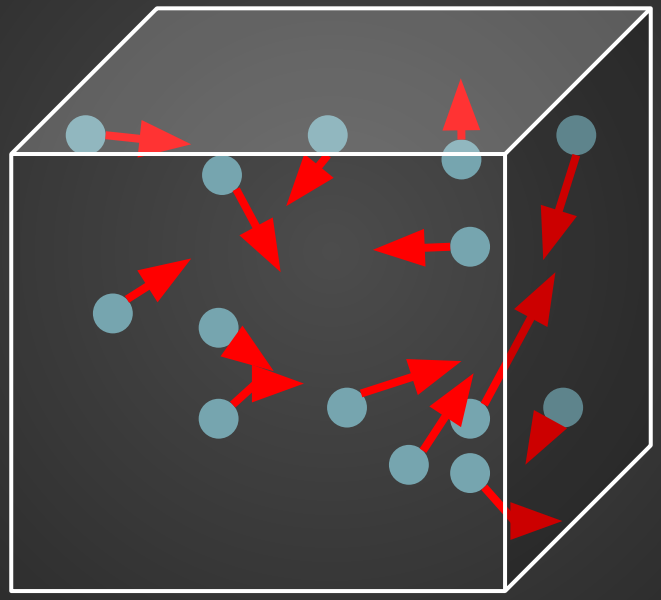
# Volumes with yt



Matthew Turk
Columbia University

“Exascale is made of people!”

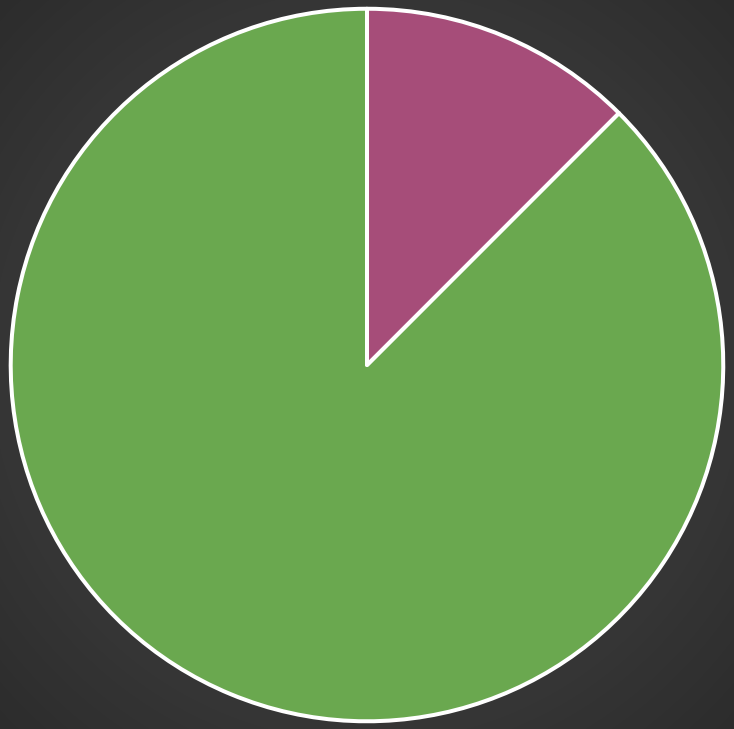
- Mike Warren, 2014

# Scientific Inquiry

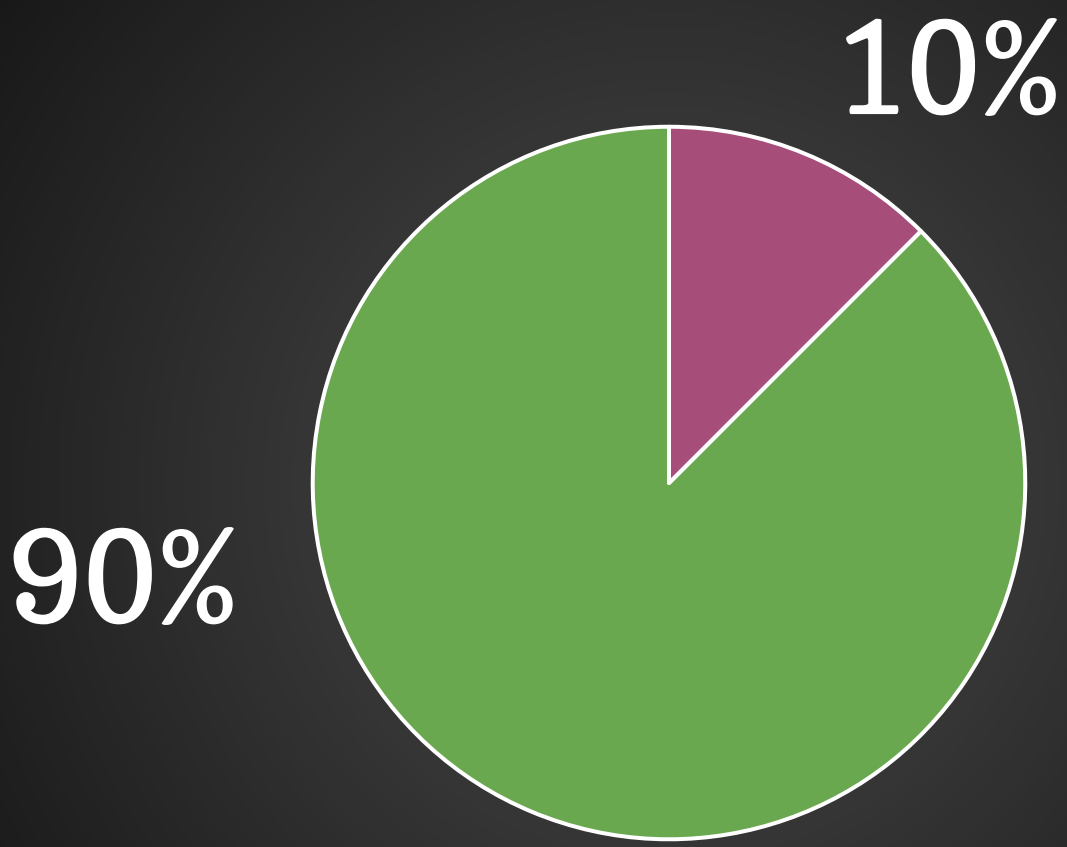
# Analyzing Data

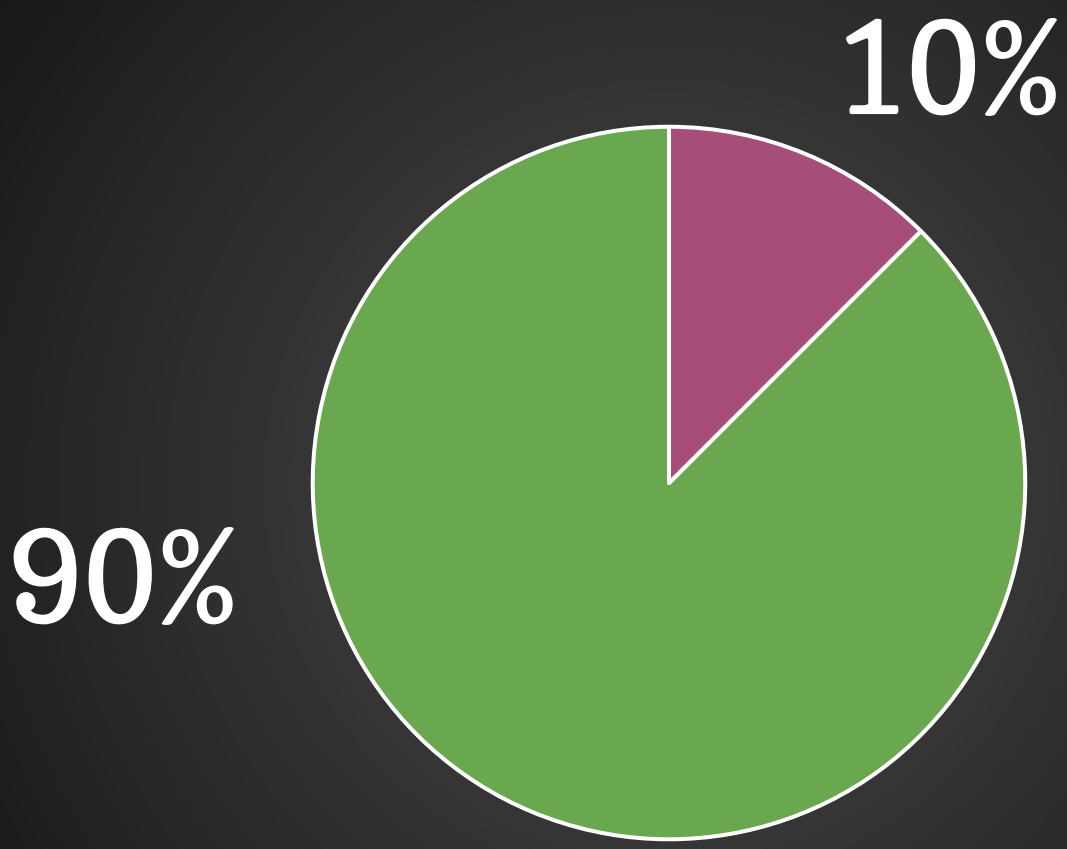
# Running Simulations

Run



Study

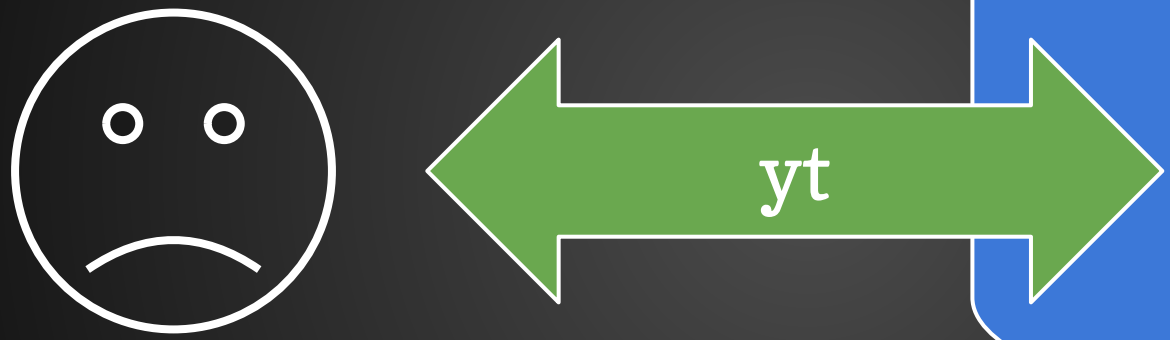

10%
90%

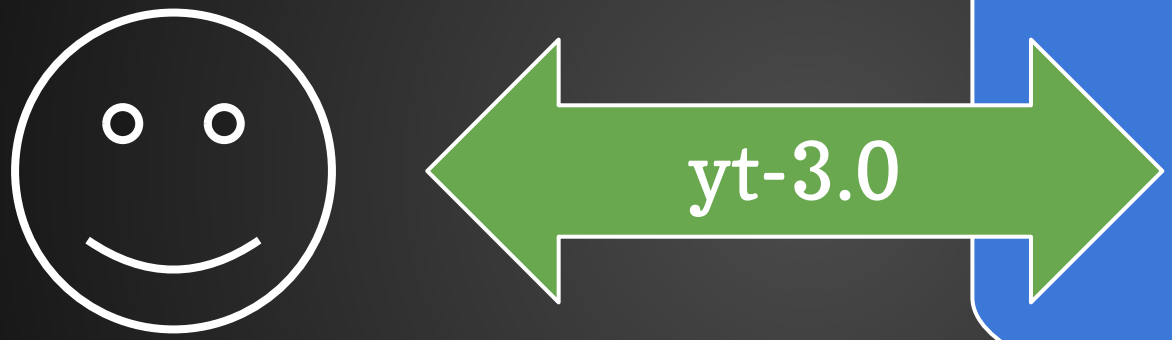



Dekel's Law


Data


yt
Data


yt

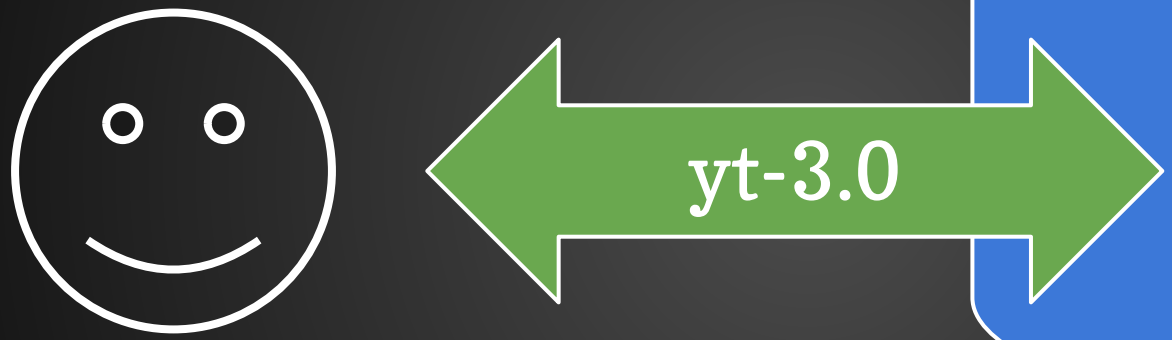

yt-3.0


yt-3.0

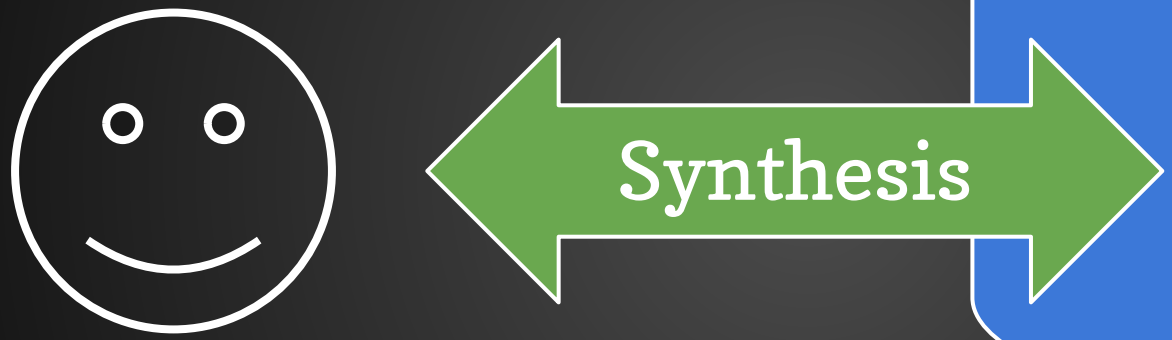

We got to break,
then fix.

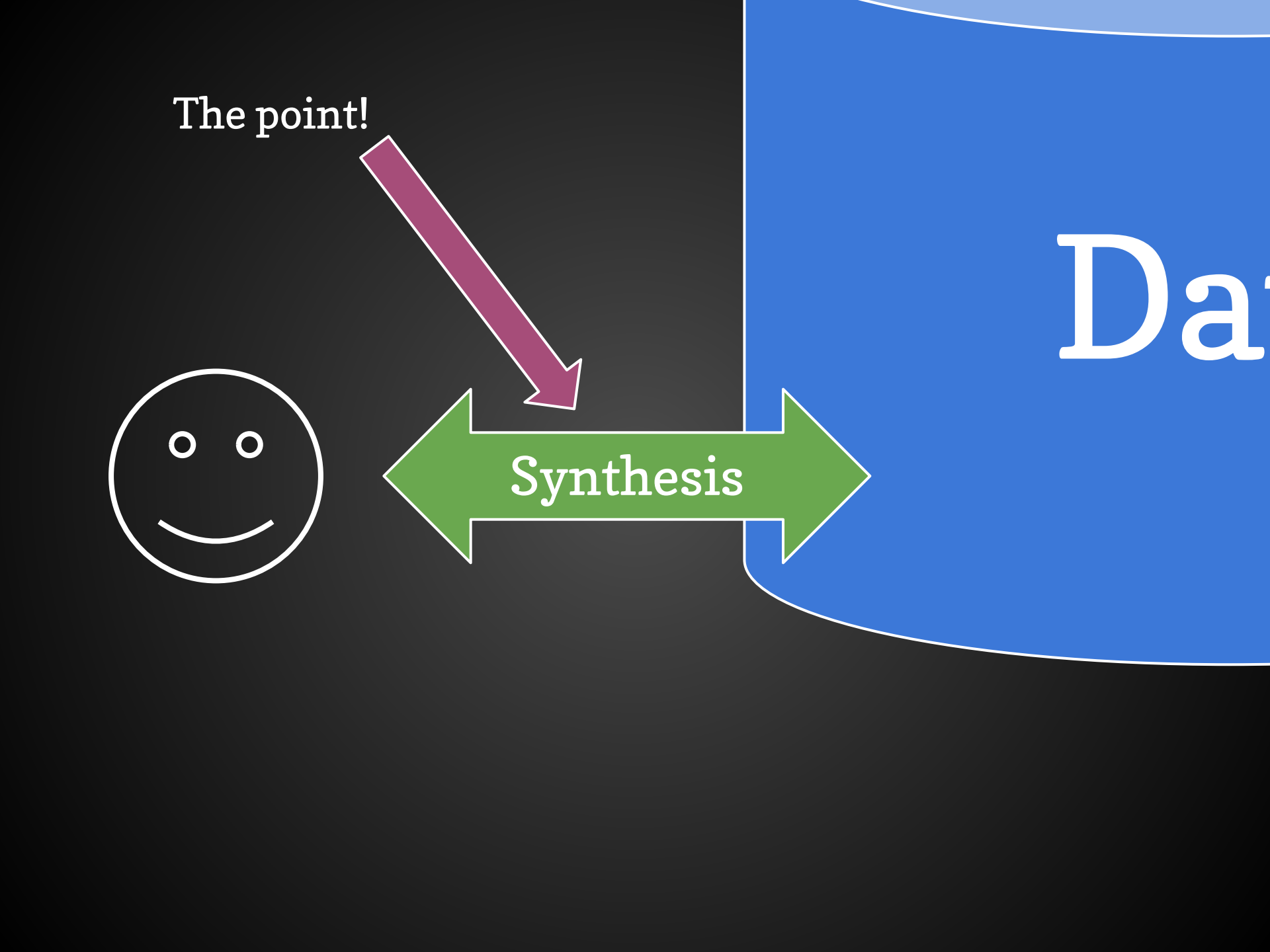
# yt-3.0

SPH, octrees, units, field types, ...


yt-3.0

yt is not the point.


Synthesis


The point!
Synthesis
Da

# How do we get there?

Clarity

Abstraction

Delegation

# Develop a data language.

# Develop a data language.

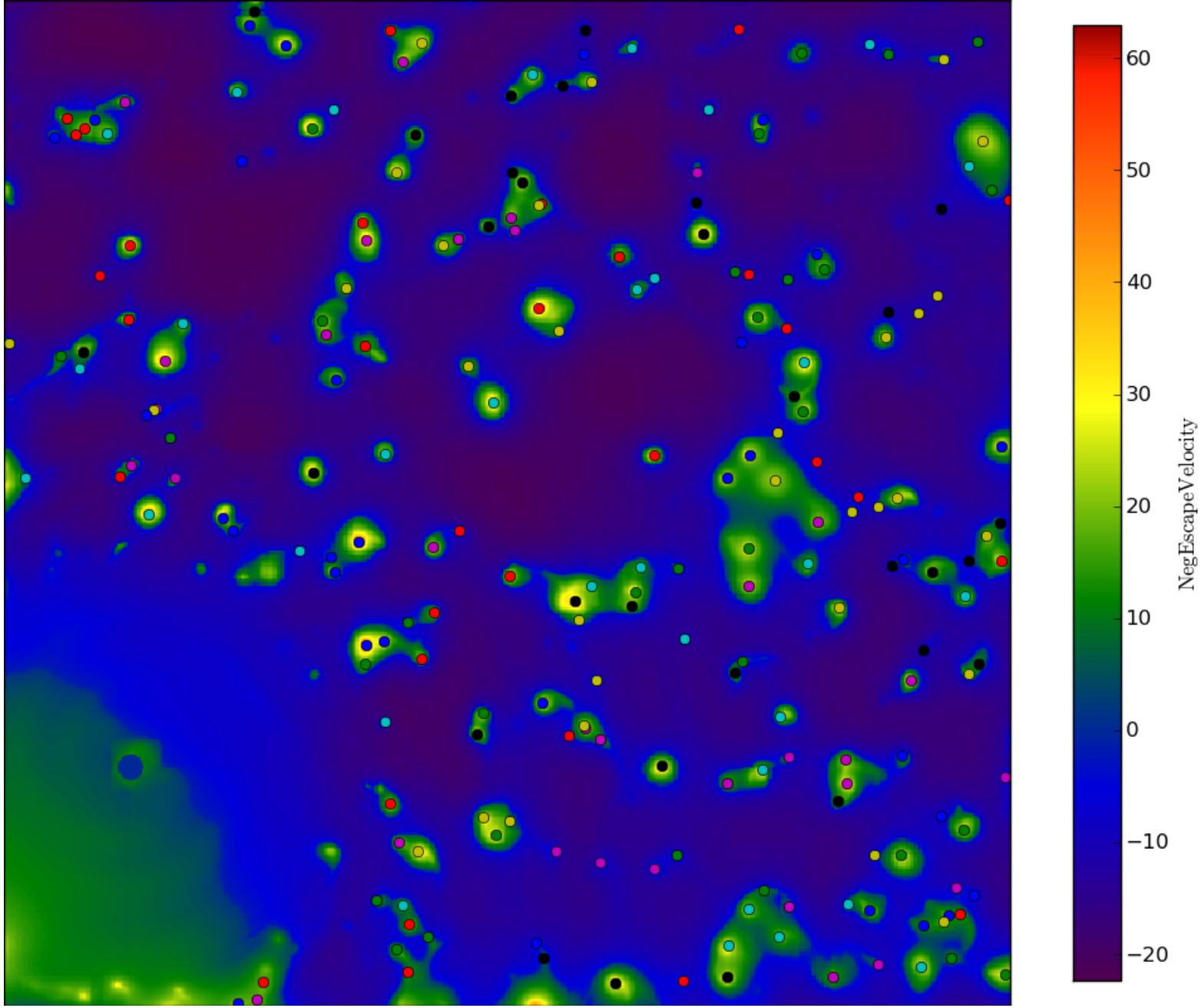
Inspection, Analysis, & Visualization

Inspection, Analysis, & Visualization

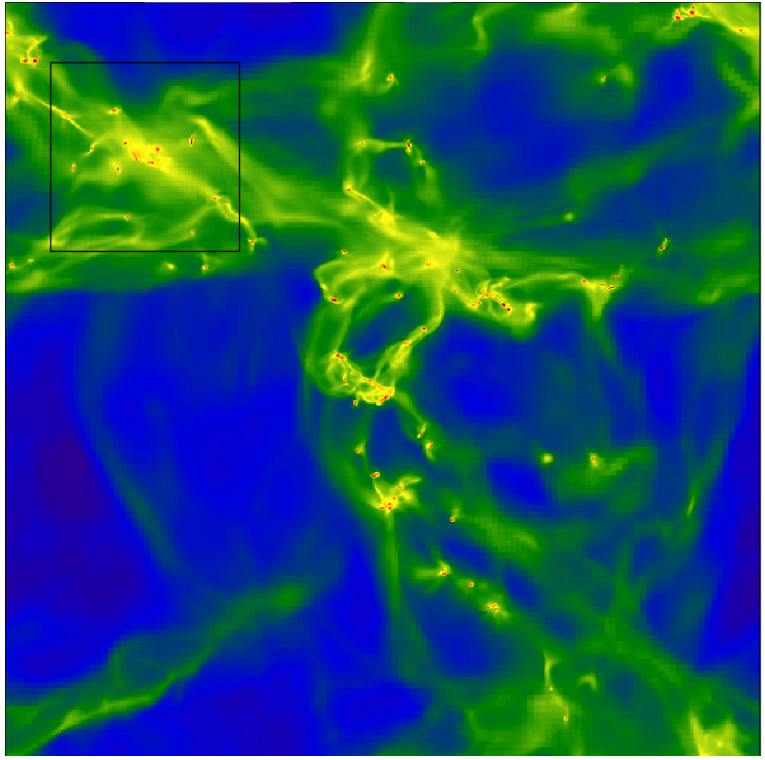
```
import yt
ds = yt.load("output_00084/info_00084.txt")
sp = ds.sphere("max", (1.0, "Mpc"))
print sp["density"]

[  3.713965e-32, ..., 8.940313e-30] g/cm**3
```

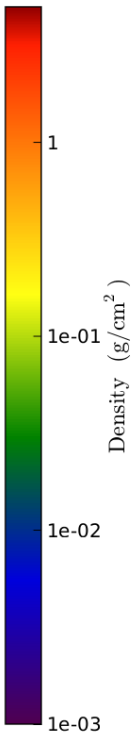
```
import yt
ds = yt.load("output_00084/info_00084.txt")
sp = ds.sphere("max", (1.0, "Mpc"))
sp.quantities.extrema("density")

(3.196587e-32 g/cm**3, 7.158091e-24 g/cm**3)
```

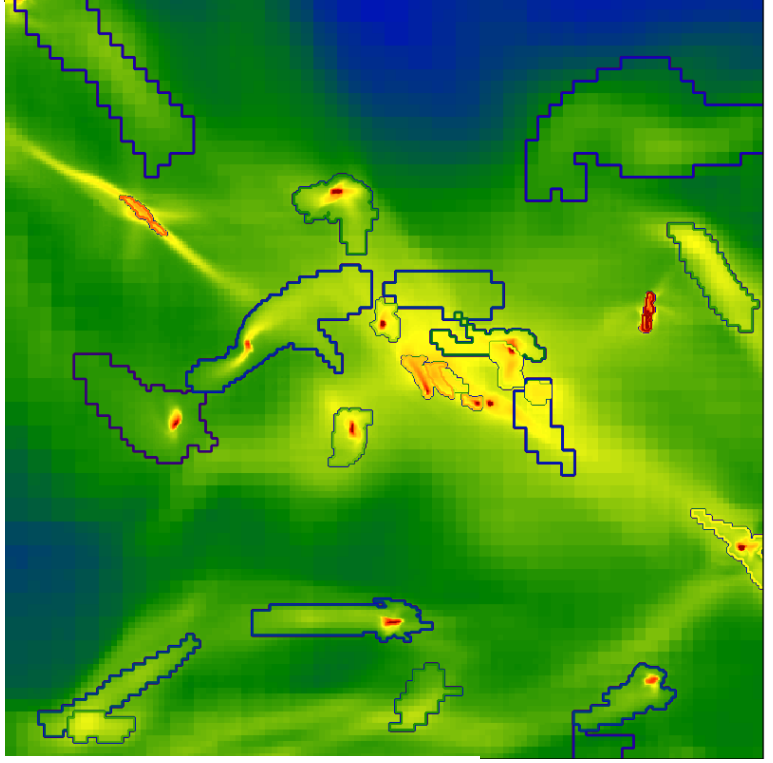
Inspection, Analysis, & Visualization

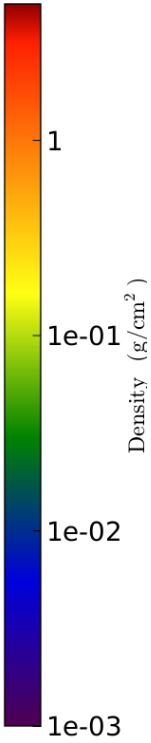


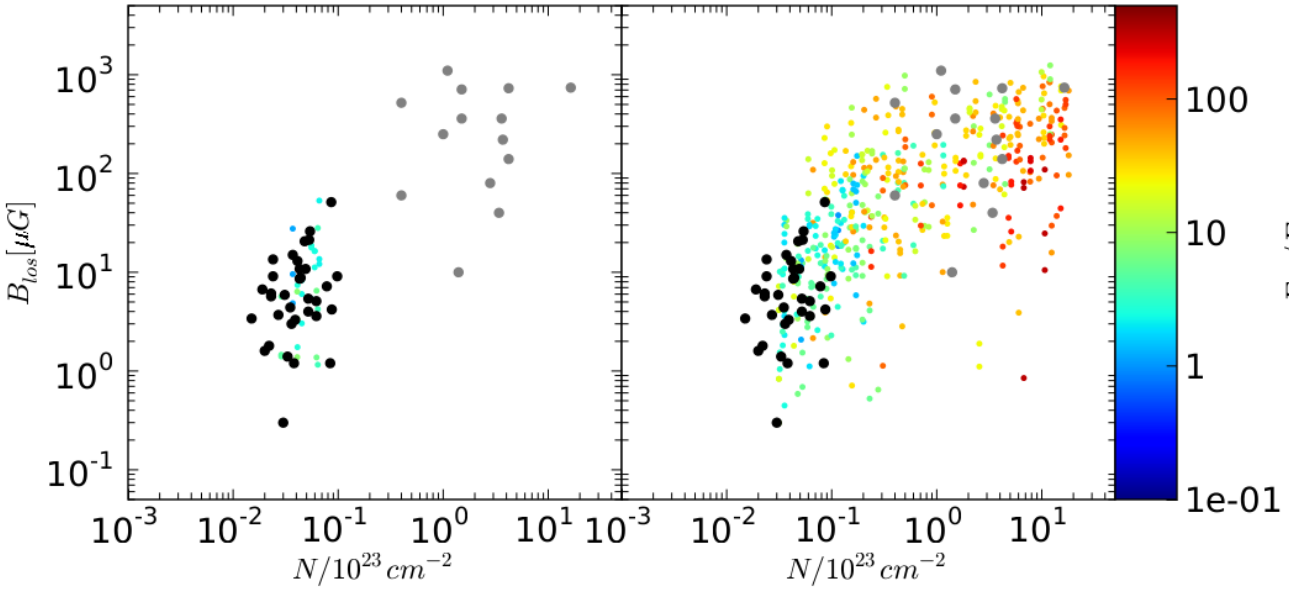

Tasker et al 2013



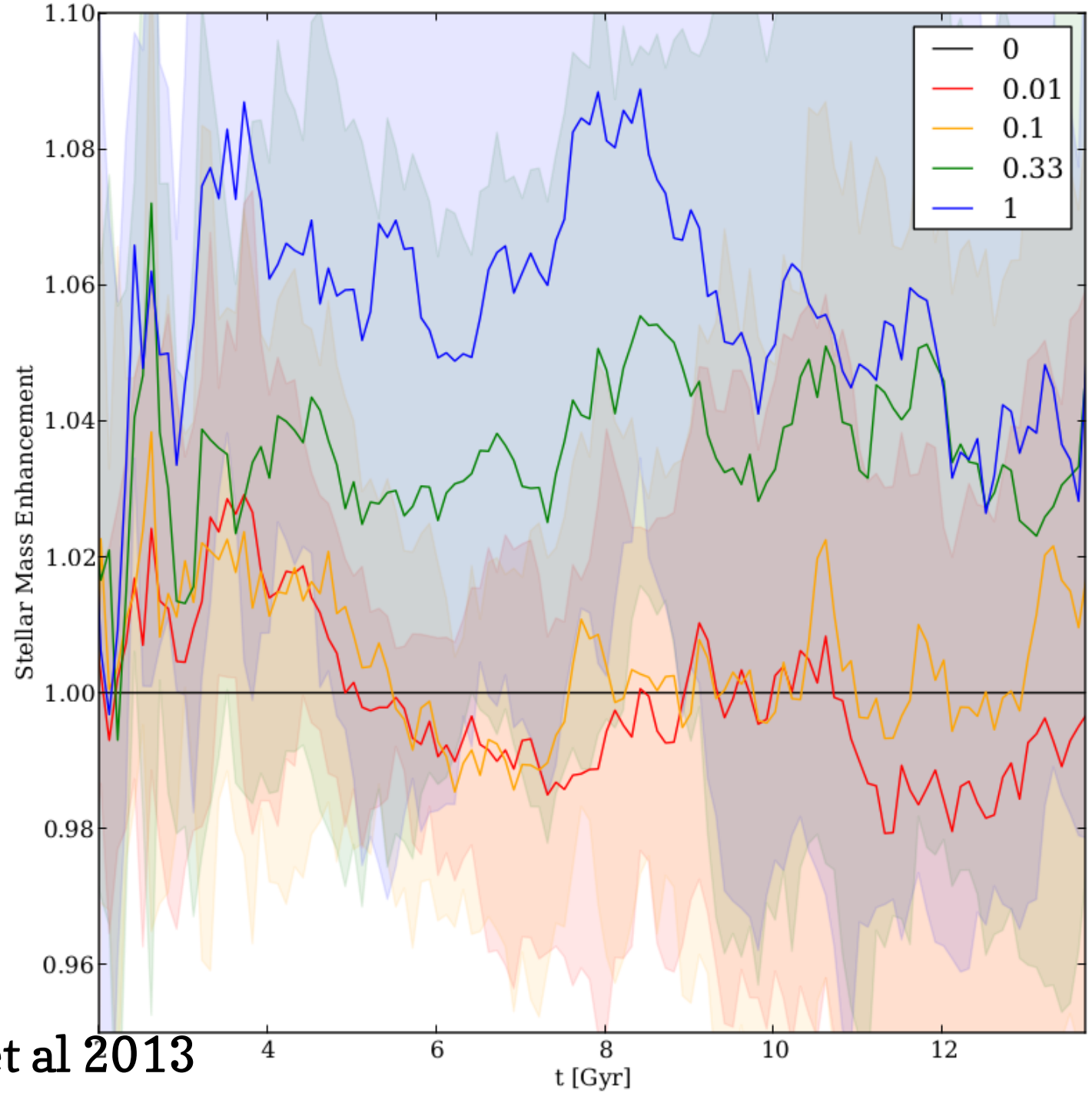


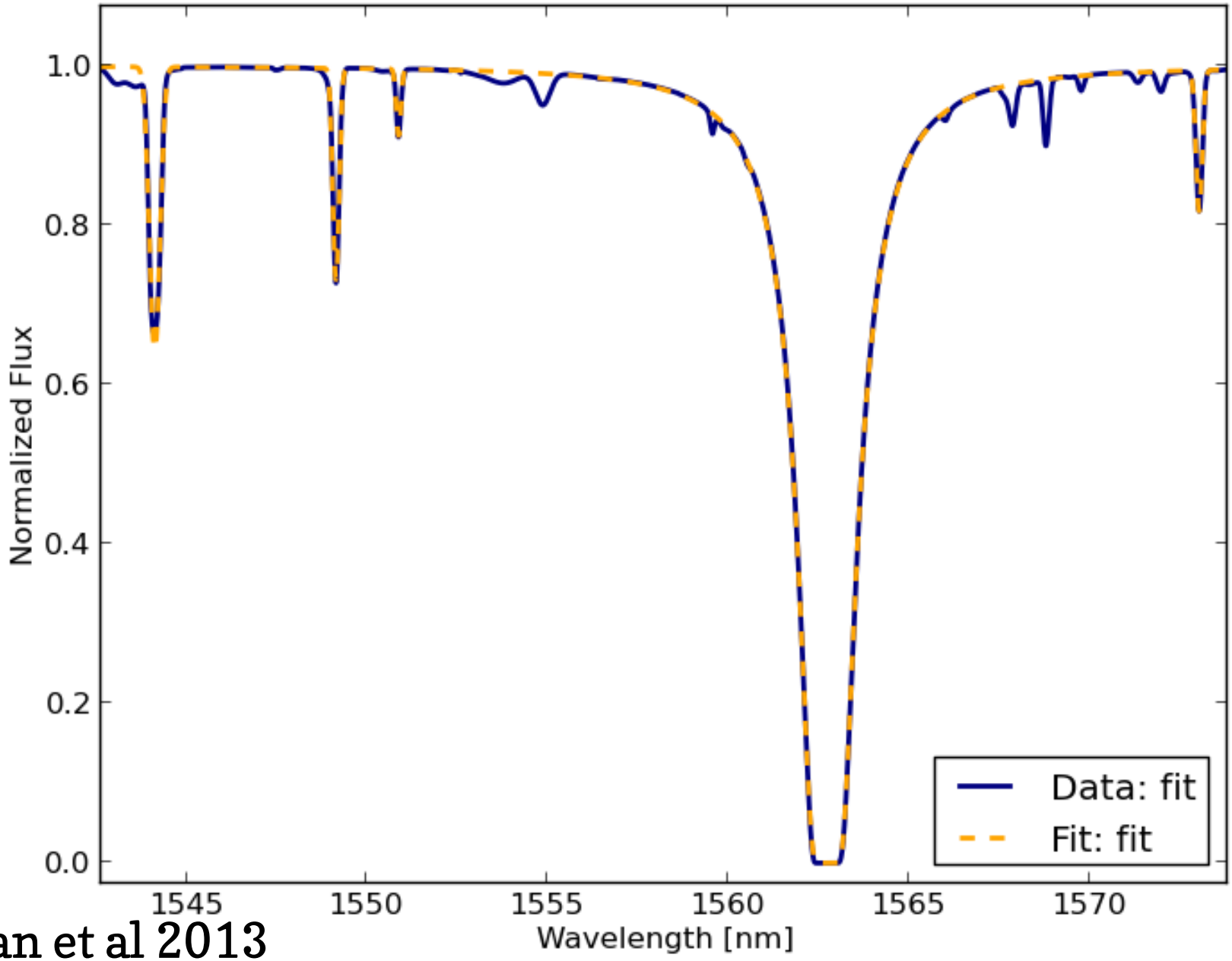


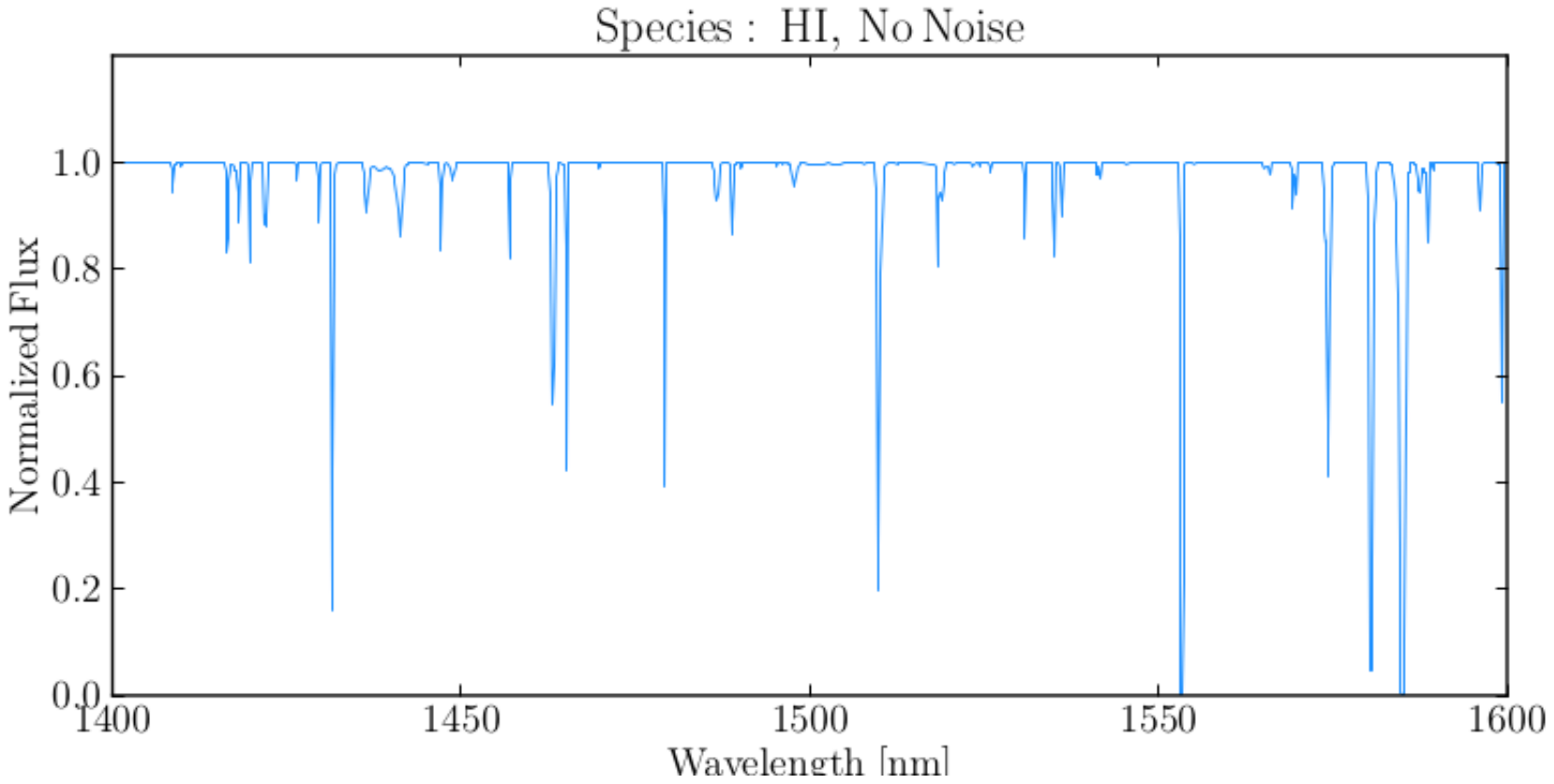

Collins et al 2012



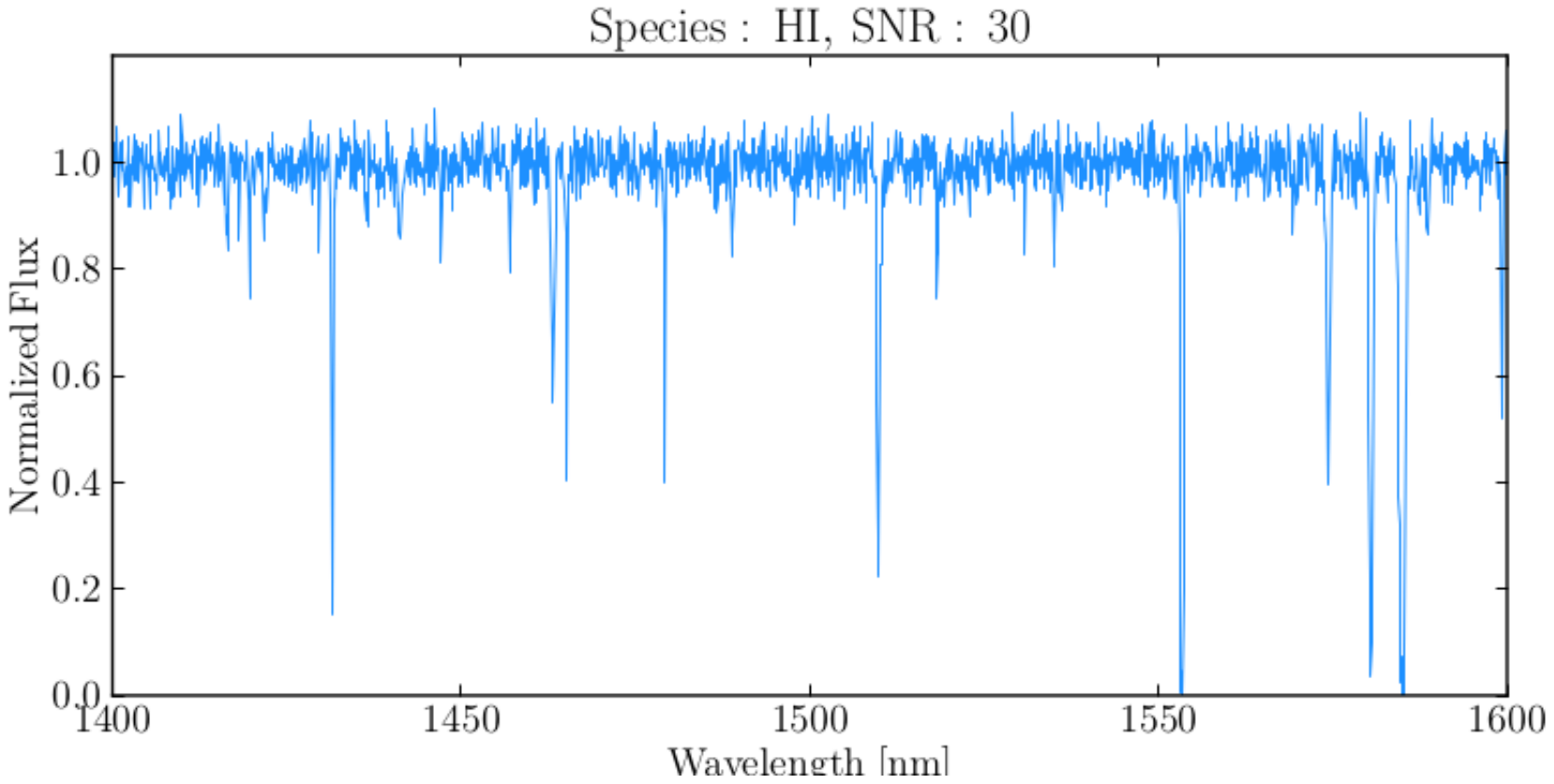

Smith et al 2013



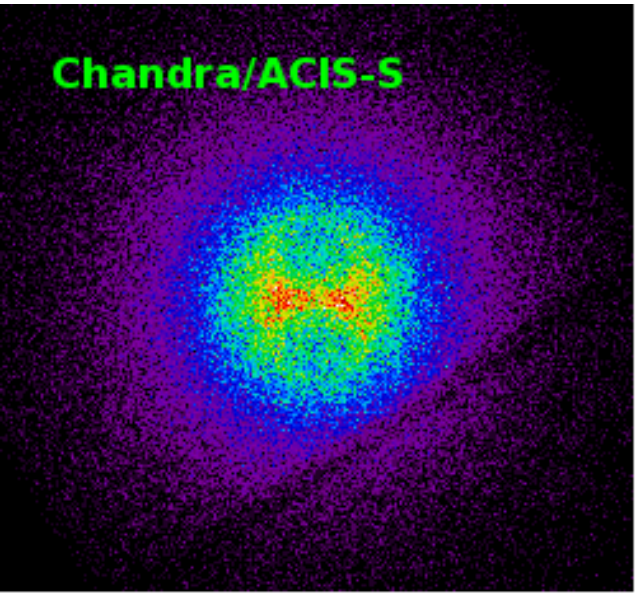

Egan et al 2013

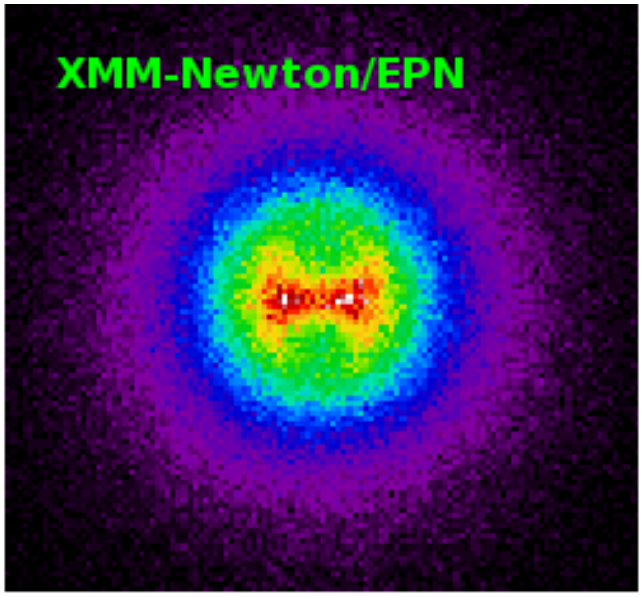


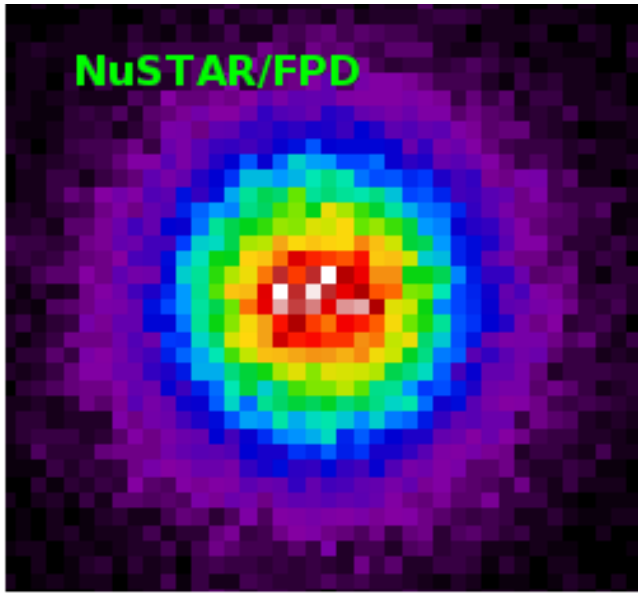

Egan et al 2013



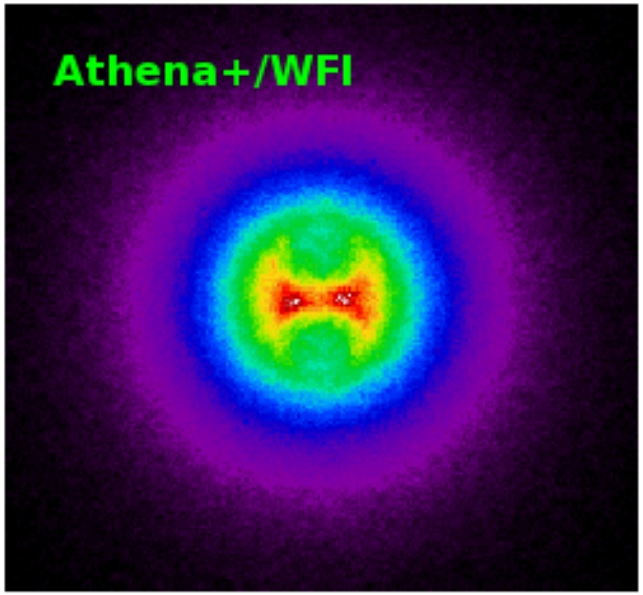

Egan et al 2013



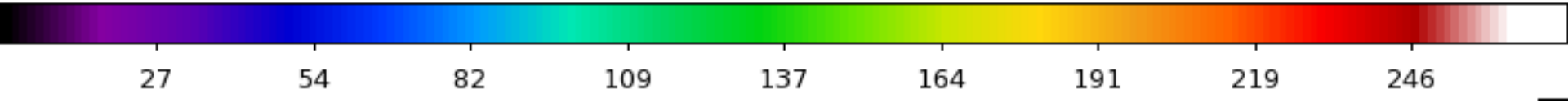




Astro-H/SXS

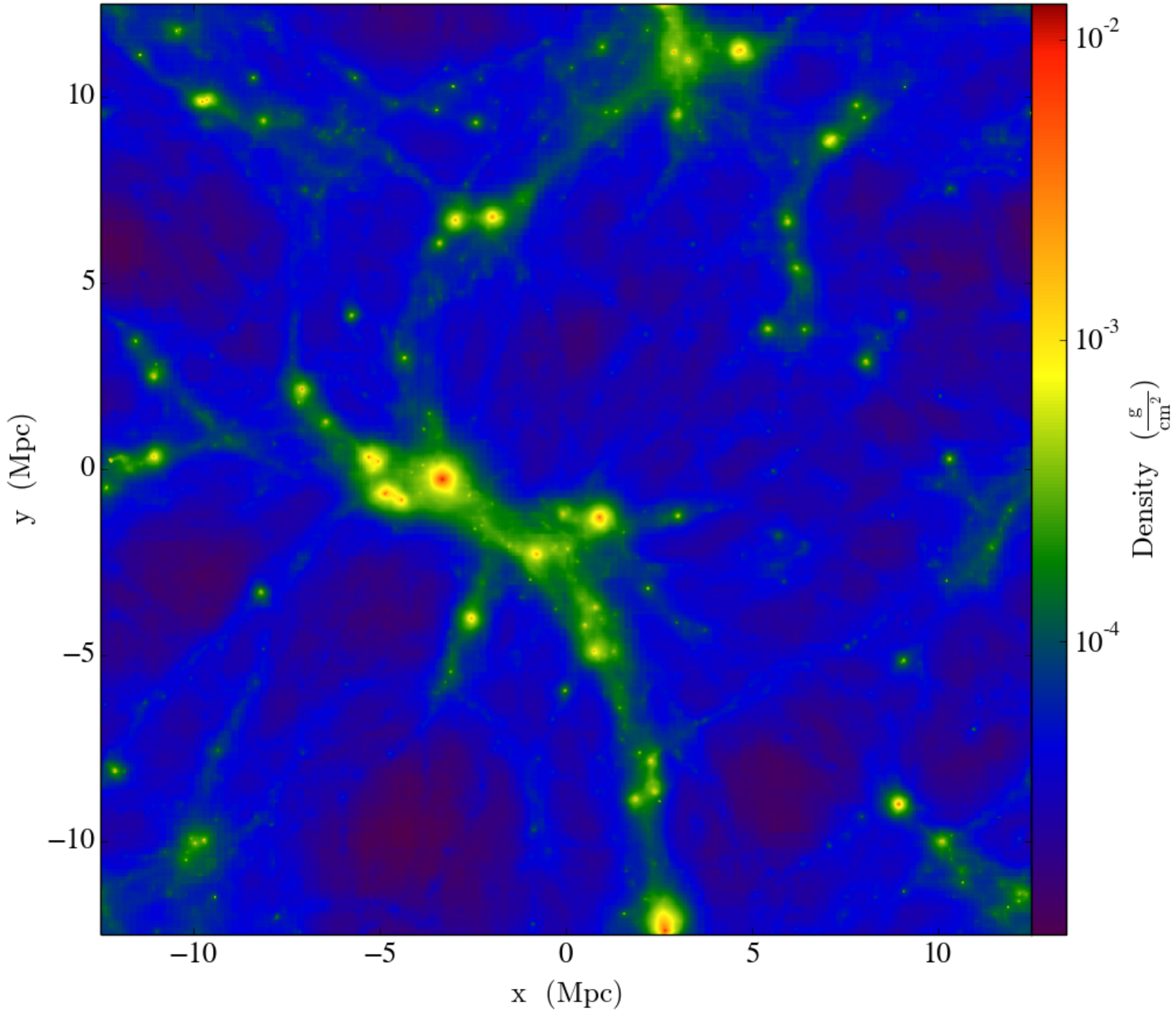



ZuHone et al

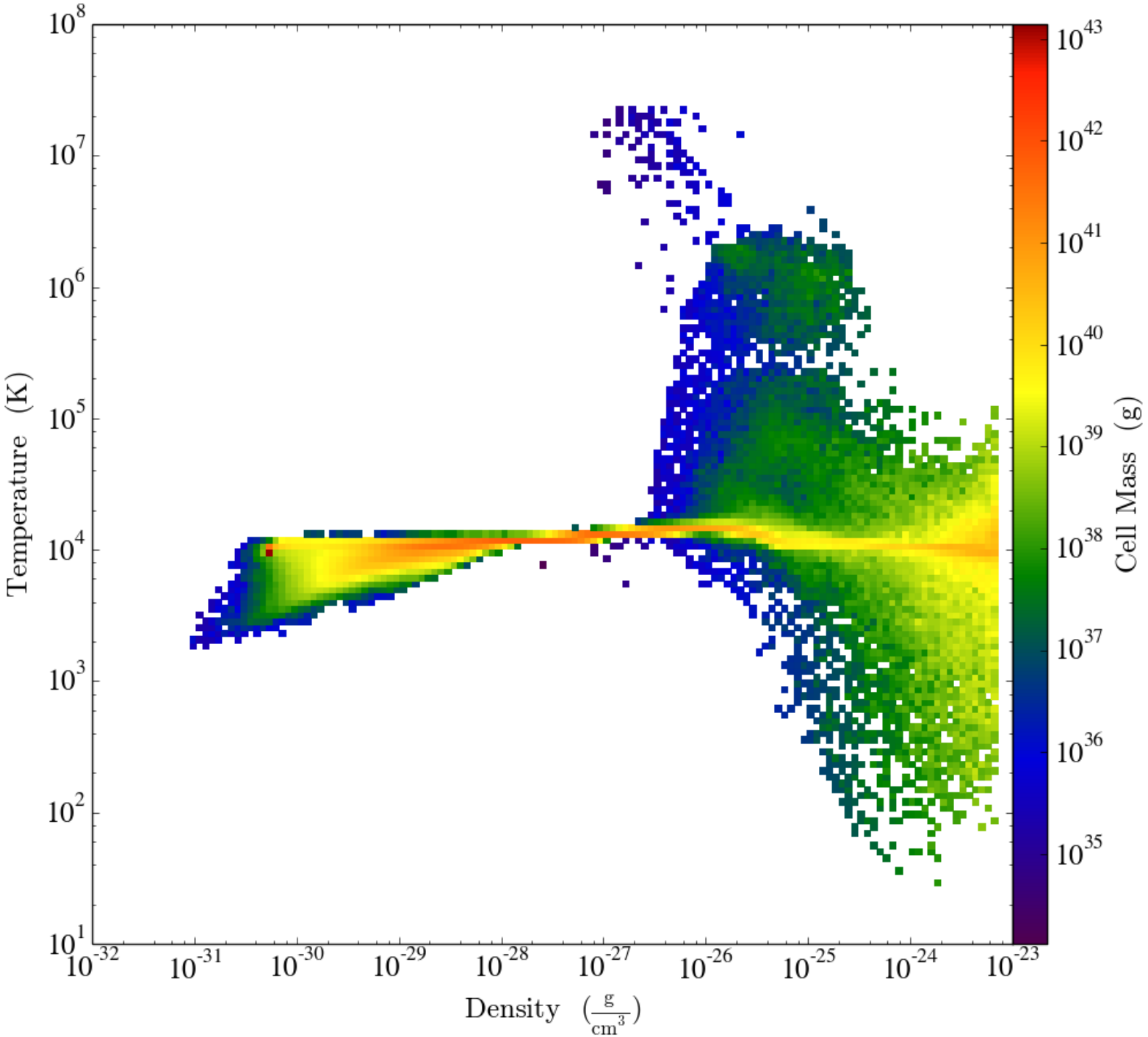


# Inspection, Analysis, & Visualization

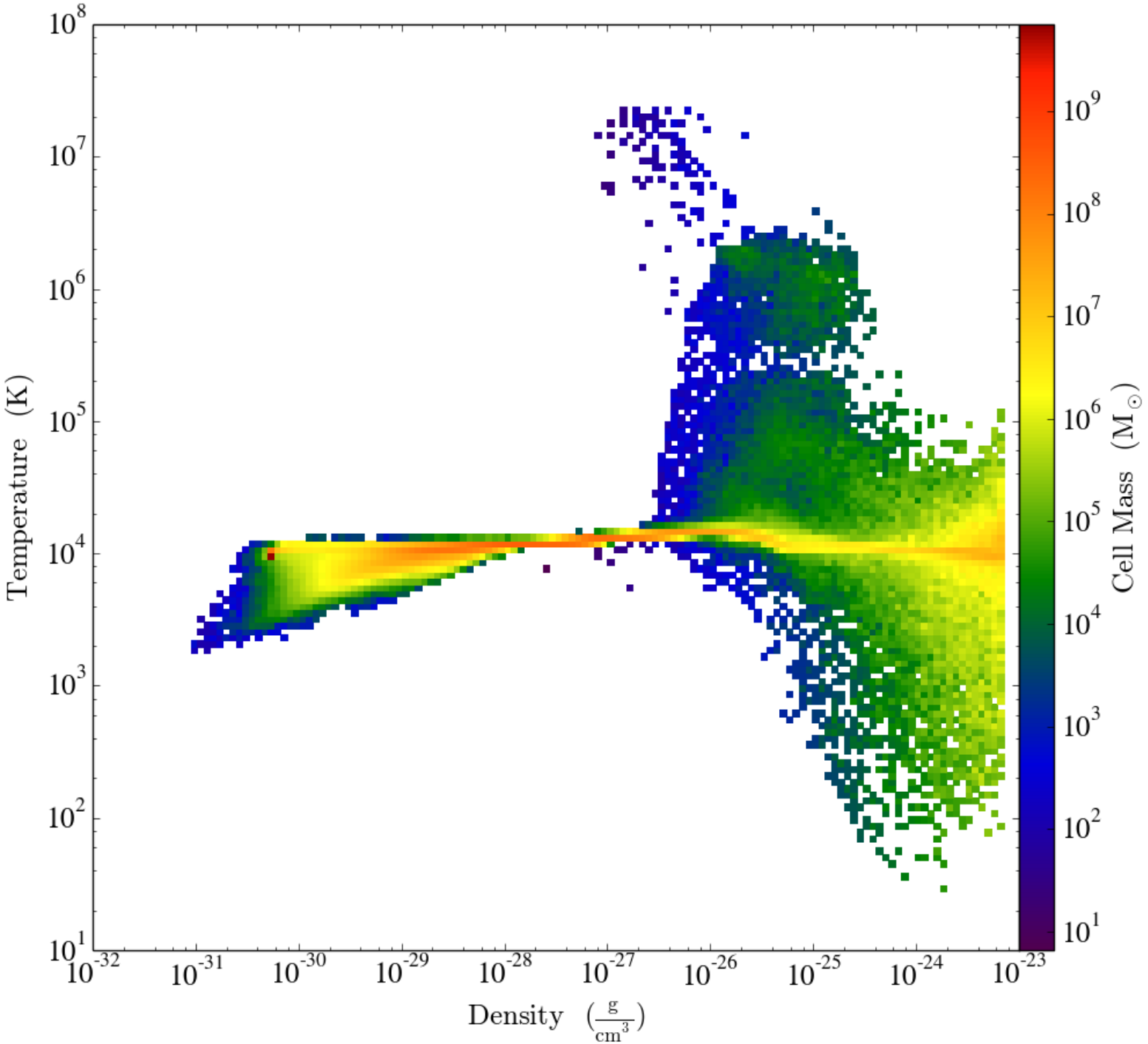
```
import yt
ds = yt.load("snapshot_033/snap_033.0.hdf")
p = yt.ProjectionPlot(ds, "x", "density")
p.save()
```

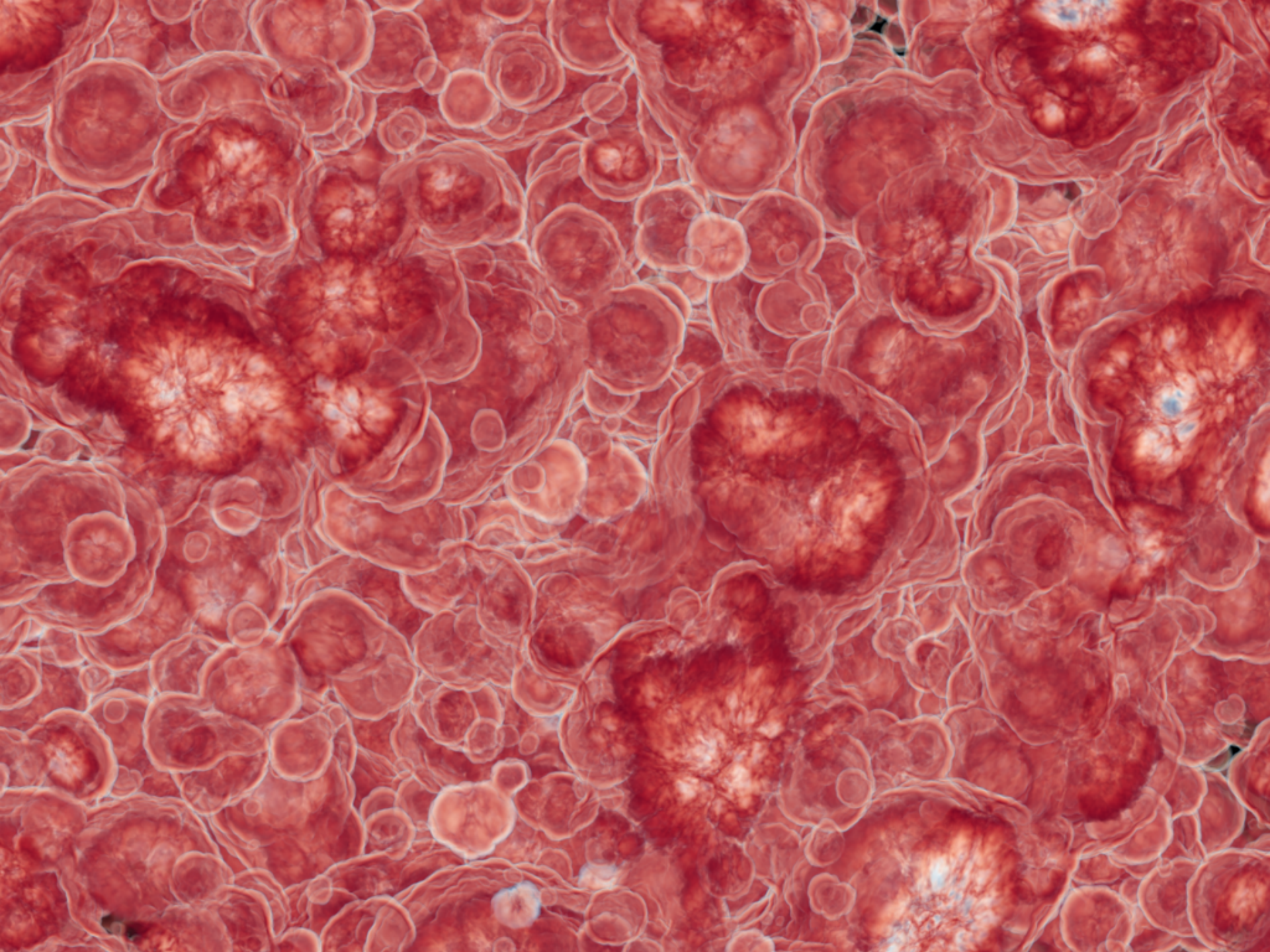

10
5
0
−5
−10
y (Mpc)
−10
−5
0
5
10
x (Mpc)
$10^{-2}$
$10^{-3}$
$10^{-4}$
Density $\left(\frac{\mathrm{g}}{\mathrm{cm}^2}\right)$

```
import yt
ds = yt.load("galaxy0030/galaxy0030")
ad = ds.all_data()
p = yt.PhasePlot(ad, "density",
        "temperature", "cell_mass", None)
p.save()
```


Temperature (K)
$10^{8}$
$10^{7}$
$10^{6}$
$10^{5}$
$10^{4}$
$10^{3}$
$10^{2}$
$10^{1}$
$10^{-32}$
$10^{-31}$
$10^{-30}$
$10^{-29}$
$10^{-28}$
$10^{-27}$
$10^{-26}$
$10^{-25}$
$10^{-24}$
$10^{-23}$
Density $(\frac{g}{cm^3})$
Cell Mass (g)
$10^{43}$
$10^{42}$
$10^{41}$
$10^{40}$
$10^{39}$
$10^{38}$
$10^{37}$
$10^{36}$
$10^{35}$

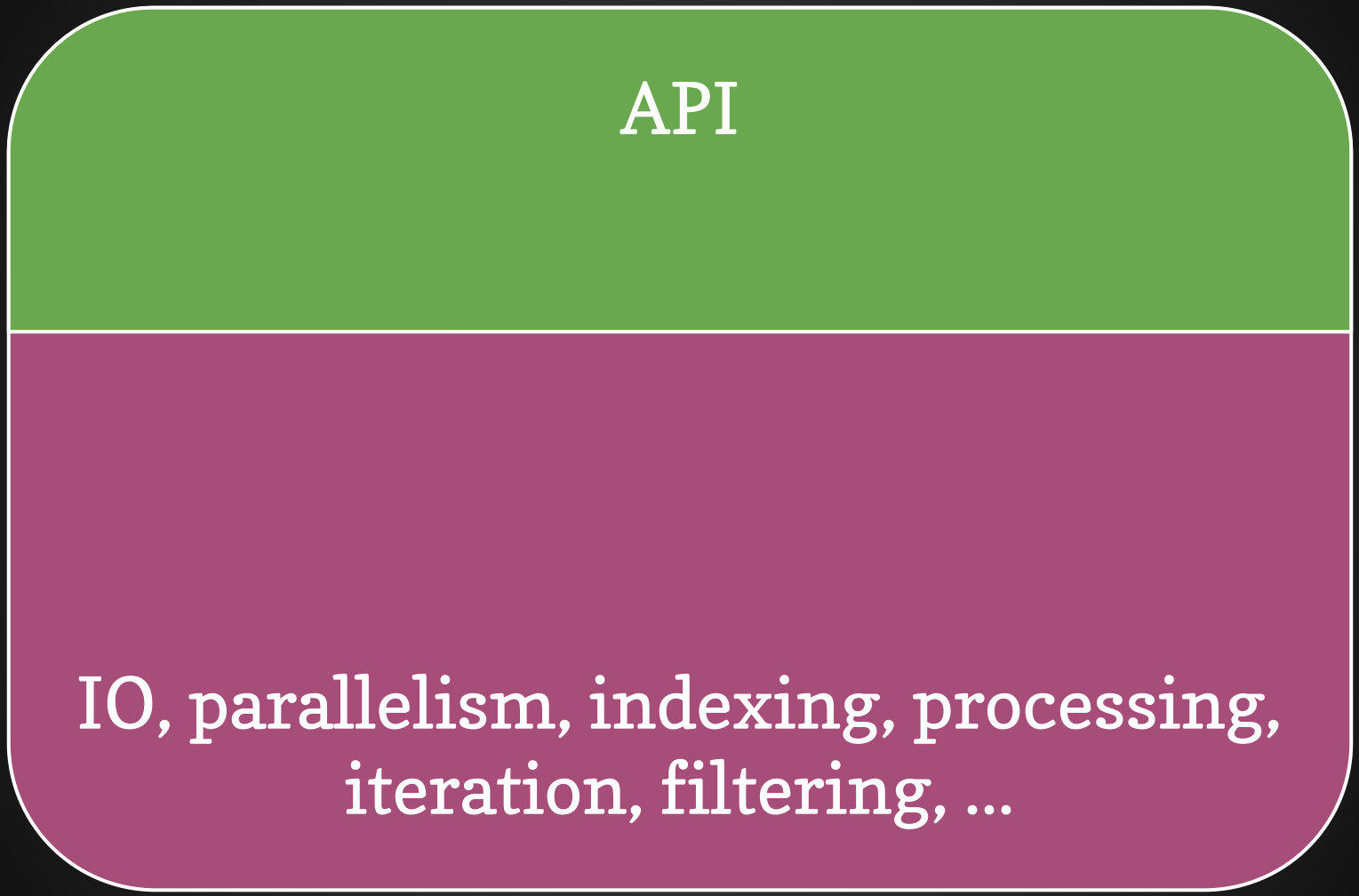
```
import yt
ds = yt.load("galaxy0030/galaxy0030")
ad = ds.all_data()
p = yt.PhasePlot(ad, "density",
        "temperature", "cell_mass", None)
p.set_unit("cell_mass", "Msun")
p.save()
```


Temperature (K)
$10^{8}$
$10^{7}$
$10^{6}$
$10^{5}$
$10^{4}$
$10^{3}$
$10^{2}$
$10^{1}$
$10^{-32}$
$10^{-31}$
$10^{-30}$
$10^{-29}$
$10^{-28}$
$10^{-27}$
$10^{-26}$
$10^{-25}$
$10^{-24}$
$10^{-23}$
Density $(\frac{g}{cm^3})$
Cell Mass $(M_\odot)$
$10^{9}$
$10^{8}$
$10^{7}$
$10^{6}$
$10^{5}$
$10^{4}$
$10^{3}$
$10^{2}$
$10^{1}$

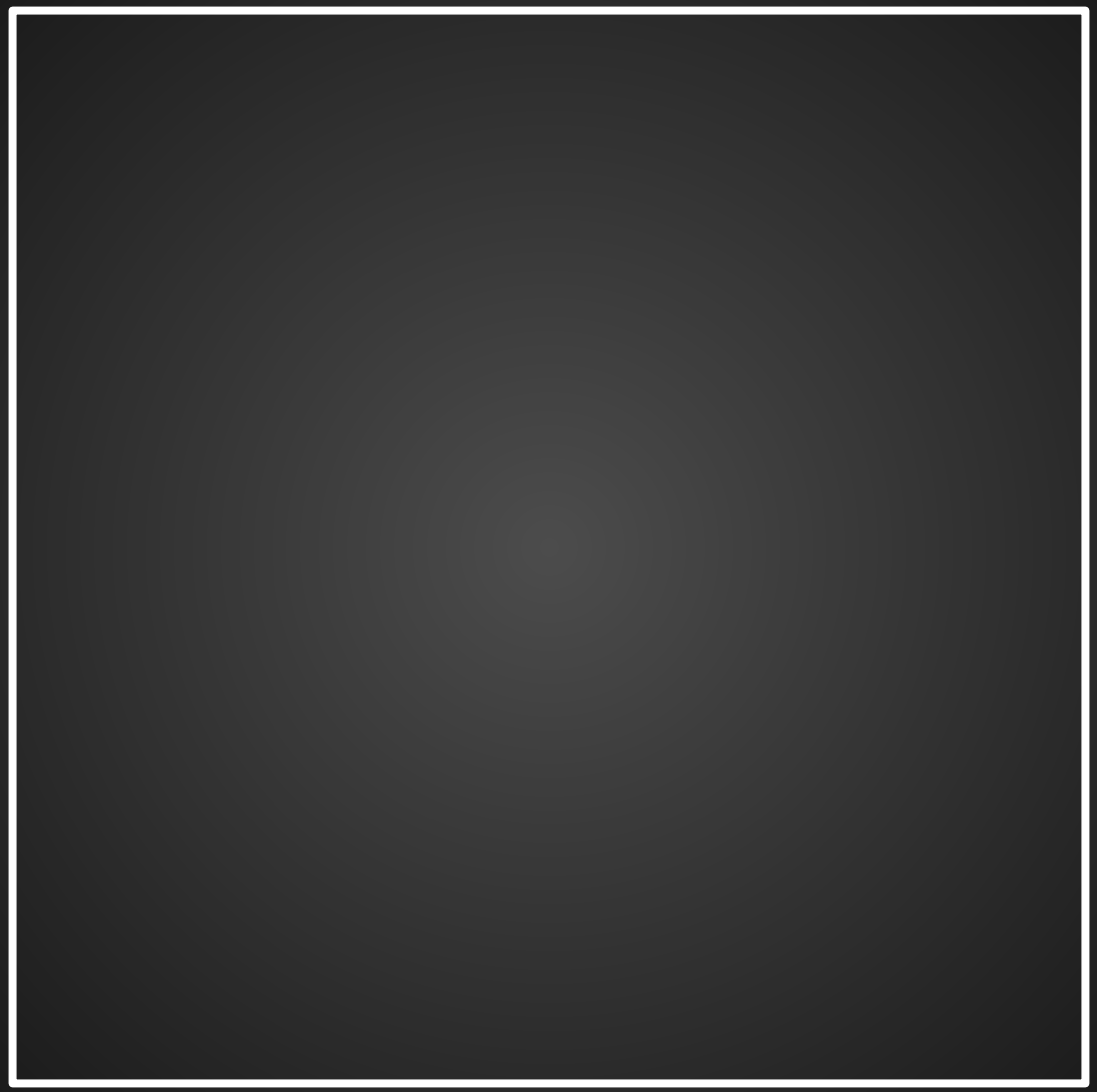


Separate responsibilities to preserve API stability.

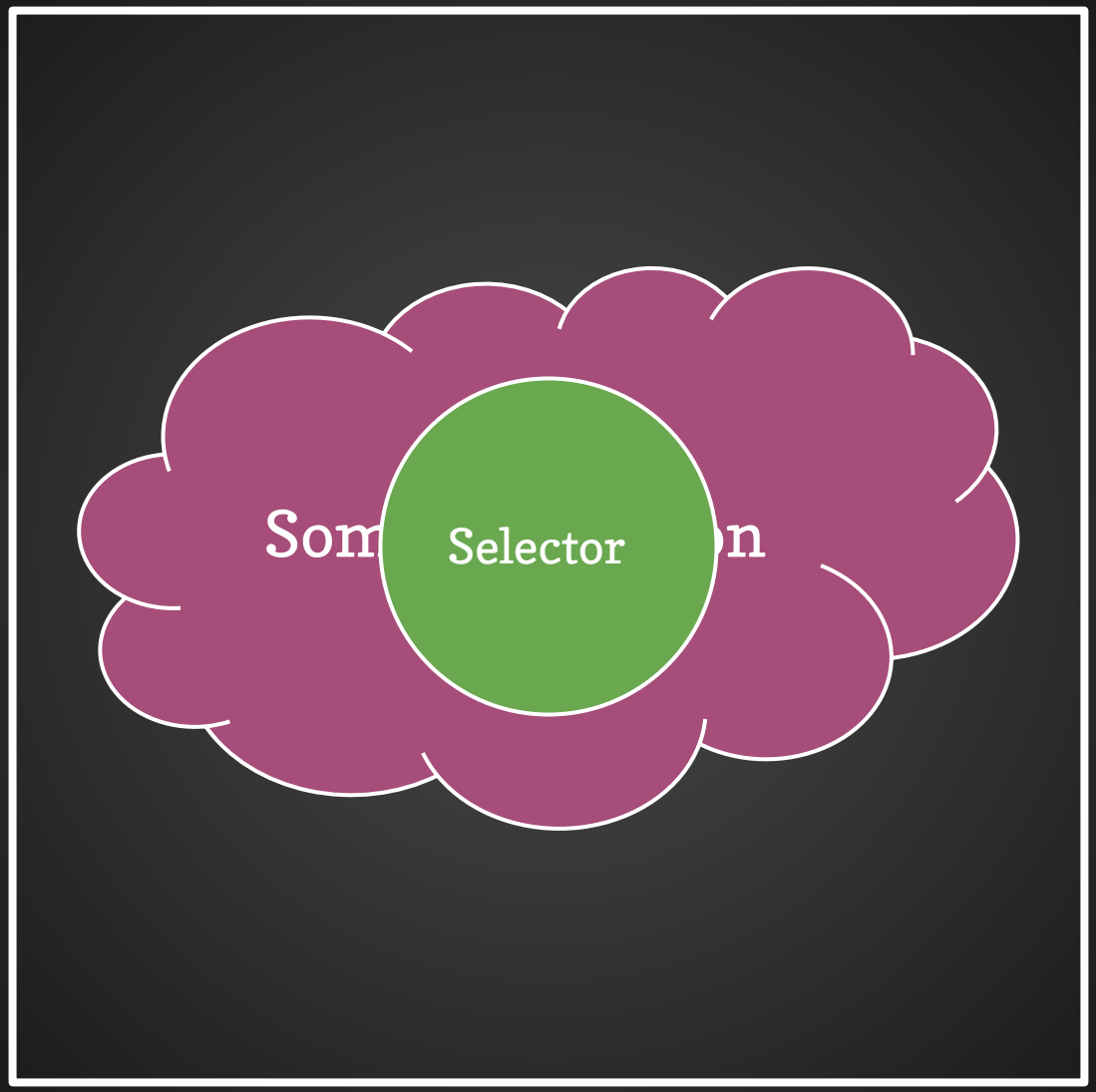
yt


API
IO, parallelism, indexing, processing,
iteration, filtering, ...

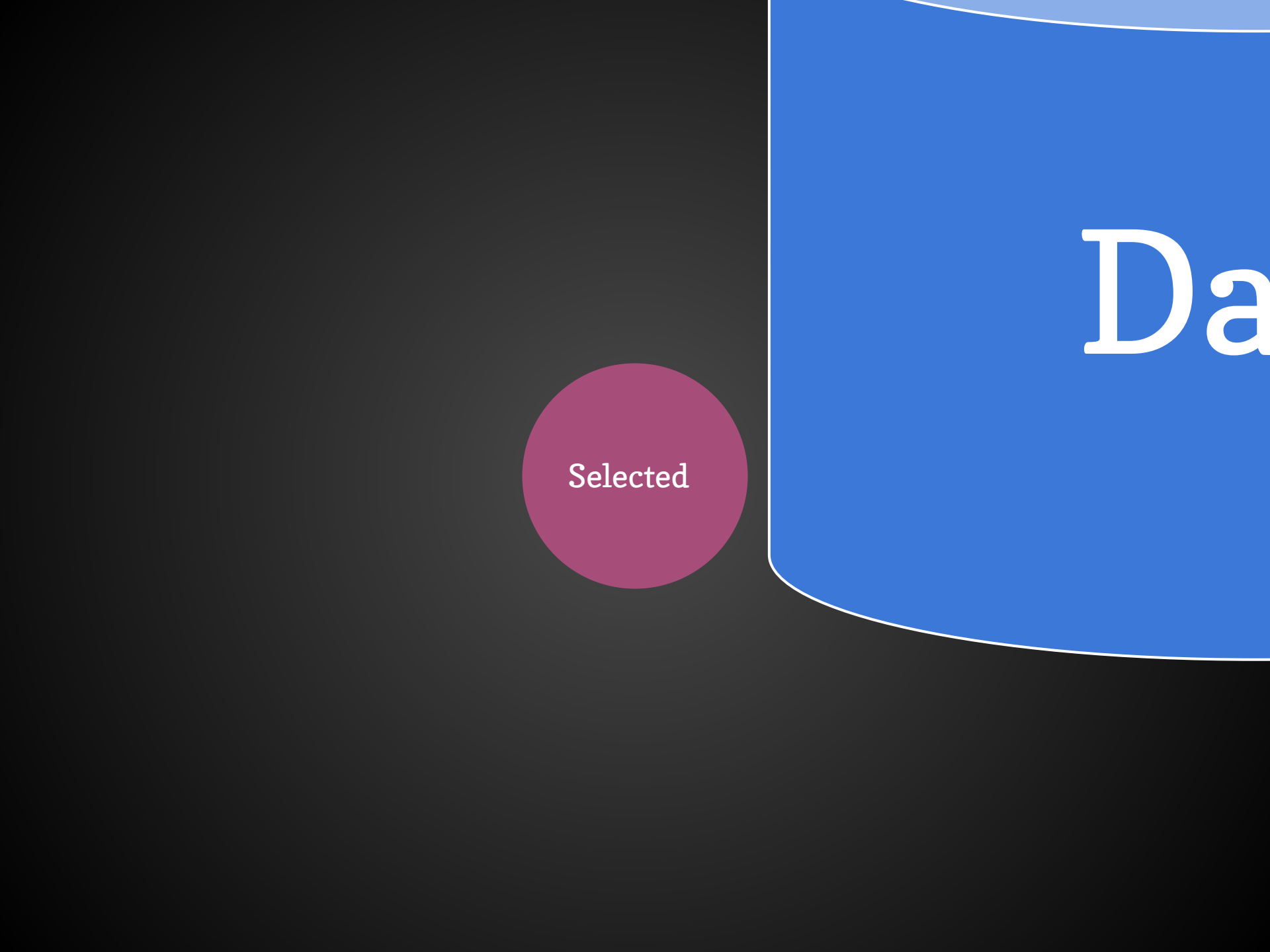
# Abstract data sources and indexing.

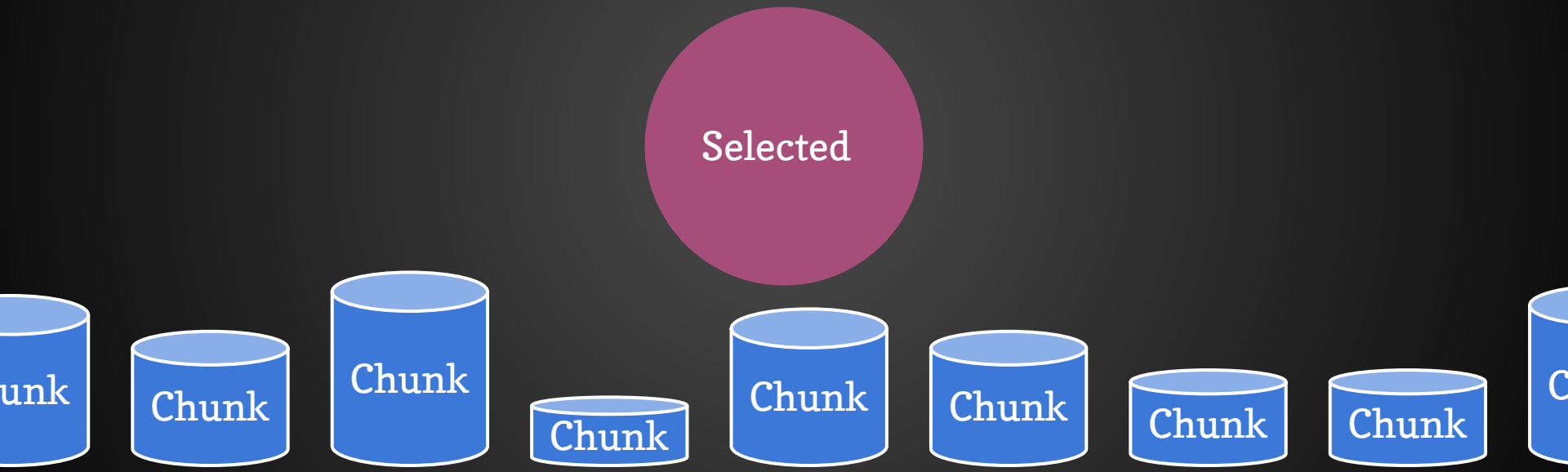



Some Simulation


Som
Selector
n

Selected


Da
Selected

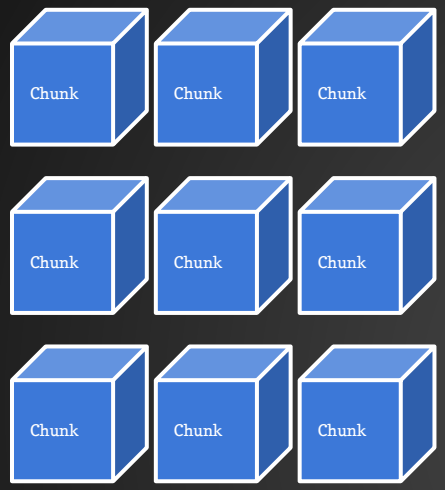

Selected
unk
Chunk
Chunk
Chunk
Chunk
Chunk
Chunk
Chunk
Chunk
C


Chunk


Values
Coordinates
Extent


Values
Coordinates
Extent
Components


Values
Coordinates
Extent
Components
Value Neighbors
Block Neighbors



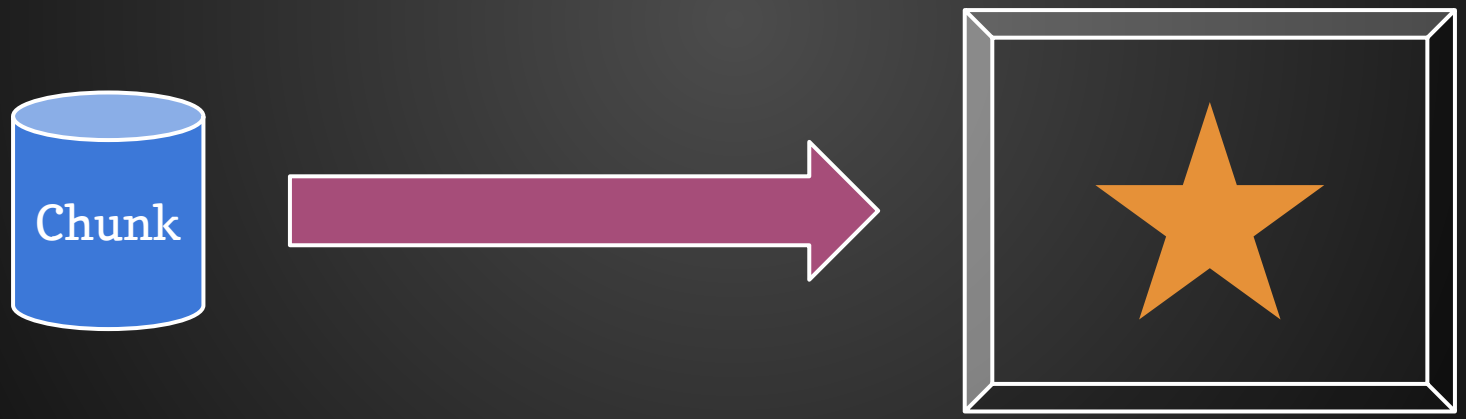

Values
Coordinates
Extent
Components
Value Neighbors
Block Neighbors

# High-Level Operations

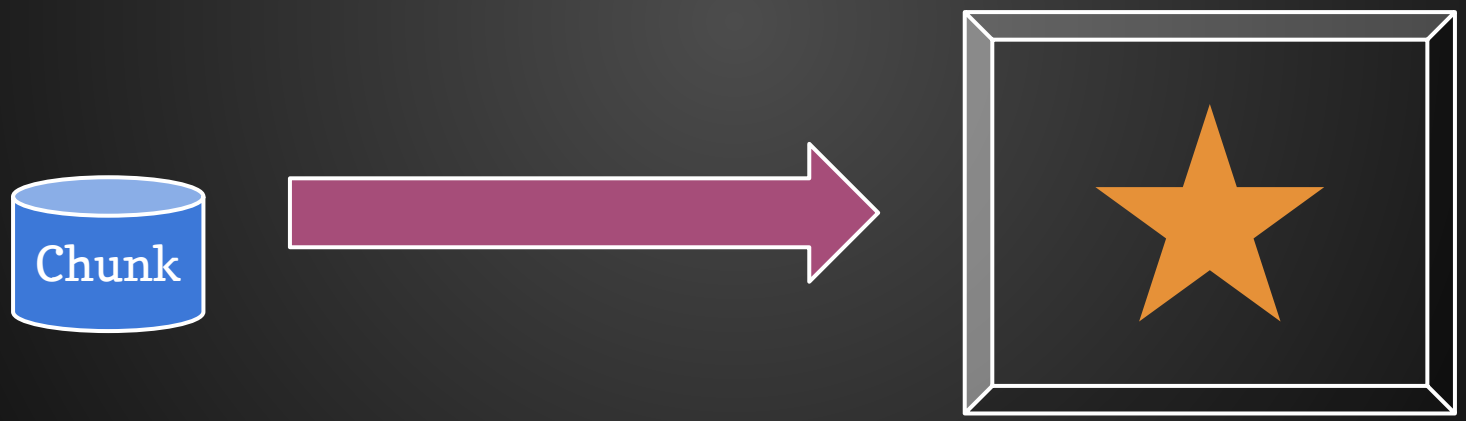
# High-Level Operations

# High-Level Operations

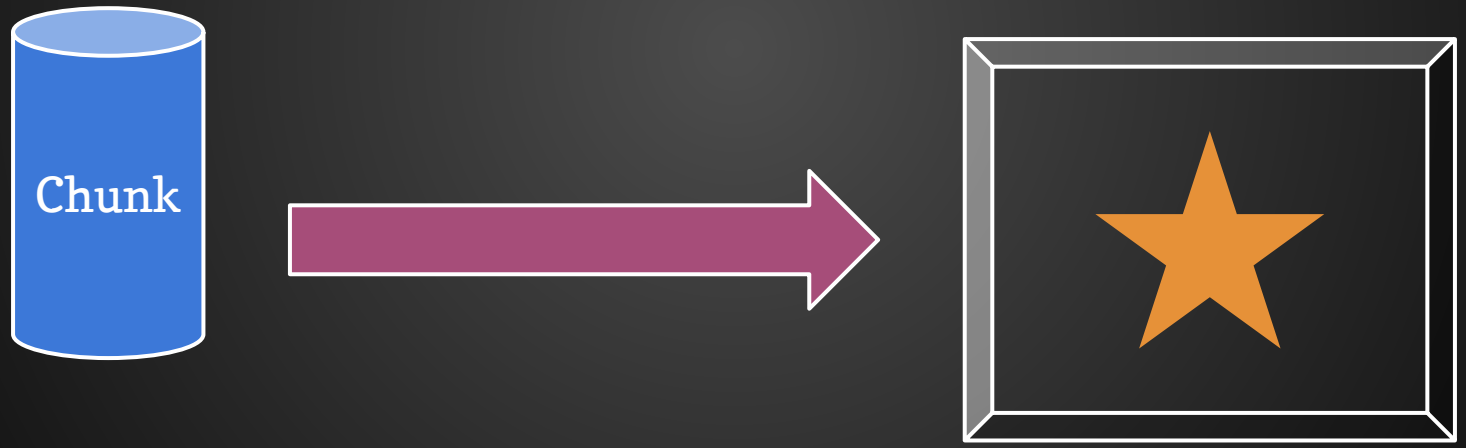
# High-Level Operations



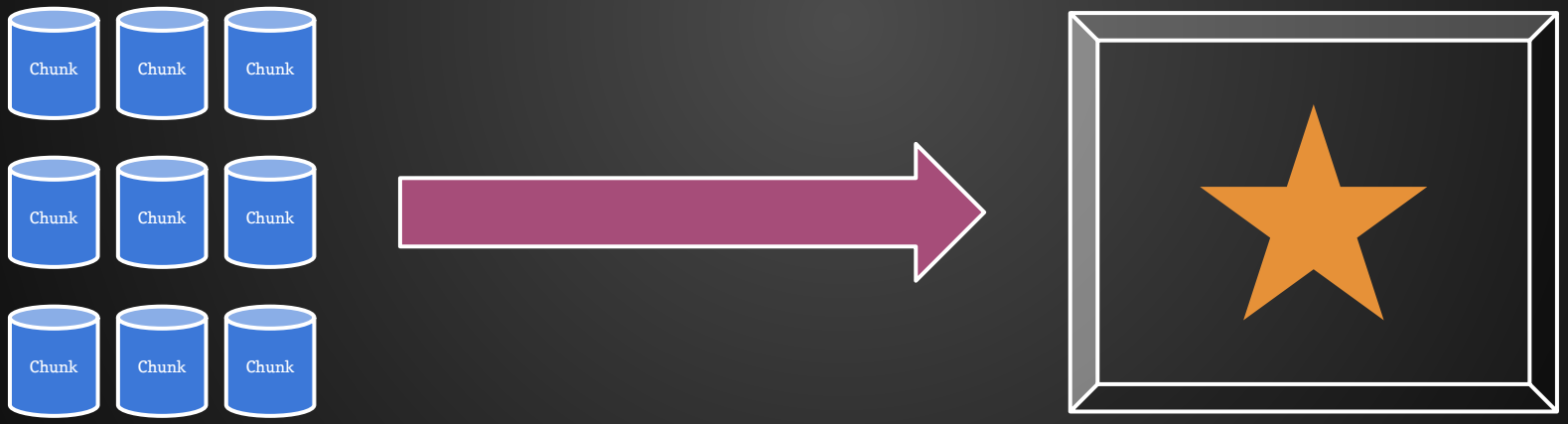
# High-Level Operations



# High-Level Operations



# High-Level Operations



# High-Level Operations

Process data.

# Low-Level Operations

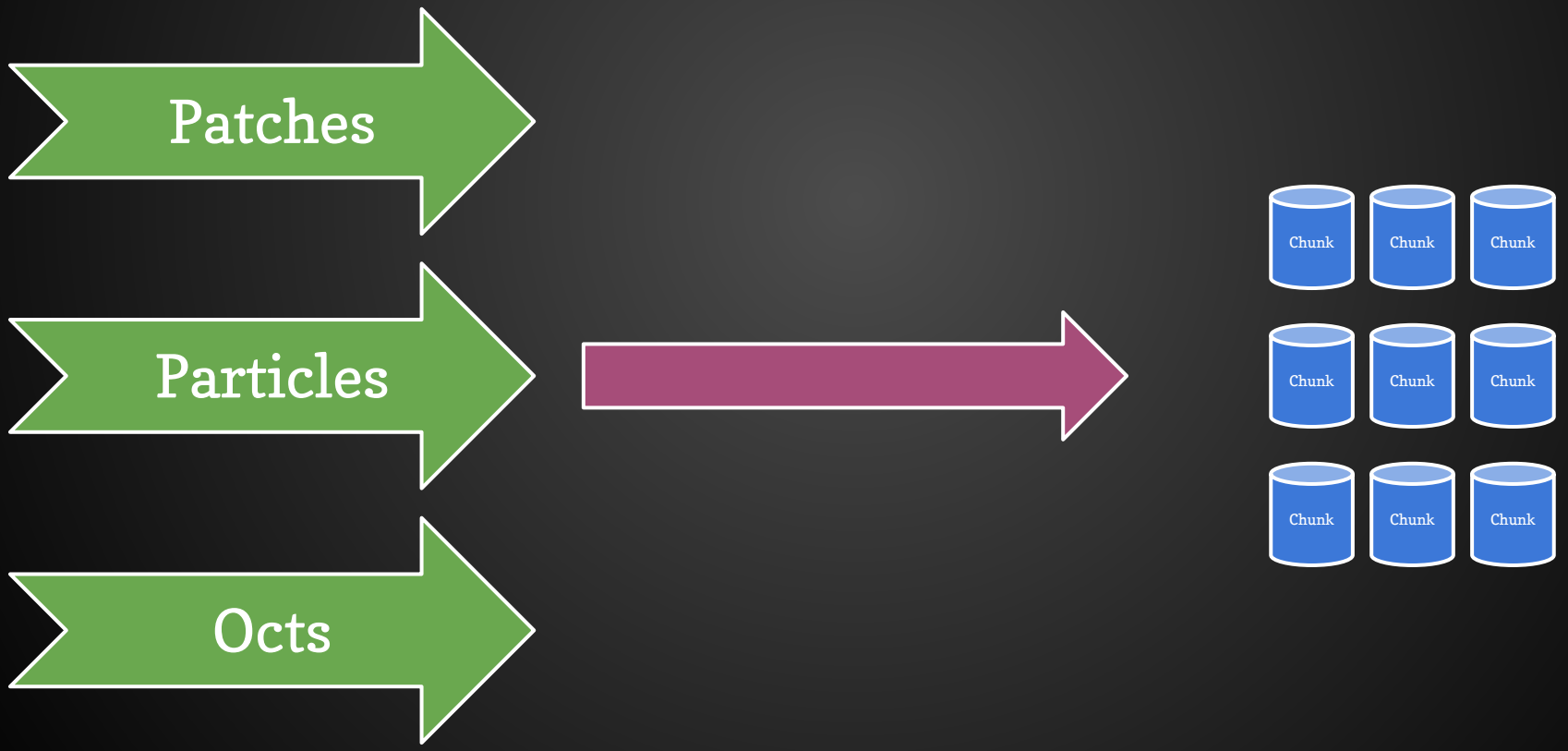
# Low-Level Operations

# Low-Level Operations


# Low-Level Operations

# Low-Level Operations

# Low-Level Operations



# Low-Level Operations

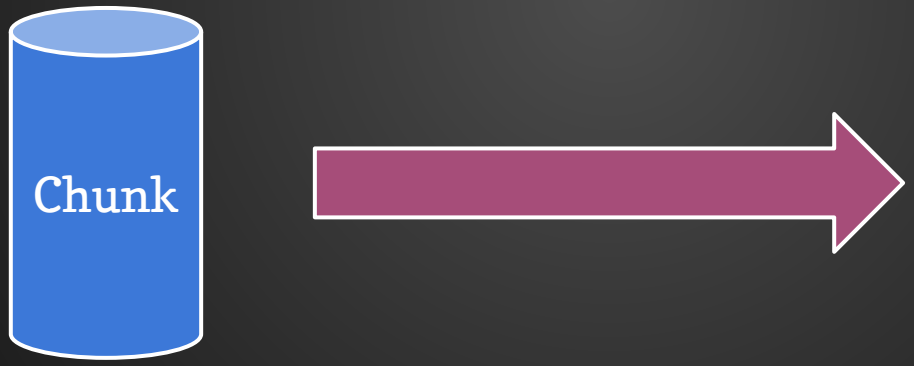
# Low-Level Operations

# Low-Level Operations

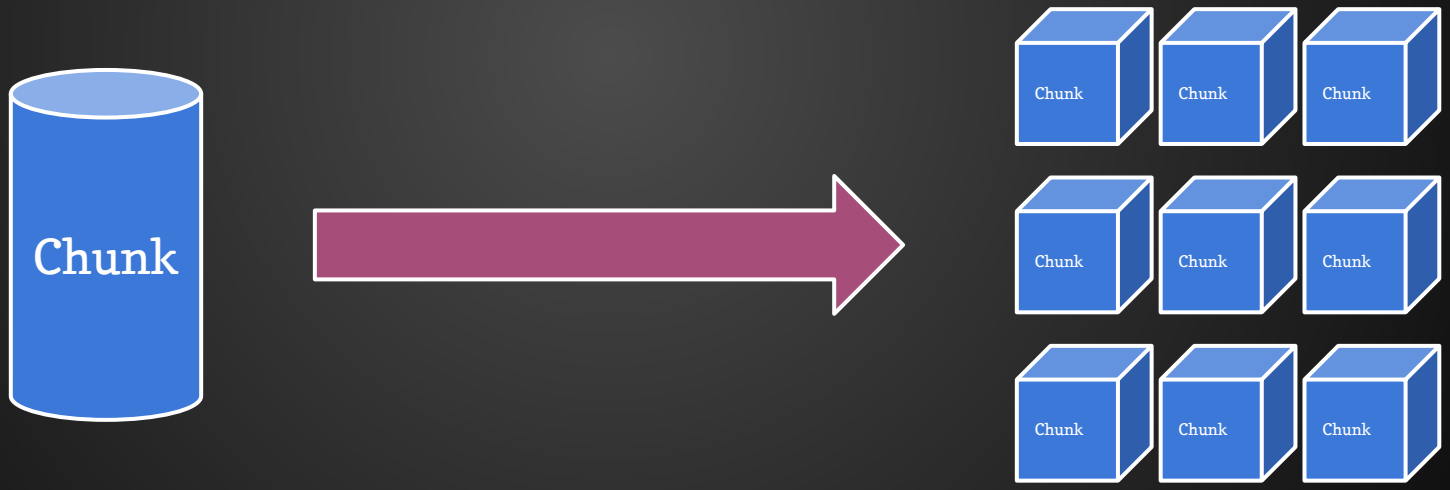
# Low-Level Operations

# Low-Level Operations

# Low-Level Operations



# Low-Level Operations



# Low-Level Operations

Index data.

# Software Infrastructure

# Software Infrastructure

# Software Infrastructure


Math

Solvers
Algorithms
IO
Parallelism
Analysis
Visualization

# Software Infrastructure


Math
Parallelism
Algorithms
Visualization

Solvers
IO
Analysis

# Software Infrastructure


Math
Parallelism
Algorithms
Visualization
IO

Solvers
Analysis

# Software Infrastructure


Domain specificity is a transient phenomena for infrastructure.

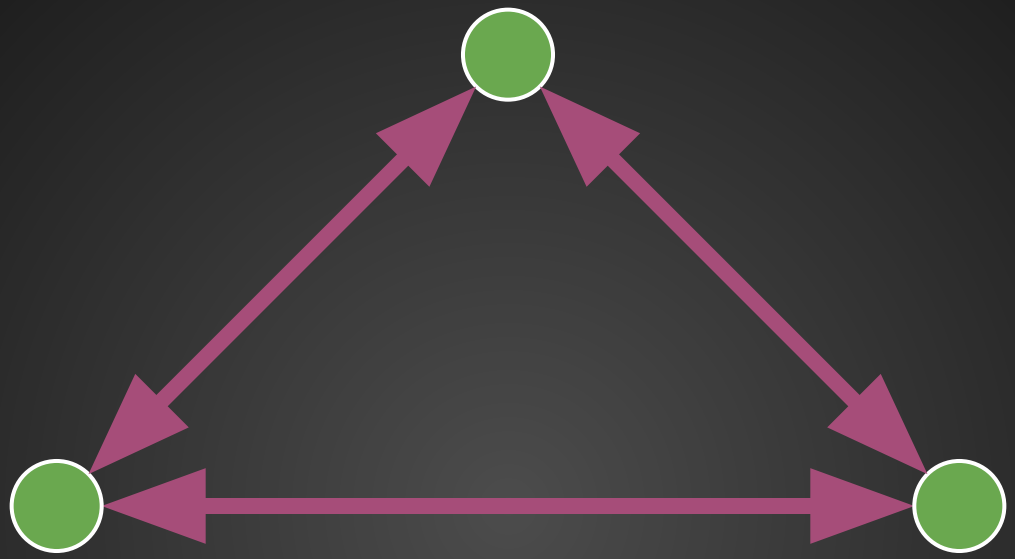
# Software Infrastructure

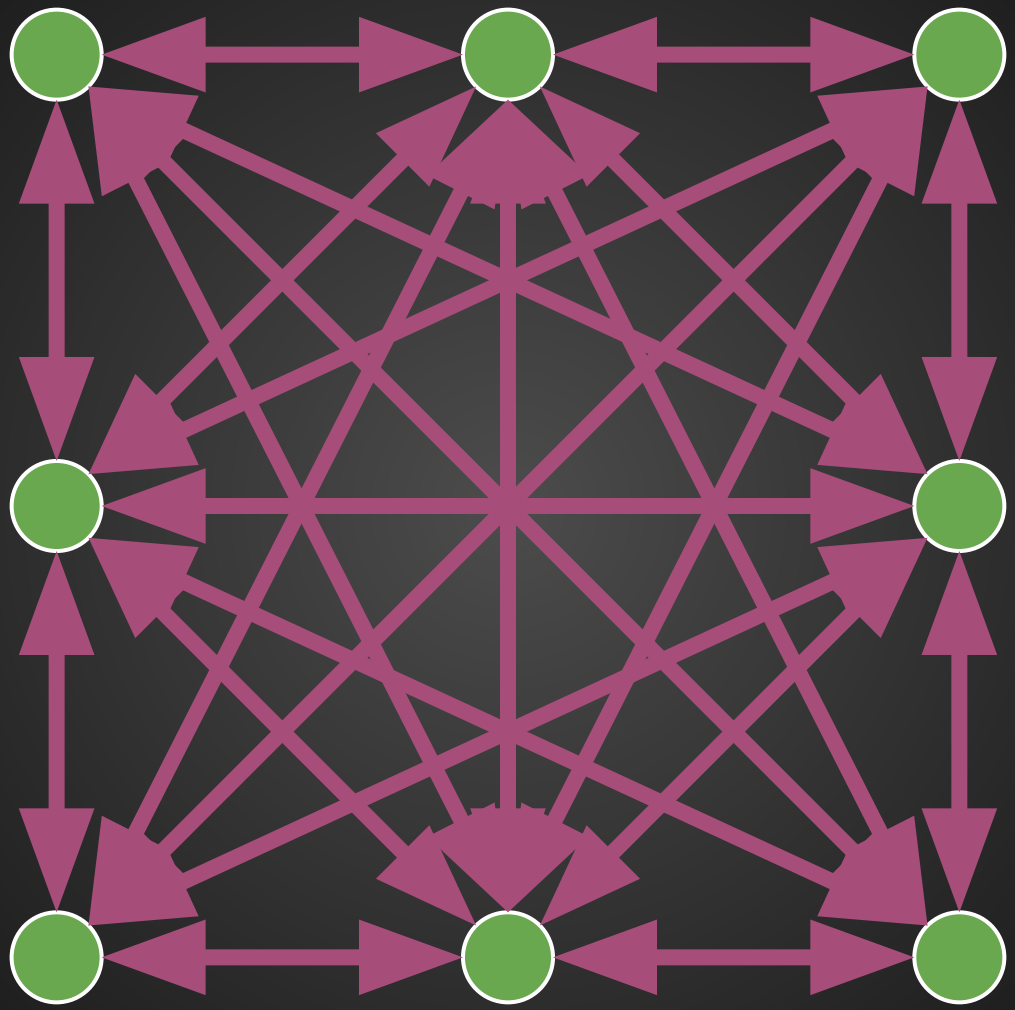

Domain specificity is a lasting phenomena for implementations.

# Not Invented Here

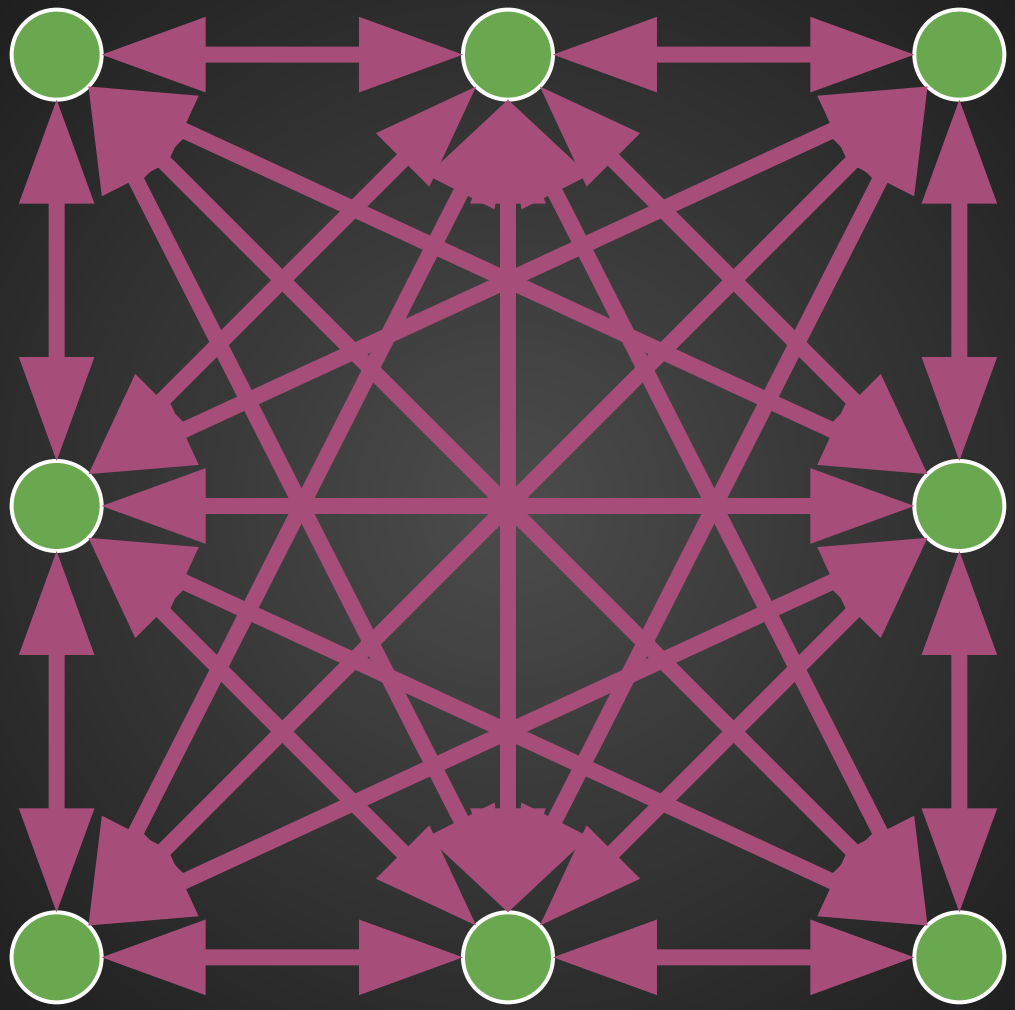
# Not Invented Here

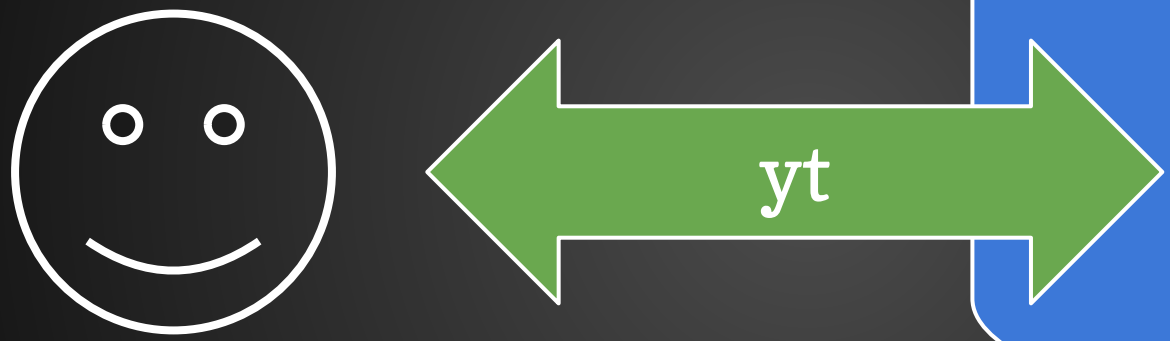
(a space-filling effect)

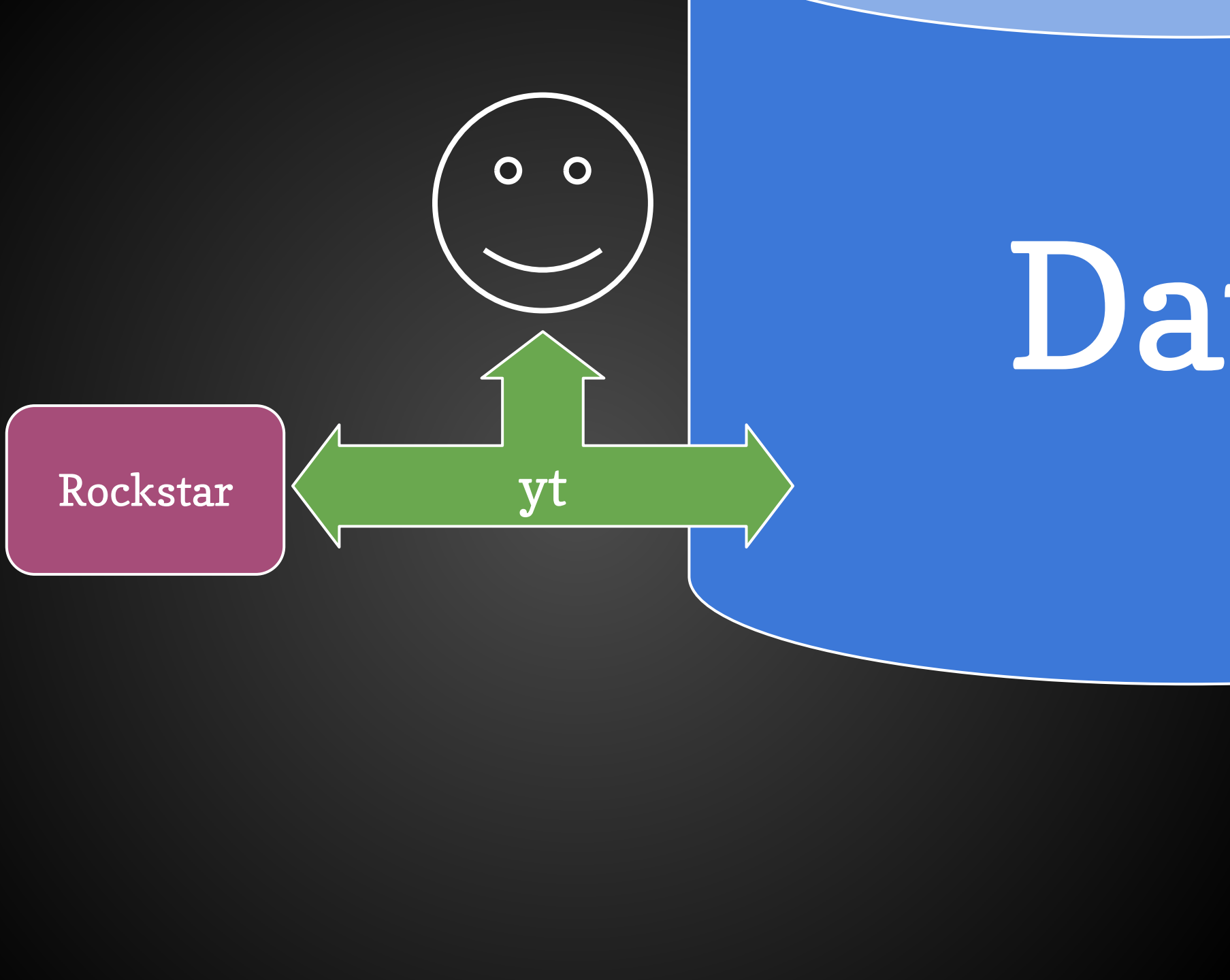


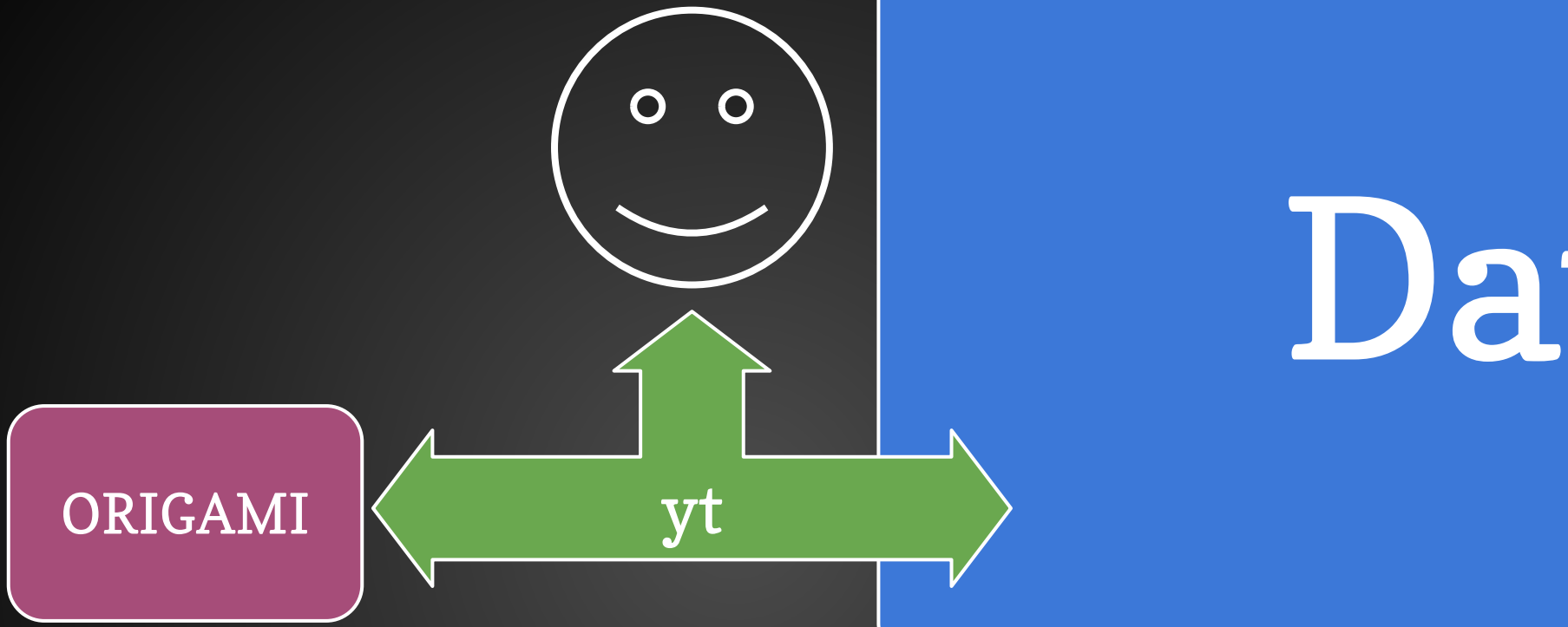


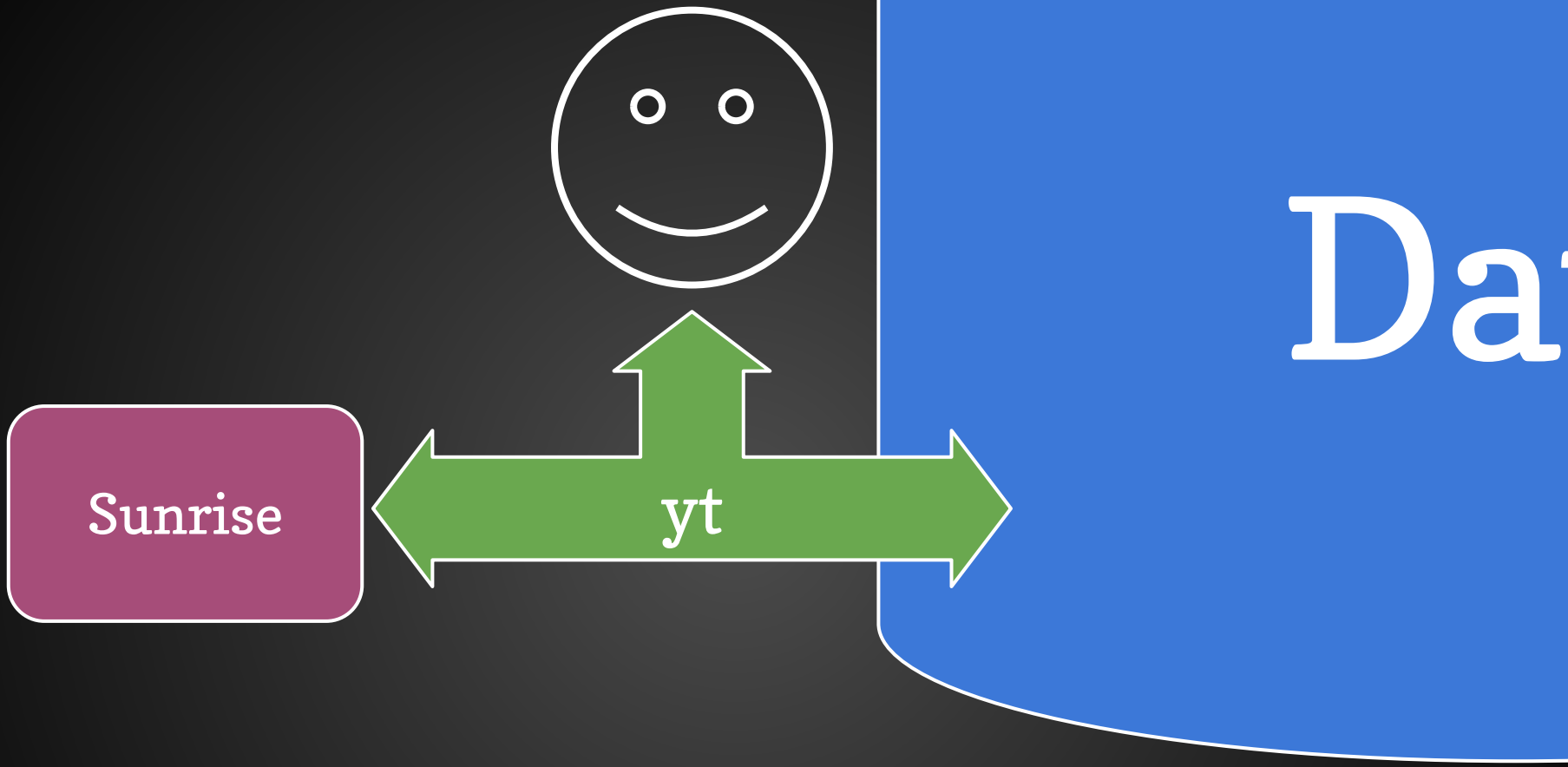
# Metcalfe's Law

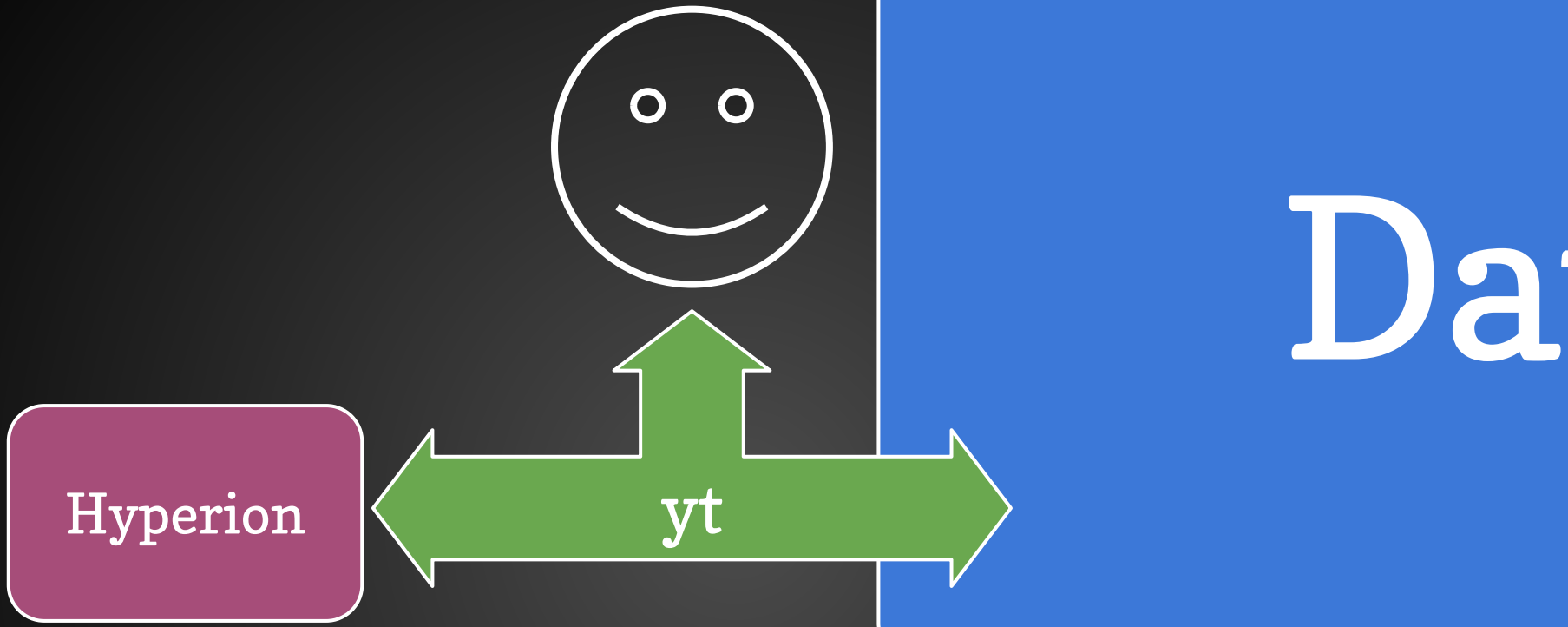


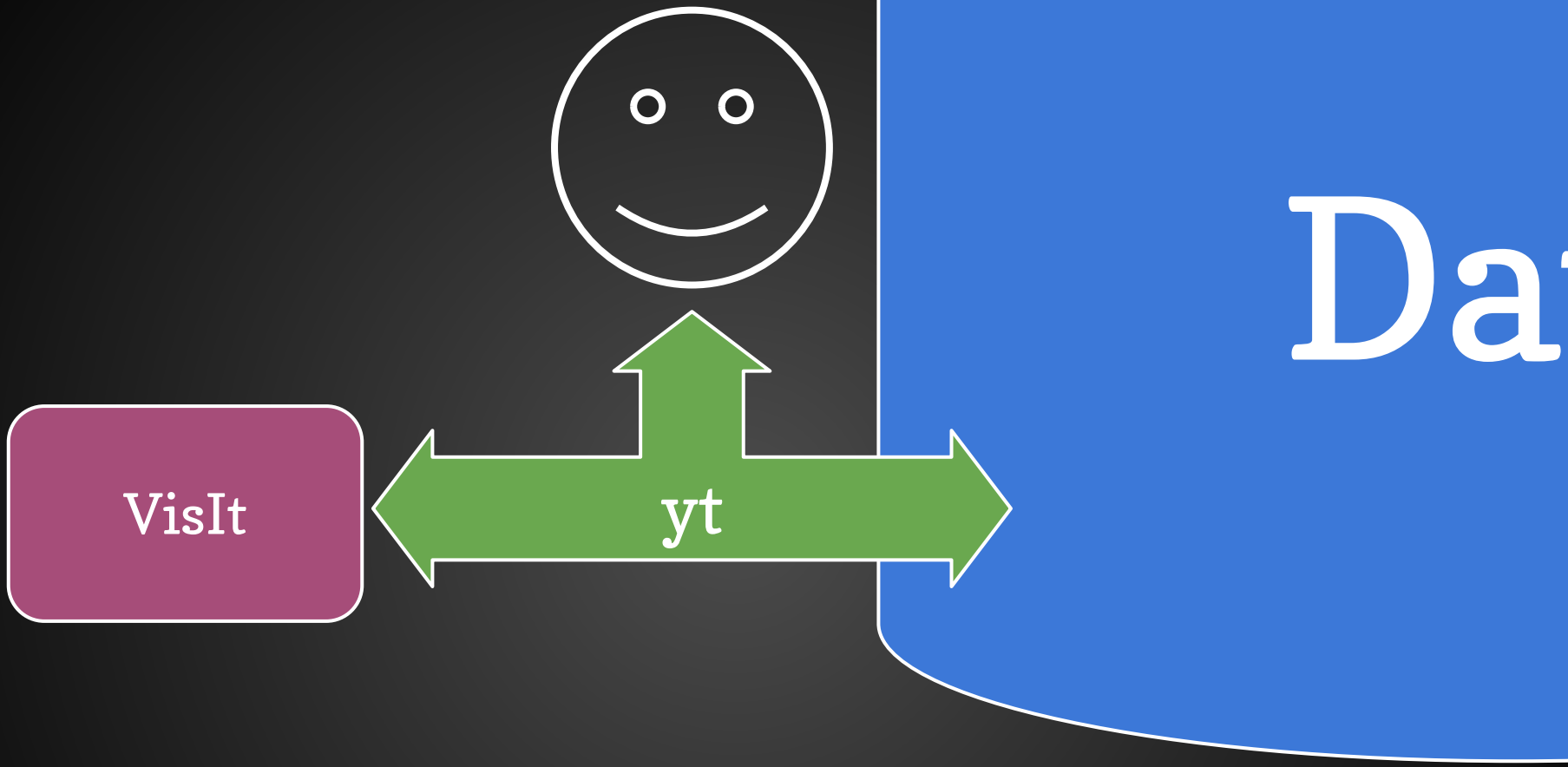

yt


Da
Rockstar
yt


Da
ORIGAMI
yt


Da
Sunrise
yt


Hyperion
yt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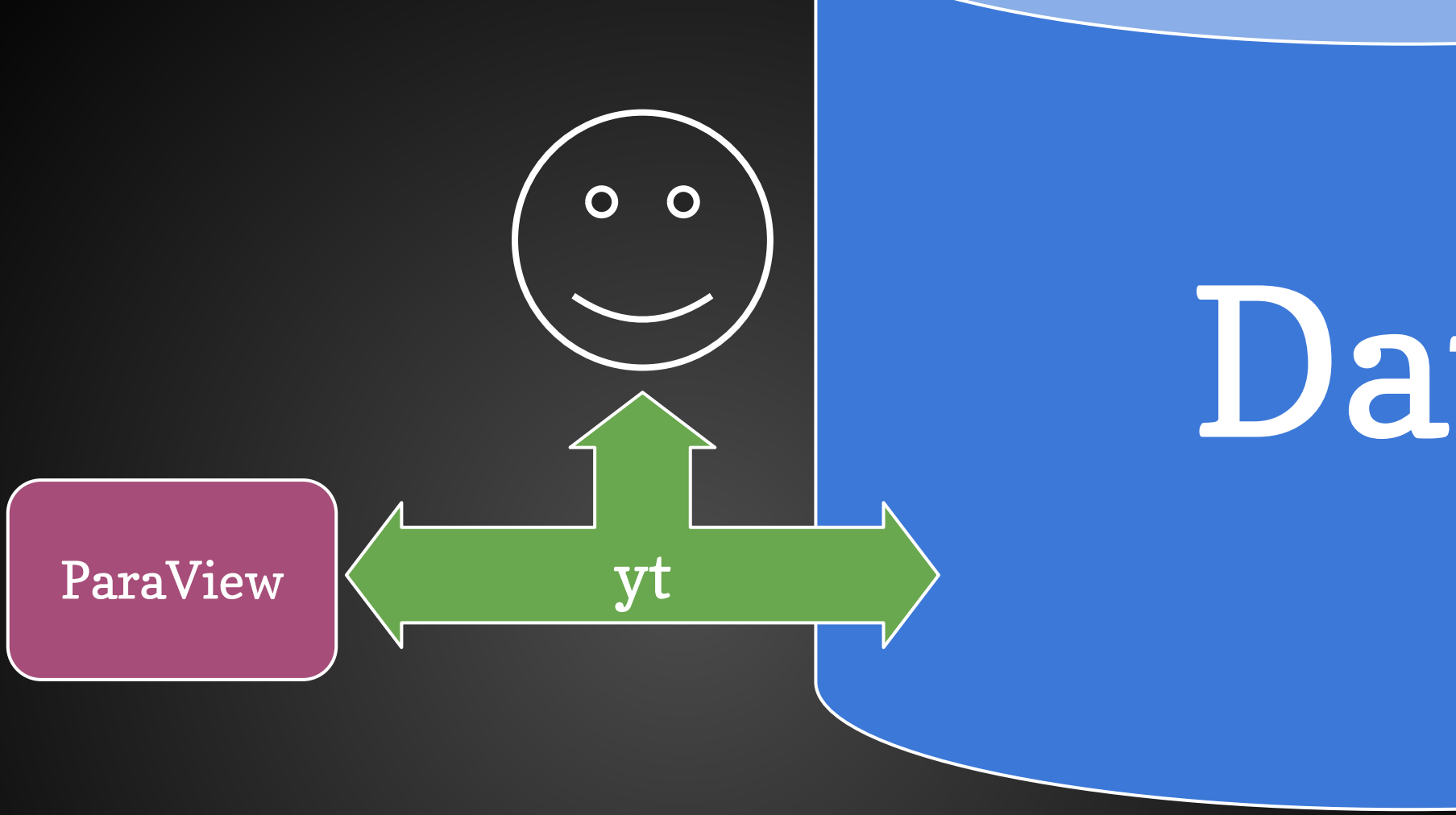
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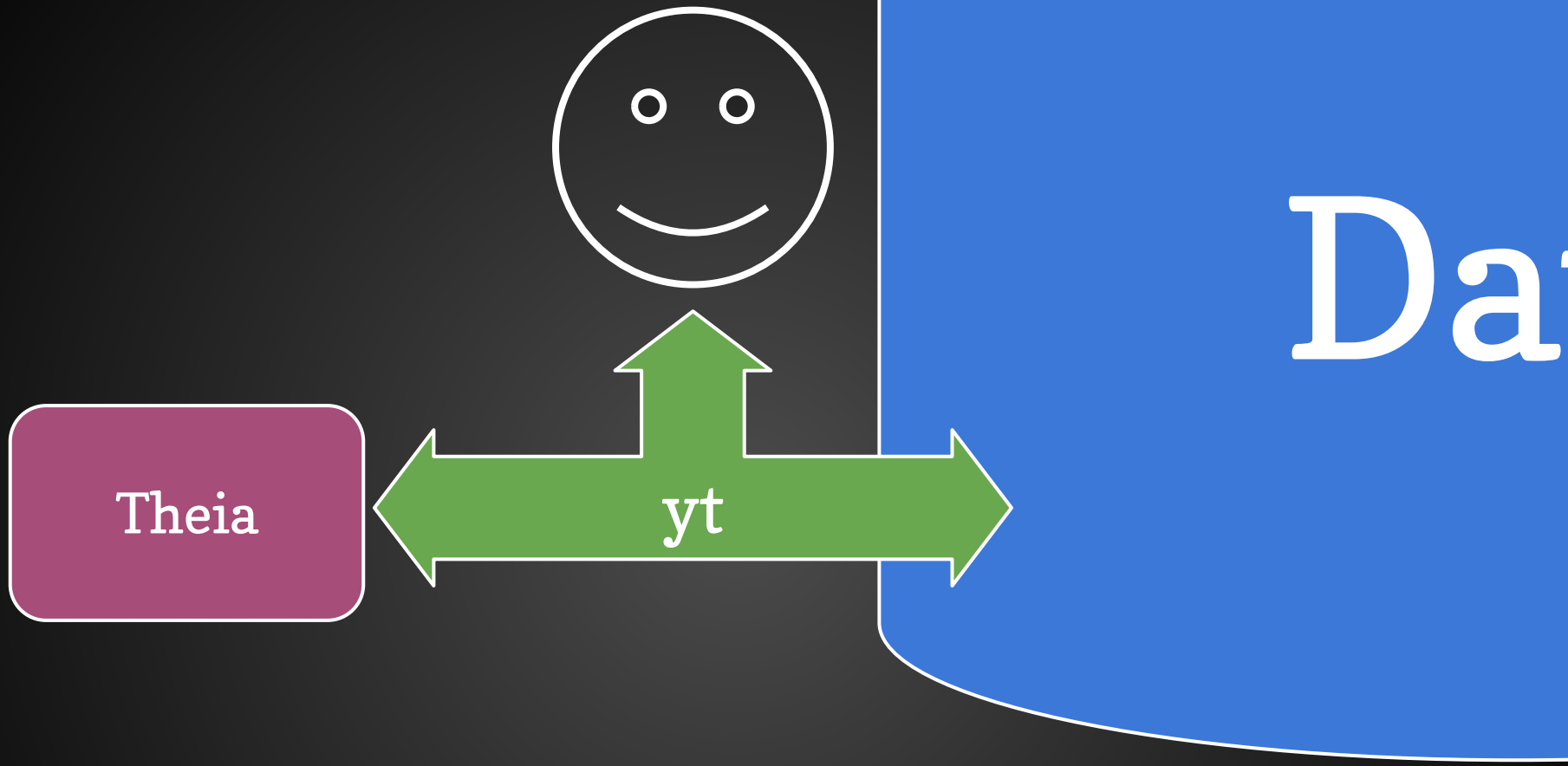
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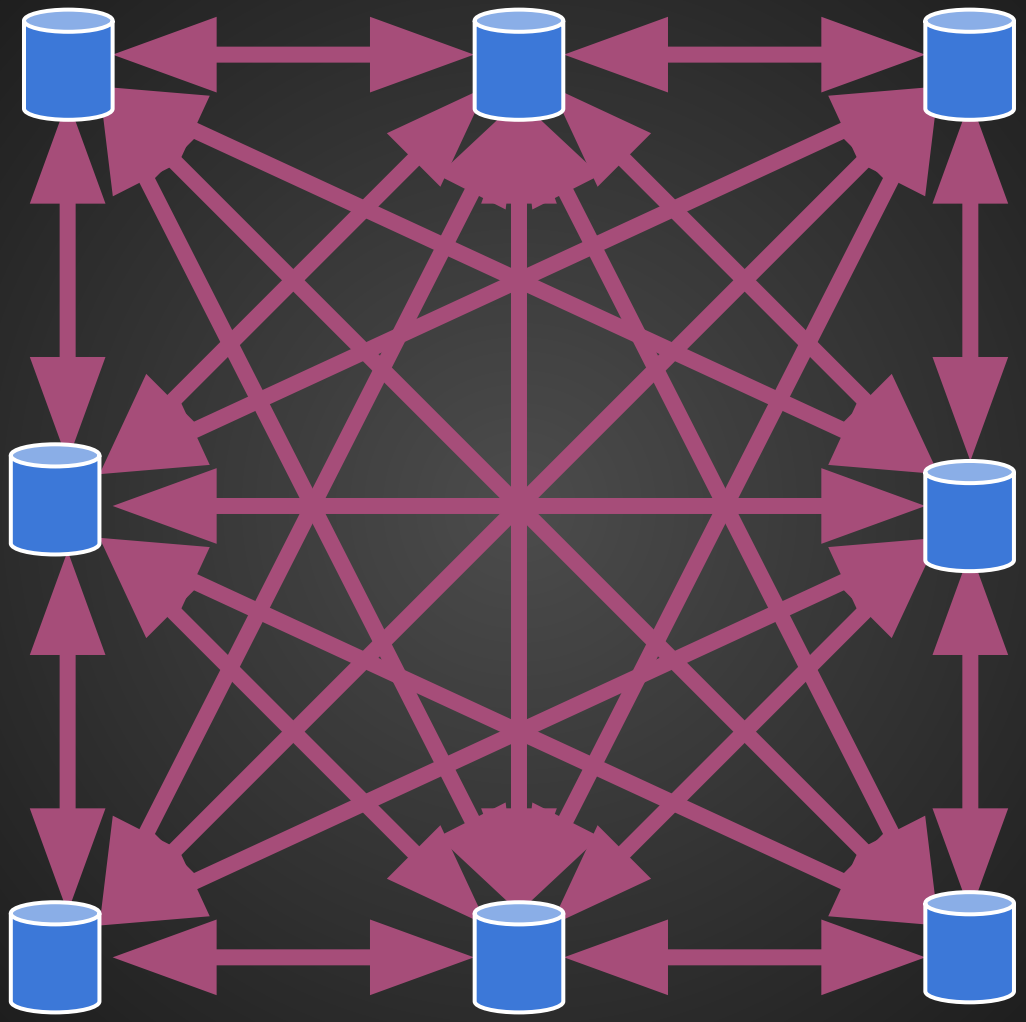
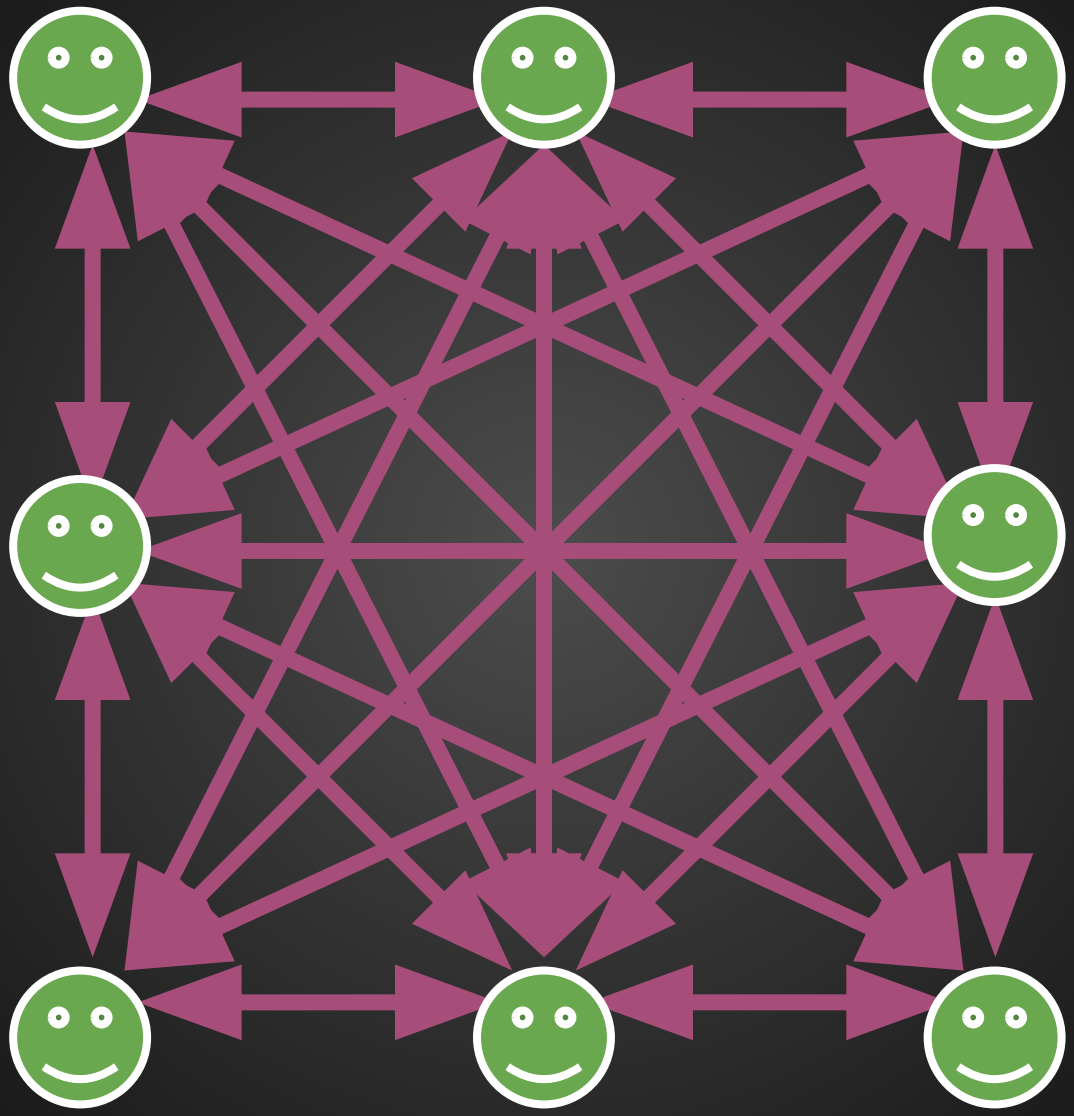
# Warren's Law



“Exascale is made of people!”

- Mike Warren, 2014

# People



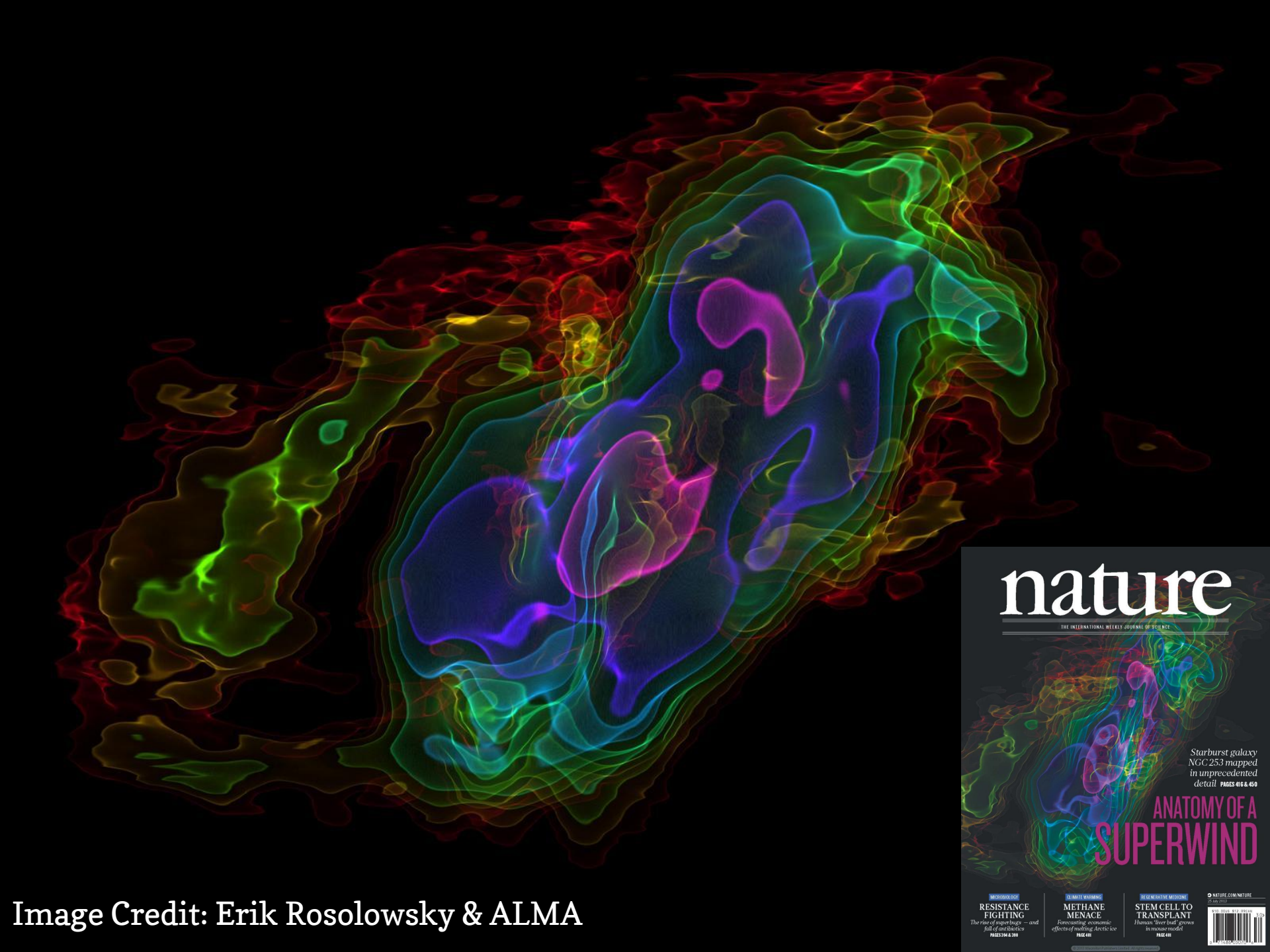
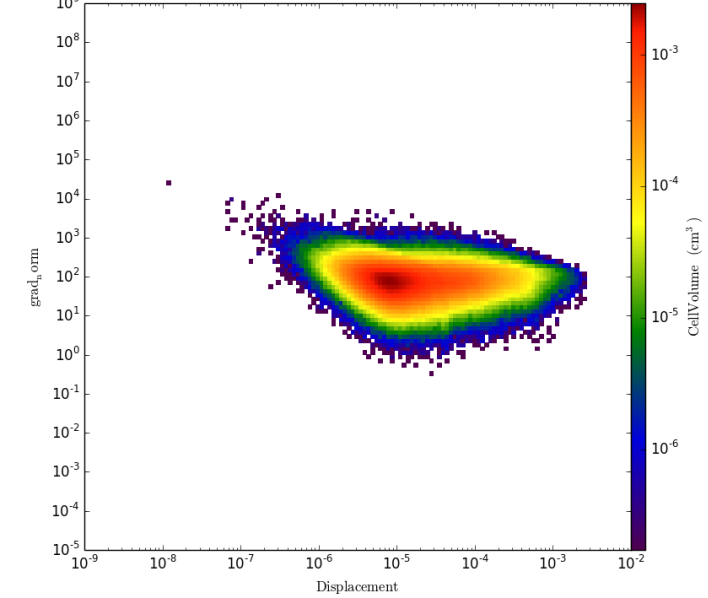
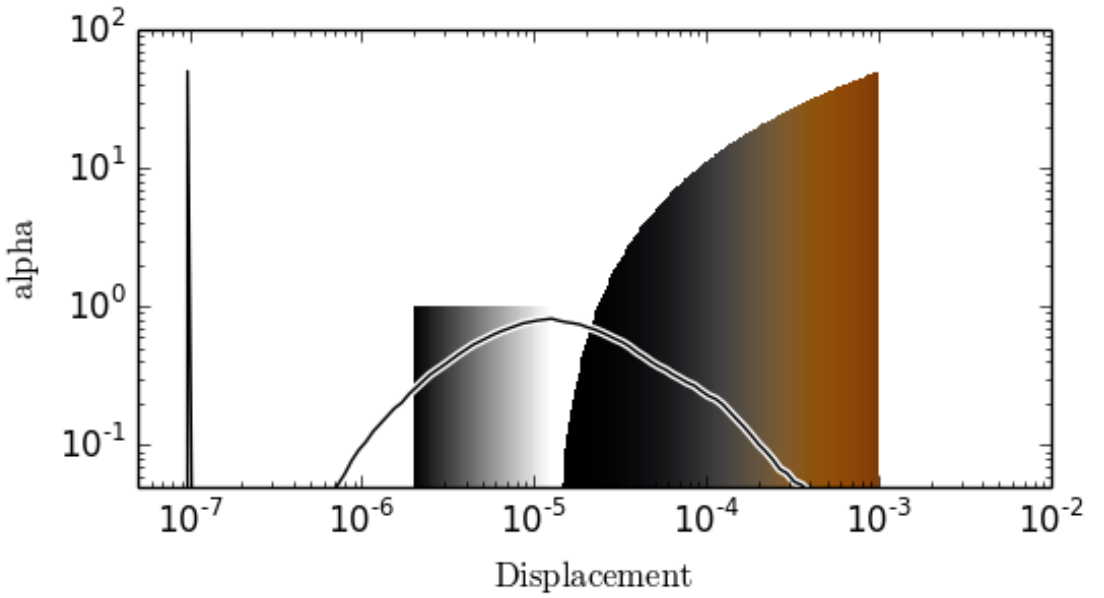
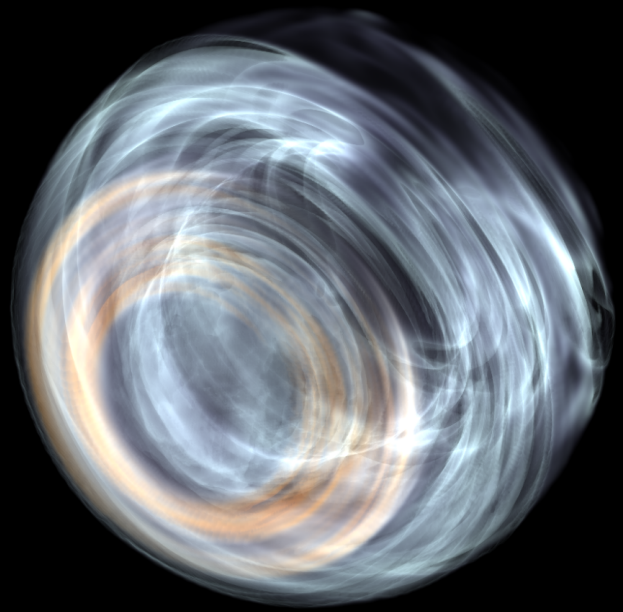


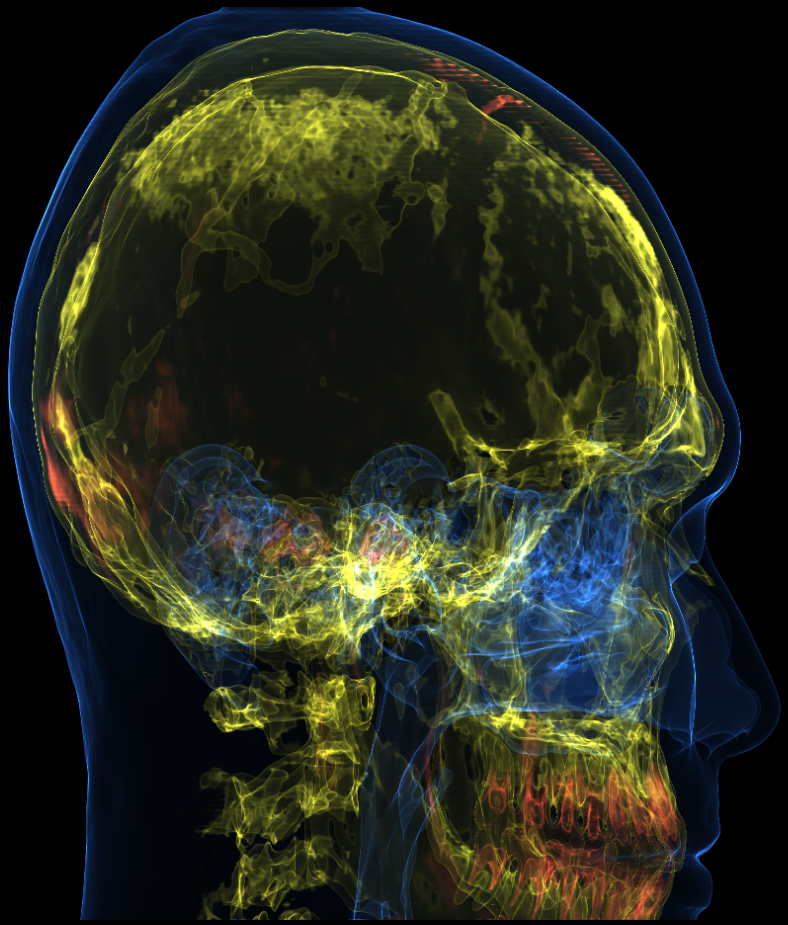

Image Credit: Erik Rosolowsky & ALMA



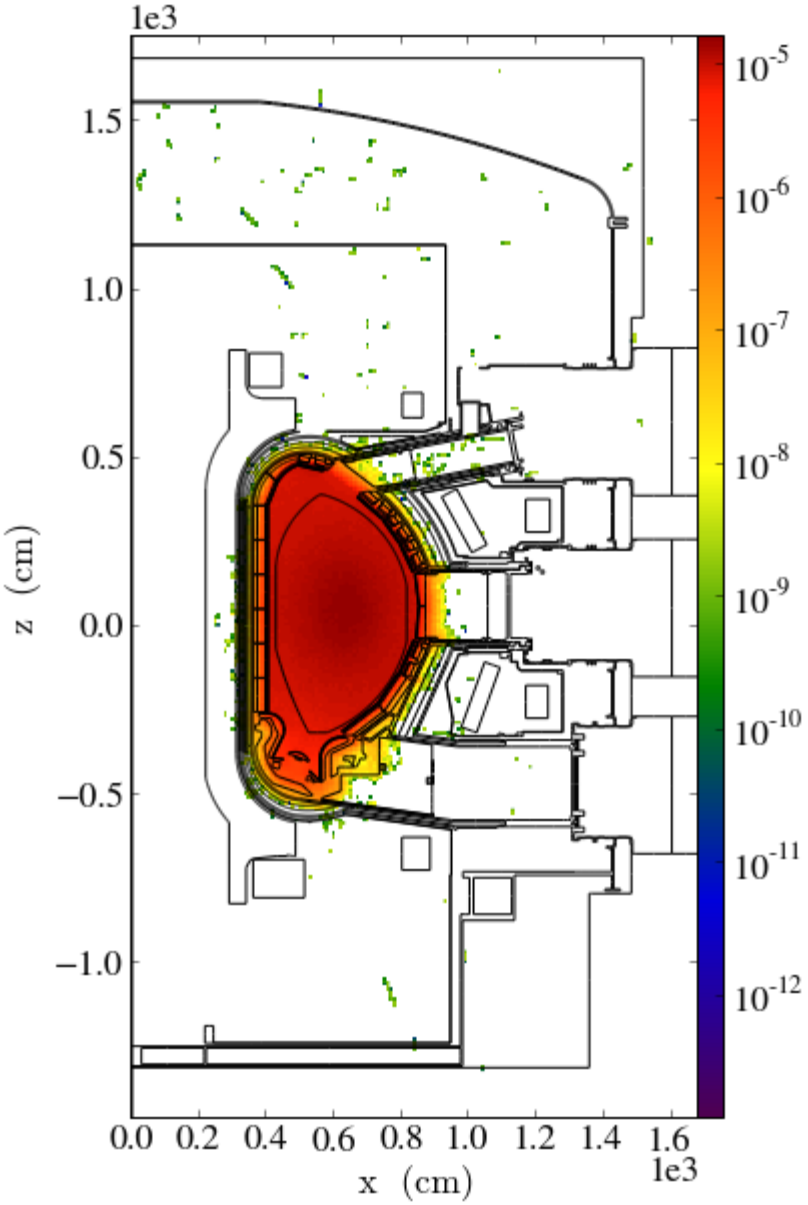

Holtzman et al

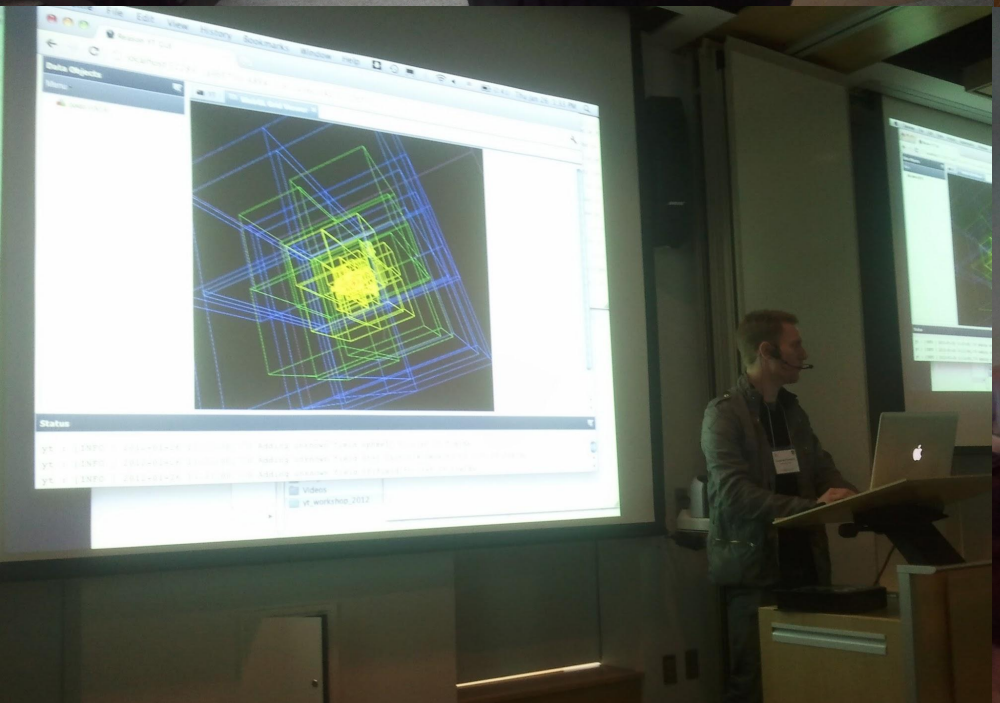




Neurodome and ITER

SubbaRao, Fisher, Shriwise





# Thank you.

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Chris Moody
Andrew Myers
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Kaylea Nelson
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Elizabeth Tasker
Stephanie Tonnesen
Sebastian Trujillo-Gomez
Matthew Turk
Rick Wagner
Andrew Wetzel
John Wise
John ZuHone