SBD and FBI Calibration

A.Tollestrup

12/4/02

Goal: Use the IBEAM as a reference standard for all current measurements.

$$Ibeam = P + \overline{P} = P(1 + \frac{\overline{P}}{P})$$

$$P = Ibeam/(1 + r)$$

$$Pbar = r \times Ibeam/(1 + r)$$

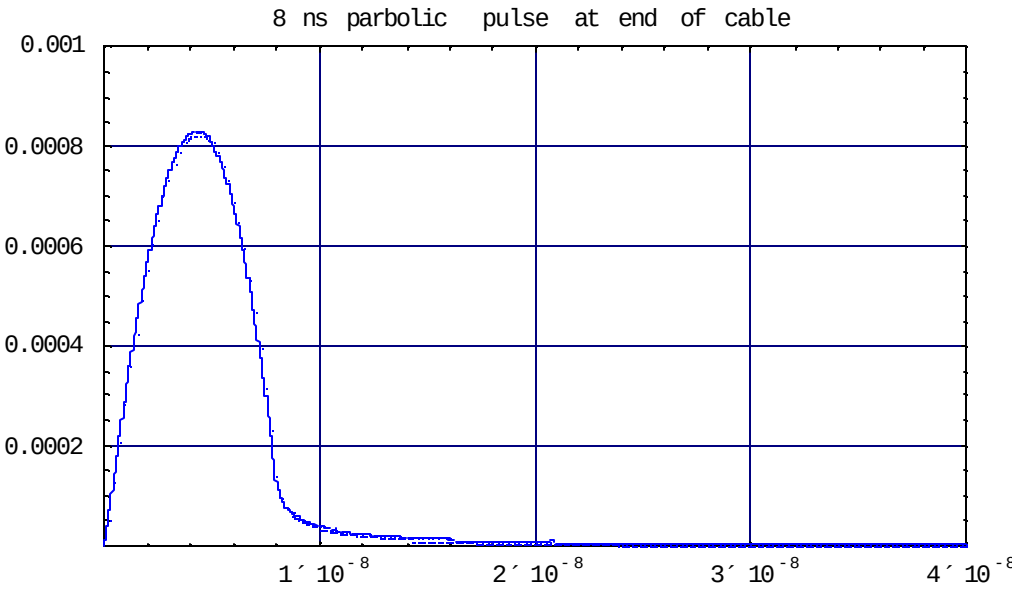
However, the SBD reads P and Pbar with a calibration constant:

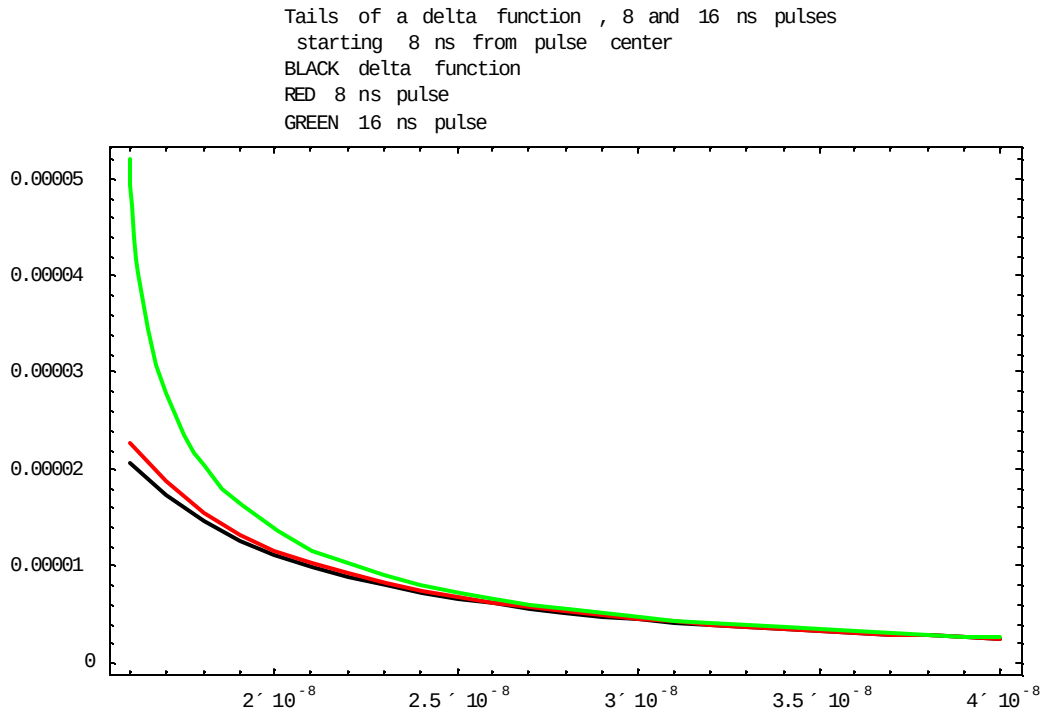
$$P = a \times P_{SBD};$$

$$Pbar = a \times Pbar_{SBD}$$

Suppose we are trying to calibrate the SBD. It has been set up as an absolute device where one measures the current in the machine by observing the voltage drop across a known resistor in the vacuum chamber wall. However, this requires an accurate measurement of the voltage by a sampling scope that is located upstairs. The approach here is to assume that Ibeam is the reference and to calibrate the SBD. This means finding a in the above equations

The measurement of the ratio r, of pbars to protons is about 0.10 to 0.15 and is not sensitive to dispersion in the cable. One can get most of the charge in a bunch by integrating over just one bucket. The tails are proportional to the charge and cancel in the ratio. The dispersion tails caused by the cable are at the several percent level as shown in the Fig.

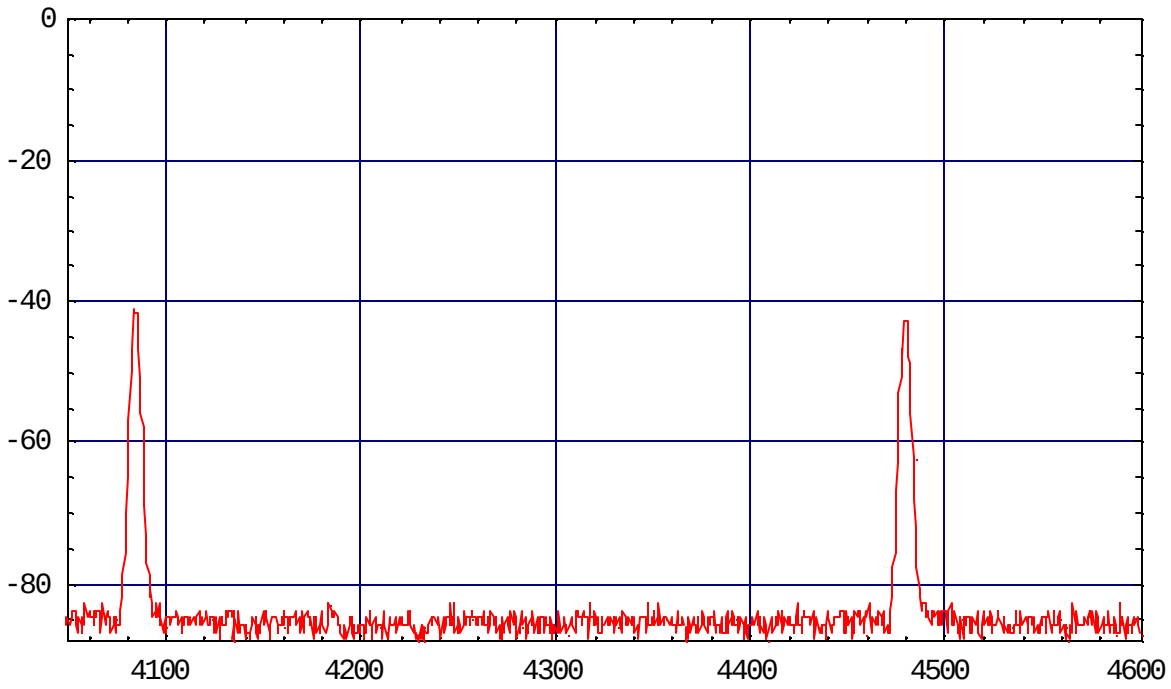




The area of the tails in the next rf bucket for a fixed pulse area are given in the following table:

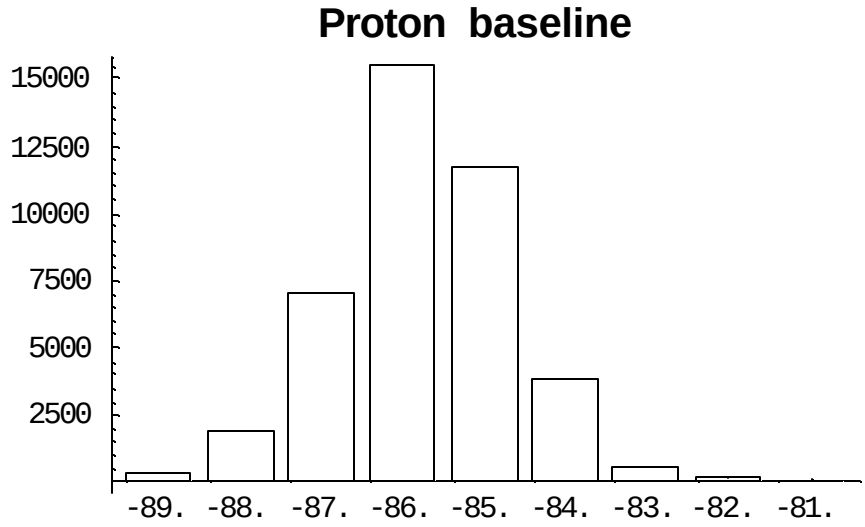
Integrated tails in following rf bucket	
Delta function	0.0255714
8 ns parabolic pulse	0.0263825
16 ns Parbolic pulse	0.0297628

There is noise on the SBD and a base line correction since the SBD is a transformer which couples the beam current to the cable. A typical 150 GeV sweep from the SBD:



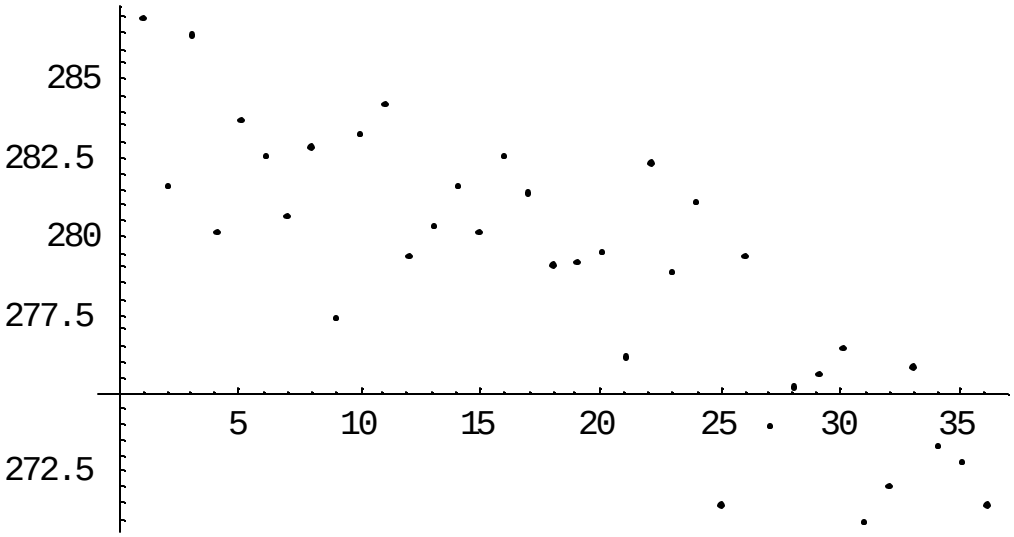
The pbar sweep has the same noise even though the gain is 10 x higher.

A histogram of the above sweep looks like (thanks to Bob Flora):



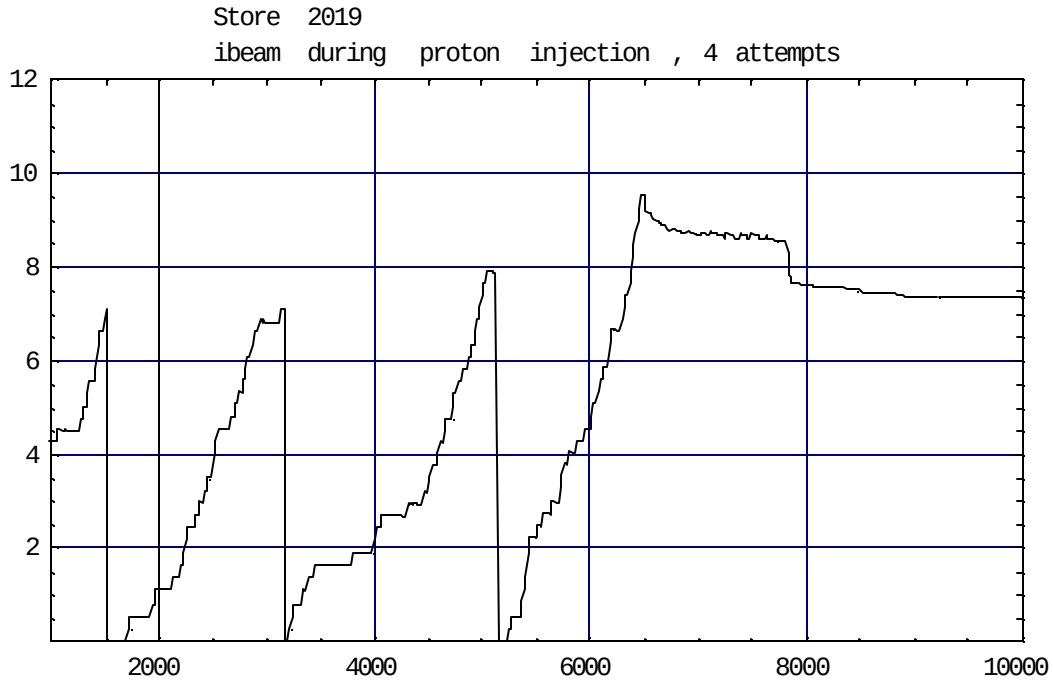
The sigma is 1.13 bins or 2 e09 protons. Or about 1% for a typical proton bunch.

Using the SDA one can also check this during proton injection, bunch 1 is remeasured 36 times:

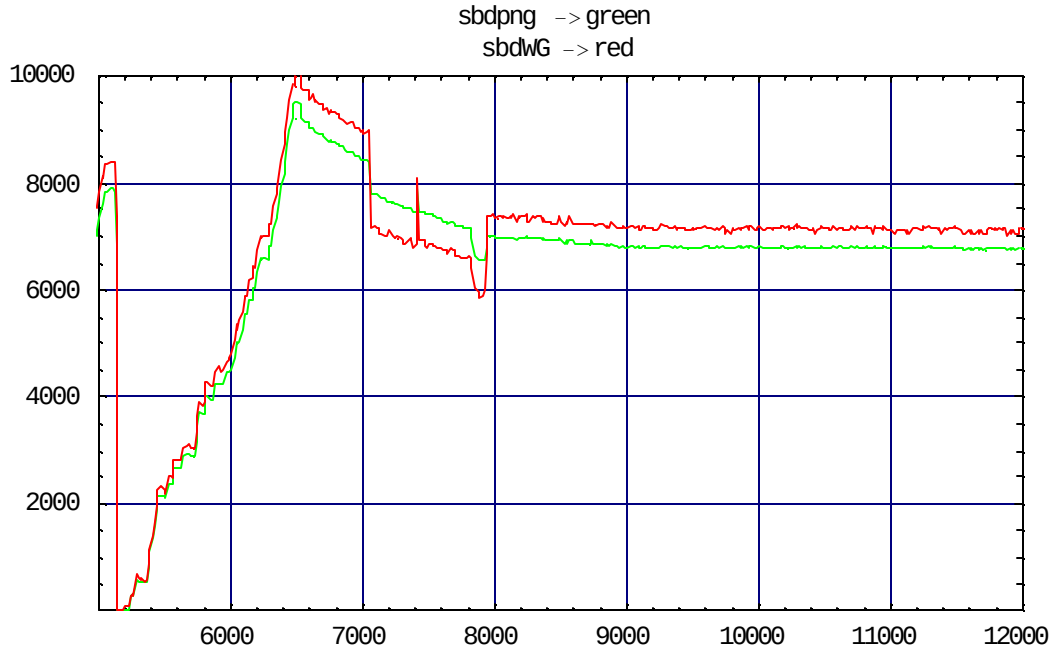


The rms deviation is 2.36 e09 around a linear fit due to the decay or about 1%.

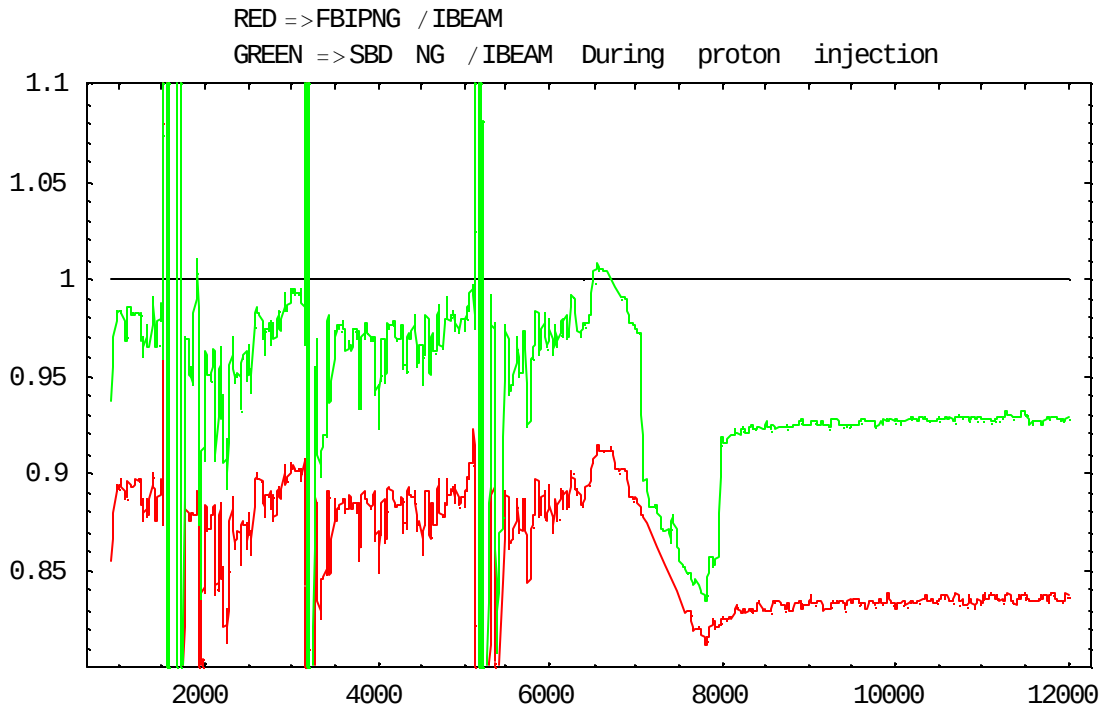
Lets try and calibrate the SBD to IBEAM as the gold standard using the above theory. The following are from Store 2019:



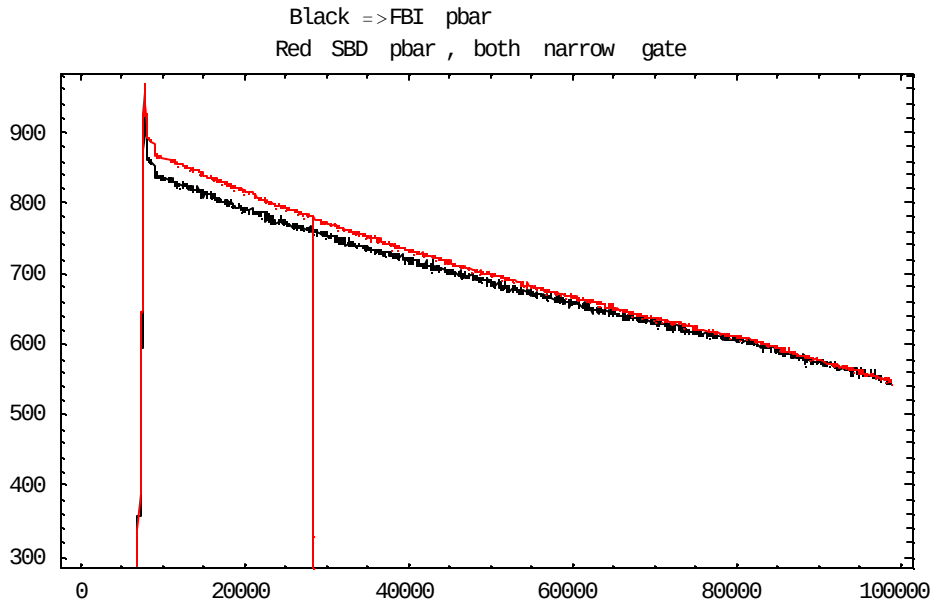
SBD wide gate and narrow gate. There is trouble from t= 7000 to 8000 seconds during pbar injection. Acceleration is at 8000:



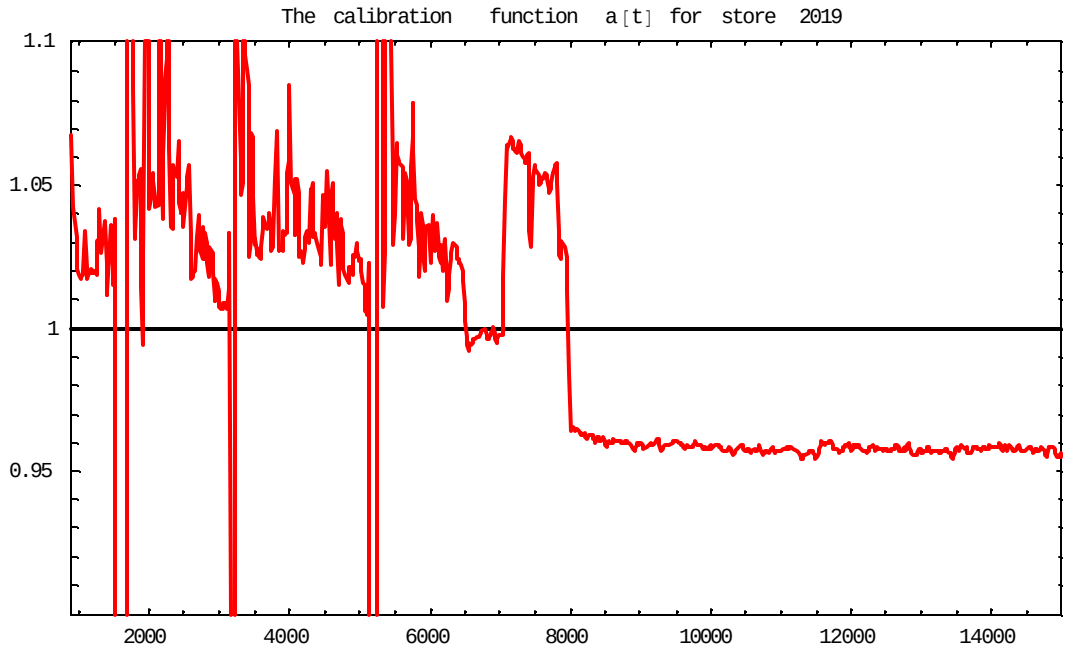
Comparison of SBDPNG and FBIPNG to IBEAM during proton injection:



After acceleration, compare FBI NG pbar with SBD NG pbar. The two measures drift during the store:



Use above equations to calibrate SBD to IBEAM. The following curve is "a" , ie what you multiply SBD values by to get correct answer.:



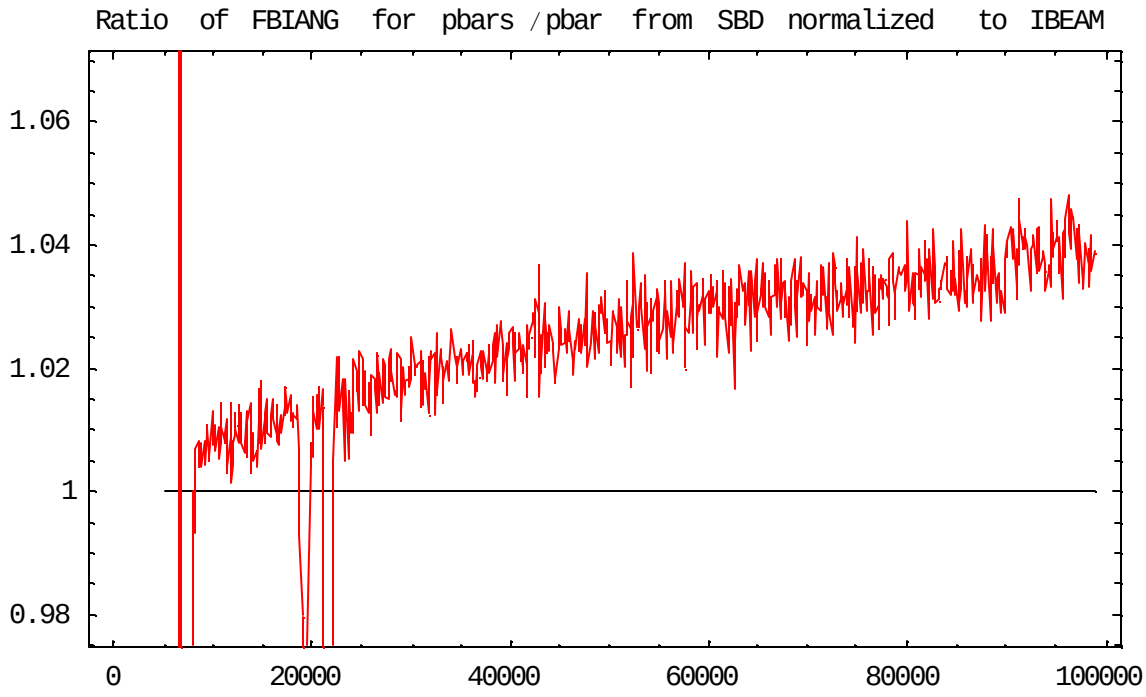
I don't understand the change in calibration between 150 GeV and 980. It may be an effect of the changing widths of the pulses as they narrow during acceleration. But the theory above doesn't indicate such an effect.

DC beam is often mentioned. That could be a small contribution at 150. However, any DC beam should come out in the first few amps of IRING, and there is at most indication of the order of 1%. DC beam has the wrong sign to explain the high reading at 980.

It doesn't matter! It is calibrated to IBEAM!

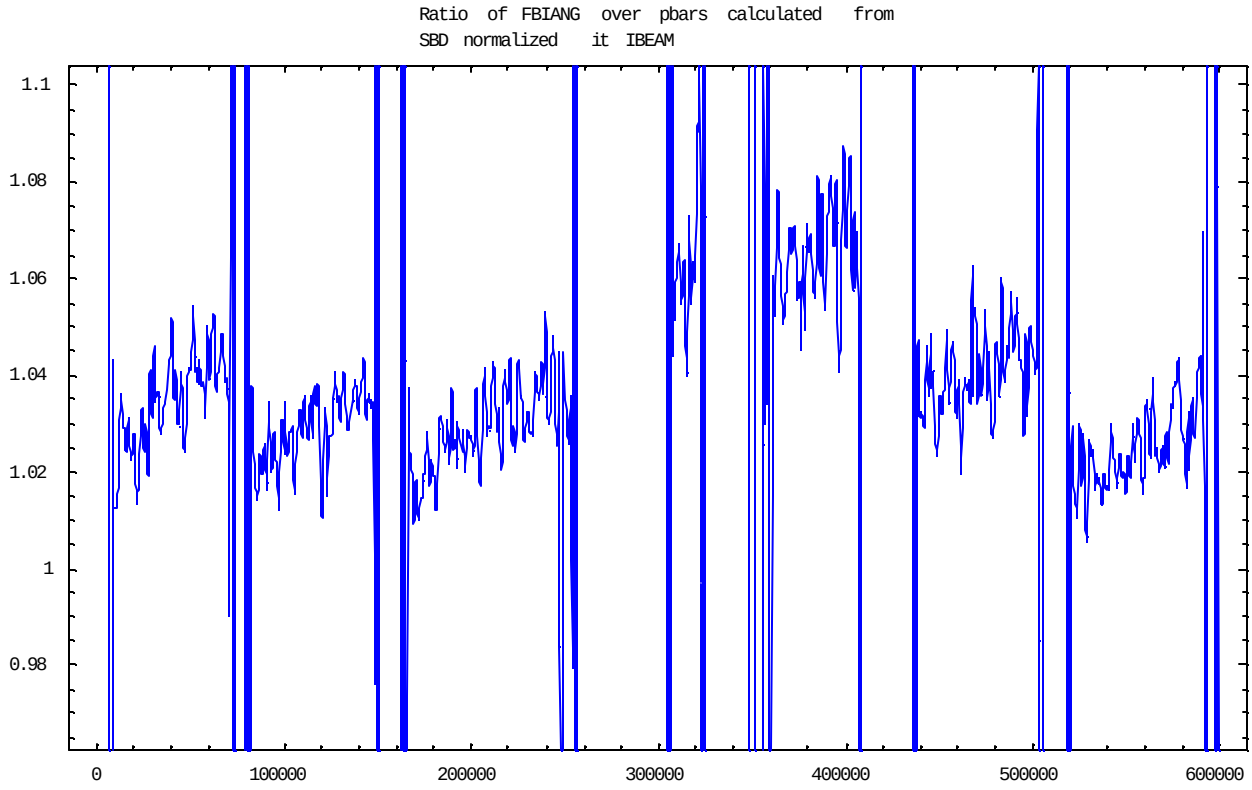
We can now examine how FBI is doing.

FBI pbar can be calibrated using the calibrated SBD. The ratio FBI/Calibrated SBD is shown:

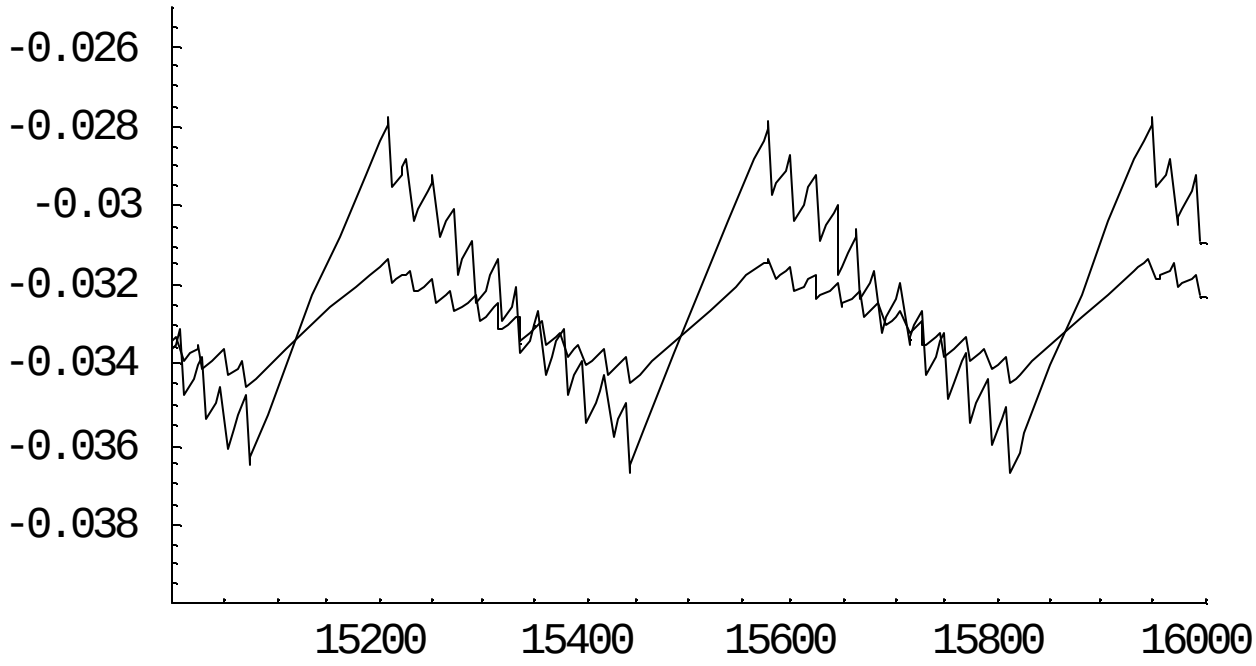


FBIANG reads high due to the wrong base line correction. The base line is mainly set by the protons, and as they decay away the base line correction changes. If the correction is not done correctly, one will get the above behavior.

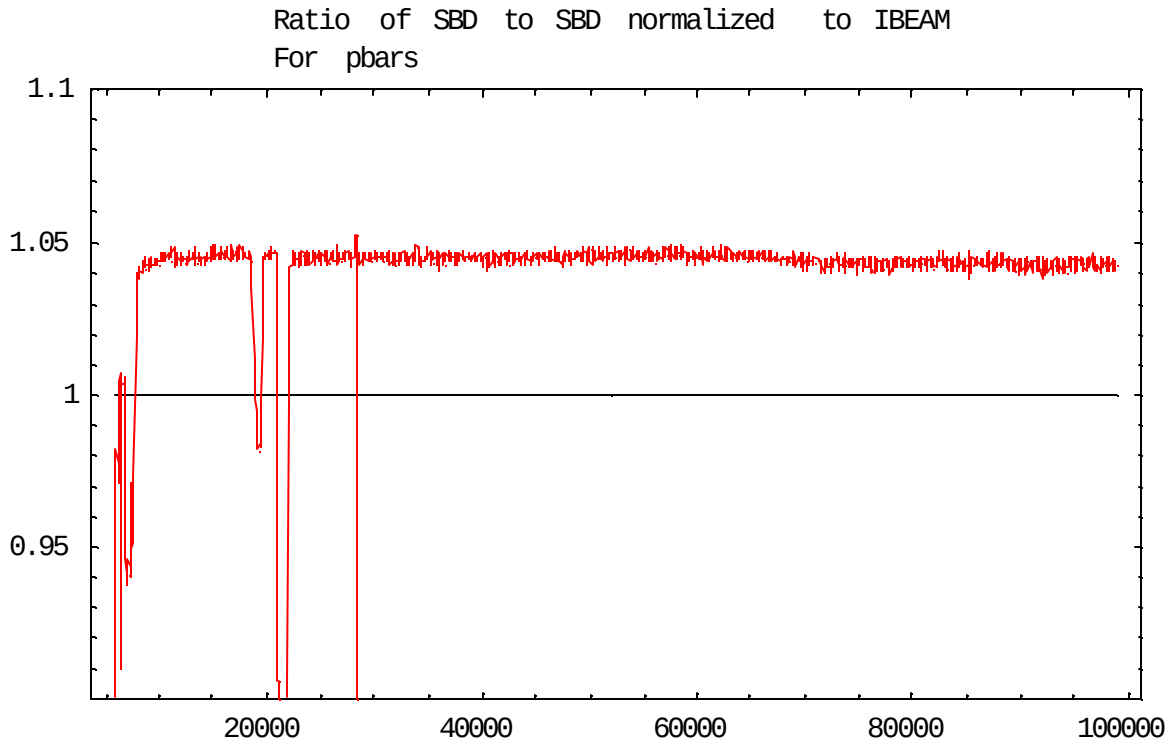
Stores from 10-27 to 11-3 giving the calibration of FBIANG / SBD pbars as calibrated with IBEAM.



Baseline seen by the FBI. The source is driven by the protons and decays with time during the store.



Finally we correct SBD NG pbar reading:



And the FBI P NG: