Status of ALMA and synergies with ThunderKAT

2011-04-20

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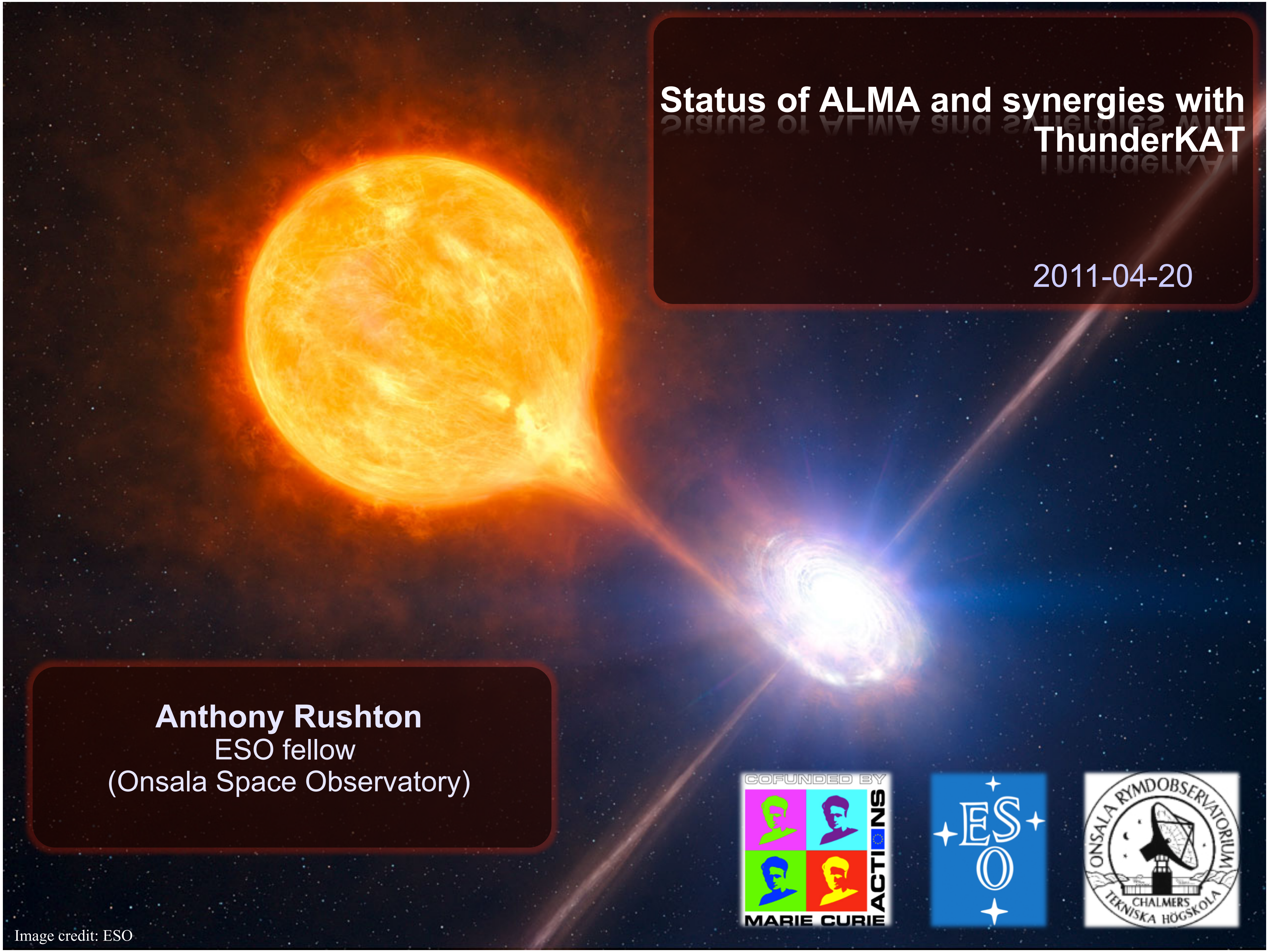


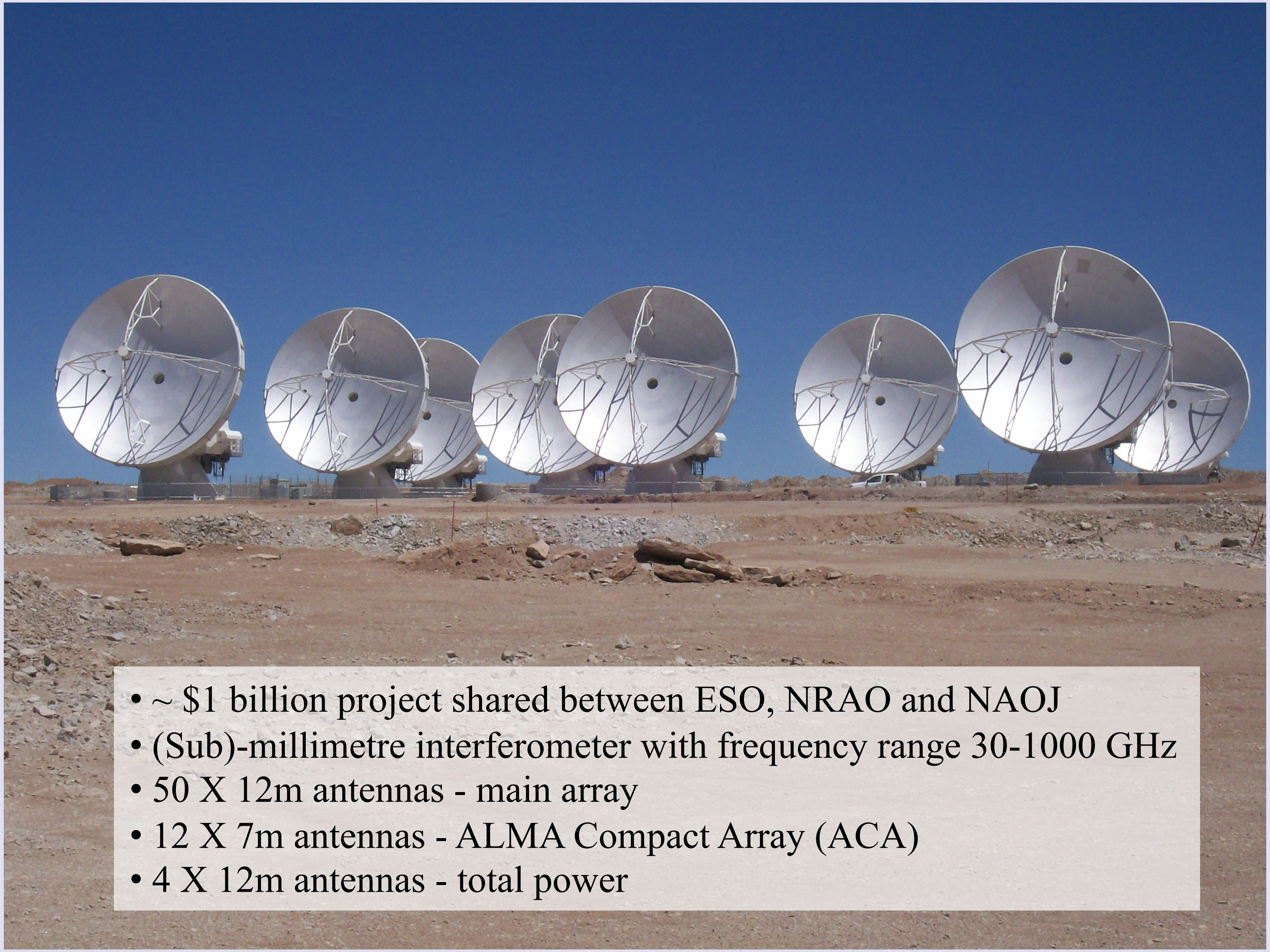
Image credit: ESO

Overview

- (Quick) status review of ALMA
- Transients at high-frequency
- ~~Synergies~~ Science between ALMA & ThunderKAT

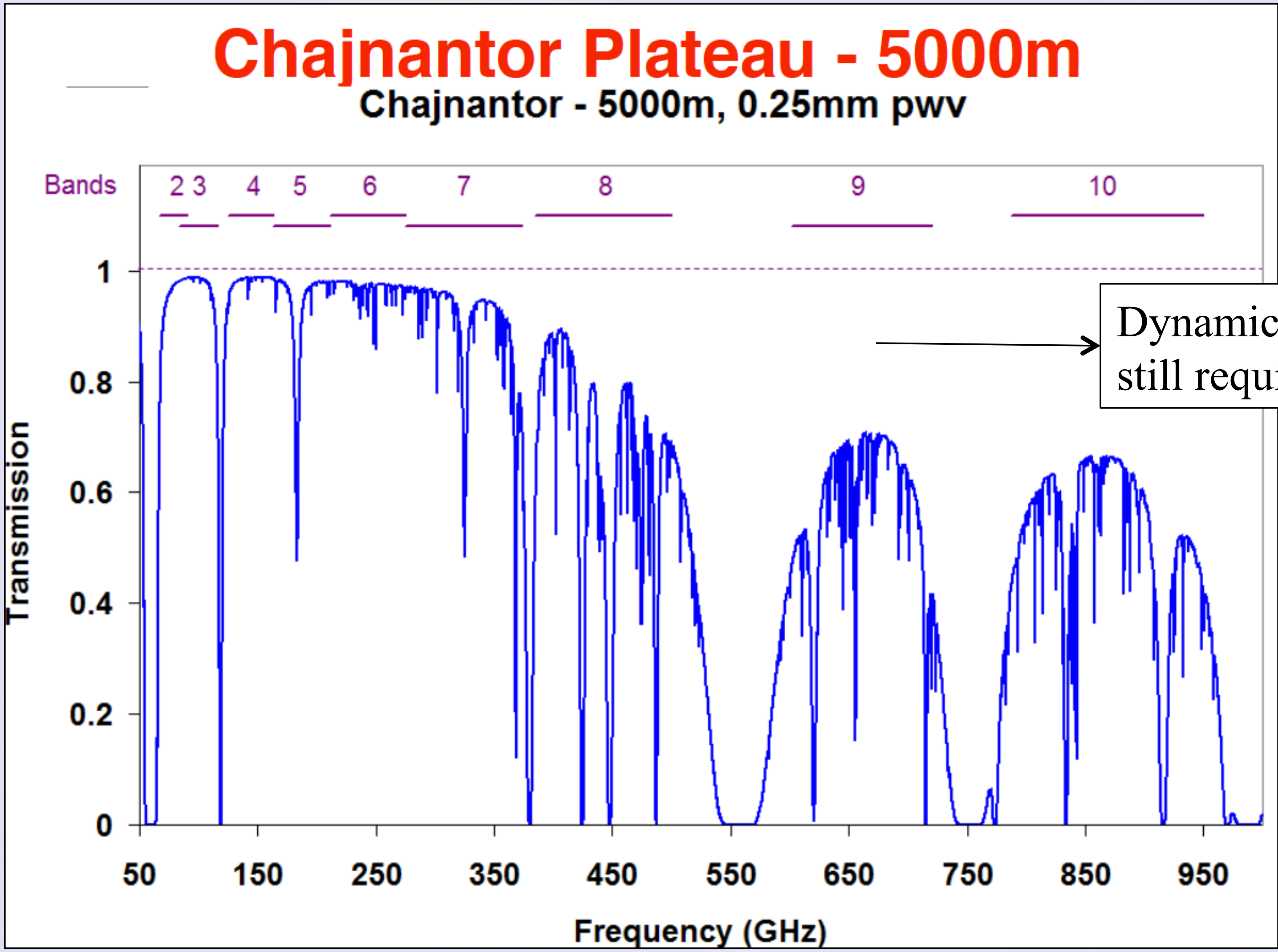
A) ALMA overview

Atacama Large Millimetre Array (ALMA)



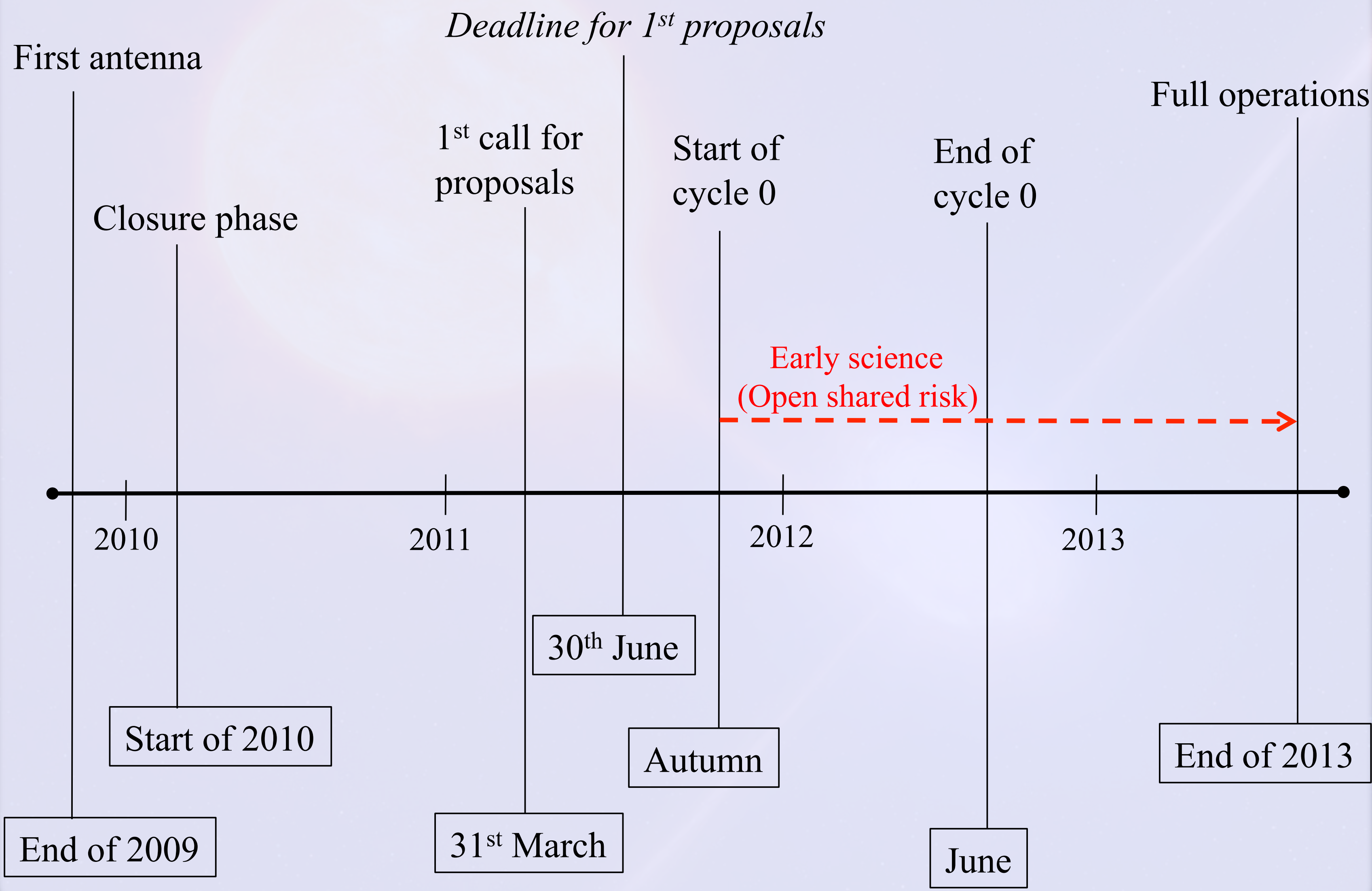
- ~ $1 billion project shared between ESO, NRAO and NAOJ
- (Sub)-millimetre interferometer with frequency range 30-1000 GHz
- 50 X 12m antennas - main array
- 12 X 7m antennas - ALMA Compact Array (ACA)
- 4 X 12m antennas - total power

World's best site for sub-mm astronomy!



Dynamic scheduled still required!

Expected project time line



ALMA early science: Cycle 0

- 16 X 12m antennas
- Configurations from compact (125m) to moderately extended (400m)
- Single field interferometry plus pointed mosaics with up to 50 pointings
- Bands 3, 6, 7 and 9 (3mm, 1mm, 0.85mm, 0.45mm)
- Several single spectral resolution modes
- 1 or 2 polarizations, no full polarization
- Amplitude calibration: 5% B3, 10% B6 and B7, 20% B9
- At most 30% of the available time for the first call (period Oct11-Jun12)
- No Solar observations
- **ToO and DDT possible** (*although limited available time*)

B) Transients at high-frequency
(Steady compact jets)

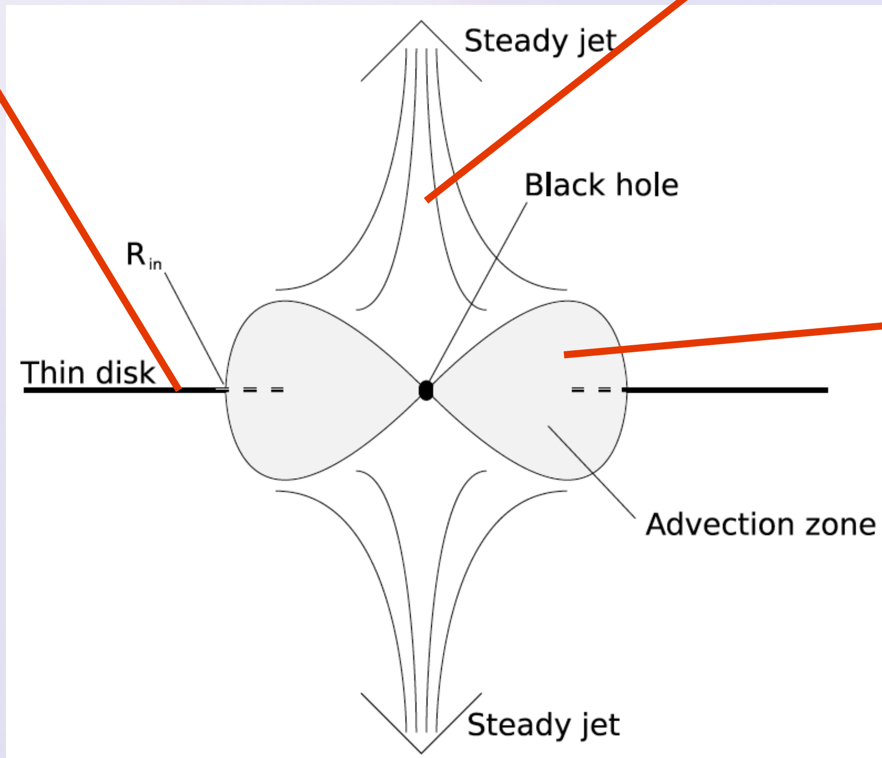
Know sources of transient (jetted?) emission

- Binary systems with a *compact object* and a *companion star*:
  - White dwarfs ($< 1.4\ M_\odot$)
  - Neutron stars/pulsars ($\sim 1.4\text{-}2\ M_\odot$)
  - Stellar black holes ($< 10\text{-}30\ M_\odot$)
- Intermediate black holes ($\sim 100\text{-}1000\ M_\odot$)
  - Ultra-luminous X-ray sources?
- Super massive black holes ($\sim 10^{6\text{-}8}\ M_\odot$)
  - Galactic Centre

The X-ray binary emission models

Thermal emission
(soft X-rays)

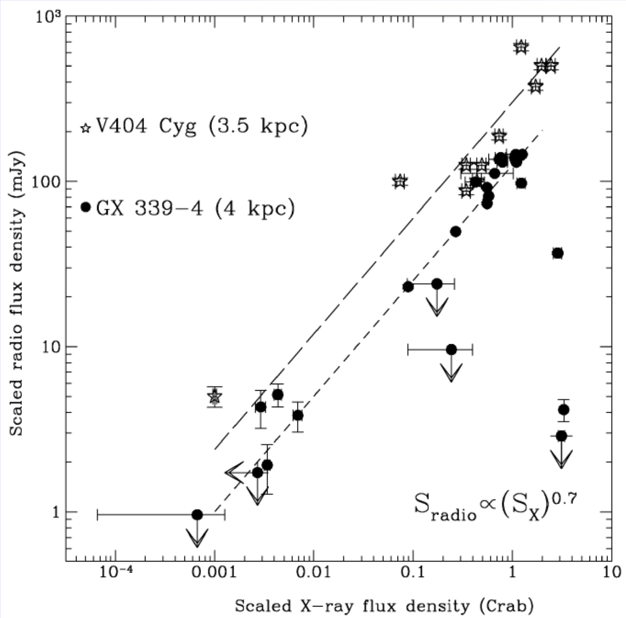
Synchrotron emission
(sub-mm & radio)

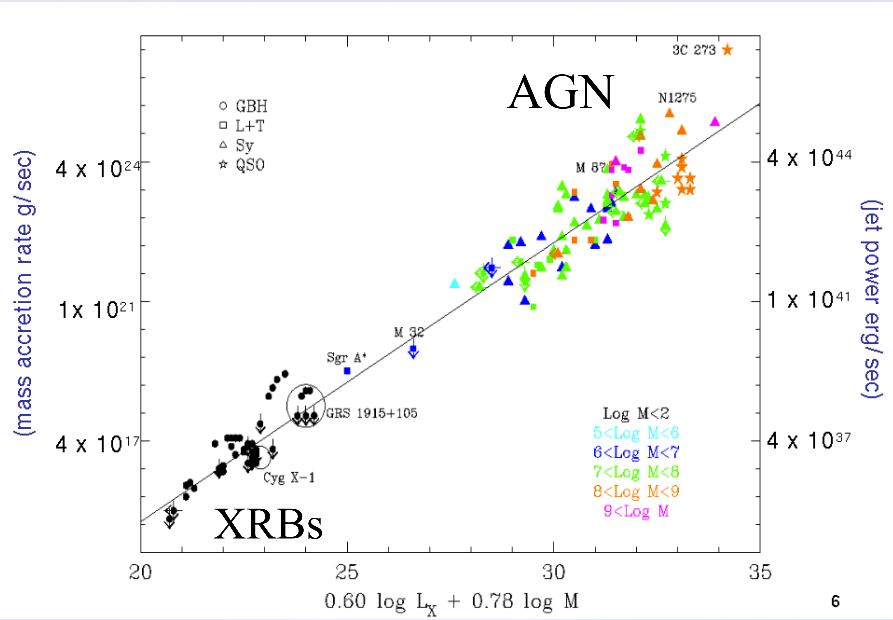


Non-thermal
emission
(hard X-rays)

The X-ray versus radio correlation

e.g. Gallo et al. (2003)





During the hard state it was empirically found:

$$\boxed{L_R \propto L_X^{0.58\pm0.16}}$$

Moreover, Merloni et al. (2003) suggested this relationship fundamentally scales:

$$\boxed{L_{X-ray} \propto L_{radio}^{0.6} M^{0.81}}$$

A radiatively efficient jet?

$$L_{\mathrm{Radio}} \propto Q_{\mathrm{jet}}^{17/12}$$

Blandford & Konigl (1979)

$$L_{\mathrm{X}} \propto \dot{m}_{\mathrm{in}}$$

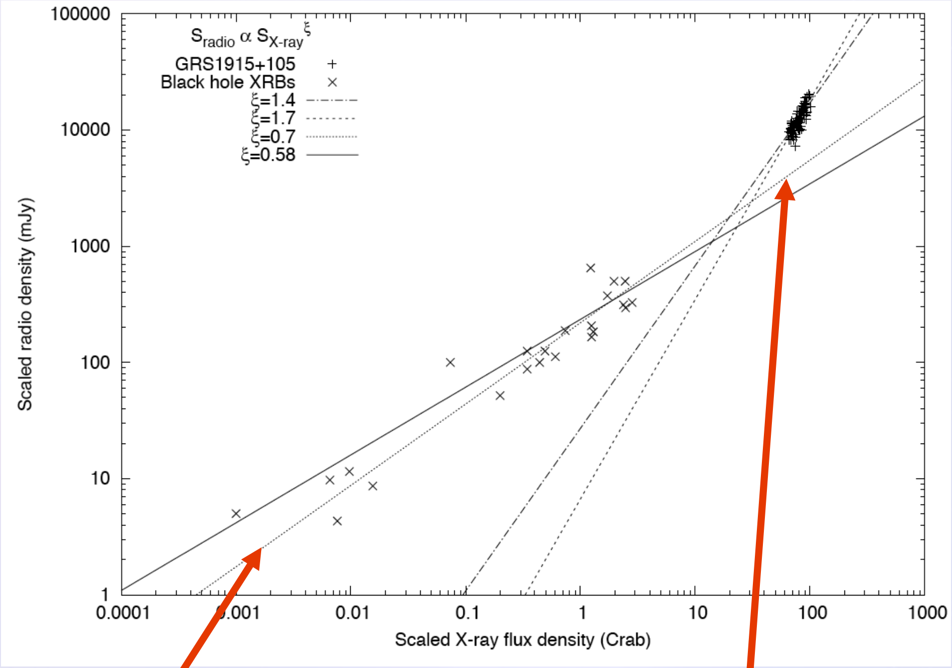
Shakura & Sunyaev (1973)

$$L_{\mathrm{X-ray}} \propto \dot{m}_{\mathrm{in}}^{2}$$

Rees et al. (1982);
Abramowicz et al. (1995)

Assuming flat jet spectrum!

Rushton et al. (2010)



Other BH sources radiatively inefficient? (Gallo et al. 2006)

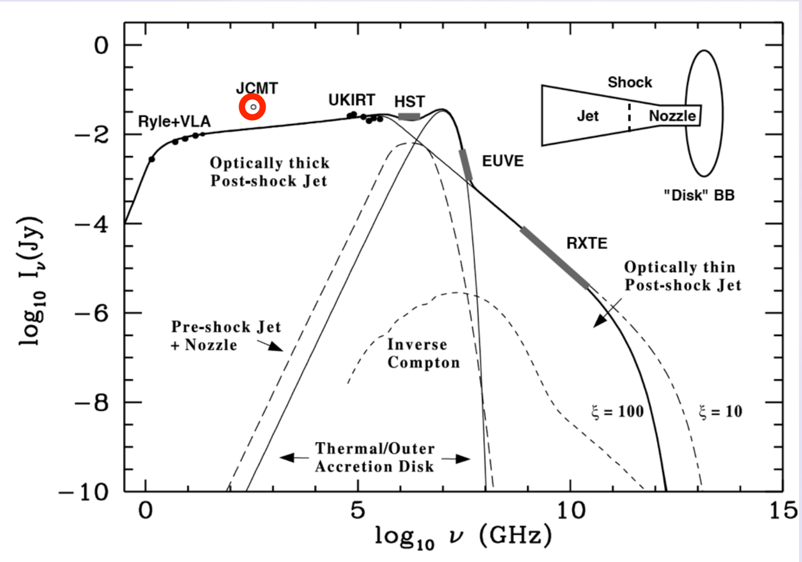
$\xi \sim 0.7$

GRS 1915+105 radiatively efficient?

$\xi \sim 1.4$

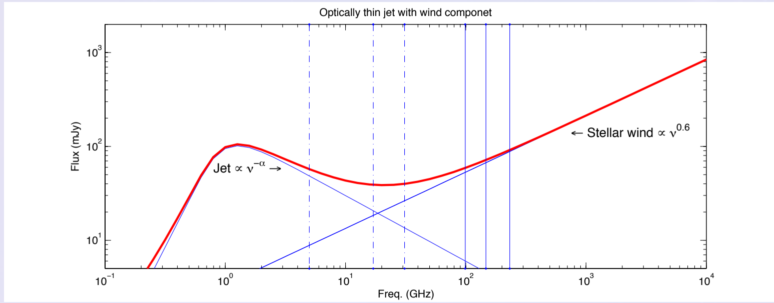
What about the SED?

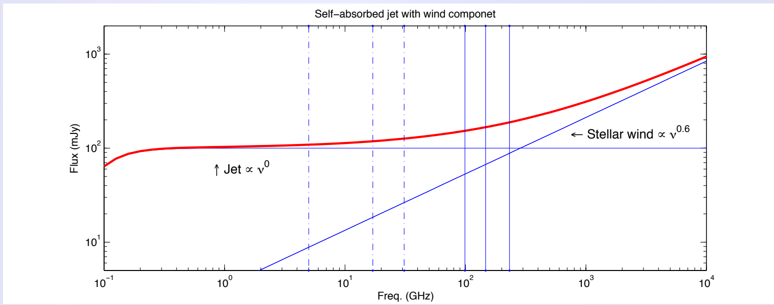
J1118+480



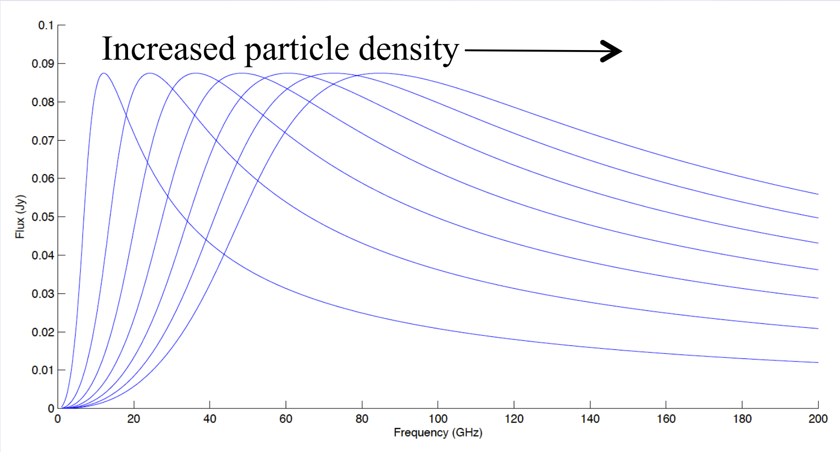
Markoff, Falcke & Fender (2001)

But do we understand all the emission mechanisms?





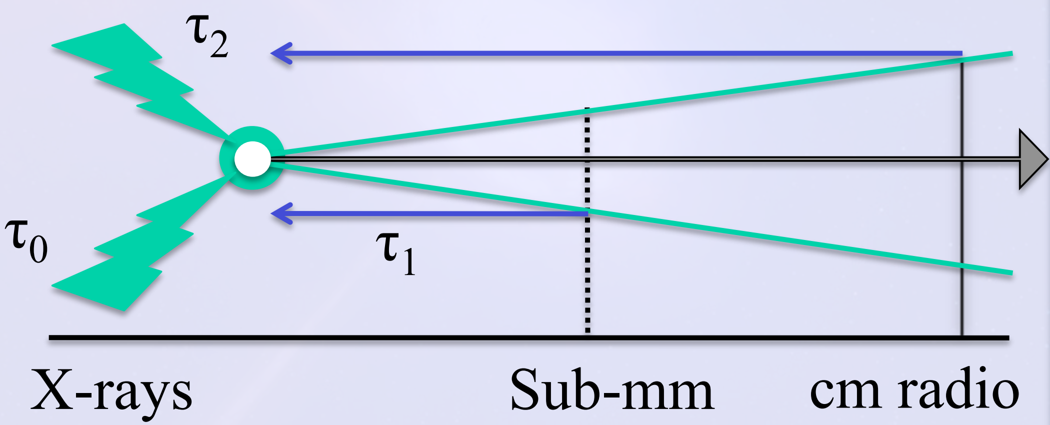
Self-absorbed jet



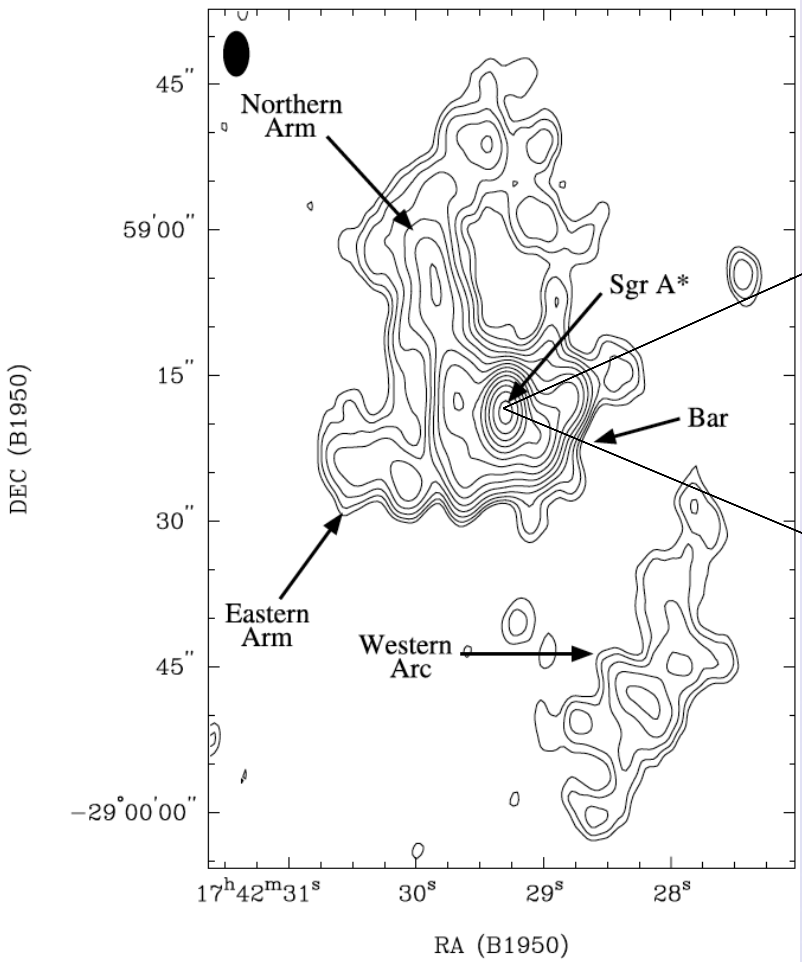
$$S_\nu = S_0 \left(\frac{\nu_1}{\nu_0}\right)^{-\alpha} \left(\frac{\nu}{\nu_1}\right)^{5/2} \left\{1 - \exp\left[-\left(\frac{\nu_1}{\nu}\right)^{\alpha+5/2}\right]\right\}$$

Blandford, Hughes, Longair, etc.

- Shortest correlation time $\Delta\tau \propto \lambda$
- *Optical observations* can be *extinct* or *confused* by stellar winds/ thermal emission

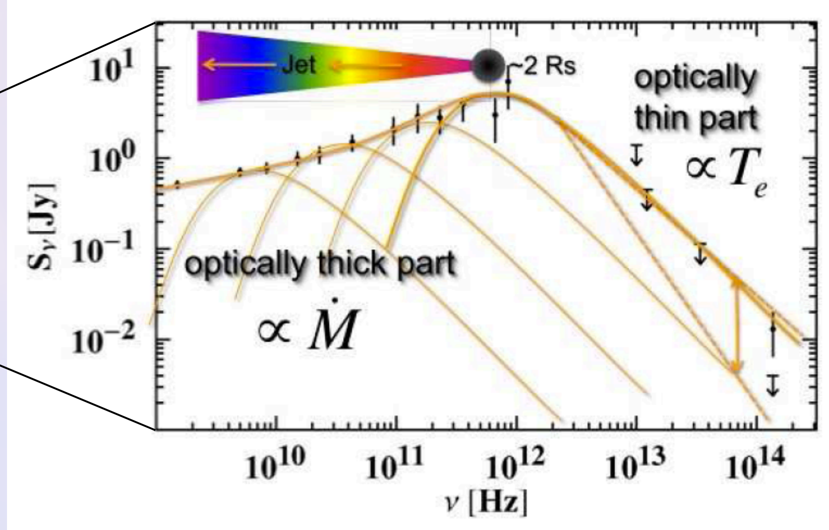


OVRO - 86 GHz



Christopher et al. (2005)

The sub-mm "bump"

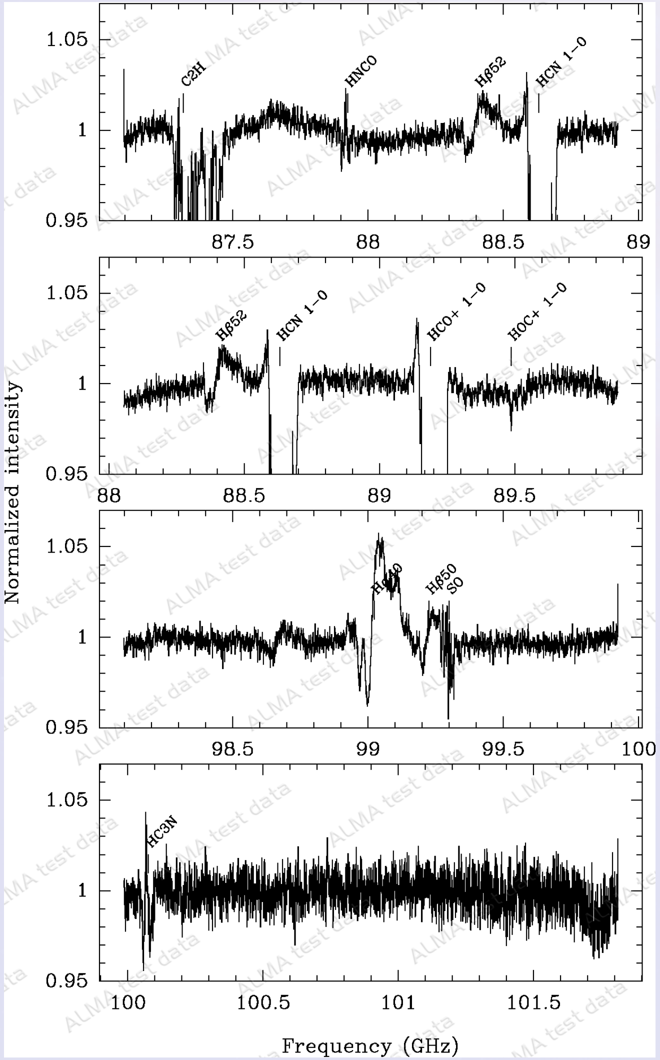


Falcke et al. (2011)

"Radio variability show a clear time lags have been seen 43 and 22 GHz"

ALMA CSV data of Sgr A*

ALMA *test data* - band 3

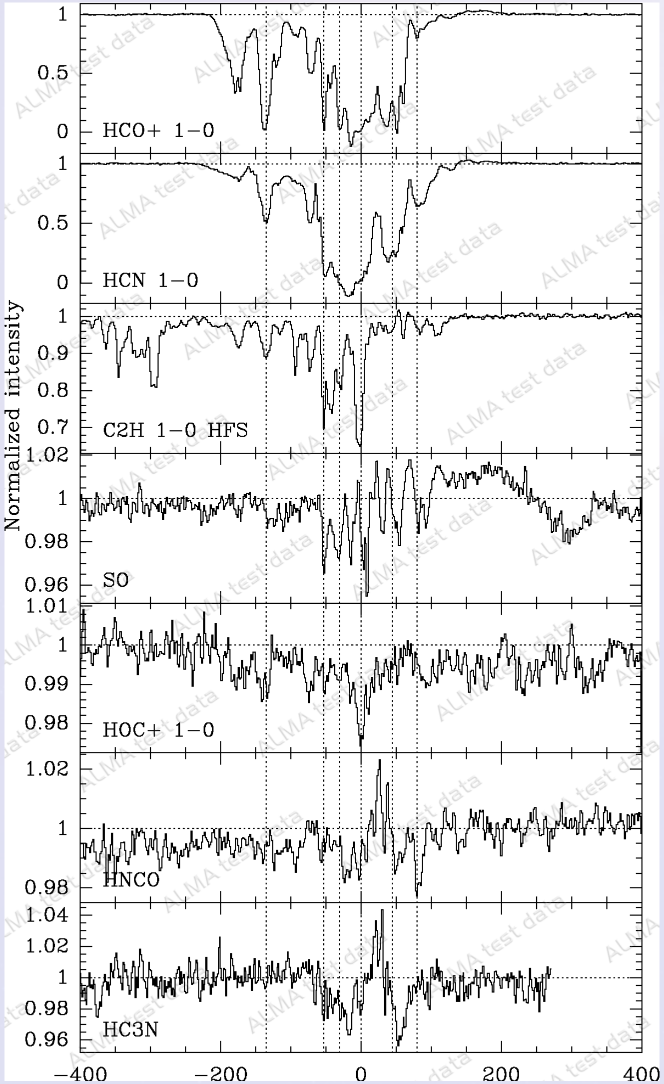


- Five 12 metre antennas
- 60 minute epochs
- Band 3 receiver
- Four spectral windows (spw)
- Center on 88, 89, 99 and 101 GHz
- 3840 channels per spw, each 488.3 kHz
- Total bandwidth of 1.875 GHz

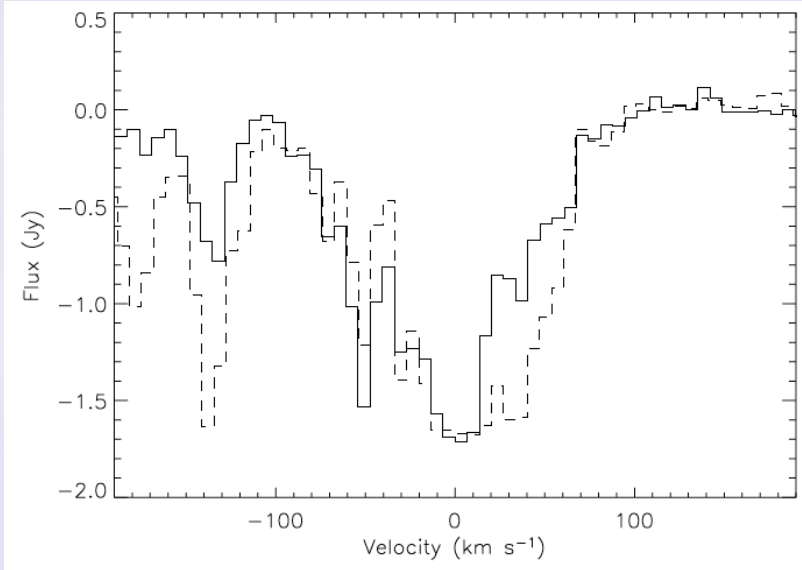
CASA
Common Astronomy Software Applications

Molecular absorption around Sgr A

ALMA *test data* - band 3



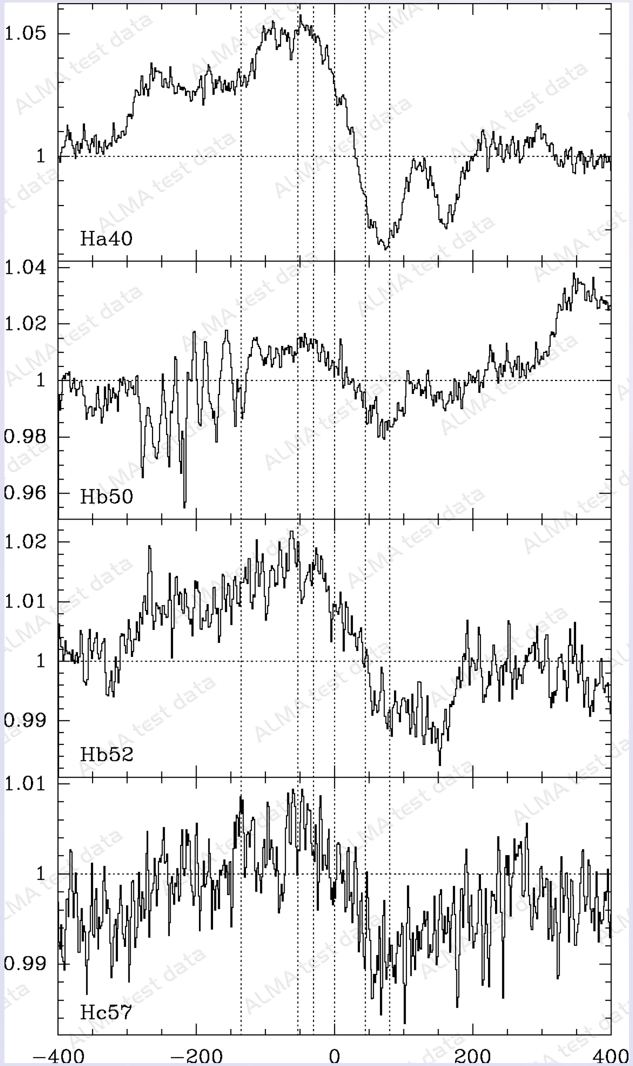
OVRO data

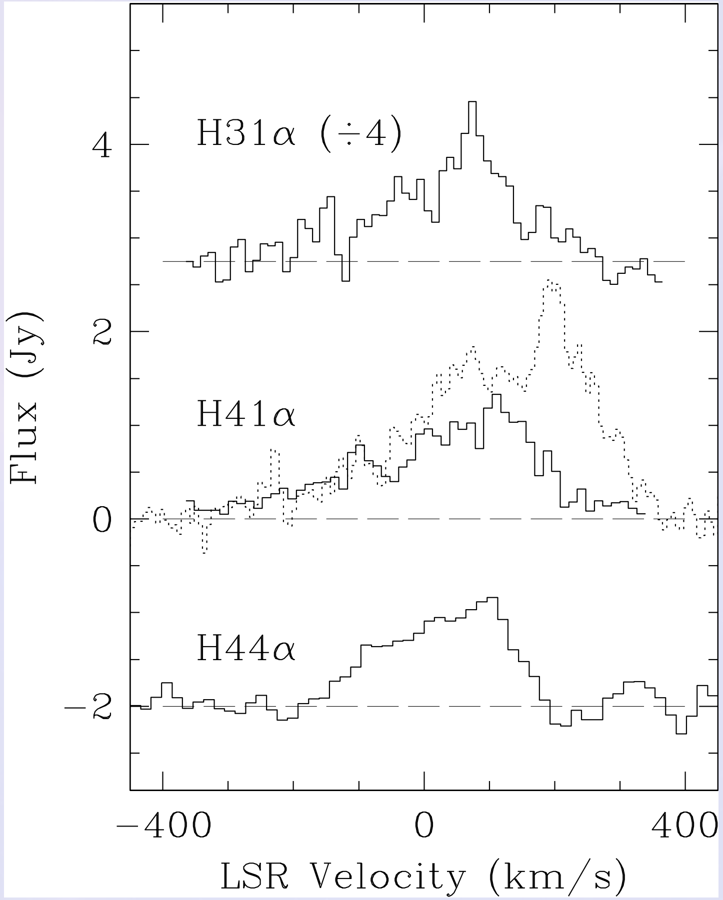


HNC (solid line), HCO^+ (dashed)
Christopher et al. (2005)

Hydrogen recombination lines from Sgr A*

ALMA *test data* - band 3





OVRO data taken from Shukla et al. (2004)

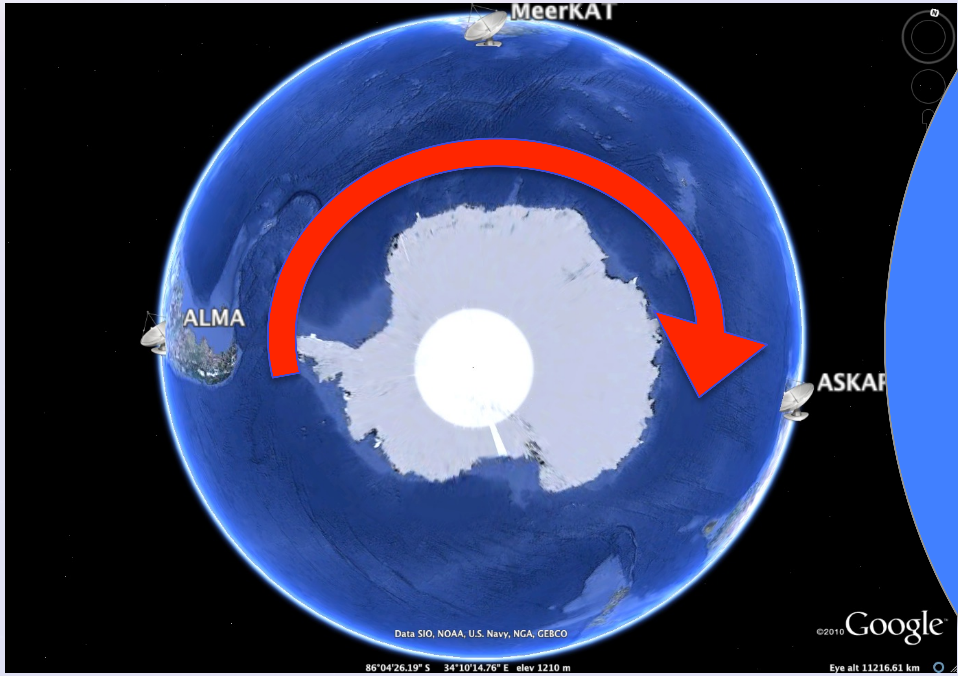
C) Science between ALMA and ThunderKAT et al.

Field of view

MeerKAT
1 deg^2

Why we picked these sites!?

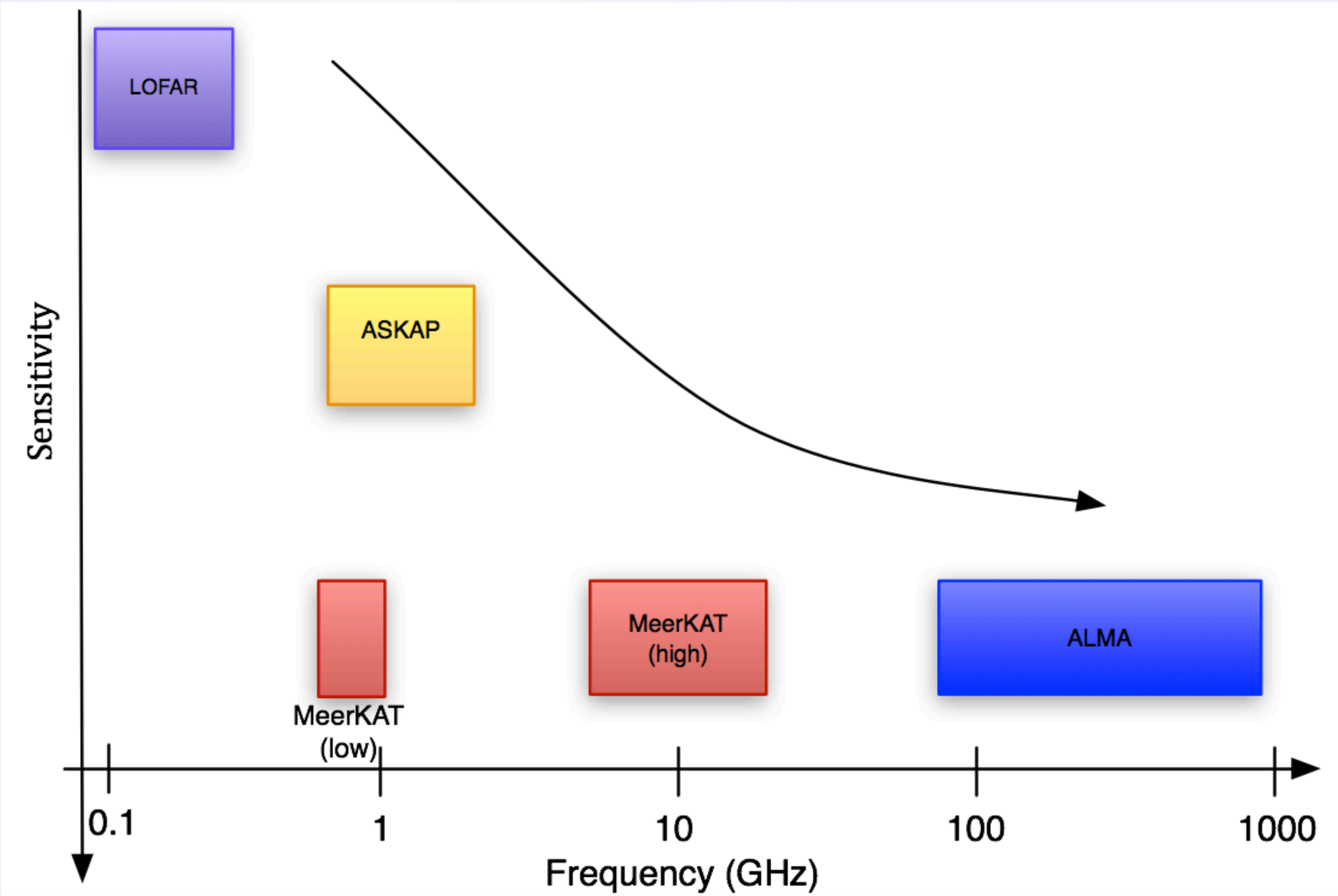
ALMA
0.02 deg^2



ASKAP
30 deg^2

(FoV to scale)

Five decades of observations



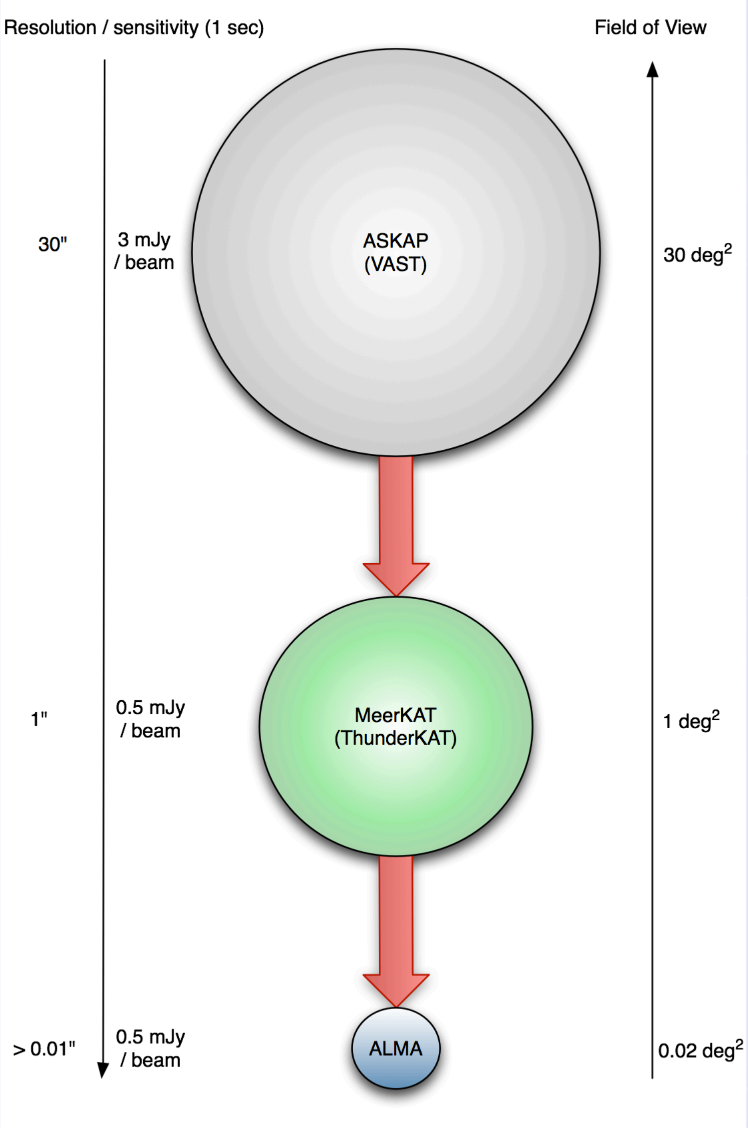
Resolution/Sensitivity

•ASKAP -> MeerKAT -> ALMA

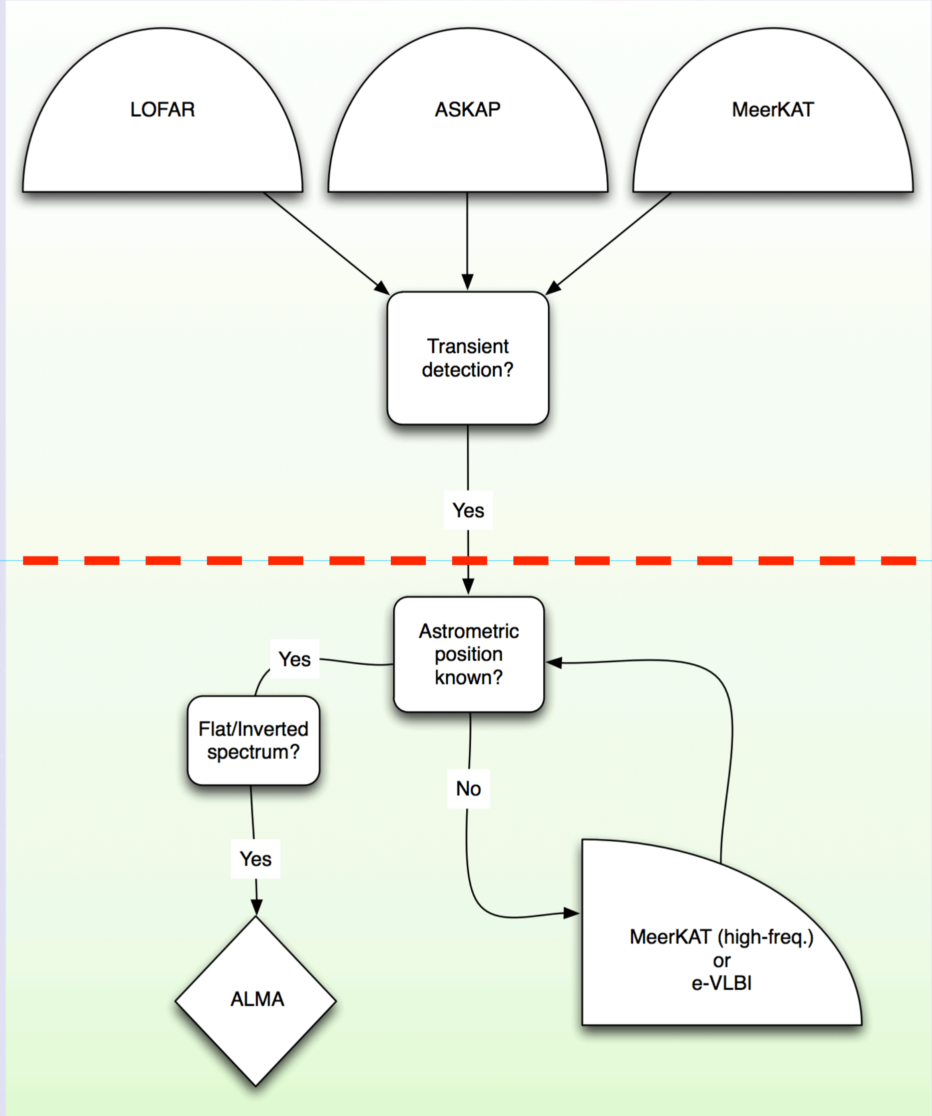
•ASKAP has best FoV

•MeerKAT has similar sensitivity to ALMA B-3 and can follow-up

•ALMA has snap shot “like-VLBI” resolution/complementary wavelengths



ALMA transient follow-up



The follow up pipline
Require:

- Source confirmation
- Astrometry
- Estimated ALMA brightness
- Time constraints

Conclusion

- ALMA is not a survey instrument
  - We need LOFAR, VAST, ThunderKAT…
  - But ALMA will be able to do >10 mas snap shots
- MeerKAT could be an important partner for ALMA
  - Same sky and similar sensitivity
  - Could provide the required spectral and astrometric confirmation
- If there is a background of radio-only emitting transients, ALMA is the next logical bands to follow-up the SED

Tweet me: @astronomer

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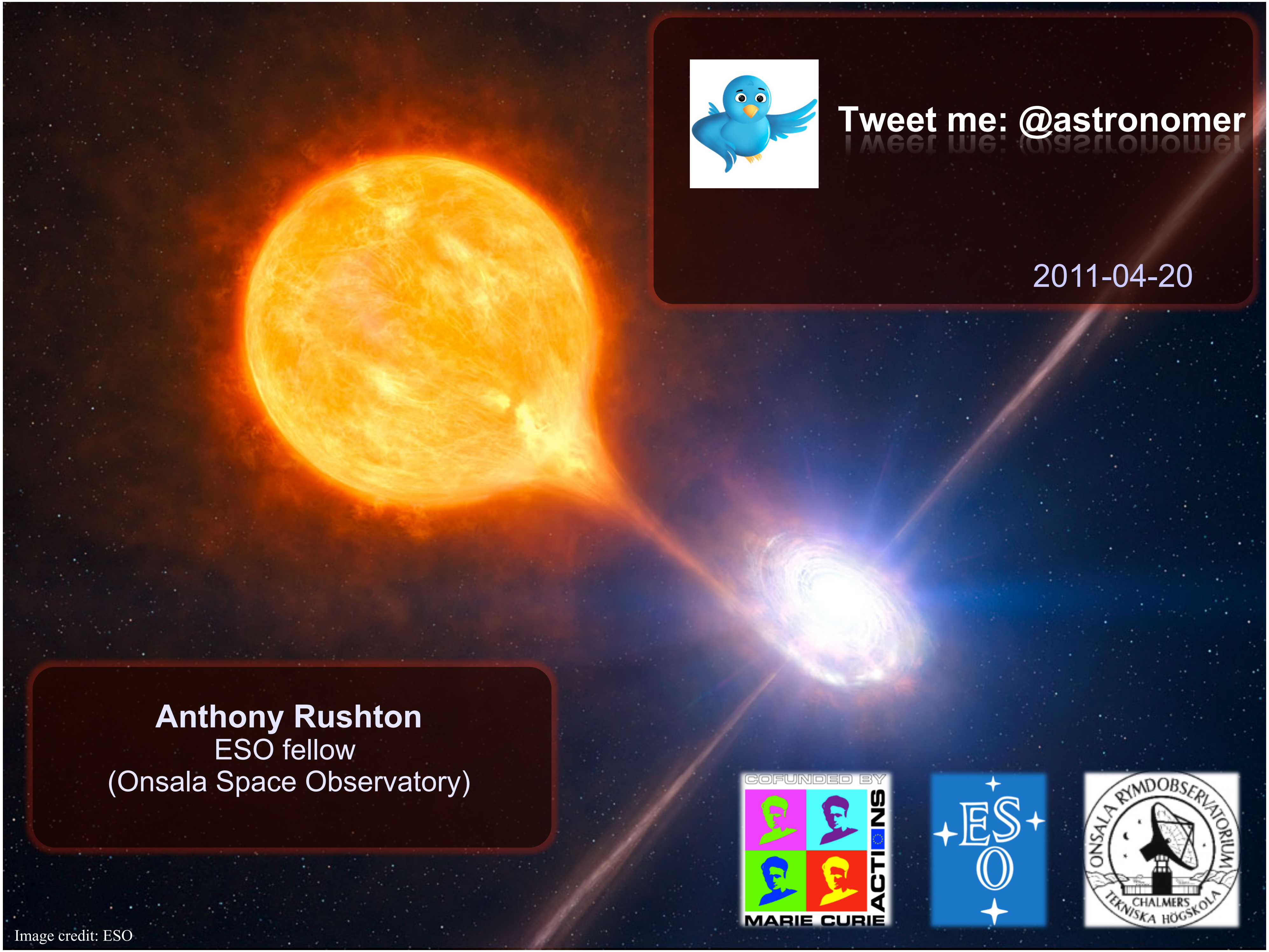

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