SNOWMASS21-AF2_AF0_pellico-158.pdf

Cross Frontiers – Booster Accumulator Ring (BAR) Workshop

Thursday Dec 15, 2020

William Pellico

Present Complex

Linac:

15 Hz

30 ma

Booster:

8 GeV,

15 Hz

MI:

150,120, 60 GeV

1.2 sec cycle

Muon Campus, 8 GeV

Fixed Target (Test Beams), 120 GeV

Physics:

G-2

Neutrino –

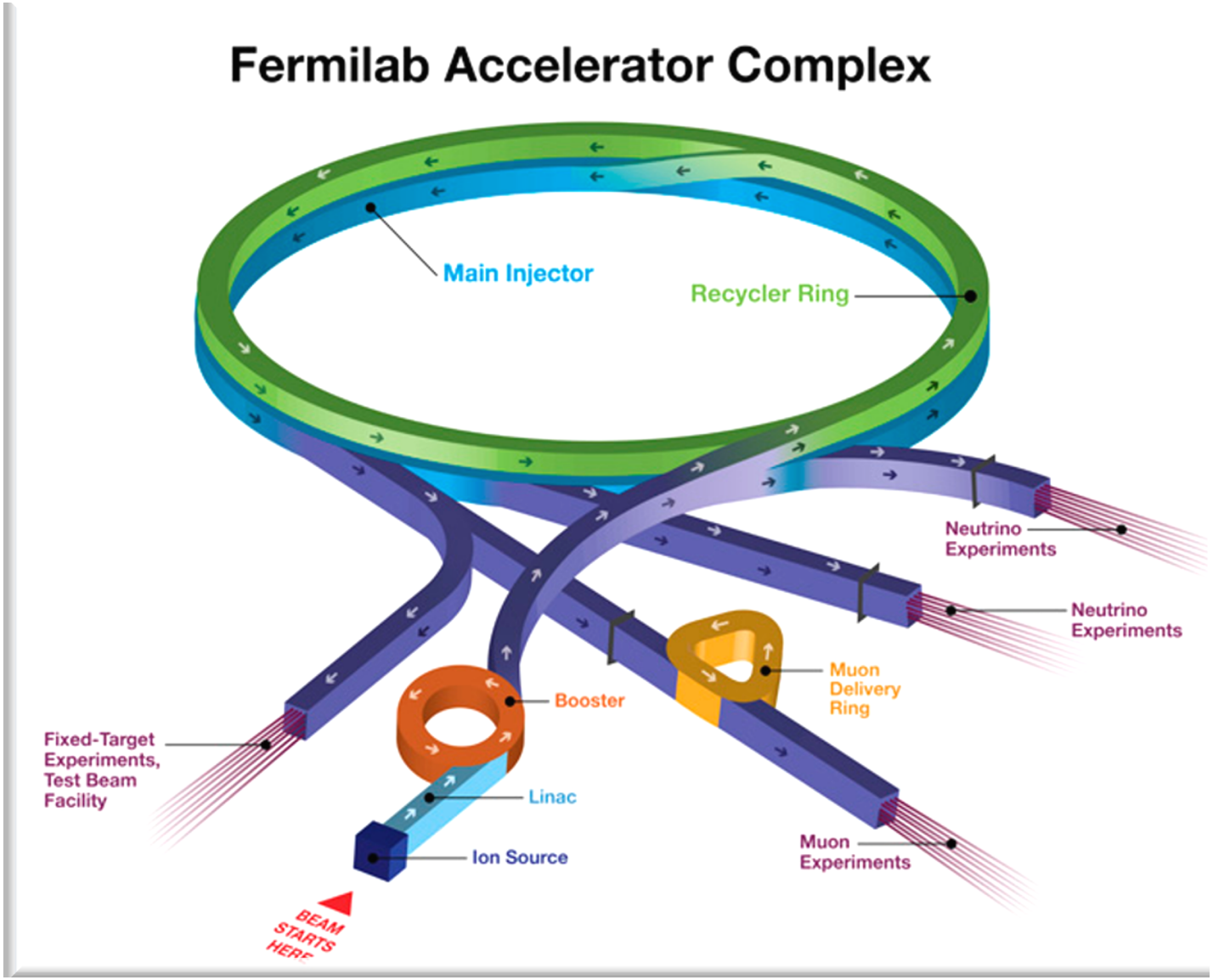
NoVA:

Short Baseline: ICARUS and SBND

Long Baseline: NOvA

Fixed Target - Misc

Dark Matter & Dark Energy



PIP-II Complex

SRF PIPII: 800 MeV:
- 2.5 ma
- High Cycle Rate
- Upgradable

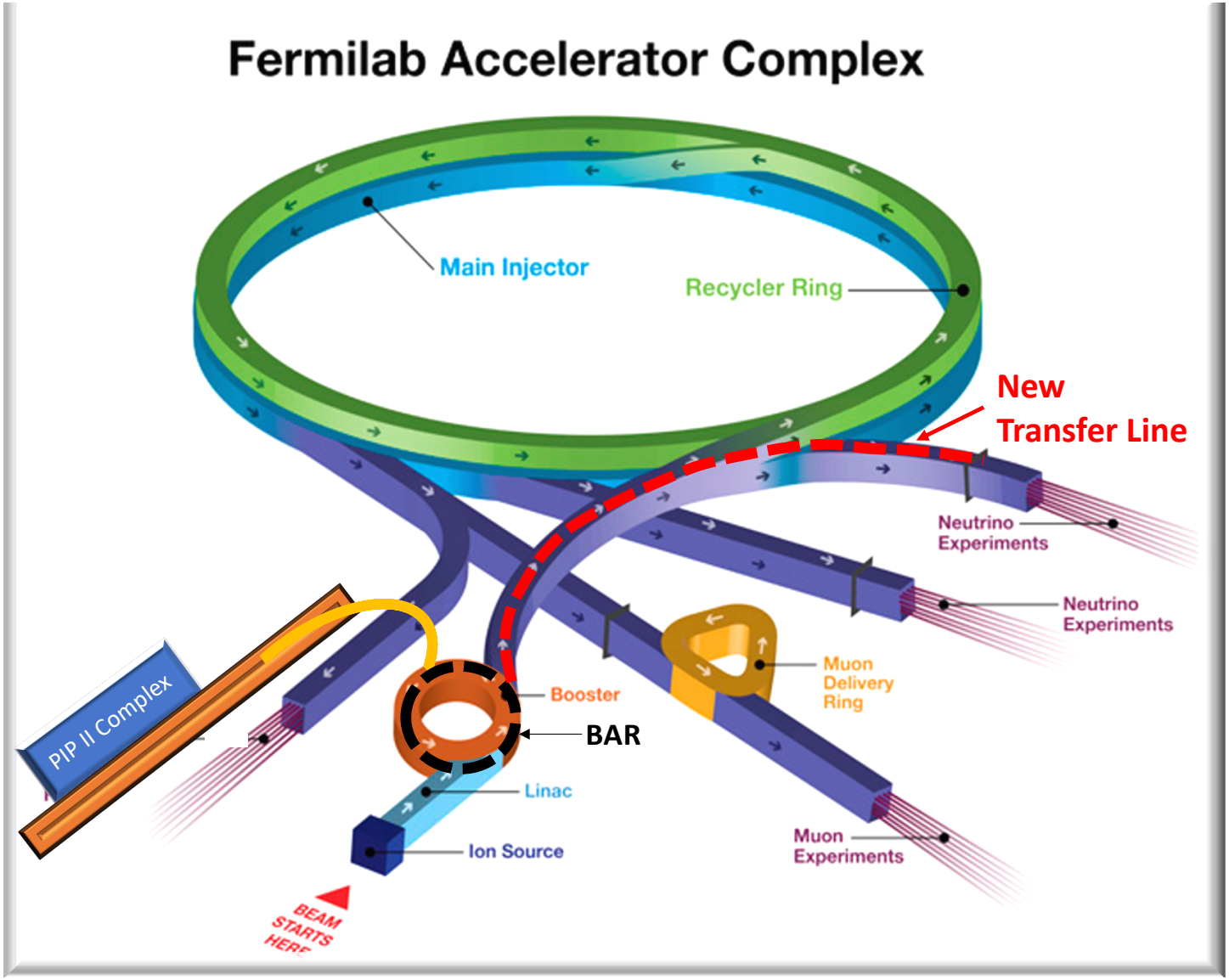
Booster:
- 8 GeV
- 20 Hz

MI: 150, 120, 60 GeV

Muon Campus, 8 GeV

Fixed Target, 120 GeV

Physics:
- Mu2E
- Neutrino - DUNE
- Fixed Target - Test Beams
- Dark Matter, Dark Energy



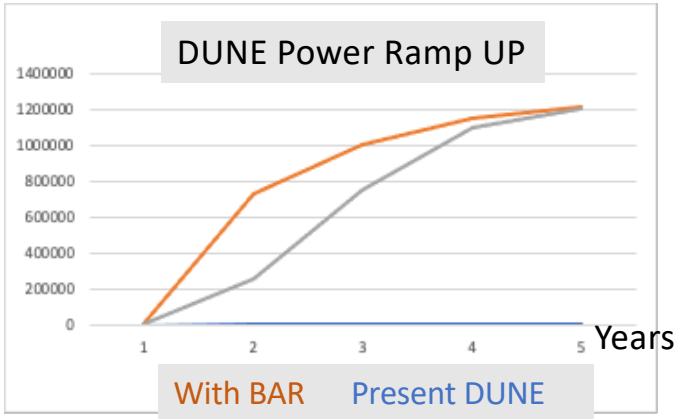
Why BAR – Why Now

- The BAR concept offers significant simplification to planned PIPII Booster injection.
  - An option for additional stages

    Talks: by Dave Johnson, CY Tan
- BAR looks to reduce DUNE power ramp up times.

  Talk: CY Tan
- BAR offers a path to quickly utilize the capability of PIPII.

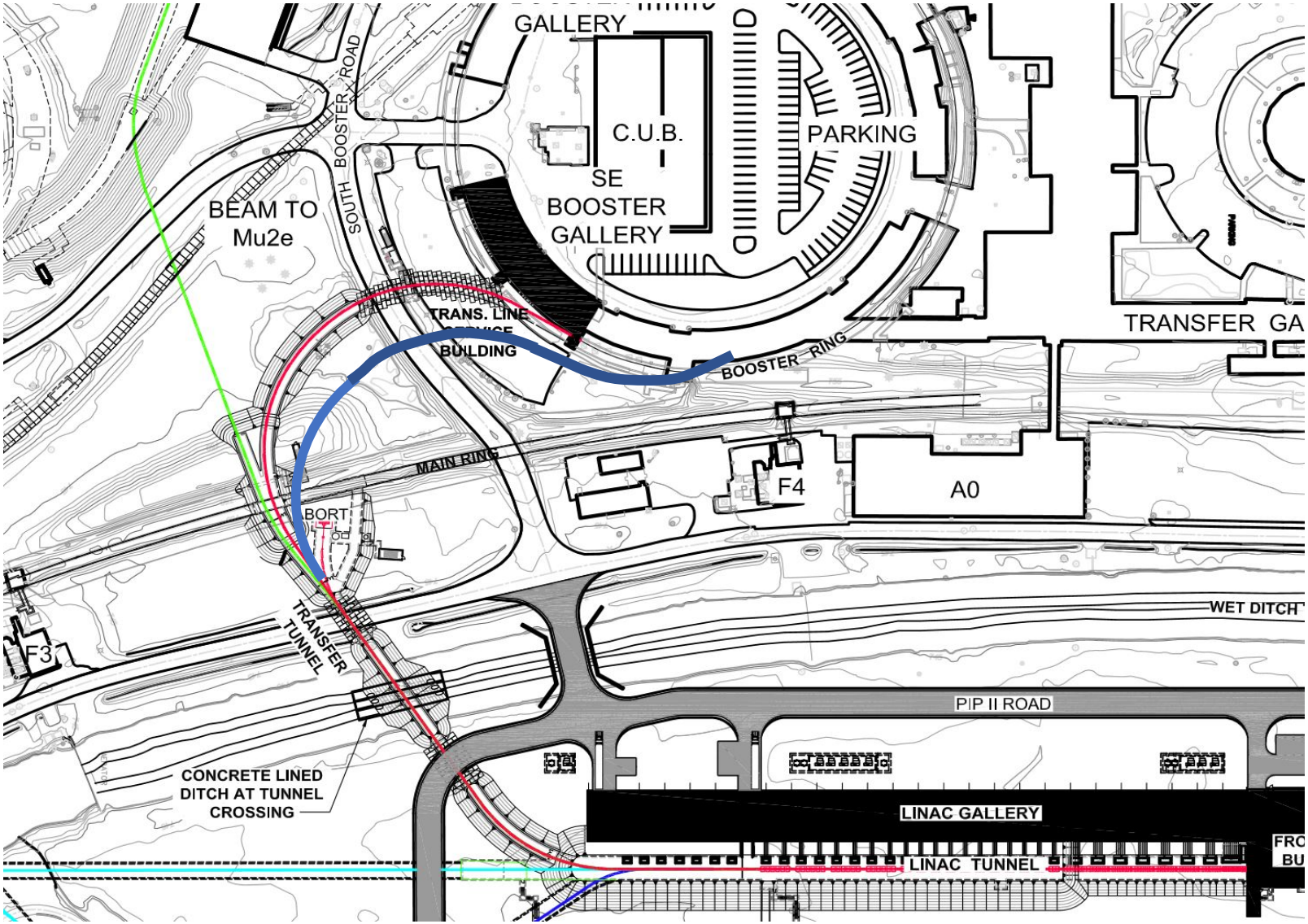
  Afternoon Talks



These benefits and the PIP II timeline require action before the planned Snowmass timeline.

- BAR provides a path to a Dark Sector program with significant savings of time and money.

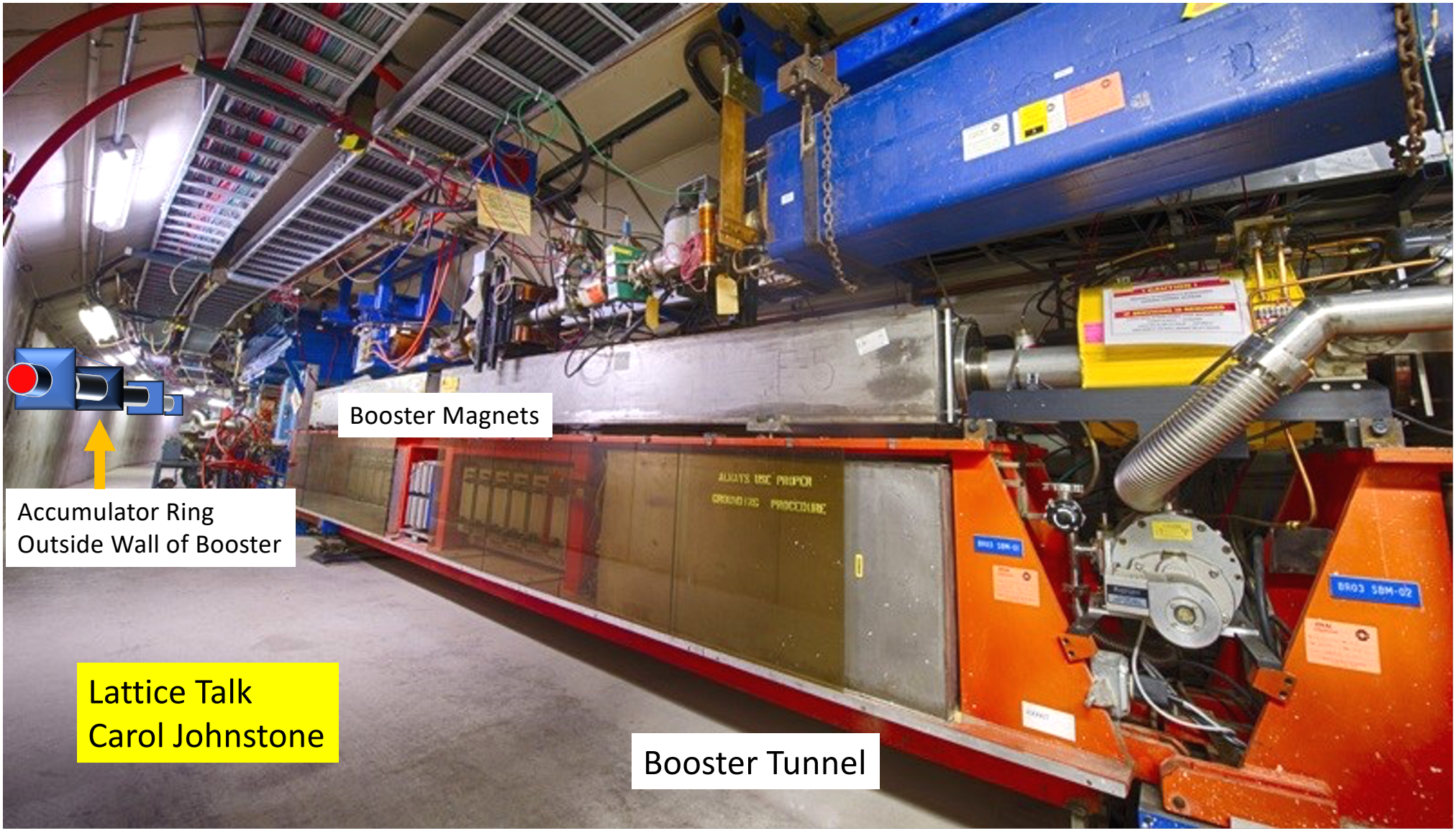
  Ready to use with PIP-II startup – no new enclosures
- BAR uses may extend beyond DS physics – Mu2e, Radiation Test Facility….
- BAR will allow accelerator scientist and engineers to test concepts needed for future storage rings and RCS.



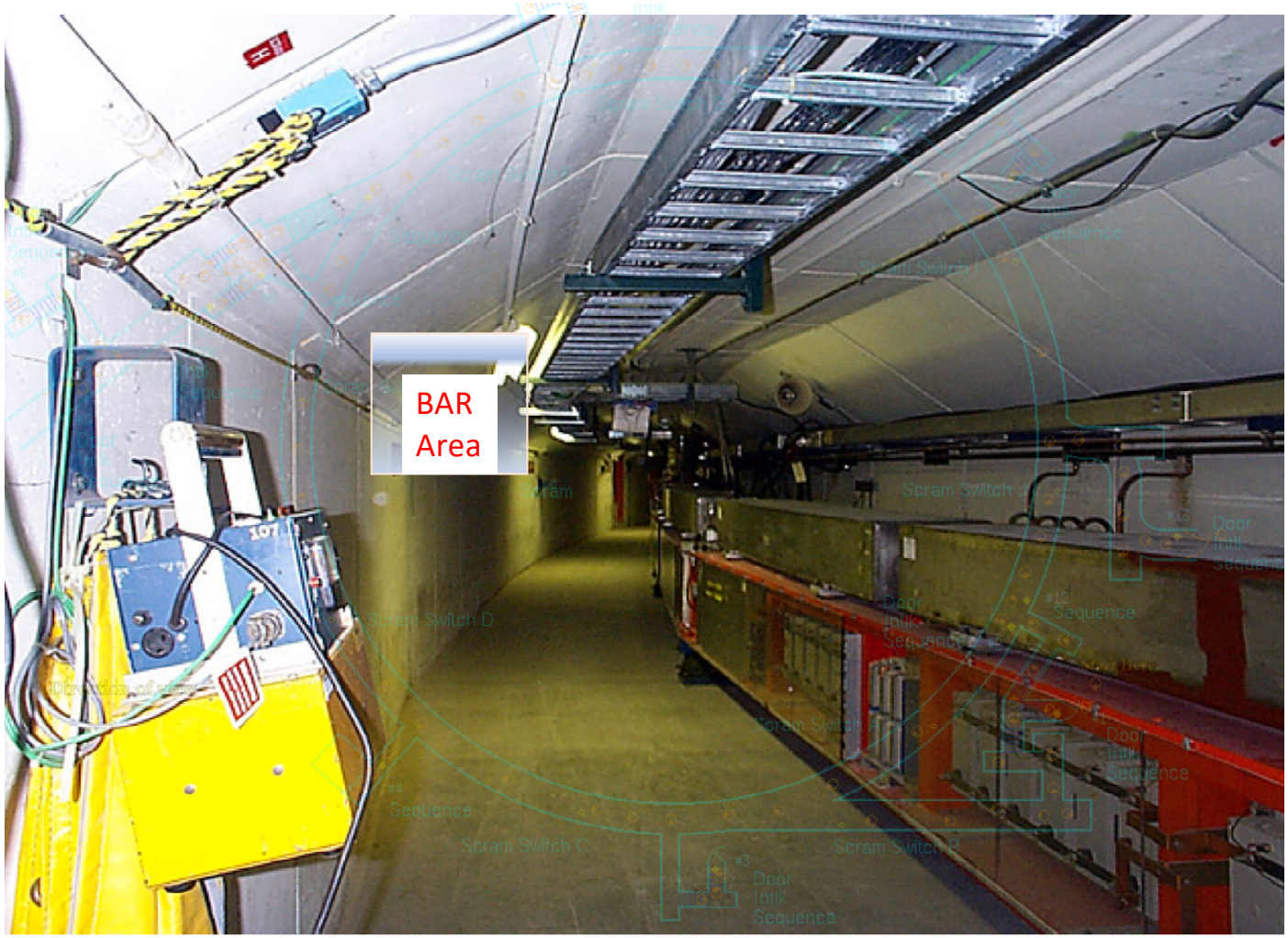
Planned PIP –II Injection

TALKS
Dave Johnson PIP II
CY Tan – Task Force

Alternate PIP –II Injection
Needs to be explored
along with lattice


Booster Magnets
Accumulator Ring
Outside Wall of Booster
Lattice Talk
Carol Johnstone
Booster Tunnel

https://operations.fnal.gov/restricted/training/booster/ss/intro2.html

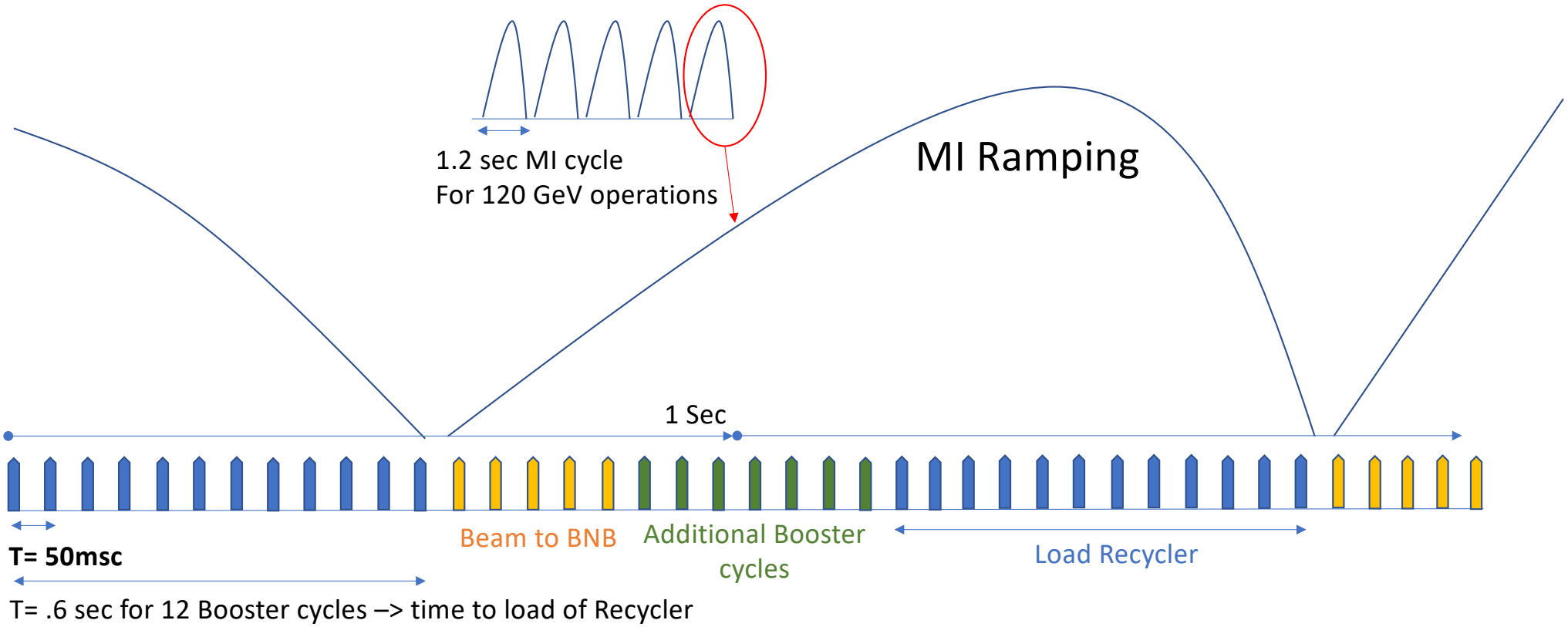


Standard Booster Area:
There are four basic enclosure forms:
This is the smallest section –

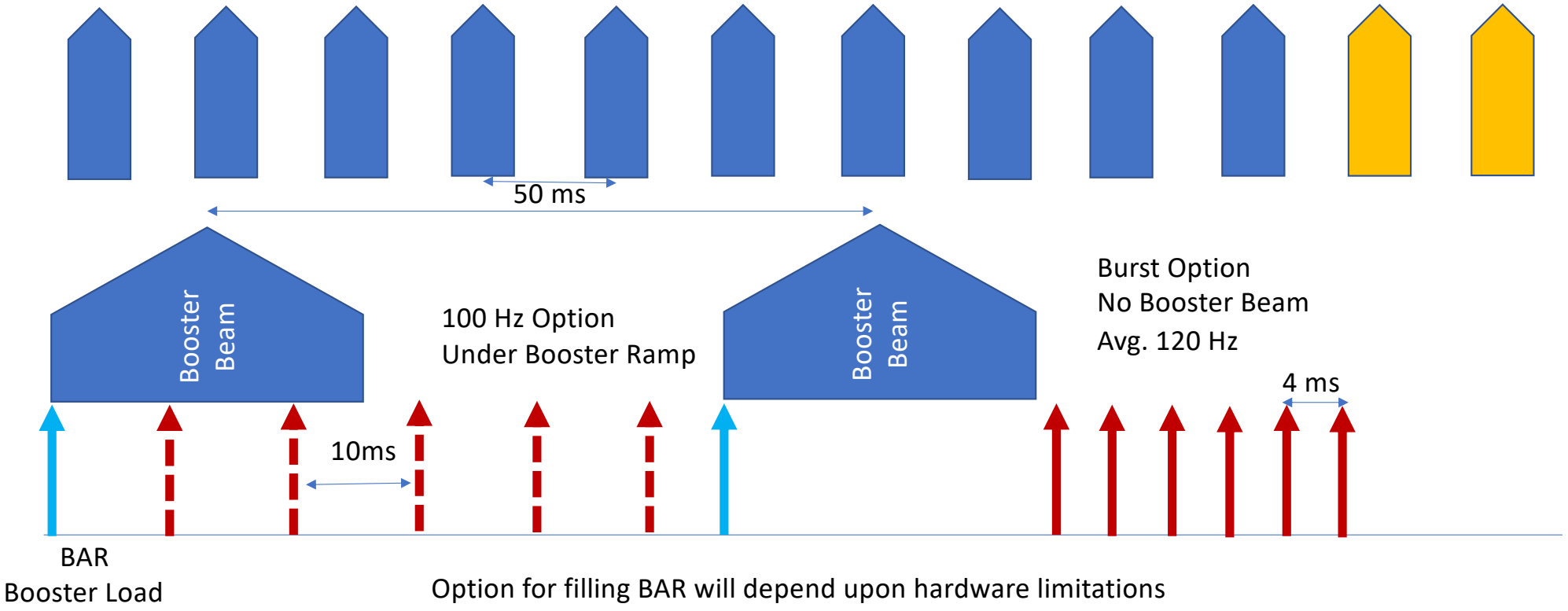
Not enough space for RF, injection or extraction but fine for standard lattice elements.

We will look to reuse old Booster trim correctors – stored away, which can operate DC at low values adequate for the storage ring.

BAR Operation
PIP-II - Booster – Recycler – MI cycles



Booster and BAR Cycles



Option for filling BAR will depend upon hardware limitations

BAR Parameter Tables – Being Investigated – **Chandra Bhat (RF Talk)**

Booster Accumulator Ring (BAR) Parameters - Booster Use		
Parameter Name	Value	Units
Booster Synchrotron Circumference	474.2	m
Booster Synchrotron Radius	75.47	m
Booster Accumulator Circumference	485.49	m
Booster Accumulator Radius	77.27	m
BAR Injection Energy (kinetic)	800	MeV
BAR Injection Energy (Total)	1738	MeV
BAR Extraction Energy (kinetic)	800	MeV
Gamma Transition(for Booster=5.4783)	6.36	???
Revolution Frequency	519822	Hz
Revolution Period	1.924	us
RF Properties		
h (matching with Booster RF)	86	Fundamental
fRF	44.705	MHz
Bucket Length	22.37	ns
Number of Booster type RF Cavities	4	
Peak RF Voltage/Cavity	50	kV
Total RF Voltage	0.2	MV
Bucket Area	0.074	eVs
Synchrotron Oscillation Period	1.27E+04	Hz
PIP2 beam Intensity	6.70E+12	ppCycle
PIP2 Bunch Intensity	8.27E+10	p/bunch

BAR – Accumulator for storage for DS Physics Search		
Option 1		
h - Harmonic Number (additional RF system)	4	
fRF	2.079	MHz
Bucket Length	480.93	ns
Number of Recycler type 2.05 MHz RF Cavities	2	
Peak RF Voltage/Cavity	5	kV
Peak RF Voltage	0.01	MV
Bucket Area	1.66	eVs
Synchrotron Oscillation Period	6.10E+02	Hz
Scaled Bunch Intensity	1.82E+12	p/bunch
Option 2		
h (additional RF system)	5	
fRF	2.599	MHz
Bucket Length	384.75	ns
Number of Recycler type 2.5MHz RF Cavities	2	
Peak RF Voltage/Cavity	5	kV
Peak RF Voltage	0.010	MV
Bucket Area	1.19	eVs
Synchrotron Oscillation Period	6.82E+02	Hz
Average Bending Radius	77.2682102	m
Average Dipole B-Field	0.063	Tesla

BAR Beam to DS program

- Assuming 100 Hz hardware limitations and Space Charge like PIP-II

100 Hz* 1E13 ppp*800 MeV*1.6E-19 = 128 kW

- More pulses and or higher intensity may be possible

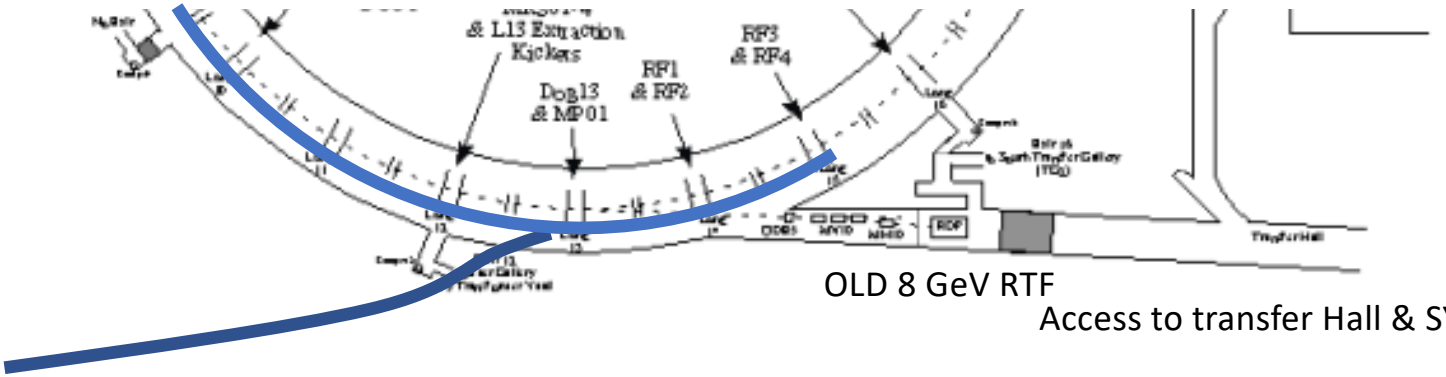
- There is also the option that PIP-II increases the beam energy to 1 GeV.
- The SC is reduced, and you can scale up the beam intensity:

100 Hz*1.5E13 ppp*1E9*1.6E-19 = 240 kW

Limitations for these intensities need to be examined – such as shielding, painting, injection foil, extraction, RF needs…..

Other Possible Uses

- So, with PIP II injection in this region of the Booster, one may consider other possibilities. These have not been vetted and only meant for discussion.
  - Could there be a use for 800 MeV beam radiation test facility?
    - Used in the past – beam dump for this use is still in place
  - Could there be a use to send 800 MeV beam back into the transfer hall – to SY?



OLD 8 GeV RTF

Access to transfer Hall & SY

Summary

The BAR offers solutions to present PIP-II to Booster operations, **an immediate extended use of the PIP-II capability**, a stage to upgrade power, an opportunity for FNAL to make a significant contribution to Dark Sector physics and an exciting area of accelerator development.

This option, by using the upgrades and facilities that exist or soon to exist, is cost effective and achievable on a short time scale.

To achieve this capability before the end of this decade is possible but needs to start now.