VIS 2015

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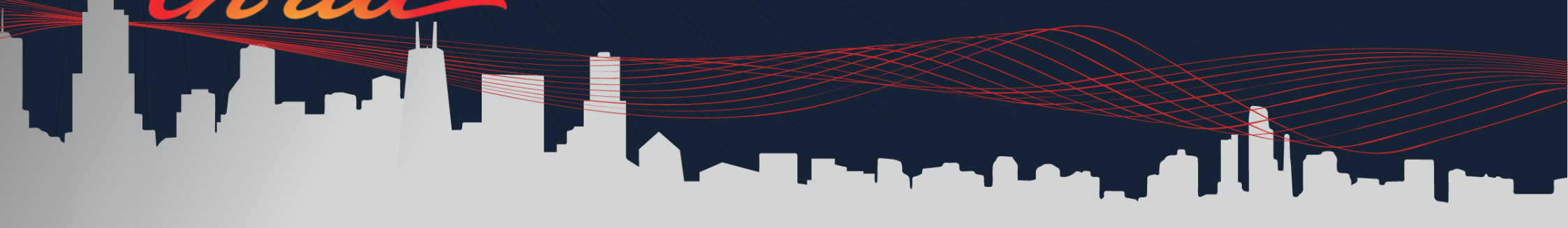
杭州电子科技大学

HANGZHOU DIANZI UNIVERSITY

university of groningen

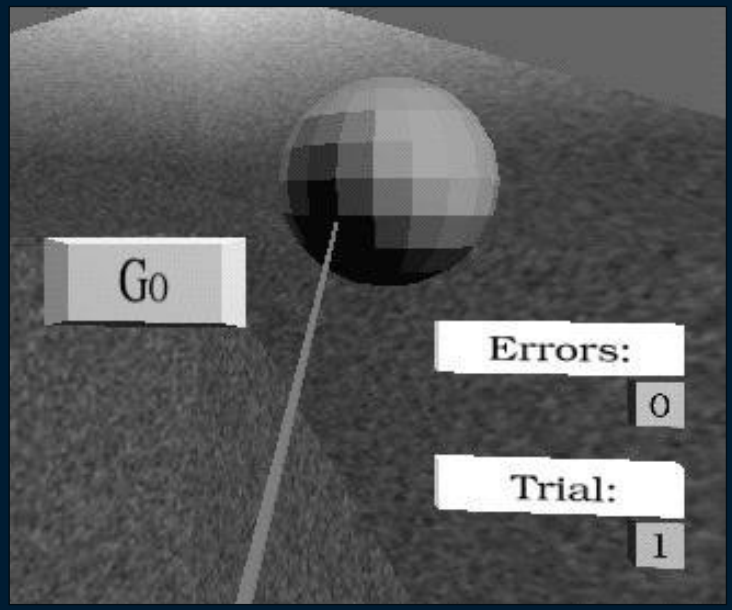
CAST: Effective and Efficient User Interaction for Context-Aware Selection in 3D Particle Clouds

Lingyun Yu, Konstantinos Efstathiou
Petra Isenberg, Tobias Isenberg



The Problem: Selection of 3D Subspaces

- 3D spatial data—basis of many visualization research questions
- **problem:** how to efficiently select particles in 3D?



[Wingrave & Bowman, 2005]

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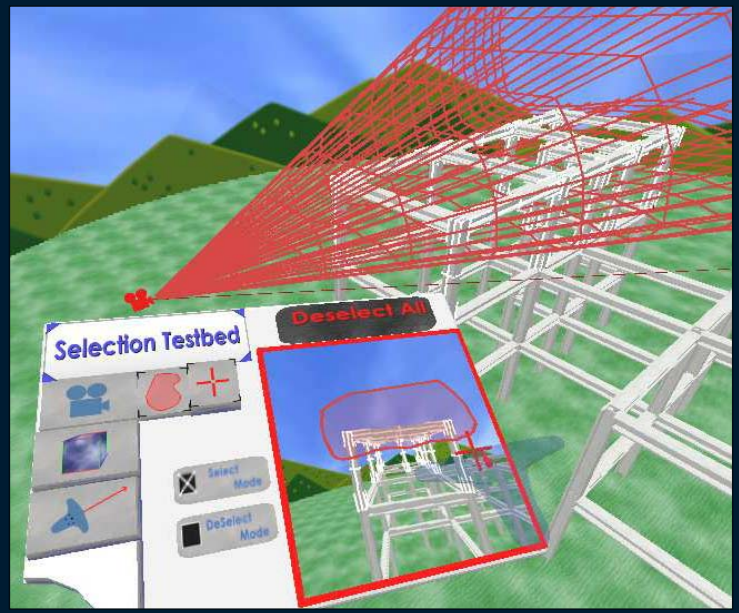

[Lucas & Bowman, 2005]

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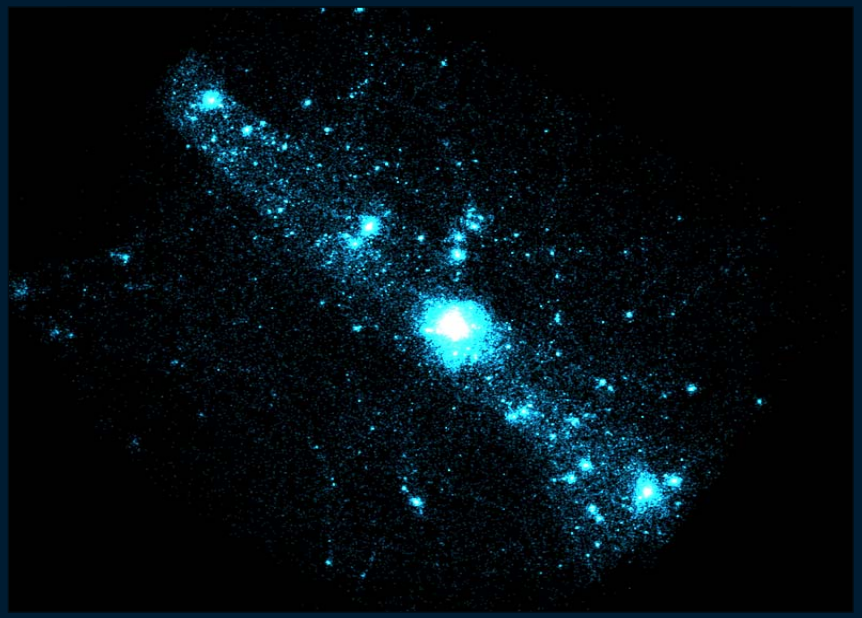

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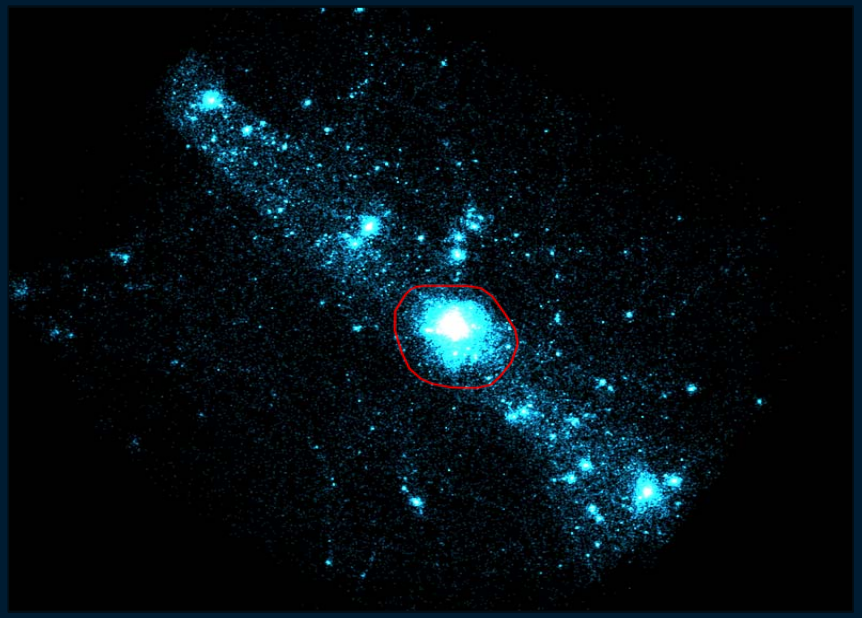

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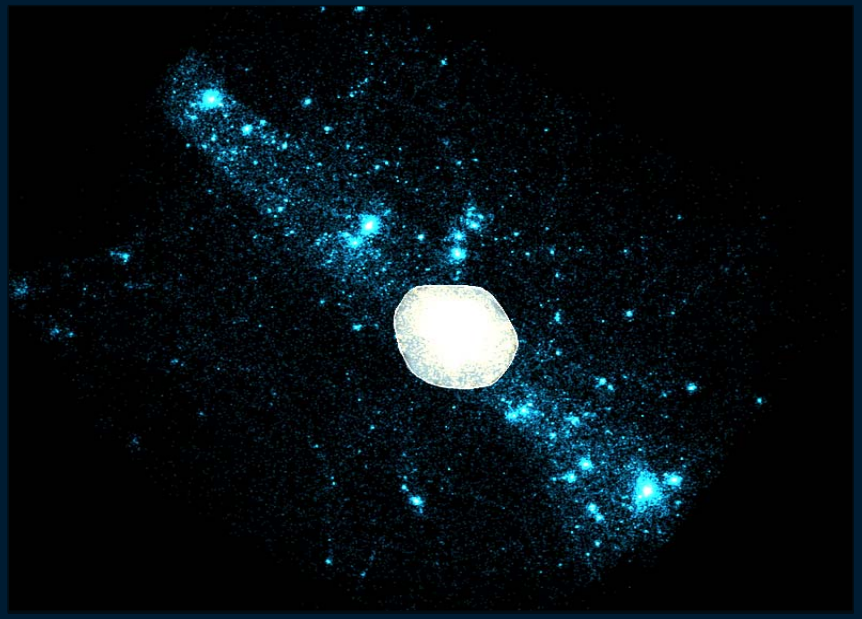

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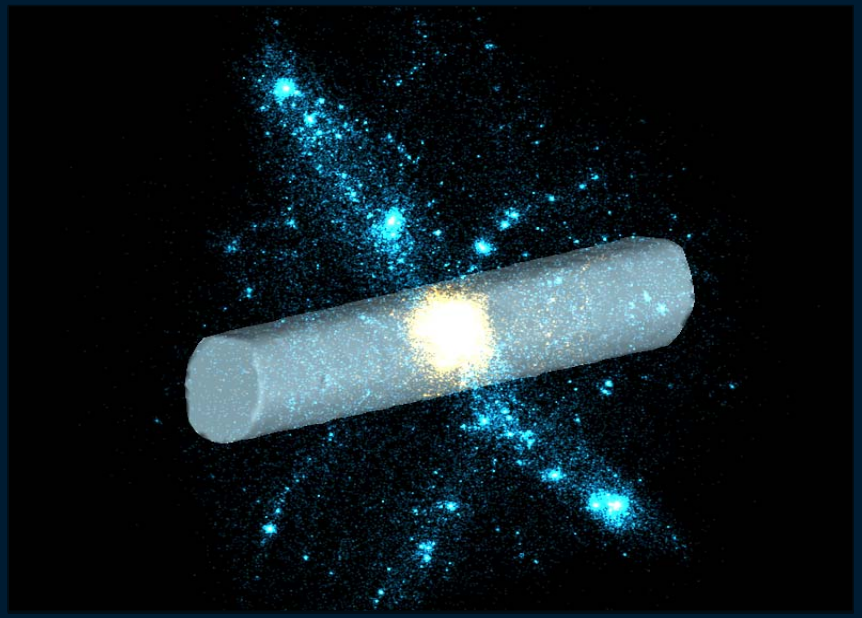

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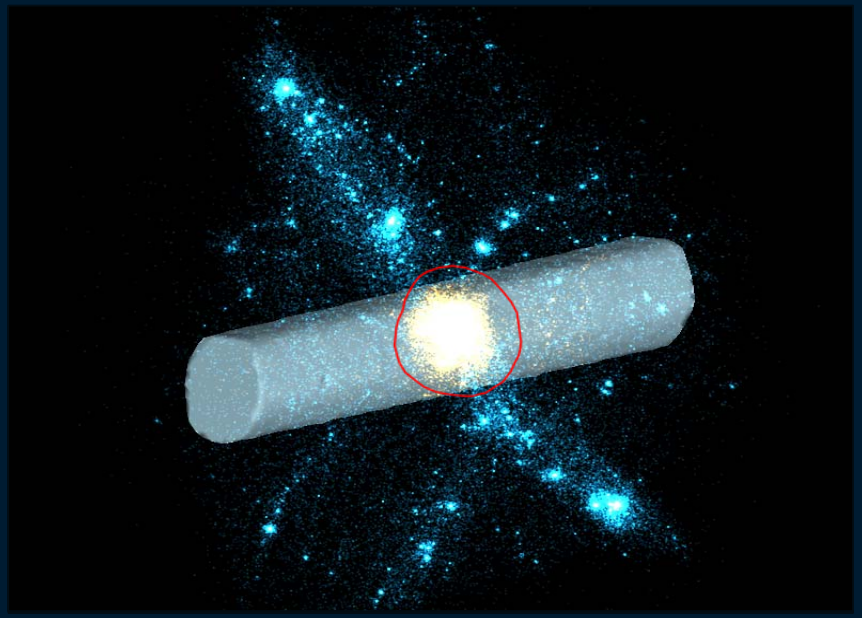

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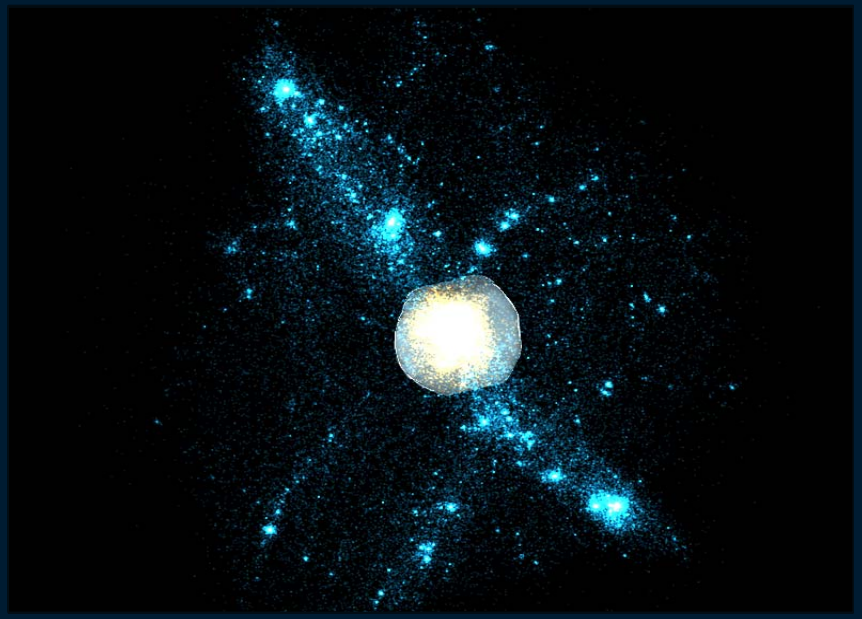

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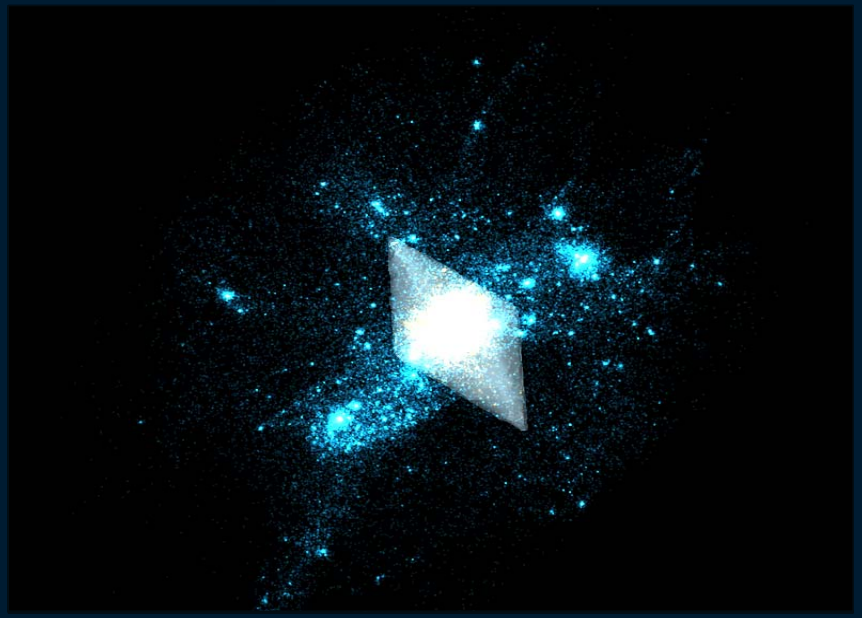

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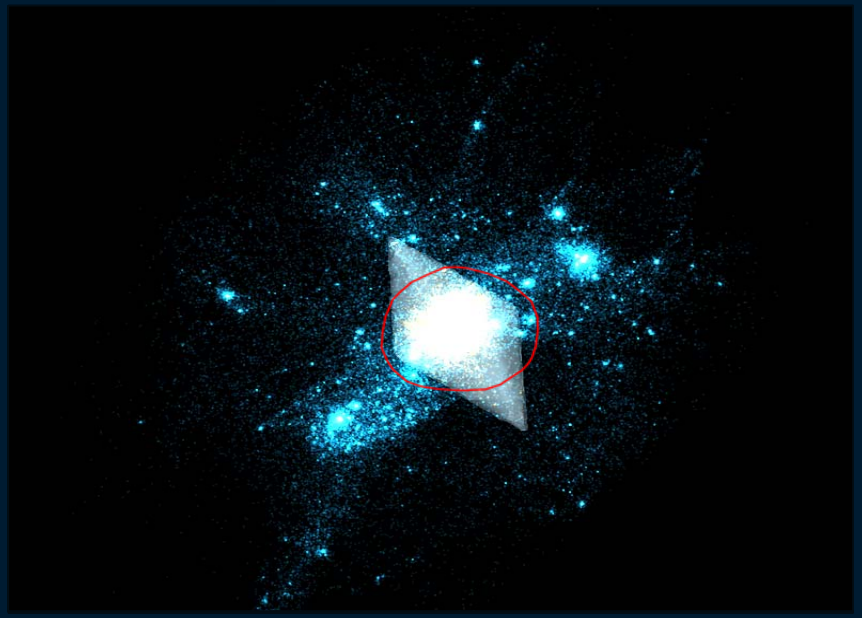

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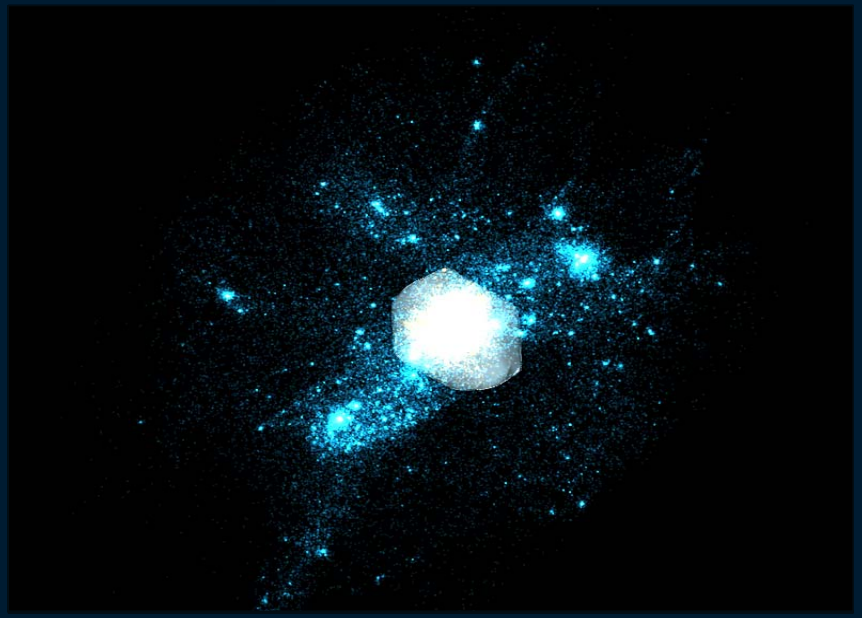

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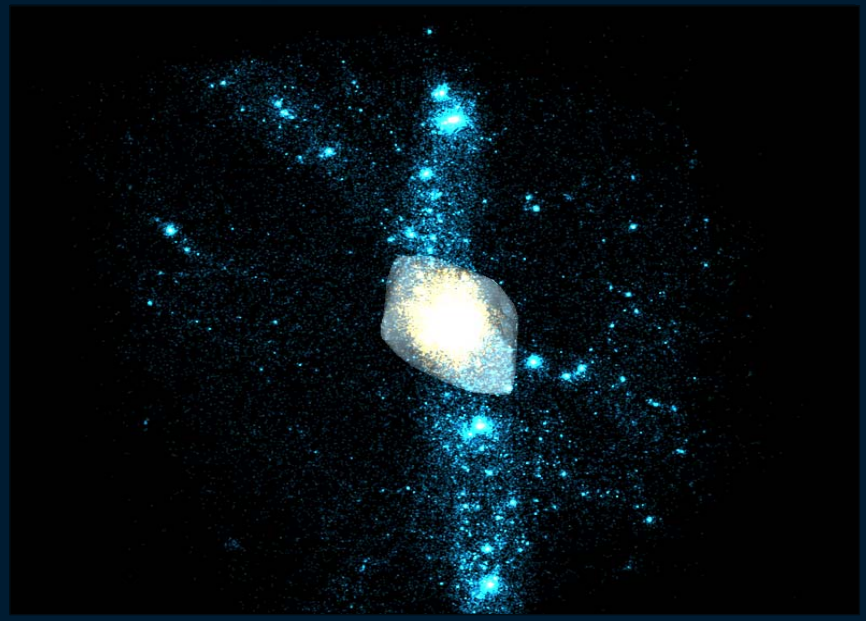

CloudLasso

- ***spatial***, ***structure-aware*** 3D selection techniques
- ***2D lasso*** interaction:
  - particle density or the scalar properties of volume data
  - Select all dense clusters through the 3D space that is enclosed by the drawn lasso
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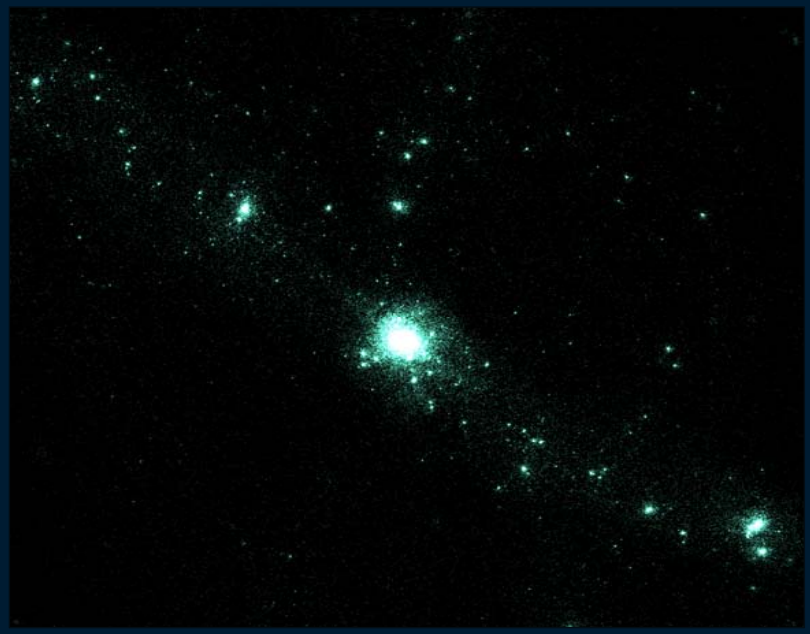

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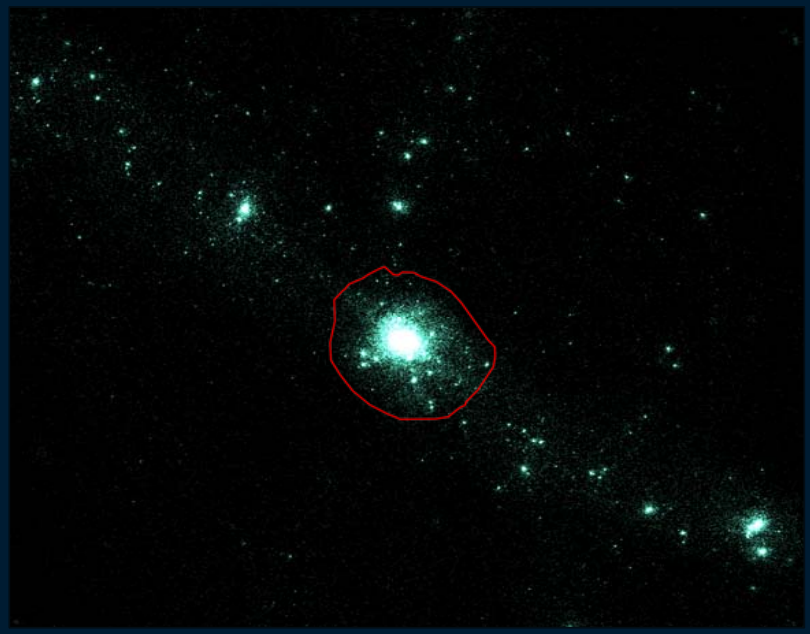

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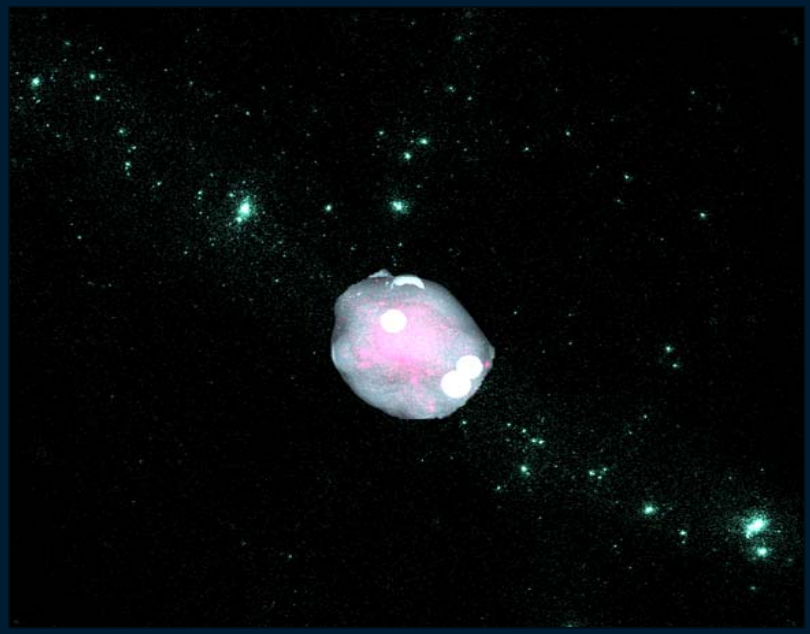

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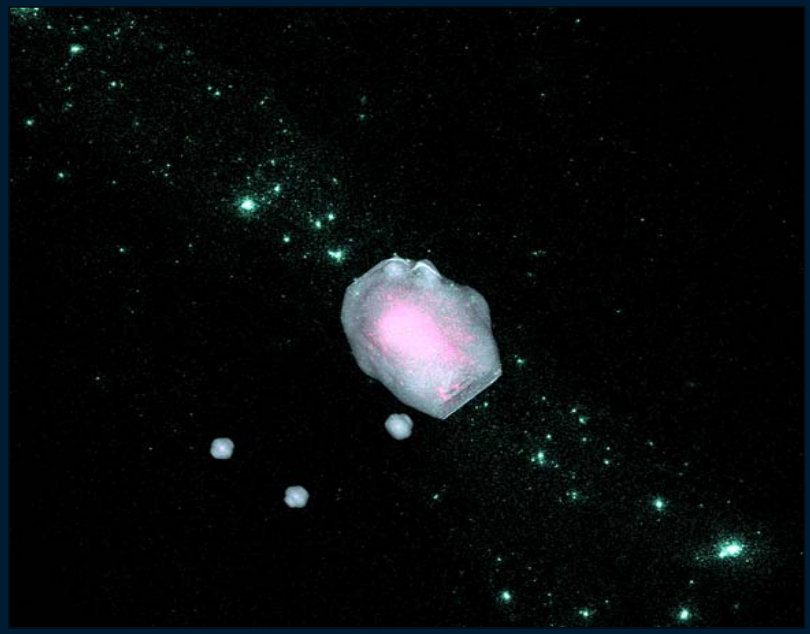

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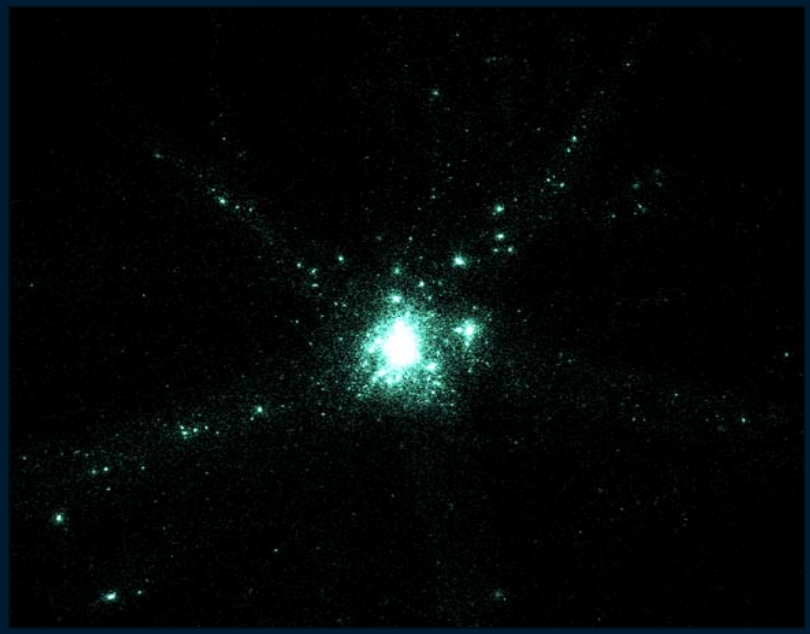

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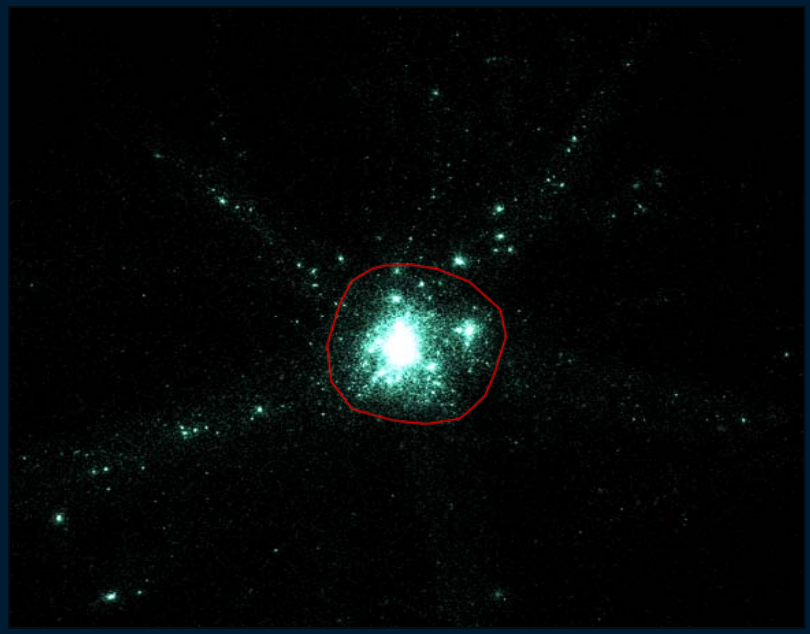

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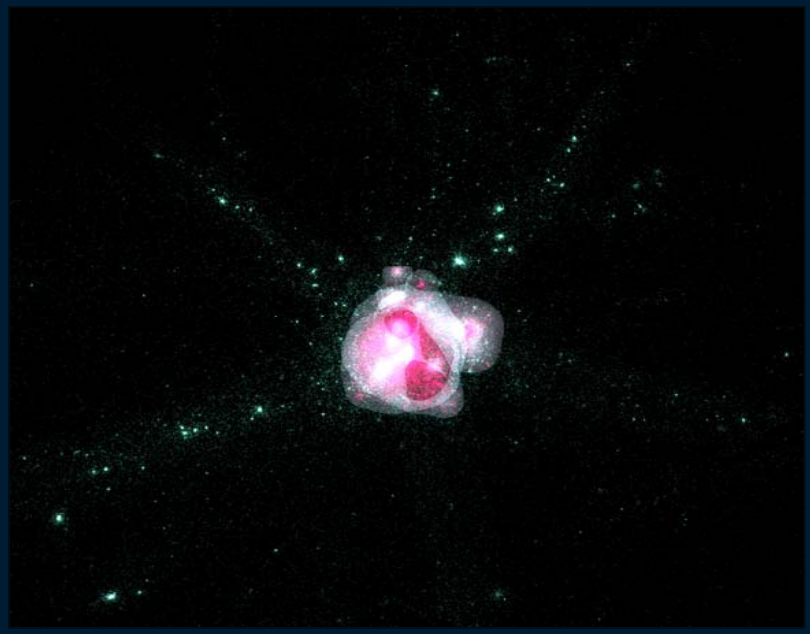

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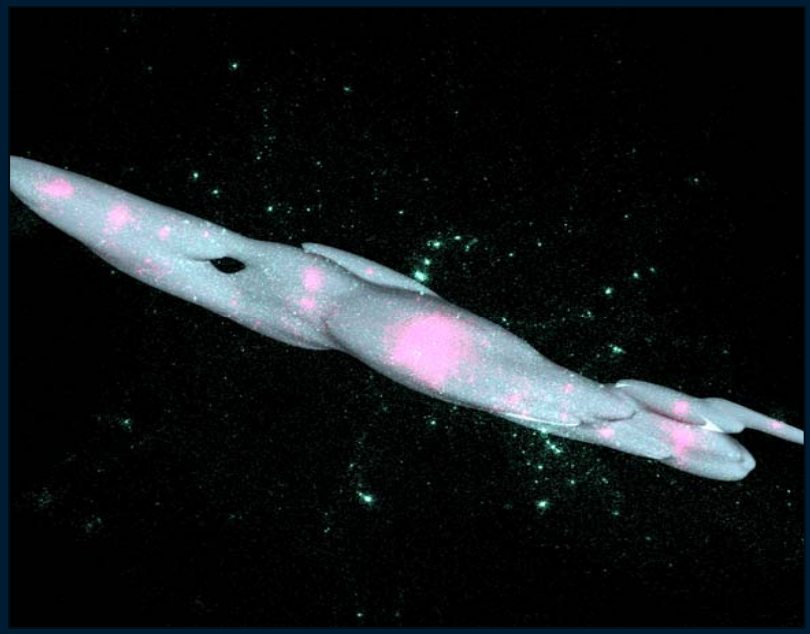

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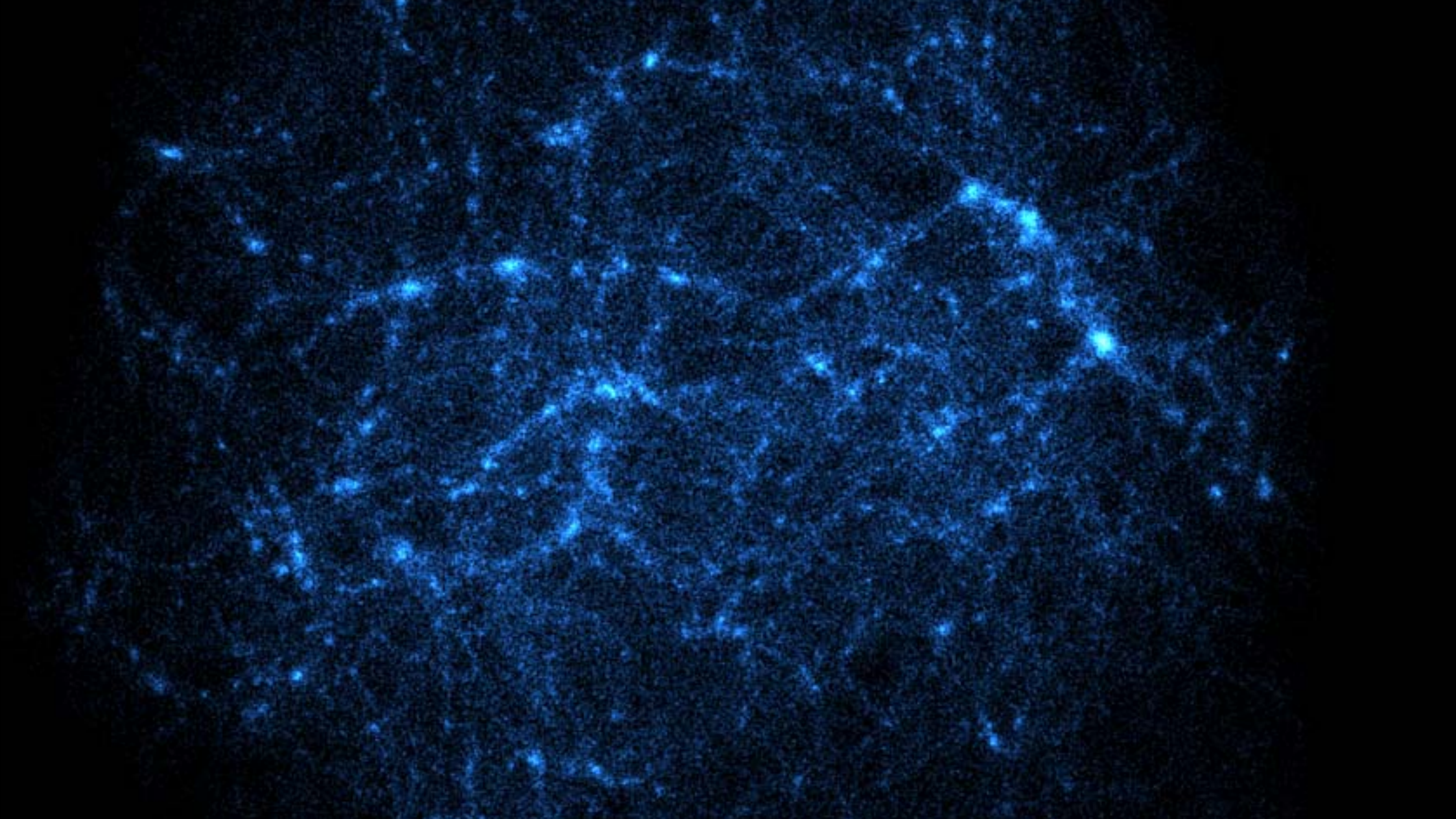
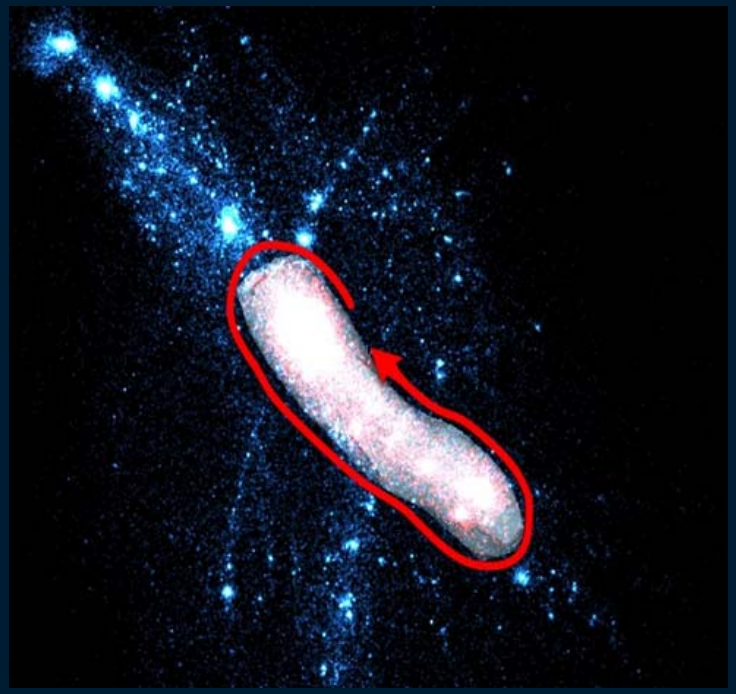


Cast

- ***spatial, context-aware*** selection techniques
  - input : 2D lasso / point
  - location or shape
  - output: ***intended*** 3D selection



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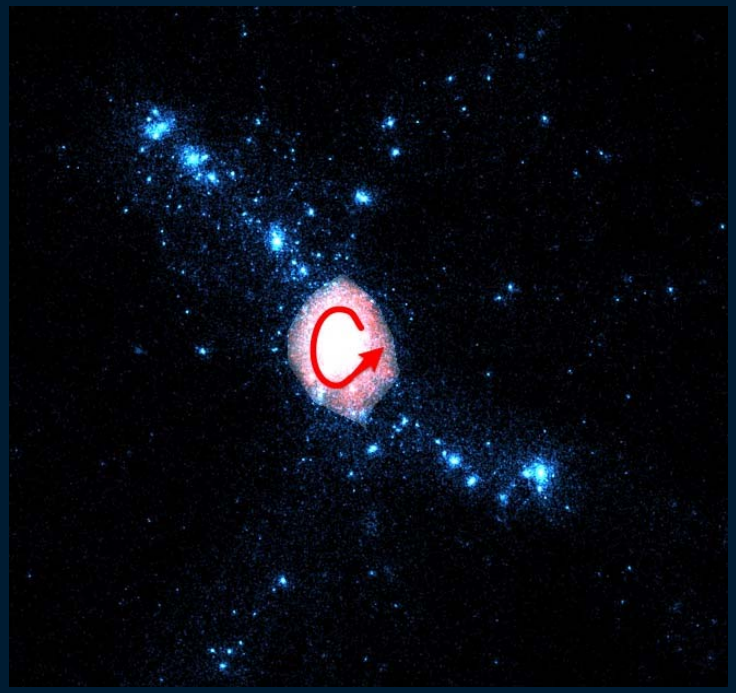

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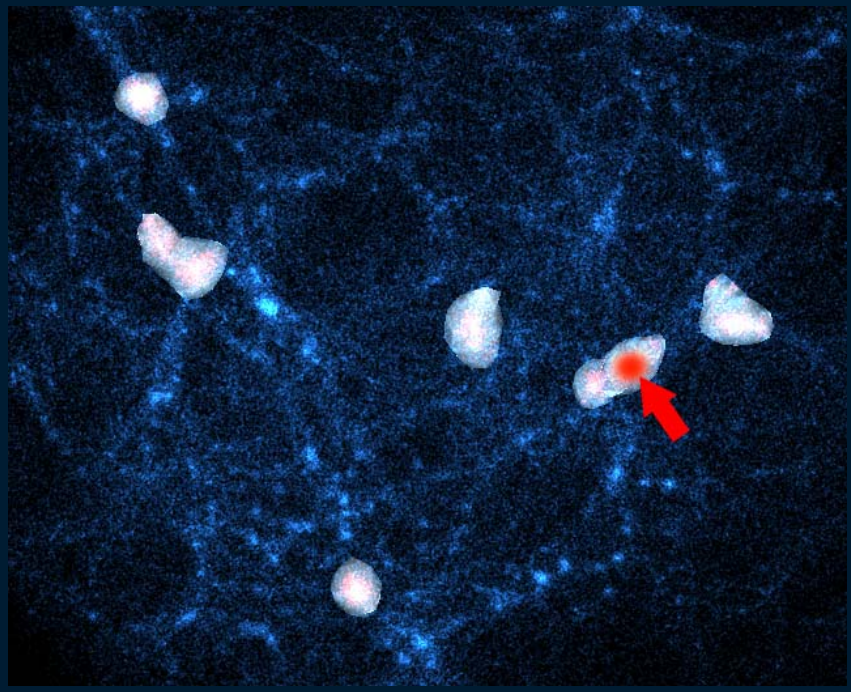
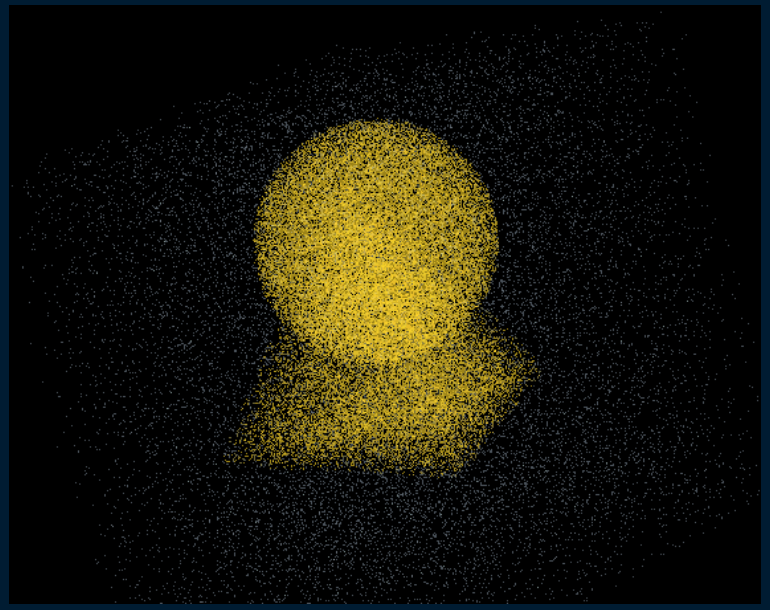


PointCast

SpaceCast

- selecting only the part that has the best overlap with the input lasso.



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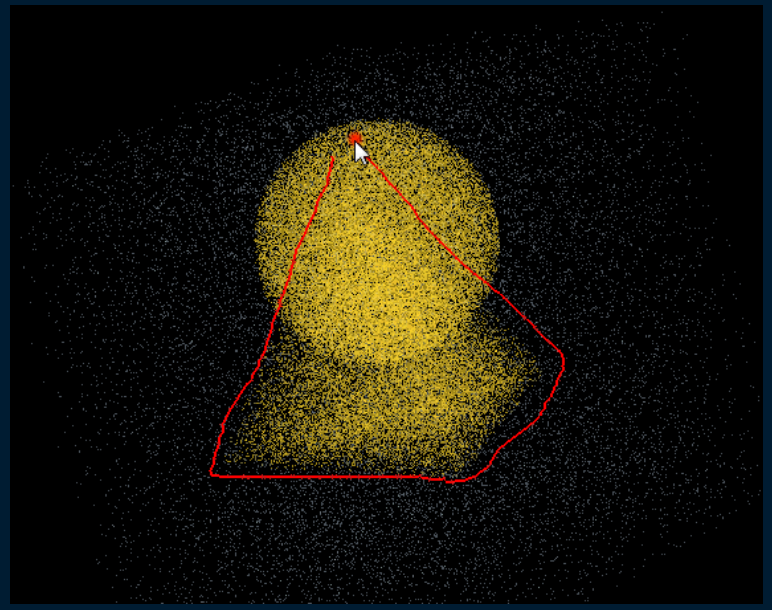

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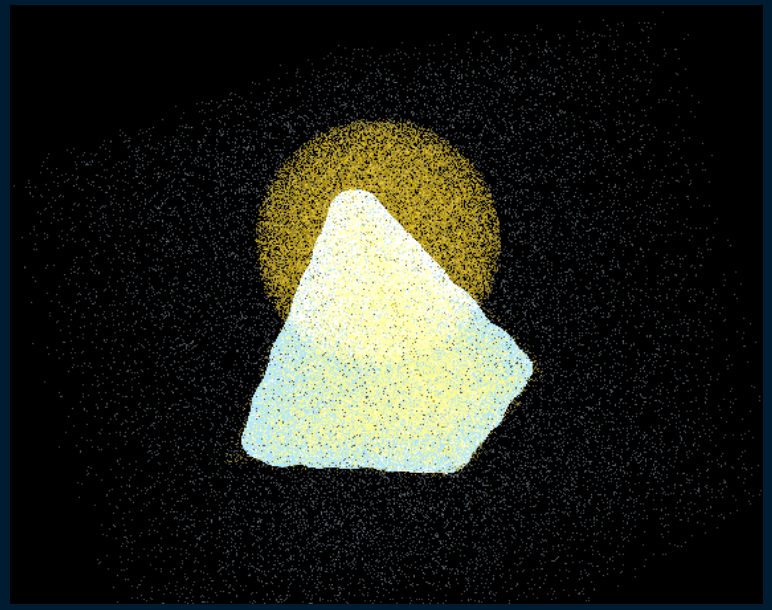

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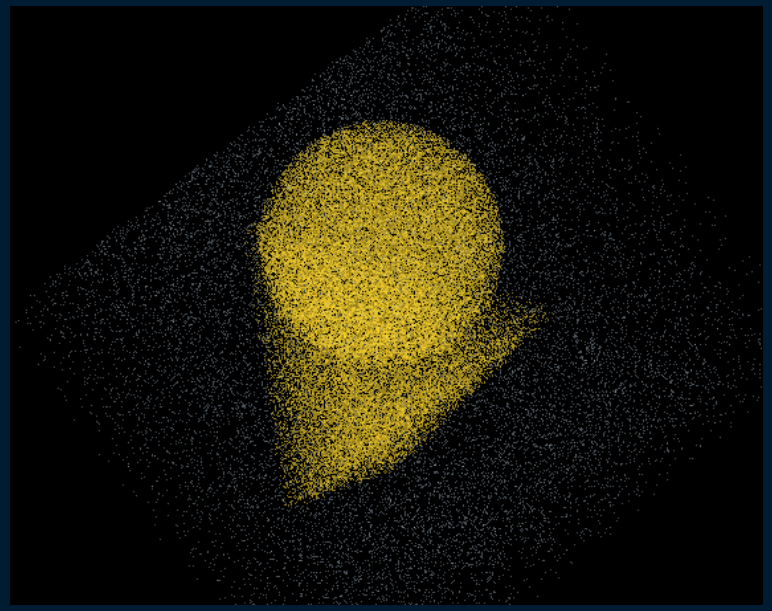

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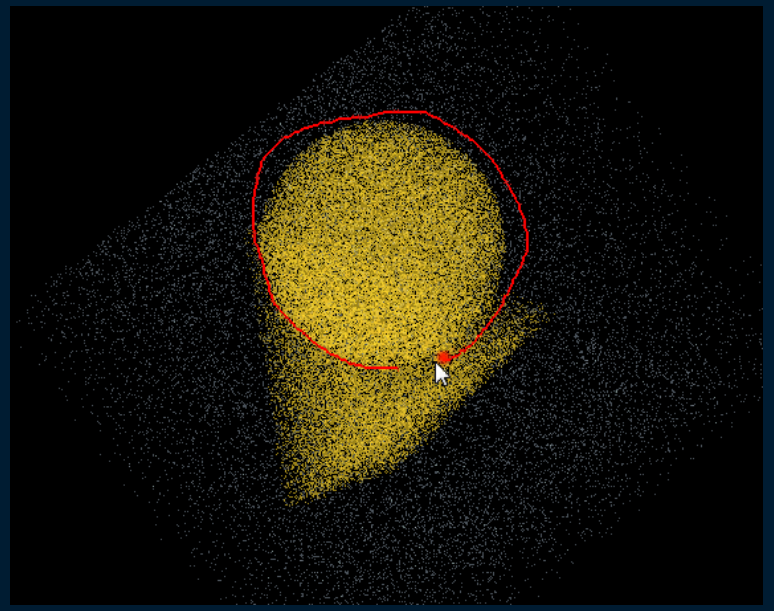

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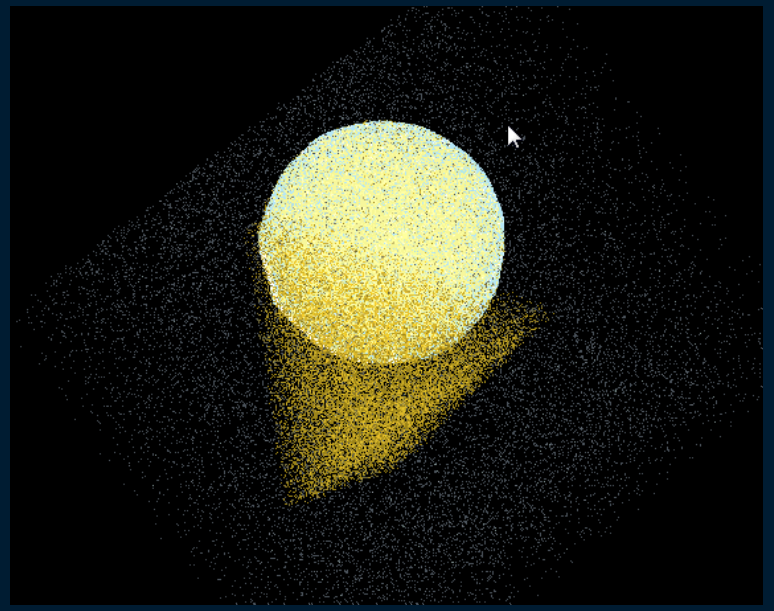

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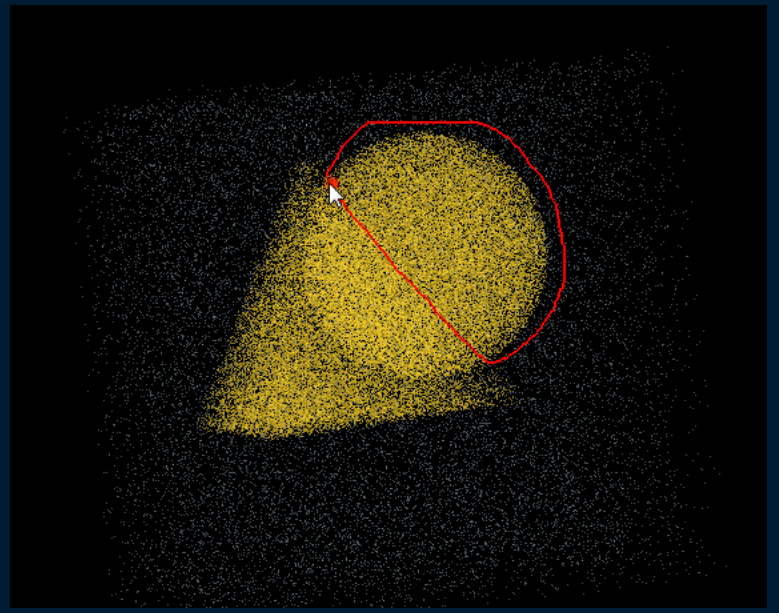

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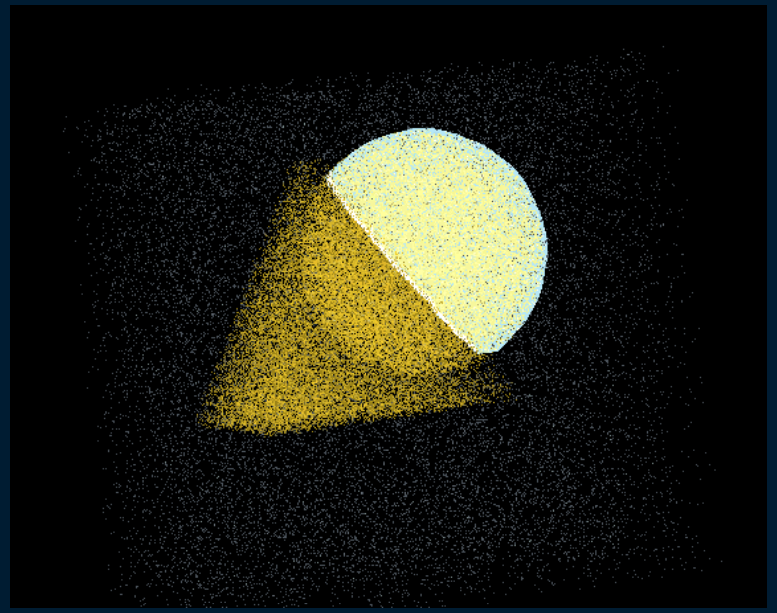

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TraceCast

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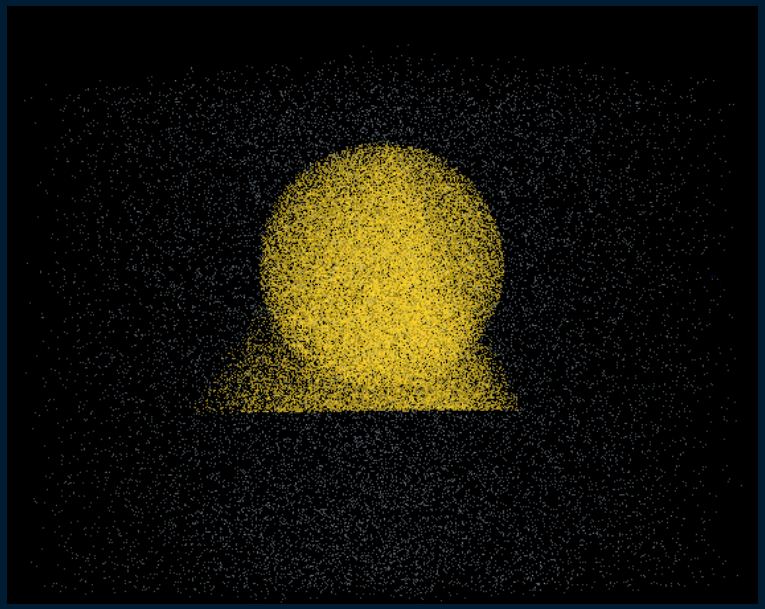

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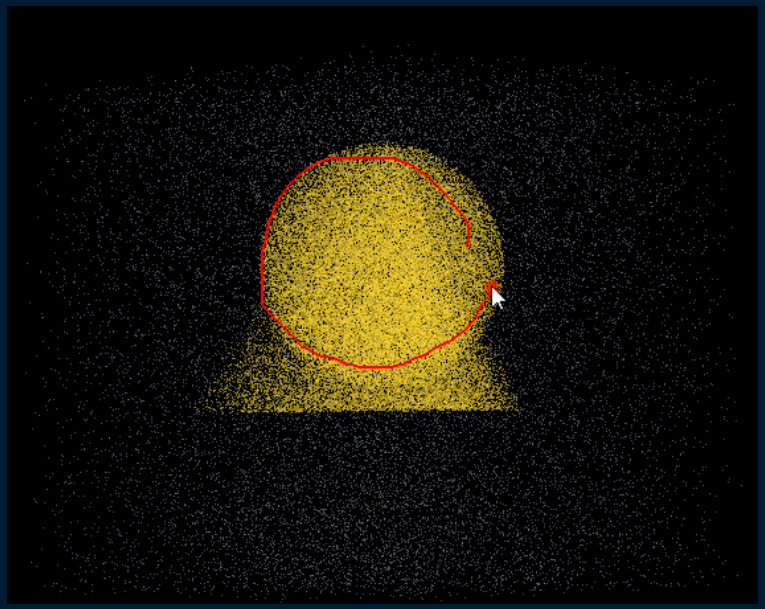

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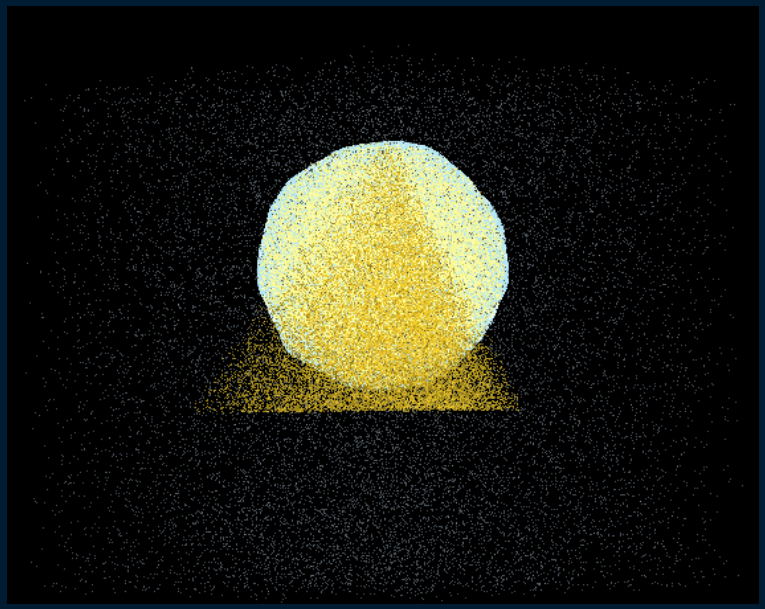

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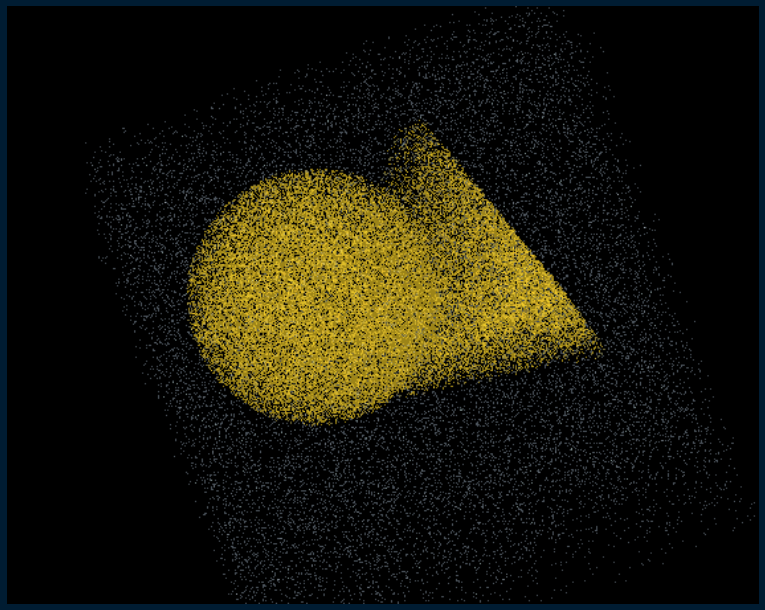

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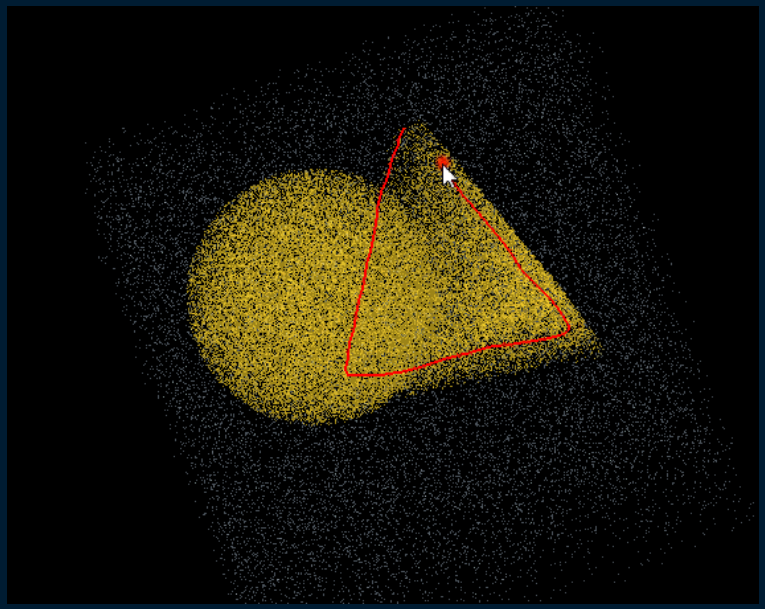

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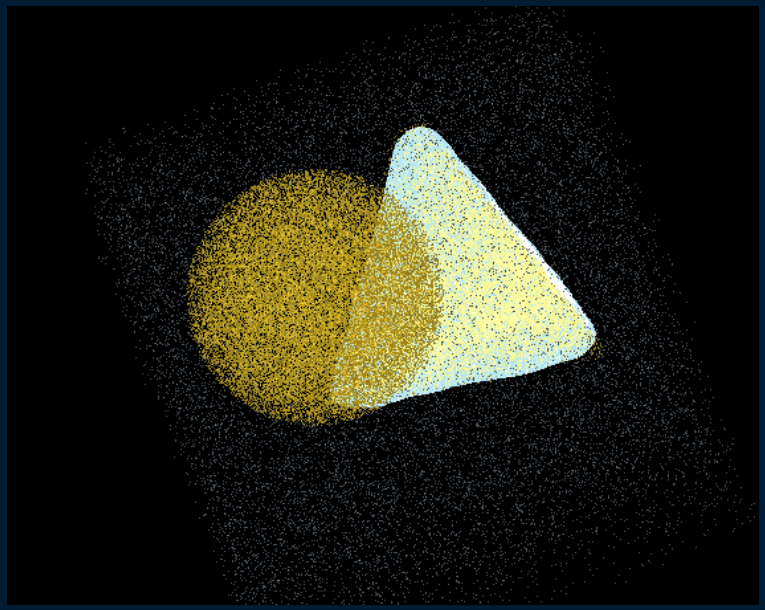

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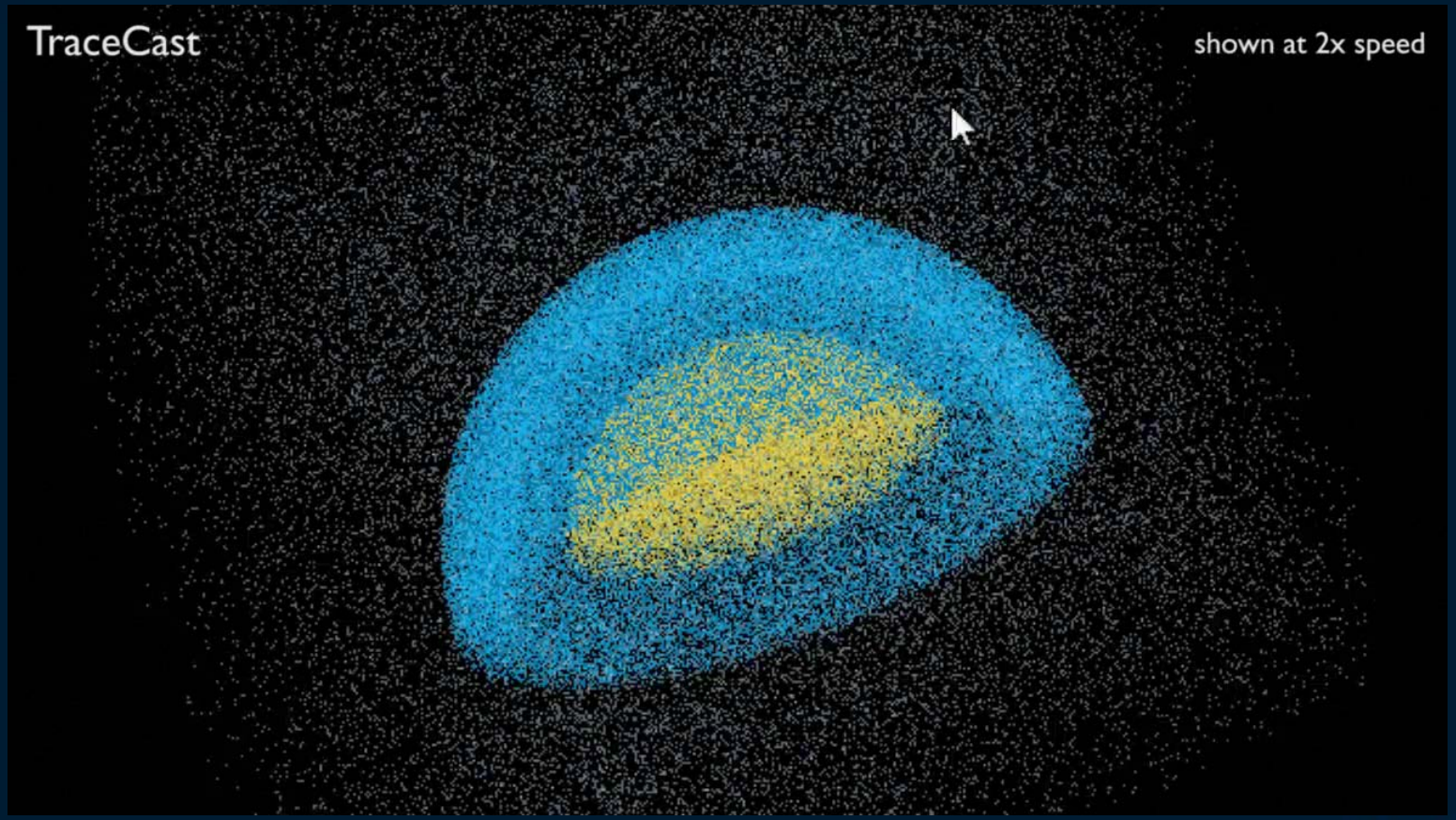

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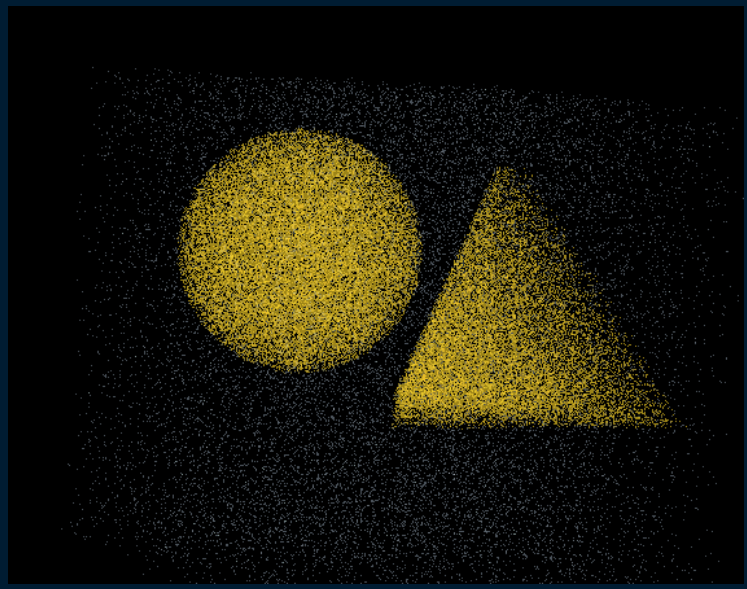
PointCast

- a single click or touch action to mark a cluster



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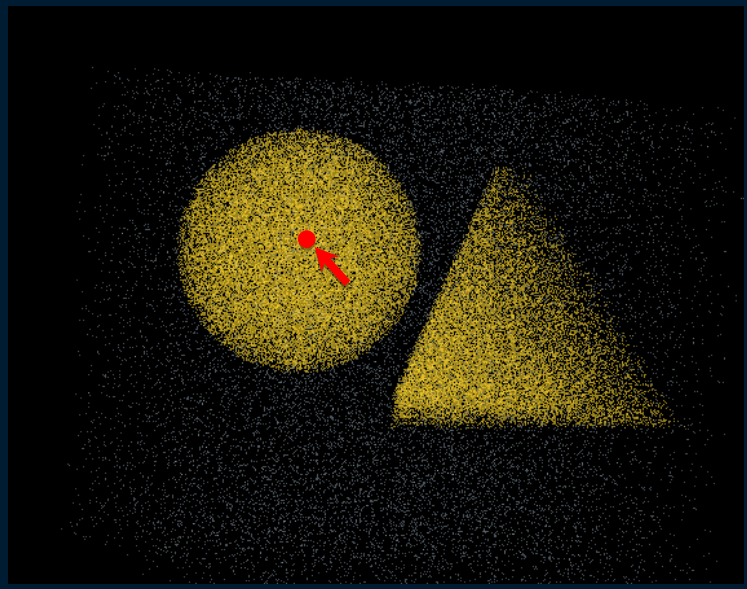

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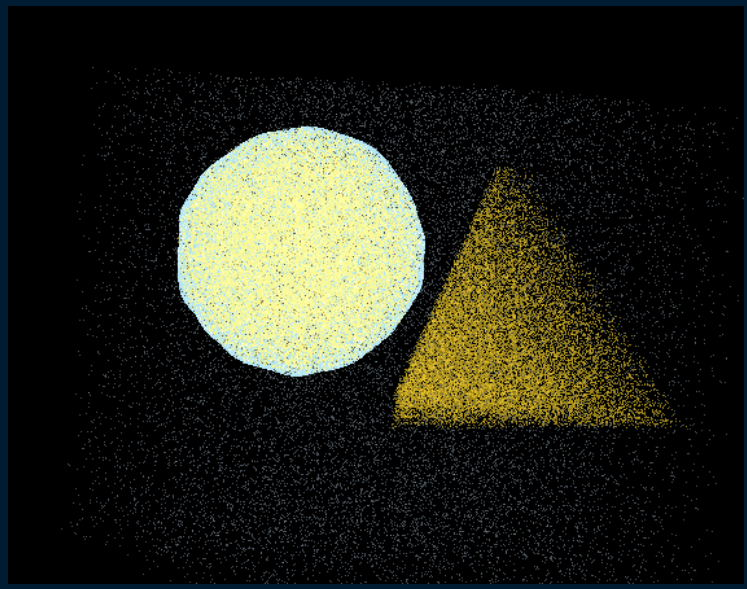

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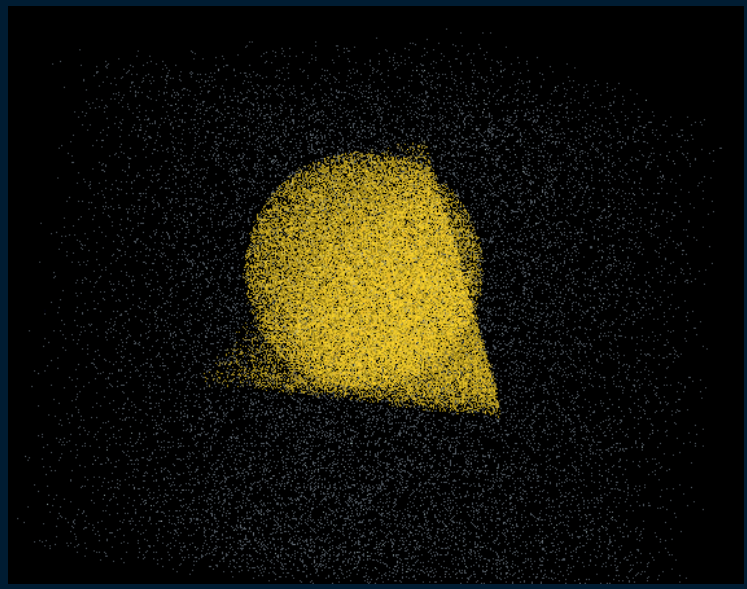

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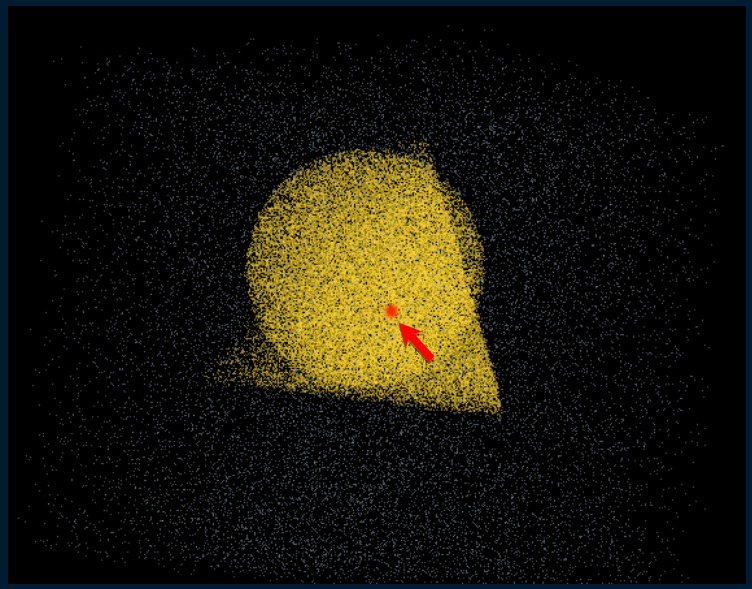

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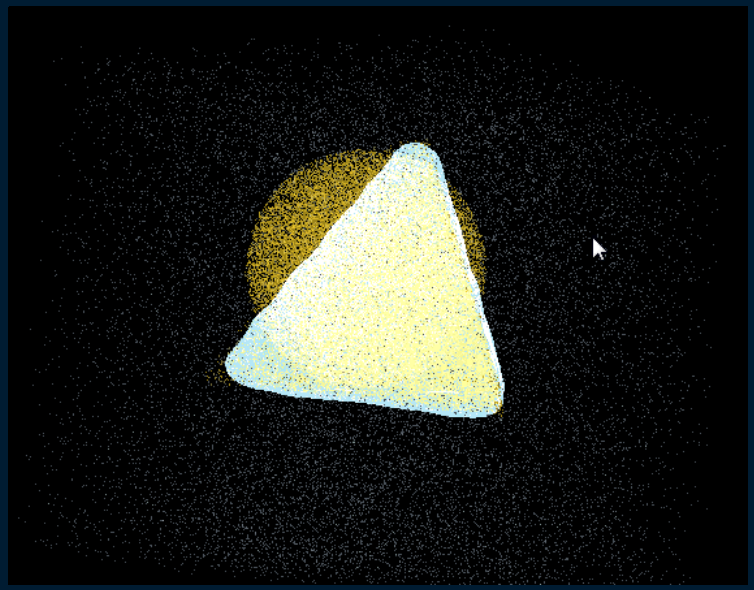

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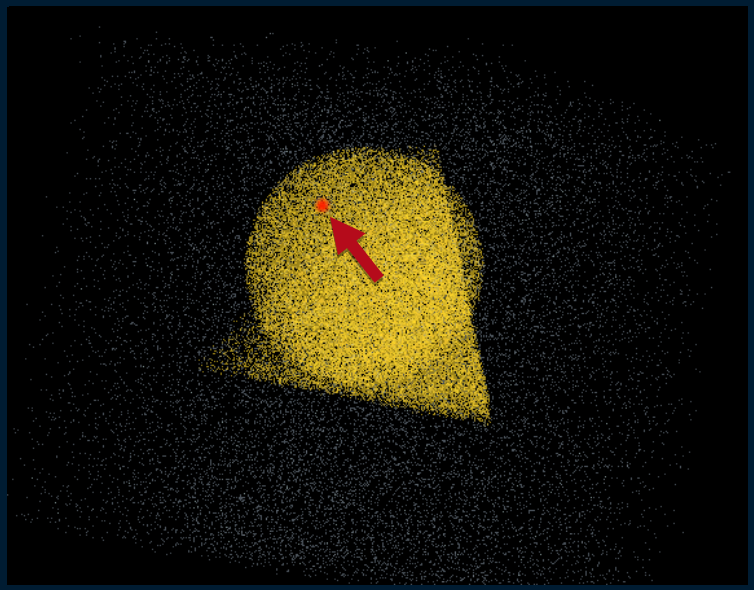

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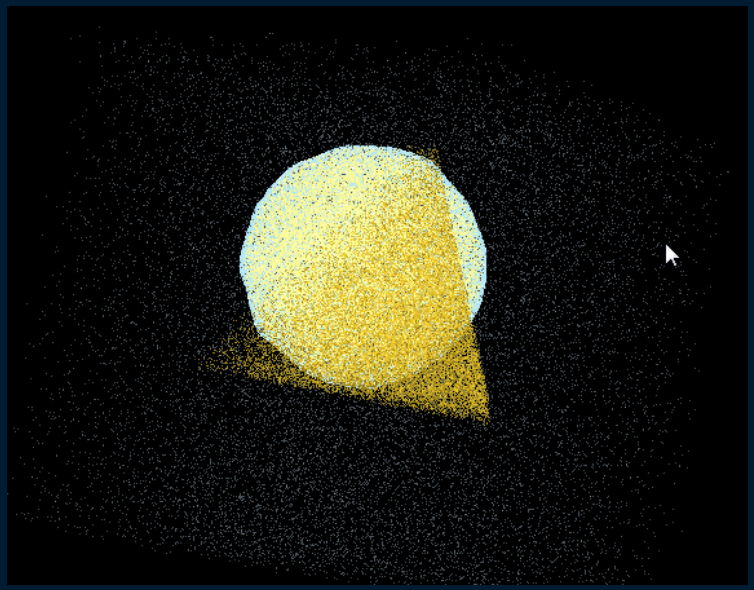
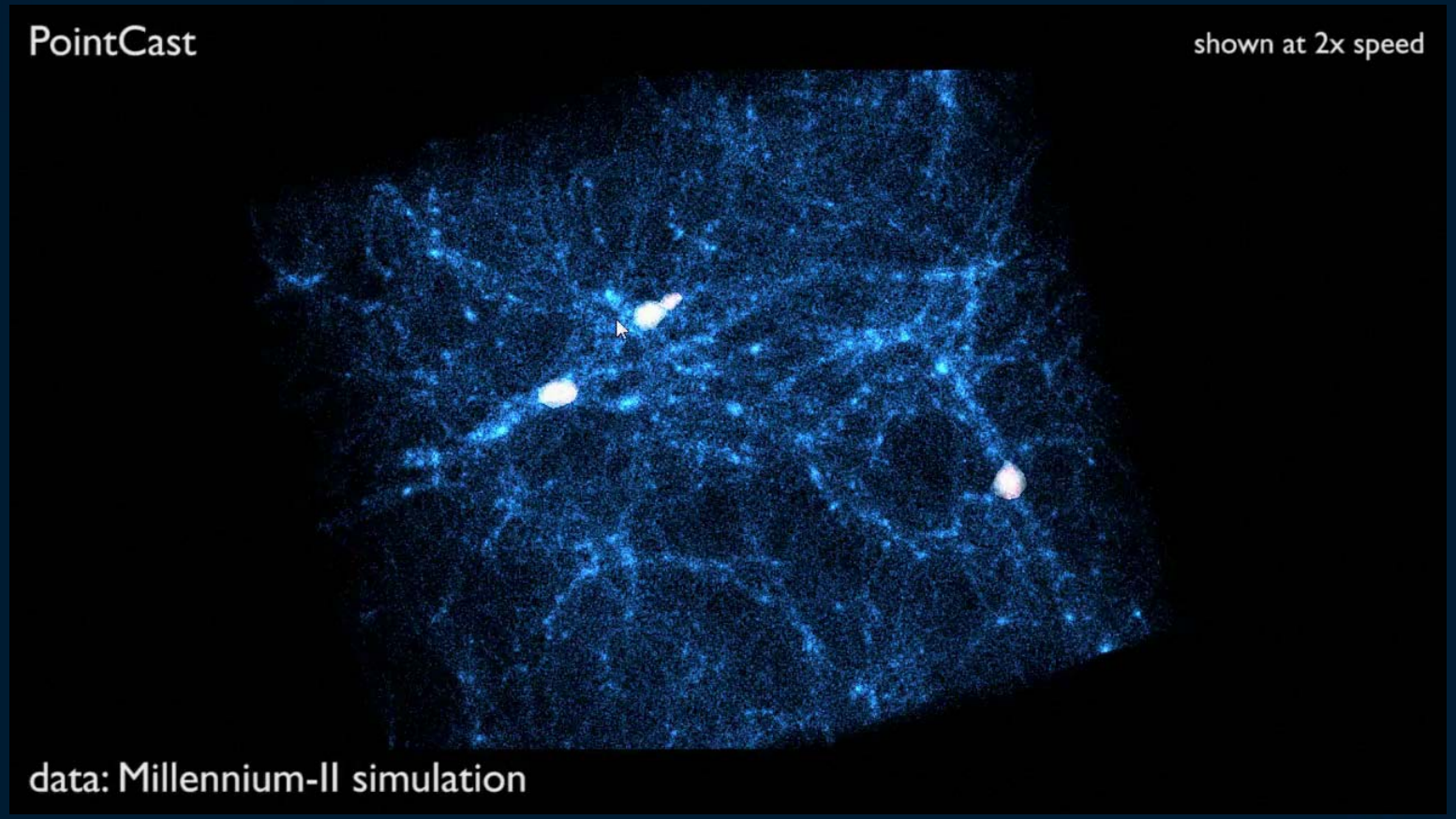


PointCast

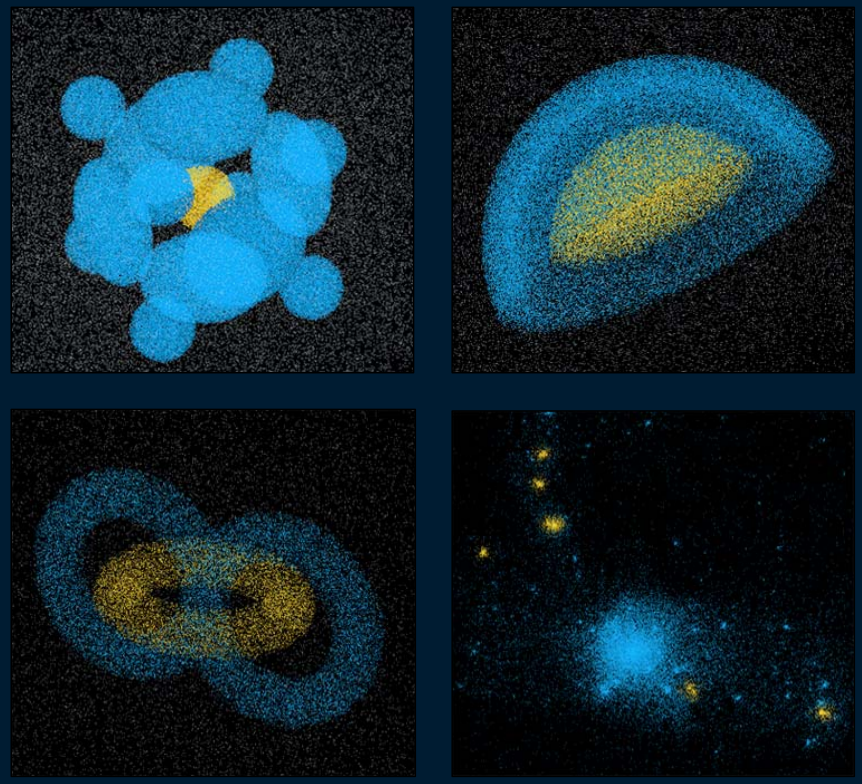


Evaluation & Validation: User Study

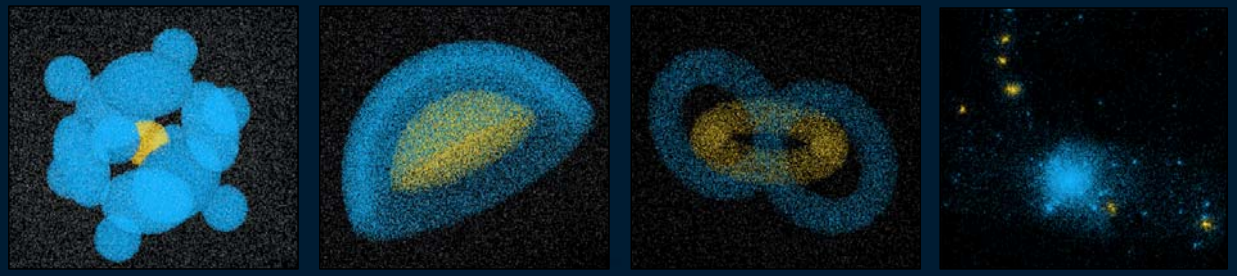
- quantitative study to confirm
- compare five selection methods
  - CylinderSelection (Tablet Freehand Lasso)
  - CloudLasso (best results)
  - three Cast members
- trackball rotation
- undo/redo
- density threshold slider
- boolean operations possible:
  - union (+): same technique
  - intersection (∩) and subtraction (−): CylinderSelection

Study Design

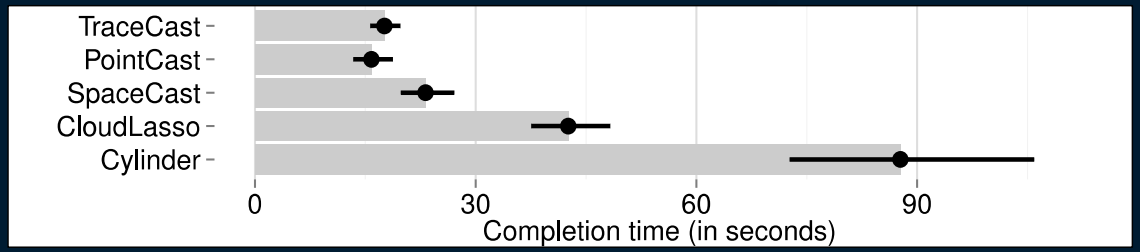
- 20 participants (6 female)
- 4 selection tasks (datasets)
- measurement of **time** and **error**
- questionnaire for subjective opinion



Study Results

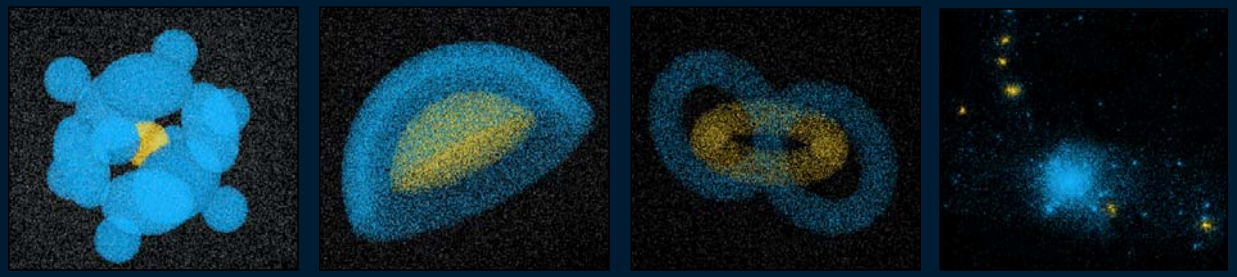


- Cast techniques were much faster than CylinderSelection and CloudLasso.
  - both PointCast and TraceCast outperform SpaceCast
  - some indication that PointCast may outperform TraceCast



- all five techniques got very accurate results.
- PointCast and TraceCast were the preferred techniques.

Study Results



- Cast techniques were much faster than CylinderSelection and CloudLasso.
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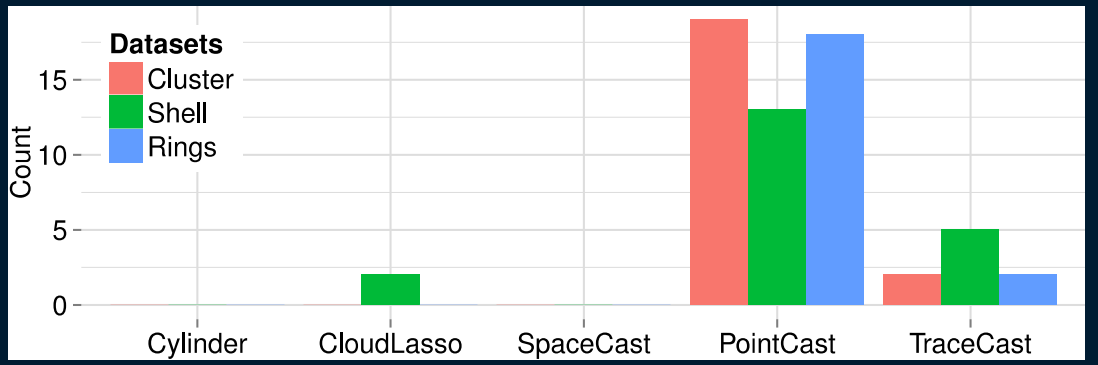
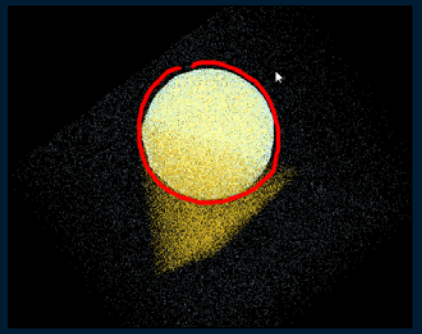


- all five techniques got very accurate results.
- PointCast and TraceCast were the preferred techniques.

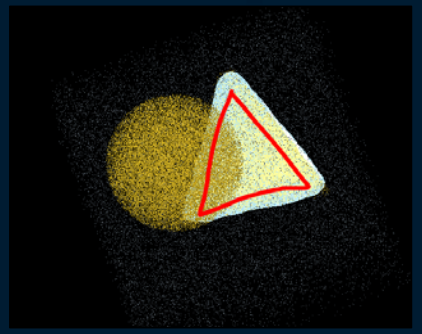
Recap

CylinderSelection

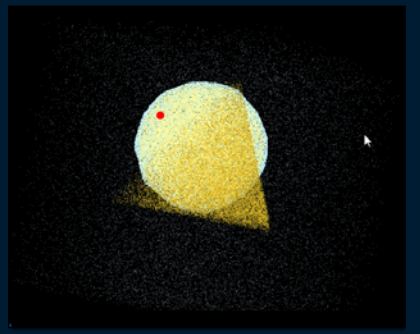
CloudLasso



SpaceCast



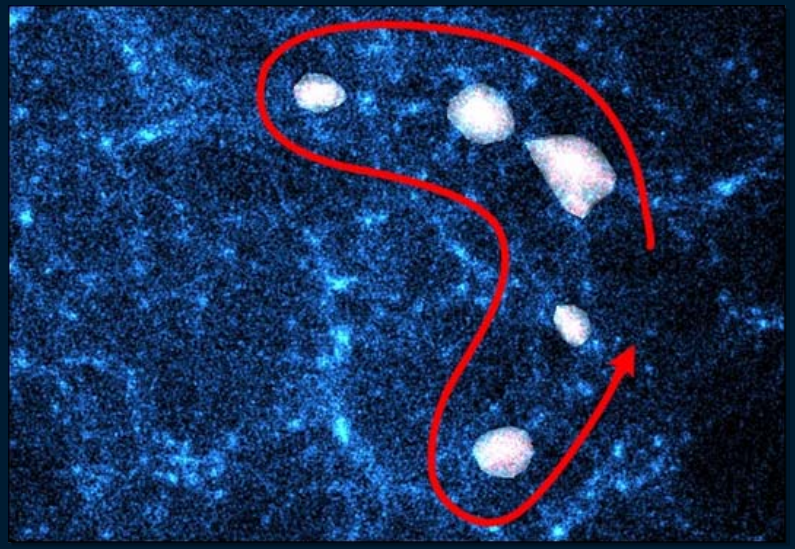
TraceCast



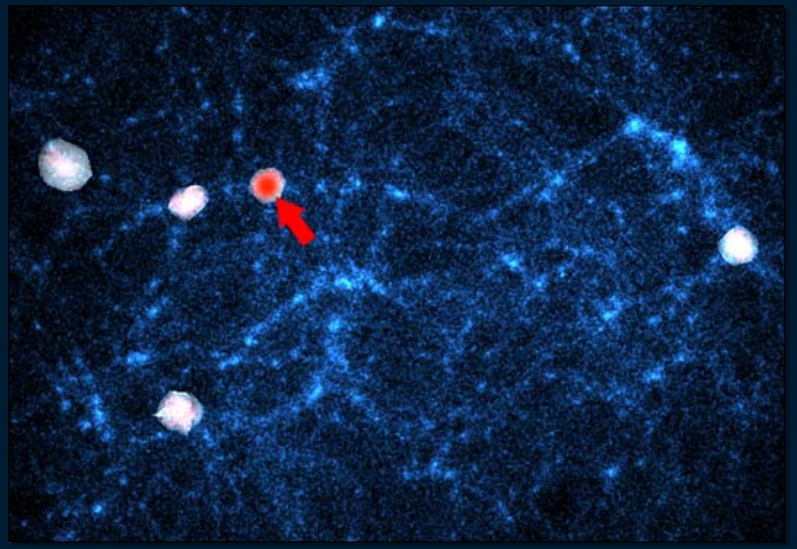
PointCast

Discussion - Selection Scenarios (1)

- multiple clusters



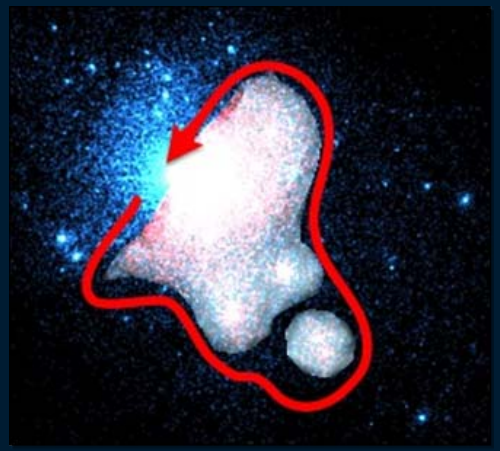
CloudLasso



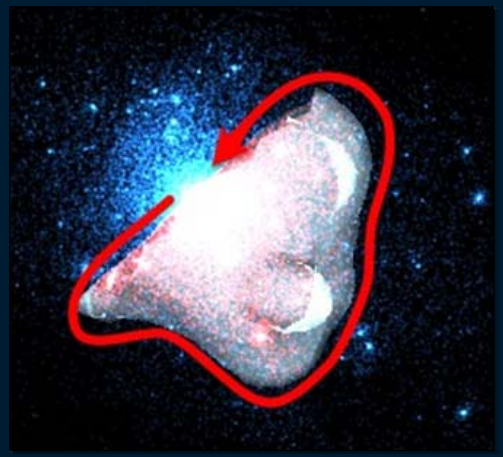
PointCast

Discussion - Selection Scenarios (2)

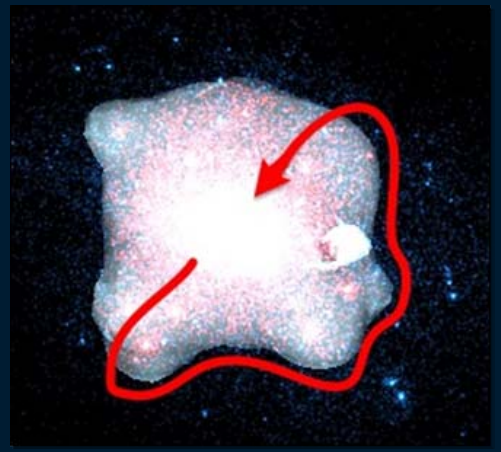
- partial selection



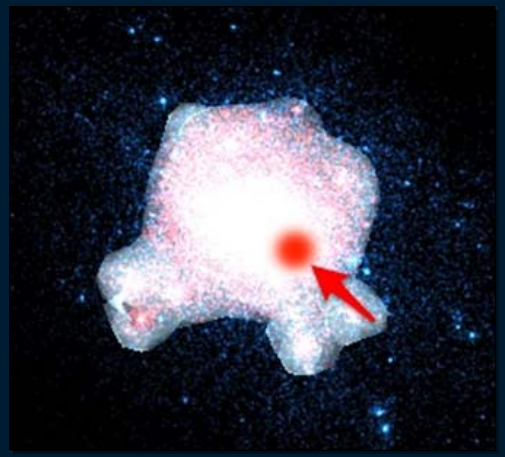
CloudLasso



SpaceCast



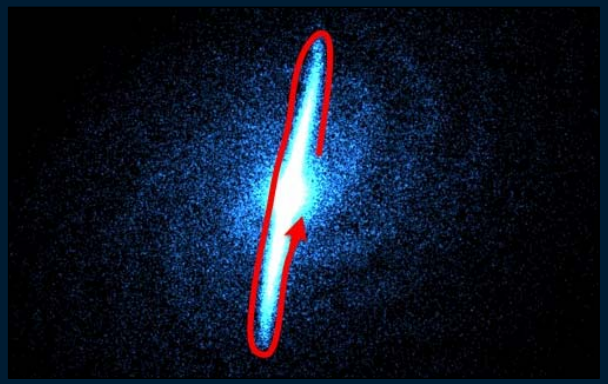
TraceCast

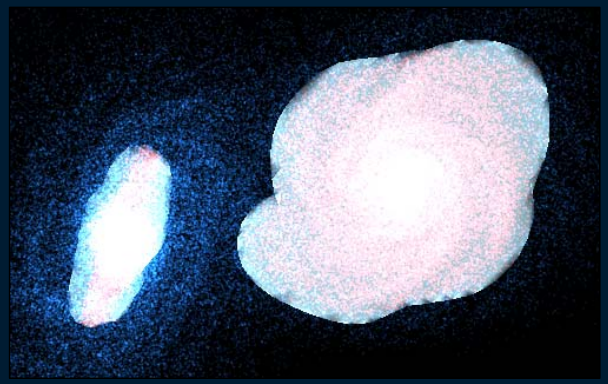


PointCast

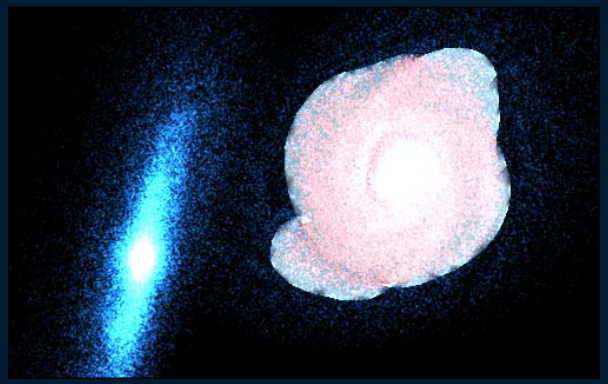
Discussion - Selection Scenarios (3)

- occlusion





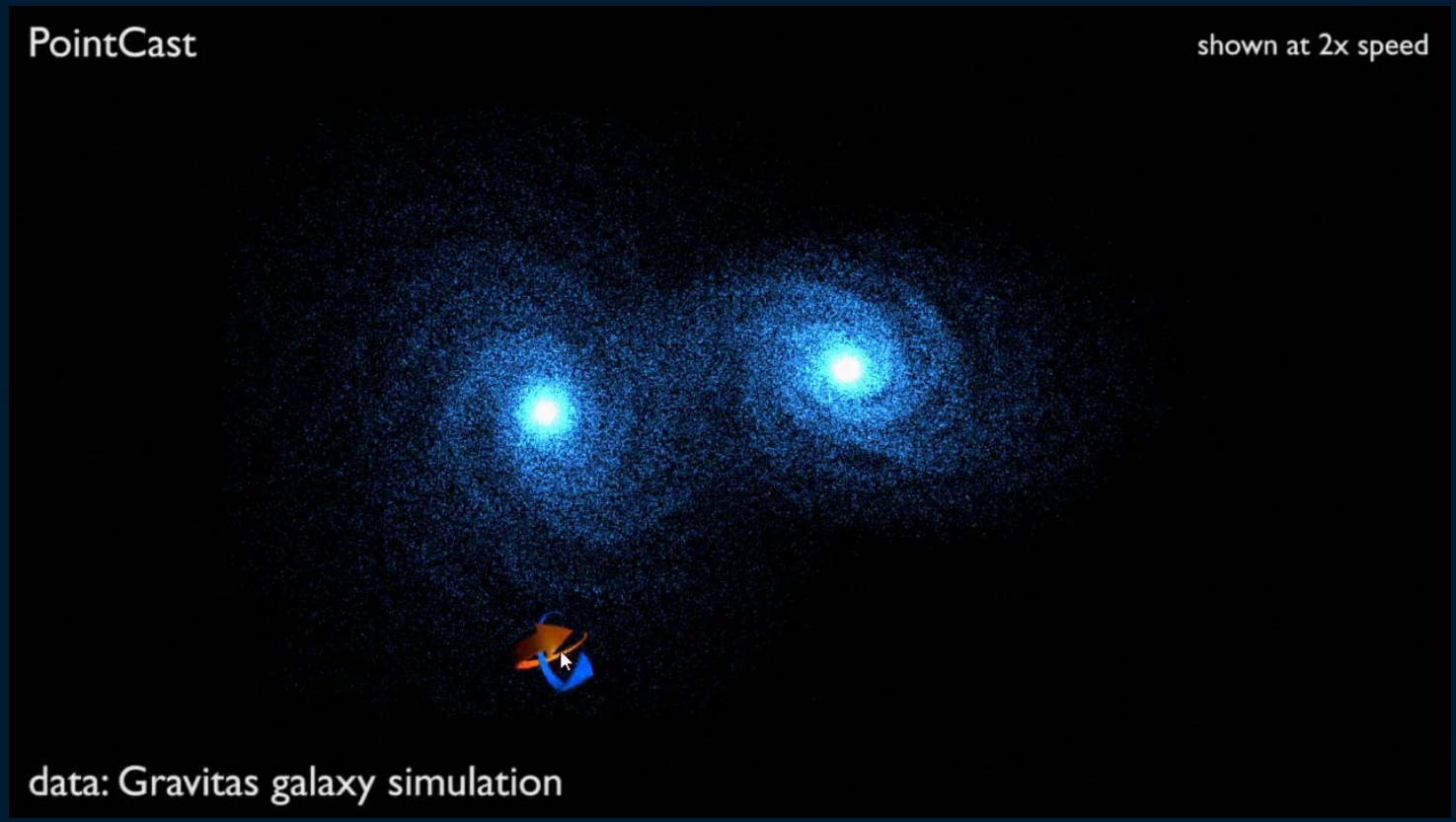
CloudLasso



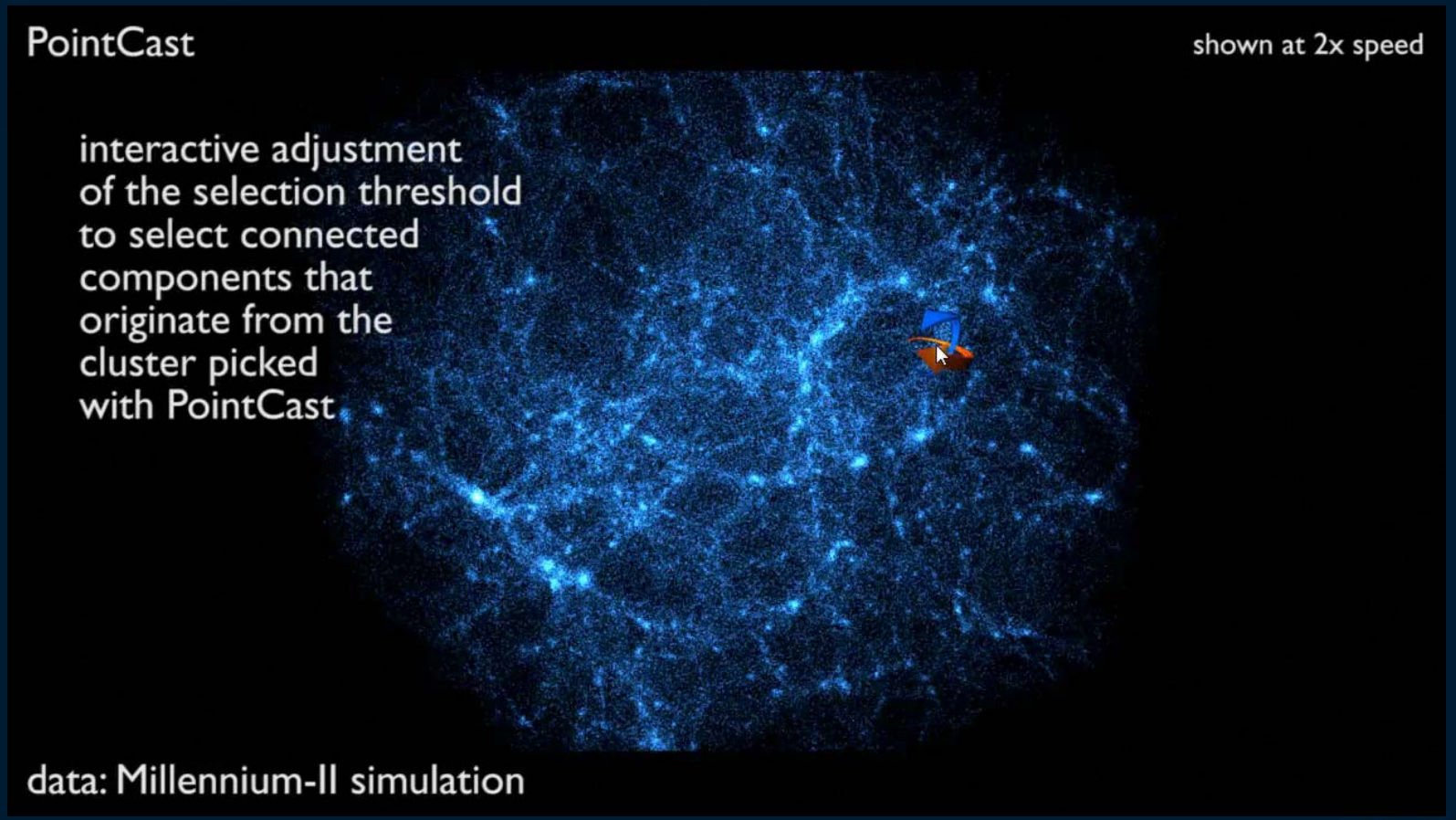
TraceCast

Discussion - Selection Scenarios (3)

- occlusion - PointCast



Structure finding



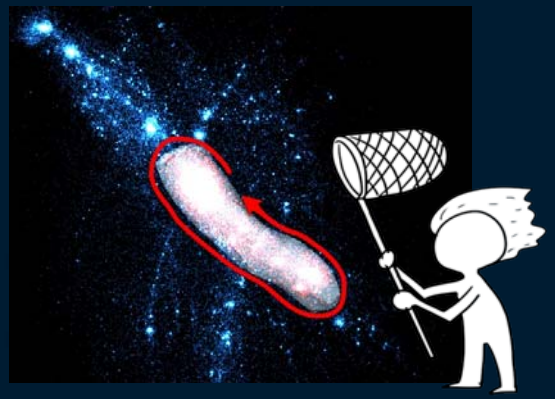
Application Domains / Future work

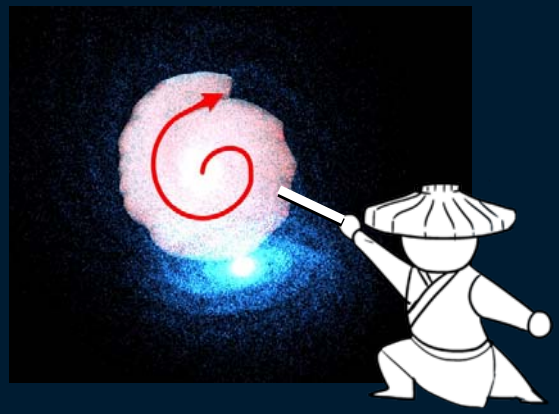
- any particle-based dataset
- use other edge-detection algorithms to determine an appropriate density isosurface
- combine different selection techniques

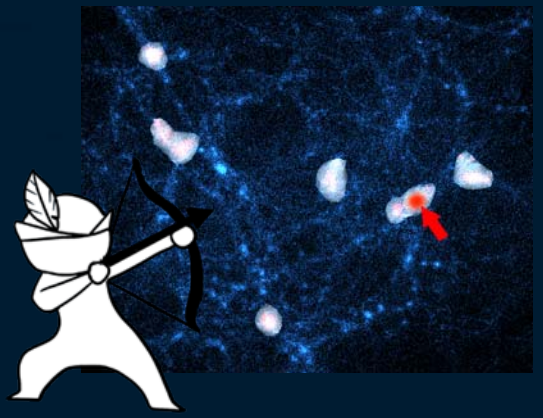
Conclusion

- Cast: a new family of context-aware interactive selection techniques
- input: lasso drawn / clicking in 2D; output: 3D space
- ***effective***: cover a wide range of possible selection goals
- ***efficient***: allow users to arrive at selections faster than standard techniques

Thank you for your attention!







Video & demo: http://yulingyun.com/projects/cast

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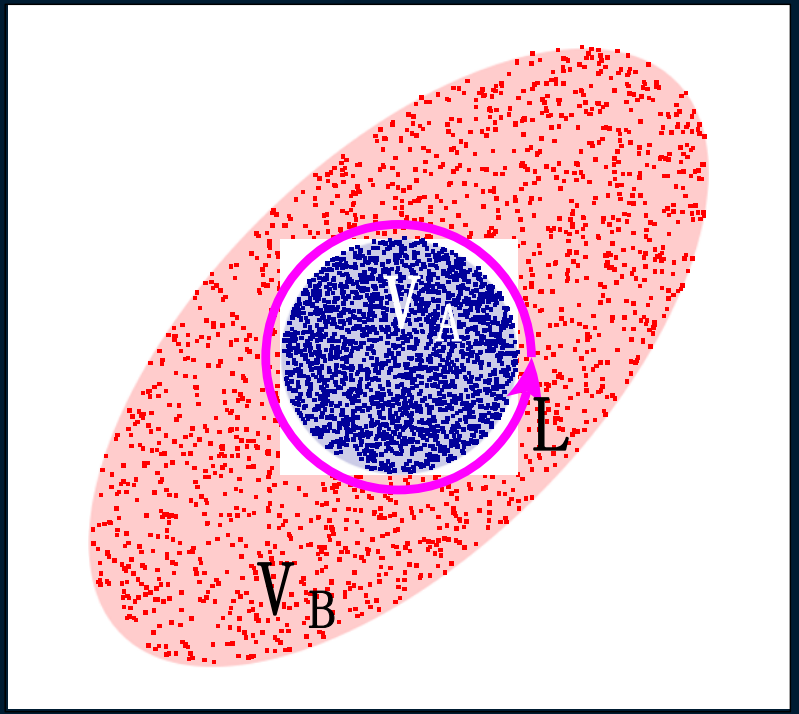
Additional Slides

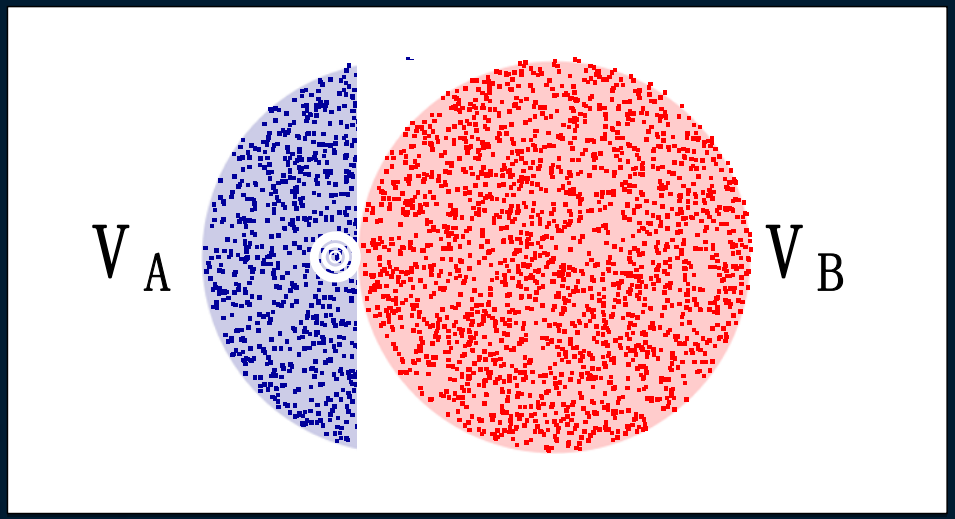
SpaceCast—Exception

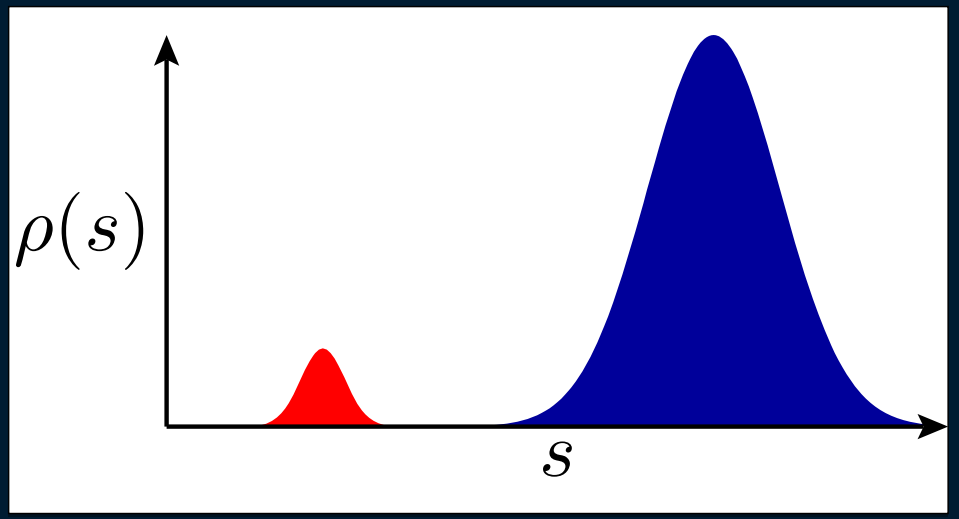
- situation:
  - V_A: small and being in the front
  - V_B: larger and being in the back
  - user intention: V_A
- user interaction:
  - $S_A < S_L$ but $S_B = S_L$
- result:
  - If $S_A > 0.8S_B$, then choose the one closest to the eye



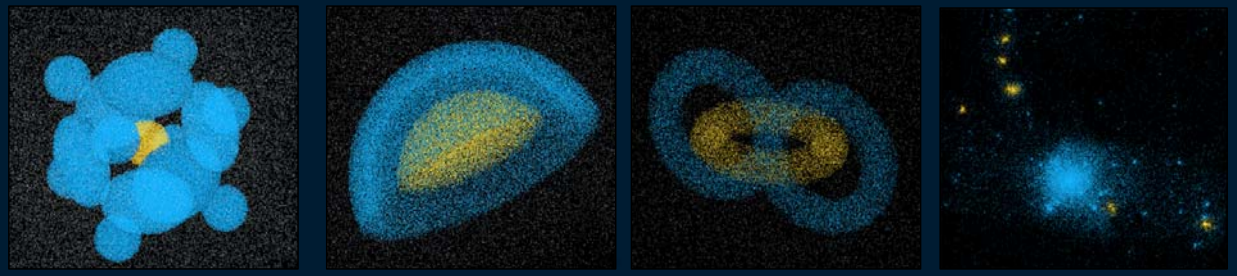
PointCast - Two exceptions

- The target cluster is behind a very faint cluster.
- The target cluster is behind another cluster V_B and the selection ray passes nearby, but outside, V_B .

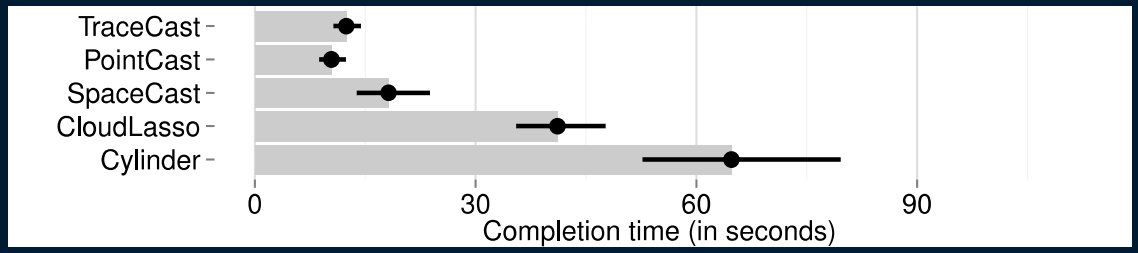




Synthetic Dataset

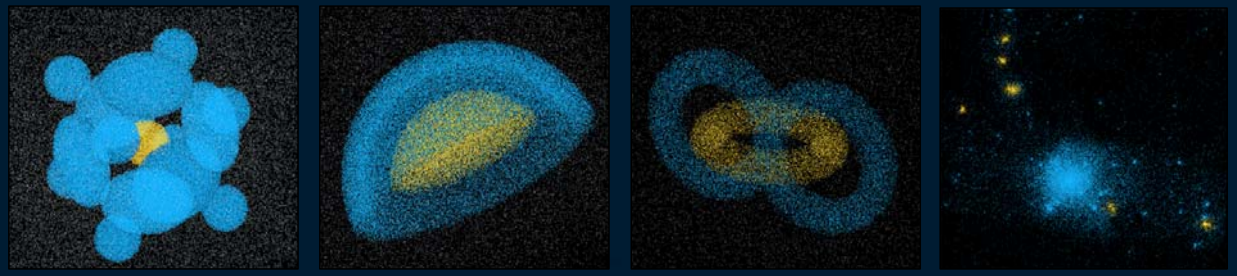


- Clusters dataset

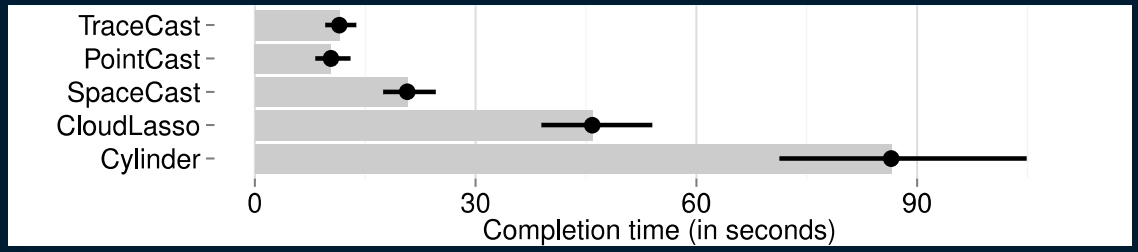


Technique	Time	CI	F1	CI	MCC	CI
Cylinder	65s	[53,80]	.99	[.98,.99]	.99	[.98,.99]
CloudLasso	41s	[36,48]	.99	[.98,.99]	.99	[.98,.99]
SpaceCast	18s	[14,24]	.99	[.98,.99]	.99	[.98,.99]
PointCast	10s	[8.8,12]	.99	[.95,.99]	.99	[.96,.99]
TraceCast	12s	[11,14]	.99	[.98,1]	.99	[.98,1]

Synthetic Dataset

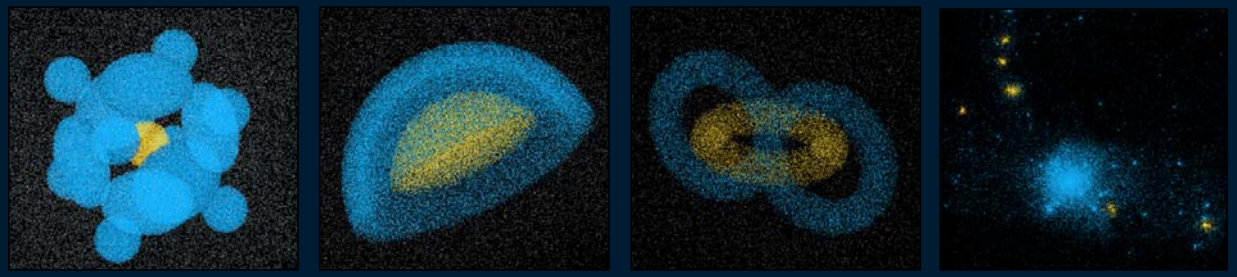


- Shell dataset

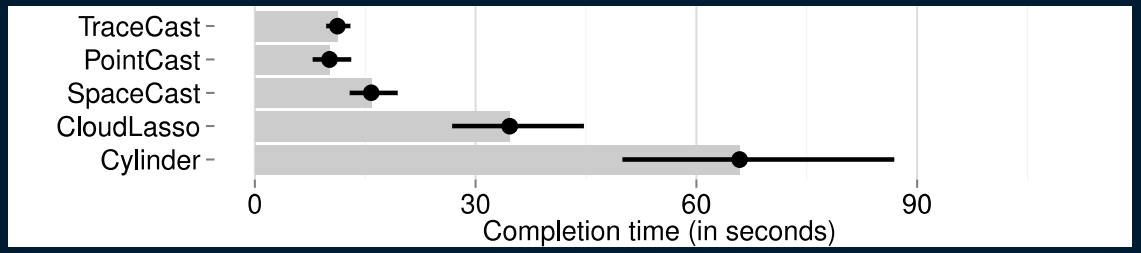


Technique	Time	CI	F1	CI	MCC	CI
Cylinder	86s	[71,105]	.97	[.97,.97]	.96	[.96,.97]
CloudLasso	46s	[49,54]	.95	[.92,.96]	.94	[.91,.96]
SpaceCast	21s	[17,25]	.95	[.86,.98]	.94	[.82,.97]
PointCast	10s	[8.2,13]	.97	[.93,.98]	.97	[.93,.98]
TraceCast	11s	[9.6,14]	.98	[.97,.98]	.97	[.97,.98]

Synthetic Dataset

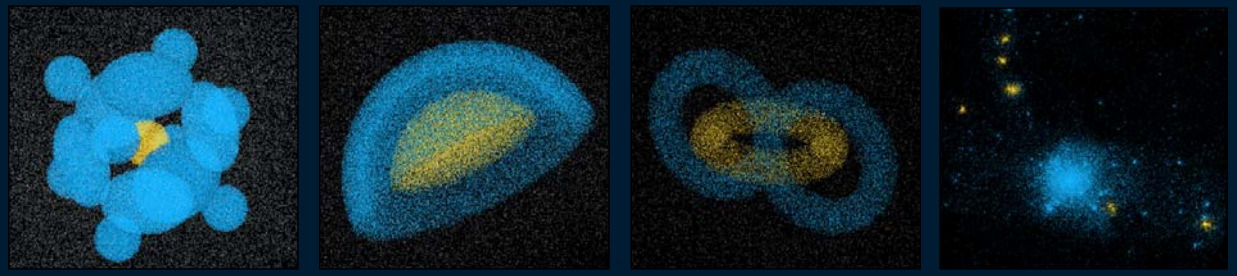


- Rings dataset

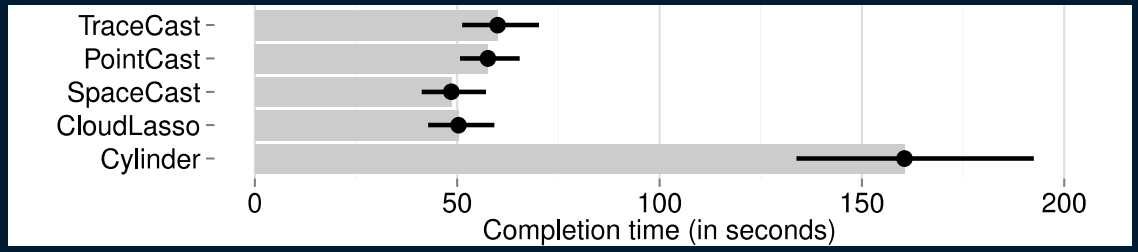


Technique	Time	CI	F1	CI	MCC	CI
Cylinder	66s	[55,87]	.96	[.96,.97]	.96	[.94,.96]
CloudLasso	35s	[27,45]	.98	[.97,.98]	.97	[.96,.98]
SpaceCast	16s	[13,19]	.98	[.97,.98]	.97	[.96,.98]
PointCast	10s	[7.9,13]	.97	[.91,.99]	.97	[.91,.98]
TraceCast	11s	[9.7,13]	.98	[.97,.99]	.98	[.96,.98]

Real Dataset



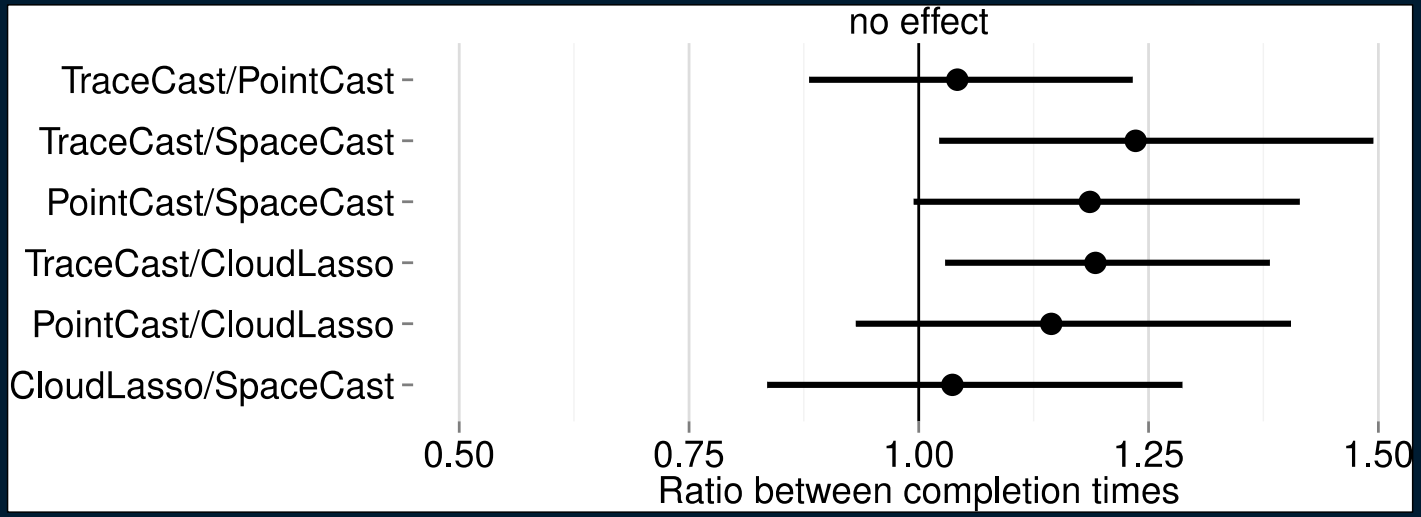
- N-body mass simulation



Technique	Time	CI	F1	CI	MCC	CI
Cylinder	161s	[134,192]	.92	[.91,.93]	.92	[.91,.93]
CloudLasso	50s	[43,59]	.94	[.93,.95]	.94	[.93,.95]
SpaceCast	49s	[41,57]	.94	[.93,.95]	.94	[.93,.95]
PointCast	58s	[51,65]	.94	[.89,.96]	.95	[.90,.96]
TraceCast	60s	[51,70]	.95	[.93,.96]	.95	[.93,.96]

Completion times

- Ratios between mean completion times for the simulation dataset.



Application Domains

- Hurricane Isabel dataset - SpaceCast