

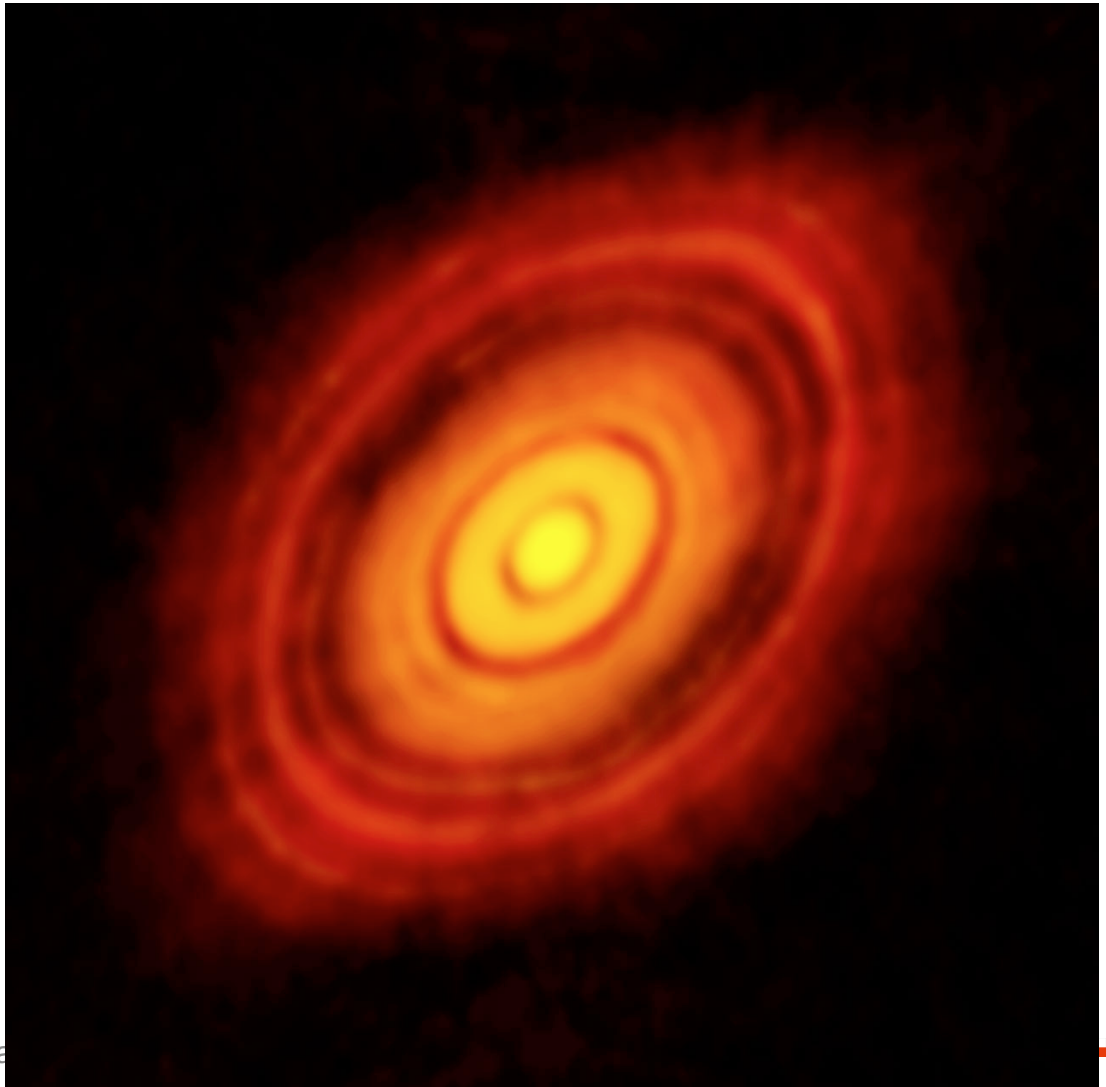
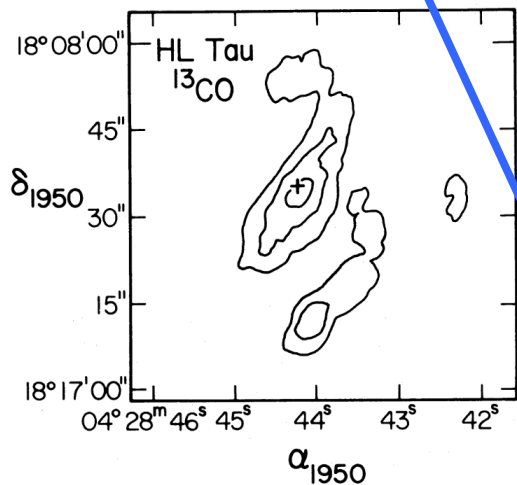
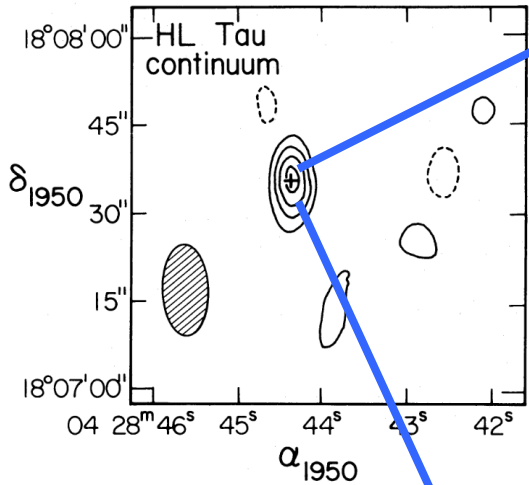
# ALMA Development

Leonardo Testi

ESO ALMA Programme Scientist

# Philosophy and goals

Inspiration: HL Tau when ALMA was conceived



# Philosophy and goals

- Going beyond “complete original ALMA project”
  - Not a compelling argument in itself
  - Anticipate and (prepare to) respond to the scientific challenges of the future (as opposite to the past)
- Transformational ambitions (with a limited budget)
  - constant scientific review of development goals
  - overarching long term scientific vision
  - beyond state-of-art technology
- Work with scientific and technical community
  - Identify and pursue areas of maximum science gain
  - Focus most effort on challenging, large upgrades

# General principles

- “Studies” prepare for “Projects”
- 3-year cycles of Studies in collaboration with institutes in the ESO MS
  - Calls in 2010, 2013, ... expect call in 2016
- Studies may have several levels
  - Develop interesting ideas into preliminary concepts
  - Provide detailed cost and planning for construction
  - Deliver small upgrades to the ALMA system
- Examples
  - Band 9 2SB, Band 2+3 components, Digitizers upgrade concepts and design
  - Band 5 preparation for production...

# Status of Studies

## ■ 2010 Call

- Preparations for ALMA B5 Full Production - done => Production Project
- Upgrade Options for ALMA B9 – done => **more R&D needed**
- Options for upgrading the instantaneous bandpass – done => New Study
- Phasing up ALMA for mm-VLBI – done => APP Project + ERC + New Study
- Design and components for ALMA B2/3 – done => New Study+
- Scientific opportunities for supra-THz – done => **Focus on SD prototype**

## ■ 2013 Call

- Develop new digitizers design to improve bandwidth – **in progress**
- Optimization/upgrade of cryocoolers - **in progress**
- Data analysis software – **in progress**
- mm-VLBI operations concepts – done => Board WG
- Advanced design and prototypes for ALMA B2/3 – **in progress**
- Solar observing modes - **in progress**

# Receivers strategy

## ■ New receivers

### ➤ Band 5

- Design and preproduction – EC-FP6 (UK, S) **2006-2011**
- Full Production Study – (NL, UK, S) **2011-2012**
- Full Production Project – (NL, S, +NRAO) **2012-2017**
- Delivering on sky, within *tightened* specs

### ➤ Band 2+3

- Preliminary wide-band/wide-if technology design and risk assessment Study – (UK, IT, IRAM) **2012-2014**
- Wide-band demonstrator Study – (UK, IT) **2015-2016**

### ➤ Supra-THz

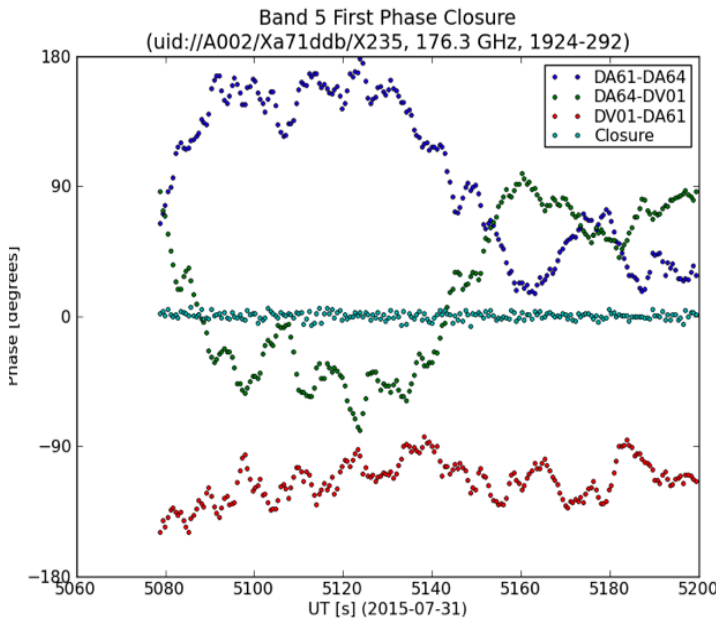
- Science and site constraints Study – (UK) **2012-2014**

## ■ Band 9 2SB & wide IF

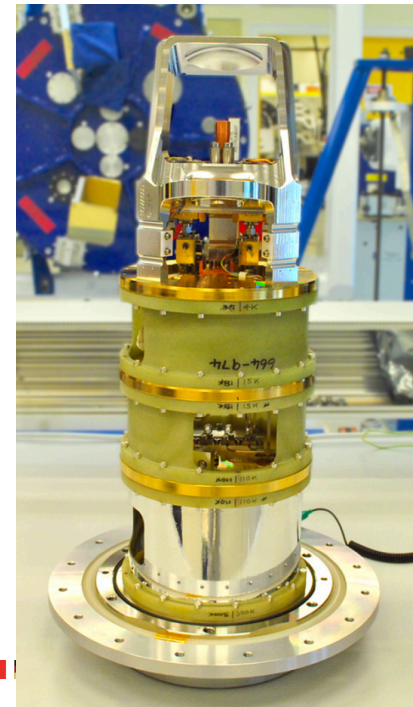
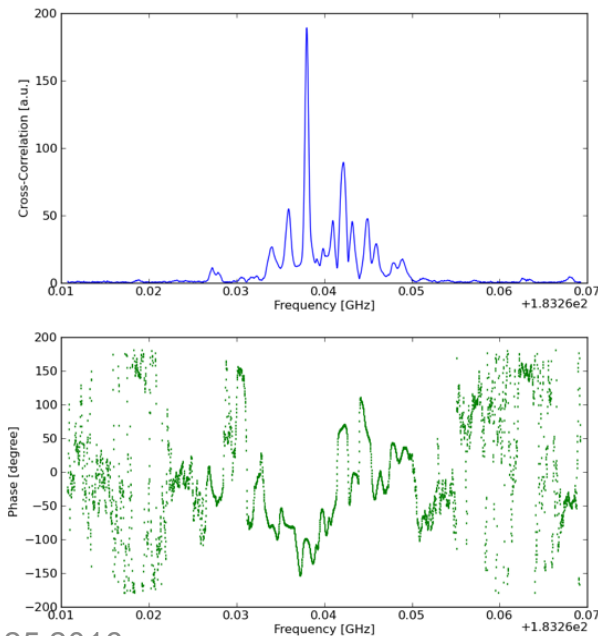
- Design Study – (NL) **2011-2013**
- Upgraded prototype at APEX, under discussion for **2016-2017**

# Band 5 project progress

- Steady progress in construction and delivery
  - 10+ cartridges in front ends, on track for Cycle 5
  - Excellent performance (T<sub>sys</sub>, SB rej, pol purity,...)
  - First fringes and AOS closure phase
  - Science Verification in progress



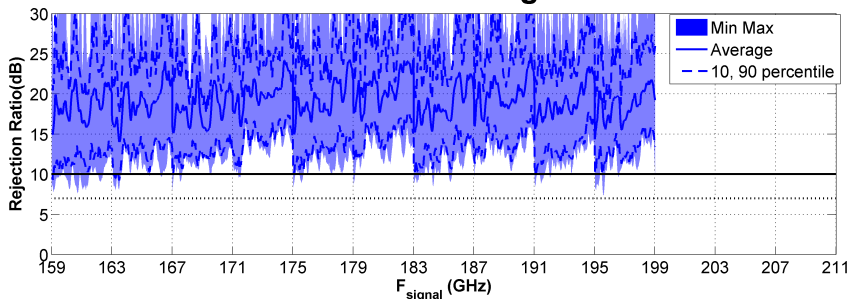
Band 5 1st Fringe (DA64-DV01) at AOS, baseline ~ 1km, OMC1 H2O Maser 183.3 GHz



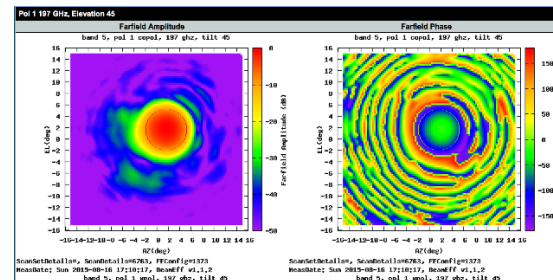
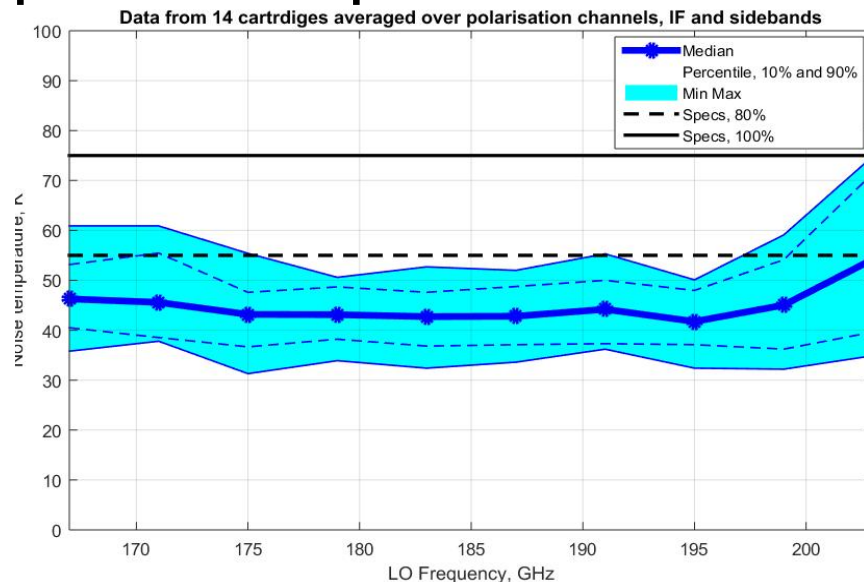
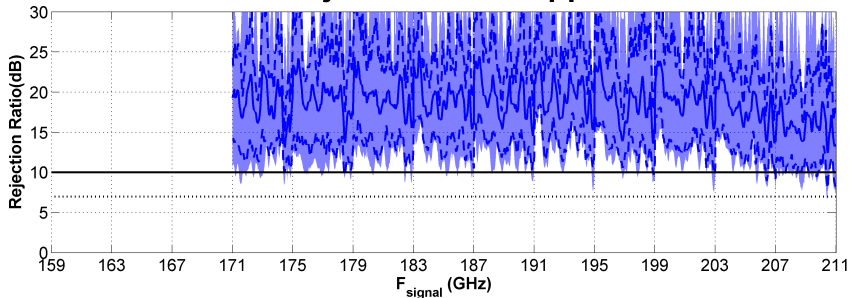
# Band 5 performance

- Meet tightened noise temperature spec
- All key specs met

Sideband Rejection Ratio Lower Sideband  
Number of Cartridges = 14



Sideband Rejection Ratio Upper Sideband

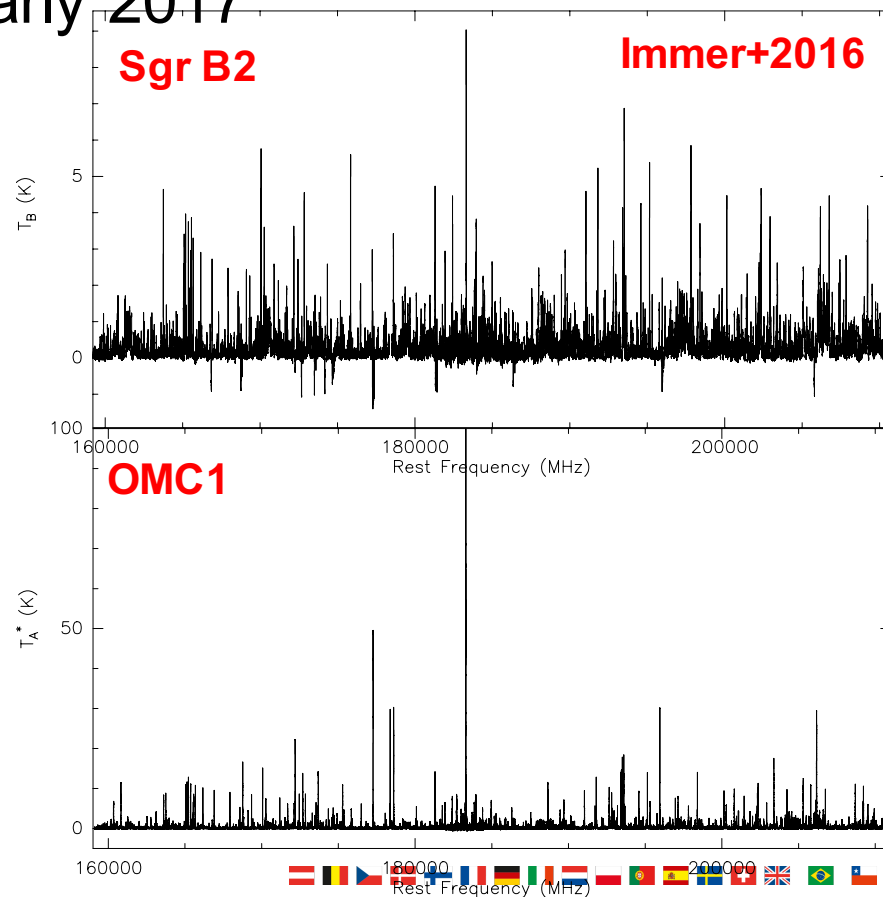
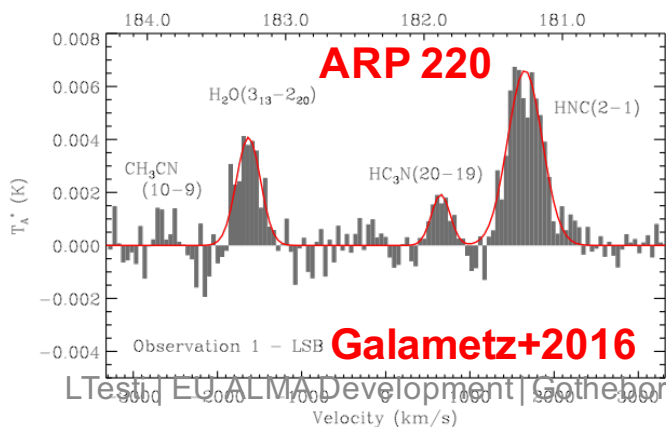
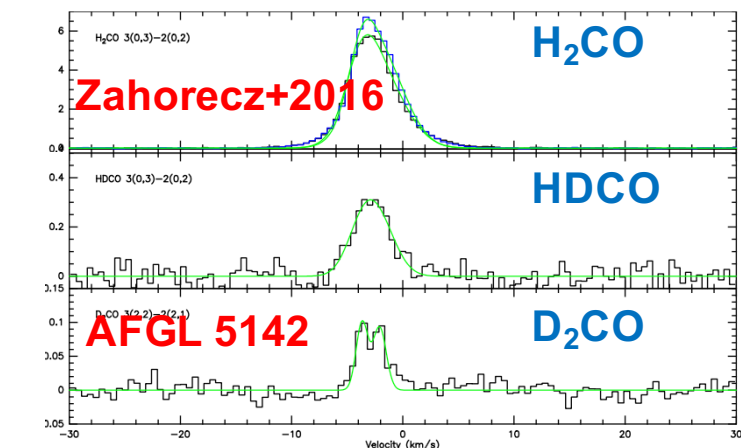


Polarization Efficiency Band 5					
RF GHz	pol	Elevation	Peak Cross dB	eta pol + spill	Polarization Eff
197	0	45	26.87	83.47	99.74
197	1	45	32.09	83.69	99.89



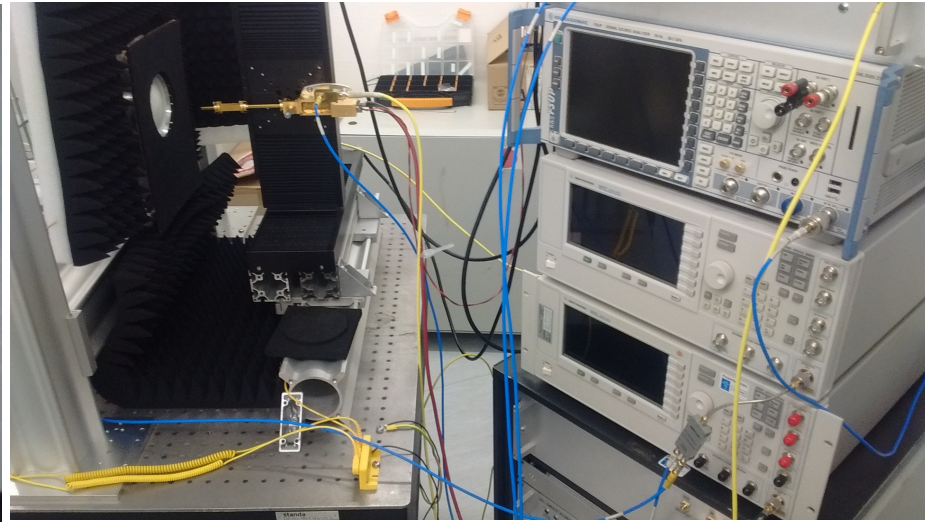
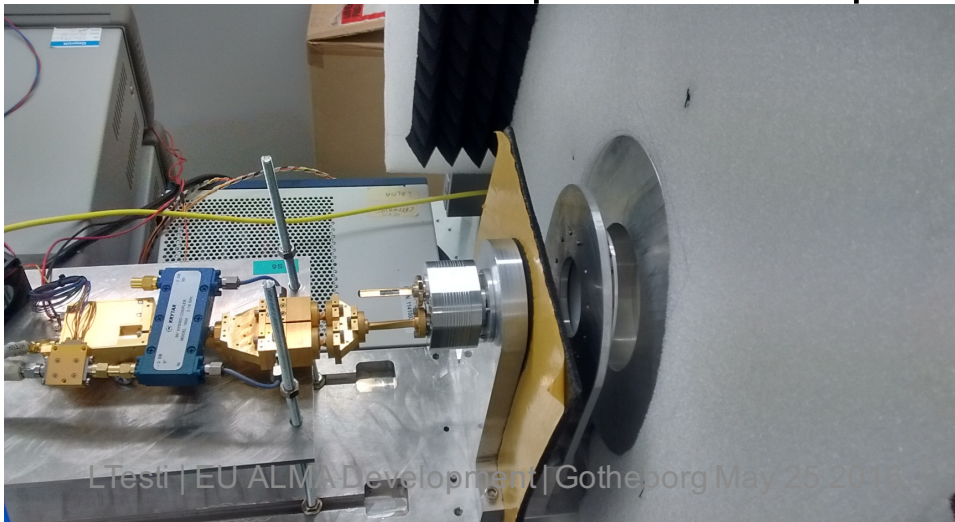
# ALMA receivers at APEX

- SEPIA: 3 ALMA cartridges cryostat
- Already installed: ALMA Band 5 and ALMA Band 9
  - Band 9 2SB upgrade in early 2017



# Band 2+3 Progress

- Phase A: optics demonstration - Completed
  - Excellence performance of optical components across the full frequency range 67-116 GHz
- Phase B: full cold prototype - Started
  - Goal to complete in ~1yr
- Final goal: single cartridge covering full frequency range from 67 through 116 GHz with broad IF
  - Could be implemented in phases



# Band 2+3 study progress

- Lengthy startup/preparation process
  - Science case published (Beltran et al. arXiv:1509.02702)
  - External support in I, UK collaboration with CL, NAOJ
  - ESO support with project management
  
- Warm bench test setup
  - Components produced, mostly delivered
  - Assembly to start in Nov 2015
  - Warm test completed by end of year
  - Support from INAF, Uni Chile, and NAOJ
  
- Cold tests and prototype
  - To start assembly and testing in 2016 in Bologna

# Backends/correlator

## ■ Double IF-bandwidth digitization system

- Simpler, more reliable system
- Final goal: digitize at least double bandwidth
- History, cost and progress
  - Internal feasibility investigation – **2011-2012**
  - New digitizers design study – (F) **2014-2016**
  - Outlook: prototype testing? **2017-2018**

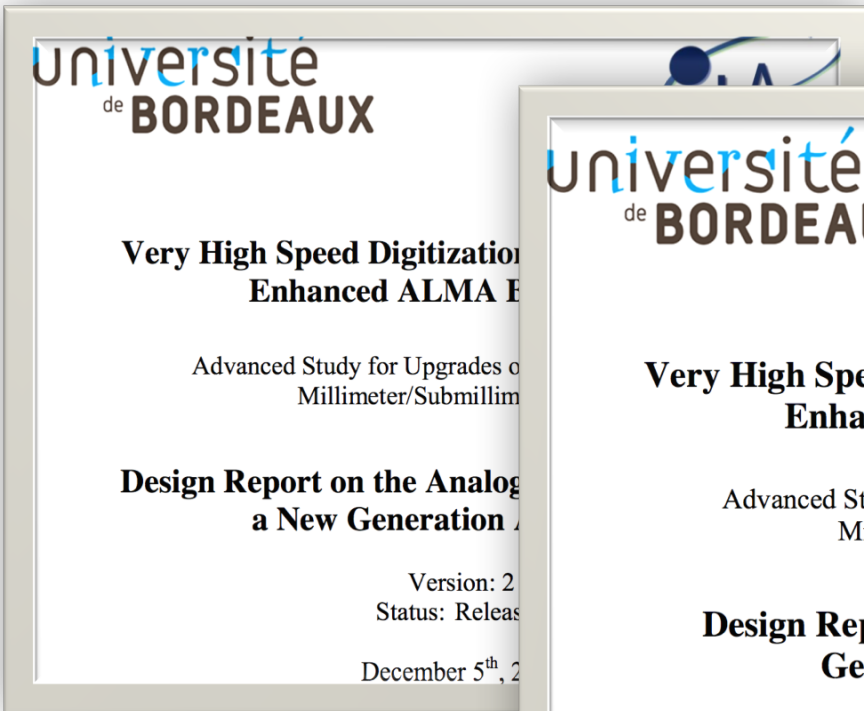
## ■ Correlator upgrade

- NRAO study with involvement from U. Bordeaux

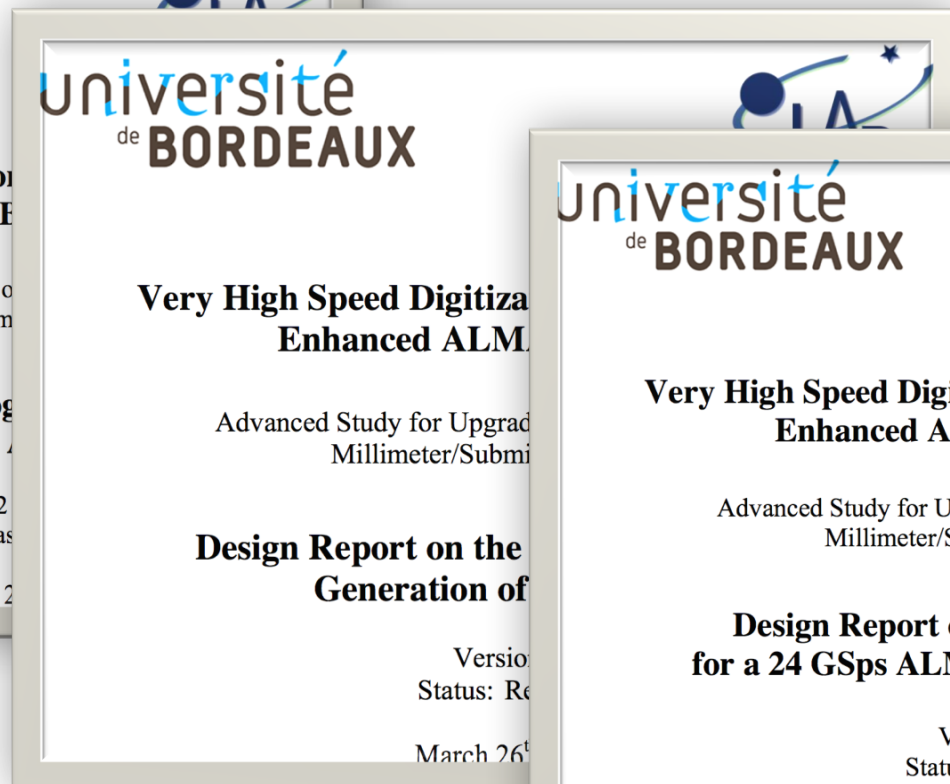
# Digitizers

## ■ Excellent progress and prospects

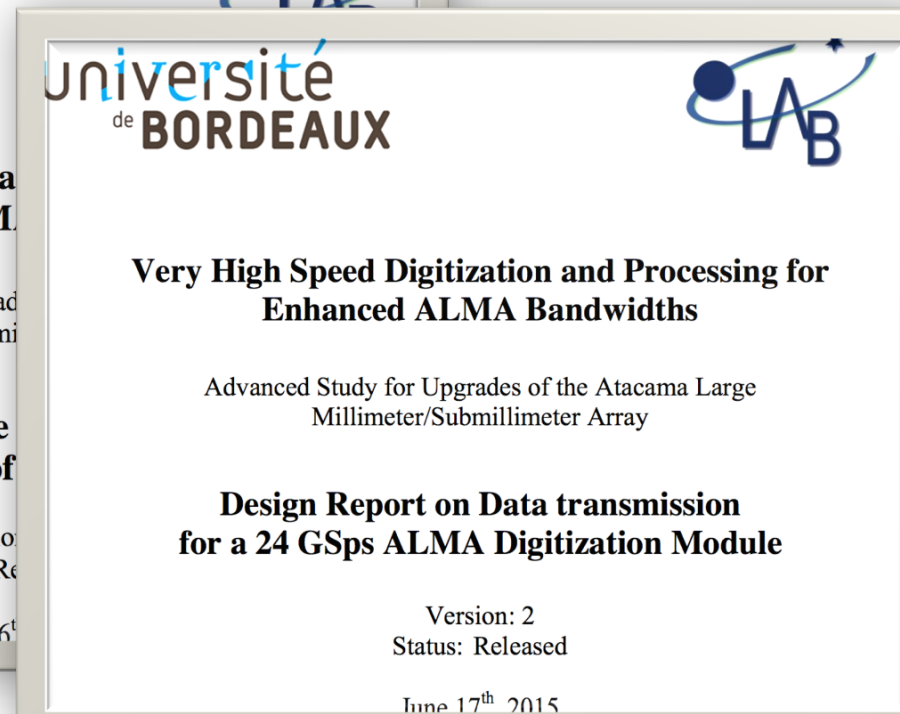
- Simplified board and double bandwidth seem both feasible and affordable – Study closes end of 2016



**université de BORDEAUX**  
**Very High Speed Digitization and Processing for Enhanced ALMA Bandwidths**  
 Advanced Study for Upgrades of the Atacama Large Millimeter/Submillimeter Array  
**Design Report on the Analog-to-Digital Conversion of a New Generation of Digitizers**  
 Version: 2  
 Status: Released  
 December 5<sup>th</sup>, 2015



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 Version: 2  
 Status: Released  
 March 26<sup>th</sup>, 2016



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**Very High Speed Digitization and Processing for Enhanced ALMA Bandwidths**  
 Advanced Study for Upgrades of the Atacama Large Millimeter/Submillimeter Array  
**Design Report on Data transmission for a 24 GSps ALMA Digitization Module**  
 Version: 2  
 Status: Released  
 June 17<sup>th</sup>, 2015

## ■ Data analysis software

- External plug-in to CASA
- Optimization algorithms, automatic line identification and radiation transfer software
- Cost and progress
  - Partly developed using independent grants (D, DK, NL) ...-**2014**
  - CASA compliant implementation – (D, DK, NL) **2014-2016**

## ■ ALMA Integrated Alarm System

- Internal Study underway – **2015-2016**



# Data Analysis Software

## ■ Good steady progress

- Several contact meetings, formal review to be scheduled in November



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 Fachgruppe Physik  
**Peter Schilke's Projects**

**Navigation** Home

Data needs for ALMA  
 XCLASS@CASA

**ALMA software**  
 Submitted by schilke on Tue, 02/24/2015 - 13:20

**ALMA Software meeting reports**

---

**User login**

Username: \* 2015-02-24:

Password: \*

- Request new password

**Kickoff meeting minutes**

**XCLASS:**

- include integration routine in XCLASS. Now, the modelled spectrum is integrated efficiently over
- continue working on the GPU version.
- several (small) bug fixes.
- plan to publish a new XCLASS release this week.

**LIME & ARTIST:**

- A number of different versions of LIME have been collected together into a Github repository.
- Bug fixes and improvements in the different versions are being merged into a "final" start versio
  - 2015-05-12: This is proceeding well. We are on track for a release of a consolidated version of



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**Navigation** Home

Data needs for ALMA  
 XCLASS@CASA  
 old myXCLASS for CLASS

**XCLASS interface for CASA**

We present eXtended CASA Line Analysis Software Suite (XCLASS) a tool package (CASA) containing a couple of new functions for modelling interface for the model optimizer package MAGIX (Modeling and Analysis) best description of the data using a certain model, i.e., finding the parameter transfer equation for an isothermal object in one dimension, whereas the fi Furthermore, the toolbox contains an interface for VAMDC (Virtual Atomic Molecular Spectroscopy) database.

This is beta software - there may be all kind of problems in installing or running database for demonstration purposes only, so we don't guarantee the validity

Please note, the XCLASS interface is for 64 bit systems only!

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**User login**

Username: \*

Password: \*

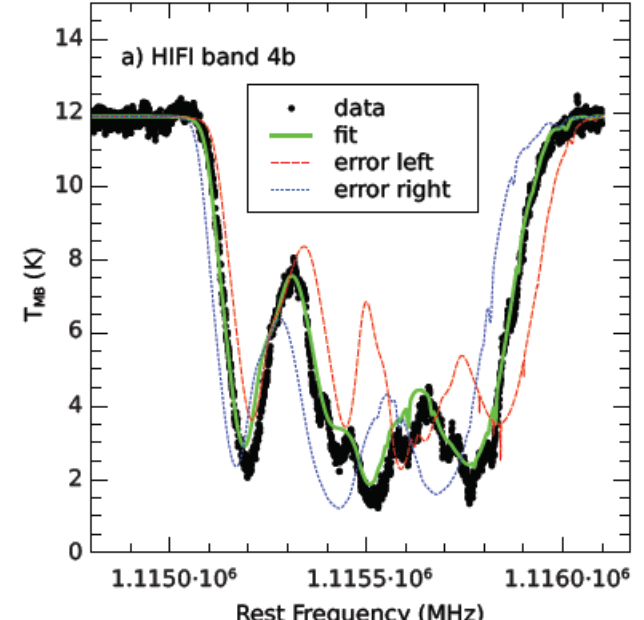
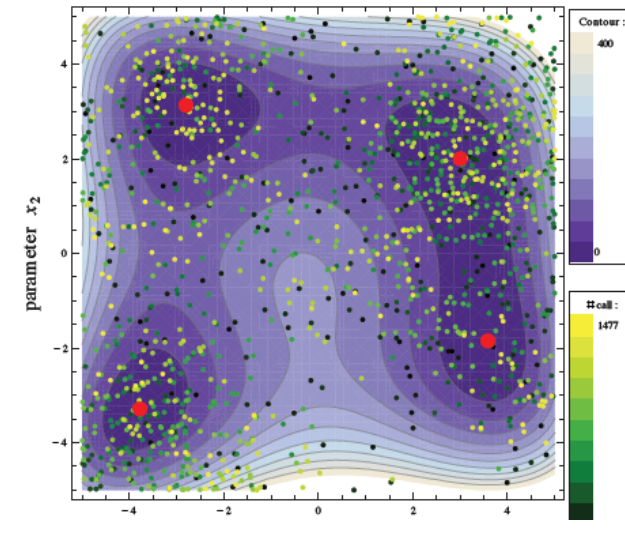
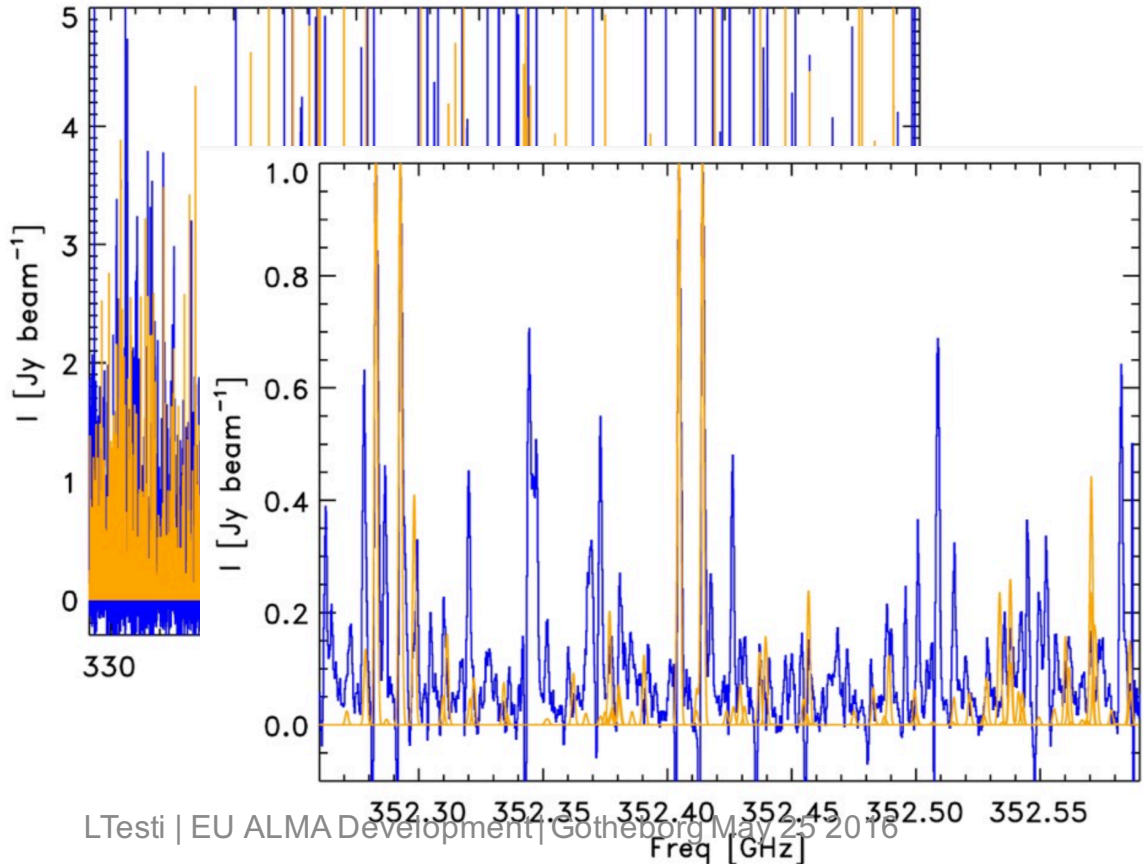
- Request new password



# Data Analysis Software

Uni Koeln, Allegro, Niels Bohr Institut

- MAGIX optimization , myXClass and Artist in CASA
- Automatic line identification - enhance archive
- “fit” using radiative transfer package (Artist)



(Moeller et al. 2013)



# mmVLBI, Solar, Cryo

## ■ mmVLBI

➤ European participation in APP – (led by MPIfR)

➤ mmVLBI operations

- ALMA as a GMVA partner 3mm – (led by MPIfR)
- High frequency: cooperation with EHT – (ERC+MPIfR)
- Internal support to the definition of mmVLBI modes –

**2010**



**2016**

## ■ Solar observing

➤ Use cases and EOC support – (CZ+)

**2014-2016**

## ■ Cryocoolers optimization

➤ Upgrade and optimization study - (UK)

**2014-2016**

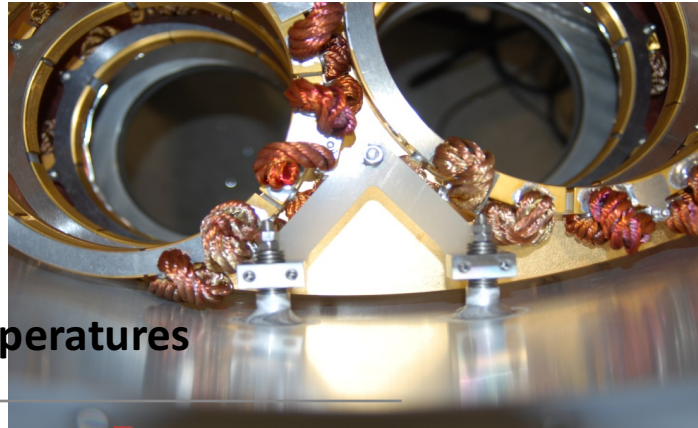
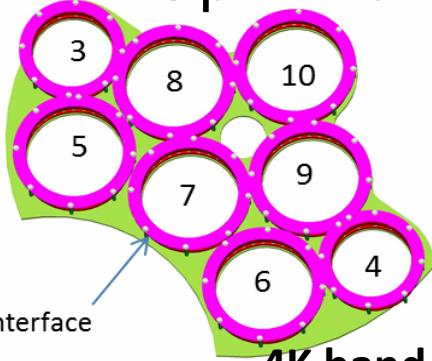
# Cryocooler optimization/upgrade

## Good progress

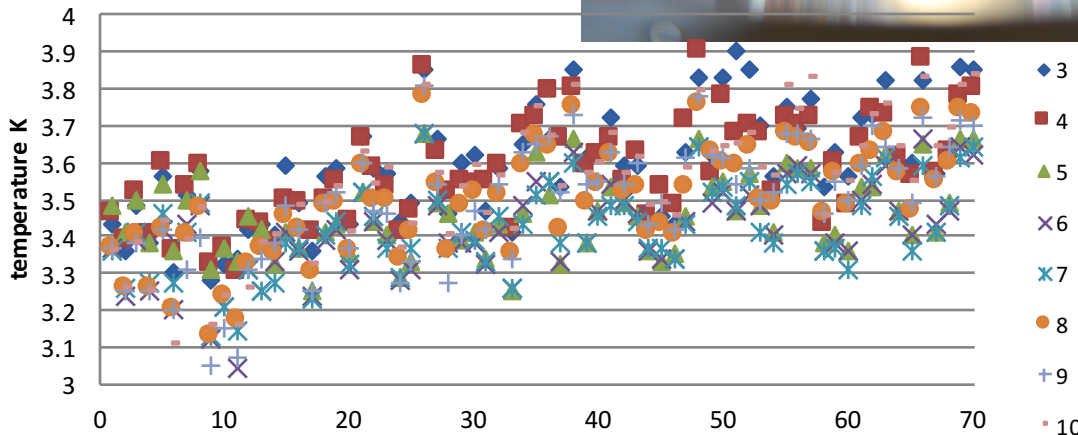
- Upgrade of cryocooler not feasible
- Optimization paths being investigated

	Study of Potential Improvements to the ALMA	Doc <del>dead</del>
	Cryocooler System	Date
		Status: Issued
		Page: 1 of 13

### Study of Potential Improvements to the ALMA Cryocooler System



4K band temperatures



### Interim report

Science and Technology Facilities Council  
Rutherford Appleton Laboratory



# Future strategy

- Complete current projects
  - Deliver Band 5 and mmVLBI operations
  
- Studies that may reach “project” maturity
  - Receivers: B9 upgrade (APEX?), B2(+3) components
  - Digital processing system
  
- Studies that aim to deliver direct benefit
  - Optimization of cryostat performance
  - Data Analysis Tools
  - Solar observing modes
  - Optimization of antenna performance

# New call for studies

## ■ Studies cycle coming to an end

- All currently running studies will come to an end in 2016/2017

## ■ New call for studies

- Released on May 24, deadline Sept 5
- Information day June 22, 2016
- Added focus on the ALMA 2030 priorities, wide bandwidth

## ■ More info on the call

- Talk with us during the workshop!