Metadata and its importance in SO/PHI's on-board data processing

K. Albert,[1] J. Hirzberger,[1] D. Busse,[1] P. Gutierrez-Marques,[1] and M. Kolleck[1]

[1]Max Planck Institute for Solar System Research

Solar Orbiter and the Polarimetric and Helioseismic Imager

► Solar Orbiter: Orbits the Sun between $1\,\text{AU}$ and $0.28\,\text{AU}$, with an inclination from ecliptic: up to $33°$ (extended mission).

► SO/PHI: Imaging spectropolarimeter at the FeI 617.3 nm absorption line. Two optical paths: FDT ($2°$) and HRT ($0.28°$, $100\,\text{km/pix}$ at 0.28AU). Extensive on-board processing: science data reduction, instrument characterisation and operational calibration. See [3].

► Full on-board data reduction: 24 raw images ($6 \times \lambda$, $4 \times \text{Pol}$) $\rightarrow$ 5 physical quantities ($\vec{B}$, v_{LOS}, T), by applying the on-board created calibration data and inverting the RTE.
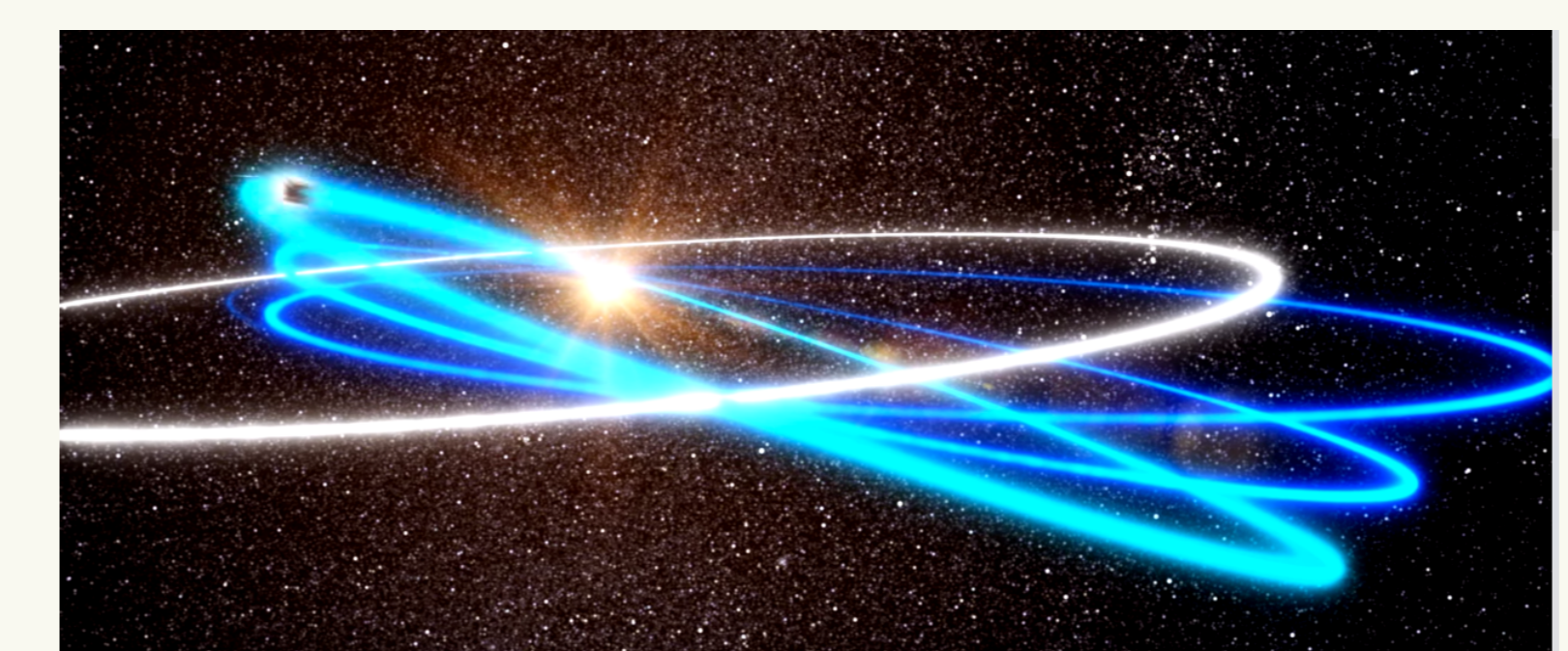

SO orbits.
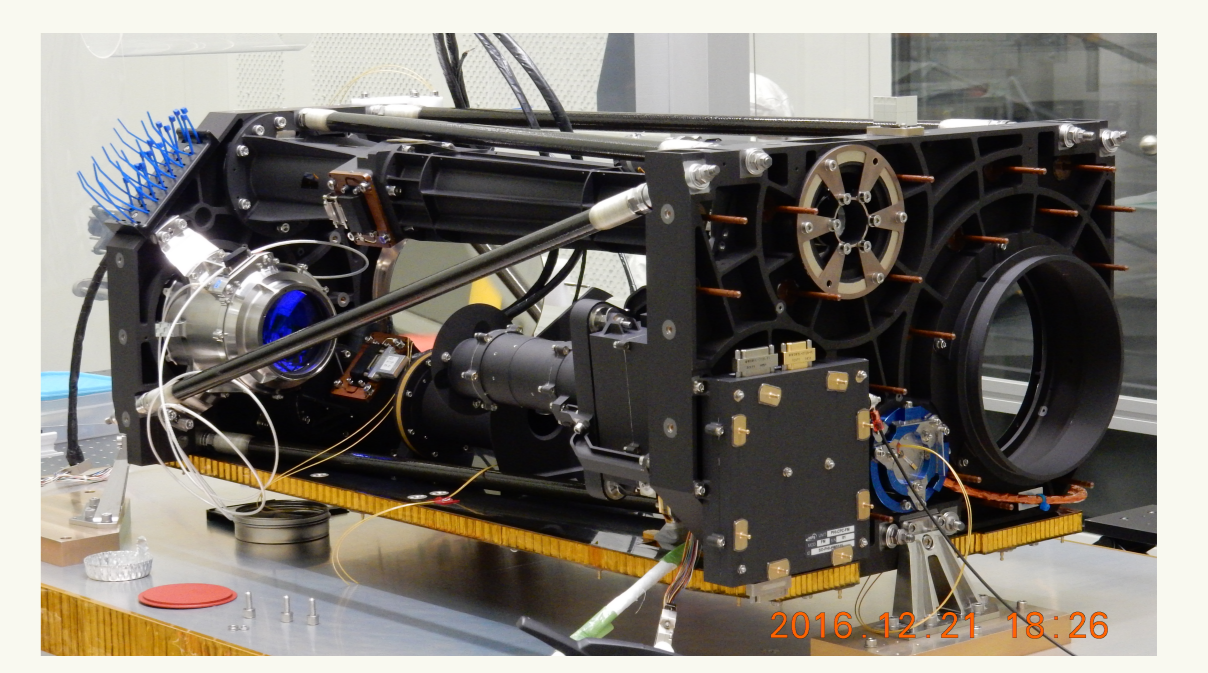
SO/PHI flight model O-unit.

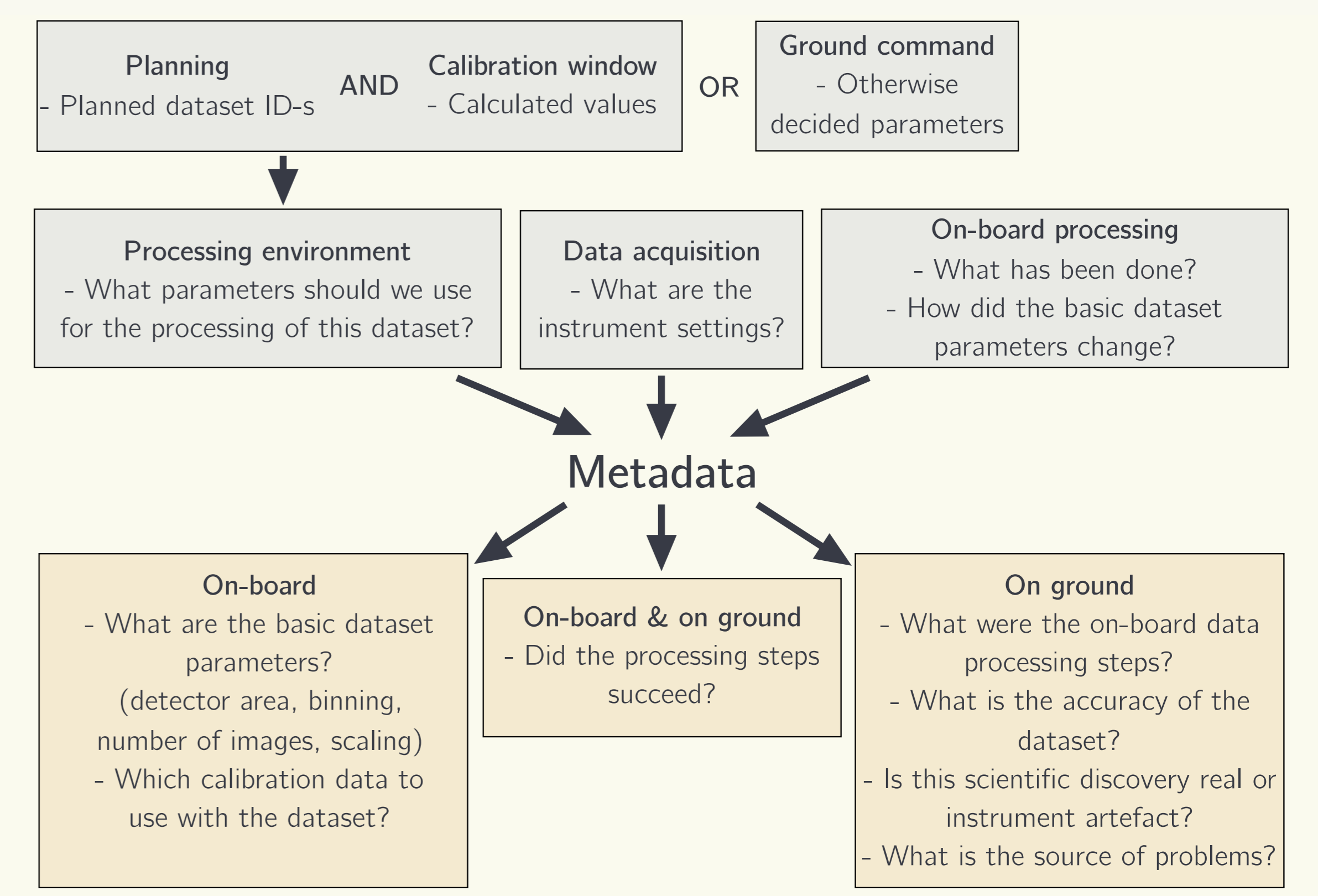## Data processing pipelines

► Functions: science data reduction, instrument characterisation and operational parameter calculation.

► Autnomy: little interaction with pipeline due to long command-response turnaround and limited TM/TC volume.

► Available hardware: 2 reconfigurable FPGAs to accelerate image processing, 1 System Controller GPU for control and back-up implementation.

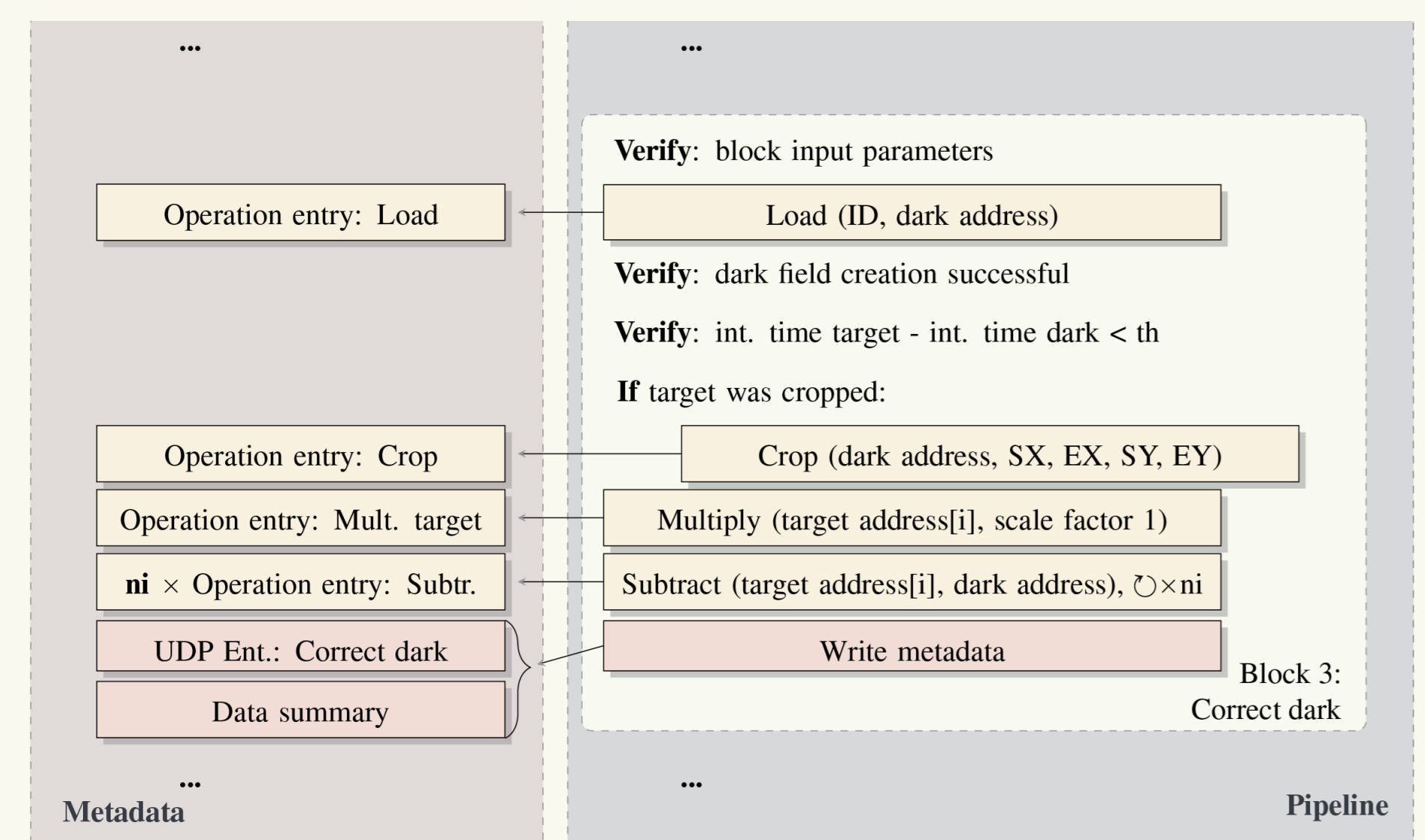► Requirements: science ready datasets as result, flexible pipelines, fixed point arithmetics (where possible).
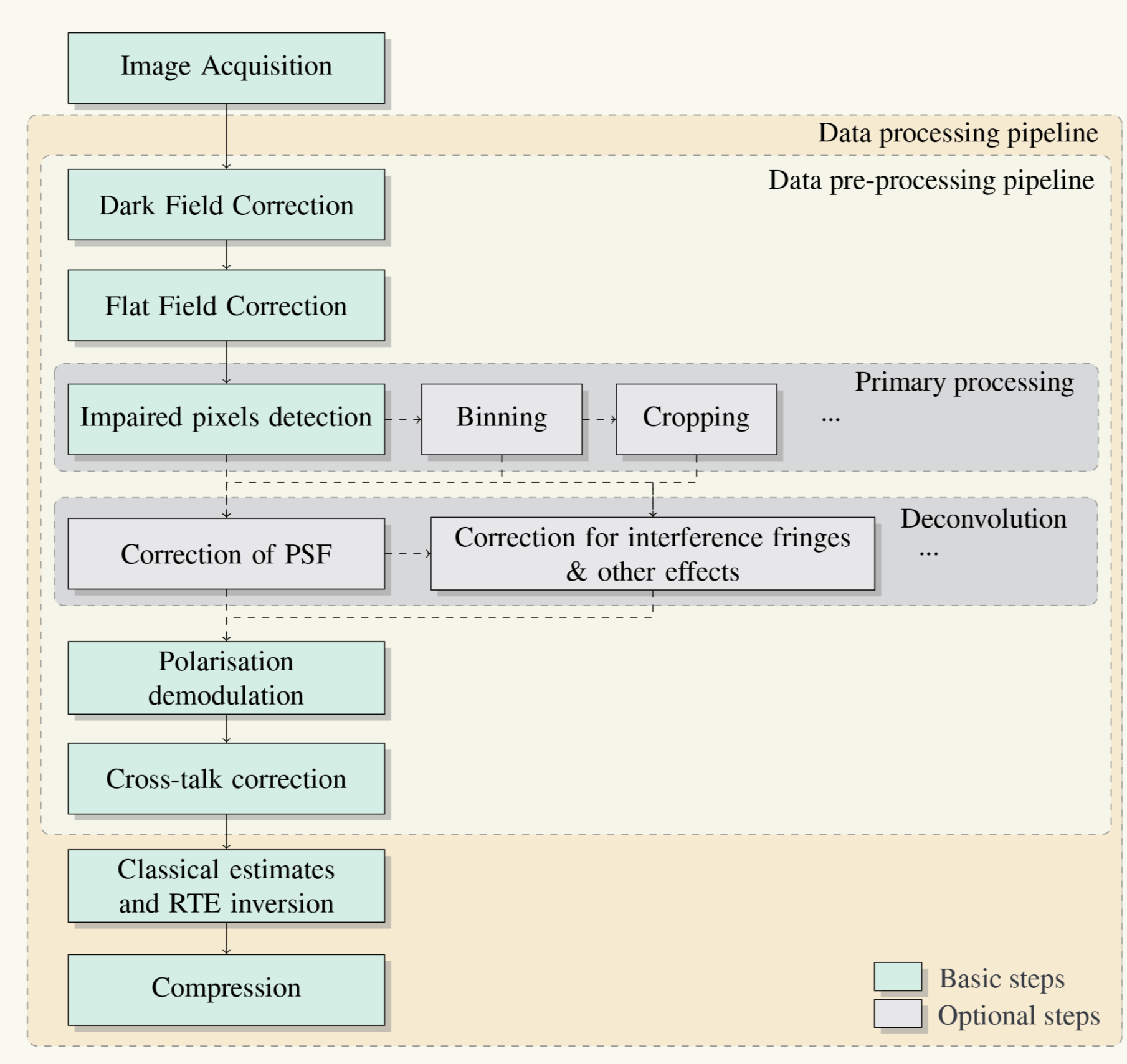
Science data processing of SO/PHI.

Metadata System

*Metadata sources and usage.*

Example metadata collection

Implementation details of dark field correction module, one of the pipeline blocks executed during science data processing.

Select ☐ All	RecordTime A24 Time	OperationID A13	OperationReturn A4	MemAddress1 A10	MemAddress2 A10	MemAddress3 A10	Rows A5	Columns A5	Scalar1 A11	Scalar2 A11
Invert	Modify	Modify	Modify	Modify	Modify	Modify	Modify	Modify	Modify	Modify
5	2019-09-25 12:50:44.0000	PROC_LOAD	0	90170	2621440	0	512	512	0	0
6	2019-09-25 12:50:44.0000	PROC_F_MUL_S	0	26214400	0	26214400	512	512	131072	0
7	2019-09-25 12:50:44.0000	PROC_F_SUB_I	0	0	26214400	0	512	512	0	0
8	2019-09-25 12:50:44.0000	PROC_F_SUB_I	0	1048576	26214400	1048576	512	512	0	0
9	2019-09-25 12:50:44.0000	PROC_F_SUB_I	0	2097152	26214400	2097152	512	512	0	0
10	...									
11	2019-09-25 12:50:45.0000	PROC_F_SUB_I	0	22020096	26214400	22020096	512	512	0	0
12	2019-09-25 12:50:45.0000	PROC_F_SUB_I	0	23068672	26214400	23068672	512	512	0	0
13	2019-09-25 12:50:45.0000	PROC_F_SUB_I	0	24117248	26214400	24117248	512	512	0	0

Operation entries in the metadata, collected during the run of dark field correction. (Excerpt.)

Example metadata based error search

Inversion results
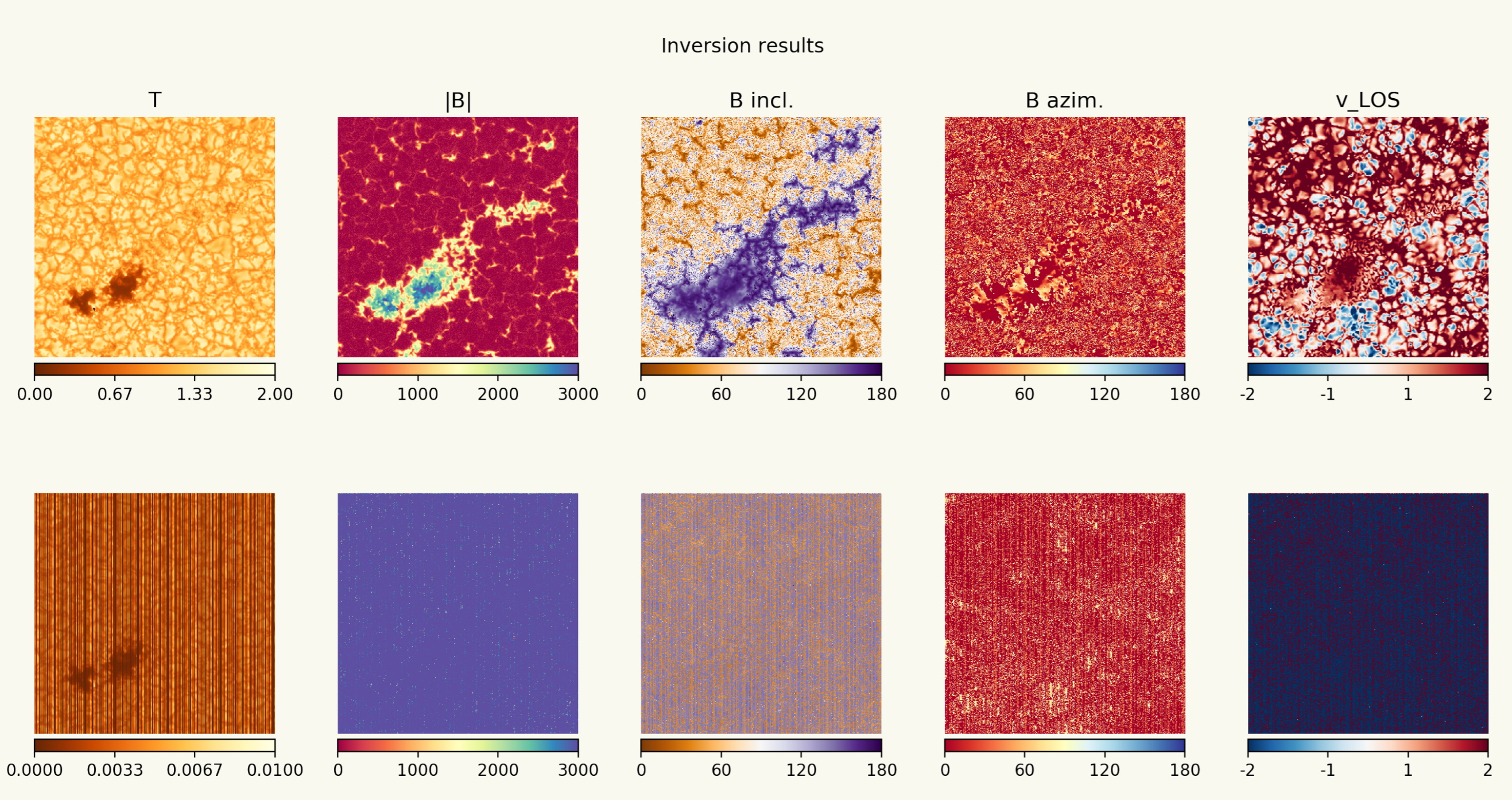
Top: expected, usual results for the pipeline. Bottom: obtained final results, clearly wrong at the first look. An incorrect demodulation matrix has been used on the dataset (can happen due to planning or operator error).

UDP entries during the pipeline run. (Excerpt.) The highlighted return values are warnings for NaN-s produced in the dataset during the operation (a usual case), and for demodulation matrix mismatch due to different feed select mechanism positions (i.e. it is for the other optical path).

References

[1] K. Albert, J. Hirzberger, D. Busse, and et al. Autonomous on-board data processing and instrument calibration software for the SO/PHI. *Proc. SPIE*, 707:10707 – 10707 – 9, 2018.

[2] K. Albert, J. Hirzberger, D. Busse, and et al. Performance analysis of the SO/PHI software framework for on-board data reduction. *arXiv e-prints*, page arXiv:1905.08690, May 2019.

[3] S. K. Solanki, J. C. del Toro Iniesta, J. Woch, and et al. The Polarimetric and Helioseismic Imager on Solar Orbiter. *arXiv e-prints*, page arXiv:1903.11061, Mar 2019.

Contact: albert@mps.mpg.de