The CHIME Observation Performance Simulator (OPSI) Software System: development and status at Preliminary Design Review

Nicolas Lamquin[1], Romain Sumérot[1], Alexis Déru[1], Frédéric Romand[1], Clarissa Hamann[2], Filippo Galassi[2], Stefano Baldacci[2], Dimitri Serrano-Velarde[2], Dimitri Lebedeff[3], Vincent Soulignac[3], Hugo Monchatre[3], Claudia Isola[4], Antonio Gabriele[4], Adrian Garcia[4], Anantha Chanumolu[4]

1-ACRI-ST 2-OHB System AG 3-TAS-France 4-ESA/ESTEC

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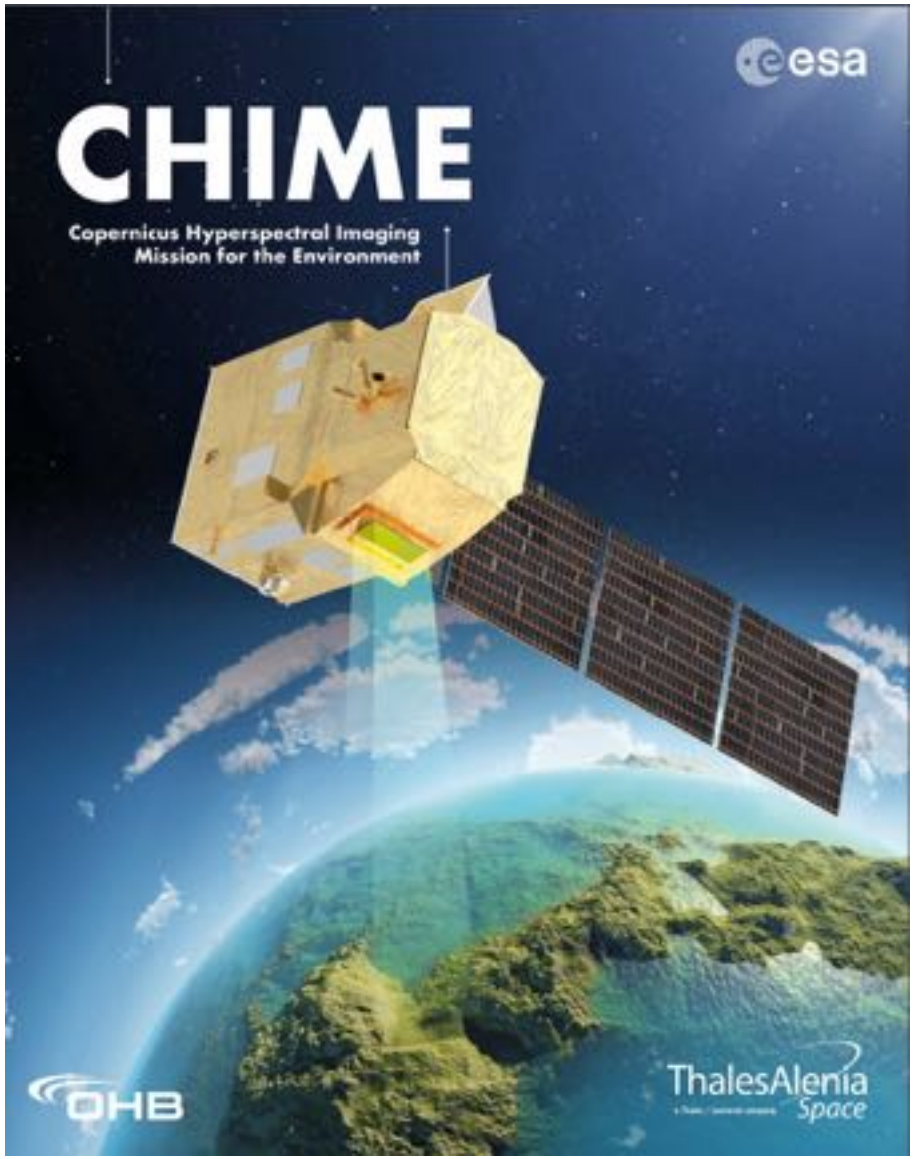
Context

- **Copernicus Hyperspectral Imaging Mission for the Environment:**
  - Copernicus High-Priority Candidate Mission (ESA)
  - Hyperspectral: 400-2500 nm / 8.4 nm sampling
  - High spatial resolution: 30 m
  - ~11 days revisit (~130 km swath) with two satellites

- **Phase B2/C/D/(E1)**
  - TAS-F, prime, resp. of the platform
  - OHB resp. of the instrument
  - ACRI-ST, as subco of OHB, implements the « OPSI » software system based on TAS-F and OHB design, algorithms, system inputs…
  - Kick Off OPSI Jan 2021
  - Launch by end of 2020s decade

- **Current status**
  - OPSI SW PDR (end of phase B) successfully achieved July 2022
  - Entering phase C

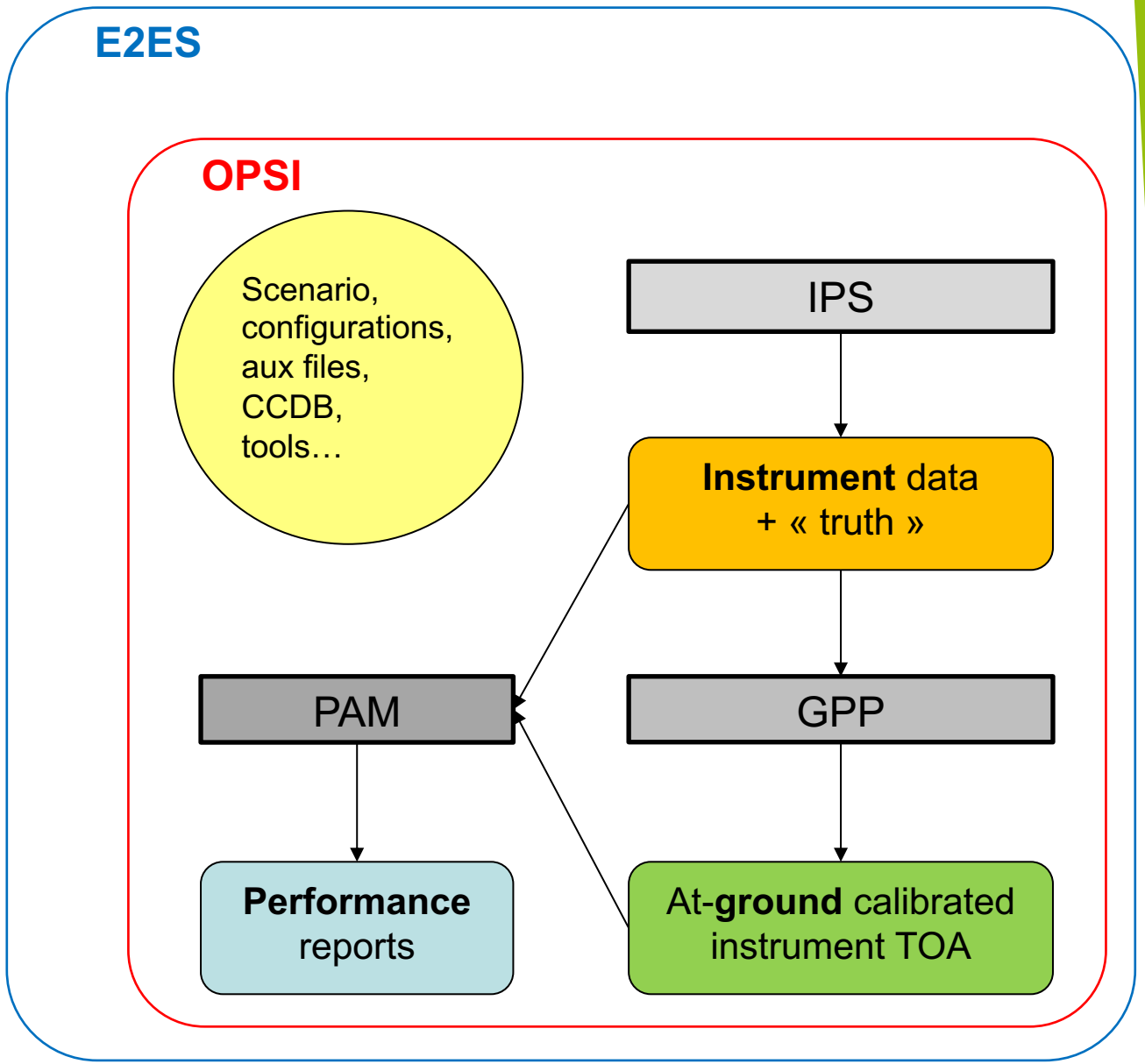


OPSI components

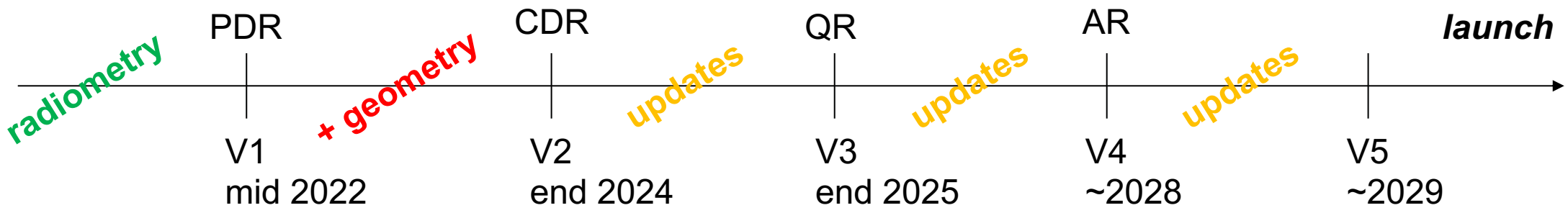
- **OPSI is composed of:**
  - IPS (**Instrument** Performance Simulator):
    - Geometry Module
    - Simplified Scene Generation Module
      - resampling TOA samples
      - interchangeable with a SGM simulating TOA
    - Instrument Simulation Module
    - On-Board Data Generation Module
  - GPP (**Ground** Processor Prototype):
    - L0 to L1C processors (TOA orthorect. reflectance)
    - Calibration modules (« online » and « offline »)
  - PAM (**Performance** Assessment Module):
    - assessment of radiometric, spectral, geometrical, and data reduction performance from L0 to L1C
  - Interfaces with viewing and orchestration tools, auxiliary data, calibration database, user configurations etc.

Interfacing in an E2E simulator which will use OPSI along with:

- SGM (BOA to TOA simulation)
- L2 and PAM L2 (performance at BOA)



OPSI development phases



GPP to be used in commissioning phase

OPSI V1 handles radiometry:

- **Instrument optical chain (simulation)**
- **GPP L1B (radiometric calibration)**
- **PAM L1B (radiometric calibration assessment)**

OPSI V2 shall handle all geometry and calibration:

- **Geometry module**
- **Instrument source packets formatting + compression**
- **All GPP (incl. L1C and calibration)**
- **All PAM (+geometric and spectral, data reduction performance)**

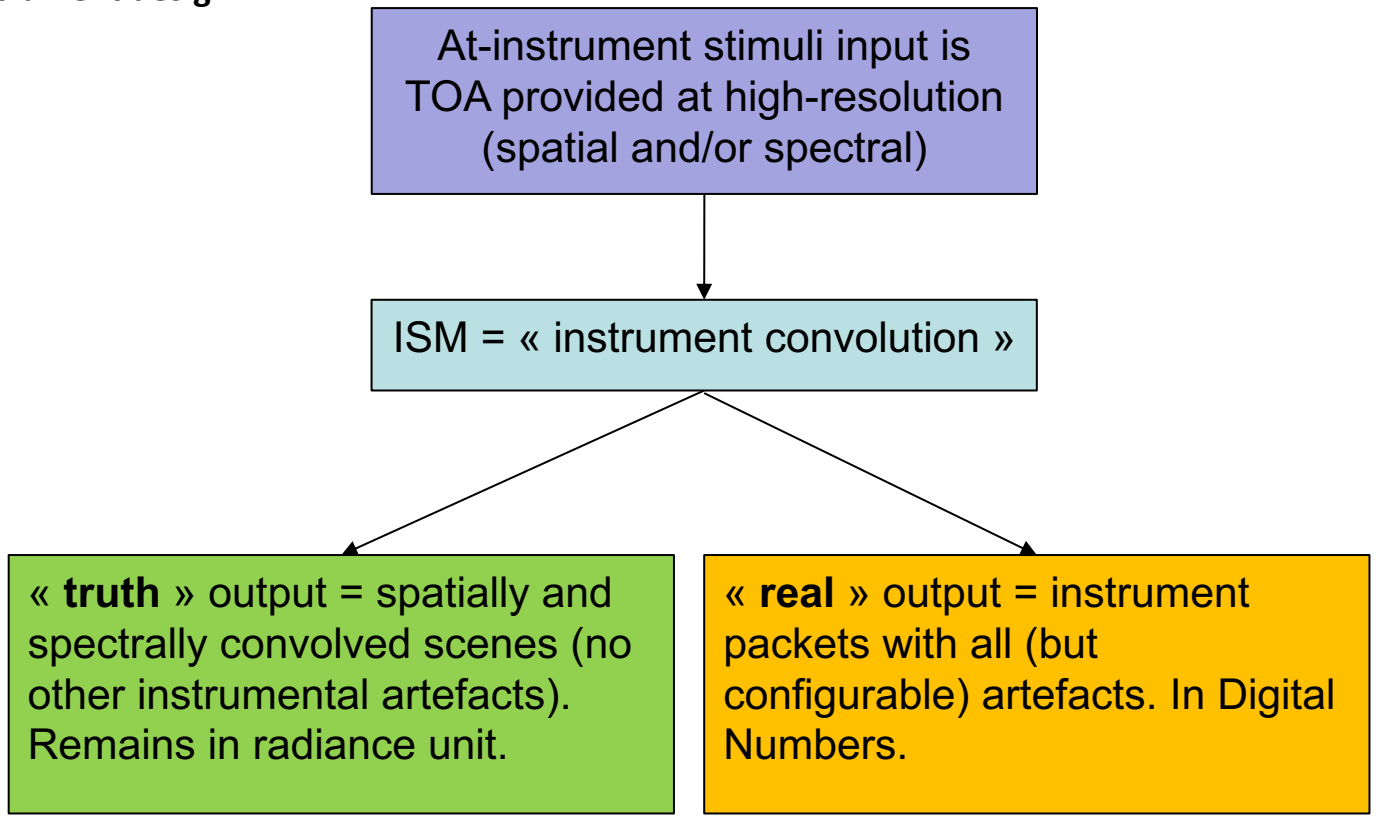
OPSI V3+ shall handle potential updates

Instrument Simulation Module (focus)

It simulates the acquisition of the instrument from optical transmissions to electronics conversion and binning.

Software objects and methods are built in accordance with instrument design:

- **Telescope**
  - Optical transmission
  - Background noise
- **Slit**
  - Signal magnification
  - Background noise
- **Spectrometer**
  - Transmission, grating and dispersion (smile)
  - Straylight
  - Parasitic noise
- **Detector**
  - Optical PSFs (incl. Pixel PSF)
  - Radiometric noise (dark, readout, shot noise)
  - PRNU
  - ADC
- **Front-end Electronics**
  - Onboard equalization
  - Binning

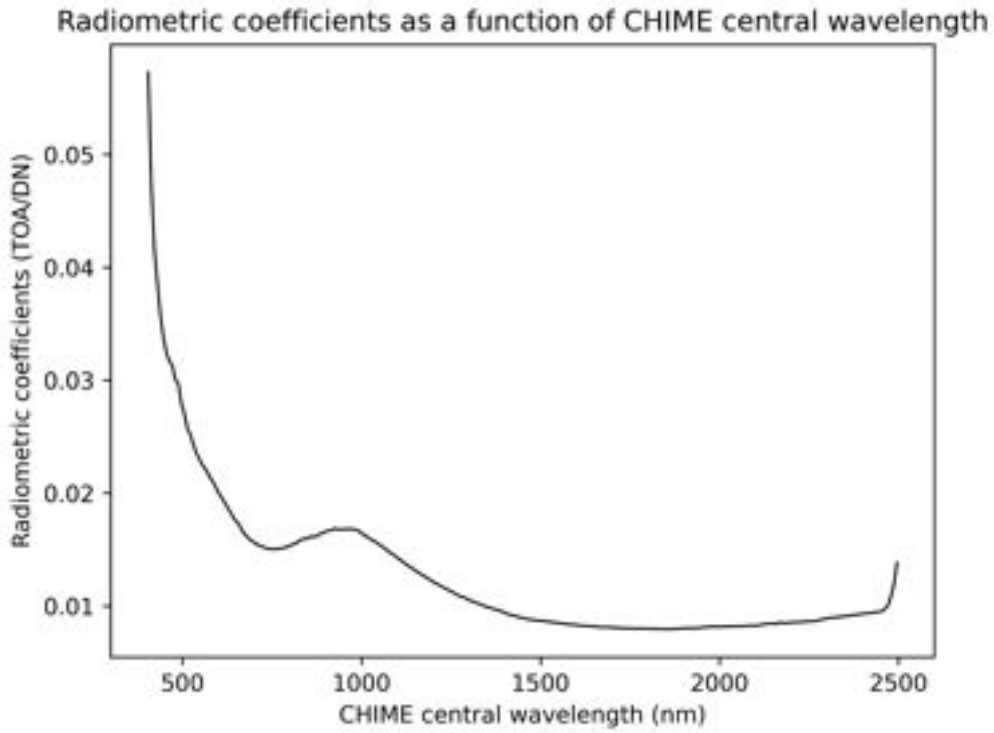


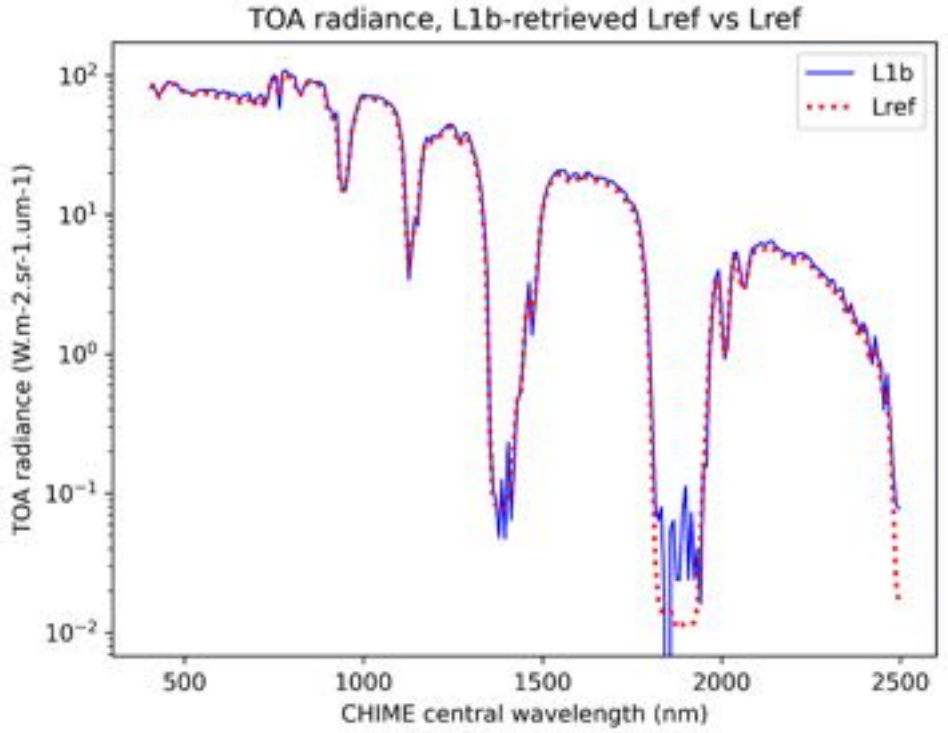
OPSI is tuneable wrt spatial and spectral dimensions as well as wrt effect contributor

Ground Processor Prototype (L1B)

Currently restricted (mainly) to L1B (radiometric correction):

- **Computes radiometric calibration coefficients (from simplified Sun-diffuser acquisitions)**
- **Inverts the optical chain to convert Digital Numbers into TOA radiance (using the precomputed radiometric calibration coefficients)**





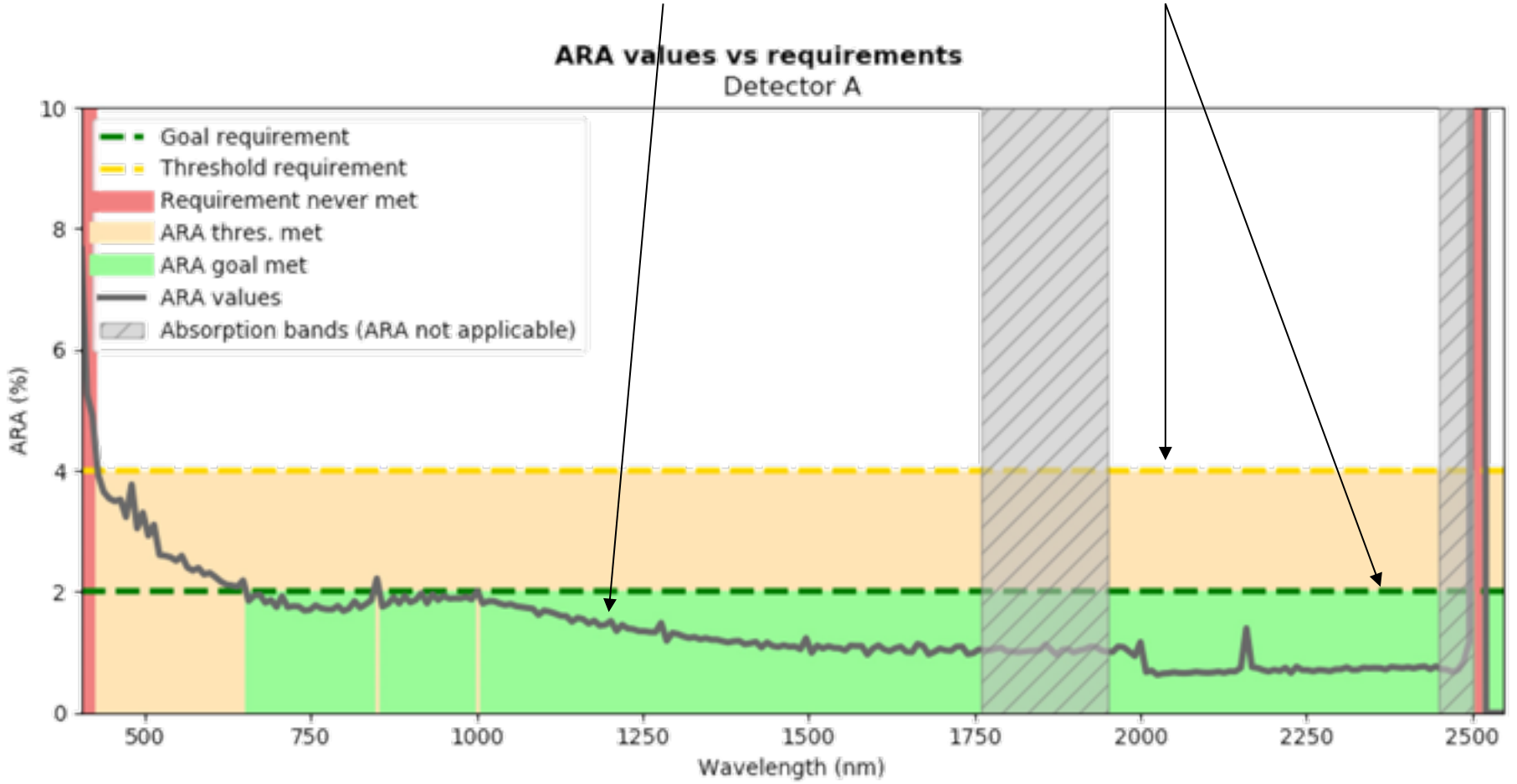
At OPSI V1, GPP L1B retrieves radiometrically-calibrated TOA radiance

Example of « truth » (spatially and spectrally convolved)

Example of « real » (L1B-retrieved)

PAM L1B: preliminary Absolute Radiometric Accuracy (ARA, %)

PAM uses dedicated scenarios to assess **system performance** against **mission requirements**



Absolute Radiometric Accuracy (%) against requirements, instrument is here simulated as « End-of-Life » (i.e. « worst-case »).

The OPSI concept is widely shared for remote sensing missions, the purpose being notably to support validation activities and verification of end-to-end requirements

The CHIME OPSI is an ongoing project, following and supporting the development of the CHIME mission

At PDR, OPSI V1 handles a preliminary version of the processing models and parameters

V2+ shall be more complete and shall assess all aspects of mission performance

Stay tuned !

Thank you !