ARENA
Interferometry Working Group

- Coordinators:
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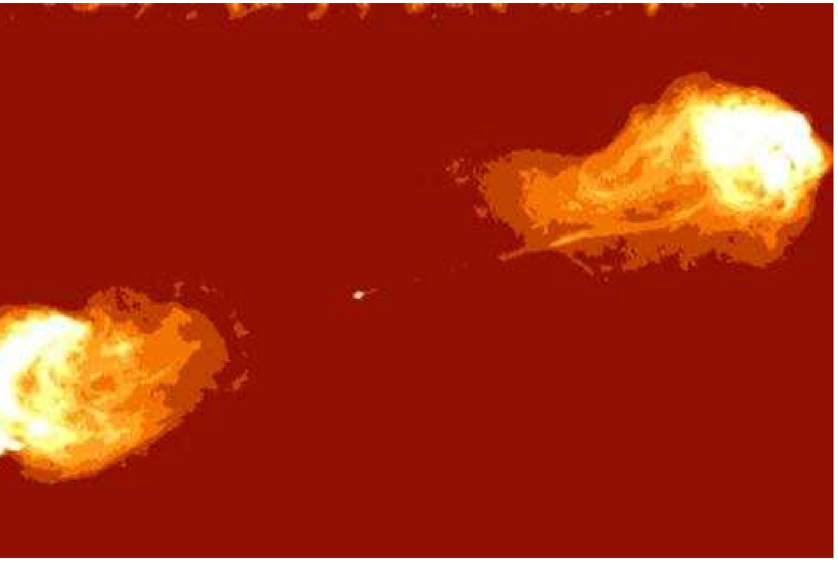
  - V. Coudé du Foresto (LESIA, Obs. Paris)
- Industry & Agency partners:
  - C. Jamar (AMOS)
  - M. Barillot (Thalès Alenia Space)
  - IPEV: Y. Frenot
- Science support team
  - O. Absil (LAOG, Grenoble): modelization
  - E. di Folco (Geneva Obs.): observing strategies
  - C. Eiroa (UAM Madrid): input catalog
  - F. Vakili (Fizeau, Nice): instrumental concepts

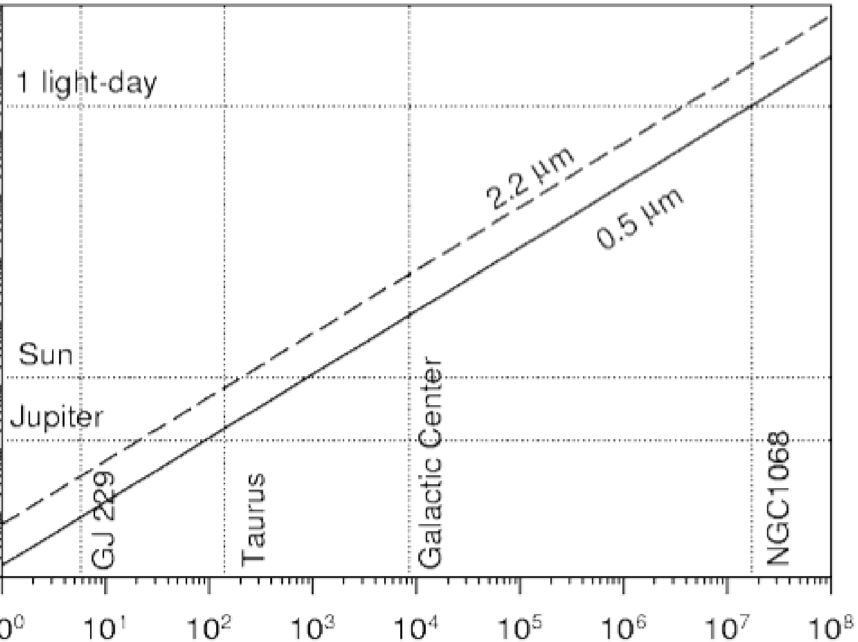
Mandate

Group activity

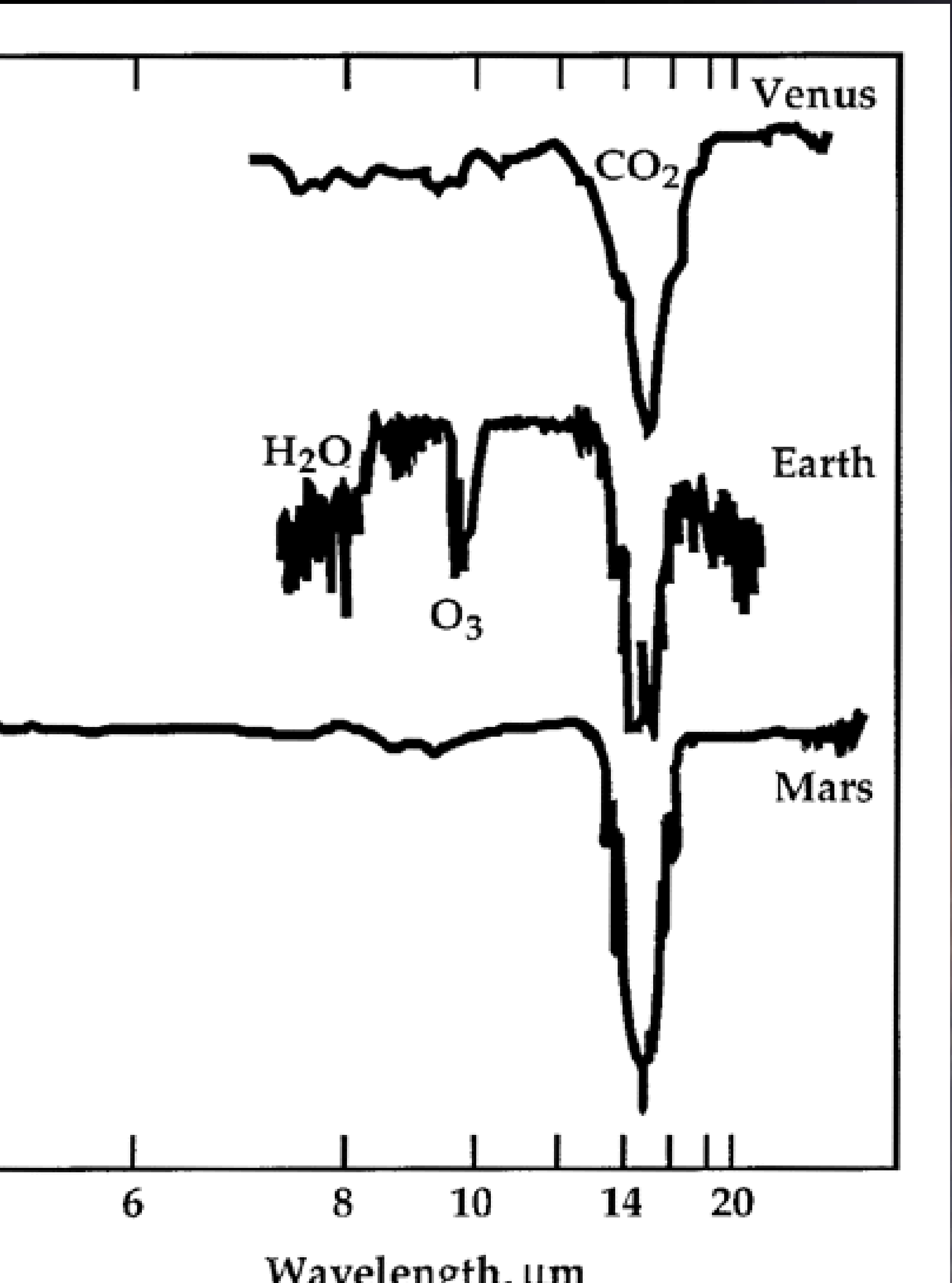
+ Documents available

The long term perspective



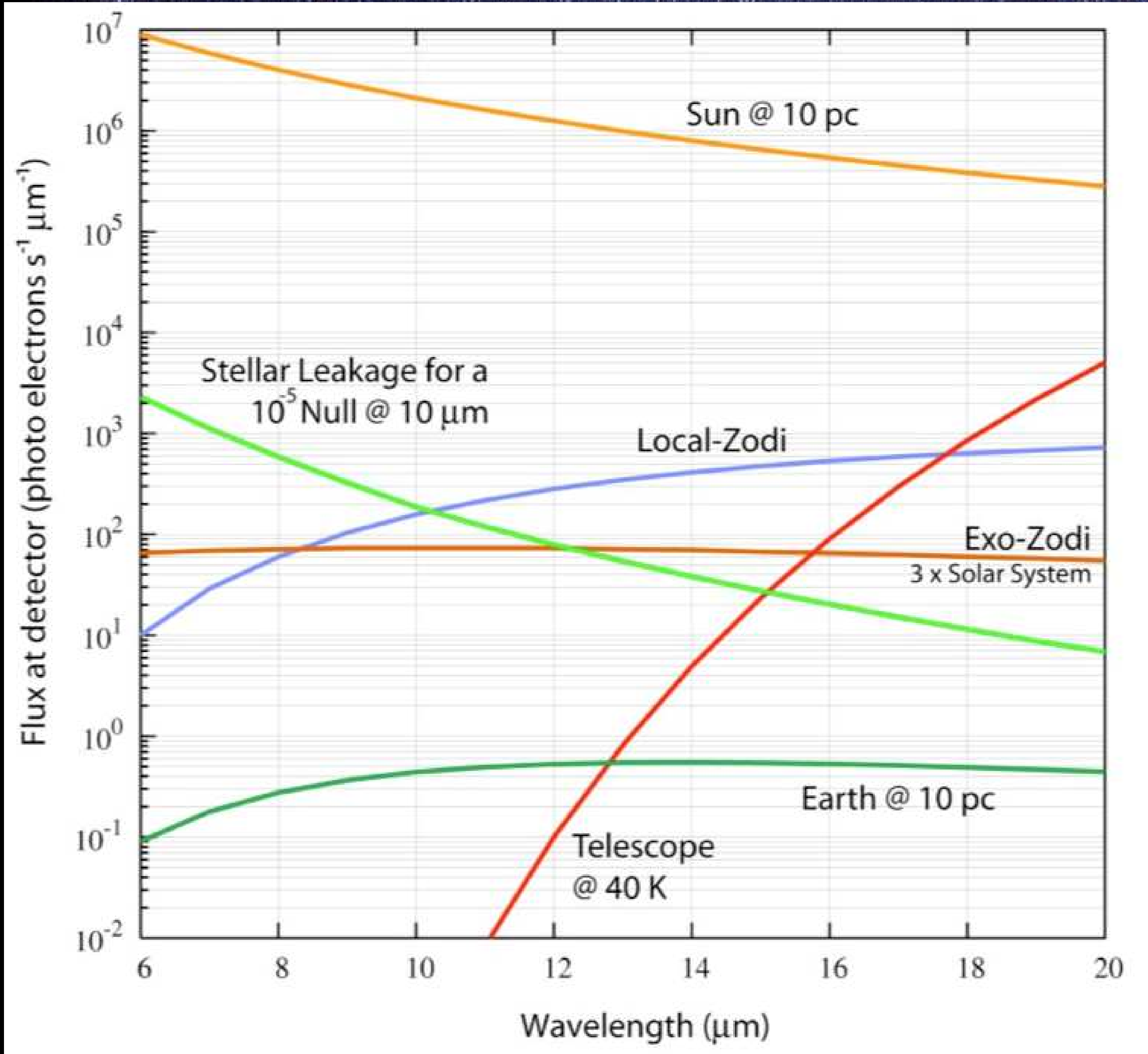


- Complex imagery capability at sub-mas resolution
  - Think of an optical ALMA (or VLBA)…
- Full-sky coverage
  - Enabled by uniquely large isoplanetic pa[t…]
    on Antarctic plateau
- Profundly impacts all domains of astrophysics
- A massive, complex machine (post-ELT?
  - Kilometric optical / IR array
  - Many telescopes, delay lines
  - Dual field for faint objects


Venus
CO2
H2O
Earth
O3
Mars
6
8
10
14
20
Wavelength, μm

What does it take to characterize exo-earths ?

Caveat: exozodiacal light ?

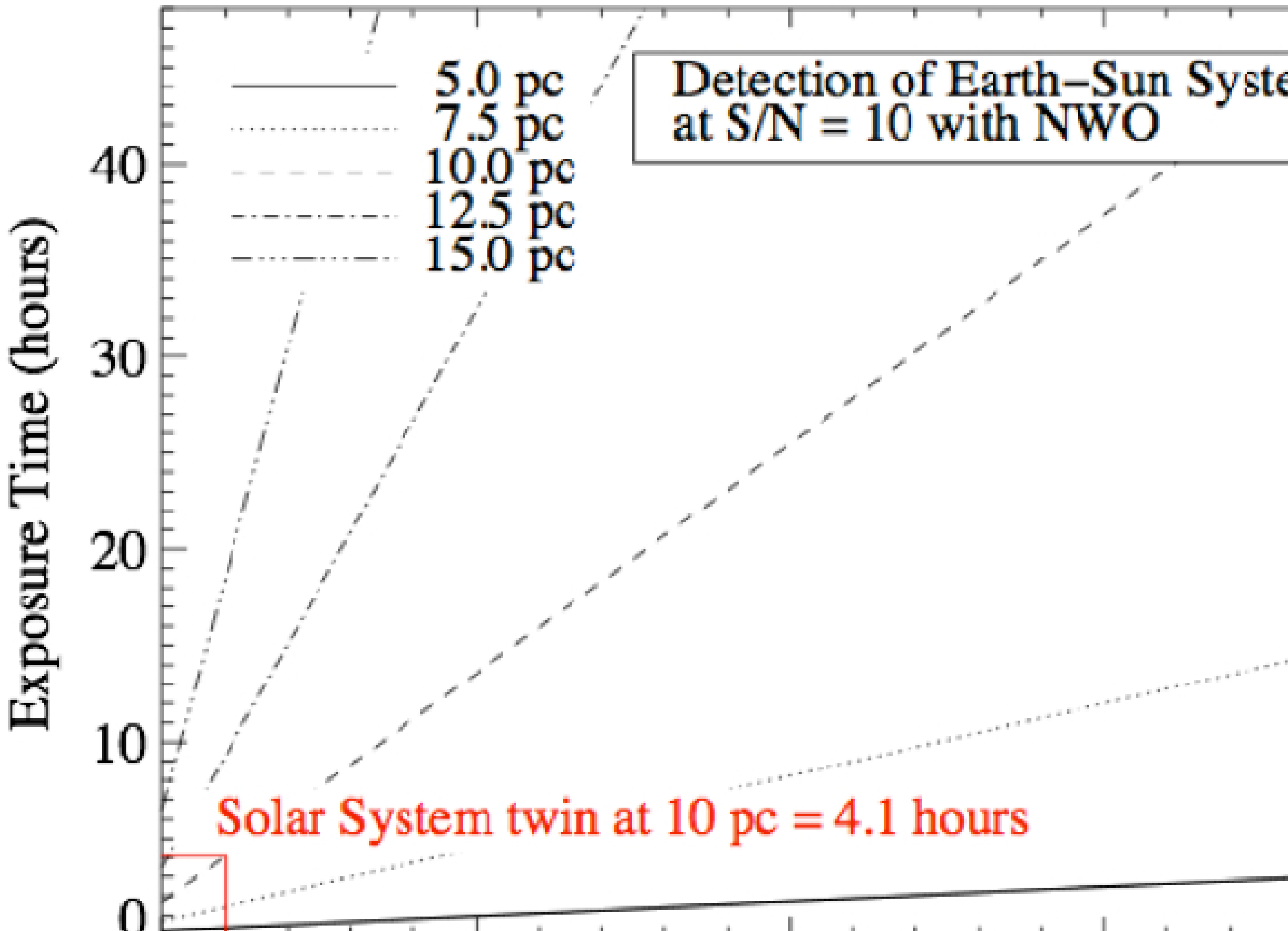


Source: DARWIN CV proposal

Even in visible light…

Cash et al. 2

Quic
déc
sont requis pour



So, why an exozodi explorer ?

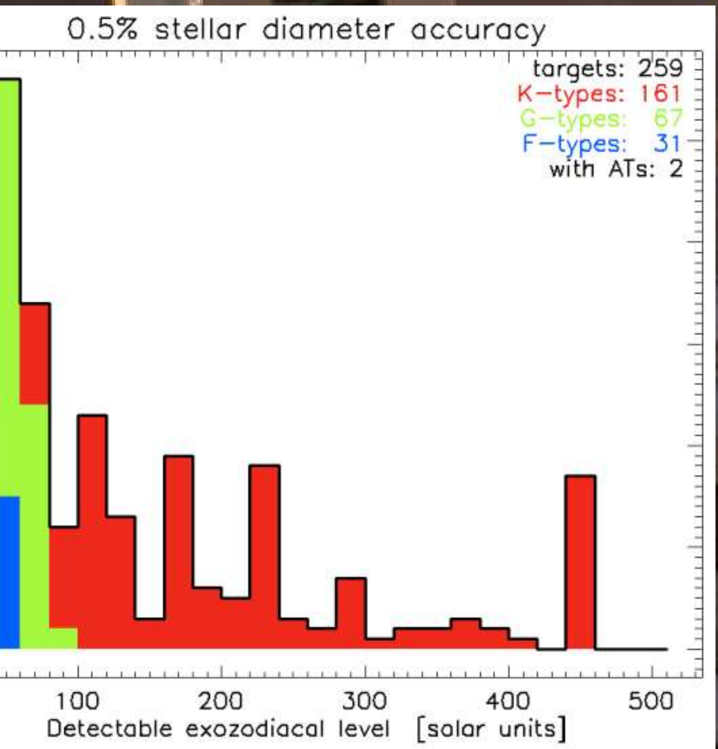
Exozodiacal characterization [...] is critical
for future characterization of habitable Earth-size planets.

Exoplanets Forum report (2008), p

- To optimize the definition and mission profile of a future space mission dedicated to the spectroscopic characterization of habitable planets
  - Correctly dimension the duration of the mission
  - Prioritize systems for which exozodi is not the dominant noise source
- To understand the exozodi phenomenon as a boundary condition of planetary systems formation

Building a pathfinder retires risk well ahead of the project
and has to be seen as
a sound *investment* towards a 1.5B€ space mission

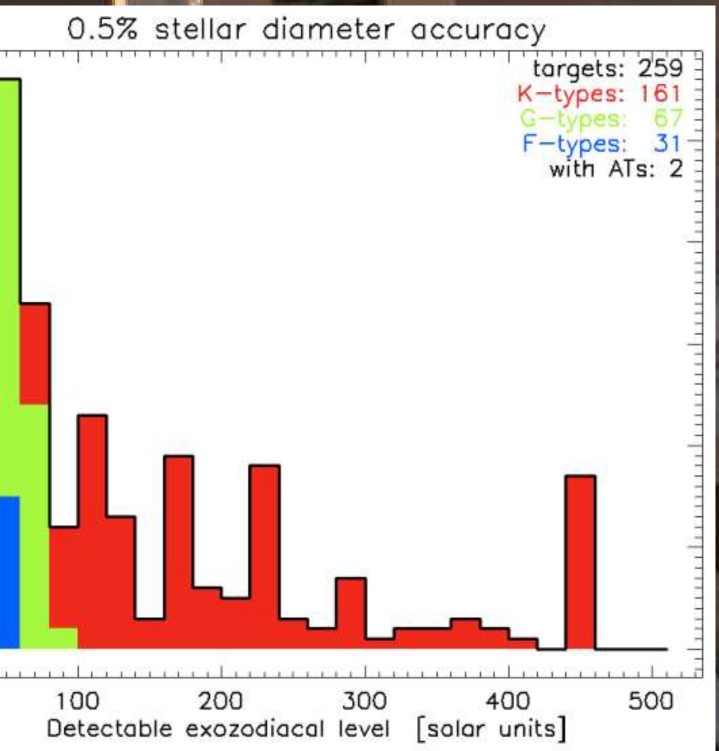
Ground-based European Nulling Experiment



tectability of exozodis
the 259 GENIE sources

- Context:
  - Potential need identified by ESA
  - ESO/ESA collaboration
- 2004/2005: phase A study
  - Concept: VLTI L band nuller instrument
  - Performance constrained by environment
  - Complex (estimated cost 20M€)
  - Must compete with other users for access t facility

Ground-based European Nulling Experiment



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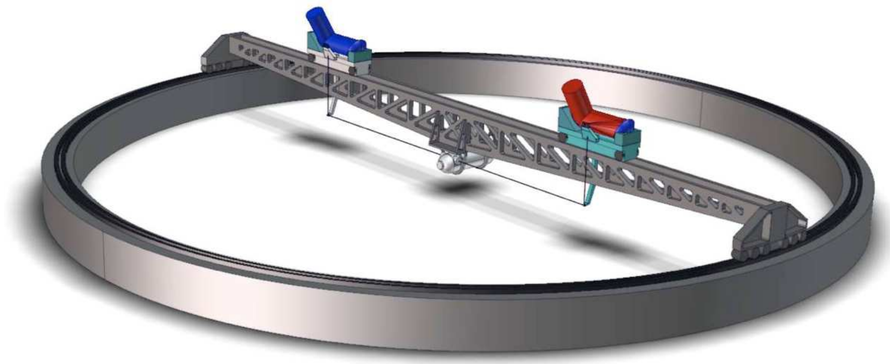
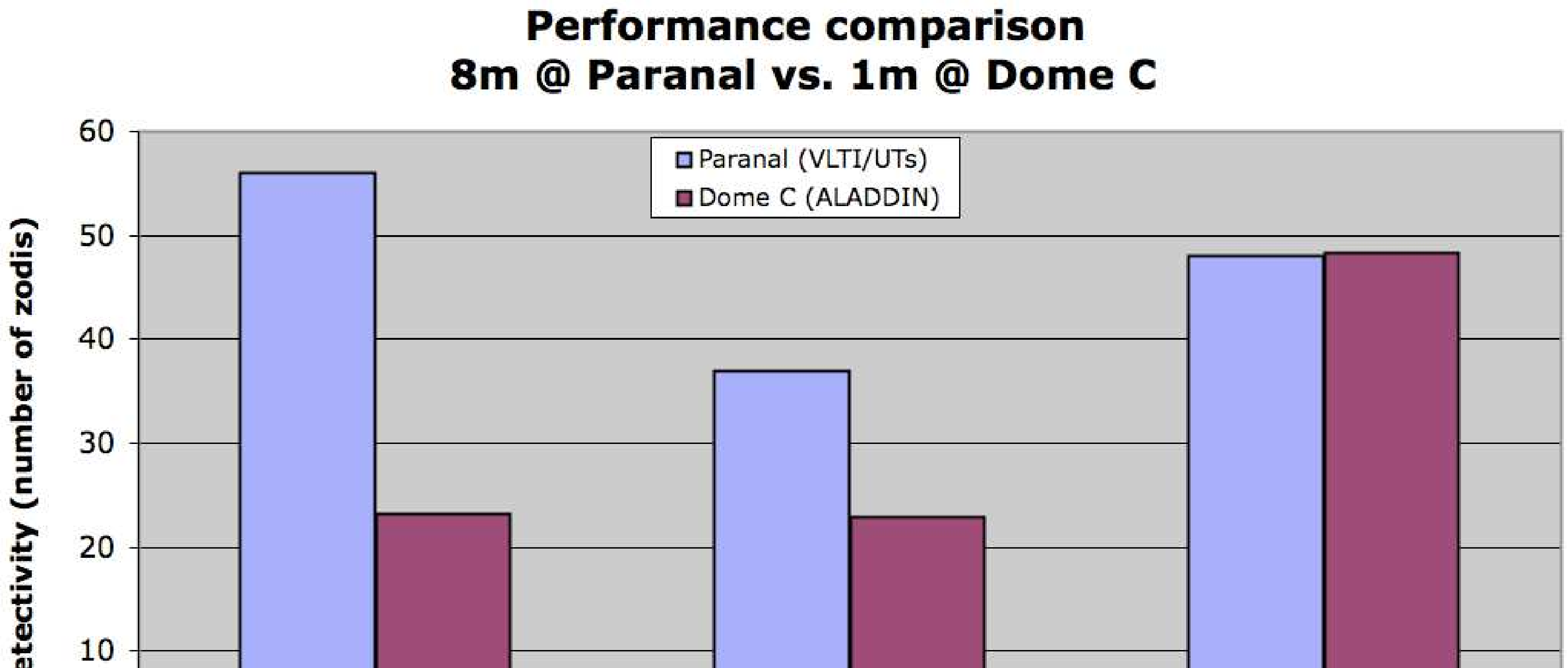
Site performance comparison

x 8m – Paranal

2 x 1m – Dome C





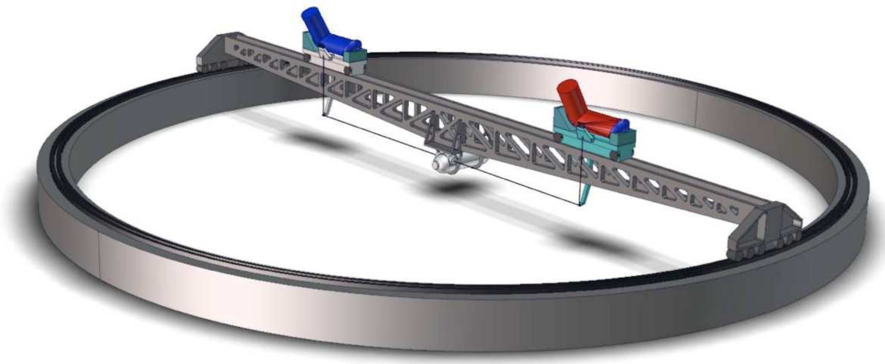
Absil et al. 2
A&A ***475****, 11*

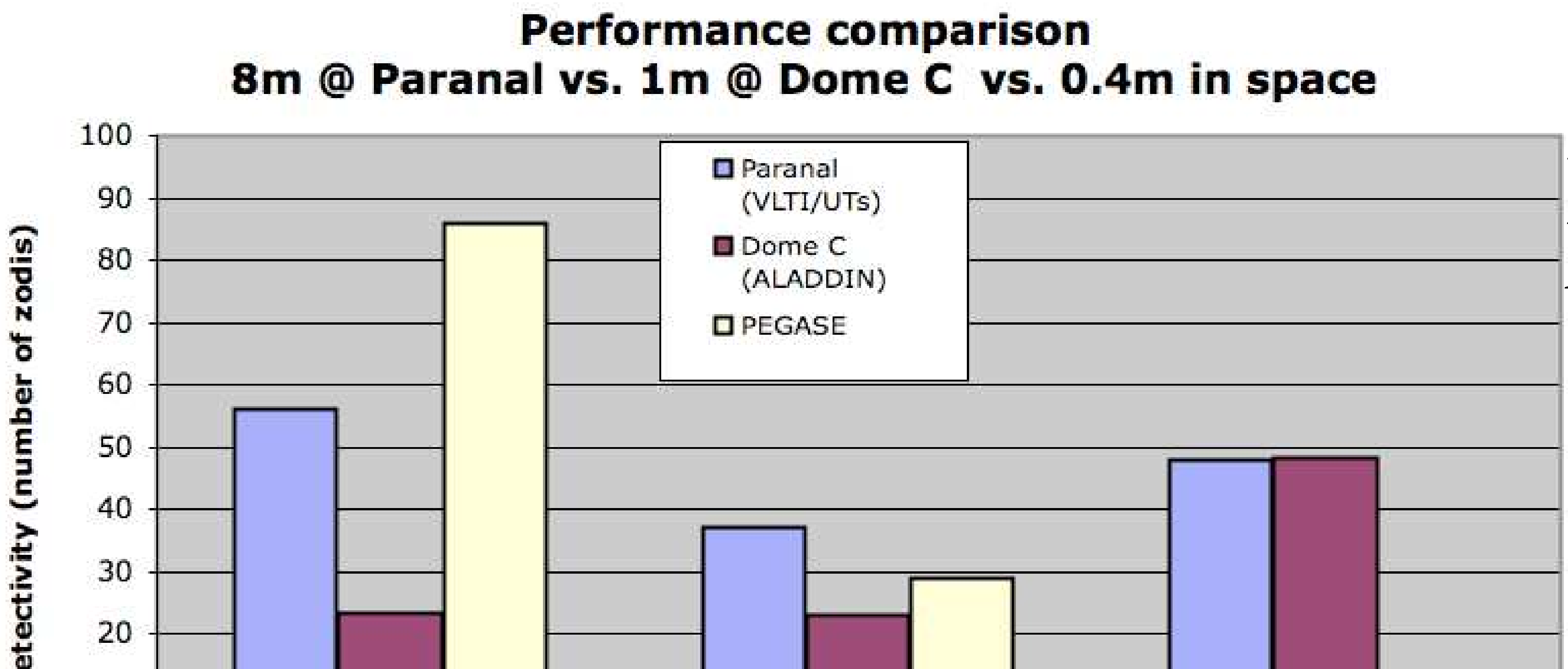
Site performance comparison

8m – Paranal

2 x 1m – Dome C

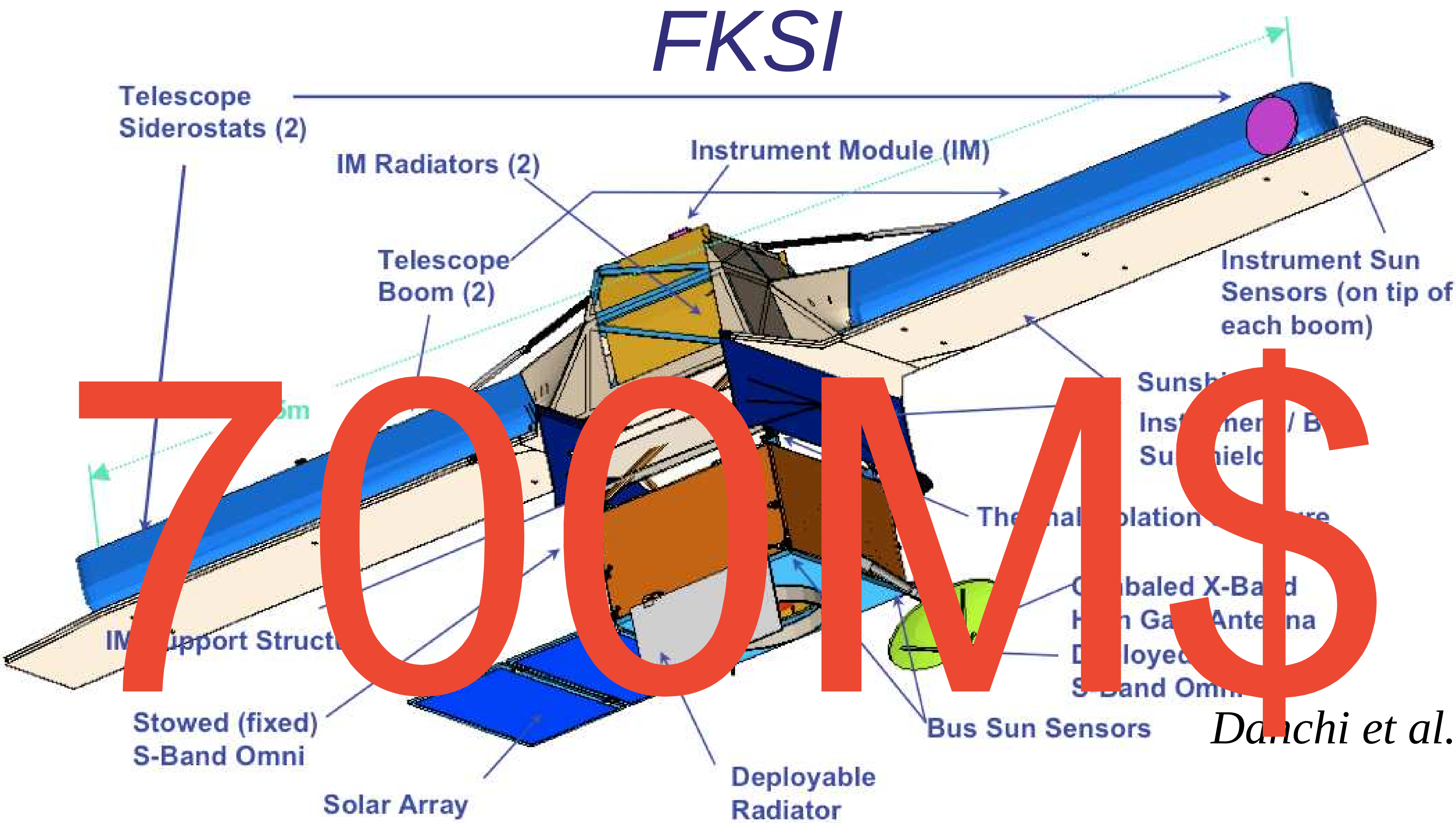
2 x 0.4m – Spa





PEGASE sin
Defrère et al
A&A ***490****, 43*

The ideal interferometric precursor looks like…



What is needed for an optimized exozodi pathfinder

- Go to the best possible location
  - Antarctic plateau features low thermal background and large r_0, long $|_0$, above ground turbulence layer
- Build a dedicated facility
  - Full access to observing time
  - Optimize design at the system level
  - No compromise due to integration into existing infrastructure
- Integrate development, deployment, operations into the concept
  - Realistically emulate a space mission (minus the launch)

The ALADDIN approach

(Antarctic L-band Astrophysics Discovery Demonstrator for Interferometric Nulling)

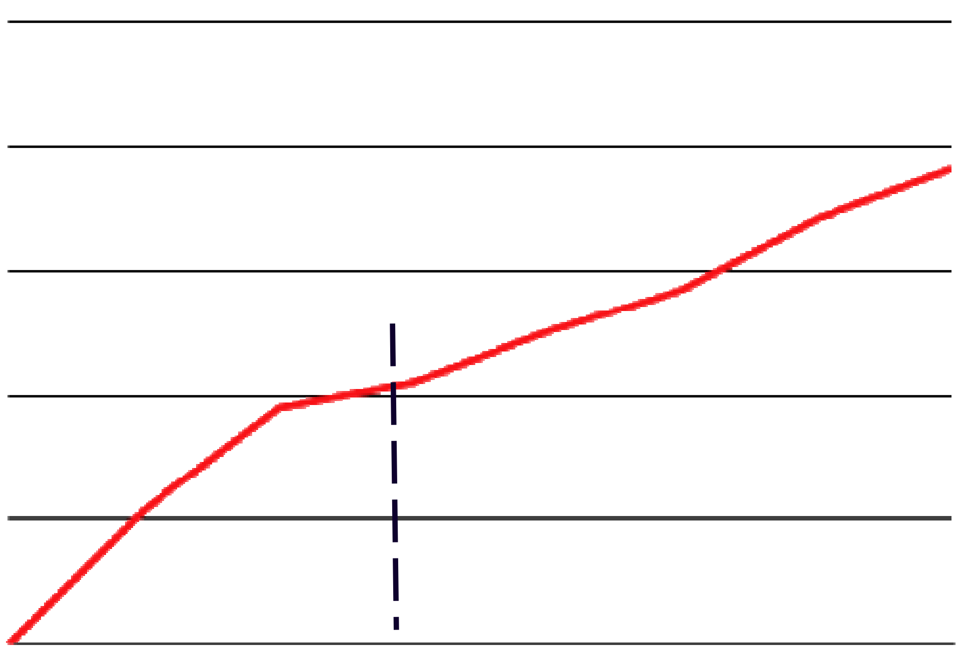
The ground layer issue

Weather constraints (winter)

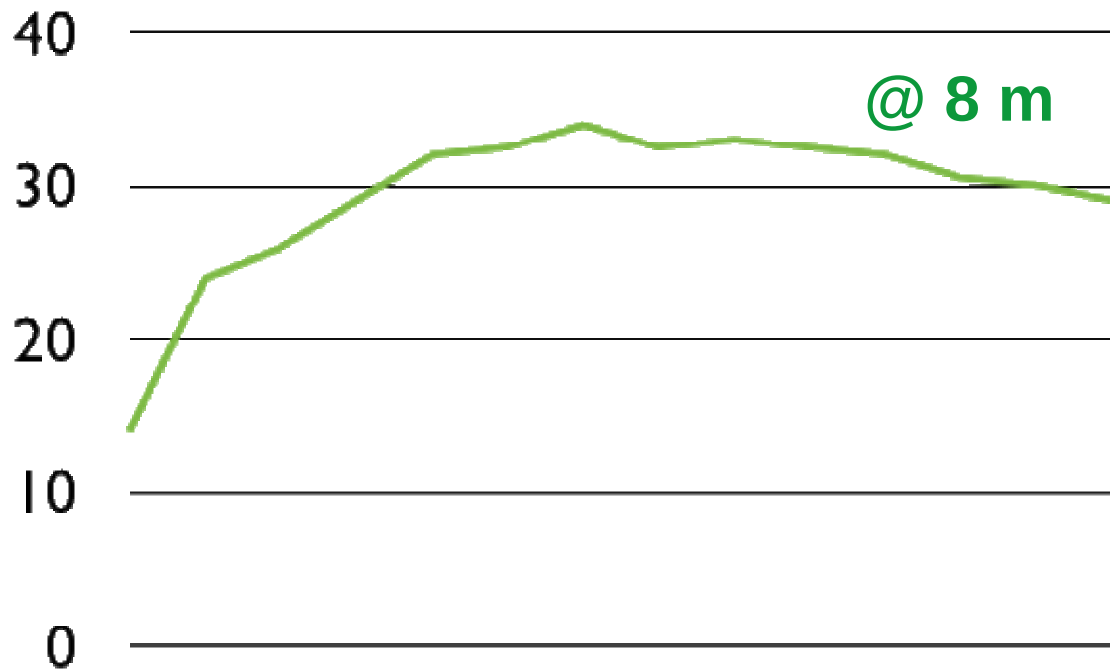
– 18m height => ~50% of down time in winter (seeing)

– Limitation: time frequency of good seeing periods

robability of beeing in free atmosphere



Duration of continuous seeing period (m



Strawman Design - Infrastructure

Claude Jamar

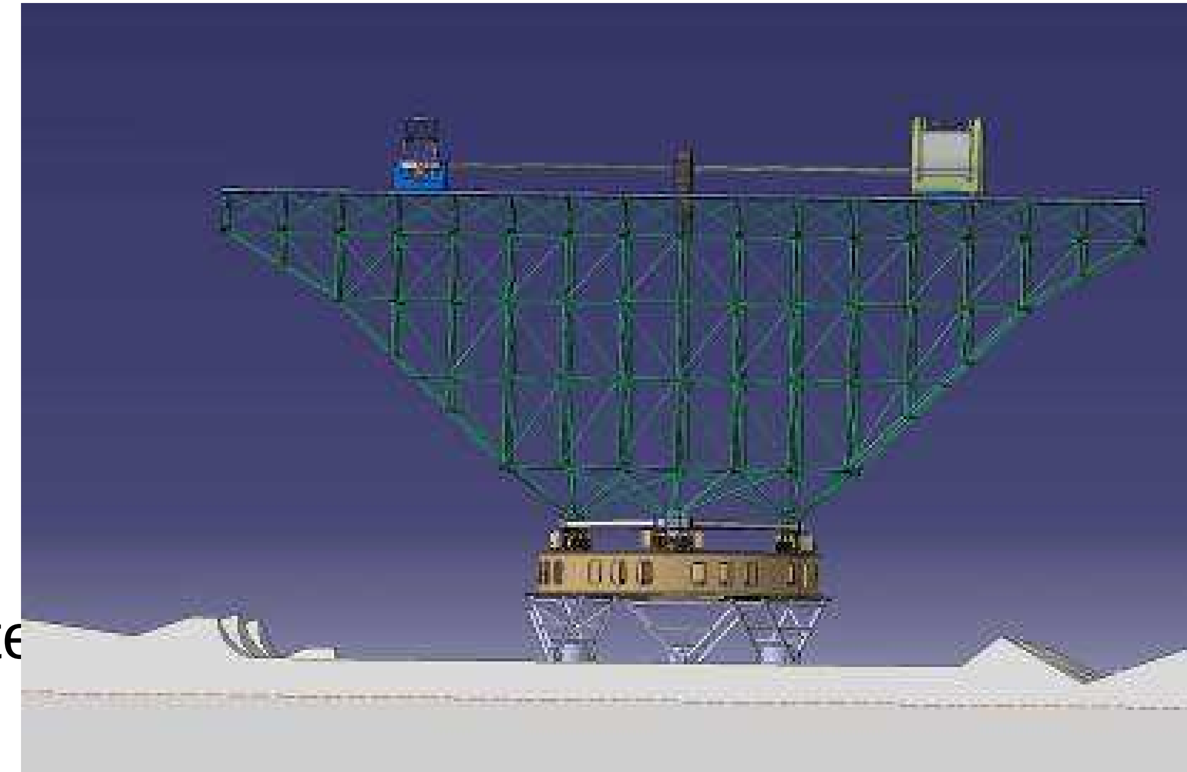
Contents

rinciples

strumental parameters

om bottom to top:

- nterface with compressed snow
- Circular track
- Track and bogies
- Wheels and bogies
- Leveling
- General view of the bottom of the syste
- Telescopes
- Nulling instrument



Instrumental parameters

Baselines: from 3 to 30m

Altitude above the snow level: 18m

Telescope diameters: 1m

Waveband: 3.1 – 4.1 µm (L-band)

Warm optics temperature >210K

Cryogenic temperature of the detectors: 100K

Fringe sensing: 2.0 – 2.4 µm (K band)

Tip-tilt sensing: 1.15 – 1.3 µm (J band)

nterface with compressed snow

Feet of the Concordia buidings

- The ground surface at Dome C is made o compressed snow with a density of a maximum of 800 kg/m³
- The structure will be deposited on the sn surface on 3 feet such as the Concordia station buildings themselves. The pressu accepted by the snow layer being 0.2 bar load shall be kept below 2 tons/m².
- For a typical mass of the structure e.g. 12 tons, the total interface area shall therefo be 60 sq.m.
- Each foot of 20 sq.m has to be adjusted t keep the track horizontal.

Circular track

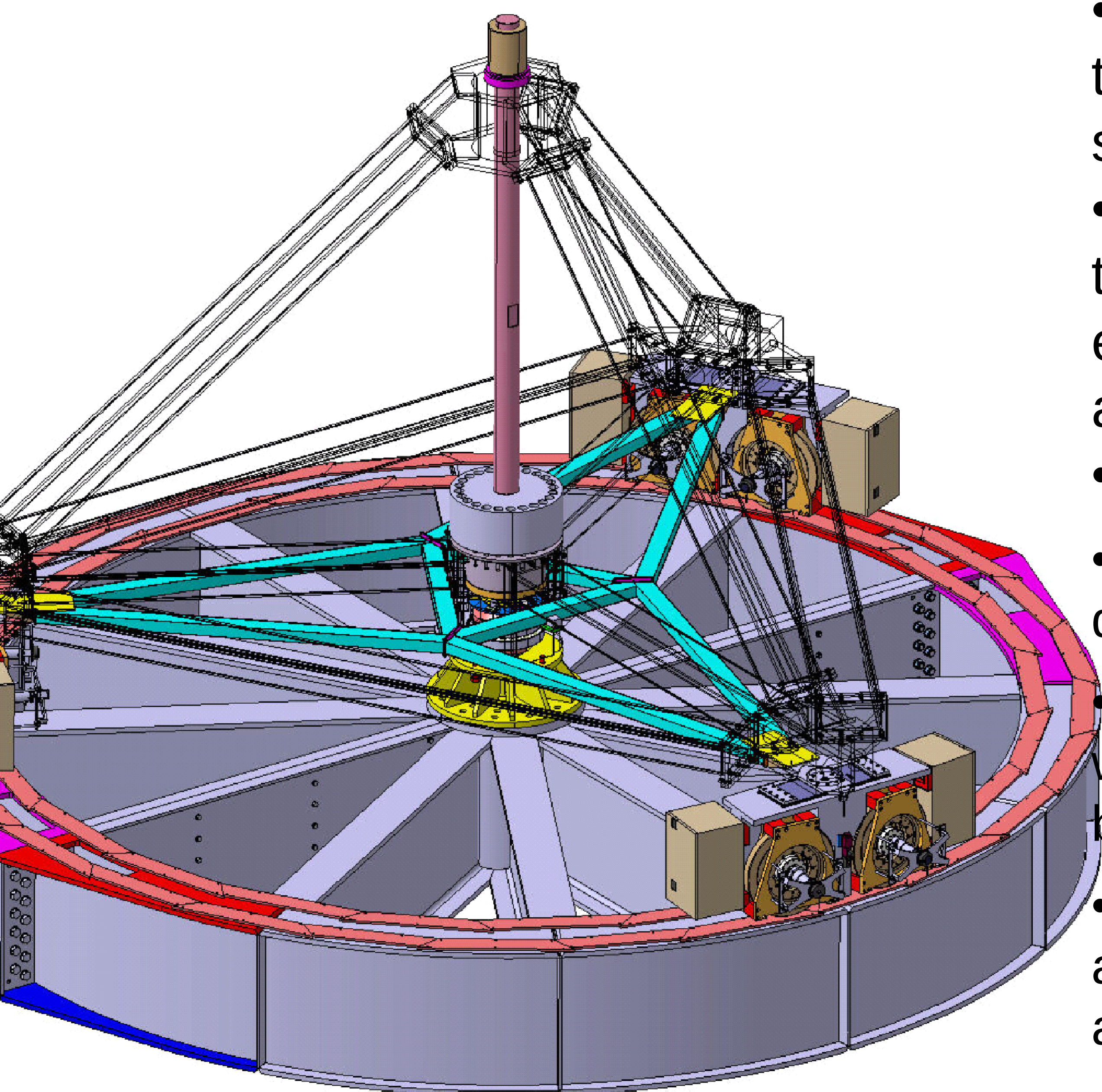
An annular structure supporting a track which allows the azimuth motion

The diameter of the track has to be about 8m with flatness of about 1 mm/m. The track is about 4m above the snow level and lies on a cylindrical annulus structured to allow wind to pass through the structure and avoid the accumulation of snow.

The horizontal position of the track is measured by inclinometers providing the information needed to actuate the motors of the feet.

The track of hardened steel material shall be made of pieces which can be accommodated in standard containers. It will be reassembled on the site.

Track and bogies



• The angle between the plane defi
the track and the horizontal plane is
smaller than 10 arcmin (3 mm/m).

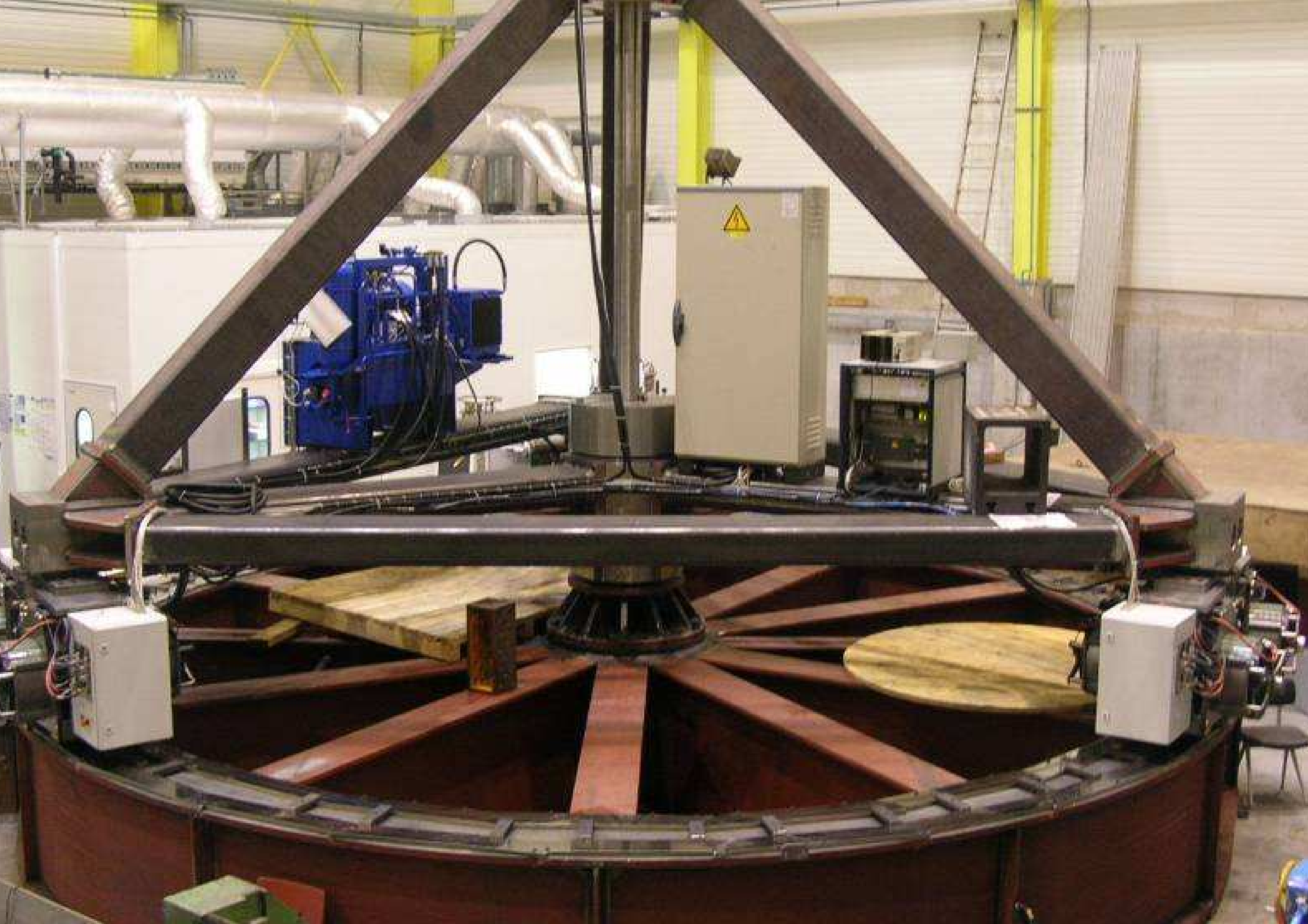
• The annular track is radially interf
to a central bearing with a central a
encoding facility to define the positi
azimuth of the superstructure.

• The general strategy of leveling is

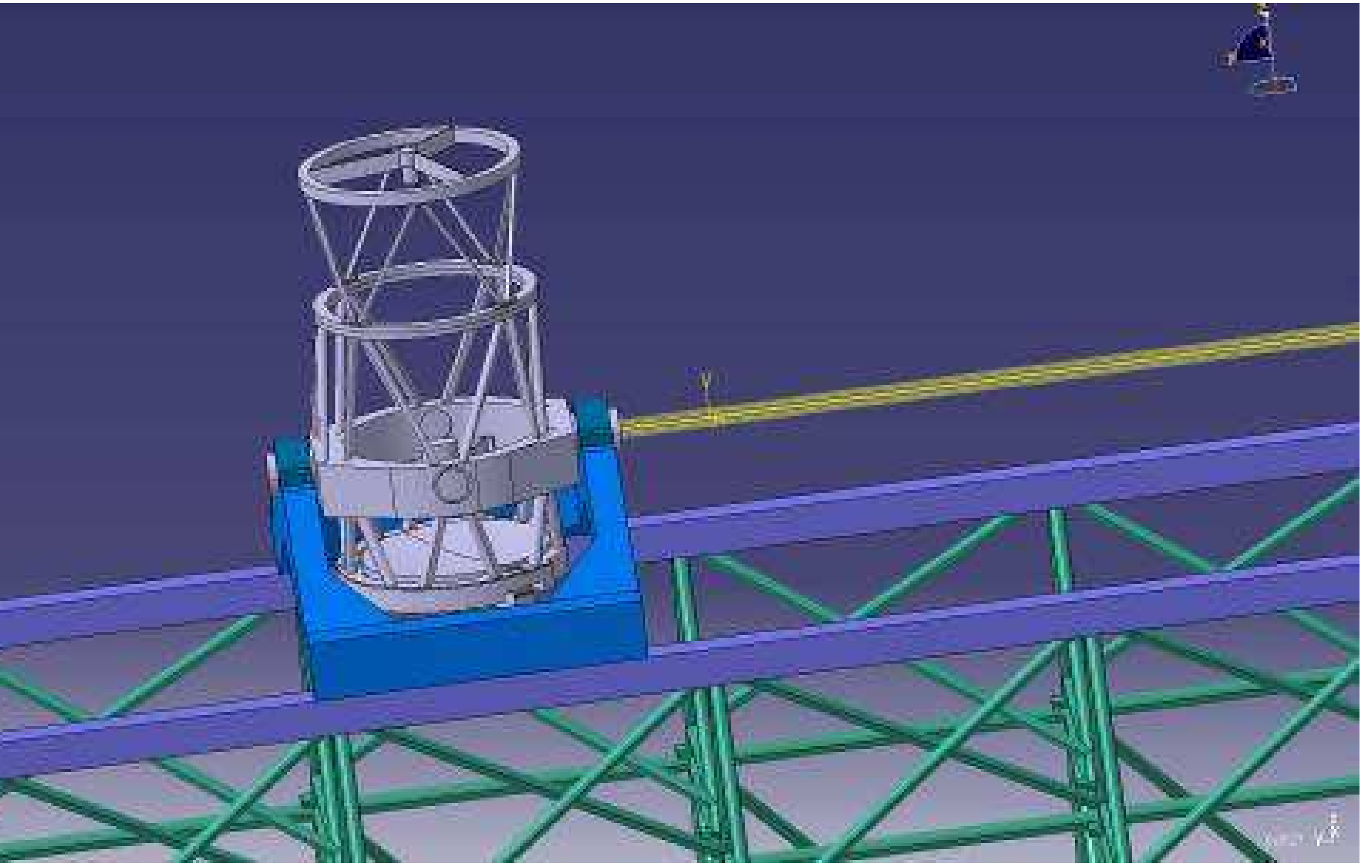
•At very low frequency (once every
day/week?) the level is got by the 3 m

•During the azimuthal rotation, the leve
with a bandwidth of few Hz by the acti
bogies.

•The vertical flexure between feet of th
annular structure is compensated by th
active bogies.



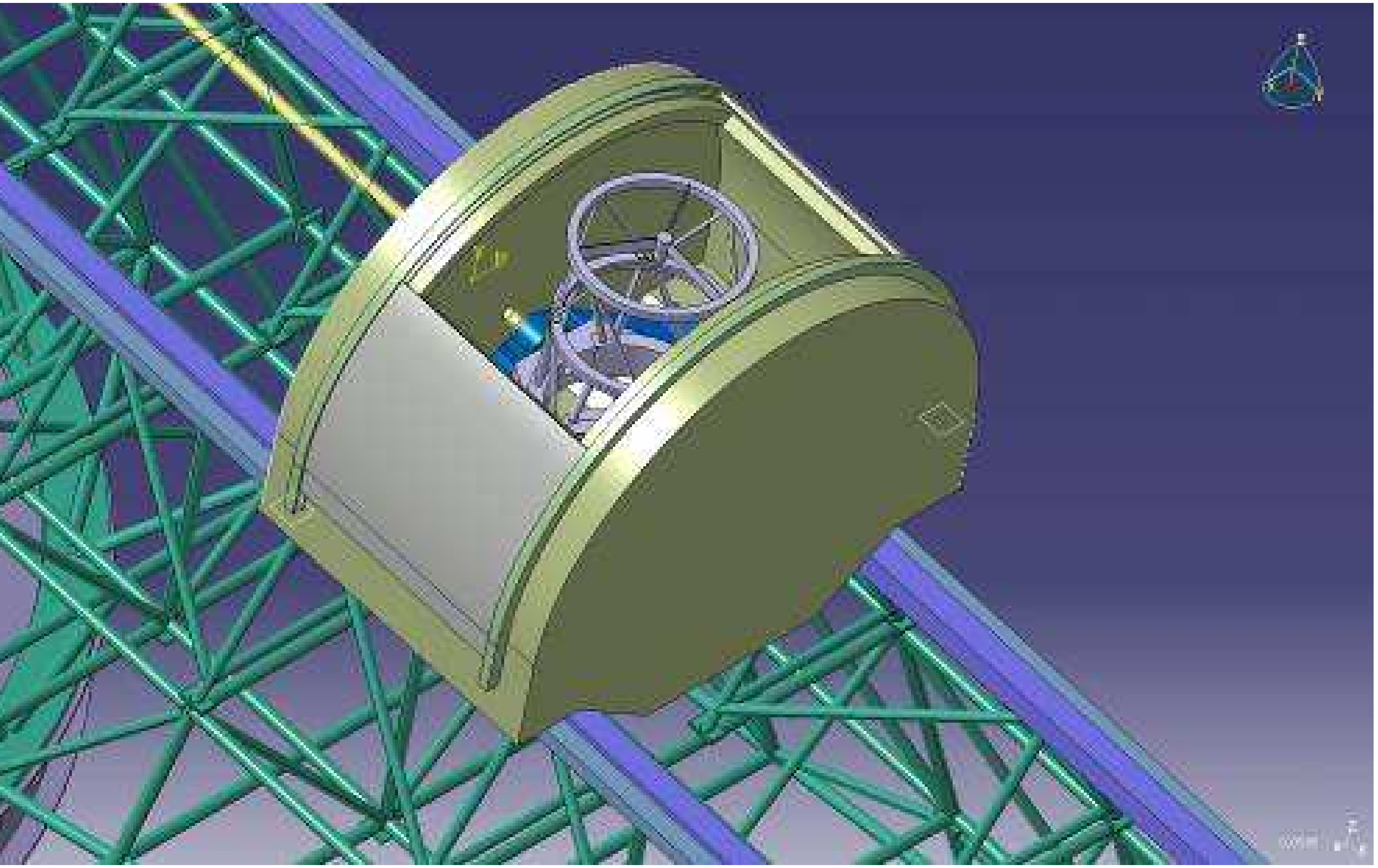
Telescopes



(inspired fro[m]
MRO
telescopes)

telescope is mounted on a trolley. The trolley is a transporter of the
cope, equipped with wheels; it circulates on a railway on top of the
ture. One wheel of each trolley is equipped with an encoder.
system will be allowed to stop anywhere along the rails
ion of the trolley measured by a HP laser interferometer

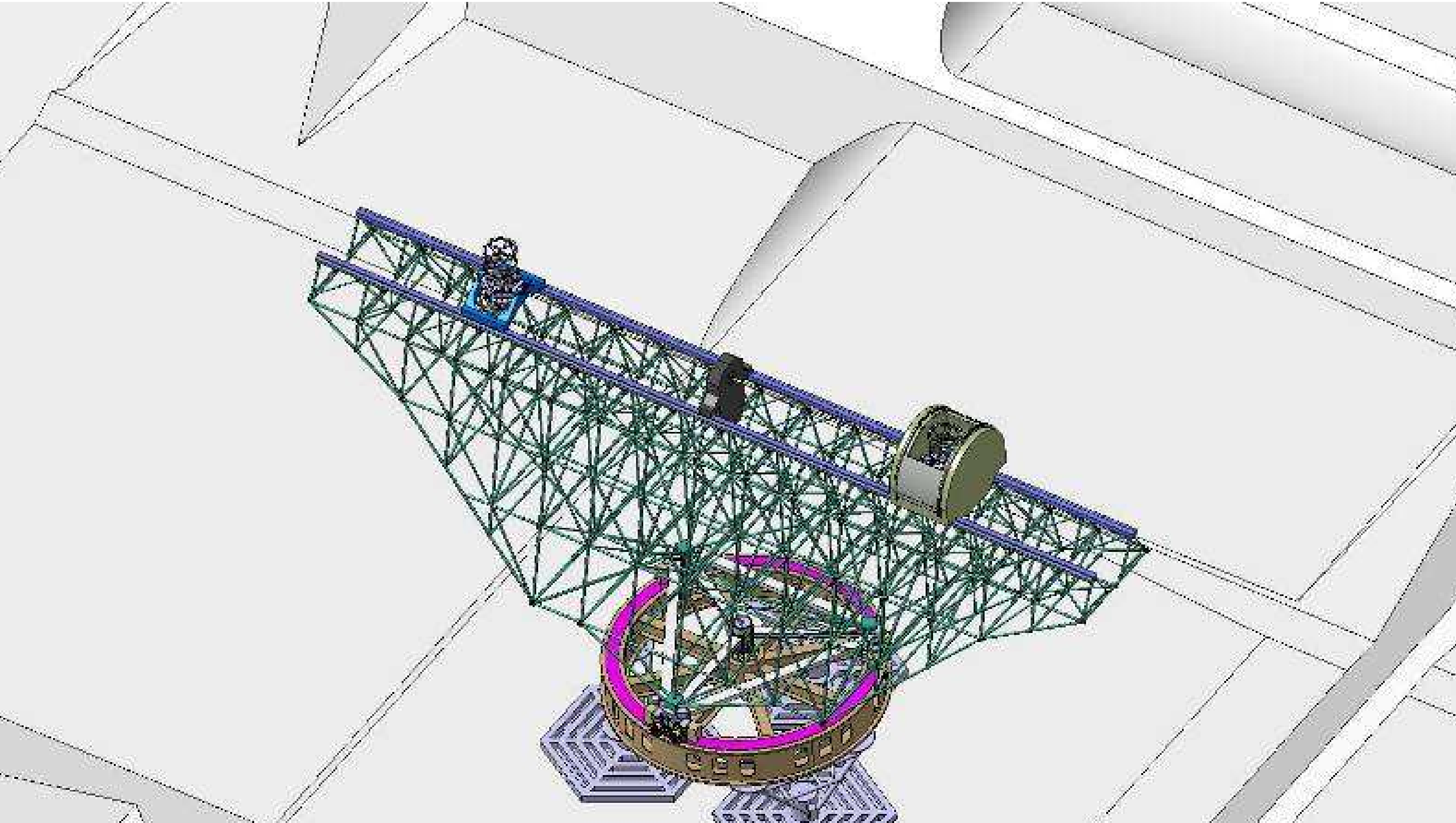
Telescopes

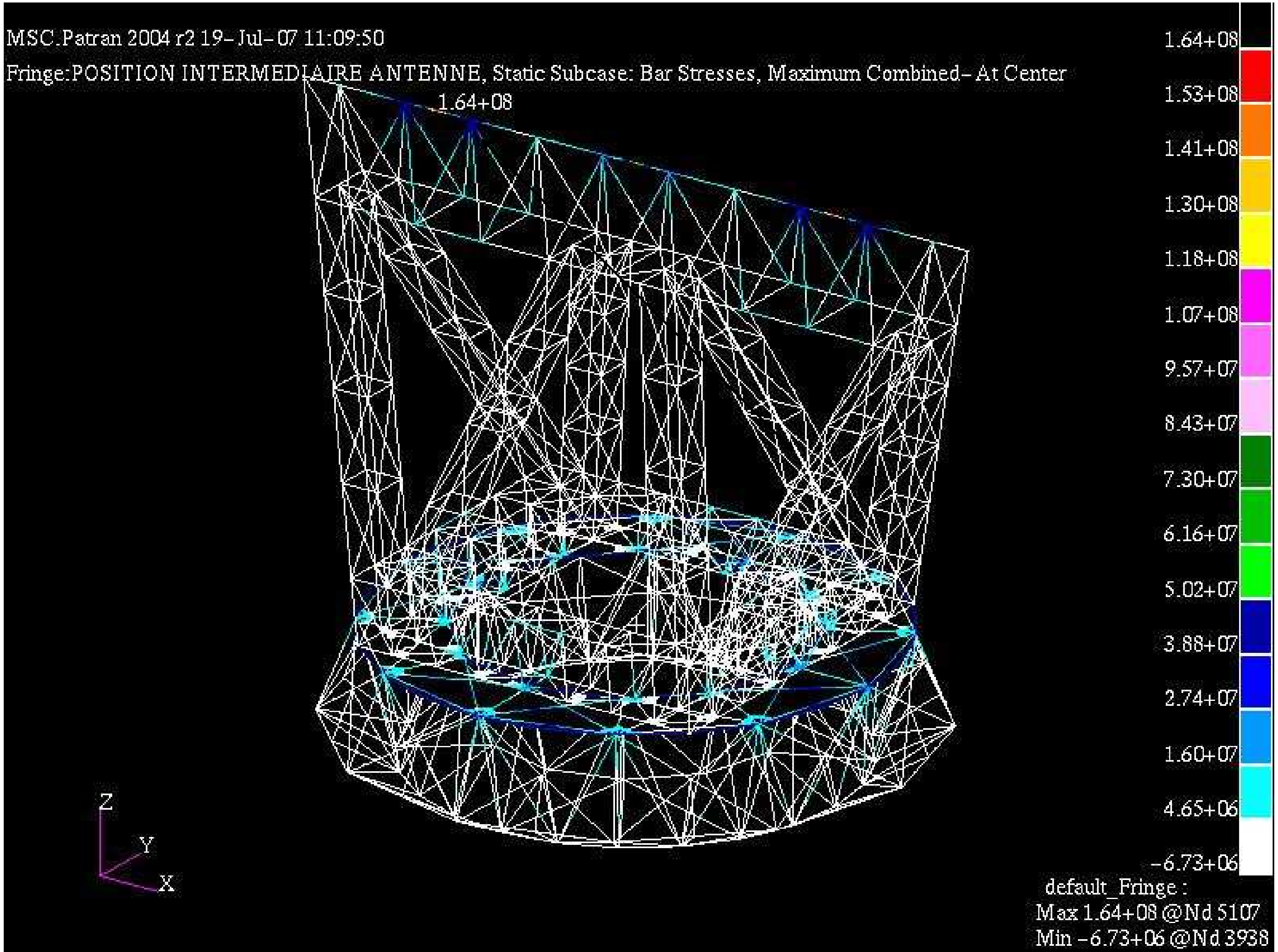


(inspired from
MRO telescope

s on the absolute distance between the telescopes and on their stabi
o be compensated by the tip-tilt system.
ys are equipped with an enclosure which protects the optical system
eather, strong winds and snow falls. The enclosure could take the sha
cylinder similar to "far west wagon"

General view





P. Bienve
T. Déche
Thalès

General Status

progress:
- esign of the beam structure
- esign of telescope trolley and telescope
- oncordia-testing frost-repellant coatings

ould be made in 5 years after preliminary tests and K.O.

ectric consumption is not an issue (motors at very low
peed, some sensors, actuators and detectors, small vacu
ump with limited duty cycle and cryocooler [500W])

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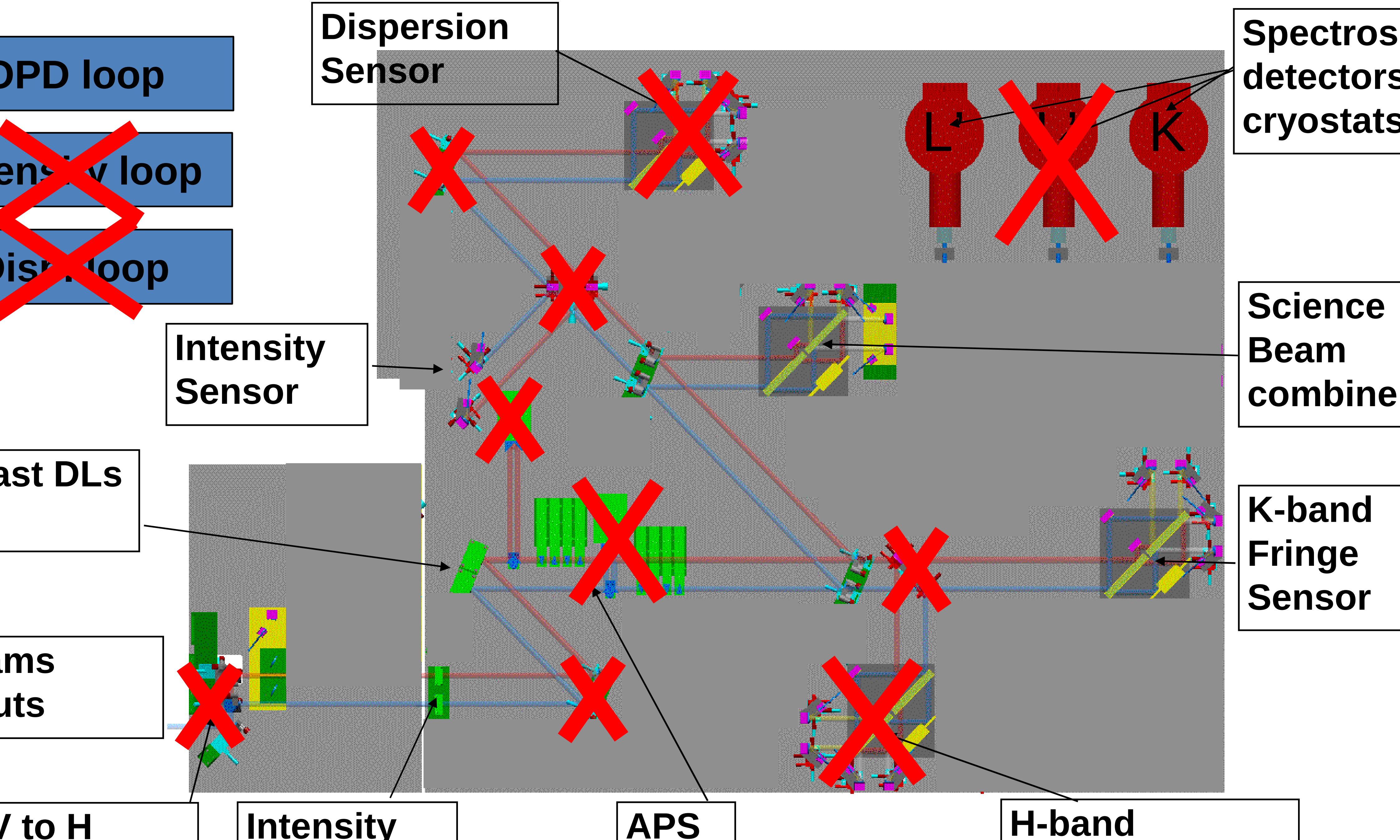
ALADDIN instrument

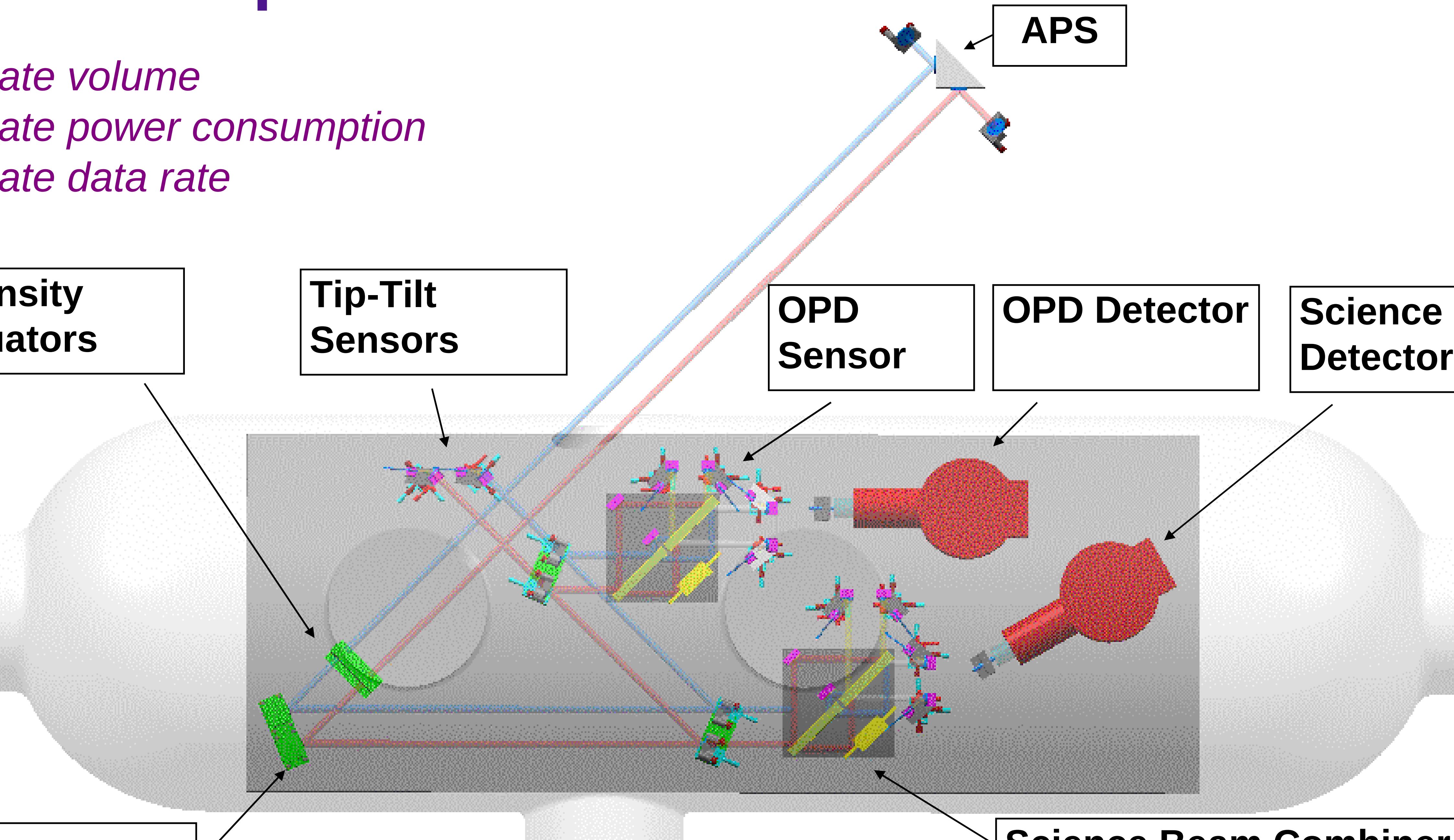
Marc Barillot

From GENIE to ALADDIN



Conceptual ALADDIN instrumen

ate volume
ate power consumption
ate data rate



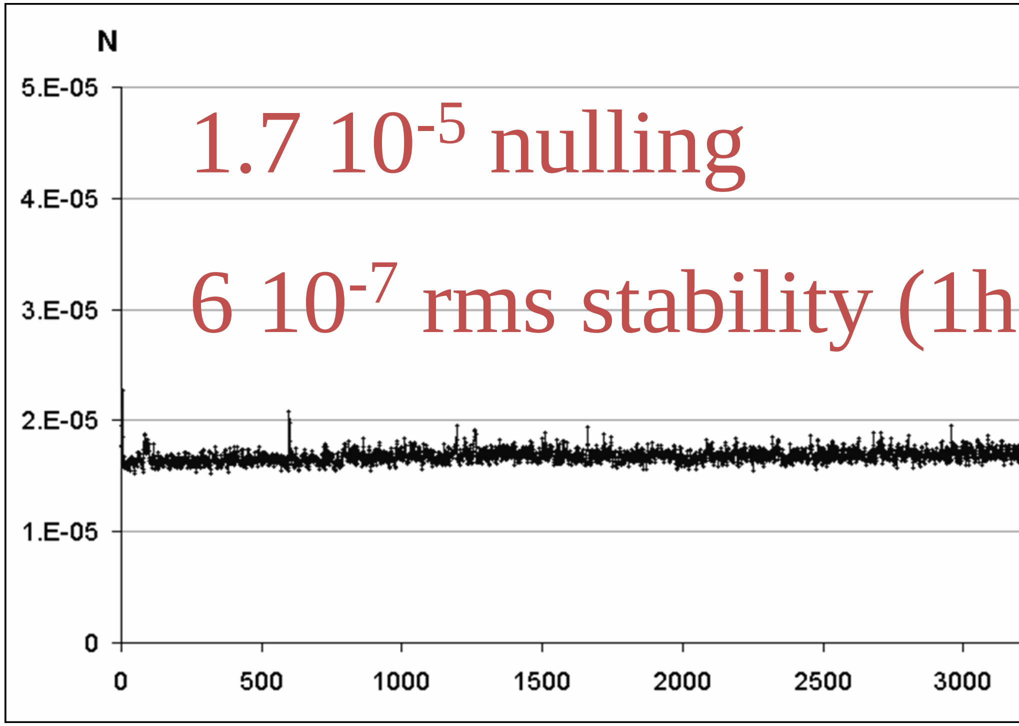
ALADDIN-I Environmental issue

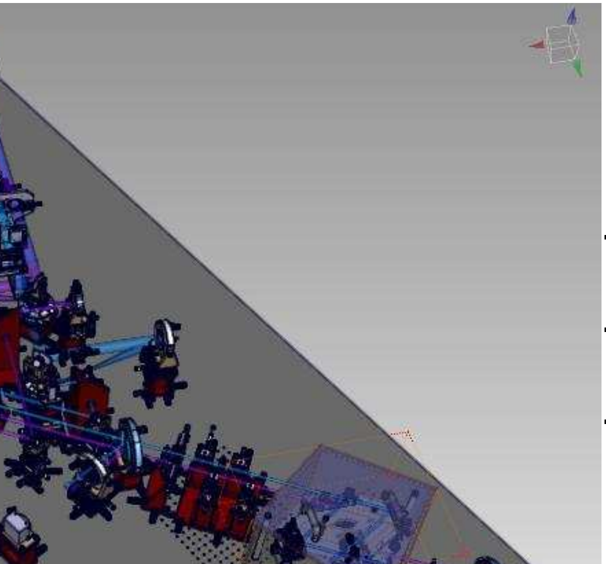
- No human intervention on site
  - Fully automatic / Remote controlled operation
  - Human intervention limited to within Concordia station
    (final validations/adjustments before transport to site and integration).
  - Regular roomspace only from Concordia (no Cl.100 clean rooms !
  - Extensive expertise of space industry in that matters

- Environmental impact = that conventional equipment
  - In operation, always inside cryostat
  - Relevant complete validation in temperate site

Development issues

- MAI² heritage
  - Nulling level and stability demo.
  - Unpolarised polychromatic source
- PERSEE heritage
  - Stability demo with perturbations
  - Relevant / available for ALADDIN





- VLTI/GENIE Heritage
  - Existing preliminary design data package
  - GENIEsim software
  - Most of GENIE Team available

Conclusion

ealistic & reasonable nulling instrument
anks to Dome-C atmosphere and design

ntarctica Compatibility : like any other instrument

trong heritage & experienced team

eady for a Preliminary Design Study

Relevance for Space

- Fully relevant precursor for Medium-class missions
  - Ref. Pegase/FKSI
  - 2-beam (Bracewell)
  - MWIR
  - Similar nulling/stability

- Relevant development step for exo-Earth mission
  - X-array based on 2 Bracewells
  - Comparable operations
    - Control loops
    - Observations (calibration, programme)
    - Data processing

Cost issue

References

- – Typical ROM-Cost of a nulling breadboard: ~1M€
- – Typical ROM-cost of a spaceborne nulling instrument: 60M€

Comparison with a space instrument development costs

- – No launch environment requirements
- – No space environment requirements (thermal / radiations…)
- – No multiyear reliability requirements
- – No technology/process/components limitation (electronics/comput !)
- – Virtually no mass/power/data rate constraints (even in Concordia !

Conclusions

he magic science case: detection and characterizatior exo-zodis

ALADDIN is a technologically feasible project under Antarctic conditions

phase A industrial study of a precursor interferometry mission is a must:

benefits from existing synergies

to get a realistic cost estimate

better knowledge of interferometric conditions in Antarctica versus astronomical temperate sites

relevance of building in the future a KOI

Measurements of $|_0$, etc. are badly needed!

Conclusion

An “unavoidable” science case…

…for which Antarctica may provide an optimal answer

Certainly not a crazy idea

Builds on many synergies

Fits into “reasonable” Dome C logistics

…and probably not exclusive of other Dome C projects