

# Subatomic (Particle) Physics in Canada

- The Canadian particle physics community
- Our subatomic physics facilities
- Our particle physics program
- Connections with the international community



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# What is the Institute of Particle Physics

- Founded in forty years ago to:
  - Promote and coordinate particle physics research in Canada
    - \* Operate a Research Scientist programme
    - \* Articulate particle physics priorities in Canada
    - \* Optimise Canadian participation in international collaborations
    - \* Expose young Canadians to the opportunities in particle physics
- Operates as a non-profit corporation owned by institutional members
  - Director & Council responsible for scientific programme
  - Board of Trustees have legal & financial responsibility
- Founded as a foil for TRIUMF's (original) nuclear physics mission
- Partnering with all Canadian stakeholders in particle physics

# The Canadian Particle Physics Community

- 190 researchers from 25 Canadian institutions
- 14 institutional members of the IPP:
  - Alberta, Carleton, McGill, Montreal, Perimeter, Queens, Regina, Simon Fraser, Toronto, TRIUMF, UBC, Victoria, Western & York
- Membership consists of
  - 120 experimentalists (ATLAS, T2K, SNOLAB, smaller experiments)
  - 70 theorists (phenomenology, string theory, formal theory)



- National lab for subatomic physics
- Canada's steward for accelerator physics
- Operates world's largest cyclotron and suite of post-production radioactive beam accelerators
- Have a growing SRF group
  - Building a 1.3 GHz electron linac
  - Funding recently approved
  - Exploring ILC **and** CERN/SPL contributions
- Hosts Canada's LCG Tier1 centre
- Detector expertise (BaBar, ATLAS, T2K)



- Funded in five-year cycles, now secure through 2015

# SNOLAB

- Initial home of SNO experiment
- Cleanroom conditions, at -2000 m
- Expanded lab facilities over the last five years
  - 3-fold increase in volume
  - 4-fold increase in floor space



- Science includes dark matter searches
  - SuperCDMS using solid state detectors
  - PICASSO liquid droplet dark matter search
  - DEAP/CLEAN dark matter search with Liquid Argon
- Neutrino-less double beta decay searches
  - EXO using gaseous Xenon
  - SNO+ with  $Nd$ -loaded liquid scintillator
- Supernova searches
  - HALO using Lead and SNO neutral current detectors



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## Defining the Canadian Particle Physics Program

- IPP projects are vetted by Council to satisfy the following criteria:
  0. Have potential to answer crucial particle physics question(s);
  1. Involve a diverse group of Canadian particle physics researchers;
  2. Have financial support for development/construction/operation or exploitation of a 'full experiment' from Canadian funding agency, not just R&D money;
  3. Be a fully approved part of the experimental programme at the host lab or in the host country;
  4. Complement existing parts of the IPP programme. The Canadian particle physics community is sufficiently small that we are better served by focused efforts on one experiment in each field/area/accelerator.

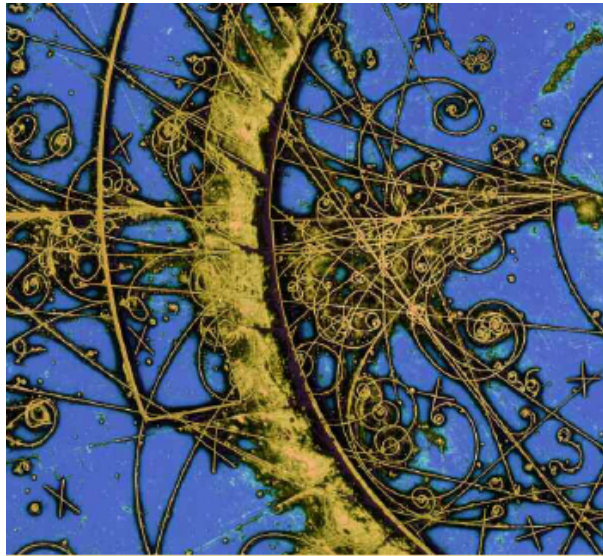
## The Current IPP Programme

Experiment	Data-taking		Investigators	
	Start	End	IPP Scientists	Investigators
ATLAS	2008 (1996)	2020?	3.5	43
BaBar	2000 (1998)	2008	1.5	8
CDF	1992	2011?		3
DEAP / CLEAN	2010 (2008)	2015+		10
EXO-WIPP	2008 (2007)	2010?		8
$\pi \rightarrow e$	2008	2011		8
PICASSO	2004 (2006)	2010+		10
SNO+	2012 (2008)	2015+		11
T2K	2009 (2004)	2015+	2.5	19
ZEUS	1992 (1984)	2007	0.5	3

- Is the IPP programme serving the community?
  - Yes,  $\geq 100$  experimental FTEs (120 experimental faculty)
- We are in the final stages of transition from

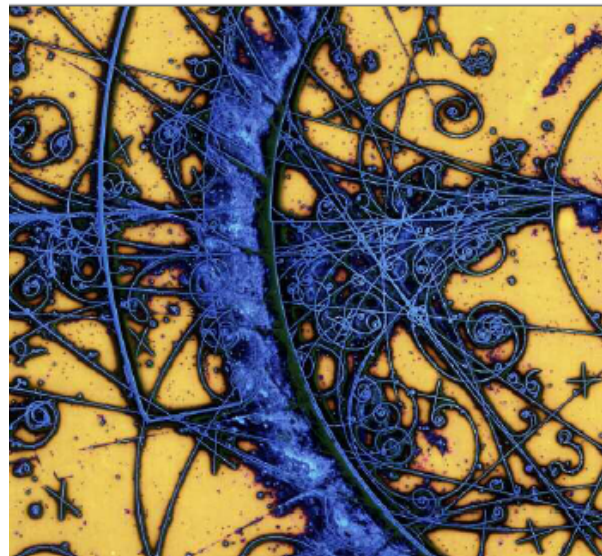
SNO  $\Rightarrow$  Picasso, SNO+, DEAP    &    ZEUS, CDF, BaBar  $\Rightarrow$  ATLAS, T2K

# Canadian Subatomic Physics Long Range Plan



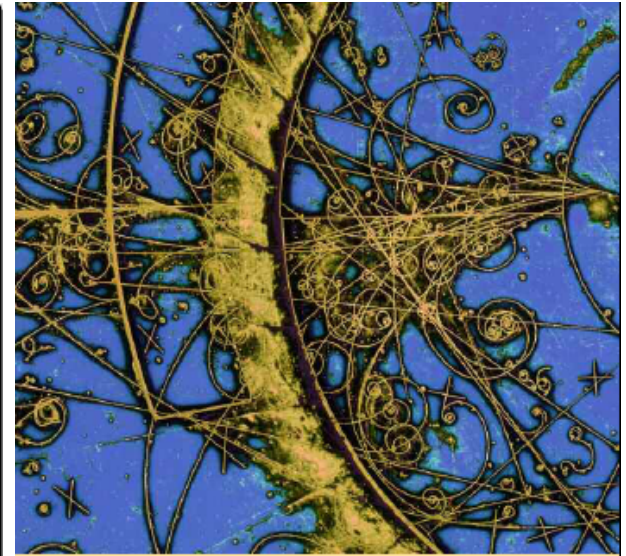
## Perspectives on Subatomic Physics in Canada 2006-2016

REPORT OF THE NSERC  
LONG-RANGE  
PLANNING COMMITTEE



## Exploring the Subatomic Realm

SUBATOMIC  
PHYSICS  
IN CANADA



## Perspectives sur la physique subatomique au Canada 2006-2016

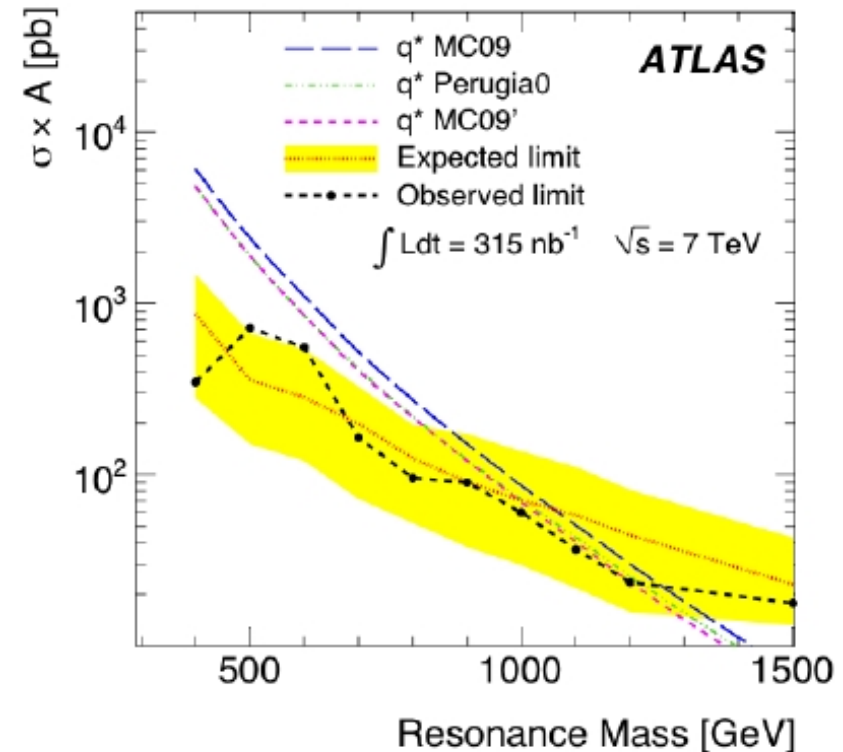
RAPPORT DU COMITÉ  
DE PLANIFICATION À  
LONG TERME DU CRSNG



## Status of our Long Range Plan Projects

- ATLAS: Explore the energy frontier at the LHC
  - Detector contributions complete, first data coming in
  - 40 faculty and 80 postdocs/students  
maintaining detector and studying the data
- SNOLAB: Infrastructure complete
  - SNO+ and DEAP/CLEAN have secured capital funding
  - First measurements in the next few years
- T2K: First neutrinos seen
  - Canadian detector contributions being commissioned
  - Canadians leading physics studies
- TRIUMF/ISAC: Exploiting RIB beams
  - eLINAC capital funding secured and design being completed
- Future: Participating in sLHC and ILC studies
  - TRIUMF SRF expertise will be crucial either way
  - Canadians prepared to contribute strongly to future HEP projects

- 4-5% of ATLAS collaboration
- Incredible start to data-taking
  - Luminosity growing by order of magnitude every month
  - First physics (surpassing Tevatron) emerging
  - Canadians active in all areas
  - Tier1 center active in re-processings
- ATLAS (and ATLAS-Canada) ready for exploit expanding datasets
- TRIUMF collaborating on sLHC injectors
- Canadians leading ATLAS upgrade R&D



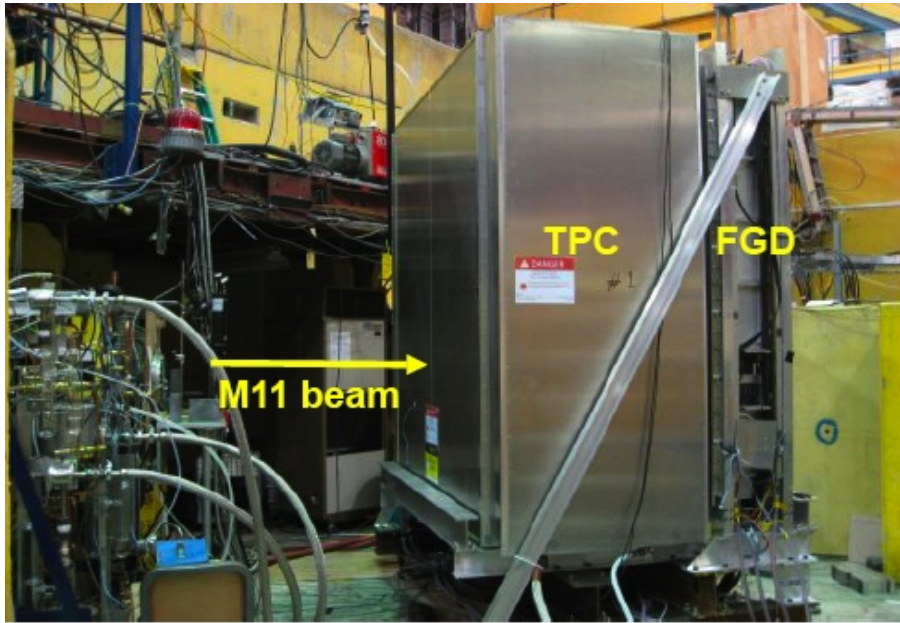
August 2010

- ATLAS-Canada continues to grow (1/2 of eHEP faculty hired in Canada since 2000)

Major commitment of 1/3 of the Canadian particle physics community

# T2K

- Canadians were the first foreign partners to sign original proposal
- Made major contributions to ND280
  - FGD, TPC
  - All modules now installed a JPARC

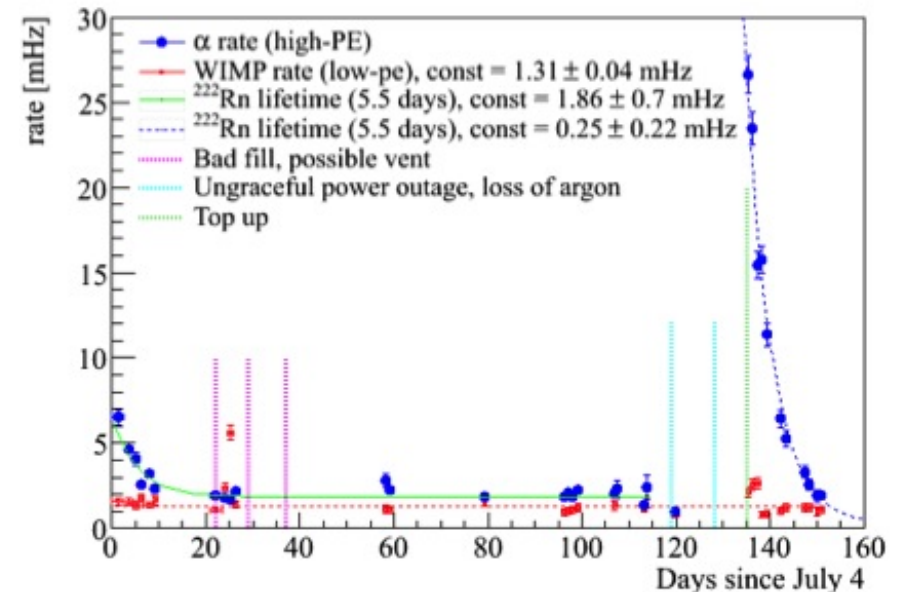


November 2008

- Neutrino beamline commissioning with OTR
    - Beams seen in spring 2009
  - Canadians leading ND280 physics program
  - PhD thesis on cross-section normalisation between near and far detector
- T2K-Canada group:
    - 15 Faculty/scientists and 18 students/postdocs
  - Canadians still largest non-Japanese group on T2K

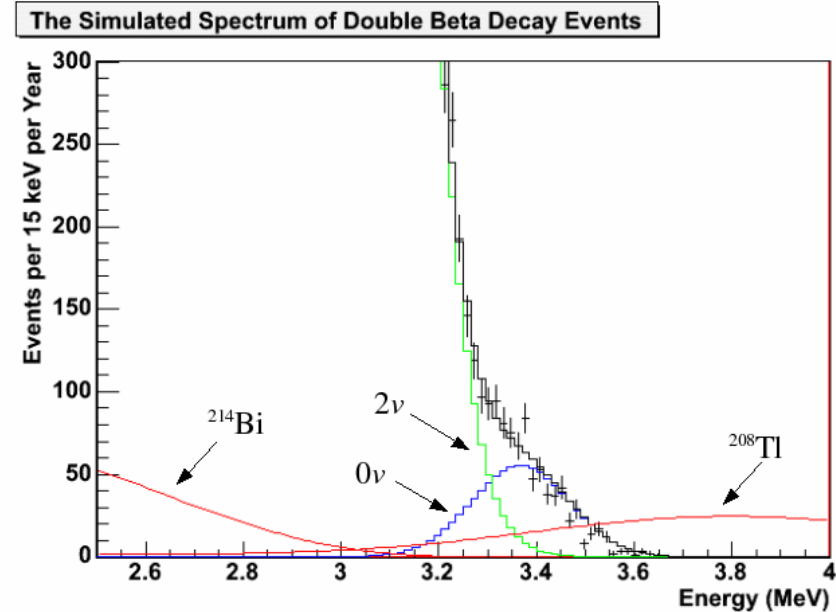
# DEAP

- DEAP uses delayed signal in Liquid Argon to distinguish dark matter candidates from  $e/\gamma$  backgrounds
- 7 kg prototype is operating at SNOLAB
- $3 \cdot 10^{-8}$  photon rejection demonstrated (goal  $10^{-9}$ )
- Seeing radon on surface of acrylic vessel
- Now working to improve cleanliness of surfaces and purity of detector elements
- Funding for 3600 kg DEAP now secured
- Working closely with CLEAN, a US-led (LANL/Yale++) led experiment that will also use Liquid Neon
- Both should be taking data by 2012



## SNO+

- $^{150}\text{Nd}$  loaded liquid scintillator to search for neutrinoless double beta decay
- Significant engineering required to *hold-down* buoyant acrylic vessel
- Have demonstrated transparency of 0.1%  $\text{Nd}$  suspension in scintillator
- Investigating isotope separation to increase active target mass without compromising transparency
- Capital funding recently began to flow 2-year construction underway
- Expect to fill SNO AV with liquid scintillator in early 2012



- Signal from 2 years running (natural  $\text{Nd}$ )

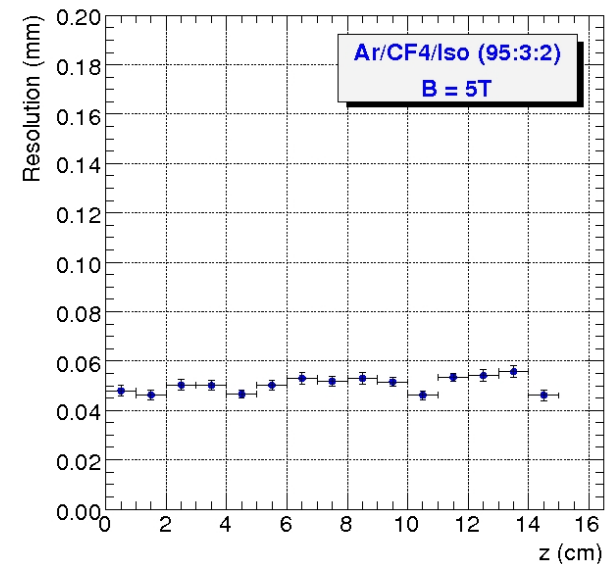
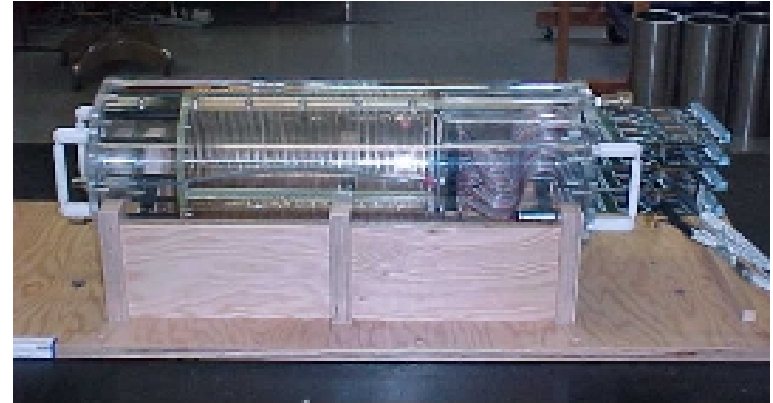
# PICASSO

- Dark matter one of the compelling mysteries
- Search with super-heated droplet technology
- Low activity detector materials are key
- PICASSO steadily increasing mass
- 2.6 kg mass now in SNO service cavern
- Recently discovered a time-correlation that significantly improved alpha/WIMP discrimination
- As a result re-established world's best spin-dependent limits
- At the same time should establish viability of bigger system
- Cooperating with COUPP (Chicago/Fermilab) on next generation



# Linear Colliders

- World-wide consensus – a lepton collider is the next machine to build
- SRF technology chosen for ILC: 2004
- Costed baseline made public: 2007
- Canadians are world leaders in
  - Resistive plate TPC readout
  - Canadian idea developing in Europe
  - Calorimeter design and prototyping
- Both efforts have been used in the T2K near detector
- TRIUMF investigating links with Canadian SRF vendor and building a machine based on ILC/SRF cavities
- With flat funding we have not *properly* supported these efforts
- Exploring future directions in planning exercise now underway



# The Future of the Canadian Programme

Experiment	Timeline		Investigators
	Start	End	
ATLAS	2008 (1996)	2025++	45
T2K	2009 (2004)	2015+	20
PICASSO	2006 (2006)	2011+	10
SNO+	2012 (2008)	2015+	15
DEAP/CLEAN	2010 (2008)	2015+	10
SuperB	2015 (?)	2025	10
Linear Collider,...	2018+ (2012)	—	20-30+

- ATLAS is centre-piece of collider physics in Canada
- Converging on SNOLAB experimental programme
- Continued involvement in 2 or 3 SNOLAB experiments
- Reap physics from T2K contributions
- Establish foundation for major commitment to next collider





# North American Cooperation in Particle Physics

- Important Canadian contributions to BaBar and CDF
- Natural geographic partners
- In the context of FALC have begun discussing a North American co-operation agreement on high energy physics
- Have had a series meetings with Canadian proponents
  - Community: TRIUMF, SNOLAB, Perimeter, IPP
  - Agencies: NRC, NSERC, CFI, Industry ministry
- Suggested a list of possible topics of common interest:
  - SNOLAB/DUSEL experiments and R&D
  - ILC development and SRF R&D
  - Building a joint position on CERN relations
  - Next generation long baseline neutrino experiments (T2K/ProjectX)
  - Facilitating movement of researchers among North American labs

# Cooperation with Japan

- Natural trans-pacific ties between TRIUMF and Japanese labs
- Build on serendipitous cooperation with systematic contributions
  - T2K is a prime example of this
  - TRIUMF/RIKEN signed MOU
- Half-day symposium hosted by Canadian embassy in Tokyo
  - July 2009 in conjunction with JPARC opening
- Presentations by Coulombe, Suzuki, Lockyer, Yano and Karlen
- Panel discussion including Vogt, Nagamiya, Orr and Hayano
- Third in series was held in Vancouver in late October

## Japan Particle Accelerator Science Symposium

Japan - Canada Collaboration and Internationalization  
in Particle Accelerator Science



July 7, 2009

Hosted by  
Co-hosted by

Embassy of Canada in Japan  
National Laboratory for  
Particle and Nuclear Physics (TRIUMF)  
Institute of Particle Physics (IPP)

In Cooperation with

High Energy Accelerator Research Organization  
(KEK)



## Cooperation with CERN

- Canadians were 20% of the OPAL collaboration
- Among the first to commit to an LHC machine contribution (1995)
- Have a strong contingent on ATLAS
- Established Canadian participation in CERN summer student programme
- Supporting at least one teacher to attend next summer's CERN teacher program
- Contributions to LHC/ATLAS are highly visible in Canada
- Contributed to SPL cavity R&D and PS2 beam dynamics studies
  - looking for other ways to contribute to LHC upgrades
- Engaging in discussion of CERN's geographic enlargement

## Summary

- Canadian particle physicists have had a major impact on the physics of BaBar, CDF, SNO, ZEUS – our on-going projects
- Already starting to see the fruits of our investments in ATLAS, T2K and PICASSO
- A number of projects are on the horizon
  - Launch of the scientific programme at SNOLAB:
    - \* DEAP/CLEAN and SNO+
  - Expand Canadian contributions to a linear collider (machine + dets)
- Significant community renewal going smoothly
  - Half of the particle physics faculty hired in the last ten years
- Restarting our Long Range Planning process conclusions in mid-2011
- Challenge: 30-40% increase in research activity while operating funding has remained **constant**