COUPP:

Chicagoland **O**bservatory for **U**nderground **P**article **P**hysics

(FNAL Test Beam Program T-945)

Development of a bubble chamber technique for dark matter detection.

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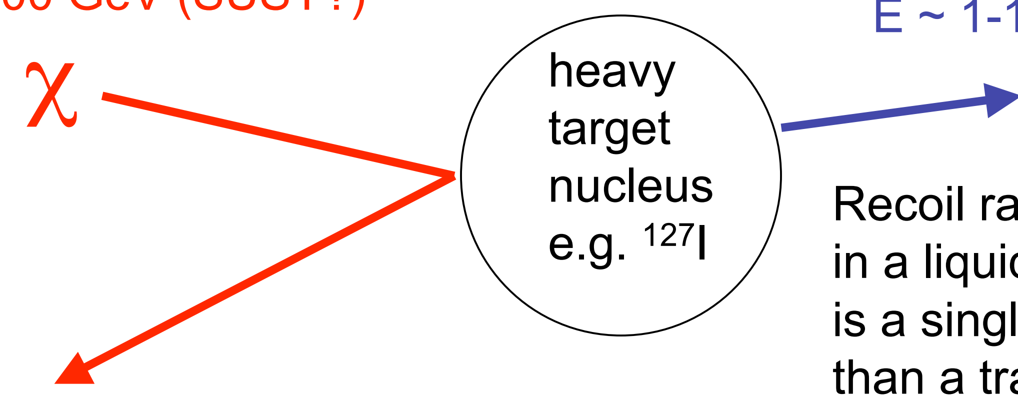
Kinematics of Dark Matter Detection

Dark matter particle from galactic halo
velocity ~200 km/s
mass 10-10000 GeV (SUSY?)

Nuclear recoil
E ~ 1-100 keV



Recoil range < 1 micron in a liquid, so the signal is a single bubble rather than a track.

<u>Measure the rate at which single bubbles appear</u>

To Prove Viability of Bubble Chamber Technique, We Need to Demonstrate:

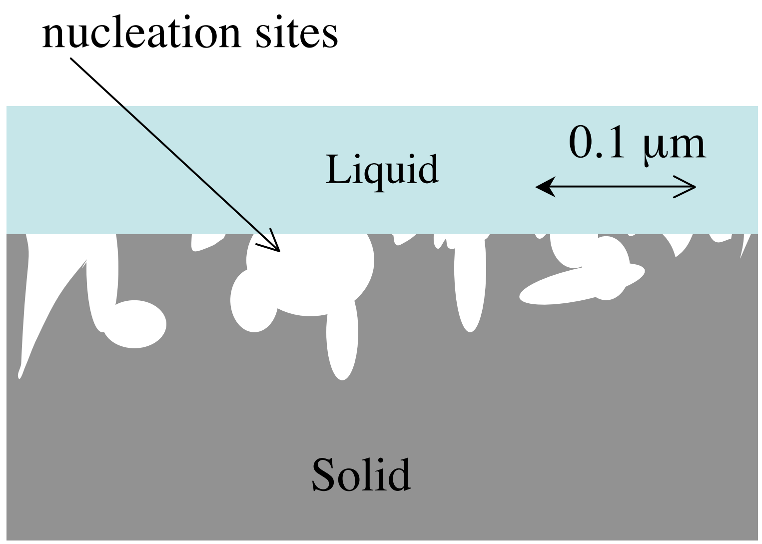
- <u>A bubble chamber which can remain expanded and sensitive for a significant fraction of the time.</u>
- Efficient detection of single bubble events from low energy nuclear recoils.
- Low backgrounds from radioactivity & cosmic rays.

Bubble Nucleation in Cracks

• Trapped gas volumes in surface imperfections are now known to be the primary source of nucleation.

• Historically, problem was overcome for high energy physics experiments by rapid cycling of chamber in sync with a pulsed beam. Bubbling at walls was tolerated because of finite speed of bubble growth.

• A few small "clean chambers" (~10 ml) were built in the 50's and 60's, with sensitive times ~1 minute.



<u>Ways to preserve superheated state:</u>

• Elimination of porous surfaces in contact with superheated liquid.

• Precision cleaning to eliminate particulates.

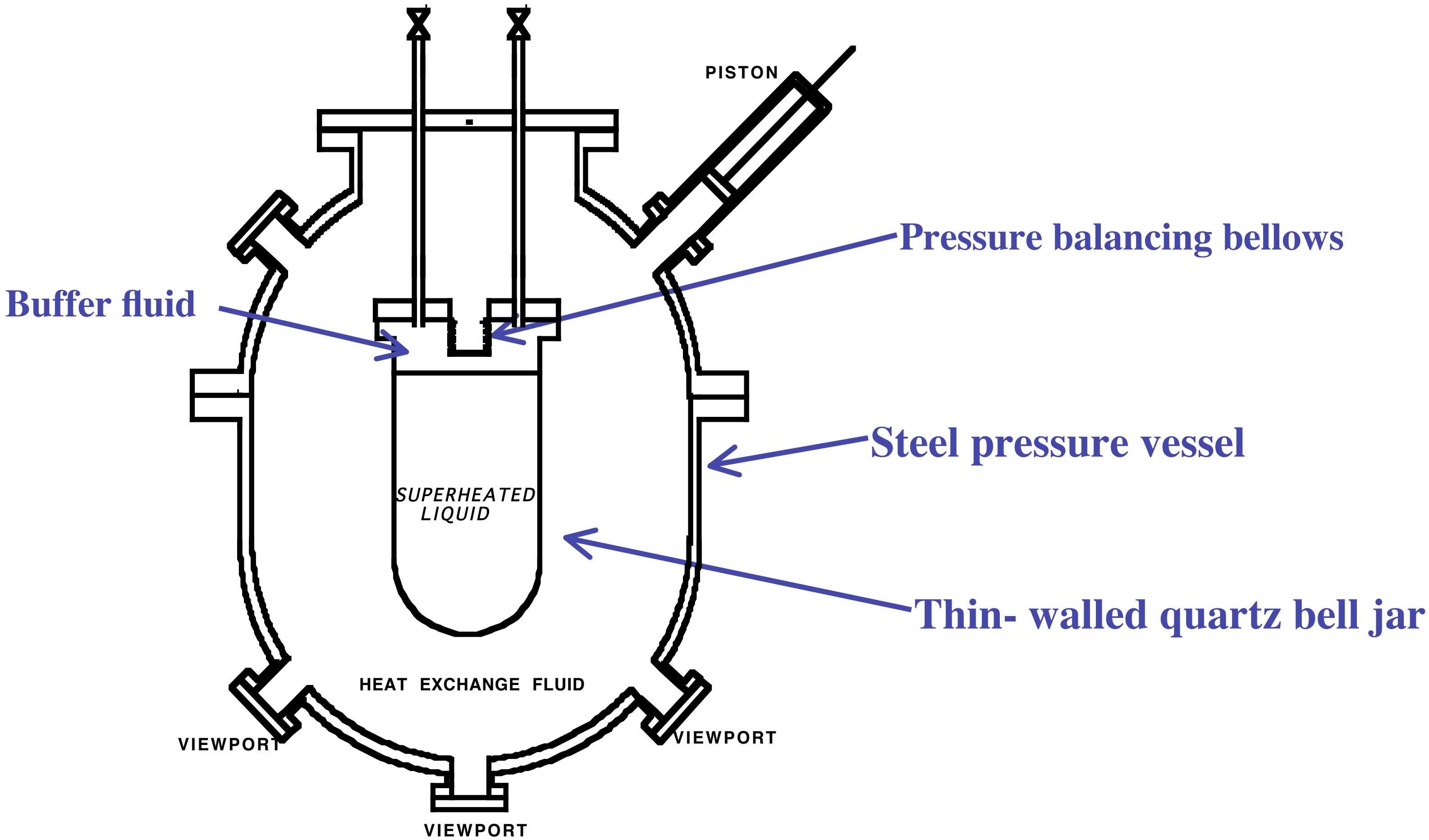
• Vacuum degassing.

•… a few other tricks borrowed from chemical engineers

Design Concept for Large Chambers

• Central design issue is how to avoid metal contact with superheated liquid.

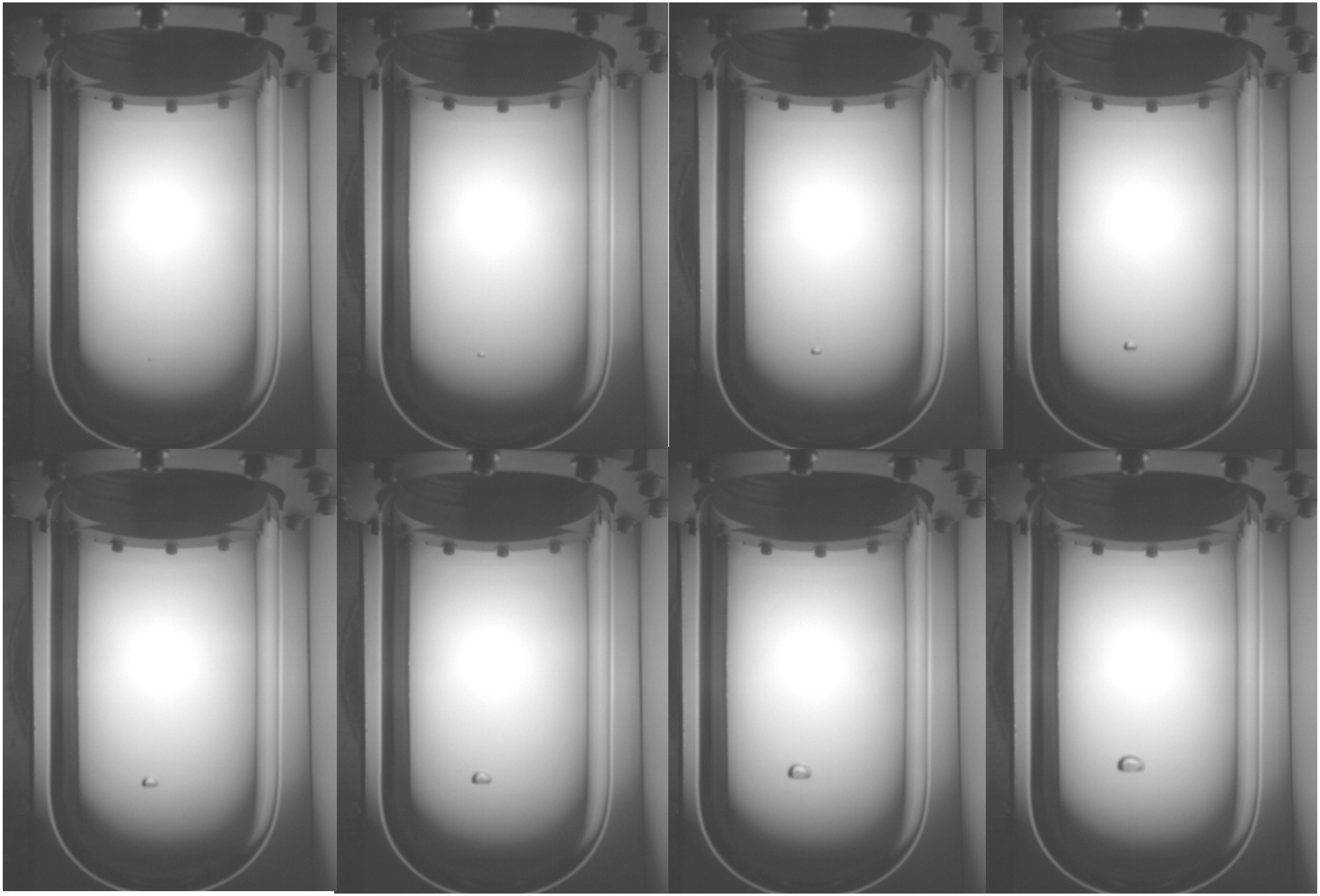
• Fabrication of large quartz or glass pressure vessels is not practical, but industrial capability exists for thin-walled vessels up to ~ 1 m^3 in volume.



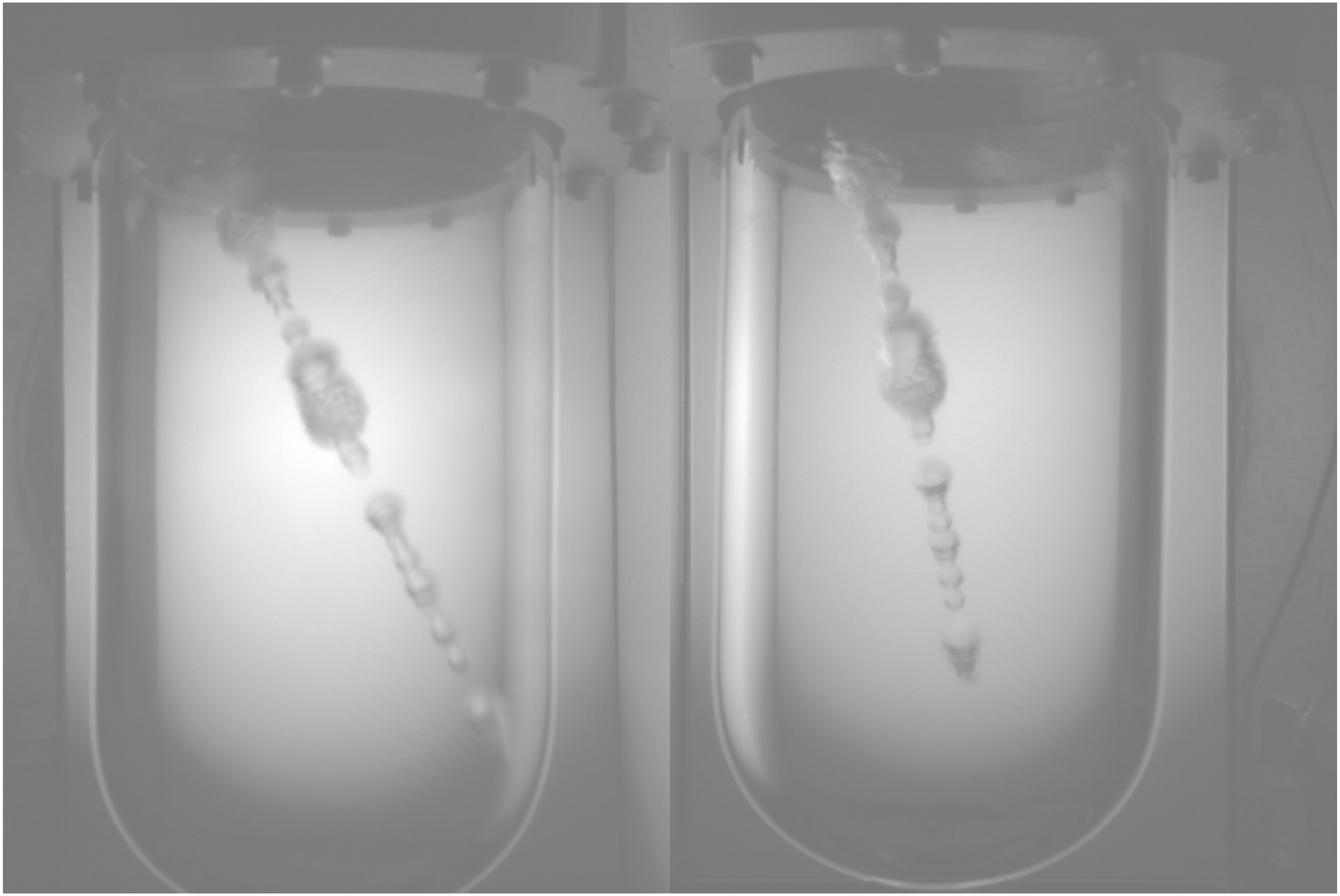
Installation of 1 Liter Chamber At Fermilab NuMi Tunnel

- Prototypes design features required for chambers up to 1000 liters

160 msec of Video Buffer (20 msec/frame)



Muon Track @ 160 psi Vapor Pressure



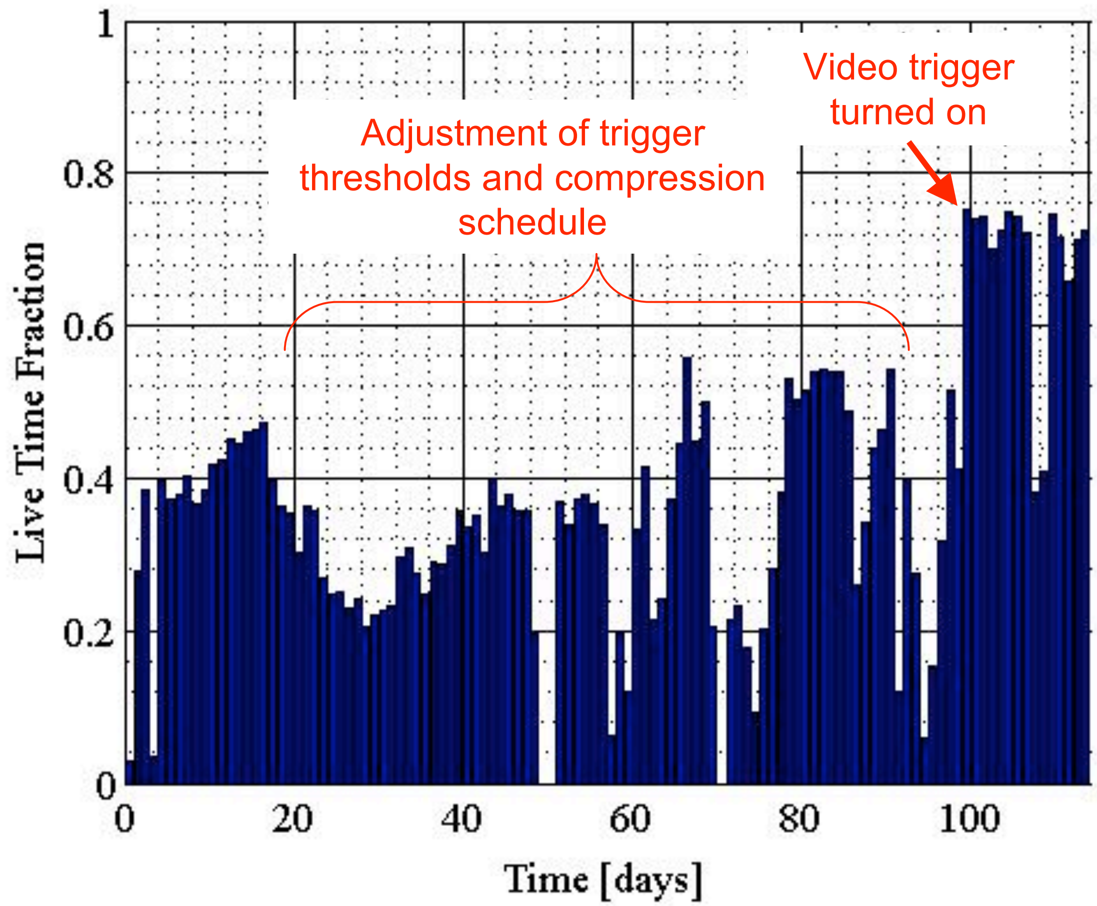
Data From December 1st ‘05 to March 27 ‘06

115 days in run
45k expansions
82 seconds mean
expansion time

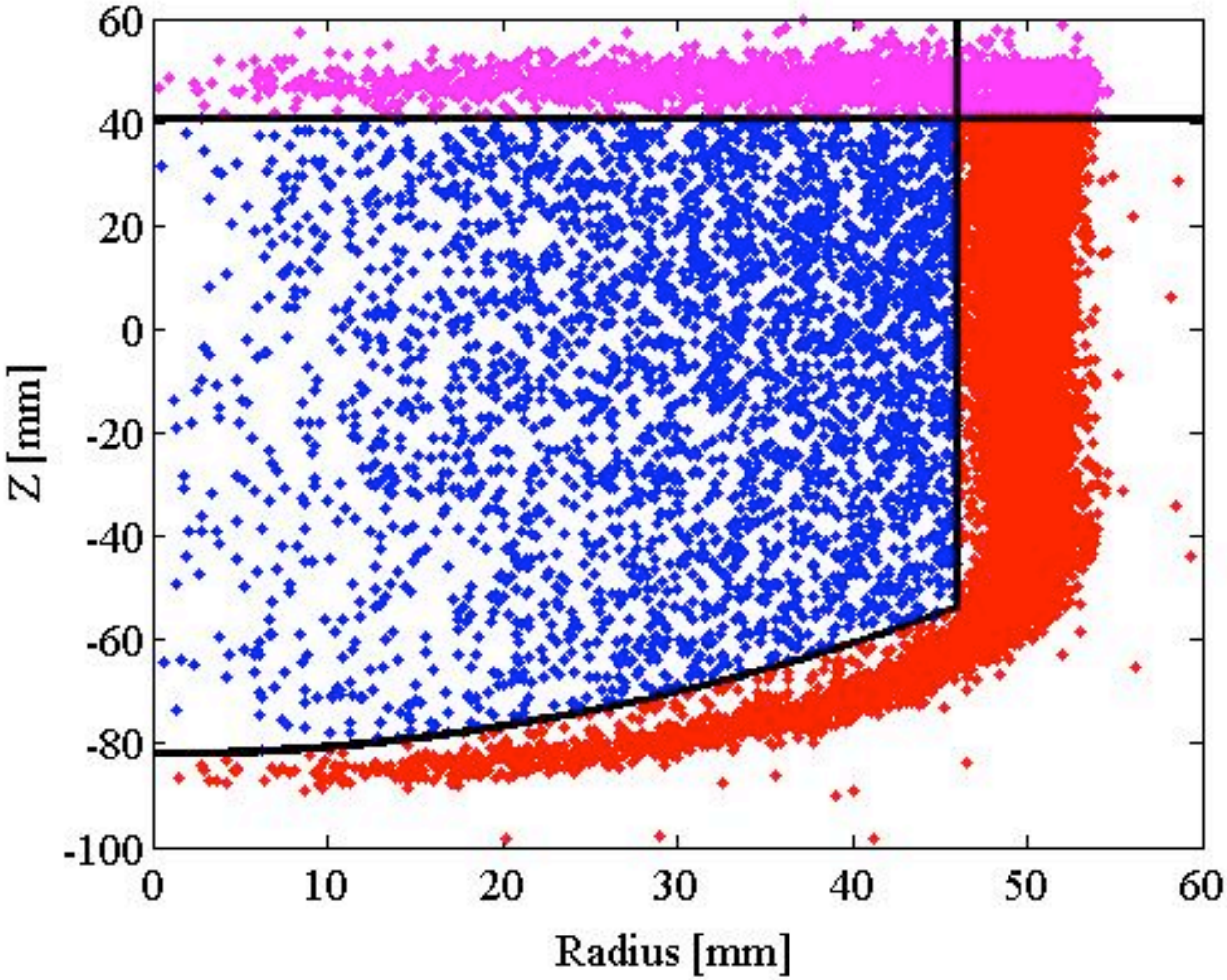
42.8 live days
= 37% of real time

15k bubbles counted

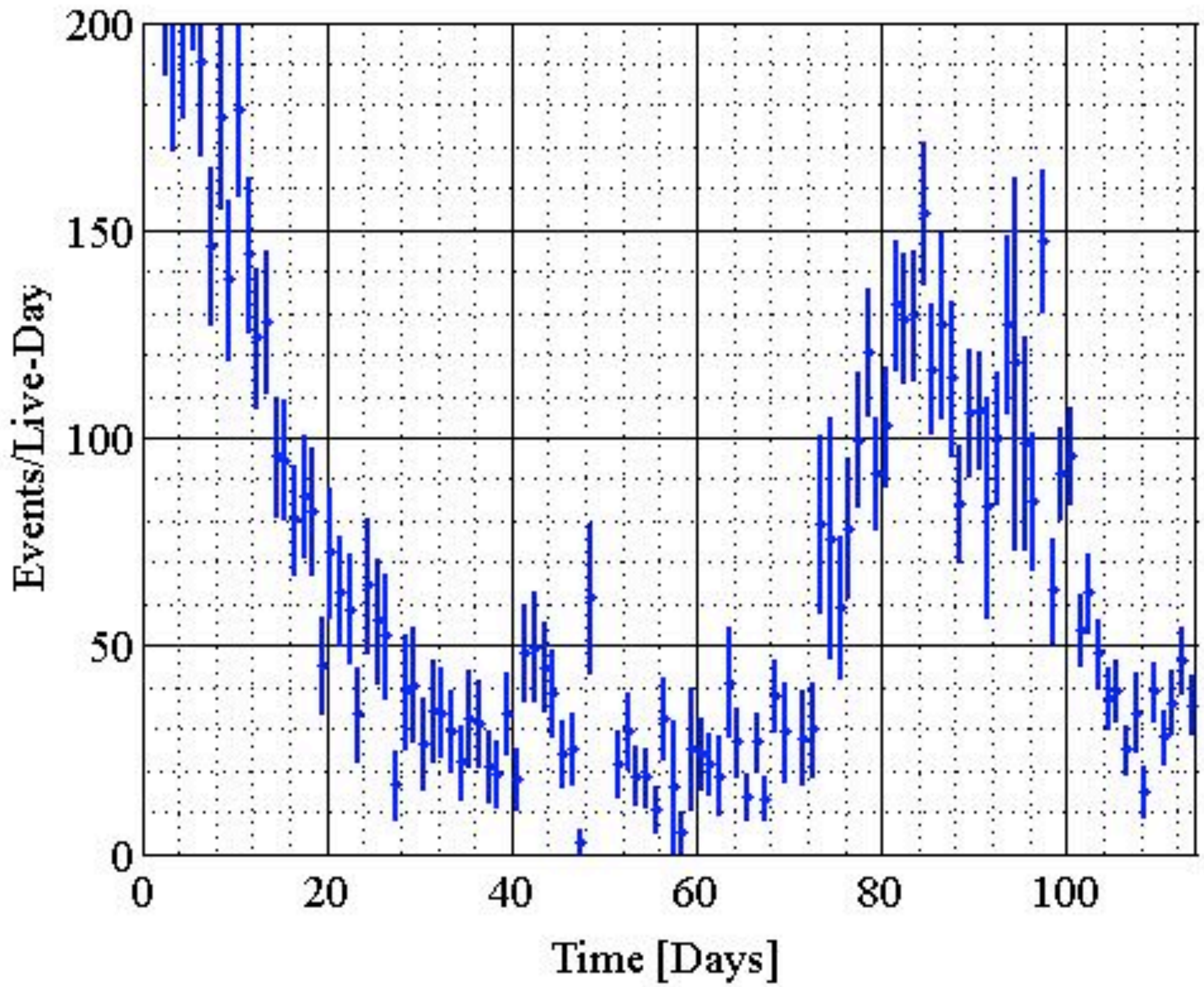
145 GB in Enstore



Radial Distribution



Rate in Fiducial Volume, 760 cc



To Prove Viability of Bubble Chamber Technique, We have demonstrated:

✓ We have a bubble chamber which can remain expanded and sensitive for a significant fraction of the time.

✓ Efficient detection of single bubble events from low energy nuclear recoils.

Work at U. Chicago using radioactive sources.

• Low backgrounds from radioactivity & cosmic rays.

Installing new radio-pure inner vessel assembly

Muon veto system (KTEV plastic scintillator)

Goal: < 1 background bubble per day