TRIUMF

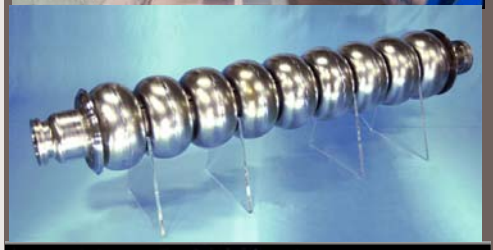
Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

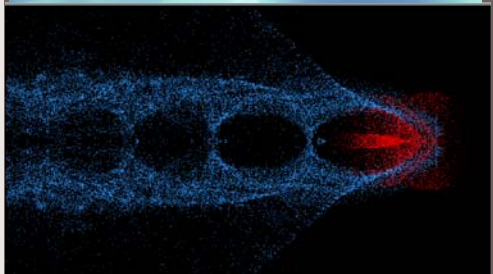
A career in Accelerator Physics

Lia Merminga | Head, Accelerator Division | TRIUMF

CANADIAN CONFERENCE FOR UNDERGRADUATE WOMEN IN PHYSICS

McGill University, January 10-12, 2014





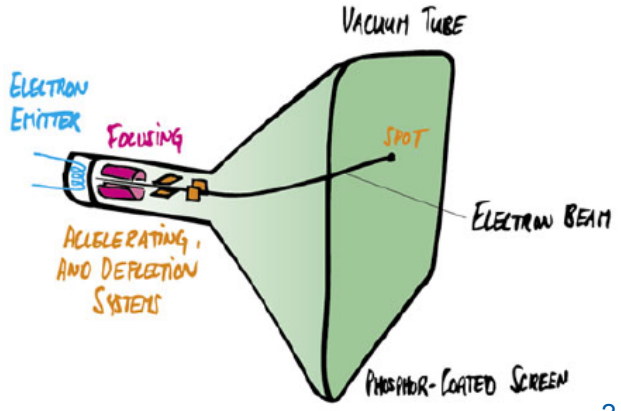
What is an Accelerator?

An **accelerator** is a device that uses electromagnetic forces to accelerate and guide charged particles.

THE ESSENTIALS

- Particle source (electrons, protons, ions)
- Vacuum
- Electric field for acceleration
- Magnetic and/or electric fields for focusing and steering
- Controls

A familiar particle accelerator:



Modern Accelerators

Early accelerators were motivated by nuclear physics.

Today, particle accelerators are essential tools of discovery for:

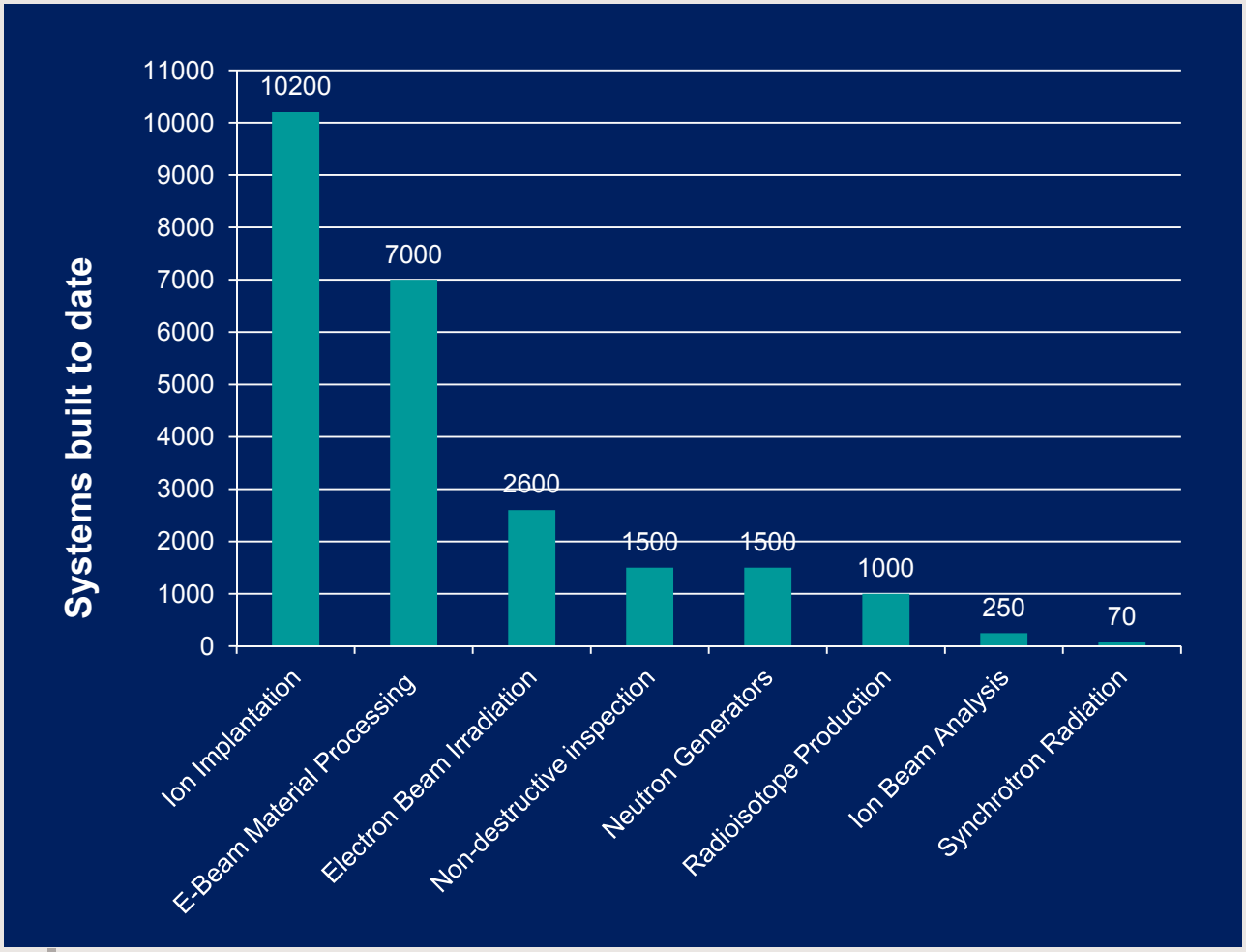
- *Elementary particle physics*
- *Nuclear physics*
- *X-ray and neutron science*

and have found broad and expanding uses in:

- *Industry*
- *Energy*
- *Environment*
- *Medicine*
- *Security*

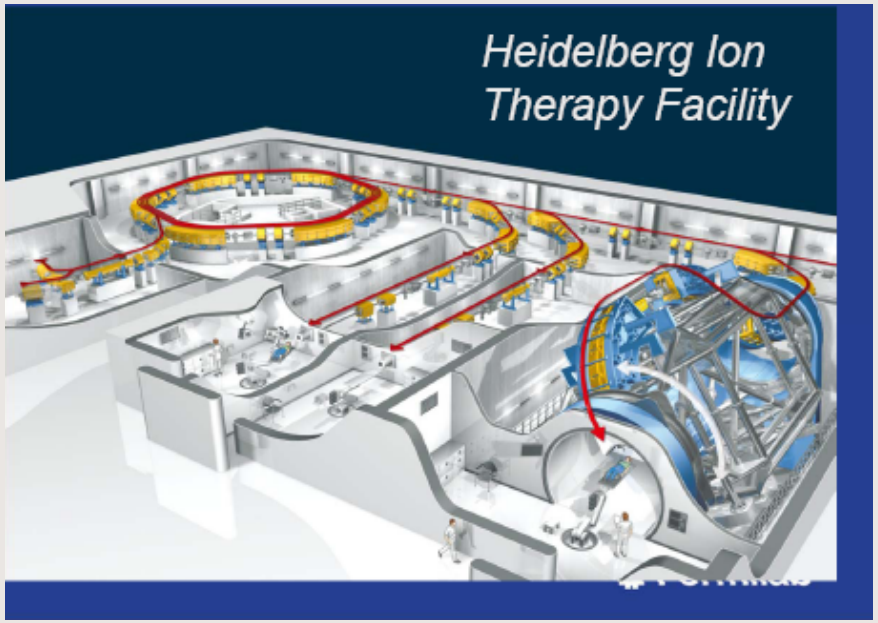
Accelerator Industry

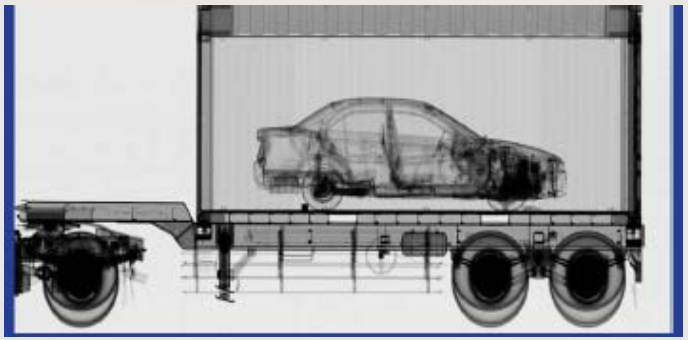
Wide variety of accelerators are enabling technology in many applications

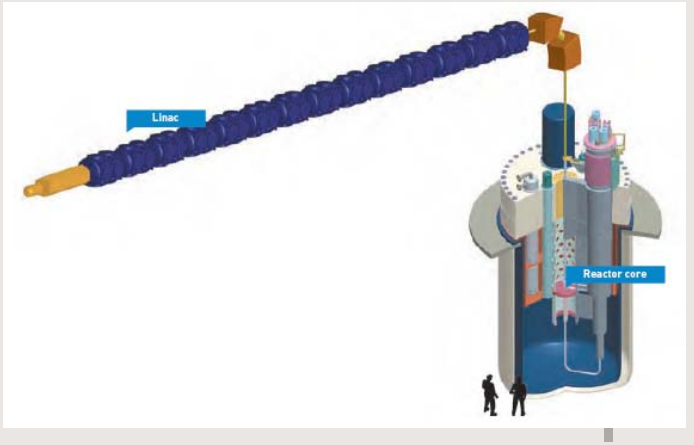


- Total built to date **>24 000**, with **>18 000 in operation**
- Presently >70 accelerator vendors worldwide, primarily in US, **Canada**, Europe and Japan, but growing in China, Russia and India
- Equipment sales ~$3B per year worldwide

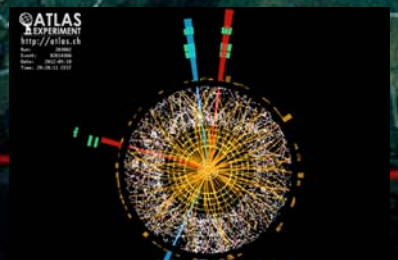
Accelerators for Society





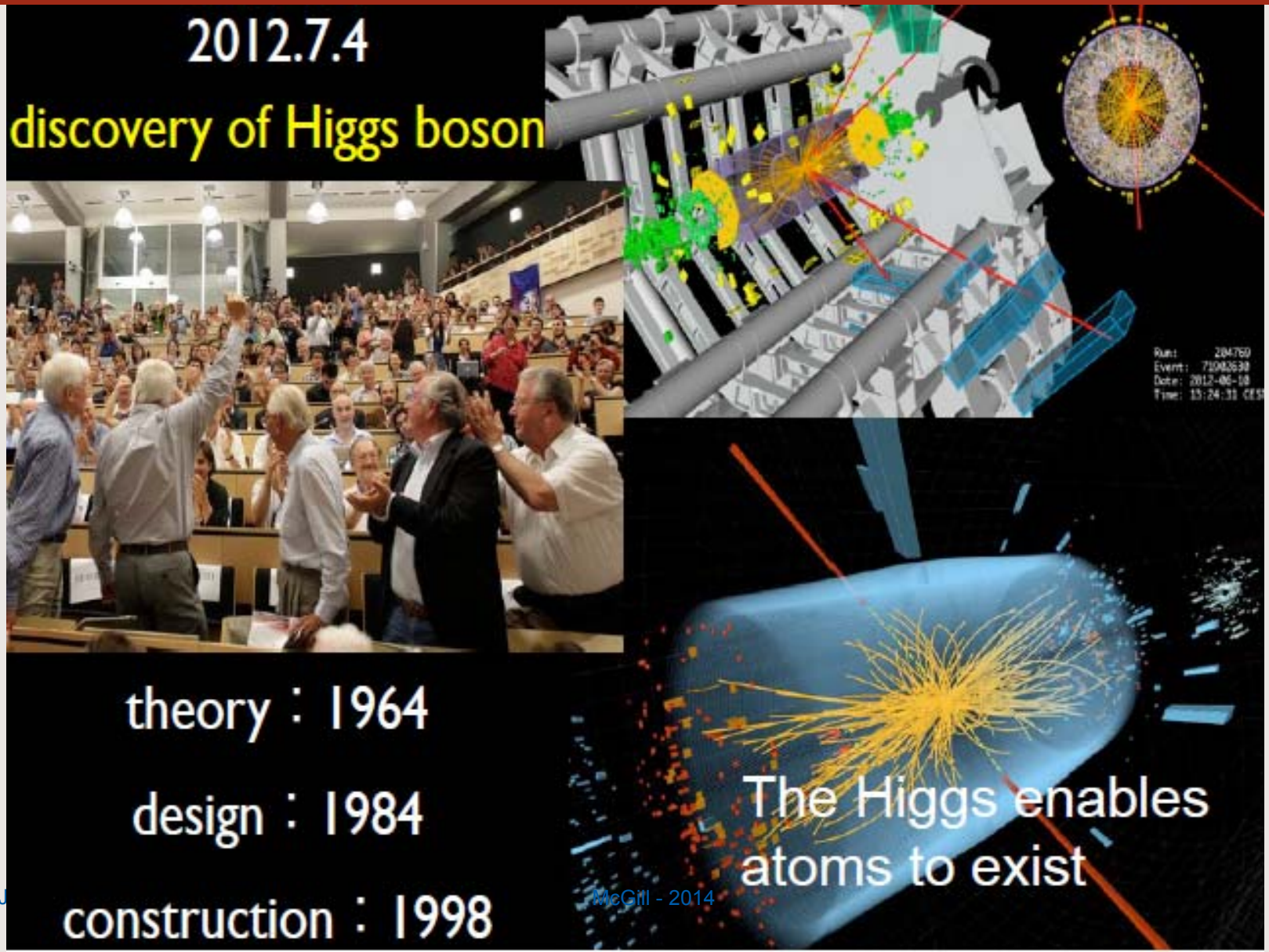


Accelerators for Particle Physics:
The Large Hadron Collider



Proton and ion collider
Circumference 26.7 km
Energy CM 14 TeV

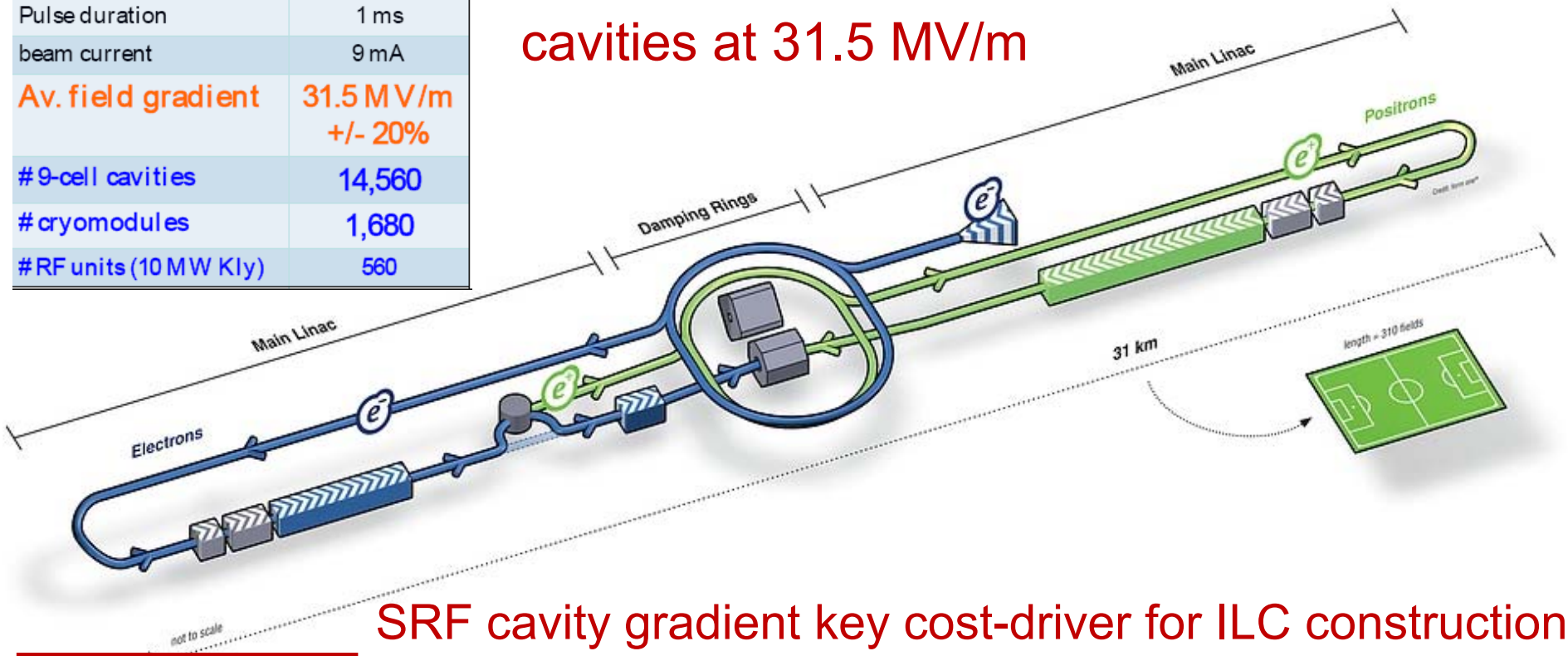
Discovery of Higgs Boson at the LHC

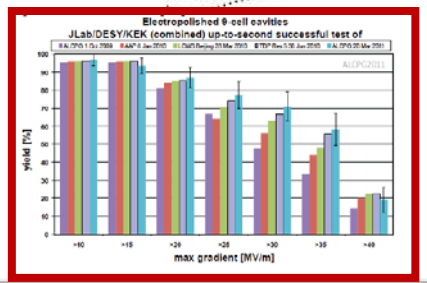


ILC: The International Linear Collider

SRF for ILC Main Linac	Value
C.M. Energy	500 GeV
Beam Rep. rate	5 Hz
Pulse duration	1 ms
beam current	9 mA
Av. field gradient	31.5 MV/m +/- 20%
# 9-cell cavities	14,560
# cryomodules	1,680
# RF units (10 MW Kly)	560

0.5 – 1 TeV CM energy e+/e- collider
31 km for 1 TeV CM based on SRF cavities at 31.5 MV/m

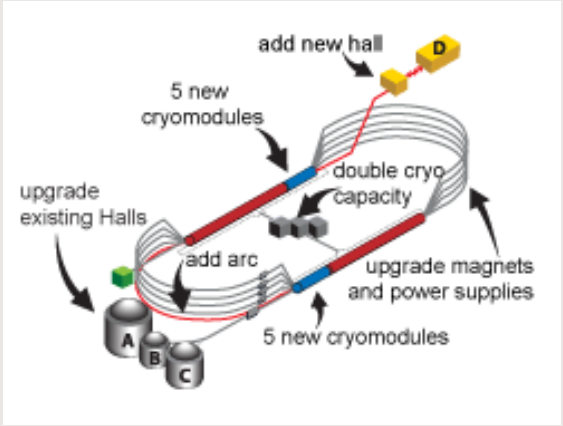




SRF cavity gradient key cost-driver for ILC construction
Key R&D objectives:
- Pursuit of very high gradient SRF linac technology
- Plan for mass-production of cavities – 14,560 cavities!

Nuclear Physics Facilities

12 GeV CEBAF Upgrade



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X-ray and Neutron Sources

Advanced Photon Source
Argonne

Spallation Neutron Source
ORNL

Linac Coherent Light Source, SLAC

PSI Cyclotron

Fermilab

XFEL (18 GeV) Under Construction in Hamburg (Germany)

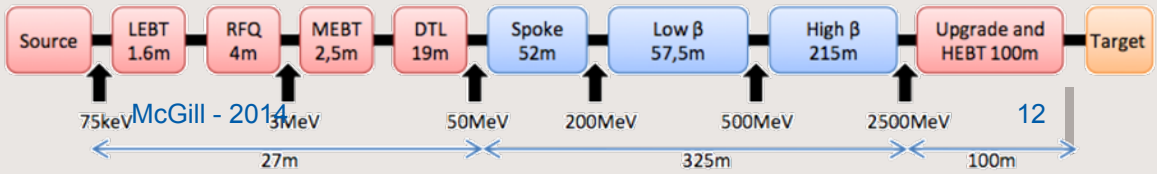
European Spallation Source, Lund (Sweden)

- Will be powered by the wind and biomass and have zero net emissions of CO_2.
- Waste heat will be used to warm homes.

2.5 GeV protons (H+)

5 MW long pulse source

High reliability >95%



Canada has two Accelerator Labs

TRIUMF

Vancouver

Canadian Light Source / Centre canadien de rayonnement synchrotron

The Canadian Light Source (CLS)

TRIUMF: A National Science Laboratory

Members

University of Alberta
University of BC
Carleton University
University of Guelph
University of Manitoba
Université de Montréal
Queen's University
Simon Fraser University
University of Toronto
University of Victoria
York University

Associate Members

University of Calgary
McGill University
McMaster University
University of Northern BC
University of Regina
Saint Mary's University
University of Winnipeg

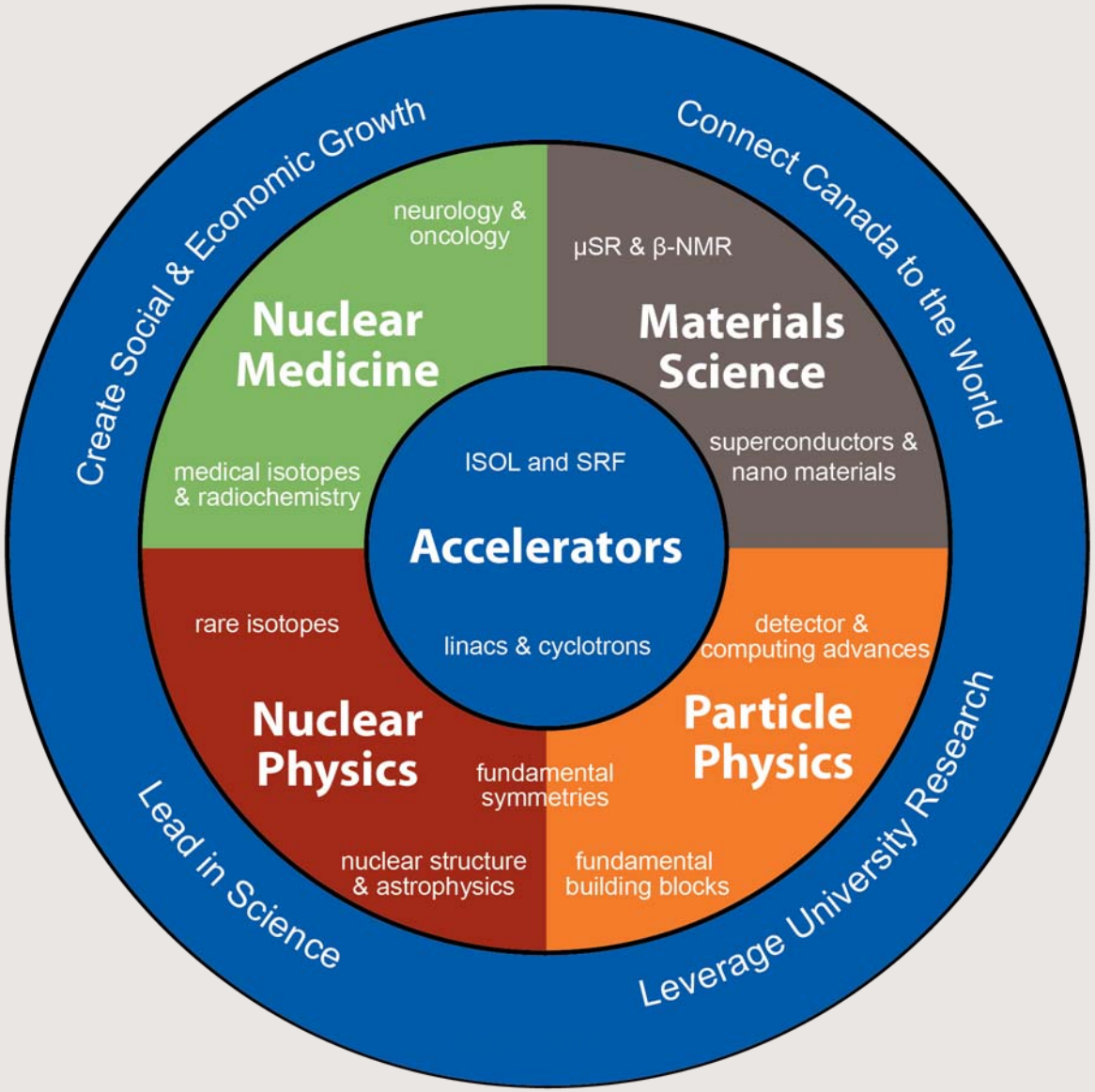
Research focus:

- Advancing isotopes for science & medicine
- Probing the structure & origins of matter

TRIUMF is owned & operated by a consortium of 18 universities

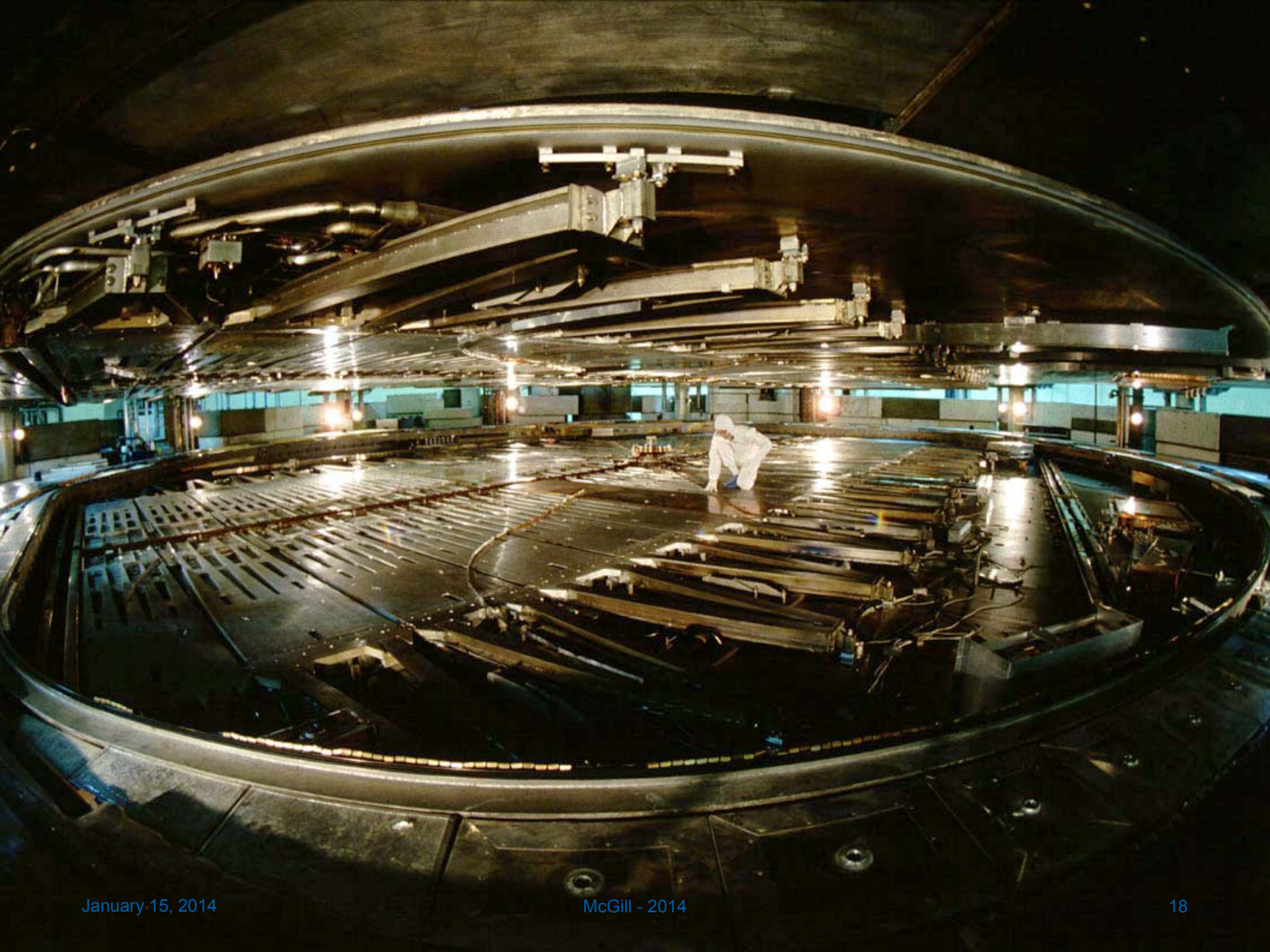
Founded 45 years ago in Vancouver

TRIUMF's Research Program

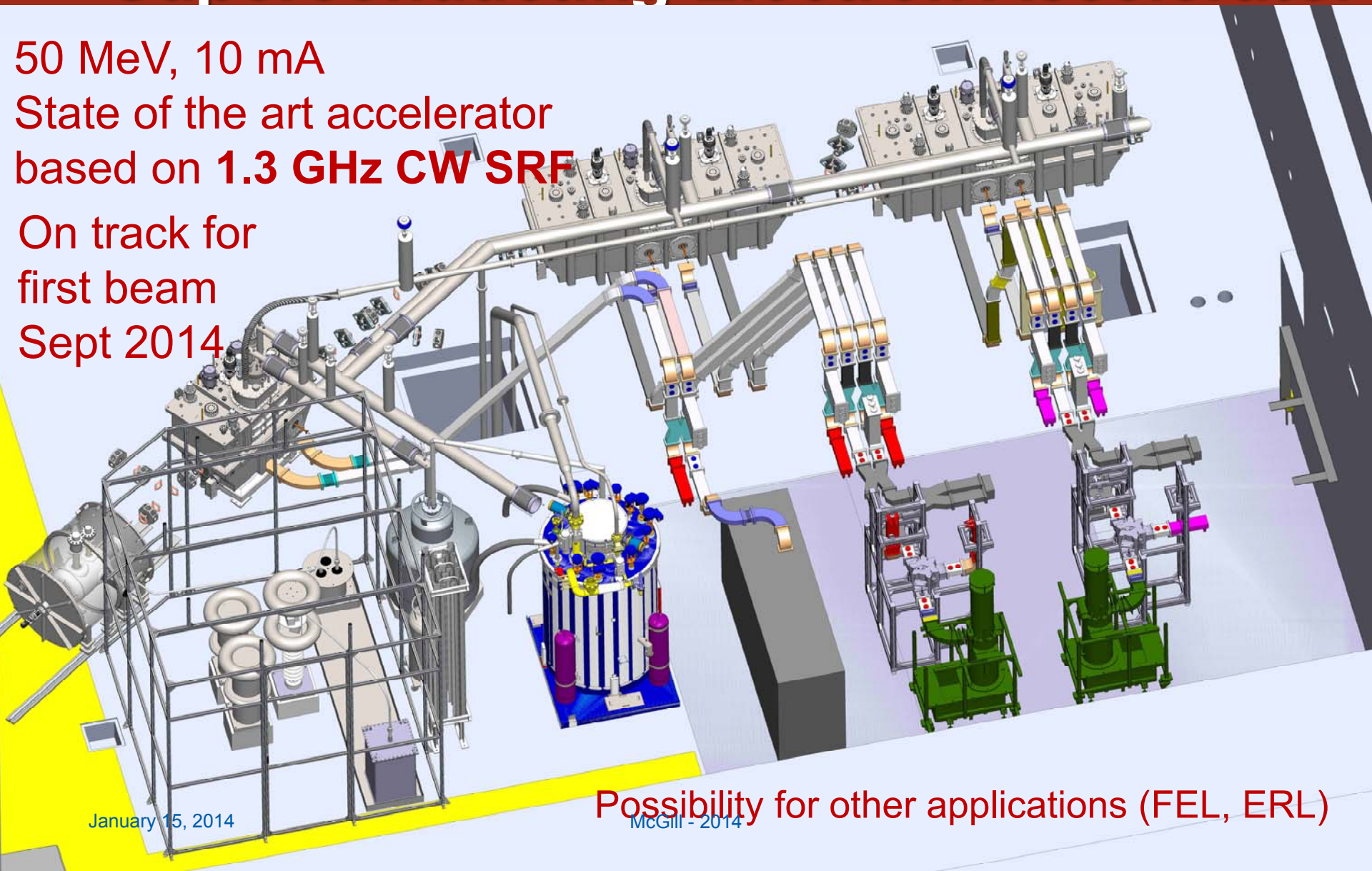


The 500 MeV Cyclotron at TRIUMF: The World's Largest Cyclotron

1972 TRIUMF, Vancouver, BC



ARIEL e-Linac : MW-class Superconducting Electron Accelerator



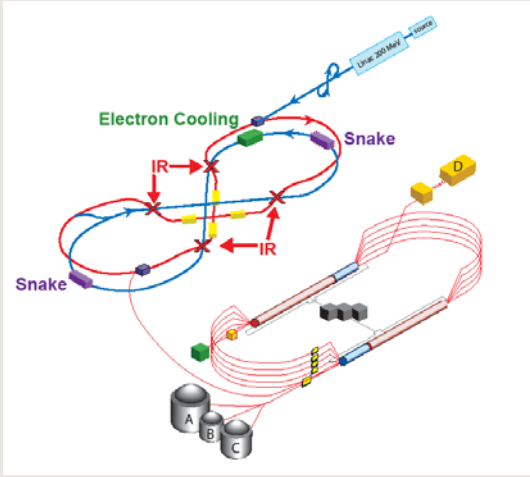
50 MeV, 10 mA
State of the art accelerator
based on **1.3 GHz CW SRF**

On track for
first beam
Sept 2014

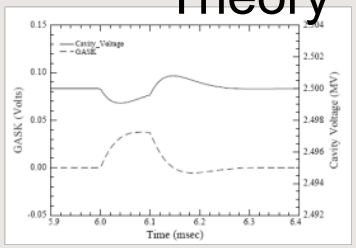
Possibility for other applications (FEL, ERL)

How do you build an accelerator?

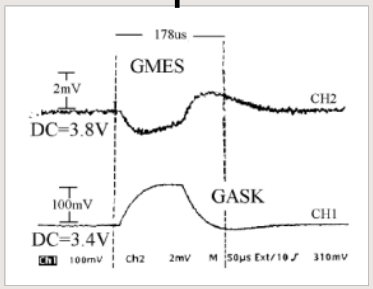
- Scientific motivation
- conception of design
- design work
- research and/or development
- project definition
- construction
- commissioning
- operation
- maintenance
- upgrades

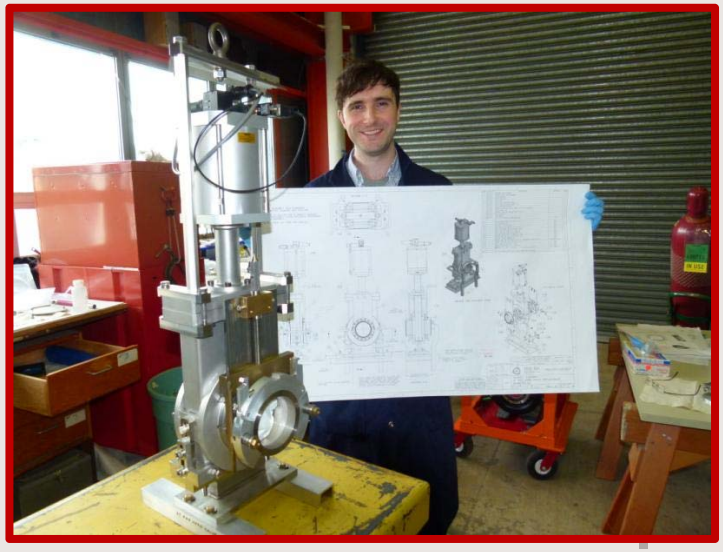


Theory



Experiment





Accelerator Science

- Modern-day accelerator research constitutes a dynamic discipline
- It is driven by:
  - demands on particle beams pushing an ever expanding performance envelope (*energy, power, intensity and brightness)*
  - advances in technology making possible in-depth theoretical and experimental understanding of the behaviour of charged particle beams for the first time

Why accelerator science?

- Has relevance and impact
- Enables scientific discovery over broad range of disciplines
- Problems are fundamental and interesting
- Problems can be solved in relatively short time scales
- Possible to use analytical, numerical and experimental techniques to solve a problem
- Demand for accelerator physicists is high and increasing

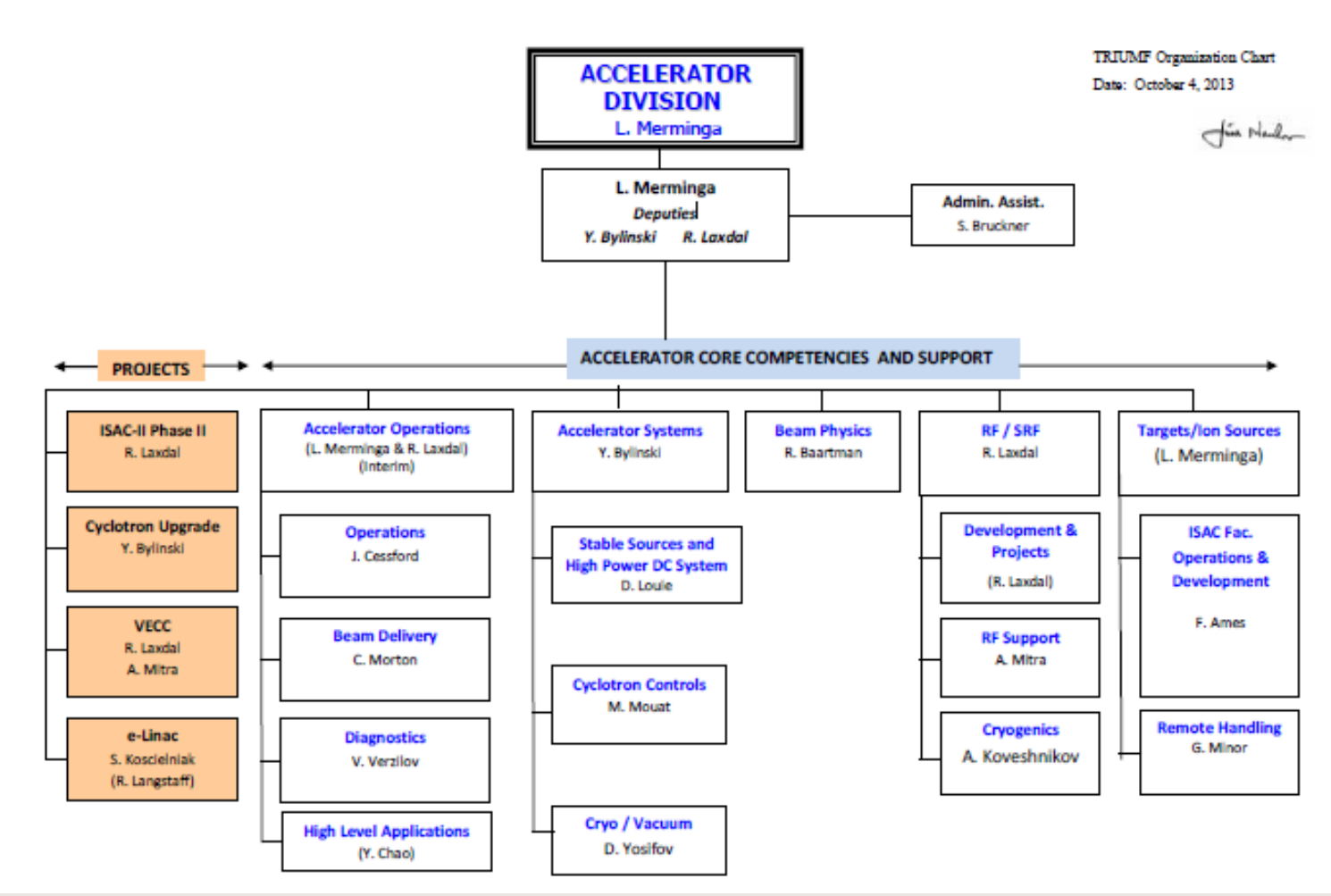
As Accelerator Division Head …

I am responsible to execute the mission of our division:

- Ensure highest availability of accelerator complex to maximize science output
- Build facilities using leading edge technology at TRIUMF & around the world
- Grow world-class research and education program in Accelerator Science & Technology
- Establish international R&D partnerships with leading accelerator facilities
- Bring accelerator and related technologies to private sector for commercialization & societal benefit

Organization

Team of 134 Accelerator Division Staff: 19 research scientists, engineers, technical personnel



Advance knowledge

TRIUMF is Canada's National Accelerator Laboratory

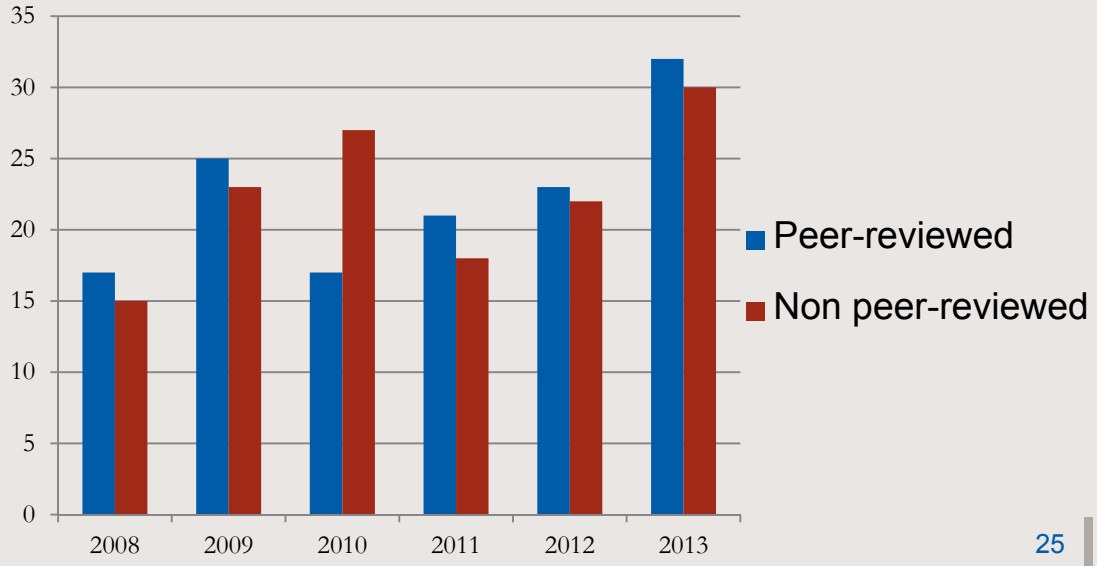
TRIUMF accelerators:

- Enable leading edge science in Nuclear & Particle Physics, Nuclear Medicine, Materials Science
- Advance the science of Accelerators

Include:

1 Nature
1 Nature Comm.
5 PRST-AB
7 PRLs
7 Phys Rev A & C

Accel. Div. publications
2008 - 2013



Create Leaders: Training of Highly Qualified Personnel

Only graduate student program in Accelerator Physics in Canada, one of few in the world

Trainees 2008-2012	undergrad	MSc	PhD	PDF	EIT*
Accelerator Physics	93	4	11	12	6

*EIT: Engineer in training

Staff Recognitions

Rick Baartman and Bob Laxdal: Fellows of the APS

Anna Grassellino: IEEE /NPSS Particle Accelerator Science &Technology Doctoral Student Award

Rick Baartman: Outstanding Referee by the APS

Shane Koscielniak and Rick Baartman: Elsevier "Excellence in Peer Reviewing" Award

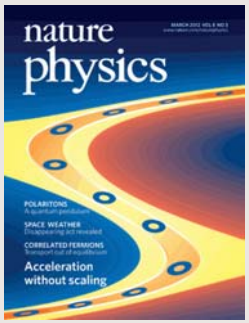
Doug Storey: NSERC CGS Scholarship

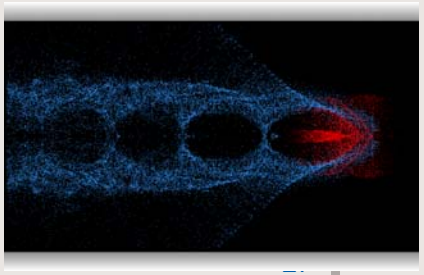
Bob Laxdal: Adjunct Professor at MSU

Graduate Student Program in Accelerator Physics and Engineering

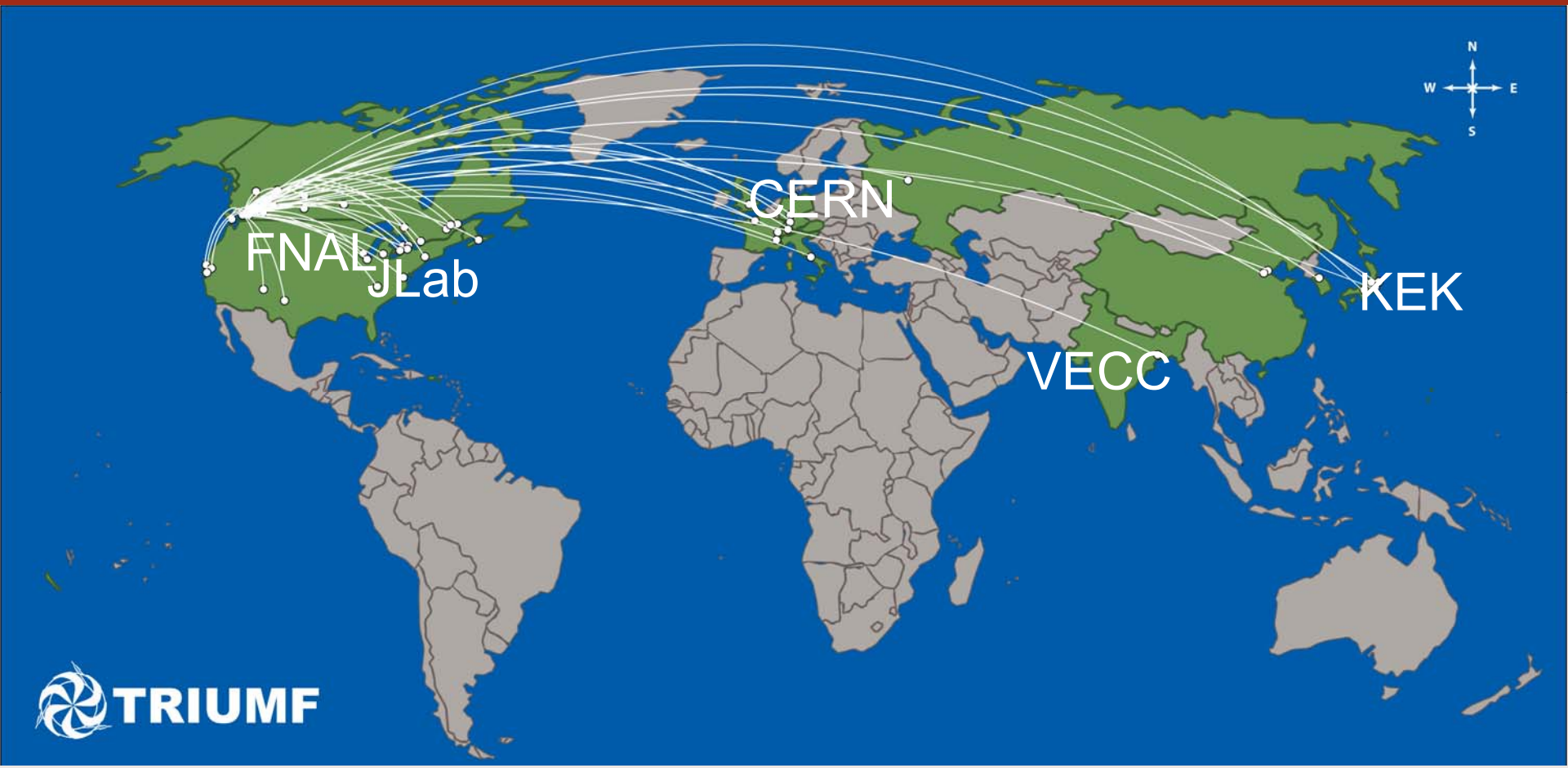
In collaboration with Canadian and international universities, we established the first graduate student program in Accelerator Physics in Canada, *one of few in the world*

- Two graduate courses on Accelerator Physics
- Ten graduate students doing thesis research at TRIUMF
- *A new initiative for TRIUMF and Canada:* NSERC grants for accelerator research and graduate student training
  - Seven proposals funded
    - Nine new requests in 2013





Connect Canada to the World: Global nature of accelerator community



Canada: UBC, SFU, U of Toronto
USA: FNAL, JLab, FRIB, Cornell
Europe: CERN (ISOLDE, LHC), HZB, IPN Orsay, GANIL, MEPHI
Asia: VECC, KEK, IUAC, CIAE, IHEP, IMP, SOREQ

Connect Canada to the World: Meetings Hosted

2008: Linac Conference

2009: Accelerator Operations Workshop – ARW

2009: Particle Accelerator Conference – PAC09

2013: Cyclotrons Conference – CYC13

2014: International Accelerator School for Linear Colliders

2015: SRF Workshop

2018: International Particle Accelerator Conference 2018 – IPAC'18

Brief CV

Education

Ph.D. (Physics) The University of Michigan, 1989
Ph.D. student in Accelerator Physics working at Fermilab

M.S. (Mathematics) The University of Michigan, 1987

M.S. (Physics) The University of Michigan, 1986

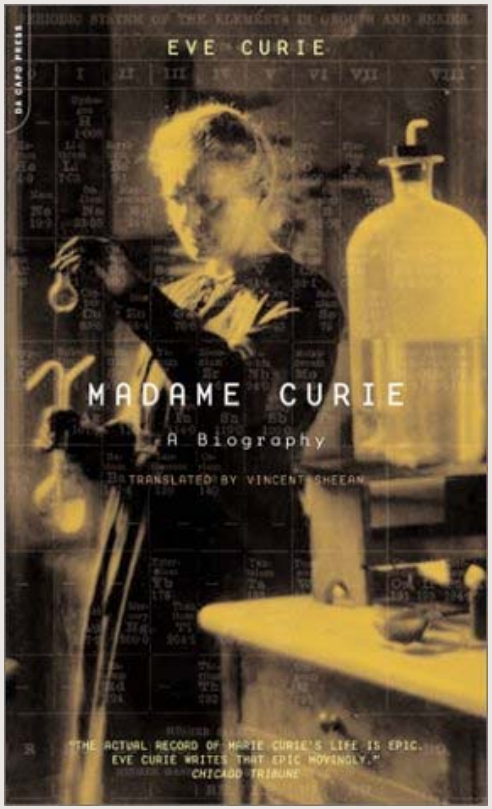
B.S. (Physics) University of Athens, Greece, 1983

Employment

2008 - present	Head, Accelerator Division, TRIUMF
2002 - 2008	Director, CASA, Jefferson Lab
1992 - 2002	Staff Scientist, Jefferson Lab
1989 – 1992	Accelerator Physicist, Stanford Linear Accelerator Center

Some early influences....

I was lucky to have superb Physics and Math teachers in High School, who definitively influenced my decision to go into Physics



13 years old

Αλκμηνη Γιουργα:
High school Physics teacher - A woman who gave excellence to her teaching and demanded excellence from us

16 years old

Mentors

In the work environment, it takes enlightened colleagues who feel secure about themselves, to mentor young women and influence their careers positively.

Work with the best in the field, even if it's painful!

TRIUMF

Focus on the work

Whenever, as a mid-career scientist, I felt that my career was not going anywhere, I resorted back to what inspired me to go into Physics to begin with, and focused on solving the next problem at hand and trying to push the envelope a little bit forward.

Career and family

Pursuing a scientific career and raising a family is not easy.

I find it the hardest to balance my family and my work, which is demanding. At the end of a long day I often feel I am not doing a good job in either. But, as a colleague once told me, I wouldn't have it any other way.

Leadership

In my mind, leadership is based on a set of immutable principles about which I feel quite strongly:

Integrity/honesty
Having a **vision** and being able to **articulate it clearly** to employees at all levels so they feel motivated to support it.
Respect for others
Technical proficiency
Decision making
Ownership; Taking **responsibility** for one's decisions and actions
Willingness to **accept risk** once the level of risk is defined
Determination, tenacity/persistence

We must identify opportunities for women to advance in the ranks, so there are more women in leadership positions

An advice I never forget

About 15 years ago, I heard **Florence P. Haseltine, Ph.D., M.D**. give a talk. She was at a very high level at the US National Institutes of Health at the time. She said she had two pieces of advice to young women in scientific and engineering fields :

"Stay focused."
"Don't take no for an answer."

Florence P. Haseltine

I took her advice to heart. This may not have to do with my being a woman, but if you come up with a new idea, somehow the tendency is that people want to turn it down (especially in science!). Don't stop. Just keep pushing. Not all ideas are good, but don't stop at the first no.

To be determined and to persevere is very important.

Closing Remarks

I feel it is very important to be technically competent, really competent. And then nothing else matters.

There are a lot of opportunities in science and engineering, and this field is more merit-based than most other fields. So if we are technically strong, we should not feel limited by anything.

Decide what it is you want to work on, and pursue it with focus and determination.

The road will be arduous but amply rewarding!

And have fun! Let's not forget:

We got into Science for the love of it!

TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

Thank you!
Merci

TRIUMF: Alberta | British Columbia | Calgary | Carleton | Guelph | Manitoba | McGill | McMaster | Montréal | Northern British Columbia | Queen's | Regina | Saint Mary's | Simon Fraser | Toronto | Victoria | Winnipeg | York

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