IBIS mask Calibration

F. Lebrun

The problem

- Since several years, we see defects in the ISGRI images that are clearly linked to the presence of bright sources (ghost residuals)
  - Strange PSF (clover shape)
  - Lines
- Finally, we got convinced that it is due to glue spread over the mask holes

Questions to be addressed

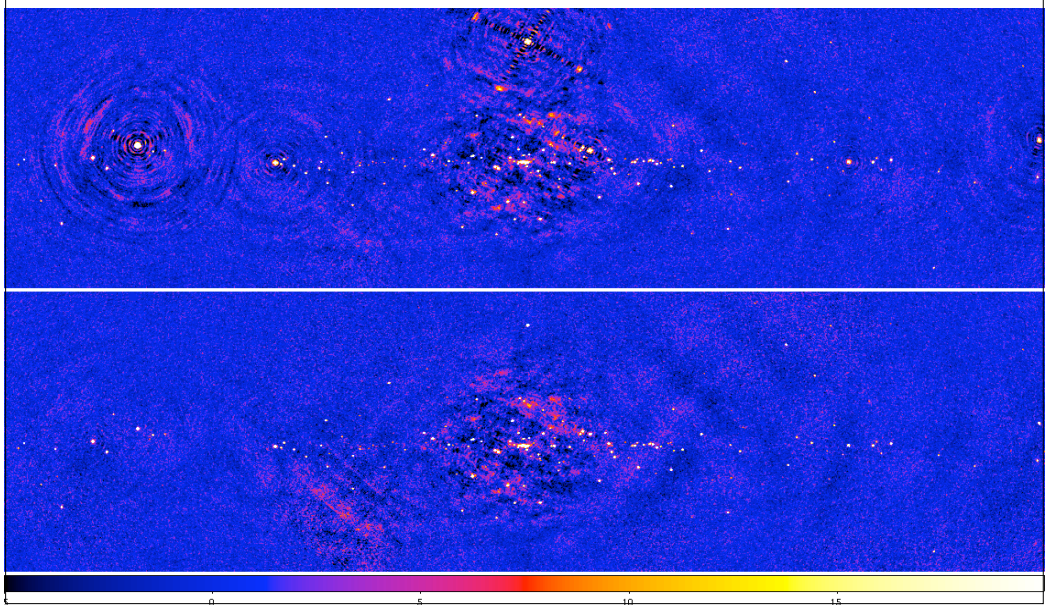
- How important is it ?
- What can be done ?
- Where is the glue ?
- Can we see the glue on mask pictures ?
- What accuracy do we need
- How much calibration time is required ?
- What have we got already ?
- Can we use other sources than Crab ?

→ A proposal

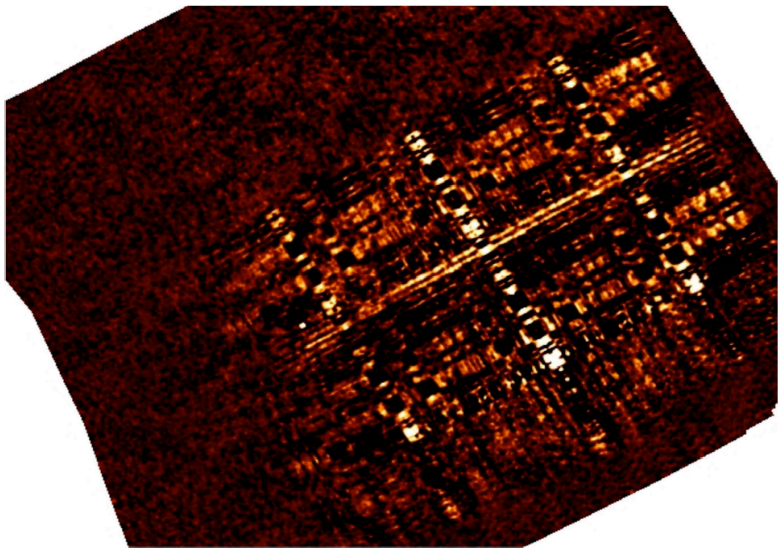
Mask knowledge and Integral legacy

- Sensitivity to faint objects strongly limited by incorrect bright sources subtraction
- Measured sensitivity >~2 larger than the theoretical one in several regions of the sky (e.g. Galactic centre)
- Integral legacy should be the most sensitive hard X-ray survey in the Galactic Central regions:
  - need to improve significantly mask knowledge to take advantage of the large amount of time already spent by Integral in the Galactic plane
- Bright Source suppression
  - Improves image quality at the expense of sensitivity for specific regions of the sky
  - Not applicable to GC because of the too large number of bright sources

Mask knowledge and Integral legacy



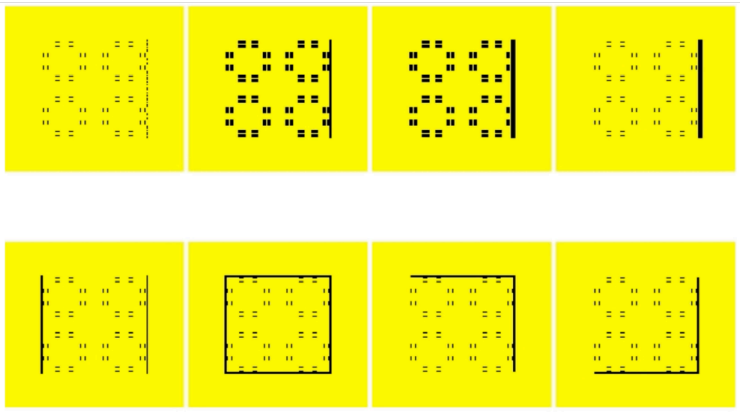
How important is it ?



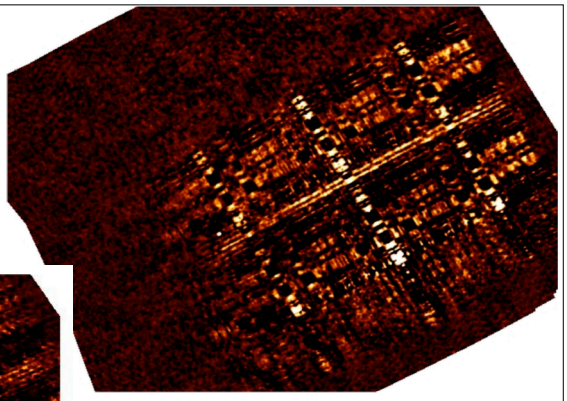
Max defects are at 16 mCrab

What can be done ?

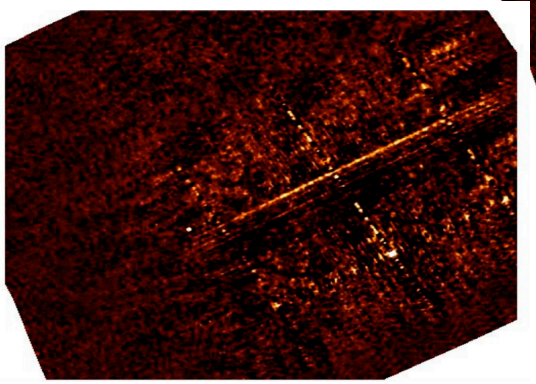
The regions affected by an unknown amount of glue can be discarded from the deconvolution process



What can be don ?

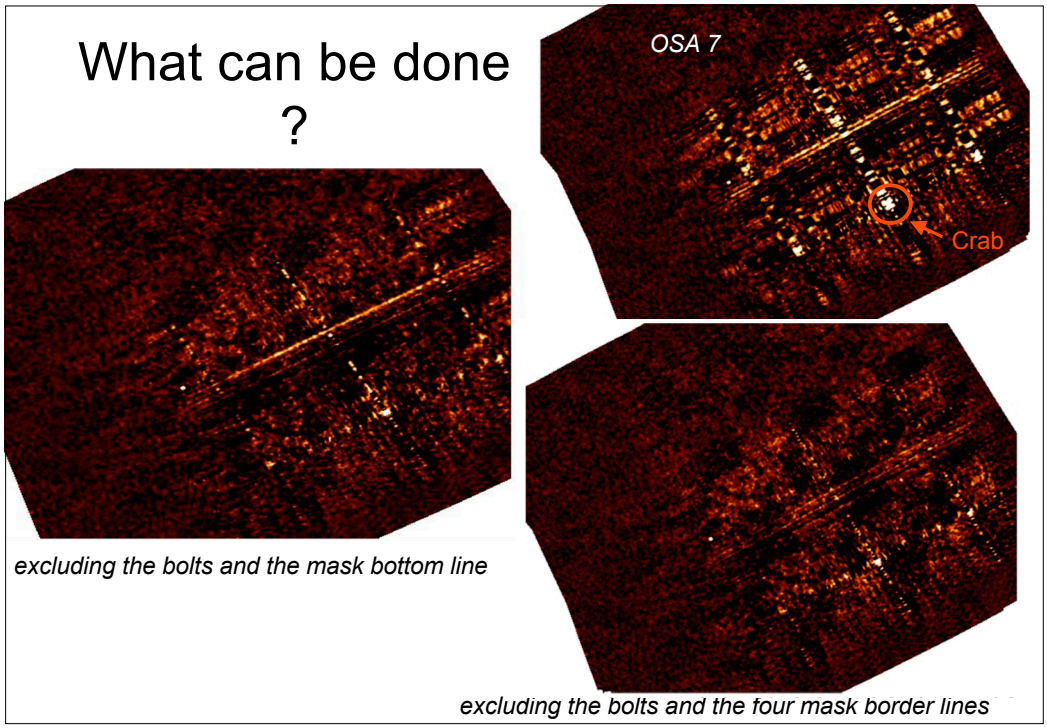


OSA-7



excluding the bolts and the mask bottom line

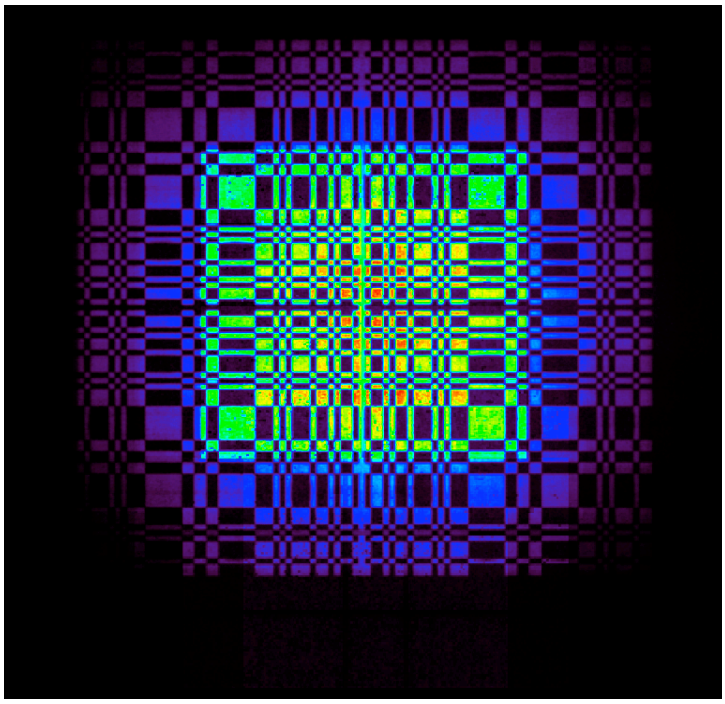
What can be done ?



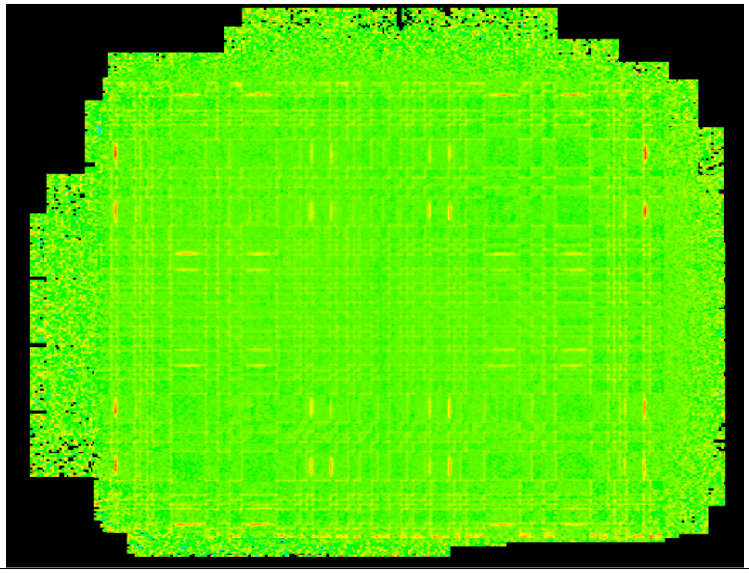
What can be done ?

- The regions affected by an unknown amount of glue can be discarded from the deconvolution process
- However this means removing several percent of the sensitive area for each detected source. In crowded regions (e.g. the Galactic center) this leads to an unaffordable loss of sensitivity.
- The proper way to deal with this problem is to improve the mask model used for the deconvolution and the source cleaning.
- Can we measure it from in-flight measurements i.e. perform a mask radiography ?

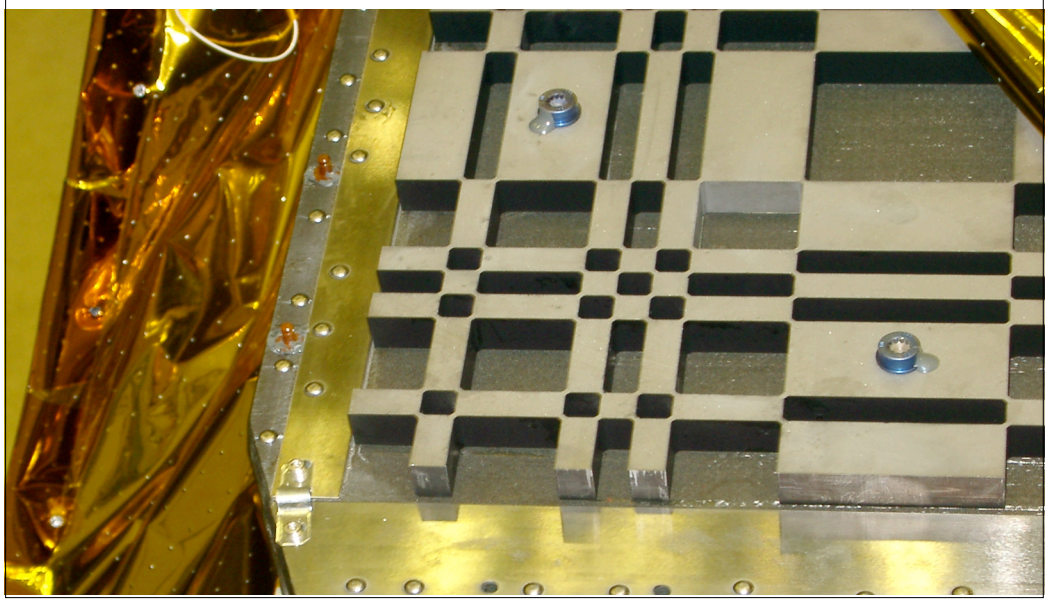
Mask radiography with Crab



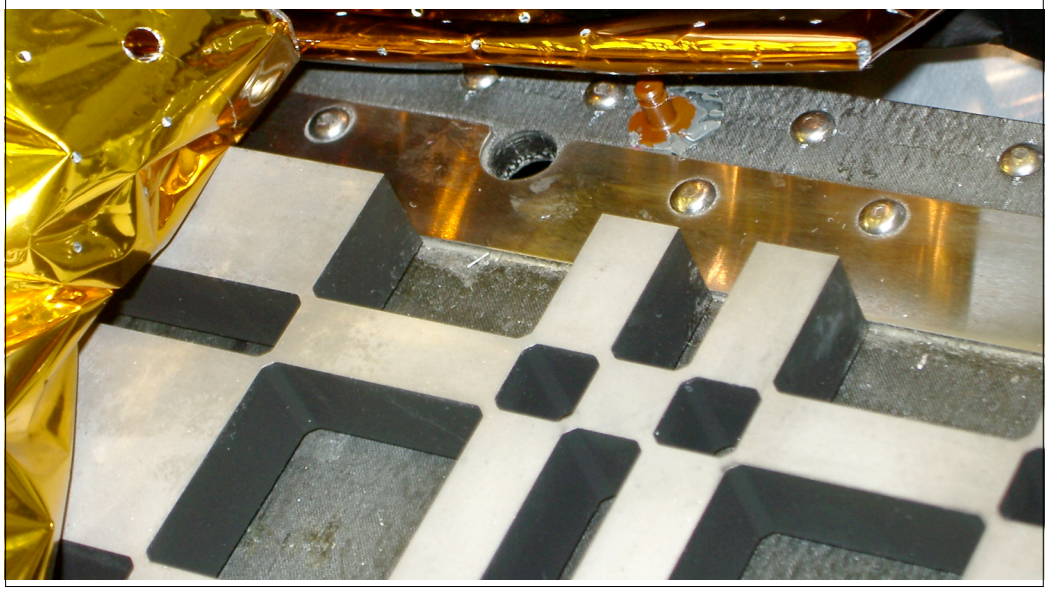
Mask radiography with Crab - mask model



Can we see the glue ?



Can we see the glue ?



What accuracy do we need ?

- Max ghost residual = 1.6 x 10^{-3} x transparency uncertainty (%), i.e. 1.6 mCrab for 1% transparency uncertainty (from simulations)
- OSA-7 → 16 mCrab max ghost residual → mask model is wrong by ~ 10%
- The broad-band (ΔE = E) ISGRI sensitivity is 0.3 mCrab (3σ) for 1 Ms.
- If we know the mask at 5% (almost the case)
  - 100 mCrab sources (~ Gal. Center) → 0.8 mCrab ghost residuals → t_{max} = 140 ks
  - 1 Crab source (Cyg X-1) → 8 mCrab ghost residuals → t_{max}= 1,4 ks

  → only the regions devoid of bright sources or with a low exposure can safely be searched for new persistent sources
- If we know the mask at 1%
  - 100 mCrab sources → t_{max} = 3.5 Ms
  - Crab → t_{max} = 40 ks

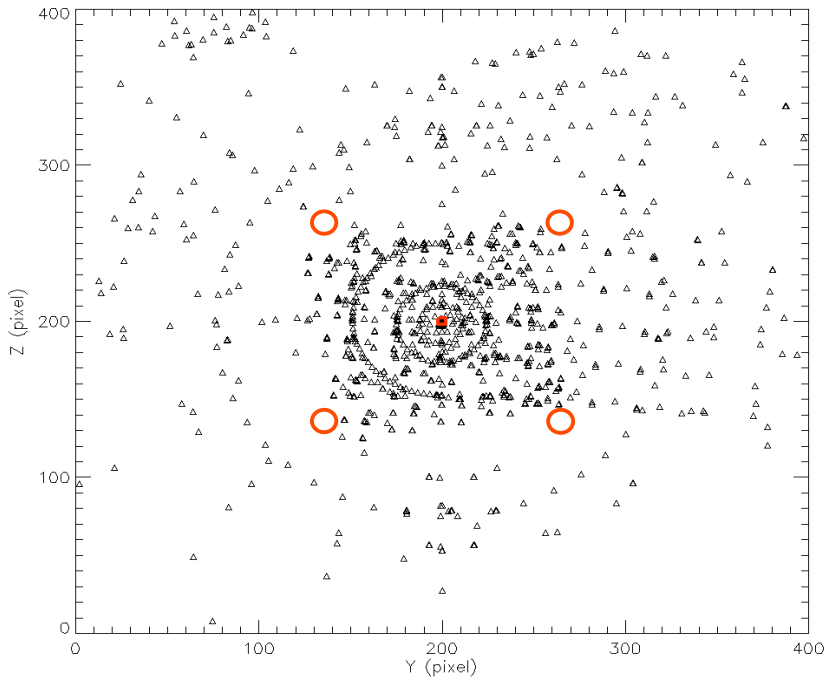
Can we use other sources than Crab ?

- Cygnus X-1, an obvious candidate, may be used but the mask images have to be cleaned for field sources (Cygnus X-3 and EXO2030). For new observations, Crab is preferable because of its stability and its clear field
- Sco X-1. Pointings 5° in Galactic latitude above Sco X-1 might help up to 40-50 keV but probably not beyond. It would be difficult to achieve a uniform coverage of the mask edges

How much calibration time is required ?

- We need 10^4 counts per pixel to reach the 1% accuracy level
- With 160 s^{-1} in the 20-40 keV band, i.e. 10^{-2} $pixel^{-1}$ s^{-1}, we need 1 Ms on every part of the mask
- The mask is about 4 x ISGRI area
- We need about 4 Ms to reach the 1% accuracy
- We have already 400 ks
- We could have 660 ks by the end of the year
- We need ~ 3.3 Ms afterwards

What have we got already ?



A proposal

- 550 ks calibration twice a year till 2012
- Compared to more immediate long exposures, this relaxes somehow the pressure on the Galactic Center
- But it increases the risk in case INTEGRAL operations stops before end 2012.
- This is ~5% of the total time; i.e. similar to the XMM calibration time

A proposal

- Point at the middle of each mask quarter
- Make a 3x3 dithering grid with 0.2 degree steps
- The time per point (2000 – 4000 s) is adapted to make complete grids
- Every time a new grid is started the center (COG) should be moved with regard to the previous ones (as done with the 5x5 grid)
- The rotation of the grid is useful for detecting serendipitous sources
- The orientation of the grid axis with regard to the instrument axis is useful for detecting serendipitous sources and should be arctan(1/3) = 18.4°

A proposal