COSMO HUB on Hadoop

https://cosmohub.pic.es

A web portal to analyze and distribute cosmology data

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Outlook

- What is CosmoHub
- Motivation
- Drawbacks
- Hadoop solution
- Comparison
- Demo
- Conclusions & future work

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COSMO HUB

Build your own Universe

Real-time data analysis of massive cosmological data without any SQL knowledge

Hundreds of millions of observed and simulated galaxies

Superfast queries means superfast results

Features to make you work faster and easier

Online plotting preview and data download

CosmoHub on PostgreSQL

- CosmoHub was first thought as a way to share data within two closed related projects, the Physics of the Accelerating Universe (PAU) and the Marenostrum Institut de Ciències de l'Espai simulations (MICE)
- It was built on top of a PostgreSQL relational database
- It was developed by people from the Institut de Ciències de l'Espai (ICE), the Port d'Informació Científica (PIC - www.pic.es), CIEMAT and IFAE
- It was hosted and operated at PIC

Some numbers

- CosmoHub is currently supporting four different cosmology projects:

MICE
Marenostrum Institut de Ciències de l'Espai Simulations

PAU

DARK ENERGY SURVEY

euclid

- ~ 400 users
- ~ 1300 custom catalogs
- ~ 250 prebuilt downloads
- ~ 3 TiB hosted data
- > 10^9 objects

Already available features

- Custom catalogs without any SQL knowledge (CSV.BZ2 only)
- Plot & preview tool: small sample of data using a scatter plot or generate a 1D-histogram (query time limited to < 2’)
- Value-Added-Data ready to be downloaded

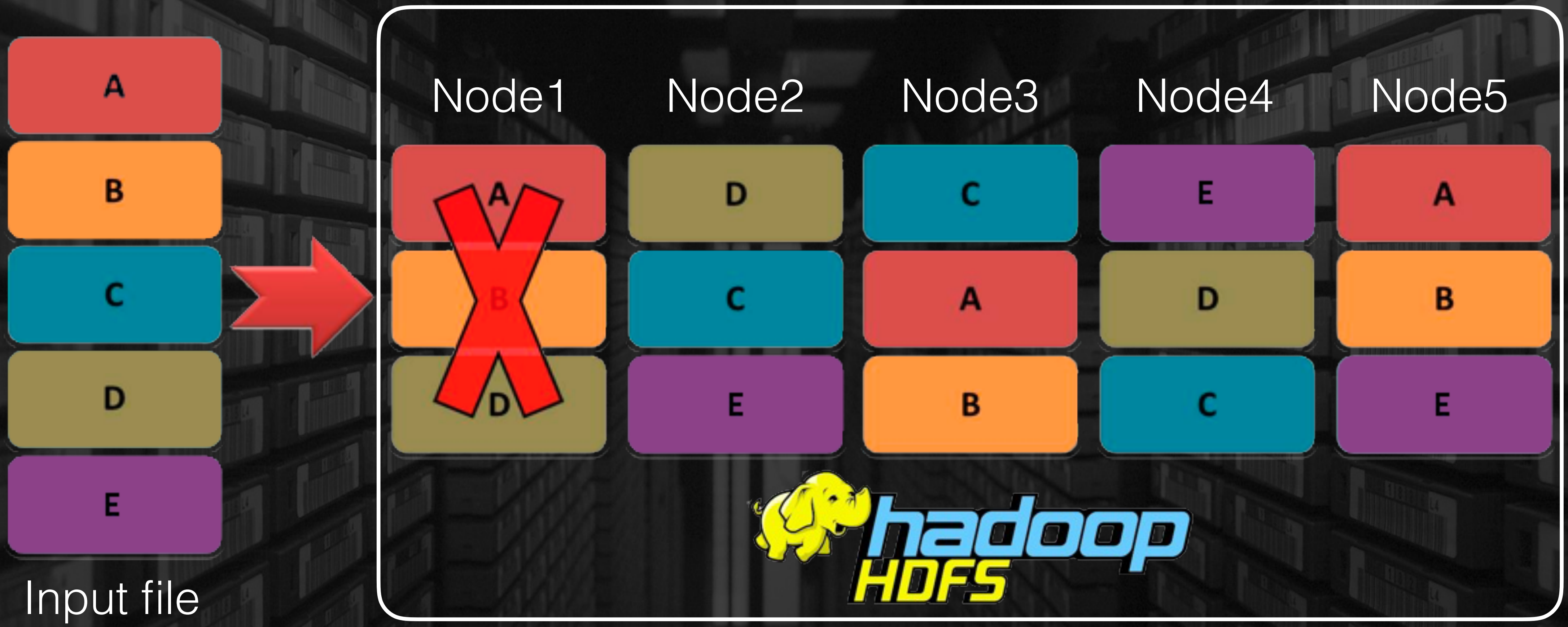
What happened?

- MICECATv2.0 catalog contains about 500M entries with more than 120 fields
- Managing large volume of data in PostgreSQL had some drawbacks:
  - Indices are not used for large datasets
    - Most custom catalogs lasted several hours
  - Changing the schema was very slow
  - Removing large subsets of data is very inefficient
- Future galaxy catalogs will contain a few 10^9 entries

Apache Hadoop & Hive

- Apache Hadoop:
  - one of the most popular Big Data platform
  - open-source software
  - based on commodity computer clusters
    - distributed storage and distributed processing
    - scalable from dozens up to even thousands of nodes
    - failure tolerance
- Apache Hive: query over massive data volumes

Hadoop basics



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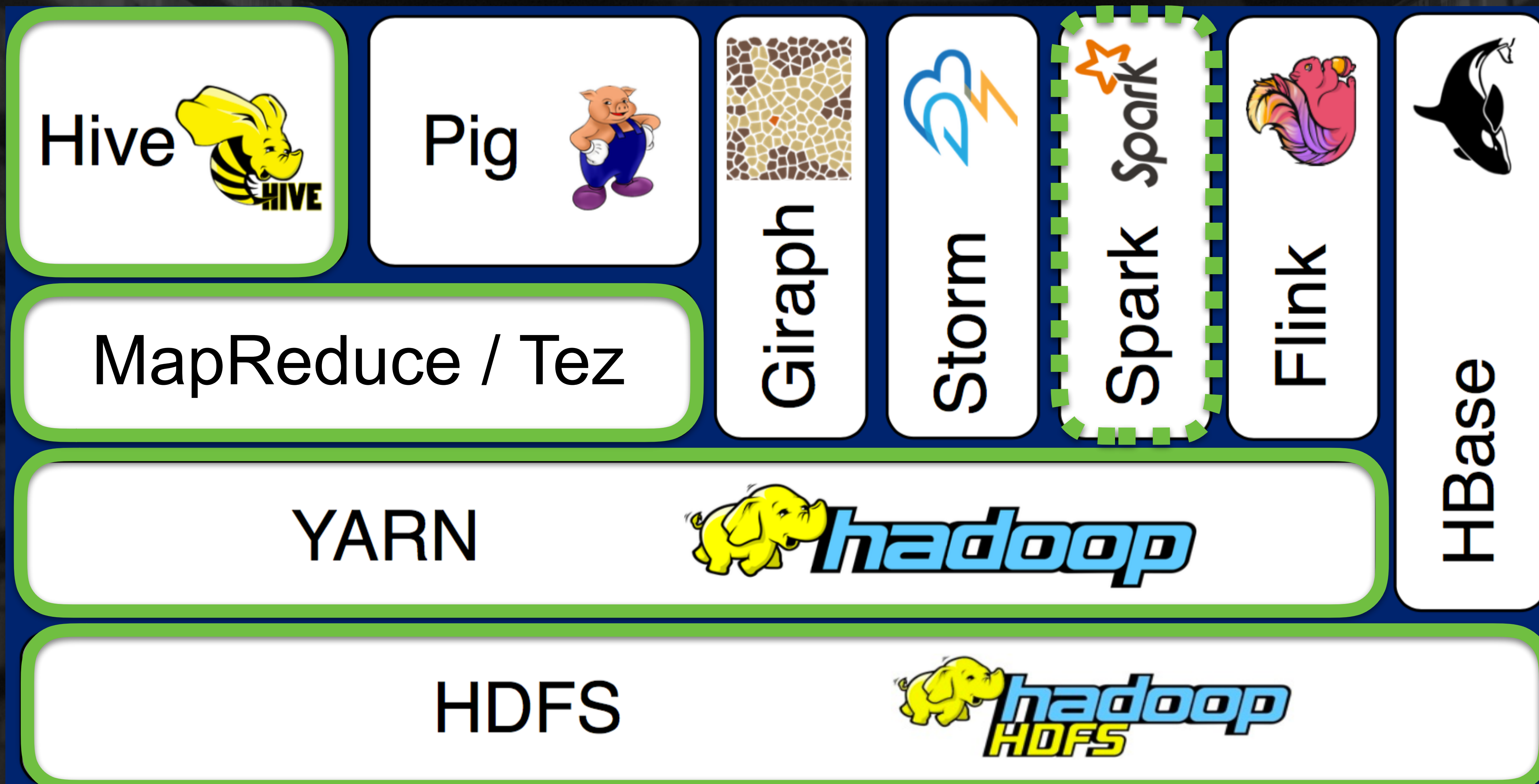
Hadoop stack



HORTONWORKS®

Hadoop vs. PostgreSQL

- Larger relative gain in execution time for increasing complexity in datasets and/or as queries request larger data volumes

(Comparisons are odious. It is very likely to unjust to one or other of them)

Hadoop

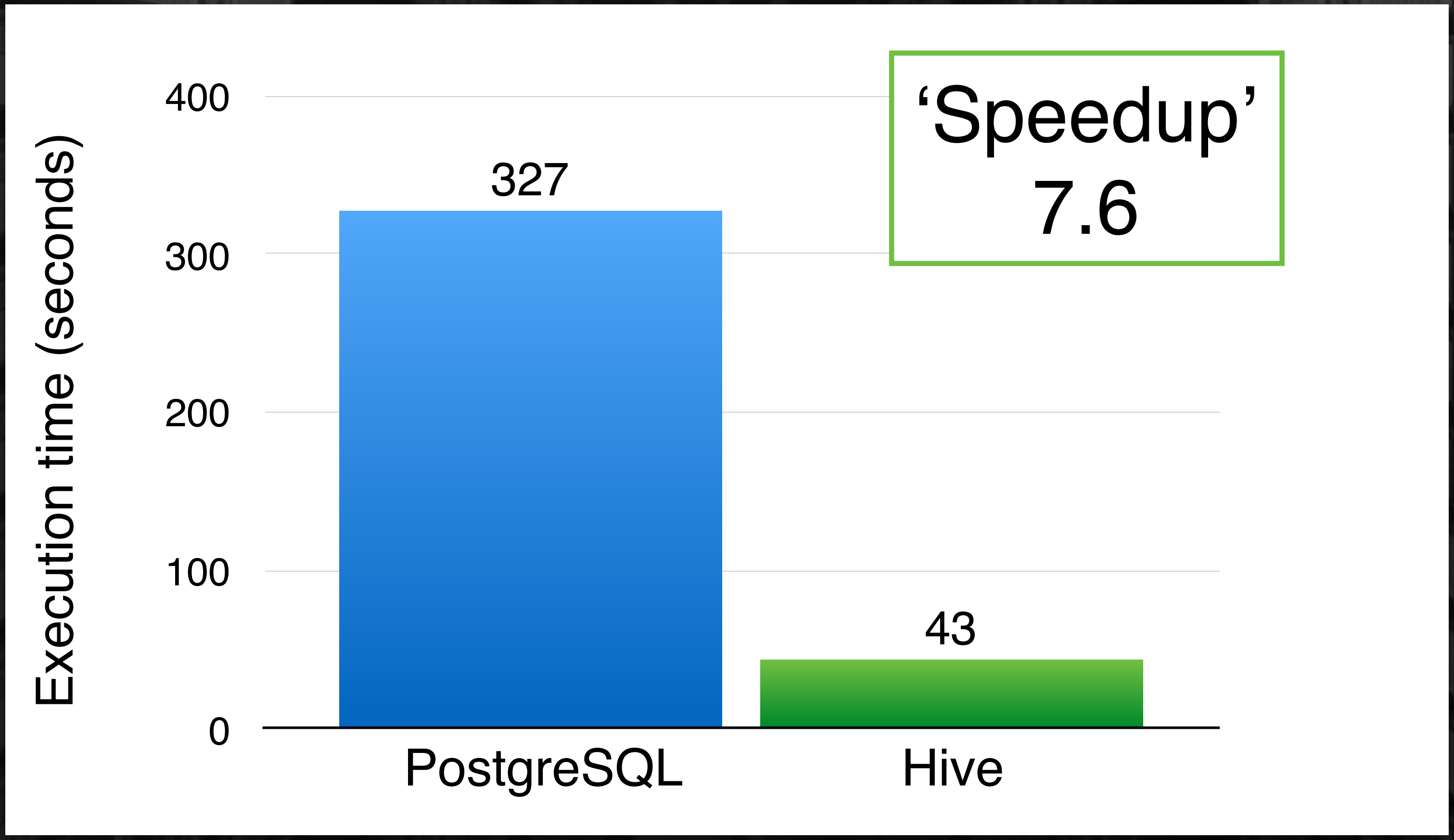
- Nodes: 15
  - Cores: 12 (Intel Xeon X5650 @ 2.67 GHz) [180]
  - RAM: 24 GiB [360 GiB]
  - DISK: 1 TiB [15 TiB raw; ~5 TiB net]
  - Network: 1 GbE

PostgreSQL

- Hardware:
  - Cores: 24 (Intel Xeon X5675 @ 3.07 GHz)
  - RAM: 96 GiB
  - DISK: 600 GB HDD x 8 (in RAID 6) ~ 3.6 TB net
  - Network 1GbE
- Software:
  - Scientific Linux 6.1
  - PostgreSQL 9.1

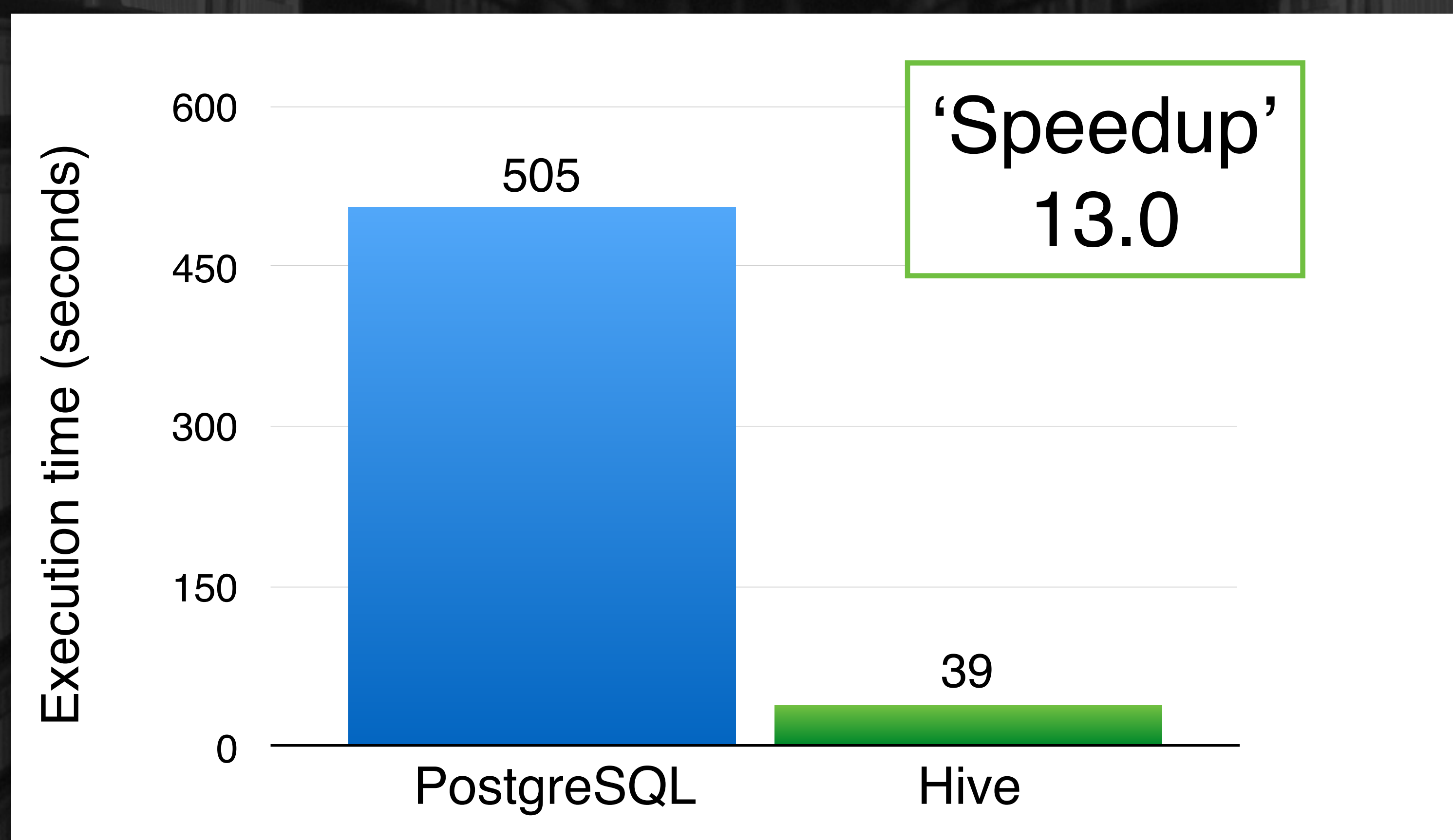
Hadoop vs. PostgreSQL

```
SELECT ra, dec, z, z_v, x_c, y_c, z_c FROM
micecatv1 WHERE x_c < 700 AND y_c < 700 AND
z_c < 700;
```
(~5.8M out of ~205M rows)



Hadoop vs. PostgreSQL

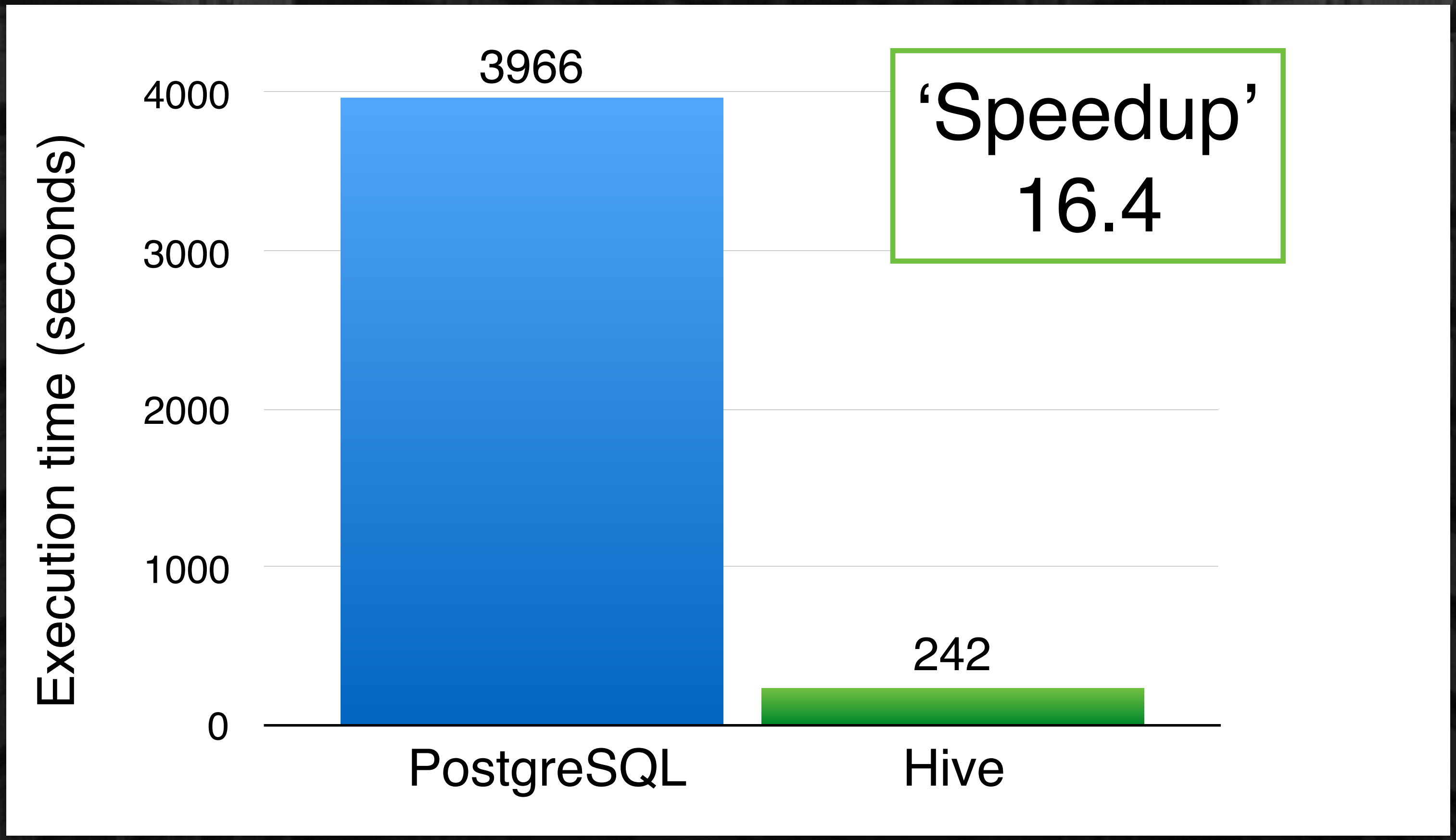
`SELECT x_c, y_c, z_c FROM micecatv1 WHERE x_c < 1e3 AND y_c < 1e3 AND z_c < 1e3;` ***(~16.5M out of ~205M rows)***



Hadoop vs. PostgreSQL

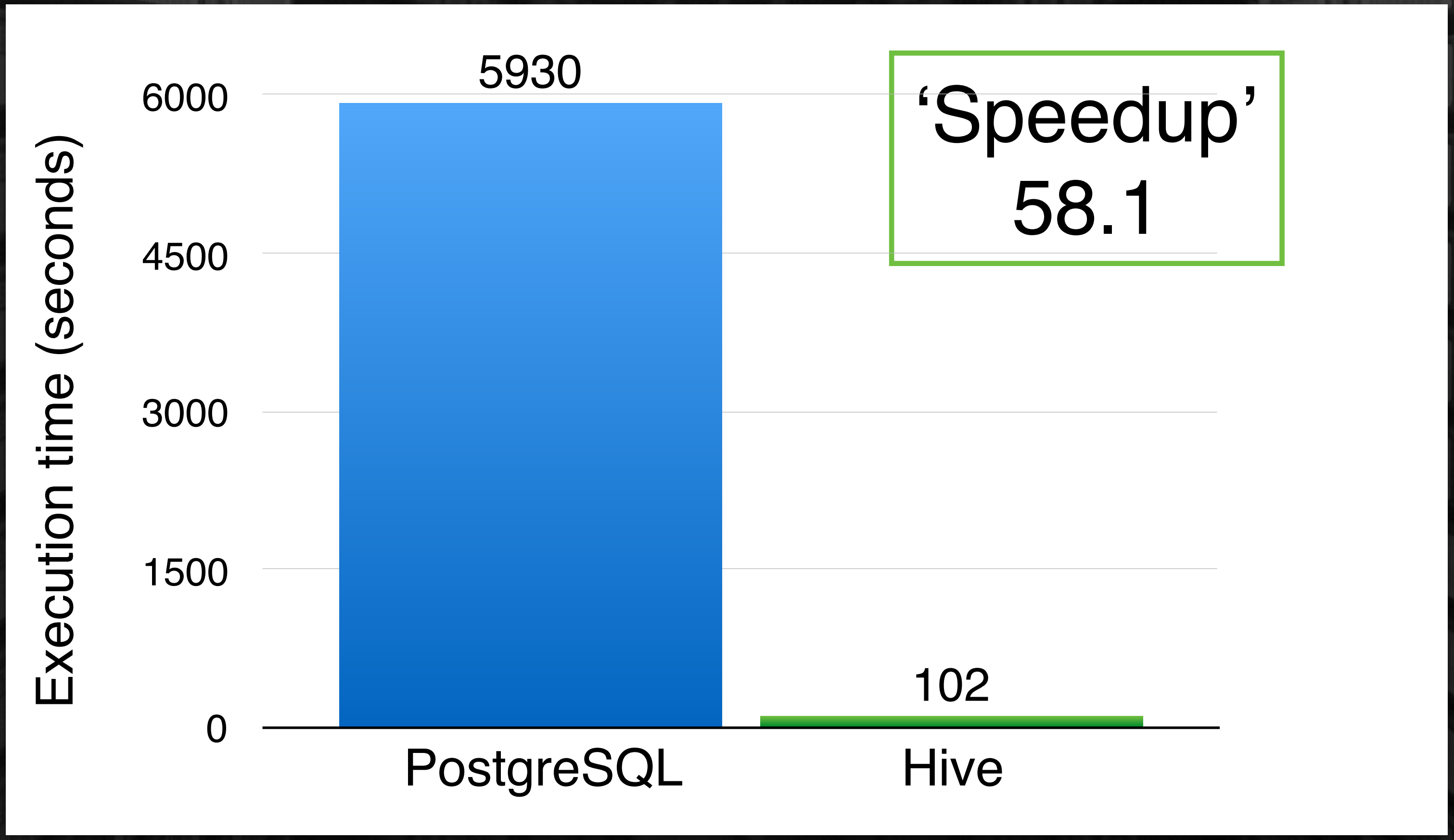
```
SELECT coadd_objects_id, ra, dec, mag_auto_i,
magerr_auto_i desdm_zp, mean_z_bpz, z_mc_bpz
FROM des_y1a1 WHERE modest_class = 1 AND
flags_gold = 0 AND flags_badregion = 0;
```

(~81.9M out of ~137M rows)



Hadoop vs. PostgreSQL

```
SELECT ra_gal, dec_gal, kappa, gamma1, gamma2
FROM micecatv2 WHERE lmhalo >= 12.16 AND
flag_central = 0 AND z_cgal > 0.4 AND z_cgal
< 0.6;
```
(~25.9M out of ~500M rows)



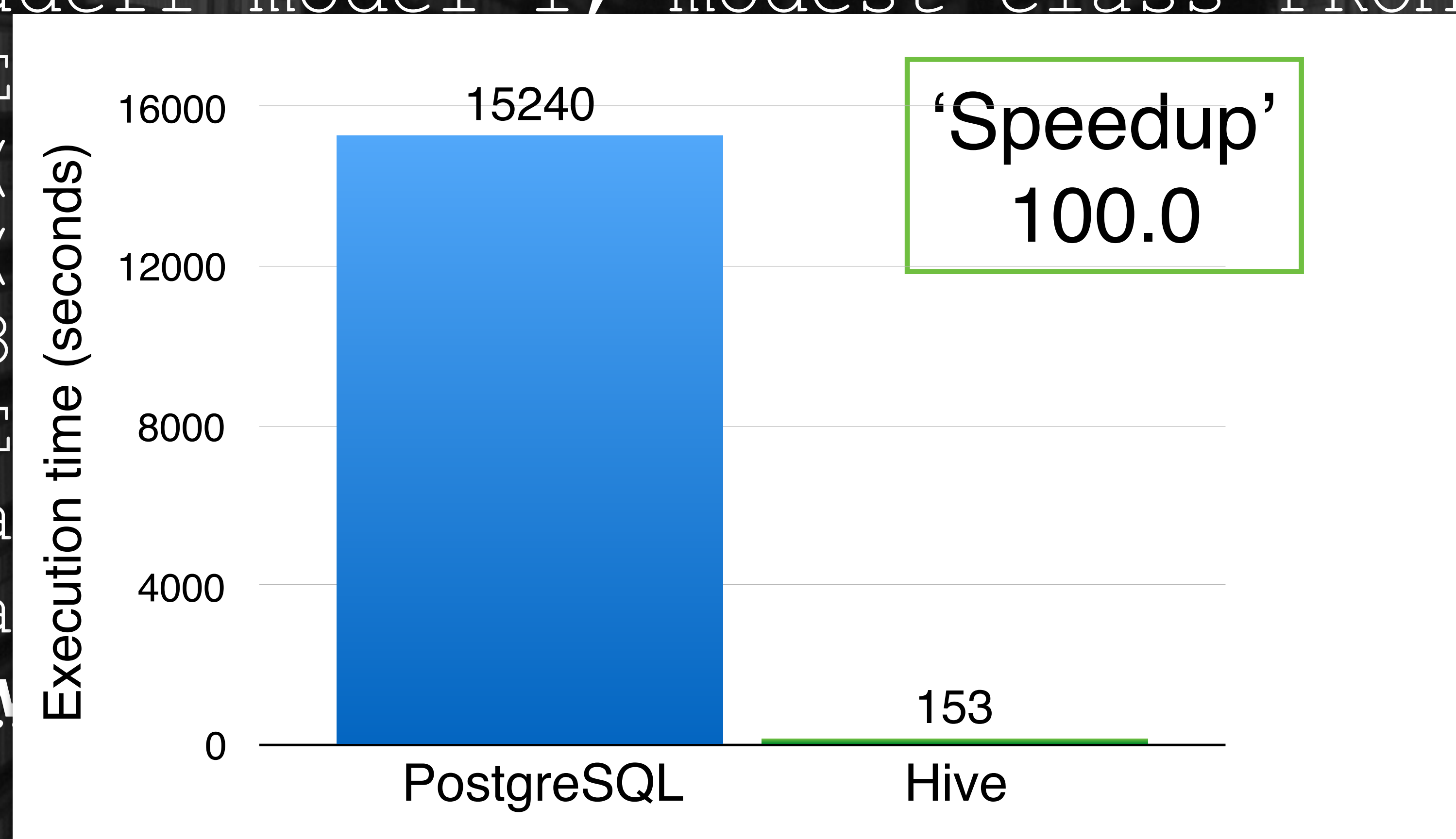
Hadoop vs. PostgreSQL

```
SELECT coadd_objects_id, ra, dec, mag_auto_g,
mag_auto_r, mag_auto_i, mag_auto_z,
mean_z_bpz, mode_z_bpz, median_z_bpz,
z_mc_bpz, t_b, spread_model_i,
spreaderr_model_i, modest_class FROM des_y1a1
WHERE mag_auto_i > 17.5 AND mag_auto_i < 22
AND (flags_badregion <= 3 and flags_gold = 0)
AND ((mag_auto_g - mag_auto_r) BETWEEN -1.
and 3.) AND ((mag_auto_r - mag_auto_i)
BETWEEN -1. and 2.5) AND ((mag_auto_i -
mag_auto_z) BETWEEN -1. and 2.) AND (ra < 15
or ra > 290 or dec < -35);
```

(~34.8M out of ~137M rows)

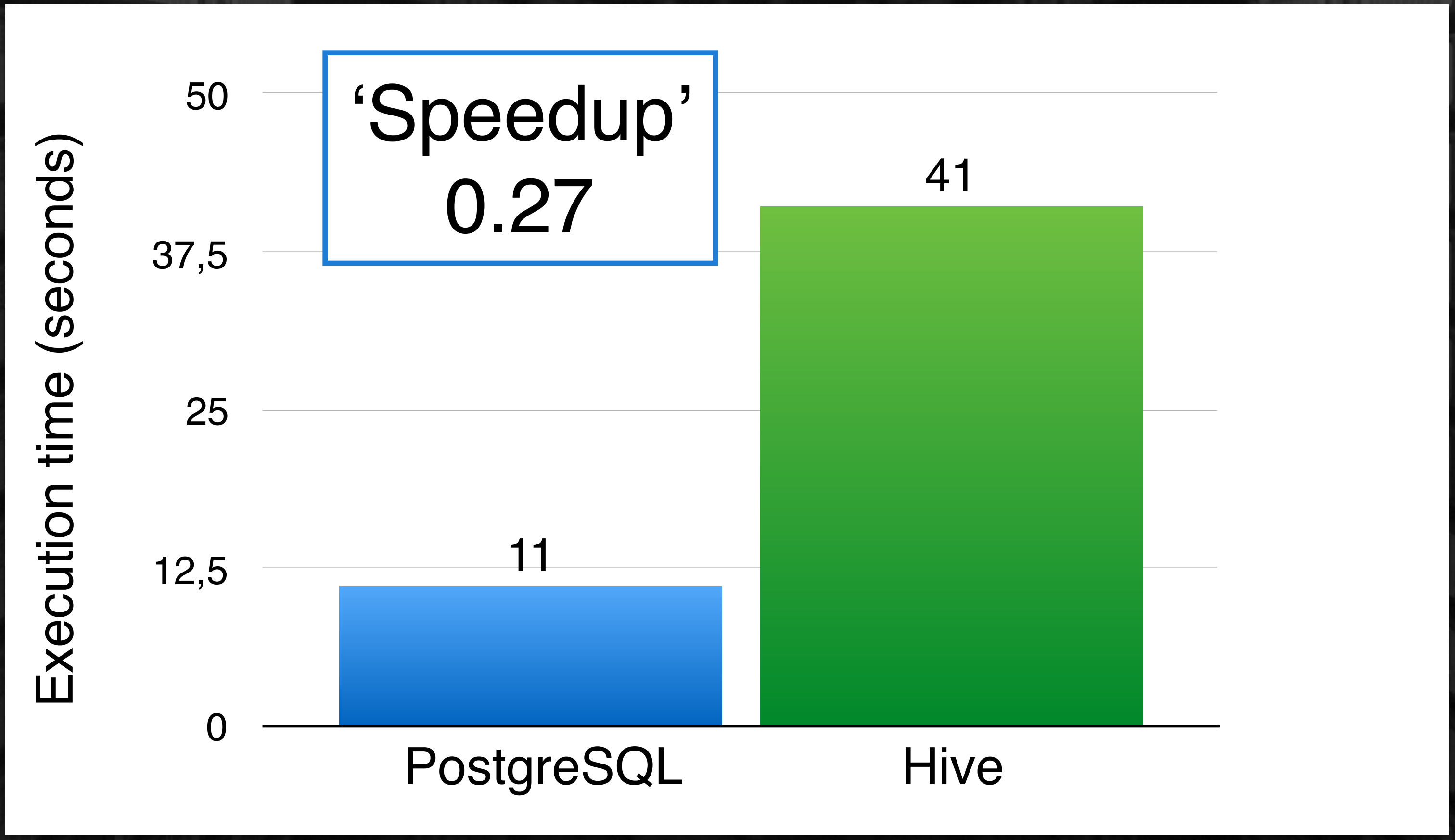
Hadoop vs. PostgreSQL

SELECT coadd_objects_id, ra, dec, mag_auto_g,
mag_auto_r, mag_auto_i, mag_auto_z,
mean_z_bpz, mode_z_bpz, median_z_bpz,
z_mc_bpz, t_b, spread_model_i,
spreaderr_model_i, modest_class FROM des_y1a1
WHERE … i < 22
AND (… gold = 0)
AND (… EN -1.
and 3 … i)
BETWE … i -
mag_a … (ra < 15
or ra … ***out of***
~137M



Hadoop vs. PostgreSQL

SELECT z, log_m FROM micecatv1 WHERE z < .25 AND z > .23 AND ra < 20 AND dec < 20; ***(~52K out of ~205M rows)***



Properly using indices and a very small amount of data requested!

CosmoHub on Hadoop

- CosmoHub is a portal for real-time analysis and distribution of massive cosmology data without any SQL knowledge
- It is built on top of Hadoop and uses the Apache Hive infrastructure
- It is fully developed, hosted and operated at PIC

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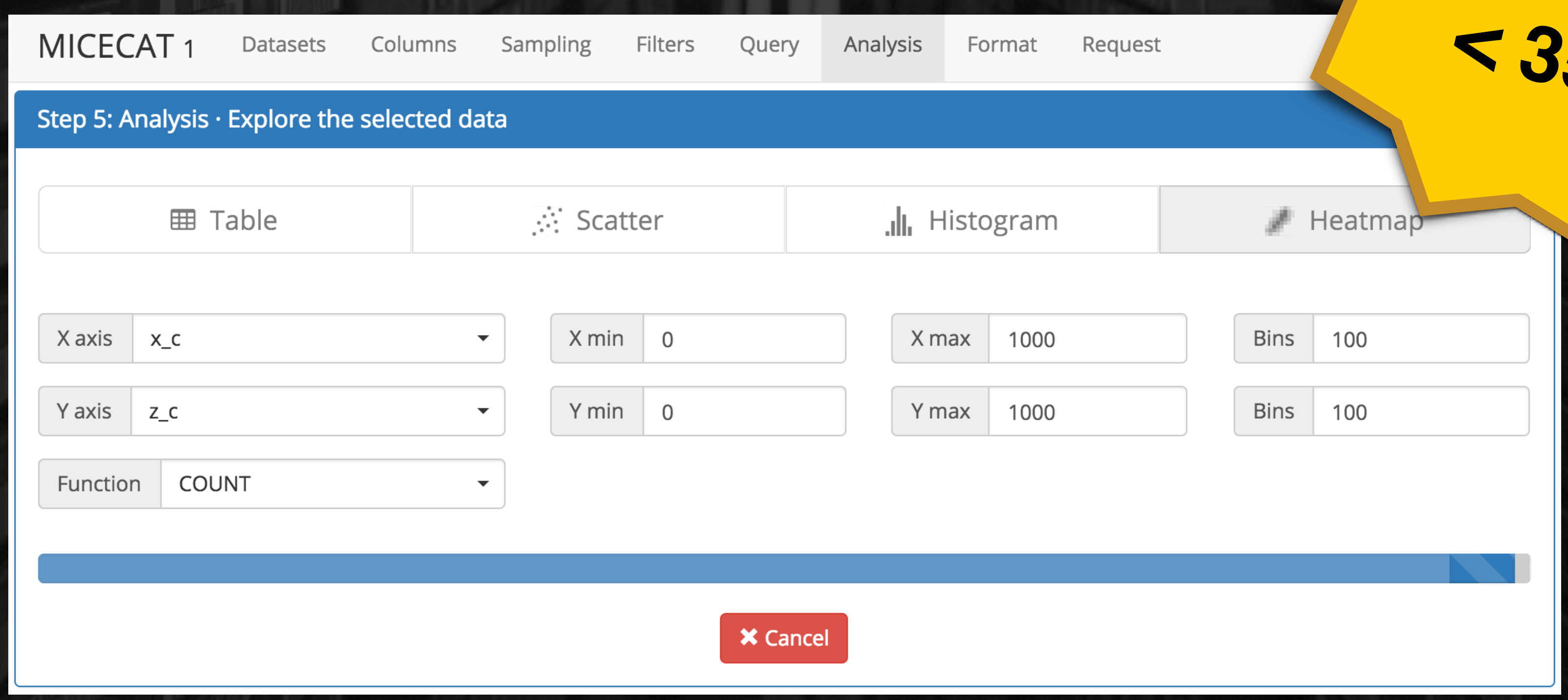
New features

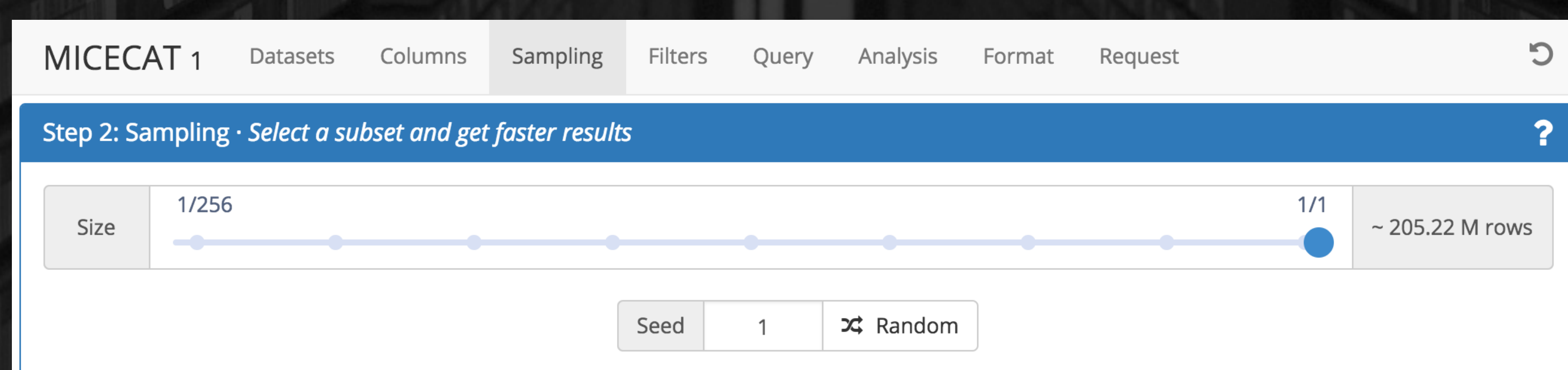
- Real time analysis (no time constraint)
- Sampling: select a random subset of the catalog to get faster results when exploring the data
- Heatmap plot
- 2 more file formats to download the selected d… and ASDF

500M
< 35”



New features

- Real time analysis (no time constraint)
- Sampling: select a random subset of the catalog to get faster results when exploring the data
- Heatmap plot
- 2 more file formats to download the selected data: FITS and ASDF



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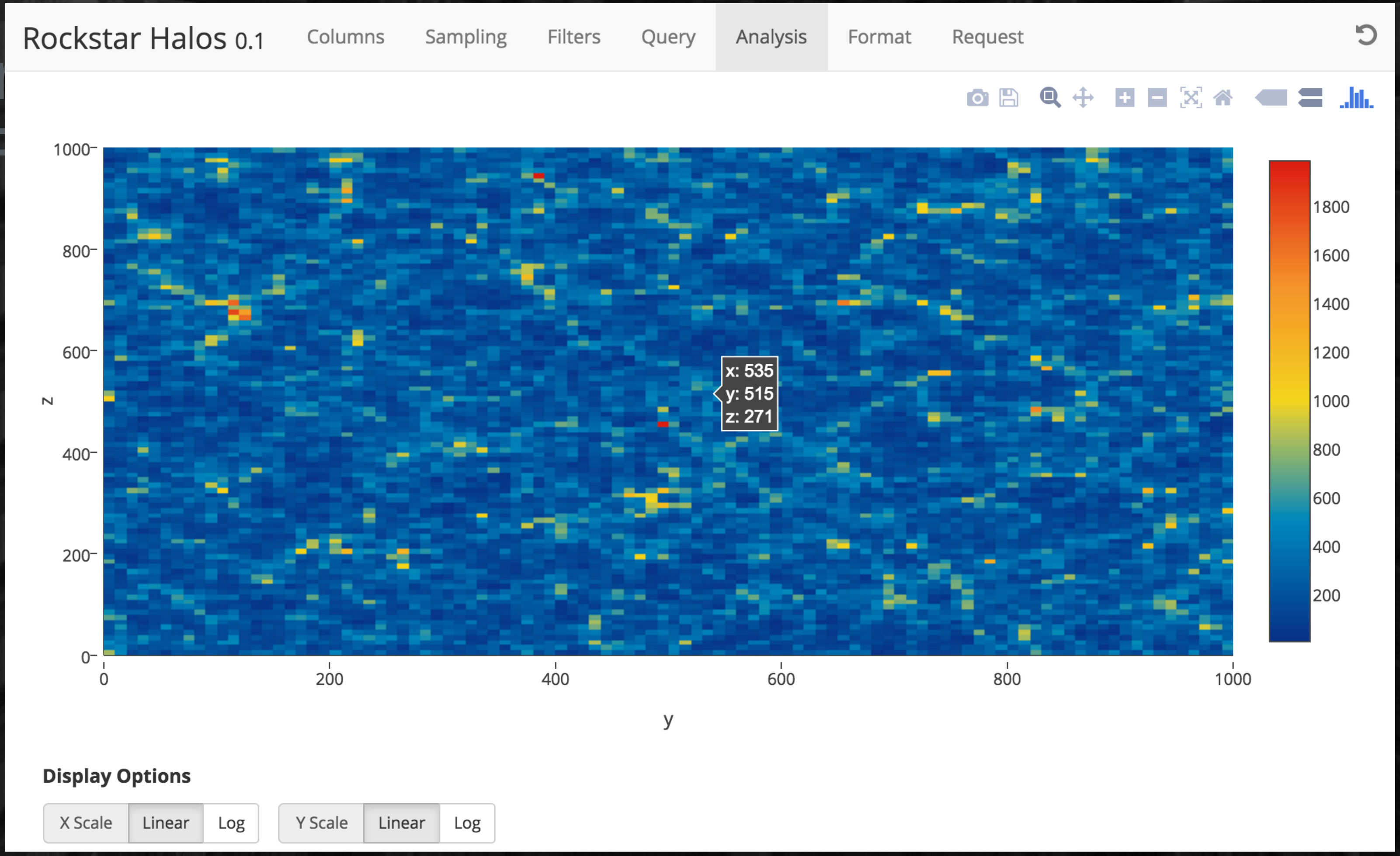

- 2 mor … FITS and ASDF

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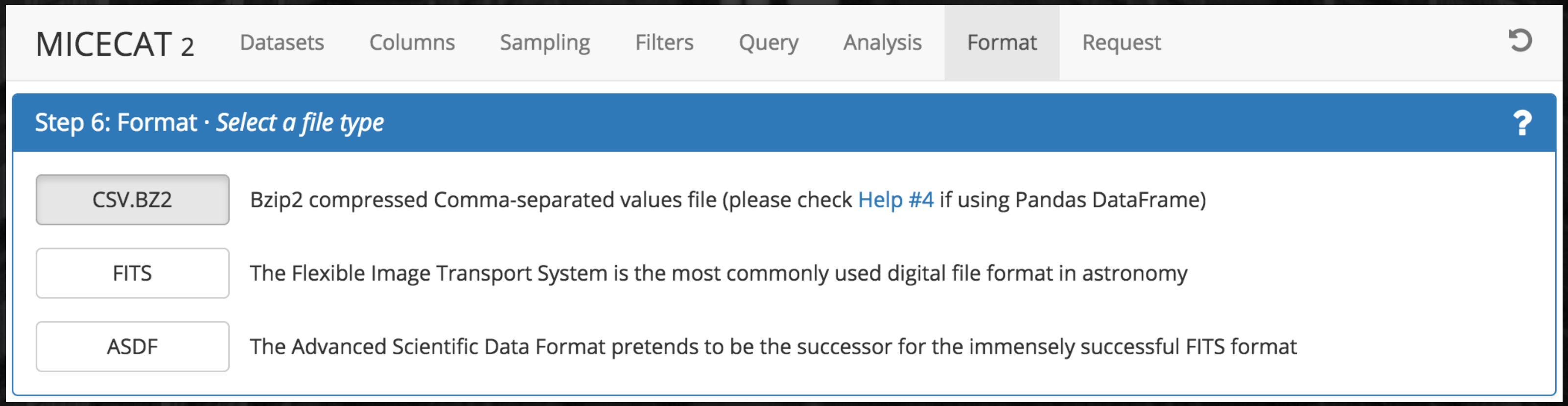

Demo

Conclusions & future work

Conclusions

- Great improvement in response time
- New release is more reliable
- Still exploring the vast Hadoop ecosystem

Future work

- New plot types and analysis
- Collaboration with more experiments
  - More data, more catalogs, more users
- Other use cases (other than Cosmology)

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Thanks for your attention!

Backup slides

Hive tuning

- We have set the platform so that queries over large tables are really fast:
    - Apache Tez execution engine instead of the venerable Map-reduce engine
    - ORCfile: a new table (column based) storage format
    - Vectorized query technique: batches of 1024 rows at once

Load balancing

- Set up two different queues given the two different profiles:
  - ‘Interactive’: real-time analysis (low latency)
  - ‘Batch’: custom catalogs (high latency)
- Configure queue shares and preemption:
  - batch jobs take idle resources to maximize efficiency (10-90)
  - interactive jobs can take resources from batch queue (90-100)

Backend

- ReST API powered by Flask:
  - flask-restful - ReST framework
  - sqlalchemy - database ORM
  - websockets - bidirectional communications
  - gevent - asynchronous framework
  - pyhive - hive connection library
  - pyhdfs - hdfs bindings

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Frontend

- Responsive Web interface powered by:
  - Angular JS - web app oriented HTML framework
  - Bootstrap - responsive frontend framework
  - Plot.ly for plotting
  - Wordpress as backend to edit "static" content

ANGULARJS by Google

WORDPRESS

B

plotly.js

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Demo

CosmoHub YouTube channel