**Before beginning calibration, check that the right transformer is selected. The device BIX.XF_SELCTN can be found at the pet current transformer page at *Ags/Instrumentation/Current_xfmrs/current_xfmr.* Change the entry in column C1 as needed for the appropriate user.

I. Calibration Pulse Setup for 29XF104 (Heavy Ions):

1. The calibration pulse has to be set up manually. There is no computer related program that controls the pulse.
2. Setup location:
   a. HITL –3 House
   b. "INSTRUMENTATION" rack (yellow on the left-hand-side)
   c. 11th module, first row (#D36-E175-5)
   d. Calibration source signals:
      Trigger: "Reset Out"
      Calibration pulse: "Pulse Out"
3. Enabling the calibration pulse:
   a. Connected a portable scope to the two signals above –verify that the calibration pulse has the following shape:

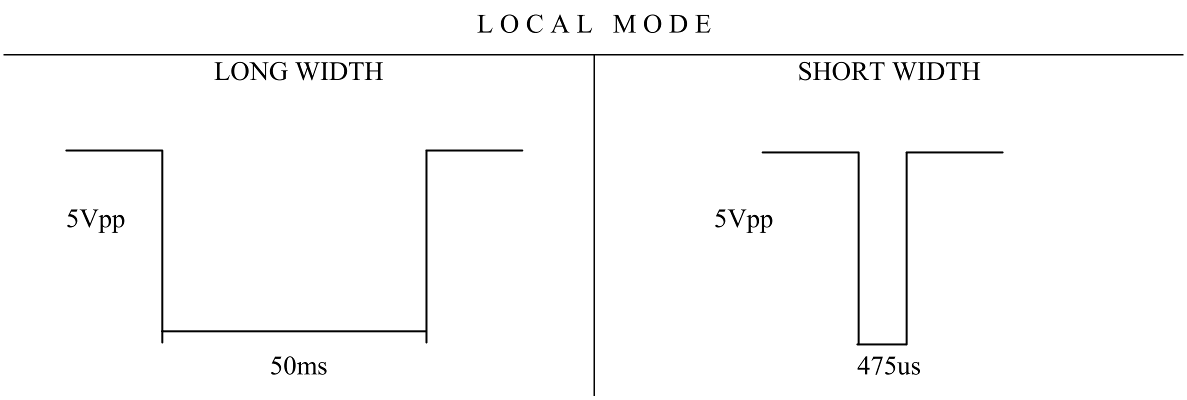


Figure 1 – Calibration Pulse

   The computer mode ONLY forces the test/cal pulse to the "short width" above.

   b. Connect the test/cal pulse to the 1:3 distribution box.

c. Make sure the outputs of the distribution box are connected to the following BNC connectors of the "PATCH" rack:

GC 28-A (25XF)

GC 31-A (27XF)

GC 33-A (29XF –the only one that it is observed in room A-222)

d. Using a probe, check on the three outputs in the first row of the 6th module in the INSTRUMENTATION rack (SL Diff 8 Channel Rcvr/Drvr), as shown on the schematic below:

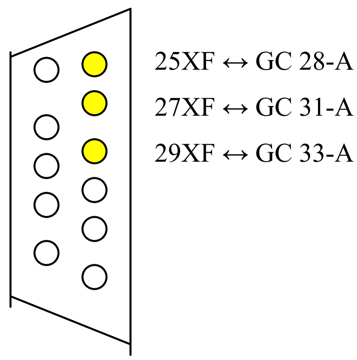


Figure 2 – Schematic of Module Output Pins

The above three outputs should correspond to the pulse below:

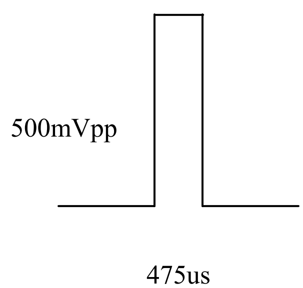


Figure 3 – Calibration Pulse Output

Which corresponds to **50uA** at **LOW** gain; at **HIGH** gain the voltage level is 5Vpp/50uA (see *SpreadSheet/Tandem/Location/HITL_PS_House3/CDC.HITL3.INS/**BTI.FCGAIN3.PL*** or *SpreadSheet/Tandem/section_29/BTI.FCGAINS3.PL**)***

II. Calibration Pulse for NX-58

1. LINAC personnel must be contacted for the calibration pulse to be turned on. No local control exists for this pulse.

III. Calibration Pulse for HPX1

1. No information on calibration pulse.

IV. Mode of Operation and Booster Input Transformers

1. 29XF104 – used for Heavy Ions (Gold, Silicon, Iron, Titanium, Carbon)
    a. Check to see what gain setting this transformer is set for at the following location in SpreadSheet: Tandem/section_29/BTI.FCGAINS3.PL. This device will either be set LOW (low gain) or HIG (high gain).
    b. The calibration pulse used for this transformer has the following properties: LOW GAIN: current=50uA, voltage amplitude=500mV, and pulsewidth=470us; HIGH GAIN: current=50uA, voltage amplitude=5V, and pulsewidth=470us. Use the following equation to calculate the expected intensity of the calibration pulse: $\#\,\text{ions} = {}^{It}\!/_{qn}$ where I=current, t=pulsewidth, q=1.6x10^{-19}, and n=charge of the ion (n=32 for Gold, n=5 for Silicon, and n=10 for Iron, n=20 for NSRL Iron, n=18 for NSRL Titanium, n=6 or 5 for NSRL Carbon). This equation will produce expected calibration pulse intensity and is the value that the scalars should be set to. If the calibration method using the calibration pulse is utilized, go to section V, part 1. If the calibration is being done without the calibration pulse, use the ratio of 50uA=500mV for low gain or 50uA=5V for high gain for scaling the beam current and go to section V, part 2 on how to do calibration with the scaling method.
    c. The decimal point on the scalars traditionally should be read as x10^9 for gold, x10^{10} for silicon, and x10^{10} for iron, x10^9 for NSRL iron, x10^9 for NSRL Titanium, and x10^9 for NSRL Carbon. For example, the gold calibration pulse expected intensity would display on the scalar as 4.580 (to be read as 4.580 x 10^9) and for silicon, the calibration pulse expected intensity would display 0.294 (to be read as 0.294 x 10^{10}).
2. NX-58 – used for HEP (High Energy Protons)
    a. The calibration pulse for this transformer has the following properties: Current=30mA, Voltage Amplitude=3V, and Pulsewidth=200us. Using the same equation from section IV, part 1a, these values produce an expected calibration pulse intensity of 37.45x10^{12} protons (37.45Tp). If the calibration method using the pulsewidth is utilized go to section V, part 1. If the calibration is being done without the calibration pulse, use the current/voltage ratio of 10mA=1V to scale the beam current and go to section V, part 2.
    b. The decimal point on the scalars should be read as x10^{13}. For example, the calibration pulse would display on the scalars as 0.375, which is read as 0.375x10^{13}.
    c. The input signal is connected to Channel 1 of Receiver A at RK73A-E03.
3. HPX1 – used for Polarized Protons

a. There is no information available on the calibration pulse. However, the ratio of current/ voltage is 1mA=1V and can be used to scale the beam current as described in section V, part 2.

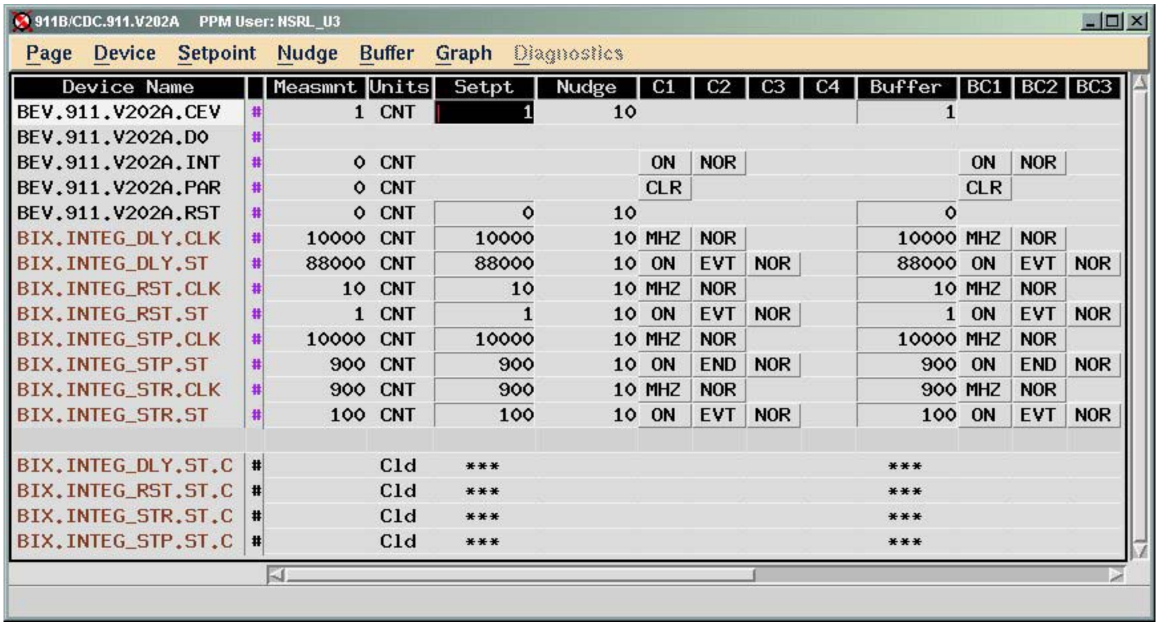
b. The decimal point on the scalars should be read as $x10^{11}$.

V. Calibrating the Booster Input Transformers:

1. With the calibration pulse ON

   a. Using the rack-mounted scope in Building 911A, Room 222, measure the pulse received at the appropriate input location for the given transformer being used: RK72J03 for transformer 29XF104, RK73I02 for transformer NX-58, or RK73F07 for transformer HPX1. The output should not be directly viewed from any of these points – connect the signal to the x1 buffer amp located at RK73A-E08 and view the signal from the output of the buffer. The scope can be triggered using the Integrate signal at RK73G14.
   Note: The signal for HPX1 is normally buffered through a x10 amplifier at RK73A-E08 to get the correct scalar decimal point value.

   b. It is necessary to move the calibration pulse into the integrating window using pet. The path for the signals is Booster/Location/911B/CDC.911.V202A. See Figure 4 for a picture of the pet page. An alternate and more recommended path is Ags/Instrumentation/Current_xfmrs/current_Xfmr. The device setpoints that may need to be changed are the devices listed on the picture beginning with BIX.INTEG_DLY.CLK through BIX.INTEG_STP.ST.C. Since an integration is performed to calculate the number of ions, it is necessary to move the integrating window to enclose the calibration beam pulse as shown in Figure 5. Take note of the original values of any device that will be changed, as it will need to be re-entered at the end of the calibration. Devices ending with ST are the pulse start delay times and devices ending with CLK are the pulsewidth times. The RST device controls when the integrator is reset, the STR device controls the start time of the integrating window and the STP device controls the stop time of the integrating window. The devices BIX.INTG_STR.CLK and BIX.INTG_STP.ST should always have the same setpoint as the stop pulse is triggered from the end of the start pulse. Adjust these devices until the integrating window has enclosed the calibration pulse – a good place to begin is by adjusting the integrate start delay time and continuing from there.



911B/CDC.911.V202A PPM User: NSRL_U3

Page Device Setpoint Nudge Buffer Graph Diagnostics

Device Name		Measmnt	Units	Setpt	Nudge	C1	C2	C3	C4	Buffer	BC1	BC2	BC3
BEV.911.V202A.CEV	#	1	CNT	1	10					1			
BEV.911.V202A.DO	#												
BEV.911.V202A.INT	#	0	CNT			ON	NOR				ON	NOR	
BEV.911.V202A.PAR	#	0	CNT			CLR					CLR		
BEV.911.V202A.RST	#	0	CNT	0	10					0			
BIX.INTEG_DLY.CLK	#	10000	CNT	10000	10	MHZ	NOR			10000	MHZ	NOR	
BIX.INTEG_DLY.ST	#	88000	CNT	88000	10	ON	EVT	NOR		88000	ON	EVT	NOR
BIX.INTEG_RST.CLK	#	10	CNT	10	10	MHZ	NOR			10	MHZ	NOR	
BIX.INTEG_RST.ST	#	1	CNT	1	10	ON	EVT	NOR		1	ON	EVT	NOR
BIX.INTEG_STP.CLK	#	10000	CNT	10000	10	MHZ	NOR			10000	MHZ	NOR	
BIX.INTEG_STP.ST	#	900	CNT	900	10	ON	END	NOR		900	ON	END	NOR
BIX.INTEG_STR.CLK	#	900	CNT	900	10	MHZ	NOR			900	MHZ	NOR	
BIX.INTEG_STR.ST	#	100	CNT	100	10	ON	EVT	NOR		100	ON	EVT	NOR
BIX.INTEG_DLY.ST.C	#		Cld	***						***			
BIX.INTEG_RST.ST.C	#		Cld	***						***			
BIX.INTEG_STR.ST.C	#		Cld	***						***			
BIX.INTEG_STP.ST.C	#		Cld	***						***			

Figure 4 – pet page for Timing, the devices in orange lettering are used for the integration of Booster Input Beam (BIX.INTEG_DLY.CLK to end). Setpoints in this picture are for Fe+20 (NSRL)

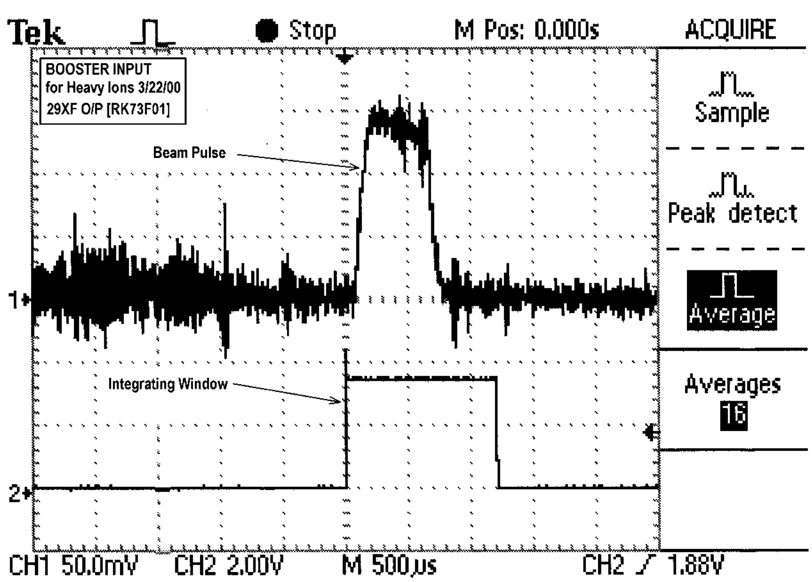


Figure 5 – Integrating Window Relative to Beam Pulse

The reading on the scalar depends on the current mode of operation. If the expected scalar reading does not match the actual scalar reading, adjust the gain value also located at the main current transformer pet page for the device BIX.XF_BINPT.GAIN. A gain setting of 0 is equivalent to x0; a gain setting of 255 is equivalent to x10.

2. With the calibration pulse OFF

   a. Since the calibration pulse can't be controlled locally and therefore somewhat time consuming to turn the calibration pulse on, calibration of the Booster Input Transformers are often done without using the calibration pulse and is instead done by estimating beam. This is also a useful method for validating the calibration as done in step 1.

   b. Using the rack-mounted scope in Building 911A, Room 222, view the signal at RK72J03 for transformer 29XF104, RK73I02 for transformer NX-58, or RK73F07 for transformer HPX1. These outputs should not be viewed directly from these ports but instead first buffered through a x1 buffer at the module at RK73A-E08 with the output of the buffer used for display on the scope. The scope can be triggered using the Integrate signal at RK73G14.

      Note: The HPX1 signal is usually buffered through the x10 amplifier to obtain the correct scalar decimal point value.

   c. Check to make sure that the beam pulse is located entirely within the integration window as shown in Figure 5 above. If the beam pulse is not within the integrating window, use Figure 4 and the information given in section IV, part 1b to move the integrating window – a good place to begin is moving the integrate start delay time earlier or later depending on where the beam pulse is compared to the integrating window.

   d. Measure and record the amplitude and pulsewidth of the beam pulse. Divide the amplitude by the transfer function for the given transformer to estimate what the actual amplitude is read by the transformer at the origination point. The transfer function for 29XF104 is 0.62, for NX-58 it is x0.95, and for HPX1 it is unknown – do not divide by anything in this case, experience with calibration in the past shows the unknown transfer function does not impact the calibration greatly. Knowing the calibration pulse current/voltage ratio for the transformer as given in Section IV, you can scale the voltage amplitude of the beam pulse to a current.

   e. Using the equation: $\#ions = {}^{It}\!/_{qn}$ (where I=current, t=pulsewidth, q=1.6x10^{-19}, and n=charge of ion; 1 for protons, 32 for gold, 5 for silicon, and 10 for iron, 20 for NSRL iron, 18 for NSRL titanium, and 6 or 5 for NSRL carbon) solve for the number of ions. This value should match the reading on the scalars.

      Note: The signal for HPX1 is normally buffered through a x10 amplifier. Therefore when calculating the number of polarized protons, the value needs to be divided by 10 to get the correct number of protons.

      Example:

      (1) For Silicon beam, measured voltage amplitude of 400mV and pulsewidth of 320us at Room 222, Building 911B.

(2) Transformer 29XF104 is used which has a transfer function of 0.62. To find amplitude at transformer: 400mV ÷ 0.62 = 645mV

(3) Transformer 29XF104 at low gain has calibration pulse scaling of 50uA=500mV (If it was set to high gain, ratio is 50uA=5V)

To find current I: $\frac{50\mu A}{500mV} = \frac{I}{645mV} \Rightarrow I = 64.5uA$

(4) Knowing that n for Silicon is 5, can solve for # of ions

$$\#ions = \frac{It}{qn} = \frac{(64.5uA)(320us)}{(1.6x10^{-19})(5)} = 2.58x10^{10}$$

(5) The scalars should read a value of $2.58\text{x}10^{10}$ for the measured amplitude and pulsewidth.

(6) Remember to pay attention to units – there is a mixture of mV, V, uA, A, etc.!

If the calculated value and actual value of the scalars do not match, place the appropriate receiver on an extender card. Adjust the gain value also located at the main current transformer pet page for the device BIX.XF_BINPT.GAIN. A gain setting of 0 is equivalent to x0; a gain setting of 255 is equivalent to x10.