

Considerations for TAO

- Must handle large datasets.
- Average request in hours (ideally minutes).
- Scale over large number of distributed cores.
- Use an SQL capable DB.

How to choose a
DBMS?



Dataset sizes

Data access patterns

Data representation



Dataset sizes

Data access patterns

Data representation

Millennium

- $\approx 750,000,000$ galaxies
- $\approx 300\text{GB}$
- <http://www.mpa-garching.mpg.de/galform/virgo/millennium>

Bolshoi

- $\approx 2,500,000,000$ galaxies
- $\approx 1\text{TB}$
- <http://hipacc.ucsc.edu/Bolshoi>

Dataset sizes

Data access patterns

Data representation

Science Modules

Lightcone

Mock Image

SED

Telescope

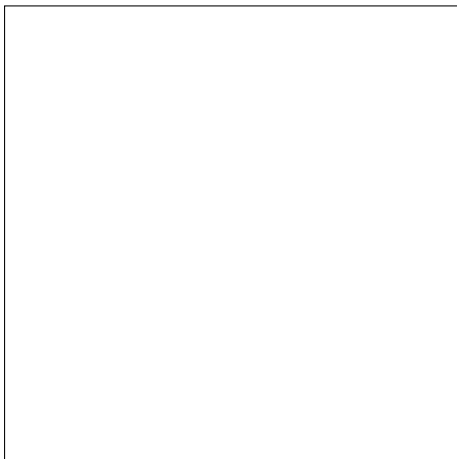
Science Modules

Lightcone

Mock Image

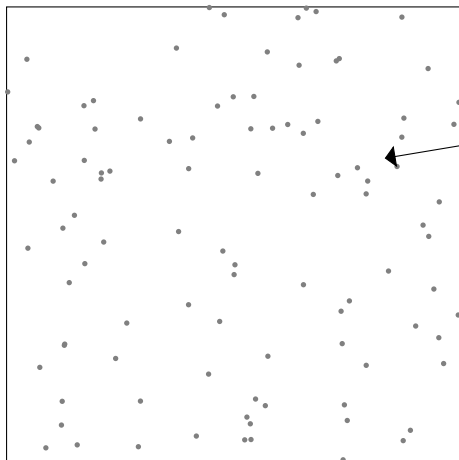
SED

Telescope



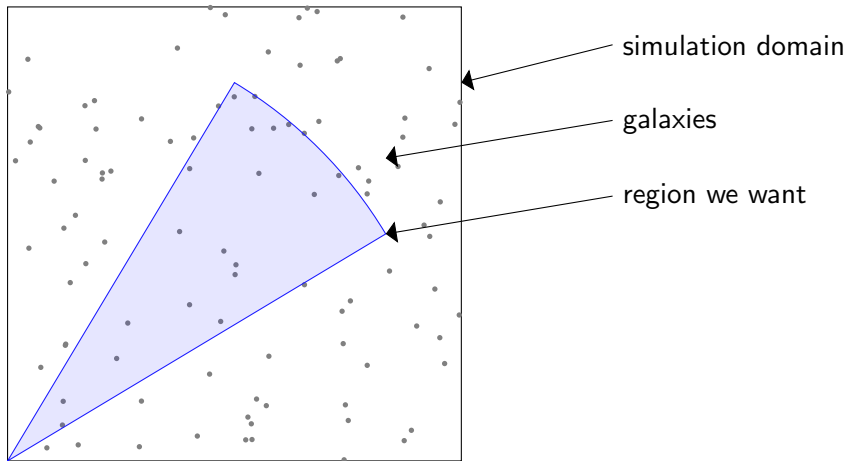
simulation domain

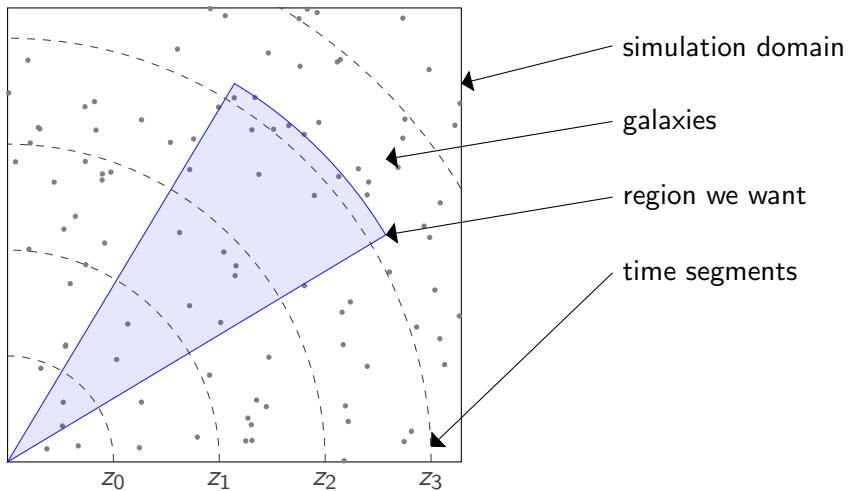




simulation domain

galaxies





```
SELECT * FROM snapshot_004 WHERE (9437.5 + IF(39.8397 + Pos1 < 62.5,  
39.8397 + Pos1, Pos1 + 39.8397-62.5) - 0) < 9427.7048129608065 AND (9437.5 +  
IF(39.8397 + Pos1 < 62.5, 39.8397 + Pos1, Pos1 + 39.8397-62.5) - 0) >  
9408.2000081888491 AND (187.5 + IF(26.503 + Pos2 < 62.5, 26.503 + Pos2, Pos2 +  
26.503-62.5) - 3.45846e-323) < 246.78854155076195 AND (187.5 + IF(26.503 + Pos2  
< 62.5, 26.503 + Pos2, Pos2 + 26.503-62.5) - 3.45846e-323) > 0 AND (187.5 +  
IF(55.9087 + Pos3 < 62.5, 55.9087 + Pos3, Pos3 + 55.9087-62.5) - 6.90856e-310) <  
246.78854155076195 AND (187.5 + IF(55.9087 + Pos3 < 62.5, 55.9087 + Pos3, Pos3  
+ 55.9087-62.5) - 6.90856e-310) > 0 AND SQRT(POW((9437.5 + IF(39.8397 + Pos1  
< 62.5, 39.8397 + Pos1, Pos1 + 39.8397-62.5) - 0), 2)
```

+ POW(((187.5 + IF(26.503 + Pos2 < 62.5, 26.503 + Pos2, Pos2 + 26.503-62.5) -
 3.45846e-323), 2) + POW(((187.5 + IF(55.9087 + Pos3 < 62.5, 55.9087 + Pos3, Pos3
 + 55.9087-62.5) - 6.90856e-310), 2)) < 9427.7048129608065 AND
 SQRT(POW(((9437.5 + IF(39.8397 + Pos1 < 62.5, 39.8397 + Pos1, Pos1 +
 39.8397-62.5) - 0), 2) + POW(((187.5 + IF(26.503 + Pos2 < 62.5, 26.503 + Pos2,
 Pos2 + 26.503-62.5) - 3.45846e-323), 2) + POW(((187.5 + IF(55.9087 + Pos3 < 62.5,
 55.9087 + Pos3, Pos3 + 55.9087-62.5) - 6.90856e-310), 2)) > 9414.6512343460909
 AND SQRT(POW(((9437.5 + IF(39.8397 + Pos1 < 62.5, 39.8397 + Pos1, Pos1 +
 39.8397-62.5) - 0), 2) + POW(((187.5 + IF(26.503 + Pos2 < 62.5, 26.503 + Pos2,
 Pos2 + 26.503-62.5) - 3.45846e-323), 2) + POW(((187.5 + IF(55.9087 + Pos3 < 62.5,
 55.9087 + Pos3, Pos3 + 55.9087-62.5) - 6.90856e-310), 2)) < 9427.7048129608065
 AND

$$\begin{aligned}
 & (9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - \\
 & 0) / (\text{SQRT}(\text{POW}((9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + \\
 & 39.8397 - 62.5) - 0), 2) + \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \\
 & \text{Pos2} + 26.503 - 62.5) - 3.45846\text{e-}323), 2))) > 0.070737201667702906 \text{ AND } (9437.5 + \\
 & \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - \\
 & 0) / (\text{SQRT}(\text{POW}((9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + \\
 & 39.8397 - 62.5) - 0), 2) + \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \\
 & \text{Pos2} + 26.503 - 62.5) - 3.45846\text{e-}323), 2))) < 1 \text{ AND } \text{SQRT}(\text{POW}((9437.5 + \\
 & \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - 0), 2) + \\
 & \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \text{Pos2} + 26.503 - 62.5) -
 \end{aligned}$$

$$\frac{3.45846e-323}{2}) / (\text{SQRT}(\text{POW}((9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - 0), 2) + \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \text{Pos2} + 26.503 - 62.5) - 3.45846e-323), 2) + \text{POW}((187.5 + \text{IF}(55.9087 + \text{Pos3} < 62.5, 55.9087 + \text{Pos3}, \text{Pos3} + 55.9087 - 62.5) - 6.90856e-310), 2)))) > 0.070737201667702906 \text{ AND } \text{SQRT}(\text{POW}((9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - 0), 2) + \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \text{Pos2} + 26.503 - 62.5) - 3.45846e-323), 2)) / (\text{SQRT}(\text{POW}((9437.5 + \text{IF}(39.8397 + \text{Pos1} < 62.5, 39.8397 + \text{Pos1}, \text{Pos1} + 39.8397 - 62.5) - 0), 2) + \text{POW}((187.5 + \text{IF}(26.503 + \text{Pos2} < 62.5, 26.503 + \text{Pos2}, \text{Pos2} + 26.503 - 62.5) - 3.45846e-323), 2) + \text{POW}((187.5 + \text{IF}(55.9087 + \text{Pos3} < 62.5, 55.9087 + \text{Pos3}, \text{Pos3} + 55.9087 - 62.5) - 6.90856e-310), 2)))) < 1$$

Very large amount of data to search
+ Complicated SQL query
+ Multiple users
= Trouble

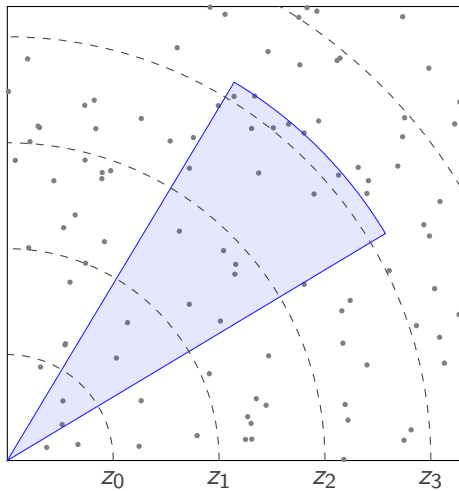
Solution

Distribute over multiple servers.

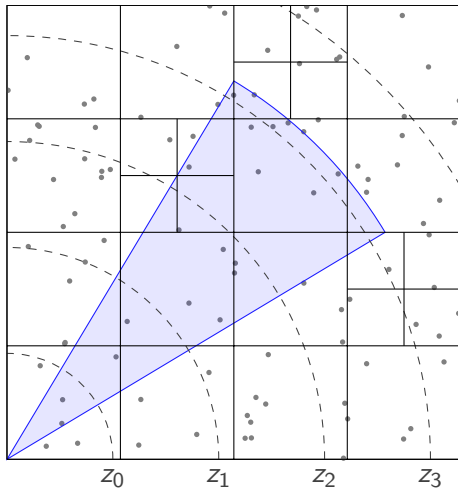
Distributed DBMS Systems

- MySQL Cluster
 - Difficult to manage.
- pgpool
 - Bugs with some queries.
- PostgresXC
 - Older PostgresQL.
 - Small development team.
- Custom (PostgresQL)
 - Reinventing the wheel?

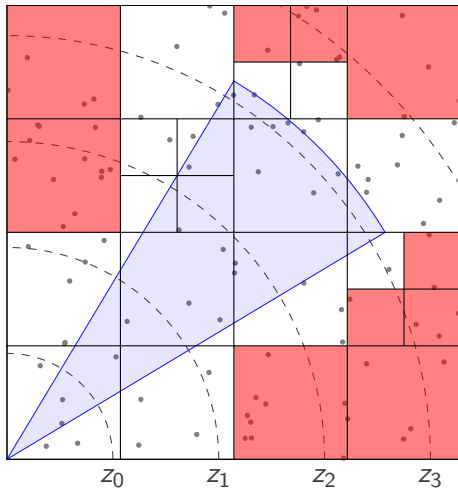
We can do better!



We can do better!



We can do better!



Dataset sizes

Data access patterns

Data representation

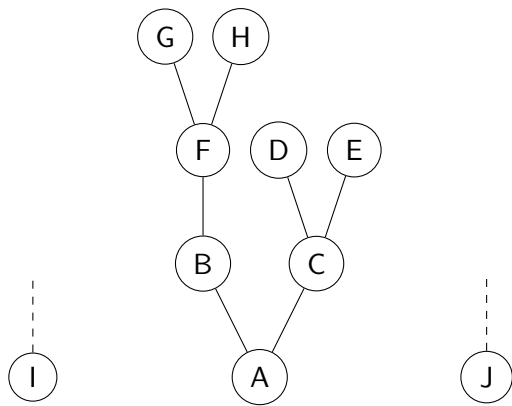
Science Modules

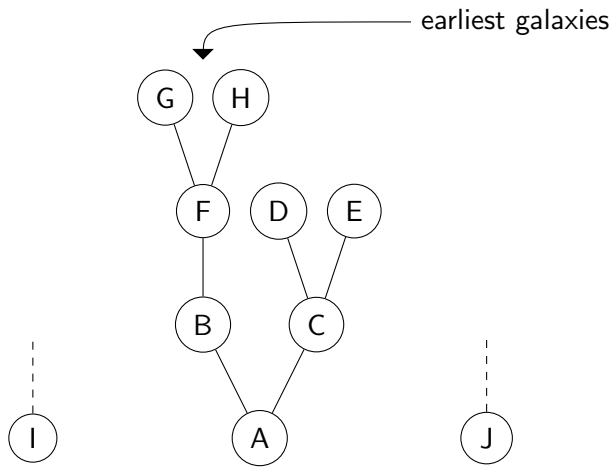
Lightcone

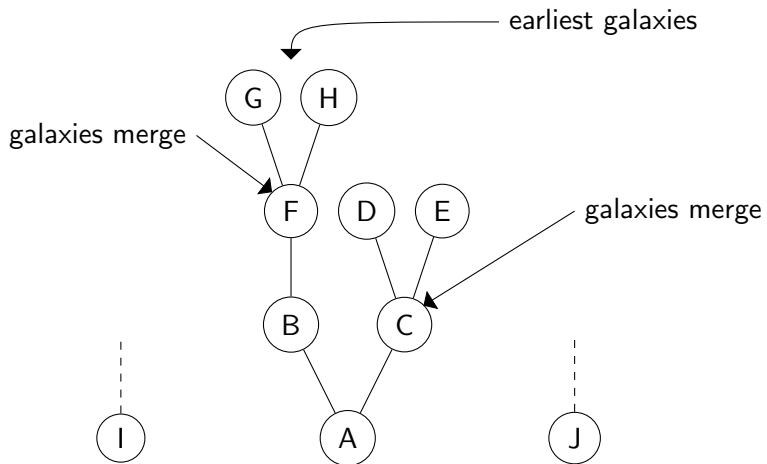
Mock Image

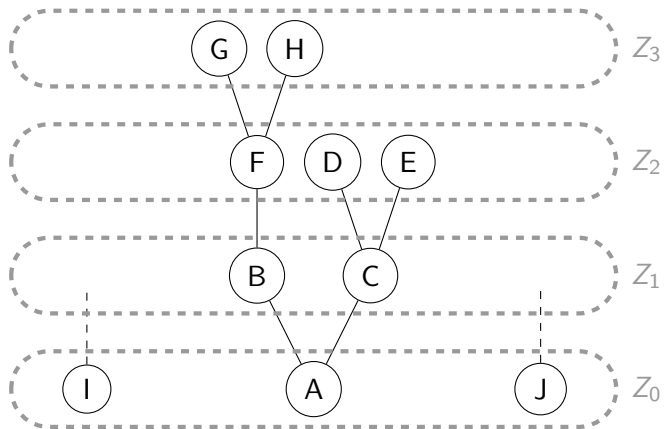
SED

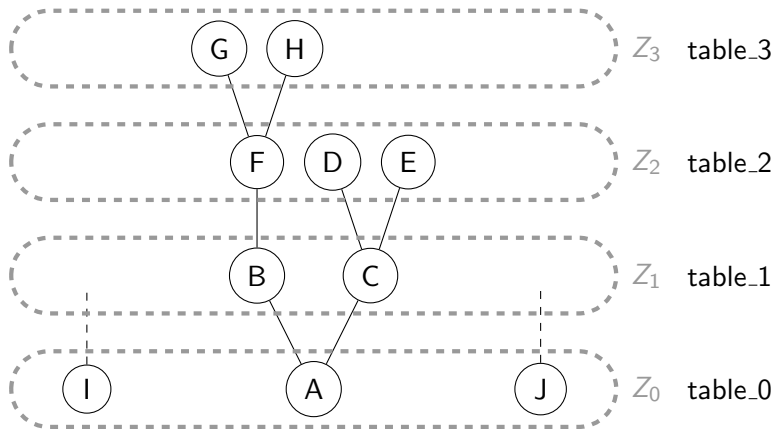
Telescope

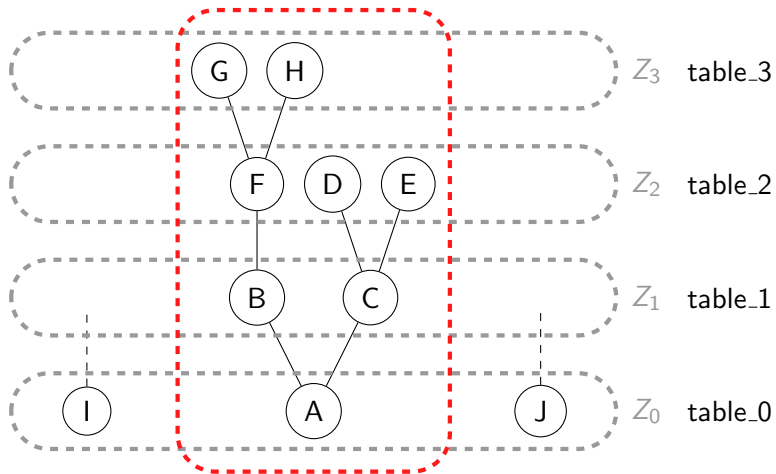




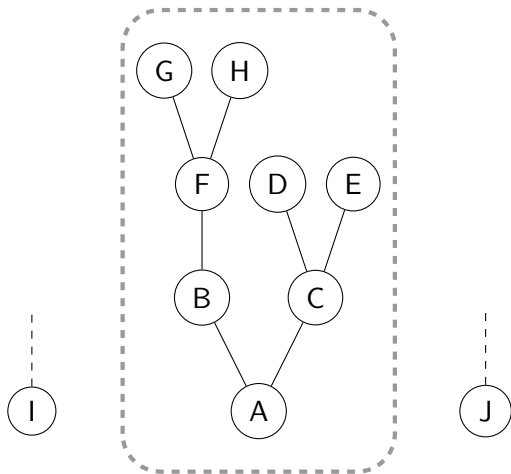








table_0



Database is looking good...

... what about large computation?

\approx 2.5 billion galaxies in Bolshoi dataset, how many to process, on average, per request?

We will need to parallelise computation.

Science Modules

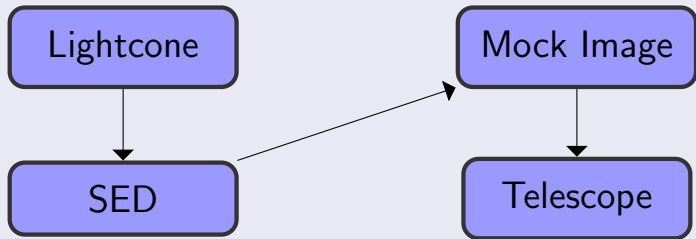
Lightcone

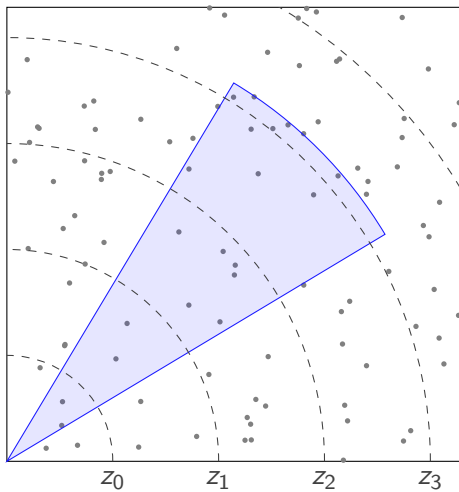
Mock Image

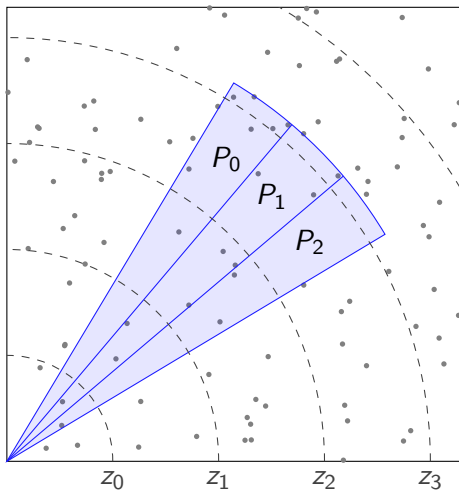
SED

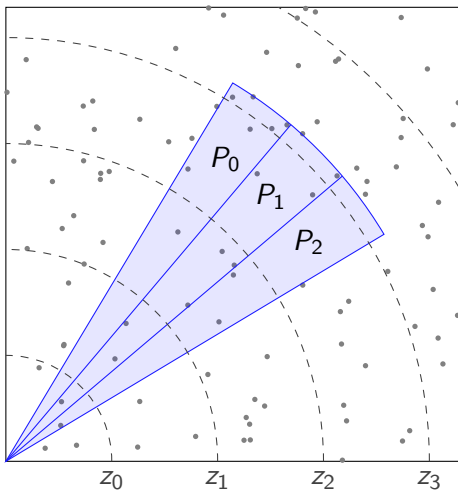
Telescope

Science Modules









Balanced? Probably, but
need to investigate.

We will also utilise GPUs (eventually).

Algorithms

- Cubic spline interpolation.
- Fourth order Gaussian integration.
- Both easily accelerated by GPUs.

