A year of commissionning in Chile at the Vera Rubin Observatory

a success for the Filter Exchange System 🇫🇷

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VERA C. RUBIN
OBSERVATORY

Outline

In November 2024 I was sent to the Vera Rubin Observatory to integrate and commission the Filter Exchange System of the LSSTCamera and train local engineers on how to use and maintain it.

This presentation is a **photo tribute** to this "mission longue durée".

I want to to share the experience and the feelings that have made this trip unique and feel like a consecration after **decades of team work among five IN2P3 labs**.

Unless specifically stated, all photos in this presentation have been taken by me
or extracted from my phone.
Feel free to reuse with proper attribution and ask me for the original for better quality.

A big thank you

I have had the privilege to spend a year over there and this could not have happened without the help or participation of many people from the filter exchange team, who have made my experience much better (sometimes painful also :) over the past 8 years

Françoise Virieux
Eric Aubourg
Bernard Amade
Camille Parisel

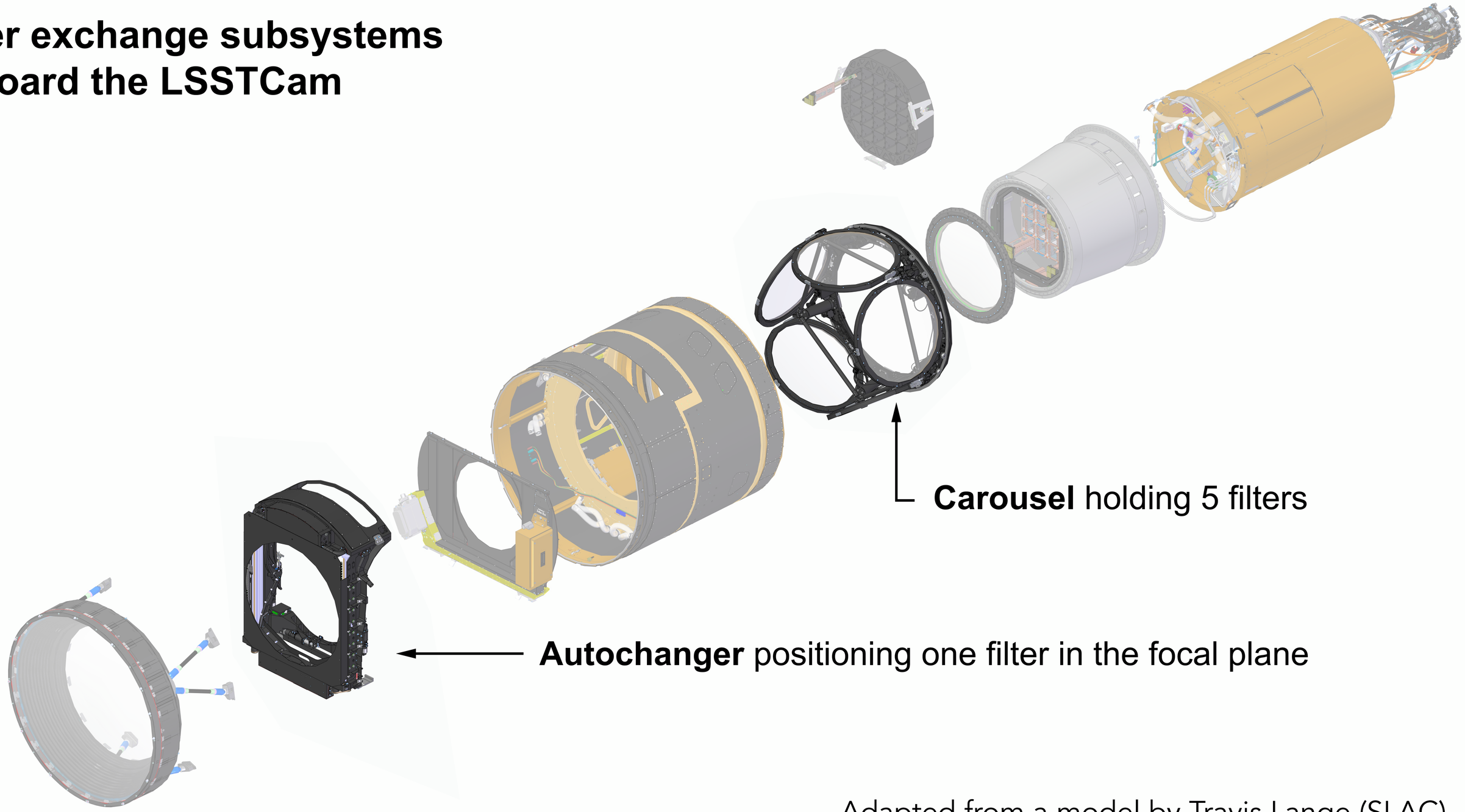
Pierre Antilogus
Claire Juramy
Didier Laporte
Guillaume Daubard
Julien Cordian

Antoine Bernard
Johan Bregeon
Francis Vezzu
Mile Kusulja
Eric Lagorio

Aurélien Marini
Patrick Breugnon
Fabrice Gallo
Pierre Karst

+ **special thanks** to the SLAC Camera team, the observers and the Chilean crew
in particular Jacques, Freddy, Roberto, Mario, Claudio, Juan, Stuart Yousuke, Tony, Max, Kevin F., Sean, Andy, Aaron, Travis, Hannah, Margaux, Juan-Carlos

Filter exchange subsystems onboard the LSSTCam



Carousel holding 5 filters

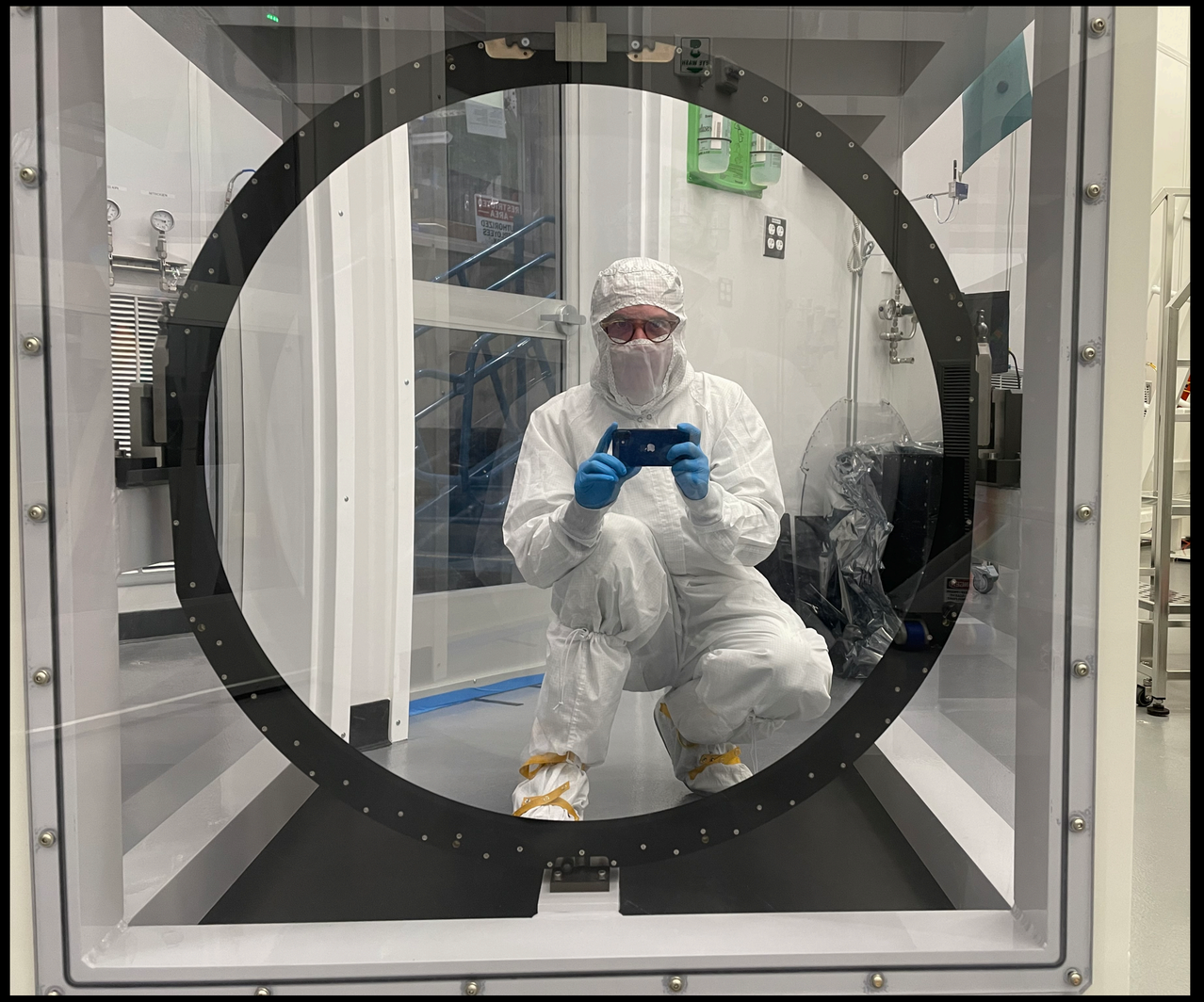
Autochanger positioning one filter in the focal plane

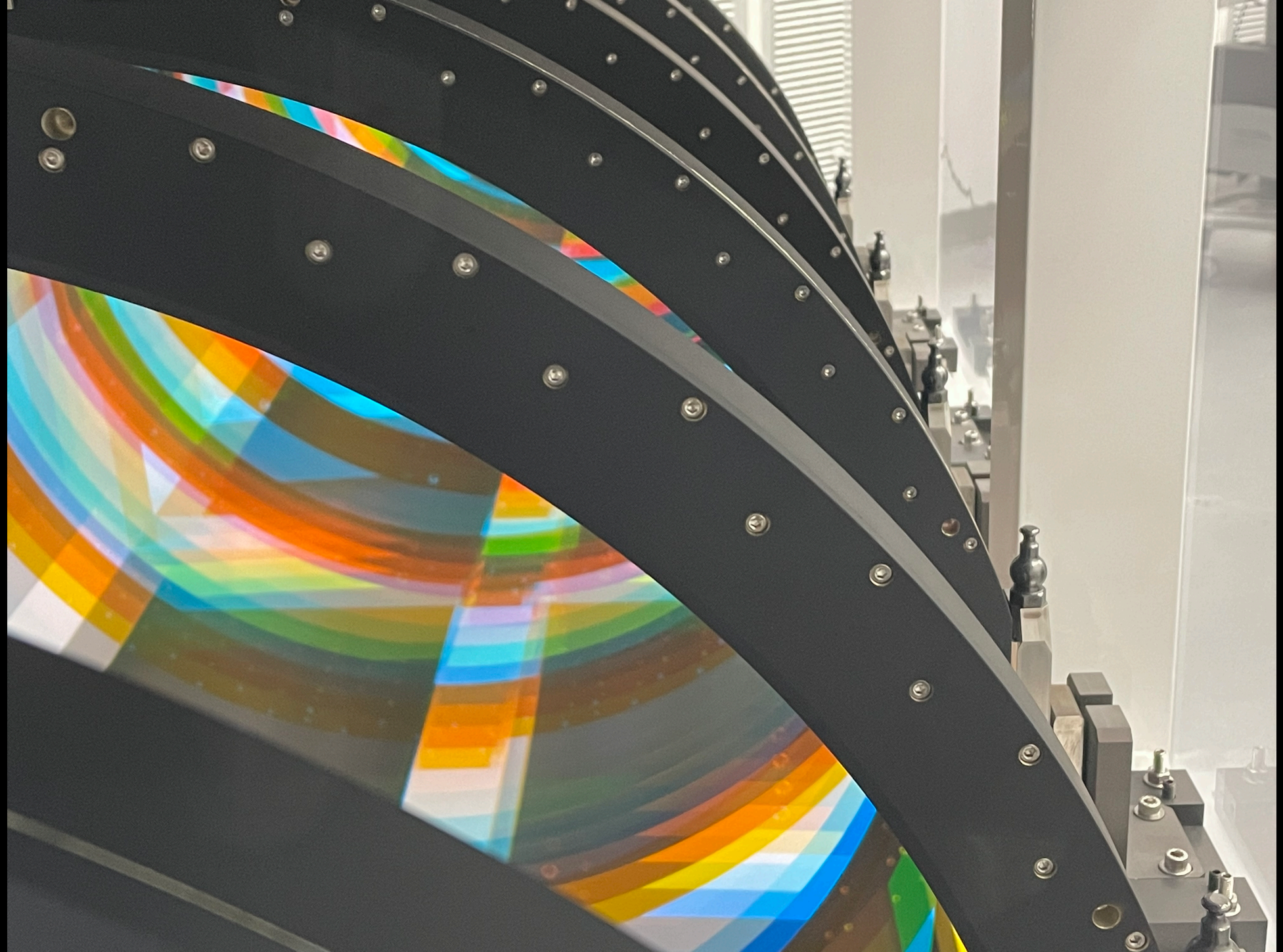
Adapted from a model by Travis Lange (SLAC)

And a loader to insert / extract filter from camera

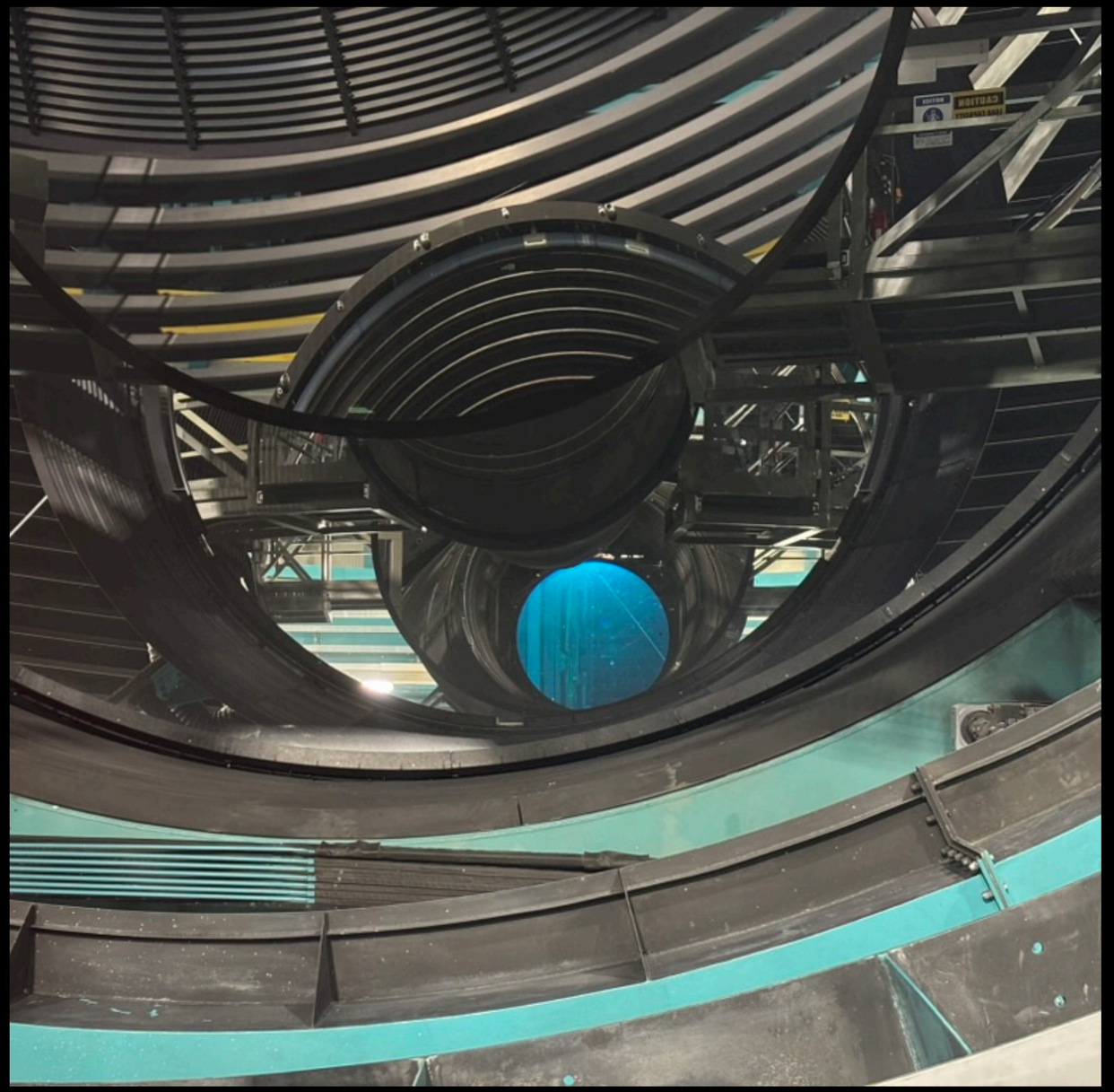
Credit Travis Lange (SLAC)

Taking care of filters – 75 cm – 25-38 kg



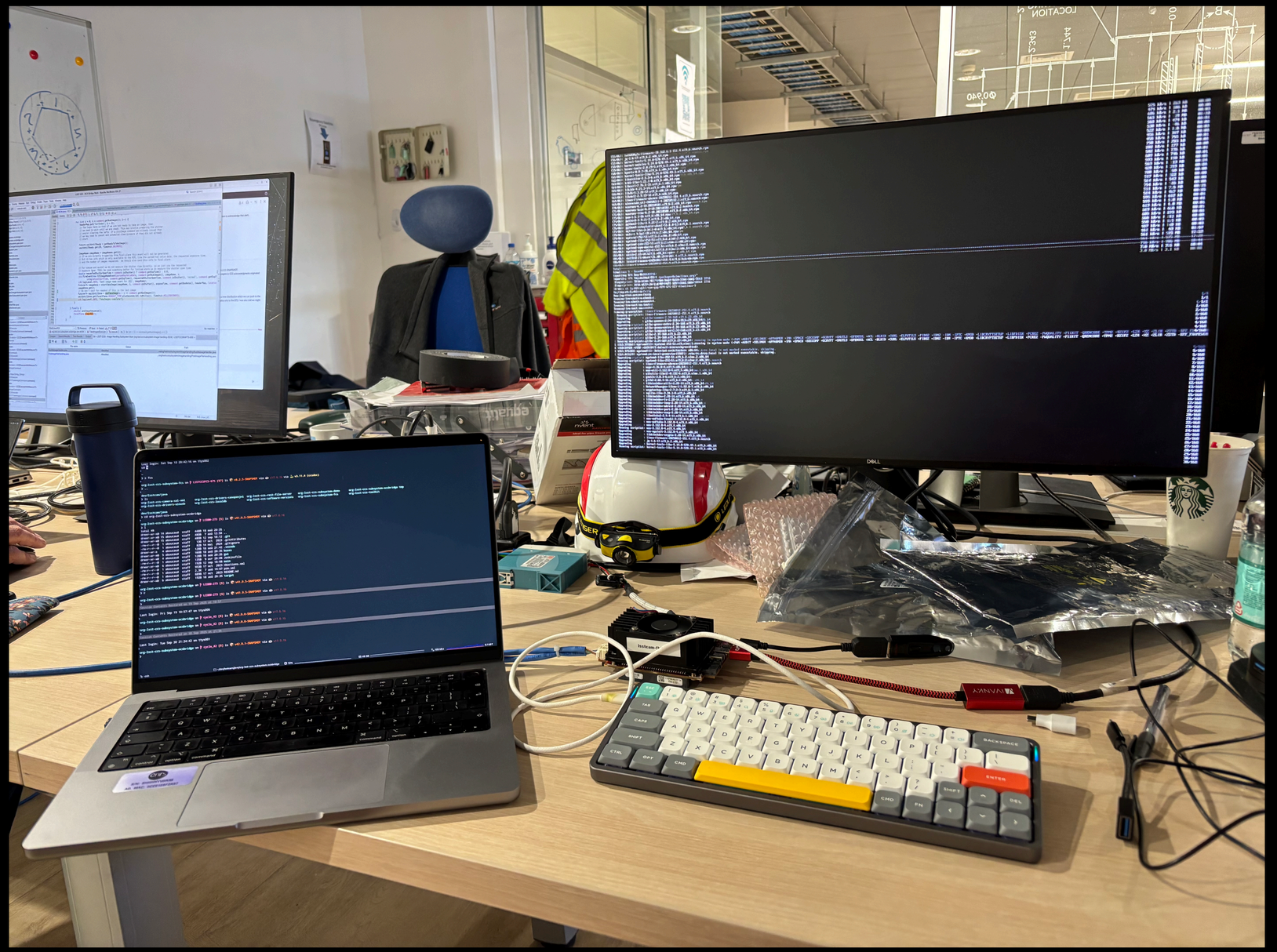


Goal: integrate Filter Exchange System in the observatory

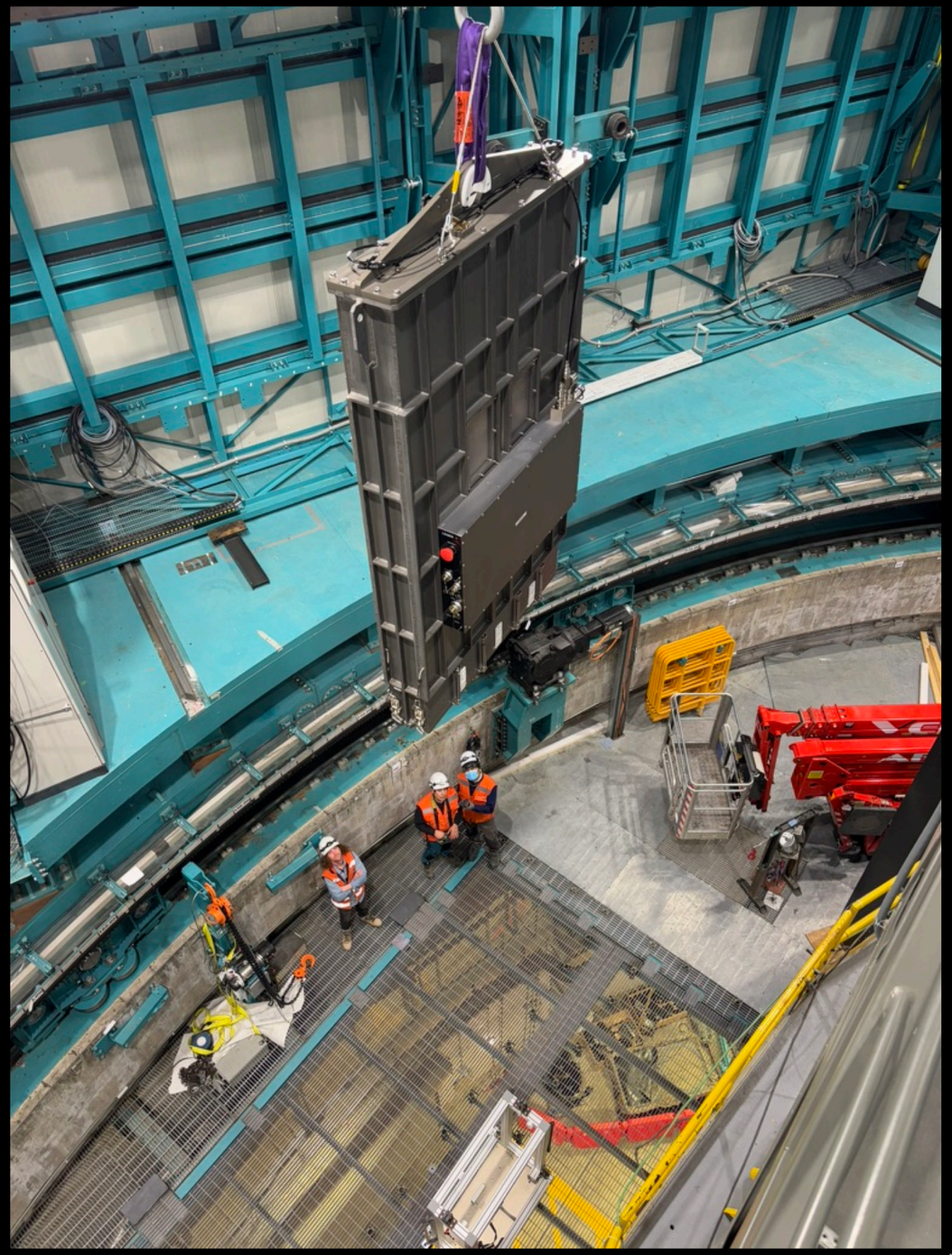


r filter installed in the camera

My life most days on Summit



Lot of time spent adjusting the procedures in place



and training the local engineers

Sometimes you even have to climb under the camera to fetch **a screw that fell INSIDE** during maintenance

¯_(ツ)_/¯

FES test bench @ LPNHE

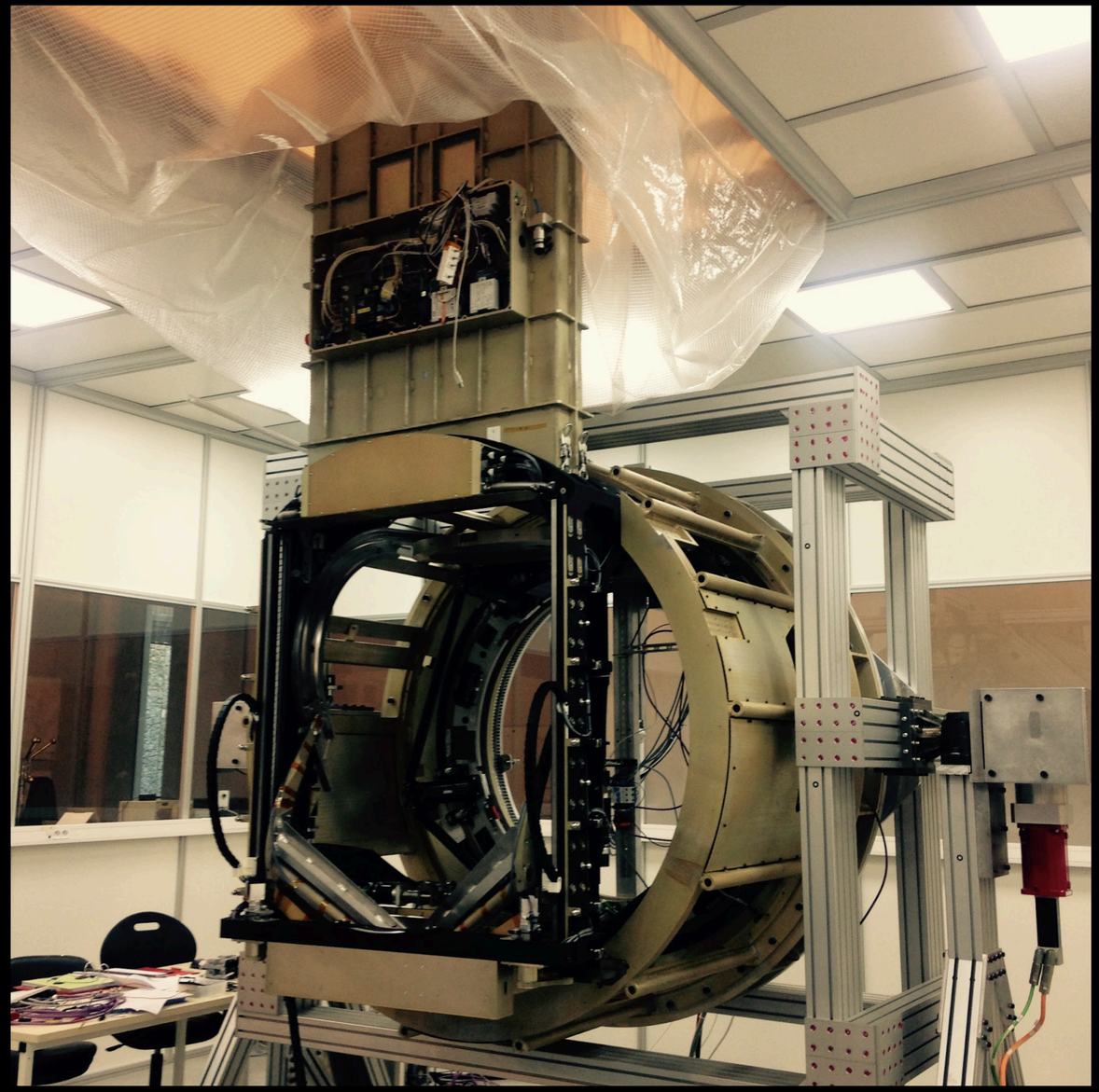
Our biggest asset this year !

We tested most software updates on the FES prototype prior to the deployment on camera.

One caveat..

someone has to maintain the prototype

Most of these very important tests were done by **Antoine**



Focus on the software side

Antoine, Pierre, Alexandre

Filter Changer Software (FCS) is 40 000+ lines of Java*

Here are the major step that were addressed during the past year

- **integration into the observatory** software (Python)
- streamlining of all major operations (filter changes / swaps)
- improvement of the **monitoring** of the FES sensors (~100), motors (13), controllers (22) and the 3 protection units
- addition of several **auto-recovery methods** to limit the need for stoppage when the issue is known
- major update of the FES GUI for observers

*not my choice !

FES performance after 1+ year of commissionning

General numbers – 04/25 > 04/26

- **3222 filter changes** (~ 9 filter changes a day - expecting ~ 17/night in ops),
- 85d without a filter change (maintenance, AOS tuning, bad weather)
- 197d with 5+ filter changes / 132d with 10+ / 49d with 20+
- **71 filter changes in a single night** – maximum recorded for filter focus offset calibration

Filter swap numbers – 04/25 > 04/26

- **53 filter swaps** (either from camera or filter storage box)
- **11 *u/y* swaps** (half the rate we expect in operations

Error rate (software / hardware alarm that blocks any operation)

- Was **~5 % around first light**
- Currently estimated **at the level of 0.1%** (every 1000 filter change)

Performance of the FES and mitigation implemented will be presented at SPIE this summer

Filter Exchange System project requirements

- **filter change duration < 90s :** currently at **84s on average** ✅
- **filter positioning repeatability < 150µm :** currently at **± 100µm on average** ✅

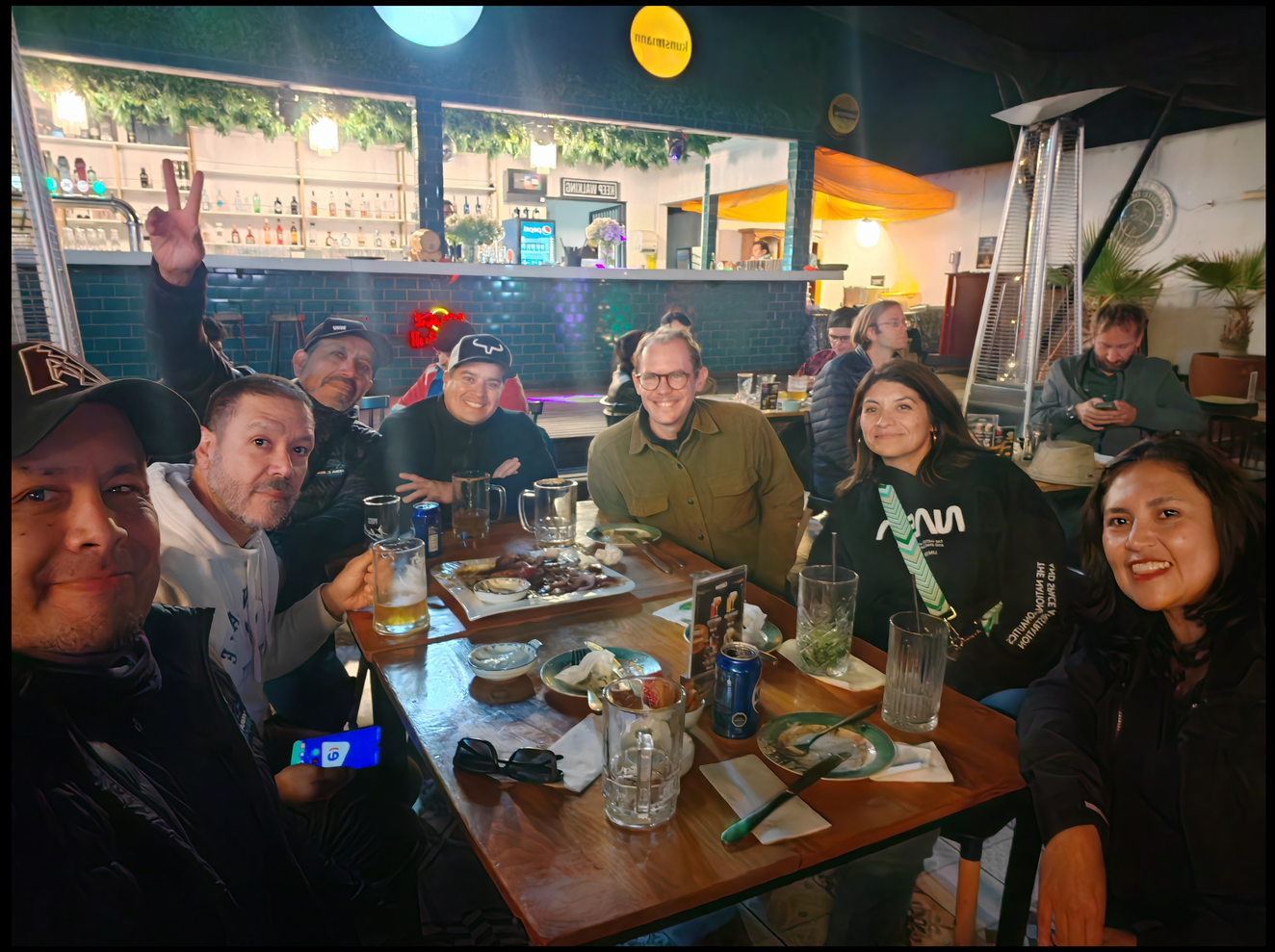
Overcoming these challenges was only possible with the help of great people

Vera Rubin au Lowell Observatory en 1965.
© Smithsonian Institution

1928-2016

The LSSTCamera Team (SLAC)

The Chilean crew



The visits from the French team

And especially "El Pedro"

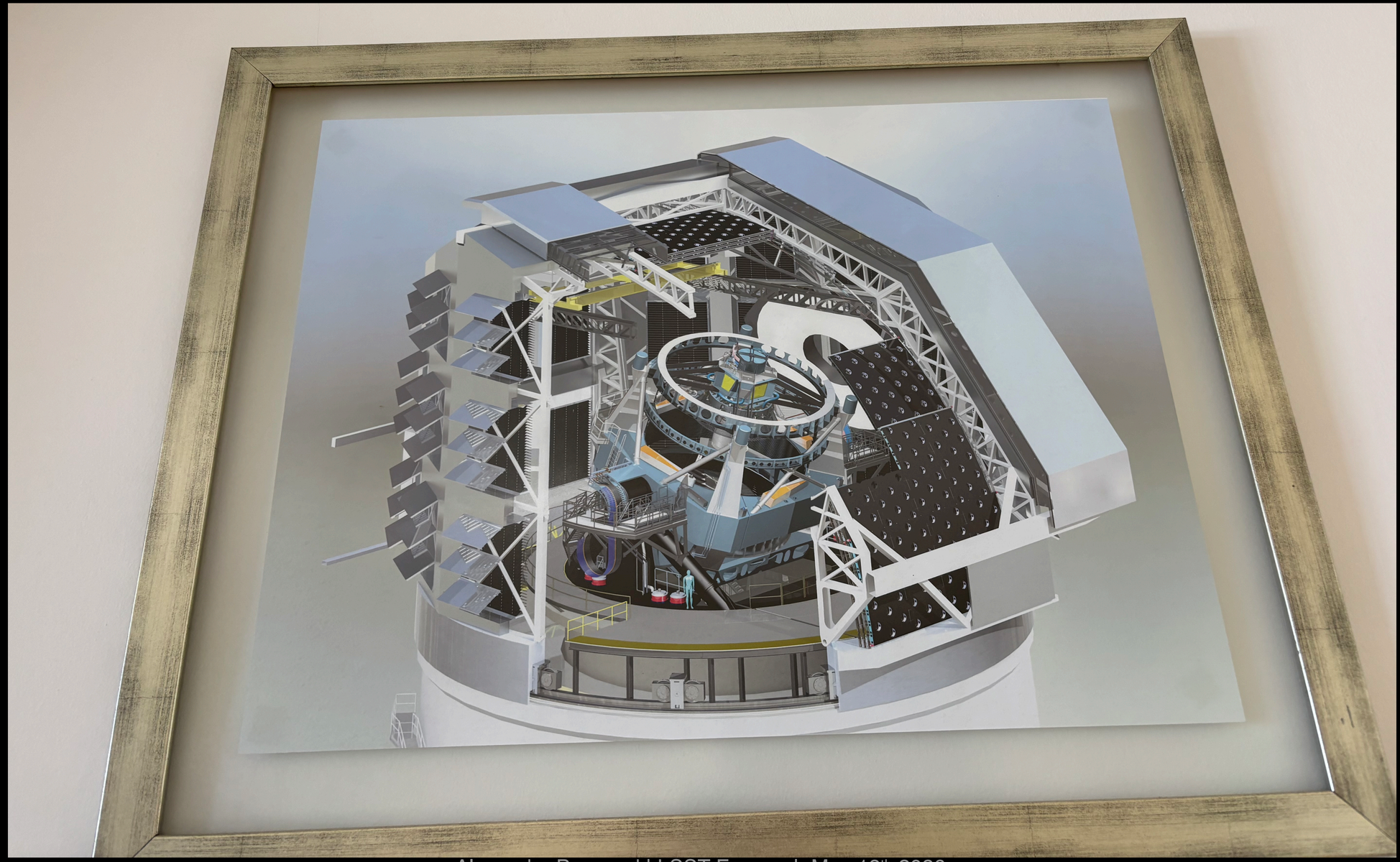
visited > 4 months in 2025

Even shared a room when the Hotel Pachón was too busy


E

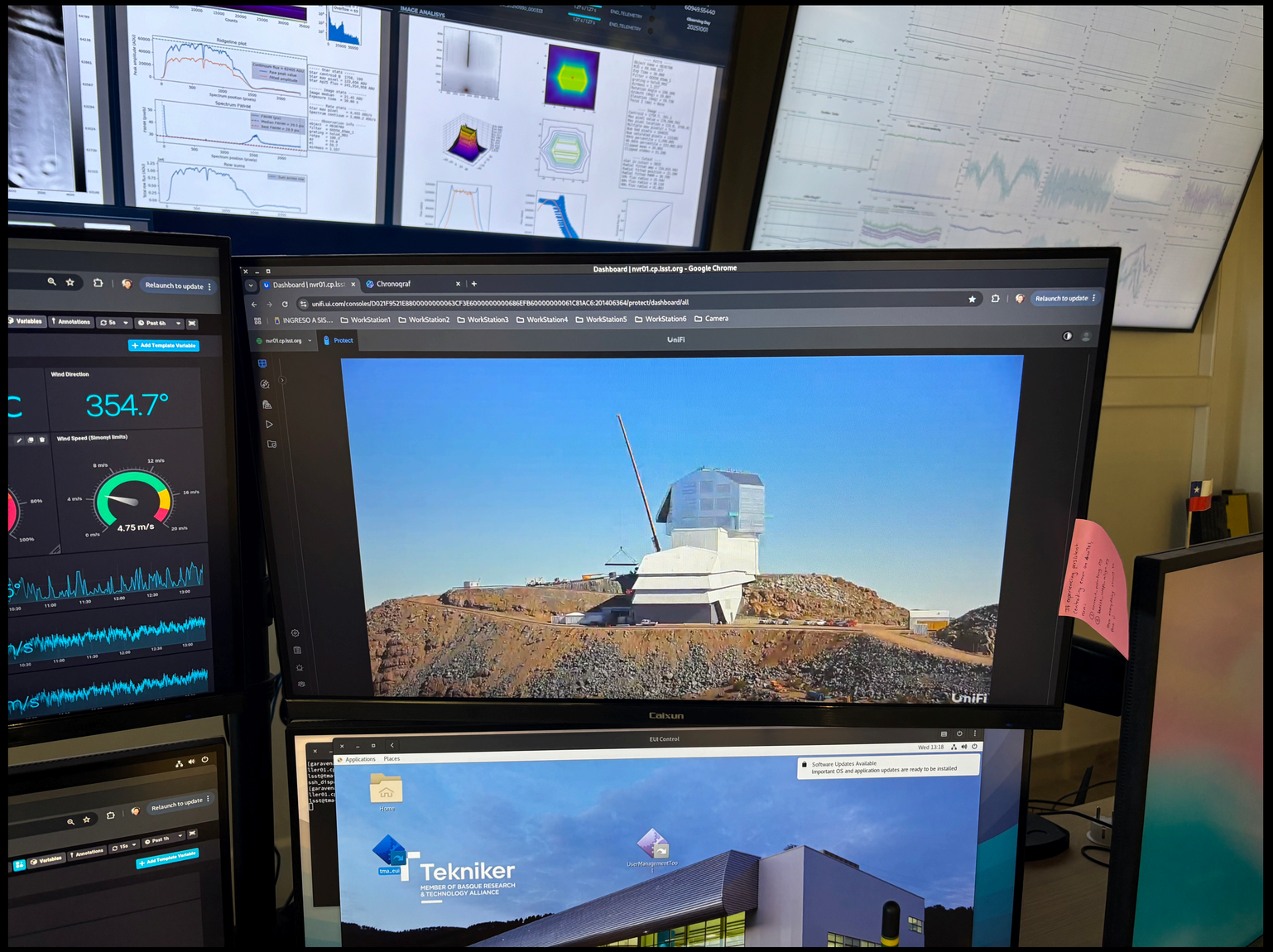
Working in a giant observatory you have some surprises

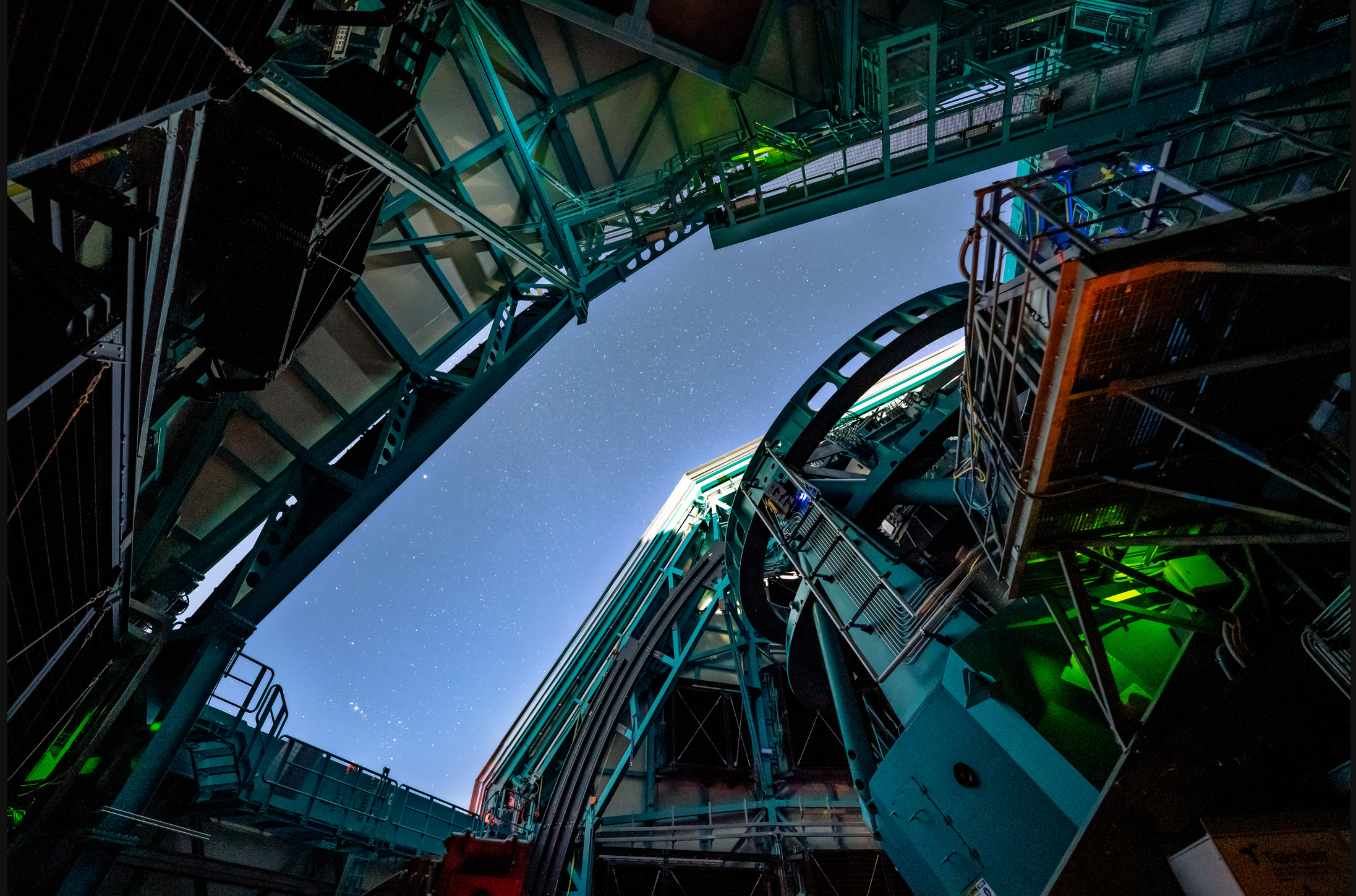
You see giant panels getting installed




KONECRANES
RAYNOR
RAYNOR
RAYNOR

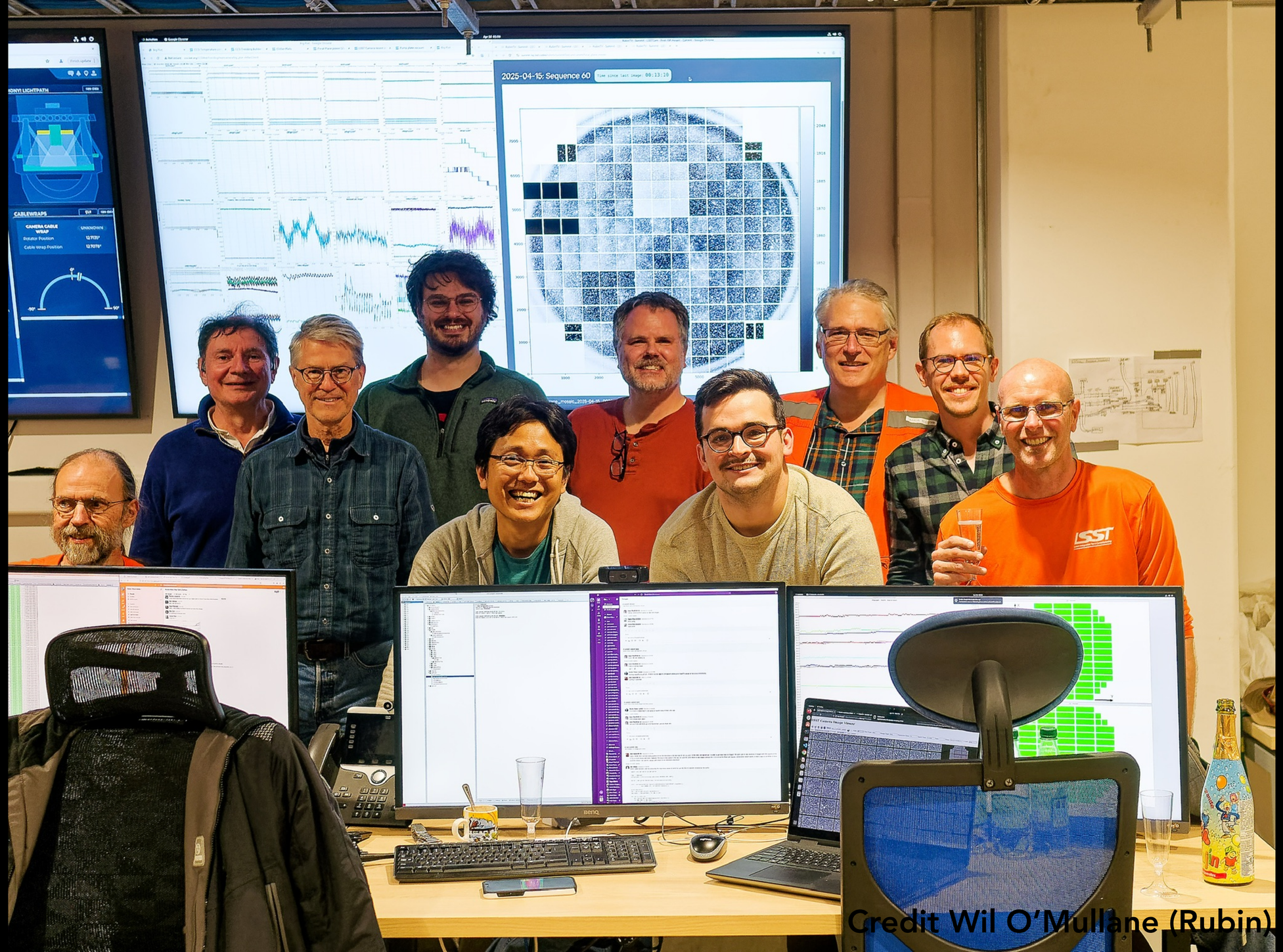
An intense operation (needs no wind)





You can share the emotion of the first image displayed live in the control room

Credit Wil O'Mullane (Rubin)



Credit Wil O'Mullane (Rubin)

Enjoy doing a live with France from the summit for the first light event

Be featured in Le Monde

25 février 2026

science & médecine Le Monde

L'observatoire Vera-C.-Rubin et son dôme ouvert, le 21 avril 2025. L'amas ouvert M41 est visible au-dessus du télescope. RUBINOBS/NOIRLAB/SLAC/NSF/DOE/AURA/P. HORALEK (INSTITUTE OF PHYSICS IN OPAVA)

L'observatoire **Vera-C.-Rubin,** au firmament de l'astronomie

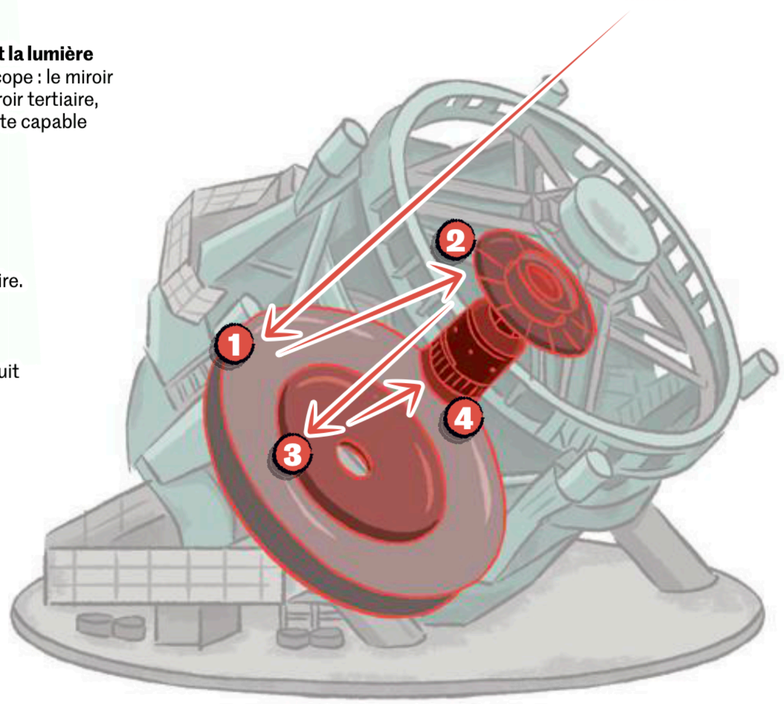
Le télescope Simonyi

1 Le miroir primaire
C'est le **premier miroir** qui **reçoit la lumière du ciel**. Particularité de ce télescope : le miroir primaire est monté autour du miroir tertiaire, afin d'avoir une monture compacte capable de se déplacer rapidement.

2 Le miroir secondaire
Construit autour de la caméra, le miroir secondaire **reçoit la lumière du premier miroir** et la réfléchit vers le miroir tertiaire.

3 Le miroir tertiaire
Dernier miroir, celui-ci est construit **à l'intérieur du miroir primaire**. Il réfléchit sa lumière vers la caméra du télescope.

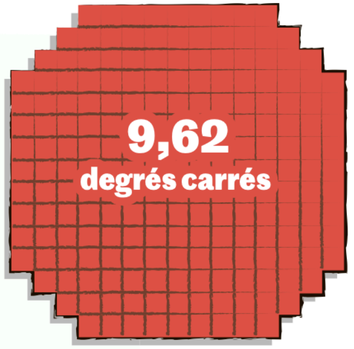
4 La caméra
Montée dans le foyer du télescope, l'imposante caméra **photographiera chaque morceau de ciel avec un temps de pose de 30 secondes**. L'image sera ensuite lue et assemblée en 2 secondes.

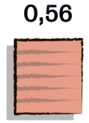


Socle du télescope
Le télescope repose sur un fin film d'huile, ce qui lui permet de **déplacer les 350 tonnes de l'instrument silencieusement et rapidement** vers sa prochaine cible dans le ciel.

Comparaison des champs de vue des télescopes, en degré carré

Simonyi
Observatoire Vera-C.-Rubin
(terrestre)





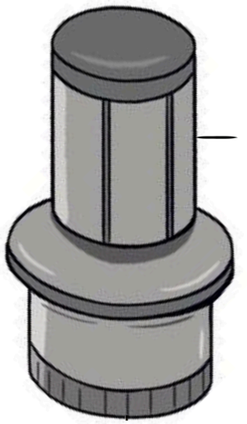
Euclid
(spatial)

0,0025
James-Webb
(spatial)

0,002
Hubble
(spatial)

La caméra numérique

- Poids : **3 tonnes**
- Dimensions : **1,65 mètres X 3 mètres**



Le cryostat
Ce **système de refroidissement** entoure la caméra pour maintenir le plan focal à une température de **– 100 °C** et ainsi **éviter toute perturbation dans l'acquisition des images**.

Les filtres de couleur
Cinq des six filtres de couleur peuvent être montés sur le corps de la caméra et permettent à celle-ci d'**observer dans des longueurs d'onde spécifiques**, qui vont de l'ultraviolet au proche infrarouge.

Le système de changement de filtre, est **capable de remplacer un filtre de plus de 30 kilos en 90 secondes** avec une précision de 0,1 millimètre (l'épaisseur d'un cheveu).

Le plan focal
D'un diamètre de 64 centimètres, ce plan contient **189 CCD**, des **capteurs photosensibles**, parfaitement alignés et espacés d'un quart de millimètre. Chaque CCD permet de collecter **16 millions de pixels**. Assemblés, ils forment une **image d'une résolution de 3 milliards de pixels**.

Les objectifs
La caméra est équipée de trois objectifs qui servent à **concentrer successivement les rayons lumineux entrants vers le plan**.

Infographie : *Le Monde*, Gary Dagorn, Audrey Lagadec
Sources : Space Telescope Science Institute ; ESA ; Observatoire Vera-C.-Rubin

On the public outreach side

Your better half can be super creative

by Alexandra Claraz

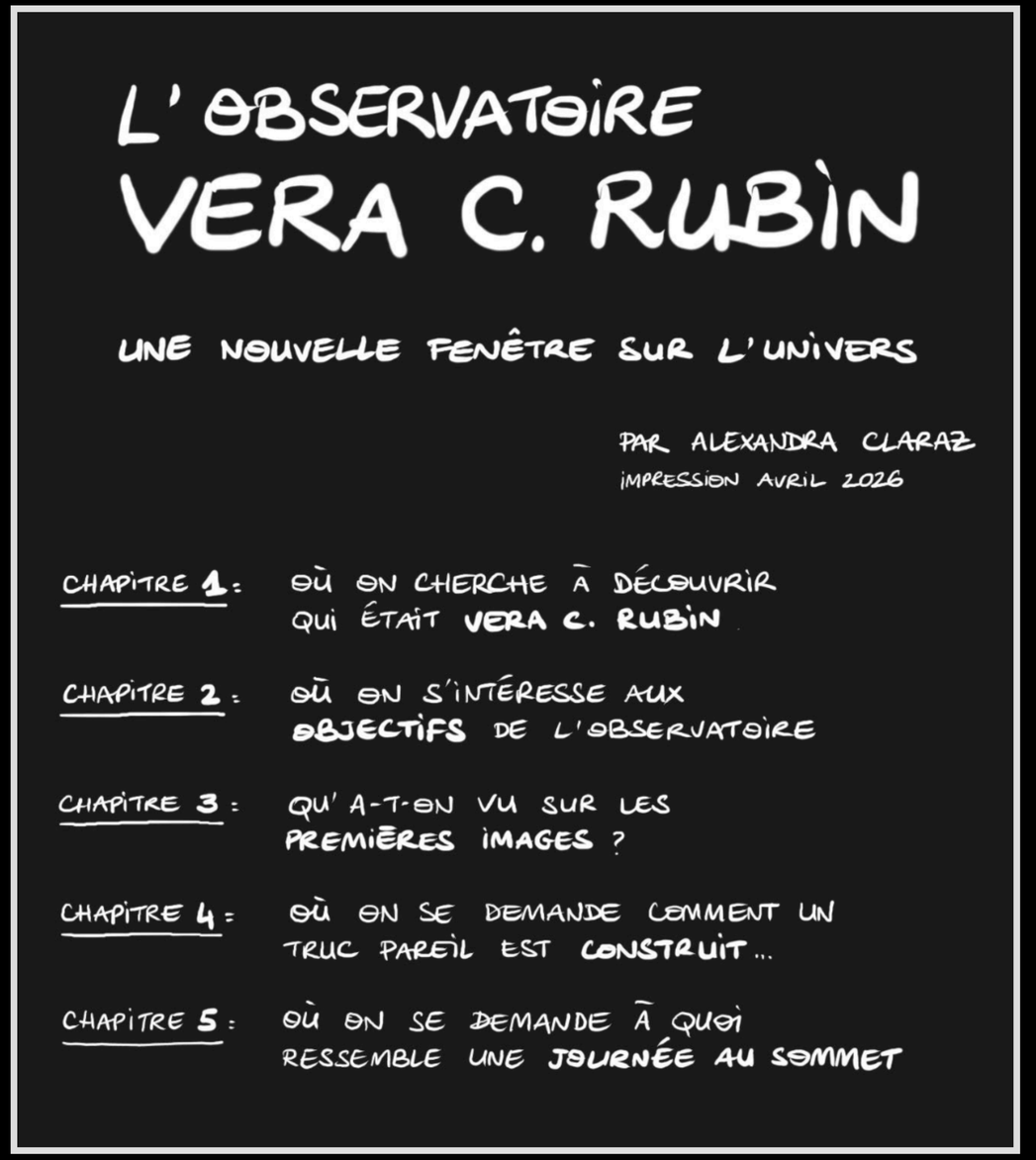
and create an entire comic of the project and the life of Vera Rubin *

Some of you have had access to the v1 (February).
There is a v2 (April) and Alexandra is working on the v3.

Those interested for giving feedback can contact Johan.

We are currently in discussion with CNRS Edition
for a publication in 2027 but also working on material
for public outreach for LSST France.

* intended for high-school level audience



Apart from cool science & engineering the summit has a lot to offer

You can witness the French PI being brave

Meet the local fauna

Spot galaxies with the naked eye

And the great Milky Way

Witness beautiful sunsets

in la Serena too..

We can even spot
the green ray..

and I learned the desert has flowers.. (some years)

El desierto florido (Oct 2025)

Thank you for your attention

Takeaway message

If you have the opportunity in your career to do a long-term mission abroad, the experience you get out of it is worth all the efforts !