COUPP:
Chicagoland Observatory for Underground Particle Physics
(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 $\sim 200\ km/s$
mass $10-10000\ GeV$ (SUSY?)

Measure the rate at which single bubbles appear

- heavy target nucleus e.g. $^{127}I$
- Nuclear recoil
  $E \sim 1-100\ keV$
- Recoil range < 1 micron
  in a liquid, so the signal is a single bubble rather than a track.
To Prove Viability of Bubble Chamber Technique, We Need to Demonstrate:

• 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.

• 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.

Ways to preserve superheated state:

- 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 m³ 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

Adjustment of trigger thresholds and compression schedule
Video trigger turned on
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