

# DOMEc UPDATE (2015)

Gil Moretto  
CRAL/CNRS, Lyon, France

On behalf of French / Nice DomeC Community

Lyu Abe, Karim Agabi, Eric Aristidi, Marcel Carbillot, Merieme Chadid, Eric Fossat,  
Tristan Guillot and Jean Vernin and Aziz Ziad

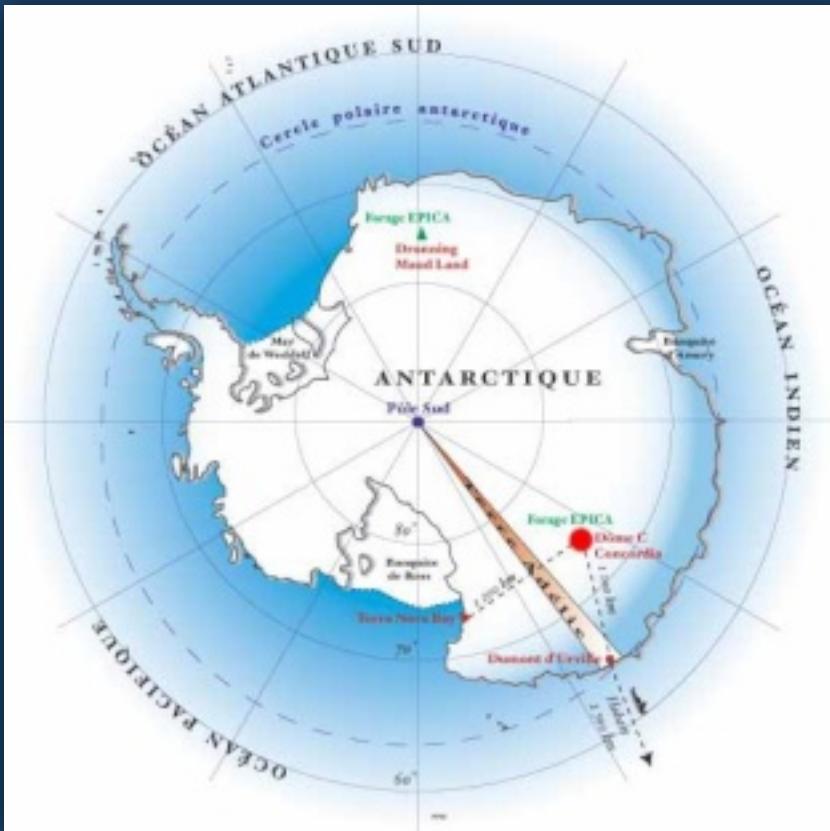
Astronomy and Astrophysics from Antarctica  
Third Workshop of the SCAR AAA

7-10 August 2015, Kilauea Military Camp, Hawaii, USA



# Dome C

## French-Italian Concordia Station



### Logistics IPEV/PNRA



Gil Moretto - SCAR/AAA - 2015



# Dome C

## Concordia Station

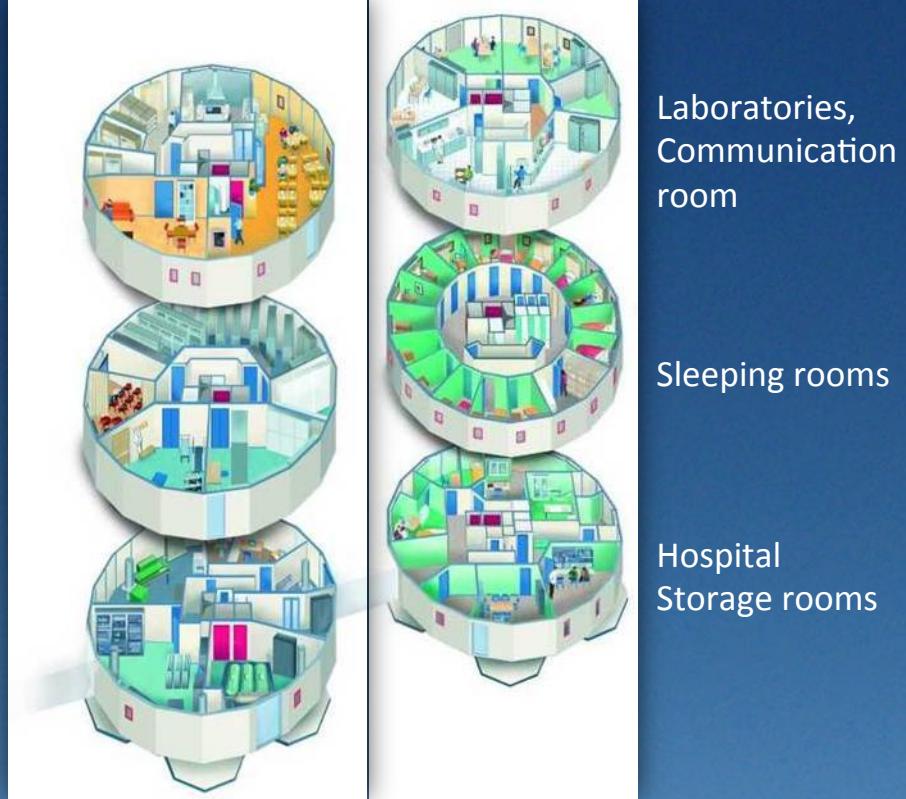
### Hosting capability

Summer: 80  
(incl. « summer camp »)  
Winter: 16

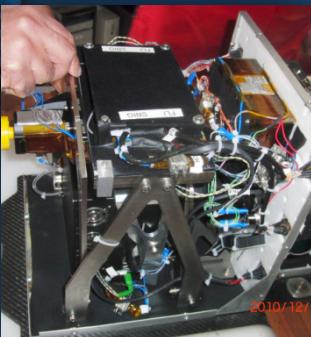
Kitchen, Restaurant  
and Library

Storage, Training,  
Video Rooms

Technical Rooms



# DomeC Astronomical Activities



## Site characterization

Balloons	2005	(Nice)
DIMMs/GSM	2001-2013	(Nice)
SCIDAR	2006, 2012	(Nice)
PBL	2012-2013	(Nice)
SONICs	2000-2014+	(Grenoble/Nice)

## Optical Photometry/Spectroscopy

PAIX	2007-2015	(Nice)
ASTEP	2008-2013+	(Nice)
LUCAS	2008-2009	(OHP/Nice)

## Solar Astronomy

(ESCAPE) Study Phase (Paris/Nice)

## IR photometry

IRAIT/AMICA 2014 (Peruggia/Paris)

## Millimetric/Sub-mm astronomy/CMB

COCHISE (Roma)  
IRAIT/CAMISTIC 2014 (Paris)  
QUBIC/BRAIN Pathfinder (Paris/Roma)

# Site Testing at Dome C

## AstroConcordia Program

Eric Aristidi, Tristan Guillot, Aziz Ziad, Kariam Agabi, Eric Fossat, ...  
CNRS/ Université de Nice Sophia Antipolis, Nice, France

### Site-testing AstroConcordia Campaign :

- ◆ 15 Summer Missions (2000 – 2014);
- ◆ 9 Winterovers (2000 & 2014).

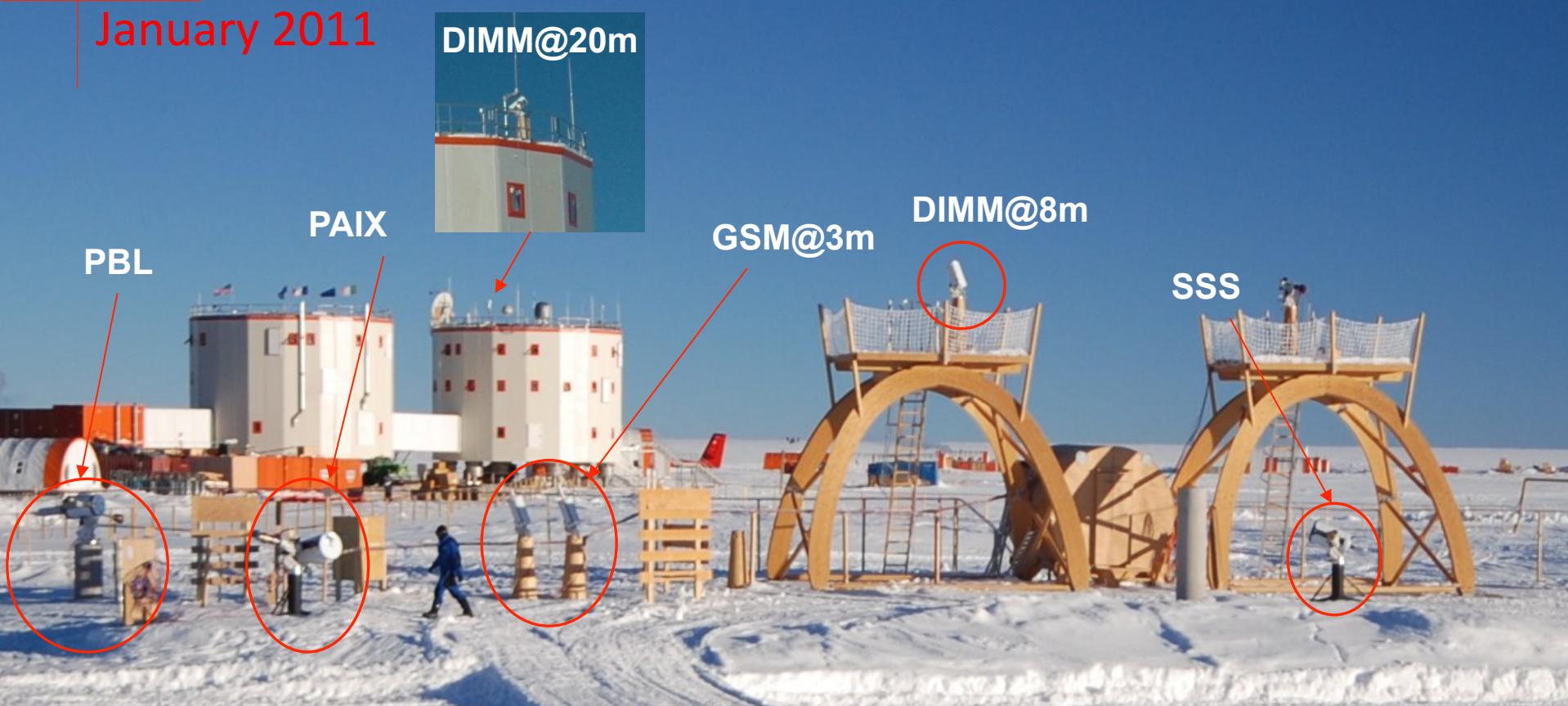
### Atmospheric Parameters Measurements:

- ◆ the optical turbulence (seeing  $\varepsilon_0$ );
- ◆ the refractive index structure constant  $C_n^{-2}(h)$ ;
- ◆ the isoplanatic angle  $\theta_o$ ;
- ◆ the coherence time  $\tau_0$ ;
- ◆ and the outer scale  $L_0$ .



# DomeC Site-Testing Instruments

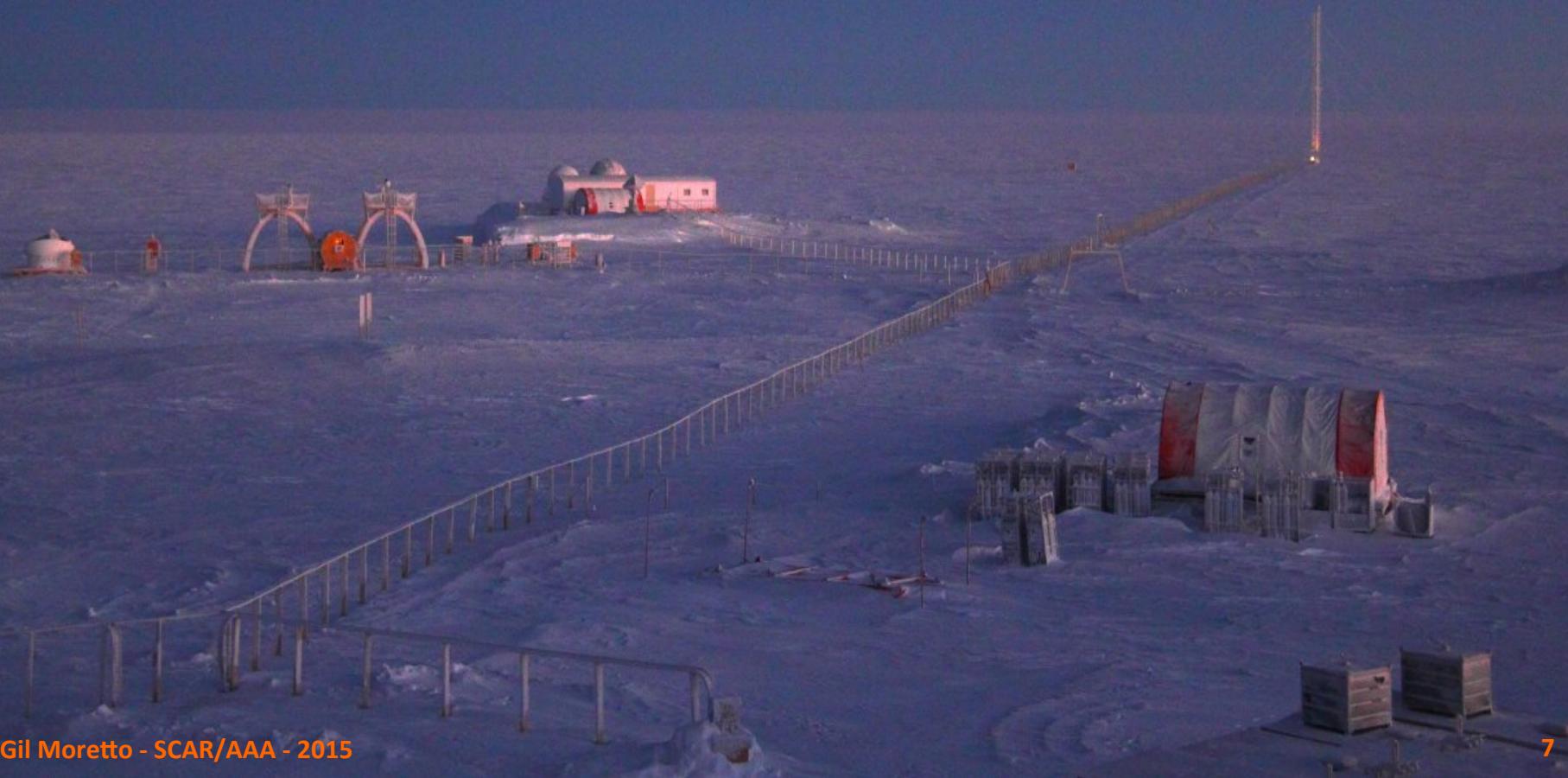
January 2011



- ◆ DIMM: Differential Image Motion Monitor;
- ◆ GSM: Generalized Seeing Monitor = 2DIMM;
- ◆ SSS: Single Star Scidar;
- ◆ PAIX: Photometer for optical atmospheric extinction measurements;
- ◆ PBL: Profileur Bord Lunaire, an outer scale profiler and
- ◆ 35 Balloon Flights (winter 2005) for temporal and vertical variation in  $C_n^2(h)$ .

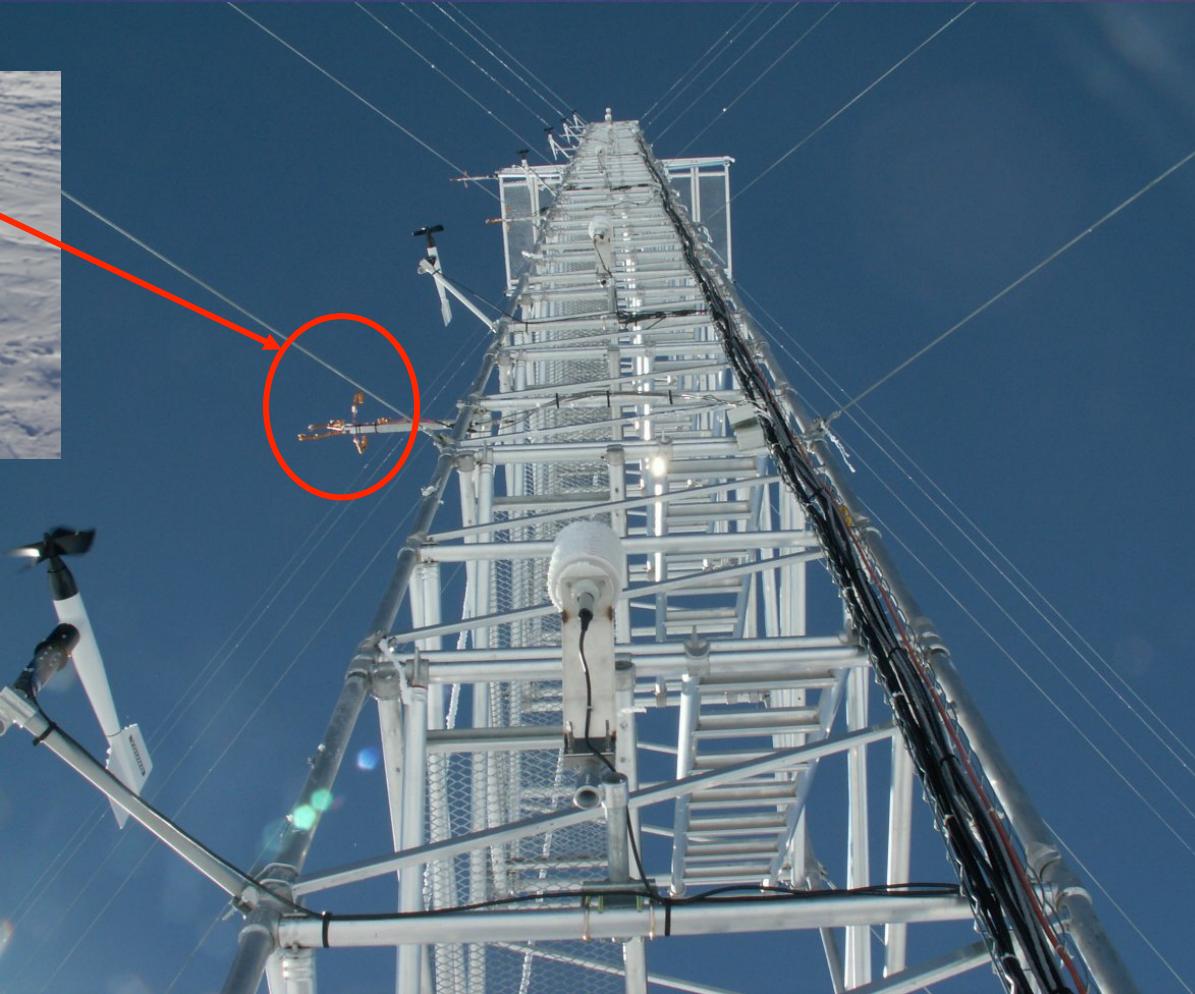
# DomeC Site-Testing Instruments

US Tower (@45m)



# DomeC Site-Testing Instruments

US Tower (@45m)



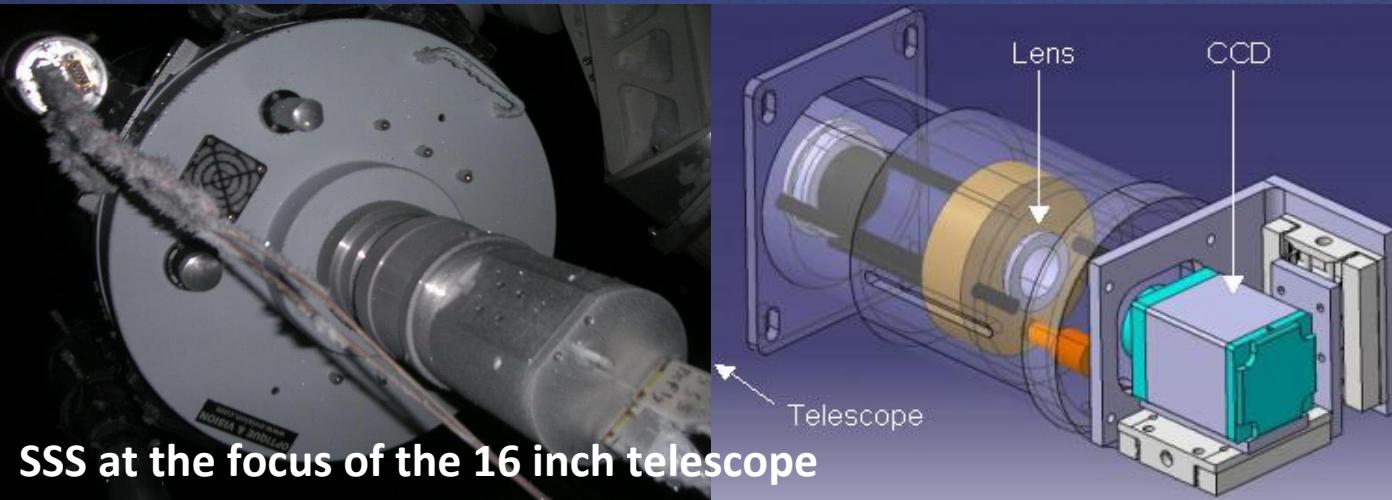
- ◆ SONIC ANEMOMETERS: Measurement of Microthermals (2007).

# Instrument Development

## SSS: Single Star Scidar

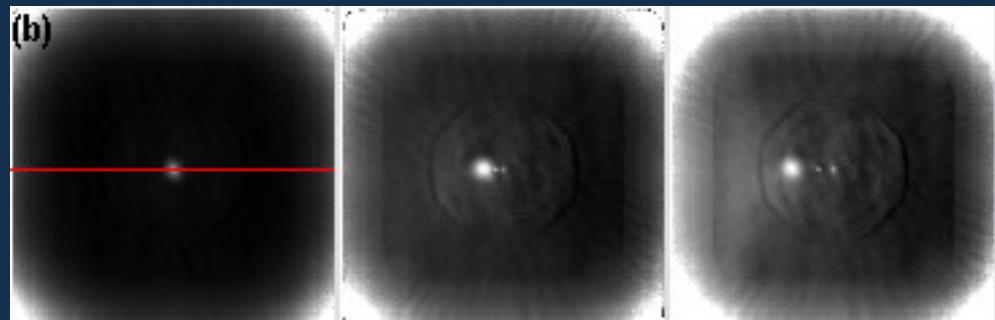
A turbulence profiler to replace the balloons.

In operation: 2006 and 2011



SSS at the focus of the 16 inch telescope

Star Canopus at the SSS focal plane. The structure and the evolution of the flying shadows on the pupil give access to the turbulence profile

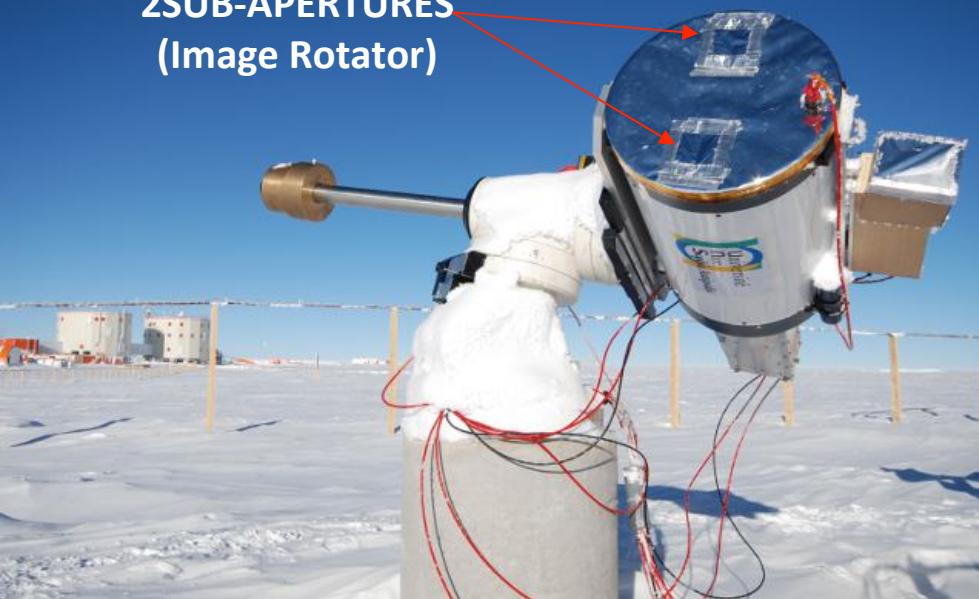


Cross-correlations between temporally spaced images computed in real time for increasing temporal lags (multiples of 7ms)

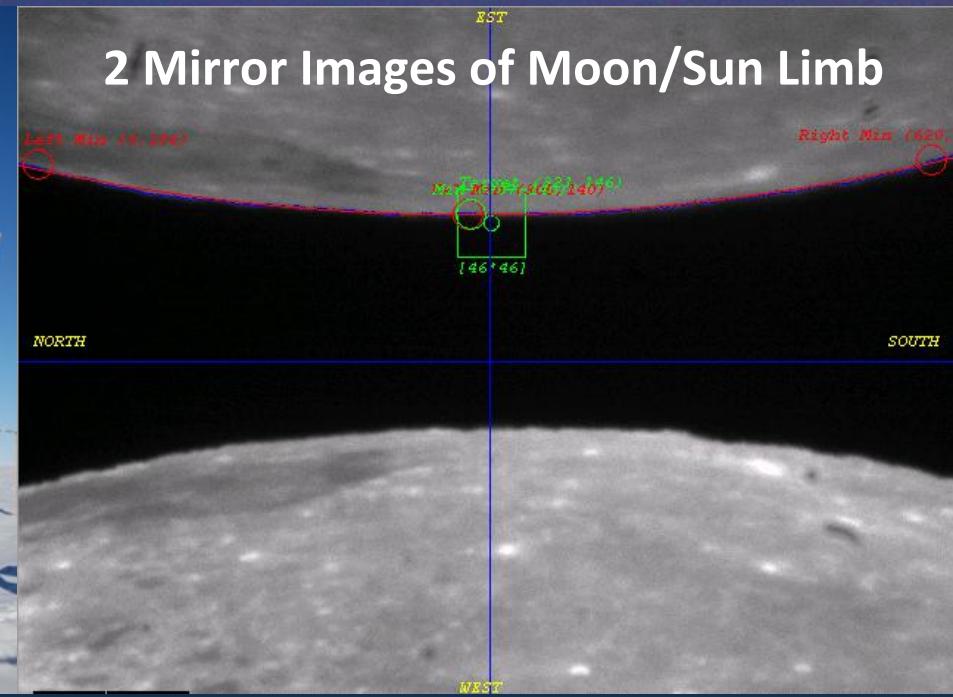
# Instrument Development

## PBL : Lunar/Solar Limb Profiler

2SUB-APERTURES  
(Image Rotator)



2 Mirror Images of Moon/Sun Limb



### Principle

- ◆ Extraction of the limbs;
- ◆ Cross-correlations of the motions of 2 points of the same limb;
- ◆ Cross-correlations of the motions of the same point in the two images (idem DIMM).

**Aim: to obtain  $C_n^2$  and  $L_0$  profiles (with ~100m vertical resolution) and the integrated parameters.**

# Instrument Development

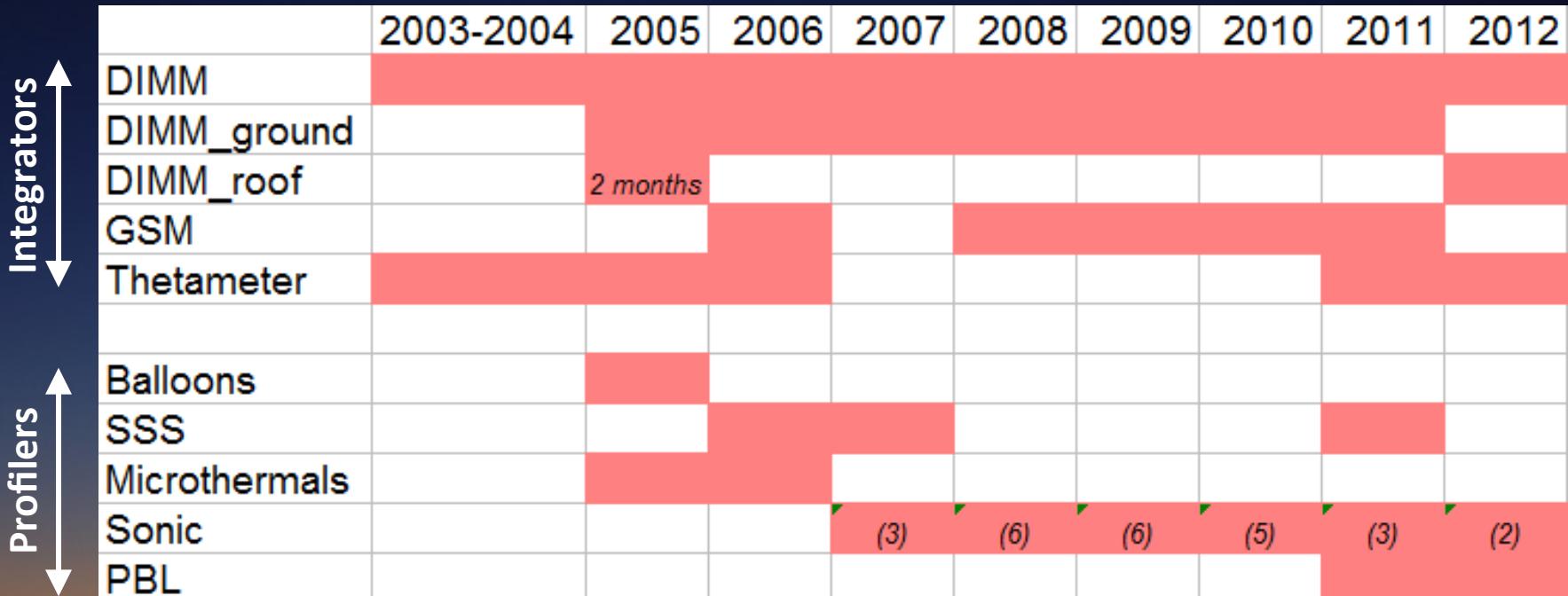
PBL: Winter Operation Maintenance (26/05/2011) T=-50°C!!!



A PRICELESS EXPERIENCE!

# On-site Experiments

(2003 - 2012)



- ◆ **DIMM** : Seeing ;
- ◆ **Thetameter** : Isoplanatic angle ;
- ◆ **GSM** : Seeing + Outer scale
- ◆ **Balloons** :  $Cn^2$  / Wind speed profile (vertical res. 5m) whole atm.
- ◆ **SSS** :  $Cn^2$  / Wind speed profile (vert. res. 1km) whole atm.
- ◆ **PBL** :  $Cn^2$ /Wind speed/Outer scale profile (vert. res. 100m) whole atm.
- ◆ **SONIC** : local  $Cn^2$ /wind speed (6 Sonics between 8 and 45m)

+ integrated params  
Seeing, isop. angle,  
coh. time

# Winter Integrated Parameters

Turbulent Boundary Layer = 23m

Above 23m Seeing ~ 0."36



	<b>Seeing</b>	<b>Isop.</b>	<b>Coh. time</b>
<b>DIMM/GSM</b>	<b>0.4 "</b>	<b>4.1 "</b>	
<b>SSS</b>	<b>0.3 "</b>	<b>6.9 "</b>	<b>10.2 ms</b>
<b>Balloons</b>	<b>0.4 "</b>	<b>2.7 "</b>	<b>6.8 ms</b>
<b>AASTINO 2004<sup>1</sup></b>	<b>0.3 "</b>	<b>5.7 "</b>	<b>7.9 ms</b>
<b>Simulations<sup>2</sup></b>	<b>0.3 ''</b>		
<b>Mauna Kea</b>	<b>0.6 "</b>	<b>1.9 "</b>	<b>2.7 ms</b>
<b>Paranal</b>	<b>0.8 "</b>	<b>2.6 "</b>	<b>3.3 ms</b>

<sup>1</sup>Lawrence et al 2004

<sup>2</sup>Lascaux et al 2011

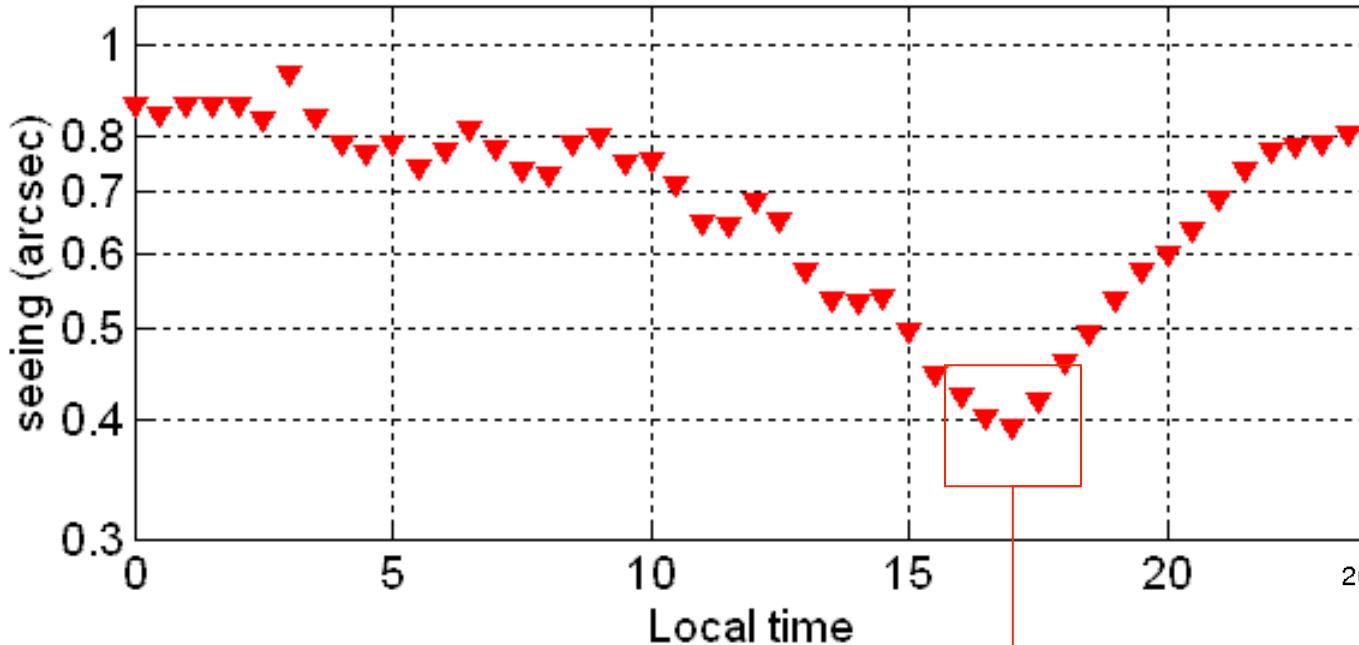
} @Ground

# Summer Integrated Parameters

DIMM@8m Seeing (Dec. – Jan.)



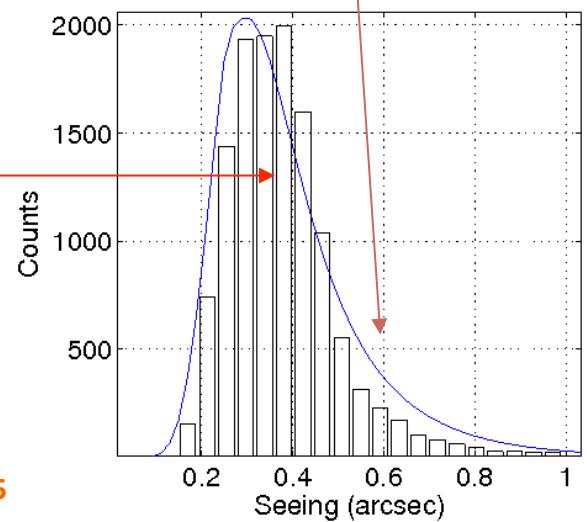
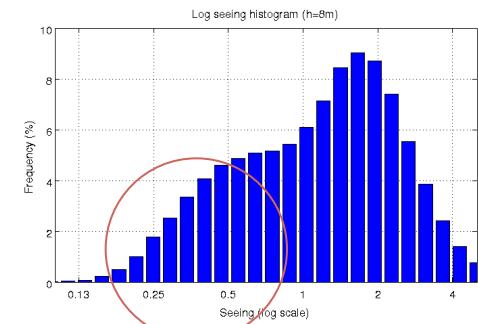
Hourly averaged



Summer  
Seeing =  $0''.40$   
[0.3 – 0.5]

Seeing  
Histogram  
(4pm–6 pm)

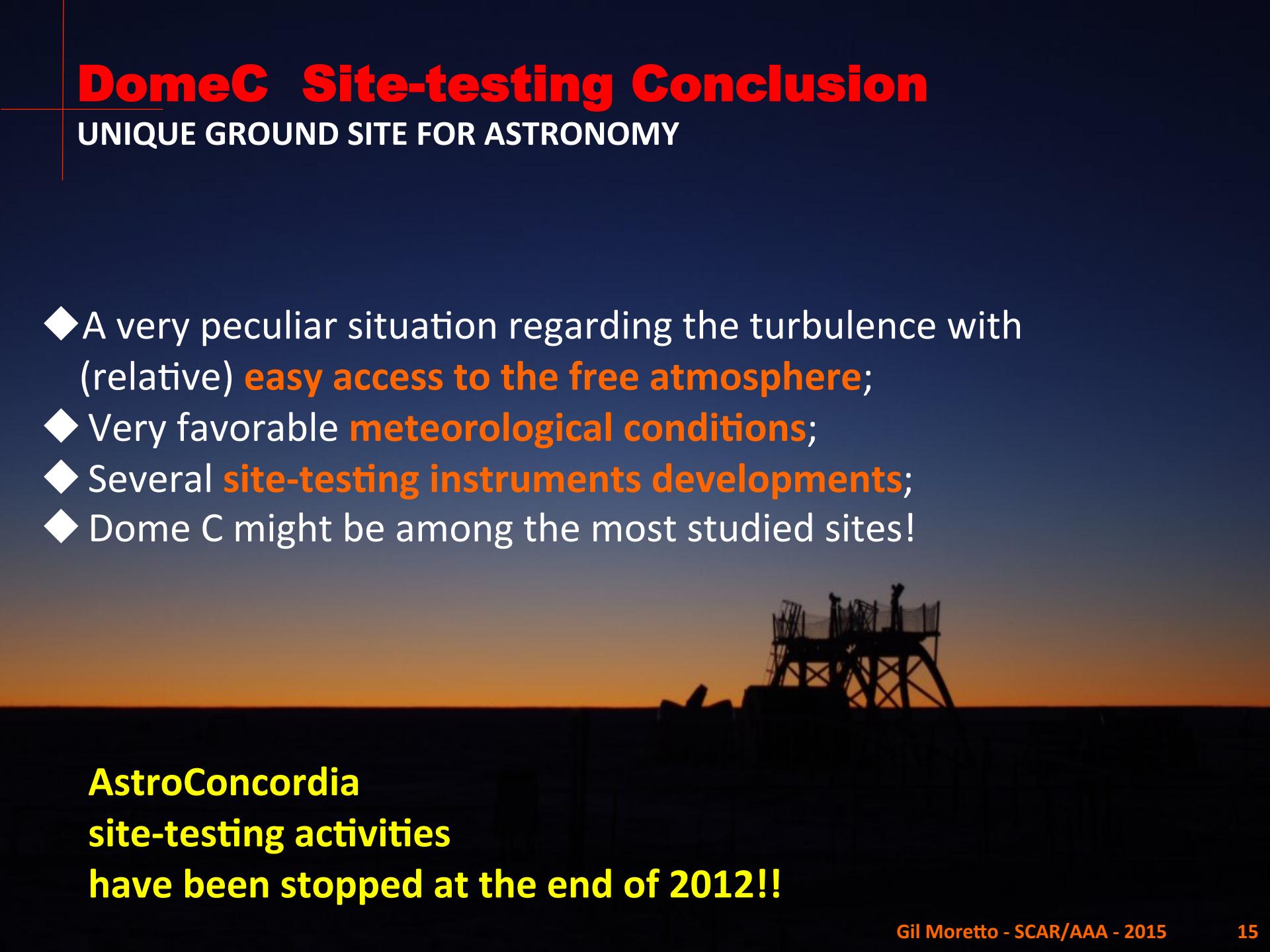
Seeing Histogram



# DomeC Site-testing Conclusion

UNIQUE GROUND SITE FOR ASTRONOMY

- ◆ A very peculiar situation regarding the turbulence with (relative) **easy access to the free atmosphere**;
- ◆ Very favorable **meteorological conditions**;
- ◆ Several **site-testing instruments developments**;
- ◆ Dome C might be among the most studied sites!

A silhouette of scientific equipment, likely a telescope or antenna, mounted on a metal frame against a dark blue and orange sunset sky.

AstroConcordia  
site-testing activities  
have been stopped at the end of 2012!!

# DomeC Site-Testing References

- Agabi, A., Aristidi, E., Azouit, M., et al. 2006, PASP, 118, 344  
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Schöck, M., Ziad, A., Chun, M., et al. 2002, Internal report  
Travouillon, T., Aristidi, E., Fossat, E., et al. 2008, in Proc. of the SPIE, vol. 7012, Ground-based and Airborne Telescopes II, ed. L. Stepp & R. Gilmozzi (SPIE), 70124B–70124B-5  
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Vernin, J., Chadid, M., Aristidi, E., Agabi, A., Trinquet, H., & van der Swaelmen, M. 2009, A&A, 500, 1271  
Ziad, A., Aristidi, E., Agabi, A., et al. 2008, A&A, 491, 917

Petenko et al., *Observations of optically active turbulence in the planetary boundary layer by sodar at the Concordia astronomical observatory, Dome C, Antarctica*; A&A, 568, 2014.

Ziad et al., *First results of the PML monitor of atmospheric turbulence profile with high vertical resolution*; A&A, 559, 2013.



# Dome C ASTEP

## Antarctica Search for Transiting Exo-Planet Project

A remotely operated photometric telescope

Lyu Abe and the ASTEP Team

CNRS/ Université de Nice Sophia Antipolis, Nice, France

### Scientific Goal:

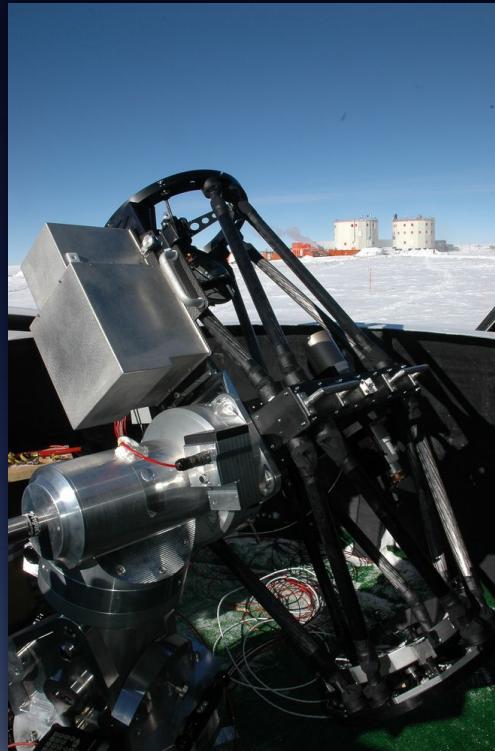
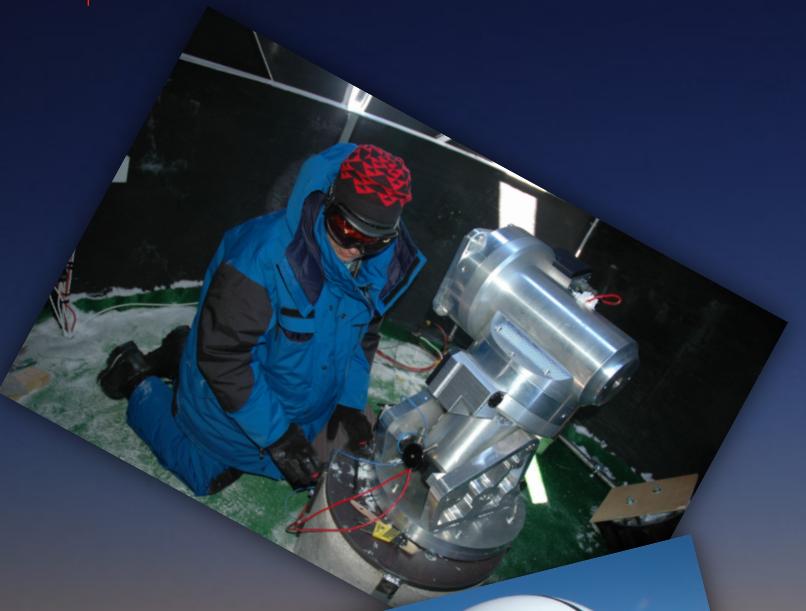
- ◆ ExPNs Transits: know targets characterization, new planets search;
- ◆ ExPNs Microlensing;
- ◆ M-Dwarfs;
- ◆ Tidal star/planet dynamical interaction.

### Technical Goal:

- ◆ Operation & winterization of a telescope for precision photometry in Antarctica;
- ◆ Remote Operation.

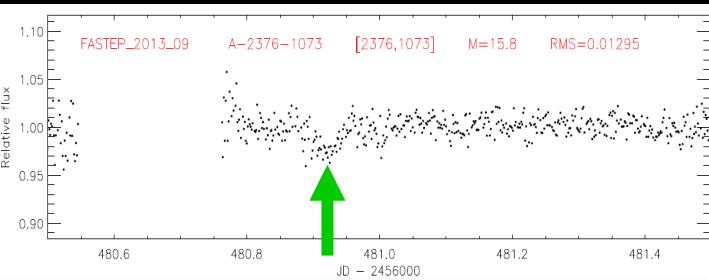
# ASTEP @Concordia

## ASTEP400 [2009 - 2010]

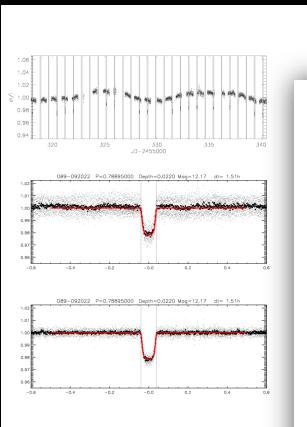
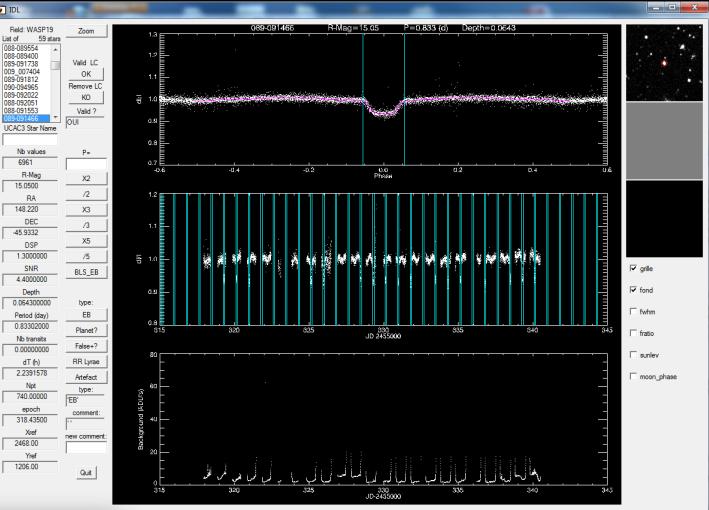


# ASTEP400 Results

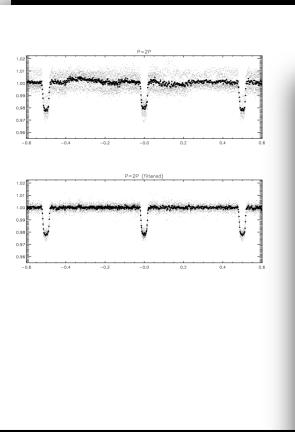
## Up to 2013



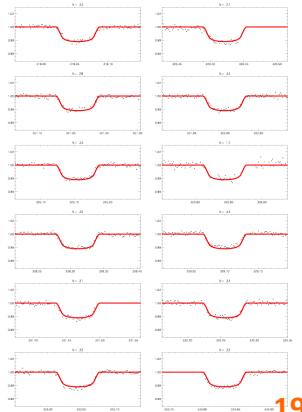
- ◆ About 300 Science Images/Night;
- ◆ About 6TB of Data/Year
- ◆ Two Custom Pipelines:
  - On-site aperture photometry pipeline @Domec;
  - Optimized to produce daily lightcurves and sent to Nice (France);
  - Few milli-mag precision on brightest stars;
  - A flexible & useful checking data quality on a daily basis.



Raw Lightcurve +  
Folder LC



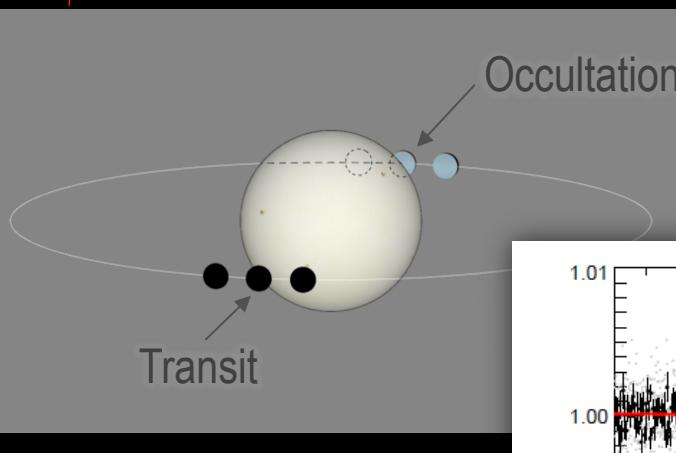
Double Period  
Folder Check



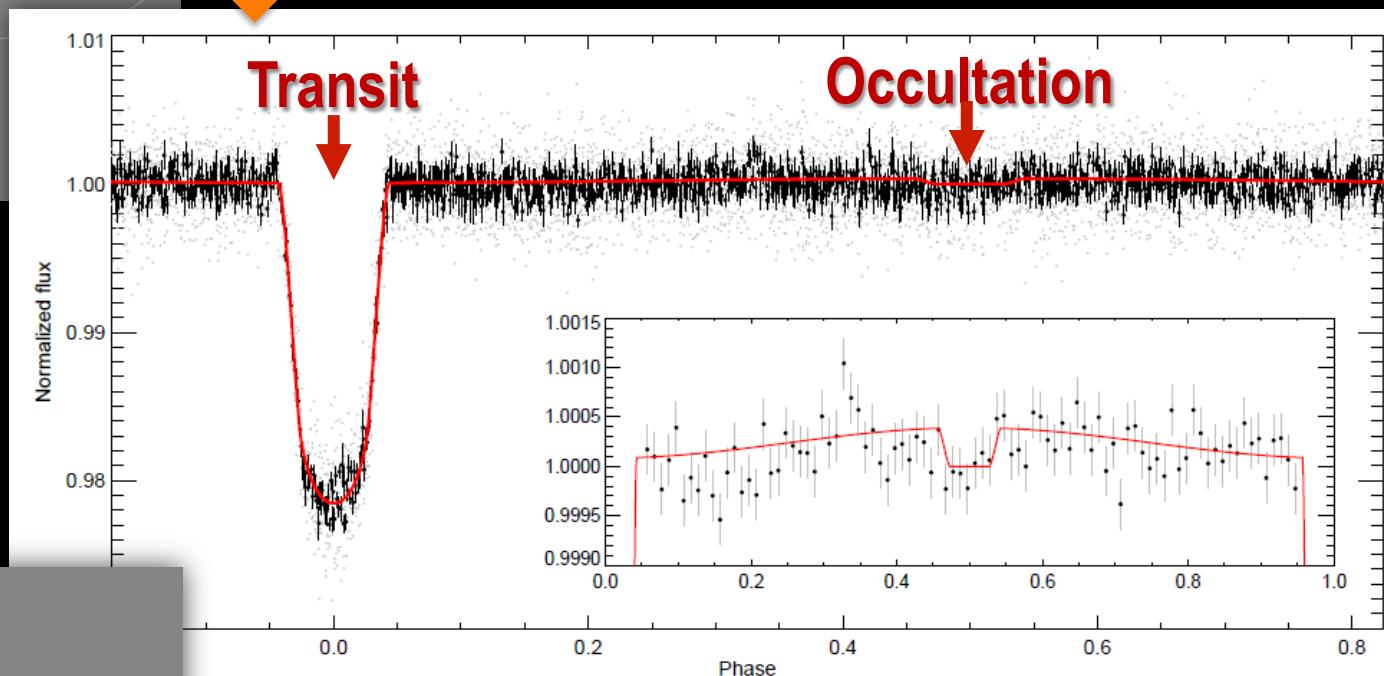
Individual  
Transit Events

# ASTEP400 Results

## Planet WASP-19b Occultation



Measured occultation depth 400ppm (upper limit)  
– at the limit of the detection capabilities.



Observed « Phase effect » present in the data  
(unexplained at the moment, but not due to the planet).

→ See Abe et al., A&A, 2013 for more details

# Thermal design and on-site tests

## DomeC Winterization Know-how.

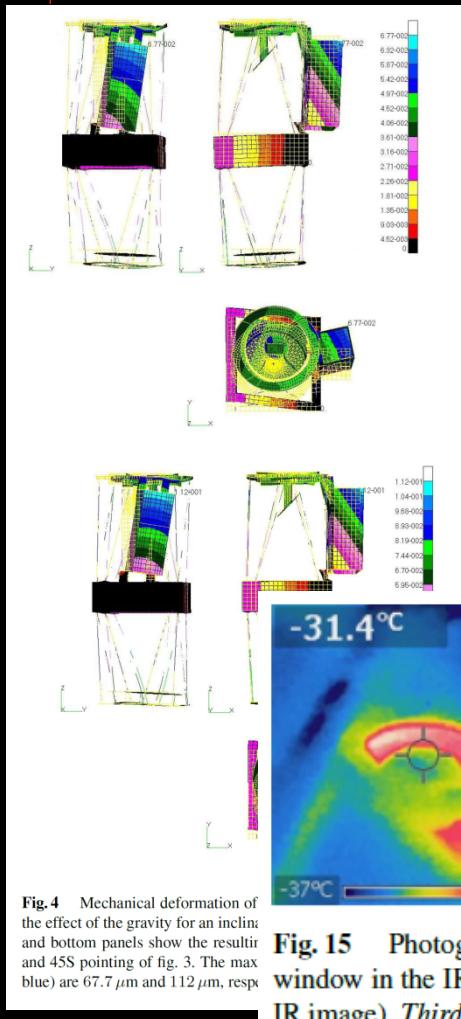


Fig. 4 Mechanical deformation of the effect of the gravity for an incline and bottom panels show the result of the 45S pointing of fig. 3. The max (blue) are  $67.7 \mu\text{m}$  and  $112 \mu\text{m}$ , resp.

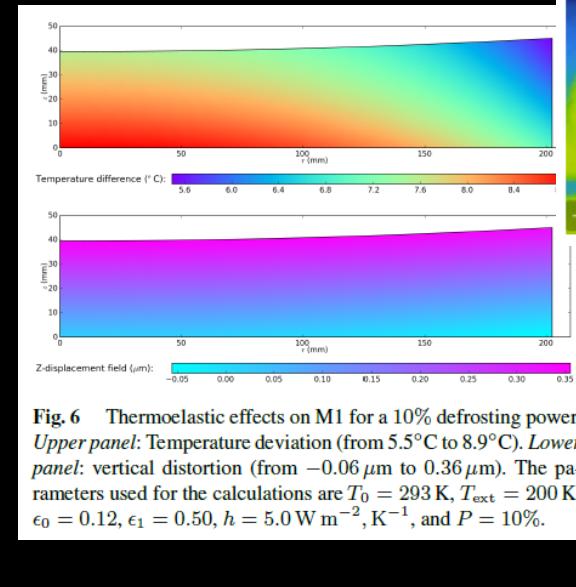


Fig. 6 Thermoelastic effects on M1 for a 10% defrosting power. *Upper panel:* Temperature deviation (from  $5.5^{\circ}\text{C}$  to  $8.9^{\circ}\text{C}$ ). *Lower panel:* vertical distortion (from  $-0.06 \mu\text{m}$  to  $0.36 \mu\text{m}$ ). The parameters used for the calculations are  $T_0 = 293 \text{ K}$ ,  $T_{\text{ext}} = 200 \text{ K}$ ,  $\epsilon_0 = 0.12$ ,  $\epsilon_1 = 0.50$ ,  $h = 5.0 \text{ W m}^{-2}, \text{K}^{-1}$ , and  $P = 10\%$ .

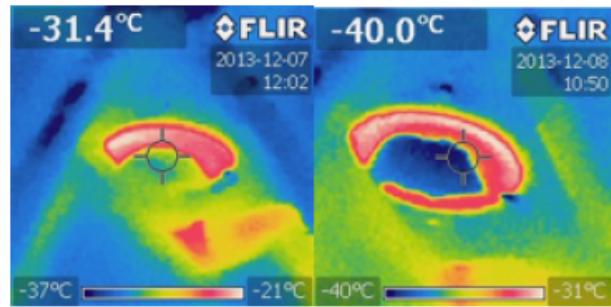
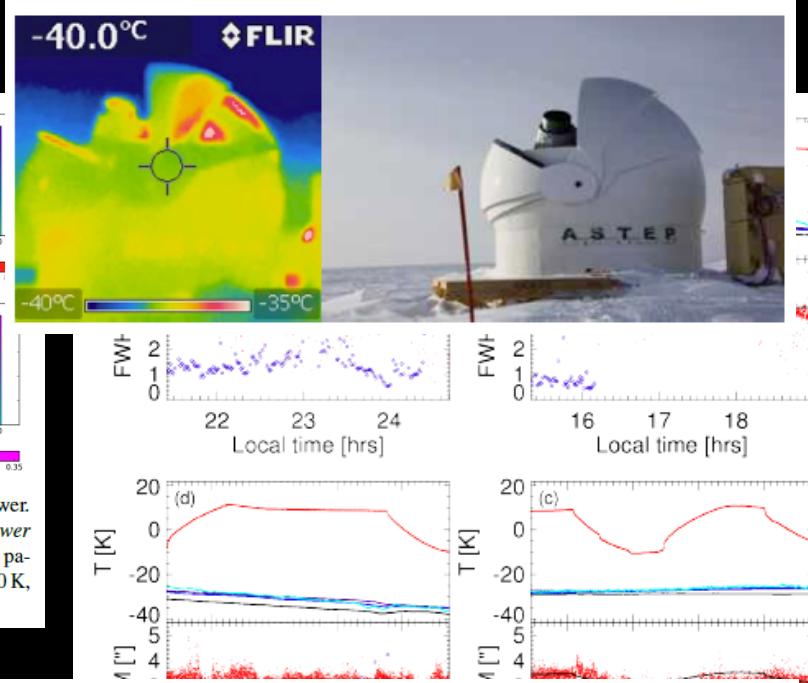
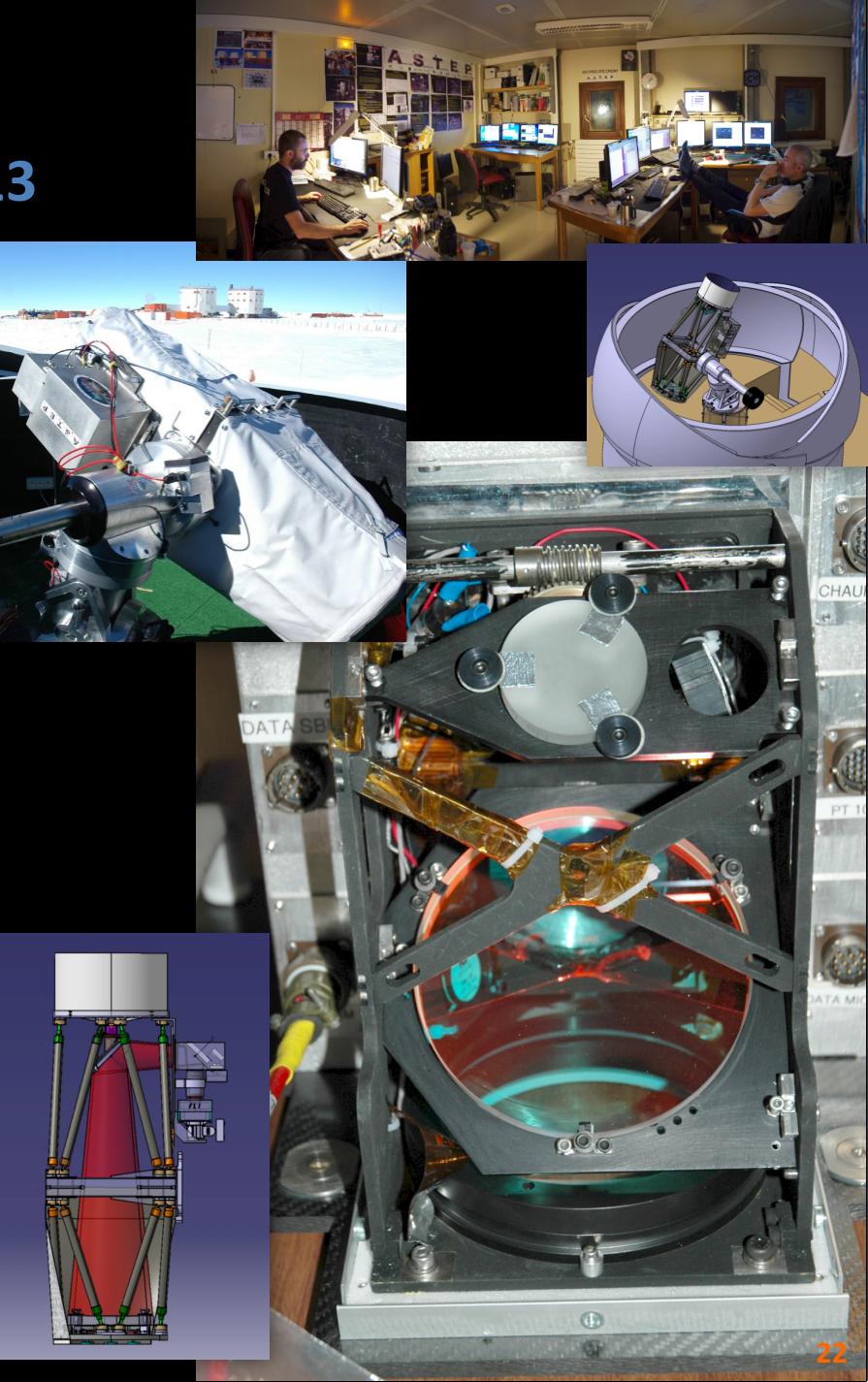


Fig. 15 Photographs of the camera entrance window in the infrared and visible. *First photograph from the left:* Camera box entrance window in the IR when heated to  $+10^{\circ}\text{C}$  inside the camera box. *Second photograph:* Camera window in the IR when heated  $-8^{\circ}\text{C}$  (2nd IR image). *Third photograph:* Blowup of the camera window in the visible to scale with the IR photographs. *Fourth photograph:* Visible photograph is taken from near the M1 mirror, looking up towards the camera window and the M2 mirror.

# ASTEP400 Summary

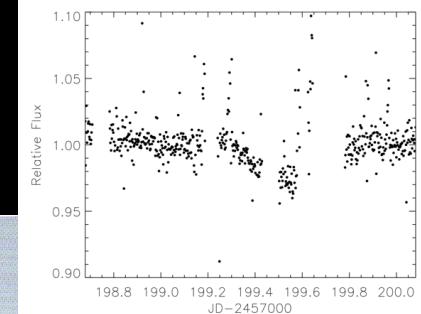
## Successful operation by end of 2013

- ◆ Technical goals completely fulfilled.
- ◆ Follow-up is critical for ExPns detection:  
dedicated spectrometer is needed on site!!!
- ◆ No operation scheduled in 2015!
- ◆ ASTEP400 is back to Nice/France (upgrade).



# Perspective

15 years of Dome C site operation  
experience must be kept!



PAIX 2007-2008

- ◆ The only instrument active (2015) at DomeC: **PAIX–Visual Photometer** (Nice) to track and observe variable stars (RR Lyrae, FM) and in occasional support to ASTEP program.

- ◆ The **IRAIT/Italy** an 0.8m near and mid-IR: ???

- ◆ Promote **Collaborations and Partnership**.

- ◆ Establish **Synergies around AAA**:

- DomeA/AST3/KDUST Project (China/Australia);
- nIR AST2 Telescope (Chine) @ Dome C ?????

- Li-Fan Wang and Charling Tao



IRAIT Installation  
2008-2009

# Keep Looking for ExPNs



# ASTEP References

Guillot et al., « *Thermalizing a telescope in Antarctica: Analysis of ASTEP observations* », Astronomische Nachrichten (Astronomical Notes), 2015; <http://arxiv.org/abs/1506.06009>

Abe et al., « *The secondary eclipses of WASP-19b as seen by the ASTEP 400 telescope from Antarctica* », A&A, 2013. <http://arxiv.org/abs/1303.0973>.



# ASTEP Program Collaborators

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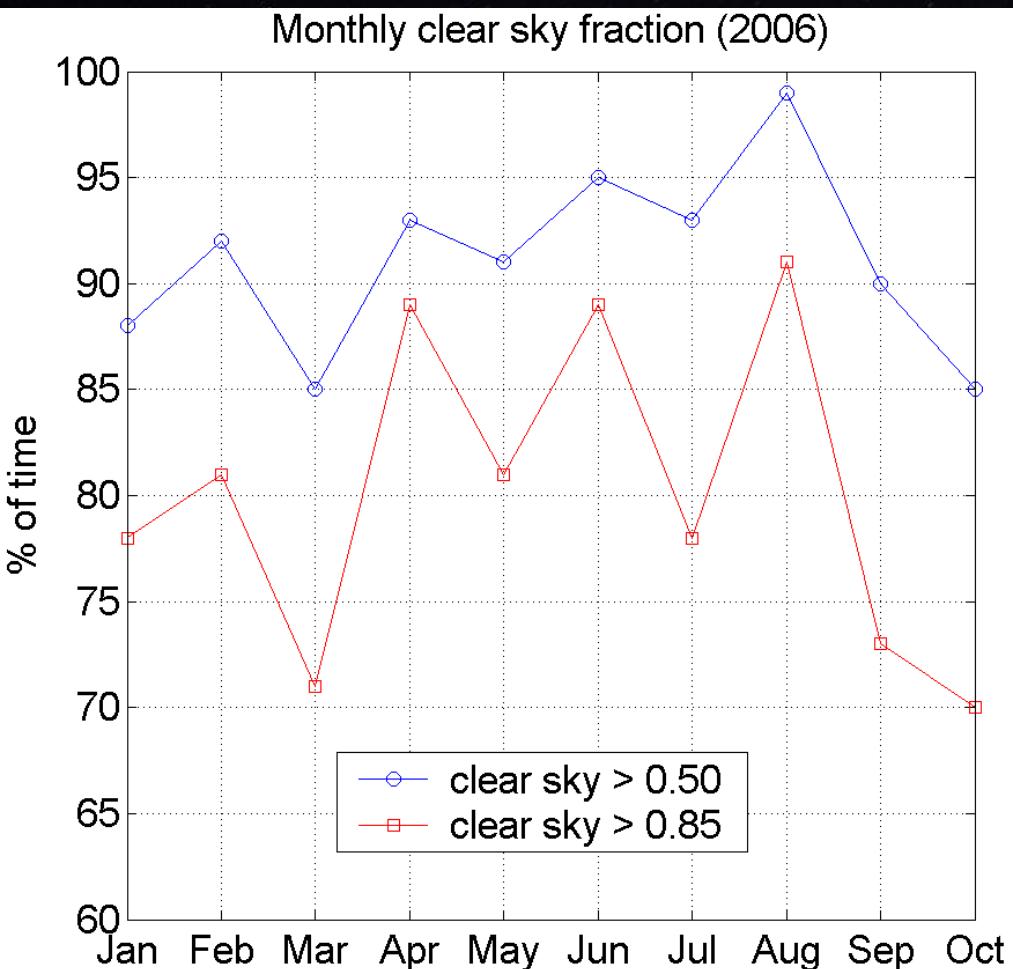
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- MORE DETAILS

# DomeC Weather

Visual Observations: 4-5 points/day



~ 80% of clear nights  
(85+% of the sky is free)

- ◆ Mauna Kea (Hawai'i)<sup>1</sup>: 67%
- ◆ Paranal (Chili)<sup>2</sup> : 87%

ASTEP-South (WO 2008)<sup>3</sup>

Continuous observations  
around the Pole (4x4 deg)

85% of clear nights  
(62% photometric+23% veiled)

<sup>1</sup> Kaufman & Vecchione, 1981

<sup>2</sup> Sarazin, 2001

<sup>3</sup> Crouzet et al., 2010

<sup>4</sup> Mosser & Aristidi, 2007