

Summary of Bubble Chamber Beam Test – Sept 2015

November 9, 2015

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

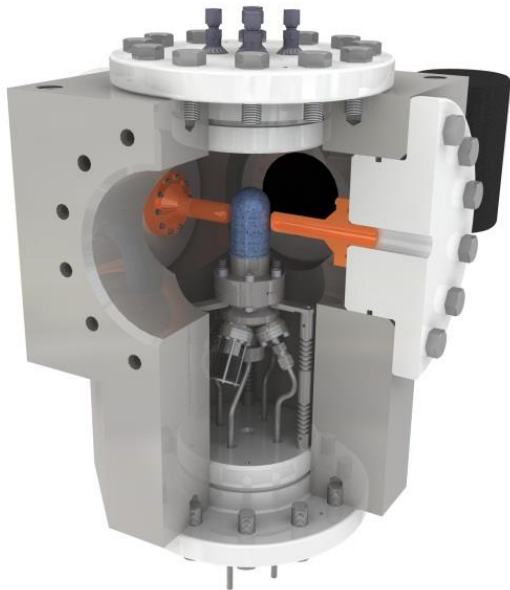
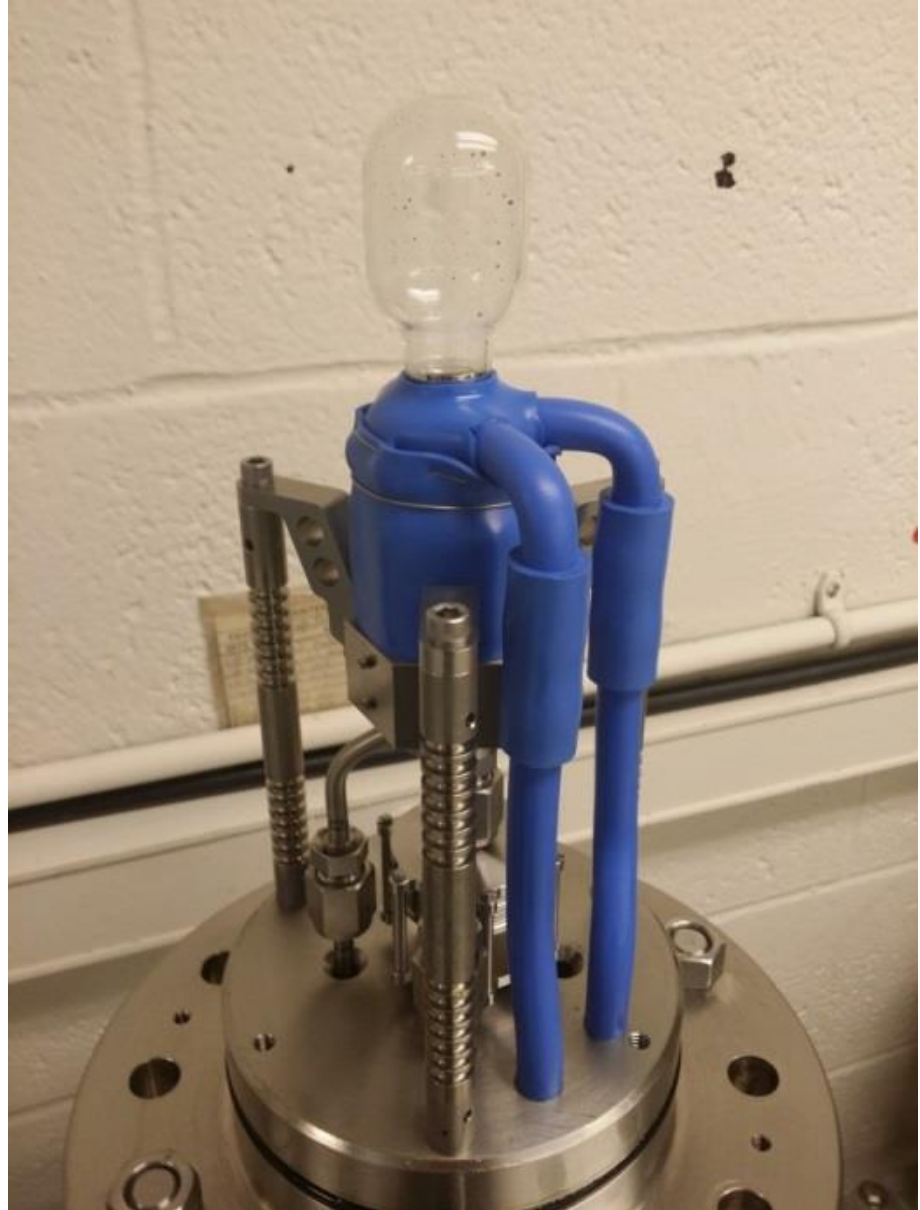
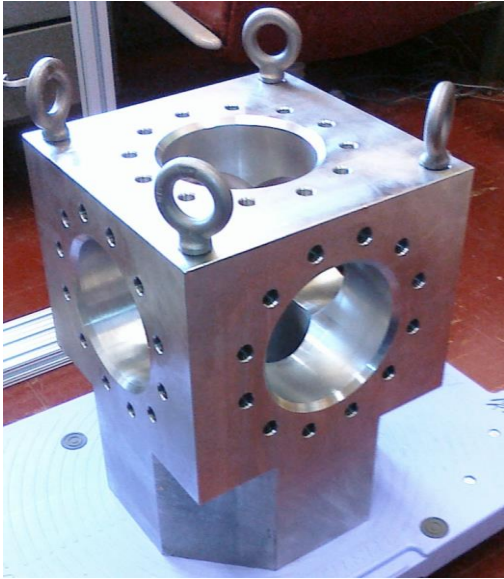
OUTLINE

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

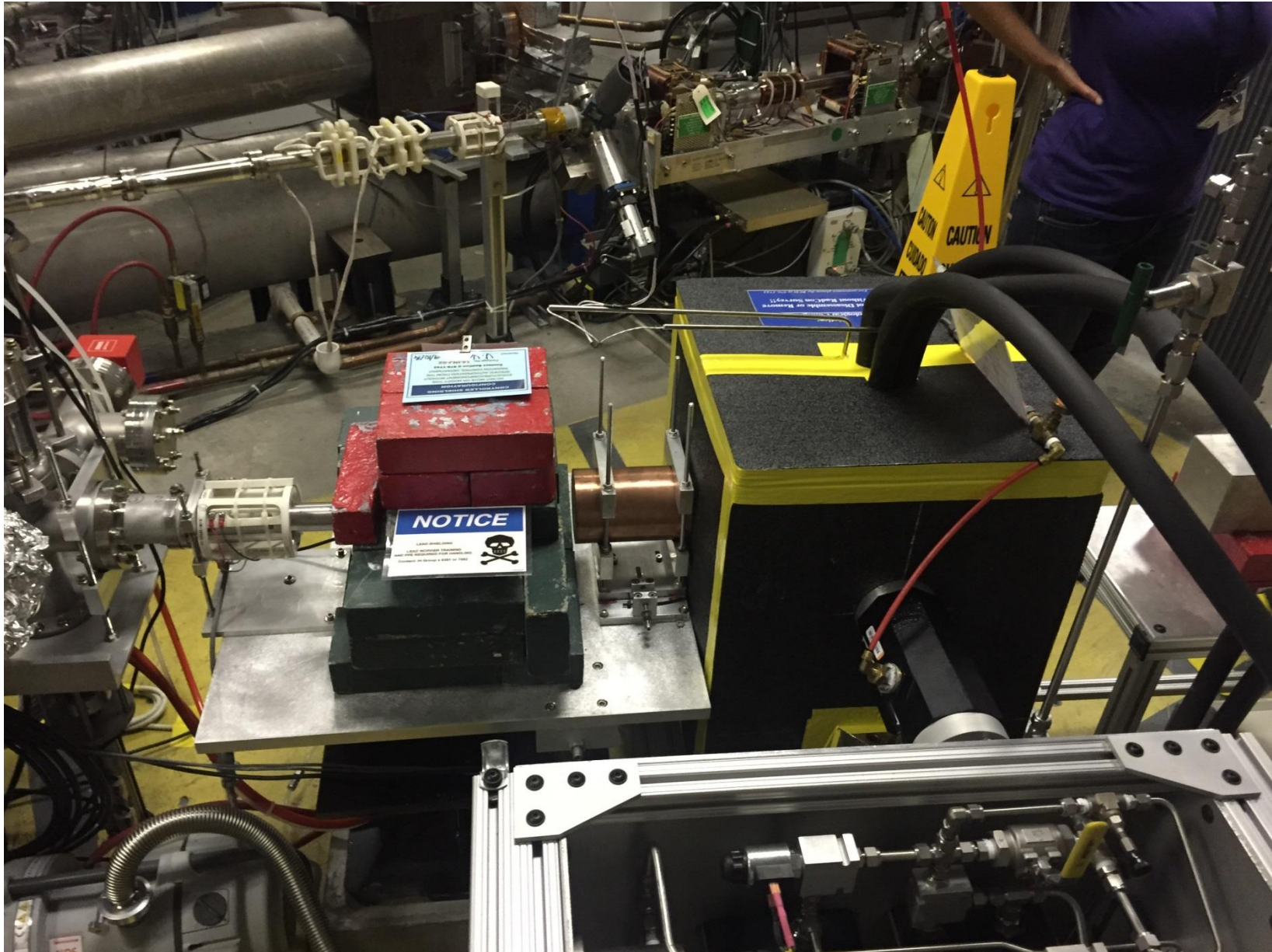
CHRONOLOGY

Aug 3 – 11	Chamber installed in Injector.
Sept 8	TOSP was approved.
Sept 8 – 10	Chamber filled with N ₂ O.
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. Changed to 8.5 MeV KE and took data at 0.4 μA.
Sept 15	Replaced ceramic break. Noticed many events with no beam: about one every a few seconds coming from bottom of N ₂ O glass cell.
Sept 16	Refilled with fresh N ₂ O 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

FILLING CHAMBER WITH N₂O

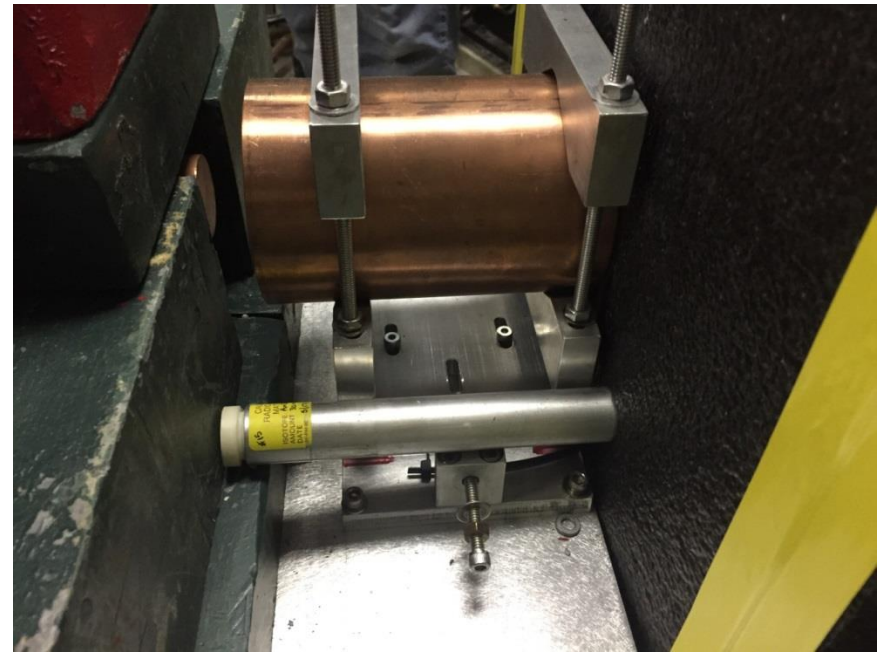
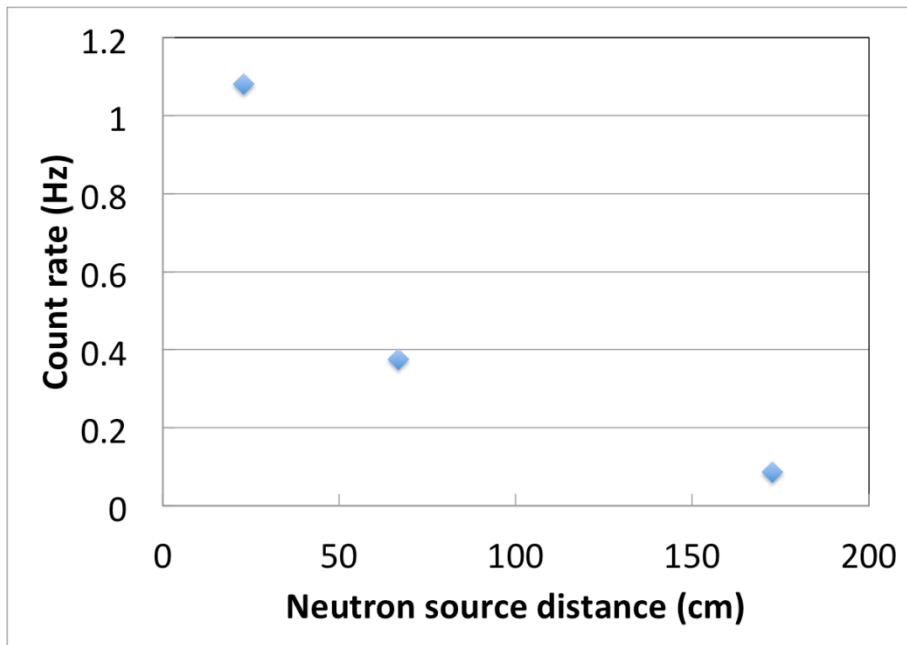
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FIRST DAY OF SEPTEMBER TEST

- Filled chamber with N₂O. Reached stability in operating temperature:
 - T = -8°C, P = 325 psi
 - For ¹⁴N(γ,p)¹³C, P = 300 psi
 - Quenching (high) Pressure = 835 psi
- Measured very low cosmic ray background of about 1 bubble per 8 minutes in JLab tunnel vs 1 – 2 bubbles per minute at Duke or Argonne
- Tested sensitivity with neutron source
- Produced 7.7 MeV electron beam on 6 mm Cu radiator

NEUTRON SOURCE TEST

- Used Americium–Beryllium (α -n)neutron source ($^{241}\text{Am}^9\text{Be}$)
- Three distances(source on thermal insulator, 17.3 in, 59 in)
- Obtained expected drop in count rate



DATA TAKING

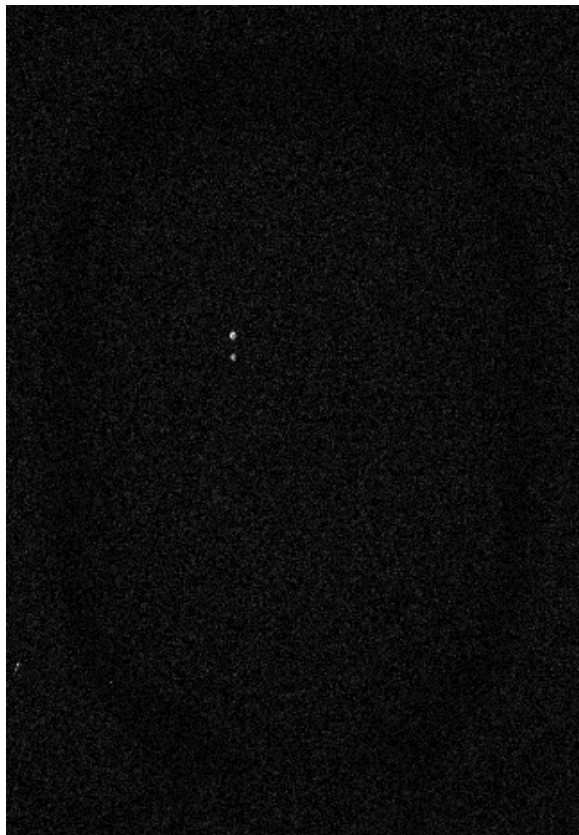
- Took data from Injector Service Building
- Brad will work with accelerator network personnel to be able to take data from MCC



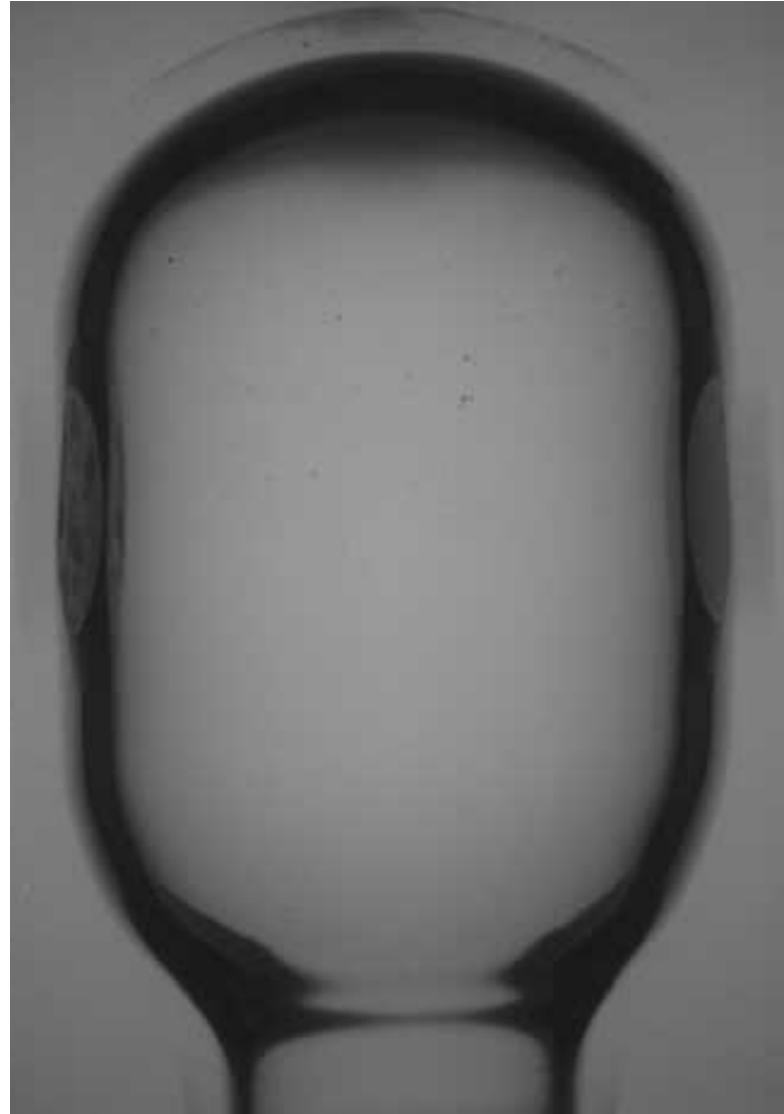
FIRST PHOTODISINTEGRATION EVENT WITH BREMSSTRAHLUNG BEAM

 **Jefferson Lab**


Argonne
NATIONAL
LABORATORY

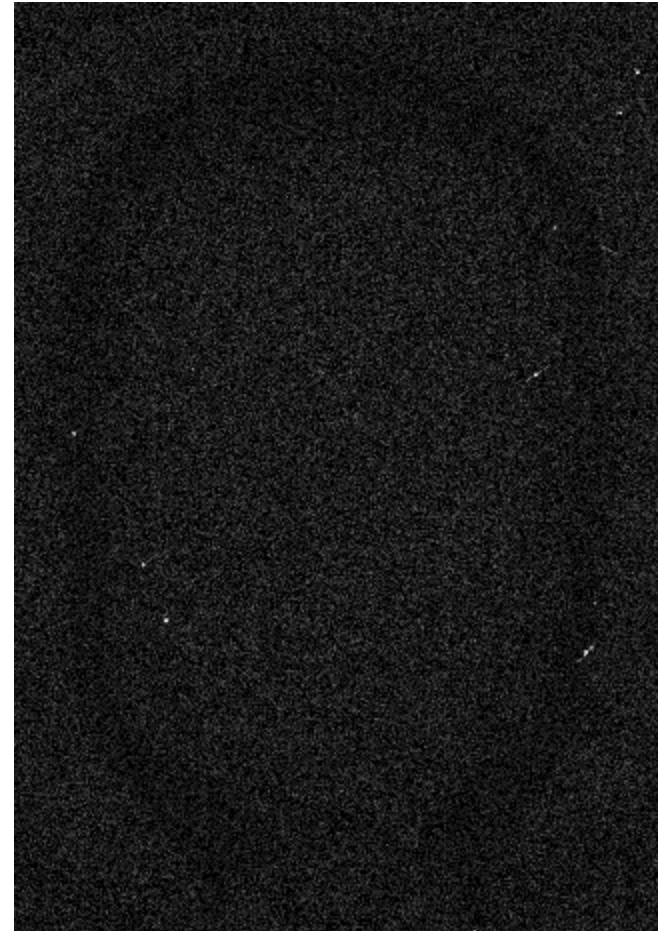
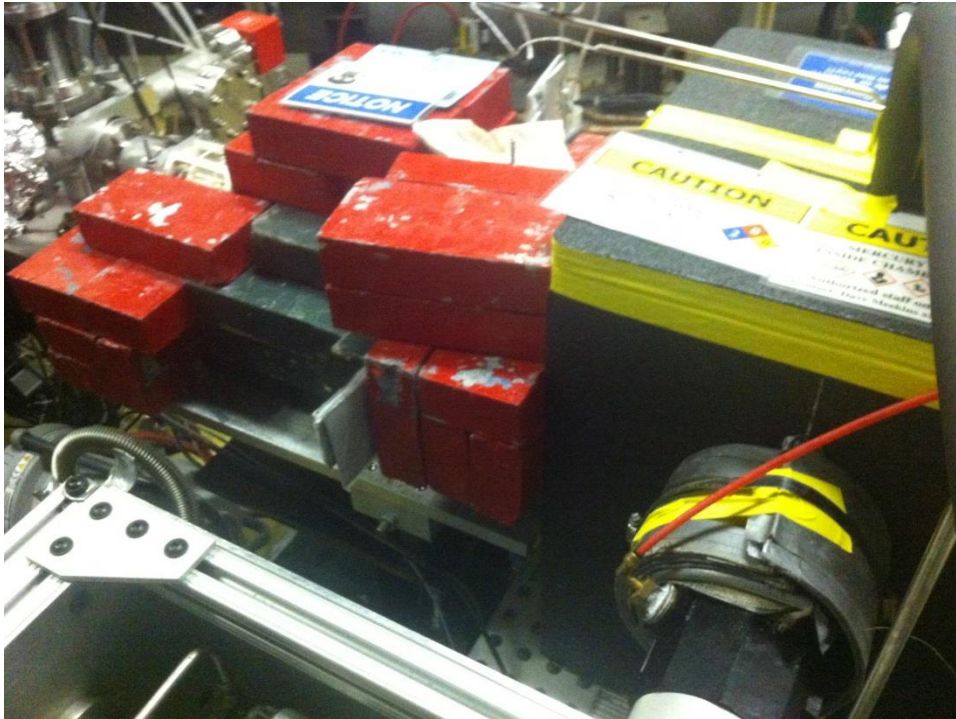


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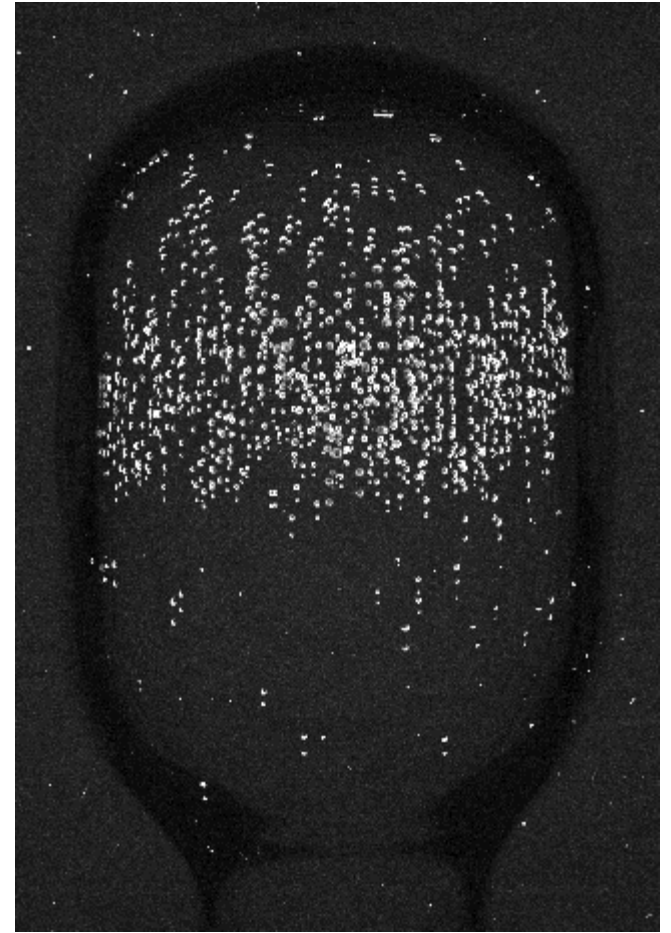
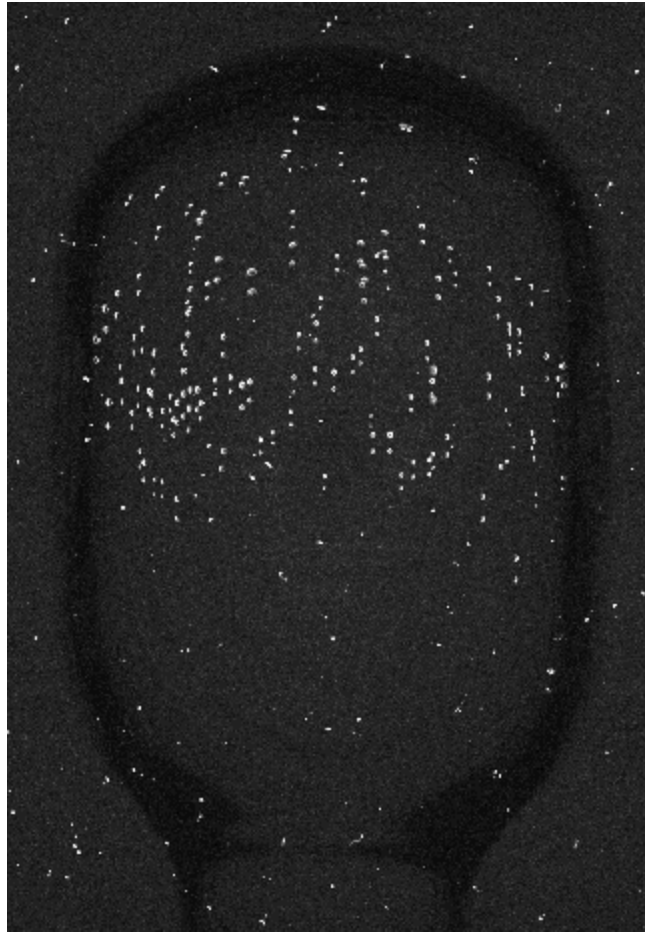


RADIATION HITTING CAMERA

- Event trigger at with beam current at $0.4 \mu\text{A}$
- Solution: shield camera

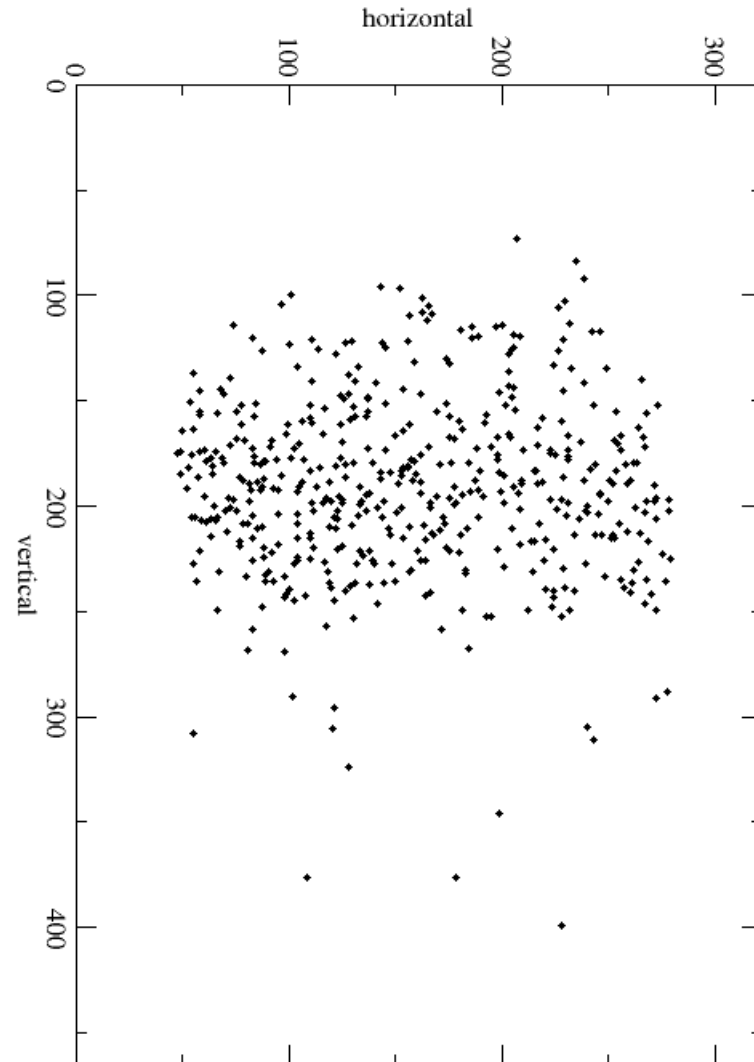


EVENTS IN FIDUCIAL VOLUME



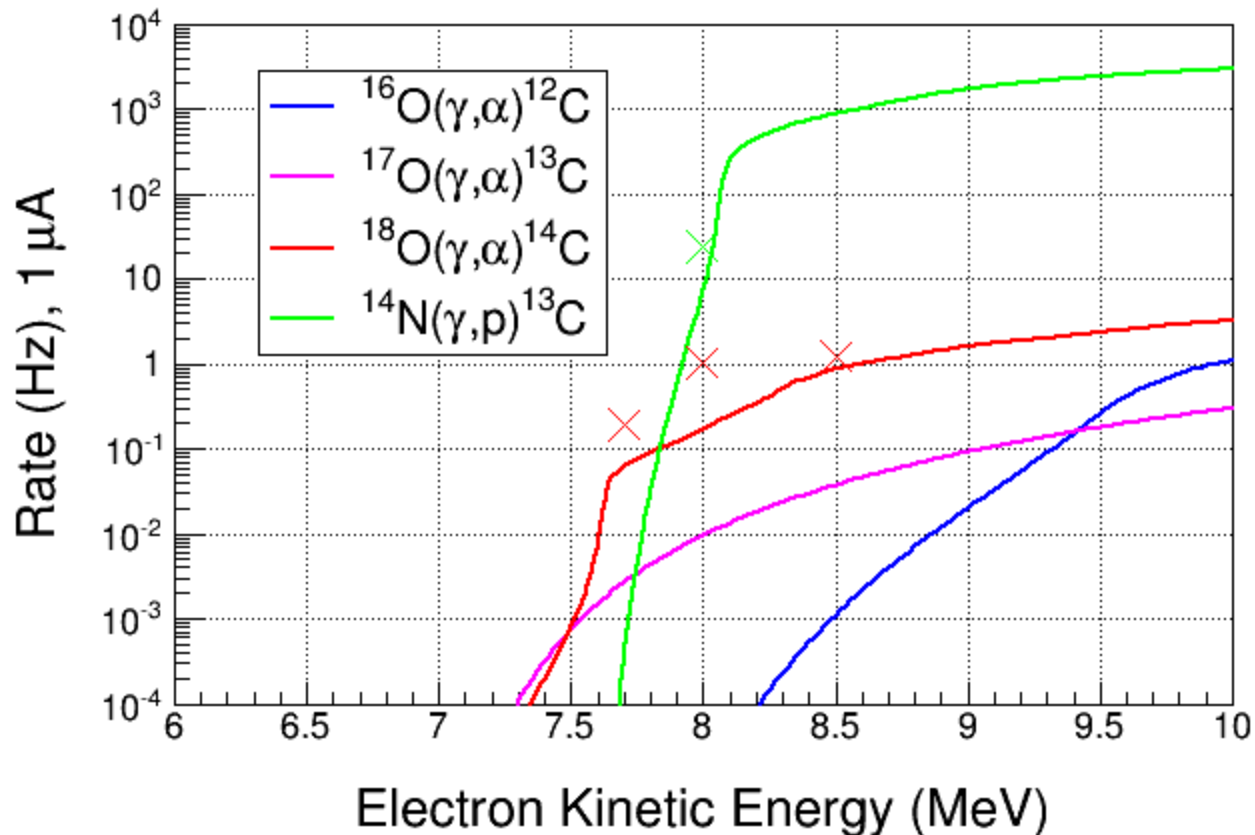
Two beam
energies

EVENTS IN FIDUCIAL VOLUME



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

- Measured event rate vs beam energy
- Measured rate from $^{14}\text{N}(\gamma,p)^{13}\text{C}$ with lower operational pressure



BEAM ENERGY MEASUREMENTS

- As of now, beam energies used during September 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}

BEAM POSITION MEASUREMENTS

- What was beam position on radiator during test?

SUMMARY

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 $^{18}\text{O}(\gamma, \alpha)^{14}\text{C}$ cross section at five energies
- Found sensitivity as expected to $^{14}\text{N}(\gamma, p)^{13}\text{C}$ 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?
- Ceramic break failed
- Beam position on radiator
- Better alignment



List of Improvement

I. Easy

- Better light coverage
- Improve 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

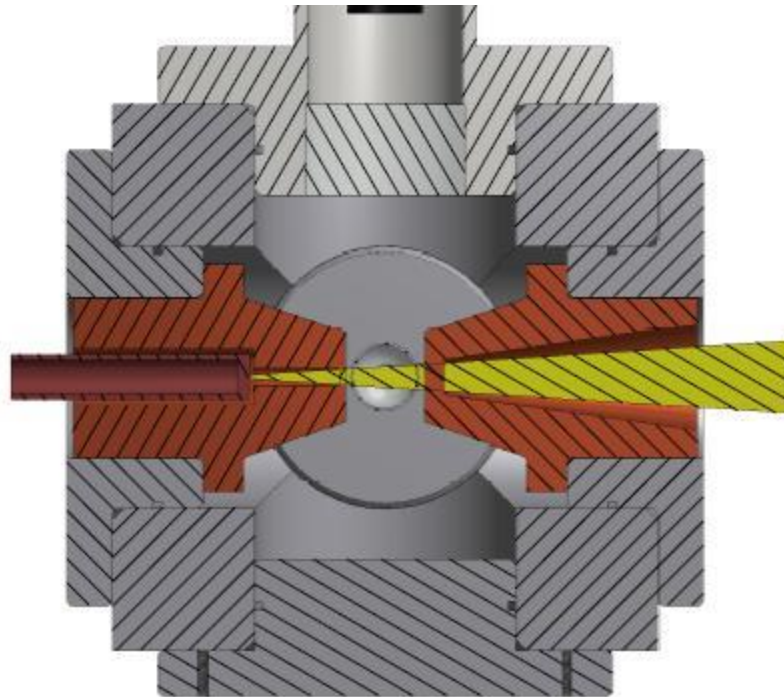
II. Tough

- 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.



Must
study in
GEANT4

WORK SINCE SEPT RUN

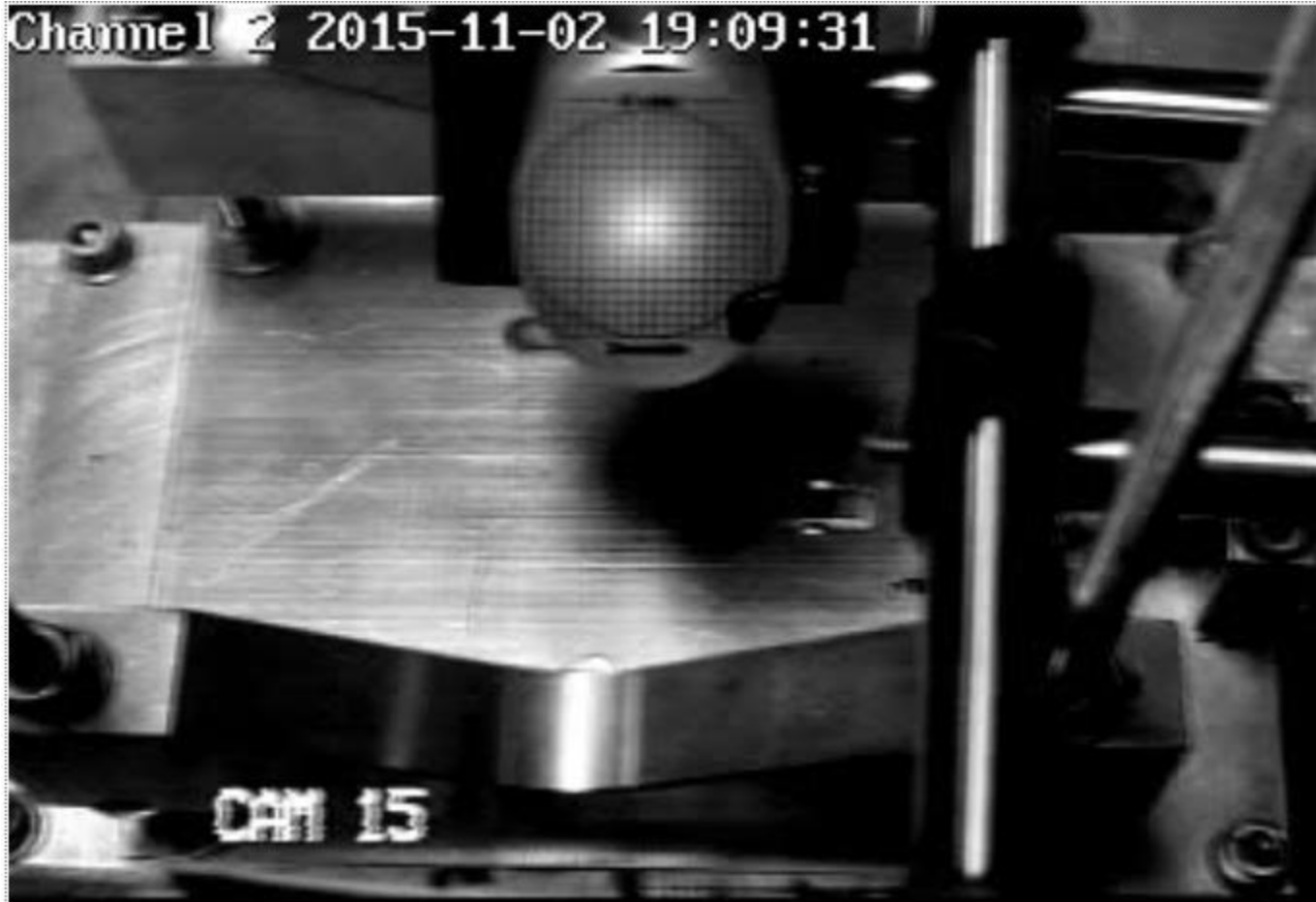
- Covered about 80% of 2D spectrometer line with steel sheet to shield earth's magnetic field
- Calibrated $\frac{1}{4}$ cryo unit gradients using 2D line
- Added mu-metal to 5D line – to add steel sheet in Jan 2016
- Grames developed a procedure to set and measure beam energy
- Measured beam position 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



UPCOMING BEAMLINER 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)
- Align 5D line
- Replace lead shielding with copper and iron
- Test the bubble chamber laser shutter (Gumby Shutter) – show photo

SCHEDULE

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

Injector
Facility
Development
Time

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

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