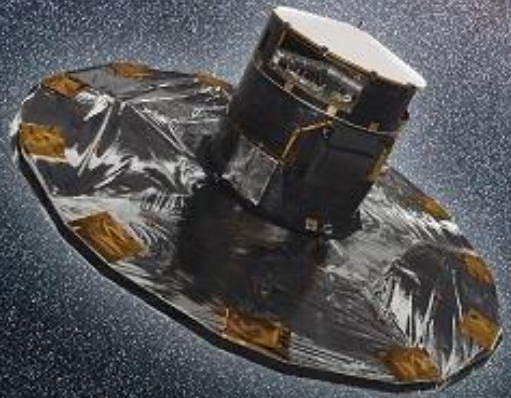
Gaia Mean spectra: Representation & calibration



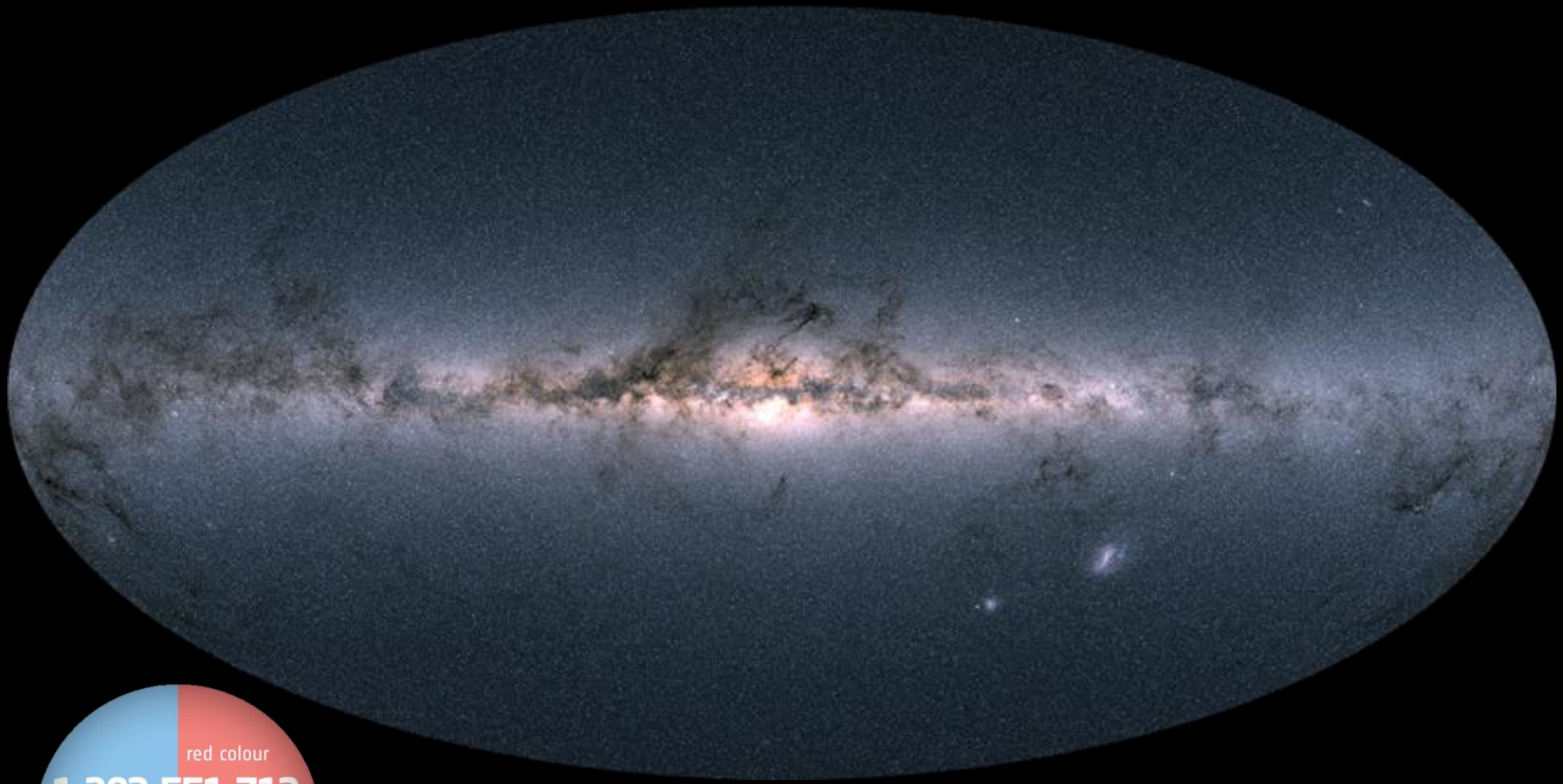
Josep Manel Carrasco

Barcelona, 17-19 February 2020

Institute of Cosmos Sciences (ICCUB-IEEC)

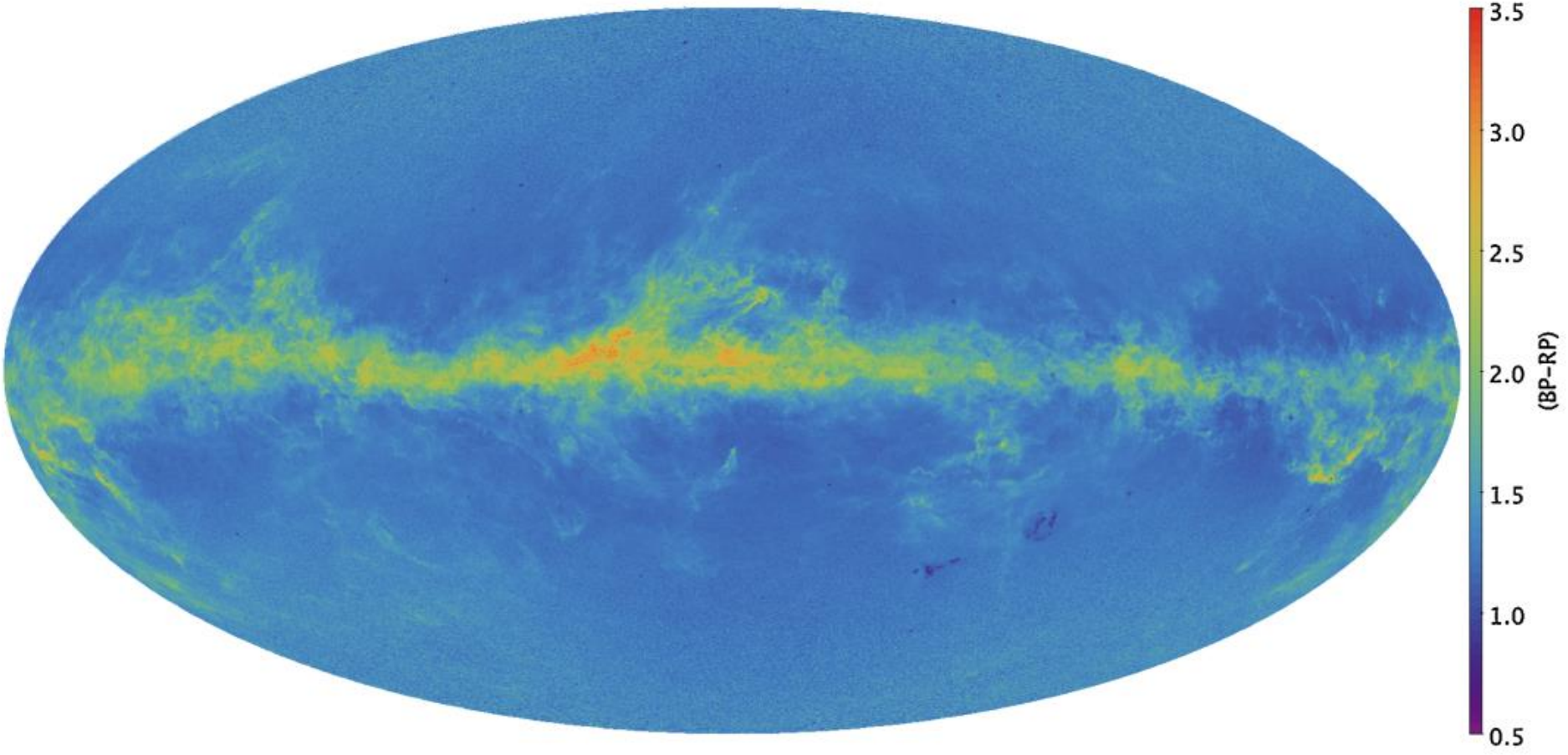
Coordination: Red Española de Explotación Científica de Gaia

SECOND GAIA DATA RELEASE (25/04/2018)



Gaia DR2 imatge (integrated flux per píxel)

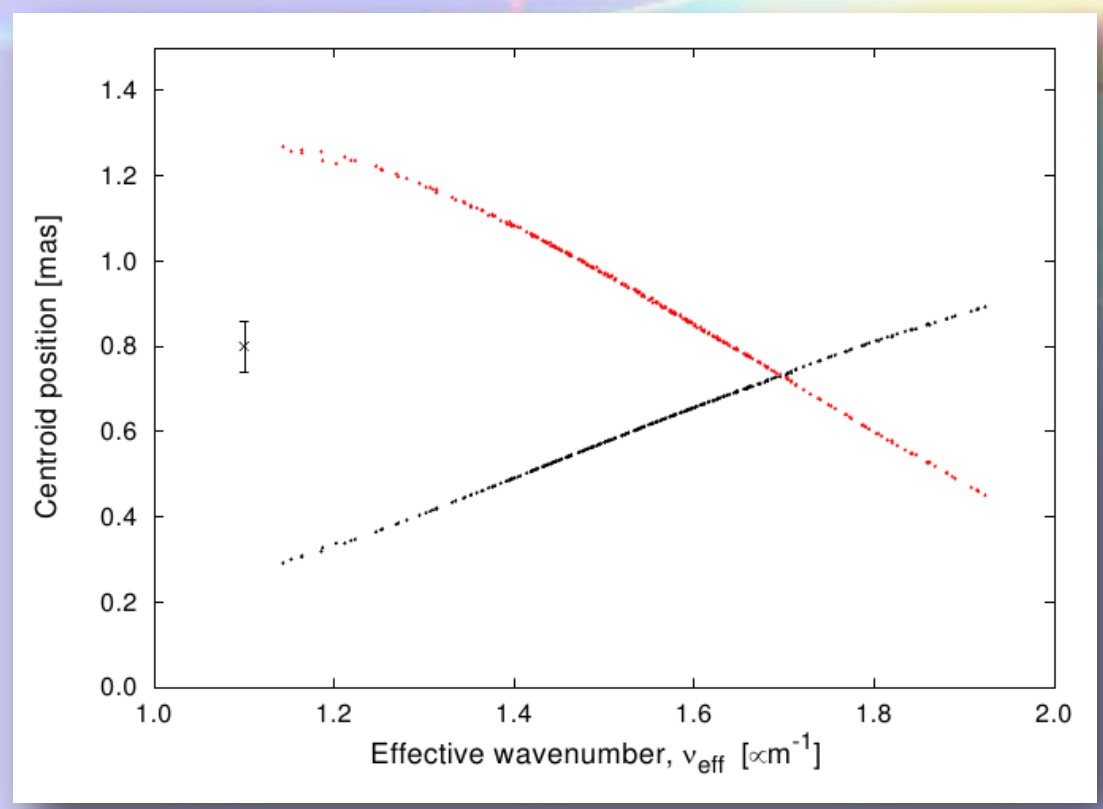
SECOND GAIA DATA RELEASE (25/04/2018)



Gaia DR2 imatge (integrated flux per píxel)

Why photometry?

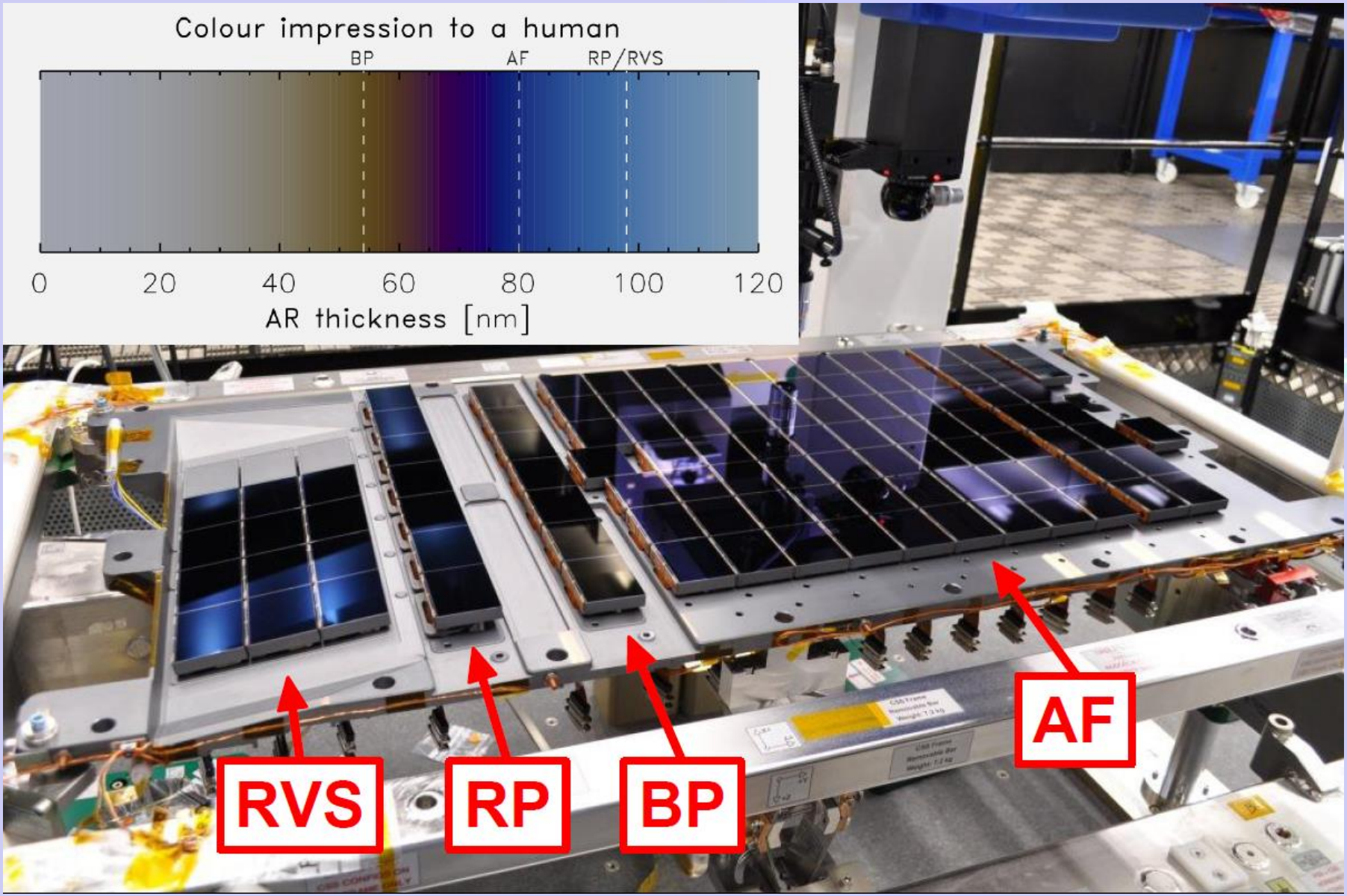
- Photometry is necessary to account for the **chromatic aberrations** in the astrometric focal plane to achieve microarcsec accuracy level



GAIA-CA-TN-ESA-JDB-028

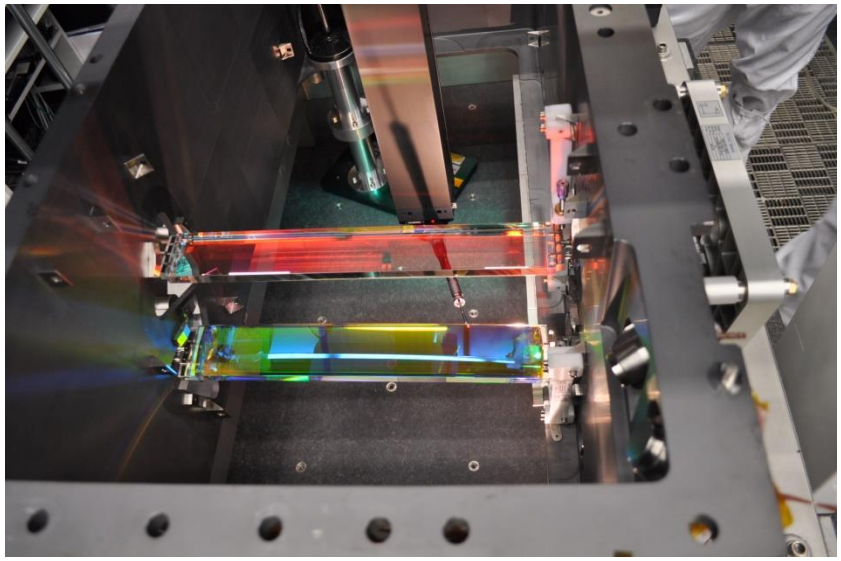
Centroid positions for the polychromatic diffraction images of different spectra versus effective wavenumber, for two representative WFE maps. Stellar spectra from the Pickles library (A_{550} = 0 and 2 mag). The error bar shows the photon-statistical centroiding error σ_ξ for a single-CCD transit of a bright star (G < 13 mag).

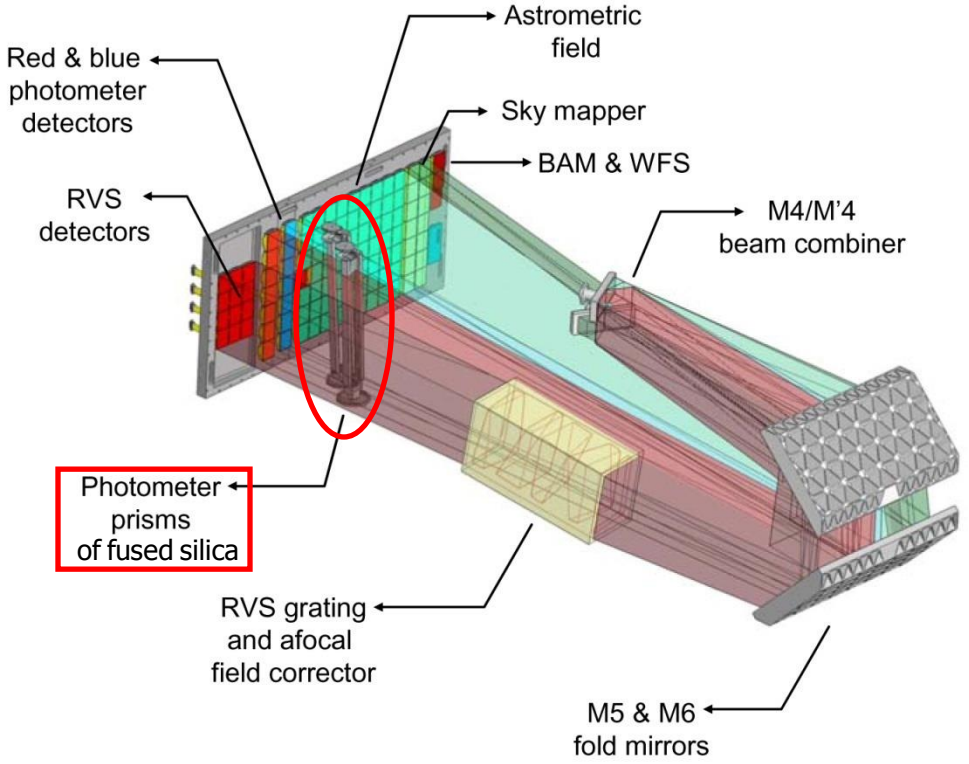
The Colour of Gaia's eyes



PoW : 2 Oct 2015

BP/RP spectrophotometers

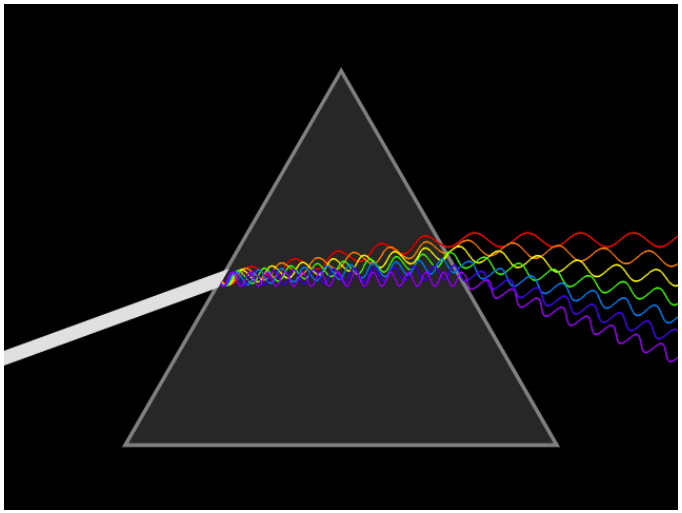


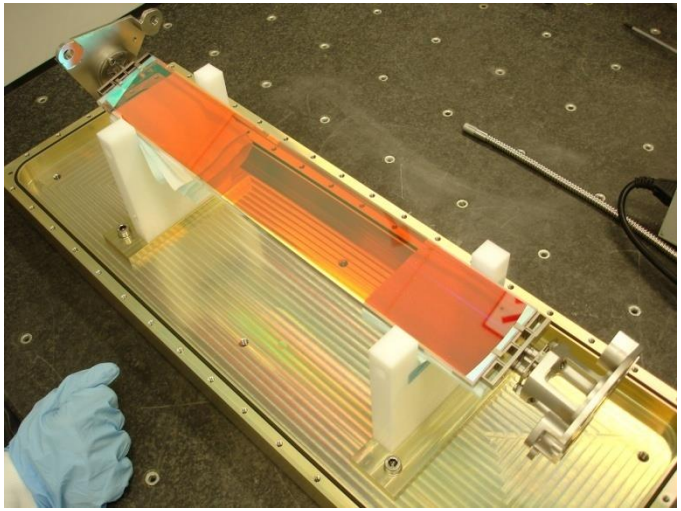


Figures courtesy EADS-Astrium

Blue photometer:
330–680 nm

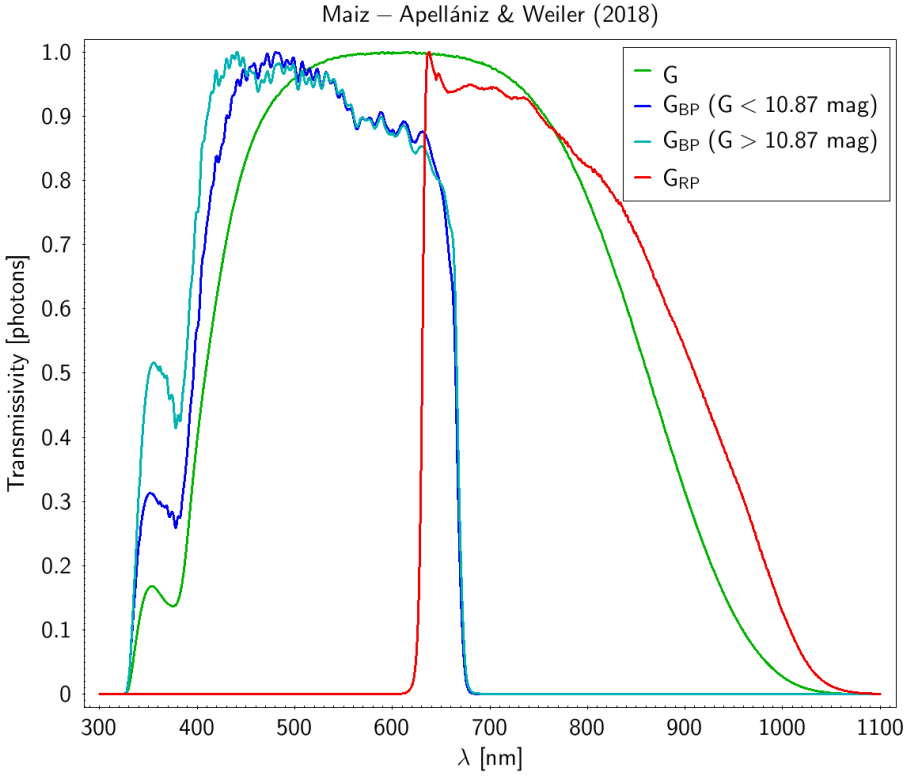
Red photometer:
640–1000 nm



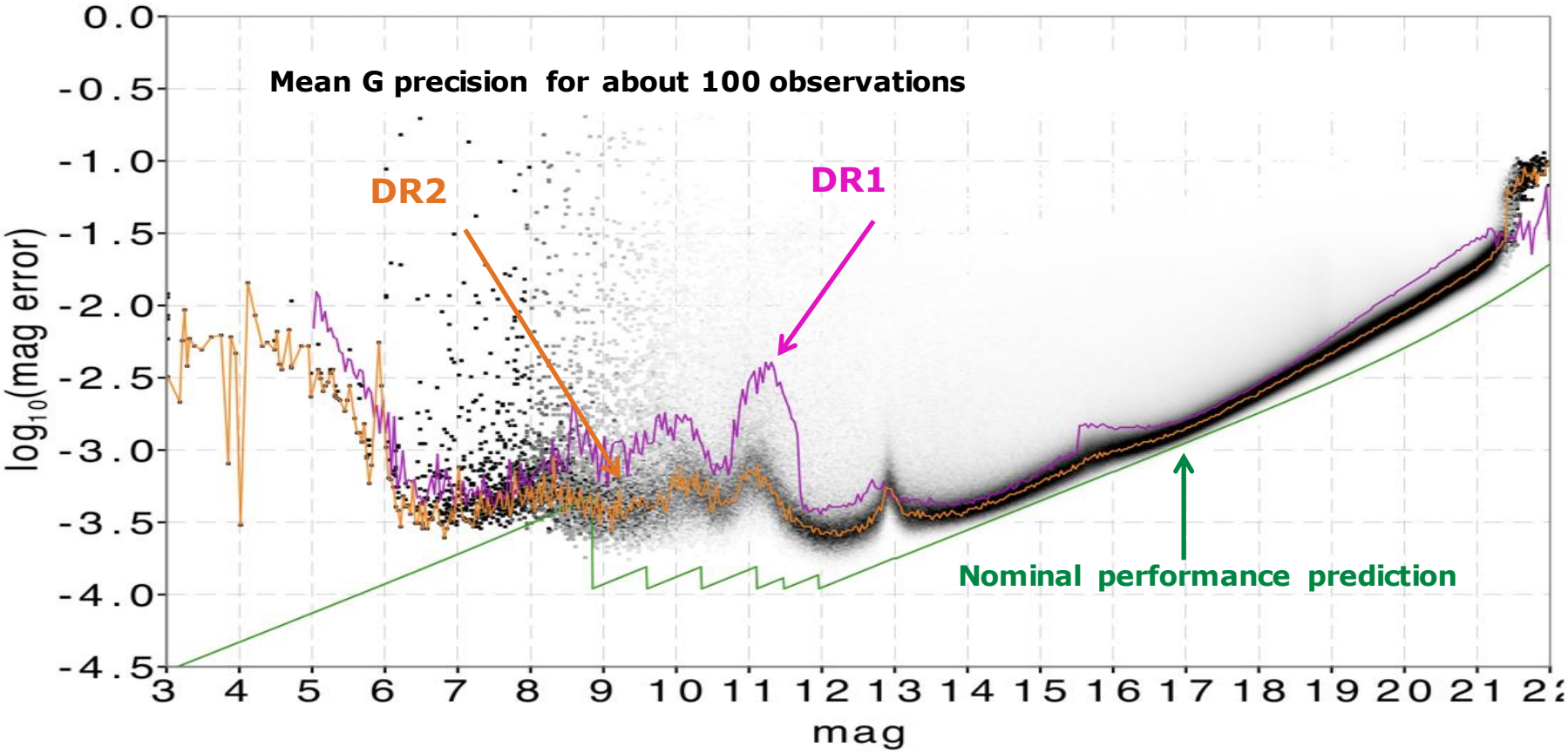


Coverage & Resolution

- **Wavelength coverage:**
  BP: 330-680 nm,
  RP: 640-1000 nm



GDR2 Photometric performance



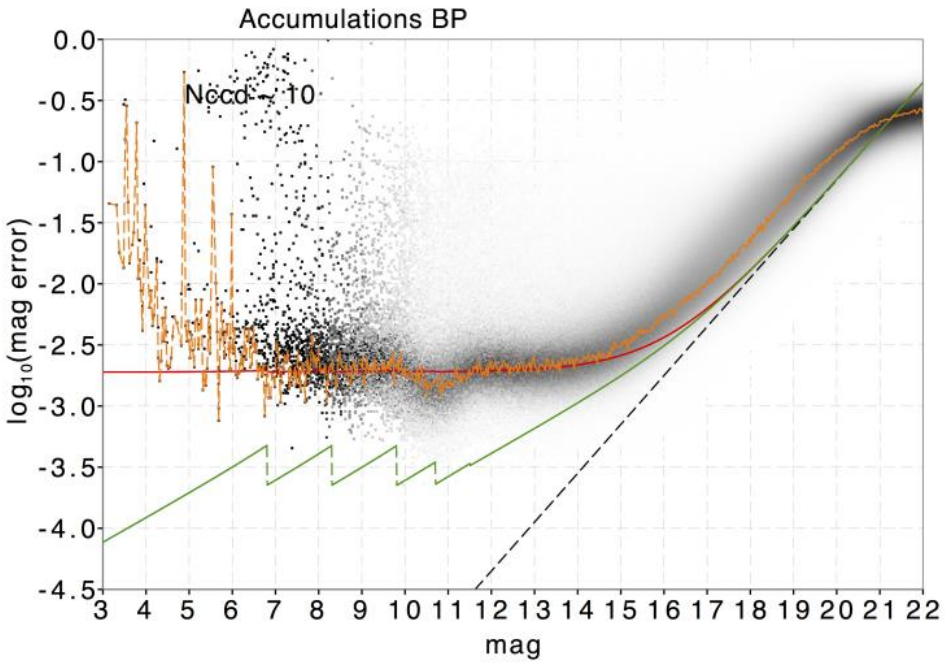
Systematics $\lesssim$ 10 mmag.

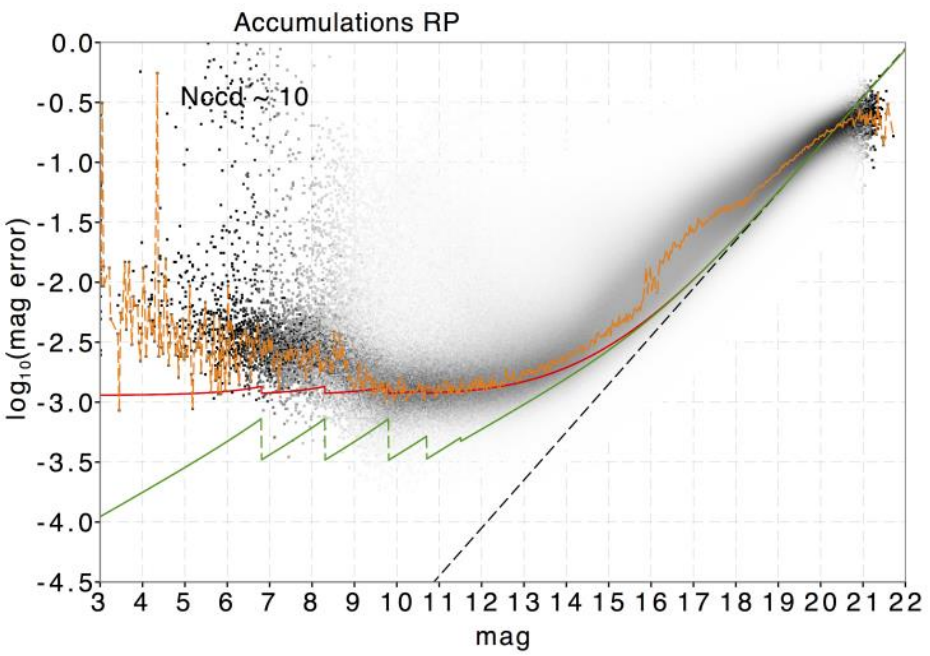
Remaining caveats:

- Faint end dominated by stray-light
- Bright end affected by saturation effects
- Calibration issues at window class regime transitions

Expected improvement in EDR3

GDR2 Photometric performance





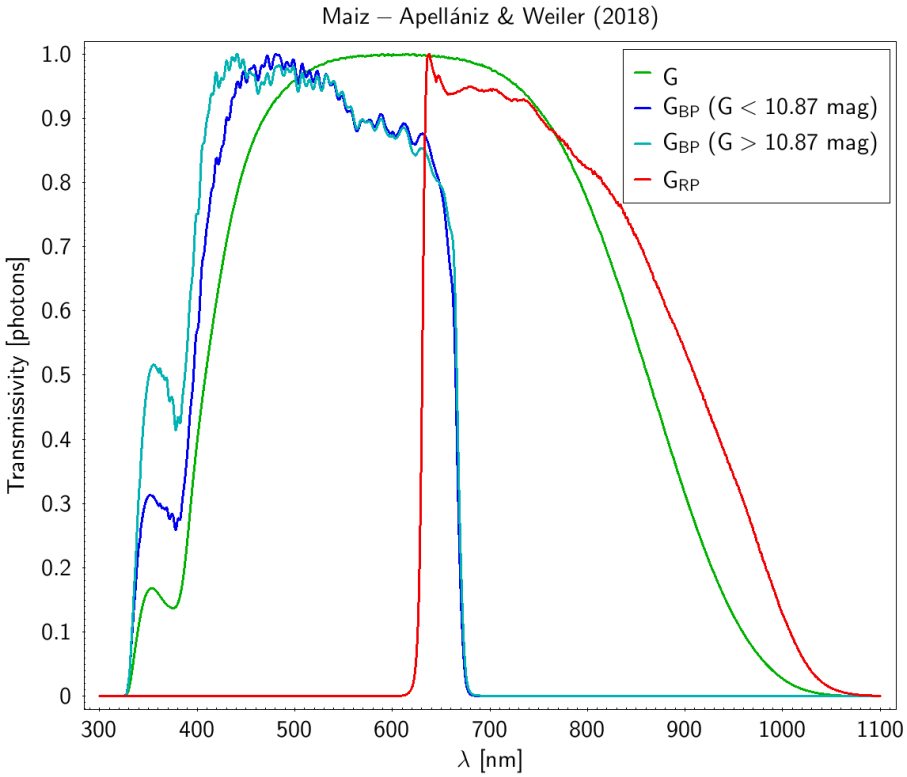
Red line: 5 and 3 mmag calibration error threshold in BP and RP, respectively

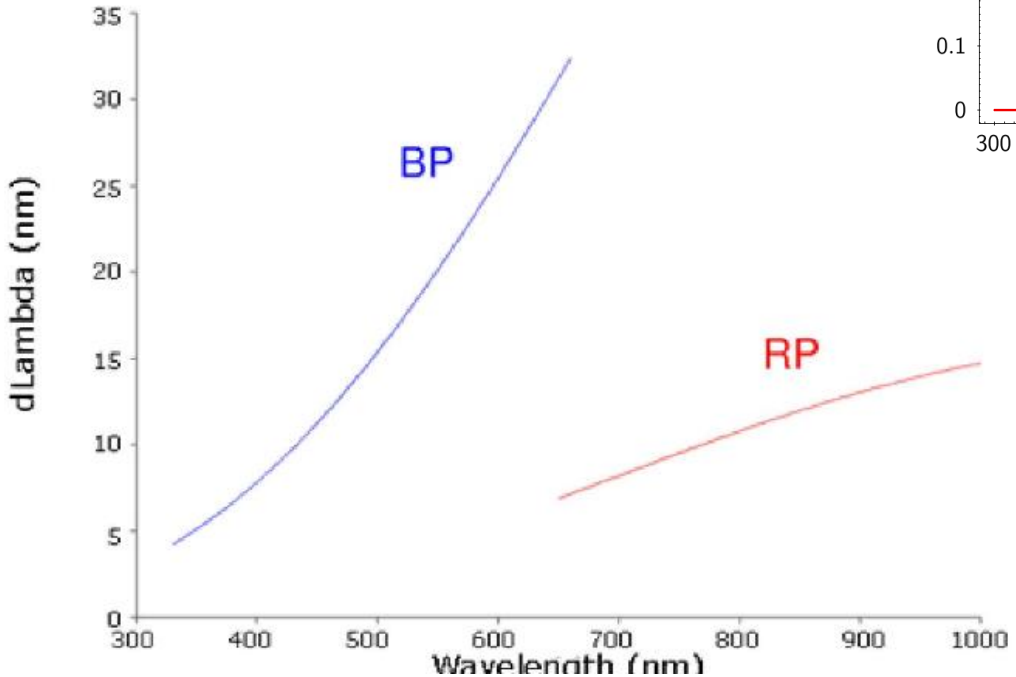
Future photometric content

- **EDR3 (Q3 2020)**
  - 34 months of input data (~ 1.8 billion sources)
  - Improved integrated photometry (G, G_{BP} , G_{RP})
  - $\sigma_G^{EDR3} \sim 0.7\ \sigma_G^{DR2}$
- **DR3 (H2 2021)**
  - **Mean BP/RP spectra** (TBD subset of sources, with astrophysical parameters determination) + Tool to handle BP/RP spectra.
  - Photometric variablity (~ 7 million sources)
  - Solar system photometry (~ 100000 sources)
  - Mean BP/RP reflectance spectra for solar system objects (~ 5000)

Coverage & Resolution

- **Wavelength coverage:**
  BP: 330-680 nm,
  RP: 640-1000 nm
- **Resolution:**
  BP: 4-32 nm/pixel
  RP: 7-15 nm/pixel

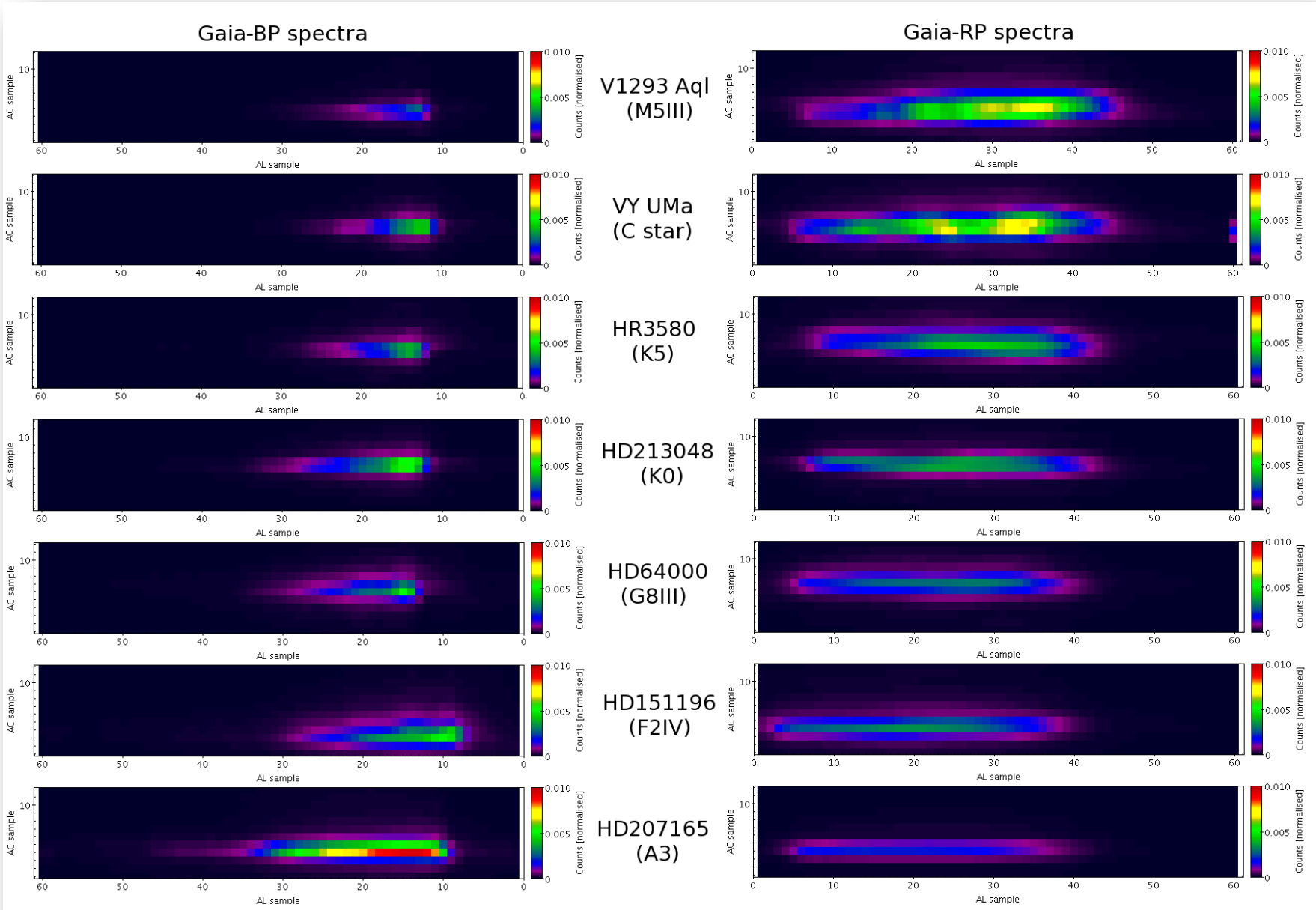




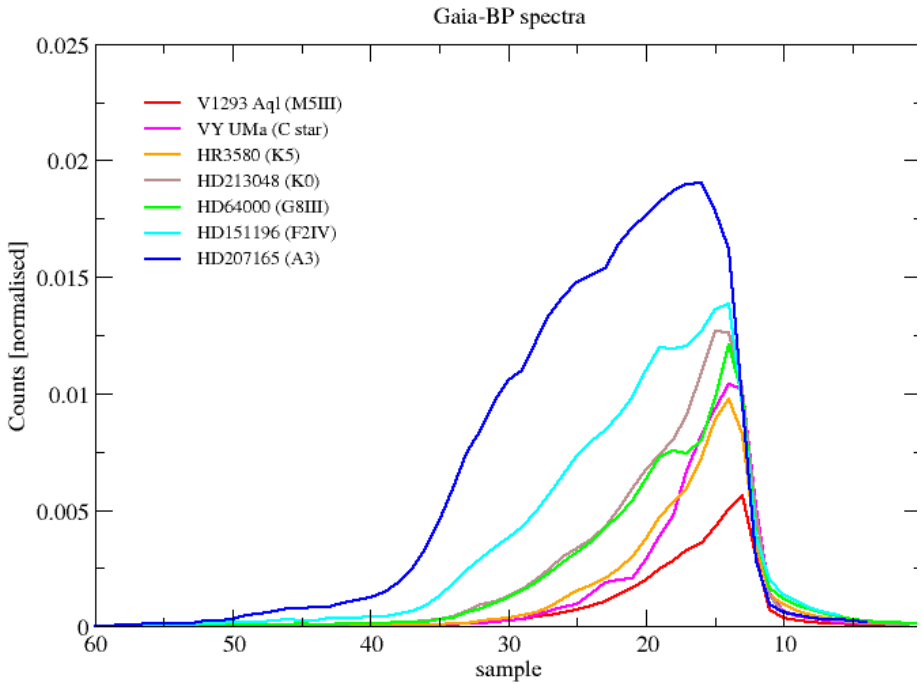
- Different resolution in different pixels
- PSF blurs the wavelength information in Gaia

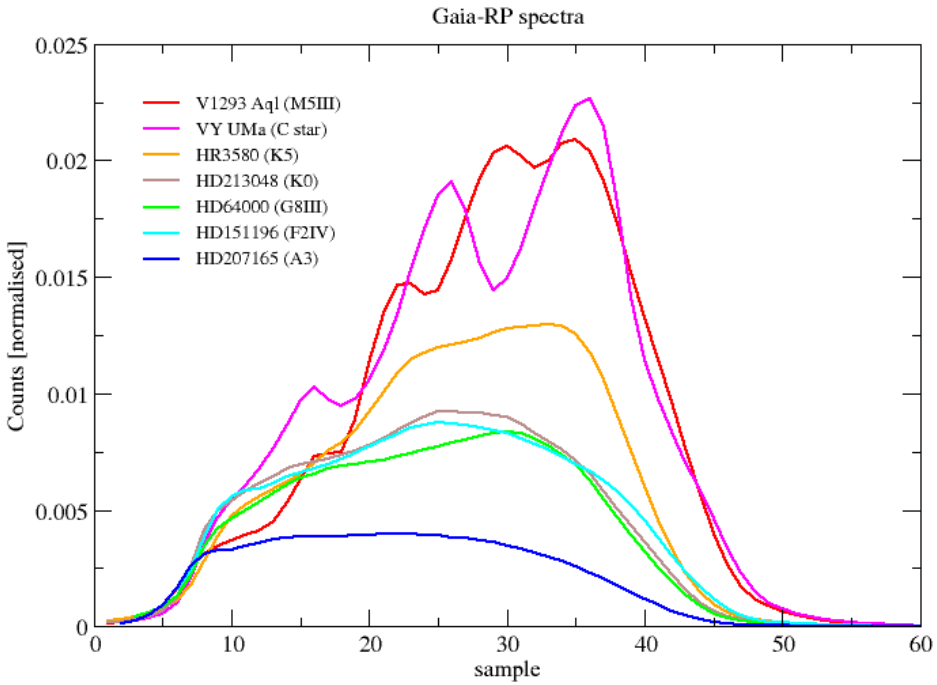
→ Challenging calibration

First XP spectra (commissioning)



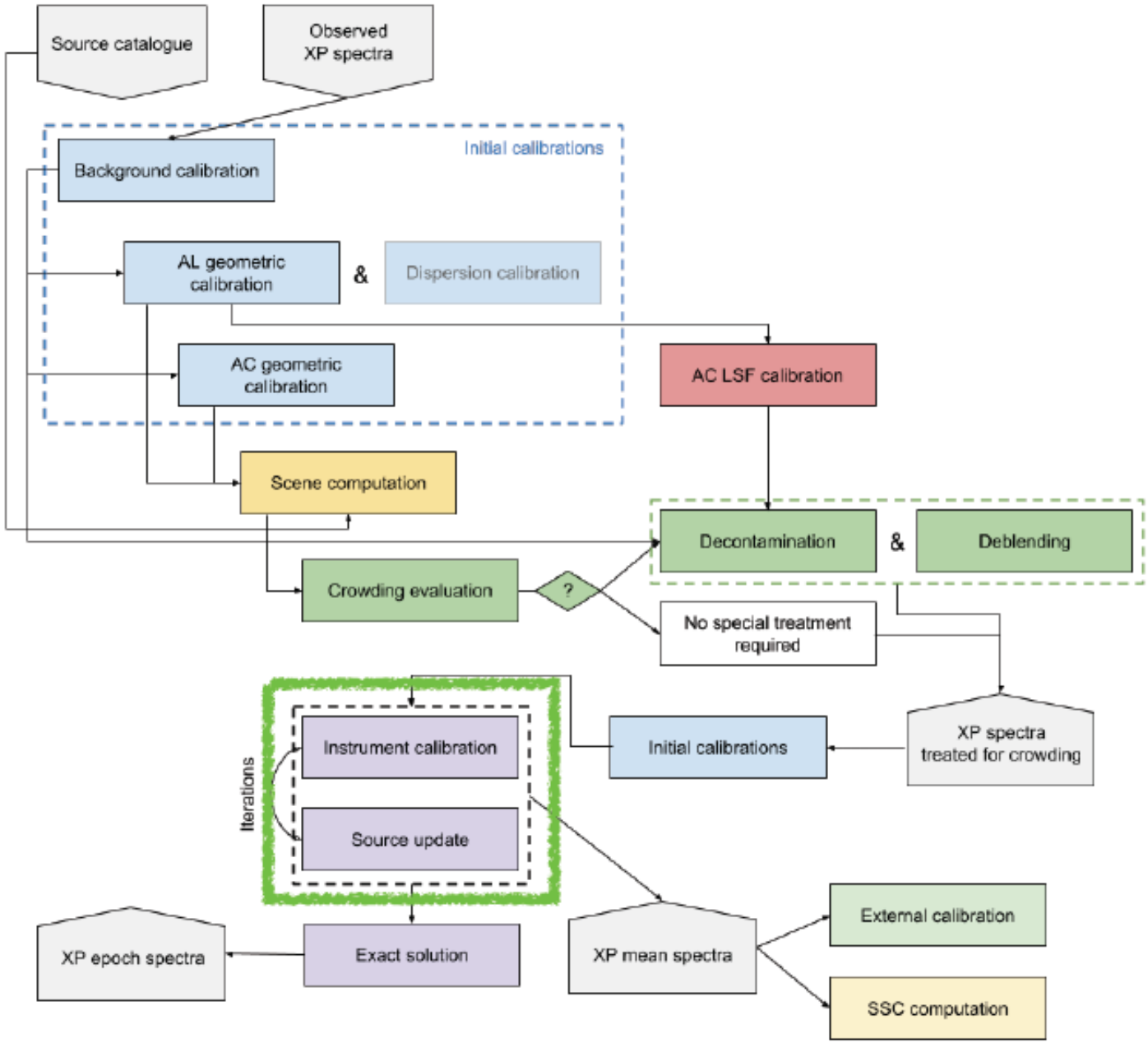
First XP spectra (commissioning)



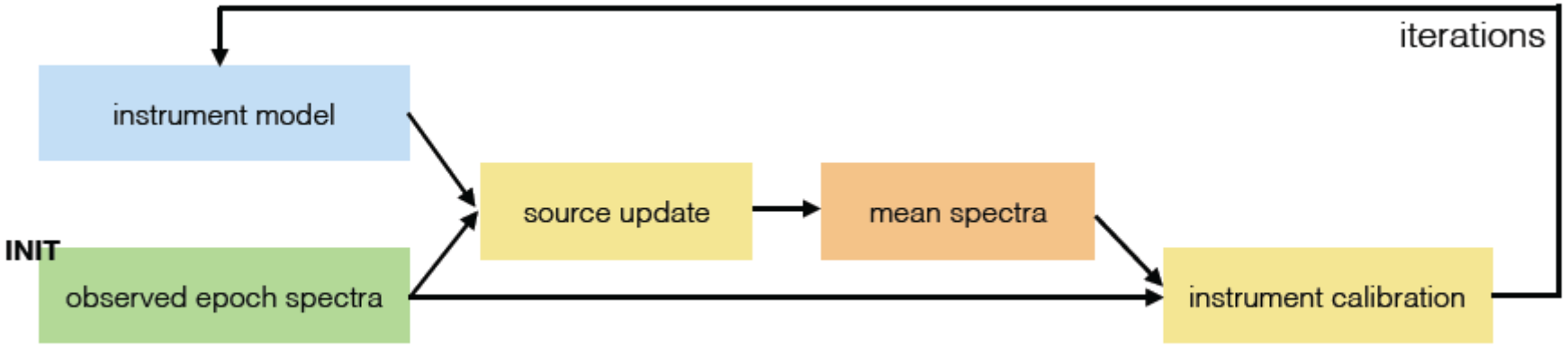


PoW : 5 Jun 2014

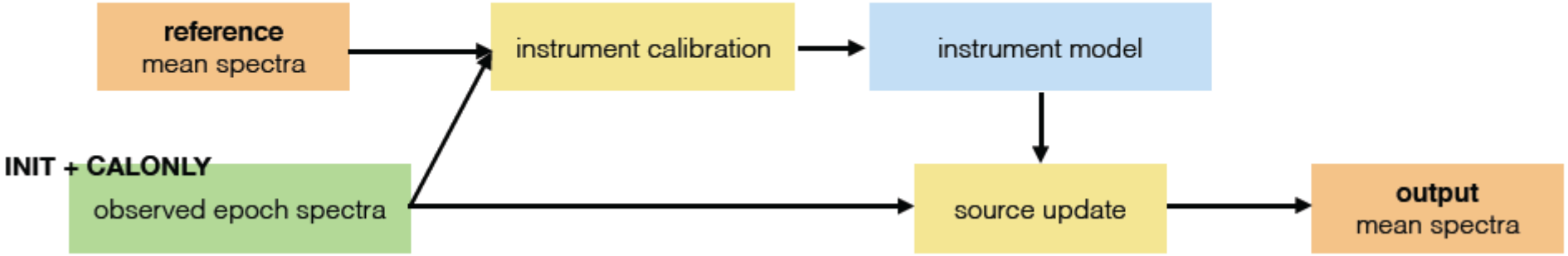
BP/RP Processing Flow



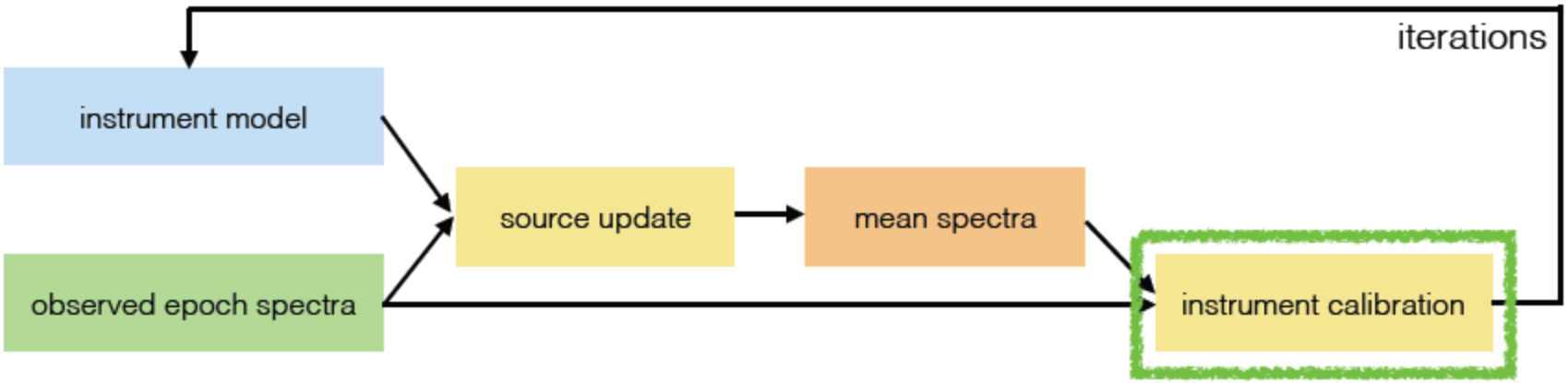
BP/RP Internal calibration



Initialisation - Iterations are required to establish a catalogue of **reference** spectra



BP/RP Internal calibration

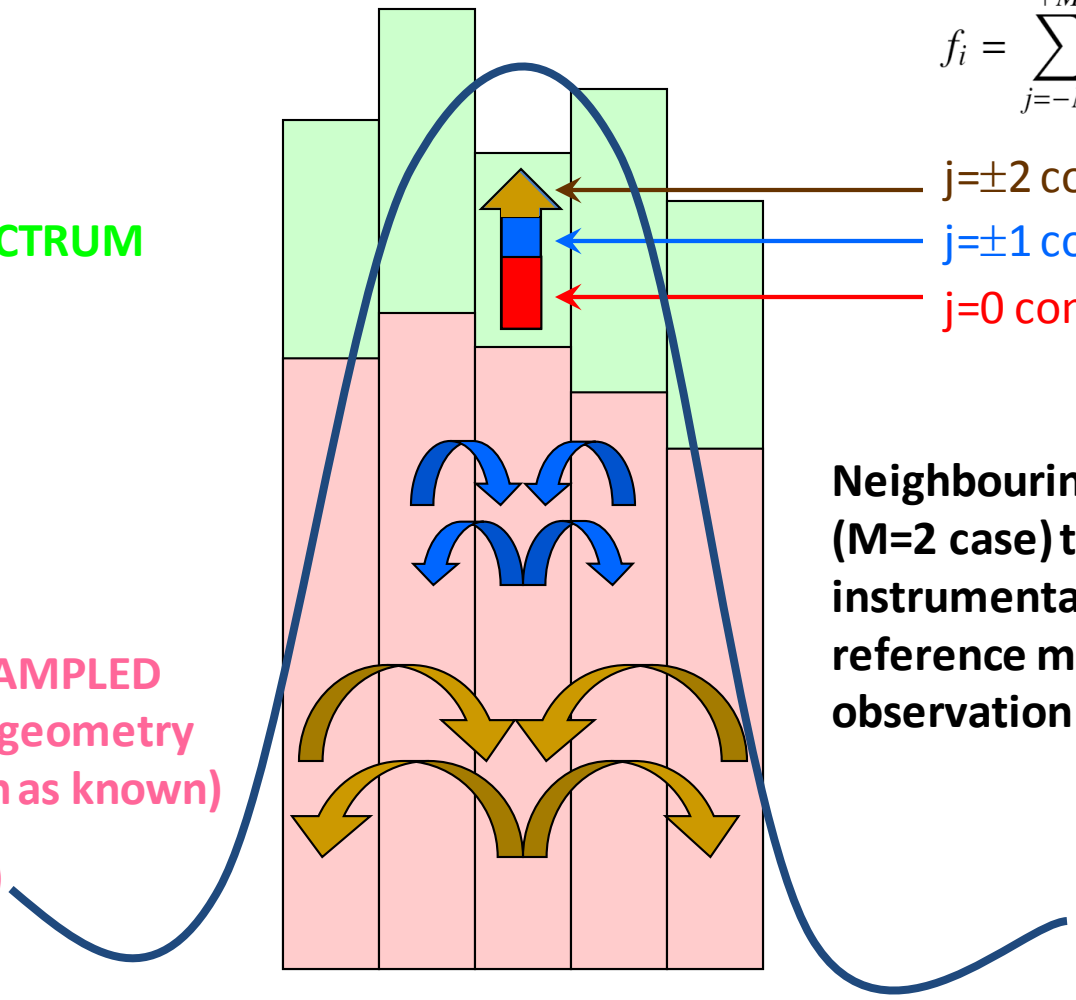


all observations of a given **calibration unit** contribute to the definition of the calibration

$$f_i = \sum_{j=-M}^{+M} a_{ij}\, h_{i+j}$$

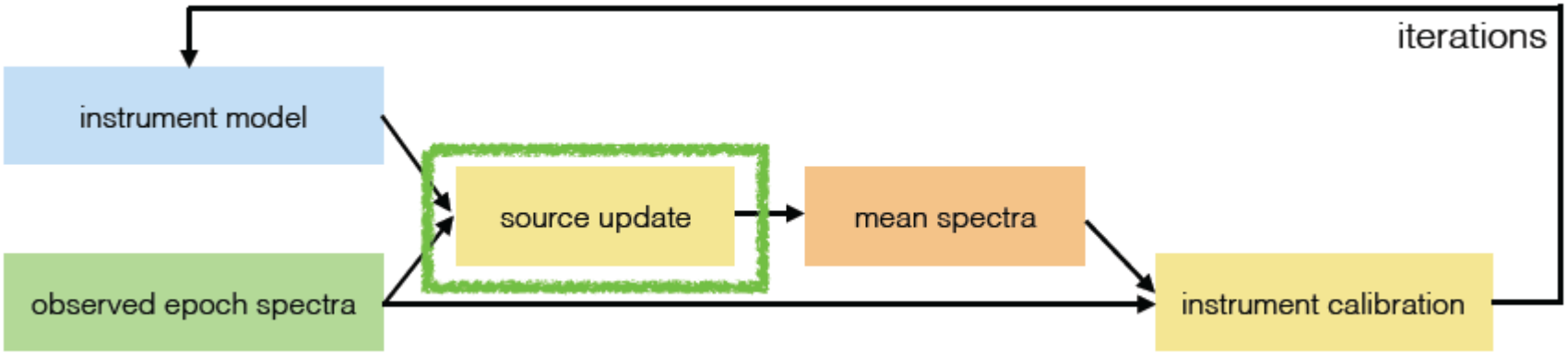
Neighbours influence

$$f_i = \sum_{j=-M}^{+M} a_{ij} \cdot h_{i+j}$$



Neighbouring samples influence (M=2 case) to take into account instrumental changes effects from reference mean spectrum to observation to be predicted.

BP/RP Internal calibration



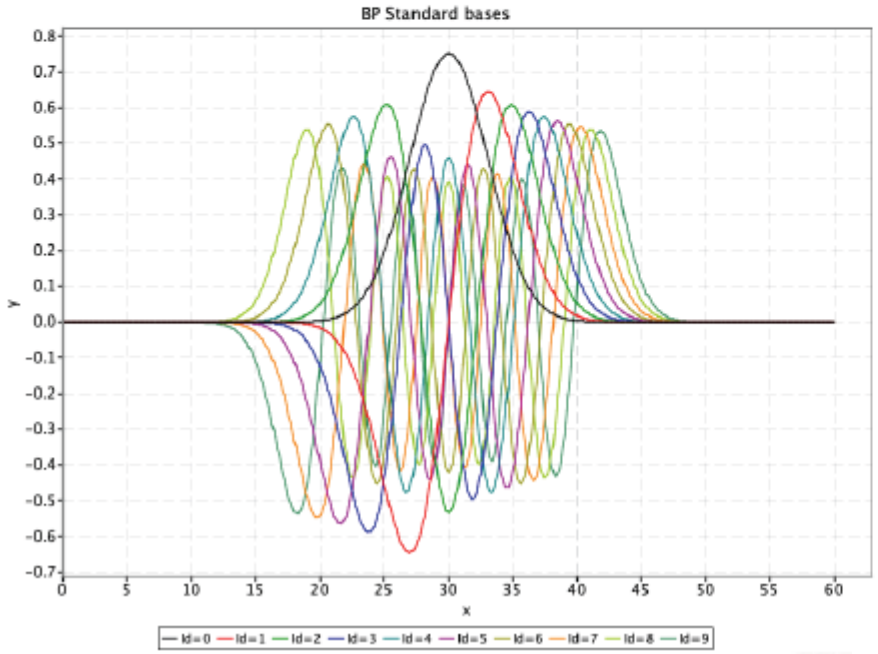
all observations of a given **source** contribute to the definition of the mean spectrum

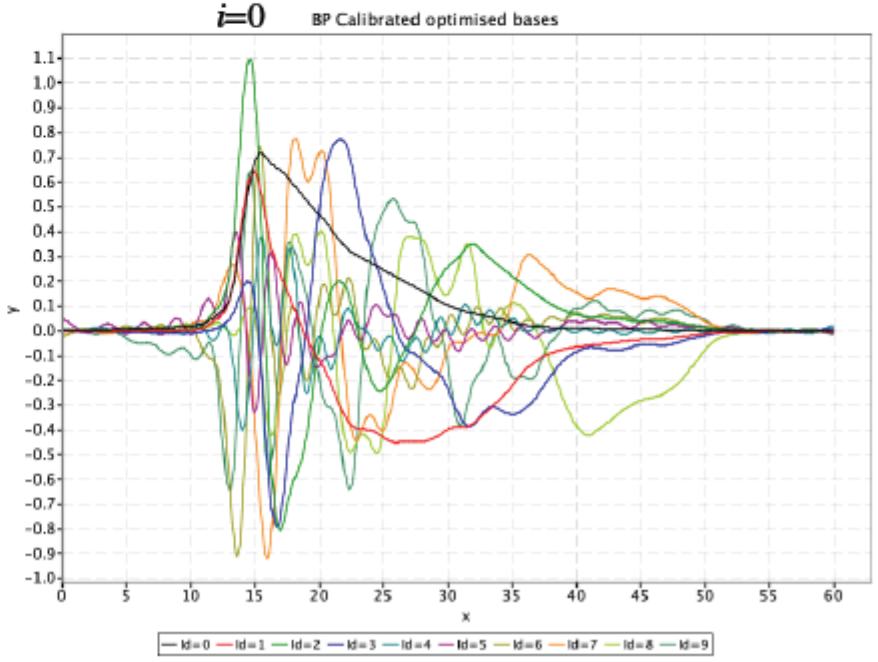
$$f_i = \sum_{j=-M}^{M} a_{ij} \sum_{k=0}^{K} b_k B_{k,i+j}$$

Mean spectra representation

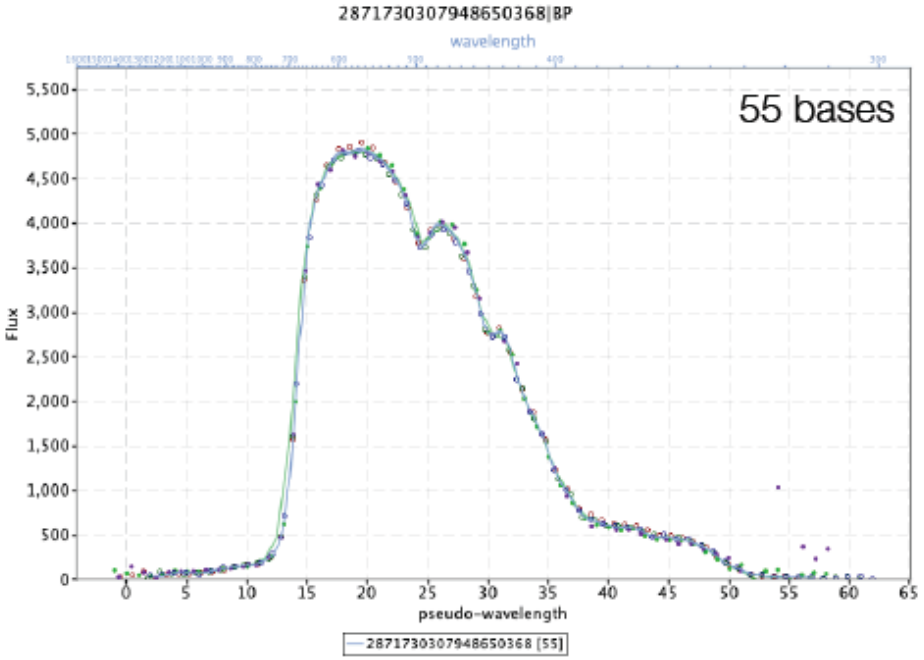
Internally calibrated XP mean spectrum : $f(u) = \sum_{i=0}^{N-1} b_i \cdot \varphi_i(u)$

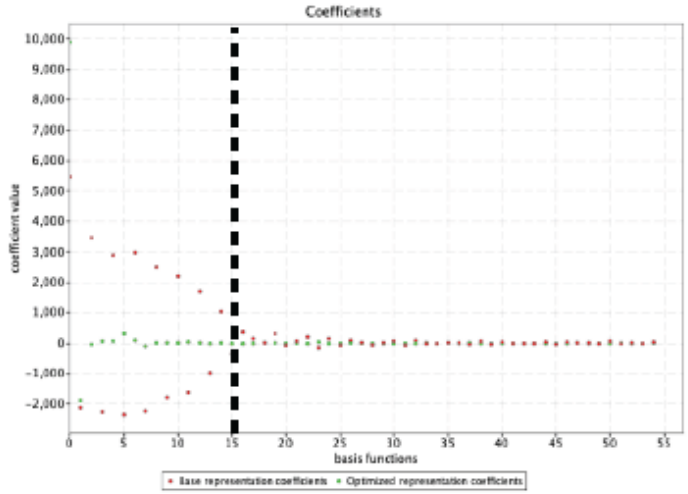
Externally calibrated XP mean spectrum: $s(\lambda) = \sum_{i=0}^{N-1} b_i \cdot \phi_i(\lambda)$

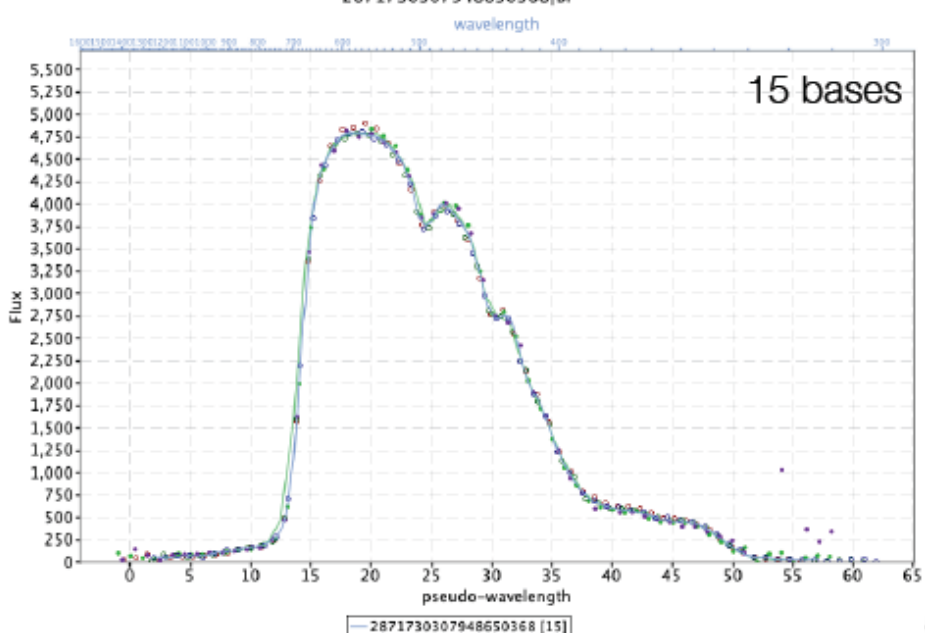




Optimisation of the basis functions





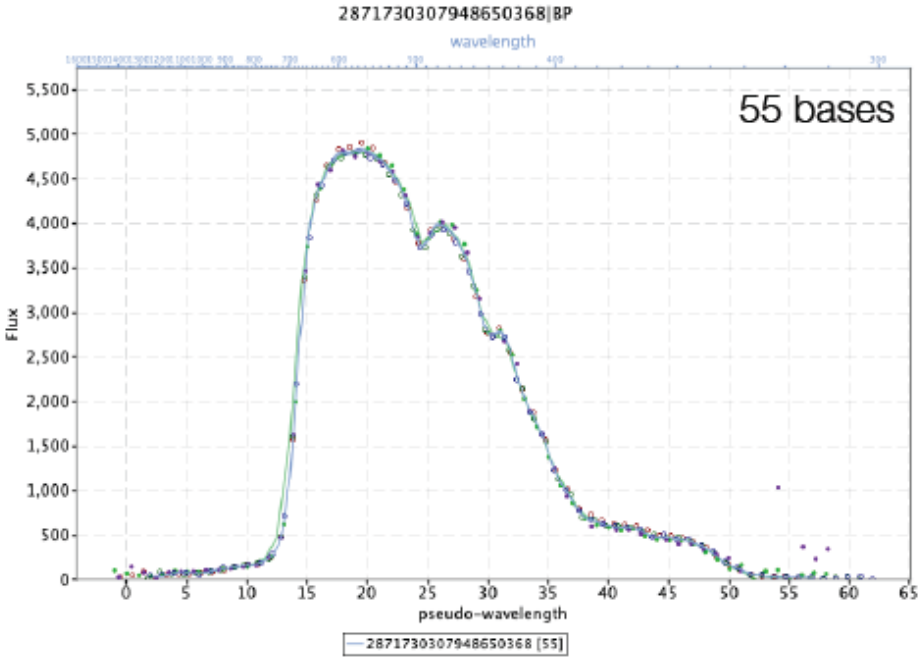


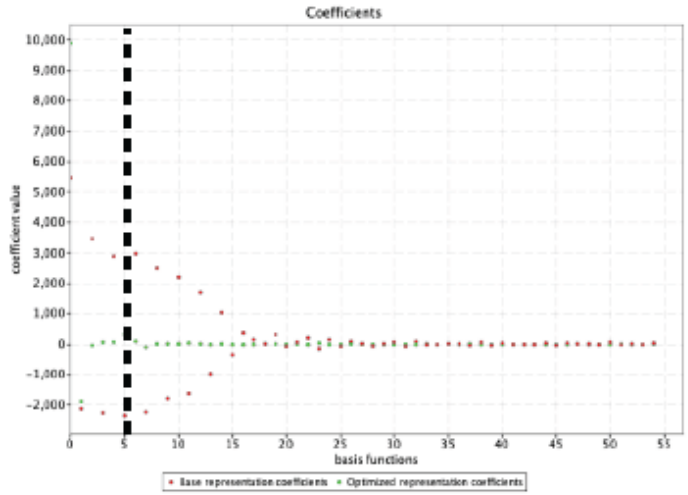
Source coefficients and the basis functions will be published

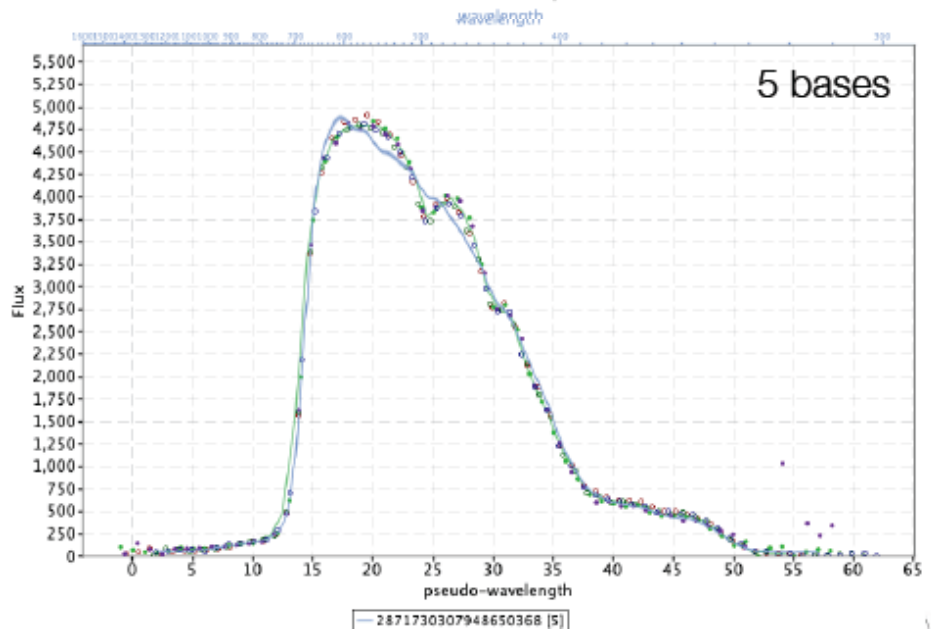
+ Tool to derive sampled spectra from the coefficients

+ Sampled spectra for a subset of sources

Optimisation of the basis functions







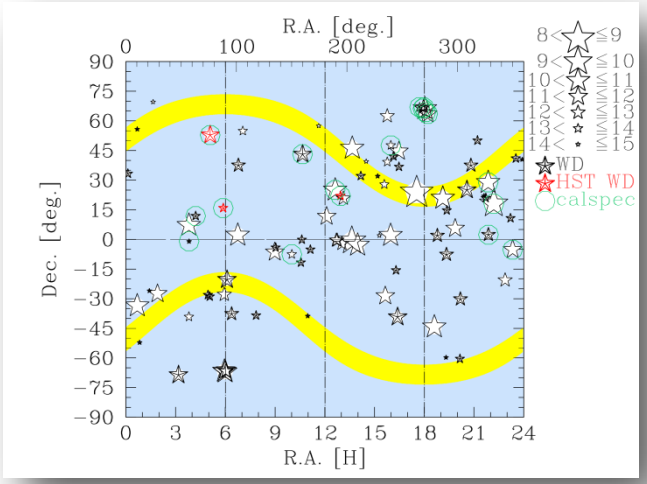
Source coefficients and the basis functions will be published

+ Tool to derive sampled spectra from the coefficients

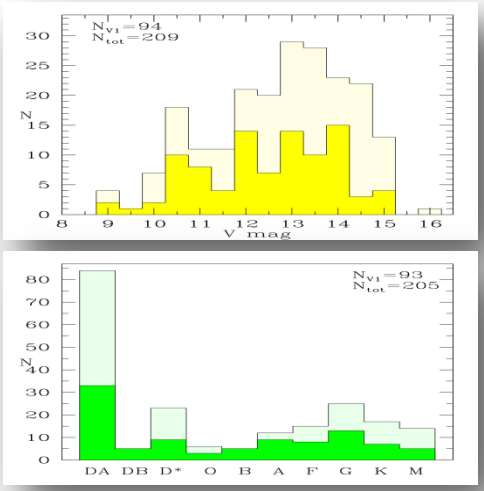
+ Sampled spectra for a subset of sources

External Calibrators (SPSS)

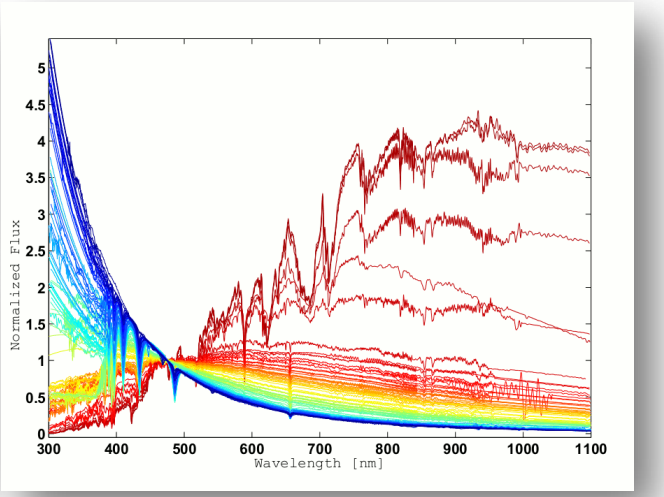
The link between Vega and our SPSS will be ensured by 3 *Pillars*; used to calibrate the *Primaries* (50), our ground-based calibrators spread over the whole sky. They will in turn enable to calibrate our *Secondaries* (200), the actual *Gaia* grid.



Sky position distribution



V and SpT distribution



Absolute BP/RP spectra

Pancino et al 2012, MNRAS 426, 176

(updated in 2019 adding more sources)

Future photometric content

DR4 (TBD)

- Full catalogue
- All epoch and transit data for all sources

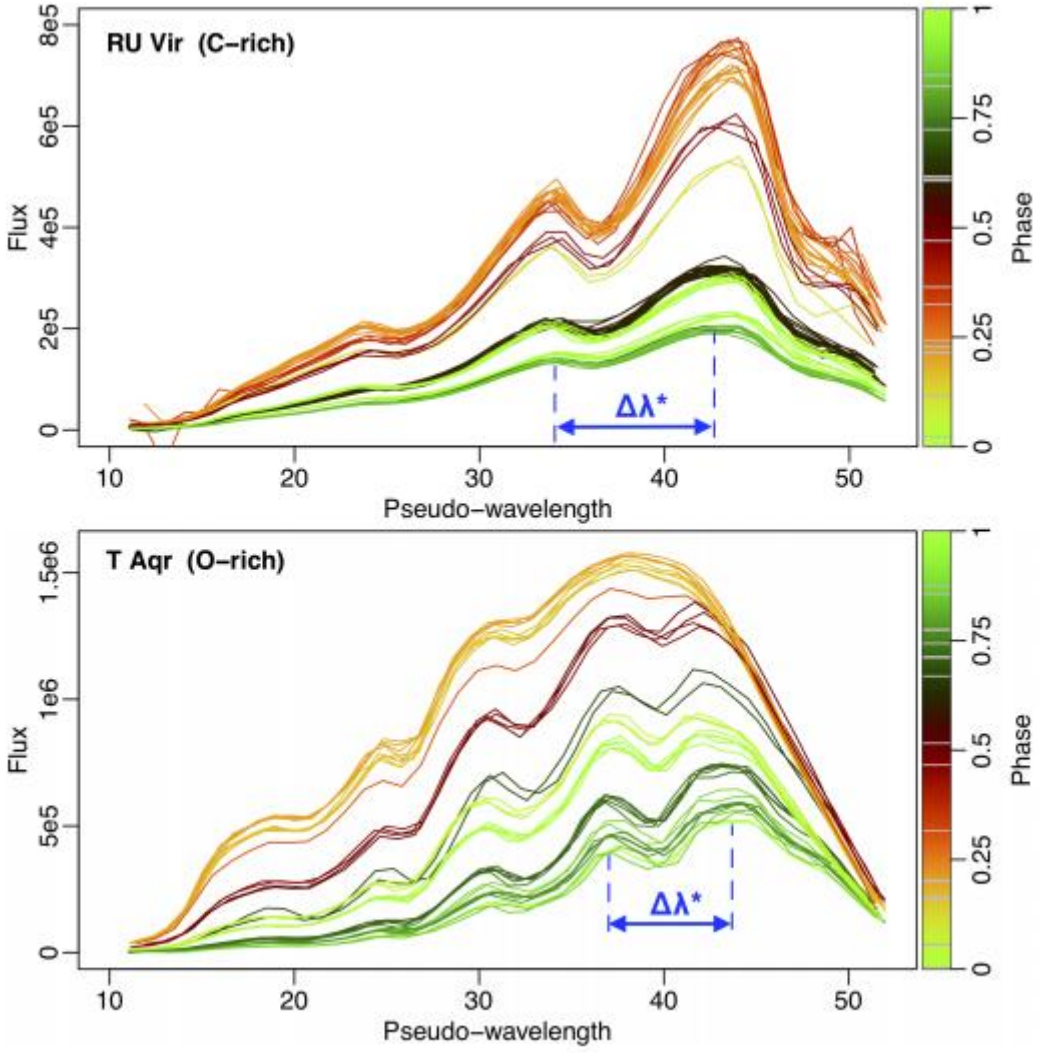
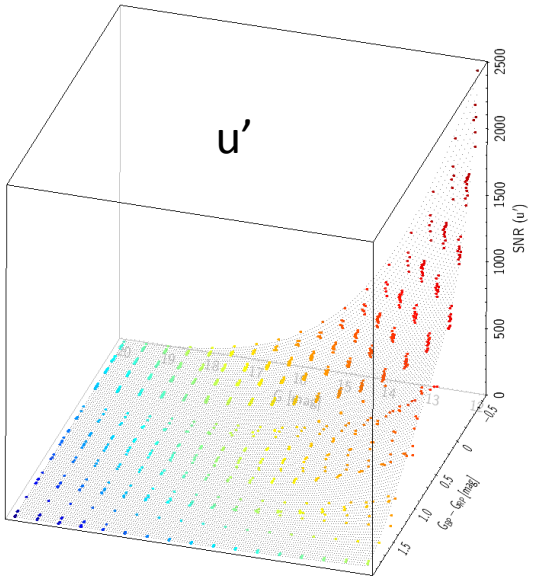
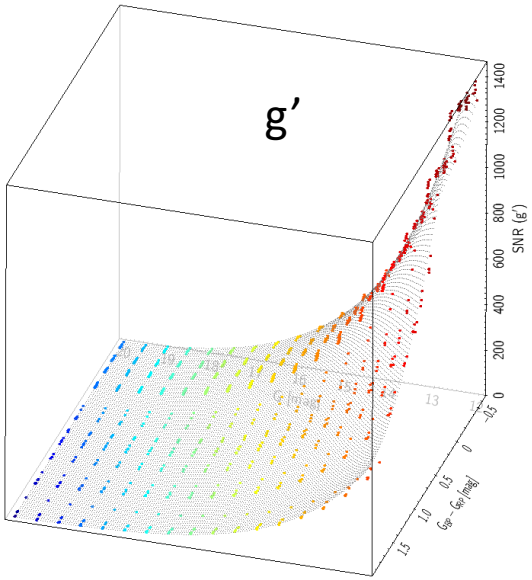


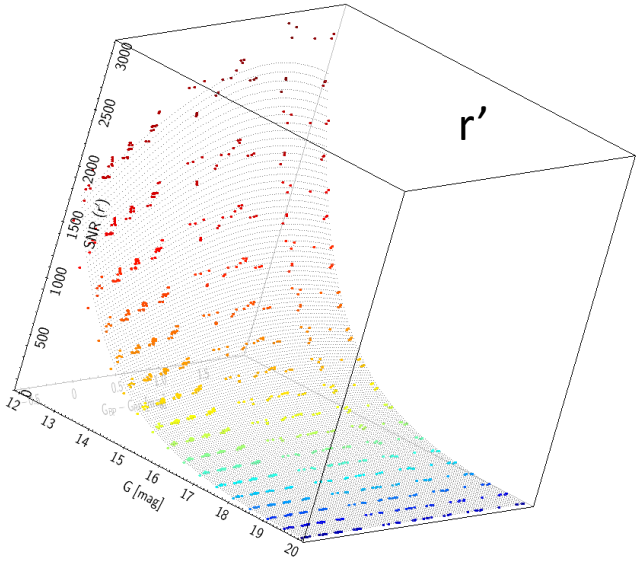
Image credits: ESA/Gaia/DPAC, Mowlavi et al.

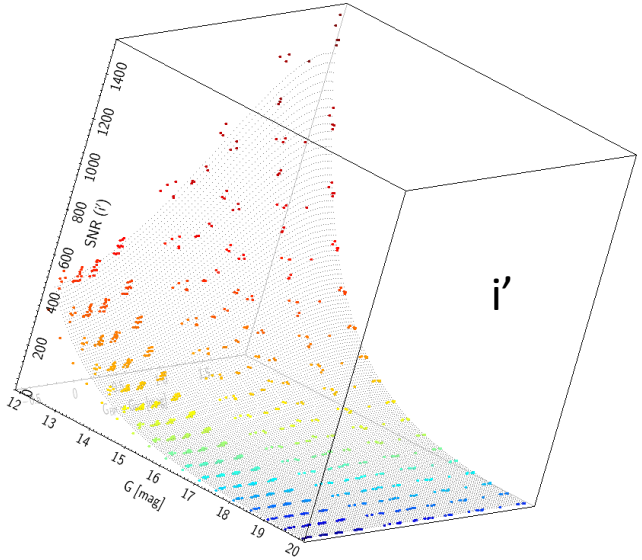
Synthetic photometry from XP spectra

BP/RP spectra could potentially be used as library of standards

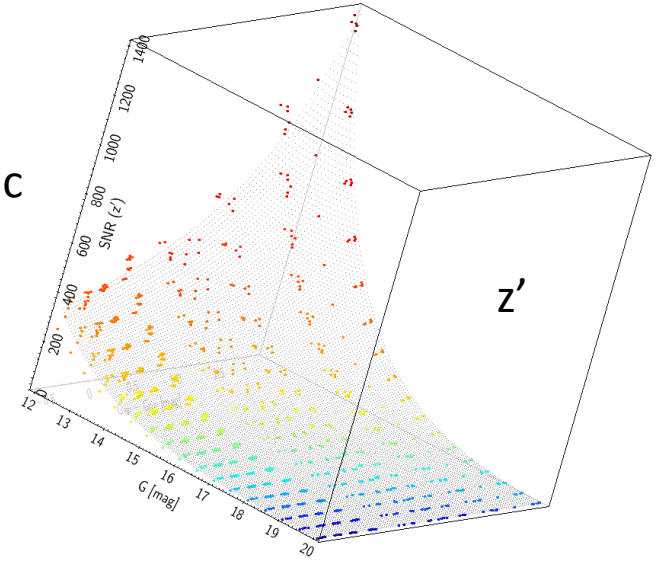








Fitted $SNR_x=f(G,G_{BP}-G_{RP})$ relationships from synthetic photometry (BaSeL-3.1 + WDs) for SDSS, Johnson, Hipparcos/Tycho, …



Thank you