

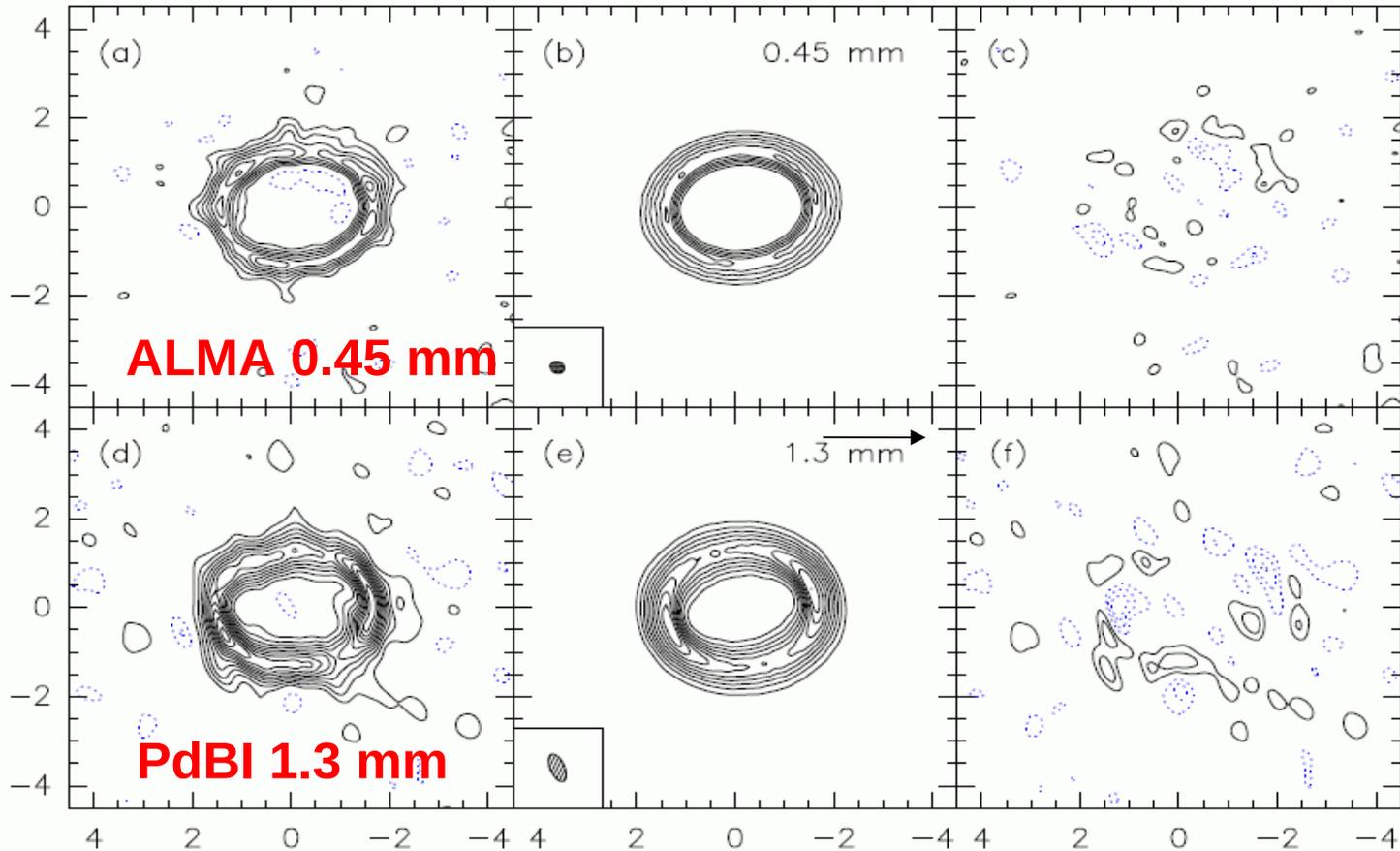
NOEMA status

SMA science in the Next Decade

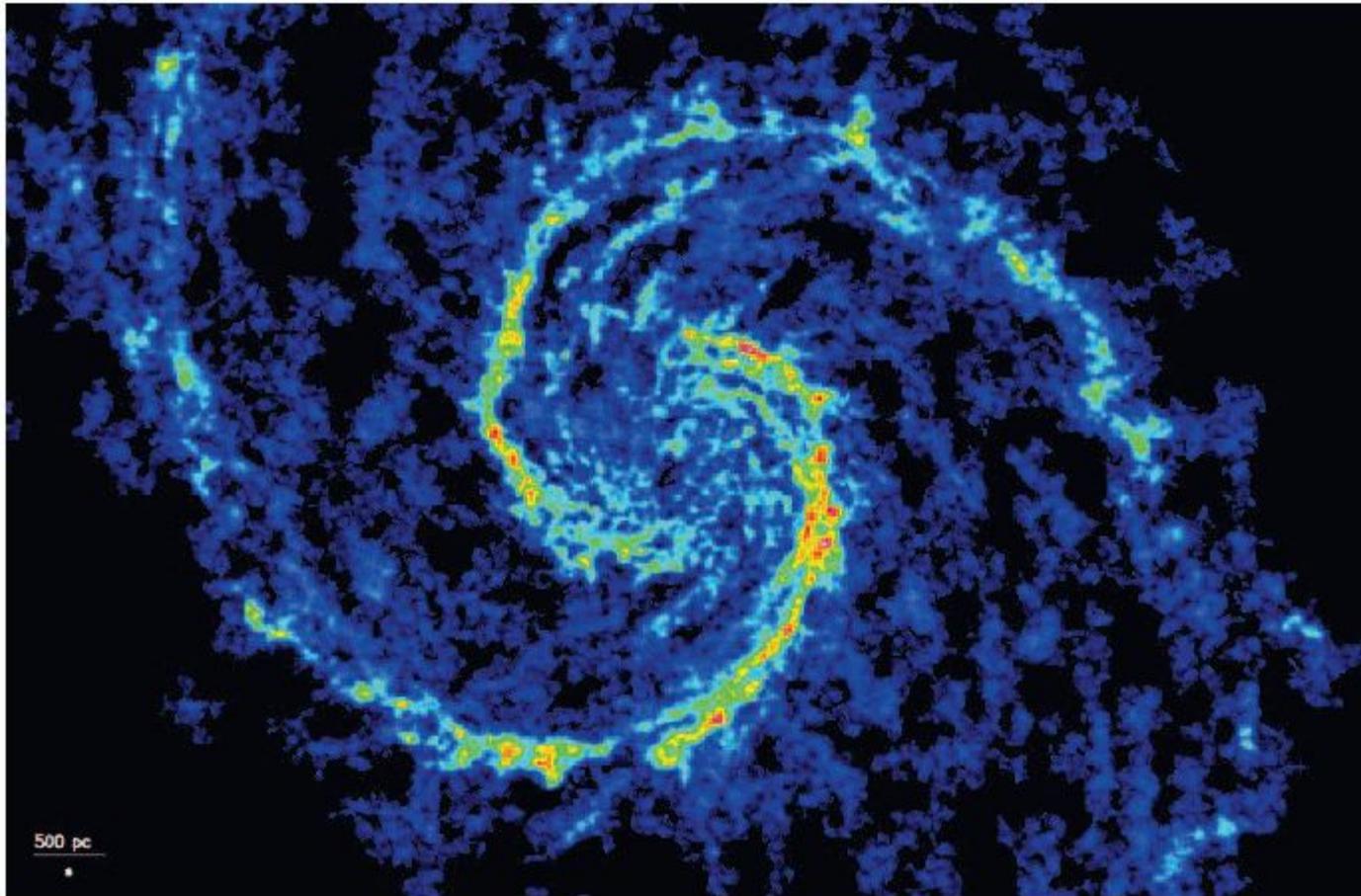
Taipei – 27/28 Oct. 2016

- IRAM is funded by **CNRS** (France) – **Max-Planck-Gesellschaft** (Germany) – **IGN** (Spain)
- Two mm (70-375 GHz) observatories: 30-m on Pico Velata (Sierra Nevada, Spain) and interferometer on Plateau de Bure (French Alps)
- World wide open, call for proposal twice a year
- Technical/software/support center in Grenoble, France

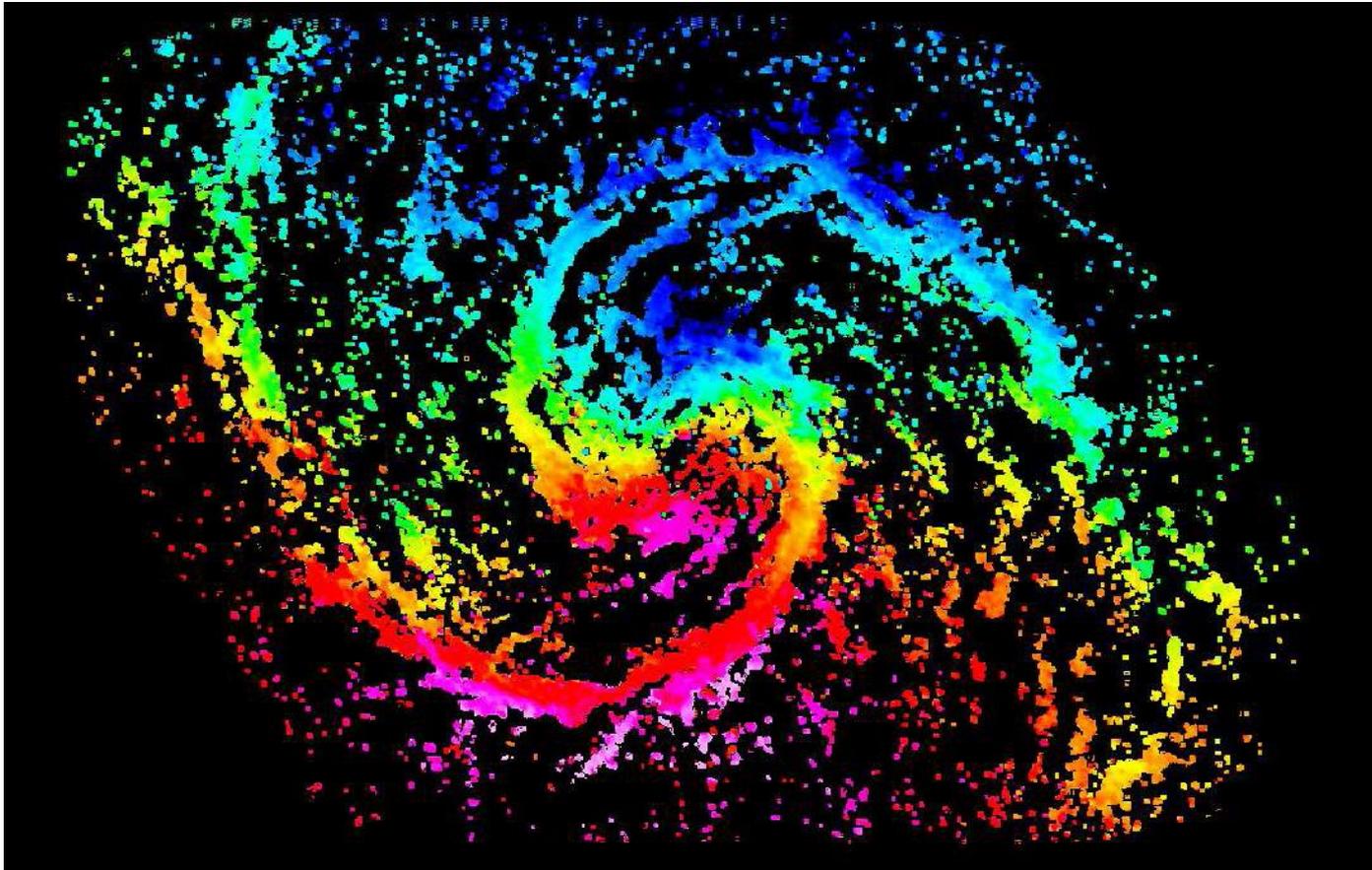




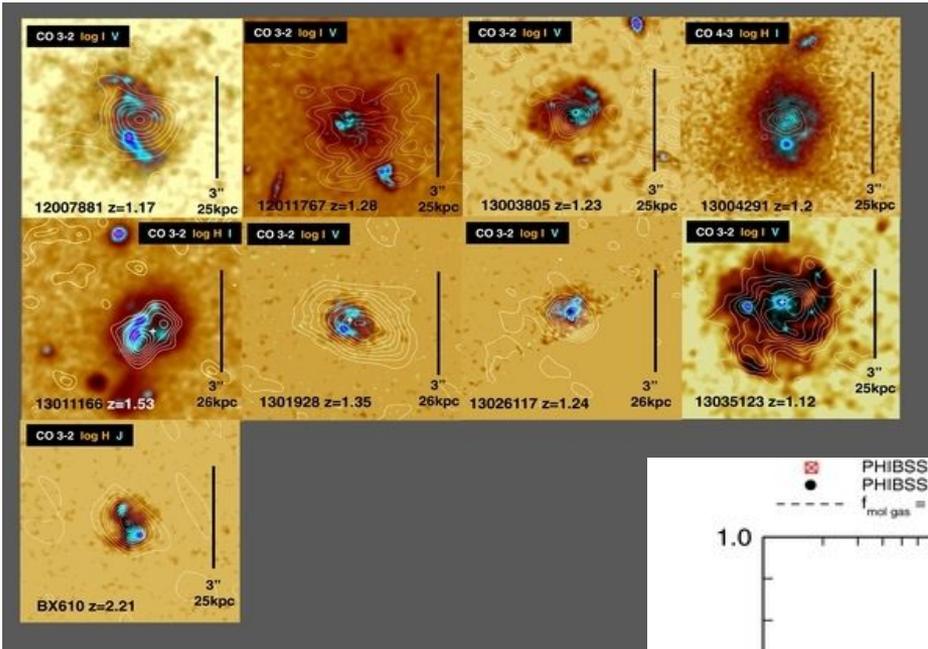
Dust emission in the **GG Tau** circumbinary disk
(Dutrey et al. 2015 Nature)



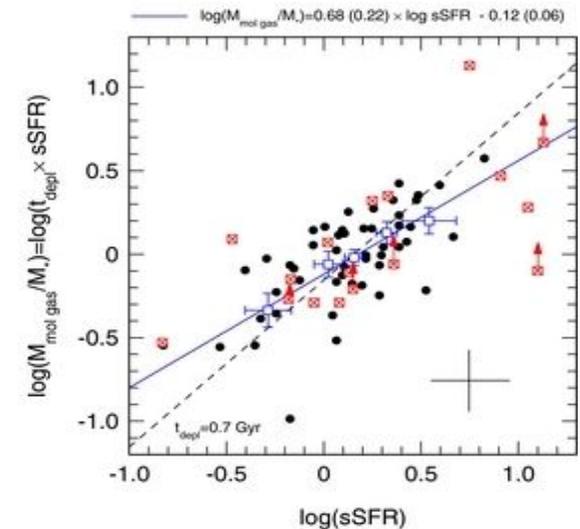
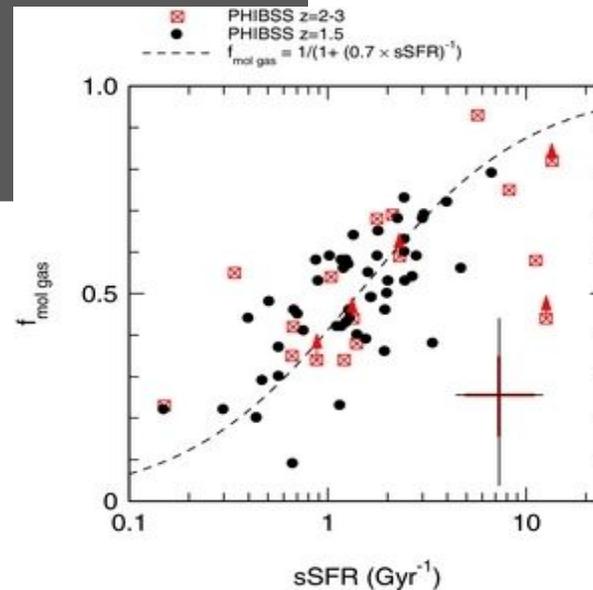
CO(1-0) in M51 (Schinnerer et al. 2014, Pety et al. 2014)
PdBI + 30m as short spacings

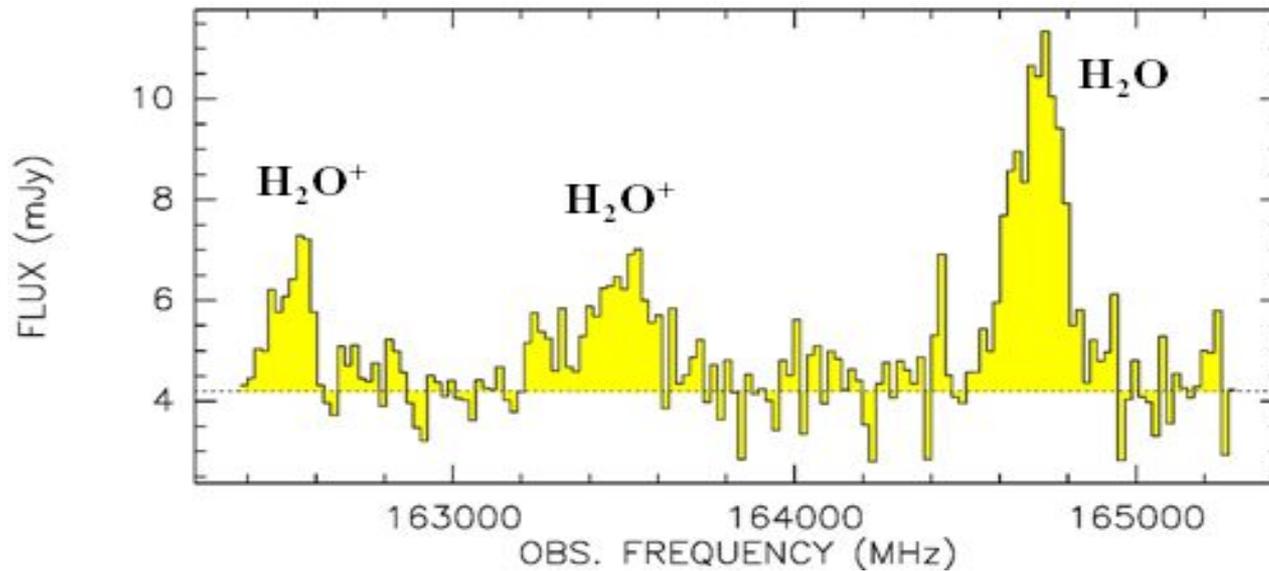


CO(1-0) in M51 (Schinnerer et al. 2014, Pety et al. 2014)
PdBI + 30m as short spacings



PHIBSS survey of CO(3-2) in $z = 1-2$ galaxies @ peak of star formation
(Tacconi et al. 2013)





Water in a high-z lensed Herschel galaxy
(Omont et al. 2016)

Plateau de Bure interferometer



- 6 x 15m antennas
- 4 Rx bands (80 – 371 GHz)
- 2 correlators
 - Narrow (2 x 1GHz, 8 units [40kHz...2,5MHz])
 - Widex (2x3.6GHz, 2MHz)
- Baselines up to 0.8km

Northern Extended Millimeter Array Extension of the IRAM Plateau de Bure interferometer



Northern Extended Millimeter Array

- Double the number of 15 m antennas from 6 to 12
- New receivers:
 - 4 bands covering 70-370 GHz
 - Each band is 2 polar x 2SB x 8 GHz = 32 GHz/ant
- New correlator:
 - Full low-resolution coverage (continuum, line surveys)
 - *and* (up to 128) high-resolution spectral windows
- Dual-band operations
- Extension of the baselines from 0.8 to 1.6 km
- New WVRs, upgrade of antennas 1-6

Advanced mm astronomy calls for

- an **ALMA-competitive array in the northern hemisphere**
 - with sensitivities within a factor of 2-3 (same science)
 - provides full-sky coverage in the [mm + intermediate ang. resolution]
- an instrument **optimized for mm astronomy**, which allows for **large surveys**
 - source surveys (high-z/nearby galaxies/star forming regions...)
 - spectral surveys
- an instrument that allows rapid and efficient **technological upgrades** (small number of antennas)

NOEMA Phase I (2017)

4 new antennas (7-8-9-10)

new receivers (4 bands, 70-350 GHz)

12-antennas correlator PolyFix

NOEMA Extension Programs

VLBI

Refurbishment antennas 1-6

Dual band observations
Rx + second correlator, clone of PolyFix

Baseline extension (1.6 km)

NOEMA Phase II (2019)

2 new antennas (11-12)

NOEMA
funding

MPG
CNRS/ANR
ERC
U.Michigan



NOEMA factsheet

| Collecting area | | |
|-----------------|---------------------|-------------------|
| | Interferometry | Short spacings |
| ALMA/ACA | 5655 m ² | 914m ² |
| NOEMA/30m | 2121 m ² | 707m ² |

| Bandwidth per polarization | |
|----------------------------|-----------|
| PdBI | 4 GHz |
| ALMA | 2 x 4 GHz |
| NOEMA/30m | 2 x 8 GHz |

Sensitivities NOEMA vs ALMA

| | |
|------------------------|------------------------|
| Line observations | NOEMA rms < 3 ALMA rms |
| Continuum observations | NOEMA rms < 2 ALMA rms |

Unique NOEMA features

| | |
|------------------------|--|
| Larger bandwidth | Gain factor 2 in observing time for spectral surveys |
| Dual-band observations | Gain factor 2 in observing time for multi-bands projects |
| Correlator | Full continuum sensibility for all observations |
| Correlator | High flexibility : many high-resolution lines simultaneously |

NOEMA Phase I in a Nutshell

| | |
|---------------------------|---|
| Antennas | 10 Summer 2017 |
| Bands | 1: 72-116, 2: 127-179, 3: 200-276, (4: 275-373 GHz) |
| Angular resolution (Max.) | 1.2"/0.8"/0.5" @ 90/140/230 GHz |
| Conversion factor | 100 K/Jy.beam natural weighting |

Spectral resolution and 1σ sensitivities @ 90/140/230 GHz at DEC 50°
after 8 hr in conditions of PWV 5/3/2 mm

| Simultaneous Low and High-resolution Modes | | Survey Mode |
|--|--|--|
| 8,000 x 2 MHz channels over 16 GHz | 8 x 16 x 64 MHz windows with 62.5 KHz | 0.25 MHz channels over 16 GHz |
| 7/9/15 uJy/beam over 2 x 16 GHz | 0.15/0.16/0.22 mJy/beam in channels of 100 km/s | 1.6/2.1/3.8 mJy/beam in 0.25 MHz channels |

**Antenna 7
Inauguration
22 Sept. 2014**





NOEMA operated with 7 antennas since Spring 2015

Antenna 8
6 Apr. 2016





Antenna 8 20 Oct. 2016

Northern Extended Millimeter Array Extension of the IRAM Plateau de Bure interferometer



Northern Extended Millimeter Array Extension of the IRAM Plateau de Bure interferometer

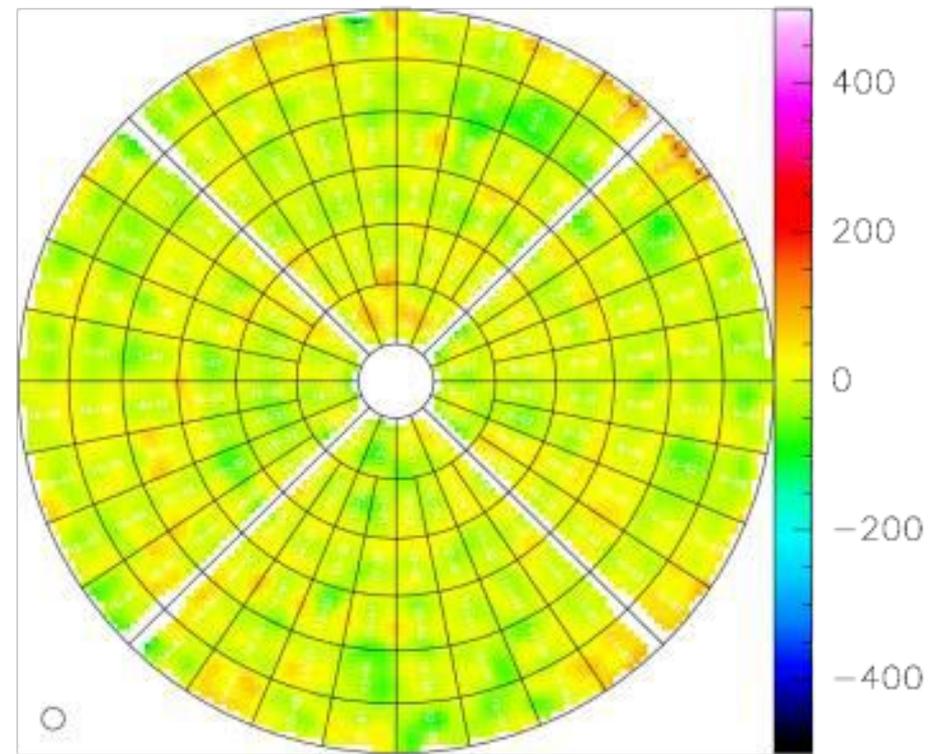
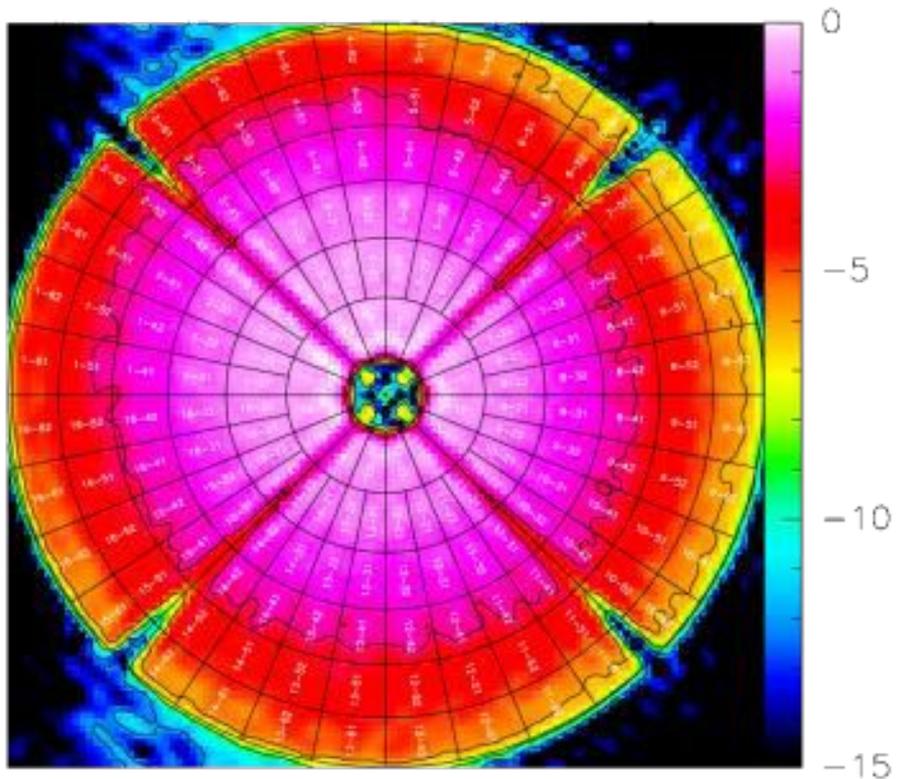




NOEMA with 8 antennas (19 Apr. 2016)

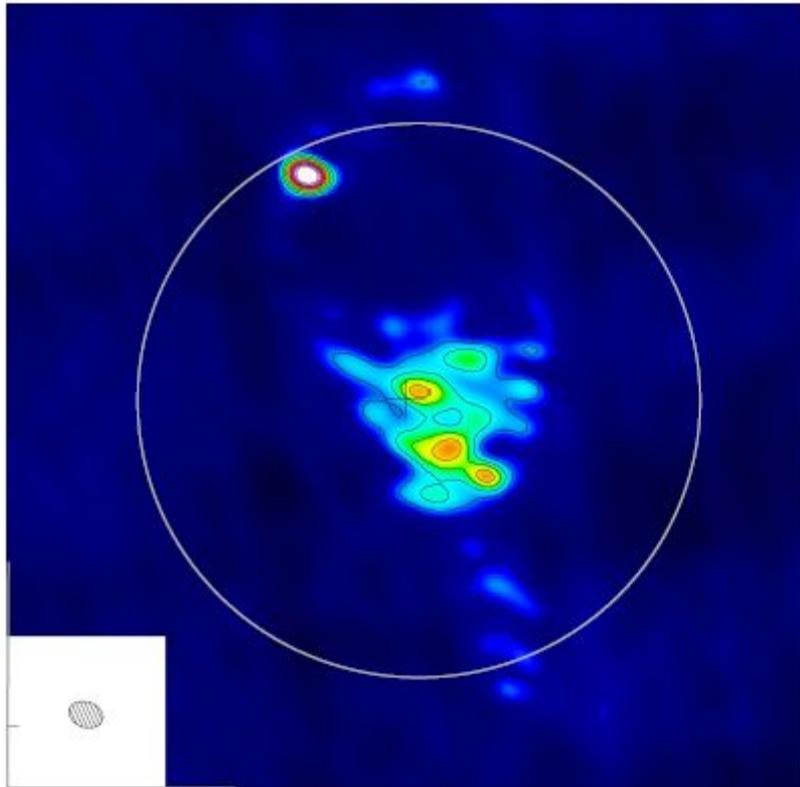
Rms/ring: 29.5 23.1 22.8 22.5 25.5 31.8
Amplitude (back view)
-15.000 to 0.000 by 3.000

Normal errors (back view)
-500.000 to 500.000 by 100.000



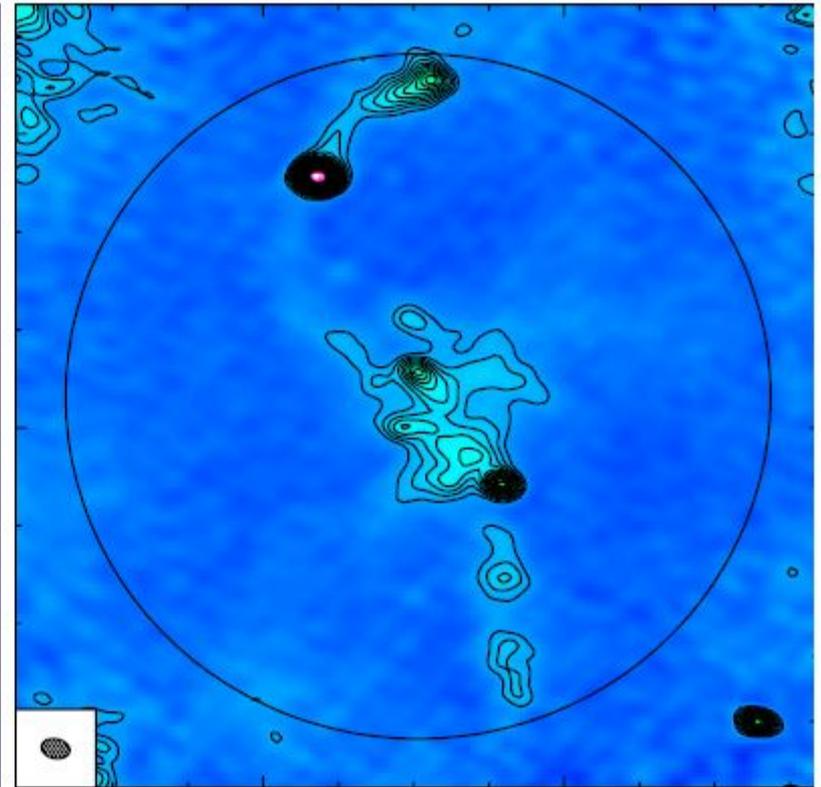
Surface rms Antenna 8 = **26 μm**

NOEMA8



OMC2-FIR4, SOLIS LP
Caselli & Ceccarelli, B1
RMS = 0.10 mJy/(3.5x2.7")

ALMA35 Cy 3



OMC2-FIR4, Ceccarelli
2015.1.00261.S, B3
RMS = 0.15 mJy/(2.9x2.0")



Construction Antenna 9 (26 Apr. 2016)



18 October 2016

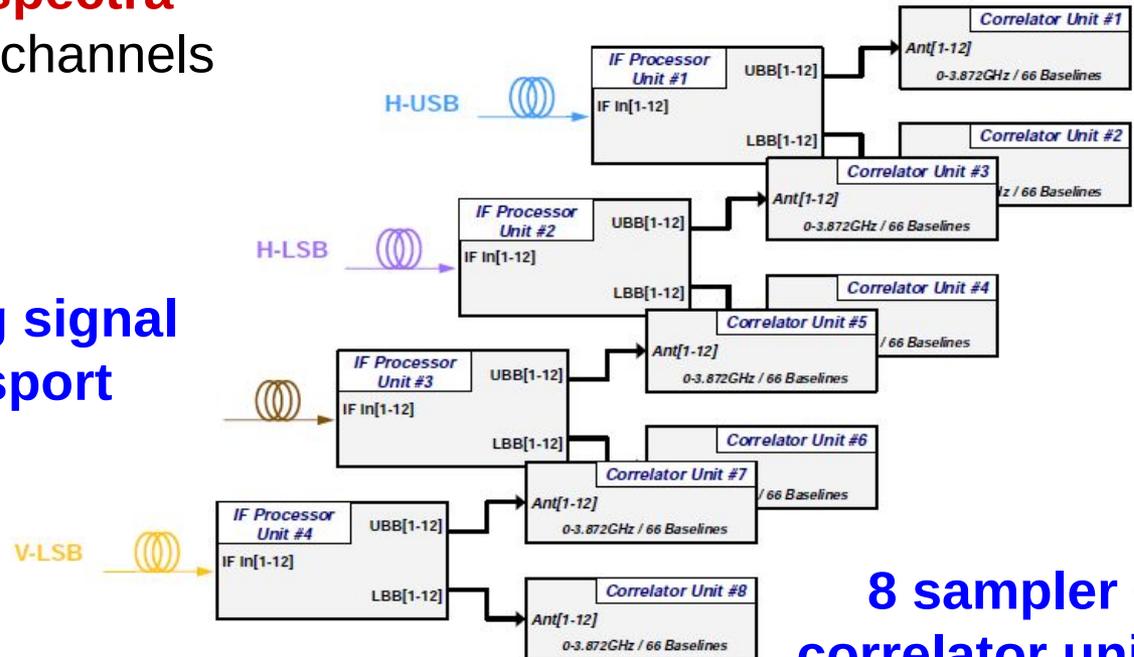
Antenna 10
18 Oct. 2016



NOEMA correlator: PolyFix

- New generation correlator based on **FPGAs**
- FX architecture
- **Simultaneous continuum and line capabilities**
 - **Low-resolution spectra**
- Up to 150000 spectral channels

Analog signal
transport



IF processor
4 GHz bands

8 sampler +
correlator units
processing
12 ant x 4 GHz

NOEMA correlator: PolyFix

**Mode 1 :
continuum +
lines**

complete 16 GHz coverage in each polar. with 2 MHz channels

AND

128 windows of 64 MHz (= 8 GHz coverage) with 62.5 kHz channels, each window tunable individually in steps of 64 MHz*

**Mode 2 :
survey mode**

complete 16 GHz coverage in each polar. with 250 kHz channels

**Mode 3 :
continuum +
high-res. lines**

same as mode 1, but with 64/32/16 windows of 64 MHz with 32/15/8 kHz channels

* With the constrain of having 16 windows in each of the 8 4 GHz-wide correlator units

NOEMA receivers

- **2 polar x 2 sidebands x 8 GHz = 32 GHz/antenna**

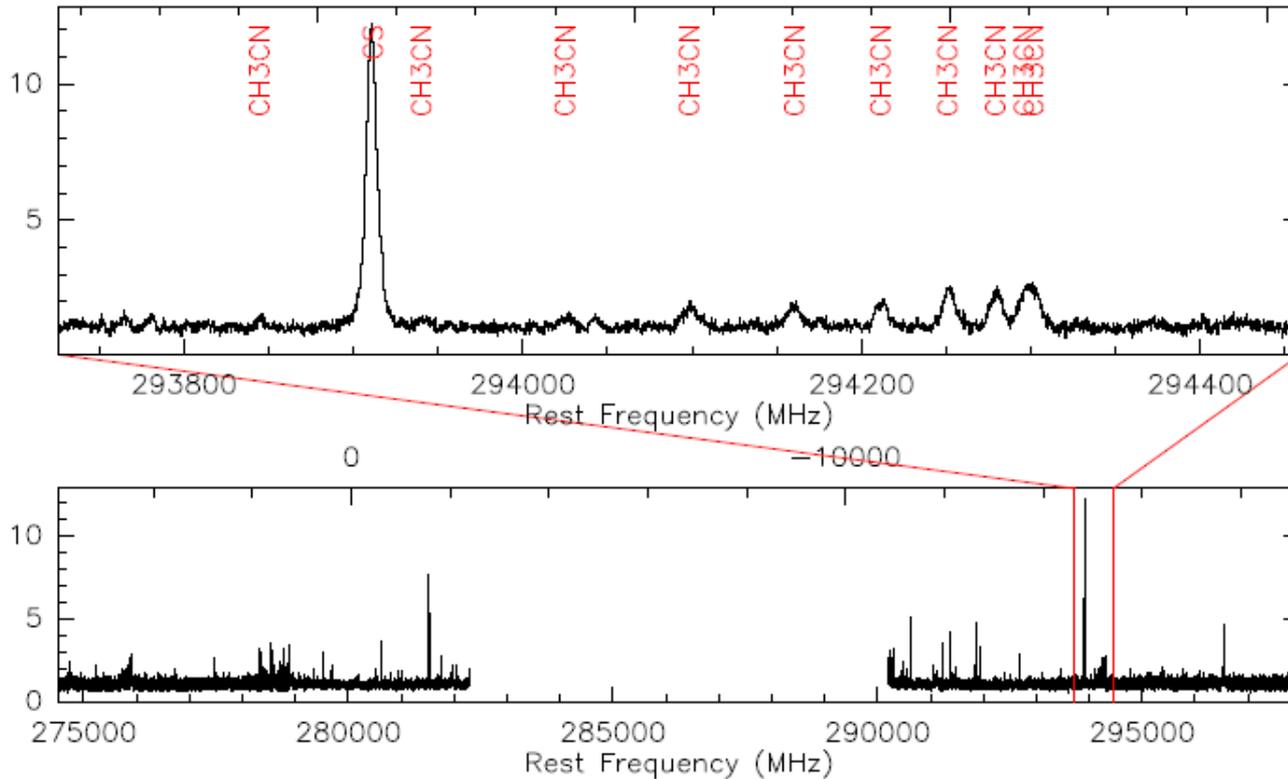
| NOEMA receivers | | |
|-----------------|--------|-------------|
| Band 1 | 3 mm | 72-116 GHz |
| Band 2 | 2 mm | 127-179 GHz |
| Band 3 | 1.3 mm | 200-276 GHz |
| Band 4 | 0.8 mm | 275-373 GHz |



- New receivers already installed on Antenna 7, 1, 2, 8, 3, 4, 5
- Antennas 6 equipped before end of 2016

NOEMA receivers : IF

16 GHz per polarization – already available with EMIR @ 30 m since 2012

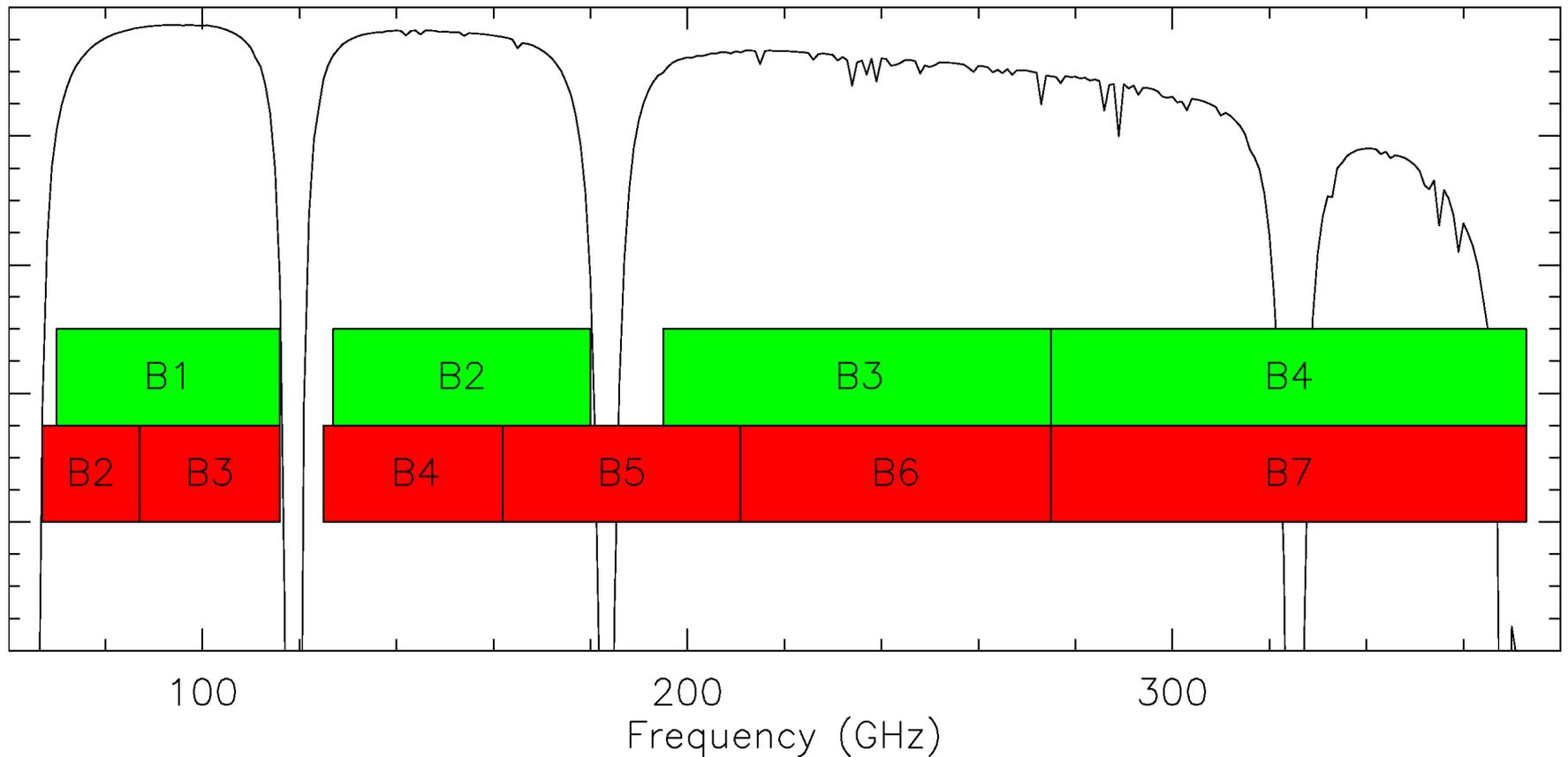


(EMIR 230 GHz band tests 2012, Kramer et al.)

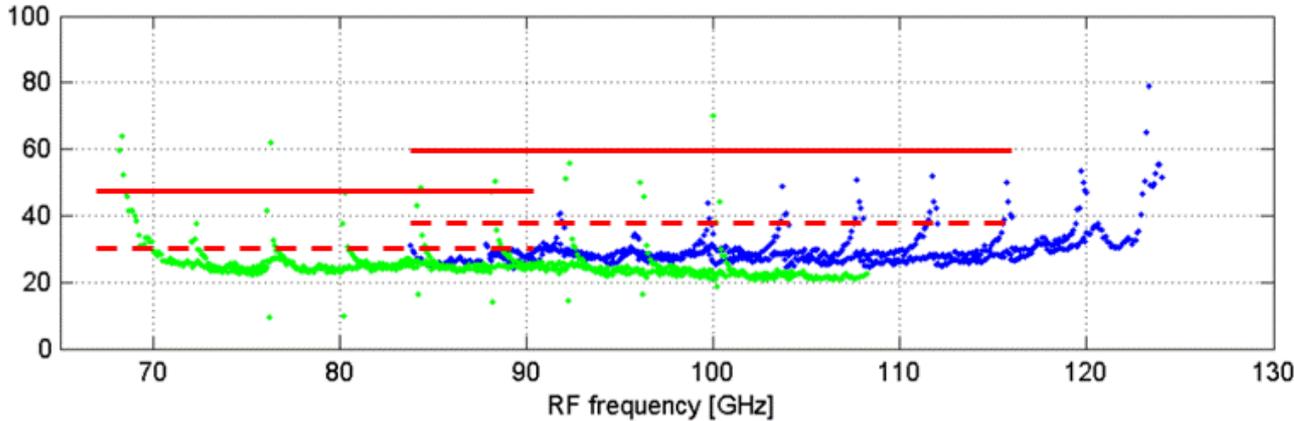
NOEMA receivers : IF *and* RF

NOEMA IF=16 GHz

ALMA IF=8 GHz



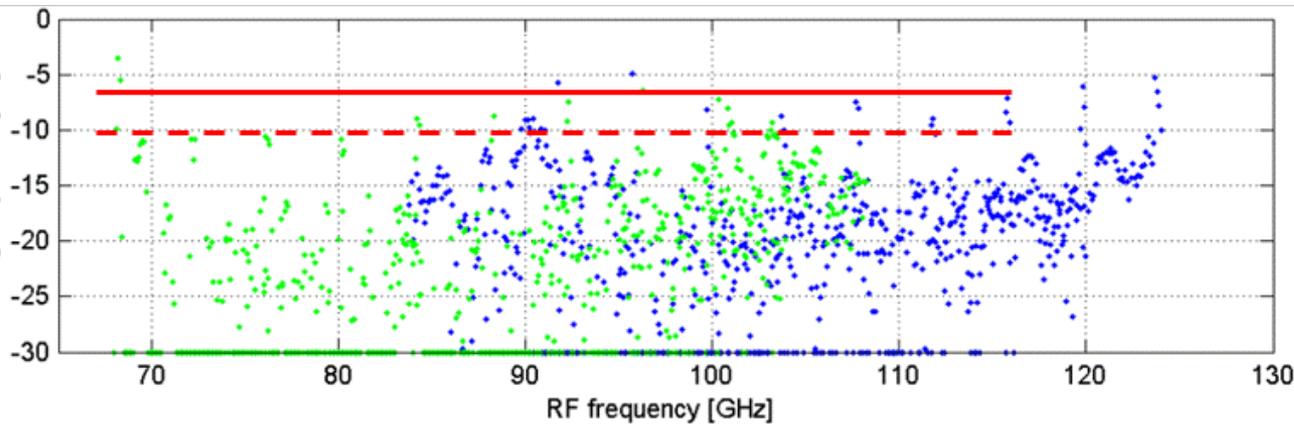
NOEMA receivers : Band 1



NOEMA/EMIR Band
1 mixer (Maier et al.)

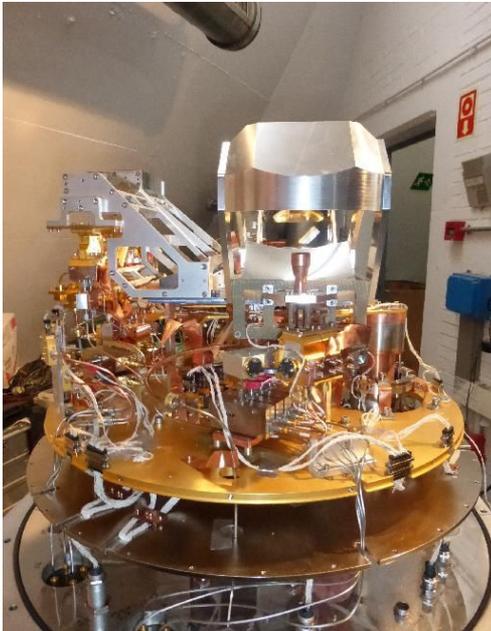
2x8 GHz IF

Covers **70-122 GHz**
= (almost) full ALMA
Band 2+3

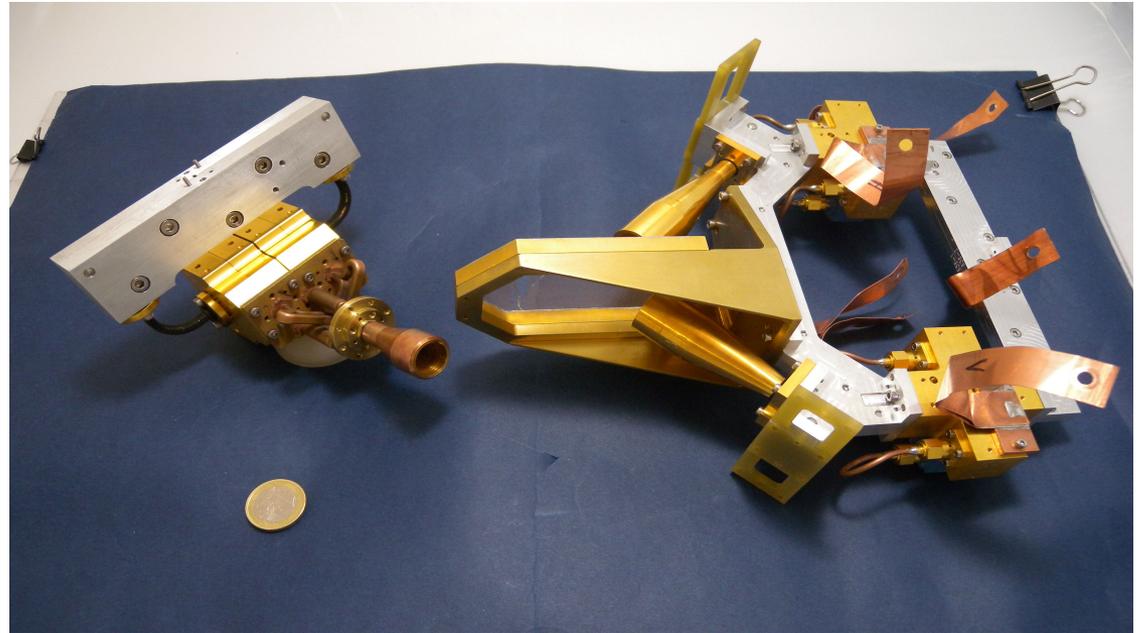


EMIR Band 1 upgrade December 2015

- NOEMA Band 1 mixer (Maier et al.)
- New optical module, covers **67-116 GHz** (Fontana et al.)

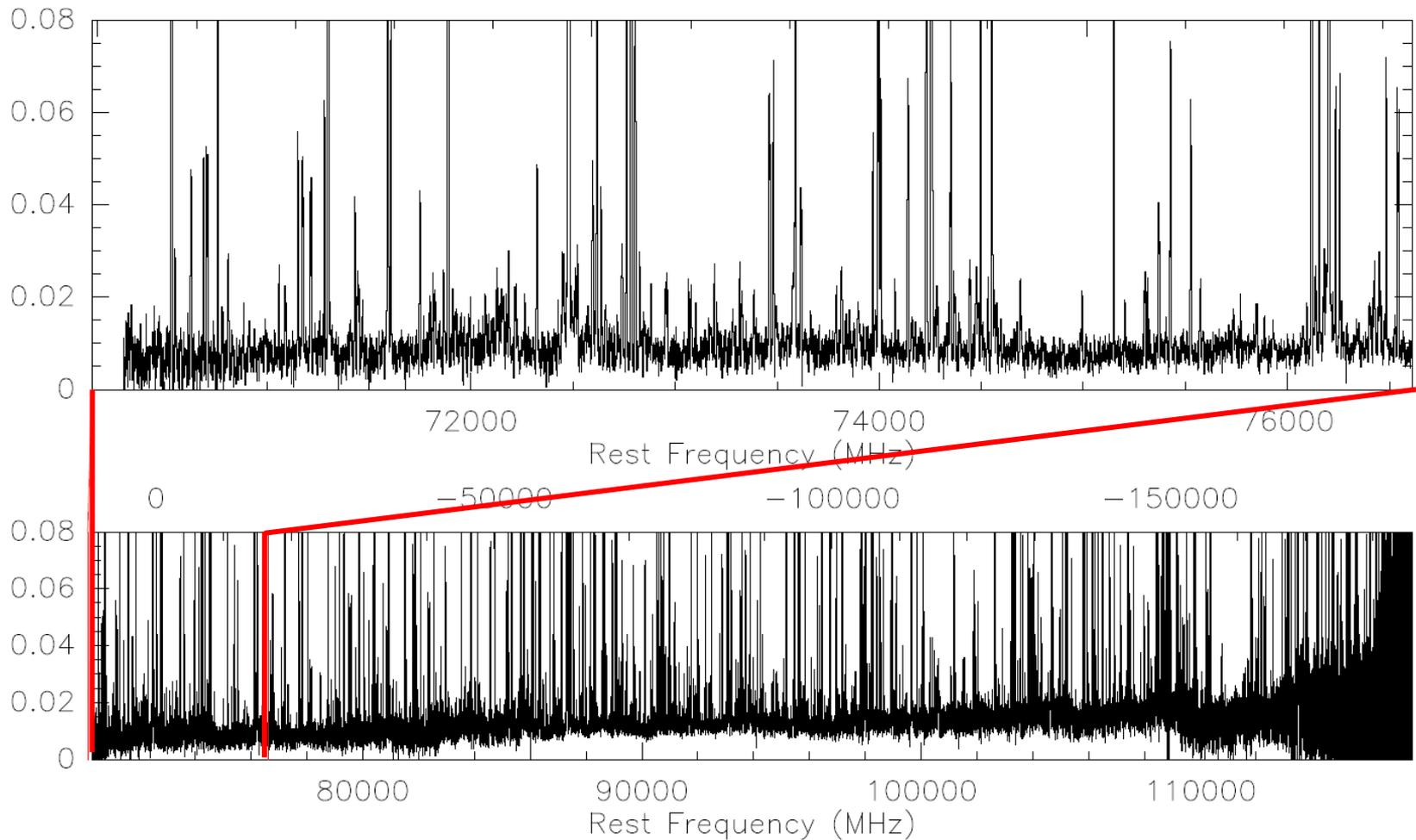


EMIR



New and old optical modules

Upgrade of EMIR/30m December 2015 – IRC10216

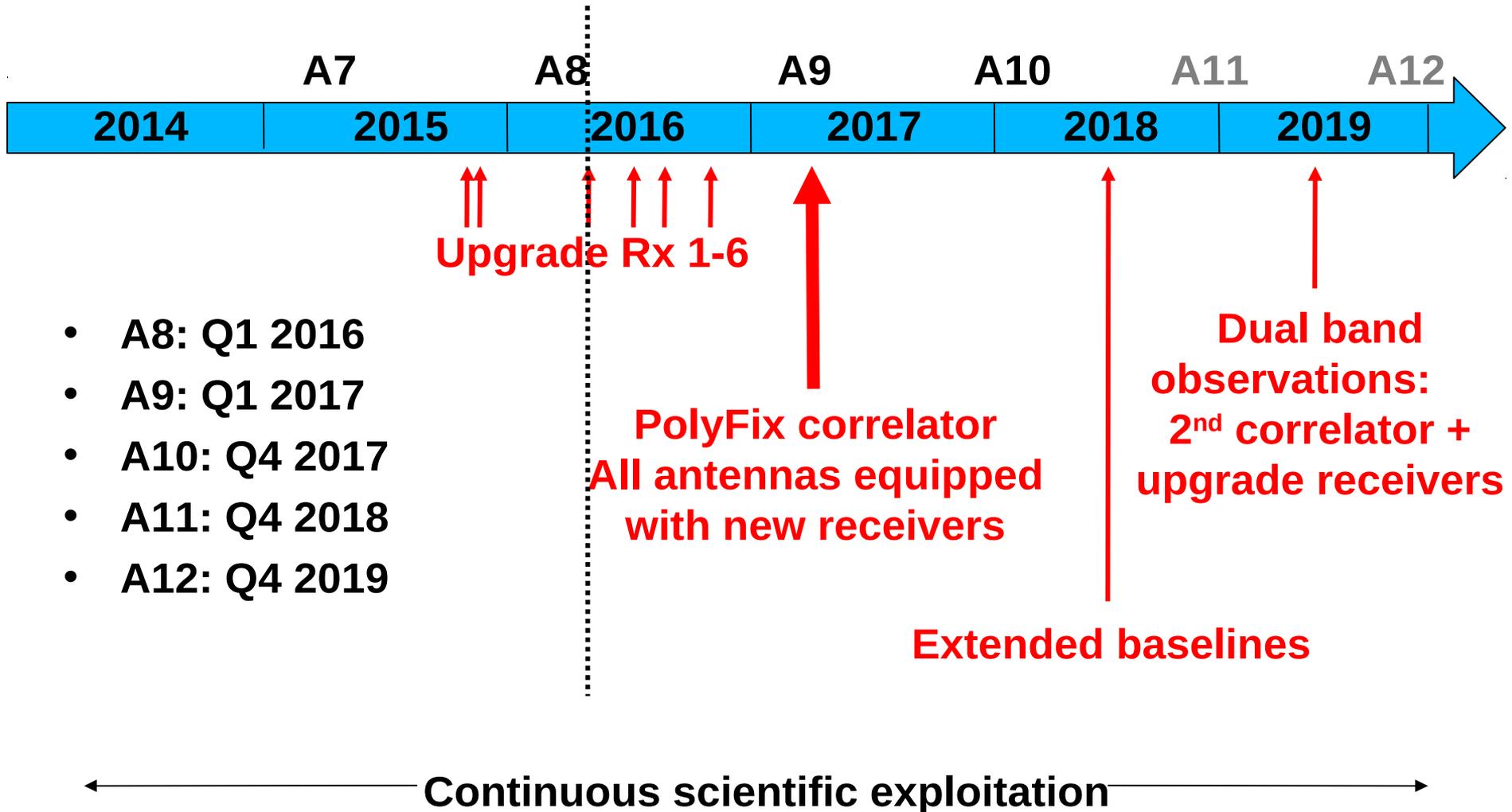


Simultaneous observations with two bands (e.g. 3 + 1.3 mm) : gain in observing time + calibration accuracy

Science goals : several transitions from same molecules, spectral indexes, complement main project, etc.

- Receivers: require new optics to allow for dual-band operations. Major upgrade of the (2015) receivers already planned in 2018-19
- LO, signal distribution, IF transport already implemented
- Correlator : 2nd correlator will be built immediately after completion of Polyfix#1 (baseline = cloned performances)
- Software: real-time + data acquisition + data processing. Strongly based on Plateau de Bure experience 1995-2005: dual band receivers 3 + 1.3 mm

Timeline NOEMA



- * **12x 15m** antennas
--> collecting area = 2120m² ; surf.rms = 30μm
- * 4 bands 2SB receivers
--> 2x8 GHz RF in each polarization
- * Dual band operation
--> 2 correlators with 2x7.7 GHz in each polarization
--> instantaneous IF bandwidth = **62 GHz**
- * Up to **1600m** baselines
--> 0.1" @ 345 GHz





Institut de
Radioastronomie
Millimétrique
