Instrument Integration Lab (IIL)

You are going through the process of designing an instrument and integrating it into a control system by publishing the results. You will use the current transformer from the CTL lab as signal for your Beam Current Monitor (BCM). You will use a pulse generator to simulate the beam. This pulse generator is preprogrammed for you with a suitable signal and output trigger to trigger your digitizer (scope). To match a real world situation, the pulses come at you at 60Hz, see if you can keep up. Your first transformer to use is the hand-made one from the CTL lab. Once you have implemented your BCM based on that transformer, you can use one of the Pearson's transformers. To implement the BCM you must:

- Design the Signal Acquisition and Signal Processing based on an ICD,
- Calibrate and document your system
- Publish the results on Channel Access, and
- Display the results on an EDM Console

This might seem like a full day's work and it is, but we need this for our real jobs and this way you will be doing our work. We did get started though and some code is available to you. The programming environment to implement the BCM is LabVIEW. If you are familiar with that then this is great and your development will be quicker. However, this lab is not focusing on programming and instead you will spending time first on designing your system on paper (your notebook) and then with our help, implement this in LabVIEW through the use of preprogrammed templates. You will then customize the system by setting up parameters such that are needed for acquisition and processing.

We have the latest in EPICS connectivity available in the form of a brand-new Channel Access Server, implemented in LabVIEW. This will help you to do quick publishing of your results to the network.

The teacher laptop will function as a console, in particular, an EDM console. Once you have the results displaying live on this console, you are done!

All exercises in this lab are to be done as a group; the experienced ones should give those new to this a chance to figure it out as well. You'll start at looking at the ICD for your instruments and then design your instrument.

If you have questions during the exercises, ask!

The US Particle Accelerator School

Beam Current Monitor System

Interface Control Document

Preface

Overall Description

The BCM System is to demo how and instrument is designed and implemented. The hand-made transformer will be the pickup for the signal, with the pulse generator the beam pulse source. External timing is from the pulser (AWG) is to be used as the trigger to the scope.

General Capabilities

1. Acquire a waveform at minimum of 10MHz from the transformer at 10 to 60 Hz with 60 desirable and 10 Hz required.

2. Display a waveform representing the beam pulse at 1Hz or more.

3. Calculate the charge per pulse.

4. Accuracy of 2% in the charge per pulse and the current values in the waveform.

5. The system must be able to measure pulse lengths of 1 to 10usec.

6. The Charge and the beam pulse waveform must be displayed on EDM through Channel Access.

System Configuration

Packaging

A compact system is required that takes up only up to 4U in a standard size rack.

Cabling

The "beam" signal will run from the AWG to the transformer primary winding, the signal from secondary winding will be connected the digitizers first channel.

Analog Data Acquisition

Minimum sample rate will be 10MHz.

Front End Data Processing

1. Data scaling. The data must be calibrated to reflect the current of the beam to within 2% of calibration (calibration and. Current monitor must agree within 2%) The scaled and processed waveform PV name should be USPAS_Diag:BCMXX:WF_Y and USPAS_Diag:BCMXX:WF_X with XX replaced by the serial number of your BCM (Pick a number between 00 and 99).

2. Total charge per pulse. The charge must be calculated and presented in micro Coulombs for display on the console. The charge PV name should be USPAS_Diag:BCMXX:Q

3. Droop correction. The droop must be corrected to accurately represent the beam pulse.

IIL Experiment #1: Design the BCM

IIL1.1 Given the specifications written in the ICD, design the data acquisition by drawing diagrams with function blocks. Think of how you have to setup a scope or digitizers by hand and what you needed to do. Ok, here is a hint; you had to set the impedance, coupling, vertical range, and horizontal timing (sampling rate and number of samples). What parameters are you keeping adjustable, which ones can be constants?

IIL1.2 Design the signal processing. What are you going to do with the signal once you have it? How are you going to deal with the droop? What are the important results you can calculate with a Beam Current Monitor? What is the most basic number the Beam Current Monitor can publish? Anything you can do to minimize noise issues? What parameters are you keeping adjustable, which ones can be constants?

IIL1.3 Design the data publishing or API. What are the variable types should you publish? What would be acceptable rates? For this design, ignore the update rates but comment in your notes about what you think it should be

When you have finished call upon one of the teachers to review your acquisition, signal processing, and the API.

IIL Experiment #2: Implement the BCM

Depending on your LabVIEW experience, you have different options. Your three options are:

1) The experienced LabVIEW user: Implement mostly by your own. The Toplevel program is there and the setup for the pulse generator. Surely there is extra credit in it this way. If you run out of time, you can fall back to an already implemented program
2) Middle of the road: Use a structured template and do some coding within routines that are already layout but not implemented
3) The "what-the-heck-is-LabVIEW?" way: Use an almost ready to go program, customize it and find the bugs. Yes, I put one in there to see if you could find it. Or was it two? Do read through the program diagram to see what is going on.

IIL2.1 Implement your BCM system. This includes your publishing of the data but the console display for the BCM will be made in the next exercise.

IIL2.2 Hookup your system transformer and setup the AWG to generate pulse and the digitizer to take the waveform.

Setup:

- Connect the PFI0 of the PXI 4545 AWG to the EXT TRIG in of the PXI-5122 digitizer.
- Connect the Ch0 of the AWG to the toroid and the output of the toroid to the Ch0 of the digitizer as shown in Figure 1.1, except change Ch1 to Ch0)

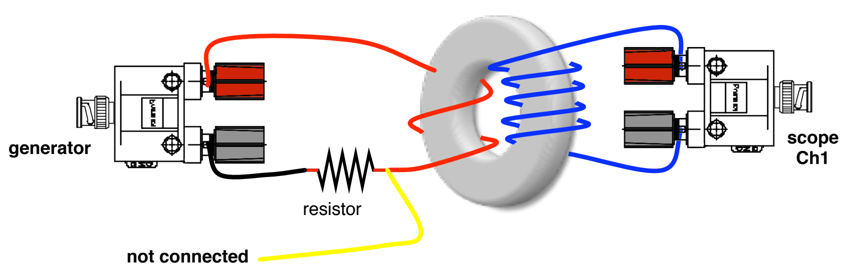

Figure 2.1. Configuration of the IIL2 experiment.

IIL2.3. Verify the operation of your BCM and signal processing. Is the droop correction working? How long of a pulse can you acquire and correct before the droop correction has a baseline problem?

IIL2.4. Calibrate your BCM. Provide proof of calibration by writing a table of measurements and referring to calibration certificates. Assume the scope has a traceable (NIST) calibration certificate called SCOPECAL01 and the resistor is exactly 50 Ohms according to the RESISTORCAL01 certificate.

IIL Experiment #3: Implement the console display

Many accelerator labs use an EPICS based control system, so does SNS. Your instrument might as well not exist if nobody but you can see its results. Your ICD stated that it has to use an EDM console. Successful display of the BCM waveform and charge means you have completed the IIL. The instructor's laptop will function as the EDM Console. You will have to use it to implement the EDM screen. Luckily, a template is available.

IIL3.1. Open the BCMXX.edl file. See instructions below.

1) Ask the instructor for access to the console and to run the USPAS console.
2) Open the BCMXX.edl screen, see Figure 3.1

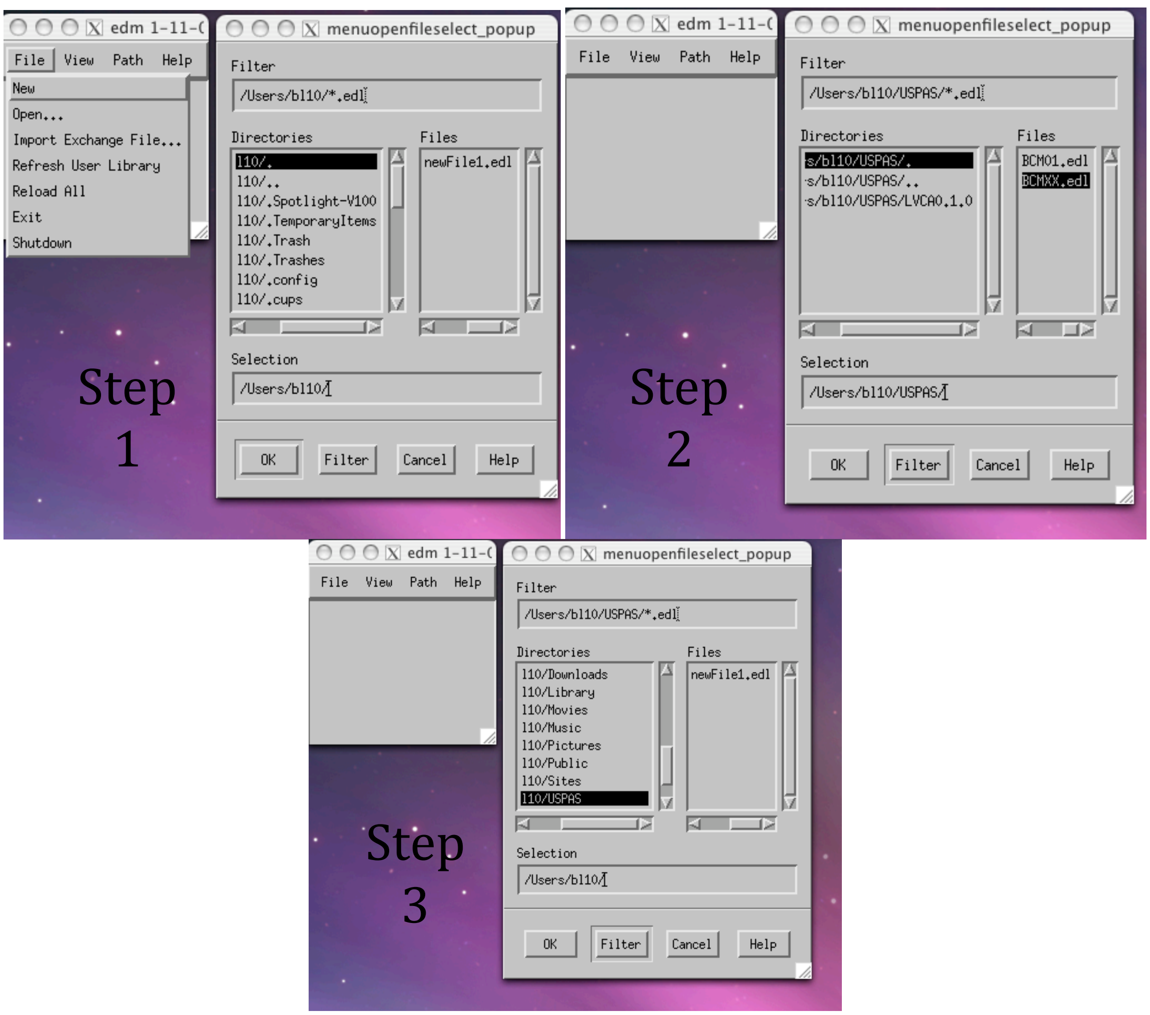

Figure 3.1. Finding and opening the BCMXX.edl screen.

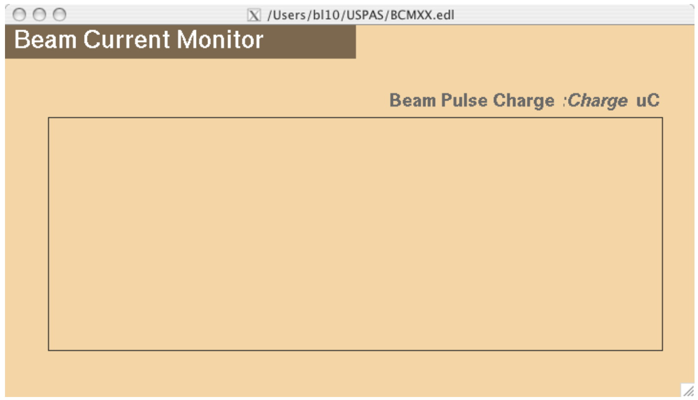

Figure 3.2. The BCMXX.edl screen in edit mode.

IIL3.2. Customize the waveform display of the BCMXX.edl file, see Figure 3.2, to implement your screen. See instructions below. You will have to change the names of the PVs to match with your BCM's PVs.

1) Middle click on the rectangle box to edit the properties, see Figure 3.3
2) Click on the X/Y Trace data button.

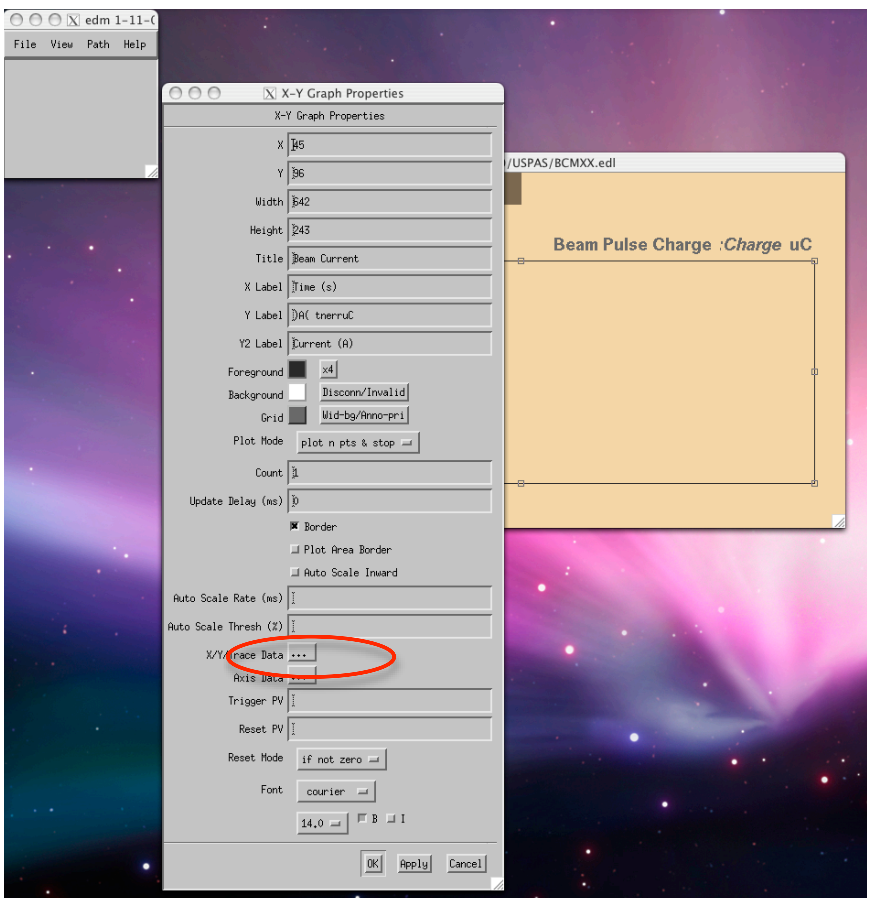

Figure 3.3. The X-Y Graph properties window.

IIL3.3. Customize the Trace properties; see Figure 3.4, to implement your screen. See instructions below. You will have to change the names of the PVs to match with your BCM's PVs. Hit close on the bottom right when done. Then hit OK on the X-Y Graph properties window to lock in the changes.

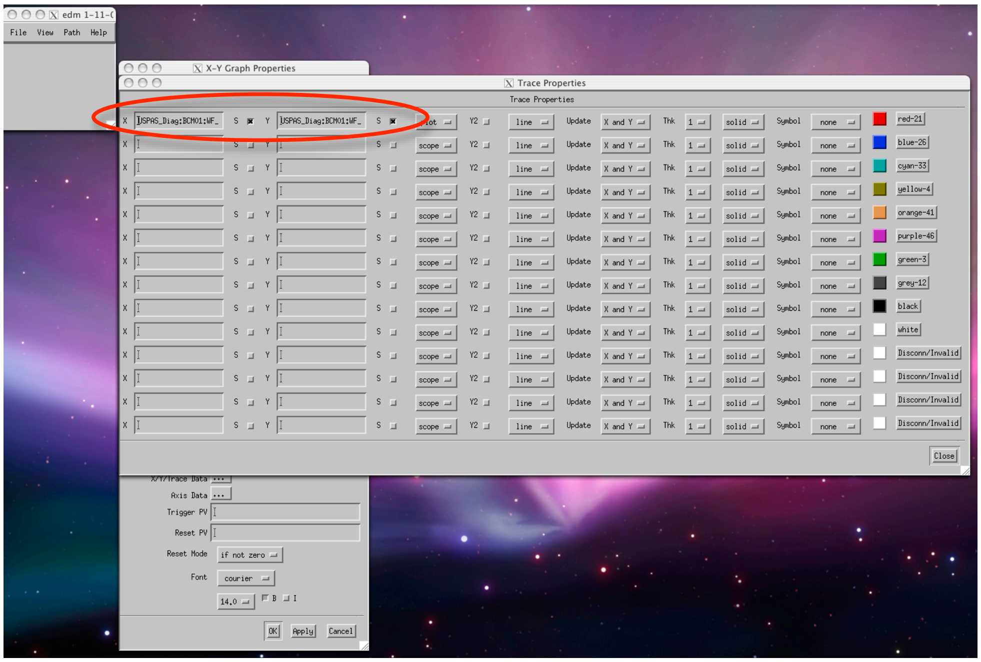

Figure 3.4. The X-Y Graph properties.

IIL3.4. Save the edl file by middle clicking on the background of the BCMXX.edl window. Do a "Save as" and rename it to reflect the version of your BCM. For example, BCM27.edl. See figure 3.5.

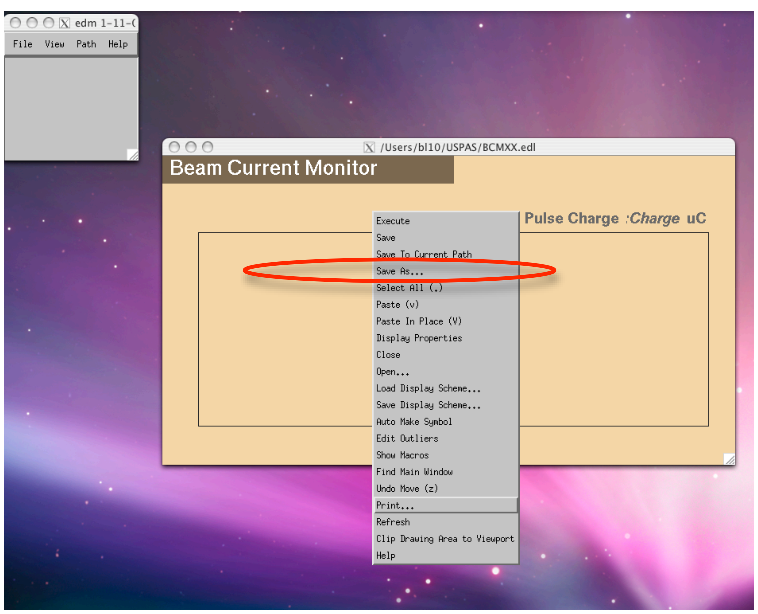

Figure 3.5. Saving the file.

IIL3.5. Modify the PV name of the numerical indicator displaying the Charge. Middle-click on the indicator to open its properties window. See figure 3.6. Click Ok to apply the modification and exit the properties window. Save your file again!!!!!

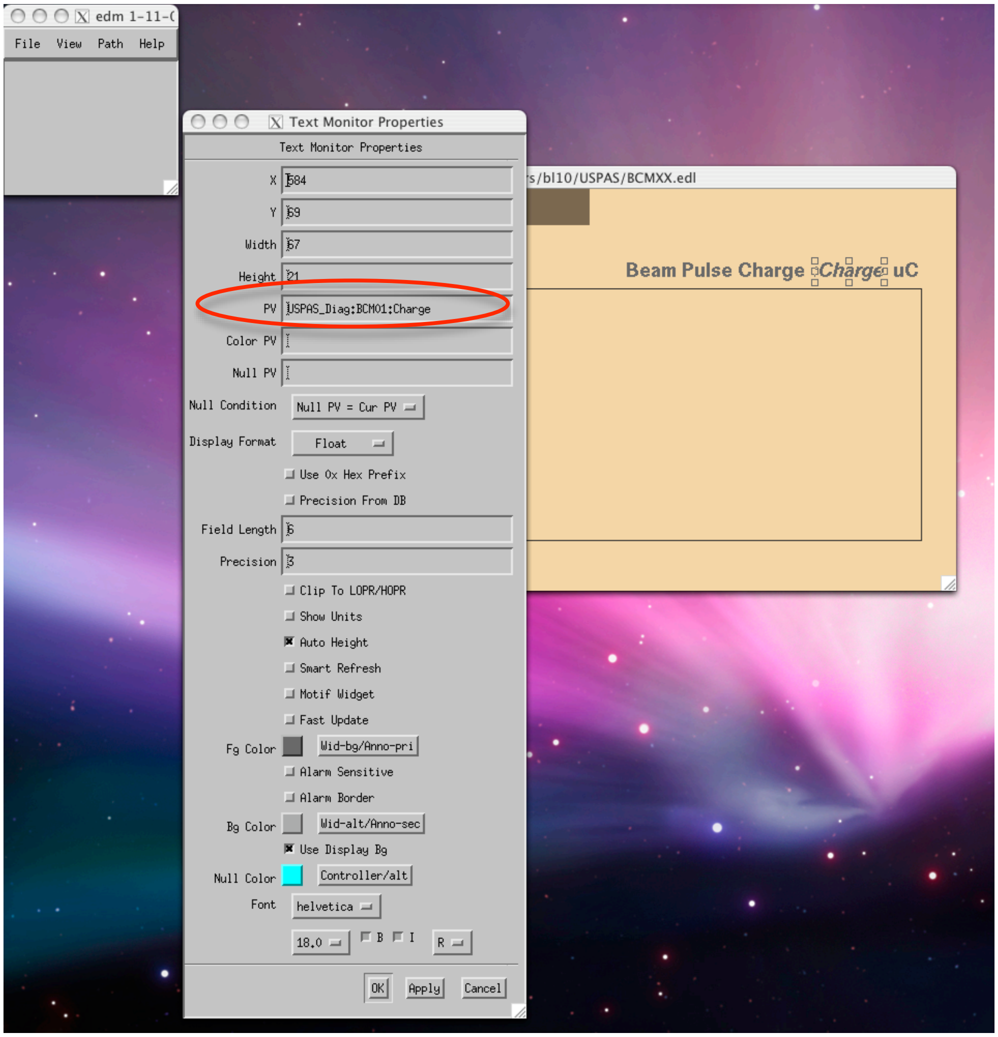

Figure 3.6. Modifying the PV for the charge.

IIL3.6. Middle click again on the background and now select Execute to run your display and see you data start updating, see figure 3.7

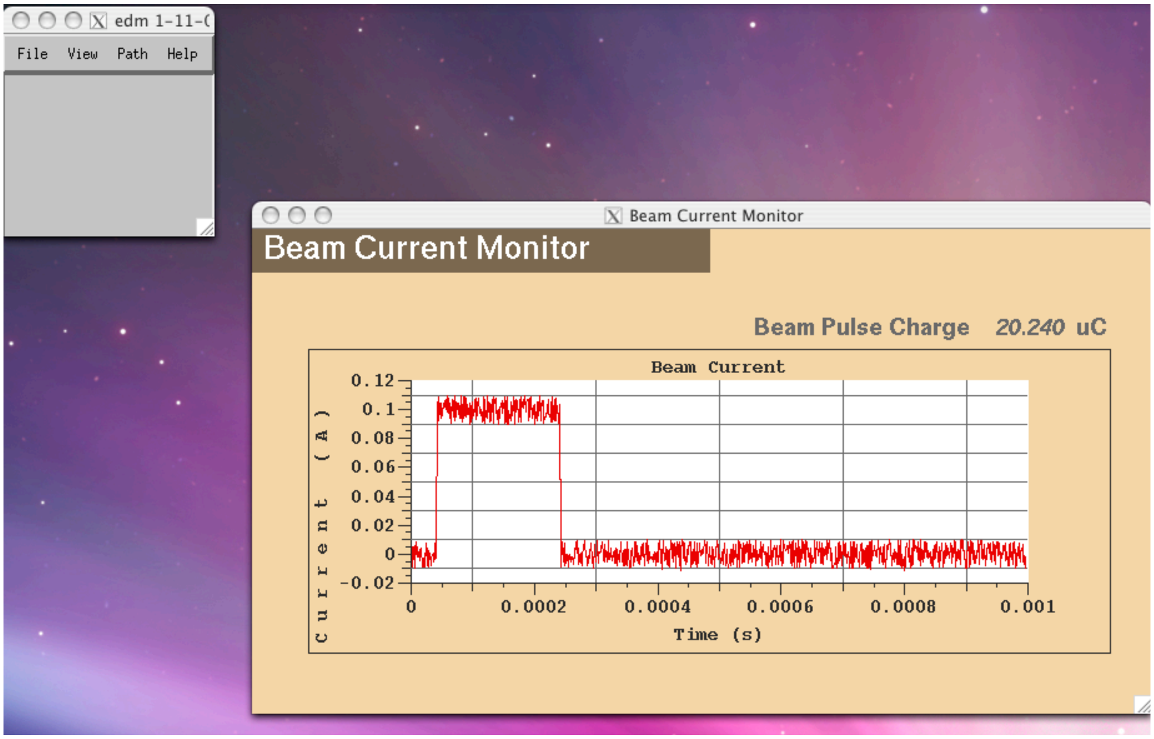

Figure 3.7. Showing off your newly integrated Current Monitor.