Instrument's Status & Anomalies

INTEGRAL MOC

Content

- General
  - Instrument anomalies
  - Low perigee effect
  - Impact of solar flares
- Instruments
  - SPI
  - IBIS
  - JEM-X
  - OMC
  - IREM

General: Instrument Anomalies

- Since last IOCG (June 2012), all anomalies were recoverable with standard procedures
- Impact is loss of science time
- No increase in frequency of anomalies
- Integral ESAM Entry
  - #3 on 07/06/2012
  - #4 on 16/08/2012

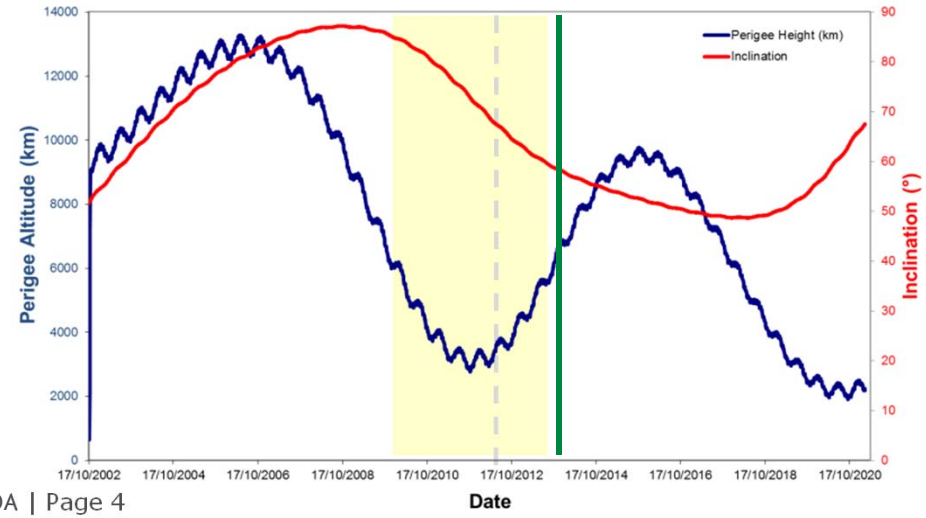
General: Low perigee effect on the instruments

- Perigee raised
  - No passage of INTEGRAL through inner proton belts anymore → no increased likelihood of SEUs (DPE crash, reset of units & HV breakdowns, LCL flips, IREM crashes)
  - No increased heat input into SPI cooler due to Earth albedo (seasonal effect)

    → No special perigee attitude needed to minimize heat input

    → Reduced fuel consumption
  - No damage on instruments due to period of reduced perigee: even most critical subsystems, e.g., the cryocooler not affected at all by low perigee

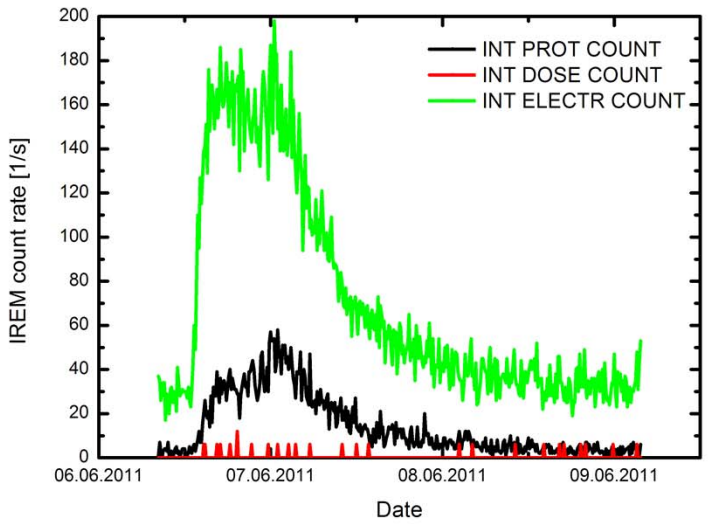
No low perigee effect on instruments anymore



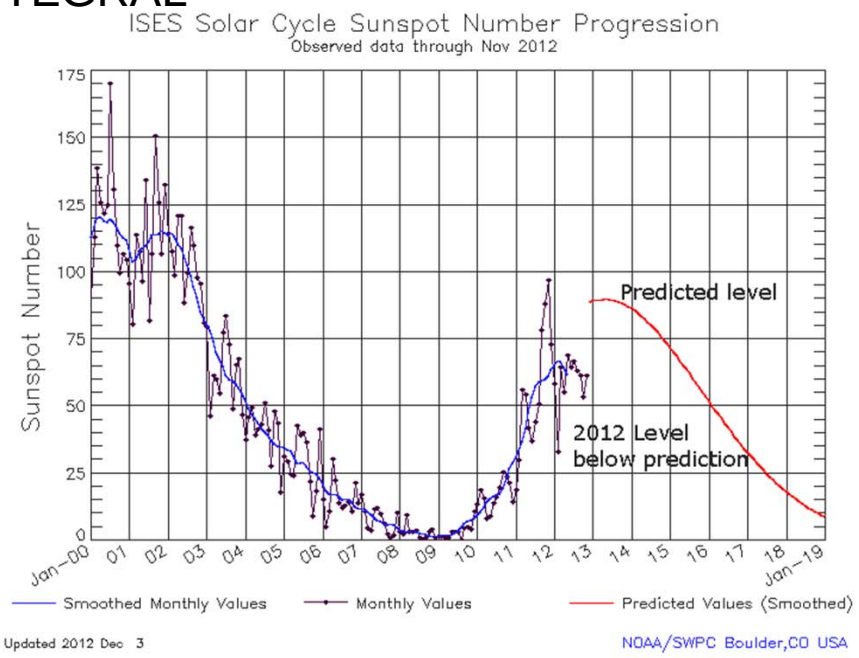
General: Impact of Solar Flares

- INTEGRAL equipped to cope with such events
  - Onboard functionality
  - Ground operations procedures
  - Mission performance margins

  → No significant threat to mission



- Impact on science time
- Since last IOCG: 9 solar flares affecting INTEGRAL
- Ongoing very weak solar cycle #24
  - Start: Jan 2008
  - NASA's prediction:
    - peak early 2013
    - least active cycle in the past 100 years



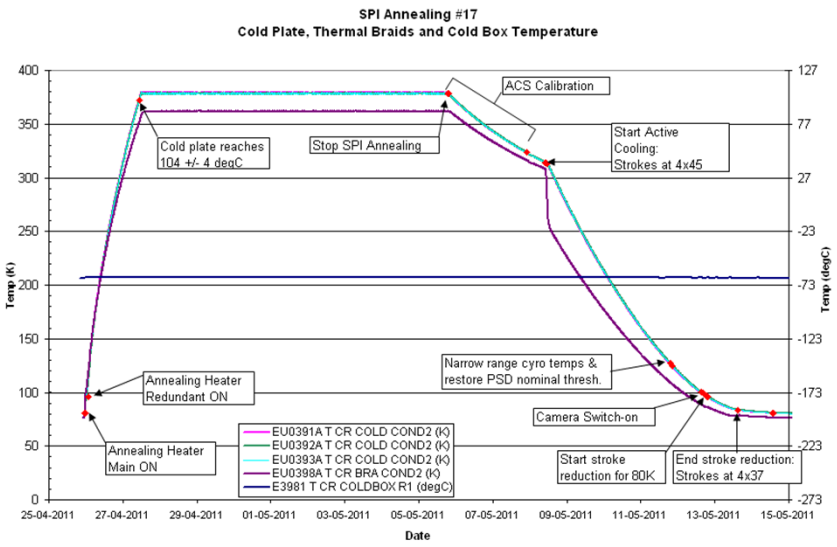
SPI Operations: Overview

- **Overall status of SPI is nominal with all prime units still in use**
  - **DPE/IASW:** Nominal (IASW 4.3.5)
  - **ACS:** Nominal, except for failed FEEs 57 & 81 which are OFF
  - **AFEE:** Nominal except failed GeD#1, 2, 5, 17 (HV=0.5kV, PSD disabled)
  - **DFEE:** Nominal
  - **PSD:** Nominal
  - **Cryocooler:**
    - Cold Plate Temperature maintained in 80K range
    - Temporary degraded performance due to CDE2 LCL trip-off on 4/11/09 (INT_SC-273); fully recovered after following annealing
    - Reconfiguration of CDE power supply configuration: 2-LCL configuration of CDE1 (Oct 2010) & CDE2 (Mar 2010) more robust
    - CDE power consumption vs stroke setting & CDE LCL current stable
    - Operations at high stroke settings no longer necessary outside annealing

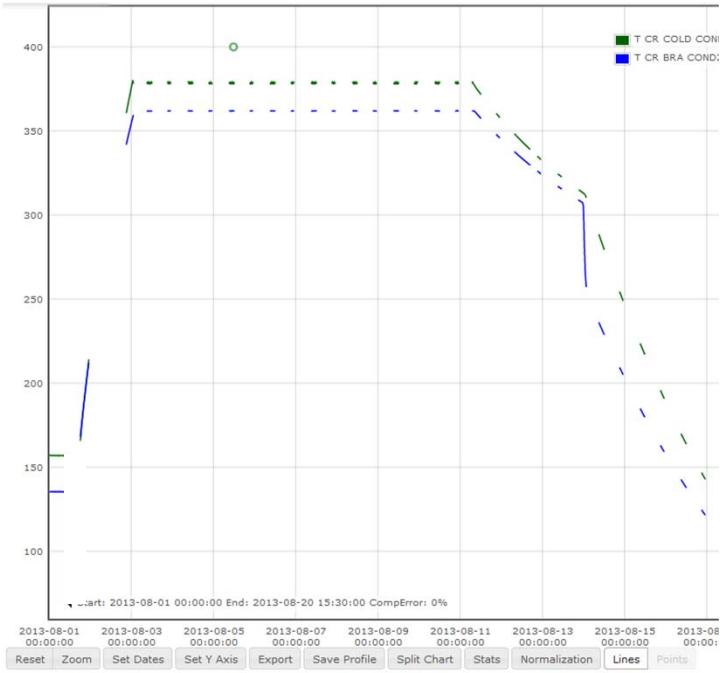
SPI: Annealing

- The gradual degradation in the energy resolution of the Ge detectors has been recovered after each annealing
- SPI Annealing #21 (August 2013) performed with reduced G/S coverage

  → separate agenda point



representative temperature evolution



SPI: Anomalies since last IOCG

- **Change of GeD AFEE DC output voltage (see last IOCG meeting)**
  - Higher leakage current of GeD # 8 and #11 at beginning of de-gassing of cold box during annealing #18 (**22/11/2011, *INT_SC-352***).
  - Possible reason: Destructive flash of the HV, partially destroying the preamplifier (FETs, transistor switches, diodes)
  - Preventive action: Reduction of GeD nominal operating HV from 3kV to 2.5kV (April 2012) to decrease risk of further GeD failures (only slight impact on scientific performance (few %))
  - Change of outgassing operations: Switch-off LVPS for affected detectors during outgassing (applied for Annealing #20)
- 02/09/2013 *INT_SC-440* **SEU on PPDU GSW 3A1 causes SPI switch-off**, recovered back to nominal (impact ~11 hrs)
- Several **PSD channel rate malfunctions**, recovered back to nominal (impact ~45 min)
- 23/03/2013 *INT_SC-421* **SPI ACS FEE malfunction causing LSL error,** recovered back to nominal (impact ~3 hrs)
- 15/10/2012 *INT_SC-409* **SPI DFEE HSL error OOL toggle in and out,** poss. reason: size of the DFEE transmission exceed the DPE buffer. Recovered back to nominal by itself after about 40min

IBIS: Overview

- **Overall status of IBIS is nominal with all prime units still in use**
  - **DPE/IASW:** Nominal (IASW 1.9)
  - **ISGRI:** Nominal, about 600/16384 dead pixels, stable since commissioning
  - **PICsIT:** Nominal, 55/4096 dead pixels (add. 2 dead pixels after launch)
  - **VETO:** Nominal

IBIS: Anomalies since last IOCG

- **IBIS VETO crash**
  - 03/07/2012 *INT_SC-392* IBIS VETO crash during VETO activation, recovered back to nominal (impact ~5.5 hrs)
  - 07/05/2013 *INT_SC-425* IBIS VETO crash, recovered back to nominal (impact ~4 hrs)

- **IBIS VETO breakdown,** Standard recovery of mode cycle (impact ~1-1.5hrs)
  - 29/08/2012 *INT_SC-406* IBIS VETO VDM07 HV Breakdown
  - 17/09/2012 *INT_SC-408* IBIS VETO VDM02 HV Breakdown
  - 25/10/2012 *INT_SC-410* IBIS VETO VDM06 HV Breakdown
  - 20/04/2013 *INT_SC-424* IBIS VETO VDM13 HV Breakdown
  - 12/11/2013 *INT_SC-448* IBIS VETO VDM16 HV Breakdown

- **IBIS PICsIT Latch Up,** Standard recovery (impact ~45 min)
  - 01/07/2012 *INT_SC-393* PDM06
  - 18/09/2013 *INT_SC-441* PDM07

JEM-X: General & Anomalies

- **Overall status of JEM-X is nominal with all prime units still in use**
  - Both units operated in parallel, TM allocation: 8 packets/cycle each
  - Both units are in very similar state of health

- **Anomaly:** Checksum (CRC) error during the instrument reconfiguration after eclipse: quick recovery (impact: ~30min if any) *Note: not experienced during ongoing eclipse season #24*

- **Degradation:** Gradual JEM-X anode degradation:
  - Steady rate of 1% of detector area/year since commissioning
  - Compensated by HV reduction

OMC: General & degradation

- **Overall status of OMC is nominal, no anomalies have occurred**

- **Degradation:** CCD degradation is very minor
  - Number of hot pixels (higher dark current): increasing slowly with time at a constant rate
  - Number of black pixels: remains stable
  - Dark current: increases very slowly but remains negligible
  - CCD temperature: increases slightly over the years due to the loss in efficiency of the radiator
  - Stable sensitivity: no darkening of the optics/lenses due to radiation, no change in transparency of the CCD coverglass coating (indium tin oxide) and no degradation of the CCD spectral response
  - No impact was seen from the period of lower perigee

IREM: Status & outlook

- **Overall status of IREM is nominal, no permanent failure since launch**

- Up to now: 144 IREM resets (probably caused by SEUs)

Instruments: Summary and Conclusions

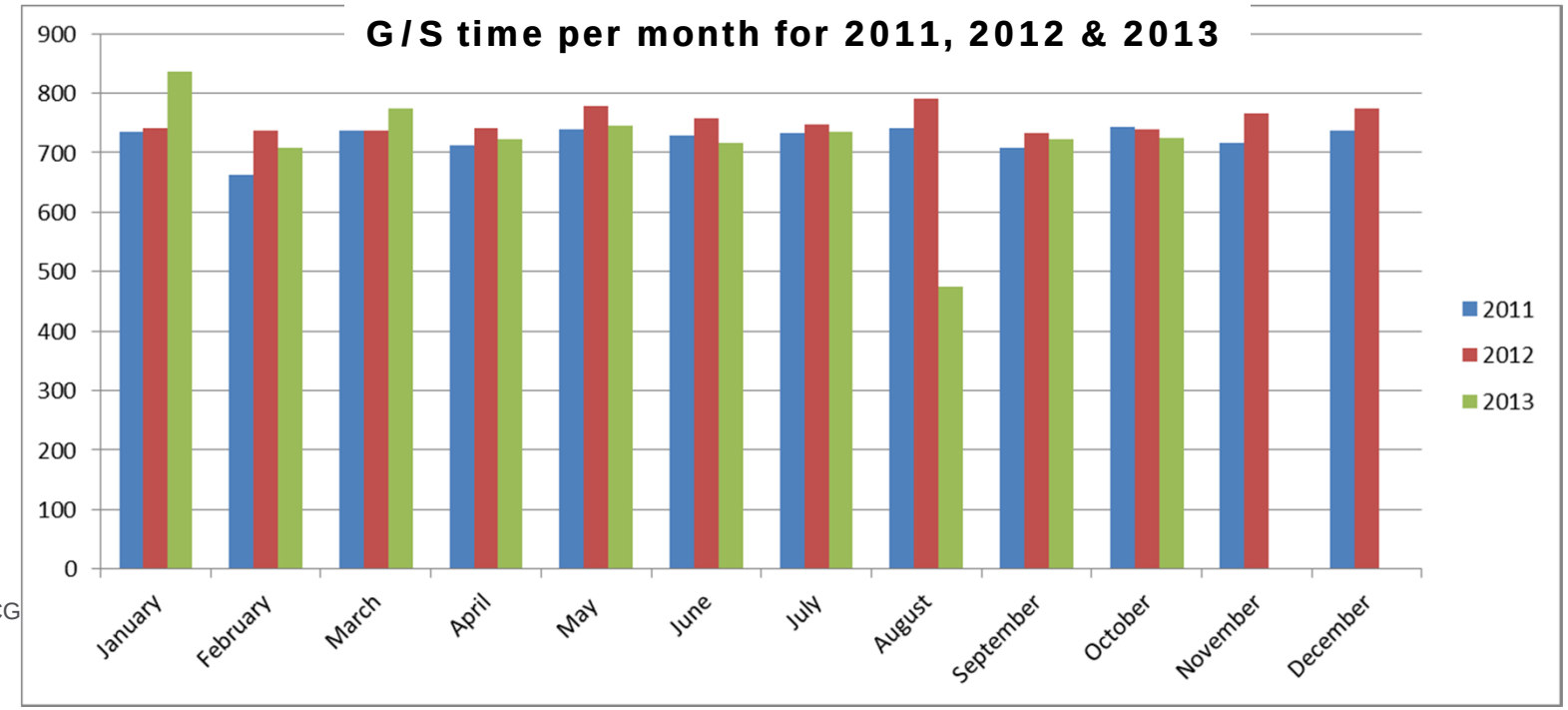
- All instruments' health is nominal
- Full redundancy is still available
- All instruments can be operated using nominal procedures
- SPI cryocooler operations are stable
- Minor performance degradation
- No effects of proton belts seen on any instrument
- TM bandwidth margin is sufficient and shows signs of improvement with new solar cycle
- Scientific performance remains excellent

→ No open issues for continued operations

Pre- & post perigee operations

- Pre perigee operations
  - JEM-X to SAFE delayed to rad belt entry

- Post perigee operations
  - G/S AOS coupled to rad belt exit altitude, instead of start of visibility to save G/S time to decrease costs (saving up to 90min per rev.)



IBIS Status & Technical Questions: Shorter pointing durations - technical limits

- IBIS team to
  - investigate disabling calibration source data for IBIS (TM usage goes down if really bright sources)
  - supply 2 procedures on how to disable and how to re-enable packet generation for PICsIT histograms to enable pointing durations of < 1750s

→ IBIS expert availability missing: Giovanni involved in other missions (available only in emergency)

Integral Special Operations

SPI annealing #21 with reduced G/S contact

INTEGRAL MOC

Content

- Recap on planning & operations
- Achievements
- Lessons learned
- Open issues & way to go ahead

Recap: Planning

G/S coverage requirements

- SPI annealing #21 activities (all temperature driven)
- Standard platform operations to ensure satellite's health and safety: attitude maintenance, reaction wheel biasing incl. influence of orbit control (to compensate for slow deviation over several weeks in the target orbit), wheel speeds to minimize risk of RW caging (b/w 500-1500 rpm & no near-constant speed for 24hrs), AOCS daily maintenance after every AOS, RMU calibration, bright star in 1st elementary search window of STR in case guide star is lost outside G/S coverage
- Extra S/C engineering activities: STR blemish pixel survey & CLCW ratio adjustment

Mission Planning

- PSF: Dedicated PSFs generated with standard PSF generation S/W (configuration files created to be re-used in the future)
- POS: generated at MOC directly from PSF bypassing ISOC
- EPOS: w/o instrument EDs; small OSL at start of every G/S pass
- T/L: generated normally
- AHFs generate & transfer

→ **Considerable extra effort required by FD to support this special period**

Recap: Operations during period with reduced G/S coverage

- Instruments in perigee configuration (but SPI)
- Regular G/S passes every 12 hours for 2 or 3 hours + additional for SPI annealing activities where necessary
- IBAS commanding disabled
- Anomalies: 9 ARTS reports (2 S/C, 7 Ground/planning)
  - Most: IMCS issues due to the system not being designed for reduced G/S contact
  - OOLs (Instrument status OOLs; S/L OOLs on wheel speeds, since low wheel speeds planned; SPI OOLs due to rad. belt entry/exit outside G/S coverage)
  - Instrument anomalies
    - PSD channel rate malfunction outside G/S coverage (missed by Spacon)
    - IREM crash outside G/S coverage
- High additional load on Spacon
  - 16 ops instructions: manual real-time activities & expected OOLs
  - "Free" Spacon capacity could not be used for other tasks

  → more training / guidance needed (Note: 3 unexperienced Spacons on shift)
- High additional load on On-call SOE & SPI SOE: Lots of calls
- ...

Recap: Operations for SPI annealing itself

- SPI annealing #21activities executed successfully w/o problems (very good preparations)
  - Timing of G/S coverage for annealing activities was good
  - But all critical SPI annealing activities (20 hours in total) performed
    - during night (cannot be changed) or
    - at the weekend (can be changed; ISOC needed SPI for rev. 1318)
- High workload for SPI SOE
  - Spacons (especially the new Spacons)
    - Lots of ops. instructions
    - Lots of questions/calls regarding SPI
    - Little support: even small configuration changes performed by SPI SOE instead of Spacon
    - Spacon shift handover during G/S gap → information missed
  - No backup SPI SOE
  - SPI SOE = on-call SOE during SPI annealing period

Achievements – Overall net saving

- **Goal as reported during IUG Jan 2013**
  - Reduce G/S coverage to 18hrs/rev or 108hrs/annealing
  - Estimated saving of about 189K€/year (2 annealings)
- **Results for SPI annealing #21**
  - Netto G/S time used in 6 revs: 124hrs instead of 411hrs → Overall saving of G/S time: 287hrs
  - Blemish pixel survey: no impact on science → 8 hrs science gained
- **Outlook**
  - More AOCS calibrations during period with reduced G/S contact → gain science time
  - Increase in G/S rates to be expected (overall ESA saving of zero)
  - Actual net saving for INTEGRAL is TBD

Outcome – Overall investment / effort

- High manpower required especially by FCT/FD
- **Preparation:** Summed effort of whole MOC team for this special period: ~20 WD(?) (meetings, emails, preparation, TN, iteration of TN, ops. instructions, OCR, additional effort for actual SPI annealing)
- **Execution**
  - No science for IBIS, JEM-X and OMC for 6 revs
  - Overtime outside working hours & on weekends
    - SPI annealing: 20 hours
    - On-call IMCS issues related to period with reduced G/S contact: 5 hours

Recap: Lessons learned

- **SPI annealing activities**
  - Have continuous G/S coverage after SPI camera switch on to fully monitor temp. decrease to 80K (needed for analysis of the GeD performance in case of problems)
  - Adaptation for upcoming SPI annealings with reduced G/S coverage
    - Only slight adaptation of G/S planning: shorter ACS calibration & have full G/S coverage after camera switch on
    - Adaptation for SPI annealing with outgassing of the cold box
  - **In general:**
    - SPI annealing with reduced G/S contact (duration: 18 days) further restricts LTP
    - No annealing with reduced G/S coverage during eclipse season
- **System** not designed for reduced G/S contact → lot of additional work necessary for for planning (MOC), execution (MOC) & post processing (ISDC)
- **Timing of G/S passes** & SPI annealing activities: avoid nights & weekends (instead of 11 & 23 local → e.g., 9 & 21 local)
- Mission planner went on leave w/o proper handover/problems solved (MOC & ISOC)
- Temperatures of instruments (e.g., OMC lens) more stable than during normal operations
- Dedicated training of Spacons needed for this special period (+ experience)
- Follow up MCS anomalies in ARTS
- ...

Lessons learned: Impact on ISDC

- IREM data from times of contact not useful: unable to process correctly the available data (even using the consolidated data)
  - ISDC TM processing S/W unable to determine the correct time ordering of the packages
  - Reason: On-board clock cycle comparable with time b/w two G/S passages
  - Result: Decided, NOT to ingest data of revolutions 1320-24 in the INTEGRAL archive. TM stored and archived, but not the results of the pipelines
  - Investigating a way to make the auxiliary data available w/o the results of pipelines
- Problems in managing resources during SPI annealing, as the system is designed to be always operative
  - *"Forcing a system to behave in a situation that was not foreseen at the time of the project start brings a lot of additional work for teams that in the meanwhile have been reduced and lost some important expertise".*

Lessons learned from ISOC

- POSes:
  - sent by FD via mail to ISOC & then returned from ISOC to MOC → internet planning page automatically updated
  - Less work for ISOC in total, since FD generated the POSes
- No Planned Observation sequence (POD) generated → manually created & sent by mail
- No OMC Pointing Parameter (OPP) generated
- Manual work to enter observations into database

Way forward

- SPI annealing procedures need to be updated according to the changed execution (G/S coverage, ACS calibration, monitoring of temperatures..)
- Good documentation as guideline for future periods with reduced G/S coverage
  - Summary from FD & FD WikiPages
  - Ops instructions in place
  - Input for G/S planning (AOCS, SPI, FD/orbit)
  - ARTS reports
  - DigiLog
  - TN summarizing mission planning for this period
  - Minutes from lessons learned meeting & followed up in actions
- Configuration files for missions planning have been set up by FD for use in future SPI annealing periods with reduced G/S
- Implement lessons learned

Calibrations during period with reduced G/S contact

AOCS calibrations to be performed during period with reduced G/S coverage

- Not during SPI annealing:
  - IMU calibration: to be done before eclipse season start or before EO
  - Thruster torque rescaling: transparent to ISOC, therefore no need
  - Inertia calibration: only done when needed (currently not foreseen)
- Already done / planned during SPI annealing:
  - Full thruster torque calibration (6hrs during working hours)
  - External torque model calibration, i.e., data collection via sequence of small slews
  - STR blemish pixel survey TBD (8hrs during working hours)
- FCT to decide if during SPI annealing:
  - SAS threshold calculation: done twice a year and around equinox
  - FSS/STR misalignment calibration: done every 3 years together with SAS cal.

Integral Special Operations

EO 3.1 pre-perigee

INTEGRAL MOC

Content

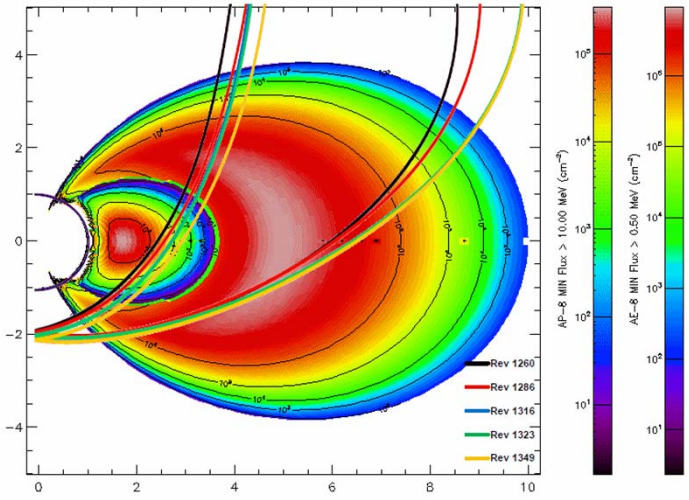
- Recap on planning & operations of EO 3.1
- Conclusions & lessons learned
- Overview of EO 3.2
- Open issues & way to go ahead

Note: The science outcome will be presented by Marc on Wednesday

Recap:
Advantages of pre-perigee EO 3.1

- Lower instrument's internal background
  - → background not biased following belts passage
  - → better data quality
  - → possible to extract EO modulation

- EO at lower altitude (critical altitude at belts entry is much lower than at belts exit - in contrast to 2006)
  - Larger Earth apparent angular radius
  - Earth moves faster → duration of EO is shorter → easier to meet the off-on-off pointing requirement



EO 3.1: Preparation & Operations

- Thorough analysis of pre-perigee option → no additional risks & safety issues
- Main trade off
  - EO as close as possible to perigee, but end of STR blinding at least ~0.5 hours before LOS_TC of MSP to allow for attitude reconstruction (mappings)
  - Use of Maspalomas gives more flexibility since LOS at MSP is about 20min later than at REDU or KIRUNA
- Additional requirement: Earth transit fully within IBIS FoV (whole light curve)
- Strategy used for pre-perigee EO 3.1: Post-perigee strategy with adaptations
- EO 3.1 successfully executed with midpoint of observation 5.25hrs before perigee

Conclusions & lessons learned

- Post-perigee EO strategy works for pre-perigee EOs (needed to be adapted)
- No additional risks or problems for pre-perigee EO
- Operations slightly less complex
- Science outcome is better *(see Marc's talk)*
- As always: EO 3.1 lessons learned session

Recap: Operational effort for each EO

- Highly “non-standard” from operational point of view
- Operational success ensured by careful planning of EO and lots of effort on all sides (ISOC, FD, FCT):
  - Planning starts 7 weeks before every EO
  - Preliminary planning, final planning, detailed sequence of events, careful review of sequence, TN with all the relevant information
  - Regular meetings, telecons & mails to follow up status
  - Execution of EO: dedicated EO shifts (software support on-call, FD & FCT on site), ISDC on call, ISDC activities

EO 3.2 (Dec. 16/17th, 11Z at EOA): Status

- Planning on course
  - Preliminary planning files already created with only minor problems
  - Currently ISOC is working on the operational POS
- Differences wrt EO 3.1
  - Midpoint of observation is 5.5hrs instead of 5.25hrs before perigee (since raise in JEM-X count rates at end of EO 3.1)
  - Lessons learned of EO 3.1 implemented

Open issues & way forward

To be resolved by MOC

- Reduce effort of planning of EOs, e.g., skip preliminary planning (TBD)

To be decided by IUG/scientists (ISDC/ISOC)

- Proposal of optimal timing of EOs (midpoint of observations) for every EO & if necessary change of rad. belt entry altitude:
  - How close we dare to go towards the radiation belts?
  - Who is doing an analysis on the rad. belt entry & exit altitudes & impact on count rates?
- Who else is analyzing the EO data (apart from Marc)?
- Future of EOs:
  - Frequency:
    - Dependent on reduction of effort
    - if effort not reduced: max. 3 per year possible from MOC side (considering cost cuttings)
  - Scheduling: Constraints: Eclipse seasons, Sun/Anti-Sun/Moon, SPI annealing, Public holidays, Visibility of galactic center, Crab calibration