ATLAS Endcap Signal Feedthrough Project

NSERC Review
TRIUMF
4th November 2003

- Overview
- Status
  - Feedthrough Production
  - QA/QC
  - Shipment and Reception Tests at CERN
  - Feedthrough Installation
- Budget summary
- Final Tasks
- Conclusions

Michel Lefebvre
University of Victoria
Physics and Astronomy

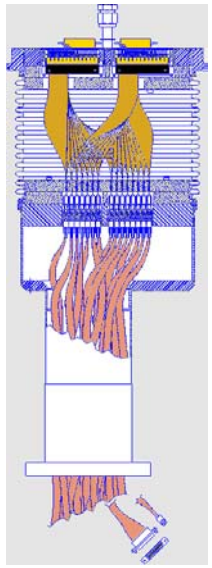
Overview

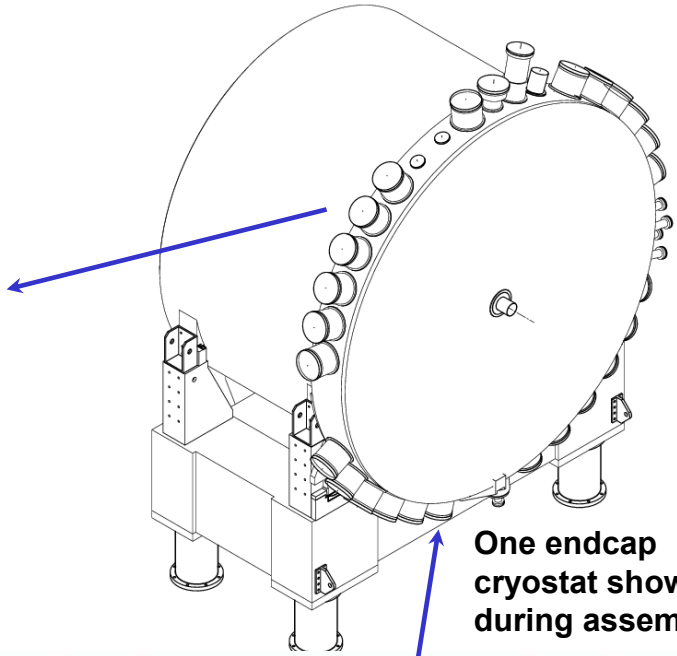
ATLAS liquid argon calorimetry has over 180k signal channels which must come through the walls of the cryostats

Each feedthrough unit carries 1920 electrical channels.

Barrel: 64 feedthrough units (+spares)

Endcap: 50 feedthrough units total (+5 spares)





One endcap cryostat shown during assembly

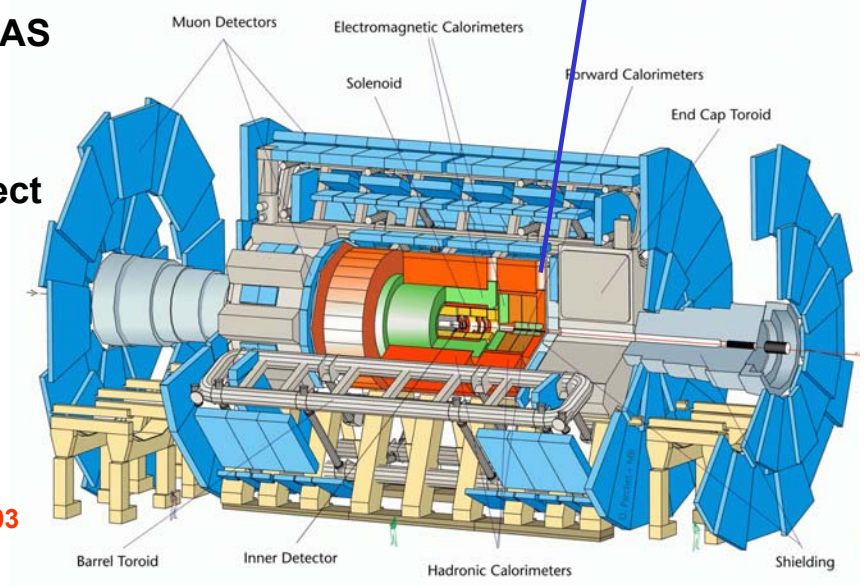
The endcap signal feedthrough project is an ATLAS common fund contribution from Canada (CHF 3360k CORE)

Part of the ATLAS Cryostat and Cryogenics Project

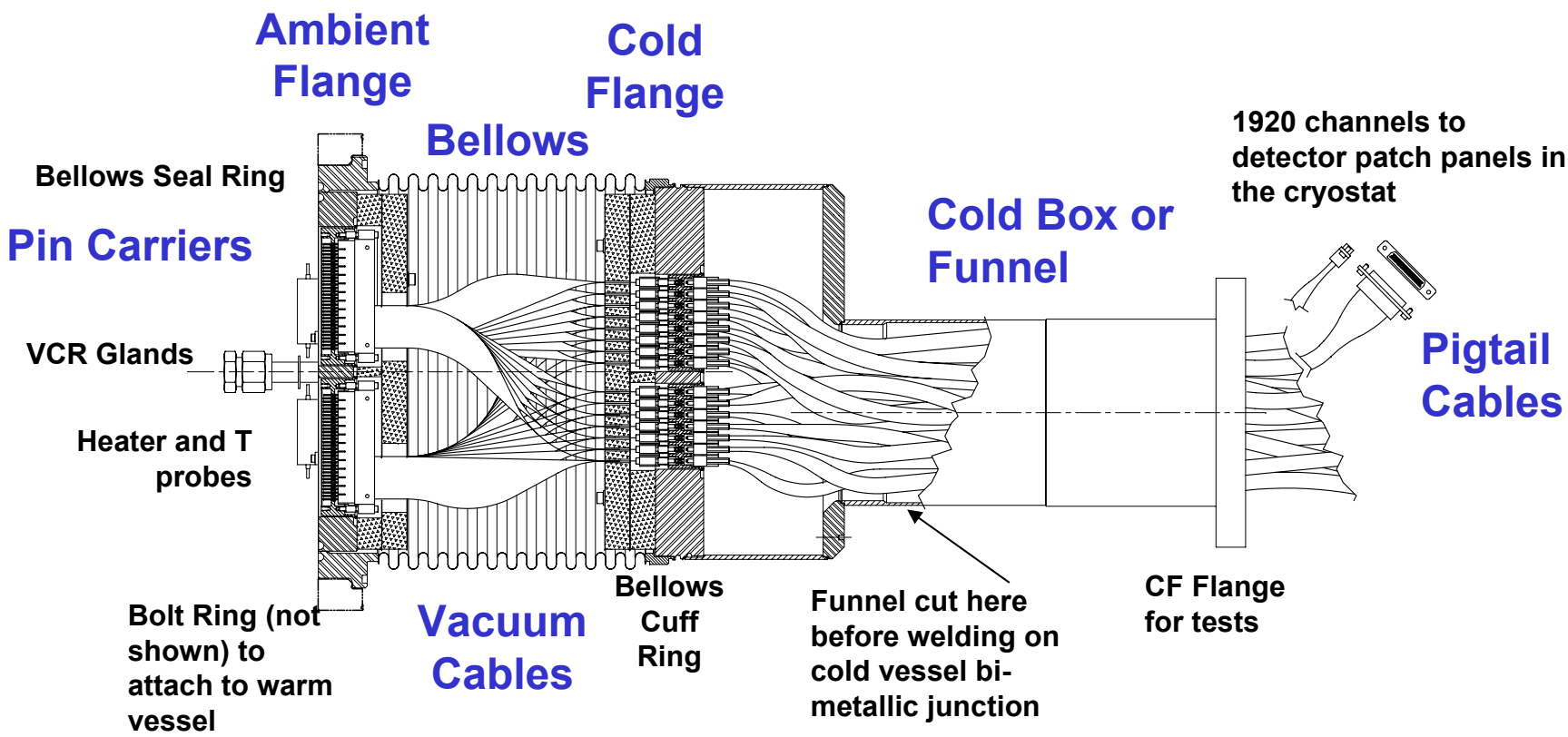
Extensively reviewed:

ATLAS reviews
Project Review, BNL, Jun 12-13 1997
Baseline Design review CERN, Oct 13th 1997
Production Readiness Review, CERN, Jan 29th 1999
Activity/Systems Status Overview, CERN, Feb 11-12 2001

NSERC reviews
TRIUMF: Jan 9 2000, Oct 19 2000, Dec 14 2001, Dec 5 2002, Nov 4 2003



Overview



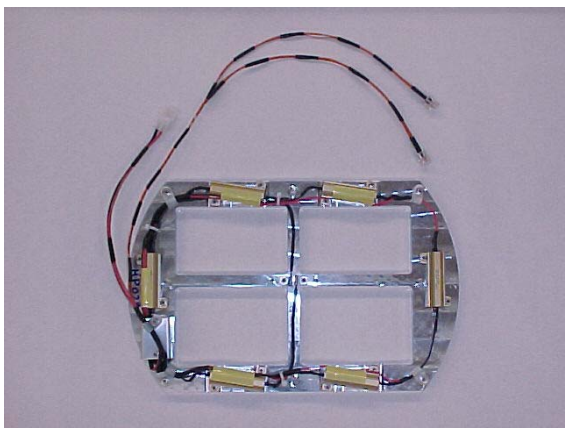
Seal ring OD = 326.4 mm

Total height = 699.9 mm

The endcap cryostats require 4 different kinds of feedthroughs

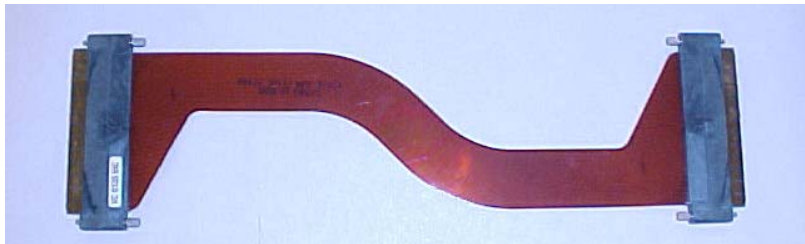
Overview

Heater plate
(require 25 for one endcap)

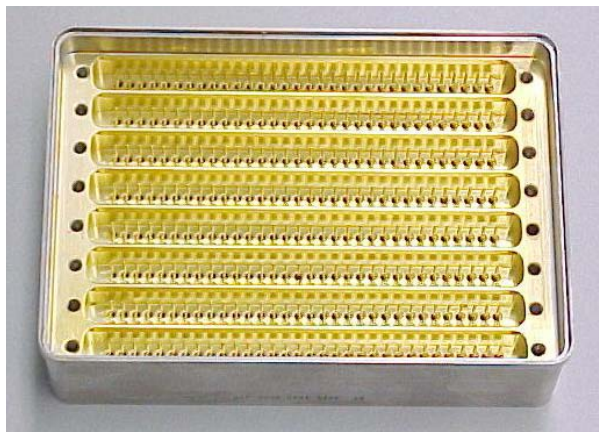


Pigtails (7 types, require
750 for one endcap)

Vacuum cables (2 types,
require 750 for one endcap)



Pincarriers (2 types, require
200 for one endcap)



Overview

Responsibilities

- Design
- Fabrication
- Commissioning
- Transport
- Reception
- Electrical tests after installation
- Assistance during installation

All responsibilities have been fulfilled

Feedthrough Production

Production at the University of Victoria
All 55 feedthrough units produced (last on 25 Oct 2002)

last welds

last dye penetrant tests

last cold test

Quality Assurance / Quality Control

QA/QC is critical to the success of the project

Very detailed document published (QA/QC version 5, Mar 02)

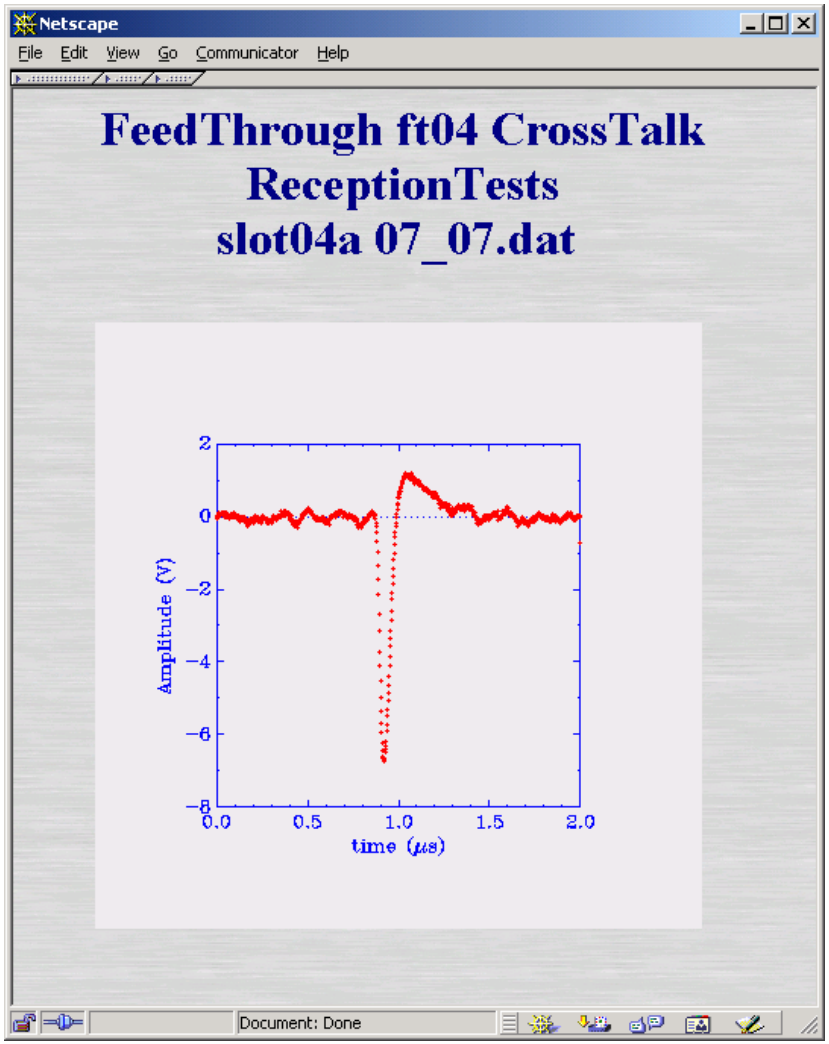
All information stored in a purpose-built database

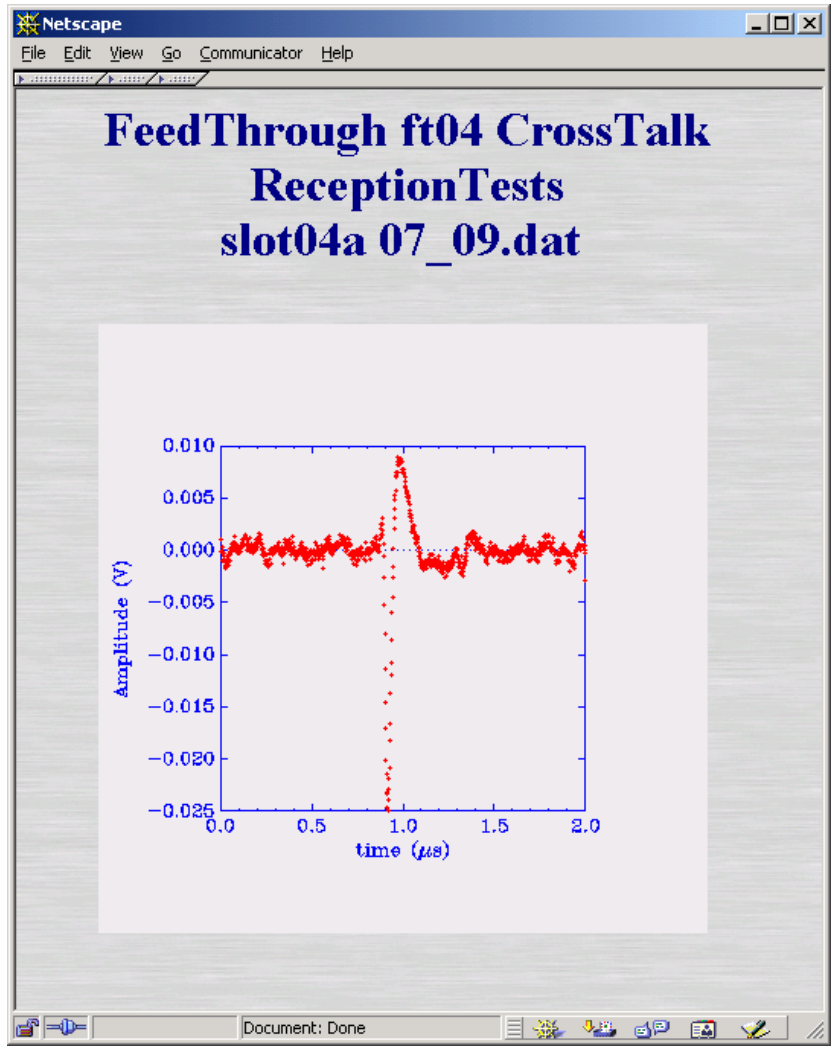
- **material traceability**
- **production and reception test results**
- **available on the web:**

  http://particle.phys.uvic.ca/~web-atlas/atlas/feedthroughs/status/

Quality Assurance / Quality Control

cross talk measurements at UVic and at CERN





Shipment to CERN

crated feedthroughs

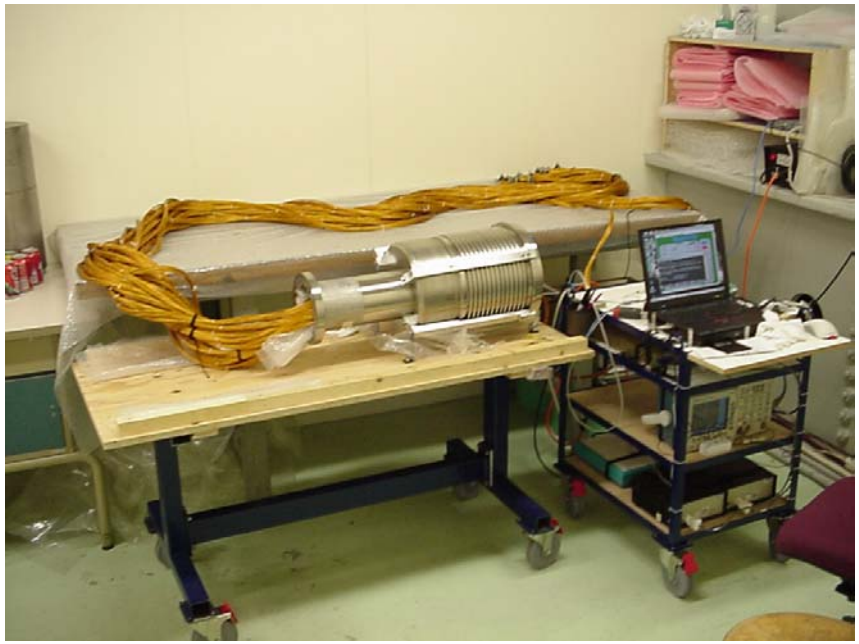
last produced feedthrough in crate
(Oct 2002)

Each feedthrough has its own crate

4 feedthrough crates are then crated together for shipment

Last shipment made January 2003

Reception Tests at CERN



Feedthrough units are tested upon reception at CERN:

- visual inspection
- leak test (ambient temperature)
- electrical test (cross-talk)

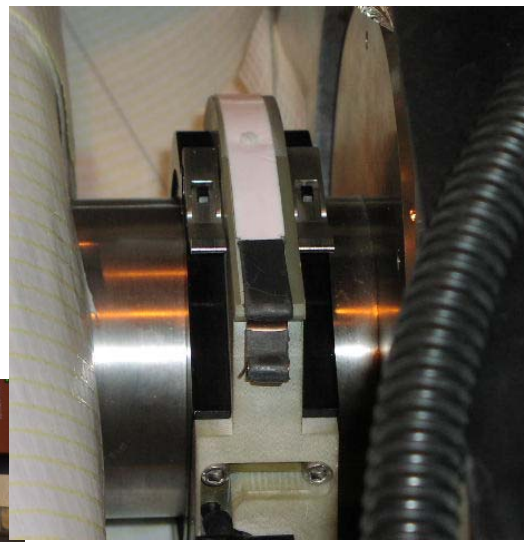
The electrical testing equipment was also used on the cryostat after feedthrough installation

Last reception tests made in June 2003

Feedthrough installation: ECC

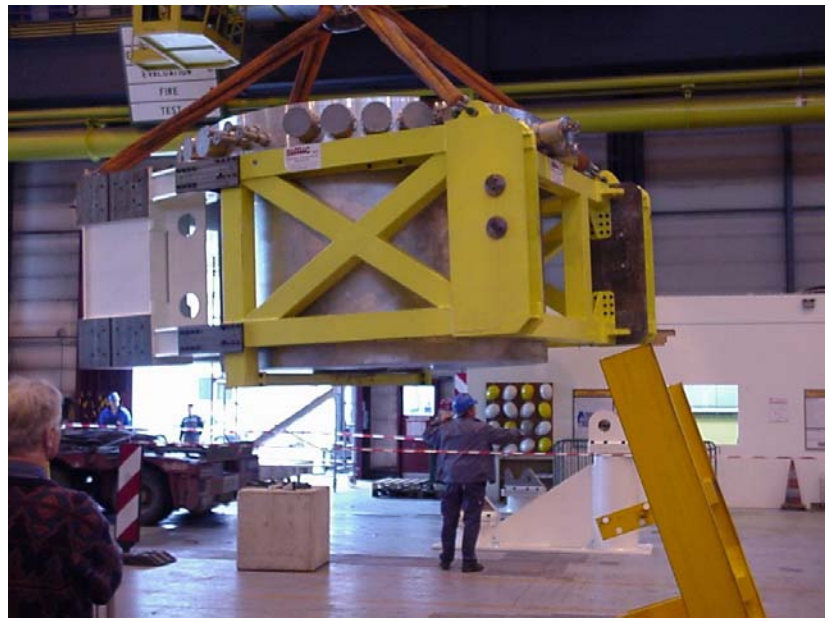
ECC arrived at CERN 20 March 2002. Cold test of ECC revealed problems with the inter-vessel stoppers; the heaters need replacing. Repairs started October 2002

ECC feedthrough installation from 5 Dec 2002 to 24 Jan 2003

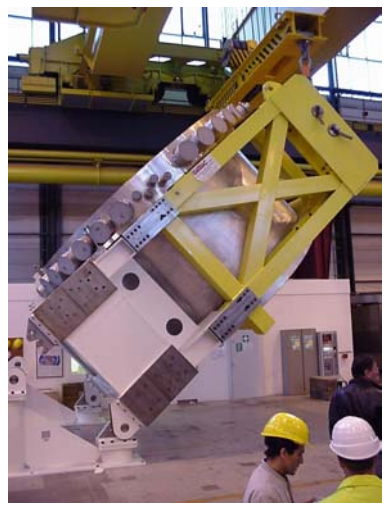


weld with orbital welder

funnel and orbital cutter



ECC reception at CERN on 20 Mar 2002



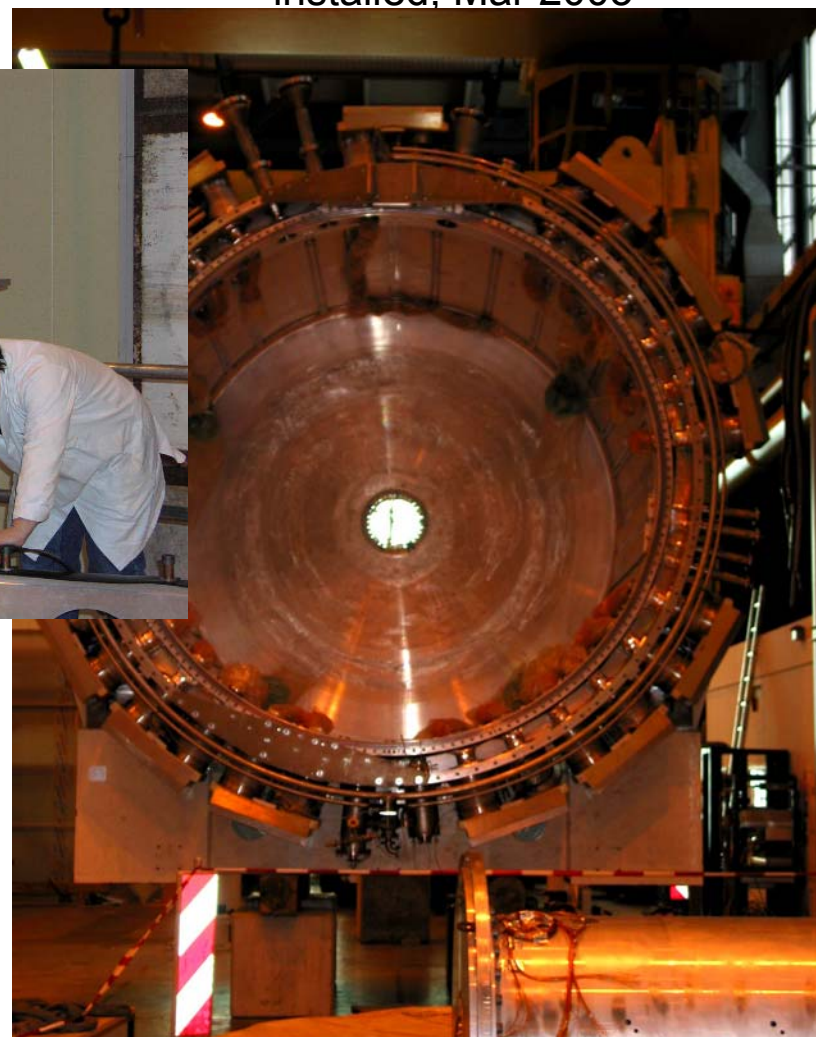
ECC rotation for cold test on 18 Apr 2002

Feedthrough installation: ECC

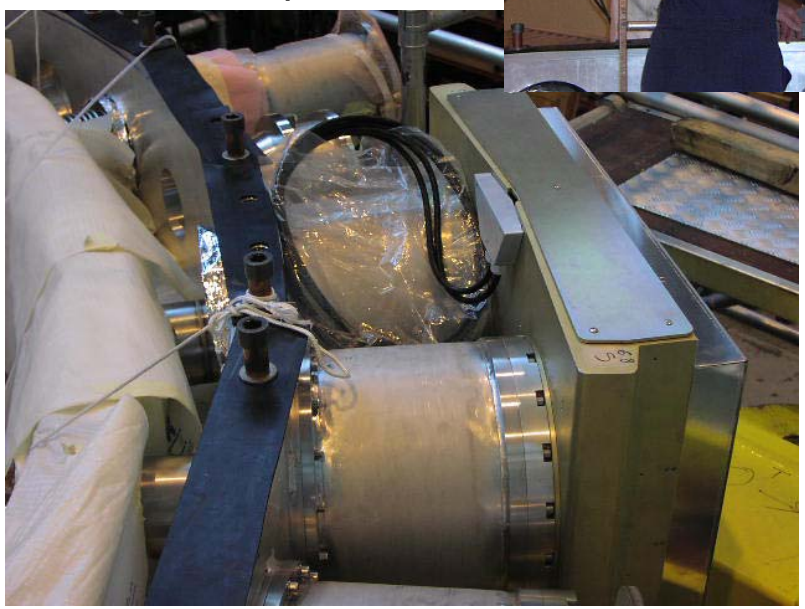
ECC feedthrough installation from 5 Dec 2002 to 24 Jan 2003

ECC feedthrough warm cable insertion and electrical tests finalized in April 2003

ECC rotated with all feedthroughs installed, Mar 2003



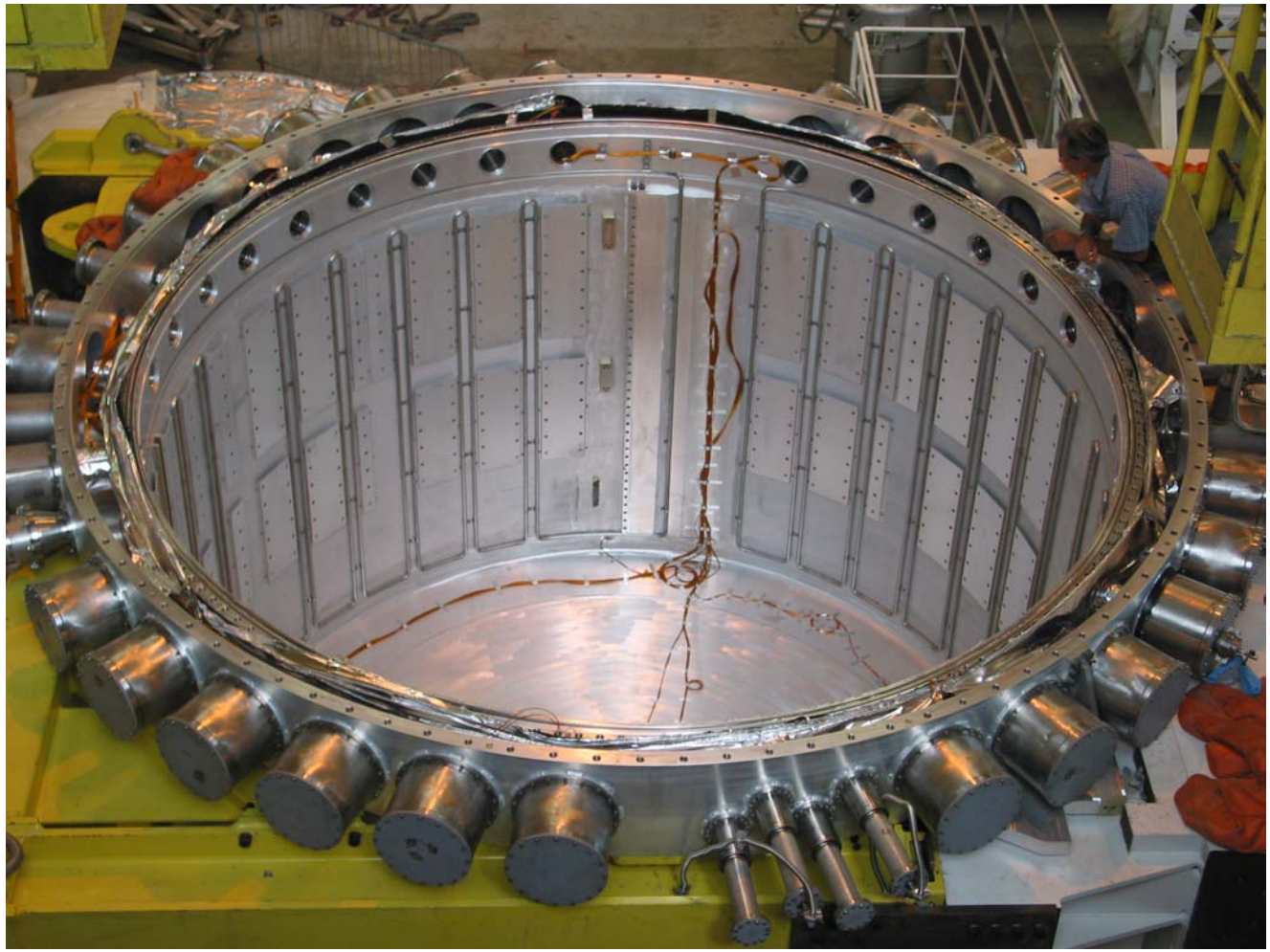
first mounted pedestals



Feedthrough installation: ECA

ECA arrived at CERN 4 June 2003.

ECA with its cover removed, CERN 26 June 2003

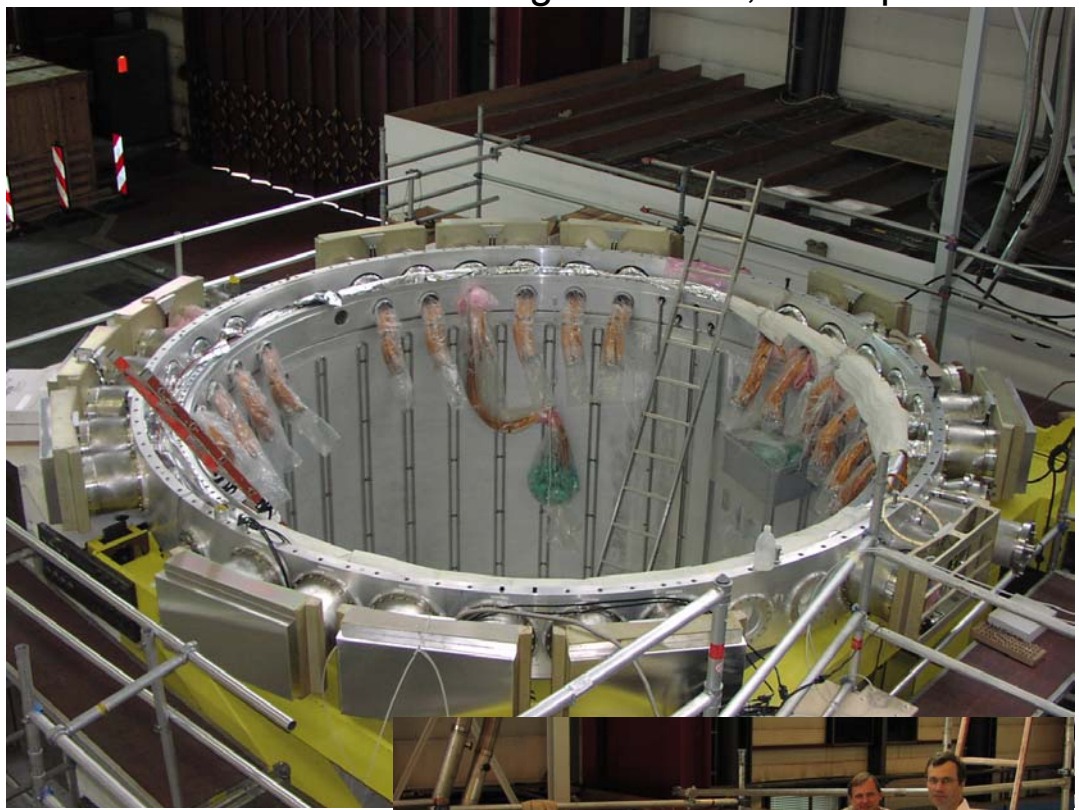


Feedthrough installation: ECA

ECA feedthrough installation from 23 Jul 2003 to 26 Sep 2003

ECA feedthrough warm cable insertion and electrical tests finalized 28 Oct 2003

ECA with all feedthroughs welded, 26 Sep 2003



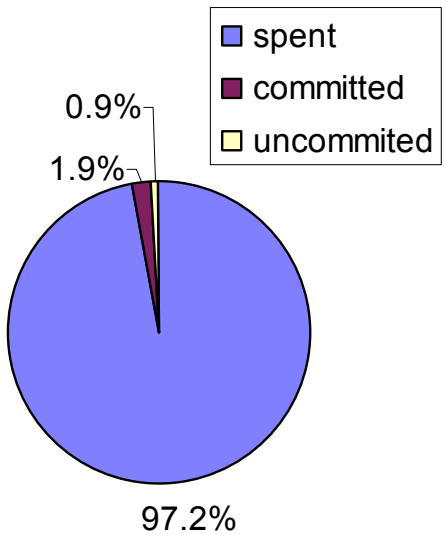
electrical testing

Budget and Management

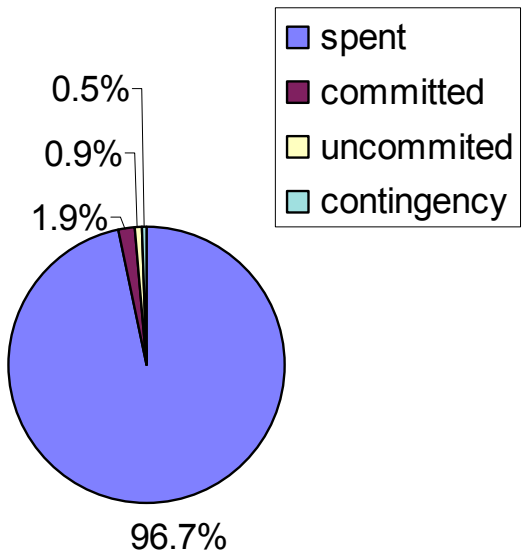
Budget Status

			(Dec02)	(Dec01)
Allocated MIG amount:	$4.280M			
Current budget:	$4.057M	**(net of contingencies)**	**($3.998M)**	**($4.091M)**
Contingencies:	$0.021M		**($0.068M)**	**($0.213M)**

Endcap Signal Feedthrough Project

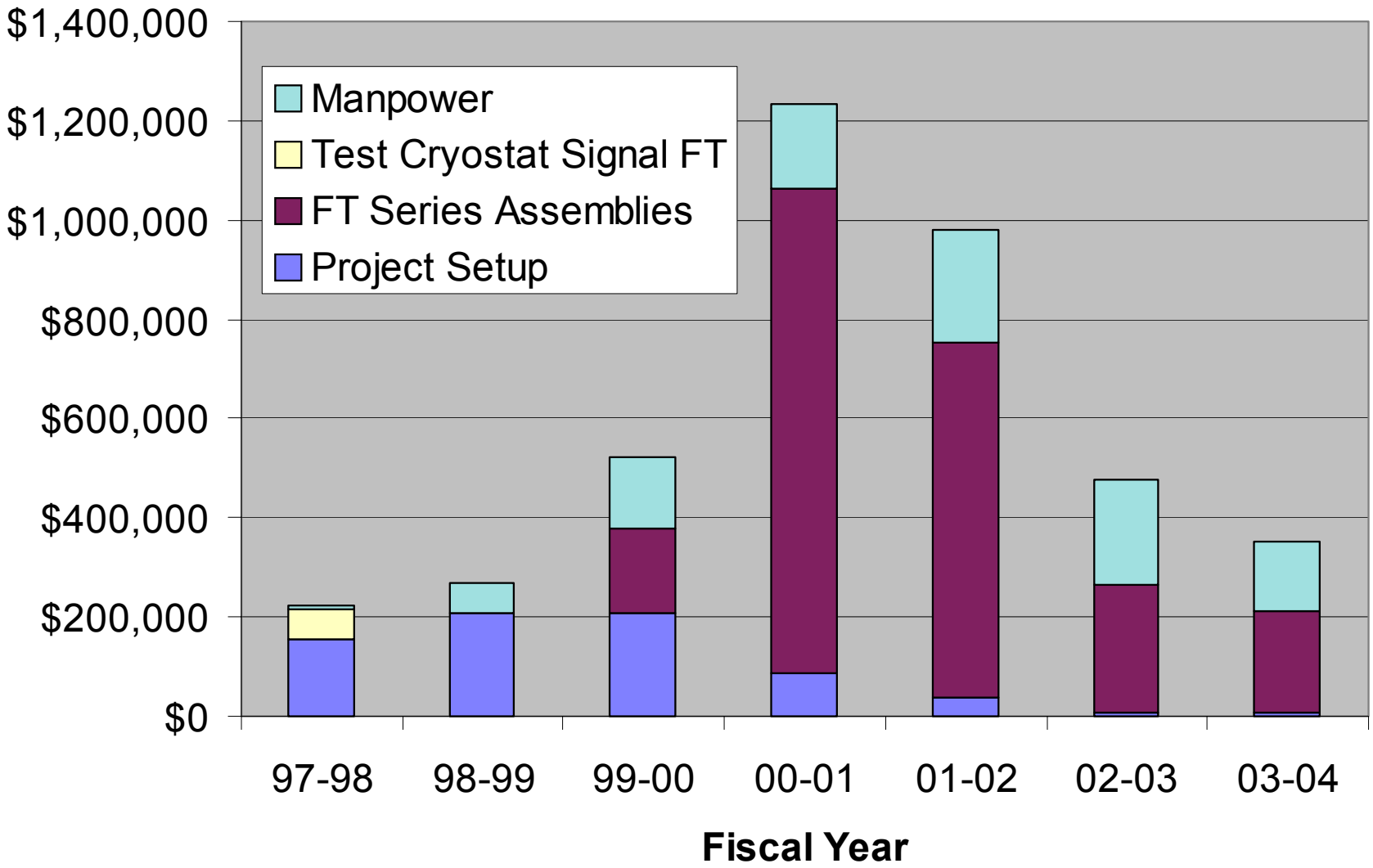


Endcap Signal Feedthrough Project including contingencies



Budget and Management

Budget Profile



Training of HQP

Aaron Dowling	**(Aug 98 – Oct 02)**
Alisa Dowling	**(Now TRIUMF Engineer)**
M. Fincke-Keeler	**(RA)**
F. Holness	**(Lab technologist, until end 2003)**
J. Lindner	**(Coop Student)**
R. MacDonald	**(Coop Student)**
R. McDonald	**(Coop Student)**
E. Muzzerall	**(Coop Student)**
P. Poffenberger	**(RA - MFA)**
G. Vowles	**(Aug 98 – Jan 02, now at UofT)**
W. Wiggins	**(Coop Student, CUPC2002 presentation)**

Publications

D. Axen et al., *Performance of the Signal Vacuum Cables of the Liquid Argon Calorimeter Endcap Cryostat Signal Feedthroughs*, ATLAS internal note ATL-LARG-2003-007 , 22 July 2003.

P. Poffenberger et al., *ATLAS Endcap Signal Feedthrough Quality Assurance and Quality Control Document, v. 5* , 28 March 2002.

T. Hodges and M. Lefebvre, *Finite Element Analysis and the ATLAS Liquid Argon Calorimeter Signal Feedthrough Assembly*, ATLAS internal note ATL-AE-EA-0005, v. 1, 20 November 2001.

M. Fincke-Keeler, M. Lefebvre and P. Poffenberger, *Cabling of the Endcap Signal Feedthroughs*, ATLAS internal note ATL-AE-AN-0001/0002 , November 2000.

M. Fincke-Keeler, R.K. Keeler and M. Lefebvre, *Performance Requirements of the Signal Feedthrough Vacuum Cables*, ATLAS internal note ATL-AE-EN-0002 , June 1999.

M. Fincke-Keeler, M. Lefebvre, *A Proposal for a Low Voltage Vacuum Cable Design for the HEC Feedthroughs in the ATLAS Endcap Cryostat*, ATLAS internal note HEC 068 , December 1998

NIM paper in preparation in collaboration with BNL colleagues

Final Tasks

Finalize the inventory

Store spare parts

Interface with ATLAS database (QA/QC and as-built information)

Decommission the feedthrough production equipment

- keep some readiness for repairs until the cryostats are in operation

NIM paper in preparation in collaboration with BNL colleagues

Conclusions

ATLAS Endcap Signal Feedthrough Project

- **Crucial component of ATLAS Liquid Argon Calorimetry**
- **Complex and manpower intensive**
- **Production at UVic finalized on 25 Oct 2002**
- **Installation completed on 26 Sep 2003**
- **Electrical tests completed on 28 Oct 2003**
- **Budget under the allocated MIG amount** ($4.28M)
  - **$4.057M + $0.021M contingencies**
  - **97.2 % of baseline costs spent**
  - **99.1 % of baseline costs either spent or committed**
- **NIM publication in preparation**

Overview

The endcap cryostats require 4 different kinds of feedthroughs

- the 64 barrel cryostat feedthroughs are all identical
- the endcap cryostats contain different calorimeters

Standard Type (EMEC)

16 per endcap, plus a total of 3 spares

30 signal vacuum cables and 30 pigtail cables (18T47, 12T48)

Special Type (EMEC)

4 per endcap, plus a total of 1 spare

30 signal vacuum cables and 30 pigtail cables (12T47, 18T48)

HEC Type (HEC and EMEC)

4 per endcap, plus a total of 1 spare

26 signal vacuum cables, and 4 low voltage vacuum cables

26 pigtail cables (4T47, 4T48, 8T49, 4T50, 6T51) and 4 low voltage pigtails

FCAL Type (FCAL)

1 per endcap

30 signal vacuum cables and 30 pigtail cables (T52)

Overview
Responsibilities

- Design
- Fabrication
  - Signal Pigtails purchased from Orsay
- Commissioning
- Transport
- Reception
  - Electrical and ambient vacuum testing
    - Leak tester provided by ATLAS CERN
- Electrical tests after installation
- Assistance during installation
  - Assistance during welding on the cryostat
  - Manpower to connect warm cables to ambient flange

All responsibilities have been fulfilled

Feedthrough installation

Special testing equipment has been developed for the warm cable insertion

- bent pin indicator (to give early warning of bent pins while installing a warm cable)
- a short-to-ground indicator
- a cross-channel-short indicator (to check for cross-channel shorts in the warm cable after installation)
- a pigtail ATI / baseplane interface for use during the post-installation cross talk tests (BNL was using a warm cable for their TDR test interface, which caused problems since the warm cables are not designed to stand up to many plugins)

A small number of electrical faults were identified and repaired

Feedthrough installation

Personnel deployment at CERN

Two persons at CERN for assistance during installation

Paul Poffenberger and Fiona Holness

- 30 Nov 2002 – 21 Feb 2003 ECC installation and electrical tests
- 29 Mar 2003 – end April 2003 ECC electrical tests
- 19 Jun 2003 – 08 Aug 2003 ECA installation
- 03 Sep 2003 – 07 Nov 2003 ECA installation and electrical tests

Extra help with pedestal installation and equipment setup/removal

Paul Birney

- two 10 day trips

Budget and Management

Budget Status

Practically all the project cost increase since the Dec 01 estimate comes from a much larger than foreseen “révision de prix” on the pigtail contract.

- The MOU between ATLAS-Canada and Orsay, signed in 1997, included a clause that pertained to “révision de prix”.
- Mechanism administered nationally (France).
- Amounts to 44,907.12 Euros (about $70k) (compared with the $15k that were budgeted, that is about 3% of the value of the contract)

I was offered the following explanations for the size of this price revision:

- a longer than anticipated duration of the contract (by about 3 years!). The contract included ALL the ATLAS pigtails and signal harnesses.
- approximately 11% increase in the hourly labour rate, an ingredient that goes in the computation of the “révision de prix”, a consequence of France going from 39h/week to 35h/week.

Completely outside the control of ATLAS-Canada

Budget and Management

Budget Summary

PBS	WBS	Description	Sep 03 02-03 $CAN	MIG COST PROFILE 97-98 $CAN	98-99 $CAN	99-00 $CAN	00-01 $CAN	01-02 $CAN	02-03 $CAN	03-04 $CAN	MIG $CAN	Sep 03 spent %	commit %	uncommit %	contingency $CAN
4	**1**	**Endcap Signal Feedthroughs**	**$477,056**	**$224,375**	**$266,888**	**$523,221**	**$1,233,416**	**$981,086**	**$477,056**	**$351,326**	**$4,057,369**	**97**	**2**	**1**	**$20,763**
4.1	**2**	**Project Setup**	**$8,116**	**$156,386**	**$207,997**	**$209,385**	**$87,171**	**$38,804**	**$8,116**	**$8,115**	**$715,973**	**99**	**0**	**1**	**$1,510**
4.1.1	3	Leak Test Setup	$2,380	$102,521	$29,420	$6,838	$39,994	$13,733	$2,380	$1,000	$195,887	99	0	1	$250
4.1.2	3	Electric Test Setup	$1,511	$6,109	$22,252	$32,803	$35,767	$12,562	$1,511	$2,767	$113,772	98	2	1	$414
4.1.3	3	Data Acquisition System	$1,816	$15,198	$5,308	$4,690	$5,550	$5,771	$1,816	$847	$39,181	100	0	0	$0
4.1.4	3	FT Assembly Tools	$0	$0	$10,135	$591	$0	$0	$0	$0	$10,725	100	0	0	$0
4.1.5	3	FT Prototypes	$0	$32,558	$140,275	$157,696	-$804	$0	$0	$0	$329,724	100	0	0	$0
4.1.6	3	Misc Project Setup Items	$2,409	$0	$607	$6,768	$6,663	$6,737	$2,409	$3,501	$26,684	87	0	13	$847
4.2	**2**	**FT Series Assemblies**	**$255,590**	**$0**	**$0**	**$167,302**	**$974,803**	**$712,338**	**$255,590**	**$203,068**	**$2,313,101**	**98**	**2**	**0**	**$10,302**
4.2.1	3	Mechanical Components	$6,556	$0	$0	$166,791	$203,563	$611,856	$6,556	$19,897	$1,008,663	98	2	0	$2,985
4.2.2	3	Electrical Components	$239,003	$0	$0	$414	$758,353	$86,050	$239,003	$182,139	$1,265,959	98	2	0	$7,318
4.2.3	3	Shipping Crates	$10,031	$0	$0	$98	$12,886	$14,432	$10,031	$1,032	$38,479	100	0	0	$0
4.3	**2**	**Test Cryostat Signal FT**	**$0**	**$58,428**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$58,428**	**100**	**0**	**0**	**$0**
4.4	**2**	**Manpower**	**$213,350**	**$9,561**	**$58,891**	**$146,534**	**$171,442**	**$229,944**	**$213,350**	**$140,144**	**$969,867**	**94**	**3**	**3**	**$8,950**
4.4.1	3	Salaries and Benefits	$141,015	$9,561	$55,092	$129,328	$142,873	$189,244	$141,015	$70,144	$737,257	96	4	0	$1,328
4.4.2	3	Consultation and Travel	$72,285	$0	$1,016	$17,206	$20,368	$40,582	$72,285	$70,000	$221,457	86	0	14	$7,622
4.4.3	3	Other	$50	$0	$2,784	$0	$8,201	$119	$50	$0	$11,154	100	0	0	$0

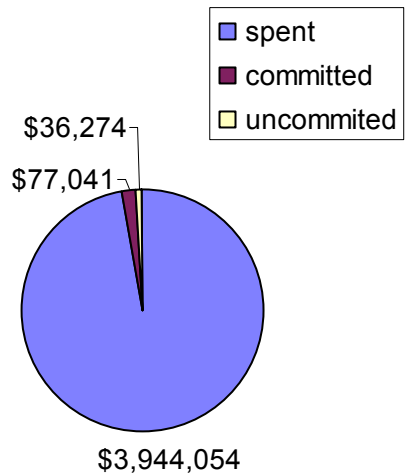
Contingencies total $20.8k and mainly come from:

- **exchange rate: +25% on 1.56$CAN/Euro (last pigtail bill)**
- **exchange rate: +25% on 1.01$CAN/CHF (last steel bill)**
- **contingency on final installation travel bill**

The budget total net of contingencies is $4.057M

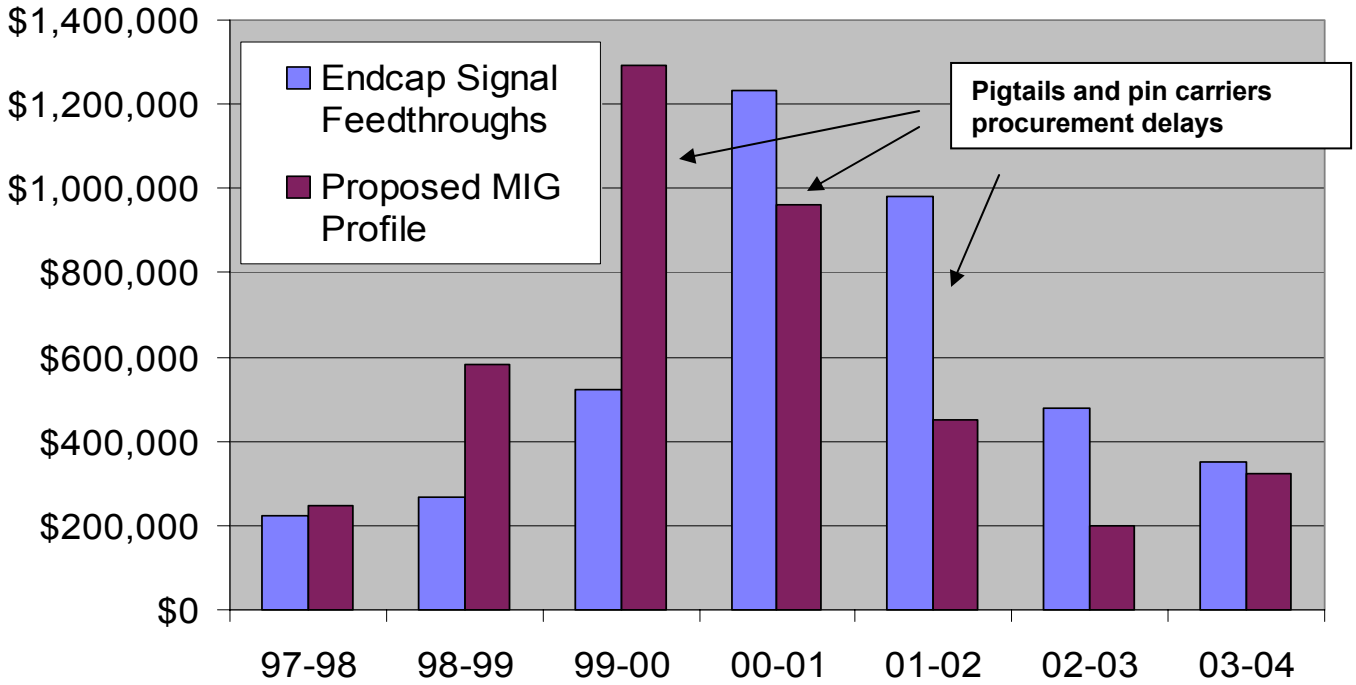
97.2% of which has been spent (Sep 03)

1.9% of which has been committed (Sep 03)



Budget and Management

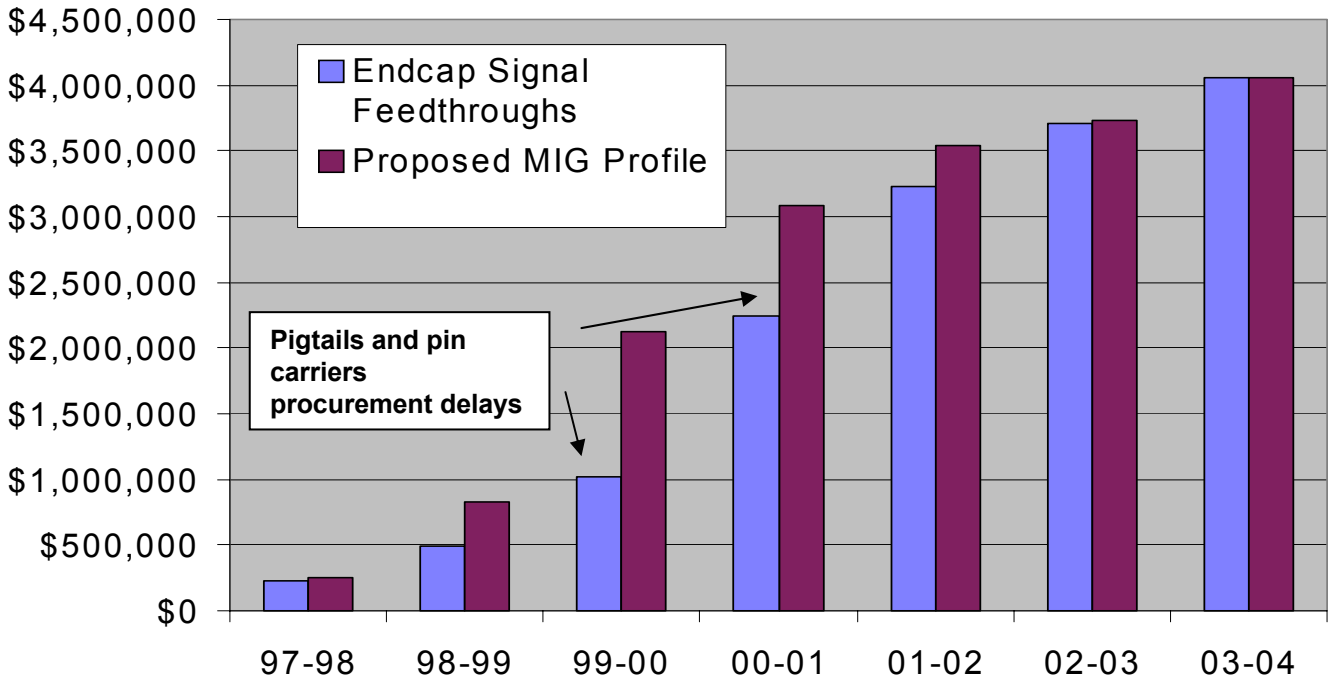
Budget Profile



	97-98	98-99	99-00	00-01	01-02	02-03	03-04	Total
Sep 03	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN
Budget	**$224,375**	**$266,888**	**$523,221**	**$1,233,416**	**$981,086**	**$477,056**	**$351,326**	**$4,057,369**
MIG spent (UVic and TRIUMF)	**$224,375**	**$266,888**	**$523,221**	**$1,233,416**	**$981,086**	**$477,056**	**$238,011**	**$3,944,054**
Proposed MIG Profile	**$249,000**	**$584,000**	**$1,292,880**	**$960,000**	**$450,000**	**$200,000**	**$321,489**	**$4,057,369**

Budget and Management

Integrated Budget Profile



	97-98	98-99	99-00	00-01	01-02	02-03	03-04	Total
Sep 03	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN
Budget	**$224,375**	**$491,263**	**$1,014,485**	**$2,247,901**	**$3,228,986**	**$3,706,042**	**$4,057,369**	**$4,057,369**
MIG spent (UVic and TRIUMF)	**$224,375**	**$491,263**	**$1,014,485**	**$2,247,901**	**$3,228,986**	**$3,706,042**	**$3,944,054**	**$3,944,054**
Proposed MIG Profile	**$249,000**	**$833,000**	**$2,125,880**	**$3,085,880**	**$3,535,880**	**$3,735,880**	**$4,057,369**	**$4,057,369**

Budget and Management

Series Assemblies Details

			MIG COST PROFILE											
PBS	WBS	Description	97-98	98-99	99-00	00-01	01-02	02-03	03-04	MIG	spent	commit	uncommit	contingency
			$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	$CAN	%	%	%	$CAN
4	**1**	**Endcap Signal Feedthroughs**	**$224,375**	**$266,888**	**$523,221**	**$1,233,416**	**$981,086**	**$477,056**	**$351,326**	**$4,057,369**	**97**	**2**	**1**	**$20,763**
4.1	**2**	**Project Setup**	**$156,386**	**$207,997**	**$209,385**	**$87,171**	**$38,804**	**$8,116**	**$8,115**	**$715,973**	**99**	**0**	**1**	**$1,510**
4.2	**2**	**FT Series Assemblies**	**$0**	**$0**	**$167,302**	**$974,803**	**$712,338**	**$255,590**	**$203,068**	**$2,313,101**	**98**	**2**	**0**	**$10,302**
4.2.1	**3**	**Mechanical Components**	**$0**	**$0**	**$166,791**	**$203,563**	**$611,856**	**$6,556**	**$19,897**	**$1,008,663**	**98**	**2**	**0**	**$2,985**
4.2.1.0	4	Low Inclusion Steel	$0	$0	$61,853	$2,431	$0	$0	$19,897	$84,181	76	24	0	$2,985
4.2.1.1	4	Pin Carriers	$0	$0	$36,827	$49,719	$593,509	$0	$0	$680,055	100	0	0	$0
4.2.1.2	4	Warm Flanges	$0	$0	$0	$20,818	$0	$0	$0	$20,818	100	0	0	$0
4.2.1.3	4	Cold Flanges	$0	$0	$0	$21,235	$0	$0	$0	$21,235	100	0	0	$0
4.2.1.4	4	Bellow Assemblies	$0	$0	$20,564	$59,726	$0	$0	$0	$80,290	100	0	0	$0
4.2.1.5	4	Bolt Flanges	$0	$0	$18,370	$0	$0	$0	$0	$18,370	100	0	0	$0
4.2.1.6	4	Funnel Assemblies	$0	$0	$12,813	$47,315	$0	$0	$0	$60,128	100	0	0	$0
4.2.1.7	4	Pipe Fittings	$0	$0	$0	$172	$0	$0	$0	$172	100	0	0	$0
4.2.1.8	4	RF Gaskets and O'Rings	$0	$0	$0	$2,146	$871	$0	$0	$3,017	100	0	0	$0
4.2.1.9	4	Insulation	$0	$0	$4,161	$0	$0	$0	$0	$4,161	100	0	0	$0
4.2.1.10	4	Welds	$0	$0	$0	$0	$17,477	$6,556	$0	$24,032	100	0	0	$0
4.2.1.11	4	CF Flanges	$0	$0	$12,203	$0	$0	$0	$0	$12,203	100	0	0	$0
4.2.2	**3**	**Electrical Components**	**$0**	**$0**	**$414**	**$758,353**	**$86,050**	**$239,003**	**$182,139**	**$1,265,959**	**98**	**2**	**0**	**$7,318**
4.2.2.1	4	Pig Tail Cables	$0	$0	$192	$192,216	$1,413	$238,518	$181,688	$614,028	95	5	0	$7,205
4.2.2.2	4	Vacuum Cables	$0	$0	$15	$471,810	$39,290	$0	$0	$511,115	100	0	0	$0
4.2.2.3	4	Low Voltage Pigtail Cables	$0	$0	$0	$29,536	$30,954	$0	$0	$60,491	100	0	0	$0
4.2.2.4	4	Low Voltage Vacuum Cables	$0	$0	$0	$38,056	$449	$0	$0	$38,505	100	0	0	$0
4.2.2.5	4	Heaters	$0	$0	$207	$6,688	$2,004	$0	$0	$8,899	100	0	0	$0
4.2.2.6	4	Extra HEC Pigtails	$0	$0	$0	$10,821	$11,940	$0	$0	$22,761	100	0	0	$0
4.2.2.7	4	Temperature Probes	$0	$0	$0	$9,225	$0	$485	$451	$10,161	96	0	4	$113
4.2.3	**3**	**Shipping Crates**	**$0**	**$0**	**$98**	**$12,886**	**$14,432**	**$10,031**	**$1,032**	**$38,479**	**100**	**0**	**0**	**$0**
4.3	**2**	**Test Cryostat Signal FT**	**$58,428**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$58,428**	**100**	**0**	**0**	**$0**
4.4	**2**	**Manpower**	**$9,561**	**$58,891**	**$146,534**	**$171,442**	**$229,944**	**$213,350**	**$140,144**	**$969,867**	**94**	**3**	**3**	**$8,950**
4.4.1	3	Salaries and Benefits	$9,561	$55,092	$129,328	$142,873	$189,244	$141,015	$70,144	$737,257	96	4	0	$1,328
4.4.2	3	Consultation and Travel	$0	$1,016	$17,206	$20,368	$40,582	$72,285	$70,000	$221,457	86	0	14	$7,622
4.4.3	3	Other	$0	$2,784	$0	$8,201	$119	$50	$0	$11,154	100	0	0	$0