The Status of Run II at Fermilab

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OUTLINE

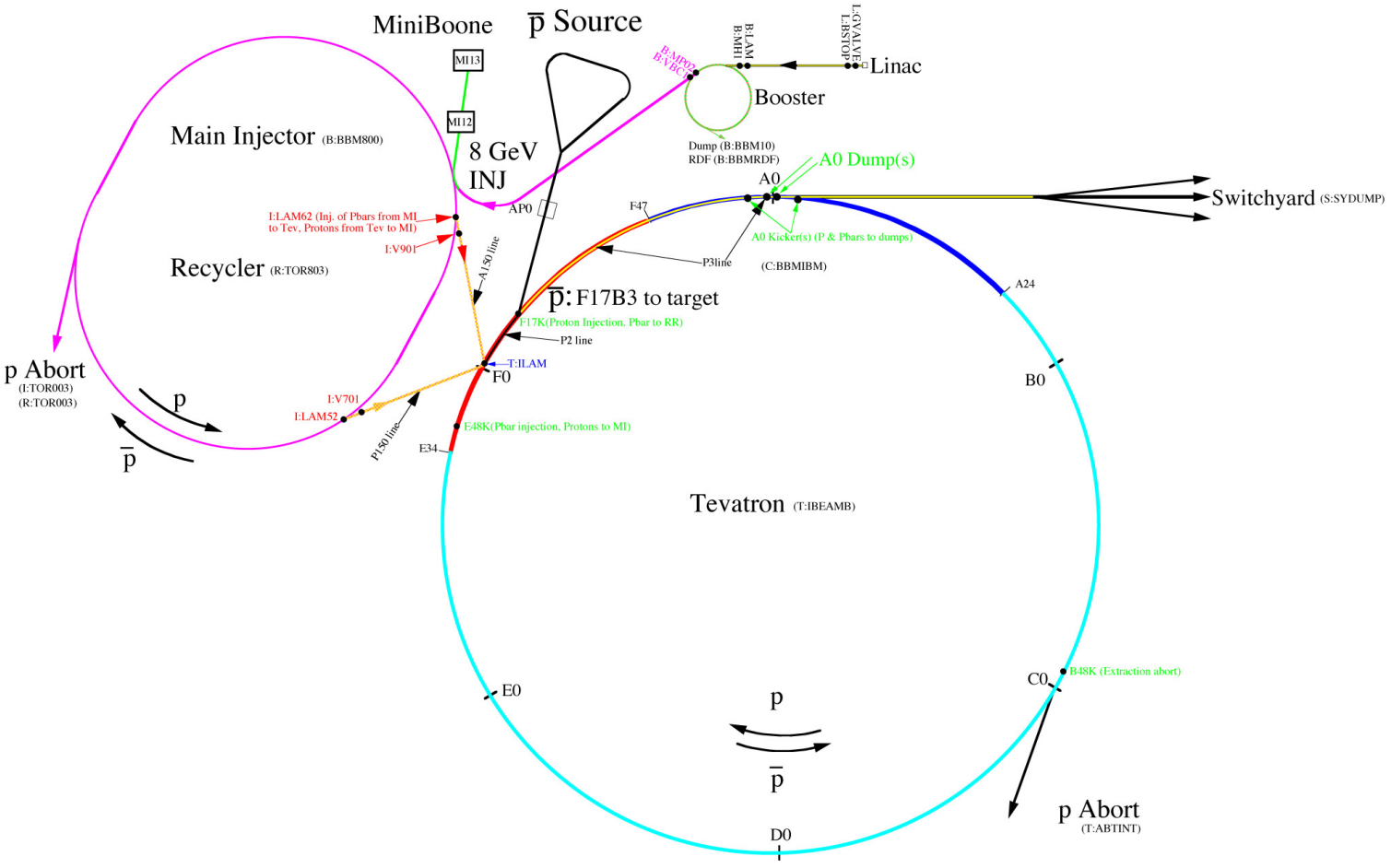
- Overview of Operations
- Run IIa: Present Status
- Recycler Commissioning
- Outlook: Future Plans

Overview of Operations

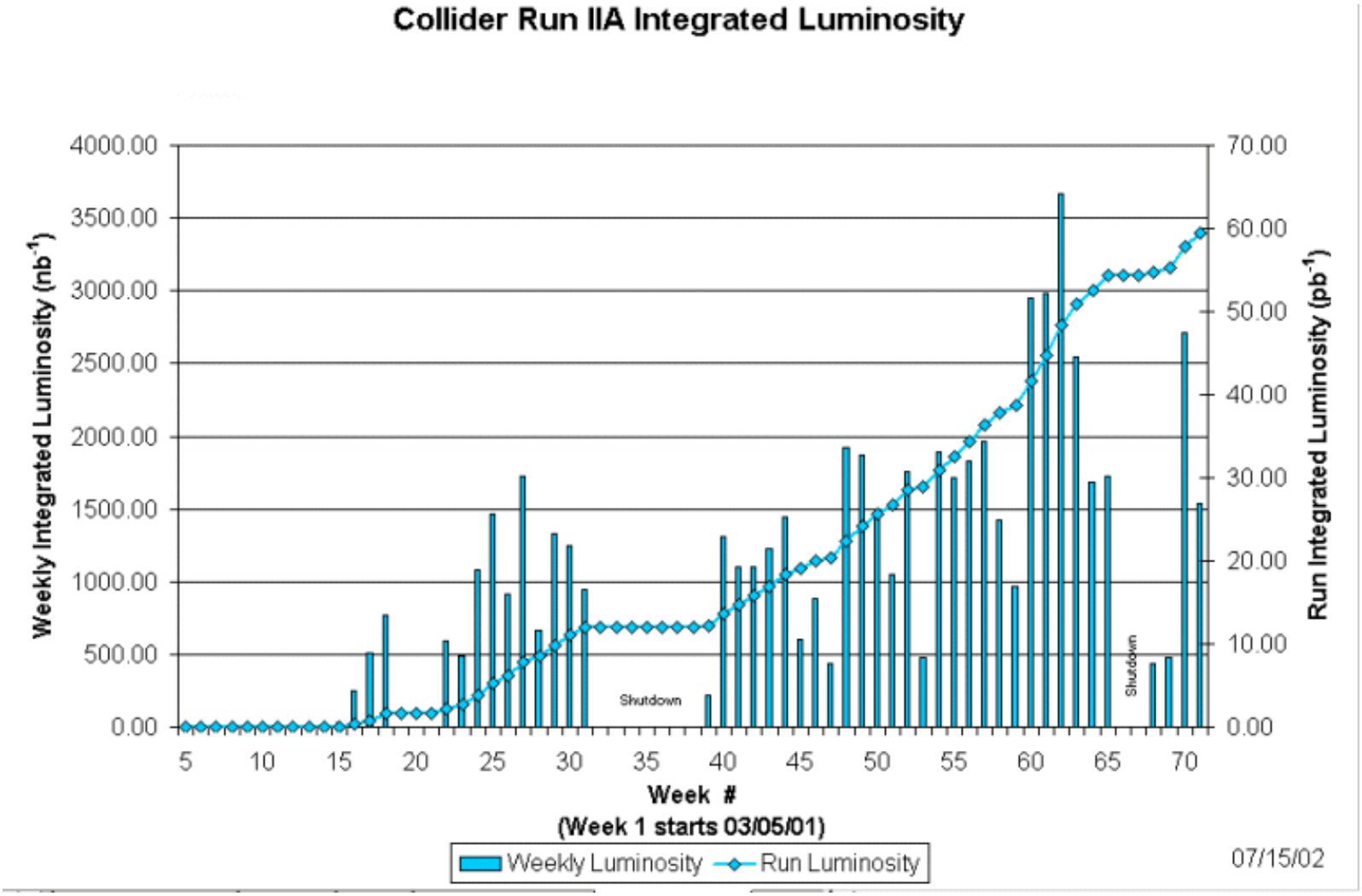
- **Fermilab Accelerator Complex - Overview**
- **Antiproton Stacking Mode**
  - Proton beam to Pbar target (every 2.4 seconds)
    84 53MHz bunches $> 8 \rightarrow 150$ GeV in MI
  - Pbar collection, debunching, cooling and stacking
- **Tevatron Shots**
  - Proton shots
    7 53MHz bunches, > 8 to 150 GeV > 1 bunch
    Repeated till 36 bunches in Tevatron
  - Antiprotons
    7 53MHz bunches, > 8 to 150 GeV > 4 bunches
    Repeated 9 times
  - Protons and antiprotons: $150 \rightarrow 980$ GeV
- **Colliding Stores**
  - Collisions at CDF and DØ
  - Store lasts ~ 14 hours

Fermilab Accelerator Complex

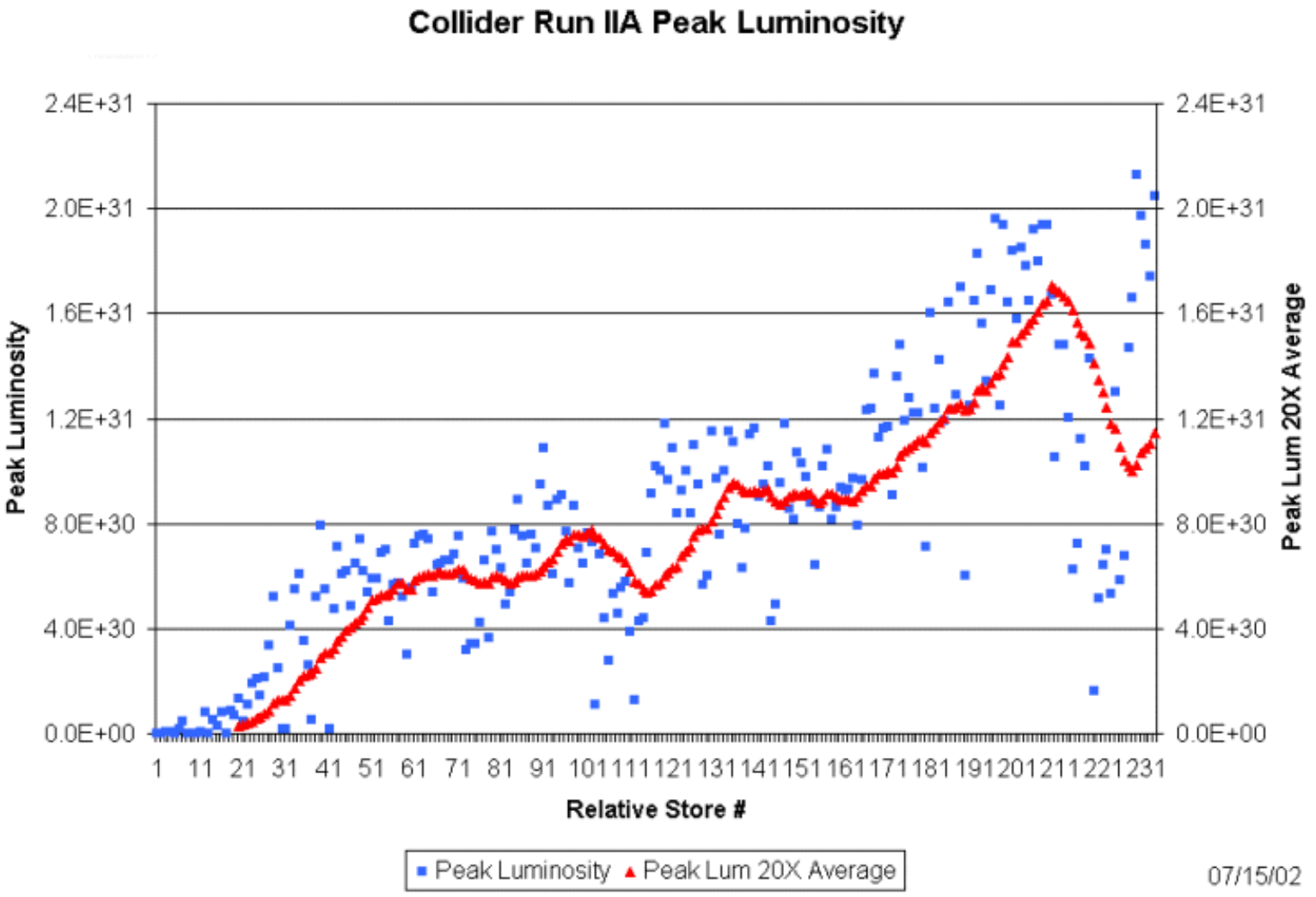
Accelerator Overview



Integrated Luminosity History



Peak Luminosity History



Status on Luminosity Parameters

Quantity	Highest lum. to 12/15/01	Highest lum. to date	Run IIa goals
Maximum $\overline{p}$ stackrate (E10/hr)	10	11.4	18
Maximum $\overline{p}$ stacksize (E10)	115	144	165
$\overline{p}$ transfer Eff.	0.23	0.49	0.80
$\overline{p}$/bunch at low β (E9)	7.6	14.1	33.0
p/bunch at low β (E9)	115	211	270
Emitt. at low β (π-mm-mr)	16.0	16.3	17.5
Peak luminosity (E31 $cm^{-2}sec^{-1}$)	0.84	2.12	8.6

Luminosity Expression

$$\mathbf{Ł} = \frac{10^{-6} f B N_p N_{\overline{p}} [6\beta_r\gamma_r]}{2\pi\beta^*[\epsilon_p + \epsilon_{\overline{p}}]} H(\sigma_l\beta^*) \quad (10^{31} cm^{-2} sec^{-1})$$

f = Revolution frequency (47.7 kHz)

B = Number of bunches (36)

$N_p, N_{\overline{p}}$ **= Bunch intensities (E9)**

$\beta_r\gamma_r$ **= Kinematic** $\beta\gamma$ **(1045)**

H = Hourglass factor (0.60-0.70)

σ_l **= Bunch length (cm)**

β^* **= IR Beta function (35 cm)**

$\epsilon_p, \epsilon_{\overline{p}}$ **= Transverse emittances (**π**-mm-mr)**

The Challenging Issues

- **Transverse Emittance**
  - Accumulator: Lattice, Cooling
  - 2 lattices: Optimized 1 for stacking, 1 for shots
  - As of now, only the beam blow-up along the transfer lines need to be addressed!

- **Long range beam-beam effects**
  - Tevatron: Helix, aperture
  - Remove restrictive apertures for Maximum possible helix size
  - Install octupoles: Landau damping, chromaticity

- **CDF and DØ backgrounds**
  - Vacuum (?), more shielding

- **What else!**
  - Mismatch, coalescing, lifetime etc..

Recycler Ring Commissioning

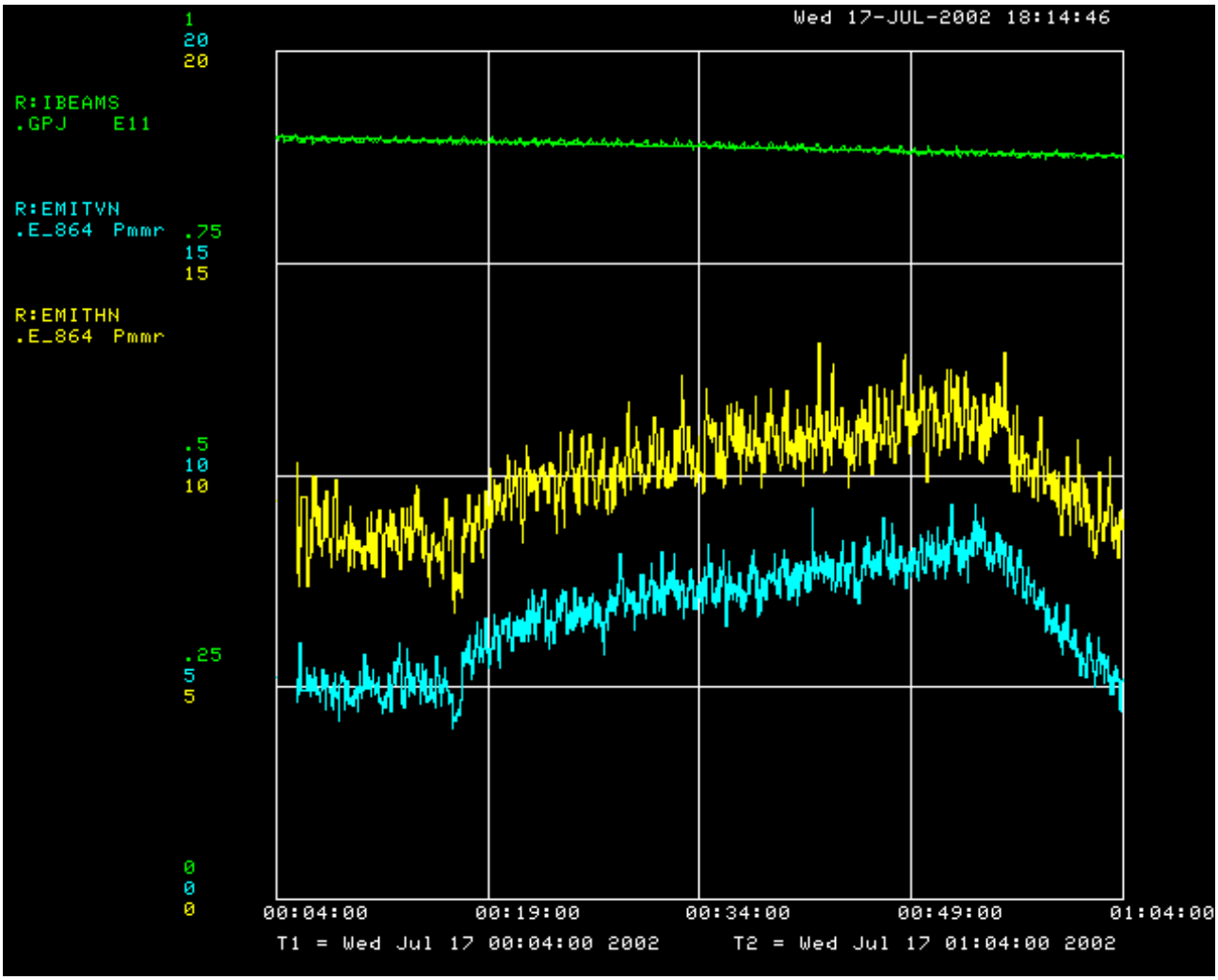
- **Located in the Main Injector tunnel, about 2m above the MI beam pipe.**

- **Recycles the residual antiprotons from the Tevatron stores; Improves the antiproton stacking rate of the Accumulator by rapid transfers; Expected to improve the overall luminosity by a factor of 2-3.**

- **Commissioning process is in full swing**
  Antiprotons as well as protons are being circulated with 50% and 90 % efficiency .

- **Presently cooled antiproton lifetime is $>$ 100 hours with Main Injector ramping**
  Proton life time is about 30 hours with MI ramping (no cooling for protons).

Antiproton Cooling in Recycler



Emittance growth $\sim$ 4 π-mm-mr

Cooling rate $\sim$ 10 π-mm-mr

RR Commissioning: Issues

- **Vacuum Improvements**
  - Ion pumps are being doubled
  - Bake longer at higher temperatures
  - Life time is expected to triple
- **Orbit Control**
  - New Trims are being added
  - New design of BPMs is in progress
- **Main Injector Ramping**
  - Additional beam pipe sheilding
  - Ramping quad power supplies
- **Beam Injection and Extraction**
  - Fix injection mismatches
  - More diagnostic instruments are being installed

Outlook: Future Plans

Besides the commissioning of Recycler, there are two major components for the Tevatron luminosity upgrade: Improving the antiproton production rate and going into 132 ns operation mode.

I. Improvements in Antiproton Production

- **Slip Stacking in the Main Injector**
  - **Stack two 84 53MHz proton bunches longitudinally in MI with two independent RF systems**
  - **Pbar production rate to improve by $\sim$ 1.8**
- **Improvements in Lithium Lens Design**
  - **Operating gradient: 750 $\rightarrow$ $>$ 900 T/m**
- **Improving Transverse Collection Aperture**
  - **Should go to $> 30\pi$-mm-mr from $\sim 16\pi$-mm-mr**
- **Increased Antiproton Cooling**
  - **From 2-4 GHz $\rightarrow$ 4-8 GHz.**

Future Plans - Cont'd

II. More Colliding Bunches - 132 ns Operation

At higher luminosities, The number of interactions per bunch (> 5) collision becomes hard to deal with for data reconstruction and background reduction in 36X36 bunch Tevatron operations. Need to increase the beam bunches by decreasing bunch spacing. Next step: 140X100 - 132 ns bunch spacing. Adds new challenges:

- **Long range beam-beam effects**
  - **$\sim$ 2 times worse**
- **Crossing angle must be introduced at IR's**
  - **Avoids parasitic head-on collisions near IR's**
- **Proton beam stability**
  - **May become $\sim$ 3-4 times worse**
- **Detector backgrounds**
  - **Could increase by a factor of 4.**