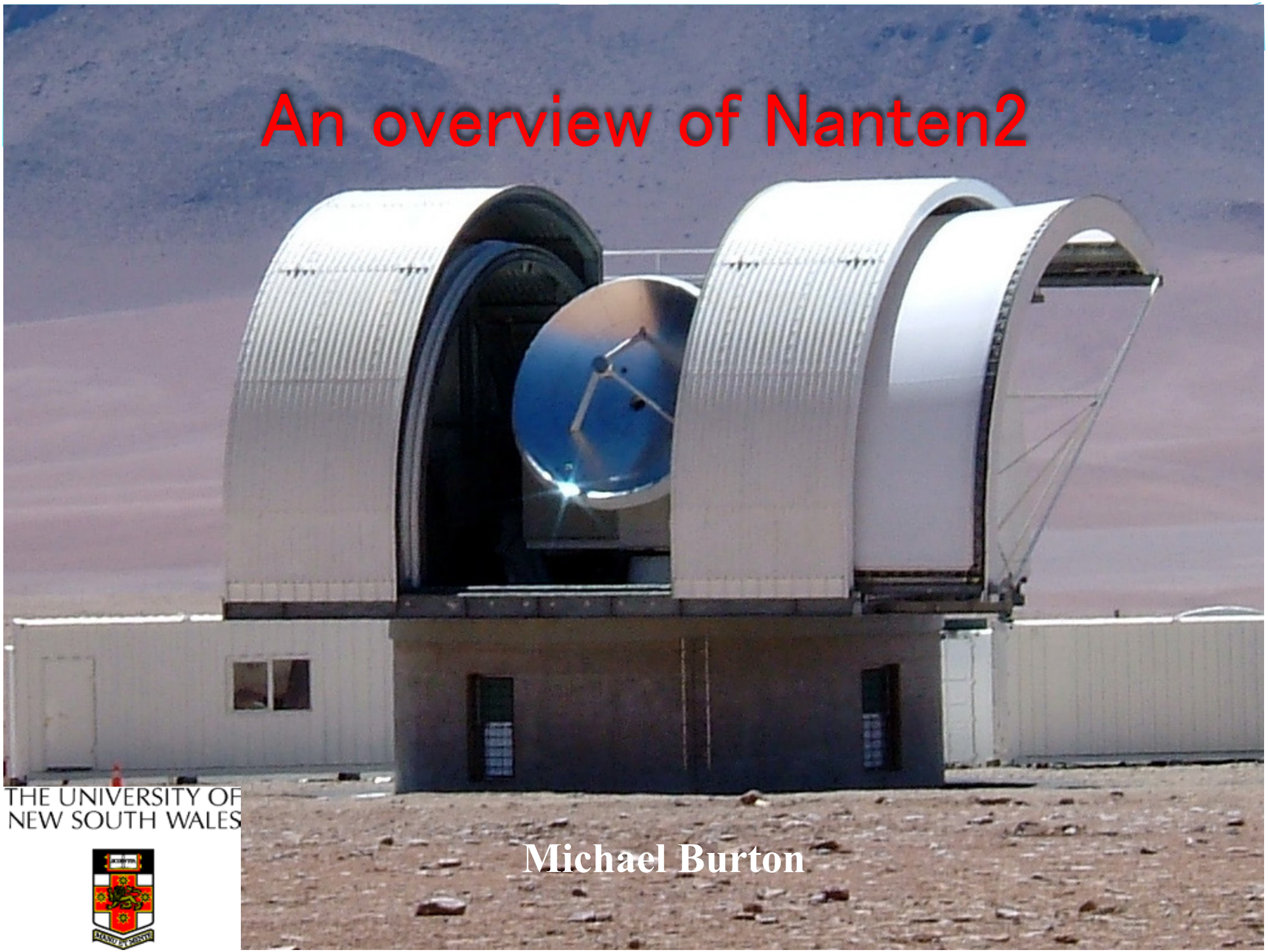
An overview of Nanten2



THE UNIVERSITY OF NEW SOUTH WALES

Michael Burton

Mopra Telescope, Coonabarabran, Australia

THE UNIVERSITY of ADELAIDE

MACQUARIE UNIVERSITY

SWIN BUR NE

THE UNIVERSITY OF SYDNEY

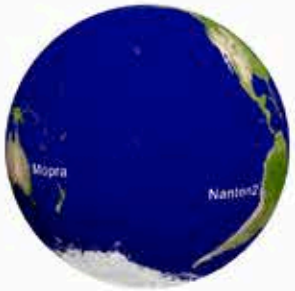
University of Western Sydney

Mopra

The Mopra Telescope is a 22-m diameter radio telescope in the Warrumbungle mountain range near Coonabarabran in New South Wales, about 450 km NW of Sydney. The telescope is situated at an elevation of 866 m.

Mopra is being used to measure the millimetre wavelength radiation emitted from molecules in the interstellar medium. This arises from giant clouds of molecular gas — the very coldest environments found in space and the sites where stars are born.

Together with Nanten2, the telescope can determine the environmental conditions within these molecular clouds.



NANTEN
Submillimeter Observatory

Nanten2

The Nanten2 Telescope is a 4-m diameter radio telescope on the Pampa la Bola of the Andes mountain range, in the Atacama desert of northern Chile, near the town of San Pedro de Atacama. Nanten2 is situated at an elevation of 4,865 m, in one of the very driest locations on the Earth.

Nanten2 is being used to measure the sub-millimetre radiation emitted from atoms and molecules in gas clouds in space. This can arise from regions where molecular clouds are being formed and also when these clouds are heated after star formation occurs within them.

Together with Mopra, the telescope can search for the places where molecular clouds are being formed in interstellar space.

UNSW

NAGOYA UNIVERSITY

Universidad de Chile

Nanten2 Telescope, Pampa la Bola, Chile

Nanten2 collaborators: Nagoya, Osaka (Japan), Cologne, Bonn (Germany), UNSW, Adelaide, James Cook, Macquarie, Swinburne, Sydney, UWS (Australia), U. Chile, ETH Zurich (Switz.), Seoul (Korea).

Nanten2 – an International University Collaboration

Nagoya, Osaka Prefecture Universities

Cologne, Bonn

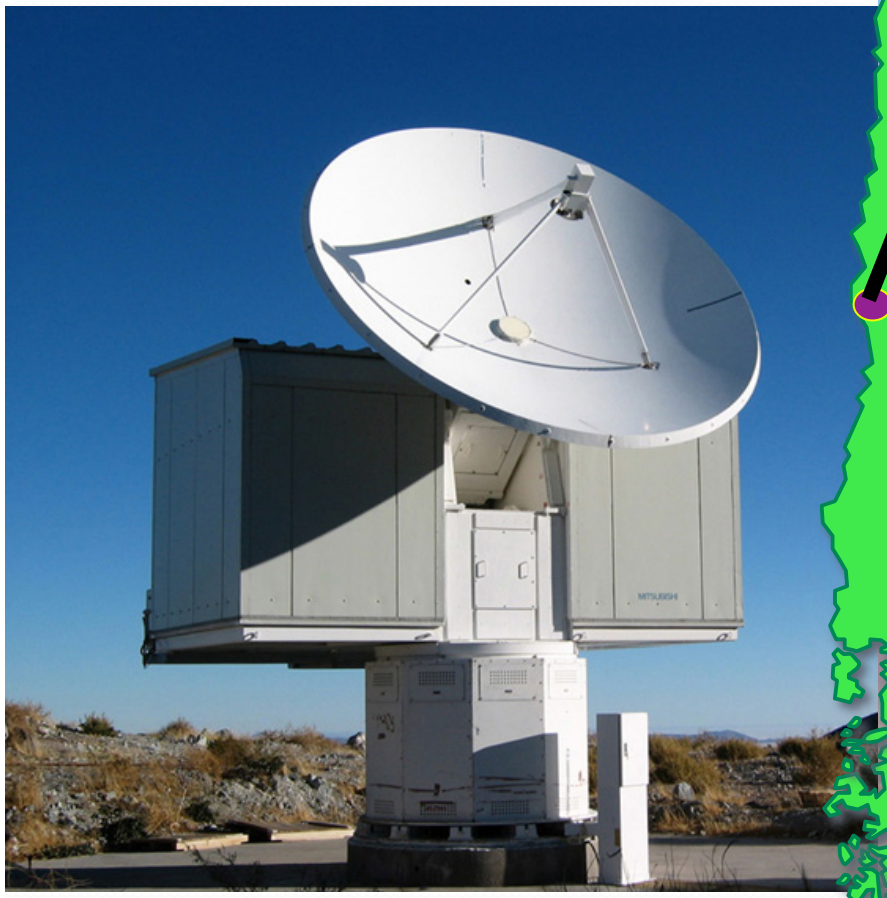
Universidad de Chile

UNSW, Adelaide, (James Cook), Macquarie, Swinburne, Sydney, UWS

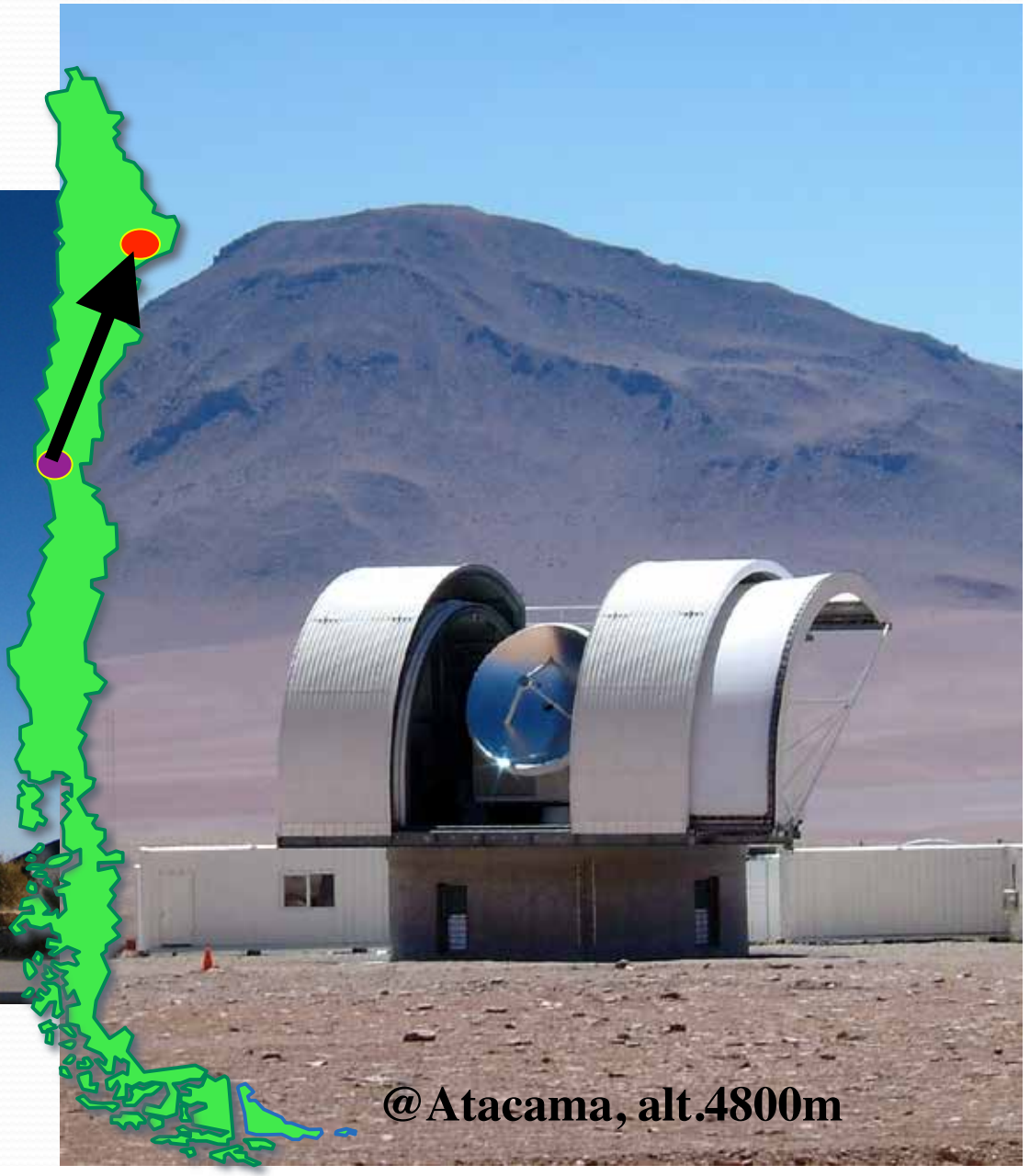
ETH Zurich

Seoul National University

Nanten & Nanten2



@Las Campanas, alt.2400m



@Atacama, alt.4800m

Nanten2

Las Campanas

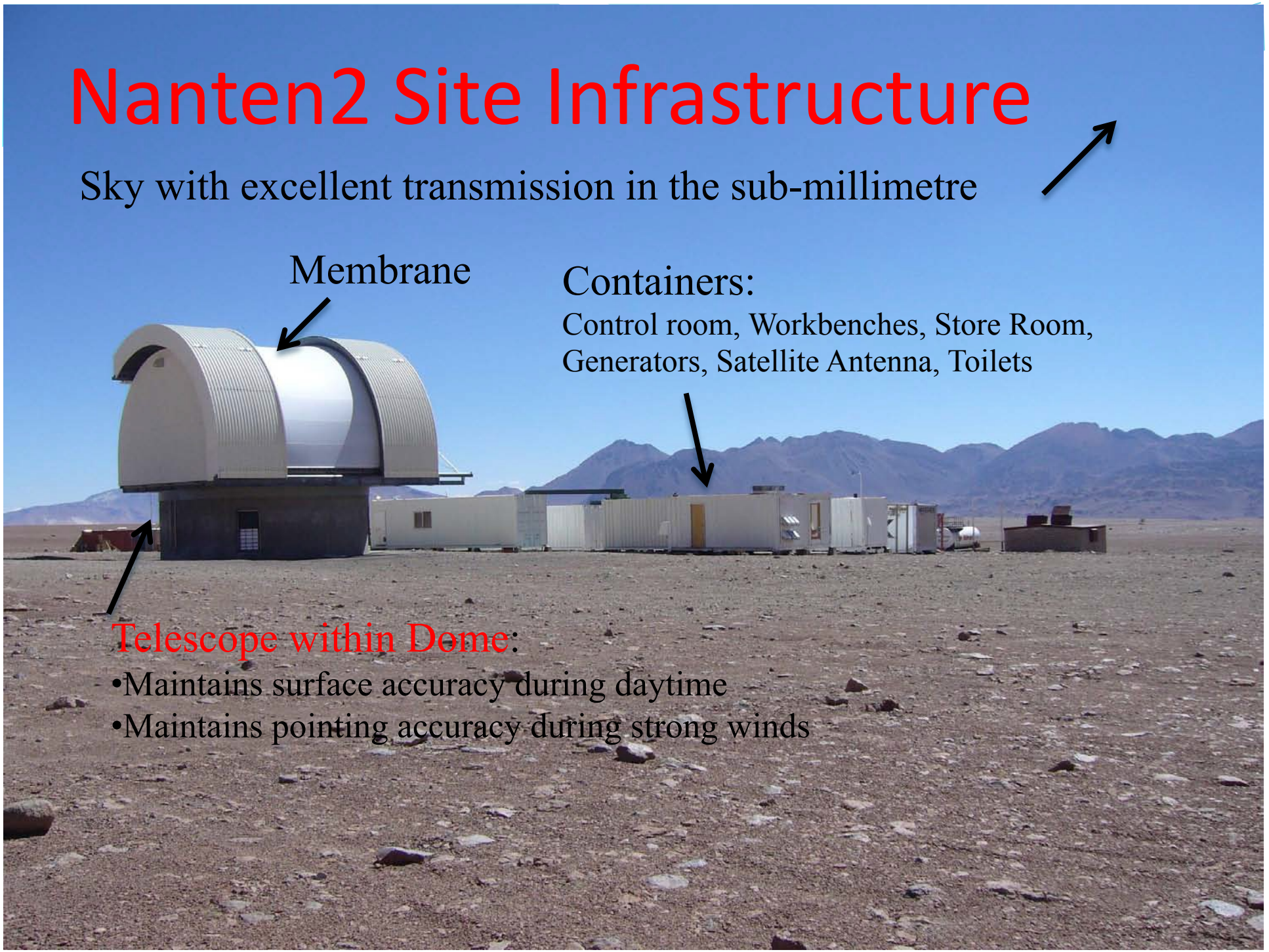
Santiago

Nanten2 Dedication 25th Nov. 2004

Timeline for Australian participation in Nanten2

- 2006: Millimetre White Paper – Offer to join Nanten2
- 2007: Australian Research Council LIEF award (100K)
  - UNSW, Sydney, Macquarie
  - Provision of Satellite internet for 3 years (2008-10)
- 2010: Failed renewal proposal
- 2011: ARC LIEF – International Facility (150K)
  - UNSW, Sydney, Macquarie, Adelaide, Swinburne, James Cook
  - Subscription Agreement (Nagoya, Köln, UNSW)
  - Purchase of Generators: Nagoya – UNSW
- 2012-2016: ARC LIEF – International Facility (150K/year)
  - Contributions to operations support
    - hardware, software, personnel
  - Internal funds to support the Australian members
- 2012: UWS join. CSIRO change Mopra access arrangements.
- 2013: JCU leave. 2nd Australian Nanten2 Consortium workshop.
  - NOSU, XFFTS, lots of snow!
- 2014: 3rd Australian Nanten2 Workshop – Adelaide.

Nanten2 Site Infrastructure



Nanten2

- 4m dish
  - Improved surface accuracy
  - Dome with movable membrane
- Remote observing
- "High" frequency receivers
  - Cologne – SMART
    - 2 x 8 pixels 500/800 GHz, DSB
    - AOS: 1 GHz / 1 MHz
      (= 0.6 km/s @ 500 GHz)
    - Upgrade to XFFTS
- "Low" frequency receivers
  - Nagoya
    - 115, 230 GHz, Single pixel, DSB
      - 1 GHz / 61 kHz x 2 bands
        (= 0.2 km/s @ 115 GHz)
    - NASCO 4-pixel 115 GHz

Nanten2

Atacama, Chile
Alt. 4800mm

Observation frequencies
460, 810 GHz simultaneously with 8 beams each
CO(7-6), CI($^3P_2$-$^3P_1$) can be observed at a same time

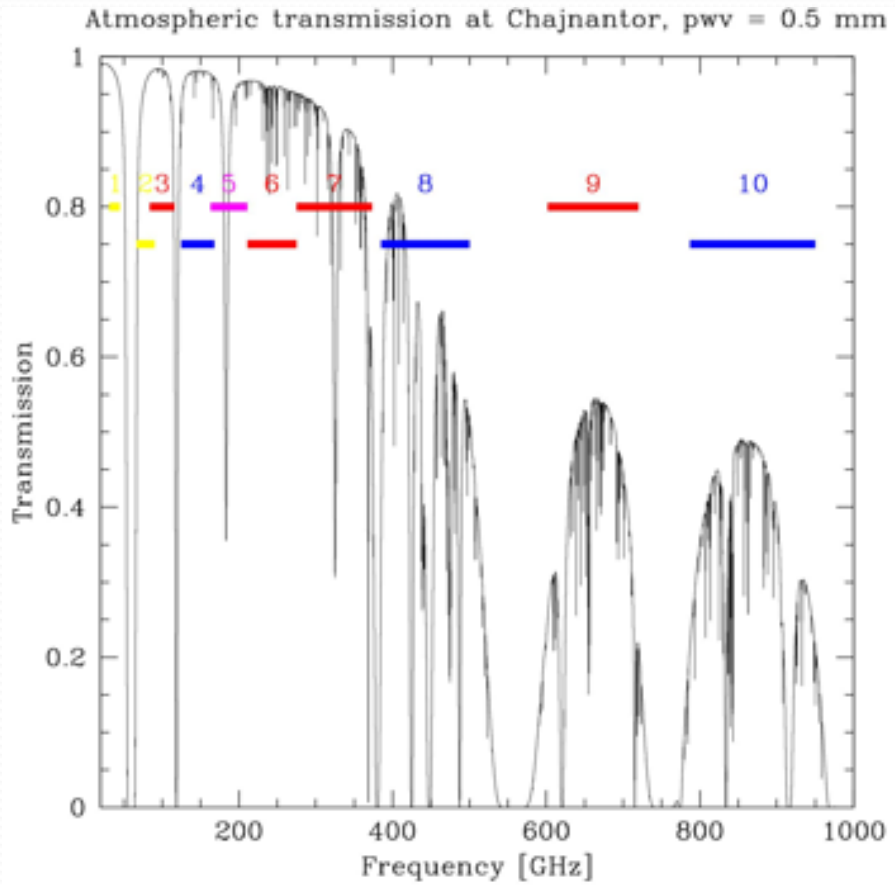
Beam
38" (460 GHz)
27" (806 GHz)

Beam efficiency
50% (460 GHz)
45% (806 GHz)

Observation mode
Position Switching
On The Fly mapping

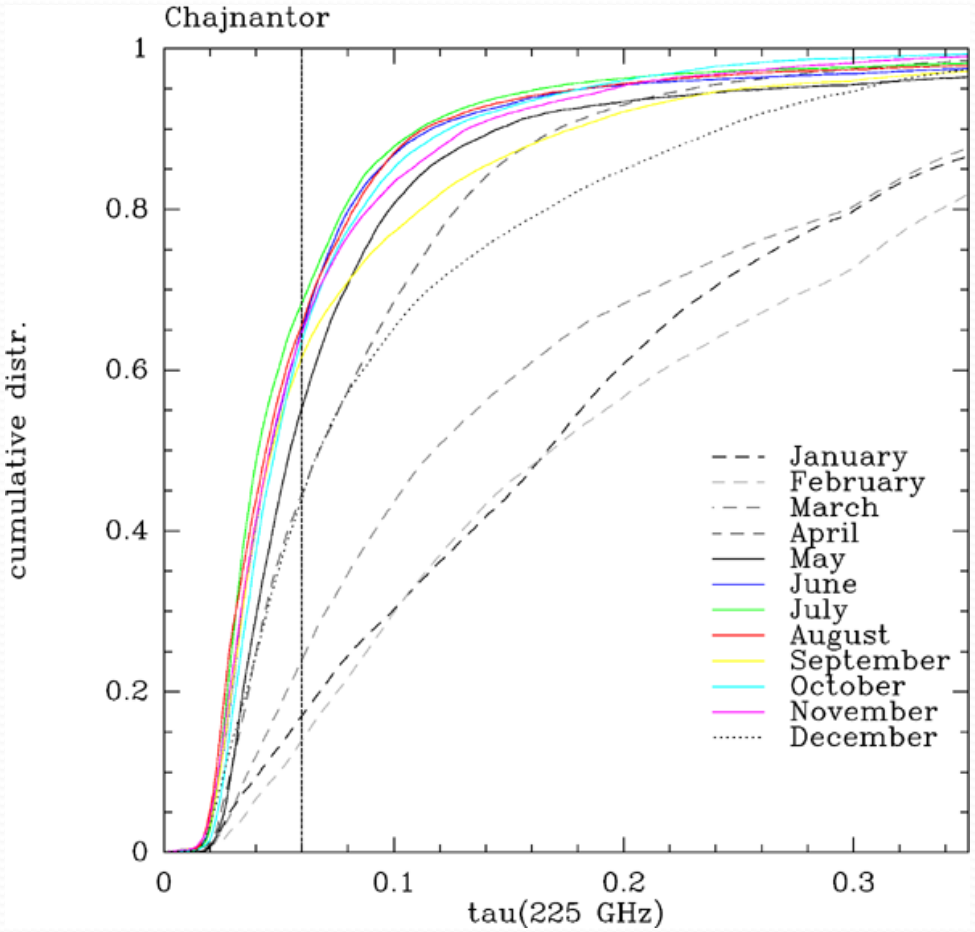
Band width@vel resn (km s^{-1})
760 @ 0.37 (460GHz)
430 @ 0.21 (806GHz)
(now larger??)

Atmospheric Transmission @ 0.5mm



Seasonal Variations

τ<0.05
For 490 GHz observing



Useful Line Frequencies for Nanten2

CO(J=1-0)	115 GHz	2.'6 (HPBW)	Nagoya RX
CO(J=2-1)	230 GHz	1.'3 (HPBW)	
CO(J=4-3)	460 GHz	39" (HPBW)	Cologne SMART
CI ($^3P_1$- $^3P_0$)	492 GHz	37" (HPBW)	
CO(J=7-6)	806 GHz	22" (HPBW)	
CI ($^3P_2$ - $^3P_1$)	809 GHz	22" (HPBW)	

8 beams in 490GHz, 8 beams in 810GHz, simultaneously

Science with Nanten2

Large scale distribution, structure, dynamics, and chemistry of the ISM in the Milky Way, LMC/SMC and nearby external galaxies

Trace Star Formation and Photodissociation Regions

Determine physical parameters such as
temperature, column density, density:

- Low-J CO, atomic carbon lines: large scale distribution of gas

- Mid-J CO lines: warm gas in dense cores

Administration and Management

The Route to San Pedro

- Nanten2 Wiki: www.astro.uni-koeln.ed/nanten2
  - Get an account (Robert Simon, Ronan Higgins ronan.higgins@gmail.com)
- Have a high-altitude medical
  - Use APEX form as per wiki instructions www.astro.uni-koeln.de/nanten2/node/17
    - Use "APEX Medical Examination for Work at High Altitude" form, but tell the Dr that you are not on duty at the APEX high site – so don't need the additional tests.
  - Can take several weeks – allow time!
  - On completion get waiver from from Wiki ("Statement of NANTEN2 working group members"), complete and get countersigned by mgb.
  - Take with you to Chile
  - Make sure you are on the approved list of observers before departure (check with Ronan)
- You must arrange your own travel insurance (e.g. via your university)
- Costs for Oz Consortium members reimbursed by billing UNSW, together with copies of receipts for major expenditure items. Done through your local CI (Burton, Rowell, Filipovic, Maddison, Green, Wardle).
  - Actual costs not official per diem rates!
  - Excess flight costs caused by late travel arrangements will not be reimbursed – plan you trip well in advance!

Observer Schedule

- Typically 3-week shifts at San Pedro
  - 2 Observers at all times
  - Usually each separated by ~1 week (for smooth handovers)
- If telescope working only need to visit site every 3-4 days
  - Collect data on disk, top-up water coolant
  - Usually Cologne – Nagoya travel in convoy with Juan (contract employee)
  - Sunday a rest day for Nagoya!
- Observing conducted from San Pedro
  - Possibility of remote observing from Oz too……
- Schedule determined by Ronan Higgins
  - Typically from May to November
- Nanten2 computer at UNSW: nanten2.phys.unsw.edu.au
  - All Oz universities have accounts (ask you local CI…..)
  - Copy of a Cologne machine; maintained by Ronan Higgins
  - CLASS software, mobsi, Raw Data

Travelling and Accommodation

1. Sydney – Santiago
   - QANTAS 3 x week direct
   - Lan Chile daily via Auckland
   - N.B. Oz passport holders pay reciprocity fee on arrival in Santiago! EU passports OK.
2. Stop-over in Santiago (if needed; usually a direct transfer to Calama is possible)
   - Book taxi at counters before departing customs area
   - e.g. Hotel in Providencia (Hotel Presidente, Av. Eliodoro Yanez)
3. Santiago – Calama
   - Numerous flights, usually very early (miners!)
4. Transfer Licancabur – www.translicancabur.cl
   - The Gringo bus. Calama airport – San Pedro. Book in advance.
5. Inform AstroNorte of your travel arrangements
   - administracion@astronorte.cl and www.astronorte.cl
   - Geraldine + Maria
   - Cologne pay for 2 rooms, so only meals need to be paid for if you are using these.
   - Breakfast compulsory, Lunch + Dinner optional (but usually take dinner unless eating out in San Pedro)
6. Need to provide brief report on return to Consortium CI (i.e. mgb).

Nanten2 Safety *(Important!)*

- New procedures will be place this year.
- Check lists to be gone through and signed off by most senior Nagoya and Cologne personnel present.
  - Log Book and Safety Inductions.
    - Hand-overs especially important.
  - Before departure to site:
    - tyres, snow chains, shovel, O_2 bottle & metre, radios.
  - At site:
    - Ladder, stop button engaged when in receiver cabin, emergency procedures signs, radios for control room – cabin communication, Maximum work hours (4, 6, then 8 hrs)

Oz Nanten2 Consortium Management Committee

- Michael Burton, Gavin Rowell, Anne Green, Stephen Lo, Sven Rogge
- Provide oversight to expenditure
- Guidelines provided to Consortium CIs
- Determines requests for support, based on:
  - Funds available, balance of experience & newcomers, needs of the consortium, reporting on previous trips, outcomes from past trips inc. publications.

Outcomes and the ARC

- 2014 is mid-point of the Australian funding for Nanten2
- Essential that science is now being produced;
  - i.e. *Nanten2 data is being used in refereed publications*.


Hidetoshi Sano

Introduction to the program….