Benchmarking/ Crosschecking DFS in the ILC Main Linac

Jeffrey C. Smith, Cornell

Peder Eliasson, Andrea Latina and Daniel Schulte, CERN

Freddy Poirier and Nickolas Walker, DESY

Paul Lebrun and Kirti Ranjan, Fermilab

Kiyoshi Kubo, KEK

Peter Tenenbaum, SLAC

The purpose

- There have been previous comparisons between ILC simulation codes.
  - **None looked at a particular Beam-Based Alignment algorithm.**
  - **Just compared simple tracking exercises.**
- This study looked at the explicit performance of BBA
  - **DFS was studied here as it is the most complex and widely used.**
  - **This was just the next step in the (hopefully) continuing endeavor to compare simulation codes.**
  - **Started at last global LET meeting Feb. 2006**
    - So report final results at this one

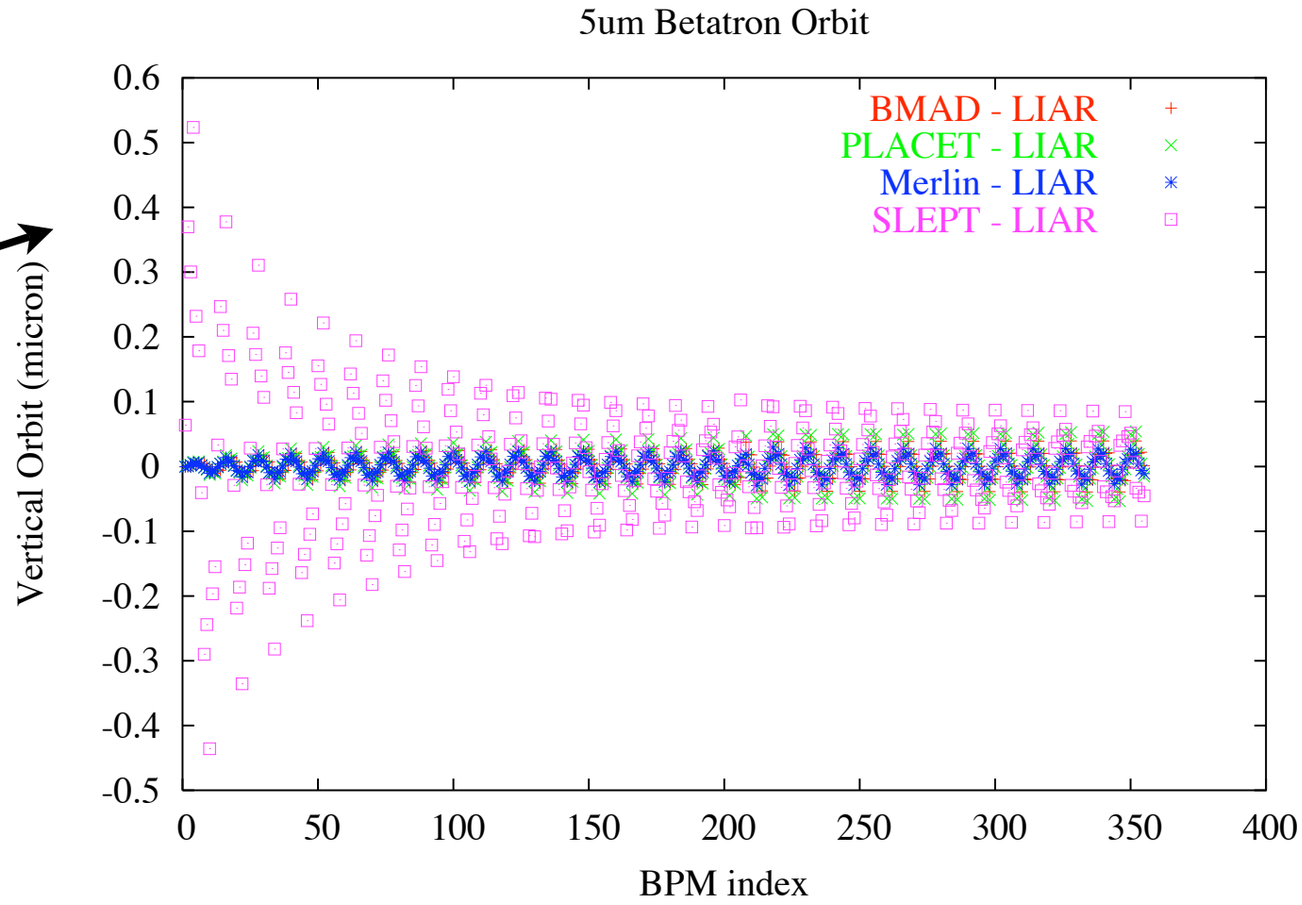
Codes and lattices

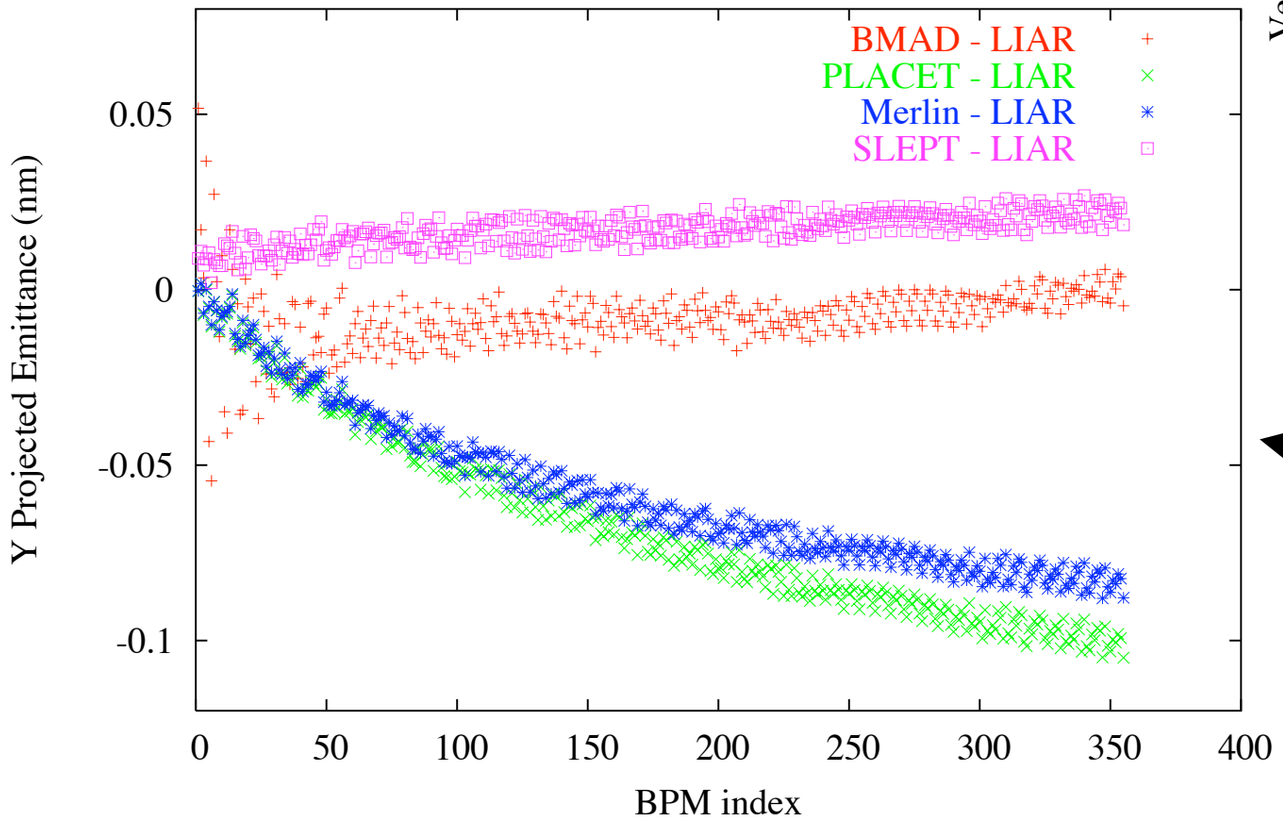
- Codes currently being used:
  - **BMAD**
  - **CHEF -- differences being investigated**
  - **Lucretia -- never used with crosschecking yet**
  - **MatLIAR**
  - **Merlin**
  - **PLACET**
  - **SLEPT**
- Lattice used in study
  - **TESLA TDR lattice since it was the most widely used at the time.**
  - **Choice was rather arbitrary**

Study #1

- Track a 5 micron vertically offset beam through ML.
- Ponderomotive force turned off in BMAD for comparison sake

Orbit difference
(10-3 micron
absolute amplitude)

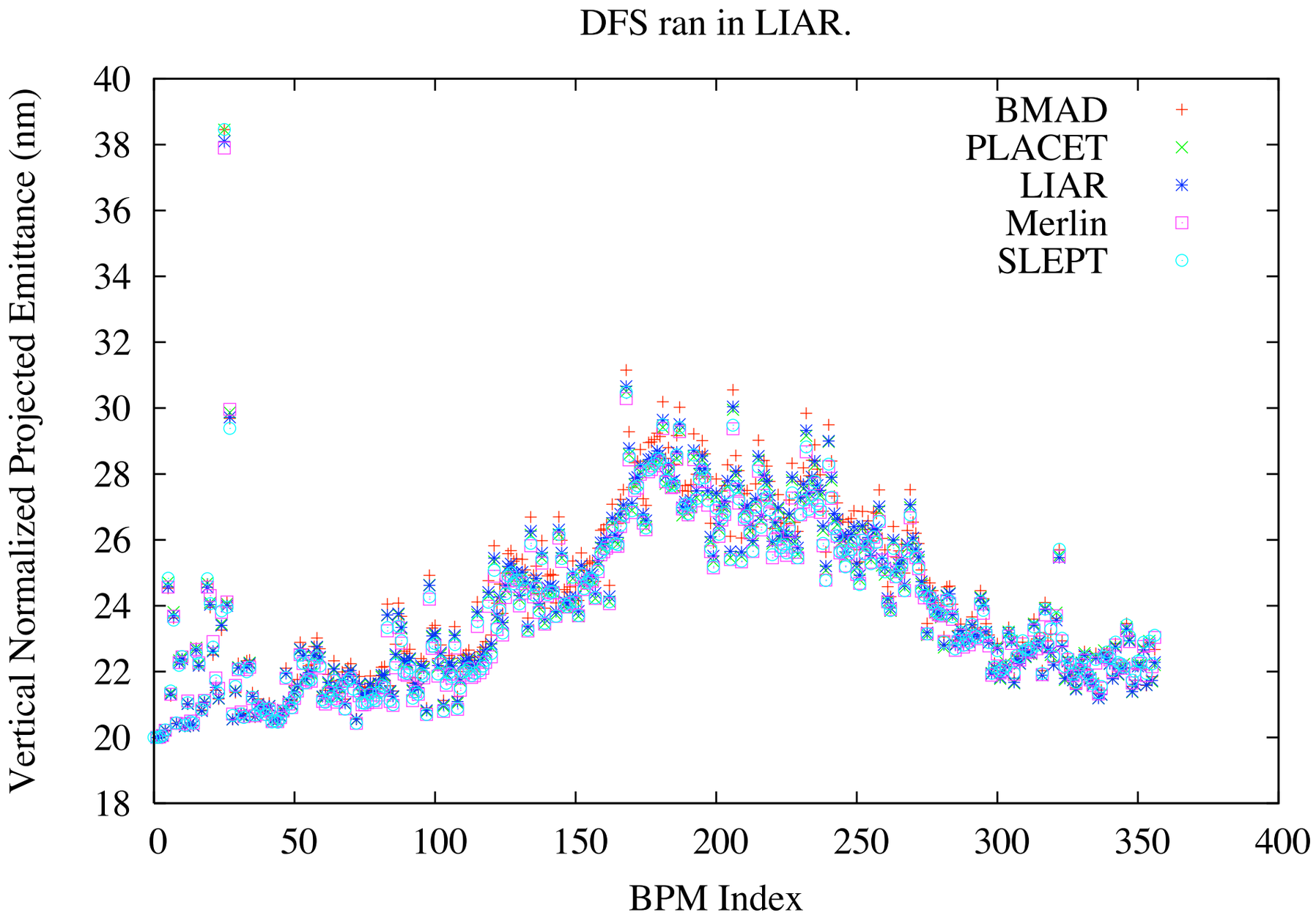




Emittance growth
difference
(~1.2 nm absolute growth)

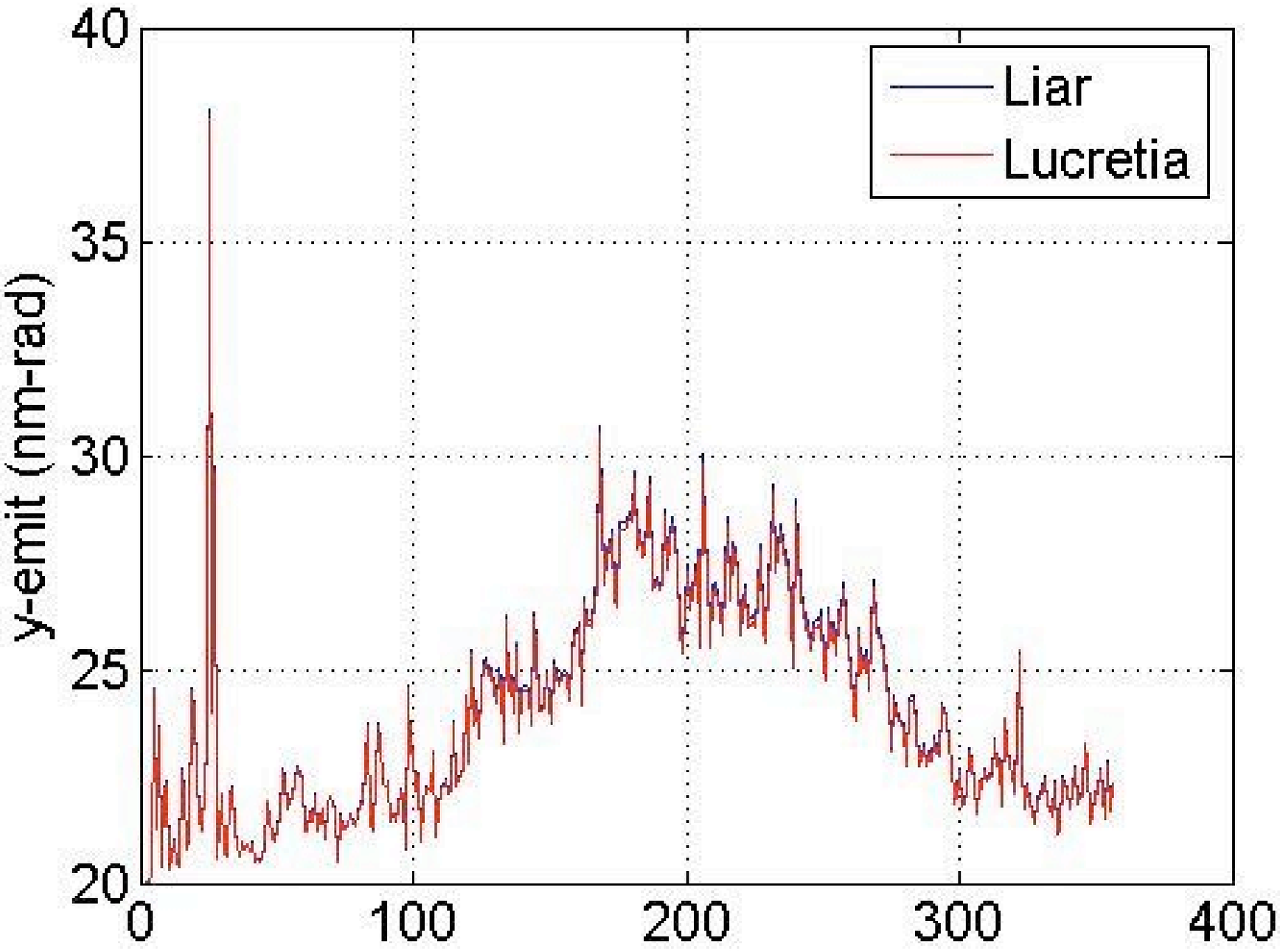
Study #2

- One code (MatLIAR) ran DFS on a set of misalignments.
  - **Misalignments and corrector settings were then read into the other codes.**



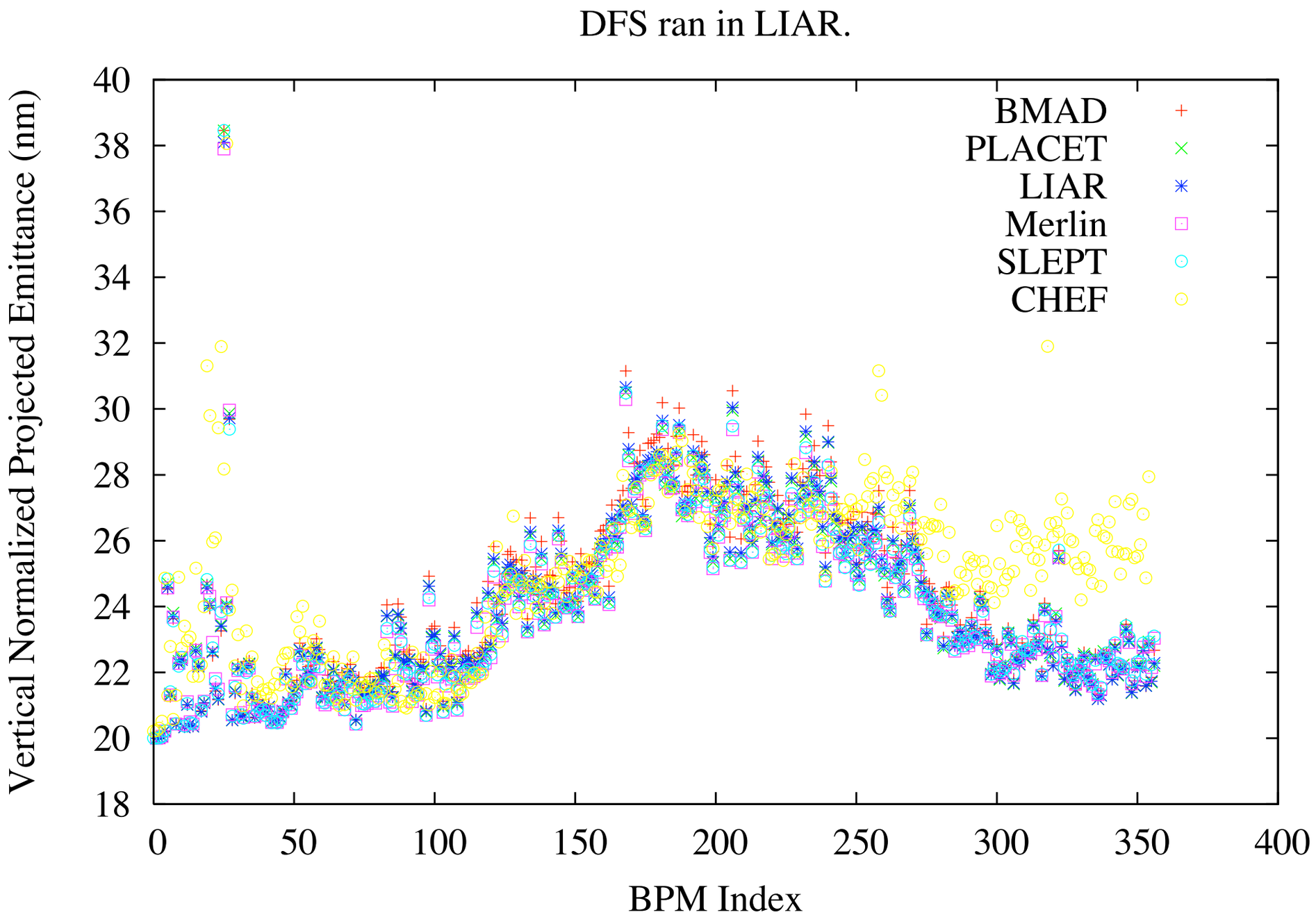
Study #2 LIAR vs. Lucretia

- Right on top of each other!



Study #2 CHEF

- Difference being investigated



Study #3

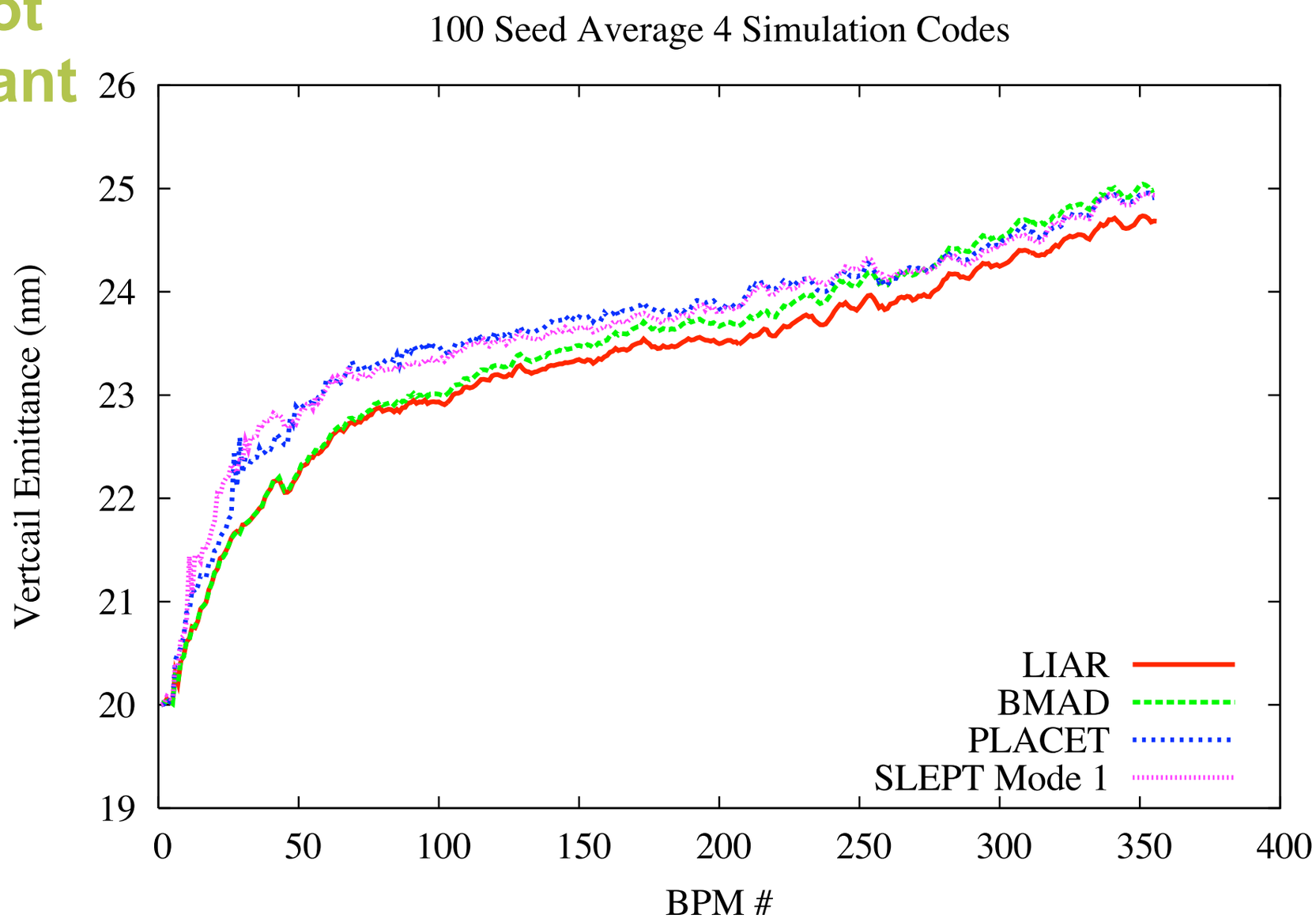
- The same 100 seed set of misalignments run DFS independently in each code.
  - **DFS method:**
    - 20 FODO cells per region, 10 cell overlap
    - 10% - 20% energy variation depending on code
    - Minimize the merit function:

$$\chi^2 = \sum_i w_1 x_{on_i}^2 + \sum_i w_2 x_{diff_i}^2 + \sum_j w_3 c_j^2$$

where x_on is the on energy orbit x_off is the off energy orbit and c_j are the corrector strengths and w_1 = 2.52E-5, w_2 = 1.0, w_3 = 0.0

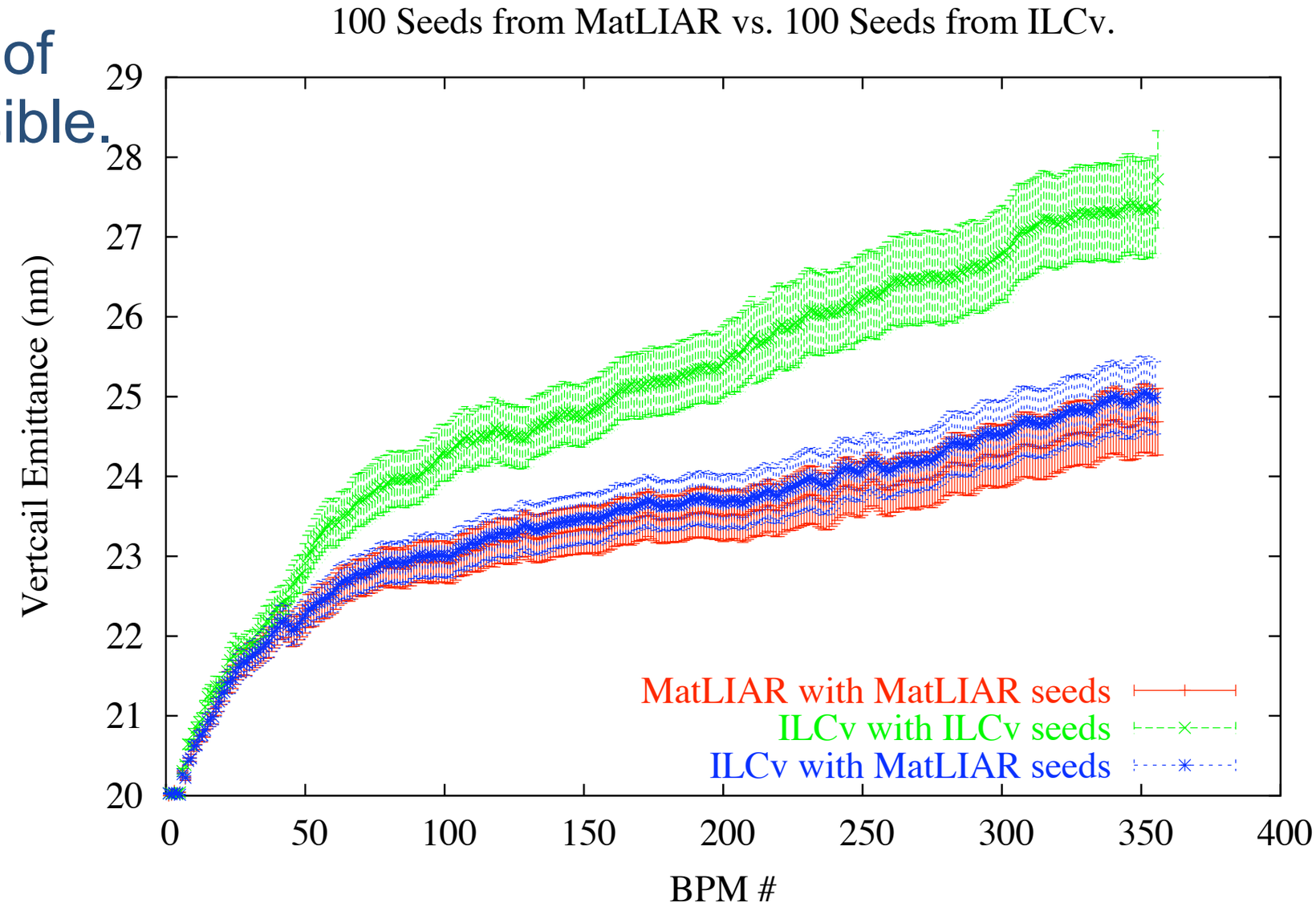
Study #3

- 100 seed set of misalignments run DFS independently in each code.
  - **Some differences between the DFS algorithms but differences do not produce significant differences in performance.**
  - **Progress made since Vancouver meeting**



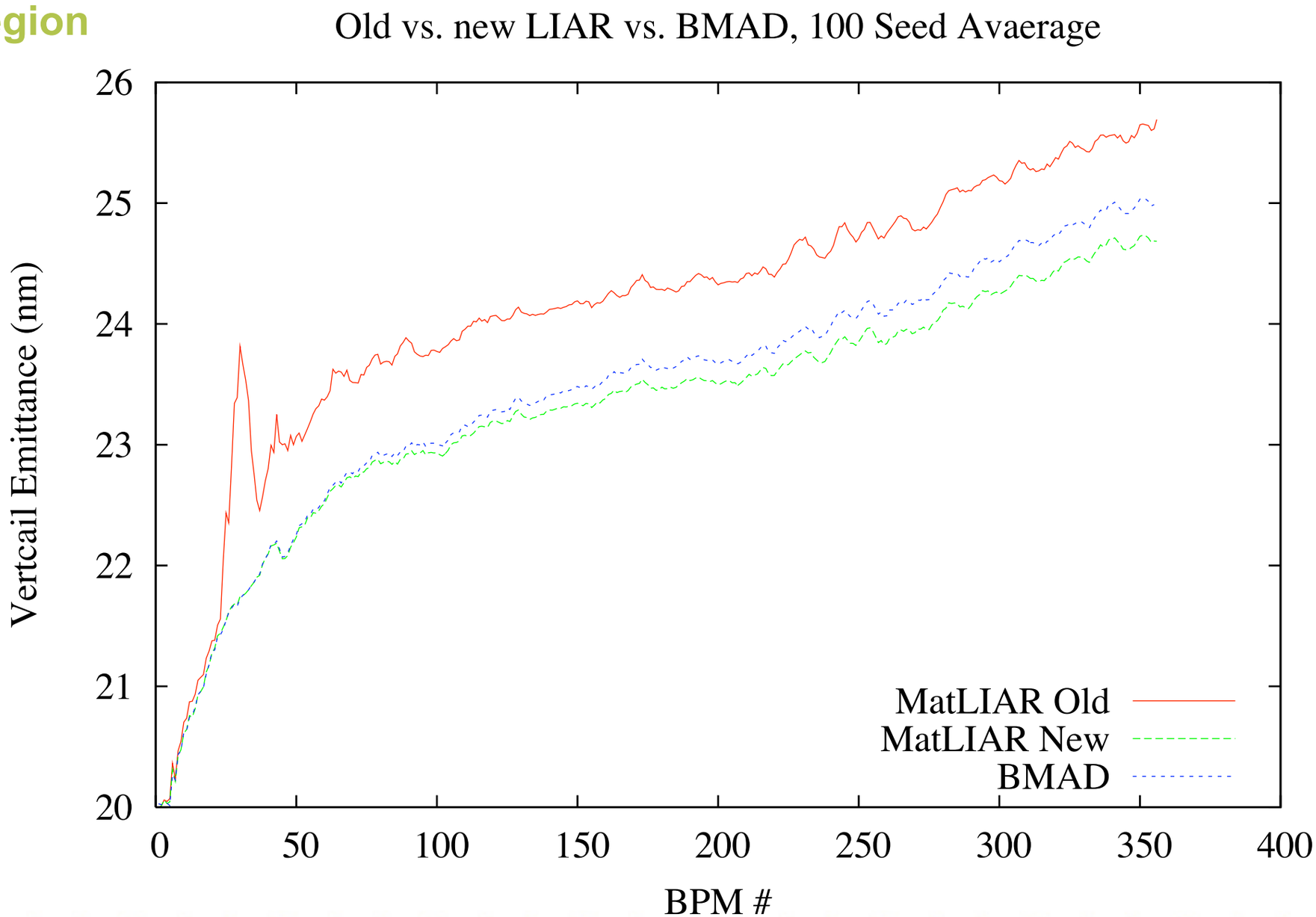
Random numbers

- Different codes generate different distributions!
- Appearently MatLIAR has hard-wall cutoffs to the Gaussian distribution skewing the seeds.
- I think this tells us we should use as realistic of misalignments as possible.



BMAD vs. MatLIAR

- Careful work getting BMAD/ILCv and MatLIAR to agree.
- Identified key components producing differences
  - **Method to re-steering off-energy beam**
  - **Steering of launch region**
  - **Precisely which cavities are turned off**
    - Perhaps some optimization can be done here.

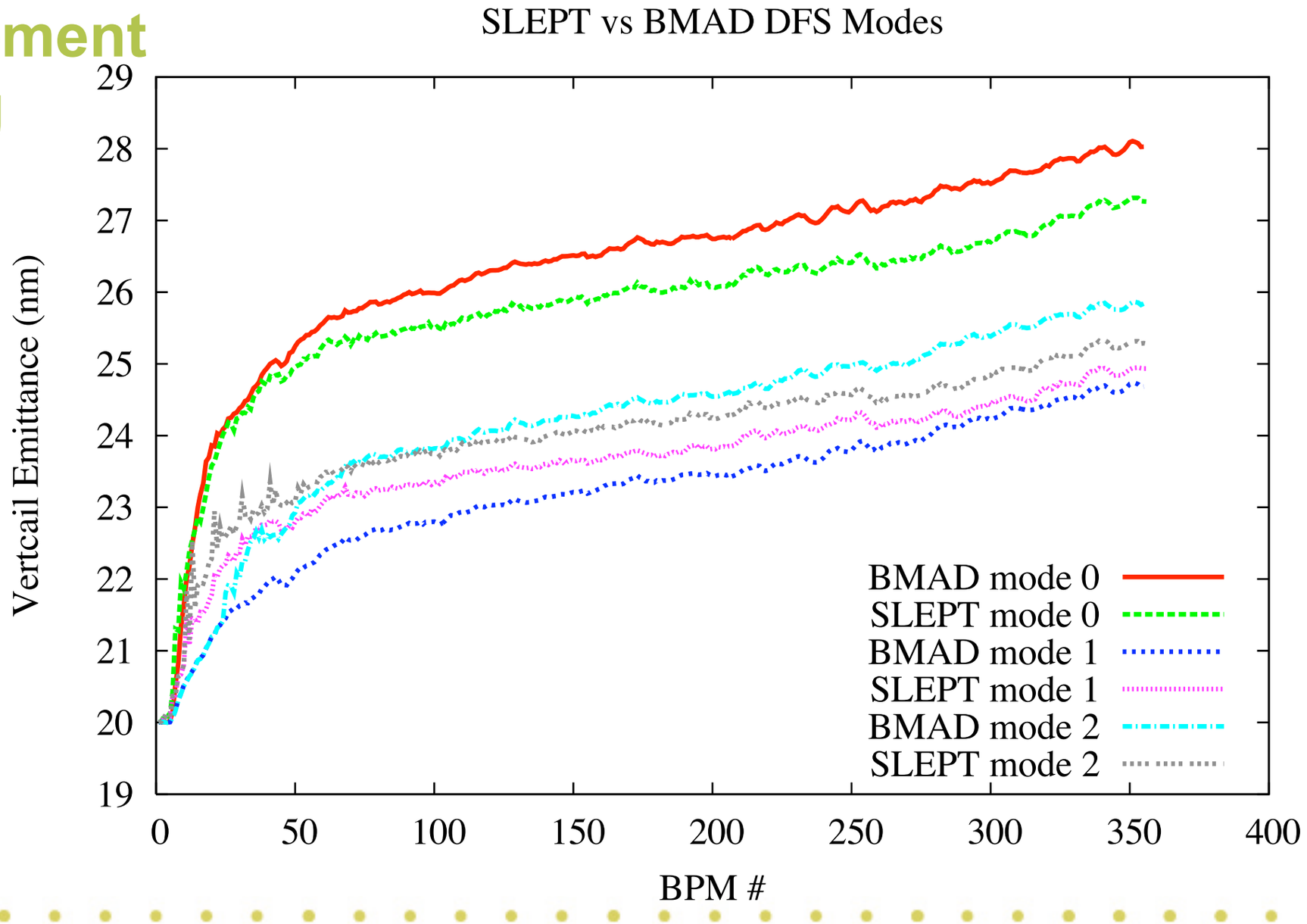


4 “modes” of DFS

- Four methods of DFS studied:
  - **“Standard” mode turns off an appropriate number of cavities and re-steers off-energy beam.**
  - **Mode 0 scales energy gradient of whole machine and including the DF region being steered. Re-steers off-energy beam**
  - **Mode 1 scales energy gradient up to beginning of region. Resteers off-energy beam**
  - **Mode 2 scales energy gradient up to beginning of region. NO re-steering of off-energy beam.**

3 “modes” of DFS compared

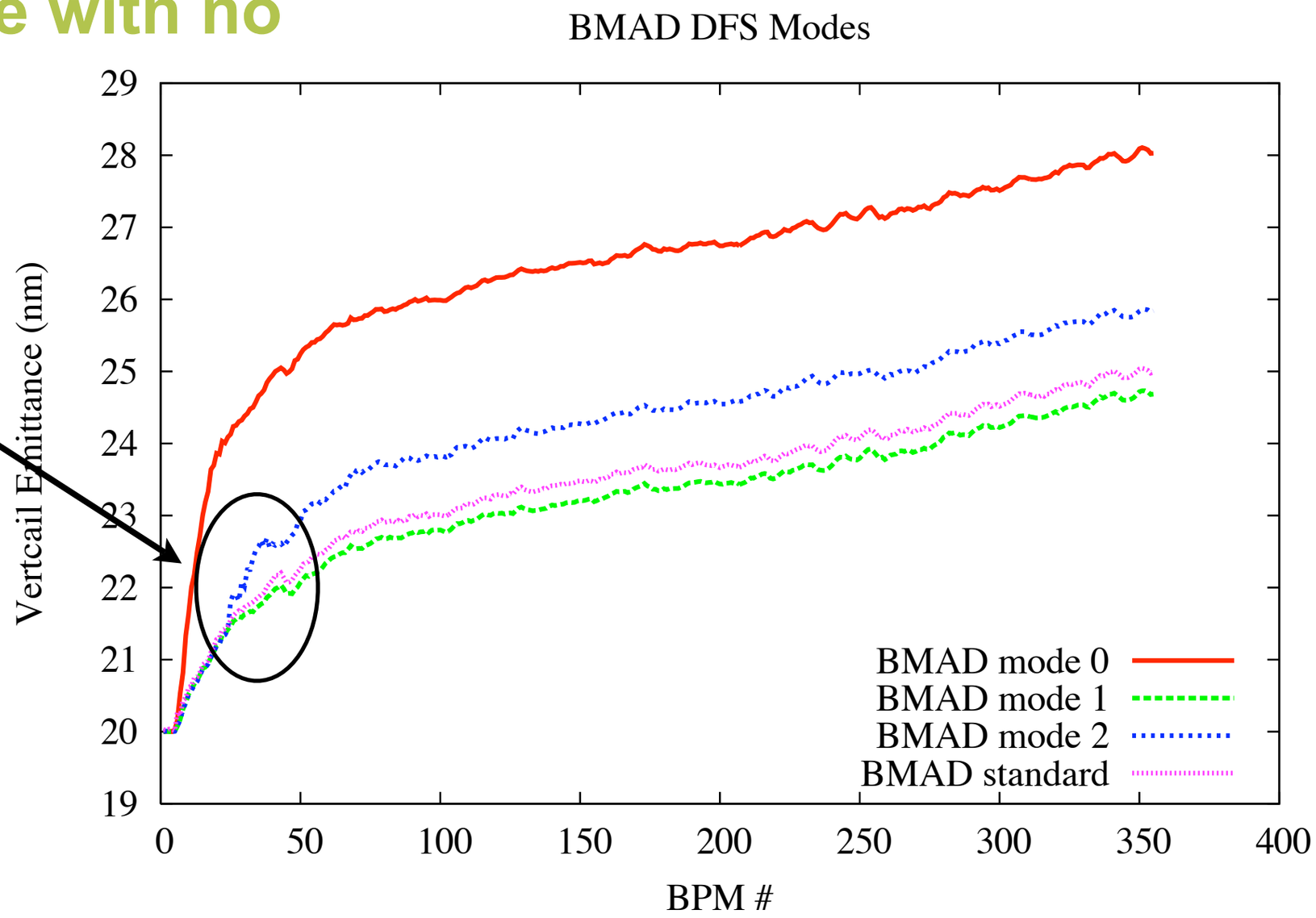
- Compare BMAD to SLEPT’s three modes
  - **Agreement is within statistical error by end of linac**
  - **Some disagreement near beginning**



4 “modes” of DFS

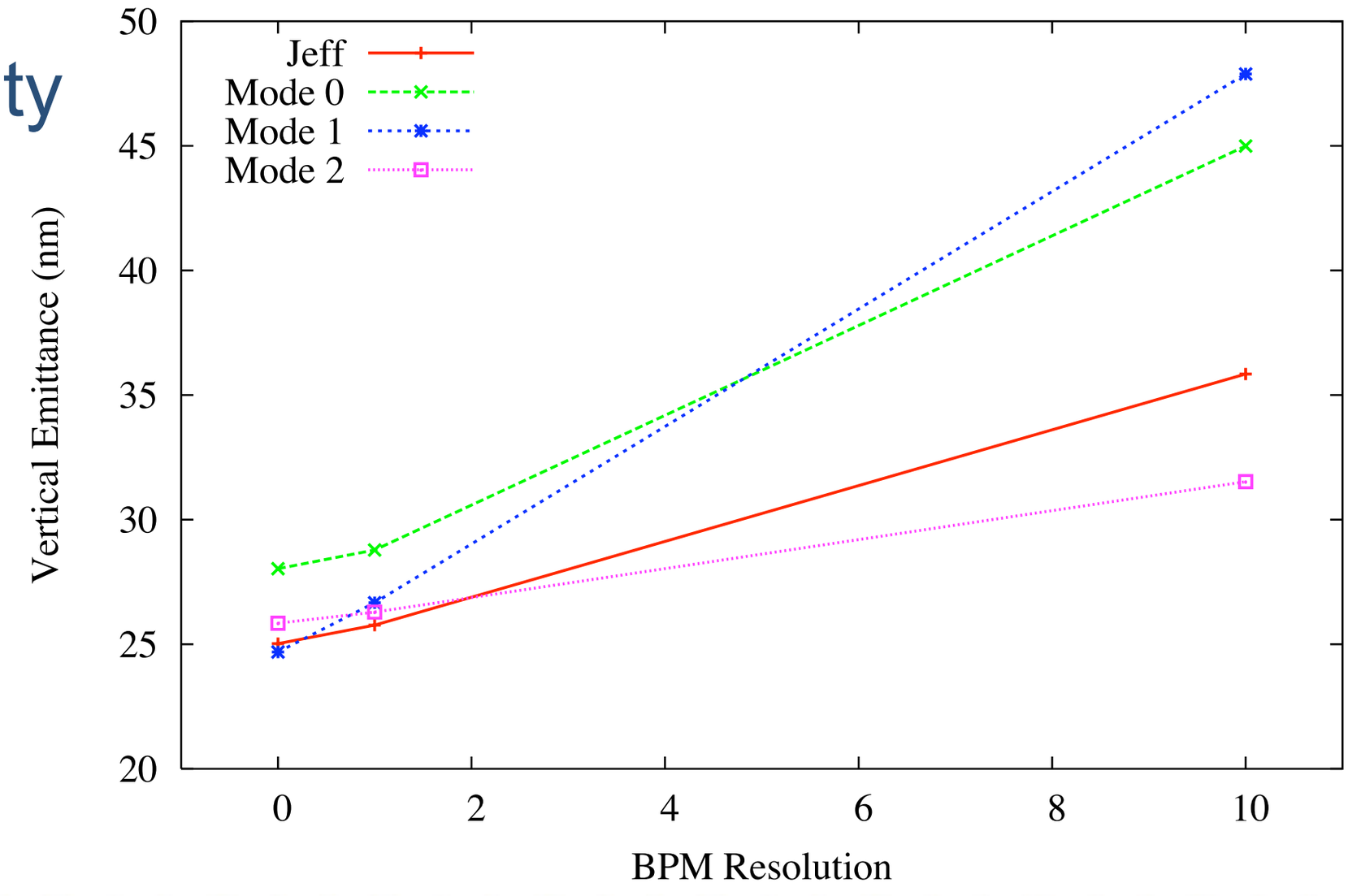
- Just looking at BMAD data
  - **Difference between Modes 1 and 2 gives importance of resteering**
  - **“standard” mode with no resteering is off scale**

Due to resteering



I like mode 2

- Doesn't give best performance but is the simplest and least dependent on BPM resolution
- Suspect resteering can be problematic and removing will probably improve sensitivity studies.



The continuing saga...

- Important to perform this crosschecking periodically.
  - **Discovered bugs in several codes in this round**
  - **Got a better understanding of some relevant parameters in DFS.**
  - **Perhaps people should include ponderomotive force.**
- Should be expanded into other sections.
- What is a solution? What metric to we use to say we agree? Emittance growth, corrector strengths, “golden” orbit.
- Should we plan comparative studies for next year?