# Dark Matter (WIMP) Direct Detection Instrumentation Needs

## Radiopure materials

Applied to a particular technology

Photodetectors ➔ silicon based (SiPMs, APDs)

low radioactivity vacuum tubes

incremental improvements in solder/base, transparent windows, tube housing

Not just noble liquids
Needed for active shields

Plastic Scintillator ➔ active elements in a neutron/muon veto

Purification of noble liquids & LS

Applied to materials (e.g. Cu, acrylic & poly, lead, components)

Applied to the means of determining radiopurity

New screening techniques – novel ideas

Improvements in HPGe sensitivity

Immersion (CTF) techniques for ultra-sensitive whole body screeners

New $\alpha/\beta$ counters and other techniques sensitive to surface contaminants

ICPMS and other MS techniques – apply to multiple materials

# RADON

Radon Mitigation techniques
- Breathable air in large enclosures
- Assembly areas, storage, handling

Radon plateout detection: beta/alpha counters, other?
sequential ICPMS
removal: cleaning methods, electropolishing

# Calibration

Internal spiking of liquids
surface implantation sources

Neutron sources
- beamlines, “howitzers”, deuterium neutron guns,
- monoenergetic, low energy photoproduction neutron sources
- broad spectrum neutron sources.

# Neutron Detection, Shielding

## Neutron Veto/Monitors

- Increase neutron capture cross section
  - Compare or improve Gd vs B vs Li in an active medium
  - Thermalize neutrons (highA + hydrogenous, Pb-loaded scintillators)
  - Pulse shape discrimination and other neutron identification schemes
- Increase light yield
  - Again, photodetectors needed to read it out
- Modular solid alternatives to LS

## Neutron benchmarking detectors

- Needs to be large and run for a long time, muon tracking
- looks like a standalone neutron veto
- similar to reactor (and reactor monitoring) neutrino detectors
- Bonner spheres and other techniques to get spectral information at all energies

## Umbrella muon veto

- Cheap ways to cover a large area

## Water tanks/Cerenkov/Purification

# Dark Matter by Technology

Can this still be "generic"?

What happens when we are all on the same experiment – is it generic then?

Bring the lists out in the open - might find synergies with other HEP projects

## Cryogenic Solid State

- Scale to large masses
  - Signal multiplexing
  - MKIDs and other readout options
  - Mass production = ties to industry or homeland security?
  - low noise SQUIDs, FETs
  - digital signal processing/FPGA for multiplexing
  - high density cryogenic cabling
- Very large Silicon detectors (also X-ray detectors, coherent neutrino detection)
- Dislocation-free Ge/Si
- Ge crystals underground (incl detector assembly)
  - avoiding industry bottleneck
- Optimize cryogenic sensors for detection of very low energy depositions

## 77K Germanium

Lower noise/capacitance, Better energy resolution, combine with $0\nu\beta\beta$

## Noble Liquids

Development of higher efficiency, lower background photosensors

totally new technology would be a game changer- HUGE area and cheap ??

Determination of scintillation efficiency versus electric field at low energy

Bolometric readout of superfluid helium scintillation and triplet excimers, for light WIMPs.

High voltage should be separated into two R&D problems, each very important:

a) high voltage delivery into noble liquids

b) suppression of electroluminescence at high cathode voltages.

Liquid phase purification of noble liquids, including nitrogen removal

Single electron detection in gas or liquid helium (for light WIMP detection).

Gas bubble sensing.

## Superheated liquid detectors

Development of new target liquids: e.g C3F8

Alternative mechanisms for re-liquifying bubbles, achieving smaller dead time.

"Geyser" scheme being studied by PICASSO groups, U. Milan Bicocca.

Low radioactivity acoustic sensors with improved reliability, smaller size.

New materials for inner vessel (plastic?).

Must not nucleate bubbles, must be transparent, low in radioactivity, chemically compatible with target liquids.

## Inorganic Crystals

Purification of materials and of production (NaI, CsI)

Investigation of new crystals

## Directional detection

Liquid/solid detectors with directional discrimination

Making gas detectors huge but cheap (and keeping head-tail discrimination)

Boost low energies of low mass WIMPs with light target mass (e.g. $HeCO_2$)