The First Two Hours Average Non-luminous Lifetime (Super Table II)

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The calculation of various beam lifetimes has been described in Beams-doc-1392[1]. The calculated luminous and non-luminous lifetime are the one intercept at t = 0. As all lifetimes in "Super Table" are calculated on the first two hours average, we have to modify our code to make it coincide with other lifetimes. This note describes the algorithm used for the calculation.

- The Luminosity:

$$L_{lum} = L_{0,lum} \times Exp\left(- t / \tau_{lum} \right)$$

we assume:

$$L_{0,lum} \approx \left(L_{0,CDF} + L_{0,D0}\right) \text{ and } \tau_{lum} \approx \left(\tau_{CDF} + \tau_{D0}\right)/2$$

- The beam intensity:

$$I_{p(\bar{p})} = I_{0,p(\bar{p})} \times Exp\left(-t / \tau_{p(\bar{p})} \right) = I_{0,p(\bar{p})} \times Exp\left(-t / \tau_{non-lum,p(\bar{p})} \right) \times Exp\left(-t / \tau_{lum,p(\bar{p})} \right)$$

- The burn rates:

$$-\left(\frac{dI}{dt}\right)_{lum} = \frac{I_{p(\bar{p})}}{\tau_{lum,p(\bar{p})}} = L_{lum} \times effCross \times 10^3 \times 3600 \left[paticles / hour\right]$$

From the 3 equations above, the average luminous lifetime for Δt :

$$\overline{\tau_{lum,p(\bar{p})}} = \frac{\int_0^{\Delta t} \tau_{lum,p(\bar{p})} dt}{\Delta t} = \frac{I_{0,p(\bar{p})}}{L_{0,lum} \cdot effCross \cdot 3600 \cdot 10^3} \frac{Exp\left(\frac{\tau_{p(\bar{p})} - \tau_{lum}}{\tau_{p(\bar{p})} \cdot \tau_{lum}} \Delta t \right) - 1}{\frac{\tau_{p(\bar{p})} - \tau_{lum}}{\tau_{p(\bar{p})} \cdot \tau_{lum}} \Delta t}$$

The average non-luminous lifetime:

$$\overline{\tau_{non-lum,p(\bar{p})}} = \left(\frac{1}{\tau_{p(\bar{p})}} - \frac{1}{\tau_{lum,p(\bar{p})}} \right)^{-1}$$

The relevant class and methods are:

Class **TeVLumLifesFromD44** (inside package **gov.fnal.controls.applications.osdaphysics.**) has been used for the calculation:

TeVLumLifesFromD44(String **aStore, true):** constructor for bunch by bunch calculation (**jb** [0:35] is bunch number.)
TeVLumLifesFromD44(String **aStore, false):** constructor for total lifetime calculation (**jb**=0).

Method **getLumiLifeFit(jb)** does the exponential fit for the first 2 hours CDF luminosity. The results are CDF luminosity at t = 0: $L_{CDF}[jb][\times 10^{30}\,cm^{-2}s^{-1}]$, and luminosity lifetime: $\tau_{L_{CDF}}[jb][hours]$.

Method **getLumiLifeFitD0 (jb)** does the exponential fit for the first 2 hours D0 luminosity. The results are D0 luminosity at t = 0: $L_{D0}[jb][\times 10^{30}\,cm^{-2}s^{-1}]$, and luminosity lifetime: $\tau_{L_{D0}}[jb][hours]$.

Method **getProtonLifeFit (jb)** does the exponential fit for the first 2 hours Proton intensity. The results are Proton intensity at t = 0: $pInt[jb][\times 10^{9}\,particles]$, and Proton beam lifetime: $\tau_{Proton}[jb][hours]$.

Method **getPbarLifeFit (ia)** does the exponential fit for the first 2 hours Pbar intensity. The results are Pbar intensity at t = 0: $aInt[ia][\times 10^{9}\,particles]$, and Pbar beam lifetime: $\tau_{Pbar}[ia][hours]$.

Method **getProtonNLLife(jb)** retunes first 2 hours average proton non-luminous lifetime.

Method **getPbarNLLife(jb)** retunes first 2 hours average pbar non-luminous lifetime.

Method **getProtonLLife(jb)** retunes first 2 hours average proton luminous lifetime.

Method **getPbarLLife(jb)** retunes first 2 hours average pbar luminous lifetime.

Reference:
[1] "Description of Lifetime Plot in the Shot Scrapbook", Beams-doc-1392