SOLEIL MIK with Ti Coating: Stored Beam Perturbation

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Starting point

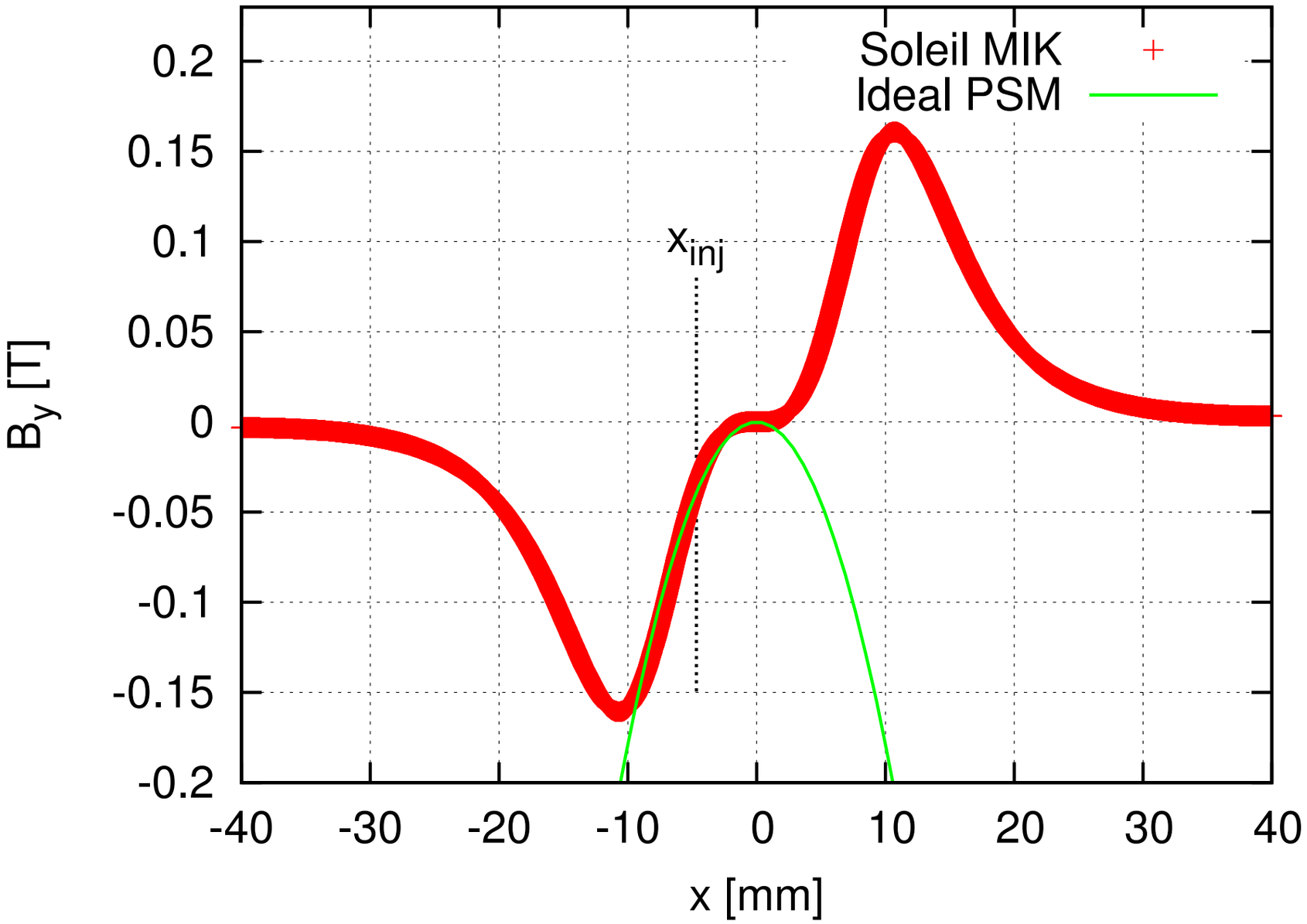
Pierre's report (May 12, 2013) on a preliminary MIK design with Ti coating:

- 20 µm ➟ <5 W (3 GeV), < 20 W (1.5 GeV), 11–13 W (SOLEIL)
  - ➡ desirable from a thermal POV, but perturbation of stored beam appears to be an issue
- Possible alternatives
  - 10 µm ➟ 9 W (3 GeV), 36 W (1.5 GeV), 26 W (SOLEIL)
  - 5 µm ➟ 16–18 W (3 GeV), 73–76 W (1.5 GeV), 46–52 W (SOLEIL)

    ...but still some debate on geometry and pulse length...?
- Field data $B_y(x)$ supplied for 5 µm case

➡ What is acceptable in terms of stored beam perturbation?

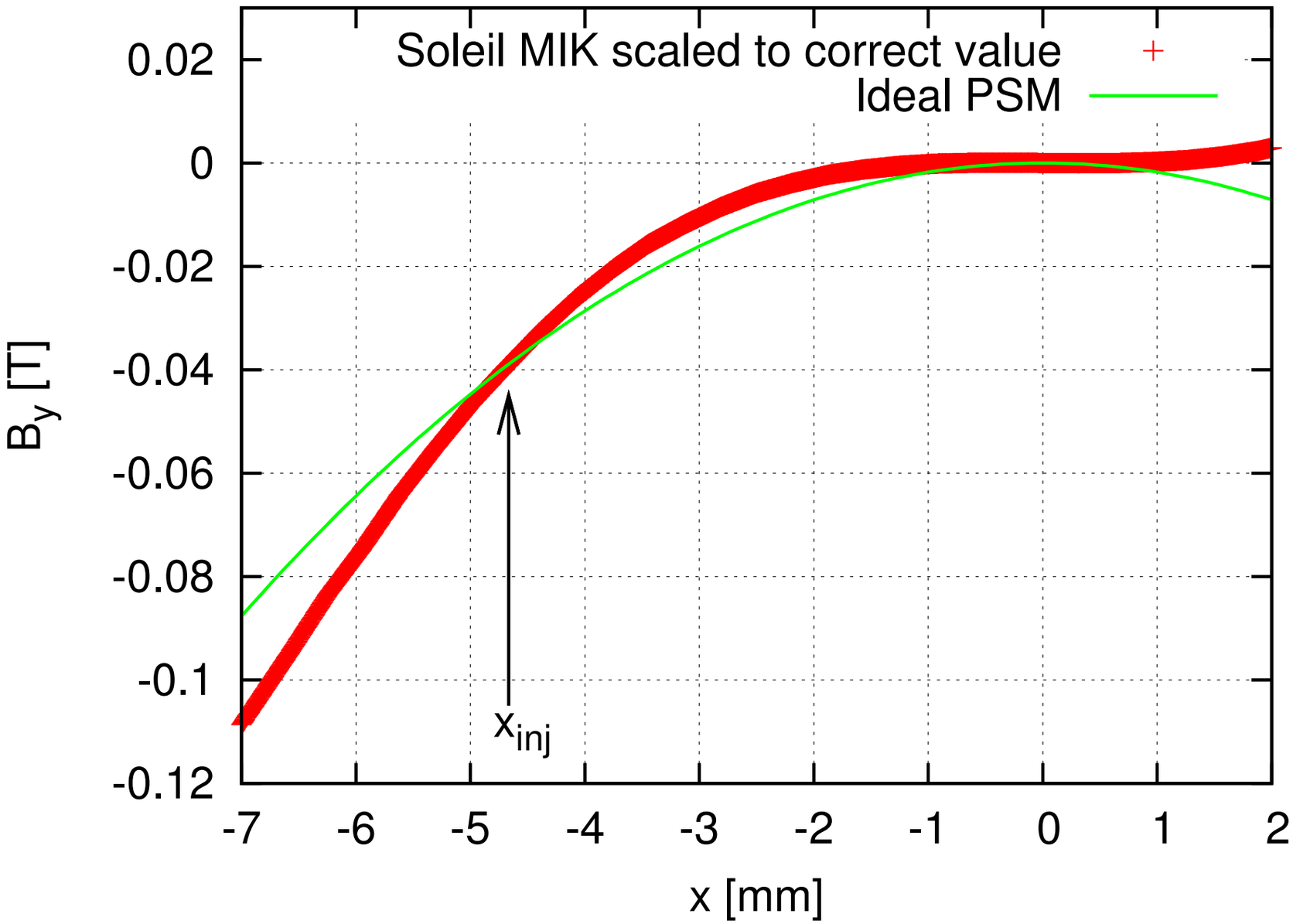
Comparison with ideal sextupole



- SOLEIL field data for 5 µm Ti coating case (8 µm step size)
- Comparison with original PSM specifications reveals insufficient field (attenuation from coating?)

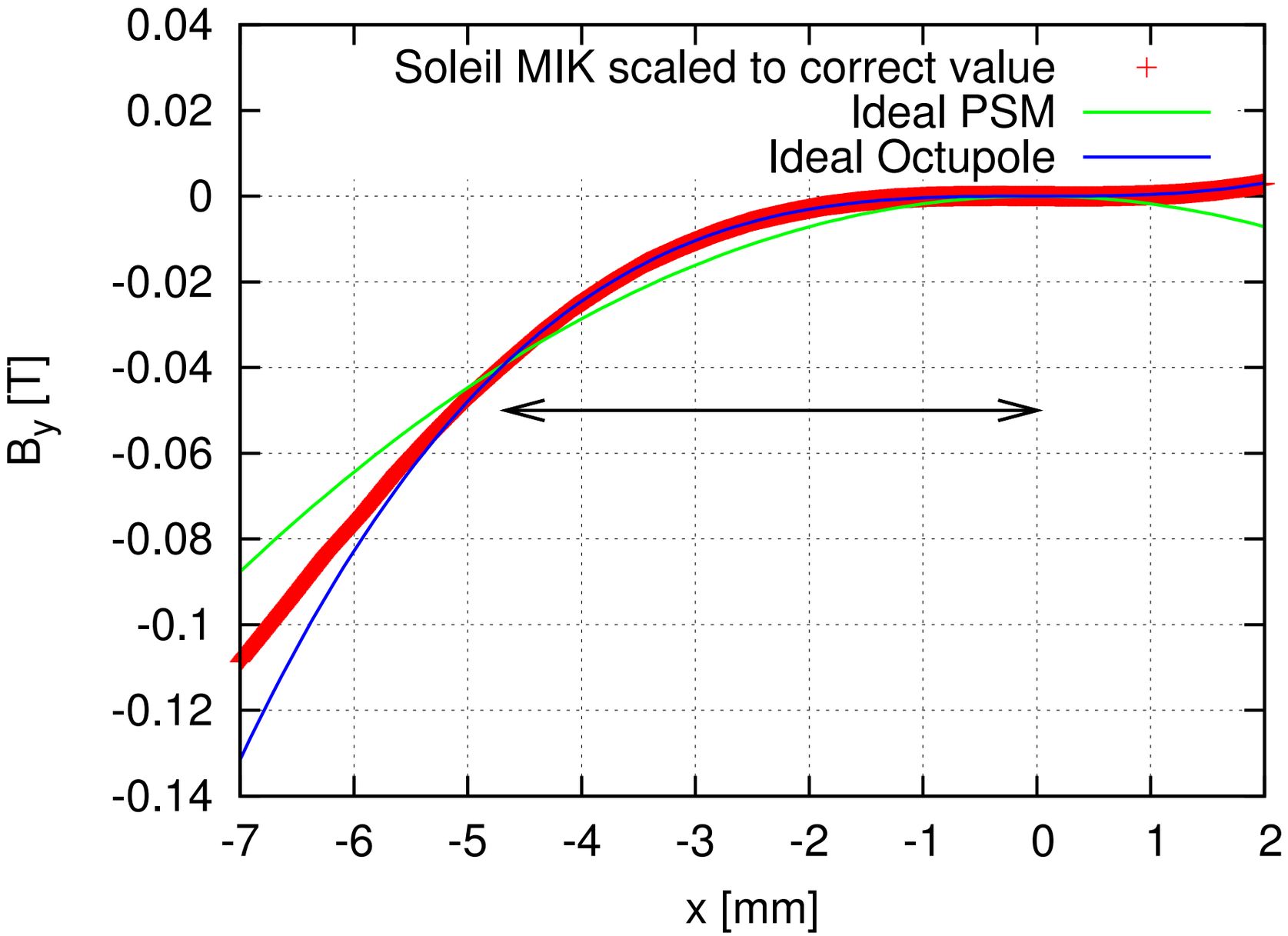
PRST-AB **15** 050705 (2012)

Comparison with ideal sextupole (magnified)



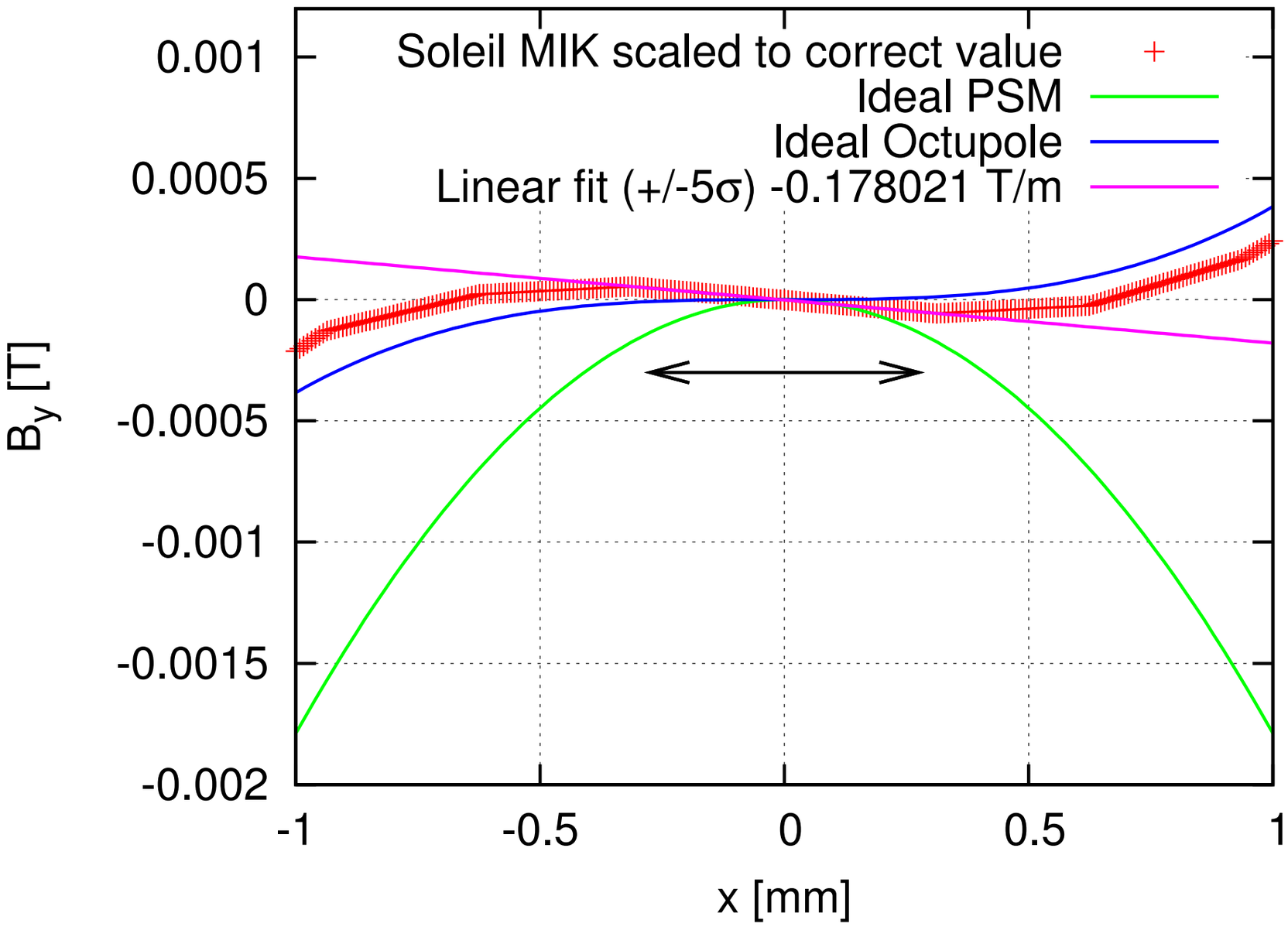
- Minor correction (+10.7%) gives design kick at proper location
  (appears too large to be caused by coating attenuation alone)
- Can already recognize flatter field distribution around stored beam
- Gradient sampled by injected beam is a bit steeper, but not an issue

Comparison with ideal sextupole & octupole



- From stored beam all the way to injected beam: SOLEIL MIK behaves like an octupole
- For larger amplitudes discrepancies start to show up
- But even there, SOLEIL MIK is closer to octupole than sextupole

Residual quadrupole



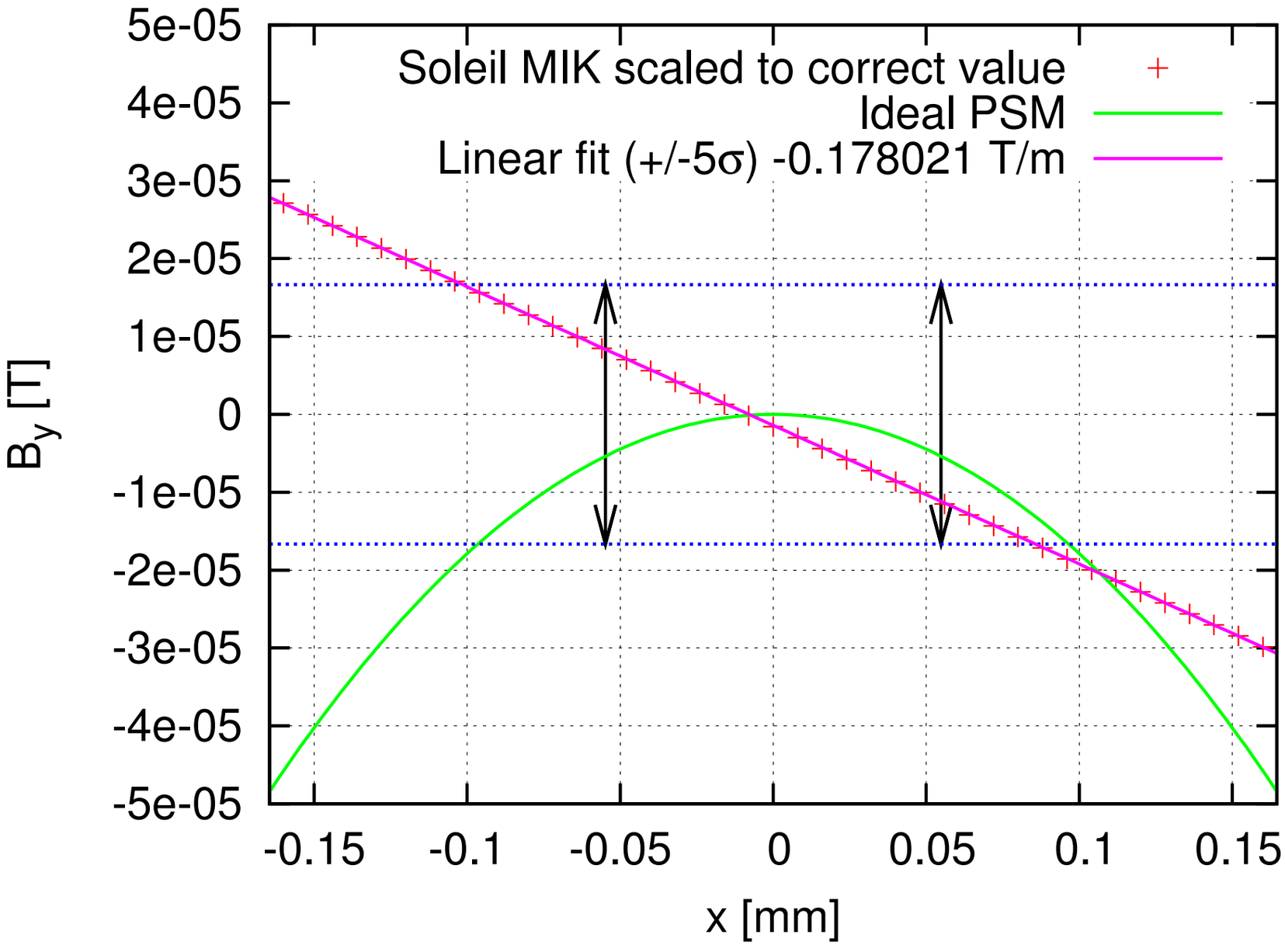
- Over about ±5σ there remains a quadrupole gradient of roughly 0.18 T/m

- ε-independent perturbation criterion for quadrupole gradient at stored beam calls for < 0.355 T/m ➞ should not be an issue

$$\left.\frac{\partial B_y}{\partial x}\right|_{\mathrm{res}} < 10\% \times \frac{B\rho}{\beta_x L}$$

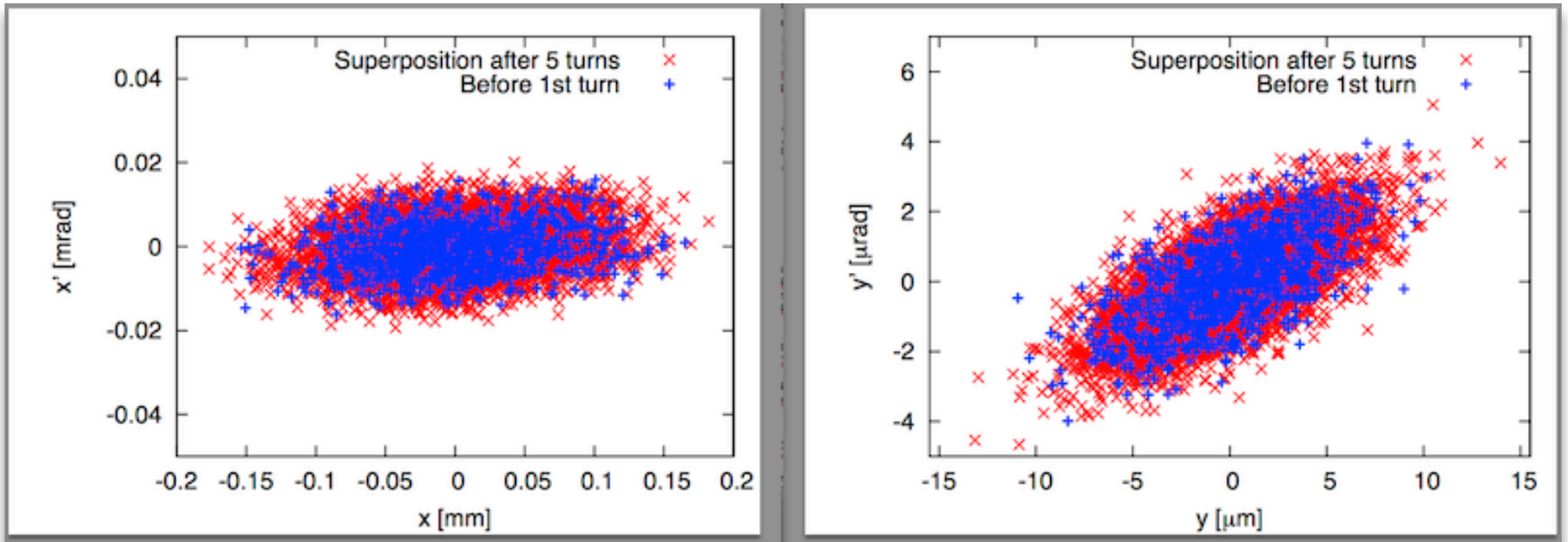
(note < 0.281 T/m for MAX IV 1.5 GeV storage ring despite much larger ε)

Residual quadrupole (magnified)

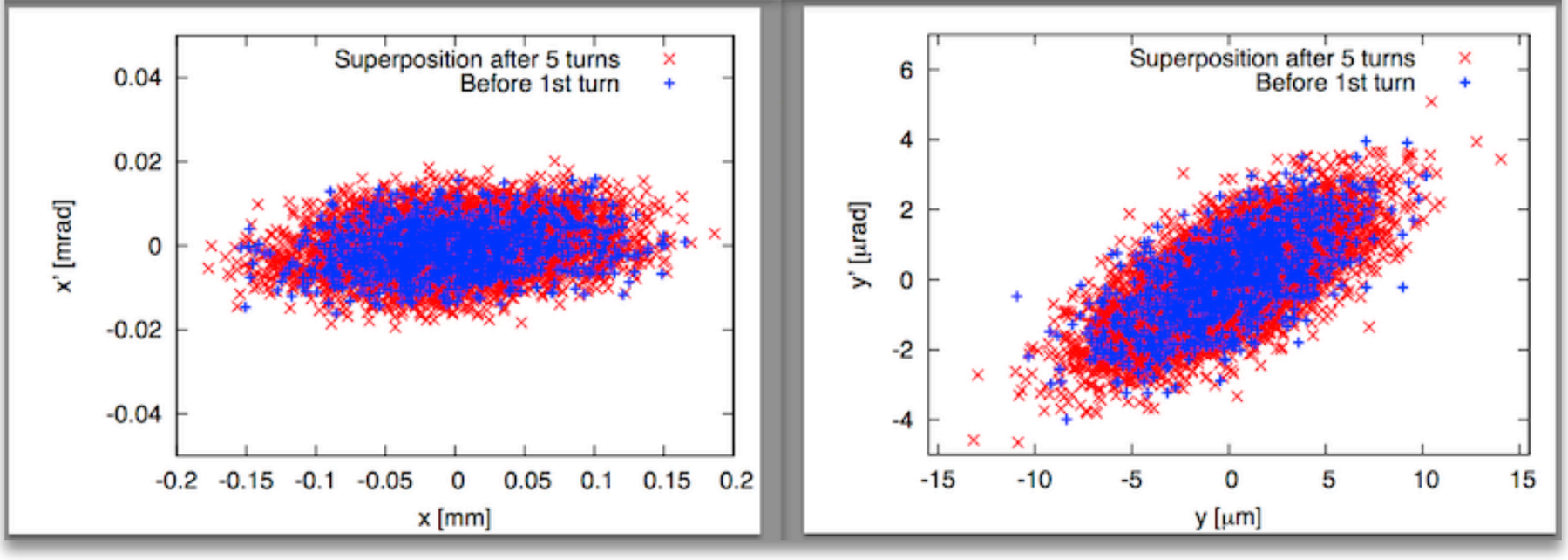


- Slight misalignment of the field (roughly 8 µm) → asymmetry? meshing?
- the 10%-of-1σ divergence limit at 1σ (16.7 µT) is clearly fulfilled by the SOLEIL MIK
- However, residual gradient leads to larger kick than residual kick from ideal PSM (for which tracking has already shown negligible perturbation)

Effect of such a residual quadrupole (tracking)



Design PSM



PQM, -0.18 T/m

➡ no substantial difference discernible (confirming ε-ind. crit.)

Conclusions

- 5 µm Ti coating does not appear to lead to excessive perturbation of stored beam (assuming effects scale linearly with current when ramping to required field)
- Full 3D model should be analyzed Analysis by L.O. Dallin & G. Bilbrough (CLS)
  - should include edge effects, terminals, and possibly bulky heat sinks
- Estimates should also be made for coating imperfections
  - coating thickness inhomogeneity can give rise to irregular multipoles rather than just attenuate field (as for thin ideal coating)
  - e.g. assume coating thickness increases by 10% across chamber cross-section