B23 system and AIV Activity @ INAF for the Band 2+3 prototype

Fabrizio Villa & Francesco Cuttaia
INAF (Istituto Nazionale di Astrofisica)
IASF (Istituto di Astrofisica Spaziale e Fisica cosmica) - Bologna

Technology Team

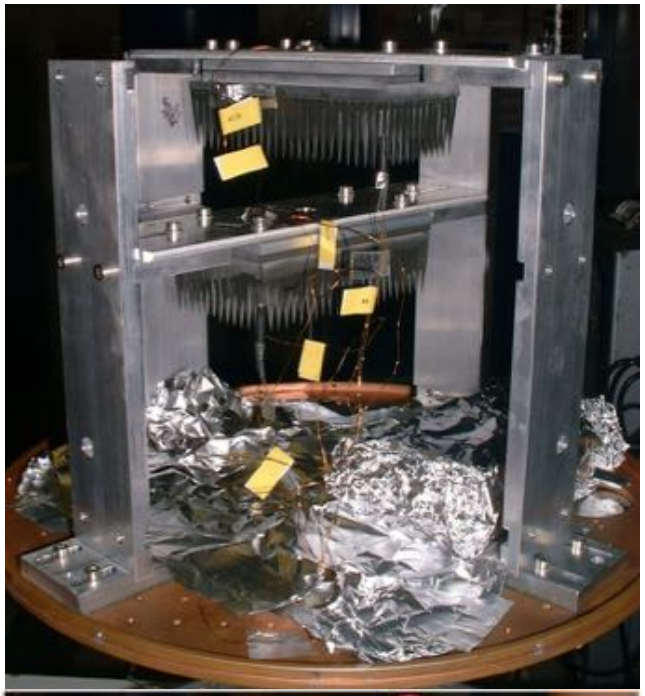
- INAF IASF
  - F. Cuttaia, A.de Rosa, G. Morgante, S. Ricciardi, M. Sandri, L. Terenzi , F. Villa
- INAF IAPS
  - A.M. di Giorgio, A. Morbidini, S. Molinari
- INAF IRA
  - S. Mariotti
- INAF OAA
  - R. Nesti et al.
- Agreement with metrology lab @ Univ. Milano
  - F. Cavaliere
- Collaboration with Electronic Lab @ Uni. Milano Bicocca to verify LNAs @ cryo
  - M. Zannoni

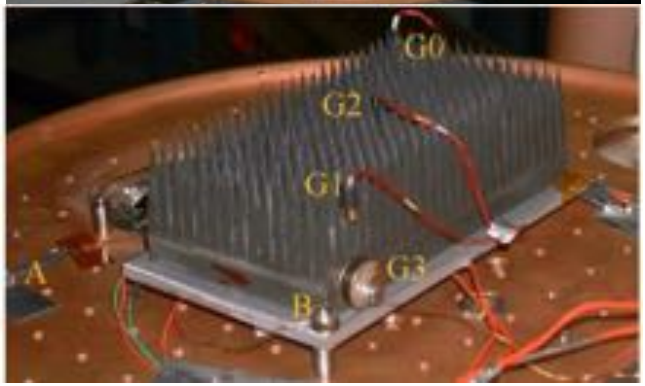
INAF Resources

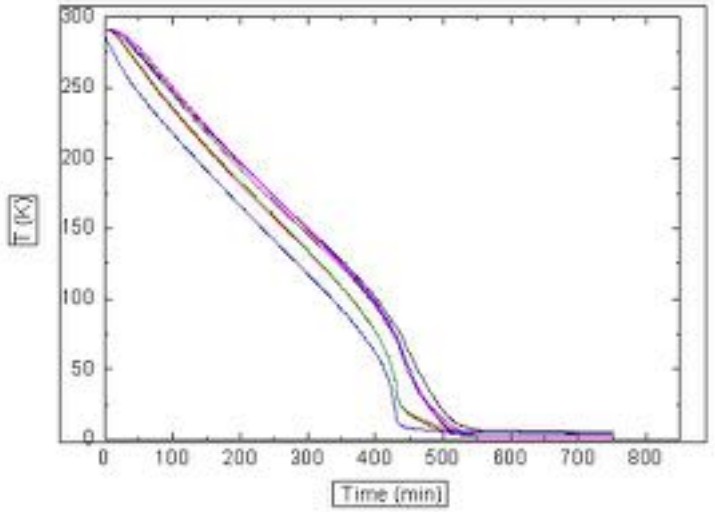
- Covered skills
  - Thermal Engineer
  - Mechanical Engineer
  - RF Engineer
  - AIV
  - Project Controller
- Facilities
  - Cryogenic Lab (3 cryo facilities)
  - TVAC Chamber
  - RF Lab
  - Clean & Integration room
  - Mechanical workshops (IASF + IAPS)
  - Metrology workshop (Unimi)
  - EM software (HFSS, GRASP)

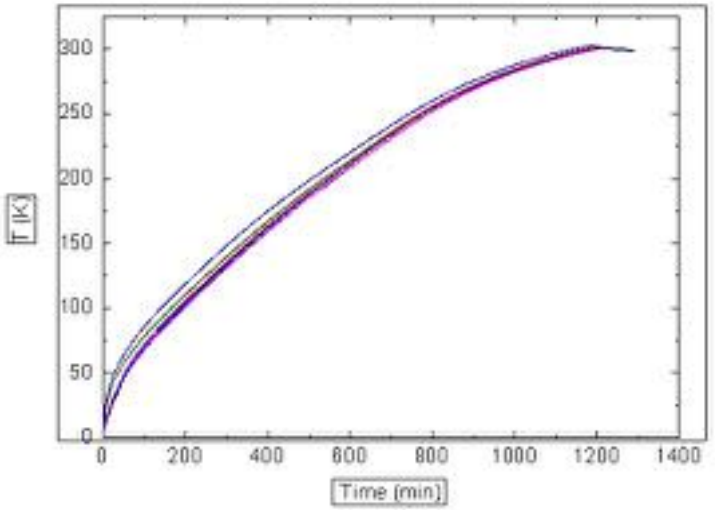
Activity at the Blue Barrel

INAF





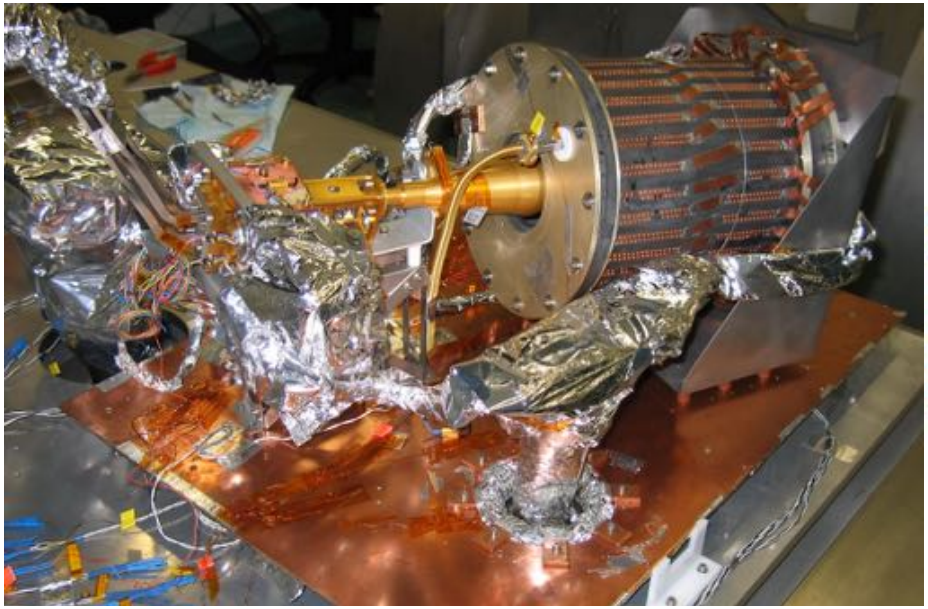


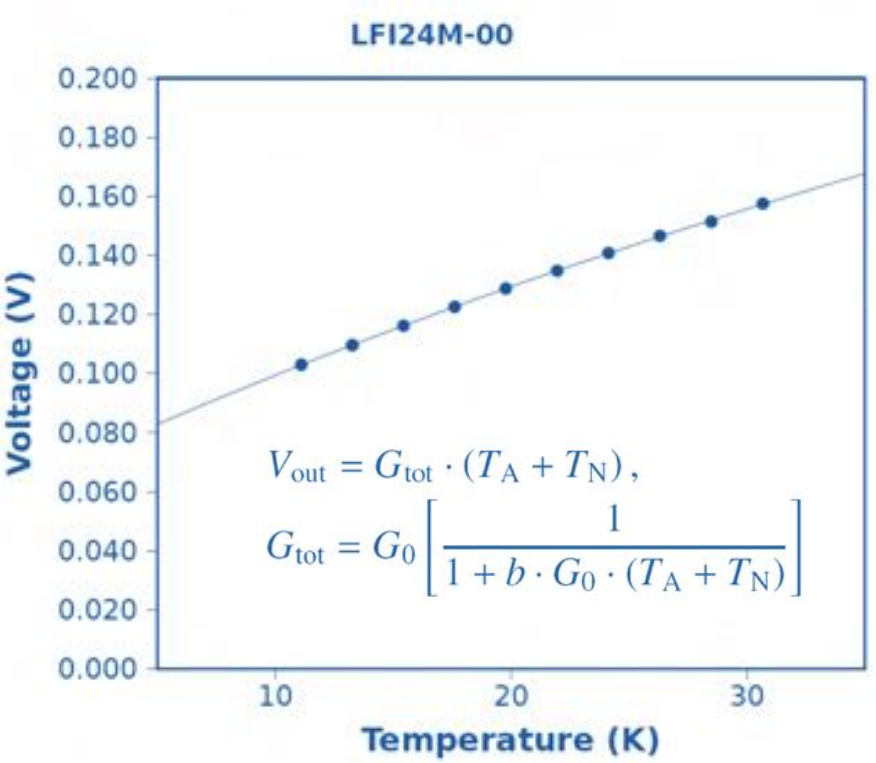


Planck heritage (1)

INAF

Calibrations @ Channel Level

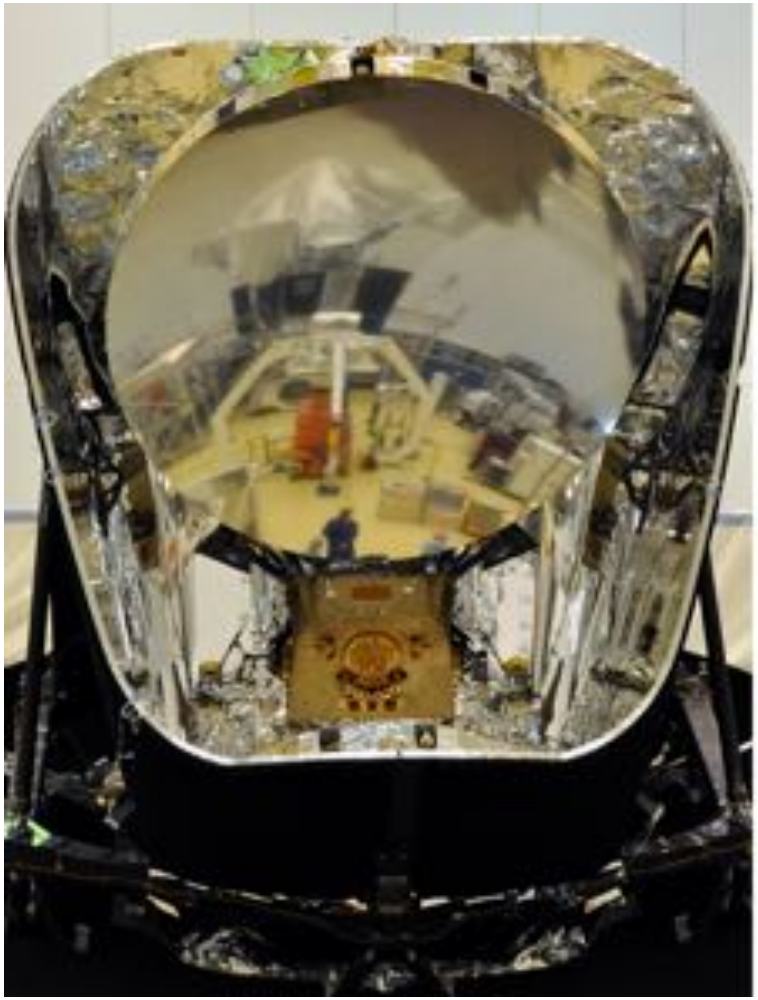


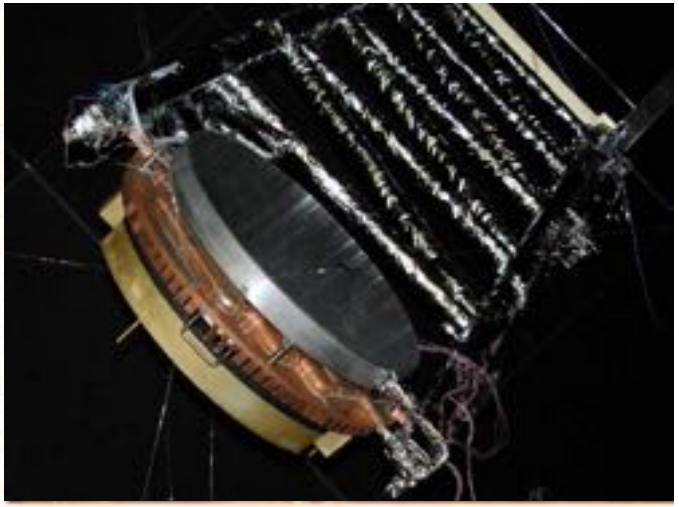


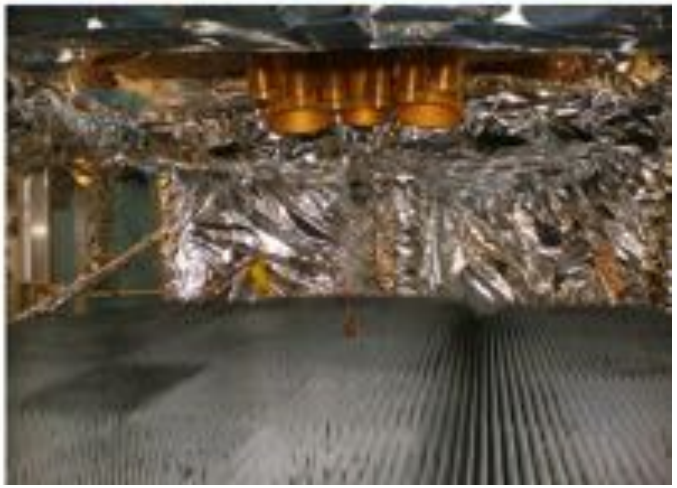
Planck heritage (2)

INAF

Calibrations @ Instrument & System Level







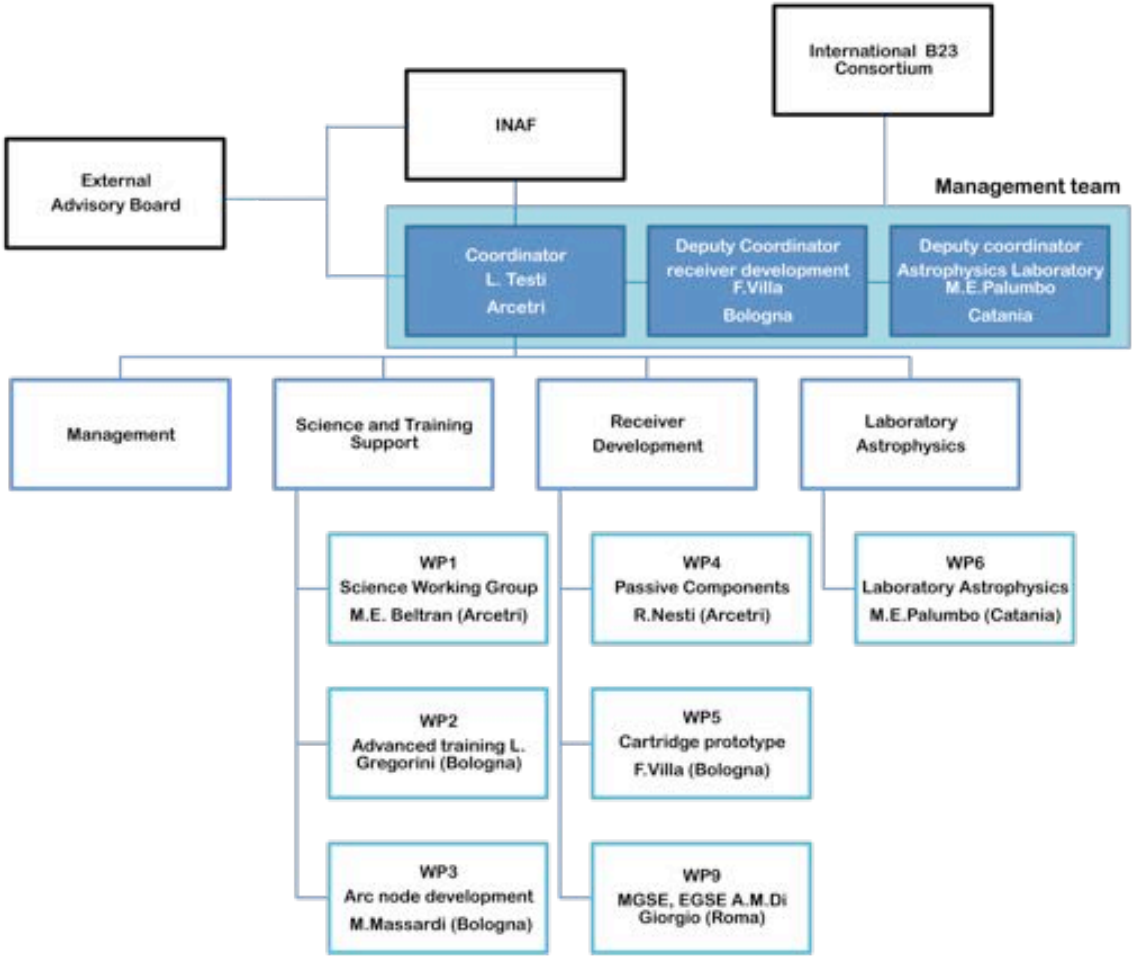
iALMA project

- **Science and Technology in Italy for the upgraded ALMA Observatory**
  - Science
  - Astrophysics Laboratory
  - Technology development

iALMA

- INAF / OAA (Arcetri)
  - PI, science, technology dev.
- INAF/ OAC (Catania)
  - Astrophysics Laboratory
- INAF / IASF (Bologna)
  - Technology dev., science
- INAF / IRA (Bologna)
  - ALMA regional center, Science
- INAF / IAPS (Rome)
  - Technology development
- University of Firenze, Bologna, Catania
  - Science, education (PhD)

iALMA organization chart



iALMA 'content'

- Develop the scientific use of ALMA via:
  - the development of science programs and Science Case for ALMA upgrade;
  - execute an integrated advanced training plan for the scientific and technical areas of the project;
  - develop the expertise and capacity of the ARC node in Bologna to support the scientific use of ALMA.

- Develop components, production, assembly and test of an ALMA Band 2+3 cartridge prototype

- Develop an innovative experimental setup in the Catania laboratory in order to execute experiments for the production of very rare complex organic molecules in astrophysical ices.

B23 development - Phase A

INAF

- iALMA and ESO funded activities
  - Warm test baseplate development
  - Documentation control and repository
  - Support to SE and AIV @ESO
  - RF tests on FH, OMT (see R. Nesti's presentation) , & LNAs spare
  - Implementation of a dedicated cryo-lab for ALMA (cryowaves lab)
  - Bias power supply of LNAs
  - Providing WG auxiliary components

Phase A: Warm test baseplate

INAF

- Definition and control of interfaces
- Design
- Manufacturing
- Alignment verification
- Pre-integration @ IASF
- Integration @ ESO

iALMA

Science and Technology in Italy

For the upgraded ALMA Observatory

- TECHNOLOGY DEVELOPMENT -

B2+3 Warm Test Baseplate
Interface Control document

Document code: IALMA-TEC-ICD-IAB-001-H

Old code: IALMA-ICD-0001 Issue 1.0

Status: Issued

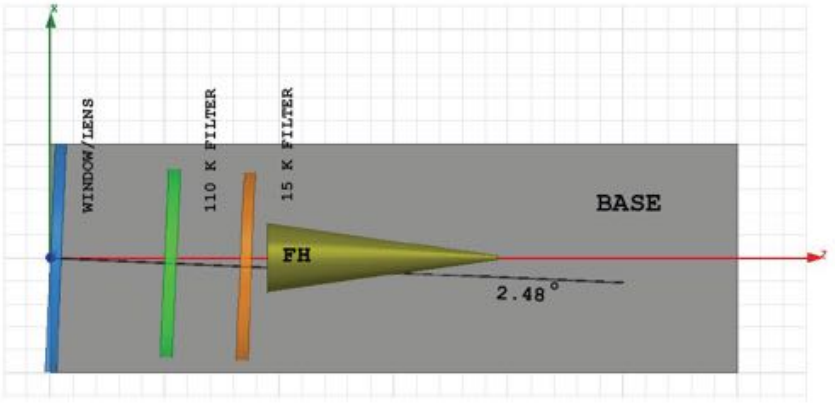
Date: 28/10/2015

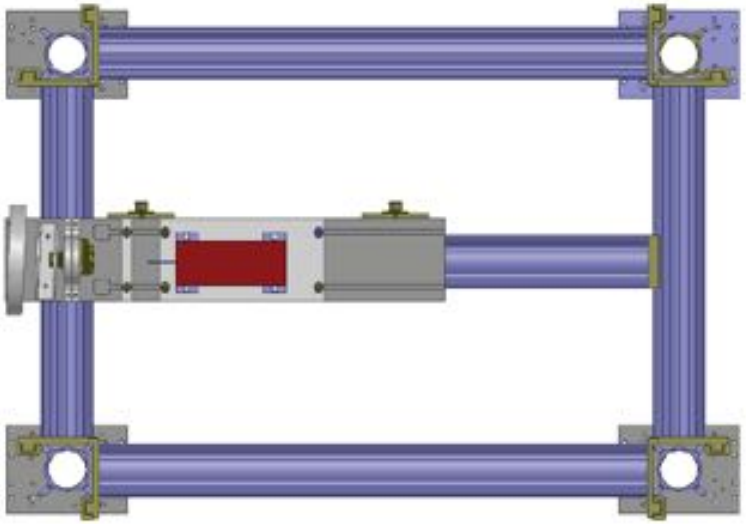
Prepared by		
Name	Organisation	Date
Francesco Cuttaia	INAF/IASF Bologna	14/01/2015
Adriano De Rosa	INAF/IASF Bologna	
Approved by		
Name	Organisation	Date
Fabrizio Villa	INAF/IASF-Bologna	14/01/2016

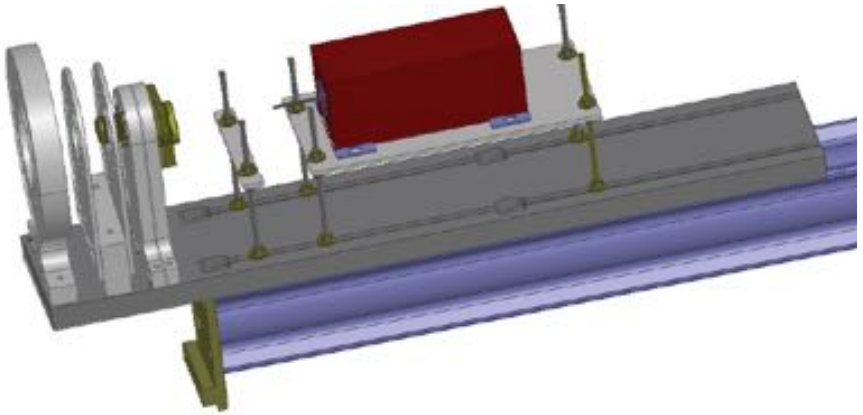
INAF

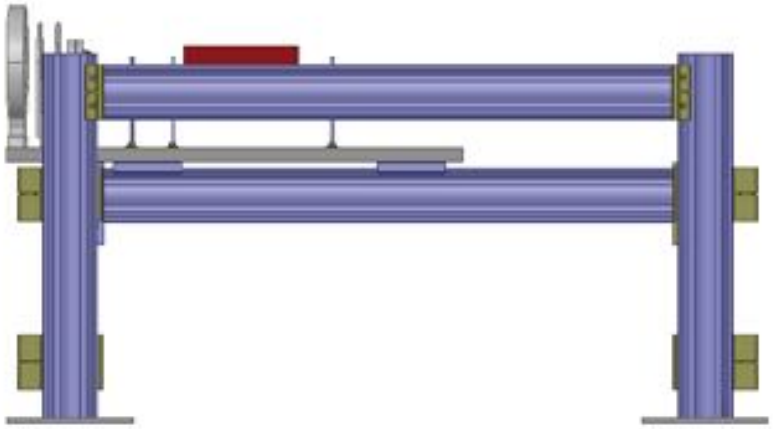
Baseplate specifications

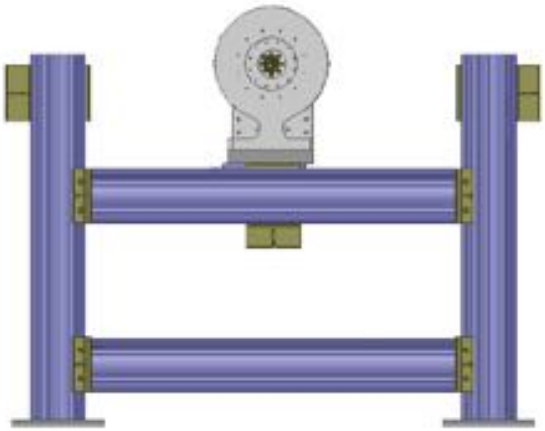
- Room Temperature Environment
- Alignment requirements and interfaces of ALMA cryostat
- Easy manufacturing
- Use of COTS (when possible)
- FH / OMT combination flexibility
- Rotation of FH + OMT polarization planes permitted
- FH test in stand alone configuration permitted





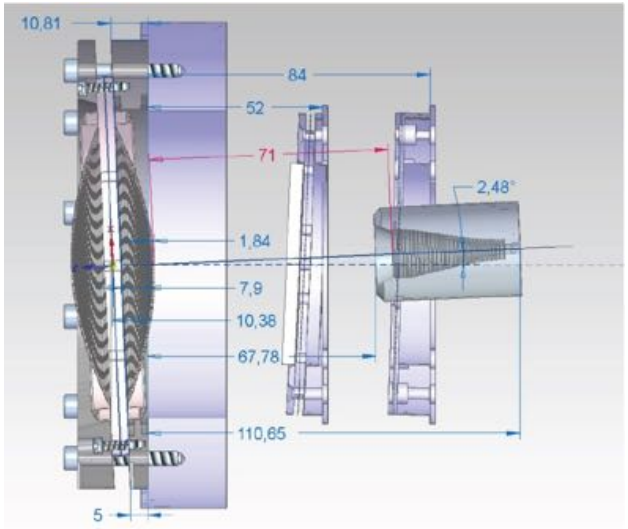


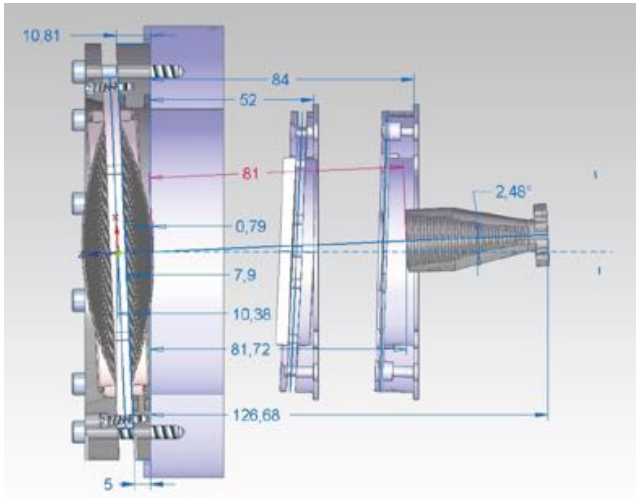




FH / OMT test configurations

- Same interfaces but different positions
  - INAF FH + INAF OMT
  - UdC FH + UdC OMT
  - INAF FH + UdC OMT
  - UdC FH + INAF OMT





Reference plane	Optical Element	Position
Telescope focal point (vacuum-window mounting top surface)	Lens	0 mm
110 K shield top surface	110 K filter	51 mm
15 K shield top surface	15 K filter	83 mm
Feedhorn plane*	"INAF" feedhorn	67.94 mm
S4 interface plane**	"INAF" feedhorn	108.88 mm
Feedhorn plane	"CHILE" feedhorn	81.82 mm
S4 interface plane**	"CHILE" feedhorn	129.4 mm

Configuration 1 and 2

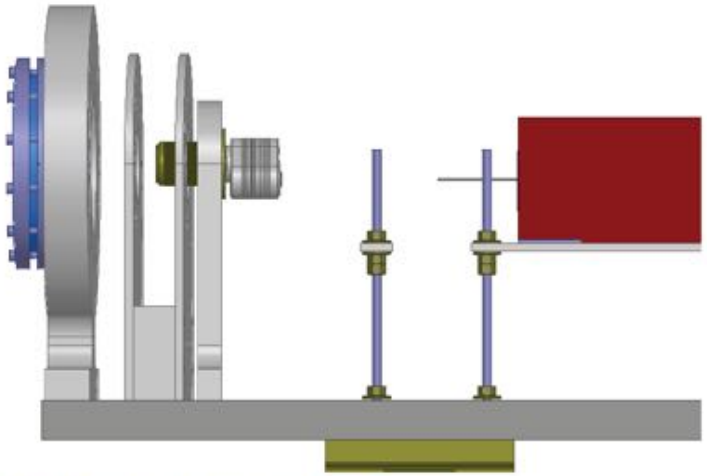


Figure 42 INAF LENS + INAF horn + INAF OMT side view

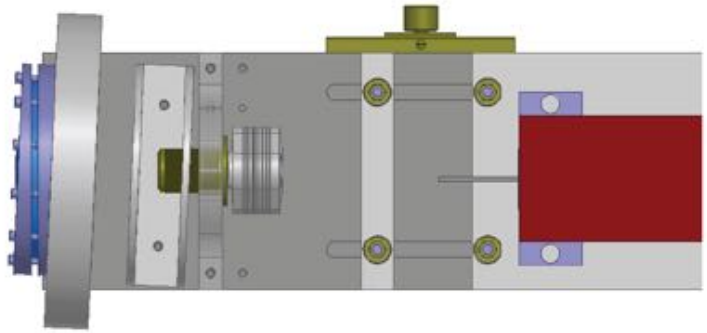


Figure 43 INAF LENS + INAF horn + INAF OMT top view

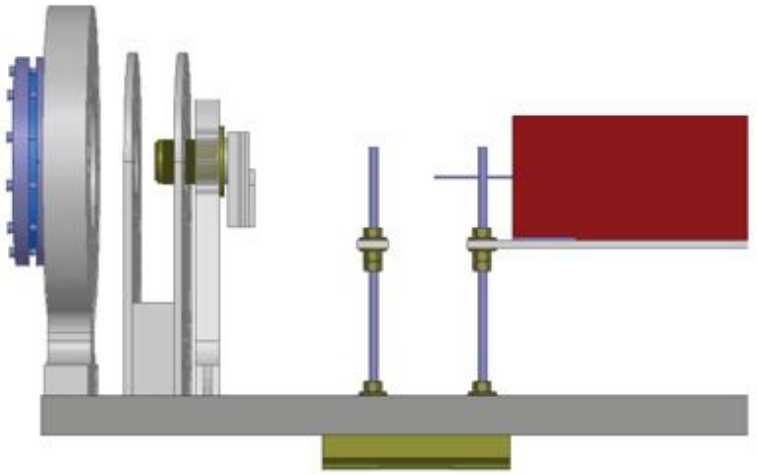


Figure 44 INAF LENS + INAF horn + UdC OMT side view

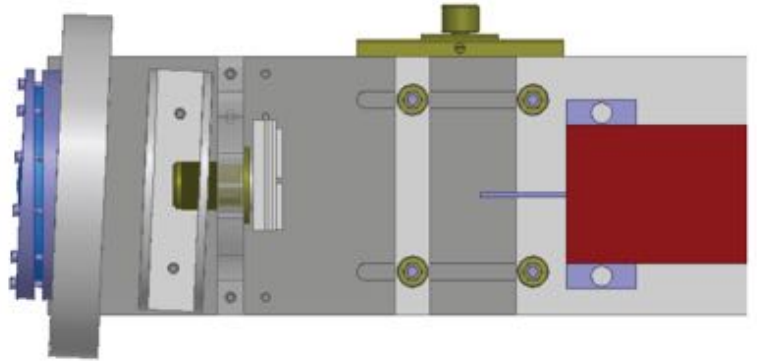


Figure 45 INAF LENS + INAF horn + UdC OMT top view

Configuration 3 and 4

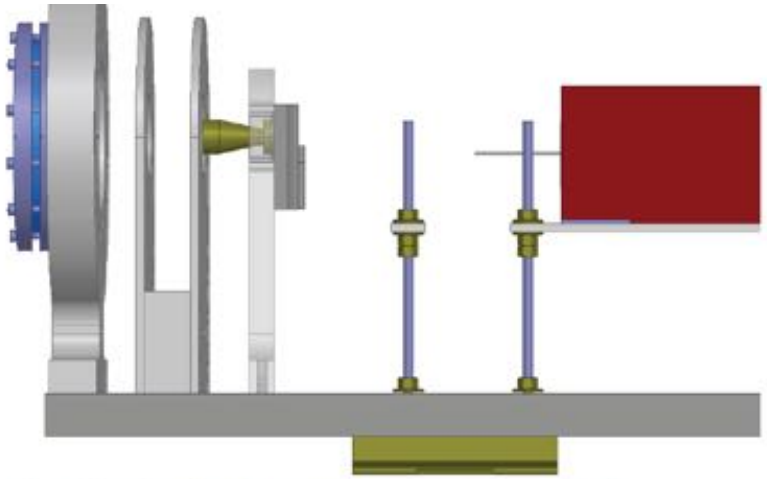


Figure 46 Configuration 3 : UdC Lens + UdC HORN + UdC OMT. Side view

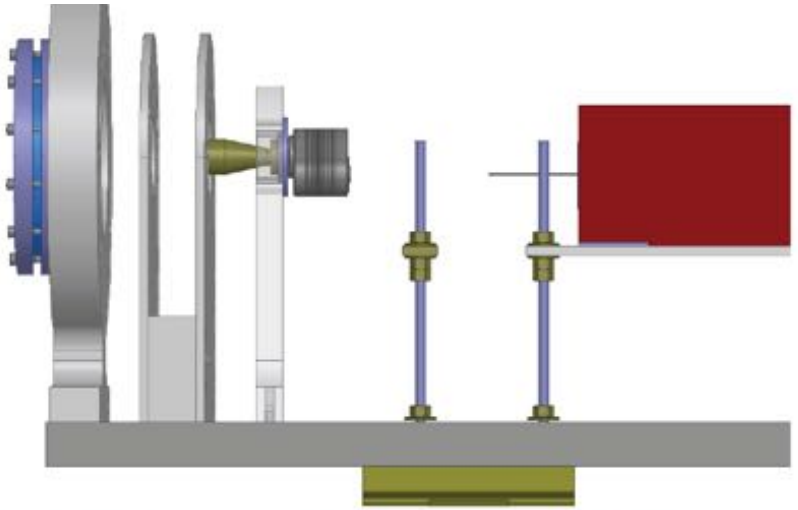
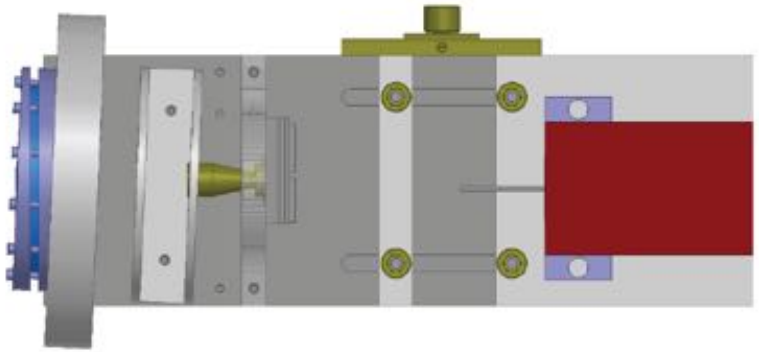
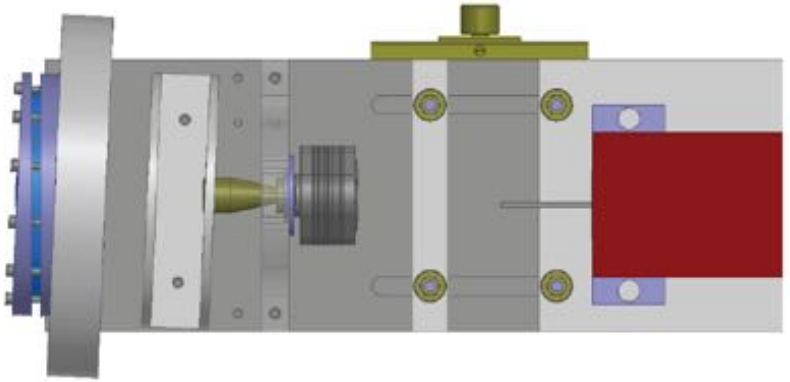
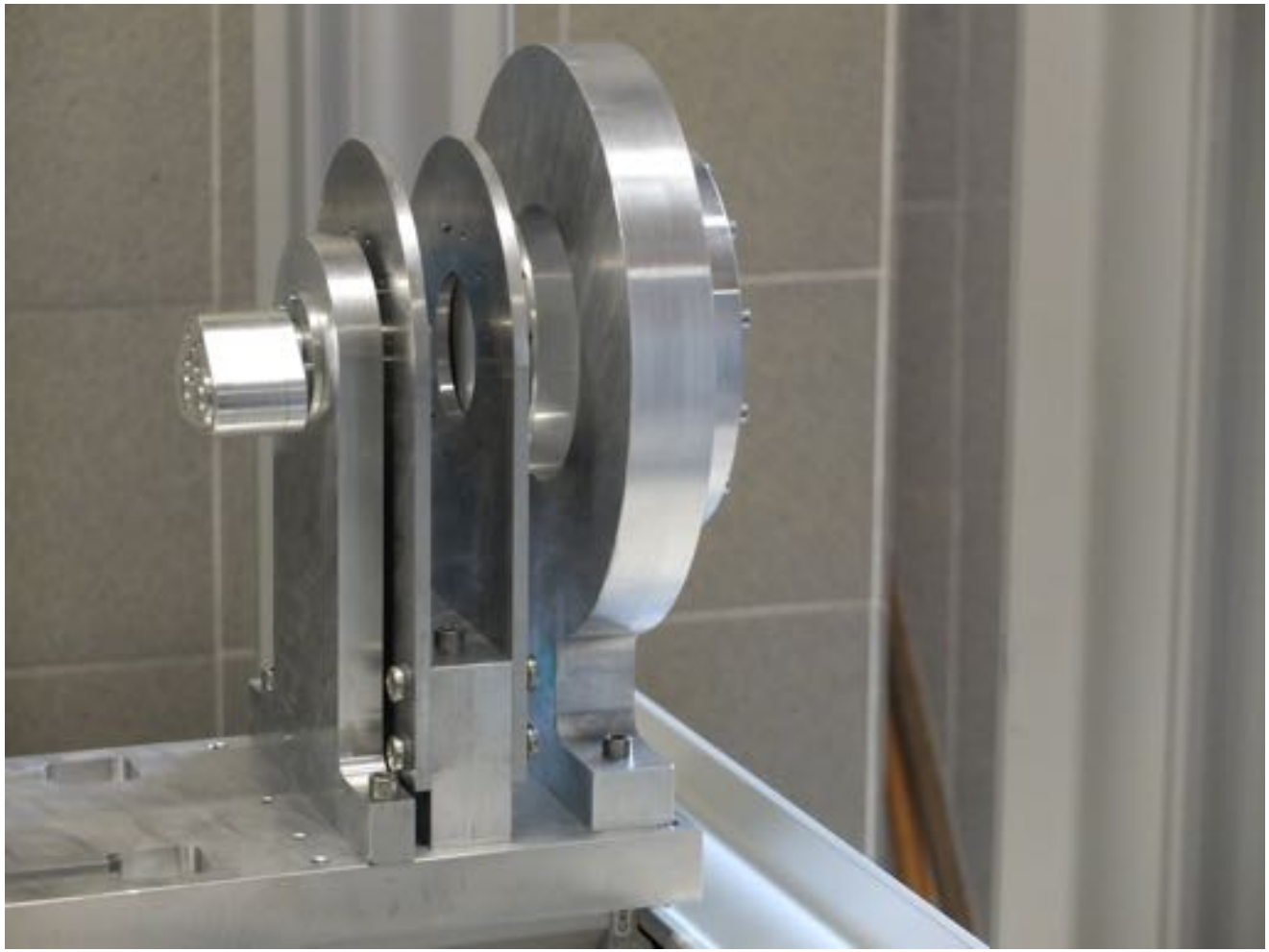


Figure 48 Configuration 4 : UdC Lens + UdC HORN + INAF OMT. Side view

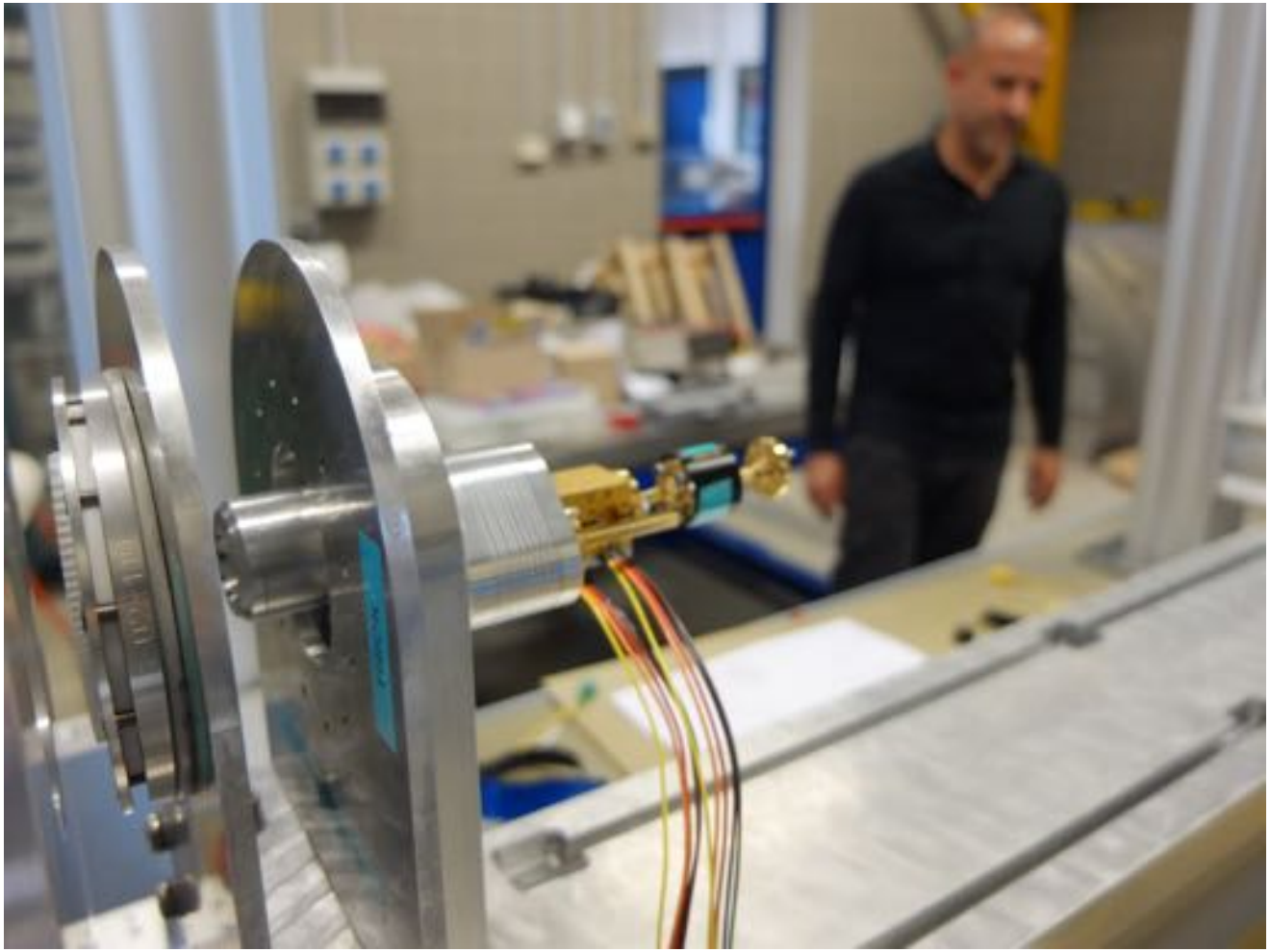




Pre-integration @ IASF

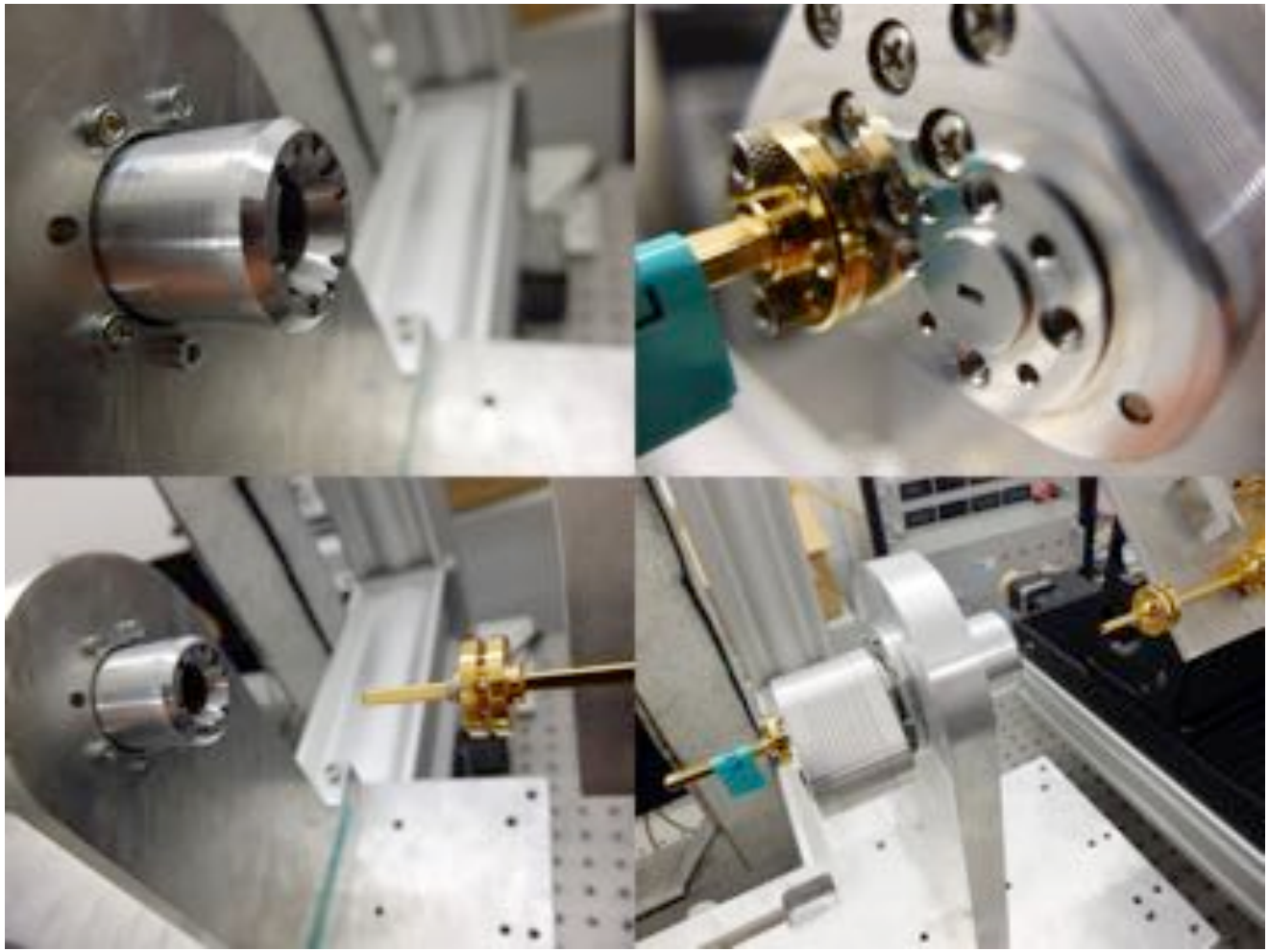


Pre-integration @ IASF

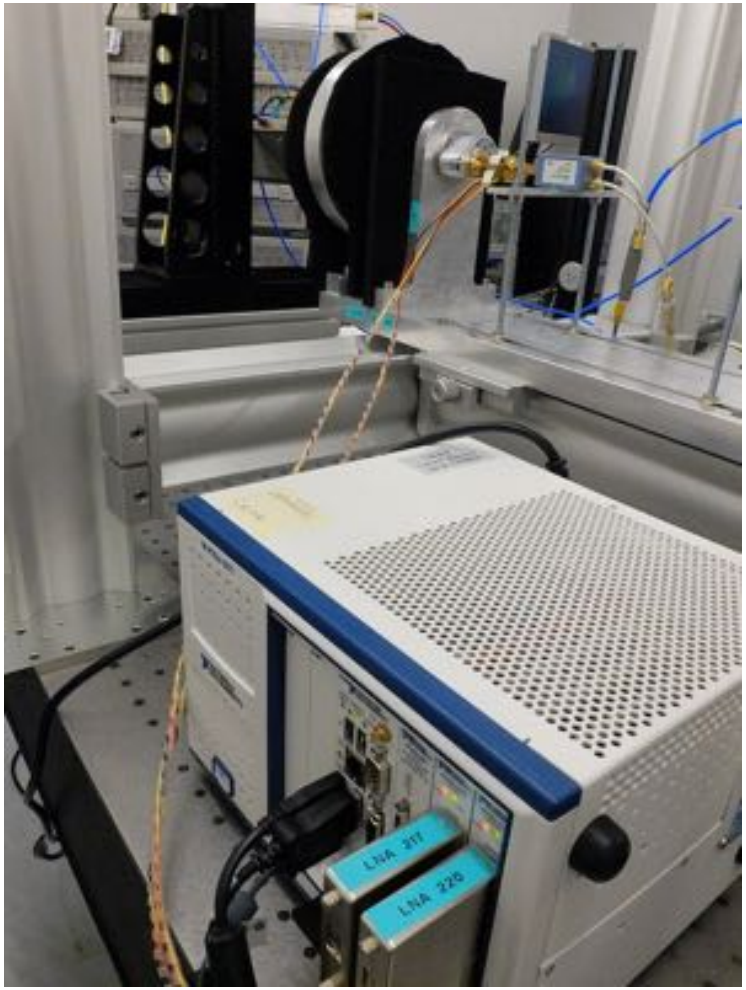


Integration @ ESO

INAF



Integration @ ESO



iALMA

Science and Technology in Italy

For the upgraded ALMA Observatory

- TECHNOLOGY DEVELOPMENT -

Report on the B23 bread-board Prototype Integration @ESO for optical warm tests

Document code: iALMA-TEC-TRP-IAB-002-A

Status: Draft

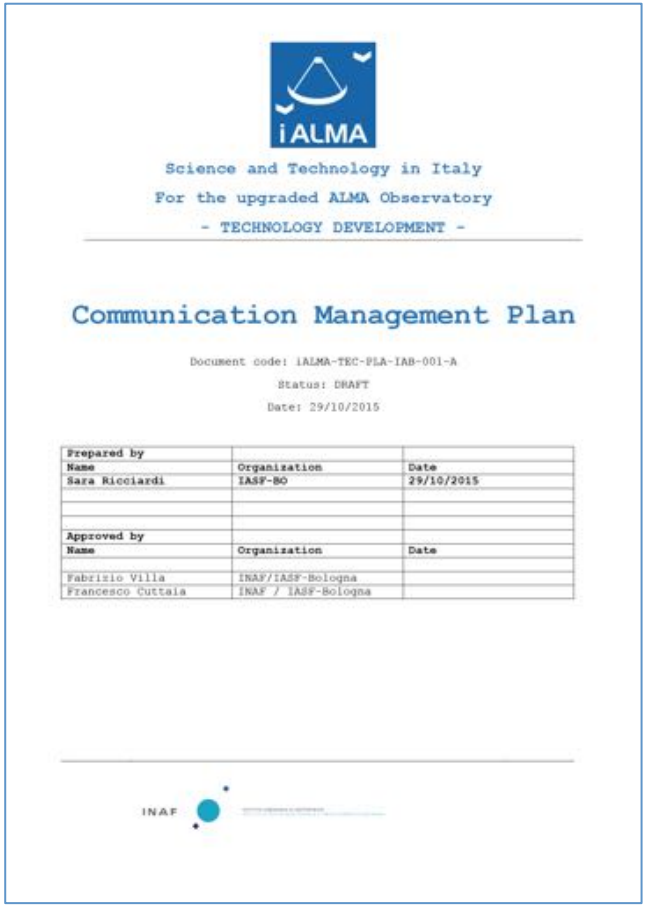
Date: 20/01/2016

Prepared by		
Name	**Organization**	**Date**
Fabrizio Villa	INAF/IASF Bologna	20/01/2016
Francesco Cuttaia	INAF/IASF Bologna	
Pavel Yagoubov	ESO - Garching	
Approved by		
Name	**Organization**	**Date**
Fabrizio Villa	INAF/IASF Bologna	20/01/2016
Francesco Cuttaia	INAF/IASF Bologna	
Pavel Yagoubov	ESO - Garching	

Documents Configuration control

INAF

- 'Lite' configuration control
  - Maintain the original format (apart for INAF docs)
- Trace progresses and changes
  - Configuration also of relevant emails
- Easy access to documentation through dedicated cloud server at IASF
- Use ALMA terminology when possible
- Maintained by S.Ricciardi



iALMA

Science and Technology in Italy

For the upgraded ALMA Observatory

- TECHNOLOGY DEVELOPMENT -

Communication Management Plan

Document code: iALMA-TEC-PLA-IAB-001-A

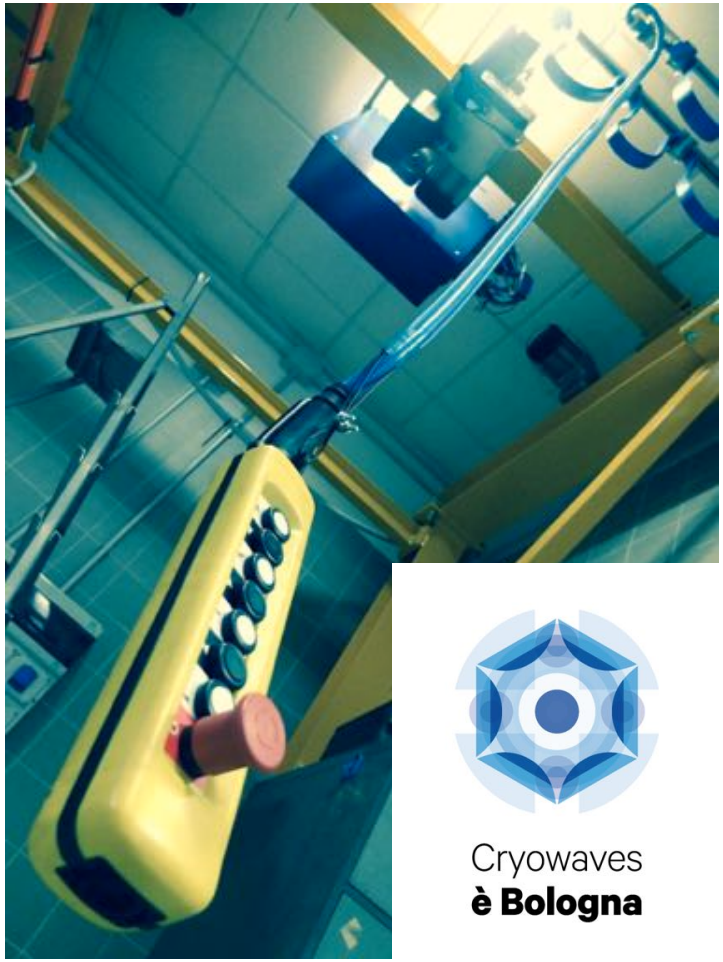
Status: DRAFT

Date: 29/10/2015

Prepared by		
Name	Organization	Date
Sara Ricciardi	IASF-BO	29/10/2015
Approved by		
Name	Organization	Date
Fabrizio Villa	INAF/IASF-Bologna	
Francesco Cuttala	INAF / IASF-Bologna	

INAF

Cryowaves Laboratory



Cryowaves
è Bologna

A laboratory dedicated to integrate, characterize, calibrate complex instrumentation mainly at micro and mm-wavelength

RF instrumentation

The 'Blue Barrel'

A cryofacility to characterise small hardware down to 4K

The 'Big Coffin'

2m x 1m x 1m cryofacility with flexible thermal / electrical interfaces

The Crane

Up to 1000Kg


CRANE
BLUE
BARREL
BIG
COFFIN

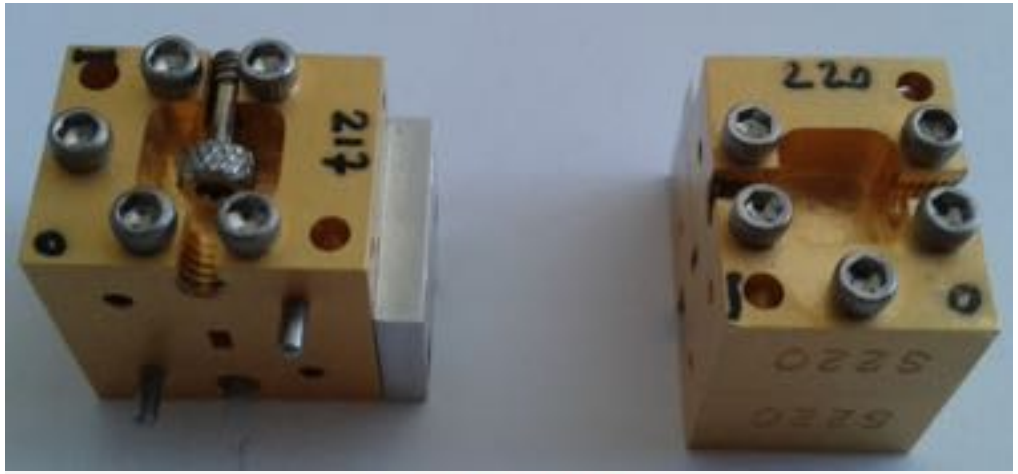

A 2.5967 K
B 35.488 K
C 112.702 K
D 136.895 K
Loop 1 Channel A
Setp 0.0000 K
Heat Disabled
P 1.0
I 0.0
D 0
MOut
+ 50.00%

Status of the Laboratory

- Laboratory already active
- Power and water cooling system for four compressor coolers (2 Sumitomo 4K, 2 Leybold @ 20K) ready next week
- Electrical wiring in progress
- Big Coffin facility dry run in B23 operational conditions expected within mid June.

LNAs – Spare (INAF)

INAF



2 LNAs available at IASF tested at OAA in different Bias and Test conditions with the VNA over the full B23 (67-116 GHz)
To be used as SPARE

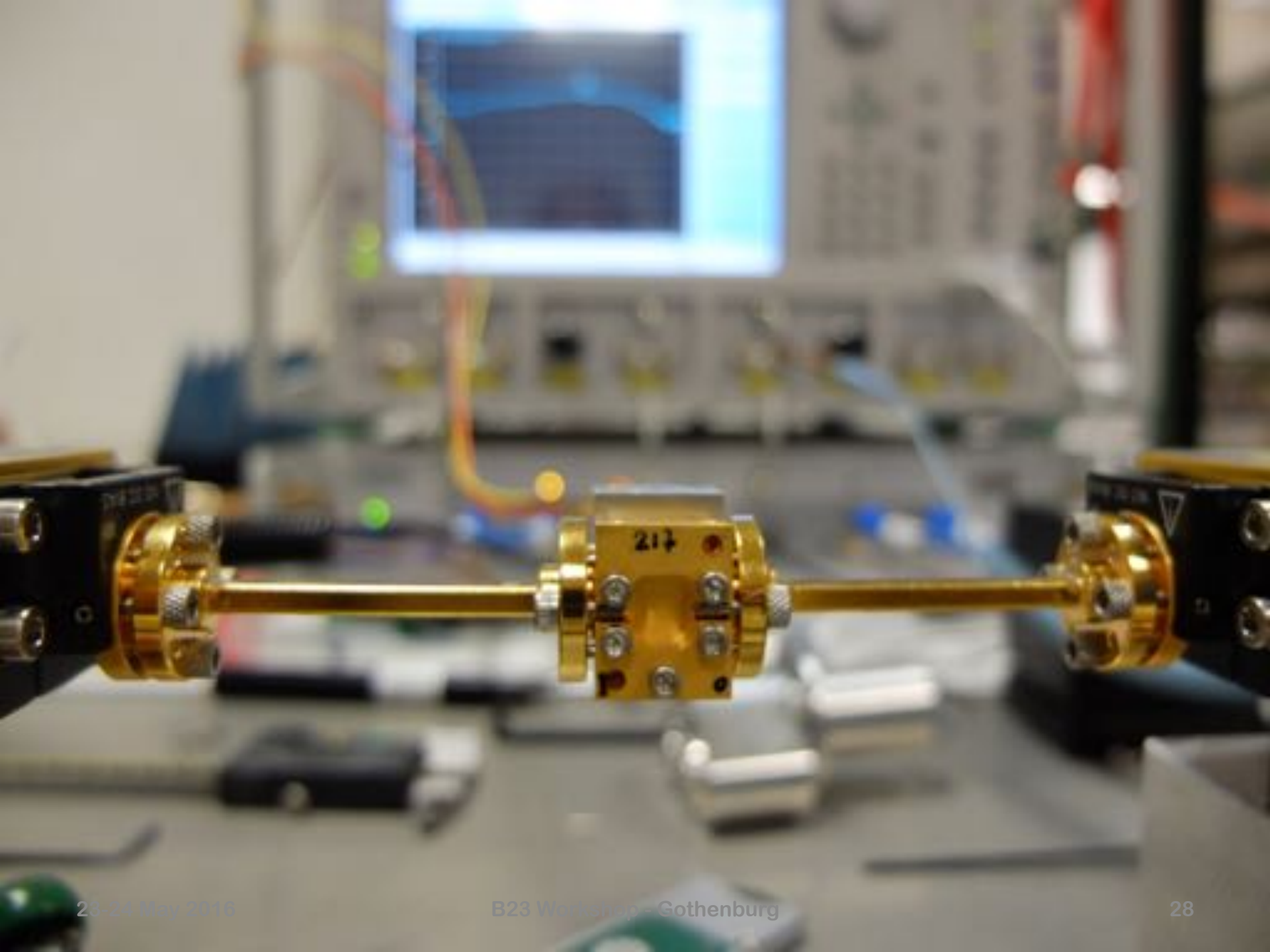
iALMA

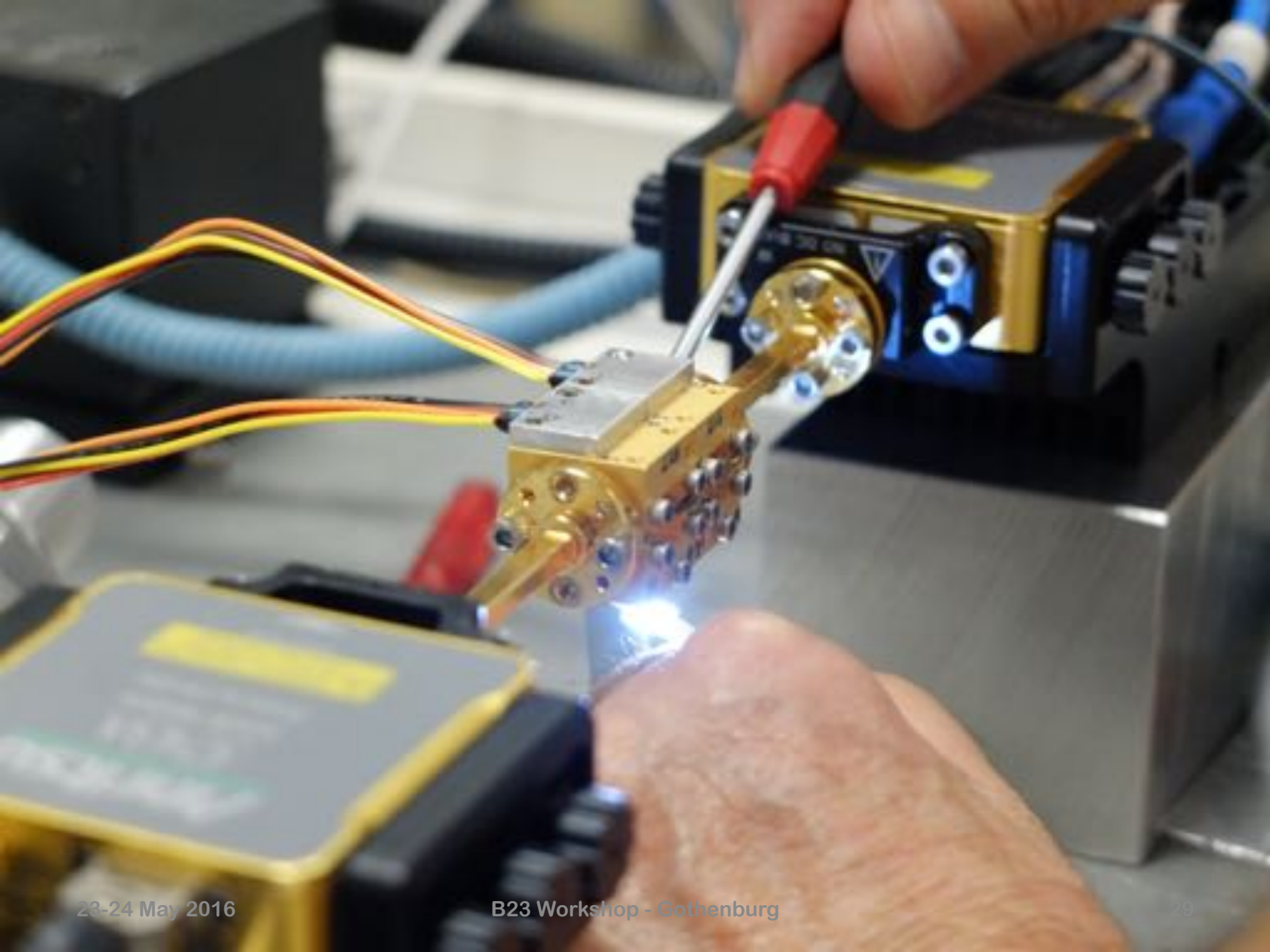
Science and Technology in Italy
For the upgraded ALMA Observatory
– TECHNOLOGY DEVELOPMENT –

INAF/JPL LNAs:
VNA WARM TEST.
As Run Procedure and Results.

Document code: iALMA-TEC-TN-IAS-001-A
Version: A
Status: Issued
Date: 14/01/2016

Prepared by		
Name	Organisation	Date
		14-01-2016
F. Cuttaia	INAF/IASF	
F. Mariotti	INAF/OAA	
E. Mesti	INAF/OAA	
D. Fanella	INAF/OAA	
F. Villa	INAF/IASF	
Approved by		
Name	Organisation	Date
		14-01-2016
Fabrizio Villa	INAF/IASF-Bologna	
Francesco Cuttaia	INAF / IASF-Bologna	


21+



B23 development – Phase B

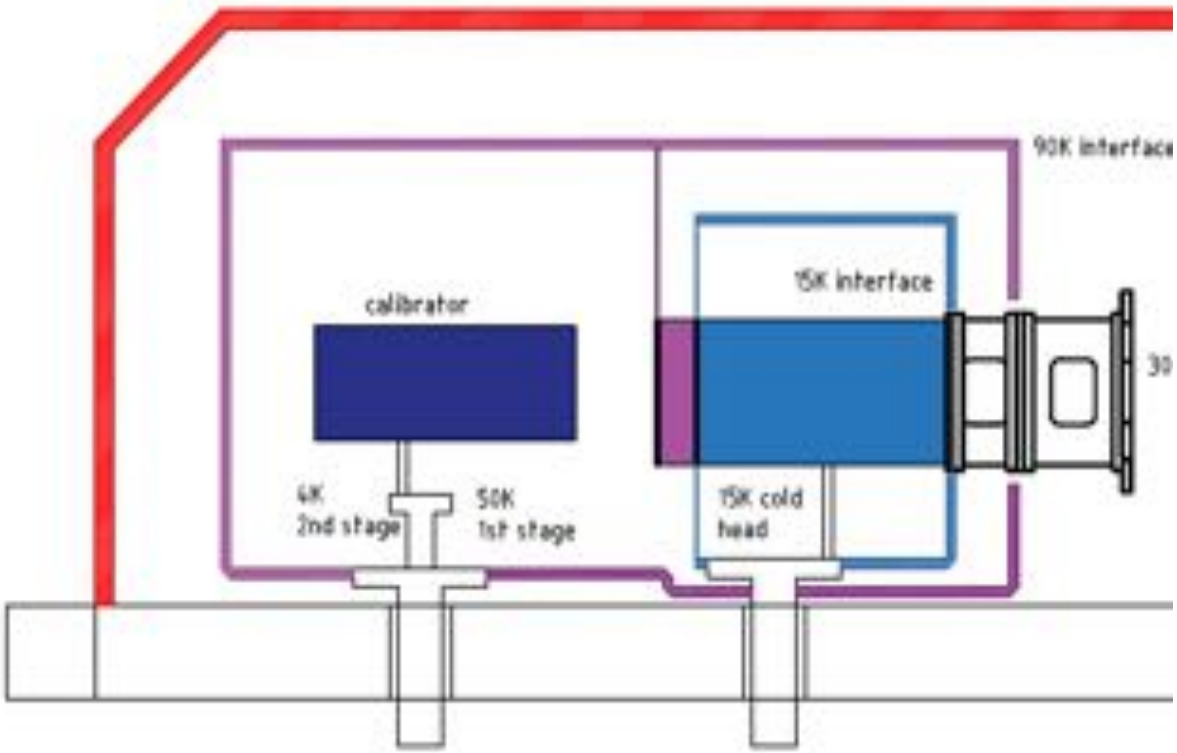
INAF

- Prototype Cartridge Development (CCA)
- Cryogenic setup
- Thermal modelling and validation
- Verification tests at unit level @ cryo
- Support to SE and AIV
- Document configuration control
- System tests @ cryo T

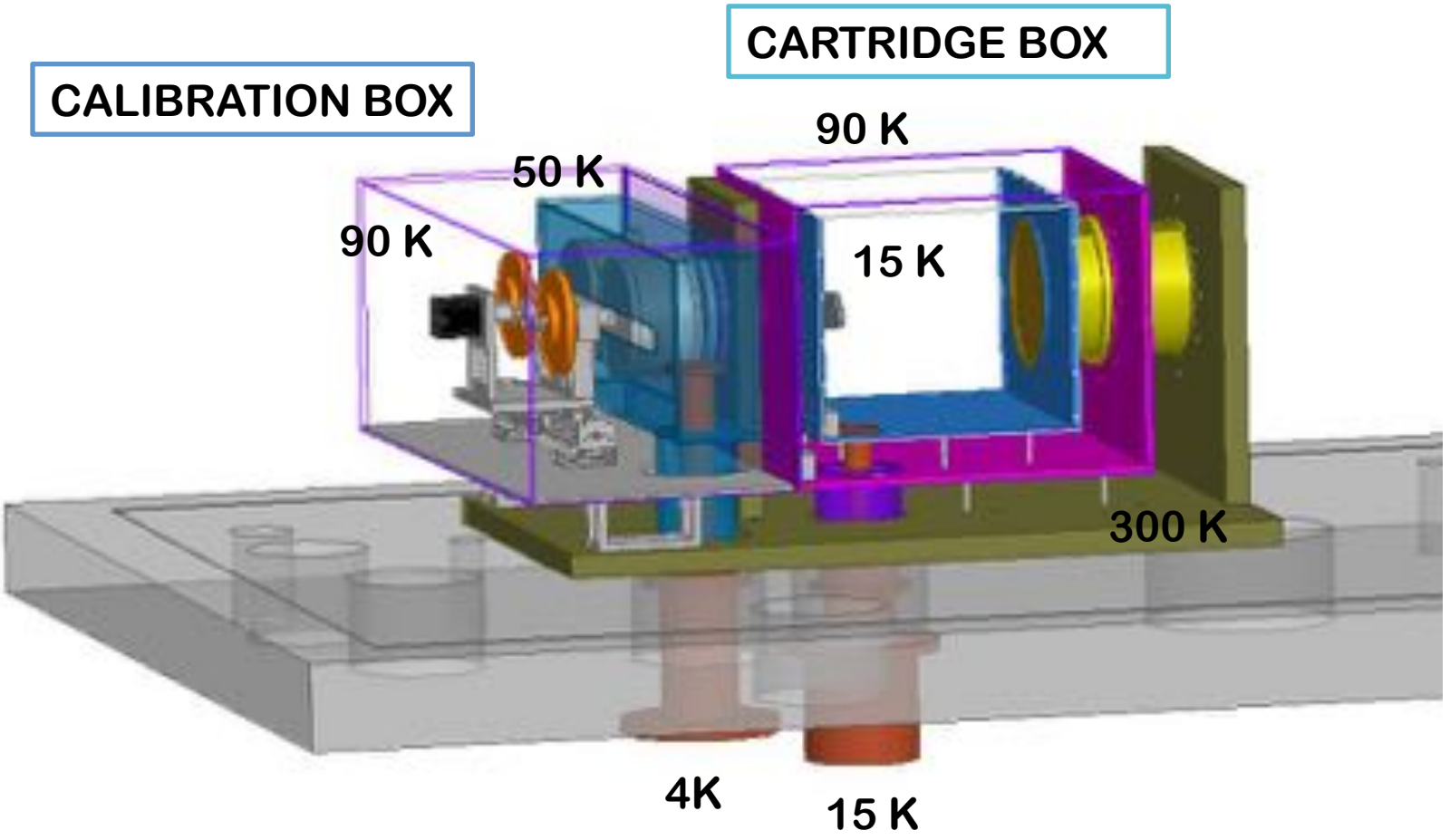
Cryogenic Setup

- To permit the calibration (basically noise perf.) of the CCA prototype @ operational condition
- Possibility to measure the noise and response by controlling the interfaces and operating the calibrator in a wide temperature range (down to ~4K)
  - Deep investigation of the prototype properties beyond requirements verification
  - Reusable for future cartridge development.
- Design, Manufacturing and validation at INAF
- Investigation of the possibility to build a ALMA like cryostat
  - in progress

Thermal scheme



Cryo setup with calibrator



Cryo Setup status

- Design almost completed
- Manufacturing starting soon
  - Beginning of June
- Critical aspects
  - WCA positioning outside chamber
  - WG routing from CCA to TVAC flange
    - not a major problem (design and characterizations)
    - Attenuation to be accounted
    - Technical solution: COTS or Custom components, flexible waveguide, plastic coated waveguides
- Goal: to be ready for Summer

Polarized Calibrator

Provides BB source for noise performance tests
Design & Modelling (RF, Thermal , Mechanical)
Manufacturing
Verification (RL & Effective RJ Temperature)
Two VVT Calibrators Design
Large Dynamic Range PID controlled:

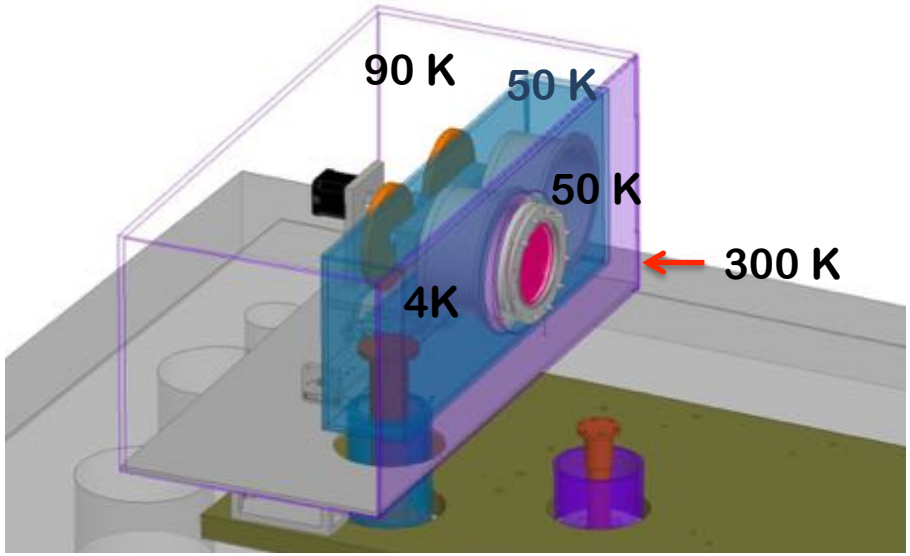
- COLD: 4 K >> 300K
- HOT: 50 K >> 300 K

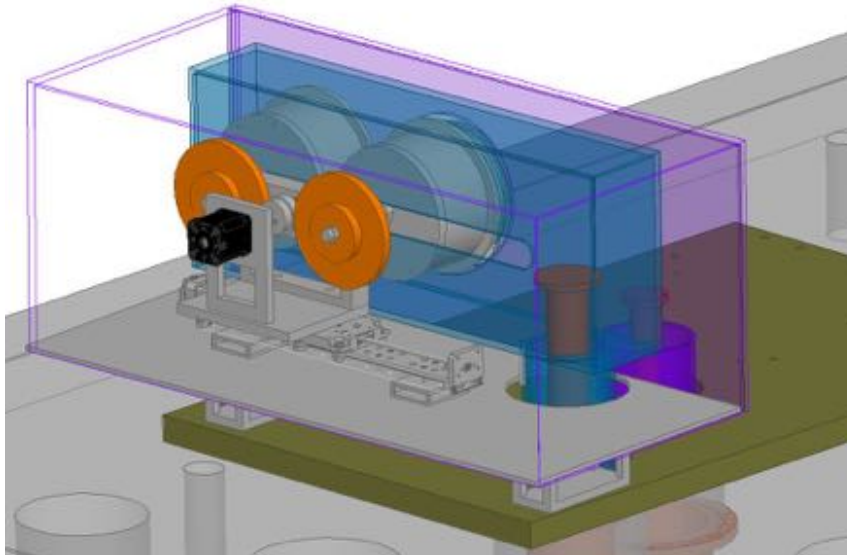
ε > 0.9999
Pol. Level set by design:
from few % to ~ 100 %
Negligible Spillover
Acceptable 1/f

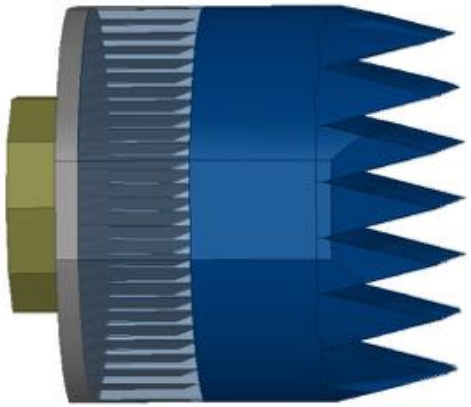
- T Period : ~ 10 s
- Pol. Period: ~ 5 s

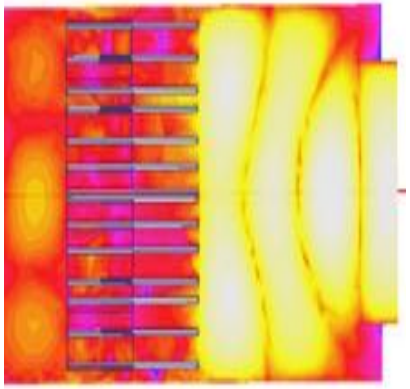
Polarized Calibrator (2)

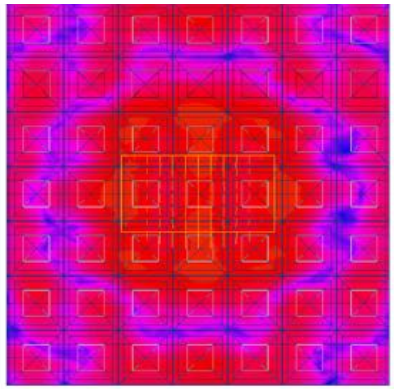
INAF











System Level tests @ Cryo

- On CCA @ INAF (test plan in preparation)
  - Noise temperature
  - Gain and Gain Compression
  - Power density
  - Spurious response
  - Signal (amplitude) stability
  - Polarization alignment check
  - Image Band suppression (TBC)

  - Susceptibility to feed/LNAs temperature
  - Susceptibility to filters temperature (added noise)
  - Attempt to measure feed + OMT loss through system noise excess measurement

V&V @ Unit Level

INAF

- Lens deformation at vacuum
  - Measurements of the profile changes if any (dedicated facility under definition)
- Platelet horn + OMT
  - Thermal Vacuum test down to 4K (15K nominal)
    - Torque and deformation
    - Thermal conductivity
- LNAs S-parameters and noise temperature
- RF tests on passive components at cryoT
  - under investigation

Unit verification tests status

- Blue Barrel cryofacility ready
  - Operating since end of February
  - cooler maintenance on May 27th
- Test setup under development
- Starting of thermal / vacuum test activity on June 6th