

# APEX Extragalactic Surveys

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MAX-PLANCK-GESellschaft



OFF ROAD  
DRIVING  
PROHIBITED





# The Case for APEX in the ALMA Era

## **Zero Spacing**

APEX Beam is larger than ALMA FOV

## **Arrays**

50 pixels in FOV = 50 antennas in mapping speed

## **Bolometers**

Larger bandwidth

# Outline

**CO Surveys**

**SZ Survey**

**Chandra Deep Field**

**COSMOS Field**

**Nearby Galaxies in Continuum**

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~~**SZ Survey**~~ (Frank Bertoldi)

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~~Nearby Galaxies in Continuum~~

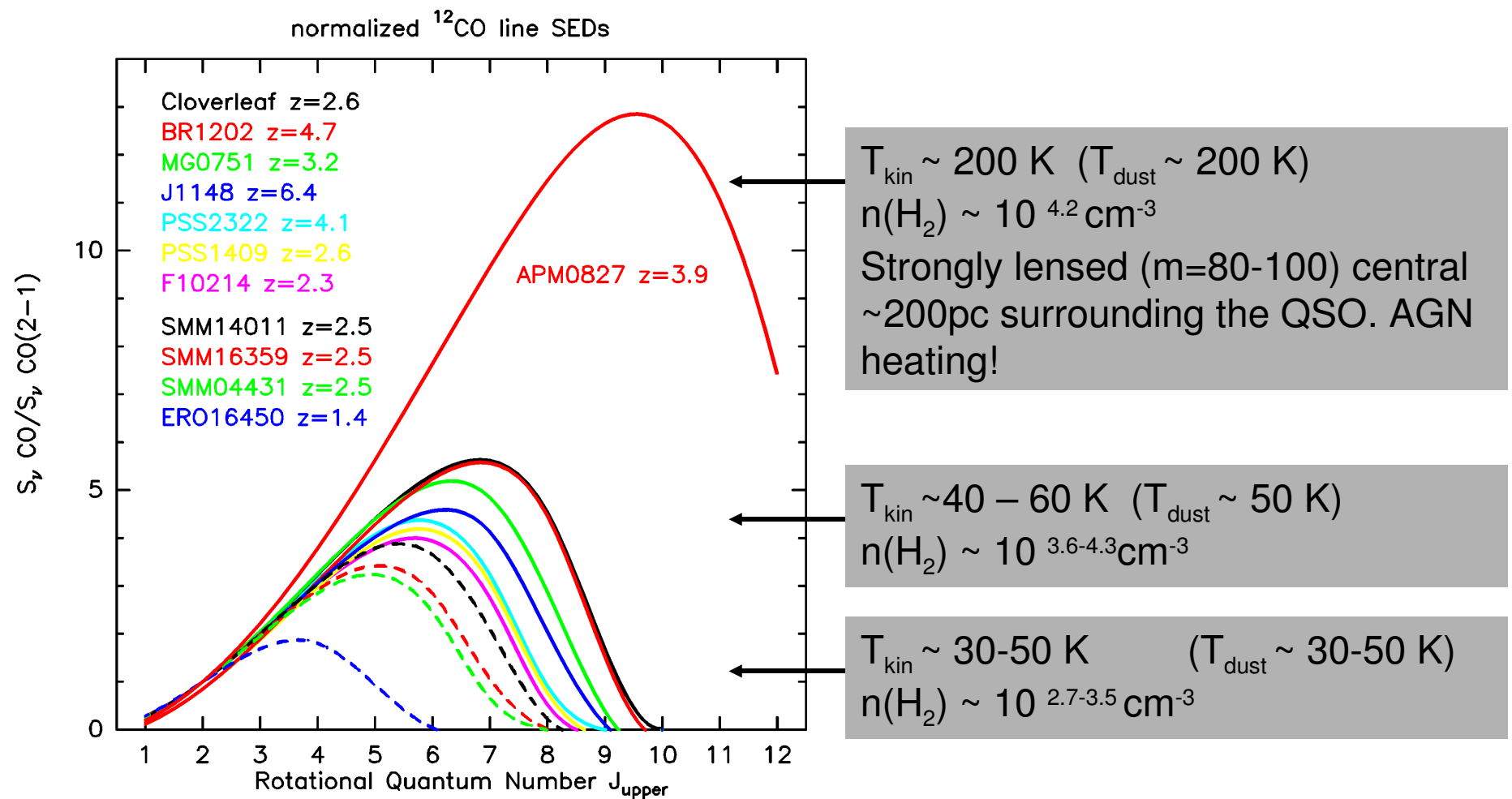






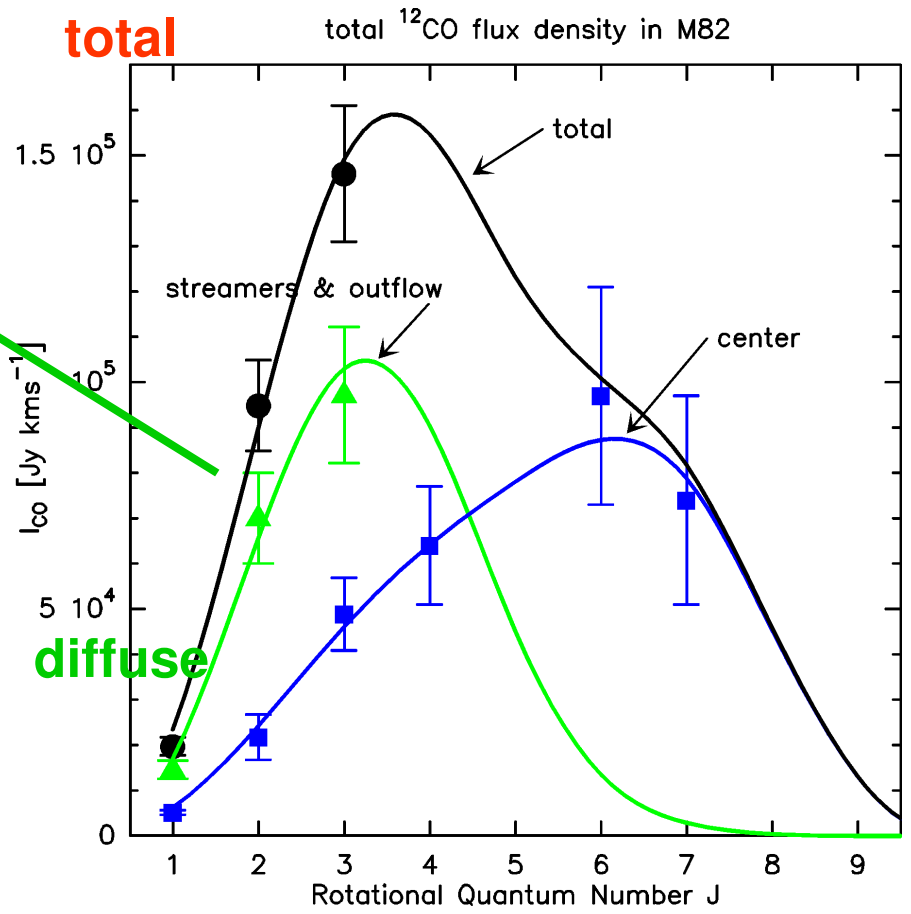
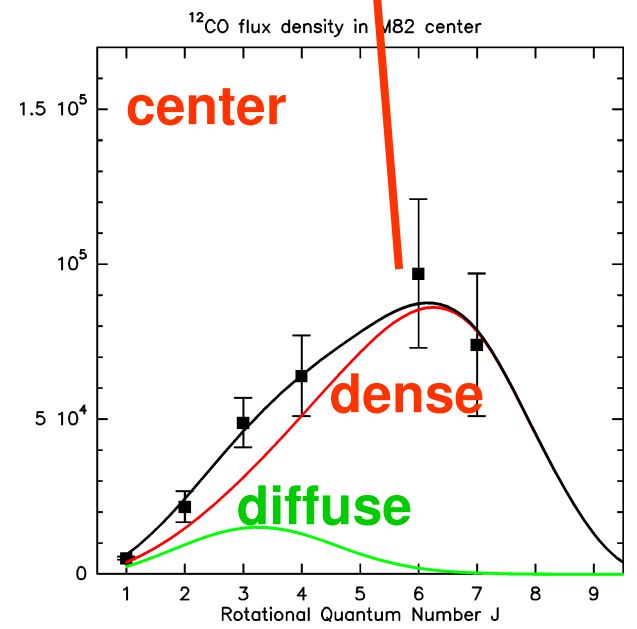
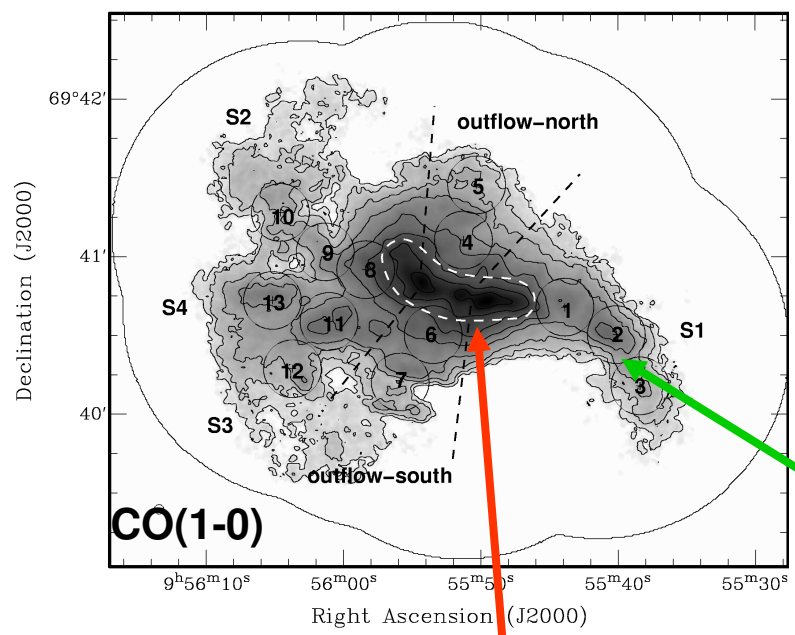
# Survey of Active Galaxy Centers

R. Guesten et al.

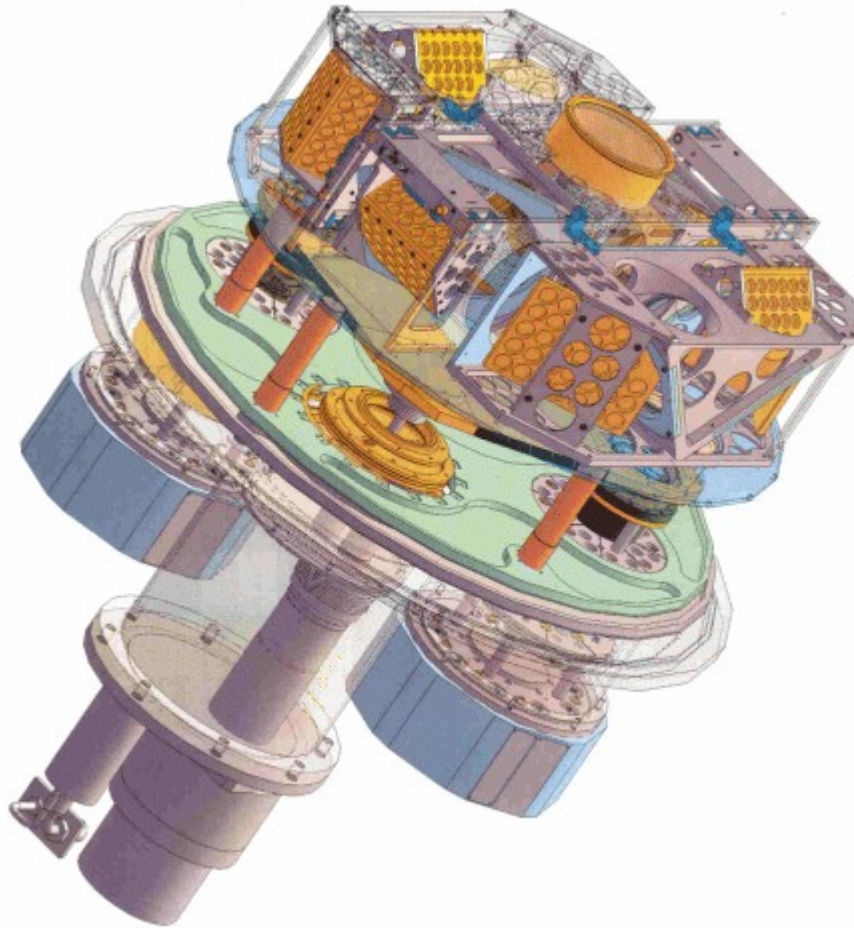


# Survey of Nearby Galaxies

A. Weiss



# CHAMP+ Array Receiver



**7 beams at 650 GHz**

**+**

**7 beams at 800 GHz**







# APEX-SZ Collaboration:

## Max Planck Institute for Radioastronomy:

K. Basu, F. Bertoldi(U Bonn), R. Güsten, R. Kneissl, E. Kreysa, K. Menten, D. Muders, M. Nord, F. Pacaud (U Bonn/MPE), R. Schaaf (U Bonn), P. Schilke, F. Schuller, A. Weiss

MPE: H. Böhringer

## University of California, Berkeley:

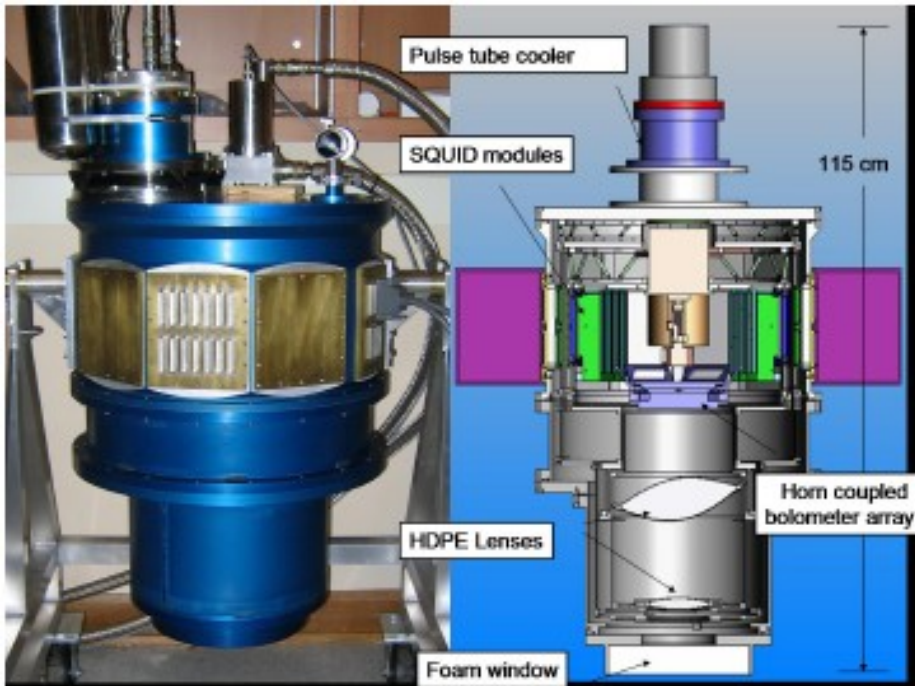
Physics Department: Sherry Cho (NIST), W. Holzapfel, A. Lee, M. Lueker, J. Mehl, T. Plagge, P. Richards, D. Schwan, M. White; LBNL: H. Spieler

U McGill: M. Dobbs, T. Lanting

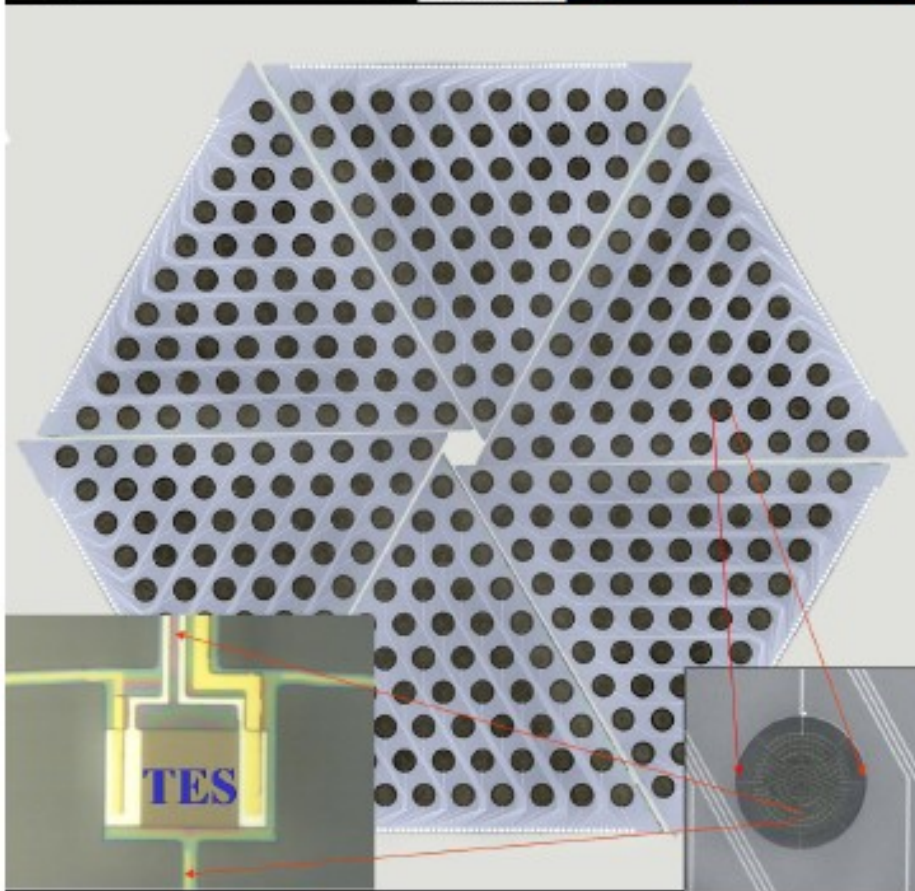
U Colorado: N. Halverson

# APEX SZ Camera (ASZCA)

UC Berkeley



- Spiderweb Transition Edge Sensor bolometers
- Micro-fabricated array with 320 elements
- 0.4 degree field-of-view
- SQUID readout, frequency multiplexing
- observing frequencies (90) 150 (220) GHz
- $\sim 100 \text{ deg}^2$ , several months integration,  $10 \mu\text{K}$ , 60" FWHM (150 GHz) resolution



## Science with APEX-SZ

Evolution of cluster mass function: constraints on  $\sigma_8 - \Omega_M$

Environmental galaxy studies at high  $z$

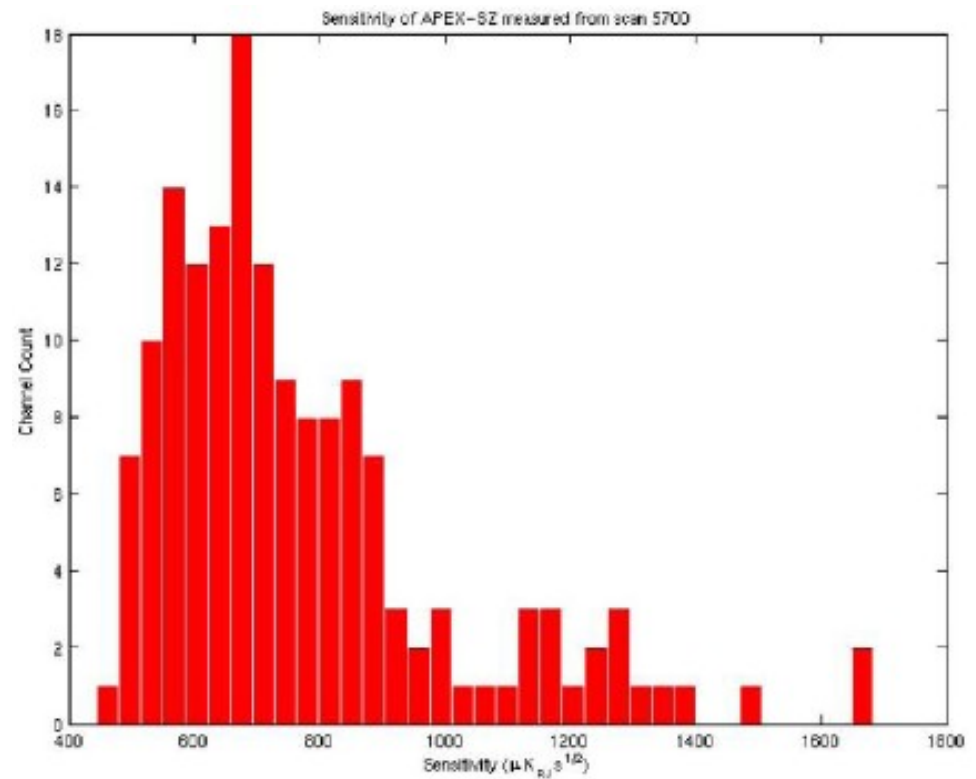
Population of inverted spectrum radio sources

High redshift star forming galaxies

Thermal history, evolution of gas fraction and M-T relation

Cluster selection, contamination,  $M - Y$  scaling relation

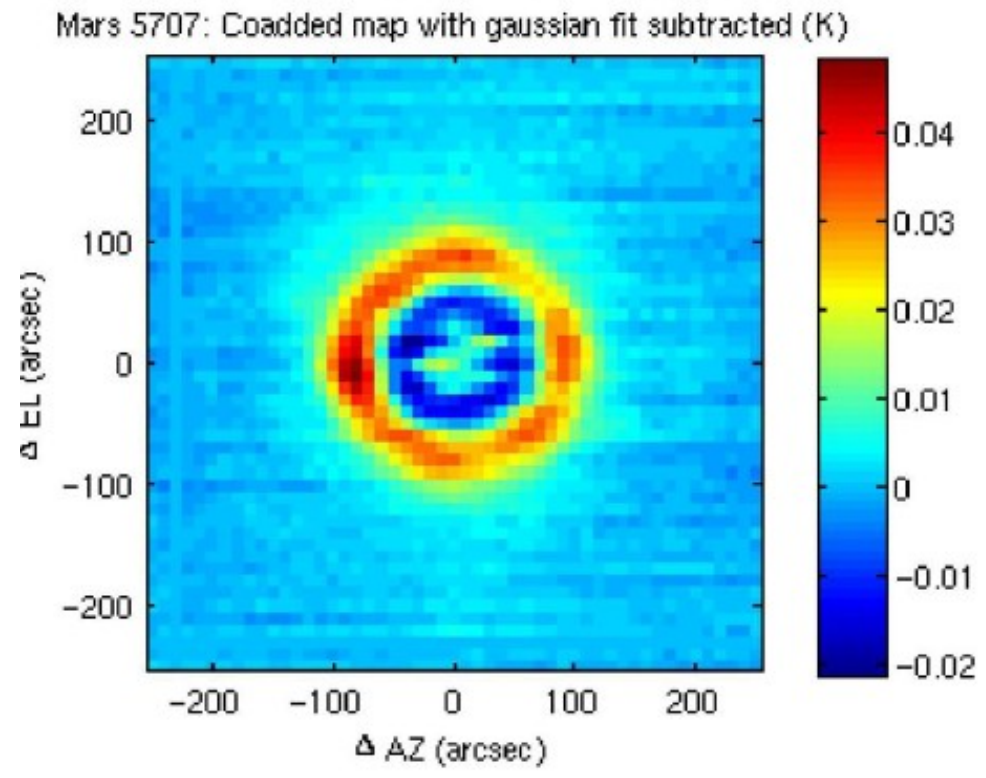
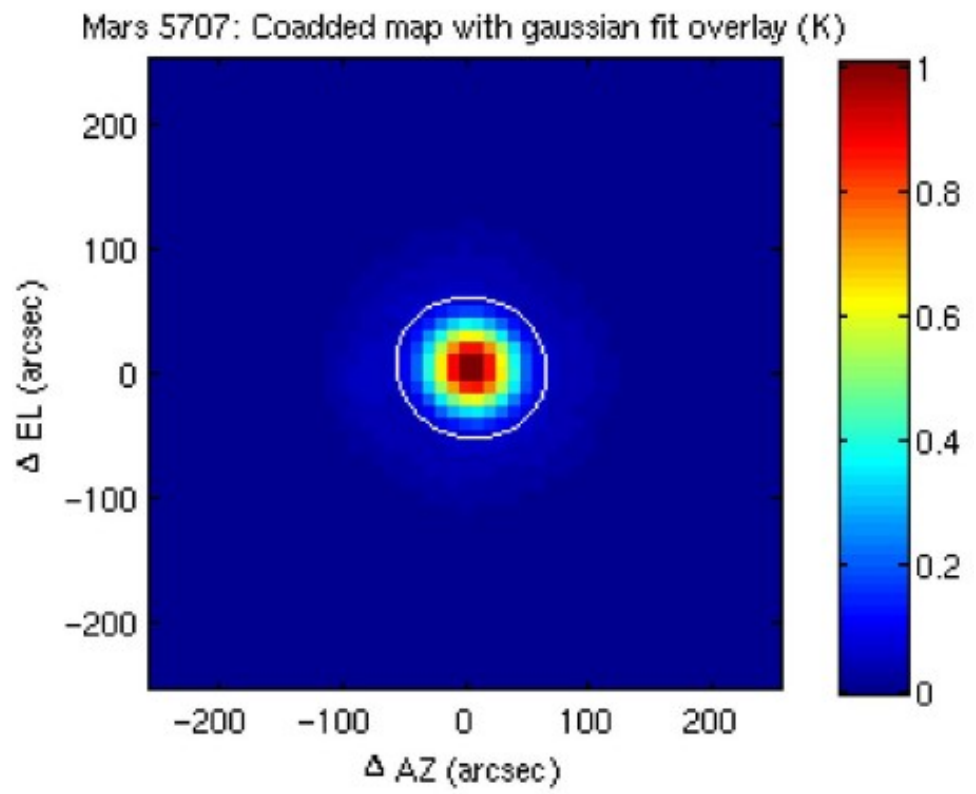
# APEX SZ Pixel Gains and Sensitivities



# APEX SZ Beam Pattern

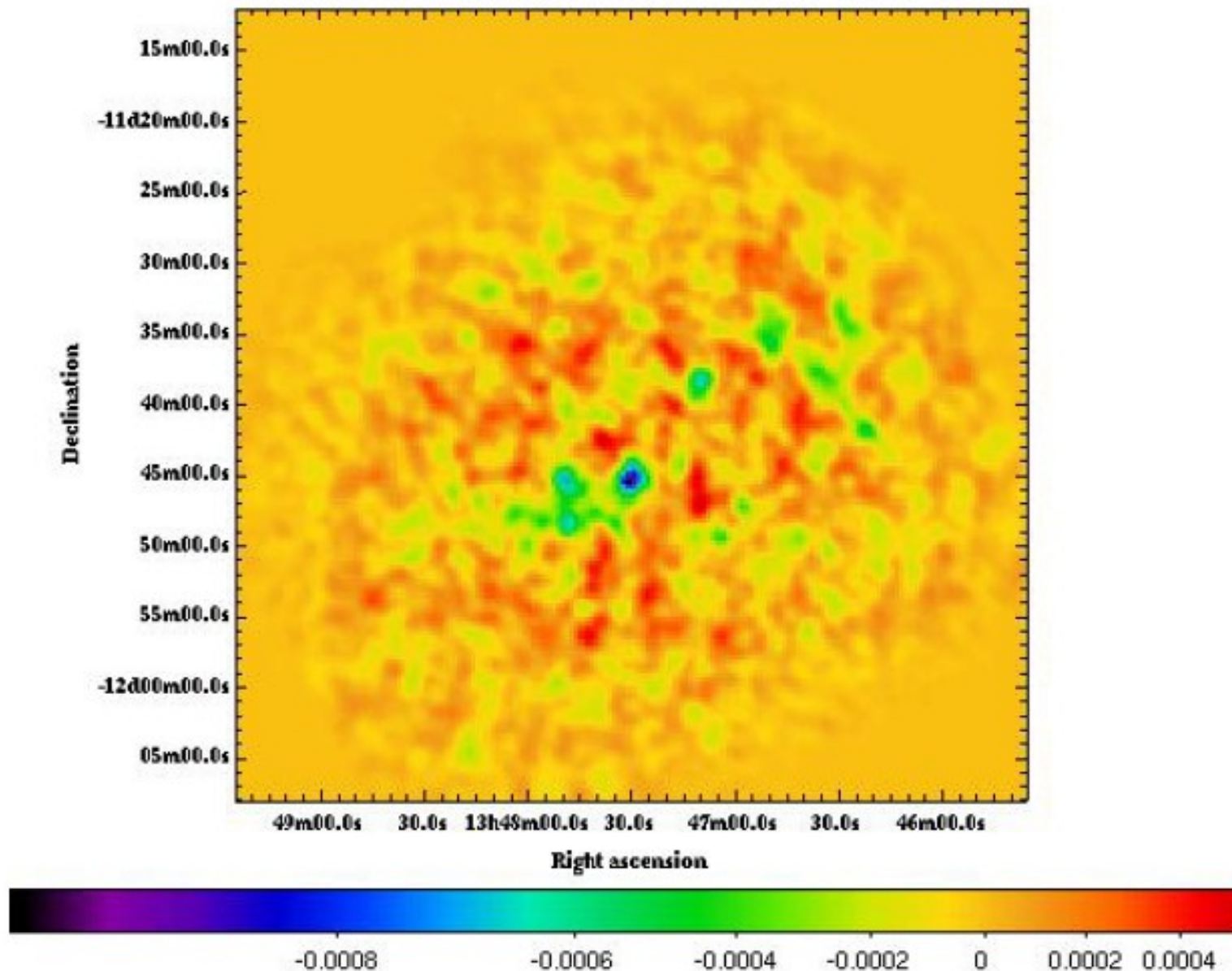
Underilluminated Primary (60' FWHM)

Pattern in line with expectations...



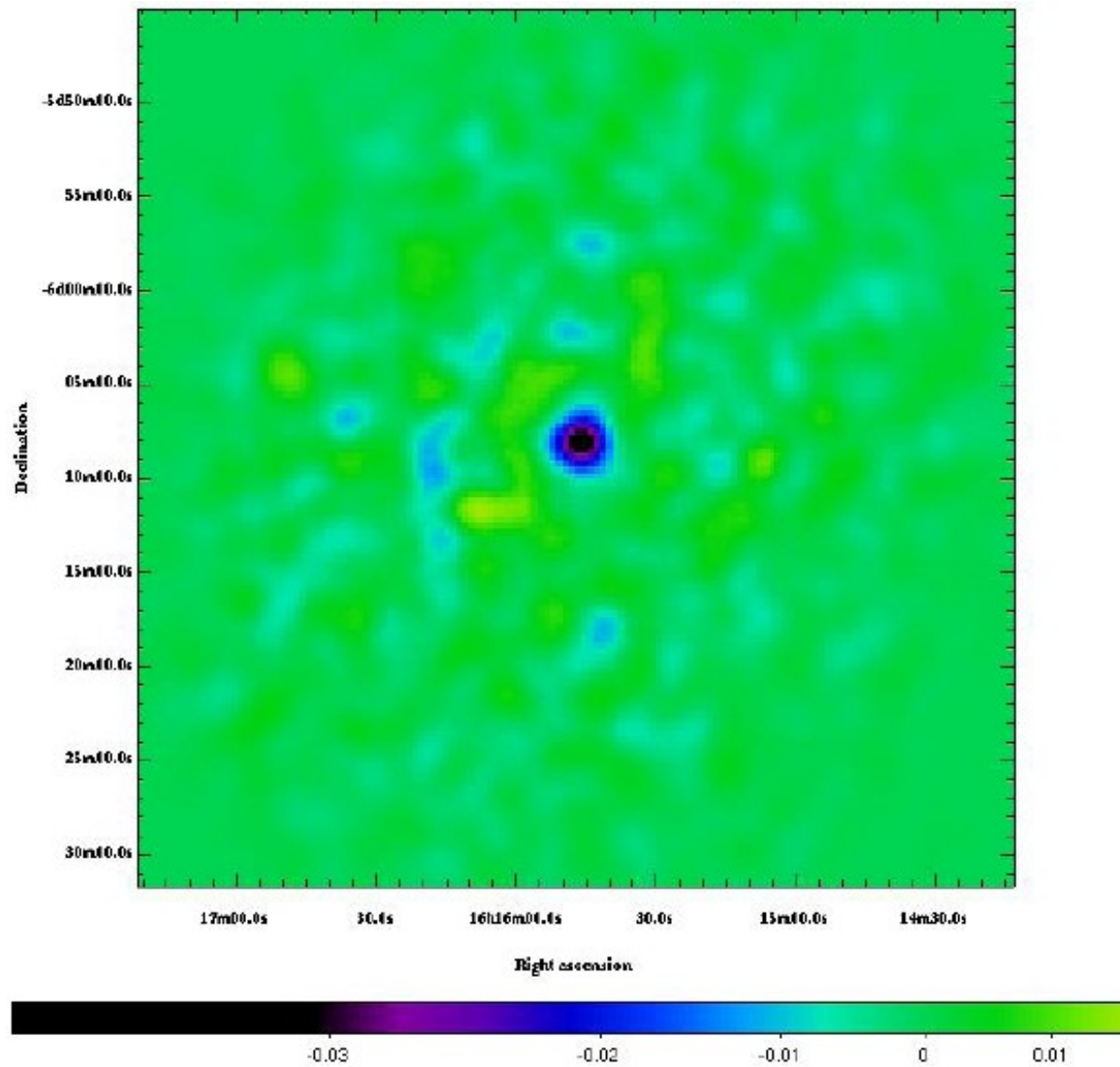


# RXCJ1347-1145 ( $z=0.45$ )





# RXCJ 1615-0608 $z = 0.20$



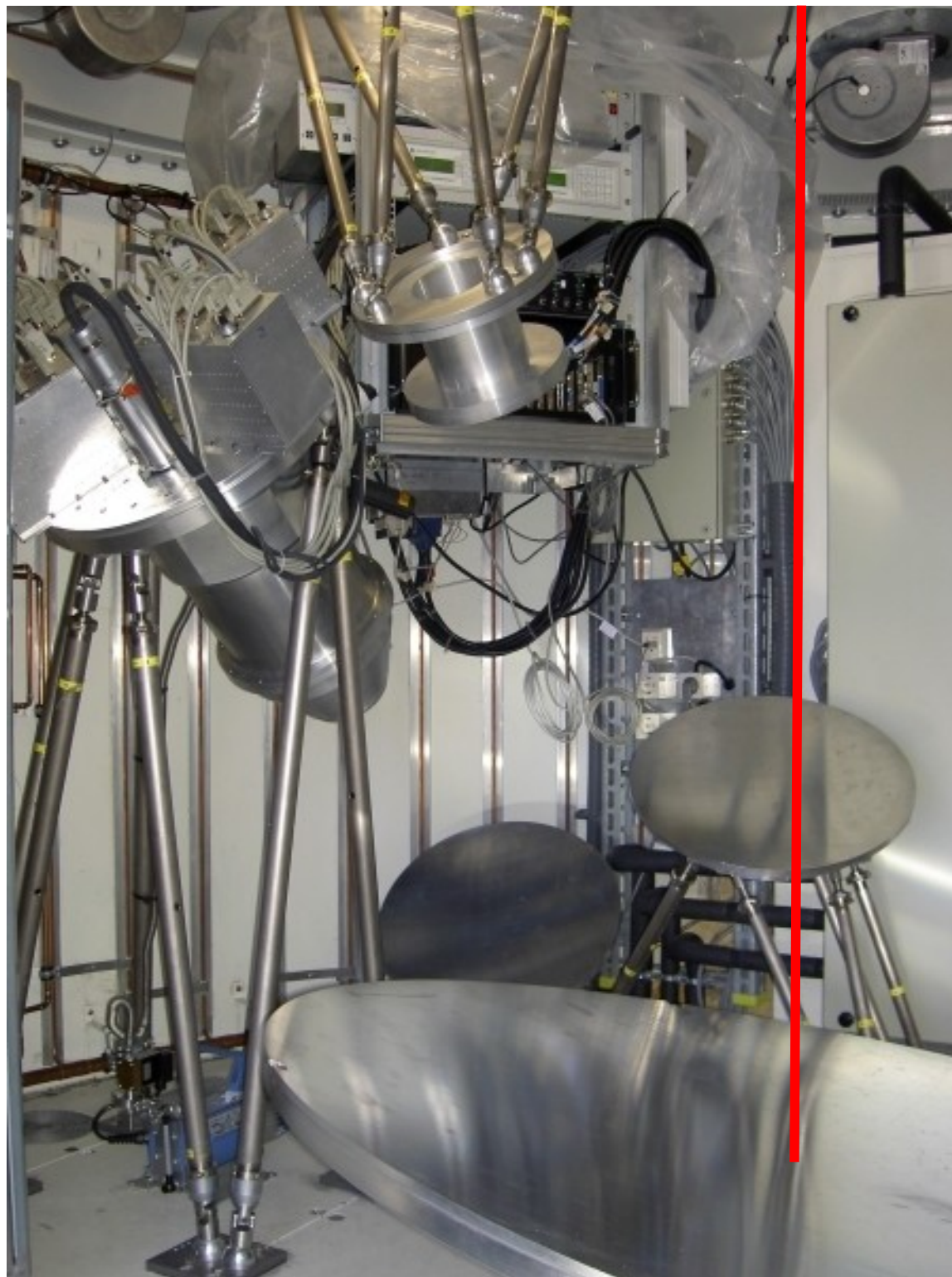




# LABOCA

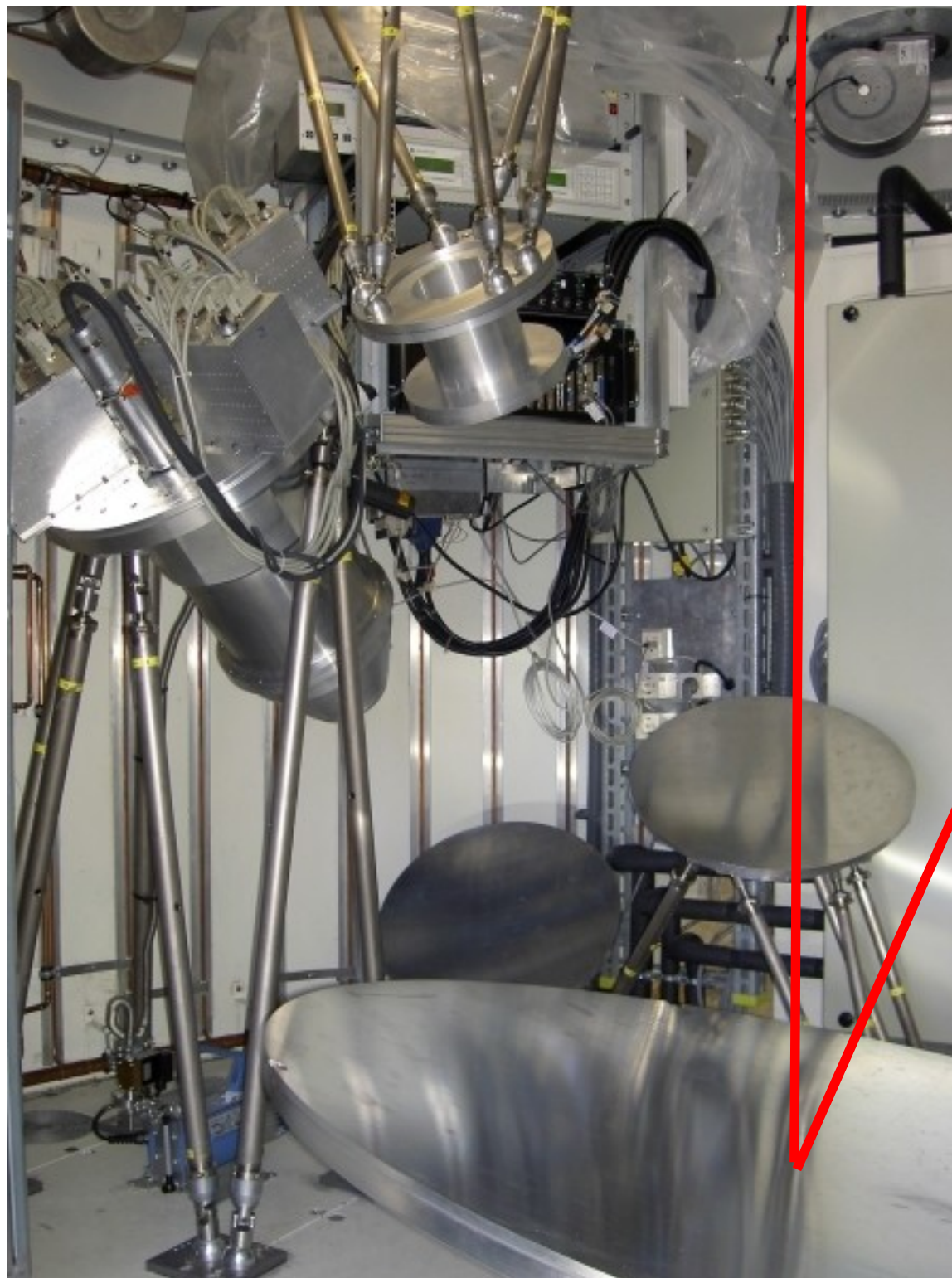


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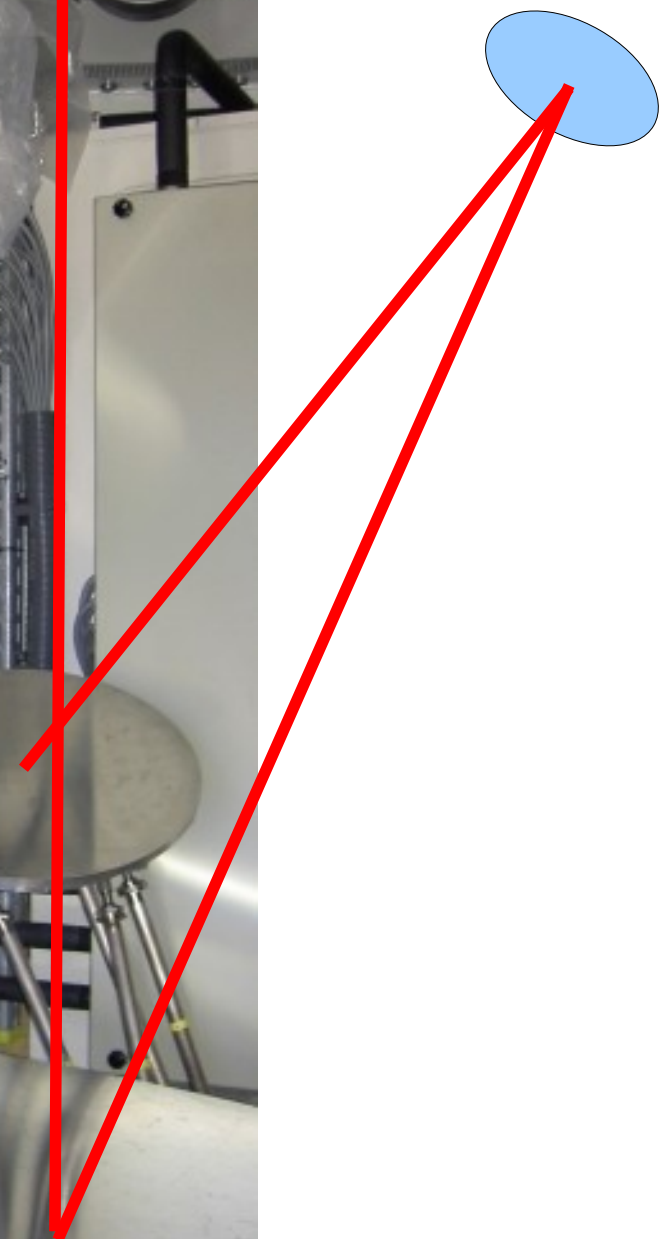
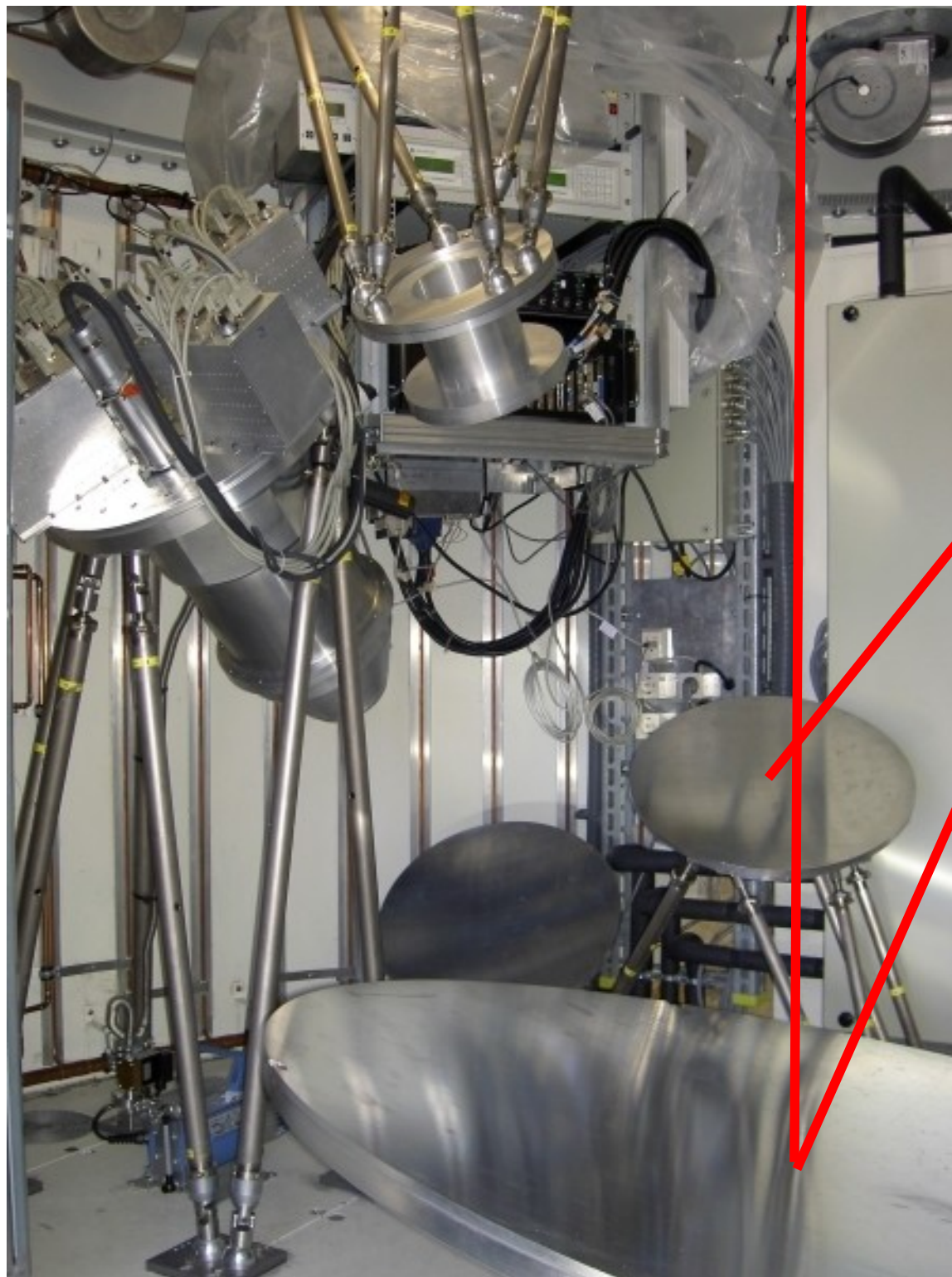




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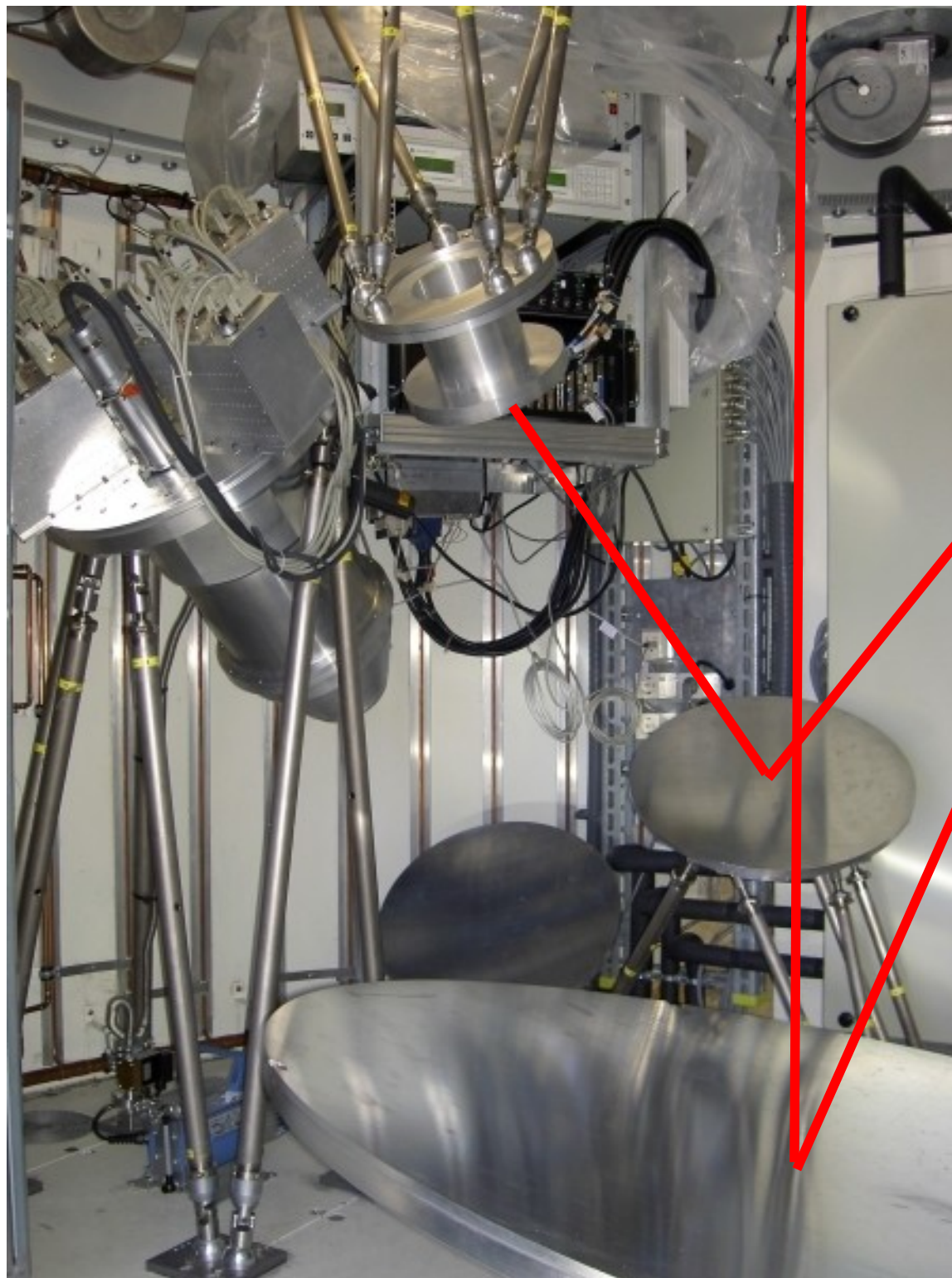


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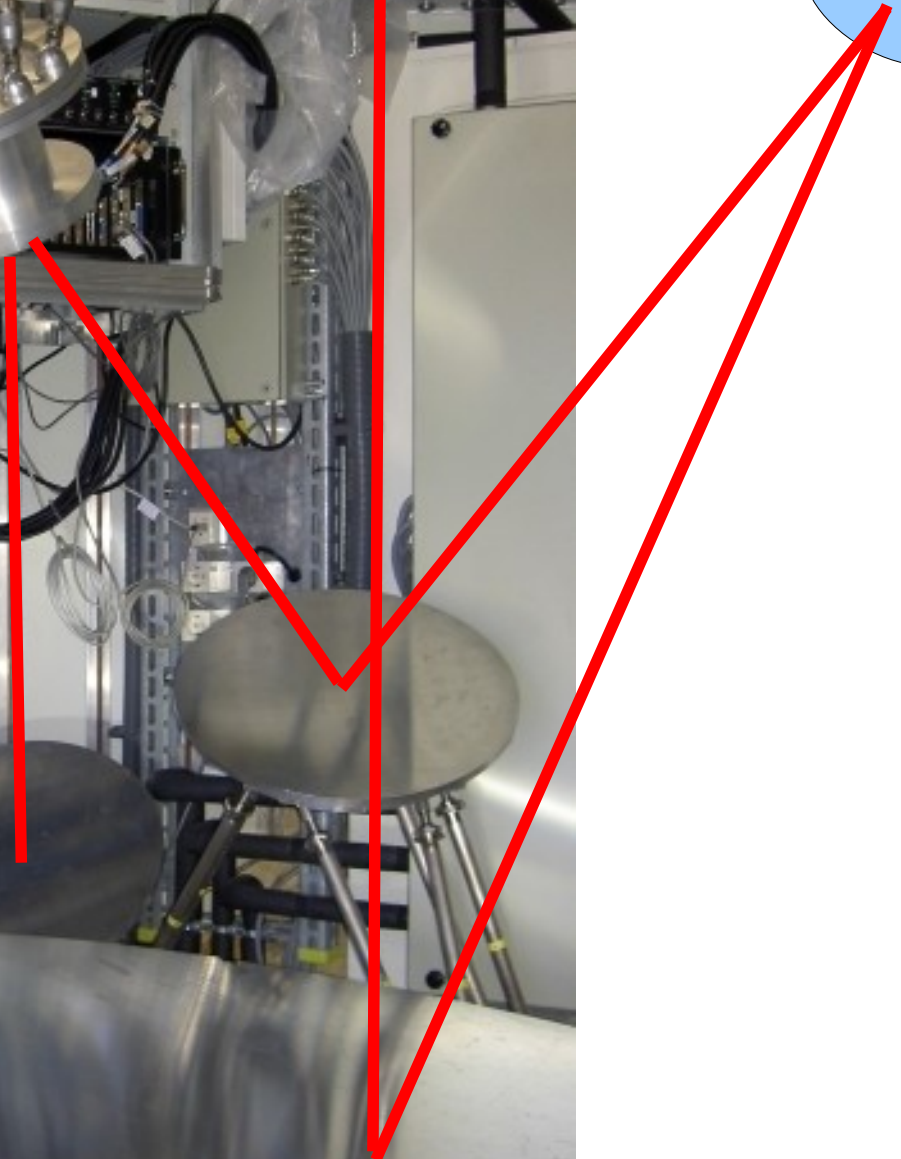
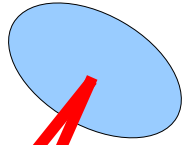
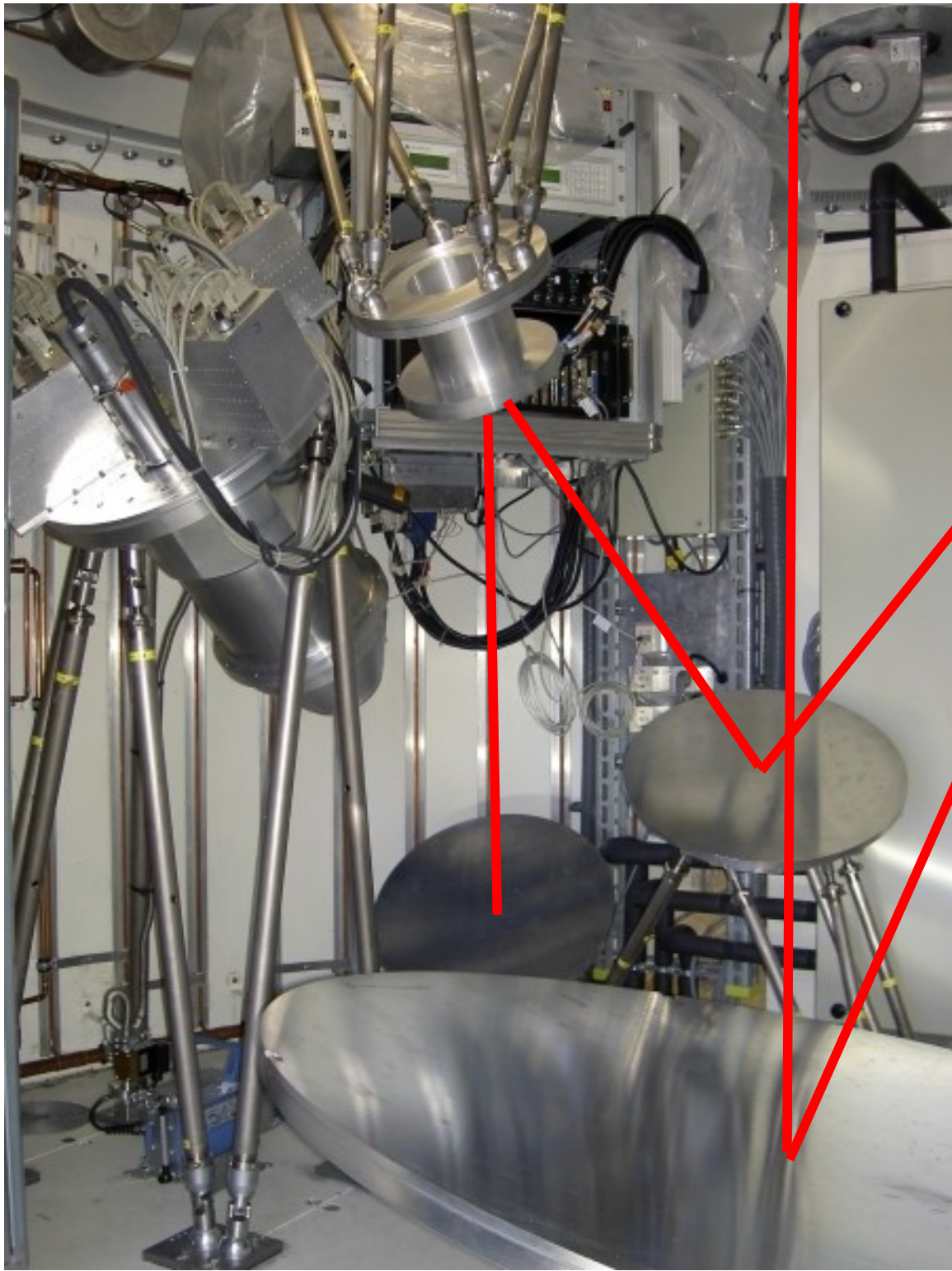




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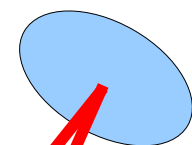
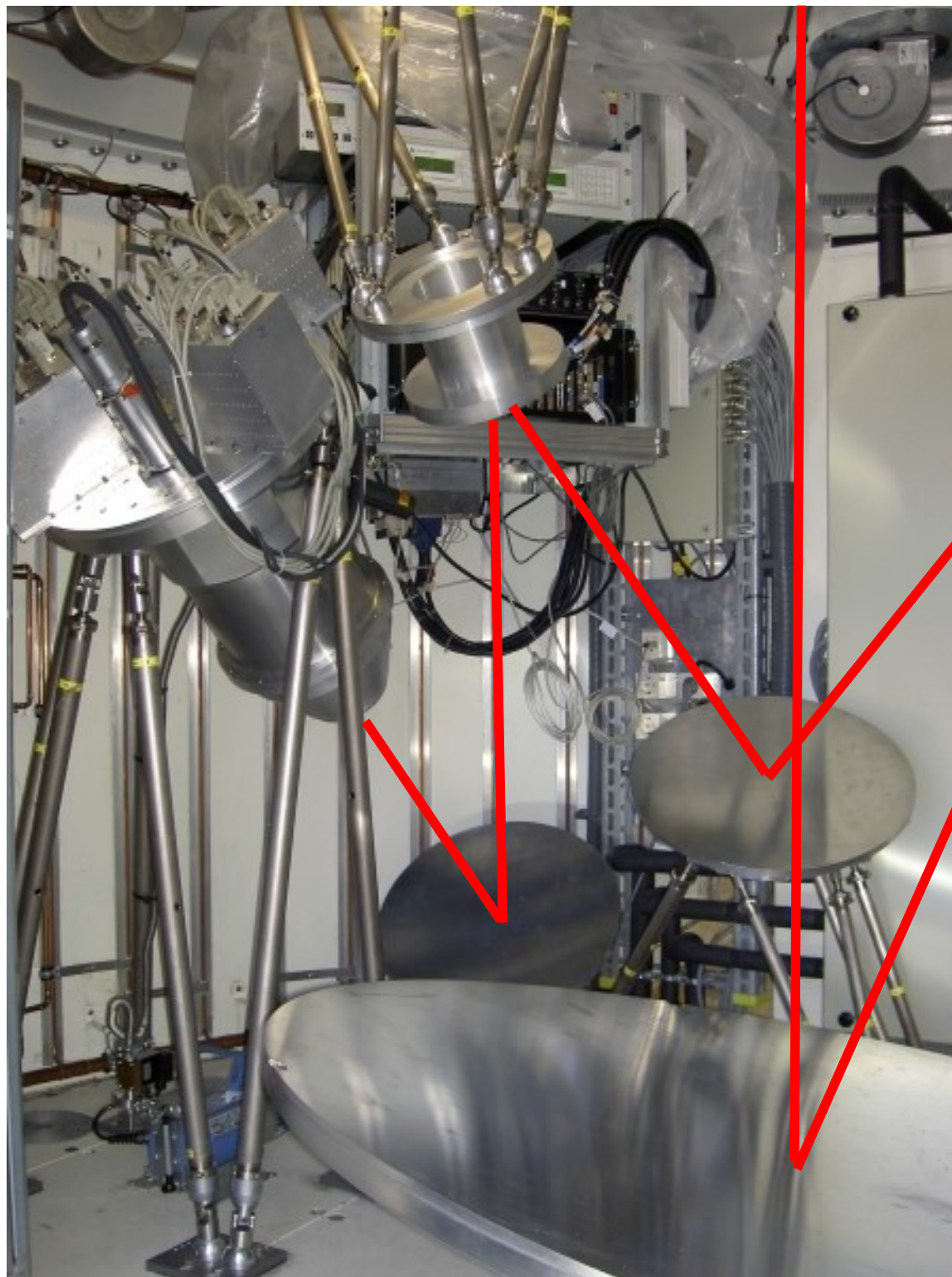


# LABOCA



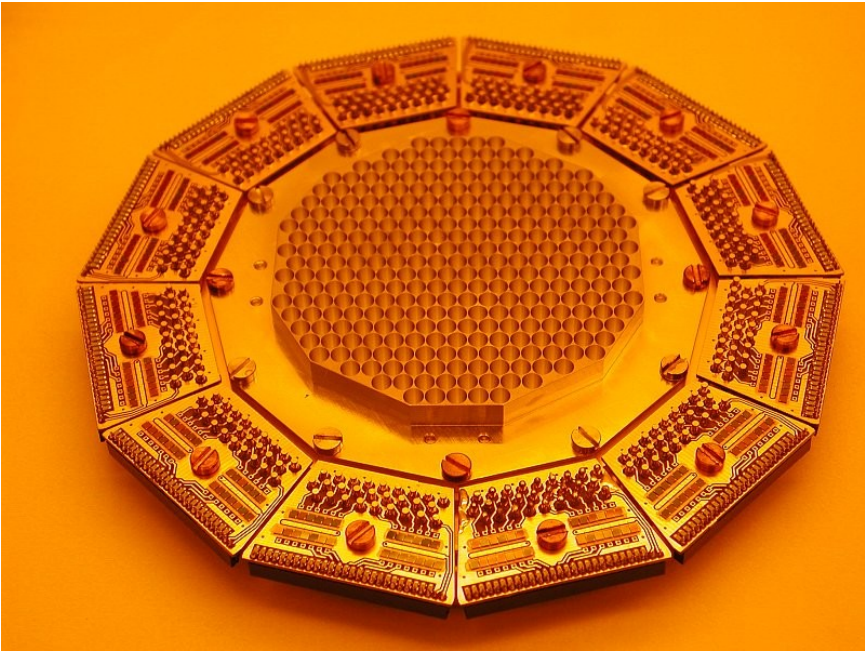
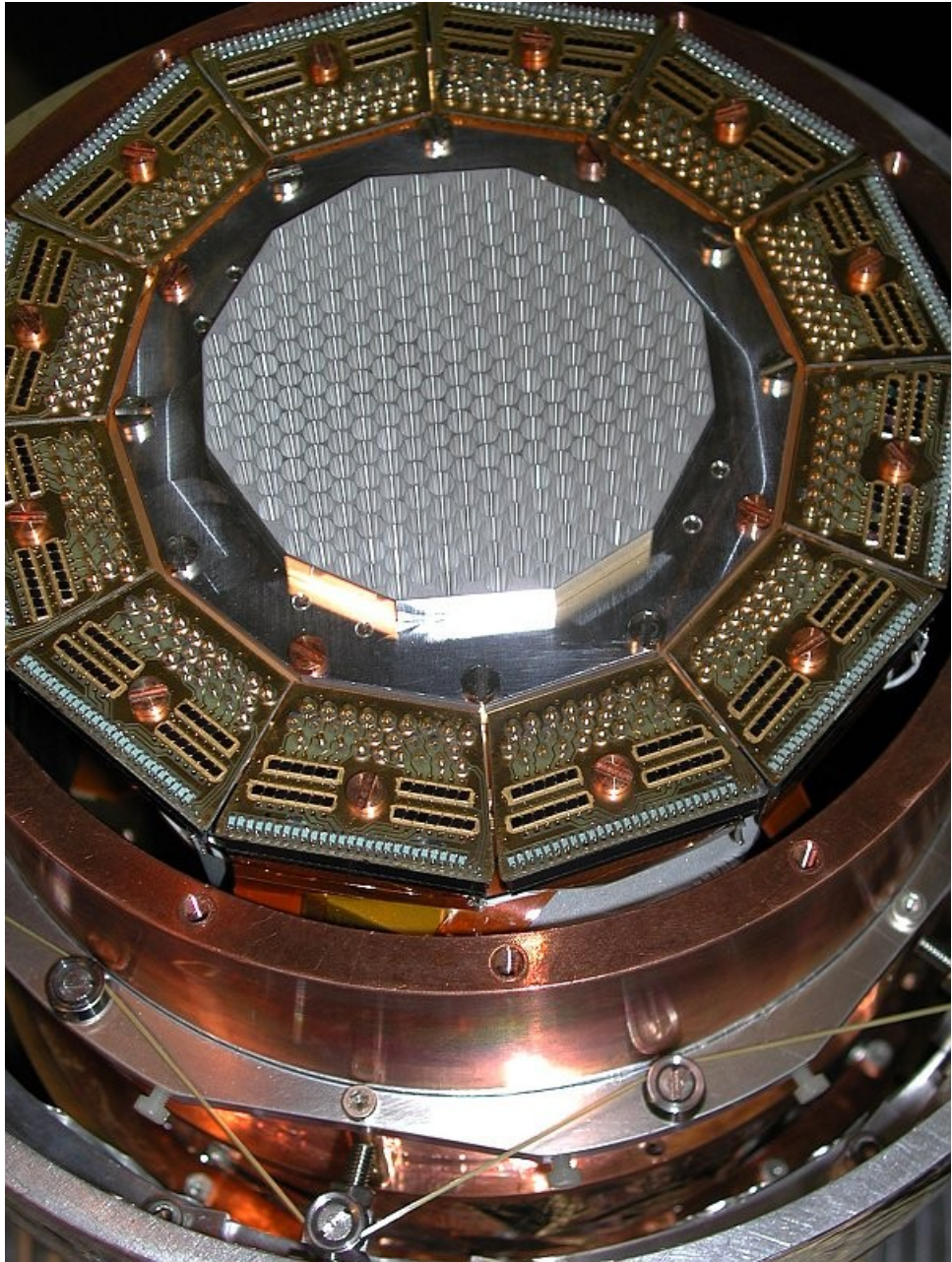
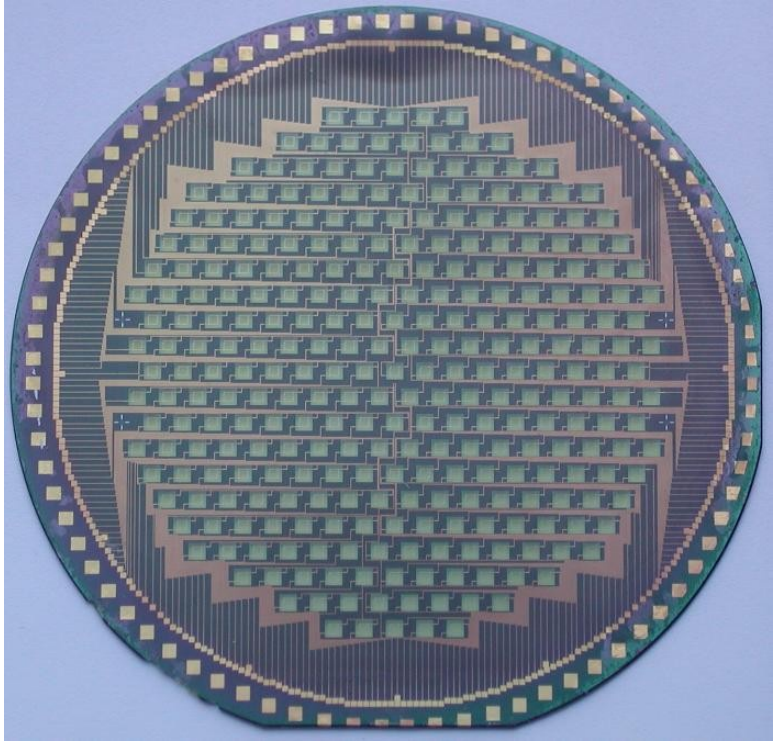


# LABOCA



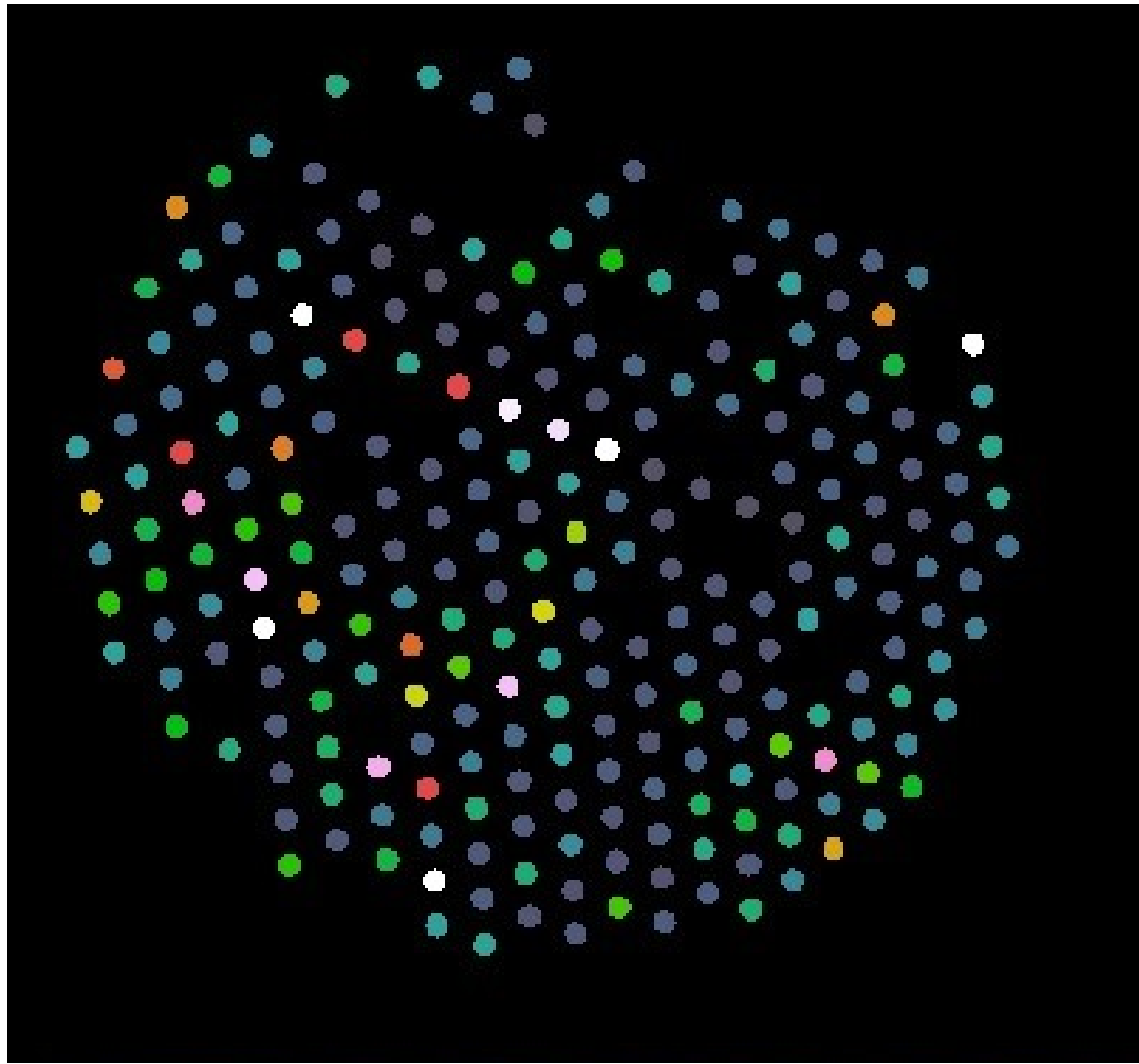


# LABOCA



# LABOCA

NEFD  
40-75  
mJy/beam s<sup>1/2</sup>



0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

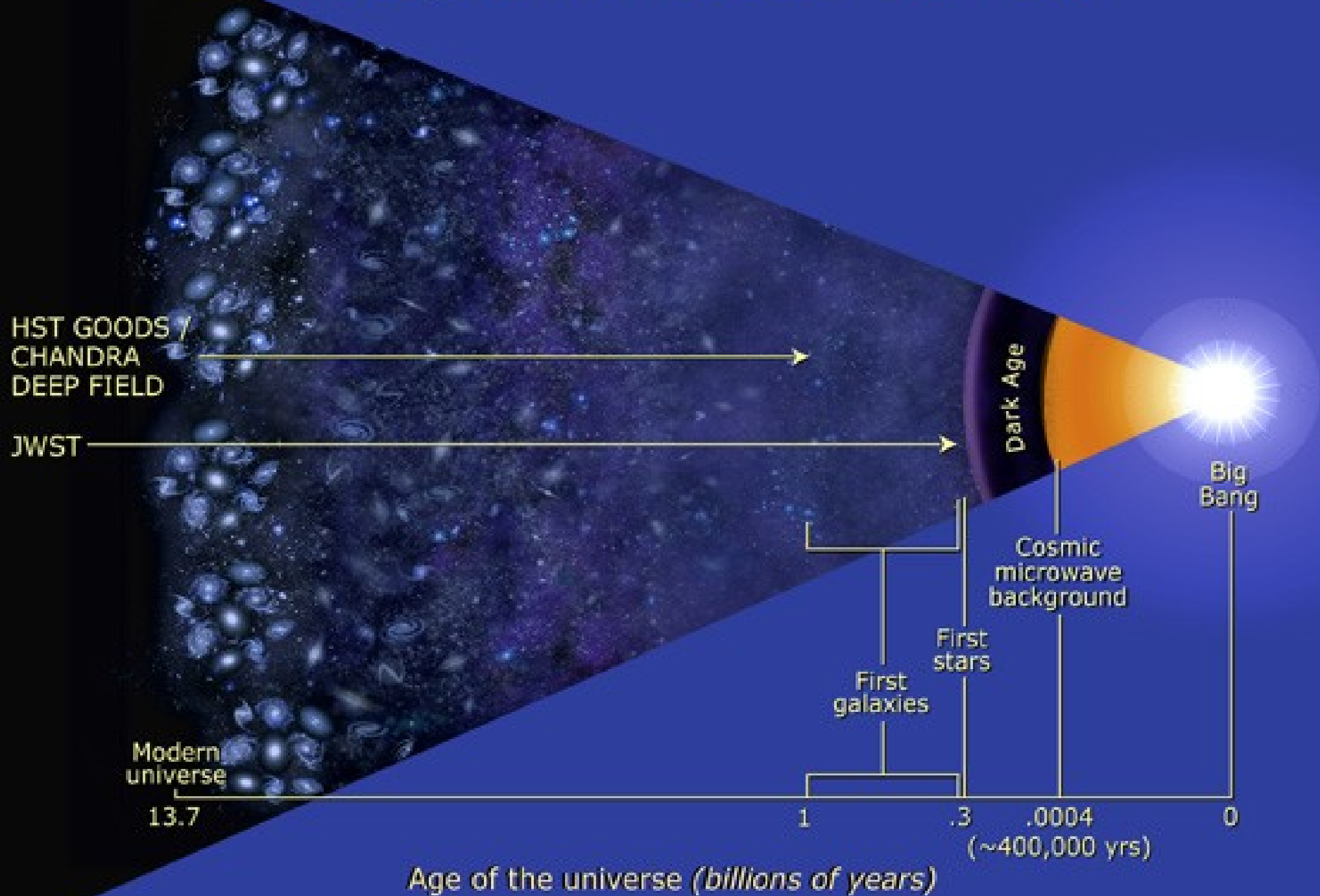


# LABOCA Science Case: Deep Fields

Collecting photons -- The more pixels the better...

<b>SCUBA</b>	<b>37</b>
<b>SHARC-2</b>	<b>384</b>
<b>LABOCA</b>	<b>295</b>
<b>SCUBA-2</b>	<b>8000+</b>

# Seeing back into the cosmos

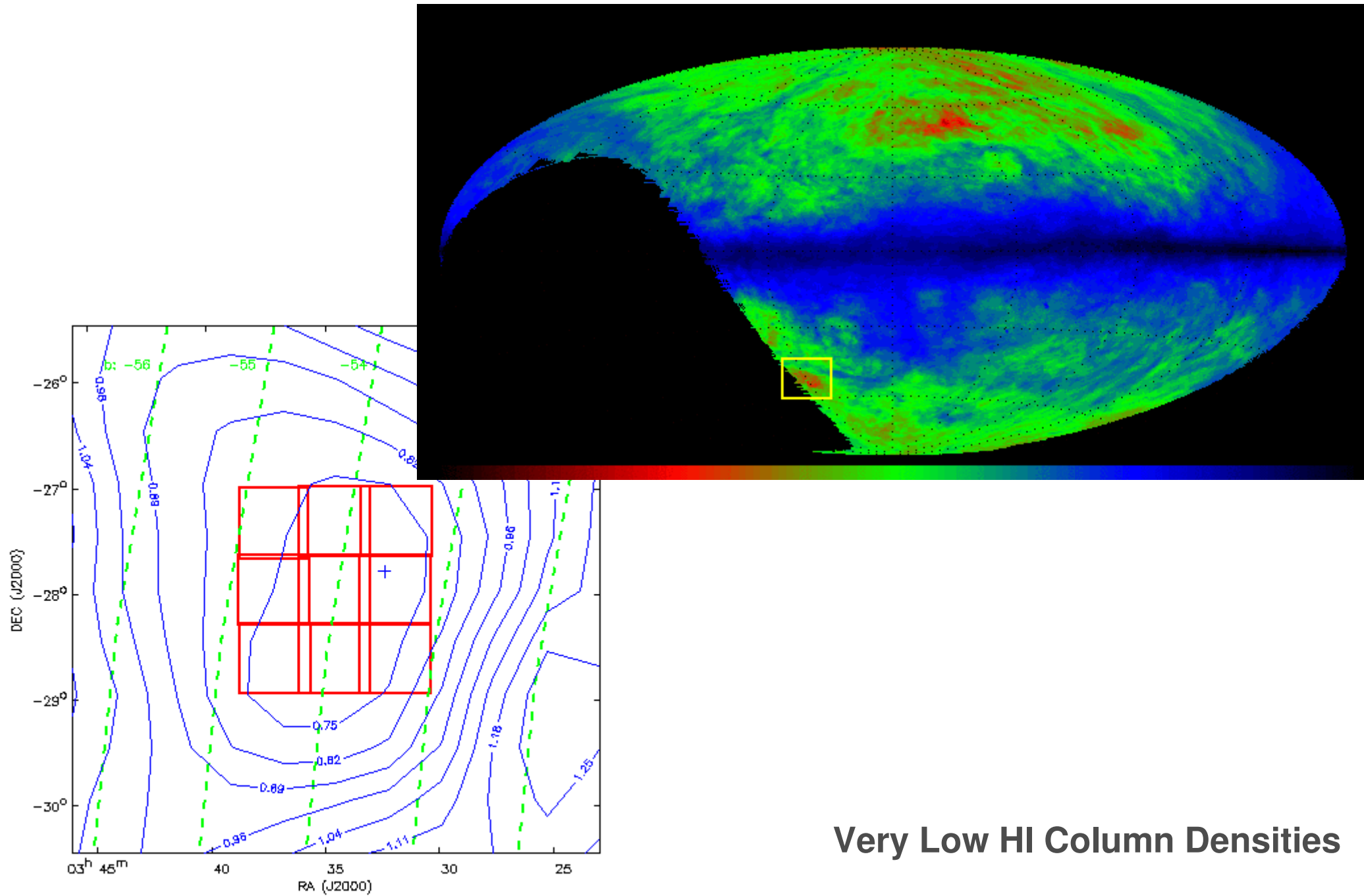


# The Chandra Deep Field South (CDFs)

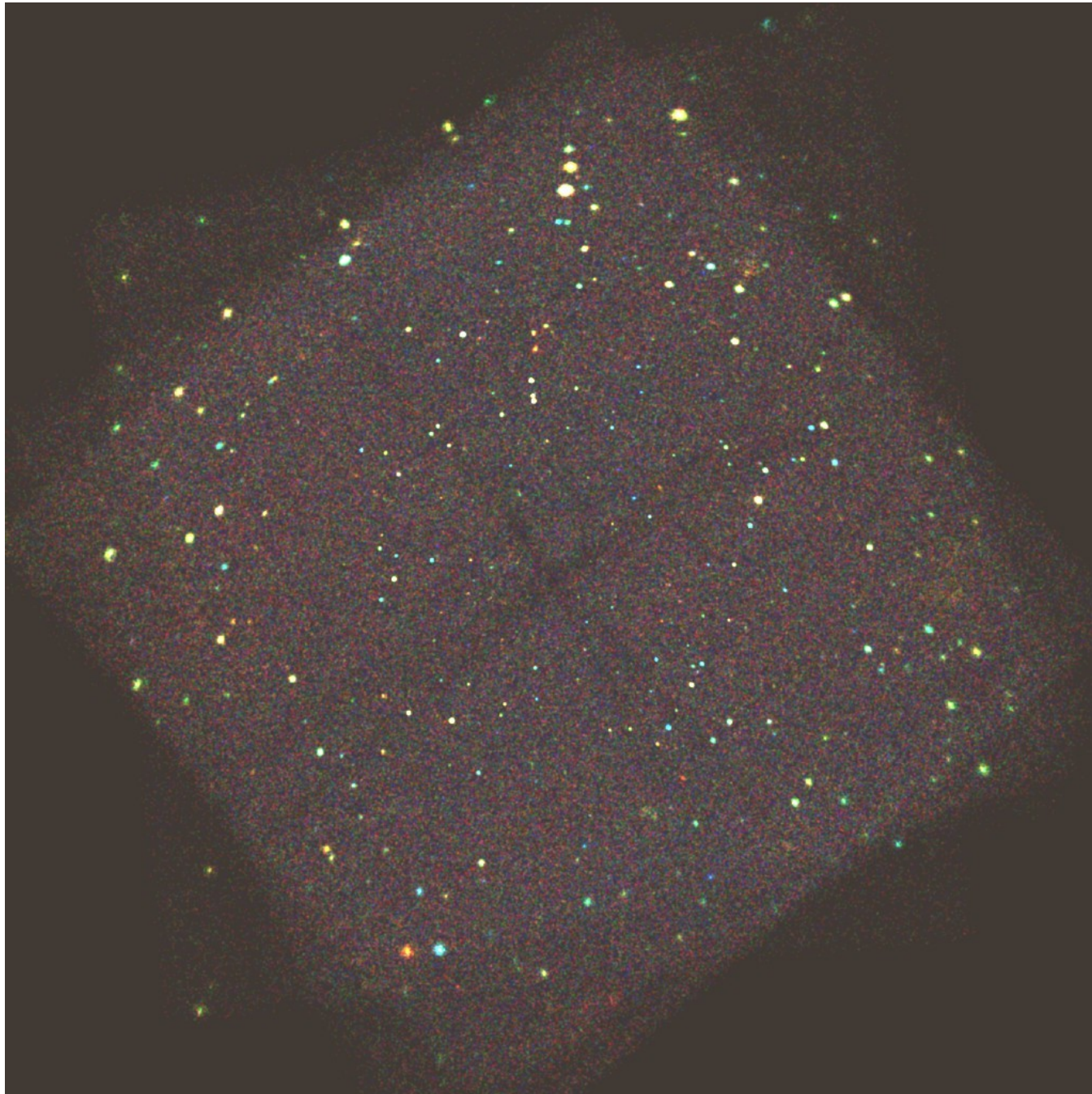




# The Chandra Deep Field South (CDFs)



**CDFS**



# LABOCA CDFS at 850um...

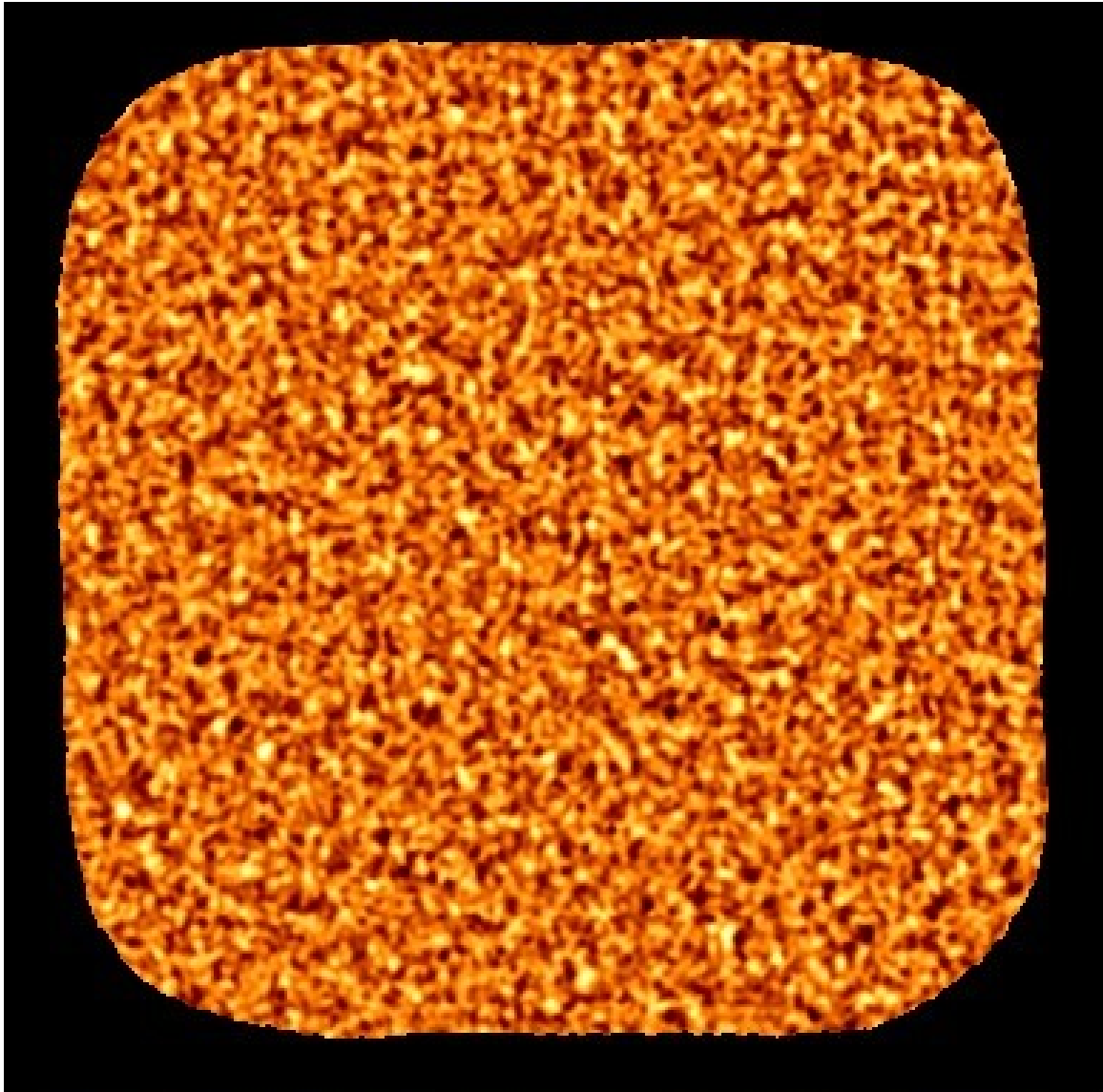
200 h scheduled

100 h complete

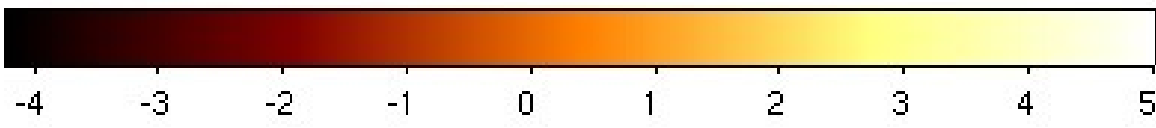
1.7 mJy RMS

Goal:

1 mJy RMS



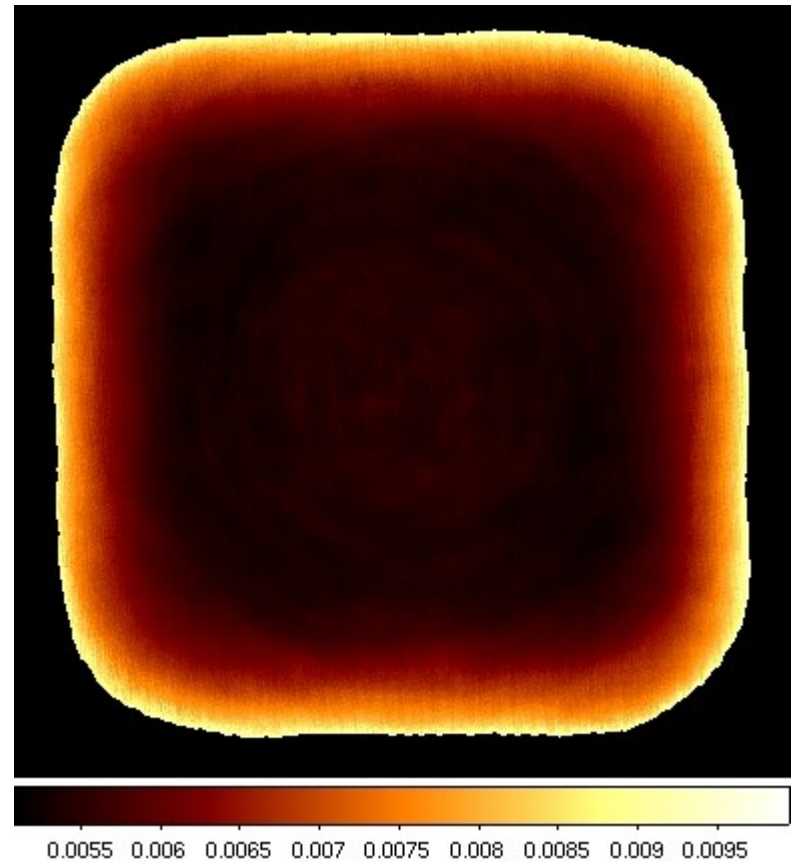
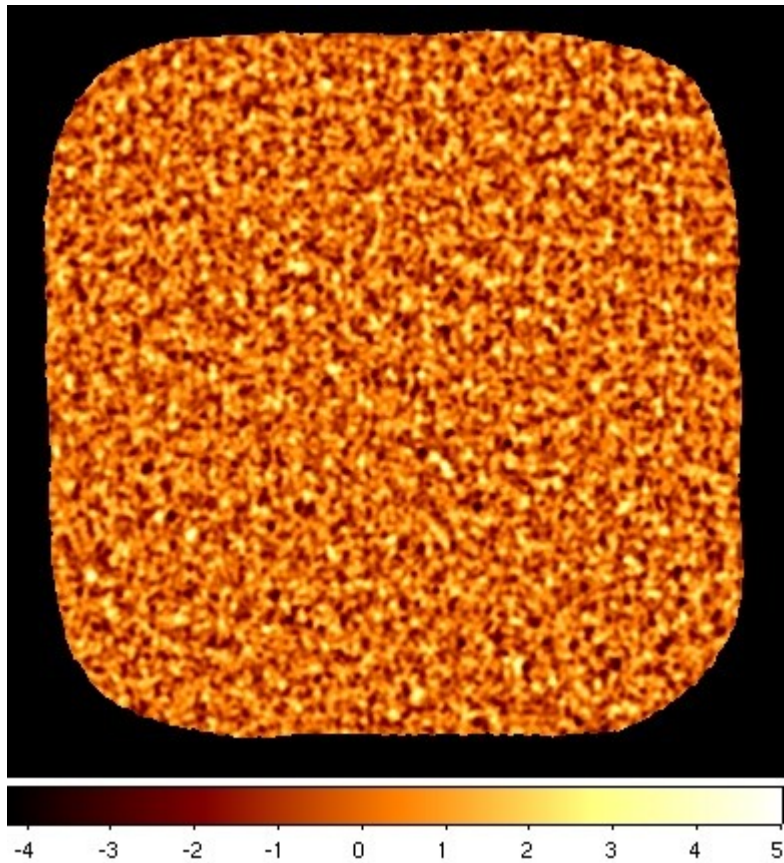
0.5 deg





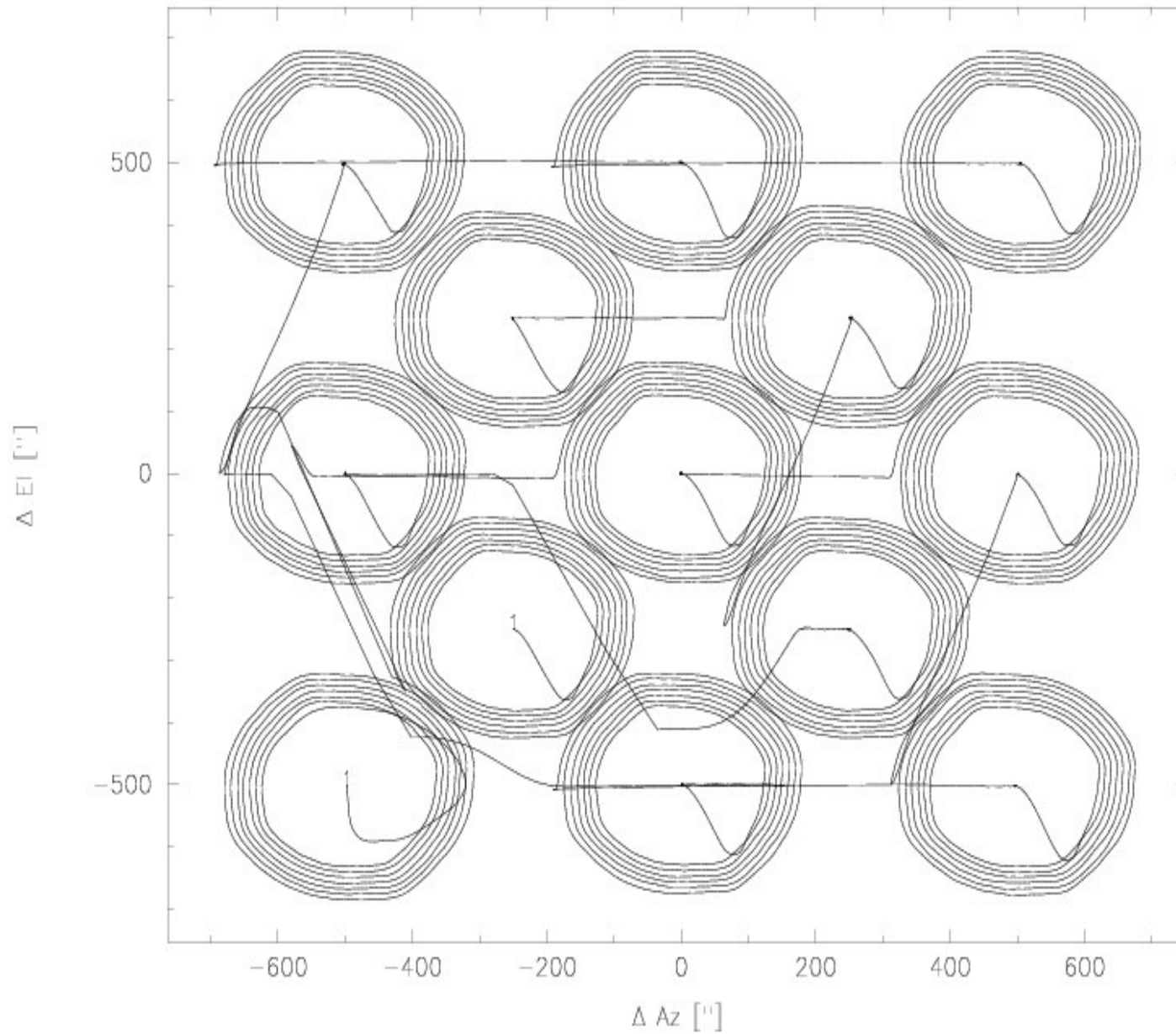
# LABOCA CDFS at 850 $\mu$ m...

(CRUSH Reduction)

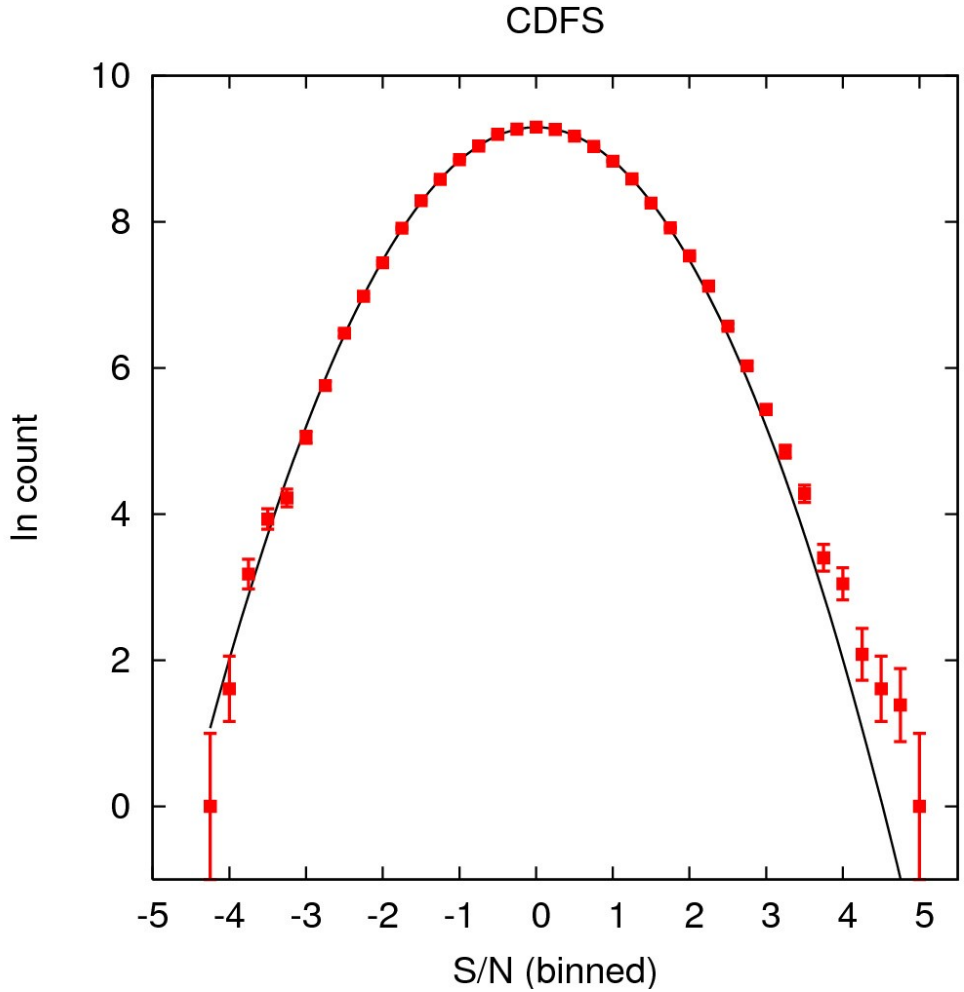
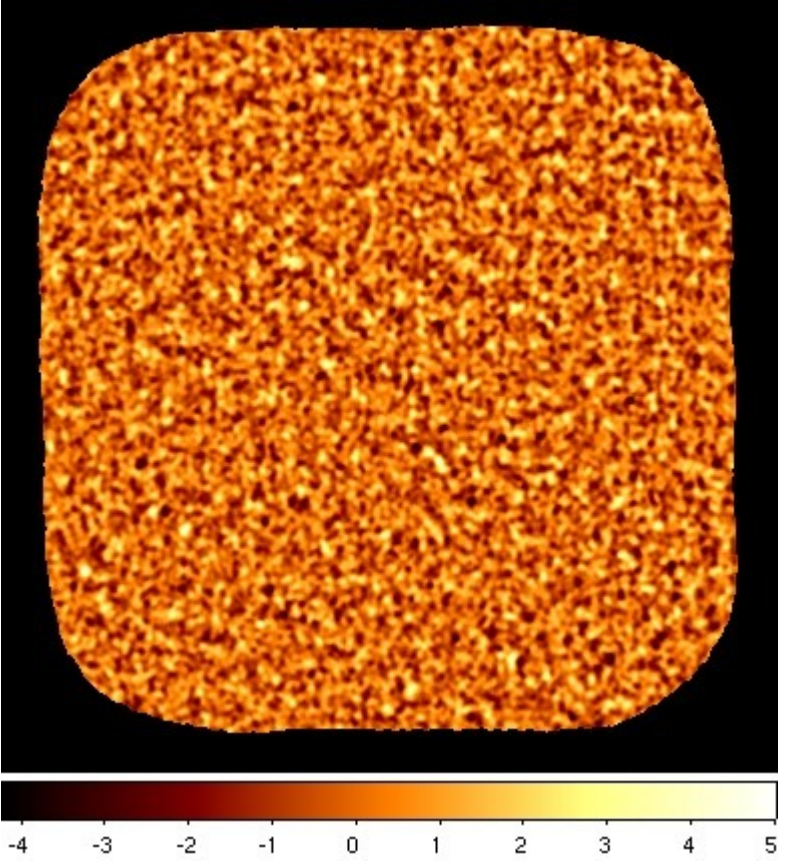


After 100 hours 0.5 deg x 0.5 deg area with uniform coverage  
1.7 – 2.0 mJy/beam rms

# Scanning Strategy: A Raster of Spirals



# LABOCA CDFS: Map Noise Distribution



Noise is **extremely** consistent with Gaussian  
with an expected tail at positive fluxes  
due to resolved and unresolved sources...







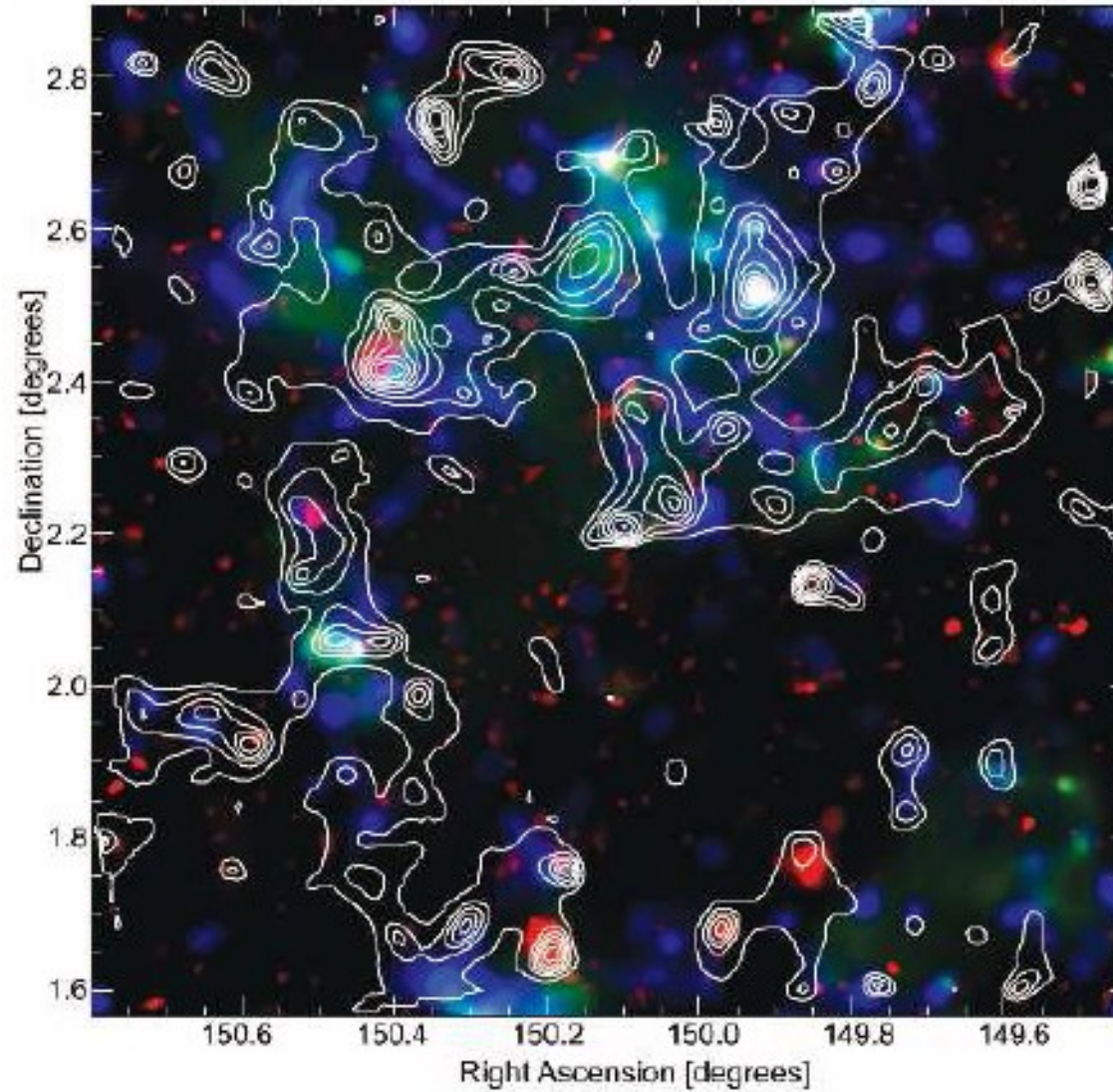
# The COSMOS Field

## Submm Galaxies and Large Scale Structure

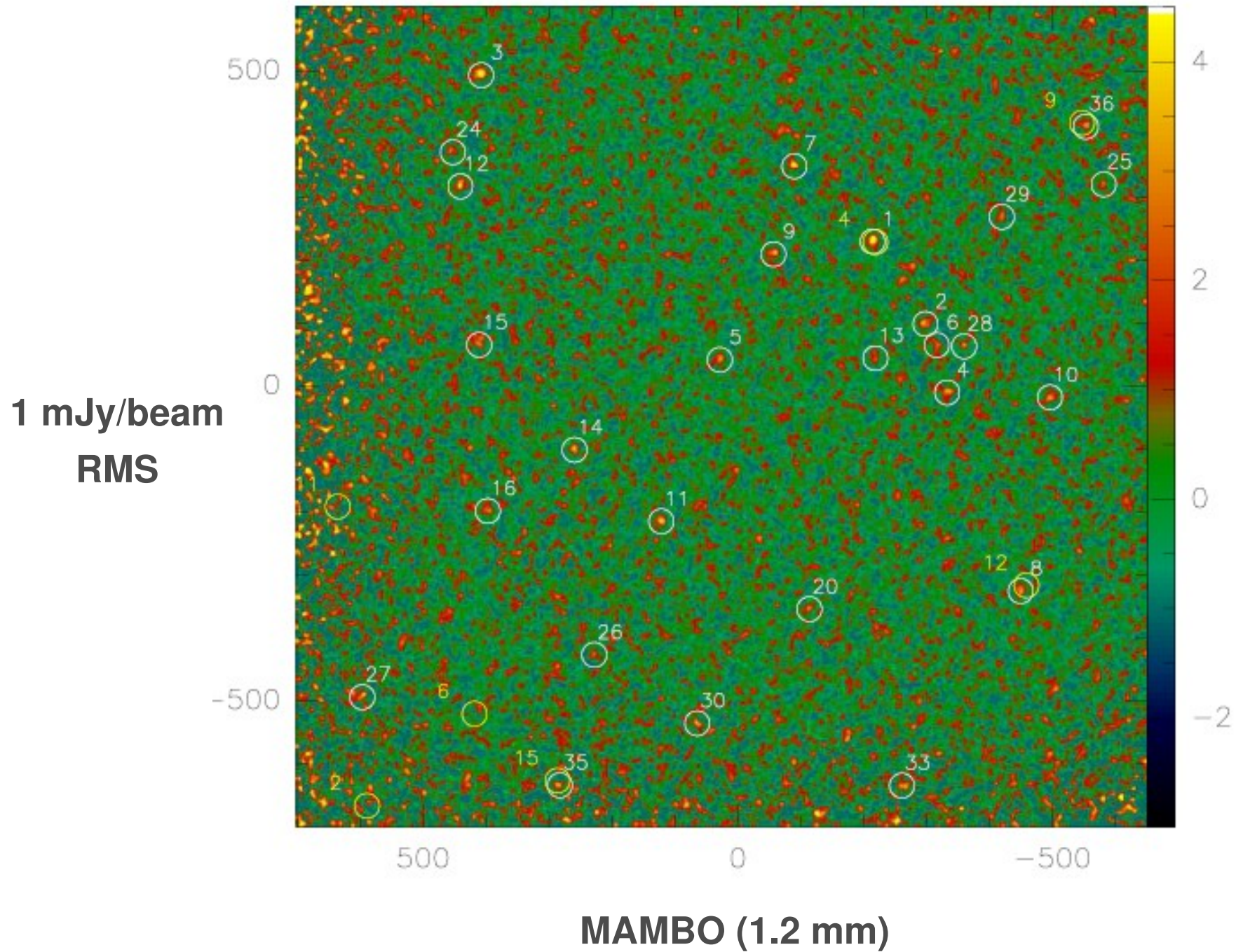
2 sq. deg

3 mJy/beam

RMS



# The COSMOS Field



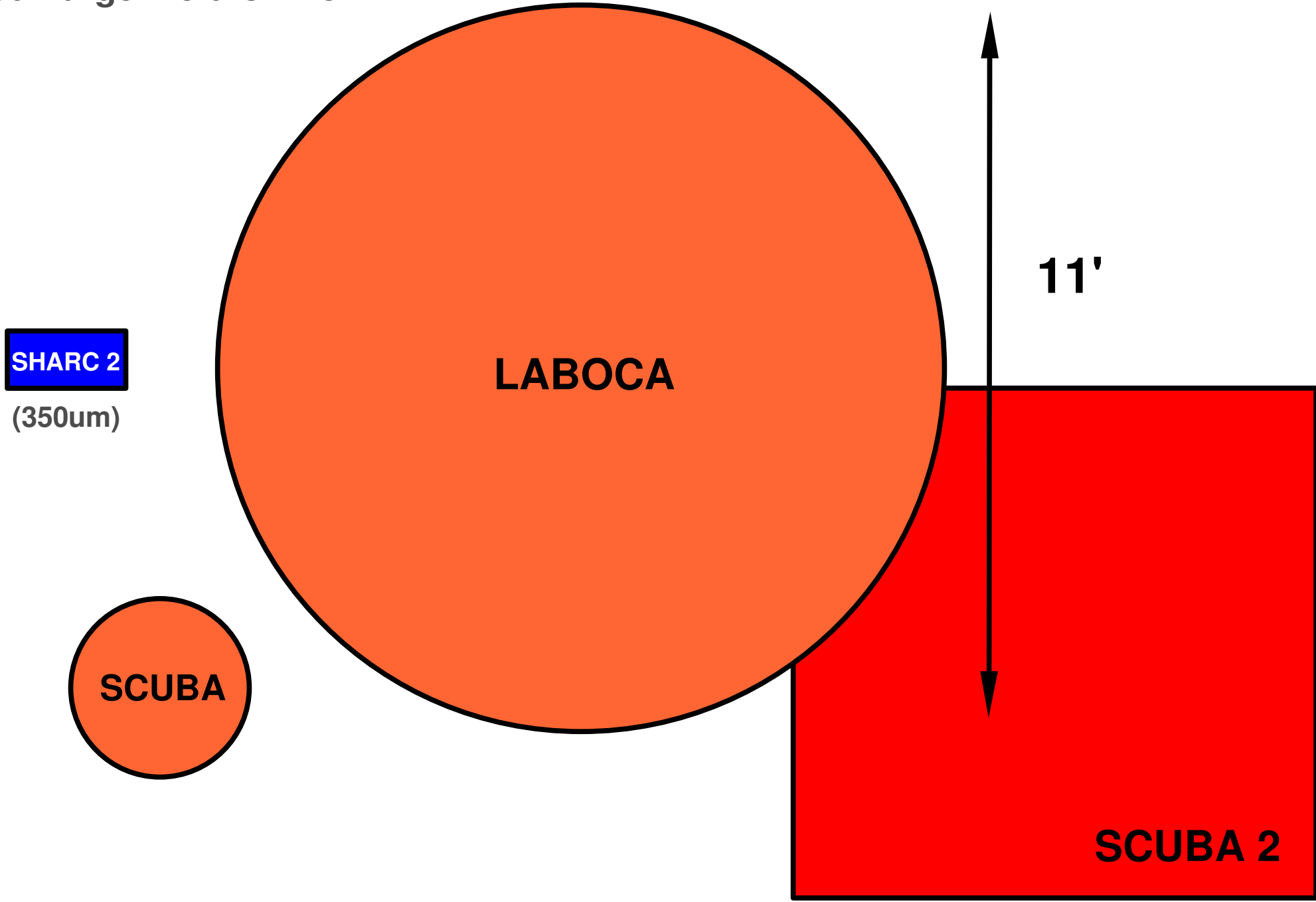






# LABOCA Science Case: Large Scale Mapping

Need Large Field-of-View

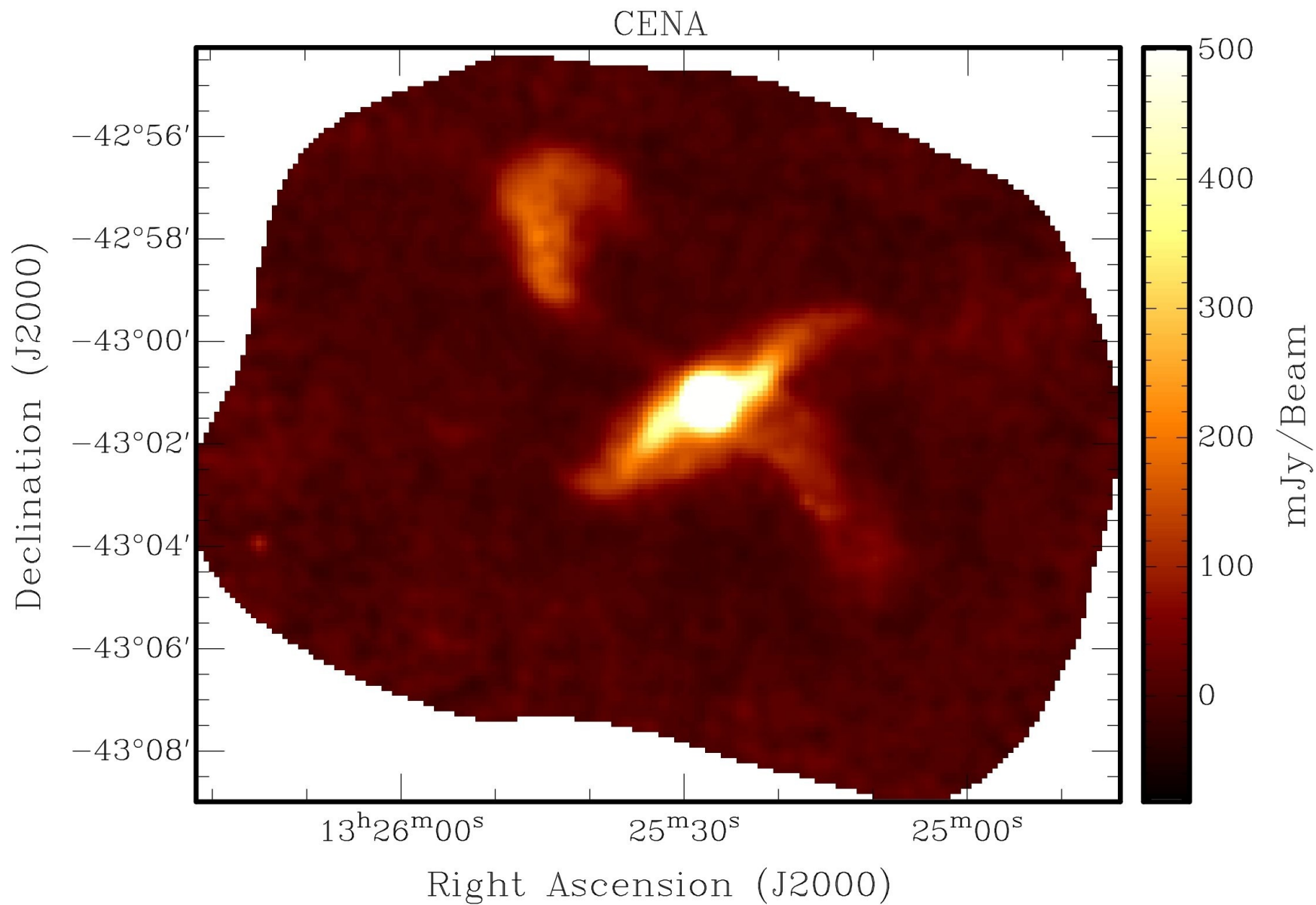


# Cen A

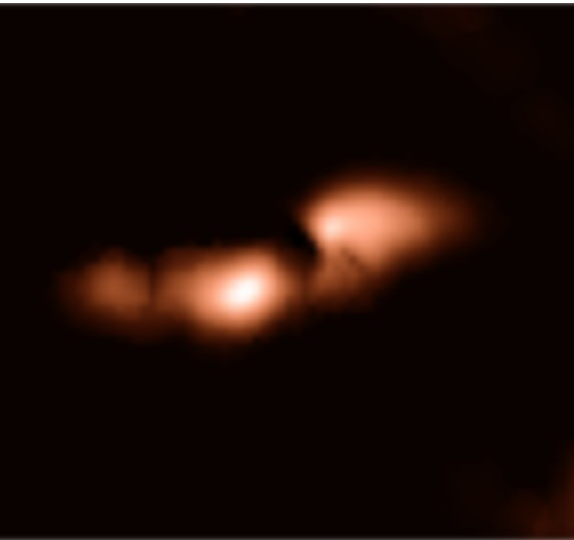




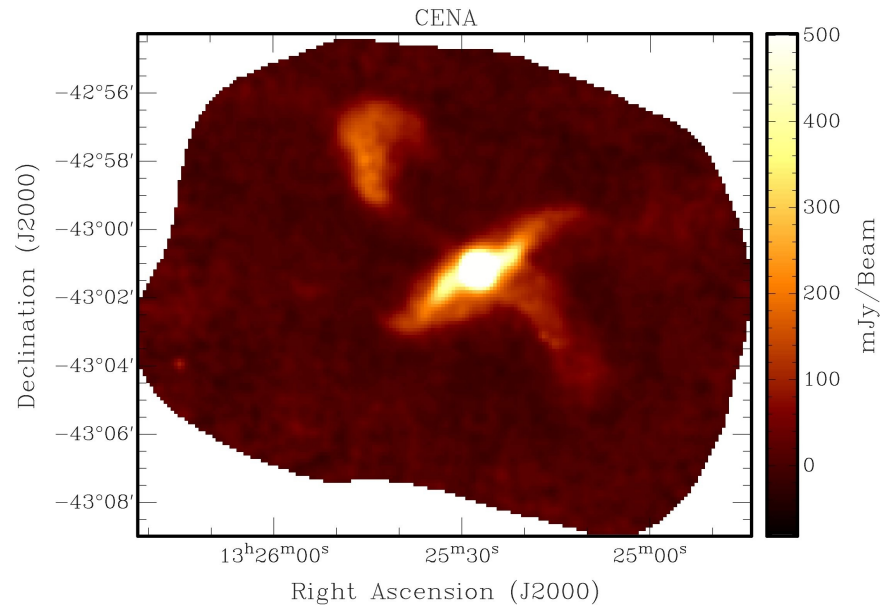
# Cen A



# Cen A



HI

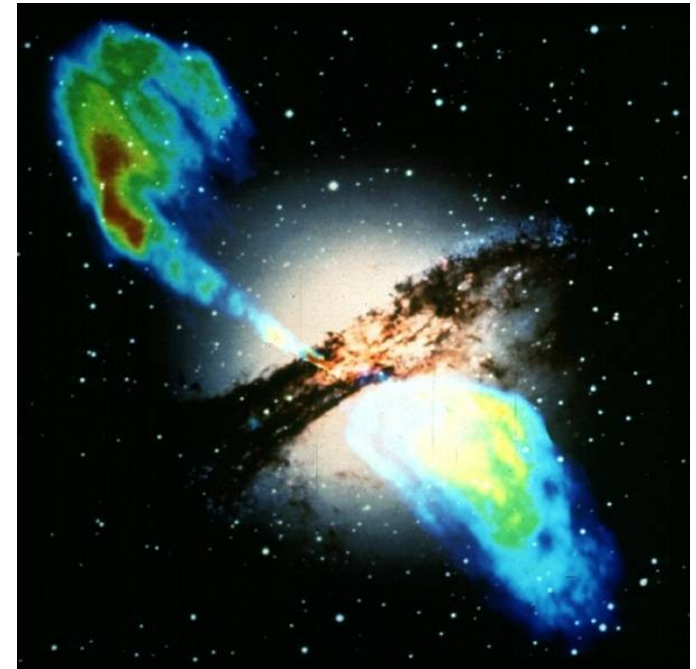
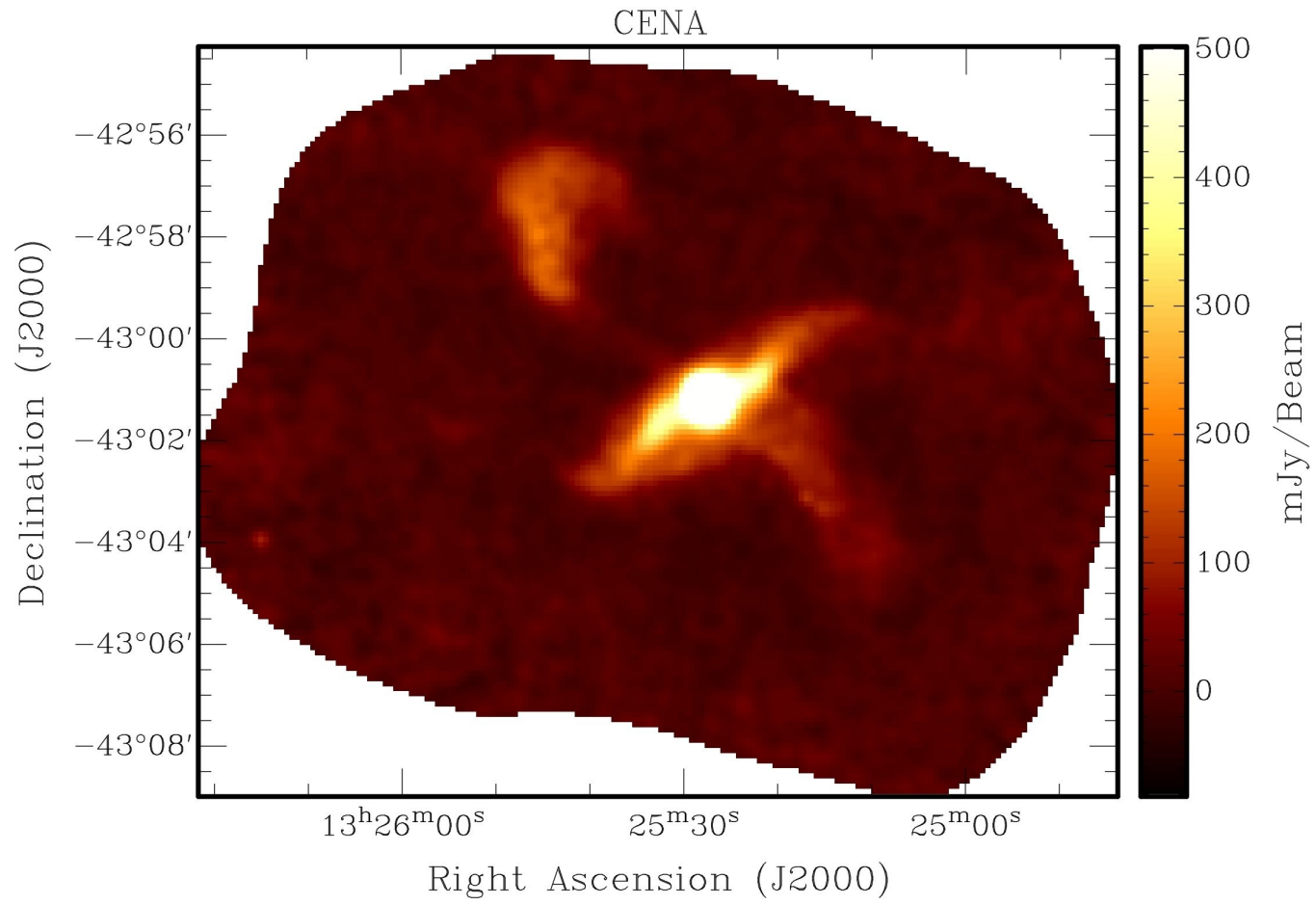


LABOCA



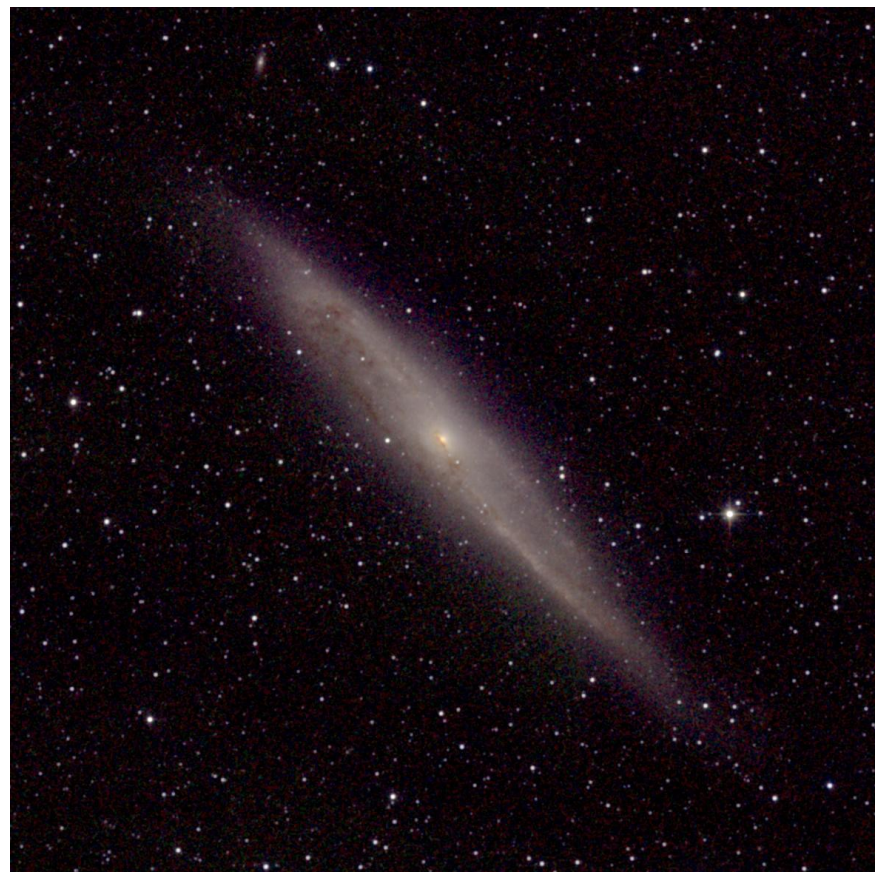
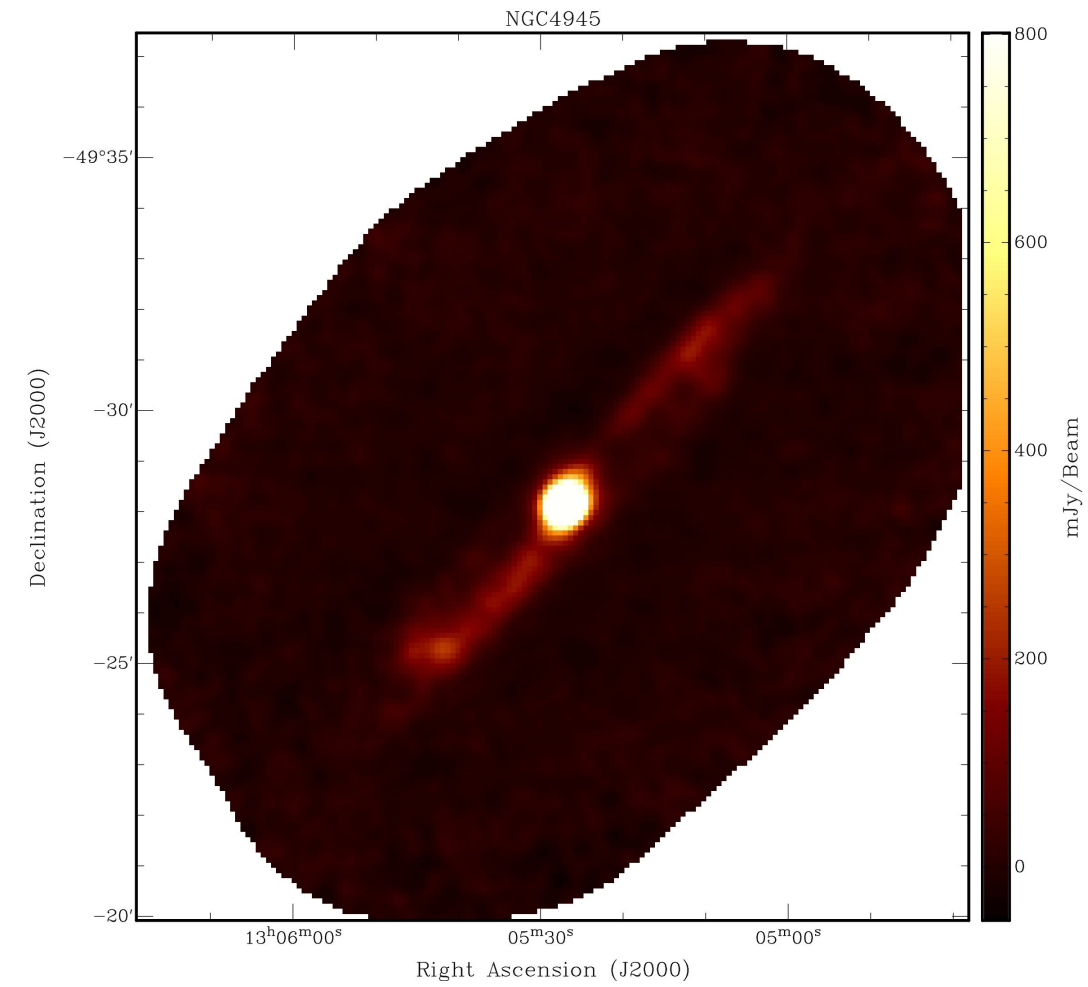
radio

# Cen A

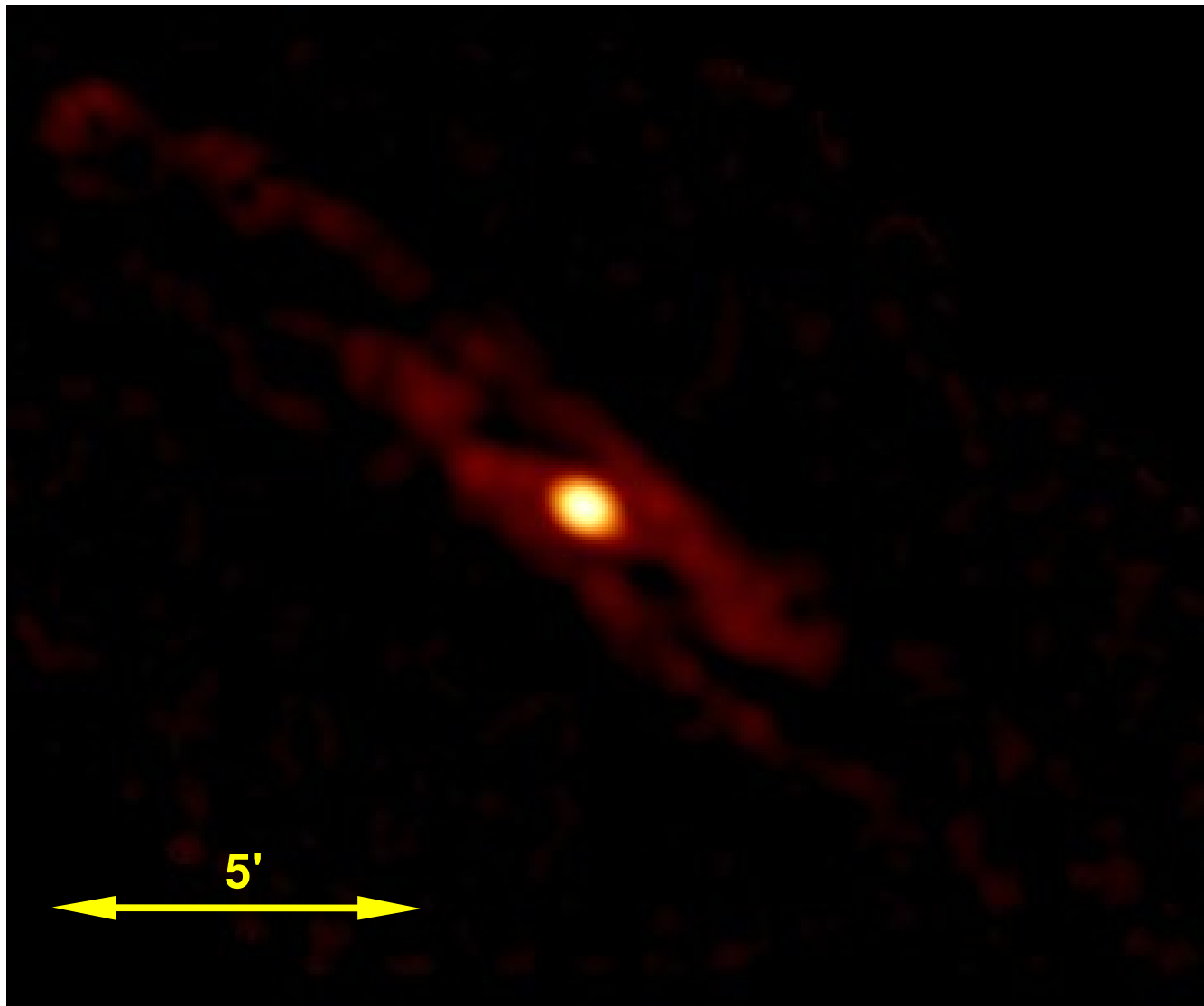




# NGC 4945



# NGC 253

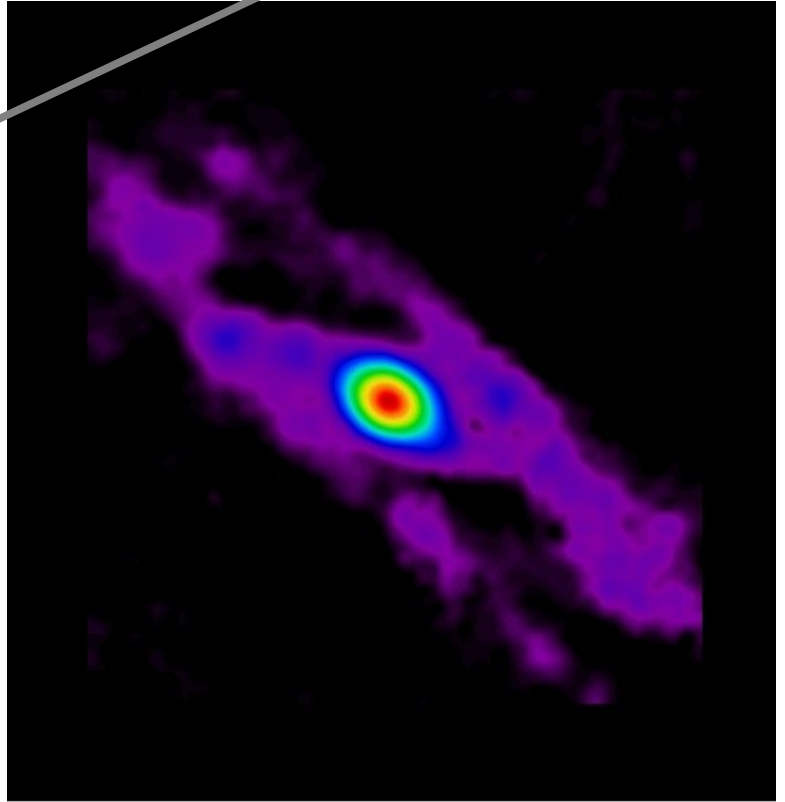
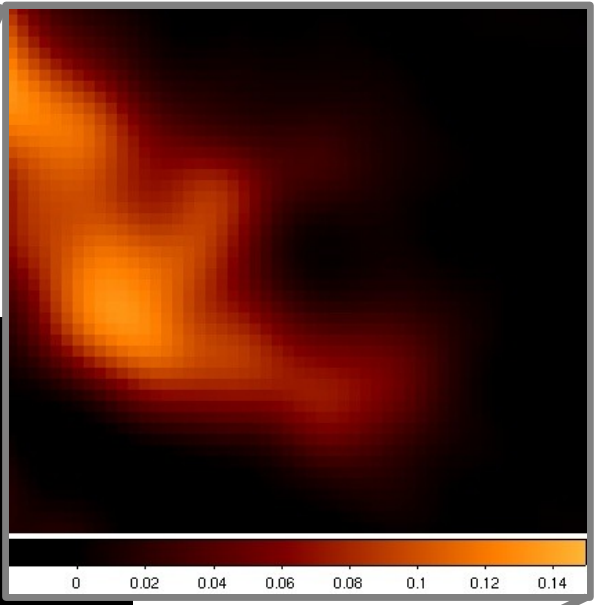
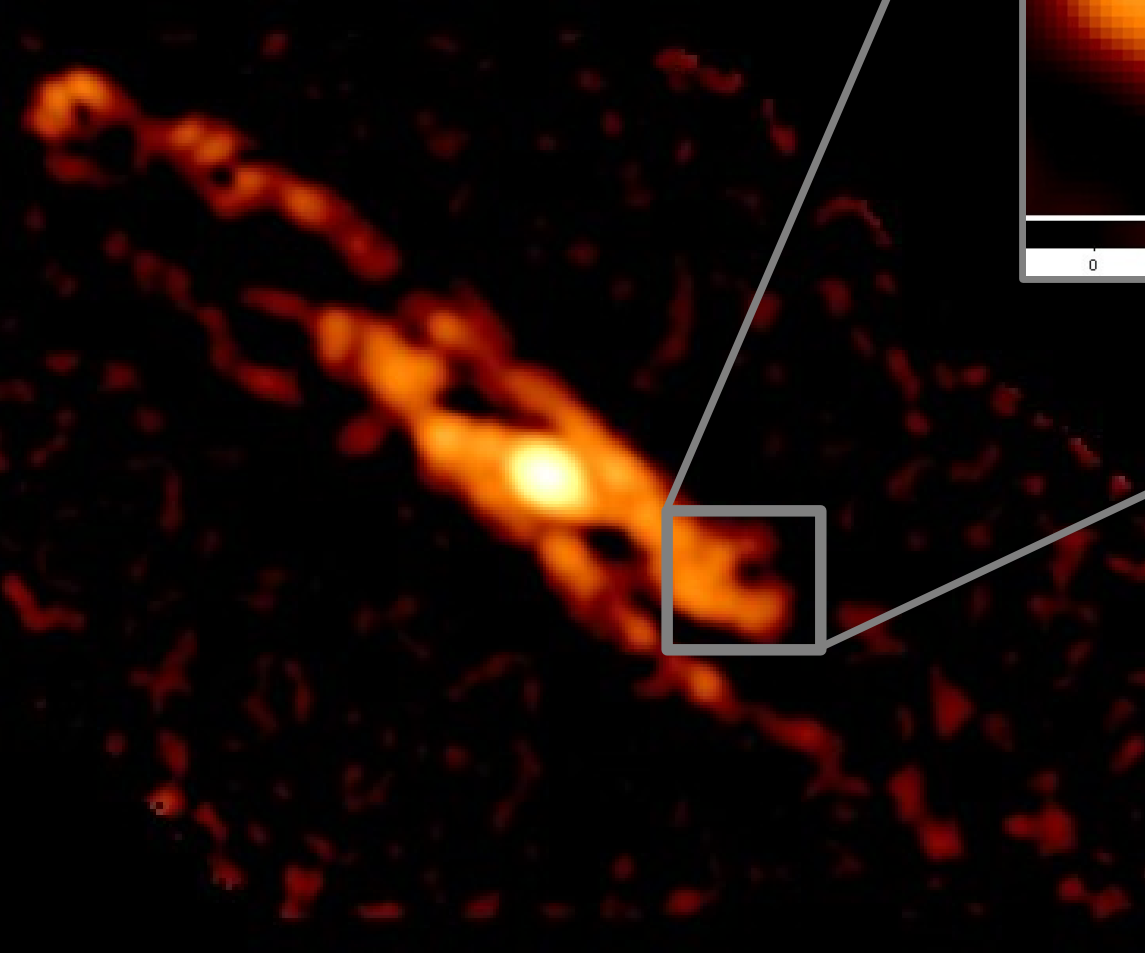


2 mJy/beam  
RMS



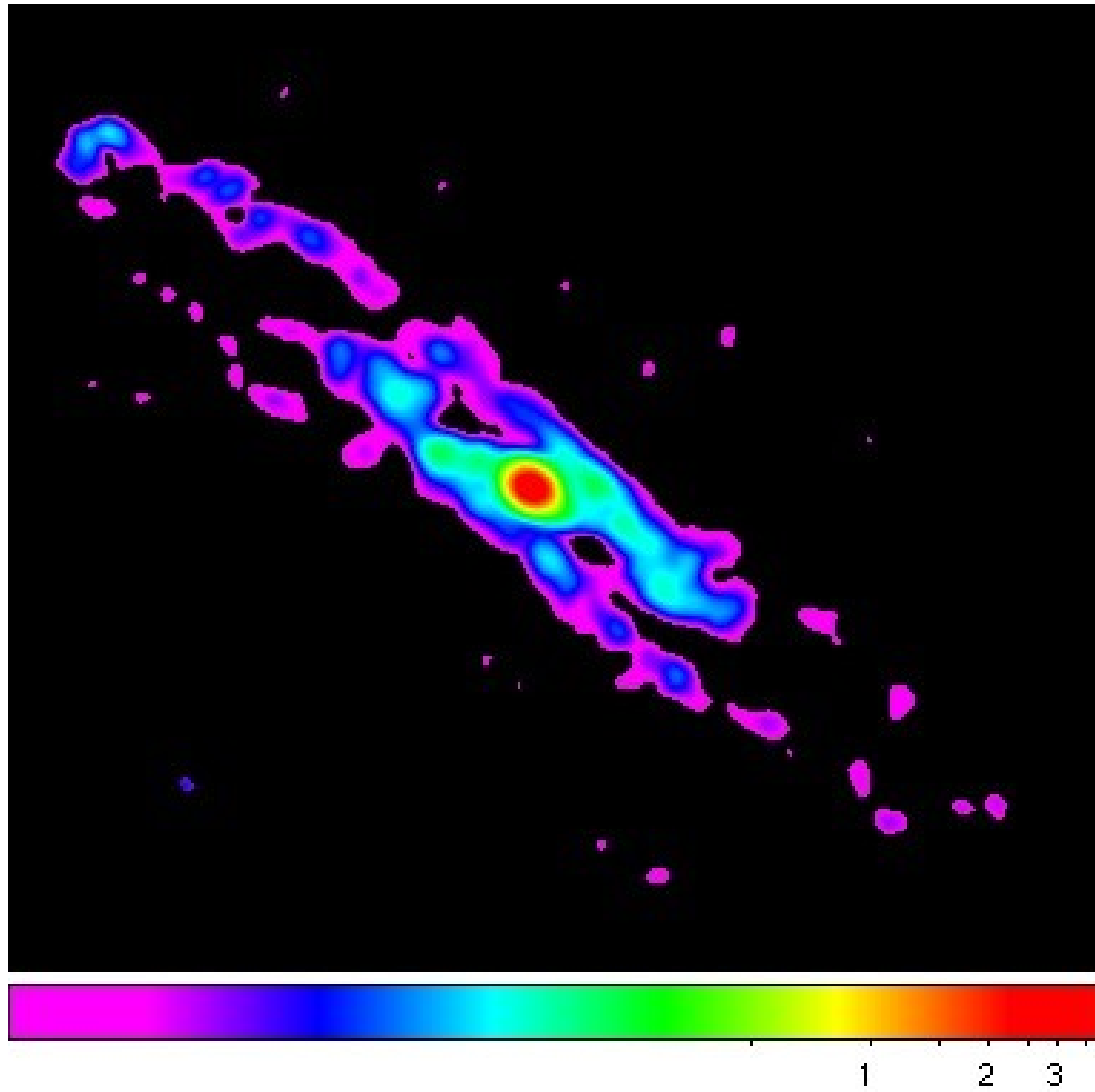
0.5 1 1.5 2 2.5 3 3.5

# NGC 253





# NGC 253



# NGC 253

