Scaling VFFAG eRHIC Design

Progress Report 2

Last time:

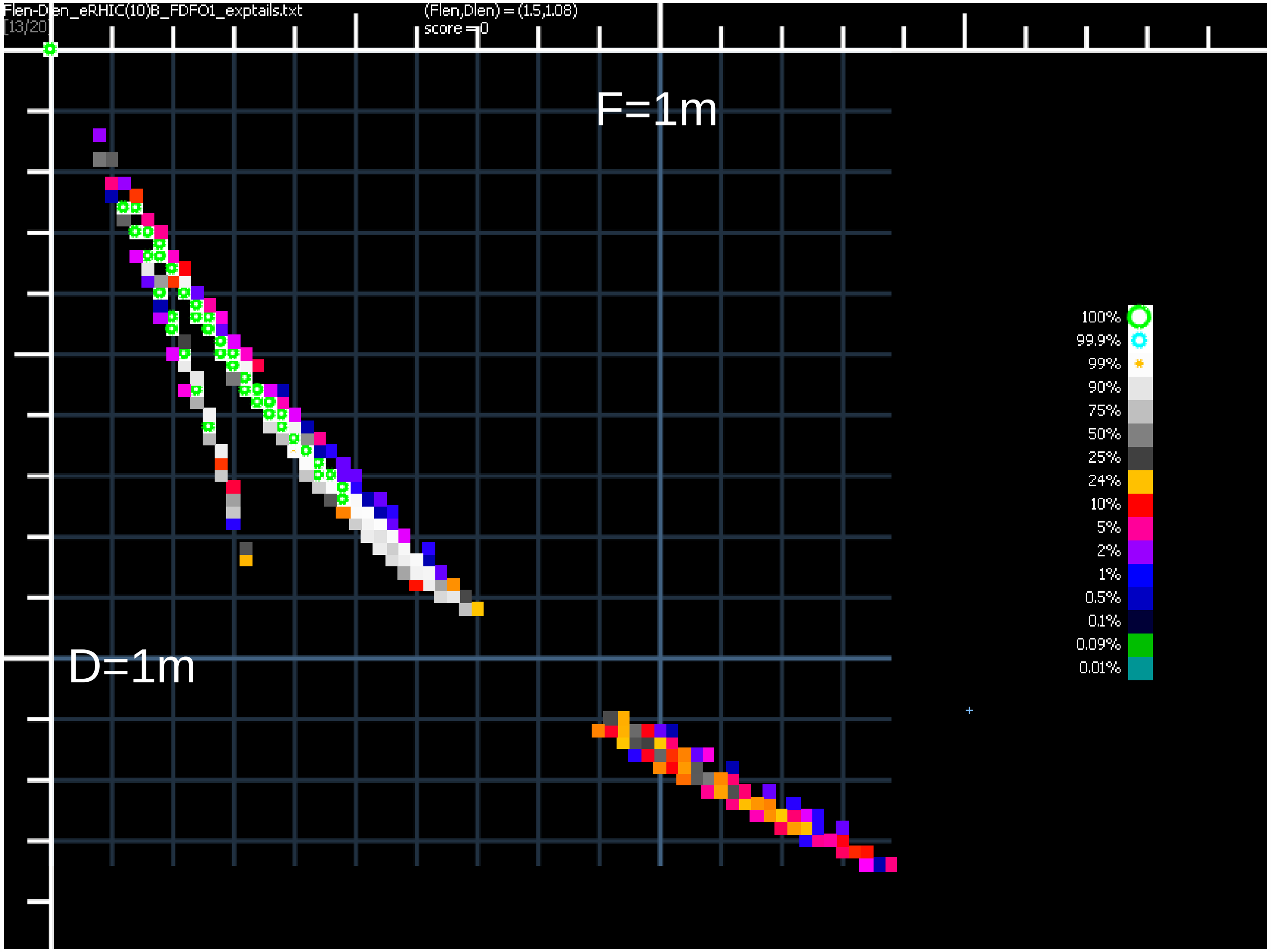
- Used a triplet lattice in the 2nd stability region to get asymmetric bends in scaling VFFAG
  - C=3.241 capable of 11.1GeV
- Dynamic aperture was poor at all practical k
  - Large maximum beta_v of 36.3m was the problem
- Defined:
  - Reference input beam distribution (using Yue's)
  - Dynamic aperture test of 2 turns at 1.2GeV
  - "GeV capability" figure of merit from synchrotron radiation limit and RMS B field per energy

I. New Lattice Search

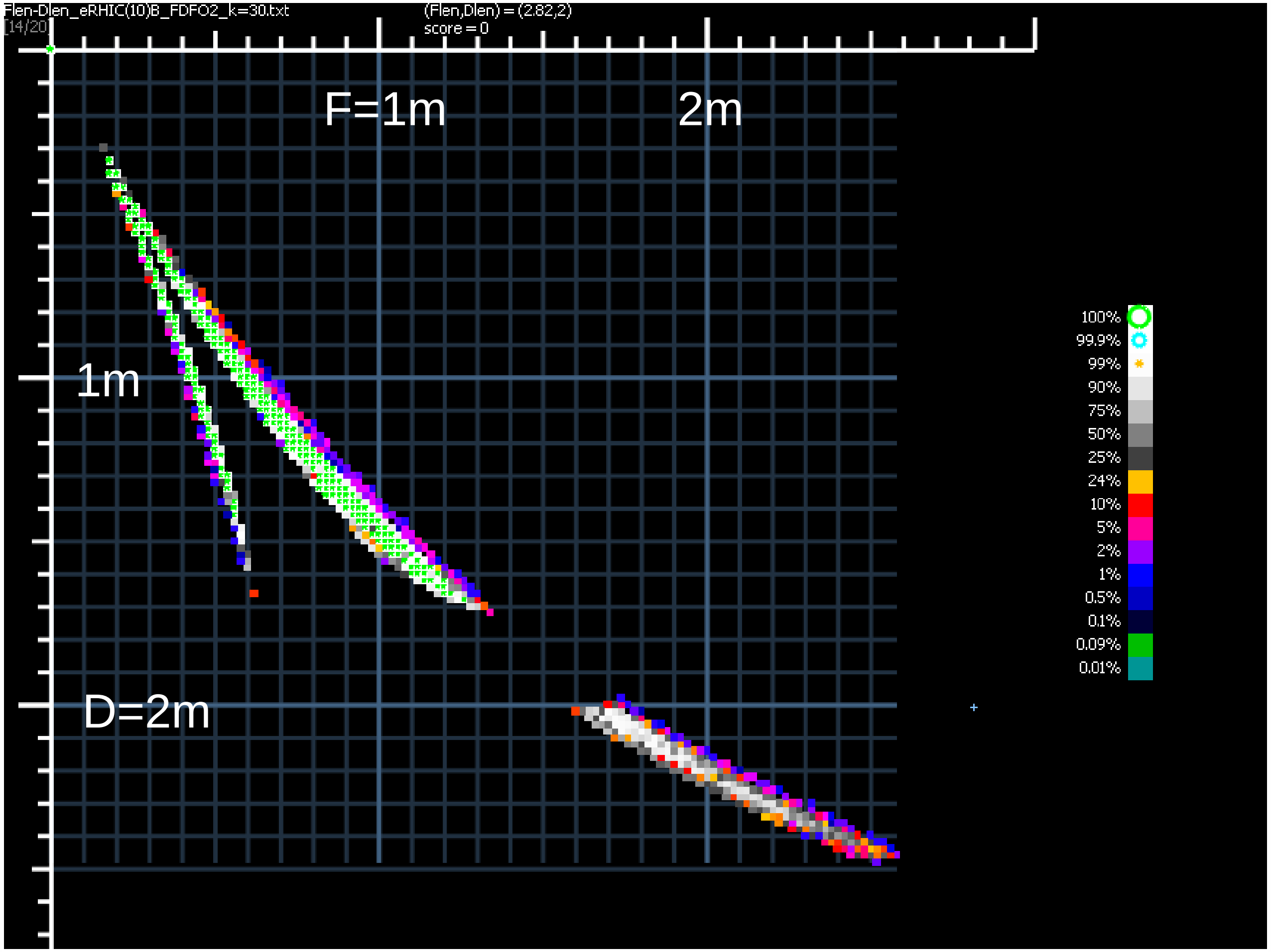
Length_F vs. Length_D plots

- Two types of lattice scan diagrams:
  - Dynamic aperture scans with 250 real particles
    - These all do 2 turns at 1.2GeV with real distribution
  - Linear optics only scans (faster)
- What has been kept constant:
  - Tunnel radius (scales B0)
  - Packing factor at either 60% or 80% (scales drifts)
  - Field strength ratio B0_F/B0_D = 1 throughout
  - k=30 or 100 m^-1 (not an issue for linear optics)

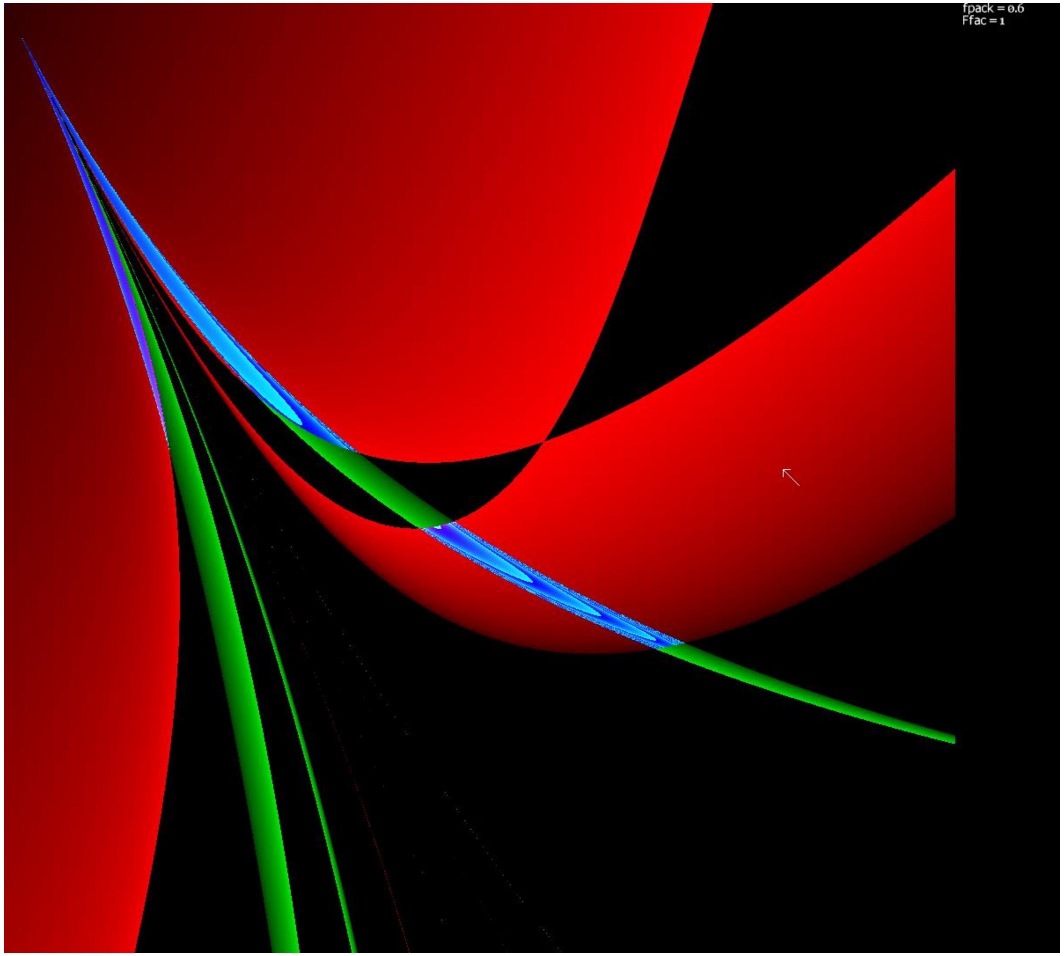
FDF2 lattice, k=100m^-1



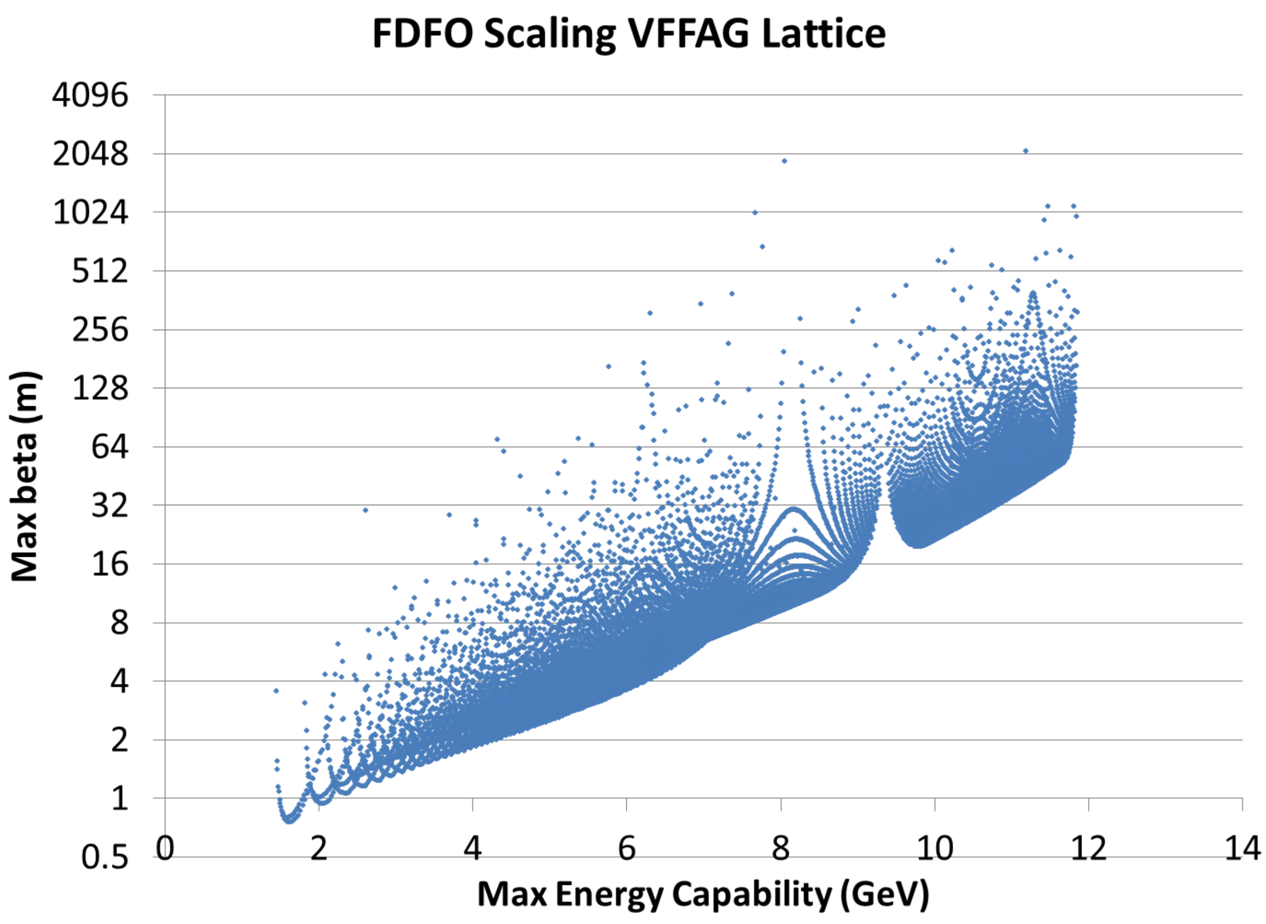
FDF2 lattice, k=30m^-1



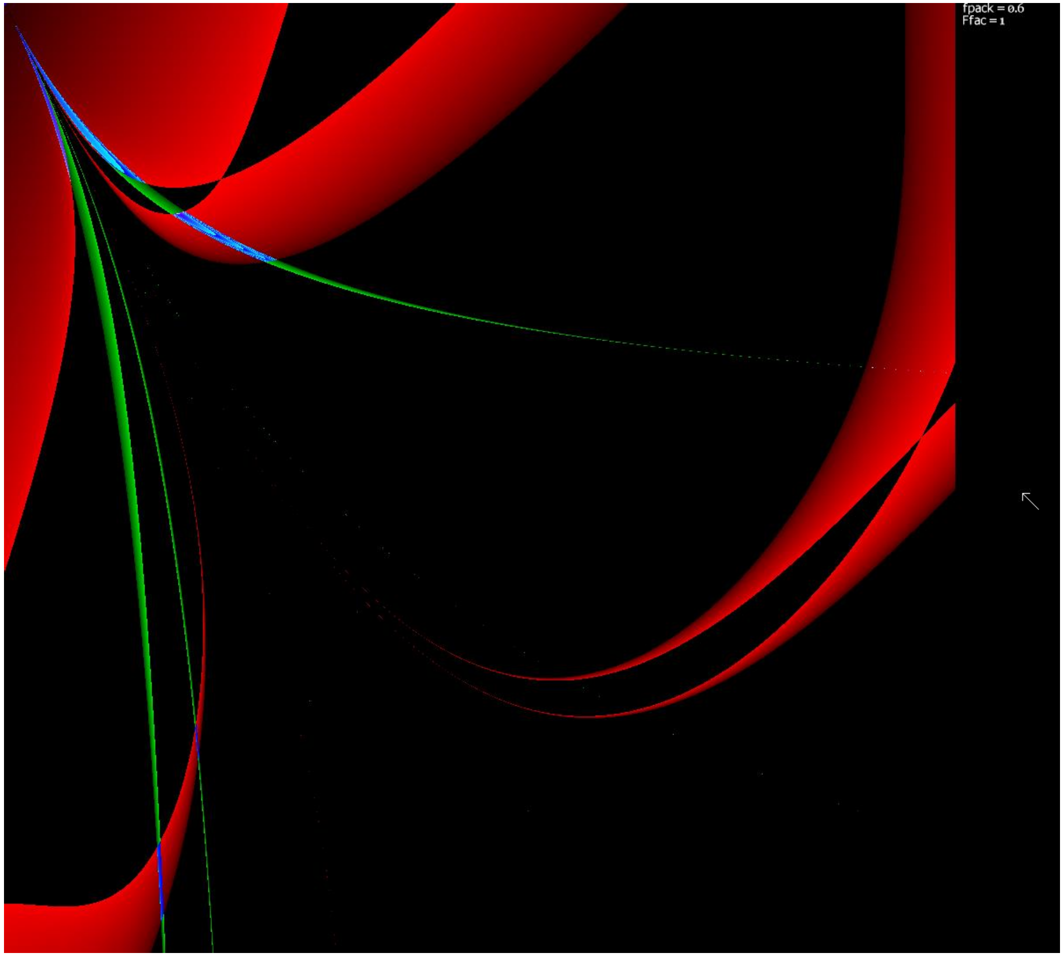
FDF2 lattice in linear optics solver



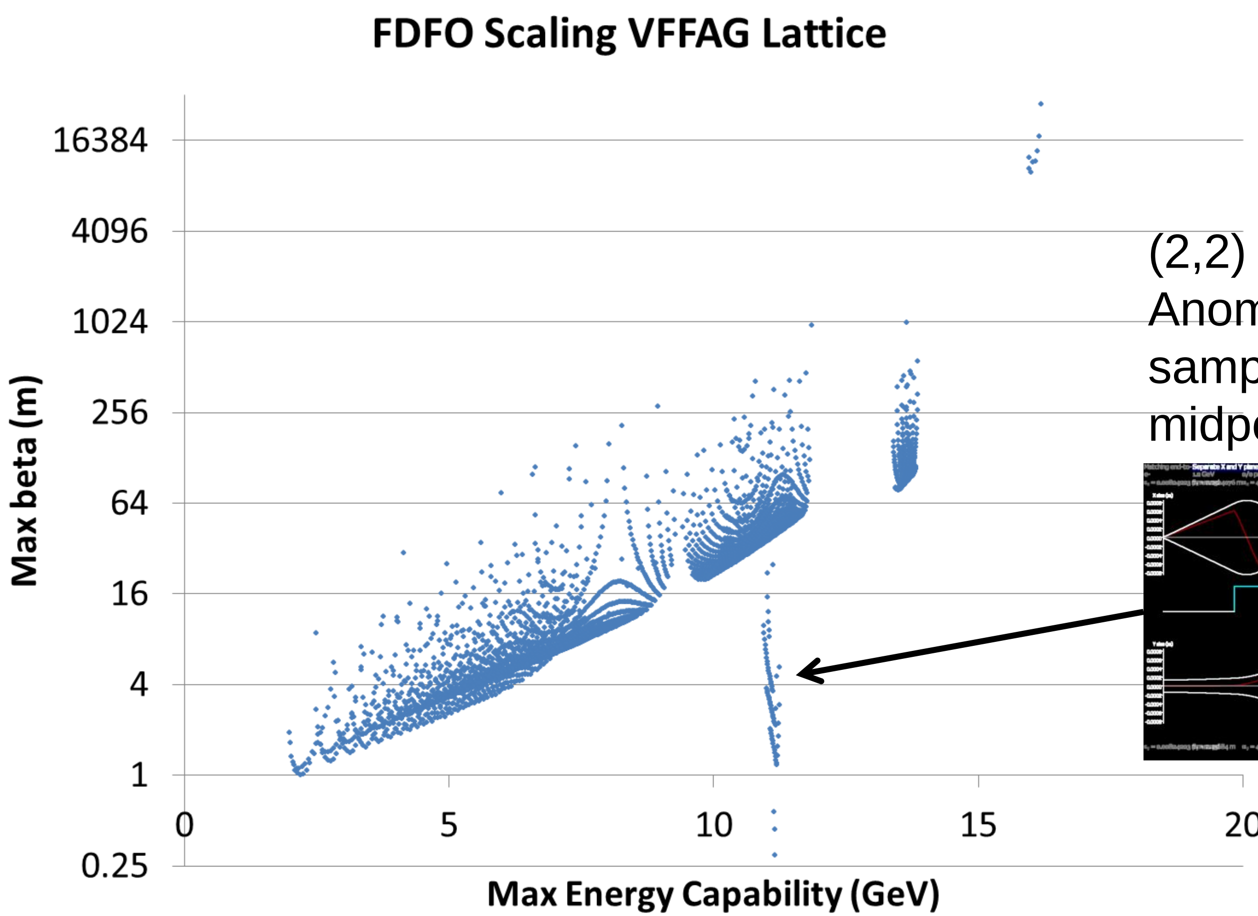
Translated to maxbeta-maxE space



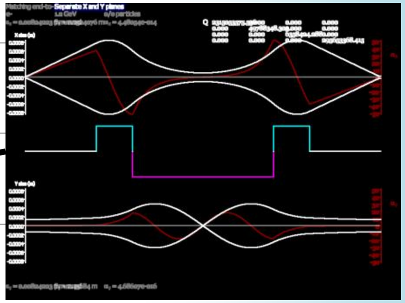
Aside: FDF2 zooming out



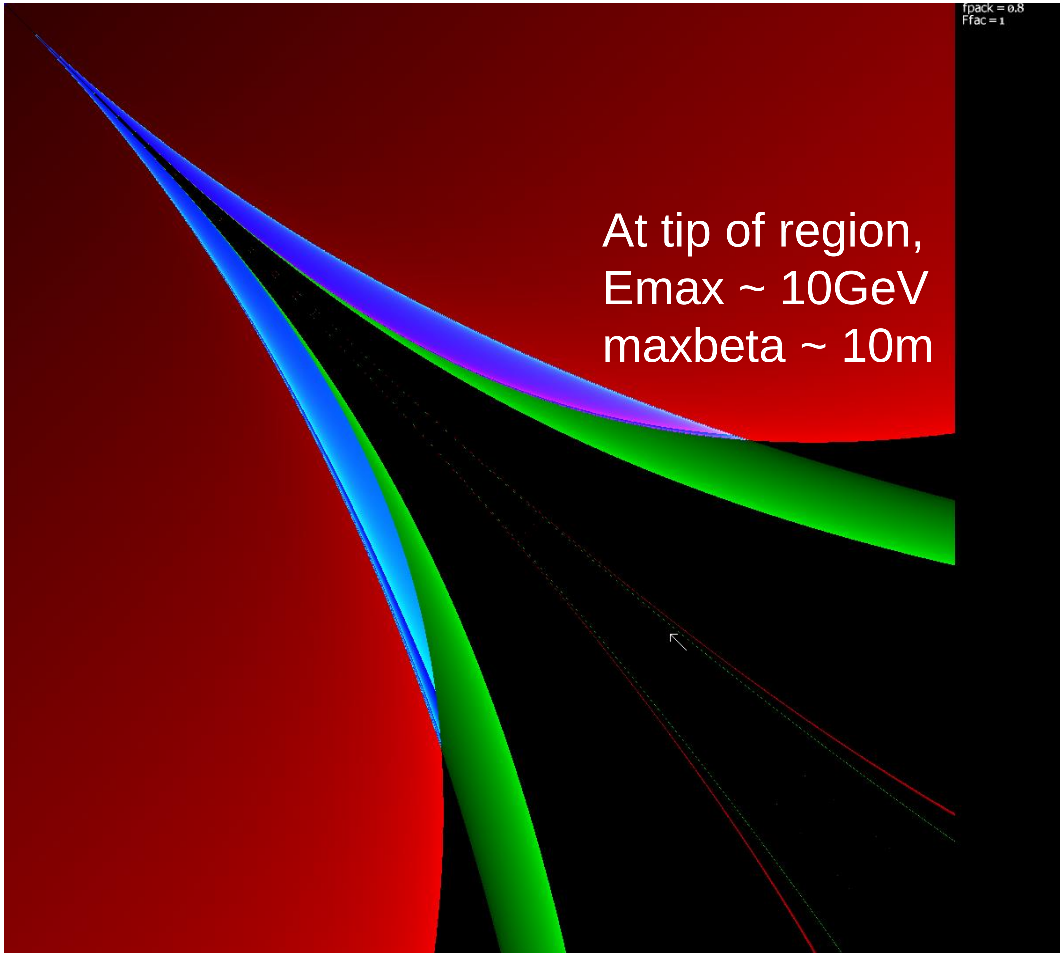
Other stability regions less useful



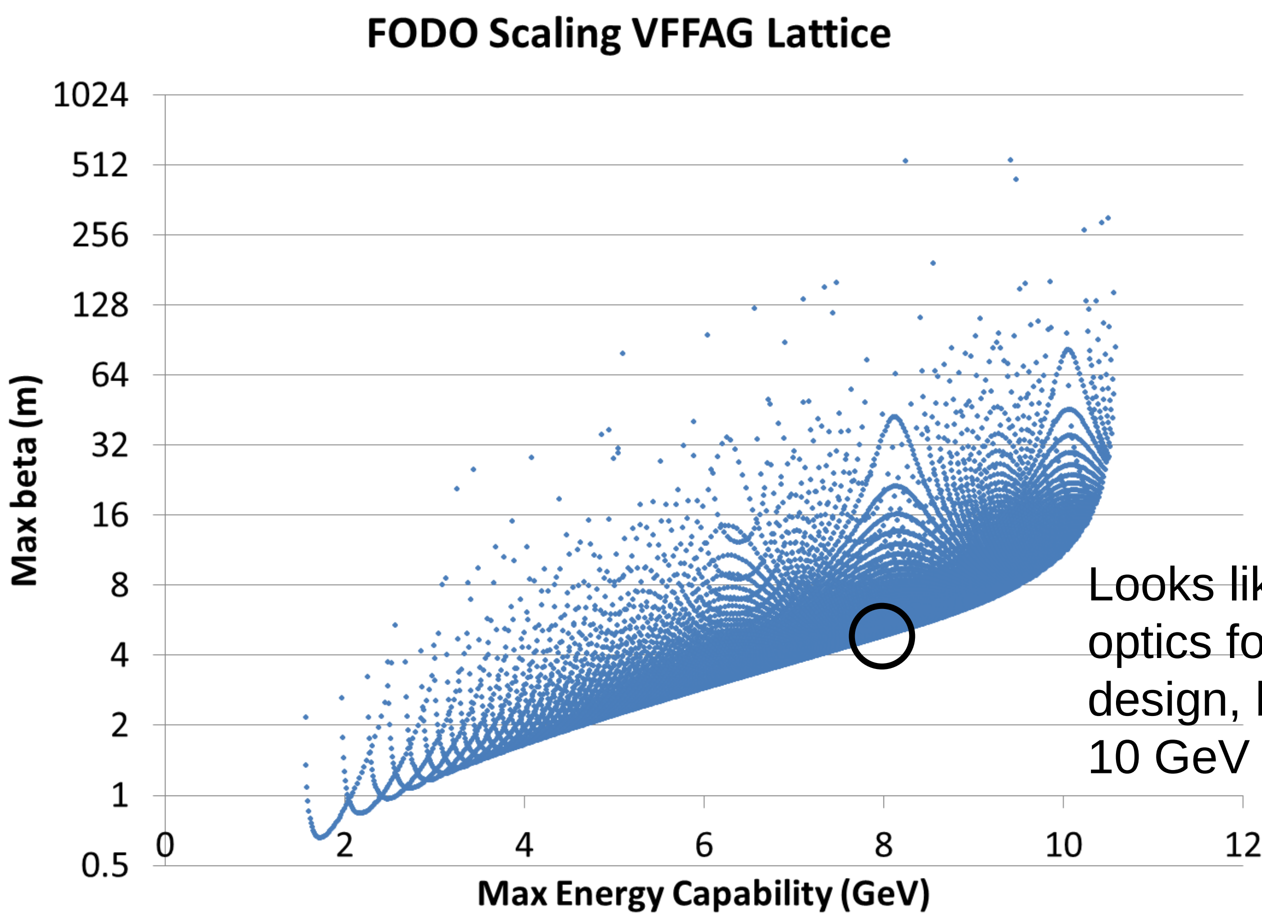
(2,2) stability region
Anomaly from sampling beta at midpoint and ends



FODO doesn't look so bad

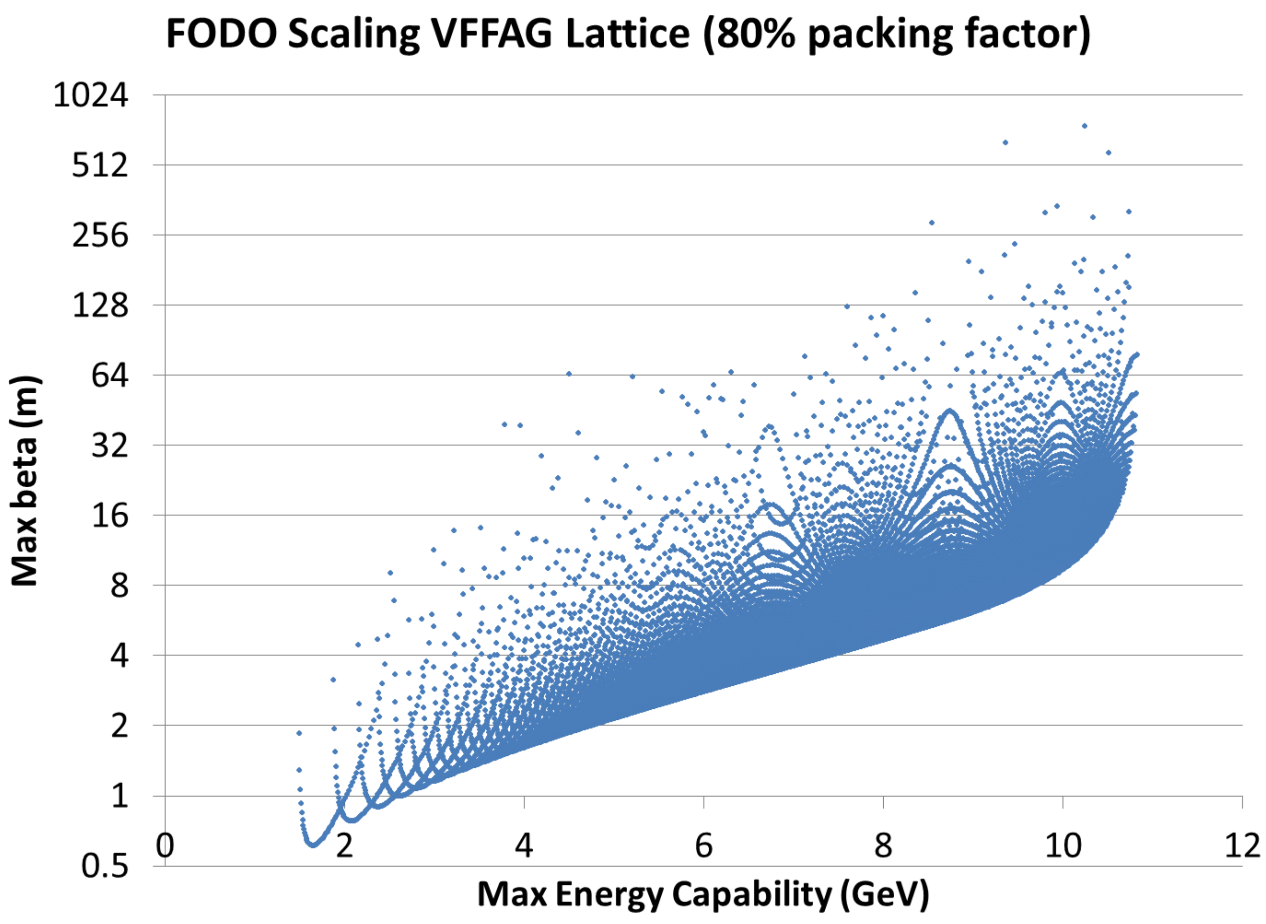


FODO at 60% packing factor

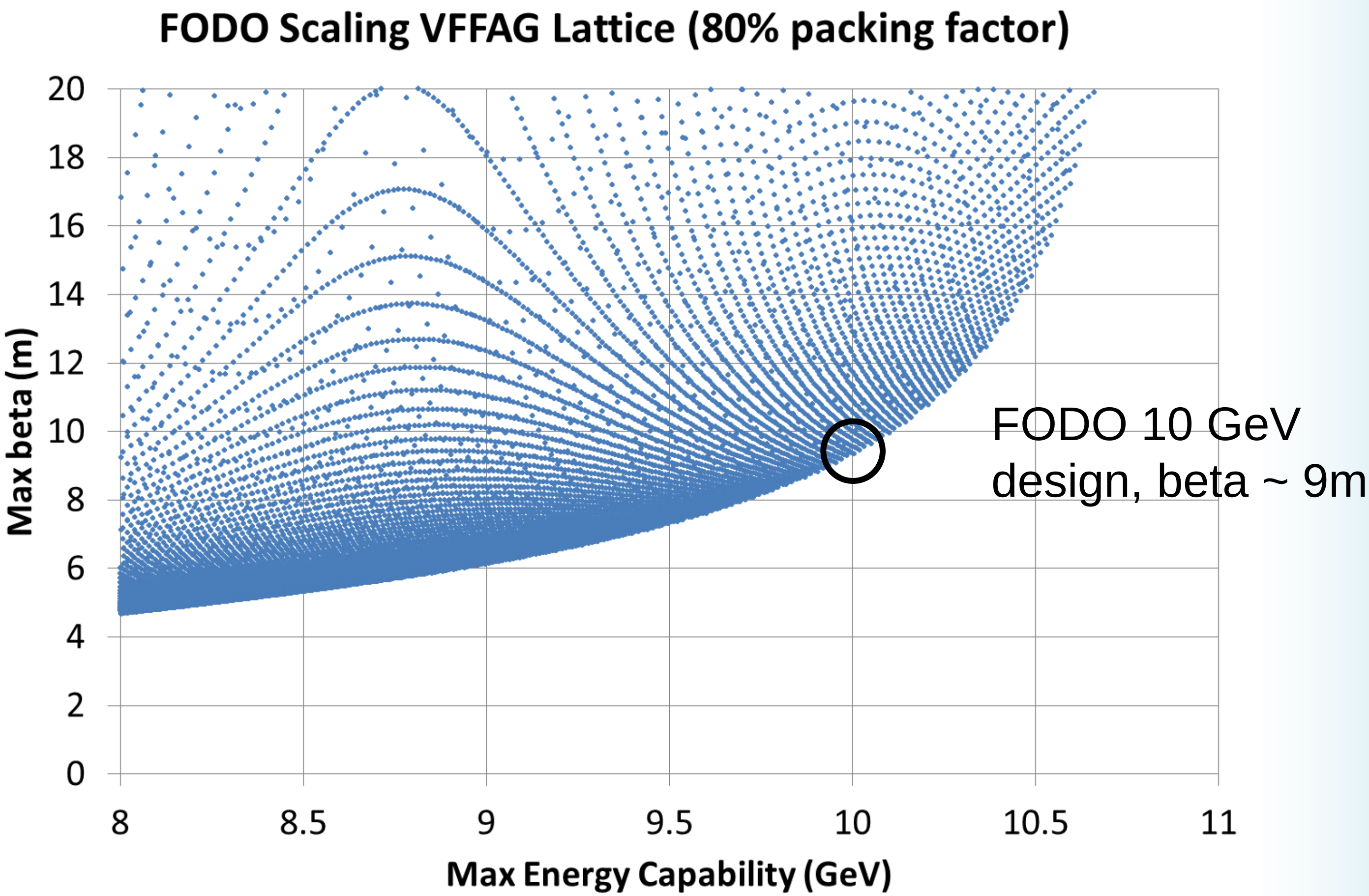


Looks like very good optics for 8 GeV design, beta ~ 5m; 10 GeV is marginal

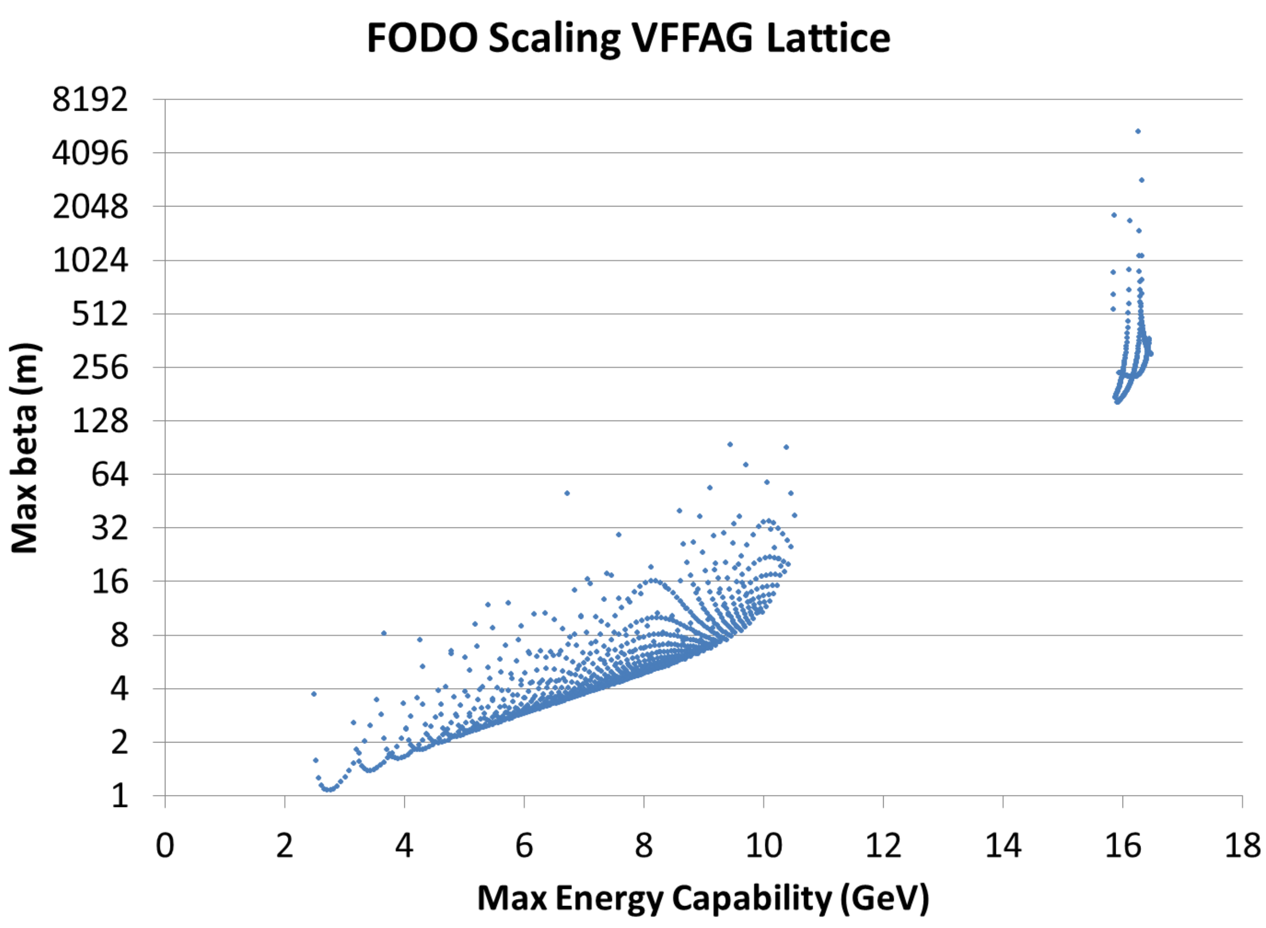
FODO at 80% packing factor



Linear view

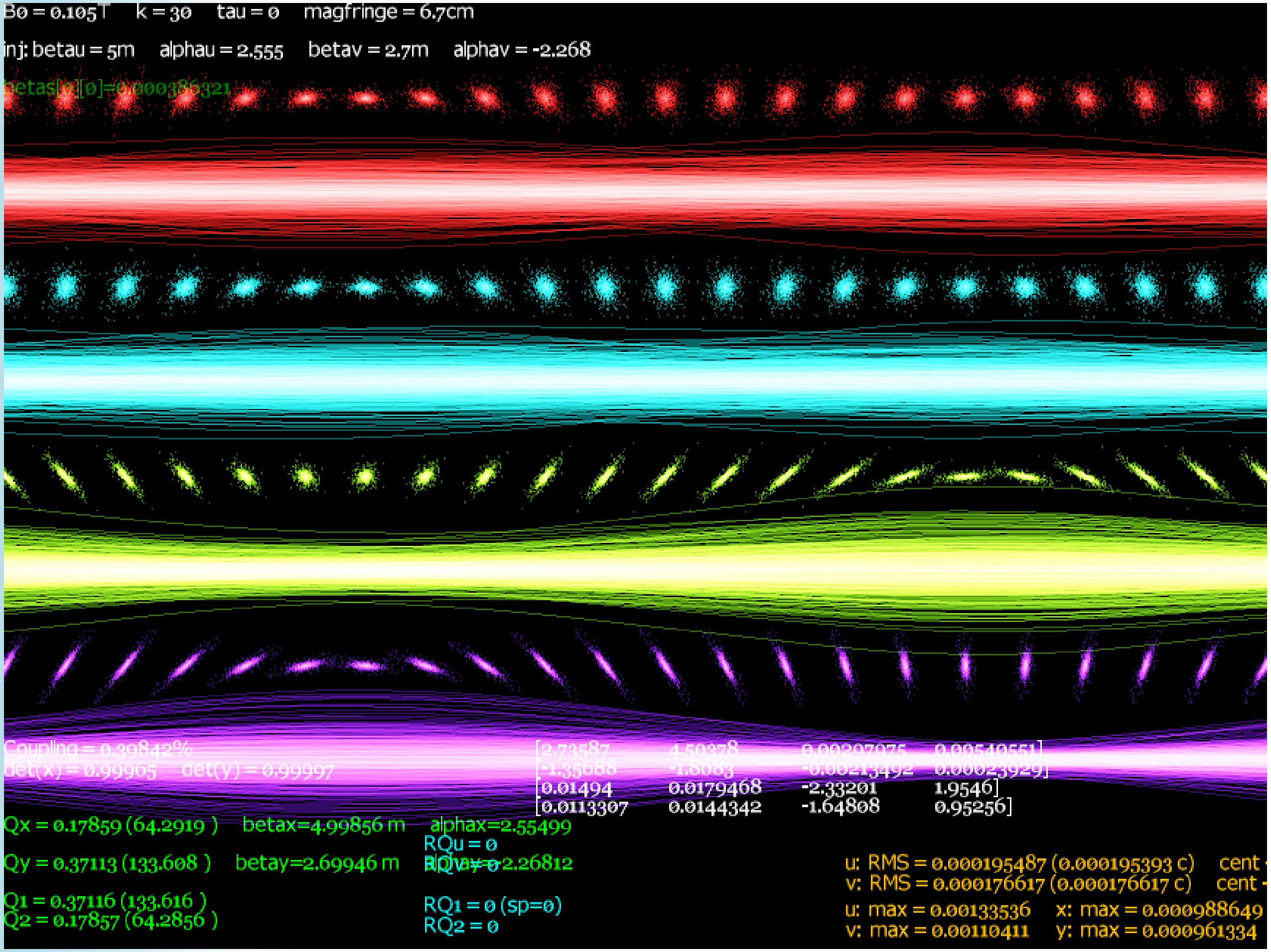

FODO Scaling VFFAG Lattice (80% packing factor)
Max beta (m)
20
18
16
14
12
10
8
6
4
2
0
8
8.5
9
9.5
10
10.5
11
Max Energy Capability (GeV)
FODO 10 GeV
design, beta ~ 9m

Aside: FODO 2nd stability region



II. FODO Lattices at 8 and 10GeV

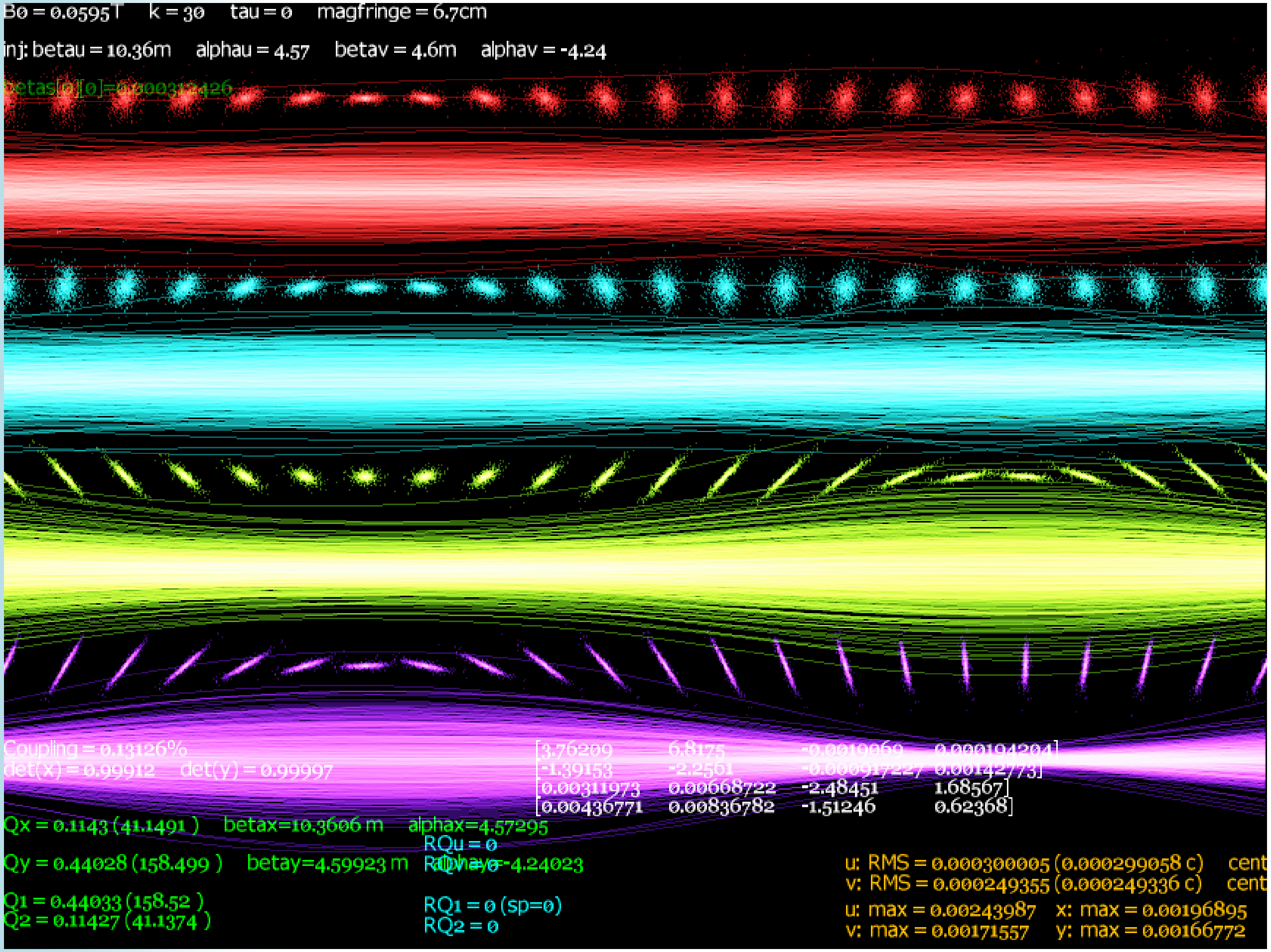
8GeV FODO lattice



Species: Electrons
Injection energy (MeV): 1200
Extraction energy (MeV): 8000
Lattice: FODO
Magnet B0 (T): 0.105
Magnet k (m^-1): 30
Magnet tau: 0
Magnet fringe length (m): 0.067
F Magnet length (m): 1.46
D Magnet length (m): 1.04
Drift length (m): 0.834
Injected normalised emittance (m.rad): 19.36381158822e-6
Injected beta u (m): 5
Injected beta v (m): 2.7
Injected alpha u: 2.555
Injected alpha v: -2.268
Injected distribution: ExpTails
Designed for tracking in: S

Cell length = 4.168 m
Orbit excursion = 0.0632253 m
Bending radius = 378.473 m
Packing factor = 0.59981
Circumference factor = 5.95238
Emax_eRHIC = 8.09533 GeV

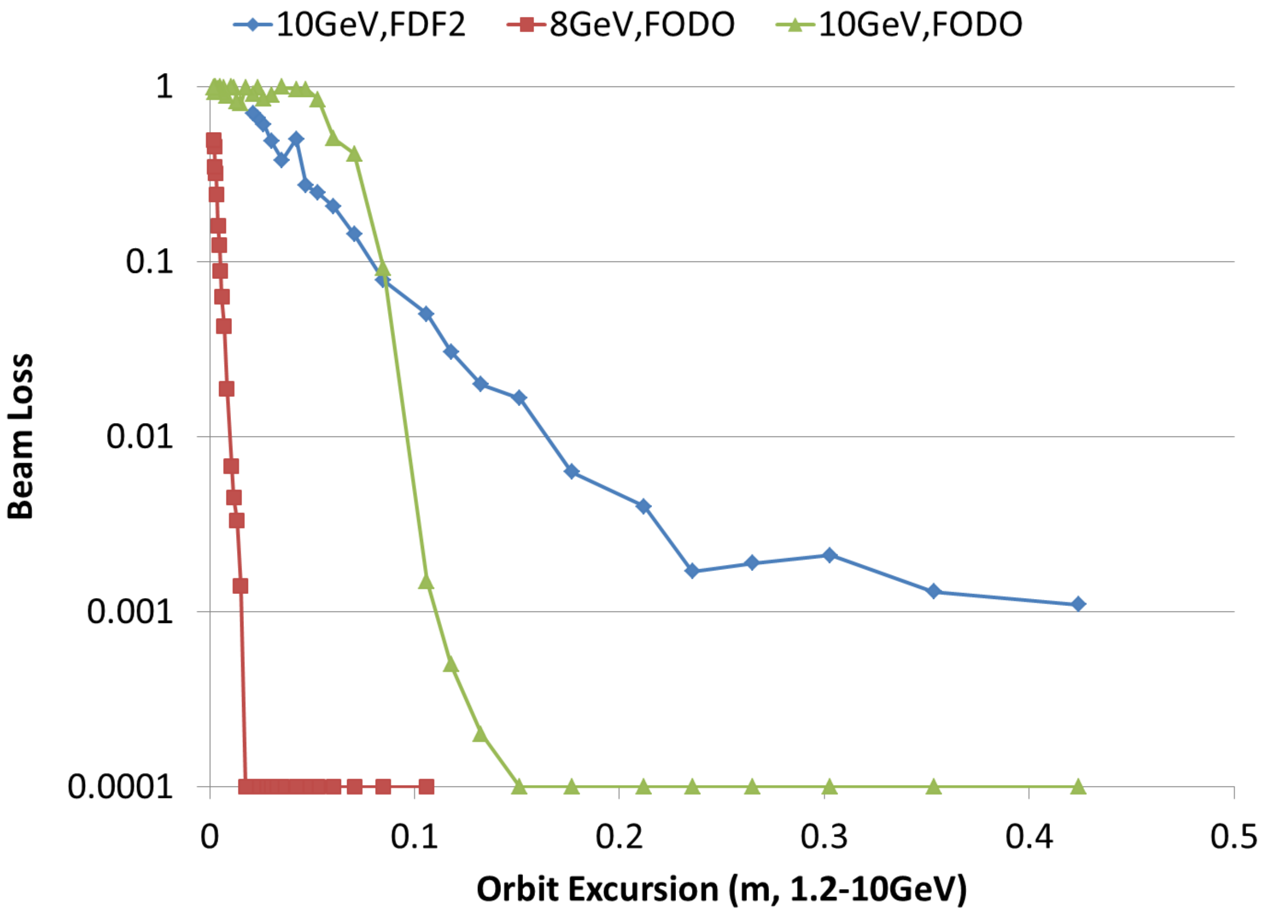
10GeV FODO lattice



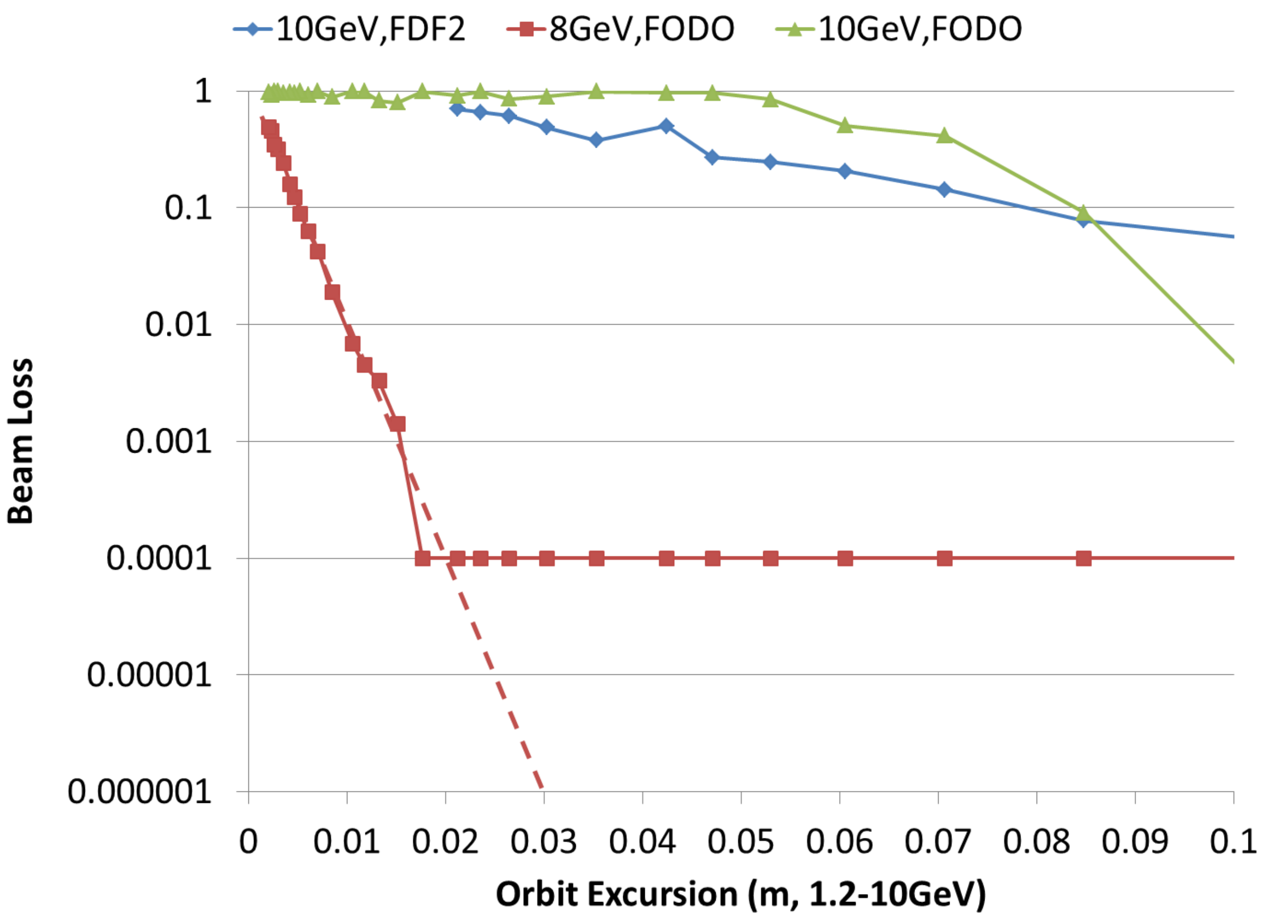
Species: Electrons
Injection energy (MeV): 1200
Extraction energy (MeV): 10000
Lattice: FODO
Magnet B0 (T): 0.0595
Magnet k (m^-1): 30
Magnet tau: 0
Magnet fringe length (m): 0.067
F Magnet length (m): 2.556
D Magnet length (m): 1.626
Drift length (m): 0.523
Injected normalised emittance (m.rad): 19.36381158822e-6
Injected beta u (m): 10.36
Injected beta v (m): 4.6
Injected alpha u: 4.57
Injected alpha v: -4.24
Injected distribution: ExpTails
Designed for tracking in: S

Cell length = 5.228 m
Orbit excursion = 0.070663 m
Bending radius = 378.339 m
Packing factor = 0.79992
Circumference factor = 4.49677
Emax_eRHIC = 10.0072 GeV

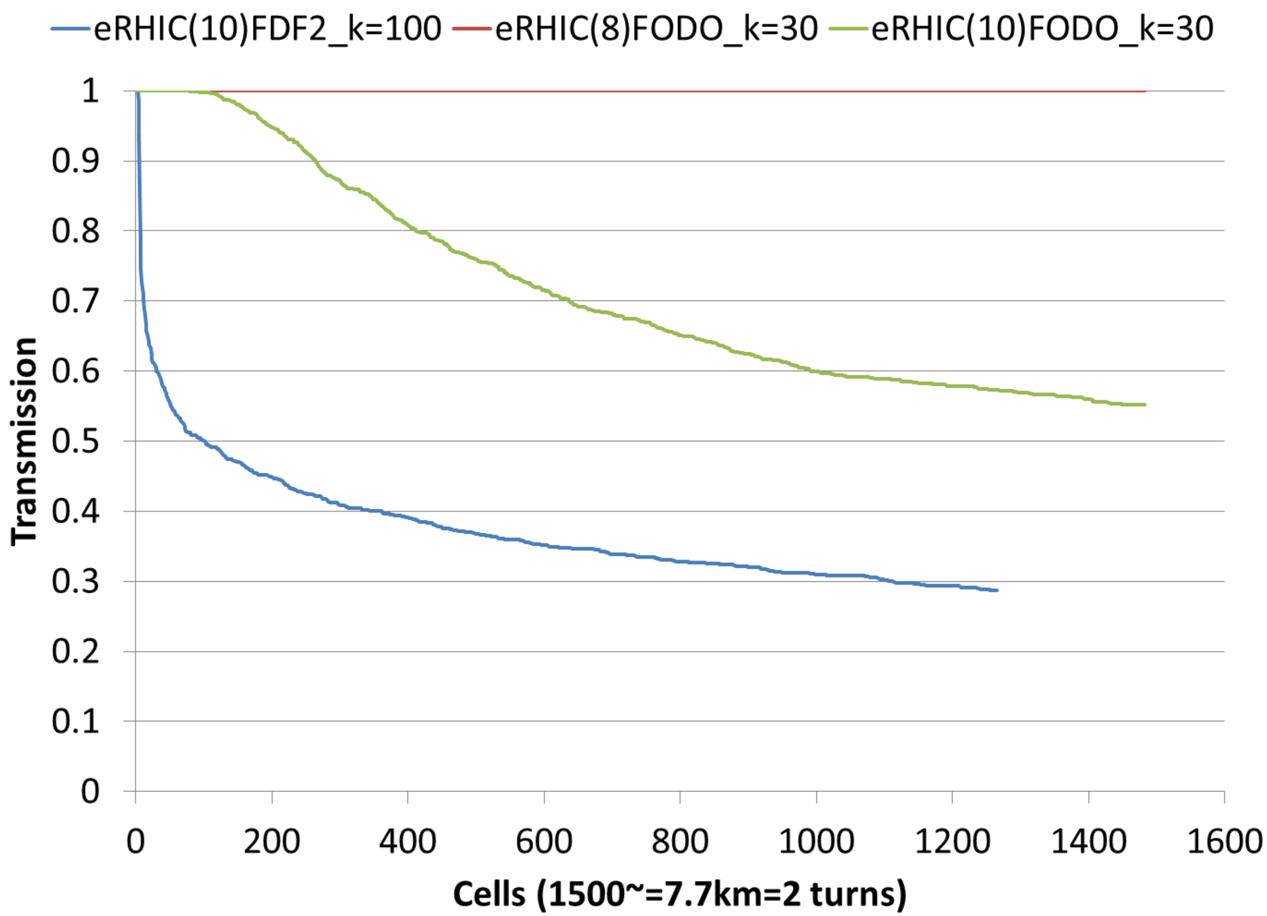
Loss performance with scaling k



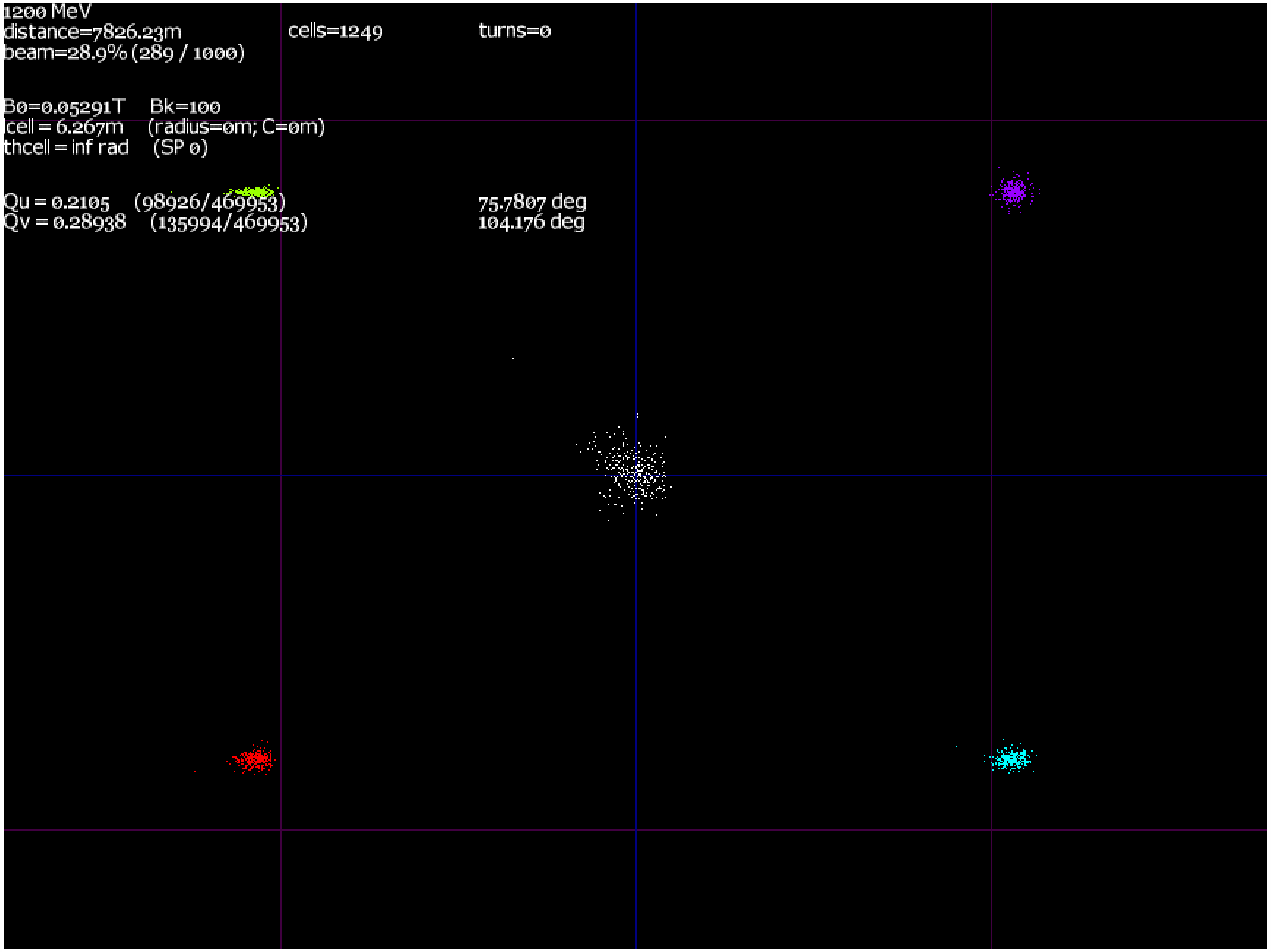
8GeV promising: need to confirm



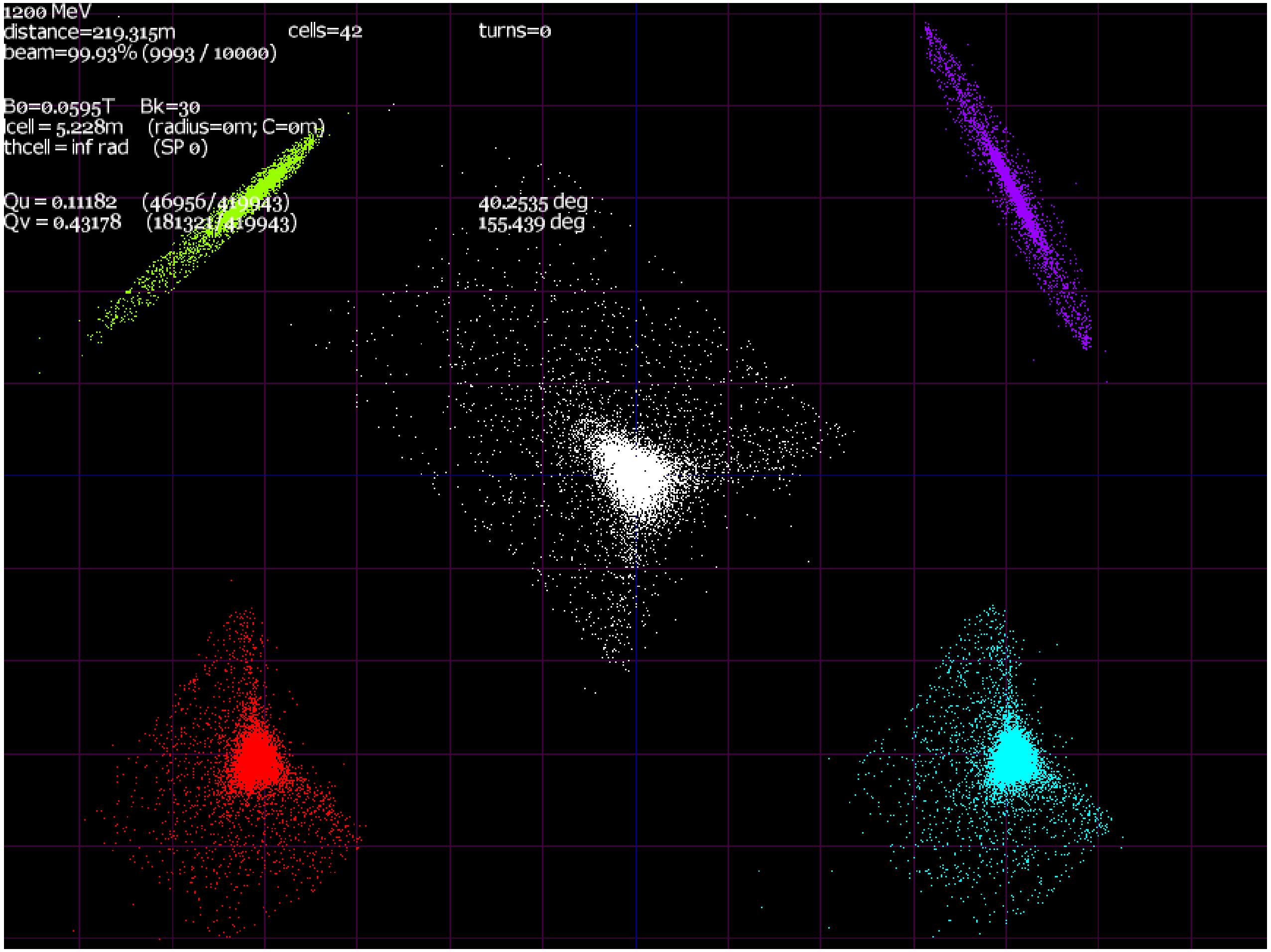
Loss patterns over time



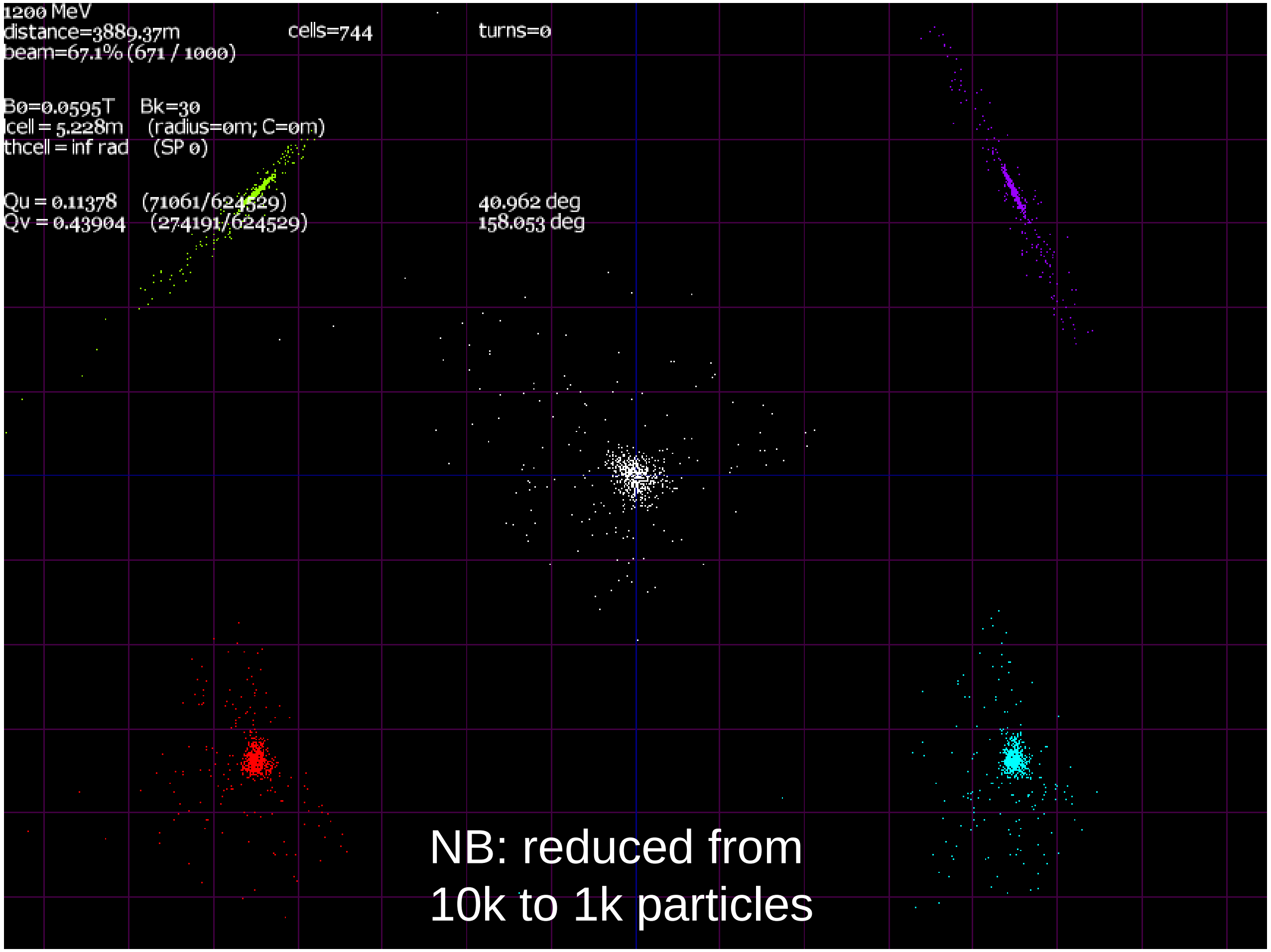
FDF2 lattice final beam



10GeV FODO bat wings



10 GeV FODO later evolution

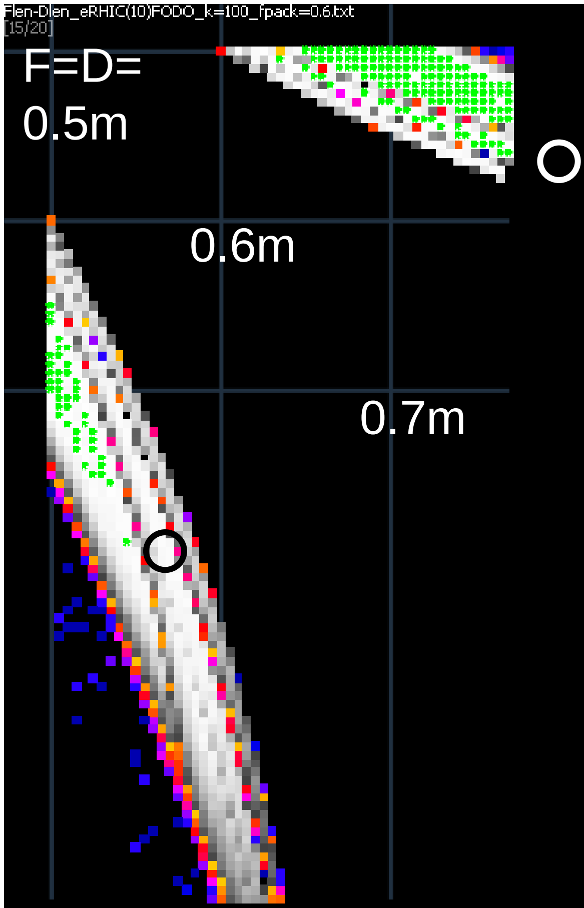


8 vs. 10, why the big difference?

- Cell tunes (Qu, Qv)
  - 8GeV FODO: (64.3, 133.6) deg = (0.179, 0.371)
  - 10GeV FODO: (41.1, 158.5) deg = (0.114, 0.440)
- No obvious fractions
- Effect seems too strong just to be larger beta
  - Beam about 50% larger physically in 10GeV FODO
- 10GeV FODO loss scaling with k looks weird
  - Resonance effect?

III. FODO Dynamic Aperture Scan

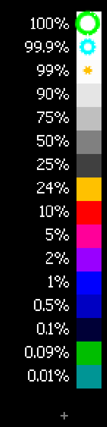
FODO 60% packing factor



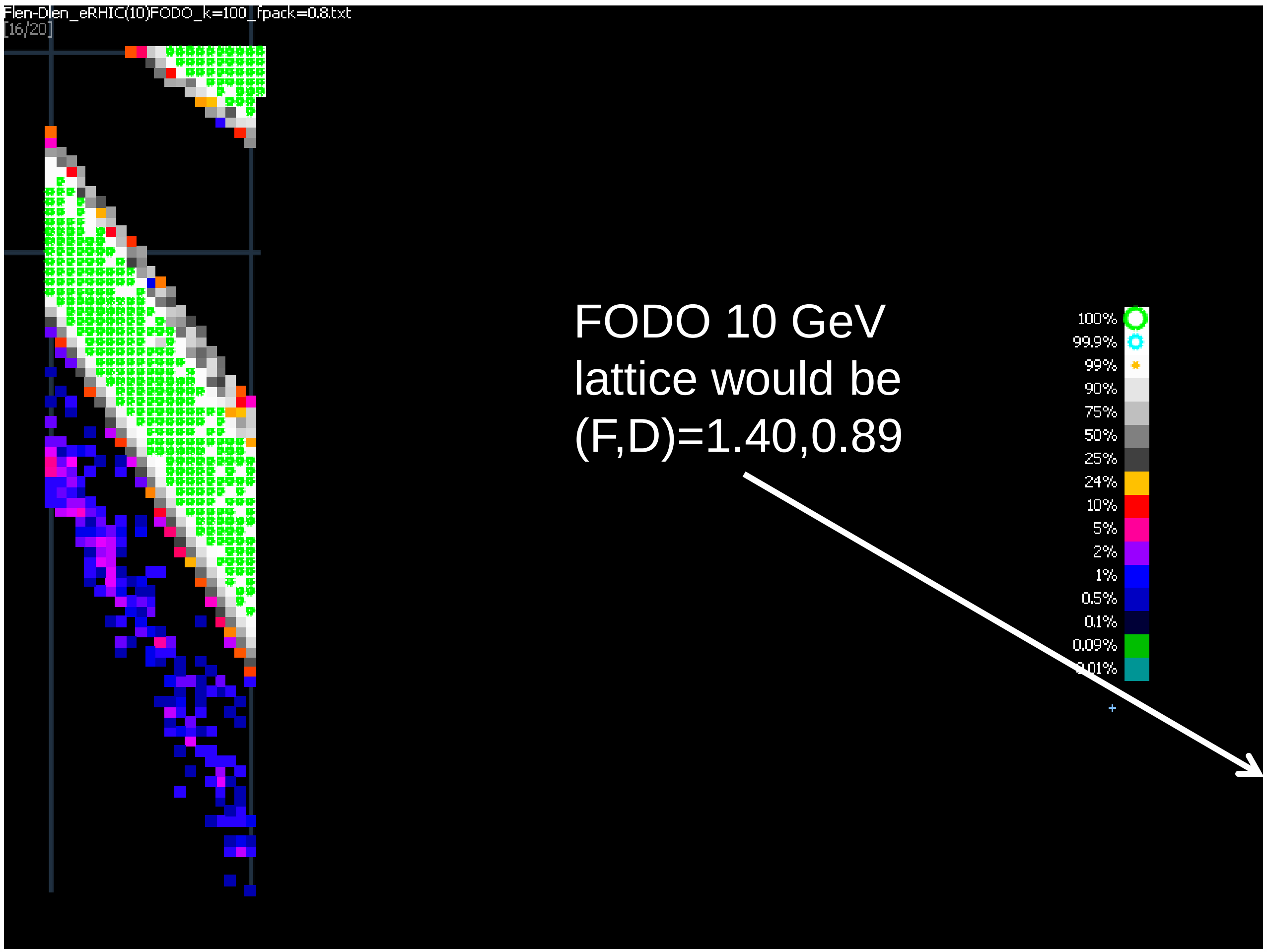
Scaled down to k=100m^-1 to be sensitive to aperture restructions.

Still calculating since Friday!

FODO 8 GeV lattice would be (F,D)=0.80,0.57



FODO 80% packing factor



IV. Future Work

Next steps (roughly in this order)

- Find best point on resonance diagram
  - Will be a FODO design at >= 8GeV
- Redo simulations with weighted particles in tails (down to 1e-6 and beyond)
- Error (misalignment) study!
- Confirm F,D lengths and recommended k
  - Give these values to Brett Parker etc.
- Develop “straight” cell for full ring lattice