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 2.2sec
      - Length set by loading 11 batches
  - 2 batches are sent to Antiproton Production Target
    - 8×10^{12} Protons on Target
    - The other 9 batches go to NuMI

- Note that Booster output is 1.1×10^{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
  - 27×10^{10} antiprotons per hour for cores< 25×10^{10}
  - Production efficiency is 20 antiprotons per 10^6 PoT
  - Rate decreases to ~18×10^{10} antiprotons per hour for cores of ~100×10^{10}
  - Fewer PoT or slower cycle time increase efficiency to above 30 antiprotons per 10^6 PoT

Protons for Antiproton Production

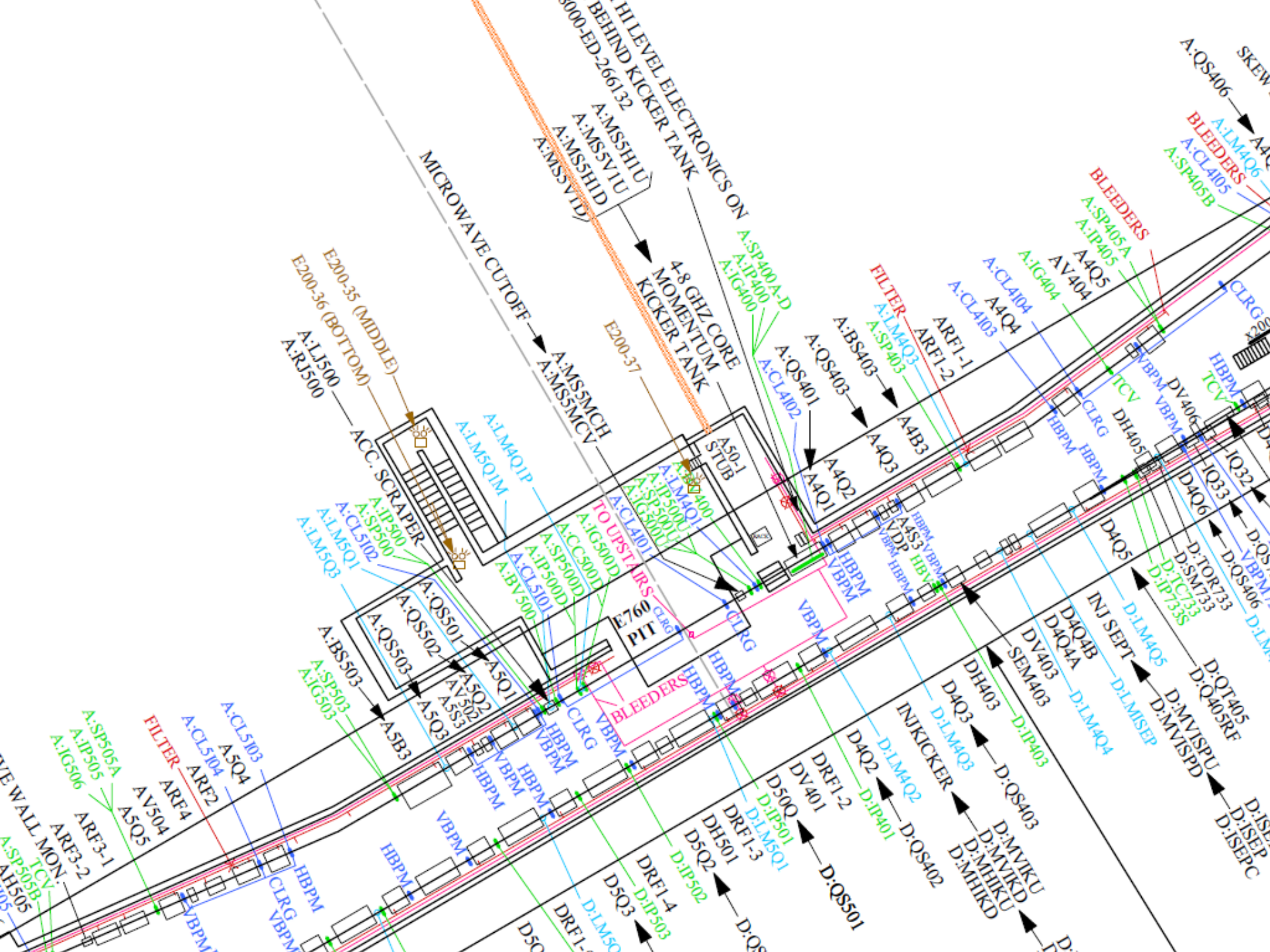
- Future Operation (Nova era)
  - 12 Booster Batches are loaded into Recycler
    - Batches are slip stacked to increase intensity
    - One turn injection into Main Injector
    - Main Injector cycle time is then 1.33sec
    - Booster output will be 1.4×10^{16} Protons per hour
  - Proton Economics
    - Other experiments will vie for remaining Booster cycles
    - Current Proton Plan is 1.4×10^{16} Protons per hour
  - 2 batches are sent to Antiproton Production Target every other cycle
    - Most likely 7×10^{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 20×10^{10} antiprotons per hour
  - Beam intensity will be 60 to 100×10^{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_{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


HI LEVEL ELECTRONICS ON
BEHIND KICKER TANK
000-ED-266132
A:MSSHIU
A:MSSV1U
A:MSSH1D
A:MSSV1D
MICROWAVE CUTOFF
A:MSSMCH
A:MSSMCV
4-8 GHZ CORE
MOMENTUM
KICKER TANK
E200-35 (MIDDLE)
E200-36 (BOTTOM)
E200-37
A:LI500
A:RJ500
ACC. SCRAPER
A50-1
STUB
A:SP400A-D
A:IP400
A:IG400
A:CL4102
A:QS401
A:QS403
A:BS403
A4B3
A4Q3
A4Q2
A4Q1
ARF1-1
ARF1-2
A4Q5
AV404
A4Q4
A:CL4104
A:CL4103
A:IG404
A:SP405A
A:IP405
BLEEDERS
A:LM4Q6
A:CL4105
A:SP405B
FILTER
A:LM4Q3
A:SP403
TCV
CLRG
HBPM
VBPM
DV406
DH405
D4Q6
D4Q5
IQ33
IQ32
D:TOR733
D:SM733
D:TC733
D:IP733S
D:LM4Q5
D:LMISEP
INJ SEPT
D:MVISPU
D:MVISPD
D:QT405
D:Q405RF
D:ISER
D:ISEPC
A:LM4Q1P
A:LM5Q1M
A:LM5Q1
A:CL5102
A:LM5Q3
A:IP500
A:SP500
A:QS501
A:QS502
A:QS503
A:BS503
A5Q1
A5Q2
AV502
A5S3
A5Q3
A5B3
A:CCS001
A:SP500D
A:IP500D
A:CL5101
A:BV500
A:IG500D
TO UPSTAIRS
A:LM4Q1
A:IP500U
A:SP500U
A:IG500U
A:CL4101
E760
PIT
CLRG
BLEEDERS
HBPM
VBPM
A4S3
VDP
VBPM
HBPM
HBV
D:LM4Q4
D4Q4B
D4Q4A
DV403
SEM403
DH403
D:IP403
D:QS403
D4Q3
D:LM4Q3
D:QS402
D4Q2
D:IP401
D:LM4Q2
INJKICKER
D:MVIKU
D:MVIKD
D:MHIKU
D:MHIKD
DRF1-2
DV401
D50Q
D:QS501
DRF1-3
DH501
D5Q2
D:IP502
D:LM5Q1
DRF1-4
D5Q3
D:IP503
D:LM5Q2
A:SP503
A:IG503
A:CL5103
A5Q4
AV504
A5Q5
ARF4
ARF2
ARF3-1
ARF3-2
A:SP505A
A:IP505
A:IG506
A:CL5104
FILTER
WALL MON.
TCV
A:SP505B
AH505
A:QS406
SKEW
A:LM4Q6
BLEEDERS
A:CL4105
A:SP405B

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: 600×10^{10} pbars/day ; 12×10^{14} pbars/year
    - 2013 • Future: 100×10^{10} pbars/day ; 2×10^{14} pbars/year
  - CERN AD
    - 2009 • Current: 350×10^{10} pbars/year
  - GSI FAIR
    - 2017? • Modules 0-3: 15×10^{10} pbars/day ; 0.4×10^{14} pbars/year
    - 2020? • Module 5: 70×10^{10} pbars/day ; 1×10^{14} pbars/year
    - 2025+ • Uprade: 140×10^{10} pbars/day ; 2×10^{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