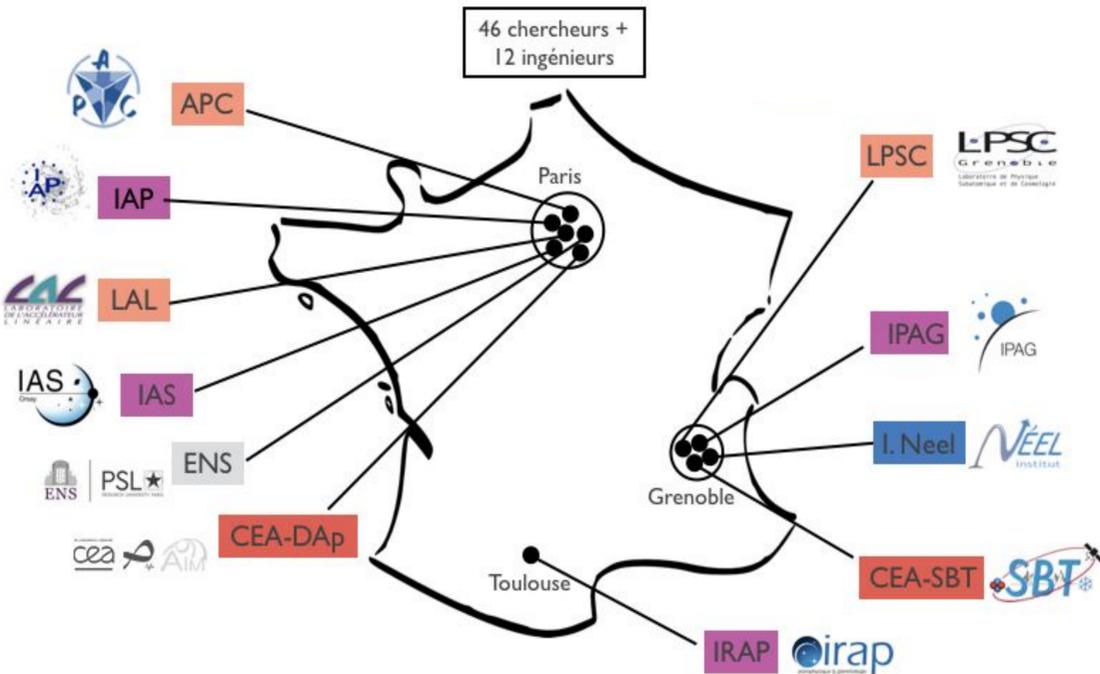


# FRANCE



## under study: CNES lead on MHFT

The French collaboration is strongly connected to the French space agency CNES, which is studying the opportunity to take the lead of the MHFT instrument.

This would imply CNES leadership and a strong contribution from the French laboratories in the integrations, calibrations and in-flight operations.

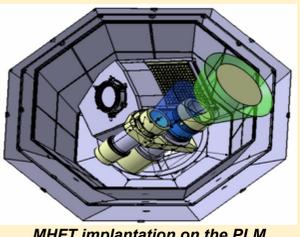
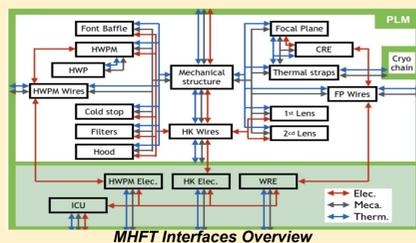
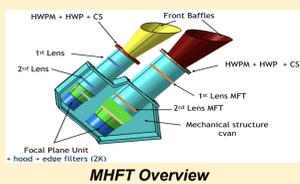
These activities would be associated to a ground segment center to perform MHFT in-flight operations and first levels data control.

## CNES Phase A activities

### System Responsibility

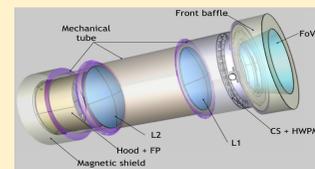
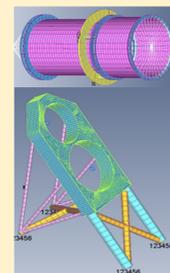
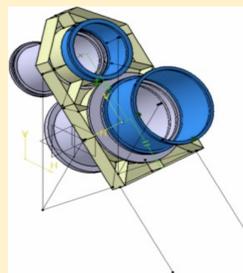
Since the beginning of 2018 the French collaboration has been deeply involved in the system design of the MHFT, through the responsibility of European System Engineer:

- System Design
- Mechanical & Thermal Architecture
- Electrical Architecture
- Cryo-chain Optimisation
- Schedule harmonization



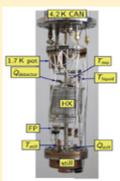
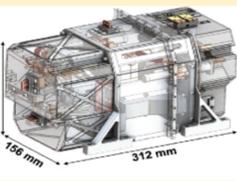
### Mechanical Structure

France is in charge of the design of mechanical structure and of the thermo-mechanical studies for MHFT. That includes all the interfaces with the various sub-systems and with the PLM:



Sub-system	MFT	HFT
Entry baffle	3 kg	3 kg
Holder + internal	30.8 kg	7.8 kg
1st lens + mount	2.5 kg	1.5 kg
2nd lens + mount	4.2 kg	1.8 kg
Cold stop	2.3 kg	1.5 kg
FP	1.3 kg	2.4 kg
Hood	1 kg	1 kg
Support 2000 + Electronics	2 kg	
Thermal control	1 kg	
Structure miscellaneous	48 kg	
Total WFO margins	99.3 kg	

### Cryo-chain & Sub-K

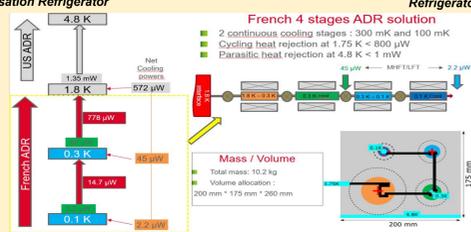


#### Trade-Off

- Available cooling power @ 2K
- Duty Cycle
- Mass
- Stability at 100mK
- Magnetic field

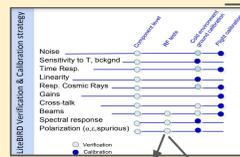
#### Conclusions

- Baseline: CADR
- Backup: ADR Hybrid Cooler
- Alternative: CCDR

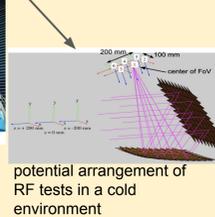
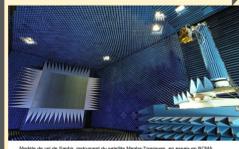


### AIT / AIV & Calibrations

France is responsible for the cold "flight-like" calibrations of MHFT and co-coordinates the RF tests. Some examples of our activities are shown below.



The cold facility is being investigated



#### Toward an Instrument Model for LiteBIRD



## Data Analysis Expertise

We have built in France a strong expertise in CMB science from instrumentation to cosmological parameters inference from our leading role in Planck-HFI and ground based experiments (Polarbear, SO). This covers the forecast and systematics studies, the end-to-end simulation effort, the map-making and the scientific analyses.

#### Systematics

- Instrument model (e.g. 4K-lines from coolers, thermal behavior)
- Cosmic ray impacts
- Time transfer function
- Beam convolution, beam leakage
- ADC non-linearity model coupled to electronics
- Cross-talk in kpixel arrays
- Gain variations
- Time-domain noise characterisation including correlations
- Bandpass effects
- Gain leakage T-P
- Optical simulations
- HWP imperfections (rotation synchronous effect, frequency dependency...)

#### MapMaking and calibration

- Calibration (orbital dipole, planets)
- Destriping-like technics including calibration + systematic templates (Planck-HFI mapmaker)
- GLS map-maker including noise correlation (SANEPIC)
- experience in mapmaking pipelines (map production, data splits, associated products, ...)
- map characterisation (noise estimation, jackknives checks, covariance matrices)
- wiener-filtering techniques, pure E-B projections
- bandpass optimisation

#### Foregrounds

- component separation methods (FGBuster in common with SISSA)
- internal CMB cleaning (template removal, ILC-like techniques)
- forecasting (XForecast)
- Galactic models (dust, synchrotron)
- Zodiacal light
- CIB
- SZ (thermal and kinetic)
- molecular lines (CO)

#### Lensing

- tools for delensing and lensing simulations

#### Power spectrum estimation

- Harmonic space: *PaSpice*, *Xpol*, *Xpure*
- pixel-domain: *xQML*, *MLE*

#### Cosmological parameters estimation

- small scales Likelihood : *Plik*, *Hillipop*
- large scales Likelihood : *Lollipop*
- sampling & minimization : *CAMEL*
- Likelihood-free techniques : *DELFI*

#### Non-gaussianity

- primordial fnl
- isotropy & statistics

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