ASIAA sub-mm VLBI Project

Dust Group Meeting 2001/08/22

Juan Carlos Algaba Marcos (林煥)
On behalf of the VLBI group
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Introduction

- Partners and Collaborators
  - Academia Sinica Institute of Astronomy & Astrophysics (ASIAA)
  - Harvard-Smithsonian Centre for Astrophysics (CfA)
  - MIT Haystack Observatory (Haystack)
  - National Radio Astronomy Observatory (NRAO)
Introduction

- Current ASIAA VLBI members
  - Algaba Marcos, Juan Carlos 林煥
  - Asada, Keiichi 浅田圭一
  - Chen, Chien-Ping 陳建賓
  - Chen, Ming-Tang 陳明堂
  - Ho, Paul 賀曾樸
  - Huang, Ted 黃耀德
  - Inoue, Makoto 井上允
  - Martin-Cocher, Pierre 馬柏翔
Introduction

- Delegates from other institutes/observatories
  - Ray Blundell (CfA)
  - Jim Moran (CfA)
  - Shep Doeleman (MIT Haystack)
  - Vincent Fish (MIT Haystack)
  - Peter Napier (NRAO)
  - Walker Brisken (NRAO)
Introduction

- What frequencies are we interested in?

![Graph showing atmospheric transmission with peaks at 230, 350, and 650 GHz, indicating interest up to THz.]
NA ALMA Prototype Antenna
NA ALMA Prototype Antenna

- **May 2010:** NSF USA released expression of interest for the Vertex NA ALMA prototype antenna
  - 12m radio antenna
  - Cassegrain Optics on an Alt-Azimuthal mount
  - Surface Accuracy for sub-mm observations
  - Operates from 30 to 950 GHz
- **Jan 2011:** ASIAA obtained antenna in collaboration with CfA, Haystack, NRAO
- **Apr 2011:** Meeting in Socorro to check status
- **Aug 2011:** Test and re-commissioning
NA ALMA Prototype Antenna

Image courtesy of NRAO/AUI/Kelly Gatlin/Patricia Smiley
NA ALMA Prototype Antenna

Image courtesy of VERTEX ANTENNENTECHNIK GmbH
Site Selection
Site Selection

- For observations around hundreds of GHz:
  - Precipitable Water Vapour (PWV) < 1mm
  - Minimal atmospheric turbulence
  - Dry, cold weather, at high altitude

- For good UV coverage:
  - Common visibilities with other sub-mm telescopes
    - ALMA, SMA,…
  - Long baselines
Site Selection

- Precipitable water vapor (PWV) distribution
  - February
  - August
  - Red area shows PWV > 10 mm.
  - Greenland is excellent throughout the year.
Site Selection

- Greenland has already facilities: Summit Station
Site Selection

- Atmospheric Conditions: PWV

Satellite-based PWV data measured by NASA Aqua and Terra/MODIS.
Site Selection

- Atmospheric Conditions: Ambient Temperature

Long-term monitoring of ambient temperature at Summit Station
Site Selection

- Atmospheric Conditions: Wind Speed

Distribution of Wind Speed in 2009 at Summit Station
Site Selection

- Atmospheric Conditions: No data for opacity
- Deployment of our own radiometer
  - Testing in Eureka station (North Canada, 80°N, 82°W)
  - Collaboration with Canadian group
- Site testing
  - Radiometer tests in Summit last week
  - Remote Control from ASIAA HQ’s
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Sub-mm VLBI
Sub-mm VLBI

Resolution [arcsec]

Frequency [Hz]

LOFAR, HERSCHEL, VLA, ALMA, MERLIN, VLA

VLBI, sub mm VLBI

IR, Optical, UV, X

EGRET, GLAST

Operational Telescopes

A. P. Lobanov 2003, SKA Memo 38
## Sub-mm VLBI

<table>
<thead>
<tr>
<th>Telescope</th>
<th>Location</th>
<th>Effective Aperture</th>
<th>Status</th>
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<td>CARMA</td>
<td>California</td>
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<tr>
<td>SMA/CSO/JCMT</td>
<td>Hawaii</td>
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<td>IRAM 30m</td>
<td>Spain</td>
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<td>France</td>
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<td>Chile</td>
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<td>LMT</td>
<td>Mexico</td>
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<td>ALMA</td>
<td>Chile</td>
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<td>MIT Haystack</td>
<td>Massachusetts</td>
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<td>South Pole</td>
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<td>Kenya</td>
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Sub-mm VLBI

- SVT (Sub-mm [or Summit] VLBI Telescope)

**Signals that span the globe**

Through a process called very long baseline interferometry, the Event Horizon Telescope would combine data from more than a dozen instruments operating in sync around the world, from Arizona to Spain to the South Pole.
Imaging a Black Hole

- Angular resolution comparable with event horizon
  \[ R_{Sch} = \frac{2GM_{BH}}{c^2} \]
  Shadow size \( \approx 5 \times R_{Sch} \)

Possible Candidates:

<table>
<thead>
<tr>
<th>Target</th>
<th>Apparent size (5 R_{Sch}) [(\mu)as]</th>
<th>Mass [(10^8 M_{\odot})]</th>
<th>Distance [Mpc]</th>
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<tr>
<td>Sgr A*</td>
<td>52</td>
<td>0.04</td>
<td>0.008</td>
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<td>M 87</td>
<td>40</td>
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**M87**

- Timescale 2-18 days
  - Fixed structure over one day: good for Earth aperture synthesis
  - Dinamical events over days
- Unlike Sgr A*, M87 has a jet
  - Study on jet formation, structure & dynamics on horizon scales
  - Provides initial conditions for jet simulations
Single Dish Uses
Single Dish

- **Single Dish Antenna**
  - Summit station equivalent to south pole station
  - 12 metres: largest antenna in a polar station
  - Site Condition: One of the best in the world
  - Telescope Performance & Site condition: THz receivers
Possible Projects

- Mapping the Inter-cluster Medium
- Wide Field & Deep Survey of High z Dusty Galaxies
- Molecule Line Survey
- New receiver development for THz region
- Planet formation and disk around young stars (...grain disks?)
- Dust production by evolved stars (cold dust is also interesting compared with hot IR dust)
- Galactic Cirrus
- Spinning dust emission at low frequencies (~30GHz/band 1)
  - Maybe we cannot compete with other telescopes about this one

Bring your proposals for next meeting!

Antenna/receiver/... requirements for these projects?
The NA-ALMA Prototype antenna was acquired by ASIAA/SAO last January

- Primary Site Candidate: Summit Station, Greenland
- Creation of a sub-mm VLBI array
  - Baselines up to 12,000 Km
  - Frequencies 230, 350, 650 GHz
  - Implies a resolution of few tens of µas
- Primary Objective: Imaging the Shadow of the Black Hole in M87
- Use of the Antenna as a Single Dish
Contact us

- http://www.asiaa.sinica.edu.tw/~vlbi
- vlbi@asiaa.sinica.edu.tw
Thank You