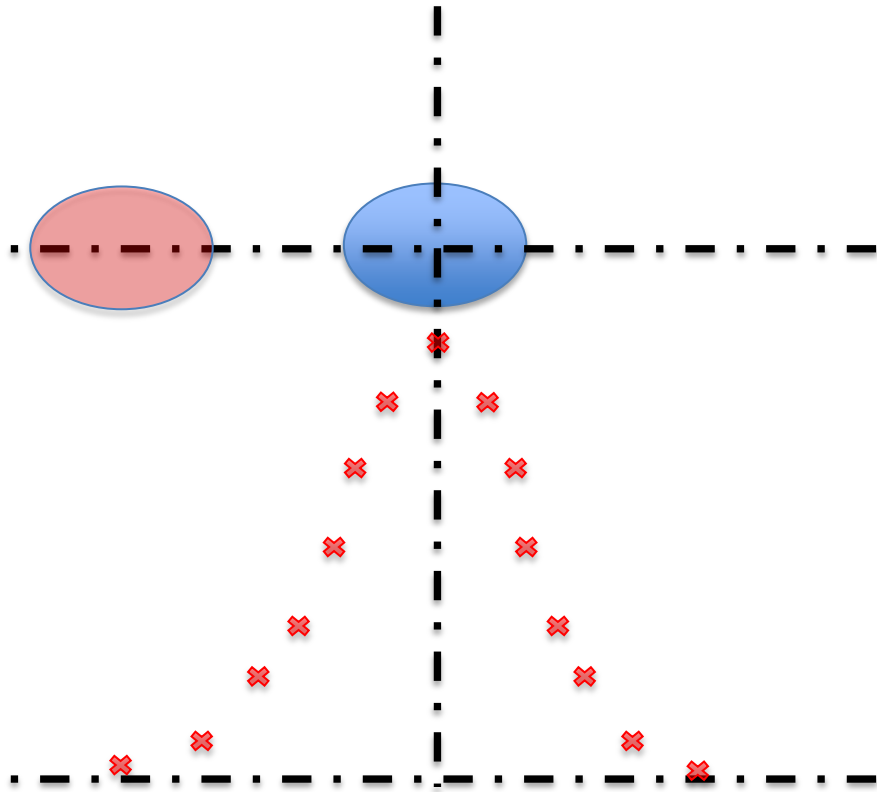


Beam-beam deflection during Van der Meer scans

T. Pieloni

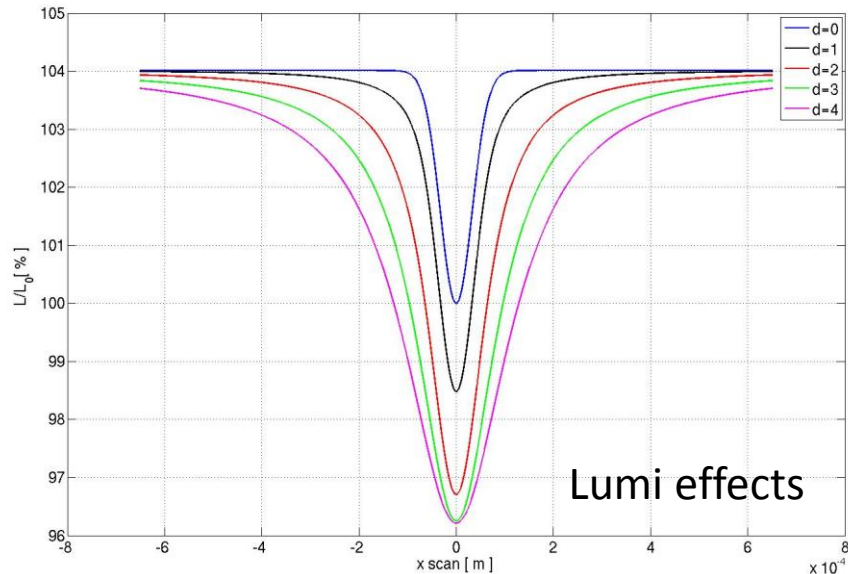
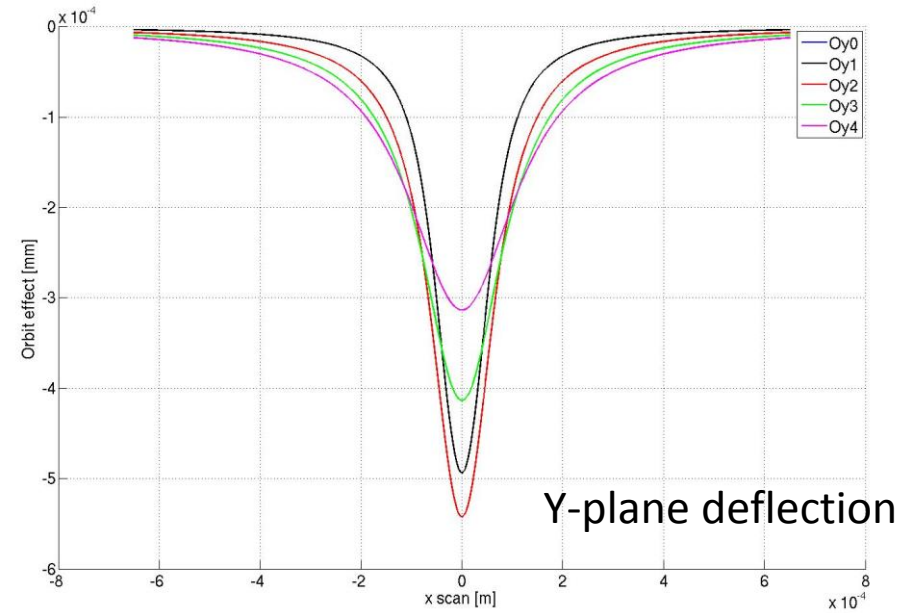
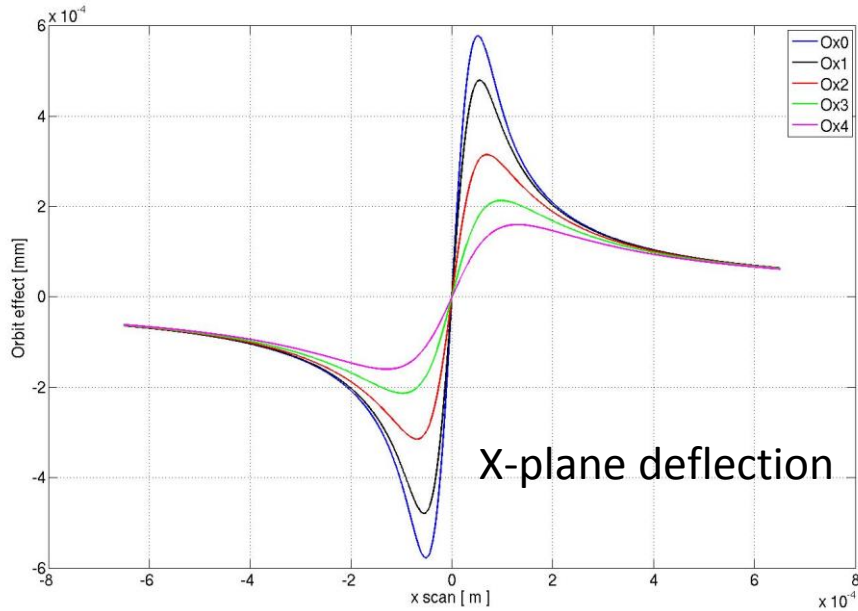
LHC Luminosity Calibration and Monitoring Working Group 8th April 2013
LHC Luminosity Calibration and Monitoring Working Group 29th April 2013

VdM Scan



Beam-beam deflection during VdM Scans:

- **Analytical calculations** using round Gaussian beams: effect is IMPORTANT!



- Calculations **extended to non-round beams** (Bassetti-Erskine formulas)
- Provide a **python routine** for non-round beams to calculate deflection for defined configuration (29th April)

Beam-Beam deflection angles and orbit

[Ref. M. Venturini and W. Kozanecki, SLAC-PUB-8700]

$$\text{Deflections: } \theta_y + i\theta_x = \frac{2r_p}{\gamma} N_p F_0(x, y, \Sigma) \quad \left\{ \begin{array}{l} \Sigma_{12} = 0 \\ \Sigma_{11} > \Sigma_{22} \\ \Sigma_{11} = \sigma_{x1}^2 + \sigma_{x2}^2 \\ \Sigma_{22} = \sigma_{y1}^2 + \sigma_{y2}^2 \end{array} \right.$$

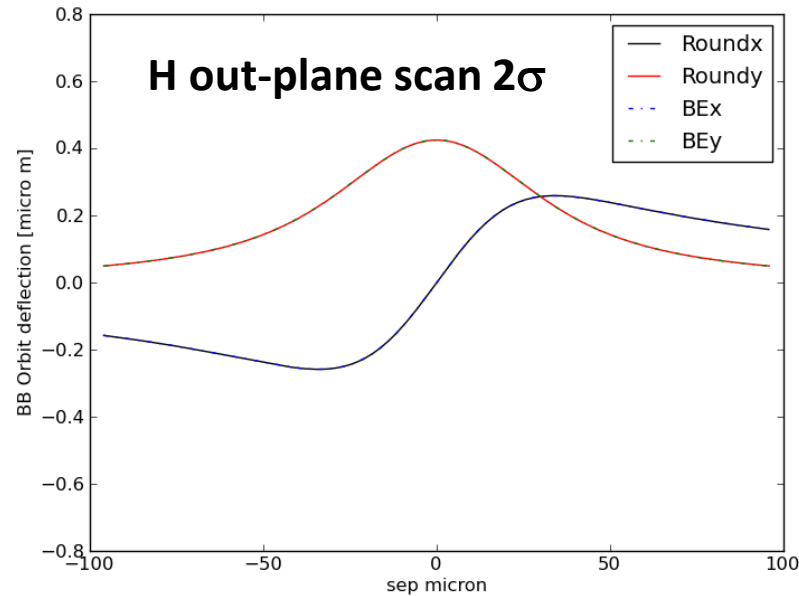
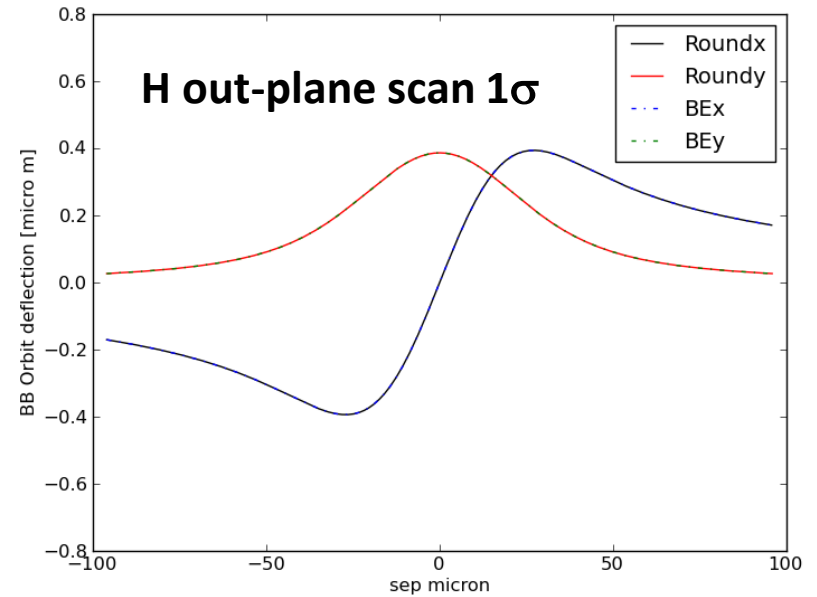
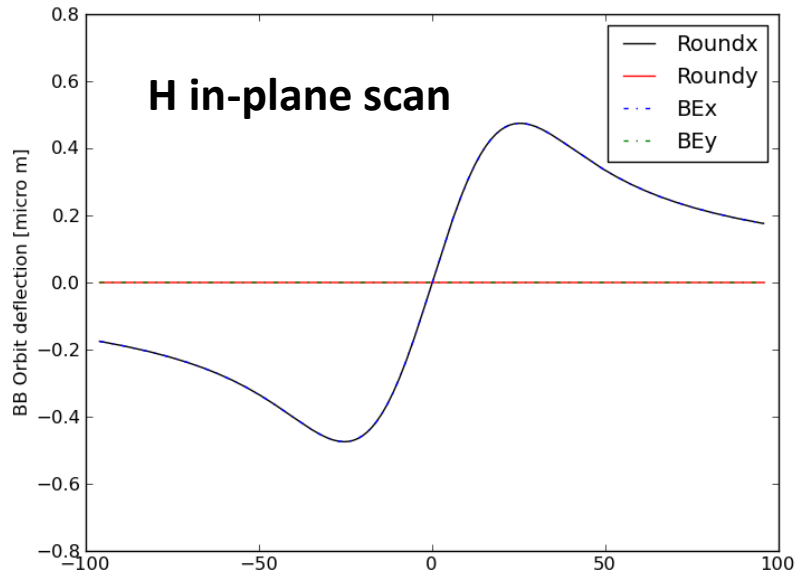
$$F_0(x, y, \Sigma) = \frac{\sqrt{\pi}}{\sqrt{(\Sigma_{11} - \Sigma_{22})}} \left[w(\alpha_1) - w(\alpha_2) \cdot \exp\left(-\frac{1}{2}(\Sigma_{11}^{-1}x^2 + \Sigma_{22}^{-1}y^2)\right) \right]$$

$$\alpha_1 = \frac{x + iy}{\sqrt{2(\Sigma_{11} - \Sigma_{22})}} \quad \alpha_2 = \frac{(\Sigma_{22}x + i\Sigma_{11}y)}{\sqrt{2\Sigma_{11}\Sigma_{22}(\Sigma_{11} - \Sigma_{22})}}$$

$$w(z) = \exp(-z^2) \operatorname{erfc}(-iz)$$

Closed Orbit effect:
$$\text{Orb}_{x,y} = \theta_{x,y} \cdot \beta_{x,y} \cdot \frac{1}{2 \tan(\pi \cdot Q_{x,y})}$$

Example 1 round beams



BBScan.py: to test the BB routine,
available for estimates

BB.py: calculation routine

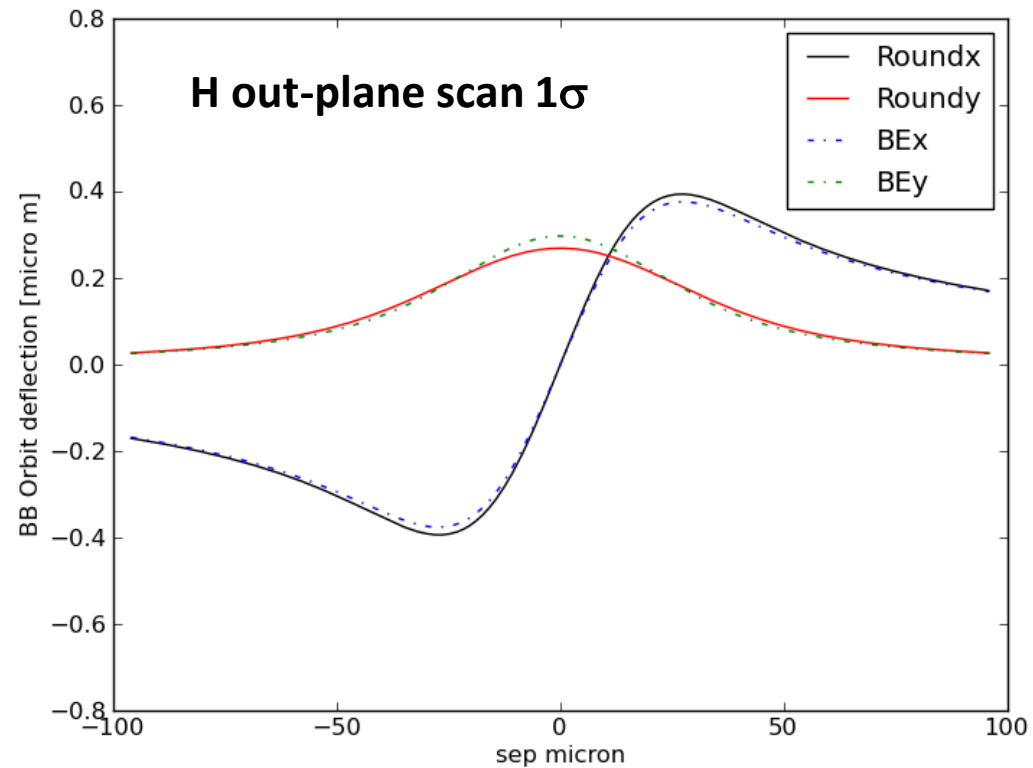
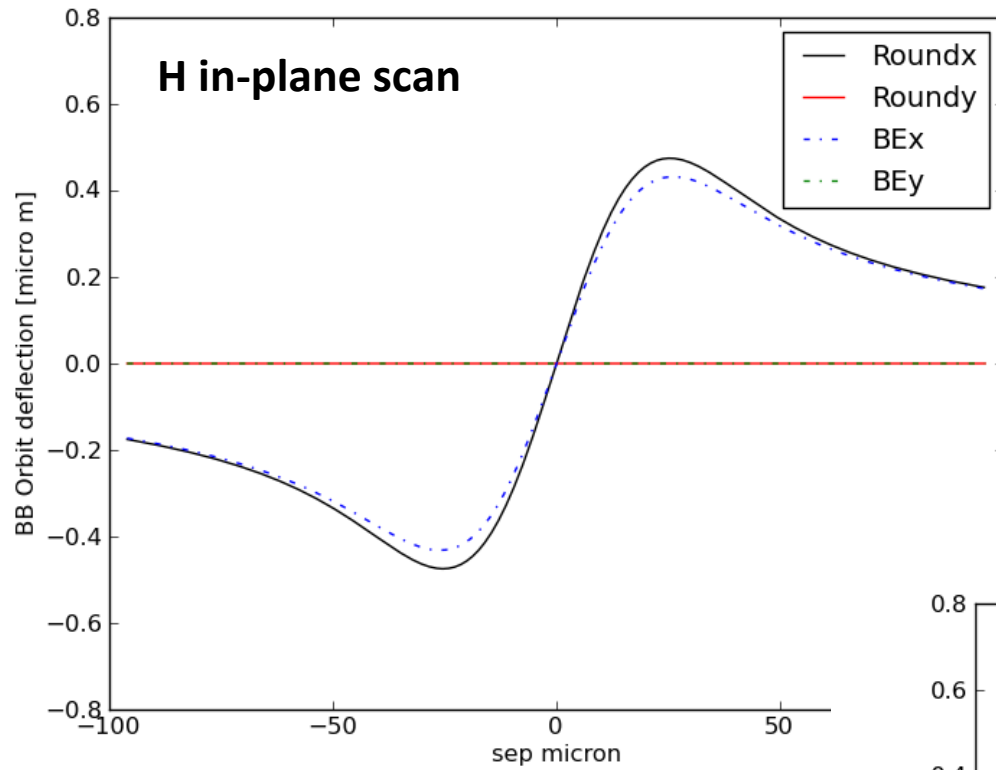
BassErsk: to calculate the electric fields
Ref. CERN-ISR-TH/80-06.

Example 2

non-round beams

$$\Sigma_x = 16\mu m$$

$$\Sigma_y = 20\mu m$$

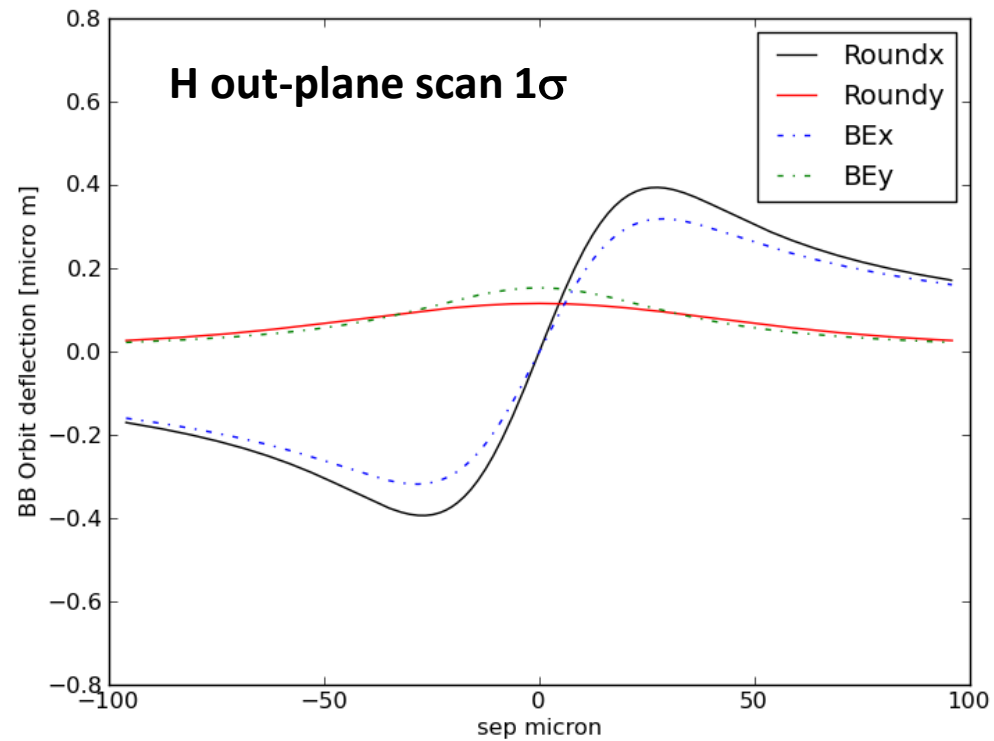
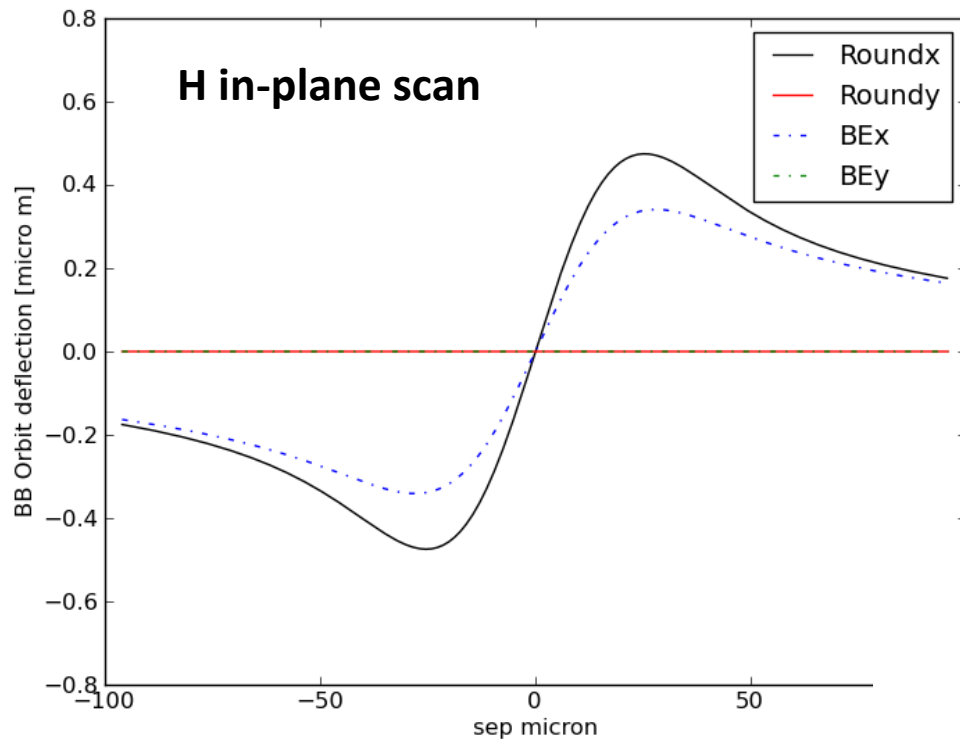


Example 2

non-round beams

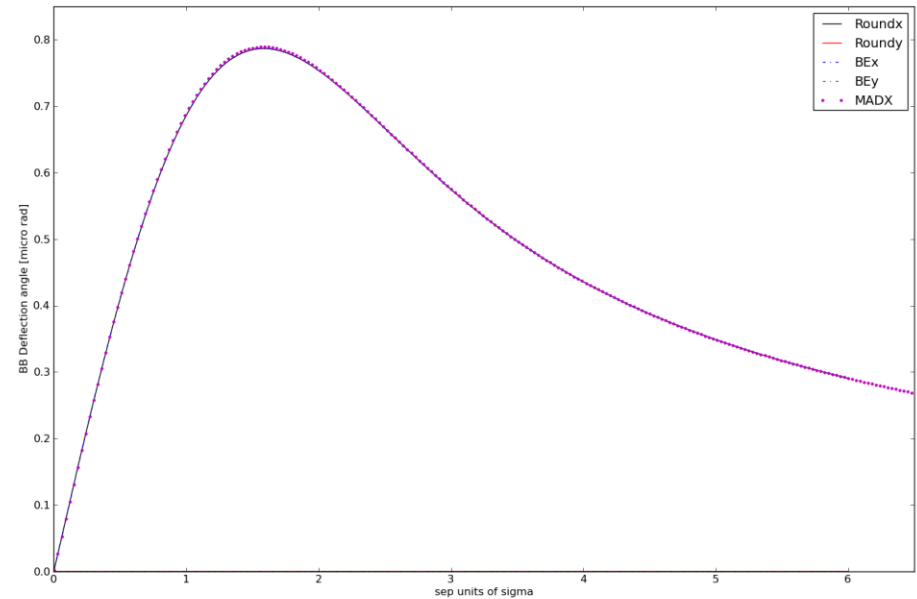
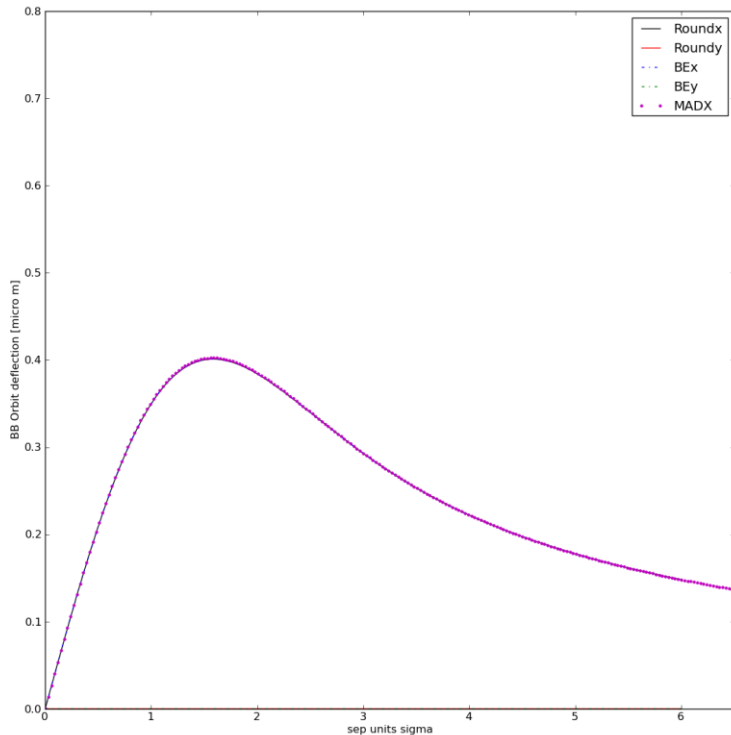
$$\Sigma_x = 16\mu m$$

$$\Sigma_y = 32\mu m$$



MADX vs analytical model IP1 scan H

VdM scans 2011 May
Emittance $4 \mu\text{m}$
Optics:



- MADX doesn't give BB angular kick and closed orbit effect?!
- TRACK in MADX gives angular kick and closed orbit effect?!

Verify with experts the implementation and ask for modifications!

With some tricks: Good agreement, differences due to dynamic beta effect

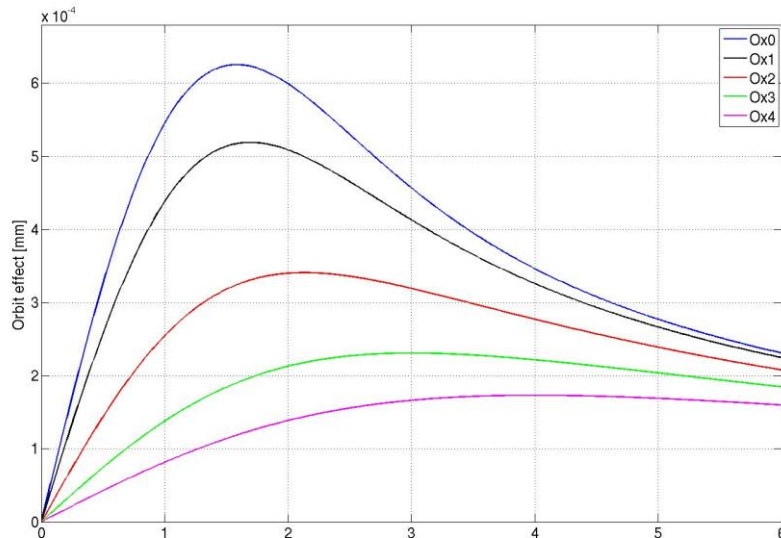
MADX:

- CASE 1 (May 2011) 3.5 TeV V6.5.coll_special.3.5TeV_1.5m10m1.5m3m.str
- CASE 2 (2012 April) 4 TeV V6.5.inj_special.str with coll tunes

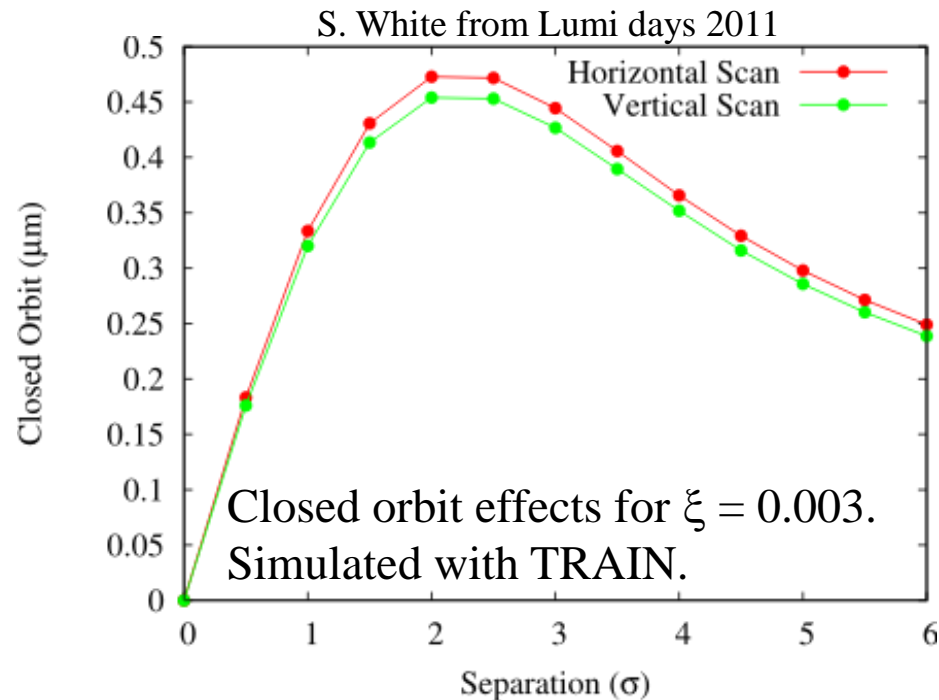
- Scan H in ATLAS and V separation in all other Ips
- V scan in ATLAS and H separation in all other ips

Next step 1

- How effects adds up with multiple Ips? Evaluate effects on Van der Meer scans May 2011 and April 2012, to allow experiments to evaluate impact on results.
- Analytical calculations do not take into account the **self consistent orbits of the two beams: TRAIN code** in next weeks



Orbit effects for $\xi = 0.003$, analytical model



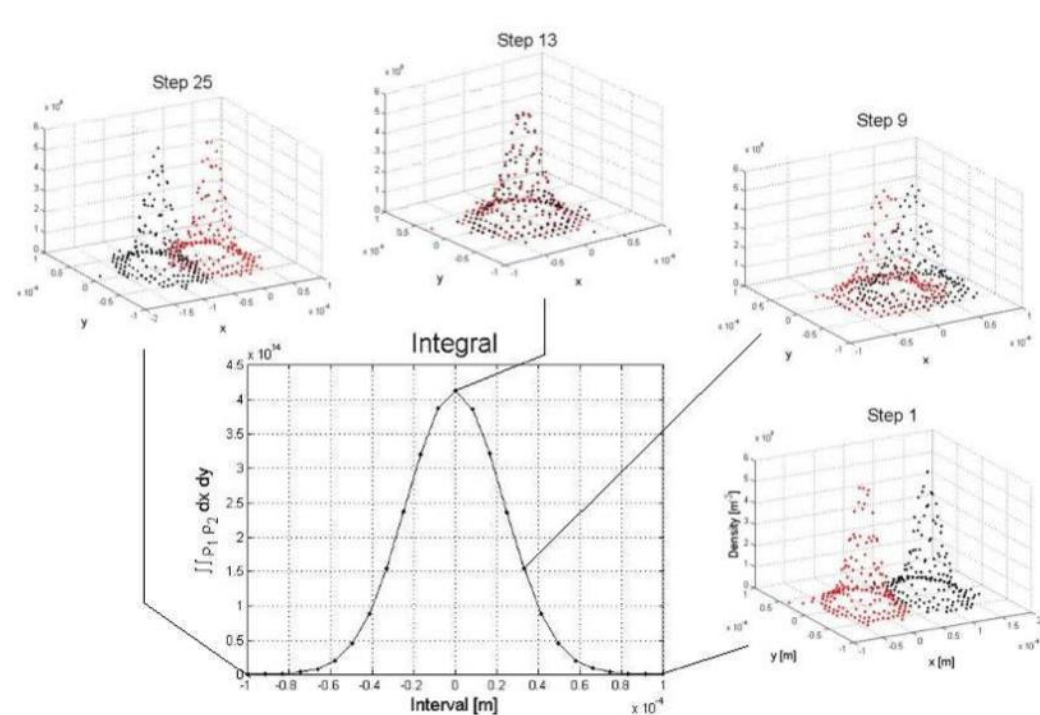
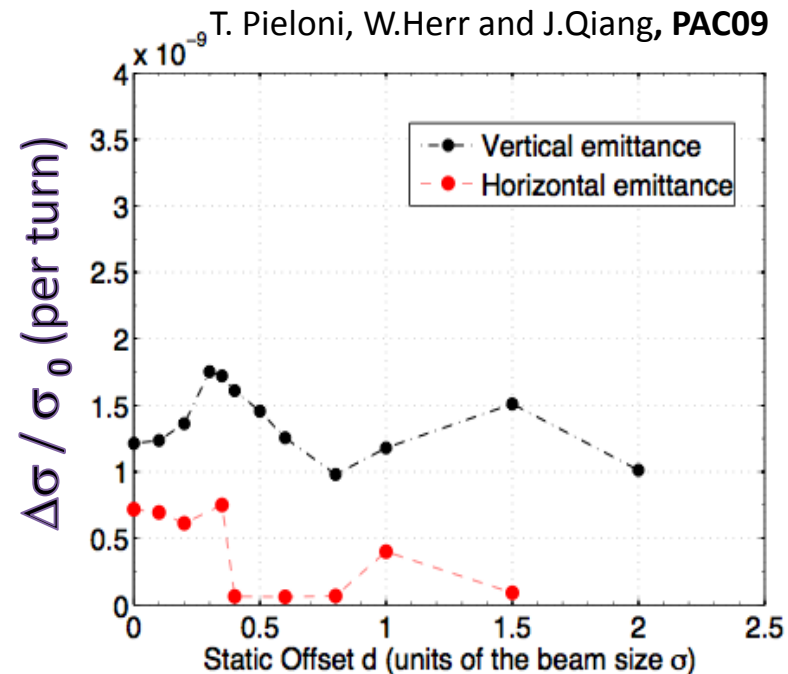
Closed orbit effects for $\xi = 0.003$.
Simulated with TRAIN.

- Reproduce **VdM scan dynamics** (interplay of different IPs), in this study assume 1 IP scan and other separated! Different scenarios should be studied!
- **Evaluate cases for after LS1** (different optics options: standard optics, ATS tunes)

Next step 2

Is there something more during VdM scans?

- Are distributions modified?
- How different initial distribution will change the results?
- Emittance growth?



Multi-particle simulations

(work started M. Schubiger & T. Pieloni):

- Any particle distribution allowed
- Leaves particle distribution evolve in time
- Time consuming simulations...will need time to conclude!