Concordia, ASTEP & Beyond

Djamel MEKARNIA

T. Guillot, L. Abe, J.-P. Rivet, A. Agabi, F.-X. Schmider , I. Gonçalves, J.-B. Daban, N. Crouzet, E. Aristidi, C. Gouvret, Y. Fantei-Caujolle, and the ASTEP Team

Laboratoire J.-L. Lagrange
Université de Nice – CNRS – Observatoire de la Côte d'Azur, France

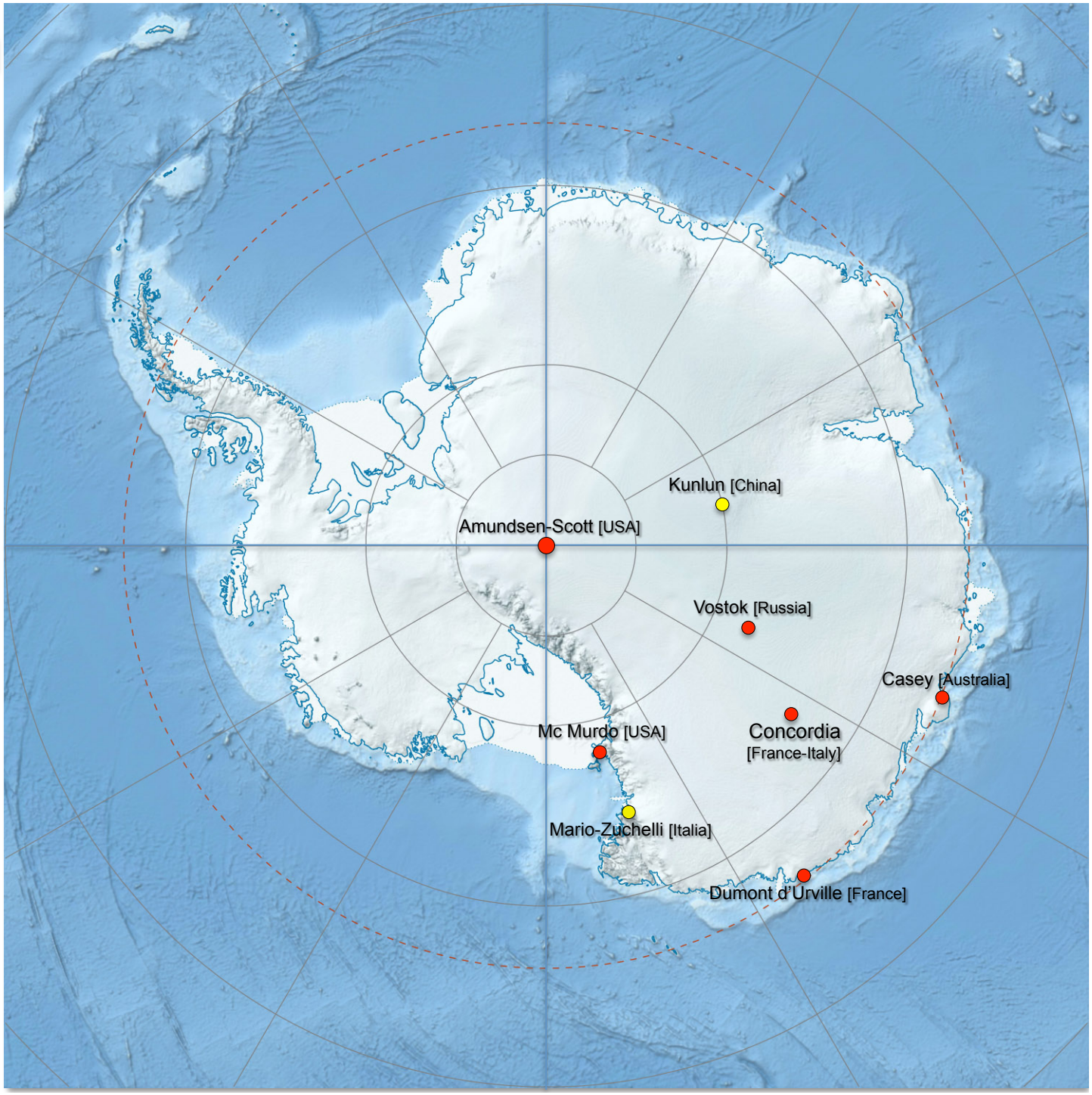
Concordia, ASTEP & Beyond

- ✓ Concordia station
- ✓ ASTEP 400
- ✓ Combined Visible-IR Observations ?

Concordia [Dome C]

75º 06’ S - 123º 21’ E

3233 m



How to reach Concordia ?

Hobart - Dumont d'Urville : L'Astrolabe

Christchurch - Mc Murdo / Mario-Zuchelli : C-17 / C-130

Hobart - Casey : Airbus A-319

Terra Nova - Concordia - Dumont d'Urville - Casey - Mc Murdo :
Twin-Otter, Basler

L’Astrolabe : Cargo delivery

Dumont d’Urville

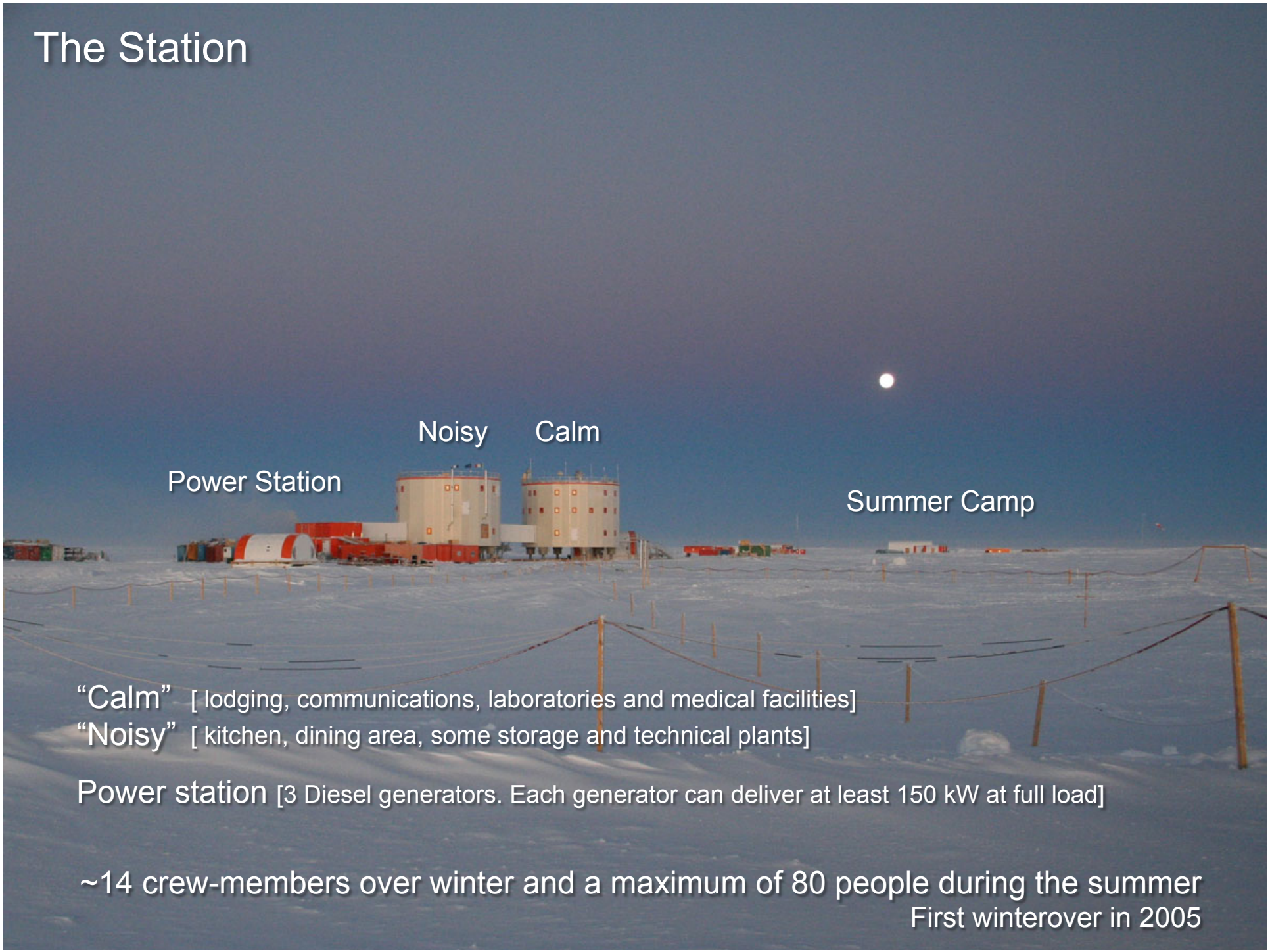
Cap Prud'homme [5 km from Dumont d'Urville]

Concordia Station, Dome C

[75° 06' S 123° 21' E, 3233 m]

- ✓ Concordia is jointly funded, built, staffed and operated by IPEV (France) and PNRA/ENEA (Italy) under a cooperative agreement signed by IPEV and ENEA in 1993.
- ✓ IPEV is a French agency for conducting and supporting french scientific research in the polar regions [Spitsbergen, Antarctic and French sub-antarctic islands (Crozet, Kerguelen and Amsterdam)]
  - 50 permanent staff, based in the headquarters in Brest, and 200 contract employees.
  - Budget : 28 Millions €
- ✓ ENEA is the Italian national agency for new technologies, energy and sustainable economic development

The Station



"Calm" [lodging, communications, laboratories and medical facilities]
"Noisy" [kitchen, dining area, some storage and technical plants]

Power station [3 Diesel generators. Each generator can deliver at least 150 kW at full load]

~14 crew-members over winter and a maximum of 80 people during the summer
First winterover in 2005

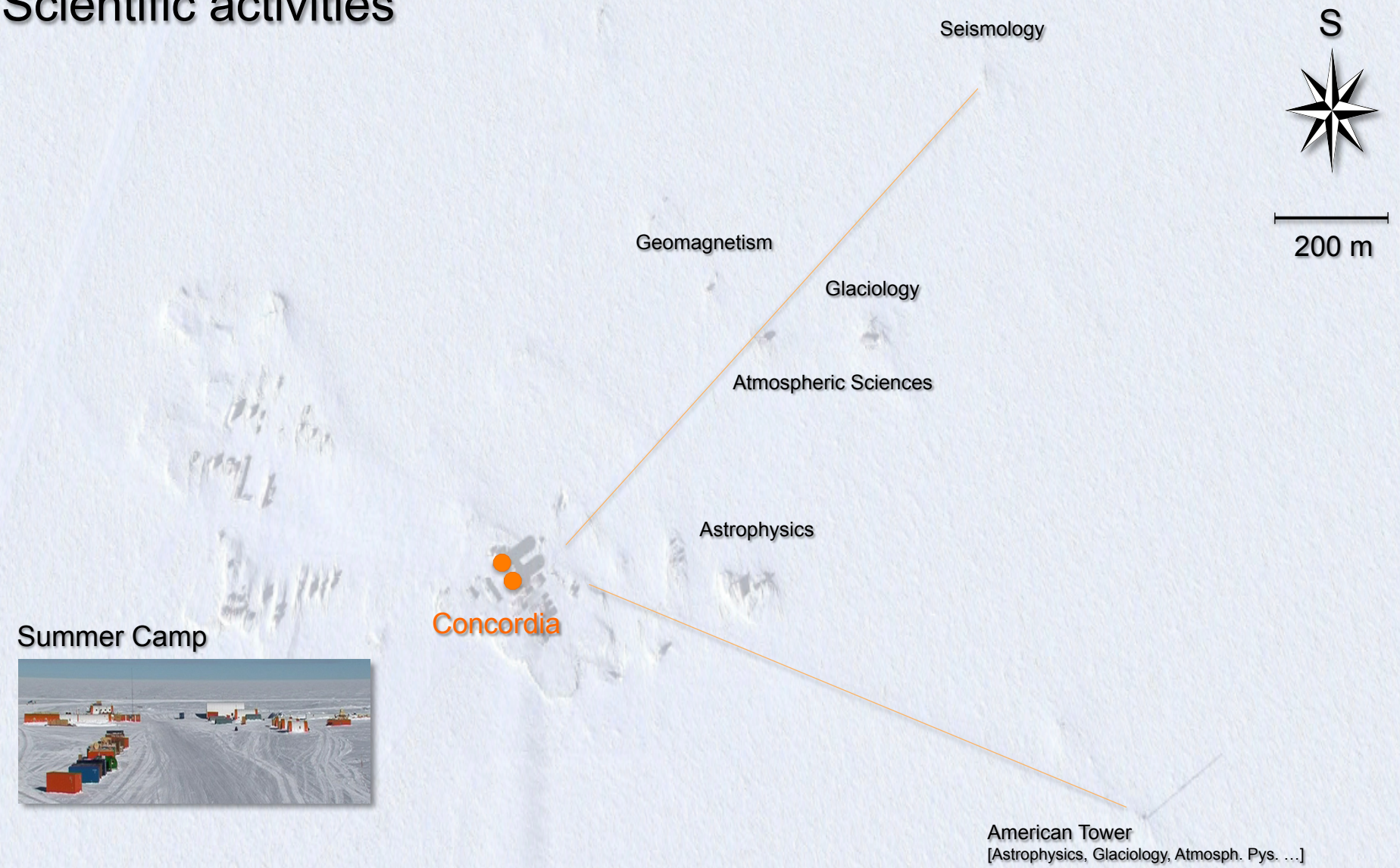

Ground traverse [Cap Prud'homme – Concordia]
1200 km ~10 days
3 traverses [Nov. Dec. Jan.] / year
500 tons of cargo
CATERPILLAR

Dumont d'Urville, Mario Zucchelli, Casey and Amundsen-Scott
to / from Concordia

Twin-Otter and Basler


Permanent satellite connection *
* VSAT 512 kbps using a 3.8m antenna

Scientific activities

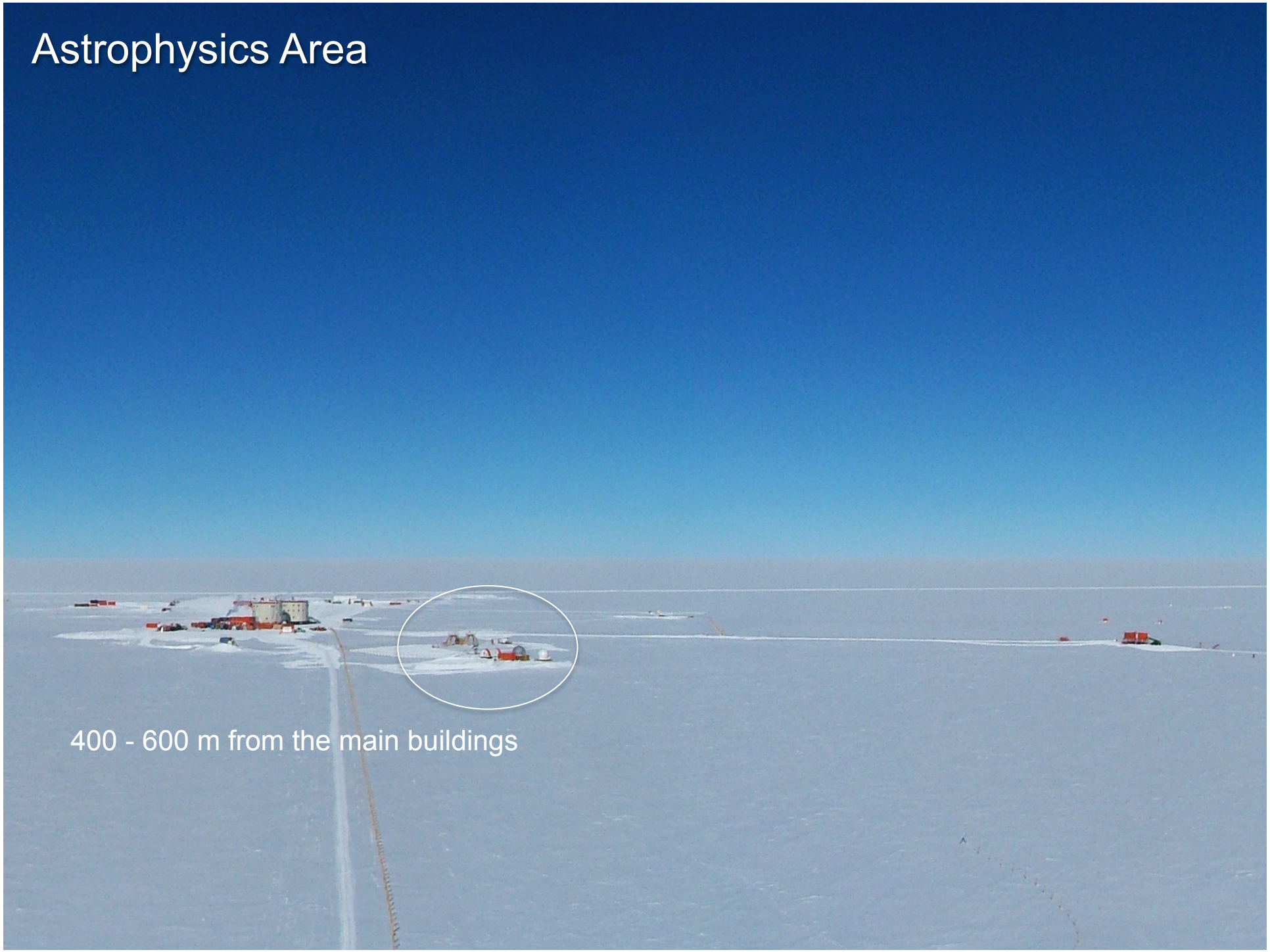


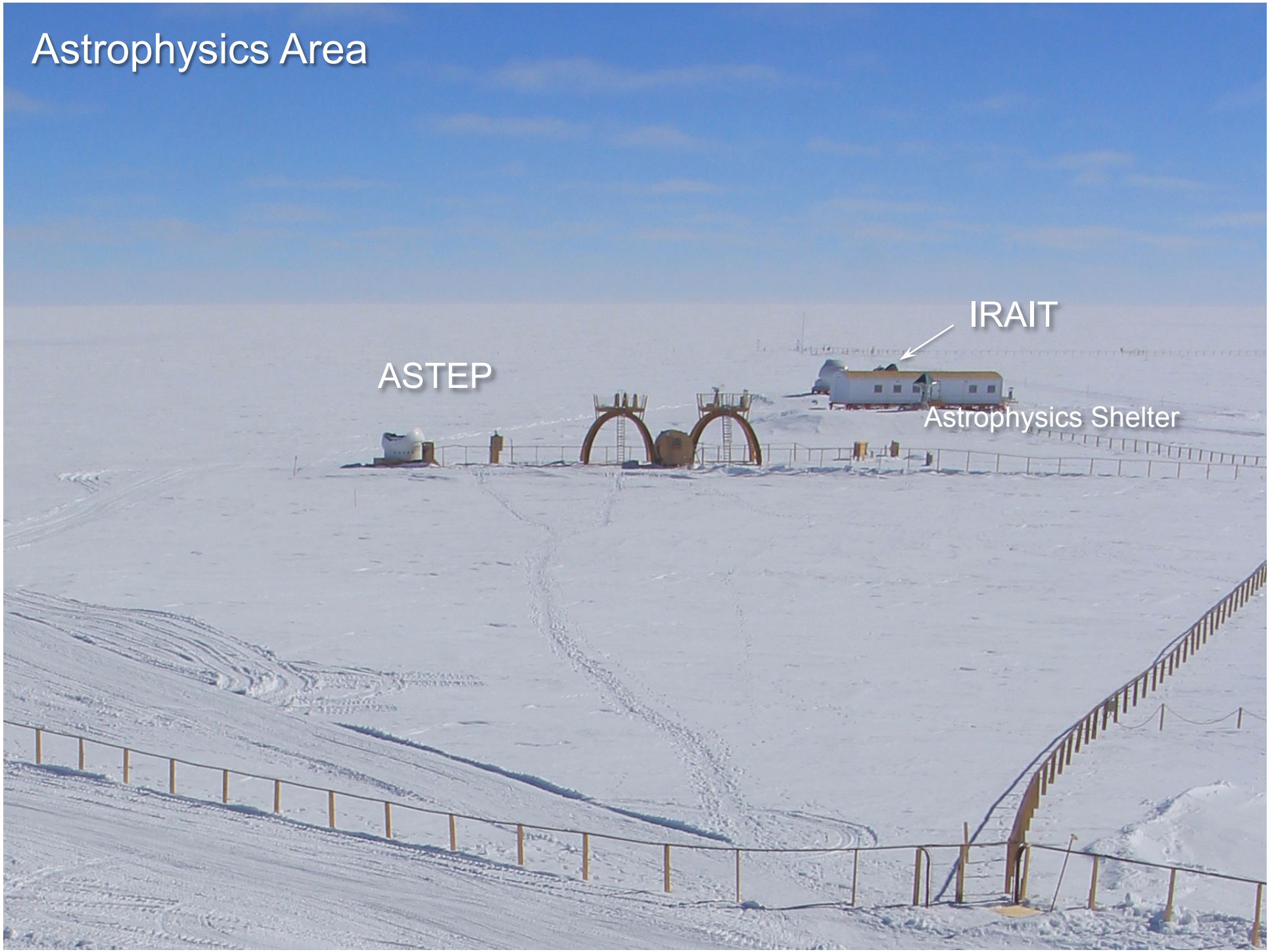
Science facilities located in area surrounding the main buildings up to 1 km away.

[+ , if necessary, summer science traverses]

Google earth

Astrophysics Area



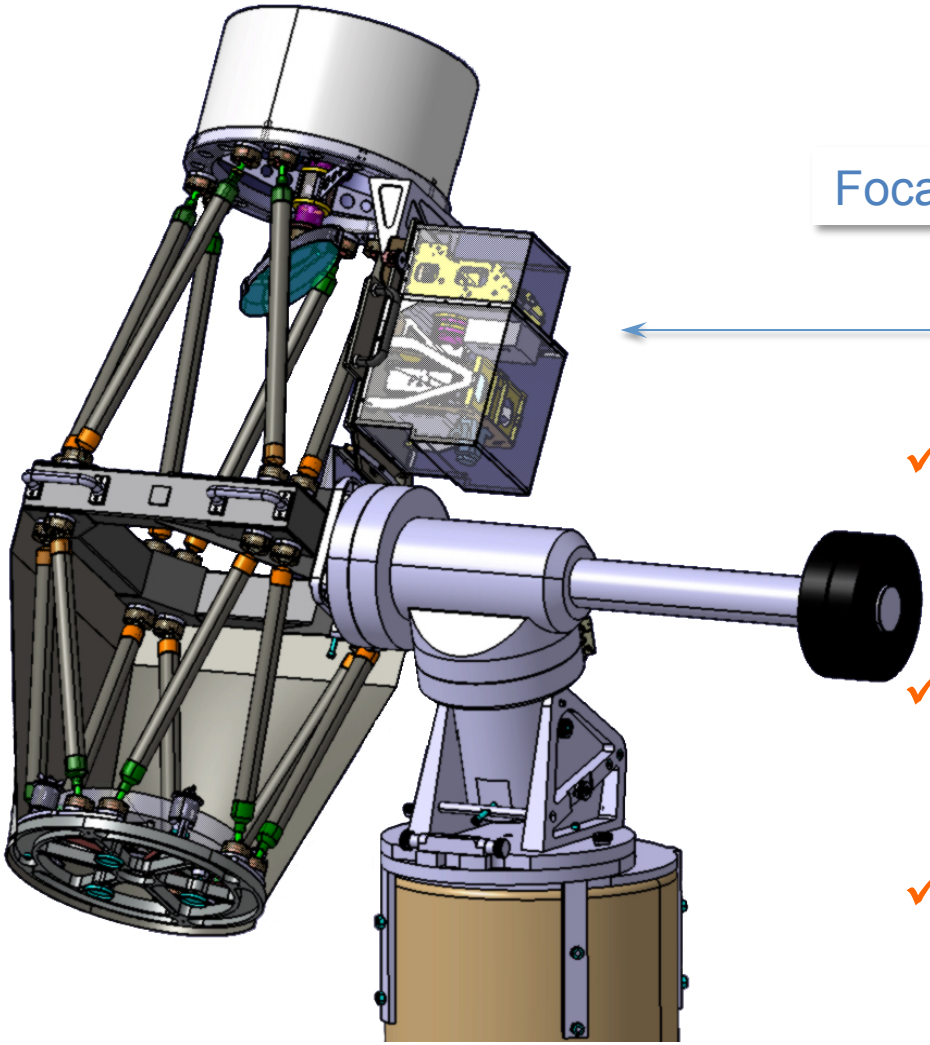

Astrophysics Area
IRAIT
ASTEP
Astrophysics Shelter

ASTEP [Antarctic Search for Transiting Exo-Planets]

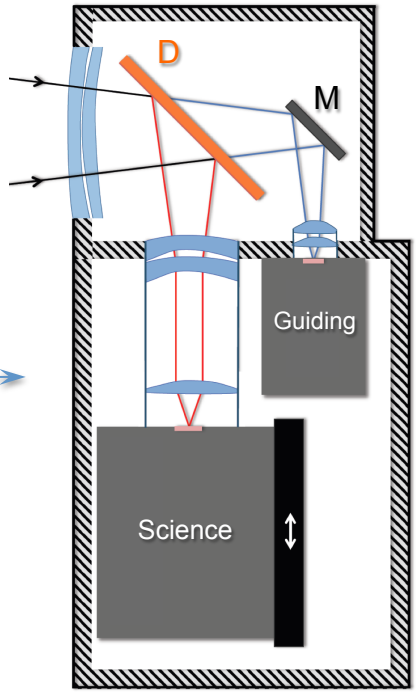
- Funded in 2006 [INSU+ANR+IPEV]
- Two instruments :
  ASTEP-South [fixed 10cm, 3.9° x 3.9° FoV refractor pointed towards the celestial South pole]. Catalog of 5954 stars
  ASTEP 400 [400 mm Newton reflector with a 1° x 1° FoV]

ASTEP 400 Characteristics

Telescope weight = 83 Kg, including 23 Kg for the focal box

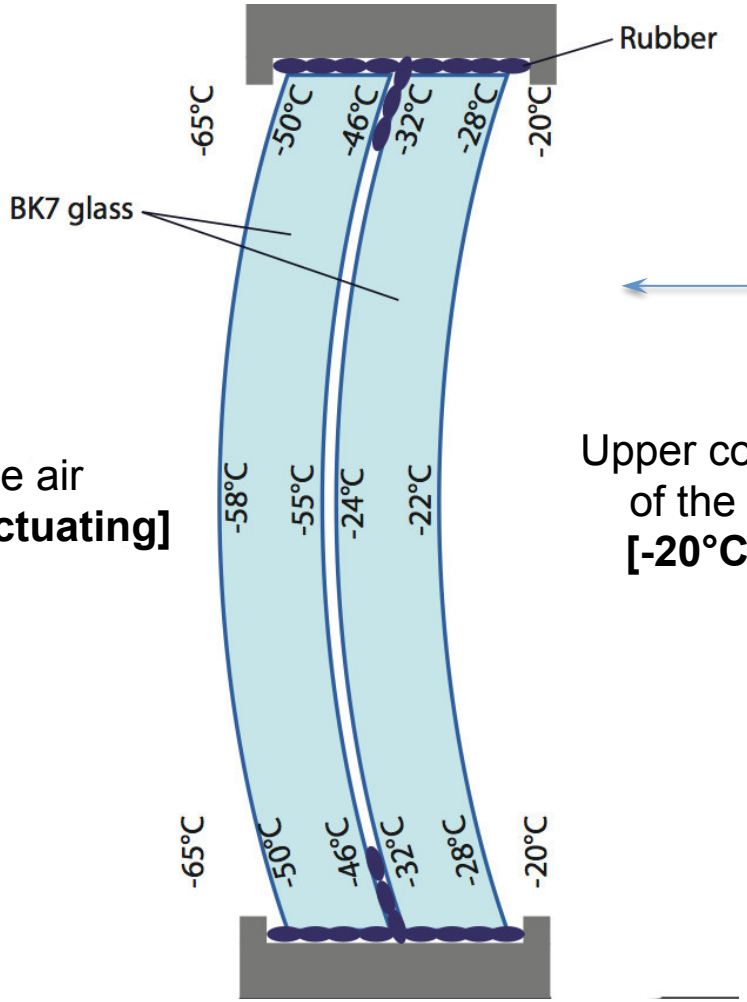


Focal box

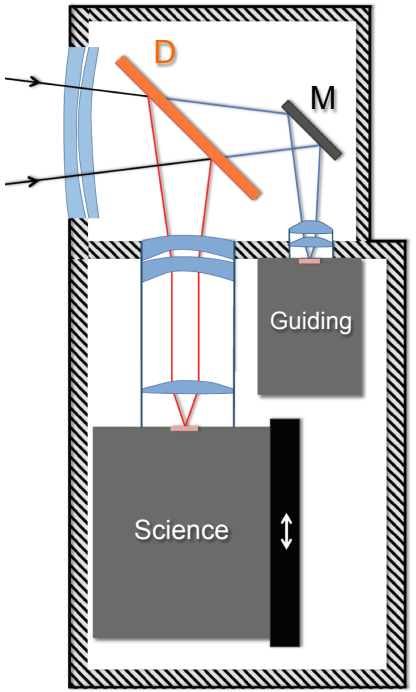


- ✓ Optical & Mechanical
  - 400mm Newton optical design, f/D=4.6
  - FoV 1° × 1° [Wynne corrector]
  - Commercial AP3600 Equatorial Mount
- ✓ Cameras
  - Cooled Science CCD [FLI 4k × 4k, ~0.9”/pix]
  - Cooled Guiding CCD [SBIG]
- ✓ Operation
  - Semi-automatic mode [scheduler]

The focal box entrance window

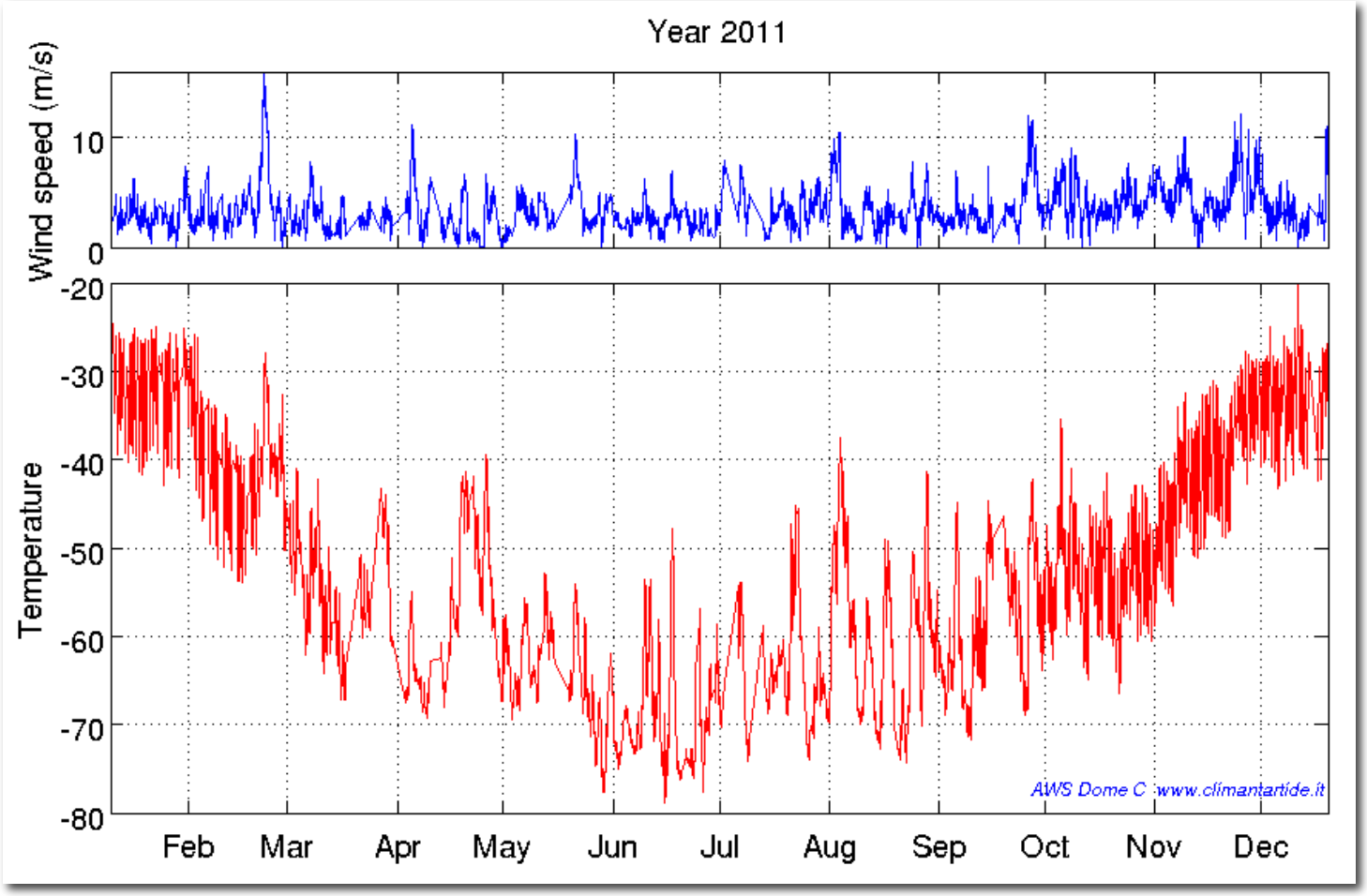


Outside air
[-65°C, fluctuating]



Upper compartment
of the focal box
[-20°C, stable]

Temperature variations

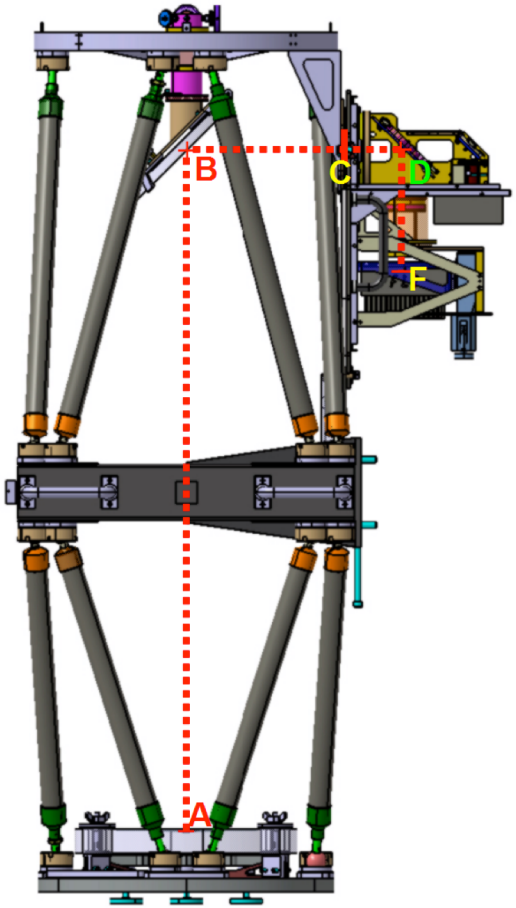


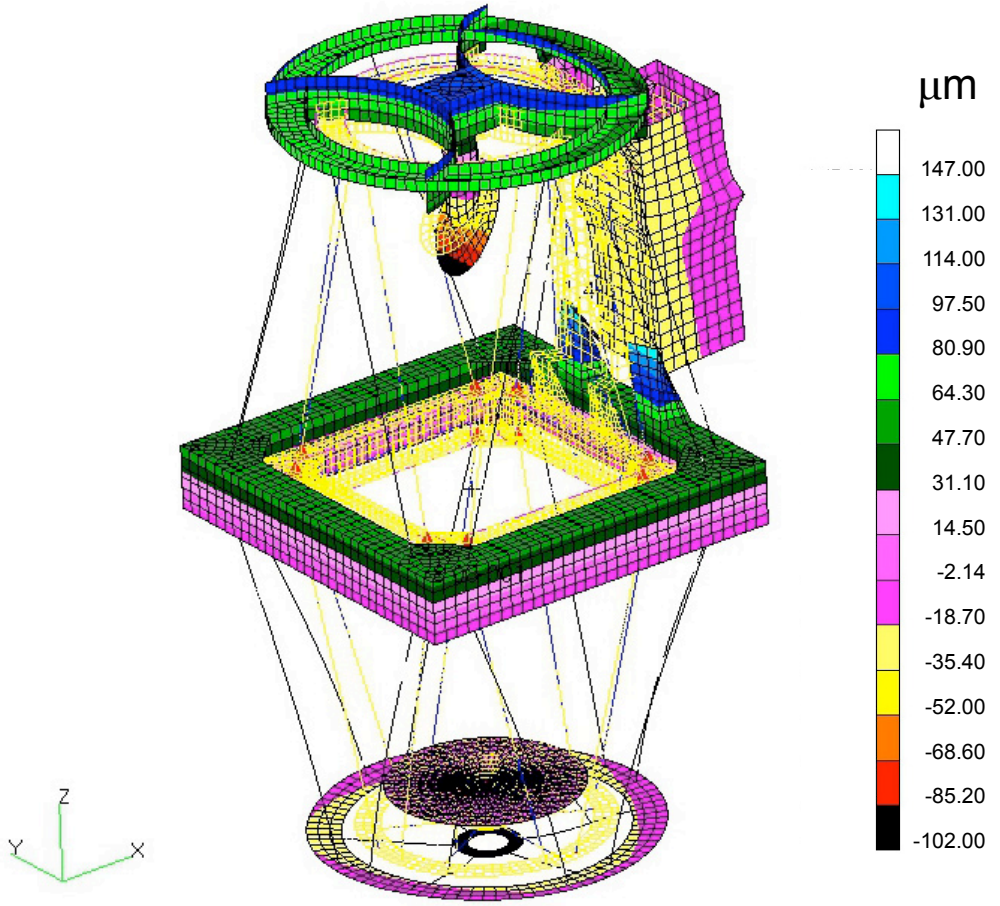
Thermal dilatation and frost formation

Thermal dilatations

ASTEP 400 :

Designed to minimize thermal expansion between point A and point F





Mechanical deformation of the telescope structure for ΔT = 30°C

ΔT = 30°C : Expansion between A and F = 150µm.

Change of the focal plane of 5µm for a temperature variation of 1°C

Frosting and snow deposit

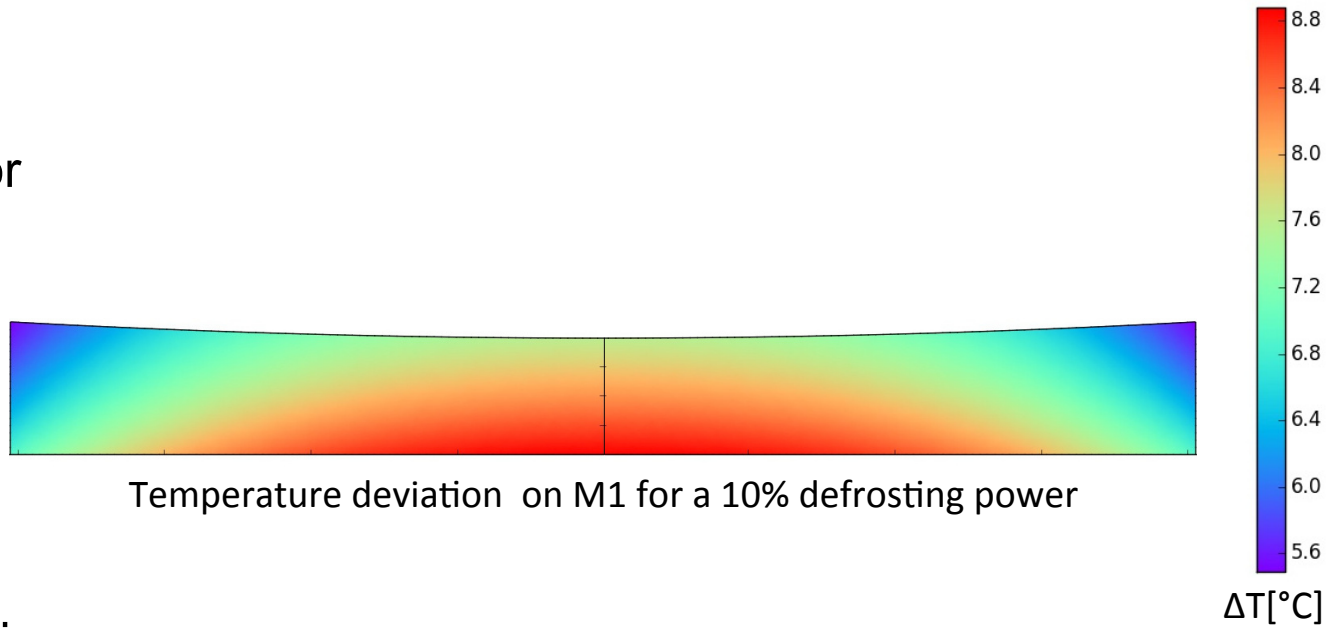
Mirror defrosting

Custom-designed planar heaters [Inconel600® stripes sandwiched between Kapton® sheets] in thermal contact with the rear faces of the mirrors [Max Power = 250W for M1 and 115W for M2].

Image quality degradation induced by the defrosting heaters :

- Turbulence and thermoelastic distortions of the mirrors themselves and of the telescope

✓ Primary mirror
Defocus



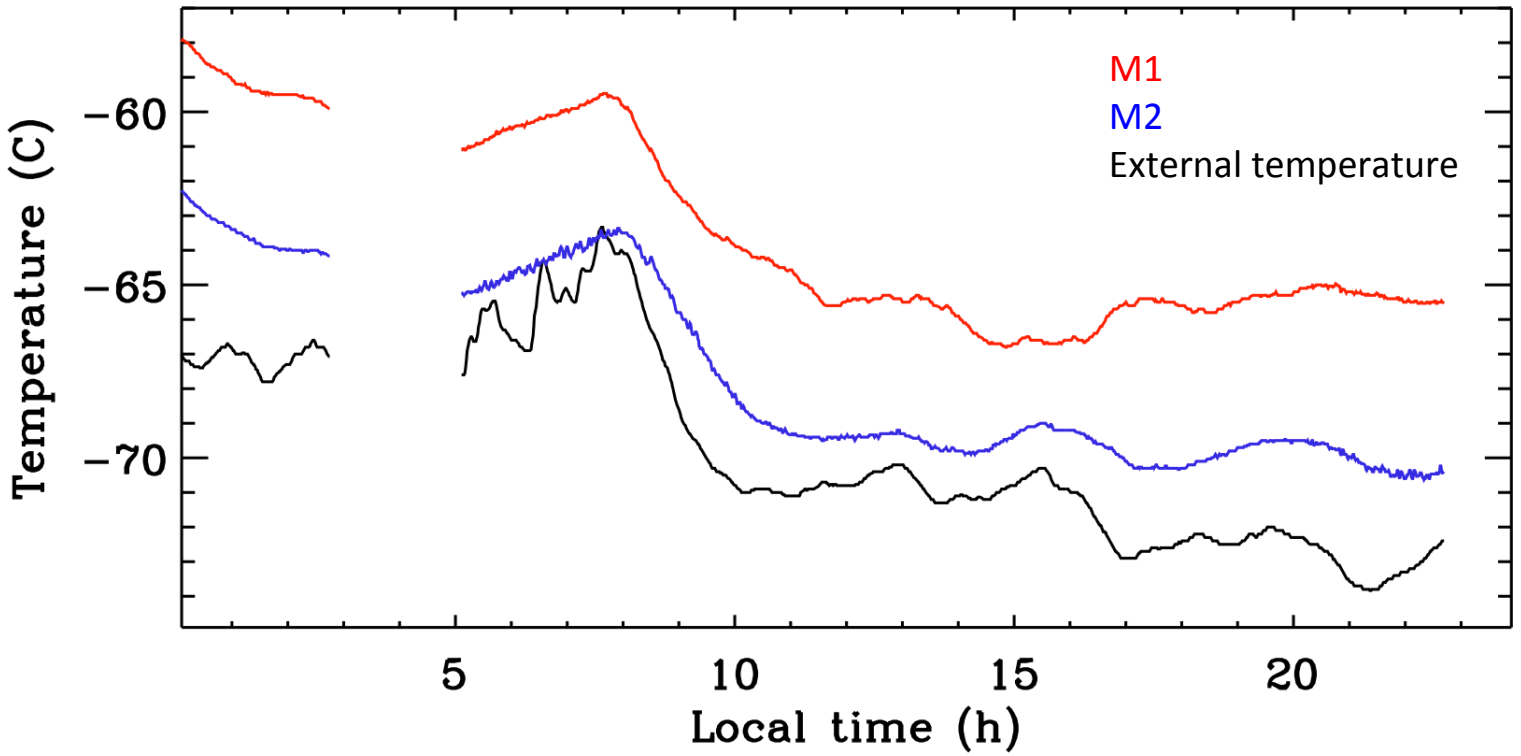
Temperature deviation on M1 for a 10% defrosting power

✓ Secondary mirror
Defocus and astigmatism

Thermoelastic distortions of the primary and secondary mirrors have a **minor effect** on the optical performances of the telescope.

Frosting and snow deposit

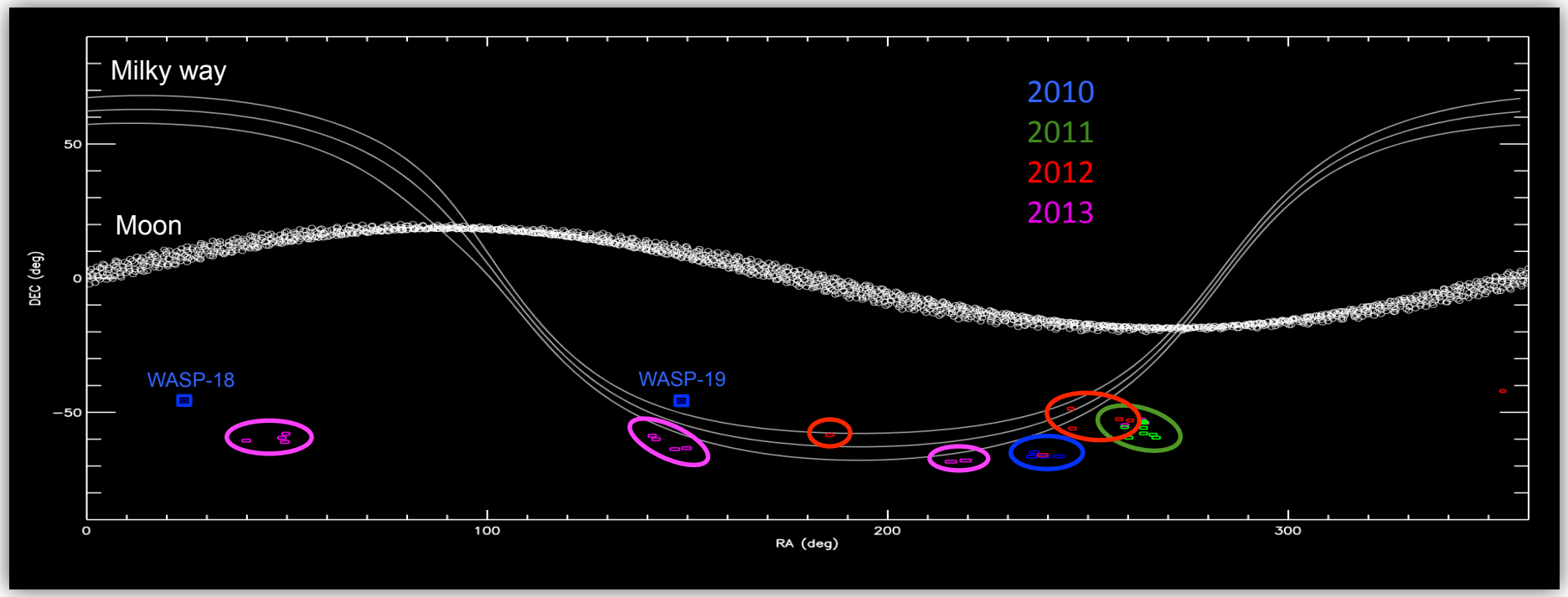
Mirrors temperature variations



ΔT ~ 6°C and 2°C for M1 and M2 respectively

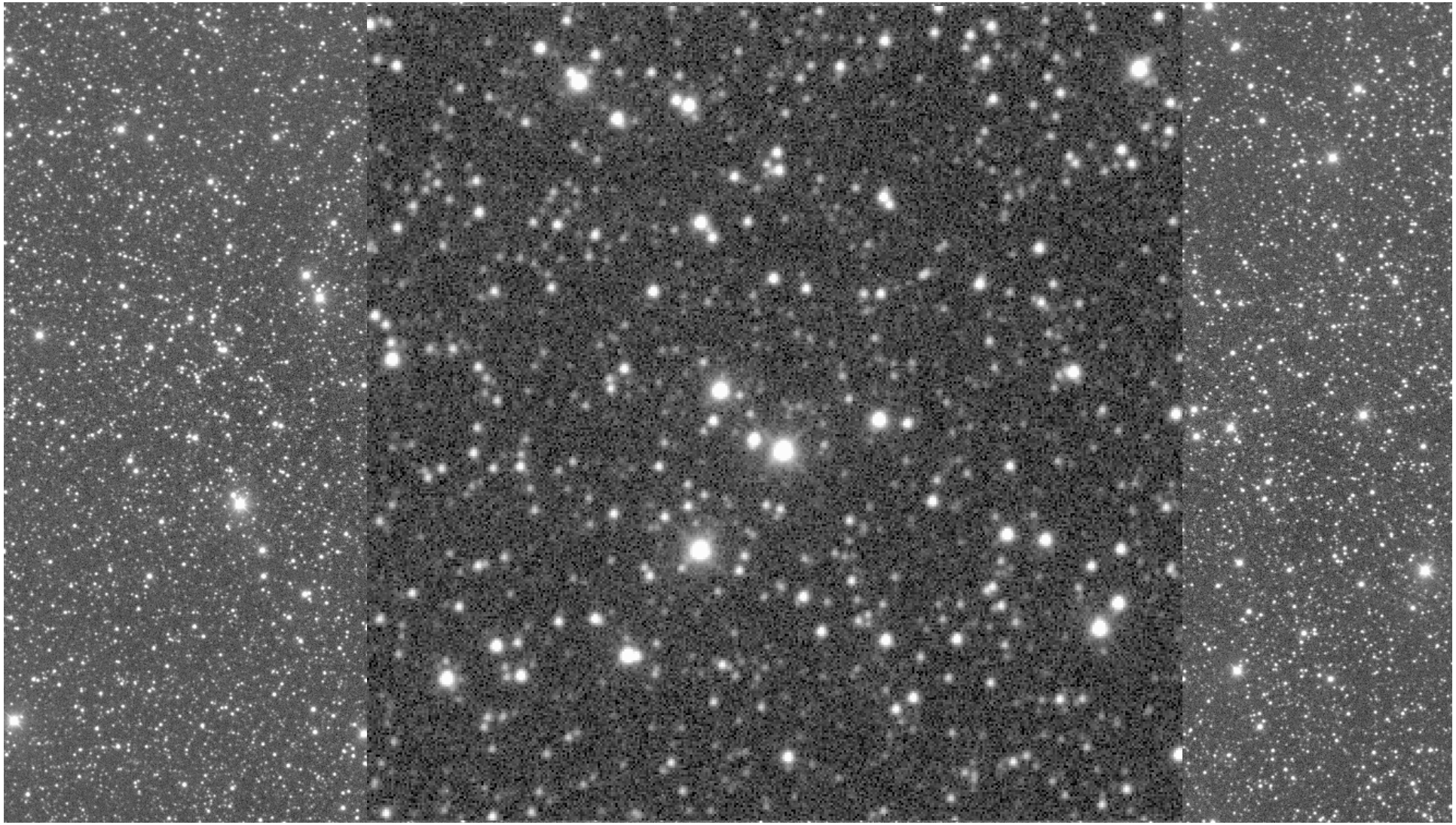
Observed fields

- 30 × 1° × 1° Stellar fields



- Each field is observed continuously during ~7 to ~30 days

ASTEP 400 : Image quality



Typical field

- ✓ FoV 1° x 1°
- ✓ ~10 000 stars at magnitudes up to R=18

Data reduction pipeline

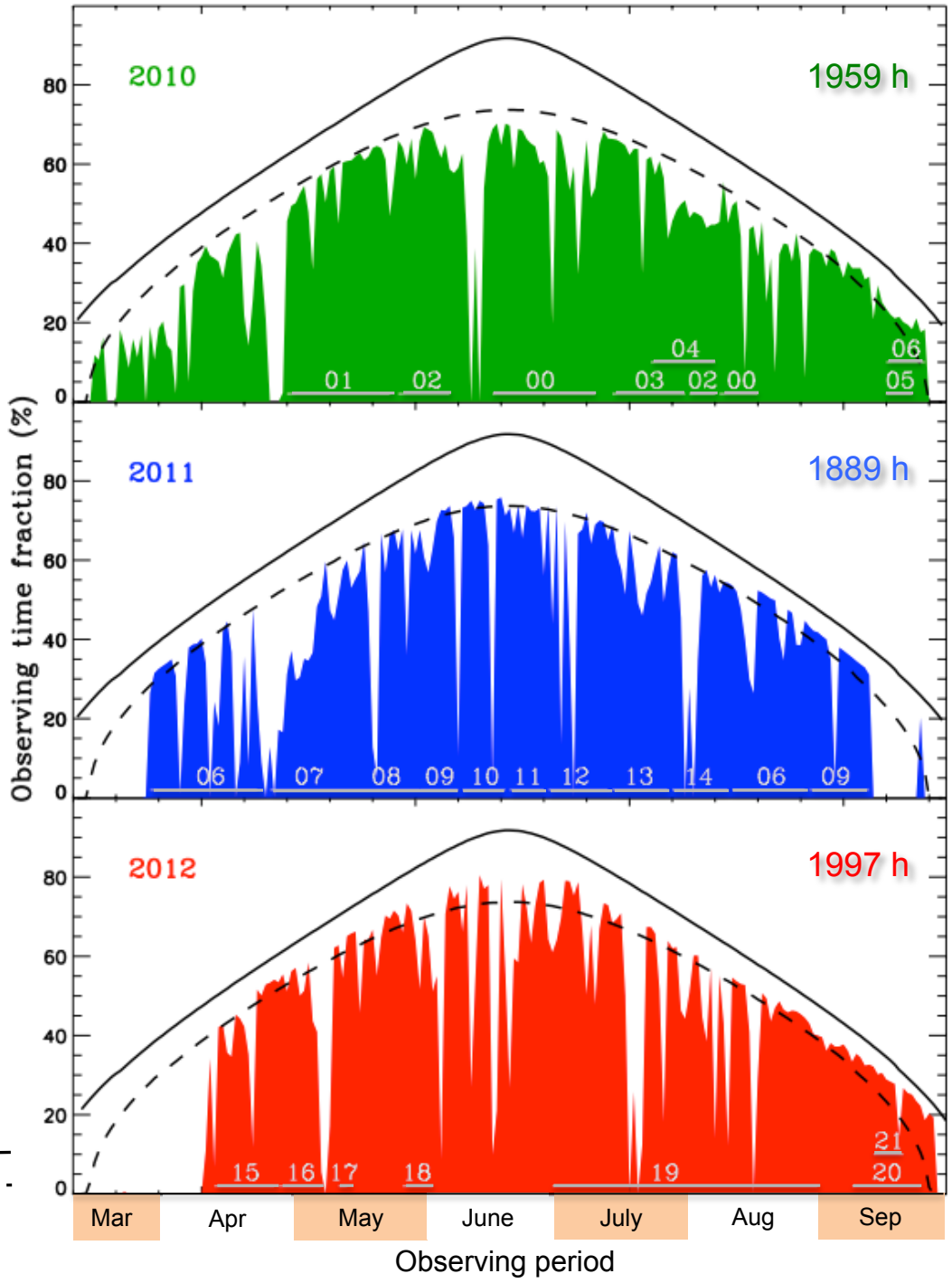
- Data
  - 400-600 frames/night [Science, Dark, Bias and Flats].
  - 15 GiB / Night, 6 TiB /Season
- 2 Custom pipelines
  - On-site aperture photometry pipeline @ Concordia
  - Quick enough to produce daily lightcurves, and send few tens to Nice
  - Accurate enough [few mmag precision] on brightest stars
  - Very useful for checking candidates on a daily basis
  - Advanced « image-subtraction » algorithm @ Nice
    [Optimal Image Subtraction, OIS, Miller et al., 2008, PASP, 120, 449]
  - Needs more computing time
  - More accurate than aperture photometry
- BLS algorithm to extract candidates with quatitative criteria
  [Box Least-Square, BLS, Kovács et al. 2002, A&A, 391, 369]
- Visual control and selection of candidates

2010-2012 data fully processed and analyzed
[2013 not processed yet]

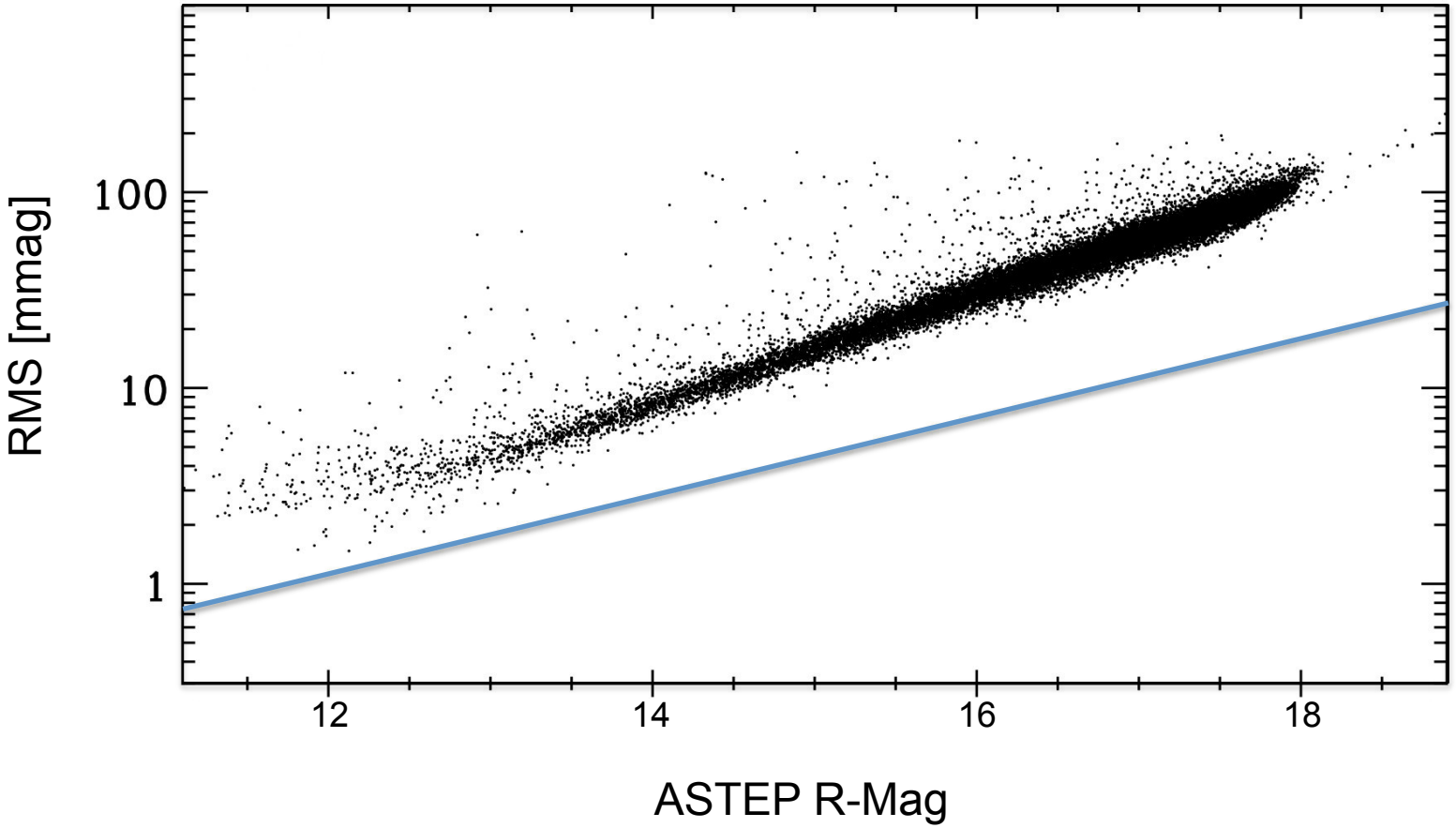
ASTEP 400 Duty Cycle

190 000 “Science” frames processed
and 310 000 stars analyzed

Sun @	
-9°	-13°
65.5%	81.3%
63.2%	78.4%
66.8%	82.8%



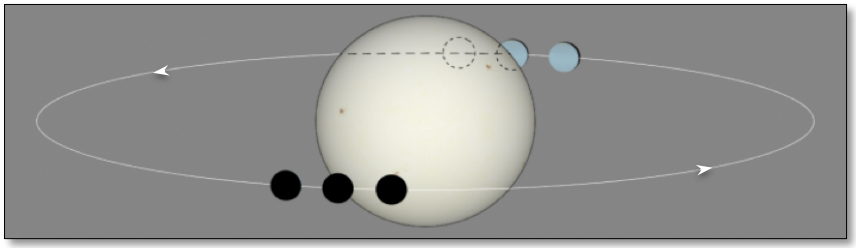
Noise analysis

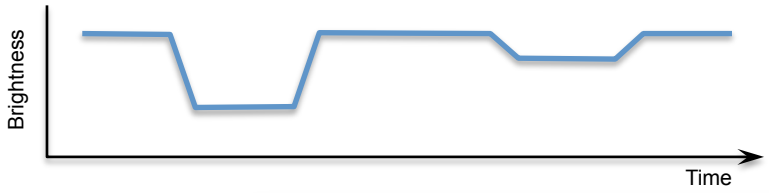


2 mmag (60 s exposure time) for brightest stars

ASTEP 400 Results : WASP-19b occultation

One of tthe shortest exoplanet orbital period [P=0.79 day (~19h), a=0.016 AU]

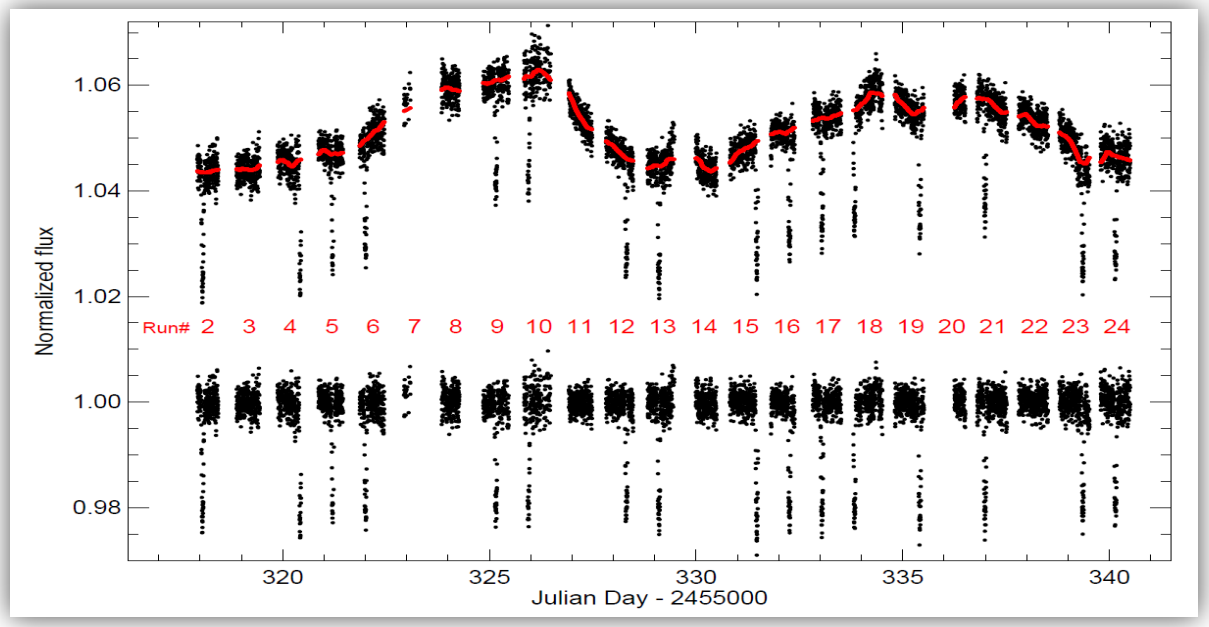




Data	Value	Notes
Average temperature	-68±7°C	
Exposure time	130 s	single frame
Frame periodicity	150 s	median
PSF FWHM	4 arcsec (4.3 pix)	median
Max. sun elevation	-10° to -6°	daily
Instrument Duty cycle♠	61%	
Overall data duty cycle	58%	~14hr daily
Science only data duty cycle	48%	

♠ fraction of time of instrument operation including science and calibration data, telescope and systems overheads.

24 days in May 2010
Very good global weather conditions

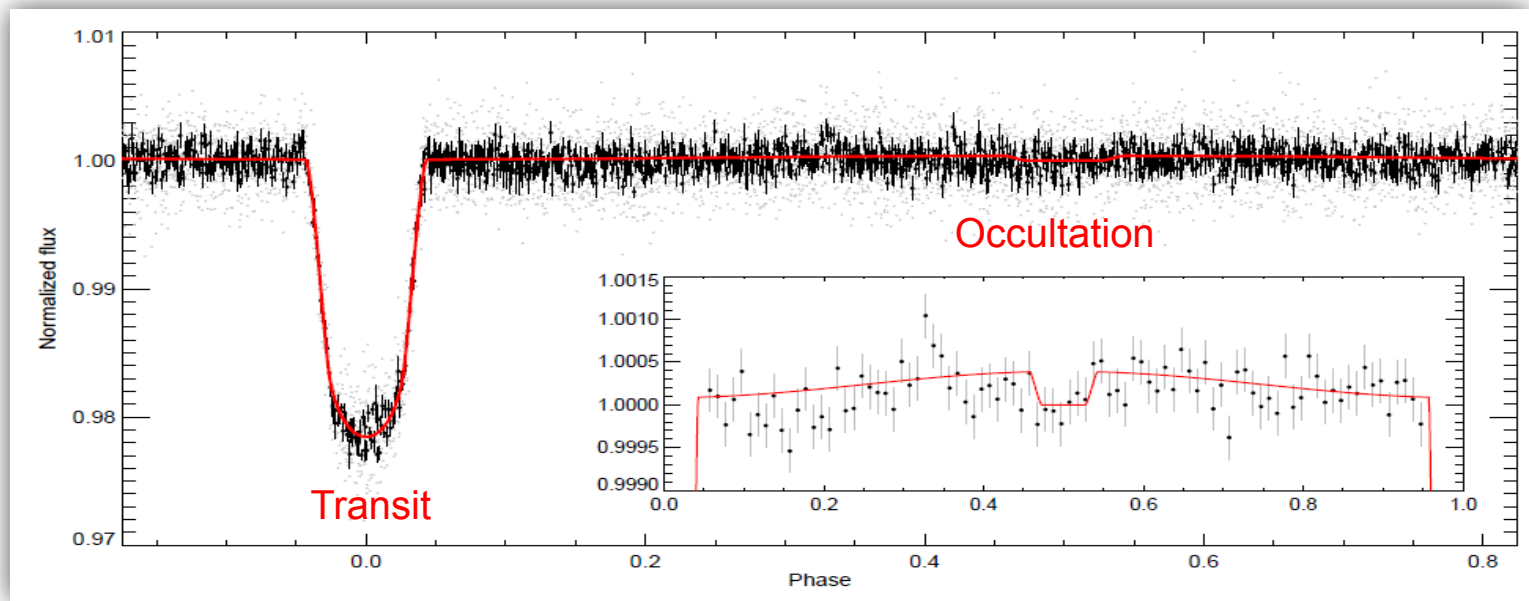


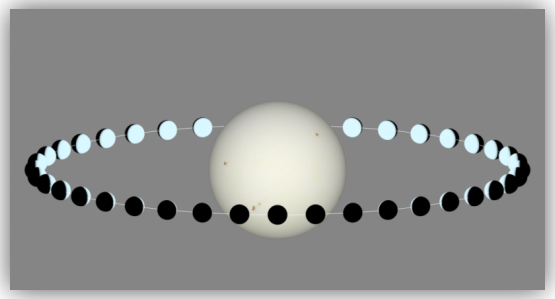
- Raw lightcurve from OIS processing [evidence of stellar activity]
- Filtered

Abe et al. 2013, A&A, 553, 49

ASTEP 400 Results : WASP-19b occultation

✓ Measured occultation depth of **390±190 ppm** with a 2σ significance





✓ Observed « Phase effect » present in the data consistent with a circular orbit

Abe et al. 2013, A&A, 553, 49

ASTEP 400 Results : Planetary candidates and Variables

2010-2012 Data

- ✓ ~ 2000 Variables & Binary systems
- ✓ 43 Planetary candidates

Radial velocity follow-up for 19 candidates

using WIFES on ANU 2.3 m telescope @ Siding Spring Observatory

Most candidates fainter than V~13 [require hours of integration time]

- ✓ 5 transit candidates are dwarfs that show no RV variations at the km/s level.

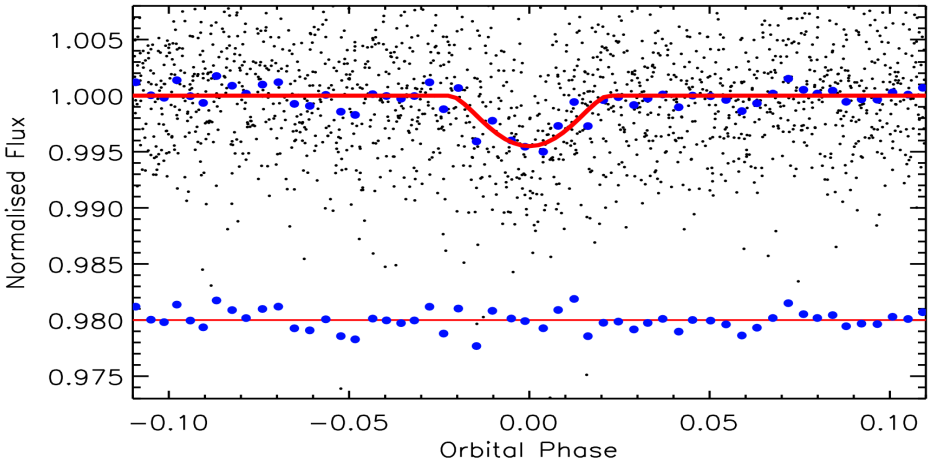
Possible good planetary candidates pending future detailed investigations.

ASTEP 400 Results : Exoplanet candidates

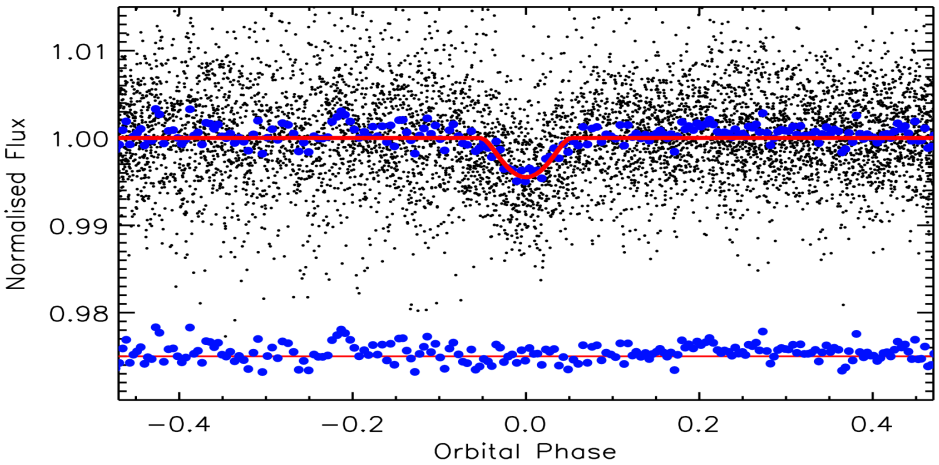
C2 A-009-0788-3195

MV=14.13

Period = 2.052 days
Duration = 2.178 hours
Depth = 0.01324
Teff = 6134 K
Dwarf. No RV variation within 2km/s



C12 A-009-3640-2734



MV=14.43

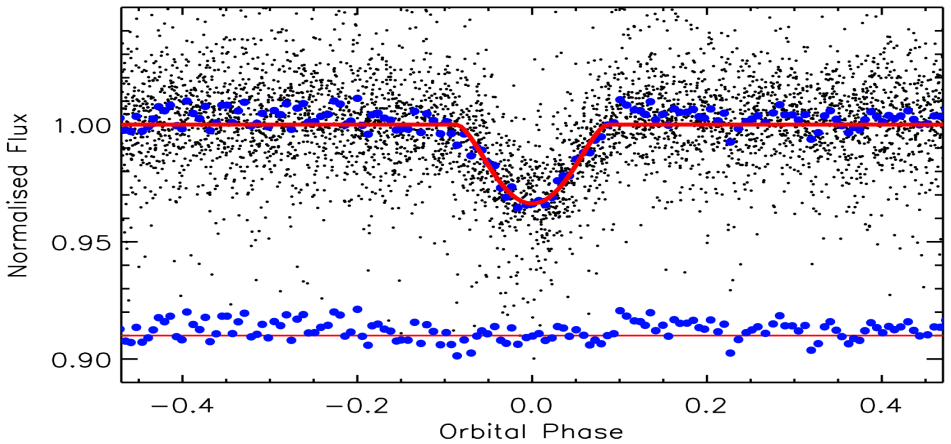
Period = 1.636 days
Duration = 3.749 hours
Depth= 0.00450

Rejected as Giant.

Mékarnia et al., 2015 to be submitted

ASTEP 400 Results : Exoplanet candidates

C19 A-021-2548-0316



MV=15.22

Period = 0.449 day
Duration = 1.77 hour
Depth = 0.0337

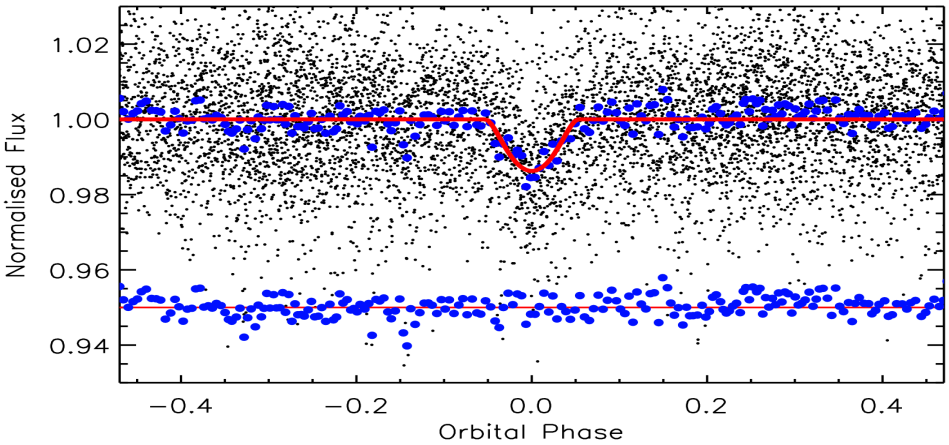
No radial velocity measurements performed

C3 A-009-3827-0876

MV= 16.50

Period = 0.527 day
Duration = 1.61 hour
Depth = 0.013

Teff = 6683 K. Present no RV variation at 5km/s



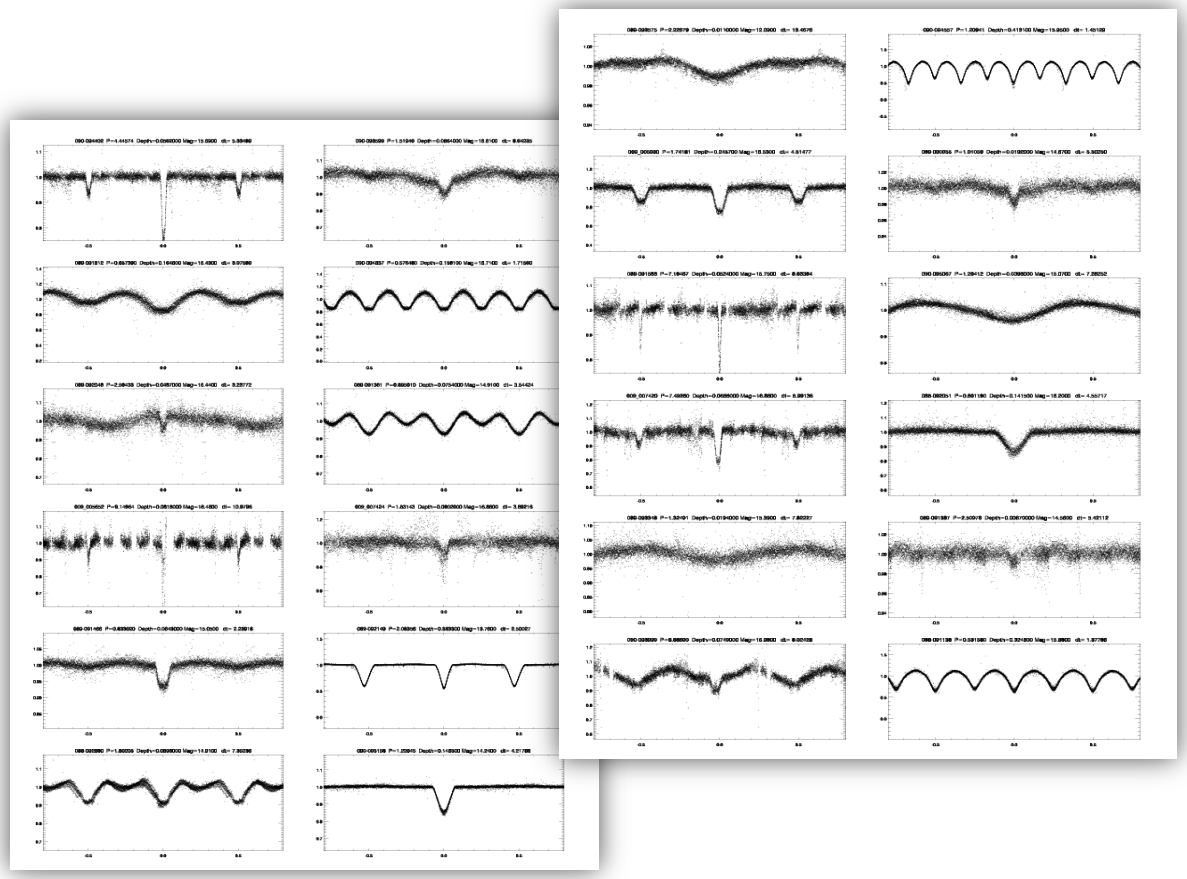
Mékarnia et al., 2015 to be submitted

ASTEP 400 Results : Variables and eclipsing binaries

~2000 variable stars [2010-2012] up to R-Mag~17

Classification in progress

[Eclipsing binary, δ Scuti, γ Dor, RR Lyrae, Stellar Activity, Long Periods and Unclassified]



Mékarnia et al., 2015 In preparation

ASTEP Lightcurve Database Service

Laboratoire Lagrange UMR7293, Université de Nice Sophia-Antipolis, CNRS, Observatoire de la Côte d'Azur

implemented by:
J. Gerakis - Observatoire de la Côte d'Azur

click here to access the service

DESCRIPTION — this page is the entry point to the ASTEP Lightcurve Database Service. The service allows external users to search for lightcurves in the ASTEP database. Note that only ASTEP 400 telescope data are currently available.

QUICK TUTORIAL — by clicking on this link, you will find useful information on how to use the service web interface to browse and retrieve (lightcurve) data.

ADVANCED TUTORIAL — the advanced tutorial will explain to you how to you use the service along with Virtual Observatory tools such as TOPCAT.

RELATED LINKS & DOWNLOADS

- A paper describing the ASTEP candidates is available here.
- Browse the candidate list using the service.
- Download the candidate lightcurves as a ZIP archive.

MISCELLANOUS LINKS

- TOPCAT software and SAMP web profile feature from Mark Taylor at the Bristol University
- Centre de Données astronomiques de Strasbourg : VizieR catalogue (using Vizquery) and The ALADIN interactive sky atlas

Plot and visualize your queries results with the TOPCAT utility.

For instructions and credits see the FAQ.

You may also read the description of all database fields description.

(Contact information)

Summary : The ASTEP Experience

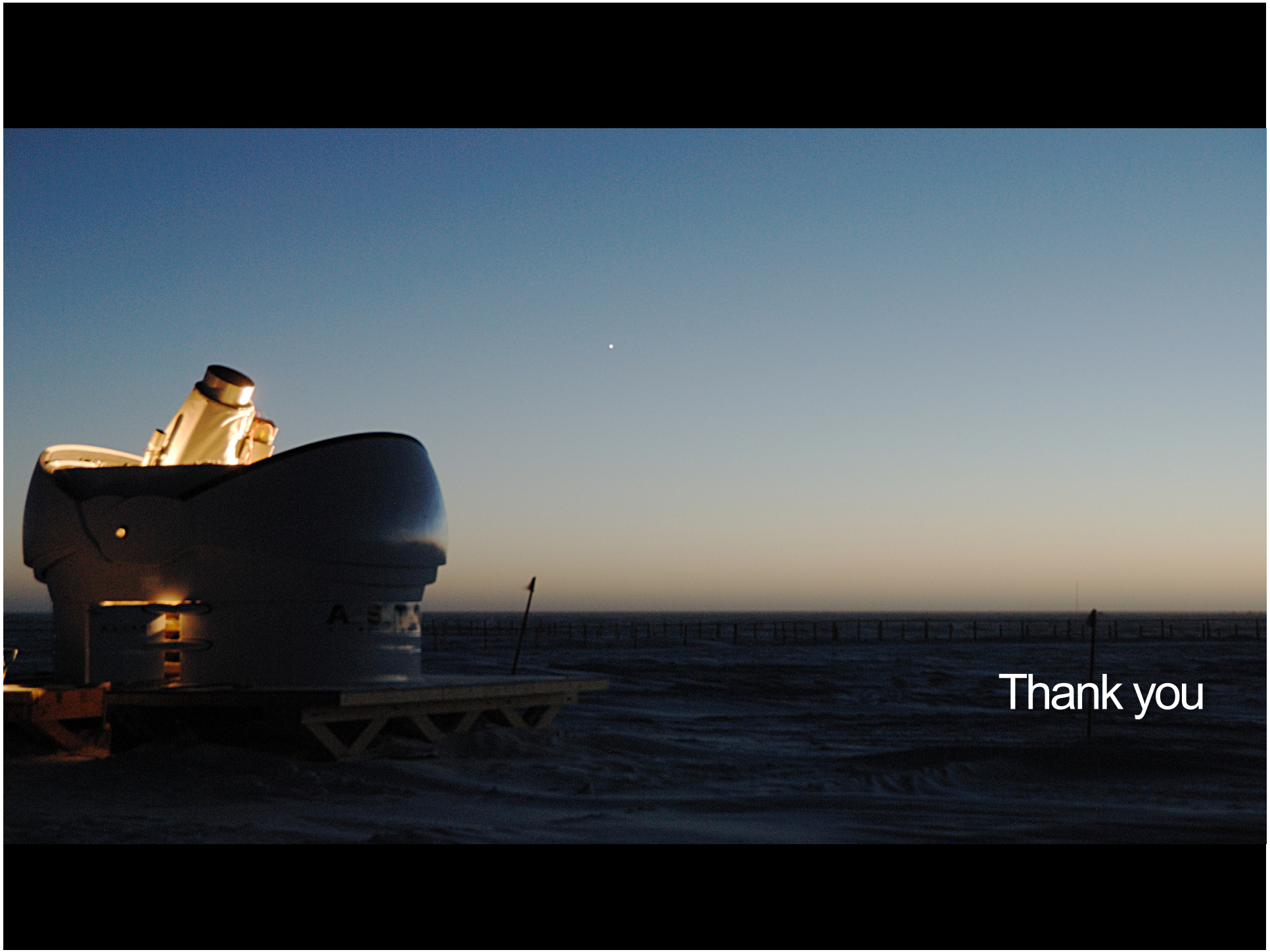
- ✓ Successfull operation of the instrument
  - Initial goals almost completely fulfilled
  - ASTEP 400 showed that Dome C is ready for Astronomy

- ✓ Technical issues
  - Coping with harsh conditions is not easy [temperature variations, white-out, …]

- ✓ Exoplanetary Science is rapidly growing
  - The strong advantage of Antarctica is the possibility to do continous observations in the IR

Future : International Collaboration

- ✓ Exoplanetary Science is rapidly growing
- ✓ Combined Visible and IR observations are important for characterising exoplanets.
- ✓ ASTEP + AST3/IR at Dome C would benefit from the great conditions there and the logistical support


Thank you