IDS-NF Accelerator Working Group: Overview and Plans

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IDS-NF Plenary Meeting
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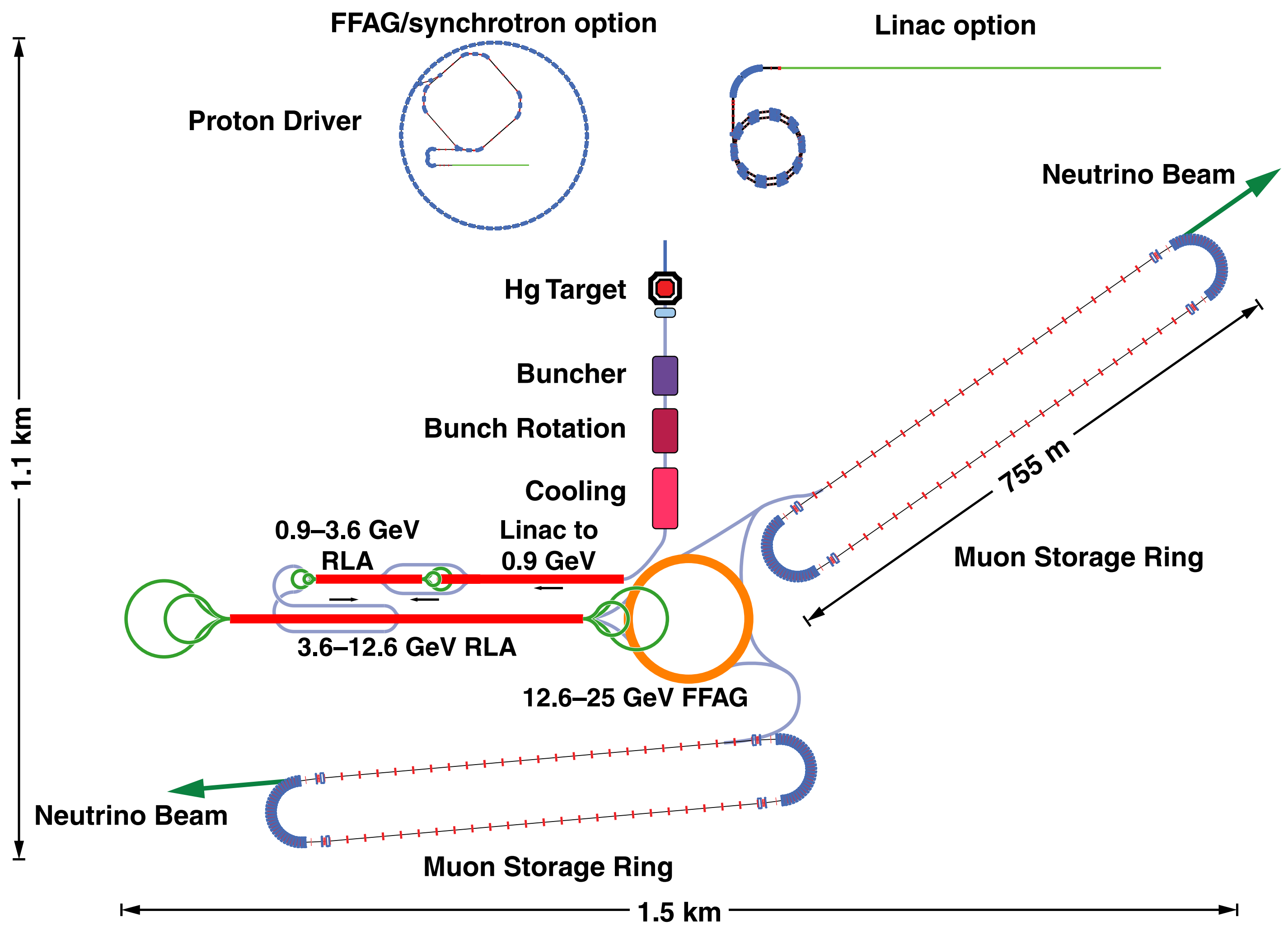
Overall Goals for this Meeting

- Specify the machine we describe in the IDR
  - Specify any alternatives we will include, but
  - Stay focused on making the case for the "baseline"
- Work out plans for the IDR
  - What do we need to include there
  - Important components to study

Neutrino Factory Accelerator Complex

- High-power proton driver, protons hit
- Target, producing pions decaying to muons
- Front end, reshapes and intensifies beam
- Acceleration, increase energy to 25 GeV
- Decay ring, neutrinos produced decay toward far detectors

Neutrino Factory Accelerator Complex



High-Power Proton Driver

- Supply protons to target to produce pions
- Basic specifications:
  - 4 MW proton beam power
  - Proton kinetic energy 5-15 GeV
  - RMS bunch length 1–3 ns
  - 50 Hz repetition rate
  - Three bunches, extracted up to 140 μs apart

High-Power Proton Driver

- Rough plan: multiple site-specific designs
- Little work done so far
- Meeting goal
  - Define what will be done for IDR
  - Do we need to specify parameters more precisely?
    - Inter-bunch spacing
    - Bunch length

Target

- Protons come in, pions come out
- Maximize production into the appropriate phase space
- Target sits in a 20 T magnetic field
- Baseline: mercury jet
- Significant engineering challenges
- Will solid targets be discussed in the IDR, and if so, how?

Target
Recent Work

- Improving performance of Hg jet nozzle
- Study mercury collection pool
- Maximizing pion production efficiency
  - Comparing simulations with HARP data
- Radiation shielding for magnets
- Solid targets: experimental work
  - Simulating shock on tungsten rods
  - Powder jet test

Front End

- Create beam suitable for acceleration and storage ring
  - Take single bunch from target, turn into bunch train (bunching and phase rotation)
    - Around 100 m long 200 MHz bunch train
    - $\pm$50% full momentum spread to $\pm$20%
  - Maximize muons in accelerator acceptance
    - Ionization cooling
    - Acceptance: 30 mm trans., 150 mm long.

Front End

- Greatest challenge: RF in magnetic fields
  - Front end channel has RF cavities in high magnetic fields
  - Experimental evidence: maximum RF gradient reduced in magnetic fields
    - Don’t give complete picture yet
- Two broad ways to address
  - Change lattice magnetic field configuration
  - Modify cavity to reduce breakdown

Front End
Recent Work

- Improving performance of buncher/phase rotation
- Studies of low-frequency (44/88 MHz) scenario
- Stretched lattices that reduce magnetic field at cavities
- High-pressure hydrogen in cavities
- Ongoing experiments studying RF breakdown in magnetic field

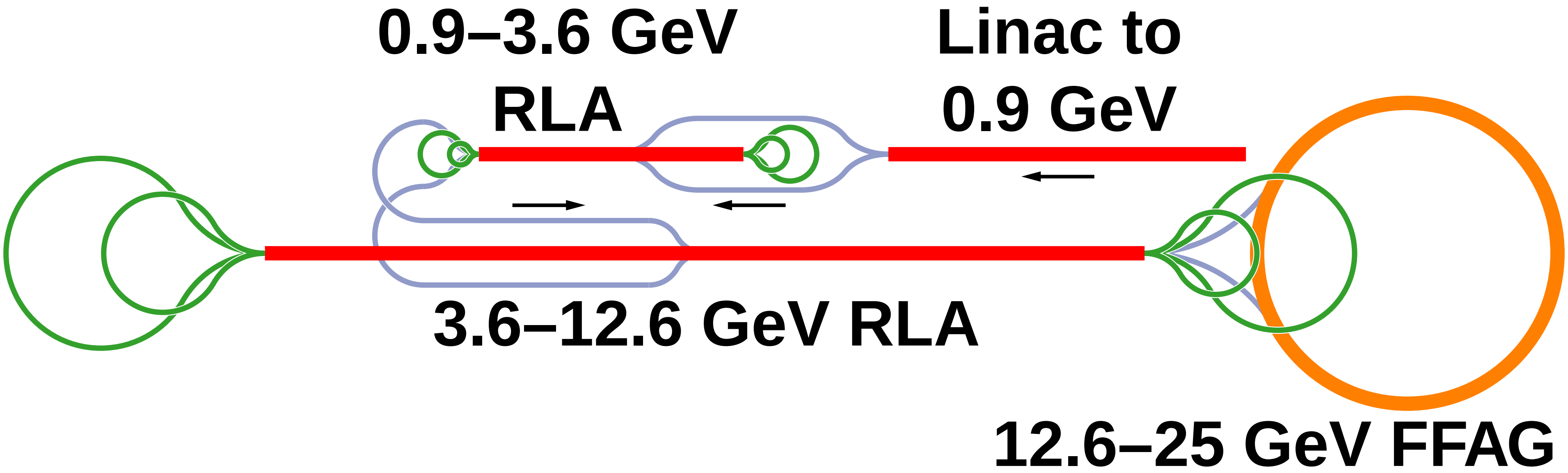
Front End

- Must choose front end technology to use
    - Multiple choices
- Longest time allotted in WG
    - Many technologies to choose from
    - Making decision based on incomplete information

Acceleration

- Increase total energy from 244 MeV to 25 GeV
- Do this efficiently
  - Maximize number of passes
  - More passes difficult at lower energies
- Several stages to maximize efficiency
  - Start with linac
  - Recirculating linear accelerator (2)
  - Fixed field alternating gradient accelerator

Acceleration Stages



Acceleration: Low Energy

- Recirculating linear accelerator (RLA)
  - Few passes, limited by switchyard
  - Two stages to get lower energy reach
- Linac for lowest energy
  - RLA won’t work at lowest energy
- Proposal for scaling FFAG at lower energy
  - Include in IDR, if so, how?

Low Energy Acceleration Recent Work

- Lattice specified
- Matching from cooling to accelerating linac
- Linac solenoid design
- Detailed tracking in linac
- Studies of scaling FFAG to 12.6 GeV
    - Harmonic number jump RF

Acceleration: FFAG

- Many passes since no switchyard
- Biggest challenge: injection/extraction
  - Large aperture, fast rise/fall
  - Similar to (but worse than) decay ring
- Beam dynamics limitation: time of flight depends on (large!) transverse amplitude, related to chromaticity
- Verify cost advantage over RLA

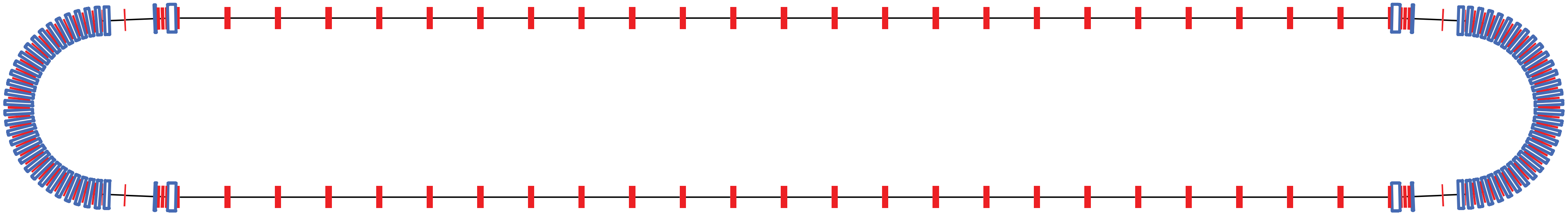
FFAG Acceleration
Recent Work

- Update of lattice parameters
- Injection/extraction studies
  - Tracking studies of symmetry breaking in injection/extraction regions
- Settled on long-drift triplet lattice
- Chromaticity correction
  - More work to be done here
- Beam loading studies

Decay Ring

- Long straight sections where muons decay
- Straight angled downward to far detector
- Keep ratio of straight (useful) to arcs high
- Baseline: two racetrack shaped rings
  - Neutrino beams to two detectors
- Discuss in-ring beam diagnostics
  - Polarimeter; Cherenkov for distribution
  - Joint with detector group

Decay Ring



Decay Ring
Recent Work

- Lattice design fairly complete
- Particle tracking, finding good dynamic aperture
- Studies of polarimeter

Accelerator WG Plan

- Broken up by subsystems described previously
- Present baseline plans and anything additional to include in IDR
- Make the case for the baseline
- Discuss what needs to go into IDR
- Leave time for discussion and debate
- Put together full picture for plenary

Accelerator WG Session Outline

Session 1	Proton Driver	1:00
Session 2	Front end	2:30
Session 3	Low energy acceleration	1:05
	Final FFAG acceleration	0:55
Session 4	Decay Ring	1:15
Session 5	Target	1:45

Special Discussion Points

- Proton driver: settle on a plan
- Front end: difficult decision here
- Decay ring: what diagnostics do we include
  - Joint discussion with detector WG
- Target: if and how solid target is included