LARP beam-beam studies

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CARE-HHH Workshop on Beam-beam effects
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Main Goals

- Support LARP's missions to help the LHC achieve higher luminosity quicker & develop expertise in the US.
- Investigate compensation schemes to mitigate effects of long-range and head-on interactions
- Investigate the impact of beam-beam interactions in IR upgrade designs
- Develop analysis and software tools to better understand beam-beam phenomena

Beam-beam collaboration

- Labs involved: BNL, FNAL, LBL, SLAC
- Topics (present, future)
  - Wire compensation experiment and simulations (RHIC, LHC)
  - Electron lens compensation experiments and simulations (Tevatron, RHIC, LHC)
  - Crab cavity simulations (LHC)

People

- BNL: N. Abreu, G. Robert-Demolaize, W. Fischer, Y. Luo
- FNAL: V. Kamerdzhiev, H.J. Kim, T. Sen, V. Shiltsev, A. Valishev
- LBL: J. Qiang
- SLAC: A. Kabel

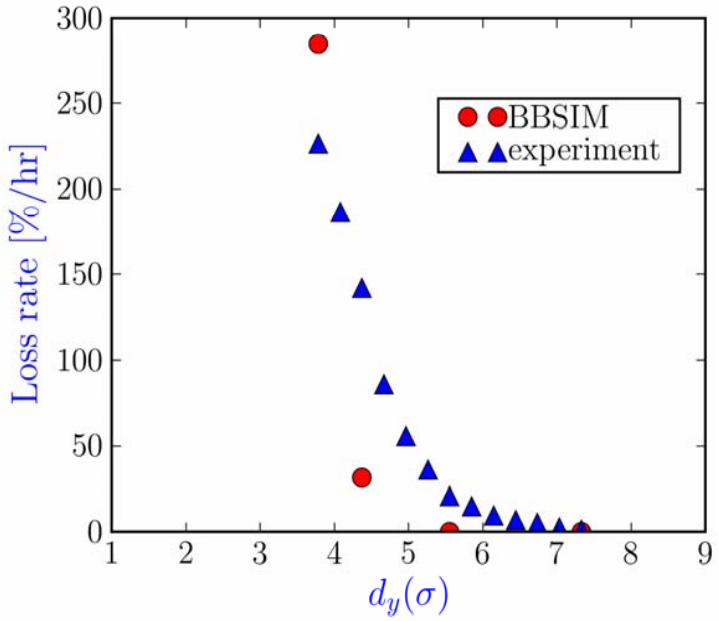
Wire compensation simulations (RHIC)

- Beam loss with changing beam-wire separation – at injection and collision
- BTF simulations with and without wire.
- Tracking and diffusion model for long term simulations
- Comparisons with RHIC store data (emittance and lifetime)

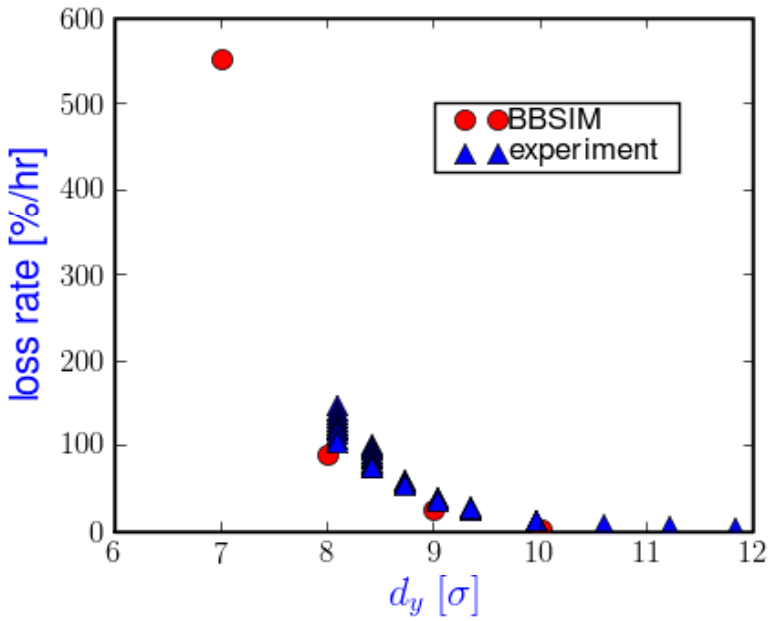
Beam losses vs wire separation

H.J. Kim

Injection energy; 2007 run in RHIC



Collision energy: 2008 run in RHIC

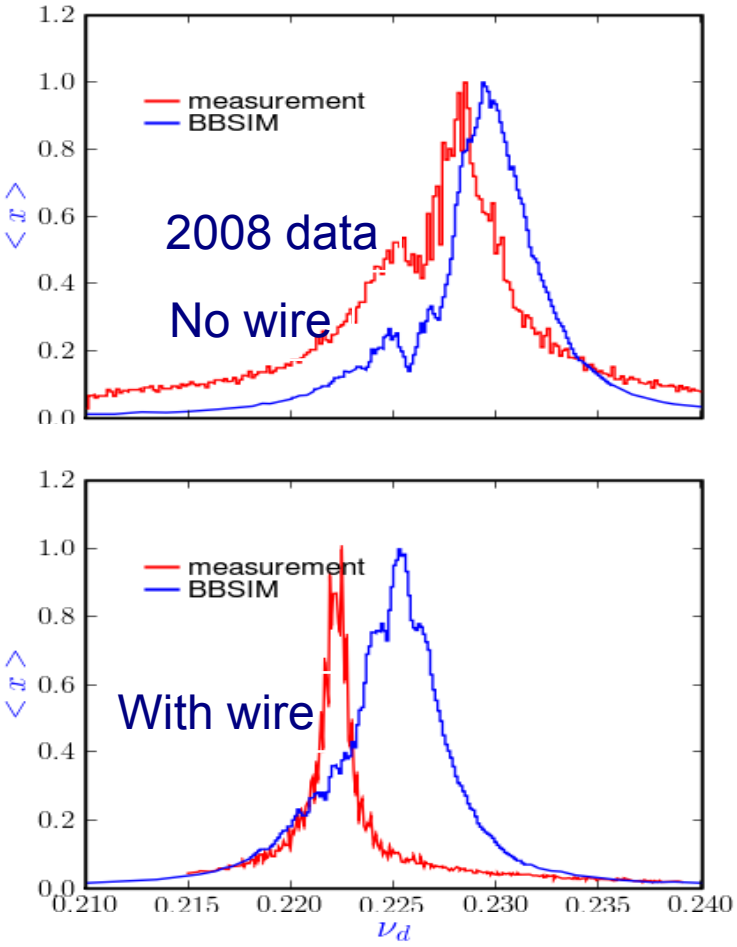


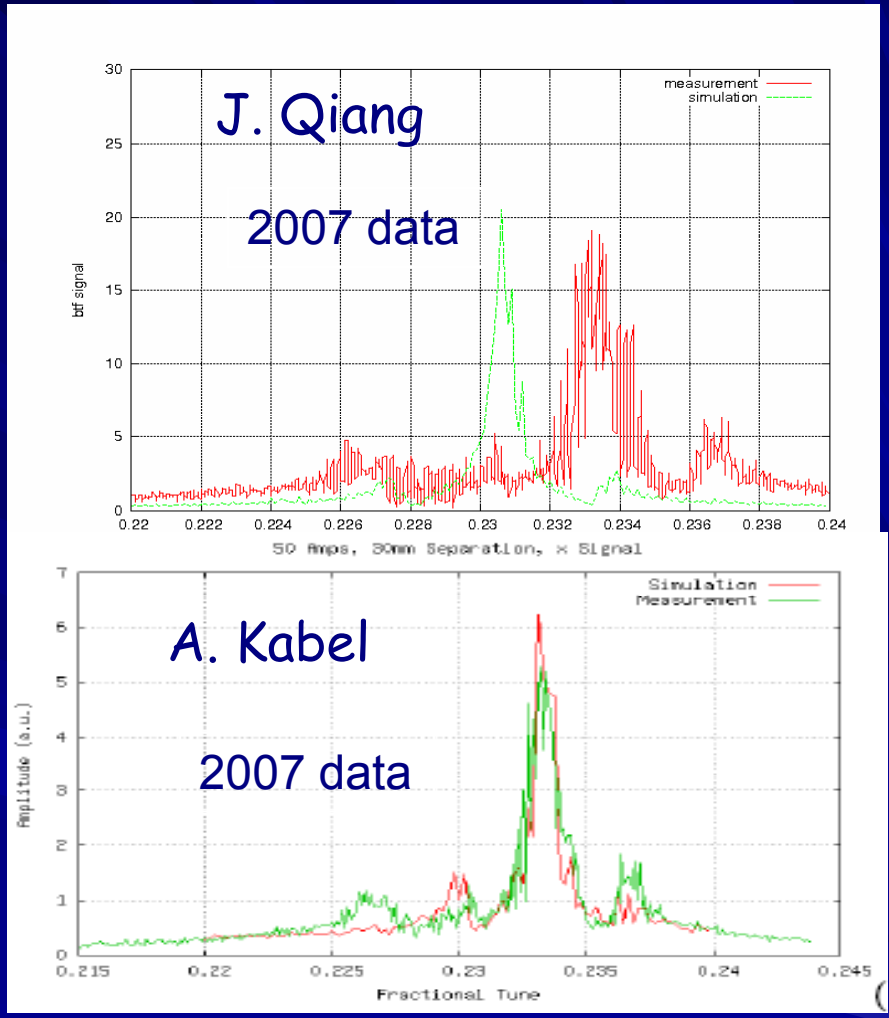
BBSIM simulations of loss rate compared with measurement.

Onset of sharp losses is well reproduced both at injection energy and at collision energy.

BTF simulations

H.J. Kim

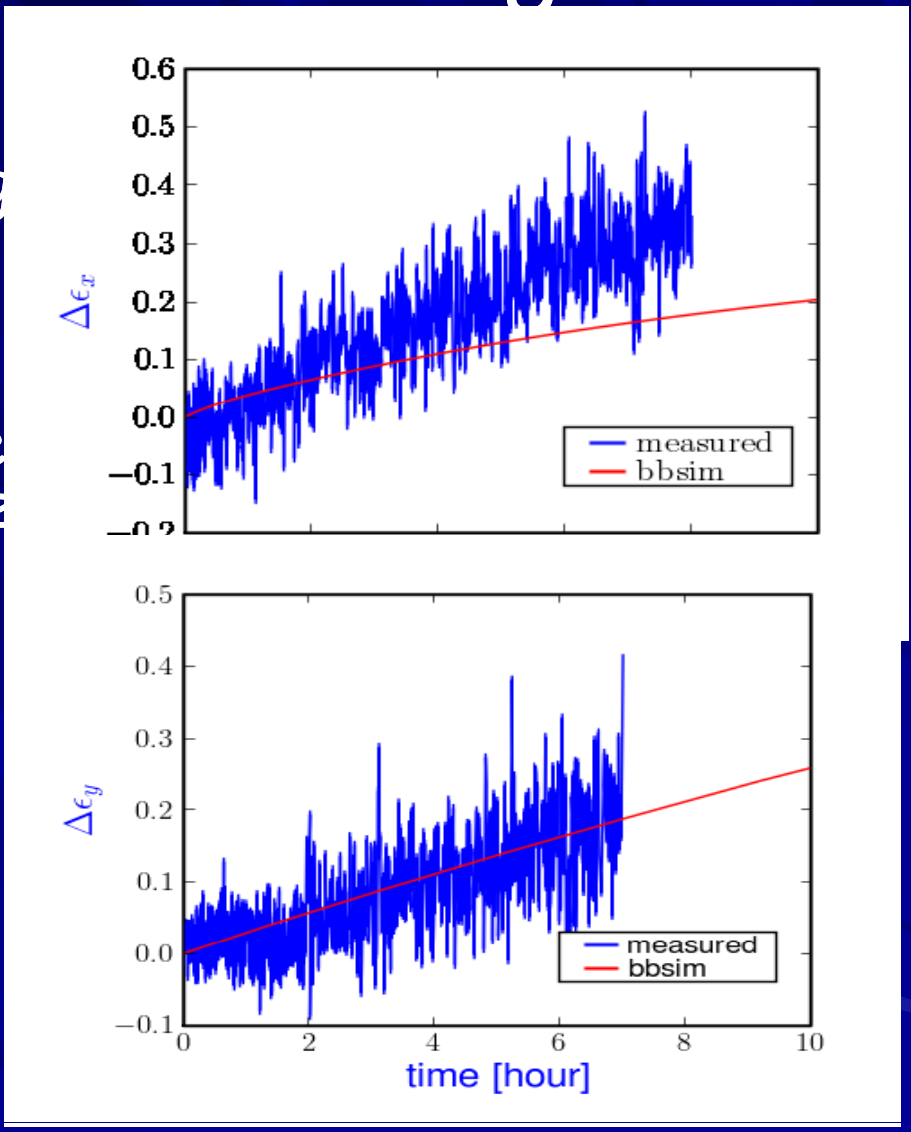




- BTF simulations without the wire agree well
- Issues with BTF measurements and simulations with the wire need to be resolved.

Diffusion model for emittance growth

- Calculate diffusion coefficients from tracking code (BBSIM) and use as input to an independent diffusion equation solver
- Evolve the density and the moments to find emittance growth and lifetime over length of the store, ~10-24 hours. This is not feasible with direct tracking.
- Initial results are encouraging, model under upgrade (3D, …)

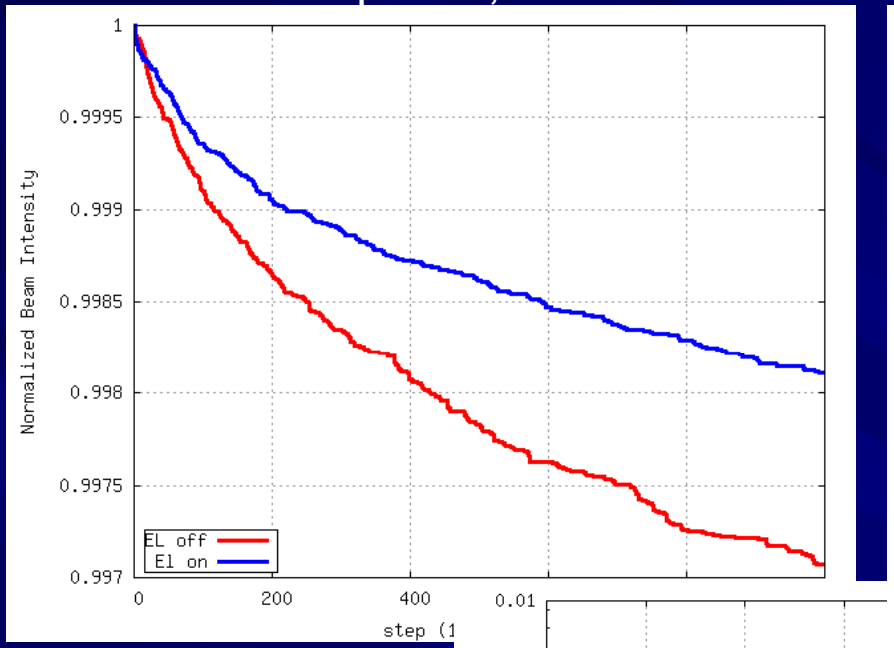


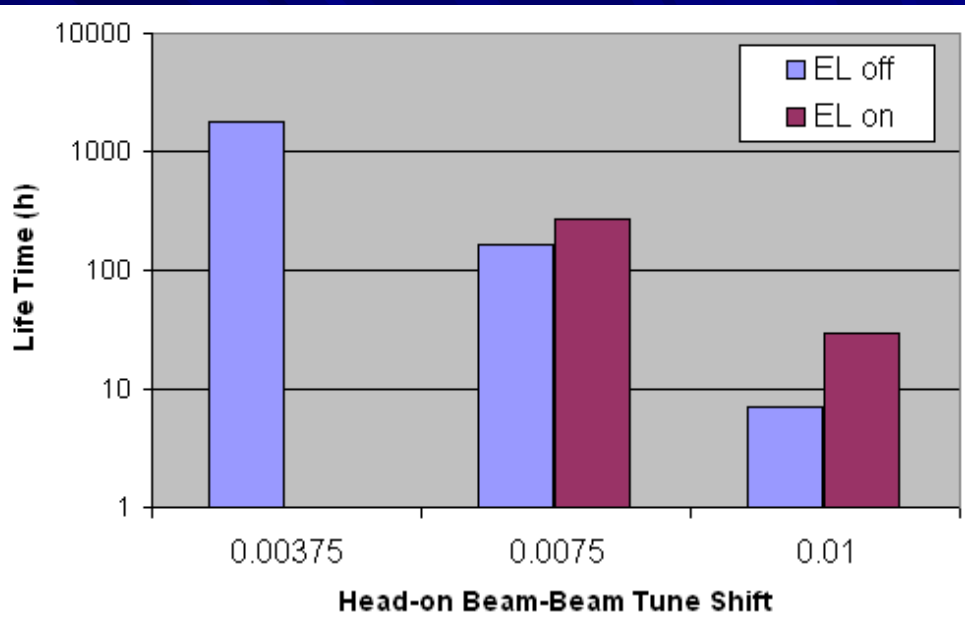
RHIC 2008 run: emittance growth comparison

Electron lens simulations for LHC

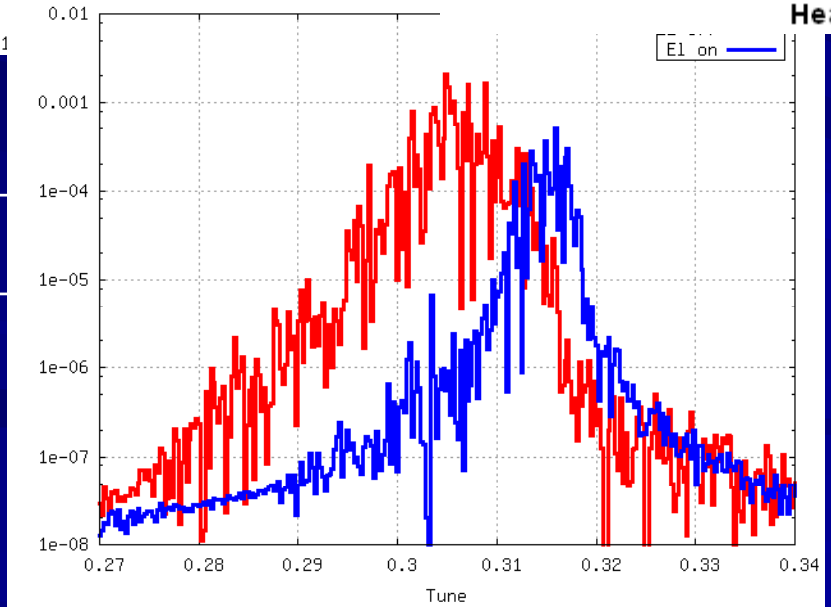
A. Valishev

E-Lens: Gaussian profile, located at bbc section near IP1



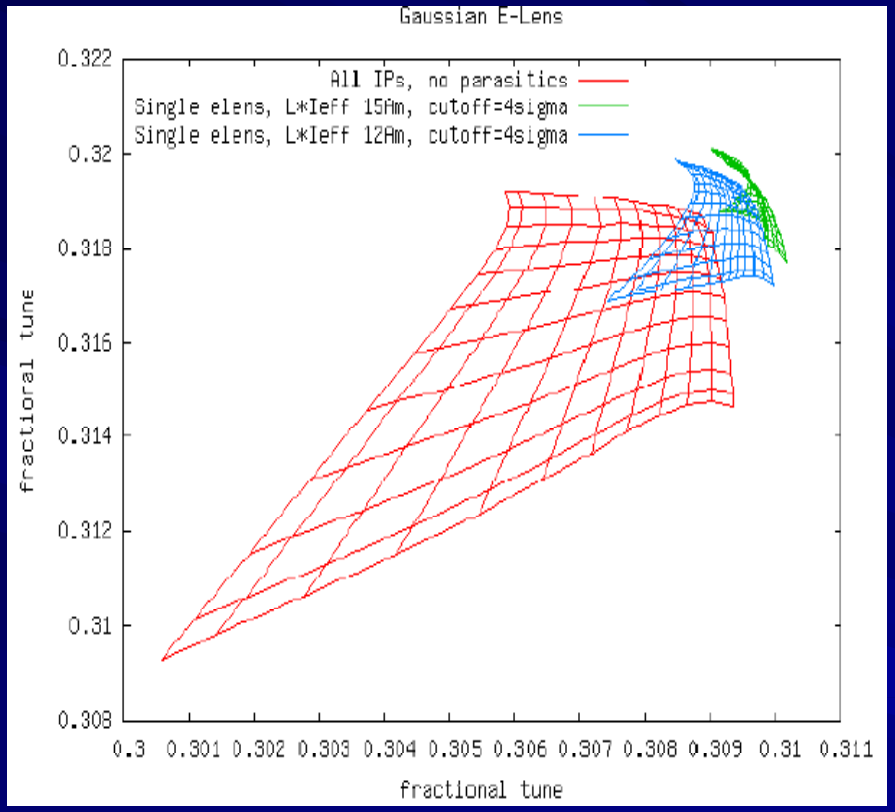


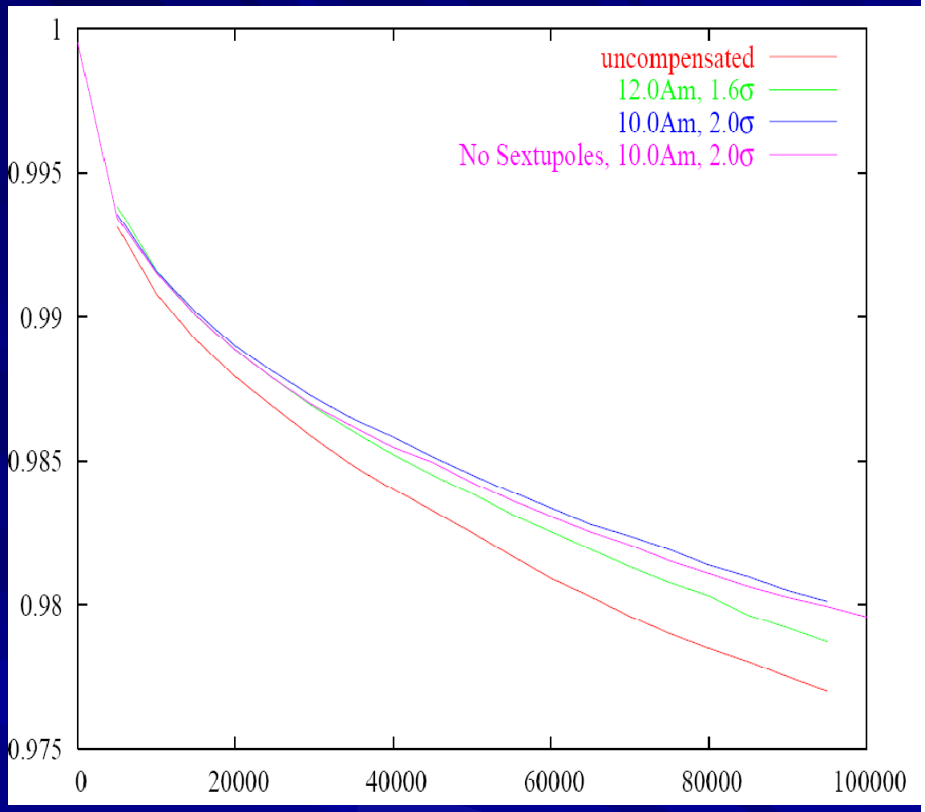
$\xi = 0.0075$



Electron lens simulations for LHC

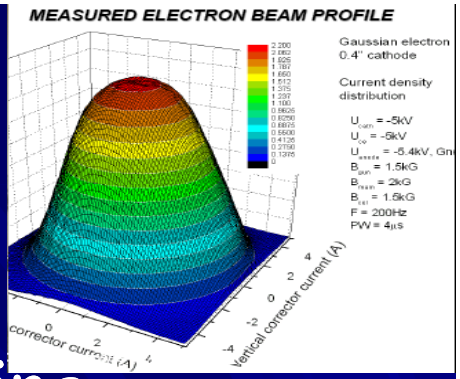
A. Kabel





- Electron beam is Gaussian with a cut-off. 10A-m is optimal.
- Approx 40% improvement in extracted "lifetime" at nominal intensity with e-lens, larger improvement at higher intensity.

Electron lens expts



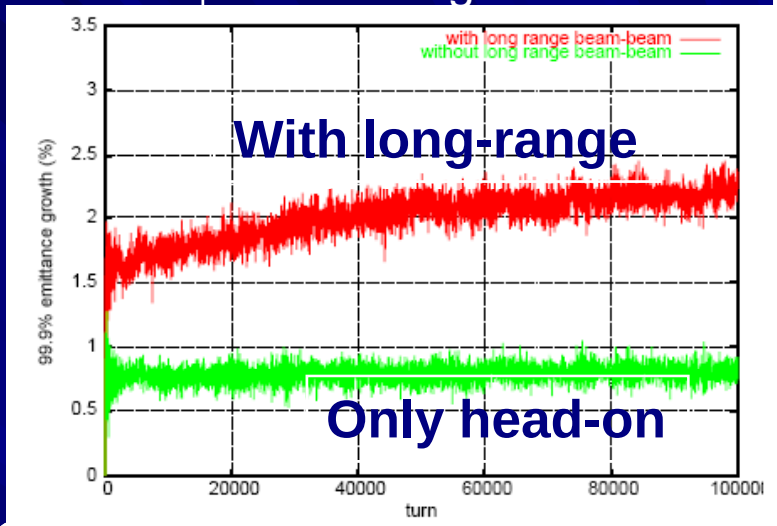
- Gaussian gun has been built. Might be installed in October 2008 or next spring.
- Beam-beam compensation studies in the Tevatron – waiting for beam study time

- Electron beam size effect on proton beam lifetime improvement
- Quantify improvement vs e-beam current
- effect of low-frequency e-current jitter on proton lifetime
- demonstrate pbar tune spread reduction

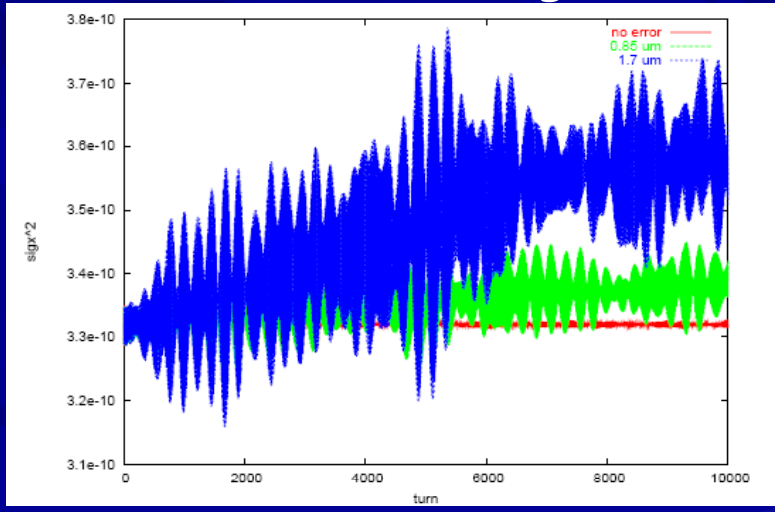
Ongoing Studies

- E-lens simulations and design at RHIC (W. Fischer)
- Impact of long-range interactions on emittance growth in the LHC with strong-strong for head-on, soft-Gaussian for long-range (J. Qiang)
- Crab cavity simulations (preliminary results from J. Qiang)
- FNAL collaboration with TechX (Boulder, CO) on
  - validation of diffusion model
  - benchmark simulations with Tevatron, RHIC data
  - strong-strong model

Emittance growth in LHC



J. Qiang



Influence of crab cavity noise

Upcoming Studies

- RHIC wire compensation experiments and comparisons with simulations
- Benefit to LHC luminosity from wire compensation (simulations)
- Electron lens beam studies in the Tevatron
- Impact of electron lens on beam behaviour in RHIC, LHC (simulations)
- Impact of crab cavity with beam-beam interactions in the LHC (simulations)

Summary

- Wire experimental data in RHIC and simulations show good agreement overall. Looking forward to compensation experiment in 2009
- Diffusion model for long-term beam evolution shows promise.
- Preliminary simulations show that an electron-lens benefits the LHC, especially at higher beam intensities. Preliminary studies in RHIC do not yet show a clear benefit.