TF Studies: A very first look

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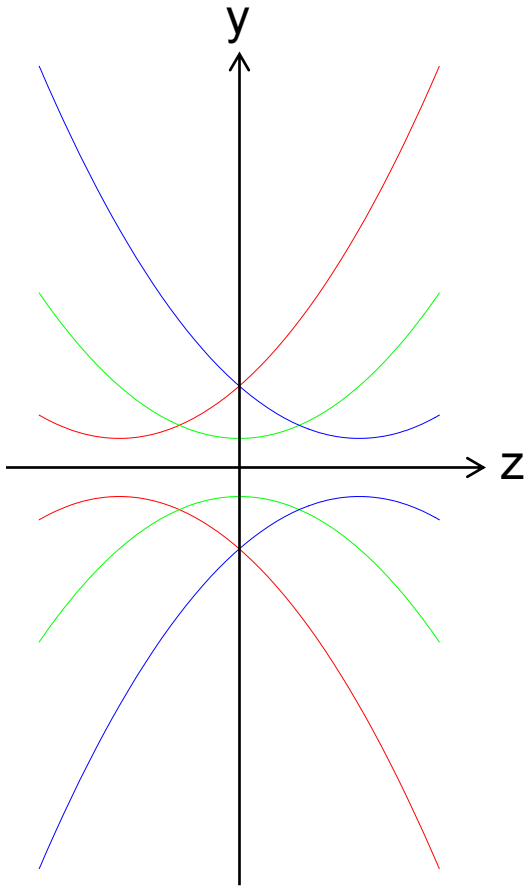
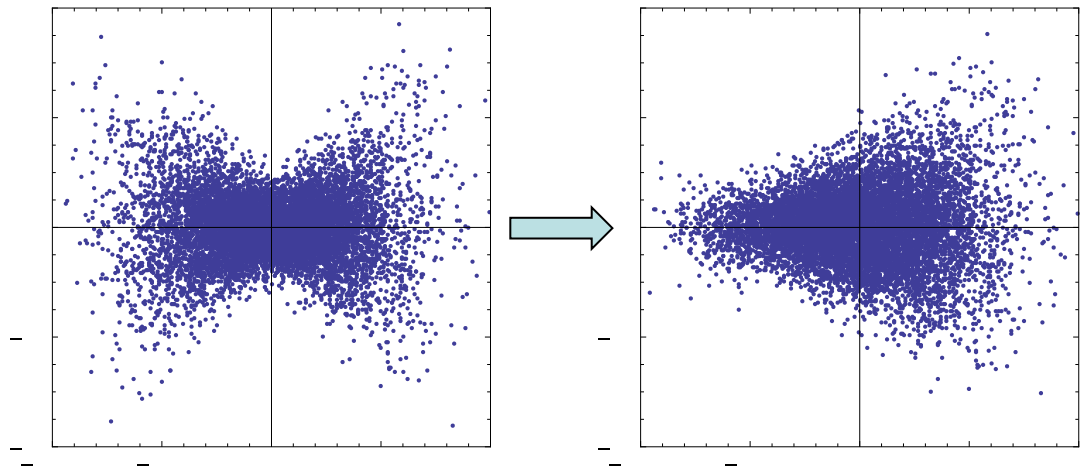
What is required for TF?



Shift the waist (focal point) of each *z*-slice by -*z*/2

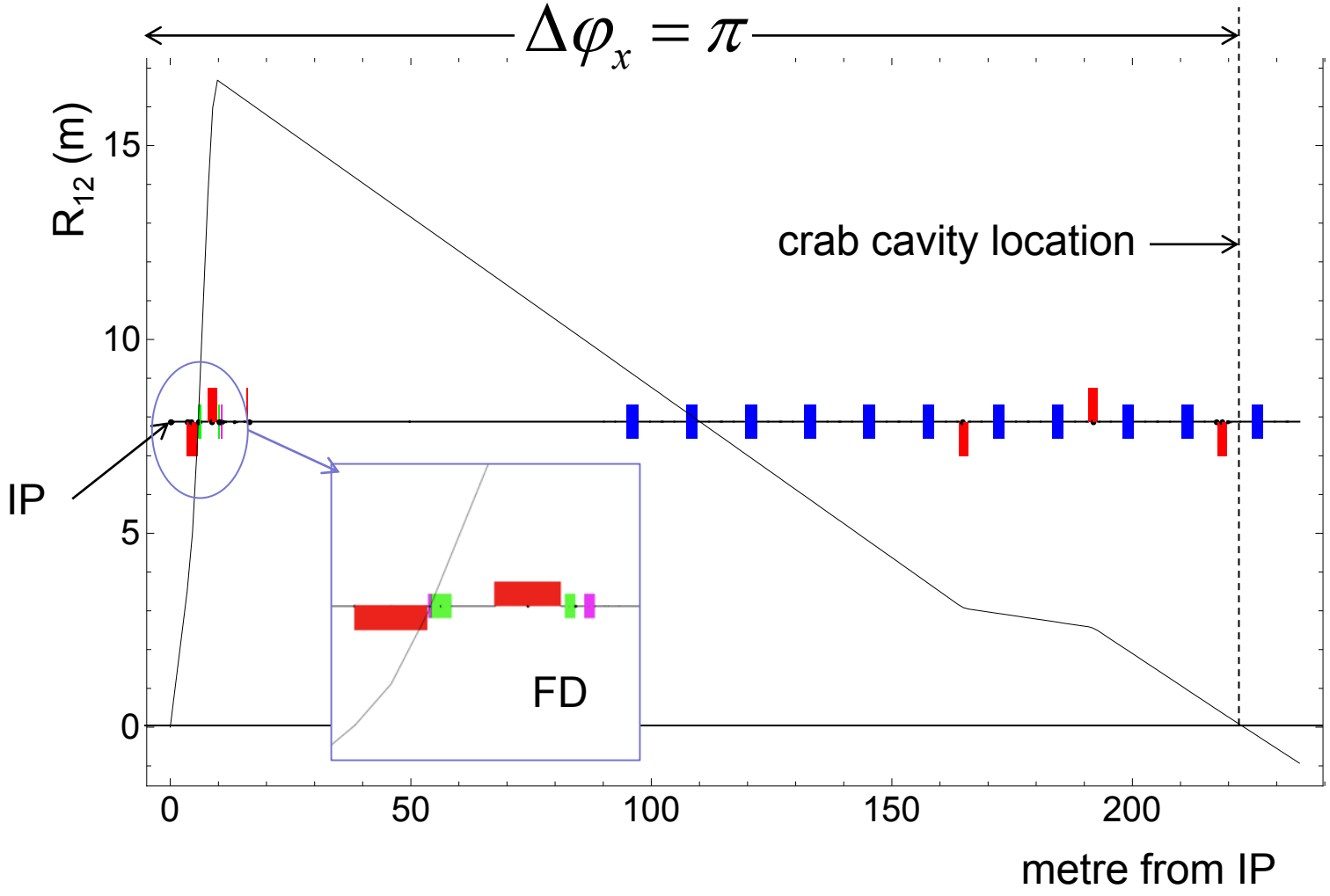
Apply an additional (coherent) shift of $-\sqrt{3}\sigma_z/2$

Note: Guinea Pig applies to both planes



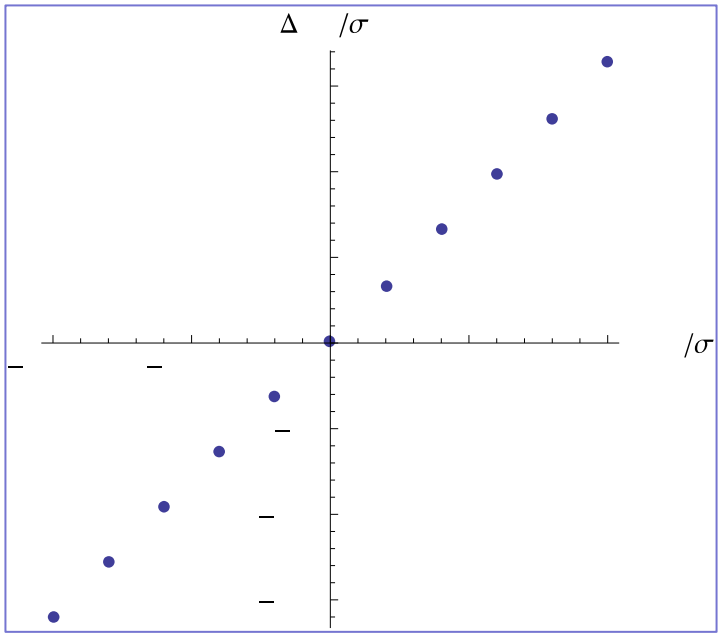
First idea: use strong sextupole in FD with fast orbit bump to generate additional focus over bunch length (crab cavity)

Generating The Crab Waist

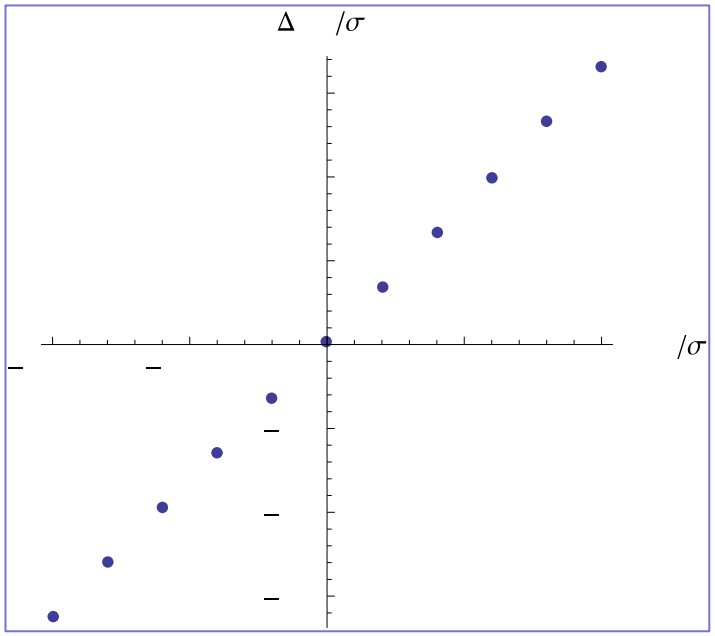


Effectiveness of Orbit Bump

Waist shifts at IP as a function of horizontal kick at cavity location



$dW_x/d\theta \sim 7\times10^5$ m



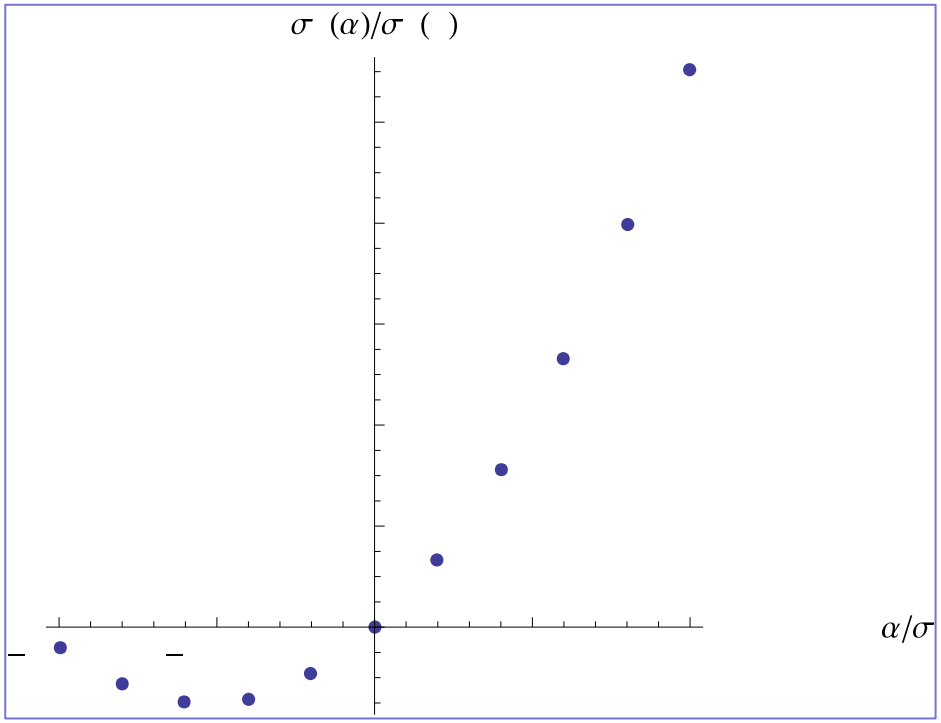
$dW_y/d\theta \sim 7\times10^3$ m

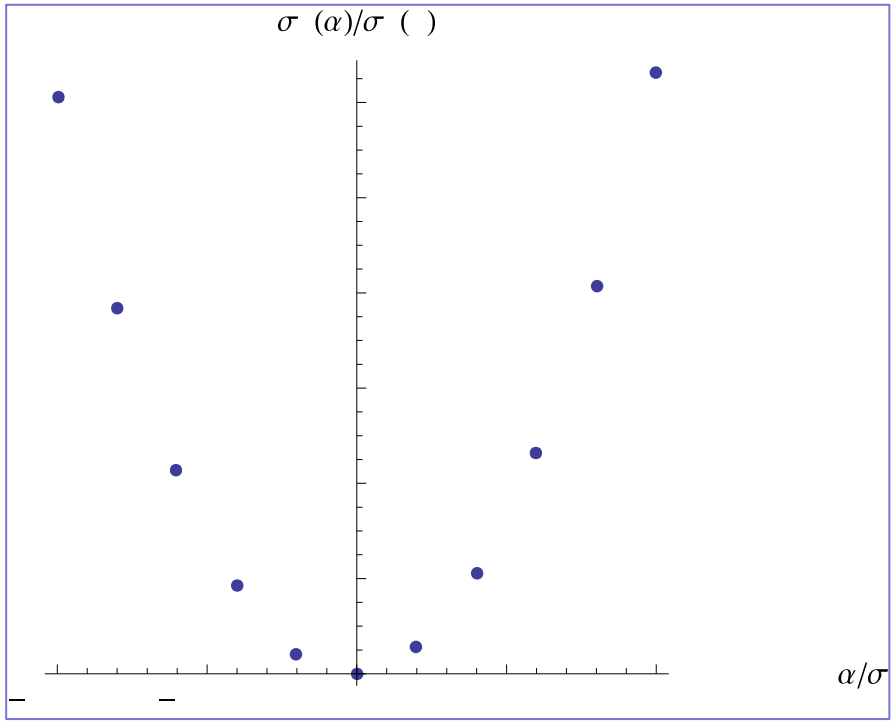
Very small kick required (<% σ)
Very linear
Factor 100 stronger in x than y ☹ (not unexpected)

(Ideally we would like to have two independent knobs)

Impact on beam size

Relative change in beam size at the shifted waist as a function of kick





Typically <1% effect for <1% σ kick

Required Cavity Kick for TF

- **Can't control both so just set vertical**
- **Waist shift of particles at z in bunch = z/2**
  - i.e. $dW_y/dz = ½$ [$\Rightarrow dW_x/dz = 50$!]
- **At crab cavity:**
  $d\theta/dz = 0.5 / 7\times10^3 = 7.14\times10^{-5}\ m^{-1}$
  - $300\mu m \times d\theta/dz = 20$ nrad (0.003σ)
- **For a 1.3 GHz cavity / 250 GeV: V = 650 kV**

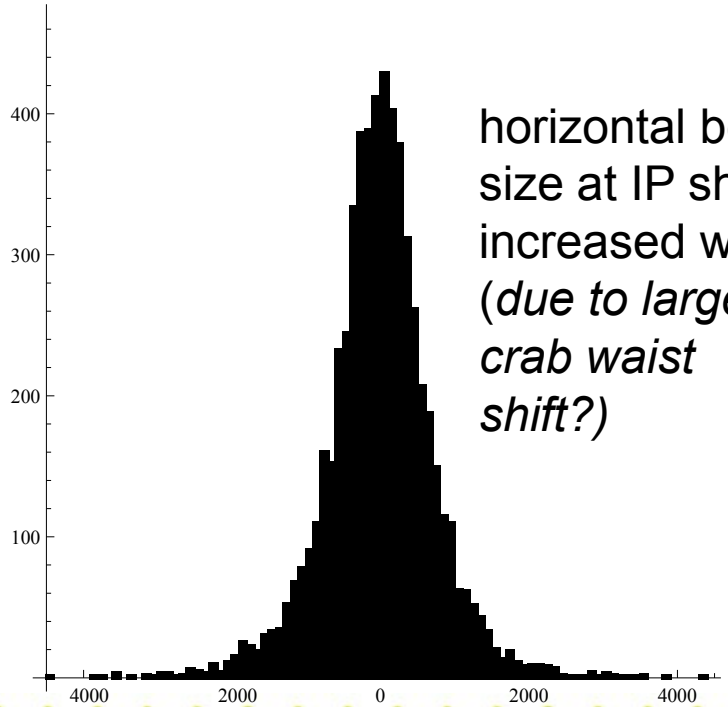
Comments on Tracking Simulation

- **Gaussian 6D bunch generated first at IP**
- **Initial coherent waist shifts ($\sqrt{3}\sigma_z/2$) applied numerically.**
  - In real world assume this to be done with waist knobs.
- **Back-tracked through FFS to location of cavity to provide initial tracking distribution**
  - Generates the correct correlations in bunch
- **Required horizontal crab-kick applied and particles tracked forward to the IP**

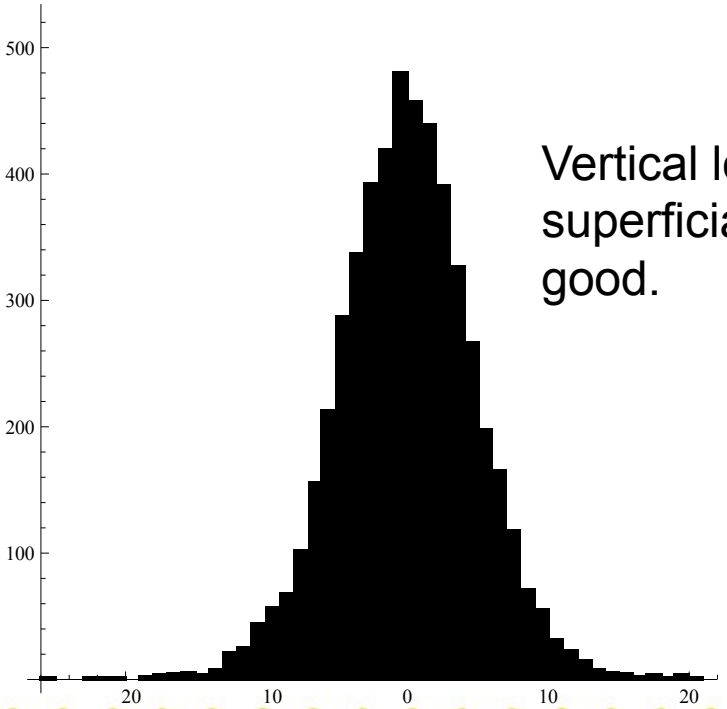
Initial Results

- **Tracked particle files (electrons/positrons) used in Guinea Pig**

- **First result showed reduction of luminosity by ~30% (i.e. 1.4×10^{34}) ☹**



horizontal beam size at IP shows increased width (*due to large crab waist shift?)*



Vertical looks superficially good.

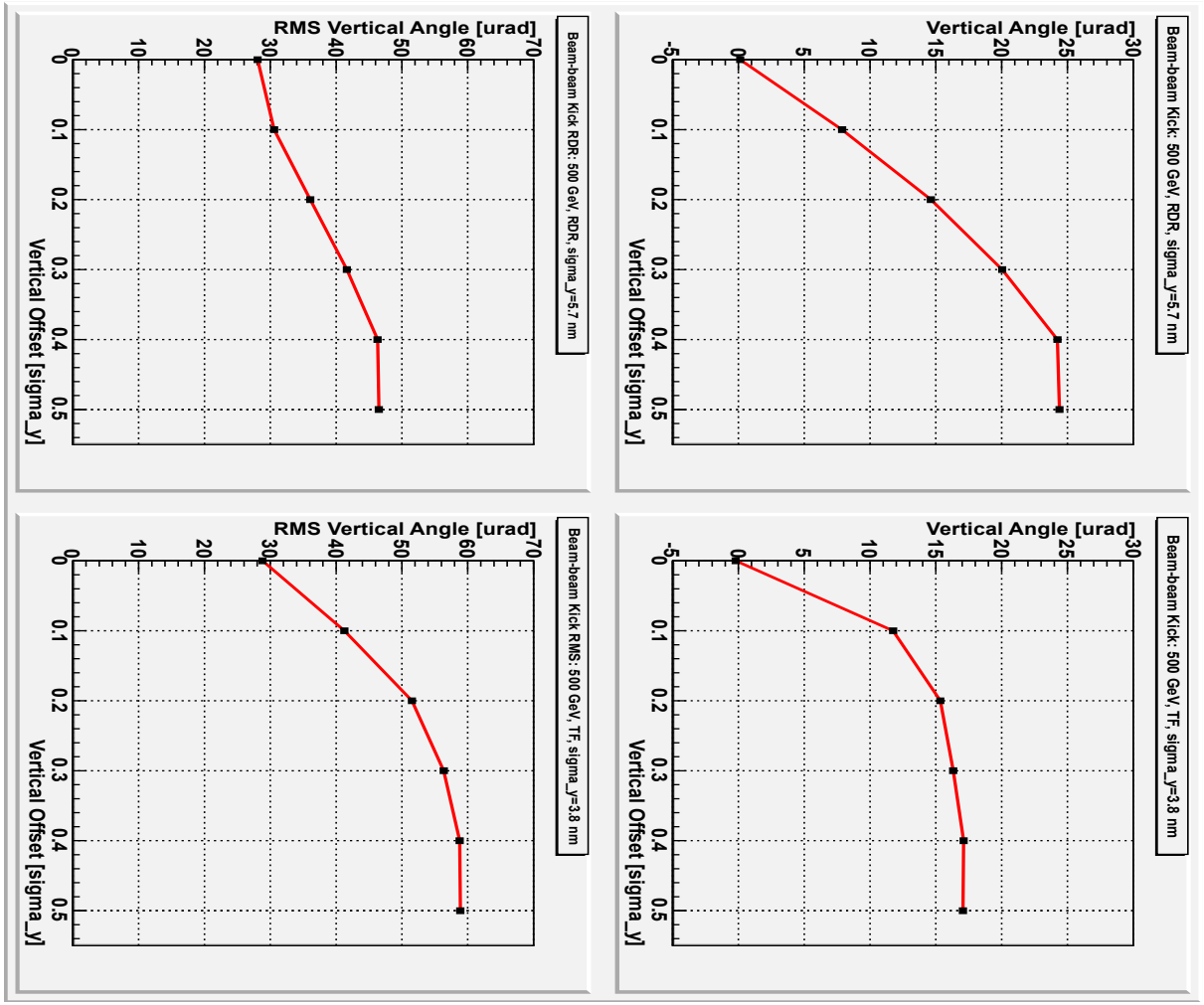
Guinea-Pig Simulations

- **Simulated interactions for**
  - RDR 500 GeV
  - SB2005 500 travelling focus
  - SB2005 500 no travelling focus
- **Dependency of luminosity vs vertical beam offsets**
- **Depenency of luminosity on gaussian vertical beam jitters**
- **Dependency of vertical kicks vs beam offset**

Vertical Kick vs Beam Offsets

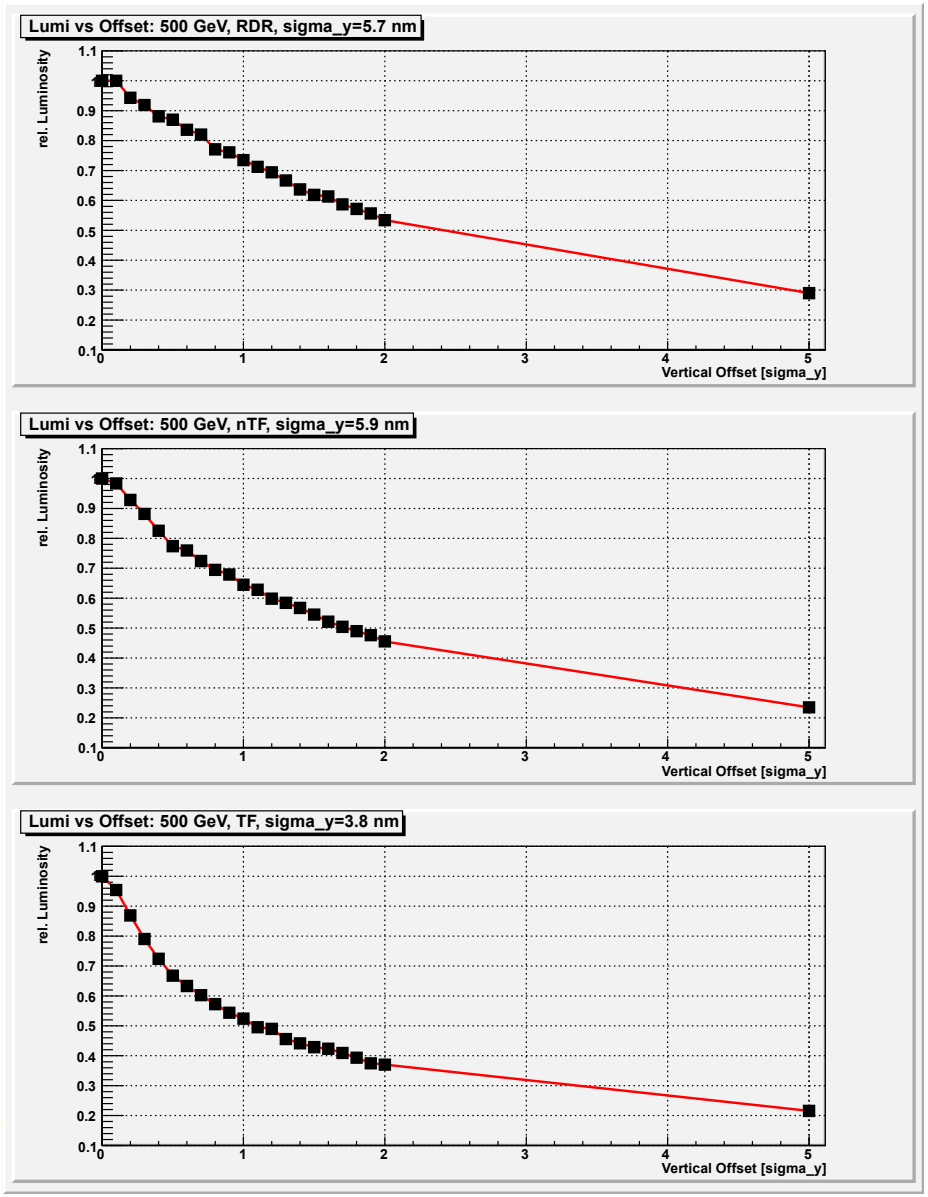
Kick angle (urad)

Kick angles RMS
In each bunch (urad)



RDR-500 (left), TF-500 (right)

Lumi vs Vertical Offset



RDR-500 (top)

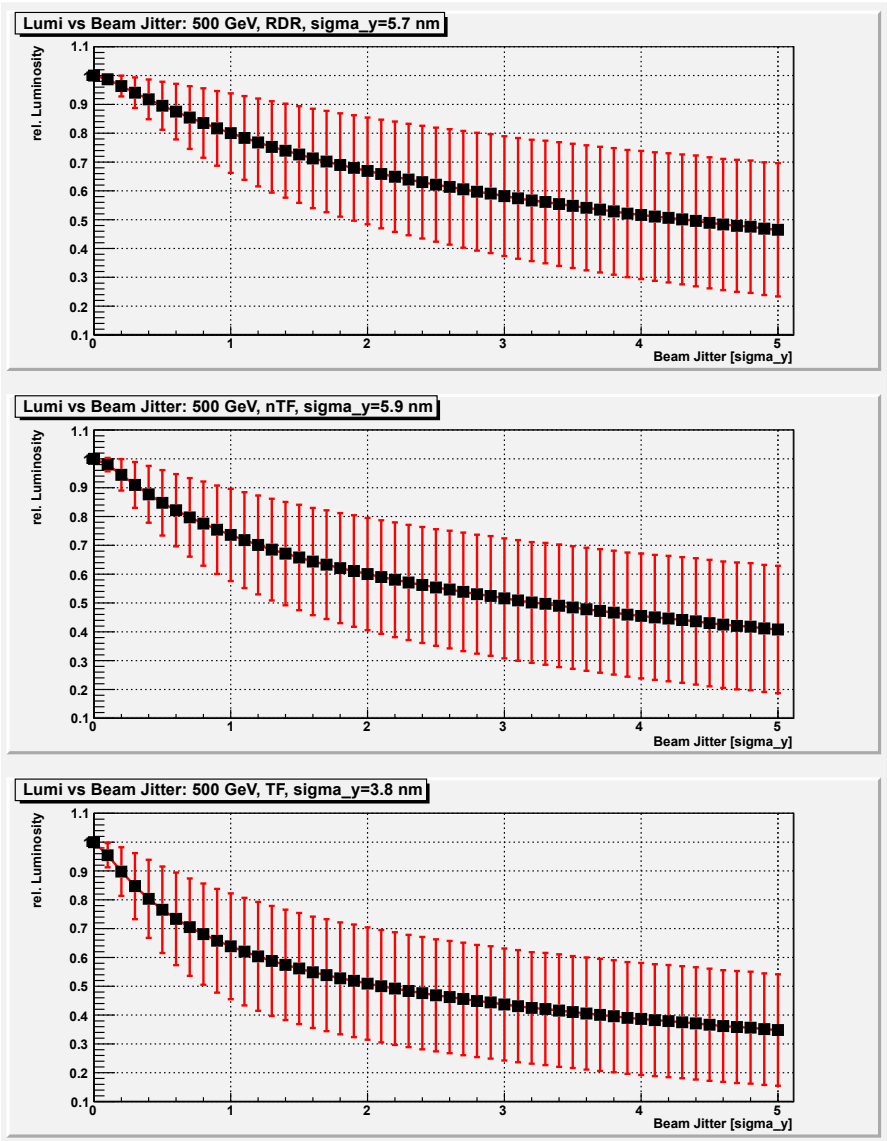
SB2009 500-nTF (middle)

SB2009 500-TF (lower)

Offset in Sigma_y:

- 5.7 nm for RDR
- 5.9 nm for 500-nTF
- 3.8 nm for 500-TF

Lumi vs Vertical Beam Jitter



RDR-500 (top)

SB2009 500-nTF (middle)

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Error bars show RMS of lumi distributions