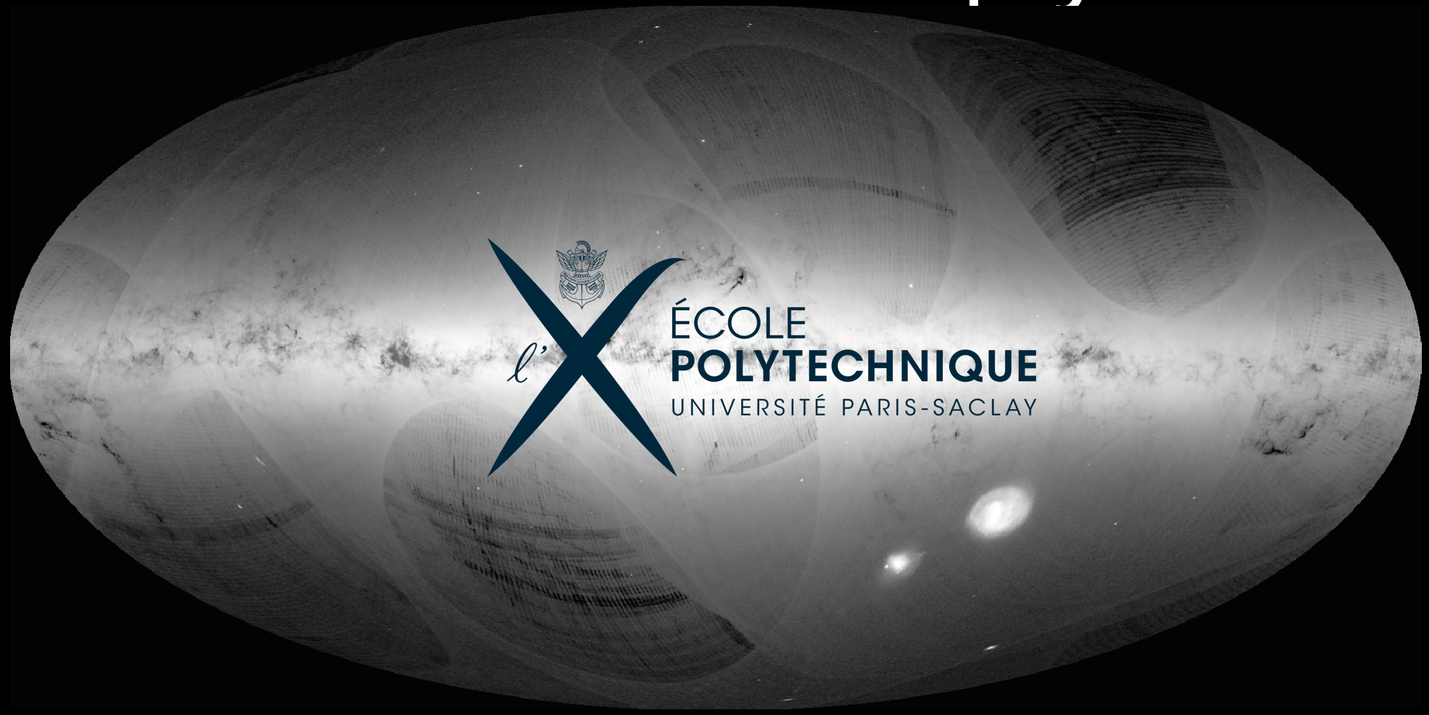
# A Billion Stars in the Jupyter Notebook




**MAARTEN BREDDELS**
data science / python / jupyter

Paris - Jupyter Day - 2018

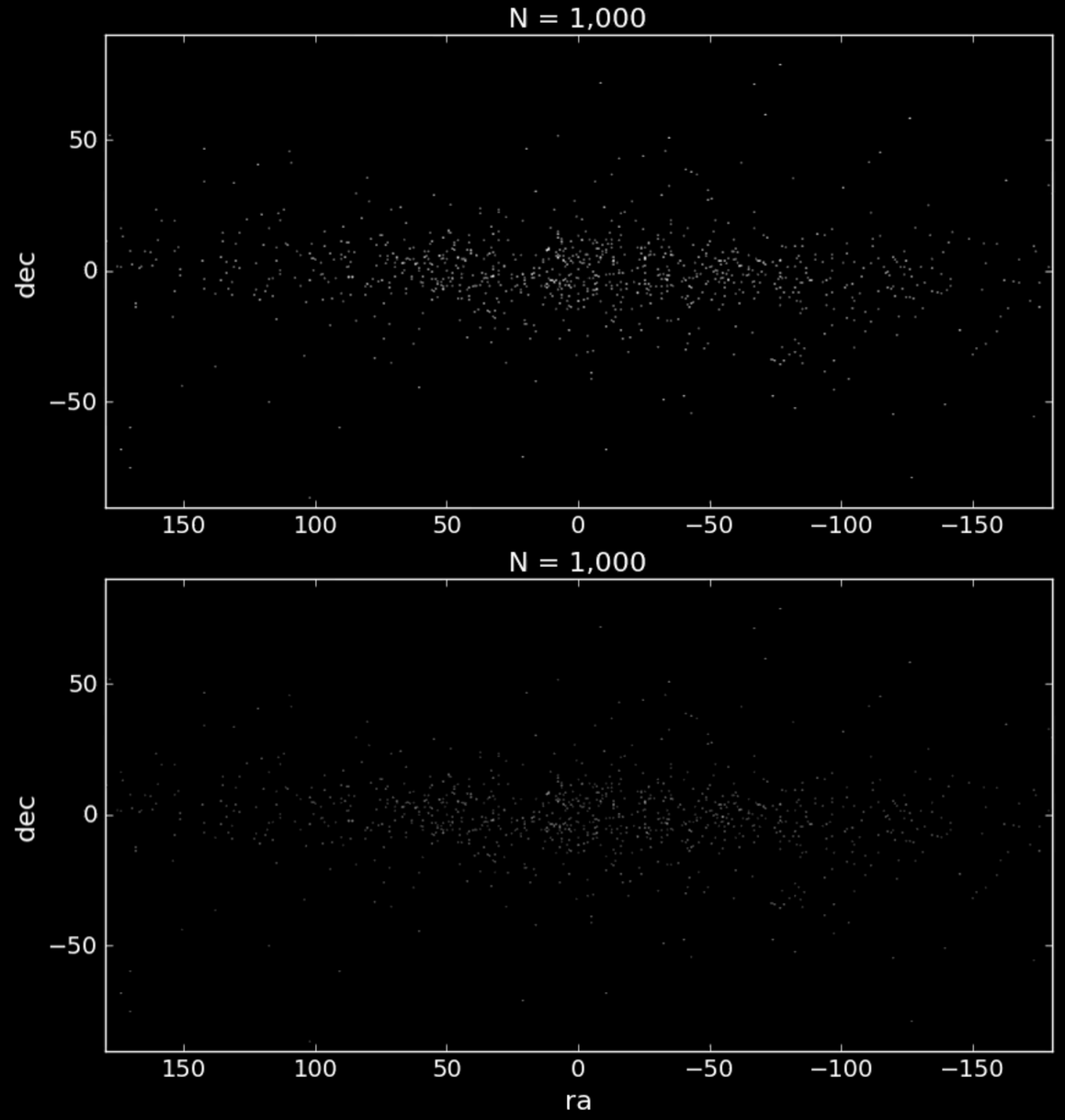
university of groningen / faculty of mathematics and natural sciences / kapteyn astronomical institute

# Agenda

- Show how to deal with a billion objects/rows/stars?
- Why use/move to the notebook?
- How can we make the notebook interactive?

# Motivation: Gaia

>1,000,000,000 stars/objects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dec
50
0
−50
150
100
50
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−50
−100
−150
N = 1,000
dec
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−50
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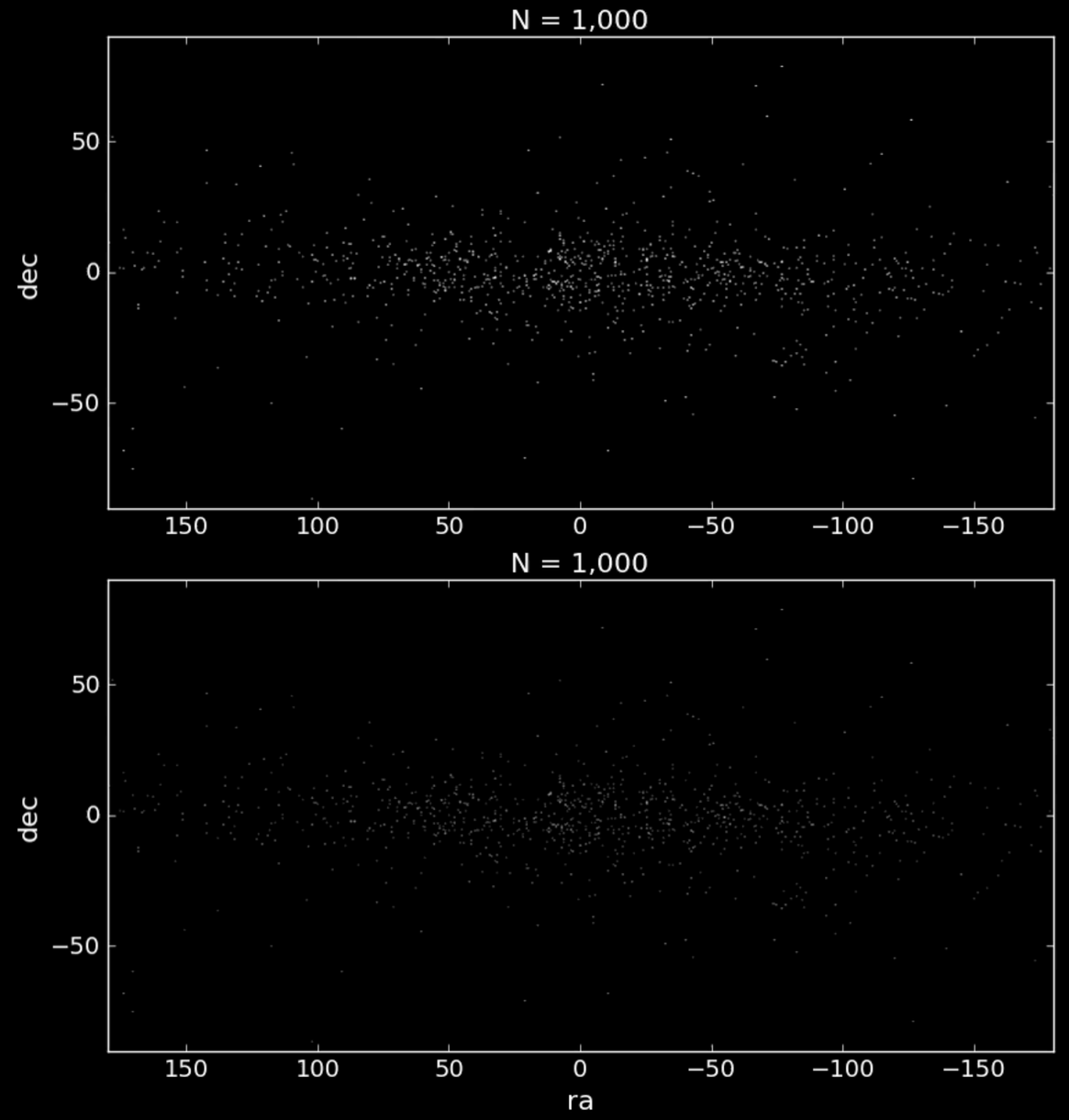
−100
−150
ra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dec
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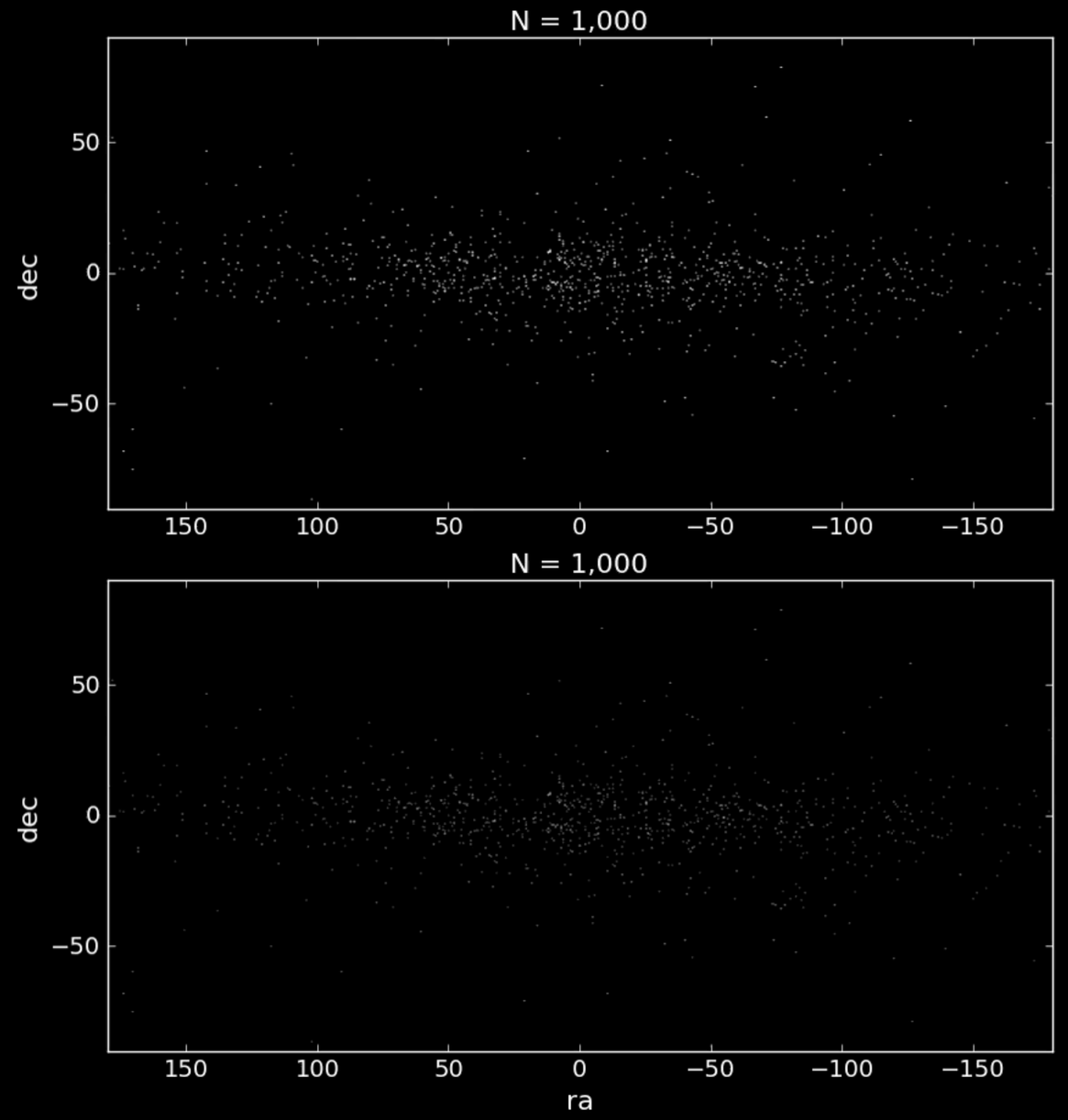
ra

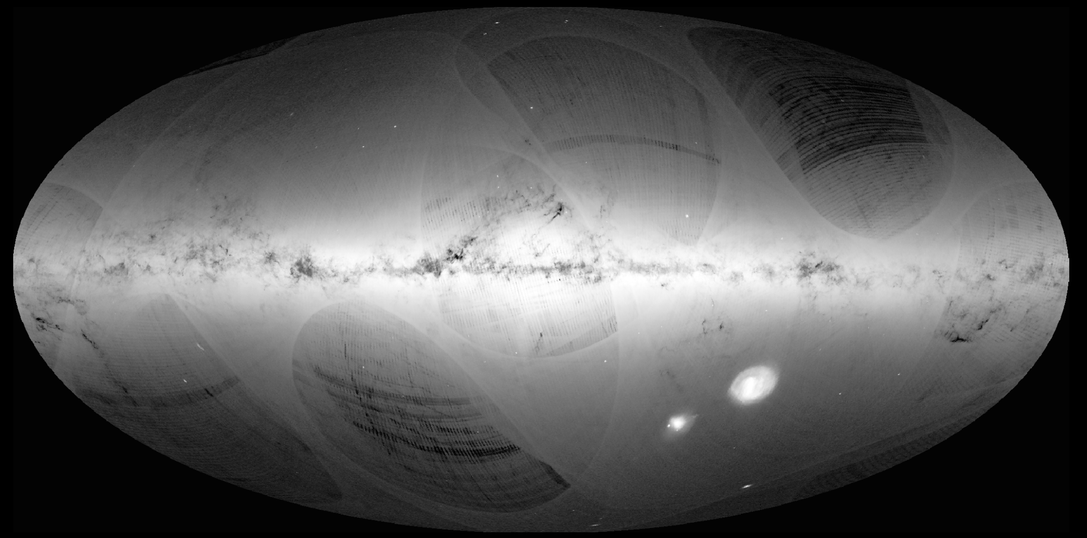
scatter



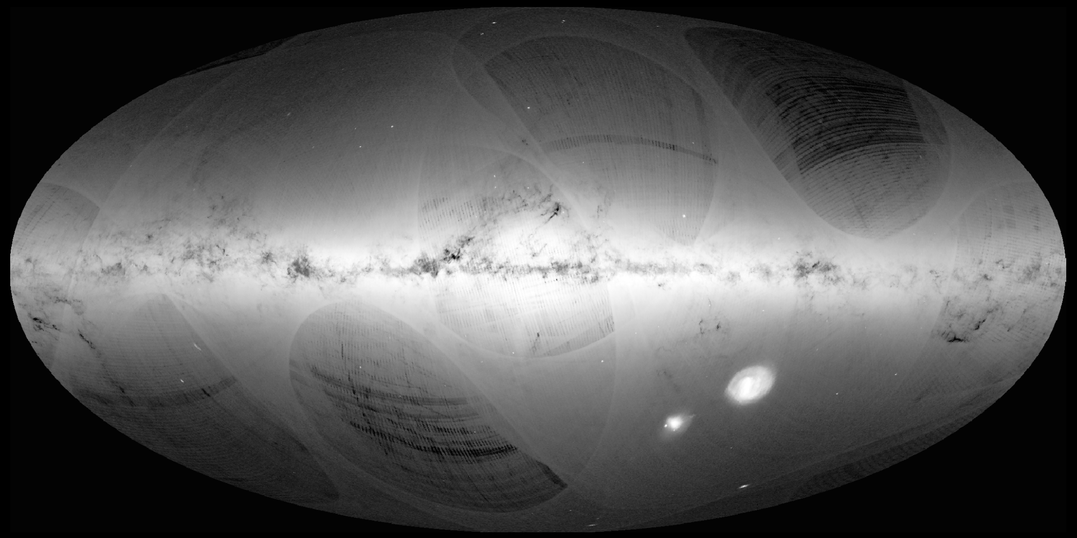

scatter

density

- How fast can it be done?



- How fast can it be done?
  - $10^9$ * 2 * 8 bytes = 15 GiB (double is 8 bytes)



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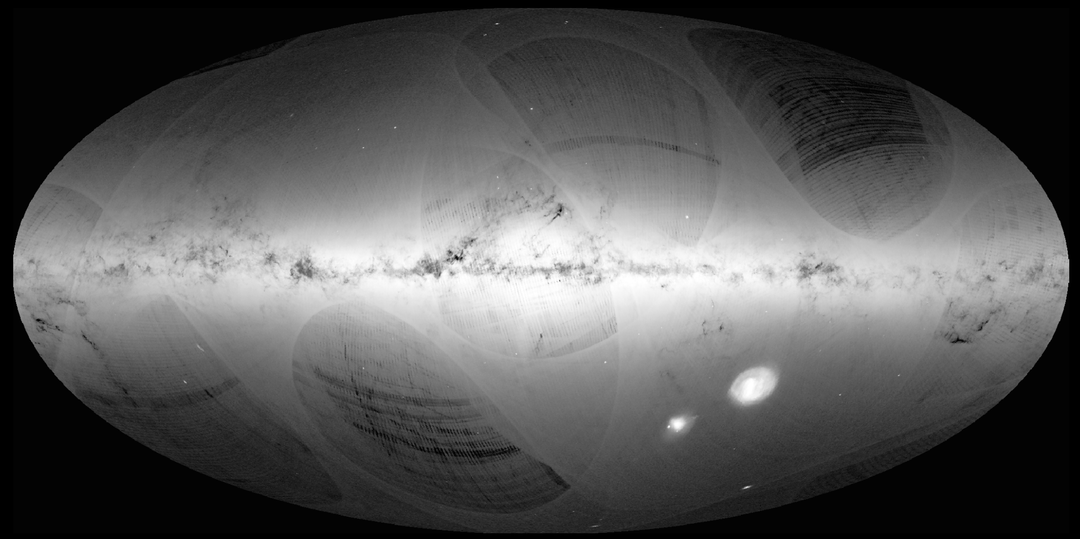

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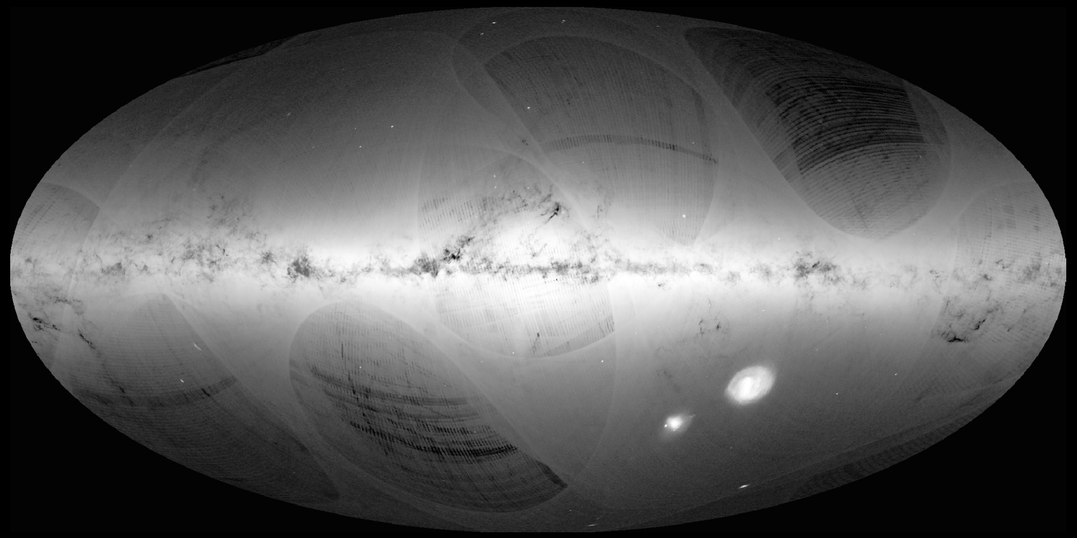

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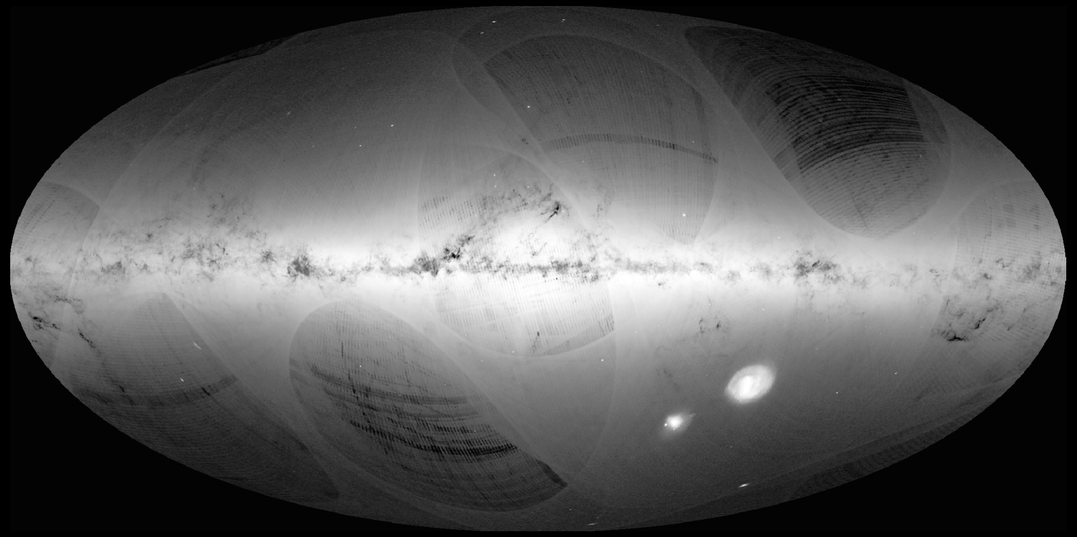

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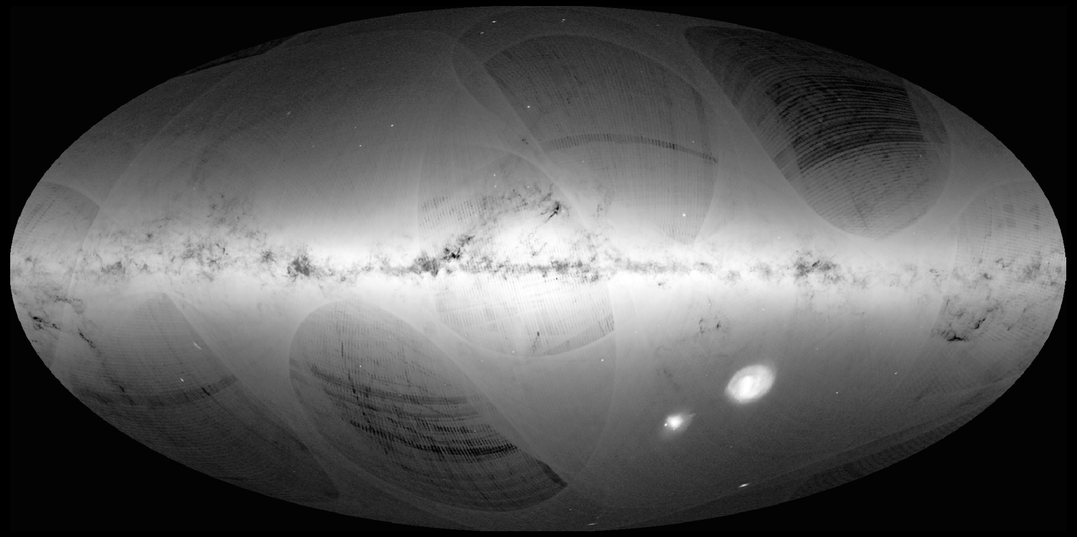
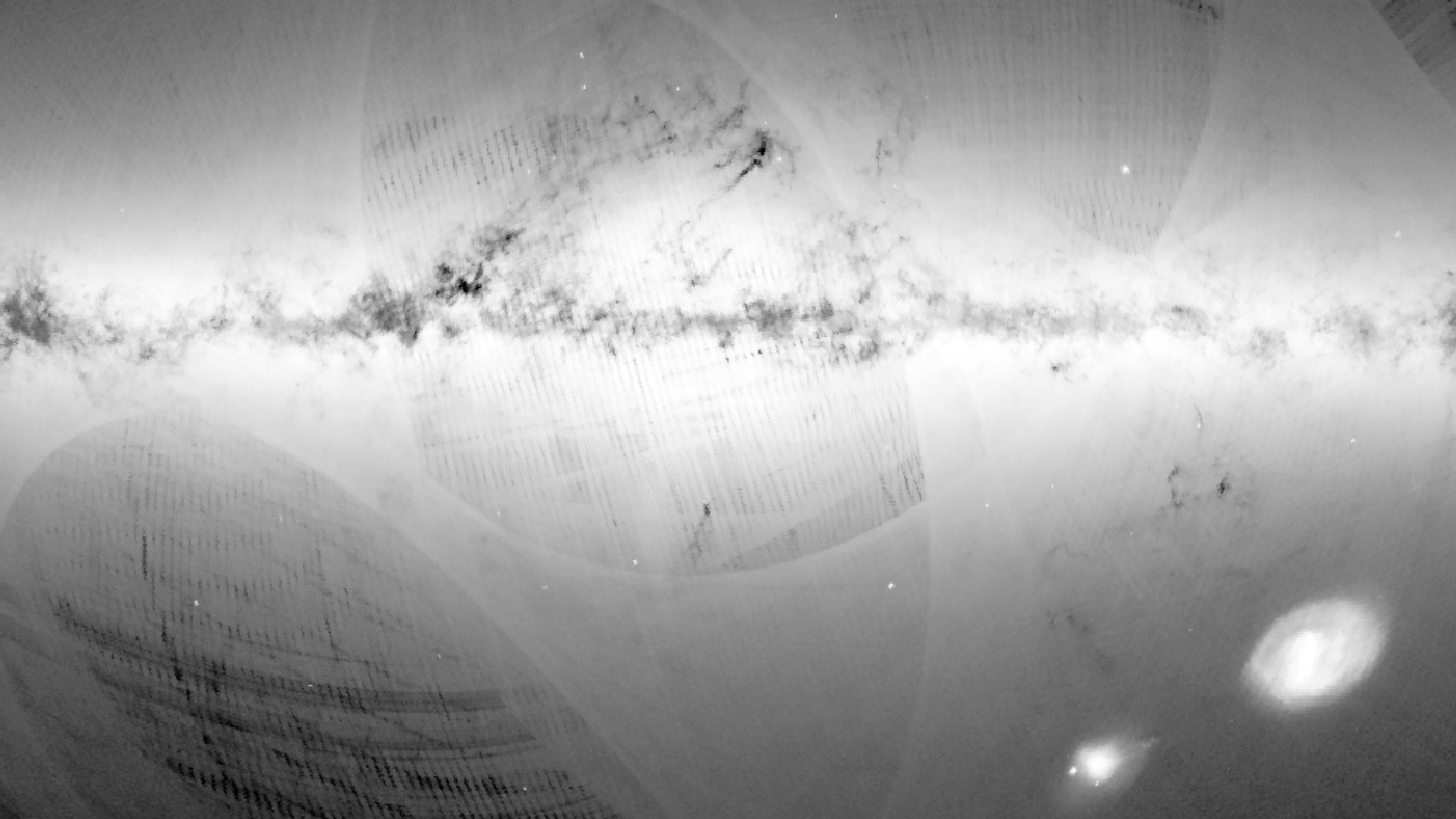
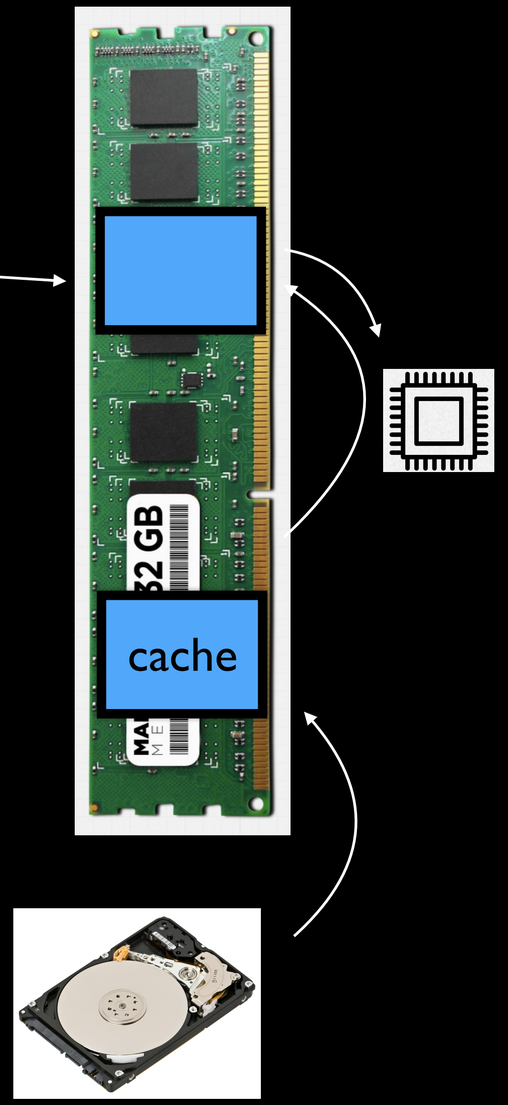
  - Histograms/Density/Statistics grids





# How to store and read the data

- Storage: native, column based (hdf5)
- ‘Normal’ method:
  - Allocate memory
  - read from disk to memory
  - Actually: from disk, to OS cache, to memory
  - Wastes memory/cache
  - 15 GB data , requires 30 GB is you want to use the file system cache



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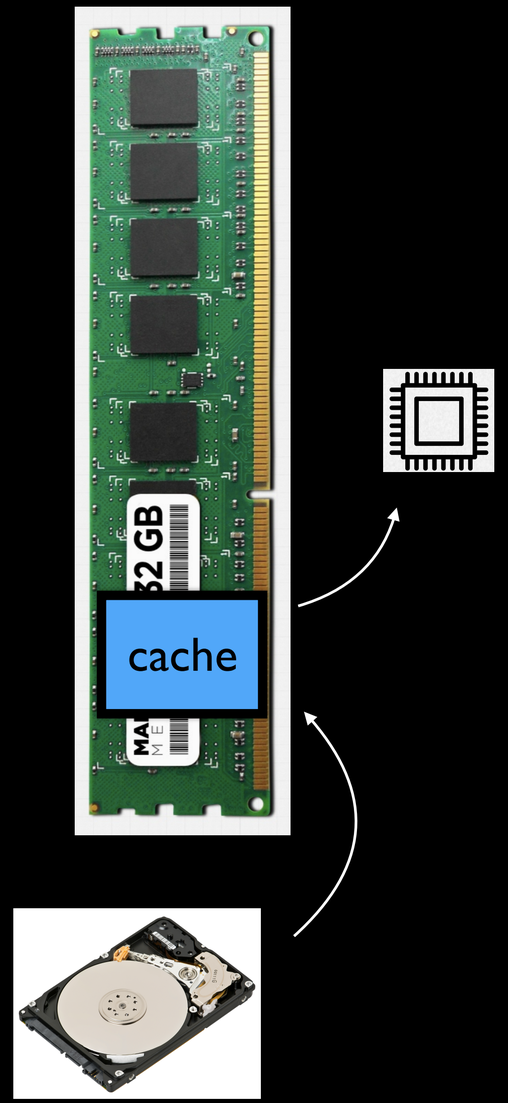

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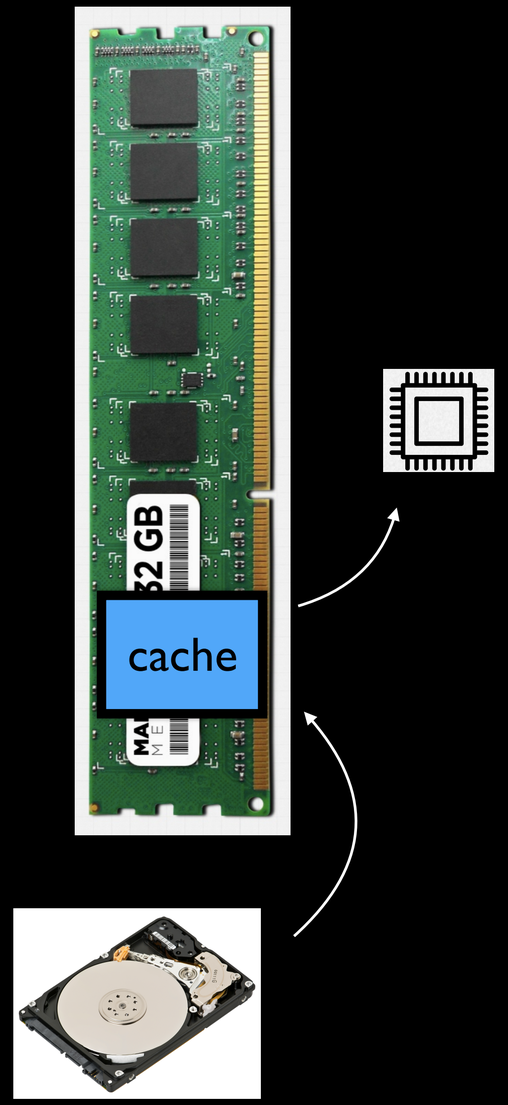
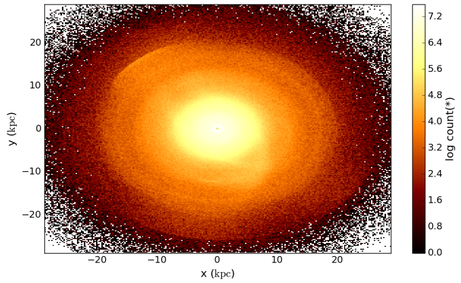
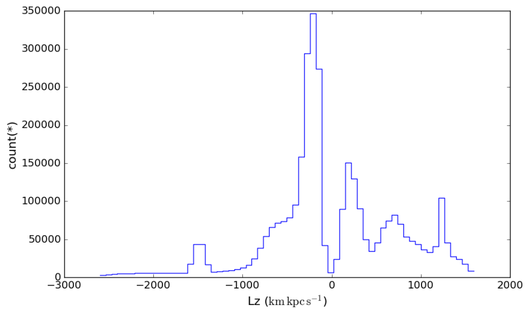
- Memory mapping:
  - get direct access to OS memory cache, no copy, no setup (apart from the kernel doing setting up the pages)
  - avoid memory copies, more cache available
- In previous example:
  - copying 15 GB will take about ~1.0 second, at 10-20 GB/s
  - Can be 2-3x slower (cpu cache helps a bit)

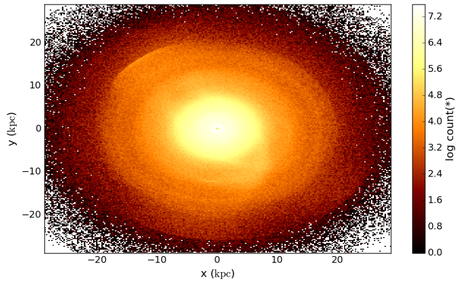



20
10
0
−10
−20
y (kpc)
−20
−10
0
10
20
x (kpc)
7.2
6.4
5.6
4.8
4.0
3.2
2.4
1.6
0.8
0.0
log count(+)

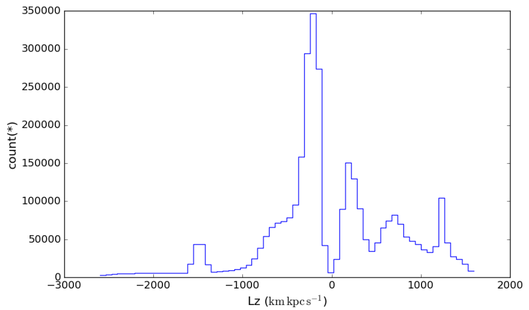
1d




2d



1d

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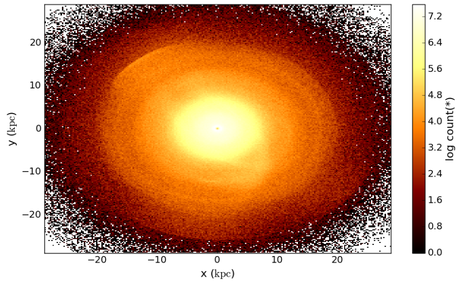
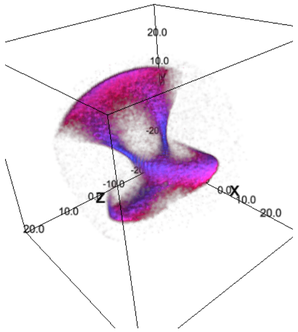
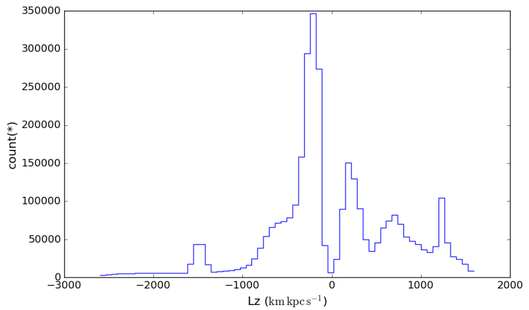



3d



0d 330,000 rows

1d

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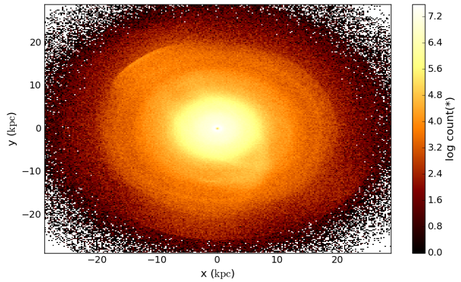


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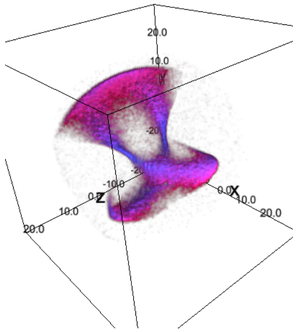

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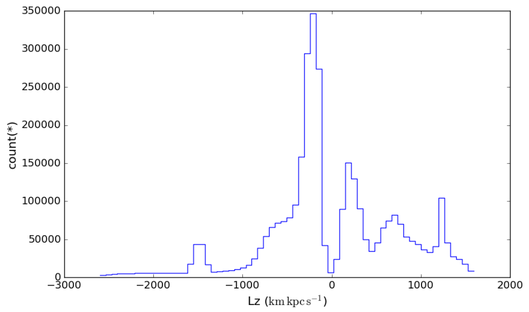


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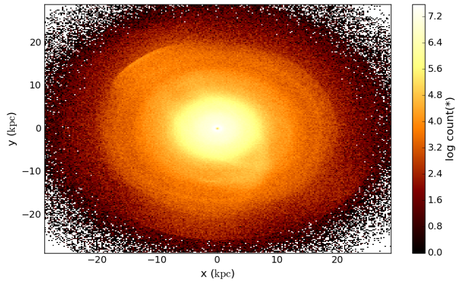


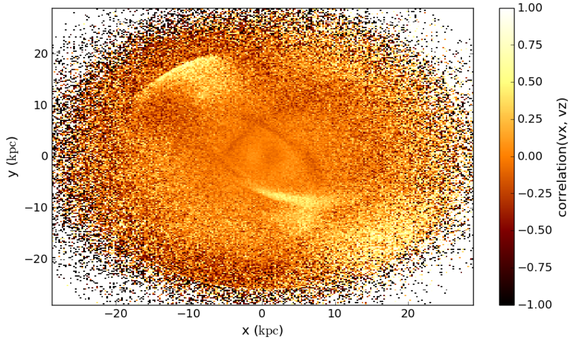


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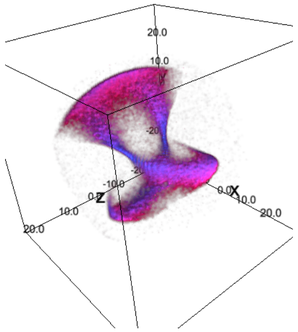

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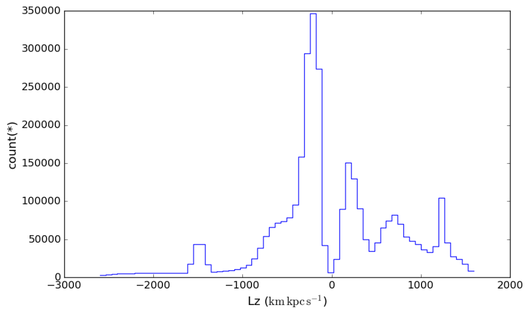


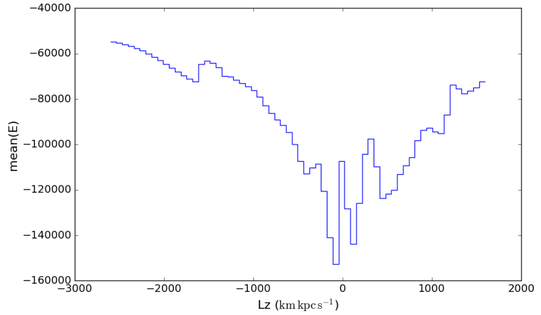


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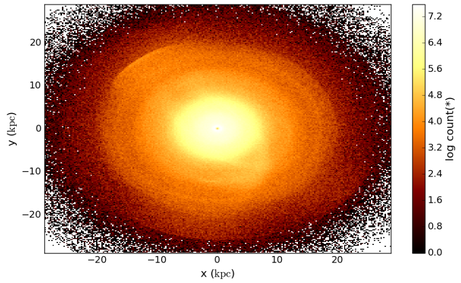


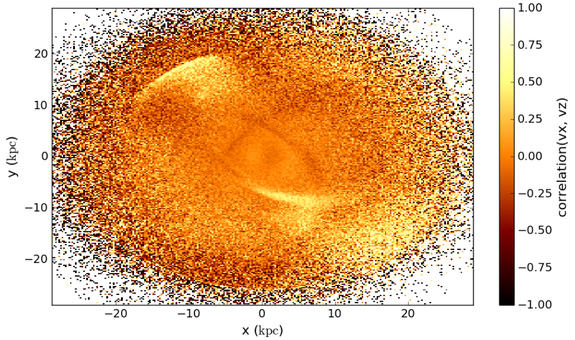


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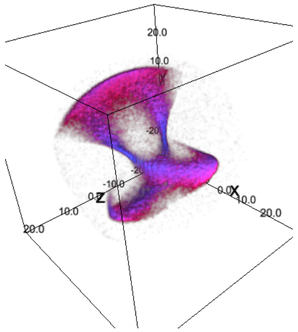

0d 330,000 rows mean: -0.083

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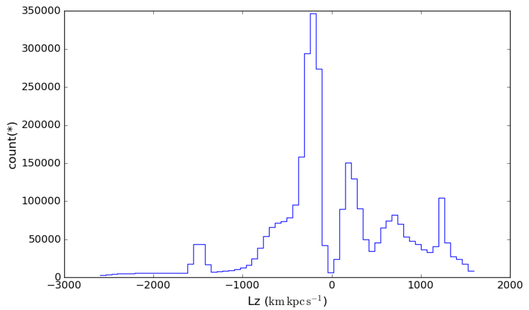


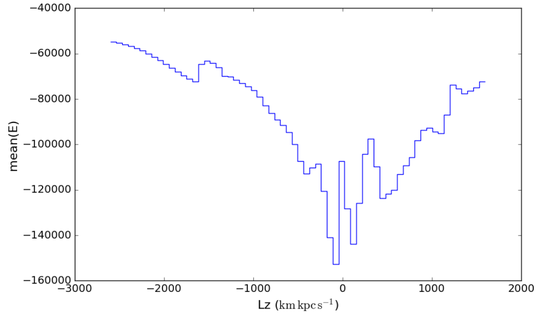


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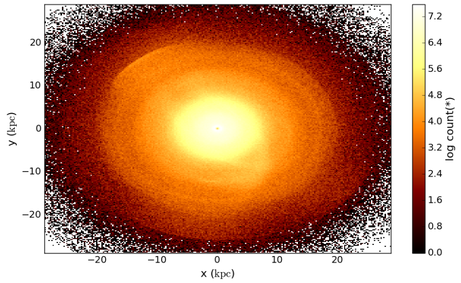


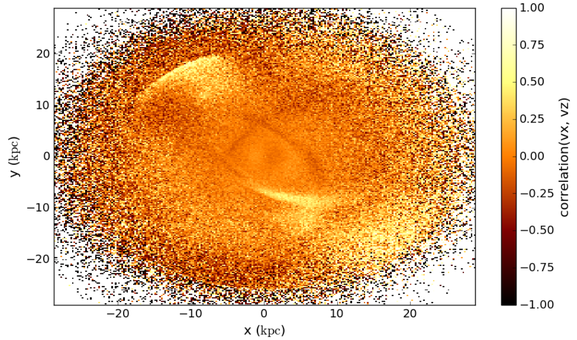


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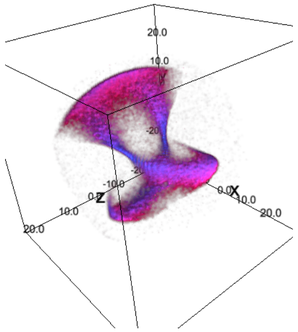

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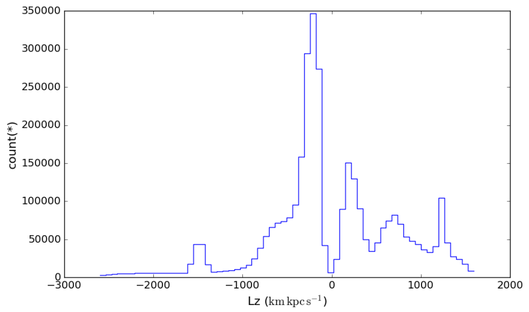


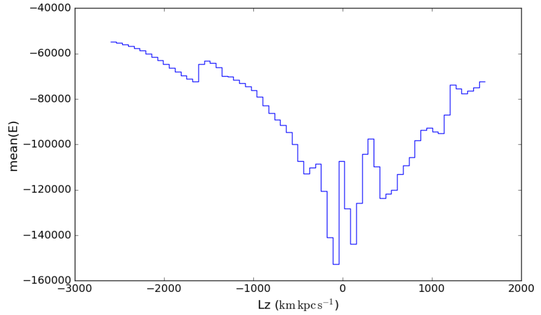


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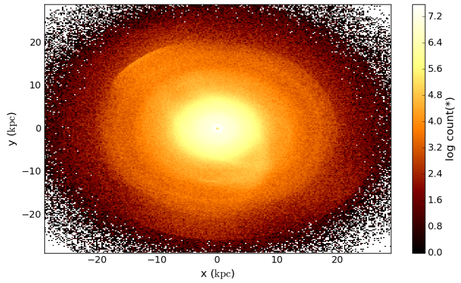


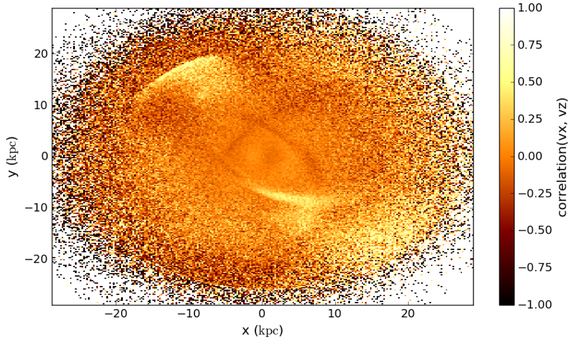


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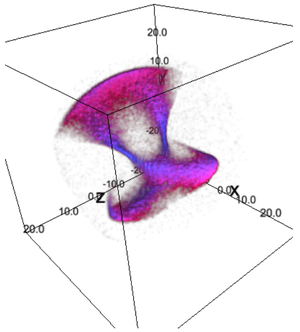

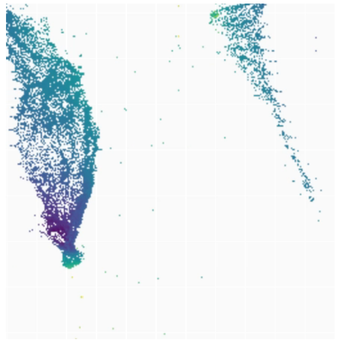

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- Does visualisation / matplotlib / bqplot / ipyvolume / ipyleaflet

# What kind of data?

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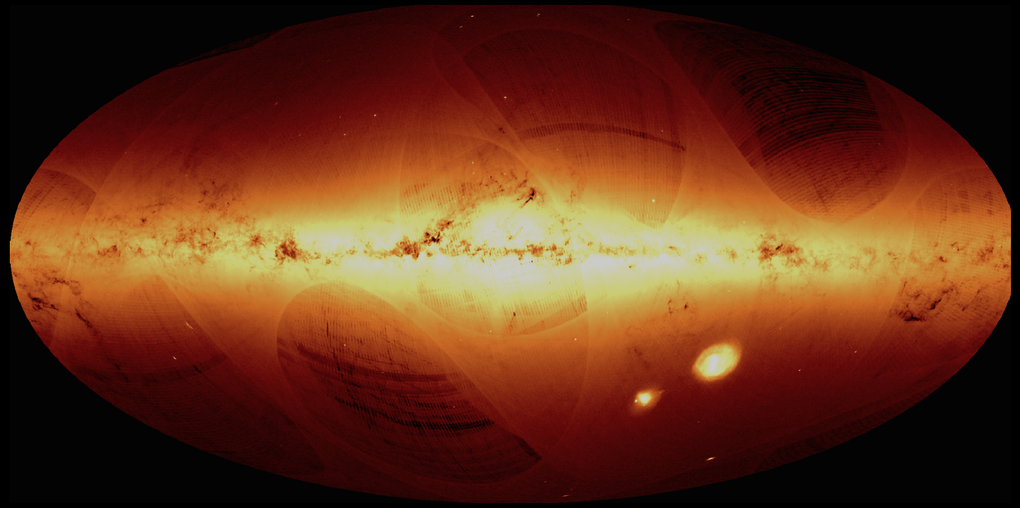

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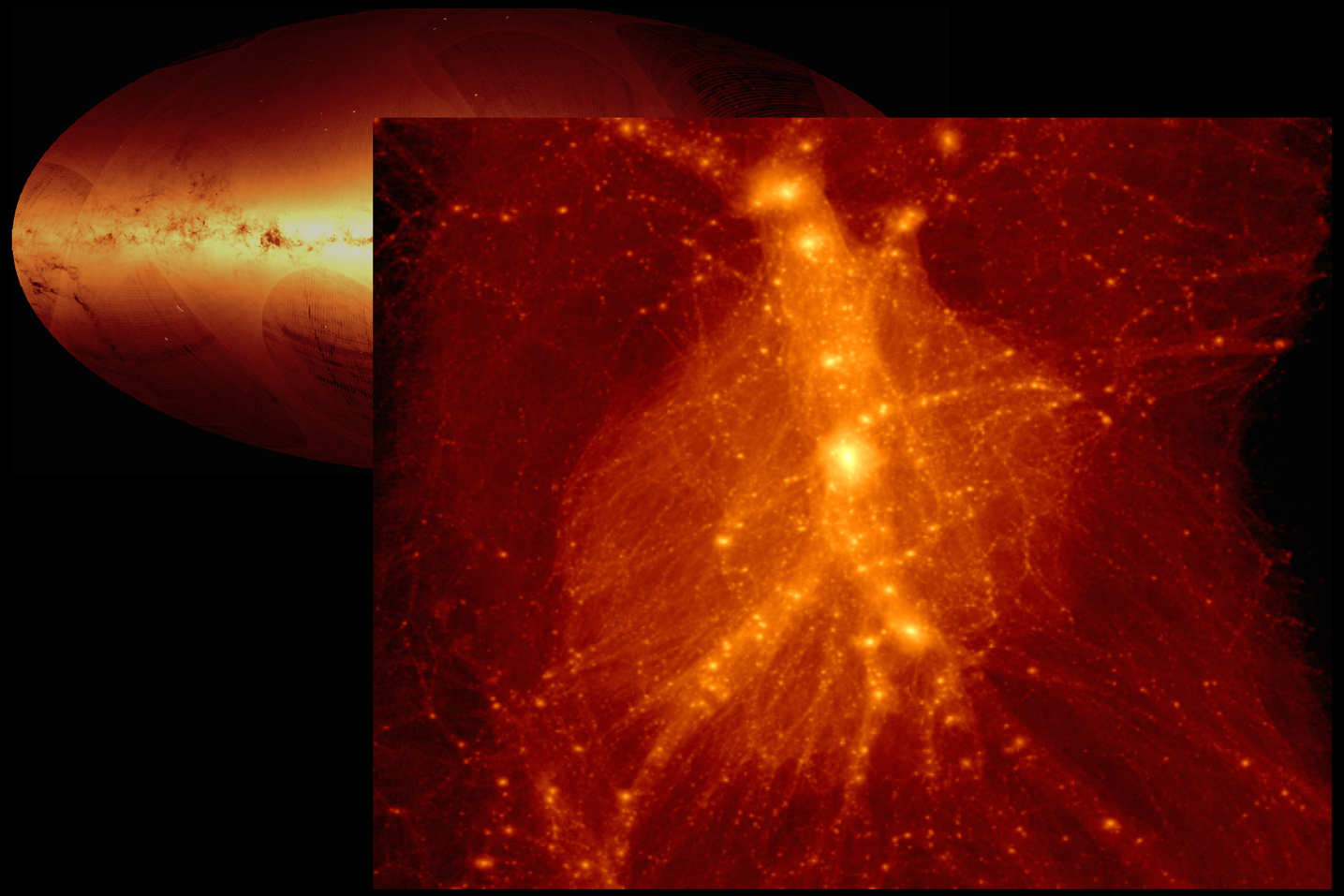

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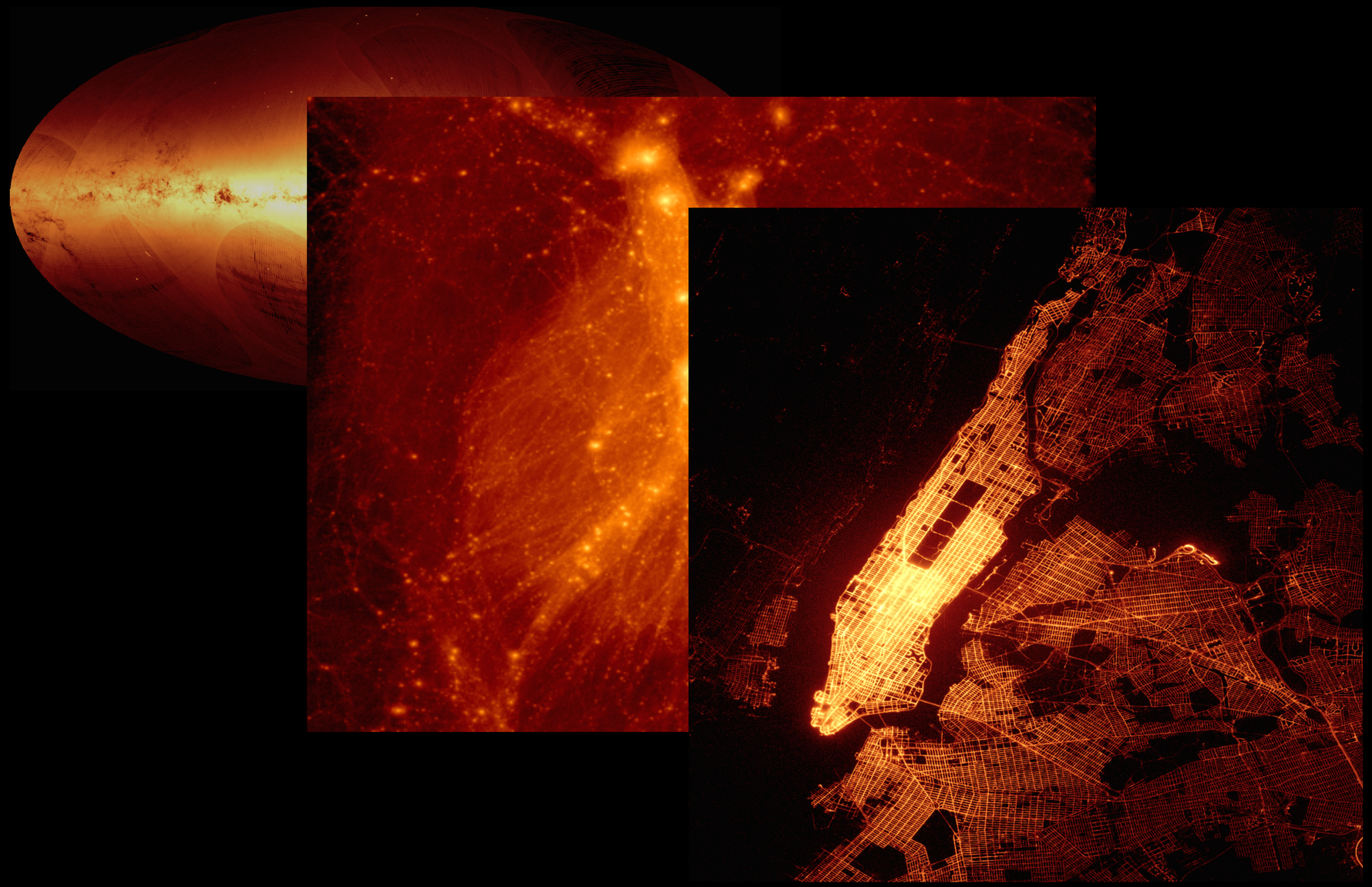

# Why the Jupyter notebook?

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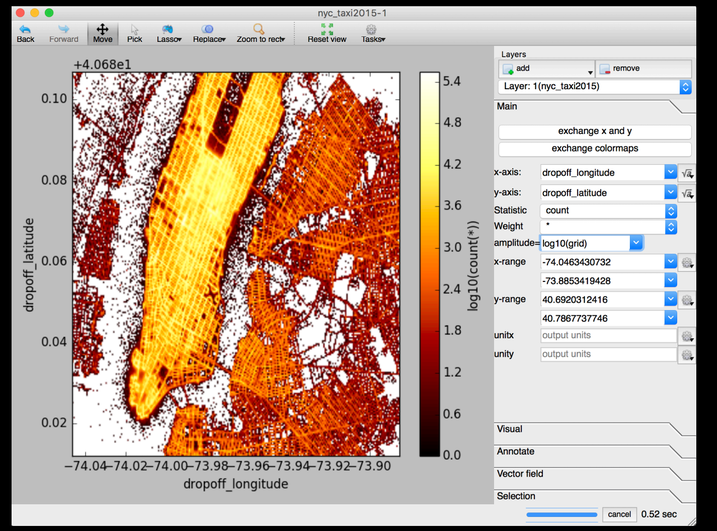
- GUI (vaex has/had this)
  - Limited in options, cannot replace a programming language



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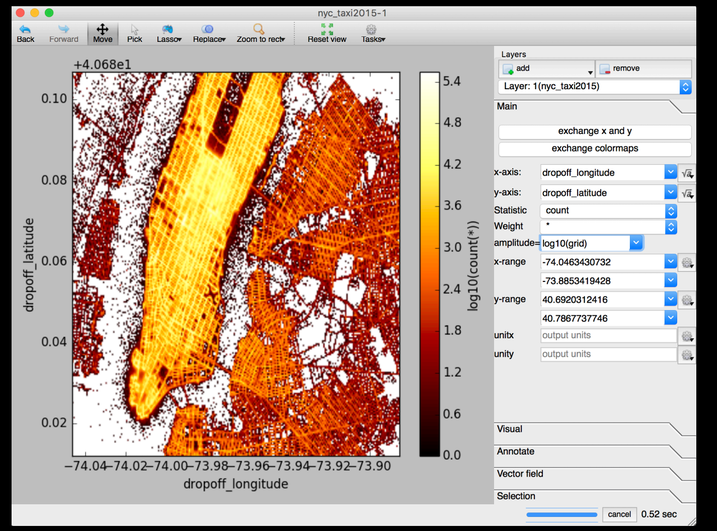
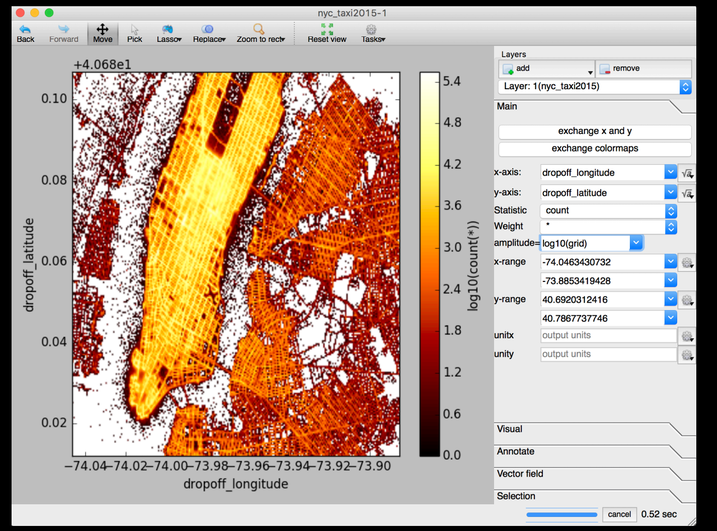
  - Limited in options, cannot replace a programming language
- Scripts
  - Anything possible
  - Slow in exploration phase



# Why the Jupyter notebook?

- GUI (vaex has/had this)
  - Limited in options, cannot replace a programming language
- Scripts
  - Anything possible
  - Slow in exploration phase
- Notebook
  - Quick exploration/iterating
  - What about interactive plots?



*“Never do a live demo”*

-Many people

# Answers

- How to deal with a billion objects/rows/stars?
  - statistics in N-d grids / vaex
- Why use/move to using the notebook?
  - Quick exploration + interactivity
- How can we make the notebook interactive?
  - ipywidgets+bqplot+ipyleaflet+ipyvolume

- maartenbreddels@gmail.com
  - www.maartenbreddels.com
  - Twitter @maartenbreddels
- vaex
  - https://vaex.io
  - https://github.com/maartenbreddels/vaex
  - pip install —pre vaex / conda install -c conda-forge vaex
- ipyvolume
  - https://ipywidgets.readthedocs.io
  - https://github.com/maartenbreddels/ipyvolume
  - pip install ipyvolume / conda install -c conda-forge ipyvolume
- Material:
  - https://github.com/maartenbreddels/jupyter-day-polytechnique-2018