Fermilab

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July 29, 2004

To: Hugh Montgomery
From: Mike Crisler
Re: CUOPP Proposal to Test a Heavy Liquid Bubble Chamber in the MINOS Near Detector Hall

I have added this attachment to the COUPP proposal to provide you with a brief assessment of the scope of the proposal and its impact on Fermilab resources, and to seek your approval and support for the initiation of a Fermilab R&D effort focused on this promising new detector technology. Over the past week I have been working at the Kavli Institute with Juan Collar and Andrew Sonnenschein on the commissioning of the 1-liter prototype chamber. We successfully condensed CF3I into the chamber Friday night, and on Monday we successfully decompressed. We have already observed stabile superheated operation with an event rate consistent with the expected neutron flux. It is quite exciting.

Our core proposal is to test this new heavy-liquid bubble chamber in the MINOS Near Detector Hall prior to moving it to its ultimate destination in the Soudan Mine. To give a sense of scale, the complete detector is contained in a three-foot square, five-foot high support frame and would be surrounded by about a foot of polyethylene shielding. Based on the very successful preliminary tests, it is likely that we might be ready to move the chamber to Fermilab by early fall. The Kavli Institute will provide the complete chamber, its ancillary equipment, and the polyethylene neutron shield. The Fermilab contributions would include engineering review/ safety analysis, engineering support for the lifting, handling and transport of the device, and coordination of the access to the MINOS hall. I would estimate that a few person-months of engineering support and one or two person-months of drafting support would be sufficient for this test.

Of course a successful test will lead to a more ambitious proposal. To give a sense of how this might develop, a 1-liter device might be followed by a 10-liter version, then by 100-liters, etc. The M&S costs will continue to be small. A system consists of vessels (pressure up to ~300psi), plumbing, a few temperature and pressure sensors, a circulating heater/chiller, video cameras, and a readout computer. There is very little electronics. I believe that it would be difficult to spend much more than $100k on a world-class dark matter detector. The opportunities I see for Fermilab participation basically fall in to the areas of bubble chamber engineering, data acquisition and triggering, and in prototype development and testing. What I would like to do immediately is to set up a small lab where we can begin working with the technology here. This would involve scrounging some equipment, and a modest budget for some specialized lab equipment. I don't imagine that this would exceed $25k. I would also like to involve some Fermilab engineers in thinking about these devices.

What we seek from the Fermilab Directorate is approval to proceed with our core proposal, and beyond that I would hope to get the your blessing to put together a design and development team and to perhaps spend an initial few thousand of PPD's remaining dollars, with the understanding that the cost of this initial effort might grow to $25K or so and would lead to a follow-on proposal for a larger device.

Draft Memorandum of Understanding

1) Kavli Institute Scientific Staff:
J. Collar, J. Hall, D. Nakazawa, K. O'Sullivan, A. Raskin, A. Sonnenschein

2) Kavli Institute will provide:
a) 1-liter bubble chamber prototype
b) support stand
c) fluid handling system
d) cameras, DAQ computer
e) fluids (purified water, polyethylene glycol, CF_3I)
f) polyethylene neutron shield
g) possible scintillation counter veto shield

(I have not asked for a detailed accounting of the Kavli costs. The equipment already exists, and represents about $50k)

3) Fermilab Scientific Staff:
M. Crisler, D. Holmgren, R. Plunkett, E. Ramberg, (D. Bauer at a later date)

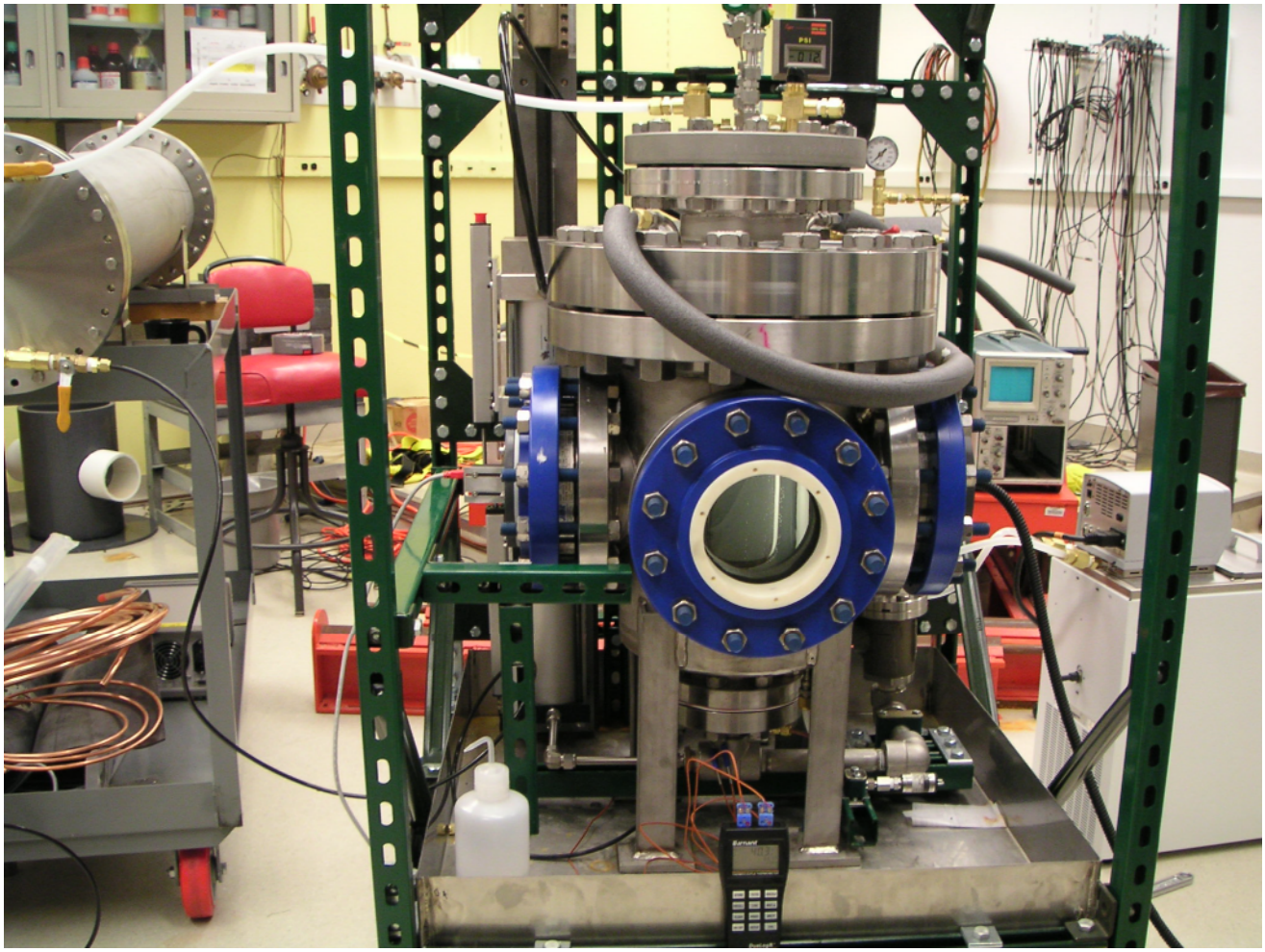
4) Fermilab will provide:
a) Engineering/Safety Analysis — 2 person-months engineering time
i) Preliminary work has already been done by Rich Schmitt.
ii) final engineering and safety analysis and report
iii) pressure vessel certification
iv) approval of fluids for use in underground lab.

b) Engineering Support for transport/handling — 2 person-months eng/design/draft
i) lifting fixture plus analysis, documentation
ii) analysis of transport issues
iii) handling underground (method for pushing "up the hill" to the muon alcove)

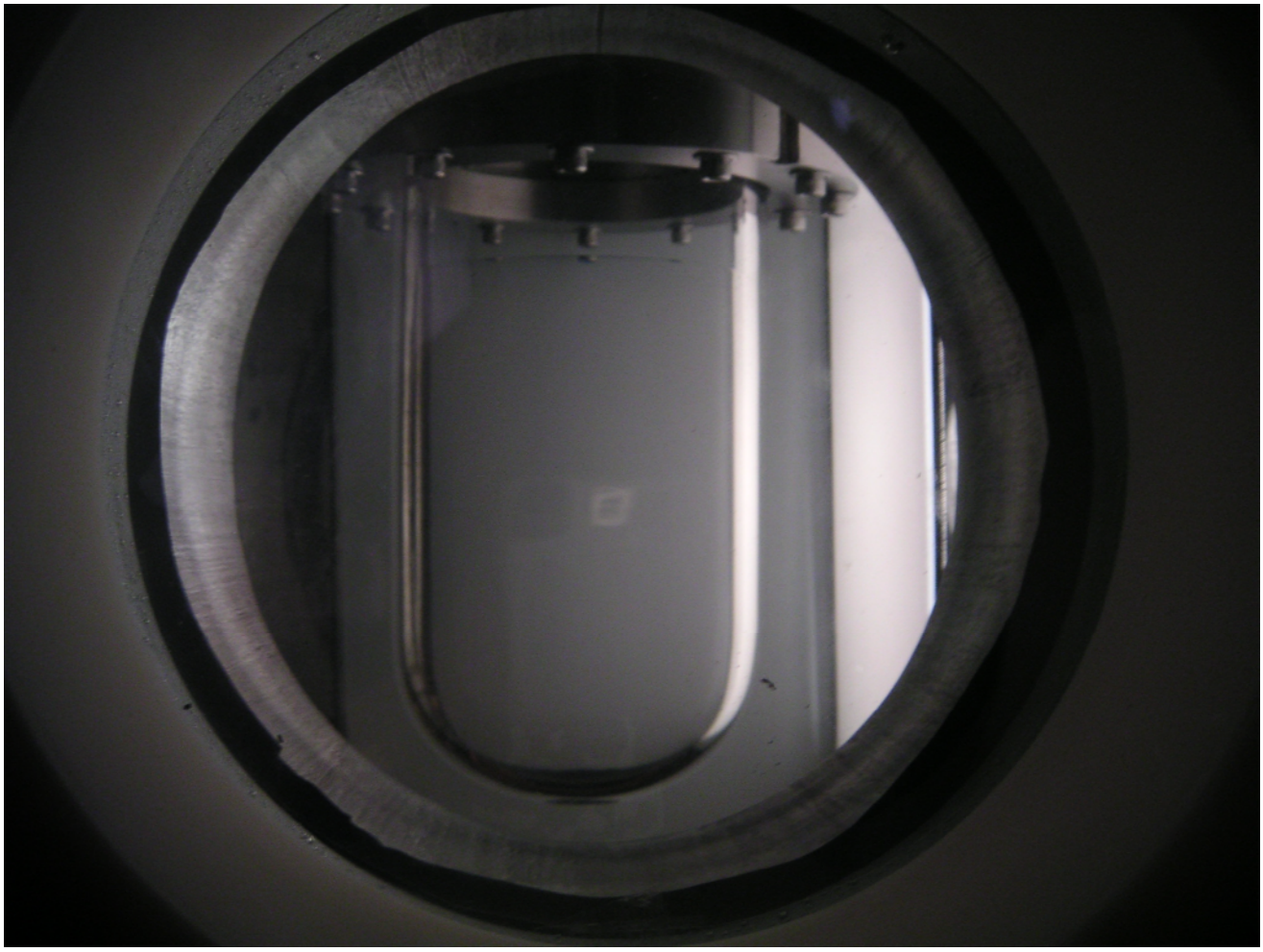
c) Access to MINOS hall.
i) Some coordination with MINOS will be required due to occupancy limits.

4) Fermilab R&D effort:
a) lab infrastructure

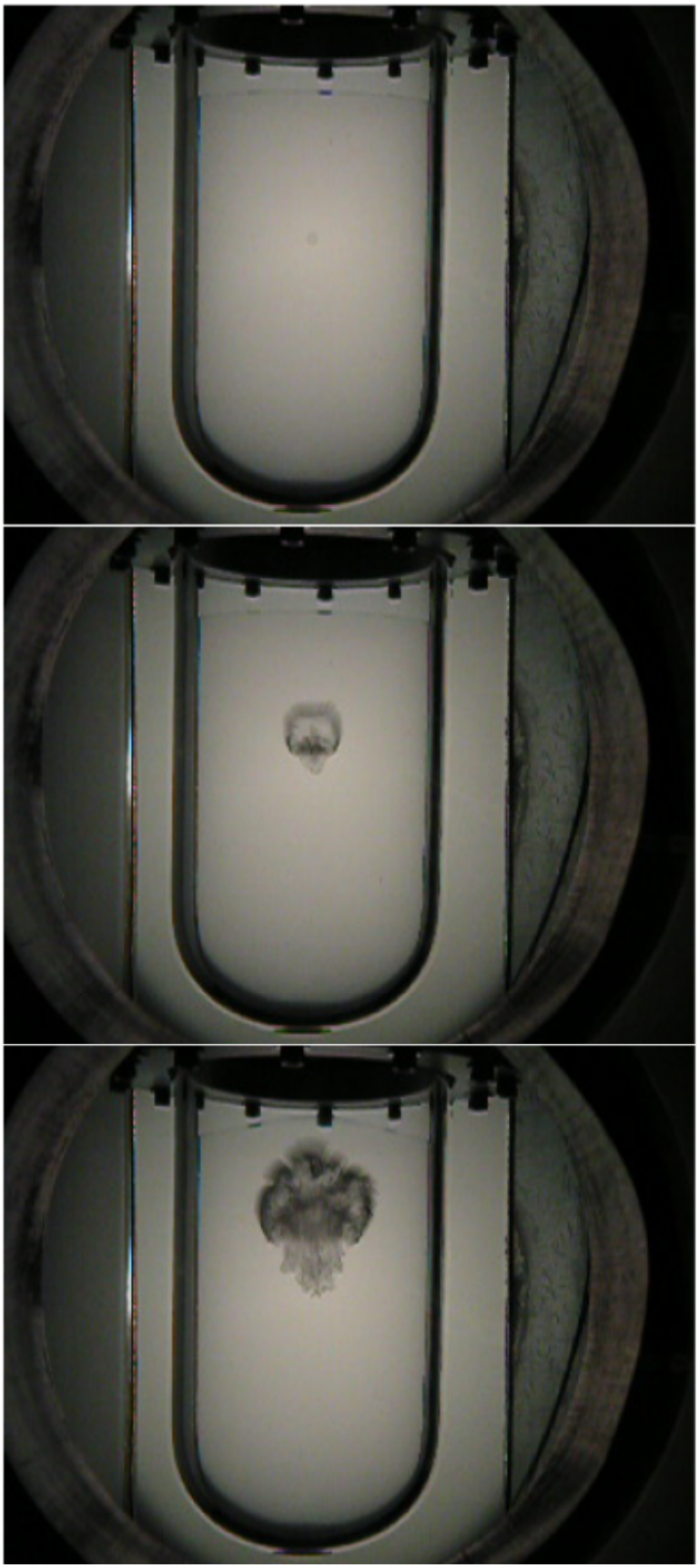
i) test vessels	$5k
ii) miscellaneous plumbing, hardware	$5k
iii) cameras and optics	$5k
iv) DAQ & controls computer and software	$5k
v) circulating heater/chiller unit	$5k
Total Initial R&D infrastructure costs	$25k (not all needs to be purchased new)



This picture is shows the full outer vessel on its support stand. The inner bubble chamber vessel is visible through the quartz window.



This is a close-up view of the active bubble chamber vessel. Note the meniscus near the top of the quartz vessel indicating the interface between the active CF_3I fluid (below) and the H_2O buffer fluid (above).



This series of frames shows the formation of a bubble, presumably due to the interaction of an ambient neutron. We've observed a lifetime of order one minute, consistent with the neutron flux in the lab and accounting for the additional shielding effect of the outer polyethylene glycol volume.