Improving Data Accessibility and System Performance Using PI at SNOLAB

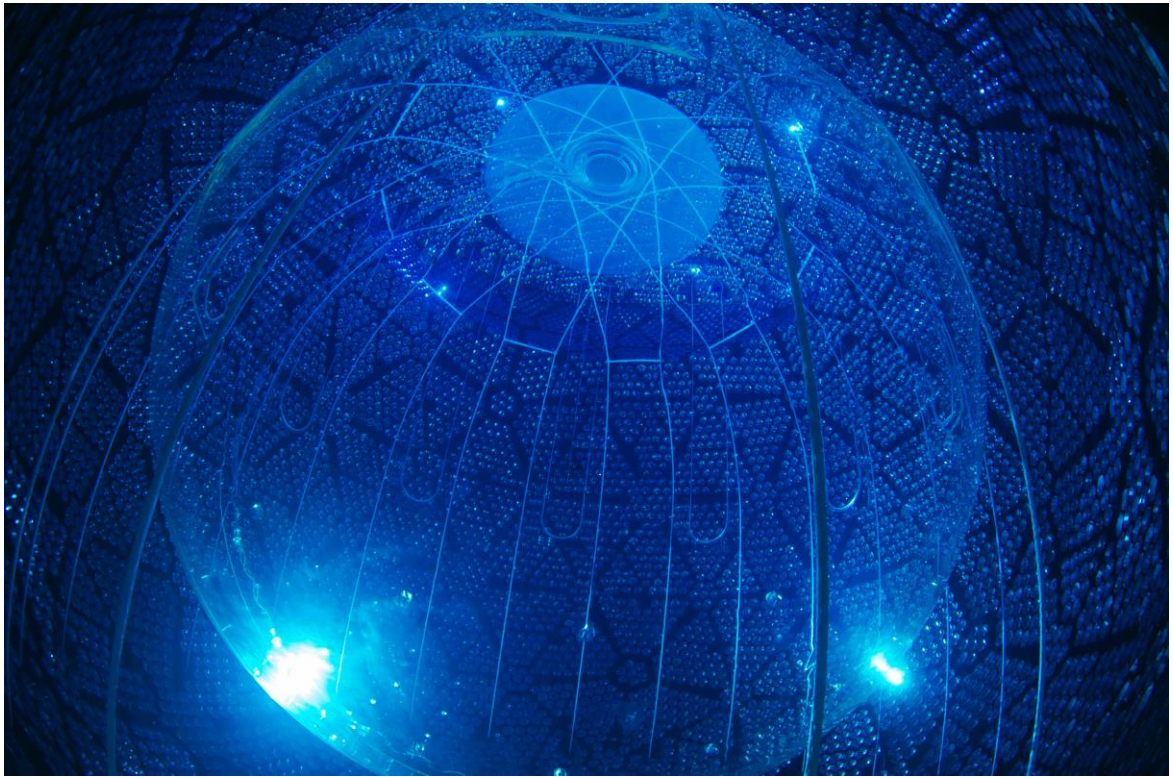
OSIsoft Toronto Regional Seminar

October 17, 2017

Allan Barr

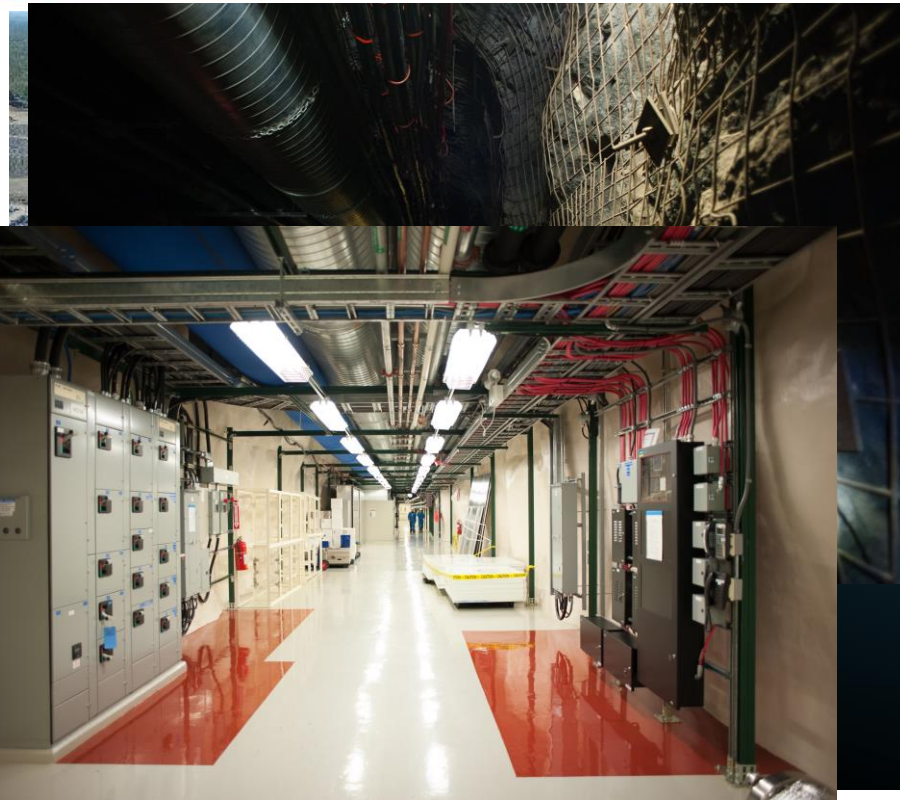
OUTLINE

- SNOLAB Overview
- The Science
- PI @ SNOLAB

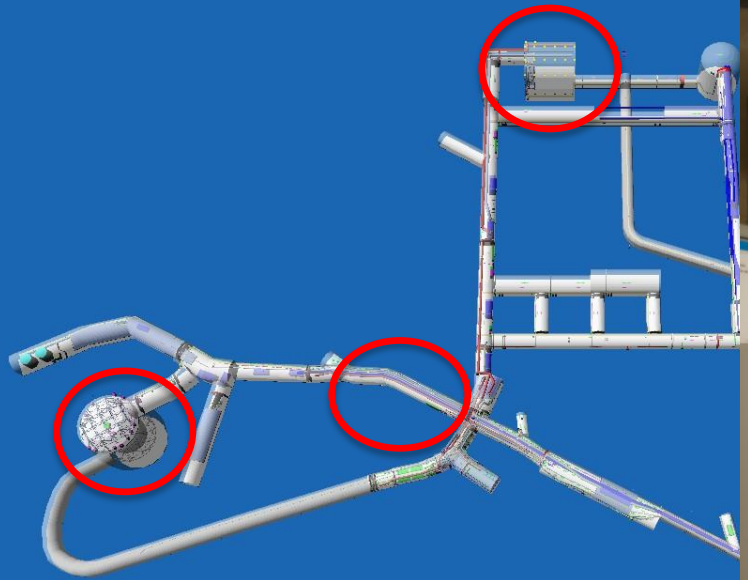


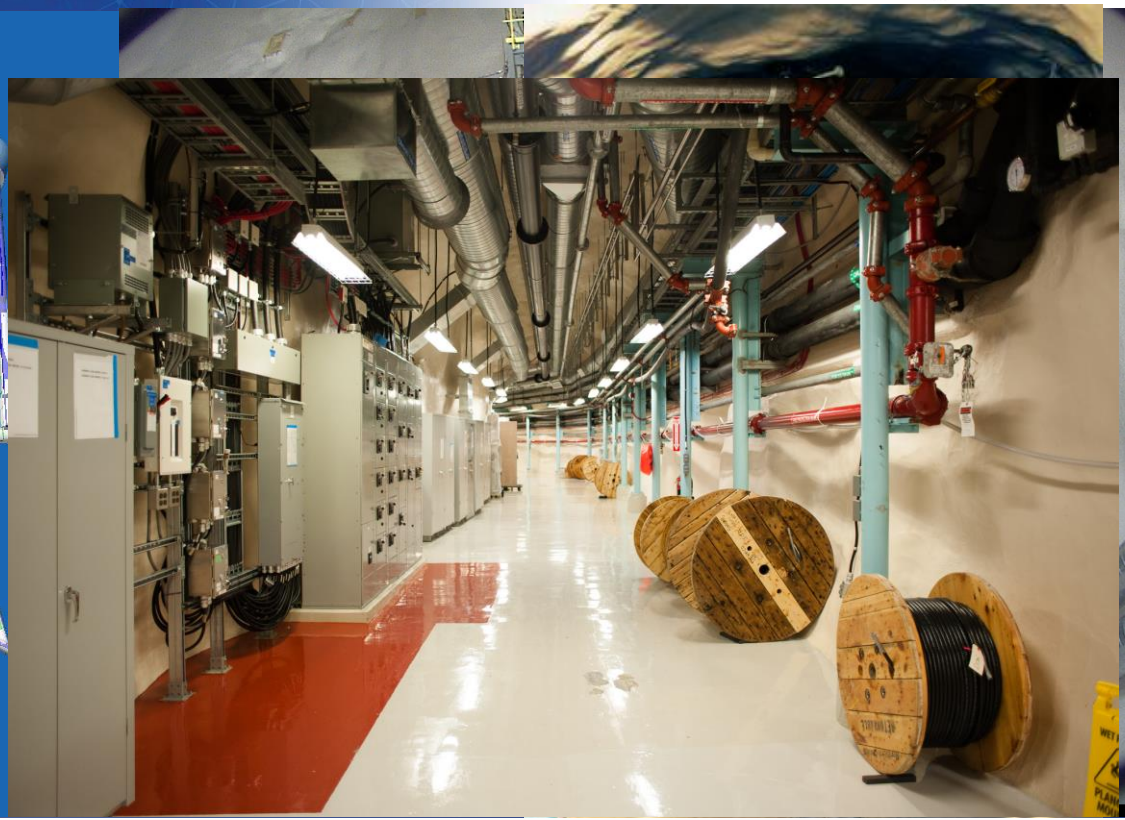
SNOLAB OVERVIEW

- SNOLAB is a deep underground science research laboratory
- Located 2km underground in Vale's Creighton Mine near Sudbury, Ontario
- Operated as a Class 2000 clean lab
- Focus is to conduct physics experiments exploring the fundamental make up of the universe.
- Carried out by constructing and operating 'industrial scale' detectors
- Science program focused on Dark matter searches, Neutrino science, Supernova



SNOLAB OVERVIEW



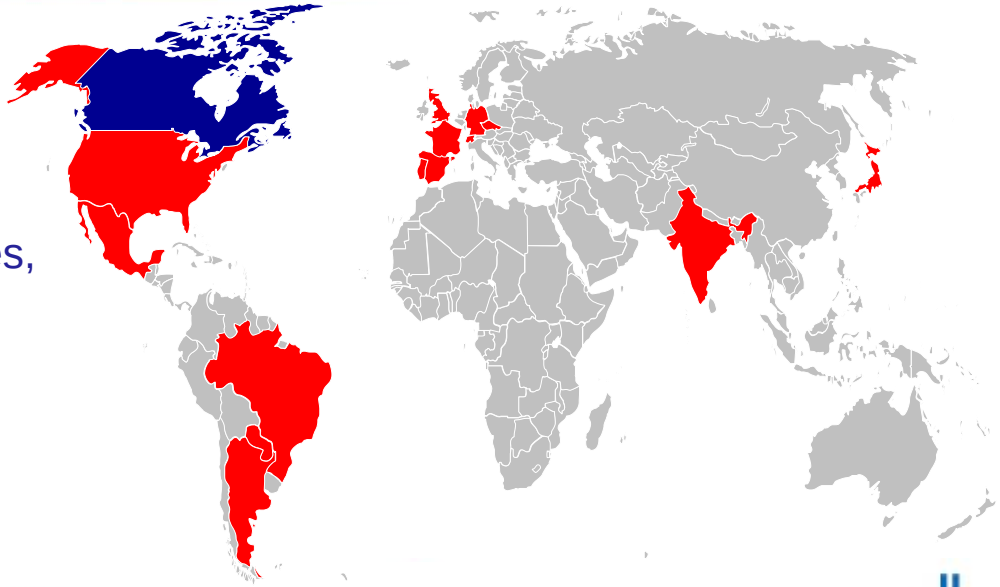


Allan Barr

Date: October 17th, 2017
Project: OSIsoft Seminar

SNOLAB OVERVIEW

- Governed by a board represented by 5 Canadian universities
- SNOLAB consists of ~100 staff
  - Scientists, engineers, cleaners, trades, support services
  - ~40 staff underground everyday
- User base of ~500
  - International collaborations of physicists
  - Technical support staff (engineers, technicians)



Carleton UNIVERSITY
Canada's Capital University

Université de Montréal

UNIVERSITY OF ALBERTA

LaurentianUniversity
UniversitéLaurentienne

Queen's University

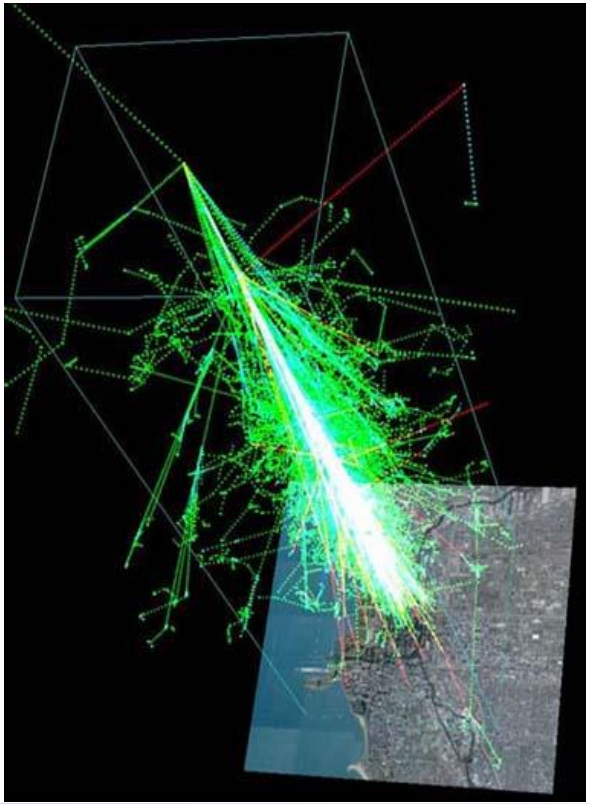
SNOLAB OVERVIEW

Why Underground

- Experiments are very sensitive
- Background radiation (cosmic) introduces unacceptable ‘noise’
- 2km of rock acts as a filter to screen out cosmic radiation
- Neutrinos, dark matter – will essentially pass through unaffected.

Why Clean

- Mine rock contains trace amounts of radiation (U, Th)
- Operate as a large clean room to prevent contamination of experimental components



SNOLAB OVERVIEW

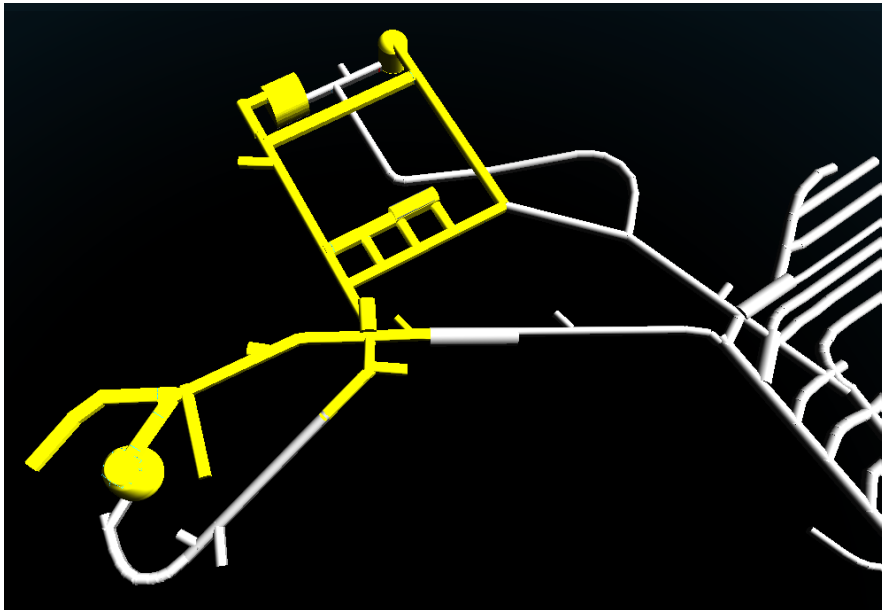
Sudbury Neutrino Observatory (SNO)

- Designed and constructed throughout the 90's
- Experimental operation began in 1999 and ran until 2006
- Purpose built to solve the solar neutrino problem
  - Allowed detection of all types of neutrinos – past experiments were unable to do this
  - Used 1000 tonnes of heavy water ($300M worth)
- Resulted in Dr. Art MacDonald being awarded the Nobel Prize for Physics in 2015
- Success of experiment led to the application to expand the existing facility

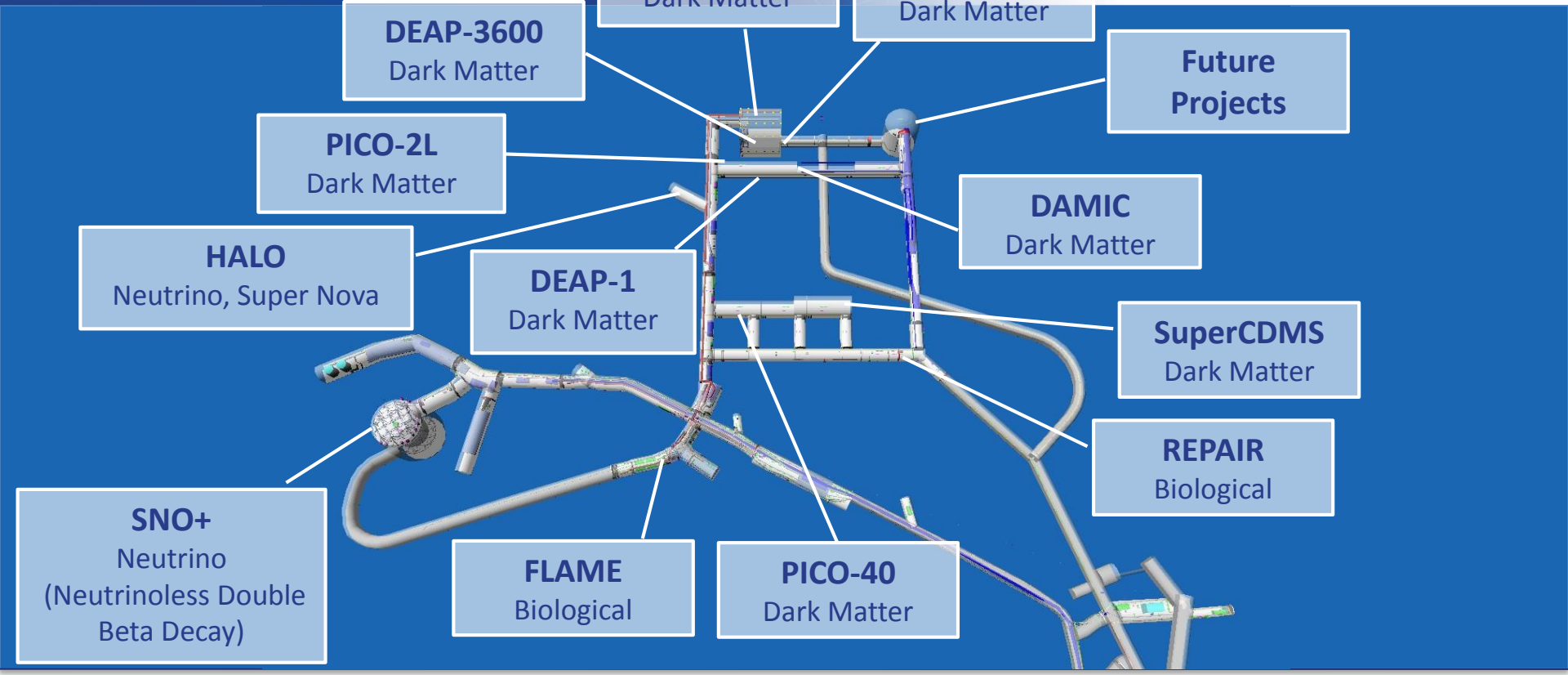
SNOLAB OVERVIEW

SNOLAB

- Evolution from a single experiment into a host facility for multiple international experiments
- Included an expansion of existing facilities
  - Excavation started in 2006
  - New spaces ‘went clean’ by 2010
  - Increased clean space from:
    - 12,196ft^2 to 53,180ft^2
    - 470,360ft^3 to 1,314,973 ft^3
- Currently host to a suite of experiments in various phases of design, construction and operation



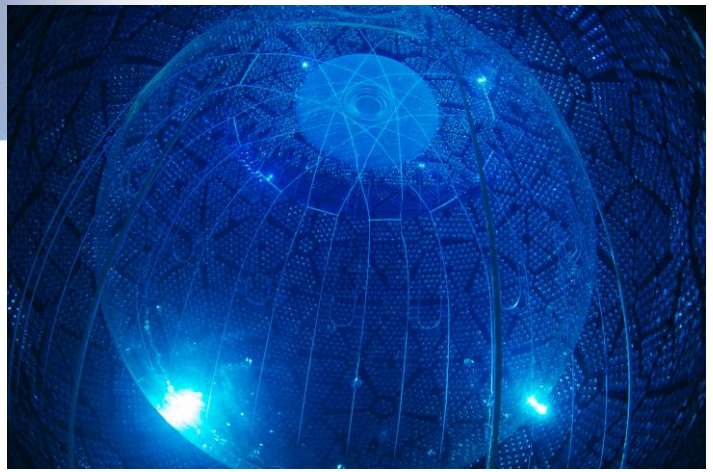
THE SCIENCE


MiniClean
Dark Matter
NEWS
Dark Matter
DEAP-3600
Dark Matter
Future
Projects
PICO-2L
Dark Matter
DAMIC
Dark Matter
HALO
Neutrino, Super Nova
DEAP-1
Dark Matter
SuperCDMS
Dark Matter
REPAIR
Biological
SNO+
Neutrino
(Neutrinoless Double
Beta Decay)
FLAME
Biological
PICO-40
Dark Matter

THE SCIENCE

Neutrino Physics

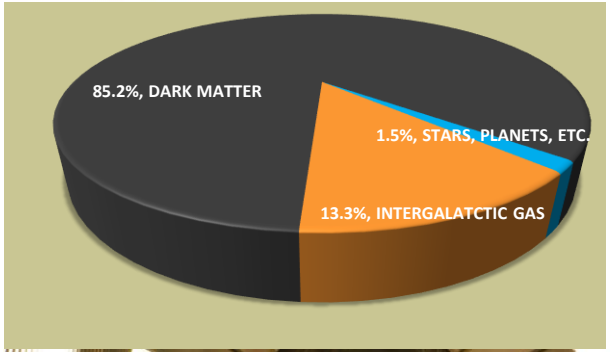
- Original SNO experiment confirmed models of how the Sun burns
- Determined that the Neutrino has a mass – added new physics to the standard model
- Going forward
  - What is the neutrino mass
  - Why is the earth hot – geo neutrinos
  - How do stars explode – supernovas
  - Precision measurements on solar neutrinos
  - Are neutrinos there own anti-particle (neutrinoless double beta decay)

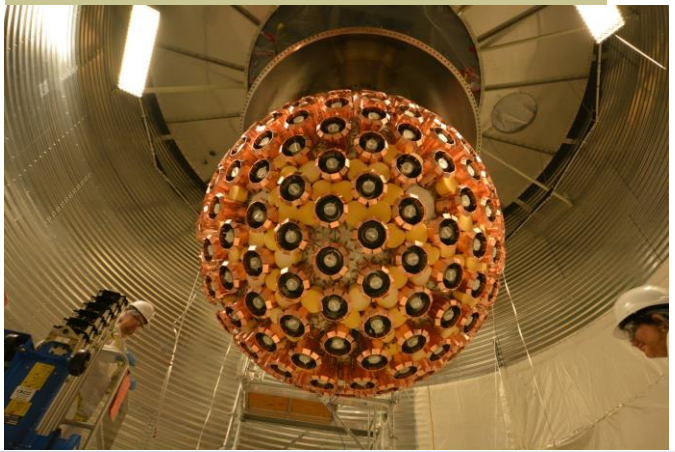


THE SCIENCE

Dark Matter Searches:

- Seeks to answer what the Universe is made of
- Evidence shows that only a small fraction of the Universe consists of standard ‘glowing’ matter.
- Unaccounted for mass is termed ‘Dark Matter’ – doesn’t emit or reflect light
- Candidate particle is termed the **W**eakly **I**nteracting **M**assive **P**article or WIMP for short
- By building large detectors – hope that particles will strike targets and produce detectable signals





THE SCIENCE

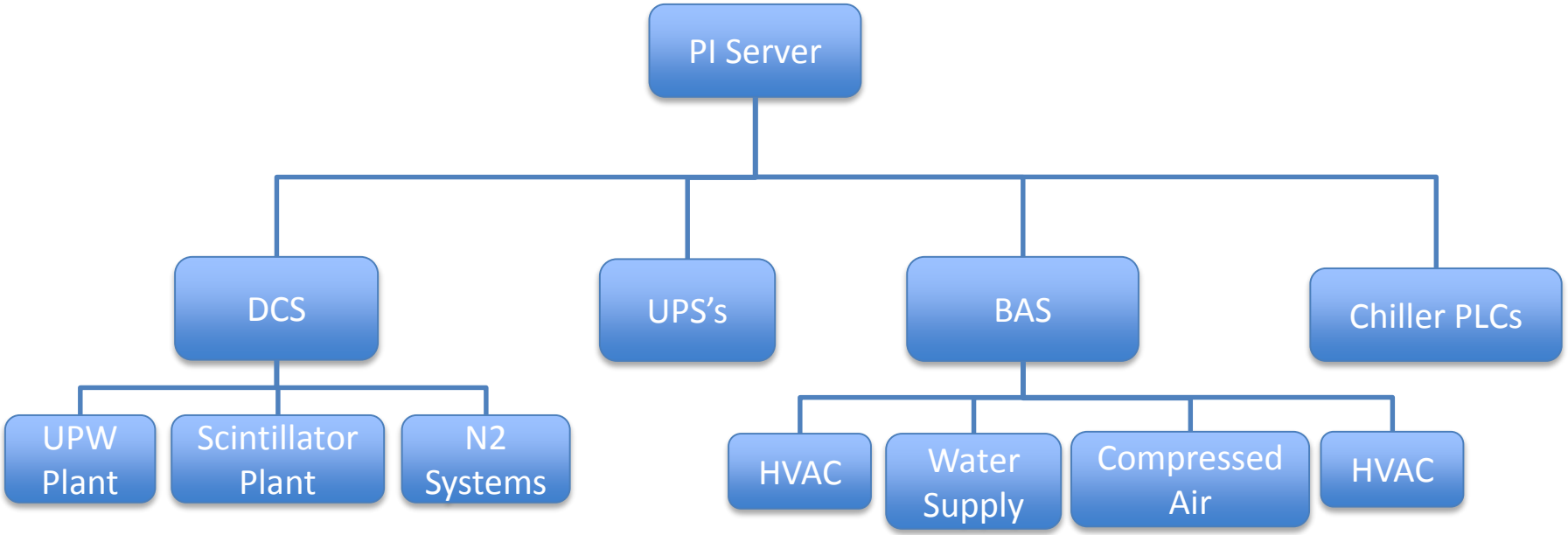
Biomedical Studies:

- Effect of background radiation on cancer rates in cells
  - Studies shown that lose doses of radiation actual provide resiliency against cancerous growths during high dose radiation
  - Extrapolating hypothesis to cells grown in radiation free environments
- Study impacts of travelling underground on fruit fly metabolism – study possible relation to miners

PI @ SNOLAB

- SNOLAB is a sizeable facility with multiple control systems collecting data (BAS, DCS, PLCs, UPSs) in different locations (surface, underground)
- We used to have no easy way to integrate data from all of different systems
- Creating trends or correlations would take hours if not days
- Reached out to OSIsoft in 2012 - Provided a PI Server – currently running at around 2000 tags
- Two main exploitations of our PI systems
  - Process control, optimization and troubleshooting
  - Data availability to experiments

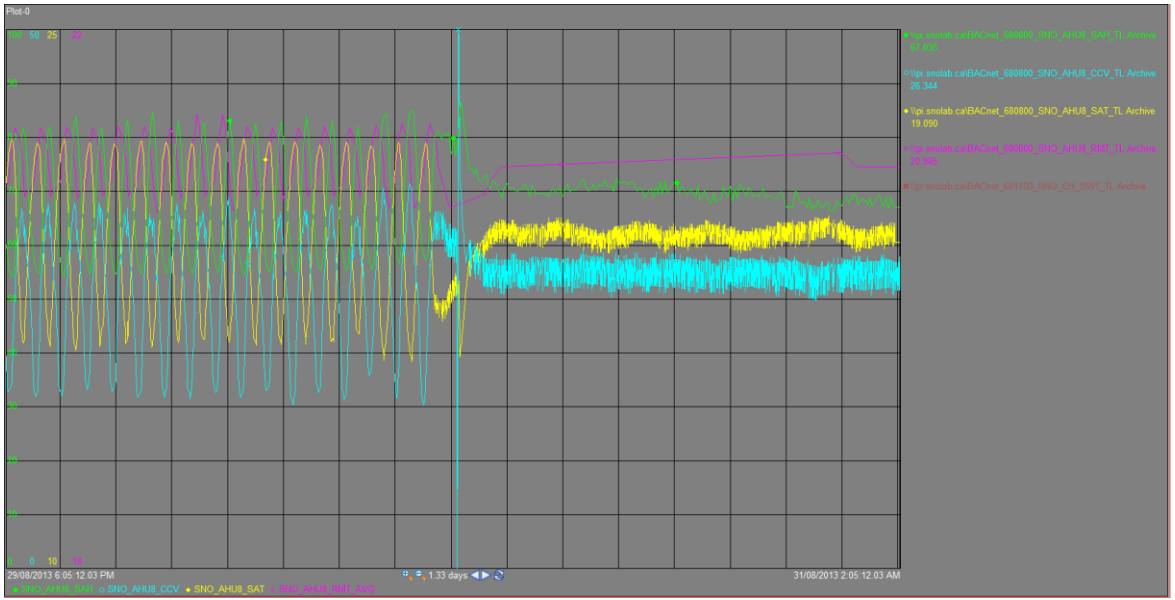
PI @ SNOLAB


PI Server
DCS
UPS's
BAS
Chiller PLCs
UPW Plant
Scintillator Plant
N2 Systems
HVAC
Water Supply
Compressed Air
HVAC

PI @ SNOLAB

Process Optimization

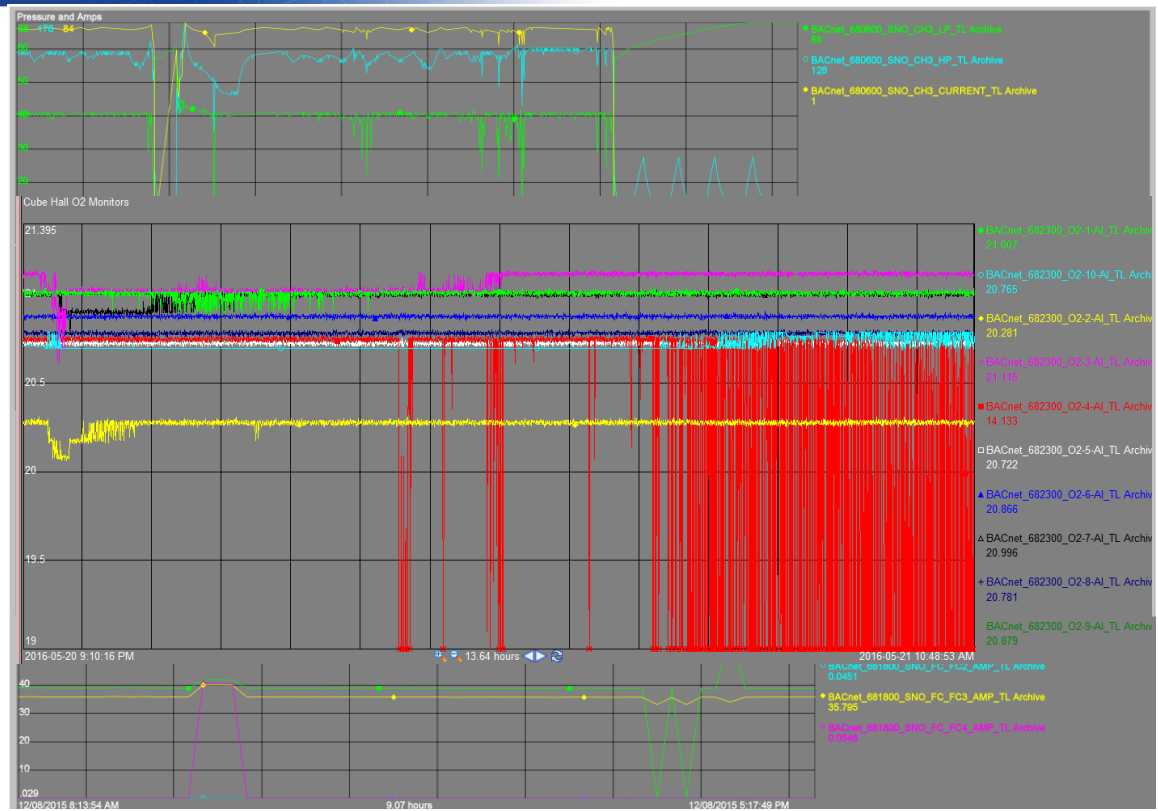
- Use PI ProcessBook and PI DataLink
- The ease of access leads to
  - Noticing problems
  - Solving Problems
  - Increasing system performance and reliability



PI @ SNOLAB

System Troubleshooting

- Diagnosing problems - allow easy preparation of trends
- Off-hour analysis order of magnitude easier
- No remote access to system necessary
- Easily layer relevant tags
- Solve issues or come to conclusions in minutes not hours
- Back to bed sooner than later



PI @ SNOLAB

Data Availability

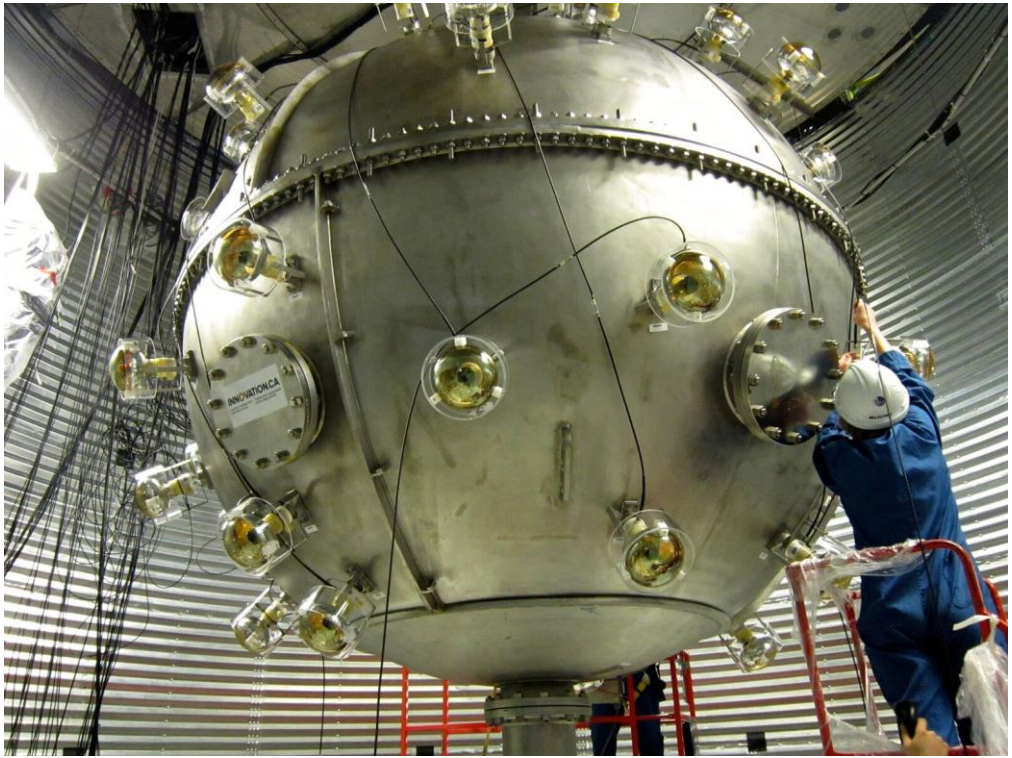
- Experiments are extremely sensitive
- Need to be able to cross reference detector performance to environmental and process data
- Required a solution that provides “Professor Proof” access to data
- Flexible enough to pull data in a specific manner for data analysis
- No drain on SNOLAB resources

```
    def Close(self):
        self.fout.Close()

    def Done(self):
        self.fout.Close()
        print 'Thank you for using PiReader. All data read in as been saved in\n('
        exit()

    def GetAllTags(self):
        # Doesn't display anything to the user. It simply loads the information i
        logging.basicConfig(level=logging.INFO)
        search_url = 'http://pi.snolab.ca/PIWebServices/PISearch.svc?wsdl'
        search_client = Client(search_url)
            # All available PI Tags
        pi_paths = search_client.service.FindPIPathsBasic('pi.snolab.ca', '*', '*
        # don't care of this is deep or shallow copy. Check if you do.
        self.pi_path_list = pi_paths.Path

    def FilterTags(self, filter):
        # Gets all the tags and then runs them through a case INsensitive
        # comparison with the Filter.
        # Example: r.FilterTags("cuBE") will find all tags with "Cube" in the nam
        self.GetAllTags()
        for tag in self.pi_path_list:
            if( str.lower(str(filter)) in str.lower(str(tag)) ):
                print tag[18:]

    def PrintAllTags(self):
        # A straight dump to screen of everys ingle available tag.
        self.GetAllTags()
        for tag in self.pi_path_list:
            print tag[18:]


    def ReadTag(self,tagName):
        rootTagName = re.sub(" ","_",tagName)
        rootTagName = re.sub("-","_",rootTagName)
        rootTagName = re.sub("/","_",rootTagName)

        # Set up ntuple - set name fixme
        # Use URL parser
        nt = TNtupleD(rootTagName,rootTagName,"Y:M:D:h:m:s:dt:value")
        nt.SetMarkerStyle(20+self.readCounter)
        nt.SetMarkerColor(self.readCounter+1)  #+1 avoids white
        # set up pi read
        logging.basicConfig(level=logging.INFO)
        timeseries_url = 'http://pi.snolab.ca/PIWebServices/PITimeSeries.svc?wsdl
        timeseries_client = Client(timeseries_url)
        piarcdatarequest = timeseries_client.factory.create('PIArcDataRequest')
        stringStart = self.startTime.strftime("%Y-%m-%d %H:%M:%S")
        stringStop = self.stopTime.strftime("%Y-%m-%d %H:%M:%S")
        piarcdatarequest.TimeRange.Start = stringStart
        piarcdatarequest.TimeRange.End = stringStop
        piarcdatarequest.PIArcManner._NumValues = '1000000' # Max number of point
        sensorName = self.pi_url + tagName
        piarcdatarequest.Path = sensorName
        requests = timeseries_client.factory.create('ArrayOfPIArcDataRequest')
    requests.PIArcDataRequest = [piarcdatarequest]
        returned_arcdata = timeseries_client.service.GetPIArchiveData(requests)
        icount = 0
    if not hasattr(returned_arcdata.TimeSeries[0], '_UOM'):
            returned_arcdata.TimeSeries[0]._UOM = ''
```

PI @ SNOLAB

Summary

- Our mission is to deliver world class science
- PI facilitates this by:
  - Allowing us to improve the performance and reliability of our systems
  - Minimize the resource load for troubleshooting issues
  - Providing facility and process data to experiments



End.

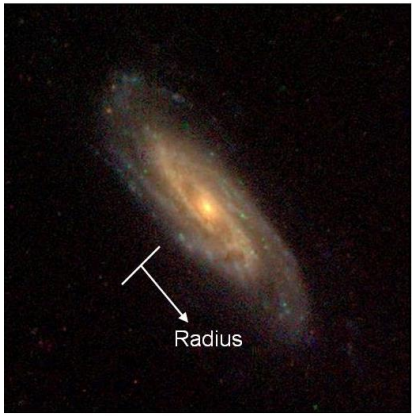
Questions?

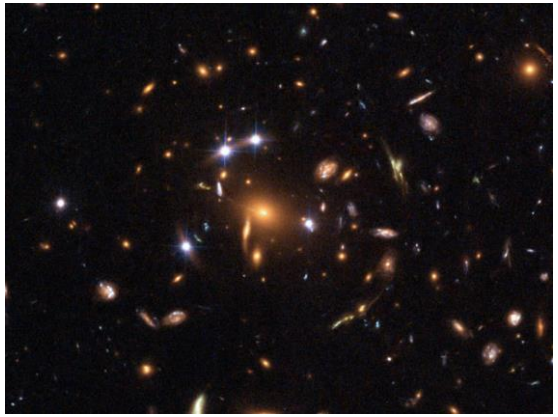
BACKUP SLIDES

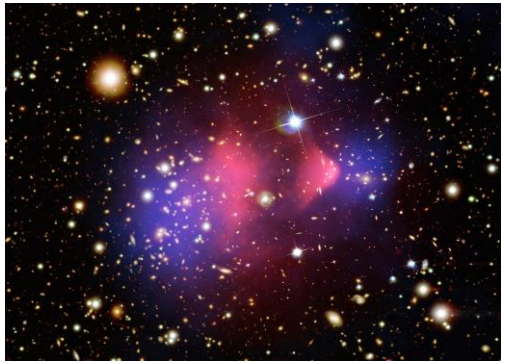
EVIDENCE FOR DARK MATTER

Substantial evidence that dark matter exists:

- Rotational Speed of Galaxies
  - Spinning faster than it should
- Gravitational Lensing
  - Bending light more than it should
- Bullet Cluster
  - After effects of galaxy clusters colliding
  - Visible matter showed signs of collision – gravity centers did not



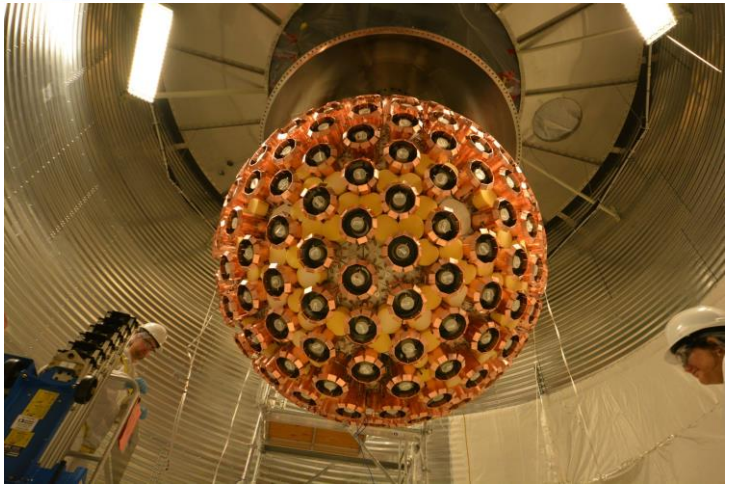




DARK MATTER DETECTION @ SNOLAB

Liquid Argon Target (DEAP/MiniCLEAN)

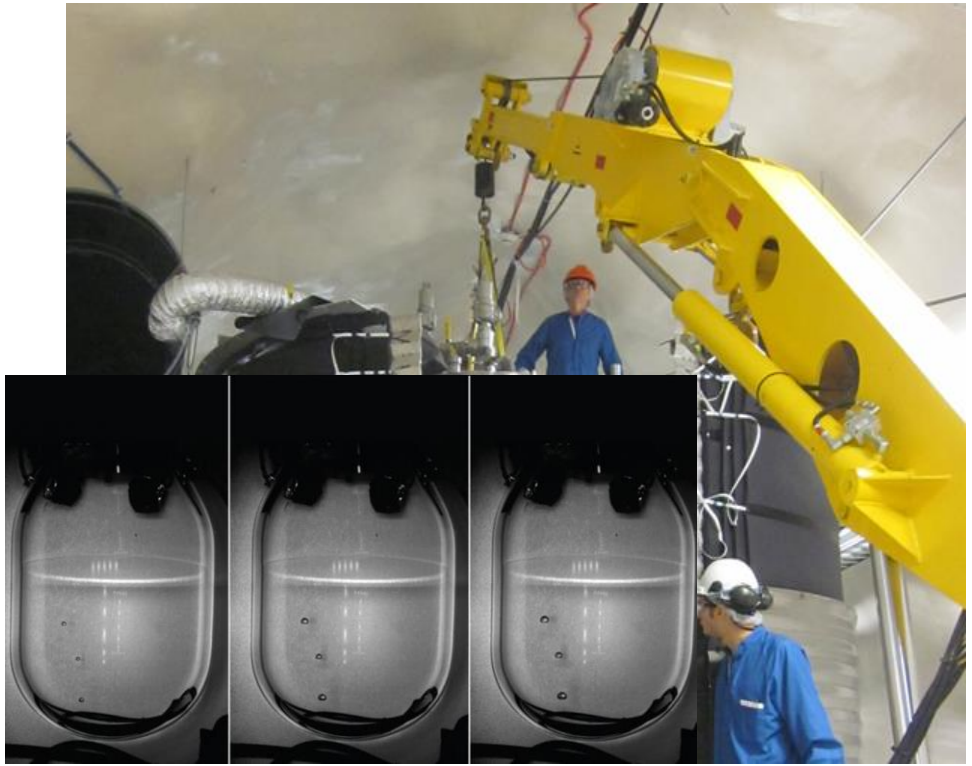
- Dark Matter collision produces nucleous recoil
- Recoil produces light
- Detector surrounded by sensitive light detectors
- Use signal characteristics to screen out background events



DARK MATTER DETECTION @ SNOLAB

Bubble chambers (PICO)

- Superheated fluid in extremely pure container
- Temperature and pressure controlled to bring into superheated state
- The ‘kick’ to cause bubble nucleation comes from dark matter or neutron collision
- Look and listen for bubble formation



DARK MATTER DETECTION @ SNOLAB

Ge and Si Crystals (SuperCDMS)

- Extremely pure Ge and Si act as radiation detectors
- Cool to near absolute zero, shield, and monitor
- Record electrical signal generated

DARK MATTER DETECTION @ SNOLAB

CCD Technology (DAMIC)

- Take pictures of nothing
- Cool to near absolute zero, limit all light and radiation
- In theory the only thing creating tracks is something you don’t understand