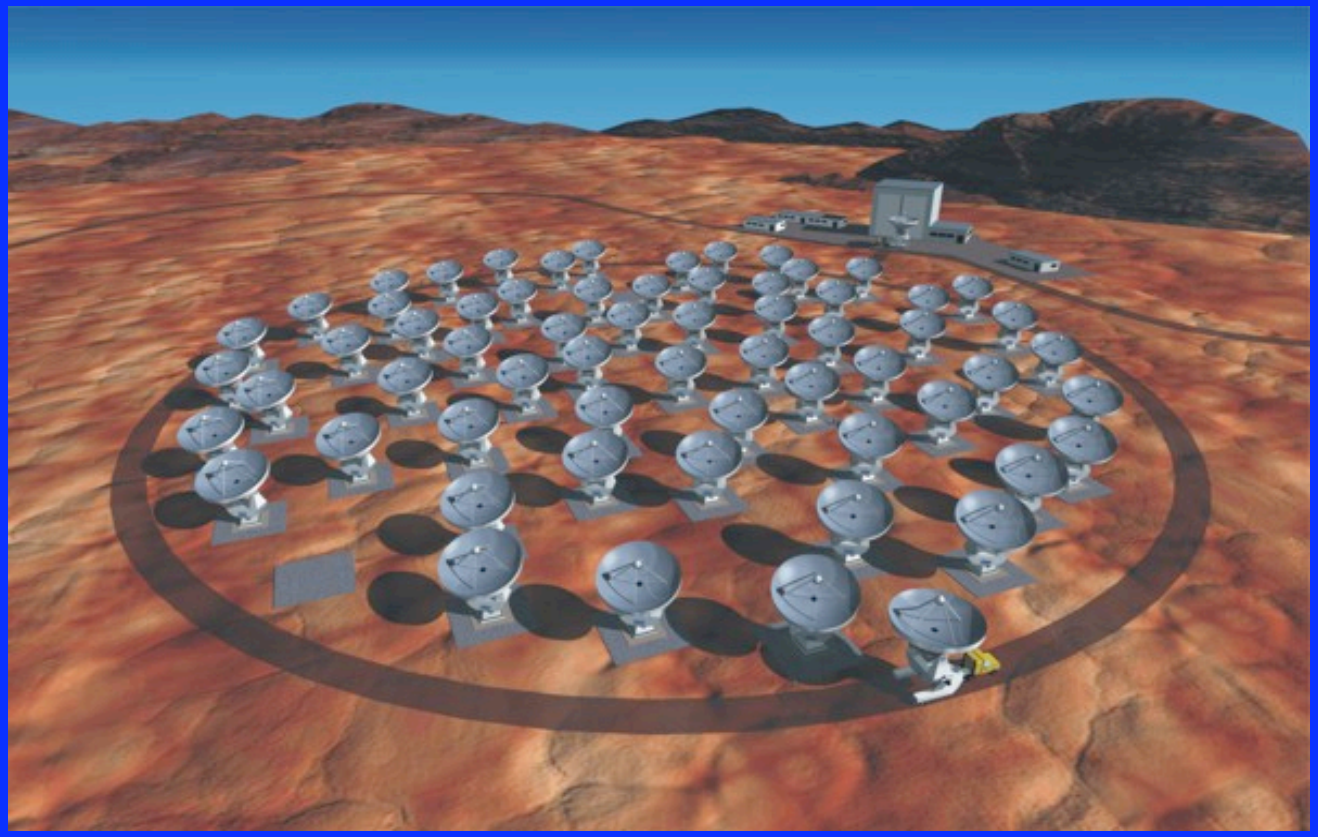
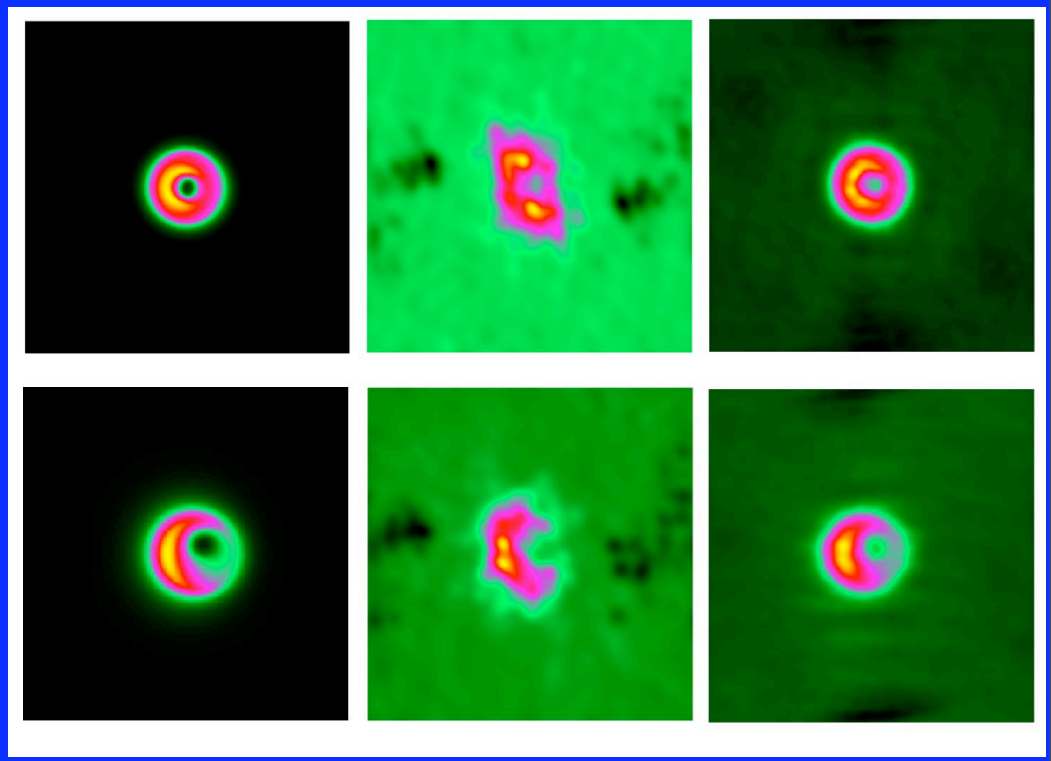
Phasing ALMA for VLBI



Sheperd Doeleman
MIT Haystack Observatory

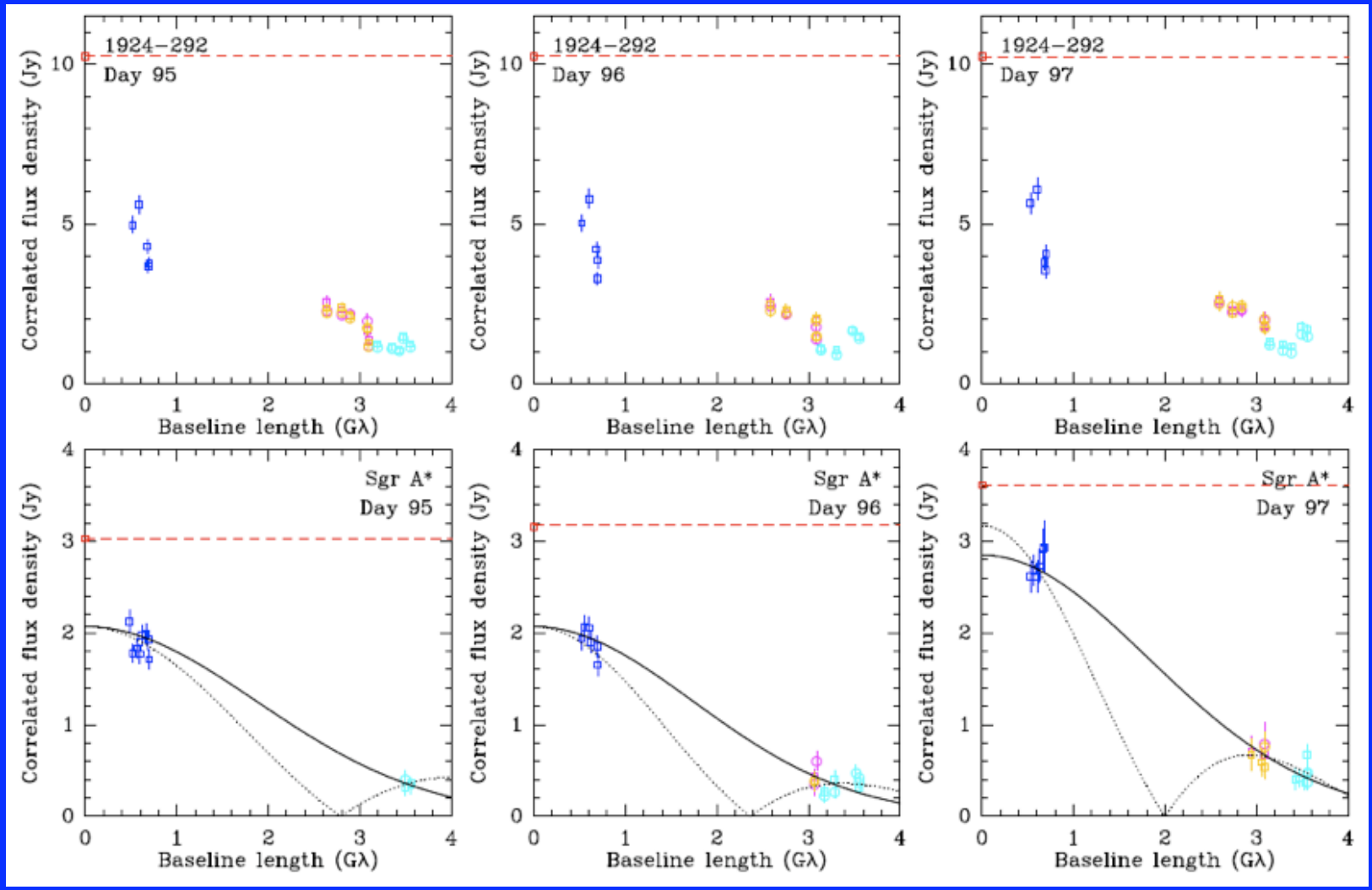
Collaboration

- ALMA Phasing collaborators: NRAO, Haystack, MPIfR, ASIAA, NAOJ, U. Concepcion
- Other (sub)mm VLBI collaborators:
  - JCMT
  - SAO/CfA, SMA
  - CSO
  - ARO/SMT
  - CARMA
  - UCBerkeley
  - IRAM



GR Model 7 Stations 13 Stations

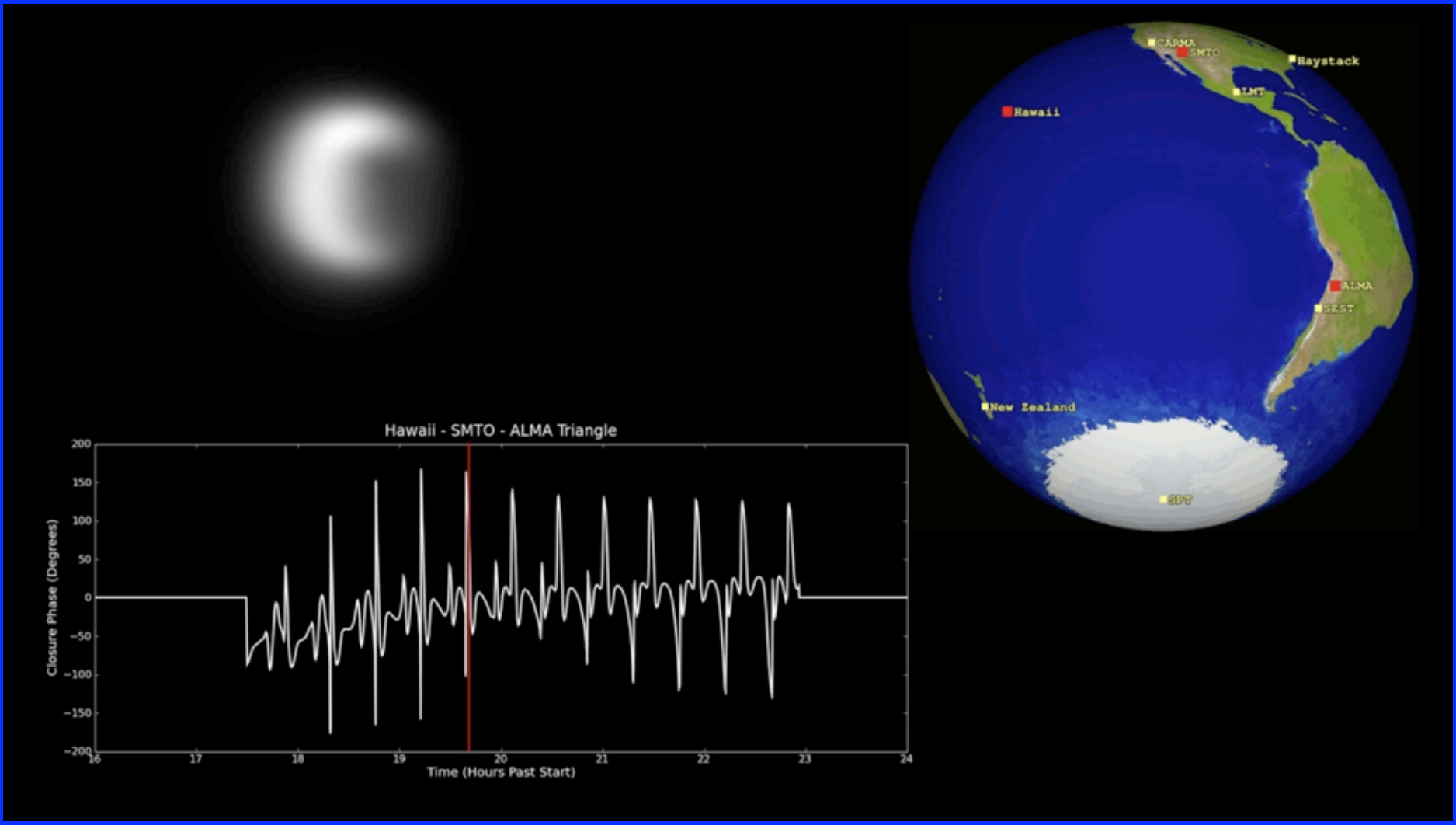
April 2009: SgrA* Flare on Rsch scales



On all three days, calibrator 1924-292 is stable, but SgrA* increases in flux density on day 97, without a change in size (43uas).

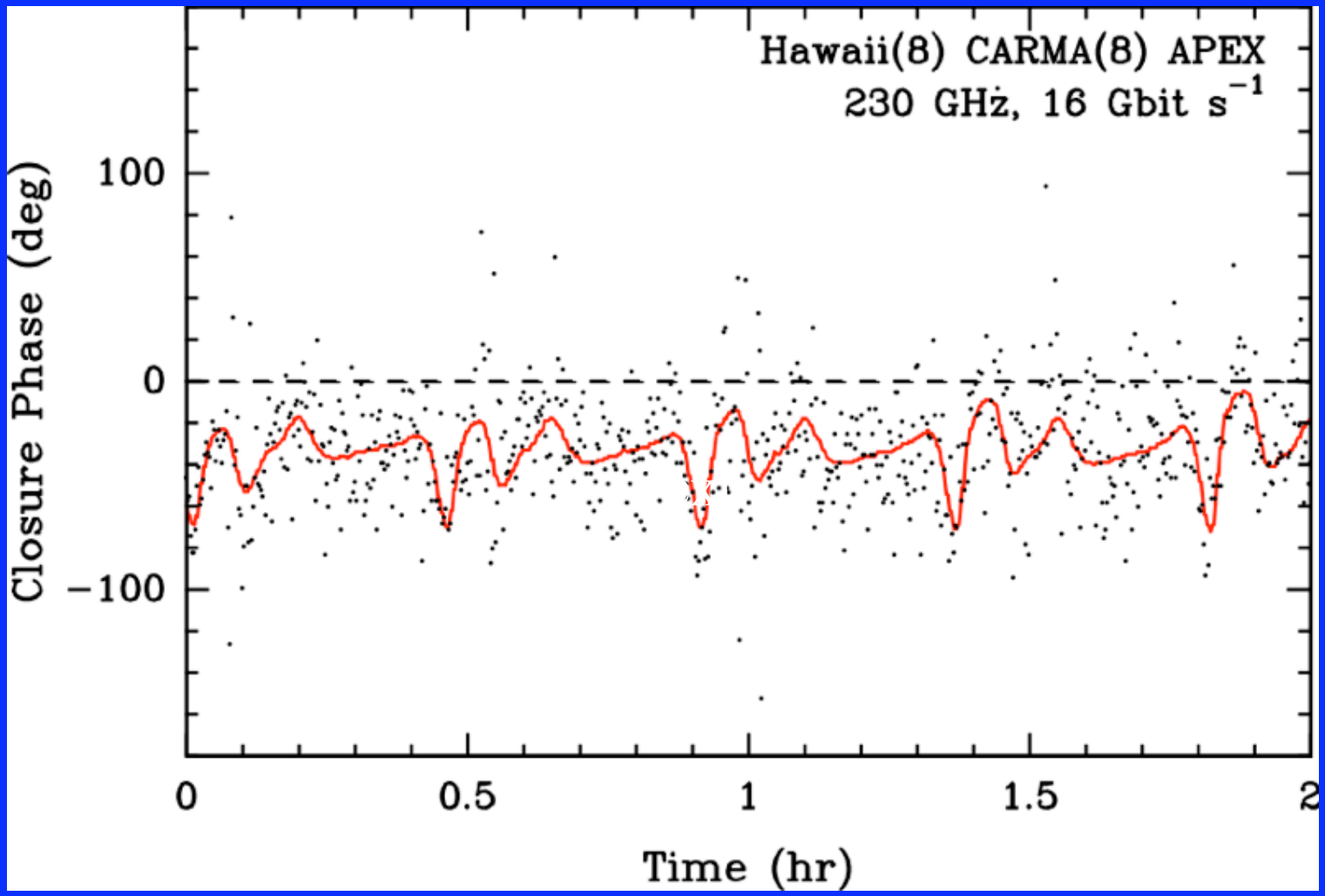
Fish et al, ApJL, v727, L36 2011

VLBI Traction on Black Hole Orbits



Upper left: hot spot in accretion flow orbits BH at Innermost Stable Circular Orbit (ISCO). Upper right: triangle of stations - SMTO, ALMA, SMA. Lower left: closure phase as a function of time. Note that orbit period is ~30 min, so many orbits observed during a single night. Extraction of orbital period gives an estimate of BH spin.

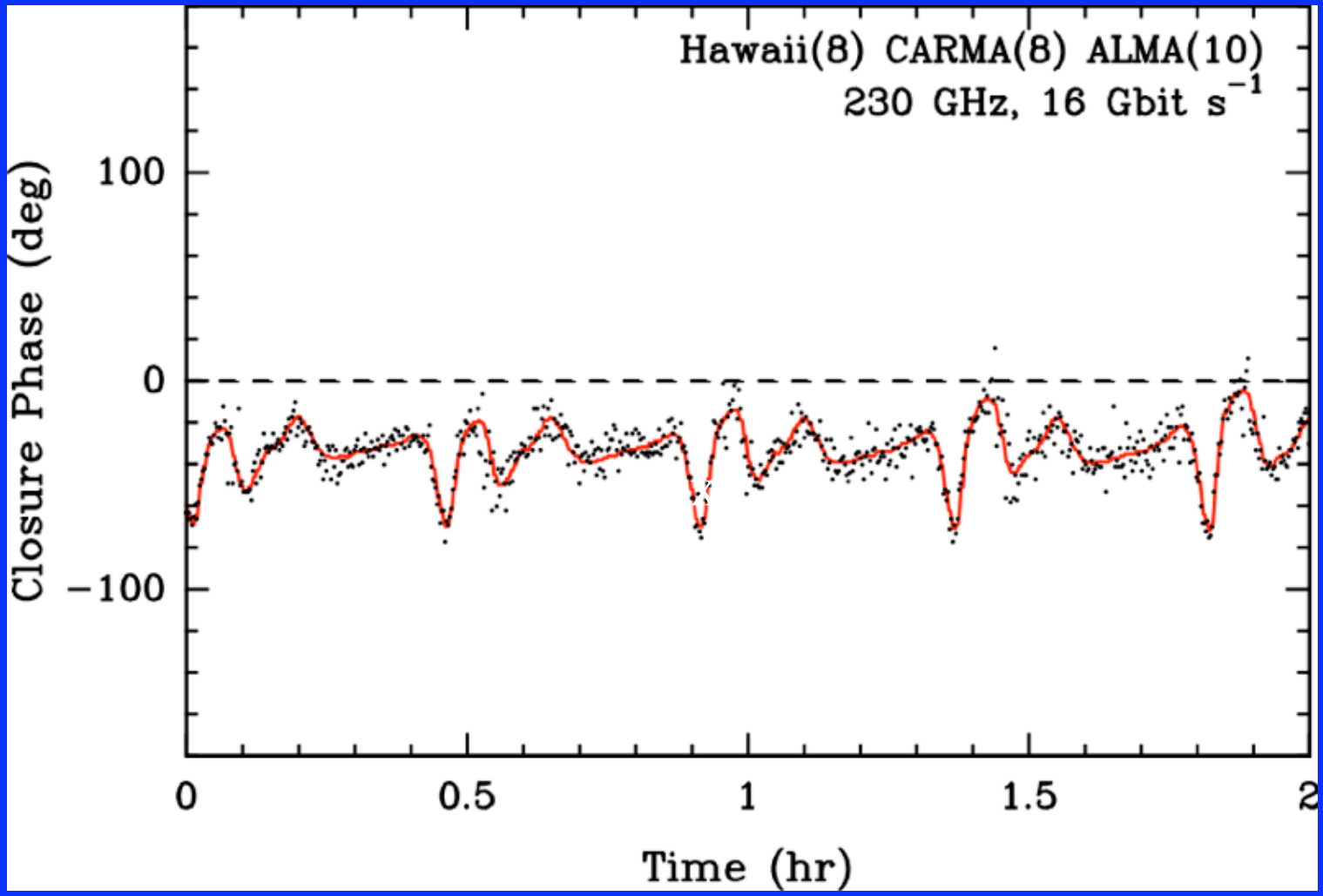
Tracking Black Hole Orbits with VLBI



Shows time variable closure phases due to orbiting hot spot as number of phased ALMA antennas increases.

Spin = 0.9
Hot-spot at ~ $6R_g$
Period = 27 min.

Tracking Black Hole Orbits with VLBI



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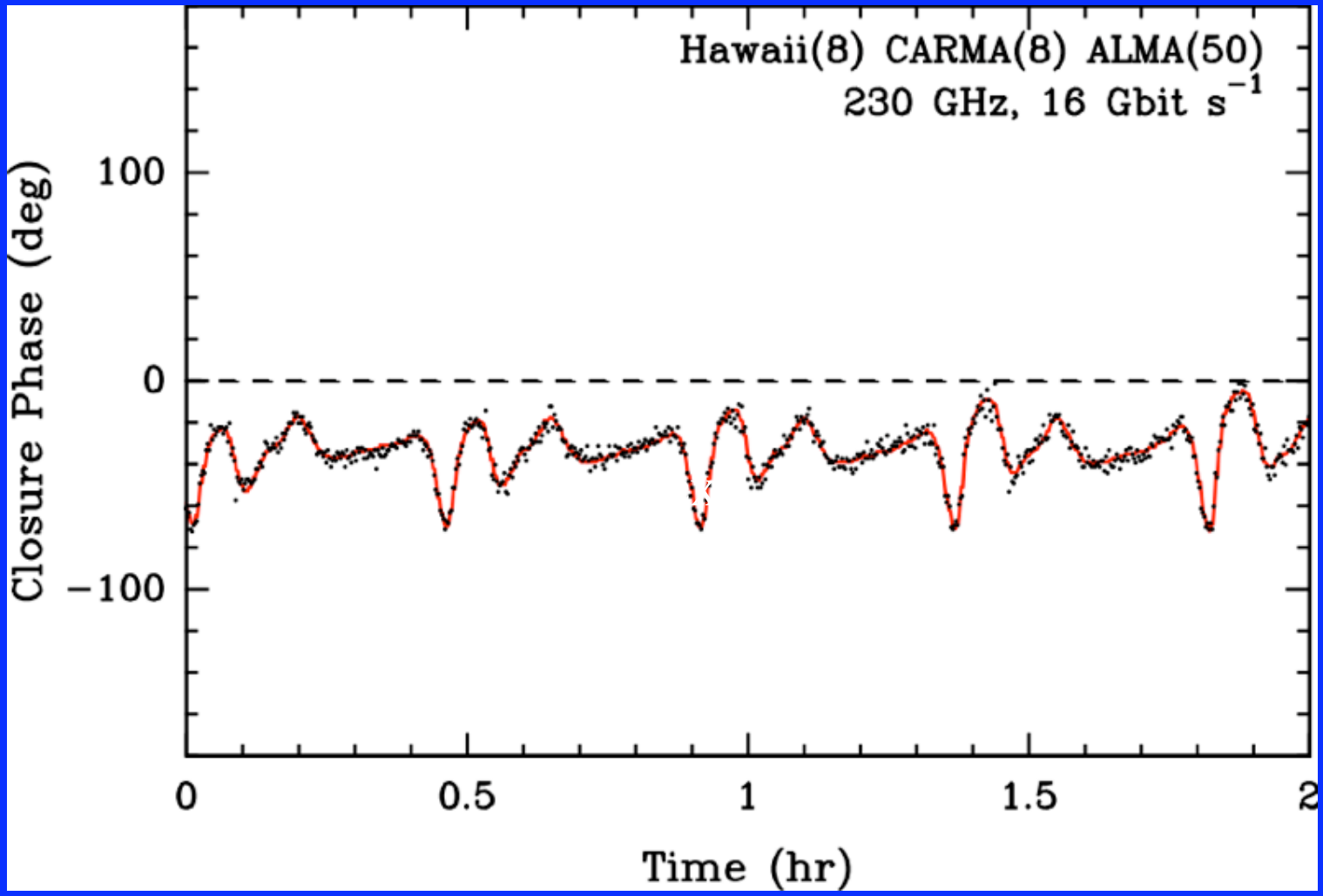

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Hot-spot at ~ $6R_g$
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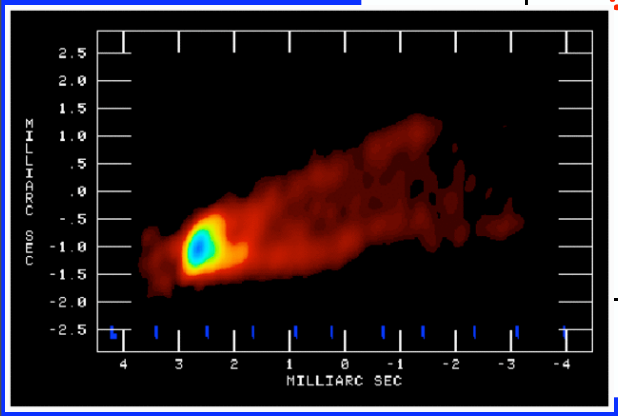
ALMA Vitals

- 64 x 12m dishes: 96m effective dish.
- Excellent site
  - SEFD (1.3mm) ~ 100Jy
  - SEFD (3mm) ~ 70Jy
  - SEFD (7mm) ~ 40Jy
- VLBA-ALMA baselines x10 sensitivity of single VLBA-VLBA baseline at 3mm.
- N-S uv coverage to VLBA sites is roughly equivalent to VLBA_MK to VLBA_SC in length.

M87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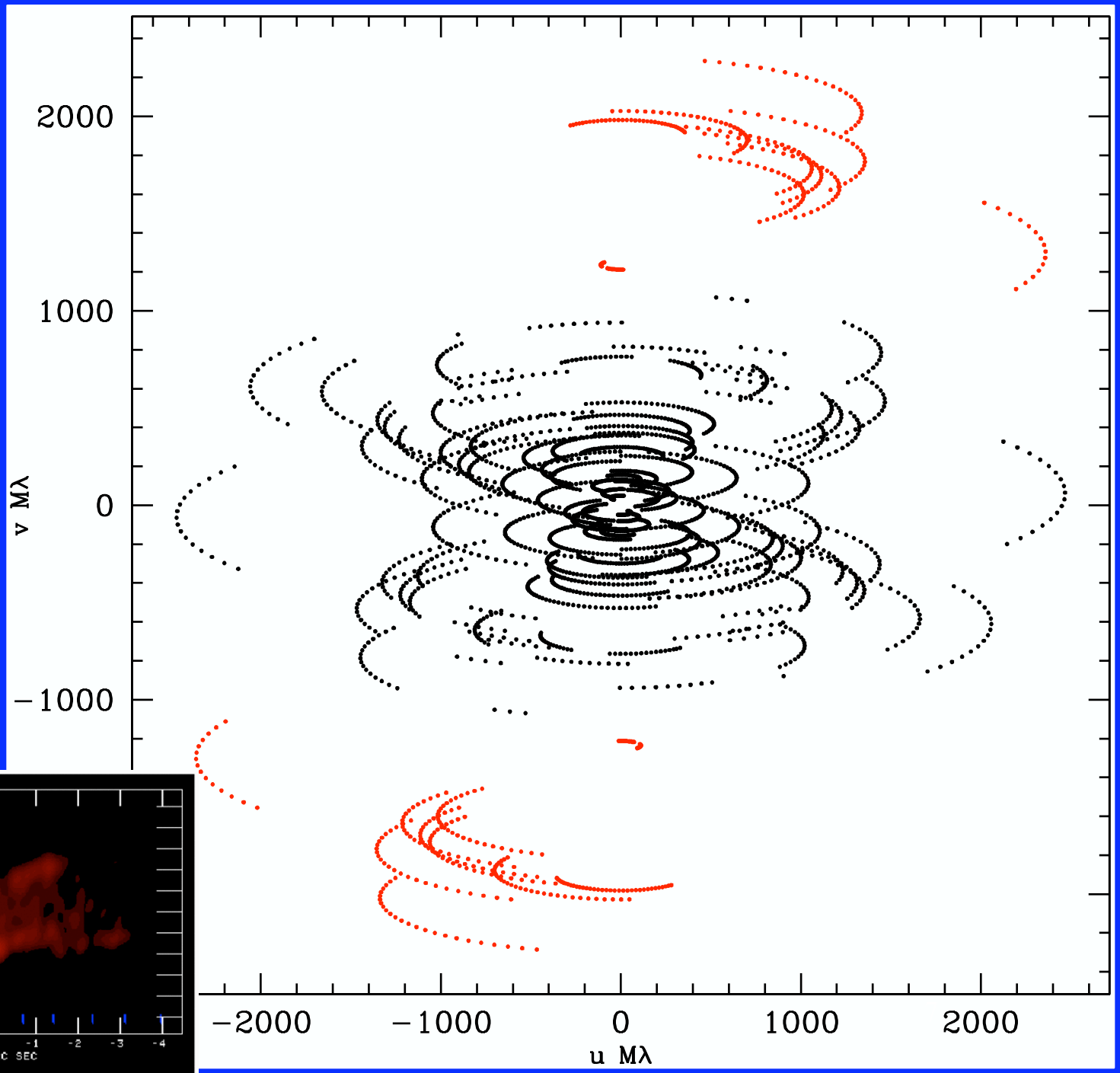
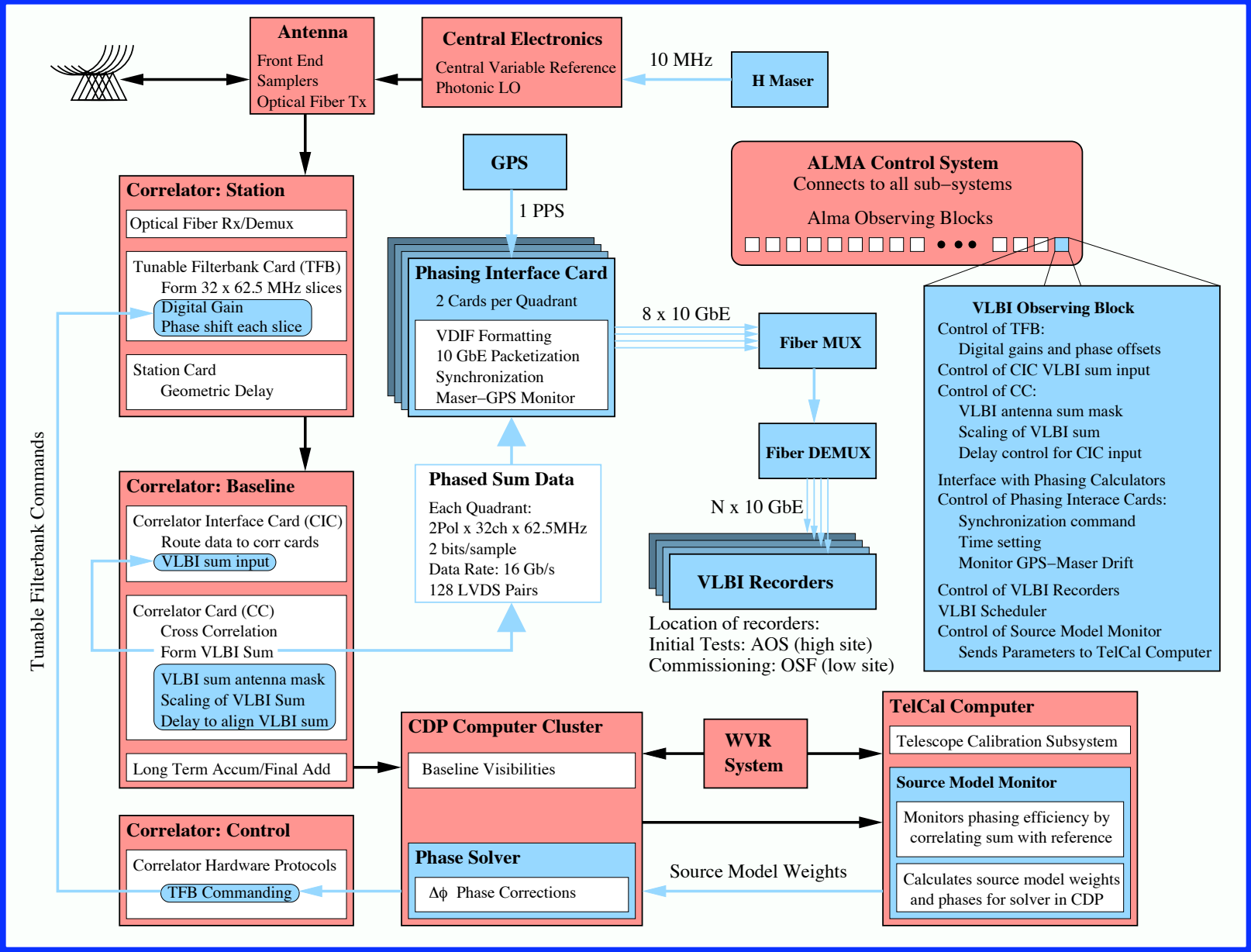

2000
1000
0
−1000
v Mλ
−2000
−1000
0
1000
2000
u Mλ

Design for Real-time ALMA phasing



ALMA Phasing Timeline

- Start 2011 (Fnding Proposal Submitted to NSF)
- Development, Design, Software: 2011-2013
- Integration, First light (1,3mm): 2013
- Commissioning: 2014-2015
- User Capability onwards.

- Implemented in parallel with normal ALMA construction: will not impact ALMA timeline.

7mm, 3mm VLBI with ALMA

- M87: jet genesis, collimation
- AGN: polarization, pan-chromatic studies
- SiO maser astrometry:
  - link IR-radio at Galactic Center
  - possible distance to LMC
- Gravitational Lenses: central images
- High resolution molecular absorption:
  - PKS 1830-211: isotopic abundances, evolution of fundamental constants
- LMT/GBT: parallax of SgrA* with VLBA (3mm)