ATLAS Liquid Argon Calorimeter

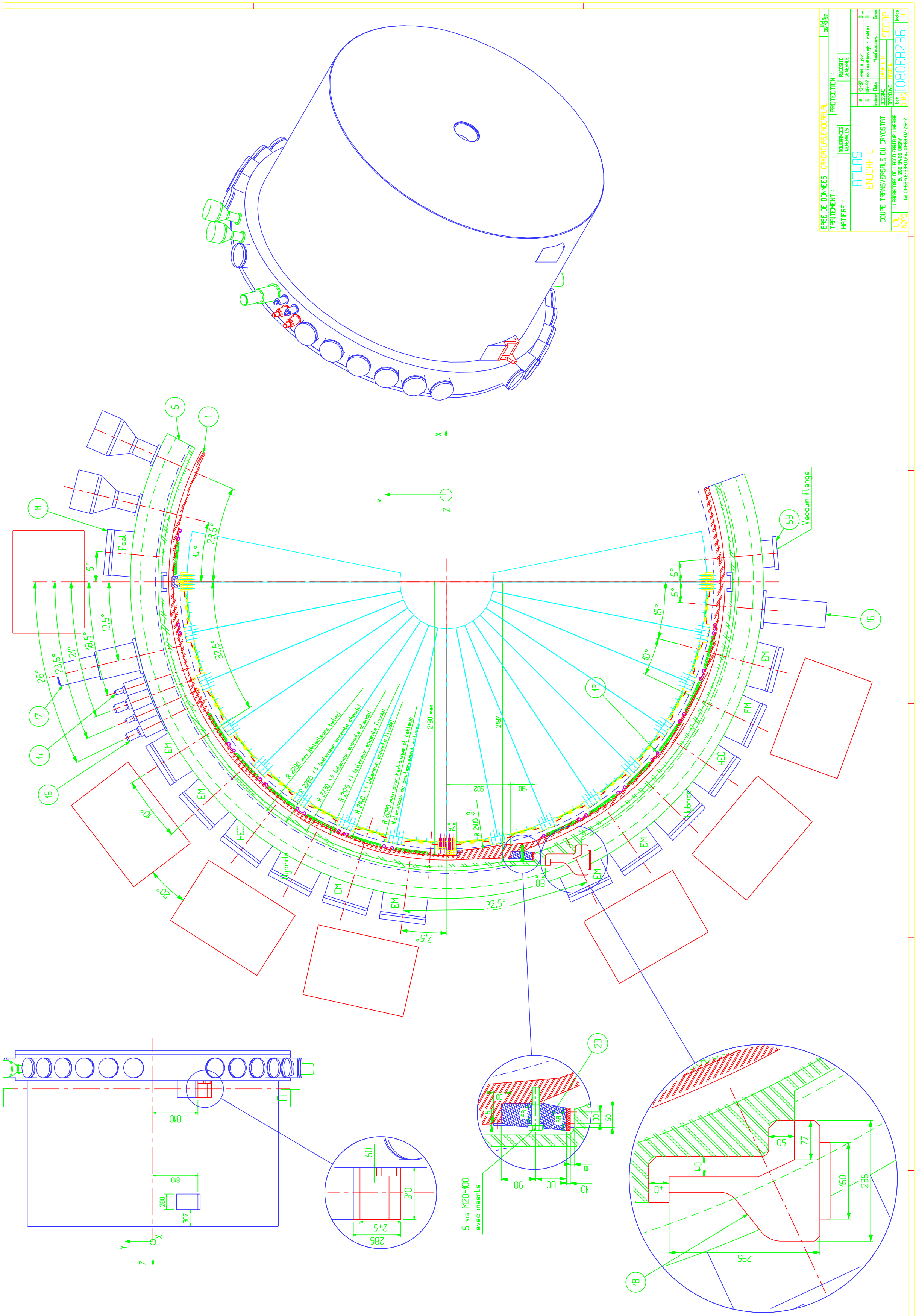
Signal Feedthroughs

ATLAS Liquid Argon Calorimeter Workshop
Schloß Ringberg
September 27-30 1998

- Brief Overview
- Prototypes
- Vacuum Cable Development
- Test Station
- Endcap Specific Issues
- Management

Presented by Michel Lefebvre
University of Victoria
British Columbia, Canada

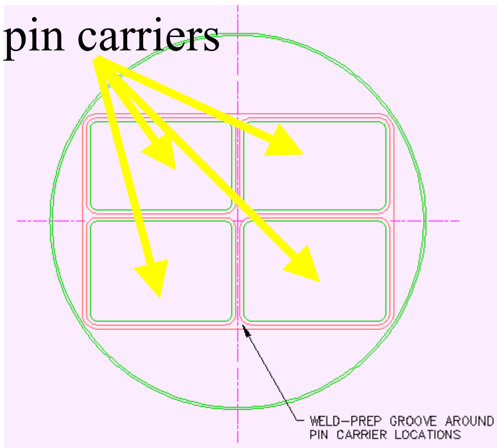
Endcap Cryostat (transverse view)

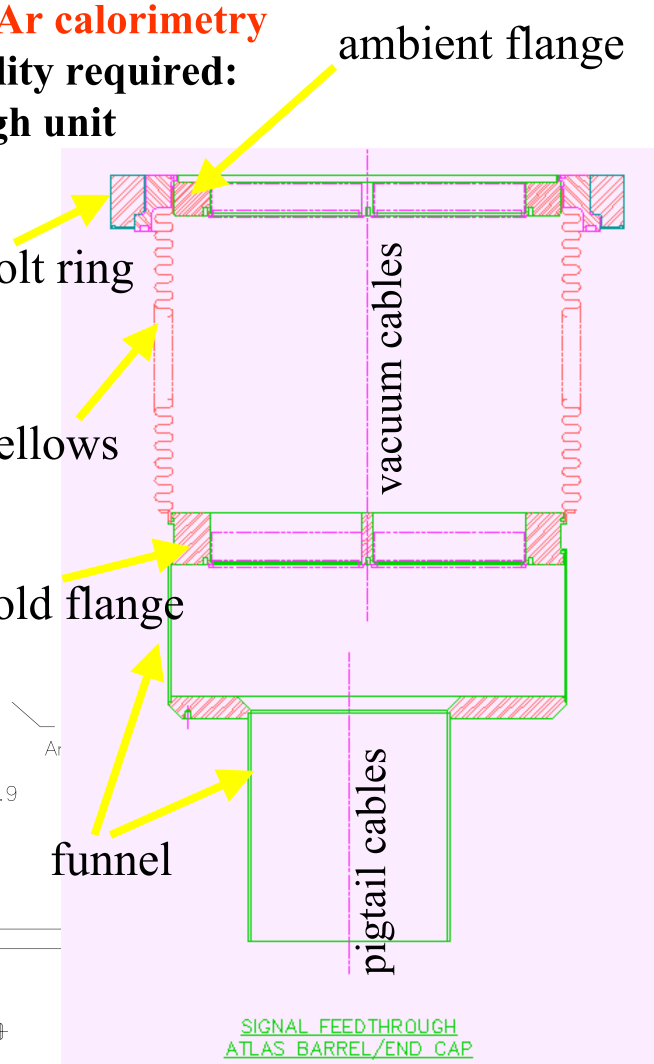


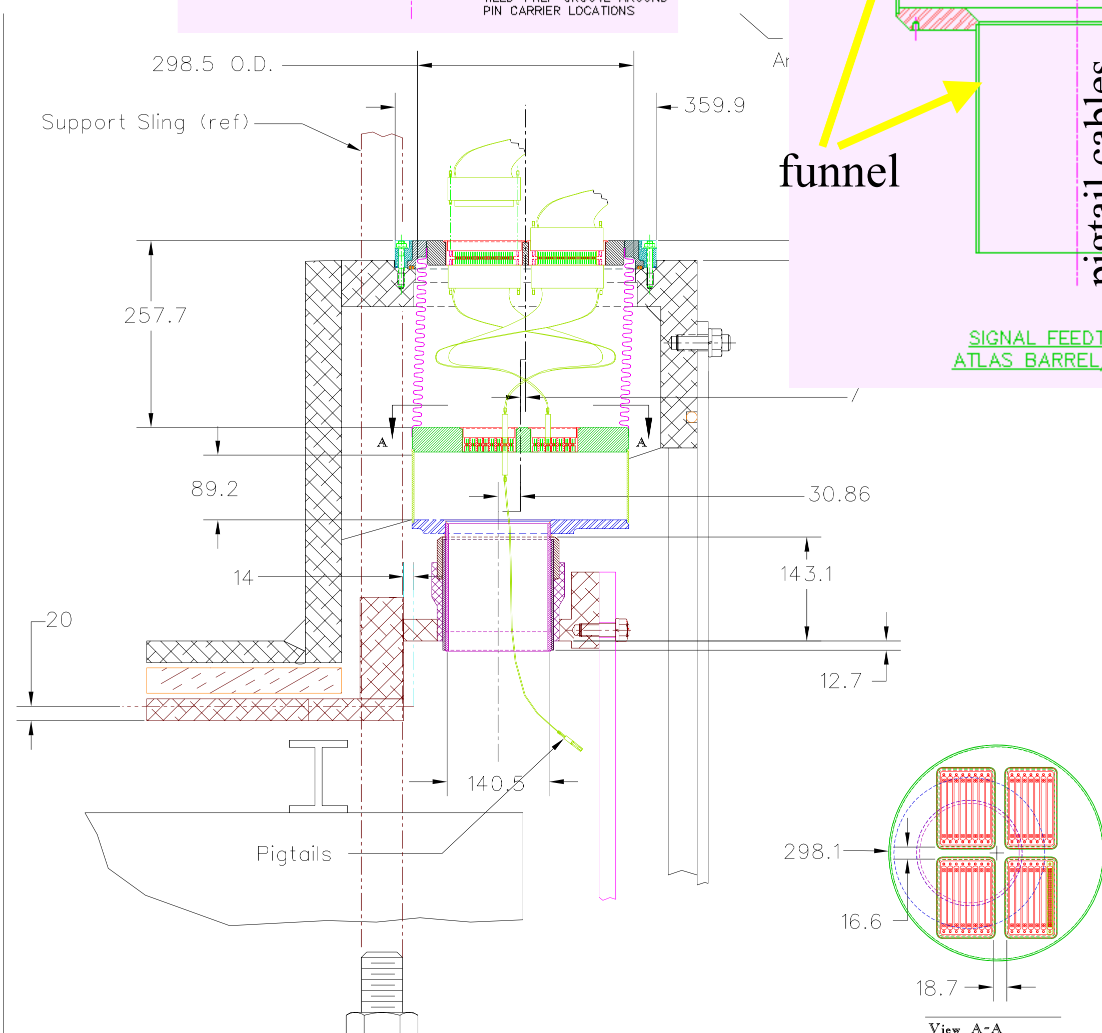
Signal Feedthroughs

Over 180k signal channels in the LAr calorimetry

High density and reliability required:
1920 pins per feedthrough unit
barrel: 64 units
endcaps: 50 units total







Design Issues

The design of the feedthrough components must satisfy many constraints:

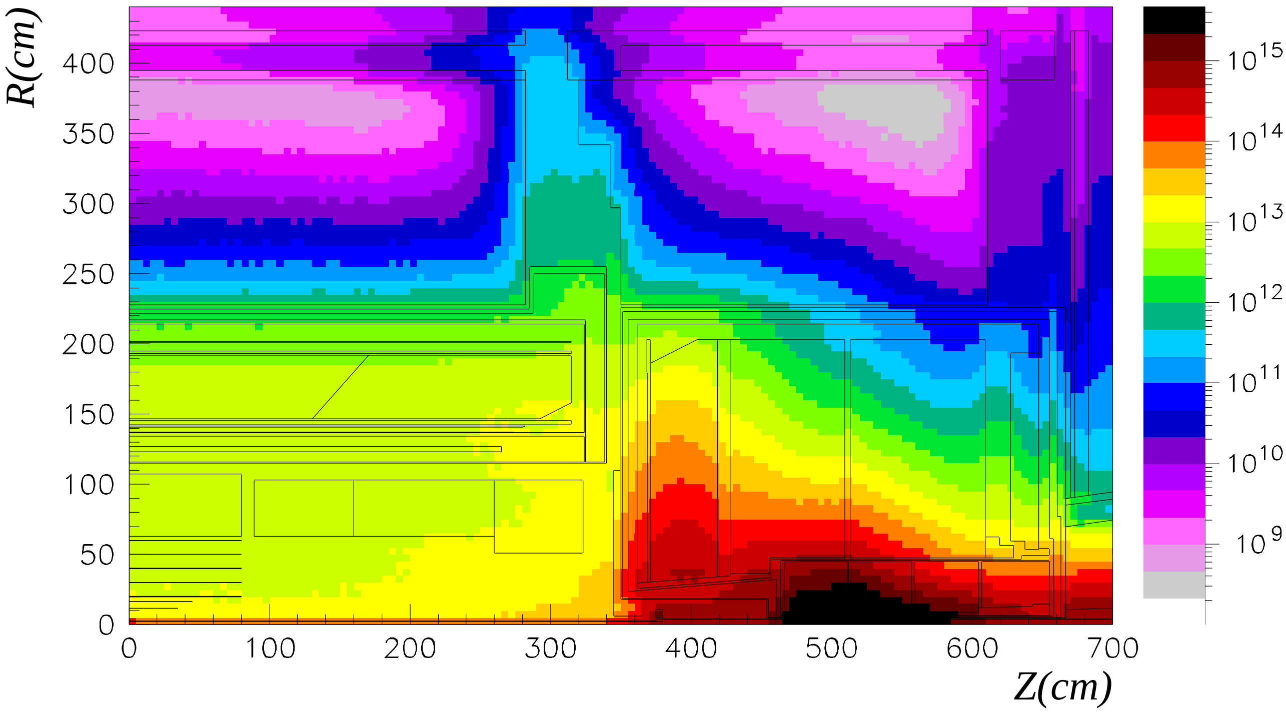
- gas and liquid pressure loads;
- stresses caused by temperature gradients;
- stresses caused by the cryostat deformations between warm and cold;
- the welding of the components together must not damage the pin carriers;
- the heat flow through the units must be kept at an acceptable level;
- the electrical properties must be adequate;
- radiation environment;

Specific to the endcap signal feedthroughs:

- special cables are needed for the low voltage for the HEC preamplifier:
    - special pigtails;
    - special vacuum cables;
    - special warm cables (not part of feedthrough project)
    - the heat flow for these special cables will be higher than for normal signal cables, but must nevertheless be kept at a reasonable level.
- there are 4 different types of endcap feedthroughs
    - 32 Standard EM
    - 8 Special EM
    - 8 HEC (HEC and some EM)
    - 2 FCAL

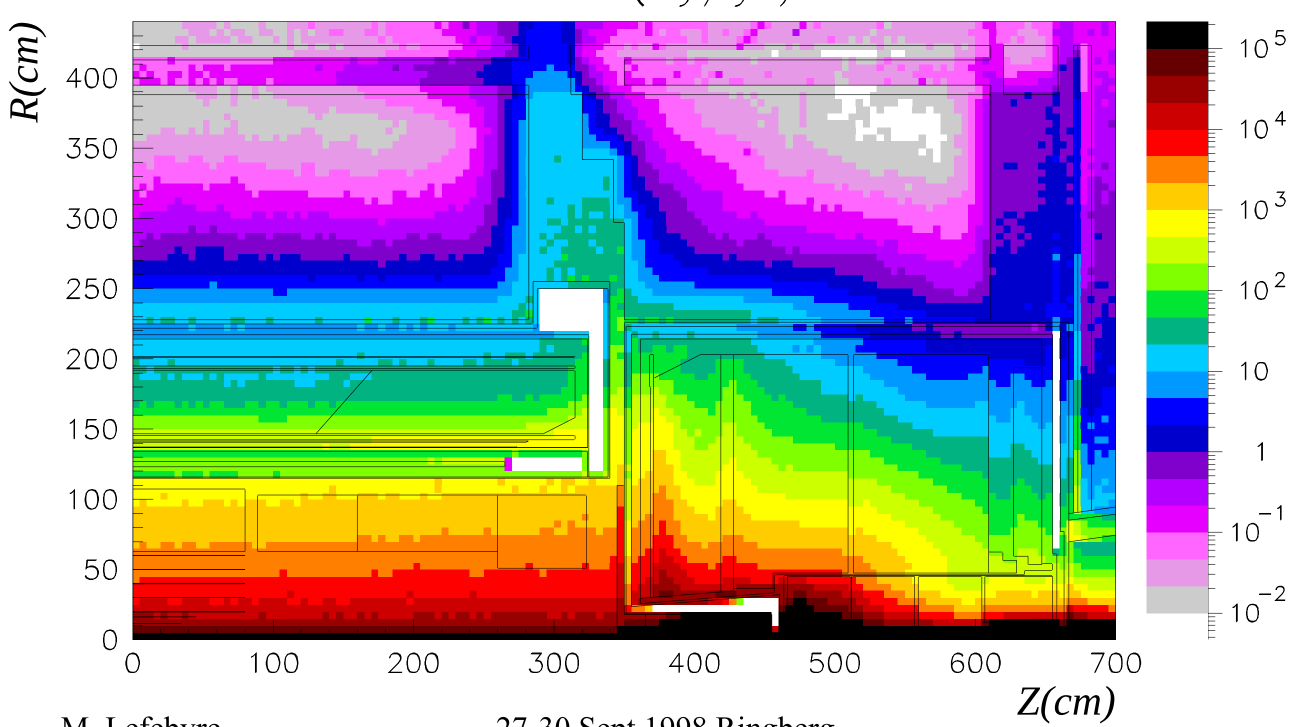
Radiation Environment

(1 MeV $n_{eq}/cm^2/yr$)

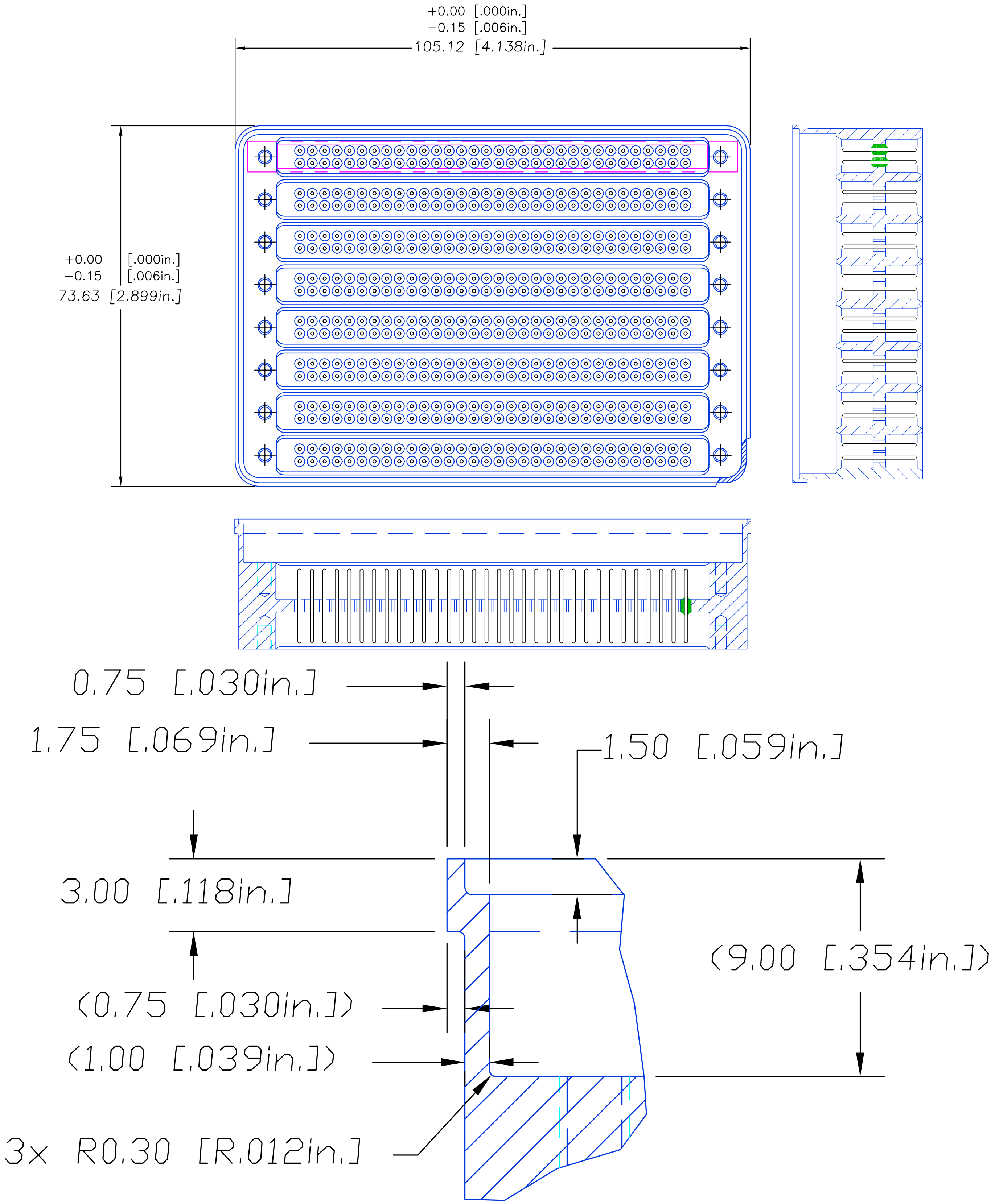


- **Up to 10^{16} n/cm²/yr and 2x10⁶ Gy/y in the FCAL**
- **Less than 10^{12} n/cm²/yr and 20 Gy/y at the EM electronics location**
- **Less than 5x10^{12} n/cm²/yr and 50 Gy/y at the Hadronic Endcap electronics location**

Dose (Gy/yr)

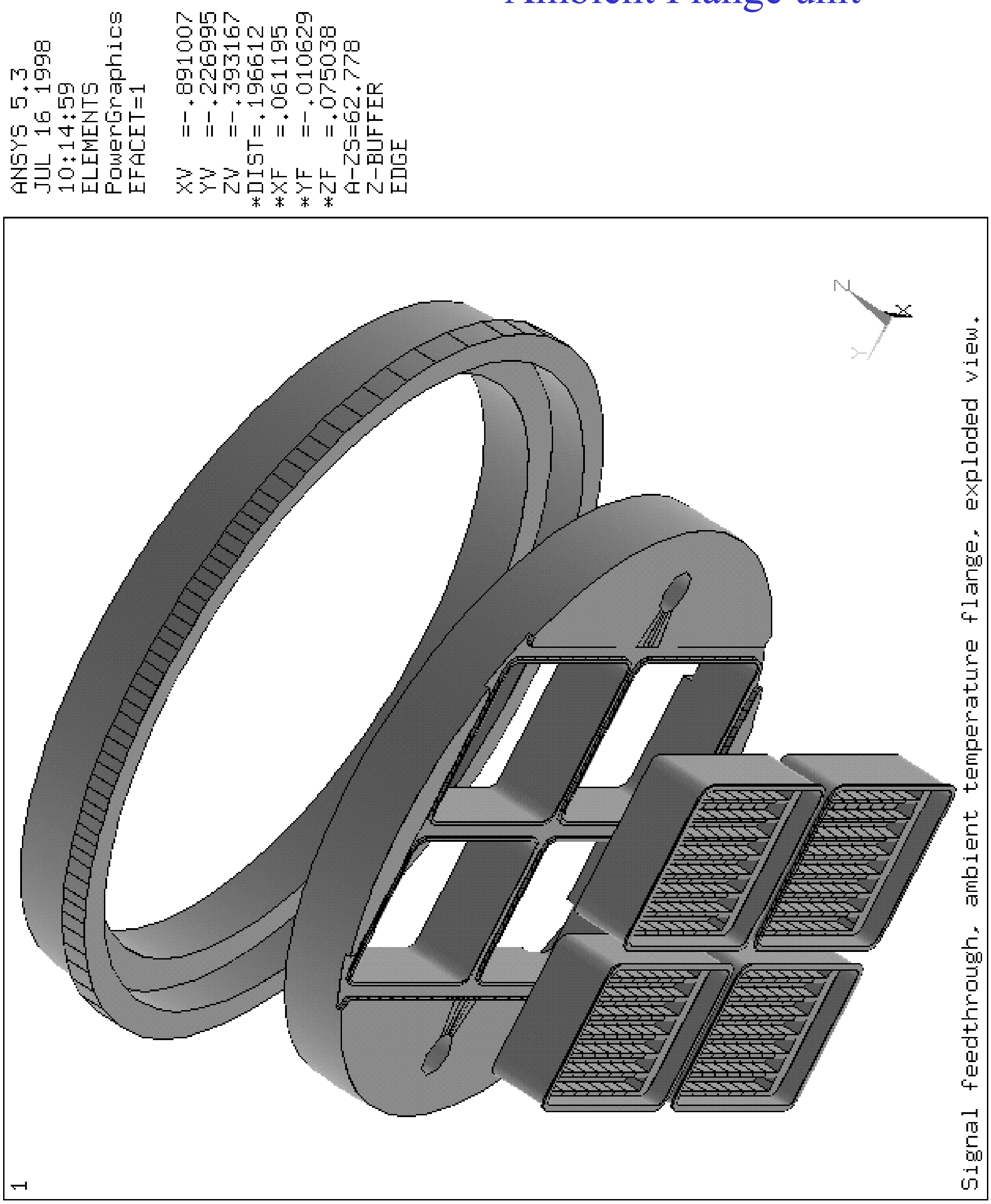


Pin Carrier Design



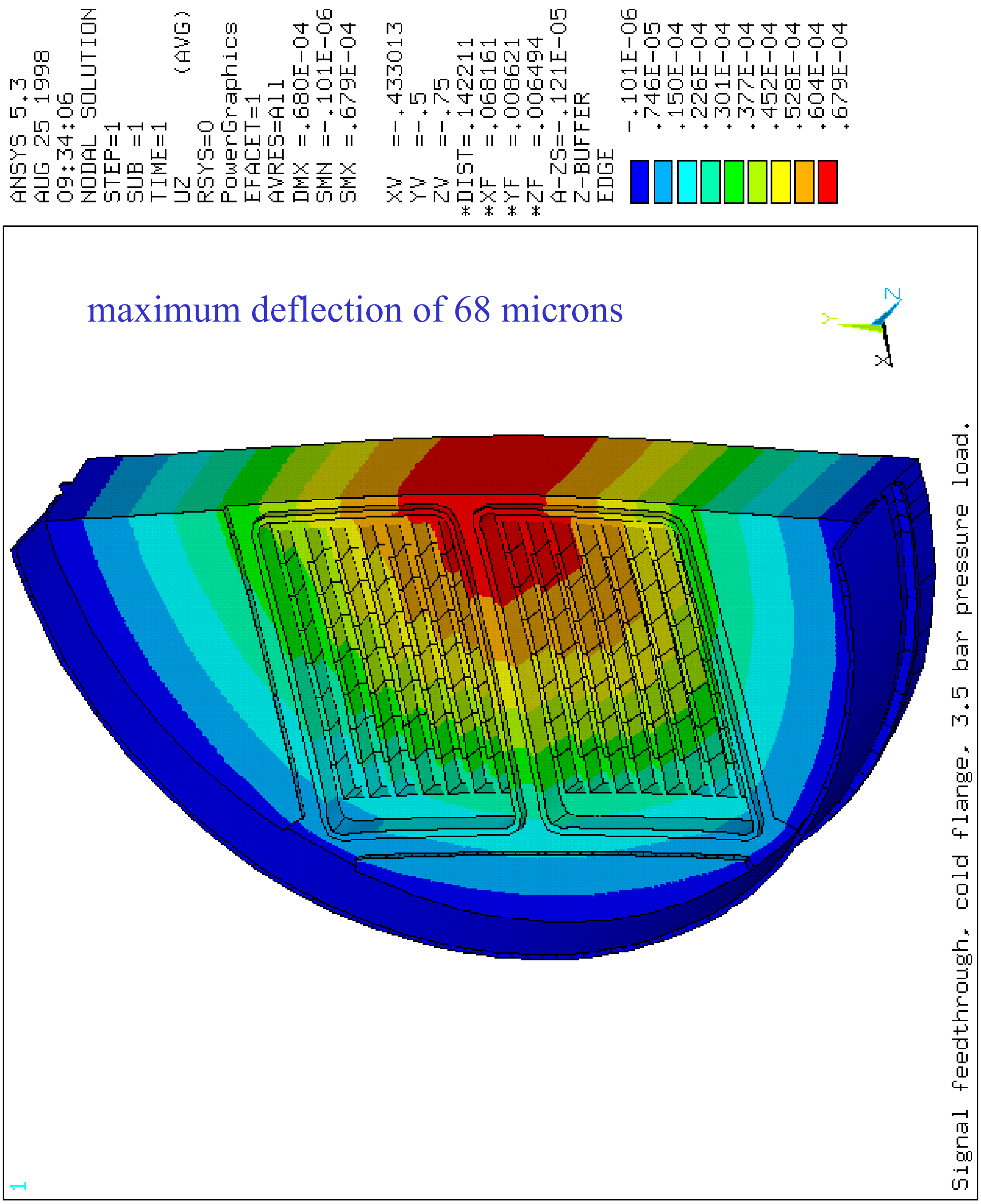
Finite Element Analysis of Feedthroughs

Ambient Flange unit



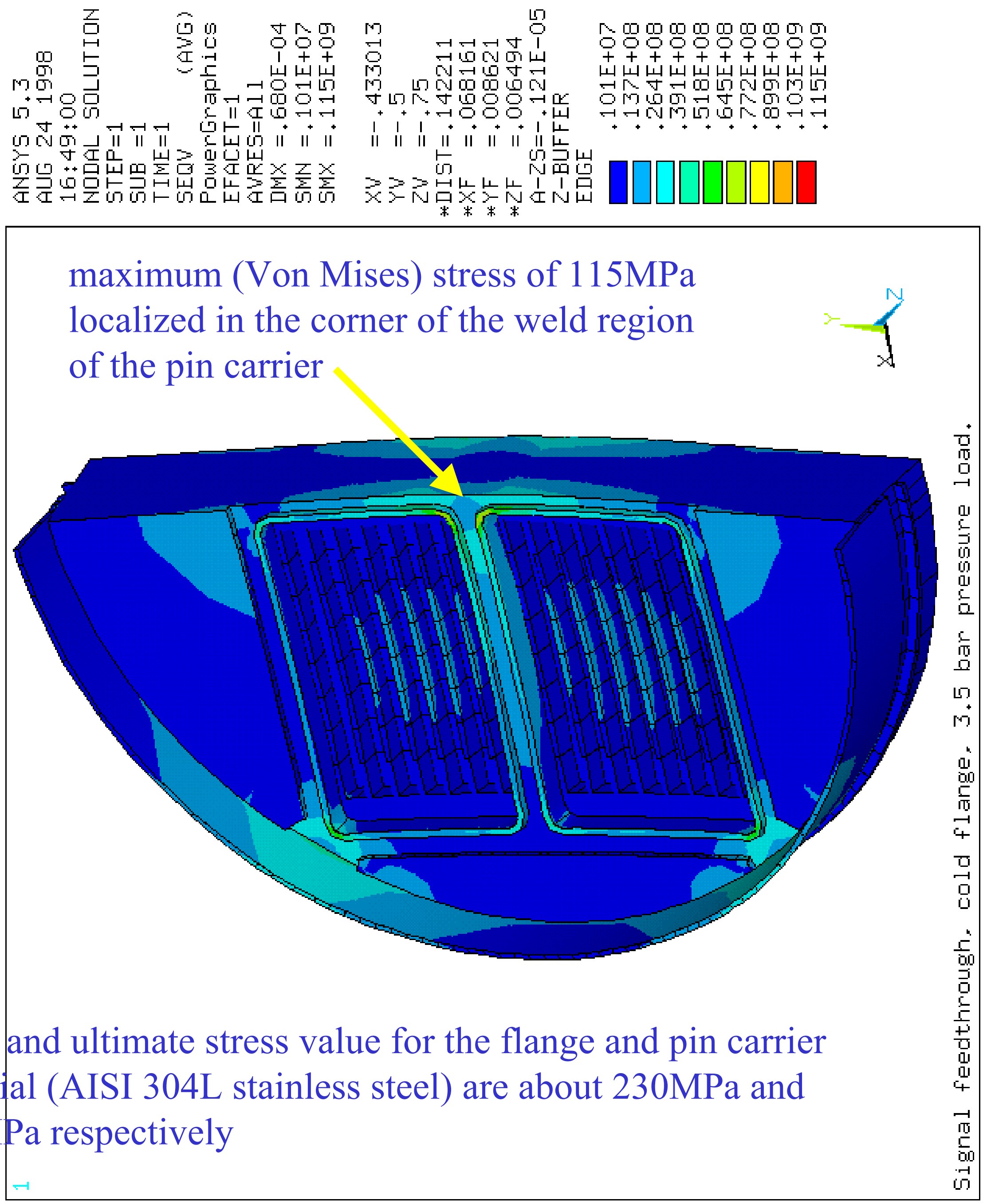
Finite Element Analysis of Feedthroughs

Cold Flange Deflection under 3.5 bar pressure load



Finite Element Analysis of Feedthroughs

Cold Flange (Von Mises) Stress under 3.5 bar pressure load, seen from the LAr side

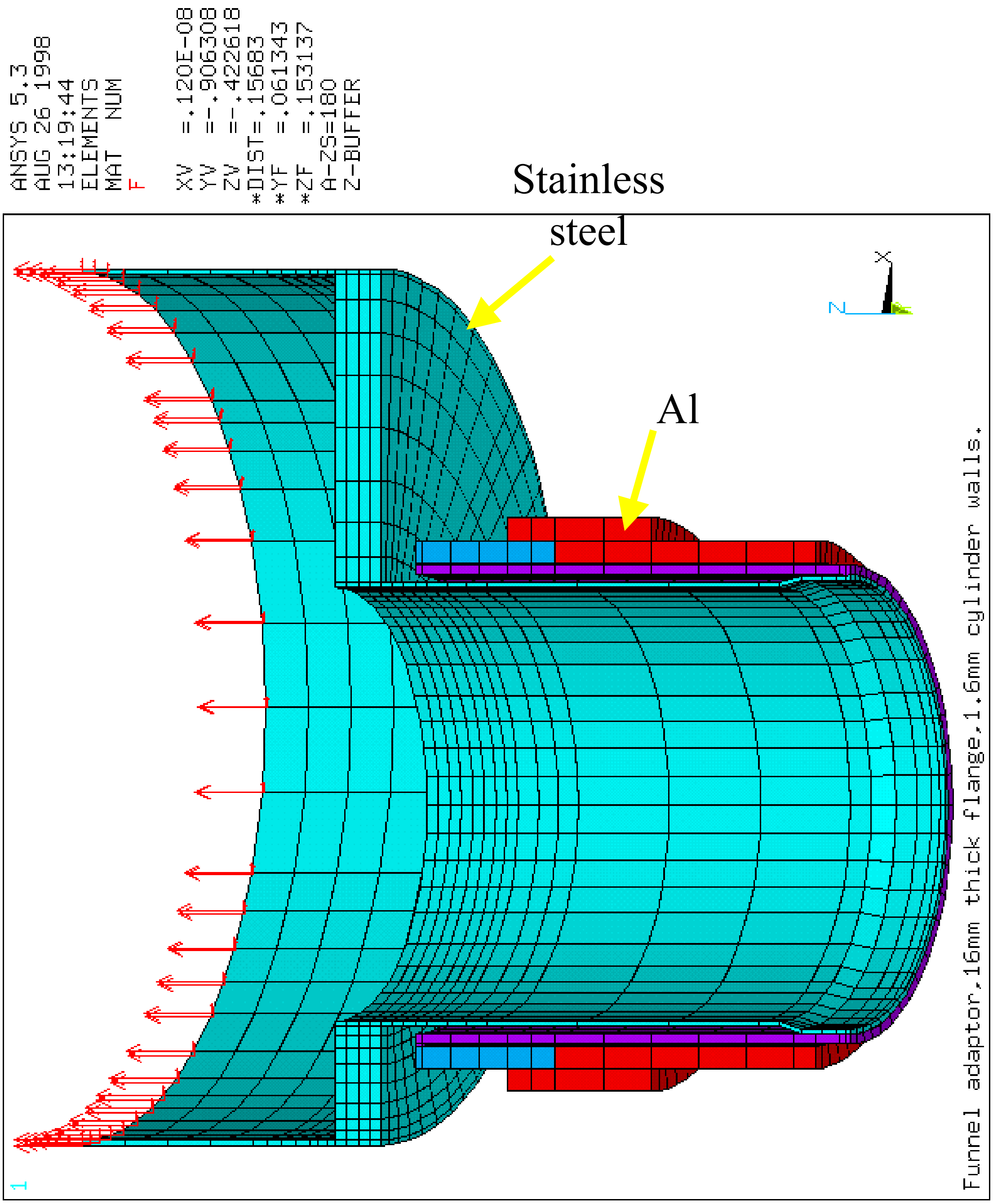


maximum (Von Mises) stress of 115MPa localized in the corner of the weld region of the pin carrier

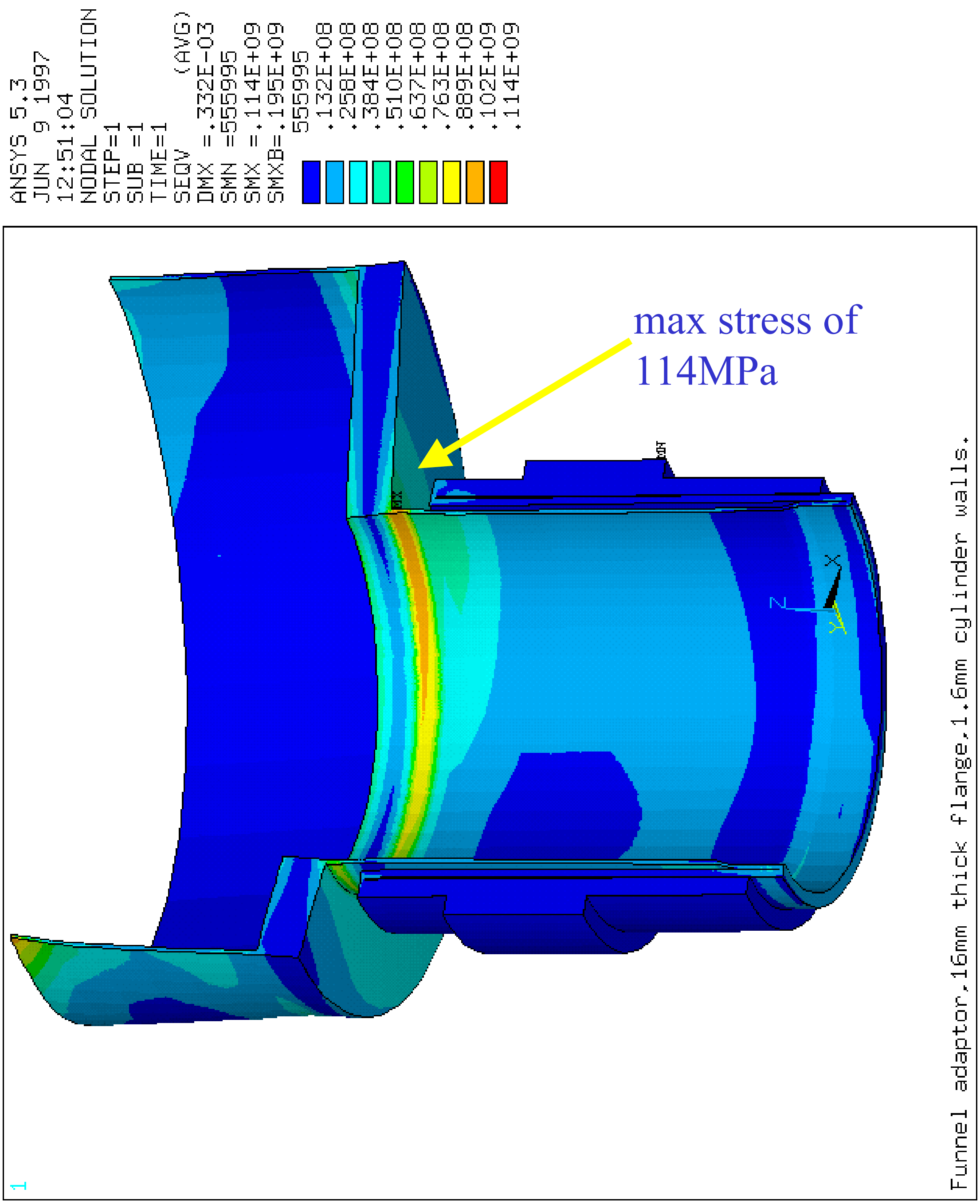
Yield and ultimate stress value for the flange and pin carrier material (AISI 304L stainless steel) are about 230MPa and 483MPa respectively

Finite Element Analysis of Feedthroughs

FEA model of the Funnel and bi-metallic joint. Simulated forces: 5387N for 3.5 bar internal pressure and 695N lateral force for the cryostats relative movements (barrel only)



Resulting Funnel (Von Mises) Stress



Pin Carrier Order for Prototypes

- BNL and Victoria plan to produce 2 or 3 feedthrough units each
- Total Order:
  - Glasseal
    - 20 pin carriers BNL
    - 20 pin carriers Victoria
    - These will be gold-plated
  - Pacific Coast Technologies
    - 10 pin carriers BNL
    - 10 pin carriers Victoria
    - These will NOT be gold-plated
- Costs
  - Glasseal
    - 448 pins: US$ 1455 each for 20 + US$ 40 for Au
    - 512 pins: US$ 1621 each for 20 + US$ 47 for Au
    - 448 pins: US$ 593 each for 500
    - 512 pins: US$ 659 each for 500
  - PCT
    - 448 pins: US$ 3872 each for 10 + US$ 1400 for Au
    - 512 pins: US$ 3961 each for 10 + US$ 1400 for Au
    - 448 pins: US$ 1997 each for 500 + US$ 200 for Au
    - 512 pins: US$ 2027 each for 500 + US$ 200 for Au

Other Mechanical Components for Prototypes

- All flanges expected late September
- 3 bellows expected 27th September
- funnel assemblies ordered, expected early October

Pin Carrier Technology Choice

• One of the most important goal of the prototyping work is to gather sufficient evidence for a pin carrier technology choice;

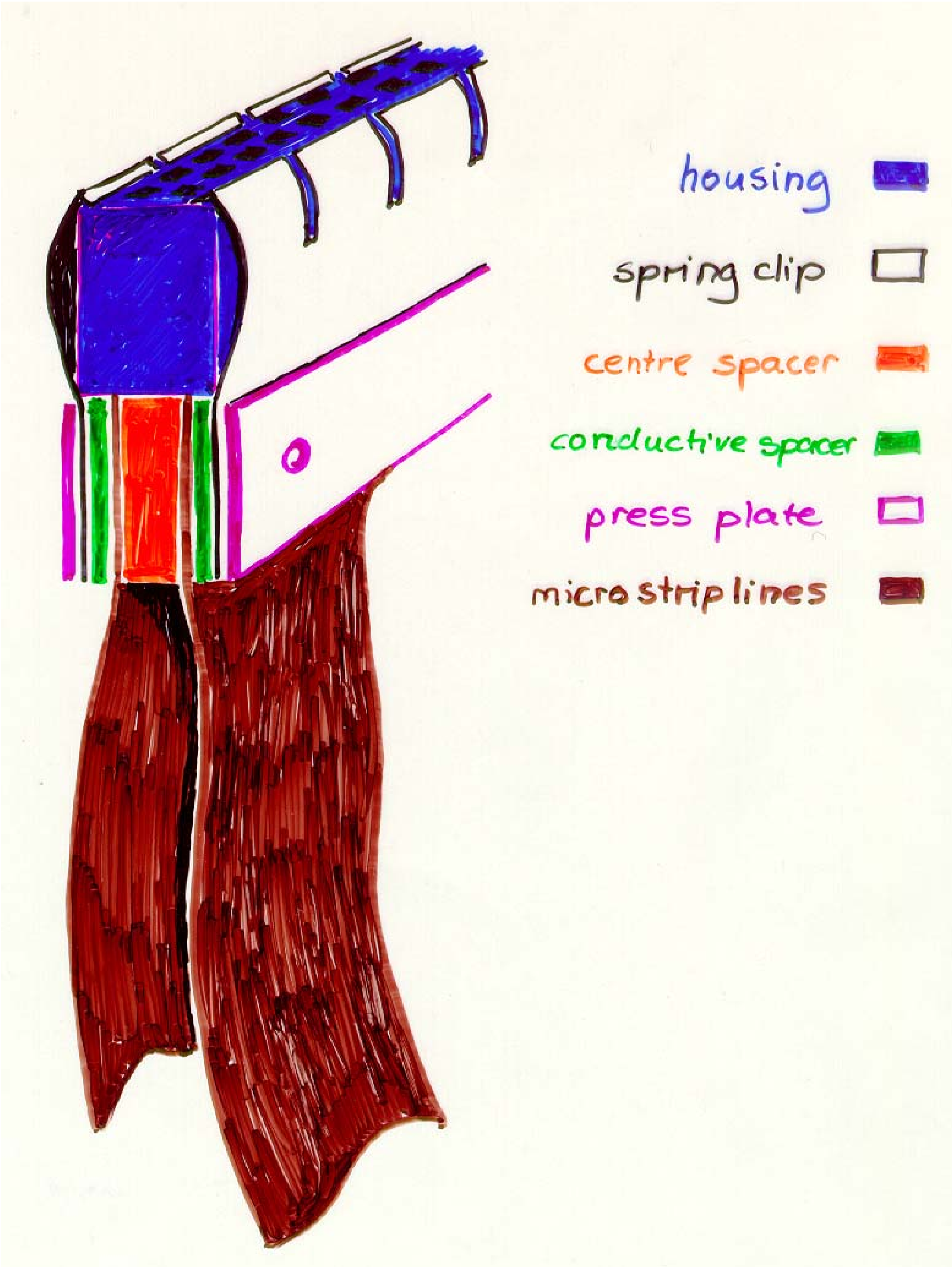
• A series of tests have been devised, inlcuding

- visual inspection;
- ambient leak testing;
- controlled temperature cycling, and leak tests;
- welding of pin carriers in flanges, and leak tests;
- complete feedthrough assembly, and leak tests;
- severe tests on a few pin carriers;
  - high pressure;
  - rapid and/or repeated temperature cycling

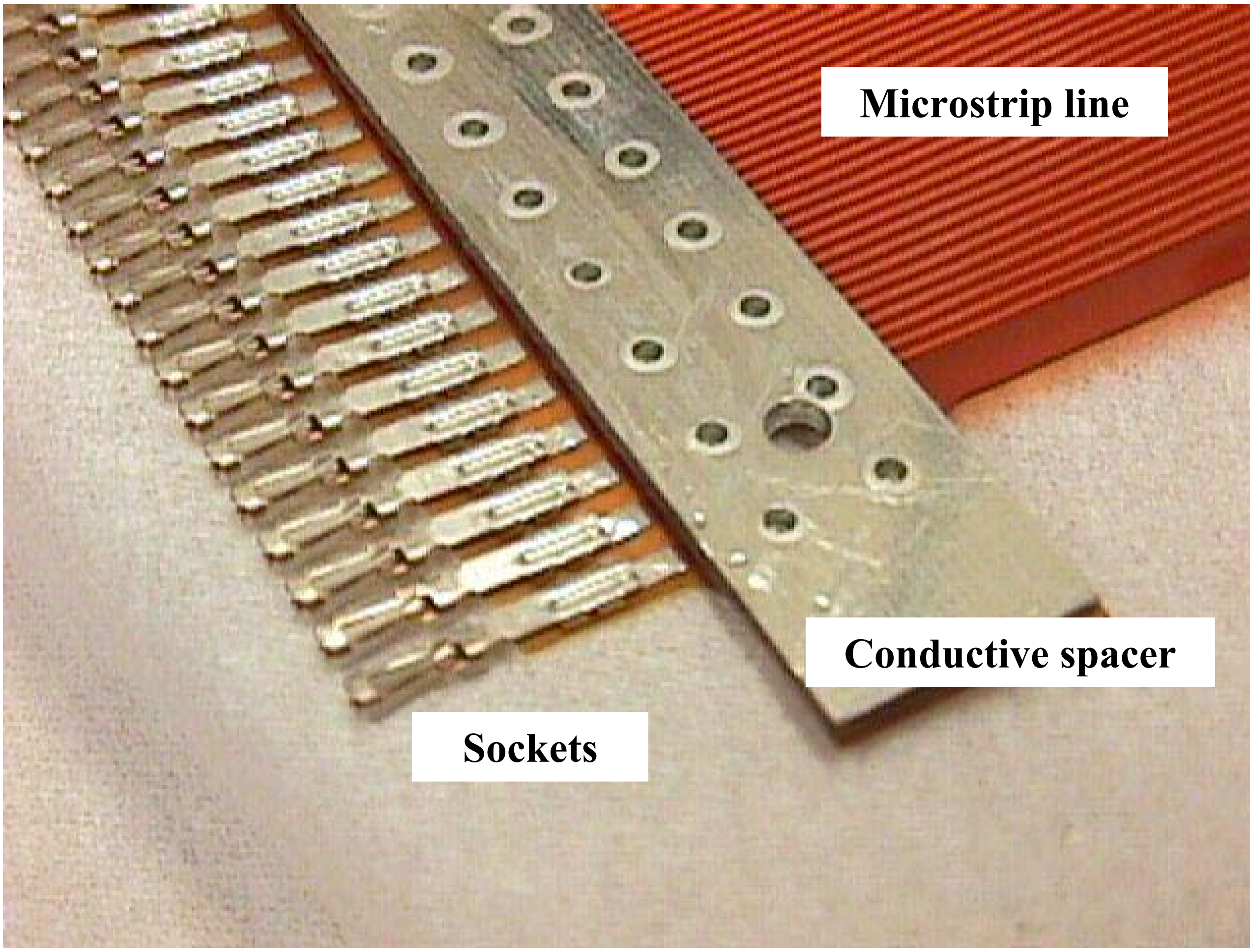
Vacuum Cable Development in Canada
Signal Cables

- All-Flex design
  - cables made up of 2 flexible microstrip lines
  - rigid part of the connector are assembled around the two strip lines
- Aim at simpler and cheaper design
- Design work:
  - E. Neuheimer (CRPP Carleton)
  - G. Hoeppel (Strataflex, Toronto)
- Connector design retained:
  - plated-through plastic spacers (Strataflex proposition)
- 20 Prototypes in hand
  - one to BNL and one to Orsay for comments
  - one was recently irradiated in Grenoble (thanks to J. Collot)
  - Many thanks to Don Makowiecki for assistance
- Work towards pre-production (100) order ongoing
- Desired schedule:
  - soon Get comments from BNL and Orsay
  - 11/98 Place pre-production order
  - 02/98 Test on pre-production cables
  - 03/99 Place production order
  - 05/99 First delivery for ECC (aggressive…)
  - 11/00 First delivery for ECA
- Comments:
  - We anticipate dates of last deliveries to be non critical

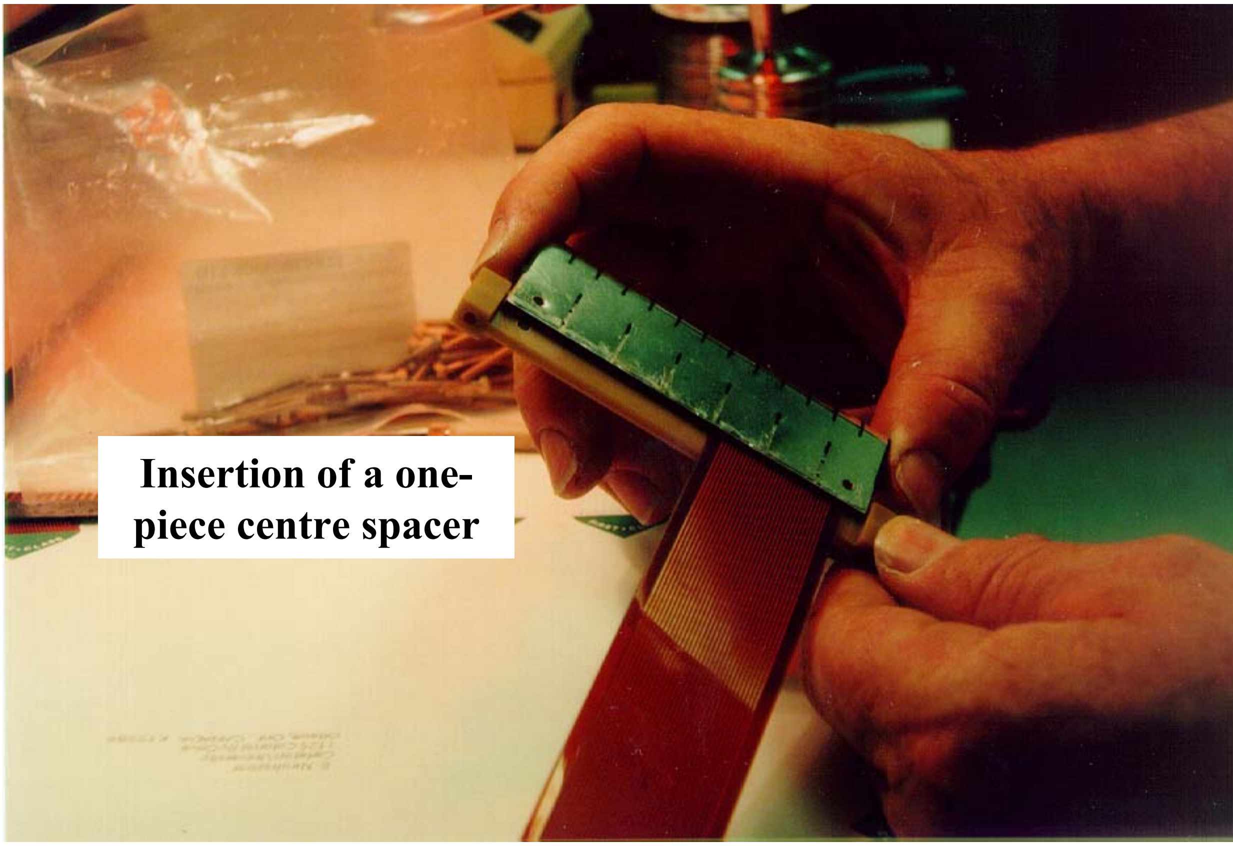
Vacuum Cable Development in Canada



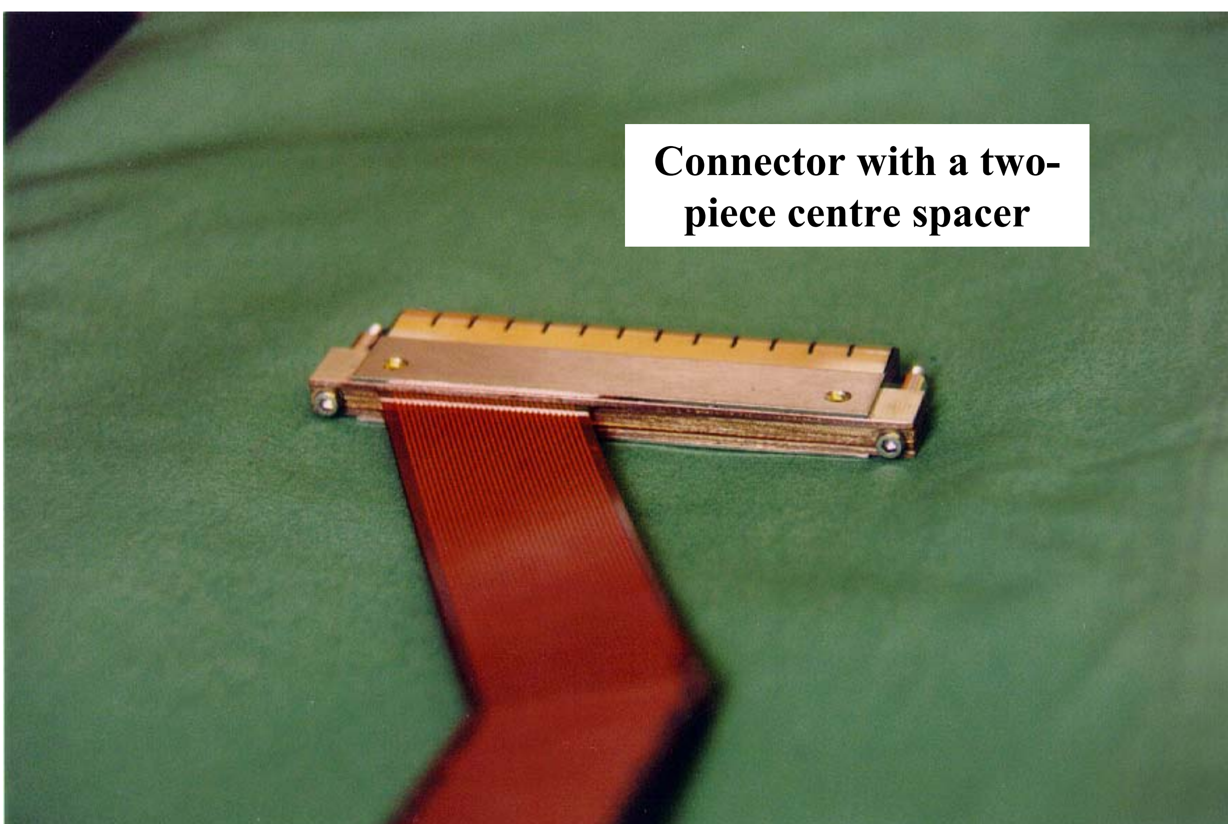
Vacuum Cable Development in Canada



Vacuum Cable Development in Canada

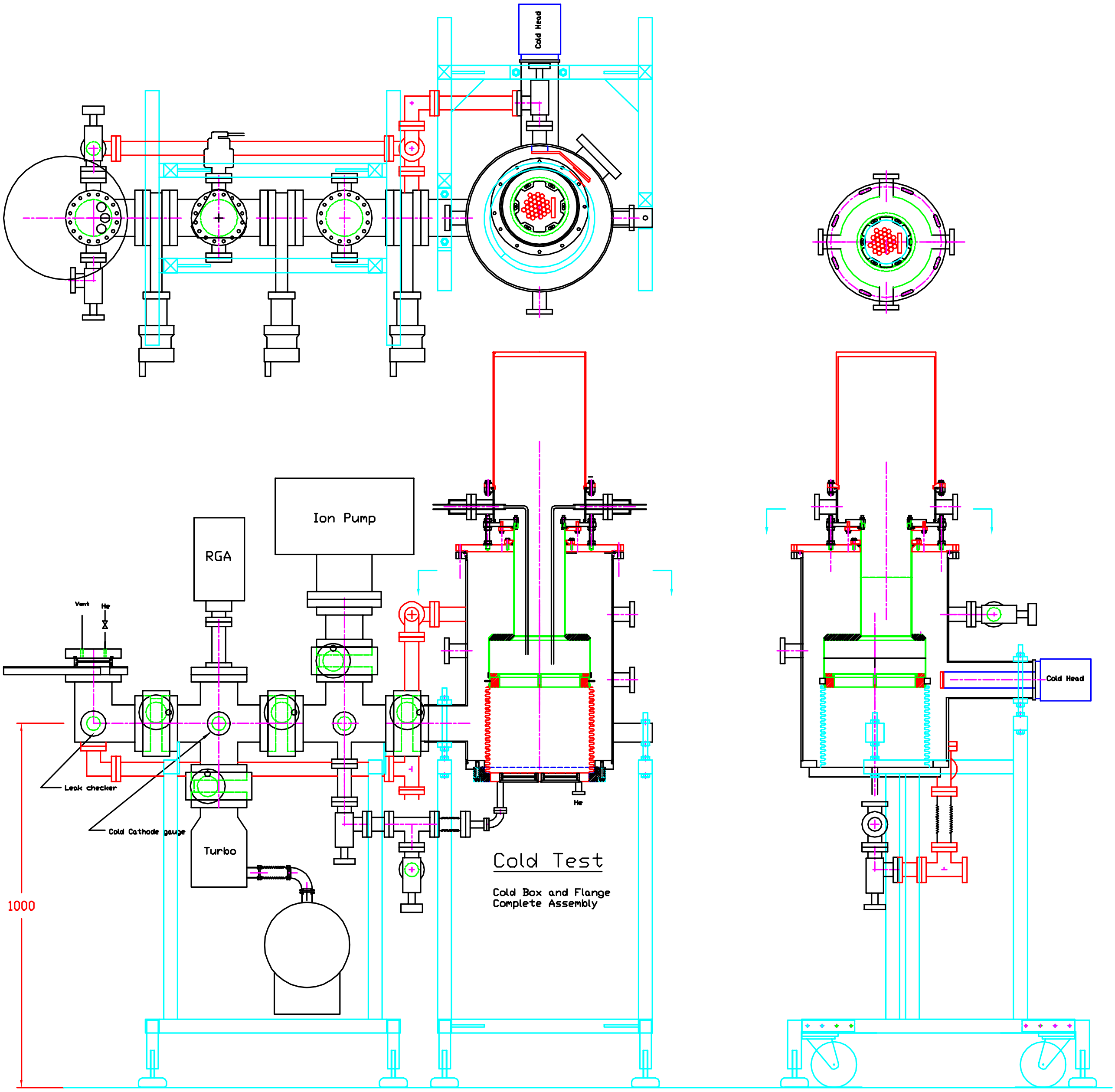


Insertion of a one-piece centre spacer



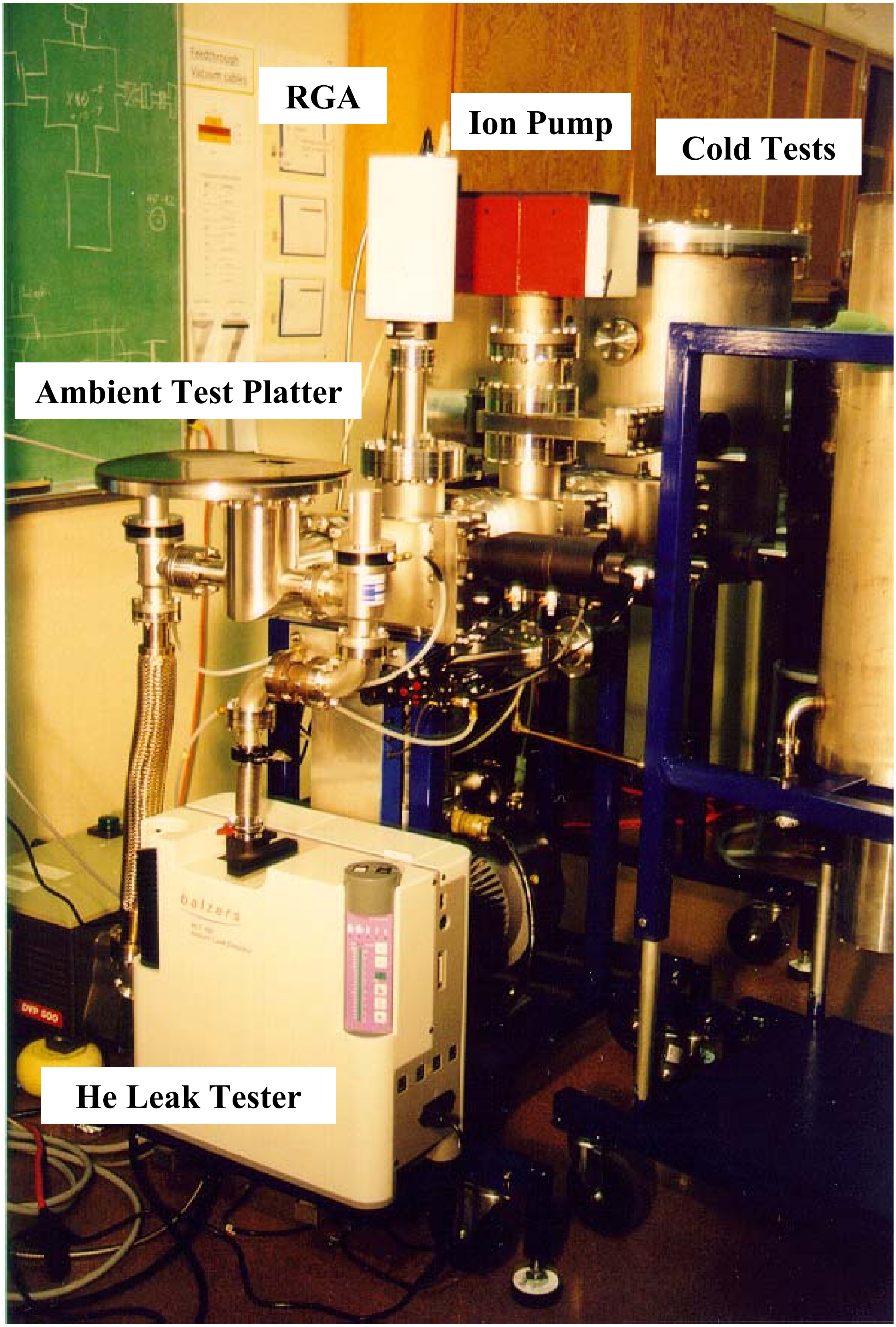
Connector with a two-piece centre spacer

Leak Test Setup in Victoria

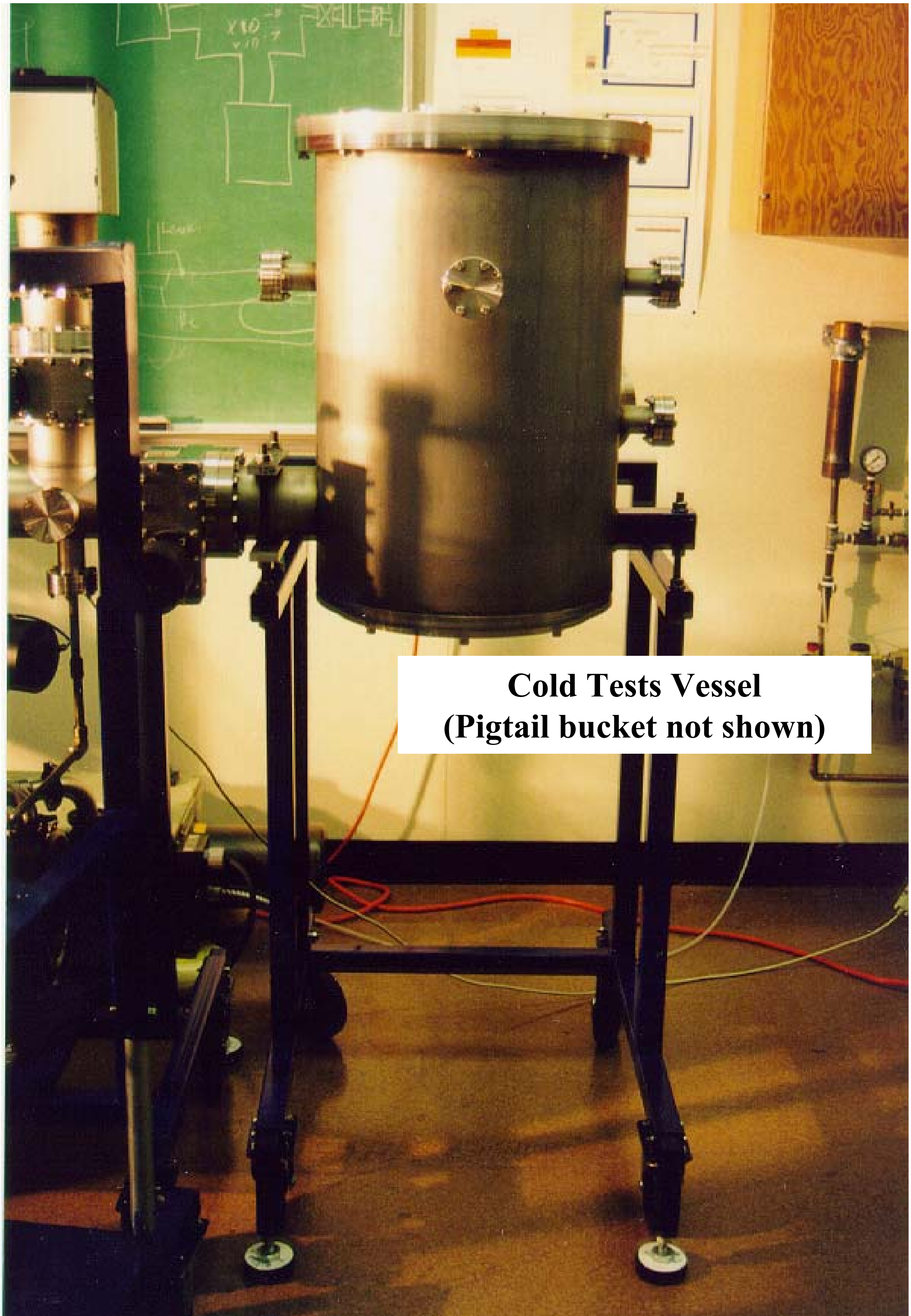


- Leak detection using He leak detector supported by an RGA
- Leak detector services warm and cold test stations
- Cooling by cryo-cooler or LN_2
- All assembled, in use

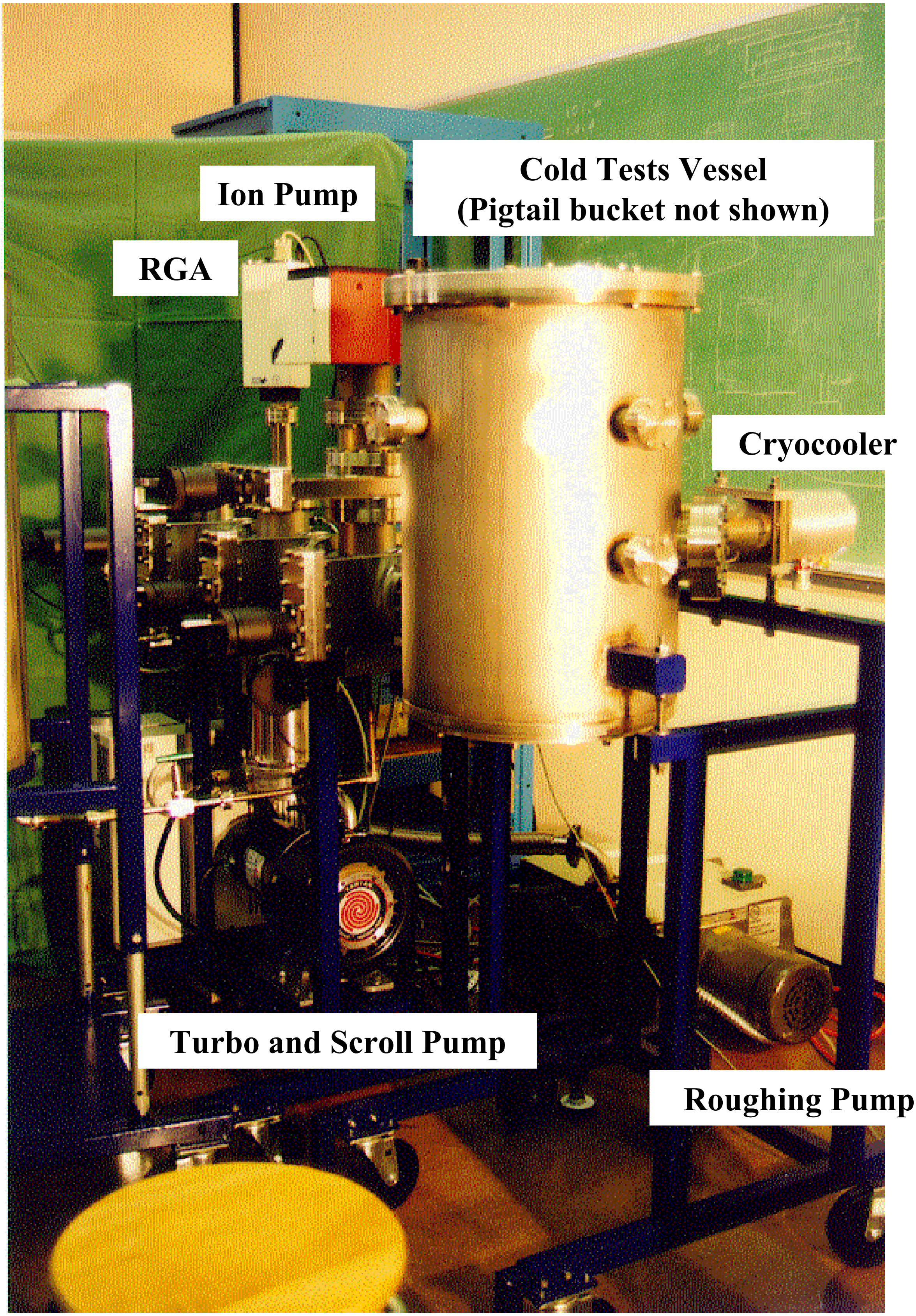
Leak Test Setup in Victoria



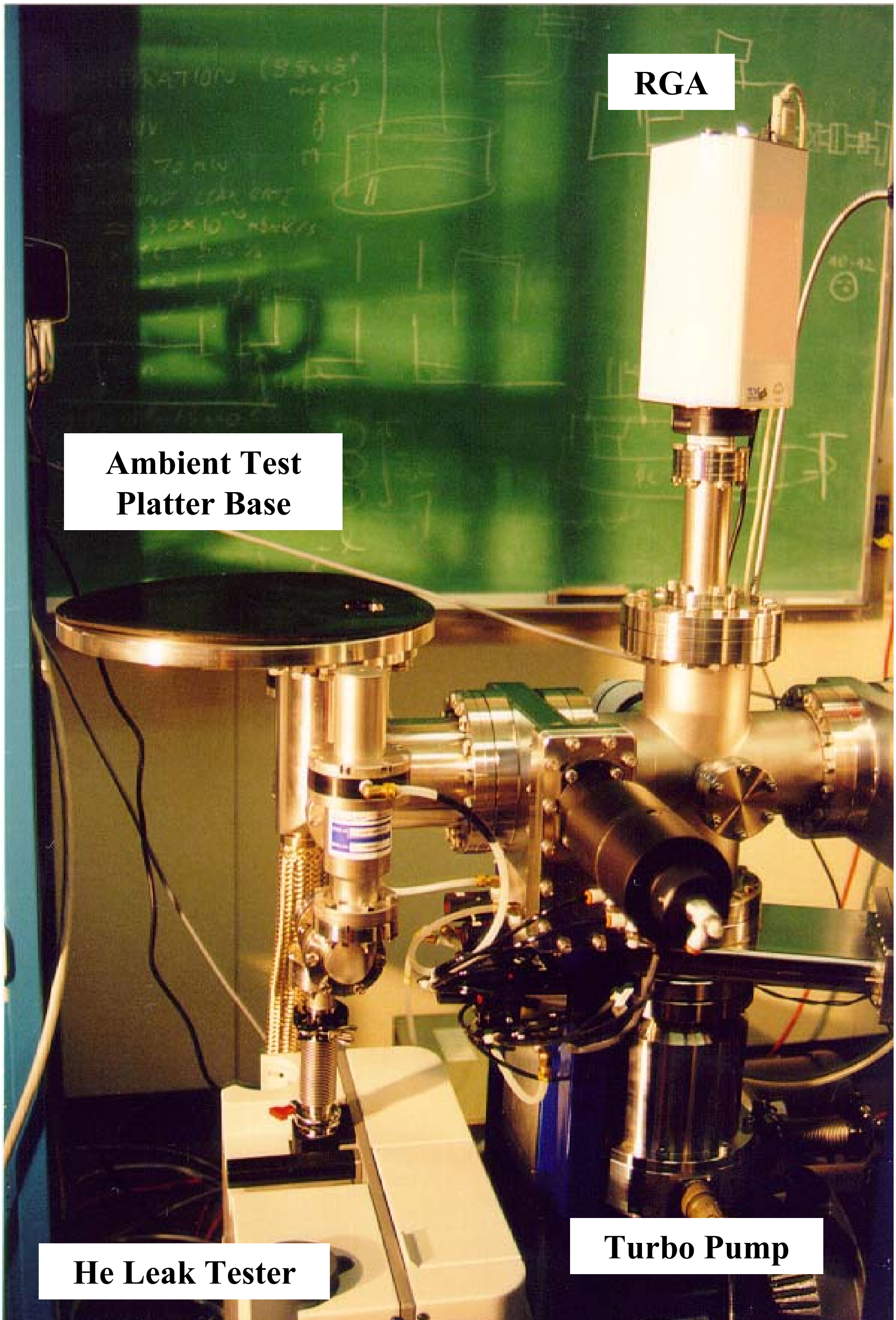
Leak Test Setup in Victoria



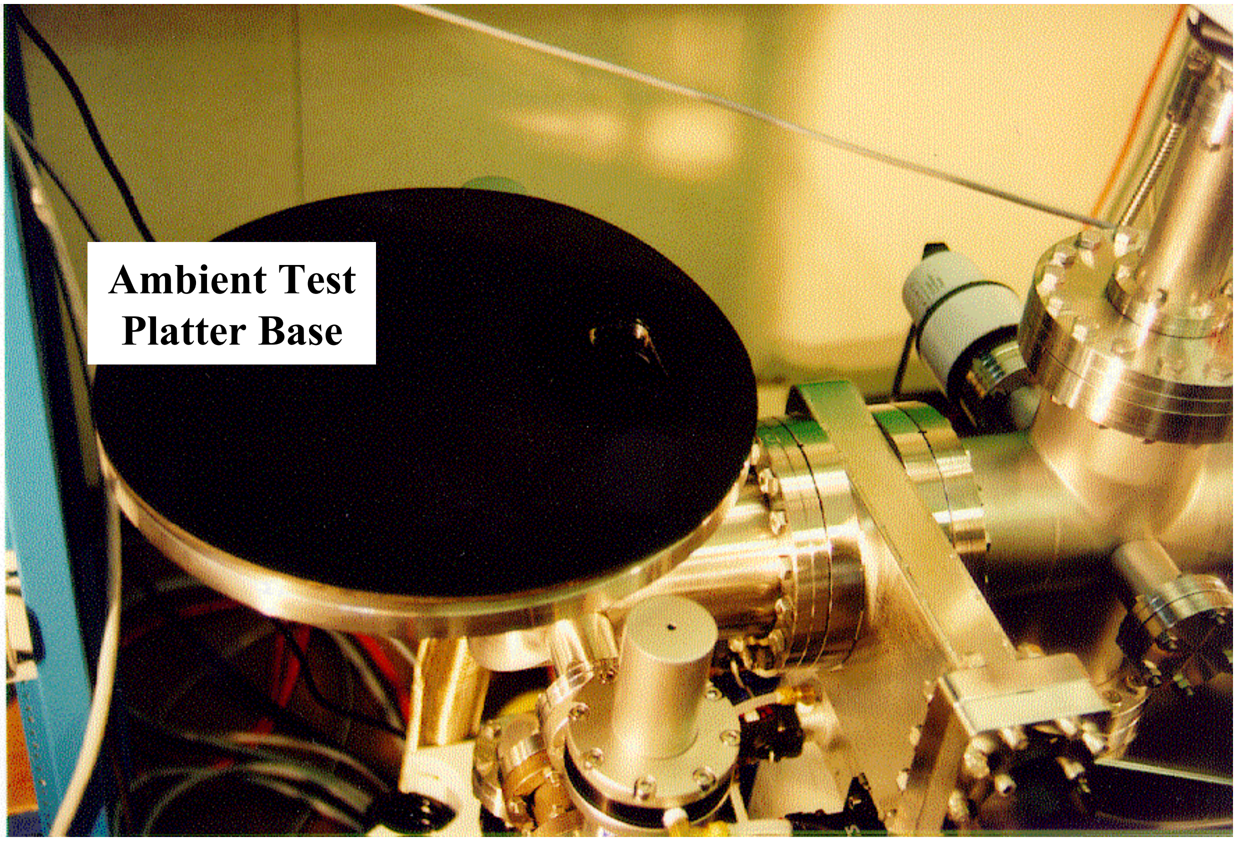
Leak Test Setup in Victoria

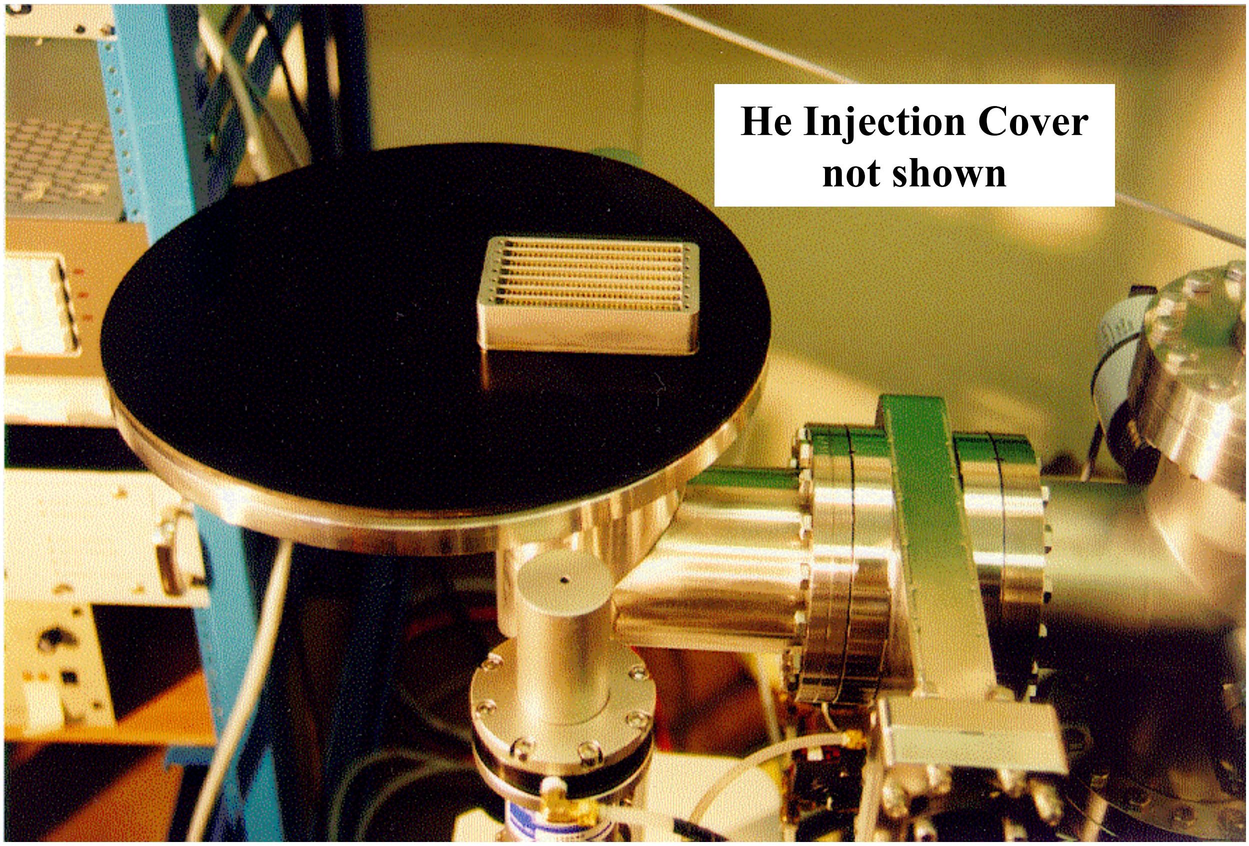


Leak Test Setup in Victoria

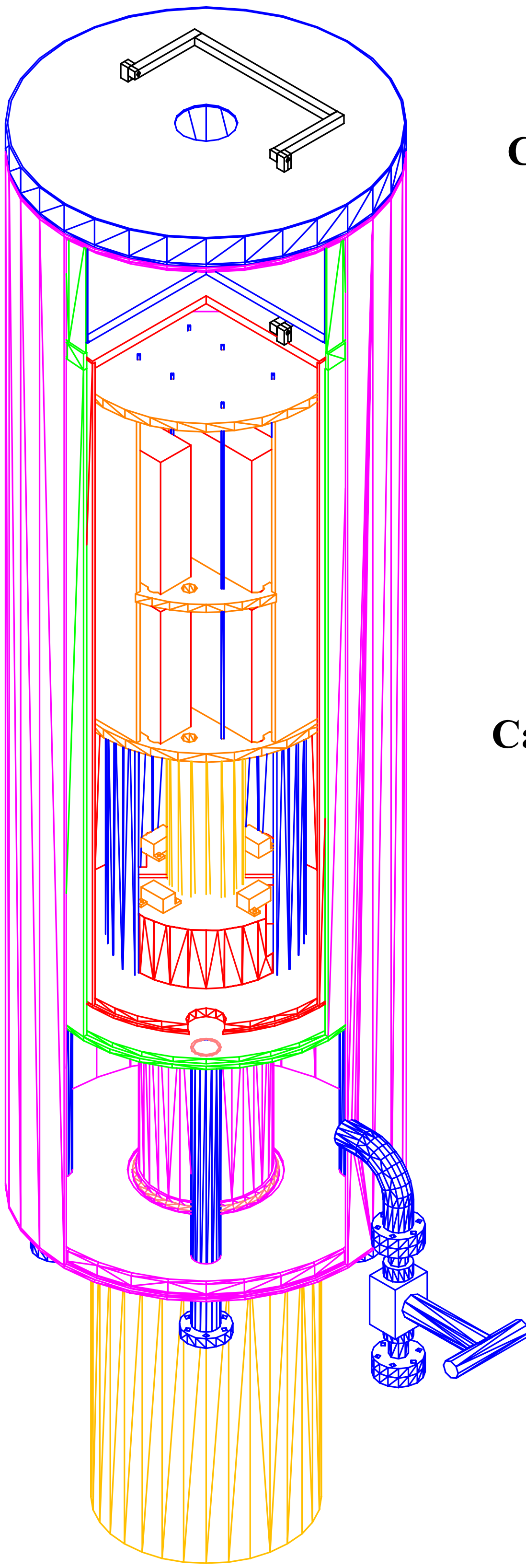


Leak Test Setup in Victoria





Leak Test Setup in Victoria



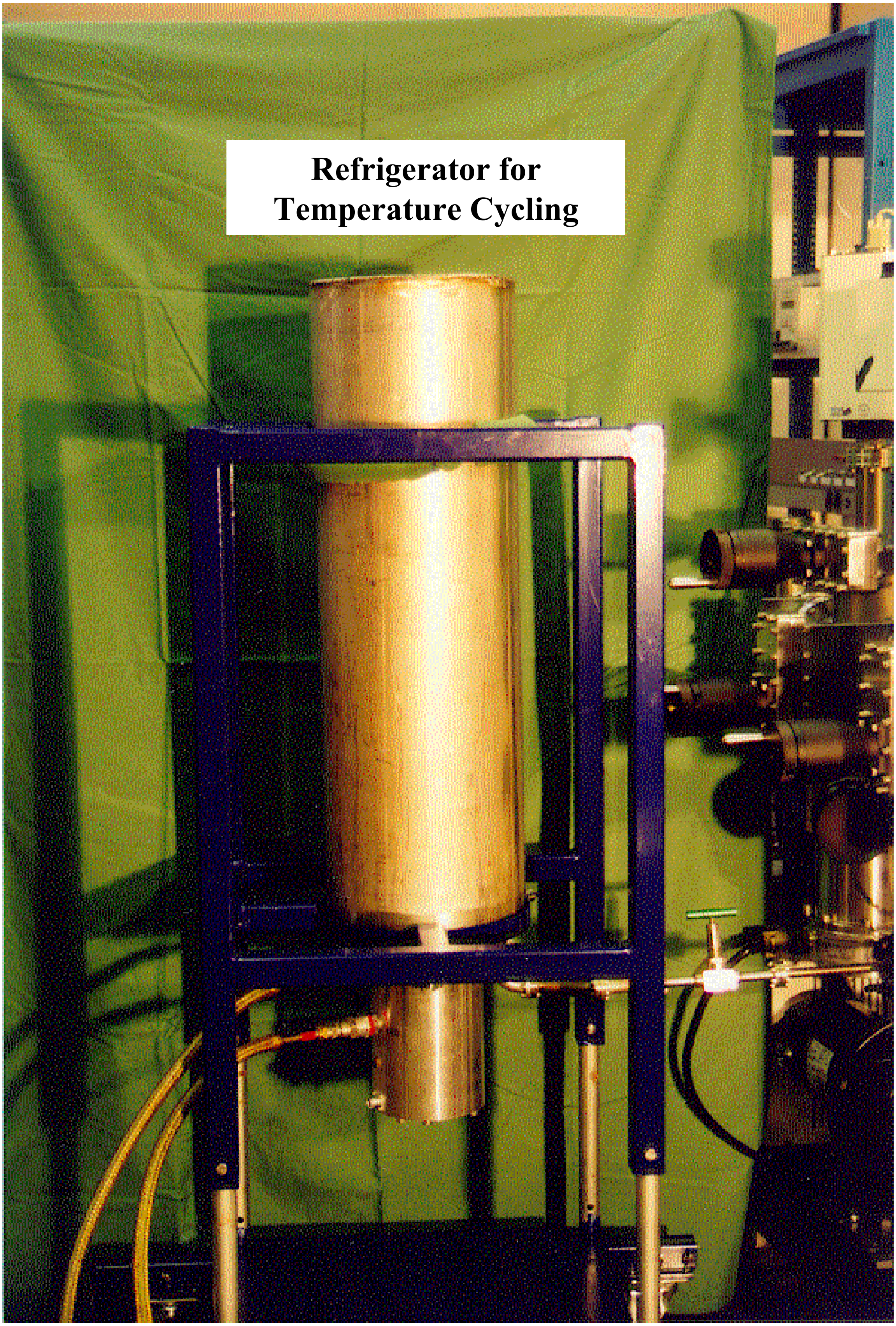
Controlled Temperature Cycling Refrigerator for pin carriers

All assembled

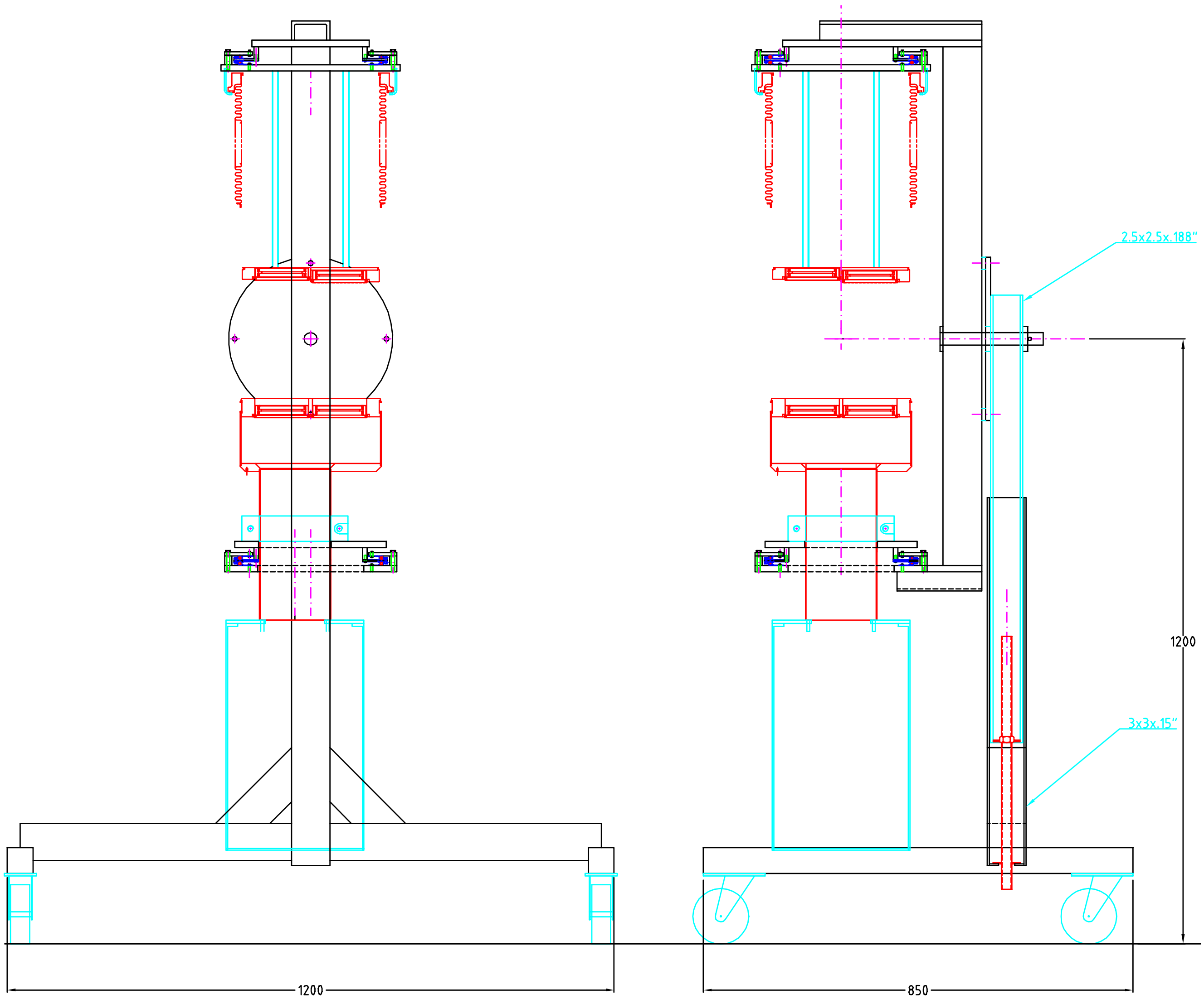
Capacity of 12 pin carriers

Cooled by Cryocooler or LN_2

Leak Test Setup in Victoria



Assembly Jig in Victoria



- Rotation about horizontal and vertical axis possible
- Various assembly scenarios under study
- Being assembled

Endcap Signal Feedthrough Project
Canadian Responsibilities

- Design
- Fabrication
  - Signal Pigtails purchased from Orsay
  - Low Voltage Pigtails purchased from MPI
- Commissioning
- Transport
- Assistance during installation:
  - Considering to cover the cost of an orbital cutter
  - Assistance during welding on the cryostat
  - Assistance for leak testing during installation
  - DC Electrical tests during the installation

Endcap Signal Feedthrough Team

Paul Birney	Senior Technologist, TRIUMF Leak test station Assembly tooling
Margret Fincke	Research Associate, Victoria Electric test station Vacuum cable development
Terry Hodges	Chief Engineer, TRIUMF Feedthrough unit design Finite element analysis
Aaron Dowling	Junior Technologist, Victoria
Richard Keeler	Faculty, Victoria Test stations Vacuum cable development
Roy Langstaff	Senior Draftsman, TRIUMF Feedthrough unit design Procurement issues
Michel Lefebvre	Faculty, Victoria Project leader
Mark Lenckowski	Draftsman, TRIUMF
Ernie Neuheimer	Research Scientist, CRPP Carleton Vacuum cable development
Paul Poffenberger	Production Manager, Victoria Leak test station Vacuum system
Greg Vowles	Junior Technologist, Victoria

On a consultant basis:

Randy Sobie	Faculty, Victoria DAQ

Endcap Signal Feedthrough Project

Top PBS Levels

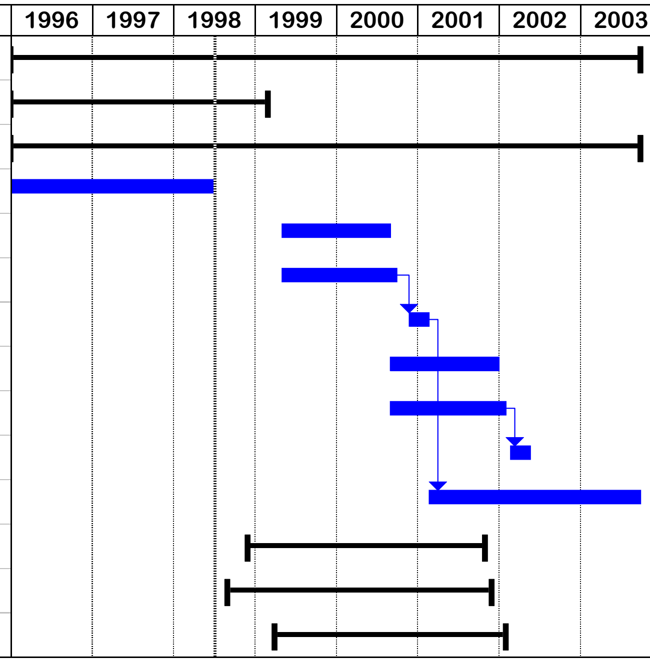
PBS	Task	WBS	Description
4		1	Endcap Signal Feedthroughs
4.1		2	Project Setup
4.1.1		3	Leak Test Setup
4.1.2		3	Electric Test Setup
4.1.3		3	Data Acquisition System
4.1.4		3	FT Assembly Tools
4.1.5		3	FT Prototypes
4.1.6		3	Management Tools
4.2		2	FT Series Assemblies
4.2	D	3	Design
4.2	AO	3	Assembly for ECC
4.2	T	3	Testing and Commissioning for ECC
4.2	A	3	Installation on ECC
4.2	AO	3	Assembly for ECA
4.2	T	3	Testing and Commissioning for ECA
4.2	A	3	Installation on ECA
4.2	RE	3	Repairs
4.2.1		3	Mechanical Components
4.2.1.1		4	Pin Carriers
4.2.1.2		4	Warm Flanges
4.2.1.3		4	Cold Flanges
4.2.1.4		4	Bellow Assemblies
4.2.1.5		4	Bolt Flanges
4.2.1.6		4	Funnel Assemblies
4.2.1.7		4	Pipe Fittings
4.2.2		3	Electrical Components
4.2.2.1		4	Pig Tail Cables
4.2.2.2		4	Vacuum Cables
4.2.2.3		4	Low Voltage Pigtail Cables
4.2.2.4		4	Low Voltage Vacuum Cables
4.2.2.5		4	Heaters
4.2.3		3	Shipping Crates

4.n for ATLAS Canada corresponds to
4.2.2.1.n in the TDR

Endcap Signal Feedthrough Project

Installation

PBS	Task	WBS	Description
4		1	Endcap Signal Feedthroughs
4.1		2	Project Setup
4.2		2	FT Series Assemblies
4.2	D	3	Design
4.2	AO	3	Assembly for ECC
4.2	T	3	Testing and Commissioning for ECC
4.2	A	3	Installation on ECC
4.2	AO	3	Assembly for ECA
4.2	T	3	Testing and Commissioning for ECA
4.2	A	3	Installation on ECA
4.2	RE	3	Repairs
4.2.1		3	Mechanical Components
4.2.2		3	Electrical Components
4.2.3		3	Shipping Crates



Dates Assumed (CB of 11/06/98)

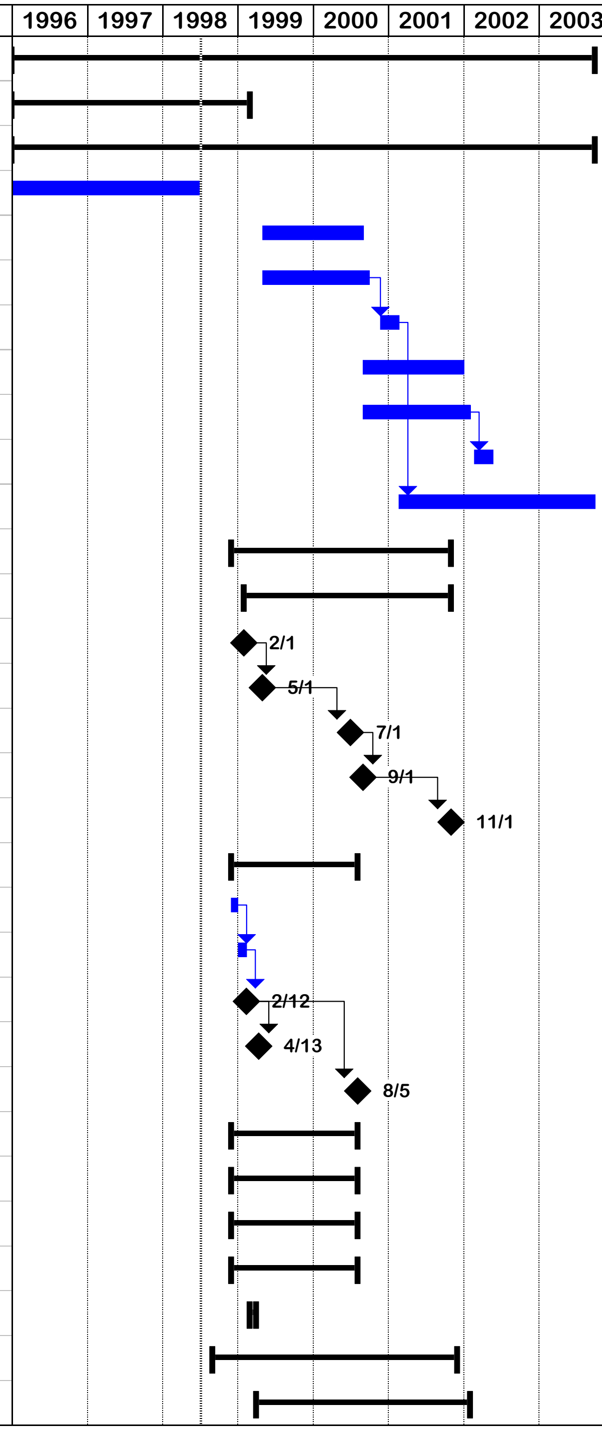
24/11/00 for 90 days Installation on ECC

22/02/02 for 90 days Installation on ECA

Endcap Signal Feedthrough Project

Schedule: Mechanical Components

PBS	Task	WBS	Description
4		1	Endcap Signal Feedthroughs
4.1		2	Project Setup
4.2		2	FT Series Assemblies
4.2	D	3	Design
4.2	AO	3	Assembly for ECC
4.2	T	3	Testing and Commissioning for ECC
4.2	A	3	Installation on ECC
4.2	AO	3	Assembly for ECA
4.2	T	3	Testing and Commissioning for ECA
4.2	A	3	Installation on ECA
4.2	RE	3	Repairs
4.2.1		3	Mechanical Components
4.2.1.1		4	Pin Carriers
4.2.1.1	CO	5	Ordering
4.2.1.1	CR	5	First Delivery for ECC
4.2.1.1	CR	5	Last Delivery for ECC
4.2.1.1	CR	5	First Delivery for ECA
4.2.1.1	CR	5	Last Delivery for ECA
4.2.1.2		4	Warm Flanges
4.2.1.2	CM	5	Market Survey
4.2.1.2	CT	5	Tendering Process
4.2.1.2	CO	5	Ordering
4.2.1.2	CR	5	Reception for ECC
4.2.1.2	CR	5	Reception for ECA
4.2.1.3		4	Cold Flanges
4.2.1.4		4	Bellow Assemblies
4.2.1.5		4	Bolt Flanges
4.2.1.6		4	Funnel Assemblies
4.2.1.7		4	Pipe Fittings
4.2.2		3	Electrical Components
4.2.3		3	Shipping Crates

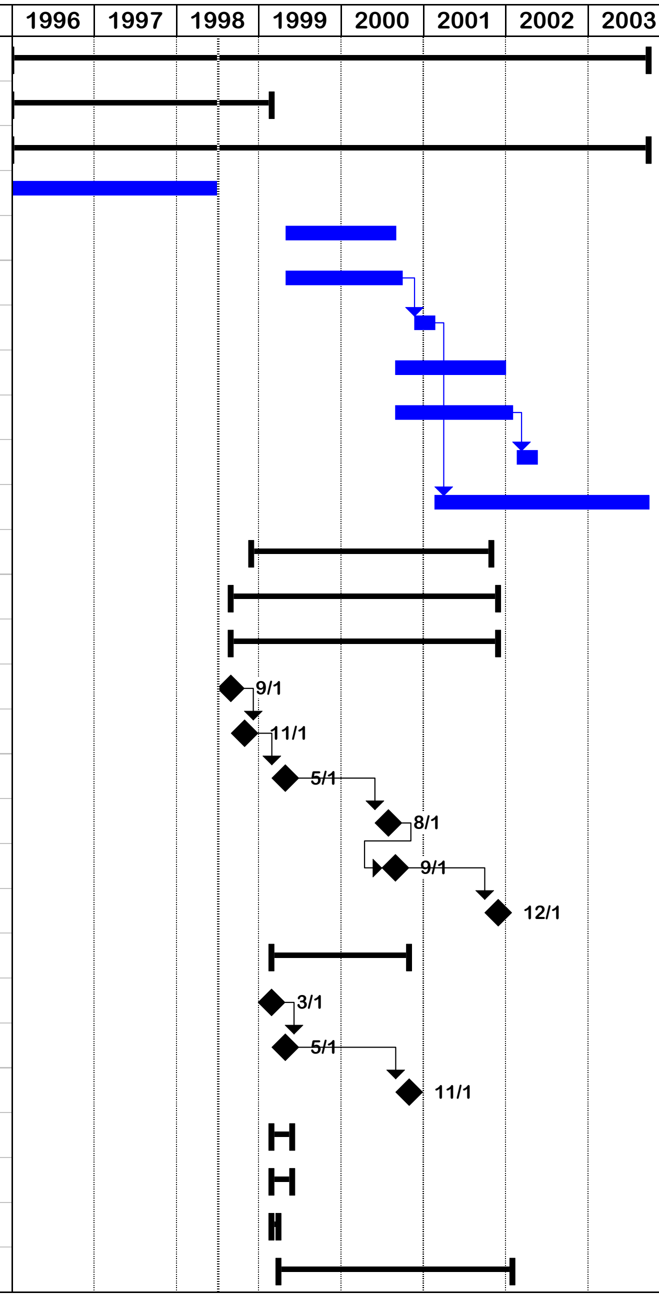


- Pin Carriers ordered shortly after PRR
- Contract preparation to start in 1998

Endcap Signal Feedthrough Project

Schedule: Electrical Components

PBS	Task	WBS	Description
4		1	Endcap Signal Feedthroughs
4.1		2	Project Setup
4.2		2	FT Series Assemblies
4.2	D	3	Design
4.2	AO	3	Assembly for ECC
4.2	T	3	Testing and Commissioning for ECC
4.2	A	3	Installation on ECC
4.2	AO	3	Assembly for ECA
4.2	T	3	Testing and Commissioning for ECA
4.2	A	3	Installation on ECA
4.2	RE	3	Repairs
4.2.1		3	Mechanical Components
4.2.2		3	Electrical Components
4.2.2.1		4	Pig Tail Cables
4.2.2.1	CO	5	Ordering
4.2.2.1	M	5	Start of Fabrication
4.2.2.1	CR	5	First Delivery for ECC
4.2.2.1	CR	5	Last Delivery for ECC
4.2.2.1	CR	5	First Delivery for ECA
4.2.2.1	CR	5	Last Delivery for ECA
4.2.2.2		4	Vacuum Cables
4.2.2.2	CO	5	Ordering
4.2.2.2	CR	5	Delivery for ECC
4.2.2.2	CR	5	Delivery for ECA
4.2.2.3		4	Low Voltage Pigtail Cables
4.2.2.4		4	Low Voltage Vacuum Cables
4.2.2.5		4	Heaters
4.2.3		3	Shipping Crates

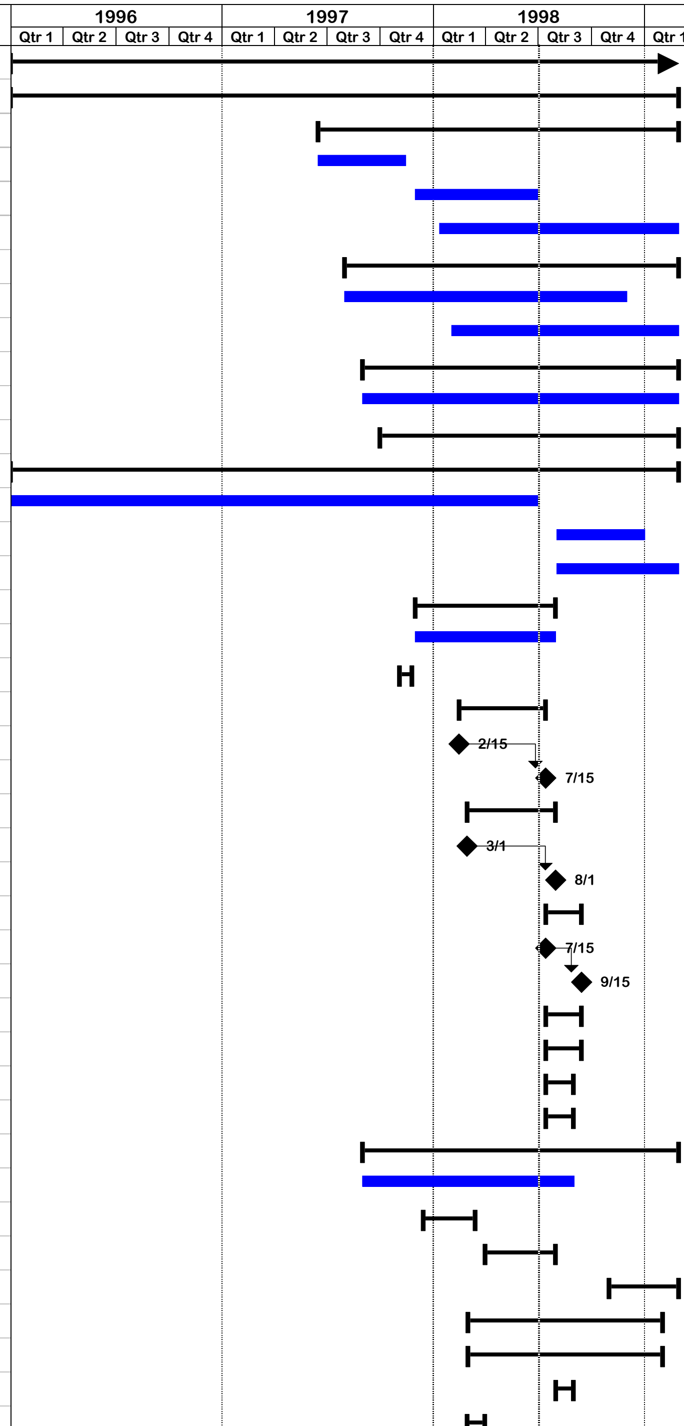


- Critical dates: Pigtails last delivery dates for EEC and ECA
- Currently, no contingency...

Endcap Signal Feedthrough Project

Project Setup Details

ID	PBS	Task	WBS	Description
1	4		1	Endcap Signal Feedthroughs
2	4.1		2	Project Setup
3	4.1.1		3	Leak Test Setup
4	4.1.1	D	4	Design
5	4.1.1	A	4	Assembly
6	4.1.1	T	4	Testing and Commissioning
7	4.1.2		3	Electric Test Setup
8	4.1.2	D	4	Design
9	4.1.2	T	4	Testing and Commissioning
10	4.1.3		3	Data Acquisition System
11	4.1.3	T	4	Testing and Commissioning
12	4.1.4		3	FT Assembly Tools
16	4.1.5		3	FT Prototypes
17	4.1.5	D	4	Design
18	4.1.5	A	4	Assembly
19	4.1.5	T	4	Testing
20	4.1.5.1		4	Model FT
21	4.1.5.1	FM	5	Manufacturing
22	4.1.5.2		4	Weld Test Flanges and Pin Carriers
31	4.1.5.3		4	Glass Pin Carriers
32	4.1.5.3	CO	5	Ordering
33	4.1.5.3	CR	5	Reception
34	4.1.5.4		4	Ceramic Pin Carriers
35	4.1.5.4	CO	5	Ordering
36	4.1.5.4	CR	5	Reception
37	4.1.5.5		4	Warm Flanges
38	4.1.5.5	CO	5	Ordering
39	4.1.5.5	CR	5	Reception
40	4.1.5.6		4	Cold Flanges
43	4.1.5.6		4	Bellows Assemblies
46	4.1.5.7		4	Bolt Flanges
49	4.1.5.8		4	Funnel Assemblies
52	4.1.5.9		4	Vacuum Cables
53	4.1.5.9	D	5	Design
54	4.1.5.9.1		5	Strip Assembly Prototypes
57	4.1.5.9.2		5	Connector Prototypes
60	4.1.5.9.3		5	Complete Assembly for Prototypes
64	4.1.5.10		4	Low Voltage Vacuum cables
69	4.1.5.11		4	Low Voltage Pigtails
74	4.1.5.12		4	Pipe Fittings
77	4.1.6		3	Management Tools



Endcap Signal Feedthrough Project

- Design Finalized
- Prototypes under construction
  - pin carrier technology choice
  - no pigtails for prototypes
  - Some vacuum cables
- Vacuum cable development progressing
- Assembly and test stations near completion
- Critical path items:
  - pin carrier technology choice
  - pigtail procurement
  - vacuum cable development
- Ongoing
  - Low voltage special cables (pigtails, low voltage)
  - flange insulation issues