Proton Source

& Site Layout

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Muon Accelerator Program Review

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Outline

- Proton Source – Proton Driver
  - Design goals
  - Project X
    - Design criteria & description
    - Upgrade path
  - Challenges
- Milestones
- Initial concept for site layout
- Summary

Design Goals

- 4 MW proton beam onto target
- Proton energy 5-15 GeV
- Bunch structure
  - 1-3 ns rms bunch length
  - Neutrino Factory
    - 3 bunch train in 320 μs at 50 Hz
  - Muon Collider
    - “Single” bunch at 15 Hz

Project X as a Starting Point

- Project X design criteria
  - A neutrino beam for long baseline neutrino oscillation experiments
    - 2 MW proton beam with energy between 60-120 GeV
  - Kaon- and muon-based precision experiments running simultaneously with the neutrino program
  - ***A path toward a muon source for a possible future Neutrino Factory, and, potentially, a Muon Collider at the Energy Frontier***

Project X Design Evolution

- Initial design (8 GeV pulsed linac)
  - Did not support kaon/muon precision measurement program
- Second design (about to be released)
  - CW 3 GeV 1 mA H^- linac
    - Above kaon production threshold
    - Produces low energy pions for low energy muon experiments
    - Allows nuclear physics experiments
    - Low energy chopping allow supporting different experiment needs
      - 325 MHz low energy RF system
    - Splitter/switchyard to simultaneously support the experiments
  - 3-8 GeV pulsed linac (accumulation in Recycler)
    - Satisfies neutrino 2 MW program
    - Additional 8 GeV beam power available for other experiments

Project X: 8 GeV Numbers

- 1 mA CW linac to feed pulsed linac

Final Beam Energy (GeV)	MI Cycle Time (s)	Particles per MI Cycle (10^{12})	8 GeV Beam Power (kW)	Accumulation Duty Factor (%)
60	0.6	125	267	3.33
120	1.33	139	133	1.67

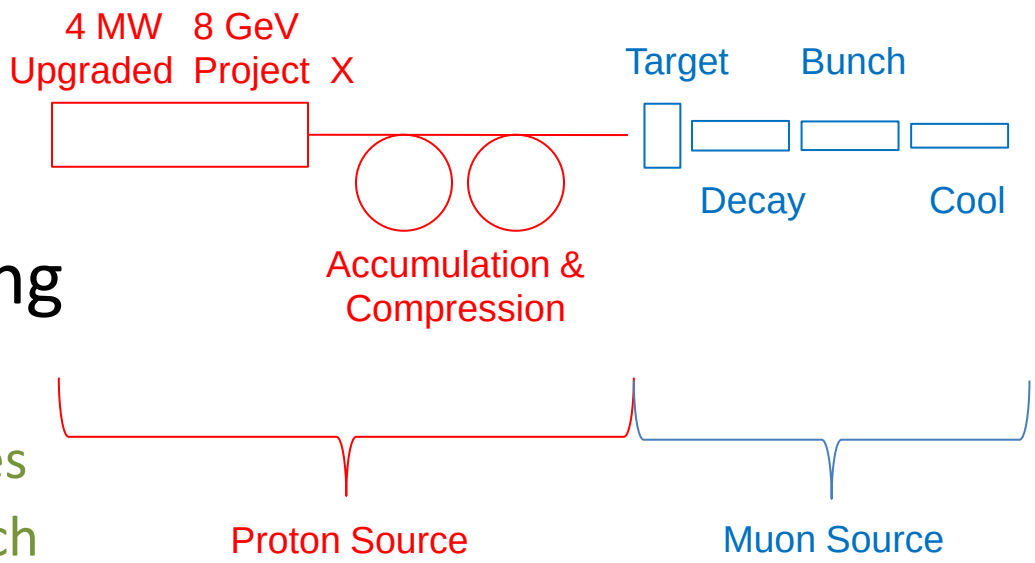
  - Design a system to deliver 300-400 kW to satisfy neutrino program & any other 8 GeV experiments
    - Accumulation duty factor of 3.75% to 5%

Project X to Proton Driver

- Proton Driver energy 5-15 GeV
  - Project X delivers top energy of 8 GeV
- Proton Driver beam power of 4 MW
  - Project X designed to deliver 400 kW at 8 GeV
- Proton Driver 1-3 ns bunch length at 15/50 Hz
  - Will require a Proton Accumulation Ring
  - Will require a Bunching Compressor Ring

Basic Concept for 8 GeV

- Proton Accumulation Ring
  - Considerations
    - Space charge
    - H^- stripping
- Bunch Compressor Ring
  - Considerations
    - Forming 1-3 ns bunches
    - NF: keeping short bunch length for many turns before 2nd and 3rd bunch extractions
    - MC: one bunch or delivery of several bunches at once to target



Beam Power

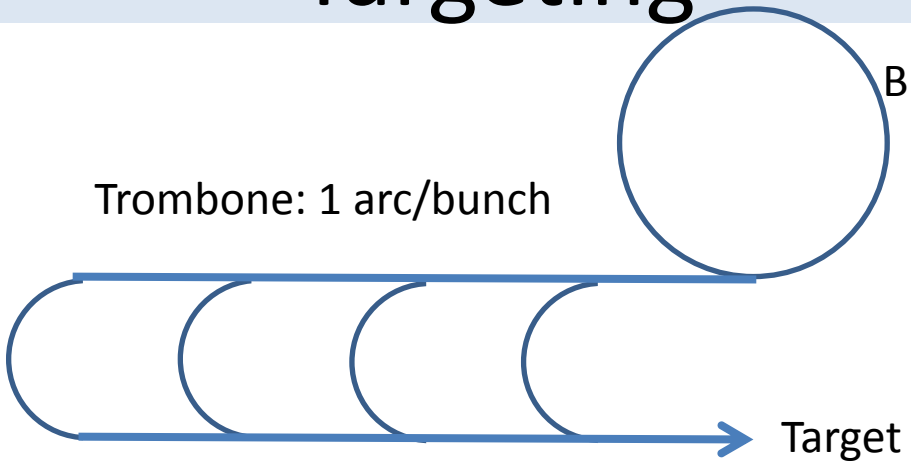
- 1 mA Project X H^- CW linac means 50% of beam to 8 GeV to achieve 4 MW
  - Accumulation duty factor is 50%
    - 10 ms @ 50 Hz or 33 ms @ 15 Hz
      - Overheating of stripping foil
      - Development of laser stripping technology
  - "Pulsed" linac for 3-8 GeV
- Possible upgrade path(s) of Project X
  - Increase CW linac beam current to 4-5 mA
    - ~2 ms @ 50 Hz or ~8 ms @ 15 Hz
  - Convert 3-8 GeV pulsed linac to CW
    - If keep to 1 mA

Bunch Structure

- Bunch in Proton Accumulation Ring
- Transfer to Bunch Compressor Ring
- Rotate to narrow bunch length to 1-3 ns

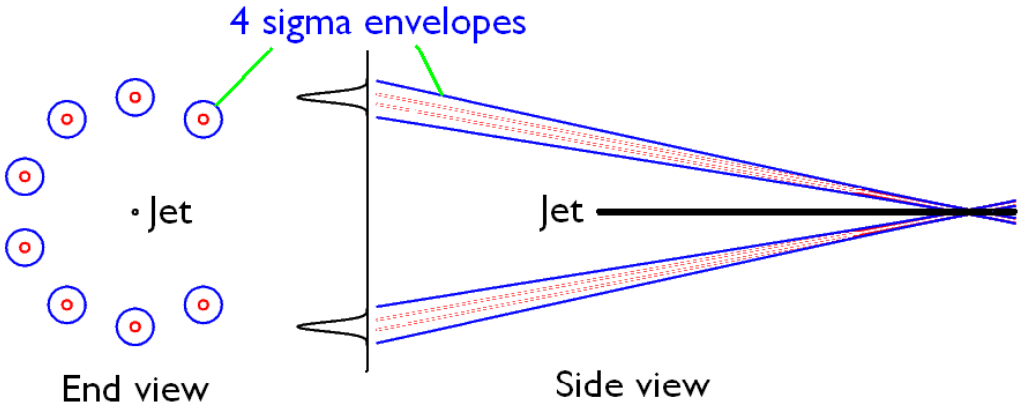
Facility	Cycle Frequency (Hz)	Bunches	Particles per Bunch (10^{12})	Time between Bunch Extractions (μs)
NF	50	3	21	160
MC	15	1	210	-
MC	15	8	26	Single-turn

Single-turn Multi-bunch Targeting



Muon Collider Proton Driver Trombone Schematic

(not to scale; bunches arrive simultaneously on target)



Each beam line provides different trajectory to target

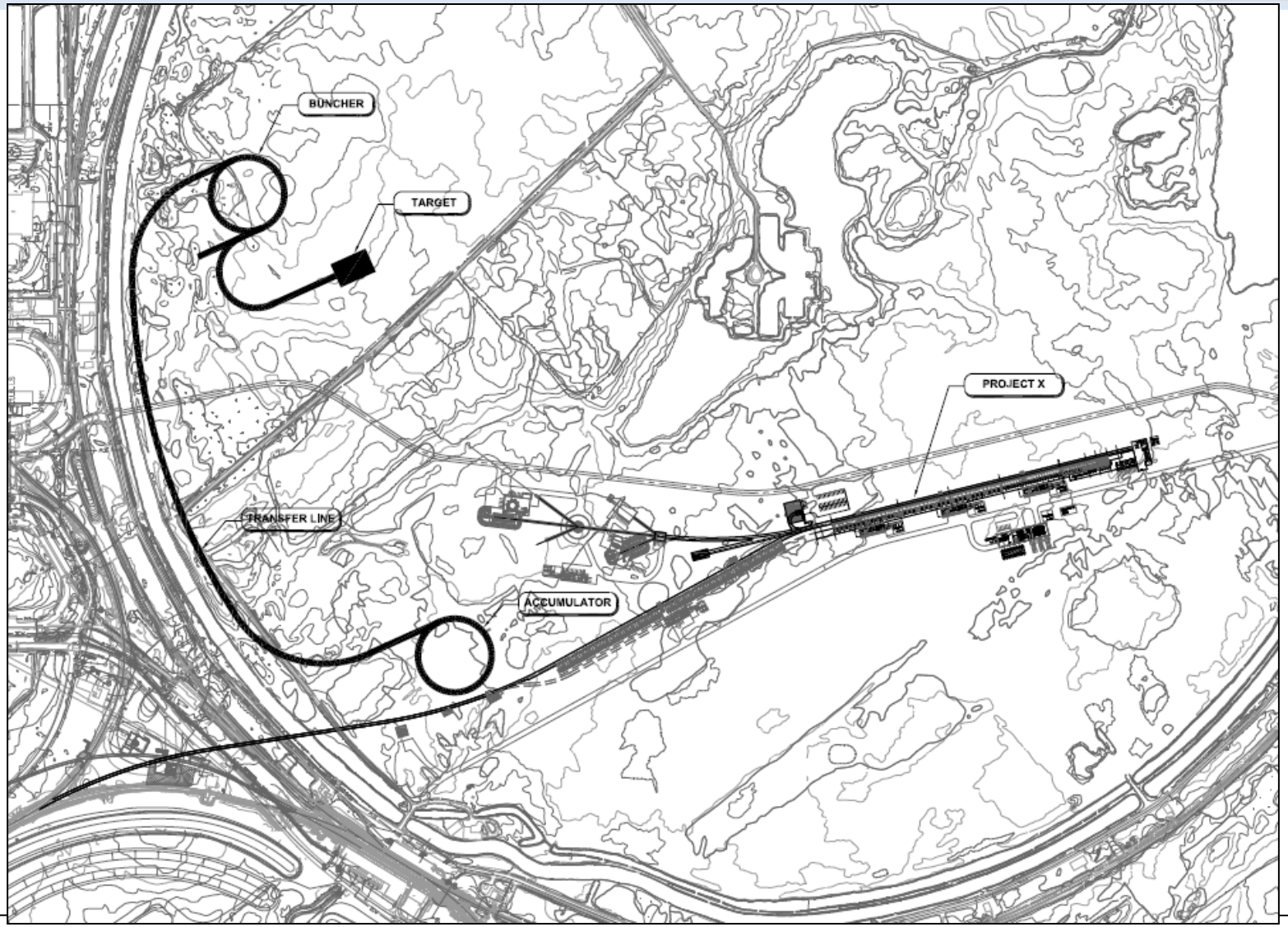
Rings Design Challenges

- Accumulation duty factor (stripping)
- Space charge
- Longitudinal stabilities
- Aperture versus magnet strength
- Peak RF voltage

Milestones

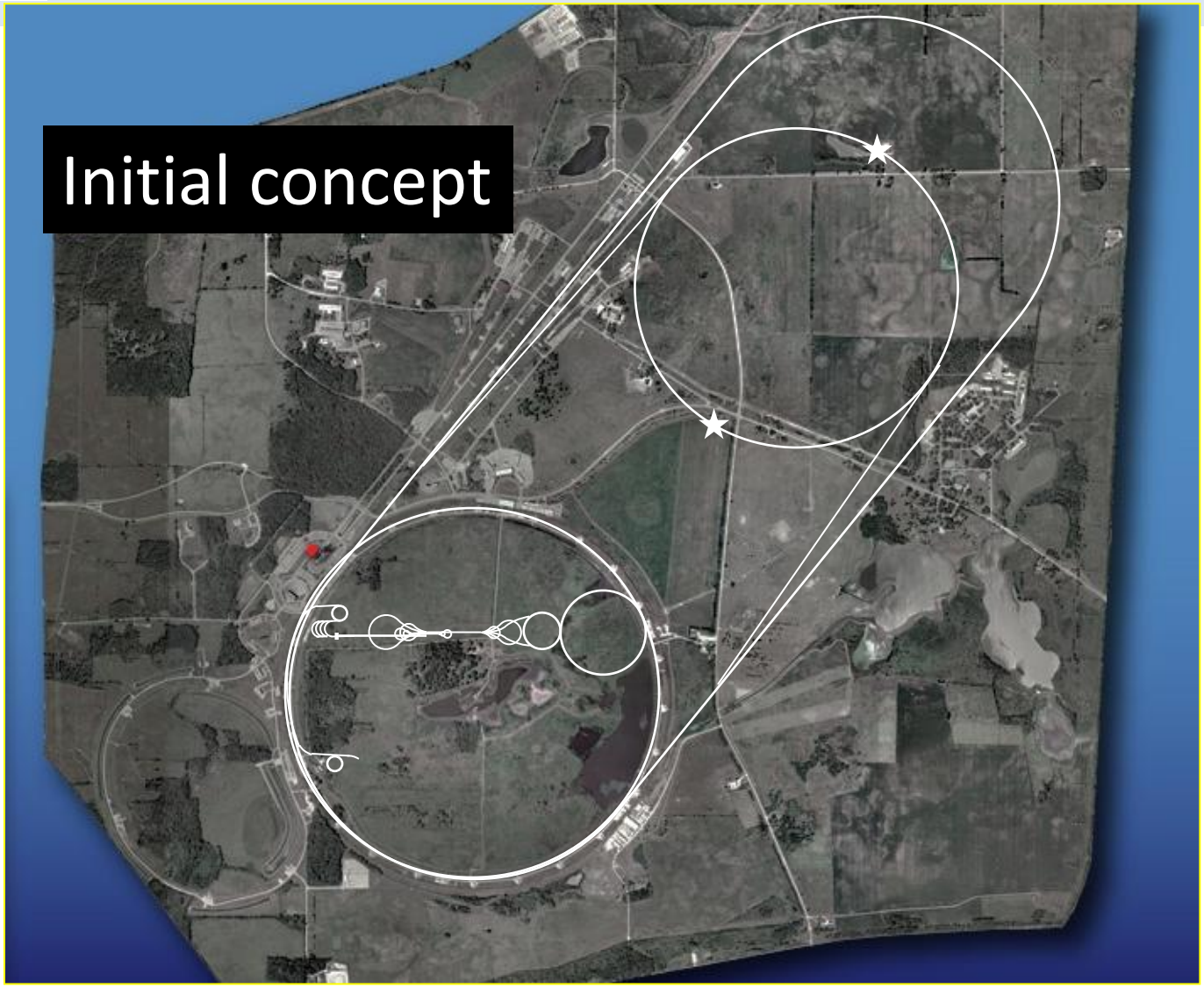
- FY11 IDS-NF-IDR
  - Including site specific engineering
- FY11 Preliminary design of upgraded Project X
- FY13 Specify Proton Driver initial configuration
- FY14 Final IDS-NF RDR report
- FY14 Interim MC DFS report
- FY16 Final MC DFS report

Project X to Proton Driver



Neutrino Factory

Muon Collider



Summary

- Designing Project X to allow for upgrades to support proton source for NF/MC
- Designing Proton Accumulation Ring and Bunch Compressor Ring
- Designing Muon Collider “single bunch” delivery system
- Work upon site layout as concepts/schemes change