

Particle Physics

Department of Physics and Astronomy

Visit of the Dean of Science

Dr. Tom Pedersen

2 October 2003

Agenda

- Introductions
- Overview talk and discussion
- Tour of laboratories:
 - Detector Development Laboratory
 - Time Projection Chamber
 - ATLAS cryogenics signal feedthrough production
 - TRIUMF Accelerator Laboratory
 - target development
 - MUSE computer cluster & GRID Canada

Particle Physics at Victoria

Outline of Presentation

- Introduction to research goals
- The particle physics group at the University of Victoria
 - the IPP and TRIUMF connection
- Research students and education
 - training of highly qualified personnel
- Research overview
 - Theory, BaBar, OPAL, ATLAS, Linear Collider, Computing
 - funding
- Particle physics group goals and future plans

The Particle Physics Group at UVic

Goals and accomplishments

- Particle Physics is a major focus of the department
- Research goals
 - to study the fundamental constituents of matter and their interactions
- Education
 - To provide access to top international research for graduate and undergraduate students
- Internationally recognized group
 - responsible for major components of international projects
 - the University of Victoria is a well known name in particle physics
 - diverse, talented, critical mass for large impact
 - 43 researchers (faculty, fellows, associates, students, technologists) from 9 countries
 - research activities include extensive period spent at world class laboratories abroad (Geneva, Stanford) Excellent graduate student training

The Particle Physics Group at UVic

Internationally recognized research group

- Faculty
 - experimentalists: Astbury, Karlen, Keeler, Kowalewski, Lefebvre, McPherson (IPP), Roney, Sobie (IPP)
 - Theorists: Picciotto, Pospelov
- Onsite TRIUMF staff
 - Birney, Charron, Dowling, Langstaff, Lenckowski
- Research associates
 - Agarwal, Banerjee, Bhuyan, Fincke, Kanaya, Poffenberger
- Graduate students
 - Bailey, Bayes, Bird, Bolokhov, Brown, Fortin, Hamano, Hughes, Ince, Jackson, Lambert, Michailopoulos, Nugent, Rosenbaum, Shaw, Teke, Vanderster (with EE), Yun
- Computer scientist
 - Bickle, Van Uytven
- Technologists
 - Holness
- Undergraduate
 - Lila Klektau

The Particle Physics Faculty at Victoria

- D. Karlen (2002) PhD Stanford 88
 - Pearce Chair of Physics
 - Chair NSERC Subatomic Physics Chair (2003)
- R. Keeler (83) PhD UBC 81
 - Director of IPP (Institute of Particle Physics)
 - Chair NSERC Subatomic Physics GSC (2000-2001)
- R. Kowalewski (97) PhD Cornell 88
 - B physics, particle lifetimes, reconstruction software (OPAL, BaBar, ATLAS)
 - Convenor of BaBar Exclusive Semileptonic Working Group, Member BaBar Publications Board (2003-)
- M. Lefebvre (91) PhD Cambridge 89
 - Electroweak physics, Calorimetry (UA2, RD3, ATLAS), Faculty of Science Teaching Award (2002-2003)
 - Founded ATLAS Canada, ATLAS Advisory Board (1998-99), ATLAS Publications Committee (2002-)
- R. McPherson (IPP - 97) PhD Princeton 95
 - OPAL Physics Coordinator (2001-2002) and Opal New Particles Searches Convenor (1997-2000)
 - ATLAS liquid argon detectors beam test software coordinator and Detector Control-System Coordinator
- C. Picciotto (68) PhD UC-Santa Barbara 68
 - Weak Decay Theory, Department Chair 1998-2003
 - Secretary-Treasurer of IPP
- M. Pospelov (2002) PhD Budker Inst. 94
 - Particle phenomenology, physics beyond the Standard Model, supersymmetry
 - Astroparticle physics and cosmology
- M. Roney (96) PhD Carleton 89
 - Electroweak, drift chambers and B & tau physics (OPAL, BaBar, ATLAS), BaBar Run Coordinator (2003)
 - BaBar Executive board (1999-2001) and International Finance Committee (2001-), Department Chair 2003-
- R. Sobie (IPP - 92) PhD Toronto 85
 - OPAL tau physics coordinator (1998-2002) and Canadian representative on ATLAS International Computing Board
 - Spokesperson for Victoria CFI Computer Storage Award 3M\$ CFI, 3M\$ BCKDF, 1M\$ IOF
- A. Astbury (83) (retired) PhD Liverpool 61
 - Chairman Int. Review Com. Muon Ionization Cooling Exp't. (MICE), Rutherford Appleton lab
 - President Elect of IUPAP (International Union of Pure and Applied Physics) and Director of TRIUMF (1994-2001)

The Particle Physics Group at UVic

Institute of Particle Physics of Canada

- Coordinates and promotes particle physics in Canada
 - 13 Universities and Laboratories, ~150 scientists
 - 32 year history
- Eight permanent scientists; two chose Victoria:
 - R. McPherson & R. Sobie
 - Research faculty carry heavy responsibilities for Canada in the large international projects of particle physics
 - R. Sobie represents Canada on several national and international committees for computing and the GRID.
 - R. McPherson is located at CERN and is responsible for coordinating the instrumentation that will monitor the calorimeters and feedthroughs that we built.
- Located in Victoria
 - Director (2001-2006): R. Keeler
 - Secretary-Treasurer: C. Picciotto

The Particle Physics Group at UVic

TRIUMF

- national laboratory supporting accelerator based research
- Victoria is one of the four founding universities
- a design group is located at Victoria
 - provides engineering & infrastructure support for particle physics
 - **essential requirement**
 - SLD Calorimeter
 - BaBar Drift Chamber
 - ATLAS Endcap Hadronic Calorimeter and Feedthroughs Engineering Support
 - Linear Collider TPC tests
 - A.S. Dowling (TRIUMF engineer)
 - R. Langstaff (TRIUMF senior designer)
 - M. Lenckowski (TRIUMF junior designer)
 - P. Birney (TRIUMF senior technologist)
 - L. Charron (TRIUMF admin assistant)

Graduate Student Record

- D. Britton, PhD (Bryman,Robertson) **Faculty Imperial College, University of London**
- P. Schenk, PhD (Astbury) Gov. Gen. Gold Medal

1995 - present

- M. Rosvick, PhD "Measurement of the Neutral Current in the Standard Model Using the Tau Polarization Asymmetries Determined from the Decay" 1995 (Keeler).
- J. Steuerer, PhD "Measurement of the Product Branching Ratio" 1995 (Astbury)
- P. Knowles, PhD "Muonic Processes in Solid Hydrogen Films." 1996 (Beer)
- **M. Vinciter, PhD "A Precision Measurement of the Ratio of the Effective Vector to Axial-Vector Couplings of the Weak Neutral Current at the Z0 Pole." 1996 (Keeler), Faculty Member of University of Alberta.**
- M. Welsh, PhD "I. The Form Factor, II. Validity of Soft Photon Amplitudes, III. Soft Photon Excess in Hadron Scattering." 1996 (C. Picciotto)
- P. Hu, MSc "A Study of the Response of the OPAL Calorimeter to Hadrons." 1996 (Keeler).
- J. Maier, MSc "The Wolfenstein-Gerstein Effect in Solid Protium-Deuterium Targets." 1997 (Beer)

Graduate Student Record

- S. Richardson, PhD "A Study of Some Rare Radiative Meson Decays", 1998 (Picciotto)
- J. White, PhD "Testing Lepton Universality using One-Prong Hadronic Tau Decays", 1998 (Sobie, Lefebvre)
- S. Bishop, MSc "A Low Noise Lifetime Measurement of Electrons Drifting in Liquid Argon", 1998 (R.K. Keeler, R. Sobie)
- L. Stumpf, MSc "A Measurement of the Branching Ratio of the Decay of the Lepton to Five Charged Hadrons", 1998 (R. Sobie, R.K. Keeler)
- T. Porcelli, PhD "Measurements of Muon Catalyzed dt Fusion in Solid HD" 1999 (Beer)
- **S. Robertson, PhD "A Measurement of the Tau Electronic Branching Ratio", 1999 (R. Sobie, R. Keeler). Governor General's Gold Medal - Now IPP Scientist McGill**
- I. Lawson, PhD "Neutral Kaon Production from One-prong Tau Decays", 2000 (Keeler, Sobie)
- **D. O'Neil, PhD "Performance of the ATLAS Hadronic Endcap Calorimeter and The Physics of Electroweak Top Quark Production at ATLAS", 2000 (M. Lefebvre) Faculty member SFU**

Graduate Student Record

- D. Fortin MSc “Performance of the ATLAS Hadronic Endcap Calorimeter Modules to Electrons and Pions”, 2001 (Lefebvre).
- P. Jackson, MSC “Hypothesis Testing Variables Applied to Trajectory Fitting in the BaBar Experiment”, 2001 (Kowalewski)
- C. Bird, MSc “Infrared Regularization in Relativistic Chiral Perturbation Theory” 2001 (Picciotto)
- C. Brown, MSc “A Study of the Leptonic Branching Ratios of the Tau at *BABAR*” 2001 (Roney).
- K. Graham, PhD “Precision Determination of the Electroweak Mixing Angle and Test of Neutral Current Universality from the Tau Polarization Measurements at OPAL” 2001 (Roney).
- M. Dobbs, PhD “Probing the Three Gauge-boson Couplings in 14 TeV Proton-Proton Collisions” 2002 (M. Lefebvre). **1st Owen Chamberlain Fellow at LBL**
- **B. Vachon PhD “Search for Excited Charged Leptons in Electron-Positron Collisions” 2002 (McPherson, Sobie). Gov. Gen. Gold Medal**
- L. Kormos PhD “A Measurement of the Tau to Muon Branching Ratio” 2003 (Sobie, Keeler).

24 degrees by 22 individuals (16 men, 6 women)

3 Governor General’s Gold Medals

3 in faculty positions & 1 IPP Research Scientist

Present students: 2 NSERC PGS, 1 FCAR, 3 UVic Fellowships

Undergraduate Student Supervision

HEP Undergraduate Students since 1997

Student's Name Group and Supervisor Period of Employment

ALLAN, Jennifer	ATLAS – R. Sobie	Jan-Apr 2003
BENNING, Manj	ATLAS/OPAL – R. Sobie	Jan-Apr 2003
GABLE, Ian	ATLAS – M. Lefebvre	May-Aug 2003, May-Aug 2002
KLEKTAU, Lila	ATLAS – R. Sobie	Sep-Dec 2003
VANDERSTER, Dan	ATLAS – R. Sobie	Sep-Dec 2002
ZWIERS, Ian	ATLAS – R. Sobie	May-Aug 2002
SMECHER, Graeme	ATLAS – R. Sobie	Jan-Apr 2002
STARKE, Tamara	ATLAS – M. Lefebvre	May-Aug 2002
GUILLAUME, Girard	ATLAS – M. Lefebvre	May-Aug 2001
LINDNER, John	ATLAS – R. Keeler	Jan-Apr 2000
GROULX, Sarah	ATLAS – M. Lefebvre	May-Aug 1998
MACDONALD, Robert	ATLAS – R. Keeler	May-Aug 1999
MCDONALD, Robbi	ATLAS – R. Sobie	May-Aug 2000
MUZZERALL, Erica	ATLAS – R. Keeler	May-Aug 2001
LINDNER, John	ATLAS MIG – M. Lefebvre	Aug-Dec 2001
WIGGINS, Wendy	ATLAS MIG – M. Lefebvre	Feb-Aug 2002
KING, Greg	BaBar – M. Roney	Jan-Aug 2002
NUGENT, Ian	BaBar – M. Roney	May-Aug 2002
MUELLER, Eilif	BaBar – M. Roney	May-Aug 2001
GIFFORD, Jonas	BaBar – R. Kowalewski	May-Aug 2000
DAY, Ben	BaBar – M. Roney	Jan-Apr 2000
DESROCHES, Louis	BaBar – R. Kowalewski	Jan-Apr 1999
COPPIN, Kristen	BaBar – M. Roney	May-Aug 1997
CHAPPLE, Erin	OPAL – R. Keeler	May-Aug 2000
CAMPSALL, Paul	OPAL – R. Keeler	May-Aug 1999
BEAUCHEMIN, Catherine	OPAL – R. Keeler	Jul-Aug 1999
PEEBLES, Dan	OPAL – R. Keeler	Jan-Apr 2001
BÉLANGER-CHAMPAGNE, C.	TPC – D. Karlen	May-Aug 2003
HOFFMAN, Brie	TPC – D. Karlen	May-Aug 2003

Research Overview

- Theory
 - particle phenomenology, astroparticle physics and cosmology
- Three large projects
 - OPAL (CERN) data analysis being finalized
 - BaBar (SLAC) started data taking in 1999
 - will continue running for several years
 - ATLAS (CERN) is under construction
 - first beam for physics expected in 2007



- Interests beyond ATLAS

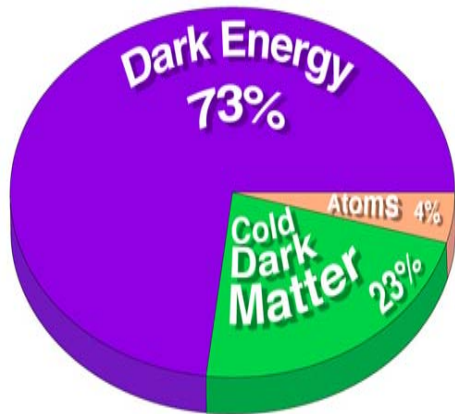
- Linear Collider
- neutrino physics



Particle theory

- **Standard Model** (SM) is the most successful theory to date and is in perfect accord with experiments. Particle theory provides calculations that help to extract SM parameters from experimental data. **SM needs a Higgs scalar** as an ultimate confirmation of its validity.
- **SM cannot be an ultimate theory**: SM parameters themselves hint at a “heavenly order” or **unification**. There is a need to **incorporate gravity**: a big theoretical challenge.
- Great disparity between gravity scale and electroweak scale calls for **new physics** at a TeV. **Supersymmetry** is a leading candidate theory. Merges with **superstrings**.
- Observable Universe cannot be explained with SM alone.

Astroparticle physics and cosmology



- What are these 73% and 23%? It does not belong to the SM...
- Why matter dominates over antimatter?
- What is the ultimate fate of the Universe? (expands forever, recollapses?)

Goals:

Determine the nature of dark matter and dark energy.

Find the solution(s) to the cosmological constant problem.

Develop a reliable theory of baryogenesis

Reconstruct the earliest moments of Universe's existence with cosmic microwave background and large scale structures

UVic theory group scientific activity

- Precision checks of the Standard Model. Calculations of rare decays, electric dipole moments, CP asymmetries. **Picciotto, Pospelov**
- Non-commutative field theories. **Pospelov, Teke**
- Dark matter, dark energy, astroparticle physics. **Bird, Pospelov**
- Phenomenology of quantum gravity, checks of Lorentz symmetry and CPT. **Bolokhov, Pospelov**
- Supersymmetry, model building, Higgs physics. **Pospelov**
- Optical activity, chiral molecules, origins of homochirality. **Pospelov**

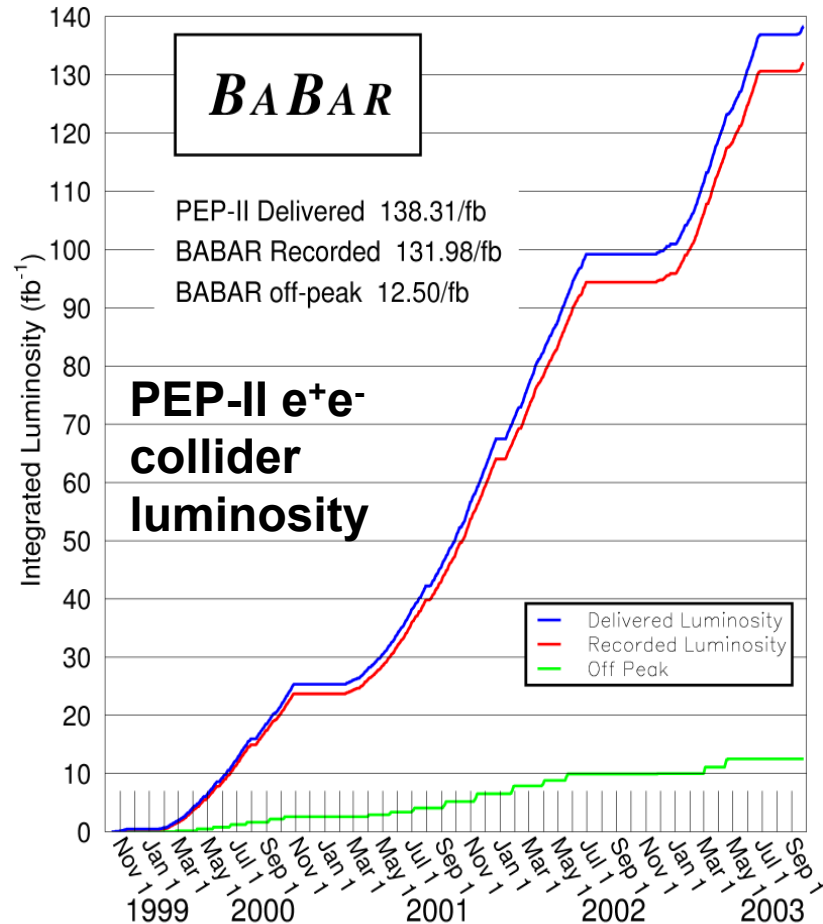
The Science of BaBar

- Matter and forces → particles and **symmetries**
- Every particle has an anti-particle ('27): $\mathbf{C}(e^-)=e^+$
- Weak interactions violate **C** and parity **P** ('56)
- **CP** symmetry relates matter to anti-matter;
CP violation first seen in K mesons ('64)
- Kobayashi & Maskawa propose ('73) mechanism for **CP** violation: requires 3rd generation of quarks (b, t)
- Gen 3 particles discovered (τ in '74, b in '77, t in '95)
- Yet... for 35 years, the standard mechanism for **CP** violation has remained *untested*

B mesons provide ideal laboratory for CP studies

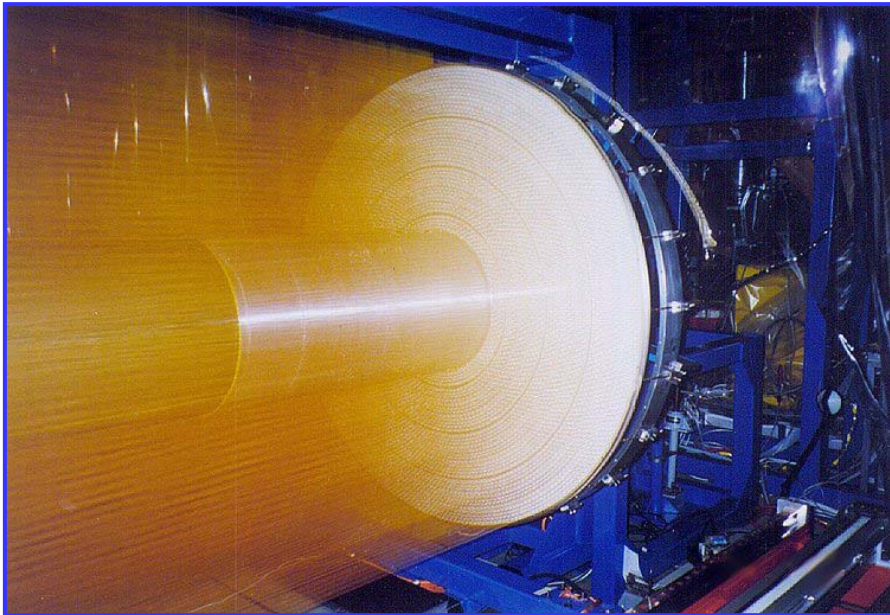
The B factories

- Why has it taken so long to study **CP** violation in **B** mesons? It's hard!
- 2 ~\$250M facilities built in late 90s; **BaBar at SLAC** (Stanford) and Belle at KEK (Japan)
- Both accelerators have broken all luminosity records (10x better than previous best)



The BaBar experiment

- Central tracking detector (drift chamber built at TRIUMF (1997)



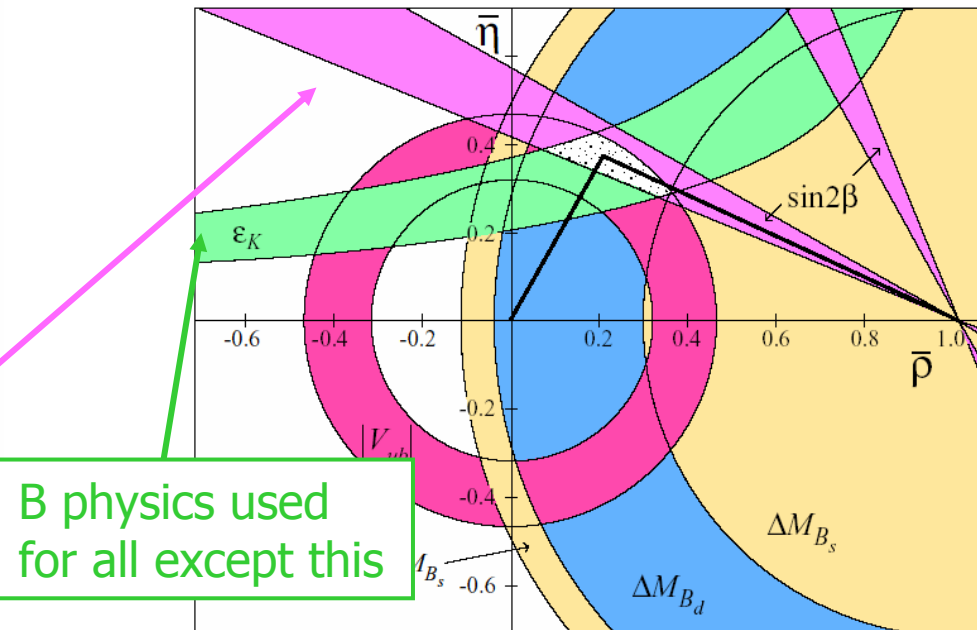
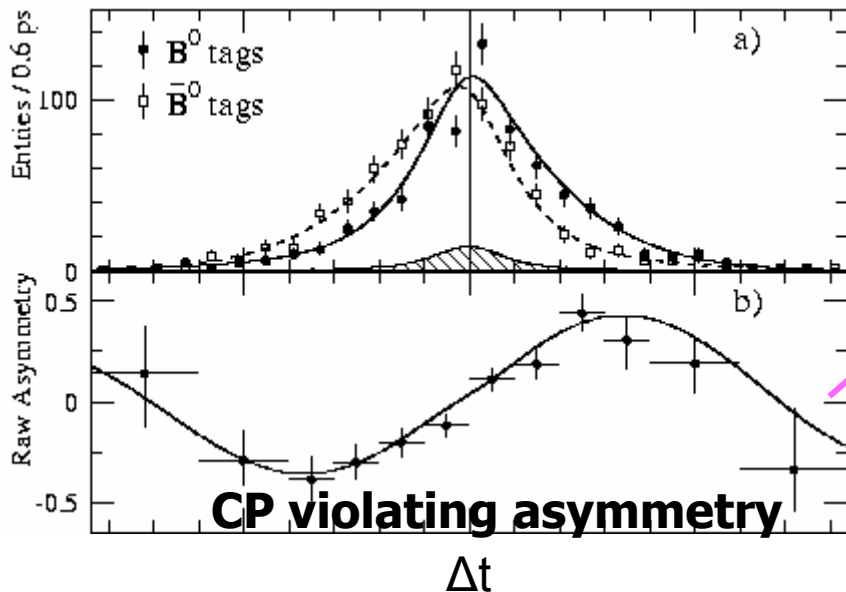
- BaBar detector installation at SLAC



CP violation in B mesons observed in 2000

Weak quark physics

- Weak transitions between quarks (e.g. $n \rightarrow p e^- \bar{\nu}$) described by 3x3 (CKM) matrix; 3 angles and 1 phase
- If Standard Model is correct, all measurements must be accommodated by these 4 parameters
- BaBar (Belle) dominate these experimental tests



BaBar and Victoria

- BaBar has ~600 Ph.D. physicists and students in 77 institutions in 9 countries (Europe, America)
- Canadian effort: 8 faculty, 5 post-docs, 12 students; 25 members in 4 institutions
- Victoria effort: 3 faculty (Kowalewski, Roney, Sobie), 2 postdocs, 6 students; 11 members
- Hosted >200 BaBar physicists at UVic in May 2002
- Local computing facilities are used for BaBar data analysis, simulations. NSERC funding for BaBar Canada computing comes to Victoria.
- Computing experts (Agarwal, van Uytven) are essential to the effort.

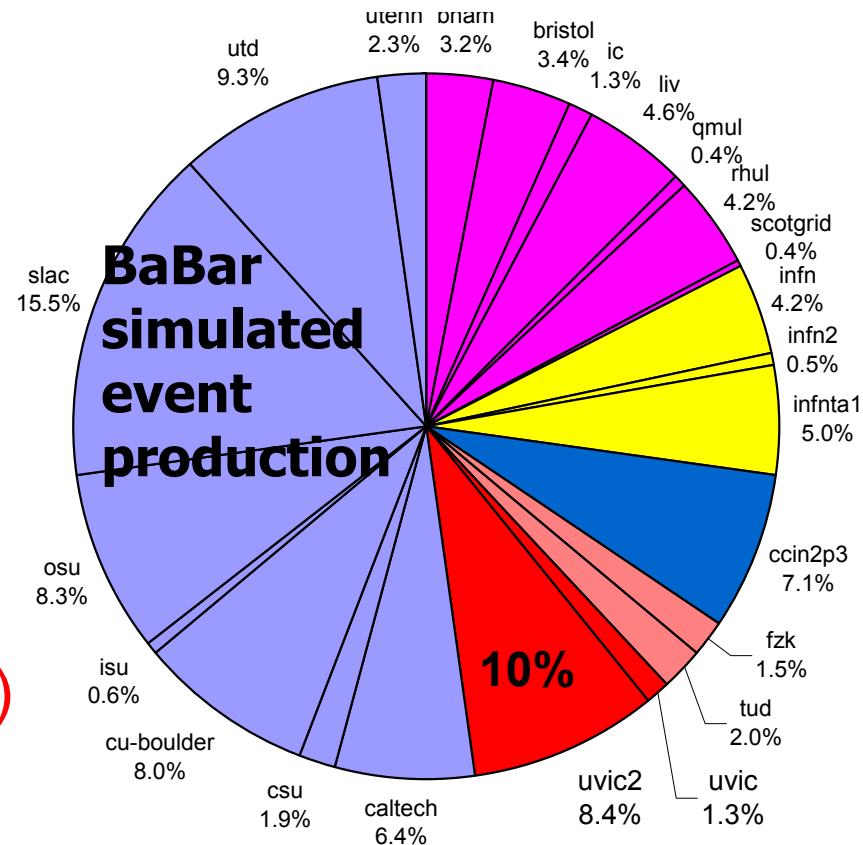
UVic group scientific activities

- CKM physics:
 - measure couplings of b quark to u and c quarks (Fortin, Hamano, Kowalewski)
 - coupling of u quark to s quark (Nugent, Roney)
- Rare decays (→new phenomena)
 - rare B decays involving “invisible” energy (Jackson, Kowalewski)
 - τ decays that violate lepton number (Brown, Roney)
- Victoria leads efforts in these areas; we also contribute to efforts in other areas

UVic central BaBar activities

- Run manager (Roney)
- Executive board (Roney 99-01), Publications board (Kowalewski), inter. finance committee (Roney)
- Detector control soft (Brown)
- Offline soft (Kowalewski, Jackson)
- dE/dx calibration (Fortin)
- Tracking (Hamano, Nugent)
- Simulation (Agarwal, Hamano)

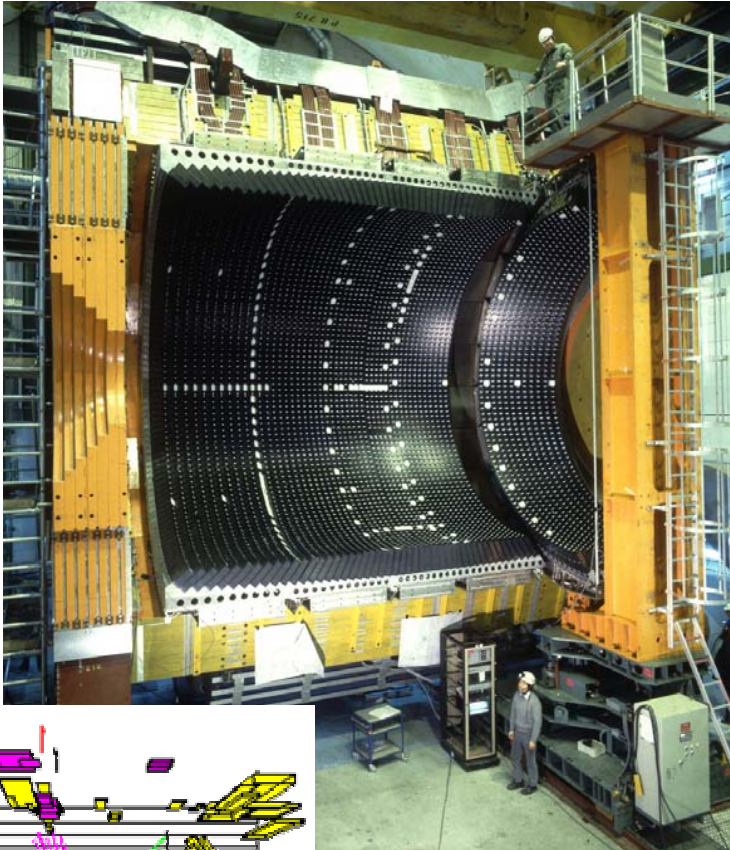
- Roney leads tau WG
- Kowalewski leads semileptonic WG



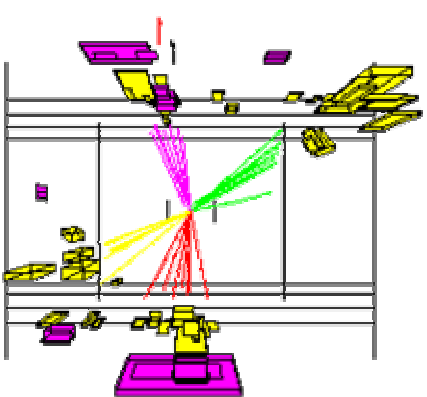
Aerial View of CERN



OPAL and Victoria



- large detector at the LEP electron-positron collider at CERN, Geneva
- data collection ended Nov 2000
- UVic group concentrated on precision measurements of the electroweak force
 - analyzing W pair data
 - triple gauge couplings (I. Bailey –PhD)
 - one of the world's most precise electroweak measurements was completed in UVic
 - Extensive searches for new types of particles – Supersymmetry & exotic higgs
- UVic hosted the international tau 2000 conference in Victoria
- Project will be completed at Victoria in a year



ATLAS and Victoria

- ATLAS: multi-purpose detector for the Large Hadron Collider at CERN
- proton-proton collision at the energy frontier: 14 TeV
 - study the origin of mass, search for new physics

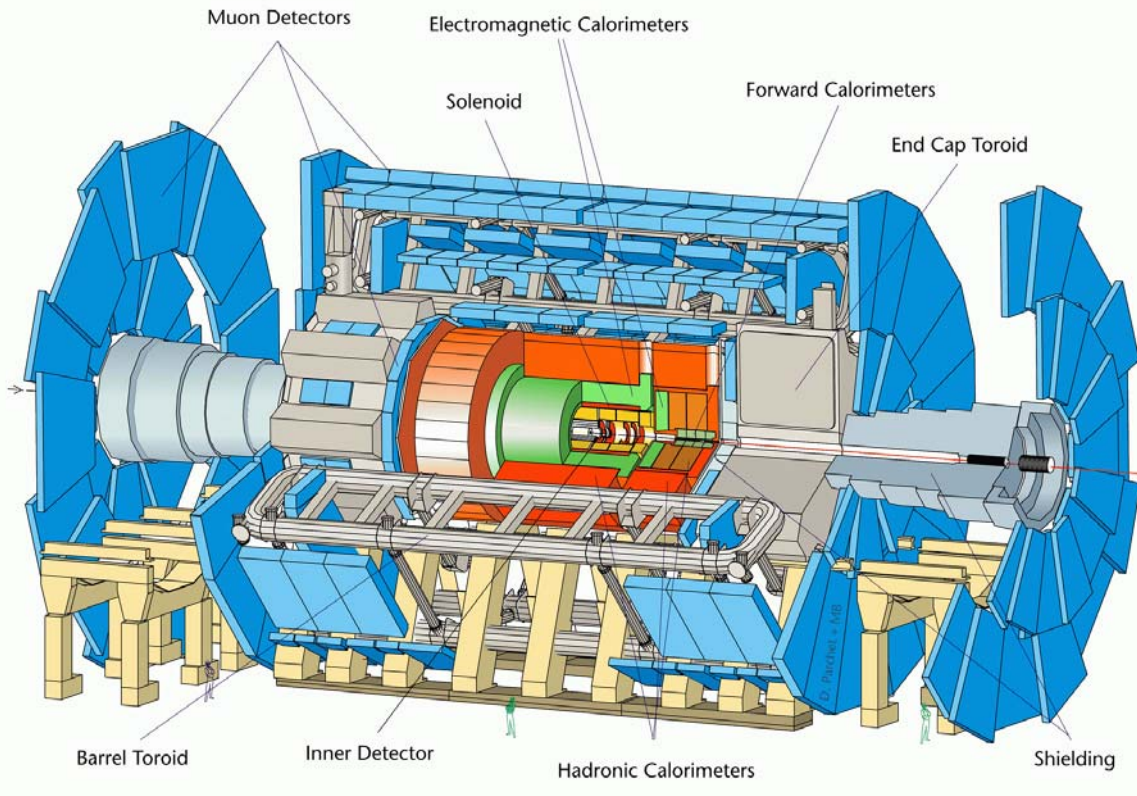
Astbury
Keeler
Lefebvre
McPherson
Sobie



Alberta
Carleton
CRPP
Montréal
SFU
Toronto
TRIUMF
UBC
Victoria
York

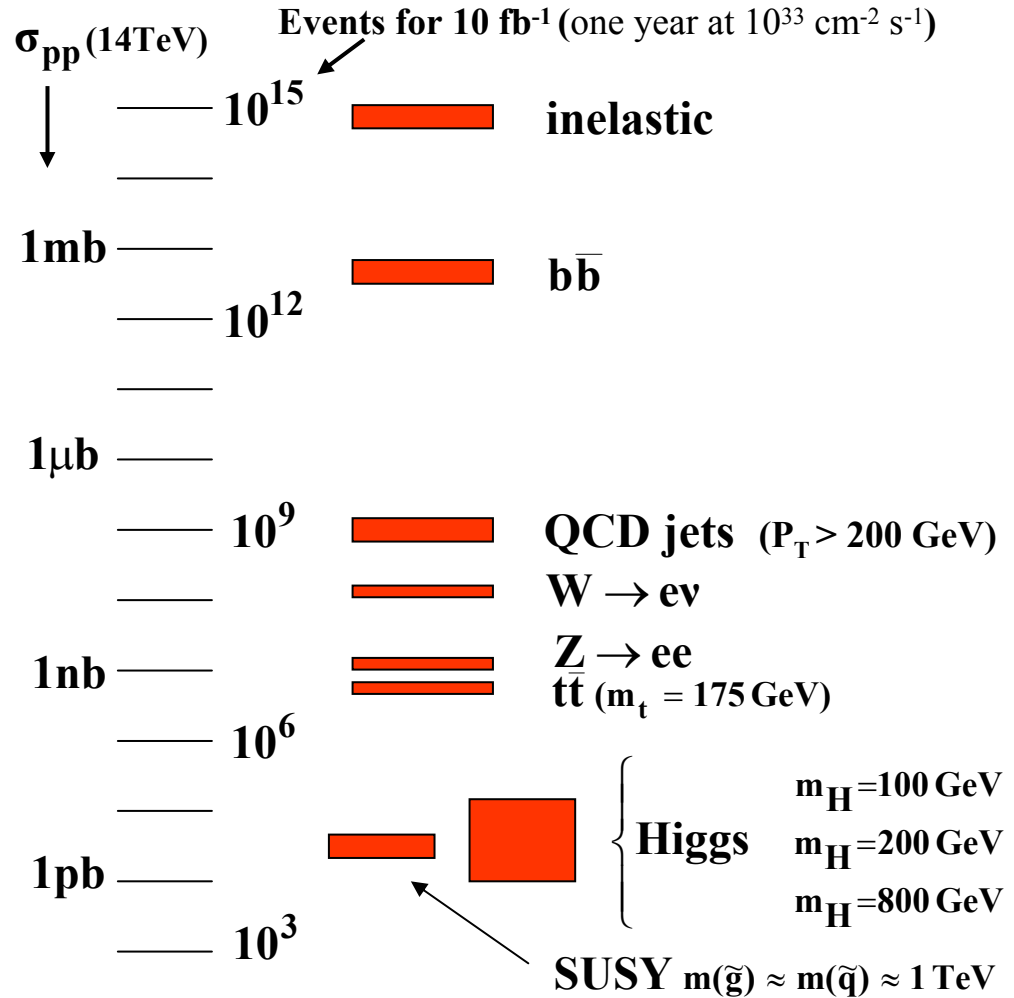
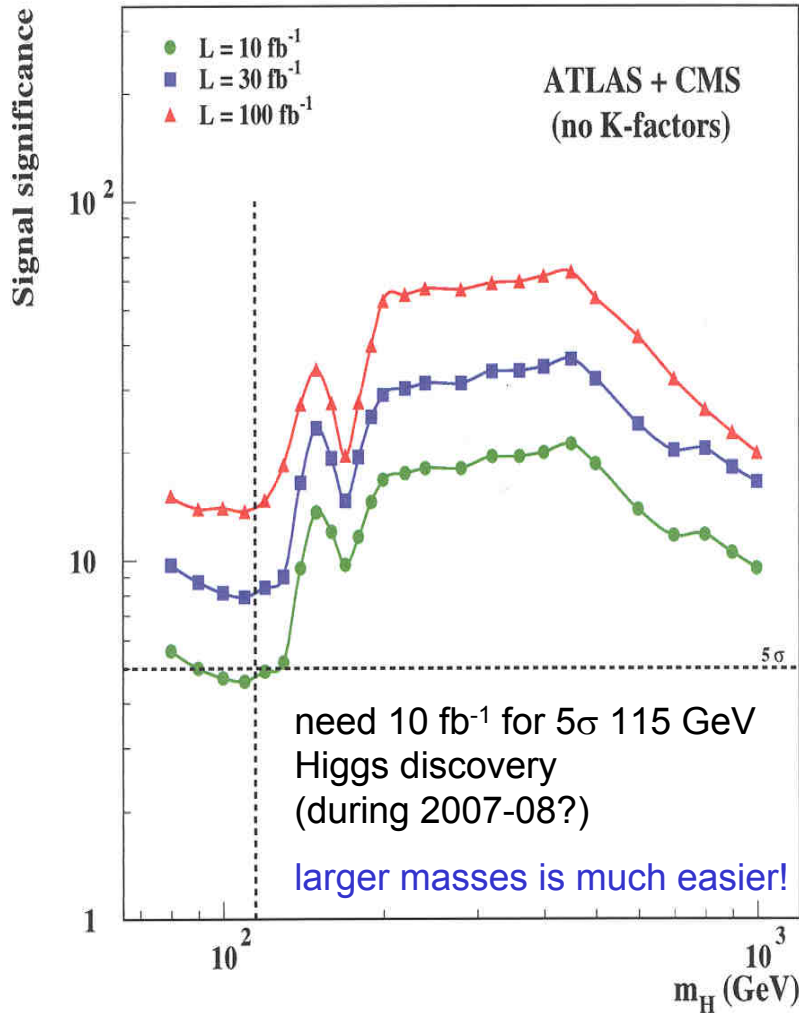
UVic graduates

J. White (M.Sc. 93)
S. Robertson (M.Sc. 94)
S. Bishop (M.Sc. 95)
D. O'Neil (Ph.D. 99)
D. Fortin (M.Sc. 00)
M. Dobbs (Ph.D. 02)
T. Ince (M.Sc.)
T. Hughes (M.Sc.)



diameter 25 m
barrel toroid length 26 m
total weight 7000 tons

LHC PP Cross Section and Higgs Discovery Potential



Higgs Mechanism



A room full of physicists chattering quietly is like space filled with the Higgs field...



... a well-known scientist walks in, creating a disturbance as he moves across the room and attracting a cluster of admirers with each step...



...this increases his resistance to movement, in other words, he acquires mass, just like a particle moving through the Higgs field...



...if a rumor crosses the room...



...it creates the same kind of clustering, but this time among the scientists themselves. In this analogy, these clusters are the Higgs particles

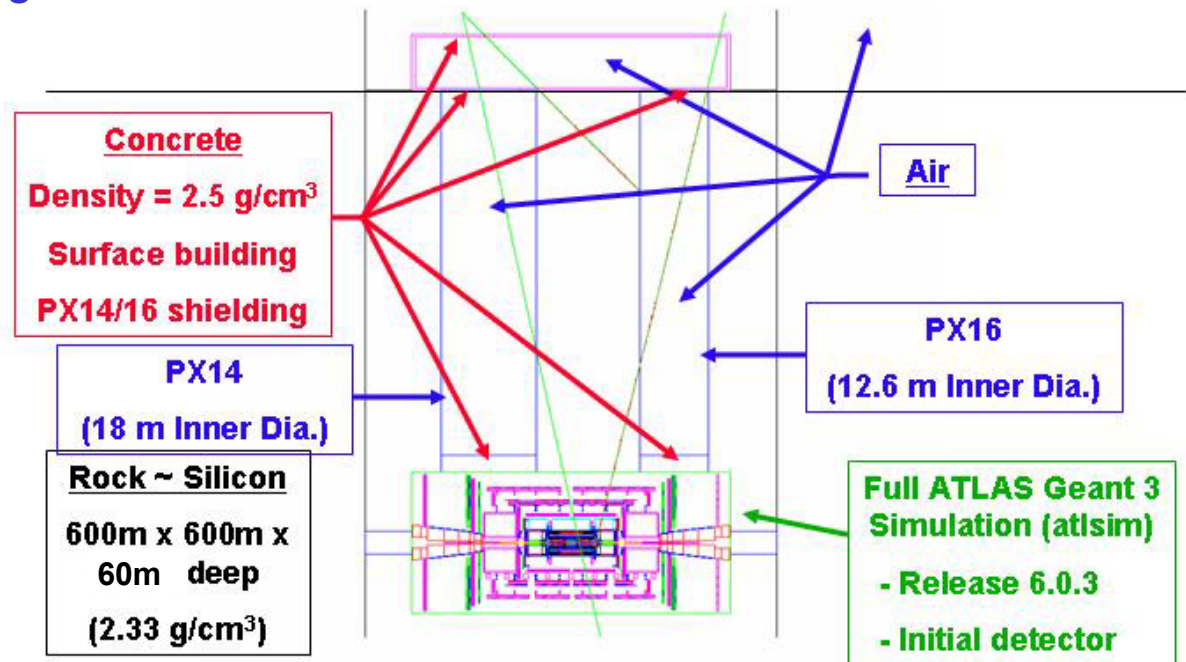
ATLAS educational web page, adapted from an idea from Dr D. J. Miller

ATLAS and Victoria

- physics phenomenology investigations
 - M. Dobbs (Ph.D. 02): Electroweak top production
 - D. O’Neil (Ph.D. 98): Triple gauge boson physics
 - N. Kanaya (R.A.): Little Higgs studies
- cryogenics components constructed at UVic (project leader: M. Lefebvre)
 - 1997 \$4.28M of Major Installation Grant for the endcap signal feedthroughs
 - installation completed at CERN on 26 Sep 2003 (P. Poffenberger, F. Holness)
 - has involved many UVic and TRIUMF scientists over the past 7 years
- design, prototyping and beam tests of LAr calorimeters
 - 1992-: S. Bishop (M.Sc. 95), D. Fortin (M.Sc. 00), S. Robertson (M.Sc. 94), J. White (M.Sc. 93)
 - important combined beam tests in 2002 and 2004
- intense reconstruction software activities
 - ATLAS liquid argon calorimeter beam test software coordination (R. McPherson)
 - beam test software development (N. Kanaya, M. Lefebvre, R. McPherson)
 - beam test data analysis (M. Fincke-Keeler, T. Hughes, T. Ince)

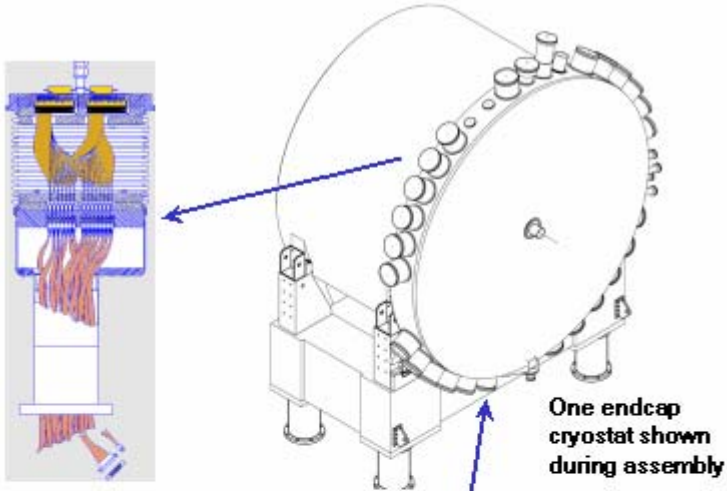
ATLAS and Victoria

- LAr detector control system
 - in charge of overall coordination (R. McPherson)
 - deployment starting with 2004 combined beam tests
- GRID computing development (R. Sobie)
 - GRID Canada
 - ATLAS data challenges
- commissioning studies (R. McPherson)
 - cosmic muons: starting in 2004
 - beam halo muons: first half of 2007

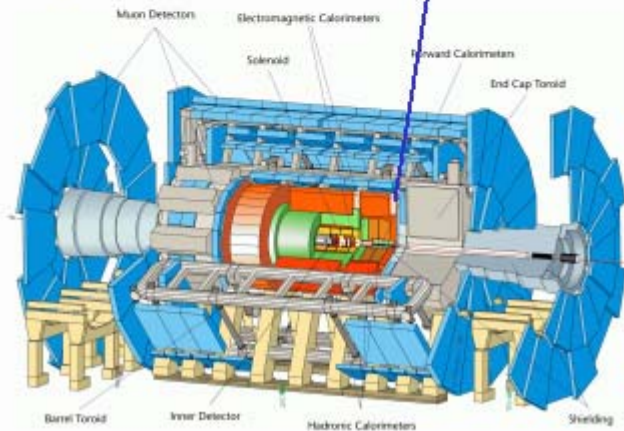


ATLAS and Victoria

- LAr signal feedthroughs



electrical tests at CERN



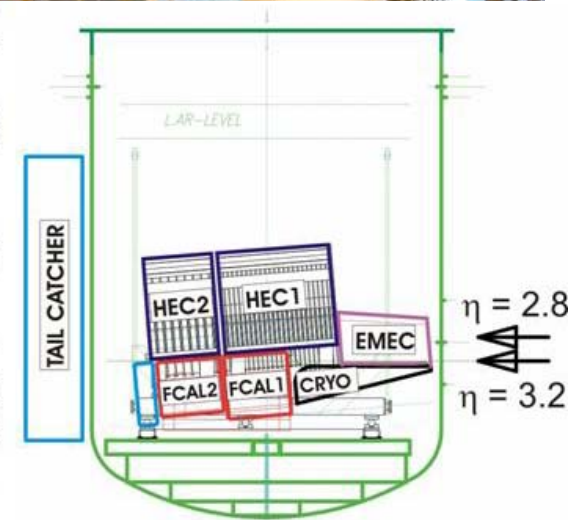
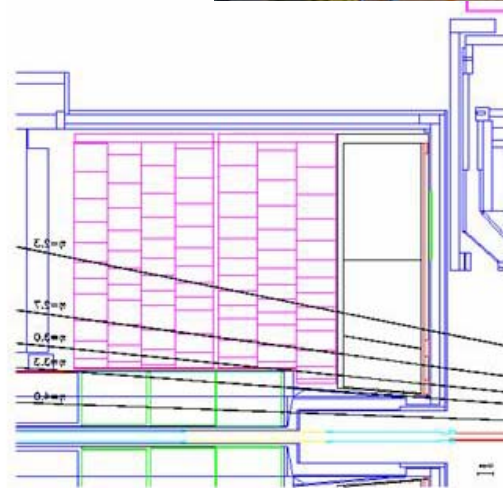
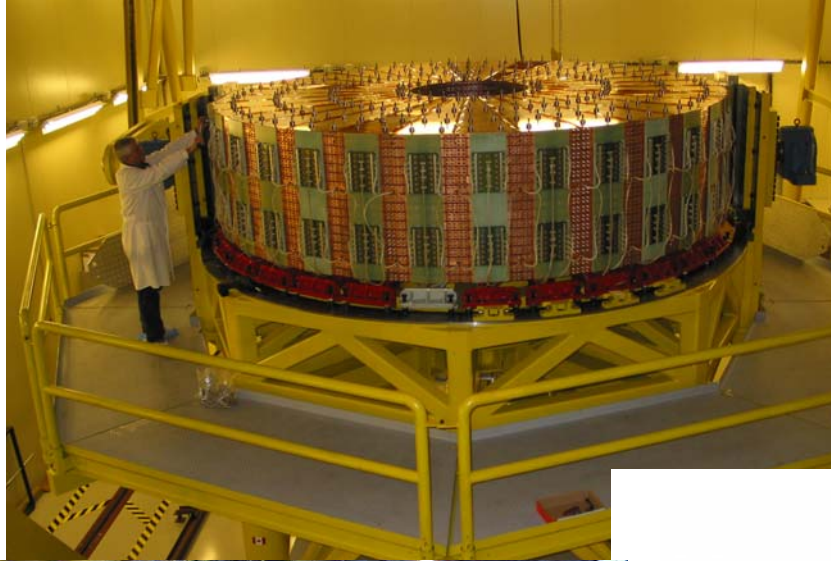
last feedthrough produced at UVic, 25 Oct 2002



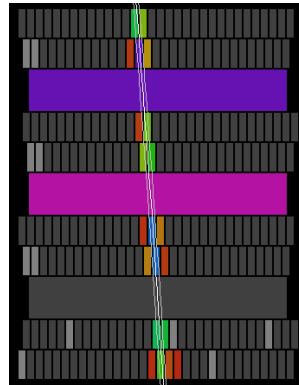
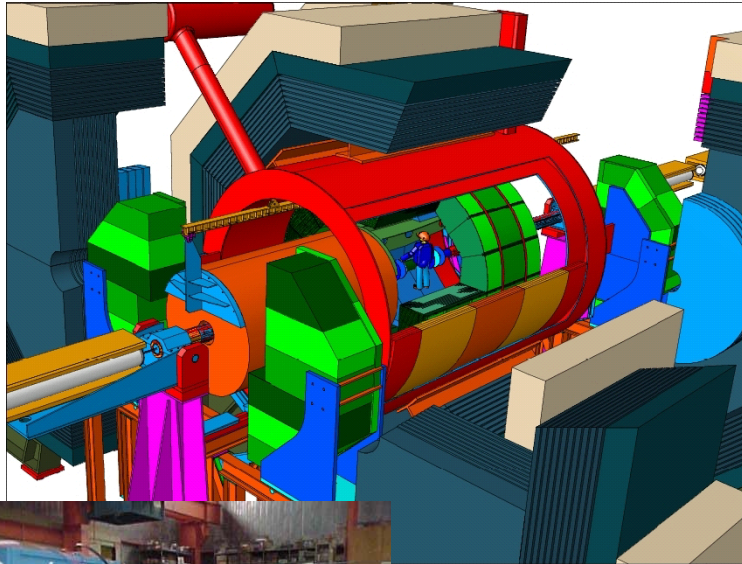
installation at CERN

ATLAS and Victoria

- LAr calorimeters integration and beam tests



Linear Collider Overview



- electron-positron collider 0.5 – 1 TeV
 - to investigate the breaking of the symmetry between the electromagnetic and weak forces
 - to elucidate new physics found at LHC
 - worldwide consensus as next project
 - operation to begin early in next decade
- detector development now underway at UVic and TRIUMF
 - time projection chamber R&D for precision tracking of charged particles
 - successful test of prototype in high magnetic fields at TRIUMF & DESY with cosmic rays
 - a leading group in the worldwide effort to develop the central part of the linear collider experiment

Linear Collider Physics

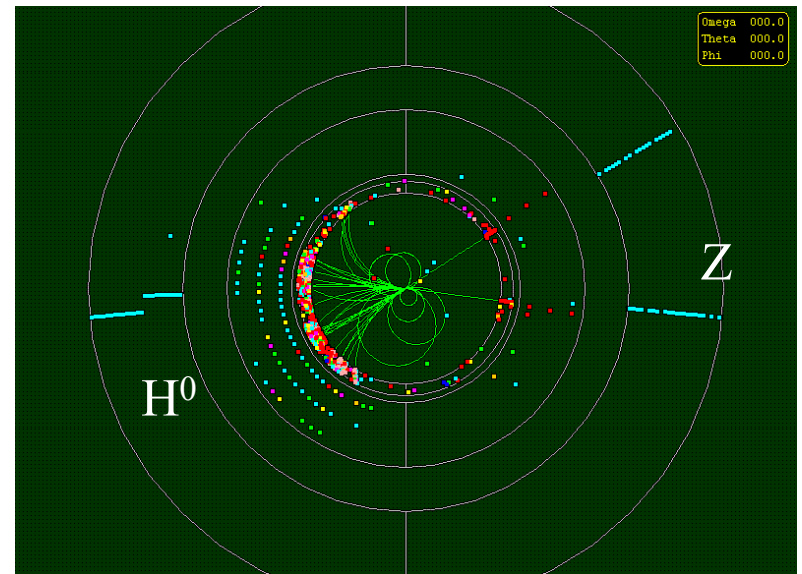
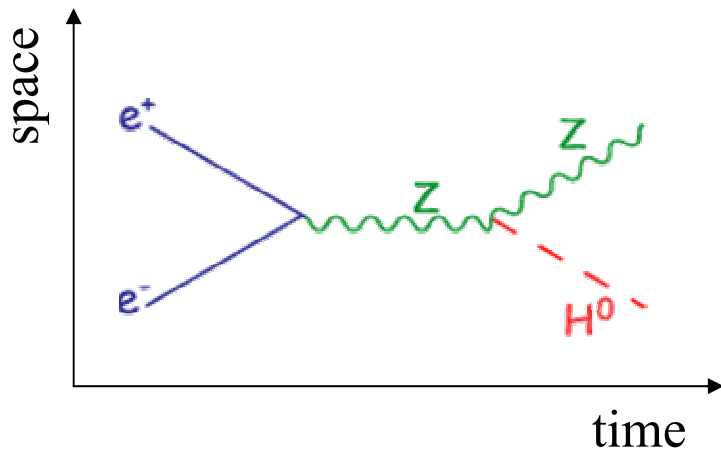
- Two forces that govern the Universe appear to be very different:
 - the electromagnetic force is pervasive
 - all of our senses rely on the EM force
 - the weak force is limited to nuclear dimensions
 - it drives the sun
- The two forces are now known to arise from a common thread: the electro-weak force
 - firmly established by precision measurements, primarily at electron-positron collider experiments (including OPAL at LEP) over the past decade
- The electron-positron linear collider is being proposed to establish the physics responsible for dividing the electro-weak force into two: the “breaking of the electro-weak symmetry”

Linear Collider Physics

- The standard model of particle physics assumes a new field is responsible for the symmetry breaking.
 - the field manifests itself in the form of a new fundamental particle: the Higgs
 - the Higgs also bestows mass to all other forms of matter
- We expect to discover the Higgs or a Higgs-like particle with the ATLAS experiment at CERN
- The linear collider is necessary to determine whether the particle is really the SM Higgs or something else...
 - is it really responsible for mass?
 - does it have the right quantum numbers

Linear Collider Physics

- The linear collider can produce large numbers of Higgs particles in a particularly well understood way that allows for a careful examination:



- The knowledge gained at a linear collider will be essential to show the way to a more complete theory of our Universe.

University of Victoria Research Computing Facility

- One of the largest research facilities in Canada
- Three main components:
 - High Performance Computer (1999)
 - Intel-based Computer Cluster (2003)
 - 200 TB High Performance Storage Facility (2003)
- Funded by 2 awards (1999 and 2002)
 - Canada Foundation for Innovation (CFI)
 - BC Knowledge Development Fund
 - IBM

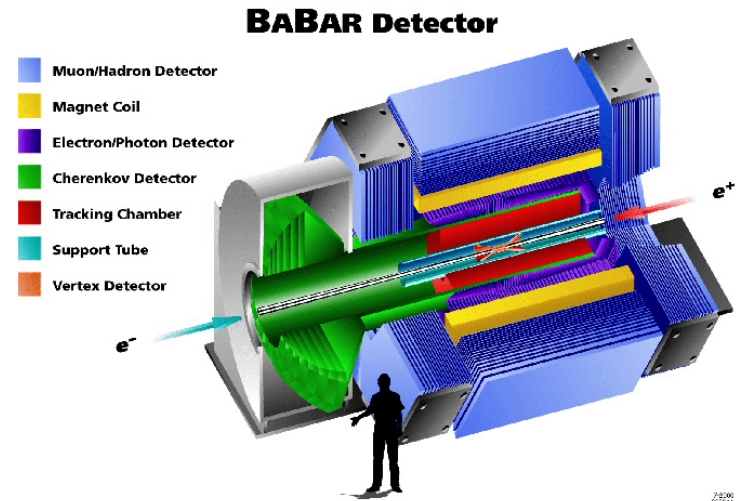
2002 CFI Award

- \$2.997 M from CFI and BCKDF (each)
 - Plus IBM donation (500K) and exceptional discount
- 4 year project (spent 25% of funds)
- \$1 M CFI-IOF allocated by UVic VP's
 - Paying 2 FTE's in CASS
 - 100K allocated for power system (UPS/generator)
- Other resources/projects participating
 - CFI TAPOR (Social Science)
 - HEP NSERC grant for processors

Mercury Linux Computer Cluster

2003 - 108 2.4 GHz IBM Blade processors

- 470th fastest computer in the world
- Currently 100% utilized - will double by end of 2003
- Used to simulate particle physics collisions for the BaBar (Stanford) ***0.5 TB data per week***



Storage Facility



- 2002 Award – 4 Year Project
 - Year 1 - 200 TB total storage
 - Disk and Tape managed by a HSM
 - Largest in Canadian University
 - Expect to double storage – exceed 1 Petabyte?
 - Operational in May 2003
- Large users include
 - Canadian Astronomical Data Centre
 - CFS Pacific Forestry Centre



HEP Linux cluster

- Linux cluster operated by HEP group since 1999
 - 60 cpu
 - 5 TB local disk storage
 - 2 Gb/s link to storage centre
- Supports interactive use by HEP group
- Supports batch use for simulation and data analysis
- Desktop computing support for HEP users requires an additional ~40 machines
- HEP in-department computing managed by Jan Van Uytven

Networks

- High-speed network is critical
- BCNET and CANARIE
 - **BCNET** is a non-profit society supporting and promoting advanced networks for the province's research and education communities
 - CANARIE provides a world-class research network across Canada and to the world
- **HEPNET MFA** supports networking for HEP community in Canada; centred at UVic



The Grid



What is grid computing?

Computing grids are geographically separated computers or computer clusters; they are linked so their processing power can be combined to act as one massive computer.

The machines can be spread out nationally or around the world sharing

Grid R&D at Victoria

- One of the leading groups in Grid Canada
 - NRC, CANARIE, Alberta
- 2002 Established a “testbed” of 50 computers at 12 sites across Canada
- Establishing a grid with the “production level” facilities (~500 CPUs)
- First application will use ATLAS simulation
- Many challenges (political, security, trust, ...)
- HQP
- Links with international grid projects

Training of HQP

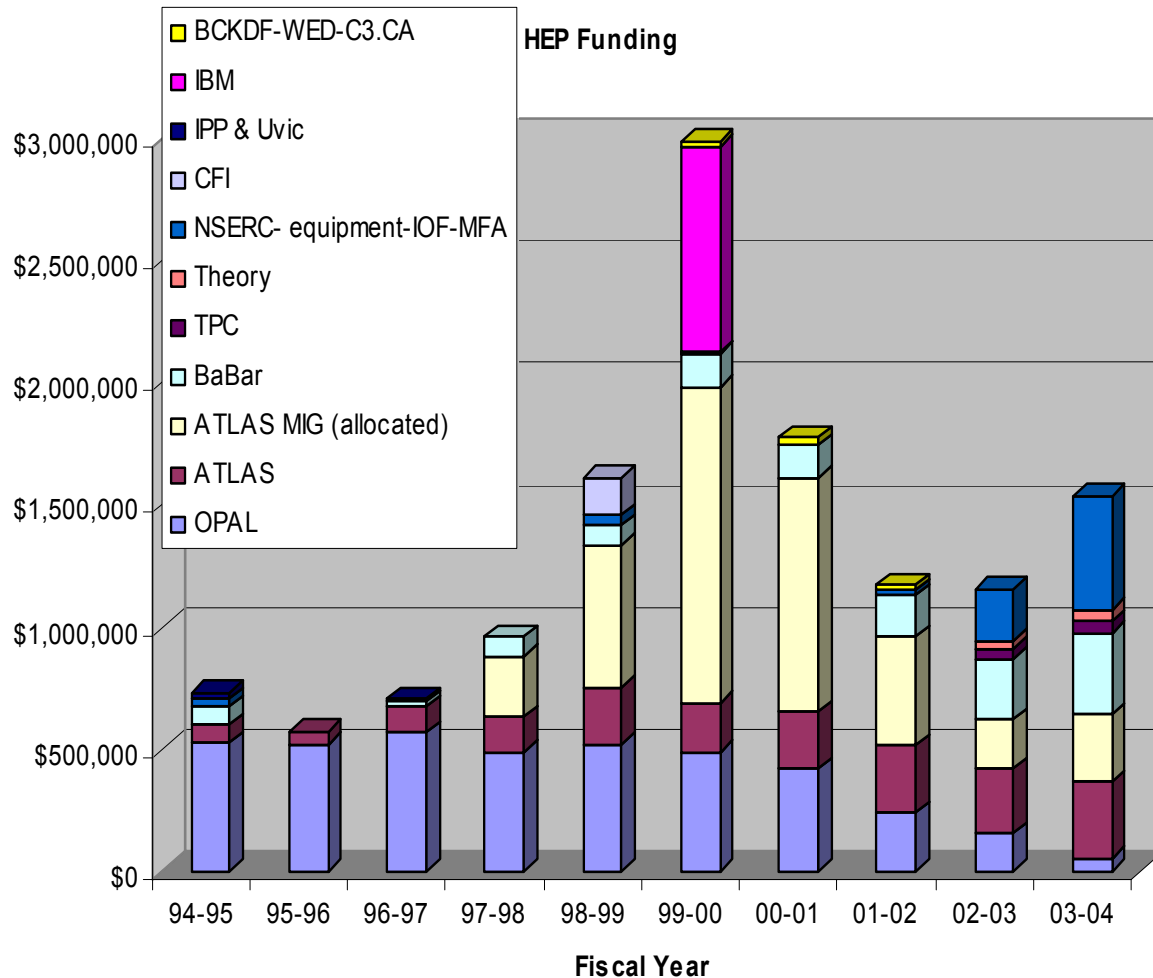
- Tremendous interest in learning about the Grid from students
 - 40 applications per term from outstanding students in physics, engineering physics, computer and electrical engineering from SFU, UBC and Victoria
- Physics and Engineering departments at the University of Victoria are jointly supervising students on Grid projects
- 2003 IEEE Gold Medal – D.Vanderster
 - Computer Engineering
 - MSc on Grid Computing



Computing Summary

- UVic has one of the largest research computing facilities in Canada
 - Used for a wide of research activities
 - Strong support from VP Research and CASS
- UVic group has made significant contributions to computing in the OPAL, BaBar and ATLAS expts
- UVic HEP group is a leader in Grid computing in Canada
- Group needs system management support personnel
 - Van Uytven paid by Discovery Grants, not eligible for MFA support

Research Overview: Funding



Excellent track record for attracting funding

- operating
 - about \$750k per year
 - ATLAS and BaBar level increasing
- ATLAS MIG
 - \$4.28M over 7 years
- IBM grant
 - February 2000
- CFI grant
 - MUSE computer cluster
 - Mercury (7M\$ funding not shown on chart)

Research Overview

- Well funded research programme in particle physics
- Involved in projects with a time line that provides continual scientific productivity
 - Completing OPAL analyses
 - Taking BaBar data and analyzing results
 - Constructing the ATLAS detector and developing the analysis software
 - Prototyping detectors for the Linear collider
 - Leading Canadian GRID activities for future analysis
- Collaborative group activity
- Needs significant theoretical input
- Needs infrastructure for computing and detector development

Research Overview

training of highly qualified personnel

- Our group's research activities provides unique training opportunities for professional and technical staff:
 - research associates and students
 - critical and independent thinking
 - perform in large international collaborations, in most cases spending a year in Geneva or Stanford
 - data analysis and computing skills
 - engineers, designer, technologists
 - very challenging projects
 - mechanical and electronic design and construction
 - computer scientists
 - leading edge computing

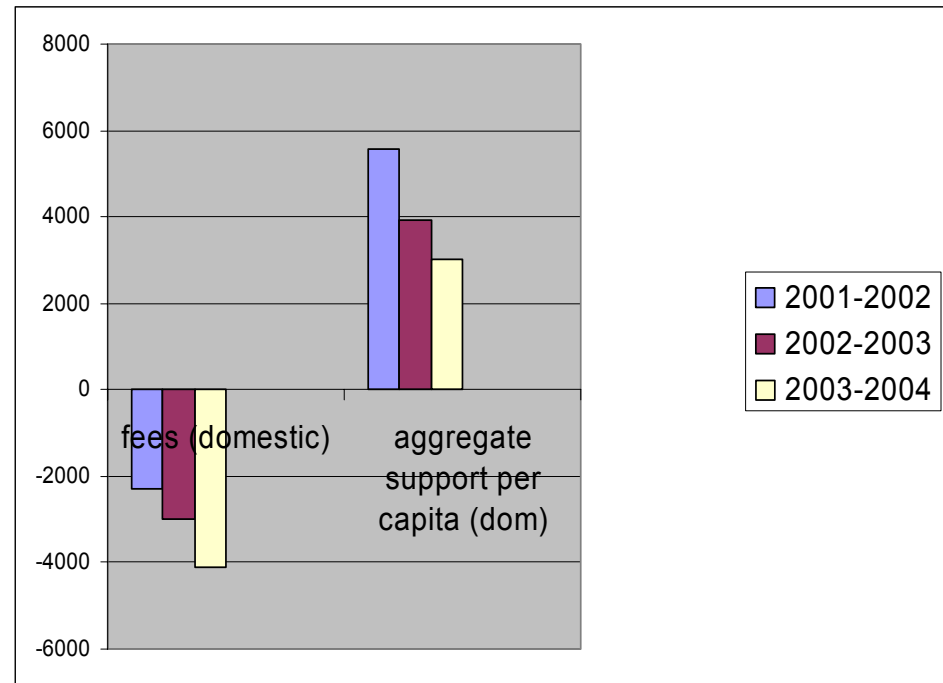
University Support for Research

Graduate student support

- A concern

Indirect costs

- Computing
 - Need technical support
- Detector development –
Need continued support for:
 - Electronics
 - Mechanical
 - Lab space



Summary

- Internationally recognized group in particle physics
- Excellent research programme:
 - finalize data analysis of world's highest energy electron-positron collisions with the OPAL detector.
 - detailed study of fundamental symmetries with the BaBar detector
 - complete detector installation for ATLAS - a detector for physics at the high-energy frontier.
 - Develop tracking technology prototype for the Linear Collider
- Actively recruit graduate students
- Bring the excitement of research to undergraduates
- Want to strengthen theory group
- Support for a Computing System Manager