DOMEC UPDATE (2015)

Gil Moretto
CRAL/CNRS, Lyon, France

On behalf of French / Nice DomeC Community

Lyu Abe, Karim Agabi, Eric Aristidi, Marcel Carbillet, 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

123°19’27”E  75°6’1”S
3230m
-20°C  to  -45°C
-50°C  to  -85°C
~3m/s

Logistics IPEV/PNRA

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Dome C
Concordia Station
Hosting capability
Summer: 80
(incl. « summer camp »)
Winter: 16

Laboratories, Communication room
Sleeping rooms
Hospital Storage rooms
Kitchen, Restaurant and Library
Storage, Training, Video Rooms
Technical Rooms

3 power modules

Gil Môretto - SCAR/AAA - 2015
# 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);

Atmospheric Parameters Measurements:
◆ the optical turbulence (seeing $\varepsilon_0$);
◆ the refractive index structure constant $C_n^2(h)$;
◆ the isoplanatic angle $\theta_0$;
◆ 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)

**Instrument Development**

**SSS: Single Star Scidar**
A turbulence profiler to replace the balloons.
In operation: 2006 and 2011

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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

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 $Cn^2$ 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)

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<td>DIMM_roof</td>
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- **DIMM**: Seeing
- **Thetameter**: Isoplanatic angle
- **GSM**: Seeing + Outer scale
- **Balloons**: $C_n^2$ / Wind speed profile (vertical res. 5m) whole atm.
- **SSS**: $C_n^2$ / Wind speed profile (vert. res. 1km) whole atm.
- **PBL**: $C_n^2$/Wind speed/Outer scale profile (vert. res. 100m) whole atm.
- **SONIC**: local $C_n^2$/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

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<tr>
<th></th>
<th>Seeing</th>
<th>Isop.</th>
<th>Coh. time</th>
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<td>DIMM/GSM</td>
<td>0.4 ”</td>
<td>4.1 ”</td>
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<td>SSS</td>
<td>0.3 ”</td>
<td>6.9 ”</td>
<td>10.2 ms</td>
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<tr>
<td>Balloons</td>
<td>0.4 ”</td>
<td>2.7 ”</td>
<td>6.8 ms</td>
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<td>AASTINO 2004(^1)</td>
<td>0.3 ”</td>
<td>5.7 ”</td>
<td>7.9 ms</td>
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<td>Simulations(^2)</td>
<td>0.3 ”</td>
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<td>Mauna Kea</td>
<td>0.6 ”</td>
<td>1.9 ”</td>
<td>2.7 ms</td>
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<td>Paranal</td>
<td>0.8 ”</td>
<td>2.6 ”</td>
<td>3.3 ms</td>
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\(^1\)Lawrence et al 2004
\(^2\)Lascaux et al 2011
Summer Integrated Parameters
DIMM@8m Seeing (Dec. – Jan.)

Hourly averaged

Seeing Histogram
Free atmosphere bump of the histogram

Summer Seeing = 0'' .40 [0.3 – 0.5]

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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!

AstroConcordia site-testing activities have been stopped at the end of 2012!!
DomeC Site-Testing References

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.

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.

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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.
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. 6  Thermoelastic effects on M1 for a 10% defrosting power. Upper panel: Temperature deviation (from 5.5°C to 8.9°C). Lower panel: vertical distortion (from -0.06 μm to 0.36 μm). The parameters used for the calculations are $T_0 = 293$ K, $T_{test} = 200$ K, $e_0 = 0.12$, $e_1 = 0.50$, $h = 5.0$ W m$^{-2}$ K$^{-1}$, and $P = 10\%$.

Fig. 4  Mechanical deformation of the effect of the gravity for an incline and bottom panels show the results and 45S pointing of fig. 3. The max blue are 67.7 μm and 112 μm, resp.

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°C inside the camera box. Second photograph: Camera window in the IR when heated -8°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.

See Guillot et al. 2015; Astr. Nachr.
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!

◆ 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
Keep Looking for ExPNs

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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 (Hawaii): 67%
- Paranal (Chili): 87%

ASTEP-South (WO 2008)
Continuous observations around the Pole (4x4 deg)

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

1 Kaufman & Vecchione, 1981
2 Sarazin, 2001
3 Crouzet et al., 2010
4 Mosser & Aristidi, 2007

E. Aristidi (Jan-Oct 2006)