PGWave parameters study for the gravitational wave follow-up with Fermi-LAT

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- Introduction to PGWave and motivation
- Simulations:
    - Flux
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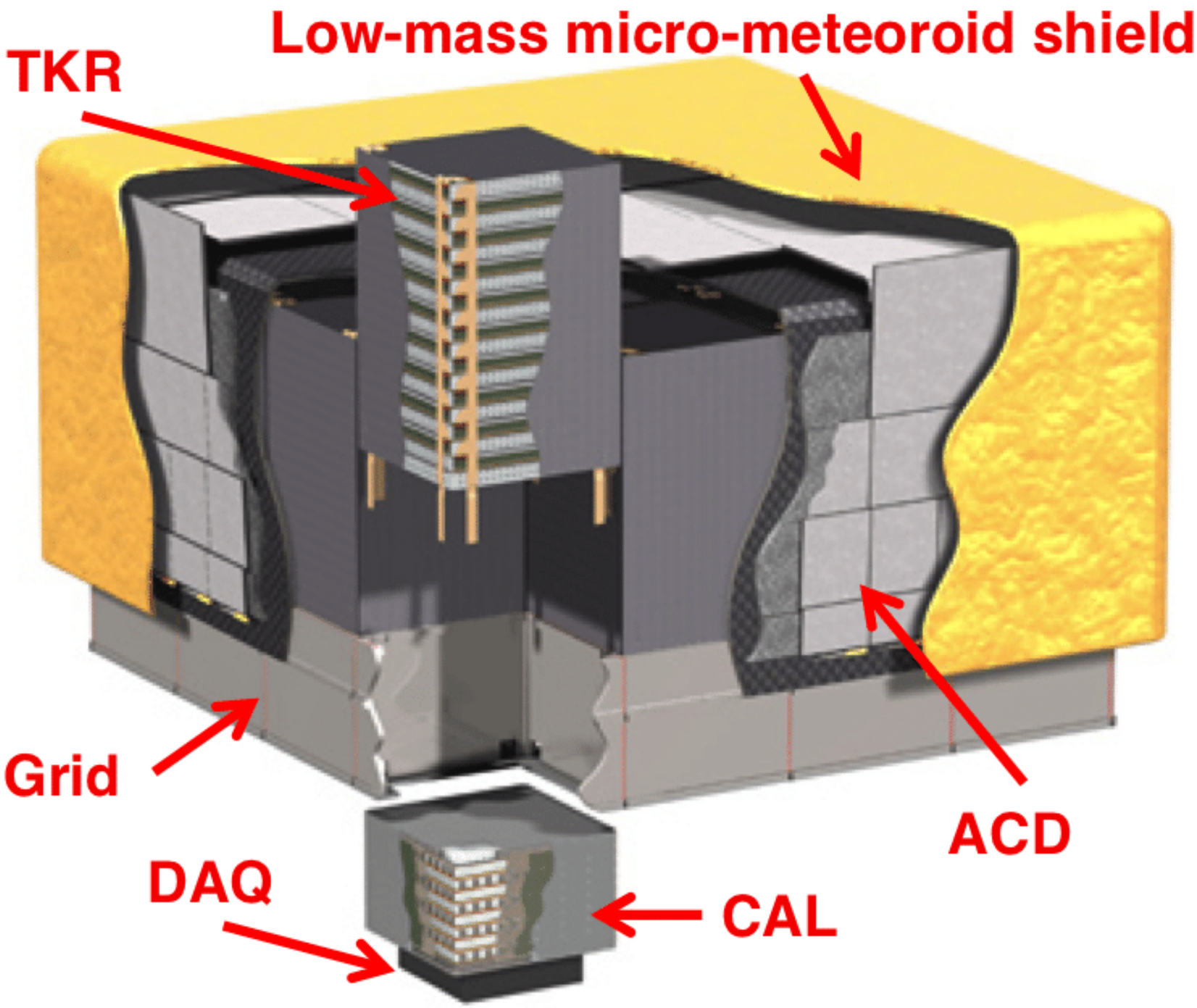
- Results
- Final considerations and future application for the GW follow-up

Fermi - LAT: detectors



PGWave method

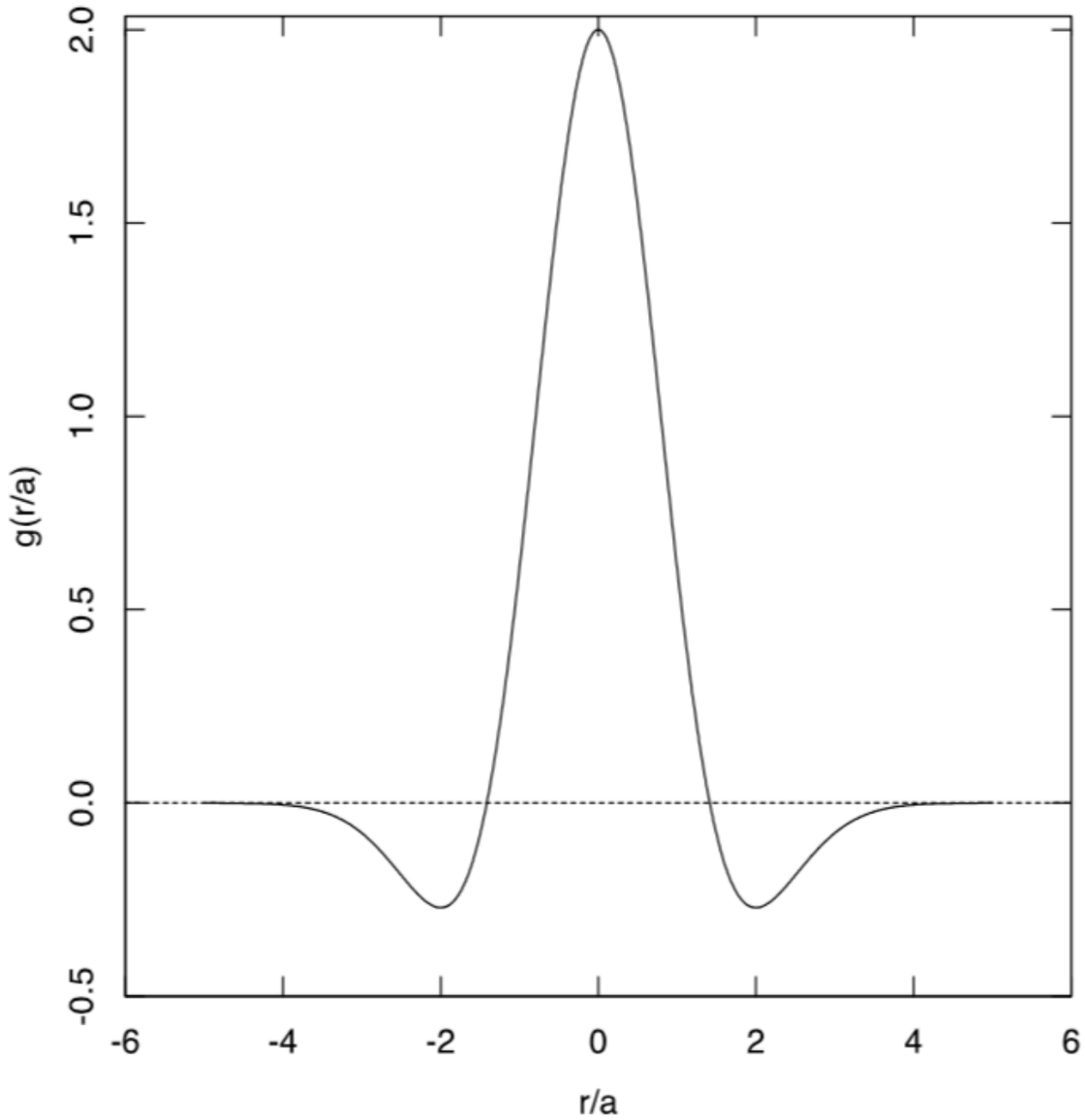
- PGWave is a source detection software based on Wavelet Transforms (WTs) that can detect sources in astronomical images.

$$w(x,y,a) = \iint g\left(\frac{x-x'}{a}, \frac{y-y'}{a}\right) f(x',y')\mathrm{d}x'\mathrm{d}y'$$

- Mexican Hat WT (2-dim.)

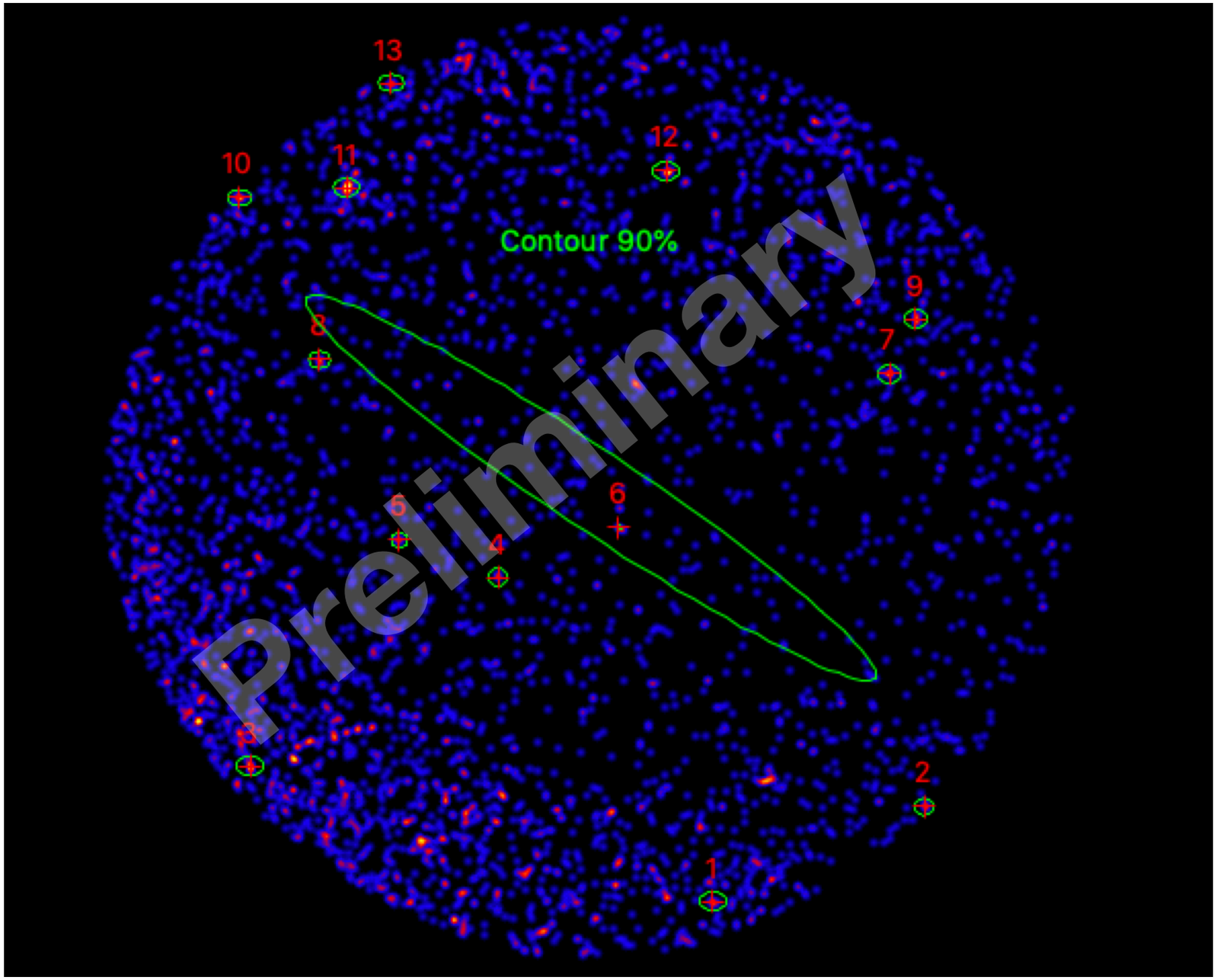
$$g\left(\frac{x}{a}, \frac{y}{a}\right) = g\left(\frac{r}{a}\right) = \left(2 - \frac{r^2}{a^2}\right) e^{-\frac{r^2}{2a^2}}$$

- We want to evaluate pgwave2D transient sources detection performance on simulated images.



PGWave method - motivation

- Cmap based on real LAT data coincident in time with LIGO/ VIRGO S190412m event. In the 90% contour ellipse pgwave2D tool seems to detect a source.



Simulations - parameters selection

- We simulated 100 skies with 100 different **fluxes**, each with randomised (100 times) position sources (l, b).

- Then we simulated 20 skies with 20 different **spectral index**, each with randomised (20 times) position sources (l, b).

- **scfile coincidence in time with LIGO/VIRGO event S190425z (real orbit data).**

- **Flux** ⟶ xml files with spectral_transient sources (1000s).

- **Index** ⟶ xml files with simple_transient sources (1000s).

Simulations - parameters selection

- gtobssim

Parameters	Value
simtime	**<u>10000s</u>**
tstart	5.7786070666642843E8
irfs	P8R3_SOURCE_V2

Simulations - parameters selection

- gtbin

Parameters	Value
binsz	0.5
nxpix	700
nypix	520

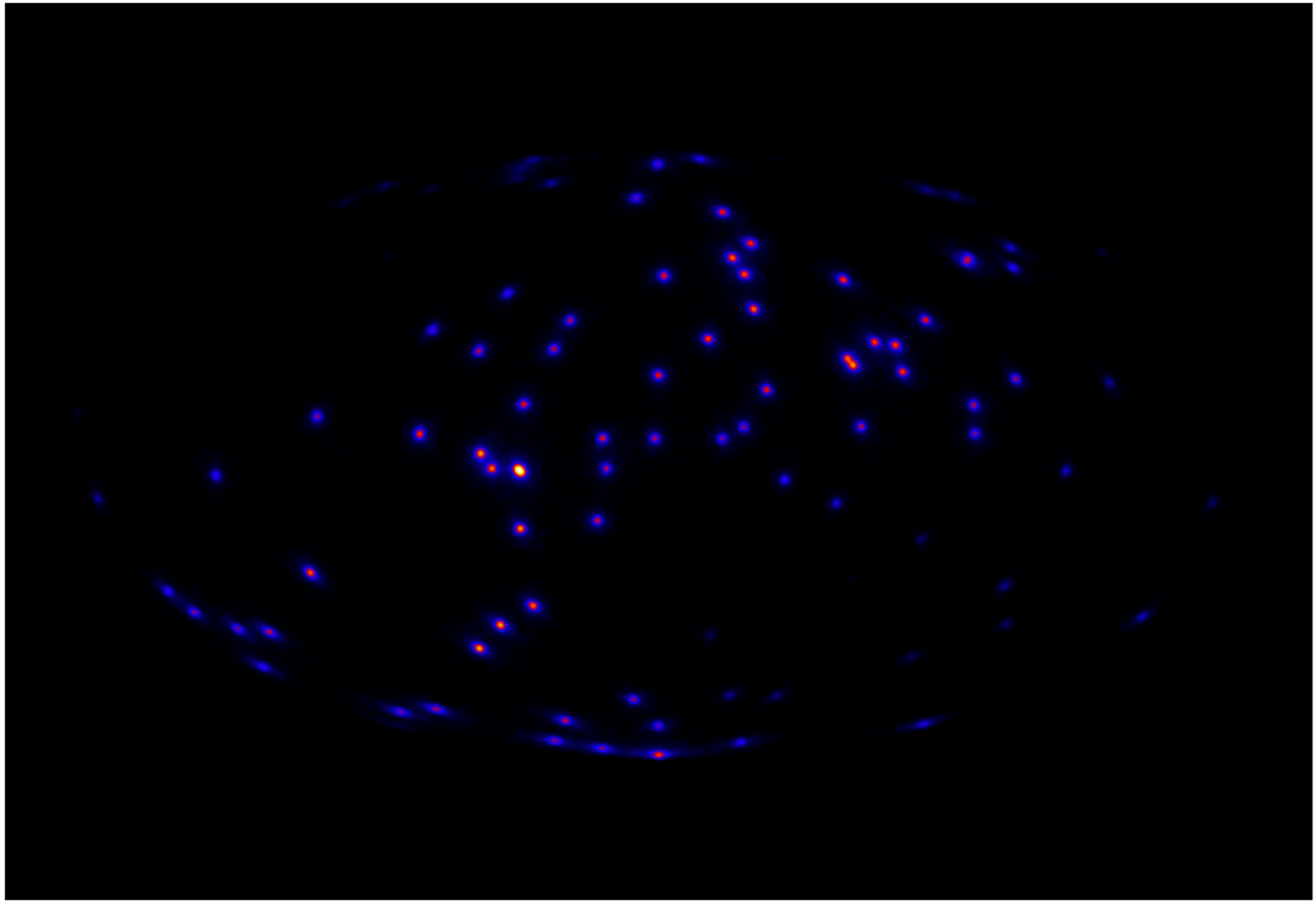
Simulations - parameters selection

- pgwave2D

Parameters	Value
N_scale	1
scala	2.2
otpix	5
n_sigma	3
k	2.6
min_pix	3

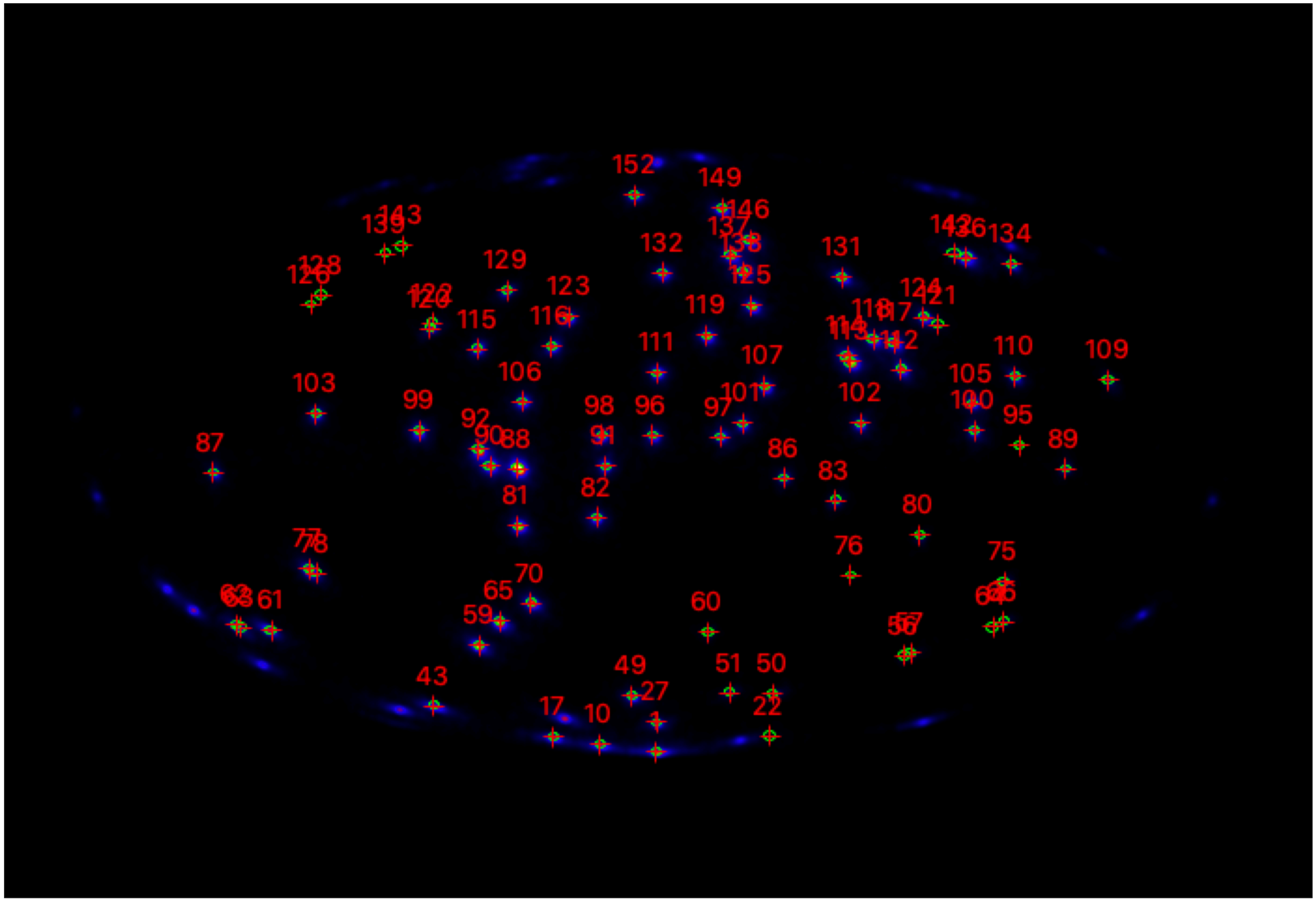
Simulations - Flux

- Flux ~ 3 photons/(m^2 s): **cmap**



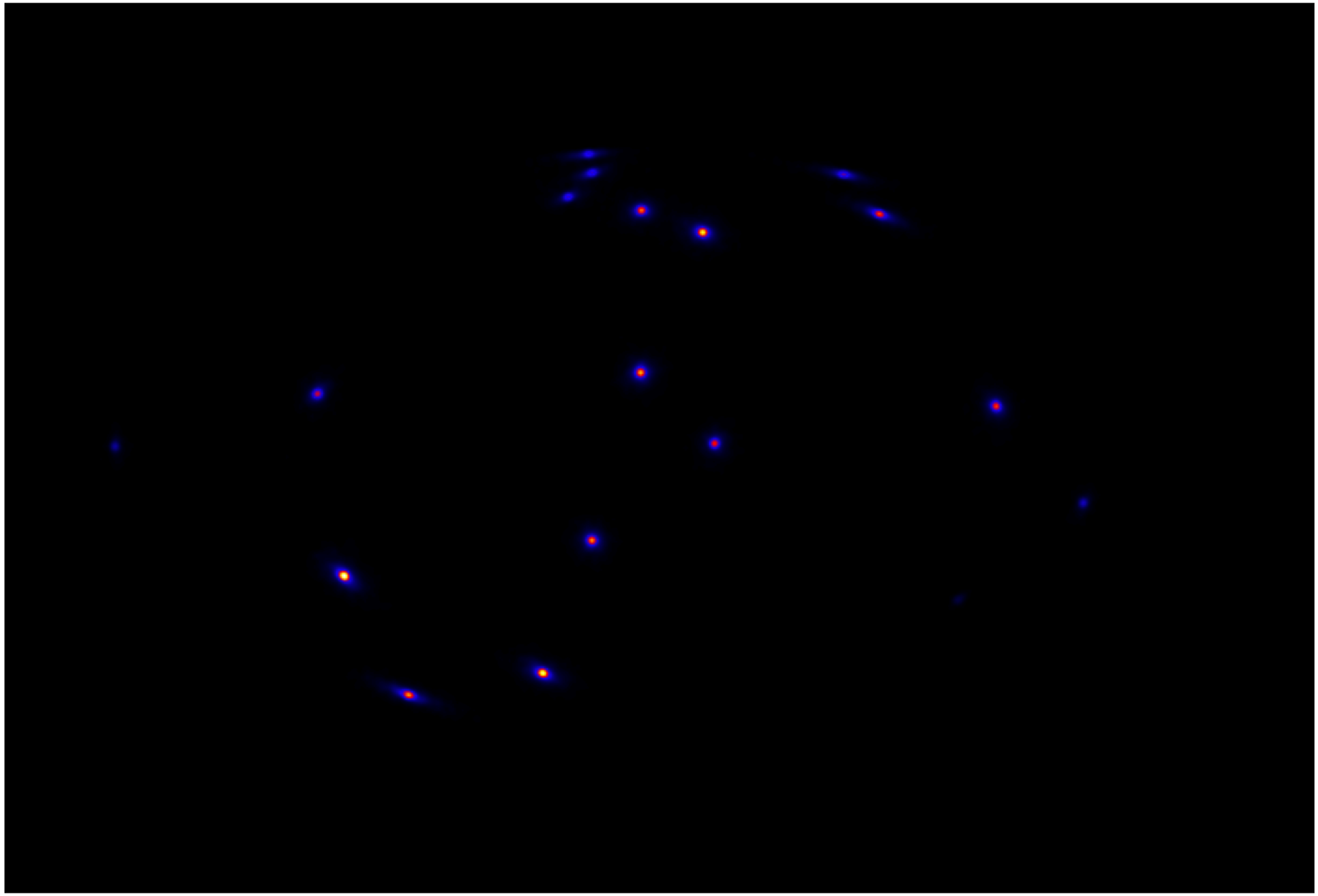
Simulations - Flux

- Flux ~ 3 photons/(m^2 s): **cmap + file.reg**



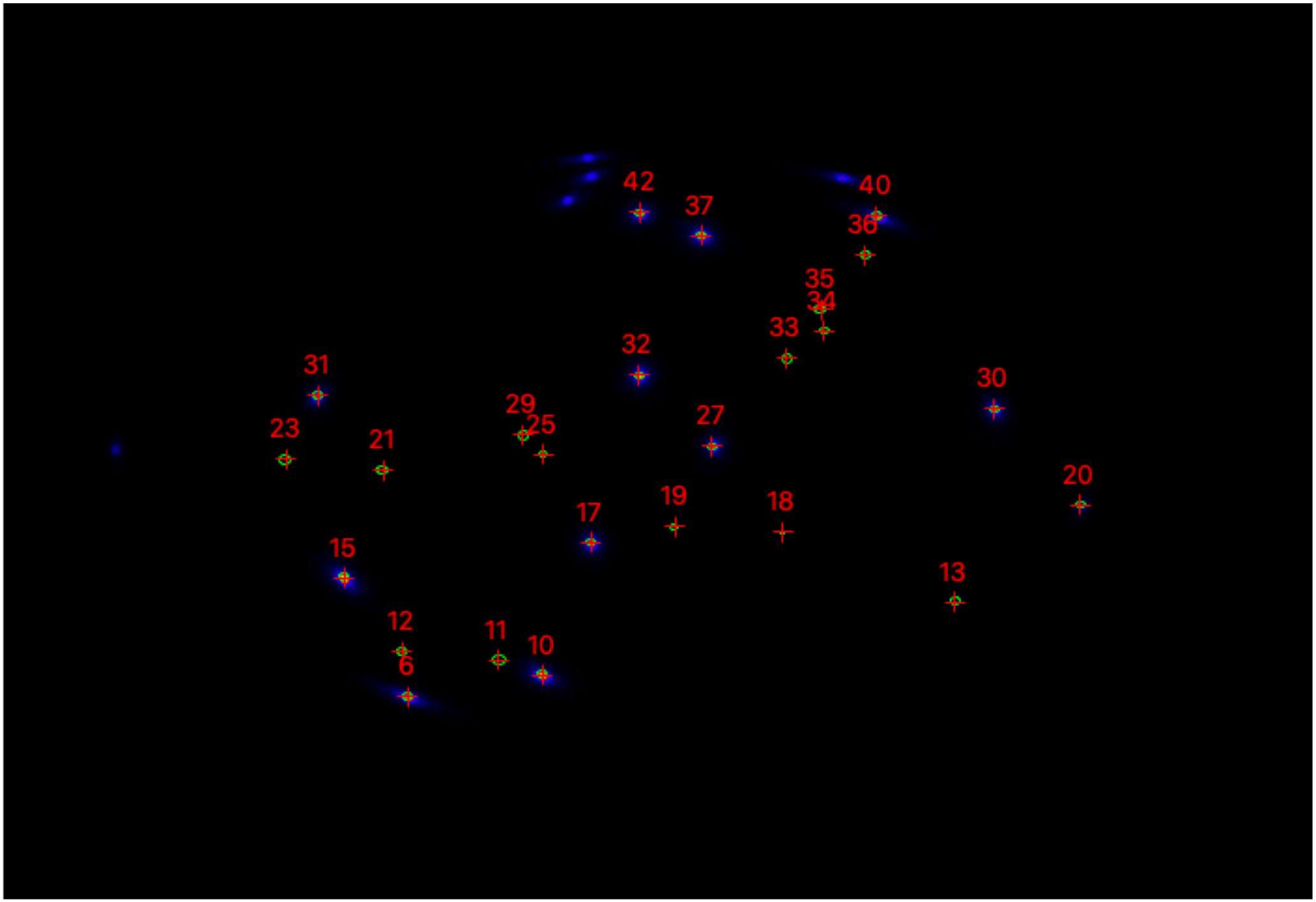
Simulations - Index

- Flux ~ 10 photons/(m^2 s) && Index ~2: **cmap**



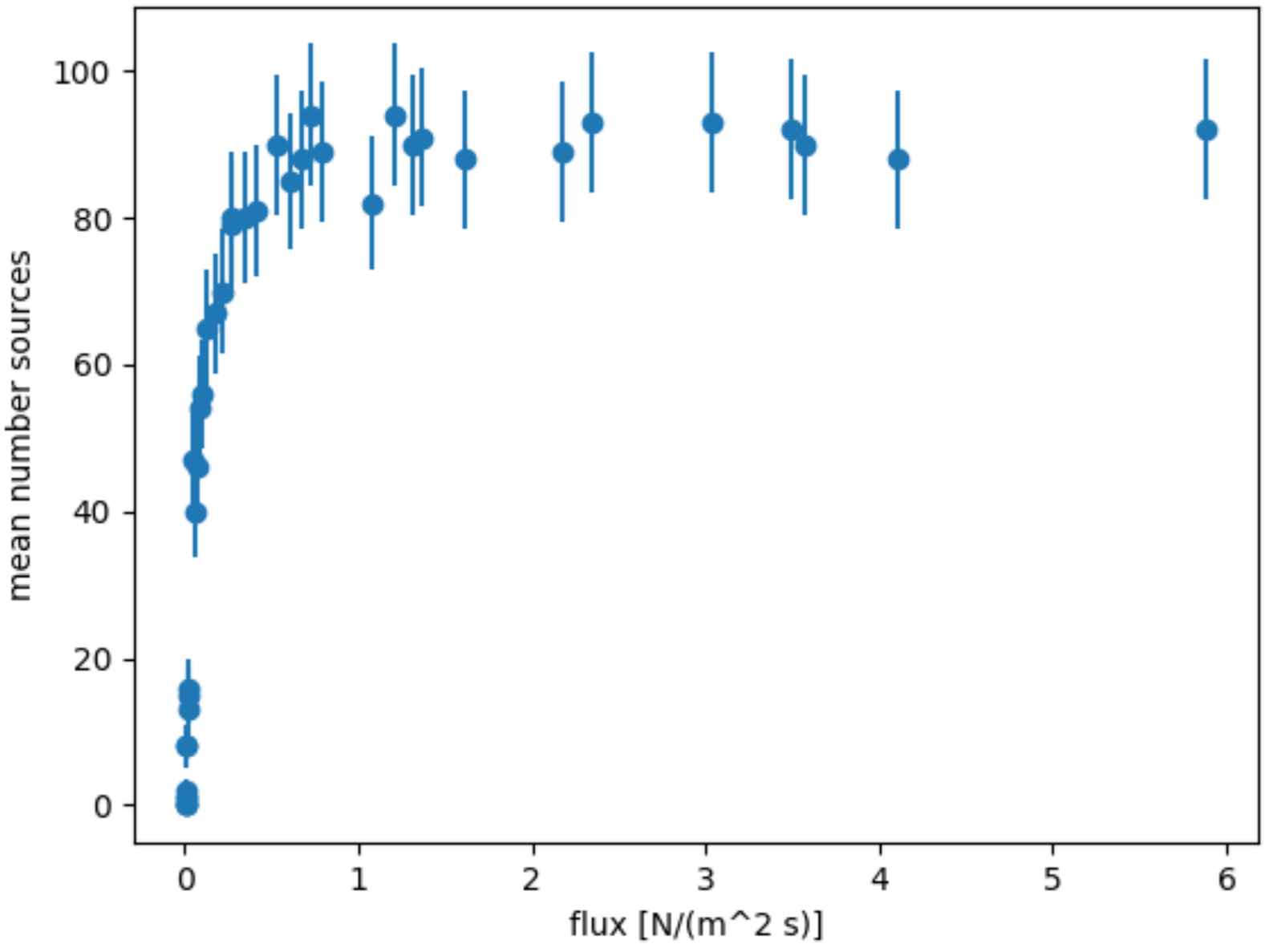
Simulations - Index

- Flux ~ 10 photons/(m^2 s) && Index ~ 2: **cmap + file.reg**

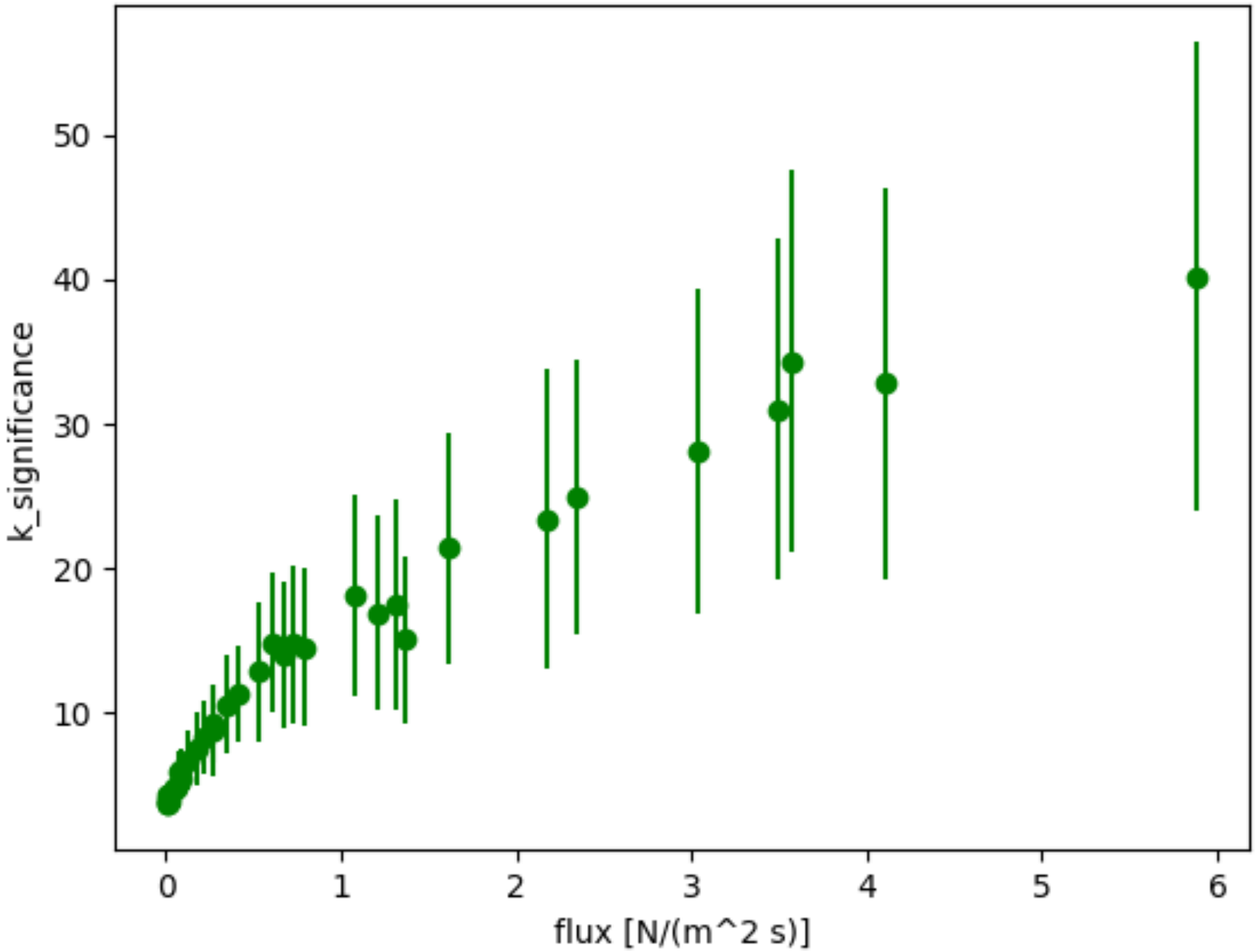


Results - Flux

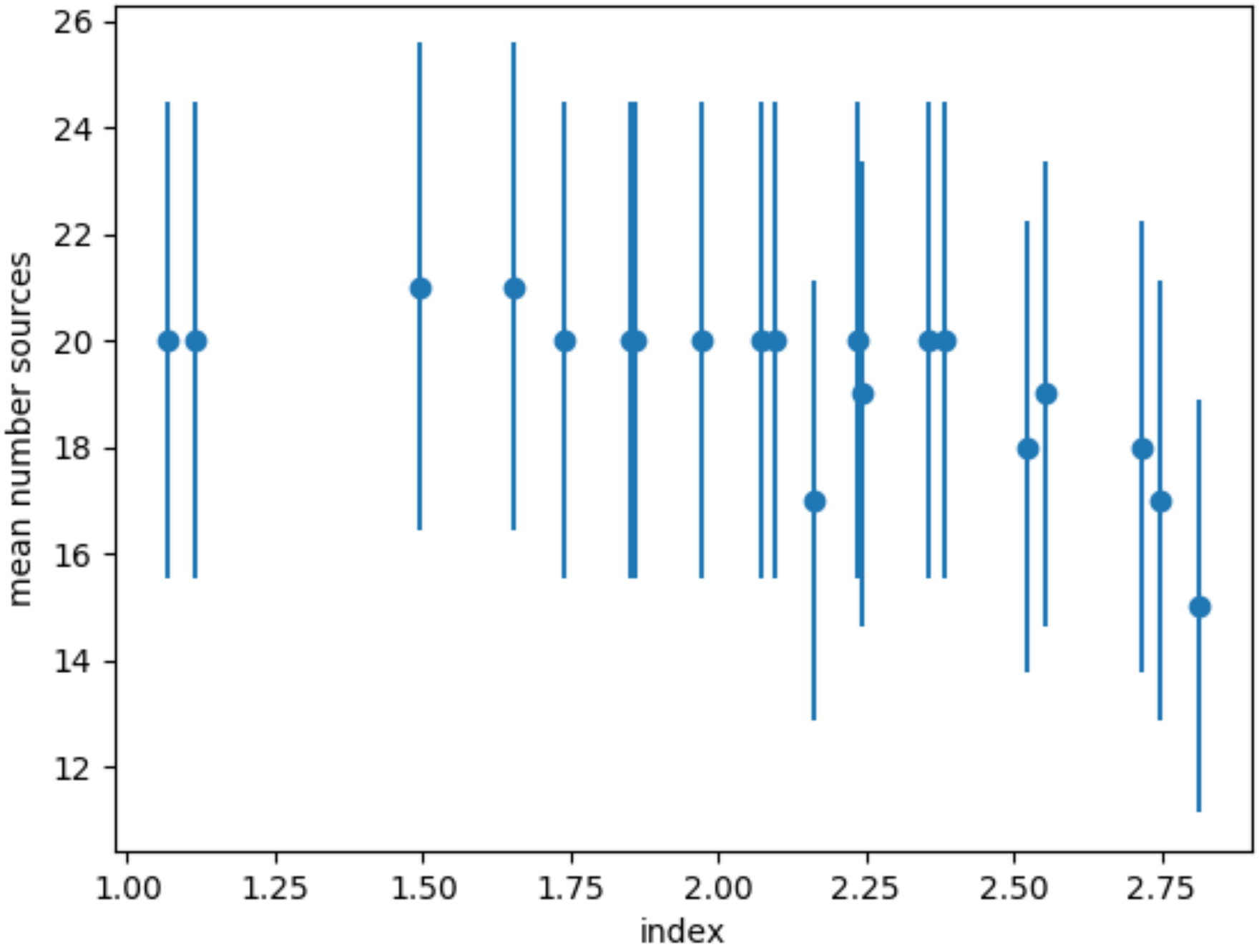
- All the following plots are produced including only that simulated sources that are also detected by pgwave2d (checking if the distance between their mutual l and b was < 0.6 deg).



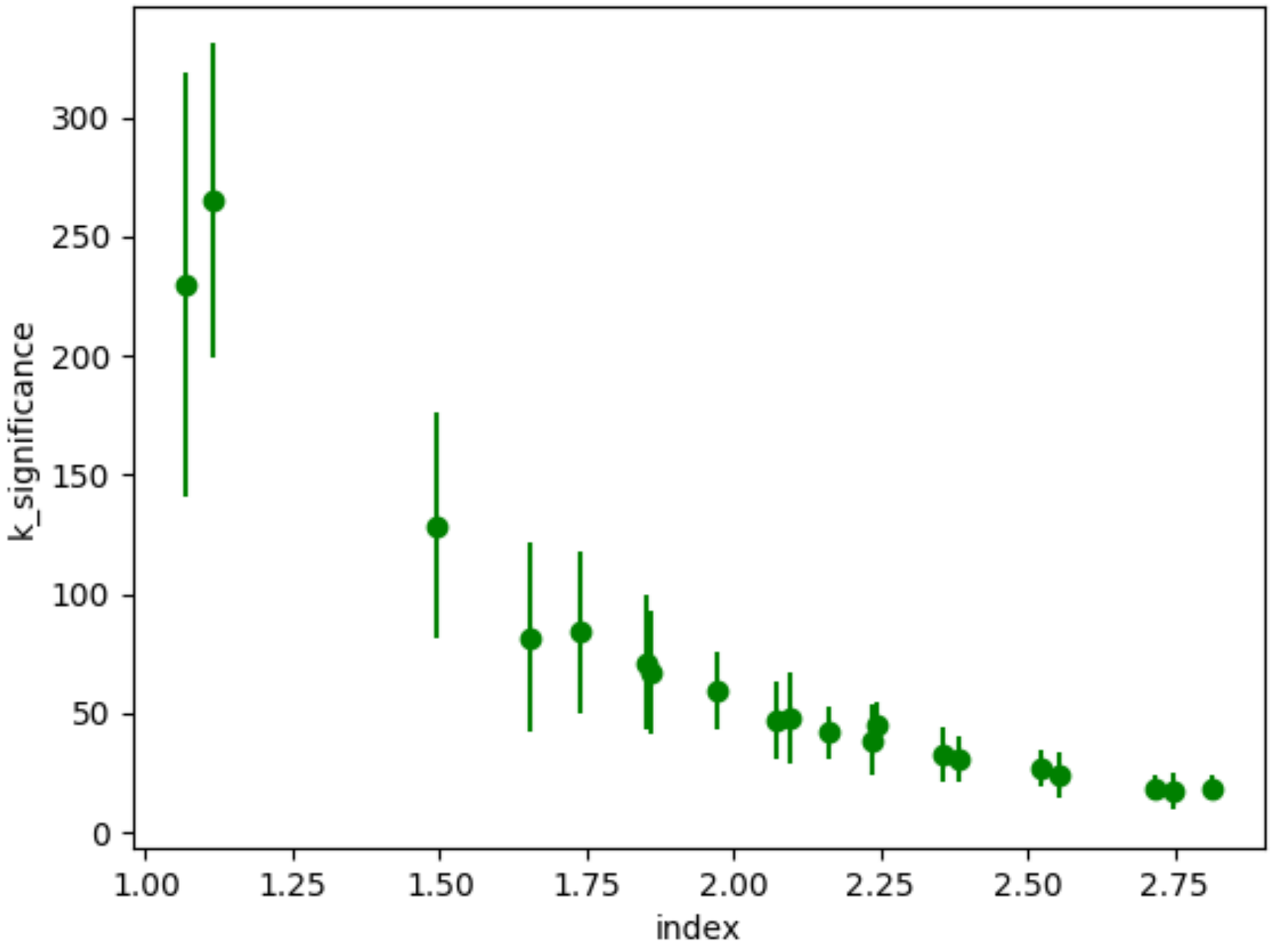
Results - Flux



Results - Index



Results - Index



Comments and future application for GW follow-up

- We made a parameters study to understand how pgwave2D tool detect transient simulated sources (1000 s).

- From our plots we can see that the number of detected sources and the k significance, as functions of flux/index, have the expected trends.

- Next step is to make a likelihood analysis on the detected sources.

- We will also modify the bin size of the cmap to see how the analysis changes.

- This is a preliminary analysis useful to prepare the future investigation of the LIGO/VIRGO contour in which search for transient sources.