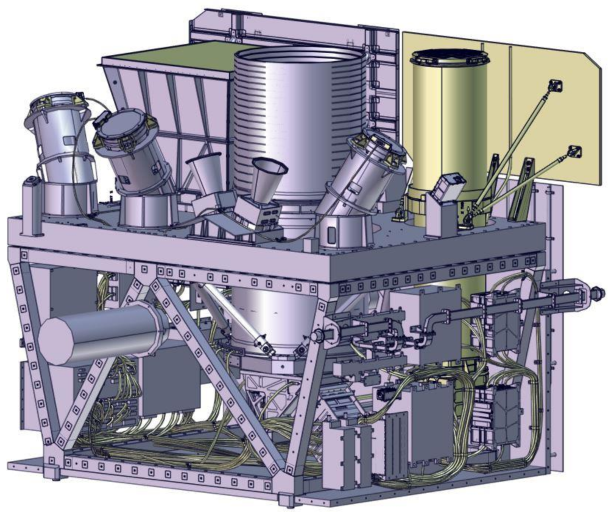
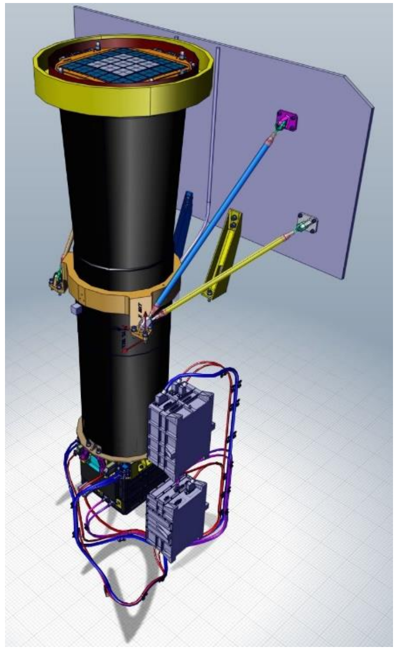
Current status of the Microchannel X-ray Telescope

Laura Gosset - CEA

Micro-channel X-ray Telescope



SVOM satellite



MXT Telescope

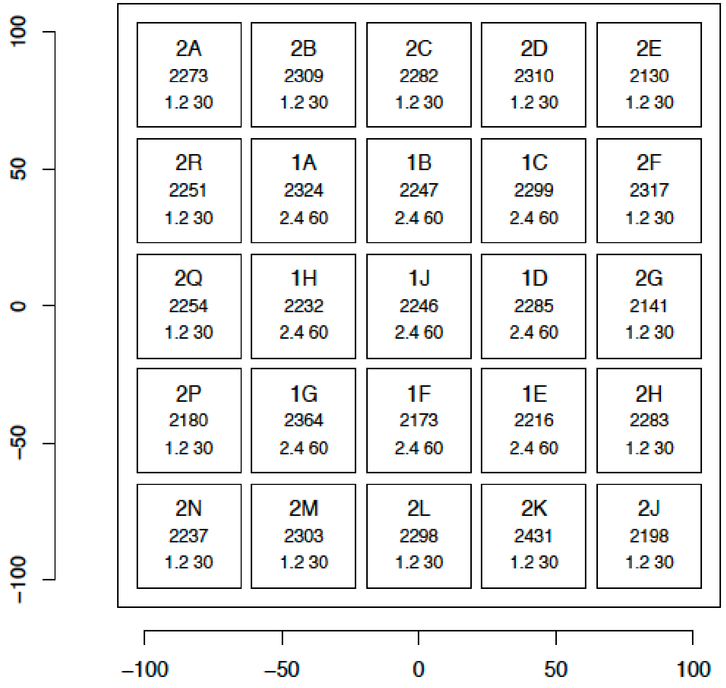
Goal = Observe GRBs and afterglows and localize them precisely

- Characteristics
  - Energy range : 0.2 – 10 keV
  - Field of view : 57 x 57 arcmin
  - Detector 256 x 256 pixels (75 µm)
  - Integration time : 100 ms
- PSF MXT < PSF ECLAIRs
  - ~ 6.5 arcmin vs 1 degree
- Localisation error
  - Calculation on board
  - MXT < 1 arcmin vs ECLAIRs < 12 arcmin

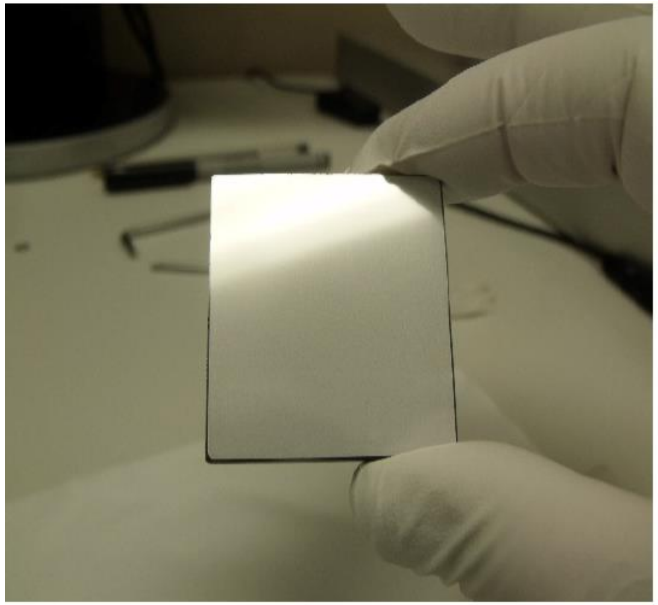
→ **MXT = transmit the position to ground based telescopes in real time**

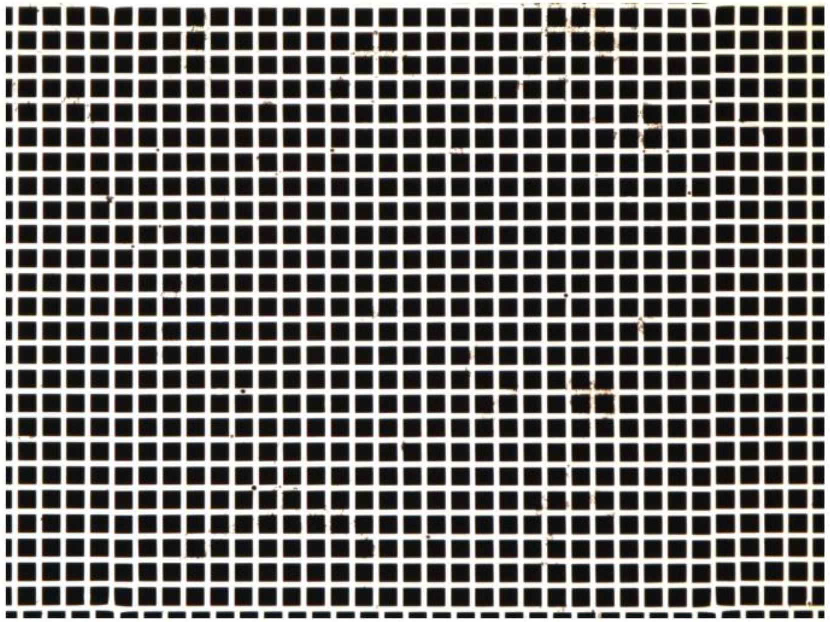
Optics configuration

- Flight Model (FM)
  - 25 MPOs of 1.2 and 2.4 mm
  - Focal length : 1.15 m

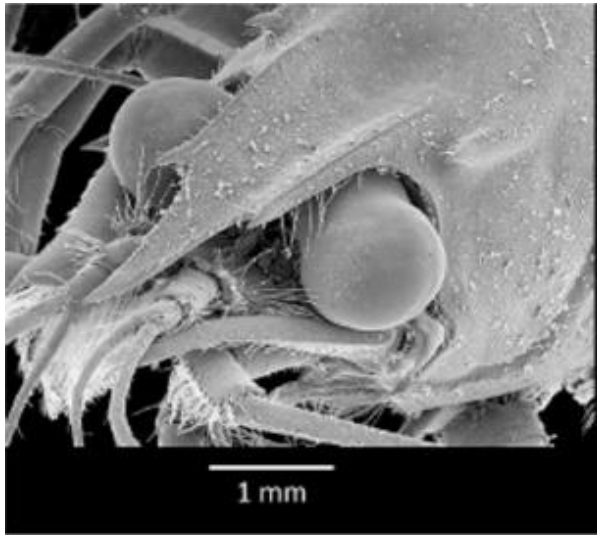


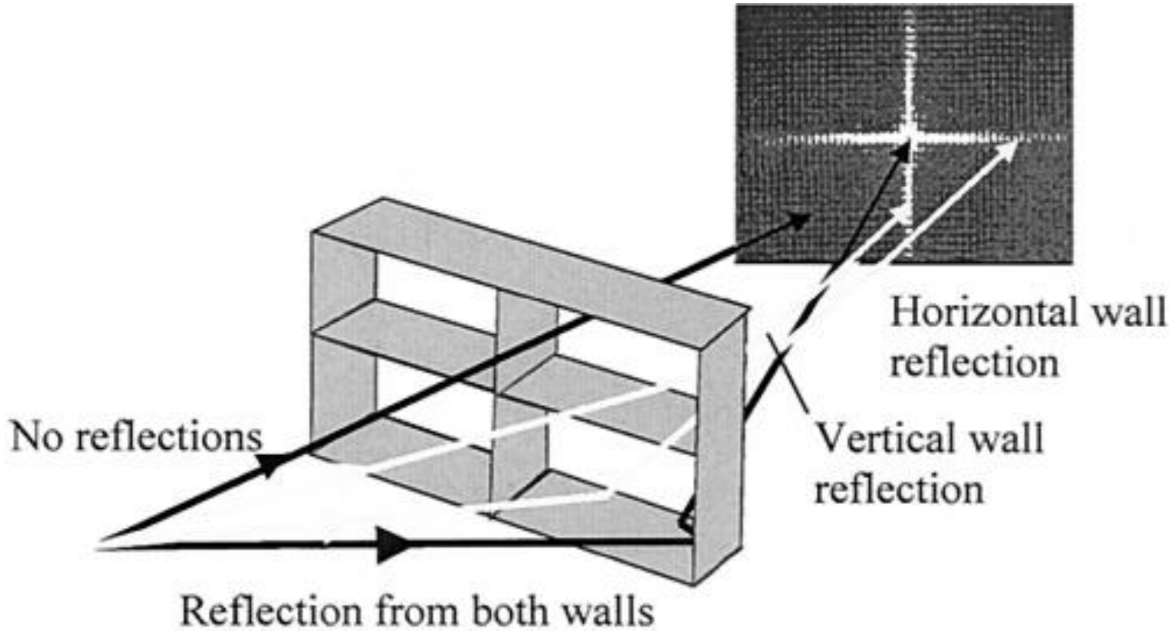
A real MPO





Lobster Eye optics

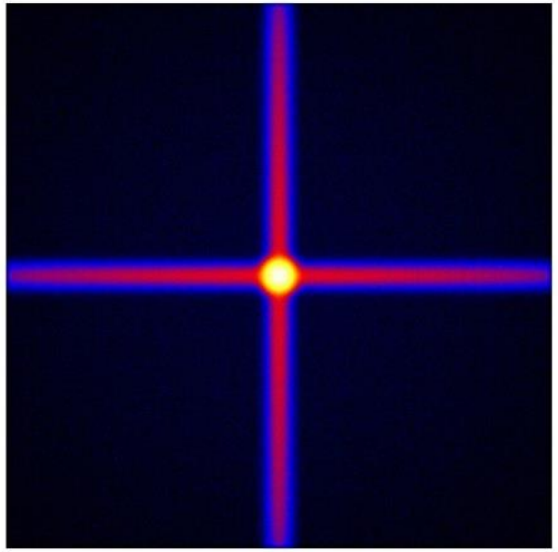




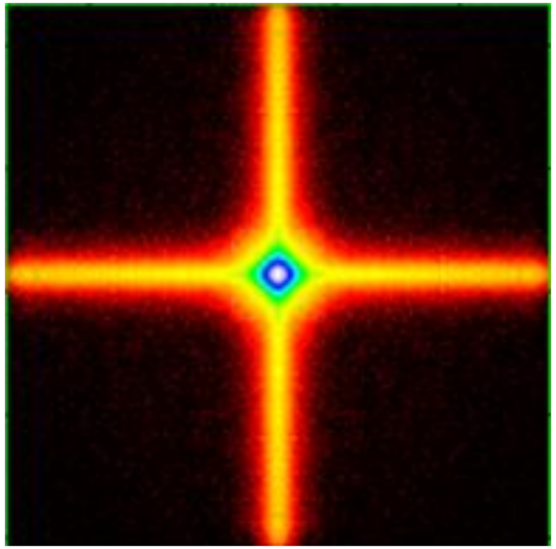
Lobster Eye pinciple
0 reflection = diffuse patch / 1 reflection = arms / 2 reflections = central spot

Point Spread Function

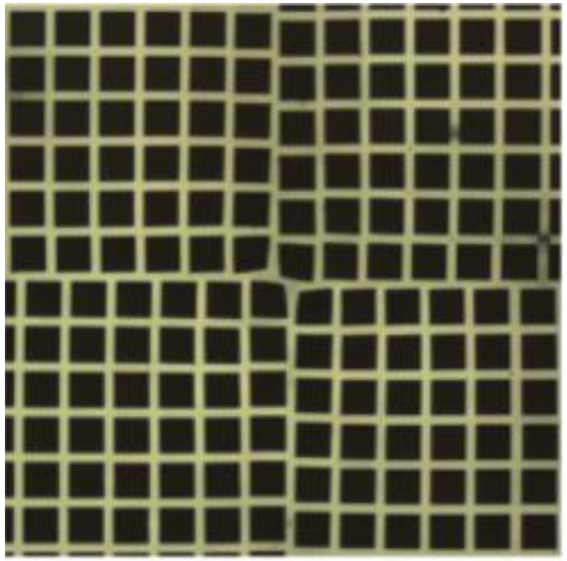
Ideal early PSF (Gaussian)
Ray-tracing simulations



Real PSF(Lorentzian)
Ray-tracing simulations
including defects



MPOs defects



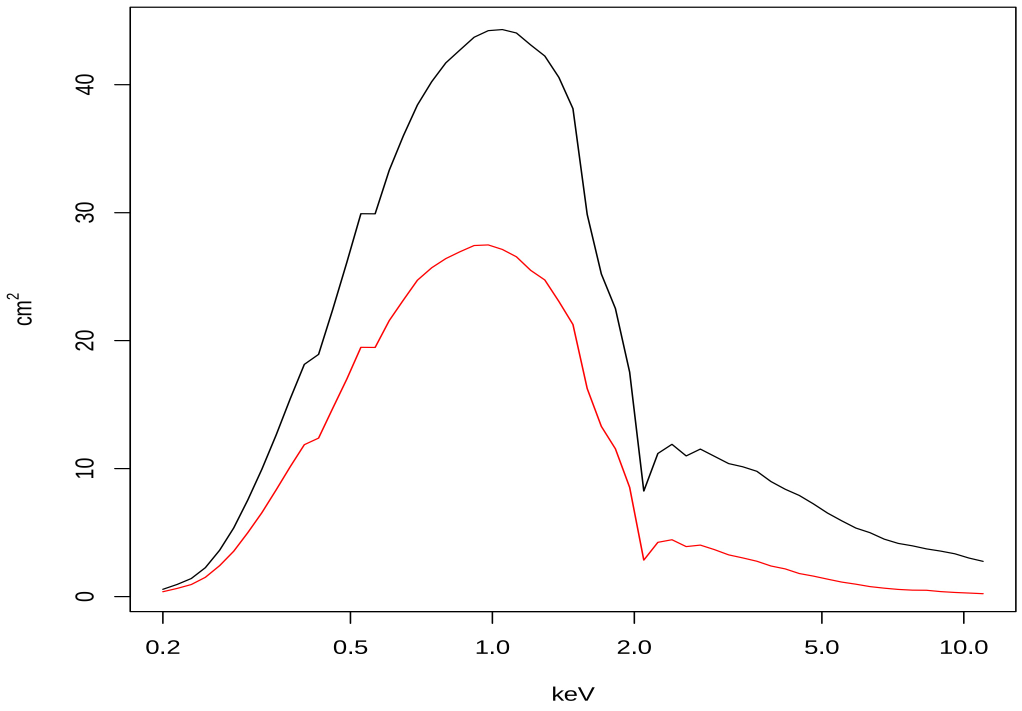
Leicester STM-MPO measurements

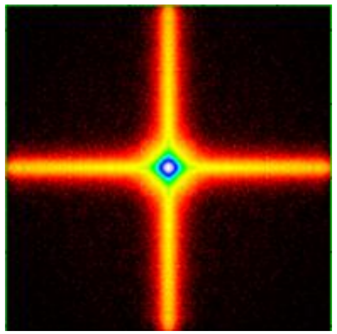
MPO	Thickness (mm)	Open area fraction	Rcur (average mm)		Efficiency	FWHM at MPO X-ray focus (old 2D Gaussian)		FWHM at MPO X-ray focus (old 1D FWHM)		FWHM at MPO X-ray focus (new 2D Lorentzian)		FWHM at MPO X-ray focus (new 1D FWHM)	
			Photonis	X-ray		mm	arcmin	mm	arcmin	mm	arcmin	mm	arcmin
YC001-A2	1.04	61.0	1745	1626	0.98	2.25	9.16	2.00	8.15	1.72	7.25	1.92	8.13
YC001-A4	1.05	60.8	1805	1861	0.93	2.57	9.49	2.16	7.97	2.02	7.69	2.08	7.93
YC001-A5	1.04	61.2	1774	1711	0.94	2.04	8.19	1.88	7.55	1.59	6.61	1.81	7.50
YC001-A6	1.05	61.0	1797	1764	0.88	2.22	8.48	1.99	7.69	1.81	7.25	2.07	8.30
YC001-A7	1.05	60.7	1806	1786	0.94	2.27	8.81	1.95	7.56	1.75	7.02	2.03	8.14
YC001-A8	1.05	61.1	1824	1873	0.96	2.28	8.42	1.96	7.23	1.76	6.71	1.93	7.36
YC001-A10	1.05	60.8	1717	1743	0.97	2.01	8.20	1.78	7.29	1.60	6.55	1.81	7.39
YC001-A11	1.05	60.2	1800	1839	0.95	2.19	8.20	1.72	6.46	1.72	6.66	1.83	7.08
YC001-D1	1.20	60.9	1899	1873	0.89	2.50	9.24	2.00	7.36	1.99	7.60	1.96	7.46
YC001-D2	1.20	60.7	1882	1839	0.92	2.77	10.40	2.18	8.19	2.17	8.40	2.32	9.01
YC001-D3	1.20	60.3	1878	1861	0.90	2.56	9.43	2.19	8.09	2.11	8.03	2.05	7.81
YC001-D5	1.20	60.7	1856	1839	0.89	2.62	9.80	2.14	8.01	2.01	7.78	2.20	8.53
YC001-C2	1.71	60.9	1904	1850	0.93	2.04	7.67	1.78	6.69	1.65	6.40	1.76	6.82
YC001-C3	1.71	60.3	1839	1820	0.85	2.53	9.65	2.39	9.12	1.94	7.64	2.35	9.26
YC001-C4	1.70	60.4	1891	1861	0.91	2.44	9.01	2.03	7.48	1.96	7.46	2.00	7.61
YC001-C5	1.70	60.8	1891	1854	0.99	2.16	8.11	1.90	7.12	1.72	6.66	1.86	7.21
YC001-B1	2.40	61.4	1875	1871	1.00	1.95	7.07	1.67	6.16	1.59	6.06	1.68	6.38
YC001-B4	2.40	60.4	1878	1839	1.05	2.22	8.33	1.87	6.99	1.78	6.90	1.90	7.36
YC001-B5	2.40	61.4	1873	1861	1.00	2.39	8.81	2.13	7.87	1.87	7.12	2.18	8.30
YC001-B6	2.40	61.4	1890	1826	0.99	1.86	6.98	1.56	5.87	1.50	5.81	1.60	6.22
YC001-B7	2.40	60.9	1865	1861	0.93	2.42	8.94	2.21	8.16	1.89	7.18	2.15	8.18

→ **Very good efficiency of MPOs**

- Over-estimation of PSF FWHM because of Leicester beam line detector aging problems
  - « Corrected » values around 6.1 arcmin

Effective area

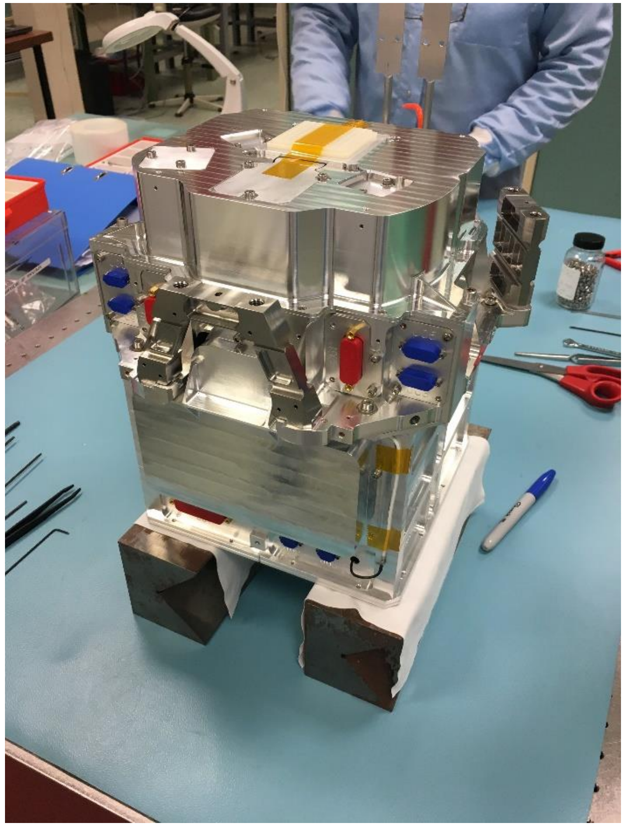




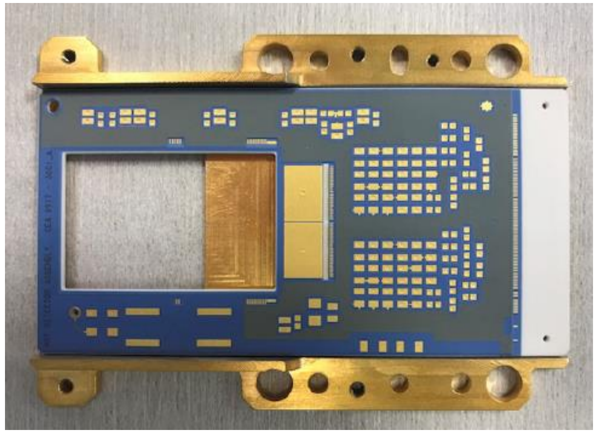
- Red = effective area with only the central spot of the PSF
- Black = effective area which include all the PSF (with arms)

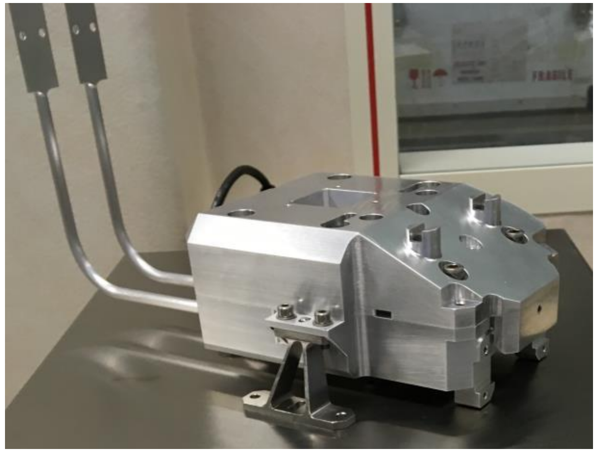
➡ **Better results by including all the PSF !**

Camera status

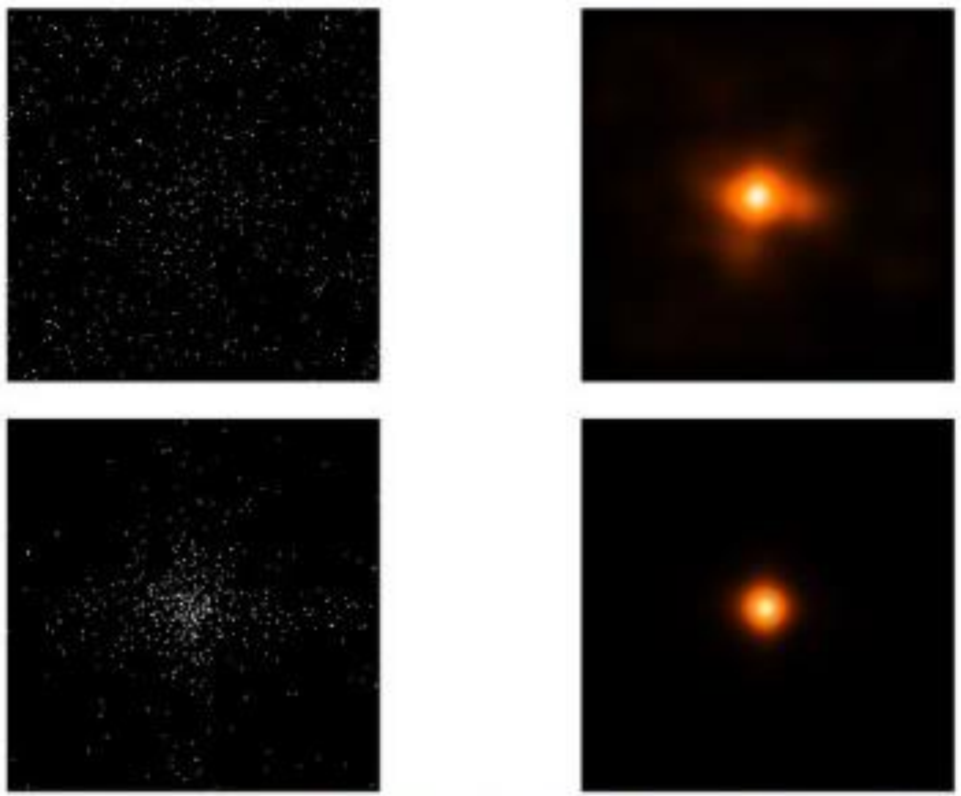


- The camera STM is built and will be delivered mid 2018
- The CAMEX have been bonded on the ceramic at MPE and are being tested at CEA
  - The detector will be mounted in summer 2018
- Inner coating of the shielding being optimized by GEANT4 simulations (2µm Au + 2µm Ni + 2µm Cu)
- UV filters will be tested at Soleil Synchrotron in June

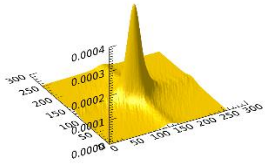




Cross-correlation method



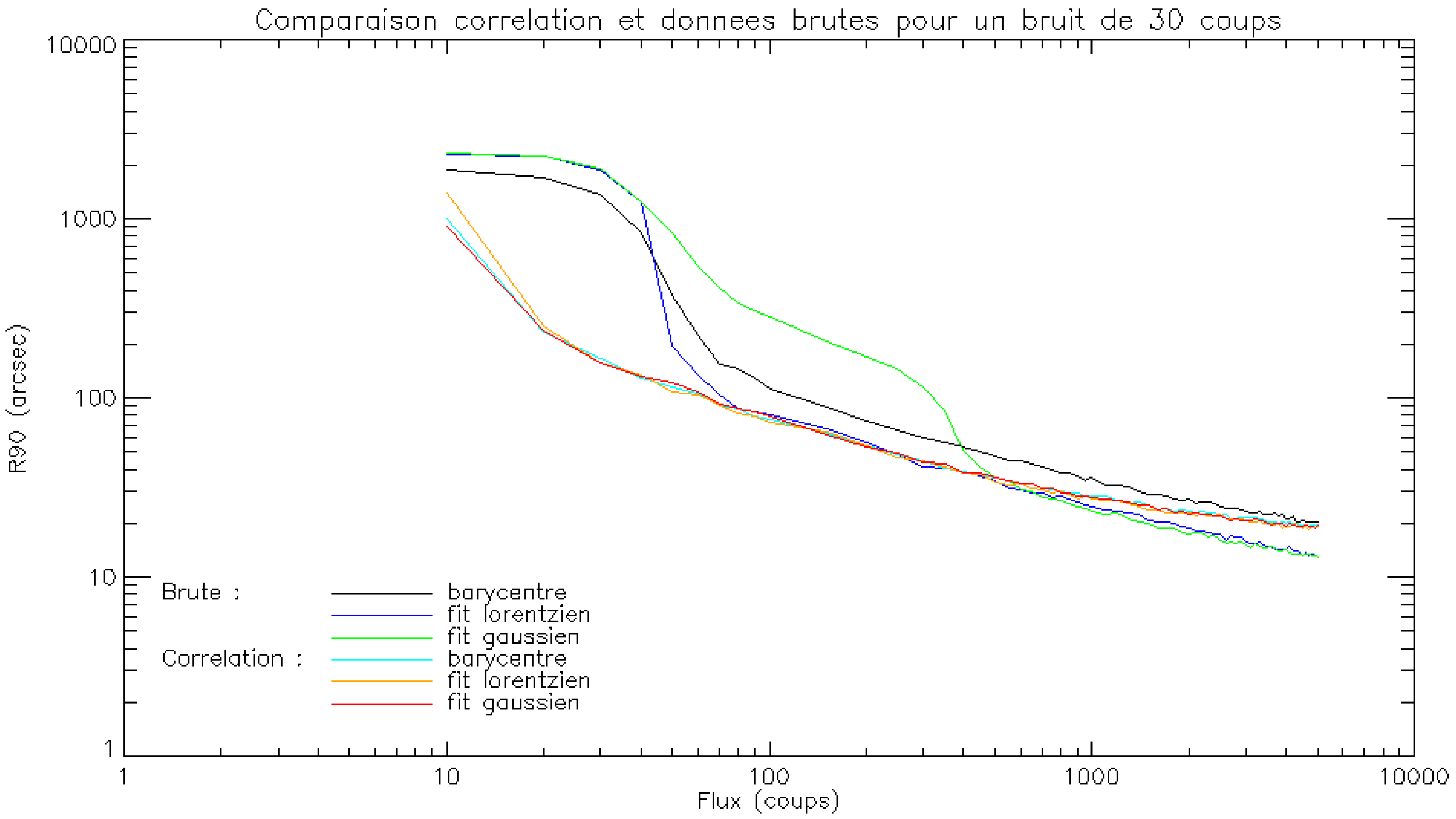
<u>Goal</u> = find the pattern of the MXT PSF on the initial data



- <u>Left</u> : initial data on the detector
- <u>Right</u> : data after the cross-correlation with the MXT psf
- <u>Top</u> : source = 50 counts / noise = 500 counts
- <u>Bottom</u> : source = 500 counts / noise = 50 counts

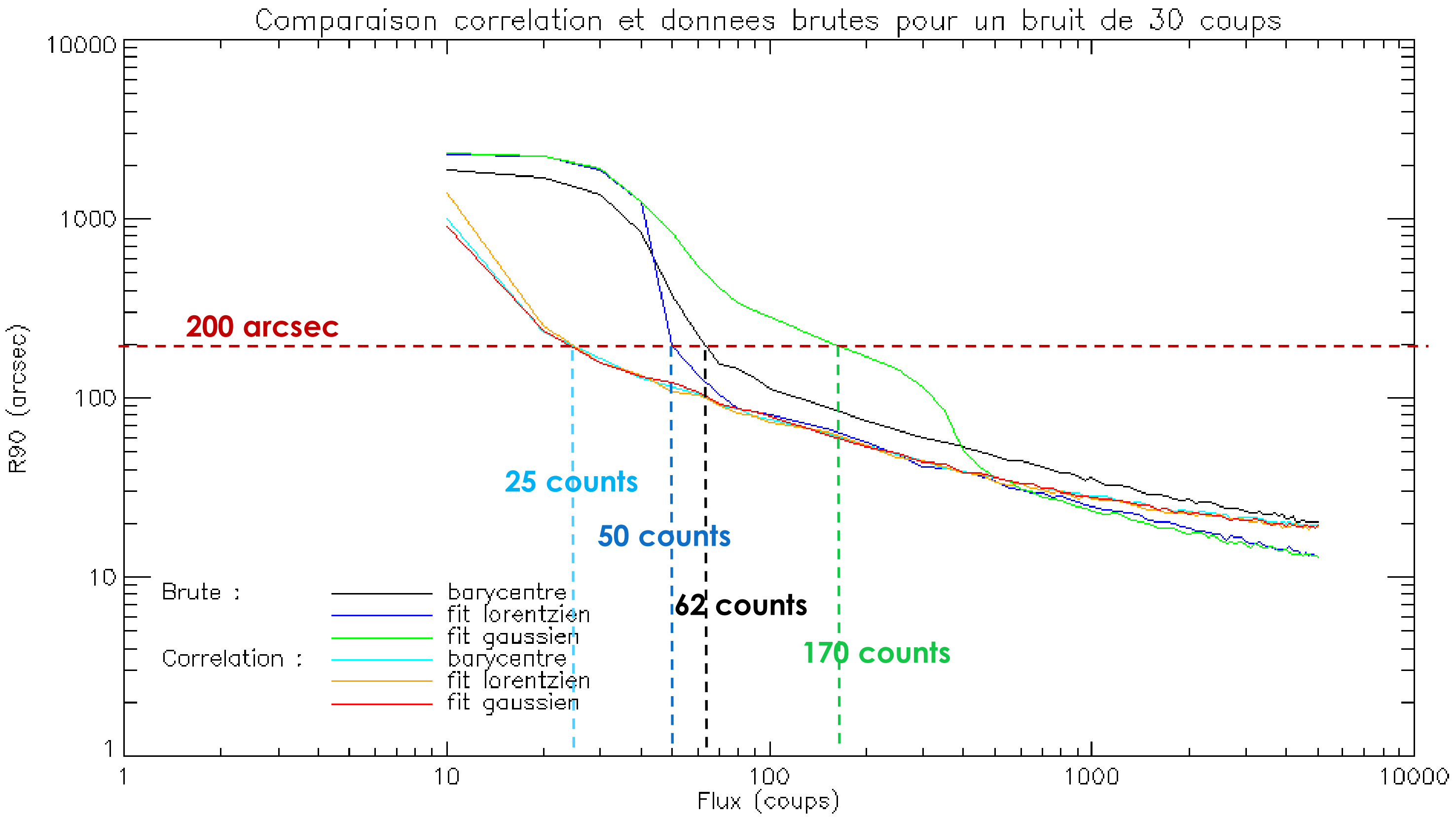
→ **A faint source can be found by using the cross-correlation method**

Comparison of localization algorithms on initial and correlated data for a low noise



- At high fluxes (>500 source counts), a fit on initial data is better
- At low fluxes, a correlated method is better and have good results at high fluxes

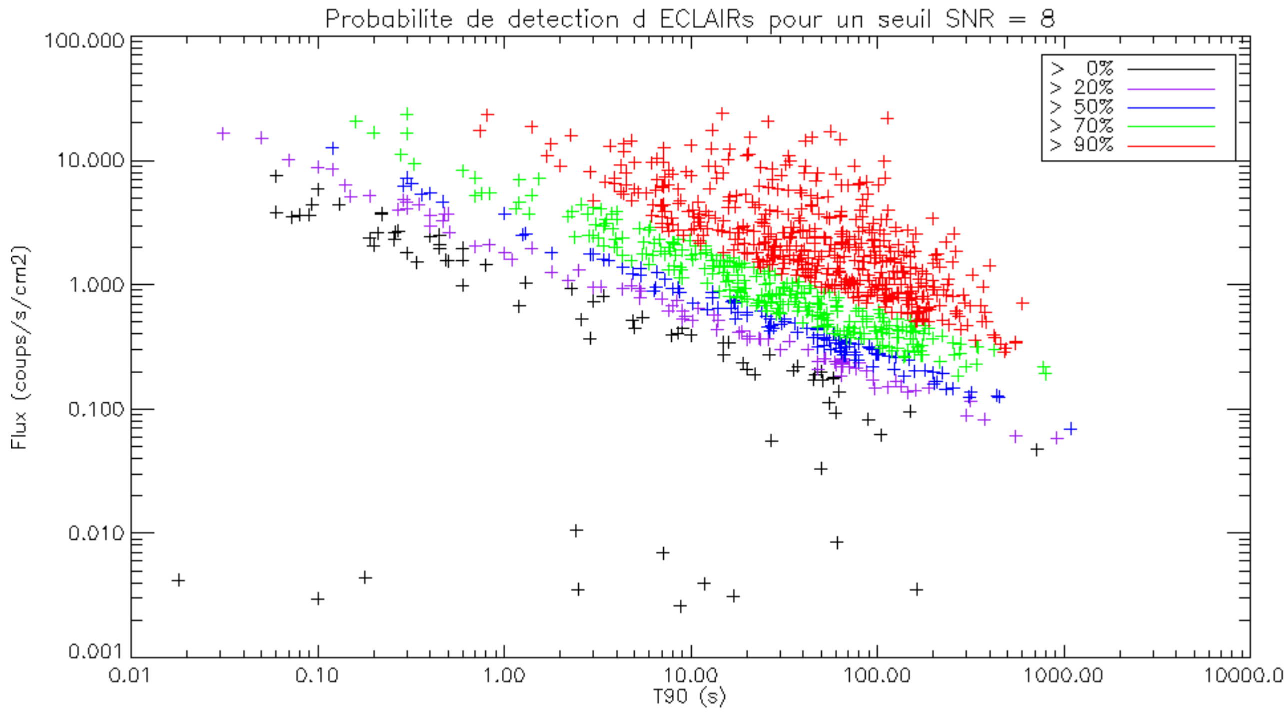
Comparison of localization algorithms on initial and correlated data for a low noise



Goal : estimate the minimal number of counts in order to have a localization

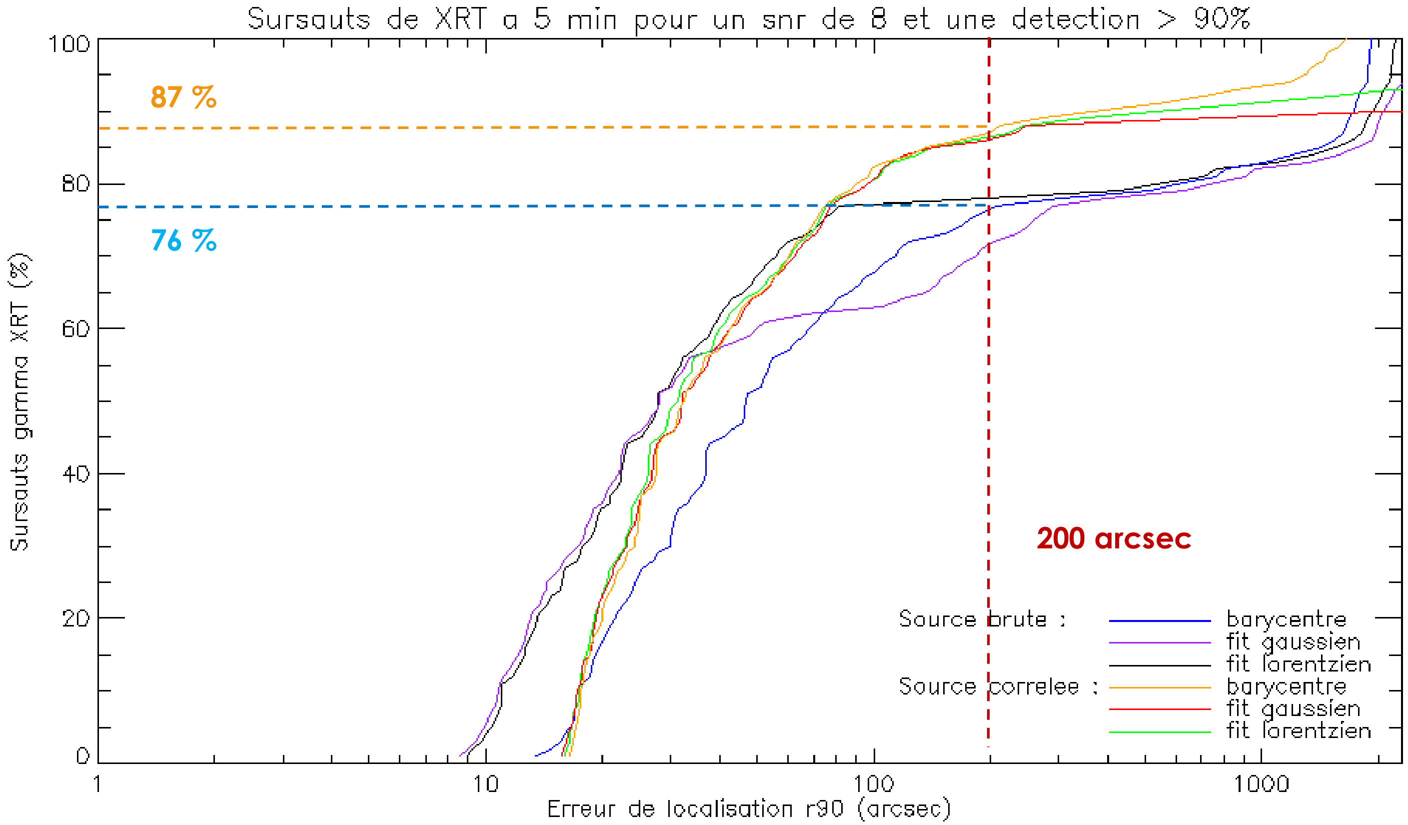
- With an error limit of 200 arcsec (MXT specifications)
  - ~ 20 - 30 counts for a correlated method
  - ~ 60 counts for barycenter on raw data
  - Advantage of barycenter = independant of the PSF shape

Localization algorithms of XRT database SNR = 8



- BAT database (Swift, end 2017)
  - Extrapolation to ECLAIRs energies
  - A.Gros calculated the probability of detection of ECLAIRs for different SNR thresholds
  - We estimated through simulations the probability of detection of MXT

Localization algorithms of XRT database SNR = 8



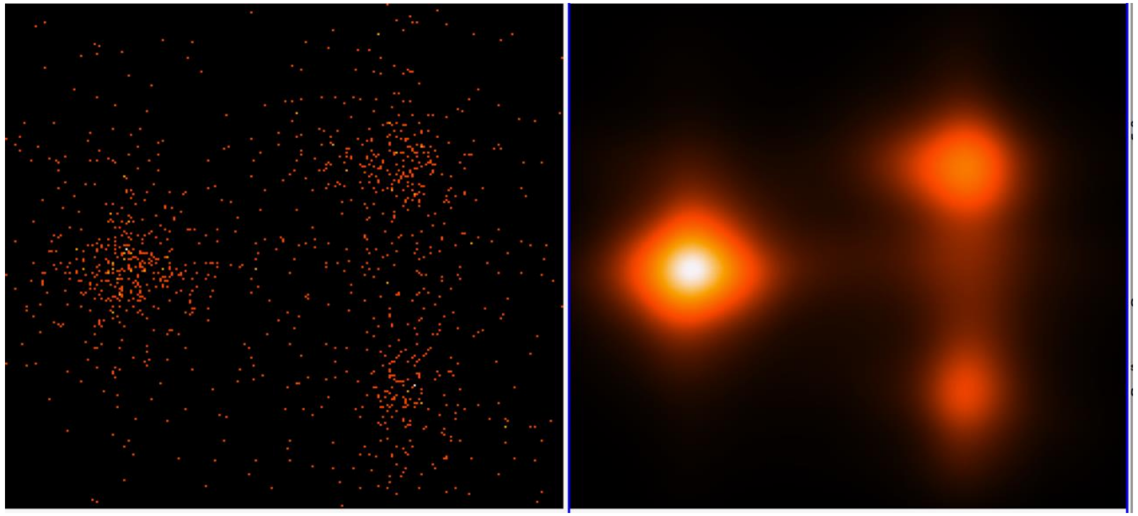
Probability of detection of MXT :

- For an error limit of 200 arcsec and a detection probability of ECLAIRs of 90 %
  - 76 % of GRBs for algorithms applied on raw data
  - 87 % of GRBs for algorithms applied on correlated data

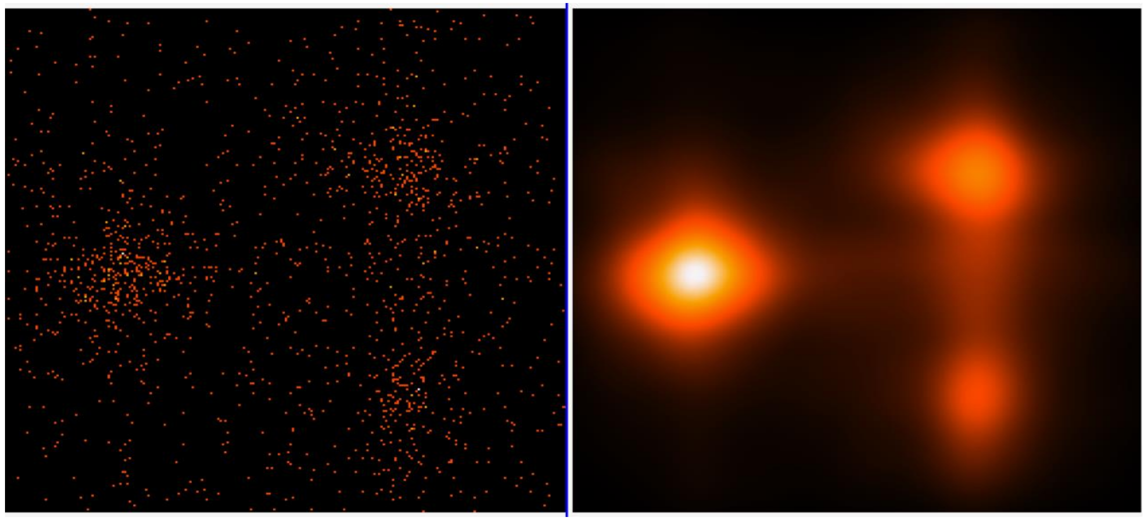
Work in progress : cross-correlation for several sources

Goals of the study :

- If MXT observes a weak afterglow with a X ray source in a FoV
- Gravitationnal waves follow-up : observation few hours later => the searched source is not always the brightest in the FoV



50 counts of noise



500 counts of noise

Conclusions

- All the MXT subsystems are progressing
  - Optical FM MPOs are already being produced at Photonis
- MXT will finish its phase C early 2019
- We are accumulating a good experience on Lobster-Eye imaging and real-time treatment (on board localization algorithms)
  - The localization algorithms applied on correlated data are efficient
  - When we apply them to XRT database selected by ECLAIRs probabilty of detection, most of the GRBs are detected by correlation