FCPA/KICP/ANL Retreat, June 5th , Fermilab

KICP Detector Development and Dark Matter Initiatives

Paolo Privitera

- Detector Development: a dedicated Major Activity in our recently awarded Physics Frontier Center

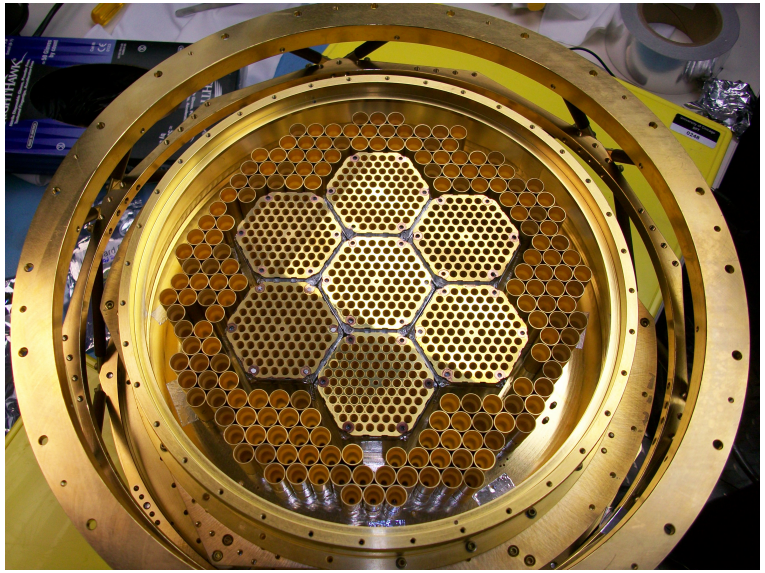
- Focus on Detector Development for Dark Matter, Inflation (CMB), Dark Energy

- Current initiatives (mainly discuss activities not covered elsewhere today, particularly DM)

- Detectors in broader KICP

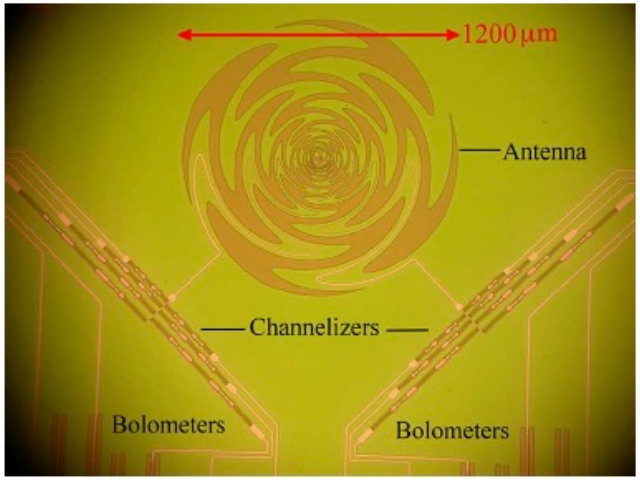
Detector Development for CMB

- HEMT activity (QUIET) no further pursued



- Strong and successful development program on TES bolometer with ANL and Berkeley (Clarence Chang today).

- Major focus for the next three years: development of multi-chroic bolometric detector arrays for CMB polarization to dramatically improve SPTpol throughput and frequency coverage for deployment in 2015 and lead the way for possible future CMBpol experiments.
(New Initiatives PFC funding)



- While not priority today, we want to keep an eye on MKIDs technology development (potential applications in CMB, DM, X rays)

Chicagoland Dark Matter Initiatives

- An unprecedented concentration of activities in Dark Matter:

  CDMS, CoGeNT, COUPP, DAMIC, DarkSide, DM-Ice

covering low mass to high mass WIMPs, different detector techniques, different systematics

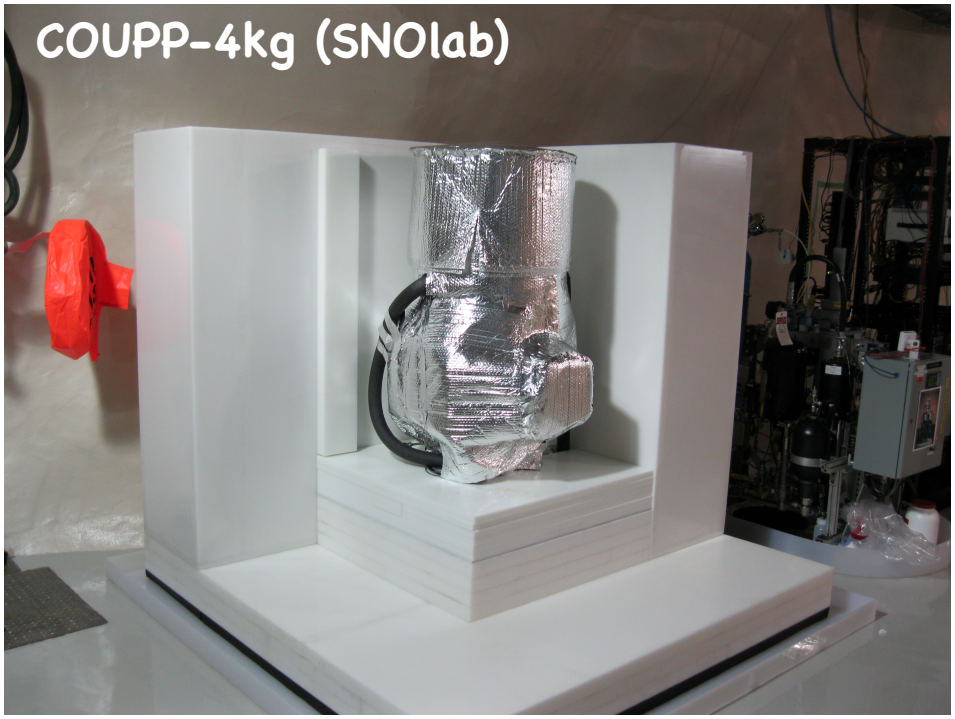
- KICP – Fermilab collaborations

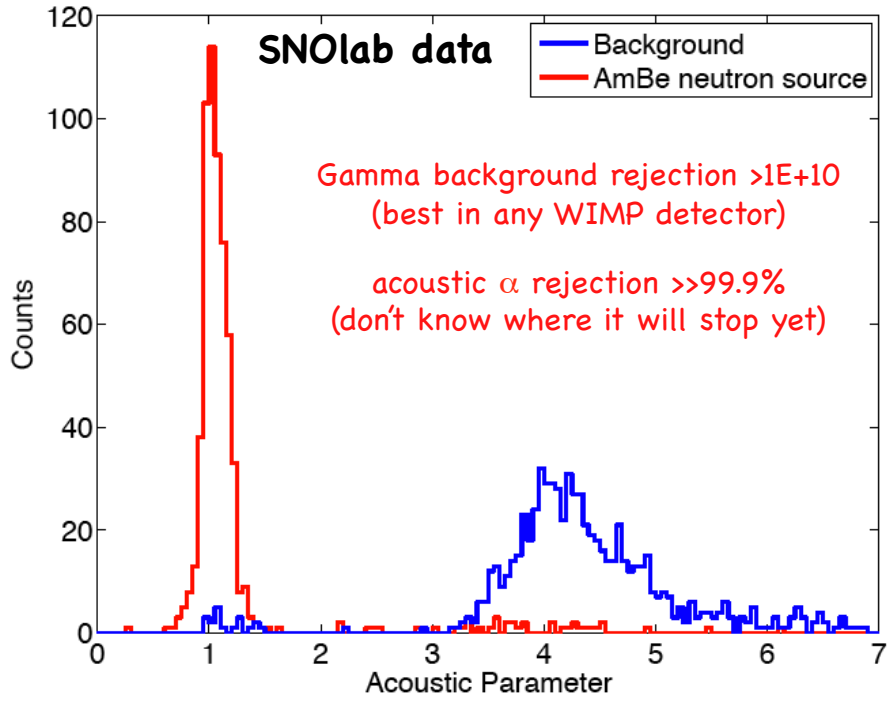
  COUPP (well established, Collar)
  DAMIC (new, Privitera)
  DarkSide (new, Grandi is joining UoC Physics Department)

- We should profit of this critical mass…….

COUPP: Bubble Chamber search for Dark Matter

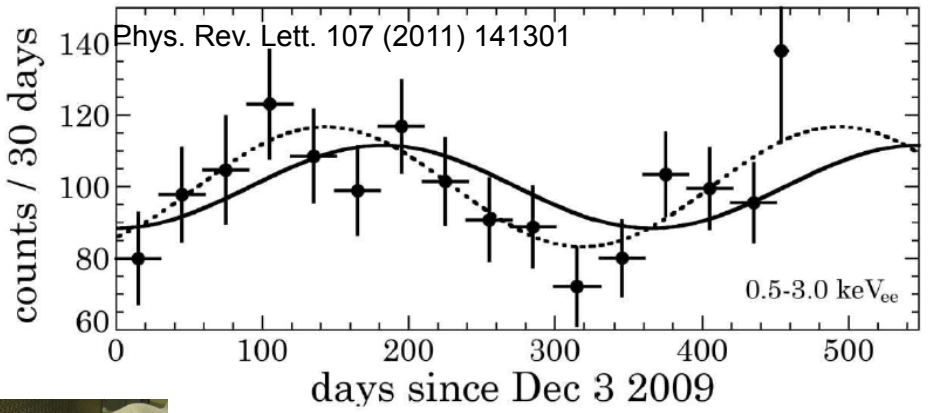
- 4 kg chamber taking data again at SNOlab after removal of (α,n) sources.
- World's best spin-dependent (SD) WIMP-nucleus coupling sensitivity, and very near CDMS' spin-independent (SI) sensitivity. New limits end of summer.
- 60 kg chamber to be installed at SNOlab August 2012. We expect world's best sensitivity for both SD & SI couplings from this device.
- 500 kg design in progress (NSF & DOE proposals). Planned start of construction 2013, installation at SNOlab during 2015.

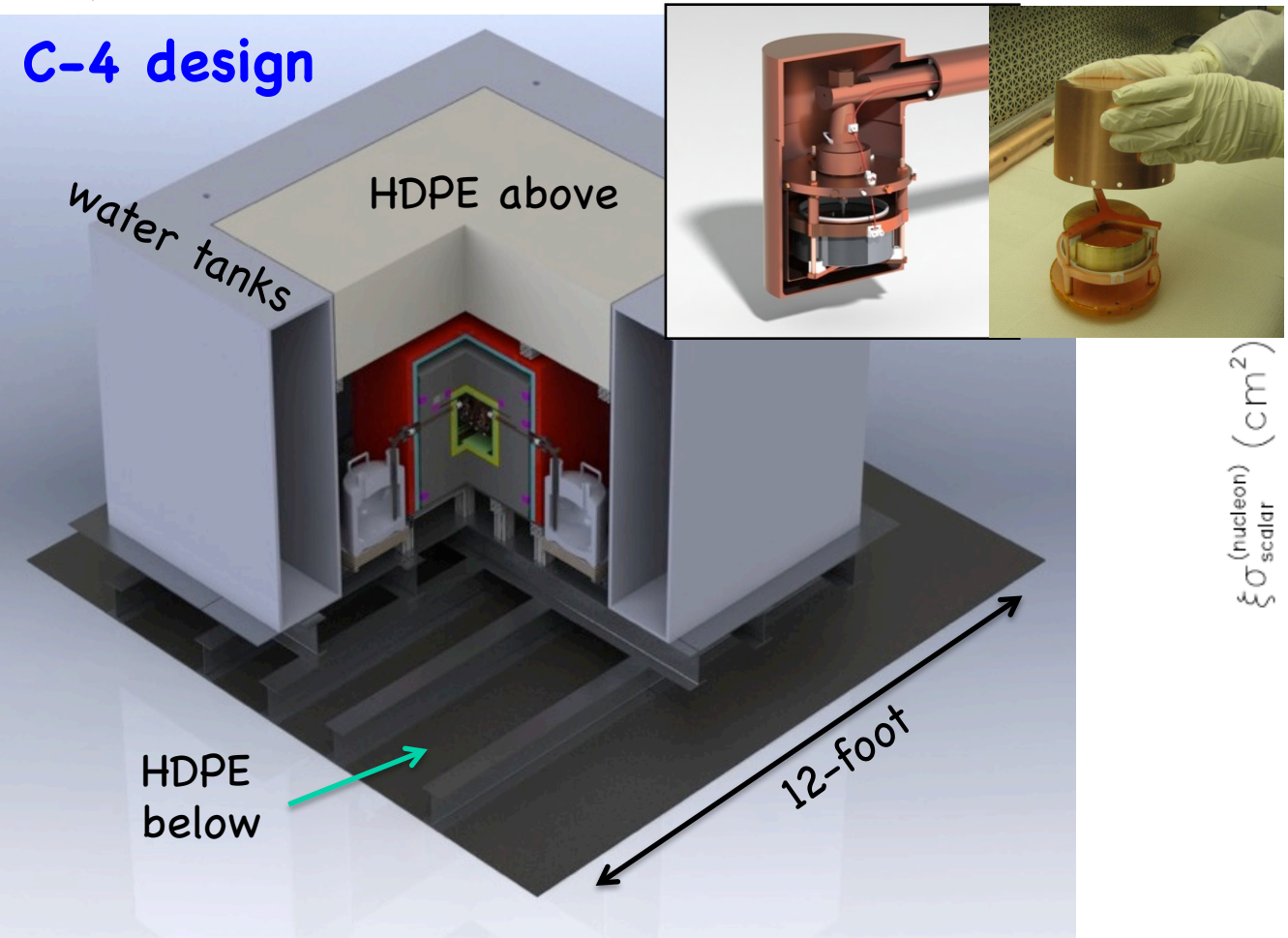


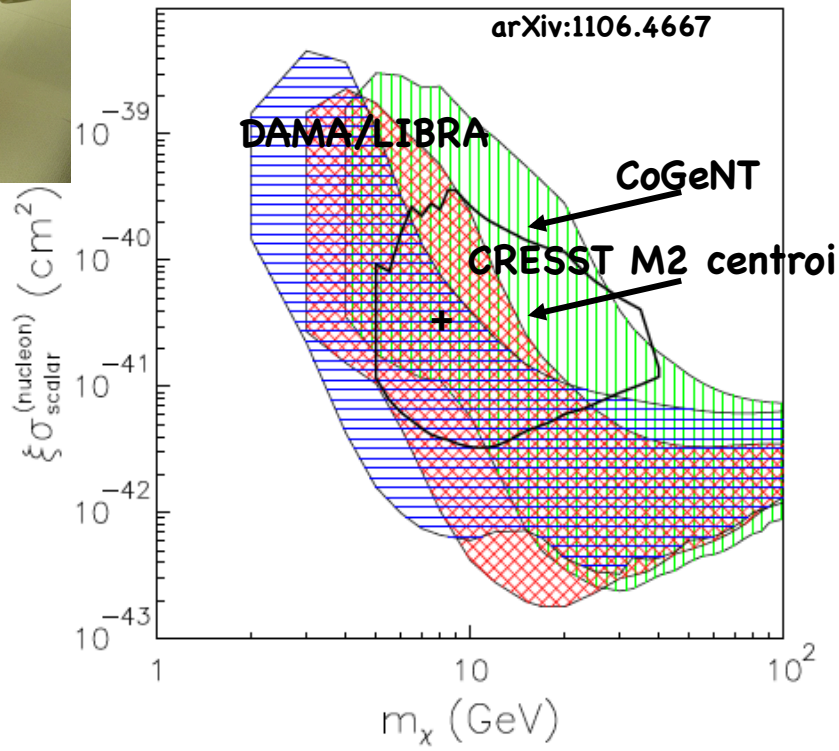


CoGeNT: dedicated search for light-mass WIMPs

- Annual modulation of unknown origin, measured with 0.4 kg crystal at Soudan, in possible agreement with DAMA/LIBRA & (now) CRESST. Compatible with a light WIMP interpretation. Additional data-taking ongoing.
- C-4 expansion to start end of 2012 in Soudan (x12 present target mass, significant reduction in bckg and threshold expected). First detector being built.
- C-4 detectors to feature measures against parallel-f electronic noise (i.e., lower threshold).
- One additional year of data from detector at Soudan to be released this summer.

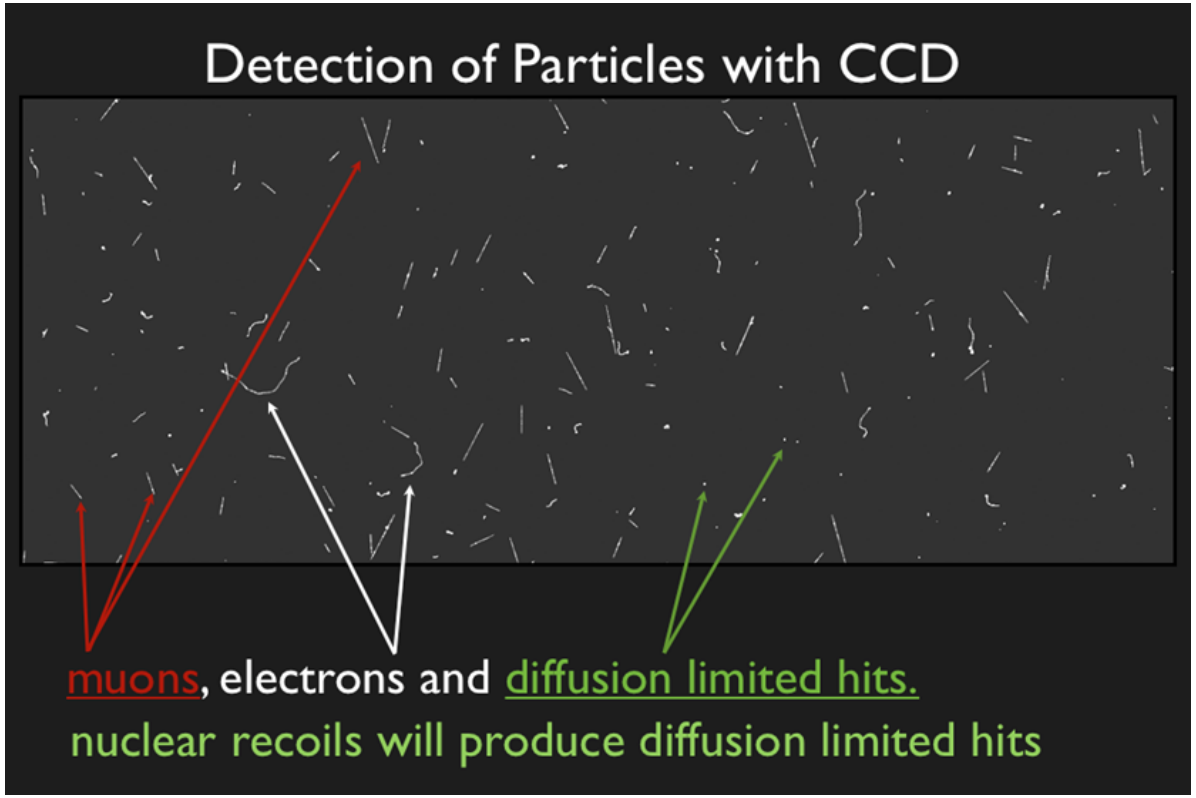




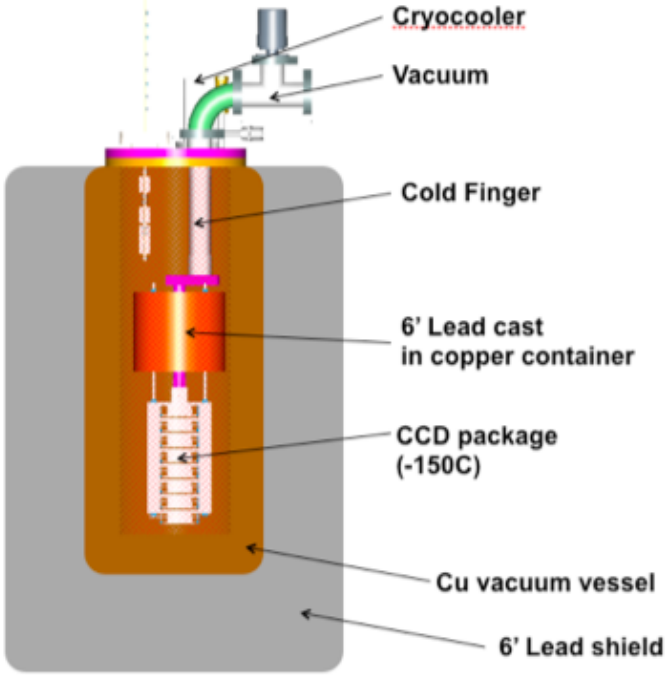


Dark Matter in CCDs

- Low energy threshold (100 eV), thick CCDs for low mass WIMP



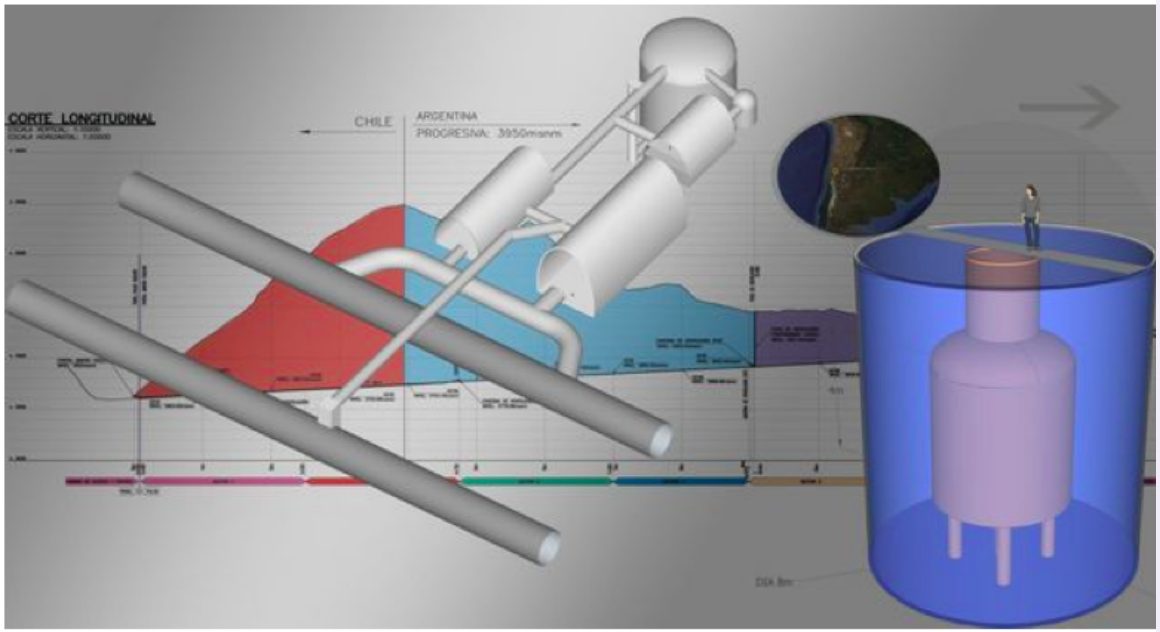
- A ≈10 g detector (1 CCD about 1 g) to be installed at SNOLAB this summer

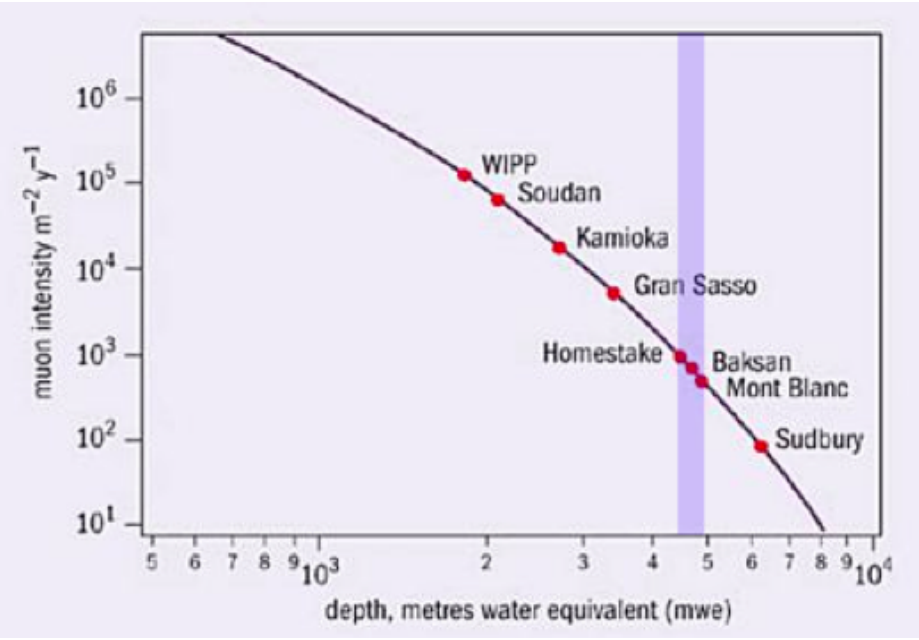


- activities starting at KICP:
  - set-up of a CCD test stand (courtesy of J. Estrada)
  - Neutron sources at KICP (Collar) and U of Notredame
  - development of ultra pure CCDs in collaboration with PNNL
  - SNOLAB data-quality monitoring and analysis

- Strategic collaboration with ANDES groups who are starting to work with CCDs

The ANDES Underground Laboratory in South America





X. Bertou

CNEA/CONICET, Centro Atómico Bariloche, Argentina

- Argentina, Brazil, Chile, Mexico (many Auger friends)
- Possible installation in a mine in Chile (before ANDES is completed)

A Cloud Chamber for Dark Matter: Dark Cloud

Paolo Privitera

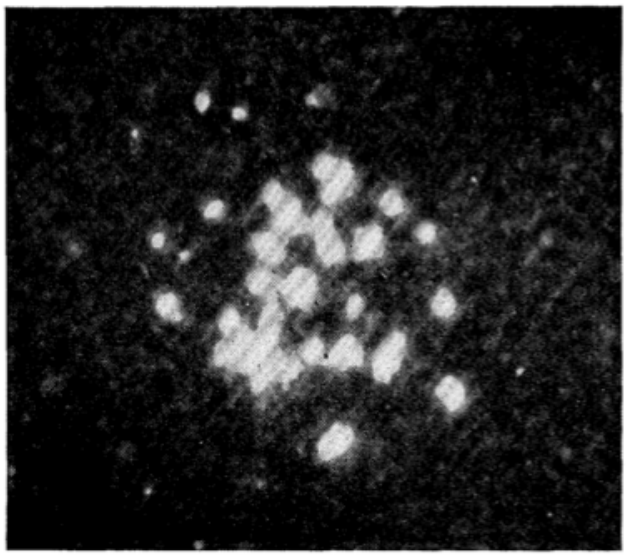
- R&D for a “new” detection technique (E. Ramberg, ..)

Condensation of supersaturated vapor on the ion trail along the particle path. Supersaturation through:

- Fast expansion
- Vapor diffusion between a hot and cold plate

Potential for Dark Matter detection:

- low energy threshold (≈100% efficient on single ion), nuclear recoil



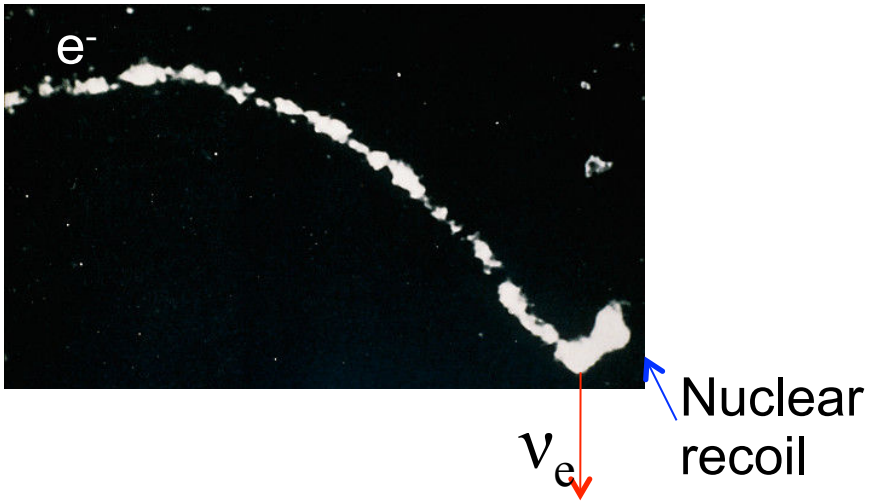
New Experimental Evidence for the Existence of a Neutrino

H. R. Crane and J. Halpern
University of Michigan, Ann Arbor, Michigan
(Received March 24, 1938)

A new method is used for determining the energy of recoil of the nucleus in the individual beta-disintegration process. A gaseous compound of radiochlorine is placed in a cloud chamber. The clearing field is removed long enough before the expansion to allow the ions to spread out so that the resulting droplets can be seen individually. A cluster of droplets appears at the beginning of the track, and this is believed to be produced by the recoil nucleus. From the number of droplets an estimate is made of the kinetic energy of the nucleus, and this is compared with that calculated from the observed curvature of the beta-ray track. It is found that the laws of momentum as well as those of energy indicate that a third particle participates in the disintegration.

- 3D reconstruction of recoil

low pressure, directional dark matter detection



Existing directional DM approaches are based on drift of ionization electrons, which diffuse along drift reducing resolution. In the cloud chamber, no diffusion

- underground operation

reduces ion load to ≈0, much better quality and stability.

- Background discrimination

α, β, γ vs nuclear recoil

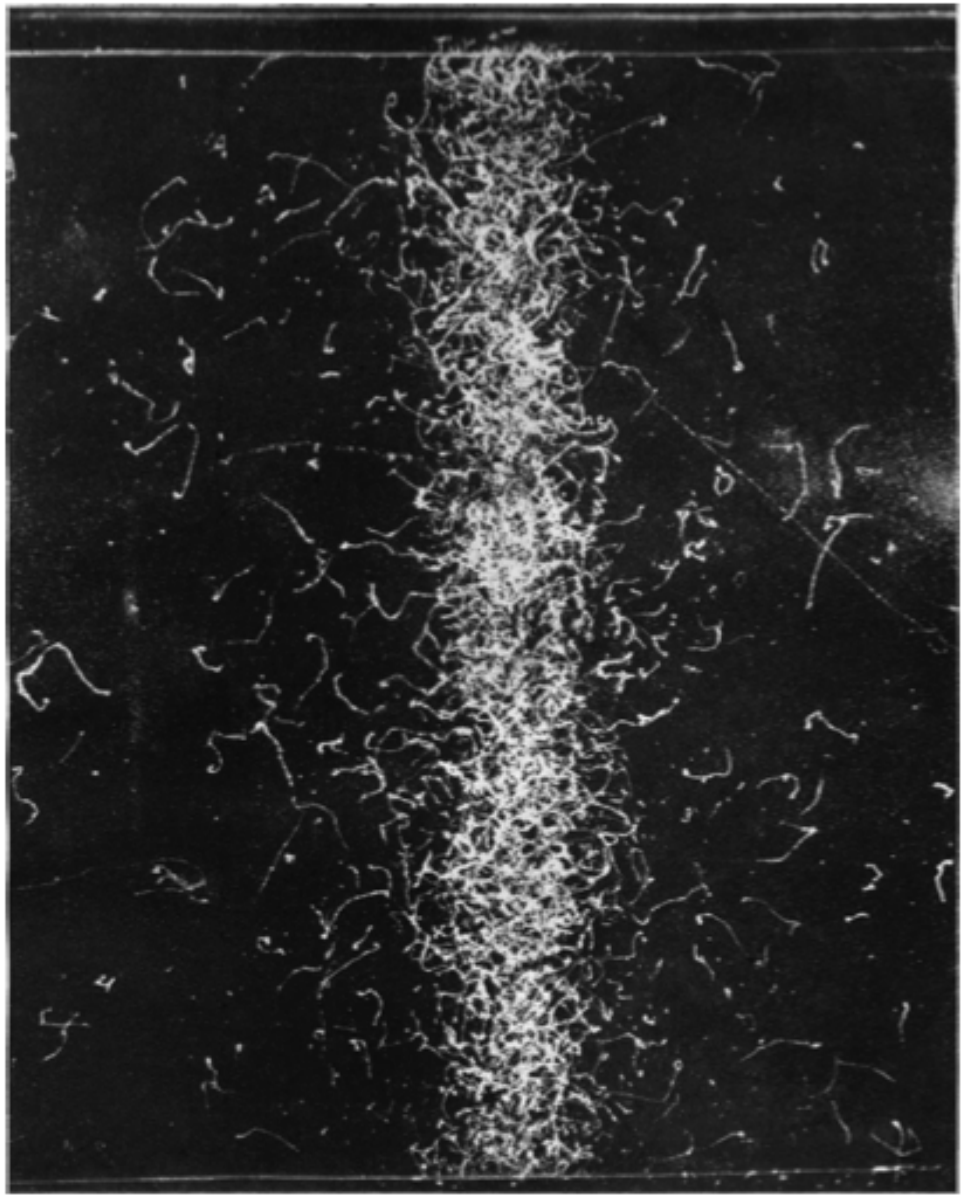
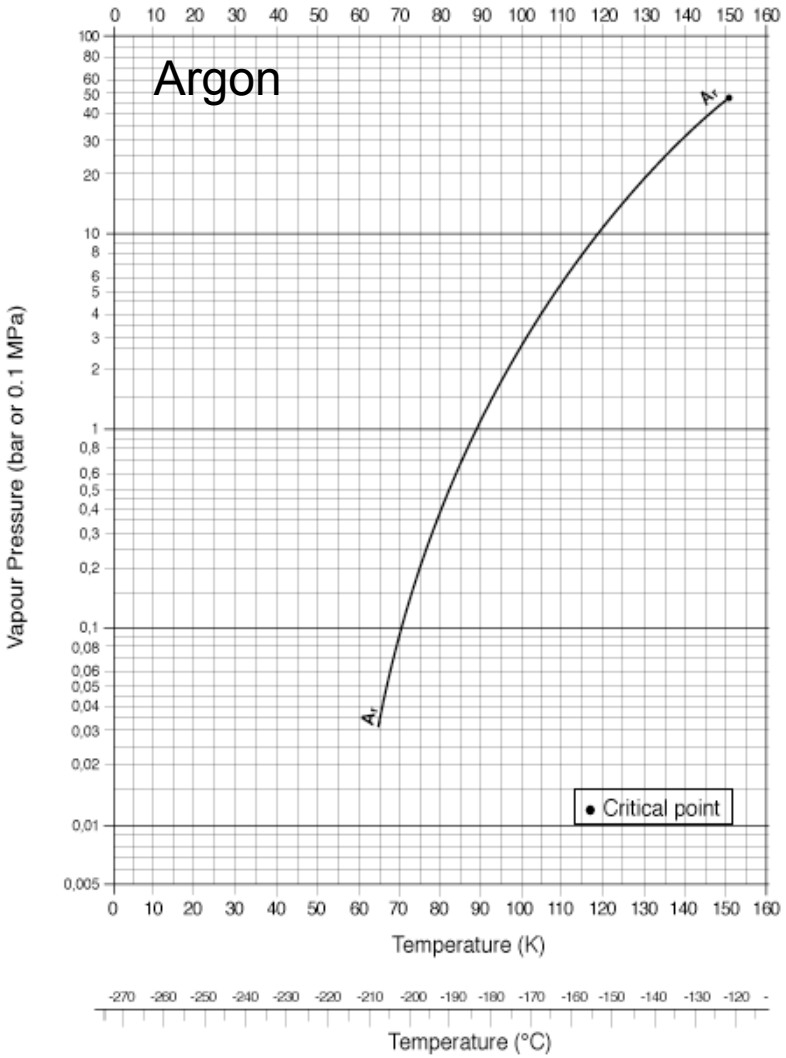
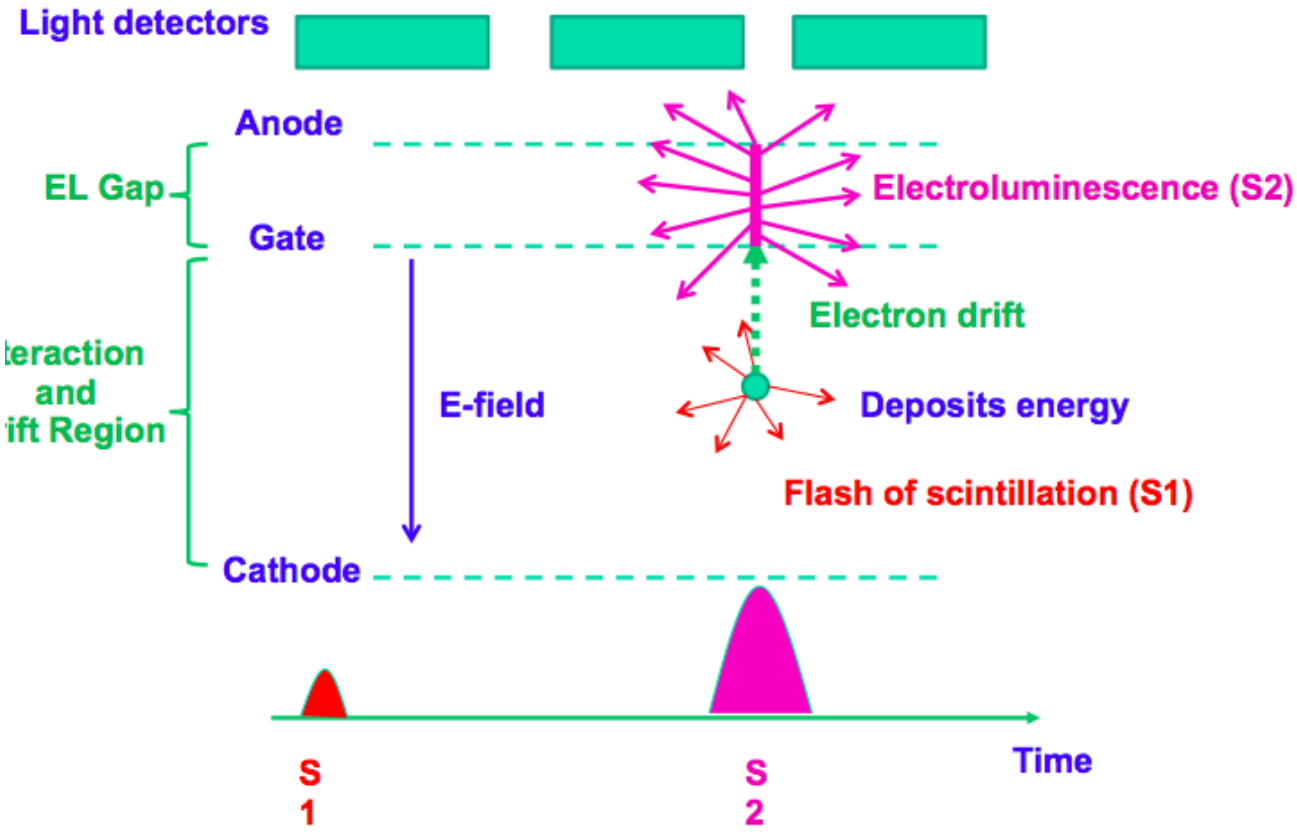


Fig. 3. – Burst of ionization produced by an X-ray beam. X-ray tube peak voltage, 40 kV; duration of the beam, less than 0.2 s; delay of the photograph, ~ 1 s.

- Build an expansion chamber operating with pure noble gases at low temperature (Argon, Xenon);
  expansion triggered by noble gas primary scintillation and electroluminescence from drifting electrons





- Advantages of S1/S2 discrimination + cloud chamber imaging

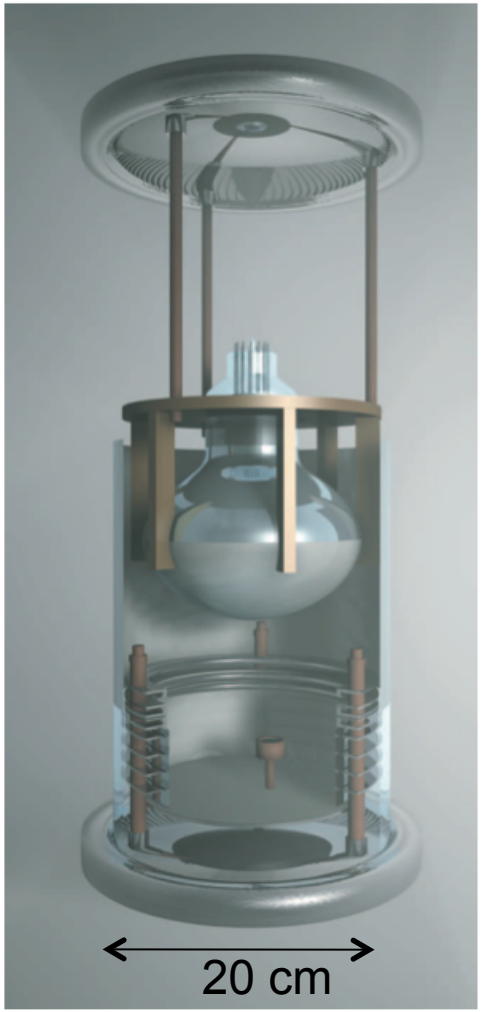
- An ideal KICP – Fermilab Collaboration…

  - Synergy with the liquid Argon neutrino/dark matter program at Fermilab (and now at UoC, Darkside). Depleted Argon, cryogenic, electroluminescence, etc.

- Synergy with COUPP, expansion and video camera techniques

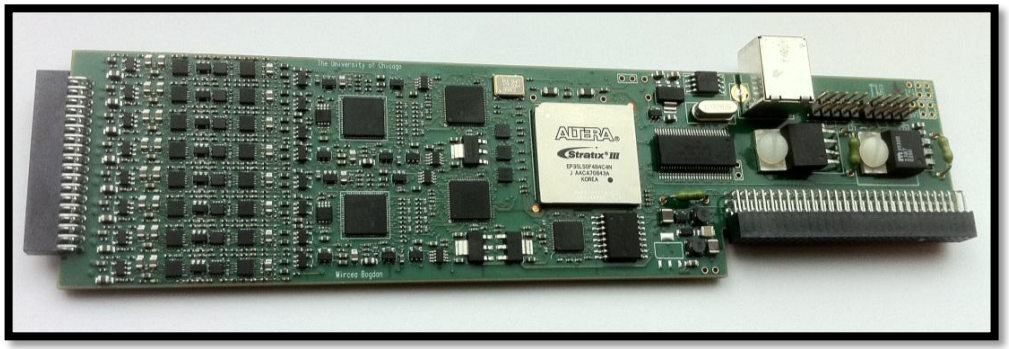
- a small size prototype (e.g. WARP 2.3 l) with mass ≈20 g not difficult

- in parallel, explore the continuous diffusion cloud chamber approach
  Refurbish Fermilab commercial cloud chamber, test at MINOS underground site



Detectors in other KICP areas

- High-density, High-speed (5 Gs/s) electronics for Cherenkov Telescope Array,
  Mechanics and Camera integration of first US telescope prototype, ANL



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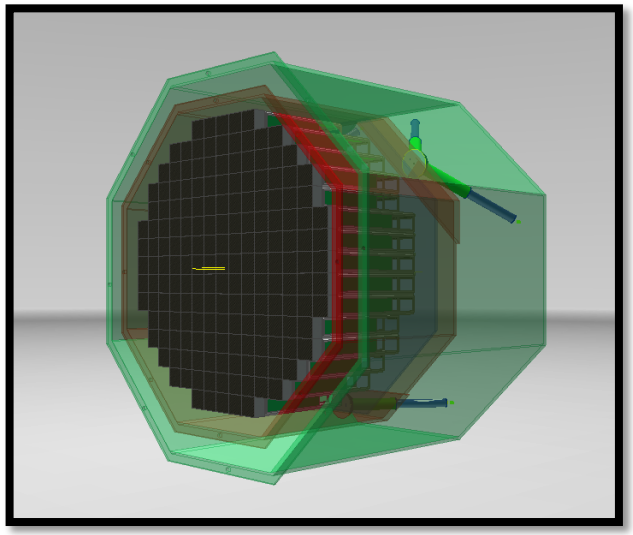


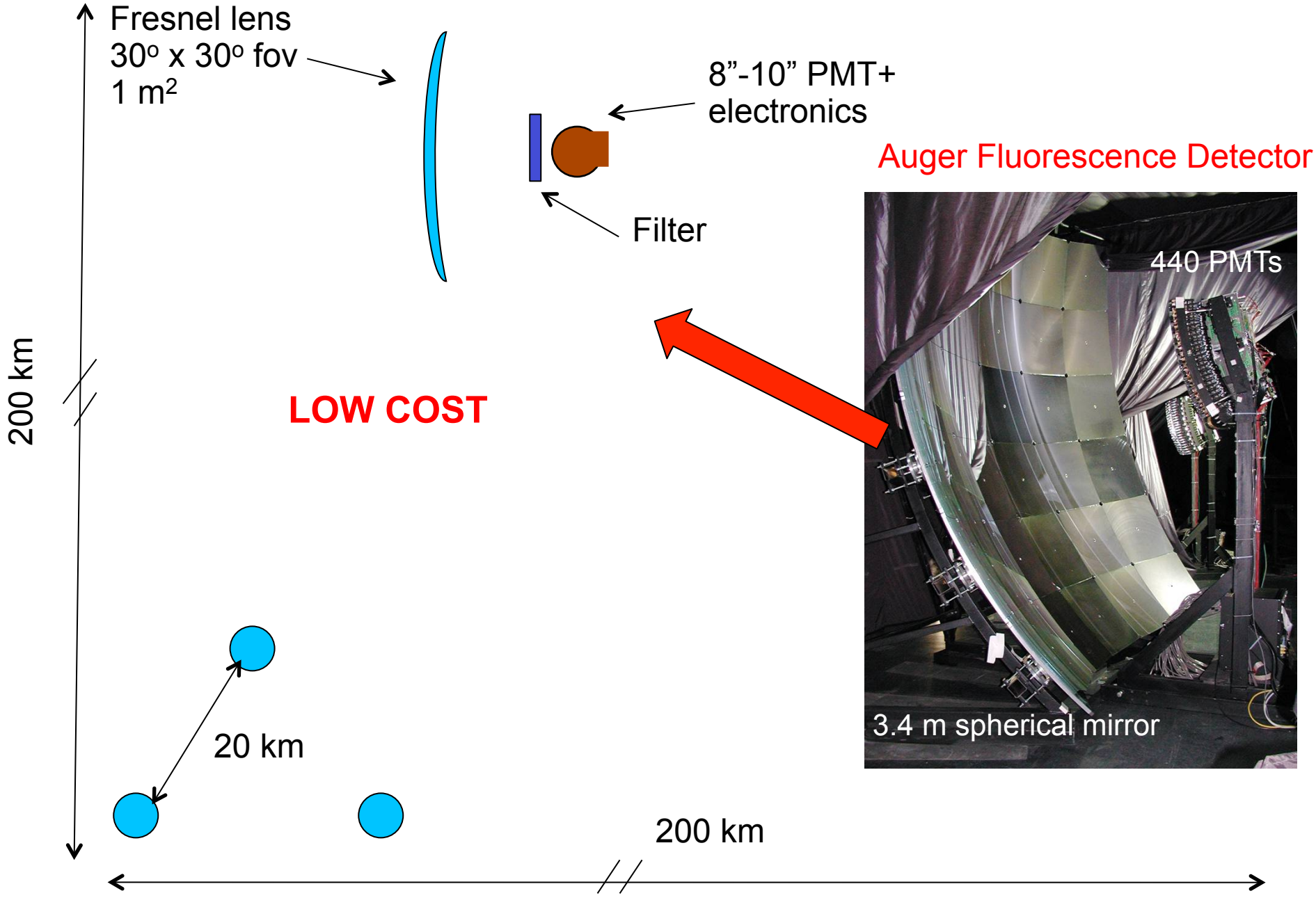
Microwave Imaging Cosmic Ray Antenna

Privitera

- Microwave emission from high energy cosmic rays. Test at the Green Bank National Radio Observatory this August

1 GHz analog bandwidth electronics

A 40000 km² FD-array for UHECRs



Outlook

- A strong KICP detector development program is taking shape

- Focus on Dark Matter, Inflation and Dark Energy, but profits from the broader KICP culture

- Development of new Detectors requires time, scale 3-5 years to fruition

- Dark Matter in Chicagoland: unique concentration of techniques, resources, expertise. Leadership in the field. How to best profit of critical mass?