The IceCube Canada research program

Core analysis efforts:
- measurements of “low-energy” neutrinos including precision extraction of the atmospheric neutrino flux, atmospheric neutrino oscillations, indirect dark matter searches
- studies of the “high-energy” diffuse neutrino flux
IceCube

- 78 Strings
- 125m string spacing
- 17m DOM spacing

IceCube (top centre view)

- Add 8 strings
  - 75m string spacing
  - 7m DOM spacing
- Add 40 strings (baseline target)
  - ~20m string spacing
  - ~3-5m DOM spacing
- ~15x higher photocathode density
IceCube diffuse working group convened @ U. Alberta; Simulations and analyses completed on Compute Canada

Starting Event Spectrum

MSc Student
S. Sarkar

IceCube Preliminary

Events per 2078 Days

Deposited EM-Equivalent Energy in Detector (TeV)
IceCube Preliminary

Starting Event Spectrum

Astrophysical Muon Neutrinos (northern sky)

IceCube diffuse working group convened @ U. Alberta; Simulations and analyses completed on Compute Canada
IceCube

The IceCube diffuse working group convened at U. Alberta; Simulations and analyses were completed on Compute Canada.
IceCube

- 78 Strings
- 125m string spacing
- 17m DOM spacing

IceCube (top centre view)

- Add 8 strings
  - 75m string spacing
  - 7m DOM spacing
- Add 40 strings (baseline target)
  - ~20m string spacing
  - 3-5m DOM spacing
  - ~15x higher photocathode density
IceCube-DeepCore

- 78 Strings
- 125m string spacing
- 17m DOM spacing
- Add 8 strings
- 75m string spacing
- 7m DOM spacing

IceCube-DeepCore top view

---

10 MeV 100 MeV 1 GeV 10 GeV 100 GeV 1 TeV 10 TeV 1 EeV
precision atmospheric neutrino oscillations

IceCube Preliminary

PhD Student
S. Nowicki

IceCube oscillations working group convened @ U. Alberta; Simulations and analyses completed on Compute Canada
IceCube-DeepCore

Indirect Dark Matter Searches

IceCube Preliminary

IceCube oscillations working group convened @ U. Alberta; Simulations and analyses completed on Compute Canada
Indirect Dark Matter Searches

IceCube Preliminary

\[ \sigma_{\chi-p}^{SD} [\text{cm}^2] \] vs \( m_\chi [\text{GeV}] \)

IceCube oscillations working group convened @ U. Alberta; Simulations and analyses completed on Compute Canada.
In addition to the core IceCube analyses, Canada has established leadership in the next generation (Gen2) developments of the IceCube facility.

New elements of IceCube-Gen2:
- PINGU (low-energy)
- HEA (high-energy)
- Surface veto

Total IceCube-Gen2 value $O(IceCube \, w/inflation)$
IceCube-Gen2 developments

- Gen2 Phase 1 proposal submitted to CFI, NSF and BMBF Fall 2016. Results expected Spring/Summer 2017.

- 25 x 3” PMTs
- Uniform angular coverage
- Digital photon counting
- All data to surface; satellite transfer

- CAPSTONE CFI ($23.2M, under review) provides the collaboration’s first large-scale facilities to design, develop, produce and test multi-PMT modules for the initial strings of Phase 1 and for NuPRISM
IceCube-Gen2 developments

- Gen2 Phase 1 proposal submitted to CFI, NSF and BMBF Fall 2016. Results expected Spring/Summer 2017.
  - 25 x 3" PMTs
  - Uniform angular coverage
  - Digital photon counting
  - All data to surface; satellite transfer

- CAPSTONE CFI ($23.2M, under review) provides the collaboration’s first large-scale facilities to design, develop, produce and test multi-PMT modules for the initial strings of Phase 1 and for NuPRISM
IceCube-Gen2 developments

- Gen2 Phase 1 proposal submitted to CFI, NSF and BMBF Fall 2016. Results expected Spring/Summer 2017.
  - 25 x 3" PMTs
  - Uniform angular coverage
  - Digital photon counting
  - All data to surface; satellite transfer

- CAPSTONE CFI ($23.2M, under review) provides the collaboration's first large-scale facilities to design, develop, produce and test multi-PMT modules for the initial strings of Phase 1 and for NuPRISM

precision measurements of muon neutrino appearance
IceCube-Gen2 developments

- Gen2 Phase 1 proposal submitted to CFI, NSF and BMBF Fall 2016. Results expected Spring/Summer 2017.
- 25 x 3" PMTs
- Uniform angular coverage
- Digital photon counting
- All data to surface; satellite transfer

- CAPSTONE CFI ($23.2M, under review) provides the collaboration’s first large-scale facilities to design, develop, produce and test multi-PMT modules for the initial strings of Phase 1 and for NuPRISM
The program continues growing

- Currently 6 faculty (Alberta, SNOLAB) @ 3.7 FTE, 2 PDFs, 1 Banting Fellow, 3 PhD students, 2 MSc student, 5 summer students

  - See talks by Sarah Nowicki, Chris Weaver and Tania Wood this week

Some group highlights since 2015

- PhD Student **Sarah Nowicki** (2015/6) and PDF **Chris Weaver** (2016/7) selected as 1 of 5 austral summer on-site leads (South Pole Station).

- **Kopper** awarded **IUAPP Young Scientists Prize** in Astroparticle Physics (August 2015)

- **Kopper** awarded CFI JELF for the *illume* GPGPU cluster ($500,000 total value, March 2016)

- **Grant** and **Krauss** awarded share of **2016 Breakthrough Prize** in Fundamental Physics (November 2015)

- **Grant** awarded University of Alberta **Faculty of Science Research Prize** (April 2016)

- **Yanez** awarded **NSERC Banting Fellowship** (February 2016)

- **Grant** awarded **NSERC E. W. R. Steacie Memorial Fellowship** (February 2017)
IceCube-DeepCore-Gen2 and Canada

• collaboration leadership appointments (since 2015)
  • co-lead future detectors (Grant) (2012 - present)
  • co-convener Diffuse neutrino working group (Kopper) (May 2015 - present)
  • co-convener Low-energy/oscillations working group (Clark) (March 2015 - May 2016)
  • PINGU analysis coordinator (Clark) (March 2015 - present)
  • chair Publications Committee (Grant) (May 2015 - May 2017)
  • IceCube-Gen2 in-ice detector design lead (Kopper) (June 2015 - present)
  • co-convener Low-energy/oscillations working group (Yanez) (January 2017 - present)
  • Collaboration Spokesperson (Grant) (May 2017-present, 2-year renewable term)
• Continued growth of the IceCube Canada program; new initiatives are gaining traction

• Canadian researchers are having impact at the highest levels in the international collaboration

• We remain at the centre of some of the most exciting IceCube discovery analyses. Longterm leadership in the future PINGU and Gen2 projects is firmly established including Phase 1 (NSF reviewer results were excellent; CFI and BMBF proposal results pending)

• Interested in the program? Please contact us!

*background photo: UofA PhD Student Tania Wood - IceCube on-ice calibration lead January 2014