The XMM-Newton survey in the Chandra Deep Field South

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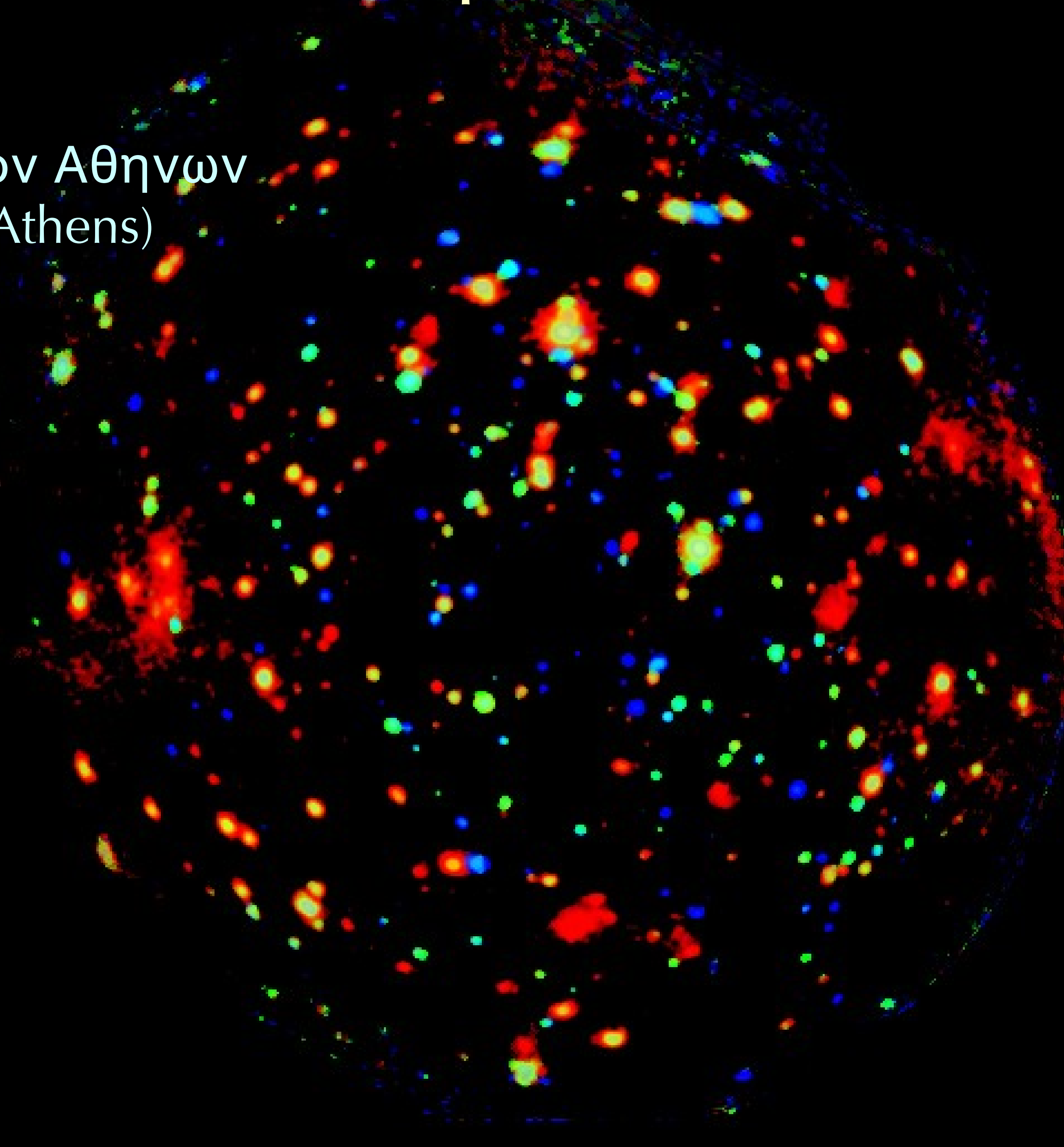
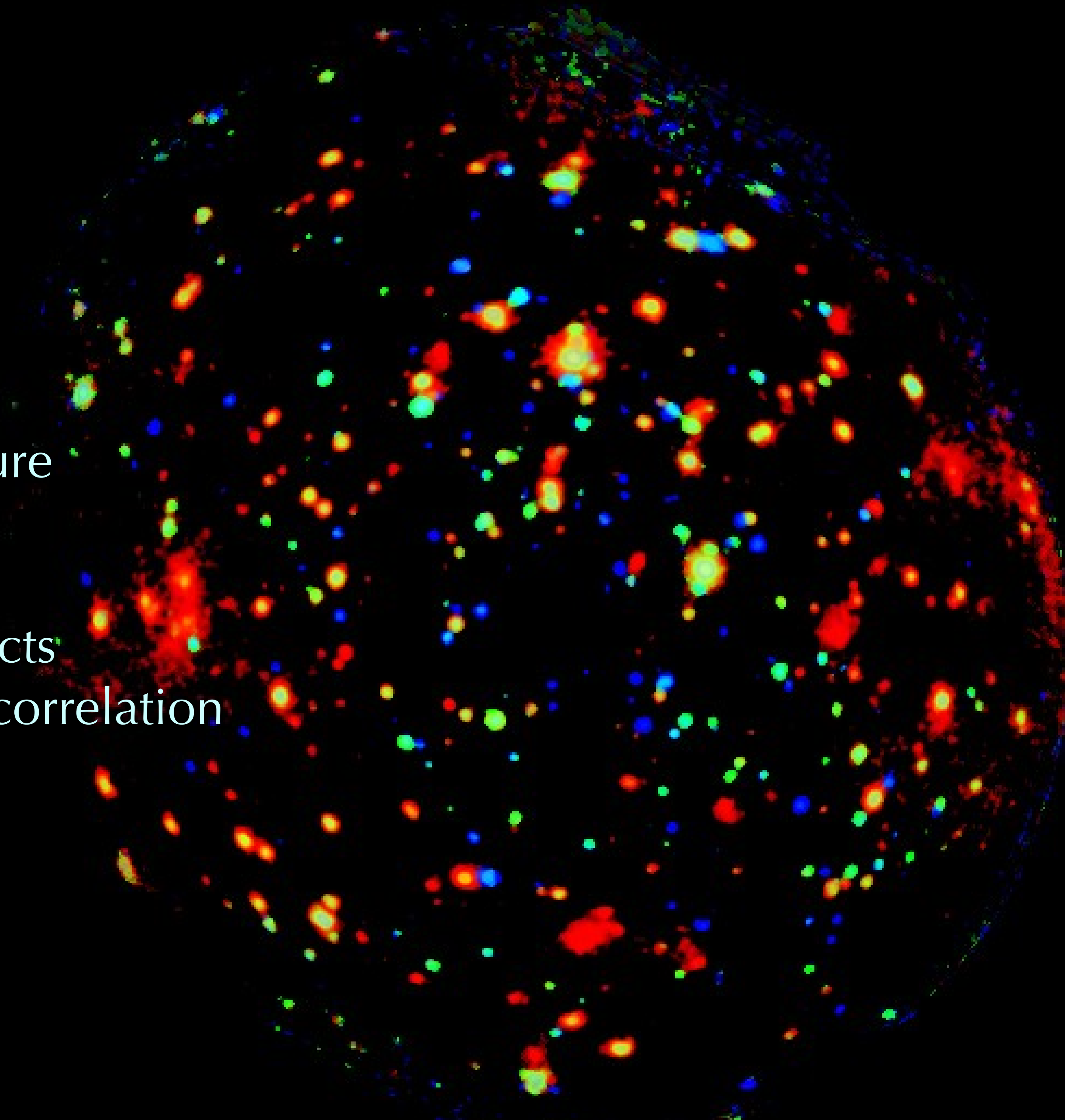
and the XMM-CDFS team



Second XMM-CDFS Meeting,
31 May-1 June 2012, Cervia

Talk summary

- catalogue status
- the simulator:
  * cosmic sources
  * soft protons
  * particles
  * simulator infrastructure and pipeline
- simulations:
  * simulated data products
  * validation and cross-correlation
  * completeness
  * reliability
  * coverage



Talk summary

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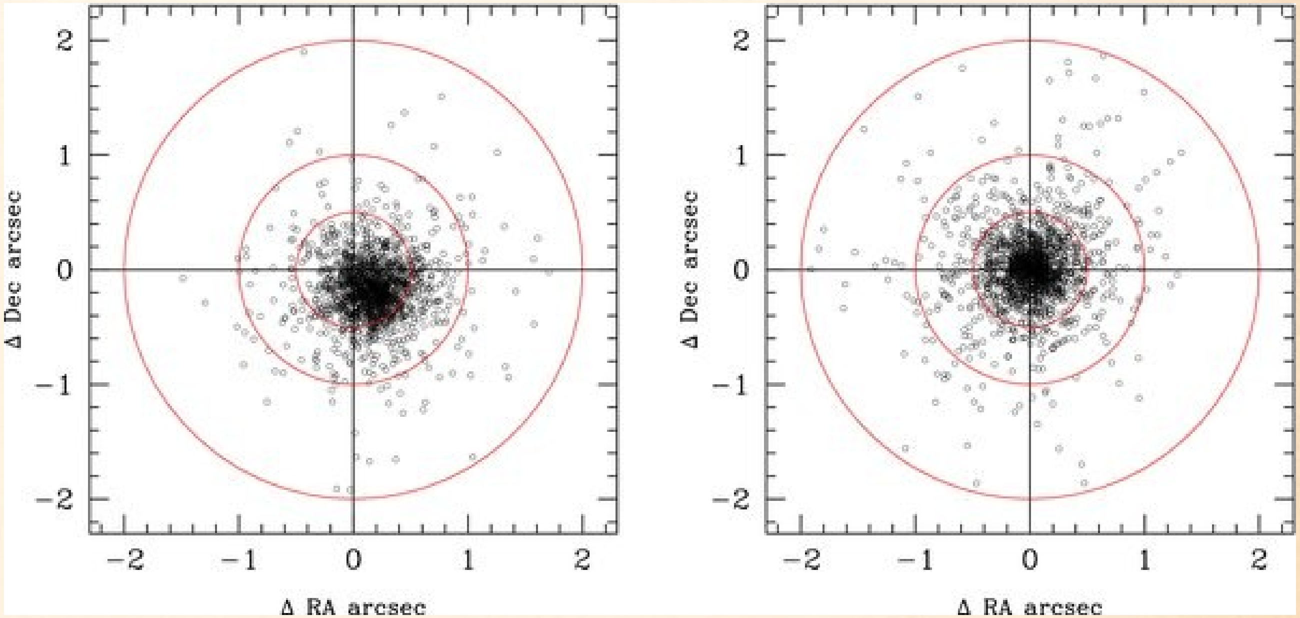
Let's start with three slides from one year ago...

Two STAGE Source detection

- source detection with the combination of PWXDetect and EMLdetect

- The power of the method is well described by Puccetti+09



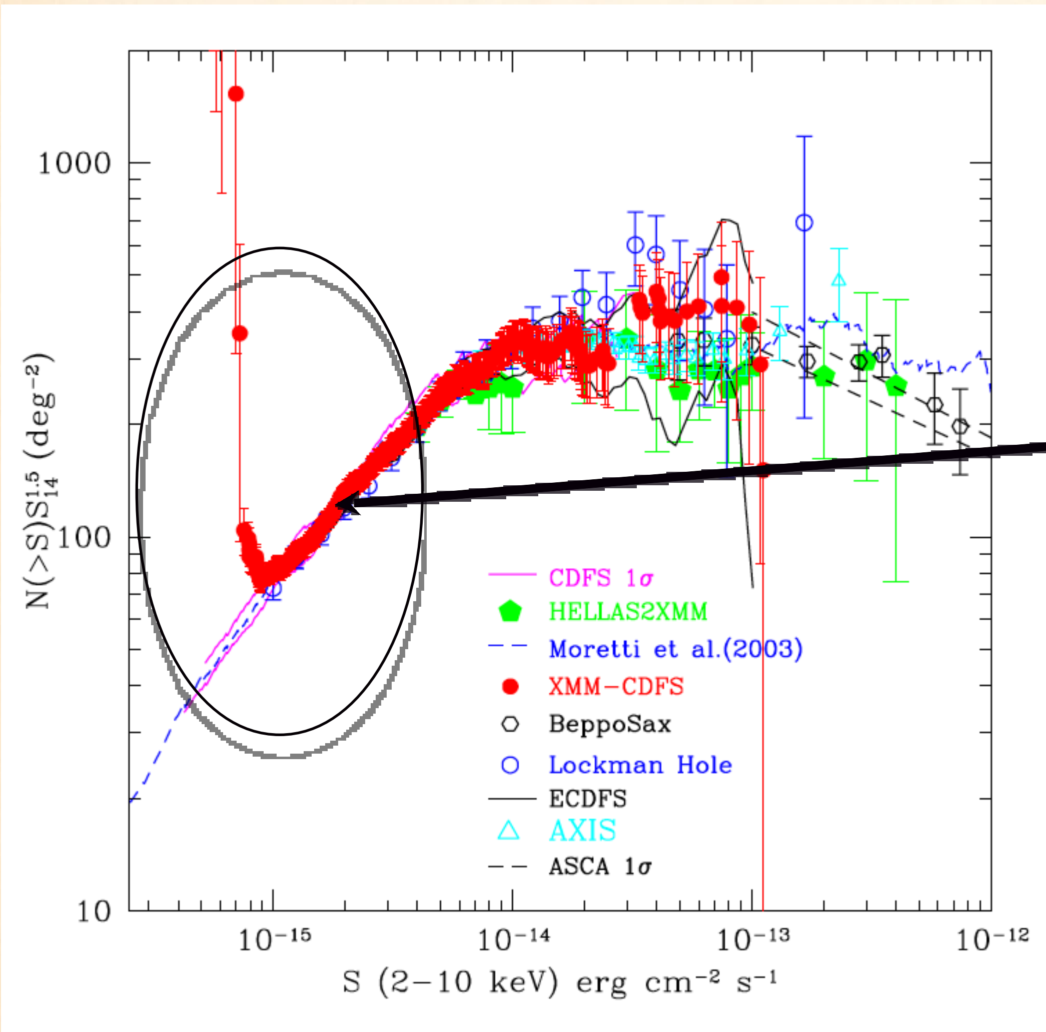
This method provides an excellent positioning of the sources because PWXD works on events and is not affected by the binning

- EMLdetect provides the best possible photometry for point-source
- We first run a low threshold run of PWD to provide an input list for EML detect
- PWD detects sources and at the same time performs a fit to the background with several possibility of σ clipping.
- The best combination was found to be 4σ for the source detection and 3σ for the background

Also:
Check with aperture photometry

- catalogues (still preliminary):
  * 2-10 keV, cut at ~~4 sigma: 411 sources~~ 4σ AND ML≥4.6: 337 sources
  * 2-10 keV, cut at 10 sigma and 1 Ms exposure: 130 sources ("spectral catalogue")
  * 5-10 keV, cut at 5 sigma: 92 sources

Number counts and simulations



Faint end very sensitive to observational biases

simulations needed to derive reliable coverage

Method:
repeat detections
on mock-up surveys

The XMM-CDFS simulator: overview

Reproduces cosmic sources + background

Background components:
- unresolved X-ray sources
- particle background (electronic noise)
- residual soft protons
- solar wind charge exchange

Each one with its own spatial distribution

(this part with thanks to K. Kuntz and S. Molendi for useful discussions about the XMM background)

The XMM-CDFS simulator: overview

Reproduces cosmic sources + background

Background components:

- unresolved X-ray sources
- particle background (electronic noise)
- residual soft protons
- ~~solar wind charge exchange~~ => negligible at E>2 keV

Each one with its own spatial distribution

The XMM-CDFS simulator: overview

Reproduces cosmic sources + background

Background
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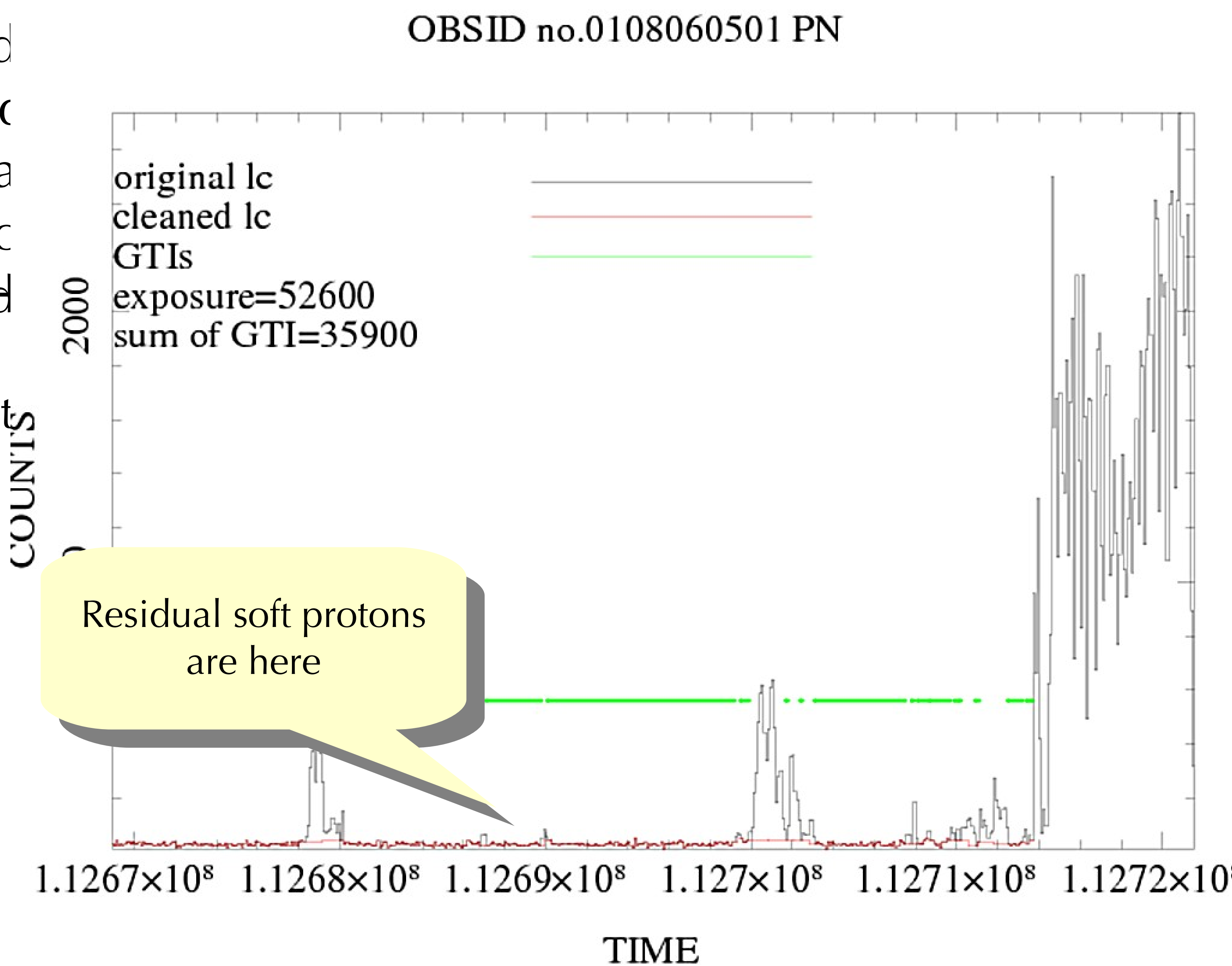
- ~~- solar wind~~

Each one wit



The XMM-CDFS simulator: overview

Background components (surface brightnesses):

$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

The XMM-CDFS simulator: overview

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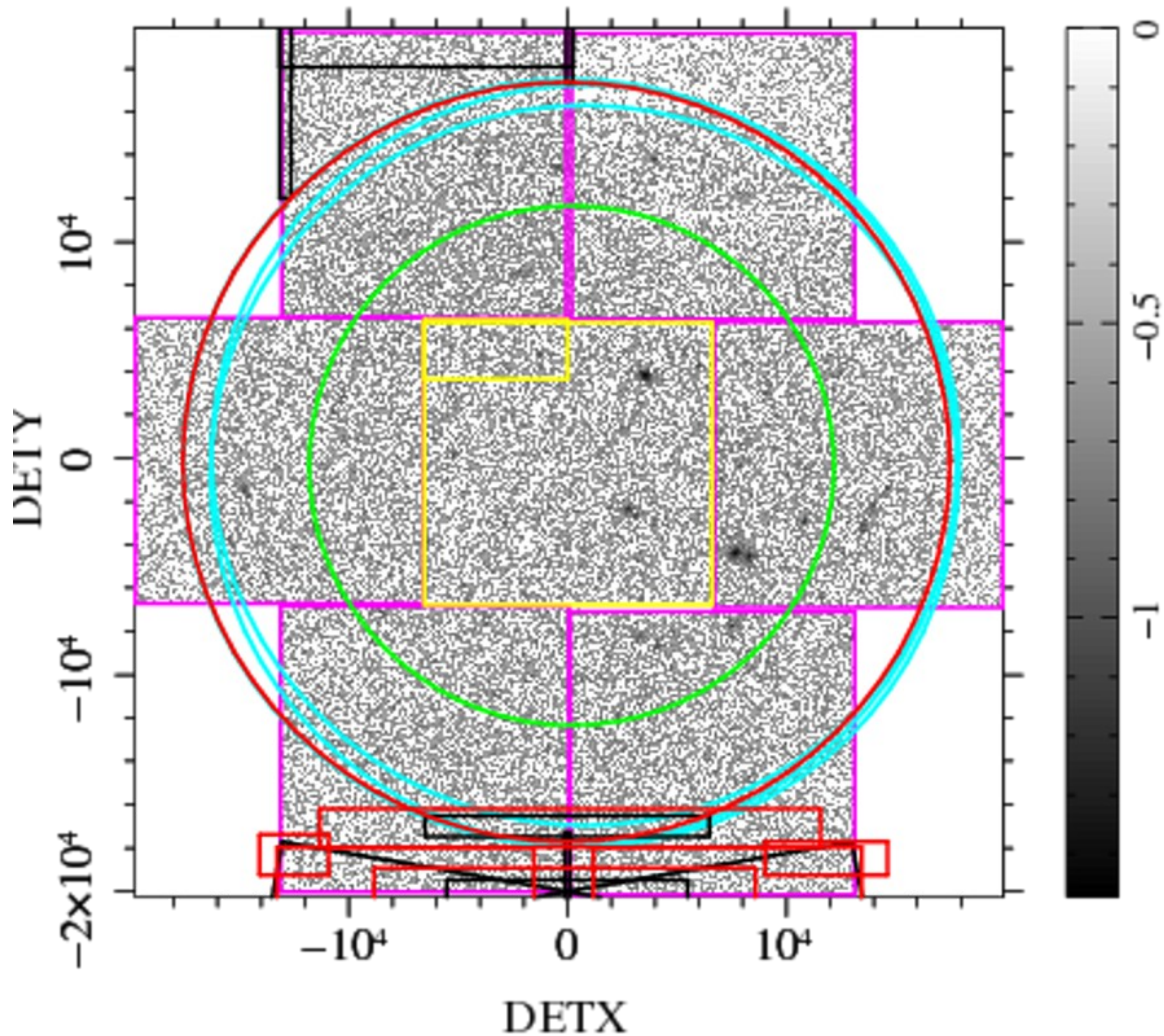
$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

$$\Sigma_{CORNER} = k\ \Sigma_{PART}$$



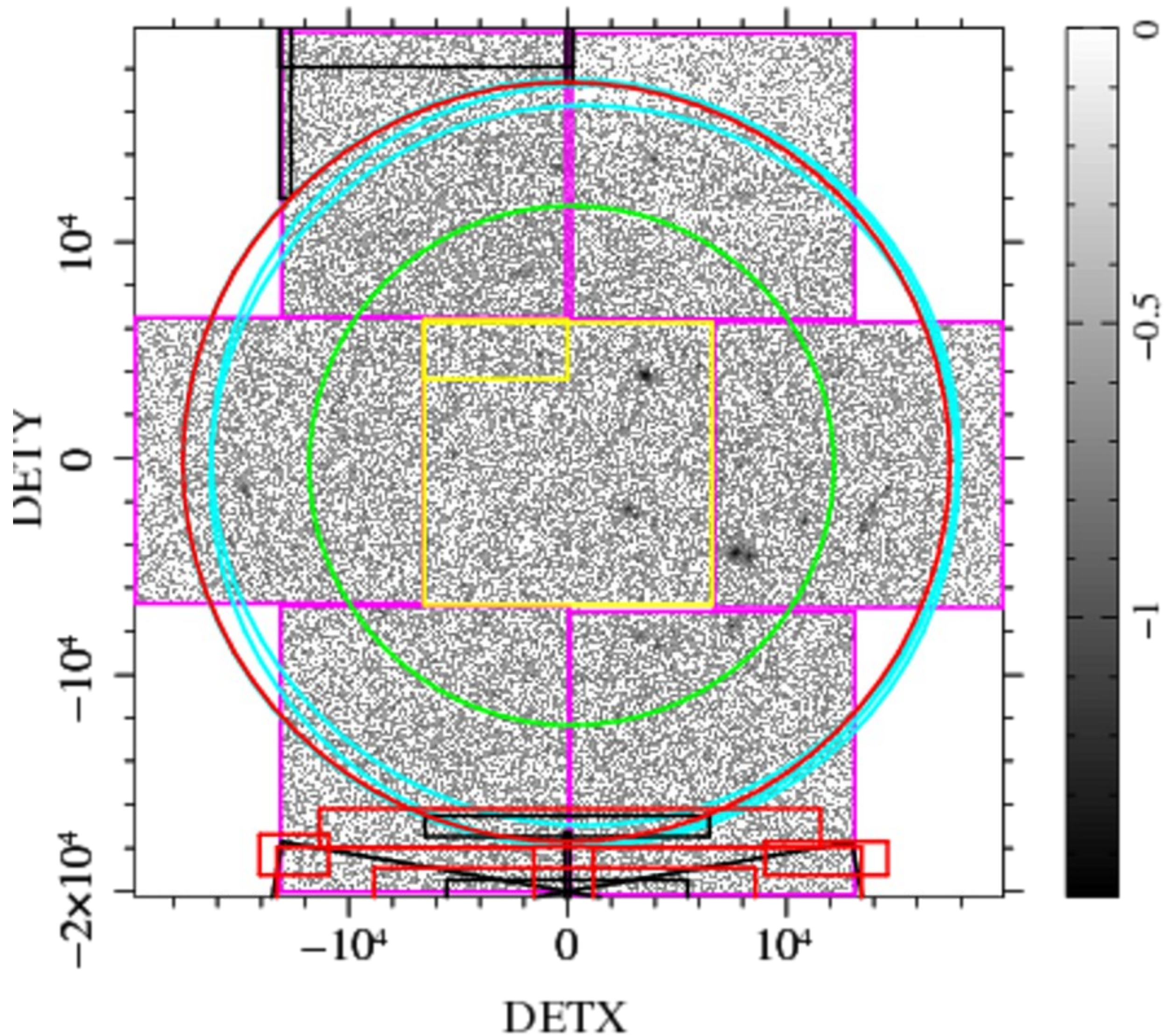
The XMM-CDFS simulator: overview

Background components (surface bright

To estimate the *k*, let's close the lid of the telescope: (**Filter Wheel: Closed**)

$$\Sigma_{FOV,FWC} = \Sigma_{PART} \cancel{+ \Sigma_{SP} + \Sigma_{COSM}}$$

$$\Sigma_{CORNER,FWC} = k\, \Sigma_{PART}$$



Filter Wheel Closed (FWC) data are available in the ESAS CALDB

The XMM-CDFS simulator: overview

Background components (surface brightnesses):

$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

$$\Sigma_{CORNER} = k\,\Sigma_{PART}$$

These are known

The XMM-CDFS simulator: overview

Background components (surface brightnesses):

$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

$$\Sigma_{CORNER} = k\,\Sigma_{PART}$$

Σ_{PART} is obtained

These are known

The XMM-CDFS simulator: overview

Background components (surface brightnesses):

$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

Σ_{COSM} is given by the integration of the LogN-LogS

$$\Sigma_{CORNER} = k\, \Sigma_{PART}$$

Σ_{PART} is obtained

These are known

The XMM-CDFS simulator: overview

Background components (surface brightnesses):

$$\Sigma_{FOV} = \Sigma_{PART} + \Sigma_{SP} + \Sigma_{COSM}$$

$$\Sigma_{CORNER} = k\, \Sigma_{PART}$$

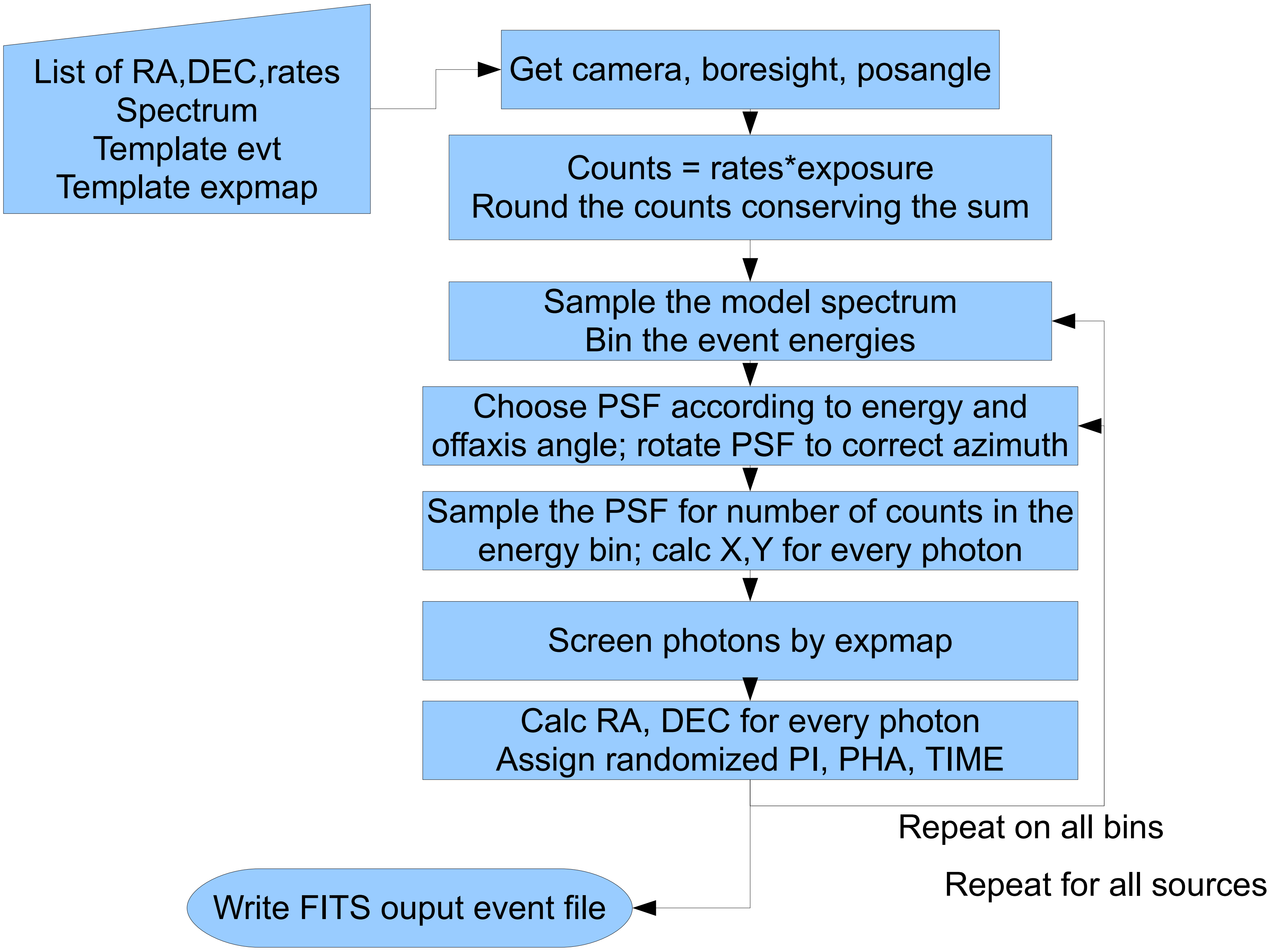
These are known

Σ_{PART} is obtained

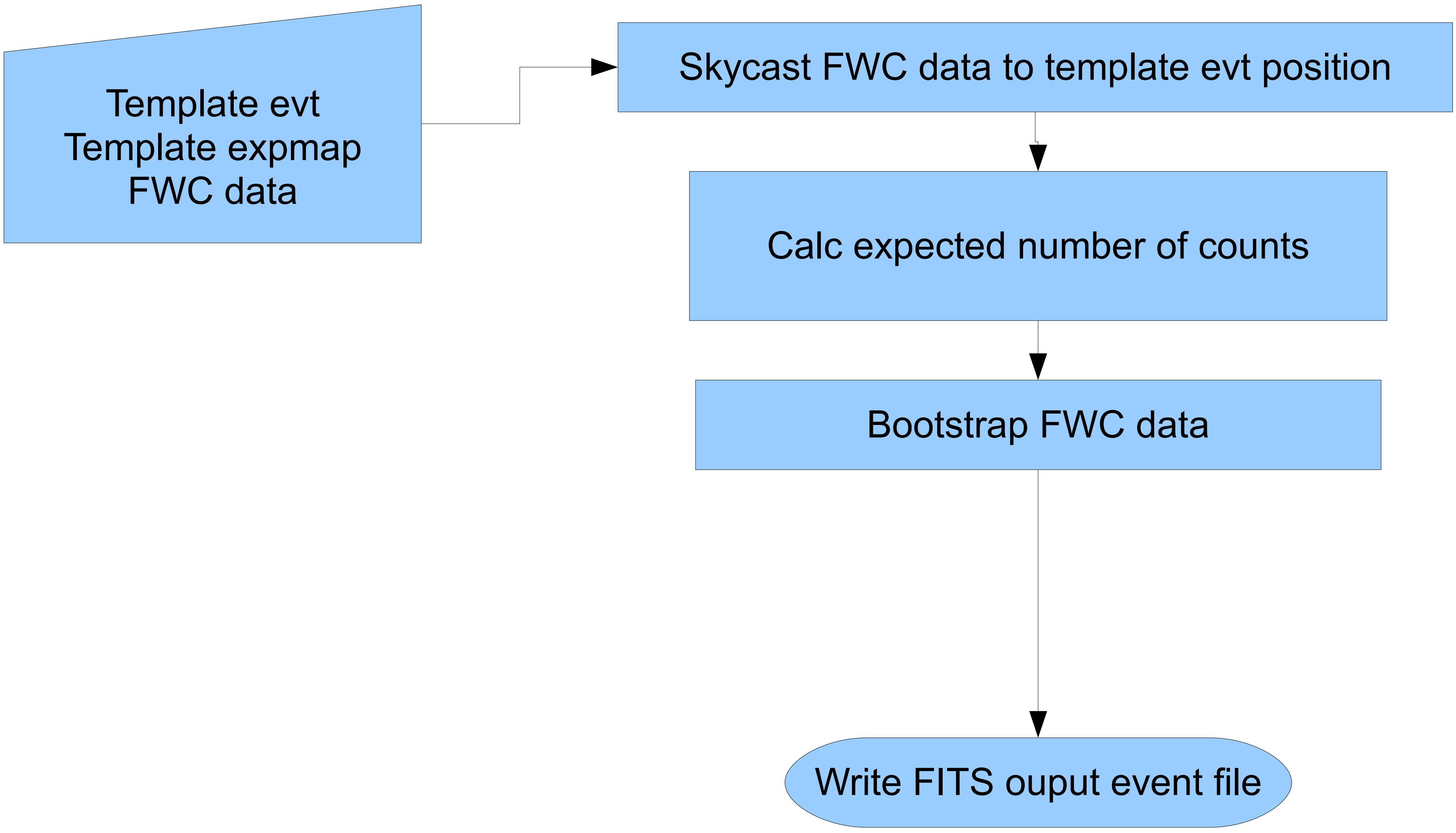
Thus Σ_{SP} is obtained

Σ_{COSM} is given by the integration of the LogN-LogS

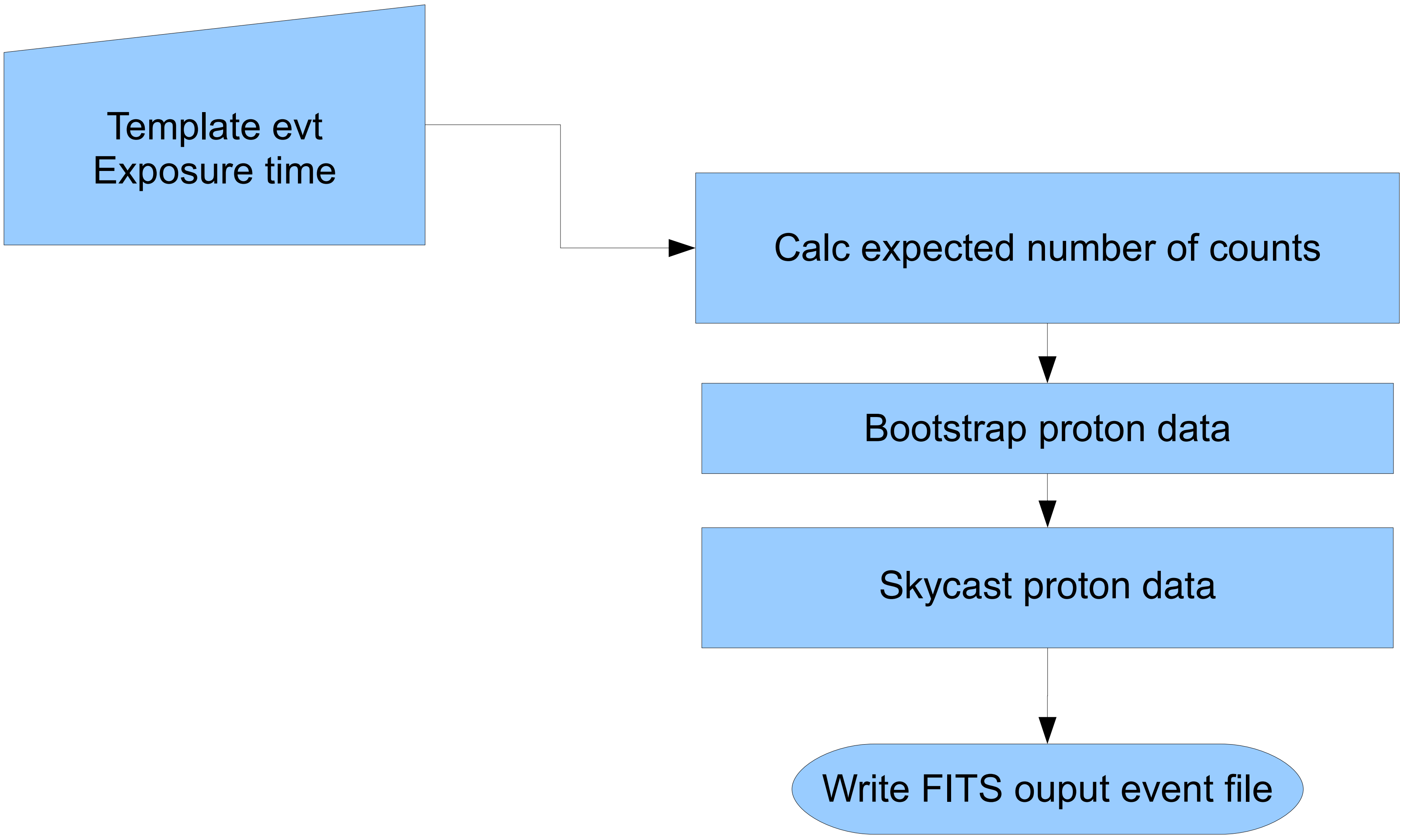
The XMM-CDFS simulator (sources)



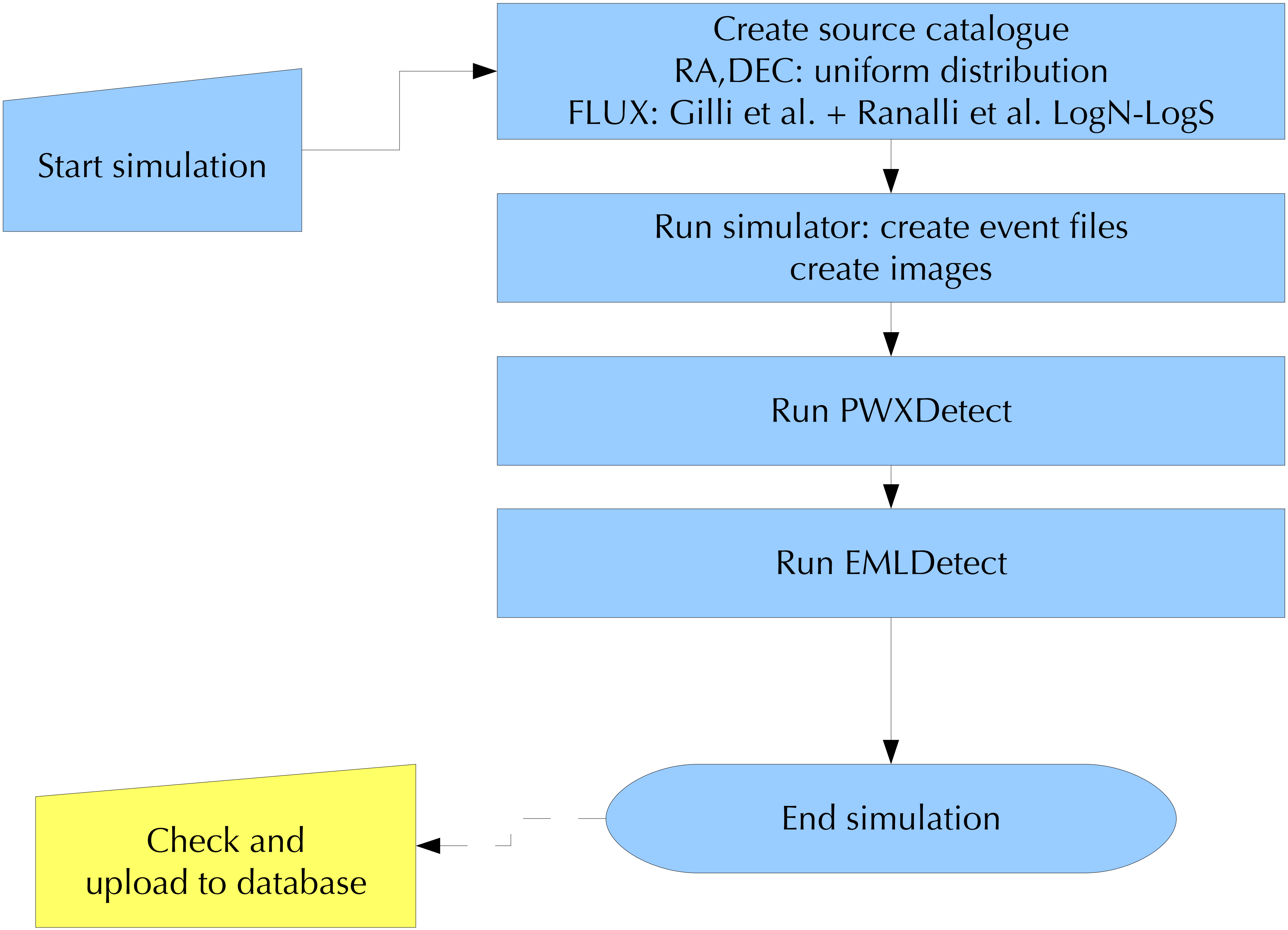
The XMM-CDFS simulator (particles)



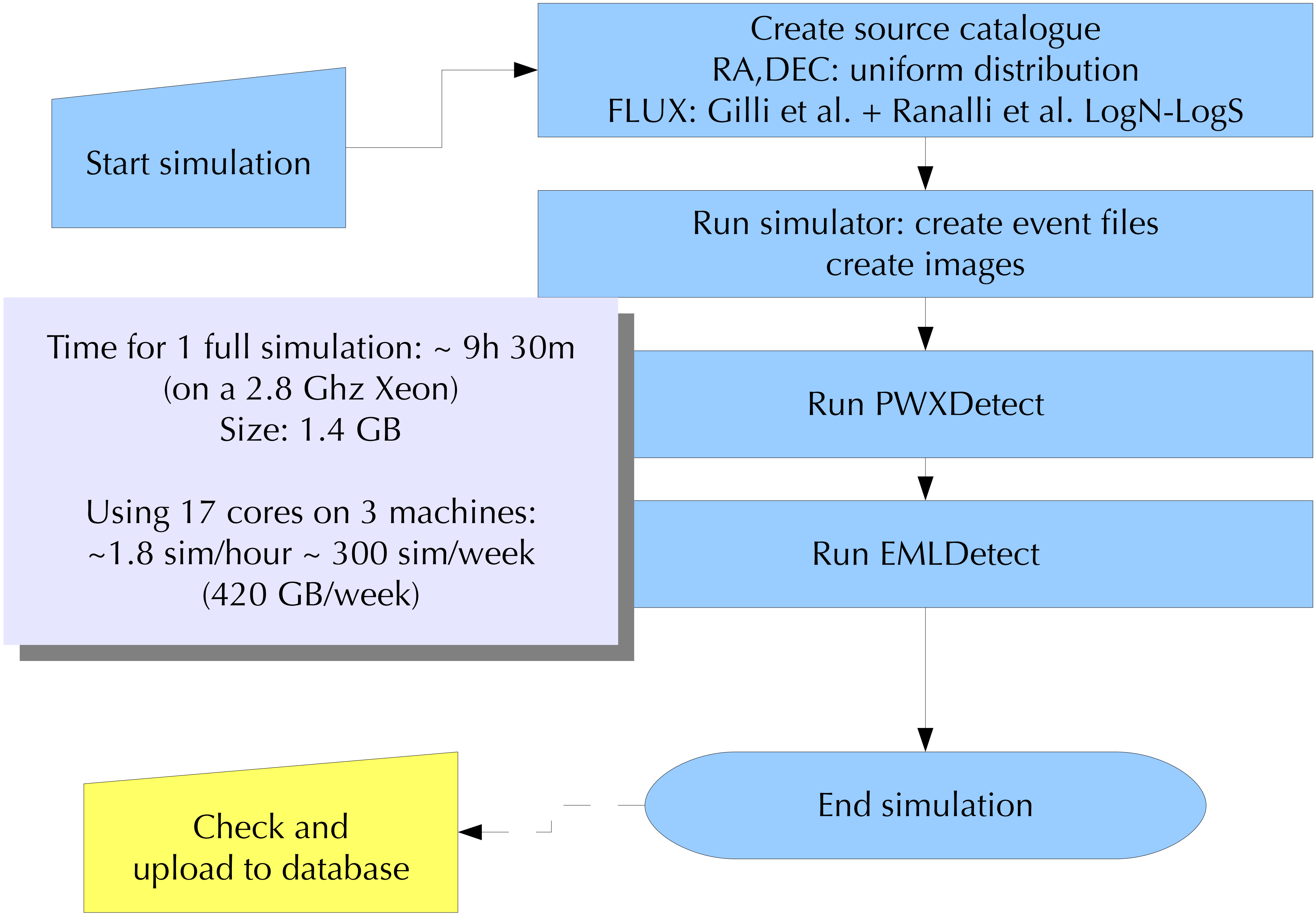
The XMM-CDFS simulator (residual soft protons)



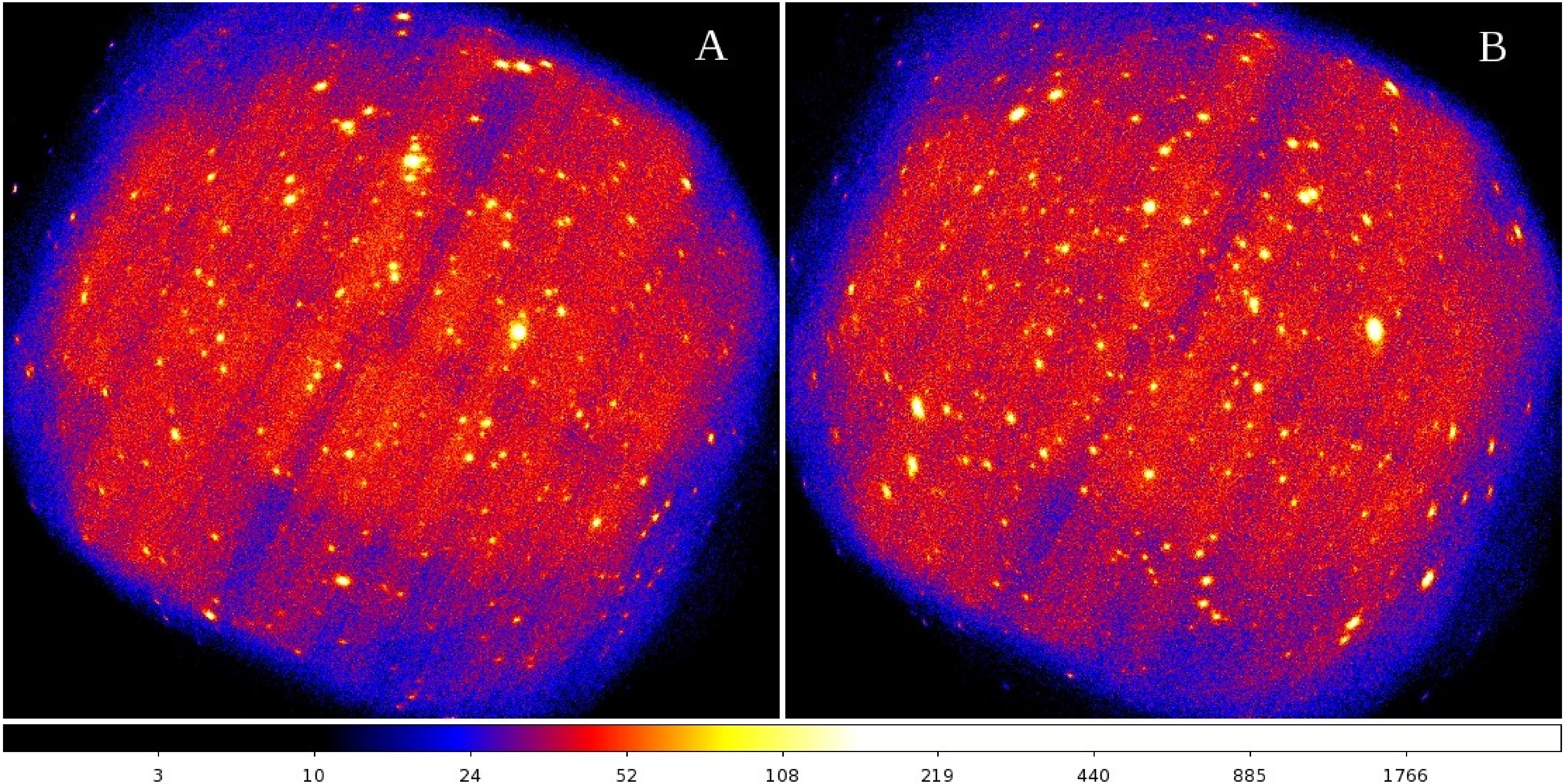
The XMM-CDFS simulator pipeline



The XMM-CDFS simulator pipeline



Simulated vs. real XMM-CDFS



The background level distribution is reproduced with a 7% error

Simulated data products:

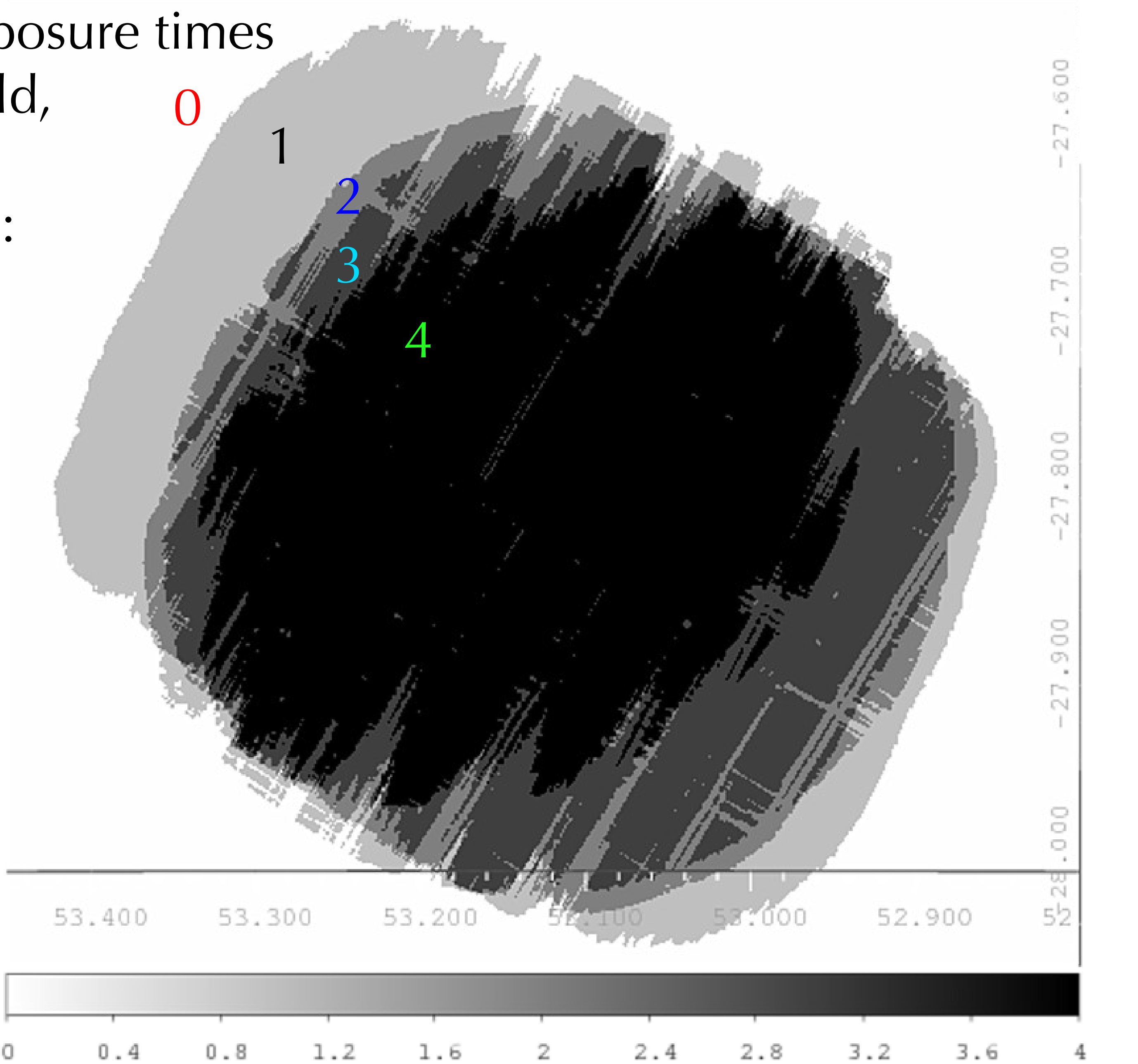
- INPUT catalogue (generated from LogN-LogS)
- PWXDected-ed catalogue (3σ-4σ thresholds)
- EMLDetect-ed catalogue ($ML \geq 4.6$)

Simulated data products:

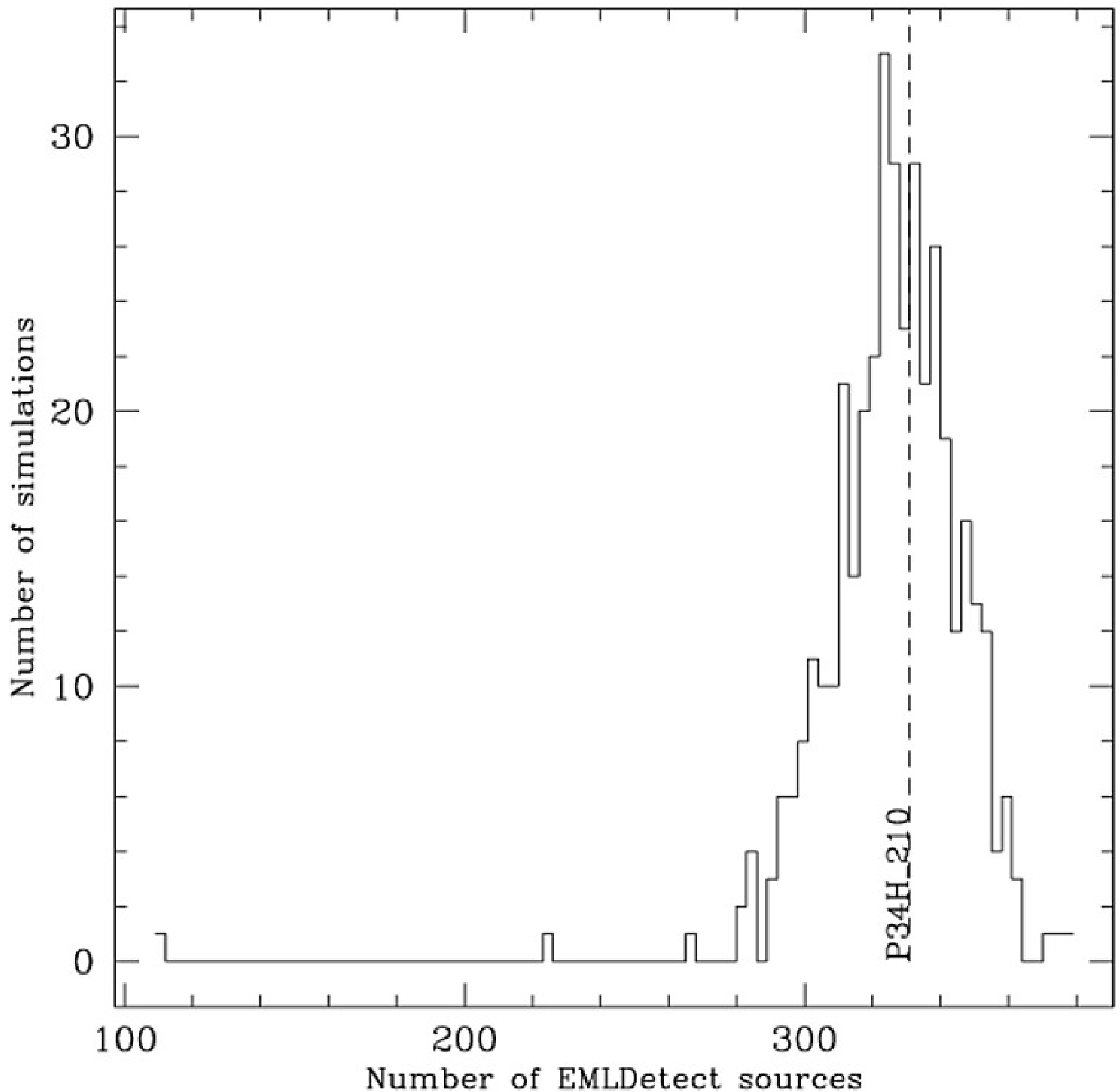
- INPUT catalogue (generated from LogN-LogS)	~500,000 sources
- PWXDected-ed catalogue (3σ-4σ thresholds)	338,446 sources
- EMLDetect-ed catalogue (ML≥4.6)	139,047 sources
	from 389 simulations

Catalogue screening: the *detector mask*

Remove sources with exposure times below minimum threshold, just like we did for the P34H_210 catalogue: retain only sources with detmask ≥ 1



EMLDetect-ed sources



Simulated data products:

- INPUT catalogue (generated from LogN-LogS)
- PWXDected-ed catalogue
- EMLDetect-ed catalogue (subset of PWXD)

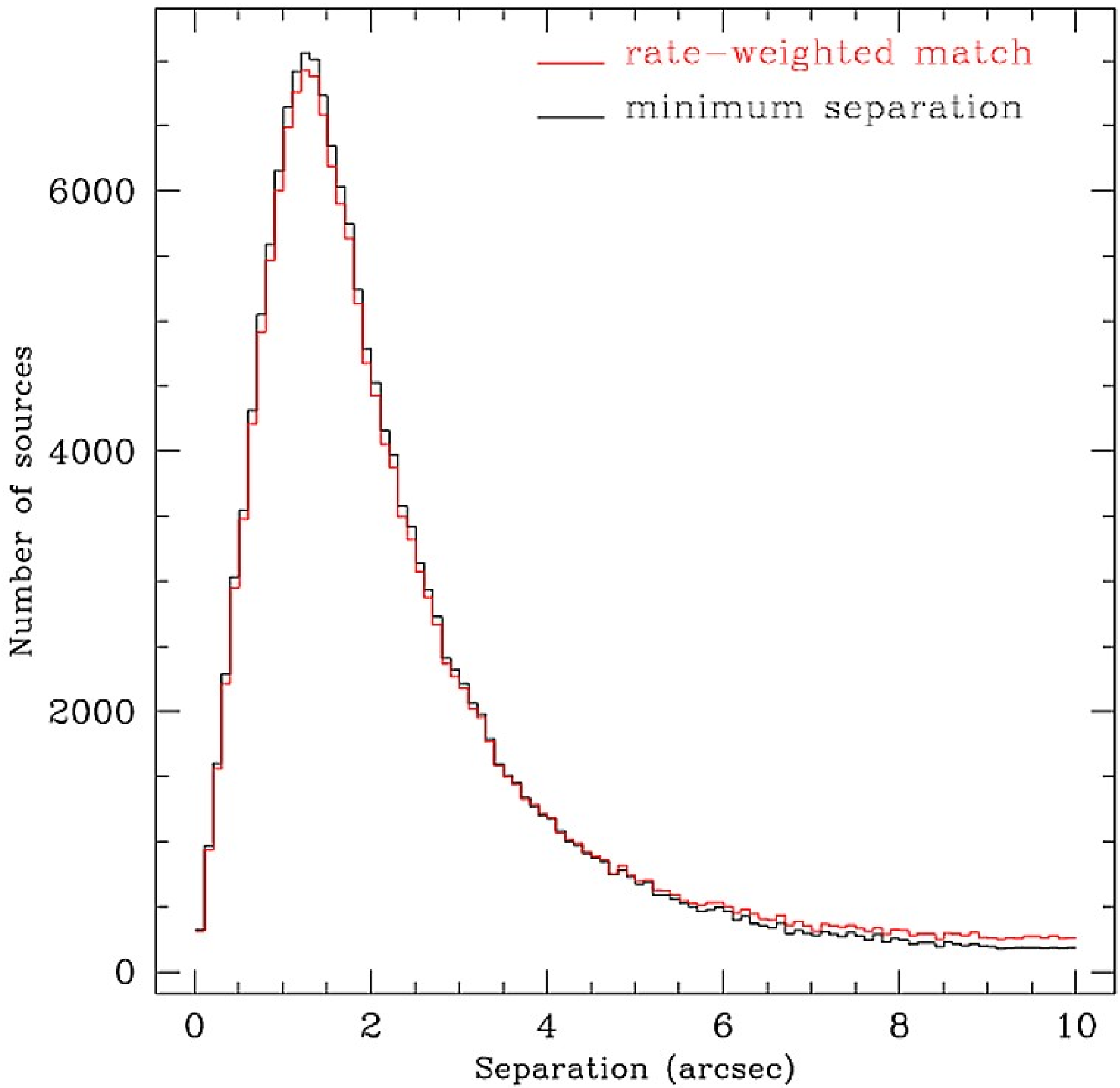
Cross-correlations:

INPUT and EMLD => *recovered* sources
INPUT and not EMLD => *missed* sources
EMLD and not INPUT => *fake* sources

Cross-correlation methods:
- nearest source
- minimum χ^2, defined as:

$$\chi^2=(\Delta RA/RA\_err)^2+(\Delta DEC/DEC\_err)^2+(\Delta S/S\_err)^2$$

Separation between input and pwxd souces



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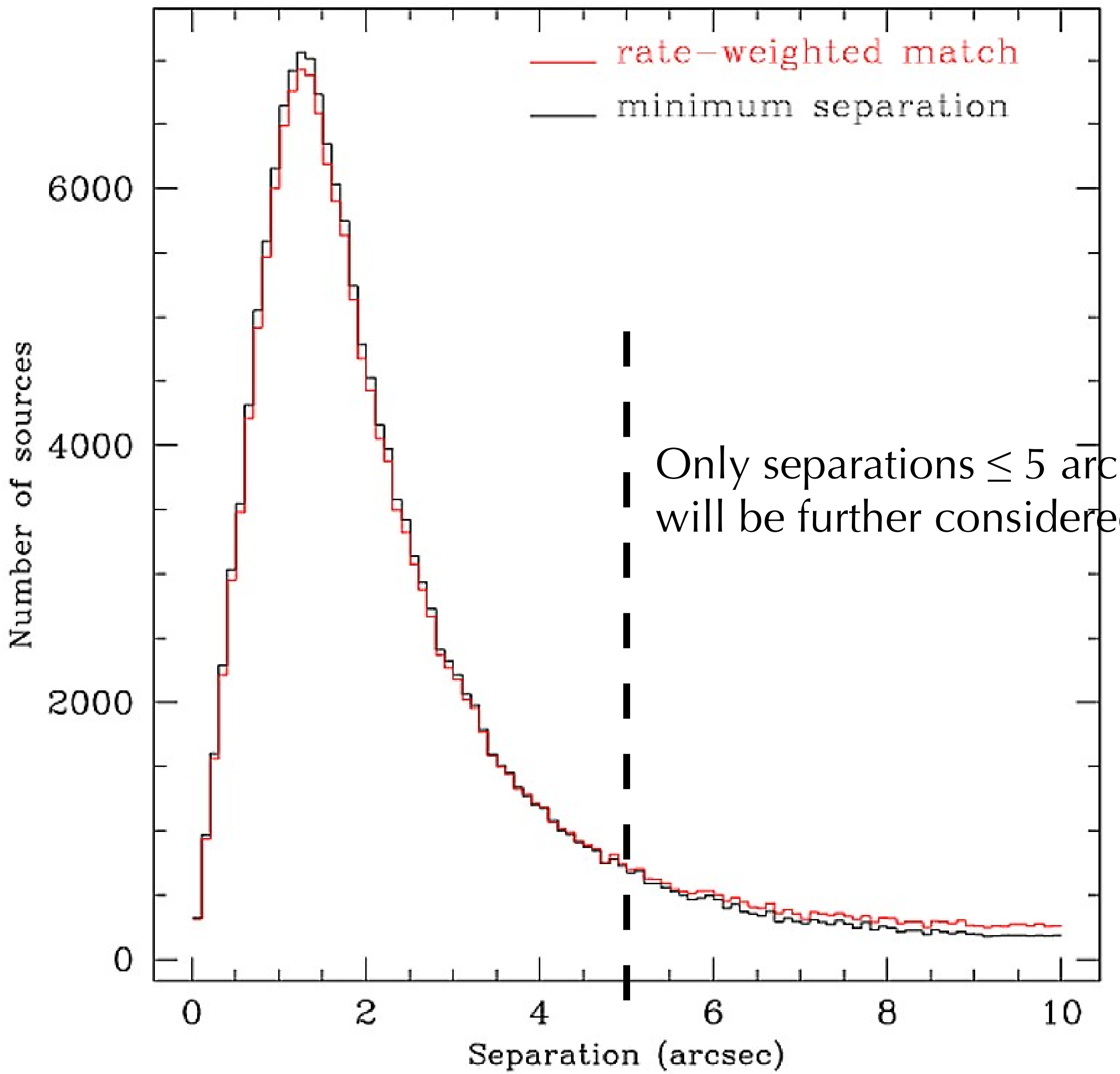
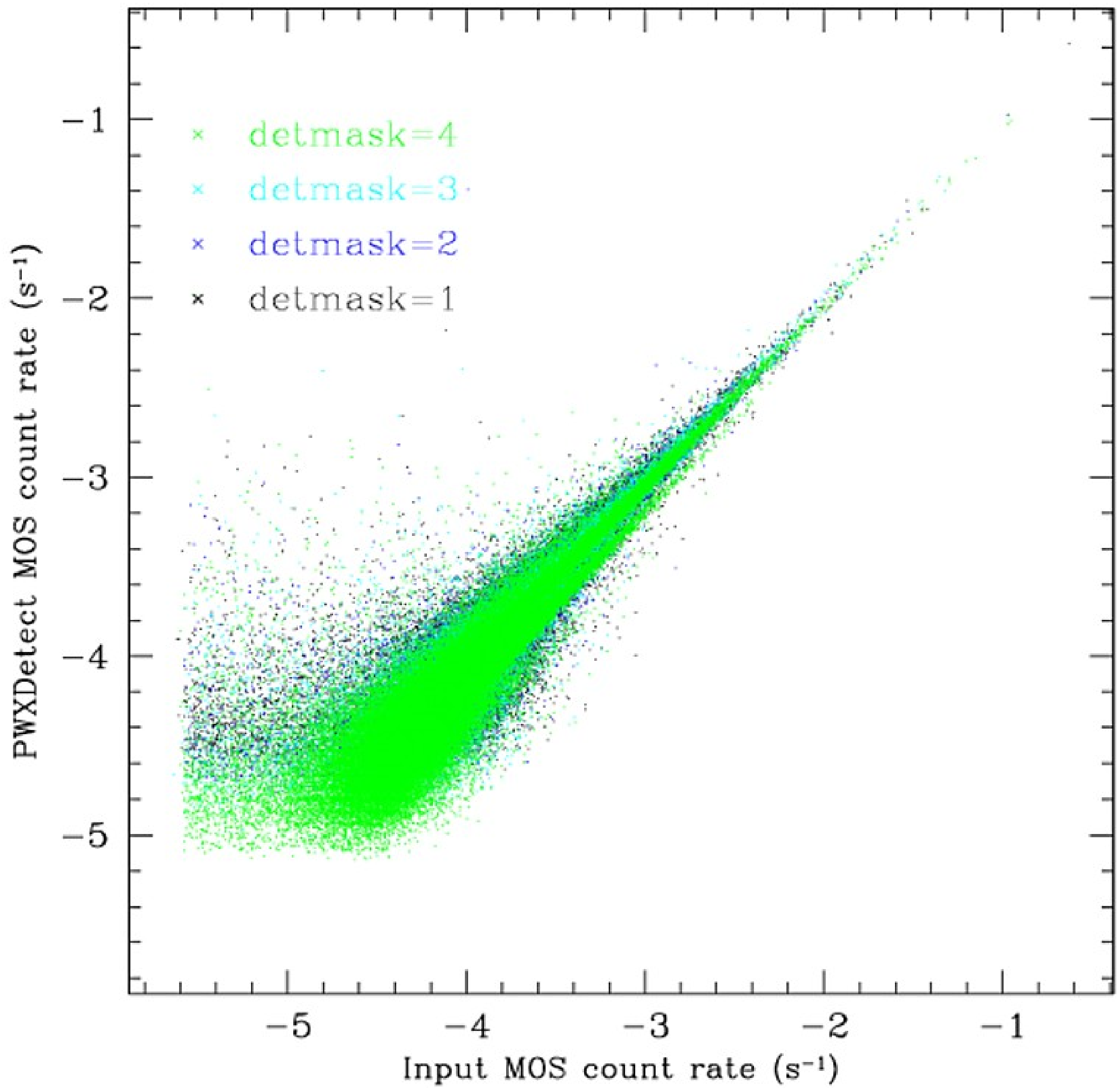


Only separations ≤ 5 arcsec
will be further considered

INPUT vs. PWXD rates (151121 sources from 389 simulations)
match: nearest source



INPUT vs. PWXD rates (151121 sources from 389 simulations)
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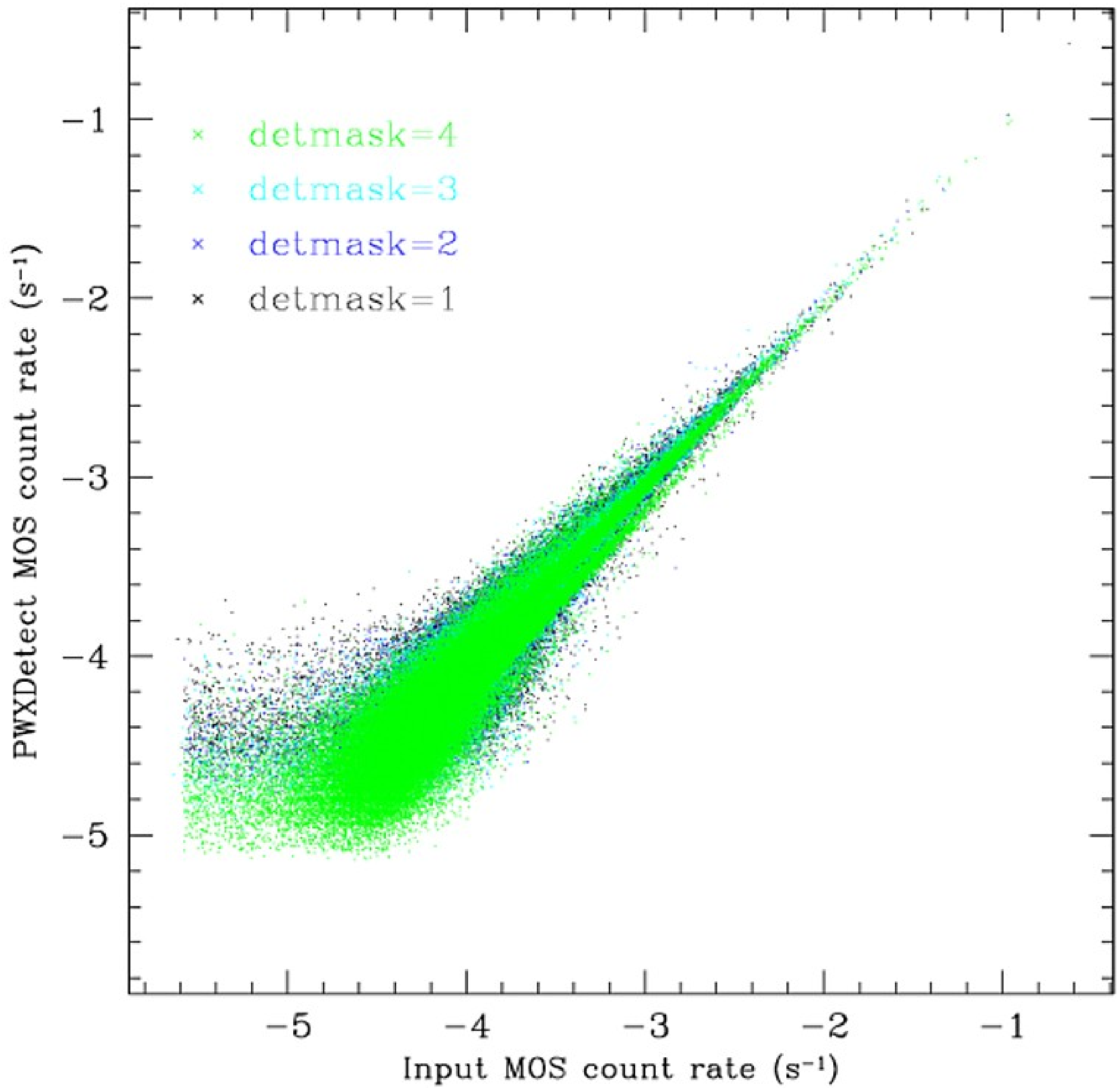
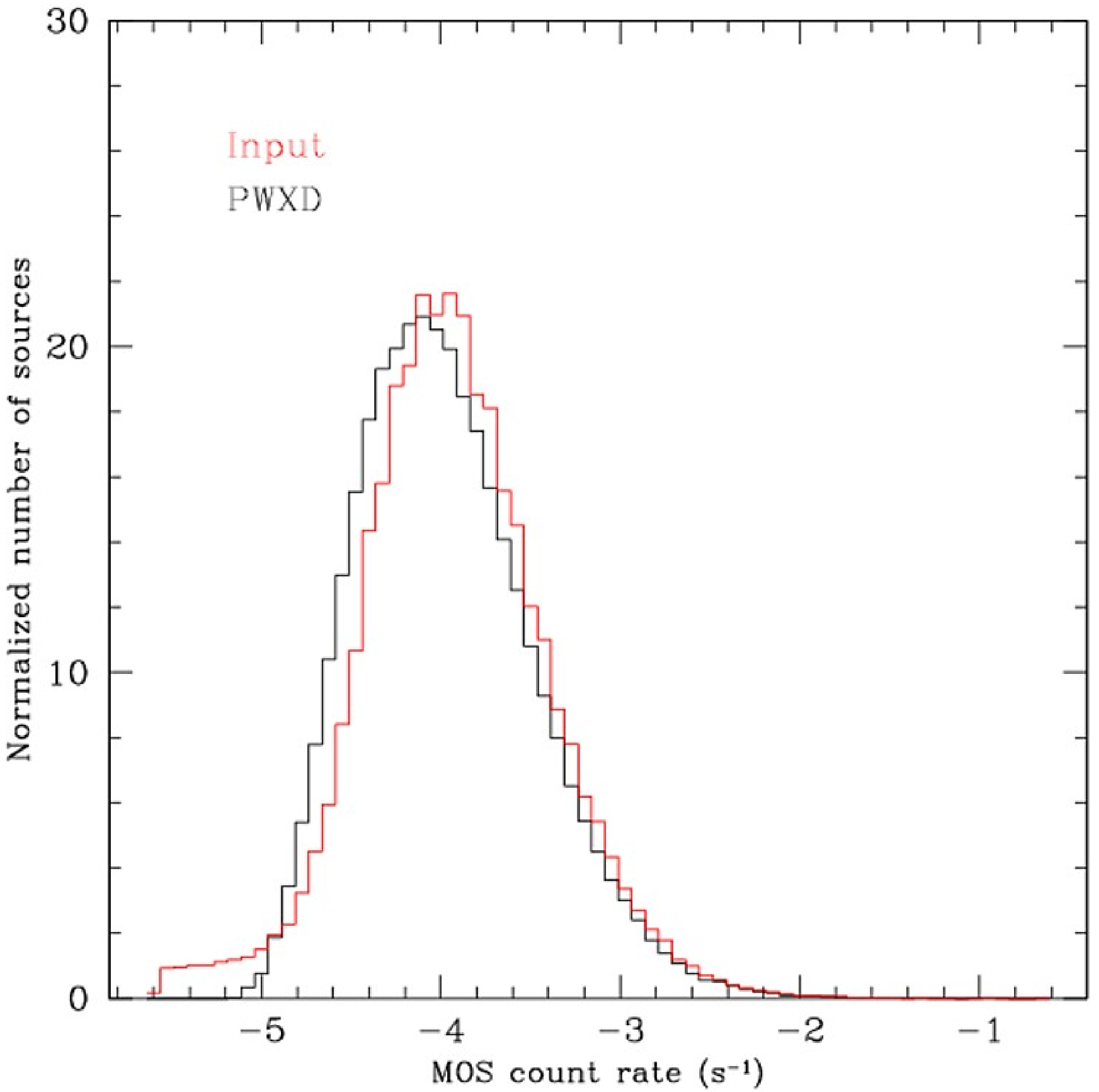
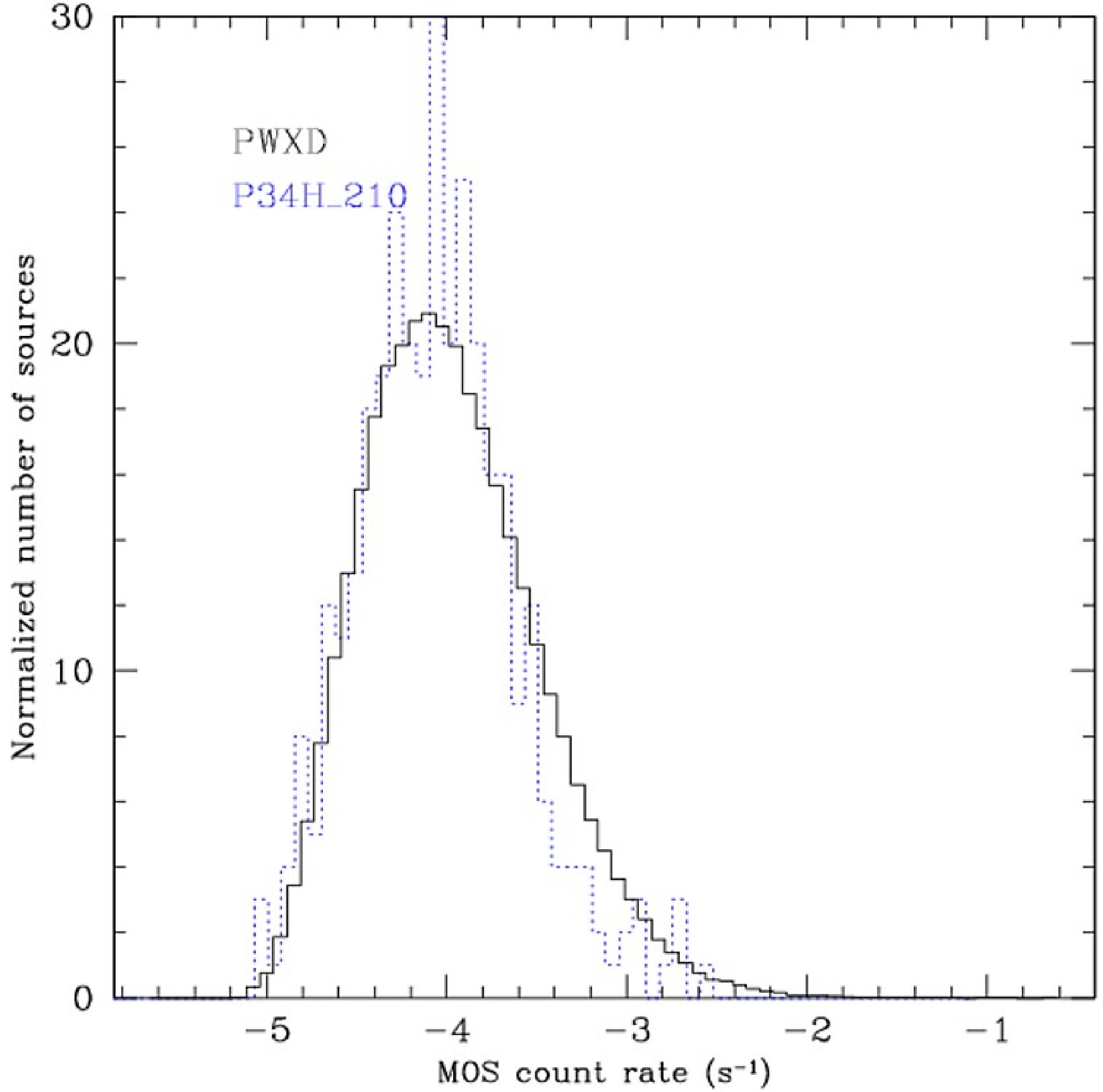


INPUT vs. PWXD rates (151121 sources from 389 simulations)
match: minimum χ^2

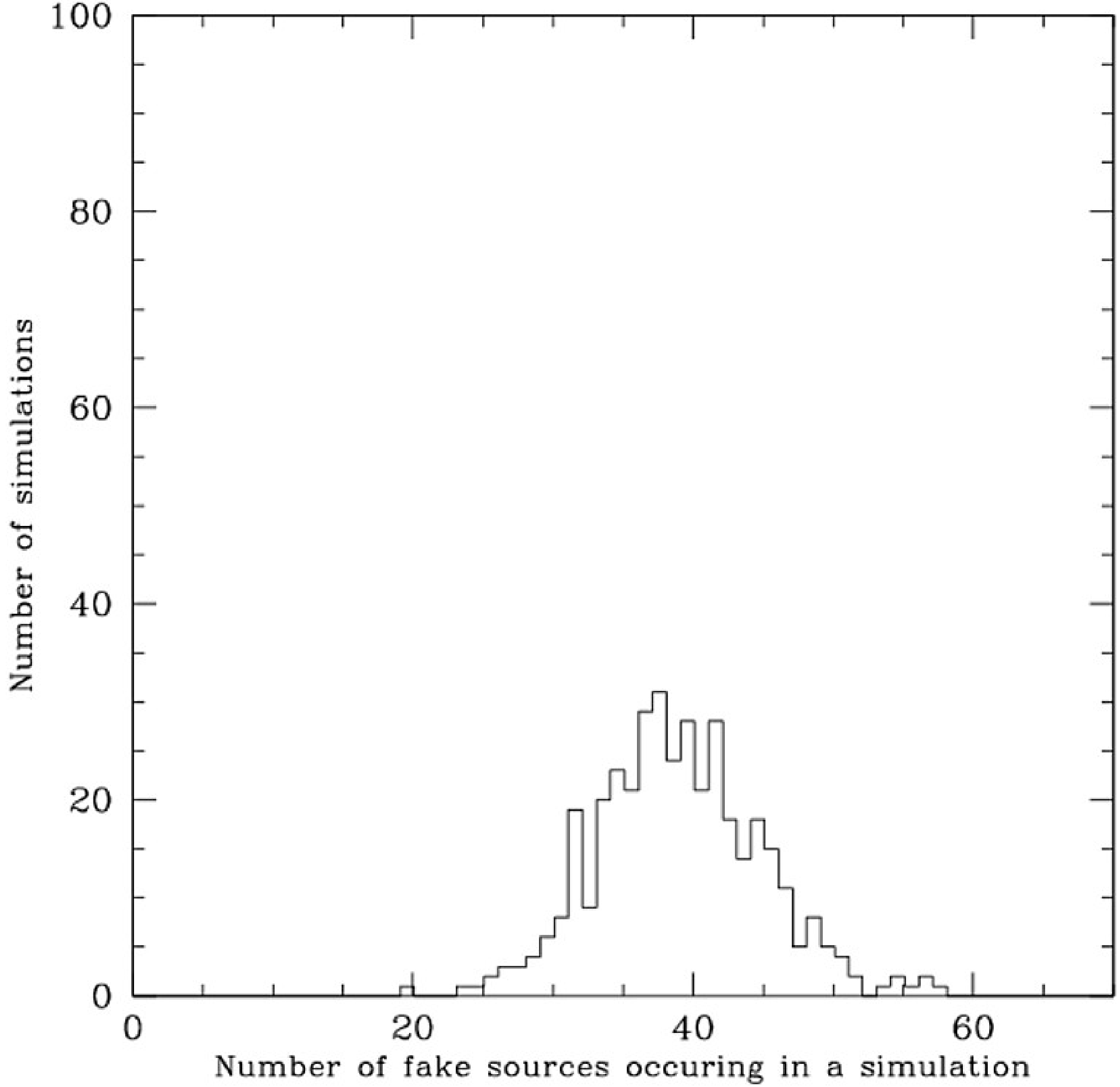
PWXD slightly underestimates the count rates



P34H vs. PWXD rates



Fake sources



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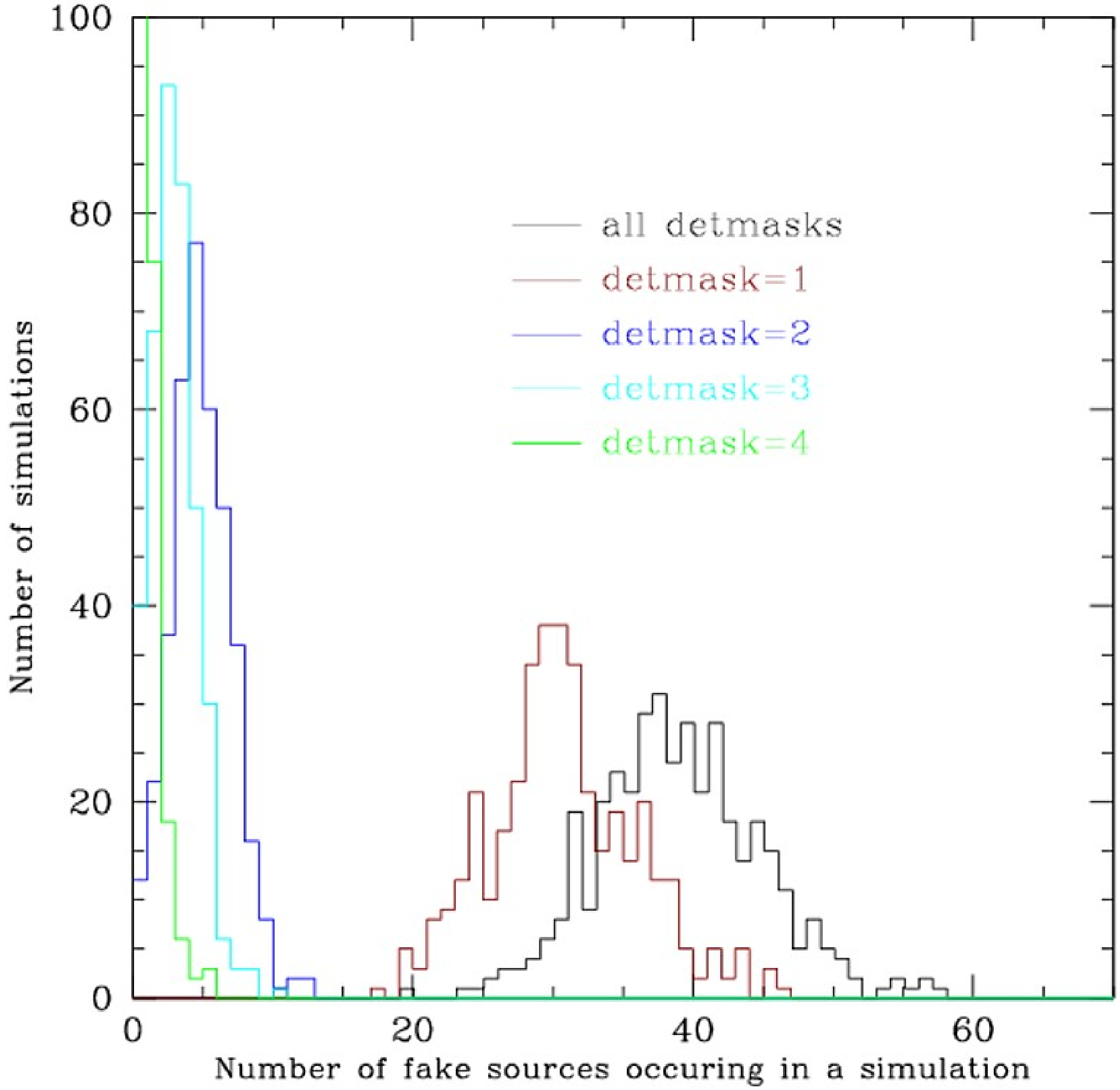
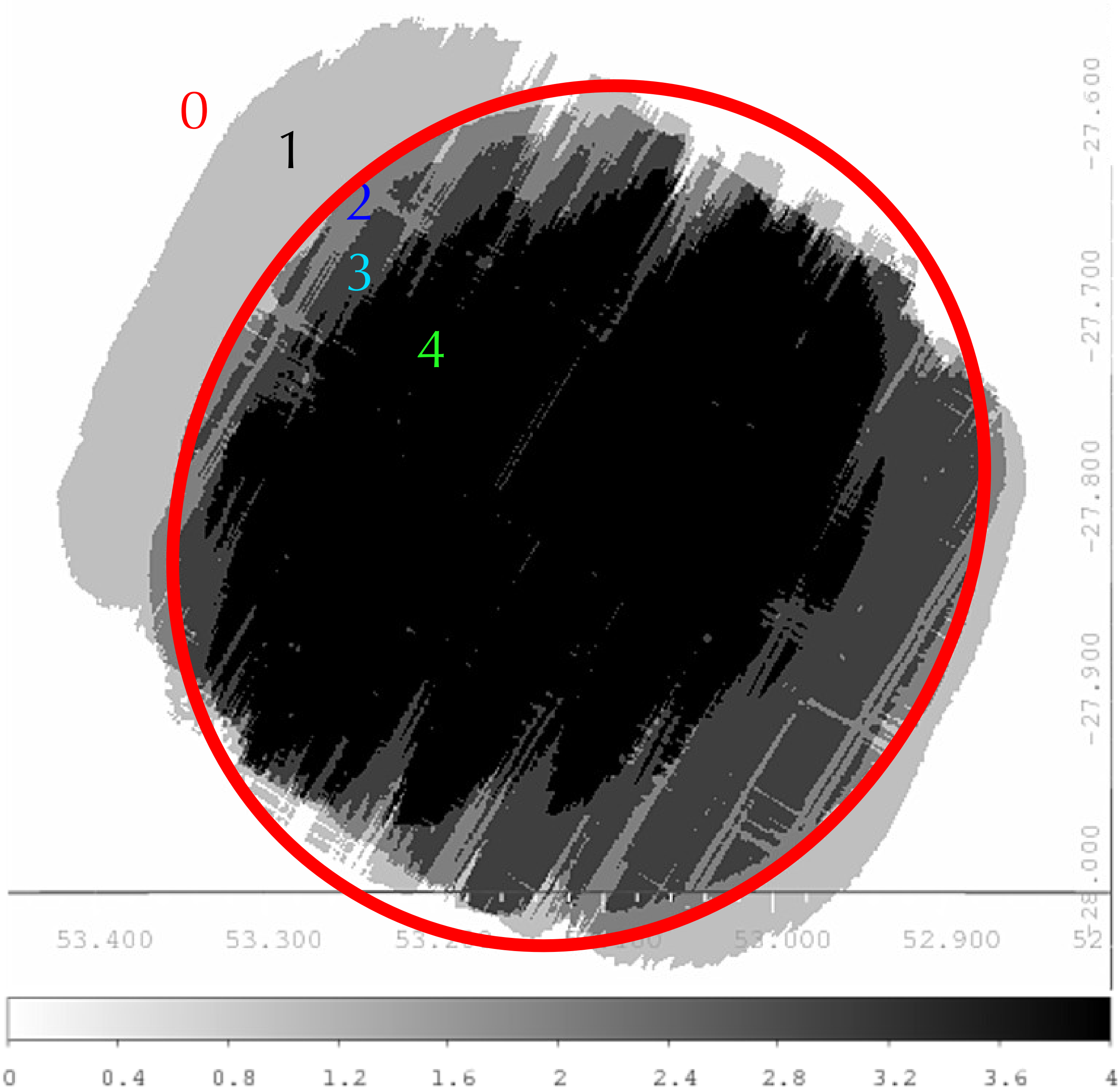


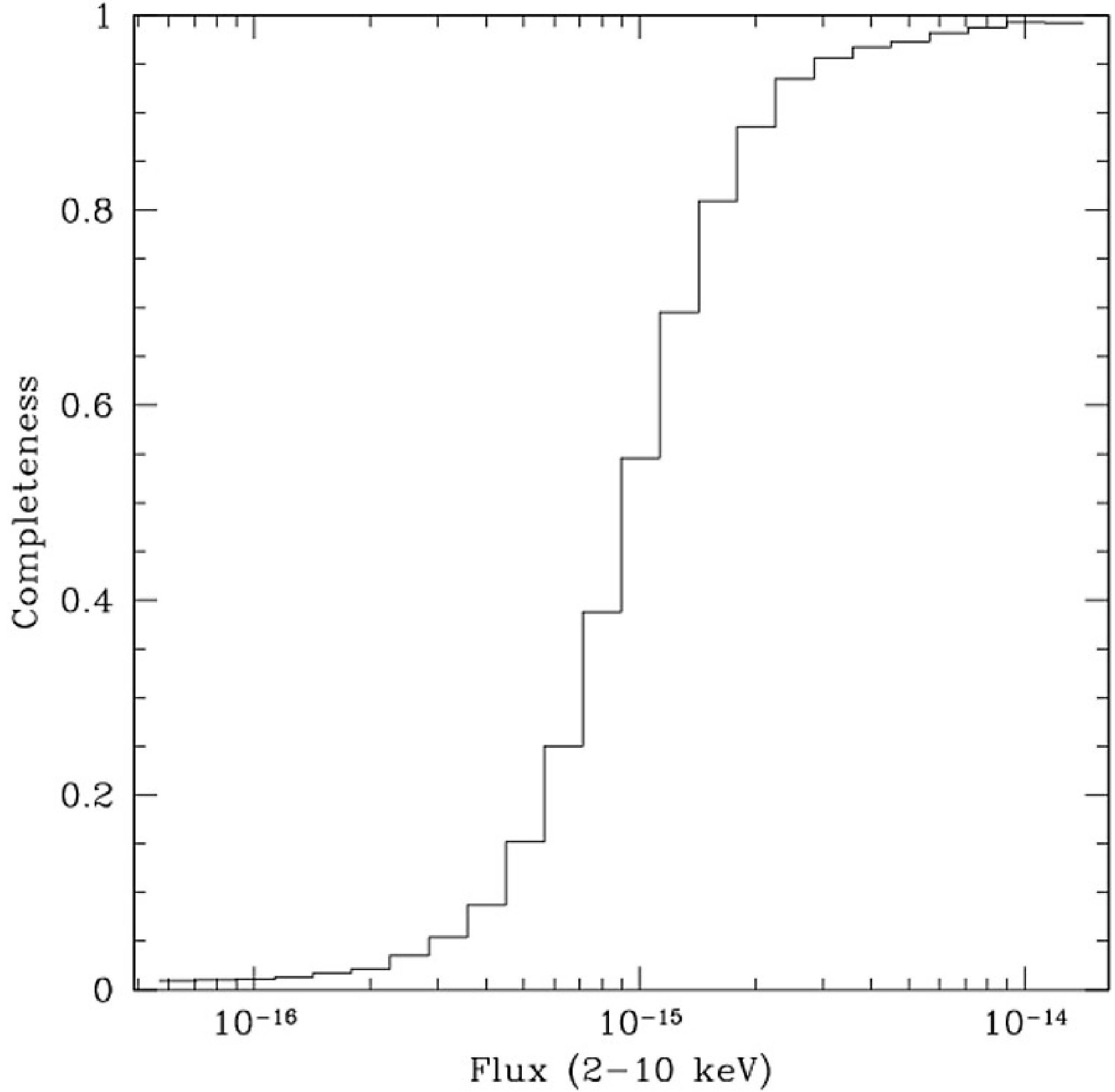
Definition of "most reliable" area

detmask ≥ 2



Completeness

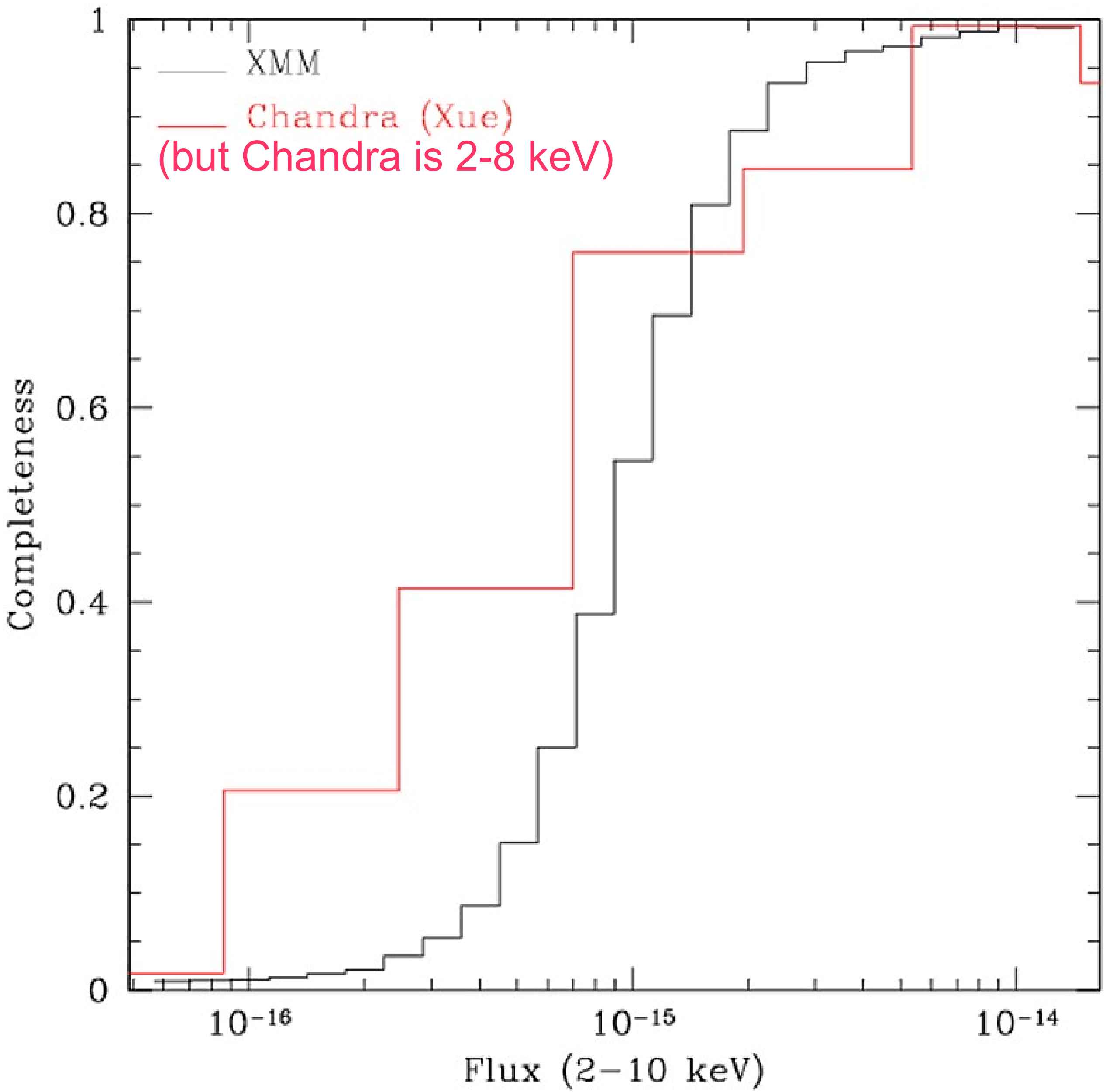
$$C(F) = \left. \frac{N(\mathrm{det})}{N(\mathrm{sim})} \right|_F$$



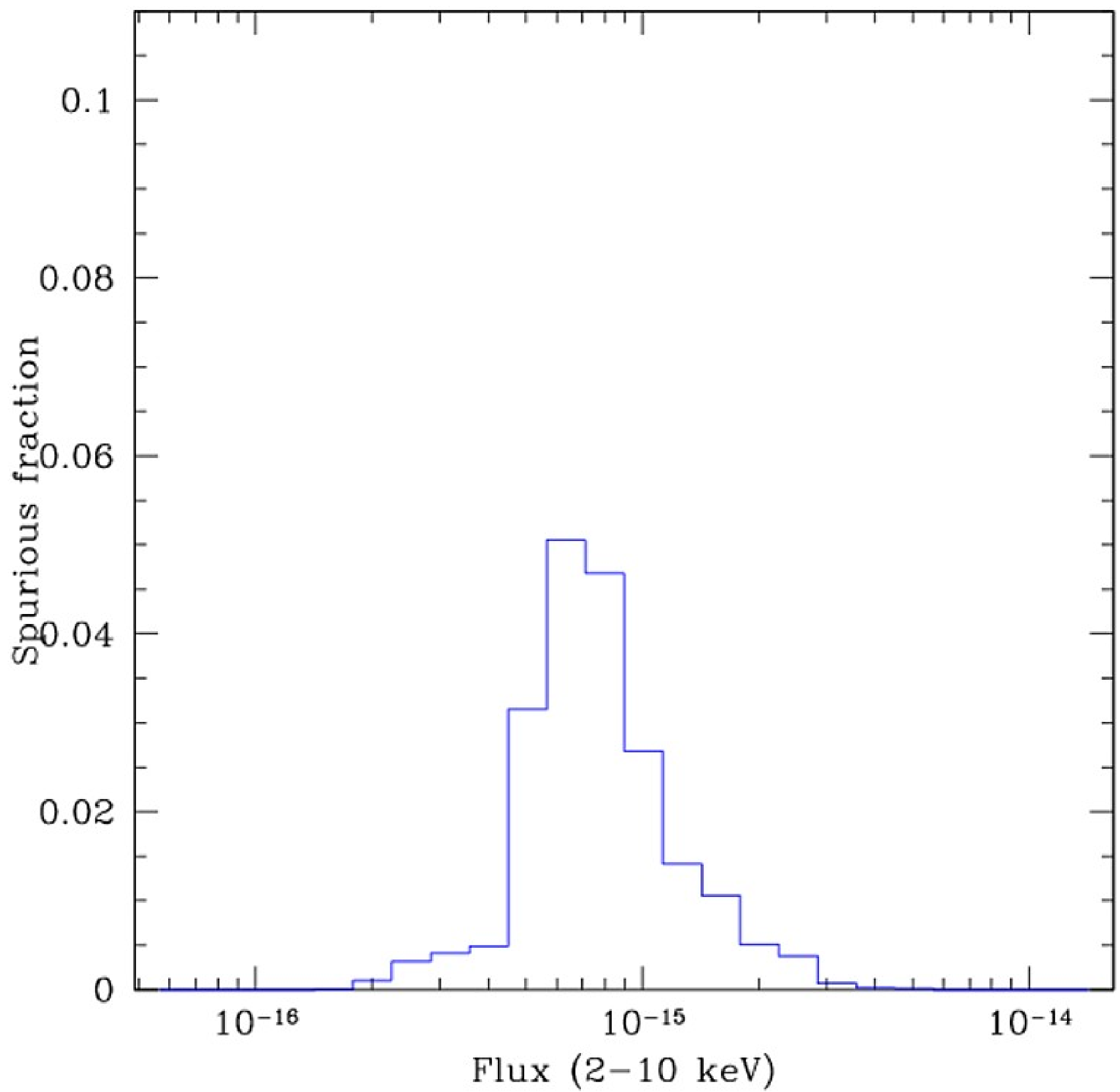
Completeness

$$C(F) = \left. \frac{N(\mathrm{det})}{N(\mathrm{sim})} \right|_F$$

Chandra may go fainter, but XMM has much better completeness in the 10^{-15} decade



Spurious fraction (N(fake)/N(sim))



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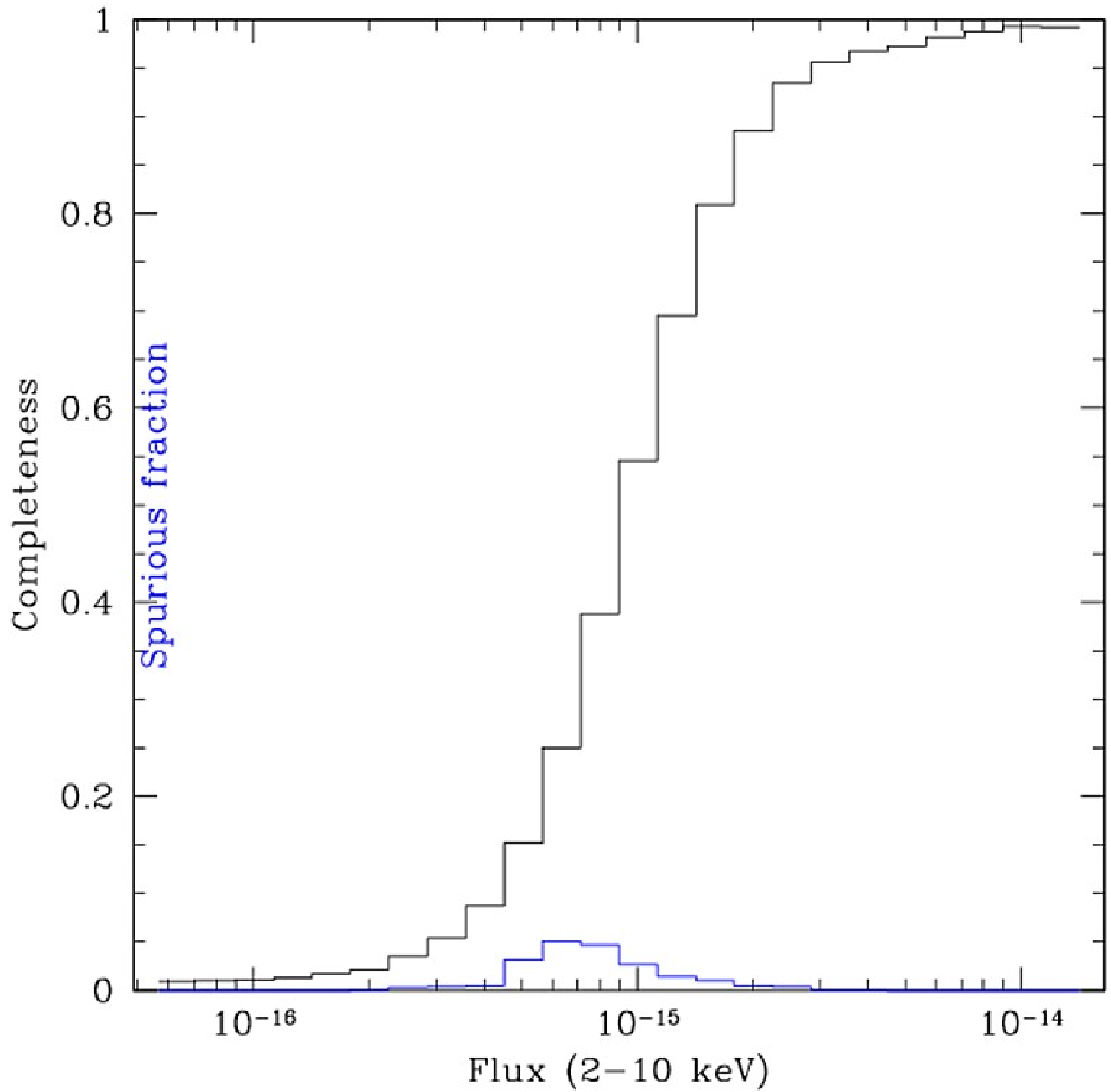
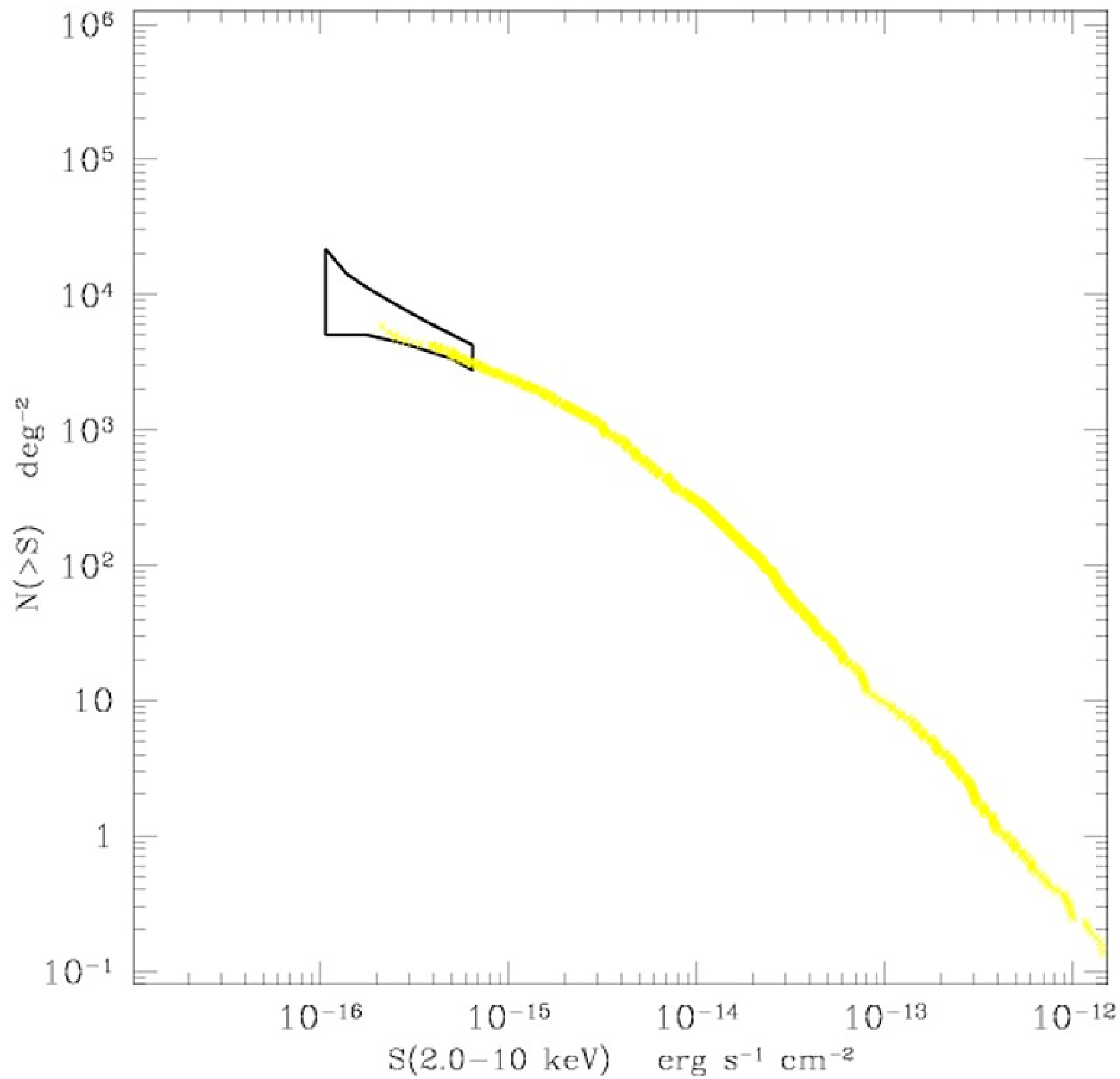


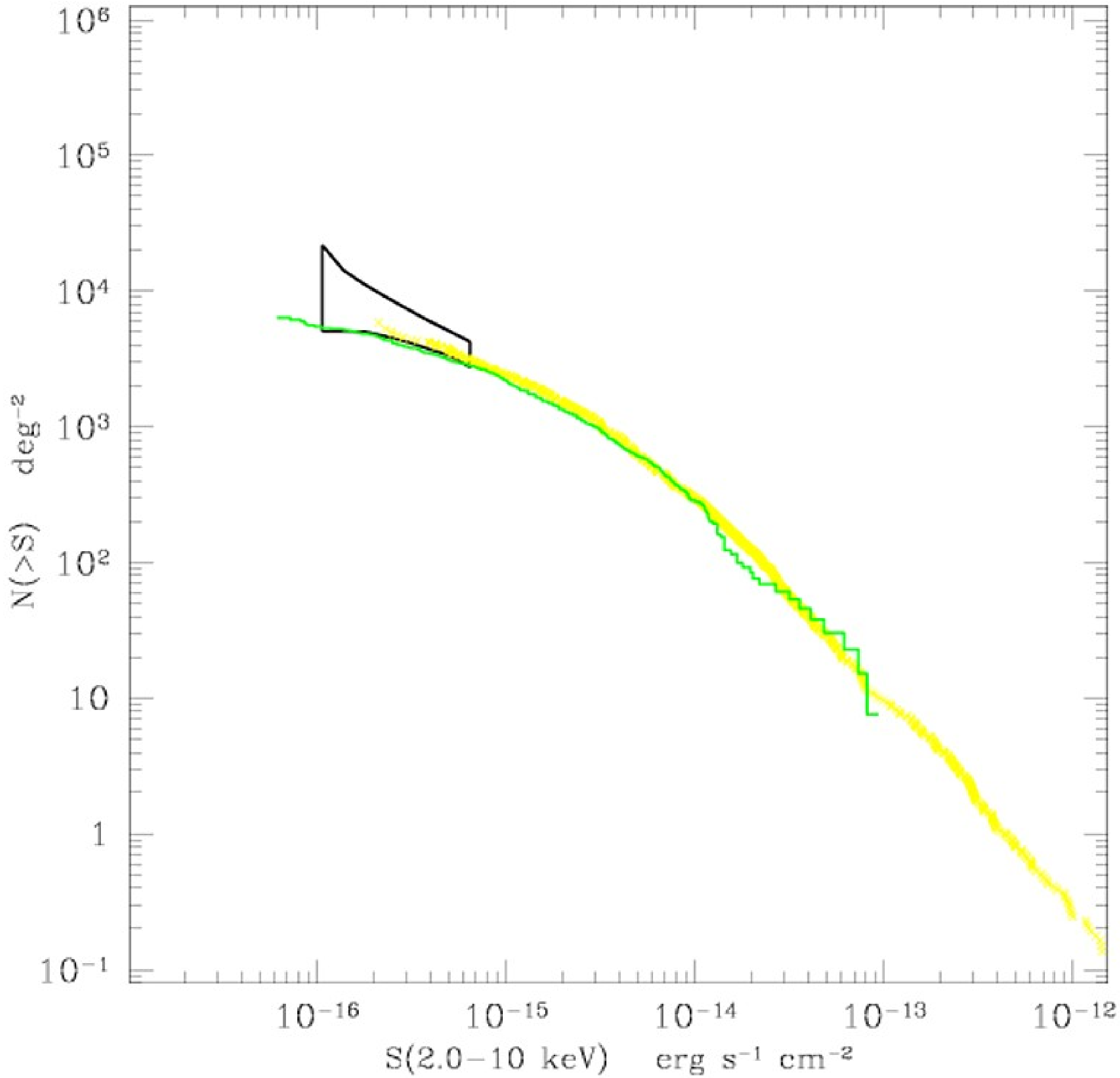
2-10 keV LogN-LogS

Moretti+Miyaji:



2-10 keV LogN-LogS

Xue:



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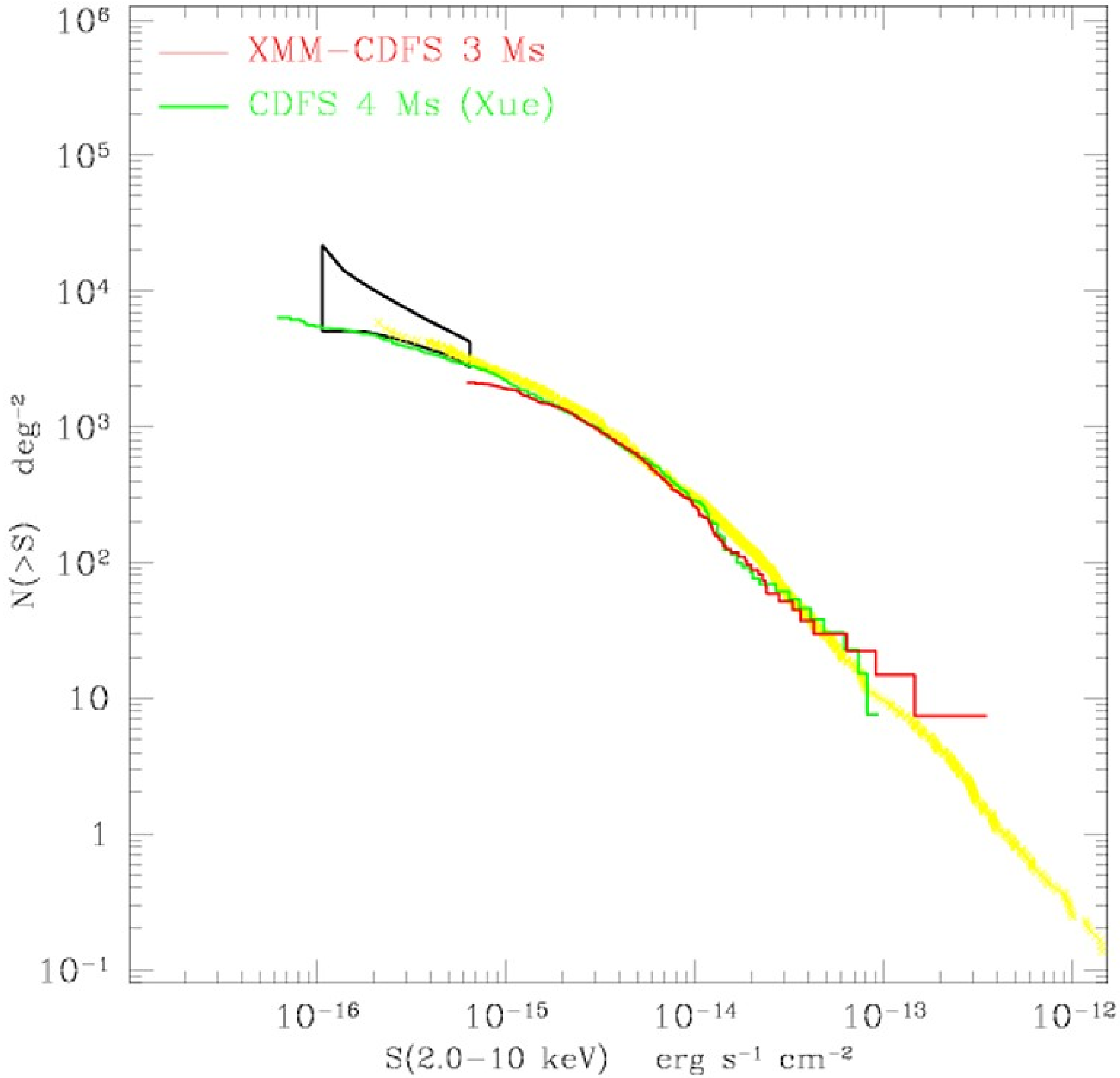

Conclusions

The P34H_210 catalogue has been validated by extensive simulations,

which have characterised it in terms of **completeness**, **reliability**, and **flux limit**.

Next steps:

* Fraction of confused sources

* Is it possible to go deeper?

* 5-10 keV where we should have real advantage over Chandra