Radiation Damage Experience with SiPM & QIE Cards
Proton Cyclotron - Mass General Hospital
(& MIT Research Reactor)

Larry Sulak
with
Jim Freeman*, Sergey Los*, Julie Whitmore
FNAL
Ashley Rubinstein, Jason St. John
Boston

dry run: CMS lab at BU 10/4/09…for efficient setup and running

beam time: 8:30 am – 8:30 pm 10/5/09

available every Saturday and Sunday

* see their talks from Wednesday morning

230 MeV protons, max energy, 1 cm initial size

3" beam scattered to cover size of PC cards
- a contoured double scatterer gives uniform beam
- ~ 2% uniformity over the 3” flat region
- beam spot size drops to 5% at the edge

beam spreading method produces circular beam spot
- no reason to set electronics cards edge on see pix

"optical bench" of 4 SiPM cards, 2 QIE control cards, 2 Peltier coolers
- spread over ~60 cm along the beam line see pix

dosimetry at each end, 1% / cm drop in intensity
- with vacuumless Faraday cup and Keithley electrometer
- rotate optical bench 180° around twice to compensate for drop

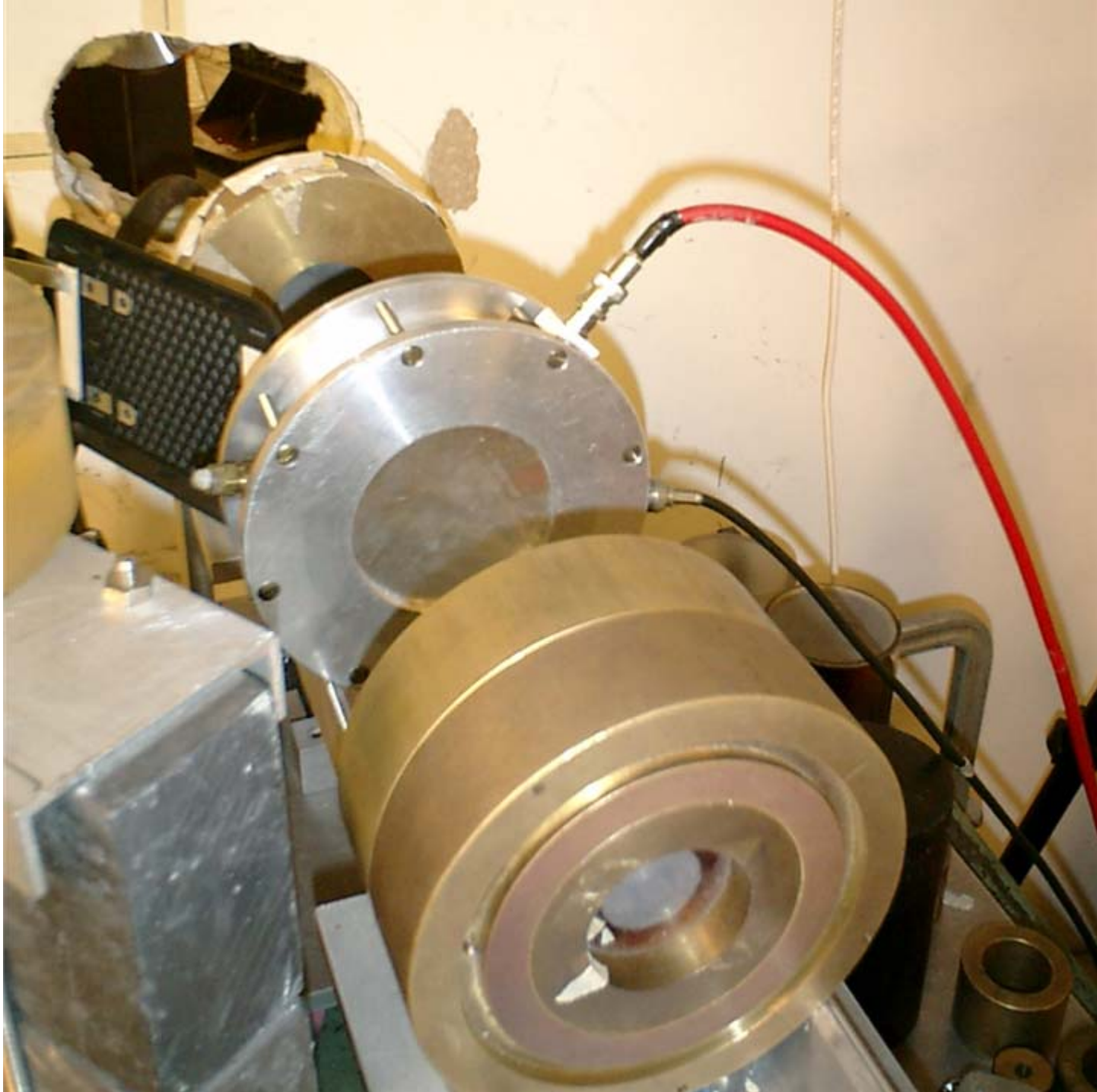
bias on SiPM, electronics clocked
- monitor signals on scope during run from outside
- lights off
- (previous run, full DAQ provided by Eric Hazen)

end of beam line:

contoured scatterers/ collimators

and

ionization counter




ADDISON-WESLEY
PUBLISHING COMPANY
Optical Bench

max intensity: 7 x 10^9 protons/cm^2/sec ~ 4 x 10^{11}/min ~ 2.5 x 10^{13}/hr = 1/3 Mrad/hr
1 centiGray = 1 Rad = 10^8 p/cm^2 @ 230 MeV

lower energies, to 100 MeV, at expense of flux, with little spread in energy

for our 3” diameter beam,

integrated fluences	beam on time since t=0	
5 x 10^{11} p/cm^2	5 min	
5 x 10^{12}	1 hr	no obvious problems
1 x 10^{13}	2 hr	bias V drops

remove sample after following each exposure

cool down at cyclotron ~5 days; MGH ships cool stuff back to you

electronics shop on-site for on-the-spot corrections

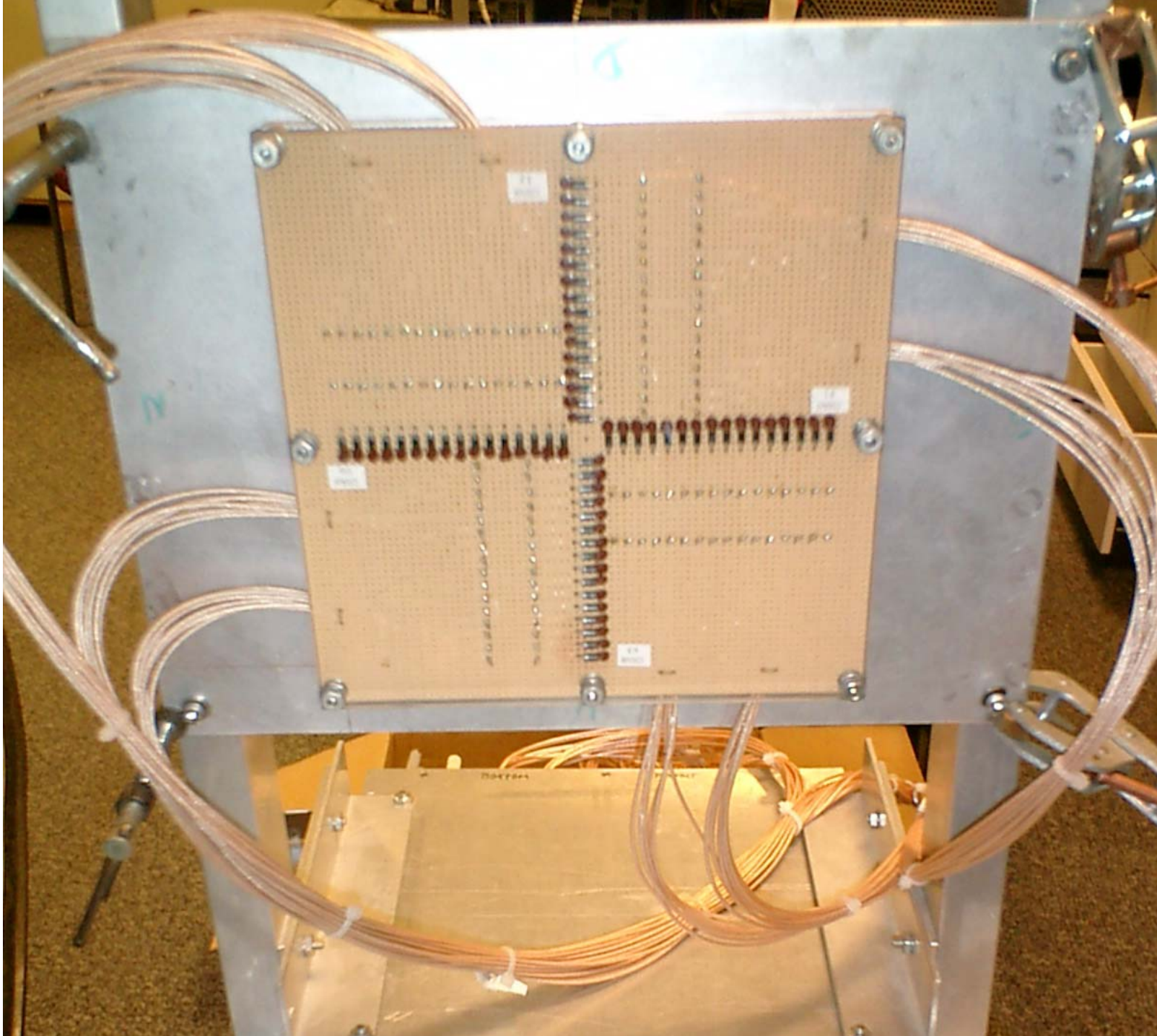
$4.8 k / 8 hr run

MGH Physicist Operator: Ethan Cascio, 617 724 9529

Reverse-Biased Diode Array

locates beam center

aligns optical bench



Lucite Beam Stop

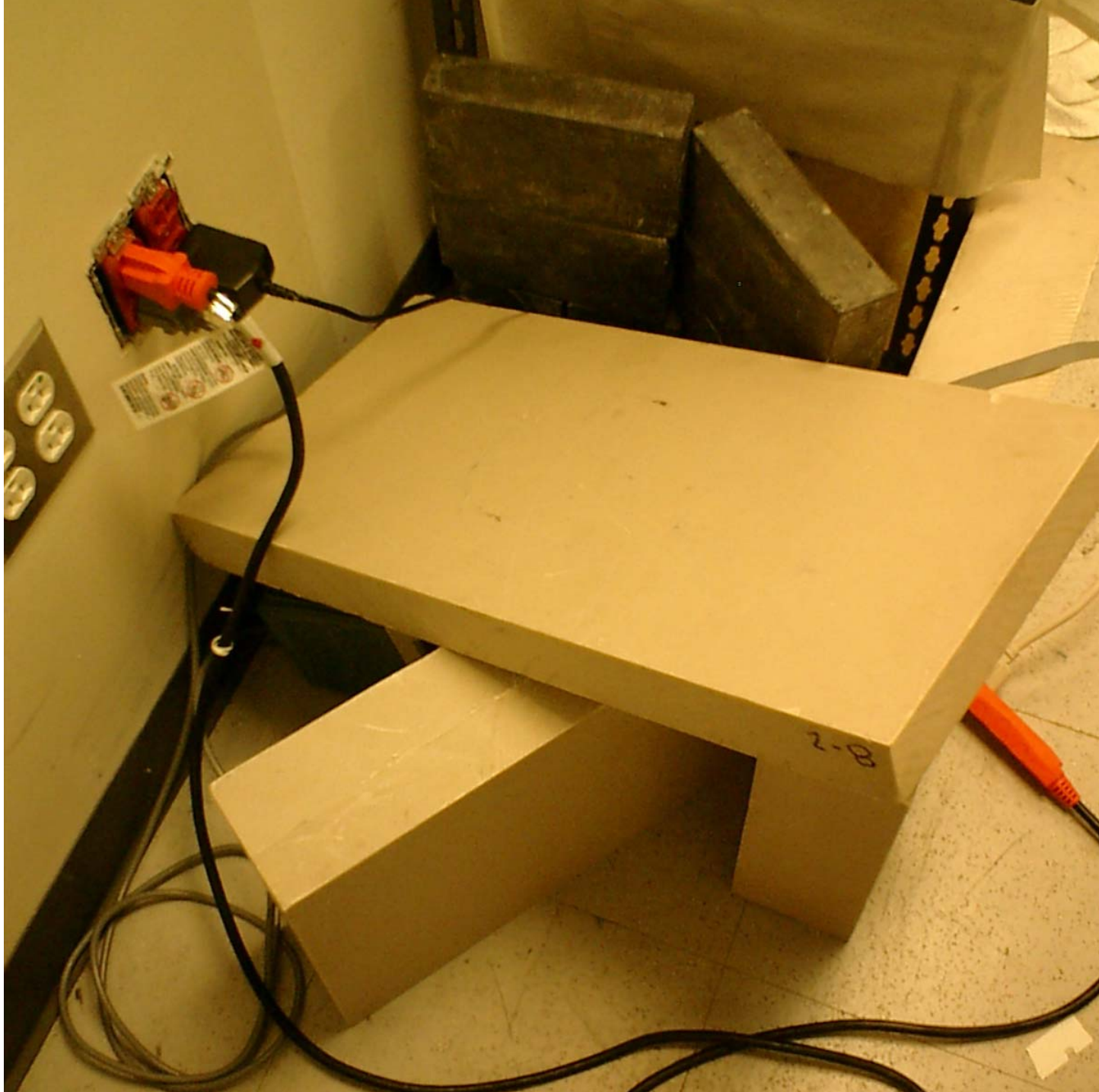
rad dam evident

Function Generator

Shielded from Neutrons

with

Borated Polyethylene



…40 m cable run

MIT RESEARCH REACTOR

operates at full 5 MW power 24 hours/day, 7 days/week

Neutron Flux Levels

Facility	Size	Thermal Neutron Flux ($n/cm^2/s$)
In-core Irradiation Facilities	Up to three available ~ 2” ID x 24”	3 x 10^{13}, (up to 1 x 10^{14} fast)
Medical Facilities:		
Fission Converter Beam	Variable beam aperture	Epithermal: 5 x 10^{9}
Thermal Neutron Beam	Variable beam aperture	up to 1 x 10^{10}
Ex-core Irradiation Facilities:		
Pneumatic Tubes	2” ID tube 1” ID tube	5 x 10^{13}, up to 4 x 10^{12} fast 8 x 10^{12}
Vertical Ports	3” ID x 24"	4 x 10^{12}
Beam Ports	12 horizontal: 4” to 12” ID	4 x 10^{12} - 8 x 10^{13} at source
Through Ports	4” Port 6” Port	5 x 10^{12} 1 x 10^{13}

Reactor Physicist: Tom Bork, 617 253 4211