The Herschel Legacy
Calibration

D. Teyssier, on behalf of the Calibration Scientists at the HSC, NHSC and the Instrument Control Centres (past and present)

Instrument and Calibration Scientists Team lead

10/05/2016
1. The POP Objectives from the Calibration Perspective
2. The Herschel Calibration Steering Group and its Legacy
3. Instrument Calibration Achievements during the POP
5. Conclusions and Remaining Work in the POP
The Post-Operations Phase Calibration Plan

Following the HSC POP Plan (HERSCHEL-HSC-DOC-1987), the calibration effort in POPs is organised around the following pillars:

- Liaison between Instrument teams, NHSC, and Herschel SOC
- Support to data product calibration improvement both via software and calibration model/files updates – includes software and product validation campaigns
- Provision of reference documentation for the Legacy Phase (instrument handbooks and DP manuals, pocket guides, web pages, etc)
- Community Support in the exploitation of the Herschel data (workshops, helpdesk, video tutorials, DP Interest Mailing Lists)
- Improvement of the reconstructed attitude (pointing)
- Coordination of cross-calibration efforts among Herschel instruments, and between Herschel and other observatories
- Support to related calibration for other observatories (e.g. ALMA)
- Validation of deliveries (products/scripts) from Herschel Key Projects (User-Provided Data Products – UPDPs) prior to ingestion into Archive
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What is the Herschel Legacy Calibration?

- Prime and Secondary Calibrator models
- Calibration software and calibration files
  - The combination of coded algorithms and instrument characterisation files (e.g. PSFs, spectral responses, photometer filter curves, etc) turned into the instrument pipelines
  - The set of interactive scripts and tools for *ad hoc* re- or post-processing of data products (from raw to final)
- Calibration documentation
  - Collection of peer-reviewed publications, instrument handbooks, relevant technical notes/reports, and software-related manuals/guides
- Calibration as public outreach
  - Various workshops organised for intra-Herschel (e.g. map-maker WS) or cross-observatory purposes (e.g. Herschel-ALMA synergies)
  - Regular Data Processing workshops targeting both advanced and novice users, and associated video tutorials
The **HCalSG** was kicked off in 2004 with a group formed by ICC calibration experts, prime calibrator modellers and scientists from other observatories.

**Main mandates pre-launch and in Operations:**

- Identify prime calibrators and support the generation of reference models at the required accuracy levels.
- Monitor progress in instrument calibration concepts and pipelines, via regular meetings and dedicated workshops.
- Coordinate calibration campaigns over the mission (CoP, PV, Routine) and optimise synergies between instruments for the allocated time.

**Main role during POPs**

- Consolidate prime calibrator models, esp. by retro-feeding Herschel findings into existing models (mostly planetary calibrators).
- Foster cross-calibration exercises between Herschel and other instruments using the wealth of data acquired over the mission.
- Monitor and support the work towards legacy documentation/publication about calibration and the reference models.
The HCalSG legacy: calibrator models

The HCalSG oversaw the production of a series of reference models, which have now reached a high level of maturity

- **Mars** (Moreno & Lellouch): prime for HIFI
- **Uranus** (Moreno + Orton): prime for SPIRE-S, secondary for PACS-S
- **Neptune** (Moreno): prime for SPIRE-P, secondary for PACS-S
- **Stellar calibrators** (Decin & Dehaes): 5 prime/3 secondary calibrators for PACS-S and PACS-P – untouched since launch – strong heritage from Spitzer.
- **Asteroids** (Müller): secondary calibrators for PACS
  - 4 brightest ones now considered prime calibrators (5% accuracy)
  - **note:** Ceres and Pallas were used to derive time-dependent telescope background models, used in the PACS-S calibration
- **Others (Titan, Callisto, Ganymede):** not used directly by Herschel

All models available as Ancillary Data Products (via the HSA and web)

See also [http://herschel.esac.esa.int/twiki/bin/view/HCalSG/NewCalSource](http://herschel.esac.esa.int/twiki/bin/view/HCalSG/NewCalSource)
Consistency between stellar and planetary model calibration shown to be extremely good (1%) – significant achievement considering the very different and independent nature of the models.
Calibration workshops (none during POPs)

- Calibrator Models workshops (Dec 2004 and Feb 2008)
  - http://www.cosmos.esa.int/web/herschel/calibration-workshop-1
  - http://www.cosmos.esa.int/web/herschel/calibration-workshop-2

- Instrument Flux Calibration workshops:
  - 2010: mostly dedicated to photometer calibration
    http://herschel.esac.esa.int/twiki/bin/view/HCalSG/CalibrationWorkshop
  - 2012: mostly dedicated to spectrometer calibration
    http://herschel.esac.esa.int/twiki/bin/view/Public/CalibrationWorkshop4
  - 2013: general wrap-up prior to POP start – led to a special topical issue of Experimental Astronomy (17 published papers)
    http://herschel.esac.esa.int/twiki/bin/view/Public/CalibrationWorkshop5

Photometer map-maker workshop (January 2013)

http://www.cosmos.esa.int/web/herschel/pacs-and-spike-map-making-workshop

- Half a dozen map-makers were benchmarked against a set of metrics – led to selection of “best” PACS-P map-makers used in the pipeline
Some HCalSG success stories

- **Planck/HFI data in bands overlapping with SPIRE-P** were used in order to assess accurate background reference levels for the photometric maps
  - Despite a lengthy iteration process with Planck team (non-disclosure of early data), the payback of this effort was significant for both projects, allowing e.g. Planck/HFI to refine their beams

- **Cross-calibration of ext. emission between PACS-P and Spitzer MIPS at 160 µm**
  - Discrepancy of >30% at high end between the two instruments initially thought to be issue with the Herschel data and their calibration
  - Data from either instruments reconciled after correction for an overlooked non-linearity issue in the MIPS 160 µm data

- **Reference calibrator models**
  - Planetary and asteroid models used by Herschel have now become a reference for modern observatories such as ALMA and SOFIA
  - Heritage for a potential SPICA mission will also be very valuable
Most, if not all, improvements applying to the calibration effort have materialised in the products in a staging fashion, related to the regular bulk reprocessing campaigns associated to HCSS user release versions.

During the POP, the following landmarks are applicable (see also the Legacy Software presentation):

- HIPE 10: last HCSS release during Operations (Dec 2012)
- HIPE 11: released July 2013
- HIPE 12: released March 2014
- HIPE 13: released April 2015
- HIPE 14: 14.0 (released Dec 2015), 14.1 (released April 2016), 14.2 (planned for June 2016)
- HIPE 15: Planned for December 2016
SPIRE-P products were already very close to science-ready when entering POPs

Main Pipeline improvements:
- Two-pass pipeline: optimised deglitching and map destriper
- Anomalous instrument behaviour mitigation (cooler burp, bolo jumps)

Introduction of new products:
- Level 2.5 (overlapping nominal and orthogonal scans) and level 3 products (mosaics of overlapping level 2 or 2.5 fields of view)
- “High Resolution” (HiRes) maps – essentially a spatial deconvolution
- Serendipity mode data

Main Calibration improvements:
- High accuracy instrument beam derived from shadow observations, allowing better extended source calibration maps
- Extended calibrated maps zero level matched to Planck/HFI

Calibration considered final
Instrument calibration achievements: SPIRE-P - examples

De-glitching (2-pass pipeline)

HIPE 11
HIPE 14

Early HIPE 9
Naïve Map
Naïve Map + Destriper
SPIRE Destriper (2-pass pipeline)

Later HIPE
Naïve Map + Destriper
Naïve Map + Extended Gain
Naïve Map + Turnarounds + Extended Gain

De-glitching (2-pass pipeline)
Instrument calibration achievements: SPIRE-P - examples

Level 3 products

Level 3 product created from Level 2

Pre HIPE 13

Level 3 product created from Level 2.5

Post HIPE 13
Instrument calibration achievements:
SPIRE-P - examples

HiRes maps

Products readily available from the pipeline for
~17% of SPIRE-P observations as level2/2.5

Pre-HIPE 13

HIPE 14
Instrument calibration achievements:
SPIRE-S

- **Main Pipeline improvements:**
  - Better characterisation of the telescope *Relative Spectral Response Function* (RSRF), resulting in improved sensitivity and spectral shape
  - Band spectral coverage extension at the edges
  - Correction for Low Res. data, improvements of the SLW spectral shape
  - Improved re-gridded cubes for fully sampled spectral maps

- **Introduction of new products:**
  - Spectra processed for all array pixels (originally: only central ones)

- **Main Calibration improvements:**
  - Improved extended source calibration based on SPIRE-P/SPIRE-S cross-comparison
  - Detailed characterisation of the FTS calibration accuracy based on secondary calibrators monitoring
  - Characterisation of the FTS beams and feedback into ad hoc correction tool for semi-extended objects

**Calibration considered final (flux & frequency)**
Instrument calibration achievements:
SPIRE-S – examples

Telescope RSRF improvement: Sensitivity figures in HR mode

HIPE 7: telescope RSRF derived using a single dark sky observation
HIPE 9: mean telescope RSRF from many dark sky observations
HIPE 11: RSRFs derived using all dark sky observations
HIPE 12.1: wider bands introduced
Instrument calibration achievements: SPIRE-S – examples

Convolved cubes for fully sampled spectral maps

**HIPE 13**
Naïve projection cubes – leads to empty pixels at under-sampled sky positions (dead detectors)

**HIPE 14**
Cubes re-gridded using convolution kernel – assigns flux at every pixel of the grid

(note also the improvements in the pipeline postcard)
Instrument calibration achievements: PACS-P

- **PACS-P products were already very close to science-ready when entering POPs**
- **Main Pipeline improvements:**
  - Introduction of new GLS mapper *Unimap*, replaced *MadMap* in HIPE 13
  - Introduction of destriper code (*JScanam*) based on *Scanamorphos*
  - Calibration blocks detection and masking
  - *Interactive scripts capable to process any number of observations*
- **Introduction of new products:**
  - Level 3 products (overlapping fields of view from level 2.5 products)
  - Level 2.5 products for Solar System Objects (in SSO co-moving frame)
- **Main Calibration improvements:**
  - PSFs and EEFs derived for various scan speeds and observing modes
  - Updated calibration corrections: projection of physical pixels onto sky, evaporator temperature correction, signal calibration for chopped observations

**Calibration considered final**
Instrument calibration achievements: PACS-P examples

Improved SNR in Level 3 products

Cal block masking

Level 2.5

GOODS-S field

Level 3

Abell 2213

HIPE 14 with calibration block detection mode

HIPE 13 w/o calibration block detection mode
Instrument calibration achievements:

**PACS-S**

- **Main Pipeline improvements:**
  - Transition from internal Calibrator-based scheme to Telescope background normalisation scheme (tracking response drift) – improvement esp. for broad band features and faint sources
  - Flat-fielding for range scan observations based on cubic splines
  - New flux calibration scheme for drizzled cubes

- **Introduction of new products:**
  - Cubes spectrally and spatially resampled on regular grids
  - Level 3 products (concatenation of spectral range of SEDs)
  - Point-source corrected spectra on top of that from central spaxel

- **Main Calibration improvements:**
  - Better beam characterisation (improved Point Source correction, and Extended Source calibration – recovery of up to 30% flux loss at low λ)
  - Instrument RSRF in leak region above 190 µm ("de-leaked" RSRF)

*Flux Calibration not yet considered final – last update will take place in the HIPE 14.2 release (June 2016)*
Instrument calibration achievements: PACS-S examples

Telescope Background Normalisation scheme

Comparison of SED from SPG 11 (black) and 14 (red)

New level3 concatenated SED for range spectroscopy

R Dor
Point-source calibrated spectrum
Instrument calibration achievements: PACS-S examples

Non-uniform illumination of PACS-S FoV

IFU Illumination effectively implies non-fully filled FoV by spaxels array

Assumed model
HIPE 13

Assumed model
HIPE 14

Measurement
HIPE 14

Toy model

62 µm

145 µm
**PACS improvements in 14.2: heads-up**

- **PACS-P:**
  - Newest version of Unimap 6.4.3
    - Introduction of error maps
    - New noise cancellation option to be activated in certain fields (e.g. Galactic Plane)

- **PACS-S:**
  - Region in red leak (above 190 µm) will not be offered in the end product (filled with NaNs instead)
    - Necessary calibration table (“de-leaked” RSRF) present in calibration tree, allowing manual processing through ipipe
    - Shall be generated as HPDPs
  - New transient correction algorithm will not be implemented in SPG – results from new flat-field approach are of similar quality
  - Improvement of postcards

- **General:**
  - *Tiding up headers and interactive scripts*
Main Pipeline improvements:
- Electrical Standing Wave automatic corrections in Bands 6 and 7
- Generation of Flux Calibration Uncertainty tables applicable to the observing frequency

Introduction of new products:
- Level 2.5 simplified products for single point observations
- Generation and provision of OFF position spectra for all modes

Main Calibration improvements:
- Better instrument PSF characterisation via bottom-up modelling of beam maps at all epochs, bootstrapped to ILT Far-Field beam data
- Detector mixer sideband gain ratio estimated on a fine frequency grid, based on a combination of in-flight and pre-flight measurements
- Masking of all spurious spectra features in Spectral Scan observations via a manually-populated calibration file

Calibration considered final (flux & frequency)
Instrument calibration achievements: HIFI – examples

**Spur mask tables for Spectral Scans**

**Electrical Standing Waves**

**Reference position spectra**

ON-target only

SPG output (on-off)

OFF position: polluted

Continuum also corrected!
Instrument cross-calibration

- **With other observatories**
  - SPIRE-P/Planck HFI: successfully used for SPIRE absolute background level calibration – good to 10%
  - PACS-P/Spitzer MIPS: very good match once MIPS non-linearity understood and corrected

- **Intra-instrument**
  - PACS-P/PACS-S continuum calibration match very well by construction
  - SPIRE-P/SPIRE-S continuum discrepancy by up to 80% led to revision of SPIRE-S extended calibration scheme

- **Across instruments: the spectrometers**
  - HIFI/SPIRE flux intensities on AGB sample agree within 10%
  - HIFI/PACS flux intensities on AGB sample agree within 30%
  - Discrepancy for the latter was factor of 3 in red leak area (@200 μm), at the time when de-leaked RSRF was not yet available
At start of POPs, the pointing accuracy was already exceeding the pre-launch specification (Absolute Pointing Error – APE – of 1”-1.6” vs a specified 2”)

Main Pipeline improvements during POPs:

- HIPE 12: Correction for improper STR focal length for OD 321-761 range introduced in pipeline (was previously ingested manually)
- HIPE 13: introduction of Gyro-based attitude reconstruction, allowing to track high-frequency changes in the S/C attitude (too heavily filtered) – esp. efficient to deal with pointing jitter.

offers the most homogeneous pointing performance over the mission

- HIPE 14: Treatment of interlacing (use of 18 stars instead of 9 in the Star Tracker system – STR), and special correction for contingency events of the STR operations (e.g. switch-over to redundant STR)

  Reconstruction now considered final in the pipeline products

Remaining work in POPs: investigation of pointing drift in observations under so-called warm attitude, leading to thermo-elastic deformation of the STR – objective is to provide report and recipe on first order correction (not pipeline)
### Attitude reconstruction performance (pointing)

<table>
<thead>
<tr>
<th>OD range</th>
<th>Raw APE (a)</th>
<th>AME (b) HIPE 12</th>
<th>AME (b) HIPE 13</th>
<th>AME (b) HIPE 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>32-320</td>
<td>1.9”-2.2”</td>
<td>1.4”</td>
<td>1.4”</td>
<td>1.4”</td>
</tr>
<tr>
<td>321-761 (c)</td>
<td>2.4”</td>
<td>1.6”</td>
<td>1.2”</td>
<td>1.2”</td>
</tr>
<tr>
<td>762-865</td>
<td>1.45”</td>
<td>1.3”</td>
<td>1.2”</td>
<td>1.2”</td>
</tr>
<tr>
<td>866-1010</td>
<td>1.1”</td>
<td>N/A</td>
<td>No data</td>
<td>N/A</td>
</tr>
<tr>
<td>1011-1452</td>
<td>0.9”</td>
<td>N/A</td>
<td>1.2”</td>
<td>0.9”</td>
</tr>
</tbody>
</table>

(a) Attitude accuracy from raw Spacecraft Telemetry  
(b) Absolute Measured Error: in contrast with the APE, applicable at the time of observation, the AME is the accuracy of the a posteriori reconstructed attitude  
(c) In this period, a colder STR baseplate operation temperature was not taken into account in the on-board focal length parameter of the STR system, leading to a poorer performance – the effectively achieved accuracy could be as bad as 8”

Adapted from Sanchez-Portal et al. 2014
## Science-readiness and calibration uncertainty: SPIRE

<table>
<thead>
<tr>
<th>Flux Uncertainty</th>
<th>Science Readiness of Standard Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute</strong></td>
<td><strong>Repeatability</strong></td>
</tr>
<tr>
<td><strong>Photometer</strong></td>
<td></td>
</tr>
<tr>
<td>Pt-source calib.:</td>
<td>&lt; 2% for S&gt;100mJy</td>
</tr>
<tr>
<td>~ 5%</td>
<td>&lt;10% for S&lt;100 mJy</td>
</tr>
<tr>
<td>Pt-source calib.</td>
<td>Ready to use as is – background</td>
</tr>
<tr>
<td>~ 5%</td>
<td>reference level accurate to 10%</td>
</tr>
<tr>
<td></td>
<td><strong>Isolated artefacts not dealt</strong></td>
</tr>
<tr>
<td></td>
<td><strong>with by pipeline in ~4% of obs.</strong></td>
</tr>
<tr>
<td><strong>Spectrometer</strong></td>
<td></td>
</tr>
<tr>
<td>Pt-source calib.:</td>
<td>6%, reduced to 3% if pointing can be</td>
</tr>
<tr>
<td>~ 4%</td>
<td>corrected</td>
</tr>
<tr>
<td>Extended calib.:</td>
<td>7%</td>
</tr>
<tr>
<td>4% or &gt; if not fully</td>
<td></td>
</tr>
<tr>
<td>extended</td>
<td><strong>Pt-source calibrated data and</strong></td>
</tr>
<tr>
<td></td>
<td><strong>extended-source calibrated data</strong></td>
</tr>
<tr>
<td></td>
<td><strong>ready to use as is for purely point</strong></td>
</tr>
<tr>
<td></td>
<td><strong>and extended sources respectively.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Not science-ready for any</strong></td>
</tr>
<tr>
<td></td>
<td><strong>source morphology in-between,</strong></td>
</tr>
<tr>
<td></td>
<td><strong>or point-source embedded in an</strong></td>
</tr>
<tr>
<td></td>
<td><strong>extended background (~55% of</strong></td>
</tr>
<tr>
<td></td>
<td><strong>sparse mode obs.)</strong></td>
</tr>
</tbody>
</table>
Science-readiness and calibration uncertainty: SPIRE

**Point source**
- **Ext. source calibration**
- **Pt-source calibration**

**Semi-Ext. Source**

**Ext. source**
- **Pt-source calibration**

<table>
<thead>
<tr>
<th>Extended calib.</th>
<th>7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% or &gt; if not fully extended</td>
<td></td>
</tr>
</tbody>
</table>

Not science-ready for any source morphology in-between, or point-source embedded in an extended background (~55% of sparse mode obs.)
## Science-readiness and calibration uncertainty: PACS

<table>
<thead>
<tr>
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<th>Science Readiness of Standard Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Photometer</strong></td>
<td>goal 10%, baseline 20% (rel.: 3%, 5% resp.)</td>
</tr>
<tr>
<td></td>
<td>5-7% - main contributor is abs. calibrator - rest is non-linearity corr.</td>
</tr>
<tr>
<td></td>
<td>&lt;1 % at 70 ( \mu m ) and 100 ( \mu m )</td>
</tr>
<tr>
<td></td>
<td>&lt;3% at 160 ( \mu m )</td>
</tr>
<tr>
<td></td>
<td>Ready to use as is, although background reference level is un-calibrated (can be derived from differential photometry of course)</td>
</tr>
</tbody>
</table>

### Spectrometer – goal 10%, baseline 20% (rel.: 3%, 5% resp.)

<table>
<thead>
<tr>
<th>Uncertainty at key wavelengths</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt-source calib.:</td>
<td></td>
</tr>
<tr>
<td>6-12 %</td>
<td>4 % 1-sigma rms</td>
</tr>
<tr>
<td>Ext. calibration:15 %</td>
<td>15% peak-to-peak</td>
</tr>
<tr>
<td></td>
<td>Pt-source calibrated data and extended-source calibrated data ready to use as is for purely point and extended sources respectively.</td>
</tr>
<tr>
<td></td>
<td>Not science-ready for any source morphology in-between</td>
</tr>
<tr>
<td></td>
<td>Beside, continuum unreliable in un-chopped obs. and in red leak (( \lambda &gt; 190 \mu m ))</td>
</tr>
</tbody>
</table>

### In-band relative uncertainty

| Un-chopped:                 | 10% |
| Chop-nod:                  | 5% below 150 \( \mu m \), 10% above |
## Science-readiness and calibration uncertainty: HIFI

<table>
<thead>
<tr>
<th>Flux Uncertainty</th>
<th>Science Readiness of Standard Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute</strong></td>
<td><strong>Repeatability</strong></td>
</tr>
<tr>
<td><strong>Bands 1 to 5 (SIS mixers)</strong> – goal 3%, baseline 10%</td>
<td></td>
</tr>
<tr>
<td>2-4% internal instrumental error (random) + 5% (syst.) Planet model</td>
<td>3-6% (pt-source), reduced to 3% if pointing offset can be corrected</td>
</tr>
<tr>
<td><strong>Bands 6 to 7 (HEB mixers)</strong></td>
<td></td>
</tr>
<tr>
<td>5-6% internal instrumental error (random) + 5% (syst.) Planet model</td>
<td>11% (pt-source), reduced to 9% if pointing offset can be corrected</td>
</tr>
</tbody>
</table>
Conclusions (1)

Post-Operations: the data mining era

- The POP is the first moment when instrument experts can look back at the wealth of the mission delivery as a whole – it is the data-mining era!
- For a cryogenic mission such as Herschel, this aspect is fundamental and the significant amount of resources and time allocated to it is/was essential.
- Some unique outputs of such “big data” approach have been possible in this period – just to name a few (from previous slides):
  - Assessment of flux calibration repeatability figures for all instruments
  - Creation of merged data products among several overlapping observations
  - HIFI beam modelling combining data collected at all epochs + ILT
  - Telescope RSRF for SPIRE-S based on all dark sky measurements collected in-flight
  - Corrected SPIRE-S extended source calibration based on systematic cross-calibration between SPIRE-S and SPIRE-P continua
  - Etc.
Conclusions (2)
Legacy Calibration in the Science Products

- Herschel is a mission with no previous observatory to specifically pave its calibration road
  - Very early work on absolute calibrator models, pursued throughout all mission phases, proved an extremely successful enterprise

- Legacy calibration in the Herschel science products
  - Photometer absolute flux accuracy (≈5-7%) virtually turns any point source detected by Herschel into a calibrator for future FIR missions
  - Spectrometer data offer high accuracy calibration (<10%) for well-defined source morphology (typically: point-like or fully extended)
  - Tools to derive more accurate fluxes for intermediate cases are available in HIPE
    - Calibration uncertainty for those cases is strongly dependent on user’s assumption on the source morphology knowledge
    - The access to those tools in the long term is essential – ideally as independent tasks outside of HIPE (e.g. Python) or within a virtualisation of HIPE
### Conclusions (3)

**Status of Legacy Calibration deliverables**

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Status</th>
<th>Where</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calibrator models</strong></td>
<td>Planets + stars compiled in Feb 2016. Asteroids TBD in May 2016</td>
<td>HSA + FTP through HELL (Cosmos)</td>
</tr>
<tr>
<td><strong>Calibration Software</strong></td>
<td>Final for HIFI and SPIRE as of HIPE 14.1 (April 2016)</td>
<td>HIPE</td>
</tr>
<tr>
<td><strong>Calibration Files</strong></td>
<td>Final version for PACS still pending (HIPE 14.2 – June 2016)</td>
<td>HSA</td>
</tr>
<tr>
<td><strong>Calibration documentation</strong>(a)</td>
<td>Handbooks exist with un-even completion state among instruments.</td>
<td>HELL (Cosmos) + respective journal repositories for refereed publications</td>
</tr>
<tr>
<td></td>
<td>Explanatory Library component populated to a large extend.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instr. webpages geared towards Ops</td>
<td></td>
</tr>
<tr>
<td><strong>Cal. Workshops</strong></td>
<td>Material is final on twiki pages – needs migration to Cosmos</td>
<td>HELL (Cosmos)</td>
</tr>
<tr>
<td><strong>Video tutorials</strong></td>
<td>Exist for already held Workshops</td>
<td>Youtube</td>
</tr>
</tbody>
</table>

(a) See also Documentation presentation for HELL schedule
Conclusions (4)
Remaining calibration work in POPs

<table>
<thead>
<tr>
<th>Workpackage</th>
<th>When</th>
<th>Priority</th>
<th>Where/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Documentation – see also</strong></td>
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<td>Documentation presentation</td>
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<td>for HELL schedule</td>
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<tr>
<td>Handbooks</td>
<td>Until June 17</td>
<td>1</td>
<td>HELL (Cosmos)</td>
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<td>Pocket Guides</td>
<td>June/Oct 16</td>
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<td>HELL (Cosmos)</td>
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<td>Instr. web pages</td>
<td>Dec 2016</td>
<td>1</td>
<td>HELL (Cosmos)</td>
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<td>Publications</td>
<td>Best effort basis</td>
<td>3</td>
<td>HELL (Cosmos), but only until end of POPs</td>
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<tr>
<td>X-calibration report</td>
<td>July 2016</td>
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<td>HELL (Cosmos)</td>
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<td><strong>Software – see also</strong></td>
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<td>Legacy Software presentation</td>
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<tr>
<td>Calibration Pipeline</td>
<td>June 2016</td>
<td>1</td>
<td>HIPE – VM for long term</td>
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<td>(HIPE 14.2)</td>
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<tr>
<td>Interactive tools</td>
<td>Dec 2016</td>
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<td>HIPE – VM for long term</td>
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<td>(HIPE 15)</td>
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<tr>
<td>Python external library</td>
<td>Voluntary basis</td>
<td>3</td>
<td>Large fraction curated outside of HSC –</td>
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<td>central storage unclear</td>
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Priority 1: Mandatory, Priority 2: Highly-desirable, Priority 3: Nice to have
### Conclusions (4)

**Remaining calibration work in POPs (cont’d)**

<table>
<thead>
<tr>
<th>Workpackage</th>
<th>When</th>
<th>Priority</th>
<th>Where/Remarks</th>
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</thead>
<tbody>
<tr>
<td><strong>Provision of Legacy Data Products – see also next presentation</strong></td>
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<tr>
<td>Expert-curated Data Products with improved calibration</td>
<td>Between now and June 2017</td>
<td>1</td>
<td>HSA and FTP via HELL (Cosmos)</td>
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<tr>
<td>Added-value Data Products</td>
<td>Between now and June 2017</td>
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<td>HSA and FTP via HELL (Cosmos)</td>
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<tr>
<td>Ancillary Data Products</td>
<td>Between now and Dec 2016</td>
<td>2</td>
<td>HSA and FTP via HELL (Cosmos)</td>
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<tr>
<td><strong>Video Tutorials – see also Community Support presentation</strong></td>
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<tr>
<td>Collection of short tutorials on how to use functionalities of the Legacy SW</td>
<td>From Jan to June 2017</td>
<td>1</td>
<td>HEL (Cosmos) + Youtube</td>
</tr>
</tbody>
</table>

**Priority 1: Mandatory, Priority 2: Highly-desirable, Priority 3: Nice to have**
Acknowledgments: past and present ESA team players

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  - Ivan Valtchanov (2005-now)
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  - Tanya Lim (2014-2015)
- **PACS**
  - Bruno Altieri (2005-2014)
  - Roland Vavrek (2003-2014)
  - Elena Puga (2011-now)
  - Katrina Exter (2014-now)
  - Luca Calzoletti (2014-now)
  - Christophe Jean (2015)
- **HIFI**
  - David Teyssier (2005-now, team lead 2015-now)
  - Miriam Rengel (2015-now)
- **Pointing**
  - Miguel Sanchez-Portal (2005-now)
  - Craig Stephenson (2013-2015)
- **DP Scientist**