ECLAIRs instrument

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APC - CEA – CNES – IAP – IRAP – LUPM

The role of ECLAIRs onboard SVOM

- **To localize during the nominal duration of the mission at least 200 GRBs of all kinds**, including events of short duration (from few milliseconds to 1-2 s), long GRBs (duration up to 1000 s), GRBs particularly rich in X-rays (e.g. events having most of their flux below 30 keV).

- **To observe the GRB field** in the X-ray and soft gamma-ray bands (4 keV to 5 MeV) 5 min before and 10 min after the time of the localization T0.

- **To measure the GRB celestial coordinates** with an accuracy better than 13 arcmin in 90% of the cases (TBC) at the detection threshold in the J2000 reference frame.

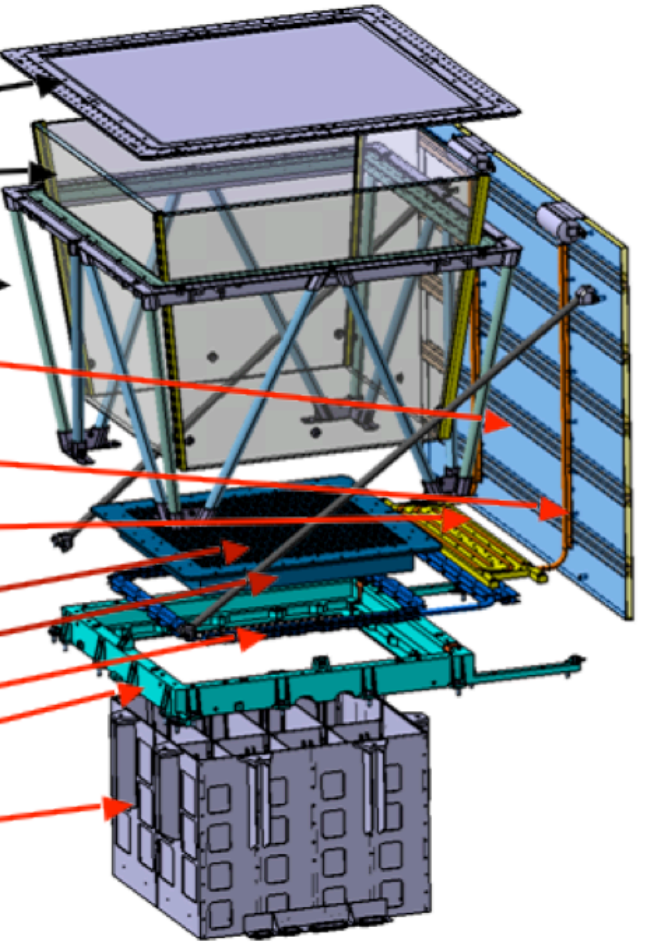
ECLAIRs – the instrument

SMS
- Coded **Mask**
- **Shield**
- **Structure**

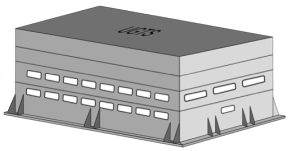
RA : Radiator Assembly
- **Radiator** *(fully equipped)*
- **VCHP**
  Variable Conductance Heat Pipes
- **IP** *Interface Plate*

DPA / Detector plane
- detector modules
- cold plate

DPA / CCHP (heat pipes)
DPA / Interface Belt
DPA / ELS



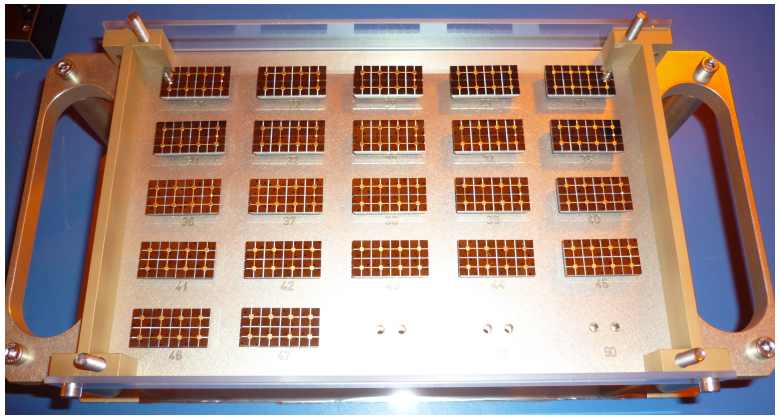
UGTS



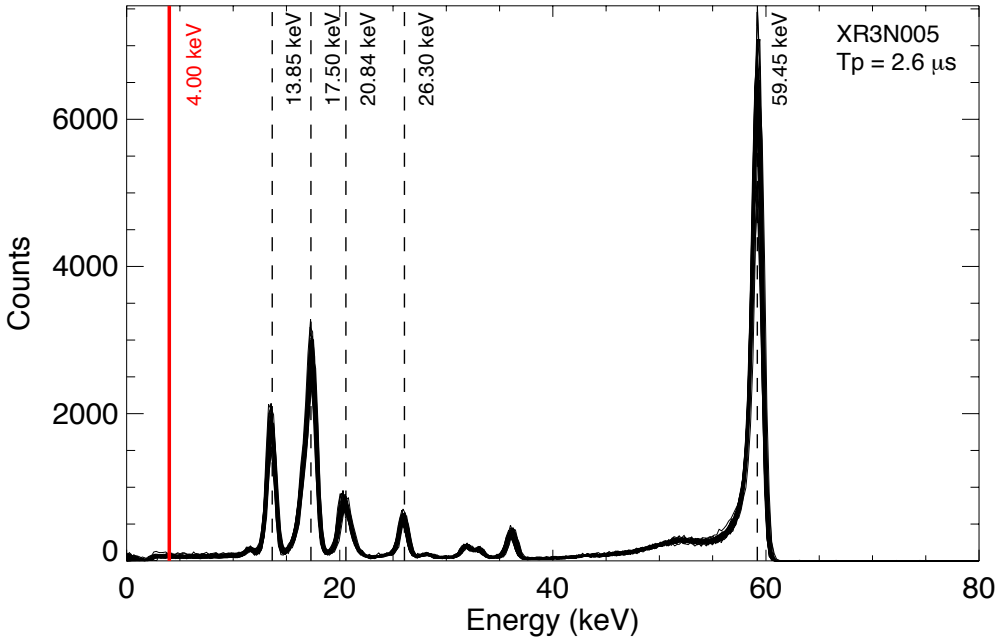
FOV : 2 steradians
Energy range : 4-150 keV
Location accuracy : 12'
Sensitivity to GRBs ~ 10^{-7} erg cm^{-2}

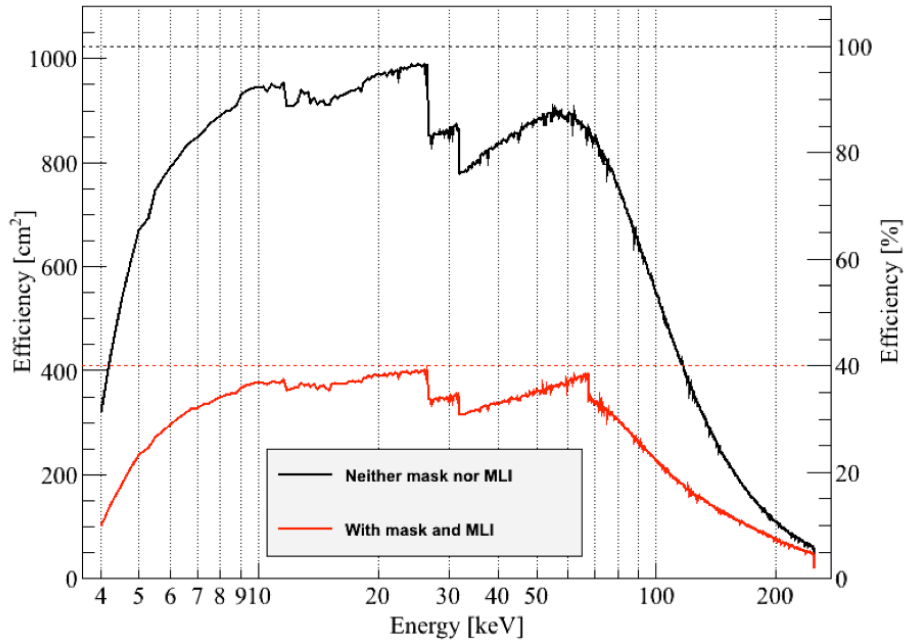
ECLAIRs - Detection plane - DPIX

- The detection plane of ECLAIRs is paved with 200 XRDPIX modules
- Each module is an hybrid housing an ASIC and 32 CdTe detectors
- 8 dedicated front-end electronics read 25 ASIC each
- 47 XRDPIX received, under testing.
- Very good results: >90% of the channels below 4 keV.
- Performance will improve with optimized ASIC parameters



XRDPIX 32 pixels calibrated spectra





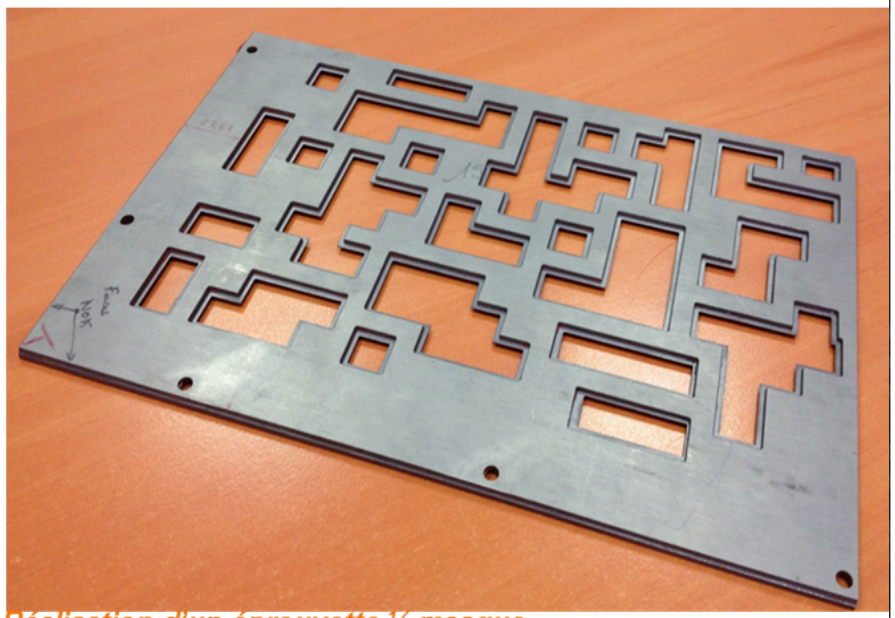
ECLAIRs – UGTS

- **Detector plane management**
  - Configuration, Housekeeping, Temp. control
  - Data acquisition and transfer to Mass Memory

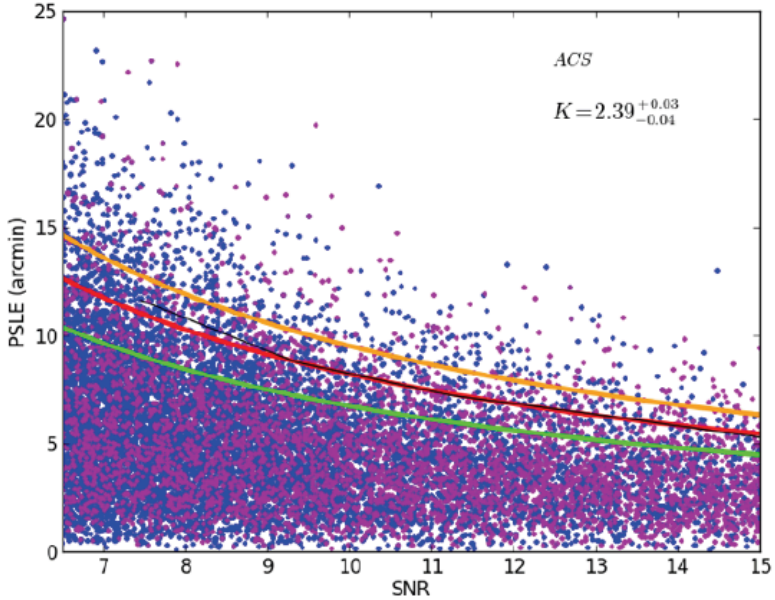
- **Trigger on GRBs of all kinds**
  - Soft and hard GRB searches
  - Count Rate Trigger for GRBs lasting < 20 s
  - Image Trigger to look for long GRBs (> 20s)
  - Localization of all triggered GRBs better than 12 arcmin using coded mask imaging
  - Near Real-time alert within seconds:
    - → Satellite slew requests
    - → VHF messages for ground follow-up

ECLAIRs - Mask and shield

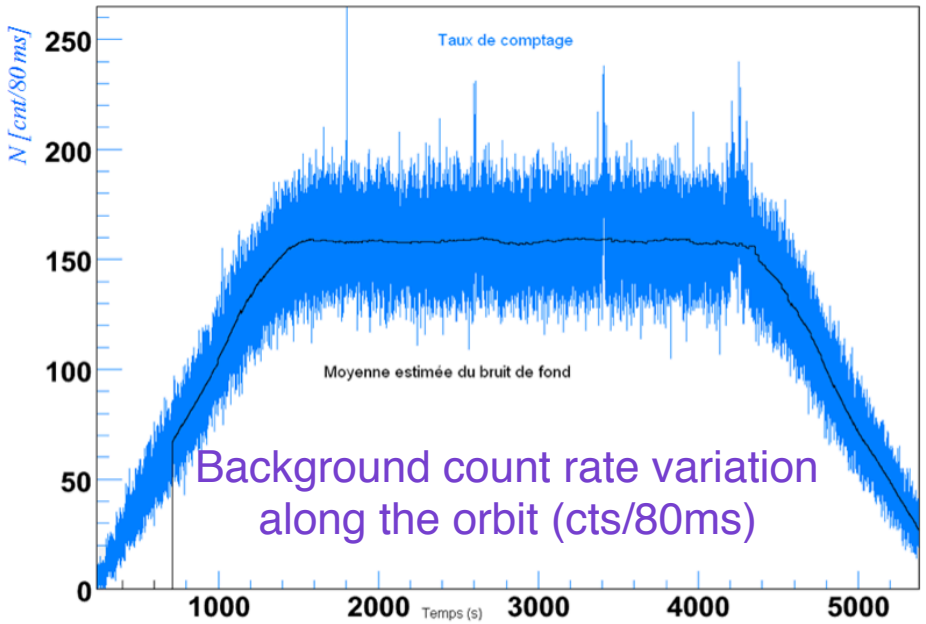
- The technology for the mask has been validated
- Detailed simulations have shown that the localization accuracy is 12 arcmin for 90% of the bursts.

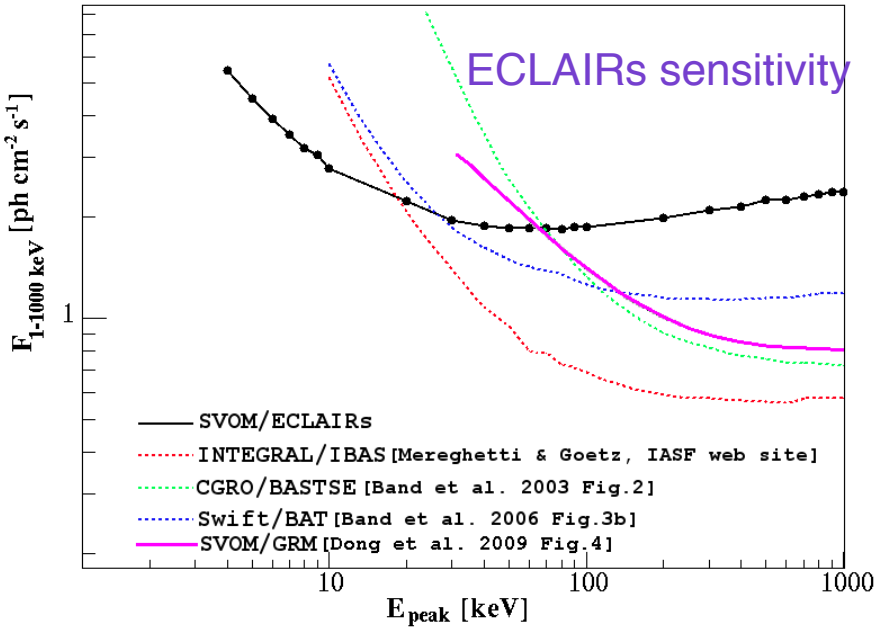


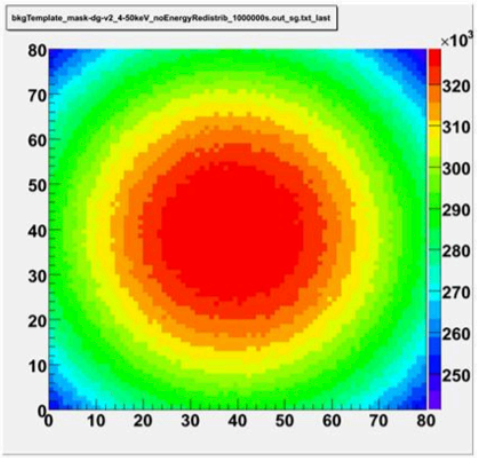
Réalisation d'un éprouvette ¼ masque

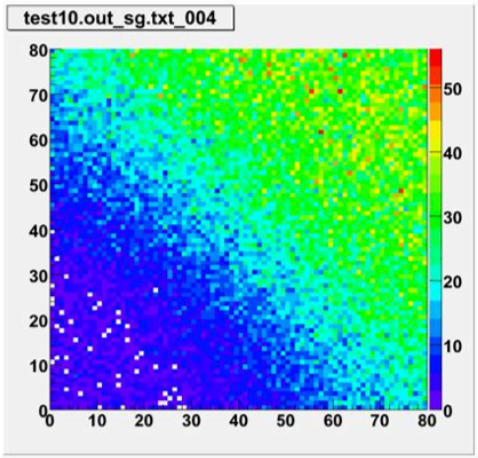


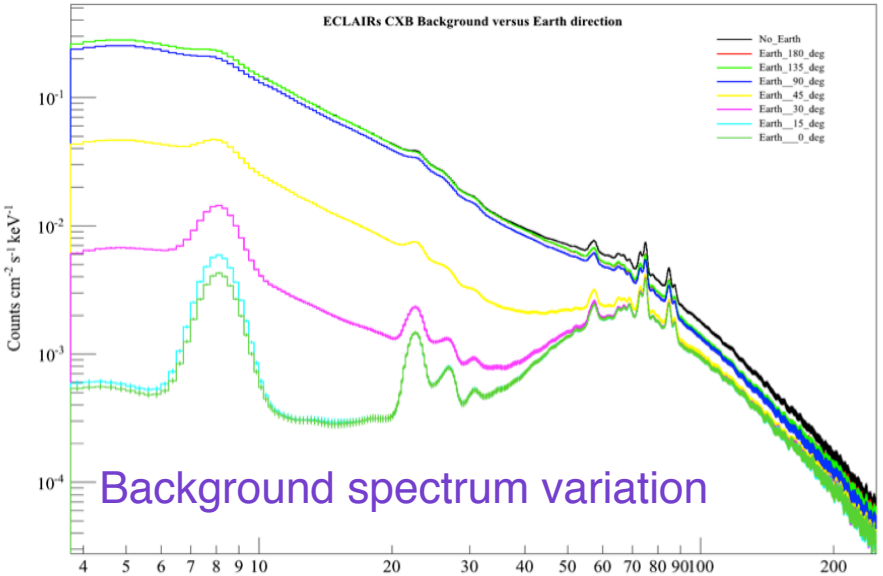
Background and sensitivity





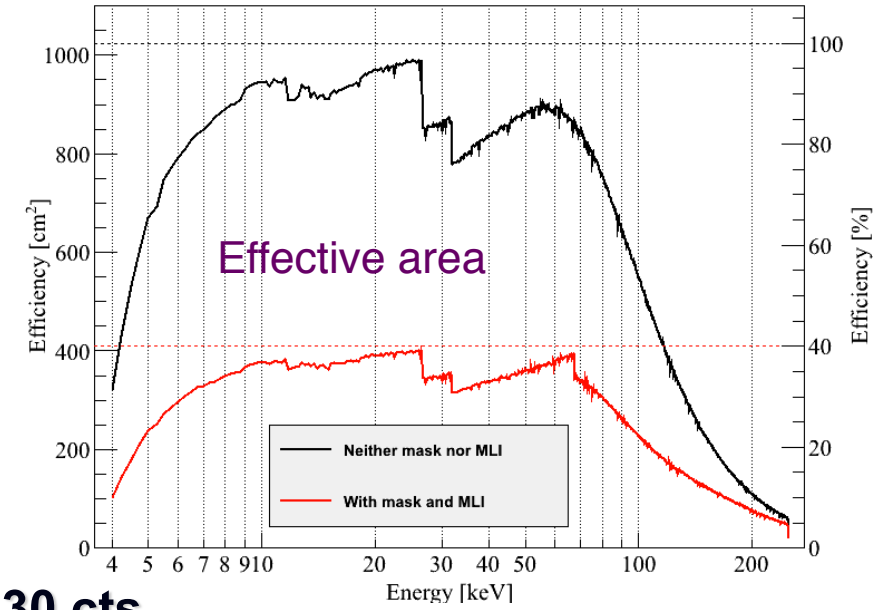




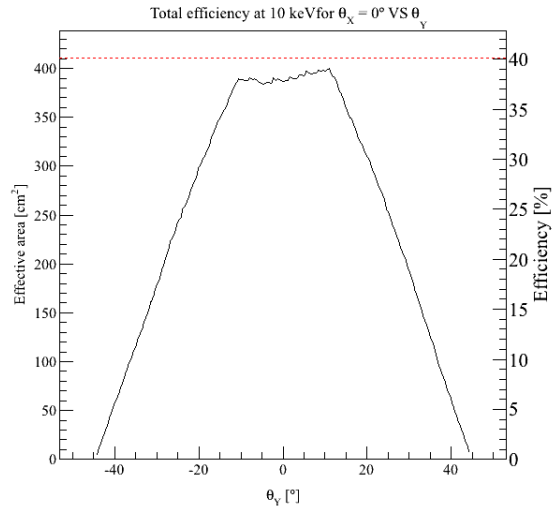


Sensitivity and background

- **Main characteristics**
  - FOV : 2 steradian
  - Energy range : 4-150 keV
  - Detection area = 1024 cm²
  - Effective area ~400 cm²



- **Typical numbers**
  - Background ≈ 3000 s^{-1}
  - Threshold (6.5 σ, 10 sec) ≈ 1130 cts
  - Sensitivity to 1 sec long GRBs (6.5 σ): ~2.5 10^{-8} erg cm^{-2} s^{-1} in [5-50] keV
  - Requires ≥150 ph. to make an image



- **Detailed response files computed from MC simulations area available.**

Triggers

- **Detect GRBs and other remarkable transients**
  - → Pointing strategy: B1 pointing law, SCO-X1 and galactic plane avoidance
- **Avoid slewing on un-remarkable transients**
  - → Have on-board a list of known X-ray sources that may trigger ECLAIRs: SGRs, X-ray bursters, microquasars…
  - → Give each source a status wrt to slew
  - → There will be a small fraction of false triggers
- **Work with GRM : on-board?? or on ground at the Science Center**

Trigger details

- **ECLAIRs must detect all types of GRBs. There are two types of trigger, based on rates and images:**
  - Rate trigger: 4 energy bands, 9 detector regions, 11 timescales from 10 ms to 20 s. Look for rate excesses and construct the corresponding image.
  - Image trigger: construct full detector images on timescales ranging from 20 s to 20 min.
  - In both cases new sources are searched in the images, if a new source is discovered a GRB trigger is issued.

- **ECLAIRs background is highly variable:**
  - The trigger algorithm must manage Earth transits, this is a significant challenge.
  - The trigger must be discriminant against bursts of particles and solar flares.
  - Further filtering will take place on the ground at FSC.

ECLAIRs data types

- **X-band scientific data**
  - **All ECLAIRs counts, with:**
    - Position (pixel)
    - Time, with 10 microsecond resolution
    - Energy: 1000 channels from 0 to 150 keV (0.15 keV/ch)
    - 'Quality': single or in coincidence
  - **Development of an off-line trigger on the ground, with a delay of few hours**
  - **HK data**
- **VHF trigger + fast GRB data**
  - **High priority ECLAIRs data sent during the slew, before MXT & VT start observing.**
- **VHF continuous data**
  - **Helps monitoring the health of the instrument in quasi real time at the instrument center (EIC).**

ECLAIRs - Number of GRBs

- **The computation of the expected GRB rate is based on simulations taking into account…**
  - **The sky: number of GRBs of each type**
  - **The instrument: field of view, effective area, energy range, trigger efficiency**
  - **The mission: orbit, pointing strategy**

- **We use the observations of Swift/BAT, with similar instrumentation, to calibrate the simulations.**
  - **FoV: 2.05 (ECLAIRs) vs 2.2 (BAT)**
  - **Duty cycle: 56% (ECLAIRs) vs 72% (BAT)**
  - **Trigger efficiency (wrt BAT): 0.8*1.34=1.07**

- ***Based on these crude simulations we expect to detect 51-75 GRB/yr, located with a precision <12'***

On going science work

- Evaluate performance with realistic hardware
- Perform detailed simulations
  - Sky, instrument, operations, data processing
- Prepare calibration activities on the ground and in space
- Prepare ECLAIRs in-flight operations