Acceleration: Status and Plans

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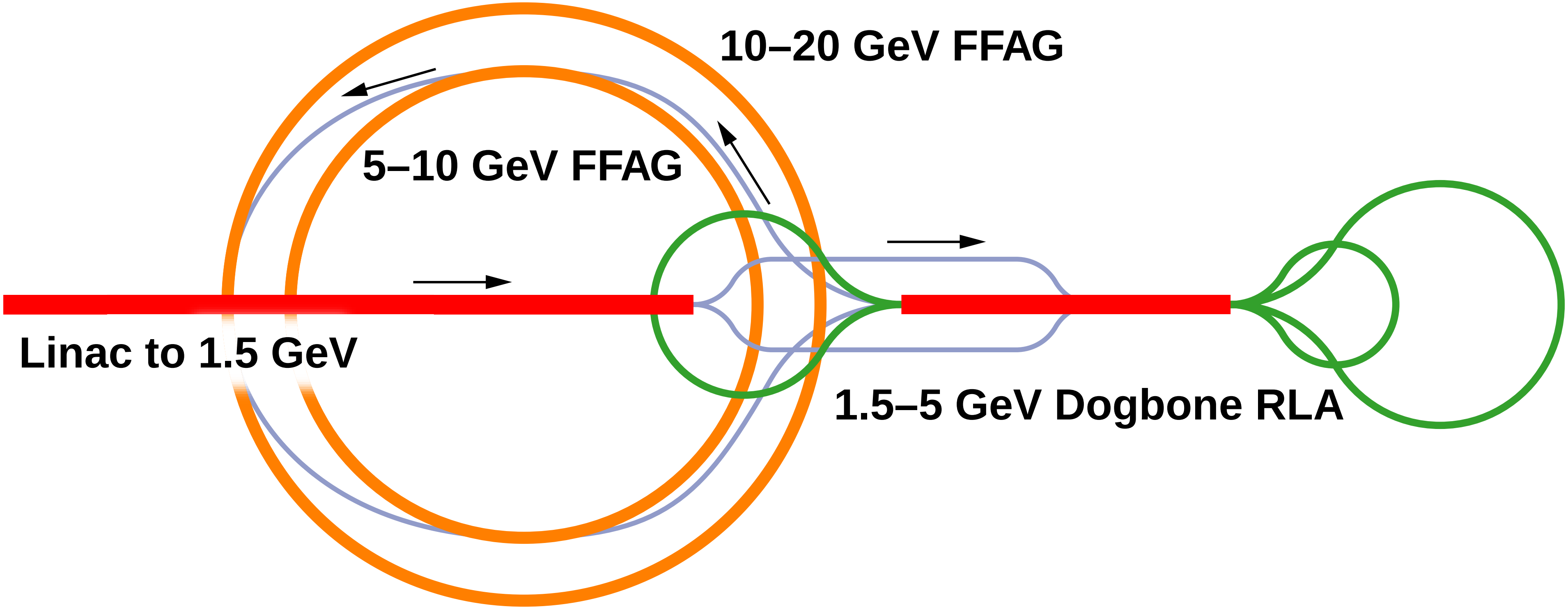
Brookhaven National Laboratory
ISS Meeting
21 August 2006

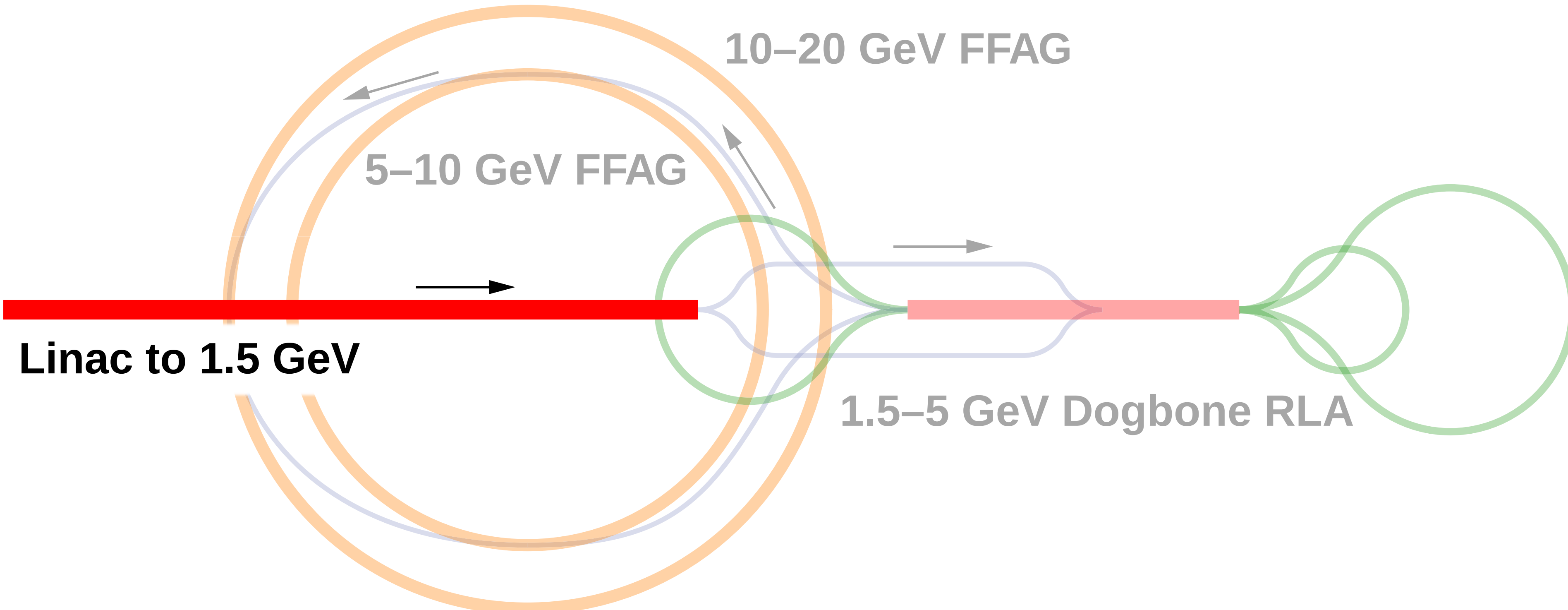
Outline

- Changes from Study IIa to ISS Baseline
- R and D plans

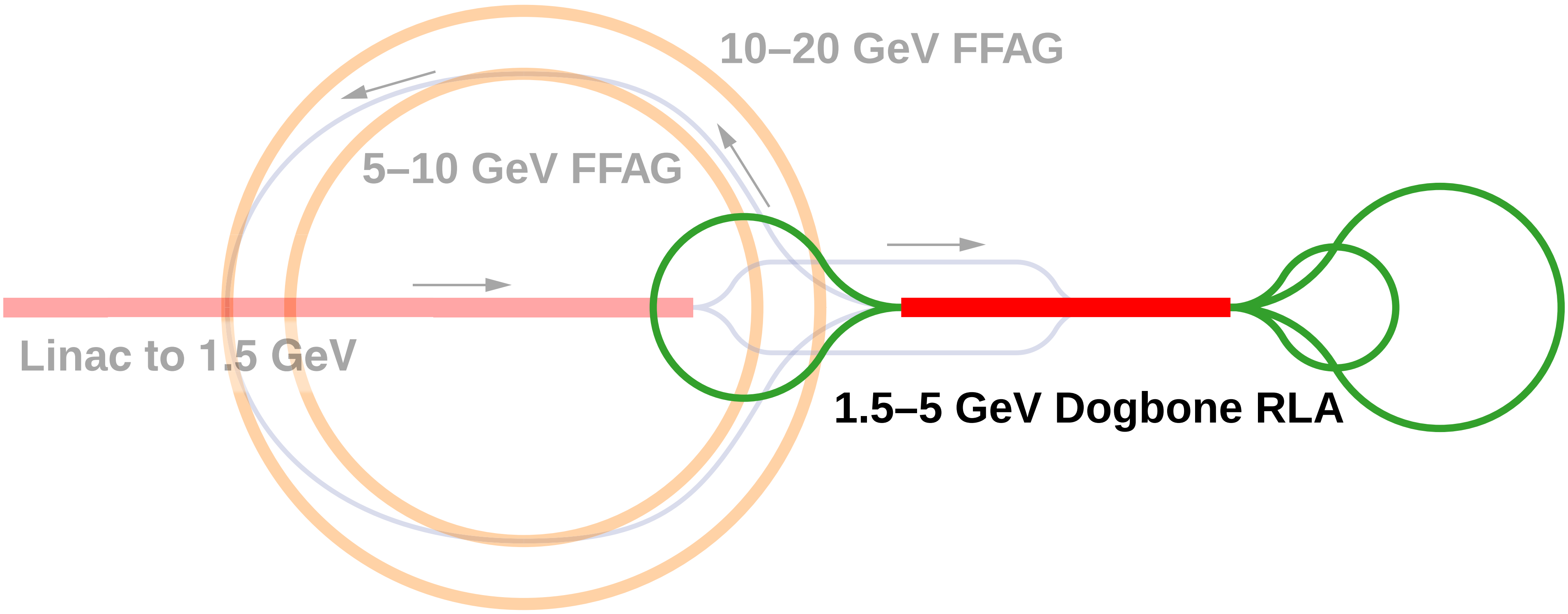
Study IIa Layout



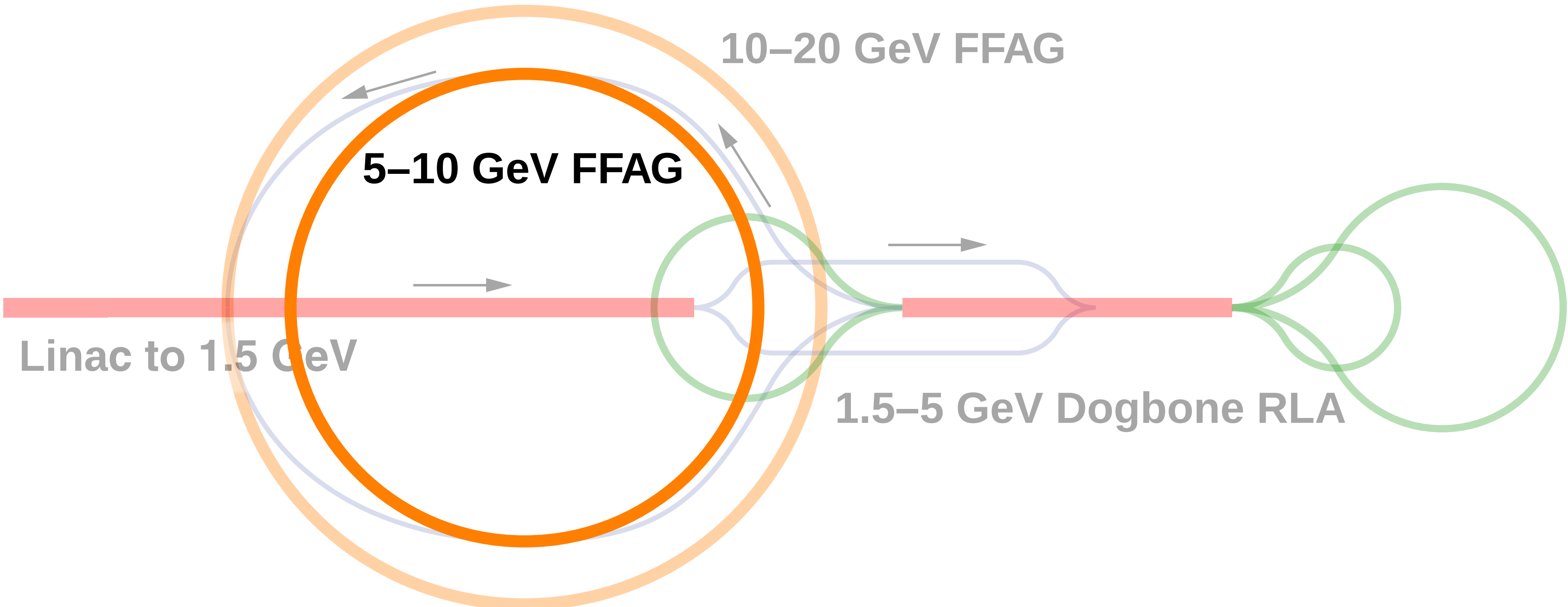
Study IIa Layout
Linac to 1.5 GeV



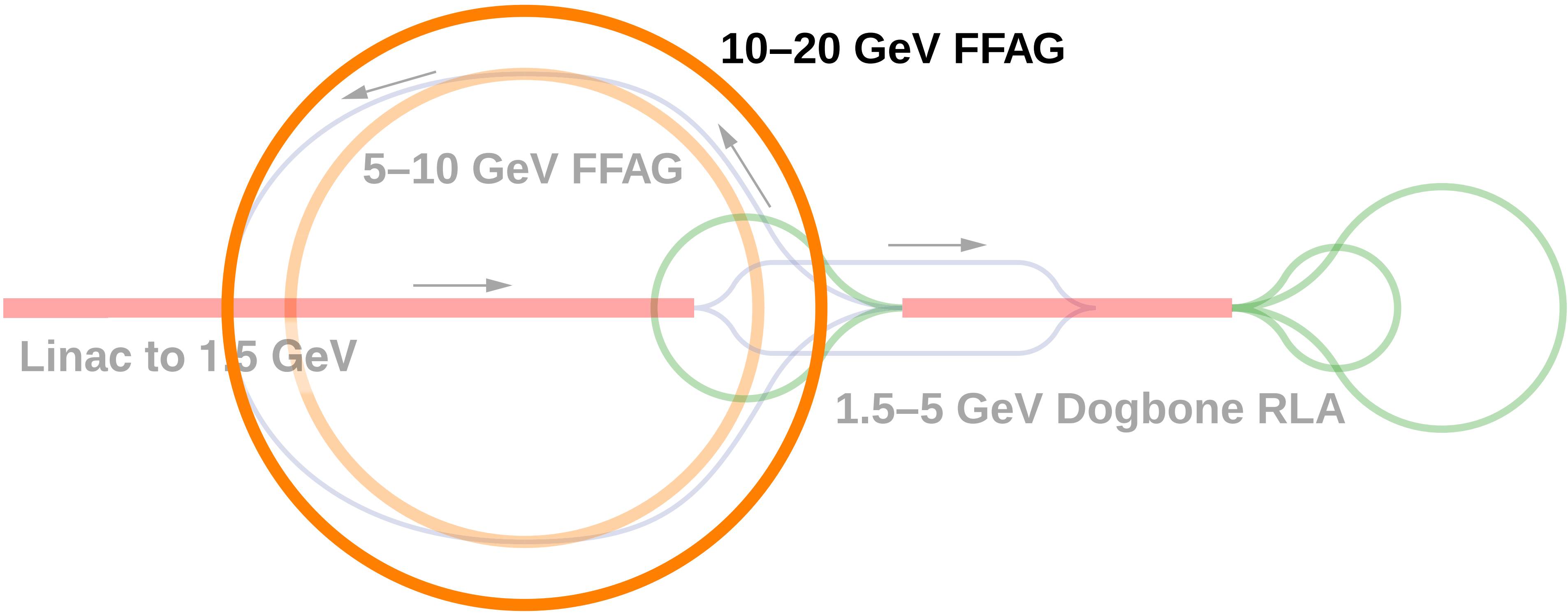
Study IIa Layout
1.5–5 GeV Dogbone RLA



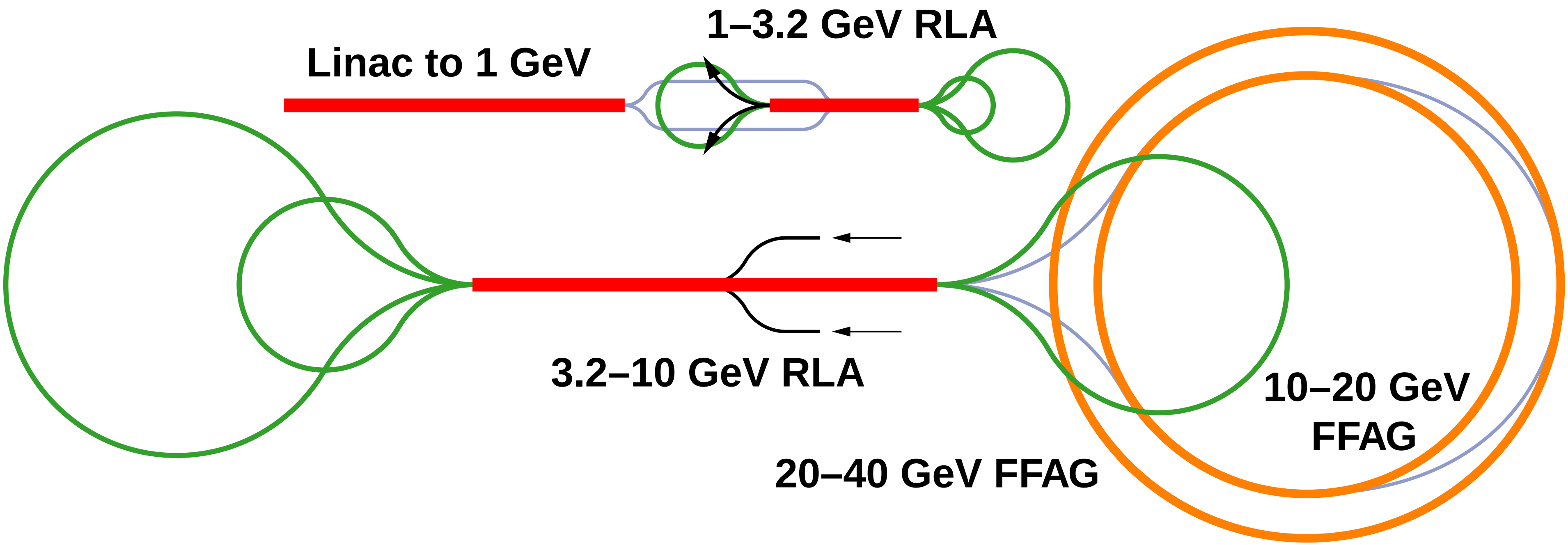
Study IIa Layout
5–10 GeV FFAG



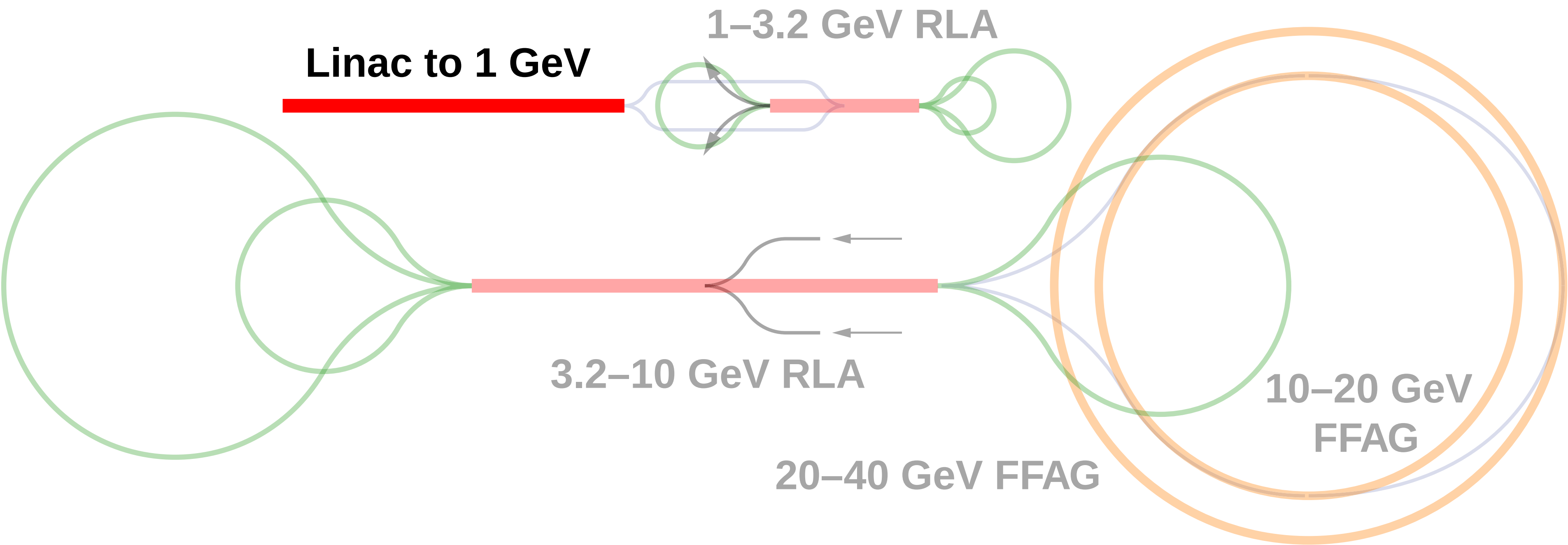
Study IIa Layout
10–20 GeV FFAG



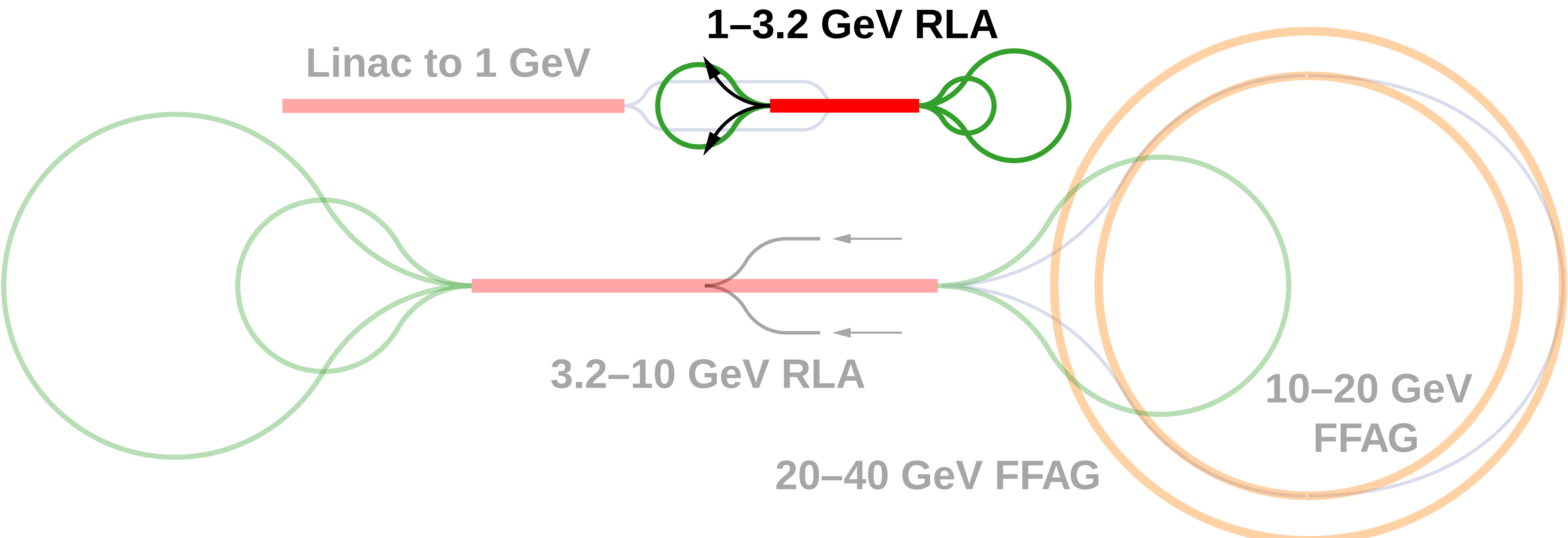
ISS Baseline Layout



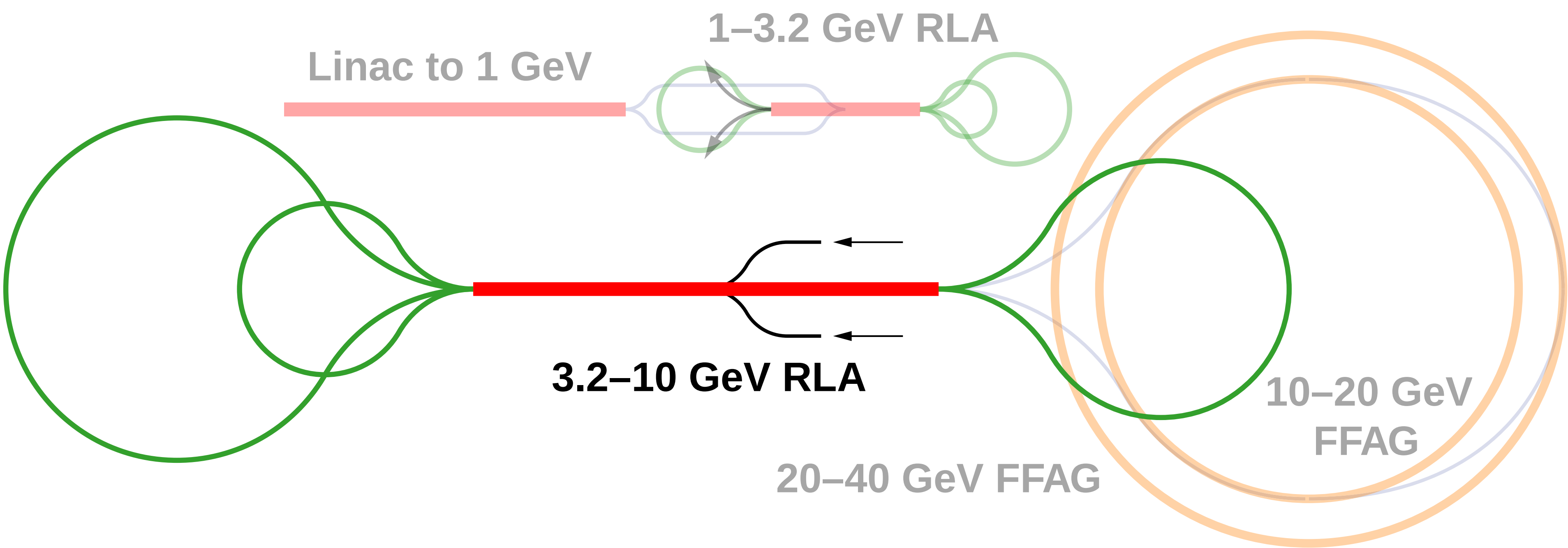
ISS Baseline Layout
Linac to 1 GeV



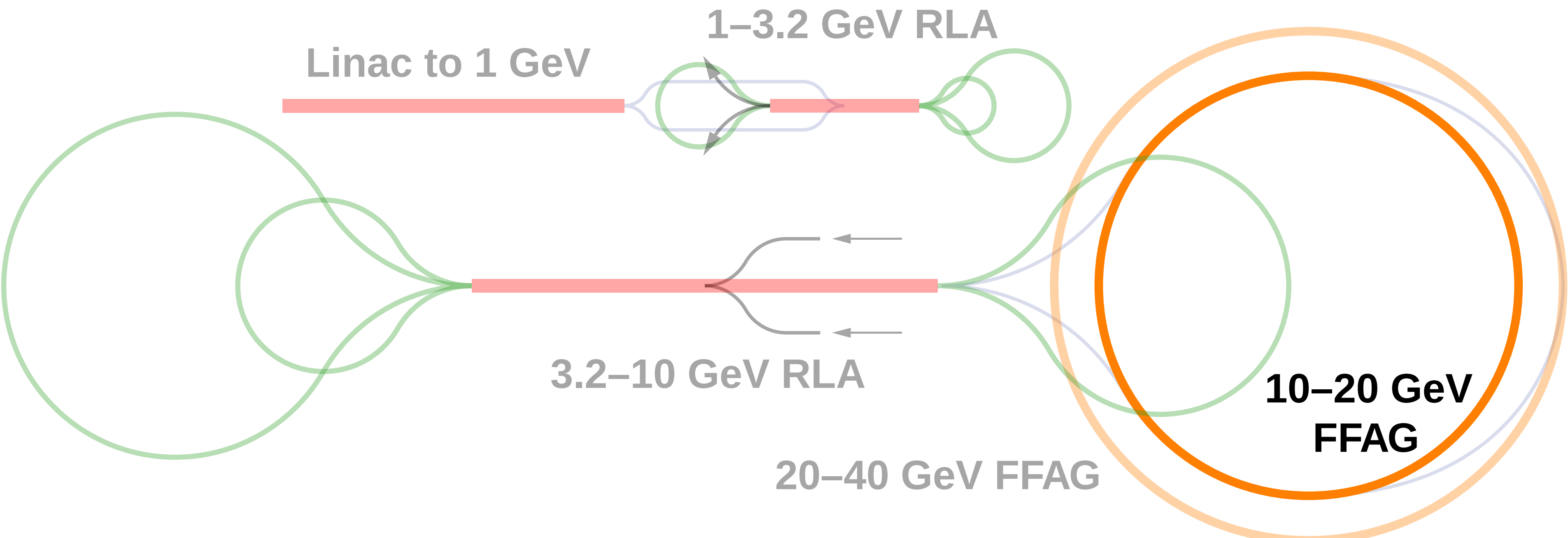
ISS Baseline Layout
1–3.2 GeV RLA



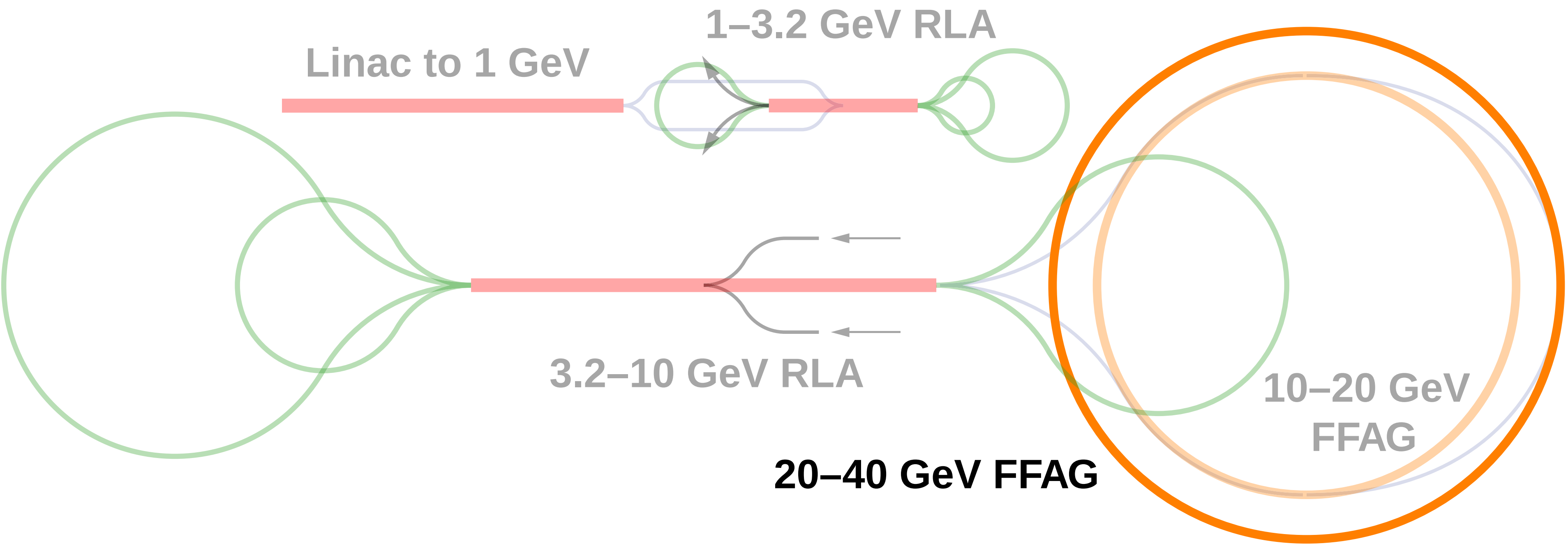
ISS Baseline Layout
3.2–10 GeV RLA



ISS Baseline Layout
10–20 GeV FFAG



ISS Baseline Layout
20–40 GeV FFAG



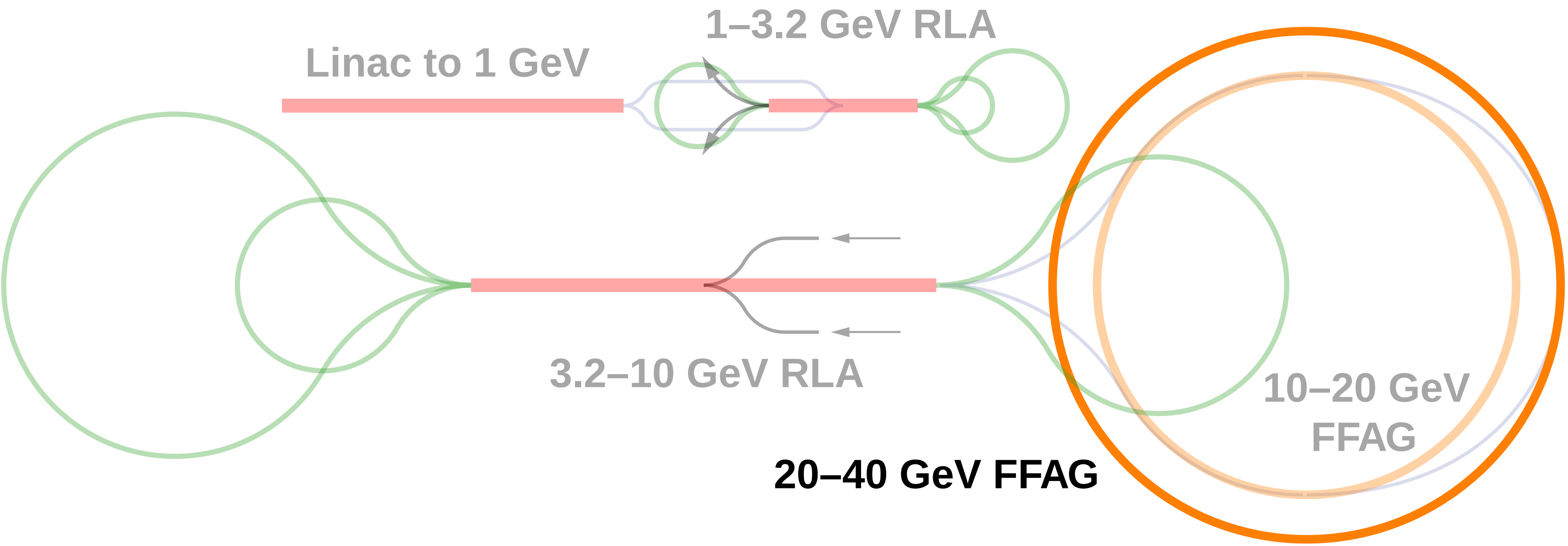
Changes from Study IIa to ISS Baseline

- Potentially increased final energy
- 5–10 GeV FFAG removed
- Second RLA added
- Shortened initial linac

Increased Energy

- There is interest in potentially going to 40 GeV final energy
- This requires an additional FFAG stage from Study IIa

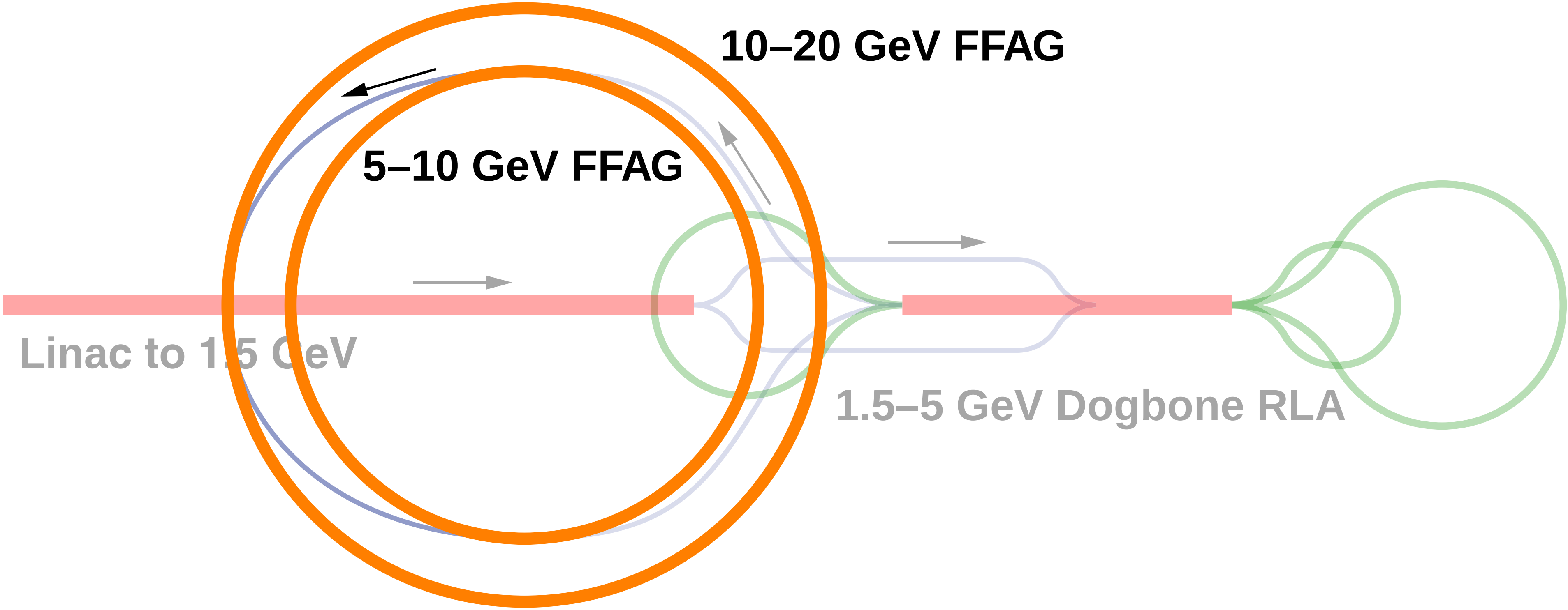
ISS Baseline Layout
20–40 GeV FFAG



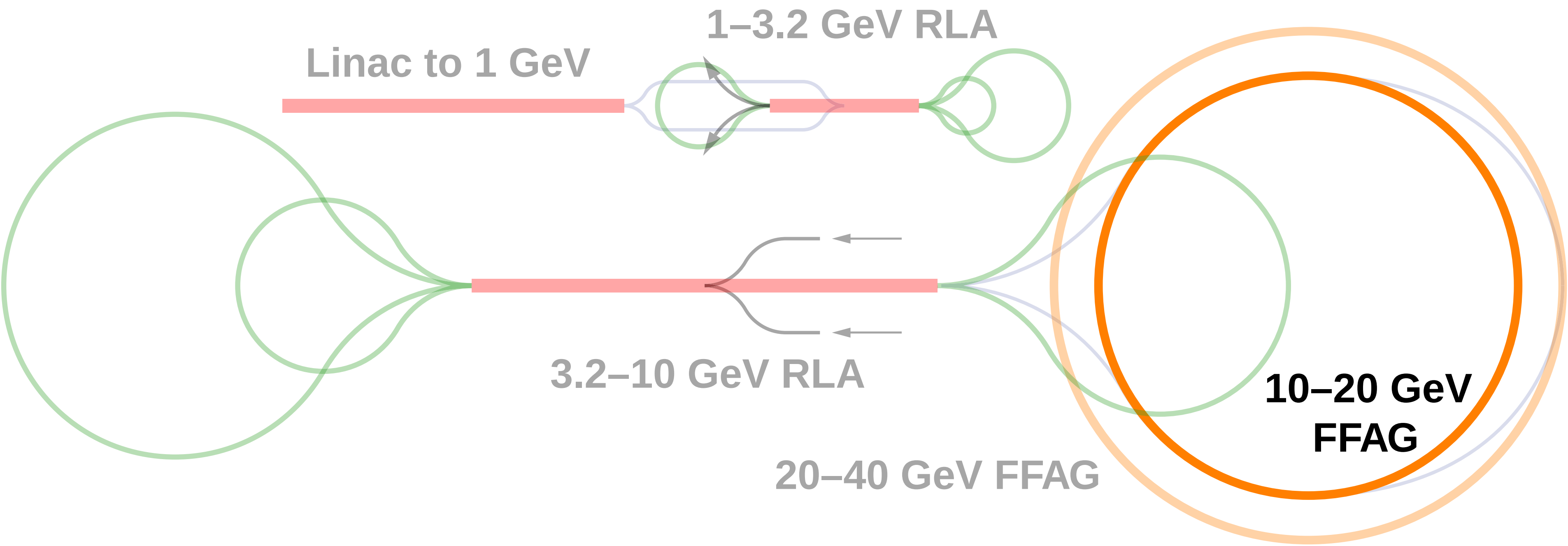
5–10 GeV FFAG Removed

- Time of flight in FFAGs depends on transverse amplitude
- Large transverse amplitude desirable to reduce cooling required
- Large amplitude particles tend to arrive late
  - Next stage wants large amplitude particles to be early
  - If going to 40 GeV, want to avoid two FFAG-to-FFAG transfers
- Methods to correct this will make FFAGs less cost effective
  - Lower energy FFAGs were less cost effective

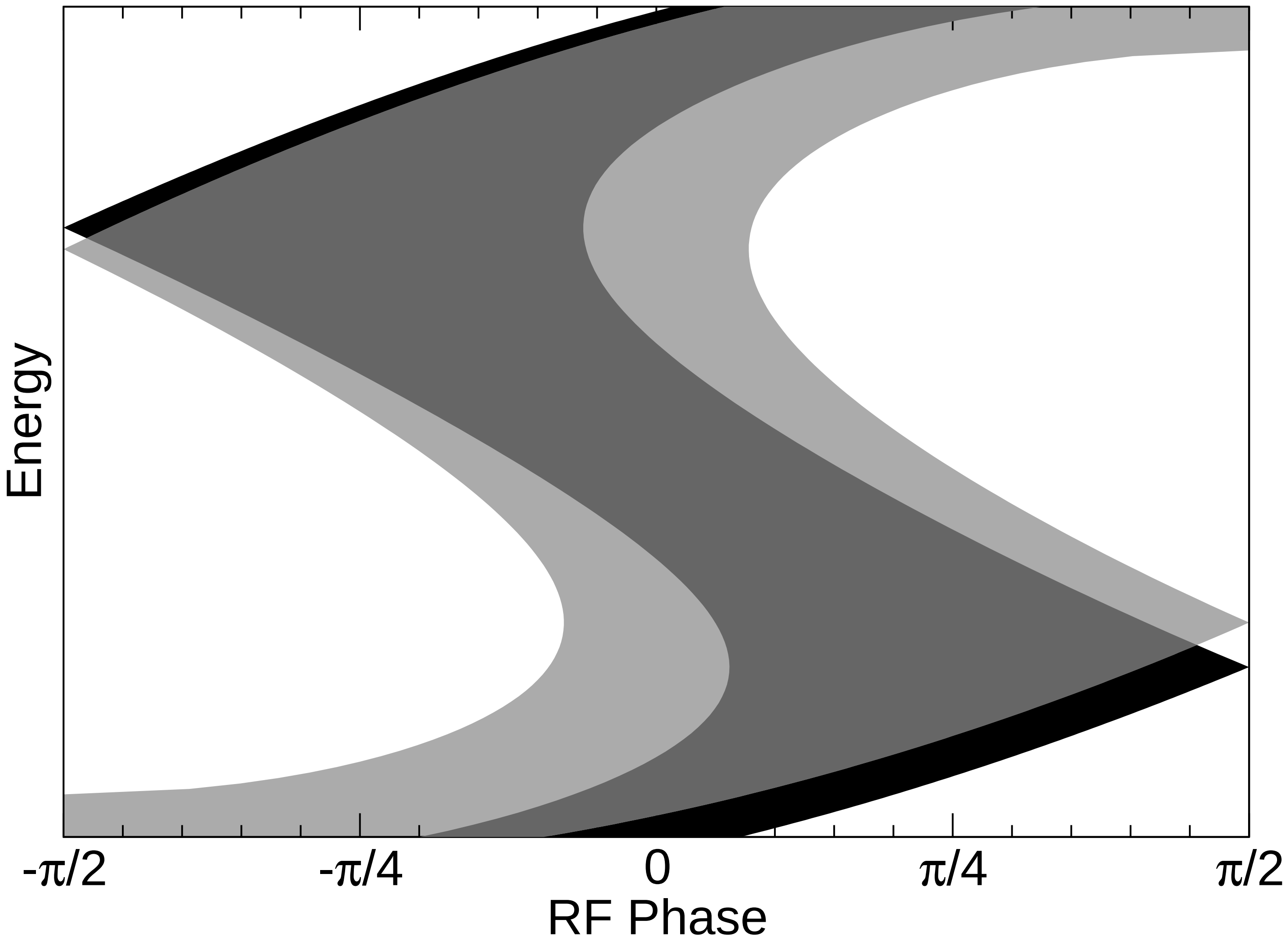
Study IIa Layout
Final FFAGs



ISS Baseline Layout
Final FFAGs



Longitudinal Phase Space
Zero and Non-Zero Transverse Amplitude



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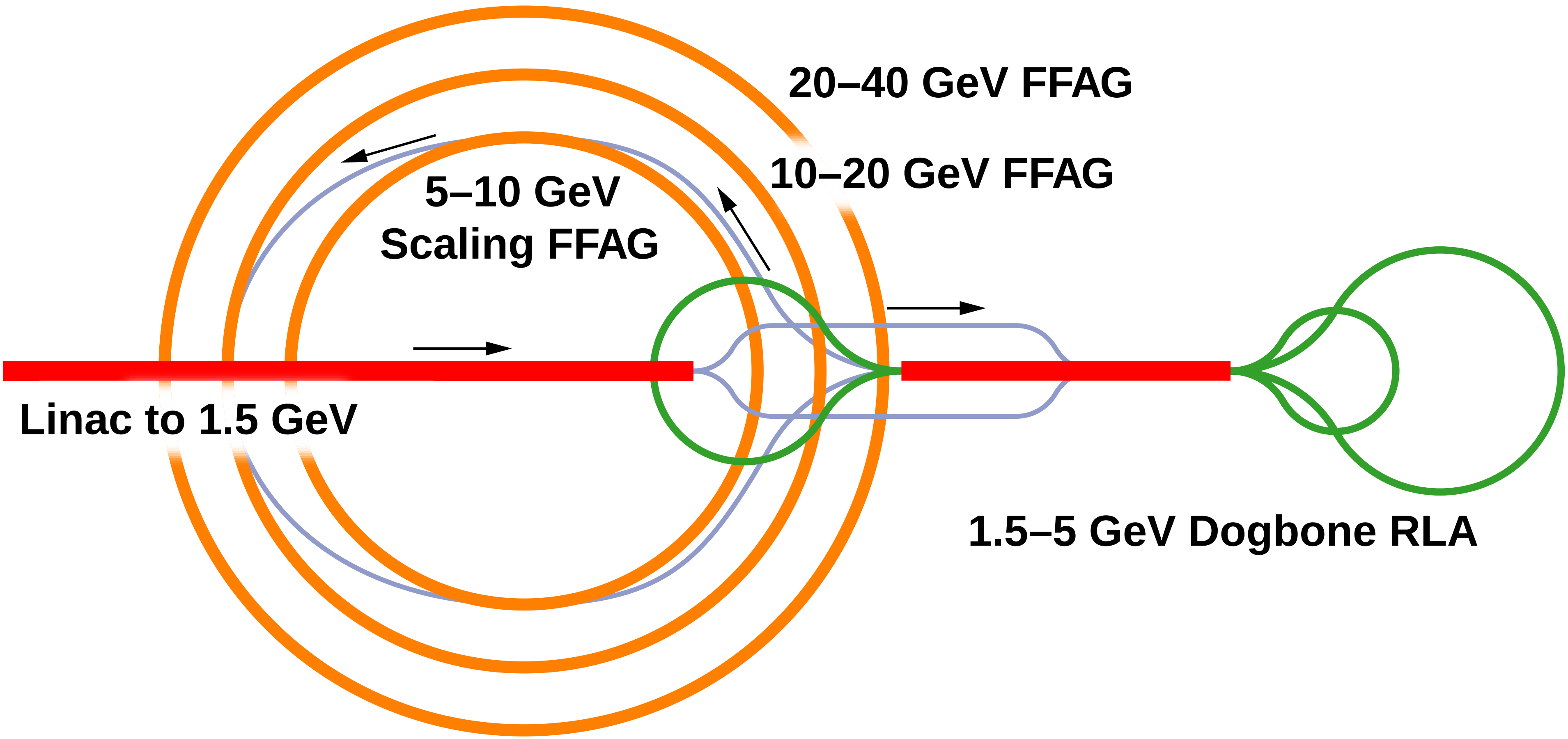
Alternative: Scaling FFAG for 5–10 GeV

- Similar to Study IIa
  - Add 20–40 GeV Non-Scaling FFAG
  - Make 5–10 GeV FFAG Scaling
- Time of flight independent of transverse amplitude (to lowest order) in scaling FFAG
- Large magnet apertures
  - Use normal conducting magnets, horizontal aperture less important
  - Normal conducting more plausible at lower energies
- To use high frequency RF, need to use harmonic number jump method
  - Ring must be filled with cavities, challenging to make this work
  - Large aperture requires using cavity higher order mode
- More details from Mori

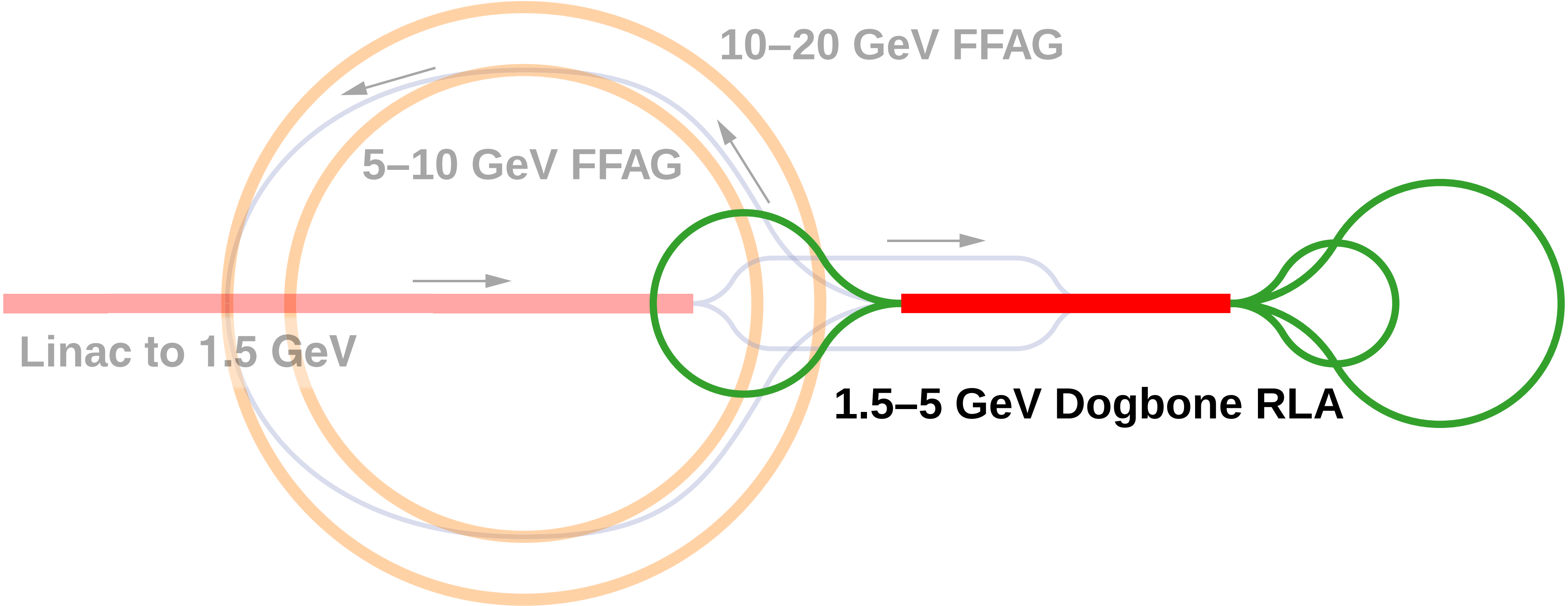
Scaling FFAG for 5–10 GeV



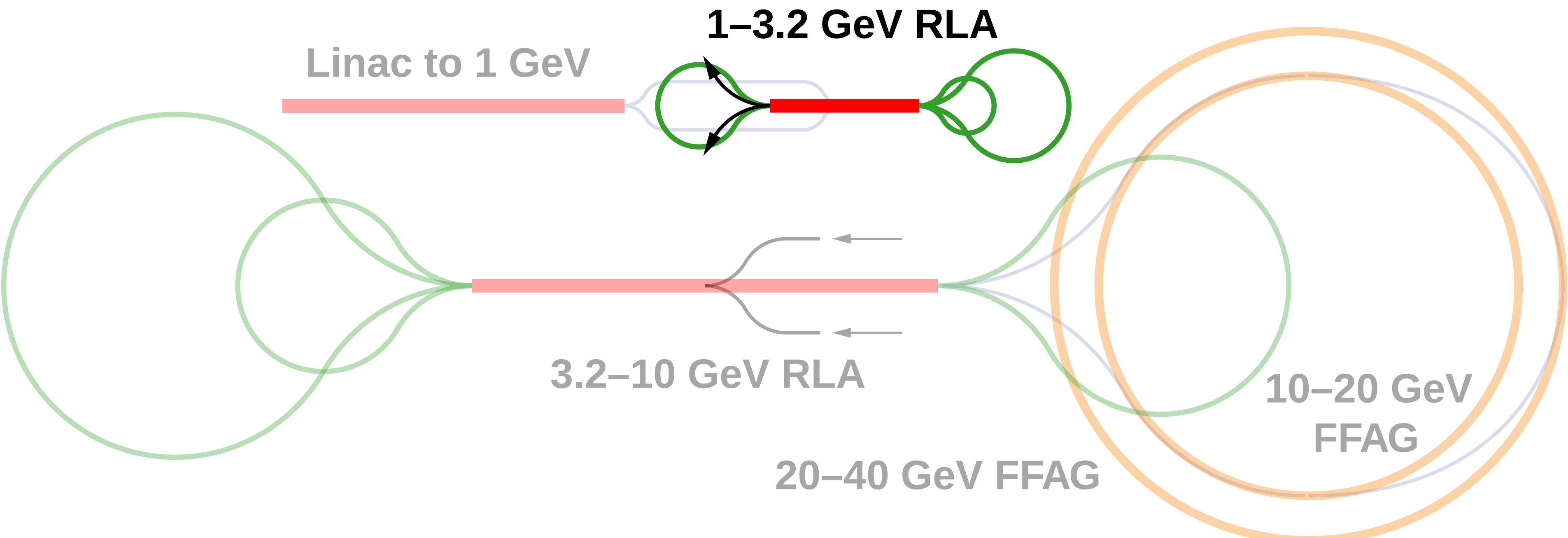
Second RLA Added

- RLAs now must go to 10 GeV
- Increasing linac lengths will increase problems with velocity variation with energy (keeping particles on-crest)
- More turns may be difficult for switchyard
- Arc-linac matching may become more difficult
- Second stage helps all this
- May also increase synchrotron oscillations
  - Helps correct bunch-to-bunch beam loading differences
  - Corrects time of flight variation with transverse amplitude, present in all linacs
- More details from Bogacz

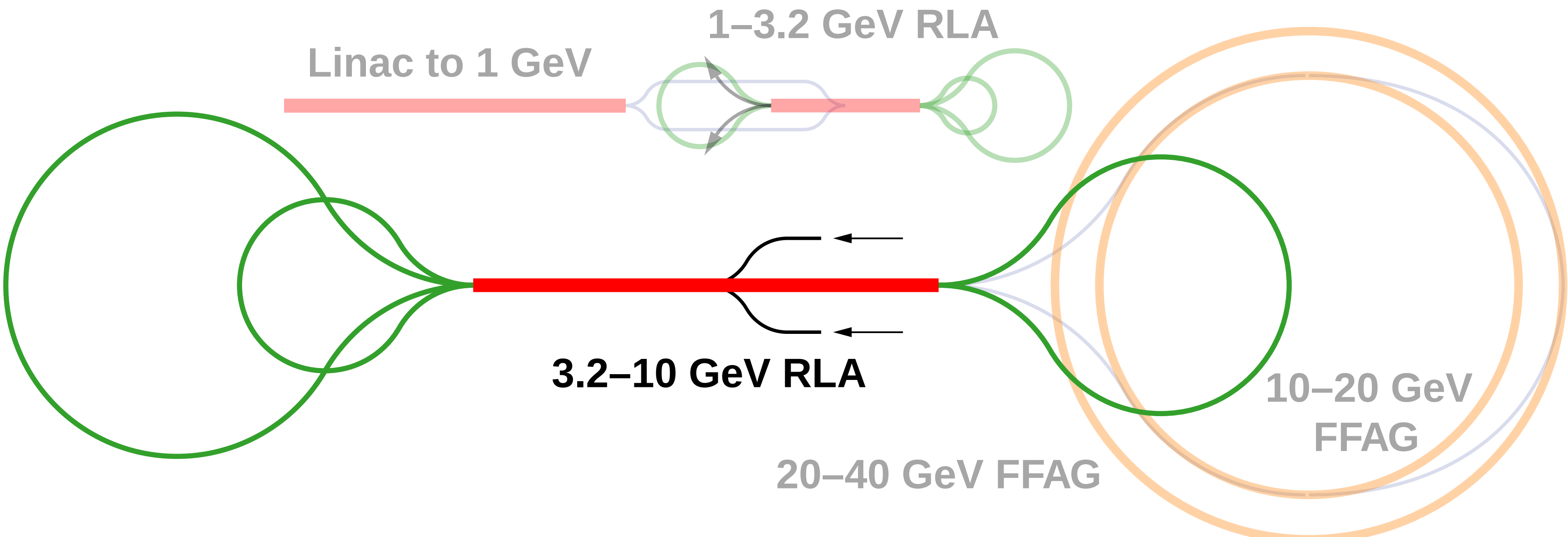
Study IIa Layout
1.5–5 GeV Dogbone RLA



ISS Baseline Layout
1–3.2 GeV RLA



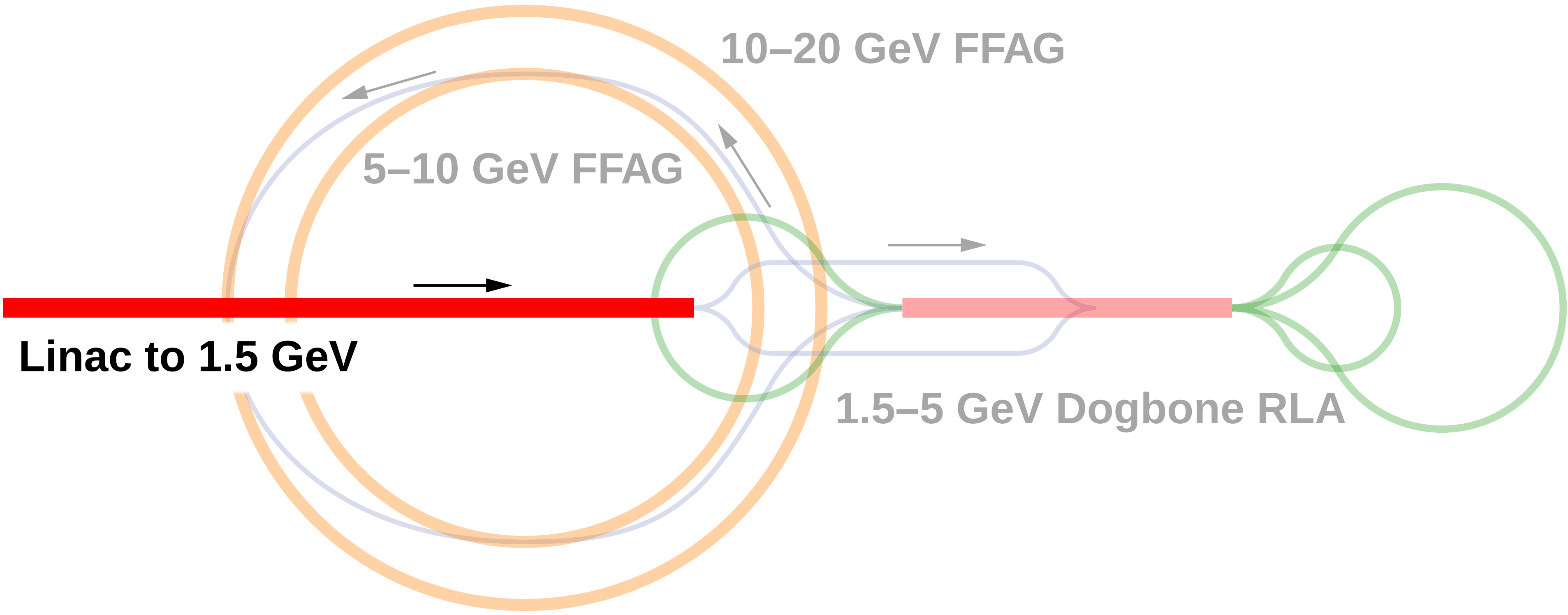
ISS Baseline Layout
3.2–10 GeV RLA



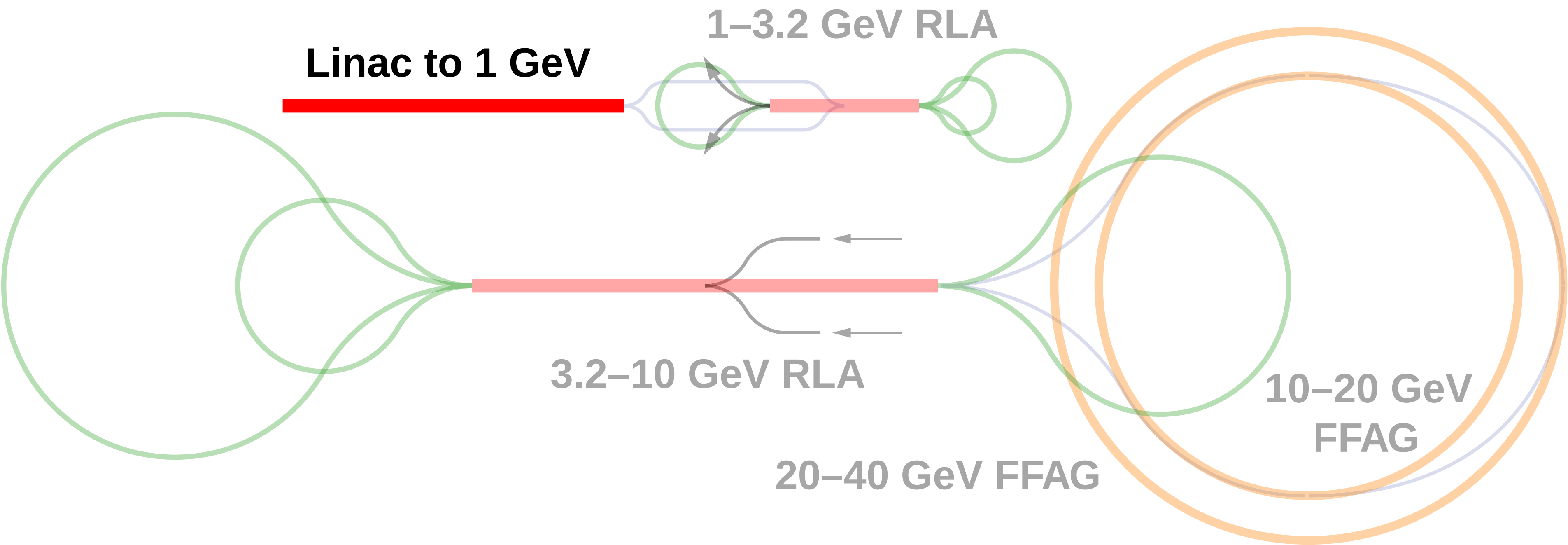
Shortened Initial Linac

- Time of flight variation with transverse amplitude also affects linac
- Probably causes some effective longitudinal blowup
- Shortening the linac helps this
  - Additioanl RLA stage helps also
- With additional RLA stage, can take advantage of lower final energy in first stages by lowering injection energy
  - RLA makes more efficient use of RF, lower cost

Study IIa Layout
Linac to 1.5 GeV



ISS Baseline Layout
Linac to 1 GeV



R and D Plans

- Linac
  - Verify the extent of the time of flight variation with transverse amplitude problem in the linac
- RLAs
  - Put together a two-RLA scenario
  - Verify performance of RLAs with finite energy spread
  - Examine possibility of more turns
  - More from Bogacz
- Scaling FFAG Alternative
  - Produce harmonic number jump scenario
  - Design compatabile magnetic lattice and cavities
  - More from Mori

R and D Plans
Non-Scaling FFAGs

- Beginnings of error analysis are in place
  - 20–50 μm displacement, 2–5 $\times 10^{-4}$ gradient
  - Make more complete; continue as designs evolve
- Produce designs that address time of flight problem
  - Some chromaticity correction
    - We've computed how much we can do without losing dynamic aperture
  - Increase RF gradient (remove empty cells)
  - Add higher harmonic RF
  - Choose RF and lattice parameters optimally
  - Positive chromaticity in transfer lines?
- Study non-scaling FFAGs using the EMMA electron model

R and D Plans
Other Items

- Time of flight variation with transverse amplitude problem means that achieving high RF gradient is essential
  - Superconducting RF research applicable to 200 MHz range
- Tracking full system
  - Pass distribution from one system to another: track transfer lines
  - Matching beam between systems, especially longitudinal
- Develop full RLA scenario for comparison
- Kickers!