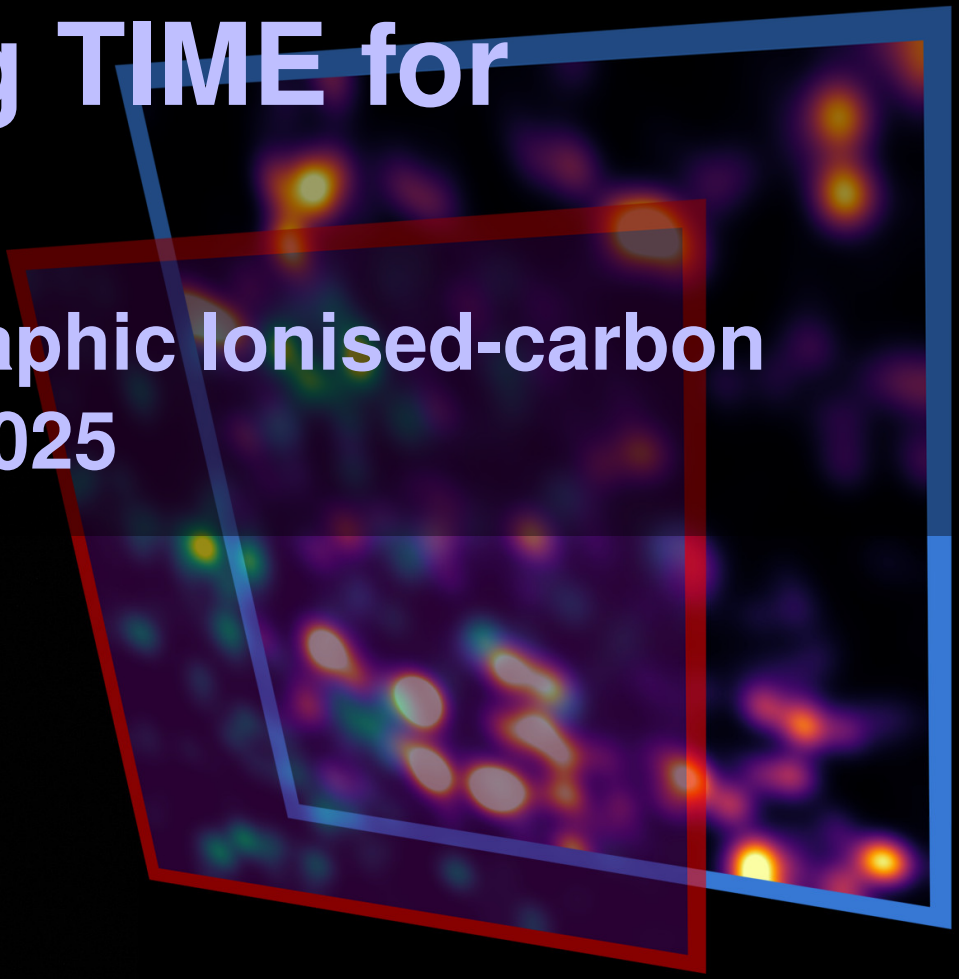
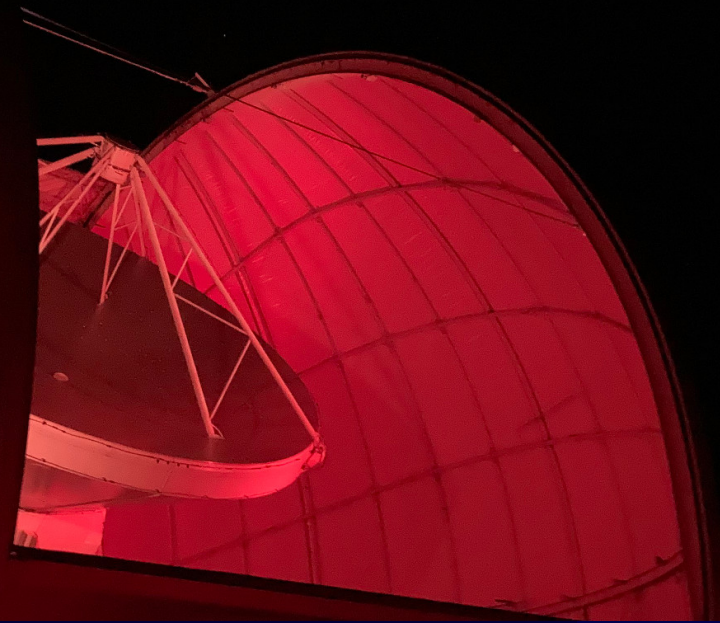
a vital pathfinding TIME for mm-wave LIM:

the status of the Tomographic Ionised-carbon Mapping Experiment in 2025





Dongwoo Chung (they/he)
on behalf of the TIME collaboration
Assistant Professor of Astronomy, Cornell University

file under ‘status’

photo: K Lau

- overall background and goals of TIME
- outcomes from 2022 and 2024 *commissioning* runs
- ongoing work for 2025 *science* deployment

TIME

the Tomographic Ionised-carbon Mapping Experiment

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Shwetha Prakash
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Sophie McAtee
Sofia Pereira
Sukhman Singh

Caltech JPL

Jamie Bock
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Kenny Lau
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NSF [AST 1910598, 23080{39,40,41,42}]

Keck Institute for Space Studies

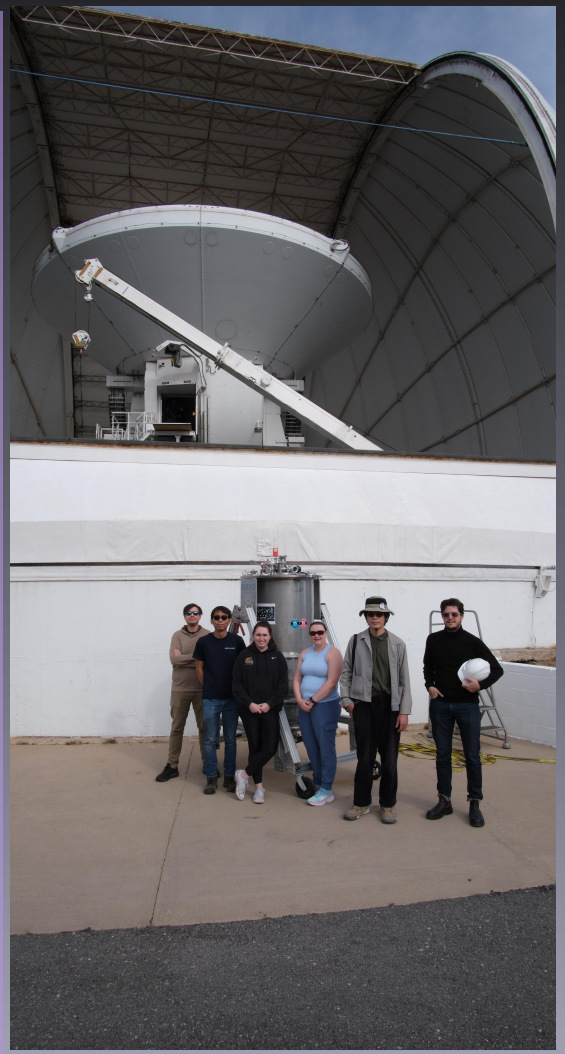

photo via E Mayer and T Natoli

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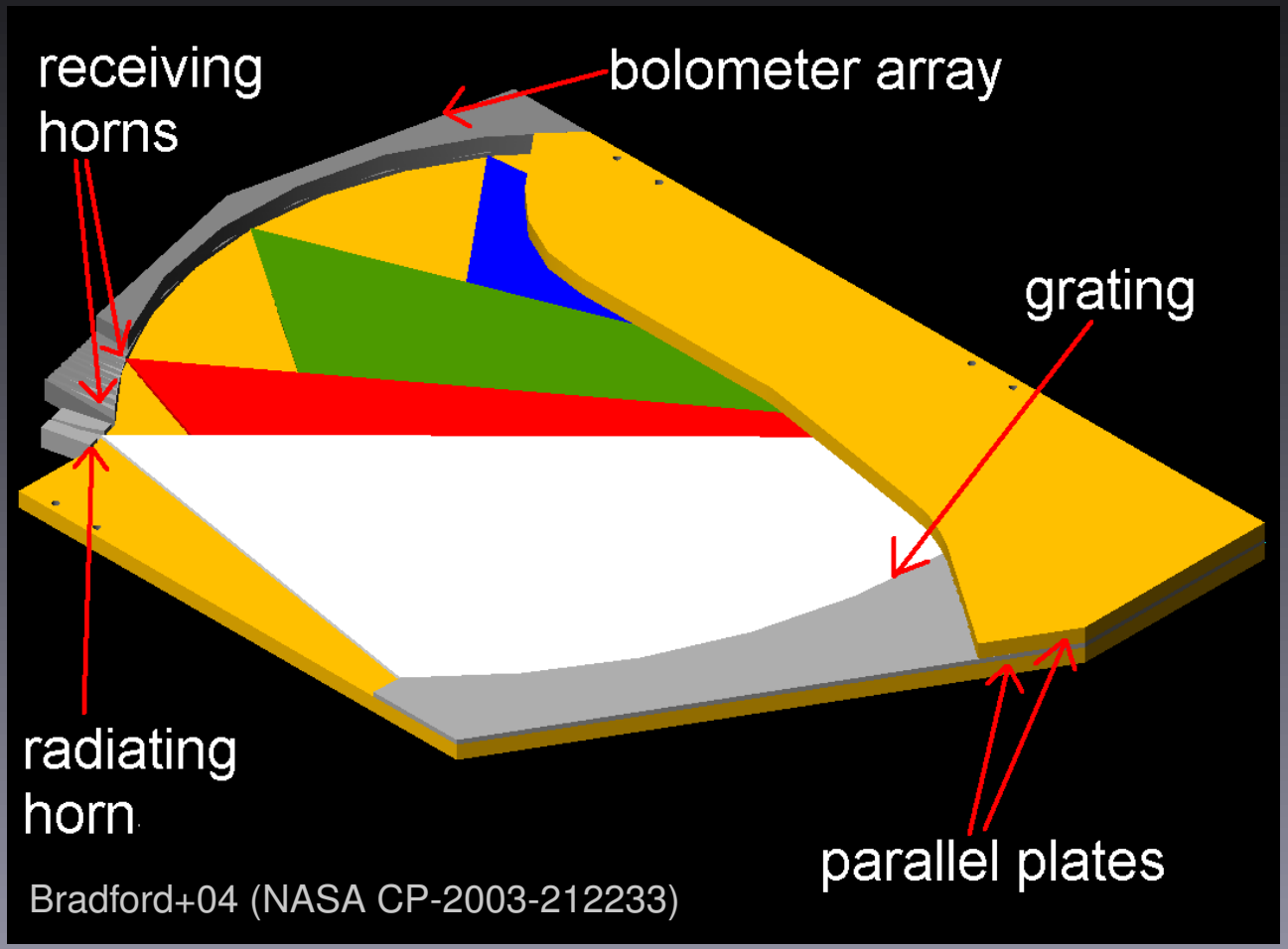
the Tomographic Ionised-carbon Mapping Experiment



- 200–300 GHz
  - [C II] at $z \approx 7$
  - various CO lines at $z \sim 1$
- TES bolometers, well proven and understood in CMB contexts
- compact waveguide grating, as used on CSO with Z-Spec

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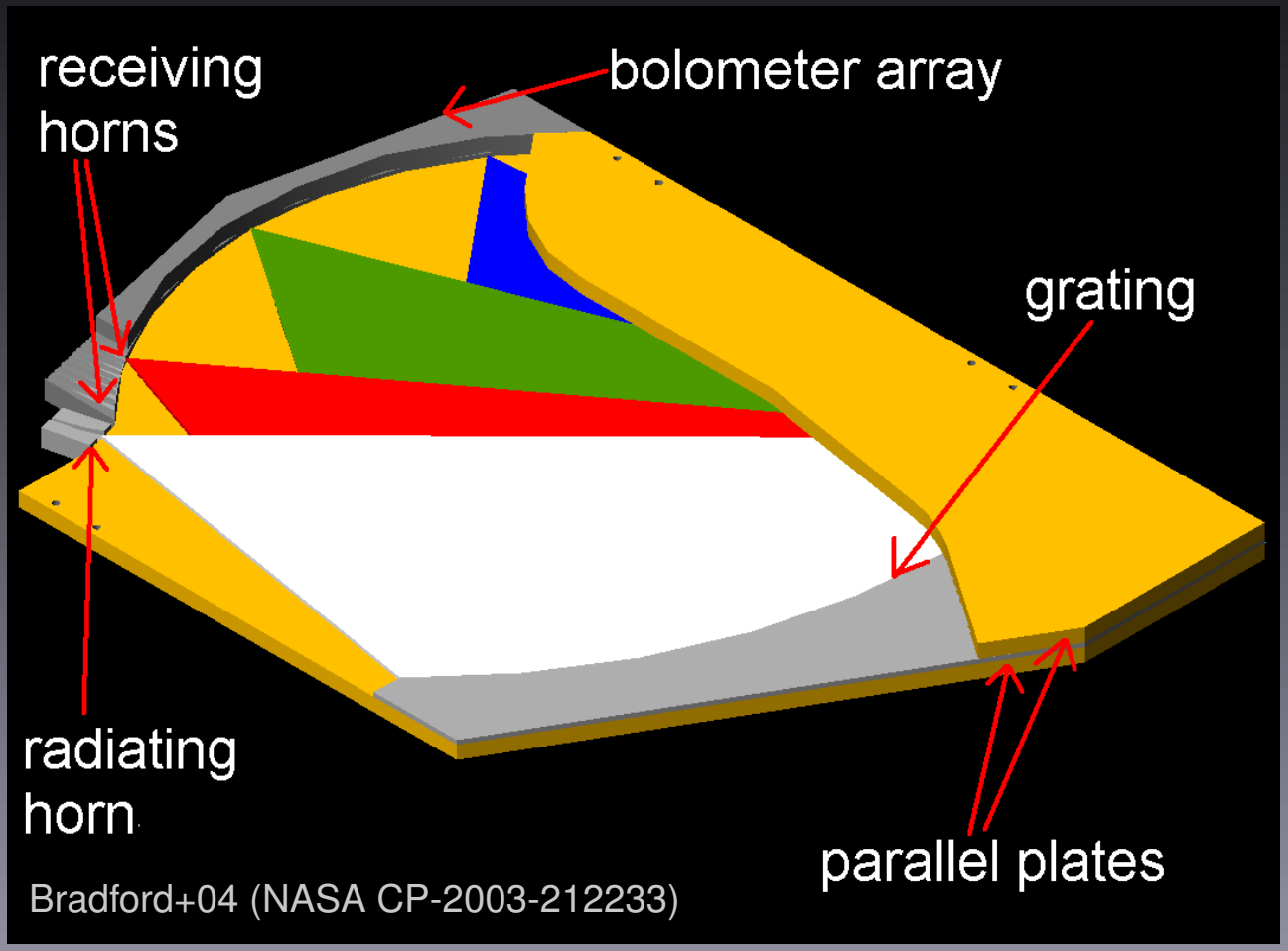
the Tomographic Ionised-carbon Mapping Experiment



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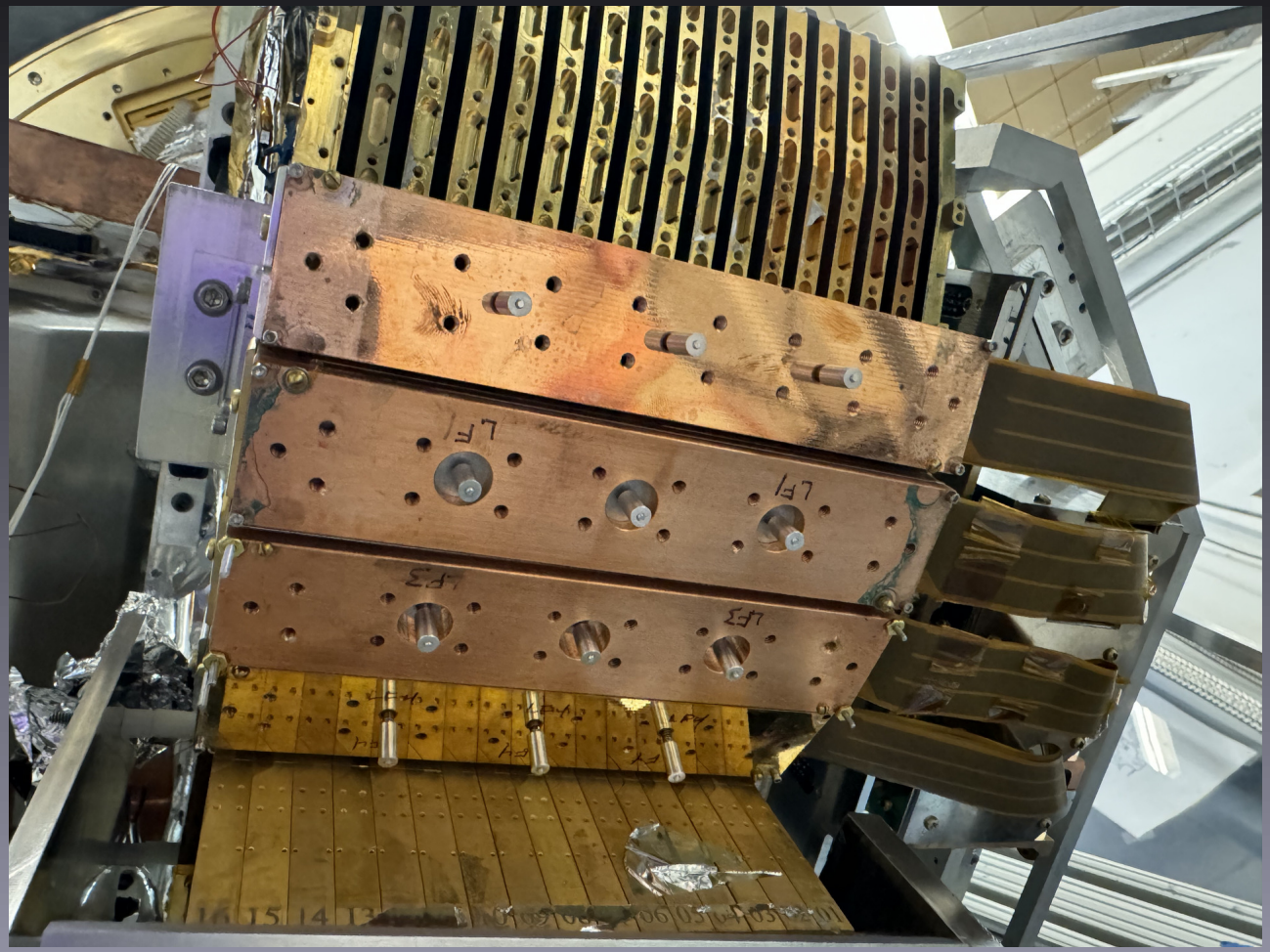

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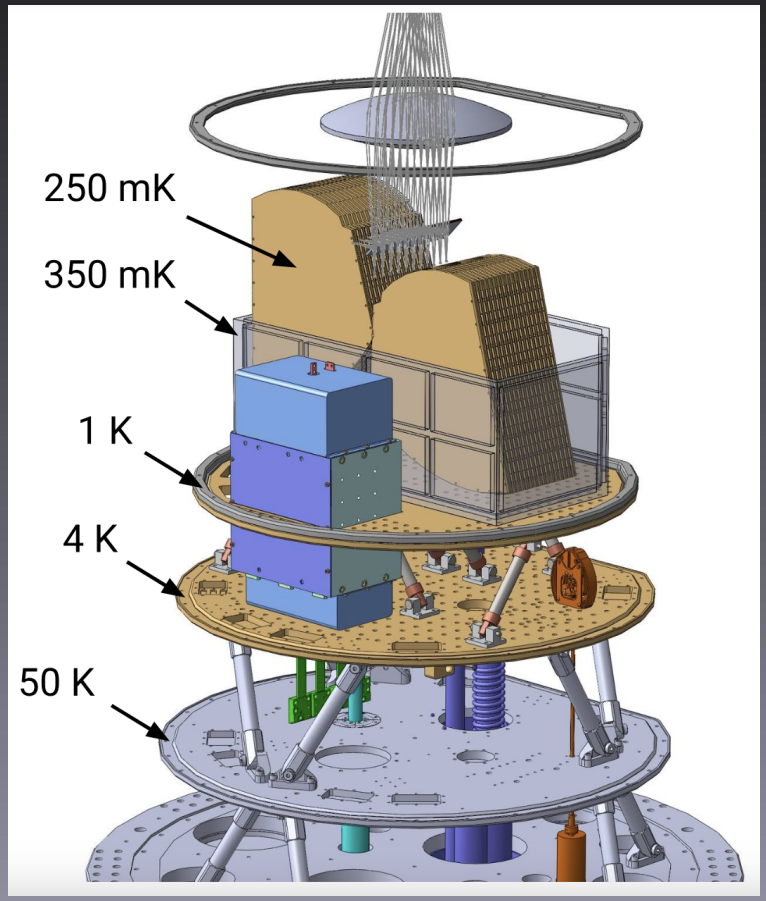
instrument design

- 2×16 feedhorns behind a polariser grid
- one grating spectrometer bank per polarisation
  - 183–326 GHz
  - $R \sim 100$ ($\delta\nu \sim$ 2–3 GHz)
- six modules of TES detectors per spectrometer
  - three LF (183–240 GHz), 8 frequency channels per module
  - three HF (240–326 GHz), 12 frequency channels per module

$\Rightarrow 2 \times 16 \times 60 = 1920$ detectors across 12 TES modules when fully populated

instrument design



$\Rightarrow 2 \times 16 \times 60 = 1920$ detectors across 12 TES modules when fully populated

- detectors designed for ≈ 300 mK
- some cold optics as well
- cooled with a set of helium sorption fridges, backed by PT and JT cryocoolers

science design

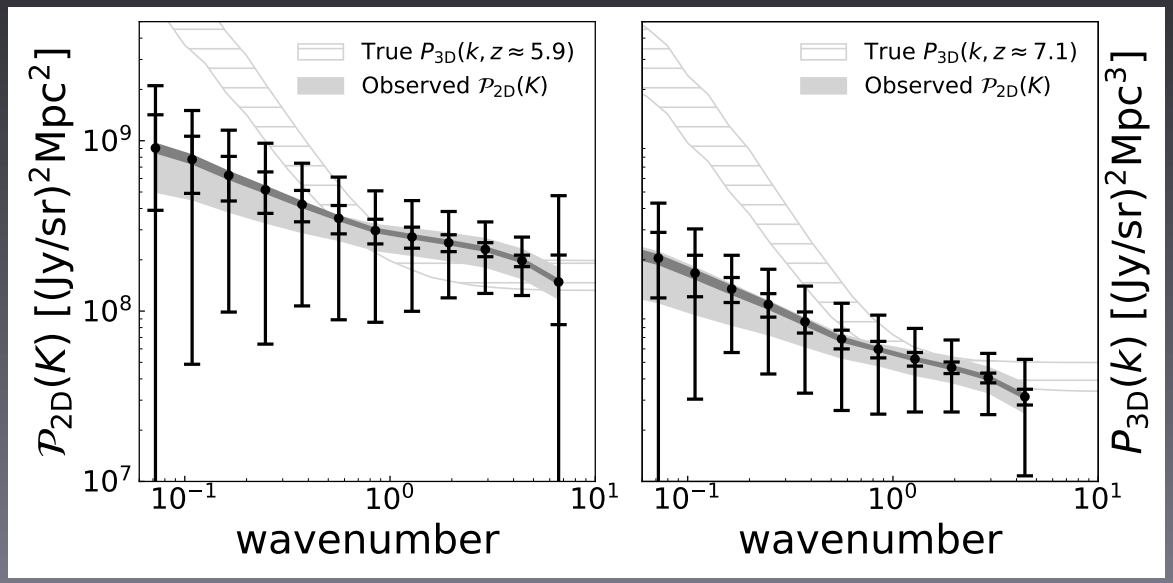


Figure: Sun+21 (arXiv:2012.09160)

- initial survey targeting 1.3 deg $\times$ 0.43 arcmin (180 $\times$ 1 beams) over $\sim 10^3$ hours
- slices of COSMOS and Stripe 82 likely, possibly additional field overlapping with COMAP/HETDEX
- also anticipating ancillary science from observations of galaxy clusters, protostellar cores, ...

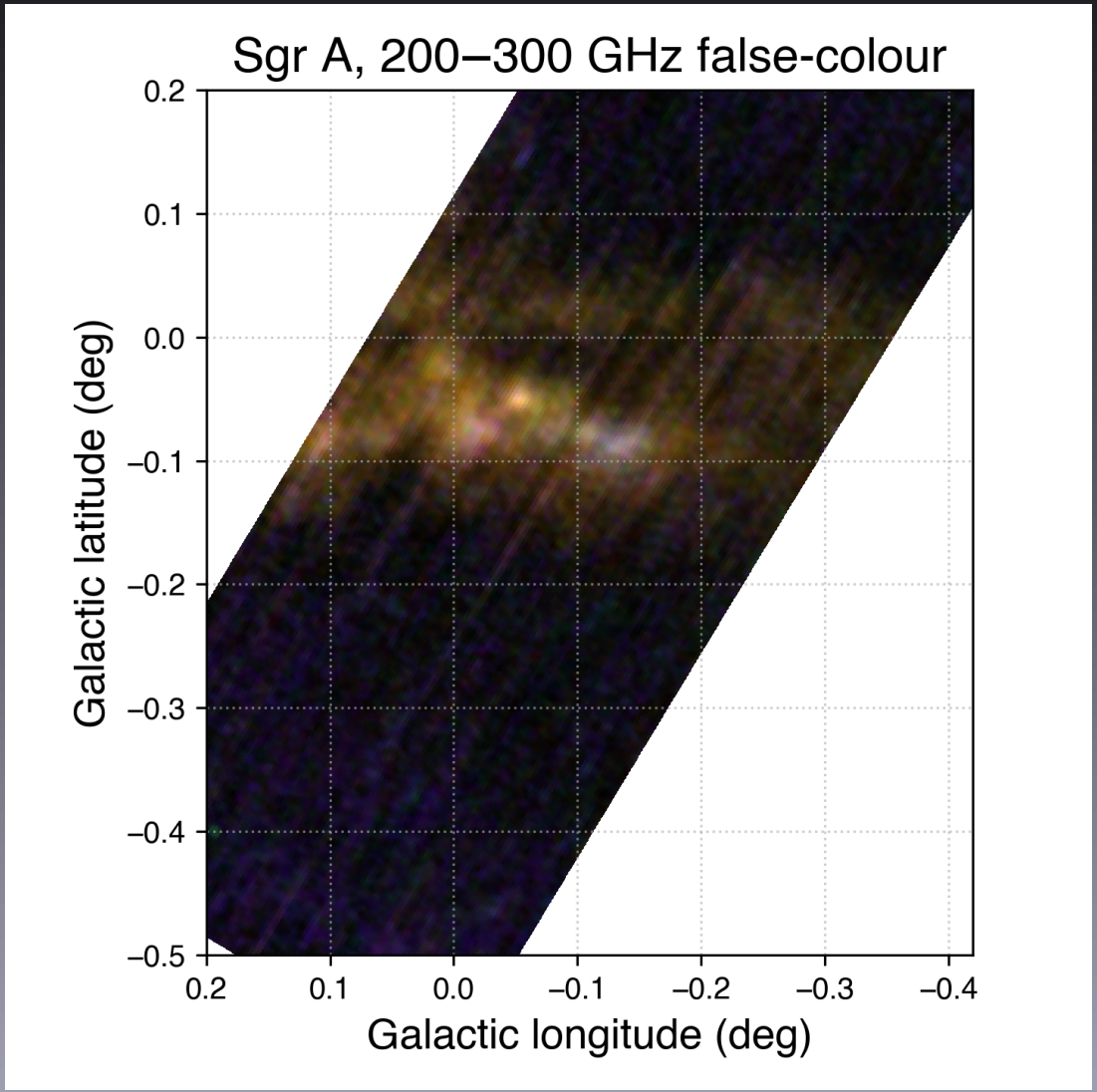
2022 commissioning run

photo D Marrone

- operated from the Arizona Radio Observatory 12 m telescope, at Kitt Peak
- verified on-sky focus, beams with partially integrated instrument (only one spectrometer, no polariser grid)
- verified hyperspectral imaging with both continuum and spectral line sources

view of the Galactic Centre

paper in prep (also prev. shown at various LIM and SPIE meetings)



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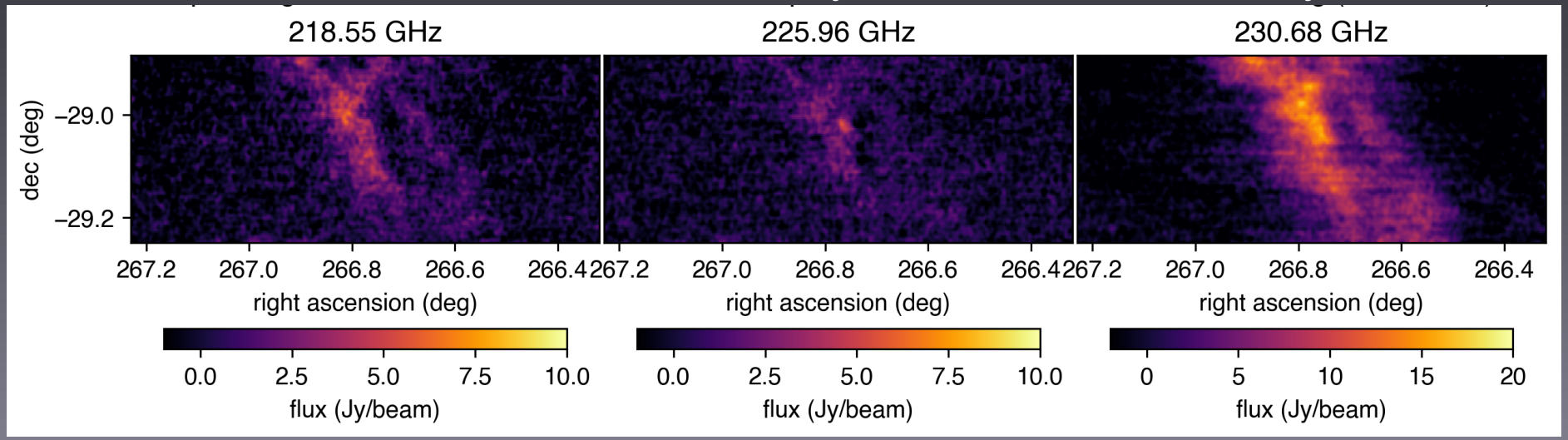
some dust + some CO | mostly dust | mostly CO



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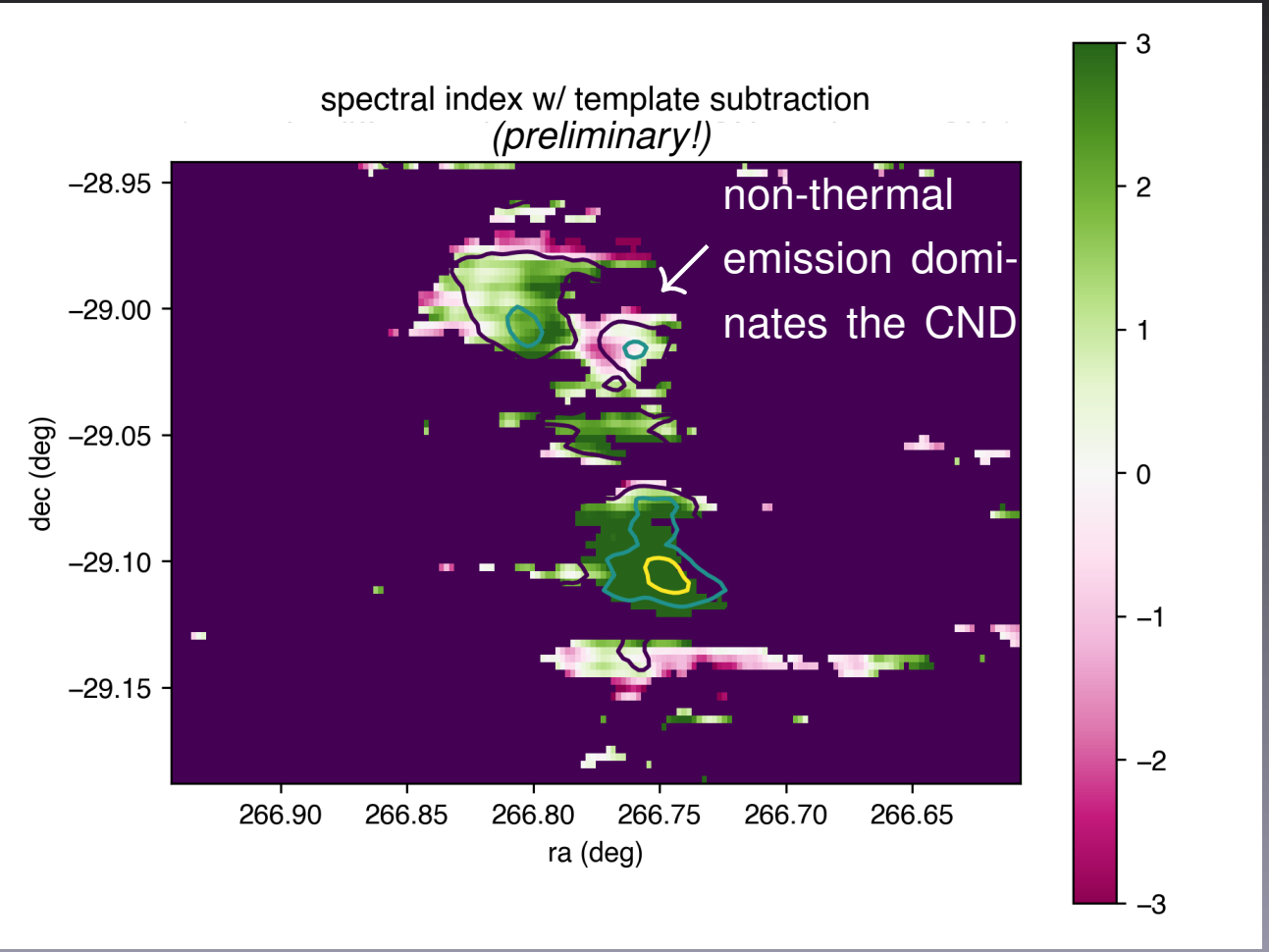
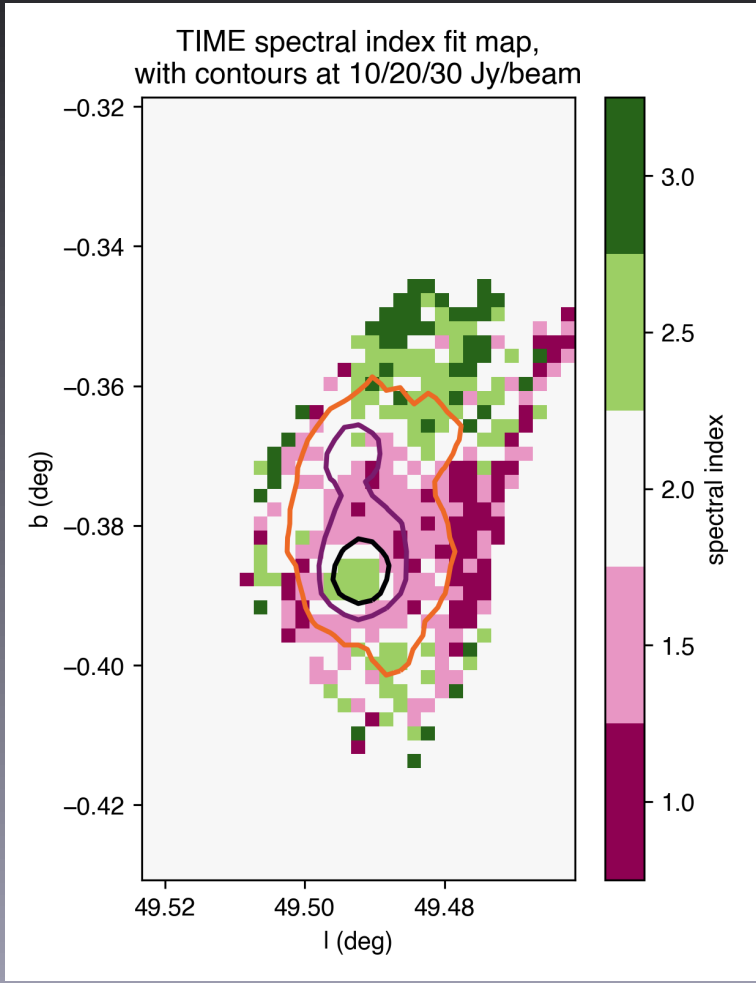
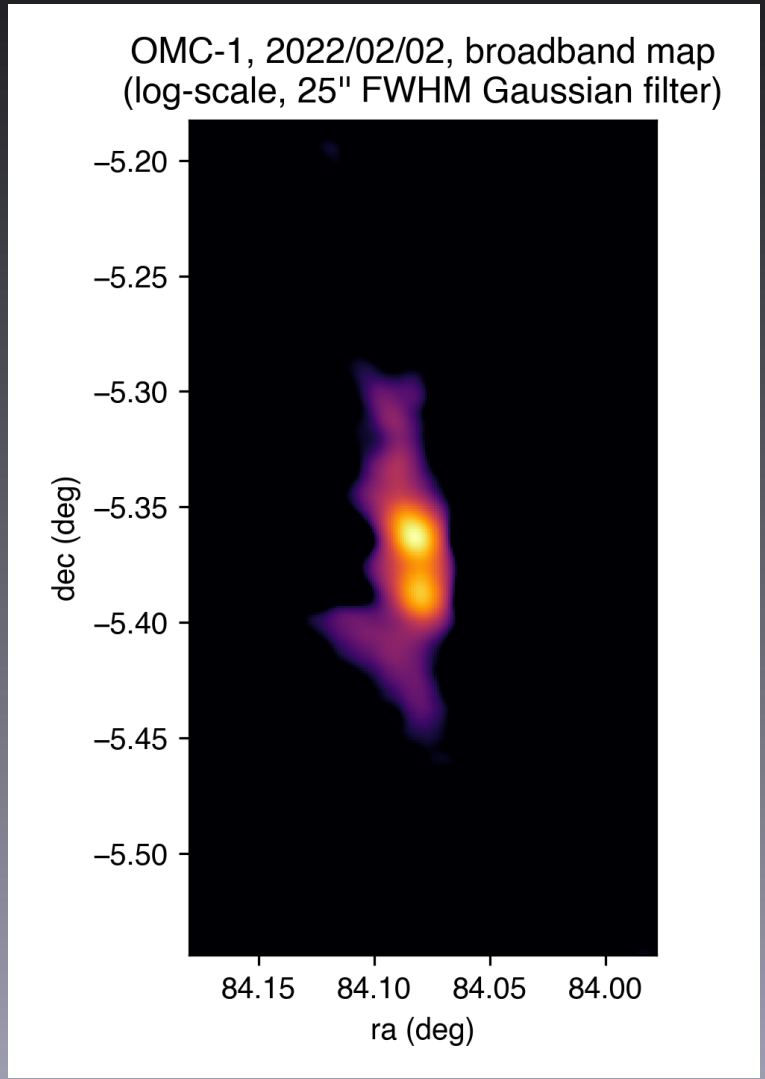


other observations

another paper also in prep

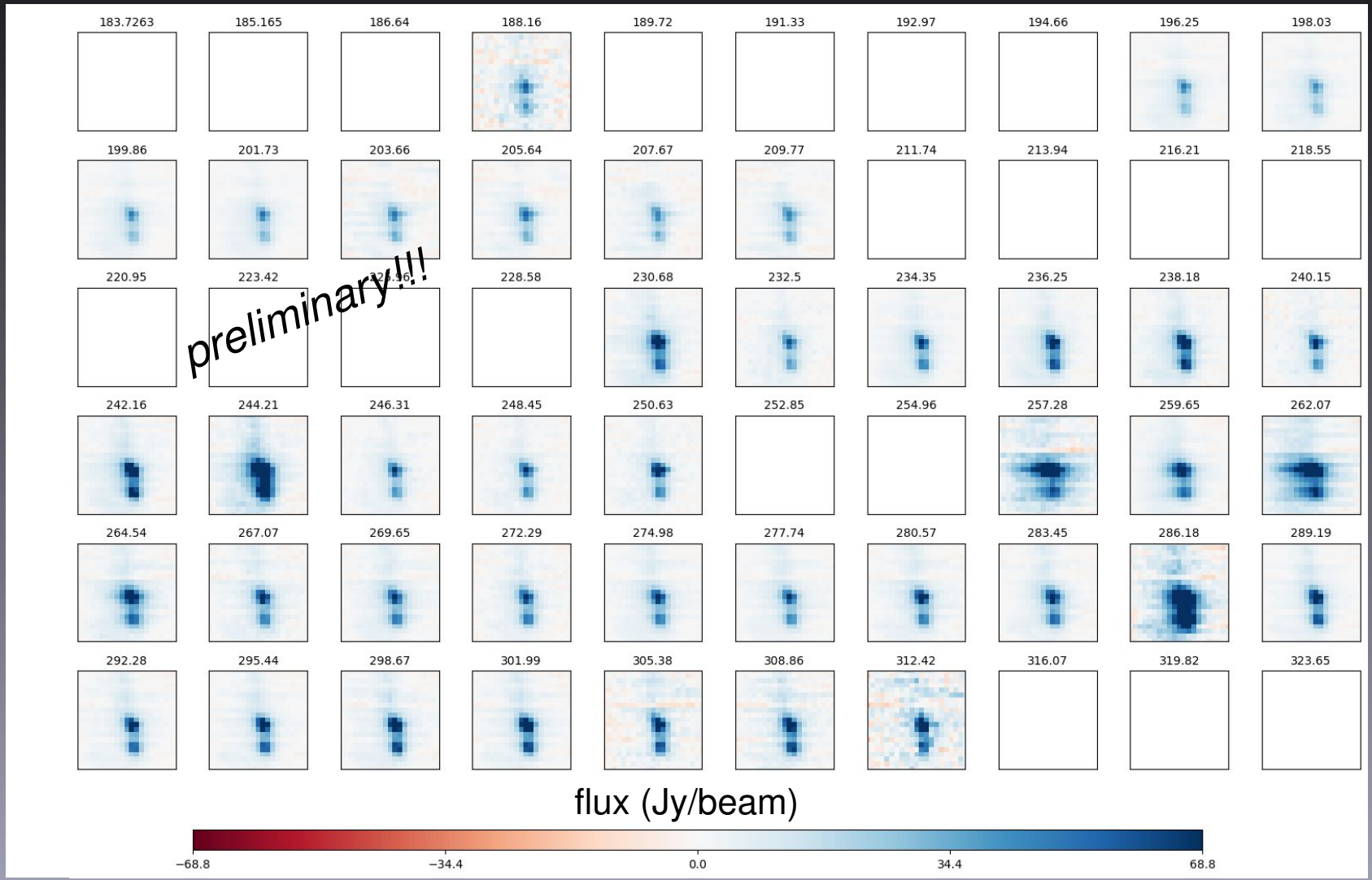
G49.5-0.4 SF region:





OMC ‘contact sheet’

another paper also in prep



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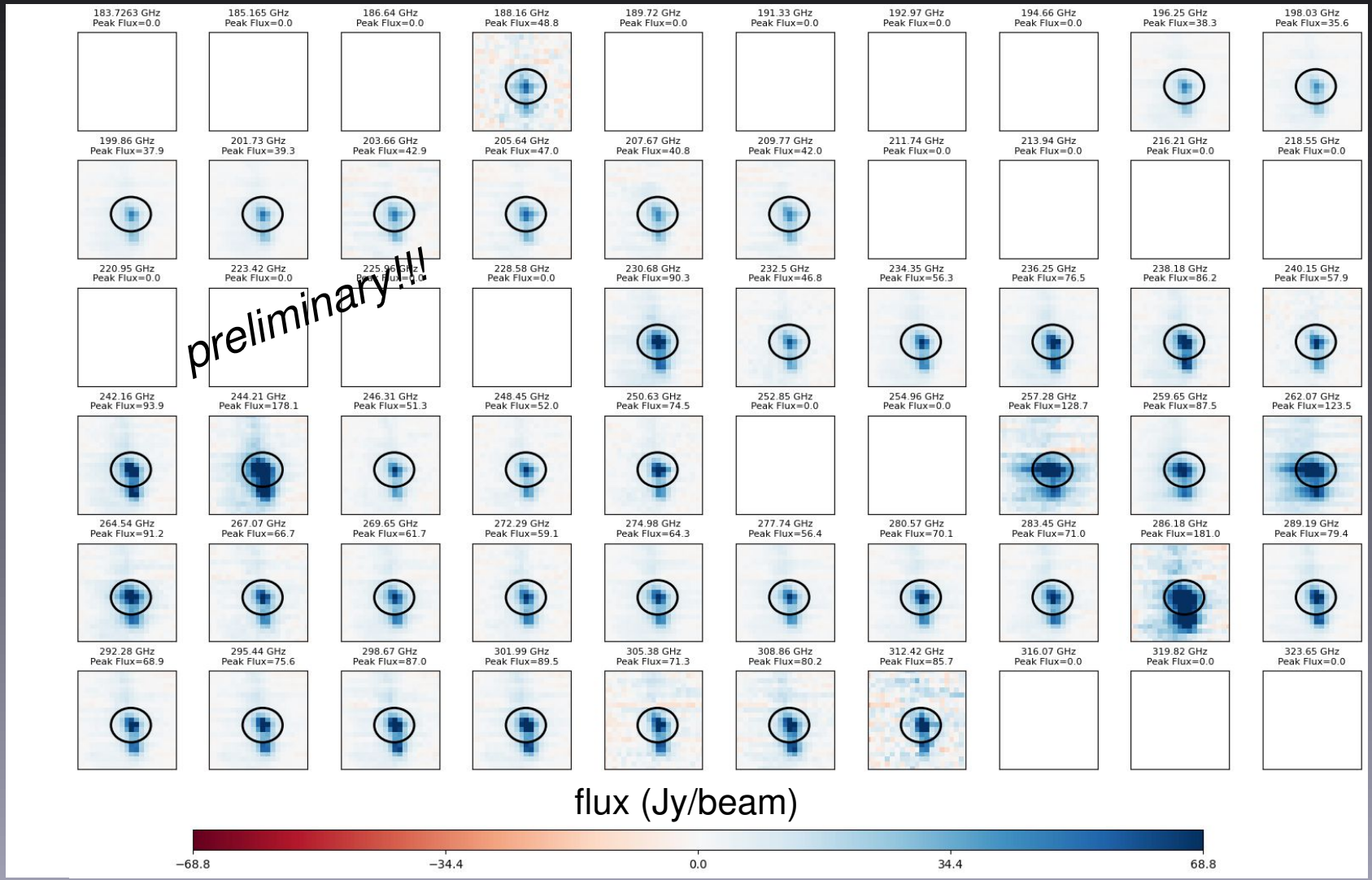


OMC ‘contact sheet’

spectrum from 3.25 hours of observations

‘contact sheets’ and spectrum via S Yang (Cornell PhD student w/ Abby Crites)

$I \sim \nu^4 \Rightarrow \beta \approx 2$ consistent with previous NIKA2 maps, CONCERTO?

2024 commissioning run

- we attempted to deploy detectors across both spectrometers, with a brand new polariser grid and cryo-mechanical design.
- in lab tests and at Kitt Peak, we discovered key cryogenic and thermo-mechanical obstacles to a happy healthy instrument.
- we are now in the process of implementing remedies and improvements for our upcoming return to Kitt Peak this winter.

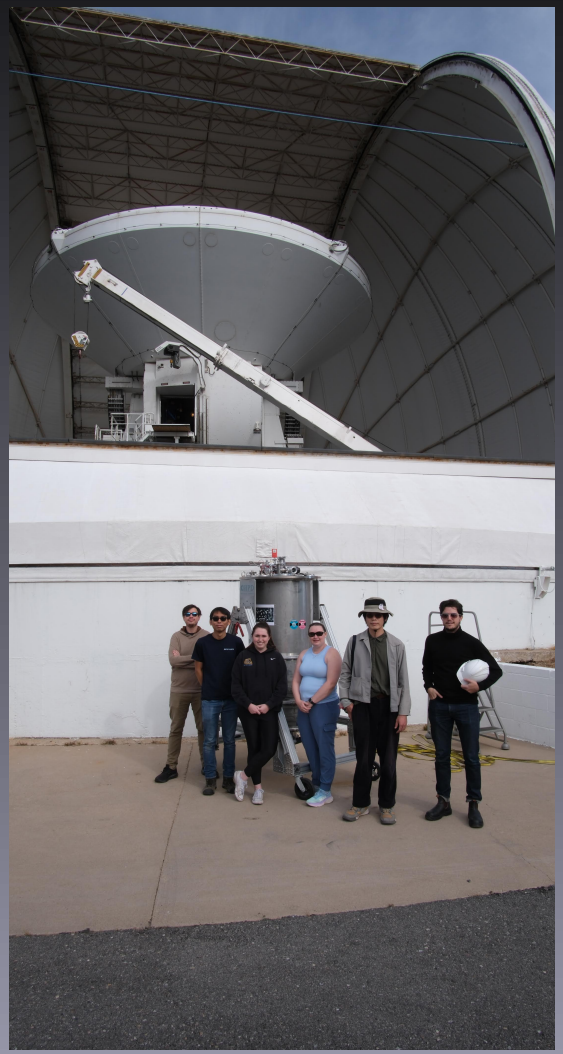
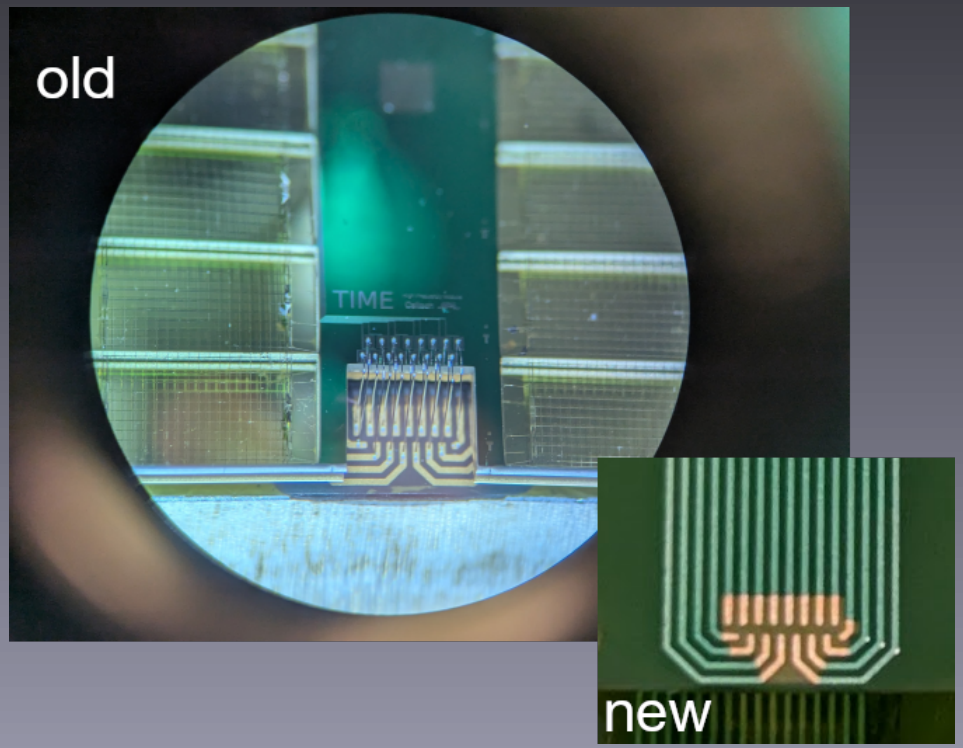


photo via E Mayer and T Natoli

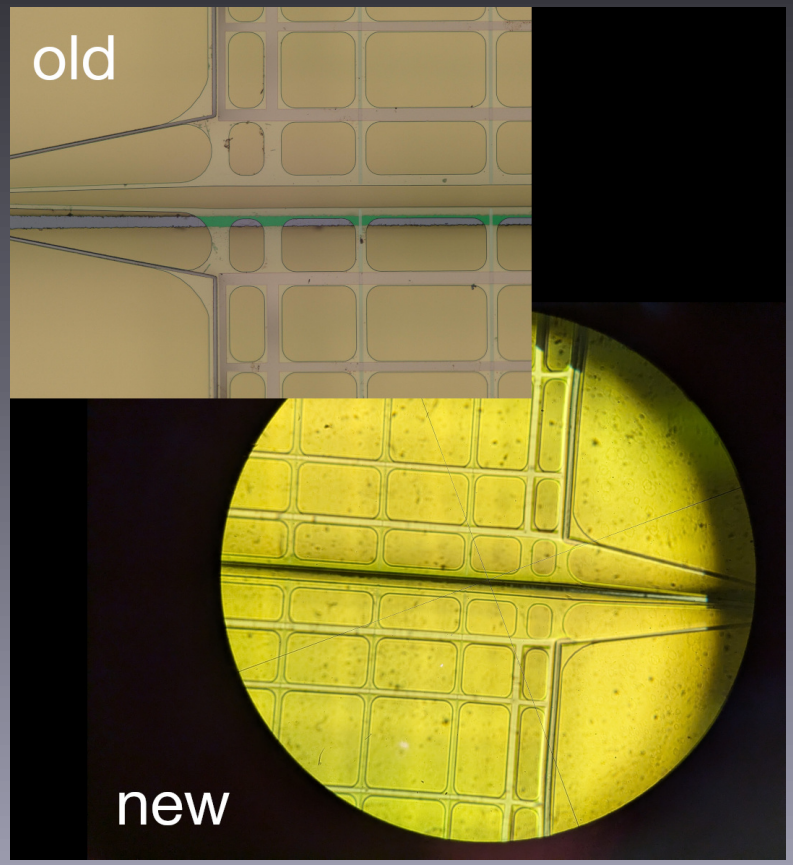
ongoing work

photos (and work) courtesy K Lau + JPL staff

new cable geometry to improve detector readout



re-fabrication of detectors to fix thermal shorts



ongoing work

nodes at Cornell and Caltech (+ weather station dev at RIT)

integrated receiver testing at Cornell

component testing possible with ‘pinkie’ cryostat at Caltech

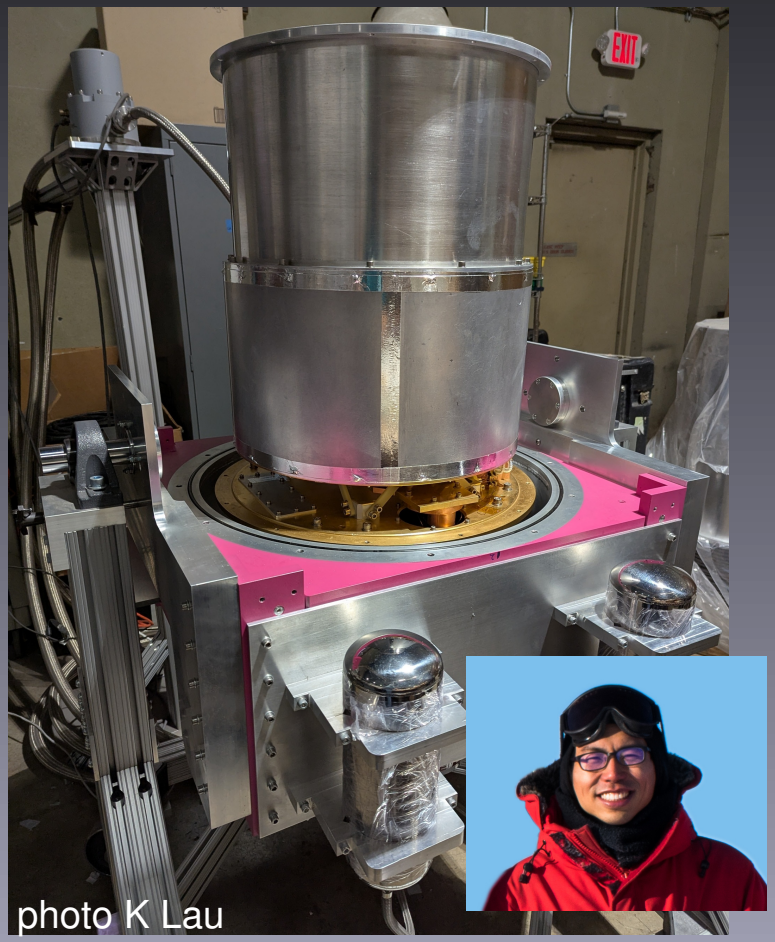


photo K Lau

conclusions

- TIME represents a set of well-understood technologies combined into a pathfinding experiment for mm-wave LIM, surveying [C II] at EoR and CO rotational lines near ‘cosmic noon’.
- our commissioning runs in 2022 and 2024 provided important tests of the TIME instrument—some wildly successful, some pointing to avenues of clear improvement.
- we expect to begin science observations this upcoming winter, and are hard at work understanding our previous on-sky data and our current instrument to enable future success.