ALMA Development

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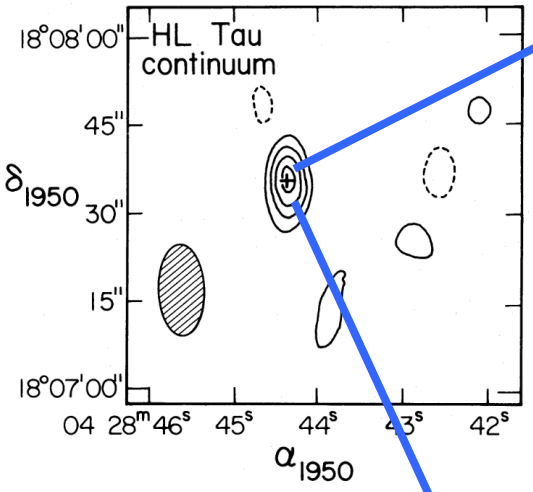
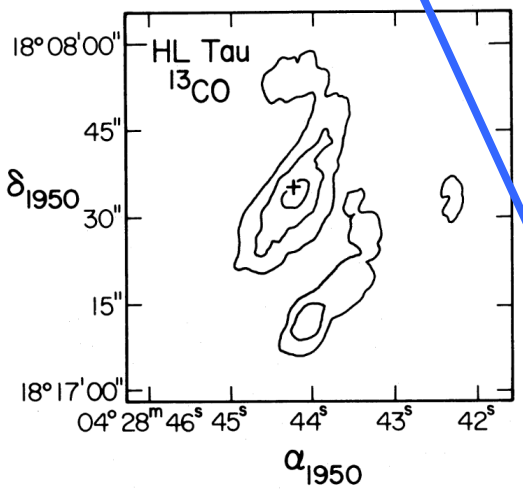
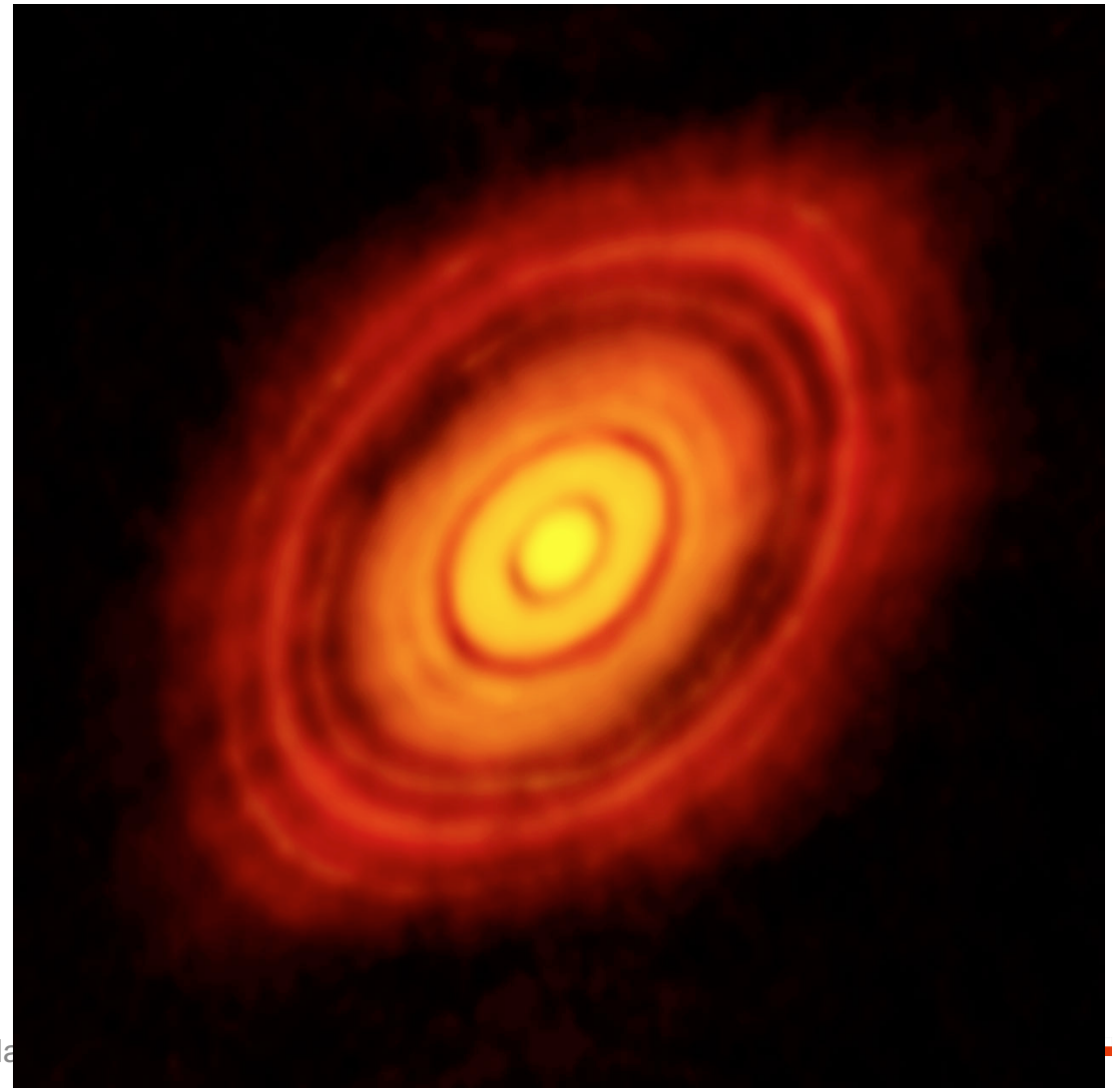
Philosophy and goals

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

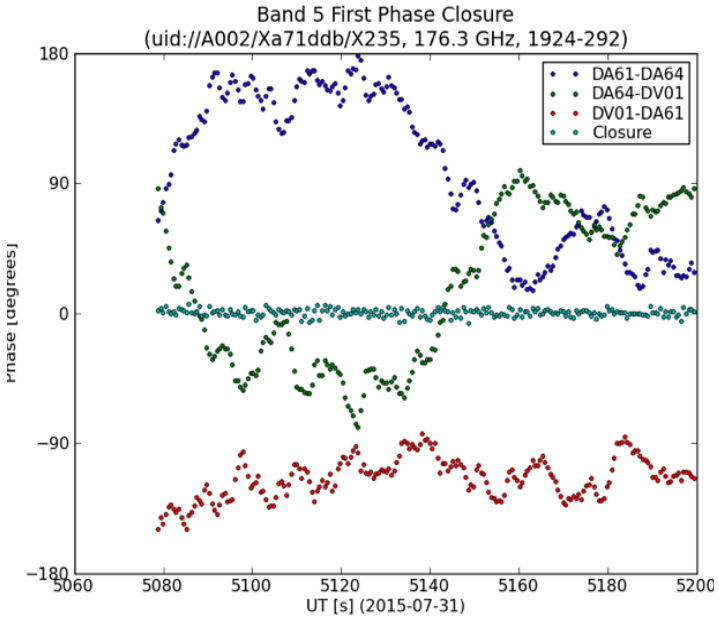
- Develop new digitizers design to improve bandwidth – **in progress**
- Optimization/upgrade of cryocoolers - **in progress**
- Data analysis software – **in progress**
- mm-VLBI operations concepts – done => **Board WG**
- Advanced design and prototypes for ALMA B2/3 – **in progress**
- Solar observing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

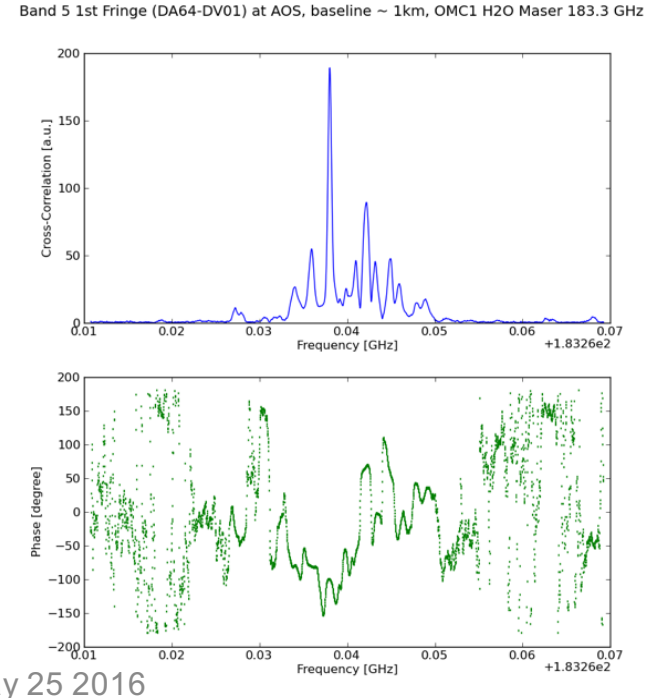
Receivers strategy

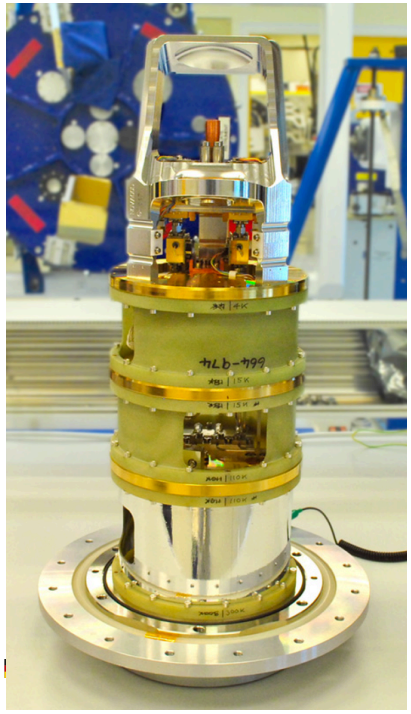
- New receivers
  - Band 5
    - Design and preproduction – EC-FP6 (UK, S) **2006-2011**
    - Full Production Study – (NL, UK, S) **2011-2012**
    - Full Production Project – (NL, S, +NRAO) **2012-2017**
    - Delivering on sky, within *tightened* specs
  - Band 2+3
    - Preliminary wide-band/wide-if 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 (Tsys, SB rej, pol purity,…)
  - First fringes and AOS closure phase
  - Science Verification in progress

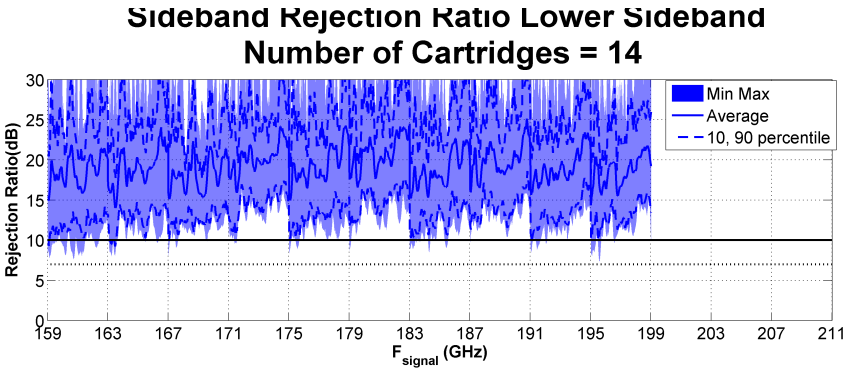


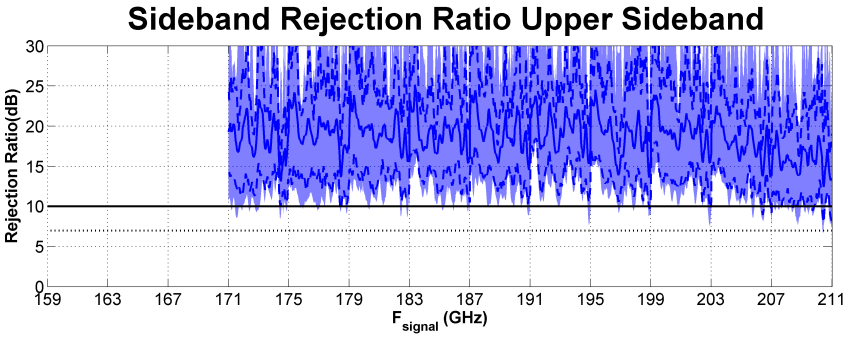


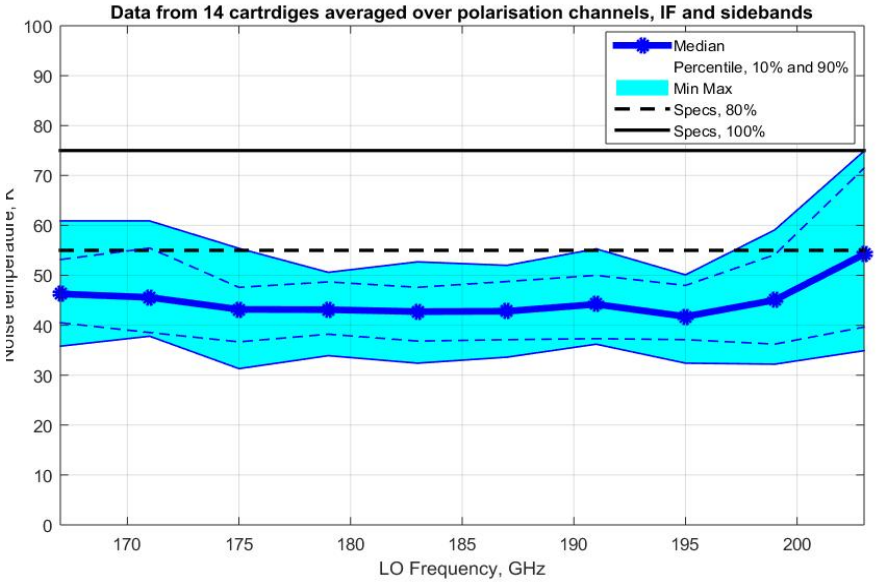


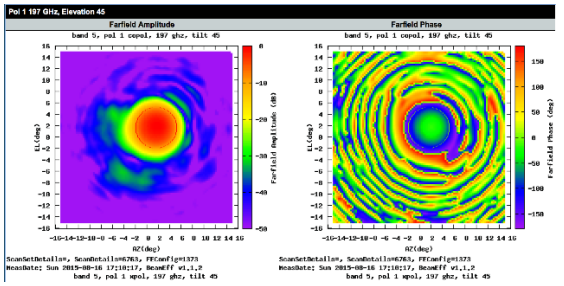
Band 5 performance

- Meet tightened noise temperature spec
- All key specs met





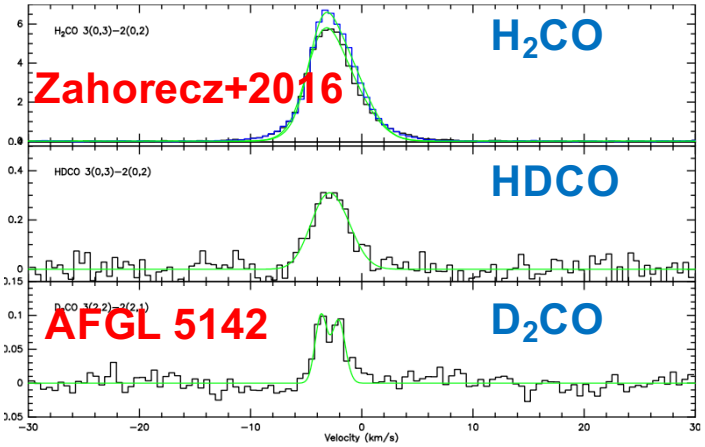


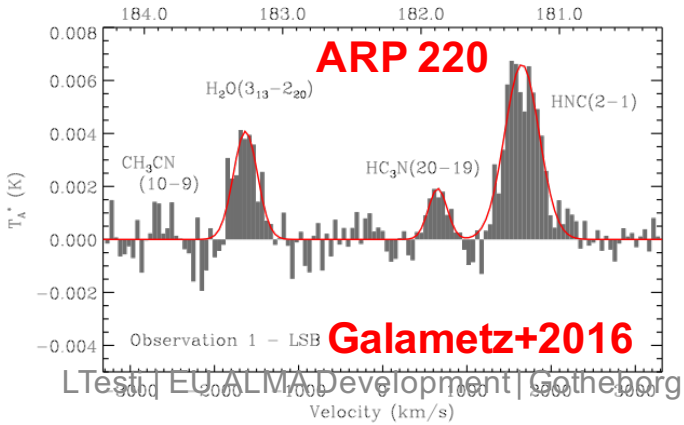


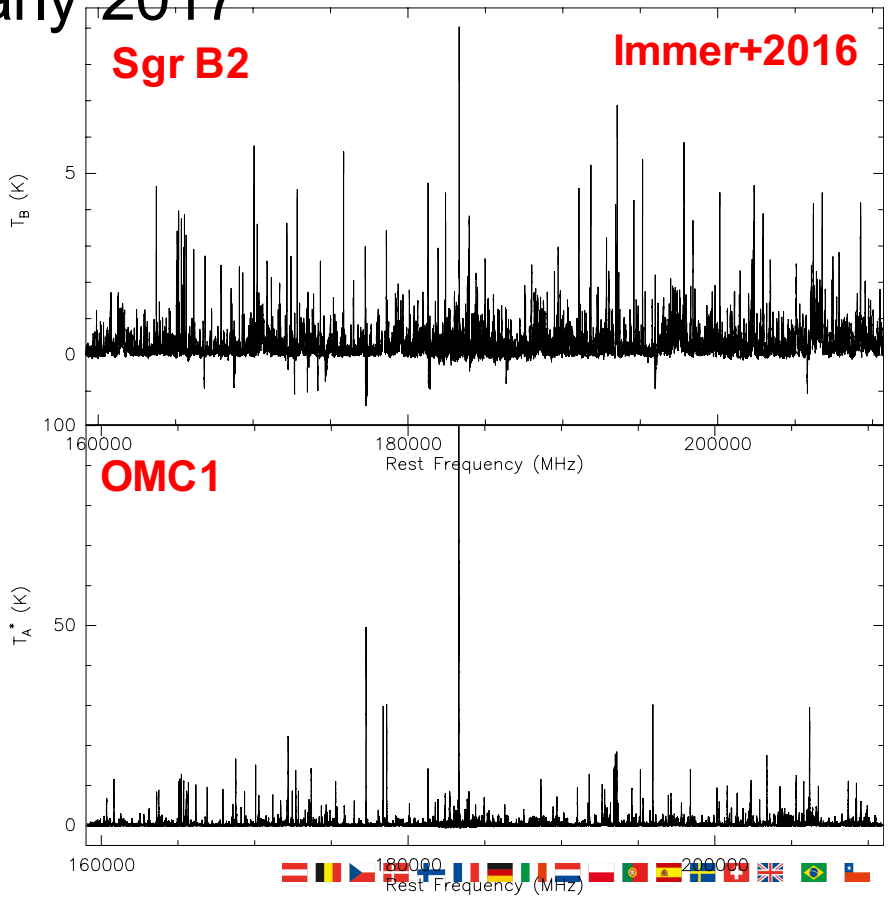
Polarization Efficiency Band 5					
RF GHz	pol	Elevation	Peak Cross dB	eta pol + spill	Polarization Eff
197	0	45	26.87	83.47	99.74
197	1	45	32.09	83.69	99.89
Meas. software version 1.0.5, Class.eff version 1.1.3					

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

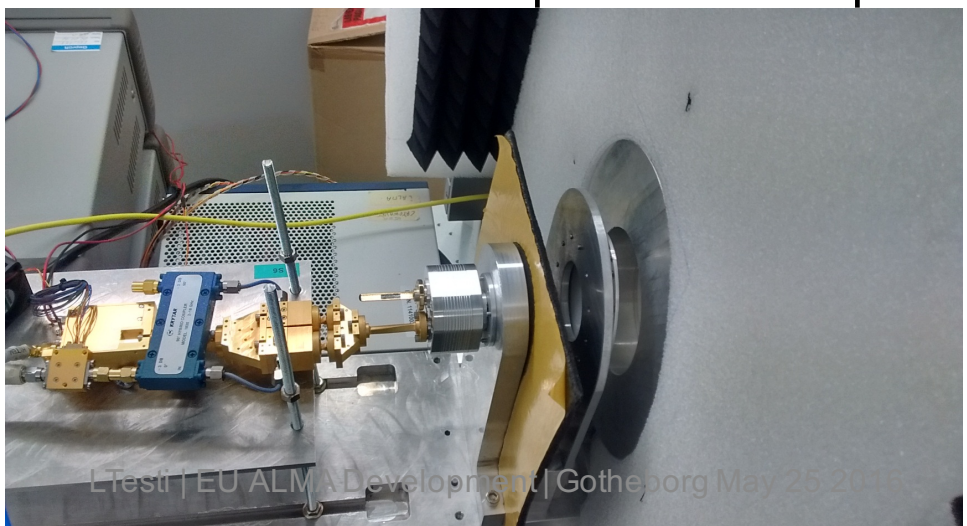


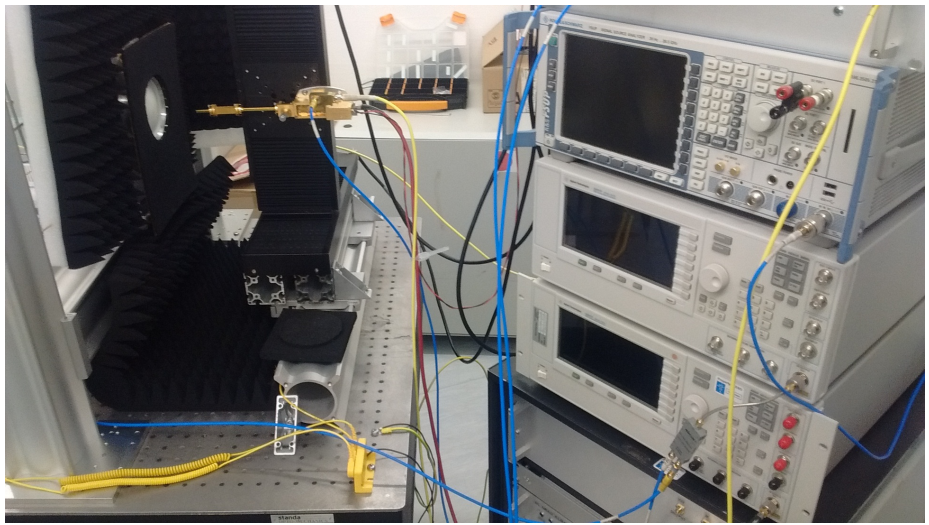




Band 2+3 Progress

- 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

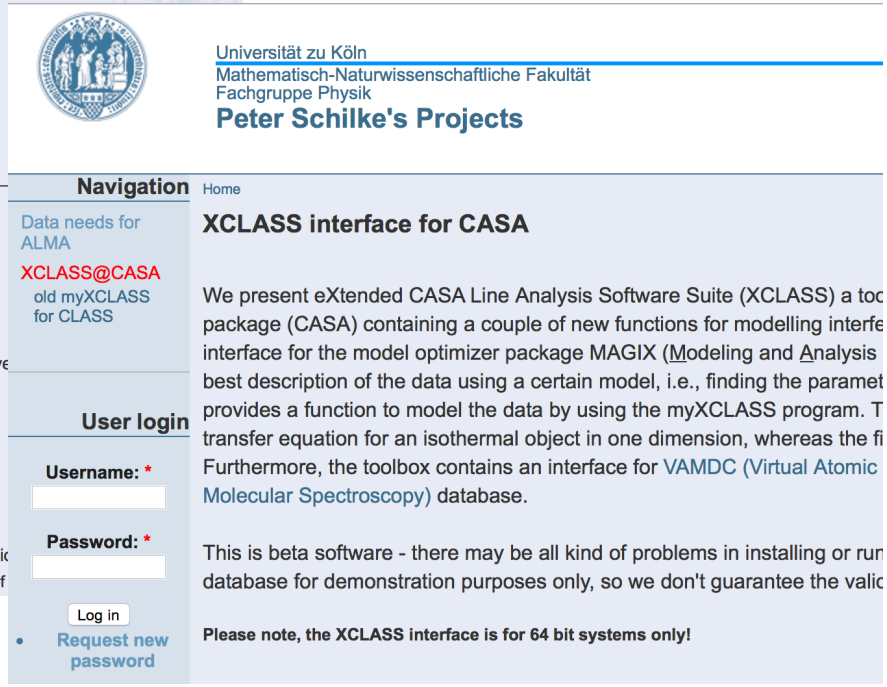
Software

- 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**

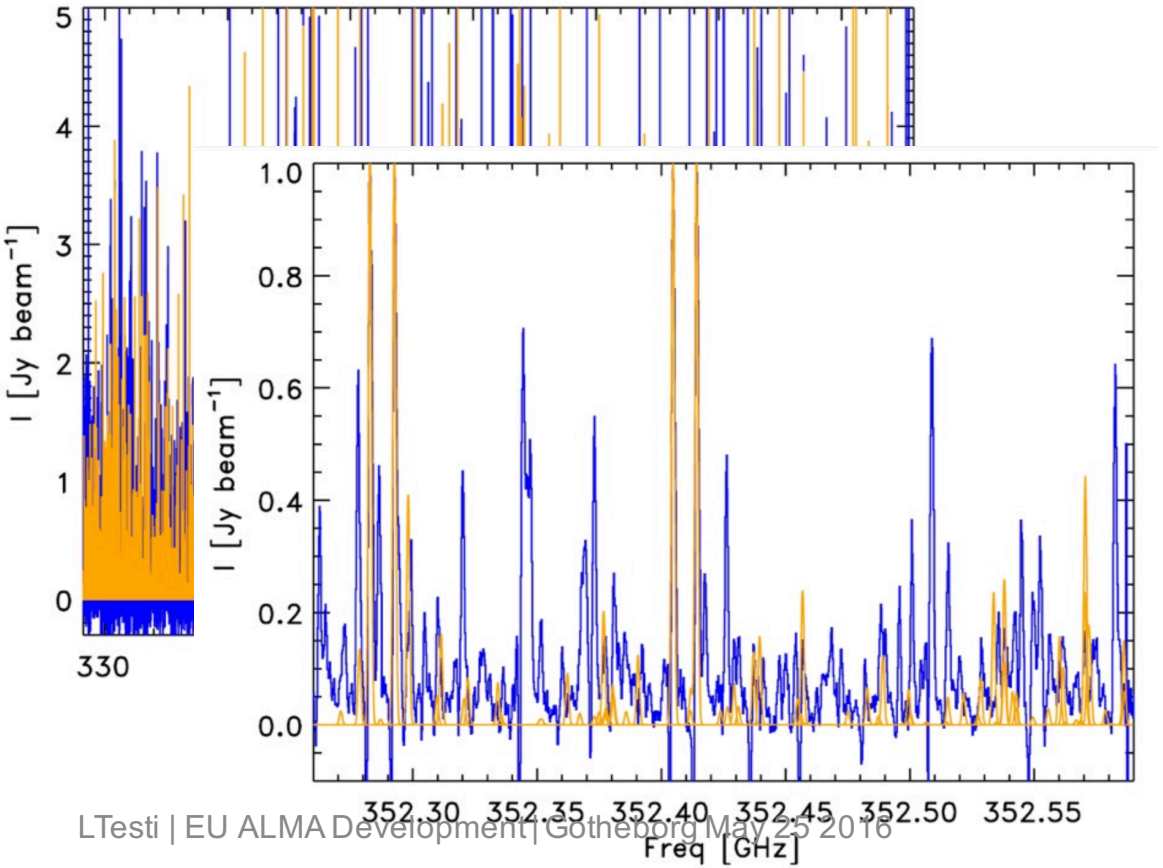
Data Analysis Software

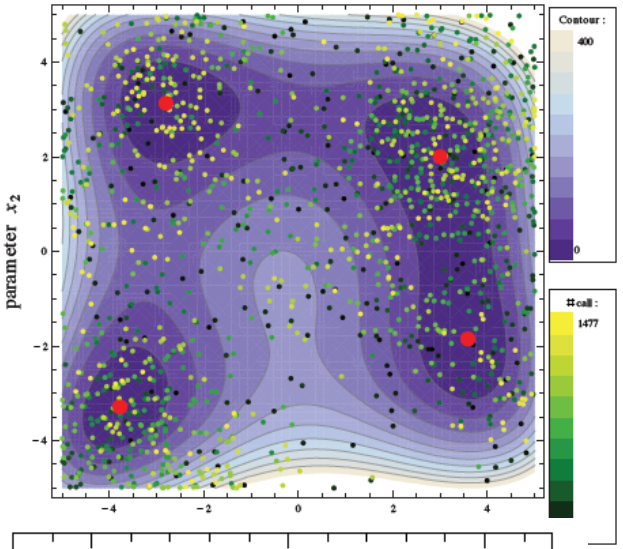
- Good steady progress
  - Several contact meetings, formal review to be scheduled in November

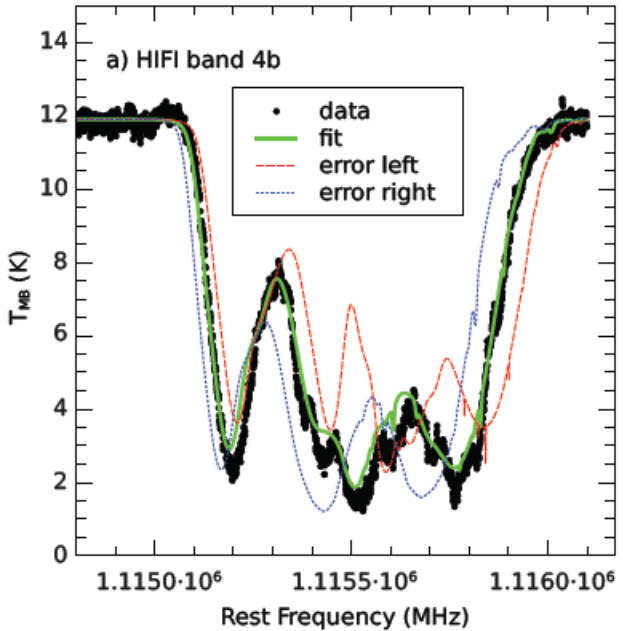


Data Analysis Software

- Uni Koeln, Allegro, Niels Bohr Institut
  - MAGIX optimization , myXClass and Artist in CASA
  - Automatic line identification - enhance archive
  - “fit” using radiative transfer package (Artist)







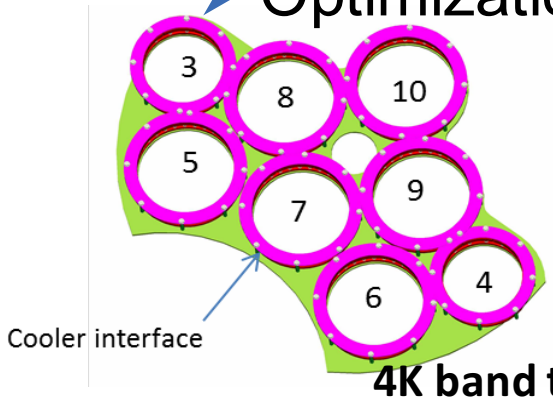
(Moeller et al. 2013)

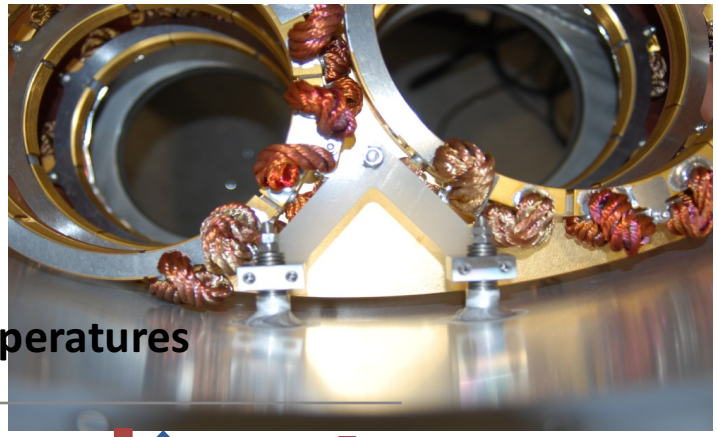
mmVLBI, Solar, Cryo

- mmVLBI
  - European participation in APP – (led by MPIfR)
  - mmVLBI operations
    - ALMA as a GMVA partner 3mm – (led by MPIfR) **2010**
    - High frequency: cooperation with EHT – (ERC+MPIfR) ⬇
    - Internal support to the definition of mmVLBI modes – **2016**
- Solar observing
  - Use cases and EOC support – (CZ+) **2014-2016**
- Cryocoolers optimization
  - Upgrade and optimization study - (UK) **2014-2016**

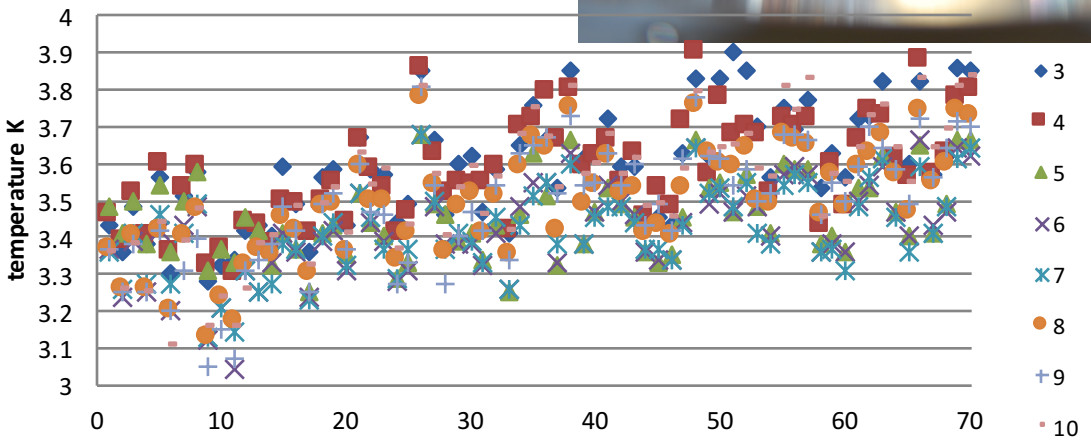
Cryocooler optimization/upgrade

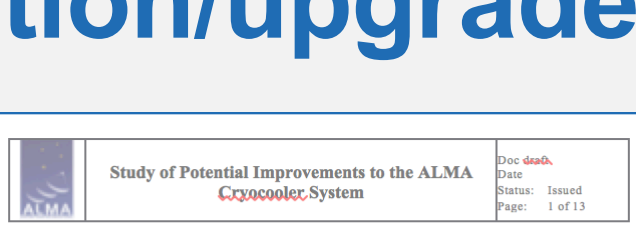
- Good progress
  - Upgrade of cryocooler not feasible
  - Optimization paths being investigated



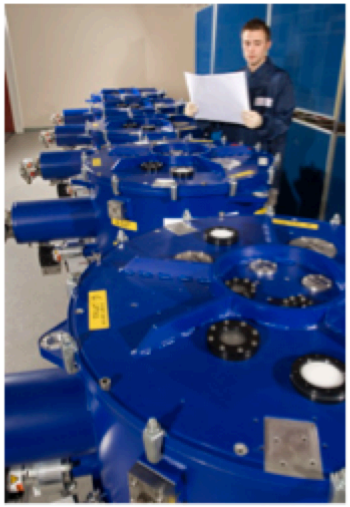


4K band temperatures





Study of Potential Improvements to the ALMA Cryocooler System



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!