

# eRHIC FFAG Design for 21GeV

- I. Final Arc Cells for Design Report
- II. eRHIC FFAGs in RHIC Tunnel

# I. Final Arc Cells for Design Report

# Minor Lattice Change

- Small adjustment to make 49.5 and 50T/m gradients in FFAG2 actually equal ( $\pm 49.515$ )
  - Saves on 2D magnet design work
  - FFAG1 can't be equalised in same way
- Dejan changed lengths in metres to inches
  - Might help with sourcing PM blocks?
  - FFAG1 adjusted to maintain integrated gradients
- Both of these are now on eRHIC Wiki
  - [http://www.cadops.bnl.gov/eRHIC/erhicWiki/index.php/FFAG\\_Design:Electrons:Lattice:Arcs](http://www.cadops.bnl.gov/eRHIC/erhicWiki/index.php/FFAG_Design:Electrons:Lattice:Arcs)

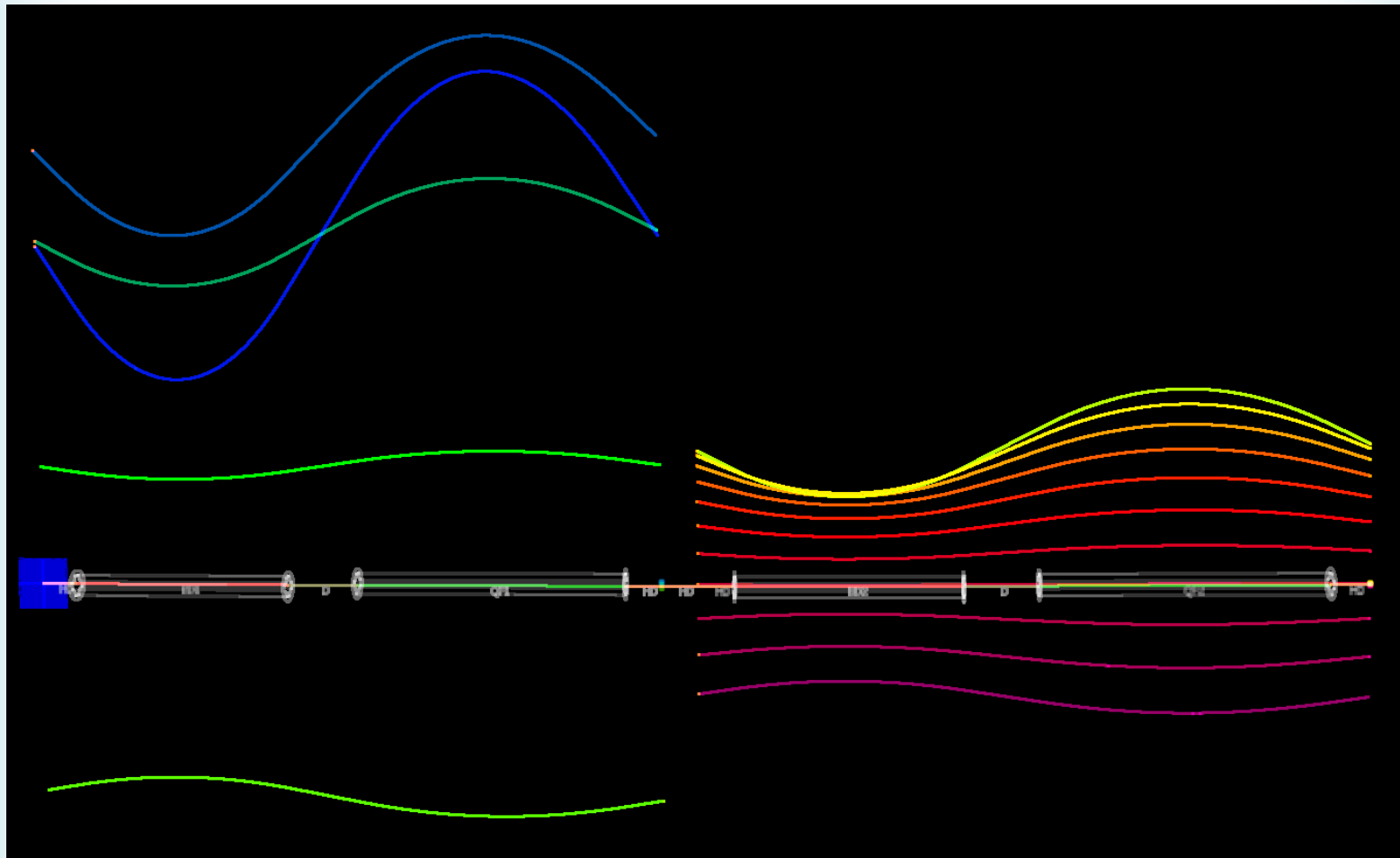
# Old Lattice (SJB 2013-Dec-26)

Parameter	Low-Energy FFAG	High-Energy FFAG
Energy range	1.334 – 6.622 GeV	7.944 – 21.164 GeV
Energy ratio	4.96×	2.66×
Turns (1.322GeV linac)	5	11
Synchrotron power	0.26MW @ 50mA	9.8MW @ 21.1GeV, 18mA 10.3MW @ 15.8GeV, 50mA 3.2MW @ 10.5GeV, 50mA
TOF range	54.7ppm (12cm)	22.3ppm (5cm)
Drift space	29.1cm	29.1cm
Tune range	0.036 – 0.424	0.036 – 0.370
Orbit range (quads)	31.3mm ( $r_{\max} = 23.5\text{mm}$ )	12.5mm ( $r_{\max} = 9.1\text{mm}$ )
Max $ \mathbf{B} $ on orbit	0.228 T	0.448 T
Max quad strength	10.1 T/m	50 T/m

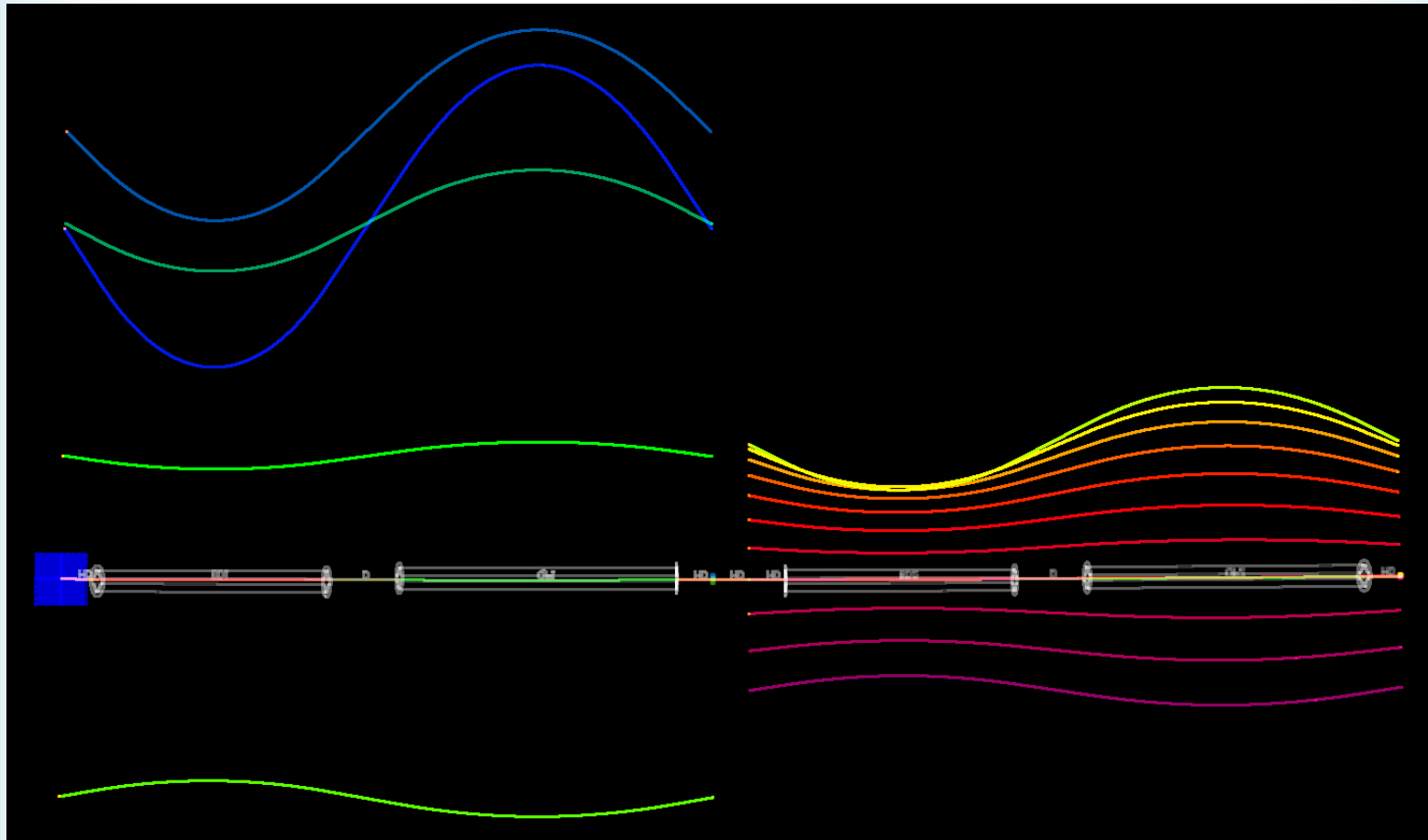
# New Lattice (2014-Jan-24)

Parameter	Low-Energy FFAG	High-Energy FFAG
Energy range	1.334 – 6.622 GeV	7.944 – 21.164 GeV
Energy ratio	4.96×	2.66×
Turns (1.322GeV linac)	5	11
Synchrotron power	0.26MW @ 50mA	9.8MW @ 21.1GeV, 18mA 10.2MW @ 15.8GeV, 50mA 3.2MW @ 10.5GeV, 50mA
TOF range	54.7ppm (12cm)	22.4ppm (5cm)
Drift space	28.8cm	28.8cm
Tune range	0.036 – 0.424	0.035 – 0.369
Orbit range (quads)	31.3mm ( $r_{\max} = 23.6\text{mm}$ )	12.6mm ( $r_{\max} = 9.1\text{mm}$ )
Max $ \mathbf{B} $ on orbit	0.227 T	0.451 T
Max quad strength	9.986 T/m	49.515 T/m

# Old Orbits Exaggerated 100x



# New Orbits Exaggerated 100x



# Old Lattice Description

Element	Length (m)	Angle (mrad)	Gradient (T/m)	Offset (mm)
All Drifts	0.2909436	0		
BD (Low)	0.9	3.014379	10.07508	-6.946947
QF (Low)	1.1	3.742197	-8.993994	6.946947
BD (High)	0.9 (as above)	3.014379	50	-3.913914
QF (High)	1.1	3.742197	-49.49950	3.913914

- Cell:  $\frac{1}{2}D, BD, D, QF, \frac{1}{2}D$
- Cells stack exactly, allowing common girder
- First 2 columns fixed, last 2 optimised
  - 50 T/m value was at upper limit of allowed range

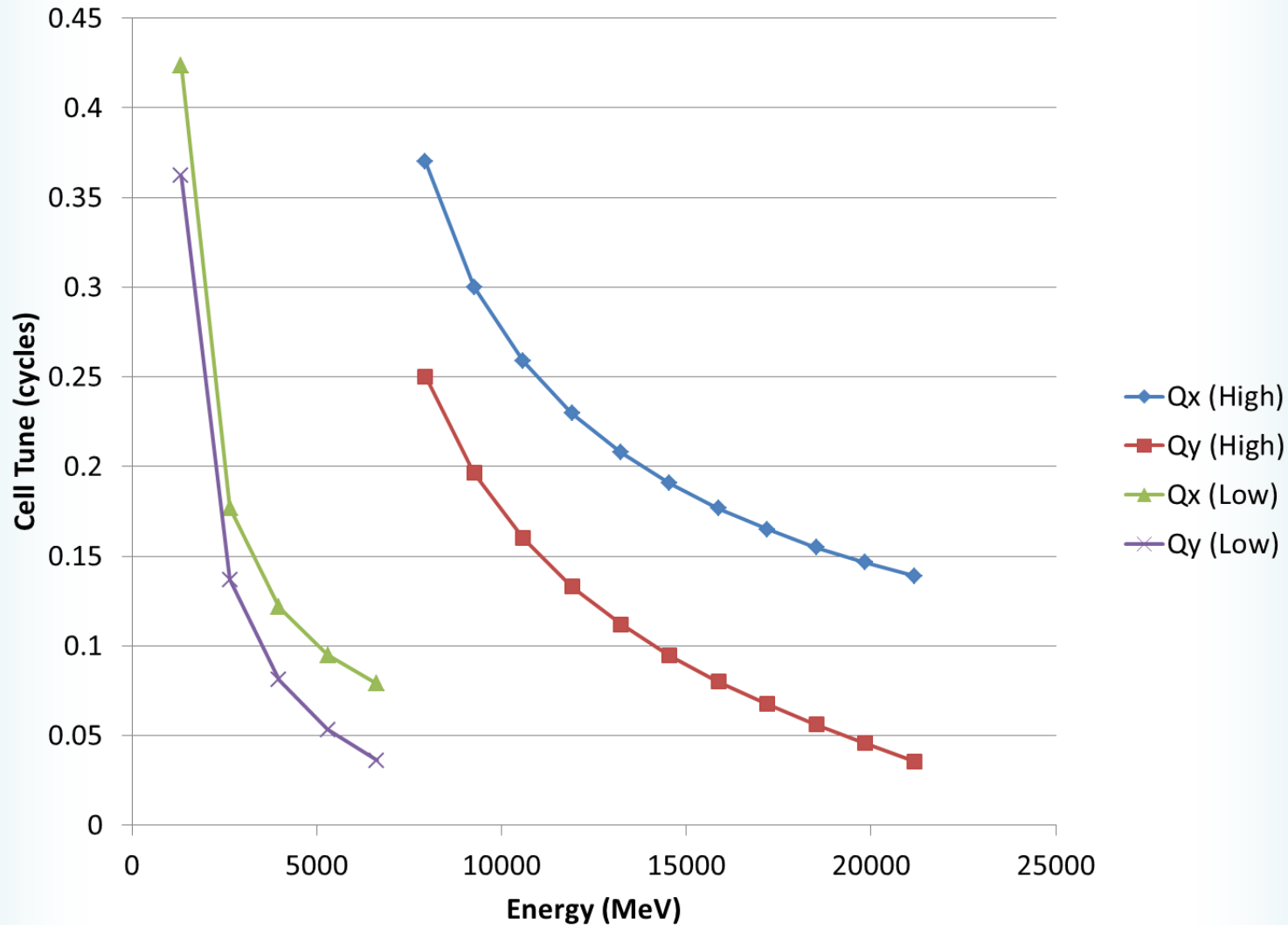


# New Lattice Description

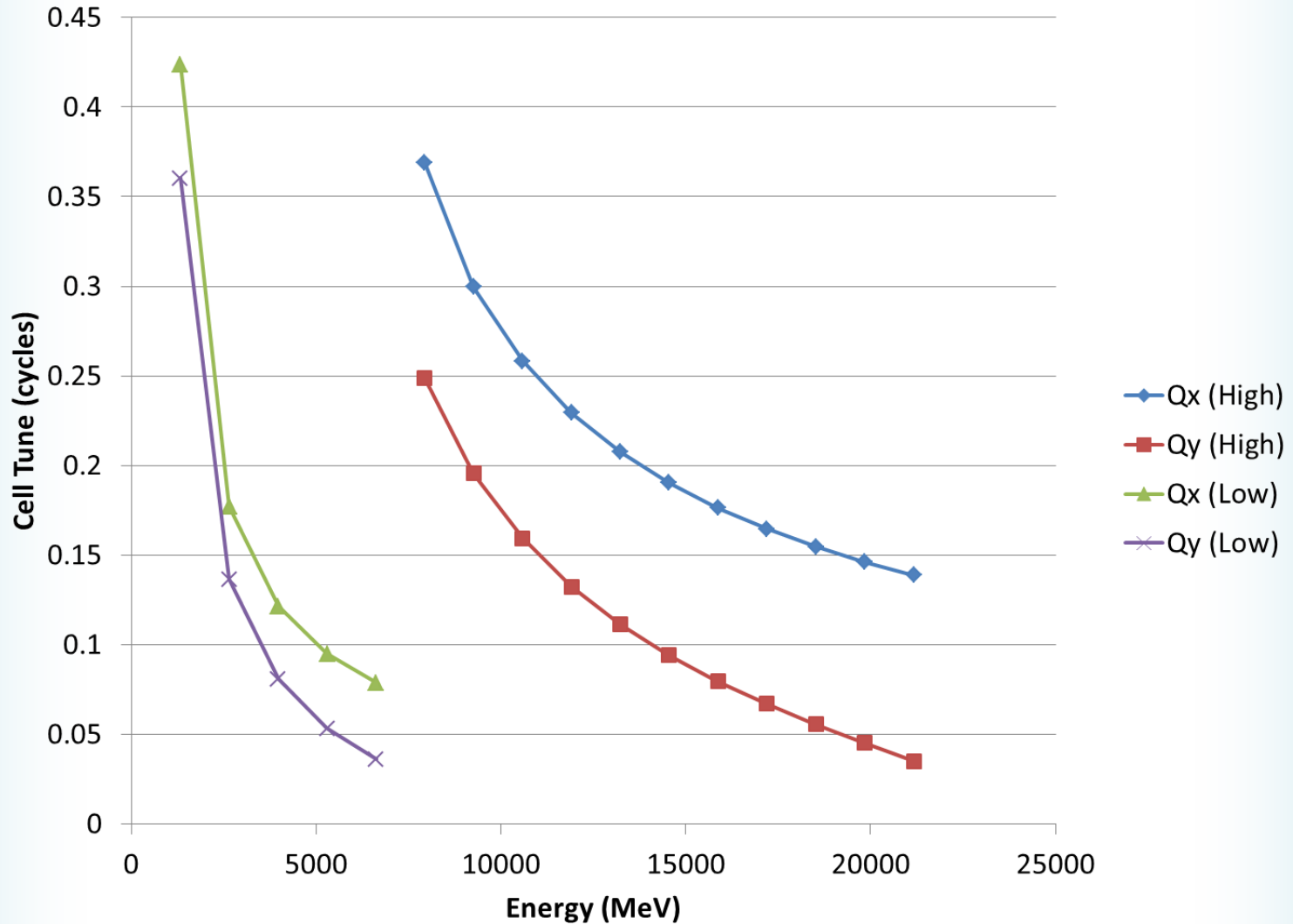
Element	Length (m)	Angle (mrad)	Gradient (T/m)	Offset (mm)
All Drifts	0.287643623	0		
BD (Low)	0.90805 = 35¾"	3.057567	9.986	-6.946947
QF (Low)	1.09855 = 43¾"	3.699017	-9.006	6.946947
BD (High)	0.90805	3.057567	49.515	-3.901098
QF (High)	1.09855	3.699017	-49.515	3.901098

- Cell: ½D, BD, D, QF, ½D
- Cells stack exactly, allowing common girder
- Specification on eRHIC Wiki
  - [http://www.cadops.bnl.gov/eRHIC/erhicWiki/index.php/FFAG\\_Design:Electrons:Lattice:Arcs](http://www.cadops.bnl.gov/eRHIC/erhicWiki/index.php/FFAG_Design:Electrons:Lattice:Arcs)

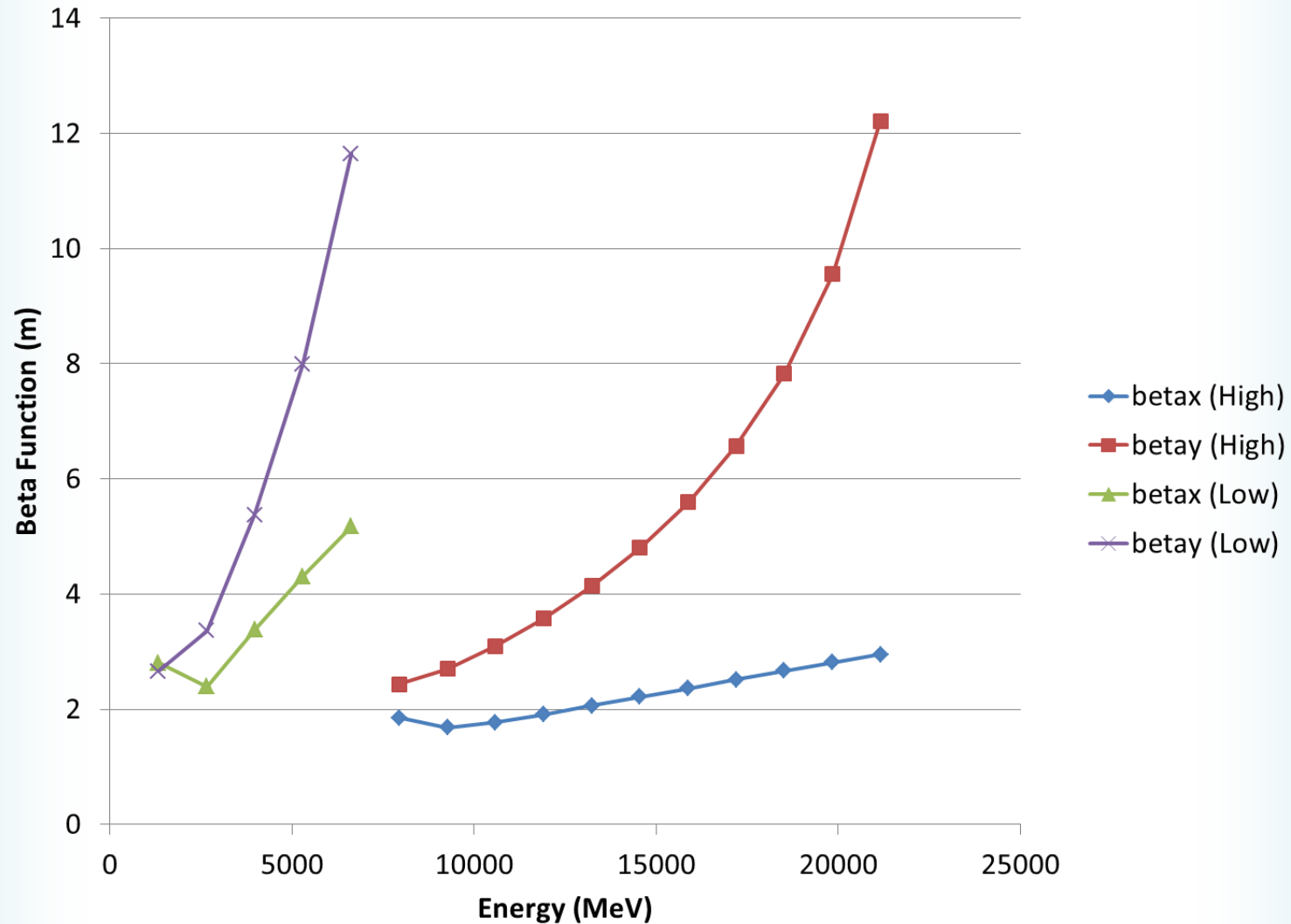
# Old Tunes



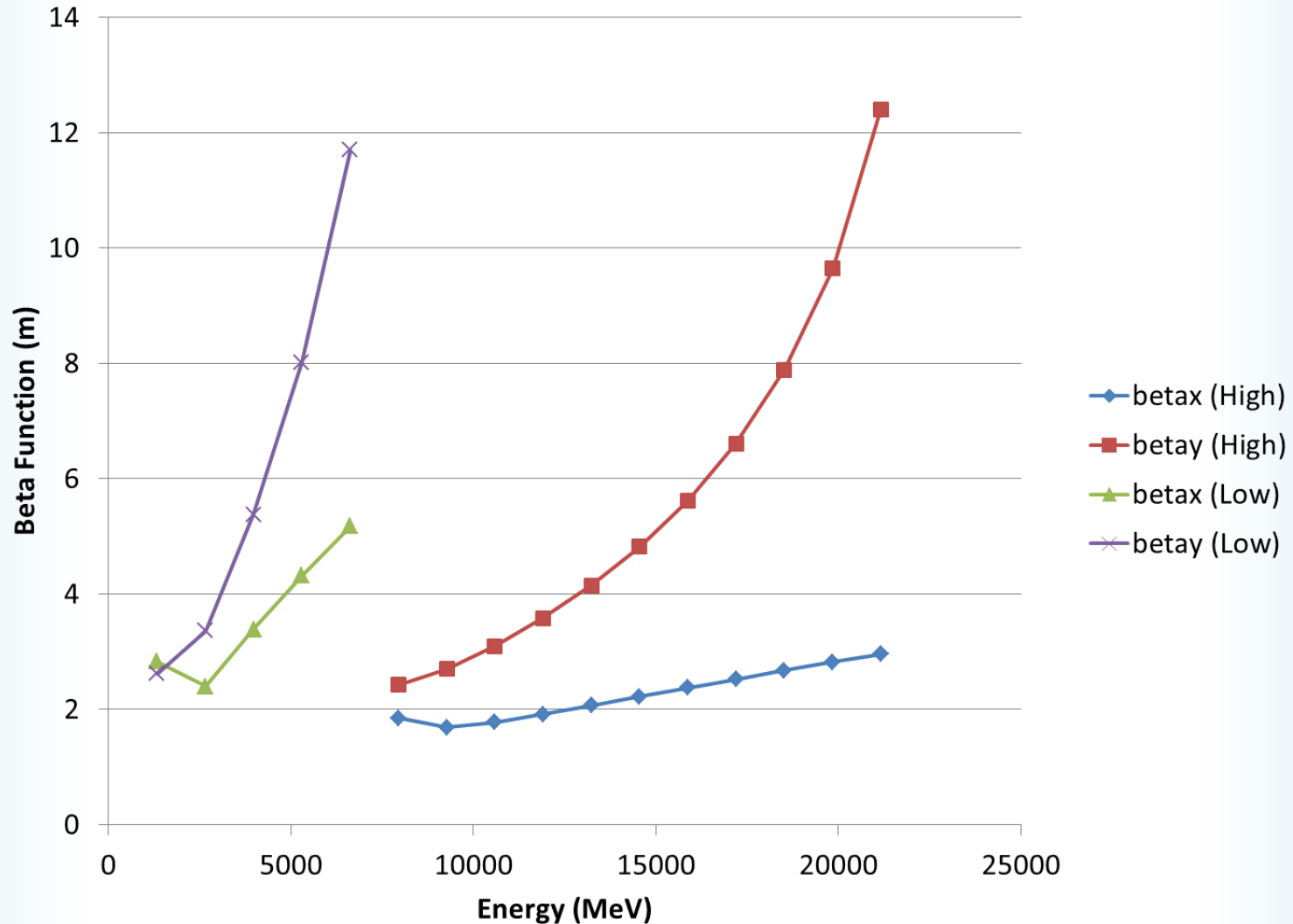
# New Tunes



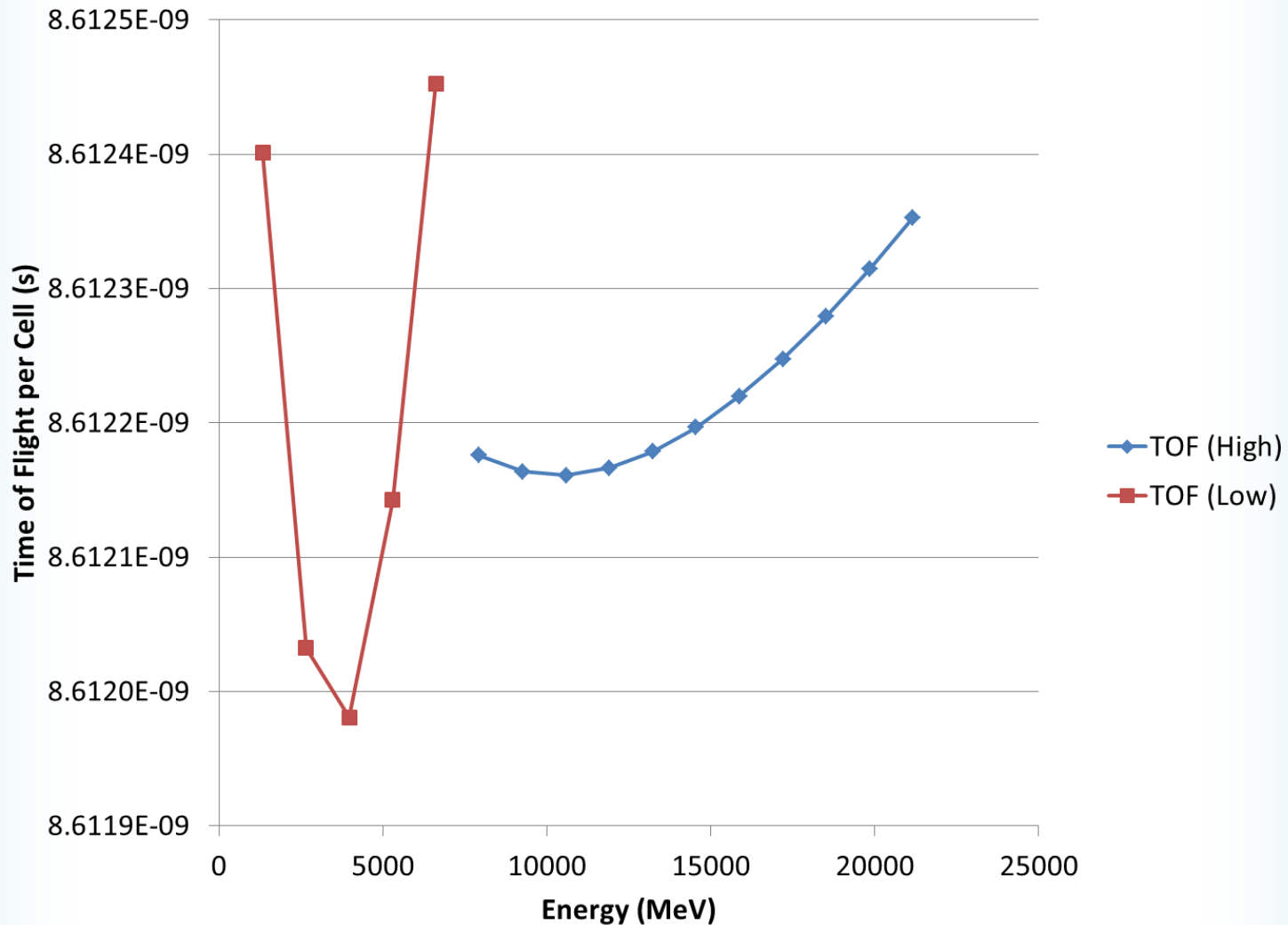
# Old Betas at Matching Plane



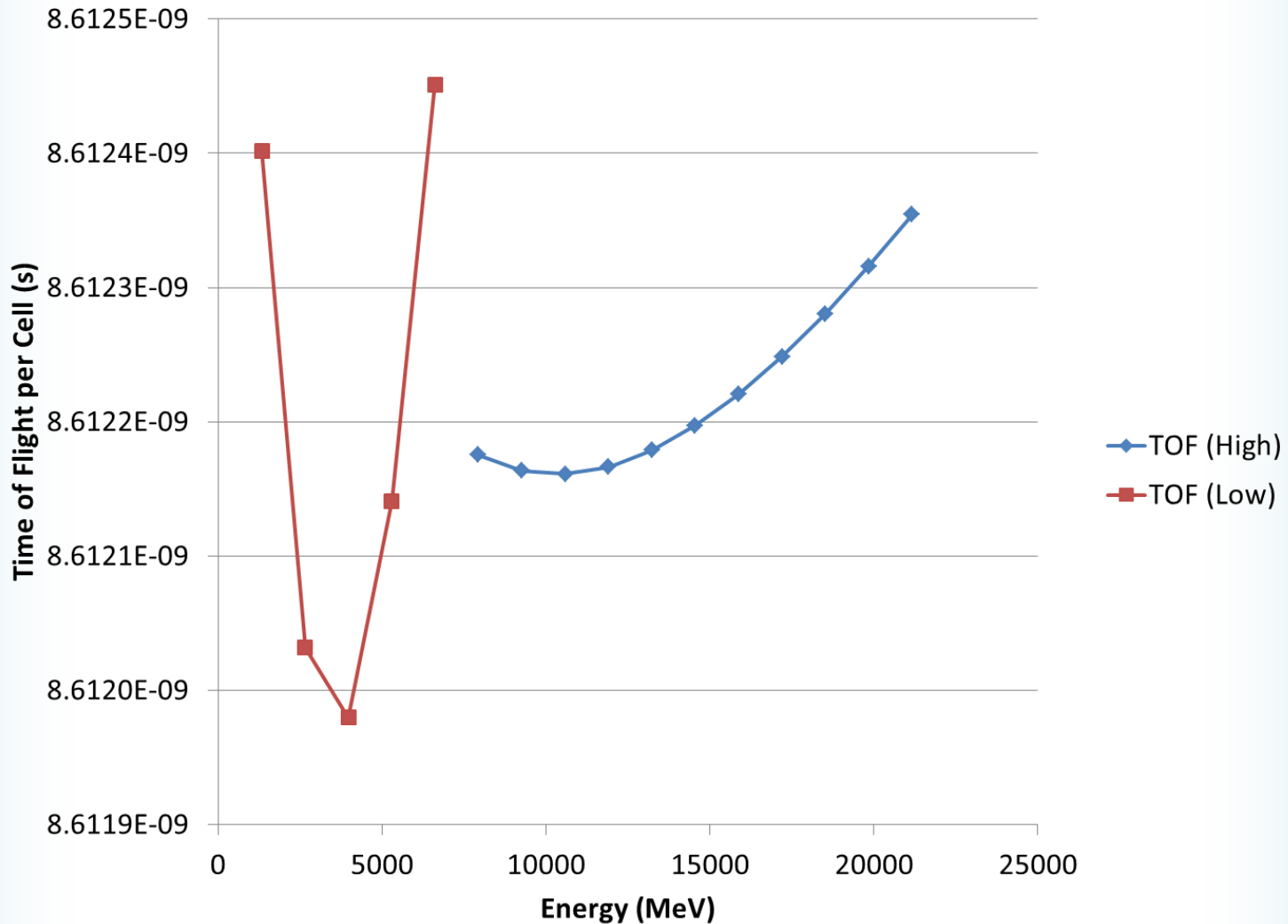
# New Betas at Matching Plane



# Old Time of Flight Variation



# New Time of Flight Variation

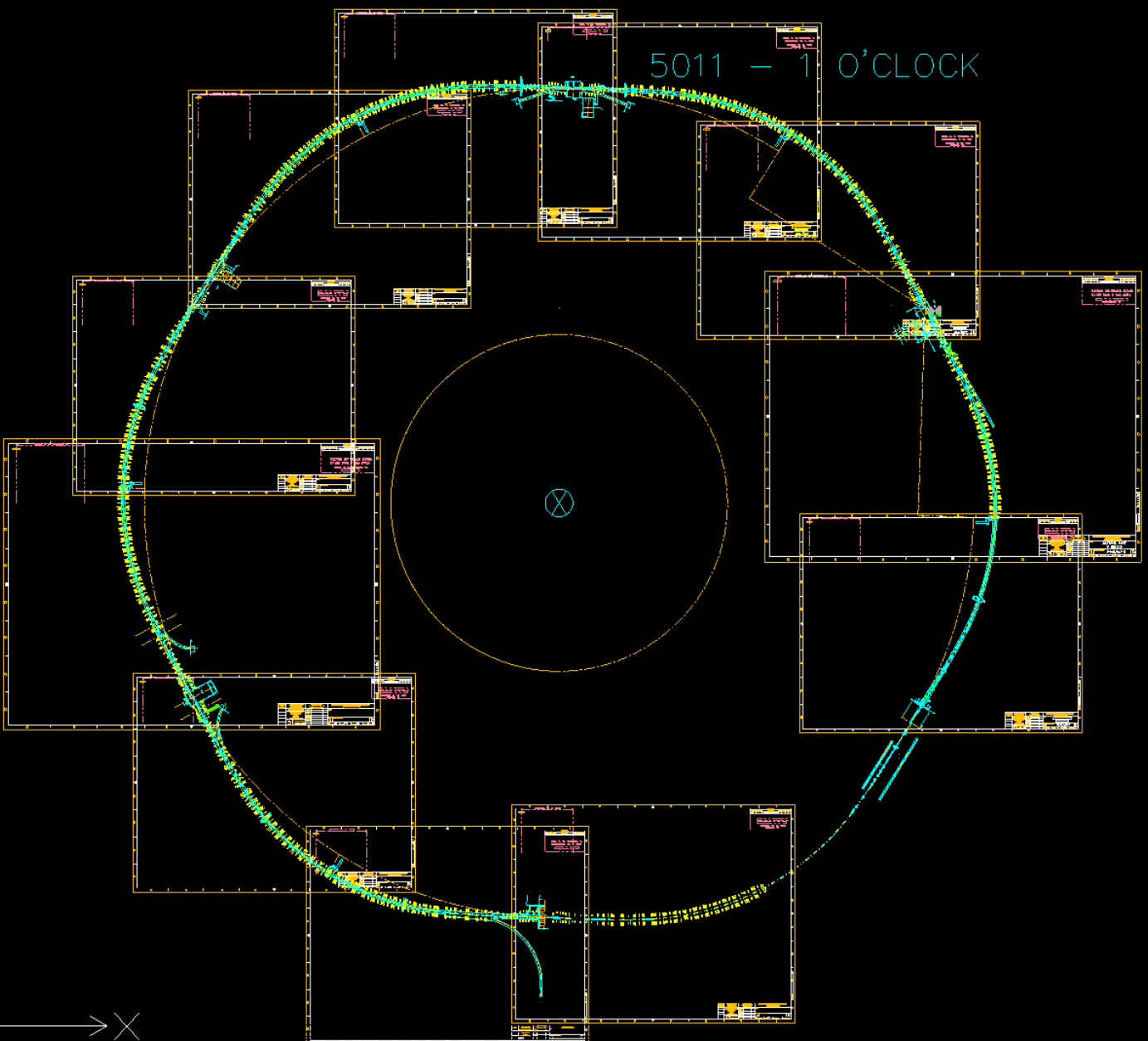


## II. eRHIC FFAGs in RHIC Tunnel

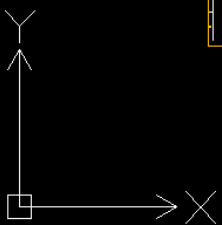


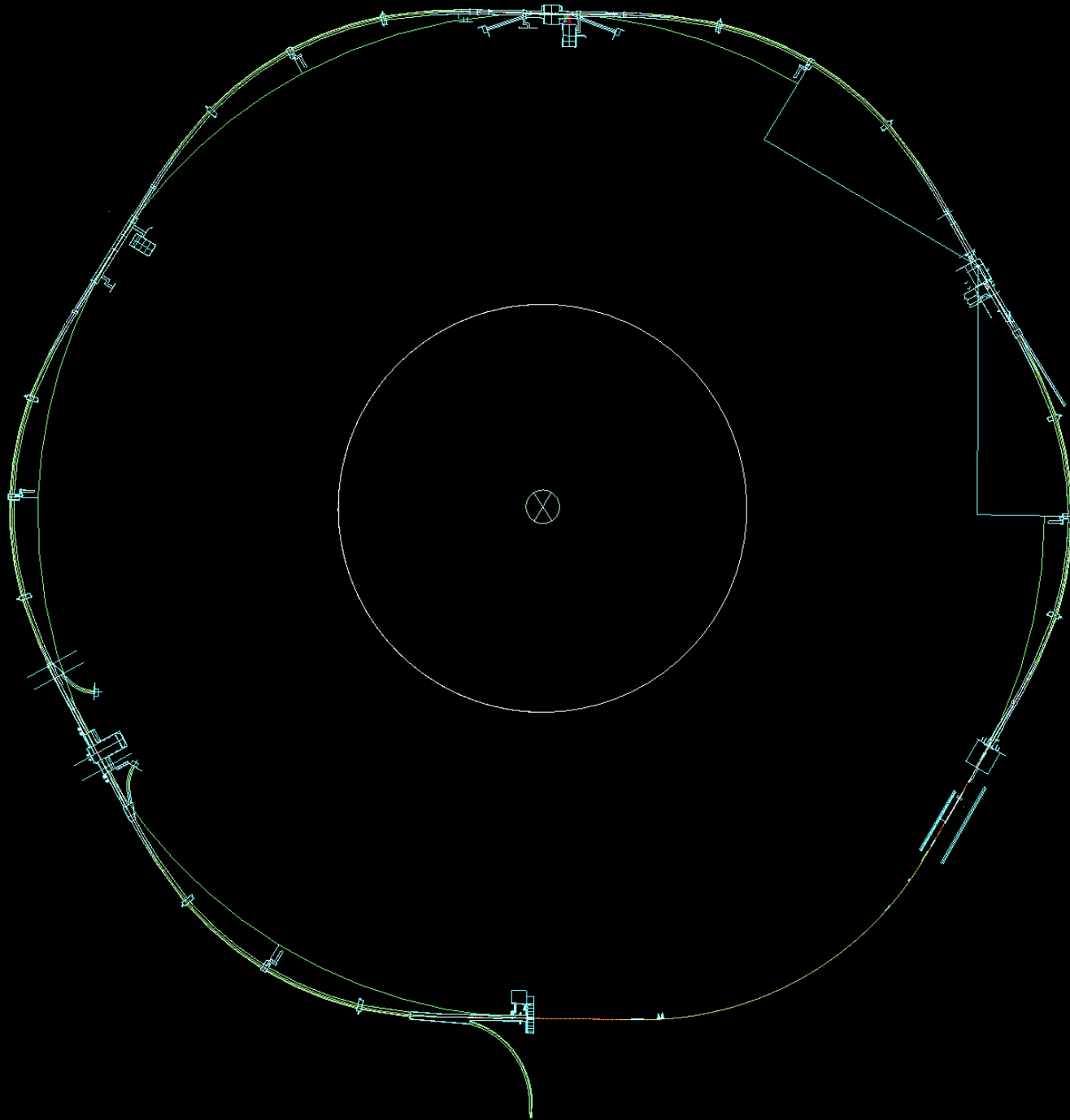
# Method

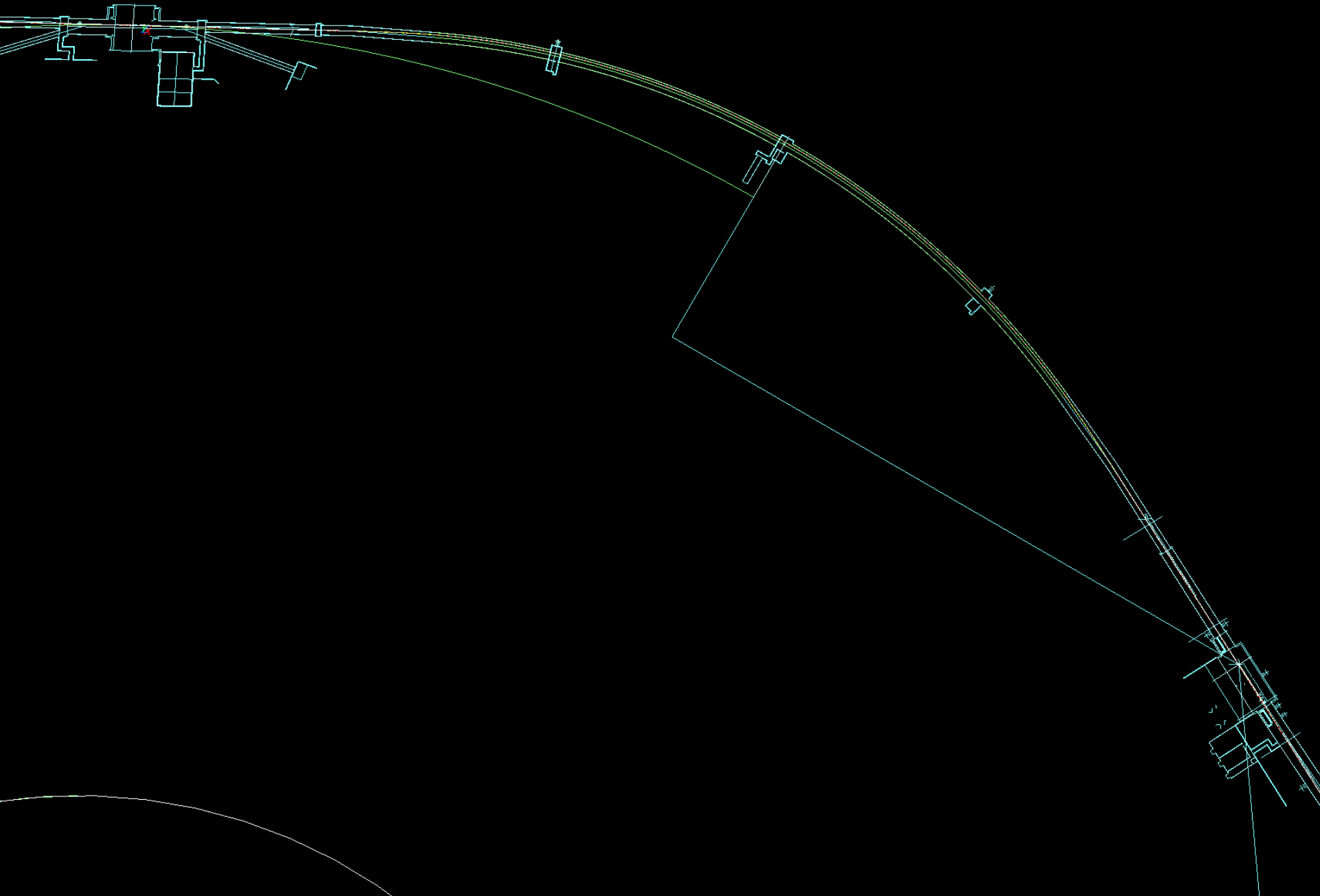
- Obtained 2D AutoCAD .dwg file of whole RHIC tunnel in plan view and survey coordinates
  - Appeared to be in inches, assumed =2.54cm
- Converted to ASCII .dxf, wrote simple importer
  - Lines, circles & circular arcs only, no reused blocks
- Got survey coords of RHIC centre & 12o'clock
  - Found out RHIC is rotated by 2 degrees wrt. North
- Overlayed this on Muon1 FFAG rings layout
  - Middle of straight started from 12o'clock



5011 - 1 O'CLOCK







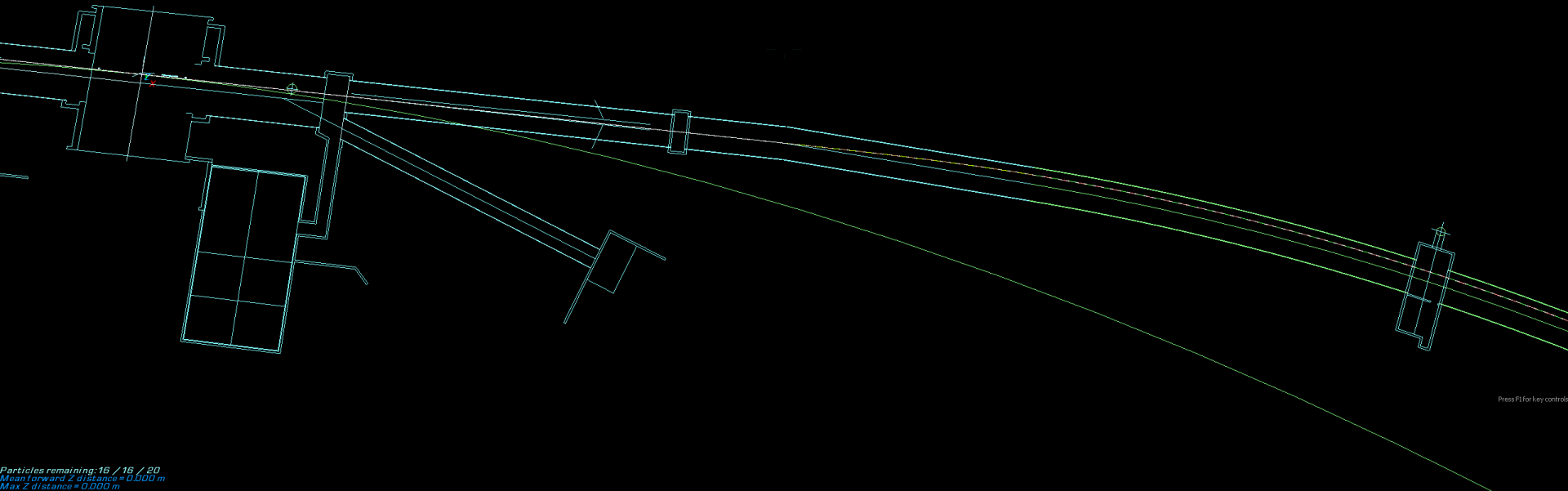
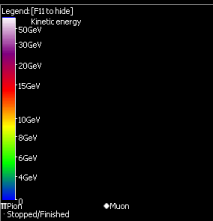
# Arc-to-Straight Matching Section

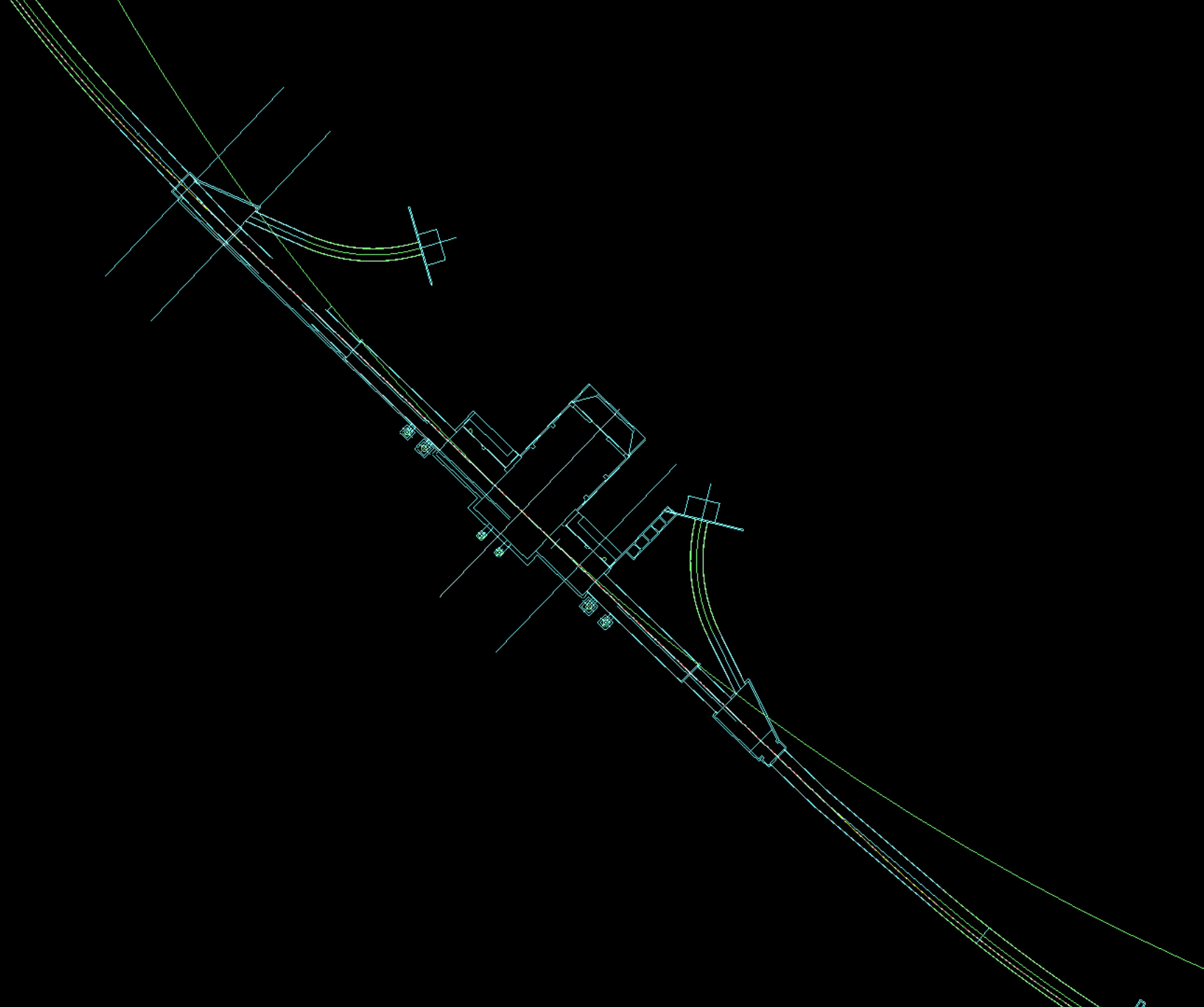
t = 0.0 ns  
Beam retained: 100.00%  
Re-impacted: 0.00% Otherwise lost: 0.00% Wrong way: 0.00%

eRHIC / 21GeV  
Autoscroll in 4m00s  
e-100.000%

Frame rate: 1/1  
Particles per 4096 (2.24ms)  
Results database: 2 entries, 154 bytes (154 bytes since last send)

View: Manual  
[PAUSED]





0%

eRHIC / 216eV  
Autosave in 4m00s

100.000%

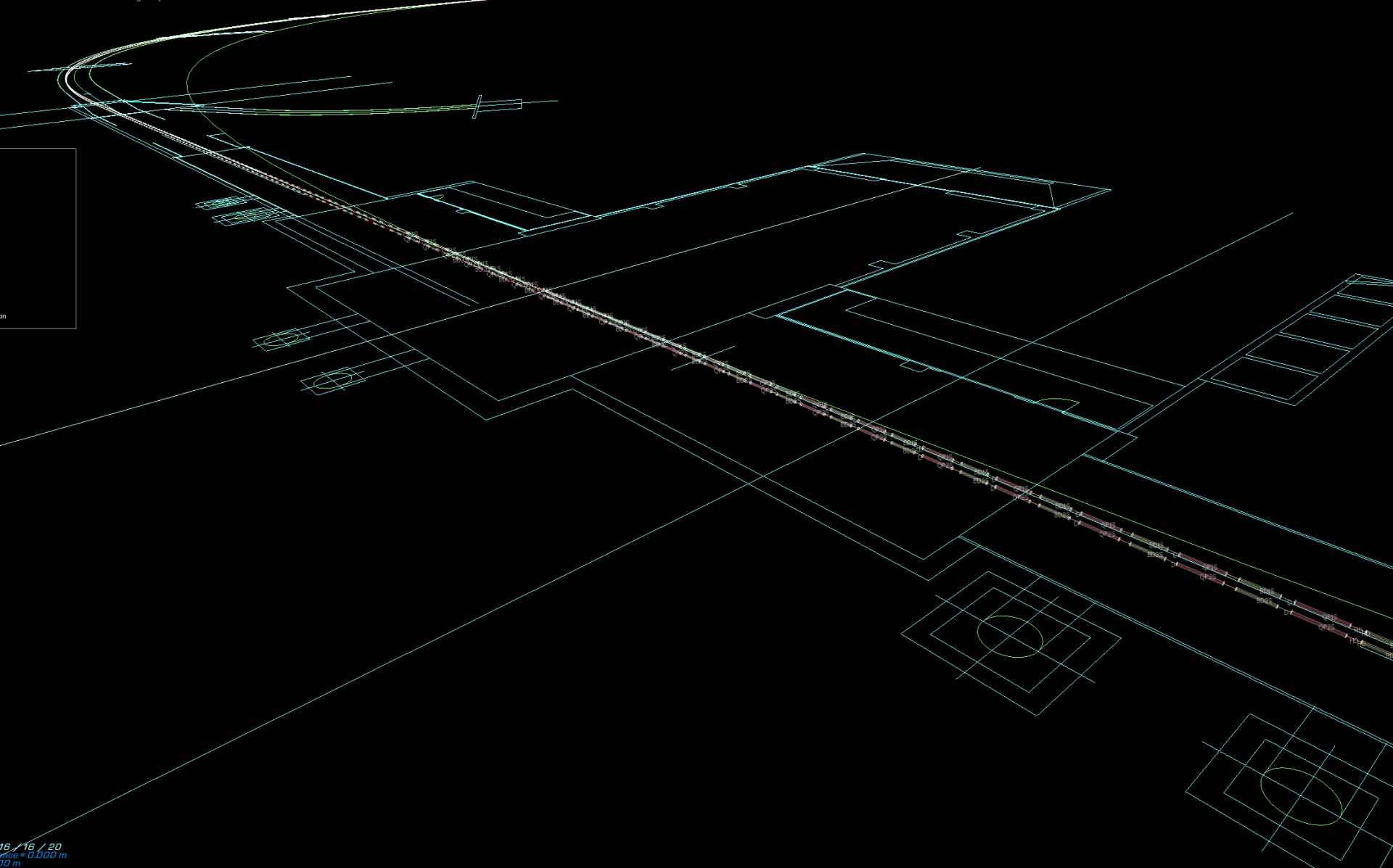
Frame-rate: 1 / s

Frame-size: 4010 (2.24mm)

Results database: 2 entries, 154 bytes (154 bytes since last send)

View: As usual

Otherwise lost: 0.00% Wrong way: 0.00%



16 / 16 / 20  
Time = 0.000 m  
00 m