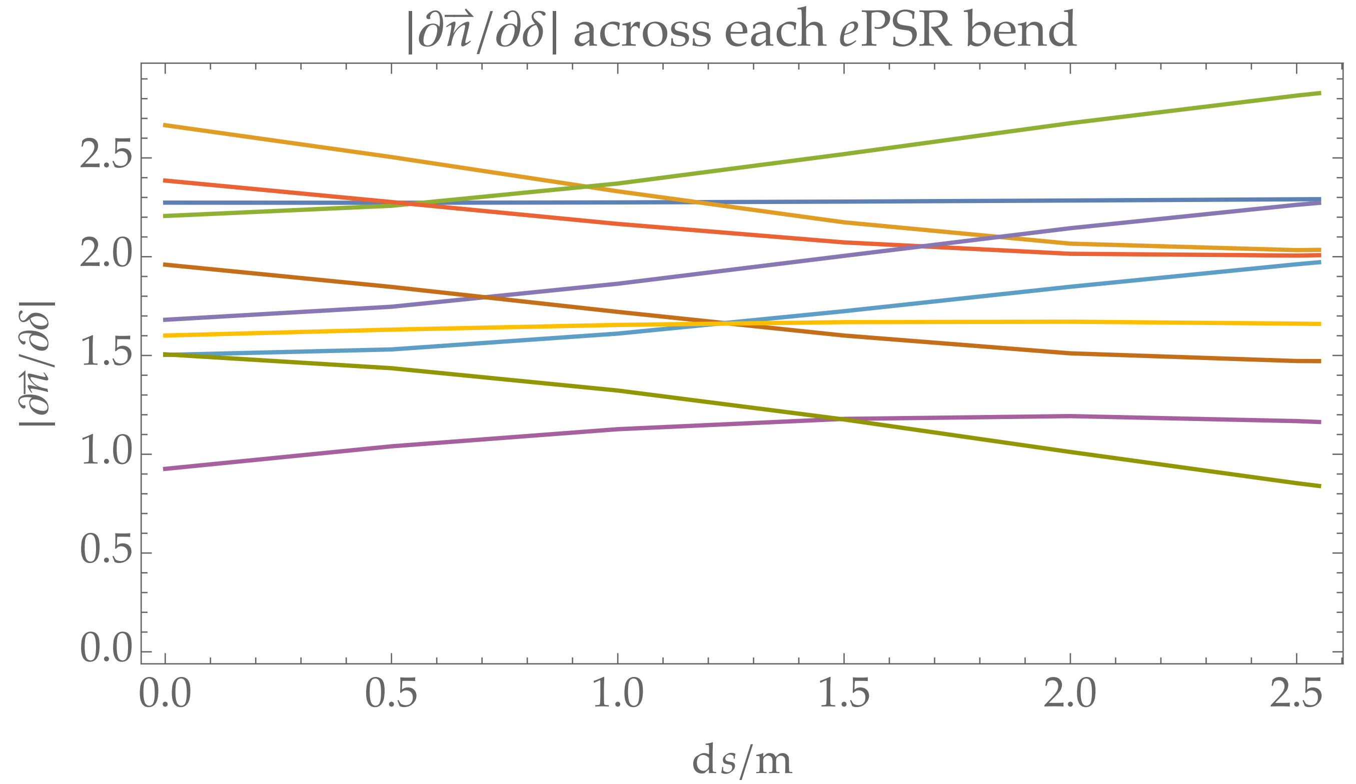
Post-process the data to

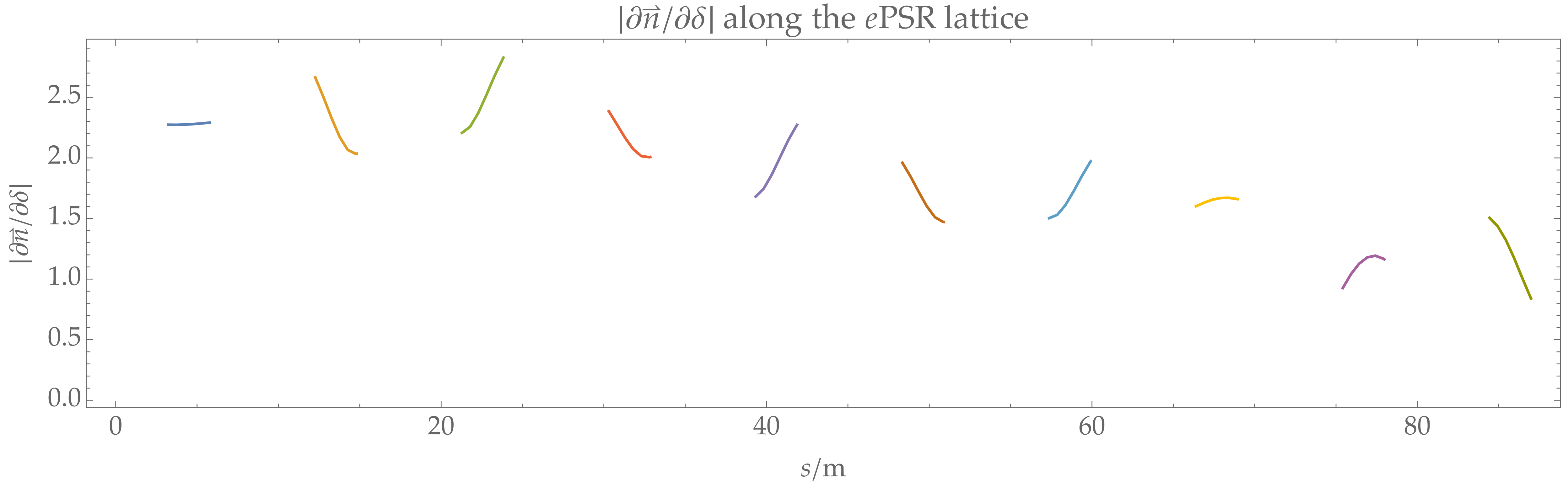
compute numerical values for $\mathrm{d}n/\mathrm{d}\delta$ at each step,

and then compute a numerical approximation of the DK result.

Initial Results for the ePSR







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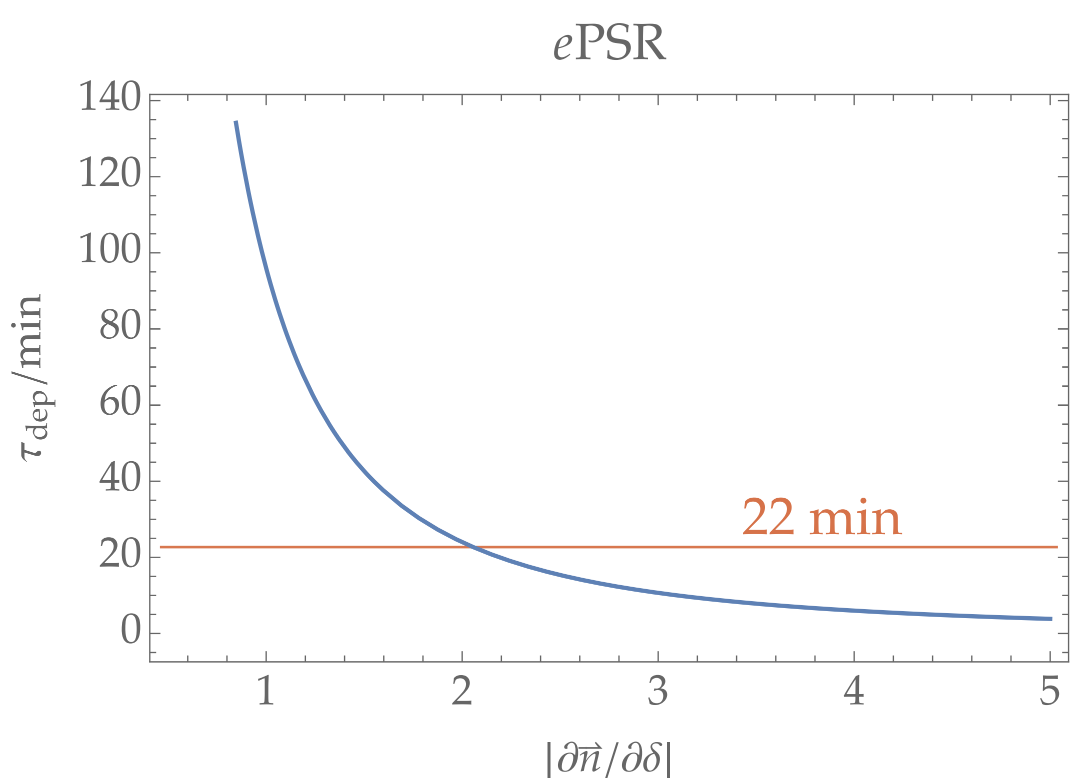

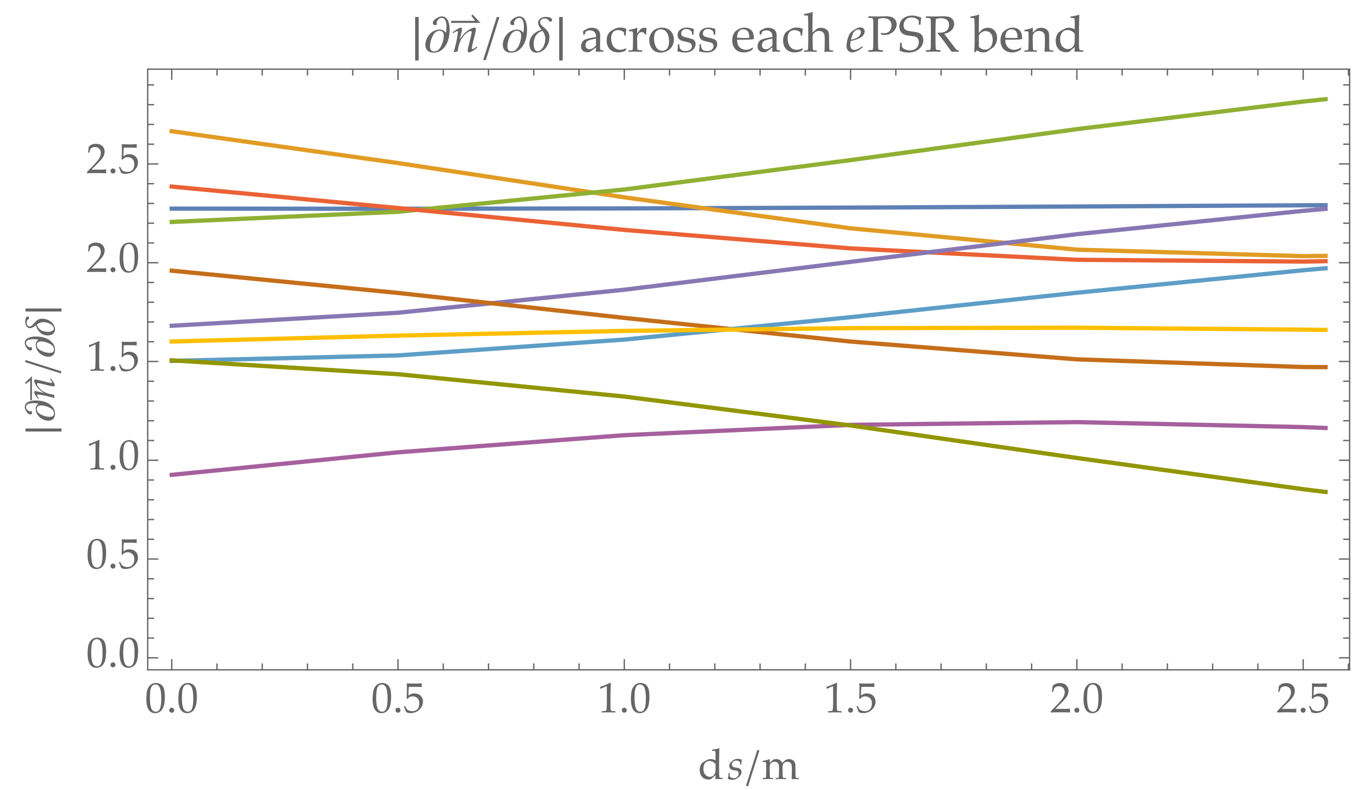

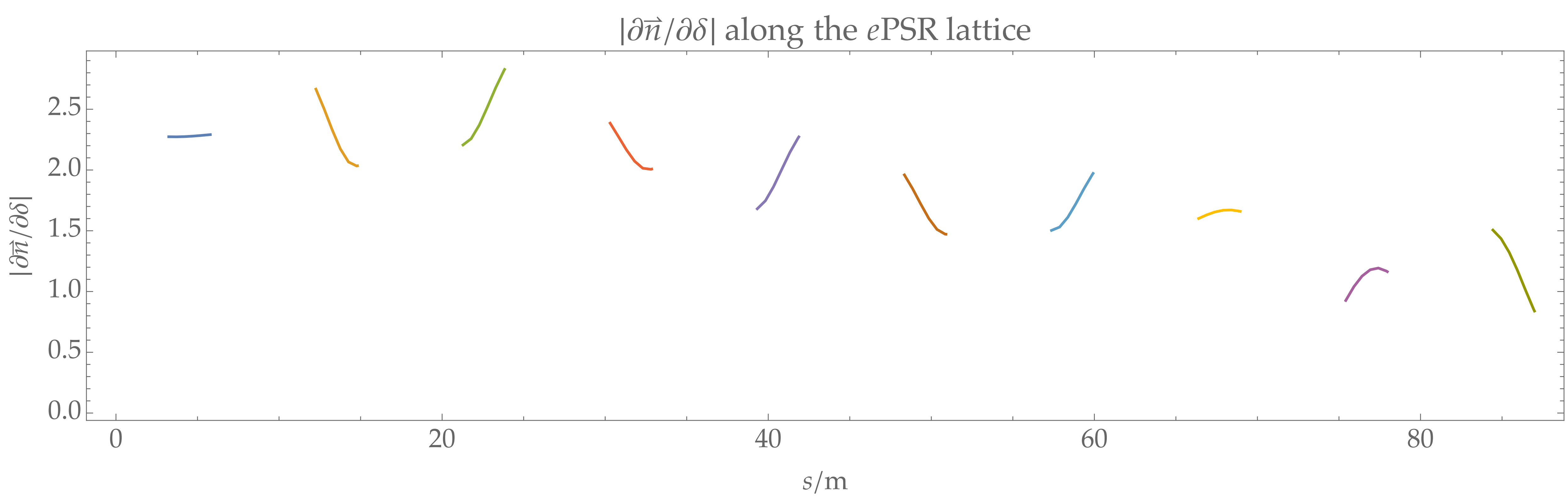

Future Work

Compare our estimates of ePSR depolarization time to ePSR tracking results.

Apply this approach to eRHIC and JLEIC lattice designs.

Use correlations between $\mathrm{d}n/\mathrm{d}\delta$ values and various error amplitudes to help identify which errors most contribute to depolarization.

Thank you!

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