Accelerator Issues

Fermilab Antiproton Experiment

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Outline

• Overview Accelerator Complex
  – Protons
  – Antiproton Stacking

• Accumulator Running for Experiment
  – Protons
  – Cycle time

• Accelerator work to be done
  – Equipment
  – Commission Ramps
Protons for Antiproton Production

• Current Operation
  – 11 Booster Batches are loaded into Main Injector
    • Batches are slip stacked to increase intensity
    • Main Injector cycle time is 2.2 sec
      – Length set by loading 11 batches
  – 2 batches are sent to Antiproton Production Target
    • $8 \times 10^{12}$ Protons on Target
    • The other 9 batches go to NuMI

• Note that Booster output is $1.1 \times 10^{16}$ Protons per hour
Antiproton Stacking

- 8GeV negative secondaries are directed into the Debuncher Ring
  - Only antiprotons survive
  - In 2.2sec, increase beam density
  - Transfer to Accumulator before next proton pulse sent to target

- Accumulator further increases density
  - Stacktail increases longitudinal density

- Numbers
  - $27 \times 10^{10}$ antiprotons per hour for cores $< 25 \times 10^{10}$
  - Production efficiency is 20 antiprotons per $10^6$ PoT
  - Rate decreases to $\sim 18 \times 10^{10}$ antiprotons per hour for cores of $\sim 100 \times 10^{10}$
  - Fewer PoT or slower cycle time increase efficiency to above 30 antiprotons per $10^6$ PoT
Protons for Antiproton Production

• Future Operation (Nova era)
  – 12 Booster Batches are loaded into Recycler
    • Batches are slip stacked to increase intensity
    • One turn injection into Main Injector
    • Main Injector cycle time is then 1.33sec
    • Booster output will be $1.4 \times 10^{16}$ Protons per hour
  – Proton Economics
    • Other experiments will vie for remaining Booster cycles
    • Current Proton Plan is $1.4 \times 10^{16}$ Protons per hour
  – 2 batches are sent to Antiproton Production Target every other cycle
    • Most likely $7 \times 10^{12}$ Protons on Target
    • Most likely only stack 4-6hr/day
      – Reduction to Nova for a day is 50% of 2/12 for 6/24 = 2.5%
Antiproton Source Cycle for Experiment

• Stack 4-6hrs
  – Stack rate: average $20 \times 10^{10}$ antiprotons per hour
  – Beam intensity will be 60 to $100 \times 10^{10}$ antiprotons

• Preparation of Antiproton Beam (<2hr)
  – Cool Beam
  – Decelerate Beam to desired energy
  – Cool Beam again before interacting with target

• Run Experiment (16-24hr)
  – Continuous readout/recording orbit and $f_{\text{rev}}$
  – Cool Beam due to target heating
Accelerator Equipment Needed

- **Ramp Control System**
  - Synchronizes changes of magnet currents with RF cavities frequencies during deceleration ramp.

- **Switchable Cooling Delay Lines**
  - Stochastic cooling timing adjustments for different energies

- **Movement of 4-8GHz Core Momentum cooling tanks**
  - A kicker tank is now encroaching into experiment area
    - Need to move kicker tanks upstream and remove/reposition stairs.

- **Continuation of procuring/making spares**
Commissioning

• Prior to running beam with detector in place, will want to re-install concrete shielding to protect experiment from showers caused by secondaries during stacking

• Ramp commissioning is done with protons
  – Will do on core orbit (not central orbit due to location of 4-8GHz momentum pick-ups)
  – Takes 2-3 months depending upon desired lowest energy and ramping efficiency
Conclusion

• Fermilab’s Antiproton Source can host an experiment with little accelerator work and commissioning.
Back-ups
World’s Best Antiproton Source

- Antiprotons produced
  - Fermilab
    - 2010 • Current: $600 \times 10^{10}$ pbars/day ; $12 \times 10^{14}$ pbars/year
    - 2013 • Future: $100 \times 10^{10}$ pbars/day ; $2 \times 10^{14}$ pbars/year
  - CERN AD
    - 2009 • Current: $350 \times 10^{10}$ pbars/year
  - GSI FAIR
    - 2017? • Modules 0-3: $15 \times 10^{10}$ pbars/day ; $0.4 \times 10^{14}$ pbars/year
    - 2020? • Module 5: $70 \times 10^{10}$ pbars/day ; $1 \times 10^{14}$ pbars/year
    - 2025+ • Upgrade: $140 \times 10^{10}$ pbars/day ; $2 \times 10^{14}$ pbars/year
Other Uses of Antiproton Source

• Mu2e has CD0
  – Tunnel Depth radiation issues
  – Earliest to be ready 2017
    • Will need 1 year to connect to extraction tunnel, remove unwanted components and install new items
• DOE is to evaluate g-2 during special Aug. review
  – Evolving desires make it more $ and more $
  – In my opinion, unrealistic about being able to support all that g-2 needs along with other projects
  – Will require more AD people to operate than antiproton experiment
• Both face proton economics issues