LISA L0.5-L2 end-to-end simulation and analysis pipeline

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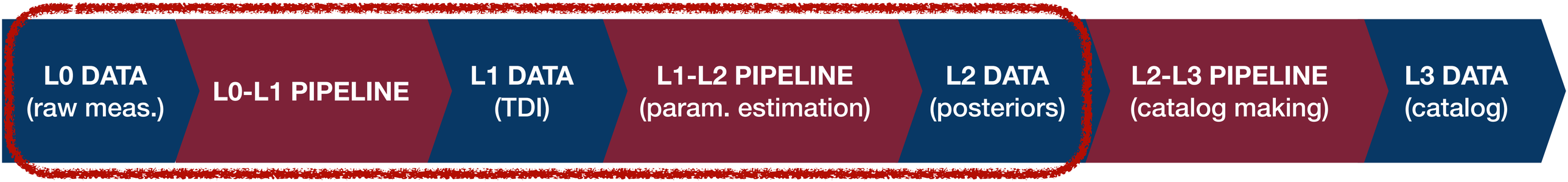
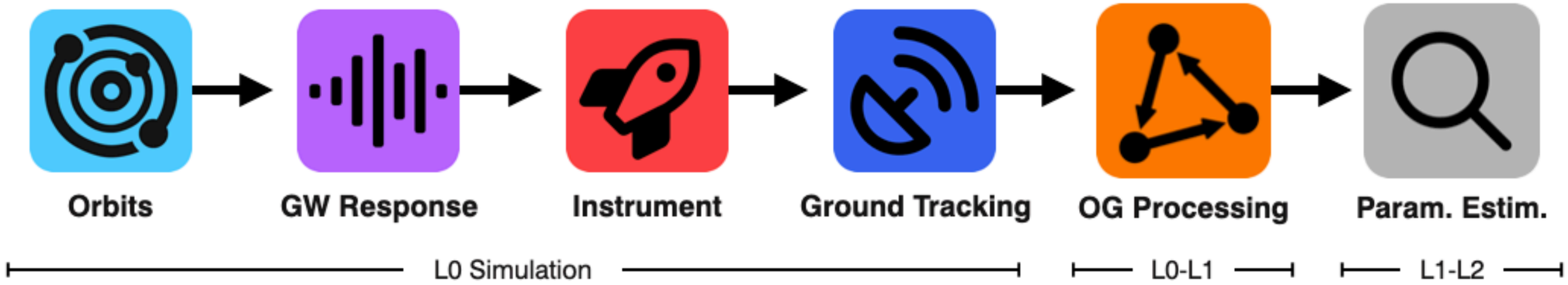
SYstèmes de Référence Temps-Espace

Overview of LISA processing

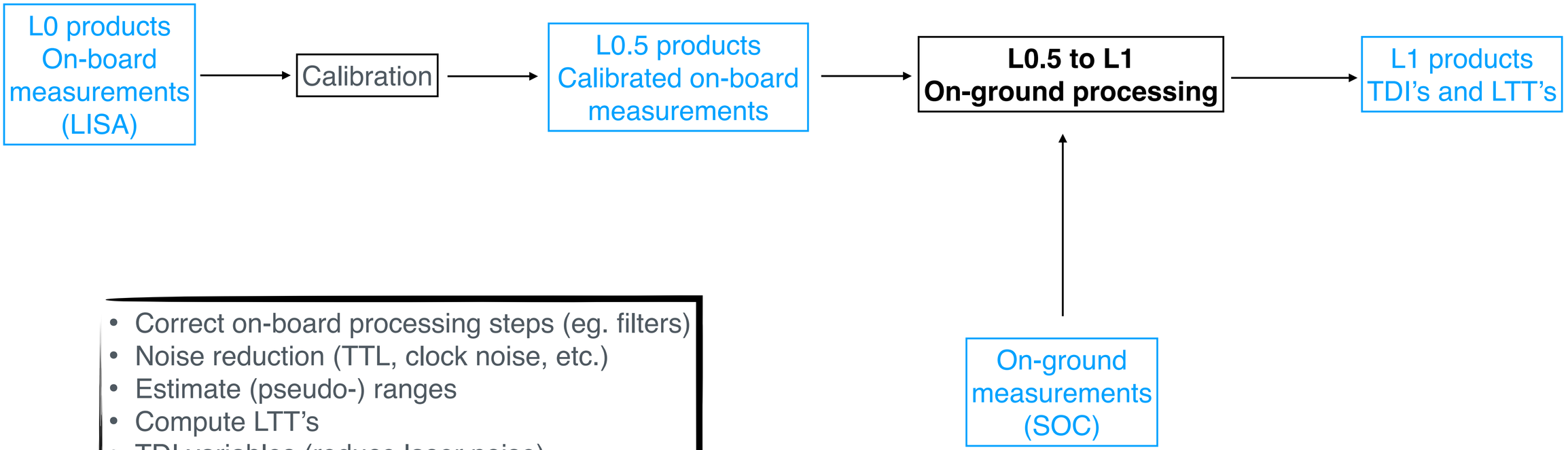
- LISA data processing and analysis sequence



- Data simulation, processing and scientific exploitation software



The L0.5-L1 step in brief.

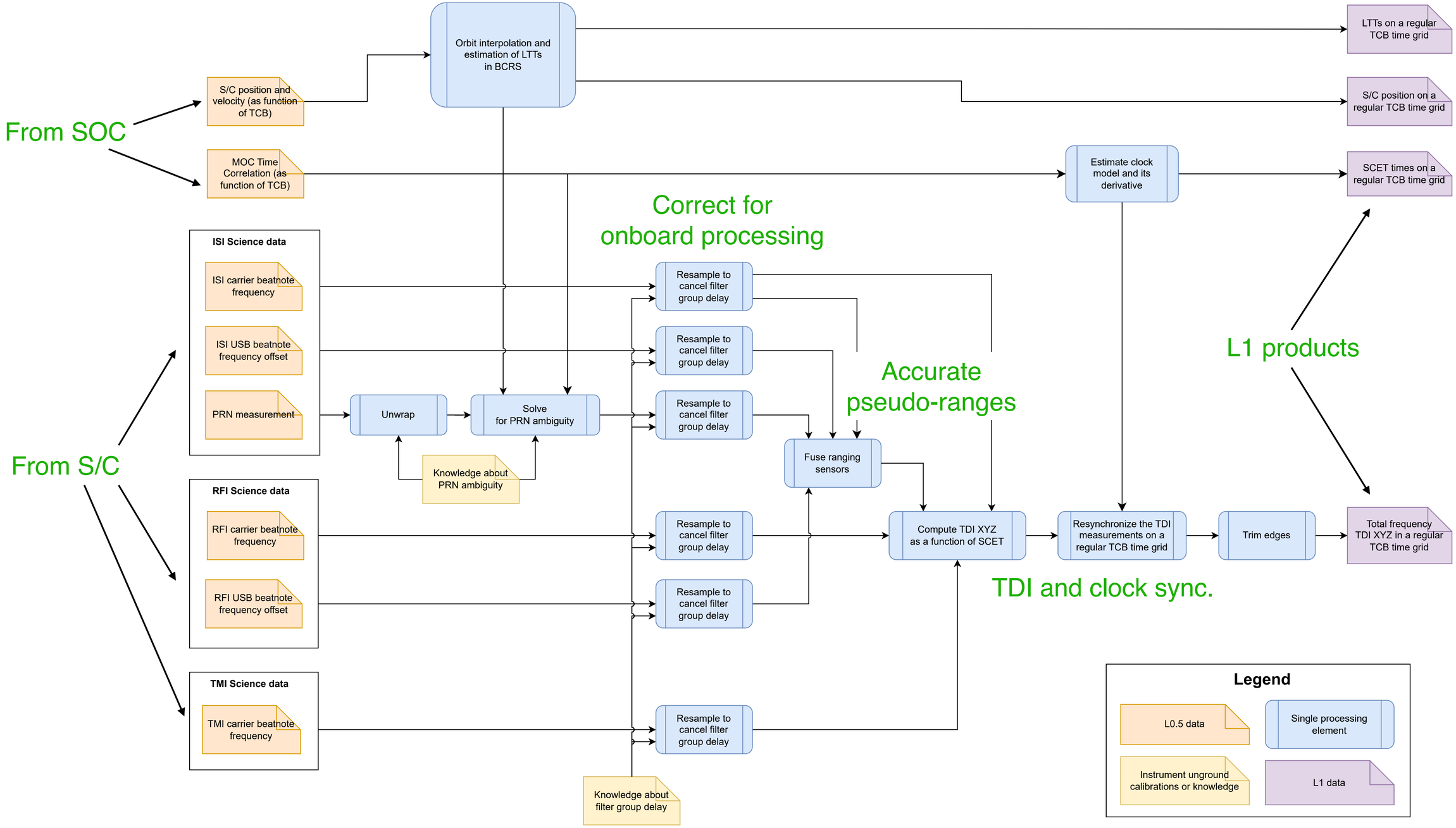


- Correct on-board processing steps (eg. filters)
- Noise reduction (TTL, clock noise, etc.)
- Estimate (pseudo-) ranges
- Compute LTT's
- TDI variables (reduce laser noise)
- Noise estimates
- Handling of gaps and glitches
- Clock synchronisation
- Etc.

Simulation of L0.5 products

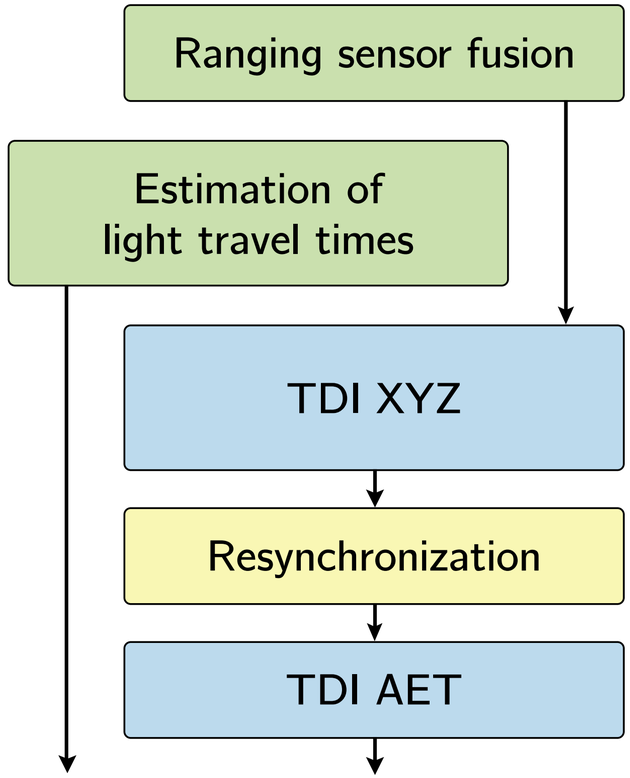
- A single bright galactic binary
- Realistic time-varying unequal arm ESA LISA orbits.
- Ground tracking providing S/C positions and time couples.
- Total frequency.
- 1 clock per S/C: different proper time, jitters and drifts
- ISI, RFI, TMI beatnotes, side-bands and PRN code.
- Instrumental noise content: laser, modulation, clock, backlink, test-mass, readout, jitter, ranging.
- On-board processing including filtering and decimation from 16 to 4 Hz.
- Laser locking and frequency planning.
- Simulation duration: 3 days (limited by RAM usage of `lisainstrument`)

L0.5-L1 on-ground data processing



“TDI without clock synchronisation”

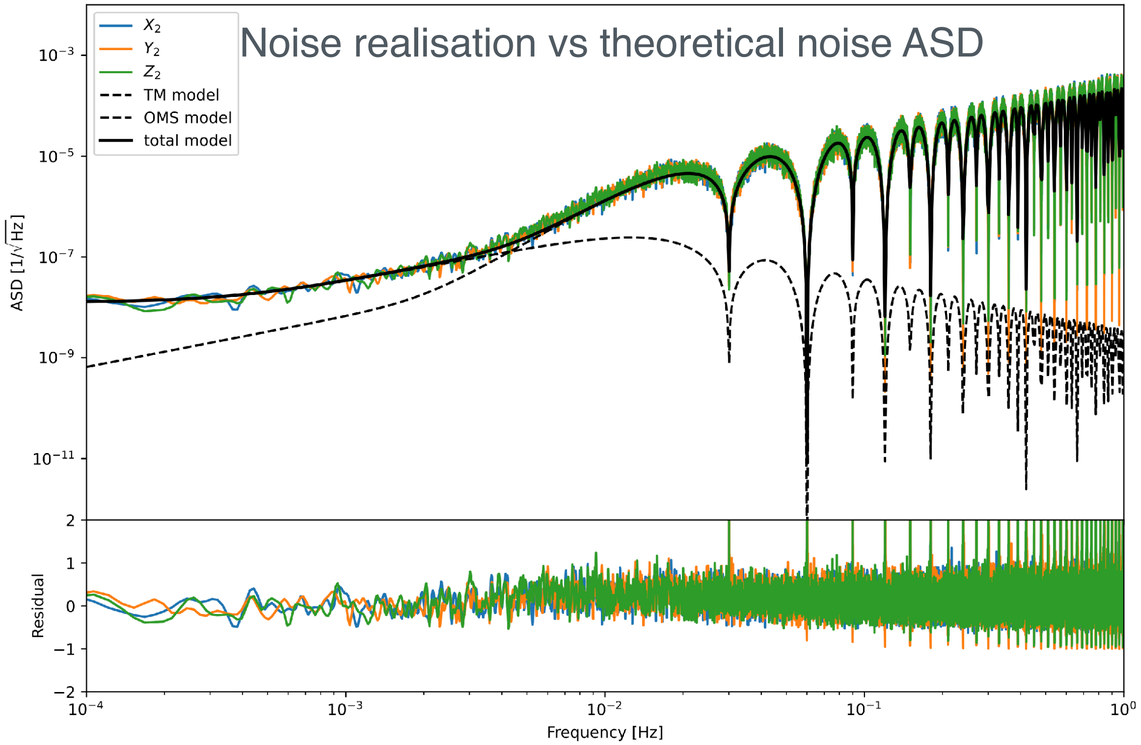
- We implement the L0.5-L1 data processing approach proposed in Hartwig et al, 2022.
- “Ranging sensor fusion” combines ground-measurements, PRN and sidebands, to provide inter-S/C pseudo-ranges sufficiently accurate for TDI.
- Light travel times in the BCRS are provided as an L1 product. They are needed for L1L2.
- Clock synchronisation to a single time frame is performed on the TDI XYZ variables. This is performed by combining the time couples with a clock model.



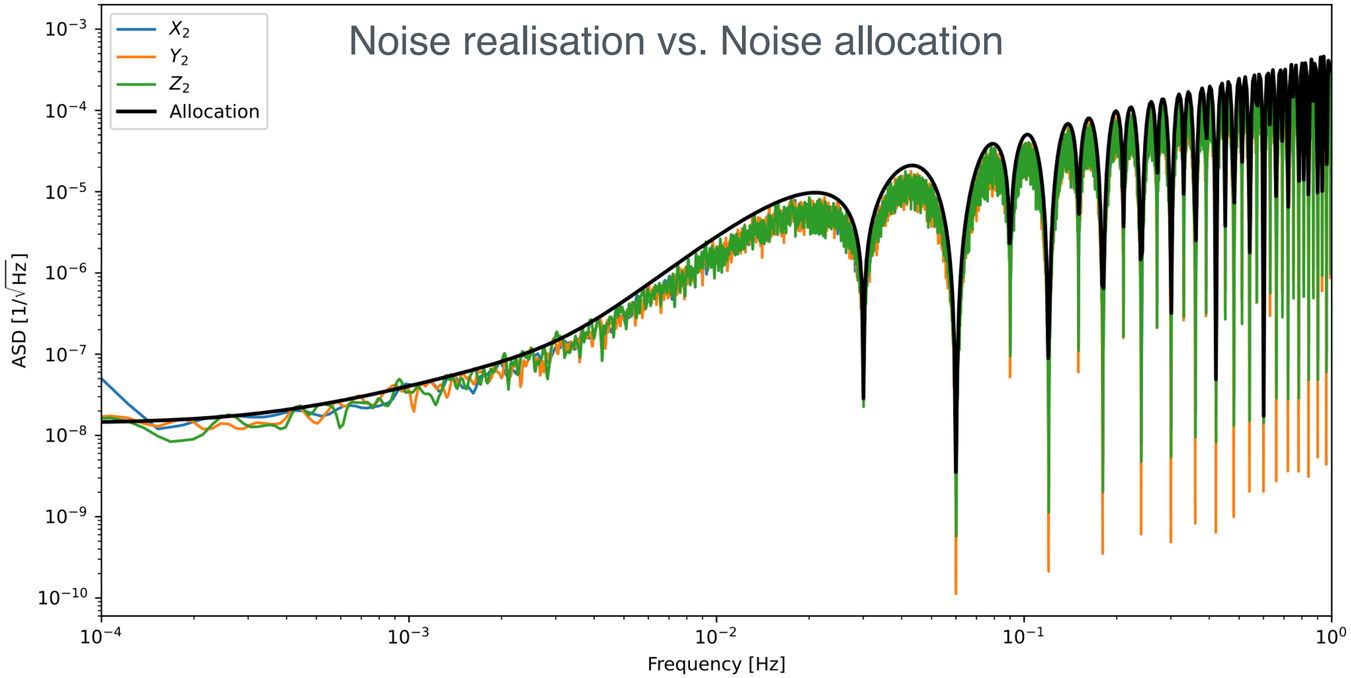
L1-L2: source parameter estimation

- We attempt to recover 5 of 8 parameters of a single GB (sky localisation and $\dot{f}$ fixed)
- Noise model: test mass acceleration noise and OMS noise, Gaussian and stationary.
- We use a Gaussian likelihood function in the Fourier domain.
- The TDI templates are computed with an adapted version of `fastGB` [Cornish+07] in the equal arms approximation
- We use `nessai` [Williams21] a nested sampling combined with ML techniques

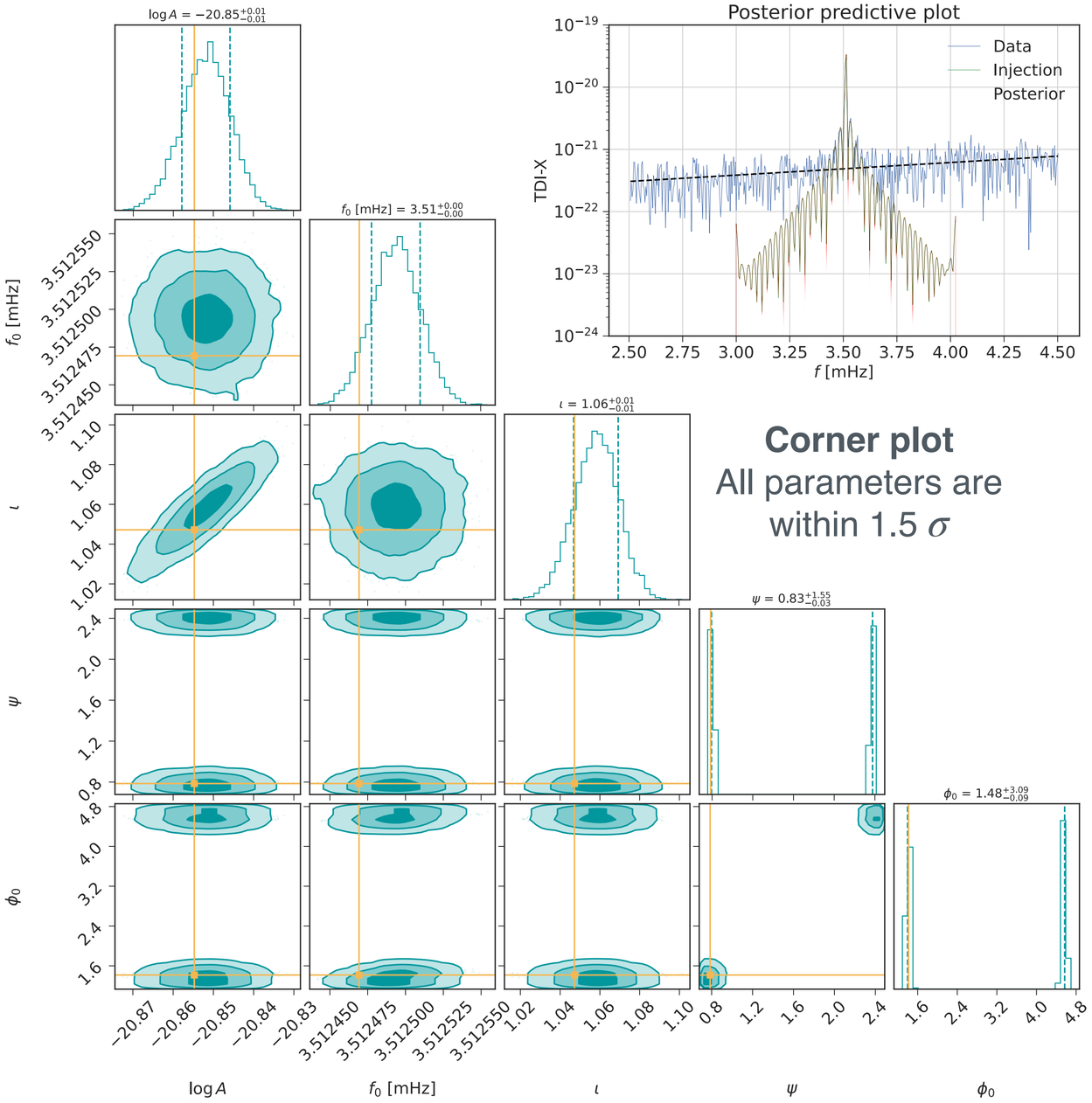
Instrumental noise consistency check

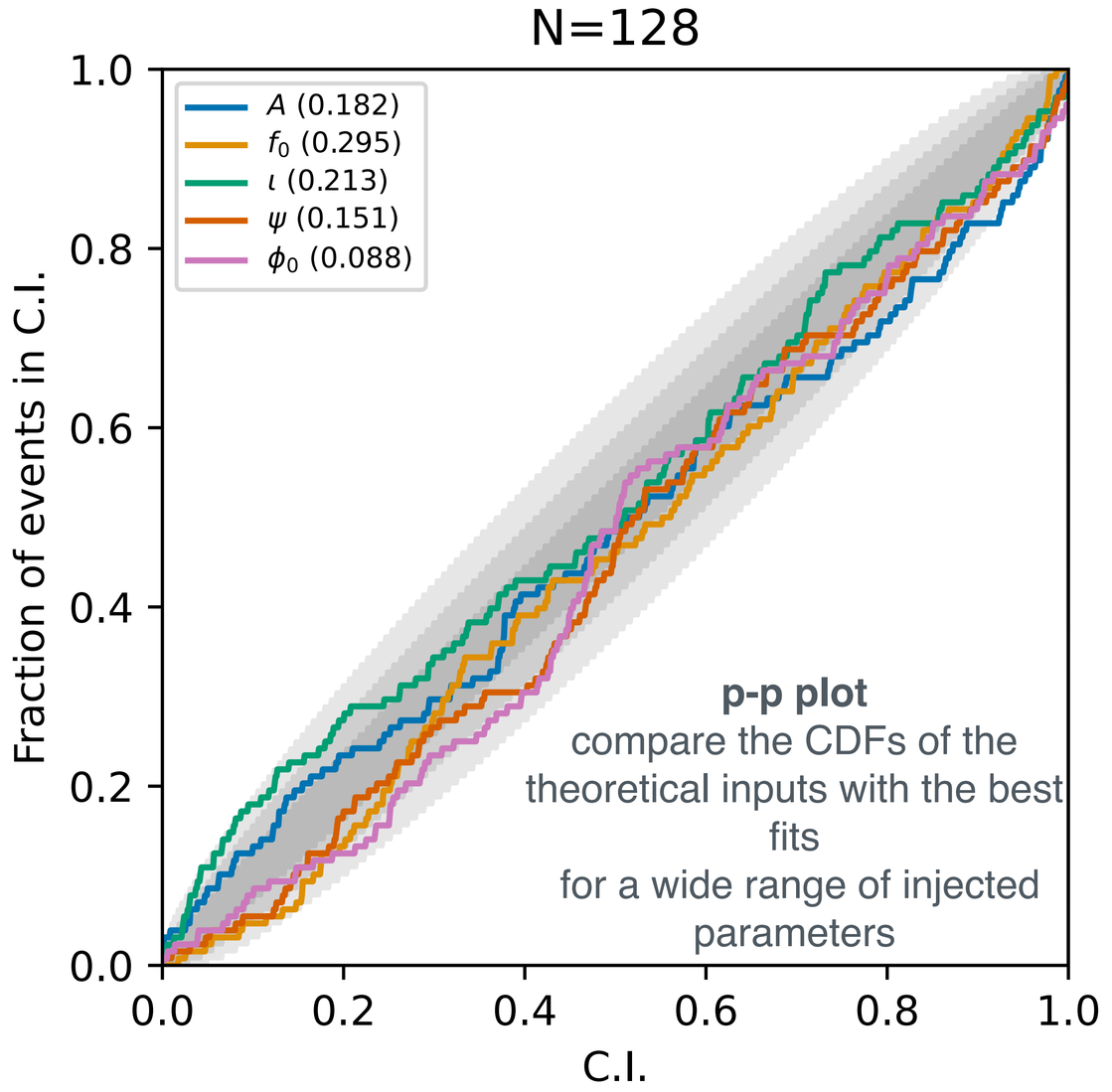


- TM and OMS agree with theoretical expectations
- The overall noise stays allocation
- No unpleasant surprise.



Source reconstruction





To come…

- More realistic orbit reconstruction
- TTL correction
- Improving the interpolation schemes used in TDI
- Other types of sources
- More realistic noise
- Longer simulations
- Gaps and glitches
- Debug/improve/refine L0.5-L1 and enhance interactions with L1-L2 actors.
- Integration into LDC