TIMESTAMPS CORRELATION ON GPU

E. Lyard for the QUASAR collaboration

Waischenfeld SII Workshop - Oct. 2025

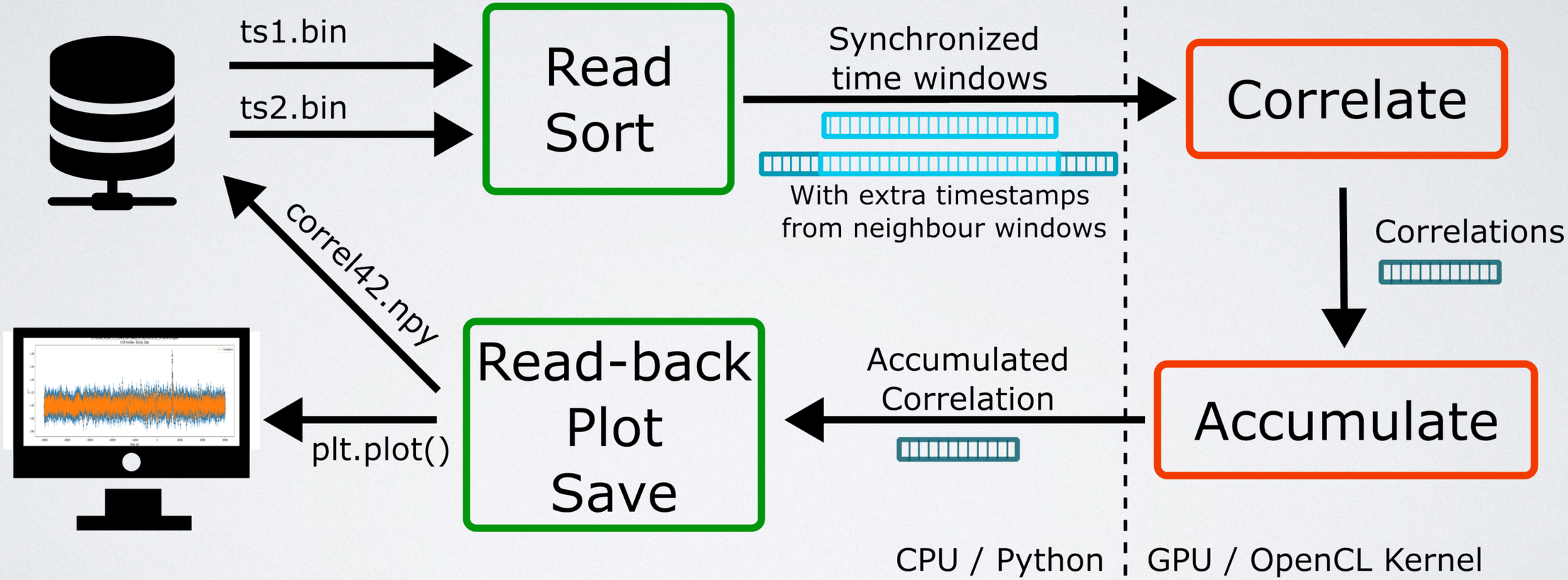
FACULTÉ DES SCIENCES
Observatoire de Genève

UNIVERSITÉ DE GENÈVE

OVERVIEW

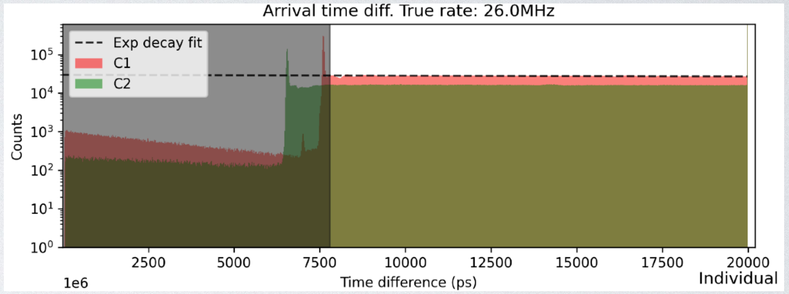
- Correlator and tools further developed to process data from photometer
  - Baseline correction applied to single photons
  - Overall tools improved
  - Cross-baseline data acquired from telescopes

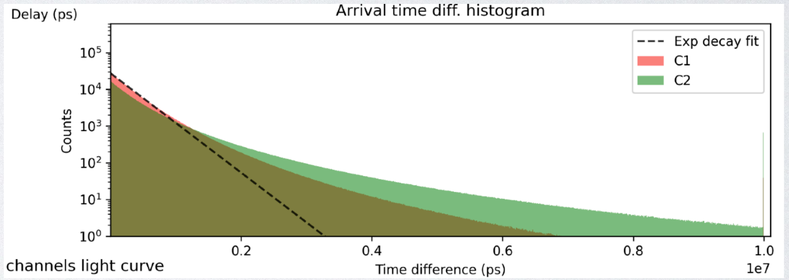
IMPLEMENTATION OVERVIEW

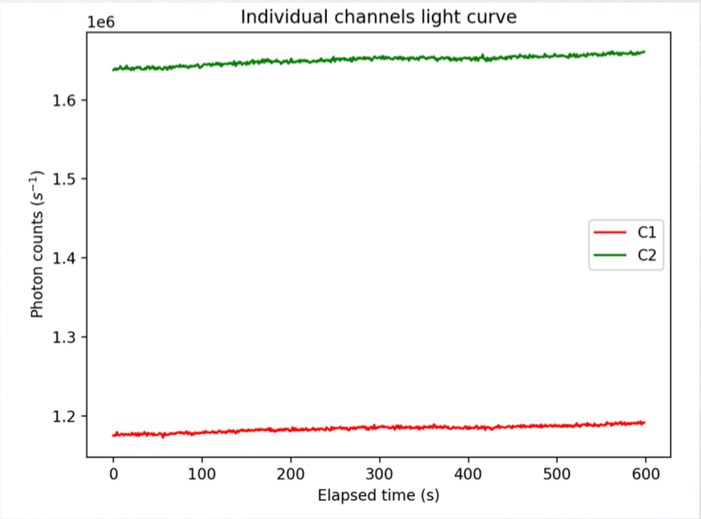


CURRENT IMPLEMENTATION

- Applies parallax delay correction
  - Photon by photon to account for fast drift
  - $v_{uvw} = Dec \times Ha \times -Lat \times v_{ENU}$
- Filters for obvious bogus timestamps
- Computes light curves
- Filters high-frequency noise
- Runs through python and openCL
  - Works on Linux, OSX and Windows
  - Installs via pip, asks which GPU to use at startup or via env-variable

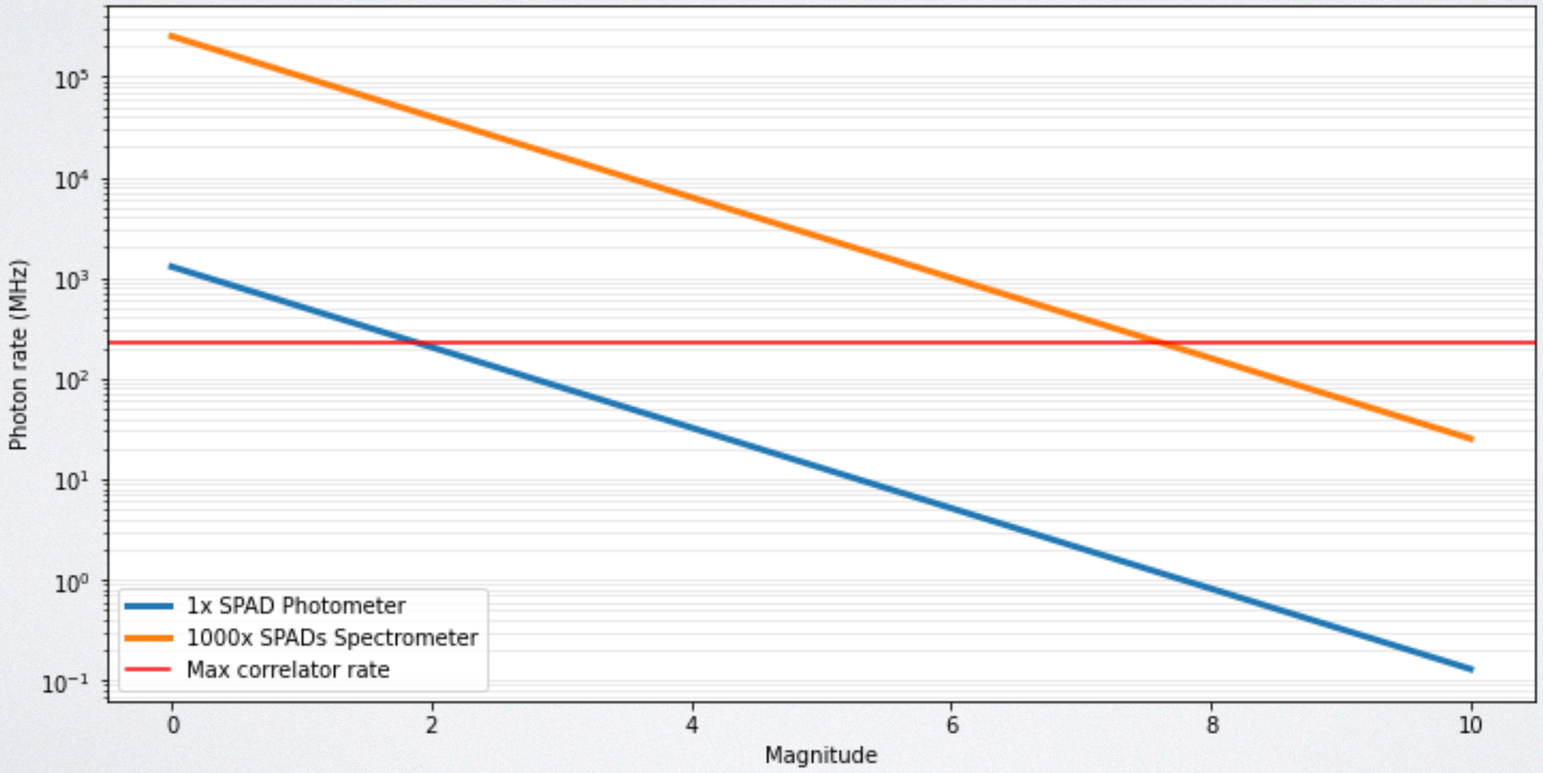






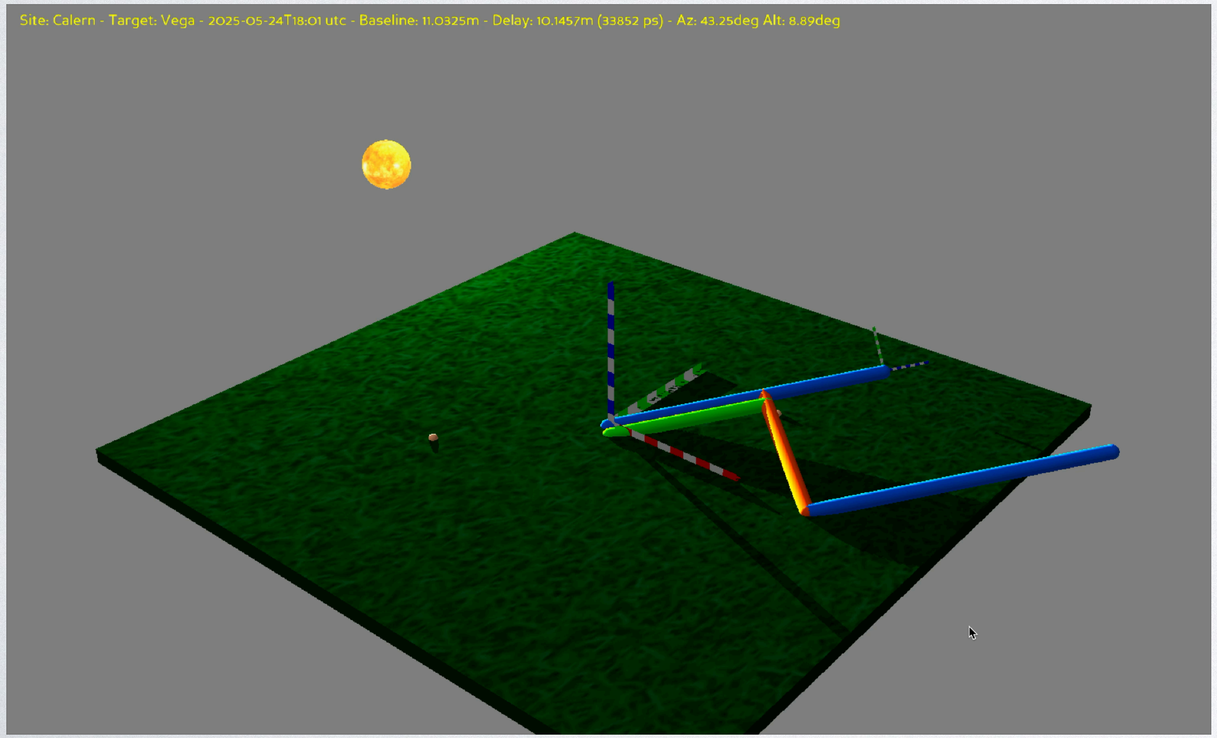
CURRENT IMPLEMENTATION

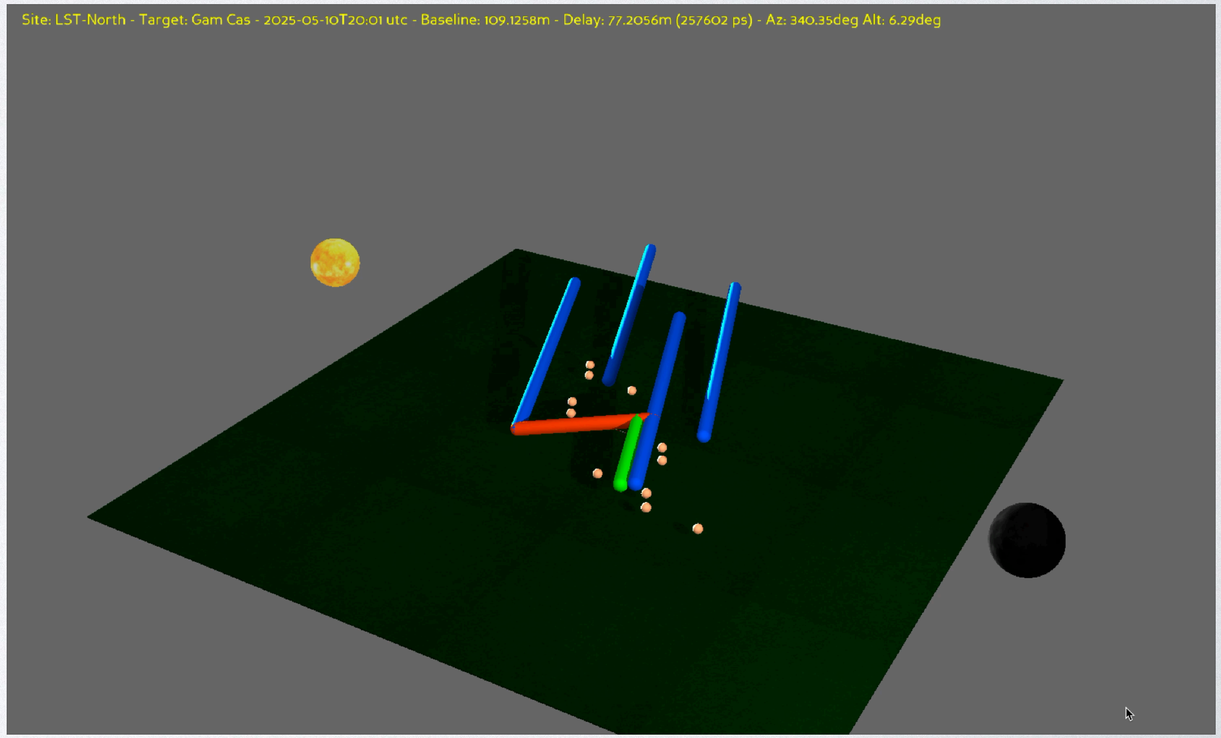
- Laptop performant enough to handle large collection area up to mag. 8, in real-time
  - Simulation of the photon rate from 2 10-meter class telescopes:



TOOLS IMPROVEMENT: 3D VIEW OF SITE

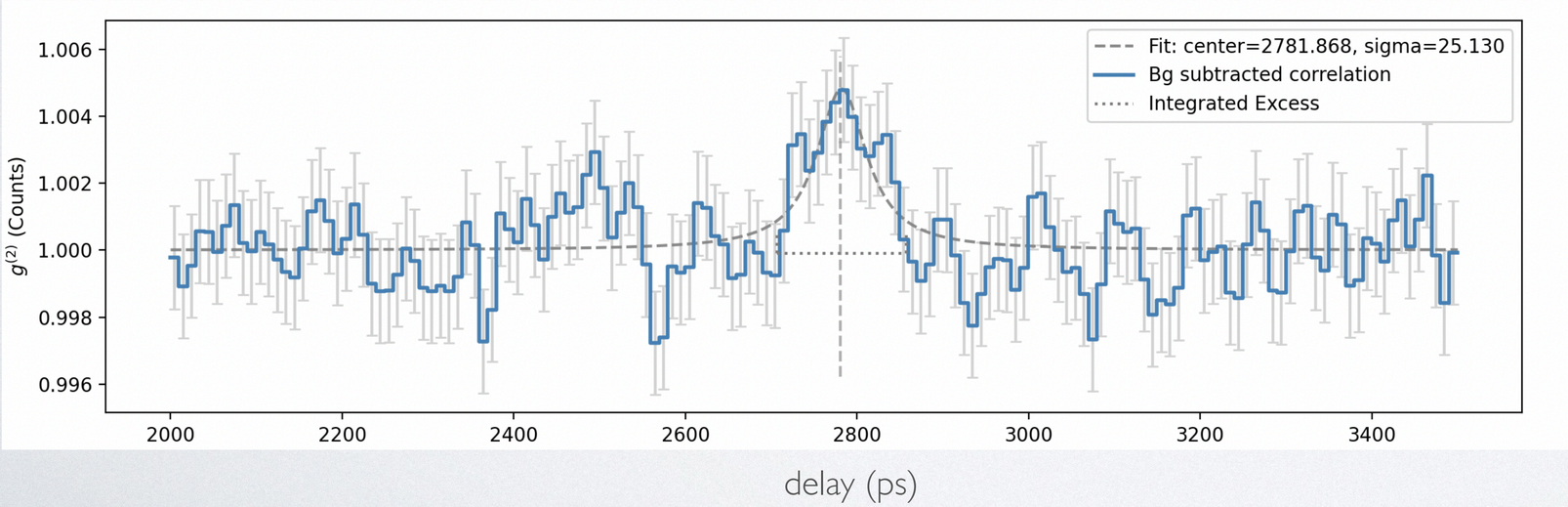
- Allows to visually plan future observations
  - Displays telescopes location and line of sight, one delay and baseline, UV tracks, Sun and Moon
  - Same code use in the correlator itself





OBSERVATIONS - SKINAKAS

- Acquired zero-baseline
  - Stack data from several bright stars
  - Baseline subtraction to remove electronic noise
  - Significance: 7.3 sigmas over 7.3 hours
  - Slight broadening under investigation



OBSERVATIONS - C2PU

- Acquire zero and cross-baseline
  - Using Epsilon and Omicron telescopes at C2PU
  - ITRF telescopes position measured better than 1mm
- Did not go according to plan
  - Our car broke-down while driving up
  - A lightning strike burned one of the SPADs from the 0-baseline setup
  - A terror attack cut the power from the grid

The power outage in Cannes was claimed by two anarchist groups who wanted to disrupt the festival.

Faits divers

La coupure de courant à Cannes revendiquée par « deux groupes d'anarchistes » qui voulaient « perturber le Festival »

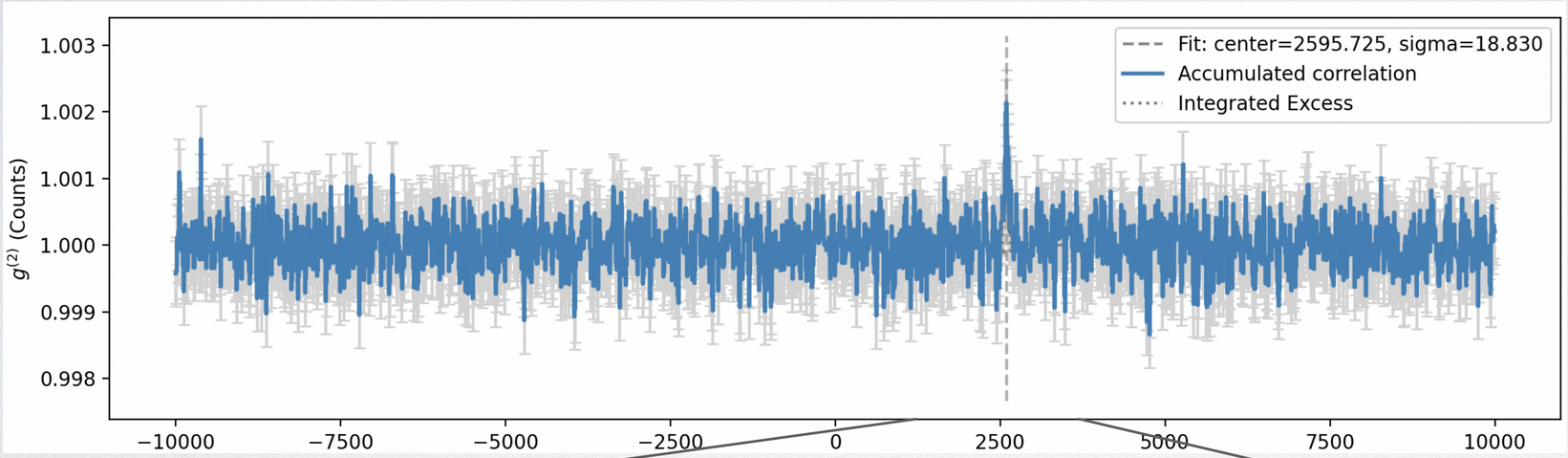
« Deux groupes d'anarchistes anonymes » ont revendiqué dans un courrier l'acte qui a entraîné une coupure de courant massive samedi. Le Festival de Cannes était bien visé.

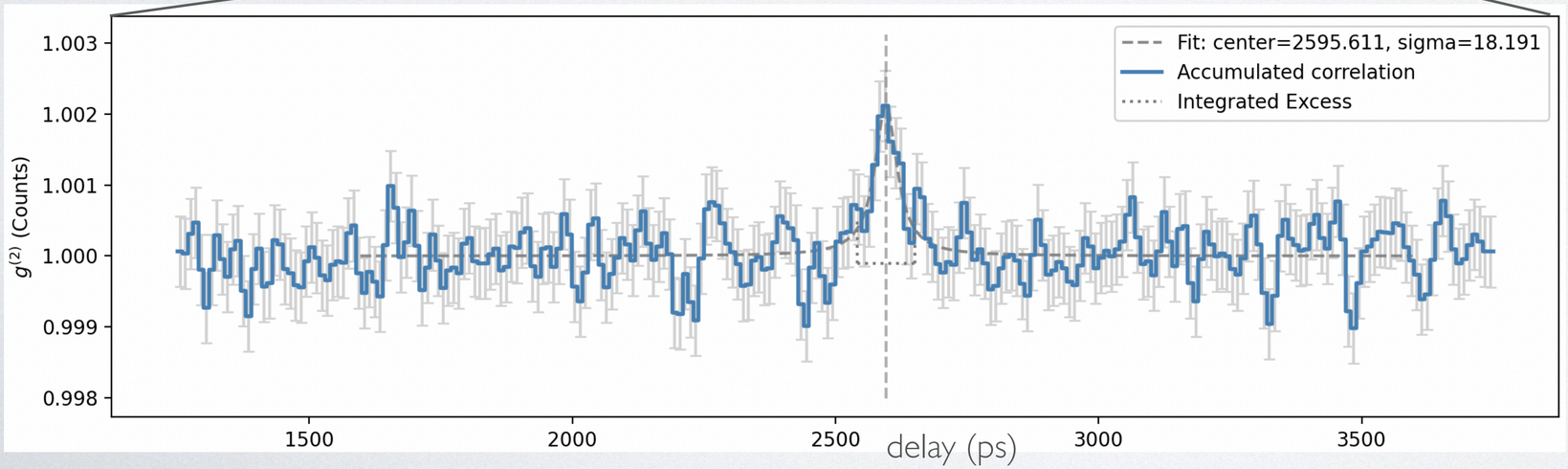
Par Manon Aublanc

Le 25 mai 2025 à 17h56, modifié le 25 mai 2025 à 18h58

OBSERVATIONS - C2PU

- Cross-baseline of Vega

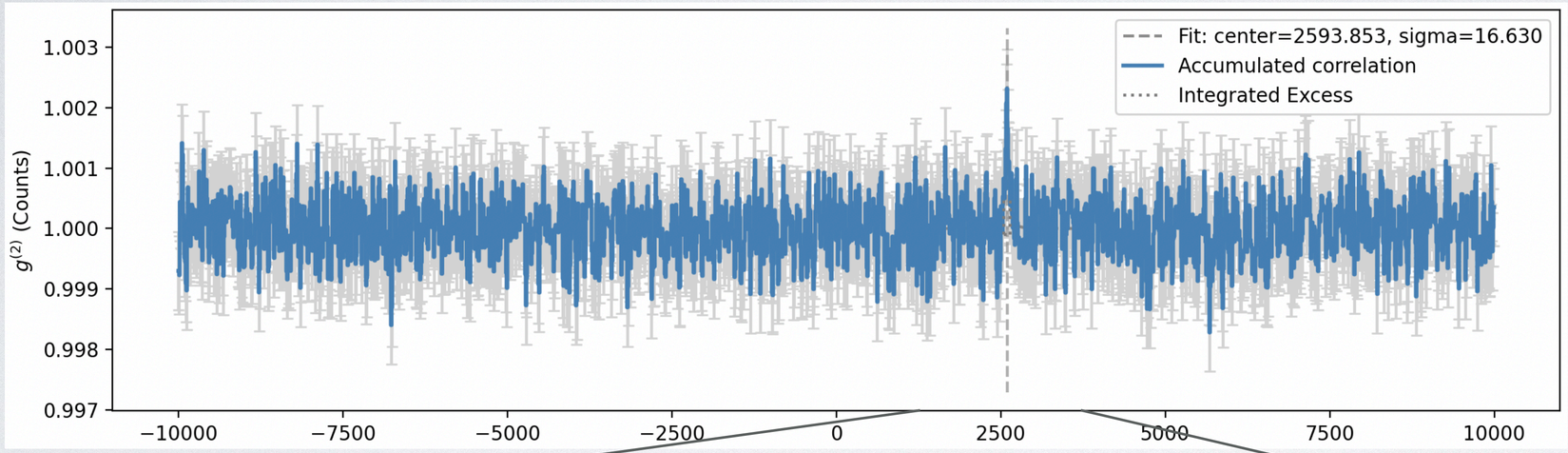


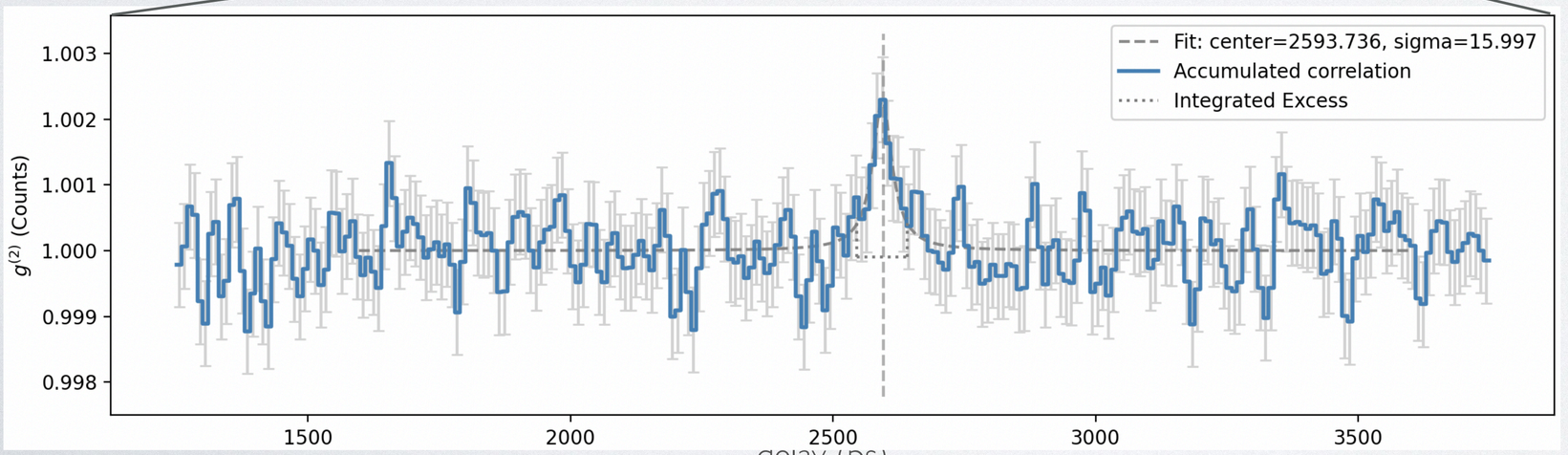


- No baseline subtracted, delay drift blurs the noise out
- Significance: 7.4 sigmas over 17.2 hours
- Excess drift speed ~3 ps / s

OBSERVATIONS - C2PU

- Efficiency much better during the only good night

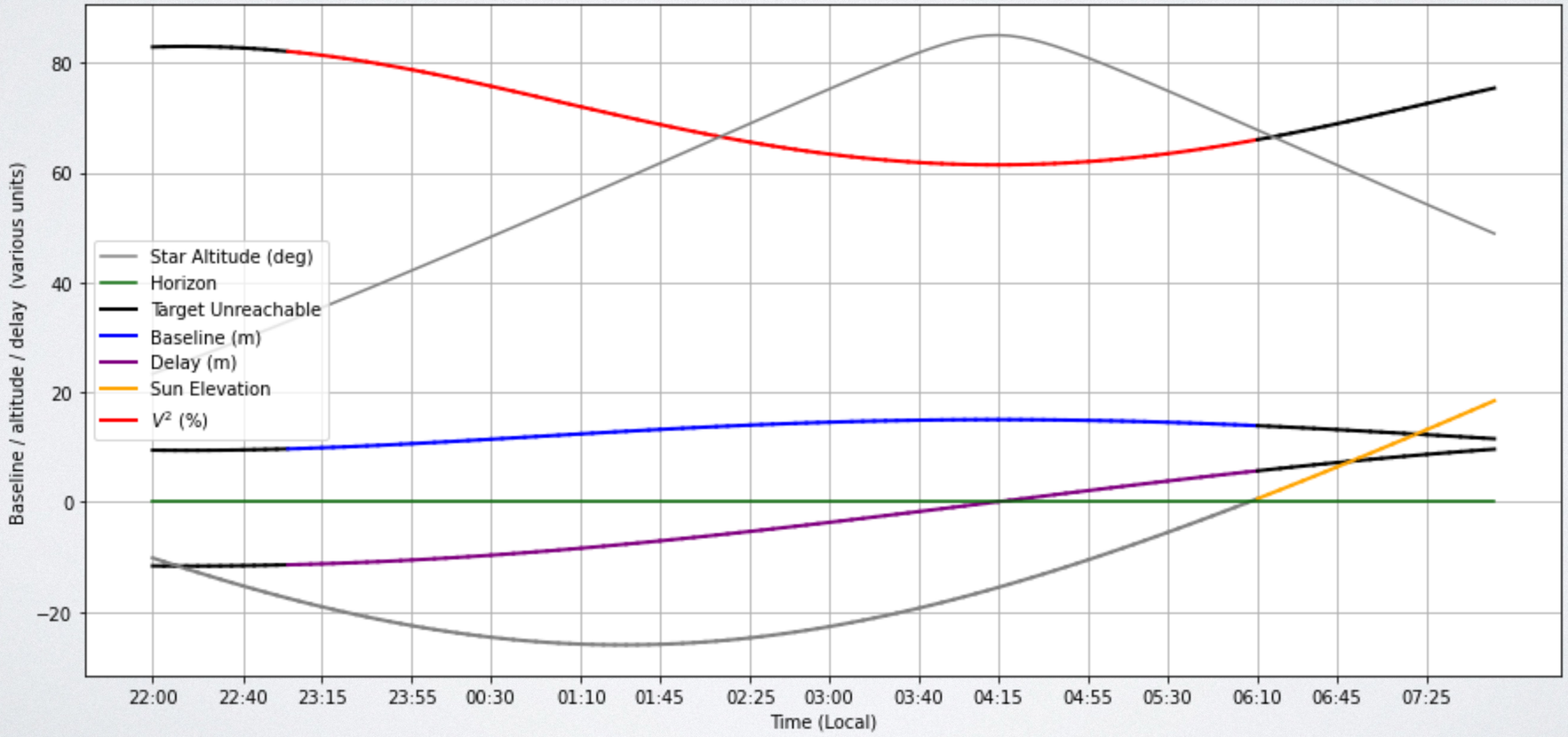




- Significance: 5.9 sigmas over 5.0 hours
- Peak a bit narrower
- Optical setup not yet optimal (vignetting)

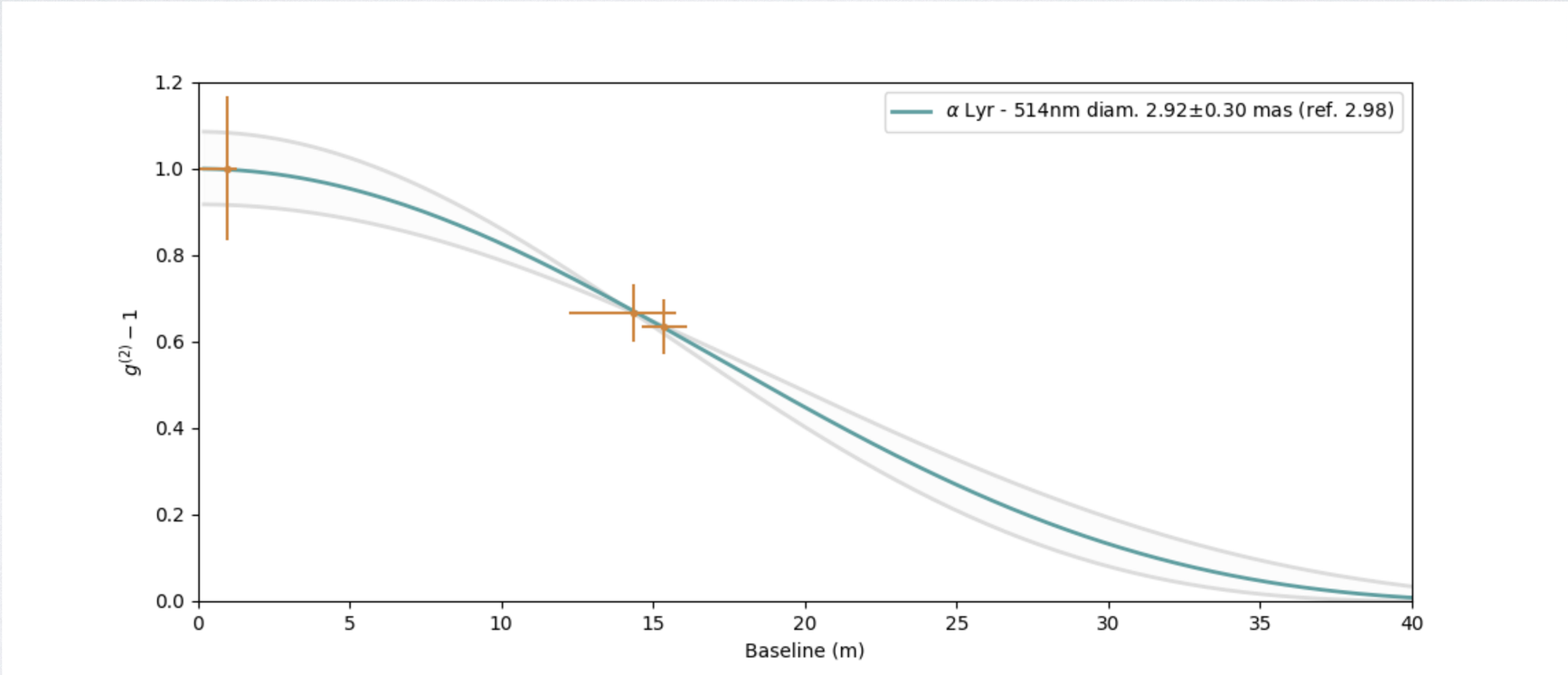
OBSERVATIONS - FIT A DIAMETER

- Baseline during Observations in Calern did not vary much
- Visibility^2 was between 0.6 and 0.8 always
  - Observations always started late due to lingering haze



OBSERVATIONS - FIT A DIAMETER - UD

- Data from Calern was split into 2x baselines
- Data from Skinakas was used as zero-baseline



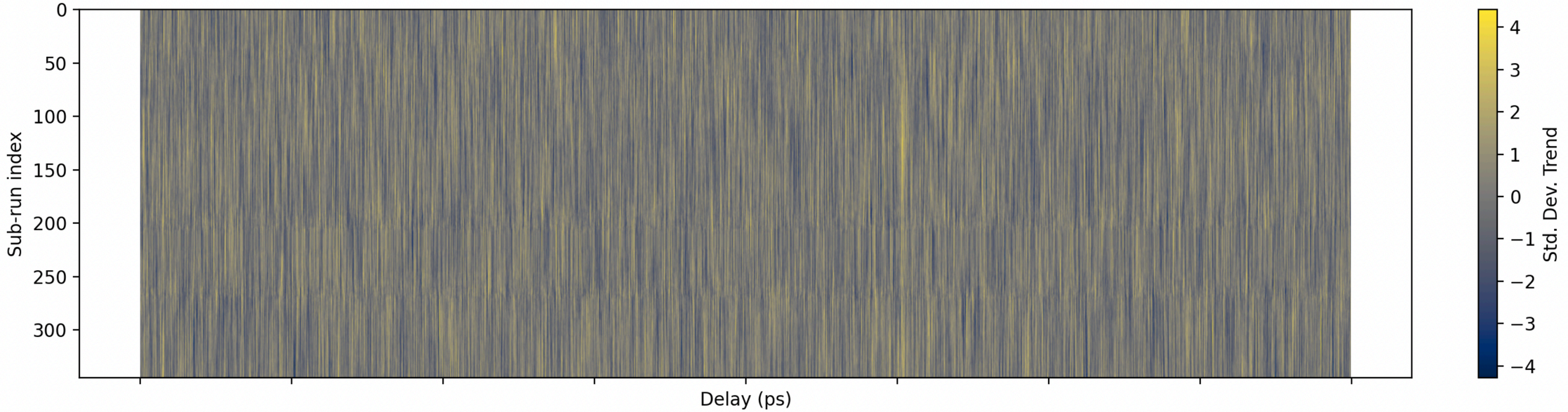
- Not enough data points to claim anything, though data meets expectations

SUMMARY

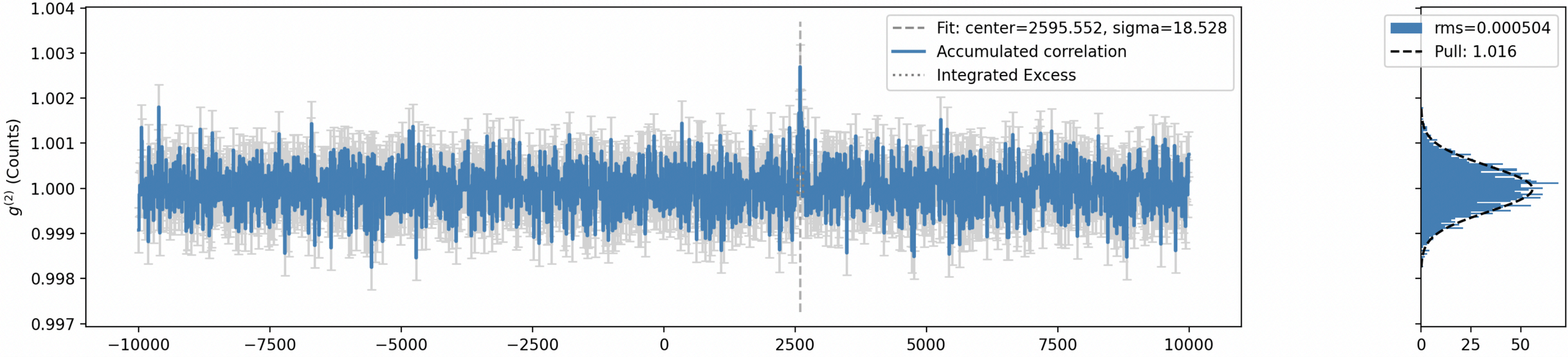
- Timestamps correlation on GPU gives immediate feedback
- Tools allow to efficiently plan and analyse observations
- Parallax correction applied to every photon
  - As long as the geometry of the observation site is known to some millimetres precision

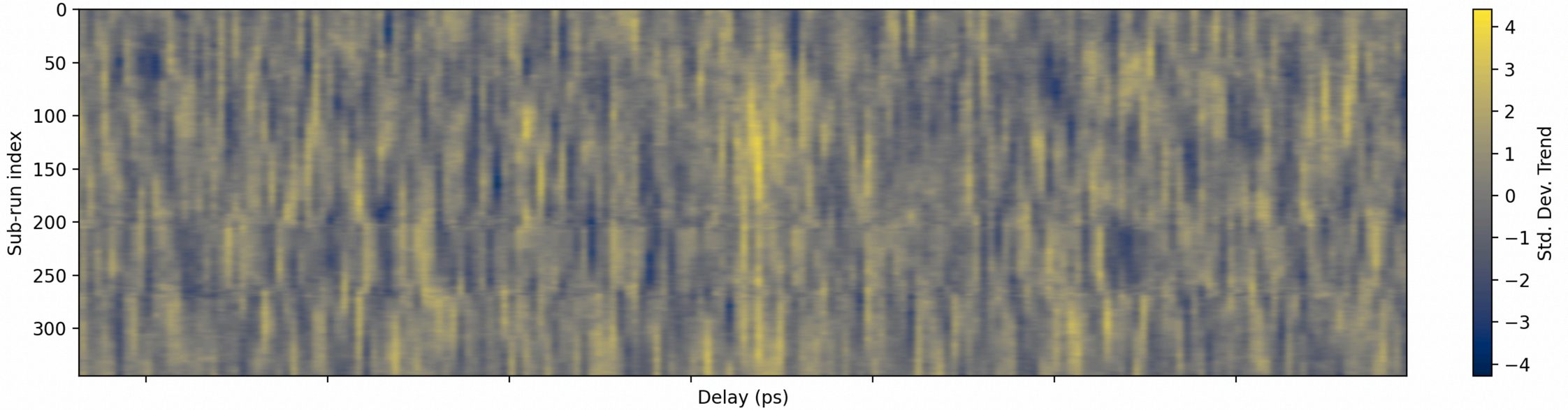
NEXT STEPS

- Implement correlation for spectrometer data
  - Including line-based calibration to match paris of channels with same wavelength
  - To start with we will go for brute-force, ie. correlate all channels with all channels
- Continue to improve code-base
- Start investigating very long baselines and non-identical telescopes geometry
  - Slewing must be modelled better than ~3mm for 10 ps accuracy
  - Atmospheric delays must be accounted for



Chan:['vega'] - On-time: 17.2H - Binning: 10ps - Veto: ['calib', 'C2XC3_2025-05-21', 'C2XC3_2025-05-22', 'spica']
Max Fit: 1.00214+/- 0.00015 - Signif.: 7.52 (50746 counts) - FWHM:37.1ps - R_Sig:5.2 - Cnts/bin:4067734





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