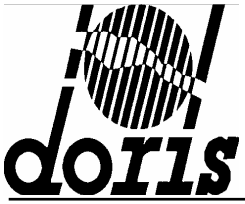


DORIS / Jason-2 : less than 10 cm orbits (soon) available for Near Real-Time Altimetry

C. Jayles, B. Besson, A. Auriol (CNES, Toulouse, France)

J.P. Chauveau, F. Rozo (COFRAMI-AKKA, Toulouse, France)

New DORIS functions

- **New DORIS DGXX receivers (please refer to A. Auriol presentation)**
  - First flight on-board Jason-2, future flights : CryoSat-2, Pléiades, Saral/Altika and HY-2
  - Number of channels increased to 7
  - New spectral analysis mode (improving cold start)
- **A LOT OF SYSTEM IMPROVEMENTS, including :**
  - DORIS is now able to “program the altimete”r by delivering the expected height of the sea surface in real-time, allowing reduction of tracking loops,
  - DORIS measurements are now available under a clear RINEX format,
  - New EGSE now allow ground-demonstration of the DORIS receiver centimeter capability before the launch,
  - …
- **First results : the very first Jason-2 Precise Orbit Ephemeris already show a near-one-centimeter accuracy.**

DIODE : DORIS Immediate Orbit (on-board) Determination

Real-time Orbit Determination software that processes DORIS measurements on-board, as soon as they are performed.

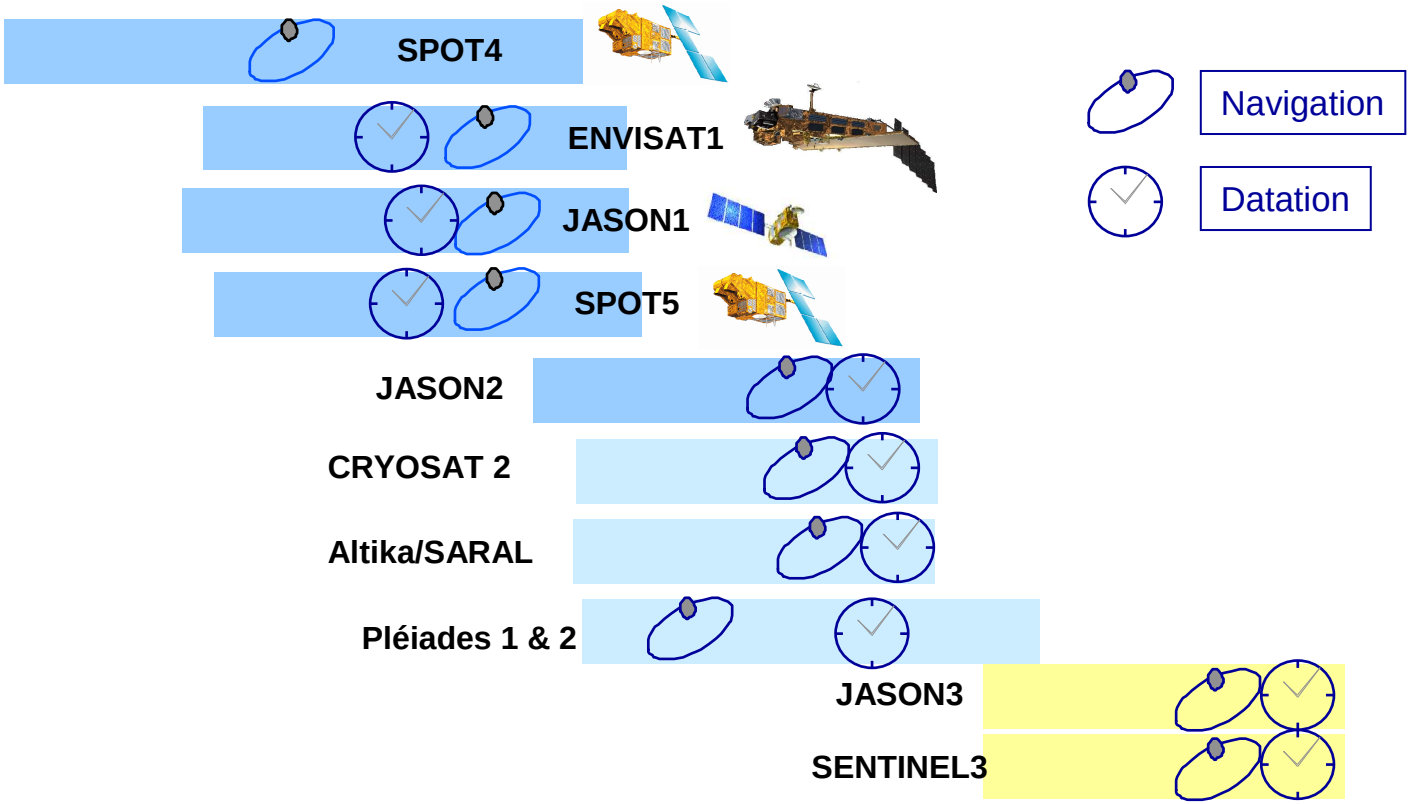
Five issues already flying on-board SPOT4 (since 1998), Jason-1 (2001), SPOT5 (2002), ENVISAT (2002), …

- accurate products: e.g. positions and velocities,
(less than 1 m RMS in 3D, radial component depending on the mission),
- availability : all sats more than 99.7%, Jason-2 100%,
- robustness w.r.t orbital manoeuvers,
- allowing advanced automation of the receivers.

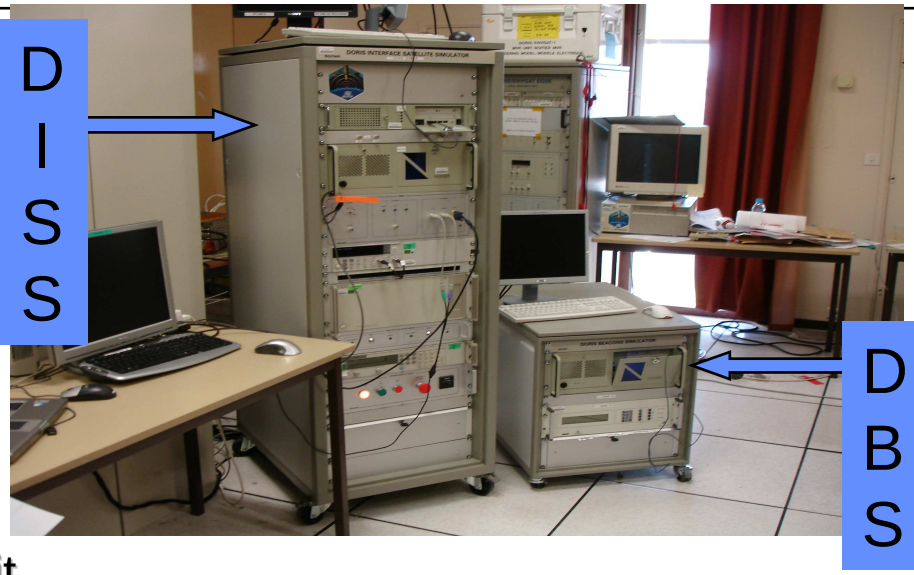
more than 30 years in space …

90 92 94 96 98 2000 02 04 06 08 2010 2013 2020

DIODE navigation cumulated time in orbit



New DORIS EGSE



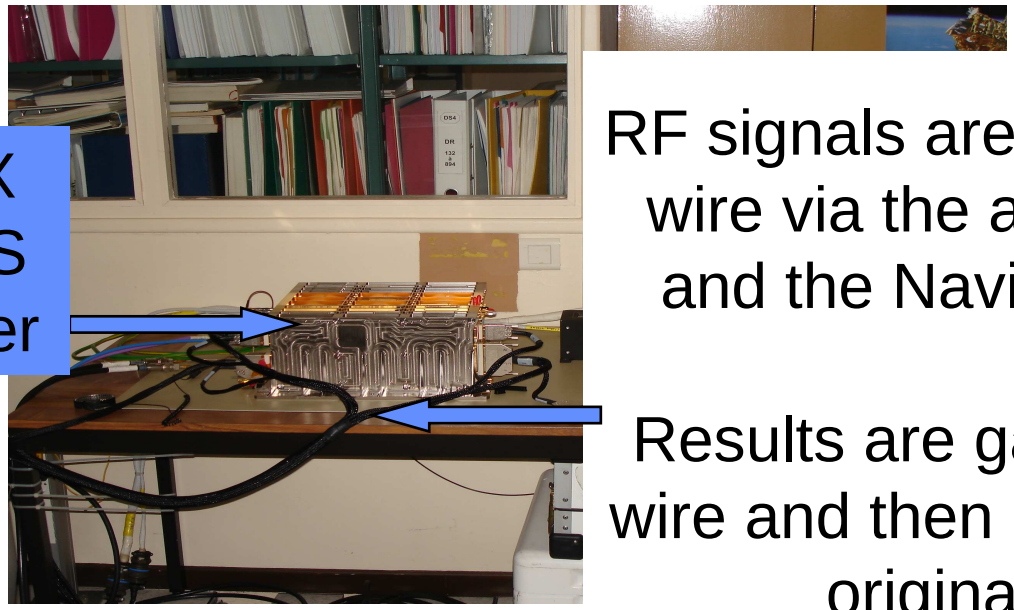
Overall design : given a
- reference orbit,
- beacon network,
- attitude quaternions, …

the L.S.D. Simulation Software processes numerical quantities (in a « scenario » file) every 10 s :
- received power on each channel,
- beacon message including synchro bit,
- propagation delay, …

The DORIS Beacon Simulator (DBS) uses these numerical data (and also the Broadcasts uploads and/or attitude quaternions) to generate a RF analogic signal.

Then the DORIS receiver is fully managed by the DORIS Interface Satellite Simulator (DISS) …

…“on the table” :



DGXX
DORIS
receiver

RF signals are injected through this wire via the antenna connection, and the Navigation is activated;

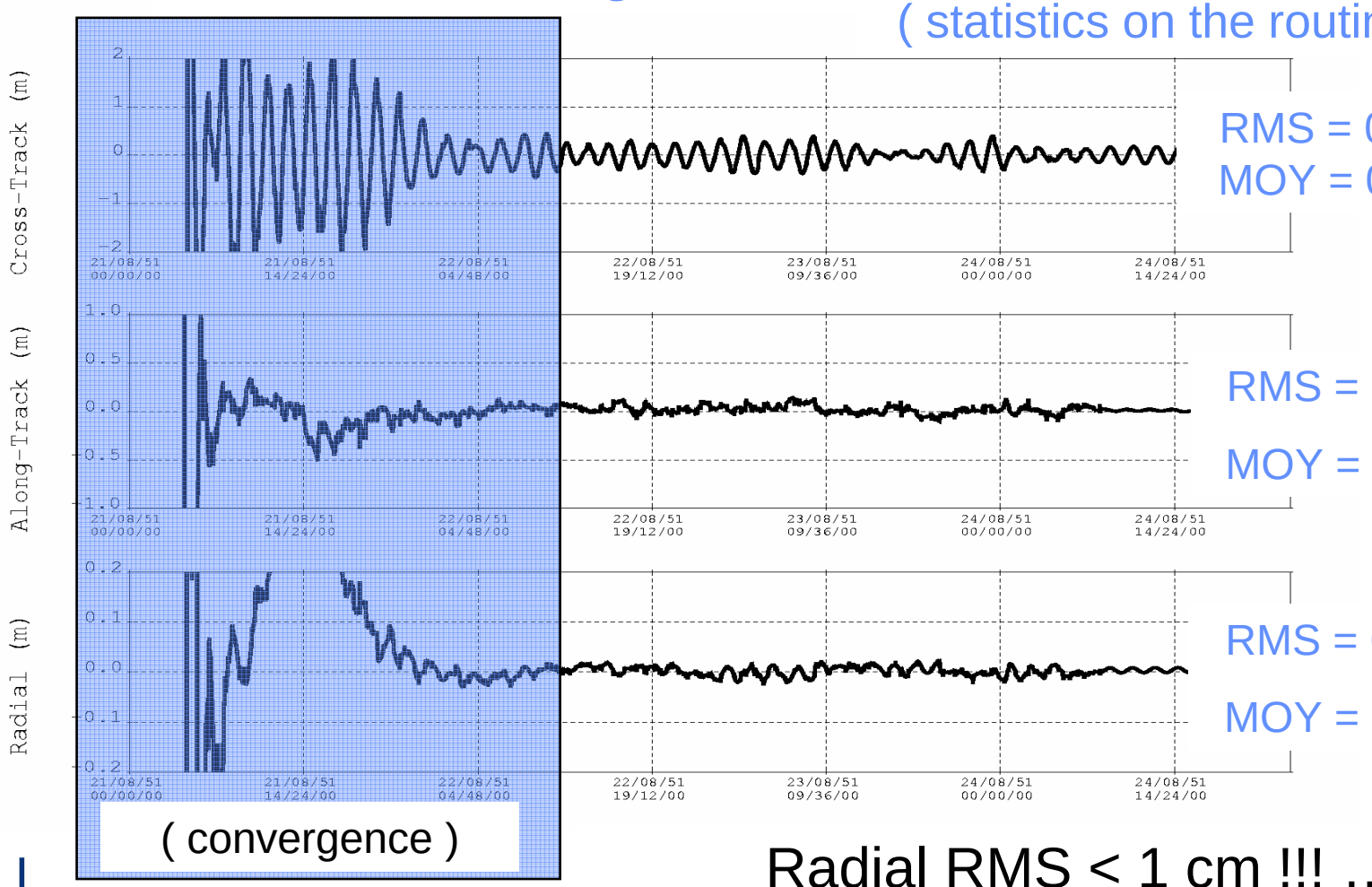
Results are gathered through this wire and then compared to the true original source orbit

This test shows BEFORE THE LAUNCH how close the navigation software is to the hardware inside the receiver :

Orbit => RF signals => Doppler => Orbit + ε

Comparison between restituted and original orbit

(statistics on the routine phase)



(convergence)

RMS = 0.178 m
MOY = 0.002 m

RMS = 0.045 m
MOY = 0.021 m

RMS = 0.009 m
MOY = 0.002 m

Radial RMS < 1 cm !!! …

DIODE mission on-board Jason-2

- **Before the flight, proof that the navigation tool was compliant with 1 cm instrumental errors. Of course 1 cm was not expected in-flight** (because of all that is not in the model : ocean tides, RF perturbations, …).

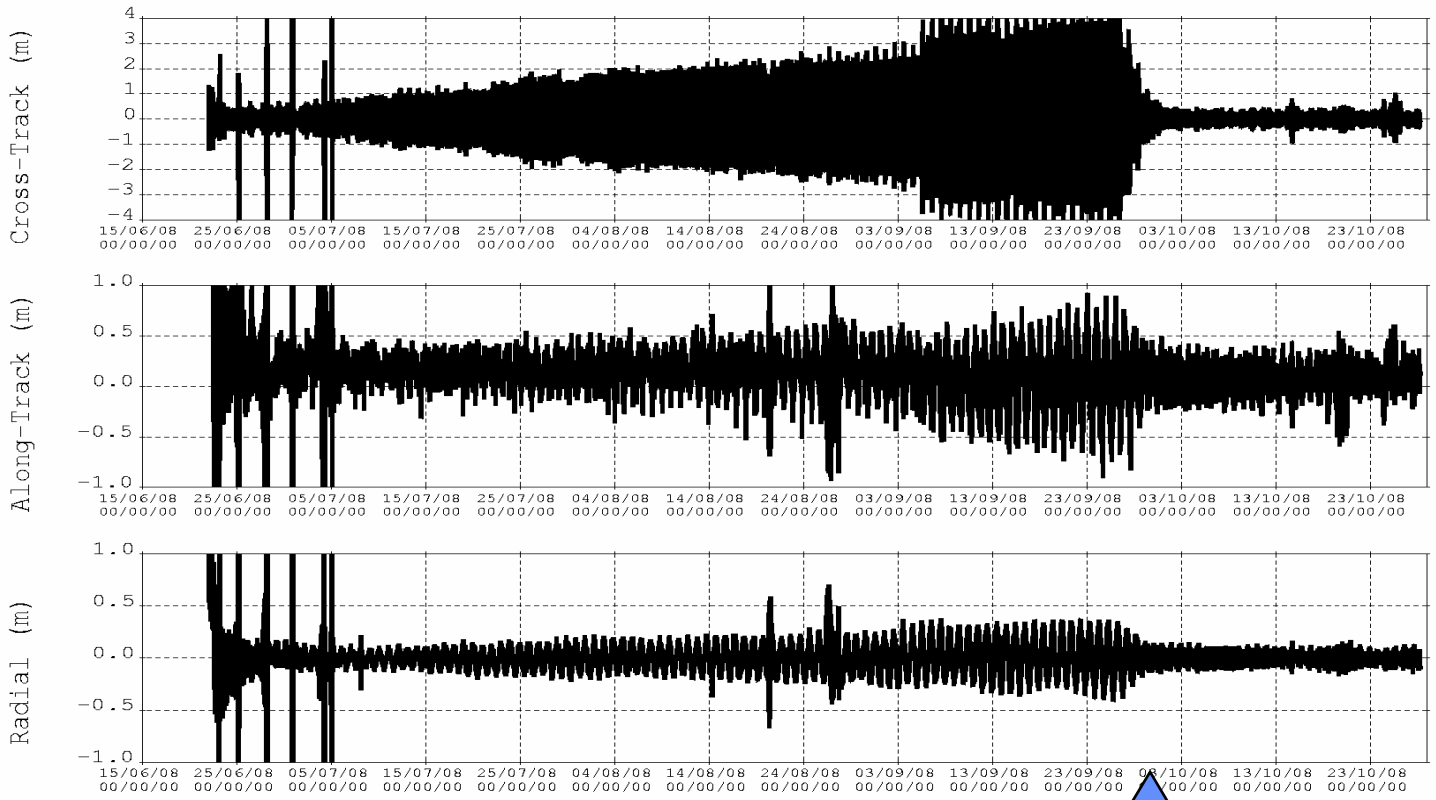
- **On Jason-2, the specifications were “below 10 cm RMS on the Radial component “ when compared to the the Precise Orbit Ephemeris (POE).**

- **The real-time DIODE orbits are delivered in the OGDR products and their accuracy is being improved as tunings of the on-board software progress.**

- **100% availability, even during large manoeuvers = a very robust function.**

ITRF positions compared with DORIS M.O.E.

(4 months of true on-board bulletins)



(larger thresholds because Cross-Track is less observable)

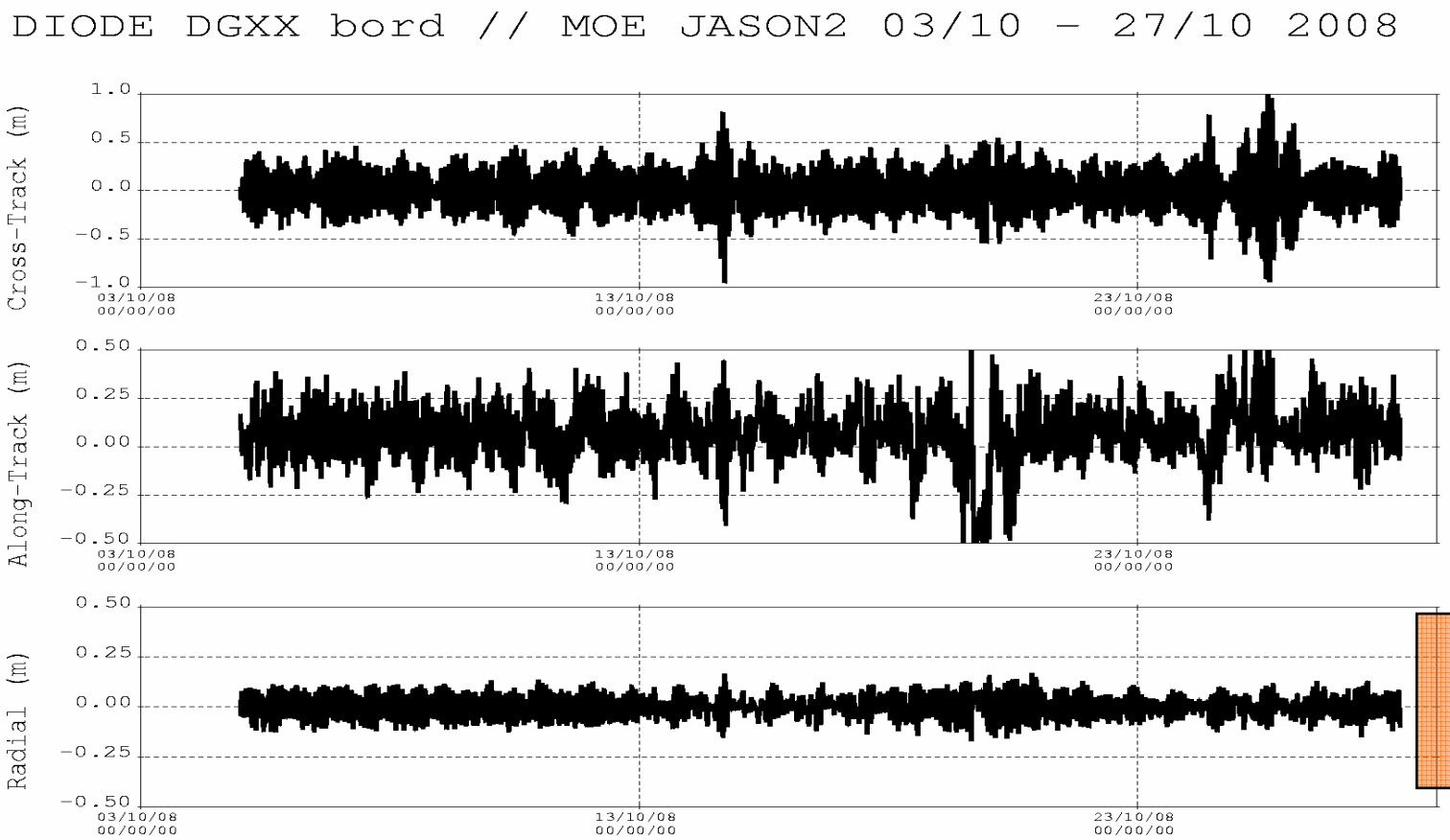
slow secular degradation understood and fixed = pole

Effects of large orbit acquisition manoeuvers

Attitude transitions : an error in our software

Pole covariance changed (and attitude model used)

October on-board results



STATISTICS

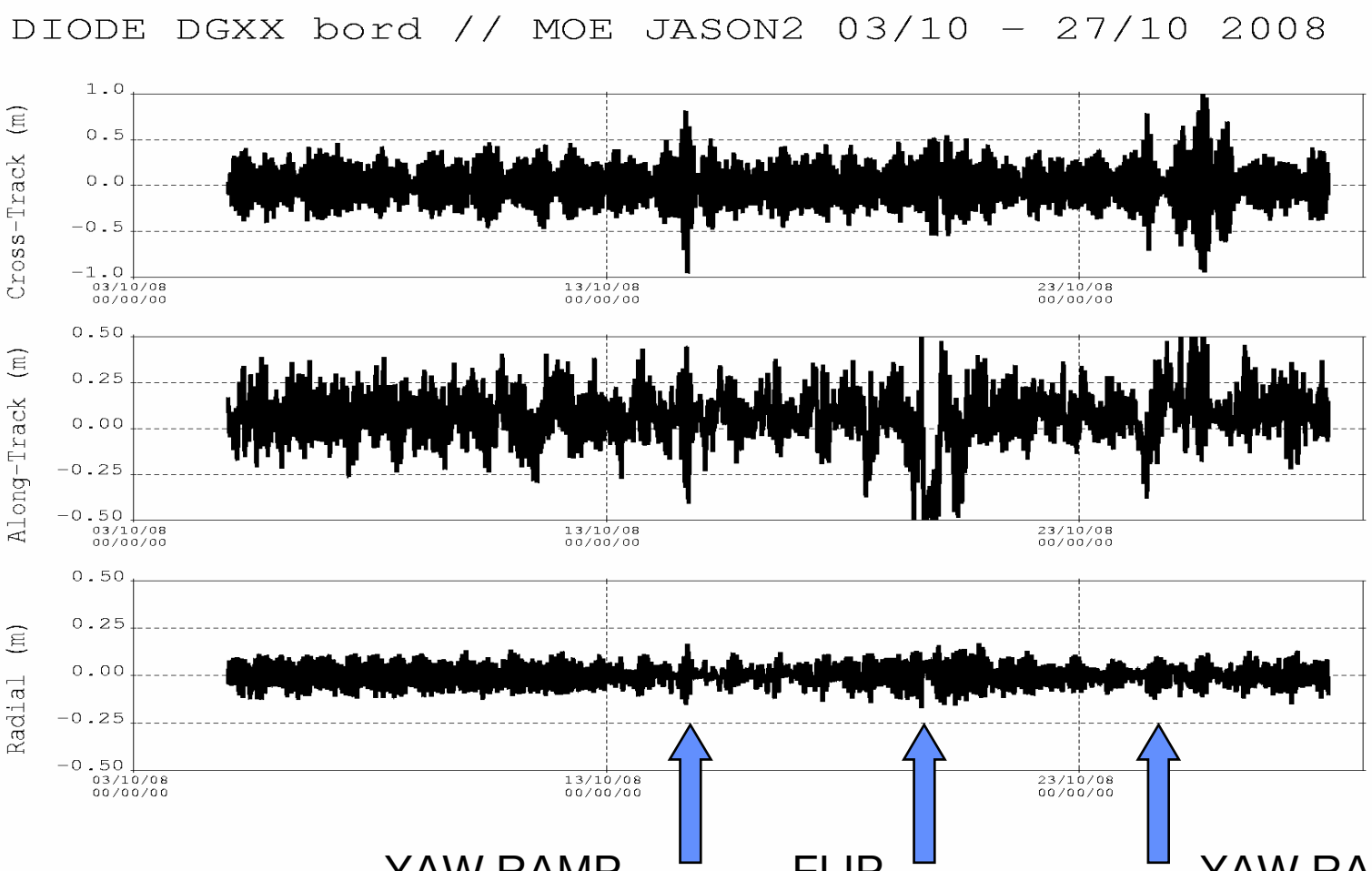
RMS = 0.217 m
MAX = 1.034 m

RMS = 0.136 m
MAX = 0.615 m

RMS = 0.055 m
MAX = 0.171 m

=> Accuracy will fit NRT Altimetry requirements

Attitude transitions now properly handled



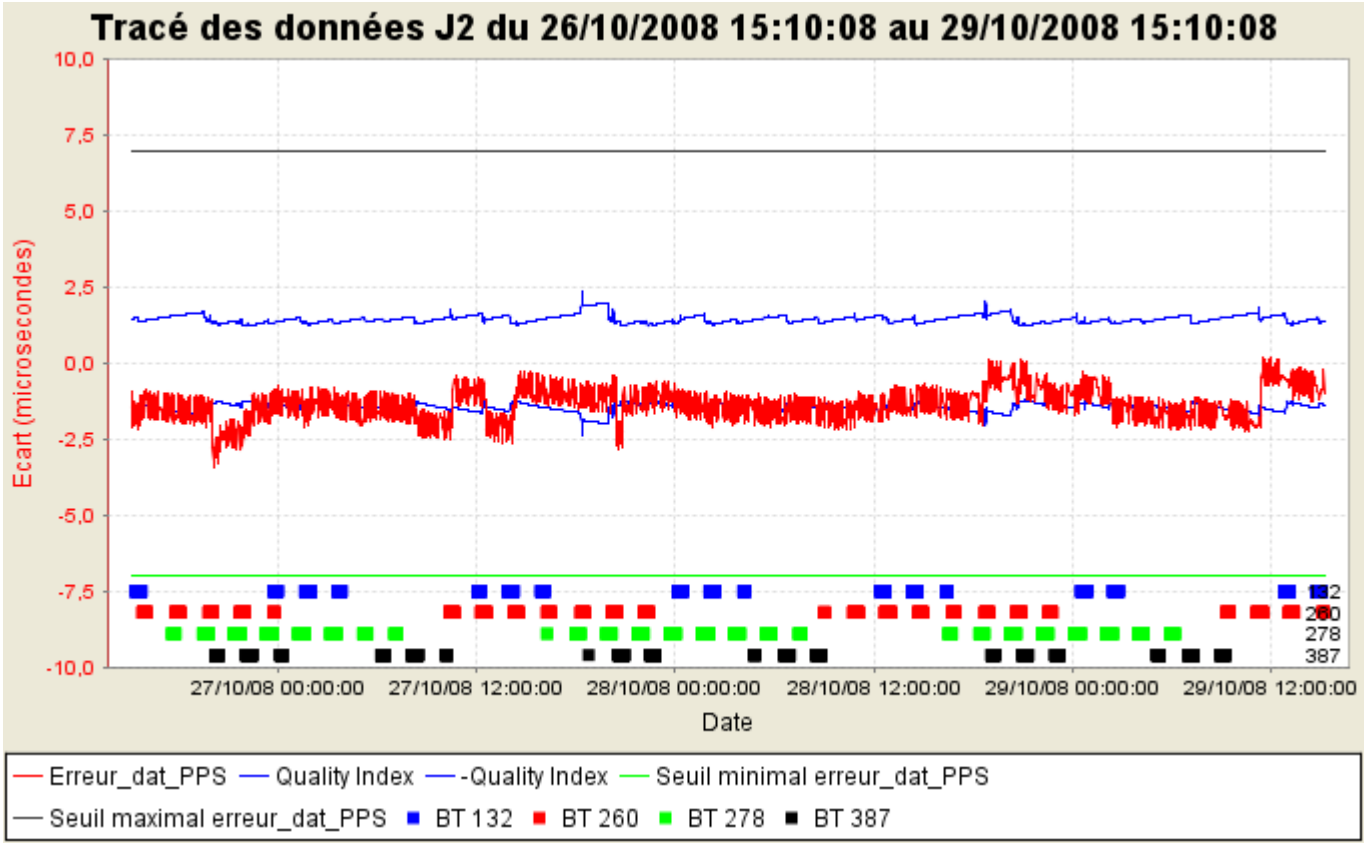
Use of the attitude model instead of the quaternions has allowed by-pass of the “error” : Radial component is almost not perturbed anymore by attitude transitions

A few informations more

In the mean time, the “error” has been identified in the attitude routines of DIODE.
A fixed version is currently being checked on ground. If the results are correct, it will be proposed for uploading (in a few months ?).

A dedicated radiation pressure model is currently being processed using four months of Jason-2 DORIS measurements. It will then be evaluated on-ground.

DORIS datation results



One microsecond "jitter" of the GPS 1 PPS

Errors = a few microseconds, some are due to DORIS, some are due to the LABEN receiver

- **Acceptance thresholds for time-tagging measurements have been raised to more filtering values => perturbations reduced**
- **Additionnal Time Beacon in the System = YellowKnife (Canada, NWT) = more points available**
- **1 microsecond bias still to be reduced**

Conclusions, perspectives

- **A few tunings are still to be performed :**

- **- 1 microsecond time bias (TBC)**
- **- quaternion routines corrected (and validated) => new software to upload (TBC)**
- **- Optimised radiation pressure efficient => new tunings to upload (TBC)**
- **…**

- **OGDR ALTITUDE IS WITHIN SPECIFICATIONS NOW : accuracy < 10 cm RMS, rather 5 or 6 cms today**

- **This will hopefully open the door to a fairly precise Near Real-Time Altimetry.**