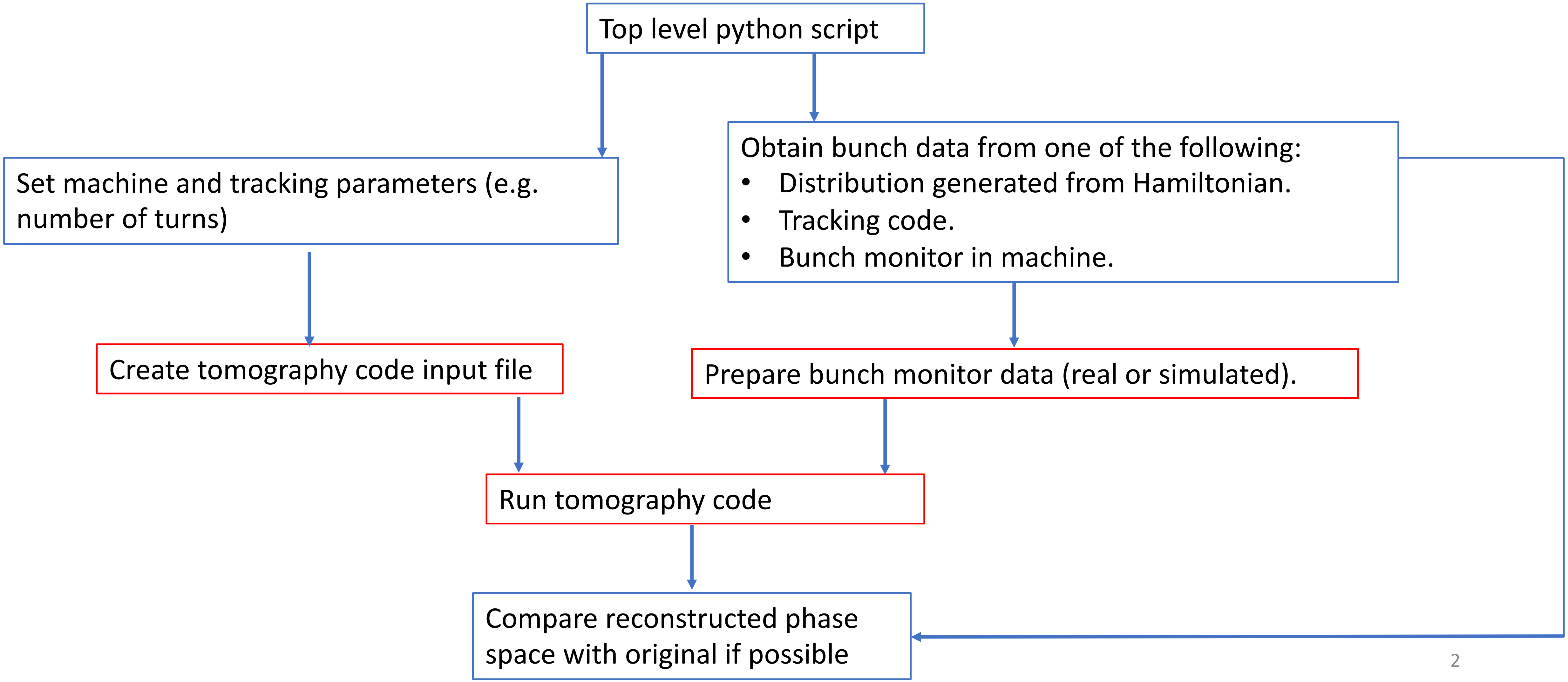
Longitudinal tomography

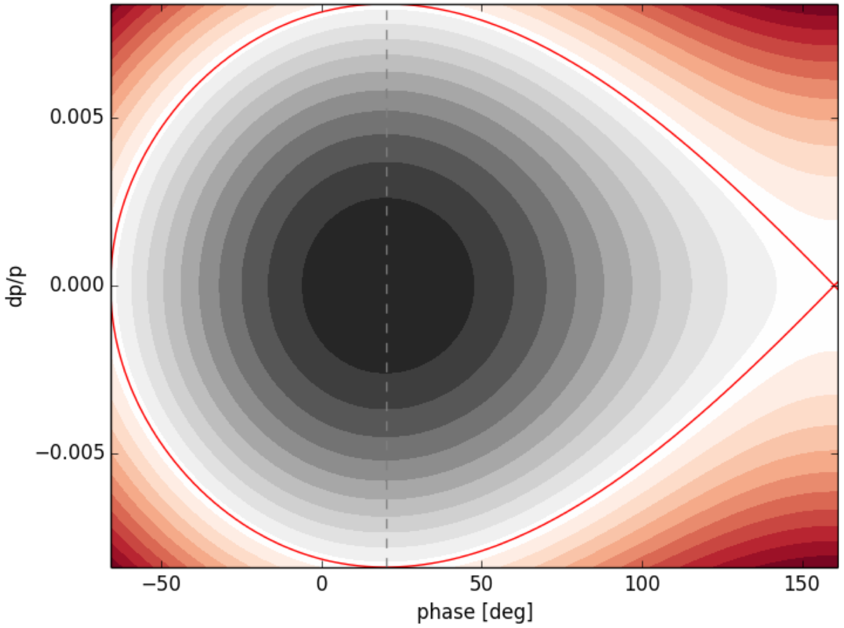
David Kelliher, 24/8/18

Tomography analysis flowchart

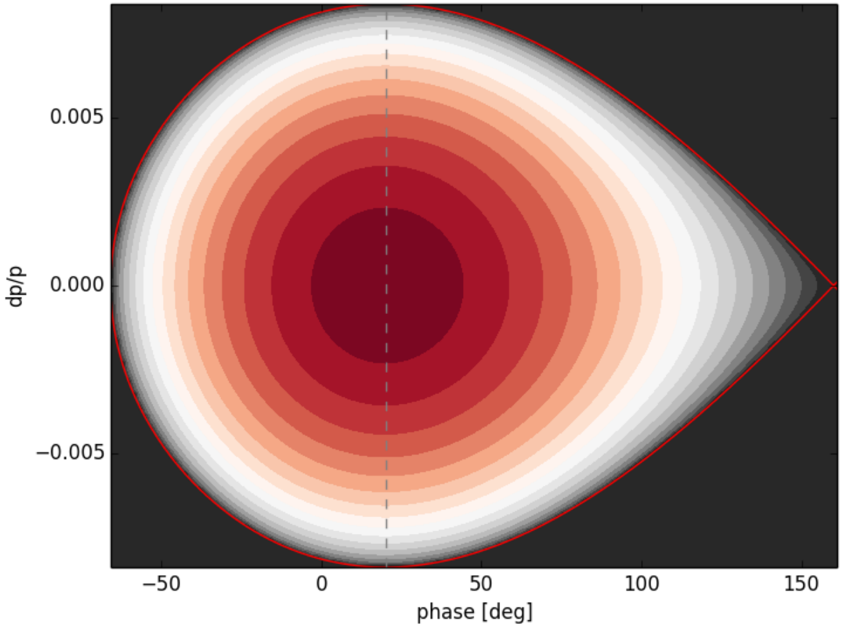


Generating a stationary distribution

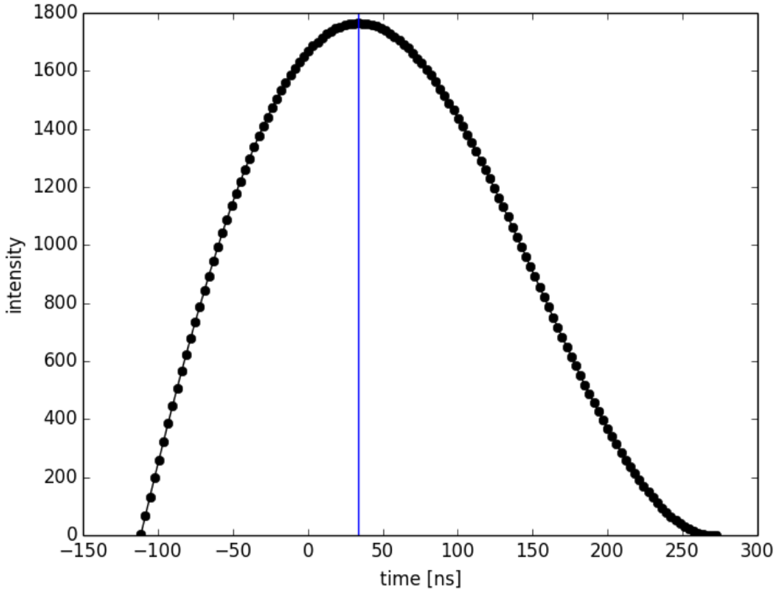
- Evaluate the longitudinal Hamiltonian on a grid producing H(δ,Φ).
- Generate distribution as a function of H (excluding $H > H_{sep}$).
- Time projection used as input in tomography code.



Hamiltonian

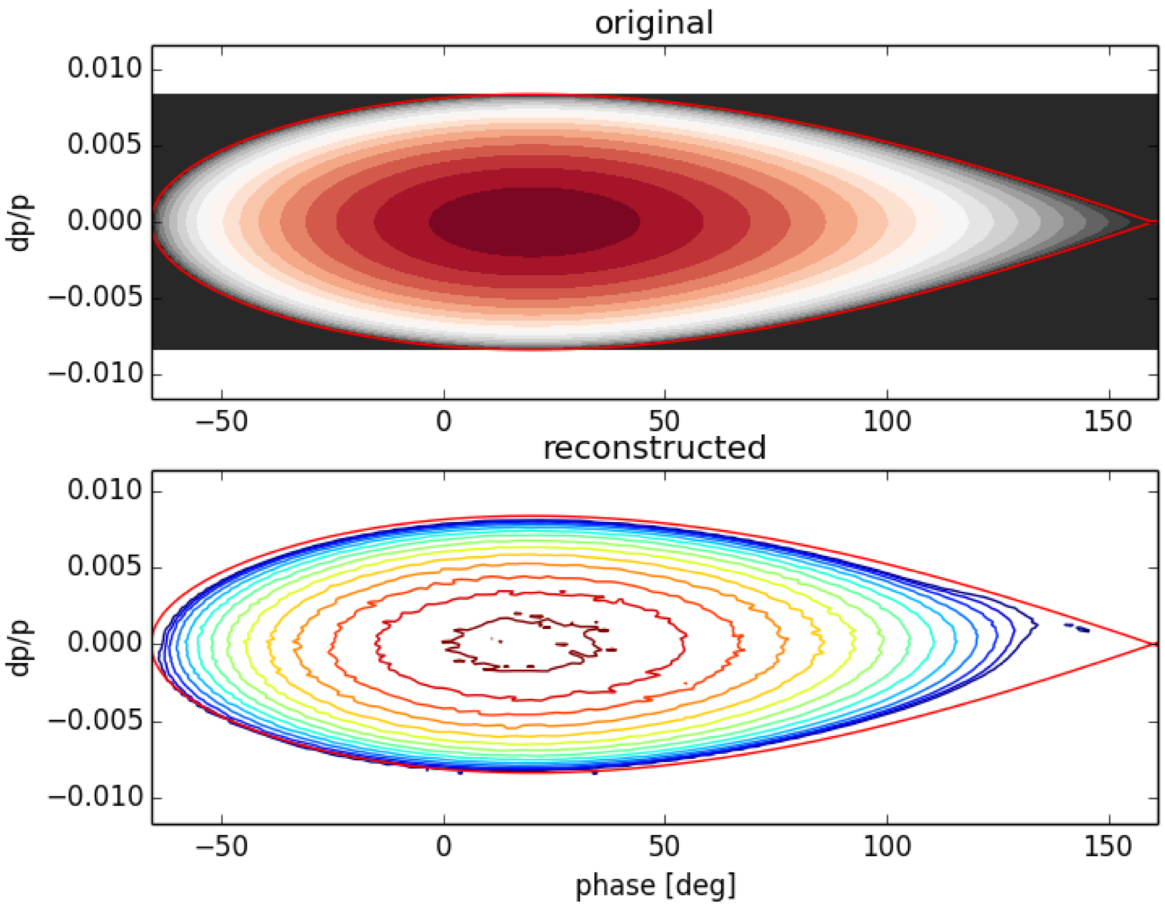


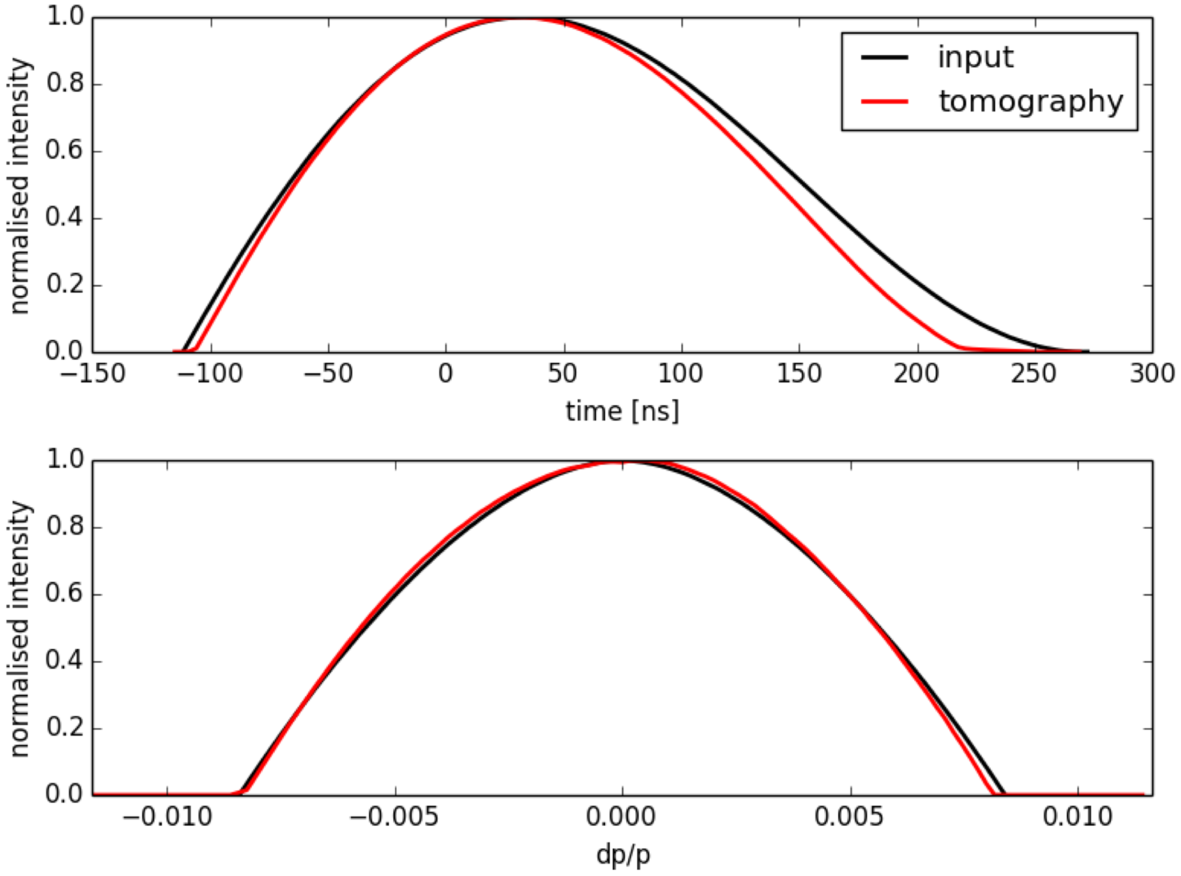
Distribution



Projection

Stationary distribution (1)

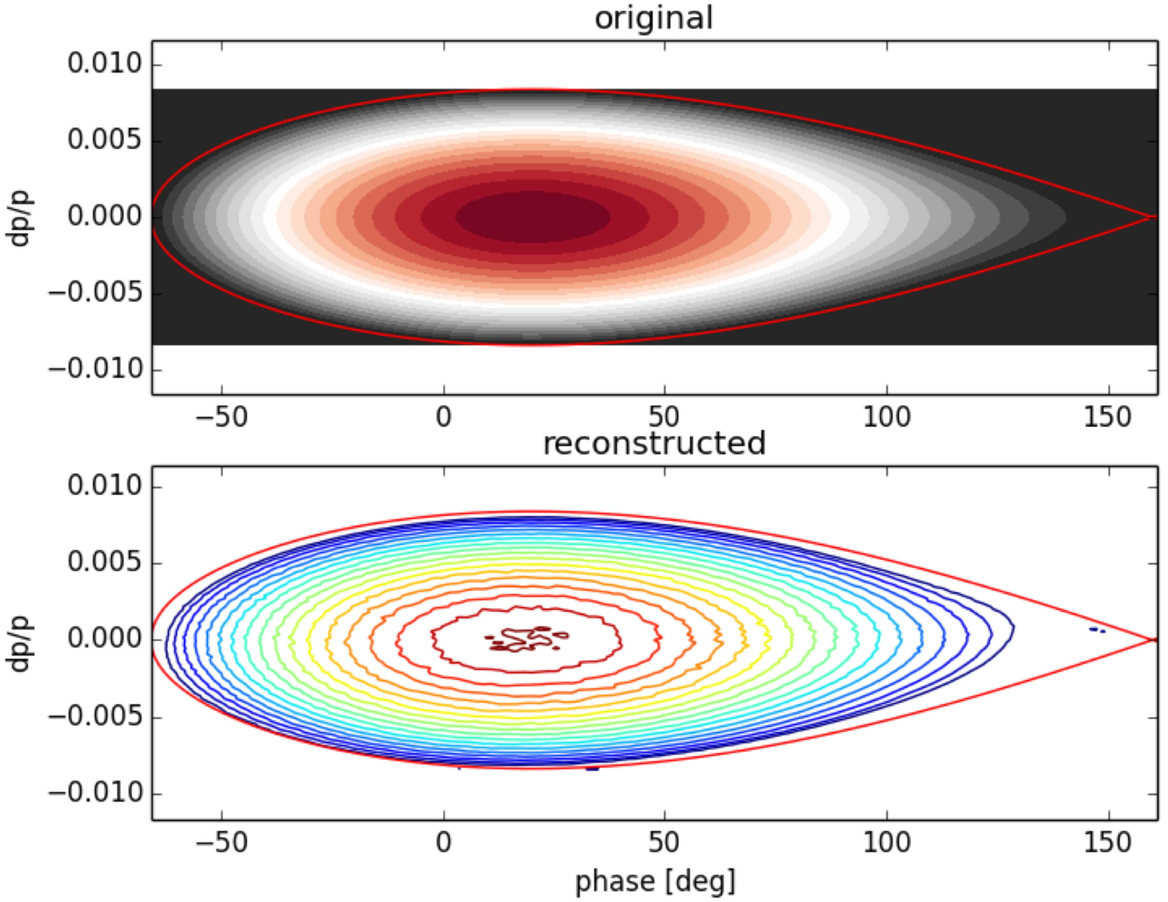


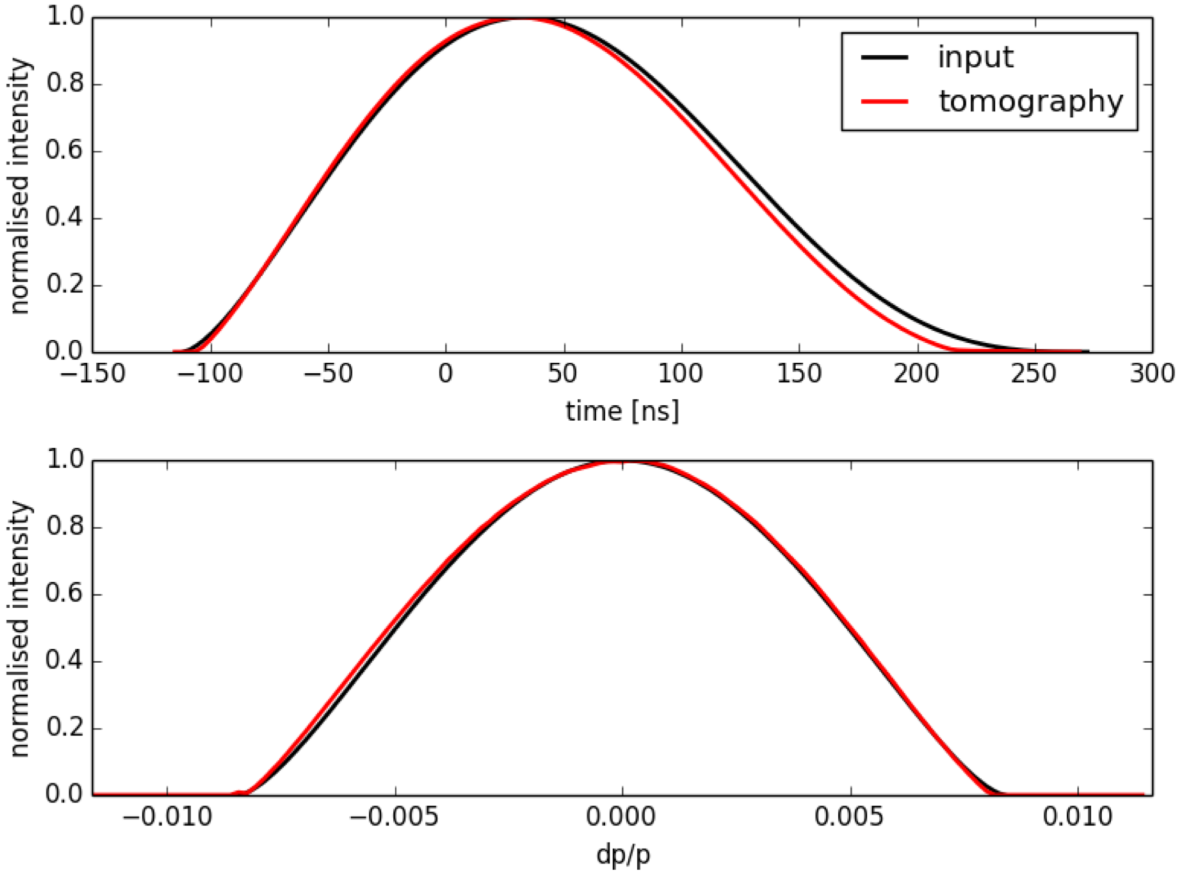


Qs: 0.005 (Ts=200), phi_s: 20 deg.
Number of bins in projection: 128
Number of “turns”: 100 (=0.5*Ts)

$$f(\phi, \delta) = \sqrt{H_{sep} - H(\delta, \phi)}$$

Stationary distribution (2)

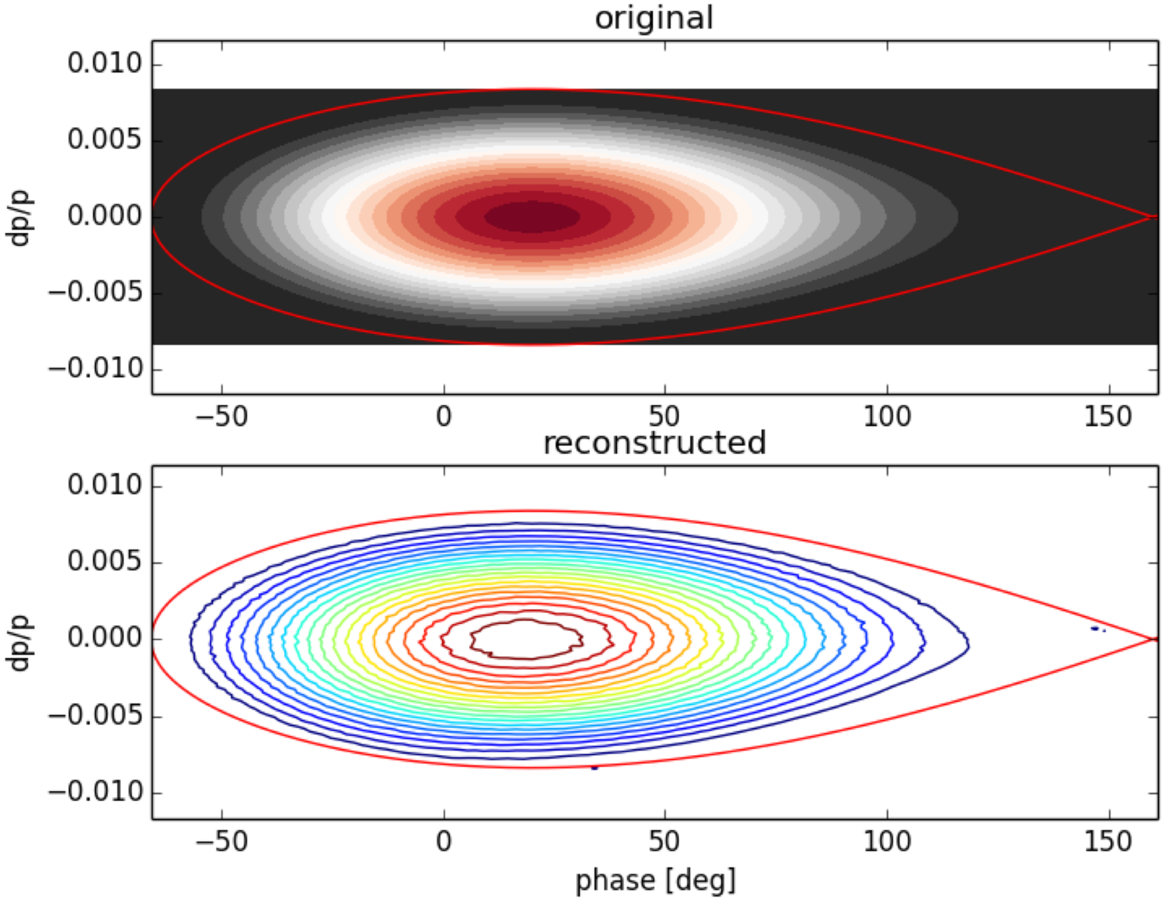


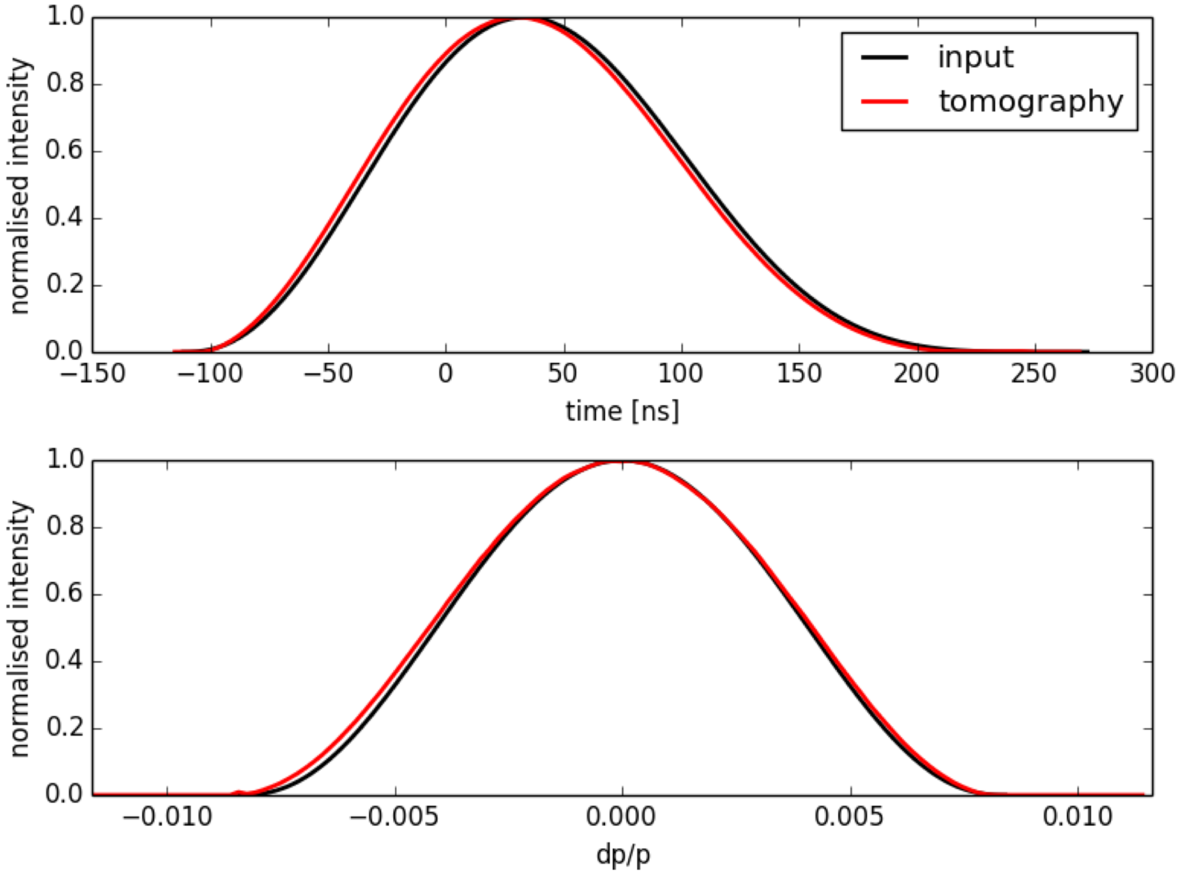


Qs: 0.005 (Ts=200), phi_s: 20 deg.
Number of bins in projection: 128
Number of “turns”: 100 (=0.5*Ts)

$$f(\phi,\delta) = H_{sep} - H(\delta,\phi)$$

Stationary distribution (3)

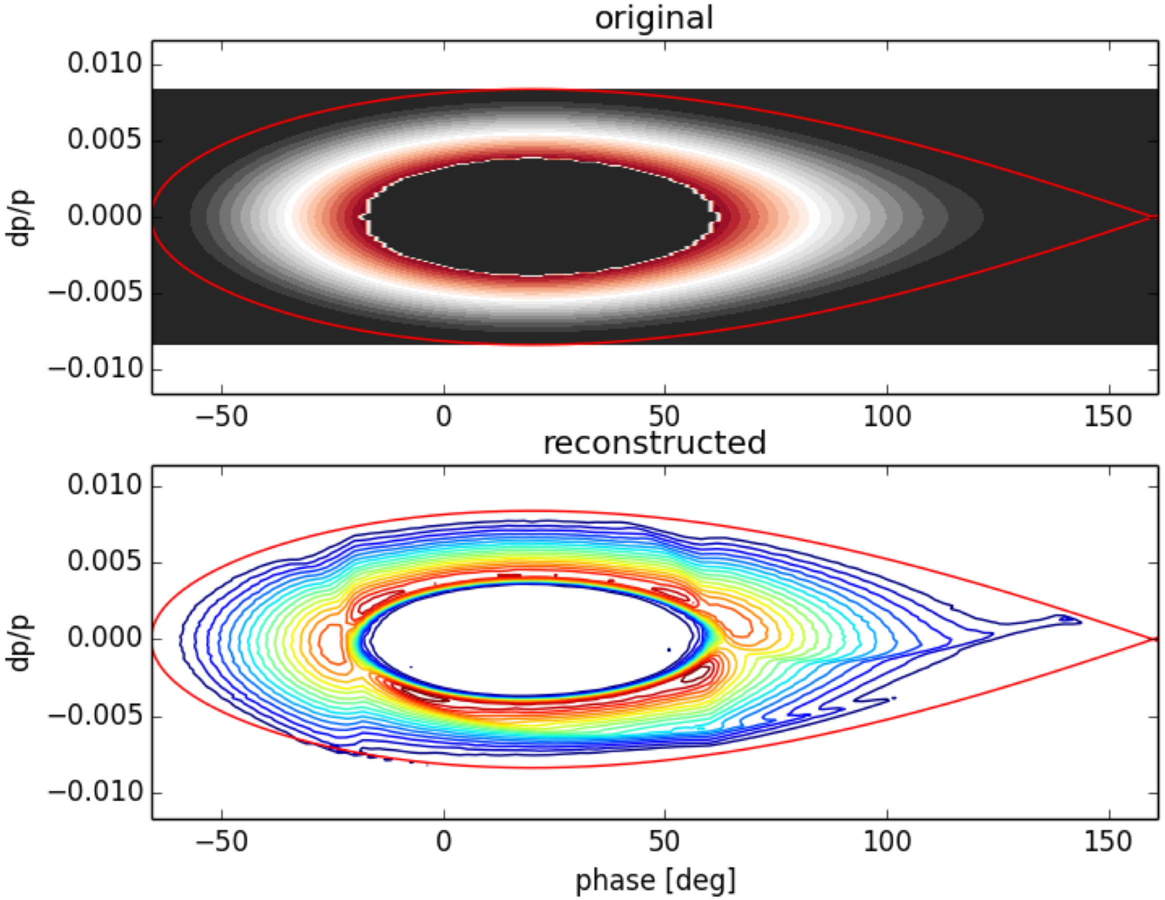


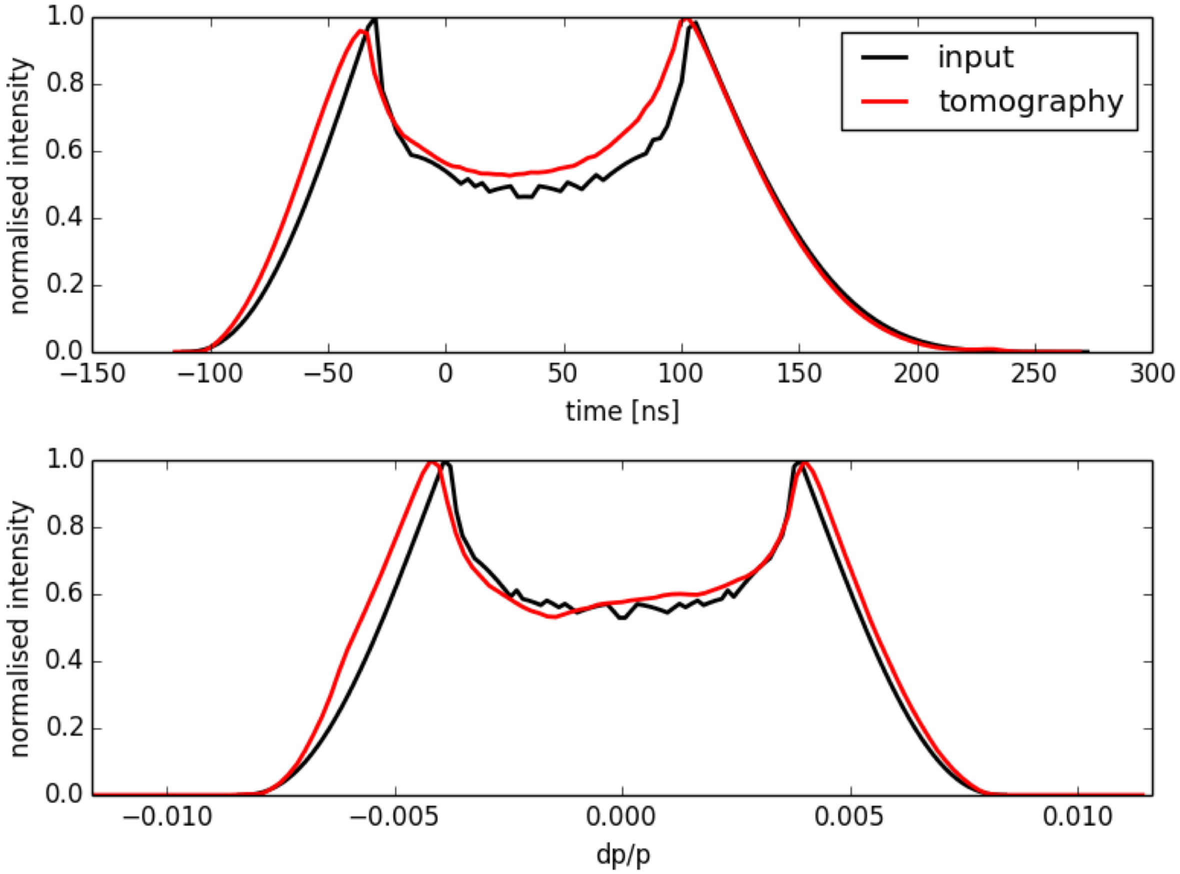


Qs: 0.005 (Ts=200), phi_s: 20 deg.
Number of bins in projection: 128
Number of “turns”: 100 (=0.5*Ts)

$$f(\phi, \delta) = (H_{sep} - H(\delta, \phi))^2$$

Stationary distribution with hole

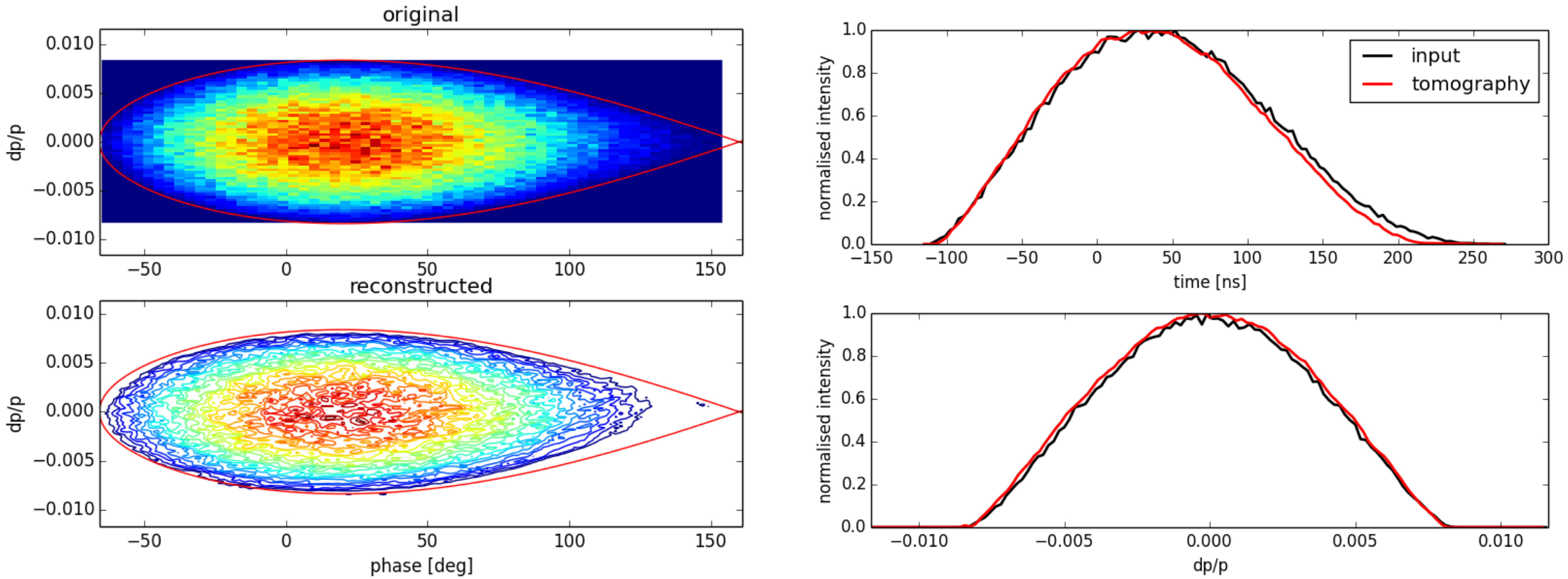




Qs: 0.005 (Ts=200), phi_s: 20 deg.
Number of bins in projection: 128
Number of “turns”: 100 (=0.5*Ts)

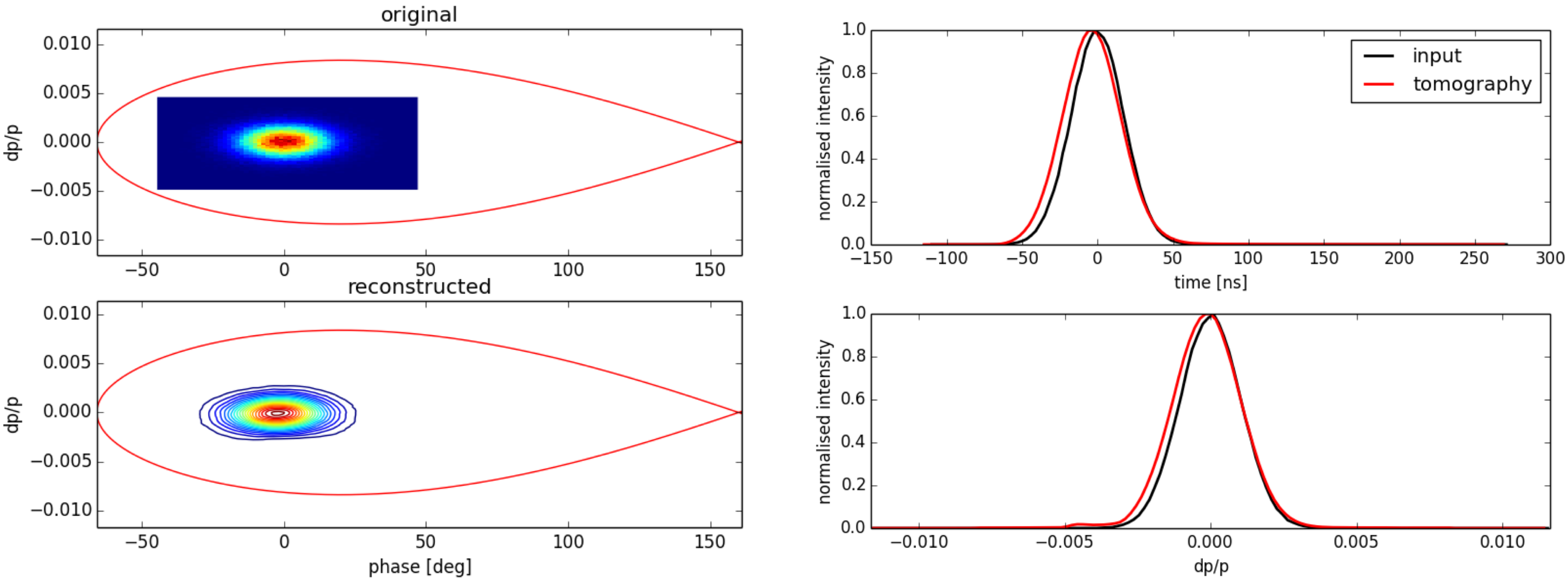
$$f(\phi,\delta) = (H_{sep} - H(\delta,\phi))^2,\ H > H_{cut}$$
$$f(\phi,\delta) = 0,\ H < H_{cut}$$

PyHEADTAIL tracking – stationary thermal distribution



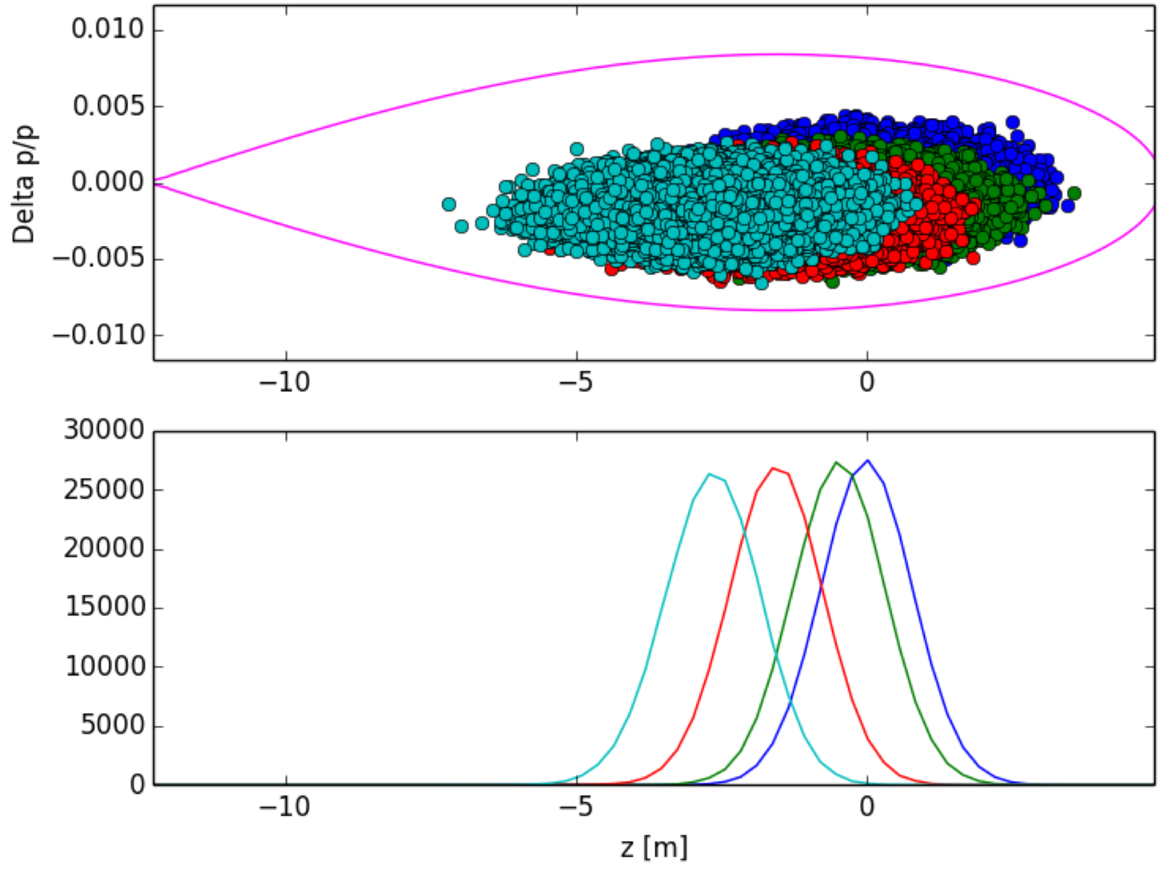
Qs: 0.005 (Ts=200), phi_s: 20 deg.
Number of bins in projection: 128
Number of "turns": 100 (=0.5*Ts)

PyHEADTAIL tracking – small Gaussian bunch



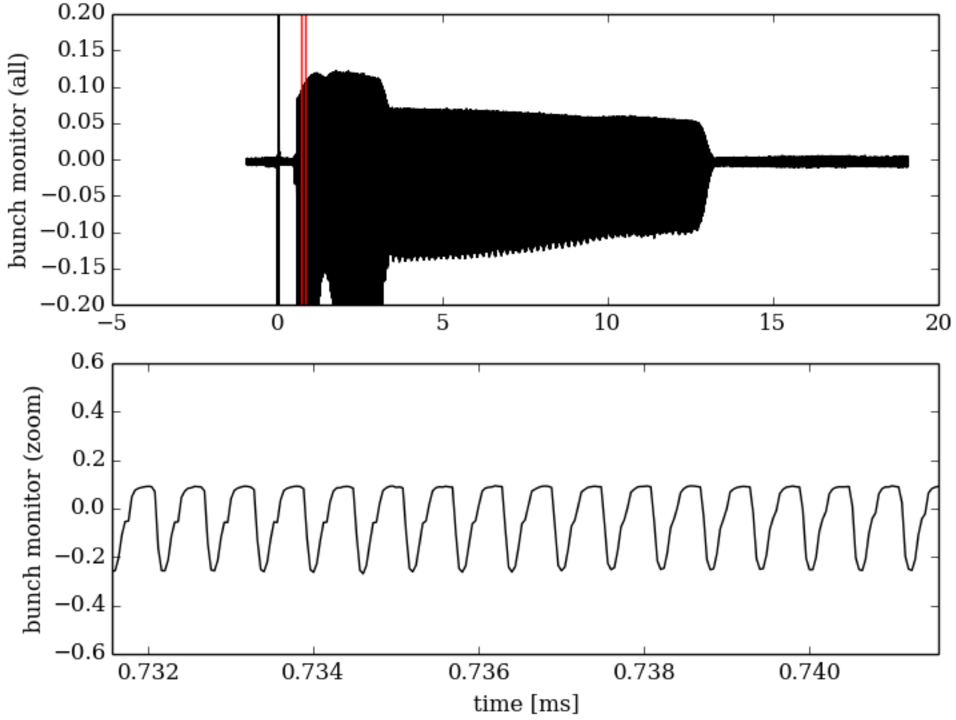
Note: Tomography code expects the bunch profile to span the bucket.

PyHEADTAIL tracking

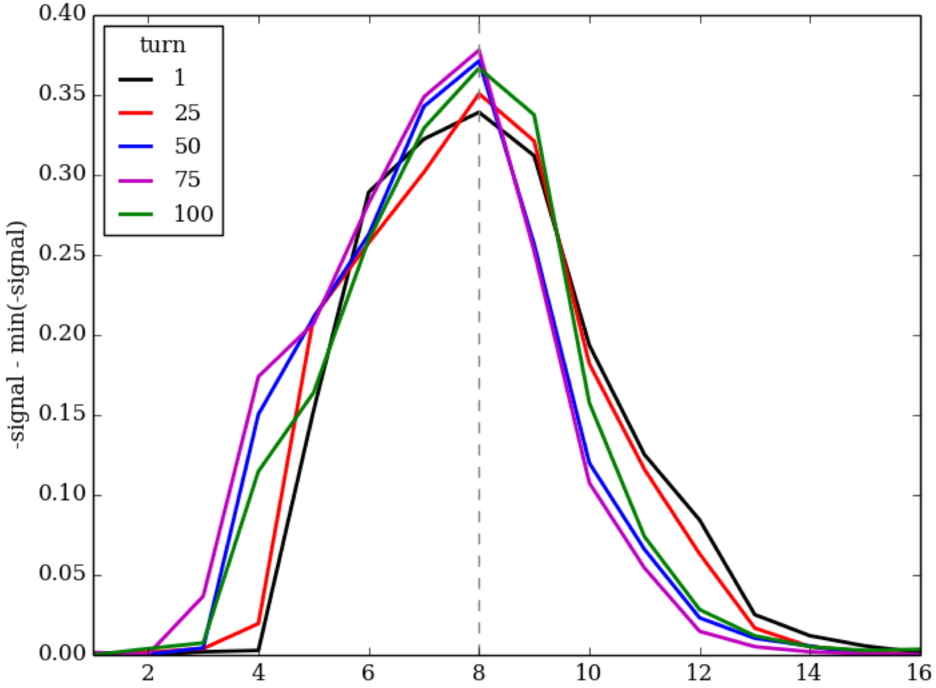


Show tracking result every 25 turns.
To do: compare with tomography results.

Bunch monitor data



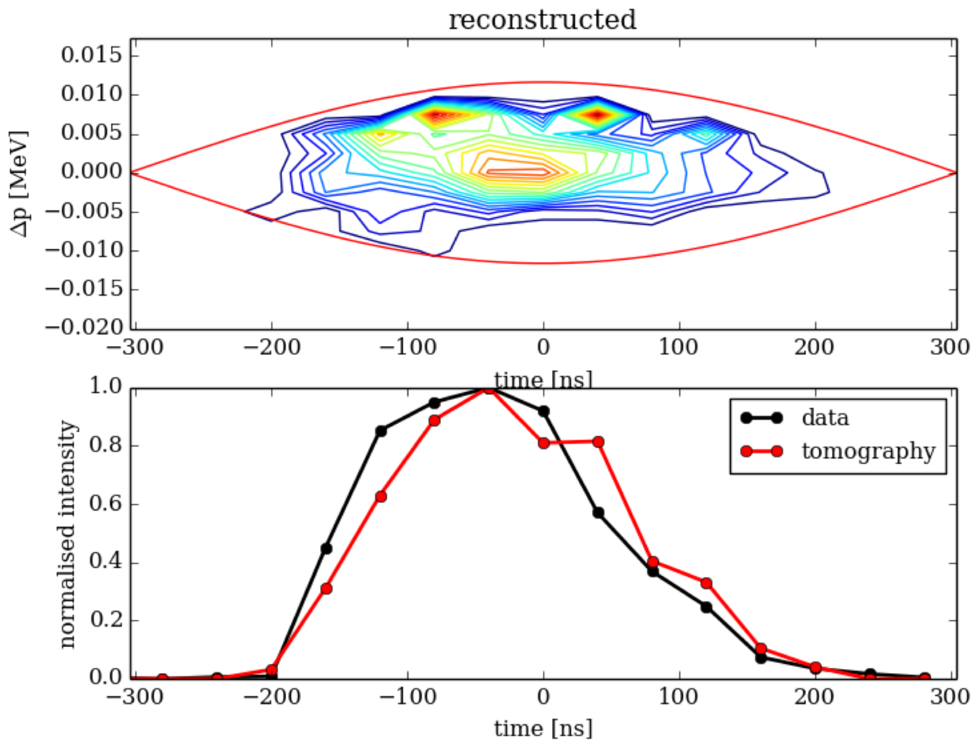
Raw bunch monitor data



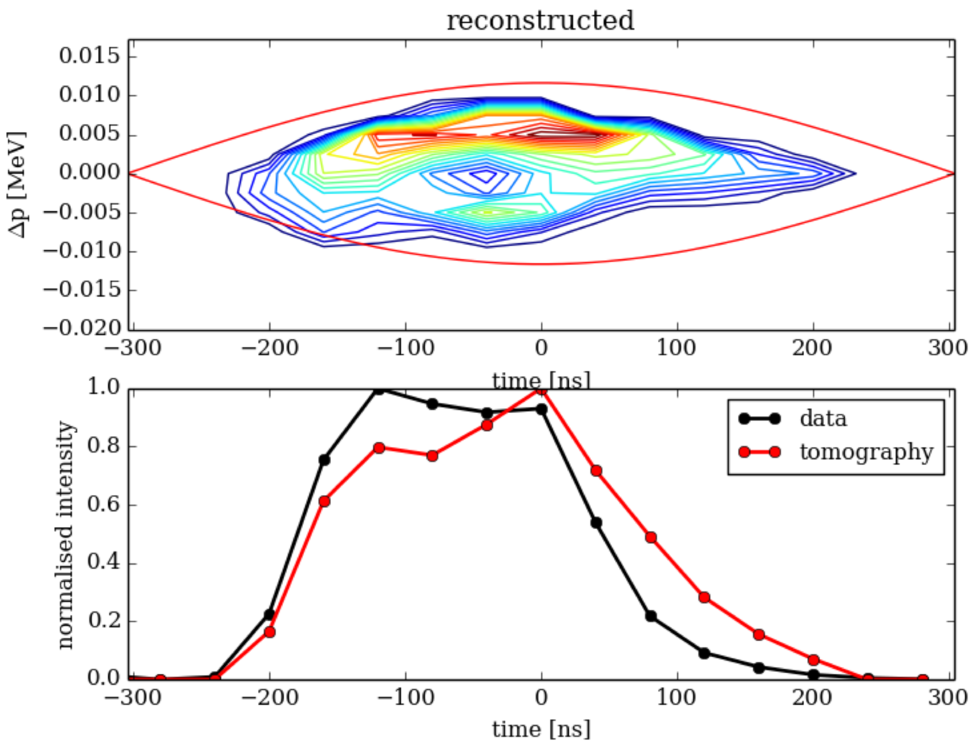
Bunch monitor data as input to tomography code

Data from 24/6/2015, 700A setting, F01, probe radial position is 760mm.

Reconstructing phase space using experimental data



t = 0.75ms



t =1.03ms

Assumed phi_s: 0 deg.
Number of bins in projection: 16
Number of “turns”: 100 (=0.5*Ts)

Tomography code issues/future work

- Resolve remaining discrepancy between input and reconstructed profile widths.
- Show turn-by-turn evolution of reconstructed phase space.
- Deal with variation of TOF with radius (allow number of ”bins per frame” to vary in the tomography code).
- Introduce foil crossing in tomography algorithm (fixed energy loss per turn?).
- Tomography in beam stacking case – can we resolve the accelerated and stacked bunches?