

Australian Government Australian Research Council

DZGrav

ARC Centre of Excellence for Gravitational Wave Discovery Site Selection for Next Generation Surface Detectors

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The Australian National University























Australian National University Acknowledgement of Country

We acknowledge and celebrate the First Australians on whose traditional lands we meet, and pay our respect to the Elders past and present.

The Ripple Effect: Rippling Out by Wurundjeri artist Judy Nicholson

M-OzGrav-

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Current Future proposals

- Current Gravitational Wave Astronomy is driven by detector sensitivities.
 - Only just scratched the surface of GW
 - 3G detector we can see >90% of the Universe
- New 3G Facilities
 - Cosmic Explorer
 - Einstein Telescope
- LISA

- **Current Facilities**
 - Voyager
 - NEMO
 - Neutron Star Extreme Matter Observatory: A kilohertz-band gravitational-wave detector in the global network



Site criteria for a surface Detector - Cosmic Explorer

- As flat as possible
 - or bowl shape surface profile
- Low seismic activity
- Commuting distance town or city
- Sufficiently close to commercial airports
- Infrastructure (roads, electrical grid, etc.)
- Low wind
- Low risk for natural disasters:
 - Cyclones/typhoons/ hurricanes
 - Flooding (including rising sea level)
 - Earthquakes
- Accessible land area
 - Current academic only
 - Need to engage and solicit local community input



Digital Elevation Model

- 3 second Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) model
 - 3 arc second resolution \approx 86 m \times 86 m
- Used for finding flat sites
- Data from:
- https://ecat.ga.gov.au/geonetwork/srv/eng/ca talog.search#/metadata/72760
- Retrieved using the AusMap plugin in QGIS.
- World coverage DEM from viewfinderpanoramas.org
 - Based on NASA's ASTER GDEM & SRTM and other sources
 - (0.46 km at equator, 0.16 km at 70° latitude, 2 bytes per point = 5.3 Gb)
 - Matches Google Earth profiles



Data from:

https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72760 Retrieved with AusMap plugin in QGIS.



Straight line along Earth's curvature

- Due to the Earth's curvature some digging
- is required for a straight laser beam to cover km scale distances.
- A bowl shape surface profile can help mitigate the 'digging'
- Due to Local gravity we need to pitch the mirror
 - ~0.3 mrad for 4 km (LIGO)
 - ~3 mrad for 40 km
- We can tolerate some tilt of the laser beam between the stations
 - Aid in finding suitable sites





Earth volume movement

- When assuming a smooth round earth, a large volume of earth needs to be removed to create a straight platform
- We can utilise natural surface profiles to minimise the amount of volume to be moved







Preliminary Candidate Sites

- Can be quite sensitive, careful with distribution
 - Indigenous custodians, landrights and relationships
 - Land use and coverage
- Once candidate sites are deemed of interest, \bullet engage with local community
 - Current efforts using public databases
 - Use data for our purpose (academically)
 - Tricky to understand, need expert advice

FORN

- Initial 'flat' site searches provide >1 M possible locations!
 - For a 20-km observatory in Australia





Relax Corner angle and fix length

- Relaxing the constraint of a 90° corner angle (here: 83°-97°)
- 40 km arms length (37-40 km)
- About the same sites, volume smaller: more solutions with V < 10⁶ m³ (white dots)







Facility design considerations

- Cost estimates for infrastructure
- Vacuum tube/pipe potential large fraction of cost
 - New technologies and alternative design under investigation
 - Architected structures
 - Air-ducts for 'remote' air-conditioning system'
 - Local Roads
 - Regional cost increase (AUS)
 - Metropol areas +1.5 3%
 - Remote areas +6.5 22%







Timeline

Top-level phased approach to Cosmic Explorer

Site search and selection proposed to start in the not to distant future



Horizon Study – May 2021



Summary

- Site-selection methods are well underway
- Scientifically good site are found
- Short list to be made in the future
- Next phase require local community engagement
 - Start early, can be a long road
- Infrastructure concept under consideration



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