eRHIC Low-Energy (FFAG) Ring

Linac vs. Local Turns Issues

- Previously I had a bunch structure that could produce gaps in the linac even with local turns
- Unfortunately the scheme still has unbalanced accelerating/decelerating bunches
  - Vladimir had 0.5% dE/E as cavity energy varied
- Can be avoided with 2nd FFAG in RHIC tunnel
  - Vladimir's idea: same revolution period means can make a single linac gap and not create a mess
  - But we don't want a 100% cost increase!

Economising a Dual-FFAG Girder

- The low energy ring (LER) will require lower magnetic fields for 1.0, 1.9 GeV certainly
  - But component count is a big source of costs
- Idea: increase cell length to a multiple of the high-energy ring cell and use a common girder
  - 2x length means 50% more components
  - 3x length means only 33% more, etc.
    - This applies to correctors, power supplies, cables and diagnostics as well as the magnets

Muon1 LER Cell Optimisations

- Used doublet designs throughout
- 2x, 3x, 4x length cells attempted
  - 5.16m, 7.75m, 10.33m
- Various constraint sets applied:
  - Tune range limits
  - TOF range limits (usually 35ppm of 2.8-10 FFAG)
  - Quad gradient and offset limits
  - Reduce synchrotron power if successful
    - But this is very small!

Muon1 LER Cell Constraint Sets

Constraint variant	Tune min	Tune max	Max offset of quad centre (m)	Max gradient (T/m)	Max magnet length (m)	Max offset of orbits at matching plane (m)	Max TOF range (ppm)	Notes
Original	0.1	0.4	0.025	10	0.5	0.03	-	
a	0.1	0.4	0.05	10	0.5	0.05	-	
b	0.1	0.4	0.1	10	0.5	0.05	-	For 4x cell, didn't help
c	0.05	0.45	0.05	10	0.7	0.05	35	Also let drifts have different lengths
d	0.05	0.4	0.05	10	0.7	0.05	35	
e	0.05	0.4	0.07	5	0.7	0.05	35	
e42	0.05	0.42	0.07	5	0.7	0.05	35	

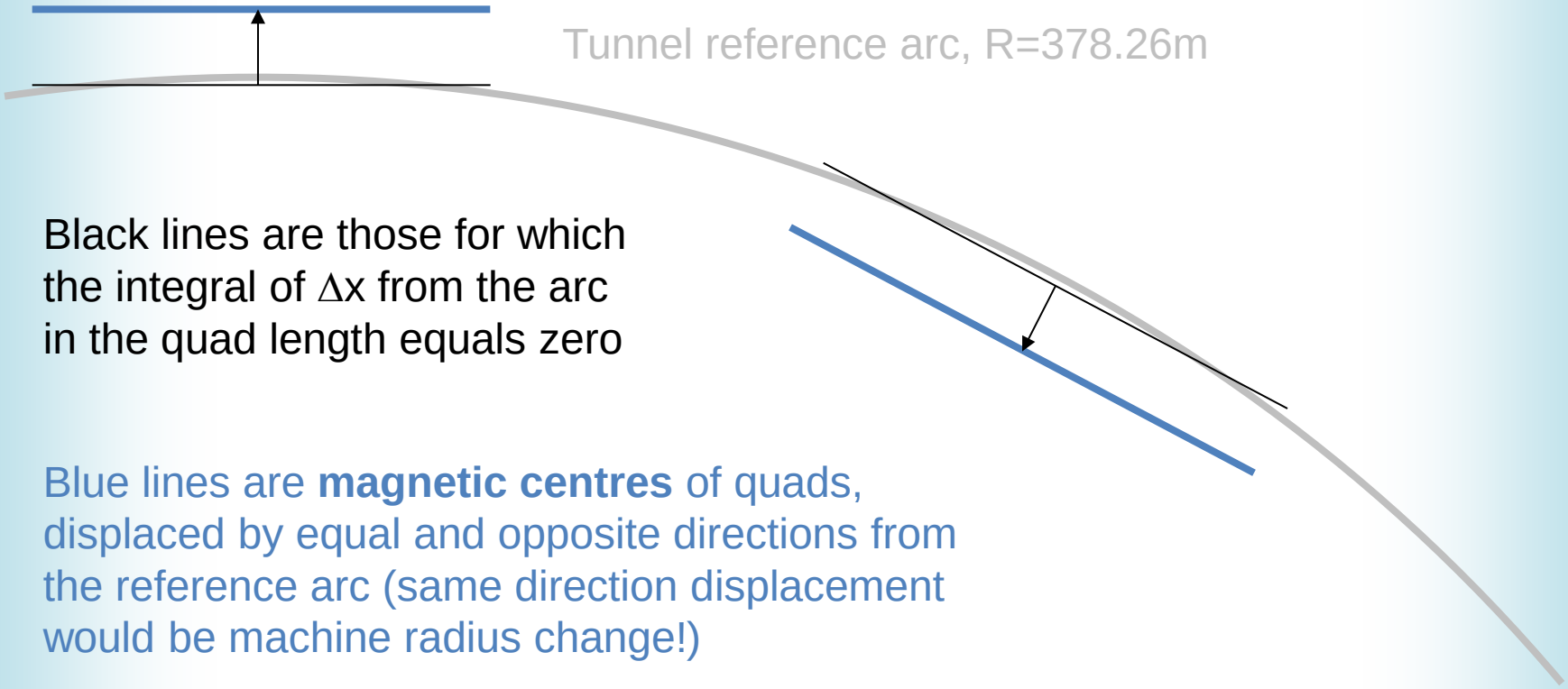
Muon1 LER Optimisation Results

Girder cells	Optimisation variant	SR power (MW)	Orbit range at matching plane (m)	Orbit range relative to tunnel arc (m)	TOF range (ppm)	Tune min	Tune max	Magnet packing factor	Max gradient (T/m)	Max field on orbit (T)	Quad offsets relative to tunnel arc (m)
2	-	0.00181	0.01919	0.02700	35.8021	0.14091	0.38398	0.18183	5.43544	0.13977	0.01649
2	a	0.00166	0.01751	0.02467	32.7802	0.10067	0.39943	0.19356	5.25526	0.11804	0.01757
2	c	0.00119	0.01563	0.02187	30.8304	0.05156	0.44909	0.27098	4.03403	0.08086	0.01747
3	a	0.00277	0.03758	0.05348	63.5660	0.10269	0.39859	0.11347	4.45445	0.18690	0.04279
3	c	0.00210	0.03178	0.05242	34.9714	0.1331	0.44951	0.17025	2.91291	0.14933	0.04119
3	d	0.00570	0.03238	0.05451	34.9990	0.15809	0.40036	0.10548	10	0.57114	0.03208
3	es	0.00215	0.03495	0.05737	34.8947	0.1634	0.40107	0.17894	2.54755	0.15850	0.03945
3	e42	0.00228	0.02957	0.04886	34.9054	0.13613	0.41563	0.15460	3.57858	0.15949	0.04155

Notes on Optimisations

- None of the 4x length optimisations (4, 4a, 4b, 4c) produced an FFAG satisfying the constraints across the whole energy range
- Neither did 3/Original and 3e
  - Optimisation "3es" is 3e seeded with 3c's design
- I would recommend going with either 3es or 3e42 from the previous slide
- Some improvement may be had from looking only at 2 orbits, not the whole range

Notes on Muon1 Quad Alignment

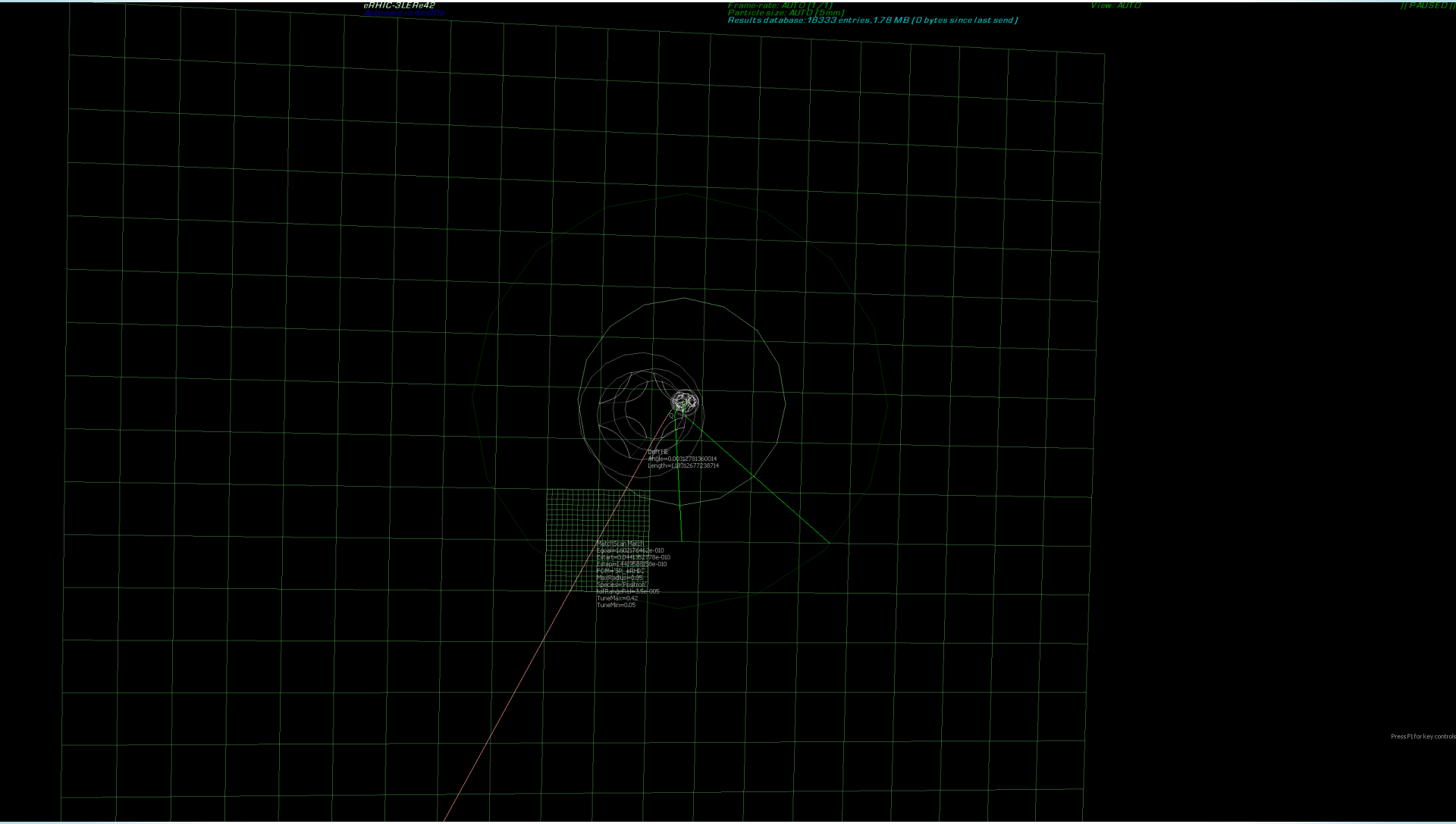


Black lines are those for which the integral of Δx from the arc in the quad length equals zero

Blue lines are **magnetic centres** of quads, displaced by equal and opposite directions from the reference arc (same direction displacement would be machine radius change!)

3x Length LER e42 Pictures

3x Length LER e42 Pictures



3x Length LER e42 Pictures