

Nov'15 eRHIC Arc Cell Candidates

Designs for 3+9 turn FFAGs

Scott's and Dejan's cells replicated in
Muon1

High-Energy Cells

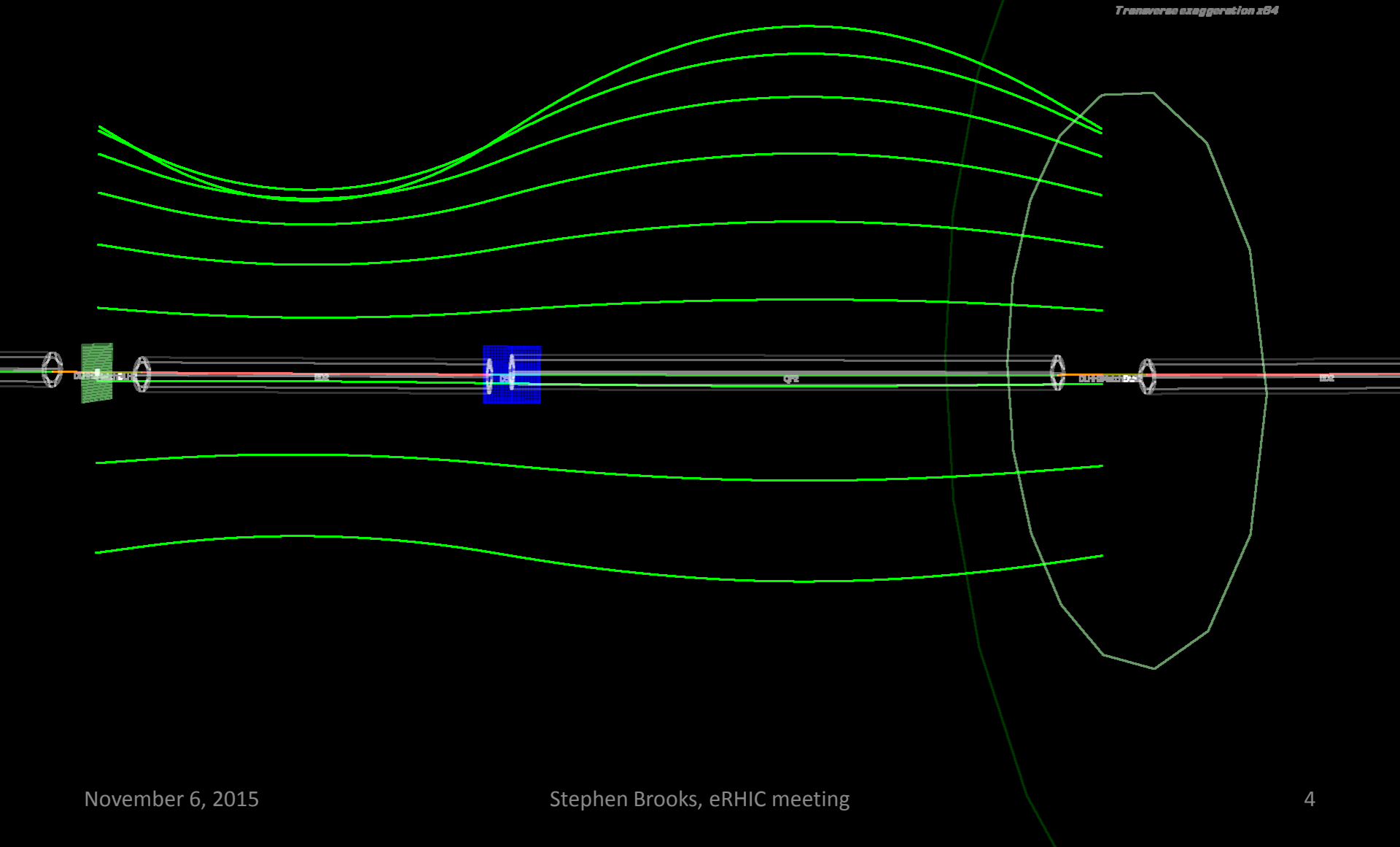
- Only presenting 3+9 configurations today
 - Favoured by management, so should be baseline
 - 4+8 probably gives $\sim 25\%$ lower synch. Radiation
- Slight difference in energies
 - Dejan: 1.67GeV linac, 20MeV injector
 - FFAG2 goes from 6700MeV to 20060MeV
 - Scott: 1.666666...GeV linac, 0MeV injector
 - FFAG2 goes from 6666.66...MeV to 20000MeV

Dejan's High-Energy Cell (3.59m)

Element	Length (m)	Angle (mrad)	Gradient (T/m)	Offset (mm)
BD2	1.241	3.652780	24.1	-6.721992
DS2	0.08	0		
QF2	1.95	5.739663	-18.05	8.975069
DL2	0.32	0		

- Both equivalent dipoles equal: $-G\Delta x = 0.162T$
– MAD central energy is 16.5GeV
- Watch out for signs: Muon1 uses negative electrons going anticlockwise (eRHIC = yellow ring)...

Dejan's High-Energy Cell Orbits

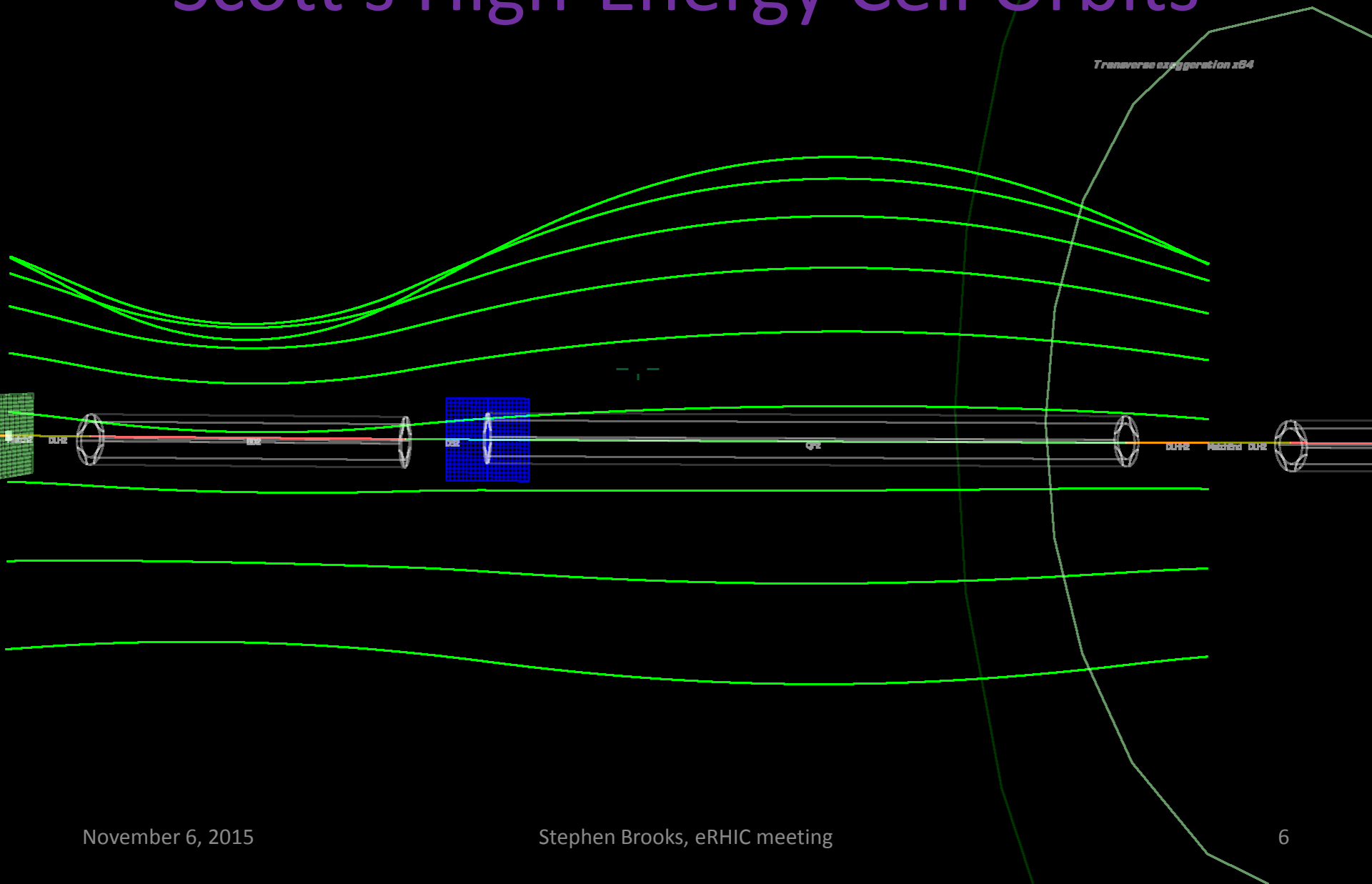


Scott's High-Energy Cell (2.92m)

Element	Length (m)	Angle (mrad)	Gradient (T/m)	Offset (mm) *
BD2	0.765130	2.013499	47.38545	-7.497158 *
DS2	0.2	0.526316		
QF2	1.552737	4.086149	-26.90183	3.199020 *
DL2	0.4	1.052632		

- * Scott aligns relative to a chord connecting the ends of an $R=380\text{m}$ circular arc, so these offsets are relative to that line instead
 - Circle continues through drifts, so they also have curvature

Scott's High-Energy Cell Orbits



High-Energy Cells Performance

Parameter	Jun'15	Dejan	Scott
Energy range	6.622 – 21.164 GeV	6.700 – 20.060 GeV	6.667 – 20.000 GeV
Energy ratio	3.20×	2.99×	3.00×
Turns	12 (1.322 GeV linac)	9 (1.67 GeV linac)	9 (1.666...GeV linac)
Synchrotron power (* L=2138m arcs) (* I=-10mA)	6.31MW @ 21.1GeV 2.27MW @ 15.8GeV 0.92MW @ 10.5GeV	3.60MW @ 20.0GeV 1.61MW @ 15.0GeV 0.62MW @ 10.0GeV	4.21MW @ 20.0GeV 2.28MW @ 15.0GeV 0.80MW @ 10.0GeV
TOF range	56.9ppm (12cm)	55.4ppm (12cm)	34.7ppm (7cm)
Long drift space	18.0cm	32.0cm	40.0cm
Tune range	0.024 – 0.346	0.023 – 0.341	0.050 – 0.345
Orbit range (quads)	30.5mm ($r_{\max}=21.7$)	31.0mm ($r_{\max}=21.0$)	20.1mm ($r_{\max}=13.2$)
Max $ \mathbf{B} $ on orbit	0.467 T	0.461 T	0.595 T
Max quad strength	28.870 T/m	24.1 T/m	47.385 T/m

Historical High-Energy Cells

Parameter	Jan'14 (50T/m FODO)	Oct'14 (30T/m doublet)	Jun'15 (4+12 turns)
Energy range	7.944 – 21.164 GeV	7.944 – 21.164 GeV	6.622 – 21.164 GeV
Energy ratio	2.66×	2.66×	3.20×
Turns (1.322GeV linac)	11	11	12
Synchrotron power (* L=2138m arcs) (* I=-10mA)	5.44MW @ 21.1GeV 2.04MW @ 15.8GeV 0.64MW @ 10.5GeV	4.95MW @ 21.1GeV 1.90MW @ 15.8GeV 0.60MW @ 10.5GeV	6.31MW @ 21.1GeV 2.27MW @ 15.8GeV 0.92MW @ 10.5GeV
TOF range	22.4ppm (5cm)	38.0ppm (9cm)	56.9ppm (12cm)
Drift space	28.8cm	45.0cm (and 6.0cm)	18.0cm
Tune range	0.035 – 0.369	0.033 – 0.410	0.024 – 0.346
Orbit range (quads)	12.6mm ($r_{\max} = 9.1$)	21.6mm ($r_{\max} = 15.8$)	30.5mm ($r_{\max} = 21.7$)
Max $ \mathbf{B} $ on orbit	0.451 T	0.416 T	0.467 T
Max quad strength	49.515 T/m	29.256 T/m	28.870 T/m

Scott's Low-Energy Cell (4.02m)

Element	Length (m)	Angle (mrad)	Gradient (T/m)	Offset (mm) *
BD1	0.529077	1.392308	13.95036	-9.813381 *
DS1	0.2	0.526316		
QF1	2.890003	7.605271	-2.991695	6.926257 *
DL1	0.4	1.052632		

- * Scott aligns relative to a chord connecting the ends of an $R=380\text{m}$ circular arc, so these offsets are relative to that line instead
 - Circle continues through drifts, so they also have curvature

Transverse exaggeration x64

Low-Energy Cell Performance

Parameter	Jun'15	Scott
Energy range	1.334 – 5.300 GeV	1.667 – 5.000 GeV
Energy ratio	3.97×	3.00×
Turns	4 (1.322GeV linac)	3 (1.666...GeV linac)
Synchrotron power (* L=2138m arcs)	0.11MW @ 50mA	0.04MW @ 50mA
TOF range	42.7ppm (9cm)	49.6ppm (11cm)
Long drift space	30.0cm	40.0cm
Tune range	0.062 – 0.277	0.050 – 0.393
Orbit range (quads)	28.1mm ($r_{\max} = 23.3\text{mm}$)	33.6mm ($r_{\max} = 23.7\text{mm}$)
Max $ \mathbf{B} $ on orbit	0.238 T	0.246 T
Max quad strength	10.6 T/m	13.950 T/m

Historical Low-Energy Cells

Parameter	Jan'14	Oct'14	Jun'15
Energy range	1.334 – 6.622 GeV	1.334 – 6.622 GeV	1.334 – 5.300 GeV
Energy ratio	4.96×	4.96×	3.97×
Turns (1.322GeV linac)	5	5	4
Synchrotron power	0.26MW @ 50mA	0.34MW @ 50mA	0.11MW @ 50mA
TOF range	54.7ppm (12cm)	31.0ppm (7cm)	42.7ppm (9cm)
Drift space	28.8cm	45.0cm	30.0cm
Tune range	0.036 – 0.424	0.033 – 0.408	0.062 – 0.277
Orbit range (quads)	31.3mm ($r_{\max} = 23.6\text{mm}$)	16.9mm ($r_{\max} = 11.1\text{mm}$)	28.1mm ($r_{\max} = 23.3\text{mm}$)
Max $ \mathbf{B} $ on orbit	0.227 T	0.266 T	0.238 T
Max quad strength	9.986 T/m	25 T/m	10.6 T/m

Next Steps

- I need a cell to present at the eRHIC R&D review in a hurry
 - I'll probably just take Dejan's high-energy ring with Scott's low-energy ring
- Probably should think a bit more before converging on Nov'15 cell for Wiki and end-to-end simulations
 - Tweak some oddities in Scott's cells (high tune...)
 - Perhaps make the two cells an integer length ratio