The Importance of Small Structure in the CGM

Cameron Hummels
NSF Postdoctoral Fellow
California Institute of Technology

Trident

Britton Smith
Devin Silvia
Bili Dong
Lauren Corlies

FOGGIE
Figuring Out Gas & Galaxies In Enzo

Britton Smith
Devin Silvia
Brian O'Shea
Jess Werk
Molly Peeples
Jason Tumlinson
Lauren Corlies
Nicolas Lehner

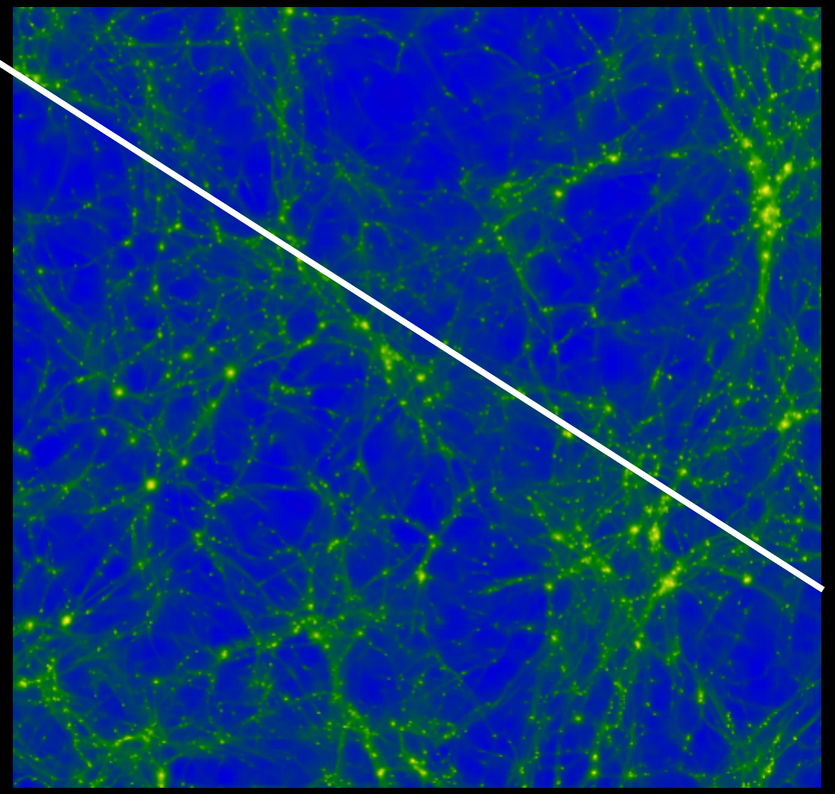
FIRE
Feedback In Realistic Environments

Phil Hopkins
Claude-Andre Faucher-Giguère
Dusan Keres
Norm Murray

A universal synthetic spectral utility
http://trident-project.org

Trident

Hummels, Smith, & Silvia 2017

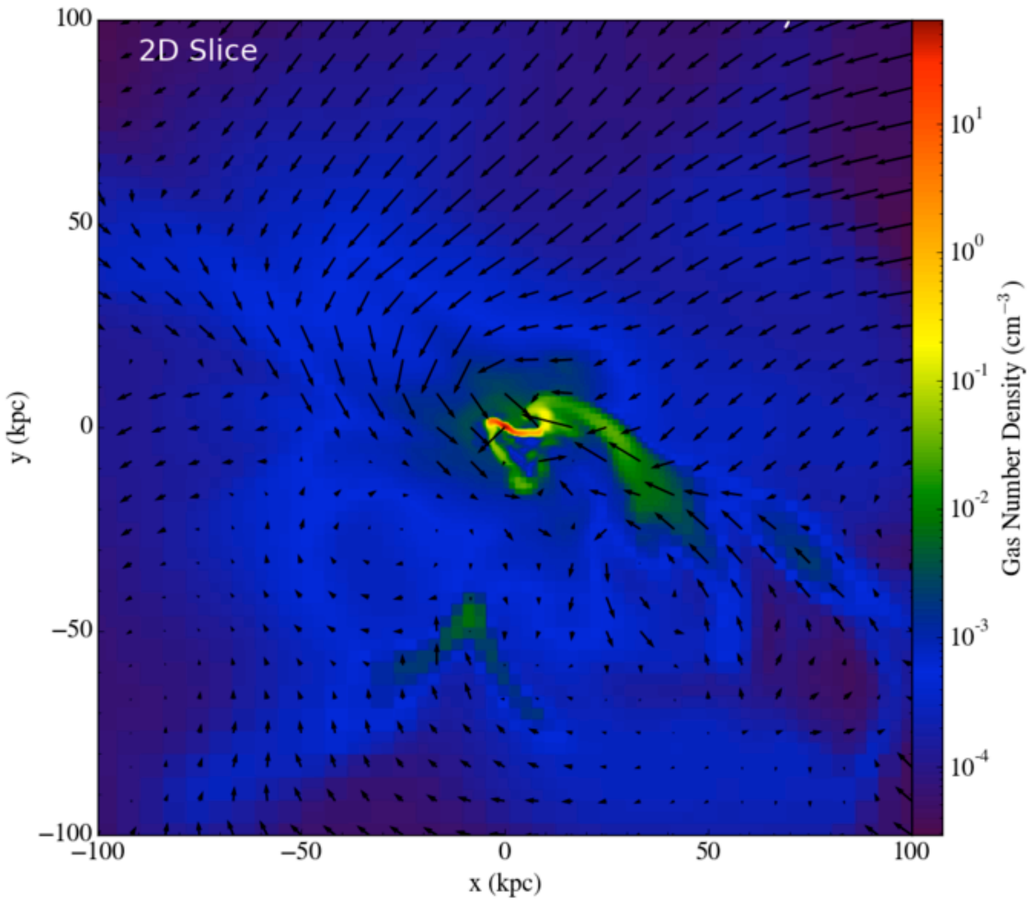


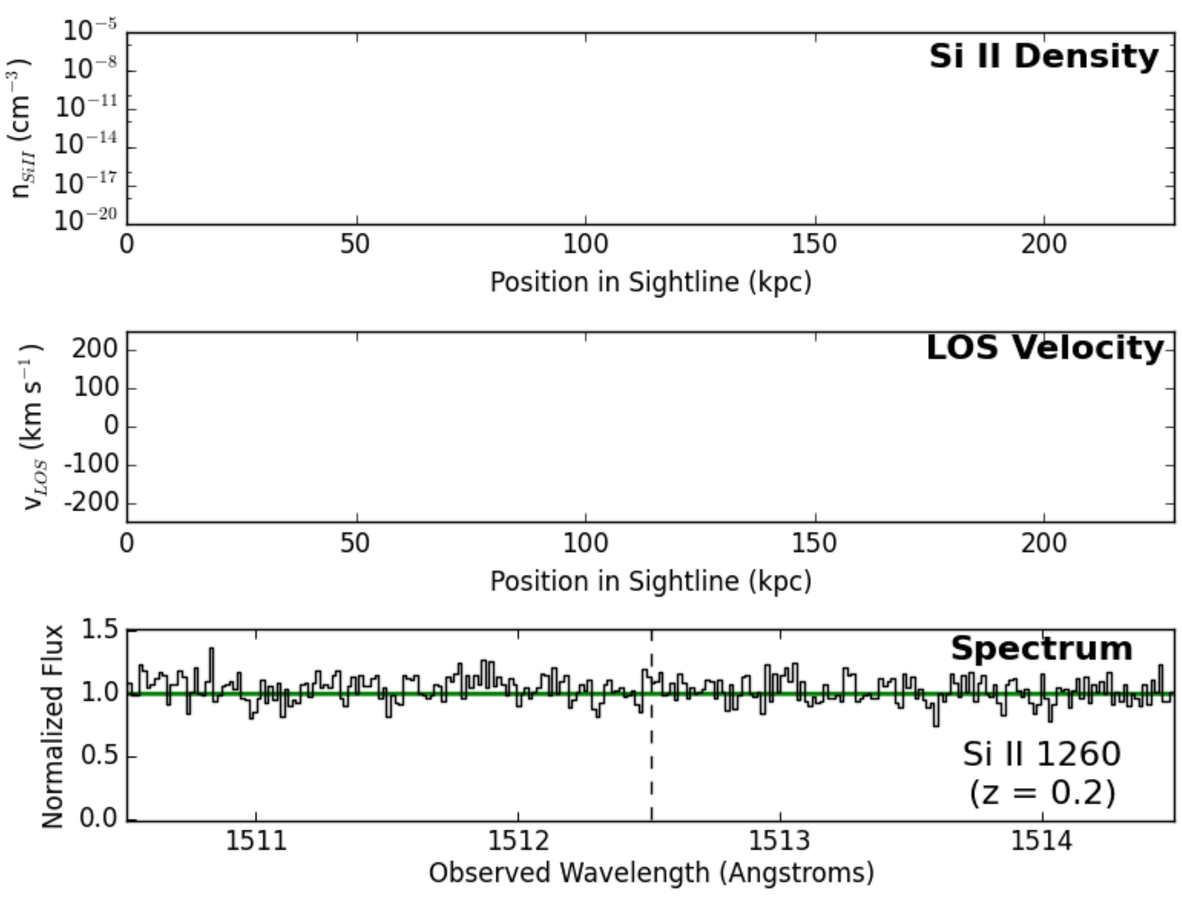
- Creates synthetic absorption spectra for any trajectory through simulated volume
- Reproduces different spectrographs (COS)
- Operates across UV, optical, and IR with many lines
- Estimates the presence of ions absent from the simulation outputs using equilibrium modeling
- Post-processing to add QSO, MW, S/N, etc.
- Built on yt infrastructure (Turk et al. 2011)
- Supports all astrophysical hydro code formats
- Fully parallelized using MPI
- Open source, Python-based code hosted on Github

A universal synthetic spectral utility

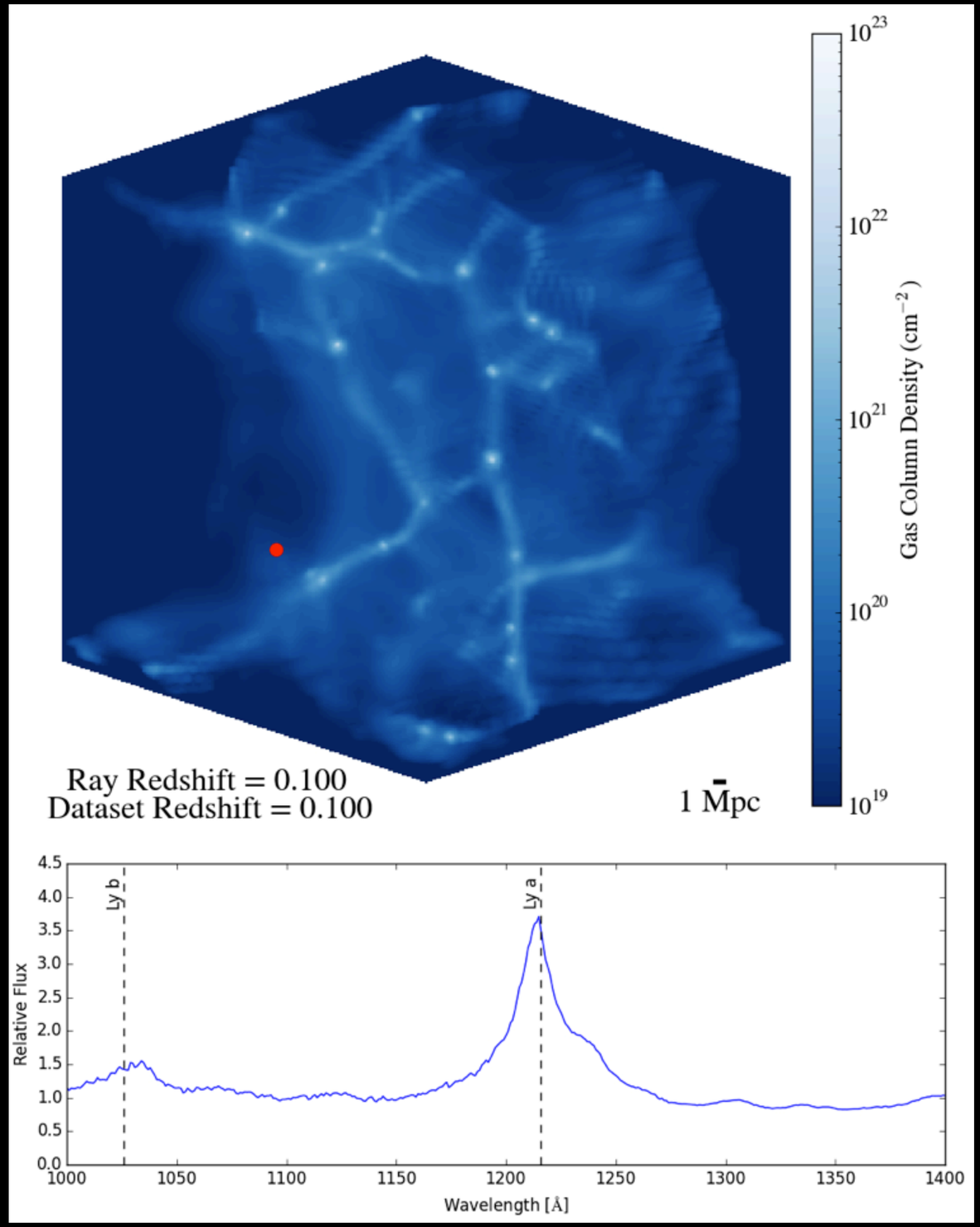
http://trident-project.org

Trident





Compound Sightline for Continuous Lightcones



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FOGGIE/Tempest Simulations (grid-based)
Strength: Resolution

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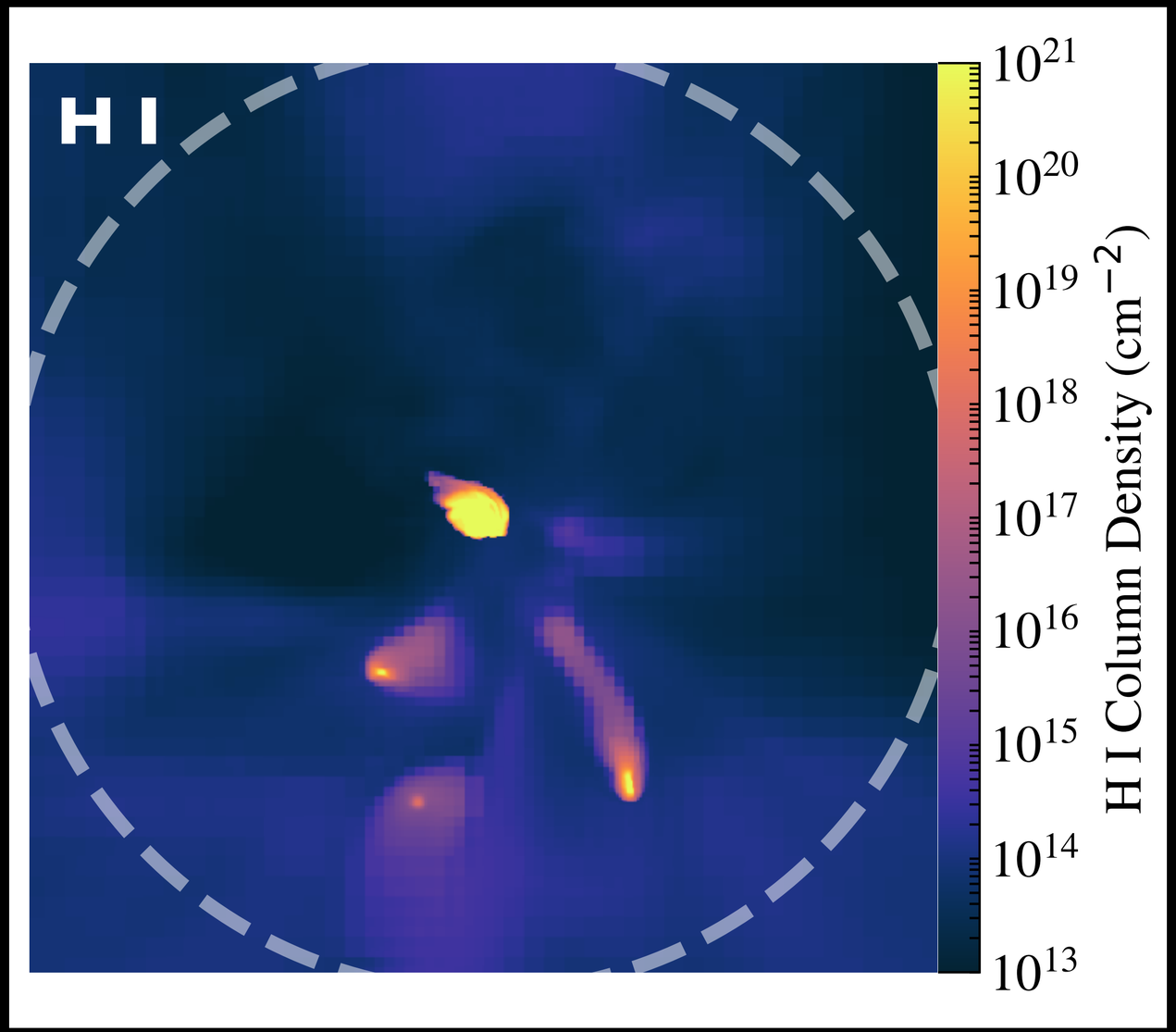
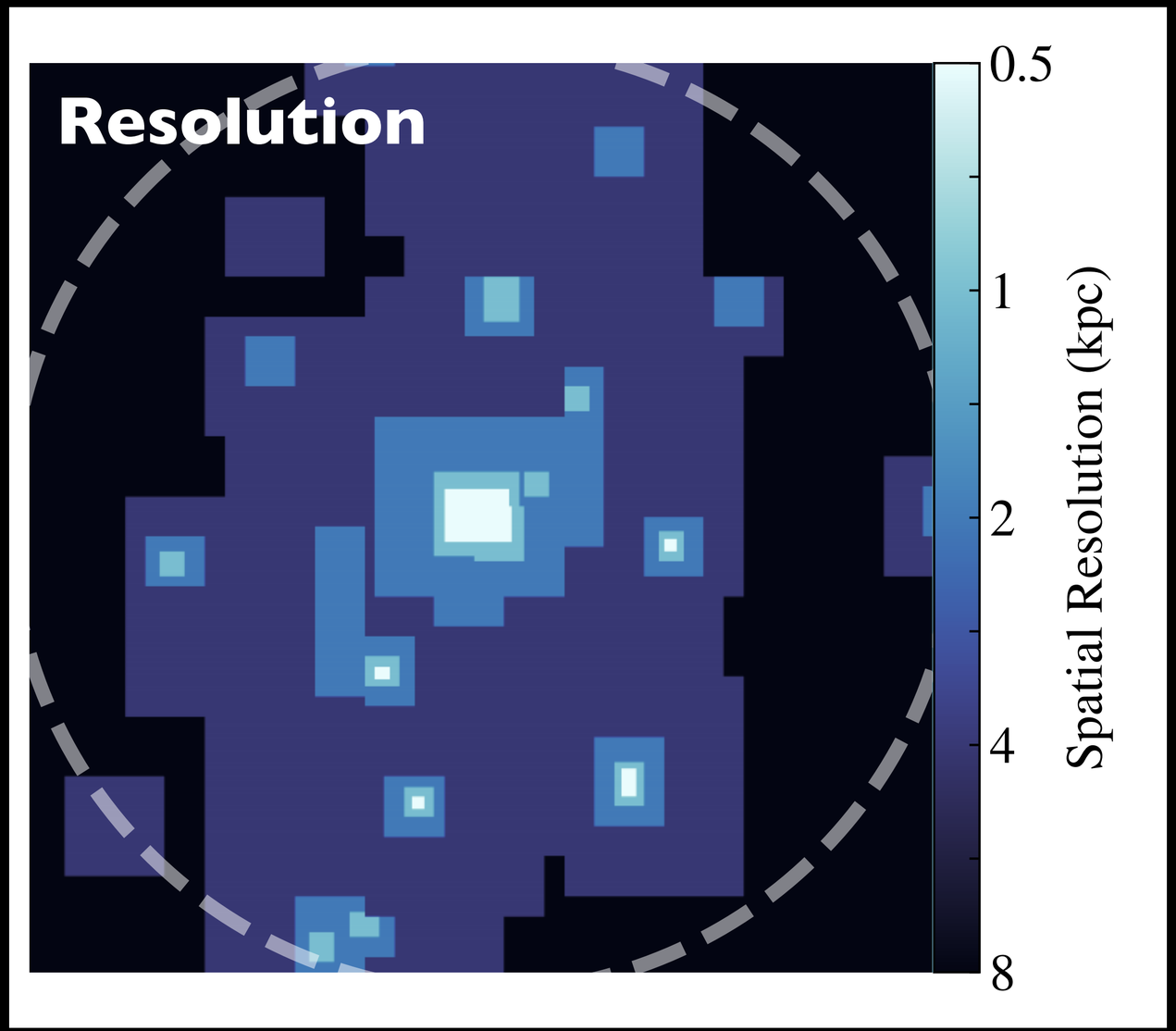


Natural Refinement

FOGGIE/Tempest Simulations (grid-based)
Strength: Resolution



Natural Refinement

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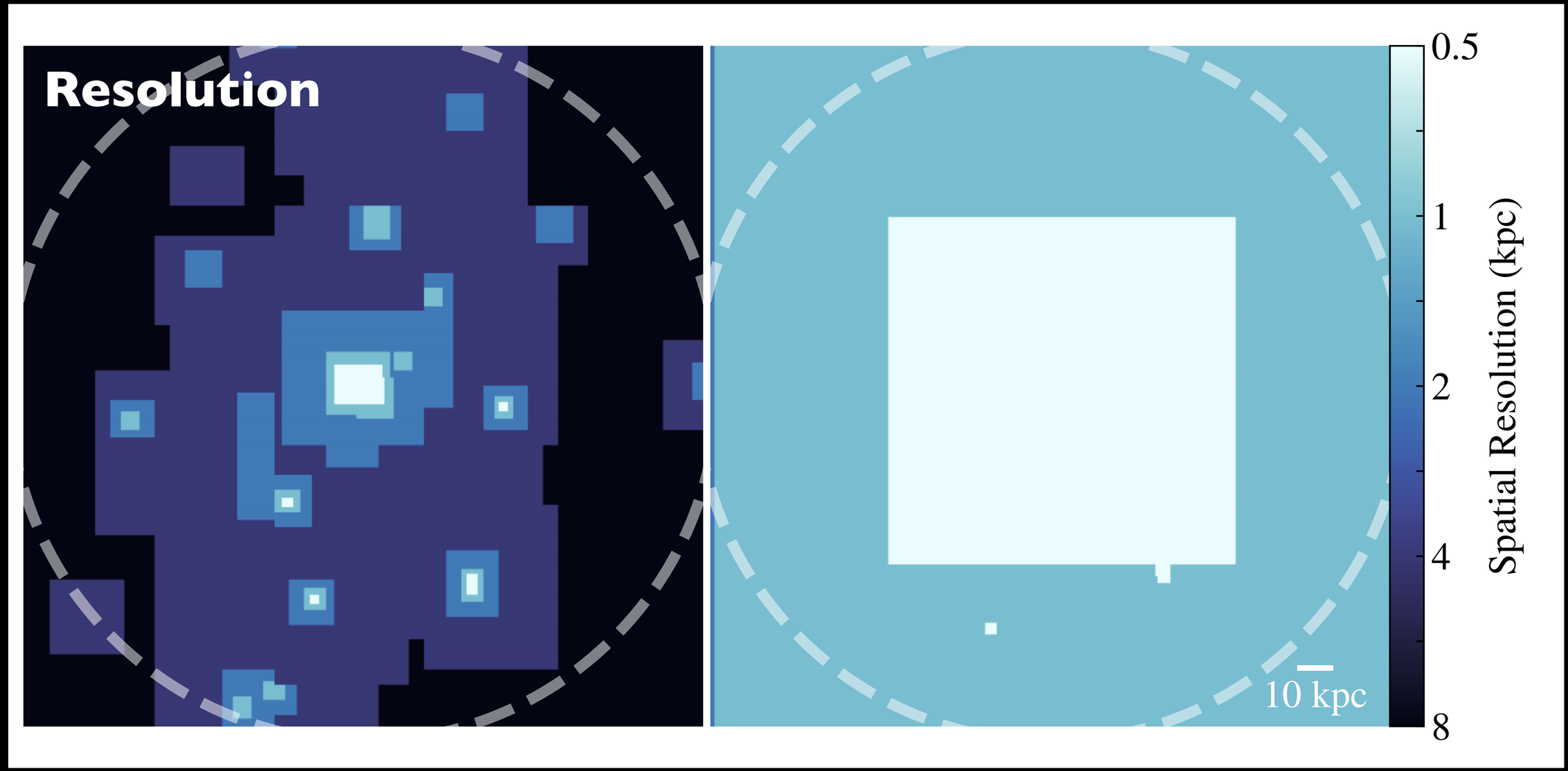
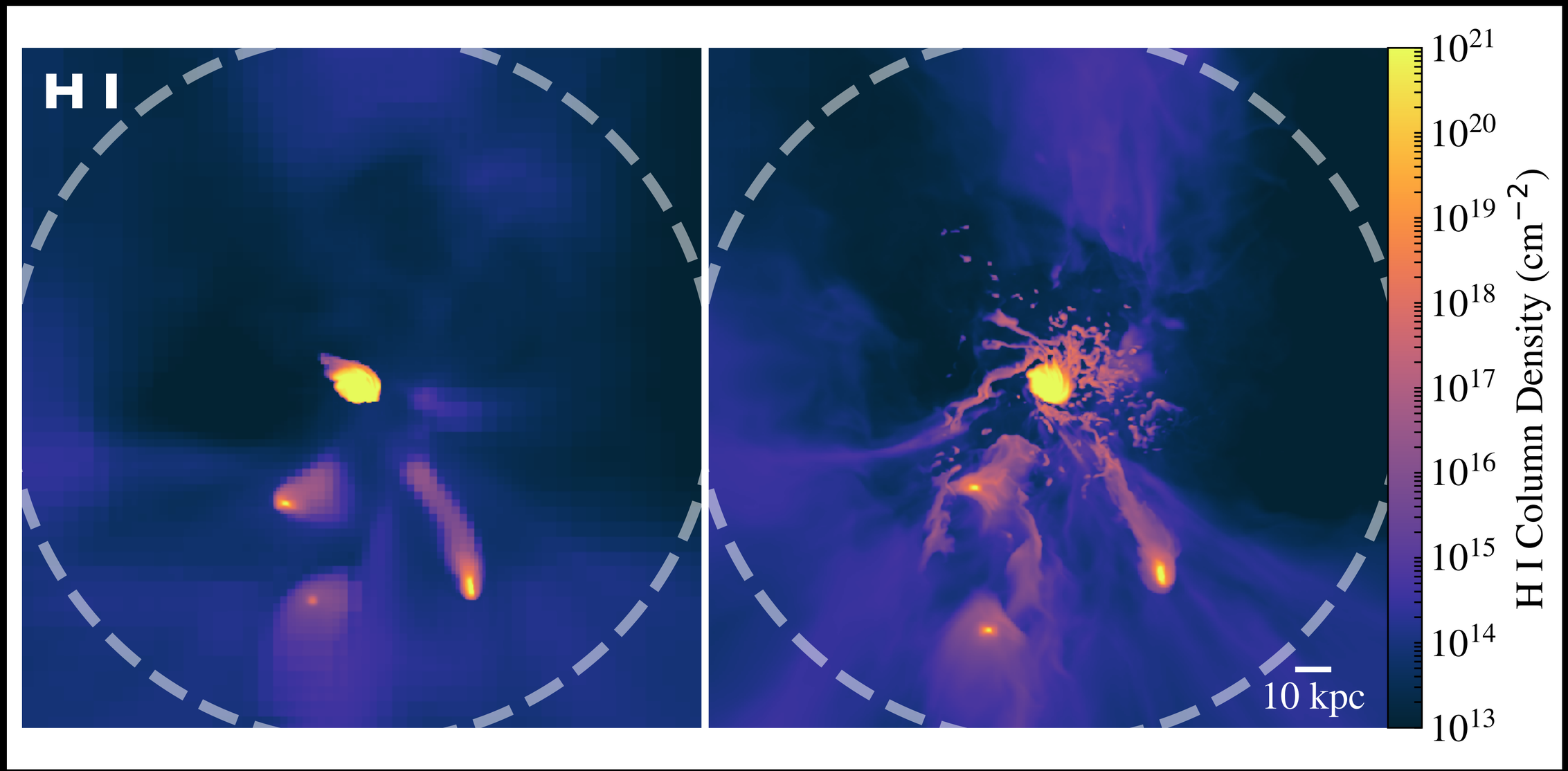


Natural Refinement

Forced Refinement

FOGGIE (Hummels+ in prep)

FOGGIE/Tempest Simulations (grid-based)
Strength: Resolution



Natural Refinement **Forced Refinement**

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FOGGIE/Tempest Simulations (grid-based)
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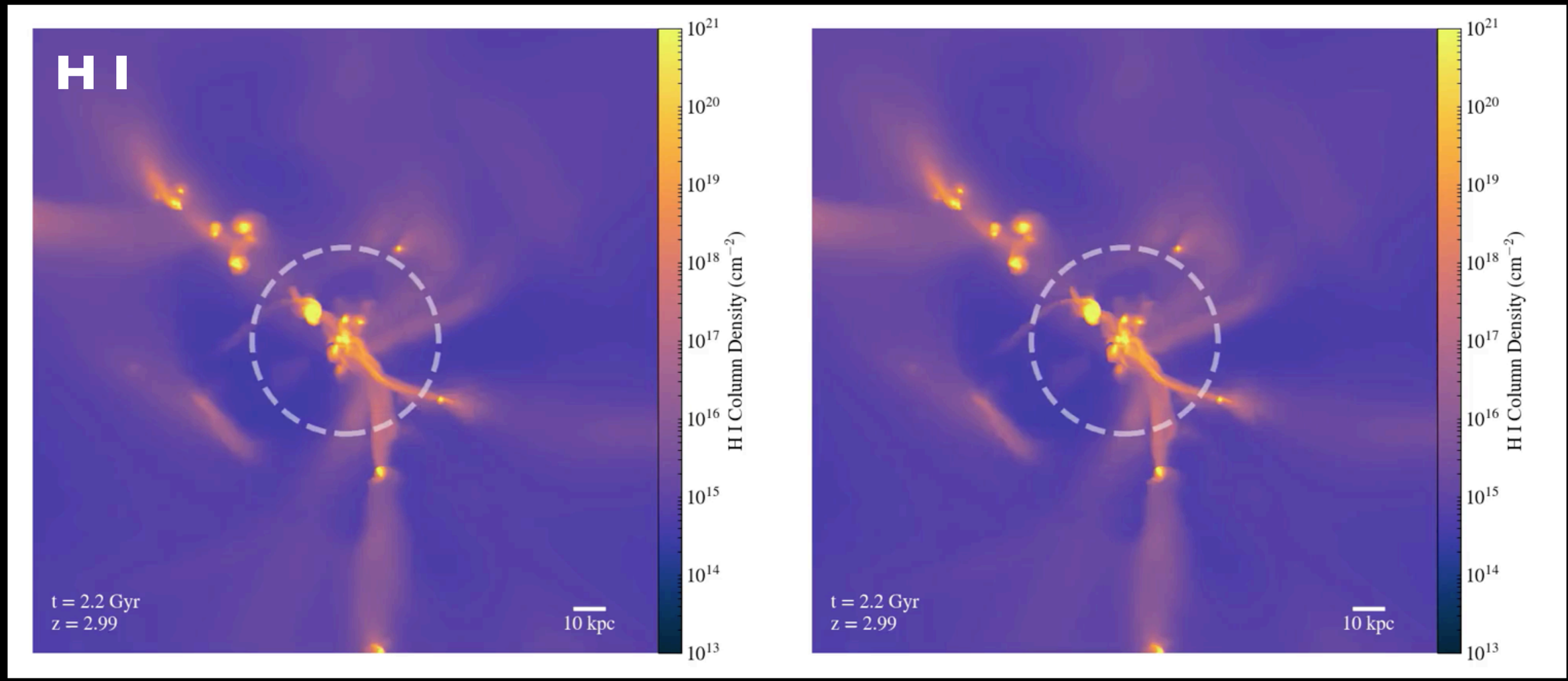

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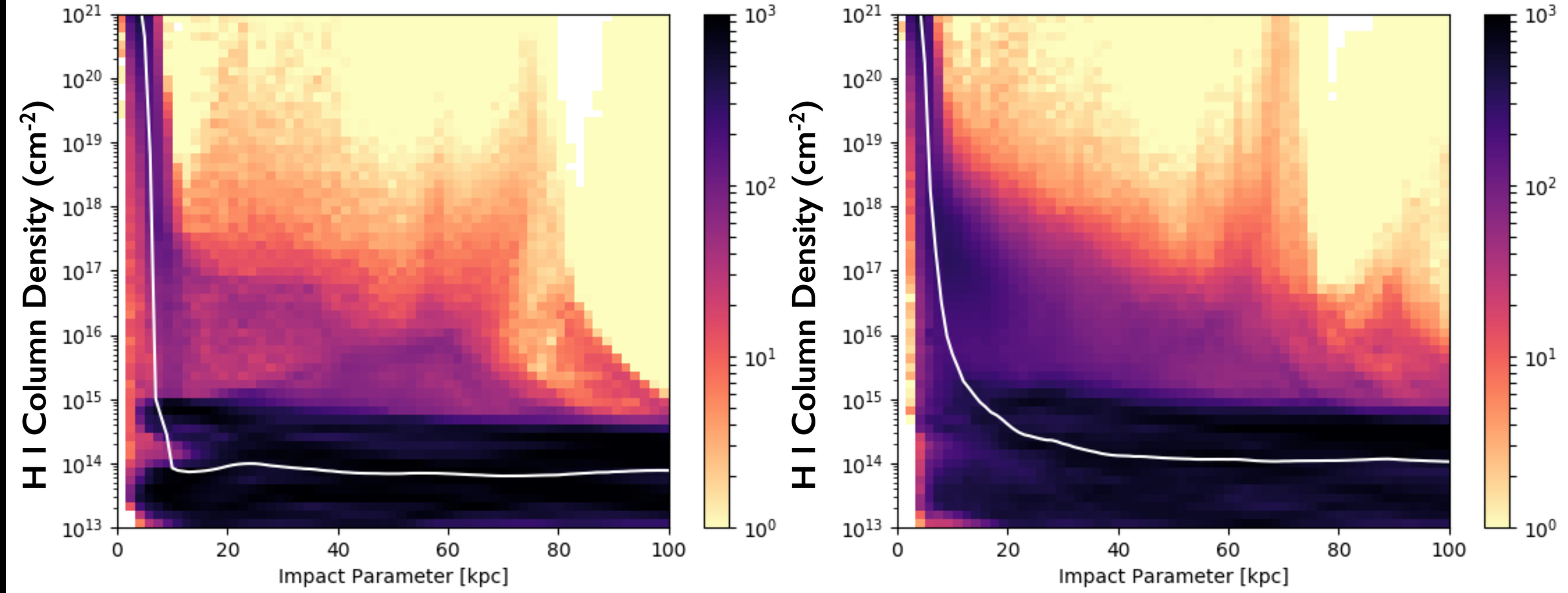

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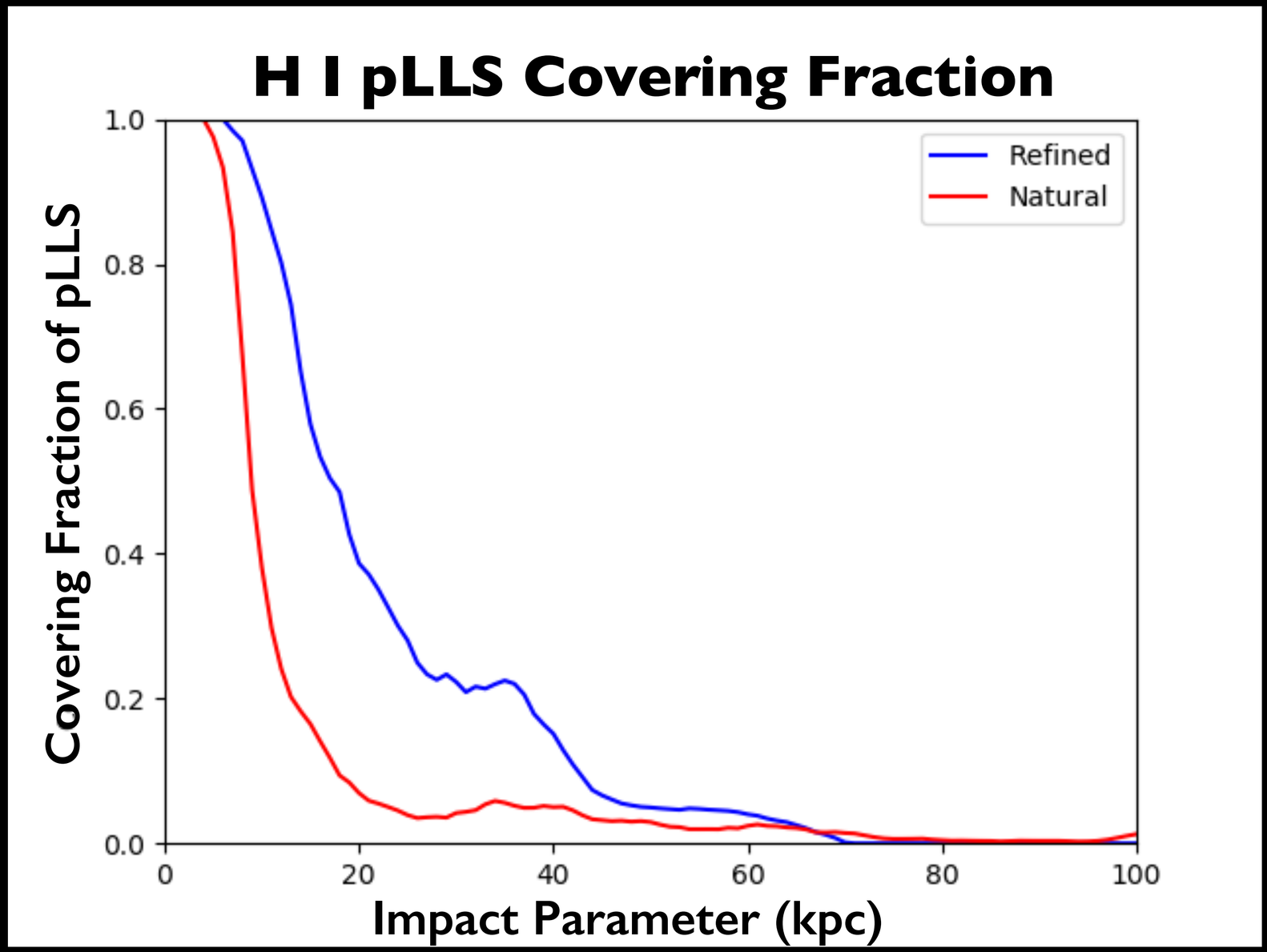

FOGGIE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

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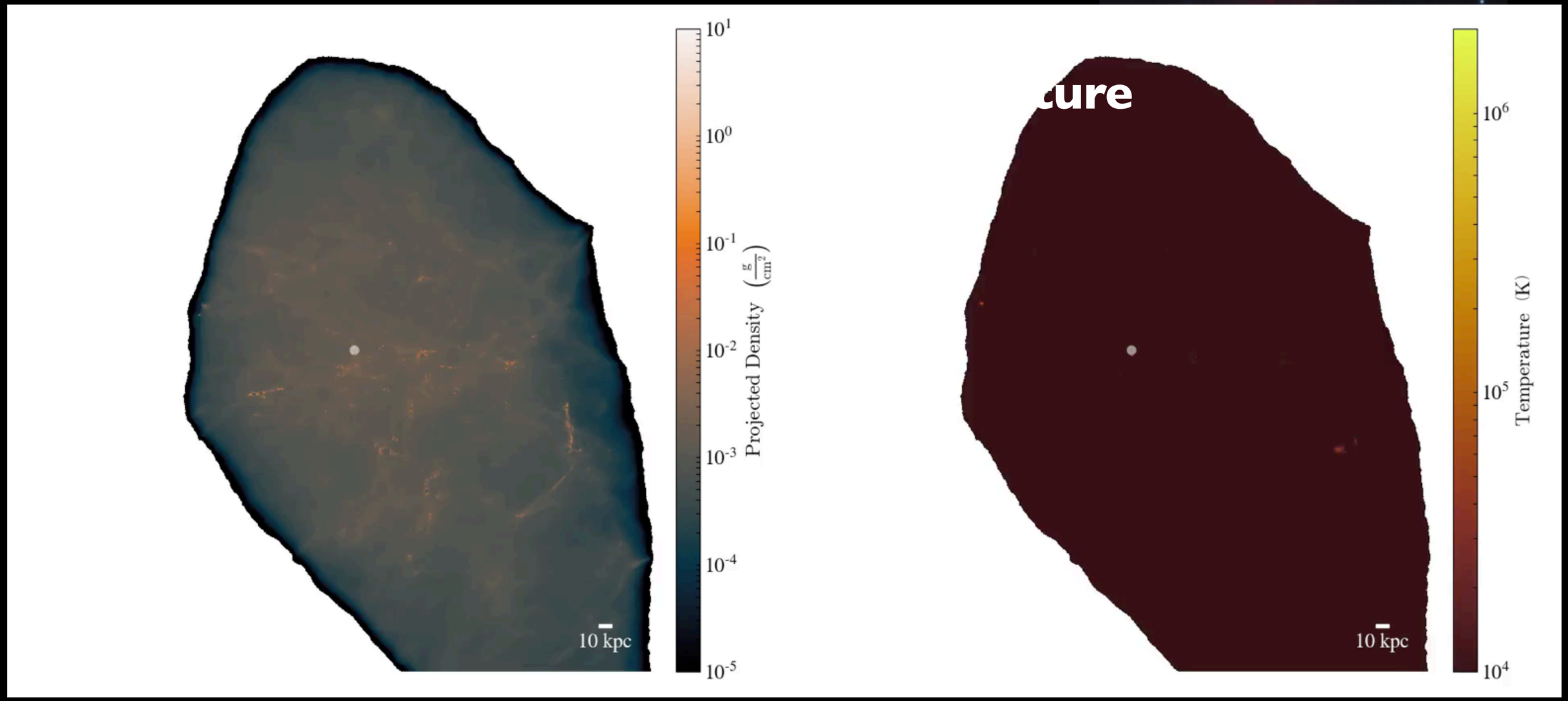
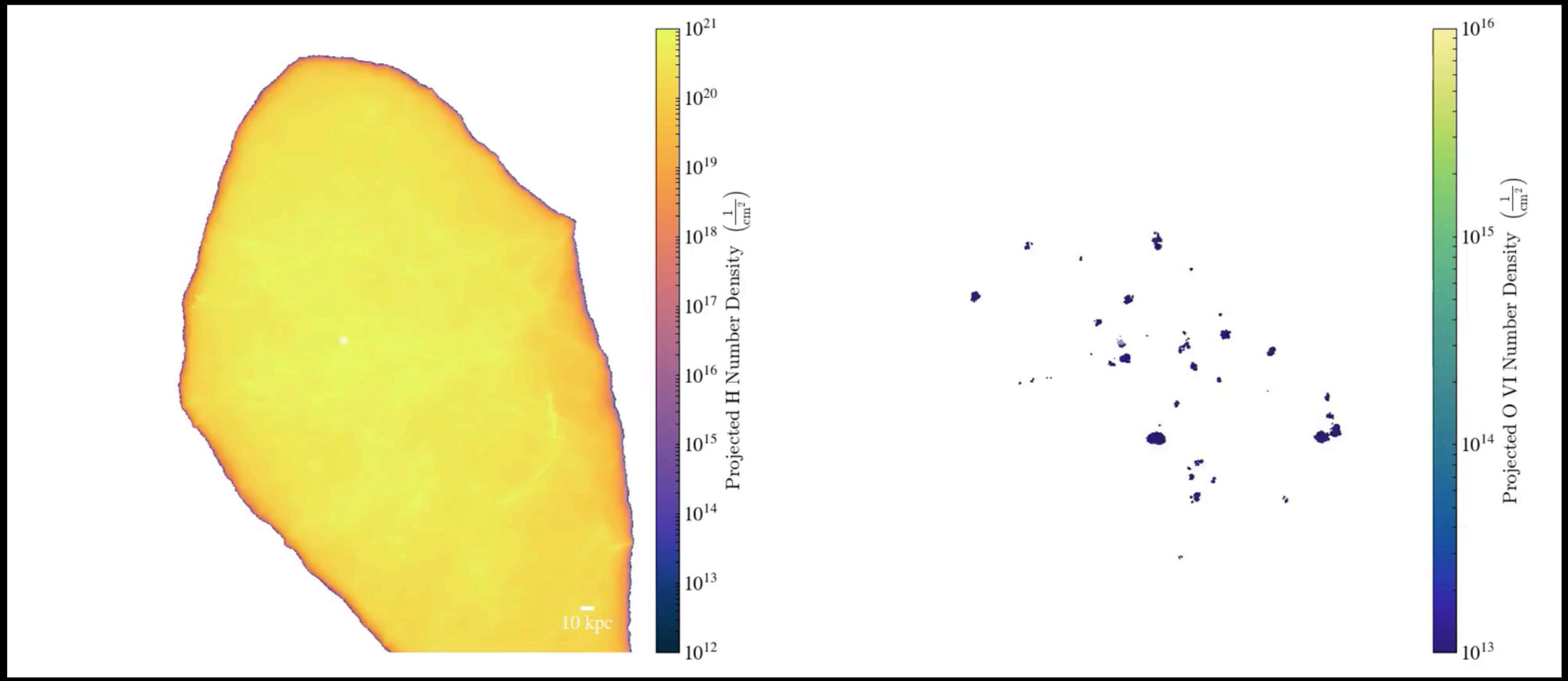


COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback



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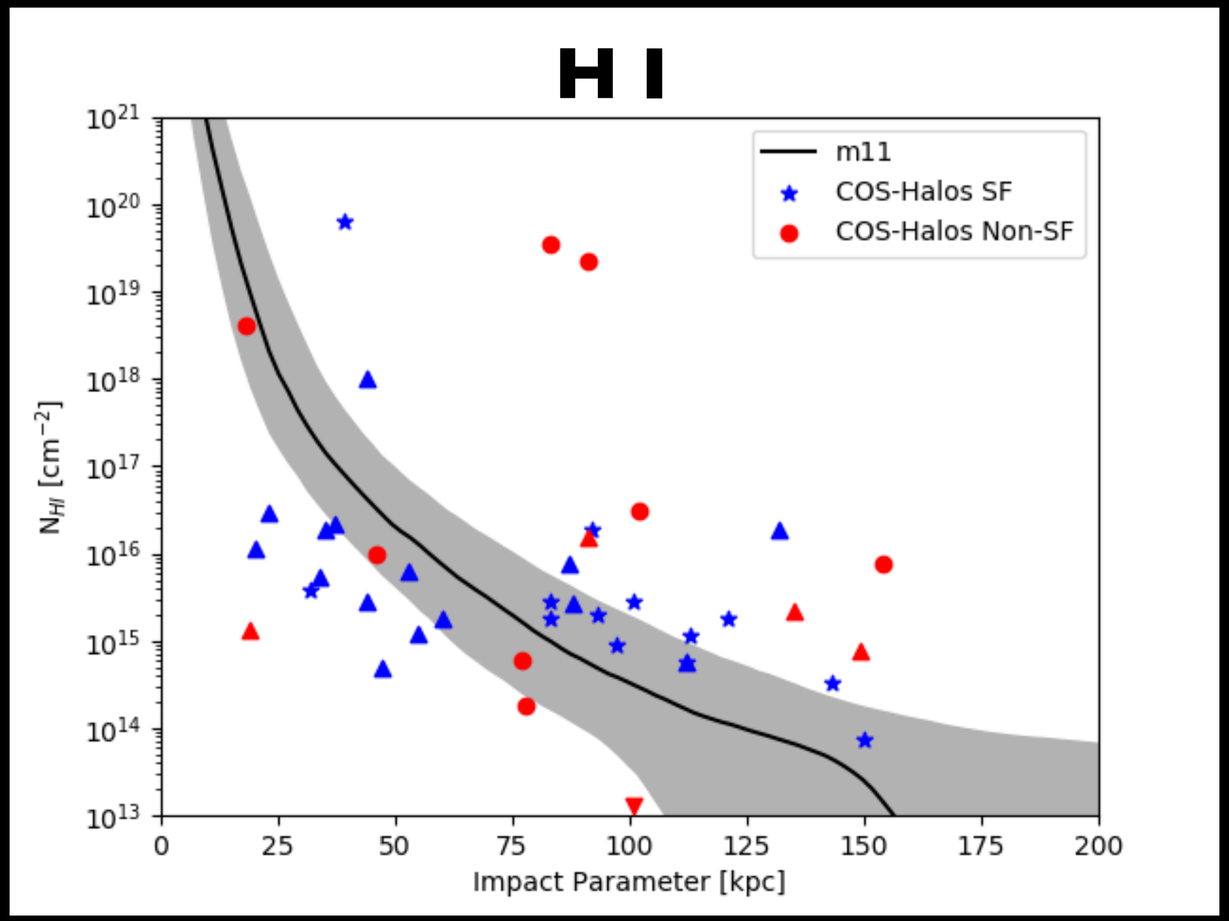

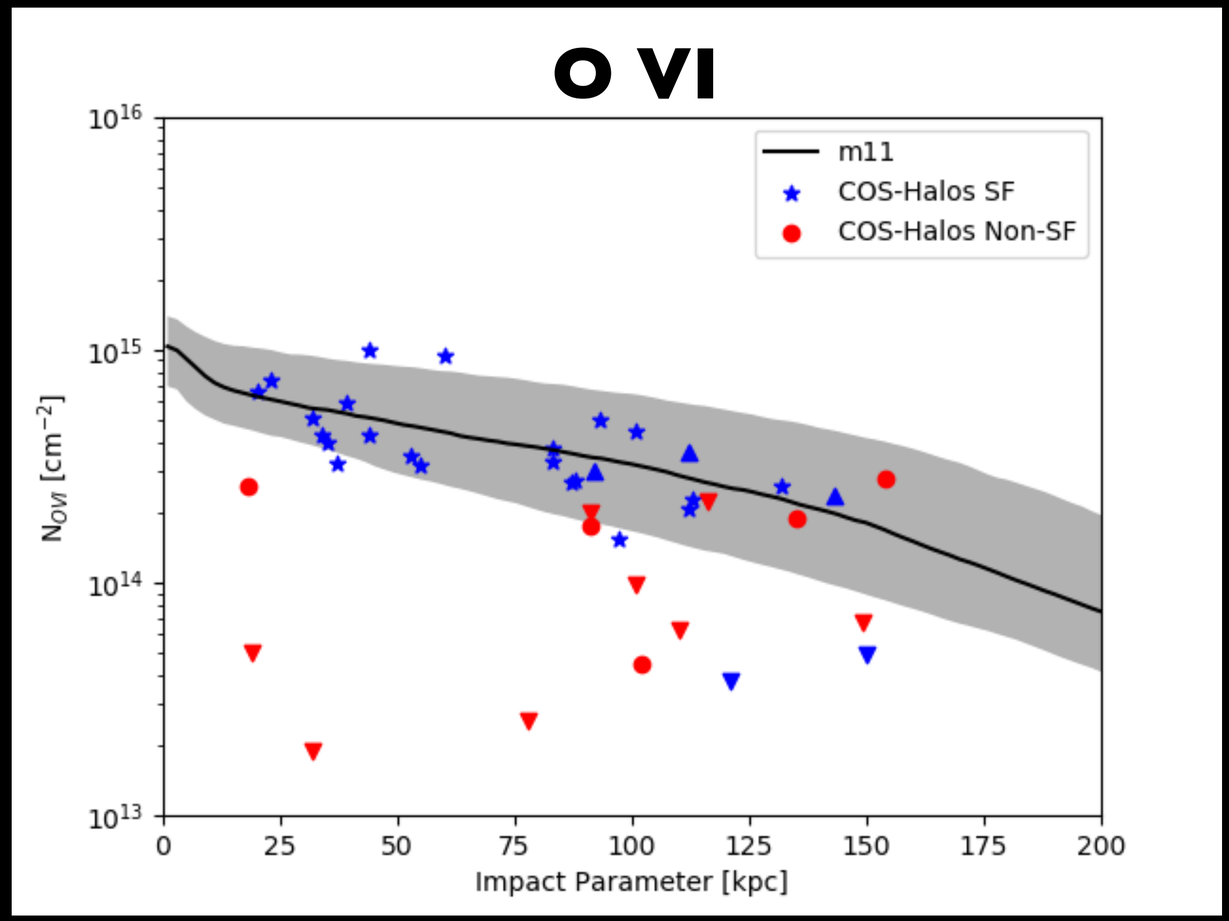

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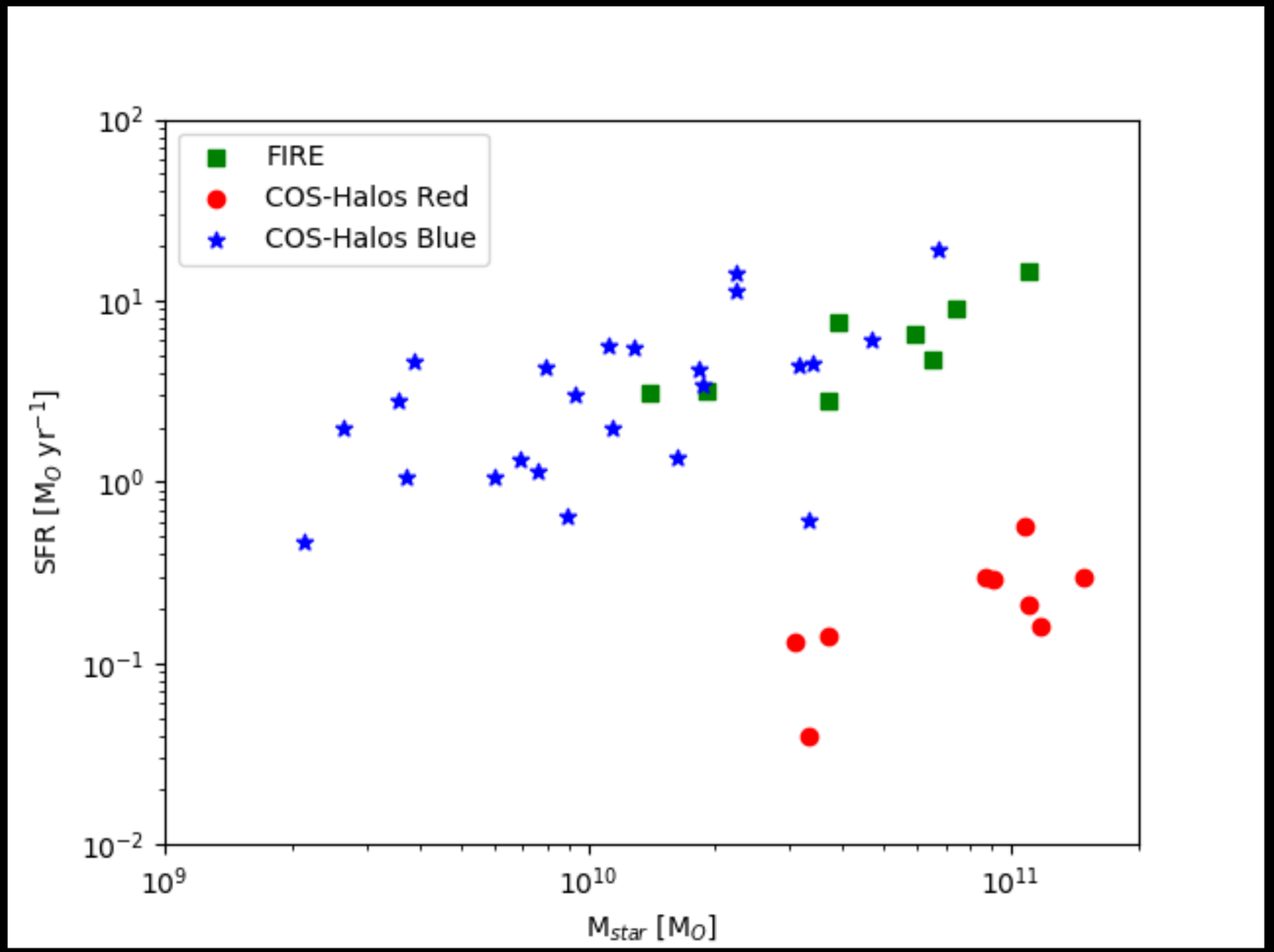
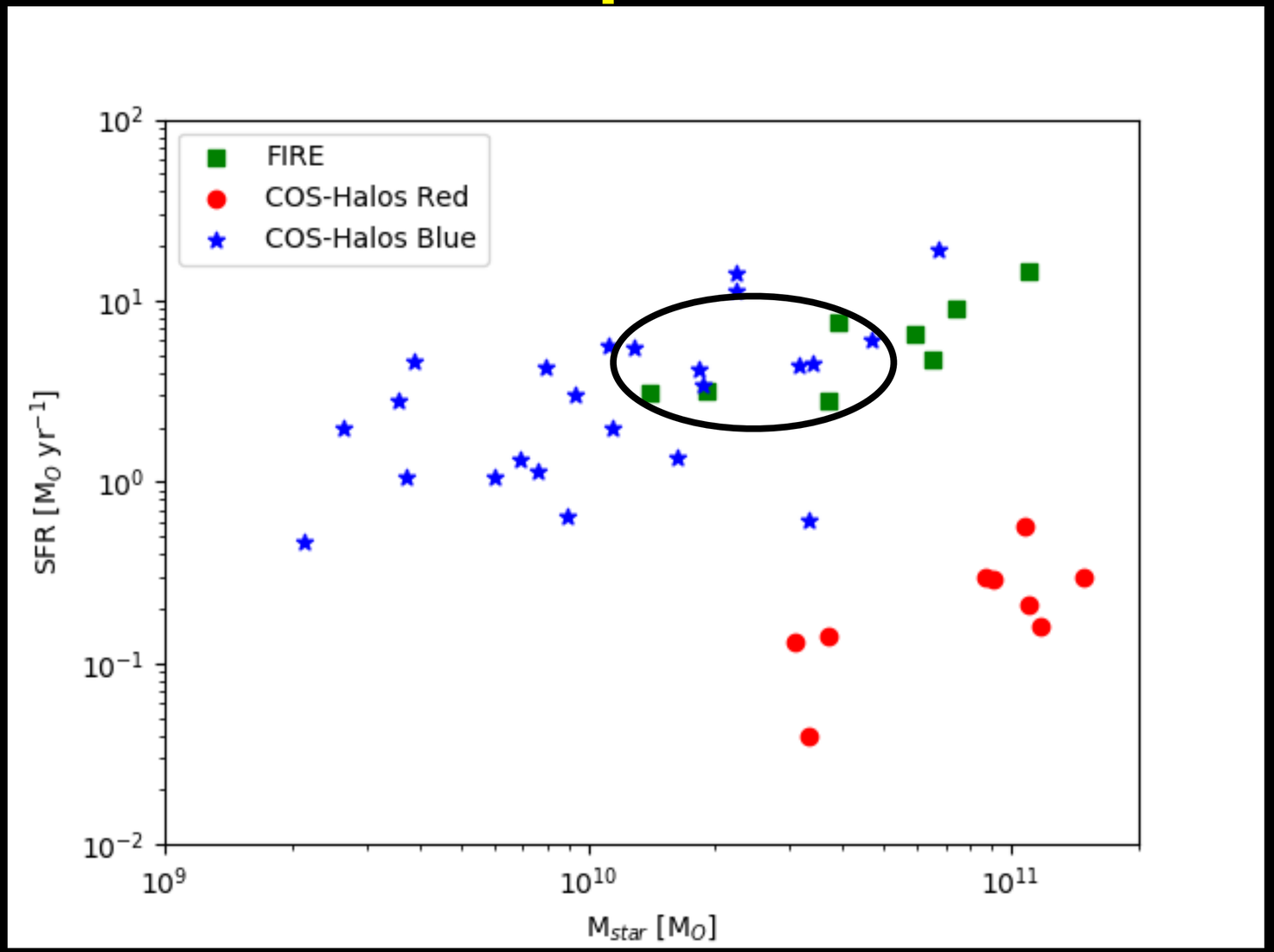


COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

Best Fit Halo Sample



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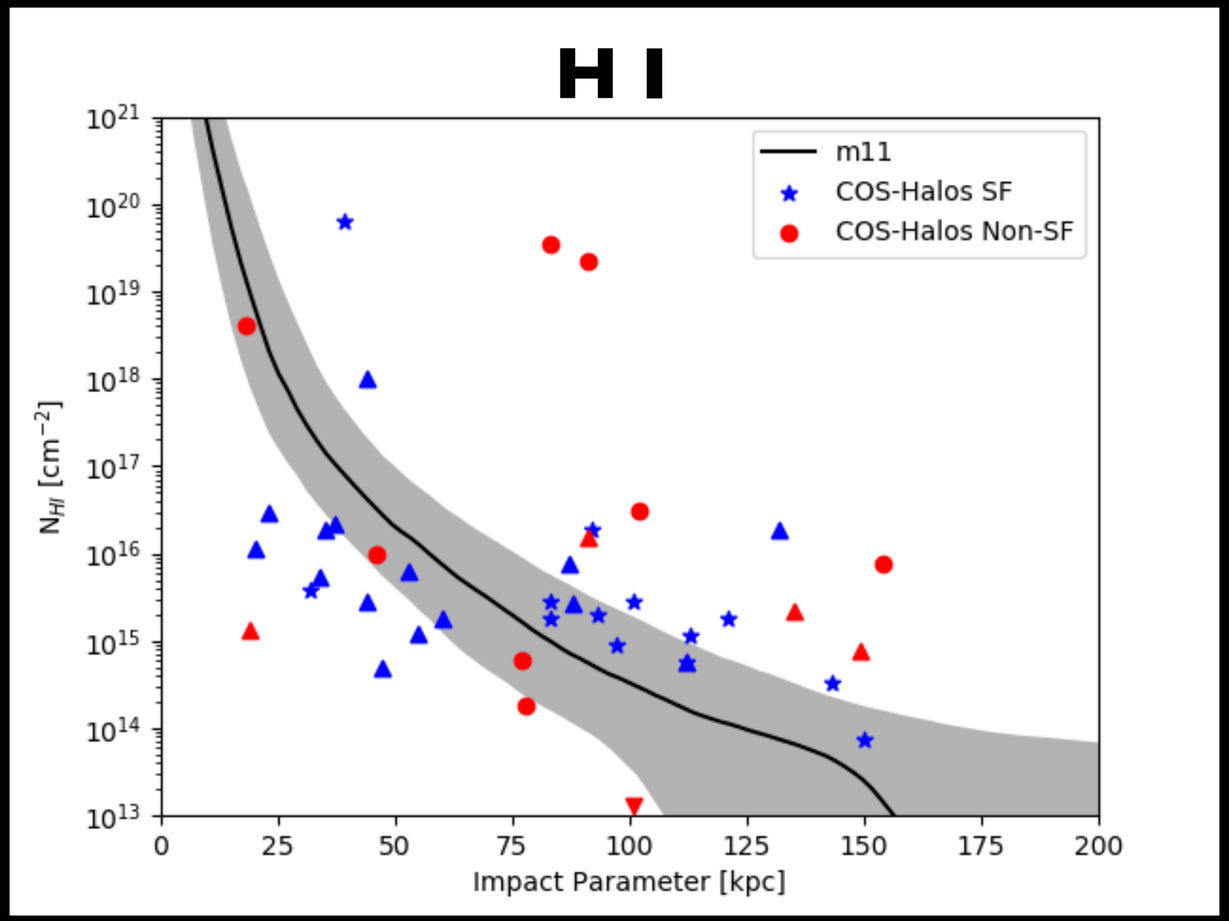
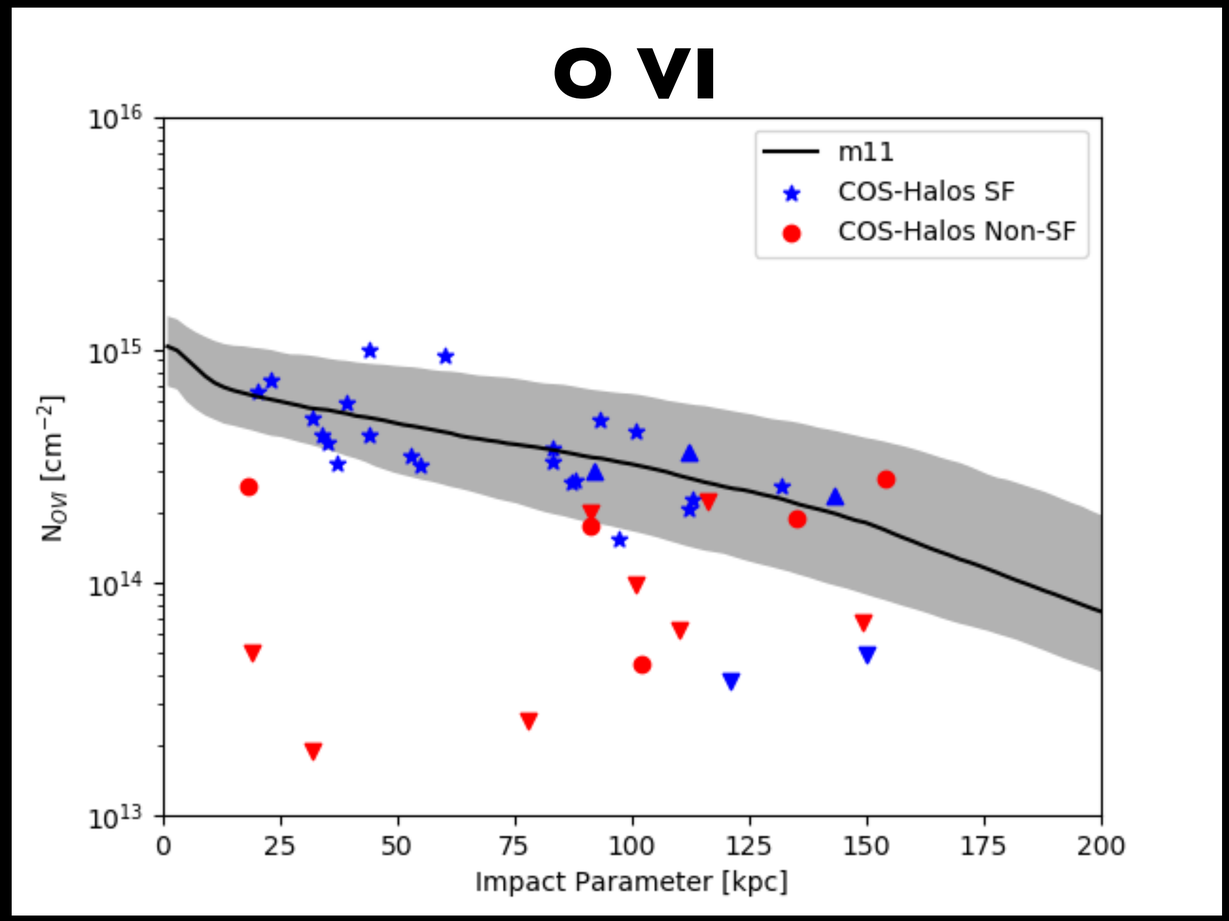
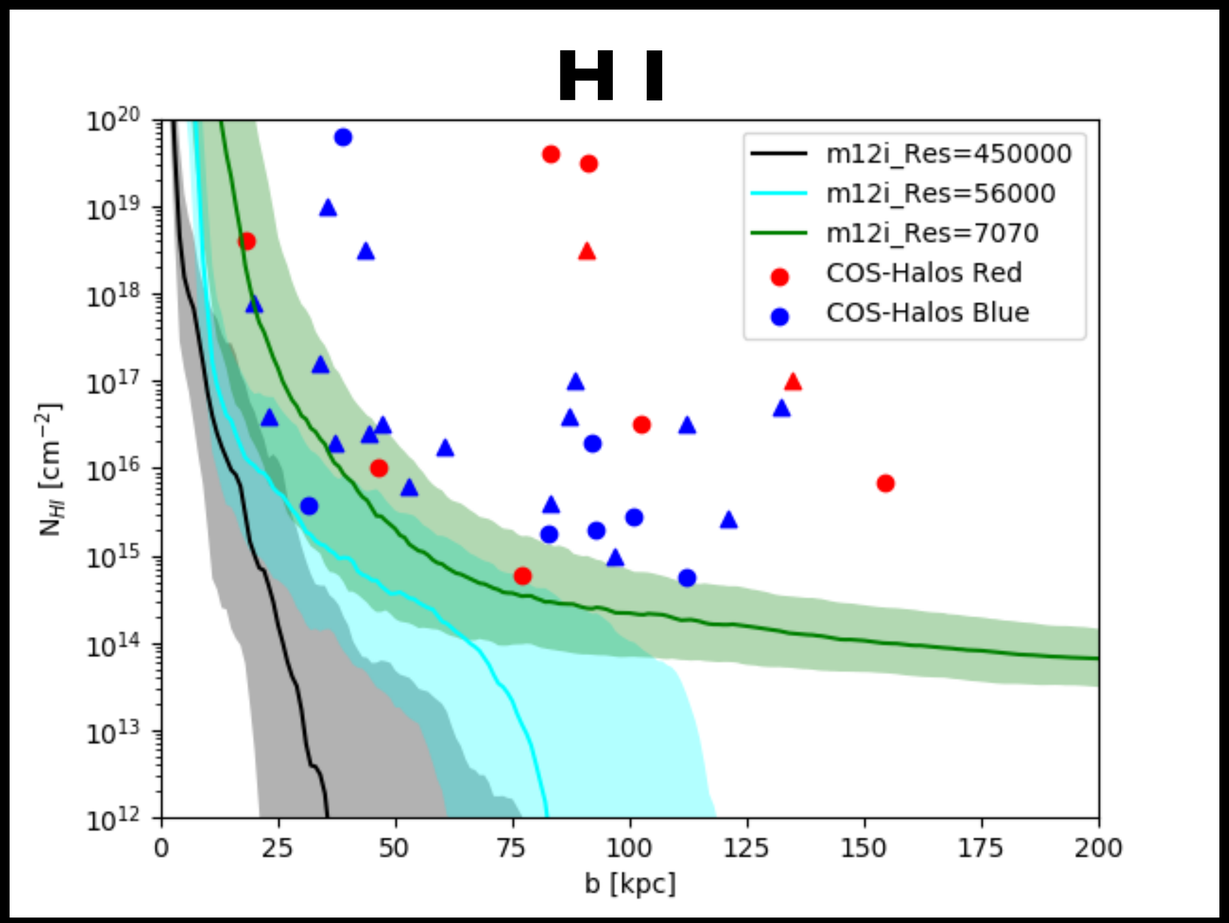


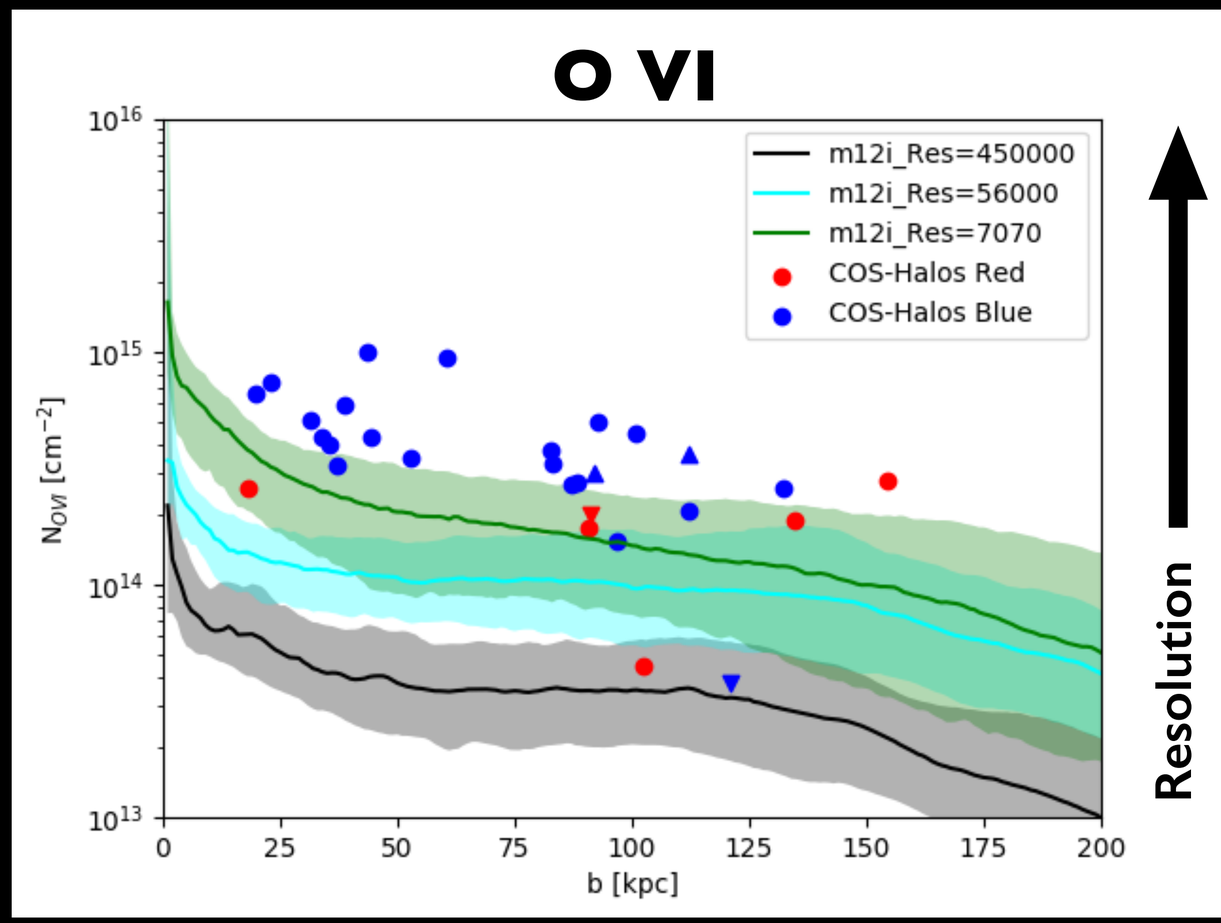


COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

Column Density vs Resolution

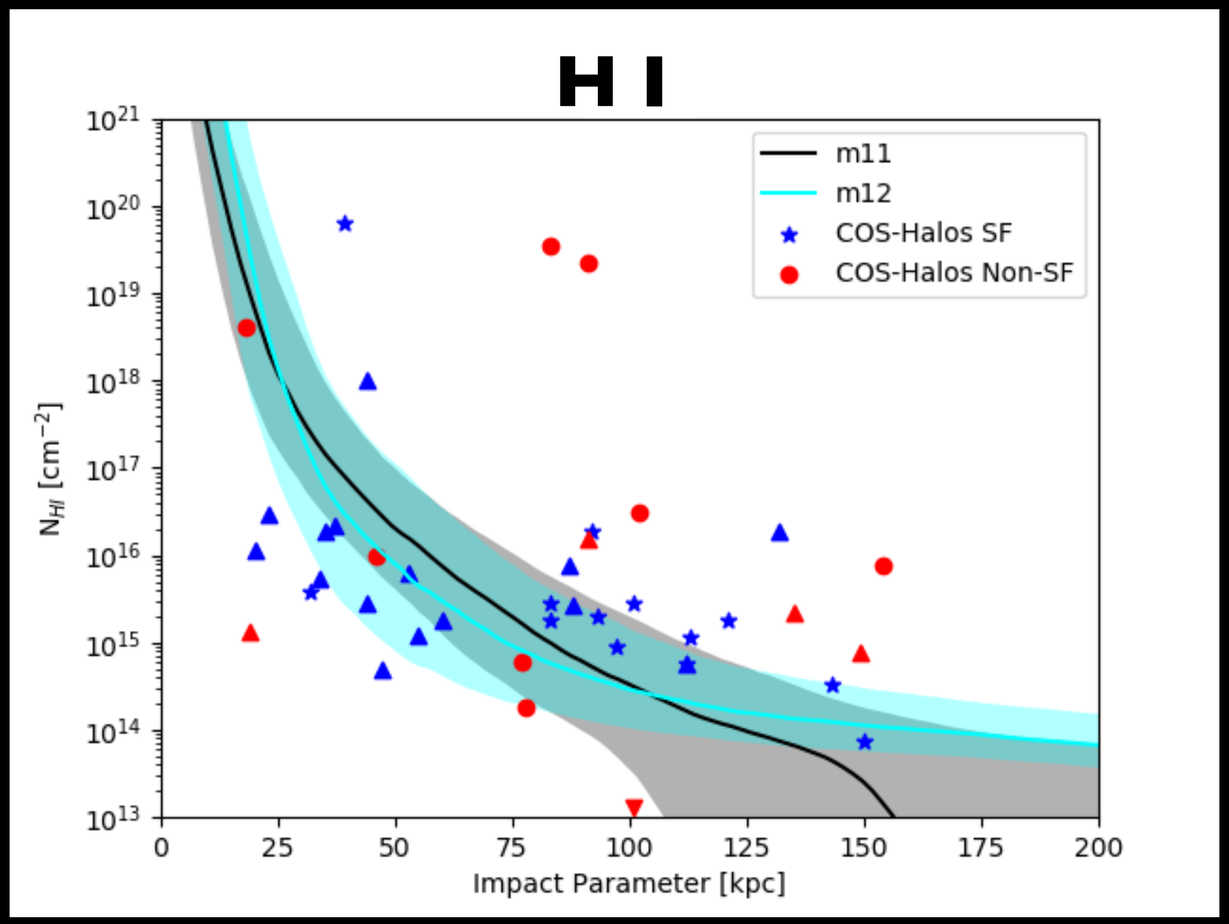


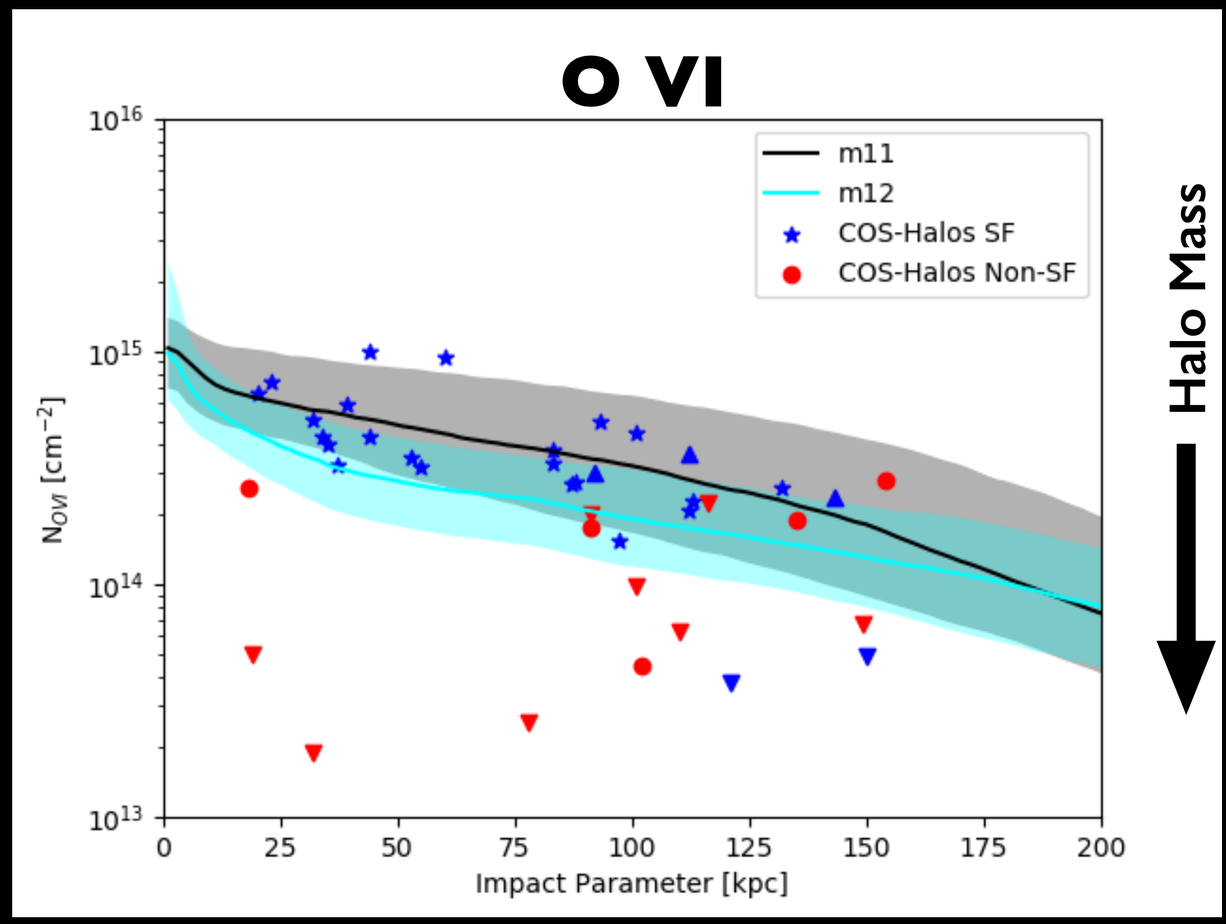


COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

Column Density vs Halo Mass





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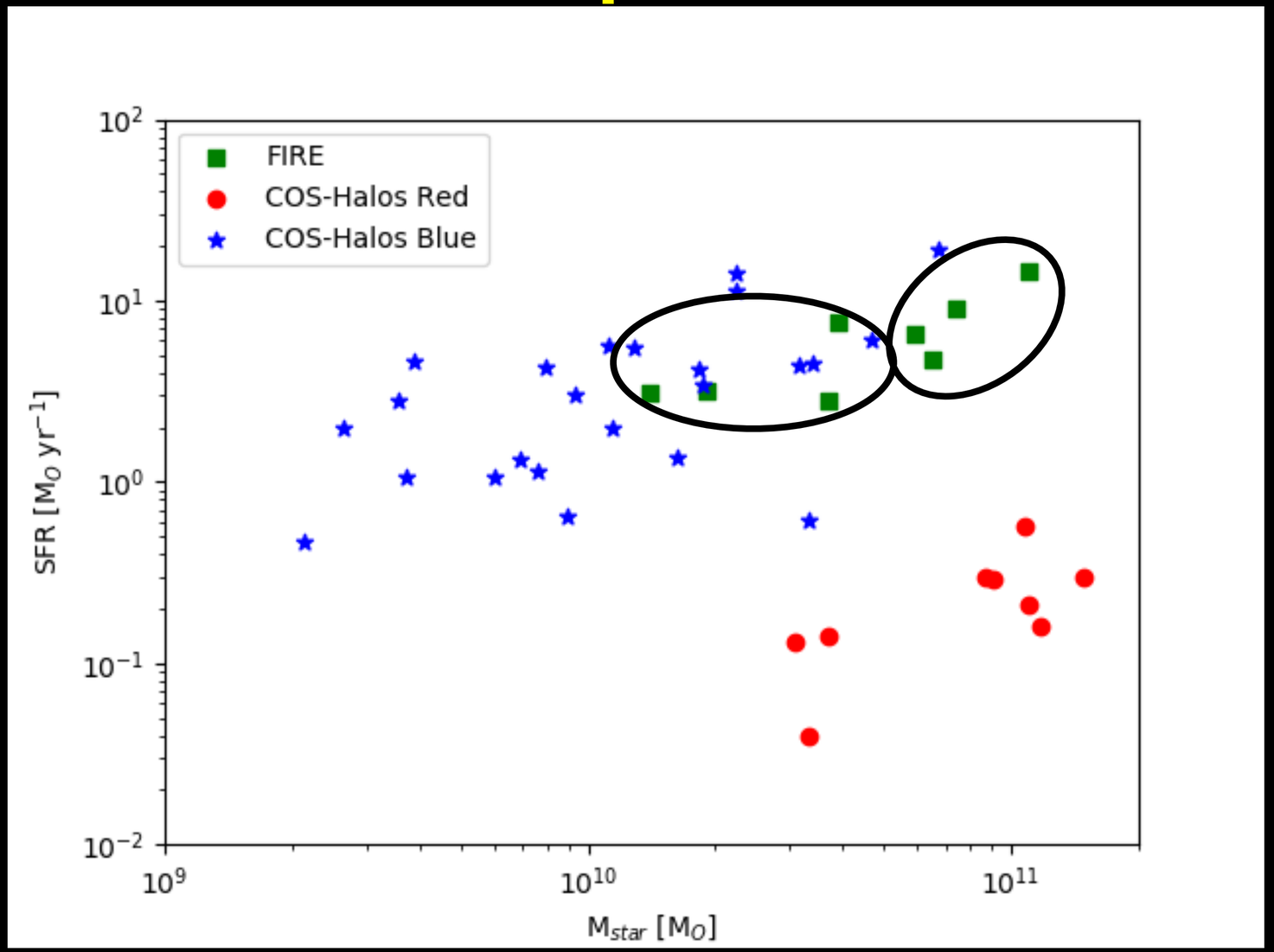
FIRE Simulations (particle-based)
Strength: Feedback

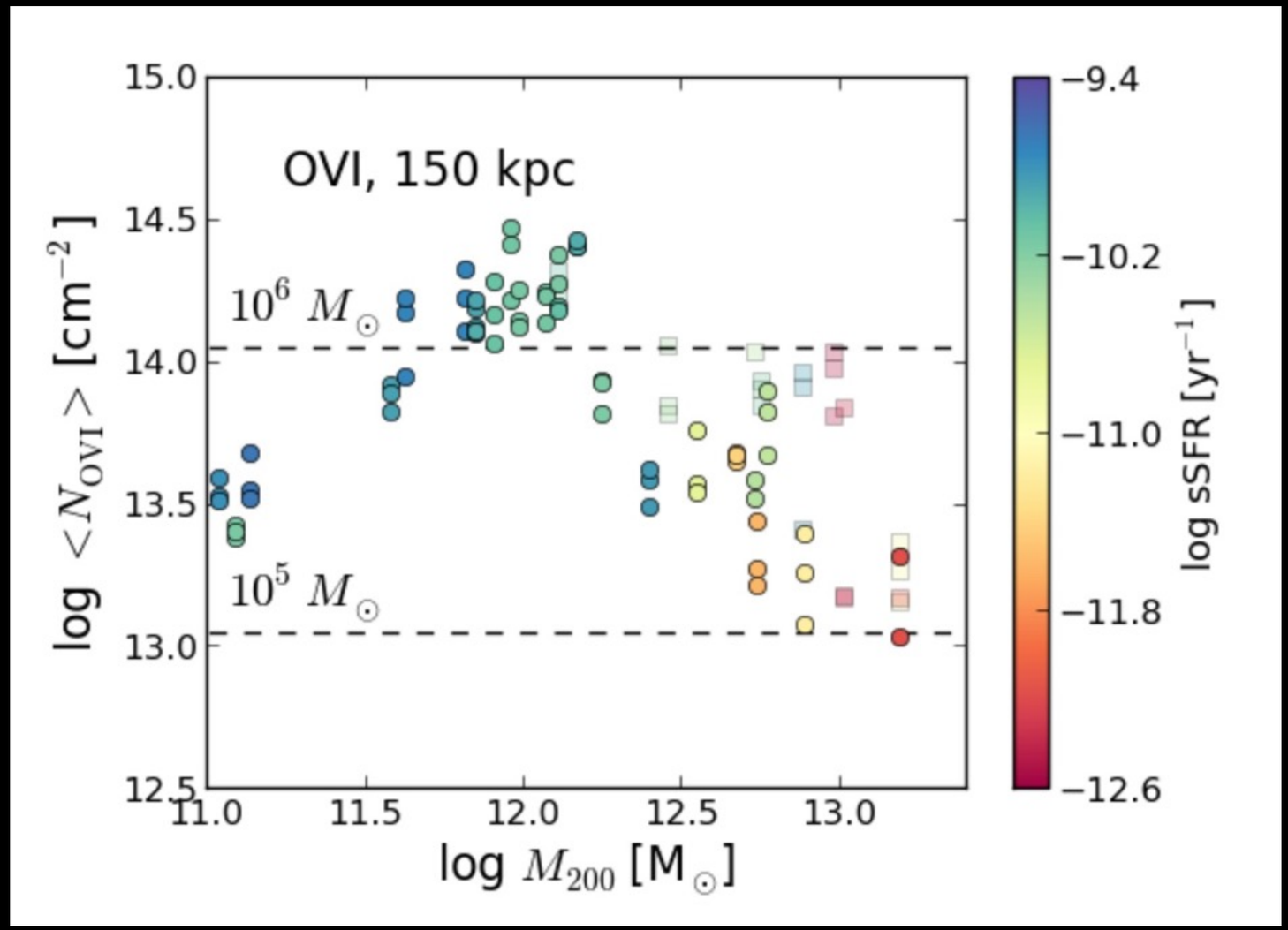
Best Fit Halo Sample



COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

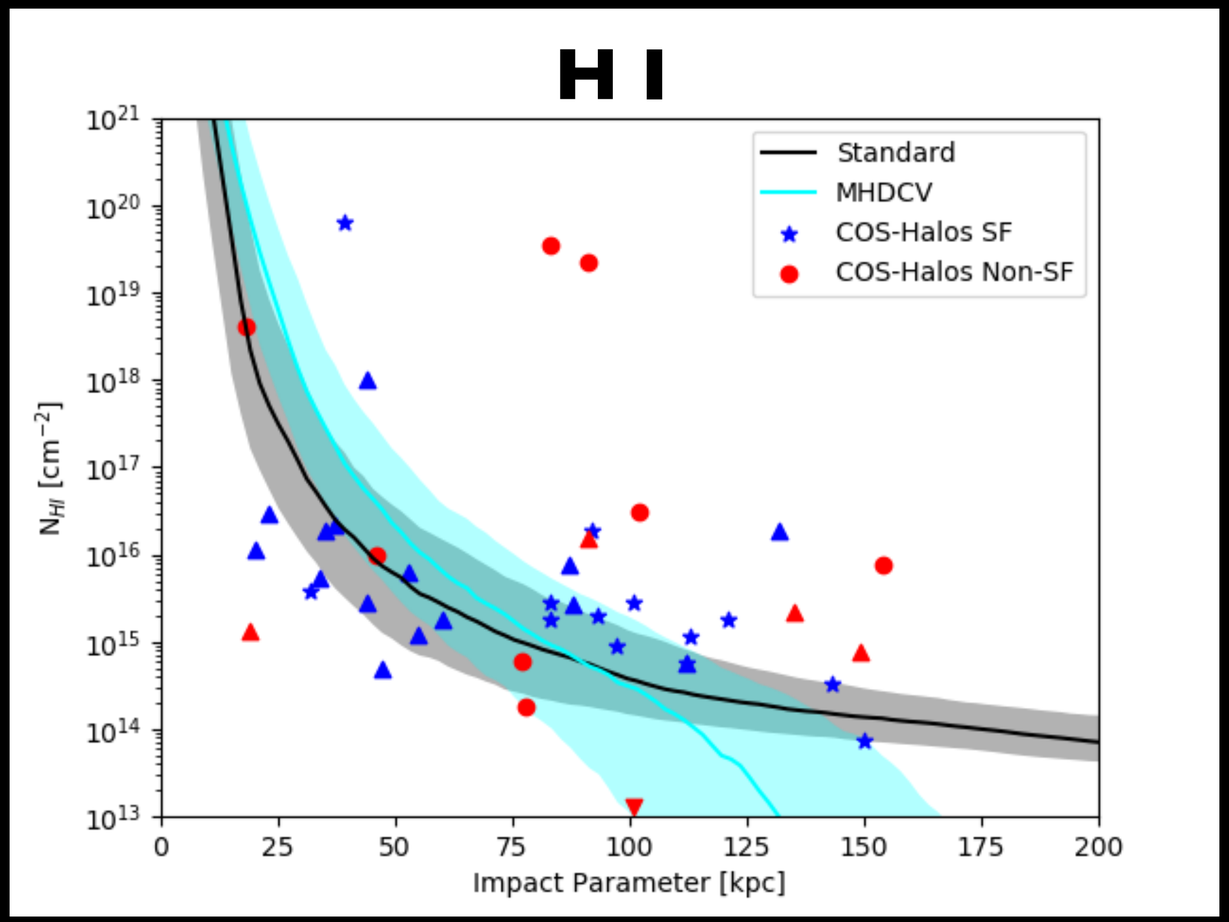
Column Density vs Halo Mass

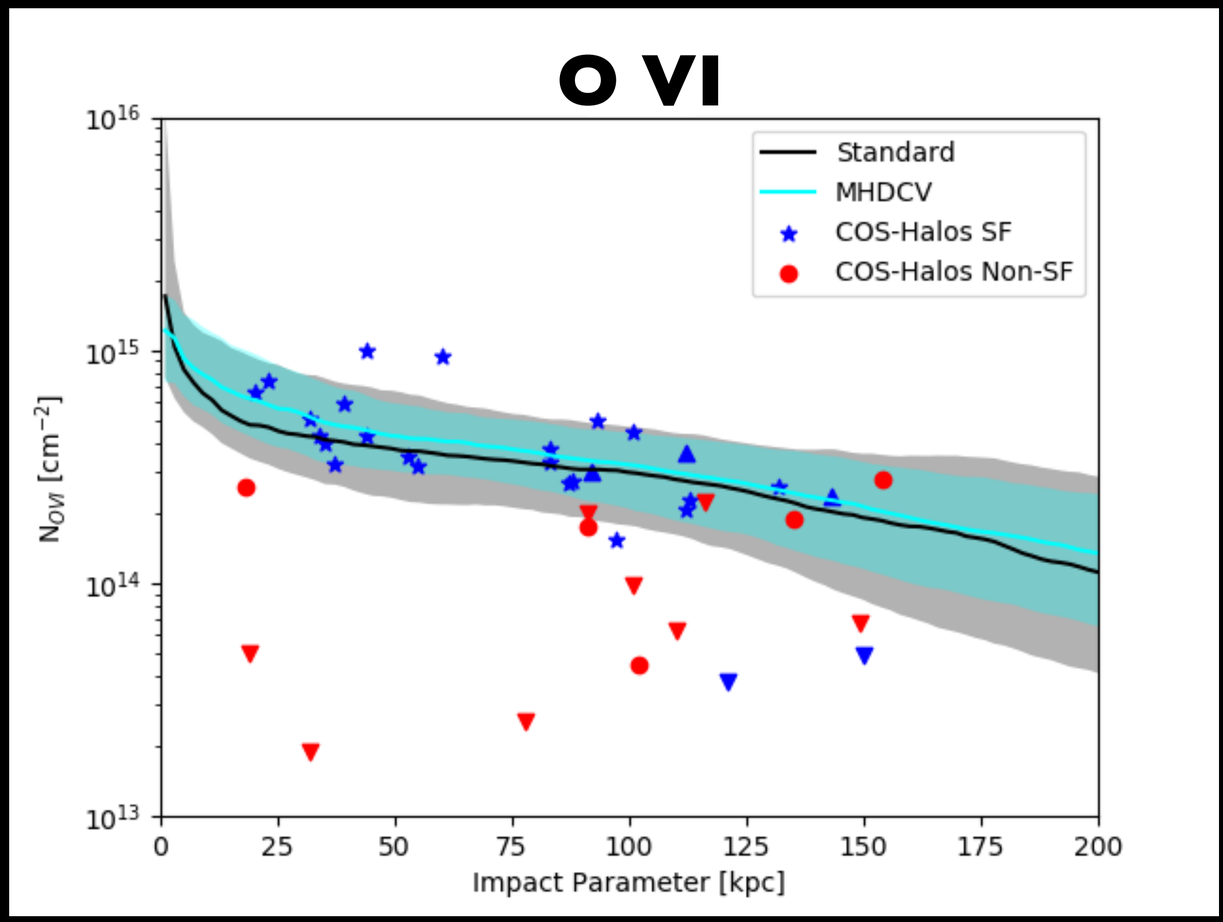


Oppenheimer+ 2016

FIRE Simulations (particle-based)
Strength: Feedback

Column Density vs Inclusion of MHD

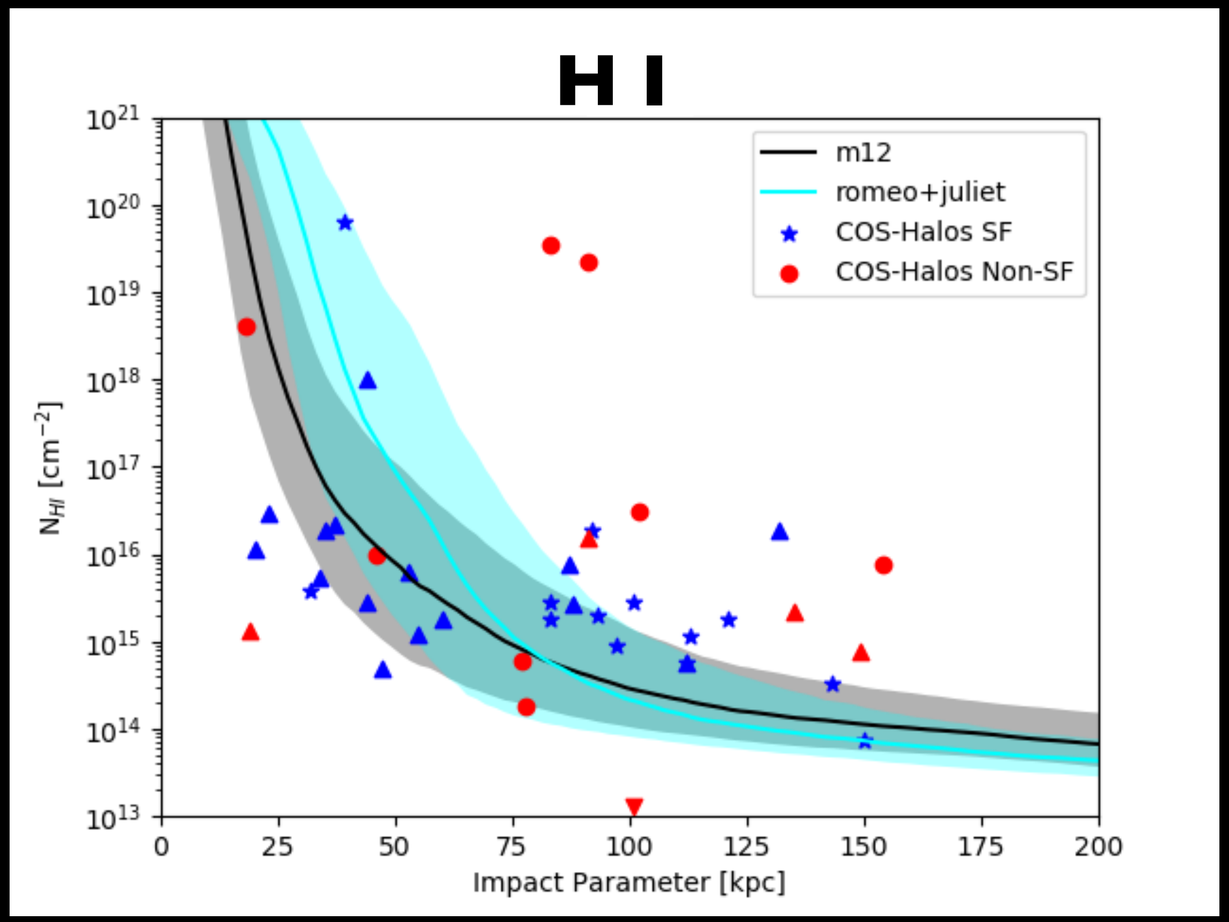


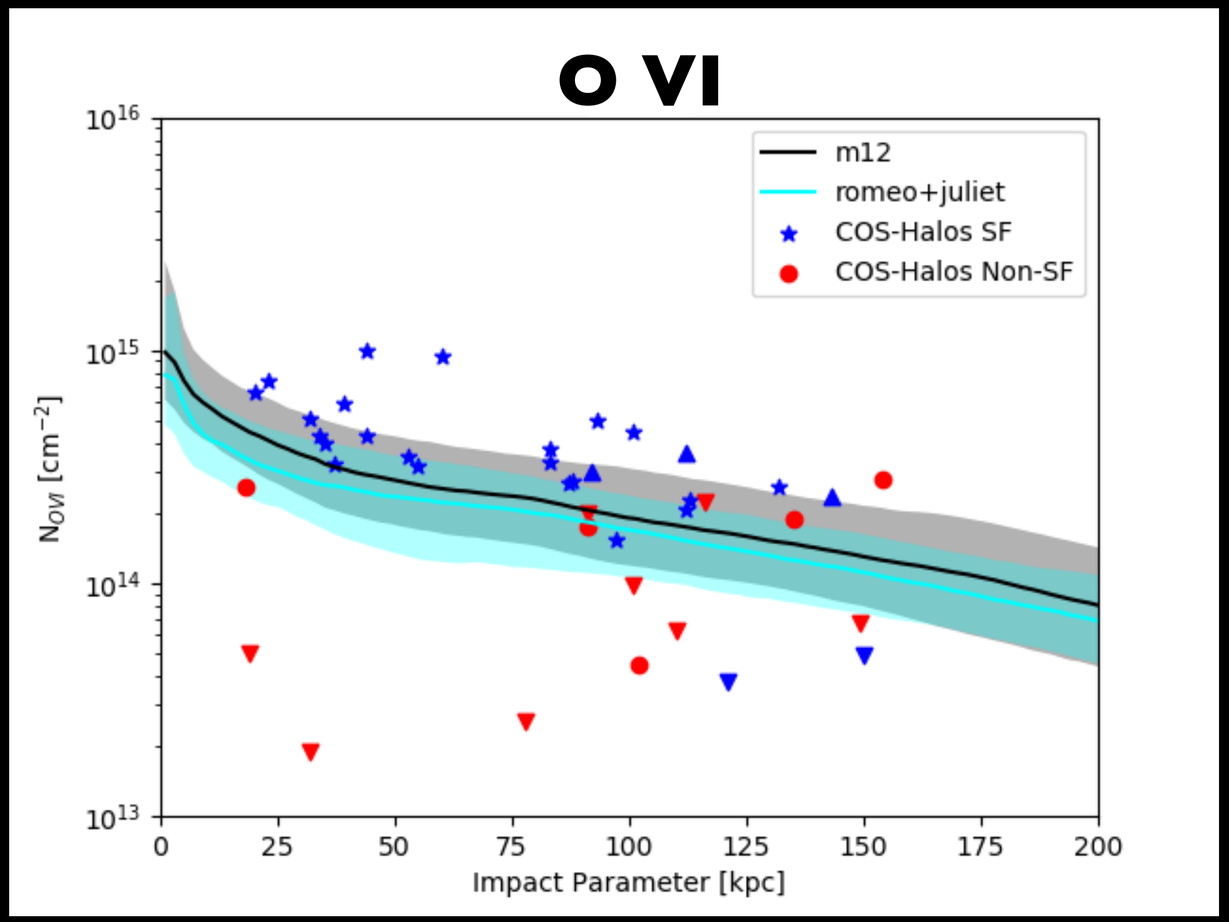


COS-FIRE (Hummels+ in prep)

FIRE Simulations (particle-based)
Strength: Feedback

Column Density vs Environment





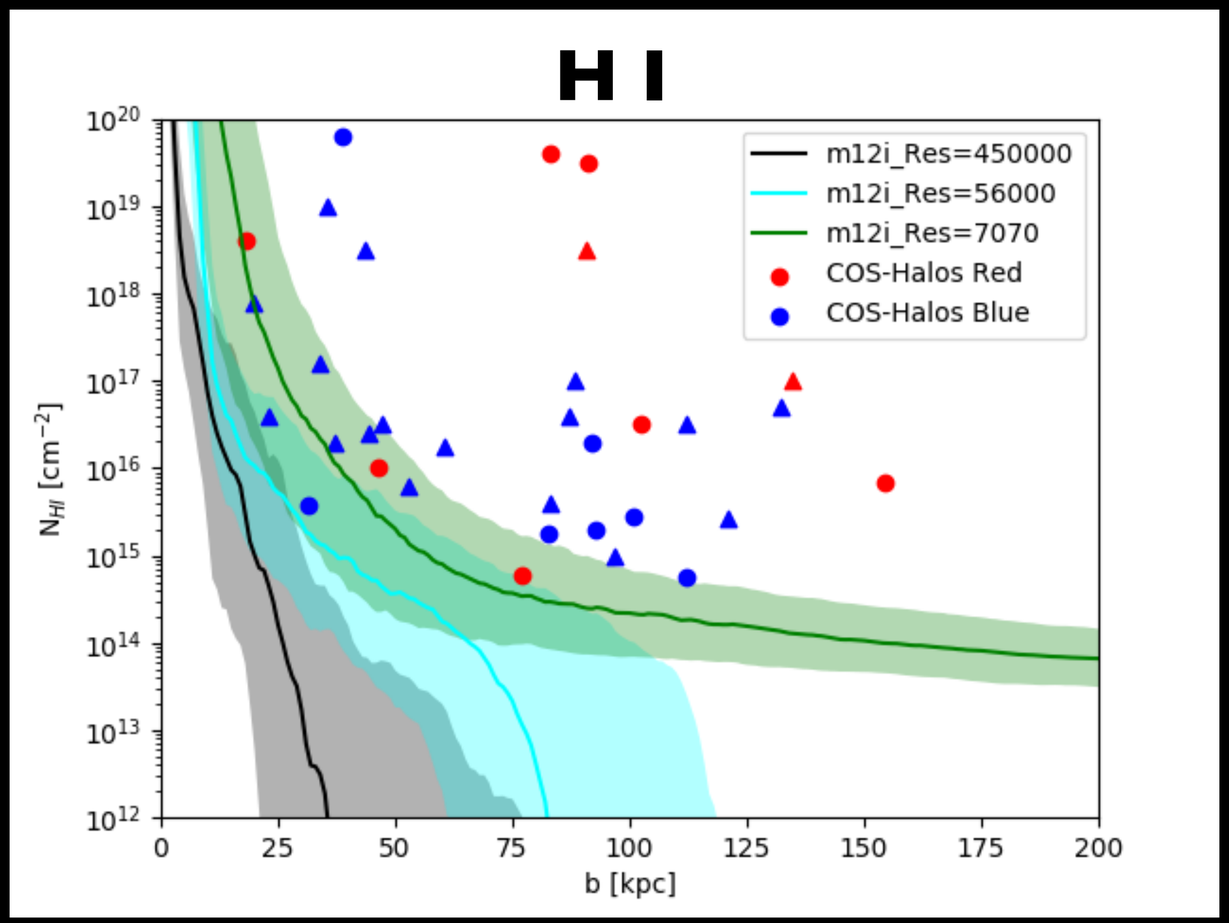
COS-FIRE (Hummels+ in prep)

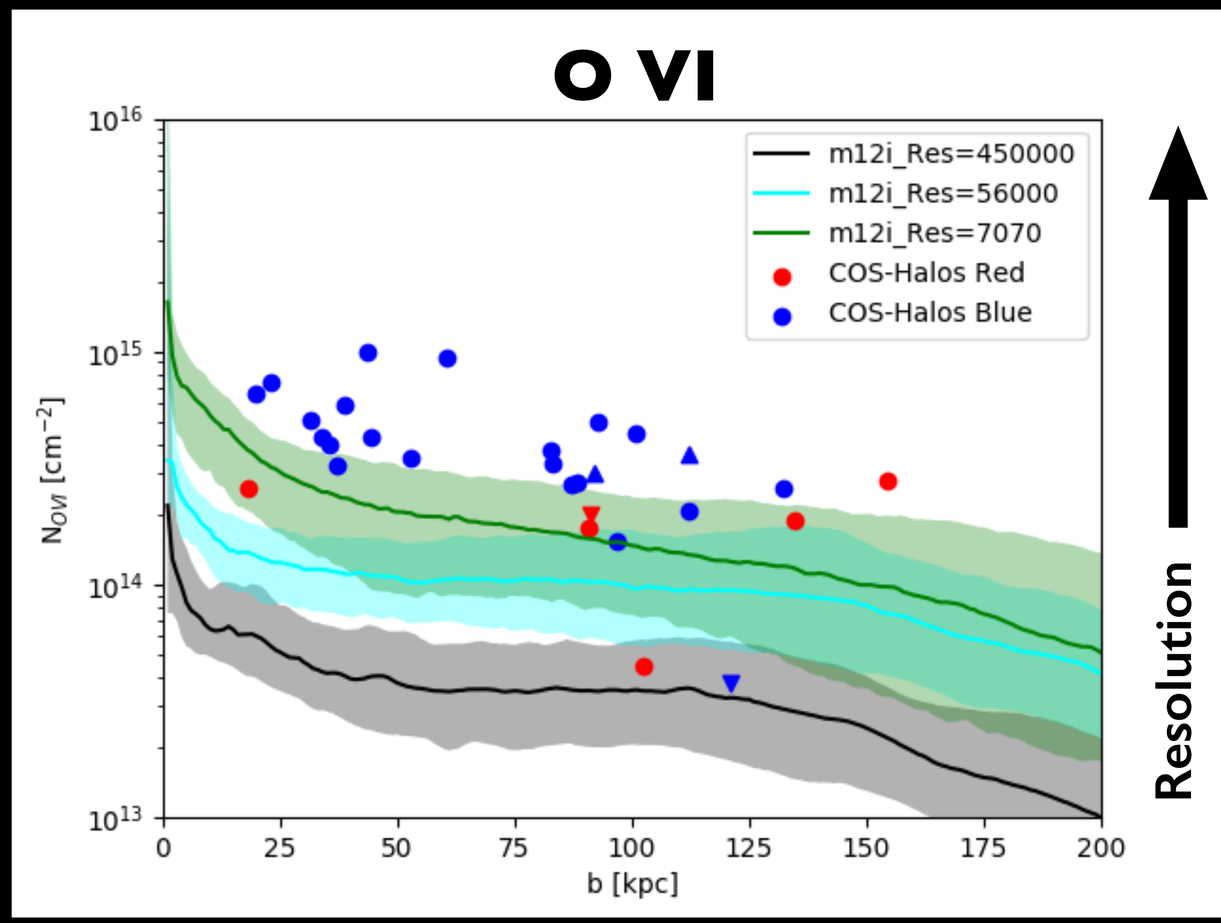
Conclusions

- Use Trident suite to post-process simulation data as synth observations (http://trident-project.org)
- Current cosmological hydro simulations do not well reproduce CGM
- New Tempest/FOGGIE runs better resolve halo (<1 kpc) and thermal instability increasing CGM column densities and kinematic structure
- Simulated FIRE CGM sensitive to halo resolution, halo mass
- Simulated FIRE CGM insensitive to galactic environment, B-fields
- Simulated FIRE sample reproduces COS-Halos oxygen without tuning

FIRE Simulations (particle-based)
Strength: Feedback

Column Density vs Resolution



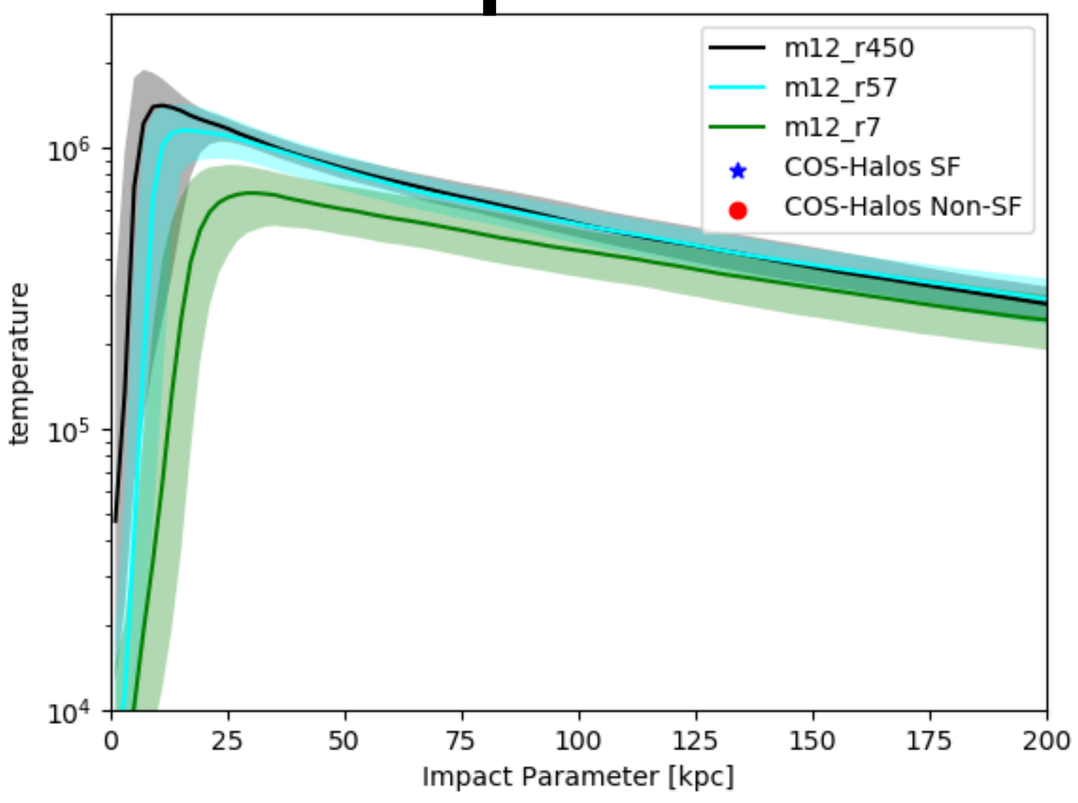


COS-FIRE (Hummels+ in prep)

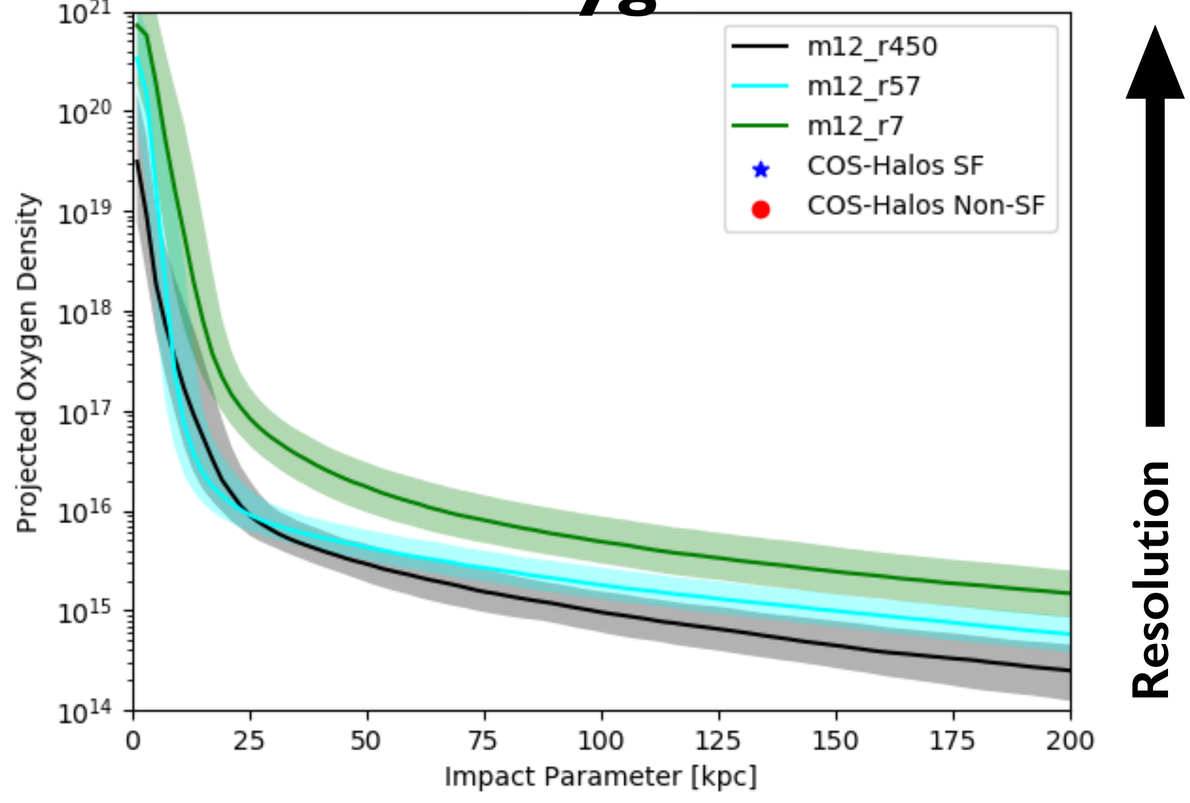
FIRE Simulations (particle-based)
Strength: Feedback

Physical Properties vs Resolution

Temperature



Oxygen



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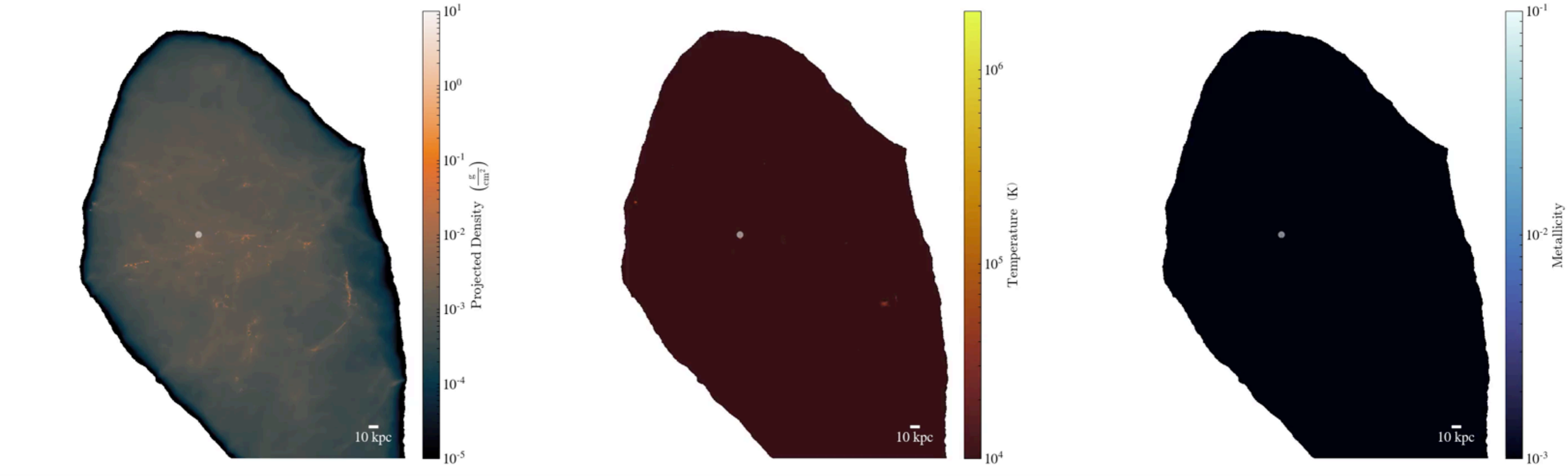
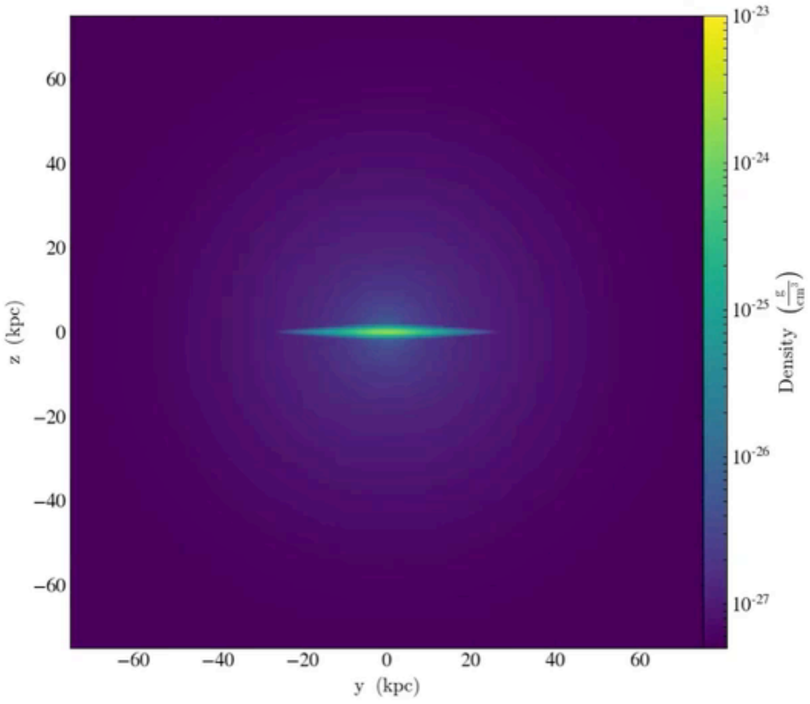
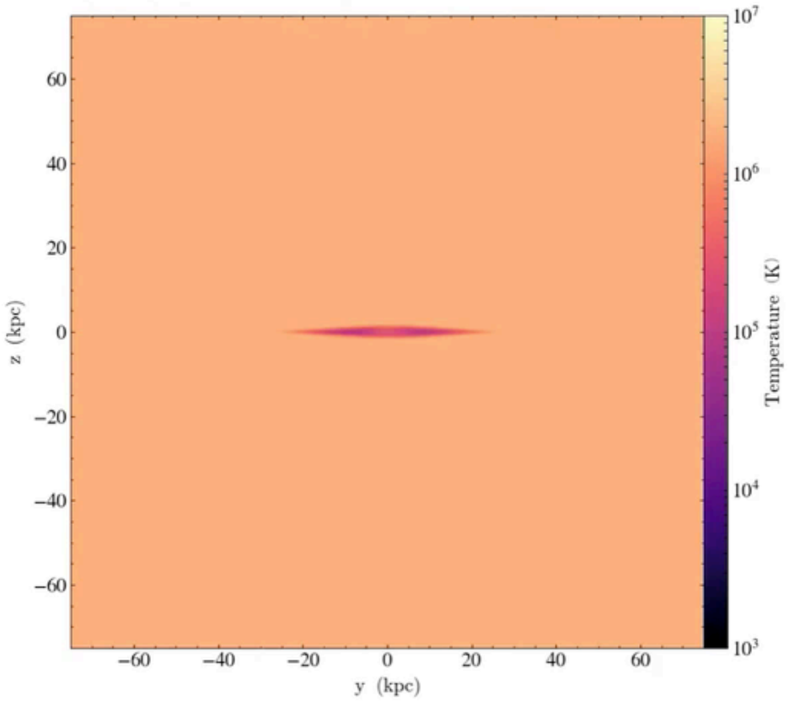
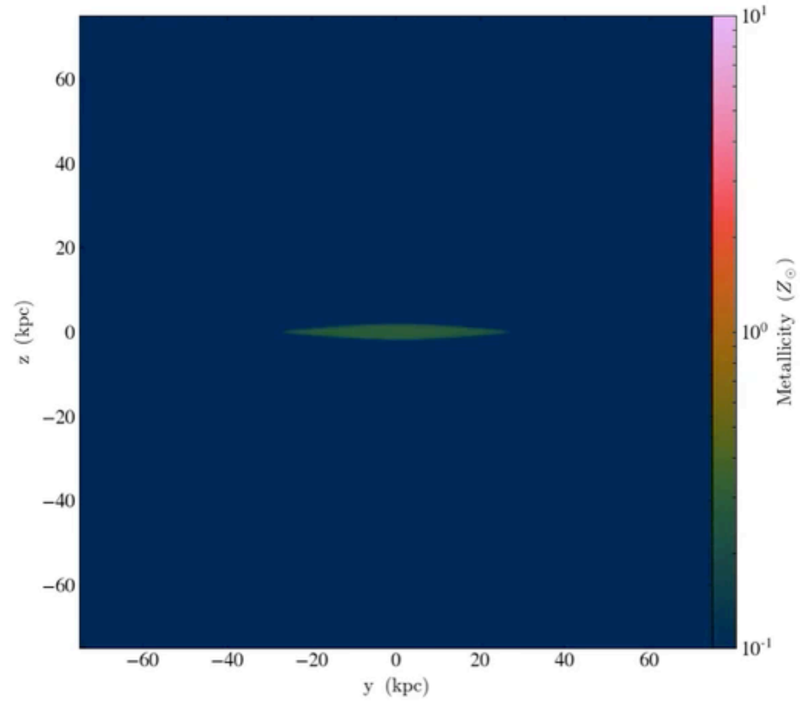


COS-FIRE (Hummels+ in prep)

Precipitation Simulation (grid-based)
Strength: Resolution







Silvia+ in prep