IR optics, solenoid field, crossing angle

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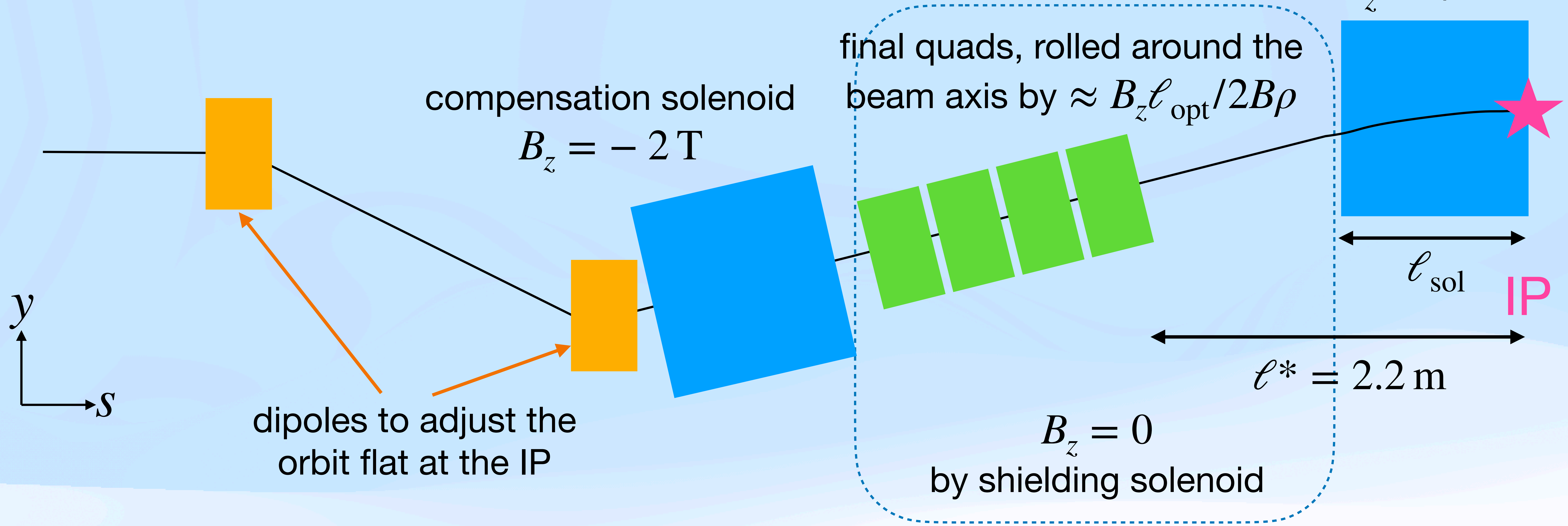
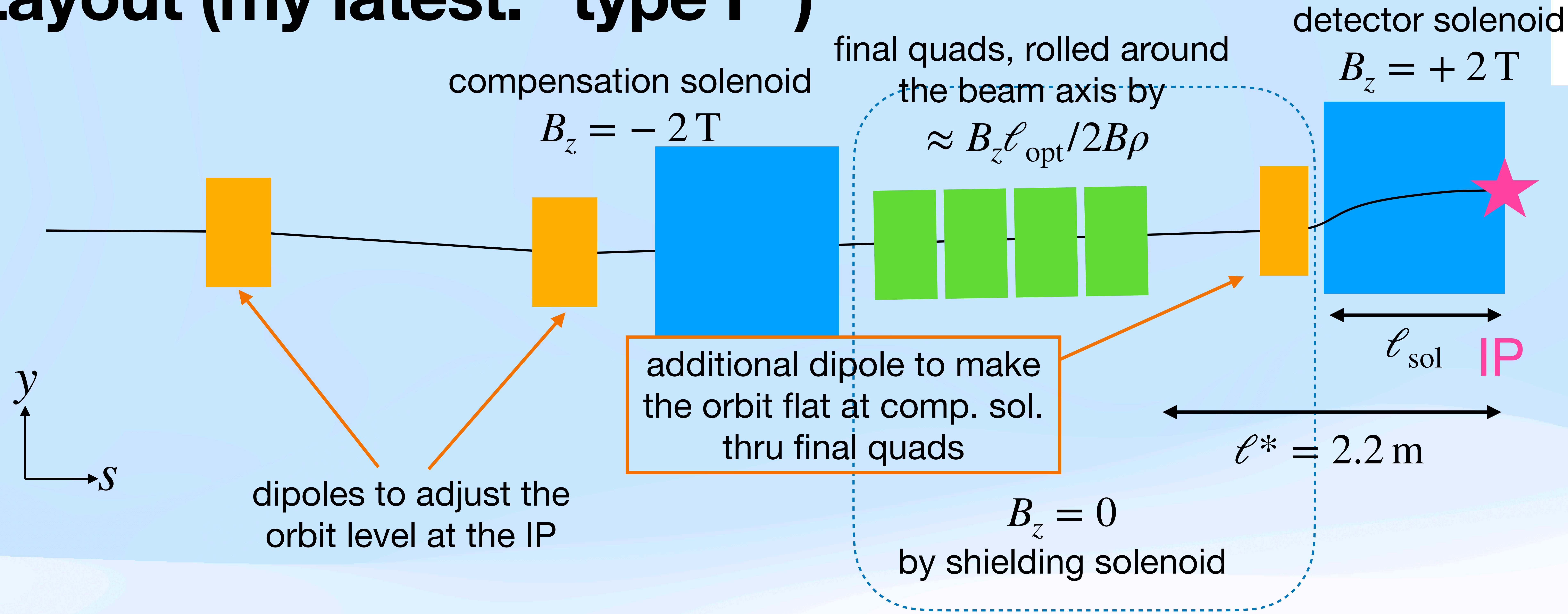
Layout (previous, “type W”)



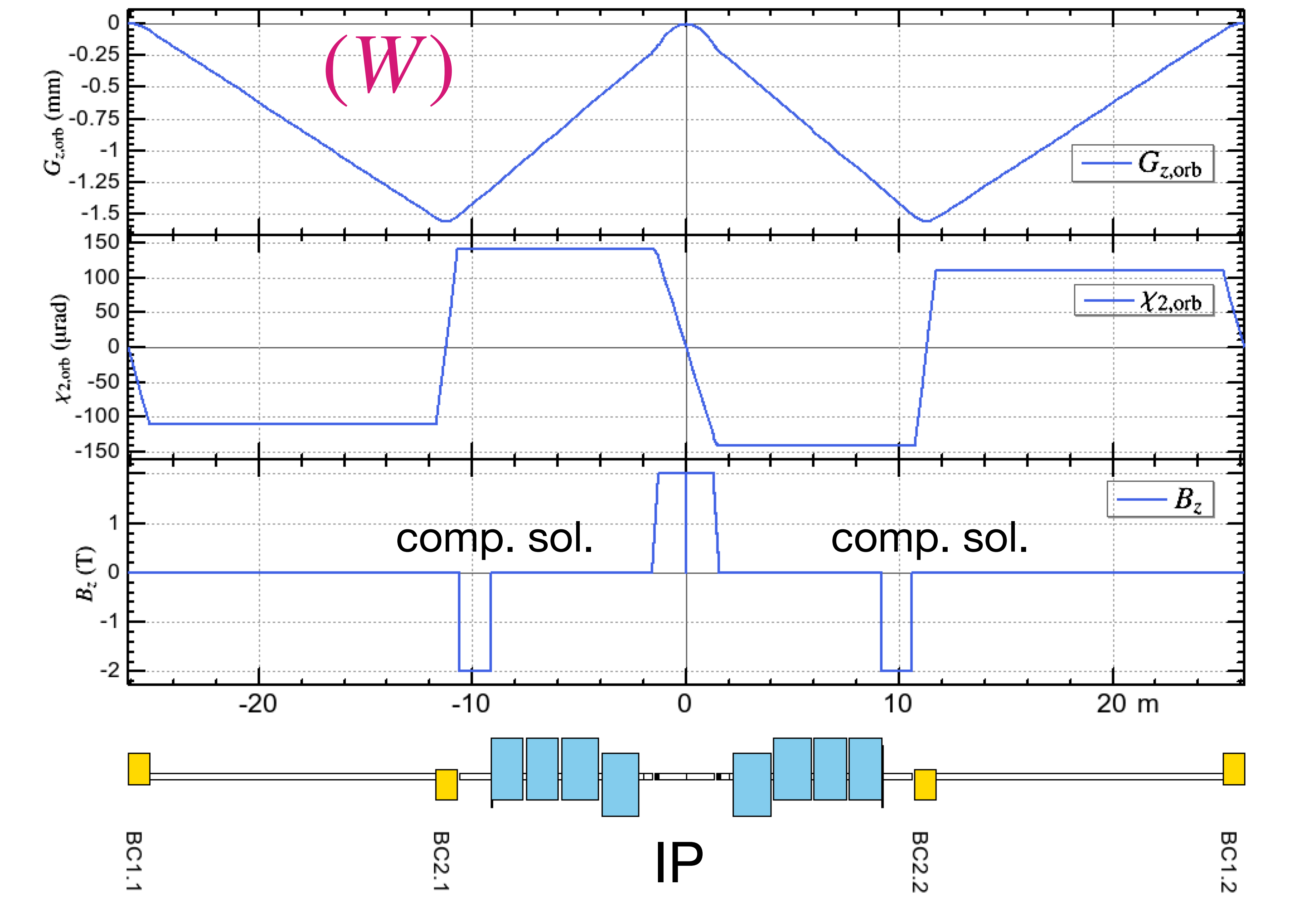
- The orbit is bent vertically by the detector solenoid.
- The final quads followed by the compensation solenoid are aligned along the beam axis.
  - This prevents additional orbit/dispersion deviation.
- Right after the detector solenoid region, the solenoid filed is completely shielded by the shielding solenoid, up to ℓ_{sol} from the IP.
  - The final quads sit in the field-free region.
- The vertical bend angle is corrected outside the compensation solenoid by two dipoles/side.

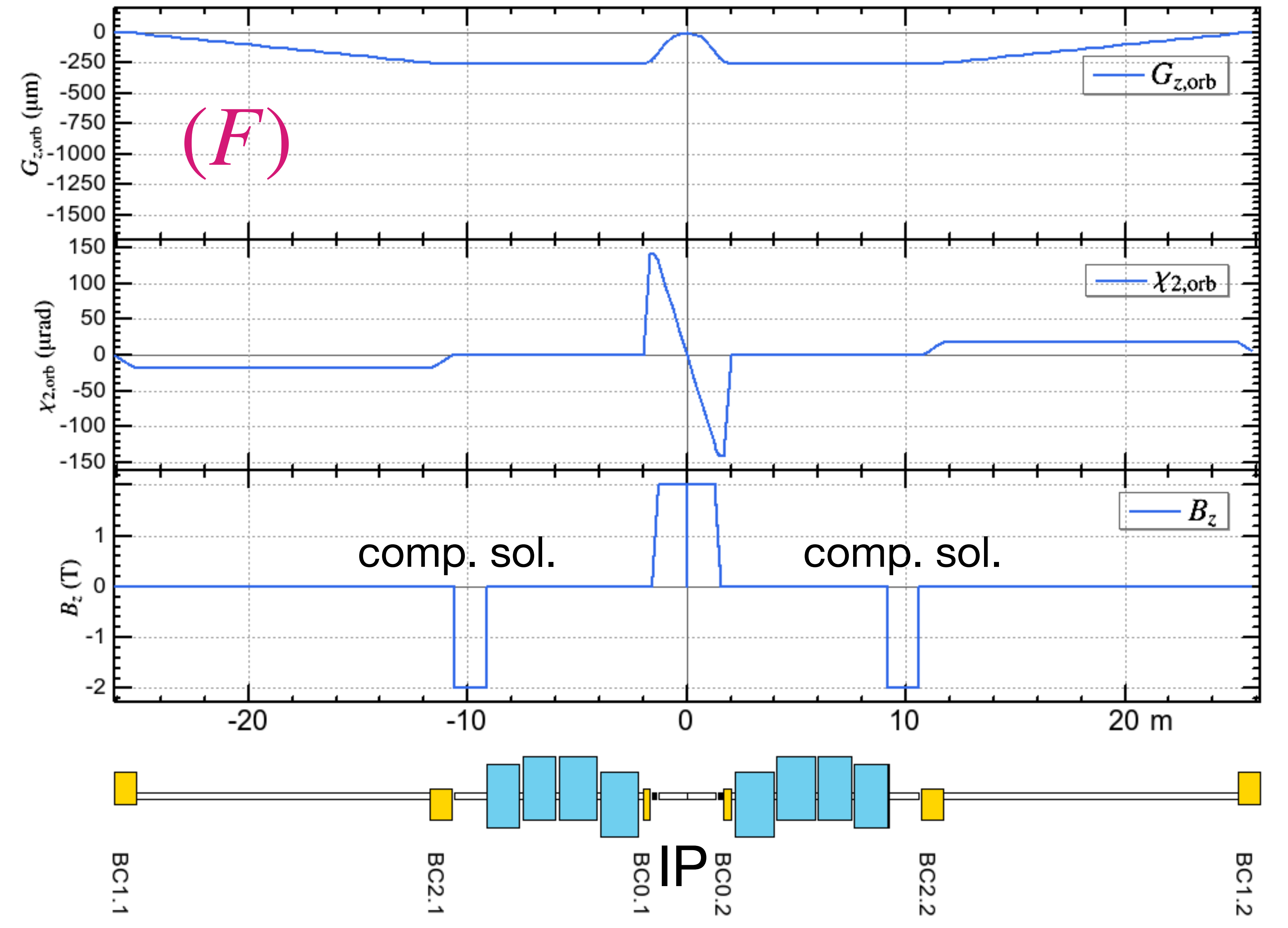
Layout (my latest: “type F”)

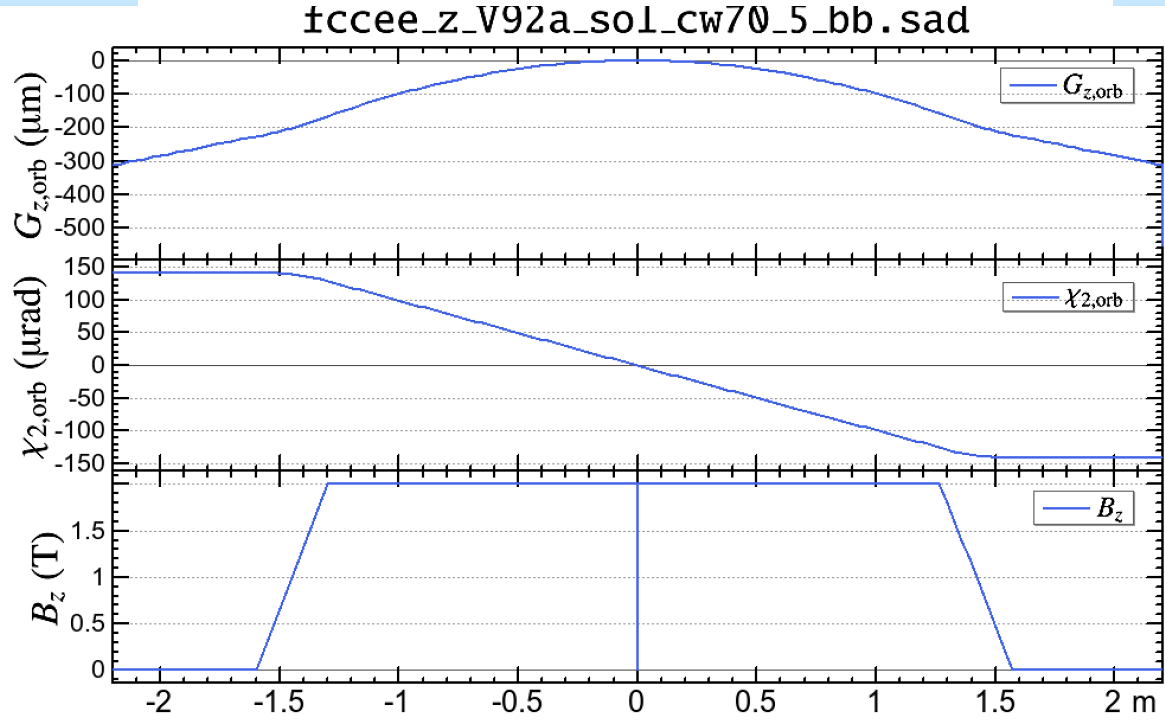


- Learnt from the design by Burkhardt/Ciarma (eg., MDI meeting #58), an additional dipole between the final quad and the detector solenoid region can make the orbit flat from the final quad through the compensation solenoid.
- Let us try this scheme and see the results.

Basic layout: two types of the vertical bump







IP

$\ell_{\mathrm{sol}} \approx 1.45\,\mathrm{m}$

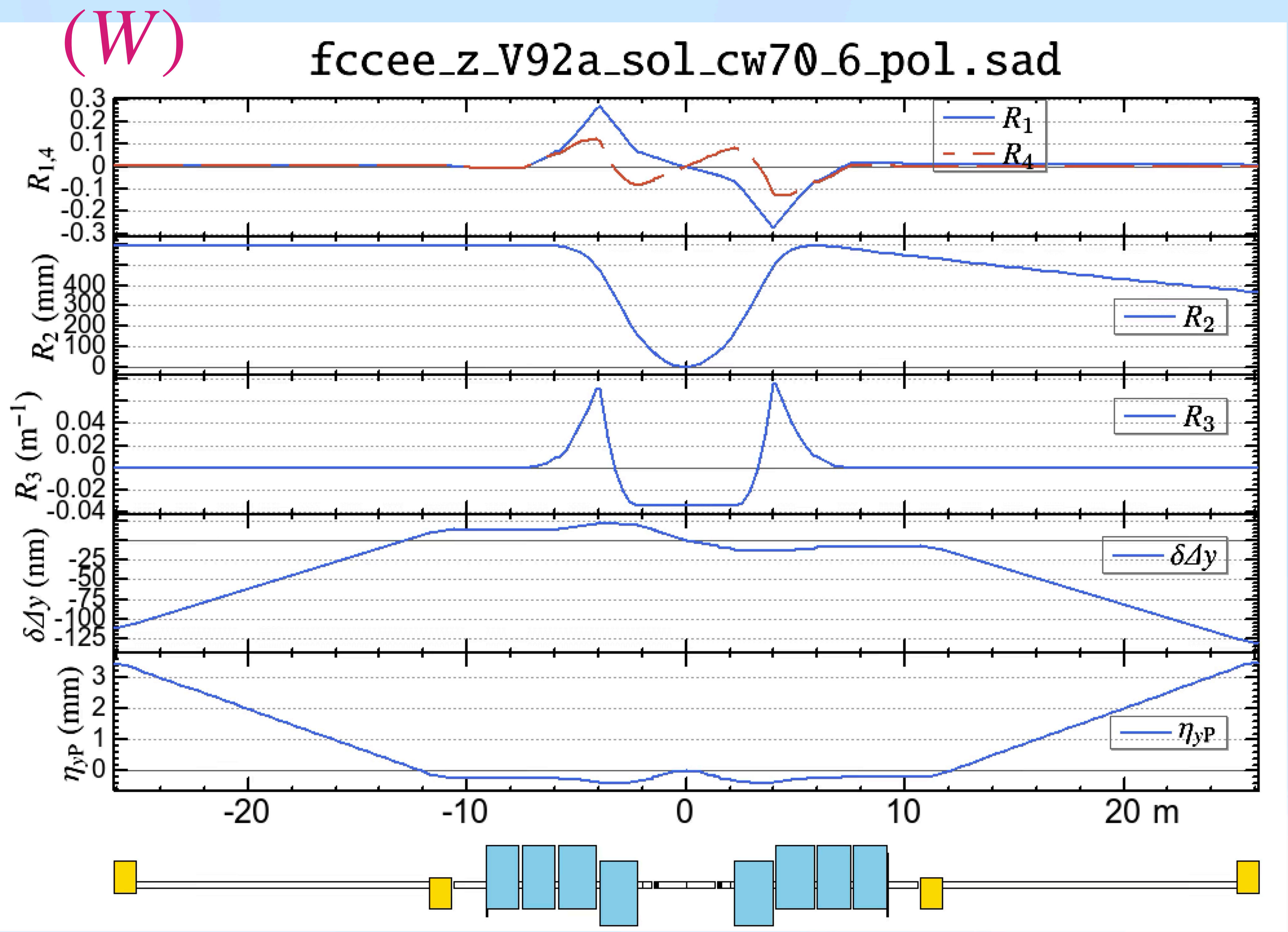
$\ell_{\mathrm{edge}} \approx 0.3\,\mathrm{m}$

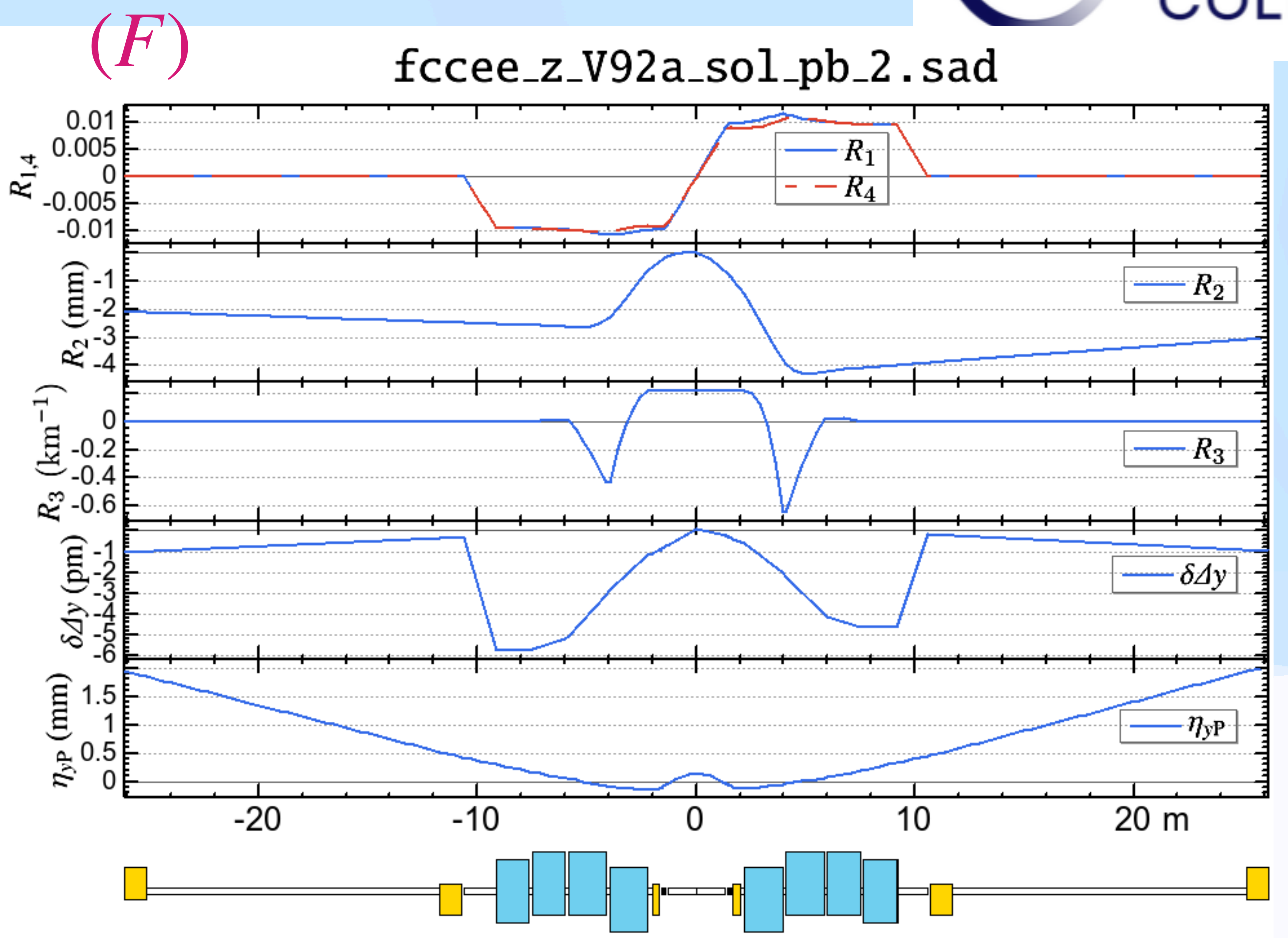
$\ell_{\mathrm{sol}} = 1.45\,\mathrm{m}$

- The type F (right) with the additional dipole "BC0" indeed makes the vertical offset of the orbit flat and small.
  - alignment of the finale quads and compensation solenoids will be much simpler.
- The resulting vertical emittance becomes 2/3 of type W.
  - still larger than Burkhurdt/Ciarma's.

Type	W	F
ℓ_{sol}(m)	1.45	
ℓ_{edge} (m)	0.3	
ε_y (pm)	0.36	0.24
$\varepsilon_{y,\mathrm{BB}}$ (pm)	1.4	-
τ (s)	16000	-
$p(\%)$		0.47±0.05

X-y coupling and vertical dispersion



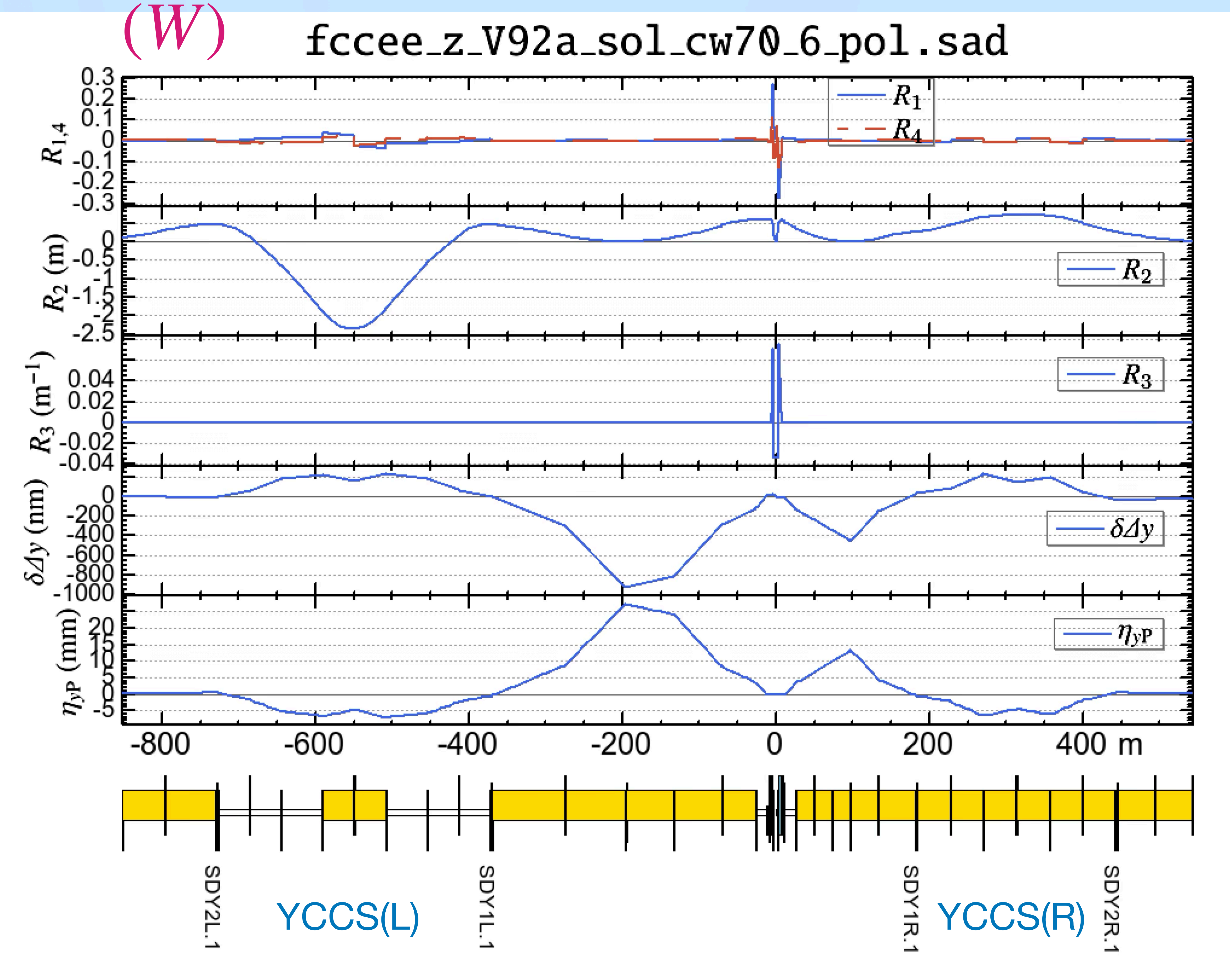


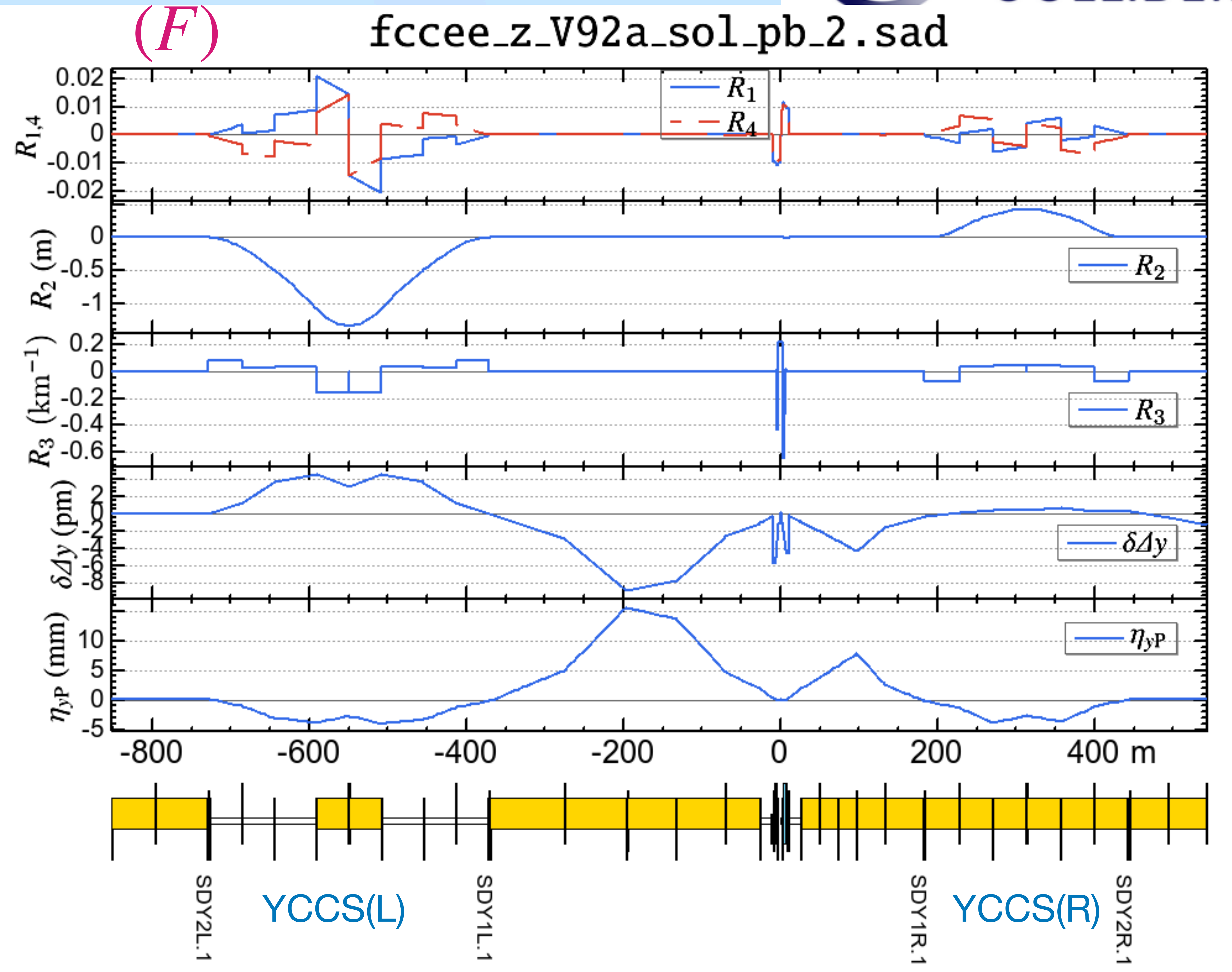
- The x-y coupling parameters $R_{1,2,3,4}$ are well confined within the compensation solenoid region as shown above.
- However, the vertical dispersion leaks toward outside.
- The profile of $R_{1,2,3,4}$ looks different for W and F. W has better symmetry around the IP.

$$R = \begin{pmatrix} \mu I & J r^T J \\ r & \mu I \end{pmatrix} = \begin{pmatrix} \mu & . & -R4 & R2 \\ . & \mu & R3 & -R1 \\ R1 & R2 & \mu & . \\ R3 & R4 & . & \mu \end{pmatrix}$$

X-y coupling and vertical dispersion

FUTURE CIRCULAR COLLIDER





- The leak of the vertical dispersion toward outside the comp. solenoid has got smaller for type F (right) than type W (left).
  - This leads to the smaller vertical emittance.

Solenoid field & crossing angle (non-local, type F)

$\theta_x = \pm 15$ mrad

B_z (T)	ε_y (pm)	$\varepsilon_{y,\mathrm{sol}}$ (pm)
2	0.24	0.11
2.5	0.61	0.20
3	1.29	0.30
3.5	2.31	0.61

$B_z = 2$ T

θ_x (mrad)	ε_y (pm)	$\varepsilon_{y,\mathrm{sol}}$ (pm)
±15	0.24	0.11
±20	0.79	0.43
±25	2.17	1.50
±30	5.13	3.71

$\theta_x = \pm 20$ mrad

B_z (T)	ε_y (pm)	$\varepsilon_{y,\mathrm{sol}}$ (pm)
2	0.79	0.43
2.5	1.85	0.73
3	3.93	1.12
3.5	7.59	2.29

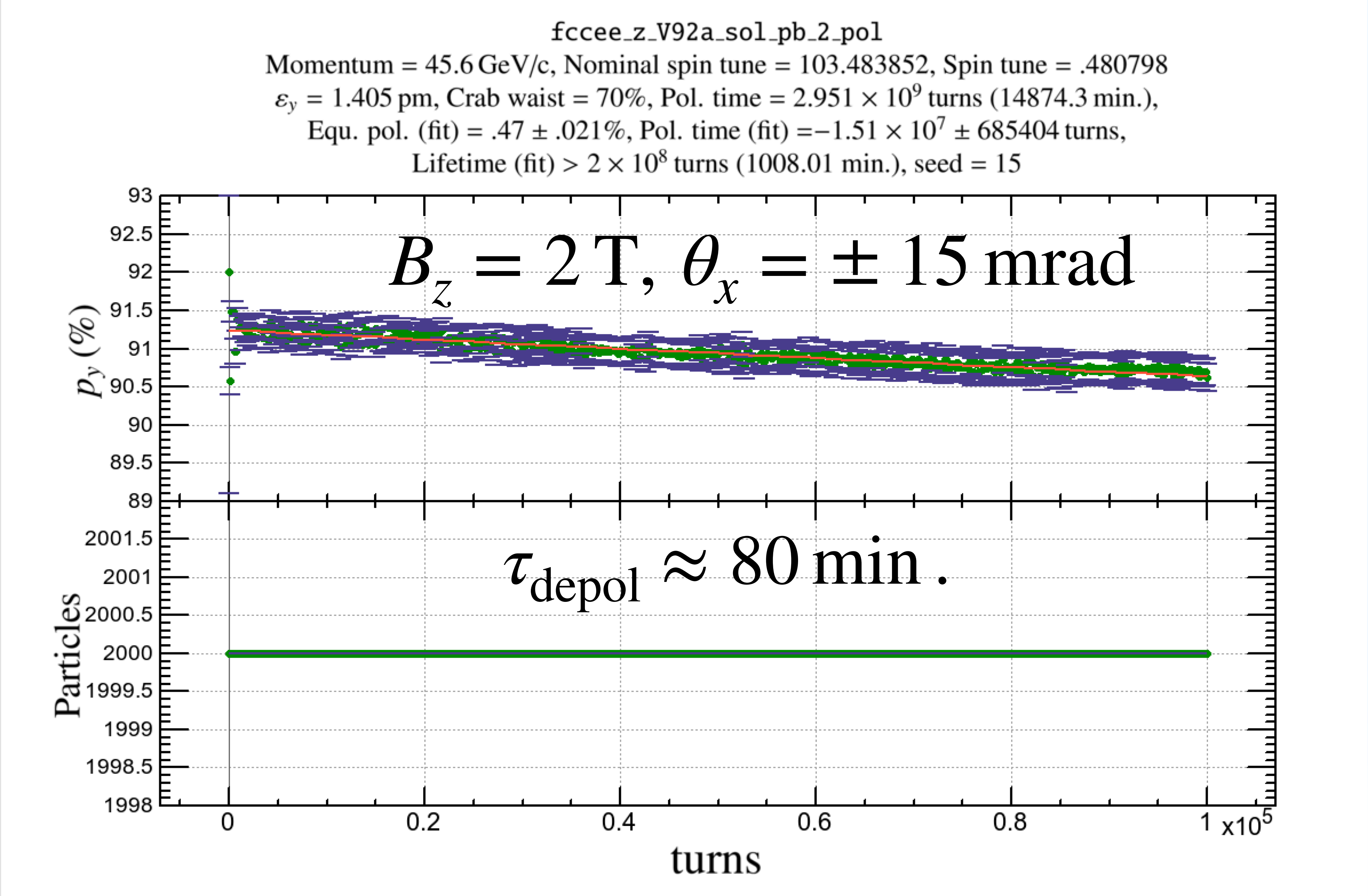
$B_z = 2.5$ T

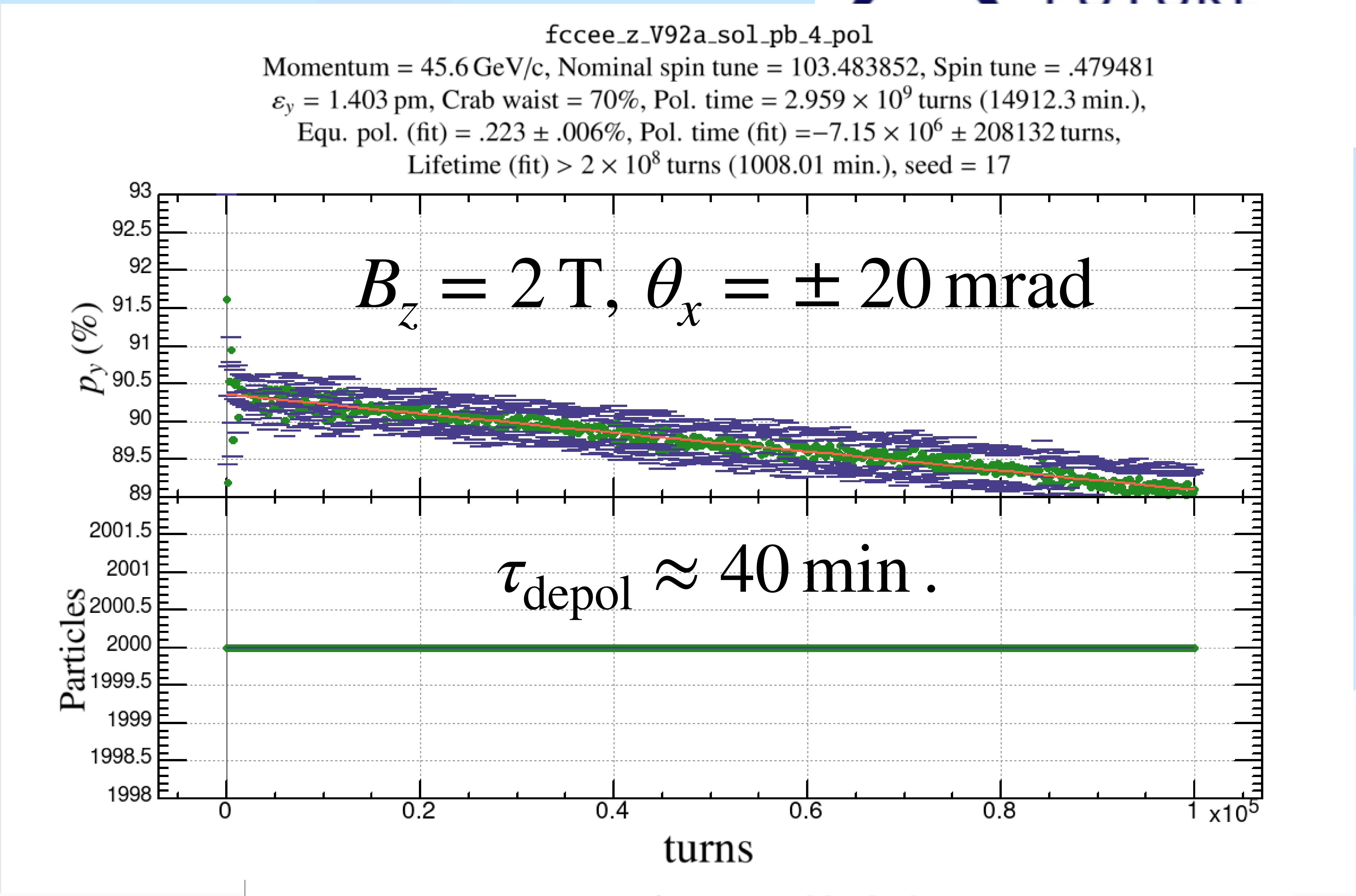
θ_x (mrad)	ε_y (pm)	$\varepsilon_{y,\mathrm{sol}}$ (pm)
±15	0.61	0.20
±20	1.85	0.73
±25	4.82	2.21
±30	11.09	5.52

FUTURE CIRCULAR COLLIDER

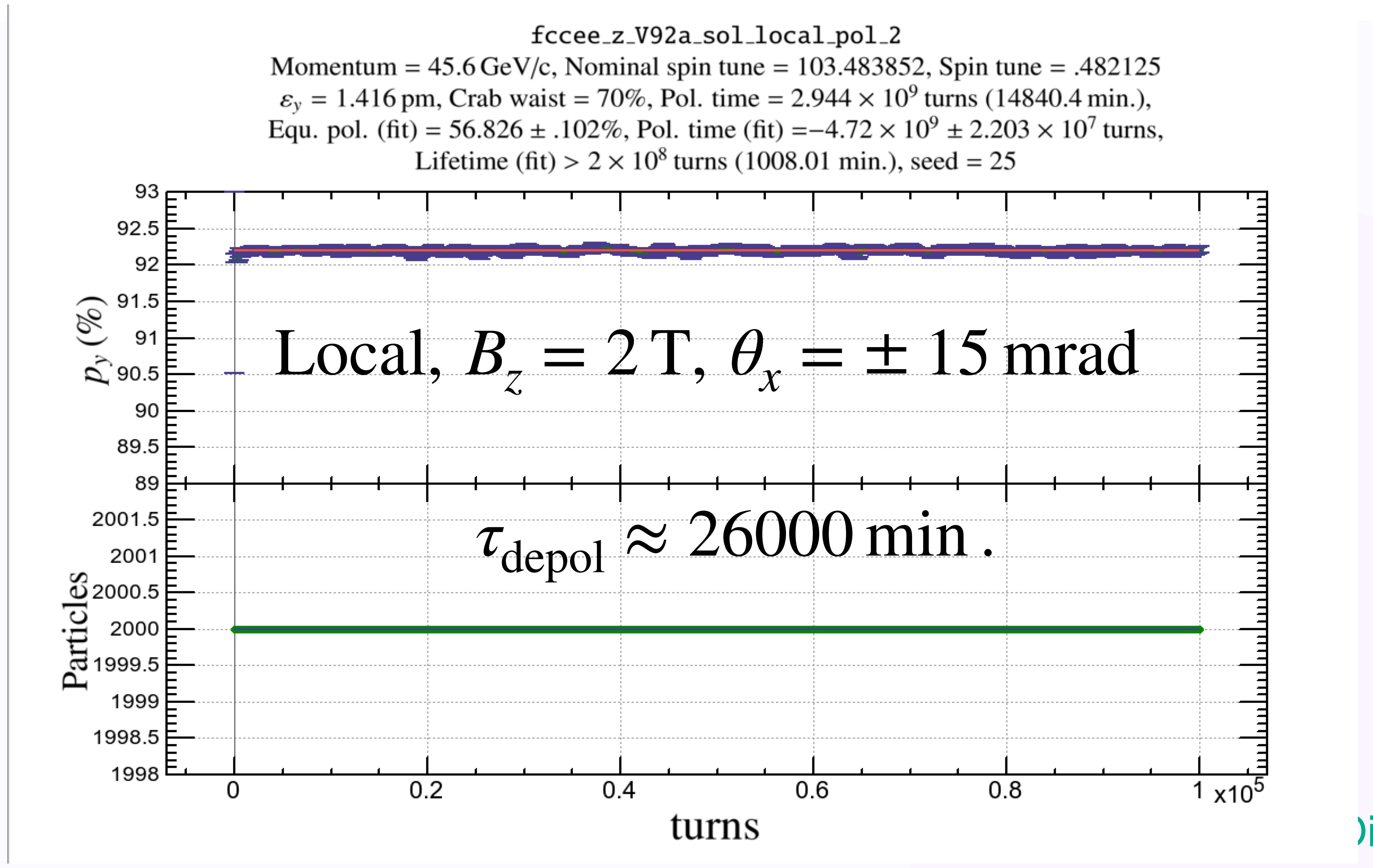
- The emittance generated by the solenoid part does not depend on the outside optics.
- The current design lattice emittance is ~ 1 pm.
- The local scheme does not have enough margin for higher field/larger crossing angle.

Polarization





- The spin tracking shows a significant depolarization for type F, with $\theta_x = \pm 15\,\mathrm{mrad}$ (left) and $\theta_x = \pm 20\,\mathrm{mrad}$ (right).
  - Tracking starts at Sokolov-Ternov polarization.
  - The equilibrium polarization may decay to around 1%, by assuming the observed depolarization speeds.
  - Depolarization is weak for the local scheme (right lower)
- Some polarization bump tunings will be necessary, if these results are true.



Summary (preliminary)

- Examined a non-local solenoid compensation scheme.
  - A type of the orbit “type F” learnt from Burkhardt/Ciarma has been tried this time.
- The vertical emittance of type F still looks larger than Burkhardt/Ciarma’s, but it is already enough small.
  - The recent required lattice vertical emittance is 1.0 pm.
- The dependences on the solenoid filed and the crossing angle are examined.
  - Either up to either $B_z = 2.5\,\mathrm{T}$ or $\theta_x = \pm 20\,\mathrm{mrad}$ looks OK for the emittance, but not for the both.
- Polarization can be an issue.
  - solvable by $e^{\pm}$ polarized injector.
  - A polarization tuning by such as vertical bumps in the arc should be investigated.