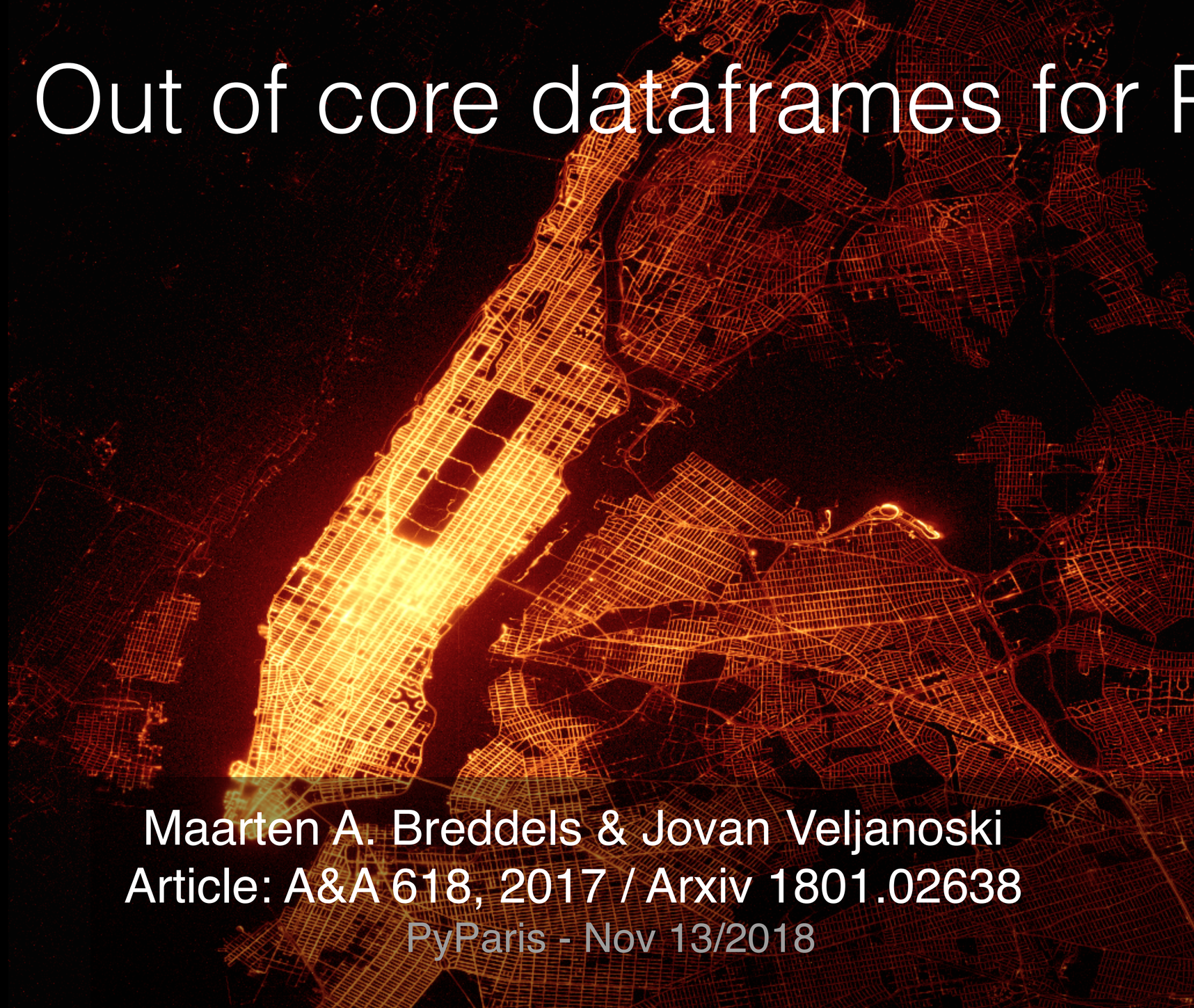
Vaex: Out of core dataframes for Python



Maarten A. Breddels & Jovan Veljanoski
Article: A&A 618, 2017 / Arxiv 1801.02638

PyParis - Nov 13/2018

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Agenda

- Why does vaex exist?
- What is vaex?
- Why is it so fast?
- Demos
- Summary

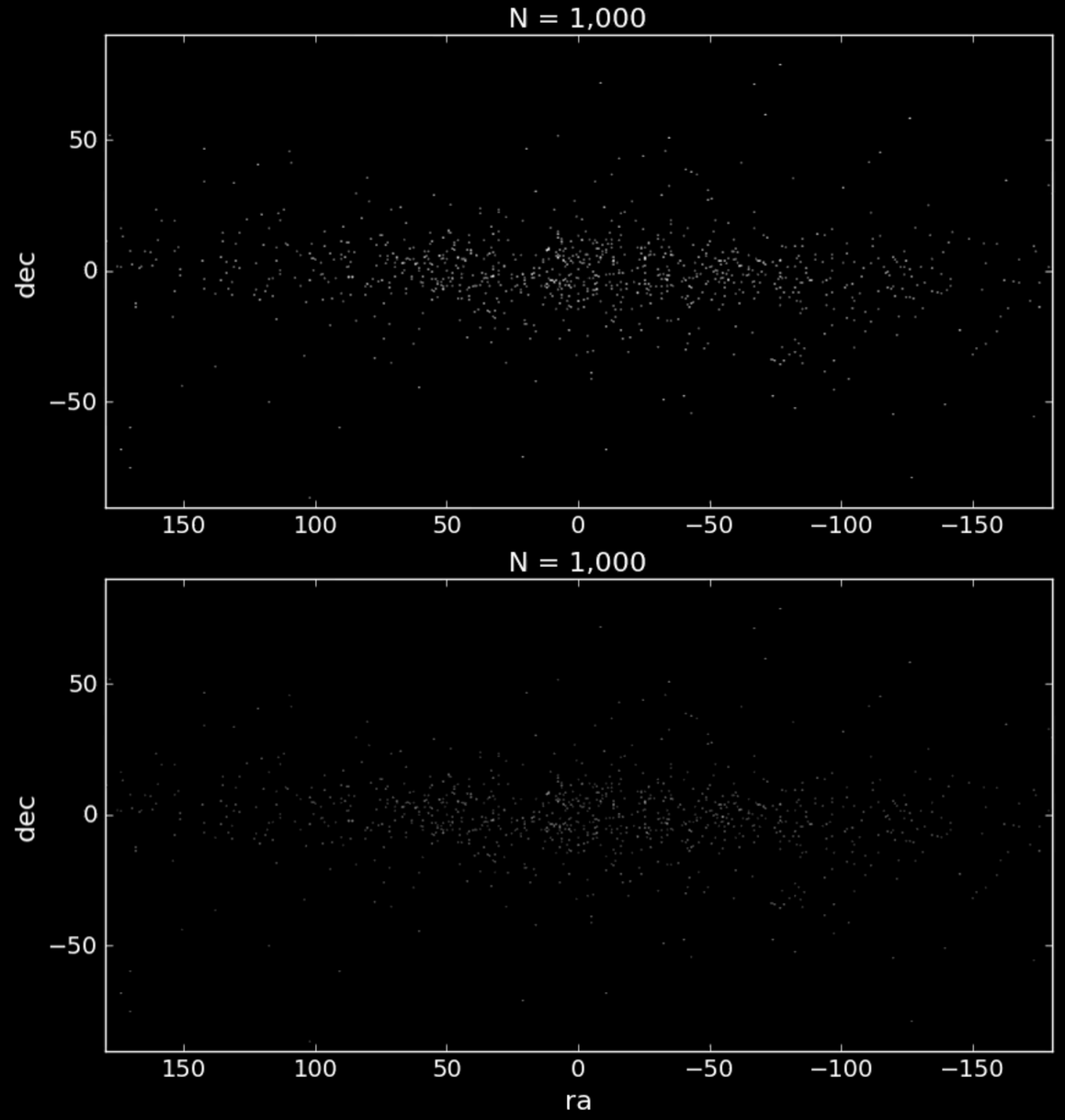
Motivation: Gaia

Motivation: Gaia

- > 1 billion stars
  - Sky positions
  - Distance
  - Motions
  - And many more
    - Errors / Correlations

Motivation: Gaia

- > 1 billion stars
  - Sky positions
  - Distance
  - Motions
  - And many more
    - Errors / Correlations
- Latest data release
  - 1.7 billion rows
  - 1.2 TB
  - 94 columns/features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dec
50
0
−50
150
100
50
0
−50
−100
−150
N = 1,000
dec
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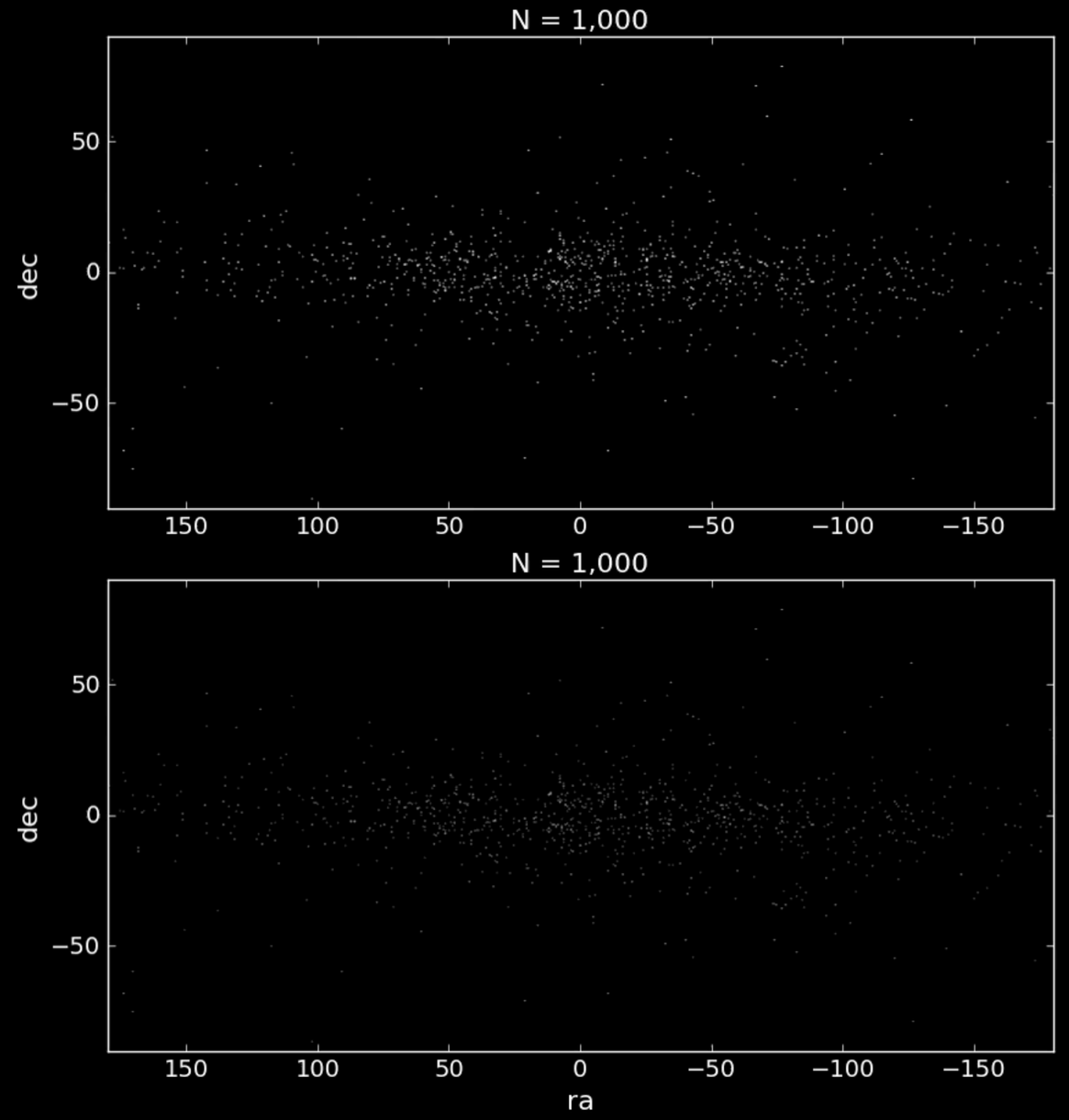
0
−50
150
100
50
0
−50
−100
−150
ra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dec
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50
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−50
−100
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N = 1,000
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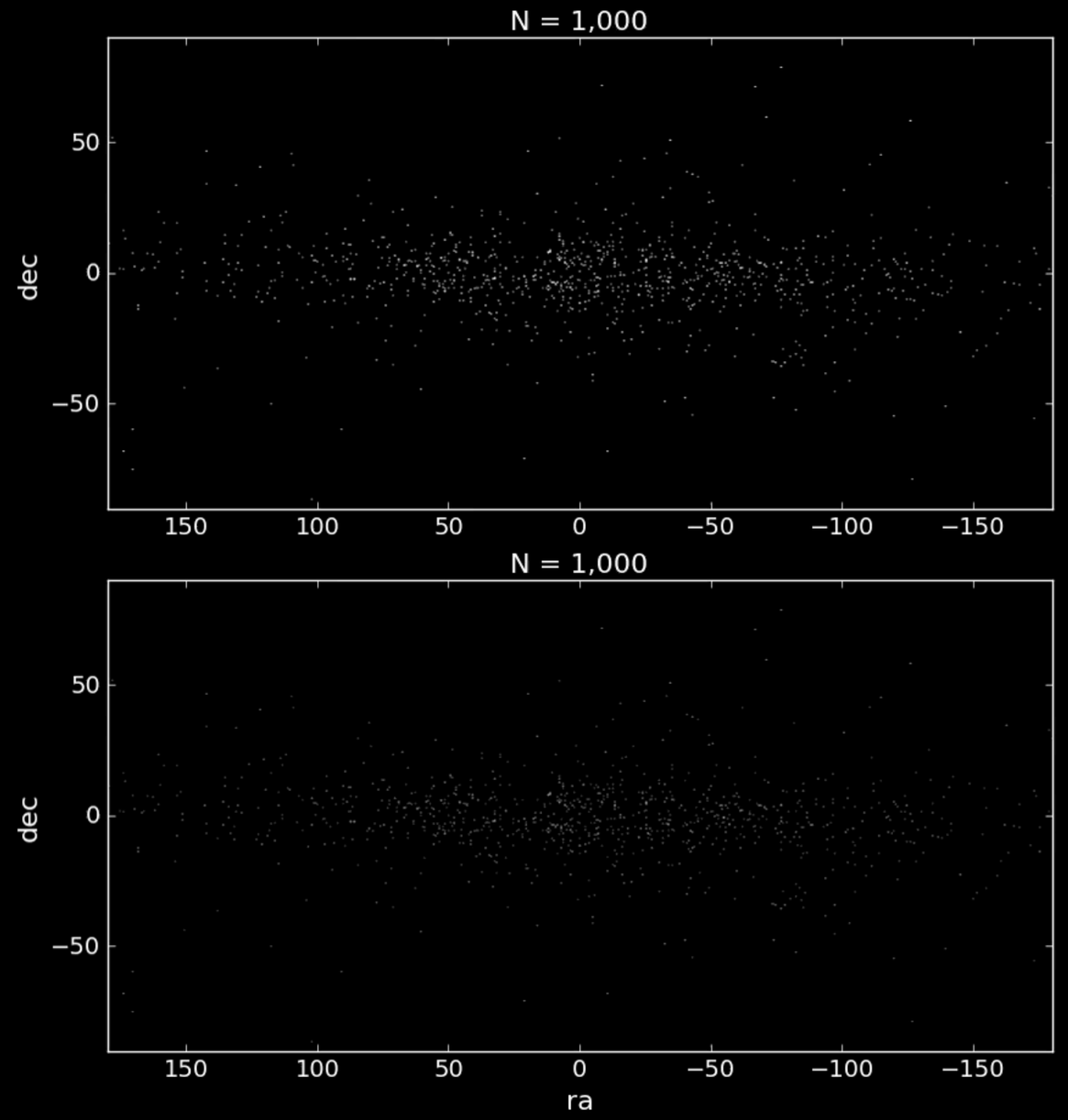
−50
dec
150
100
50
0
−50
−100
−150
ra

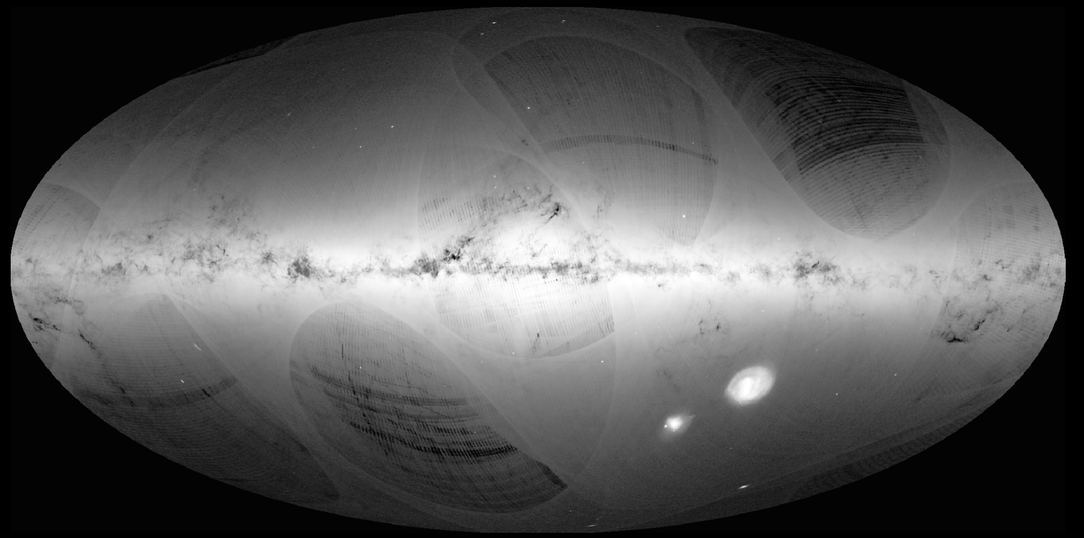
scatter



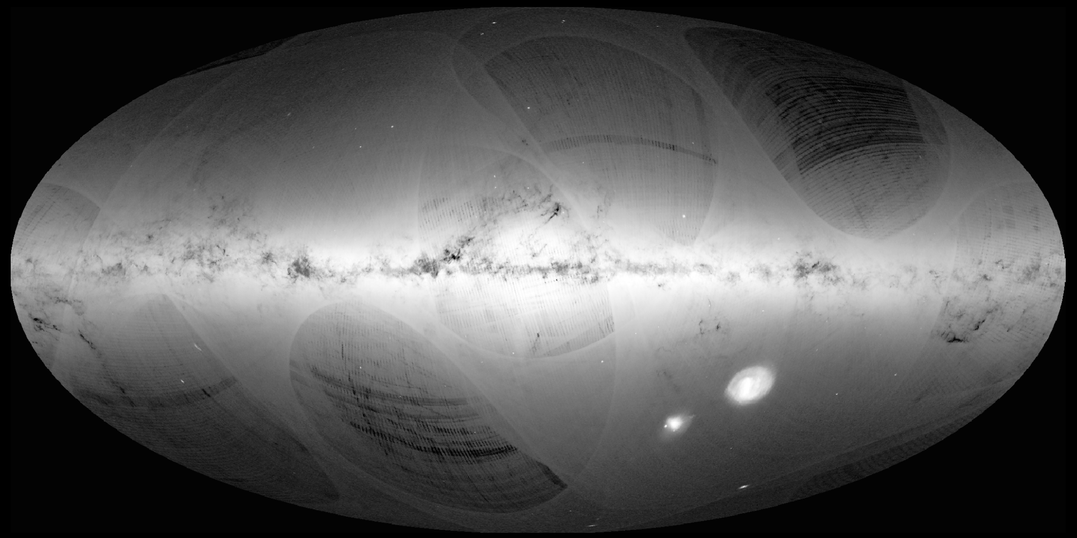
scatter

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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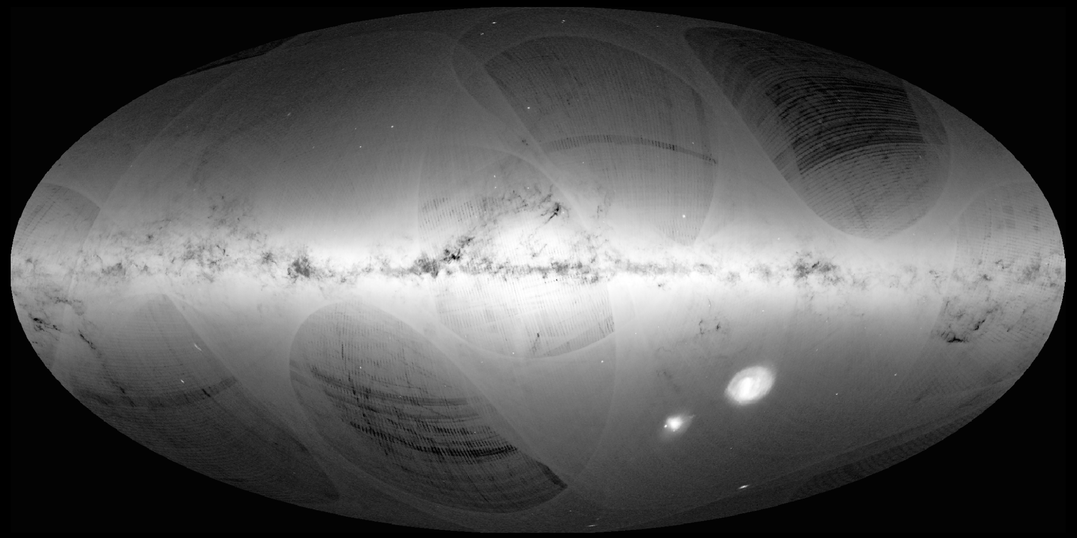
  - Memory bandwidth: 10-50 GiB/s: ~1 second



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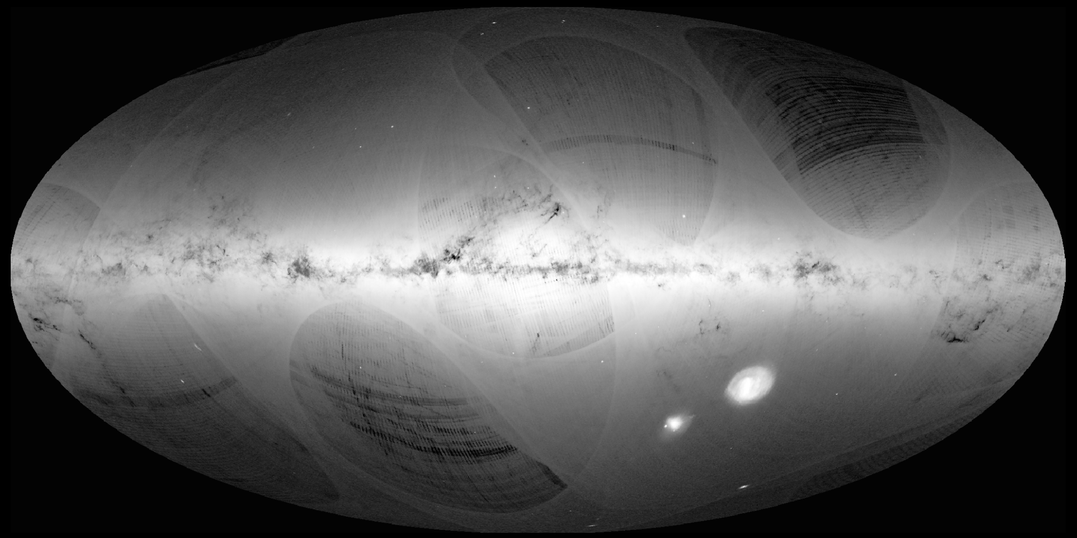

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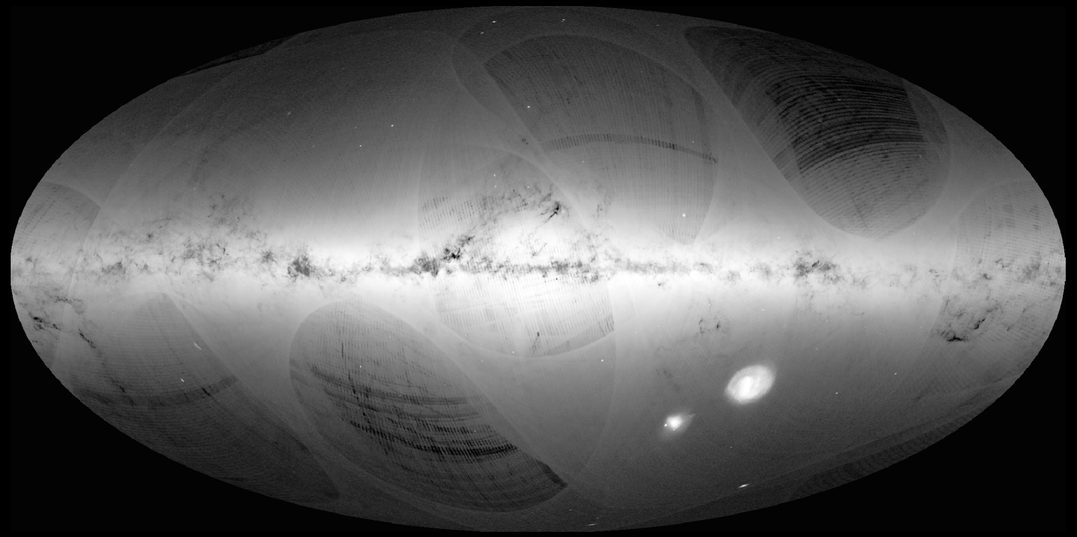
  - Few cycles per row/object, simple algorithm



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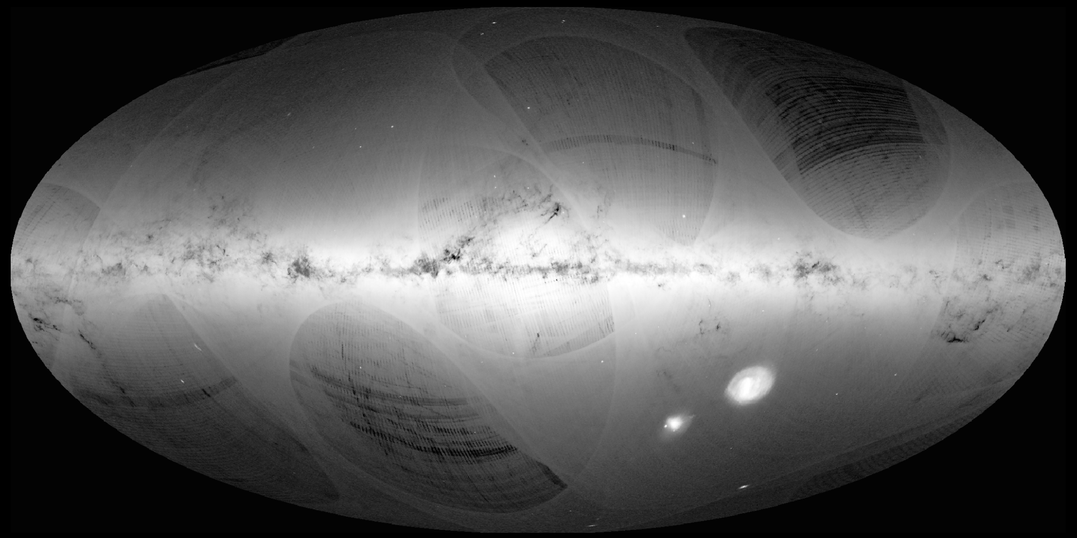
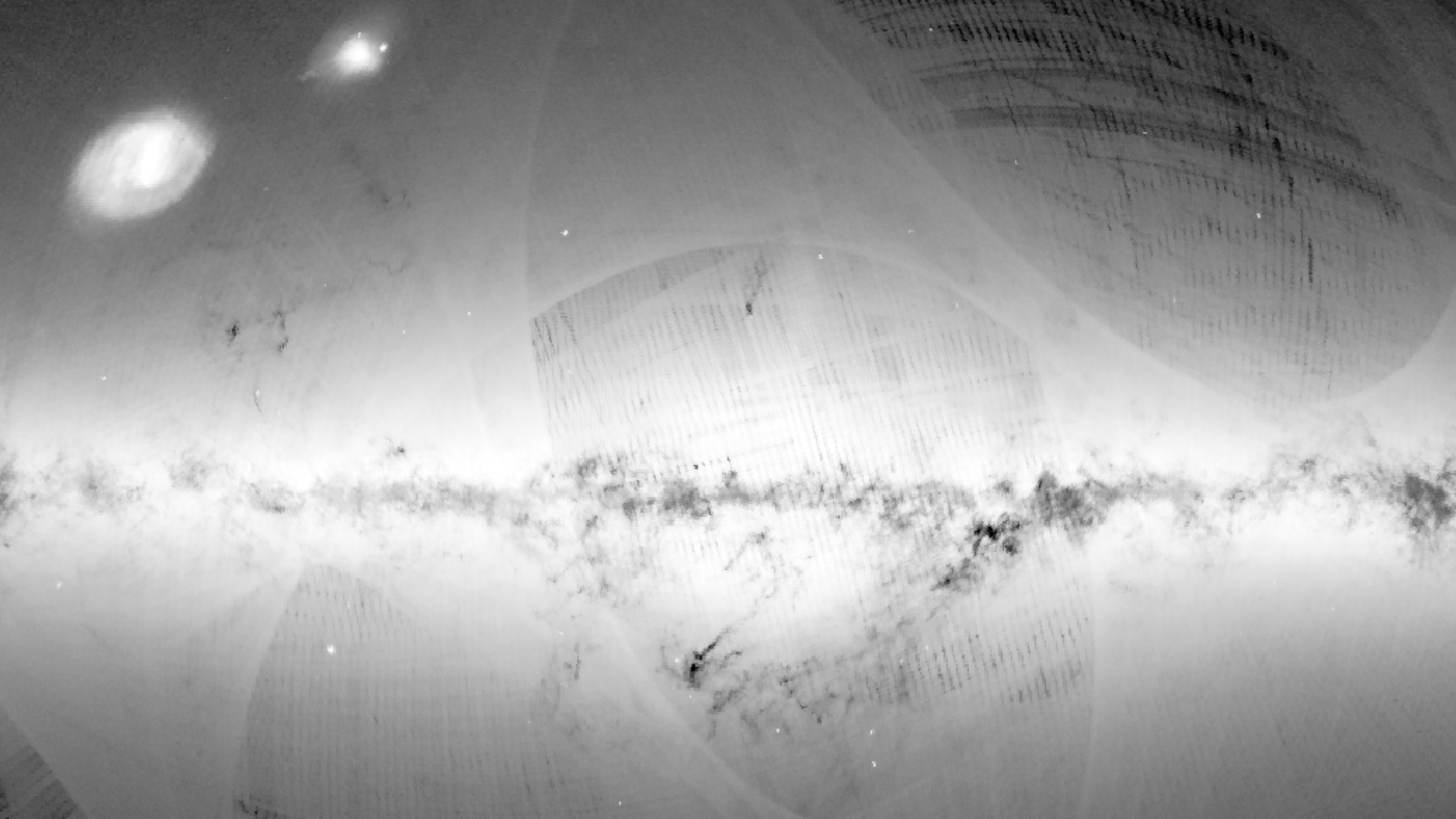
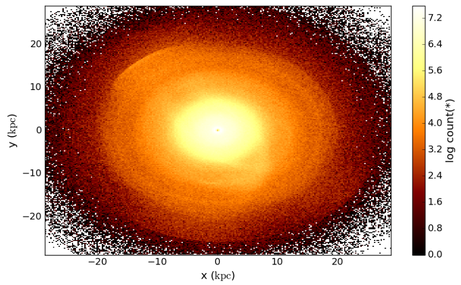
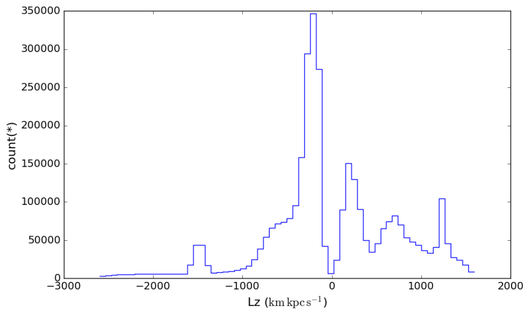
  - CPU: 3 Ghz (but multicore, say 4-8): 12-24 cycles/second
  - Few cycles per row/object, simple algorithm
  - Histograms/Density/Statistics grids



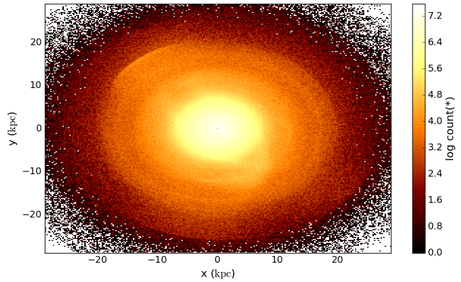



20
10
0
−10
−20
y (kpc)
−20
−10
0
10
20
x (kpc)
7.2
6.4
5.6
4.8
4.0
3.2
2.4
1.6
0.8
0.0
log count(+)

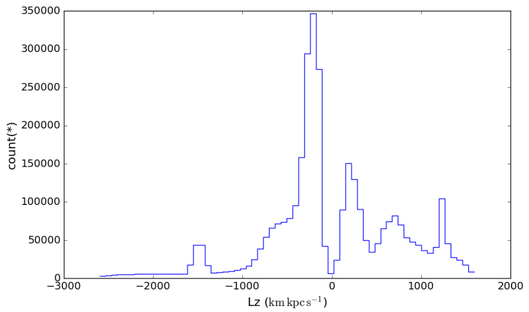
1d


350000
300000
250000
200000
150000
100000
50000
0
count(*)
−3000
−2000
−1000
0
1000
2000
Lz (km kpc s^{-1})

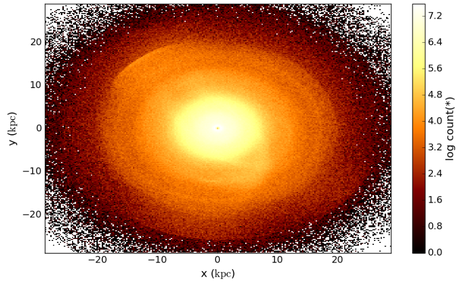
2d


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(*)

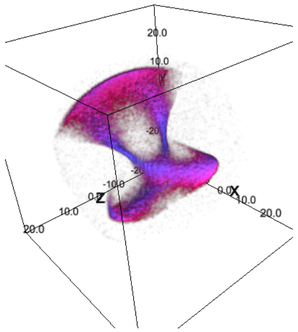
1d


350000
300000
250000
200000
150000
100000
50000
0
count(*)
−3000
−2000
−1000
0
1000
2000
Lz (km kpc s^{-1})

2d

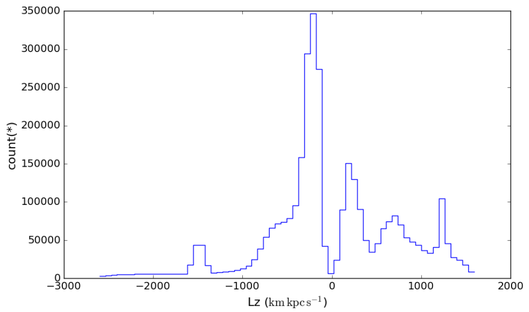

20
10
0
−10
−20
y (kpc)
−20
−10
0
10
20
x (kpc)
7.2
6.4
5.6
4.8
4.0
3.2
2.4
1.6
0.8
0.0
log count(*)

3d


20.0
10.0
0.0
-10.0
-20.0
Z
X
Y

0d 330,000 rows

1d



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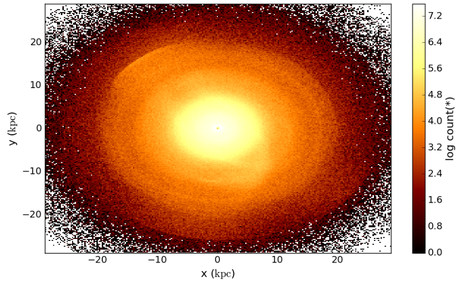

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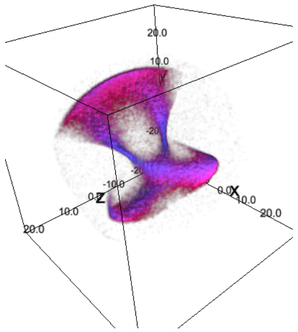
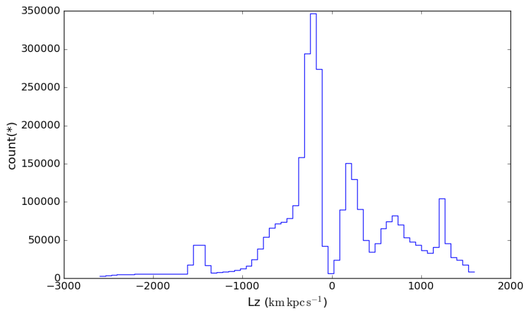


0d 330,000 rows

1d



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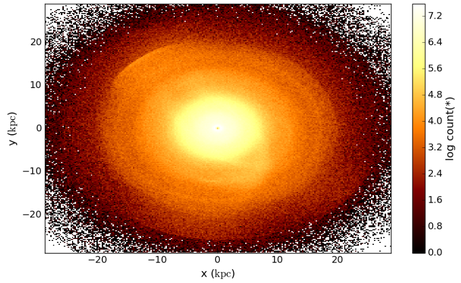

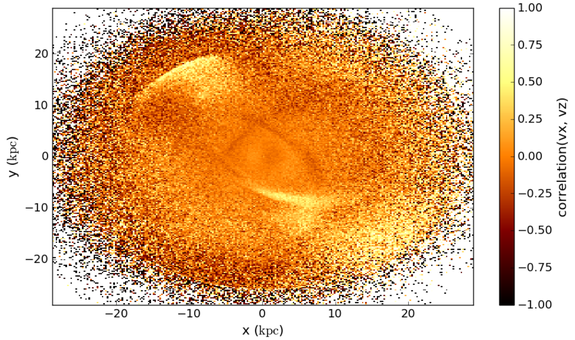

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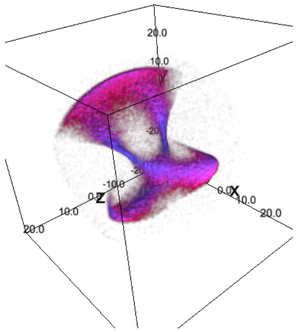
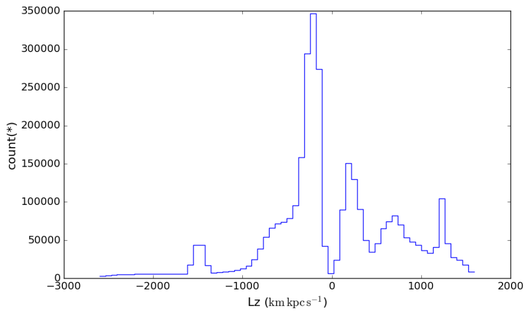
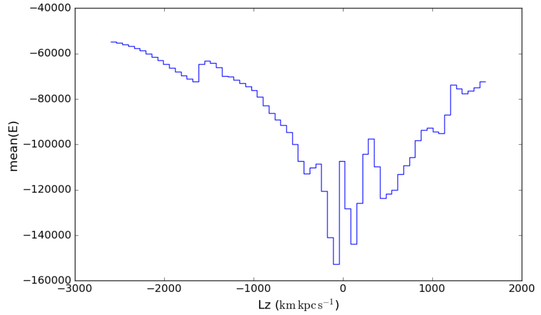


0d 330,000 rows

1d





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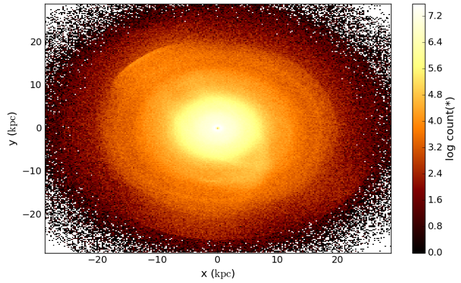

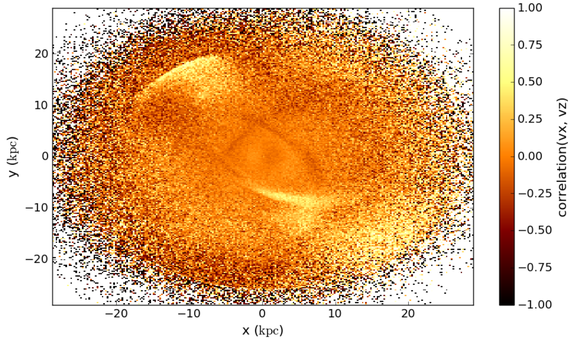

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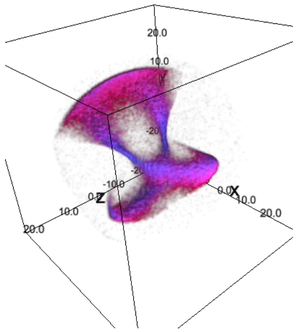

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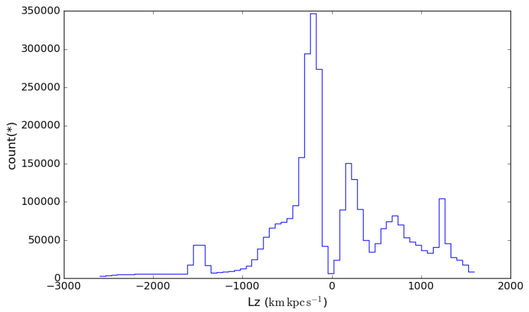
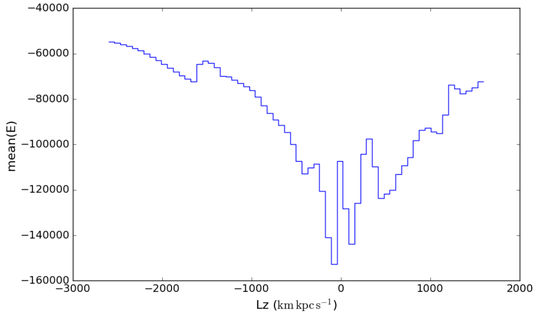
1d





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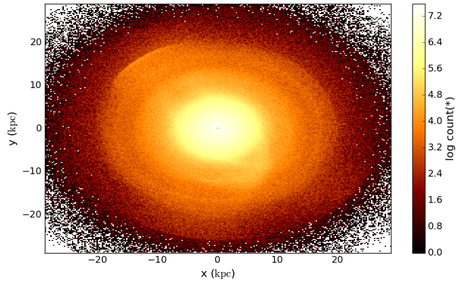

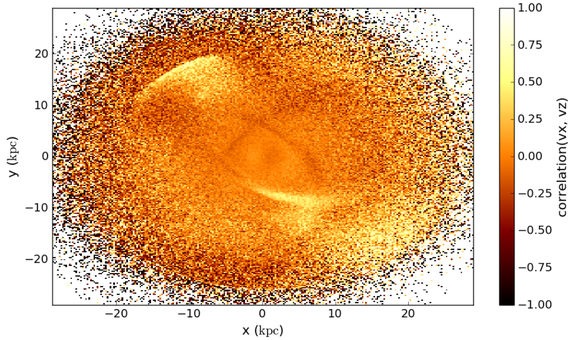

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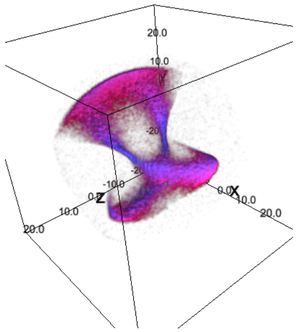
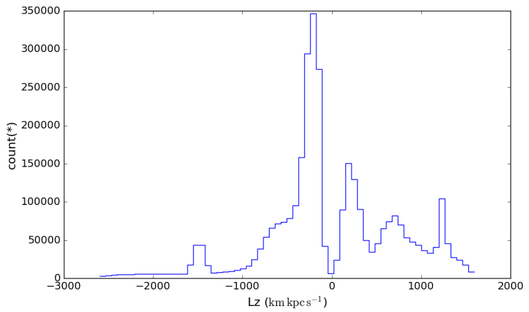
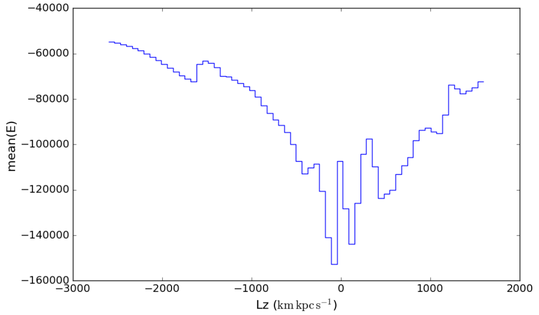


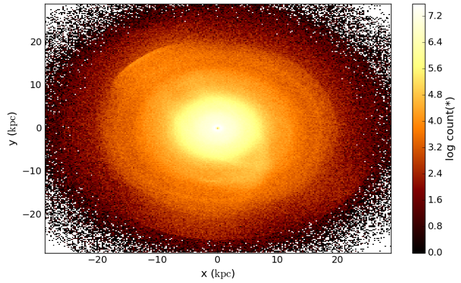
0d 330,000 rows mean: -0.083

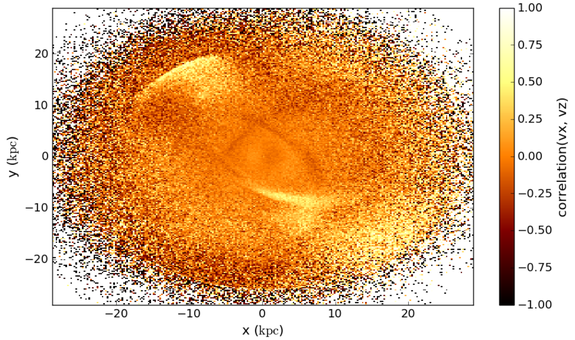
1d



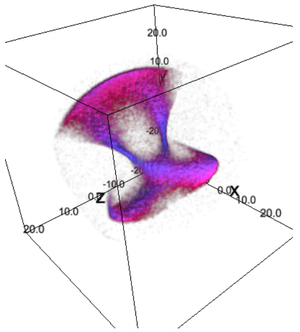


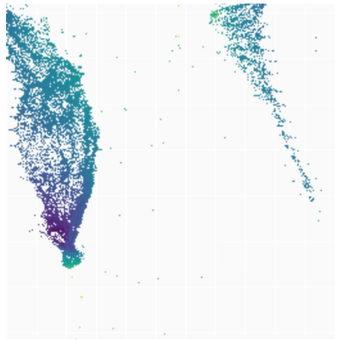
2d





3d





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  - Machine learning (Boosted Trees, K-means, PCA, ..)
  - Distributed computing (>10^{10} rows)

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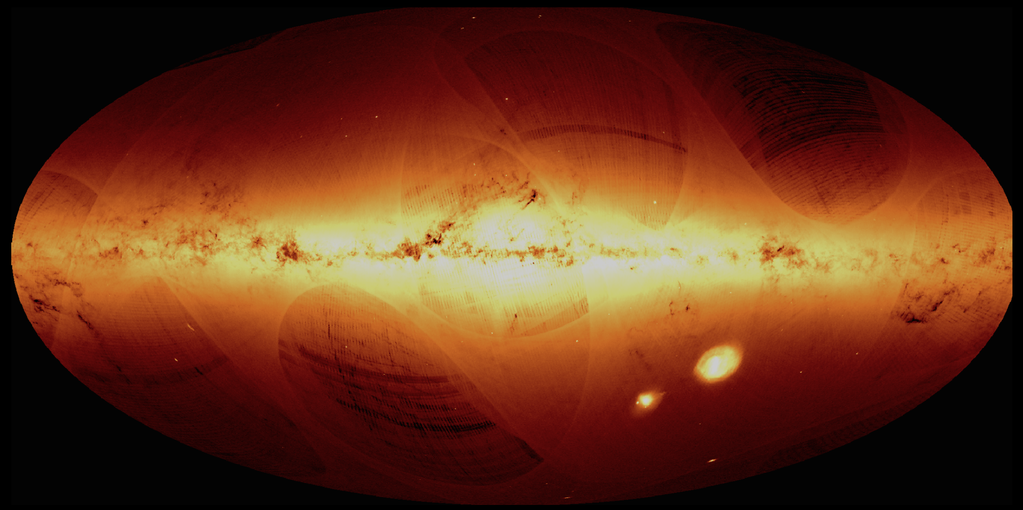

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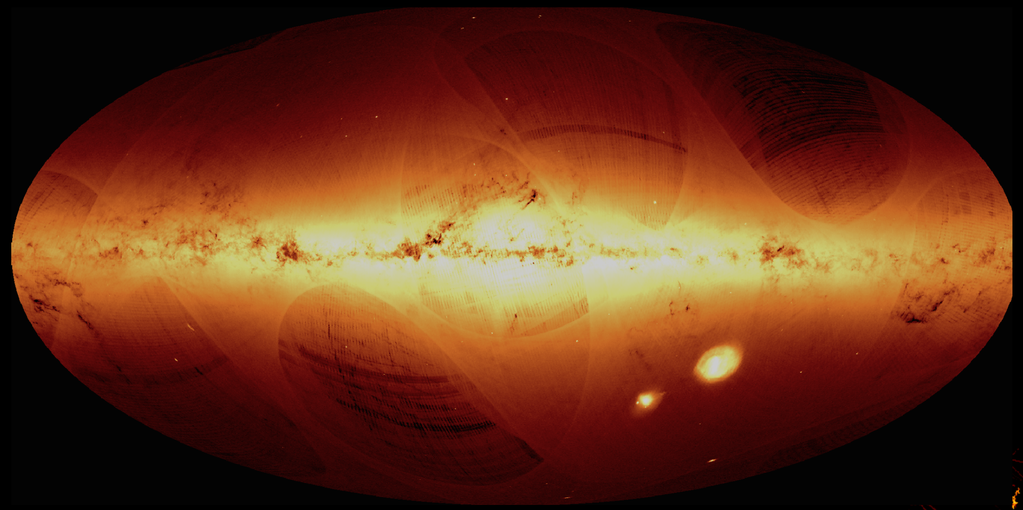

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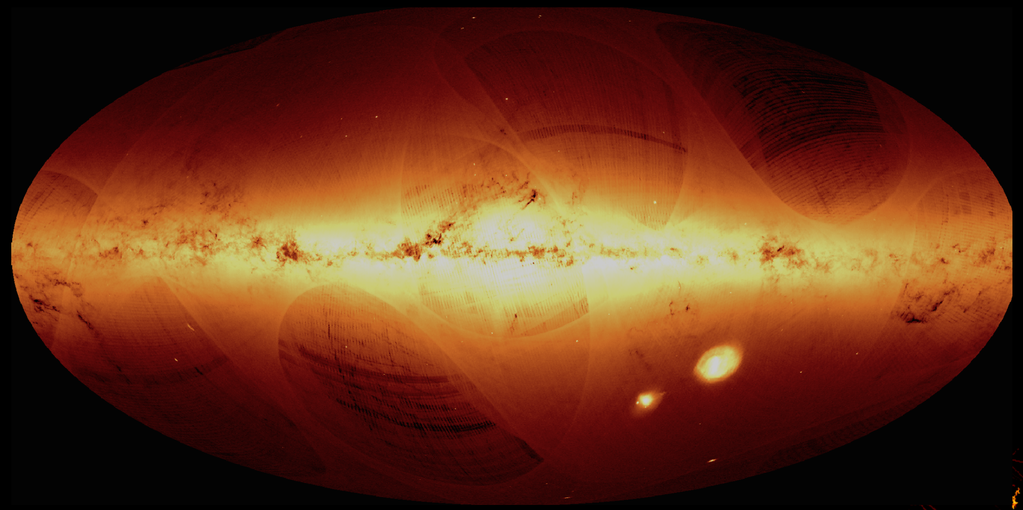

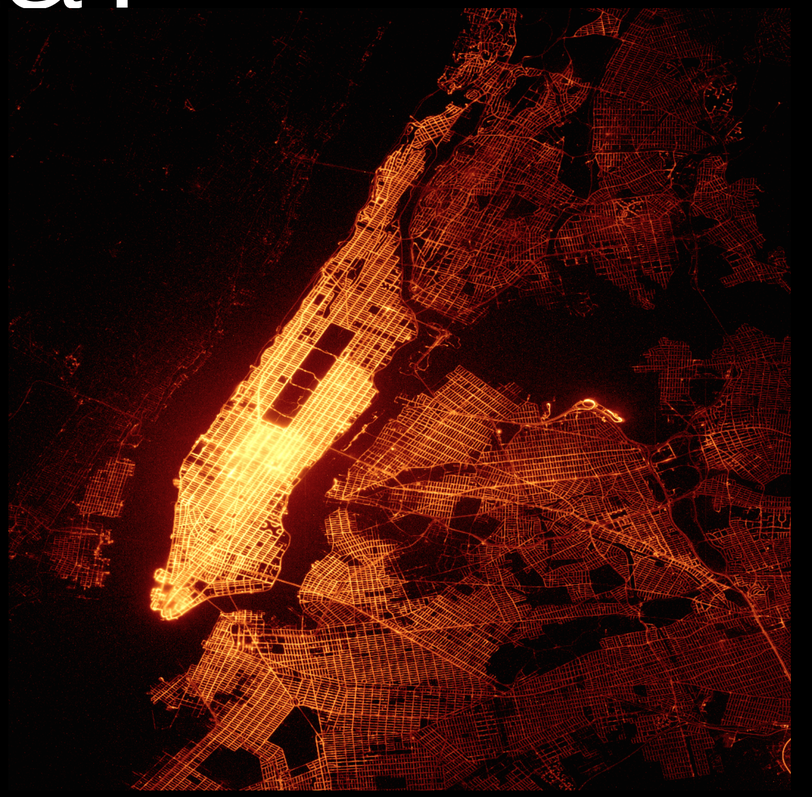

“Never do a live demo”

-Many people

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  - Large datasets should be memory mapped: Apache Arrow / hdf5
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    - No memory wasted
    - No information lost: JIT/derivatives
    - ML pipelines are a byproduct

- vaex
  - https://vaex.io
  - https://github.com/maartenbreddels/vaex
  - pip install —pre vaex
  - conda install -c conda-forge vaex
- https://github.com/maartenbreddels/talk-pyparis-2018
- maartenbreddels@gmail.com
- jovan.veljanoski@gmail.com