LIGO Australia

LIGO-Australia
The nuts and bolts

Jesper Munch

For ACIGA and LIGO

IndIGO-ACIGA Meeting
New Delhi, 8-10 Feb 2011

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Acknowledgements:
Material provided in part from:

LIGO Laboratory
especially: J. Marx and S. Whitcomb

ACIGA:

(Australian Consortium for Interferometric Gravitational Wave Astronomy)
Adelaide, ANU, UWA, Melbourne, Monash

Outcome of 2009 Shanghai meeting

LIGO Australia

CONTENTS:

- LIGO Australia Overview
- Contributions from LIGO-Laboratory
- New infrastructure required in Australia
- Construction plan
- Construction costs
- Operation
- Schedule
- Risk

LIGO Australia

LIGO Australia Summary

- **LIGO Lab has offered to locate the third advanced LIGO interferometer in Australia**
- **The NSF has approved this**
- **The offer is subject to Australia providing:**
  - **--- The infrastructure to house and operate the interferometer**
  - **--- The funds/ people to install the detector**
  - **--- The funds / people to operate the detector for 10 years**
- **Decision to accept/decline offer required by Oct 2011**
- **Detailed proposal for Australian Federal Government complete**

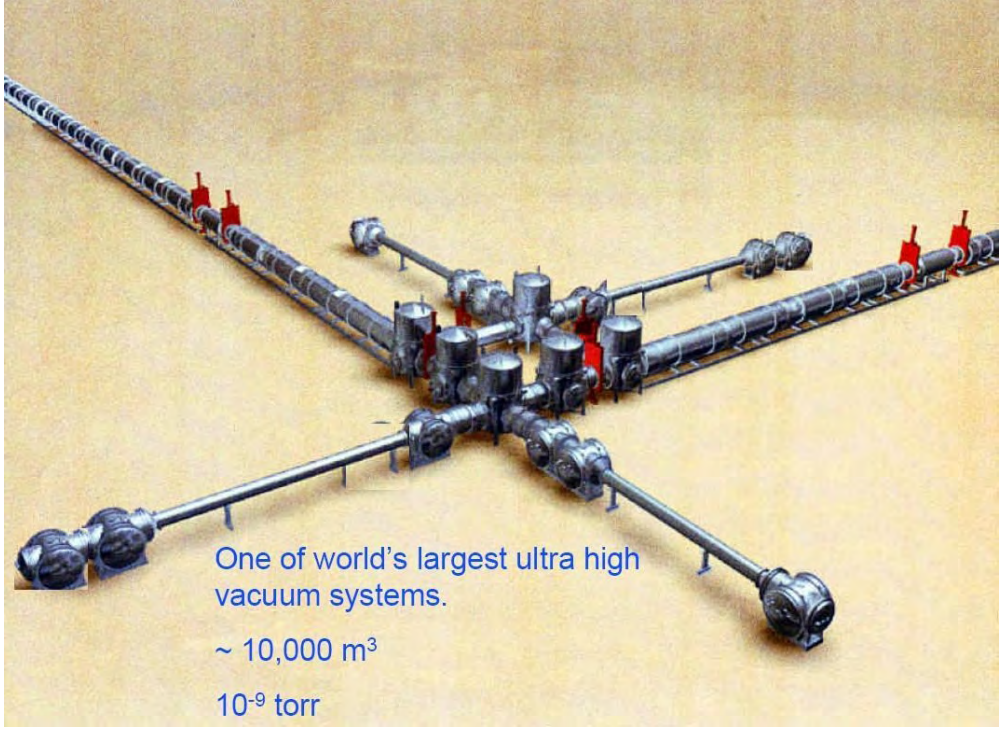
LIGO Australia

What will LIGO Laboratory Contribute?

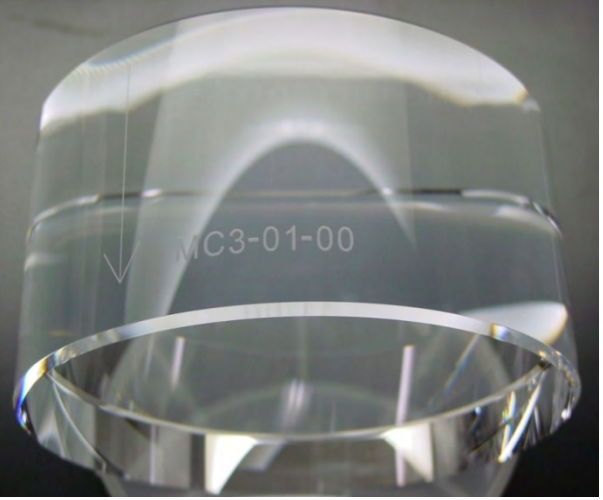
- All components for a complete advanced interferometer
- Training opportunities for LIGO-Australia staff and associate international collaborators
- Expert assistance with the interferometer components as required (assembly, commissioning, operating)
- Partial initial support for director

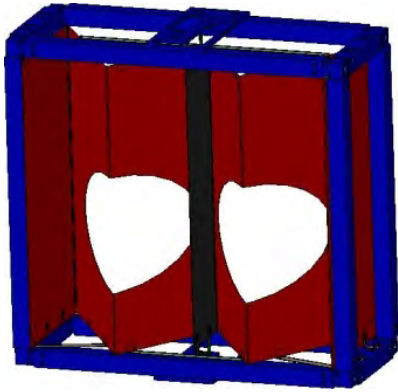
Advanced LIGO Baseline Scope

- Re-use of vacuum system, buildings, technical infrastructure
- Replacement of virtually all initial LIGO detector components
  - Re-use of a small quantity of components where possible

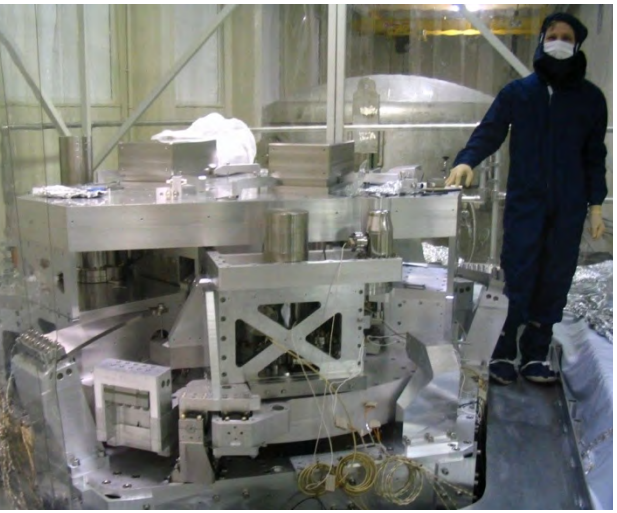


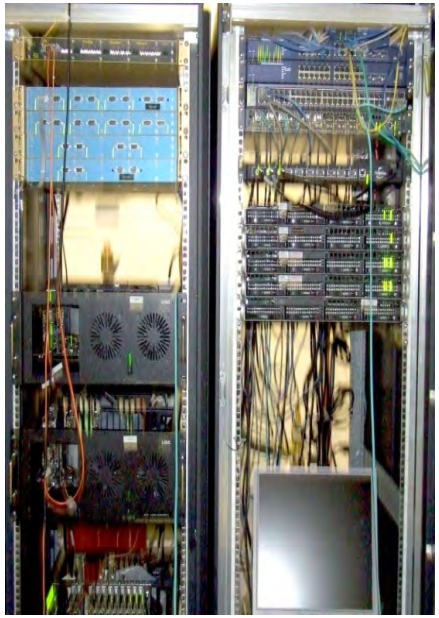
- Three interferometers, as for Initial LIGO
  - --- Can be all identical, or may choose to make one narrow-band at startup – requires exchange of one mirror
- All three interferometers 4km in length
  - --- For initial LIGO, one of the two instruments at Hanford is 2km



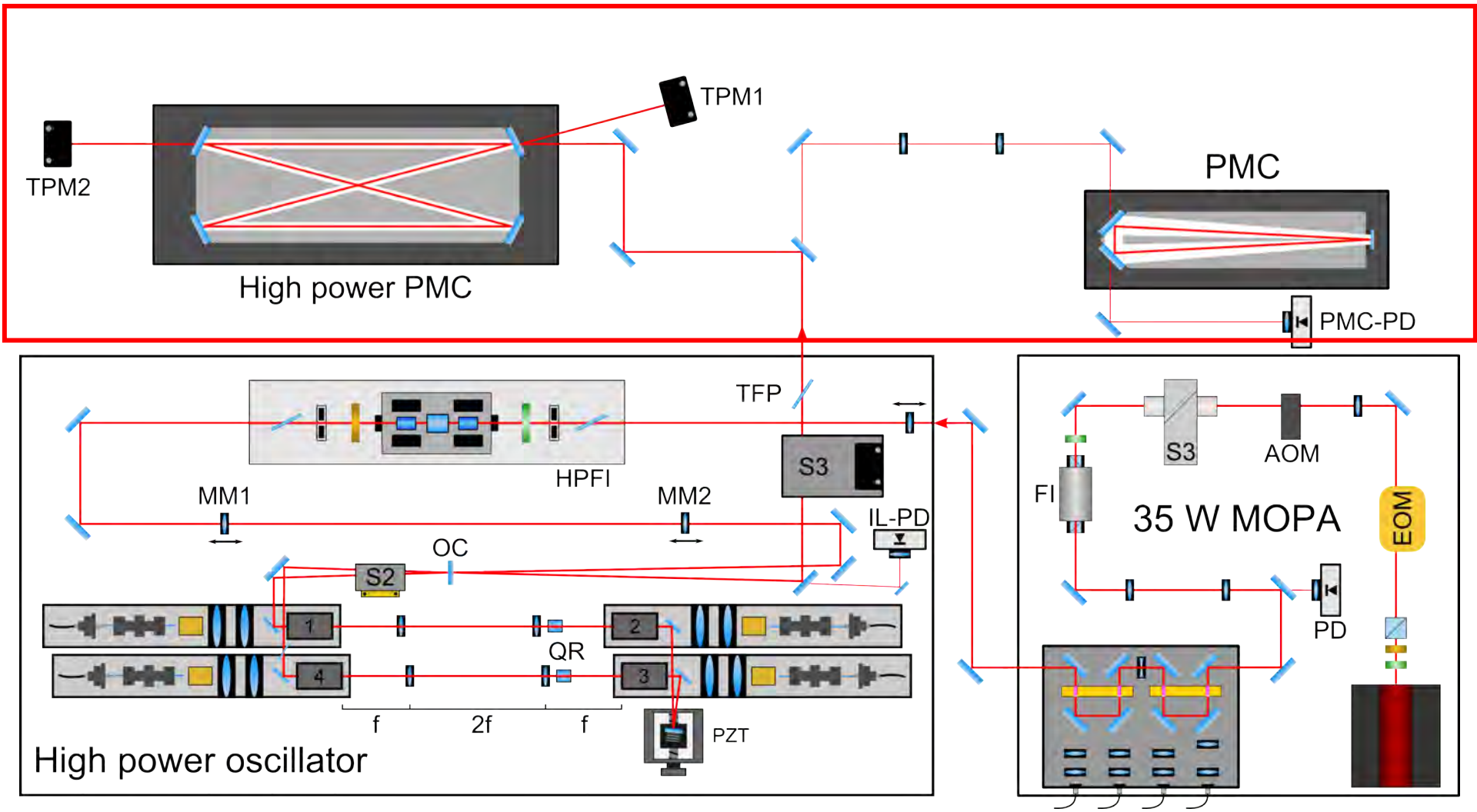


What would LIGO send to Australia?

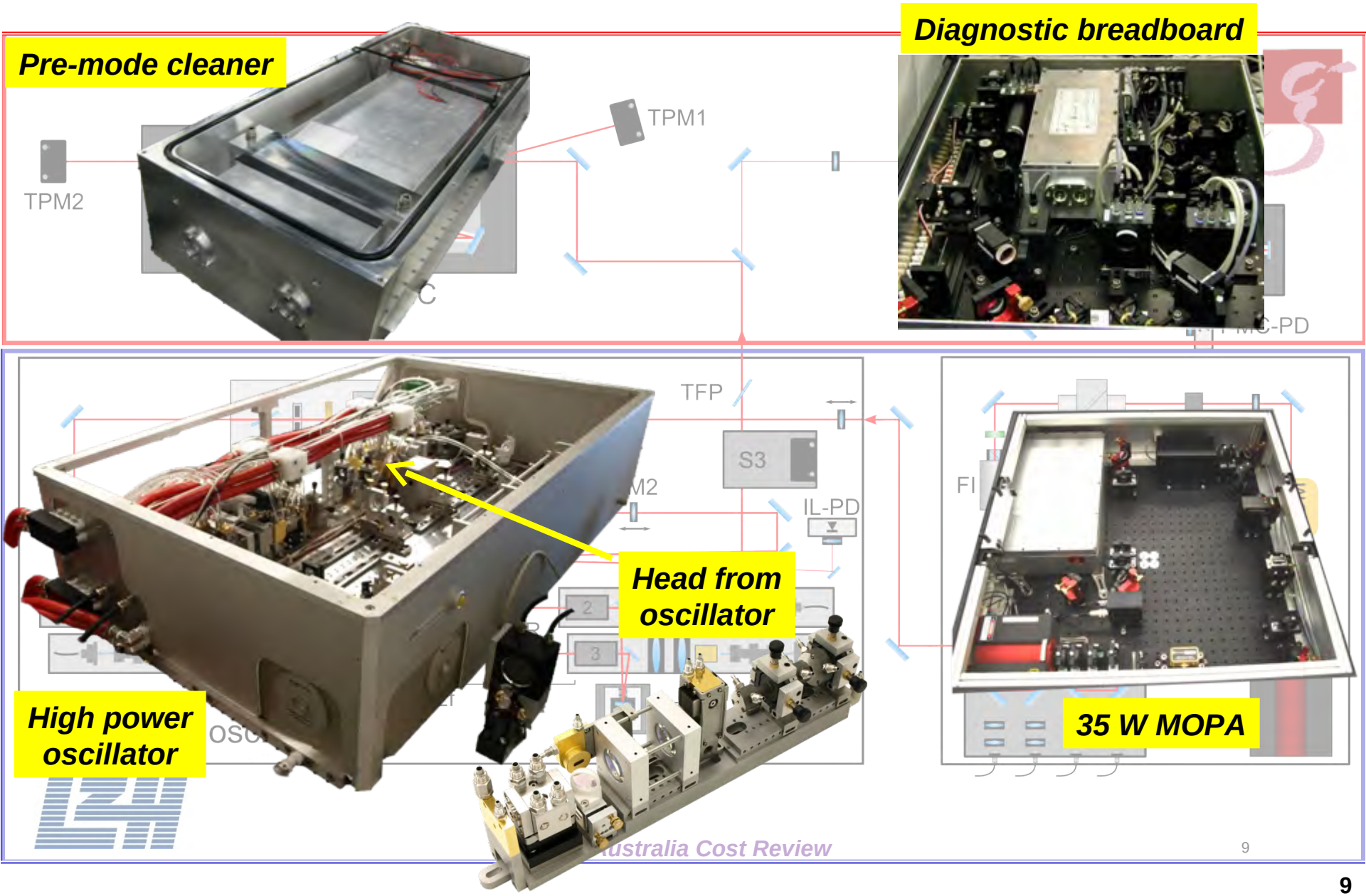




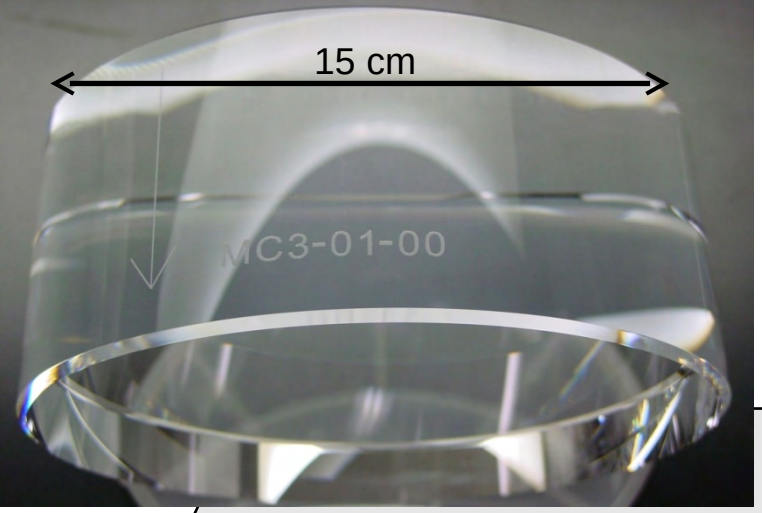
Pre-stabilized Laser
(Max Planck contribution)

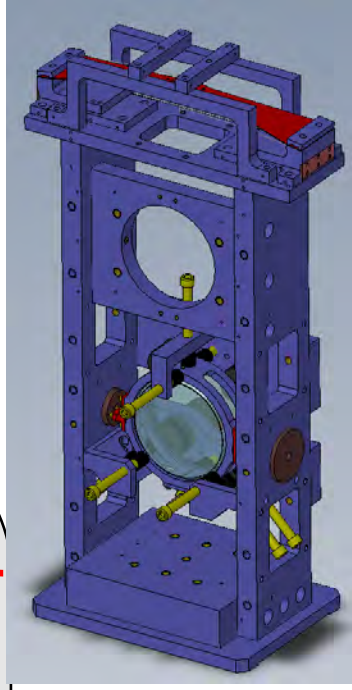


Planck Pre-Stabilized Laser
(Max contribution)



Input Optics





From PSL

RF modulation

Power control

Faraday isolator

MC1

MC3

MC2

Mode matching

PRM

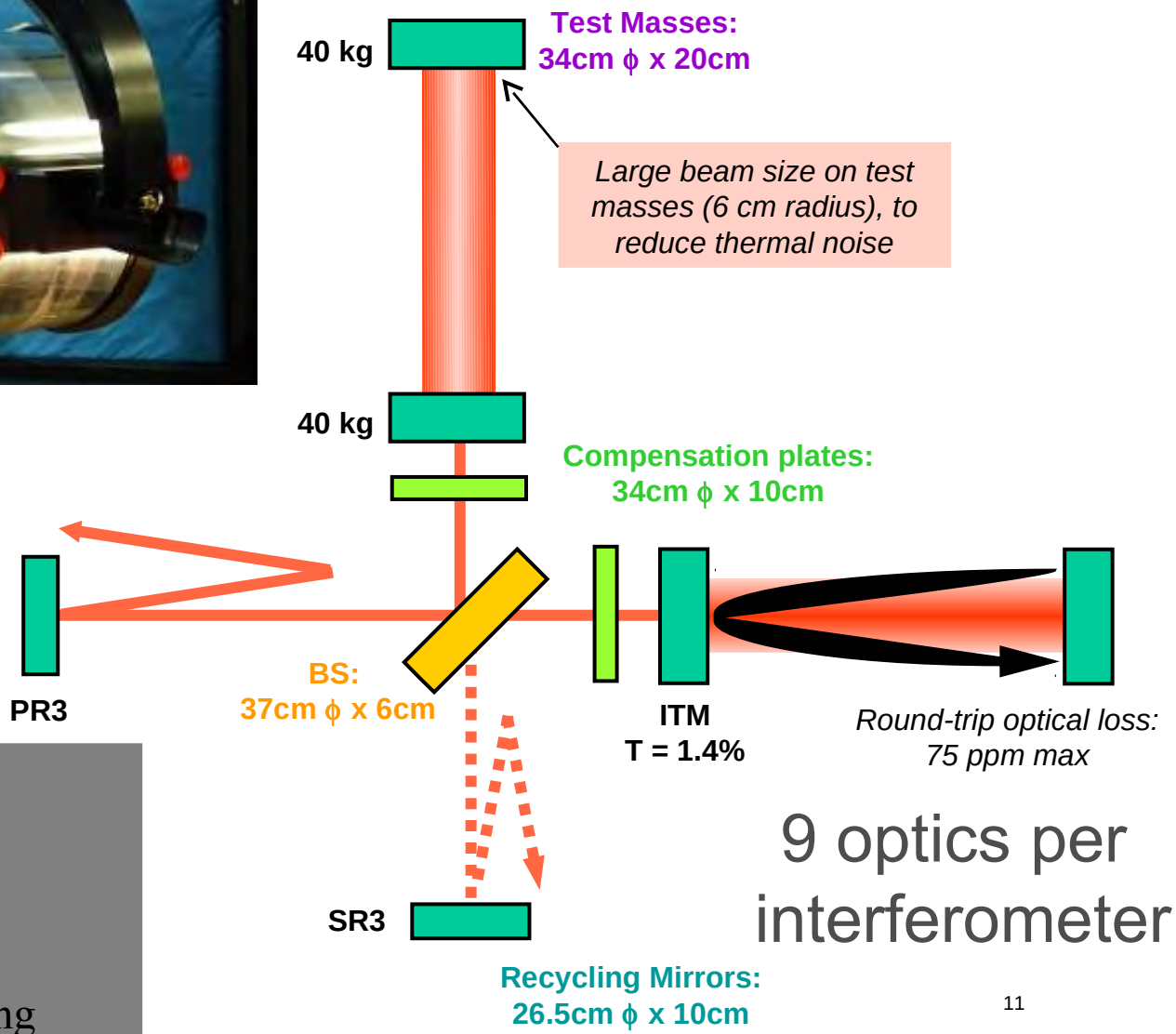
Mode Cleaner

Mode matching to IFO, thermally adjustable

Spatial filtering of light; reference for secondary level of frequency stabilization

Core Optics Components

All COC are fused silica substrates with ion-beam sputtered dielectric coatings



- Substrate procurement
- Substrate polishing
- Dielectric coatings
- Metrology
- Transport, handling, cleaning

9 optics per interferometer

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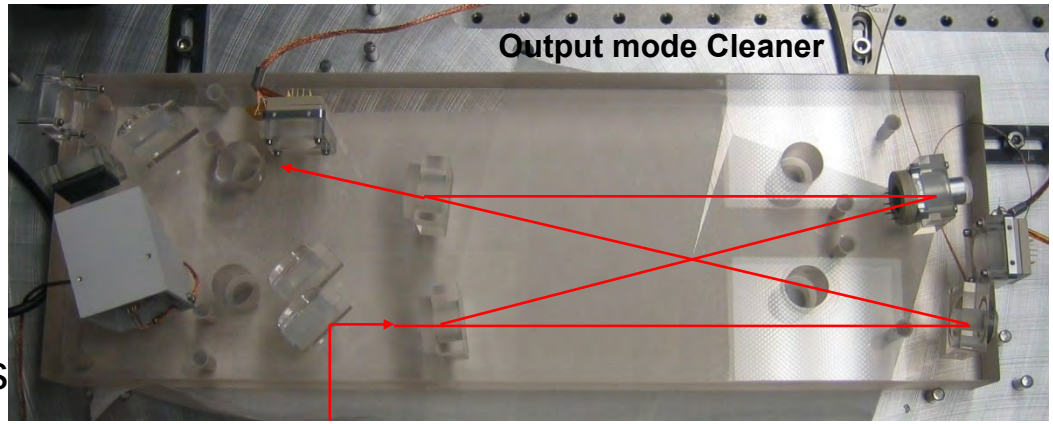
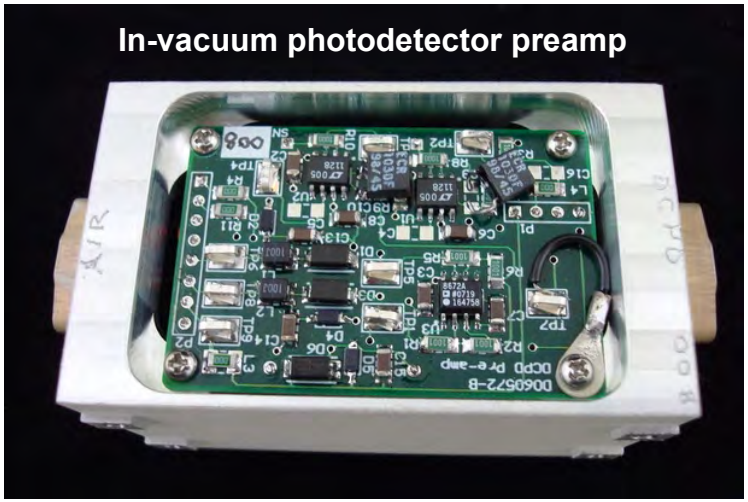
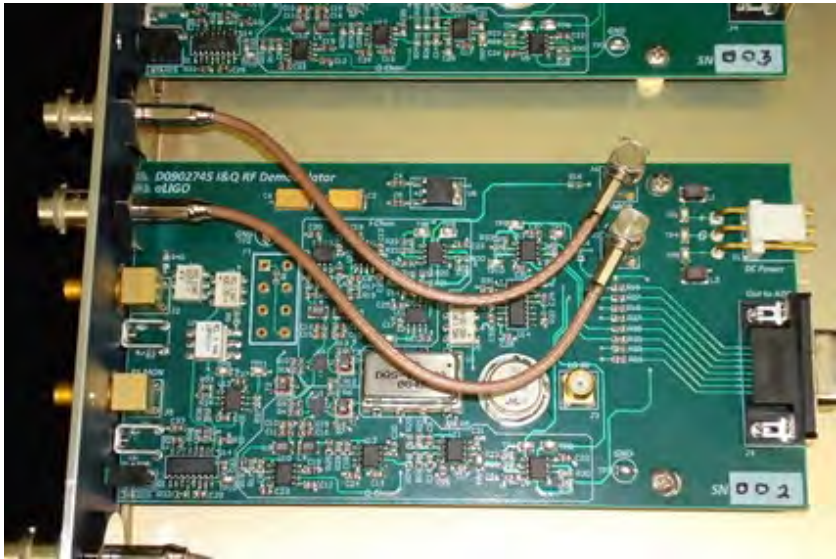
ISC: Gravitational Wave channel readout

- DC (homodyne) detection
- Angular controls
- Software and sensors for locking lengths
- Pre-lock length stabilization
- Provided by Australian partners

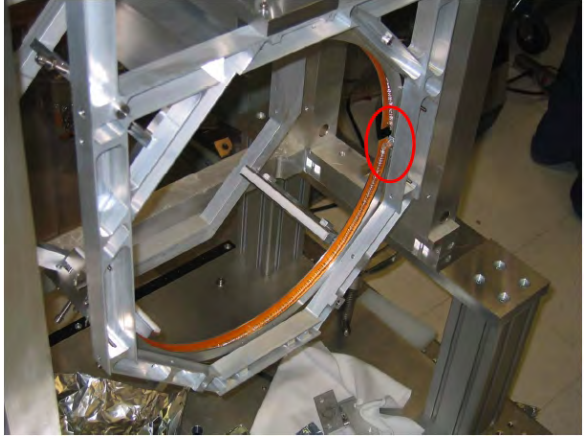




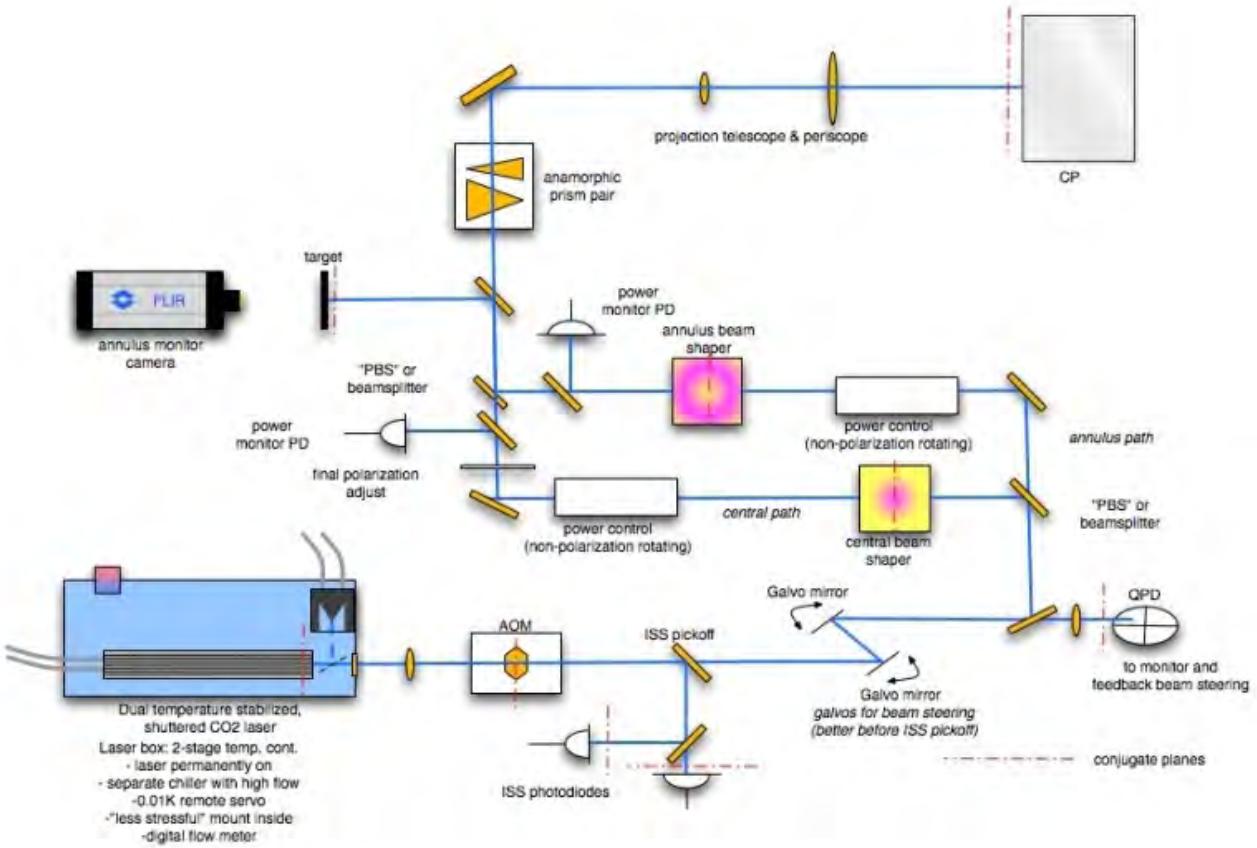


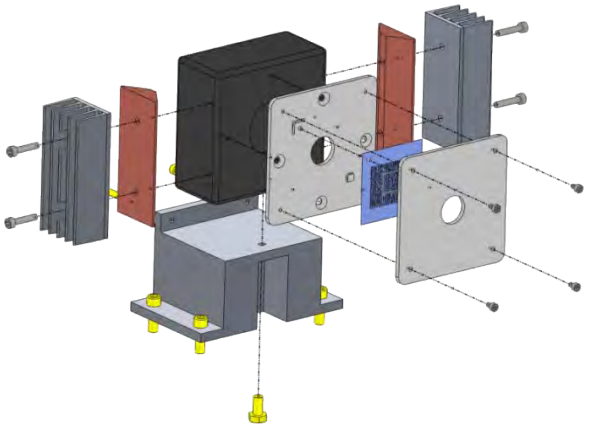
Thermal Compensation System (TCS)

- Ring Heater (4 units)
- CO2 Laser Projector (2 units)
- Hartmann Sensor (2 units)
  - Provided by Australian partners



Prototype of Baseline Ring Heater (nichrome wire would around glass former, within reflective shield)

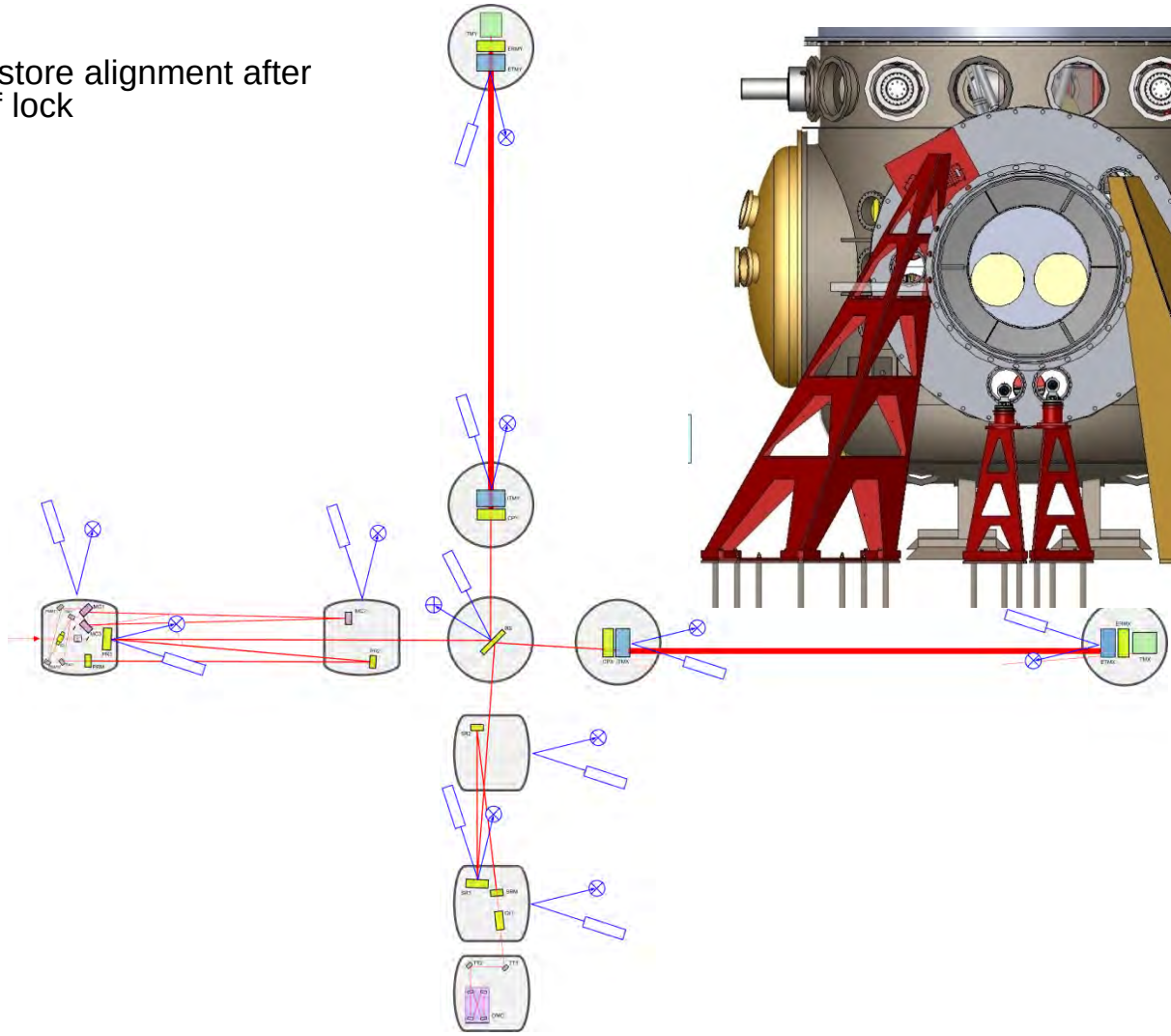




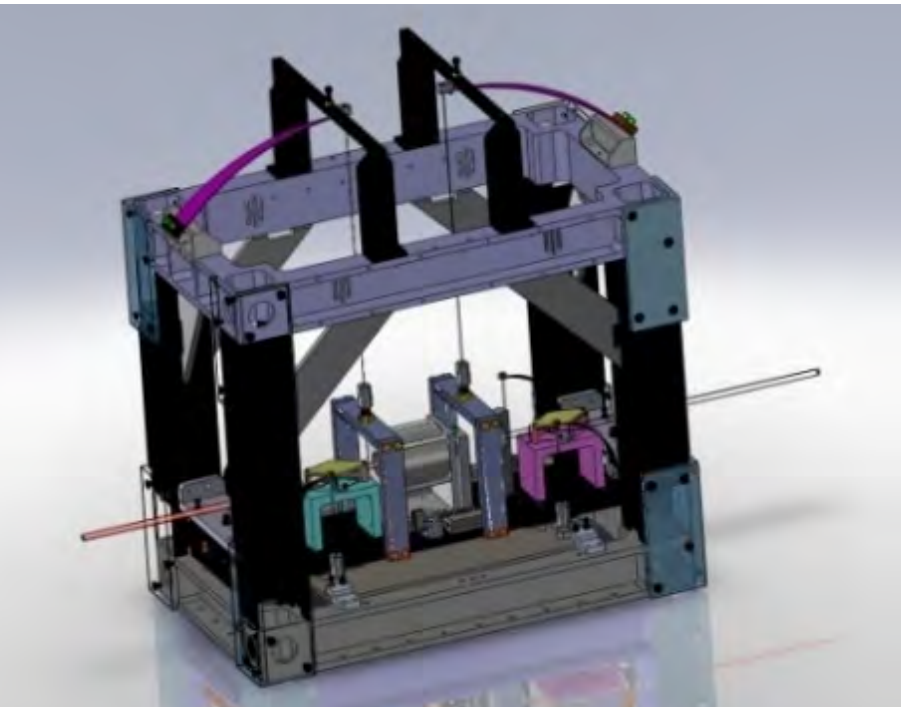
Optical Levers (OptLev)

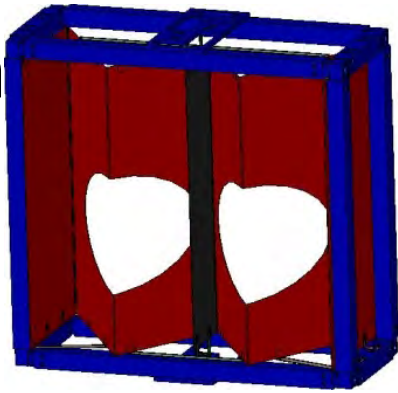
- Maintain alignment, Restore alignment after invasive work or loss of lock
- 8 units

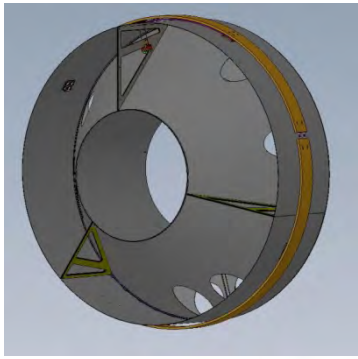
Optical Lever
Transmitter on Pylon

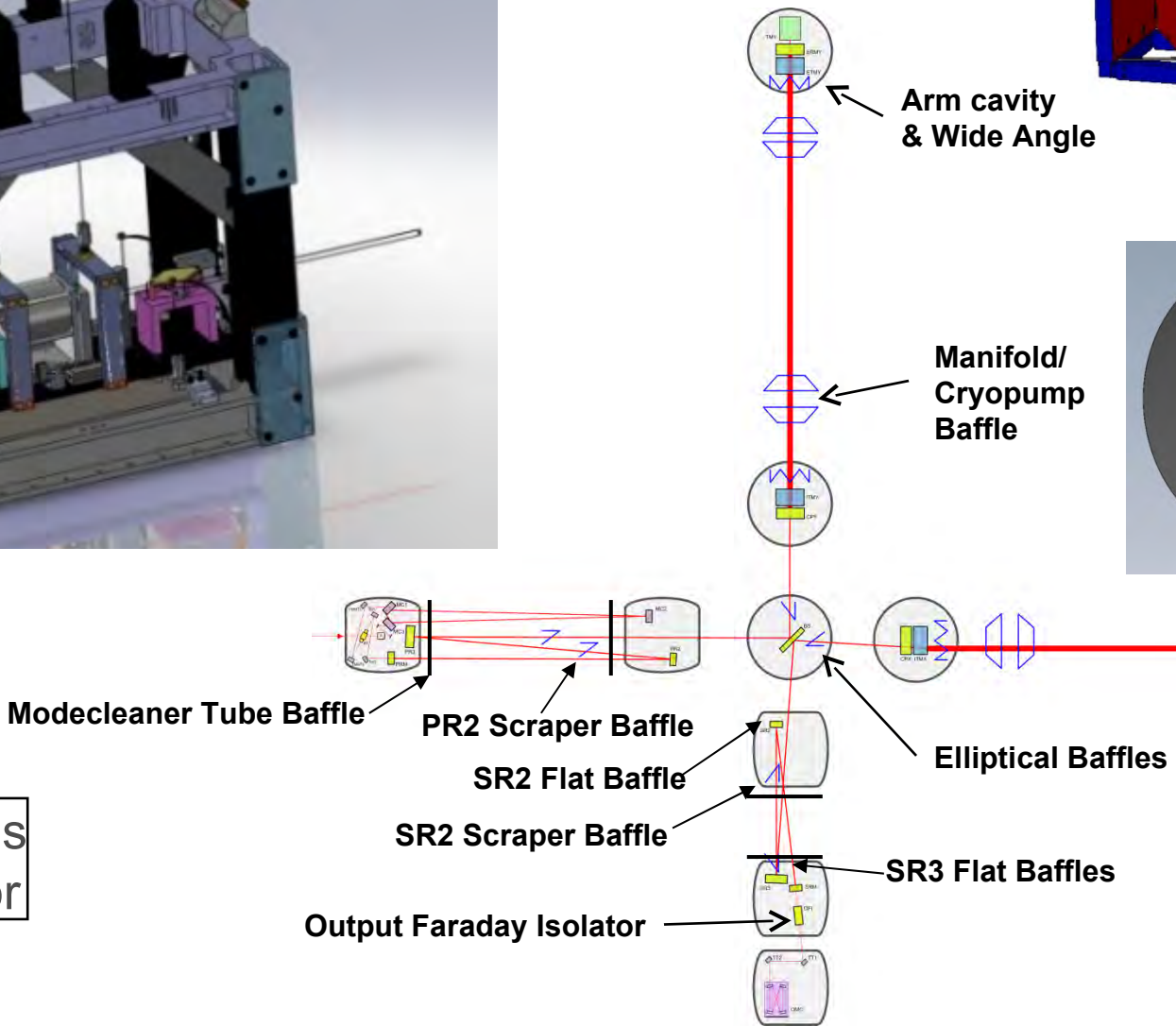


Stray Light Control (SLC), Output Faraday Isolator/suspension





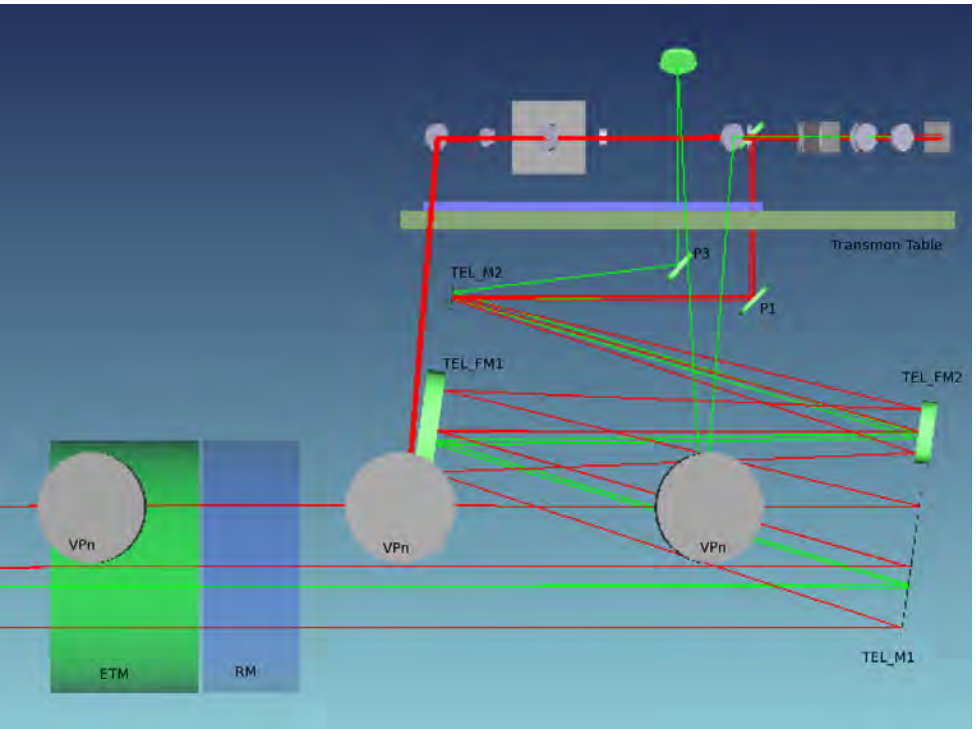


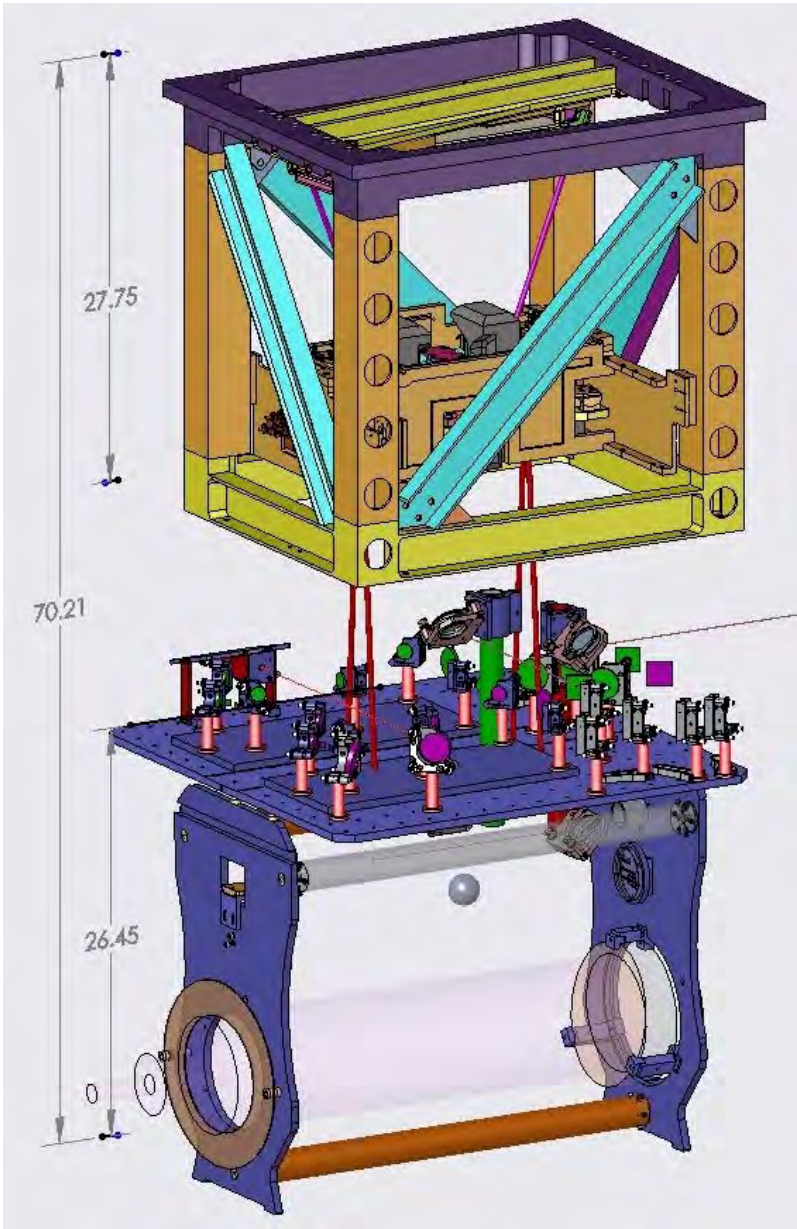


10 baffles
1 isolator

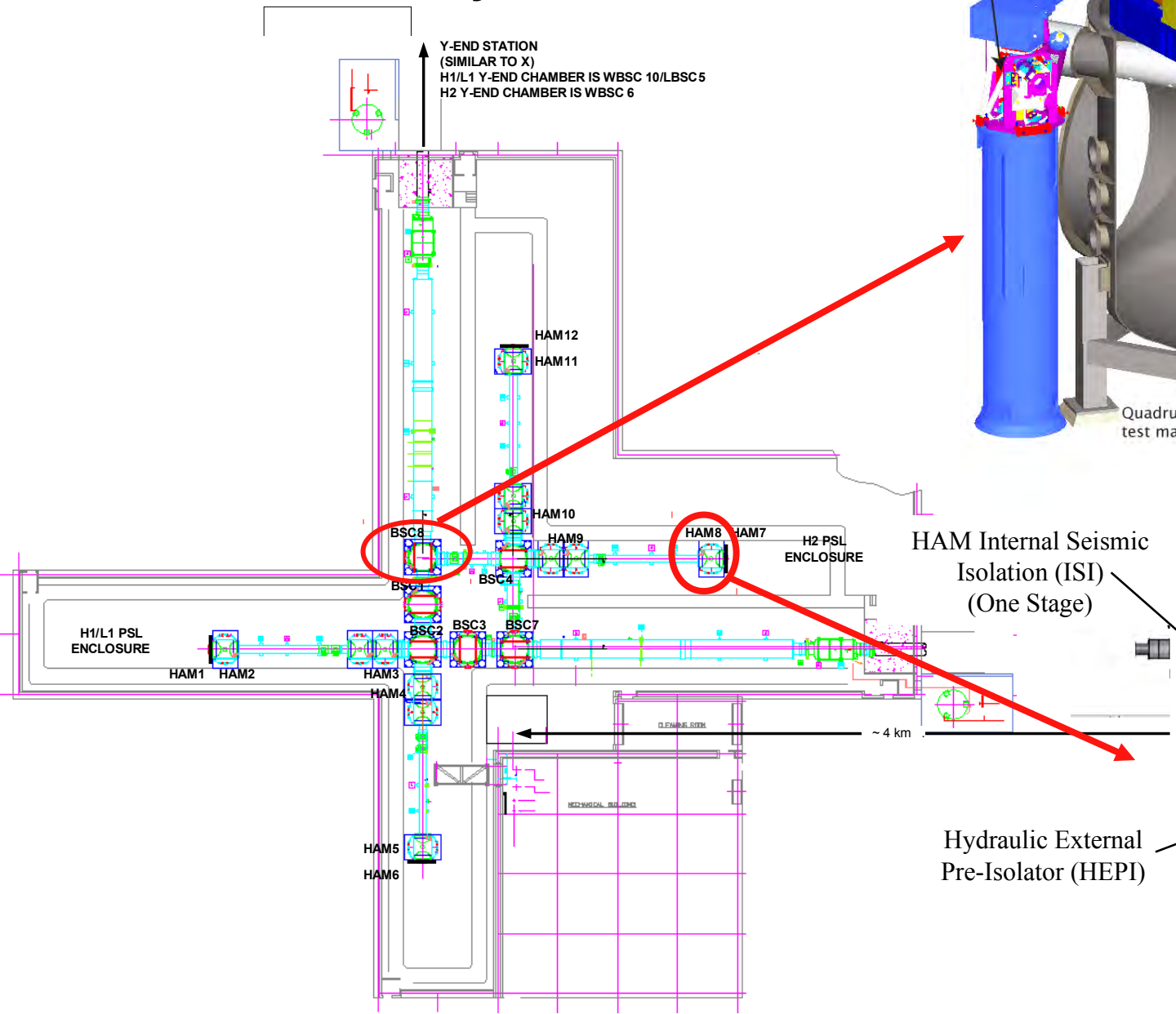
Transmission Monitor Suspension (TMS)

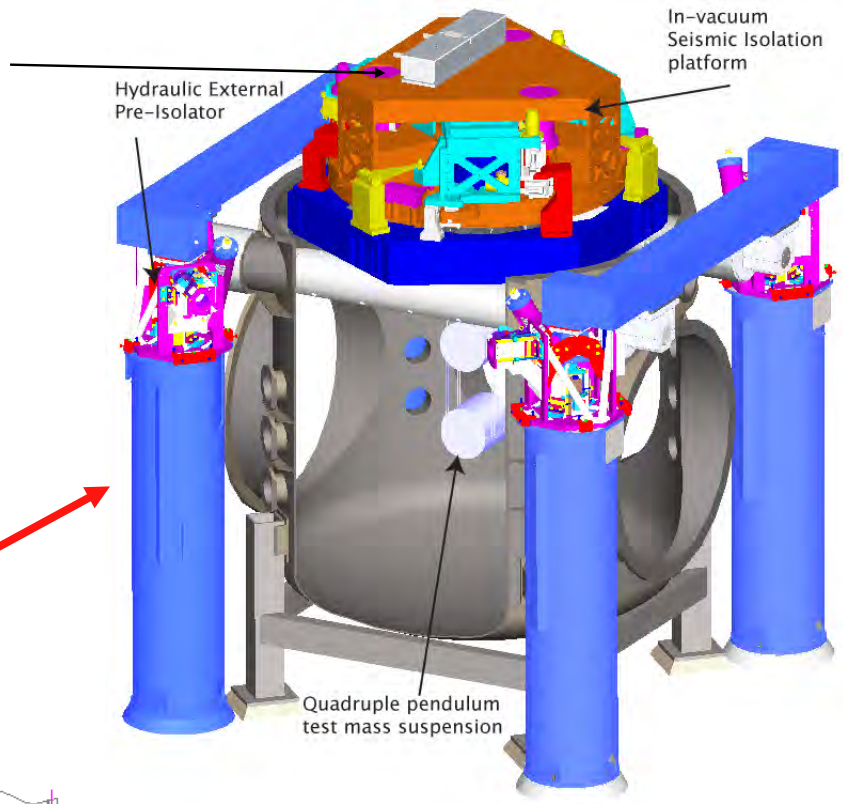
- Couples light into and out of far end of optical cavities
- 2 units per interferometer



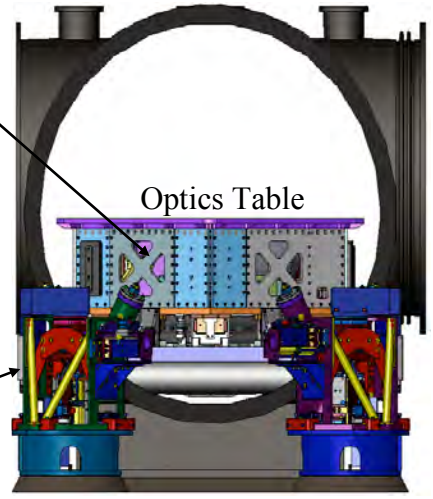


Seismic Isolation Systems



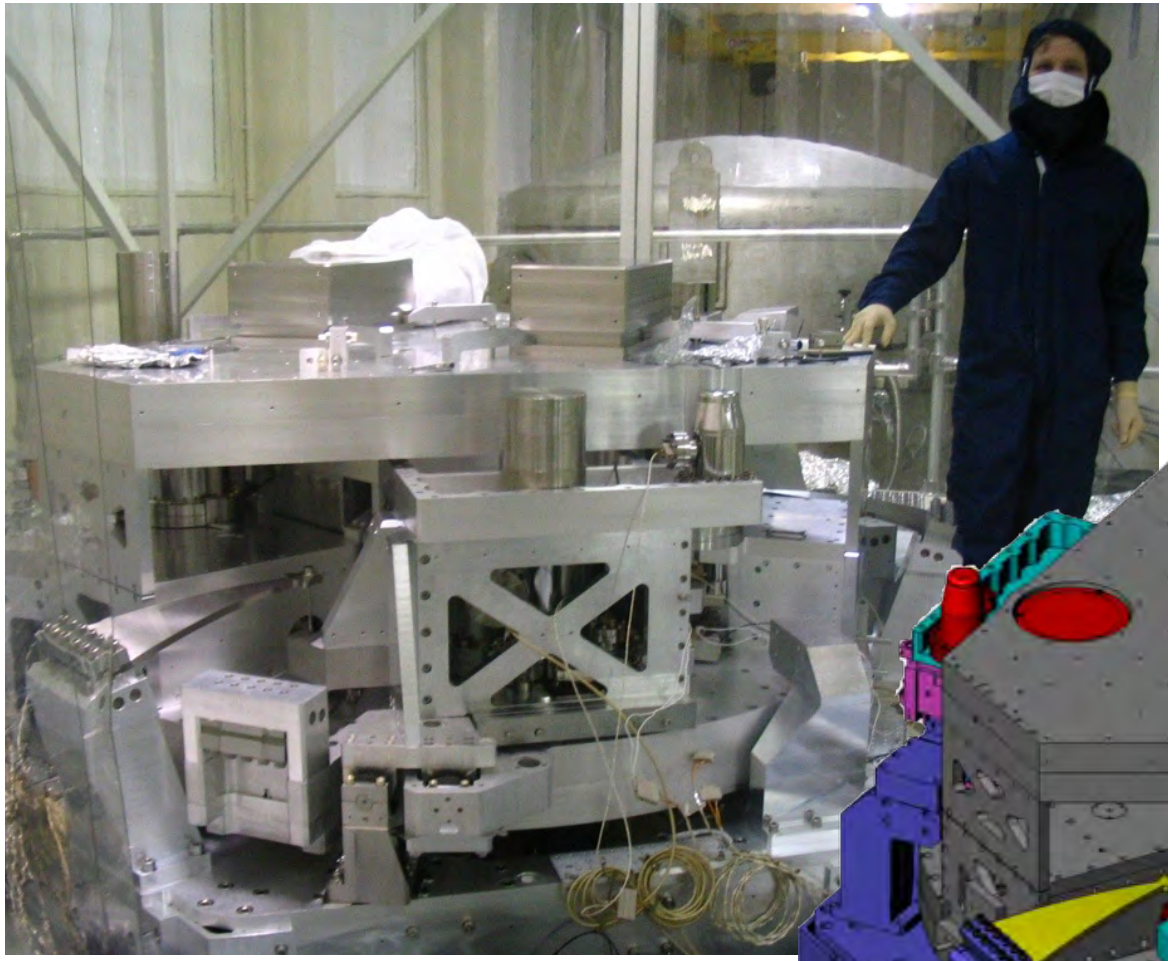


HAM Internal Seismic Isolation (ISI) (One Stage)

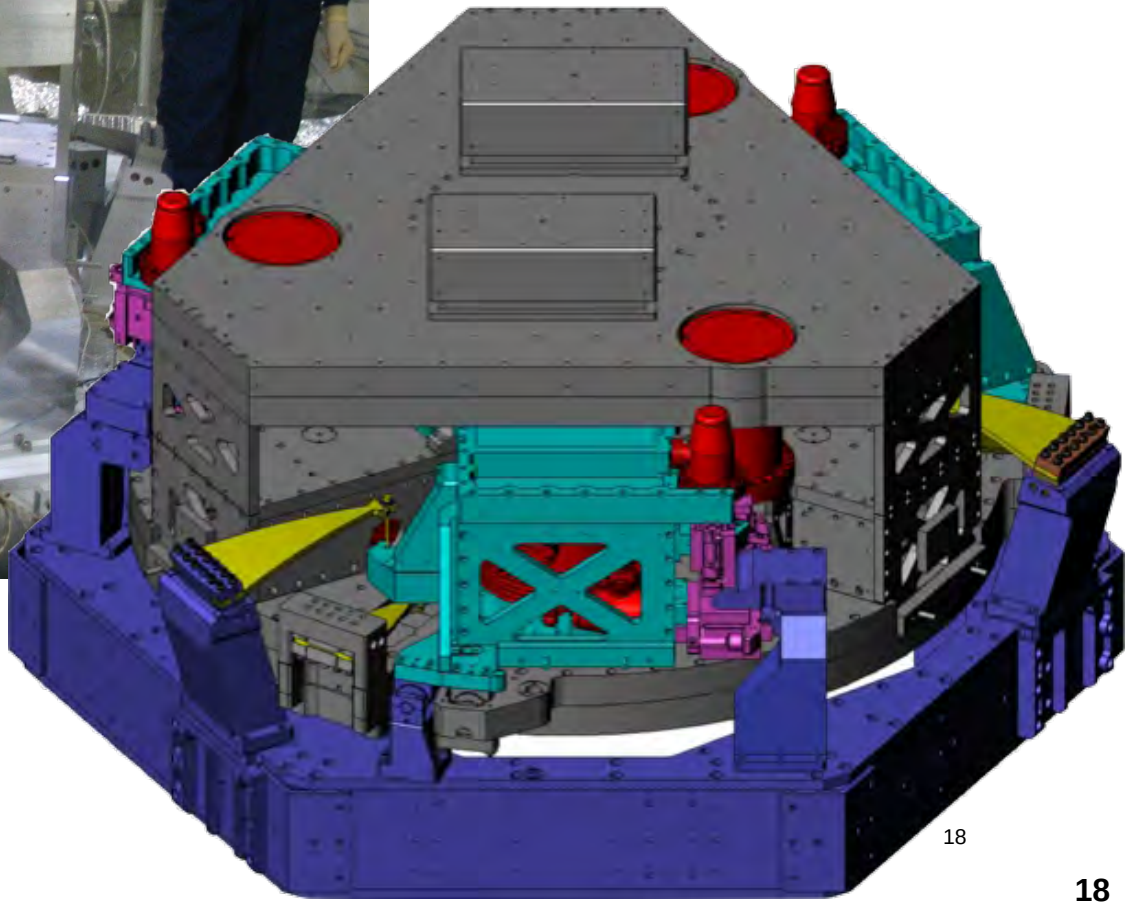


Hydraulic External Pre-Isolator (HEPI)

Test Mass Seismic Isolation



Sensors - red
Actuators - pink
Compliant elements
(passive isolation) yellow

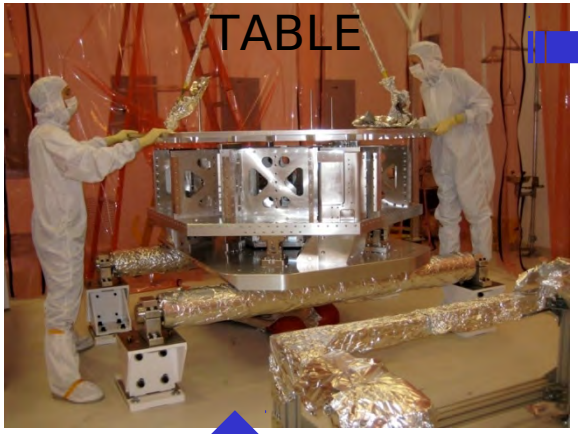


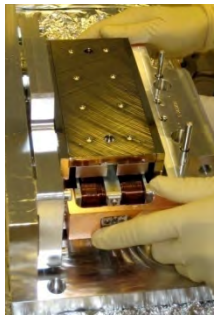
5 units per interferometer

Auxiliary optics (HAM) chamber Seismic Isolation

ASSEMBLE STAGE 0 ON TEST STAND

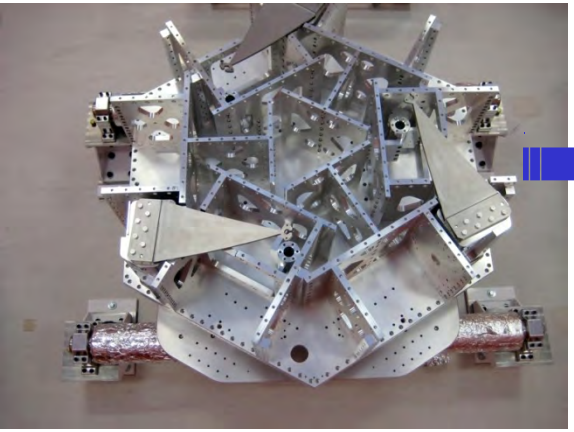
INSTALL OPTICS TABLE





ADD SENSORS, ACTUATORS, ELECTRONICS & TEST THE SYSTEM

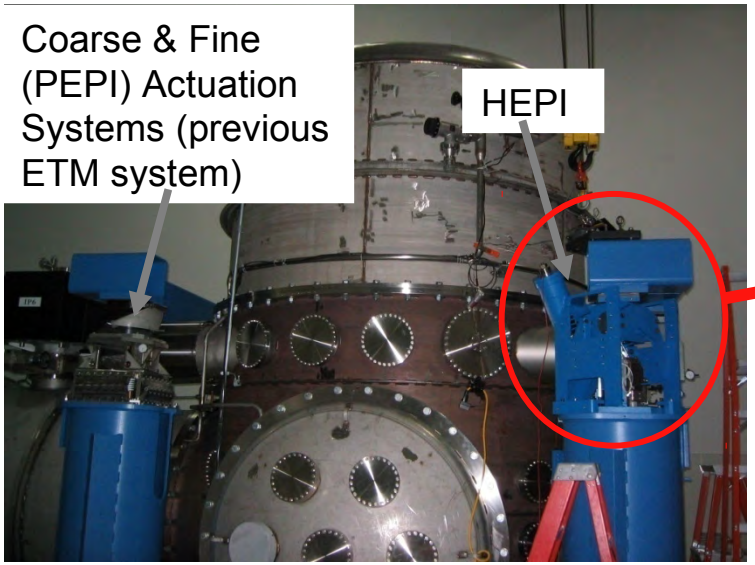
ASSEMBLE STAGE 1

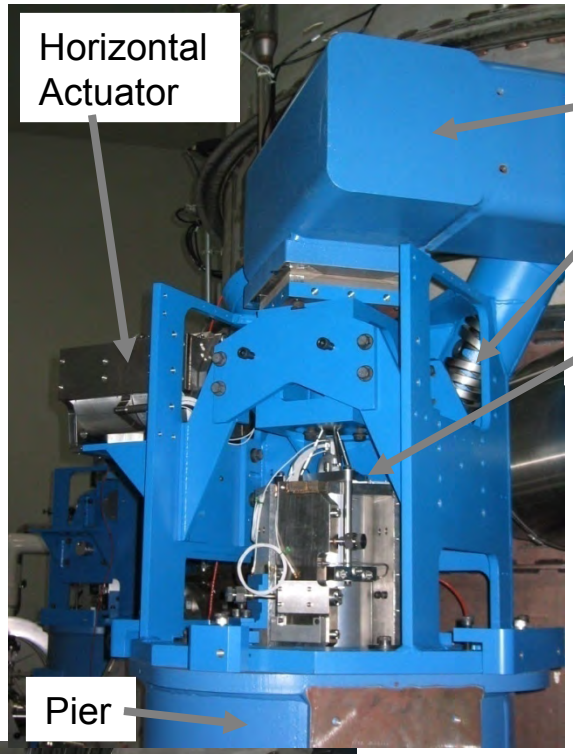


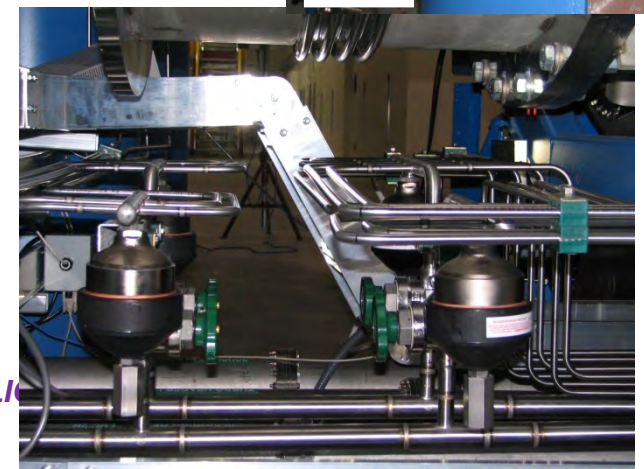
PRELOAD SPRINGS

5 units per interferometer

Seismic Isolation, Hydraulic External Pre-Isolator (HEPI)



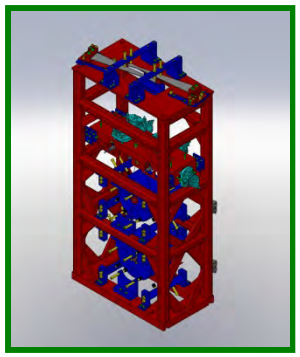


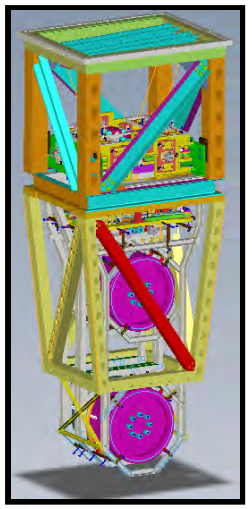


10 chambers, 4 units per chamber

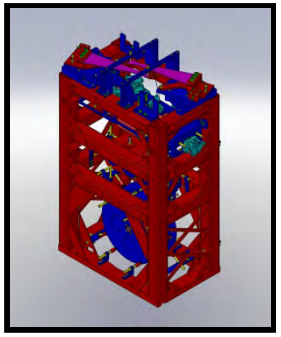
Suspensions
Test mass suspension is a UK Contribution

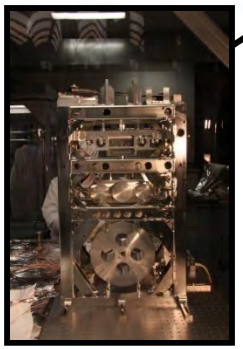
5 units per interferometer



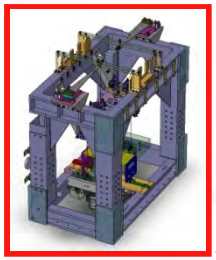


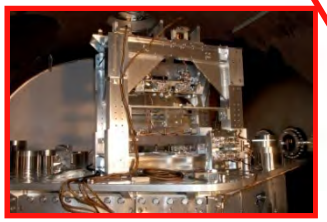
4 ½ units





2 units



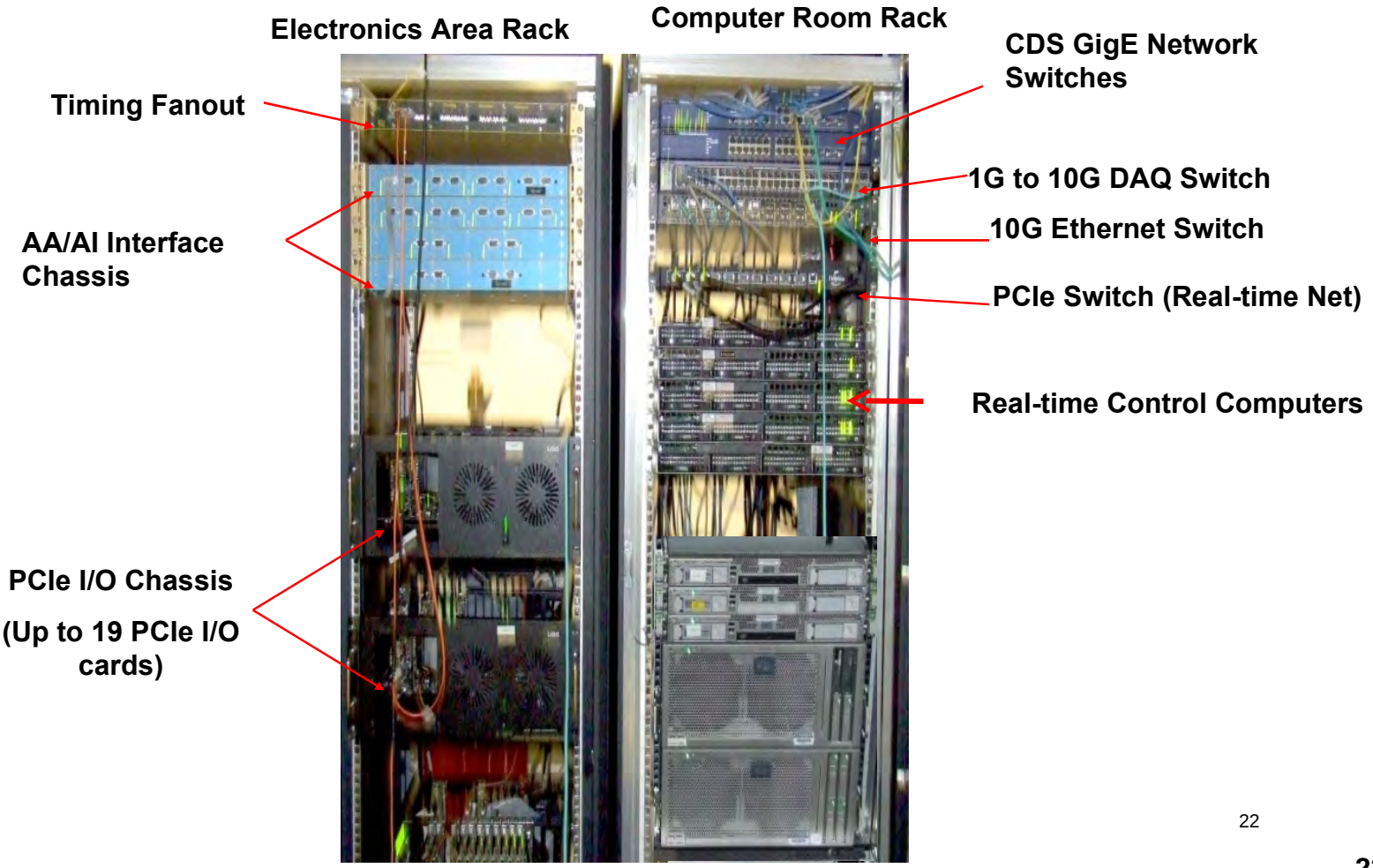


1 unit

1 unit

Data Acquisition (DAQ)

- Analog signal conditioning
- A-D, D-A, Front end computers and interfaces
- 15-20 Racks per interferometer



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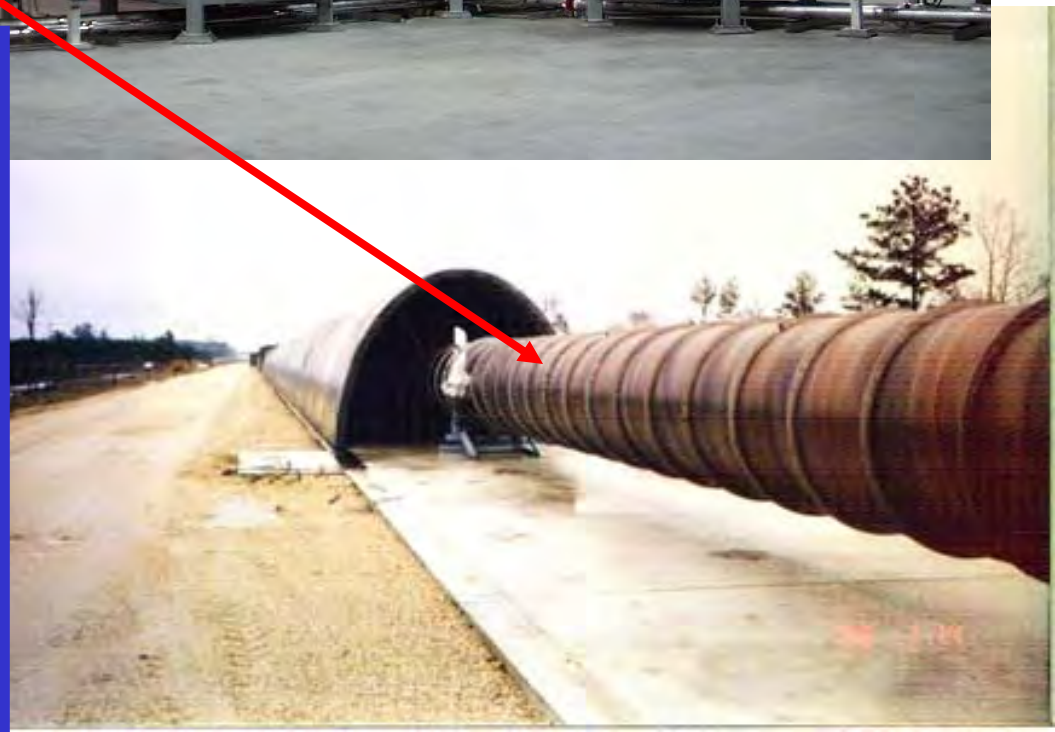
LIGO Australia

What will Australia contribute?

- All infrastructure to house and operate the detector
- Staff and contractors to build, assemble, commission detector
- Staff and maintenance to operate the detector

Australia provides a facility with-

- Vacuum system
- Site, buildings, roads

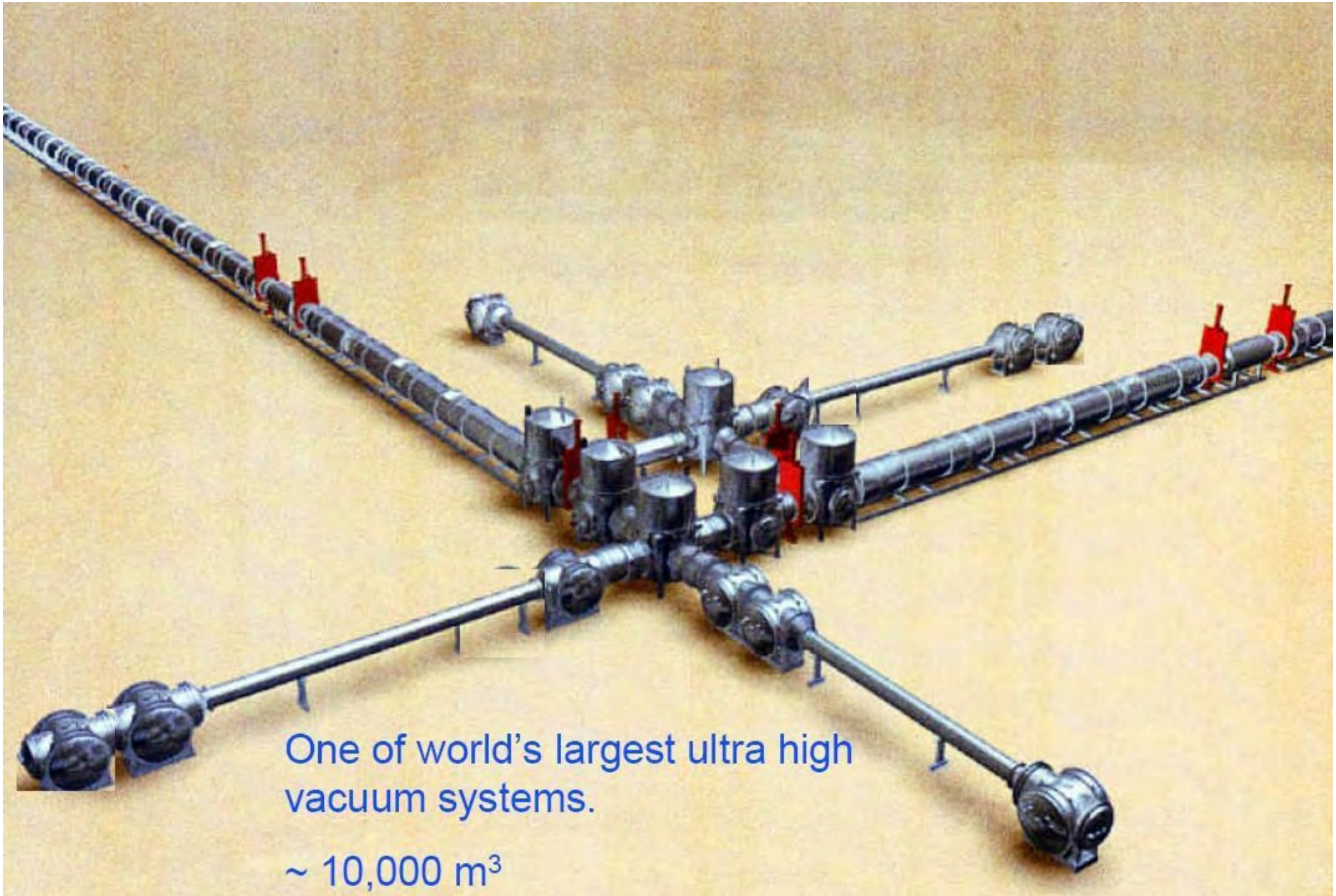


LIGO Australia

What will Australia contribute?

Vacuum System

- Upgraded copy of LIGO vacuum system
- 4km long arms, folded configuration, mid-stations
- Manufacture beam tubes on site
- Manufacture of tanks, cryo-pumps, gate valves
- Special heat treated stainless steel, per LIGO specs
- Leak detection system
- Bake-out system
- All ion pumps, valves, residual gas analyzers
- Portable clean rooms for field welding, installation



One of world's largest ultra high vacuum systems.

~ 10,000 m^3

10^{-9} torr

Dirt Moving to Mechanical

arches and beam tubes

Concrete Arches

beamtube transport

beamtube install

girth welding

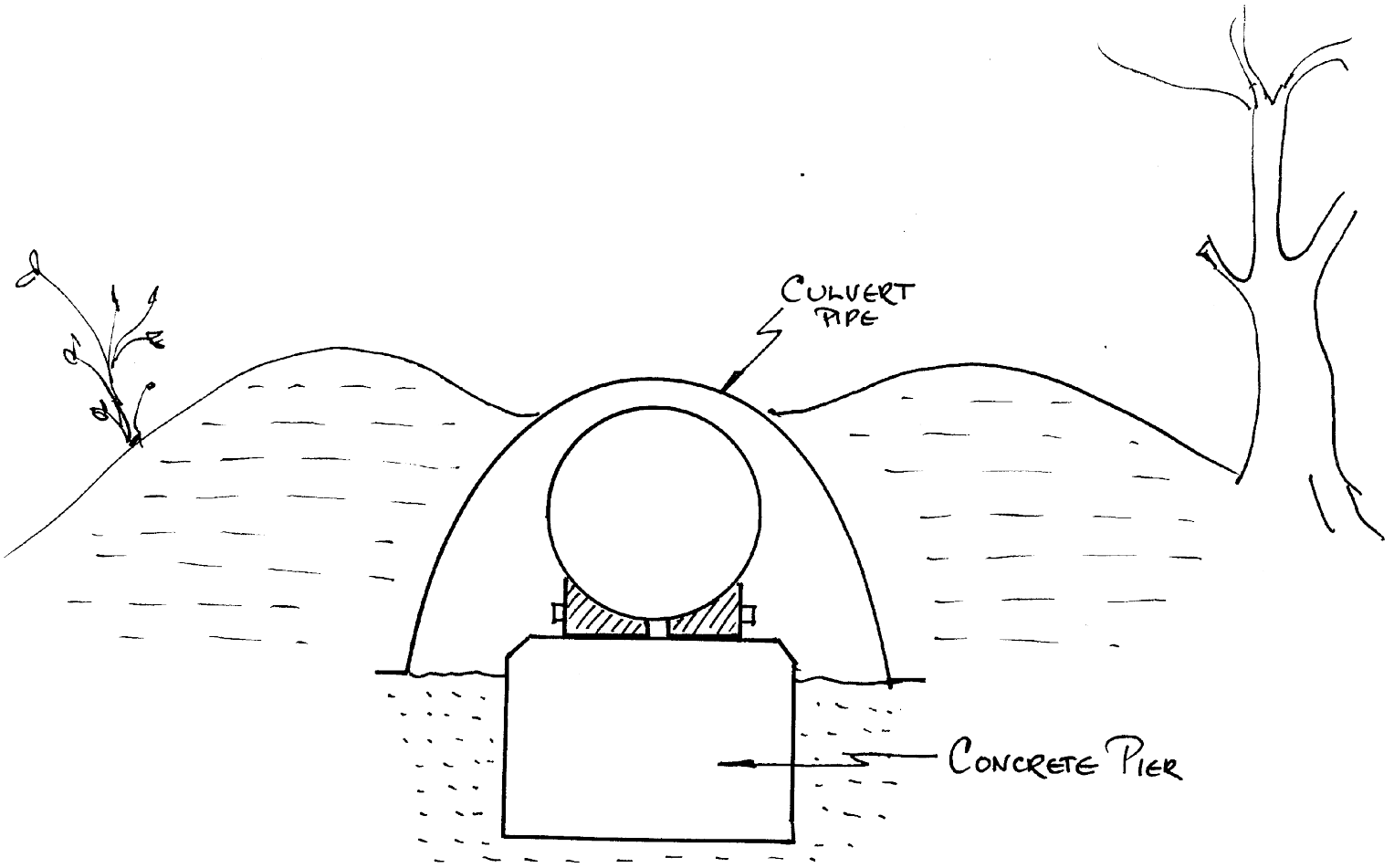
Construction in Washington

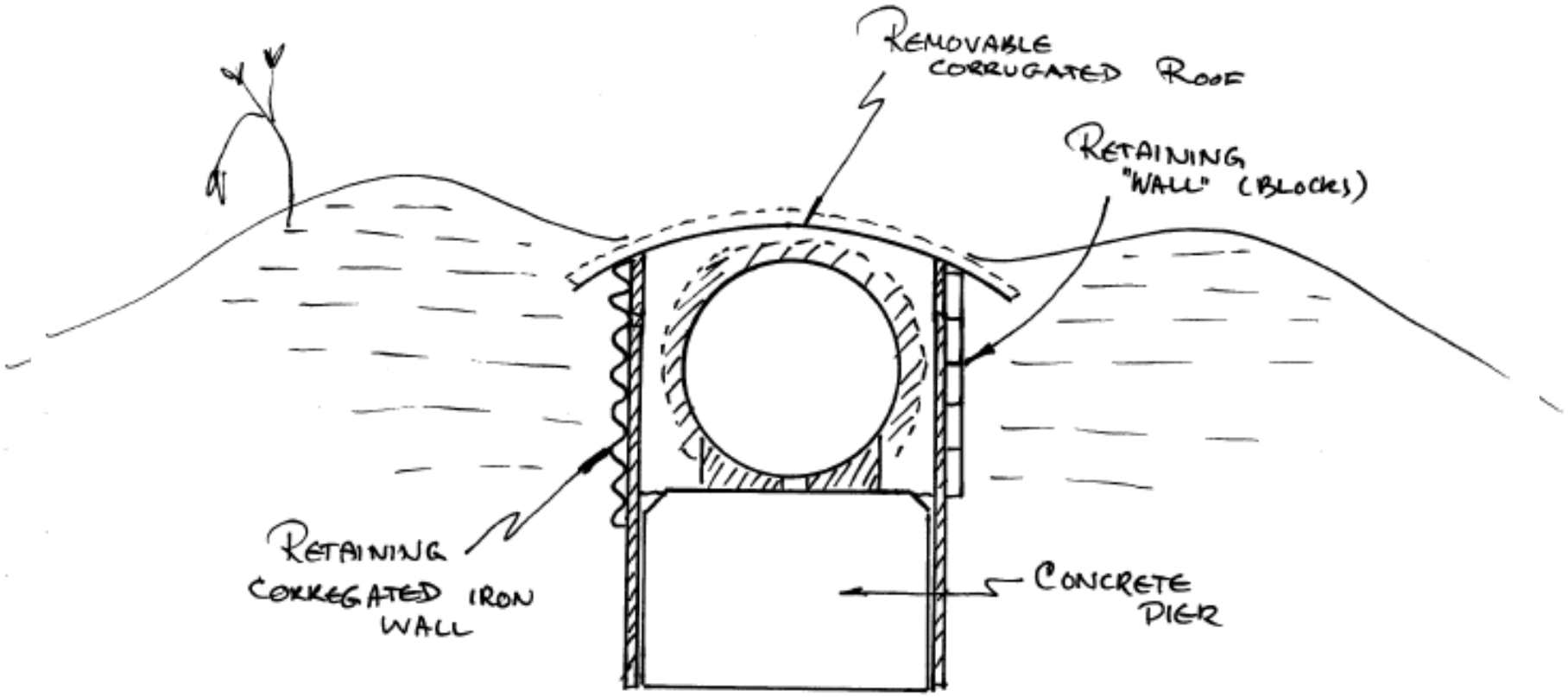
LIGO
beam tube

1.2 m diameter - 3mm stainless
50 km of weld

NO LEAKS !!

- LIGO beam tube under construction in January 1998
- 65 ft spiral welded sections
- girth welded in portable clean room in the field


CULVERT PIPE
CONCRETE PIER

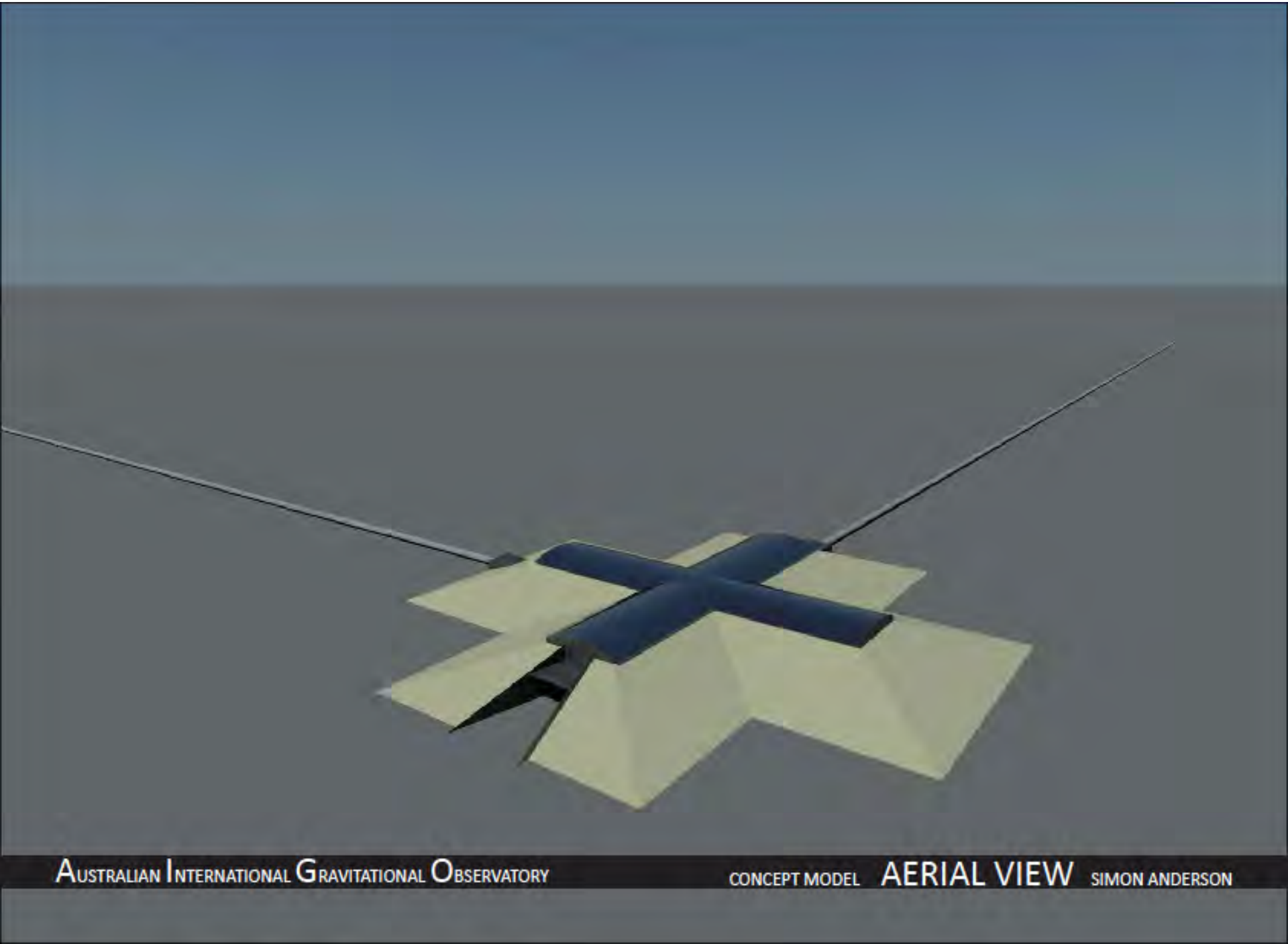

REMOVABLE
CORRUGATED ROOF
RETAINING
"WALL" (BLOCKS)
RETAINING
CORREGATED IRON
WALL
CONCRETE
PIER

LIGO Australia

What will Australia contribute?

Buildings

- 1800m^2 central buildings and end buildings:
  - Large buildings partly shielded by earth berms
  - Clean buildings, low noise, laminar flow
  - Cranes, 8m hook height
  - Air conditioning (using environmentally sustainable aquifer heat dump etc)
  - Solar power
- Mid- station buildings
- Beam tube covers
- Support buildings, maintenance, storage, offices, control room, computer rooms

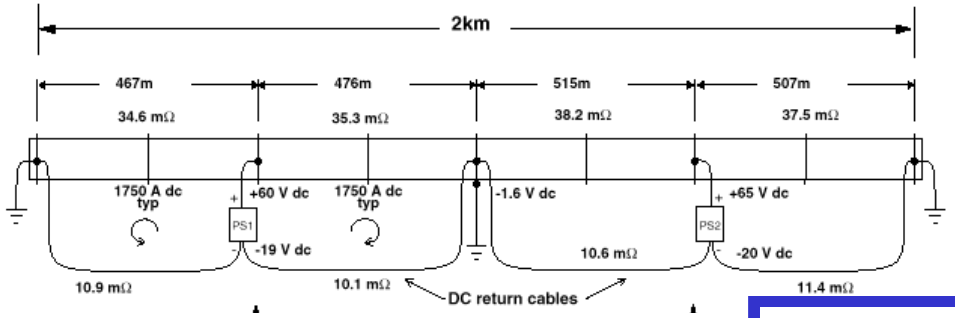

AUSTRALIAN INTERNATIONAL GRAVITATIONAL OBSERVATORY
CONCEPT MODEL
AERIAL VIEW
SIMON ANDERSON

AUSTRALIAN INTERNATIONAL GRAVITATIONAL OBSERVATORY

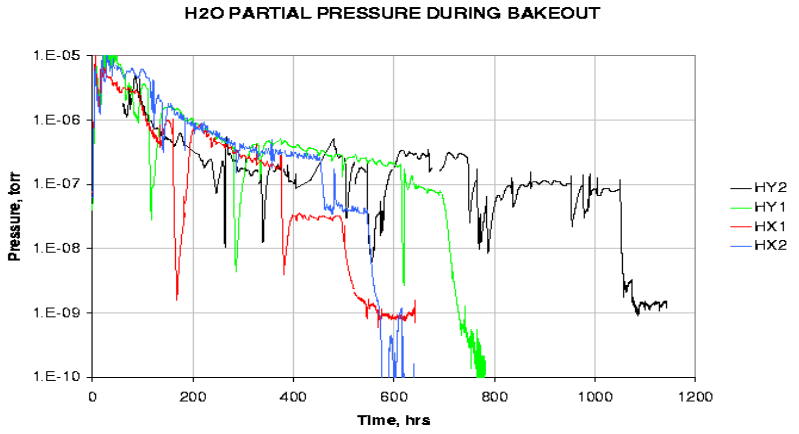
CONCEPT MODEL **ENTRY VIEW** SIMON ANDERSON

HAM Chamber Installation

Beam Tube *bakeout*

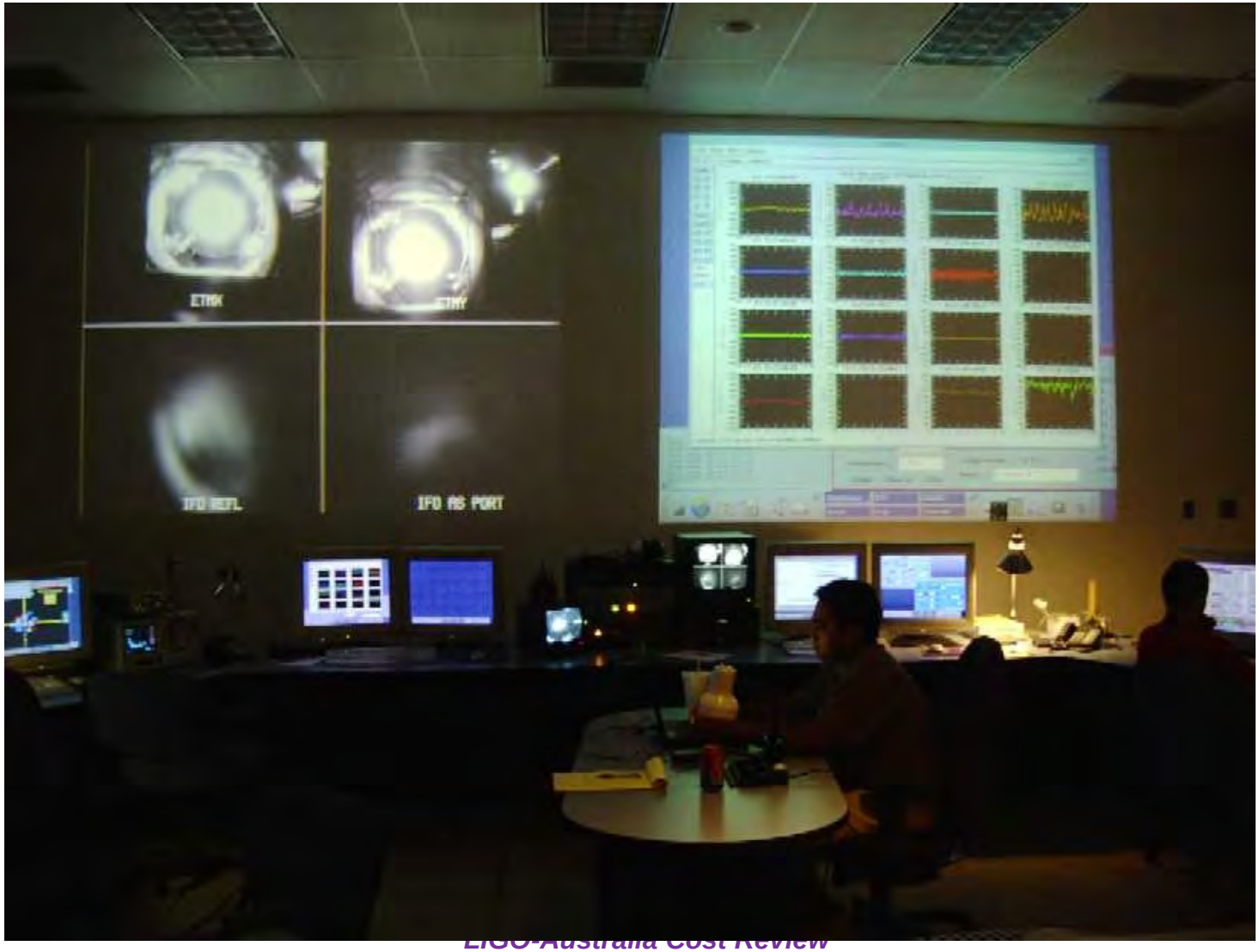


- I = 2000 amps for ~ 1 week
- no leaks !!
- final vacuum at level where not limiting noise, even for future detectors



Install and Align Under Cleanroom Conditions

LIGO Control Room



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What will Australia contribute?

Site

- 50km^2 remote site
- Conveniently located 80km N of Perth
- Bush vegetation, some trees, 15km from coast
- Sand base, seismically similar to LIGO-sites
- Existing facilities, some roads, power

LIGO Australia

What will Australia contribute?

Site

- 50km^2 remote site
- Conveniently located 80km N of Perth
- Bush vegetation, some trees, 15km from coast
- Sand base, seismically similar to LIGO-sites
- Existing facilities, some roads, power

ACIGA Universities and Facilities

Gingin High Power Test Facility

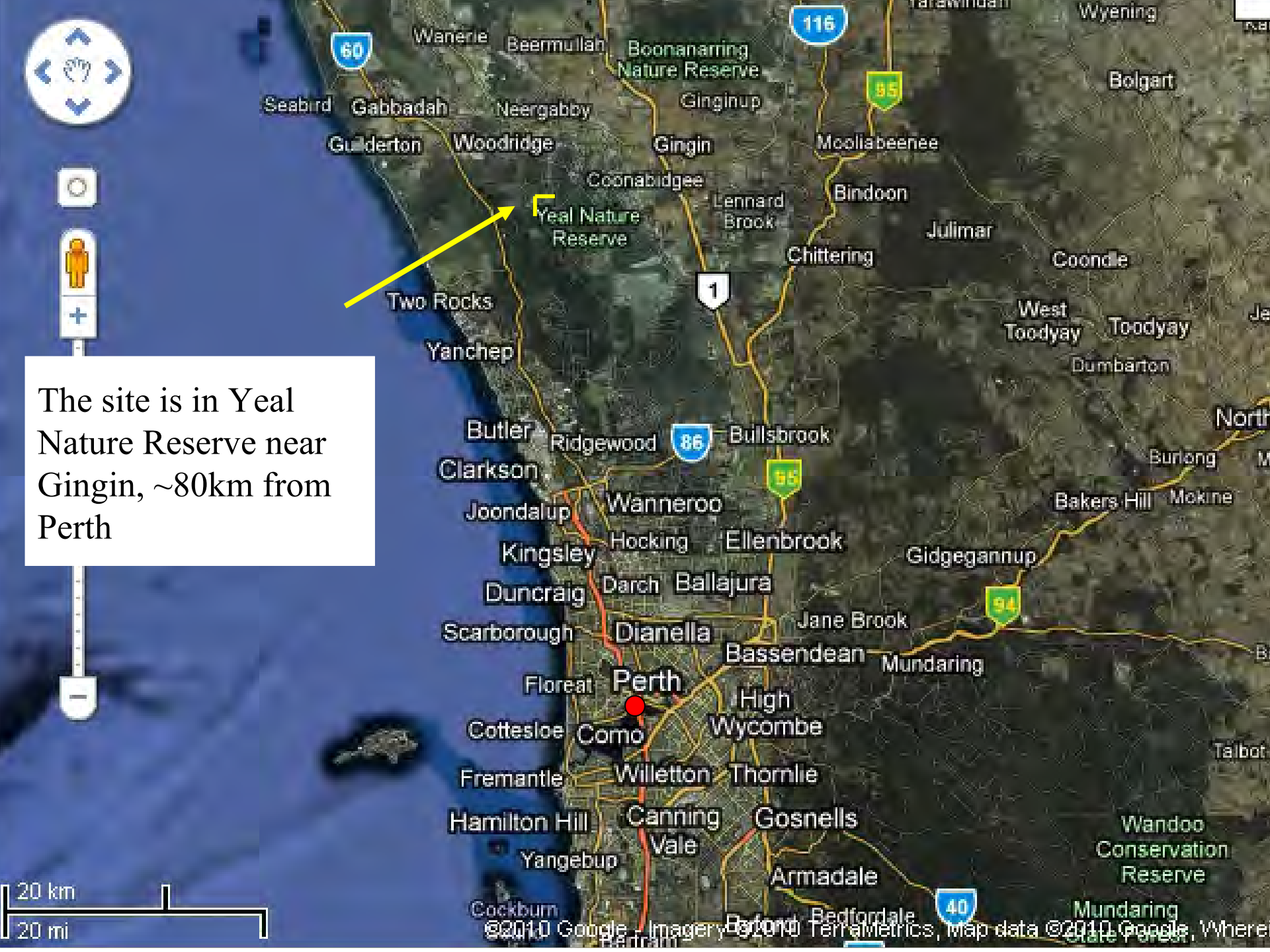
THE UNIVERSITY OF WESTERN AUSTRALIA

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Australian National University

THE UNIVERSITY OF MELBOURNE

Monash University


The site is in Yeal Nature Reserve near Gingin, ~80km from Perth
Yeal Nature Reserve
Wanerie
Beermullah
Boonanarring Nature Reserve
Seabird
Gabbadah
Neergabby
Ginginup
Bolgart
Gulderton
Woodridge
Gingin
Mooliabeenee
Coonabidgee
Lennard Brook
Bindoon
Julimar
Chittering
Coondle
Two Rocks
West Toodyay
Toodyay
Dumbarton
Yanchep
Butler
Ridgewood
Bullsbrook
Clarkson
Burlong
Joondalup
Wanneroo
Bakers Hill
Mokine
Kingsley
Hocking
Ellenbrook
Gidgegannup
Duncraig
Darch
Ballajura
Scarborough
Dianella
Jane Brook
Bassendean
Mundaring
Floreat
Perth
High Wycombe
Cottesloe
Como
Fremantle
Willetton
Thornlie
Hamilton Hill
Canning Vale
Gosnells
Wandoo Conservation Reserve
Yangebup
Armadale
Cockburn
Bedfordale
Mundaring
20 km
20 mi
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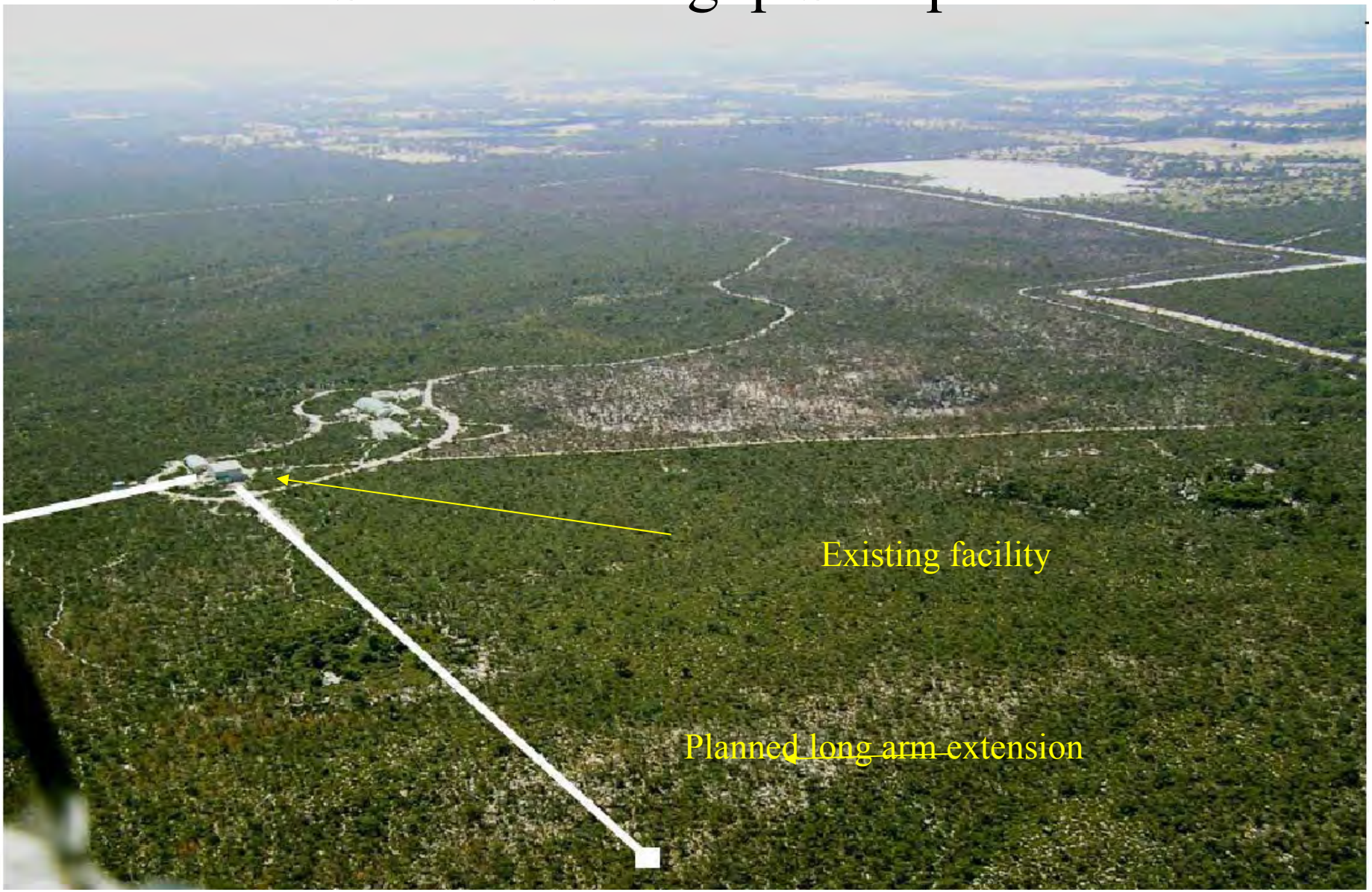
Site in Wallingup Sandplain

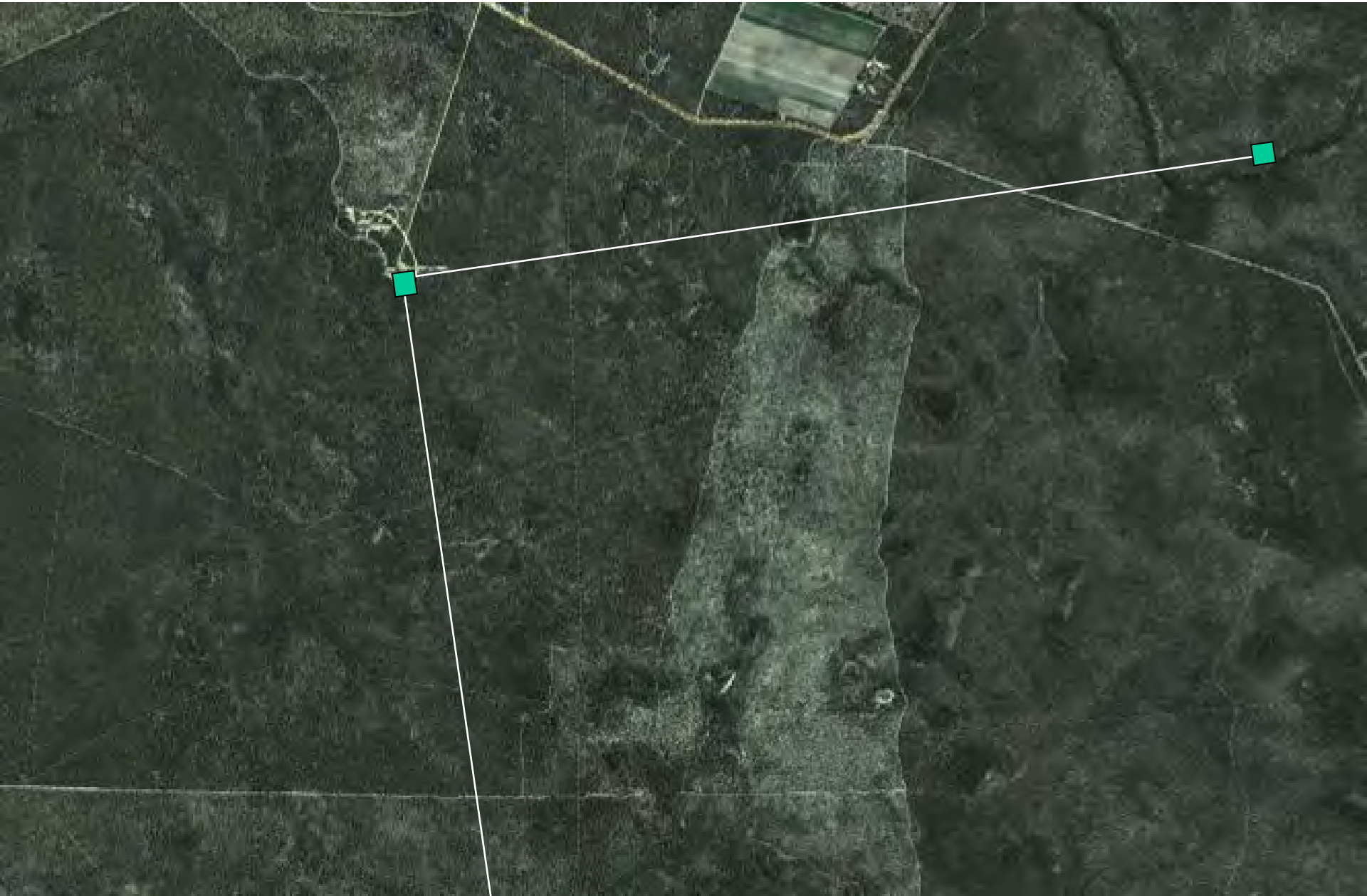


Existing ACIGA High Optical Power Facility (80m)

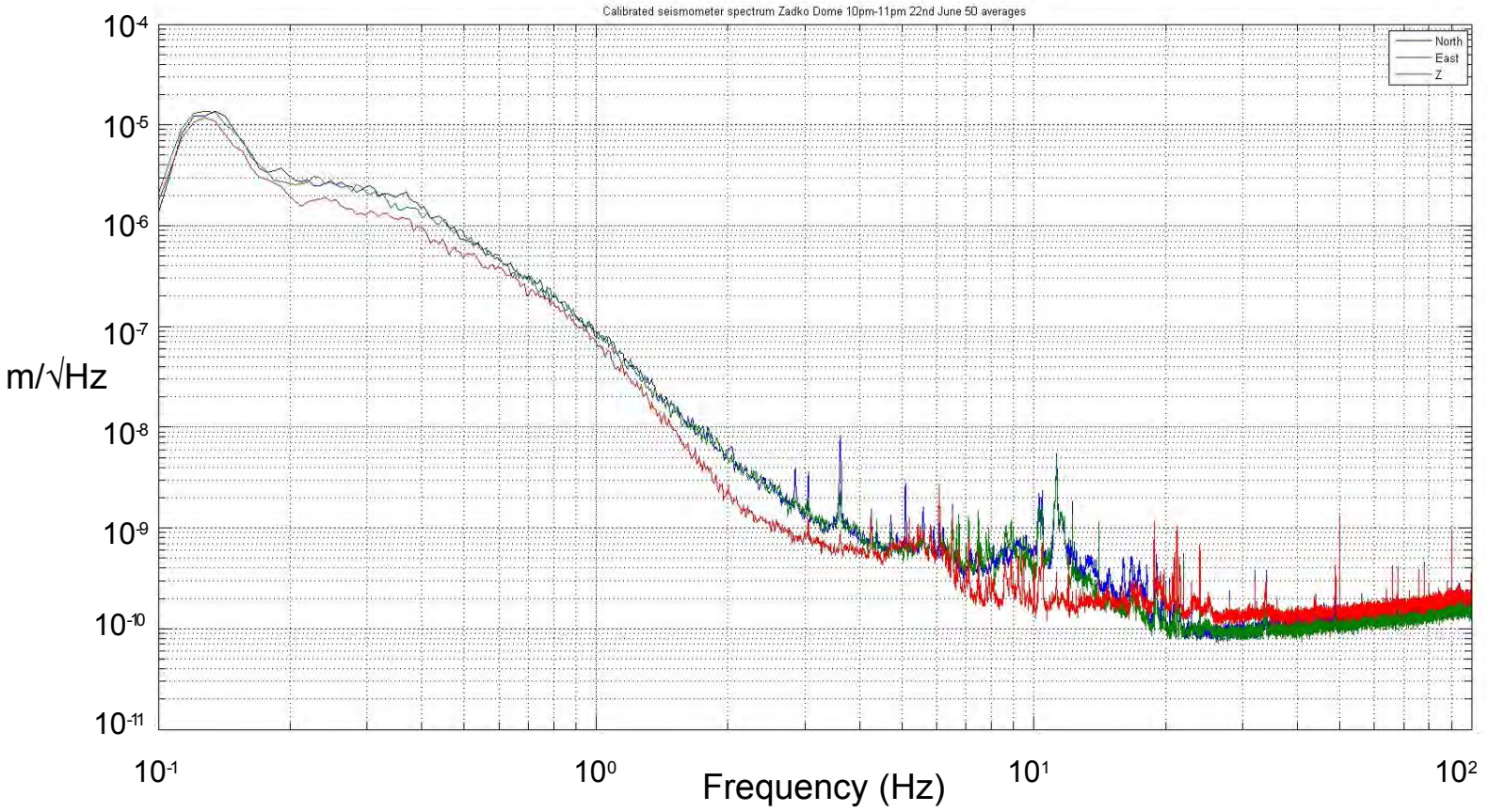

Gravity Discovery Centre
Existing 80m interferometer
Leaning Tower of Gingin
Cosmology Gallery
Zadko Robotic Telescope
Magnetic Observatory

The Gingin Site

3~5km no heavy industry buffer zone



Preliminary seismic measurements at Gingin are comparable to those of LIGO sites



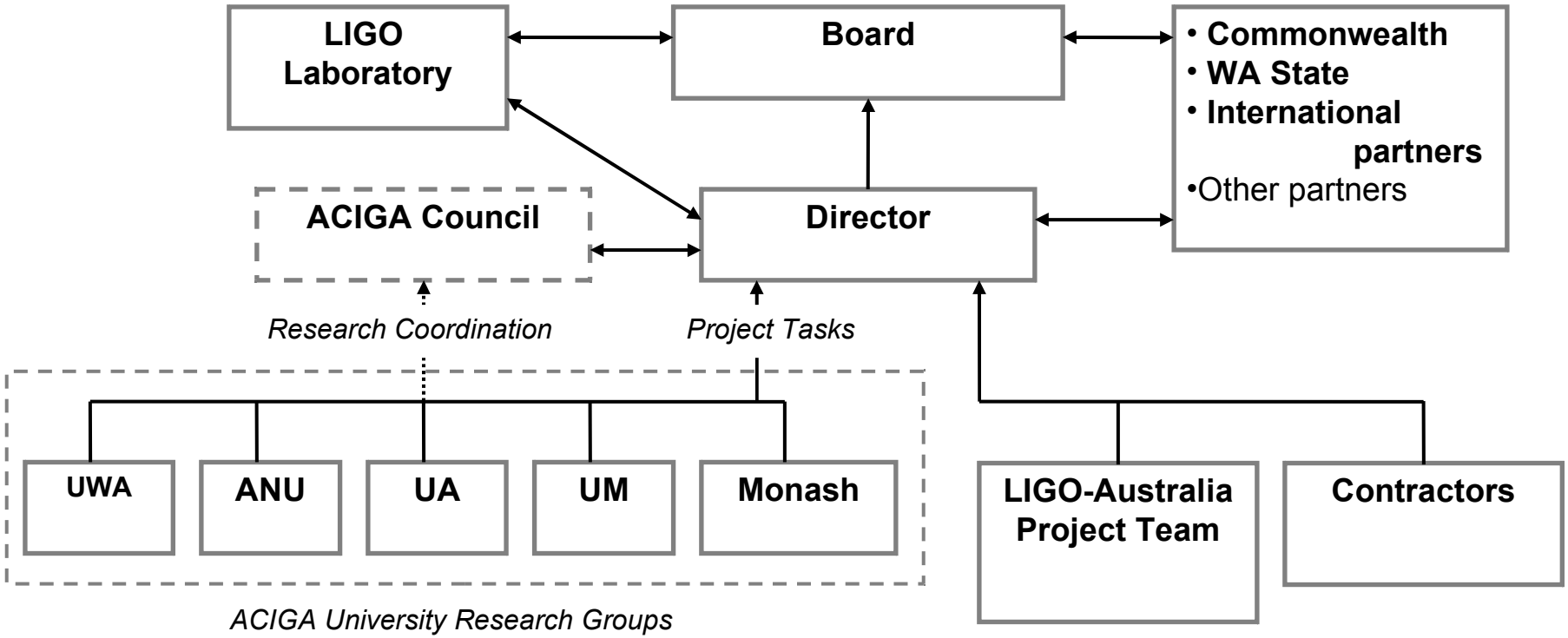
LIGO Australia

How do we propose to do it?

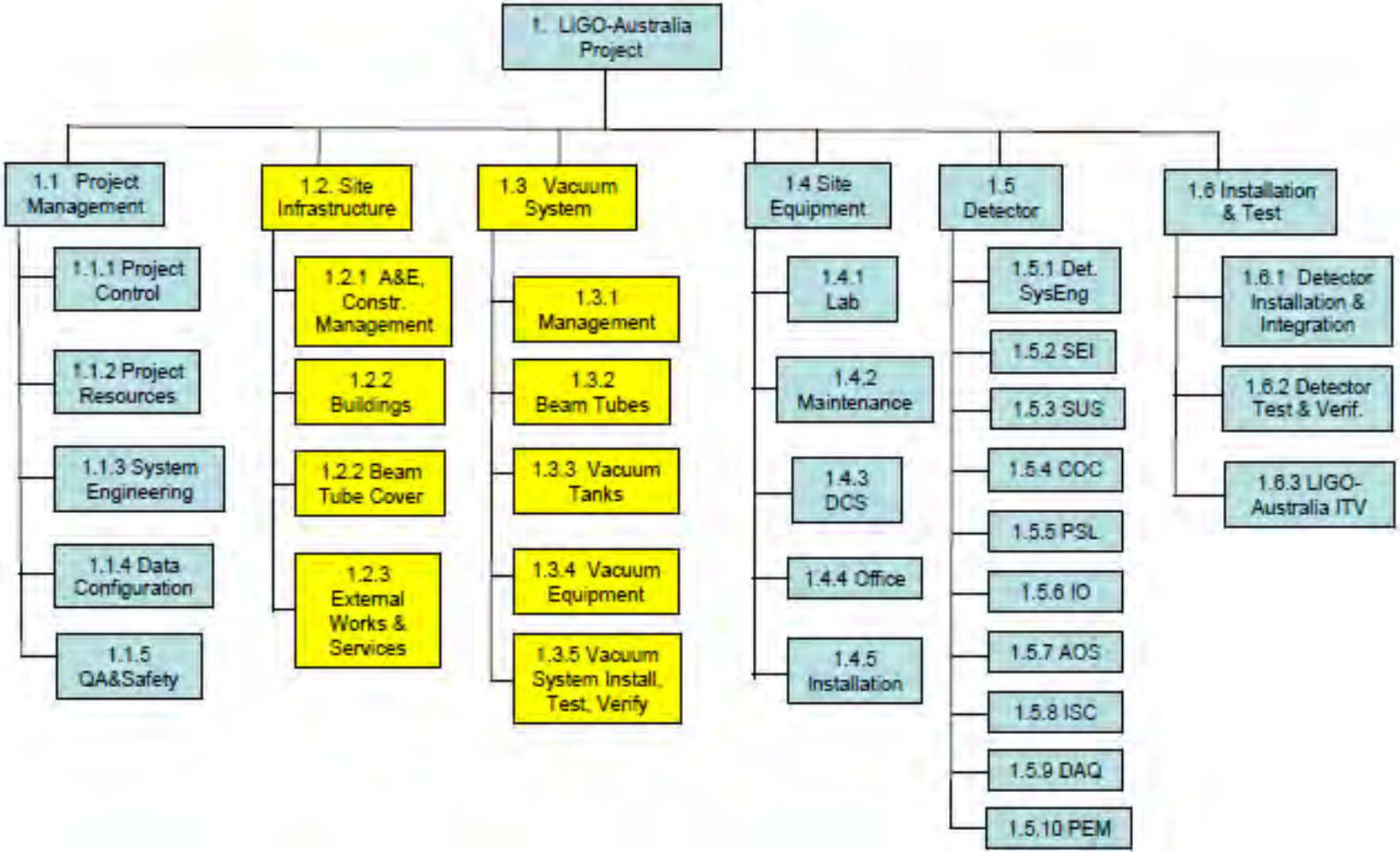
- Have established LIGO-Australia Laboratory (LAL) to house and administer the LIGO-Australia detector.
- LAL operated by ACIGA member universities
- ACIGA Universities have funded initial “war-chest”
- LAL host institution is UWA
- LAL director has been appointed: Dr Stan Whitcomb, deputy director of LIGO, Chancellorian Professor at UWA

LIGO Australia

LIGO-Australia Governance

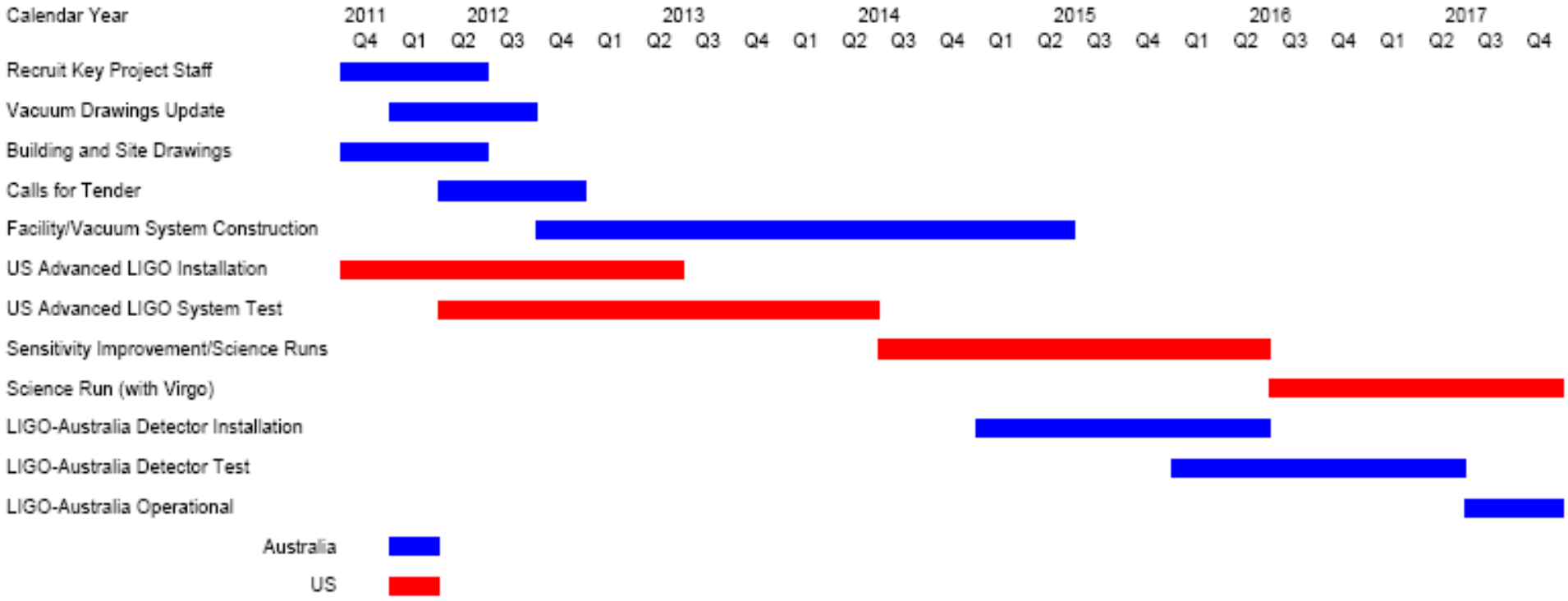


LIGO Australia



LIGO Australia

LIGO-Australia Overview Schedule



LIGO Australia

Construction Funding Profile

Funding requirement in (2010$)

FY2011-2012	$7M
FY2012-2013	$37M
FY2013-2014	$49M
FY2014-2015	$33M
FY2015-2016	$9M
FY2016-2017	$4M
Total	**$140M**

LIGO-Australia Staffing Model Construction Phase

Based on the LIGO experience the following staffing profile will be required to build facility, in addition to contractors

- **6 Instrument Scientists and 6 Engineers**
- **1 Specialist vacuum engineer**
- **15 General technicians (10 become operators)**
- **2 Computer Systems Administrator**
- **1 Site Manager and 1 Admin support**
- **1 Director of AIGO**

LIGO Australia

Can we do it---the people?

- Australia / ACIGA has ~ 15-20 key people to do this.
- Australia has excellent tube, stainless steel and welding capability. Need some improvements for large clean vacuum.
- International collaborators potentially offer much additional capability

LIGO Australia

Can we do it--- $$

- We have completed a careful, conservative budget estimate.
- Need $140M to build infrastructure on Gingin site in WA
- Need $6M/year for 10 years to operate the interferometer, starting 2016.
- Total budget of $200M over 15 years,

How do we propose to do it? continued

- ACIGA has signed MOUs with India and China
- The Indian collaboration, IndDIGO (Indian Initiative on Gravitational-wave Observations) has indicated willingness to support LIGO-Australia with scientists, students and about >10% total cost
- The China collaboration, CGWG (China Gravitational wave Working Group) is interested in collaborations and in sending people and students.

LIGO Australia

Risk

Have completed detailed risk analysis:

Low Risks:

- **Scientific**
- **Technical**
- **Management**
- **Project Schedule**

Major Risk:

Approval by Australian Funding Agencies: timing and funds

LIGO Australia

Risk Reduction

Submit proposal forthwith: VCs to meet Minister

Increase political significance:

--- National visibility

--- International support

USA: ~50%

India: ~10%

--- High level international interest and support?

LIGO Australia

Current state of Affairs

- **ACIGA has completed an unsolicited proposal to the Australian Federal Government to seek partial funding.**
- **Submit by VCs in March 2011**
- **Partial funding will also be sought in WA Government**
- **Staff support in part from the ACIGA Universities**
- **Critical commitments from International Partners are being solicited and negotiated.**

LIGO-Australia

A great opportunity

Thank you for helping to make it a reality