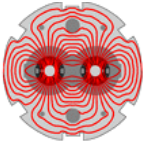# Beam-beam simulations

A.Valishev (FNAL)
with input from Y.Luo, S.White (BNL),
J.Qiang (LBNL), F.Schmidt (CERN)

LARP CM16, 5/17/2011

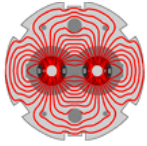# Beam-beam task in FY11

- Experiments with Gaussian EL at Tevatron were finished in FY10, focus of experimental work shifted to Hollow E-Beam Collimation (see G.Stancari's talk). Historically Electron Lens under Beam-Beam, now a separate activity.

- Numerical simulations of beam-beam effects
  - Develop simulation codes (Y.Luo, F.Schmidt, A.Valishev)
  - Support design of RHIC EL (Y.Luo, S.White)
  - Support beam-beam experiments at Tevatron (S.White, A.Valishev)
  - Simulate beam-beam effects at LHC (J.Qiang)
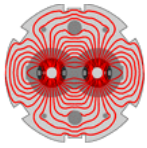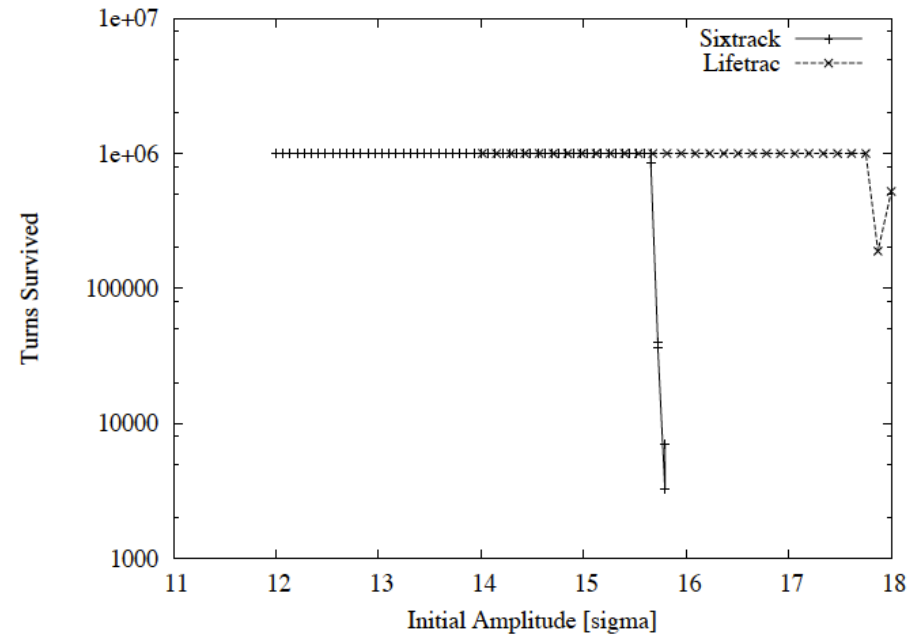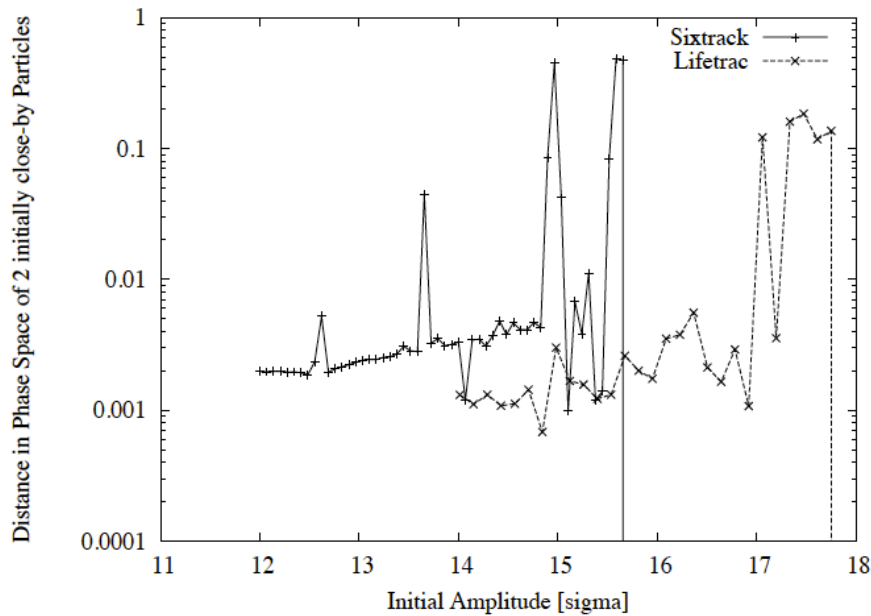 - Much activity under Crab Cavity (H.-J.Kim, J.Qiang, T.Sen)

Code Development

- ## Two-week session at BNL[#]

  - ### Code development and benchmarking

  - ### Picked one (common) test case, compare single-particle dynamical aperture

    - SixTrack (F.Schmidt)

    - Lifetrac (A.Valishev)

    - SimTrack (Y.Luo)

  - ### Work still on-going

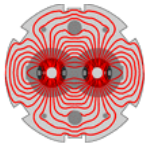# Thanks to the hospitality of C-AD (W.Fischer)
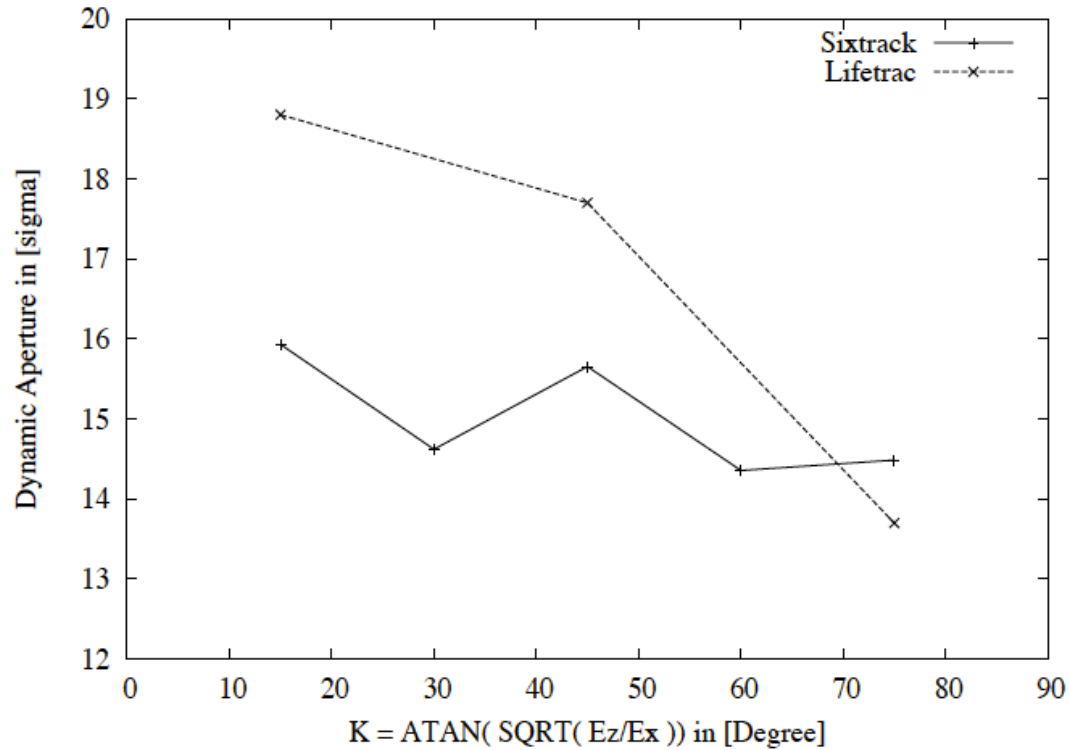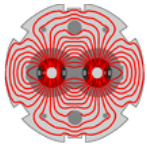
LHC Dynamical Aperture
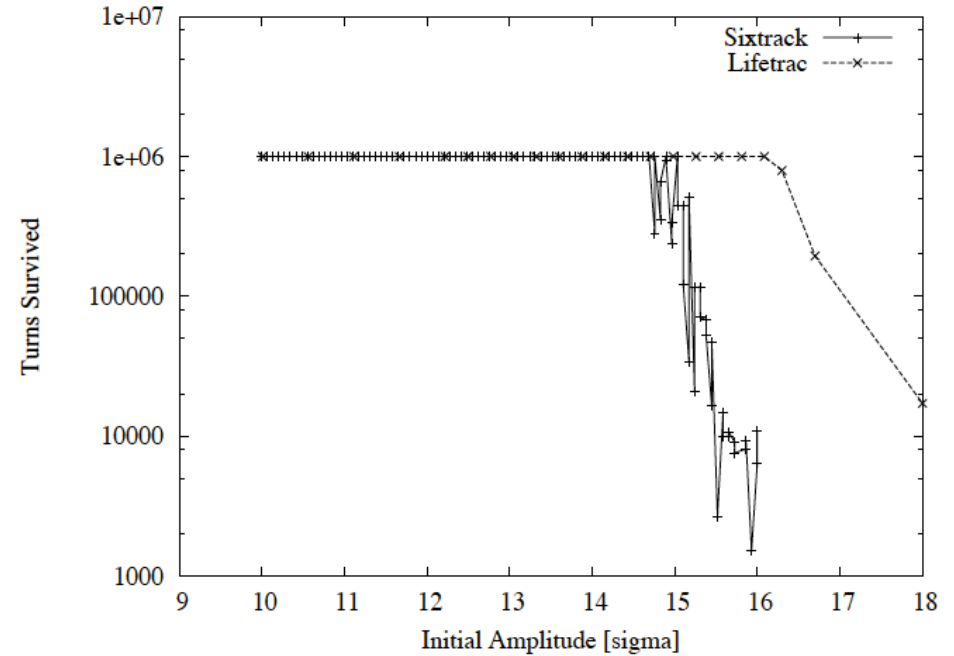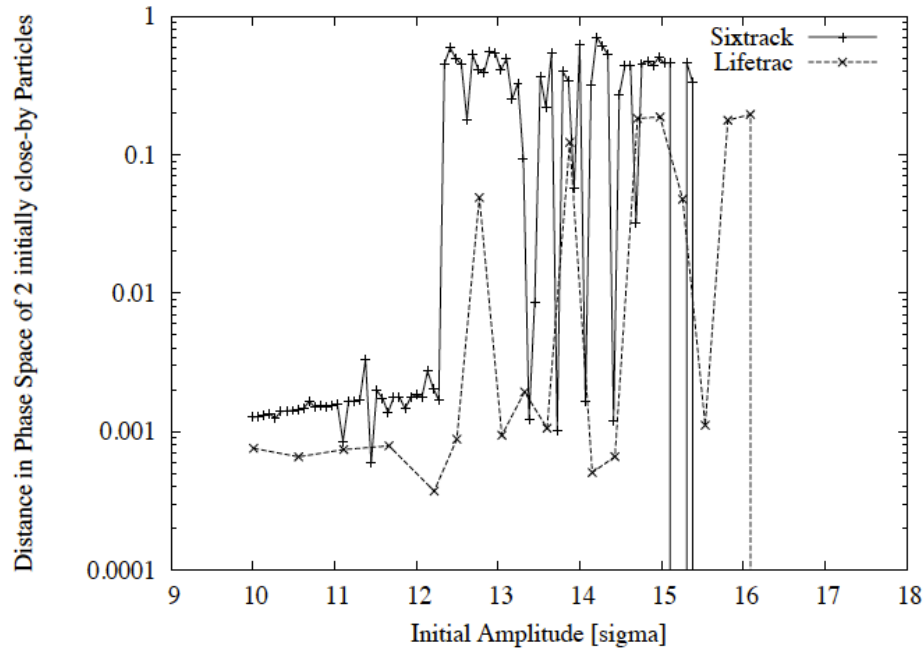# beam-beam off, errors on, δ=0

Angle in X-Y plane 45 deg

LHC Dynamical Aperture
beam-beam off, errors on, δ=0
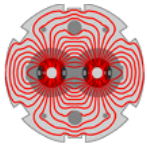
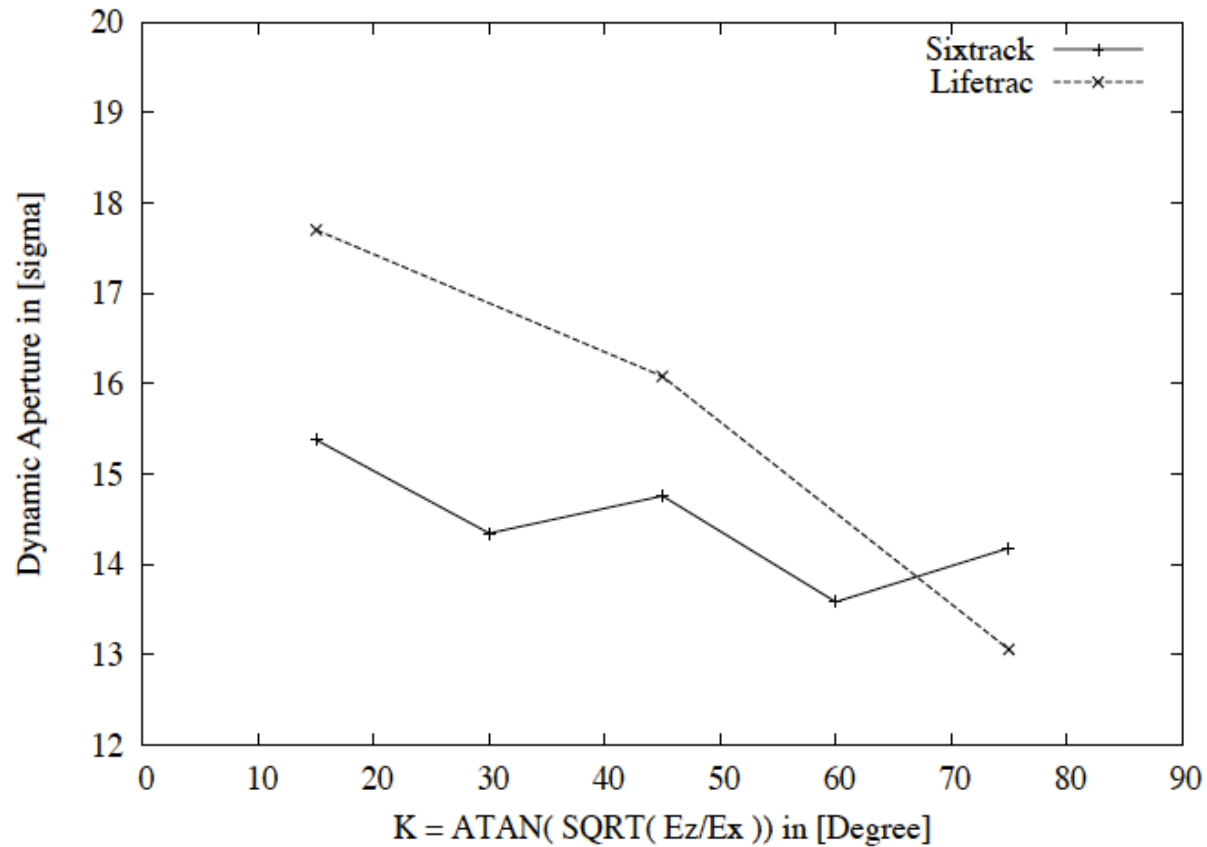# LHC Dynamical Aperture
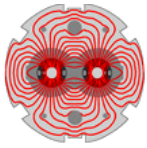## beam-beam off, errors on, δ=0.00027
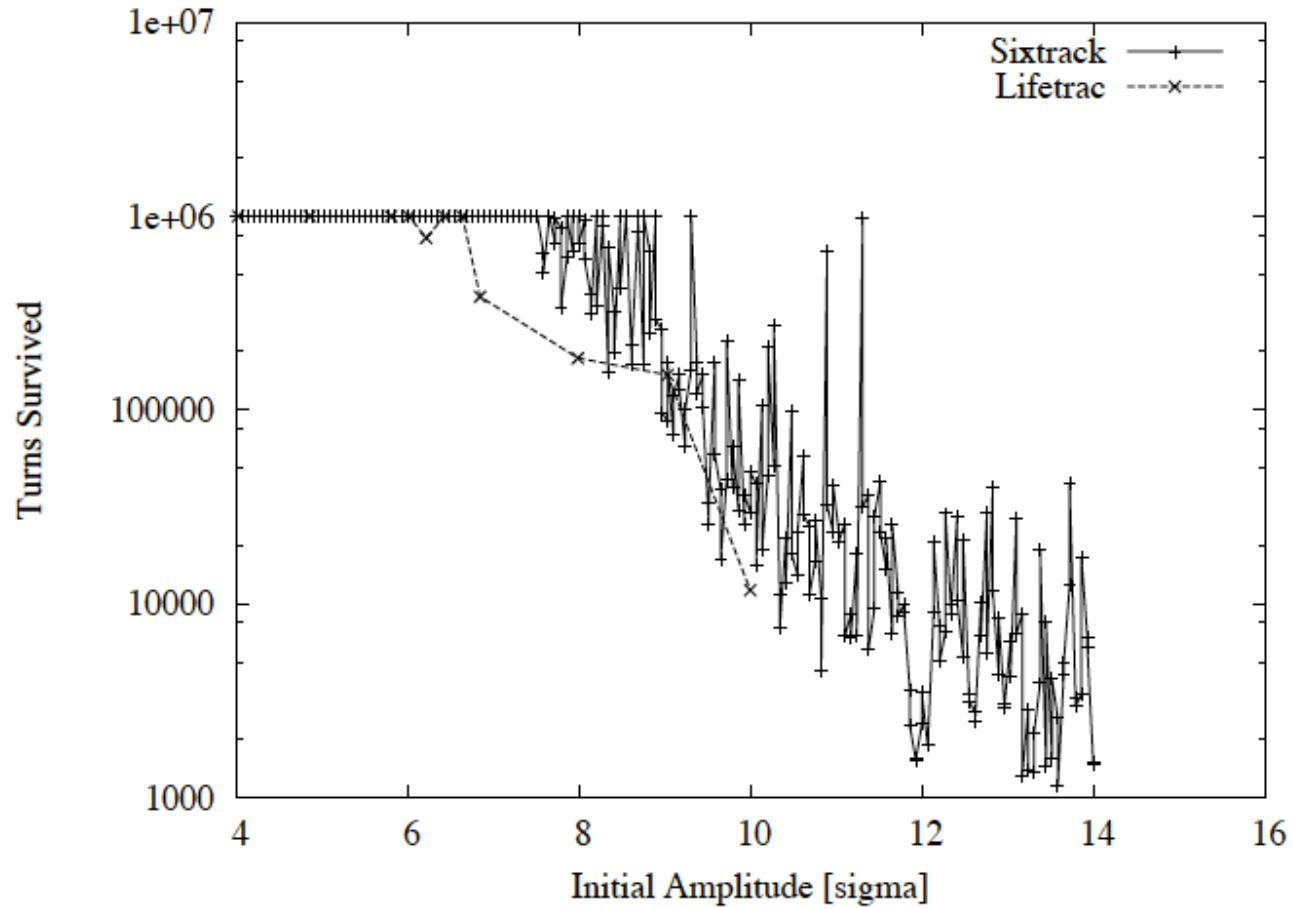

Angle in X-Y plane 45 deg

LHC Dynamical Aperture
beam-beam off, errors on, δ=0.00027

LHC Dynamical Aperture
beam-beam on, errors on, δ=0

Tune Footprint, head-on only
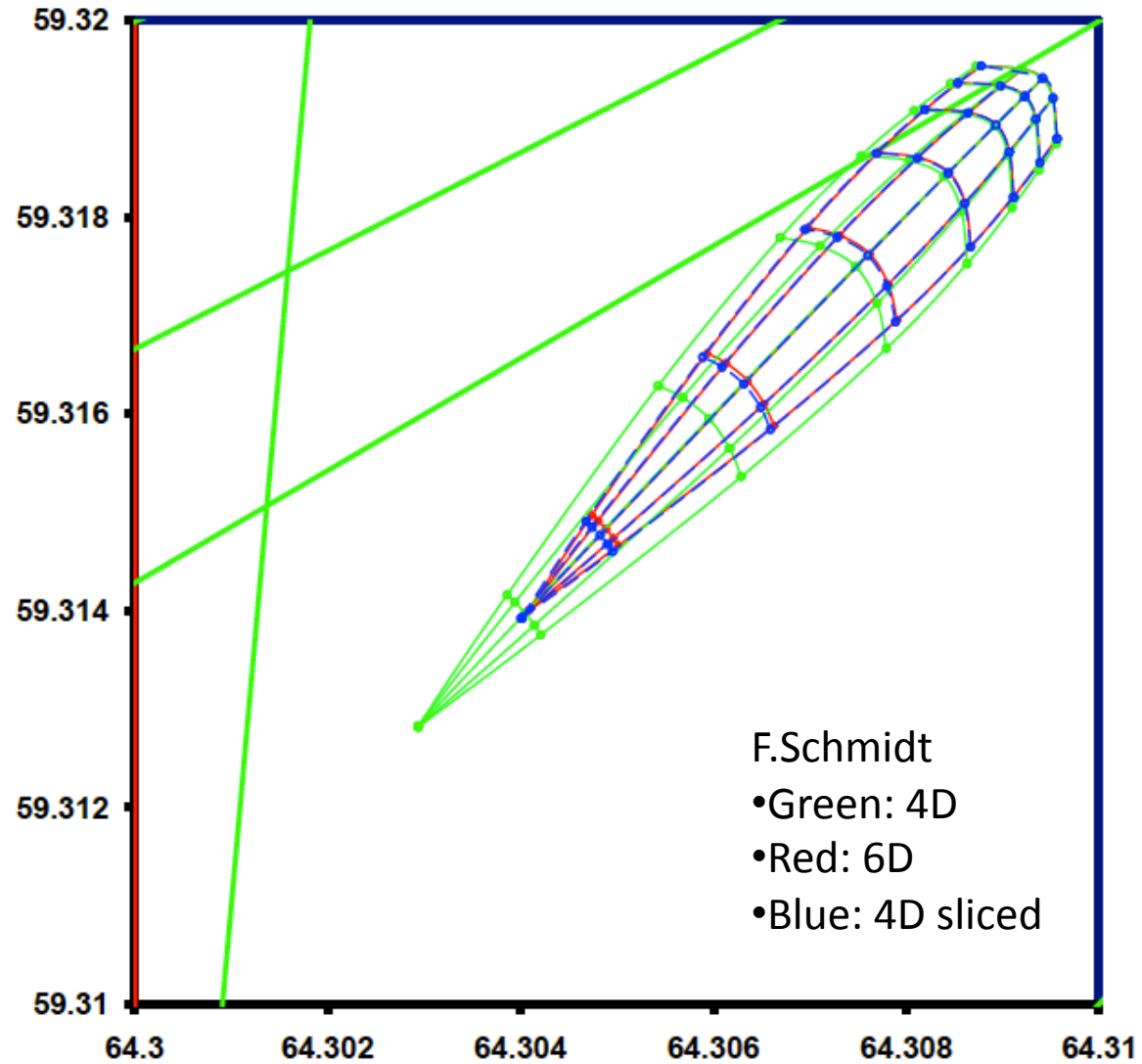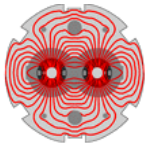

F.Schmidt
- Green: 4D
- Red: 6D
- Blue: 4D sliced
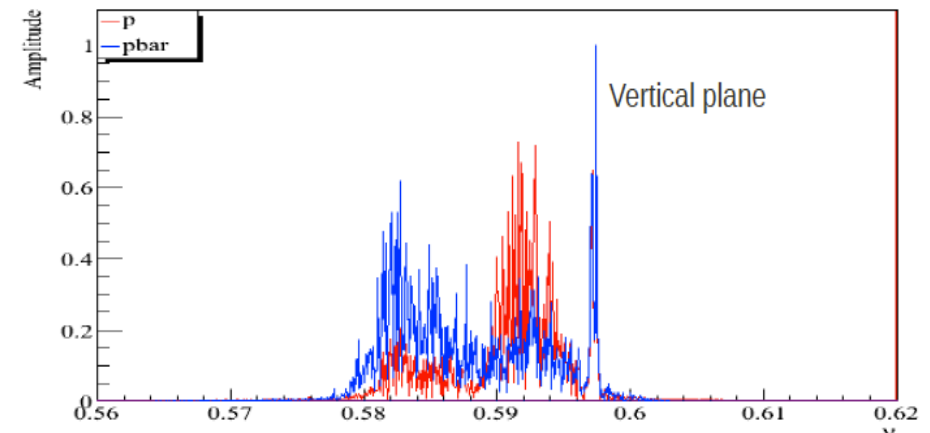
Dedicated Accelerator Physics Studies
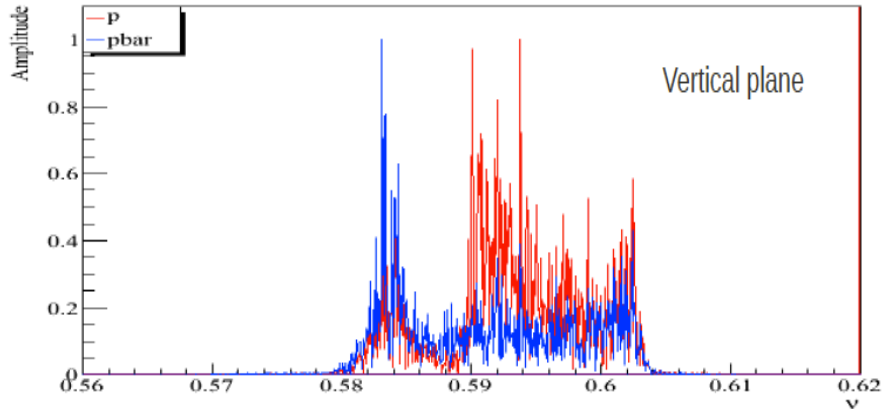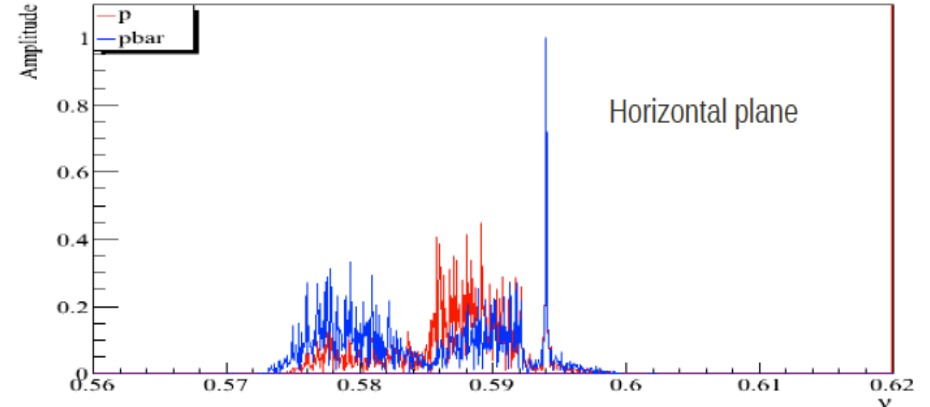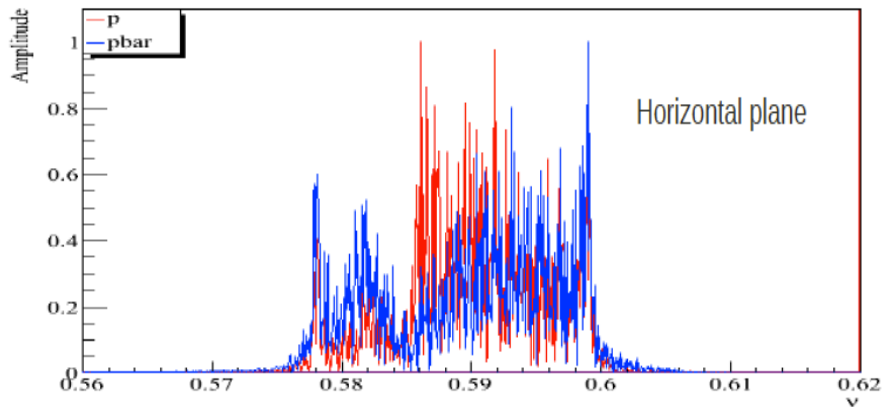# at the Tevatron

- Originally planned at the end of Run II. Now decided to plan 2-week periods with study periods interleaved with luminosity operation.

- Beam-beam period planned at the end of August
  - Diffusion Due to Beam-Beam Resonances
  - Phase Averaging
  - Coherent Beam-Beam Modes
  - Beam-Beam vs Transverse Separation
  - AC Dipole with colliding beams

- 4-5 study periods, each with 2 special 3x3 colliding stores, CERN, BNL participation expected (R.Miyamoto, F.Schmidt, S.White, …)
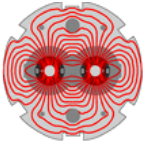
Coherent Modes
simulation for 3x3 store by S.White

Nominal emittances
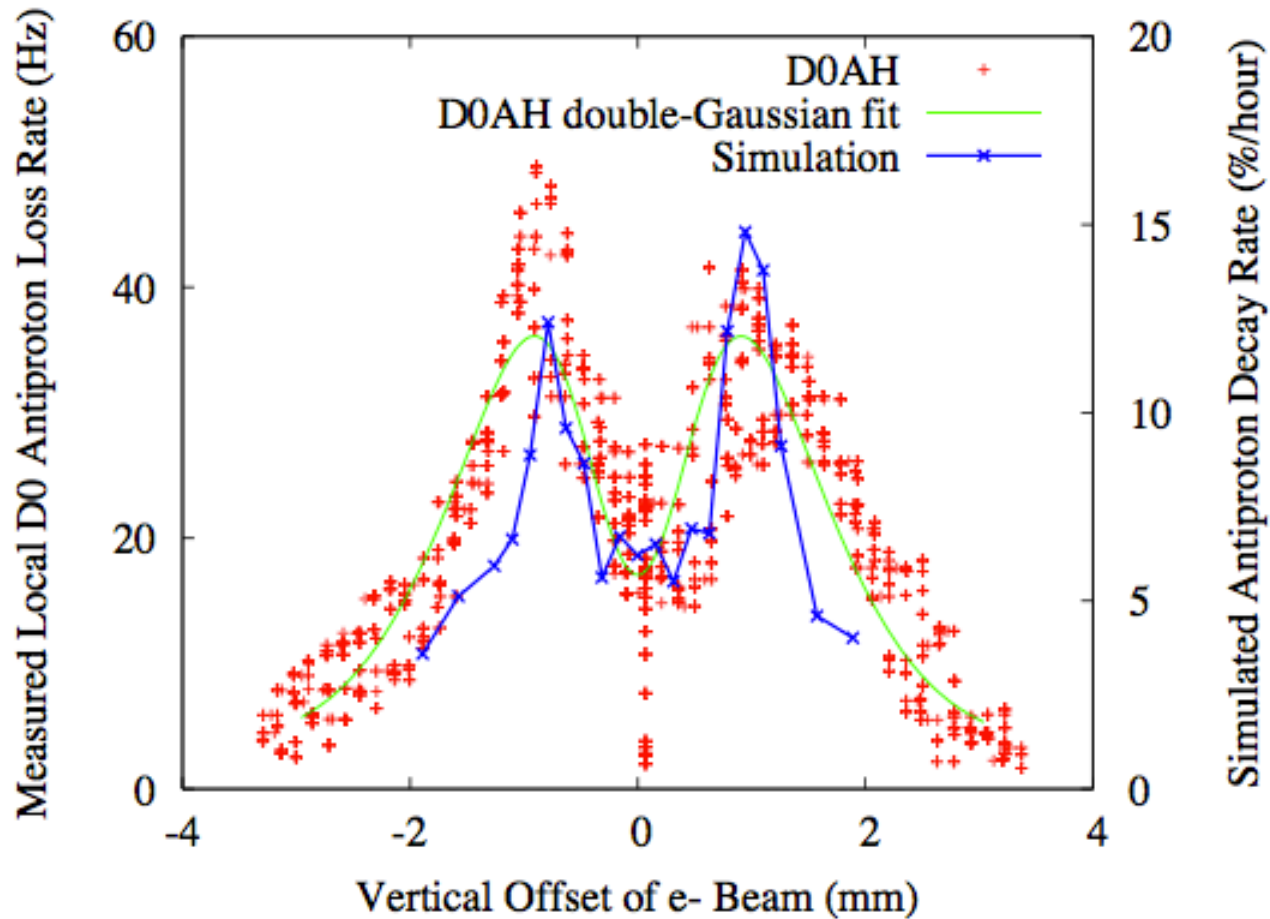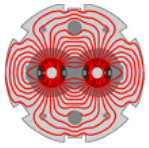
Antiproton emittance x2

Tevatron will have instrumentation capable of observing these modes bunch-by-bunch

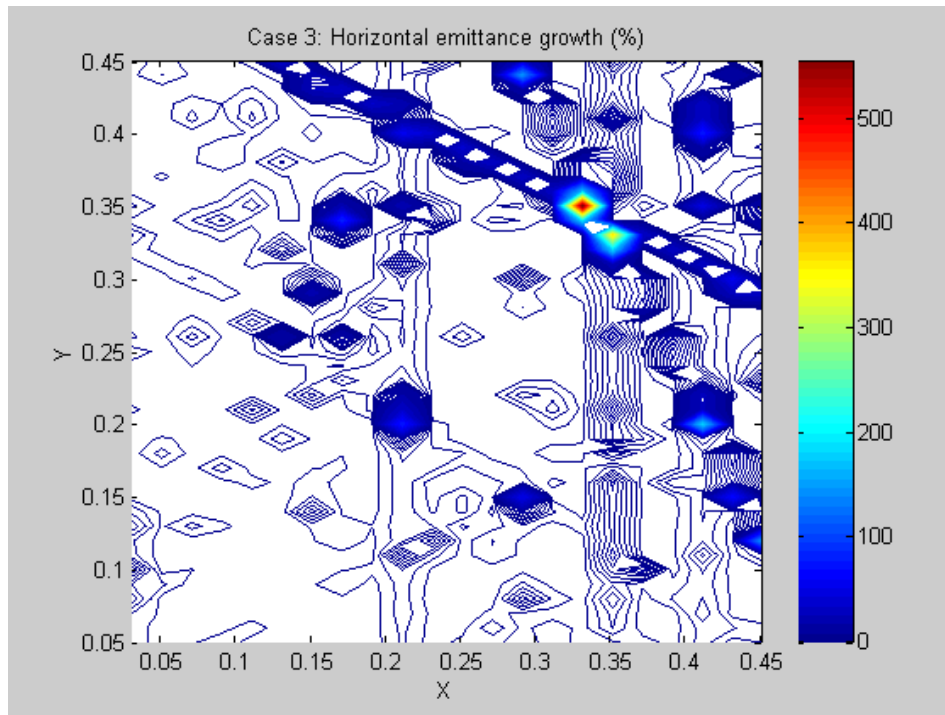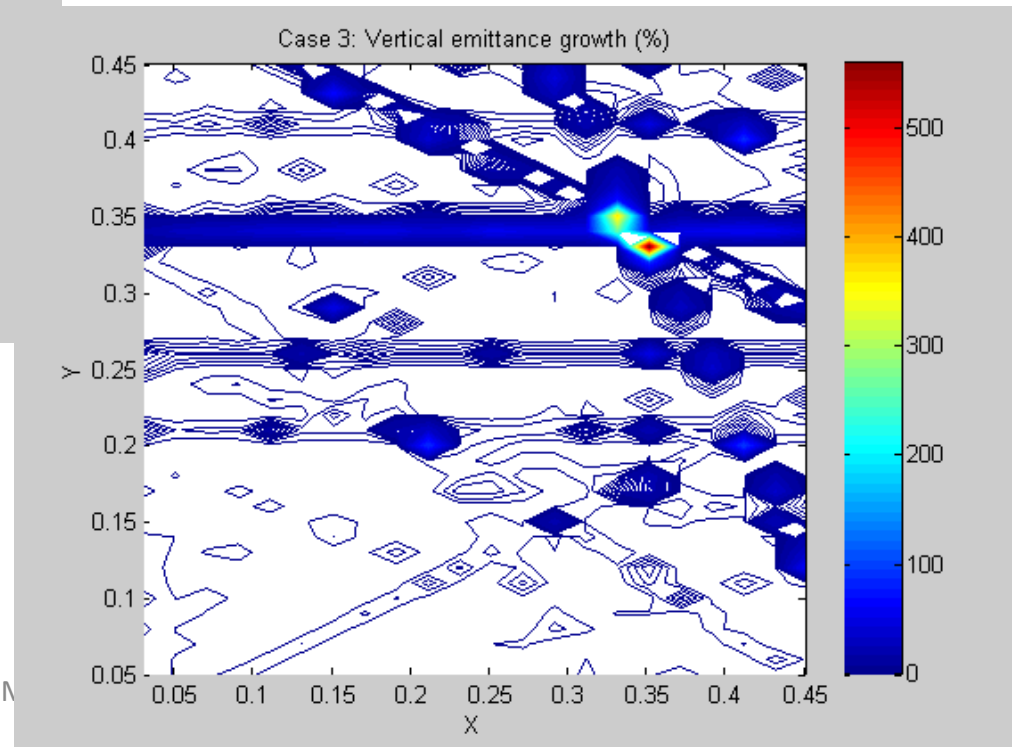# Alignment of Gaussian TEL e- and Antiproton Beams.
Code validation

Simulations of LHC beam-beam: tune scan ε=1.5μm, 3.5 TeV (J.Qiang, S.Paret)

horizontal emittance growth (%)

Case 3: Horizontal emittance growth (%)

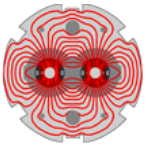vertical emittance growth (%)

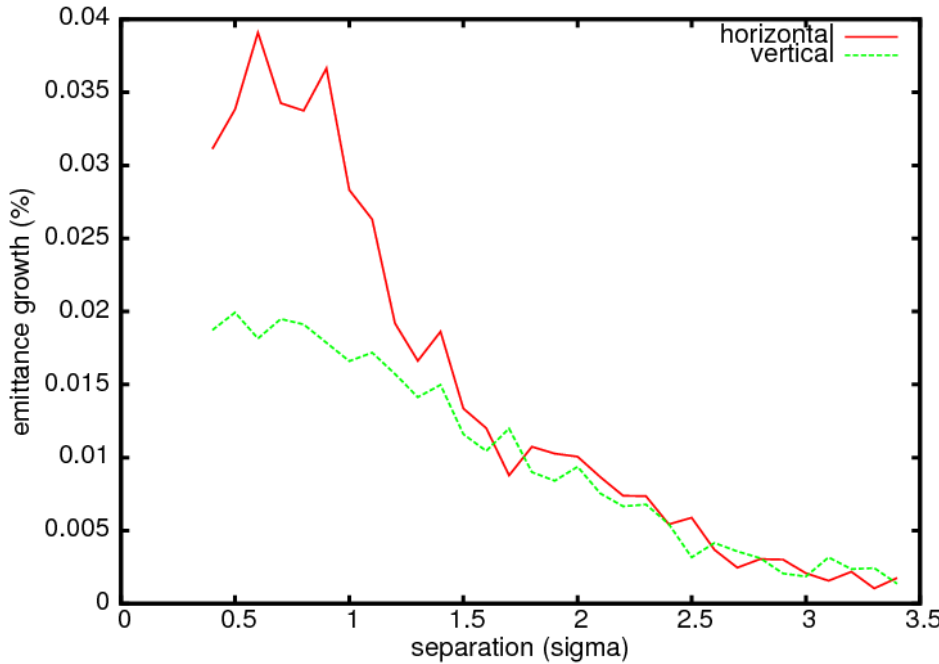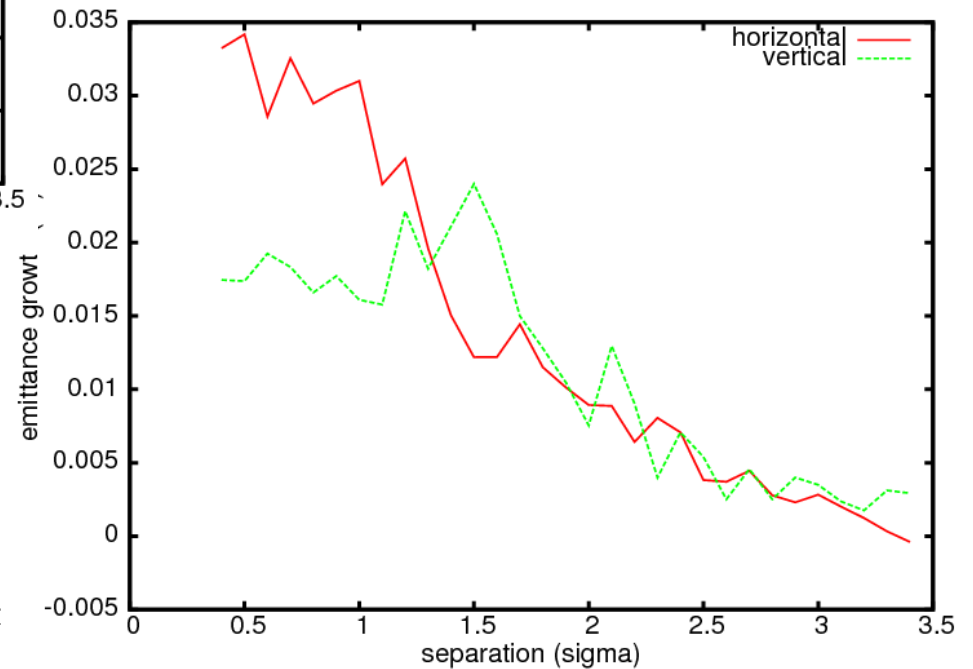Case 3: Vertical emittance growth (%)

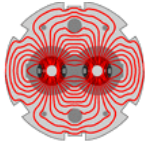# Simulations of LHC beam-beam: emittance growth vs. separation (J.Qiang, S.Paret)

LARP

Emittance growth (%)at the end of 100k turns vs. horizontal separation

Emittance growth vs. vertical separation

Summary and Plans

- Good results on code benchmarking
  - Plan to finish comparisons on test cases
- Prepare and perform beam-beam studies at the Tevatron
- Continue code development
  - Validate codes using experimental results from LHC, RHIC and Tevatron
  - Implement hollow e-beam