Run 2B Overview

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AAC Meeting

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Run II Luminosity Goals

- The luminosity goal for Run IIa is 2 fb^{-1}
  - Peak luminosity up to 2.2×10^{32} $cm^{-2}sec^{-1}$(with no crossing angle)
  - Switch to 103 bunches at 1-2×10^{32} $cm^{-2}sec^{-1}$
  - Length of Run IIa is about 3 years

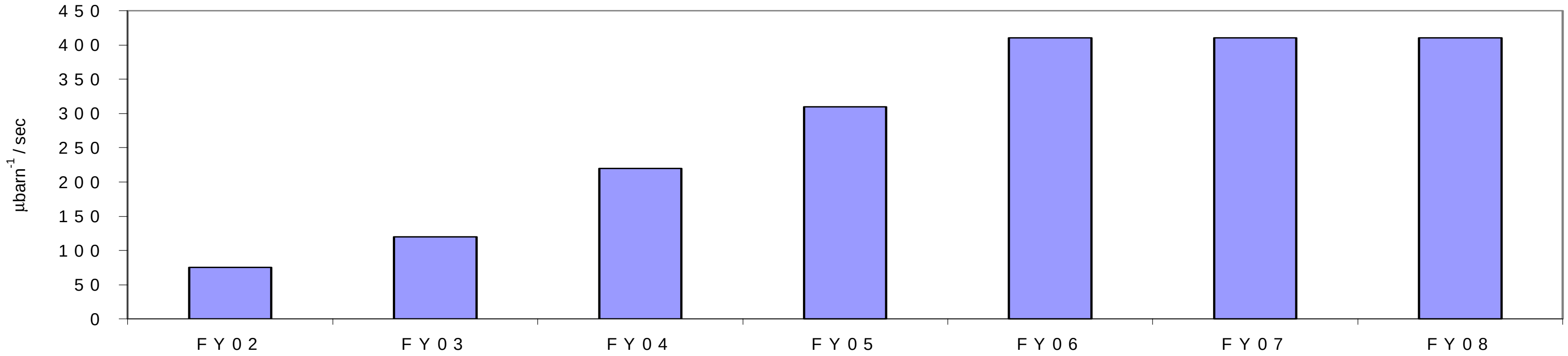
- The luminosity goal for Run IIa+Run IIb is 15 fb^{-1}
  - Increase antiproton intensity by a factor of 3
  - Peak luminosity up to 4.1×10^{32} $cm^{-2}sec^{-1}$
  - 103 bunch operation
  - Length of Run IIb is about 4 years

Run II Schedule

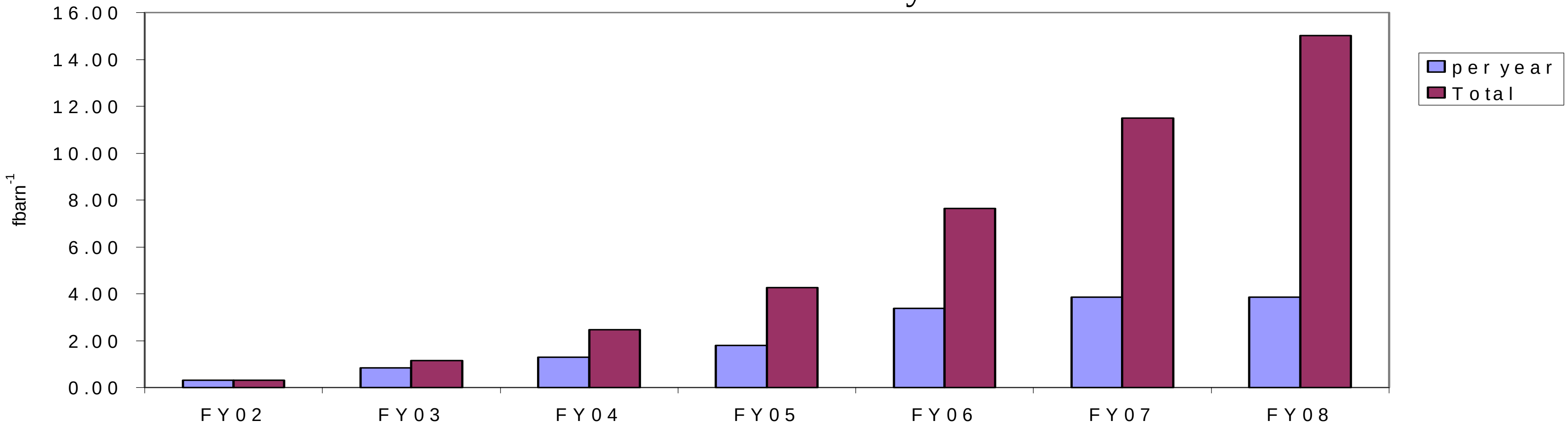
Fiscal Year	Luminosity $\mu barn^{-1}/sec$	$pbarn^{-1}$ per week	Months of Operations	Shutdowns (months)	$fbarn^{-1}$ per year	$fbarn^{-1}$ Total
FY02[1]	75	15	10	2	0.32	0.3
FY03[2]	120	24	10	2	0.83	1.2
FY04[3]	220	43	9	3	1.31	2.5
FY05[4]	310	61	8	4	1.81	4.3
FY06	410	81	11	1	3.38	7.6
FY07	410	81	11	1	3.85	11.5
FY08	410	81	11	1	3.85	15.0

- [1] Shutdown in October for Recycler alignment. Shutdown in September to install Electron Cooling push pipe.
- [2] Assume Recycler is working. Shutdown in August to install 132 nS hardware and Electron Cooling into the Recycler
- [3] Finish installation of 132 nS and Electron Cooling. Spend 1 month commissioning 132 nS.
- [4] Shutdown for Run IIb silicon and CO I-R. Initiate NUMI with 20% impact

Luminosity Schedule



Peak Luminosity



Integrated Luminosity

Luminosity Formula

$$\mathrm{L} = \frac{3\gamma f_0}{\beta^*}\left(BN_{\bar{p}}\right)\left(\frac{N_p}{\varepsilon_p}\right)\frac{F\left(\beta^*, \theta_{x,y}, \varepsilon_{p,\bar{p}}, \sigma^L_{p,\bar{p}}\right)}{\left(1+\varepsilon_{\bar{p}}/\varepsilon_p\right)}$$

The major luminosity limitations are

- The number of antiprotons ($BN_{\bar{p}}$)
- The proton beam brightness (N_p/ε_p)
- $F<1$

Antiproton Economics

$$\Phi_{\bar{p}}^{(\min)} = n_c \sigma_a L$$

- $n_c = 2$
- $\sigma_a = 70$ mb
- $L = 4.0 \mathrm{x} 10^{32}$ cm^{-2}-sec^{-1}
- $\Phi = 20 \times 10^{10}$ hr^{-1}

Run II Parameters

Run	Ib	IIa$^-$	IIa$^+$	IIb	
Typical Luminosity	1.6	8.6	11.9	41.0	x10^{31}cm^{-2}sec^{-1}
Integrated Luminosity	3.1	17.1	23.4	80.9	pb^{-1}/wk
Interactions/crossing	2.5	2.2	1.1	3.7	
Pbar Bunches	6	36	103	103	
Store efficiency factor	0.65	0.65	0.65	0.65	
Form Factor	0.59	0.74	0.40	0.40	
Protons/bunch	23.0	27.0	27.0	27.0	x10^{10}
Pbars/bunch	5.6	3.1	2.7	9.4	x10^{10}
Pbars lost in collisions	8.4	34.1	46.8	161.7	x10^{10}
Total pbars	33.6	110.2	278.8	963.4	x10^{10}
Peak Pbar Prod. Rate	7.0	17.0	19.0	62.0	x10^{10}/hr
Avg. Pbar Prod.Rate	4.2	10.2	16.2	55.8	x10^{10}/hr
Pbar Prod. Eff.	60	60	85	90	%

Run	Ib	IIa$^-$	IIa$^+$	IIb	
Reliability	50	50	50	50	%
Pbar Transmission Eff.	50	90	90	90	%
Recycling efficiency	0	0	50	50	%
Pbar Utilization	12	28	24	24	%
β*	35	35	35	35	cm
Bunch Length (rms)	0.6	0.37	0.37	0.37	m
Energy	900	980	980	980	GeV
Bunch Spacing	3500	396	132	132	nS
Crossing Angle	0	0	136	136	μrad
Proton Emittance	23	20	20	20	π-mm-mrad
Pbar Emittance	13	15	15	15	π-mm-mrad
Luminosity lifetime	17	13	13	13	hr
Store Length	16	12	12	12	hr

- without Recycler

+ with Recycler

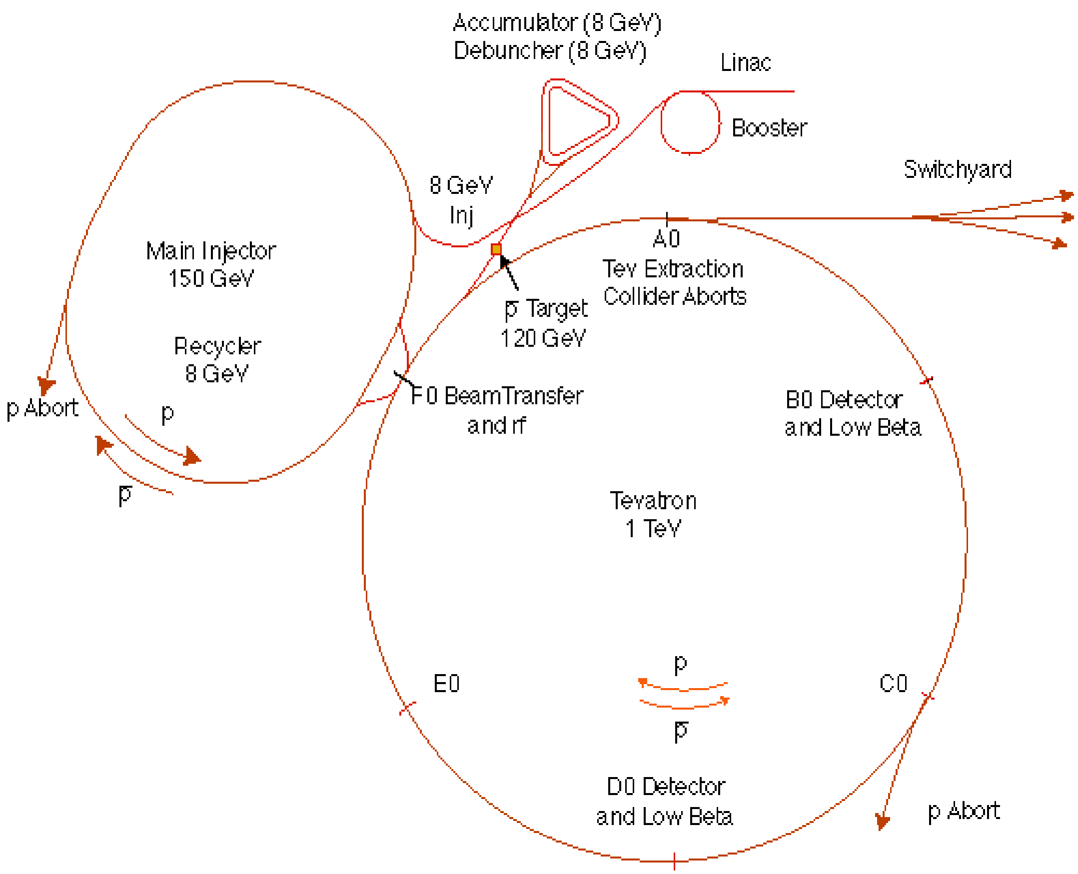
The Run IIb Plan

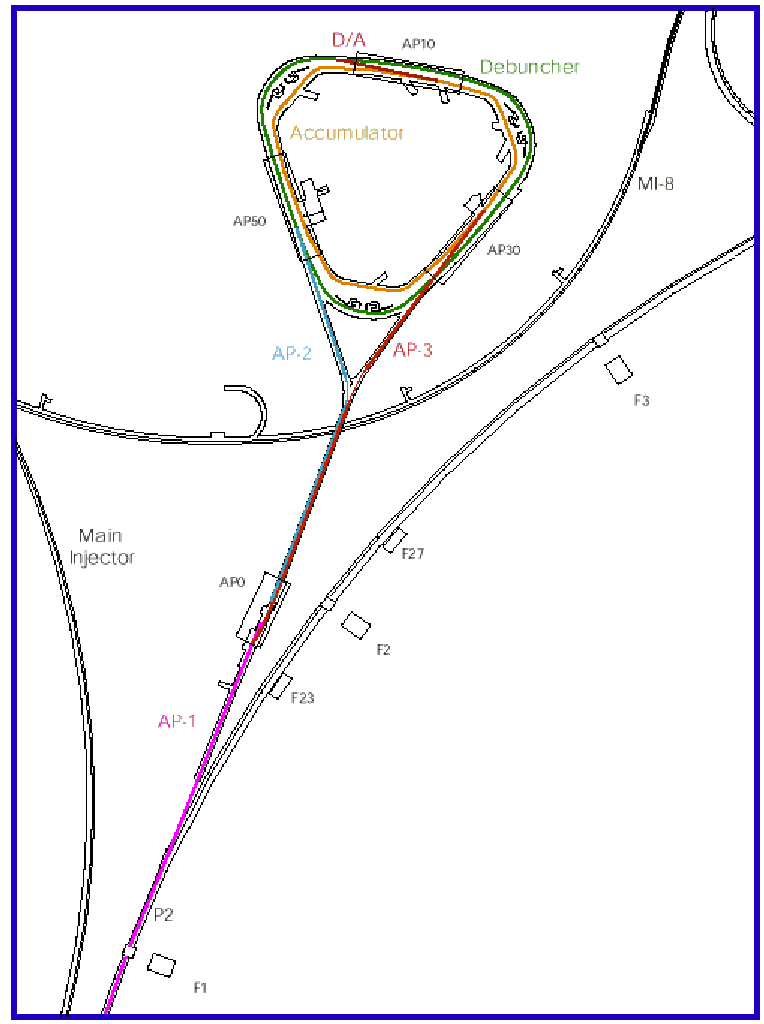
To obtain 15 fb^{-1} by 2008 we need to:

Increase the number of antiprotons in the collider by a factor of 3 over Run IIa

- without major interruption to Run IIa
- within a period of 2-3 years
- with a budget of about ~$30 M

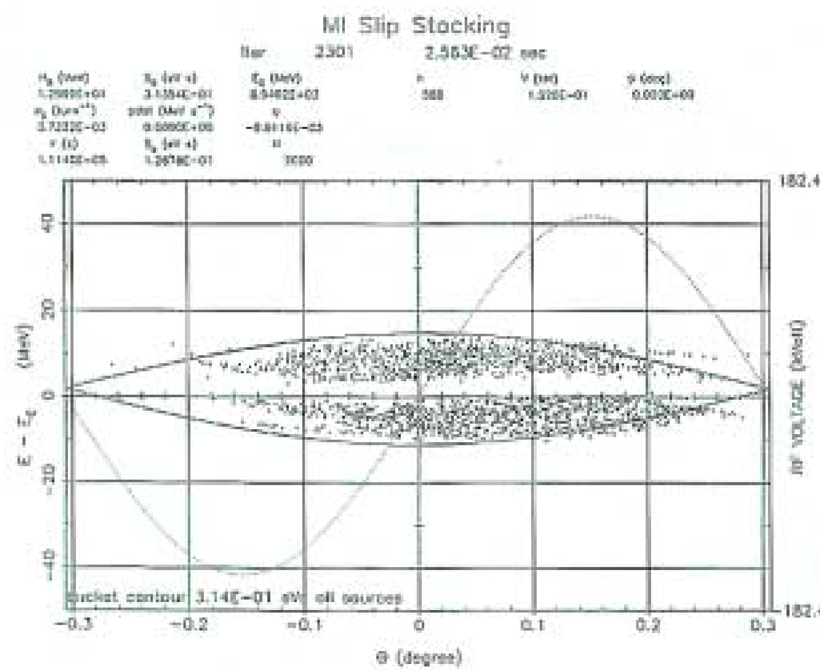
The Fermilab Accelerator Complex

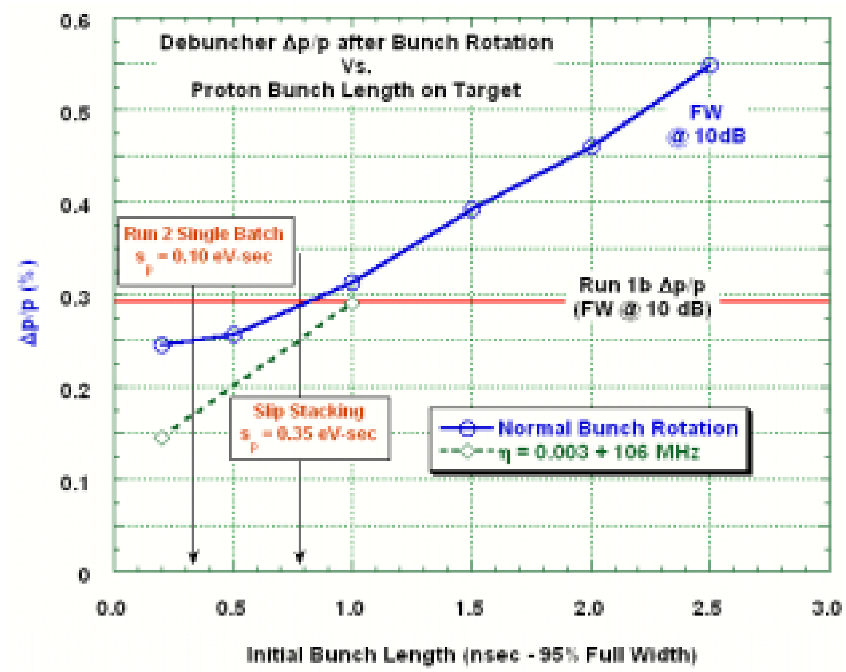




More Antiproton Flux

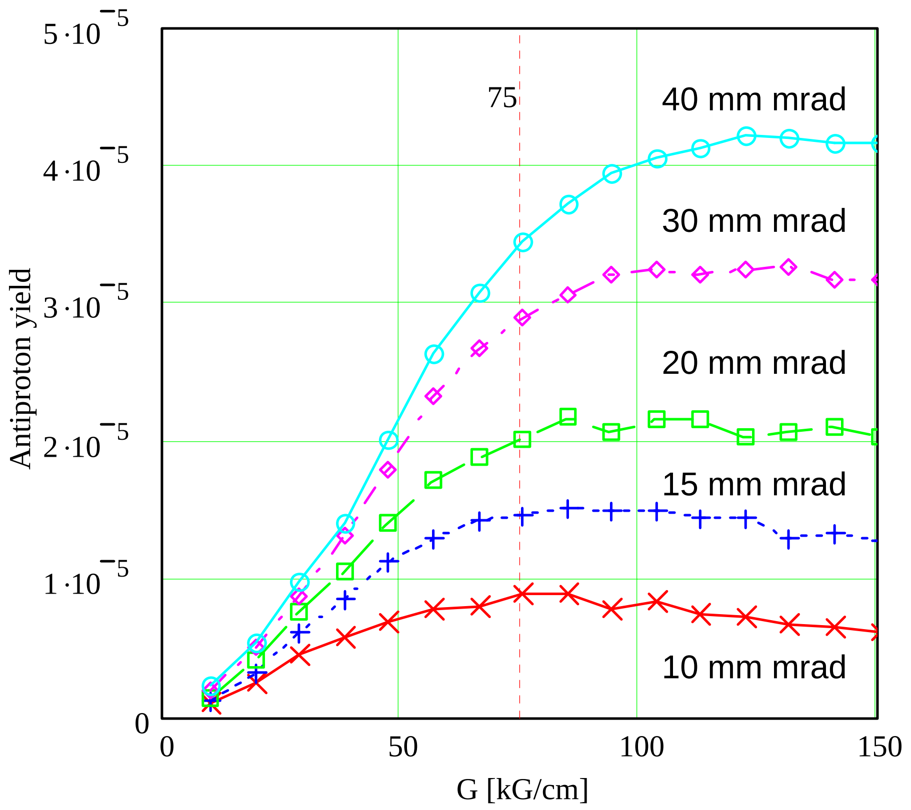
- Increase the number of protons on the antiproton production target by a factor of 1.8 by slip stacking two Booster batches in the Main Injector. (The extra Main Injector cycle time required for NUMI will reduce this factor to 1.5)





More Antiproton Flux

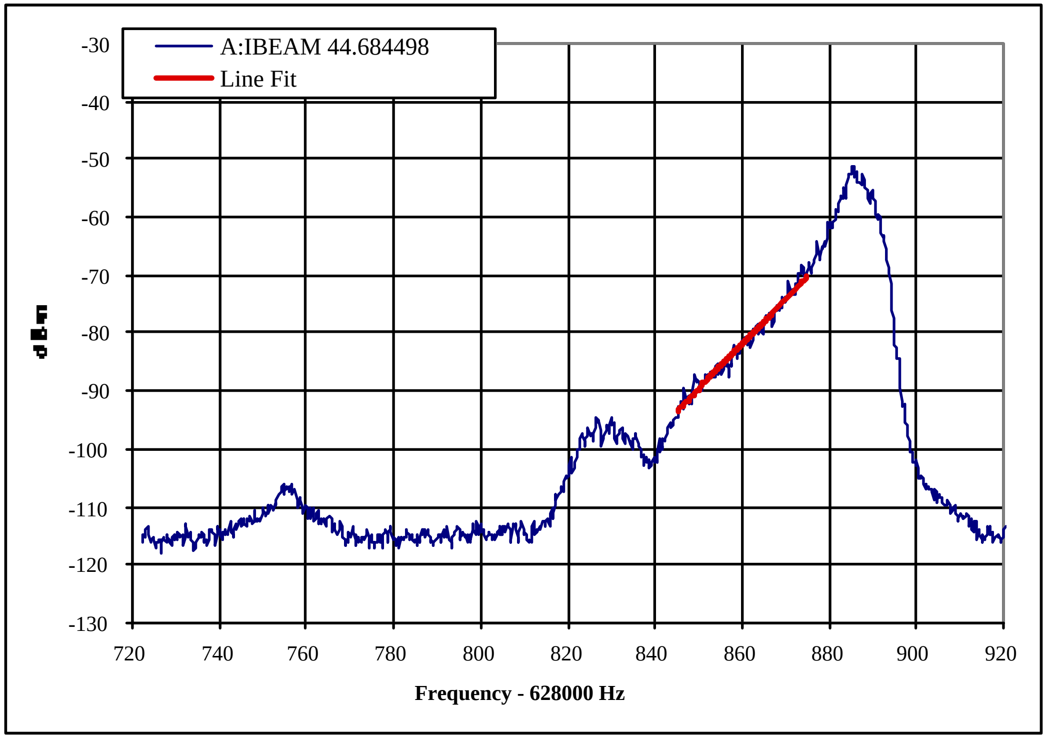
- Increase the antiproton collection efficiency by a factor of 2.0 –2.7 by:
  - increasing the gradient of the antiproton collection lens by 30%
  - Increasing the aperture of the antiproton collection transfer line and Debuncher ring by a factor of 2.7
    - Beam based alignment
    - There are only a few small aperture components that need to be replaced



Handling More Antiprotons

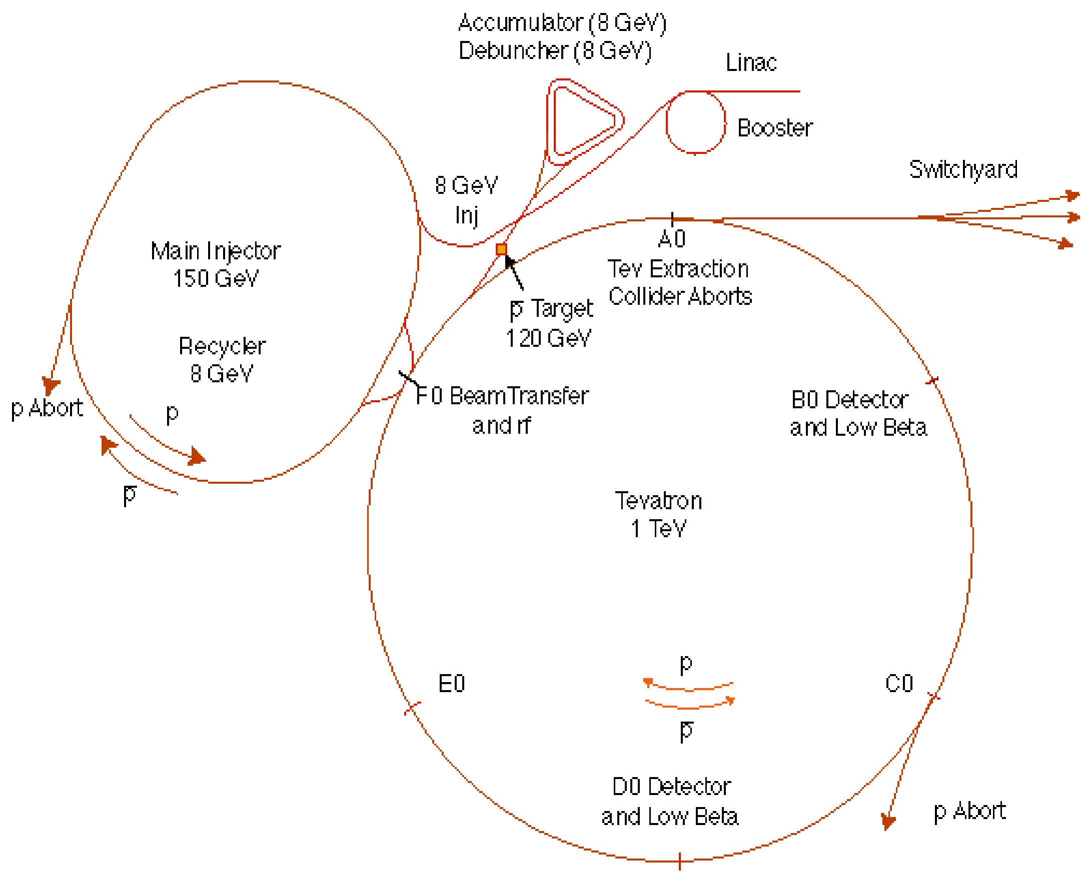
- Increase the antiproton flux capability of the Accumulator Stacktail momentum stochastic cooling system
  - Increase E_d (decrease gain slope)
    - More Flux
    - Less Cooling
    - Smaller Stacks
    - Transfers often

$$\Phi = \frac{W^2 \eta E_d}{f_0 p \ln\left(F_{\min} / F_{\max}\right)}$$



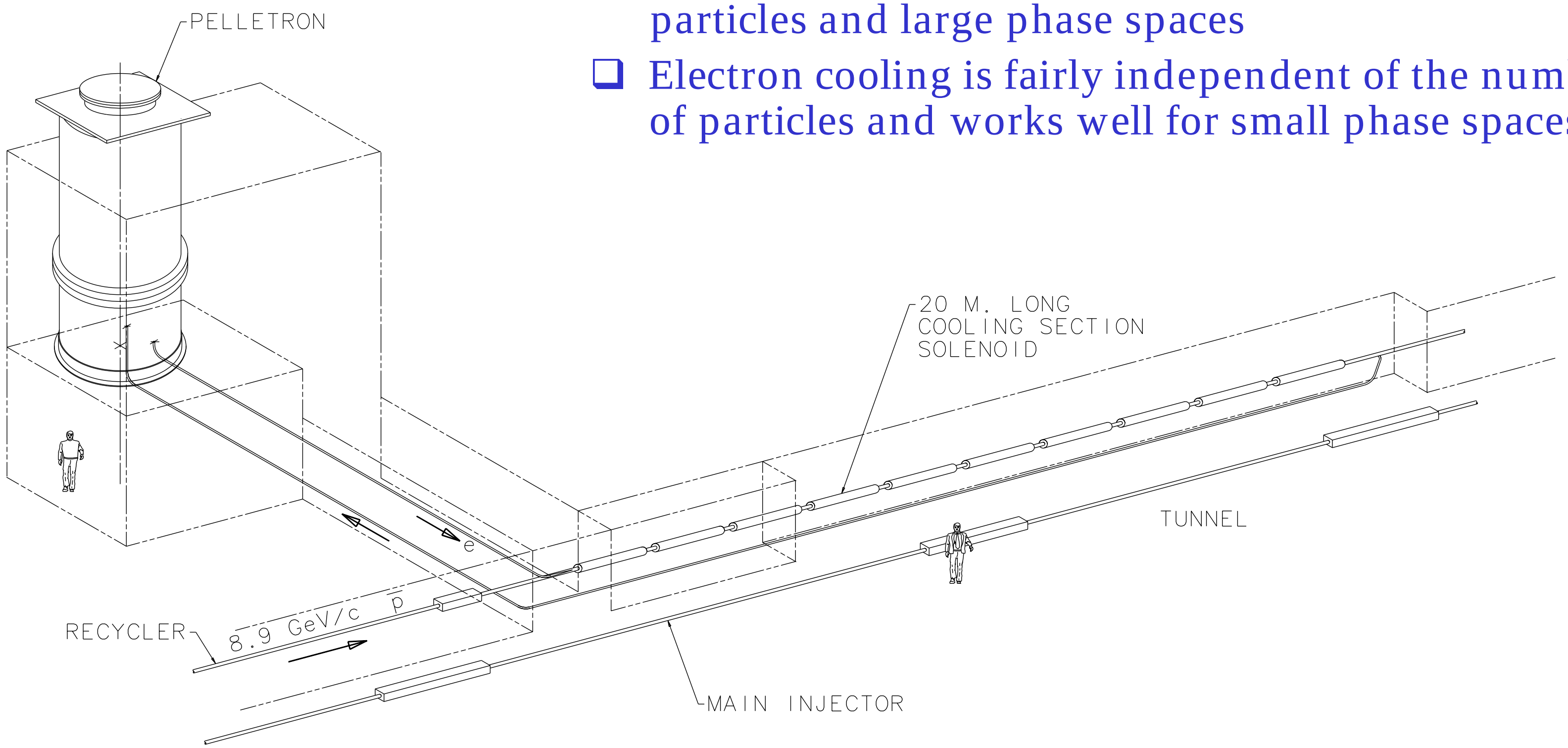
Handling More Antiprotons

- Streamline and improve antiproton transfers between the Accumulator and the Recycler
  - Construction project undesirable for Run IIa
    - Optimize optics
    - Optimize controls
    - Pbar Injection dampers



Cooling Large Antiproton Stacks

- Implement high energy electron cooling in the Recycler Ring
  - Stochastic cooling works well for small numbers of particles and large phase spaces
  - Electron cooling is fairly independent of the number of particles and works well for small phase spaces

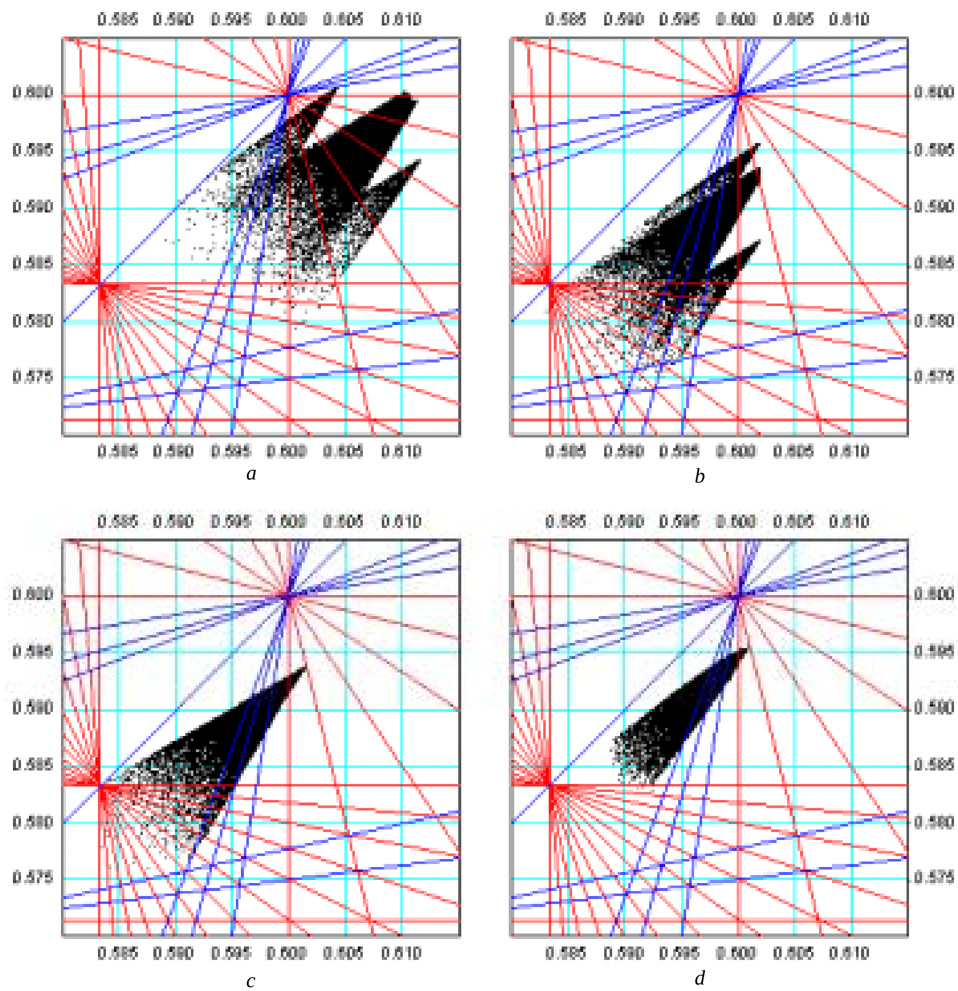


Special R&D Projects

Tevatron Beam-Beam Compensation with an Electron Lens

No Lens

One linear Lens



Two Linear Lenses

Two non-Linear Lenses