Y. Chao
HAPPEX Collaboration Meeting
02/13/04

Damping of Helicity Correlated Orbits

- What was learned from G0?
- Things we are looking into

What's New in the Accelerator for this G0 Run

- Injector

- **Low energy (100 keV- 5 MeV) model**
- **Improved beam handling and tuning methods**
  - **Earth field coils**
  - **Wien quads**
  - **Setup procedure**
  - **Transfer matrix measurements**
- **30 hz PZT**

- Accelerator Tuning/Monitoring Procedures

Contributions from

Accelerator:
Areti, Bevins, Bogacz, Chao, Grames, Hansknecht, Hutton, Kazimi, Poelker, Roblin, Tiefenback

G0:
Beck, Nakahara, Pitt

Hall A:
Armstrong, Paschke

Measured Transport from 100 keV to 3 GeV

- From 60 MeV to 3GeV

- **Measured damping of phase space:**

2-7% off theoretical

- **Measured betatron mismatch:**

40% in X; 60% in Y

- **Some linear coupling is present**

Not as good as Jan. 03 numbers, but still quite good.

- From 100 keV to 3GeV

Concatenation of measurements from IPM1I04 to IPM3HG0B

$$\begin{pmatrix} -0.00909172 & 0.052993 & 0.143469 & -0.128042 \\ -0.00471896 & 0.00488747 & -0.000145447 & -0.000232027 \\ -0.0579942 & 0.0479051 & 0.207851 & -0.209059 \\ -0.000286536 & -2.20099\times 10^{-6} & 0.00872345 & -0.00787463 \end{pmatrix}$$

- Phase space damping (theoretical sqrt: 0.0107):

  4D determinant: 0.0136

  X-submatrix: 0.0144

  Y-submatrix: 0.0137

  Not unreasonable numbers.

- Overall XY coupling:

Ratio between product of diagonal submatrix determinants and the 4D determinant (quartic root): 1.02673

- Betatron Matching:

  SVD condition number of the 4D matrix: 850.18

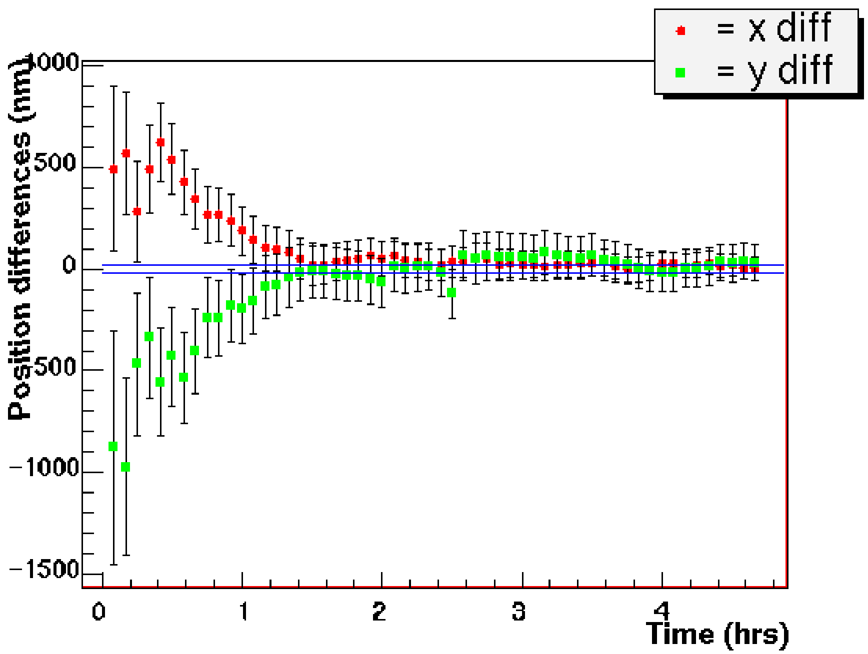
  SVD condition number of X-submatrix:14.212

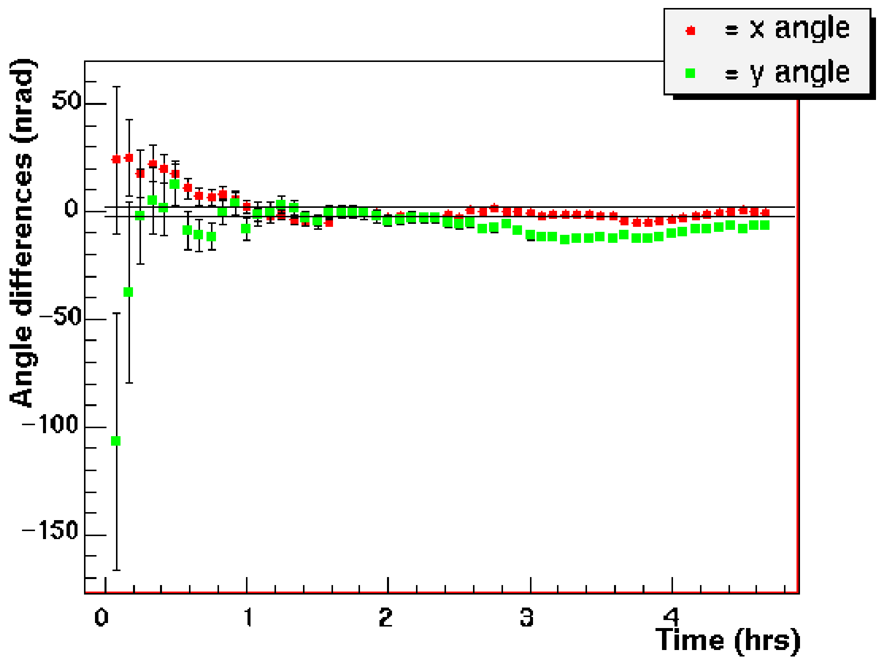
  SVD condition number of Y-submatrix:465.56

  Not unreasonable numbers.

G0 Helicity Correlated Positions

Time evolution of helicity correlated position & angle with feedback applied (K. Nakahara)





- **Observed amplitude damping of PZT signals is only of order 10**
- **Natural helicity correlated orbit damps even much less than PZT does (!?)**

What's Happening with Damping of PZT?

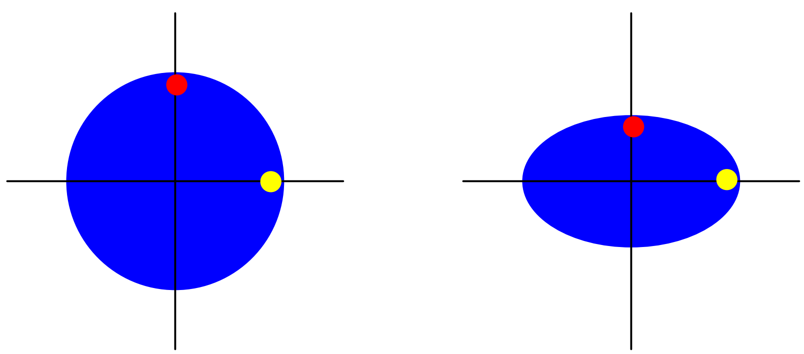
Damping of phase space area by momentum

$$\text{Area} \propto 1/P$$

- Beam emittance
- Determinant of transfer matrix

$$\text{Amplitude} \propto 1/\sqrt{P}\,?$$

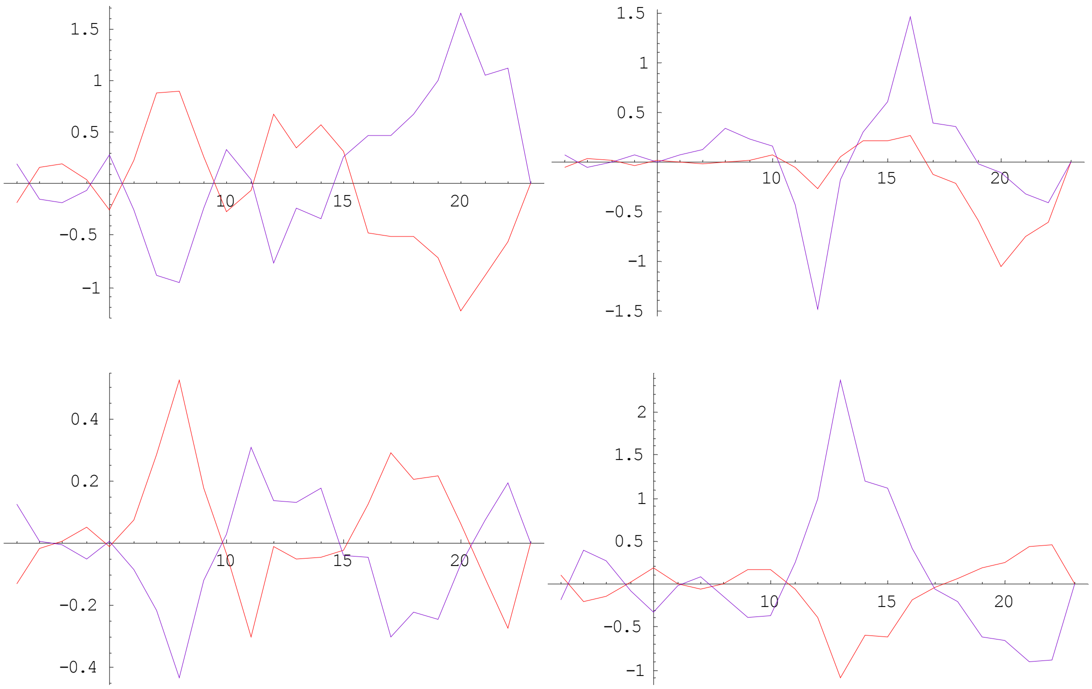
Damping of arbitrary single trajectory amplitude follows $1/\sqrt{P}$ only if acceleration is an adiabatic process such that each trajectory has a chance of experiencing the acceleration at all possible phases.

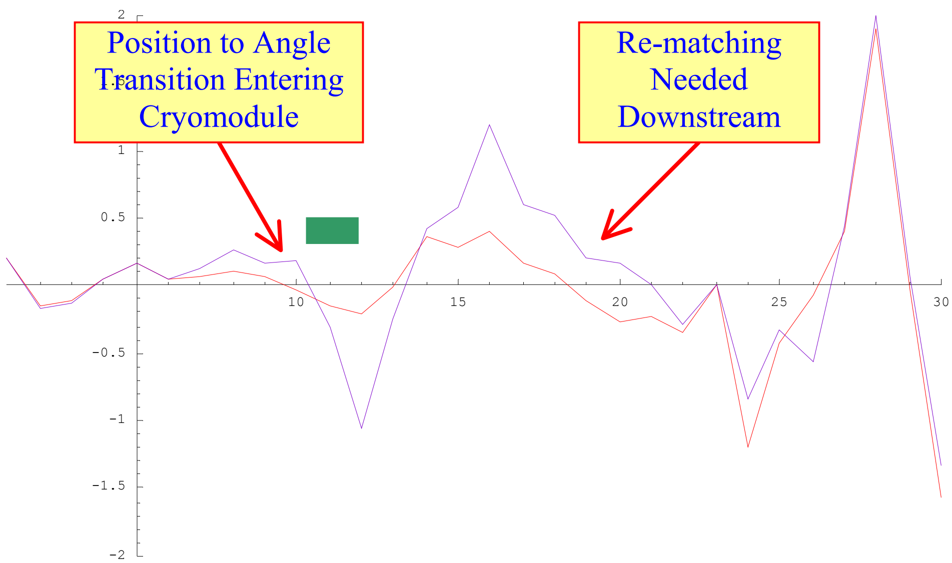


This plays an important role in accounting for the "missing" damping seen in the PZT signals, and holds promise for significant improvement.

PZT Trajectory through the Cryomodule (5 MeV → 60 MeV)

Momentum enhanced DC “PZT” orbits in the Injector





Need to

- **Maximize the “angle content” of all PZT components into the cryomodule (roughly speaking)**
- **Maintain good matching of transport and beam profile downstream**

Recent Attempts to Optimize Damping through Cryomodule (12/03 to now)

- Characterize PZT signatures
- Measure transfer matrix across cryomodule
- Obtain 5 MeV quad settings optimizing damping of PZT through cryomodule
- Re-match beam in 60 MeV region
- Fine tune using 30 hz PZT and special display tool.

Challenges

- Need to develop/test procedure for the first time
- 5 MeV line was not designed for this purpose
- Break-in of 30 hz PZT and 30 hz BPM in the front end
- XY-coupled PZT signatures
- XY coupling in cryomodule transport
- Stability of 100 keV to 5 MeV optics, thus PZT signature, needs further qualification.

More long term?

- There may be more to gain across the cryounit