Report on the ILC status in Canada

$^1/_2$

easier & communicative
(I will go over quick)

Informative report on the strategic planning process in Canada relevant for the coordination of the deployment of ILC and ILD

$^1/_2$

harder & challenging
(because
it is to plan for what to come)

Articulate a vision with the « real » status of Subatomic Physics versus Highly Qualified Personnel

International coordinated resources and funding

Report on the ILC status in Canada

Outline:

- ❑ Inform: Quinquennial Canadian Long Range Plan in Subatomic Physics
- ❑ Priority: The Physics at ILC for 2017-2021
- ❑ Synergy: Accelerator and Detector for ILC in Canada
- ❑ Strategic Planning in Canada: The timeline for 2022-2036
- ❑ Going Forward: Engage & Coordinate / Infrastructure

Americas Workshop on Linear Colliders 2020

October 19, 2020

Alain Bellerive

Carleton UNIVERSITY

Funding in Subatomic Physics in Canada

Natural Sciences and Engineering Research Council of Canada
Conseil de recherches en sciences naturelles et en génie du Canada

- Project and Individual Discovery Grants to cover mainly the support the training of **highly qualified personnel**, travel, operation, and material.
- Major Resources Support program to facilitate the access to unique experimental, thematic and technical **human resources**
- Research Tools and Instruments grants program to support the purchase of research equipment, instrumentation and hardware.
- Envelop is $29.2M per year in 2024 (increase $3.8M in 2019 → 2024) / Energy Frontier ~$6M per year (2019)

Canada Foundation for Innovation (CFI)
Fondation Canadienne pour l'Innovation (FCI)

- Main funding source for **infrastructure** to invest in research facilities and equipment in Canada's universities, colleges, and research institutions.
- Support infrastructure for junior faculty members
- Enable global leadership by supporting international and national BIG science ventures for world-class research and technology development
- Coordinate **ILD Canada** submission with future major Innovation Fund

Remark: $ = $

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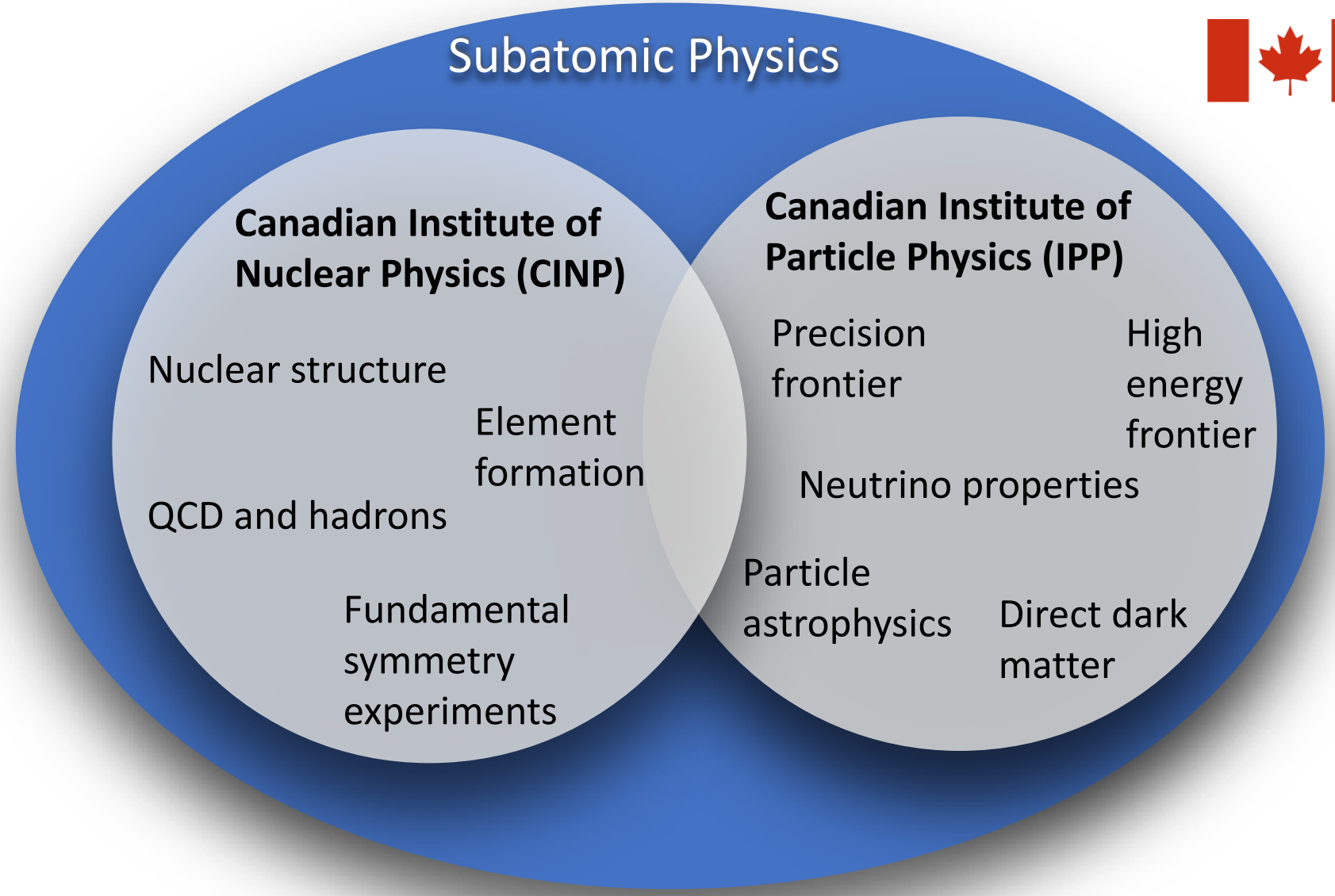
Canadian Subatomic Physics (SAP)



https://subatomicphysics.ca/

SAP community (2015) Canada

Nuclear and Particle physics

Experimental and Theoretical

233 grant-eligible researchers (12% women)

31 Universities

TRIUMF, SNOlab, and Perimeter Institute

Acknowledgement: Prof. Brigitte Vachon SNOWMASS contribution «Canadian Subatomic Physics Long Range Plan 2022-26» https://indico.fnal.gov/event/44870/timetable/

Canadian SAP Long Range Plan (LRP)

- The Canadian subatomic physics community establishes its **scientific**, and thus **funding**, **priorities** through quinquennial Long Range Plans. A new plan is solicited by NSERC and updated every 5 years.
- **It is a community based exercise**
- The LRP's advise the Canadian subatomic physics research community and relevant stakeholders on **priorities** for both current and future endeavours.
- **The most recent Long Range Plan (LRP) covered the period 2017-2021, in addition to providing an assumption-based forecast for into 2026 (+ 5 years in future).**

The Canadian SAP LRP is jointly supported by the Institute of Particle Physics, the Canadian Institute of Nuclear Physics and the Natural Sciences and Engineering Research Council. The additional stakeholders are: TRIUMF, SNOLAB, the Perimeter Institute and the Canadian Foundation for Innovation, are supportive of this process.

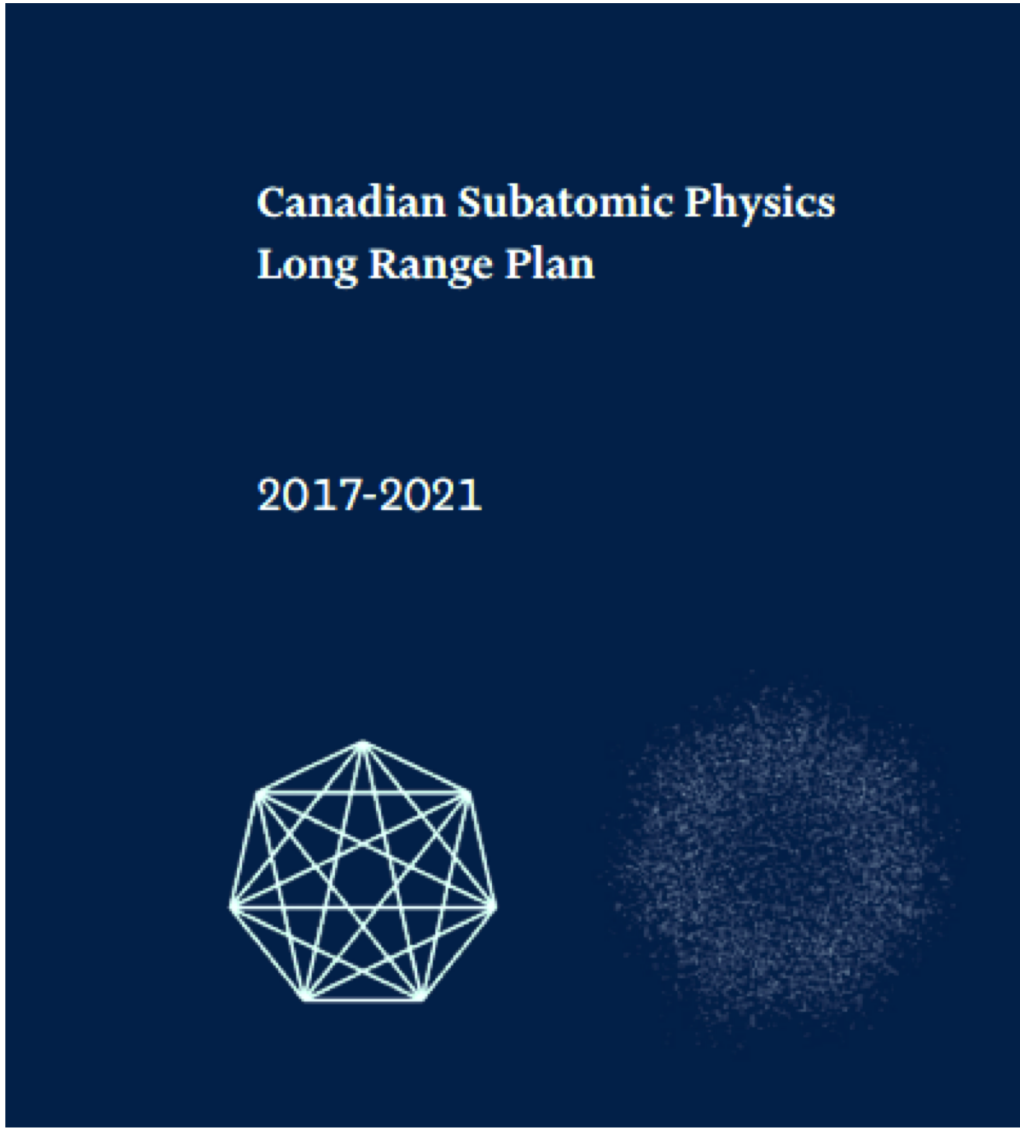
IPP INSTITUTE OF PARTICLE PHYSICS
INSTITUT DE PHYSIQUE DES PARTICULES

CINP ICPN Canadian Institute of Nuclear Physics
Institut canadien de physique nucléaire

NSERC CRSNG

SAP LRP 2017-2021 and R&D for ILC in Canada

- TRIUMF National Lab for accelerator R&D
- In Canada, we have been involved in the International Large Detector (ILD)
- Two of the LRP 2017-2021 **scientific recommendations**:
  1) Support proposals for directed and generic accelerator and detector research & development for subatomic physics.
  2) Identified the small teams of Canadian physicists working on ILD should be supported in order to maintain a stake in this important project and its broad scientific program.



SAP LRP 2017-2021 and R&D for ILC in Canada

- Two of the LRP 2017-2021 **policy recommendations**

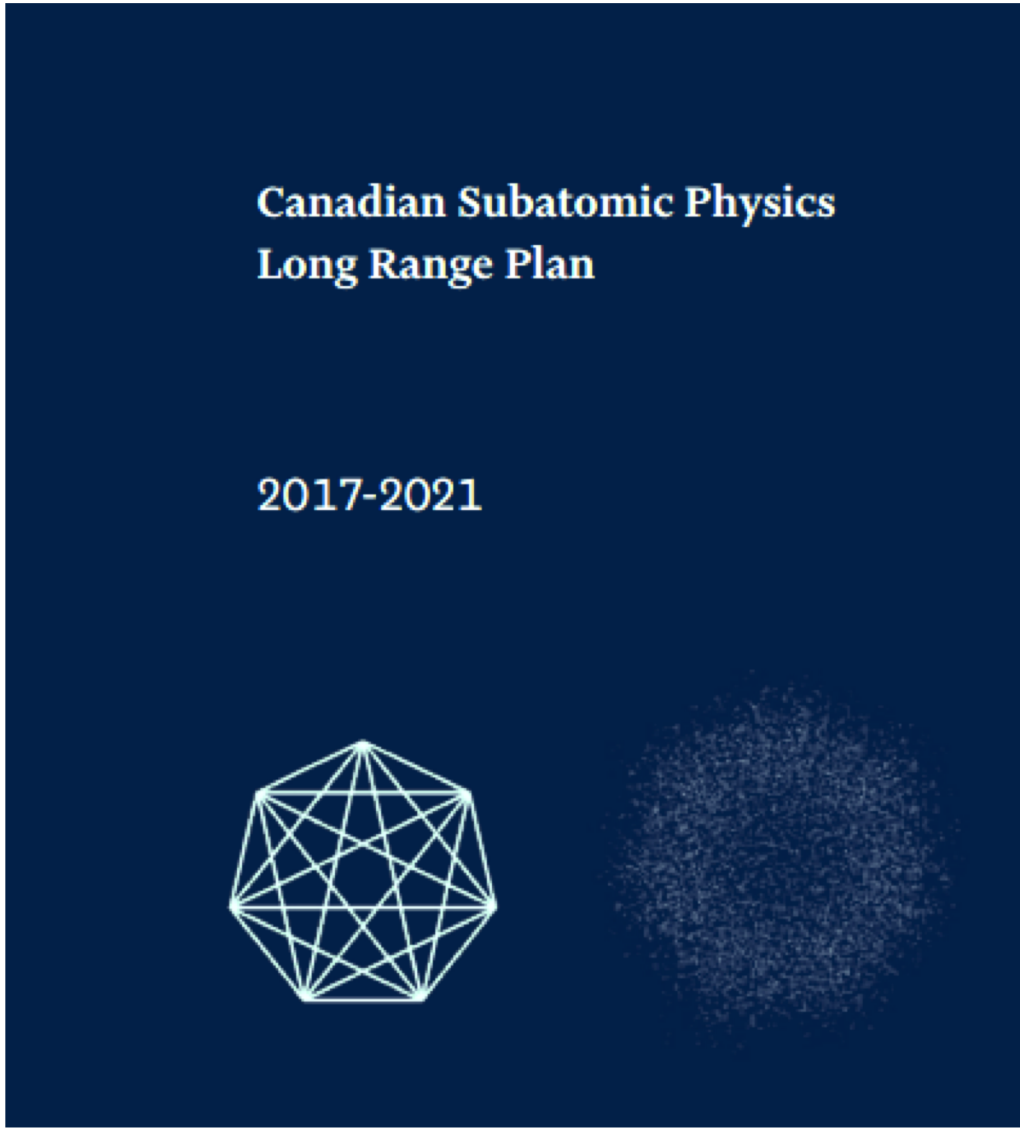
  1) Identify an office in Canadian government responsible for engaging with the international community in moving forward major new science initiatives.

  2) Carefully manage the NSERC subatomic physics envelope to allow for new projects to be developed.

- Due to the long term of deployment of large-scale projects in particle physics and the extended time of decision making to host the ILC:

  - Funding for ILD R&D has come to a critical level

  - Crucial to have a clear signal within next two years and a well defined coordination with partners



SCRF Industrialization Critical for future e^+e^- colliders

TRIUMF's Canada National Laboratory e-linac - Electron Linear Accelerator

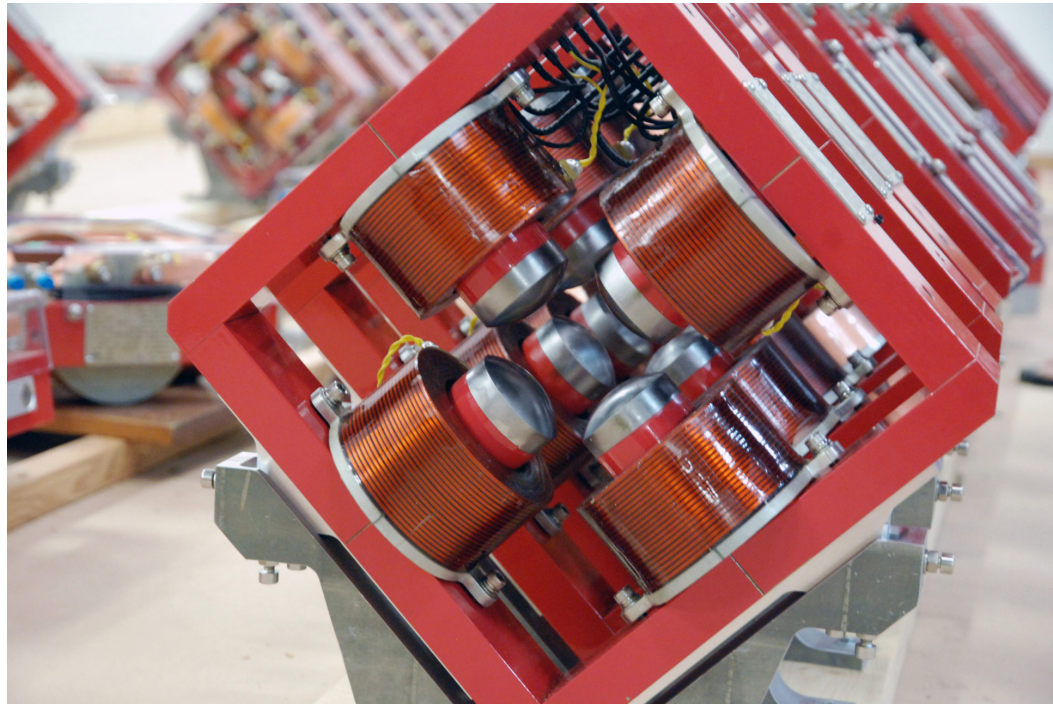
The second driver for TRIUMF's beam program is the world's highest power e-linac for rare isotope production, which will come fully online in 2021

Technology used in e-linac is similar to what is intended to be used for a future ILC

Funding for accelerator components usually follows a partnership with Industry/TRIUMF and the National Research Council of Canada

TRIUMF

Refer to talk by Oliver Kester Tuesday «Potential Canadian contributions to the ILC accelerator»



Time Projection Chamber (TPC) for ILD

Main activities on micropattern gas detector (MPGD & RD51)

- Two options with similar resolution for endplate readout with **pads**:
  - **GEM:** 1.2×5.8 mm² pads (smaller pad – more electronics)
  - **Resistive Micromegas:** 3×7 mm² pads (larger pads – less electronics)
- Alternative: **pixel** readout with pixel size ~55×55 µm²

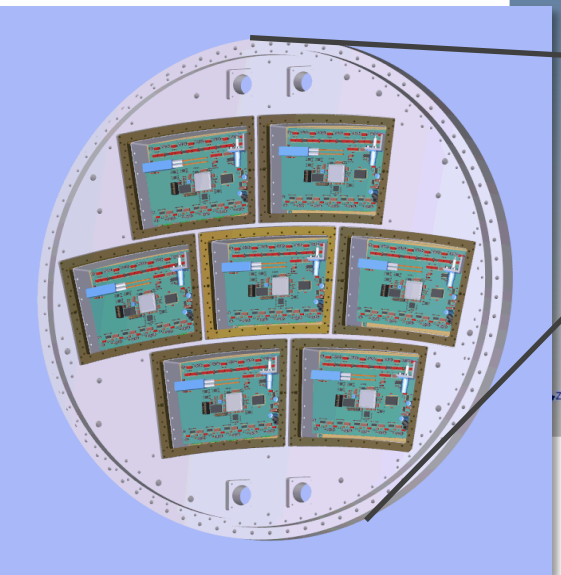
Group led by Alain Bellerive (Carleton U.)

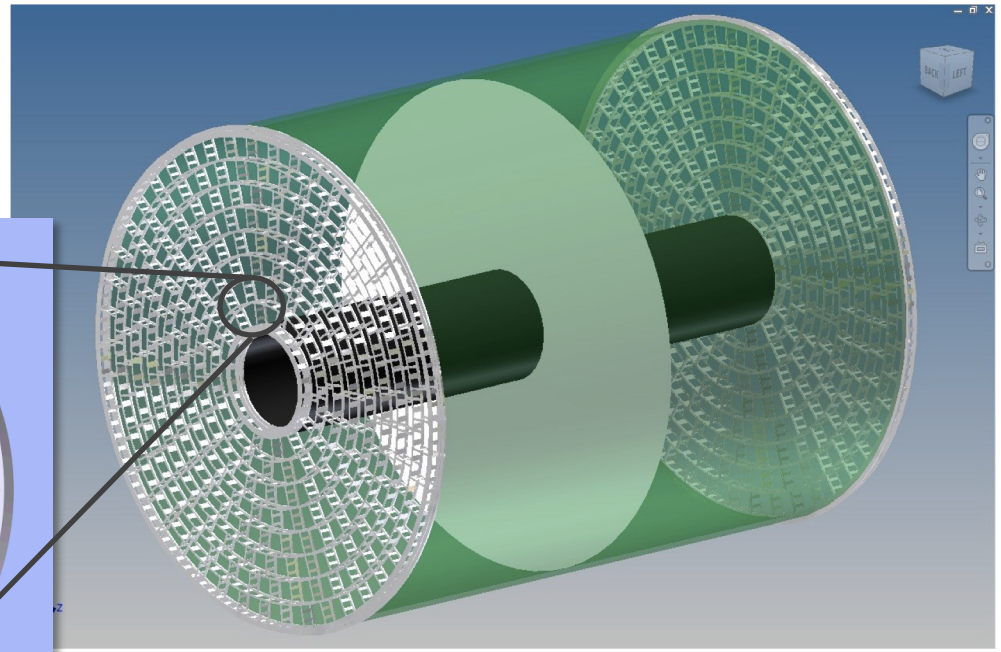
Carleton UNIVERSITY

Highly Qualified Personnel
Detector R&D 2010-20:

3 graduate students
11 undergraduate students

Large Prototype TPC
Endplate of 7 panels, ø = 80 cm





ILD TPC

Funding since early-2000:

Original NSERC Project Grant M. Dixit and D. Karlen
Several tes tbeam campaigns at KEK and DESY
Publications on GEM, Micromegas and pixel
Completed LCTPC main R&D on resistive readout
Readout scheme similar to ATLAS sTGC NSW

LCTPC Collaboration on calorimetry R&D:

3 regions (America, Asia, Europe), 25 member institutions, 22 observer institutions
A. Bellerive North American representative

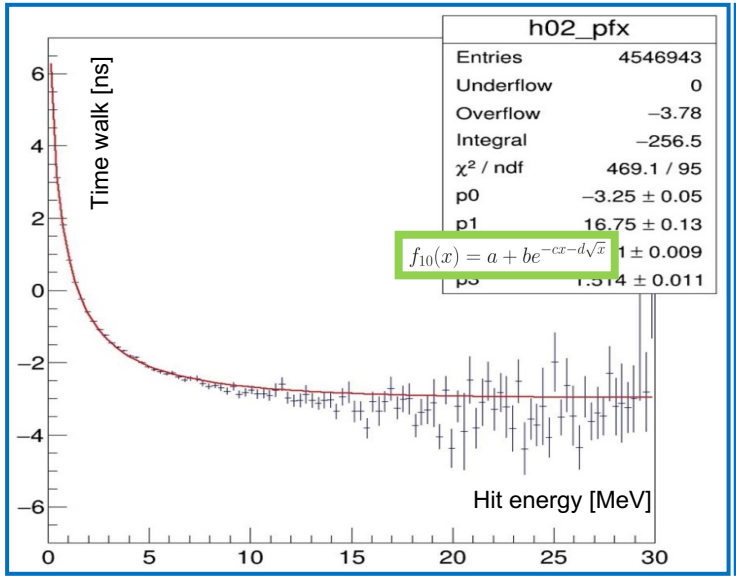
Calorimetry R&D at CALICE for ILD

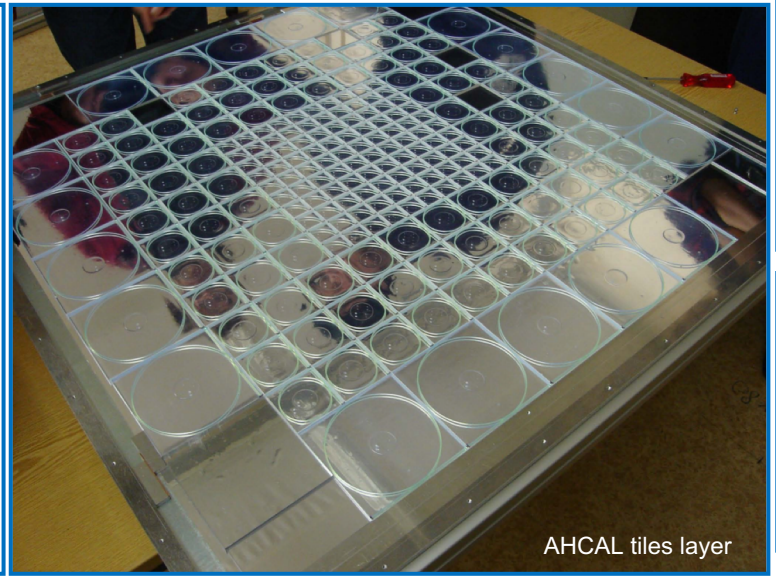
Main activities on very high granularity detectors (few cm^2):

Started in 2006 working on the **Analog Hadronic Calorimeter (AHCAL)** with simulation, alignment and performance analyses.

With NSERC funding, McGill joined Argonne (ANL) to design, build and test the novel Digital Hadronic Calorimeter (DHCAL) prototype until completion. Several publications followed.

Now on the improved AHCAL with added accurate timing information for each hit to discriminate background and further particle ID. The new CMS forward detector is based on this technology.





Group led by François Corriveau (IPP/McGill)

INSTITUTE OF PARTICLE PHYSICS

Highly Qualified Personnel
Detector R&D 2010-20:

4 graduate students
16 undergraduate students

Funding since 2010:

NSERC individual Discovery Grant renewed (2024)
2× contracts with ANL for visiting M.Sc. students
5× DAAD German summer student awards
5× NSERC USRA summer student awards
2× DAAD 3-month fellowships at MPP Munich (FC)

CALICE Collaboration on calorimetry R&D:

17 countries, 57 institutes, 336 physicists/engineers
Originally for ILC experiments, now also generic R&D

Scope Canadian next LRP 2022-2026

Scope is 2022 – 2036 (**+ 10** years in future) with plan active from 2022 – 2026

- ❑ Ensure continuous Canadian global scientific **leadership** in Subatomic Physics (SAP)
- ❑ Address Equity, Diversity and Inclusion, as well as support for early career researchers within the SAP community in Canada. **Timeline lines-up well with ILC Pre-Laboratory deployment.**
- ❑ Maximize and coordinate impact in a global field, given limited resources (human and fund)
- ❑ IPP and CINP to prepare briefs for the LRP committee to guide the redaction of the report
- ❑ The LRP **informs** funding agencies of the community's priorities; however, funding agencies still traditionally hold broad peer-review funding competition (*e.g.* **not mission-driven**)
- ❑ **The LRP communicates to international partners (and policy makers) the Canadian plans and priorities, and resource requirements [need to *pin* this one down]**
- ❑ LRP **informed** by other planning processes : USA, Europe, Japan, …

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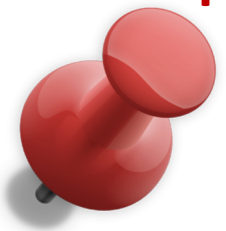

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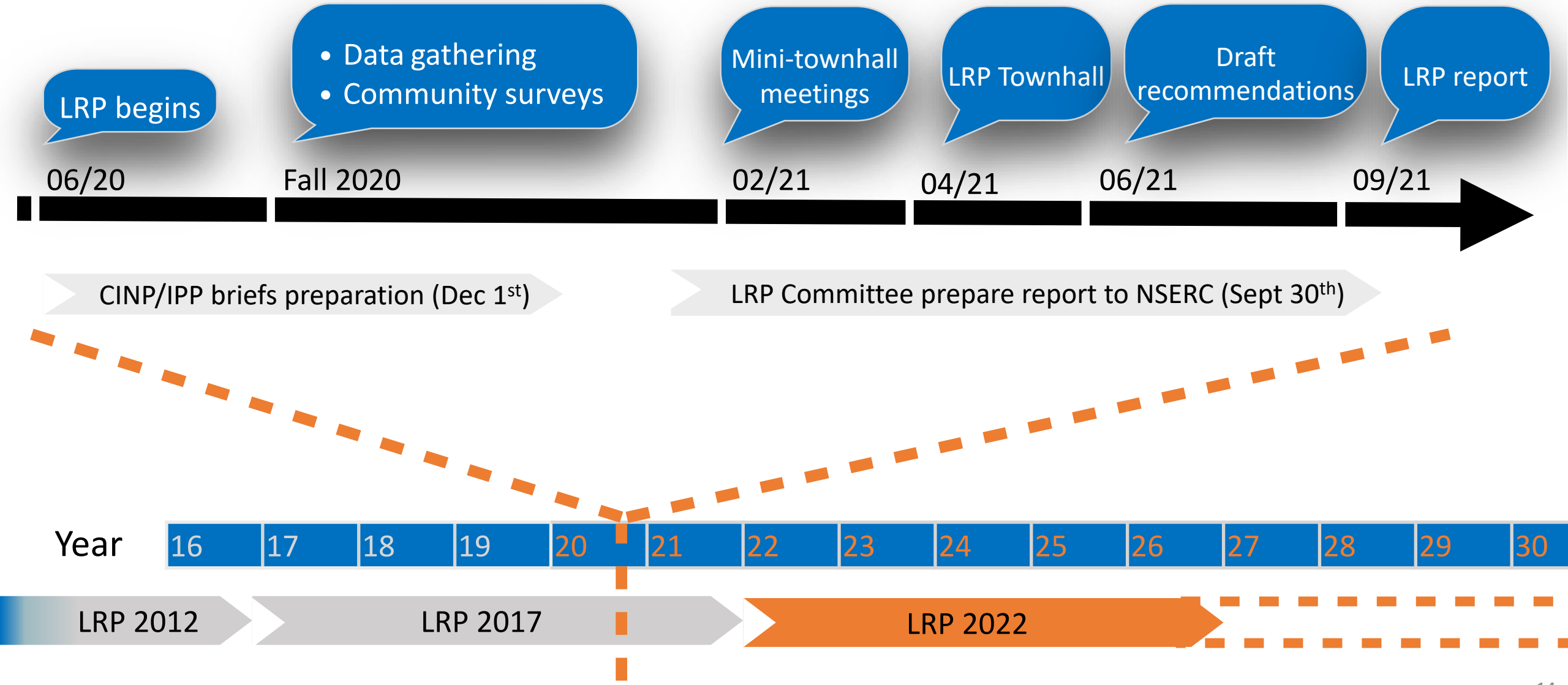

Canadian general expertise for ILC detectors

- Historically OPAL and ZEUS experiments. Contribution to gas detectors (vertex, Z-chambers), uranium-scintillator calorimeter, pressure vessel, and support structures.

- Participation in BaBar, Belle2 and T2K. Key contribution in drift chambers design and construction, as well as Time Projection Chambers and Fine-Grained Detectors.
- Synergy with other groups (*e.g.* Dark Matter, Neutrinos, Double-beta decays, etc).

- Now engaged on ATLAS at the energy frontier:
  - ✓ Hadronic Endcap Calorimeter
  - ✓ Forward Hadronic Calorimeter
  - ✓ Cryostat Feedthroughs
  - ✓ Liquid Argon Electronics for Phase-1 and Phase-2
  - ✓ Event Filter / High Level Trigger / Tier Computing / Networking
  - ✓ Beam and Radiation Monitors
  - ✓ New Small Wheel / small-strip Thin Gap Chamber (sTGC) "new Phase-1"
  - ✓ Silicon sensors for Inner Tracker (ITk) "new Phase-2"

Canadian Resources & Infrastructure for ILC Detectors

Several NSERC Major Resources Support (MRS) program and facilities across Canada to enhance technology excellence for physics discoveries at the energy frontier

- First, the Institute of Particle Physics (IPP) is an MRS program: 8 Faculty Research Scientists

At universities (unique)

- Alberta / Toronto: detector technology, engineering, electronics
- Carleton / UVIC / Winnipeg: design, draftsman, electronics, detector technology, GEANT4, DAQ
- Université de Montréal: electronics, detector technology, radiation damage

- TRIUMF: Science Technology department / Instrumentation group & National Detector Facility

- **Canada has major resources/infrastructure to design & assemble ILC detectors. Historically contributed to LCTPC & CALICE; can also contribute to muon chambers & silicon detectors**

- **Canada can further contribute to the construction/engineering of end-plates (TPC), structure (calorimeter), pressure vessel, cryostat feedthroughs, power cycling, electronics, DAQ, etc…**

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Summary - Report on the ILC status in Canada

- ❑ Canadian LRP timescale lines-up perfectly with the ILC Pre-Laboratory deployment
- ❑ Canada is engaged in ILC detector R&D (*i.e.* ILD) and plans to re-engaged in physics studies
- ❑ Canada can provide further key expertise to the ILC (accelerator & detector components)
- ❑ Canada is planning to engaged the next generation of particle physicists in ILC (& FCC)
- ❑ International partners (Japan, US, Europe) need to *timely* contact Canadian Funding Agencies
- ❑ Younger faculty members need to see an *approved* project
- ❑ To stay in the game, Canada relies on a clear signal from Japan within the next two years

Practically… in Canada

- **Approved experiment → IPP project → NSERC & CFI funding**
- ILC/ILD cannot go forward without a critical mas of people (period)
- Need to restore ILC in local strategic planning for hiring new faculty members in Canada
- New hires and dynamic junior faculty members in high-energy physics are on ATLAS
  - ✓ ATLAS is ~$6M of NSERC operating fund per year
  - ✓ $6.2M of CFI fund for ATLAS NSW and LAr Phase-1 upgrade
  - ✓ $30M of CFI for ATLAS ITk Phase-2 upgrade
  - ✓ Compare to ~$0.2M of NSERC fund per year on ILC detector R&D (used to be more)
  - ✓ Where are the people engaged?
- We need a clear signal within the **next two years** to count ILC/ILD as an **approved** project

Remark: $ = $

IPP Member Survey - Long Range Plan 2022-2036

- The ILC physics is compelling. Nice synergy between experimentalists and theorists.
- The ILC argument: the only possible global electron-positron collider project in mid-2030 !!!
- In the «The International Linear Collider A Global Project»: 25 signatures from 11 institutes from Canada.
- Does this reflect *actual* reality… what about the younger members of our community?

Survey to all the members of the Canadian particle physics community:

As we heard at the IPP Town Hall in the summer, over the past year interest in the ILC within the governments of Japan and the U.S. has grown considerably. This marks a significant change and IPP would like to understand the potential level of interest, and renewed interest, in the ILC within our community. The Subatomic Physics Long Range Plan is planning for the period from 2022-2036 with the Plan in effect from 2022-2026. An ILC could be ramping-up during the 2022-2026 period, followed by a construction period, and be taking physics data by the mid-2030's.

(i) Can you see yourself directing some of your research time to impact an ILC programme that begins taking physics data in the 2030's?

(ii) If so, in what area(s) would you focus your efforts (theory, physics analysis preparations, software, detector hardware, accelerator, other)?