VIPA spectrometer
Preparing the H2RG integration

Assemblée Générale du LabEx FOCUS - September 2023

IPAG - UGA - CNRS: Alexis Carlotti, Jean-Jacques Correia, Alexis Bidot, Jeremy Ceszkowski, Stéphane Curaba, Alain Delboulbé, Laurence Gluck, Laurent Jocou, Didier Maurel, David Mouillet, Marie-Hélène Sztefek

Univ. Montréal: René Doyon, Etienne Artigau, Philippe Vallée

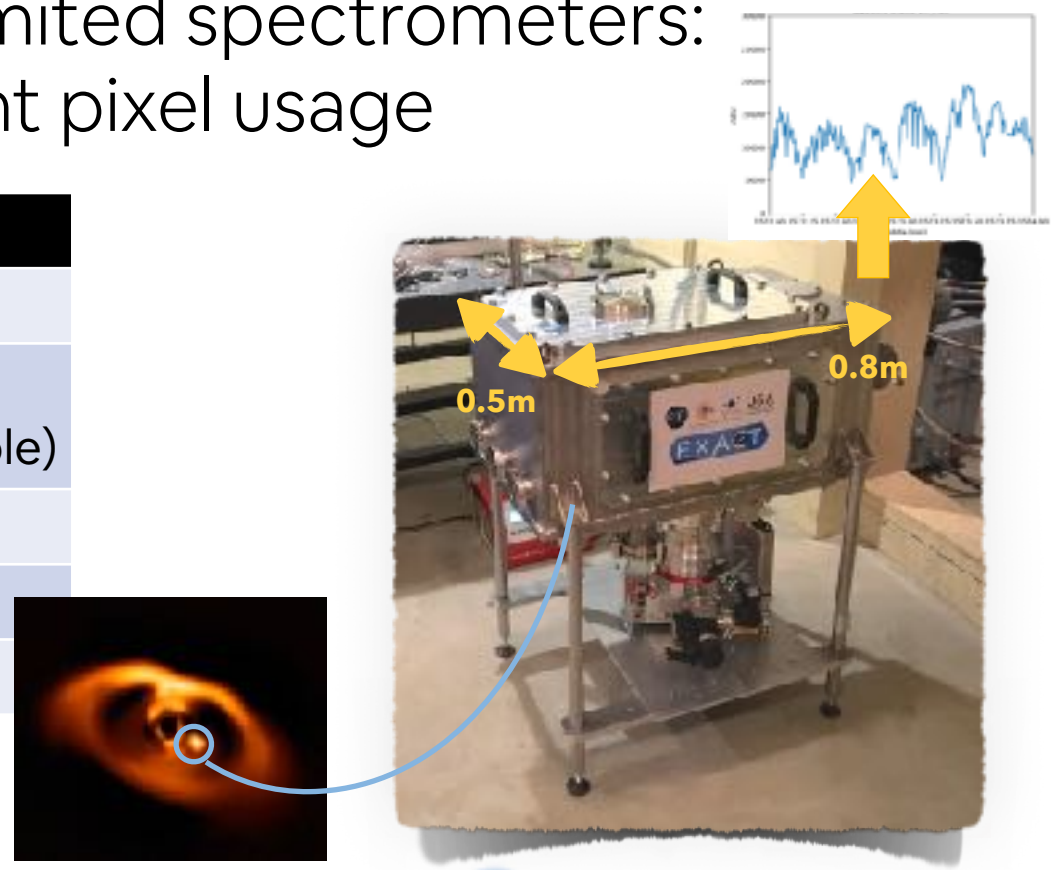
This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme, grant agreement No. 866001 (EXACT)

What is VIPA, and why is it interesting?

- High-resolution NIR spectrometer designed for diffraction-limited sources, such as exoplanets
- Significant advantages over seeing-limited spectrometers: Compact, highly transmissive, efficient pixel usage

Specifications	VLT/CRIRES+	VIPA
Volume	~6m3	0.25m3
Spectral range	Half of H band (full band in 2 obs.)	Half of H band (210nm, adjustable)
Resolution (λ/Δλ)	50000 or 100000	80000
Efficiency	~15%	~40%
Detector(s)	3x H2RG	1x H2RG*

* only half of the H2RG surface is actually used; Other half may be used to cover K band.



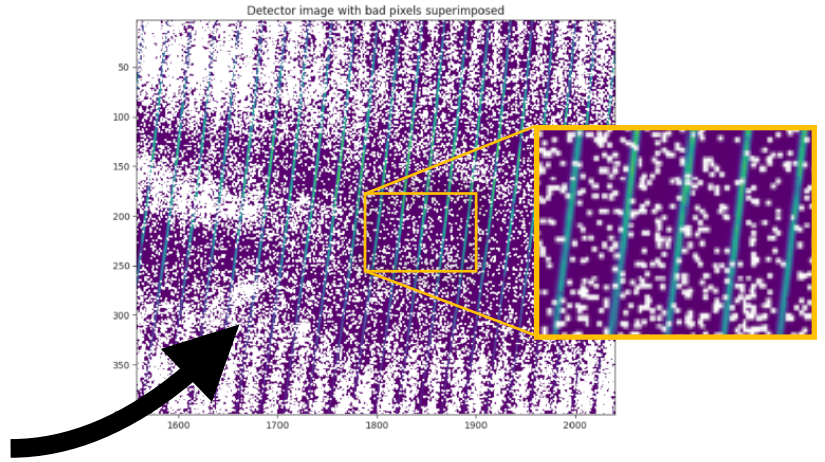
How FOCUS helps VIPA & other projects

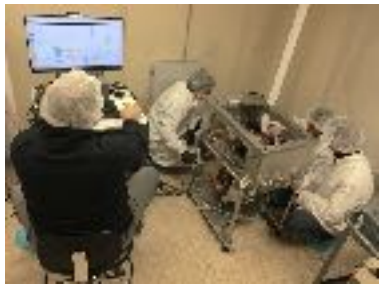
- Kickstarts projects
  - Key hardware purchased with FOCUS funding
  - 1.5yr engineer time (S. Curaba, H2RG control software)
- Can be a maturation phase for larger projects
  - Enabled **ERC** EXACT & **PEPR** Origins WP 1.5 « compact spectrographs »
  - Potential application with ELT (ANDES, PCS) & Space
- Provides a community for detector-driven projects

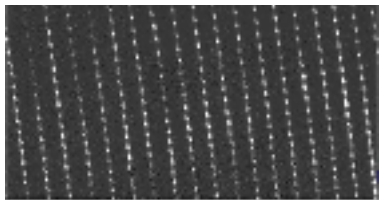
Could FOCUS support R&D projects beyond detectors?
Ex: beam shaping to use detectors more efficiently

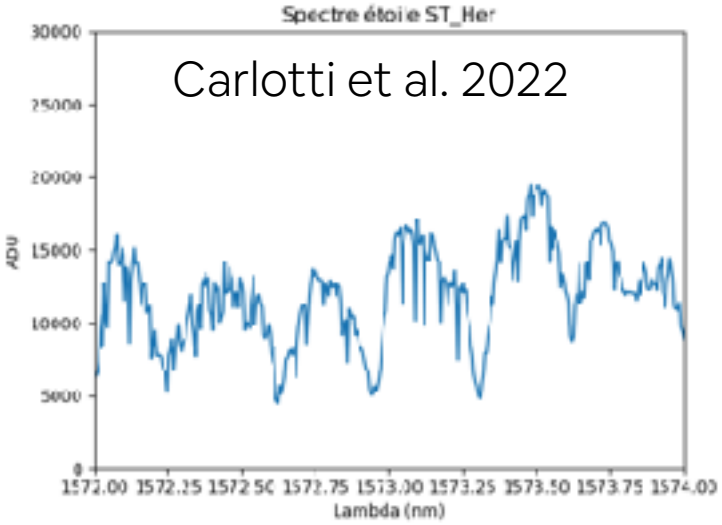
On-sky demonstration at Palomar in 2022

- Ideal location: AO system with fiber injection unit
- On-sky operability demonstration
- Signal extraction & perf. estimation with real stars
- In-situ comparison with PARVI & Freq. Comb laser
- Detector from U. de Montréal, engineering grade



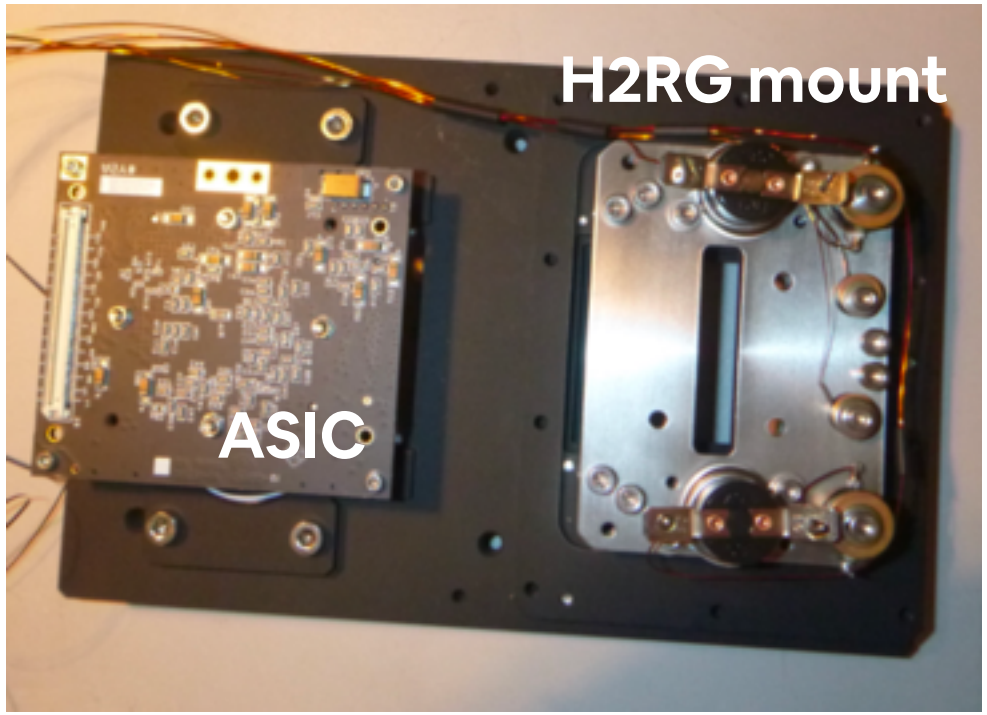


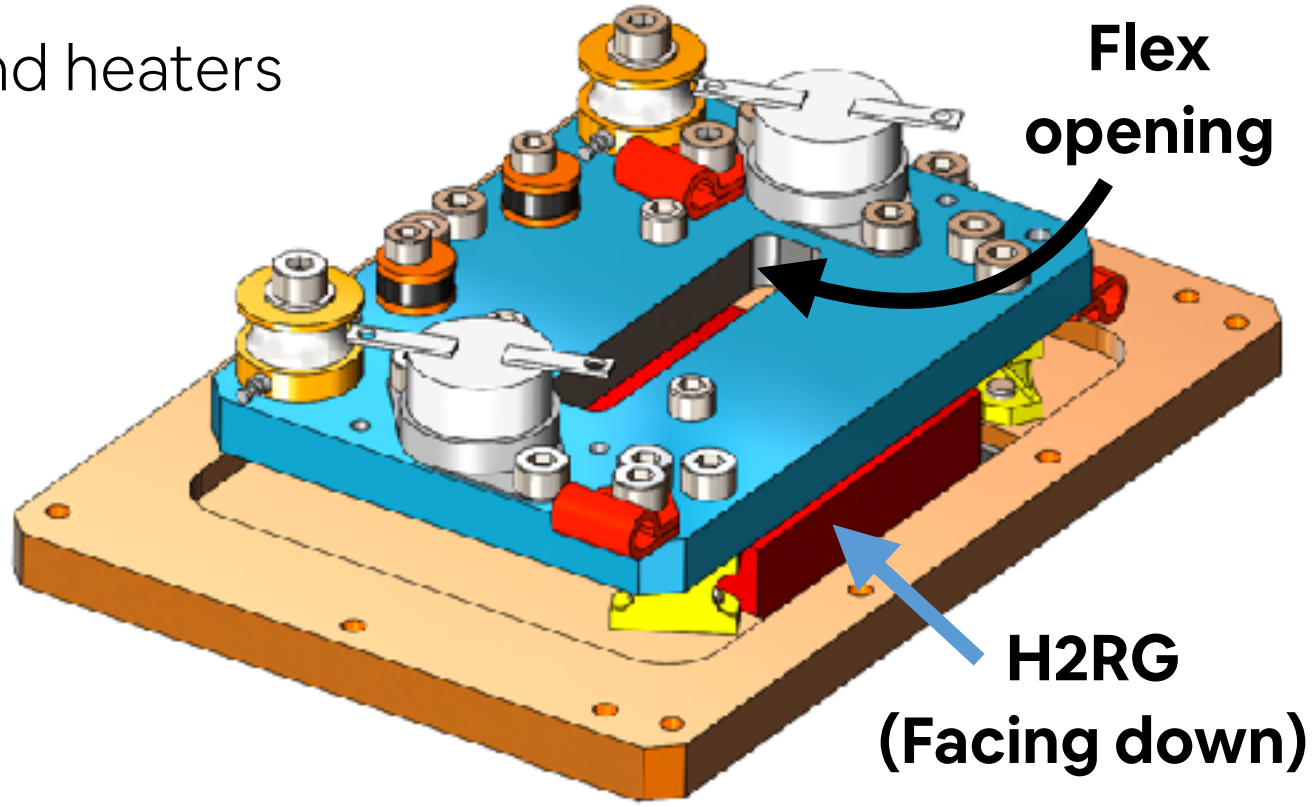




Mechanical design modification

- New H2RG mechanical support (based on U. Montréal design)
- Blue piece is Molybdenum (same as H2RG)
- Includes temperature sensors and heaters

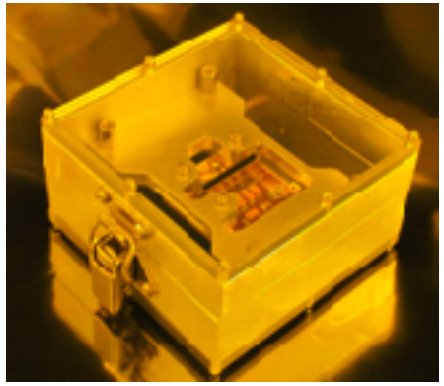


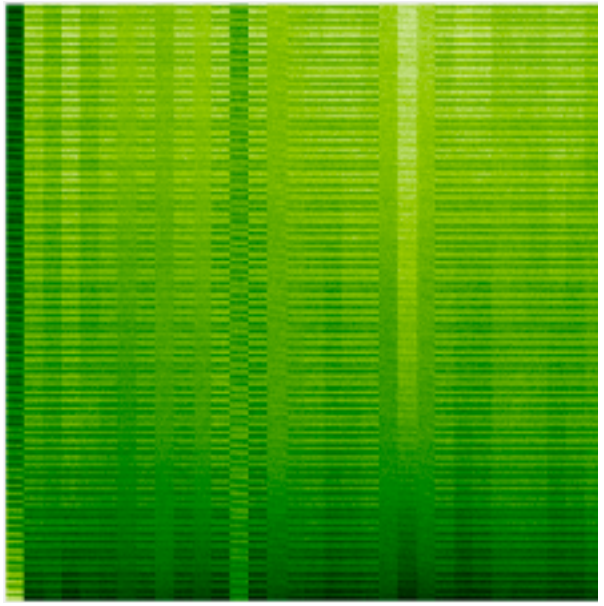


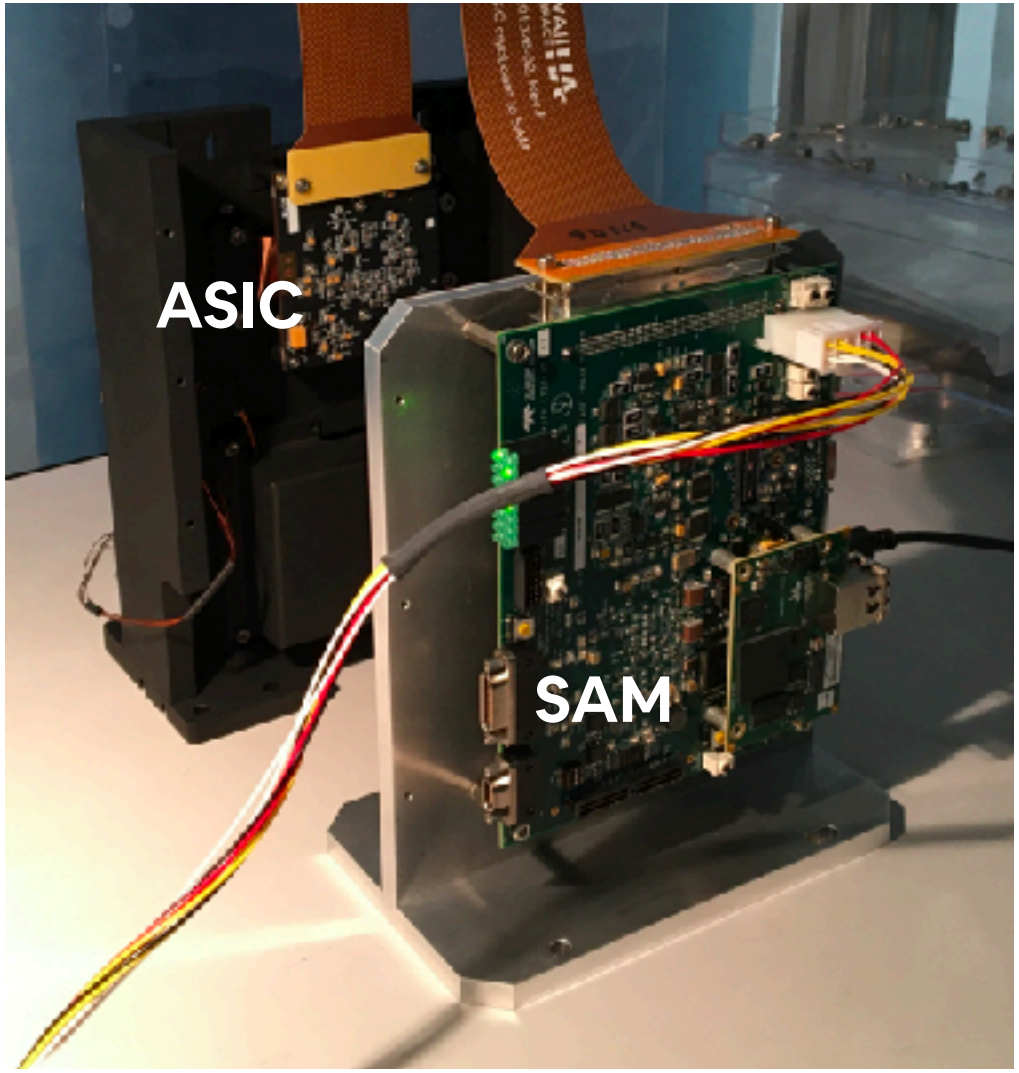
Test of ASIC, flex cables, and SAM

- Communication established with ASIC through SAM card
- Test performed with both single flex cable, and daisy-chained flex cables

Image received from ASIC (mock-up data; detector has not been installed yet)

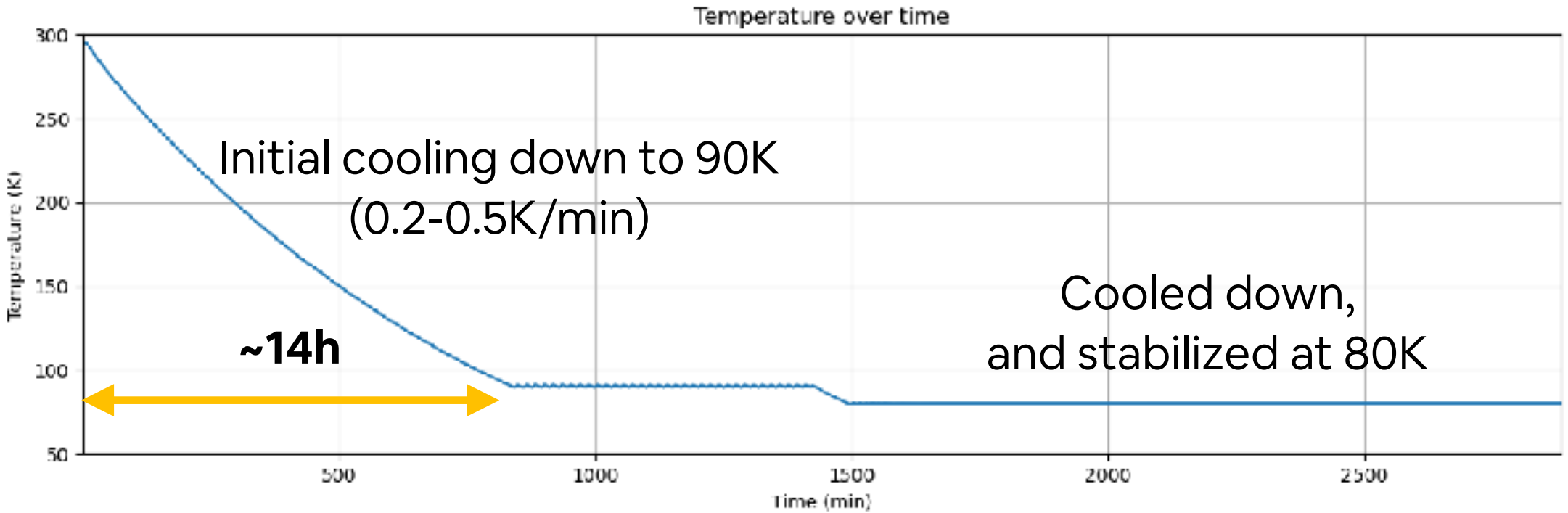






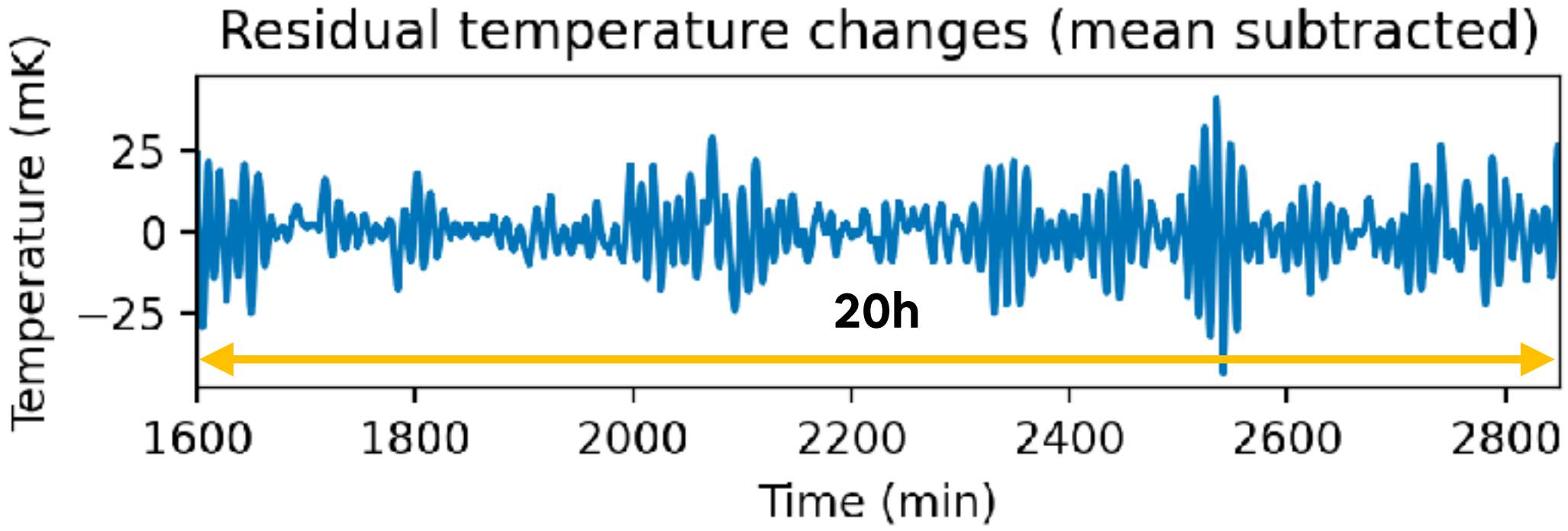
Temperature control

- Pulse tube to lower the temperature down to cryo level
- 8 temperature sensors (optical bench, the ASIC, the detector)
- Heaters & Lakeshore controller, PID tuned for 80K stability



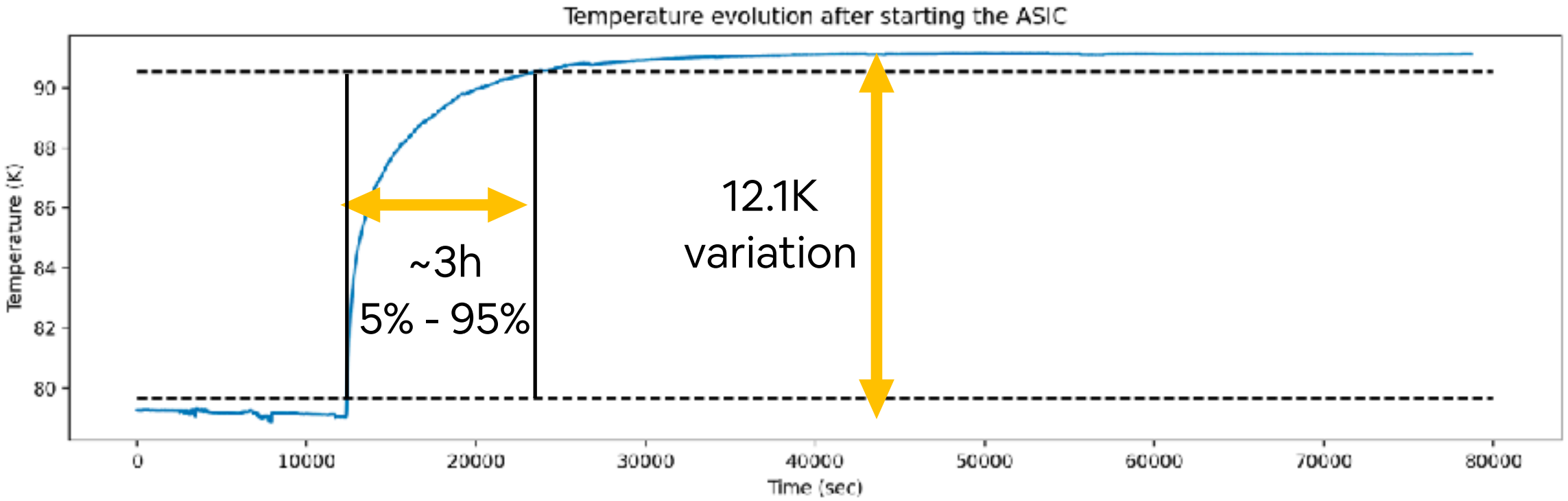
Temperature control

- Temperature stays within +/- 25mK over 20h
- Some +/-50mK jumps



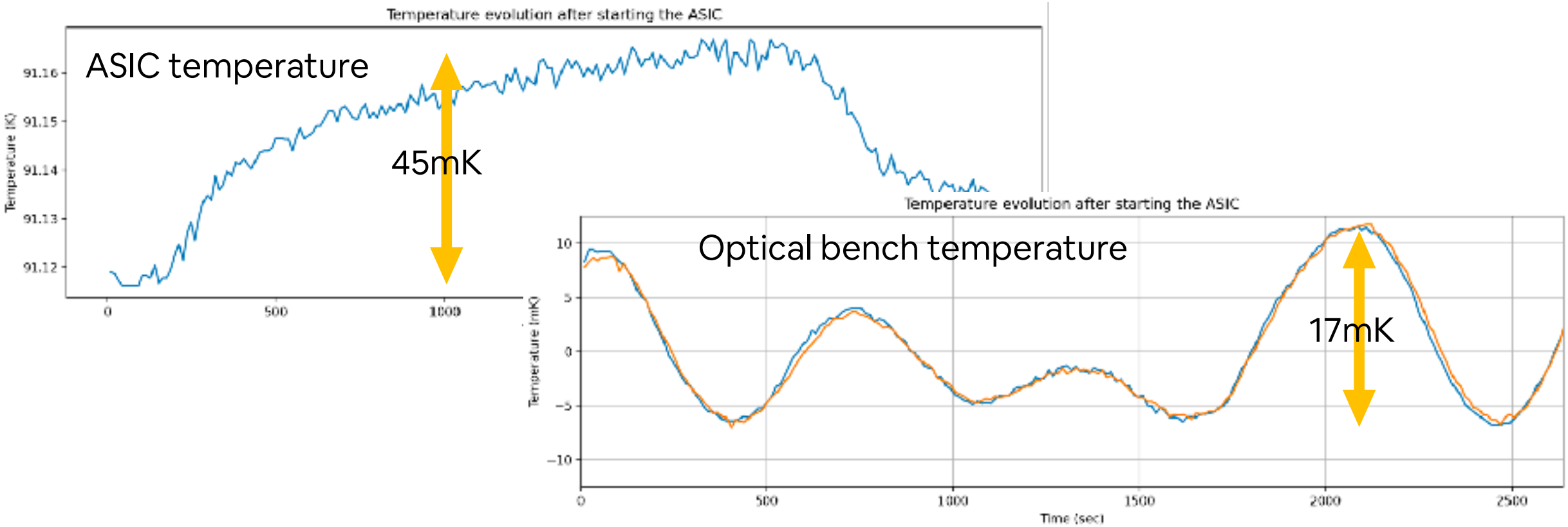
Temperature control

- Turning on the ASIC increases its temperature by 12K over 3h
- Simultaneously, detector temperature increases by 7K



Temperature control

- Starting a 30min ramp acquisition increases ASIC temperature by 45mK
- No increase of optical bench temperature, w/ ~17mK variations



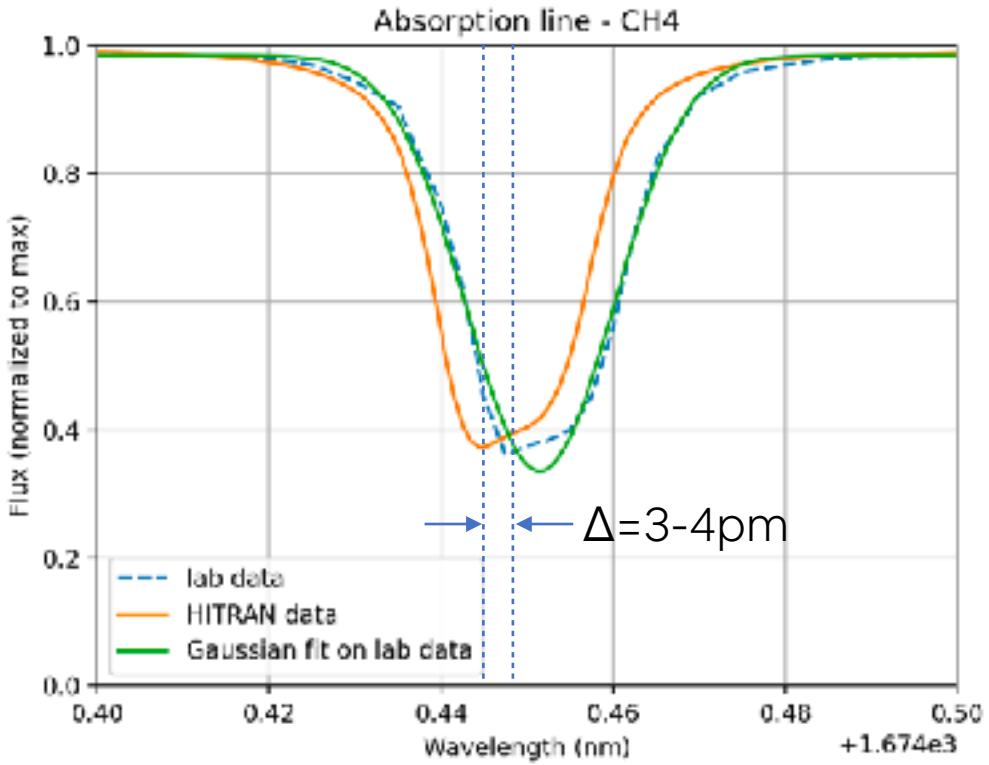
Detector integration & test

- Detector and ASIC mechanics moved from VIPA to cleanroom
- Support structure to securely hold H2RG mount during integration

- <u>October's objectives:</u>
  - Detector installation
  - Detector flat w/ multimode fiber for smooth illumination
  - H2RG performance characterization
  - H-band optics & monomode fibers to be installed back
  - Calibration in H-band w/ fibered gas cells & tunable laser

Detector integration & test

- Four Fibered gas cells: H_2O, CH_4, CO, CO_2



Validation of CH_4 gas cell wrt tunable laser:

3-4pm absorption line centering difference, in accordance w/ tunable laser wavelength control precision

Preparation for observations at OHP's T152

- First telescope VIPA observations with new H2RG
- End of 2023 / Beginning of 2024

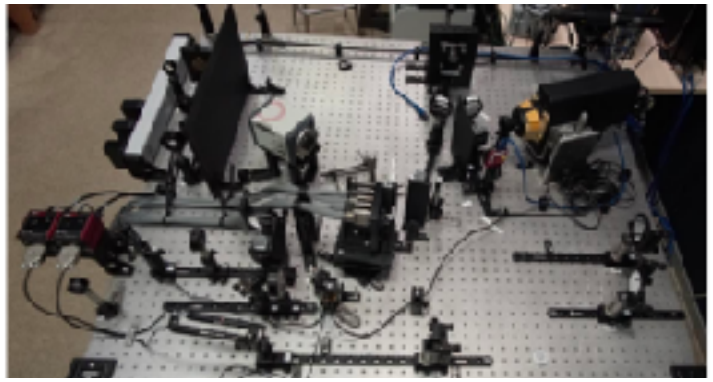
- VIPA coupling with PAPYRUS AO system (w/ fiber injection unit)
- Wavefront control to lower stellar light at the fiber location

ONERA

LAM

PAPYRUS

Institut Pythéas
Observatoire des Sciences de l'Univers
Aix Marseille Université



PAPYRUS bench, Fetick et al. 2023

Summary & perspectives

- FOCUS, a stepping stone for larger projects:
  - ERC EXACT: new science-grade H2RG to enable on-sky observations
  - PEPR Origins: VIPAPYRUS to test high angular/spectral resolution concepts on sky, e.g., wavefront control, signal processing,
  - Makes it possible to consider an application to future ELT instruments
- Future installation on an 8-10m telescope? (SPHERE/HiRISE, KPIC or SCExAO)
- Modification to include two optical benches (H & K bands at the same time)

Many thanks to:

A. Bidot, J. Ceszkowski, J.-J. Correia, S. Curaba, A. Delboulbé, L. Gluck, L. Jocou, D. Maurel, M.-H. Sztefek

Spectral range