INAF ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS
IASFPa Istituto di Astrofisica Spaziale e Fisica cosmica di Palermo

INFN Istituto Nazionale di Fisica Nucleare
Sezione di Catania

"NSB ratio" *VS.* "XY-Scanner"

Calibration history of the CO5 Bay

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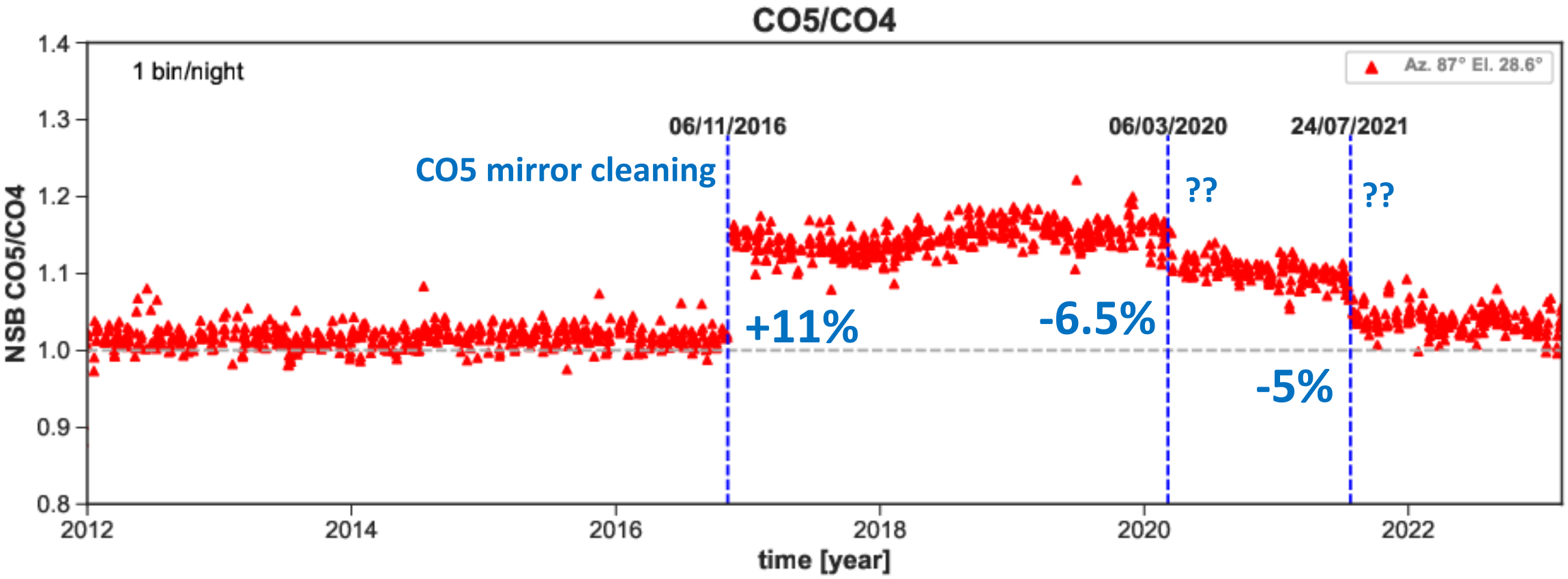
Introduction

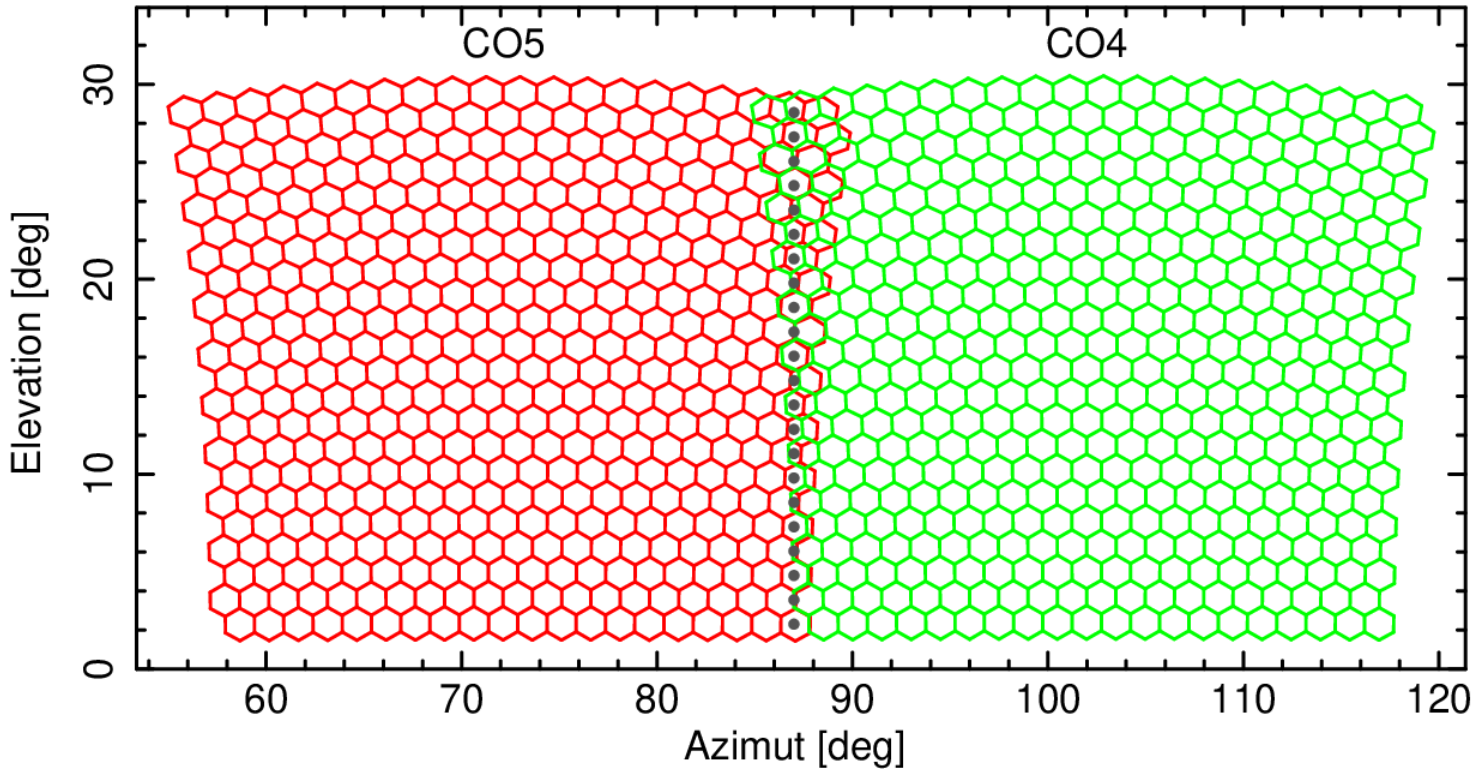
- Several significant discontinuities are often observed in the long-term evolution of the NSB ratio between adjacent FD telescopes
- In most cases, these discontinuities are due to documented hardware operations (such as e.g. mirror cleanings or LCU change), but there are also cases of discontinuities of unknown origin
- We use the XY-Scanner data to discover the physical origin of the main discontinuities observed in the long-term evolution of the NSB ratios involving the CO5 bay

The CO5 discontinuities



- In all the NSB ratios involving the CO5 bay (CO5/CO4, CO5/HE2, CO5/LL2, …) three main discontinuities are observed
- One is clearly associated with the mirror cleaning operation in Nov. 2016, while the other two, in March 2020 and June 2021, are of unknown origin.

“NSB ratio” elevation profiles



NSB vs Elevation model function

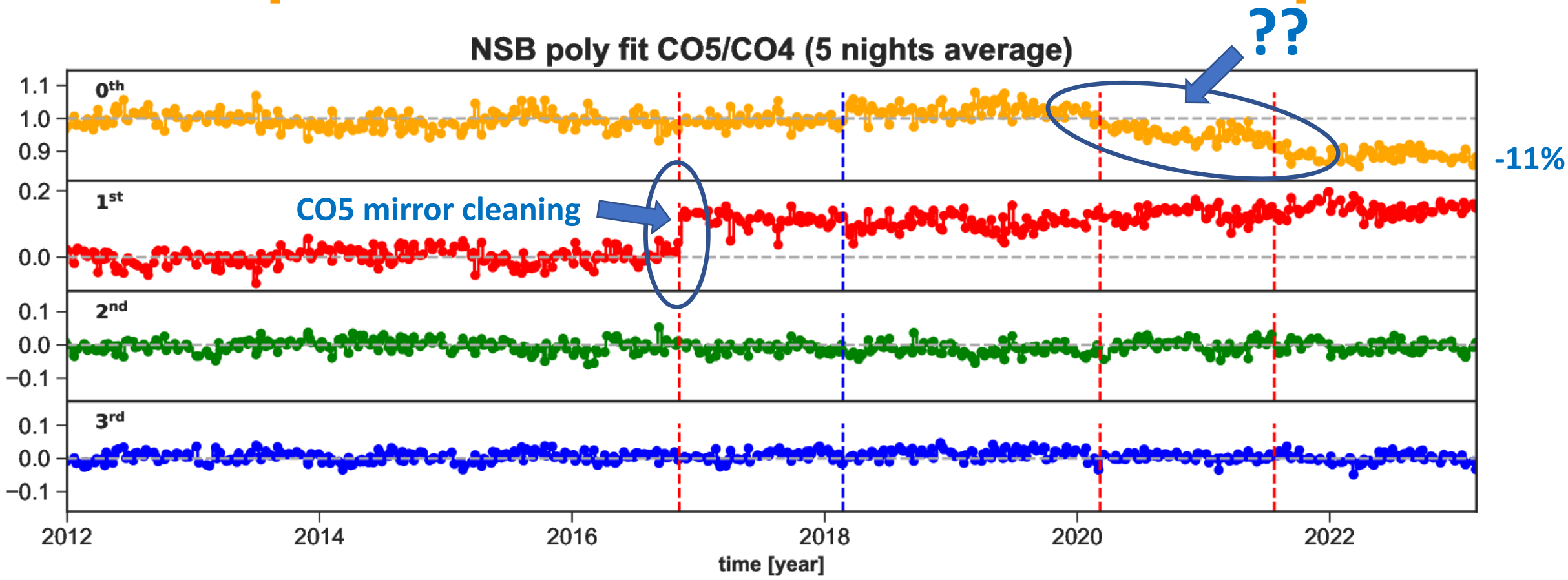
$$\mathrm{NSB}_R(y) = a * (1 + by + cy^2 + dy^3)$$

y is the normalized vertical coordinate, defined as y=0 at centre of lowest pixel row, y=1 at centre of upper pixel row

a = 0th order coeff. = normalization factor
b = 1st order coeff. = vertical gradient

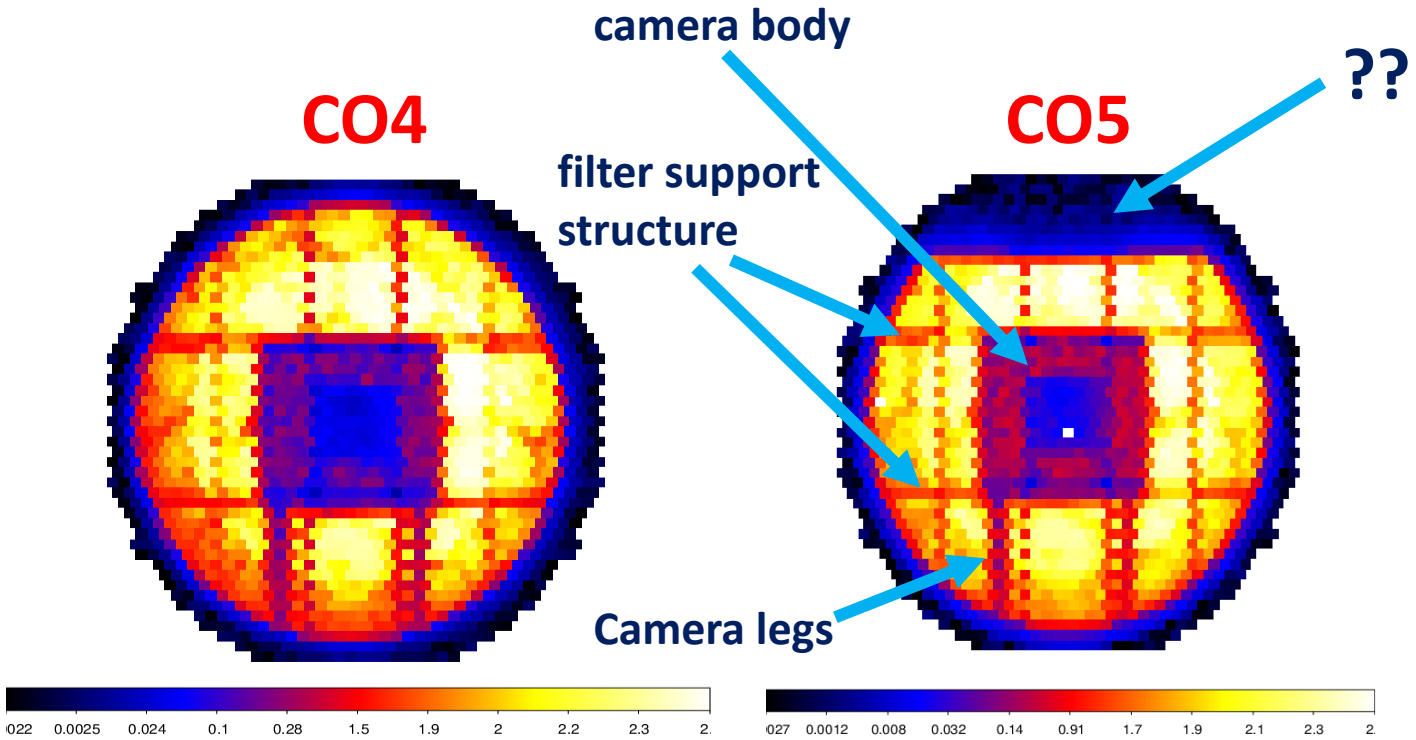
- **To obtain more information about the physical origin of the discontinuities, we fit the vertical profiles of the CO5/CO4 NSB ratio measured on each night using a 3rd order polynomial**

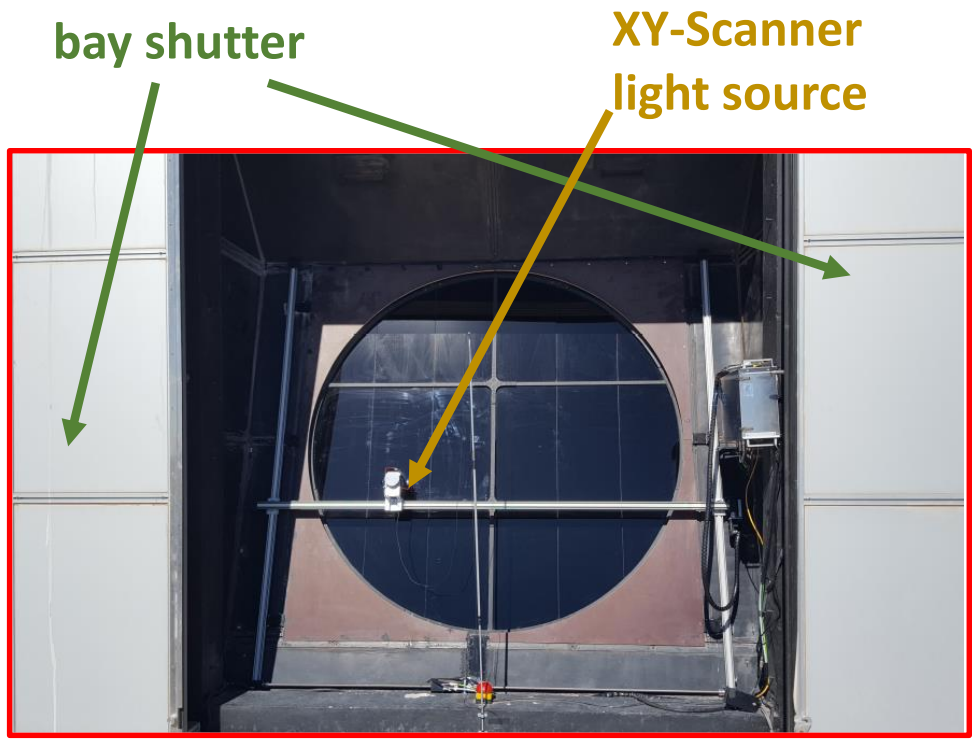
Best fit parameters of the “NSB ratio” vertical profile



- For each night we fit the vertical profile of the CO5/CO4 “NSB ratio” using a 3rd order polynomial
- A sharp discontinuity in the 1st order derivative is observed at the date of mirror cleaning while only the normalization factor decreases in March 2020 and June 2021
- To investigate about the physical origin of the observed efficiency decline we use the CO4 and CO5 data from the XY-Scanner acquisitions in 2022

XY-Scanner: CO4 vs CO5 on-axis illumination maps



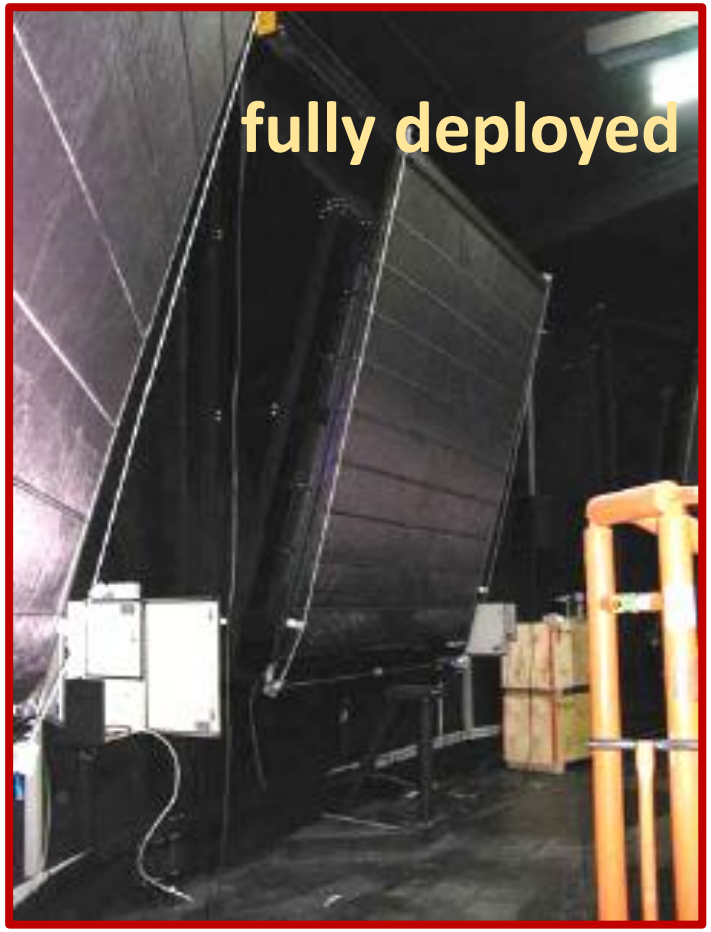


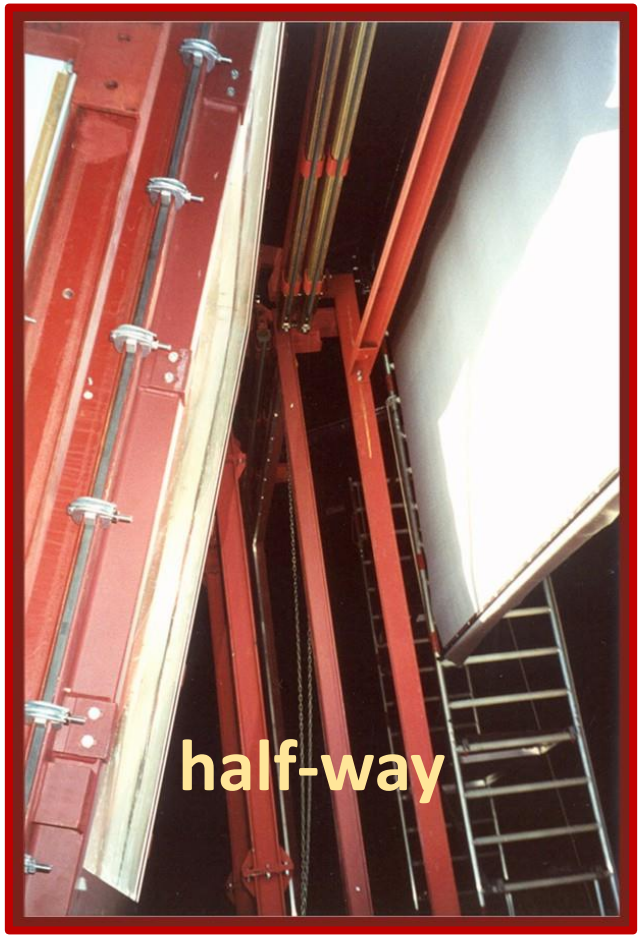
XY-Scanner on-axis illumination maps

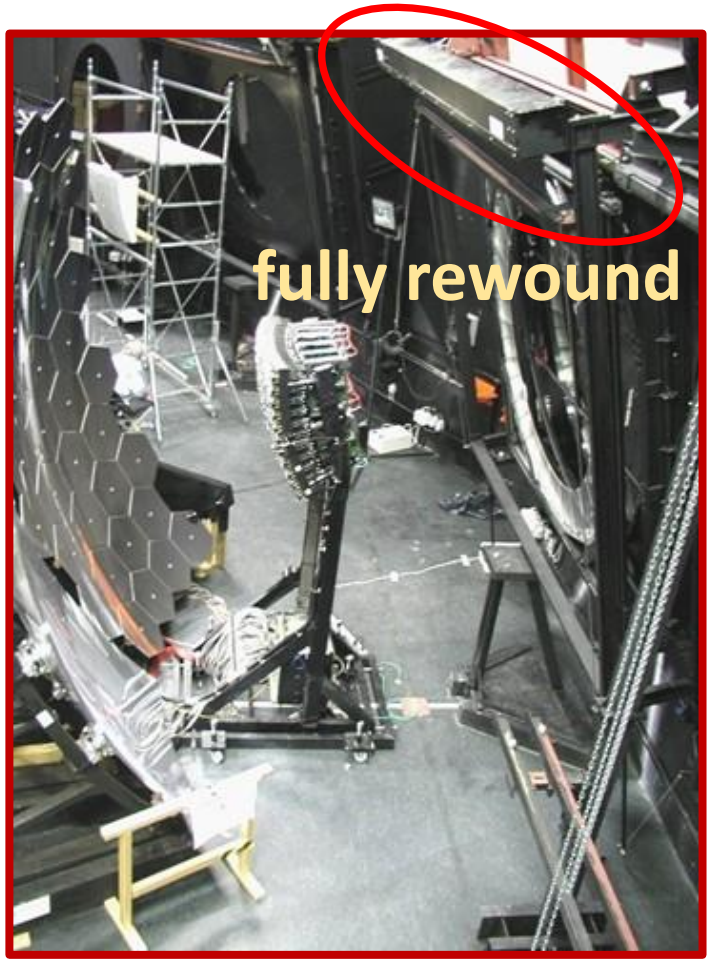
The XY-Scanner (GAP 2020-022)

- From the XY-Scanner acquisitions in 2022 we obtain the on-axis illumination maps of both CO4 and CO5 bays. The two maps are very similar except for an extended shadow that reduces the aperture of CO5
- The shadow cannot be due to an incomplete opening of the bay shutter because then a vertical shadow would be observed and also because the XY-Scanner is mounted between the shutter and the filter
- The only element in the FD bay that could produce a shadow like the one observed is …

The FD fail-safe curtain

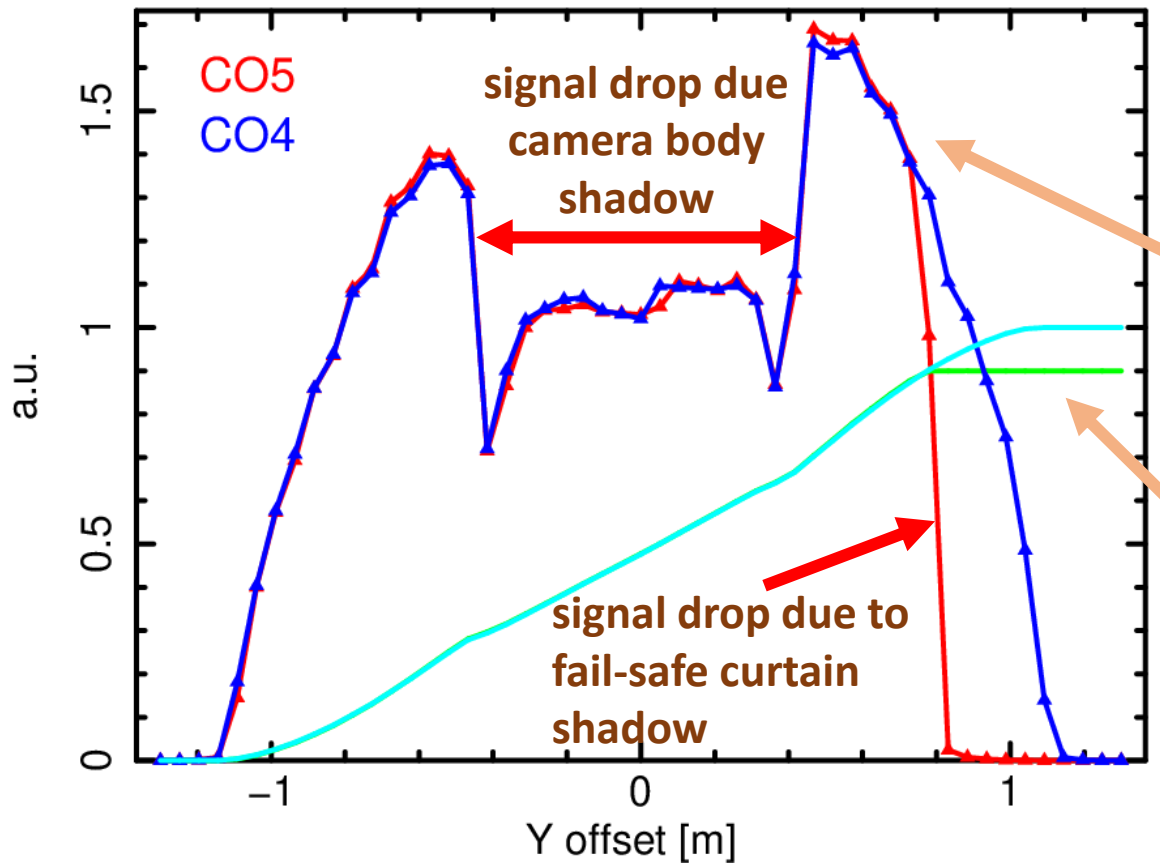






- A fail-safe curtain is mounted behind the FD aperture to prevent daylight from illuminating the camera in case of a shutter malfunction or a failure of the Slow Control System
- A problem in the rewinding mechanism would produce an reduction of the bay aperture identical the one observed in the CO5 illumination map obtained from the XY-Scanner acquisitions

XY-Scanner: measuring the CO5 efficiency loss



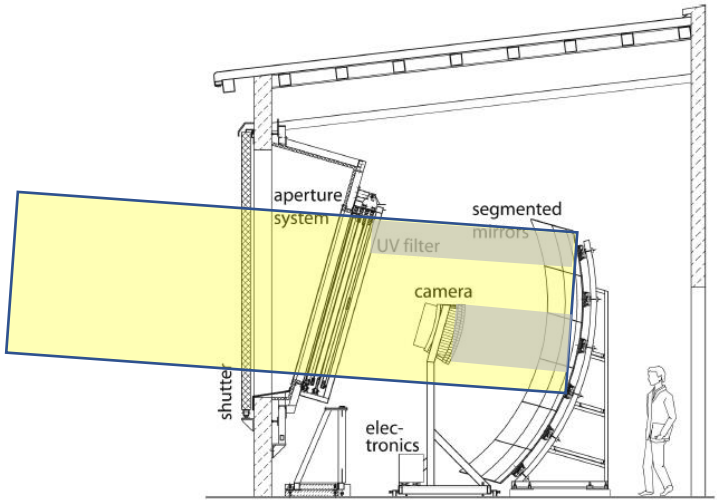
CO4 and CO5 vertical signal distributions (scaled to match) obtained from the XY scanner on-axis illumination maps as a function of offset from camera center

Normalized cumulative distributions

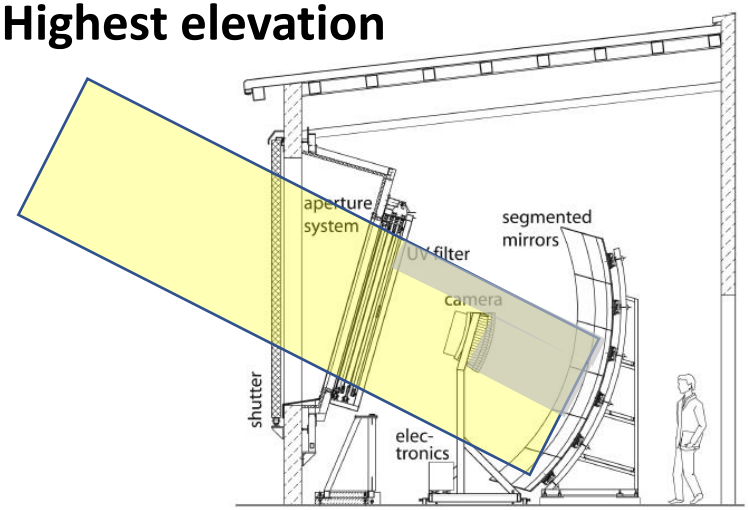
- For an accurate determination of the efficiency loss due to the fail-safe curtain shadow, it is necessary to take into account the asymmetrical distribution of the signal across the bay opening
- For this purpose we can use the vertical distribution of CO4 as a reference because it is almost identical to the CO5 distribution up to the beginning of the shadow (at Y = 0.9 m from the center)
- By comparing the two distributions, we can measure the efficiency loss (for on-axis illumination) in CO5 as ~10% which is fully consistent with the efficiency loss observed in the NSB ratio

XY-Scanner: CO5 shadows as at different elevation

Lowest elevation

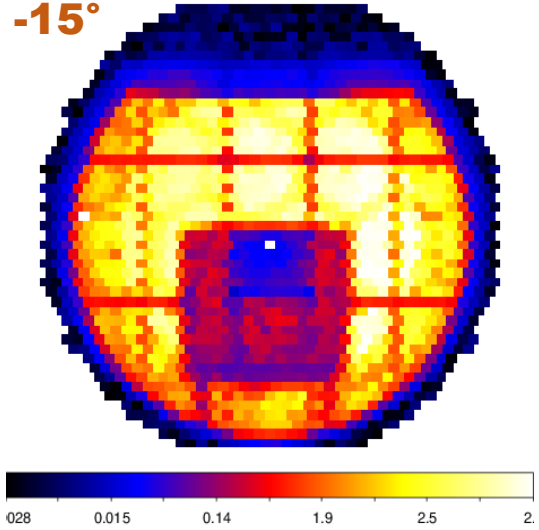


Highest elevation

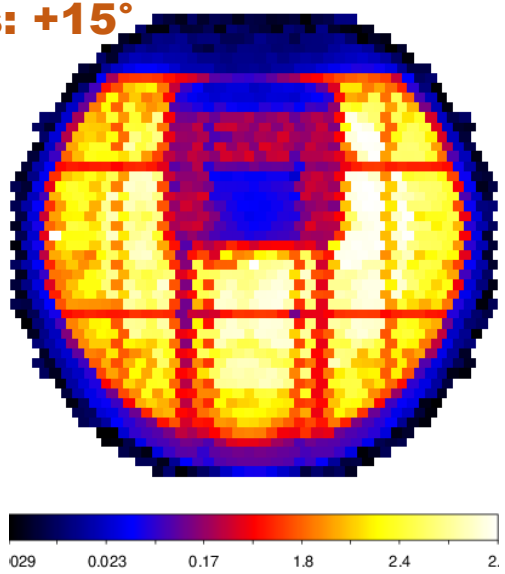


CO5 illumination maps

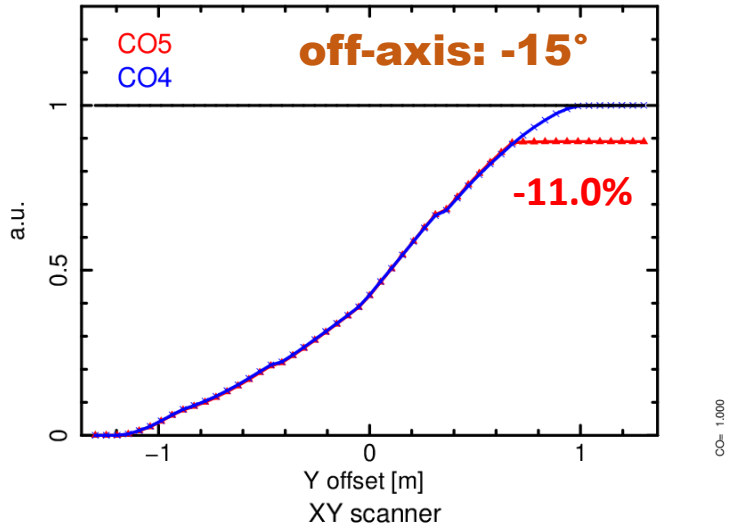
off-axis: -15°

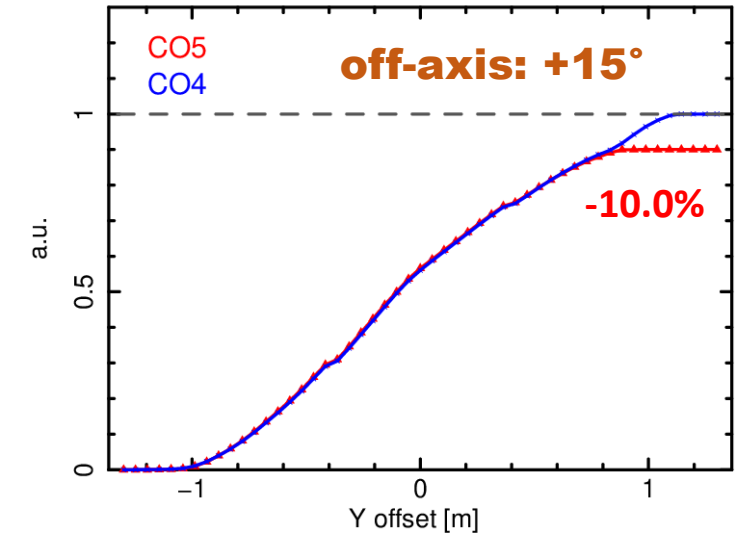


off-axis: +15°

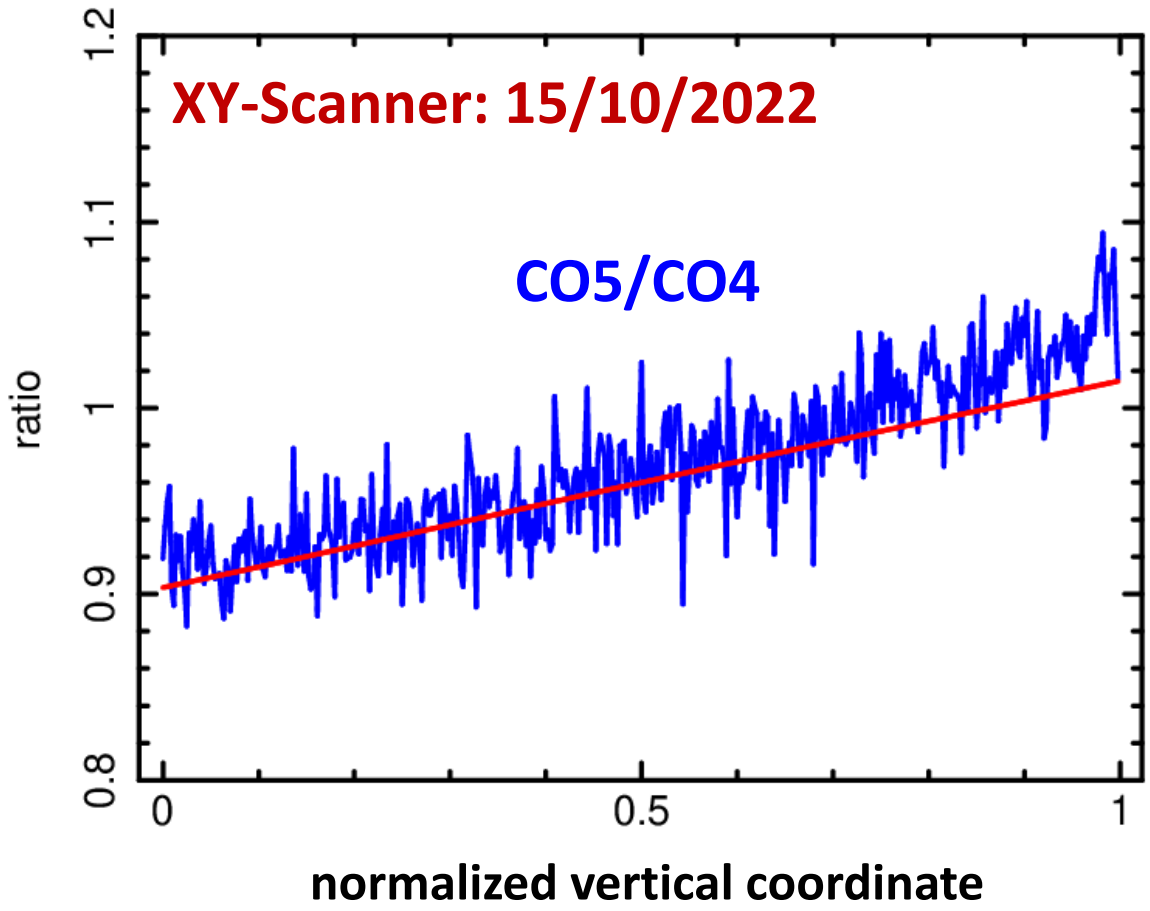


cumulative vertical distributions



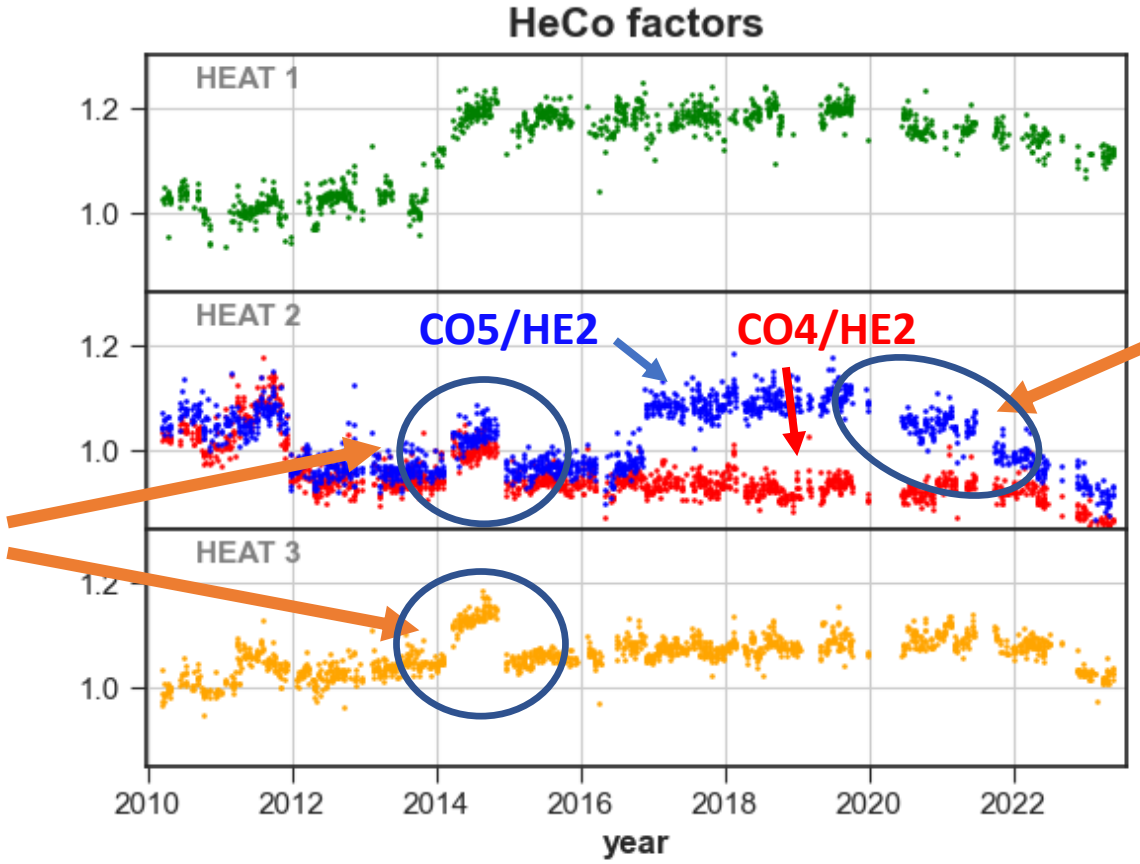


XY-Scanner: mirror cleaning effect



- Calculating the CO5/CO4 ratio from the XY-Scanner data as a function of pixel elevation, the same vertical gradient is observed as in the NSB data

Long-term evolution of the HeCo factors



temporary problem in the HE2 security curtain rewinding system?

persistent problem in the CO5 security curtain rewinding system!

- Because of the mirror cleaning and the safety curtain problem, the CO5/HE2 NSB ratio is significantly different from the CO4/HE2 ratio. The safety curtain problem apparently improved the CO5/CO4 inter-calibration, but at expenses of a $\sim 10\%$ reduced sensitivity
- The average of these two factors is stored in the Offline dB, but for comparison with the XY-Scanner data, the proper HE2 ratio (as well as elevation-dependent effects) should be considered

Conclusions

The data from the XY-Scanner allowed us to fully understand the long-term history of NSB ratios related to CO5.

The calibration of CO5 was affected by two main episodes:

- **Mirror cleaning: due to the removal of dust present during Drum acquisitions, this operation ruined the initial calibration by introducing (as of November 2016) an elevation-dependent gradient ($+11\%$) in the telescope efficiency**

- **Fails-safe curtain problem: starting from March 2020, the fail-safe curtain do not fully rewind into its housing thus partially obscuring the bay opening. The obscuration further increased in July 2021 so that currently CO5 is affected by an $\sim 10\%$ efficiency loss (almost independent on elevation)**

As the two effects partially compensate each other, the calibration status of CO5 does not appear currently much different from the initial one, however, the CO5 sensitivity is actually reduced by $\sim 10\%$ due to the smaller collection area