Andrew Hearin, Argonne National Lab

Forward-Modeling Cosmological Observables into the Nonlinear Regime
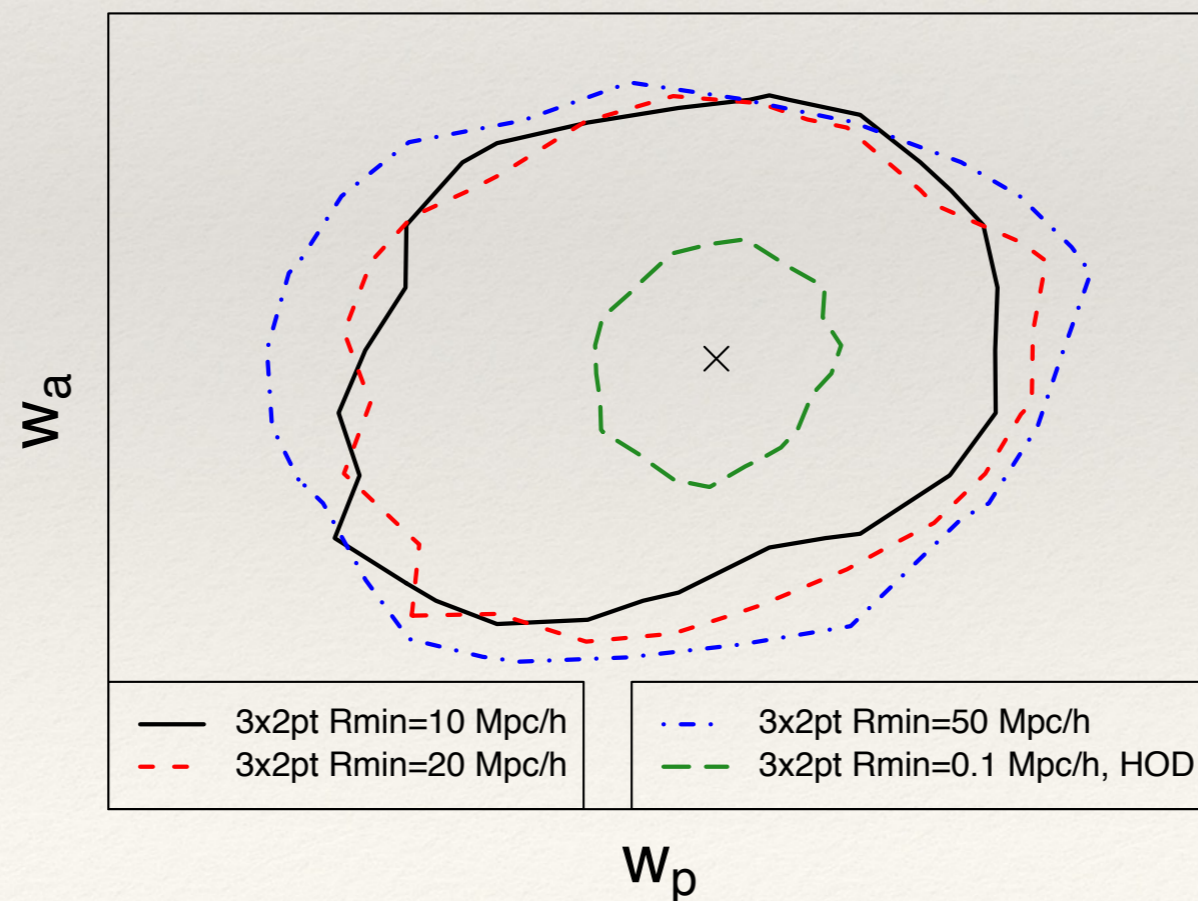
An Ambitious Cosmic Vision for a Future with High Discovery Potential

Gains from Small Scales

Proof of principle

2-4x improvement in DE constraints for Stage IV experiments

Improvements due to self-calibrating nuisance parameters
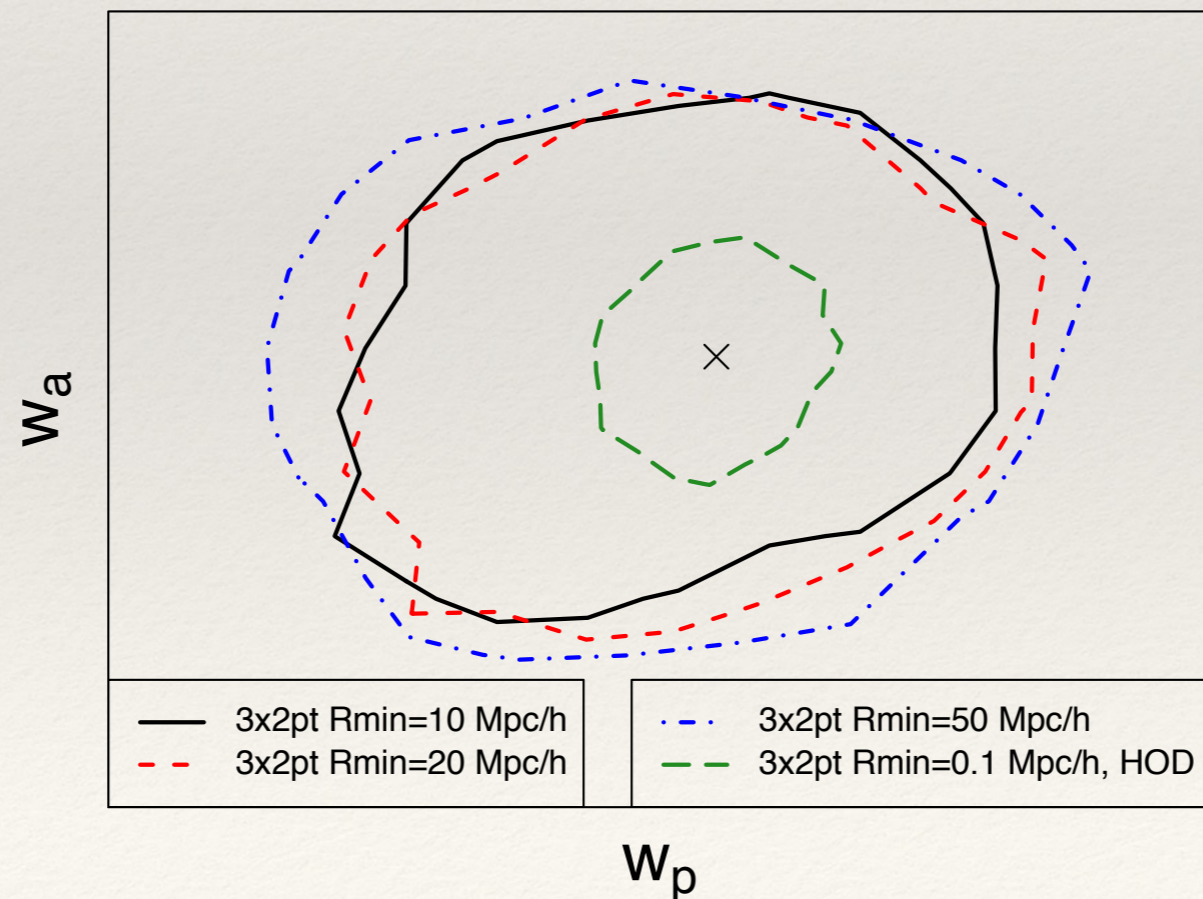from small-scale clustering and lensing

—— 3x2pt Rmin=10 Mpc/h	·–· 3x2pt Rmin=50 Mpc/h
– – 3x2pt Rmin=20 Mpc/h	– – 3x2pt Rmin=0.1 Mpc/h, HOD

—— 3x2pt Rmin=10 Mpc/h
– – 3x2pt Rmin=0.1 Mpc/h, HOD

·–· 3x2pt+cluster Rmin=10 Mpc/h
– – 3x2pt+cluster Rmin=0.1 Mpc/h, HO

w_a

w_a

w_p

w_p

Krause & Eifler 2016

Gains from Small Scales

We can surely do better, probably a lot

This exercise was for single-tracer probes
Far more information from multi-tracer cross-correlations

There is a **VAST** amount of additional constraining power
that we are simply throwing away if we only stick with single-tracer, quasi-linear probes

3x2pt Rmin=10 Mpc/h
3x2pt Rmin=0.1 Mpc/h, HOD

w_a

3x2pt Rmin=10 Mpc/h
3x2pt Rmin=20 Mpc/h
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3x2pt Rmin=0.1 Mpc/h, HOD

w_a

3x2pt+cluster Rmin=10 Mpc/h
3x2pt+cluster Rmin=0.1 Mpc/h, HO

w_p

Krause & Eifler 2016 w_p

Cosmic Visions Crossroads

Big picture choice for the future under discussion at this meeting

Quasi-linear "gold sample" cosmology

- Incremental mode-collecting for business-as-usual 1/sqrt(N) gains
- weak potential for genuinely novel discovery
- Safe path to improve existing constraints on existing vanilla models

Nonlinear multi-tracer cosmology

- Forward-model nonlinear clustering, gg-lensing, cluster cross-correlations
- Actually use the full predictive power of simulations
- Take seriously the LSST/DESI opportunity to genuinely probe new physics

Forward Modeling Approach
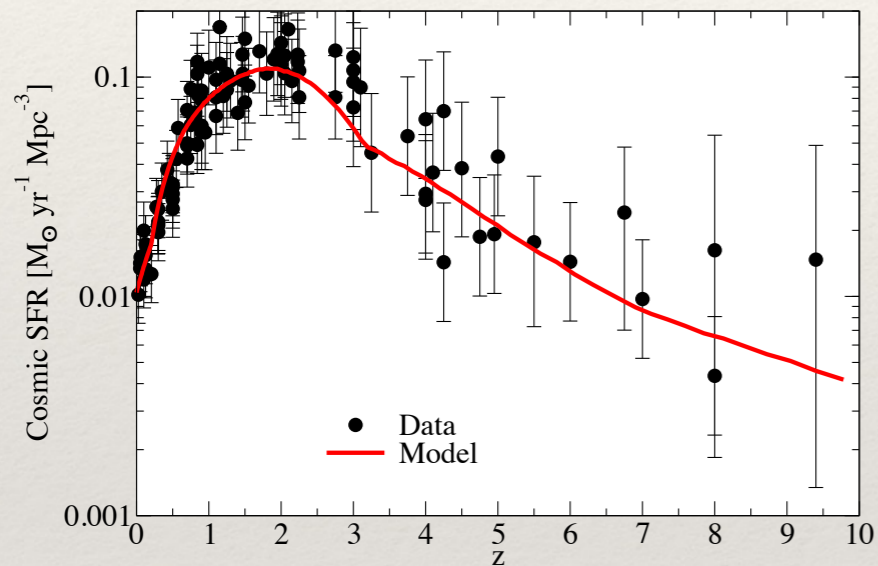
Solution to dimensionality curse
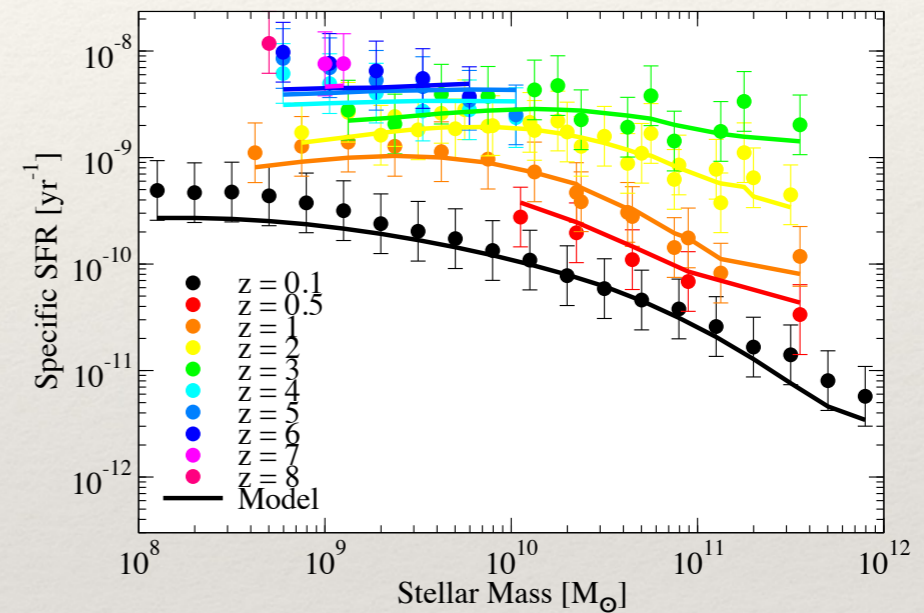
Model the differential quantity and integrate
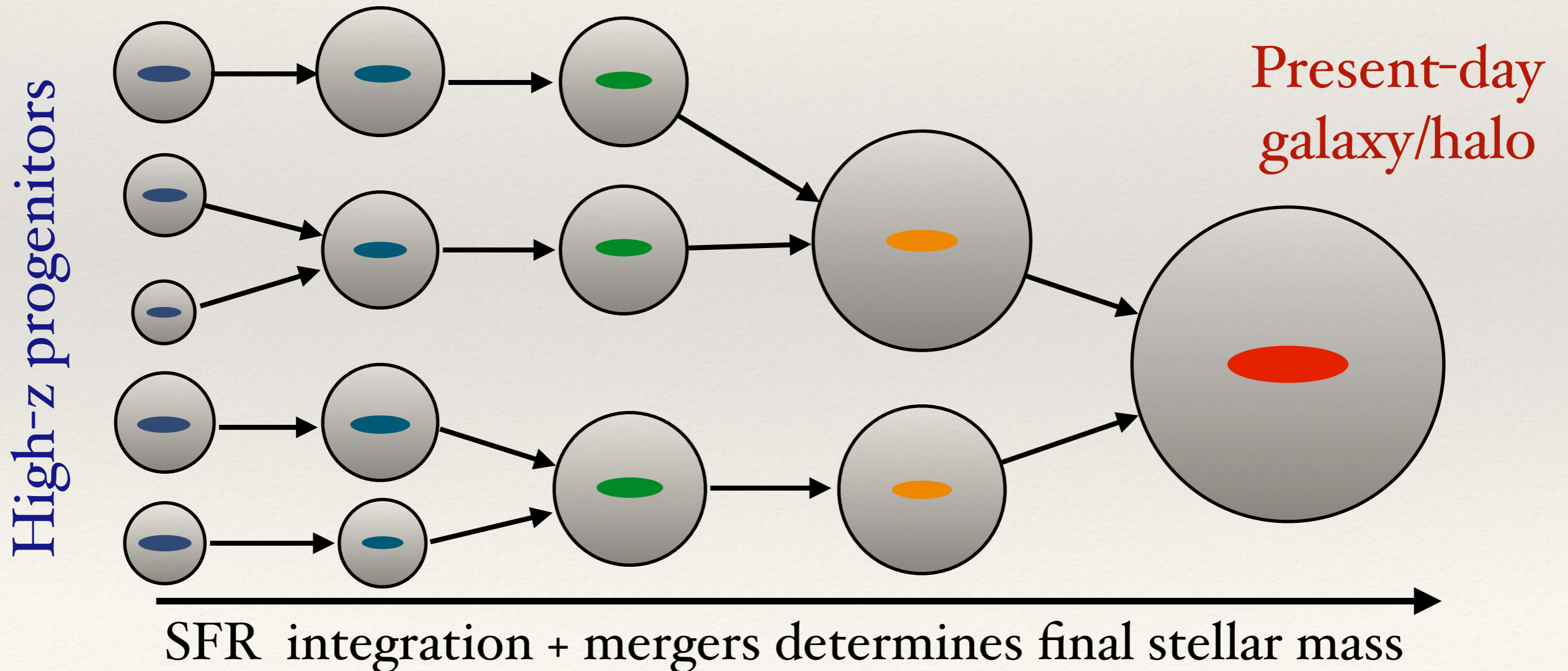
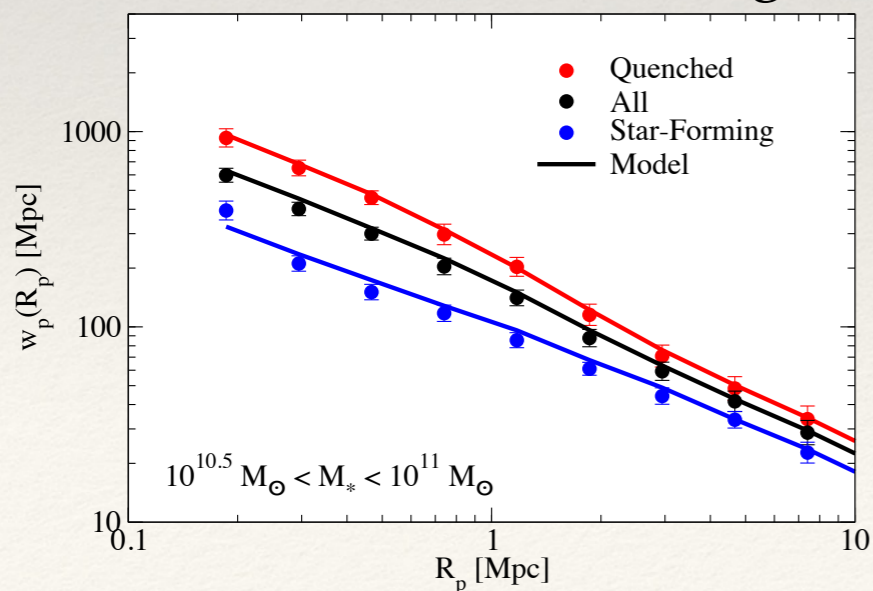Program is Well Underway
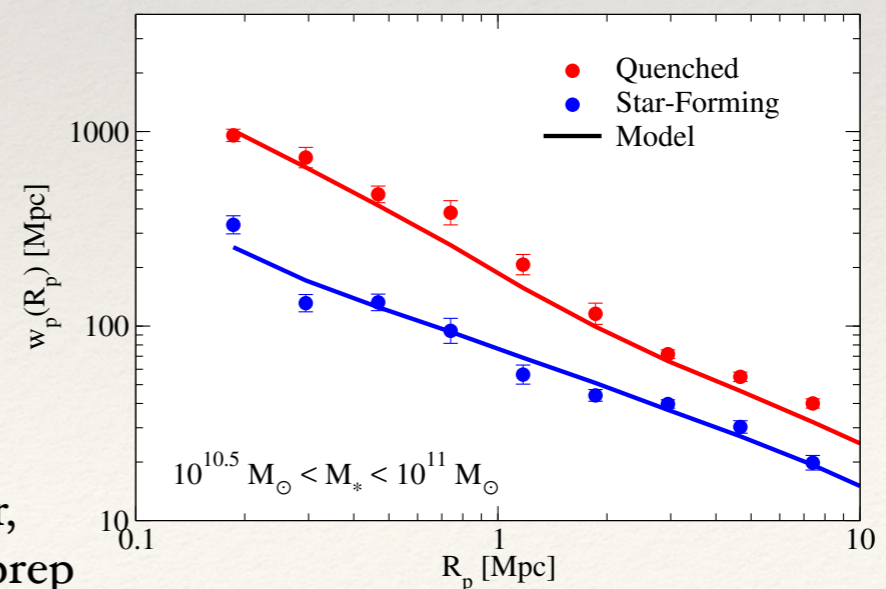
Proof of principle: best-fit UniverseMachine

SFR(z)
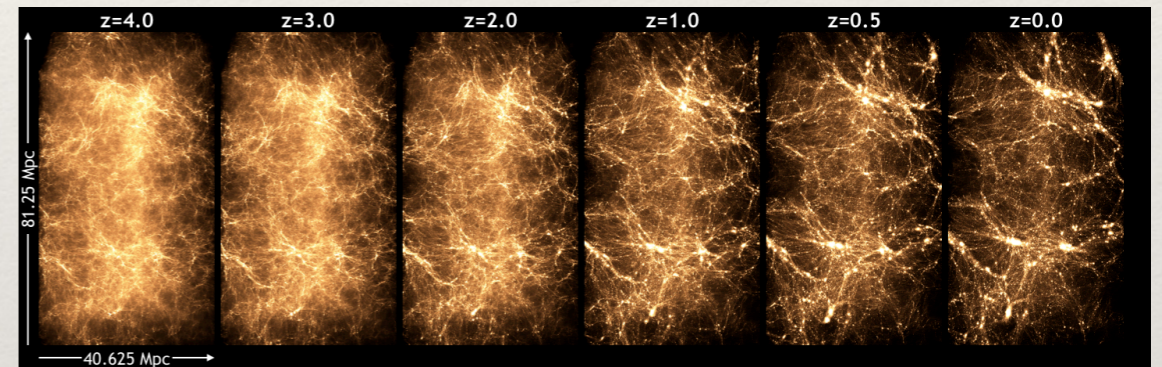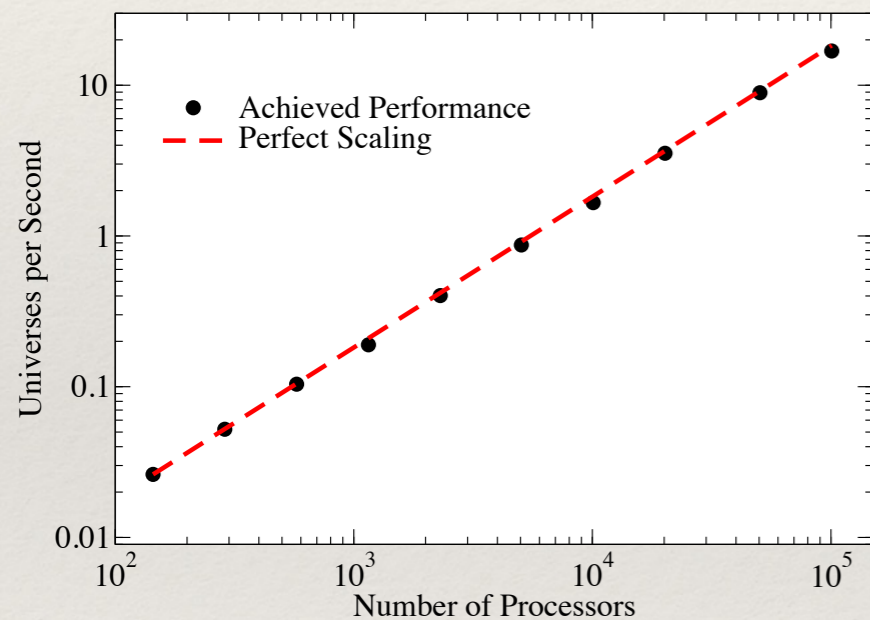
sSFR(M*, z)

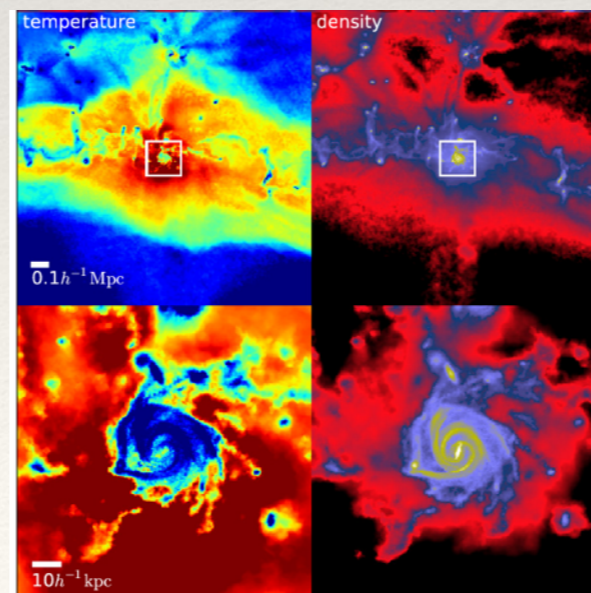z=0 SDSS clustering

z=0.7 PRIMUS clustering

Program is Well Underway

Program is not simulation-limited

Model built for scalability from ground-up

80/100 Mira-Titan sims already on disk

$L_{box}\sim 2$ Gpc; $M_{ptcl} \sim 10^{10}$

800 Mpc adiabatic hydro currently running at $z < 1$

Program is Well Underway

Program does not require "solving" galaxy formation

What is needed scientifically?

1. **Modeling**: coarse-grained model that is **flexible, efficient, predictive**
2. **Modeling**: traditional SAMs and hydro sims are critical to science validation
3. **Observations**: ~DESI-volume spec sample that is color-complete (ok if NOT representative!)
4. **Simulations**: ~Gpc adiabatic hydro suite resolving ~10^{10}Msun halos
5. **Simulations**: ~3 Gpc DM suite resolving ~10^{10}Msun halos

What resources do we need to accomplish this?

1. **Stable R&D funding**: modeling effort is long-term and cross-cutting
2. **Stable R&D funding:** truly collaborative cross-WG analysis requires serious software engineering
3. **Stable R&D funding**: simulation campaign cannot be piecemeal, requires systematic FTE(s)