Acceleration Plan for Study IIa

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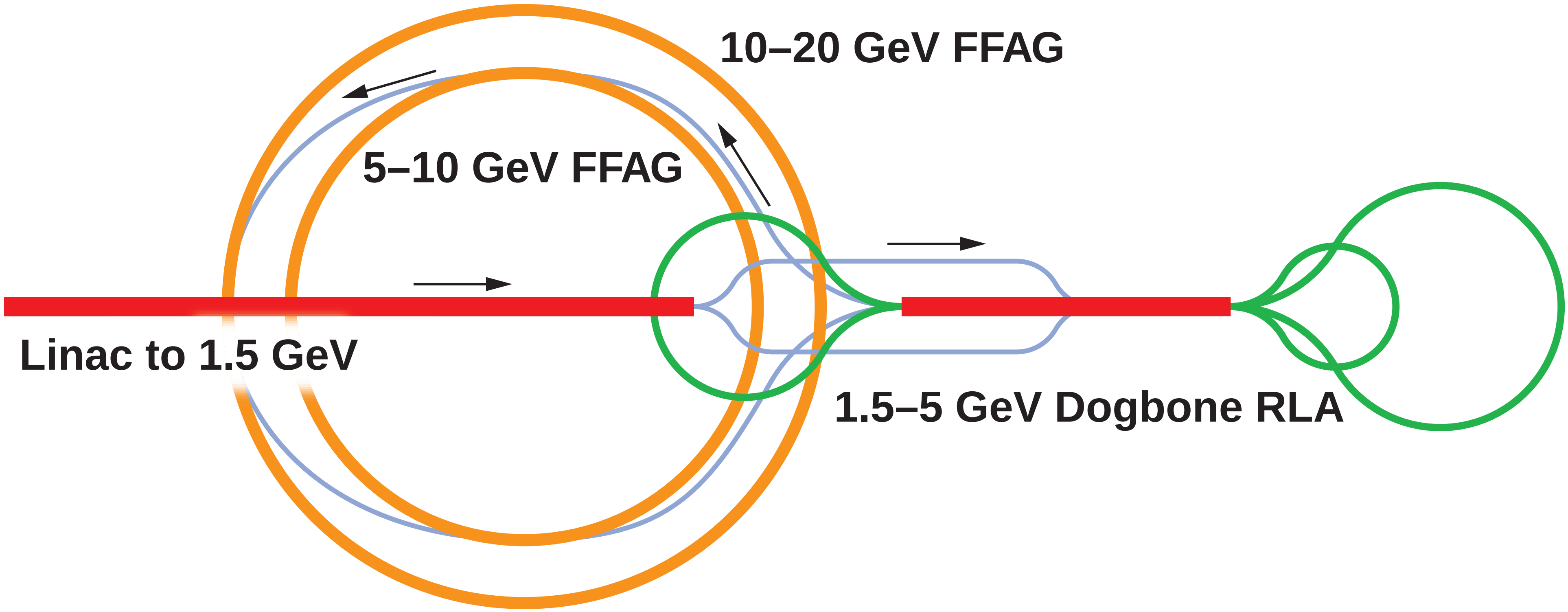
Neutrino Factory Working Group Meeting

APS Neutrino Study

The Plan

- General layout: linac, RLA, two FFAG rings.
- Start with cost-optimized FFAG parameter set (Berg)
  - 5–10 GeV and 10–20 GeV
- Obtain approximate FFAG magnet design to get end fields (Kahn)
- Track FFAG in ICOOL (Palmer)
  - 5–10 GeV first: trickiest
- Examine longitudinal transmission (Berg)
- Validate ICOOL tracking (Berg)
- Design linac and RLA for low energy (Bogacz)
- Produce kicker specifications (Palmer)
- Produce FFAG magnet design for costing purposes (Gupta?)
  - 10–20 GeV first: drives cost

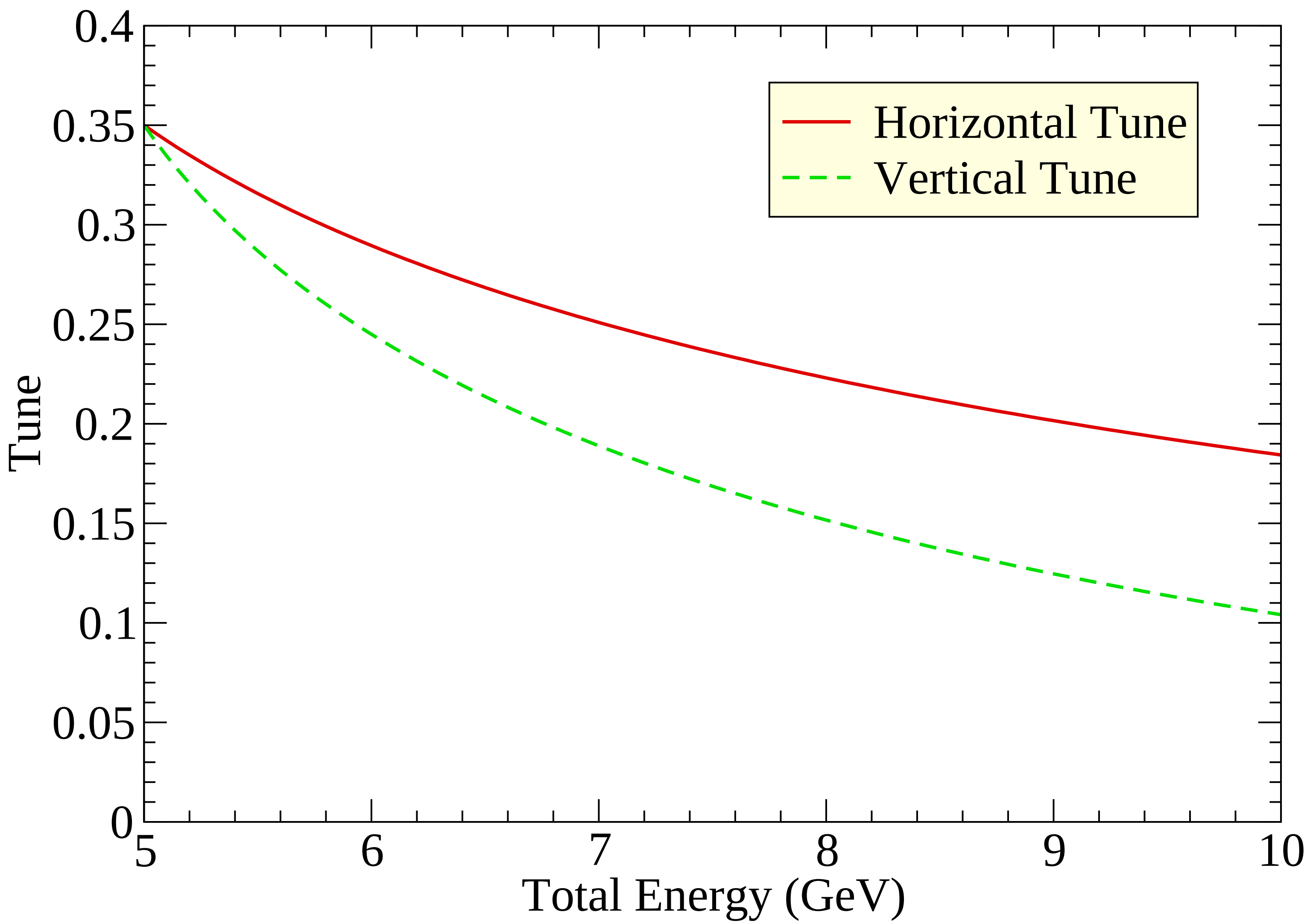
Acceleration Layout



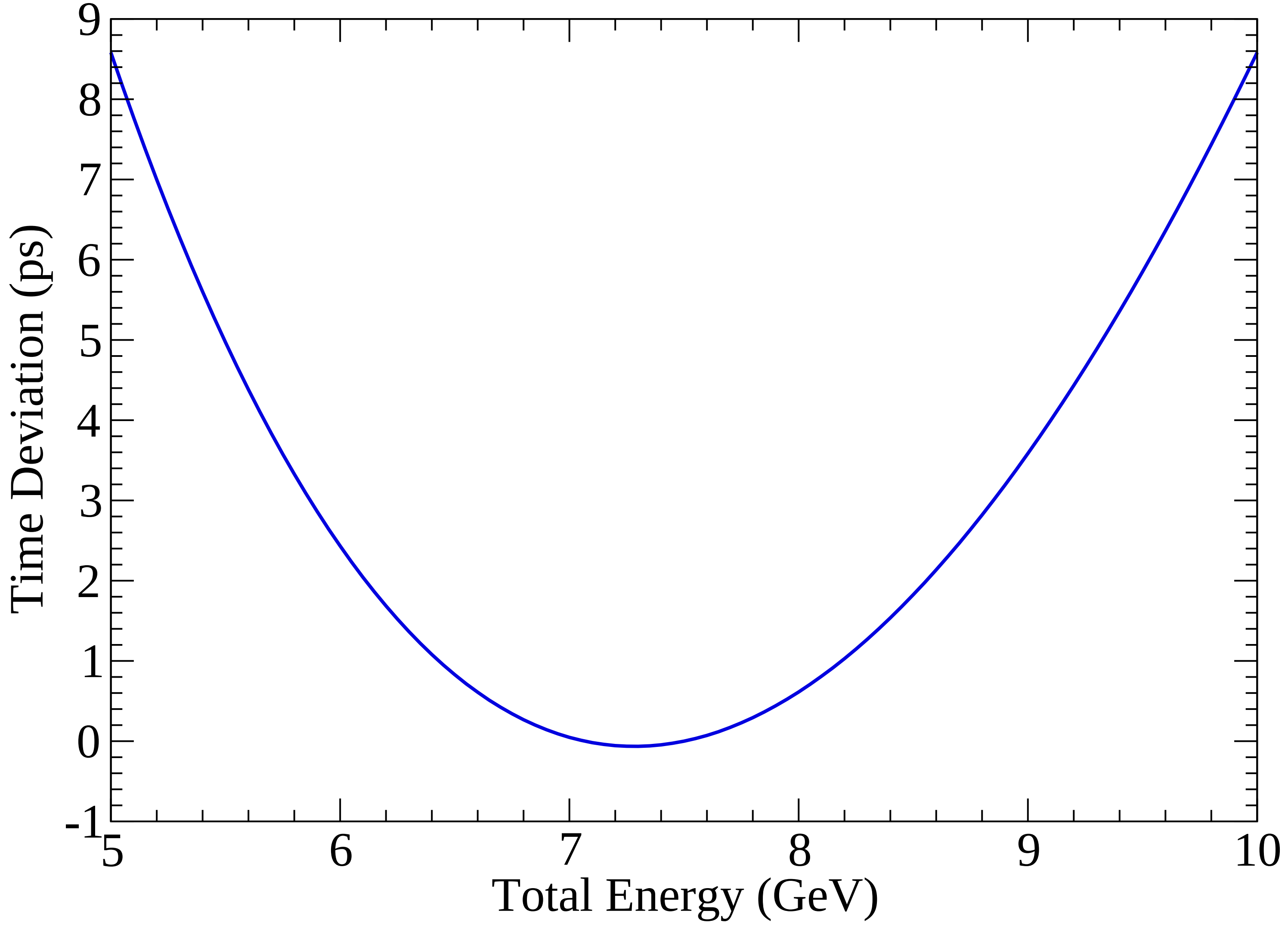
Cost-Optimized FFAG Design

- Assuming a triplet non-scaling FFAG
  - Doublets look slightly better for cost, but triplets may have better stability properties
- Specify low-energy tunes, voltage per cell, drift length for RF cavity (L_0), drift between adjacent magnets (L_Q), $V/\omega\Delta T\Delta E$ (V is total voltage, ΔT is height of time-of-flight parabola, ΔE is energy range, ω is angular RF frequency: characterizes longitudinal phase space transmission)
- Normalized transverse acceptance $A_{\perp n}$
- Time-of-flight parabola has equal values at low and high energies
- Assume 8 cells have no RF (injection/extraction)
- Minimize cost
  - Palmer's cost model, with my continuity modification
  - Magnet aperture 1.3 times that required for beam

Tunes vs. Energy



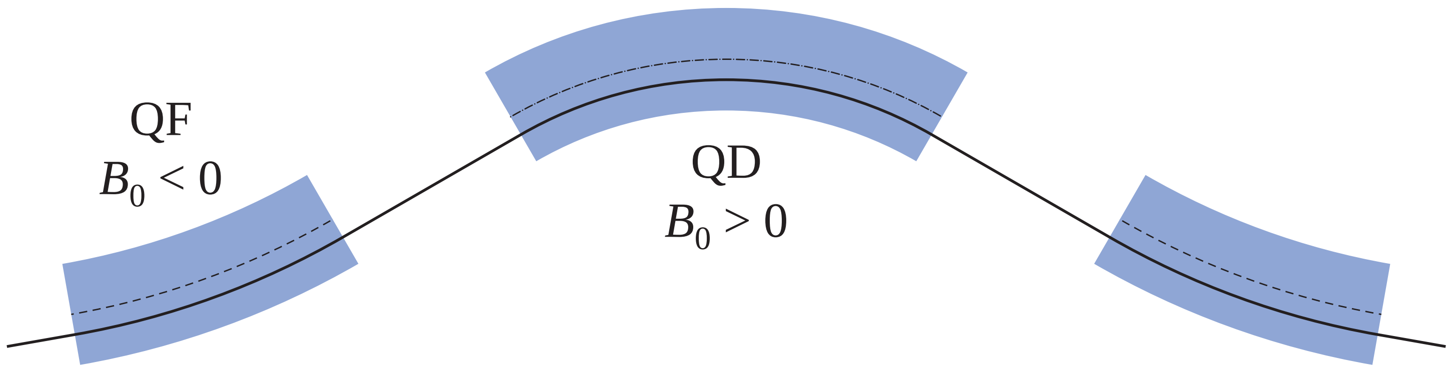
Time-of-Flight vs. Energy



Parameters: Table

E_{min} (GeV)	5		10	
E_{max} (GeV)	10		20	
$V/\omega\Delta T\Delta E$	1/8		1/12	
$A_{\perp n}$ (mm)	30			
L_0 (m)	2			
L_Q (m)	0.5			
V per cell (MV)	7.5			
f_{RF} (MHz)	201.25			
Empty cells	8			
ν_x, ν_y at E_{min}	0.35			
n	90		105	
C (m)	606.918		767.953	
V total (MV)	675.0		787.5	
	QD	QF	QD	QF
L (m)	1.612338	1.065600	1.762347	1.275747
ρ (m)	15.2740	-59.6174	18.4002	-70.9958
x_{O} (mm)	-1.573	7.667	1.148	8.745
r (cm)	14.0916	15.2628	10.3756	12.6256
B_0 (T)	1.63774	-0.41959	2.71917	-0.70474
B_1 (T/m)	-9.1883	8.1768	-15.4948	12.5874

Parameters (cont.)



- Reference orbit in magnet: L is length, ρ is radius of curvature, C is total length
- Magnet: center is x_0 from reference orbit, aperture radius is r
- Fields on reference orbit: B_0, horizontal gradient is B_1

Magnet Design

- Two parallel magnet design efforts
  - One with emphasis on end fields for tracking.
    - ⋆ Get 5–10 GeV magnets first: expect worst dynamic behavior.
    - ⋆ May not be realistic construction.
    - ⋆ Field accuracy is important.
  - One with emphasis on cost.
    - ⋆ Get 10–20 GeV first: if don't get a good cost for this, problem.
    - ⋆ Want a good cost estimate, so correct construction is important.
    - ⋆ Complete field accuracy not so important.
    - ⋆ J-PARC magnets similar

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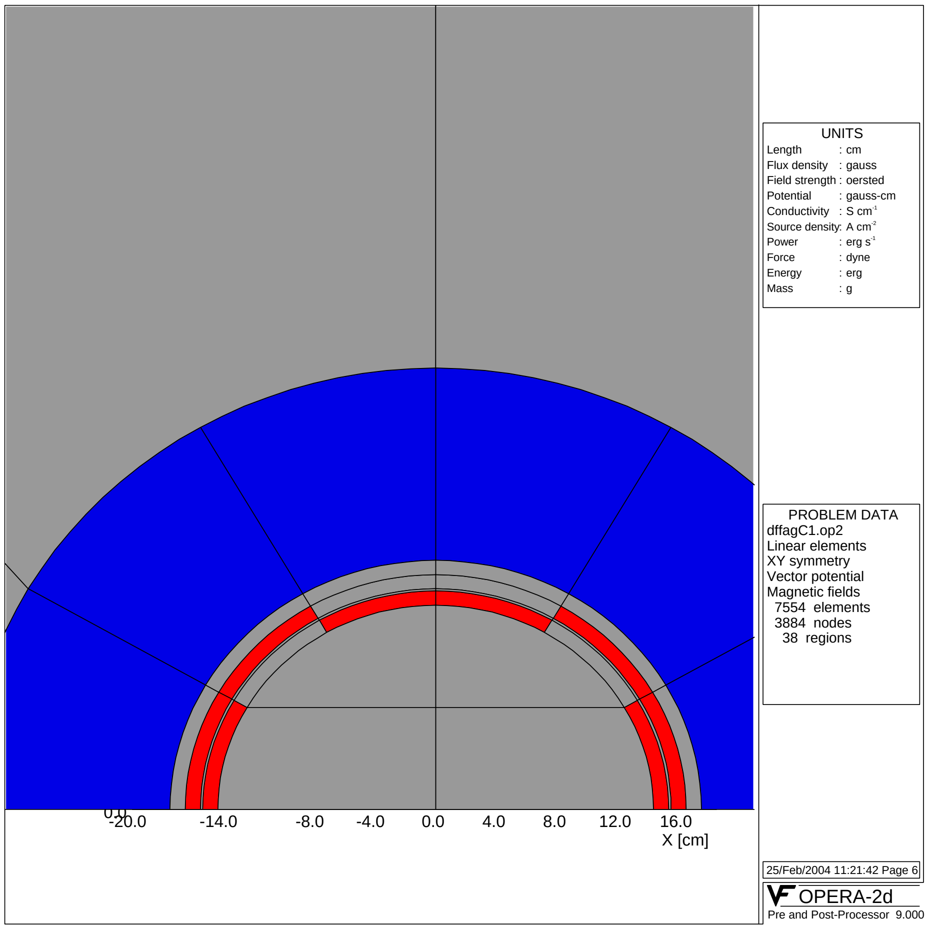
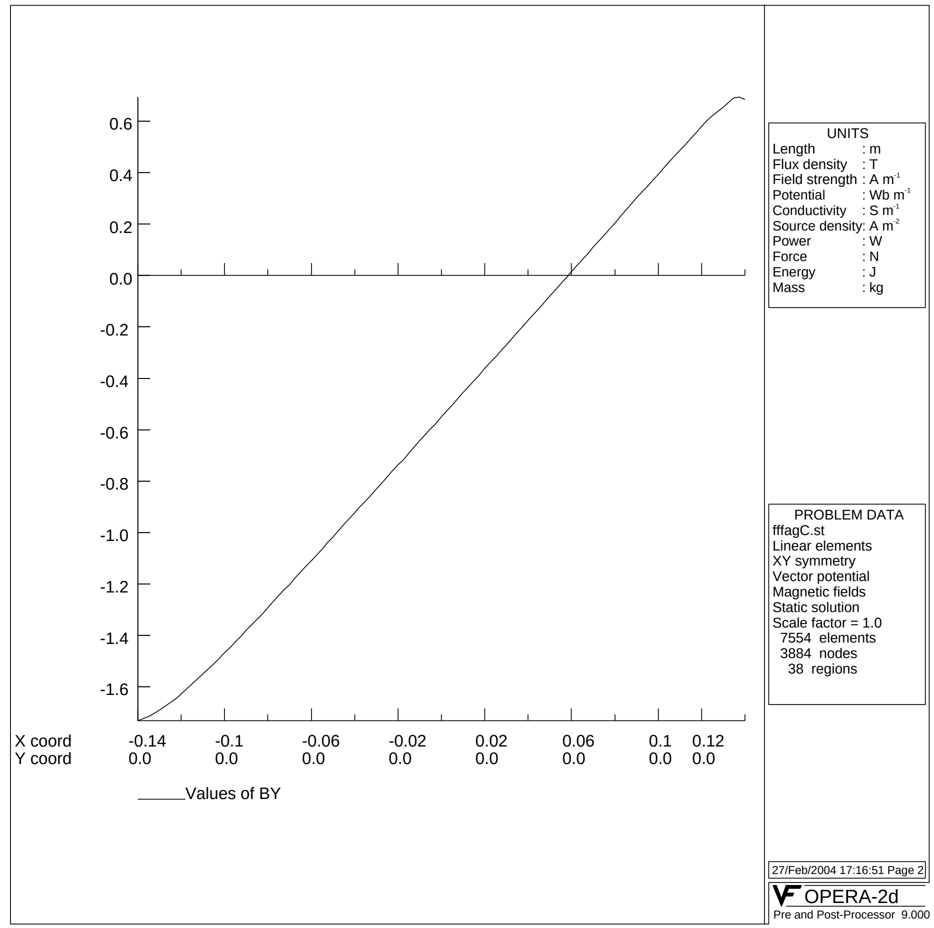
Magnet Design for Fields

Muon Collaboration

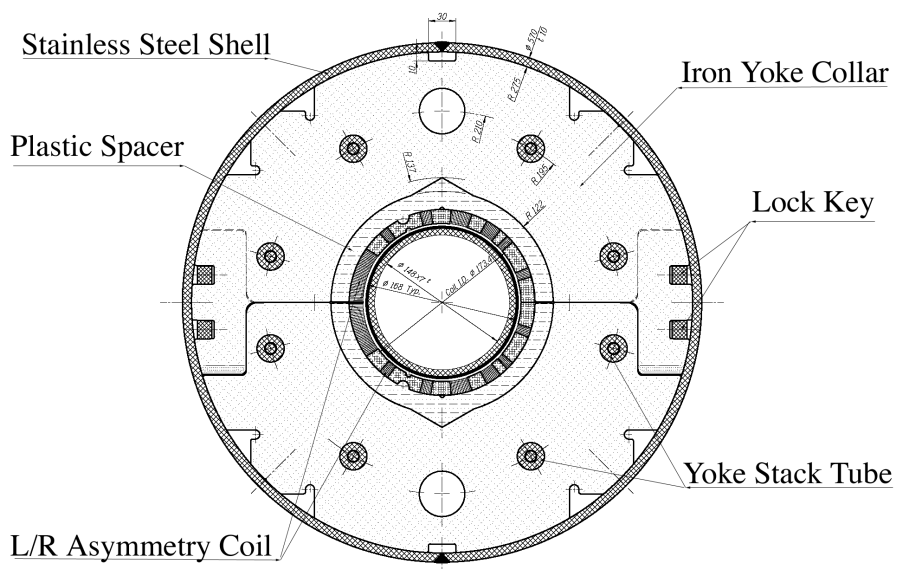
- Preliminary work by Kahn

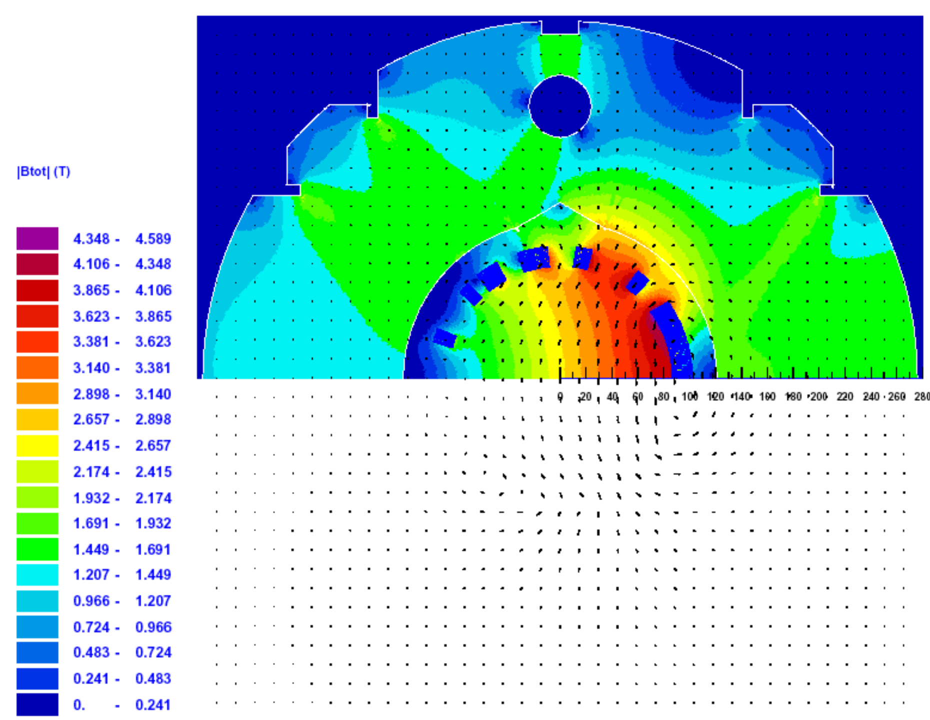




J-PARC Magnets

- KEK designed combined-function magnets for J-PARC (Ogitsu *et al.*, with BNL consultation)
- Apertures slightly smaller (8.7 cm radius), magnets longer (3 m). Not drastically different.



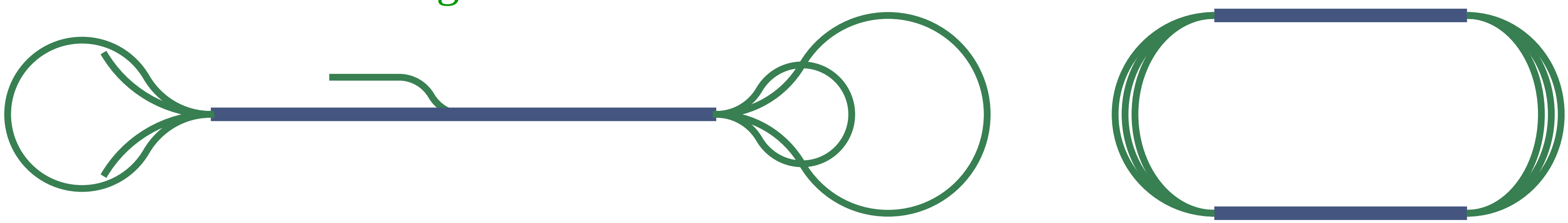


Tracking

- ICOOL tracking
  - Start with no acceleration, verify constant-energy behavior
  - May accelerate with very low-frequency RF: verify transverse behavior with acceleration
  - Accelerate to verify longitudinal acceptance: 150 mm desired
    - This is one big unknown: study by itself
    - With and without third harmonic
- ICOOL validation
  - Probably tough to validate on end fields, etc.
  - May be able to test simpler lattices against COSY, PTC, my code
  - Test both closed orbit calculation, and tracking about closed orbit

Low Energy Acceleration

- Starting point is Palmer's plan presented at collaboration meeting
  - Linac to 1.5 GeV, then dogbone to 5 GeV.
- Bogacz may make modifications if they seem best
  - Racetrack instead of dogbone



  - More passes
  - Different injection energy
- Design should provide sufficient information for rough costing
- Will do some tracking