Summary of Bubble Chamber Beam Test – Sept 2015

November 9, 2015

https://wiki.jlab.org/ciswiki/index.php/Bubble_Chamber

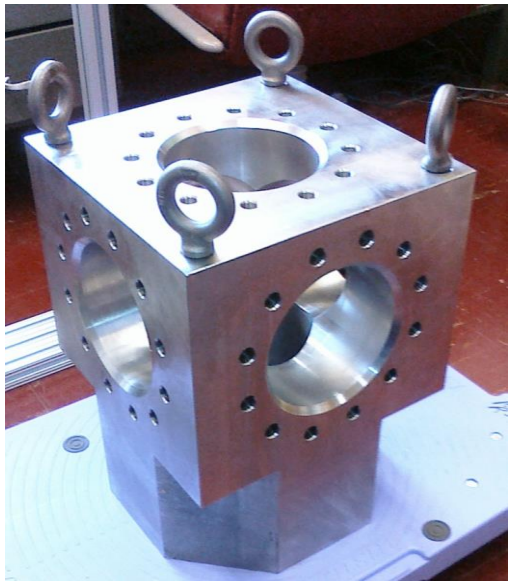
OUTLINE

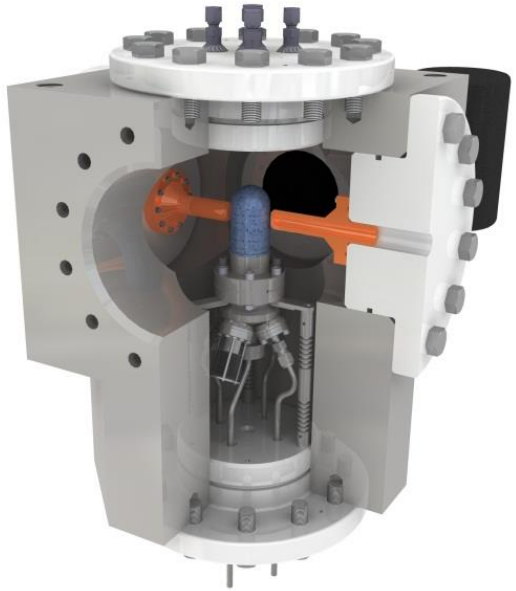
- Chronology
- No Beam Measurements
- Radiation Hitting Camera
- Measuring $^{18}O(\gamma,\alpha)^{14}C$
- Beam Energy and Position
- Summary and List of Improvements
- Progress since Sept Run
- Upcoming Beamline Plan
- Schedule

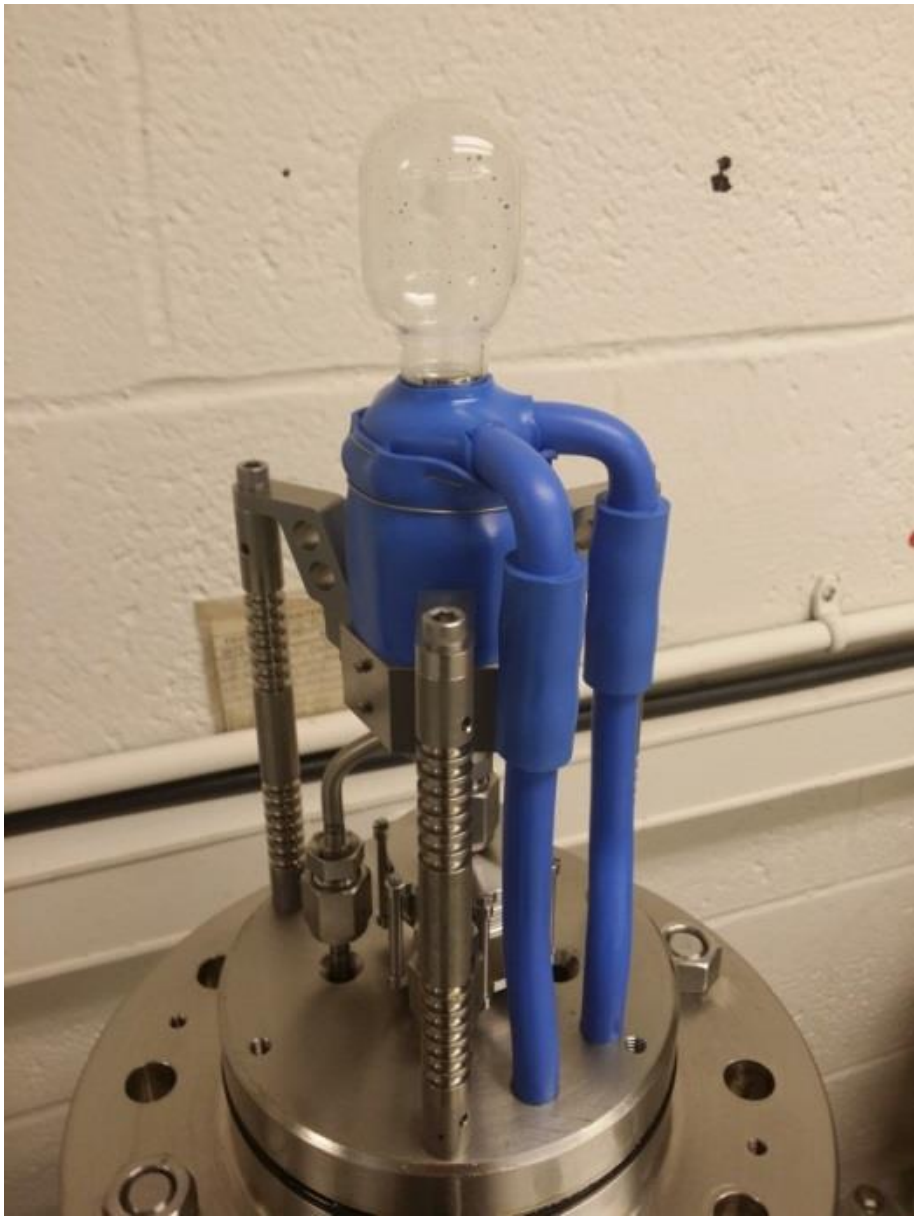
CHRONOLOGY

Aug 3 – 11	Chamber installed in Injector.
Sept 8	TOSP was approved.
Sept 8 – 10	Chamber filled with natural N_2O.
Sept 10	Speckles on camera with 0.4 μA.
Sept 11	Shielded camera. Took data at 7.7 MeV KE (0.4 μA, 30 nA) and 8.0 MeV KE (0.4 μA, 40 nA). Changed operational pressure from 325 psi to 300 psi and measured γ-p reaction on ^{14}N.
Sept 12	Pressure scan (300 – 325 psi) at 8.0 MeV KE and 35 nA. Beam position scan on to find maximum bubble rate with 0.4 μA and 320 psi. Tested camera with 10 μA on radiator - need more shielding.
Sept 13	Added more shielding but could not run at 10 μA (8.0 MeV KE). Changed to 6.5 MeV KE and collected data at 1.0 and 10 μA. Changed beam energy to 4.0 MeV KE and took data at 10 μA. Stopped due to ceramic vacuum leak.
Sept 14	Applied VacSeal to ceramic. Changed to 8.5 MeV KE and took data at 0.4 μA.
Sept 15	Replaced ceramic break with short steel spool. Noticed many events with no beam: about one every a few seconds coming from bottom of N_2O glass cell.
Sept 16	Refilled with fresh N_2O gas, background is less than 1 per minute. Took data at 8.2 MeV KE. Changed to 7.6 MeV KE. But found that background event rate was very high (1 every a few seconds).
Sept 17	Vented and refilled fresh gas, 1 background event every 30 seconds. Took data at 7.6 MeV KE and 1 μA. Background rate increased to about 1 every 5 seconds after 1 hour of beam time. Took another 30 minutes beam run followed by 30 minutes of background run. Now, one background event every 2 seconds. Bubble chamber September test is completed.

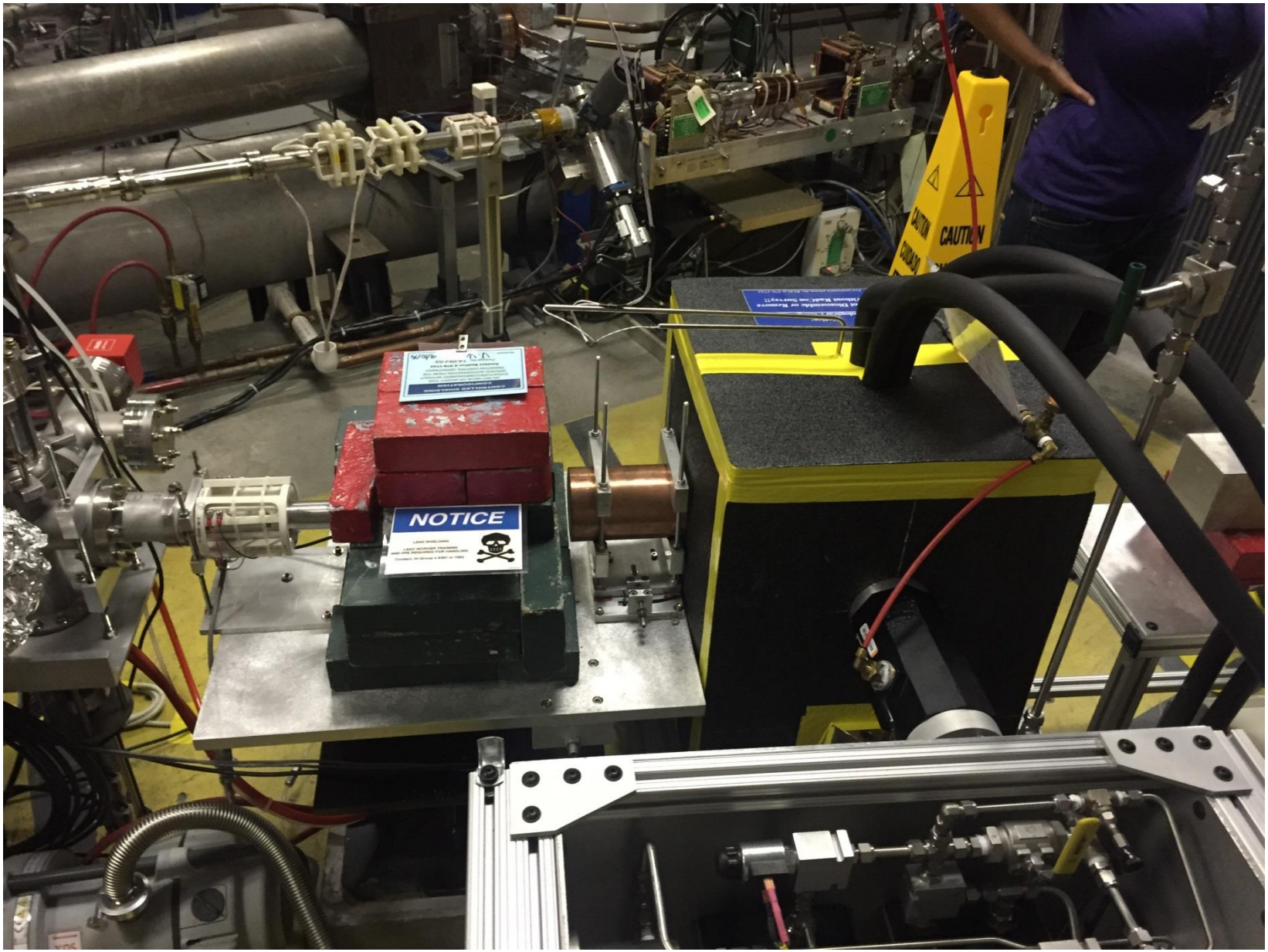
N_2O (Laughing Gas) Bubble Chamber







Chamber Installation in Injector



User Interface

LabVIEW processes images from 100 Hz digital camera

Filling Chamber with N_2O

https://drive.google.com/file/d/0B9ShTslvnOaCeFplbDU5NjZTSWs/view

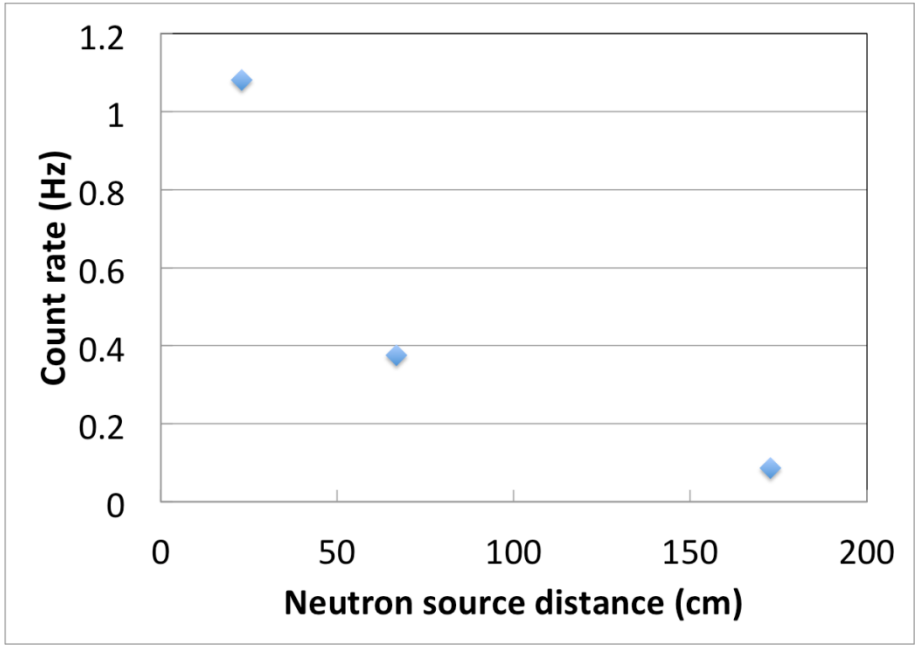
First Day of September Test

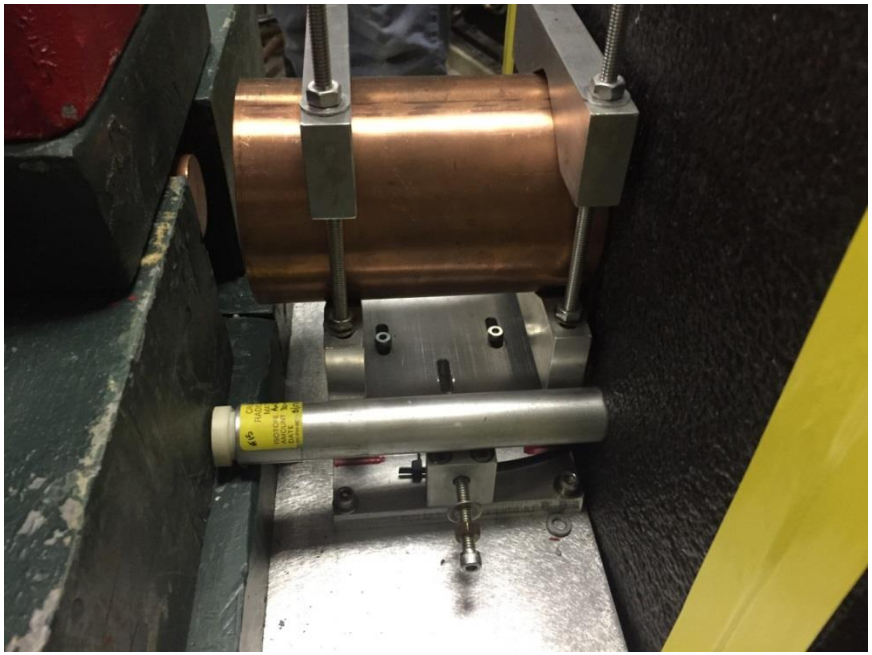
- Filled chamber with N_2O and reached stability in operating temperature:
  - T = -8˚C, P = 325 psi
  - For $^{14}N(\gamma,p)^{13}C$, P = 300 psi
  - Quenching (high) Pressure = 835 psi
  - Quenching Time = 5 sec

- Measured very low cosmic ray background of about 1 bubble per 8 minutes in JLab tunnel vs 1 – 2 bubbles per minute at Duke and Argonne
- Tested sensitivity with neutron source
- Produced 7.7 MeV electron beam on 6 mm Cu (5.4 g/cm^2) radiator/dump

Neutron Source Test

- Used Americium–Beryllium (α–n)neutron source ($^{241}Am^{9}Be$)
- Three distances (source on thermal insulator, 17 in, 59 in)
- Obtained expected drop in count rate

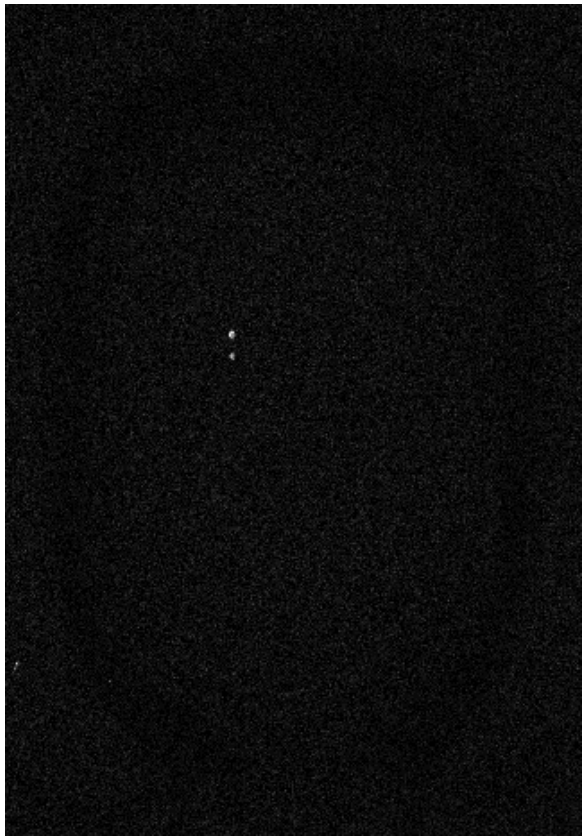




DATA TAKING

- Took data from Injector Service Building
- Brad will work with accelerator network personnel to be able to take data from MCC

First Photodisintegration Event with Bremsstrahlung Beam



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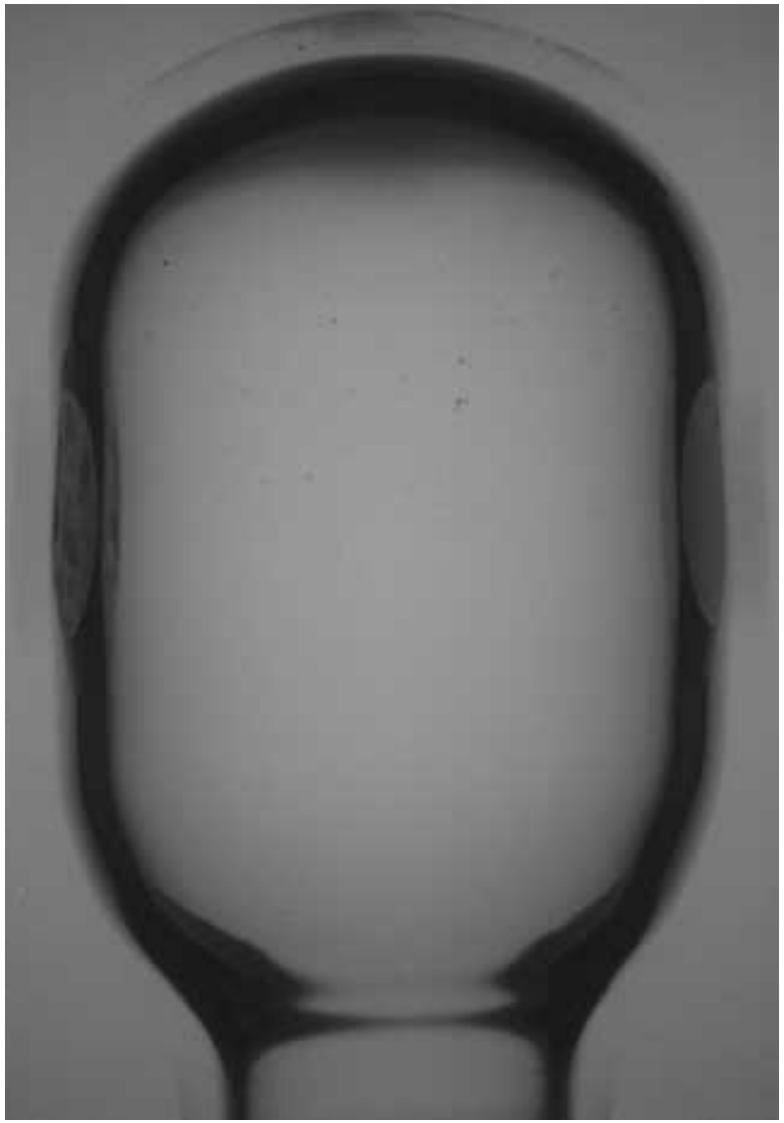
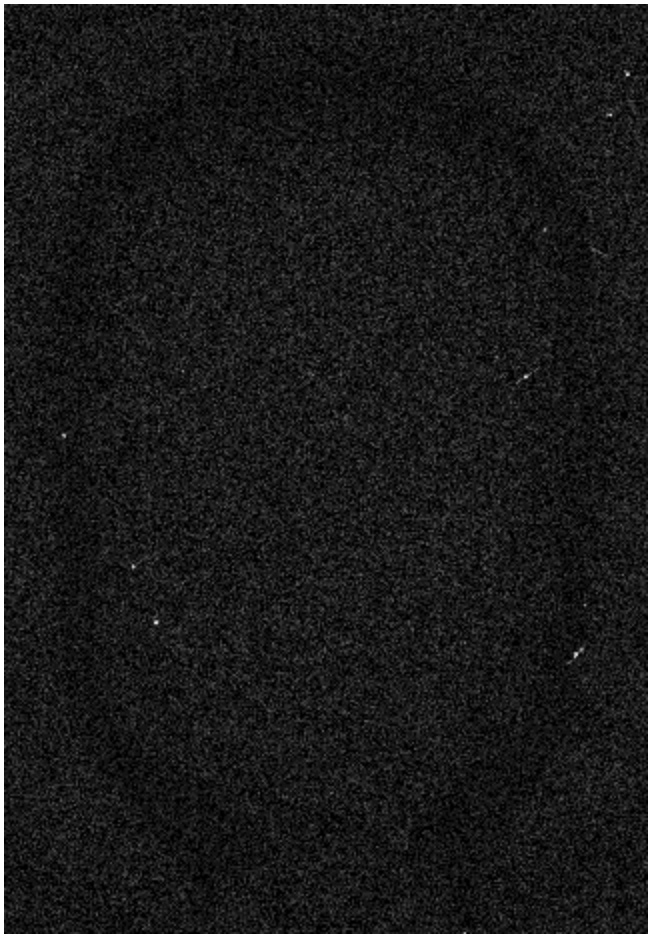
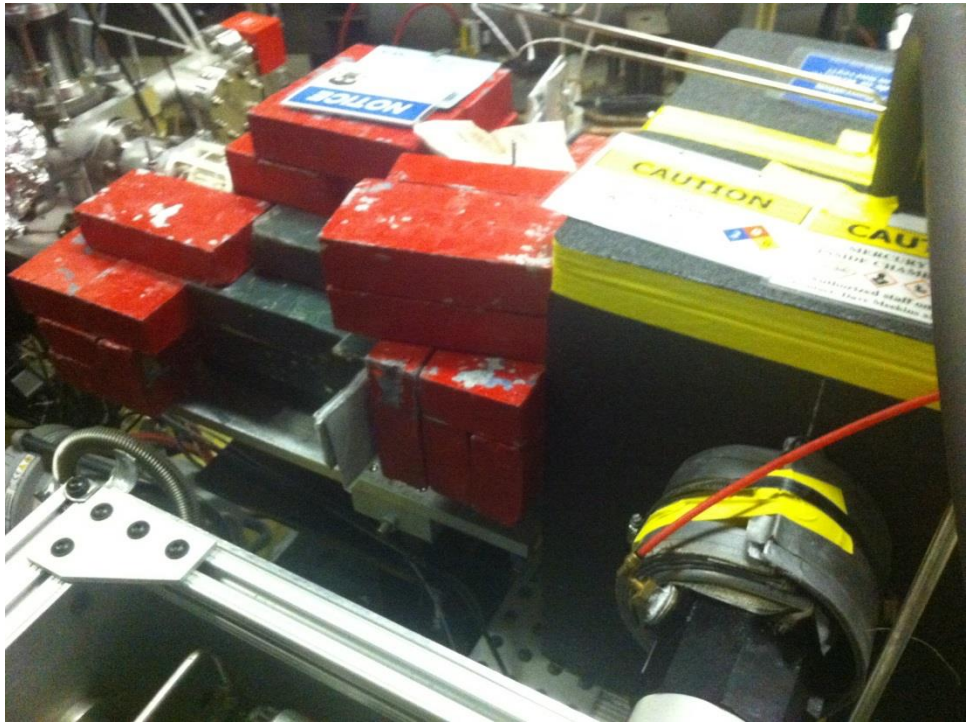


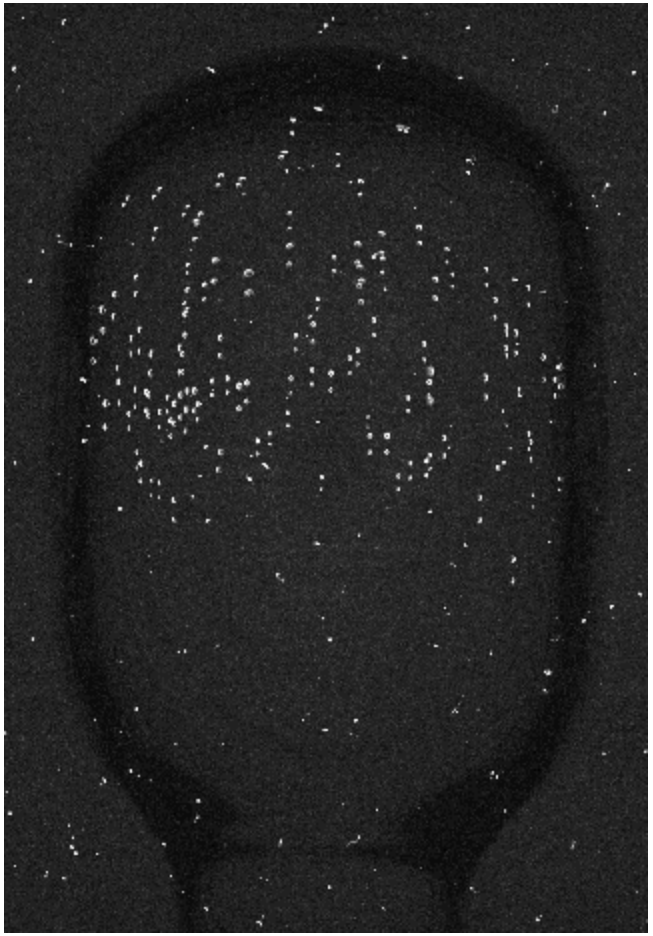
Radiation Hitting Camera

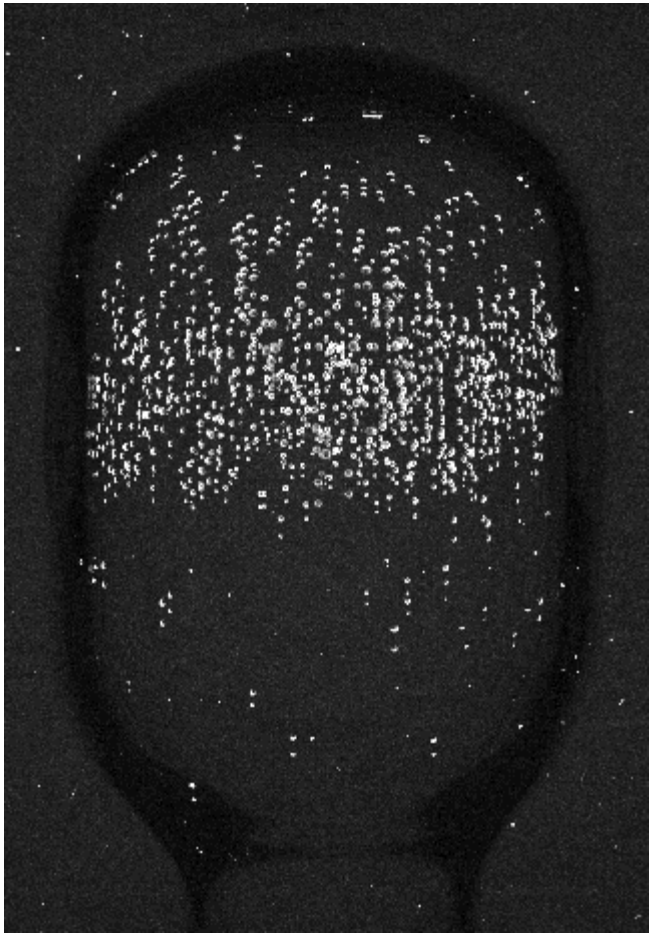
- Event trigger at with beam current at 0.4 μA
- Solution: shield camera





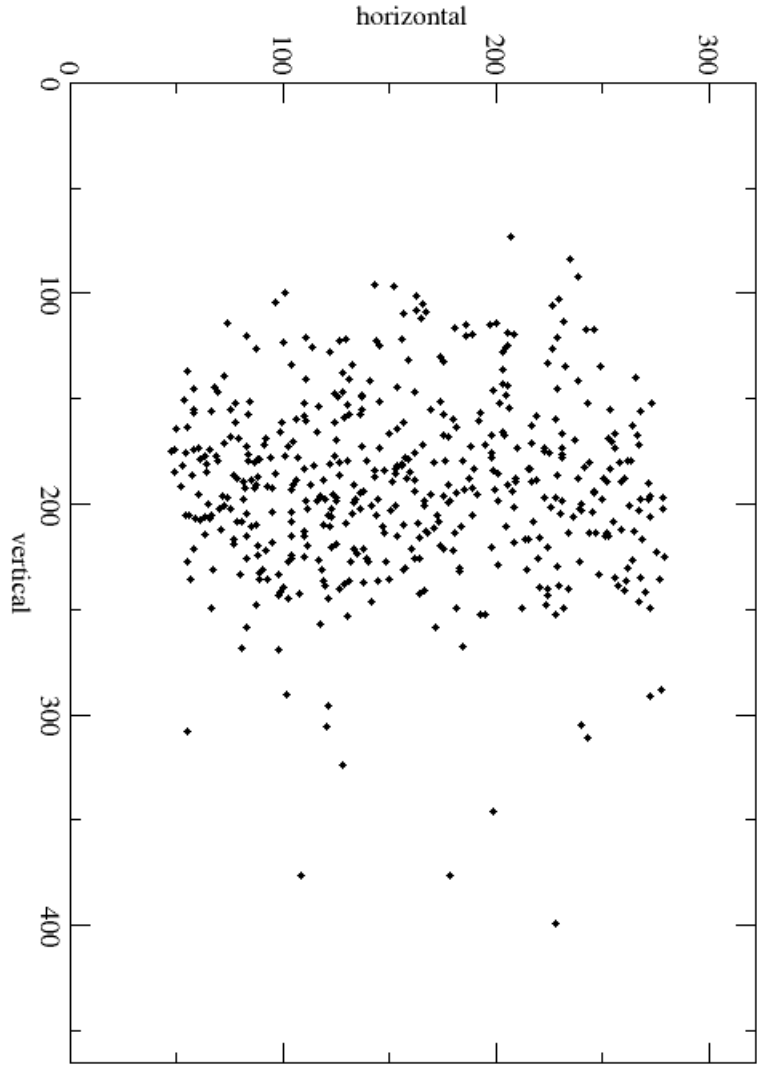
EVENTS IN FIDUCIAL VOLUME





Two beam energies

EVENTS IN FIDUCIAL VOLUME

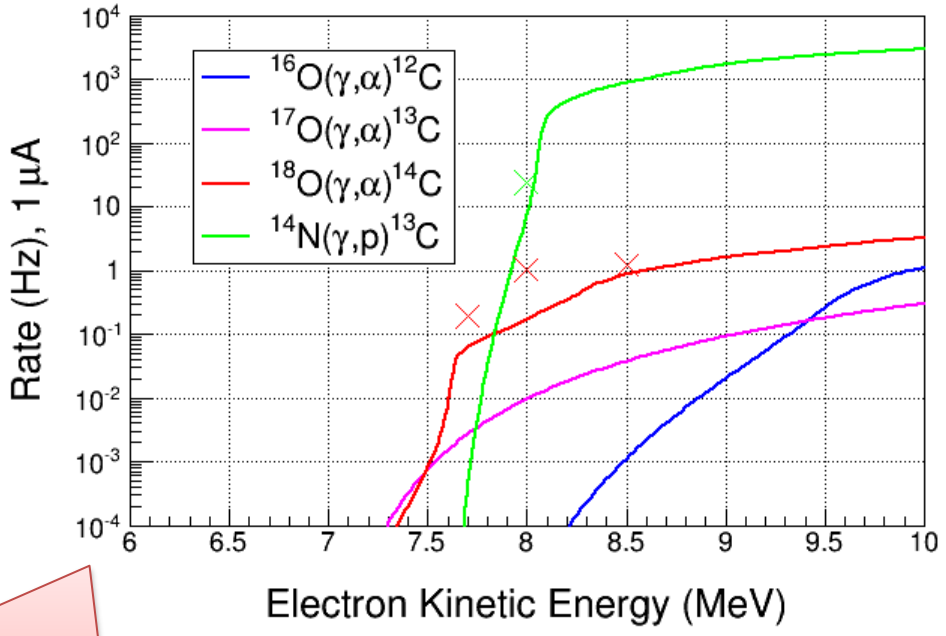


MEASURING $^{18}O(\gamma,\alpha)^{14}C$ RATE

- Measured event rate vs beam energy
- For natural N_2O, most events are γ-α from ^{18}O
- Measured rate from $^{14}N(\gamma,p)^{13}C$ with lower operational pressure

Experimental Rate = Number of bubbles in fiducial volume / (Time • Beam current (μA))

Time = Run time -
Number of bubbles • Quenching time



Predicted rate uses very rough estimate of γ-flux

Beam Energy Measurements

- As of now, beam energies used during Sept test could be off by few percent

- Beam energies used during test:

Set Kinetic Energy (MeV)	Measured Kinetic Energy (MeV)
4.0	? ± ?
6.5	? ± ?
7.6	? ± ?
7.7	? ± ?
8.0	? ± ?
8.2	? ± ?
8.5	? ± ?

Use GEANT4 to simulate Bremsstrahlung flux at these energies – find N_γ

Radiator and Collimator Survey

- What was radiator, collimator and chamber z-position during Sept test?

Beam Energy	Radiator	Collimator	Chamber
7.7, 8.0, 6.5, 4.0			
8.5, 8.2, 7.6			

Beam Position Measurements

- What was beam position on radiator during test?

GEANT4 SIMULATION

- We will use GEant4 Monte Carlo (gemc)
- Maurizio Ungaro is now a collaborator
- Will start with building geometry

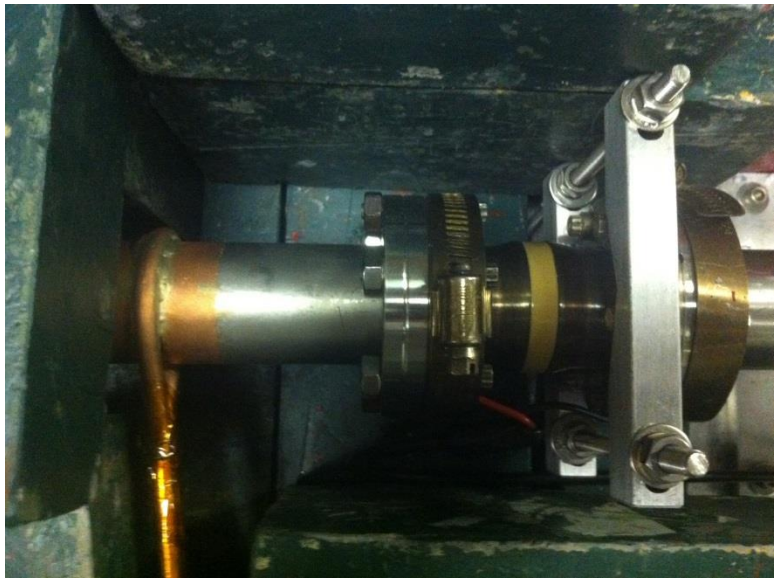
Summary (By Ernst)

Plus

- Chamber operated as expected in Bremsstrahlung beam
- Will be able to measure chamber insensitivity to gammas – we had a high intensity gamma flux on chamber
- Measured $^{18}O(\gamma,\alpha)^{14}C$ cross section at five energies
- Found sensitivity as expected to $^{14}N(\gamma,p)^{13}C$ when lowering operational pressure
- Cosmic background of about 1 bubble per 8 minutes in JLab tunnel vs 1 – 2 bubbles per minute at Duke or Argonne

Minus

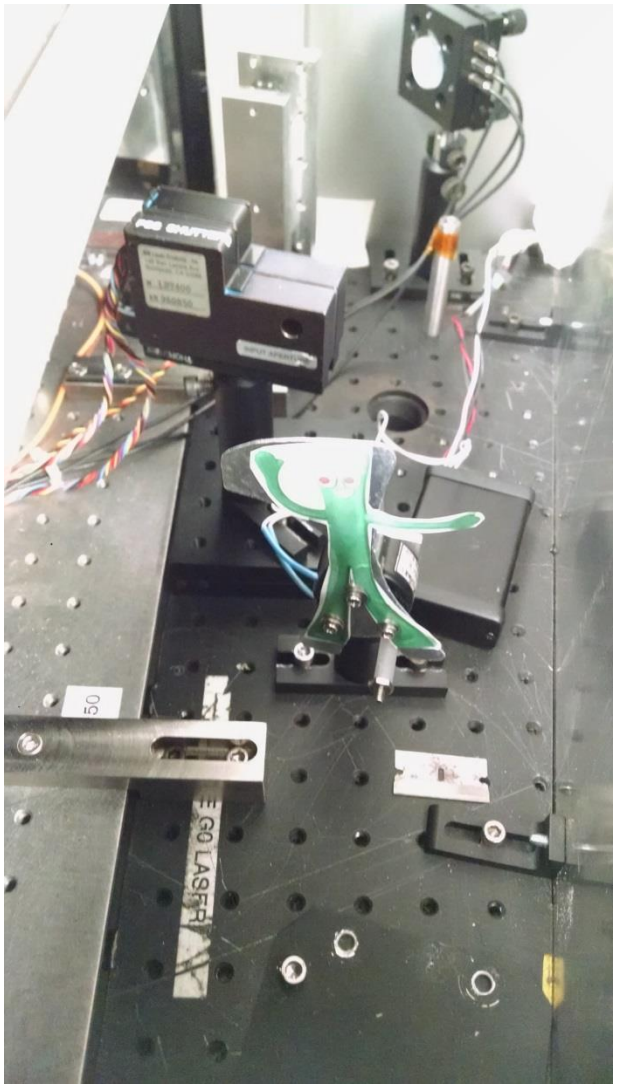
- Chemistry of mercury – why background rate changed by end of test
- Events distribution shows a cone instead of a cylinder – why? show plot
- Ceramic break failed
- Beam position on radiator
- Better alignment



List of Improvement

I. **Easy**
- Better light coverage
- Increase cooling capacity
- Introduce a lens to locate camera farther and for better shielding of gammas (camera was sensitive to gammas)
- Improve operational pressure control and regulation
- Be able to take data from MCC instead of Injector Service Building
- LabVIEW control of Gumby Laser Shutter (to stop beam during quenching time)

II. **Tough**
- One fluid system – no more mercury
- New collimator in chamber

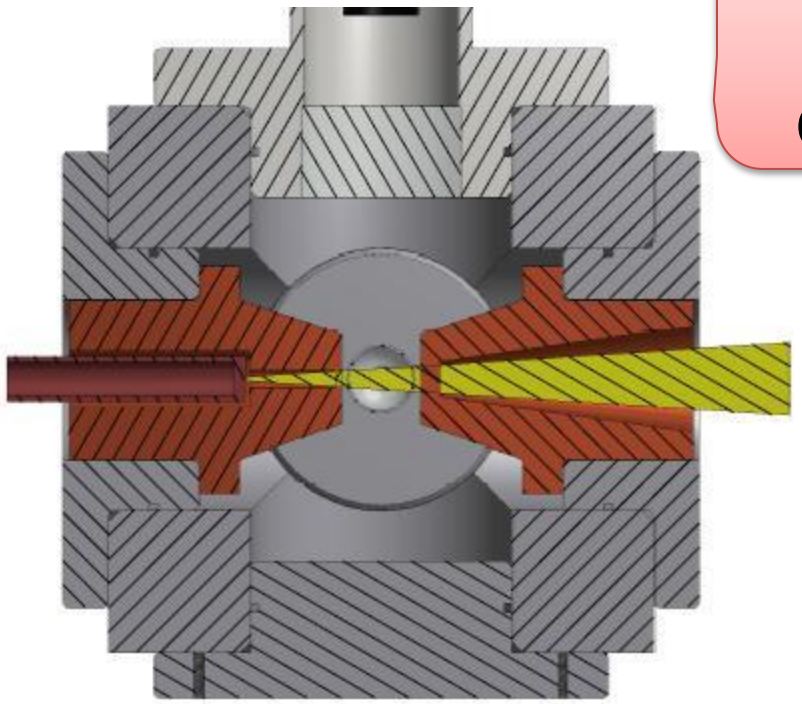


PROPOSED NEW COLLIMATOR

Advantages (Roy's idea):

1. Simple estimation of Bremsstrahlung flux
2. Lower beam currents: Maximum Bremsstrahlung flux per electron, likely a factor of 10 more flux per electron than we have now
3. Less shielding required since we would run lower beam currents
4. Far less sensitivity to electron beam alignment and centering
5. Made of silver instead of copper

What radiator thickness has better accuracy in GEANT4 (thick or thin)? How it affects Bremsstrahlung flux end-point? What about a thin radiator with sweep magnet?



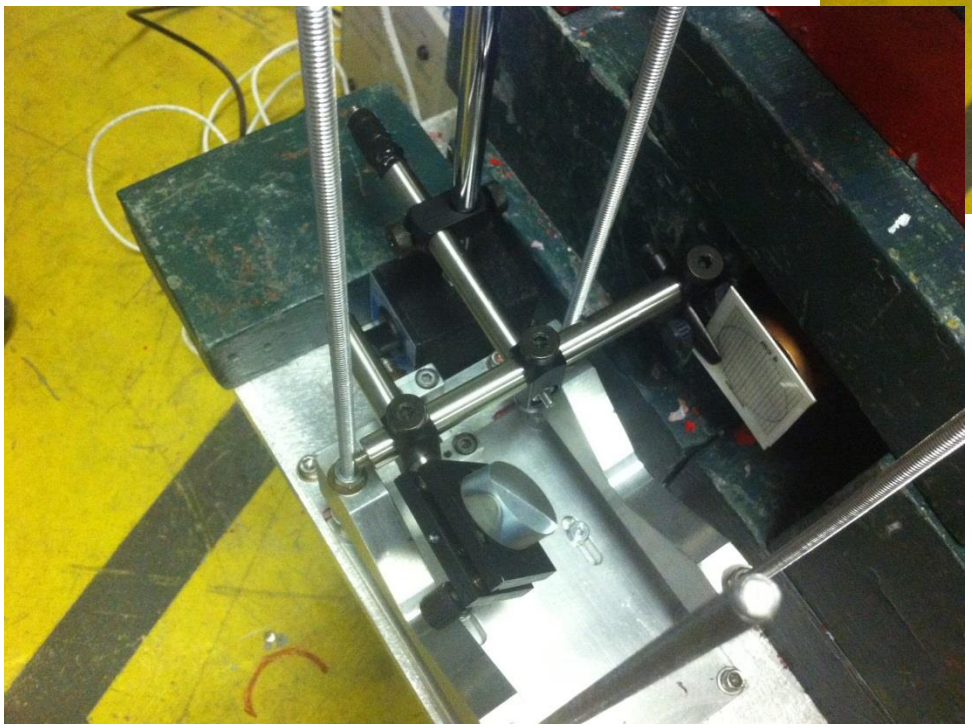
Must study in GEANT4

Progress since Sept Run

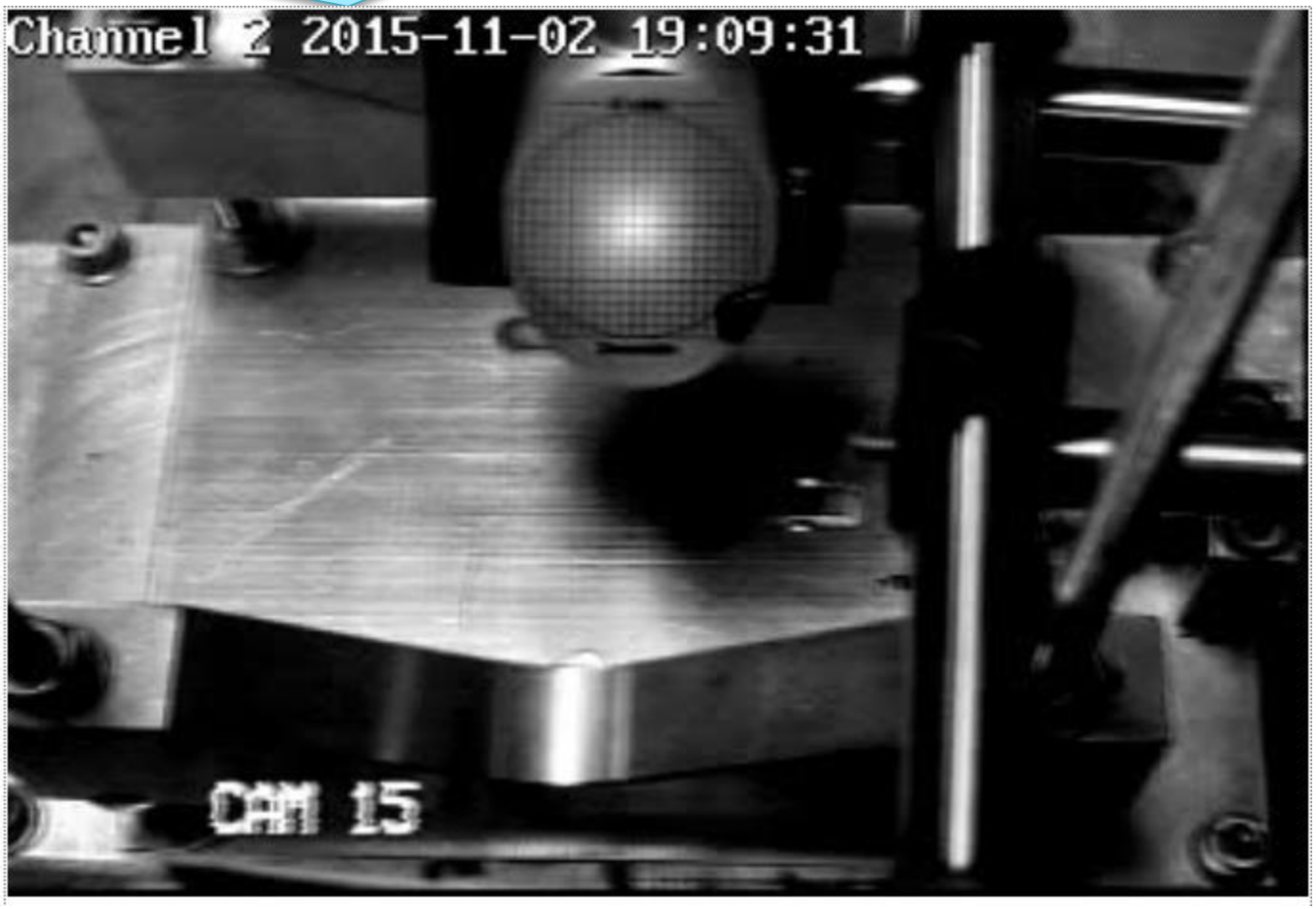
- Covered about 80% of 2D spectrometer line with steel sheet to shield earth's magnetic field
- Calibrated ¼ cryounit gradients using 2D line
- Added mu-metal to 5D line – plan to add steel sheet in Jan 2016
- Grames developed a procedure to set and measure beam energy
- Measured beam position on radiator

X-RAY FLUORESCENT SCREEN

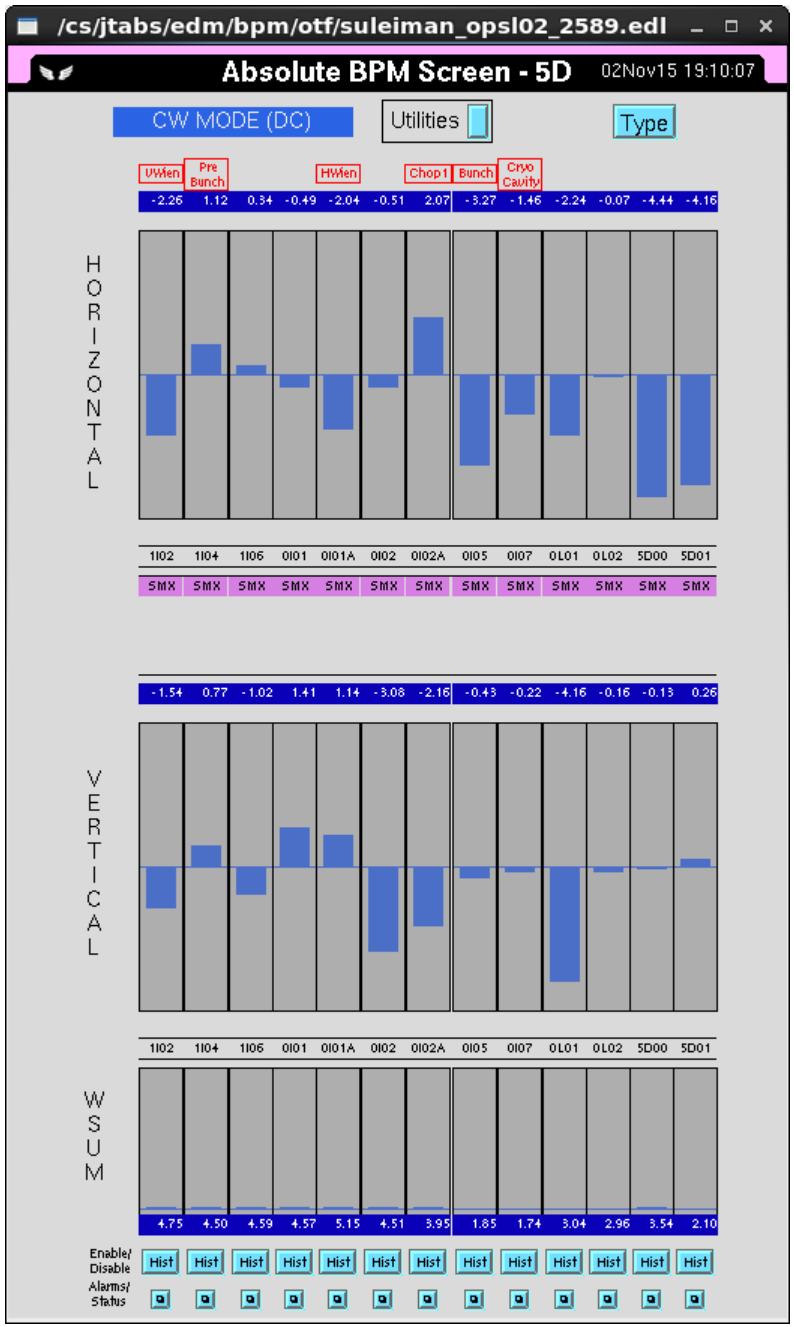
- x-ray fluorescent screen was installed in front of radiator on Nov 2, 2015
- This screen has a special coating that illuminates under x-rays and emits a green light



0.5 µA centered on x-ray screen



Need to develop procedure to center beam on radiator using 5D line BPMs and viewers for different beam energies while accounting for earth's magnetic field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Absolute BPM Screen - 5D
02Nov15 19:10:07
CW MODE (DC)
Utilities
Type
UWien
Pre Bunch
HWien
Chop1
Bunch
Cryo Cavity
-2.26 1.12 0.34 -0.49 -2.04 -0.51 2.07 -3.27 -1.46 -2.24 -0.07 -4.44 -4.16
HORIZONTAL
1I02 1I04 1I06 0I01 0I01A 0I02 0I02A 0I05 0I07 0L01 0L02 5D00 5D01
SMX SMX SMX SMX SMX SMX SMX SMX SMX SMX SMX SMX SMX
-1.54 0.77 -1.02 1.41 1.14 -3.08 -2.16 -0.43 -0.22 -4.16 -0.16 -0.13 0.26
VERTICAL
1I02 1I04 1I06 0I01 0I01A 0I02 0I02A 0I05 0I07 0L01 0L02 5D00 5D01
WSUM
4.75 4.50 4.59 4.57 5.15 4.51 3.95 1.85 1.74 3.04 2.96 3.54 2.10
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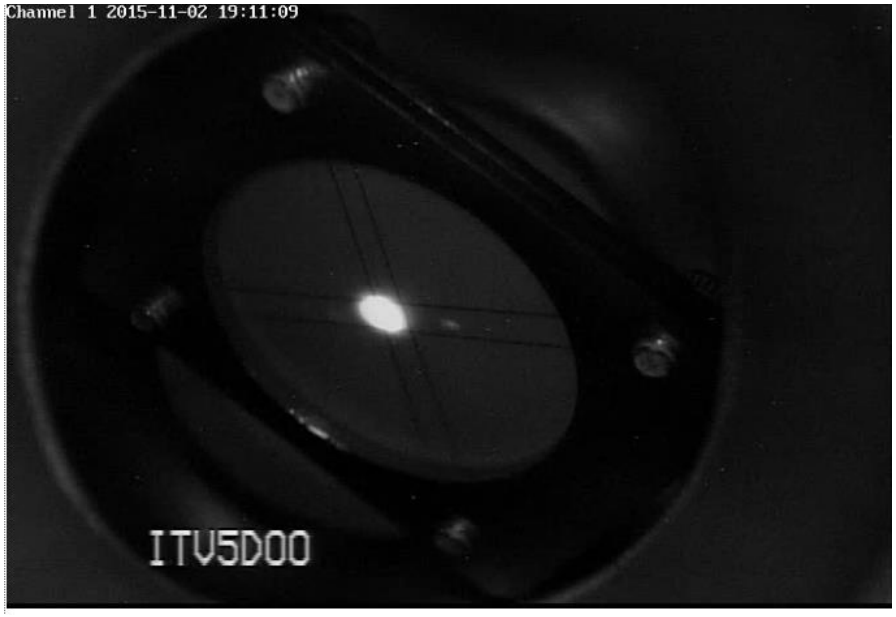
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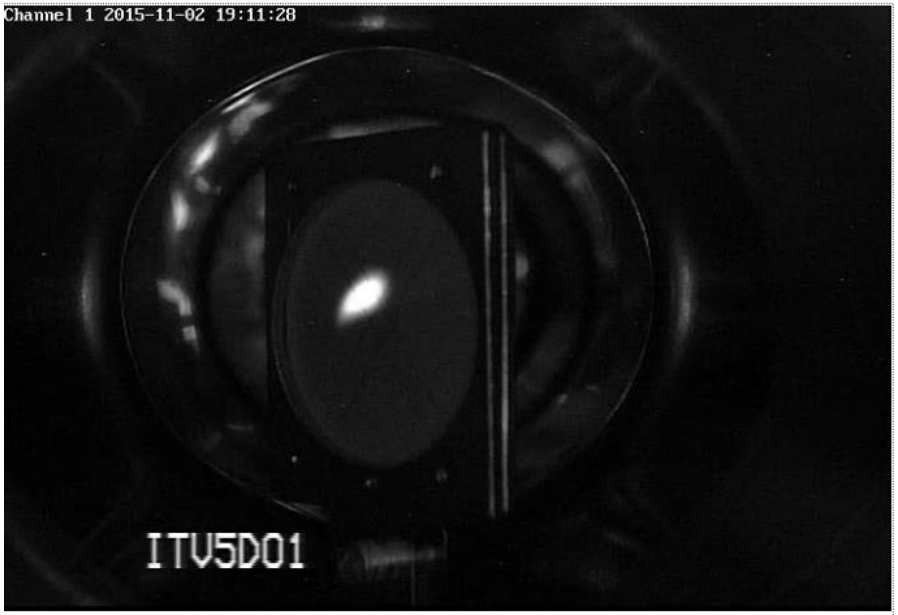
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Upcoming Beamline Plan

- Approved to run 10 µA CW and total energy of 10 MeV – redoing realistic thermal analysis to run at 100 µA (if needed?)

- Calibrate BCM and measure nA beam currents (how much low? new chamber collimator will require very low currents
- Re-isolate radiator to measure beam current?
- Survey 5D line (radiator and collimator)
- Replace lead shielding with copper and iron bricks
- Test the bubble chamber Gumby laser shutter

SCHEDULE

- Chamber was removed and shipped back to Argonne on Nov 2, 2015 for improvements
- Beam Schedule in 2016:
  I. Test Run II: May 30 – June 20
  II. Test Run III: Aug 15 – Aug 29

Injector Facility Development Time

Expectation of PAC days in FY2017
(i.e., no more test runs)

- Targets:
  I. C_2F_6
  II. Natural N_2O
  III. N_2O with enriched ^{18}O (?)

BACKUP SLIDES

To-Do-List

1. Gamma angular distribution (send to Roy)
2. Ask for Survey of beamline
3. Find old ceramic
4. Collimator position and dimensions (send to Roy)
5. Update JTabs screen