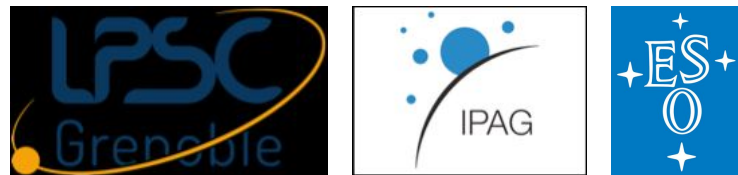


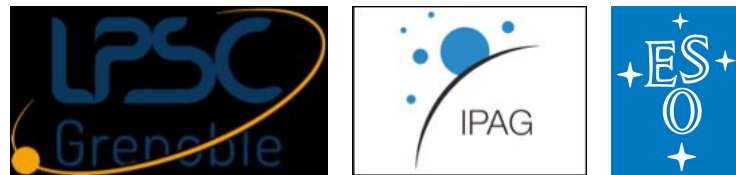
The CONCERTO wide field-of-view millimeter-wave spectrometer at APEX

Laboratoire d'Astrophysique Marseille
Institut Néel, LPSC, IPAG - Grenoble
University of Cardiff
European Southern Observatory (ESO)



The CONCERTO wide field-of-view millimeter-wave spectrometer at APEX

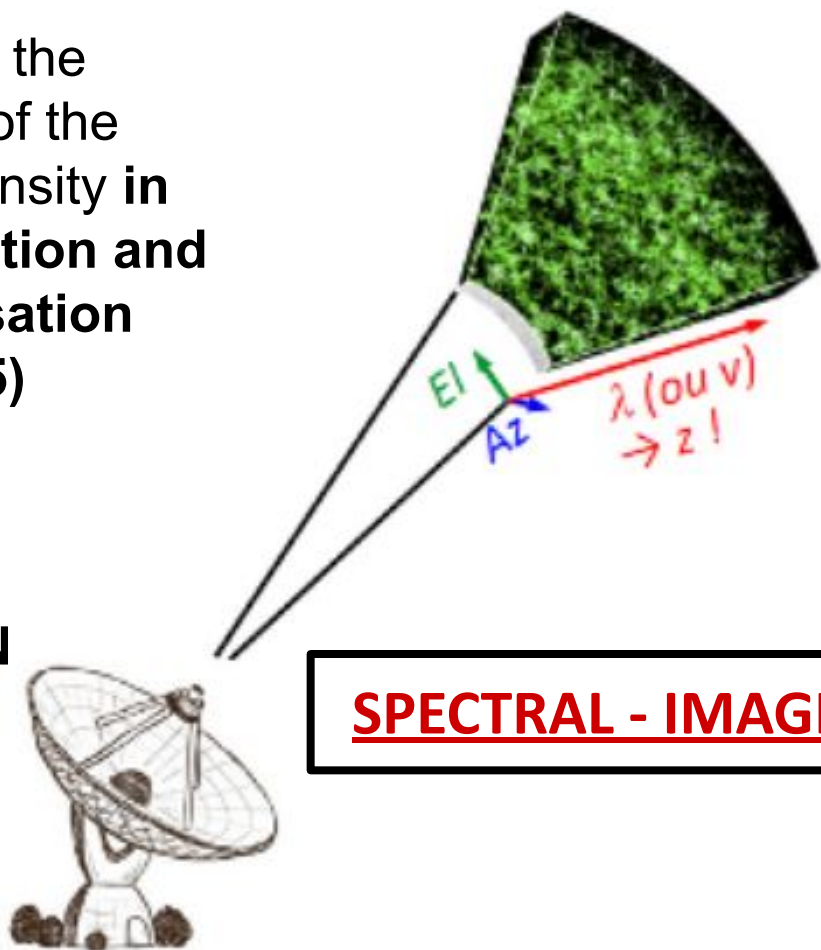
Laboratoire d'Astrophysique Marseille
Institut Néel, LPSC, IPAG - Grenoble
University of Cardiff
European Southern Observatory (ESO)



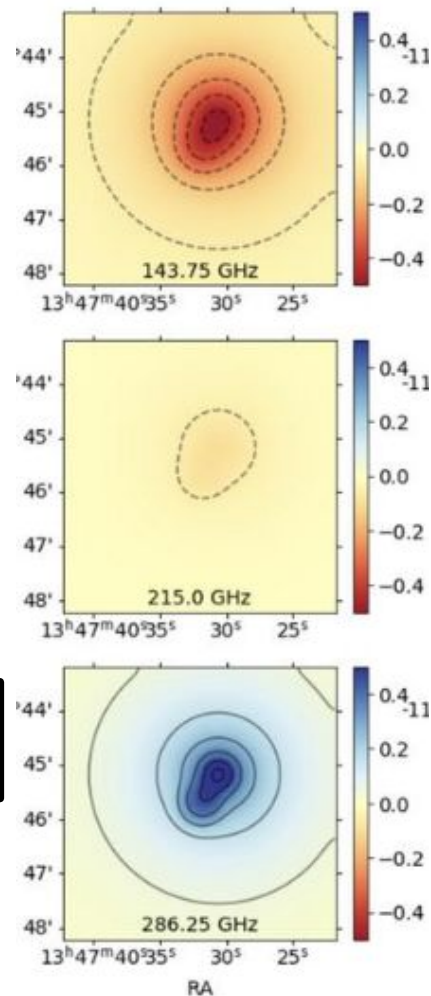
SCIENCE MOTIVATIONS: EXAMPLES

Map, **in 3-D**, the fluctuations of the [CII] line intensity in the reionisation and post-reionisation epoch ($z > 5$)

→ EARLY GALACTIC EVOLUTION



SPECTRAL - IMAGING !!



Clusters of galaxies are the largest g-bound objects in the Universe. We expect to perform a (spatial) mapping of the shape of the SZ **spectrum** for clusters at $z = 0.2-0.8$

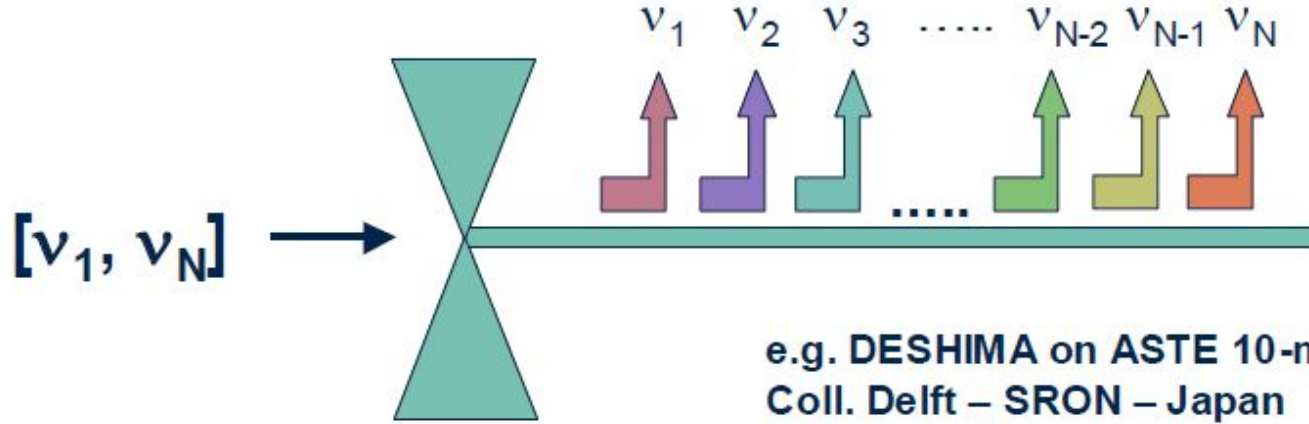
→ HIERARCHICAL LARGE SCALE STRUCTURE

Line Intensity Mapping

Galaxies clusters (SZ)

INSTRUMENT: TWO OPTIONS

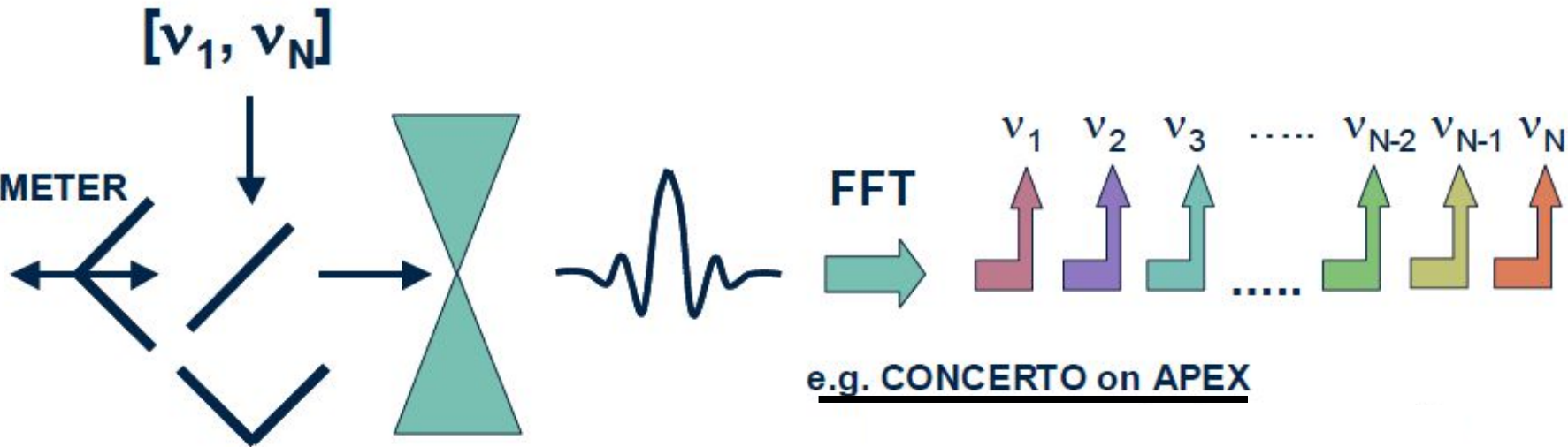
ON-CHIP



e.g. DESHIMA on ASTE 10-meters telescope
Coll. Delft – SRON – Japan
OR SuperSpec US coll.

BETTER FOR
**COMPACT
SOURCES**
AND
R=100 ÷ 1000

INTERFEROMETER



e.g. CONCERTO on APEX

BETTER FOR
**LARGE PATCHES
OF THE SKY**
AND
R = 10 ÷ 100

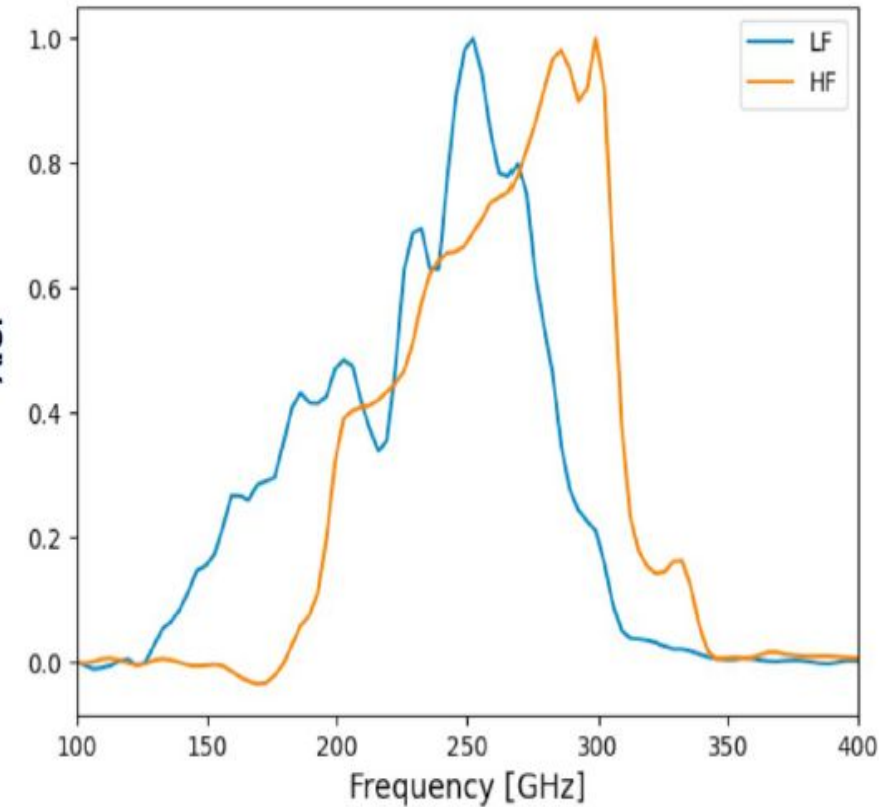
OTHER OPTIONS FOR LOW-R/WIDE FIELD: FABRY-PEROT, FILTERS .. ADVANTAGES/DRAWBACKS WRT INTERFEROMETERS

CONCERTO DATASHEET

CONCERTO coll., *Astronomy & Astrophysics* 642, A60 (2020)
 A. Monfardini et al., arxiv 2106.14028, proc. LTD19 (2021)

Table 1. Main characteristics of CONCERTO.

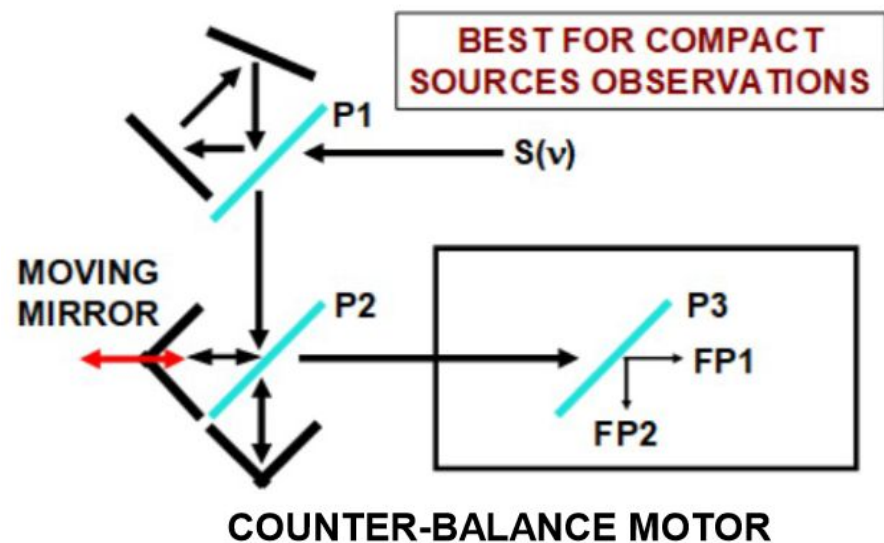
Telescope primary mirror diameter [m]	12
Field-of-view diameter [arcmin]	18.6
Absolute spectral resolution [GHz]	≥ 1
Relative spectral resolution R [#]	1–300
Frequency range HF LF [GHz]	195–310 130–270
Pixels on Sky HF LF [#]	2152 2152
Angular resolution HF LF [arcsec]	20–32 23–45
Average angular resolution HF LF [arcsec]	26 34
Instrument geometrical throughput [sr m^2]	2.5×10^{-5}
Single Pixel geometrical throughput [sr m^2]	1.16×10^{-6}
Data rate [MBytes s^{-1}]	128



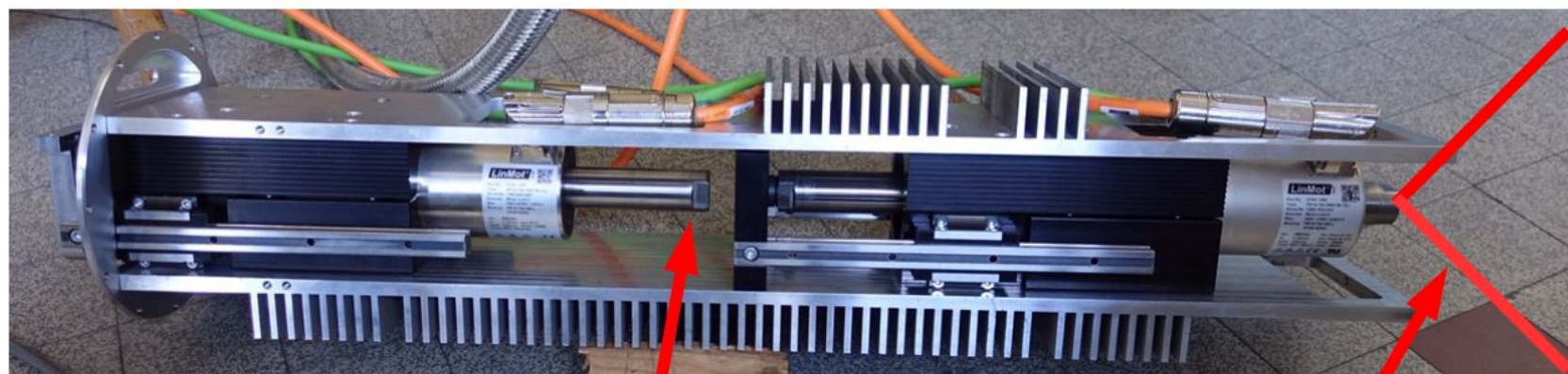
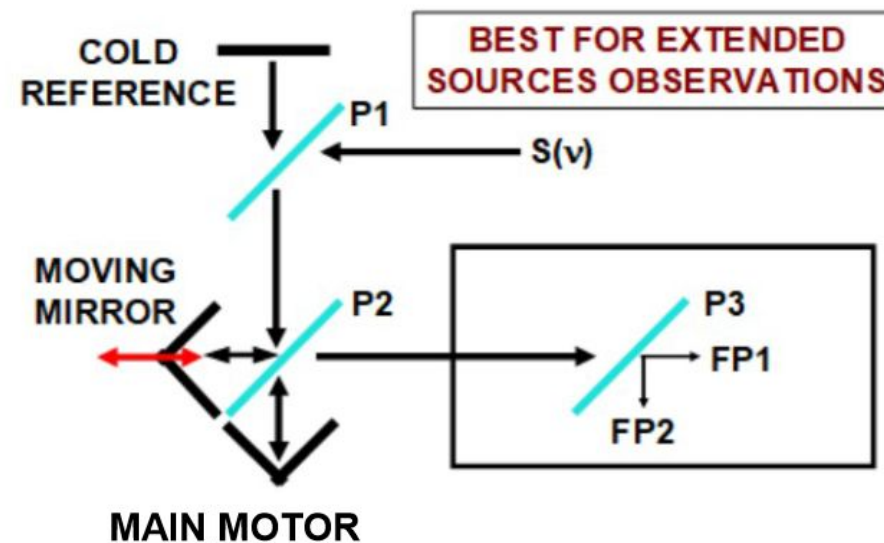
THE INTERFEROMETER

The CONCERTO collaboration,
Astronomy & Astrophysics 642, A60 (2020)

(SKY) - ("defocus" SKY)



(SKY) - (COLD REFERENCE)



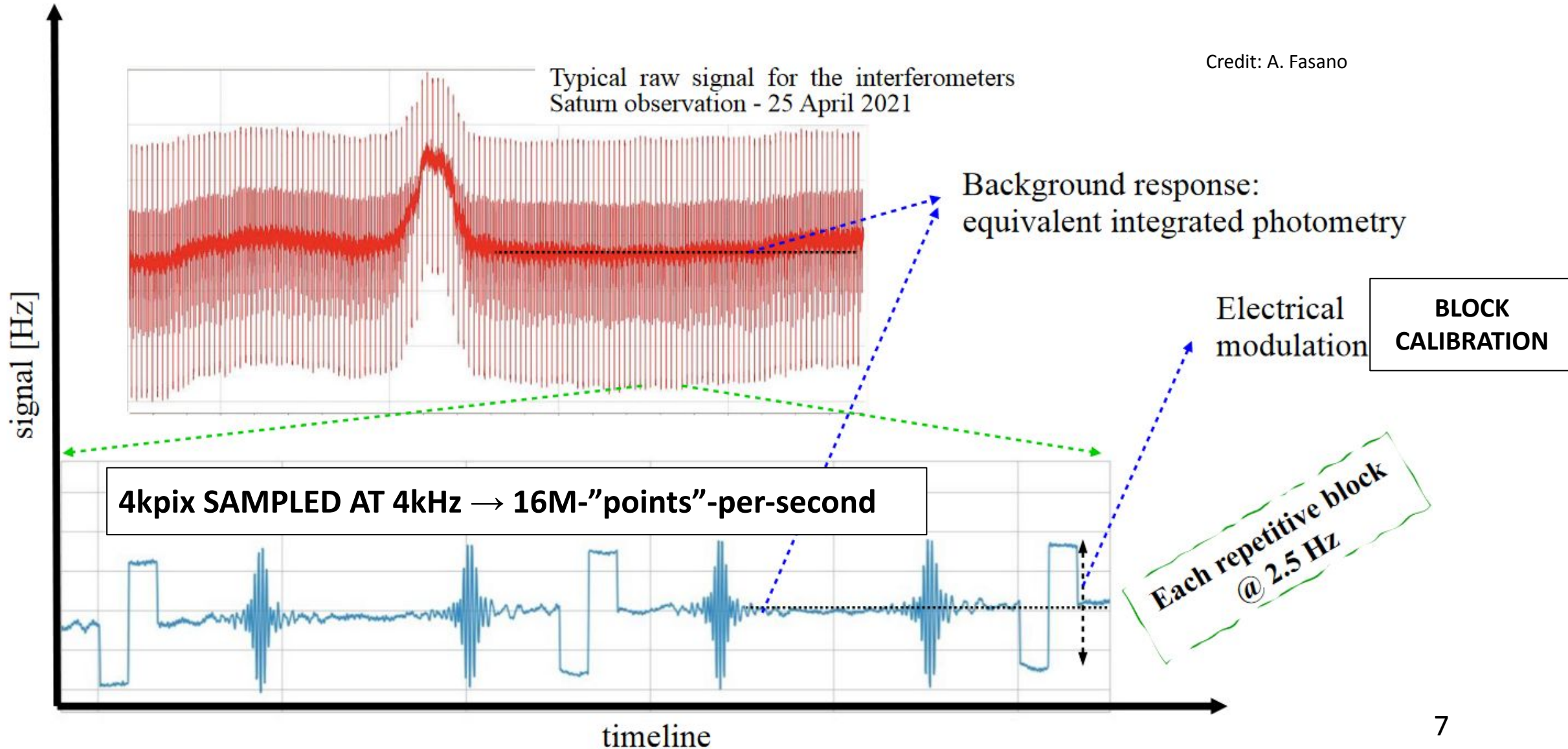
COUNTER-WEIGHT POSITION

MPI MOVING ROOFTOP MIRROR

MOVING ROOF MIRROR IS 60cm, AT 2.5 Hz !

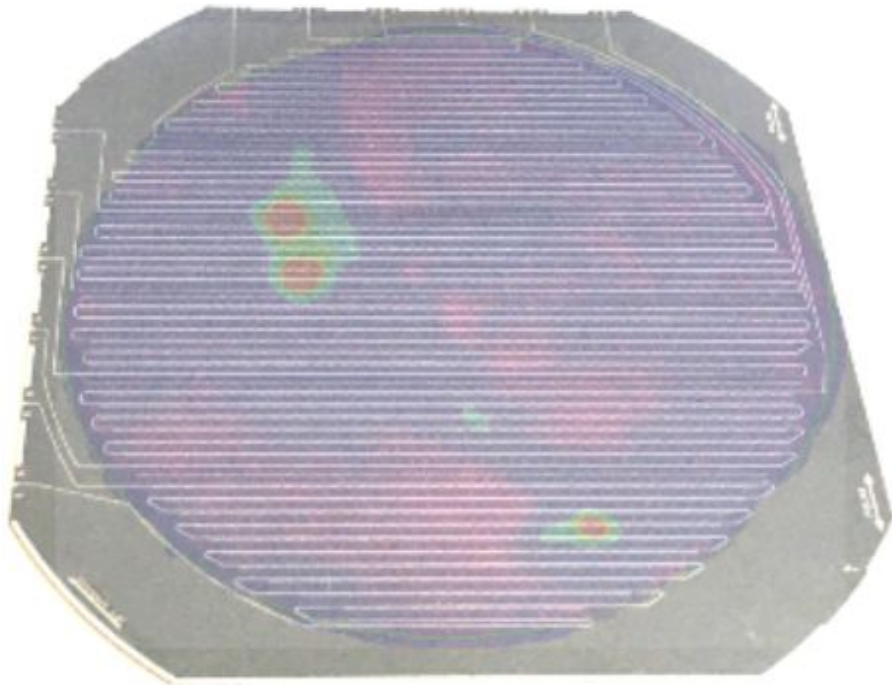
CONCERTO DATA TIMELINES

Credit: A. Fasano



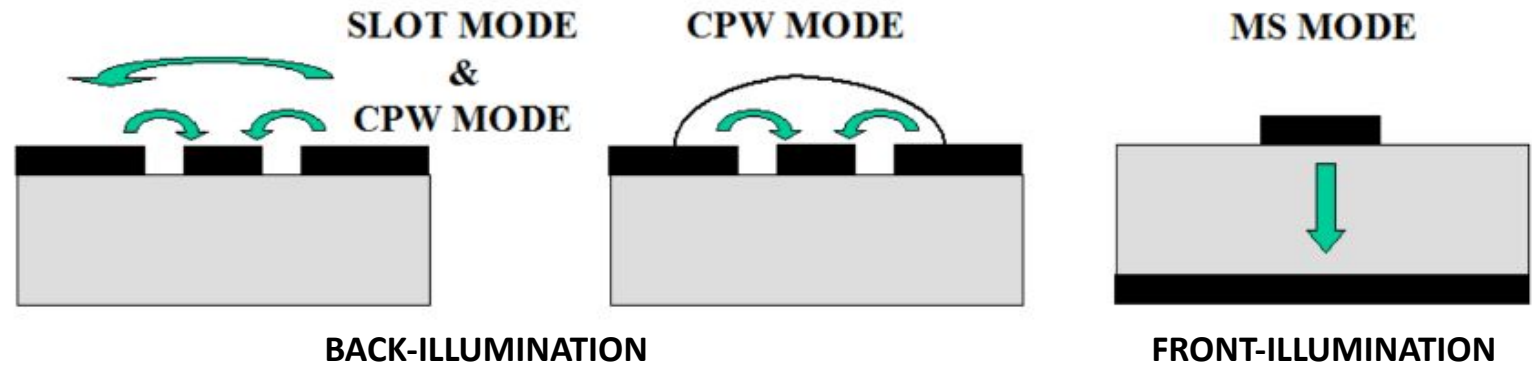
THE CONCERTO DETECTORS

A CONCERTO 2152-LEKID-pixels
Six feedlines, microstrip coupling



Cat's Paw nebula (**NGC6334**) size on top of a CONCERTO array (18.6arc-min)

CPW (NIKA1, KISS) versus Microstrip (NIKA2, CONCERTO)



For CONCERTO bands, we have used ad-hoc substrates of 105 μm (HF) and 125 μm (LF).

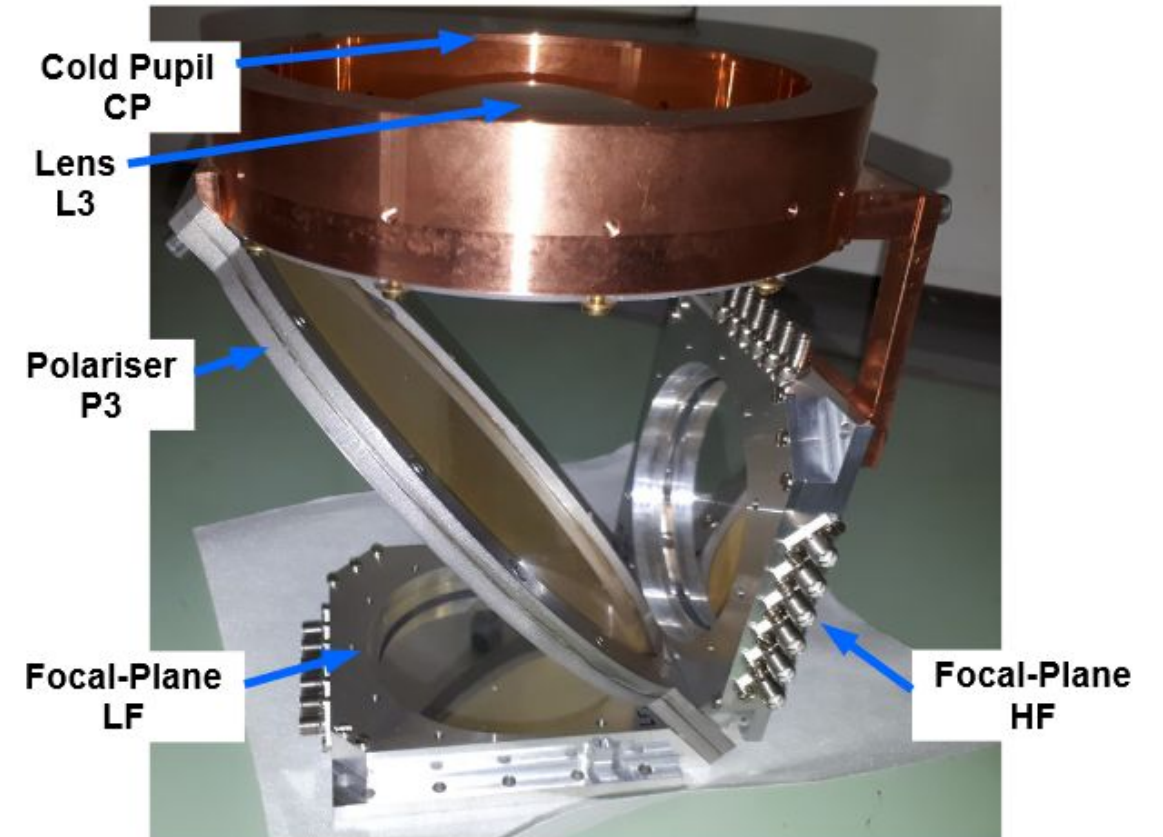
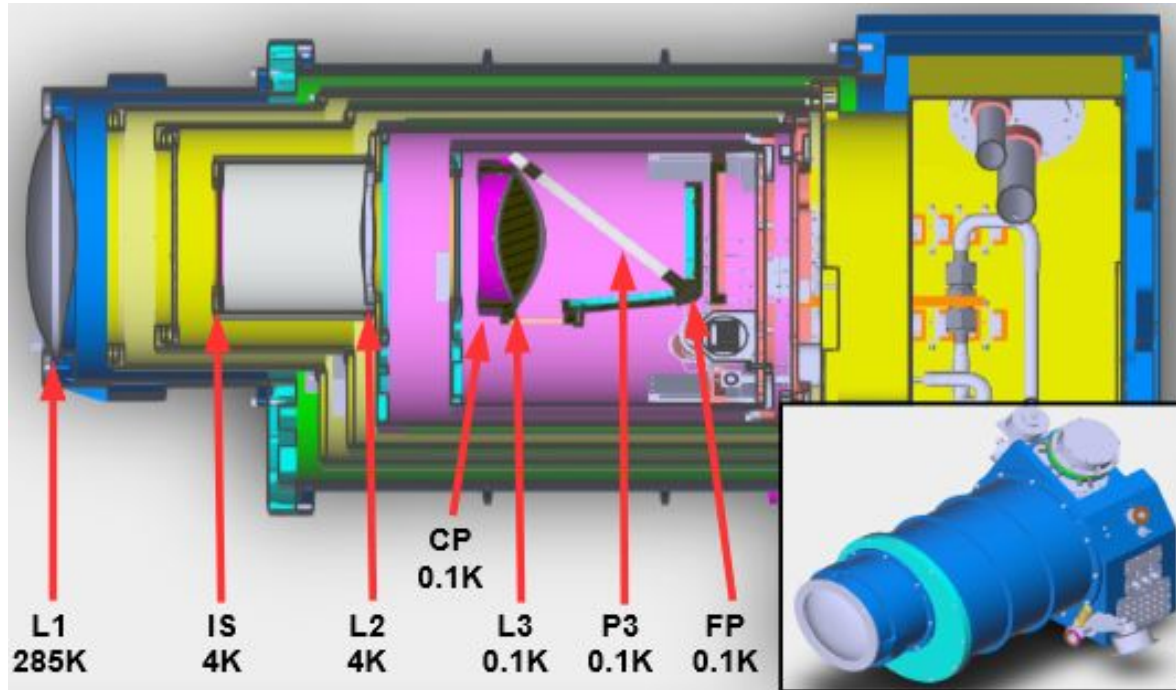
Thin Al (20nm) on the front, Al-Au on the back (RF and thermalisation)

→ **High array yield** (no more limited by litho but wafer manipulation)

→ Typically **around 90% identified resonances**

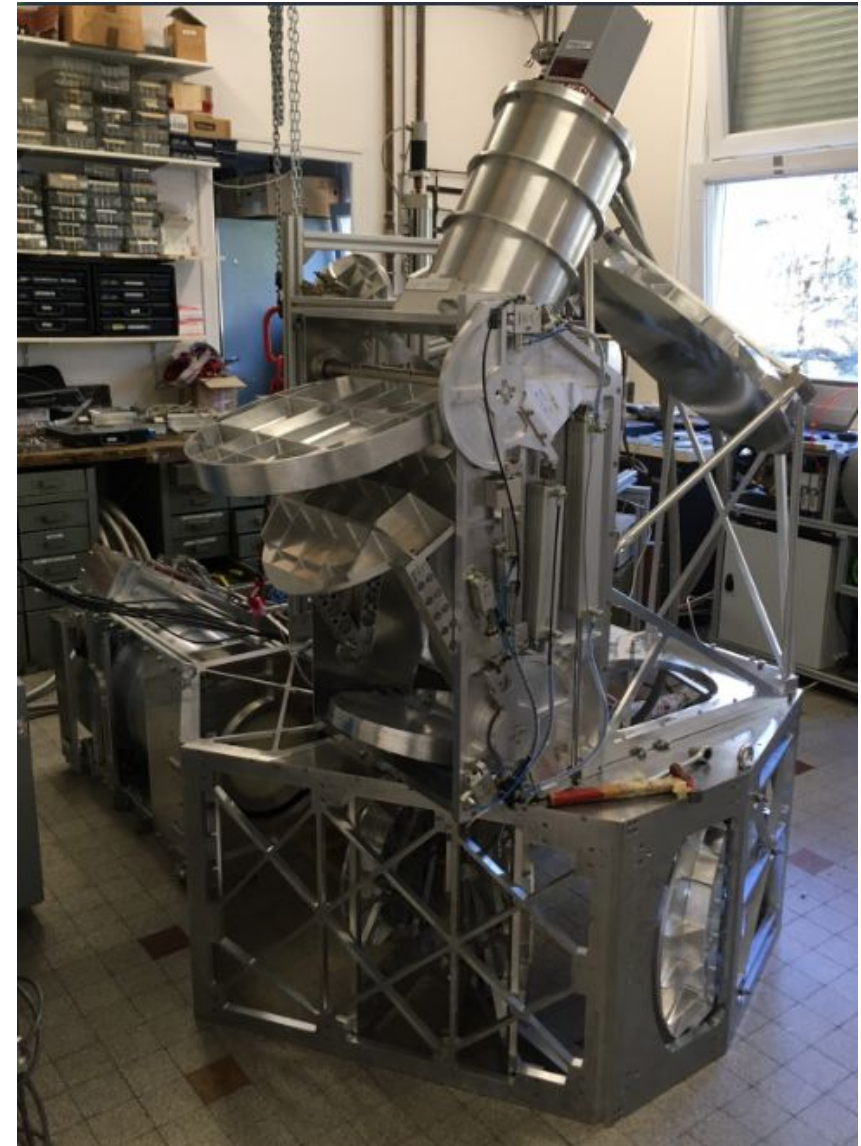
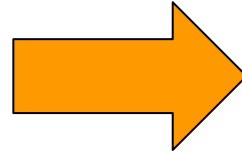
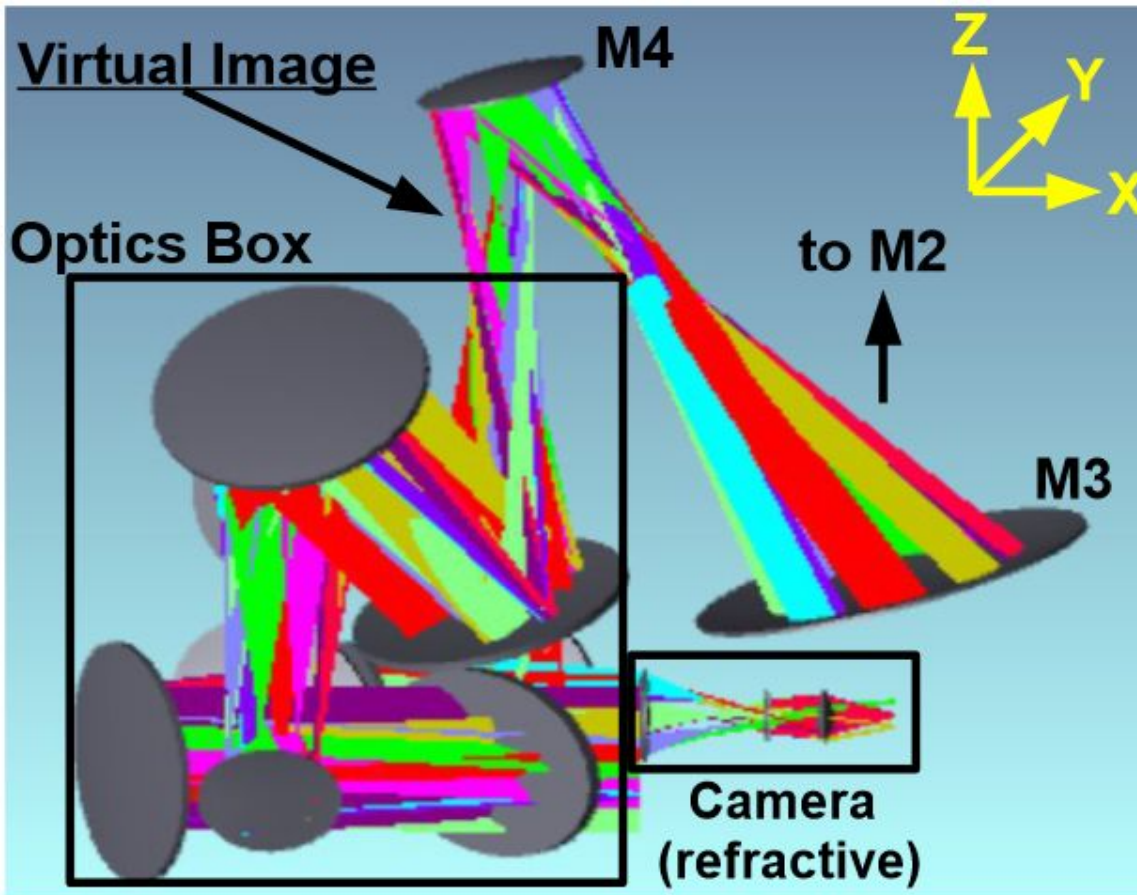
→ Made a number of arrays to select the “flight” ones

THE CONCERTO CRYOSTAT



The polarisation is projected with near 100% efficiency by a 45 degrees polarizer without sacrificing the compactness.

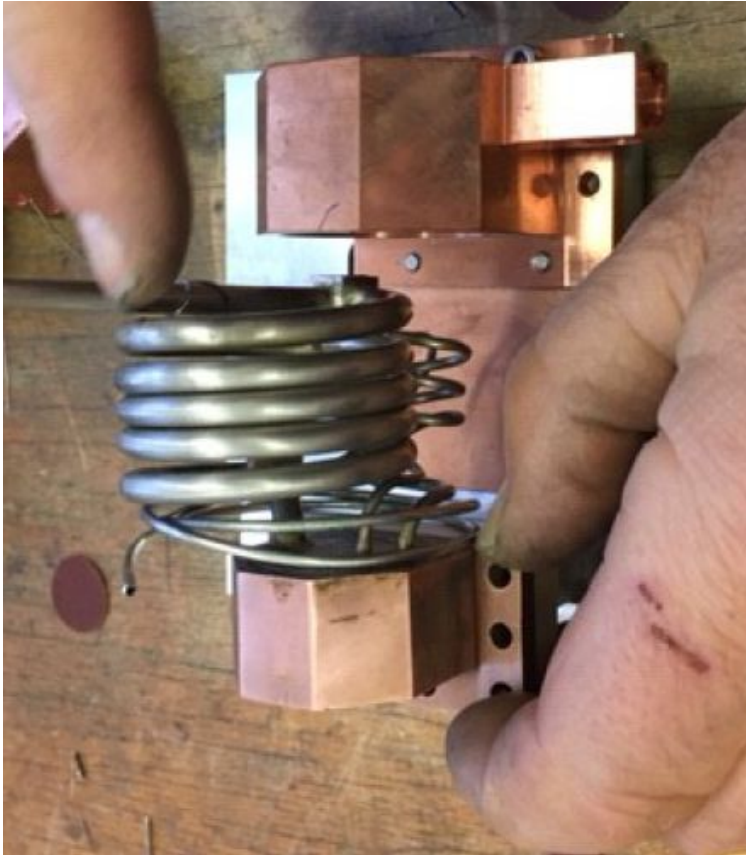
THE CONCERTO WARM OPTICS



M3 to M11 (!) PLUS TWO POLARIZERS AND TWO MORE MIRRORS FOR THE MPI REFERENCE
.... FOLLOW THE RAYS IF YOU ARE BRAVE

SOME TECHNOLOGY IN CONCERTO

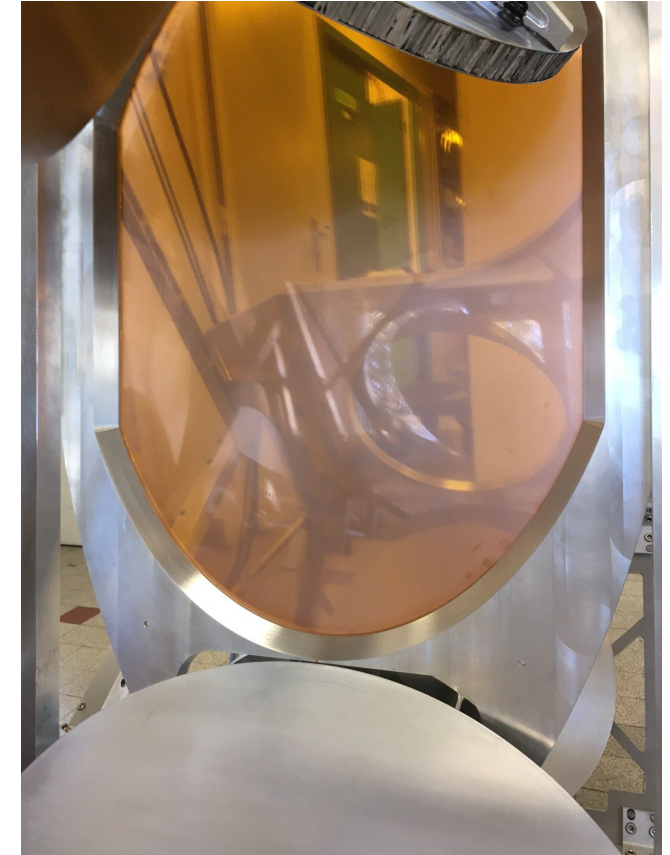
Home-made (literally)
mini dilution insert
(100% useful duty cycle)



“Chassis” Tilting. The cryostat
is designed to **work up to 85**
deg inclination → **IT DOES**



- 80cm POLARIZERS (Grenoble)
- Filters, e.g. notch (Cardiff)



THE TRIP TO CHILE (03/2021)



Chile at the highest of the pandemic, France almost ..

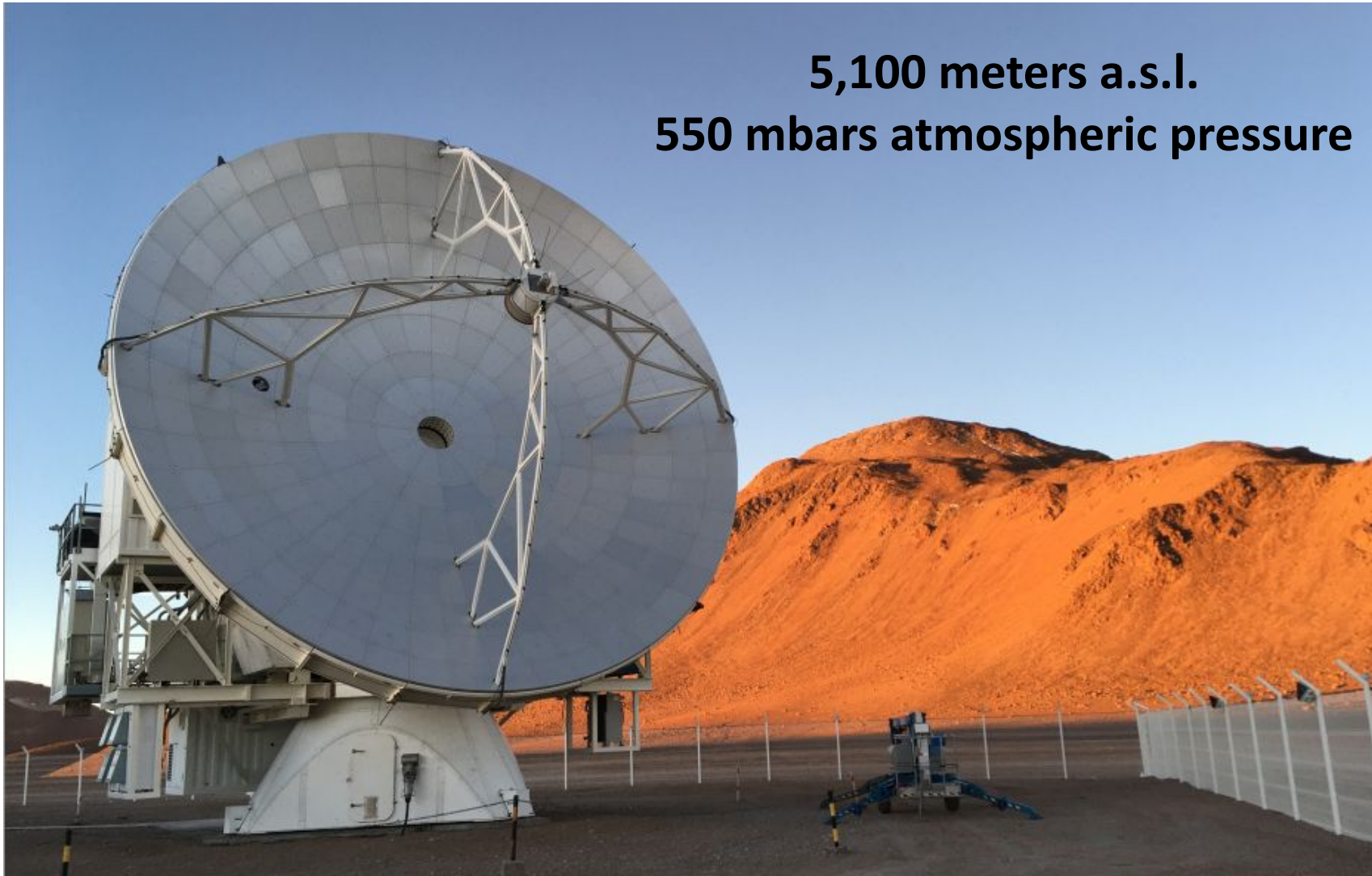
→ AN EPIC EXPERIENCE



Two small (three of us each) but highly trained teams. NOT OVERLAPPING !!

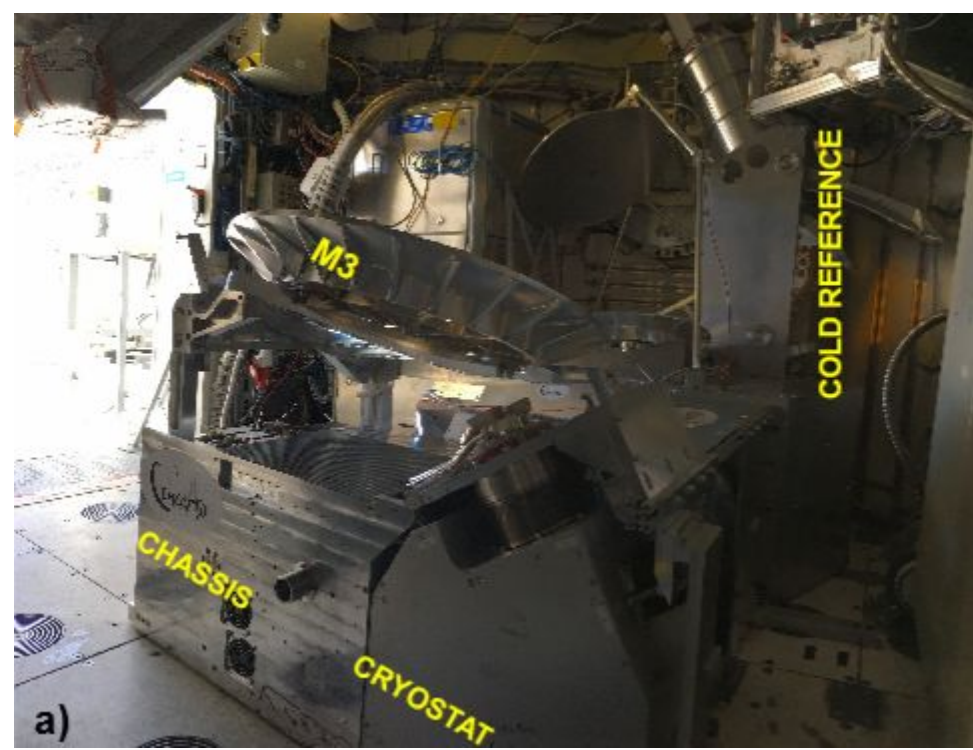
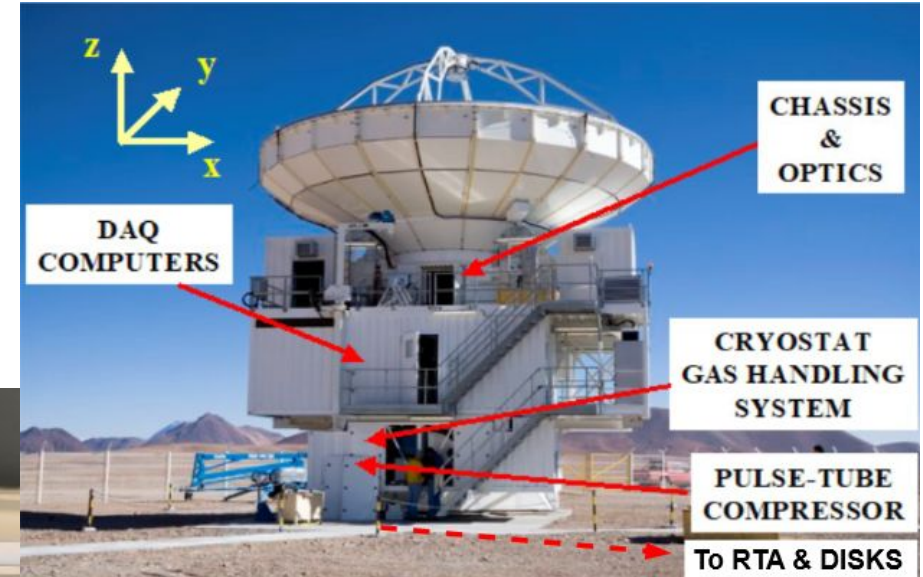
CHAJNANTOR (04/2021)

5,100 meters a.s.l.
550 mbars atmospheric pressure



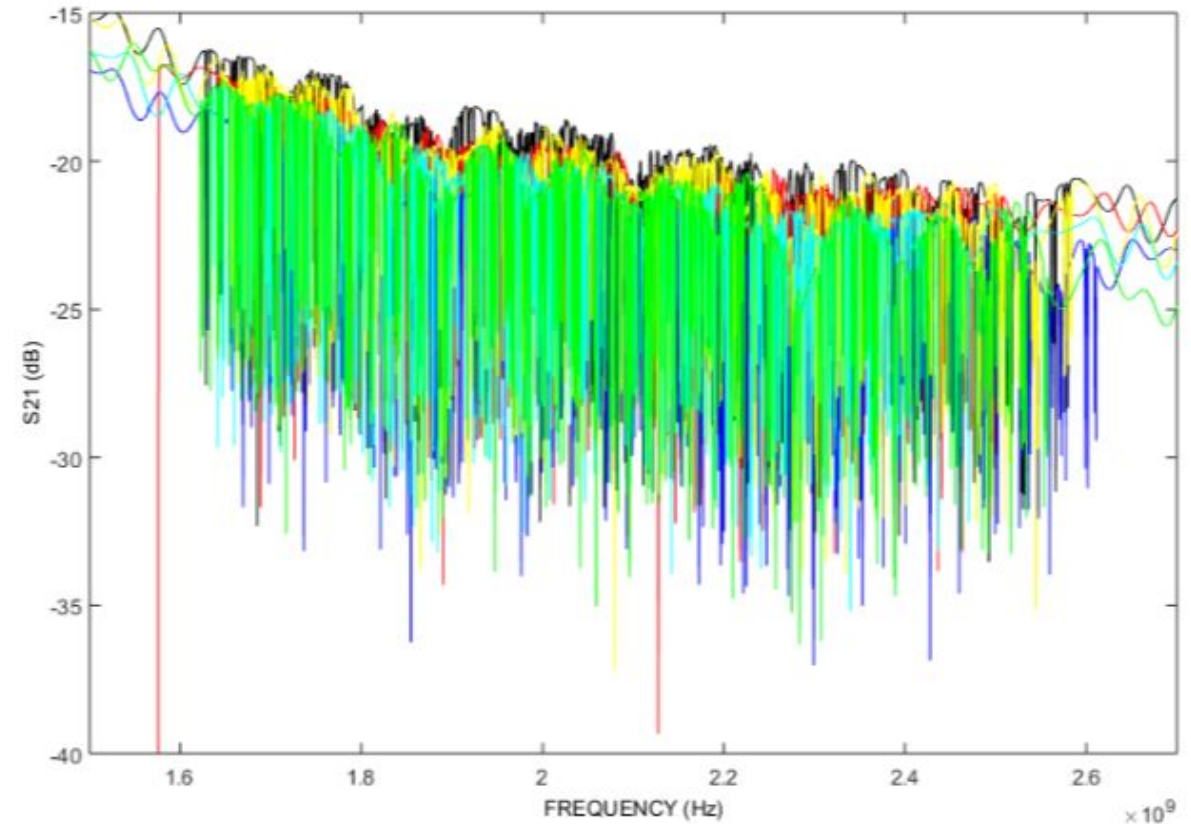
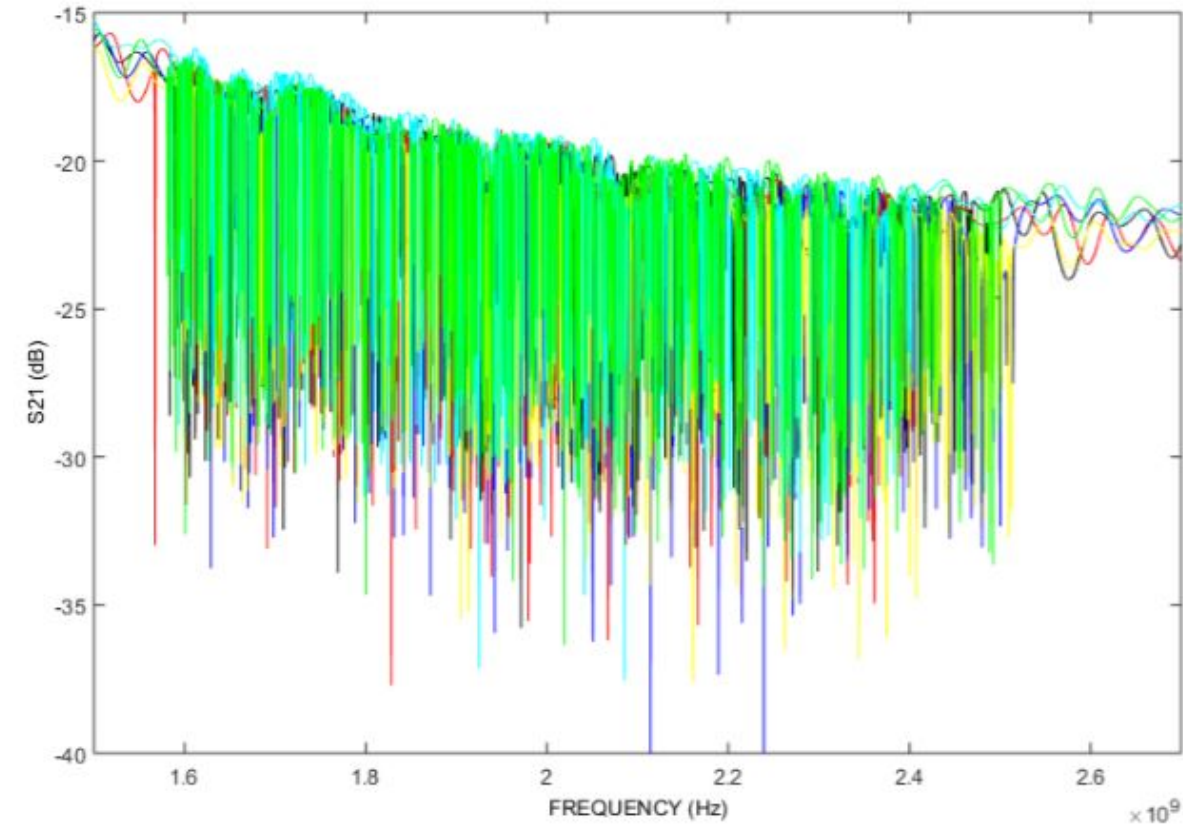
THE CONCERTO INSTALLATION

- 6th April, STARTING UNPACKING THE BOXES
- 10th April, START COOLDOWN
- 12th April, BASE TEMPERATURE → 60mK
- THEN TECHNICAL COMMISSIONING. 4th of May → CRAB
- END OF MAY ALREADY THE FIRST OBSERVATIONS IN REMOTE !!



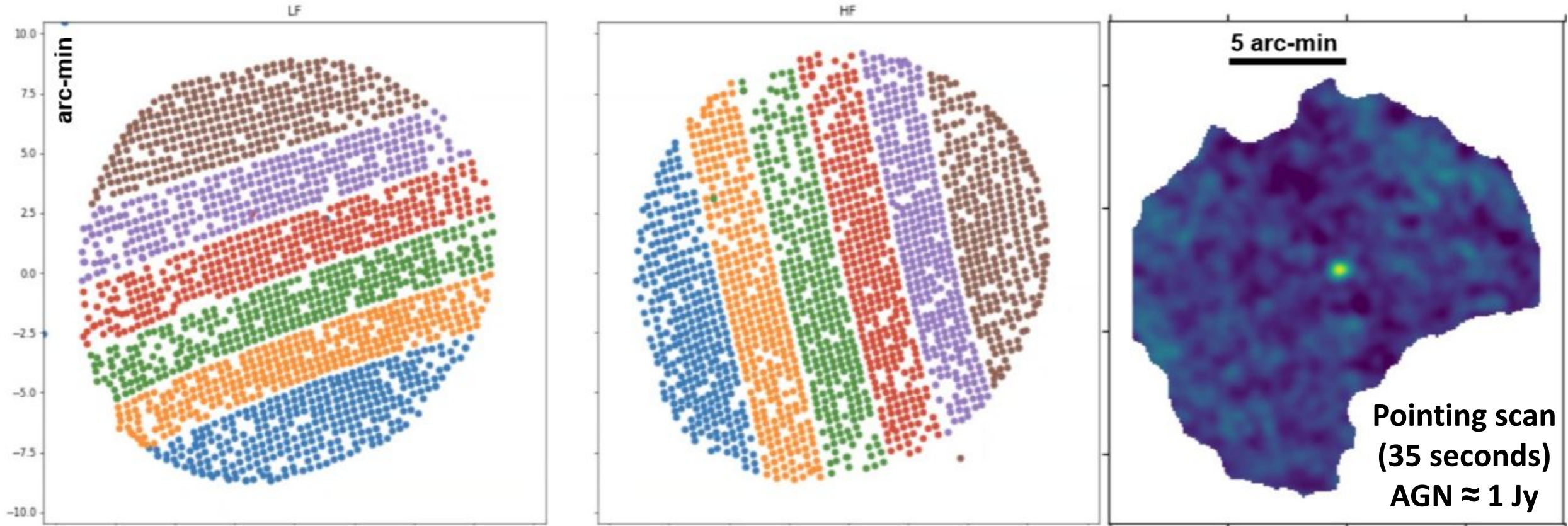
OBSERVING THE SCIENCE FIELDS SINCE JULY 100% REMOTELY

PRELIMINARY RESULTS: KID



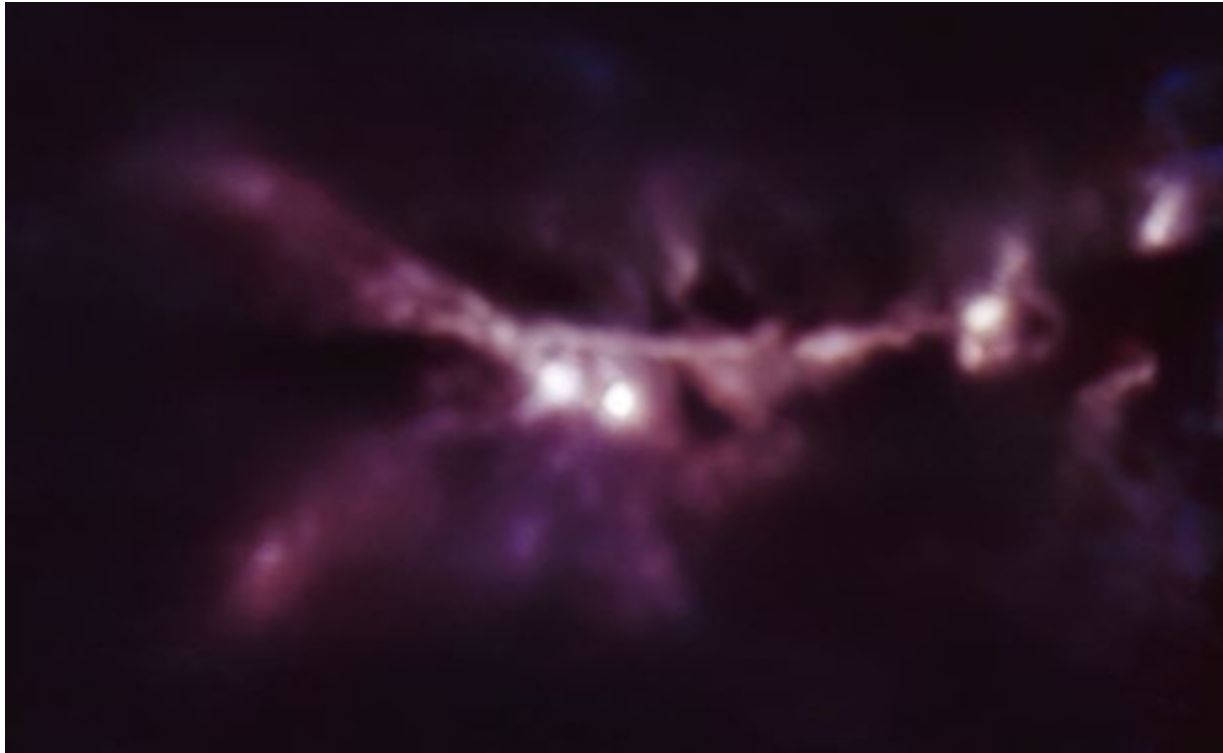
- All the (12) readout lines are connected, more than 90% of the 4,304 pixels exhibit a resonance
- The internal quality factor on APEX Sky are perfectly in line with expectations - $Q_c \approx Q_i \approx 15k$

PRELIMINARY RESULTS: ON SKY



- Around 90% of the designed pixels exhibit a beam
- Capable of mapping sub-Jy structures over hundreds of arc-min² in less than one minute telescope time
- Elliptical beams on a portion of the arrays → OPTICS problem ?

PRELIMINARY RESULTS: ON SKY



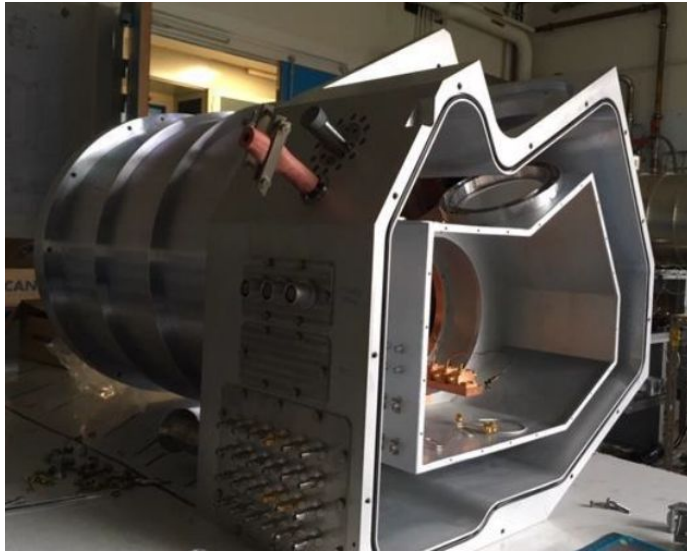
CAT's PAW NEBULA (17 minutes integration)



CRAB NEBULA (3 minutes integration)

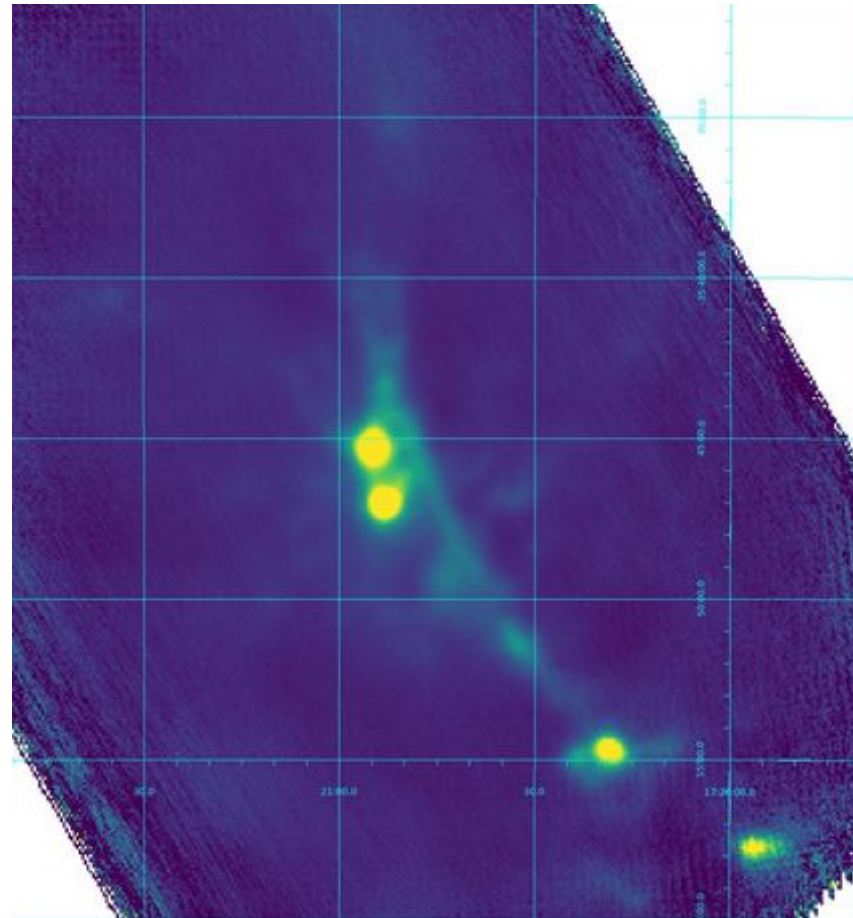
PRELIMINARY RESULTS: ON SKY

HARDWARE STATUS 12/2019 (!)

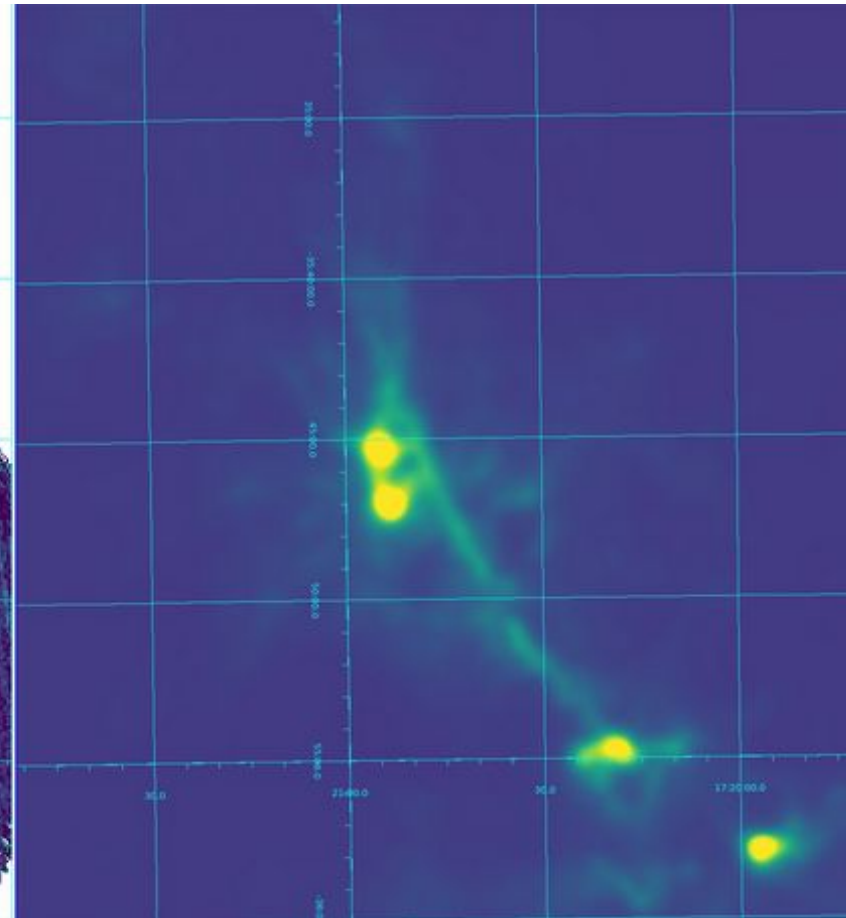


**AN EMPTY CRYOSTAT
AND MANY HOPES**

CONCERTO LF (single scan 17 min)



HERSCHEL 250um (adapted resolution)



CONCLUSIONS AND PLANS



- A **NEW OBSERVATIONAL WINDOW** IS OPEN ON THE MILLIMETRE SKY ... BUT WAITING FOR ASTRONOMERS CONFIRMATION
- THE **SCIENCE COMMISSIONING** IS ON-GOING (QUITE LIMITED BY TRAVEL RESTRICTIONS)
- WE ARE PREPARING AN **INTERVENTION DURING THE CHILEAN SUMMER 2022** TO IMPROVE THE COLD REFERENCE PERFORMANCE AND MAINTENANCE
- AN UNIDENTIFIED MONOCHROMATIC (OPTICAL) **NOISE COMING FROM THE C-CABIN** IS BEING INVESTIGATED AT TELESCOPE AND IN LAB. **ACOUSTIC ? (yesterday) → ACOUSTIC ! (today)**
- **RIGHT NOW 100% REMOTELY** AND THAT “COULD BE A PROBLEM IN CASE OF PROBLEMS”

THANKS FOR YOUR ATTENTION !!



NICE MAPS ACQUIRED
ALSO IN SPECTROSCOPIC
MODE DURING THE
COMMISSIONING

→ TO BE TURNED INTO
SPECTRA ... NOT TRIVIAL

