The IPM as a Halo Measurement and Prevention Diagnostic*

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The Relativistic Heavy Ion Collider has four ionization profile monitors (IPMs) to measure the vertical and horizontal beam profiles in the two rings. These have had problems from backgrounds caused by electron clouds, rf coupling to the beam, and radiation spray from upstream beam loss. During the 2002 shutdown two IPMs of a new design were installed. These have extremely low beam-induced backgrounds. We are able to measure clean beam profiles from deuteron beams producing about five electrons per beam bunch. With these low backgrounds measurements are being made to look for indications of beam halo. This paper reports on the results of these measurements.

*Work performed under the auspices of the U.S. Department of Energy.

RHIC IPM status

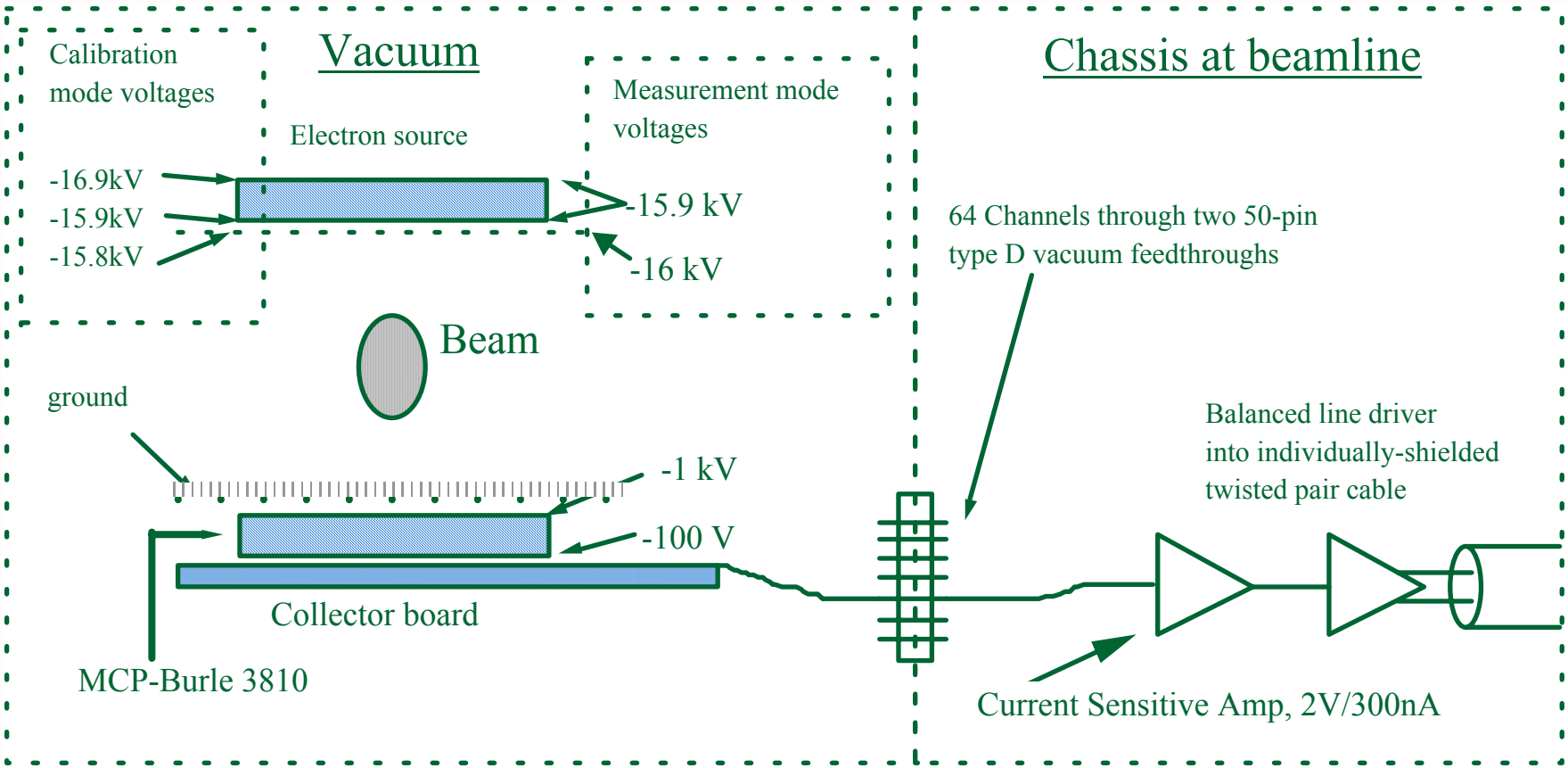
Since July

New IPMs have been built and tested on RHIC.
The sensitivity of these IPMs to rf, radiation, and electron backgrounds is far less than the original RHIC design.
A larger version of this design will meet SNS requirements.

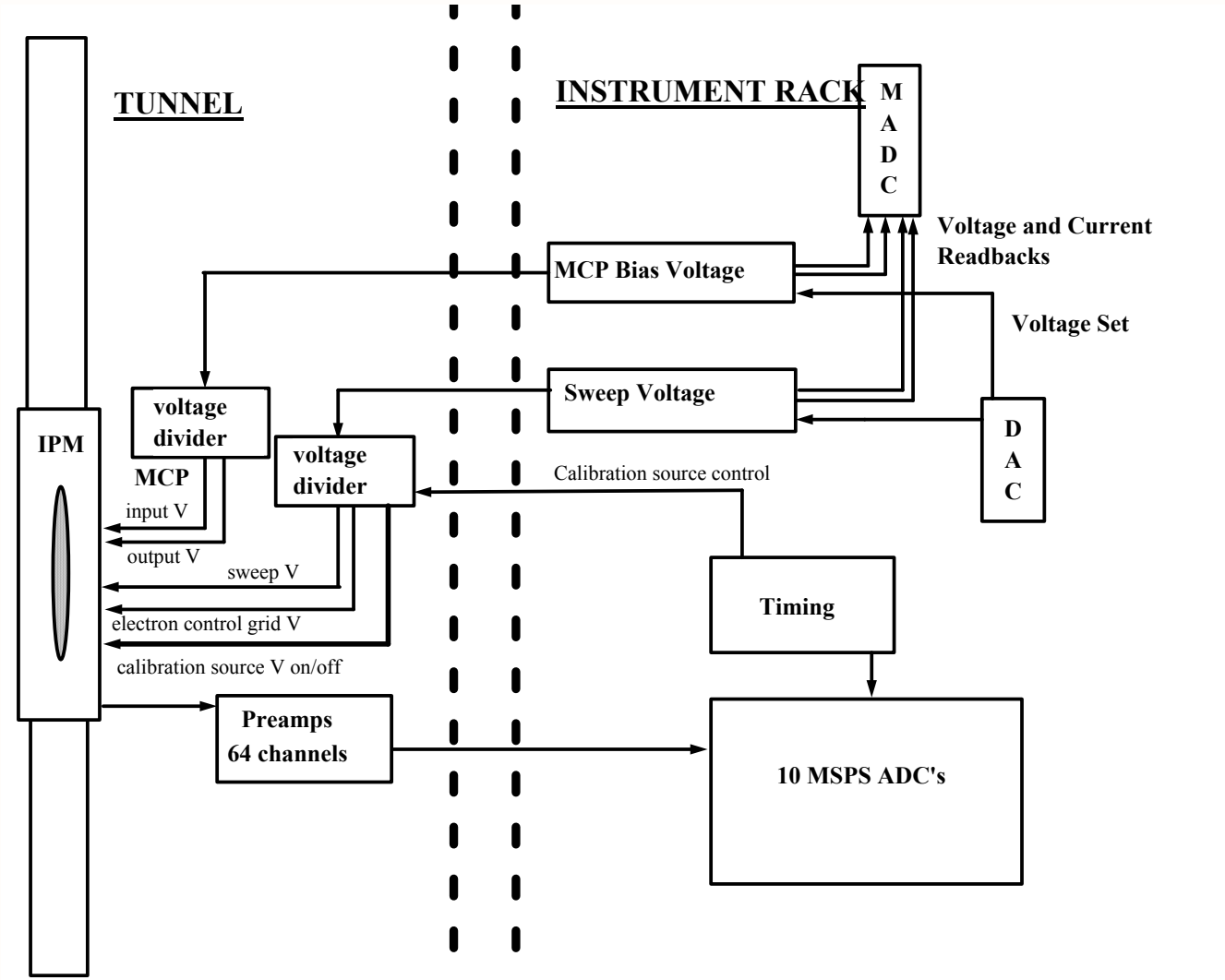
Next shutdown

An electron calibration source will be added. This will be tested on the new RHIC vertical IPMs which will be installed this summer.
Higher transverse sweep electric field will even detector sensitivity across beam.
New electrode design will permit collection of electrons or ions.

Electrical schematic



Block diagram



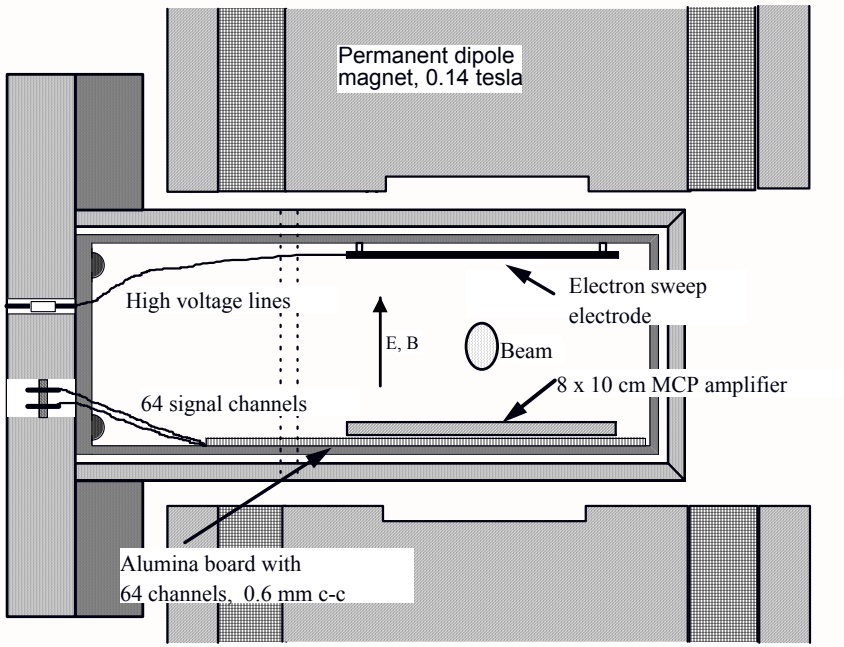
New design RHIC IPM

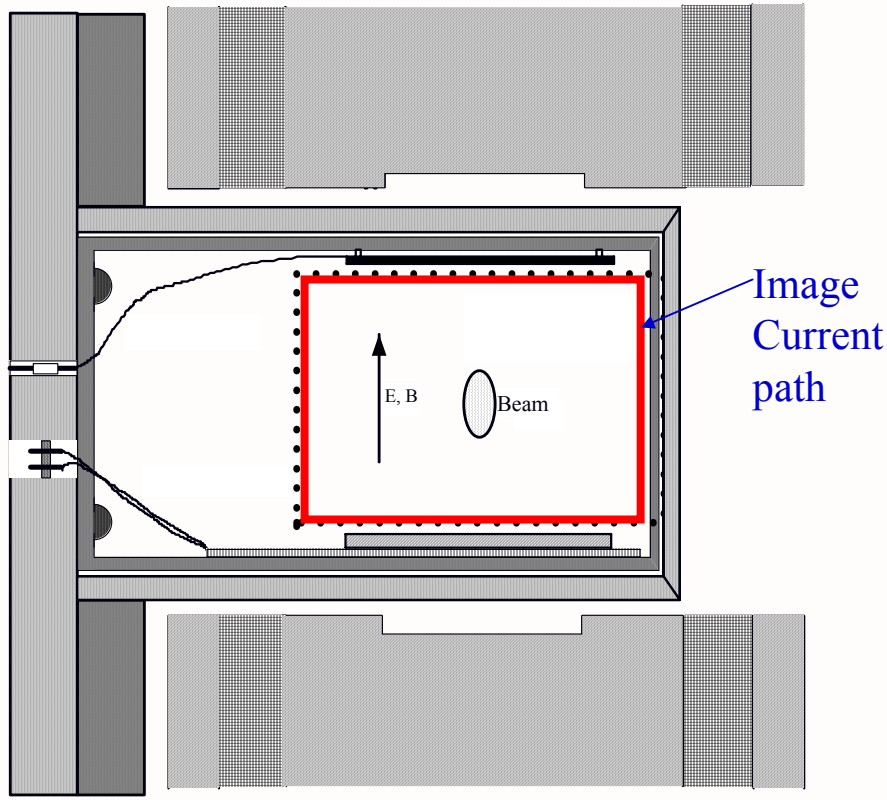
The original detector was sensitive to noise sources.

1. Rf coupling to beam
2. Radiation spray from beam loss
3. Secondary electrons

The new IPMs (horizontal in both rings) are designed to be immune from these background sources. Rf coupling and electron clouds are greatly reduced from original design.

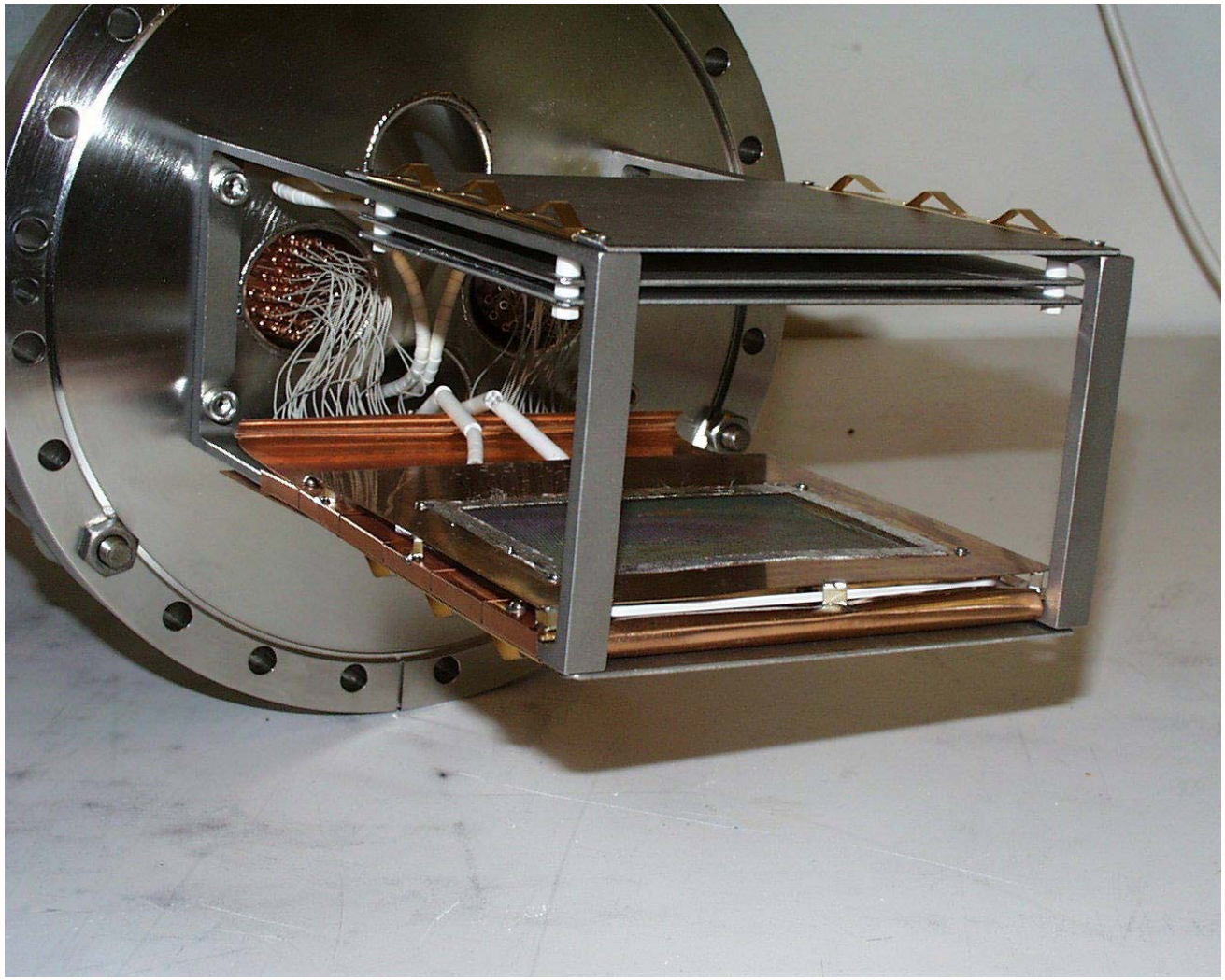
Modification of transducer



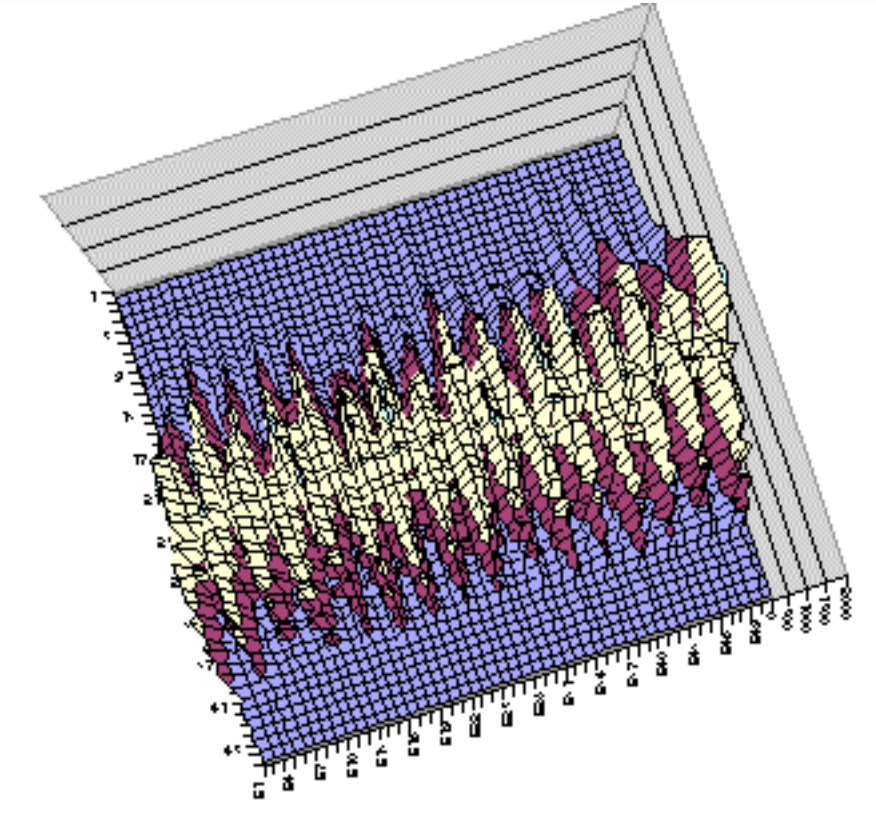


The detector components were inserted inside the beamline. This restricted the aperture and made detector components vulnerable to stray beam. The new detector chamber will allow the detector components to be outside of the image current path.

Original IPM



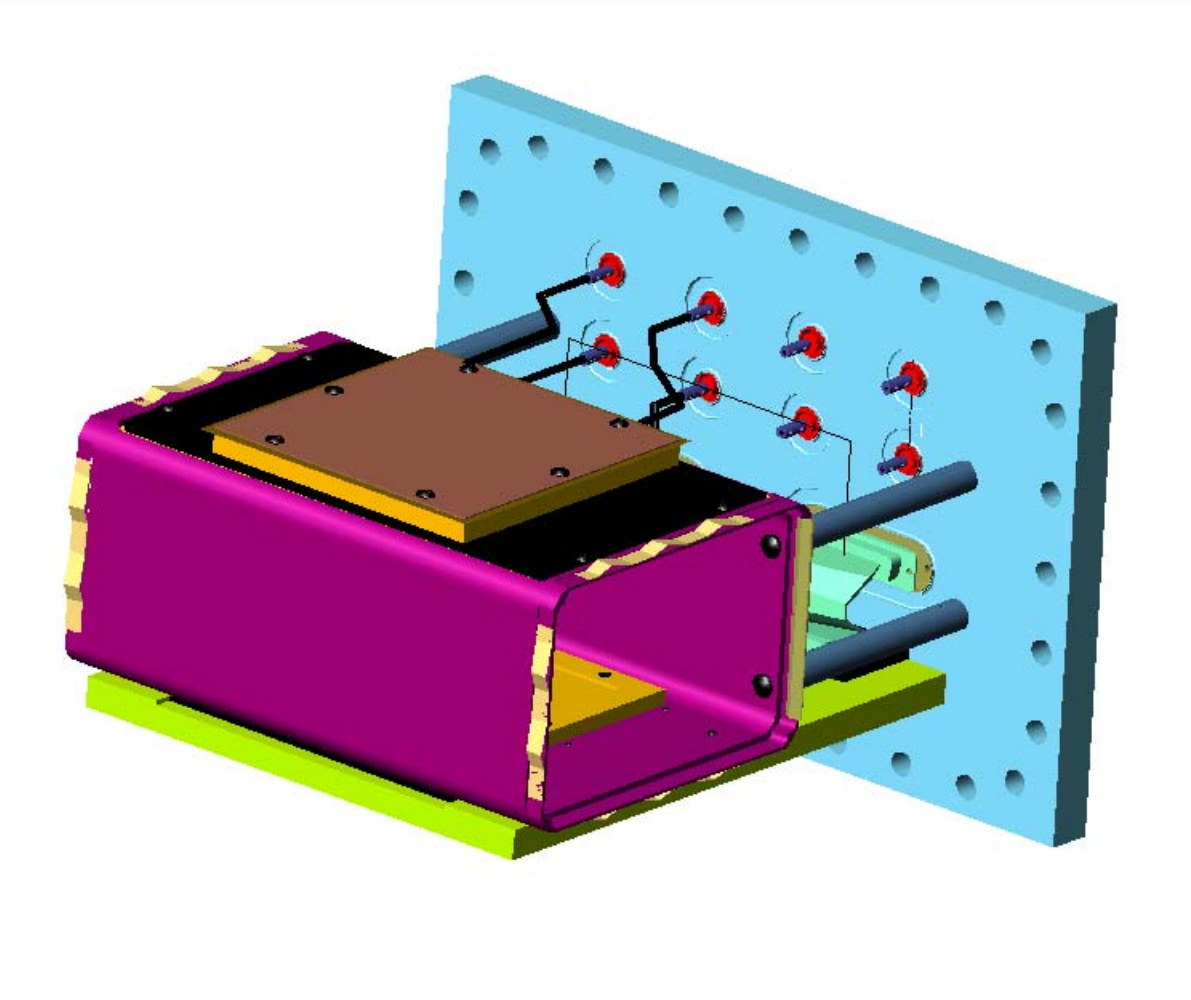
Mountain-range of one bunch at injection



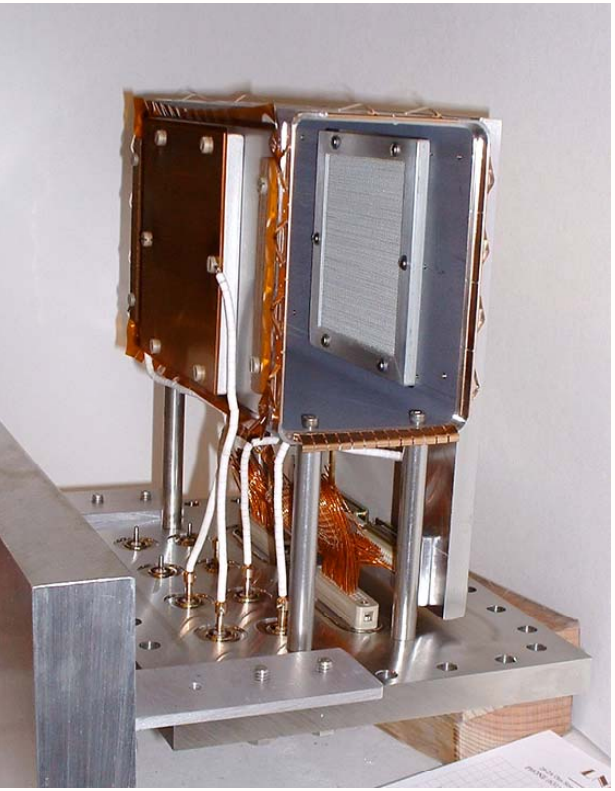
Detector channels are plotted on the vertical axis and turn number is on the horizontal axis. Data contains both tune frequencies and quadrupole oscillation.

SNS will measure 5-7 profiles on each turn so mountain-range plots of each bunch will be available.

RHIC IPM assembly



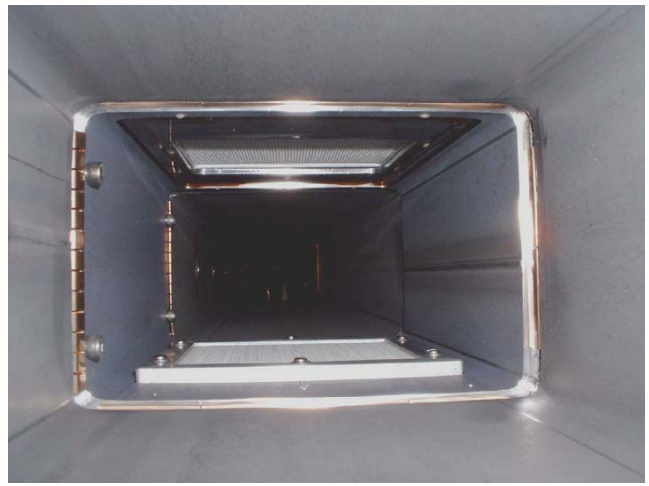
New IPM



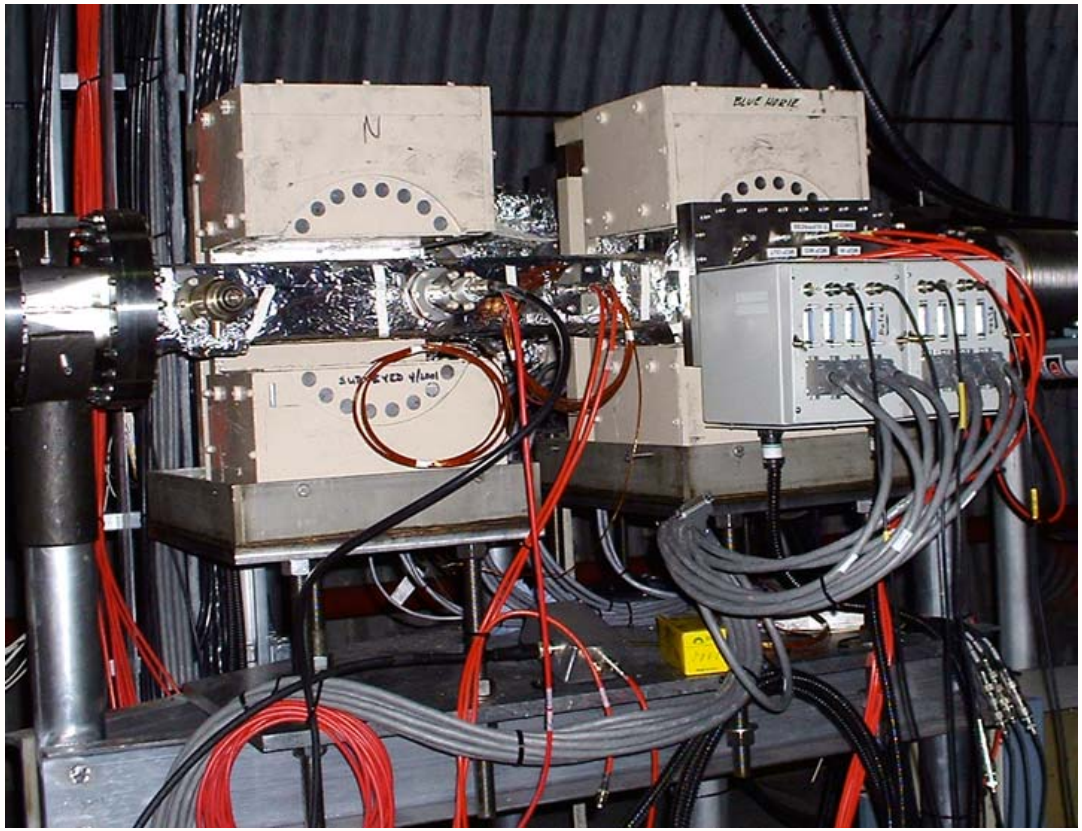
Completed transducer head. The electron sweep electrode and secondary electron suppressor grid are on the left. The microchannel plate and collector board are on the right.

Partially assembled head being inserted into vacuum chamber.

View down beampipe.



New IPMs in RHIC showing most of the SNS IPM features



RHIC IPM detector.

Most of the features seen here will be copied for the SNS IPM.

Signals penetrate the vacuum flange on 50-pin D connector feedthroughs. Amps are attached the to flange and signals carried from the tunnel on twisted pair signal cables.

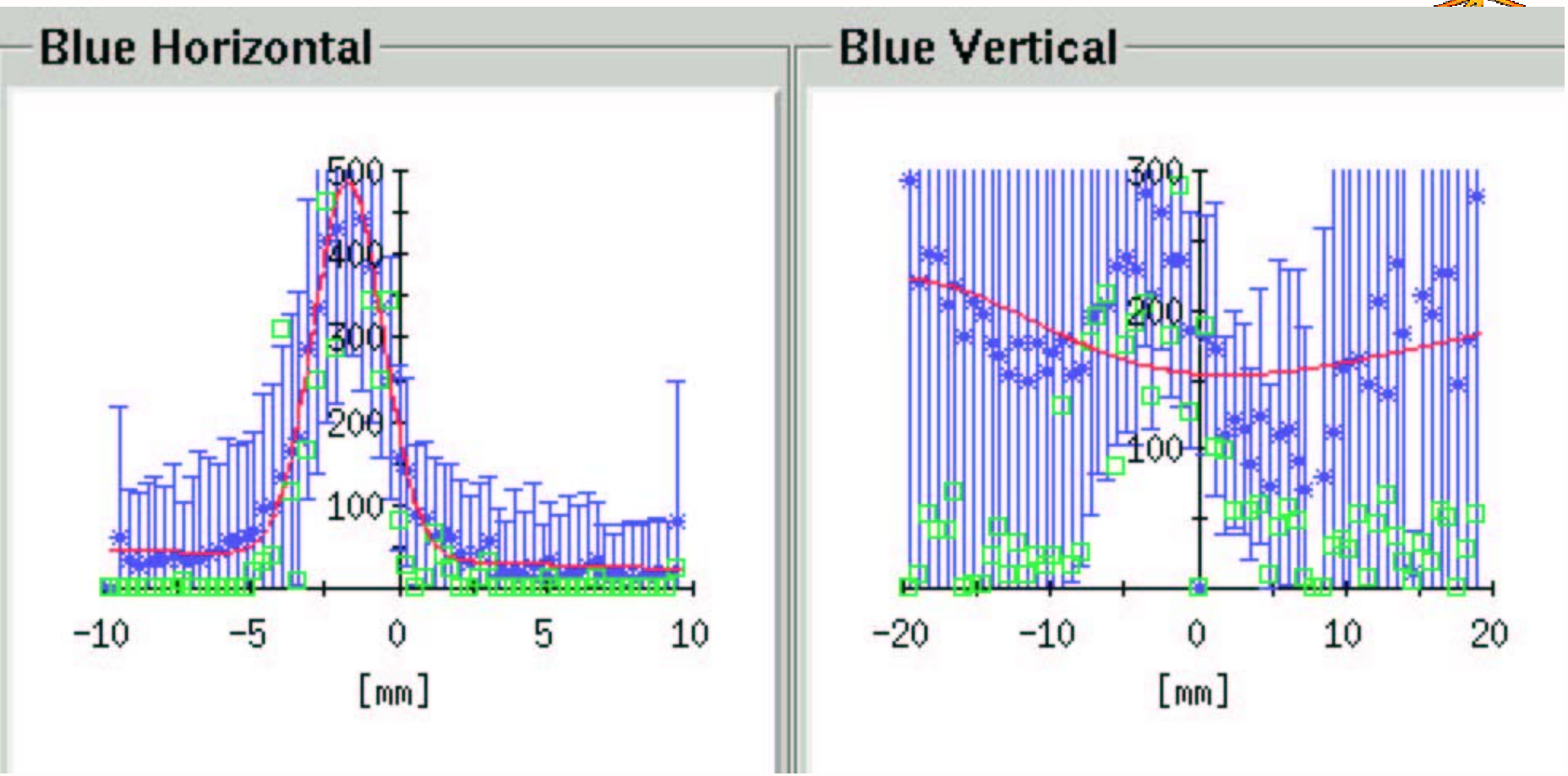
Amplifier power supplies and voltage divider box

The IPM amplifier power supplies in the RHIC tunnel (on top).

At the bottom is the voltage divider box which produces four output voltages from two inputs.

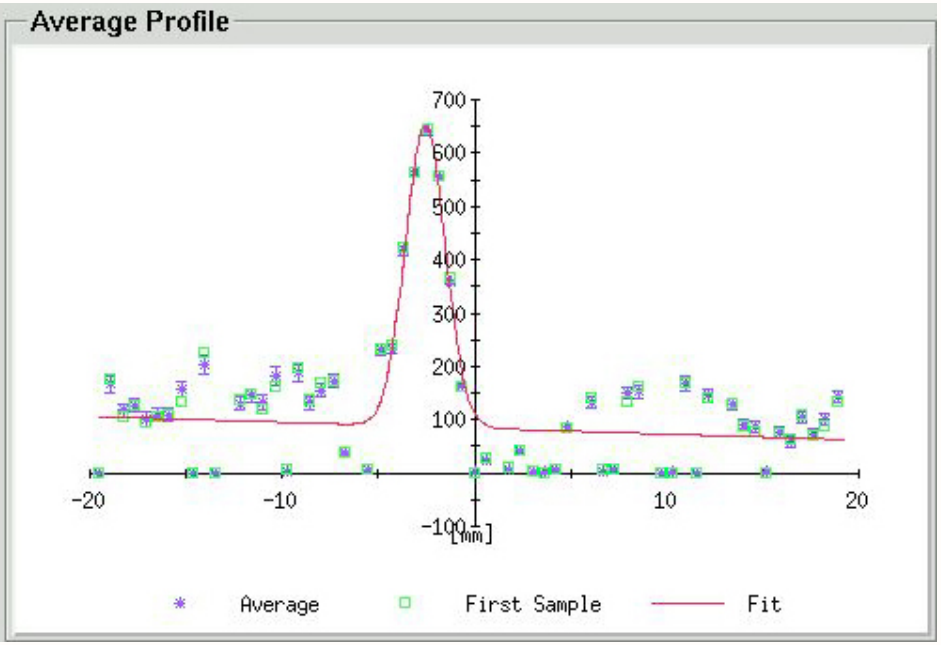
The SNS amplifiers will be powered by a similar arrangement to keep heat and 60Hz out of the amplifier chassis.

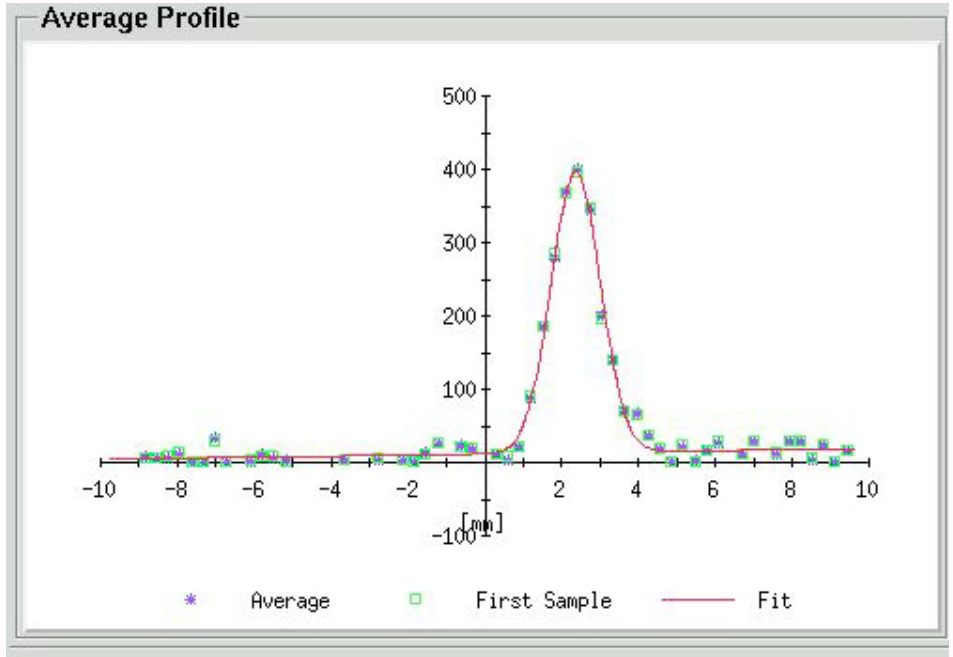
The SNS voltage divider box will have relays to switch on the electron calibration source.



New Detector Design

Old Detector Design



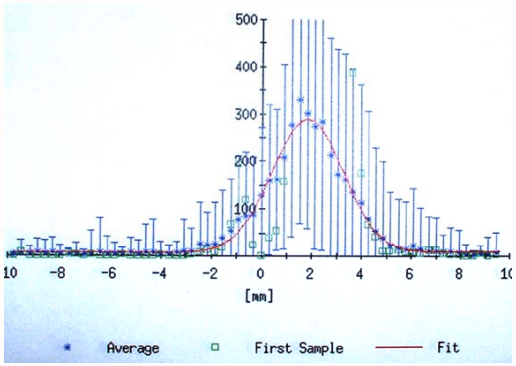


Profiles from the horizontal detectors in the yellow ring with gold beam.
The left profile is from the old design IPM (Oct. 2001) and shows a large background.
The right profile is from March 2003. The new design eliminates most of the background.
With gold beam the background is about 2-3% of peak.

Noise immunity allows good profiles with small signals by averaging.

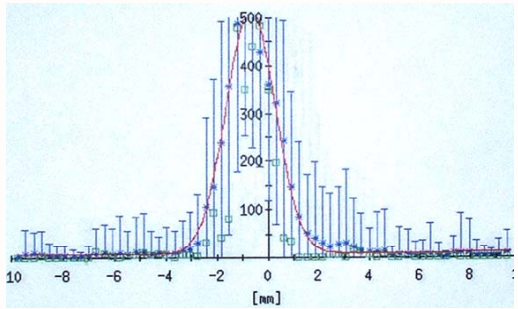
Six profiles from a ramp.

1



A single deuteron bunch generates 5-10 electrons each time it passes through the detector. The signal to any channel is a time-averaged series of "hits" and "misses".

4



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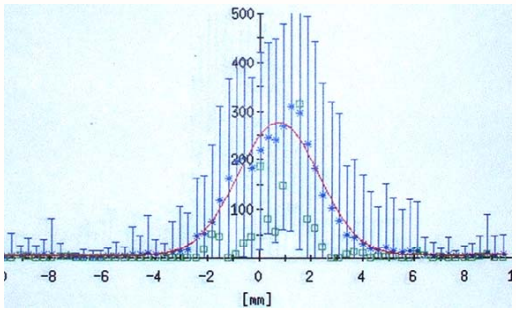
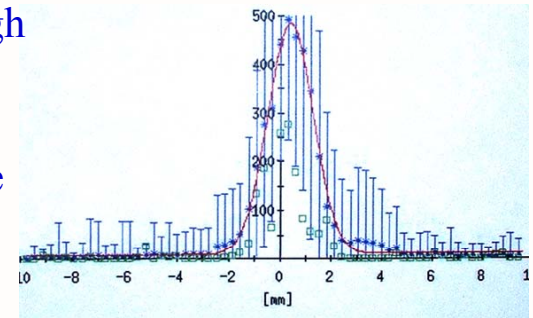


The average of 400 passes through the detector generates a smooth profile. The large "error" bars are the result of the sampling rate being larger than the data rate.

5



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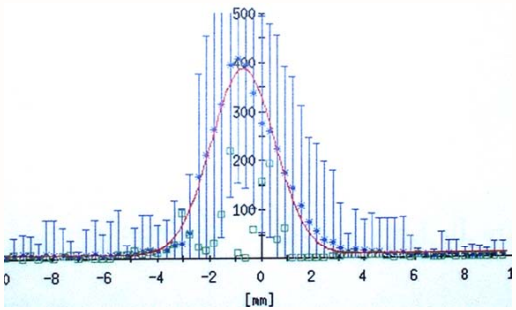
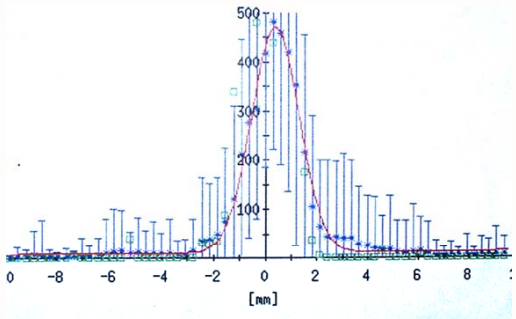
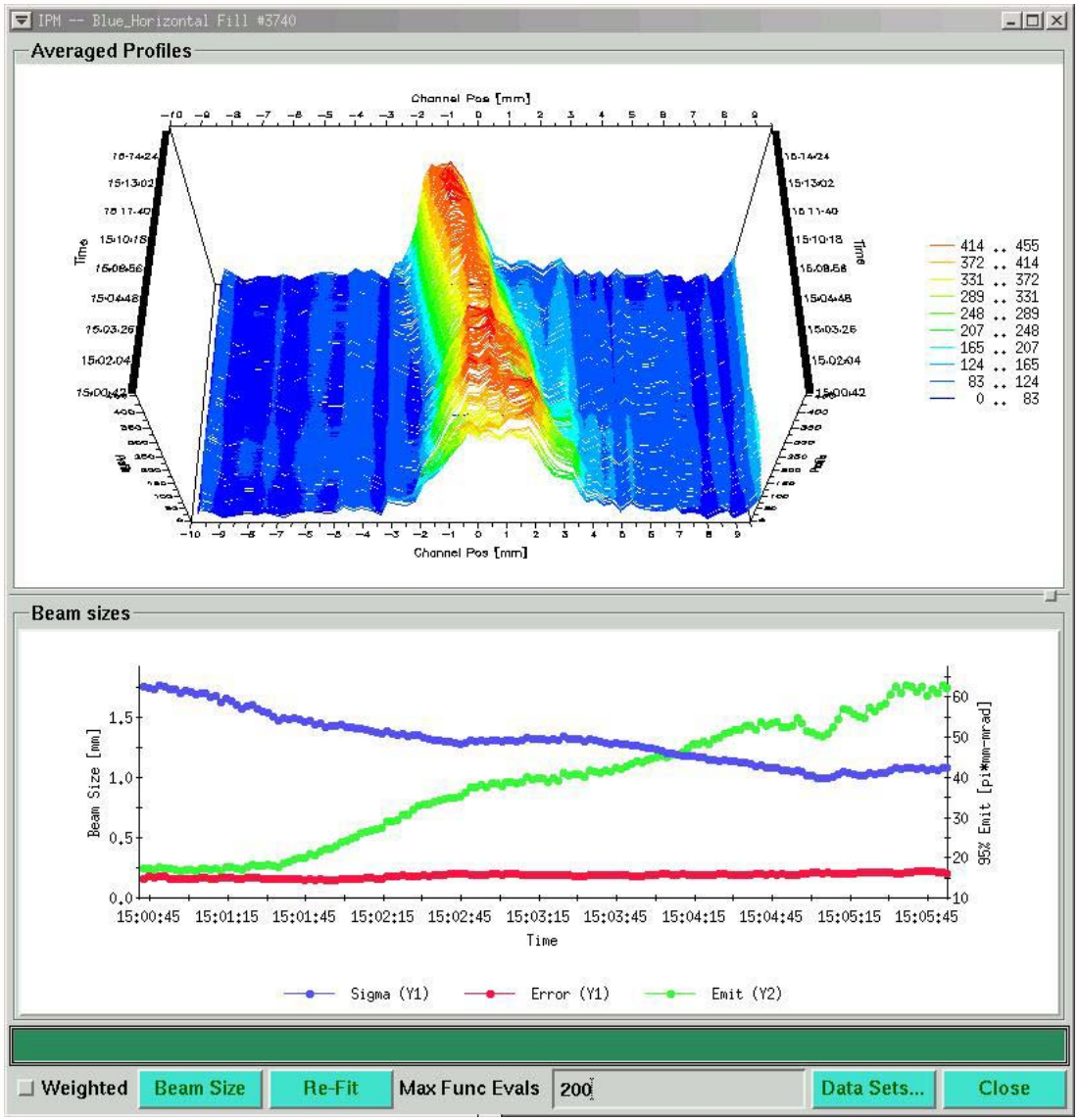


Background is unusually small for proton beam. Maybe beam is piling up at ~3σ?

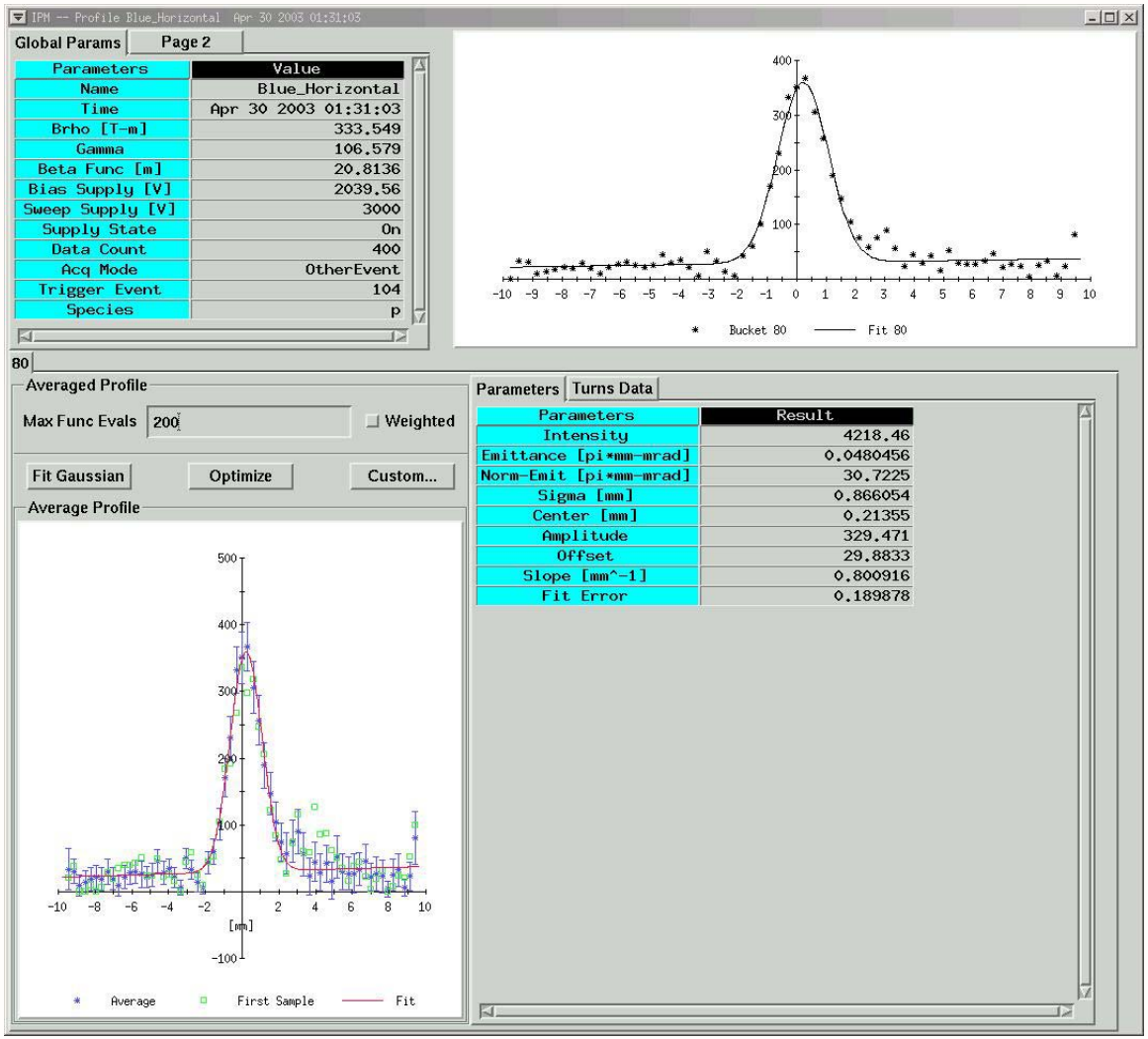
6



Profile of polarized proton beam up acceleration ramp



Typical proton profile with new IPM



Profile from single measurement with polarized proton beam.

Detector pressure is ~2×10^{-9} torr.

With protons at this pressure background is about 10% of profile peak.

Next IPM will further increase signal/noise

New IPM design has greatly increased signal/noise ratio.

For proton beams at good vacuum, S/N is about 10 at beam center. With deuterons S/N of better than 40 was measured.

Largest background seems to be background electrons. Background changes with beam optics and goes away when sweep electric field is removed.

Slight channel-channel gain variations mask small details.

NEXT IPM

Sweep field will be increased. This will increase sensitivity to signal electrons and further suppress background electrons.

Internal calibration source will allow channel-channel gain uniformity.

Accurate transverse sweep field will permit collections of ions in event of large electron backgrounds.

Exploded view of RHIC IPM

Electron calibration source MCP will be mounted here.

Sweep electrode will wrap around top half of insert

RF blocking window, 100 dB rf attentuation, 95% transparent

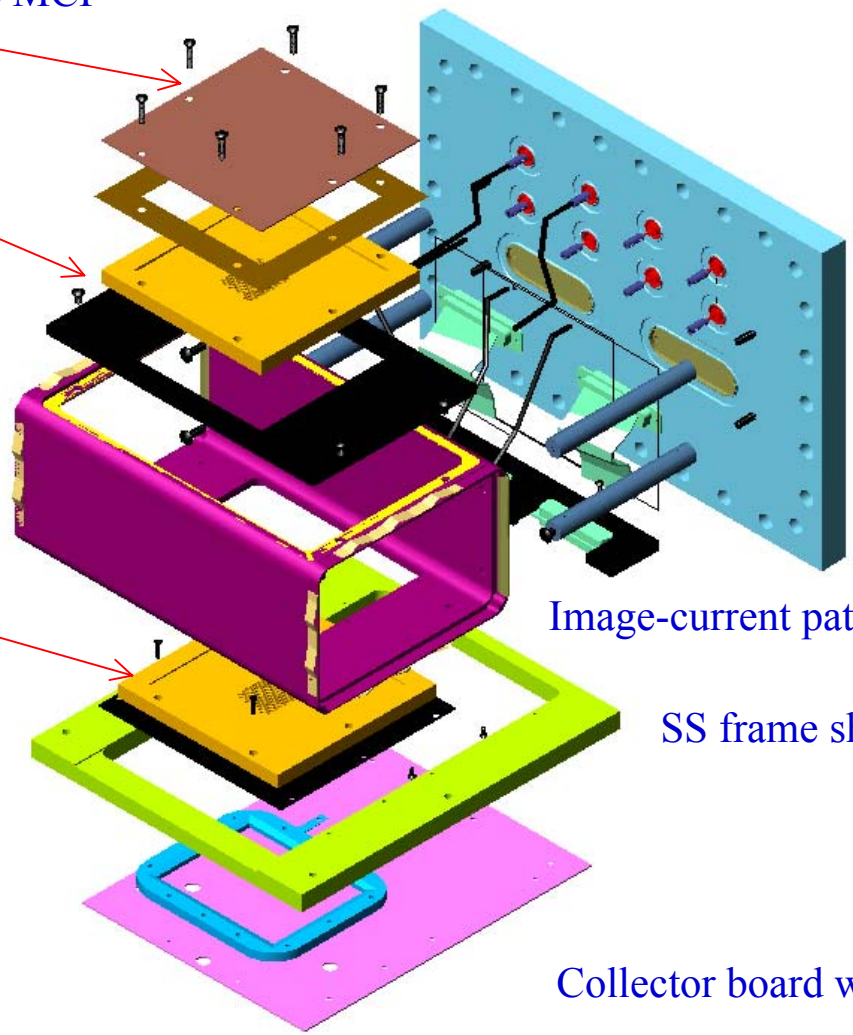
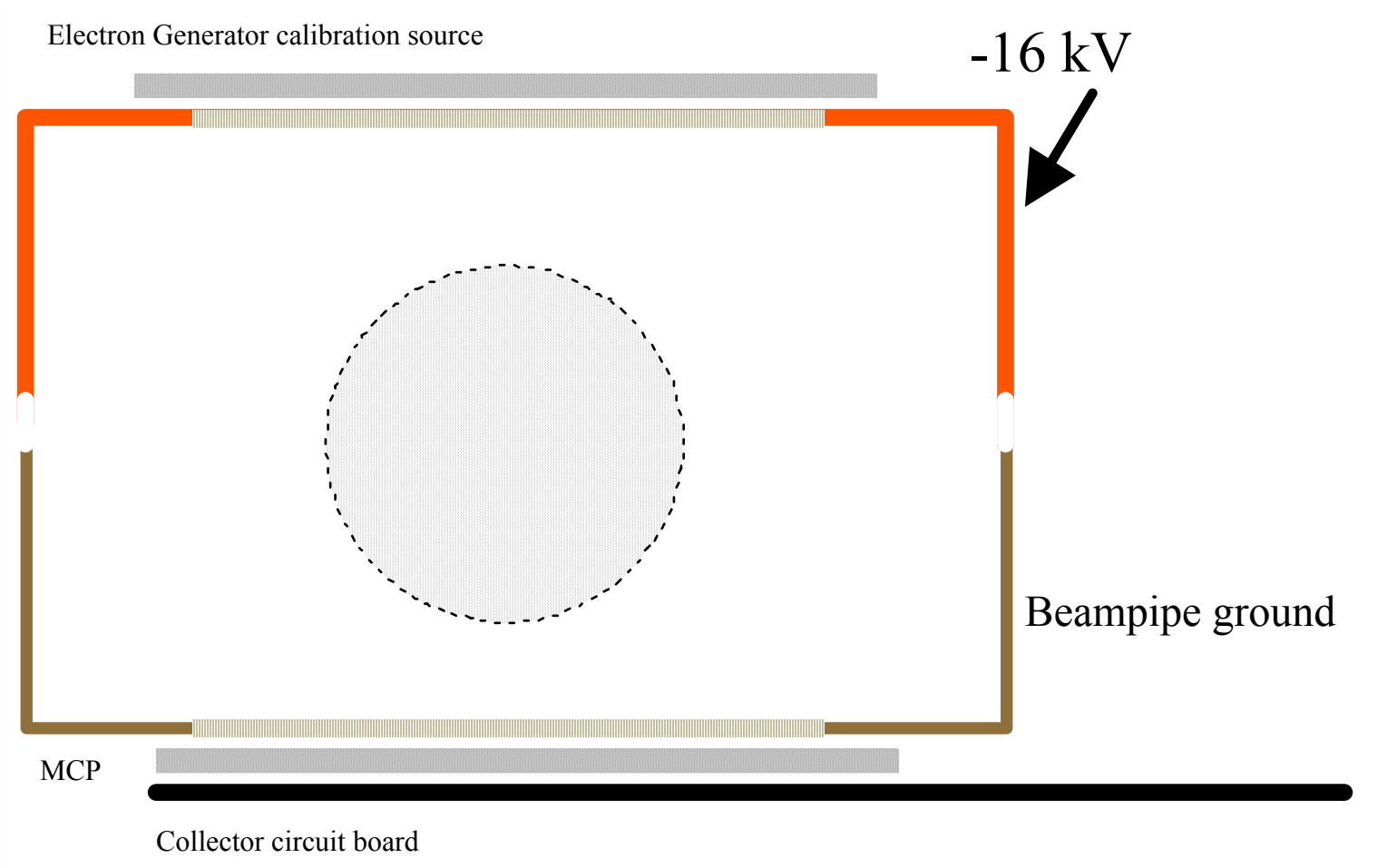


Image-current path insert

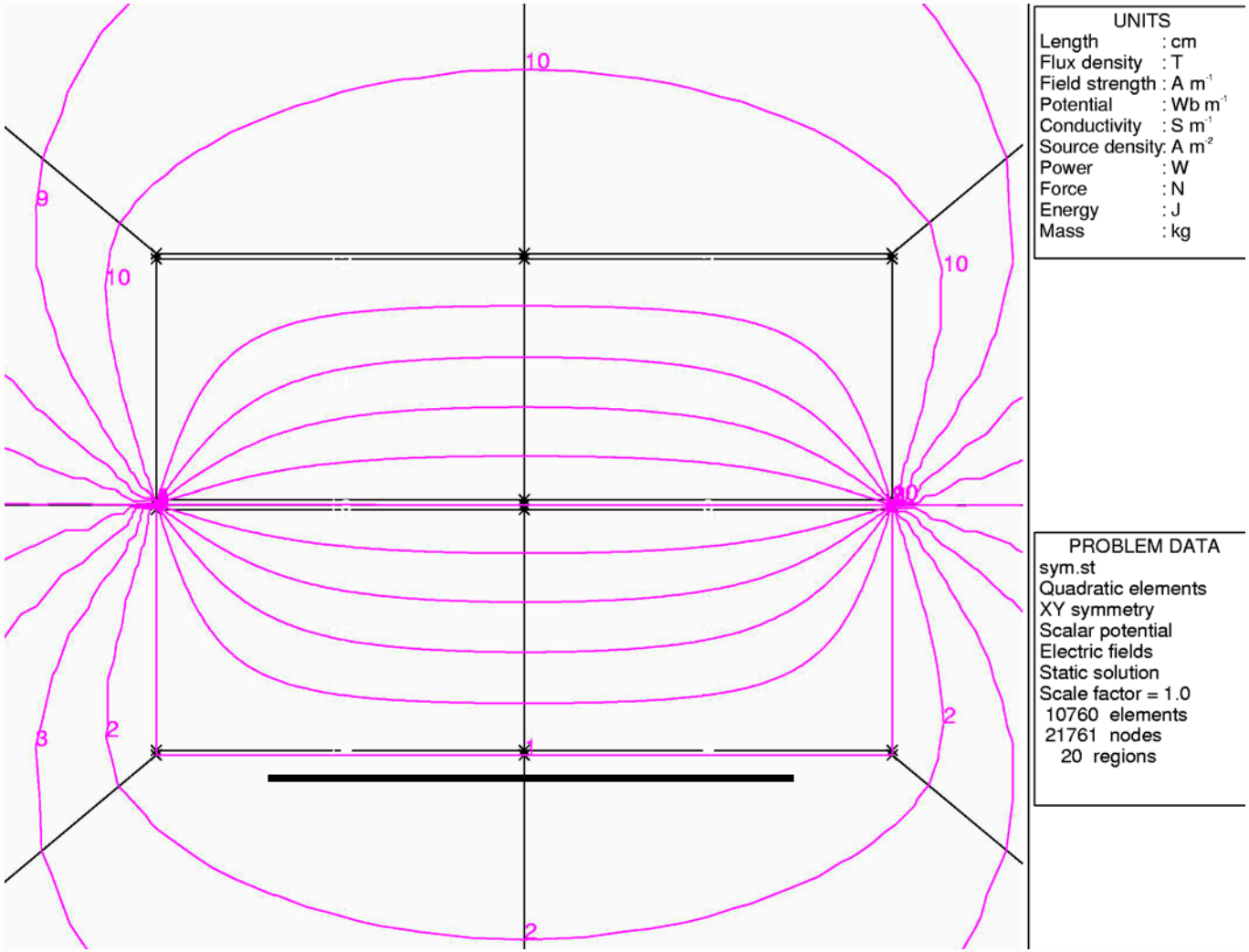
SS frame shields MCP from radiation

Collector board with MCP

Detector cross section

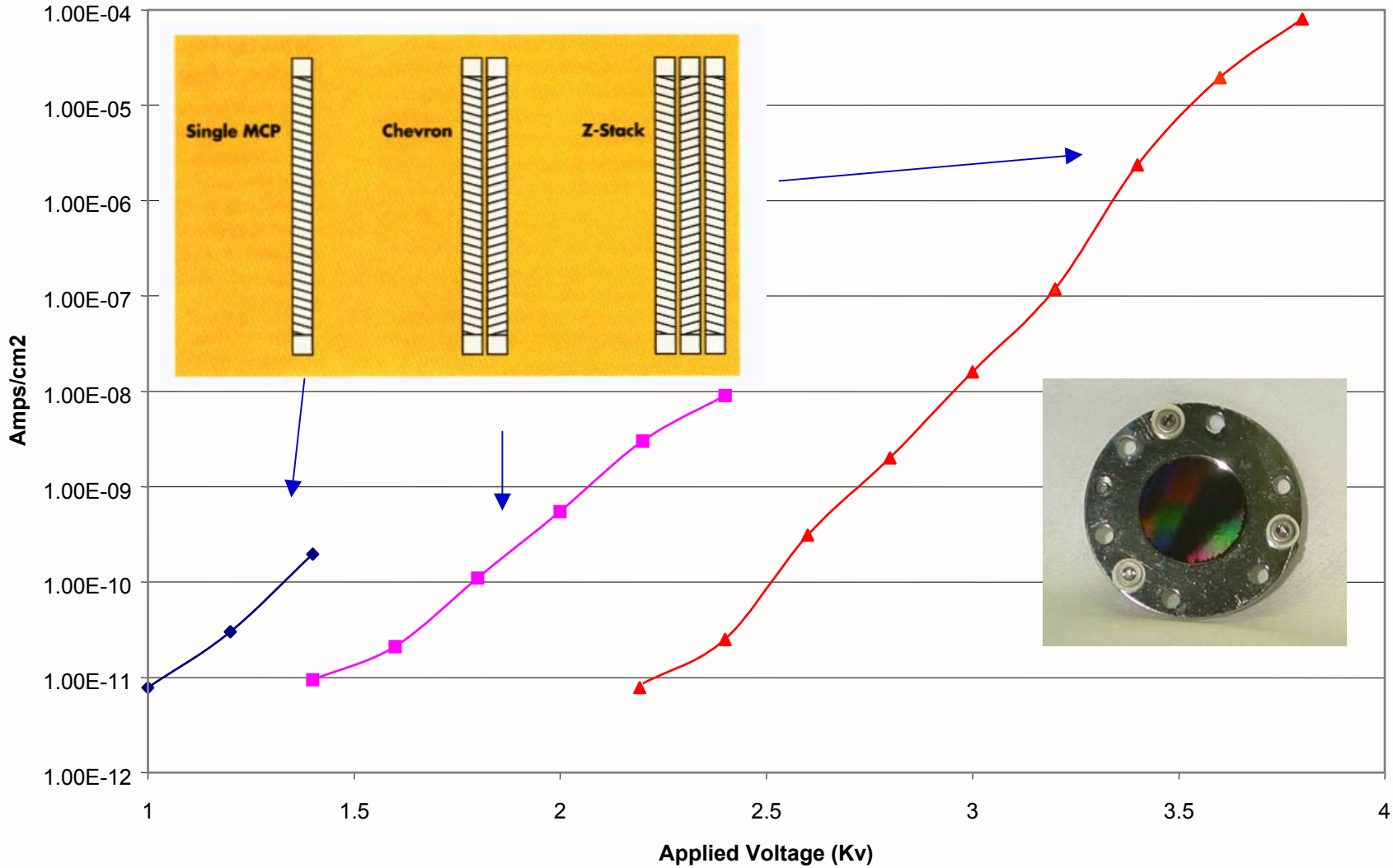


Electric sweep field shaping



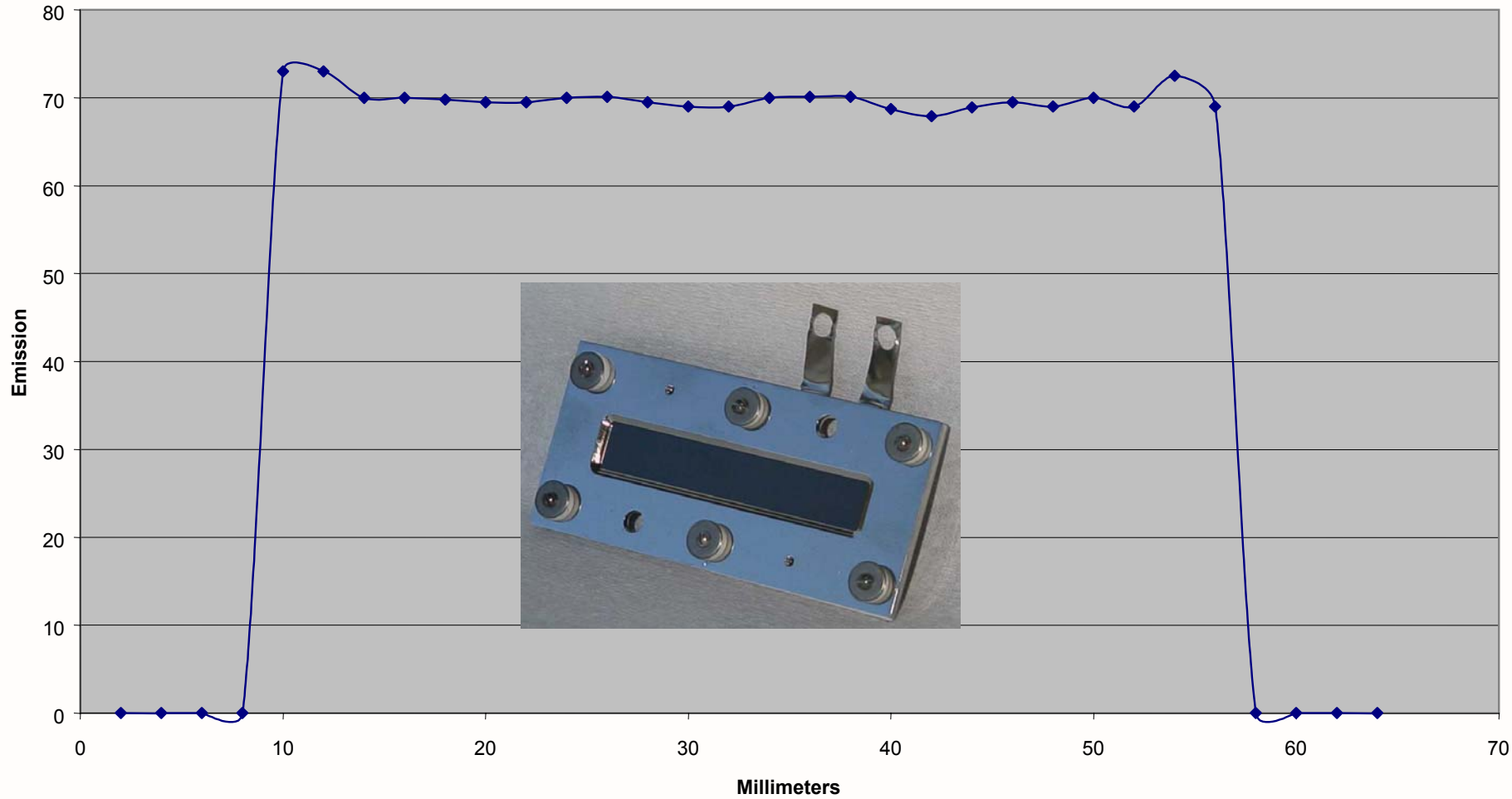
Emission Current 18mm Format

BURLE ELECTRO-OPTICS



Emission Uniformity and Beam Definition
50 X 8 mm Array, Z Configuration

BURLE ELECTRO-OPTICS



Conclusion

IPMs should be sensitive enough to see large halo effects with gold beams although a clear demonstration of this has not been observed yet.

Improvements in design which will be incorporated in the next RHIC IPMs and the SNS IPMs will increase signal/noise for protons.

a. Higher sweep field
b. Better background electron suppression
c. Accurate channel-channel calibration
d. Accurate sweep field will allow collecting electrons or ions