Status of CoGeNT/C-4 & COUPP/PICO

J.I. Collar, U of Chicago
CoGeNT generalities

* P-type Point Contact HPGe: Testing DAMA/LIBRA by reducing detector threshold (<10 GeV WIMP mass region)

* Applications at higher energy in $0\nu\beta\beta$ (MAJORANA, GERDA): excellent rejection of $\gamma$ bckgs (multiple vs. single site events).

* Discrimination against surface bckgs via PSD, down to $\sim$0.5 keVee threshold.

* Excellent detector stability: five year continuous data-taking, and counting.

* Small bulk event excess near threshold. Low-significance annual modulation in same region, restricted to bulk events. Phase compatible with DAMA/LIBRA. Amplitude is 4-7x larger than expected from standard halo WIMPs.
C-4: coming up very soon
(x10 mass, 1/3 noise, >10x bckg reduction)

* First C-4 detector features 
  ~1/3 of the noise of the 
  existing GoGeNT detector, at 
  ~x3 its mass (1.3 kg)

* Not a one-off: its noise 
  characteristics are now 
  reproducible (CANBERRA R&D 
  supported by NSF award 
  PHY-1003940). Second detector 
  expected to reach the same 
  noise figure at 2.7 kg, the 
  realistic PPC maximum.

* C-4 aims at a x10 total mass 
  increase, ~x20 background 
  decrease, and substantial 
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Design and assembly of ULB cryostat at PNNL
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C-4 to give superCDMS a run for (~1% of) their money

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Last week: side-to-side with 1st PPC (2005)

(this, or confirm modulation at 5σ in 1 year)
A search for WIMPs and tests of local dark matter velocity distributions with the CoGeNT public dataset

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\textsuperscript{2}University of Utah
\textsuperscript{3}University of Chicago

April APS meeting, Savannah, GA
April. 7\textsuperscript{th}, 2014
Apply templates to data, let parameters float within uncertainties.

Lock down these values in PDFs for later fits.
Backgrounds

Surface events
Slow-pulse L-shell decays
Mostly constrained by K-shell

Neutrons $\left( \frac{n}{n} + \frac{n}{n} \right)$
Muon flux is known

Comptons
Resistors, cosmogenically activated isotopes

Total
Good fit to the data!

M. Bellis April 2014
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**Comptons**

*Resistors, cosmogenically activated isotopes*

**Total**

*Good fit to the data!*
$M_{\text{WIMP}} = 10 \text{ GeV}/c^2$ WIMP signal in Germanium, assuming SHM.
 Streams

Non-thermalized streams of baryonic and dark matter.
$M_{\text{WIMP}} = 15 \text{ GeV}/c^2$ WIMP signal in Germanium, assuming Sagittarius stream ($v=200 \text{ km/s}$, $v_o=25 \text{ km/s}$)
Highlights of ongoing global 2D (energy, time) analysis

• Bulk and surface PDFs derived from simulated data, and separately from electronic pulser. Smooth evolution of PDF parametrization with energy (this required high-enough statistics). Compatible with no low-energy excess in the first case, but excess of low-energy bulk events remains for 2nd.

• Hard to fit a standard halo WIMP to 2D data. This was expected from large magnitude of modulation (and now from superCDMS germanium results...)

• No better luck with DM streams tried.

• Modulation seems concentrated under L-shell EC peaks (?!). Similar to DAMA/LIBRA? Interesting unconstrained possibilities under study (axioelectric DM, in medium environmental effects in EC).

• 5 year data release December 2014 (possibly final, if C-4 in place) should improve sensitivity of this analysis. To be applied ab initio to C-4.
Annual modulation: not a monopoly of WIMPs

A rough decision table:

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Searches for exotica: easy as pie.
Bubble Chambers for Dark Matter

Alan Robinson
PICO Collaboration

CAP Congress  Jun 18, 2014
PICASSO & COUPP at SNOLAB

**PICASSO**
- PICASSO-32
  - Last data Dec '13
- Geyser Detector R&D

**COUPP**
- COUPP-4kg with $\text{CF}_3$
  - PRD 86, 052001 (2012)
- COUPP-60 first run
  - Last data May '14
- COUPP-60 upgrades
- PICO-2L with $\text{C}_3\text{F}_8$
  - Last data May '14
- PICO-250L
- PICASSO-32
  - Last data Dec '13

Last data May '14
Why Bubble Chambers?

They're Scalable

- 2005: First COUPP prototype
- 2007: 1-L bubble chamber
- 2009: COUPP-4 kg at FNAL
- 2010: COUPP-4 kg at SNOLAB COUPP-60 at FNAL
- 2013: COUPP-60 at SNOLAB PICO-2L
- 2016: PICO-250?
Why Bubble Chambers?

Impressive Background Rejection

Acoustic Alpha Discrimination

Gamma Interaction Insensitivity

Multiple Neutron Scattering

Preliminary
Why Bubble Chambers?

Spin-dependent & Low mass
Ability to change target fluid
Radiation induced boiling of superheated fluid.

\[ P_g - P_l = \frac{2\sigma}{R_c} \]

\[ Q = \frac{4\pi}{3} r_c^3 \rho_b (h_b - h_l) + 4\pi r_c^2 \left( \sigma - T \frac{d\sigma}{dT} \right) \]

**Surface Formation**

**Latent Heat**

**Bubble Chamber operation cycle**

- **Meant expansion time, 39.0°C**
- **36.2°C**
- **33.5°C**
- **Max expansion time**

**Boiling Point** (33.5°C, 90 psia)
How it works

100fps stereo images

Pressure and Temp monitoring

Fast Pressure Transducer

Acoustic Transducers
How it works

Alphas are ~4 times louder than nuclear recoil bubbles.

>99.4% discrimination against alpha events demonstrated.

Observable bubble ~mm

~50 nm

Daughter heavy nucleus (~100 keV)

~40 μm

Helium nucleus (~5 MeV)
COUPP-4kg at SNOLAB

- First run deep underground.
- Demonstrated 99.4% alpha discrimination

Backgrounds

- \((\alpha,n)\) neutrons from components
- Time-clustered events.
Operational success:

- 10x more massive
- (35 kg of CF$_3$I)
- > 80% live fraction
- No multiple bubble events from neutrons
- Acoustic discrimination confirmed in large chamber
- > 3000 kg-days DM search data collected.
- Time-clustered background:
  - Correlated with temperature ramp
  - Spacially clustered around outside of active volume.
  - Anomalous acoustic power

![Graph showing acoustic power parameter calibration neutrons and recoil-like background](image)
• Suspect background from dust.

• Next steps:
  ► Assay target fluid for particulates.
  ► Installation of in-situ fluid filtration system.
  ► Elimination of sources of particulate
• $C_3F_8$ filled:
  ▶ Lower threshold
  ▶ Spin-dependent sensitivity
  ▶ Chemically inert

- >300 kg-days exposure.
- Run completed in May.
- Acoustic calorimetry.
- Designed for 250L of $\text{C}_3\text{F}_8$ or $\text{CF}_3$ target fluid
- Awaiting funding decision (DOE G2)
- Engineering of components underway