Prospective Constraints on the Mass Distribution of the First Stars from the 21-cm Global Signal

Thomas Gessey-Jones

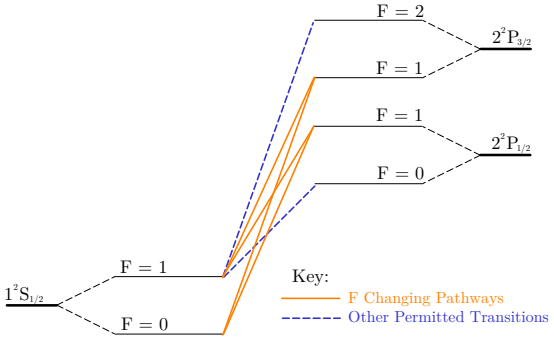
6^{th} Global 21-cm Workshop

In collaboration with Nina Sartorio, Harry Bevins, Anastasia Fialkov, Eloy de Lera Acedo, Will Handley, and Rennan Barkana

The Myriad Effects of the First Stars on the IGM

While Alive:

- WF Effect
- Lyman and CMB Heating
- Lyman-Werner Feedback
- Ionization



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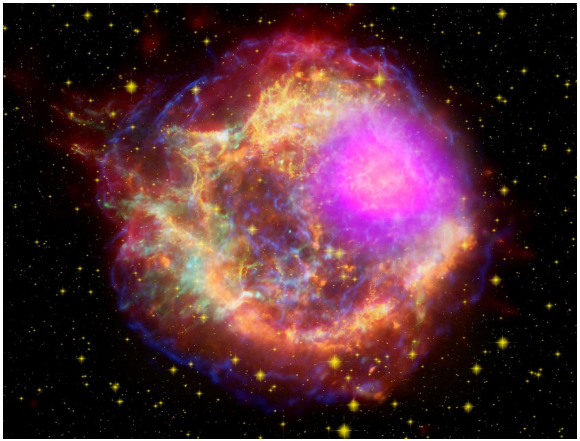


NASA/DOE/Fermi LAT Collaboration

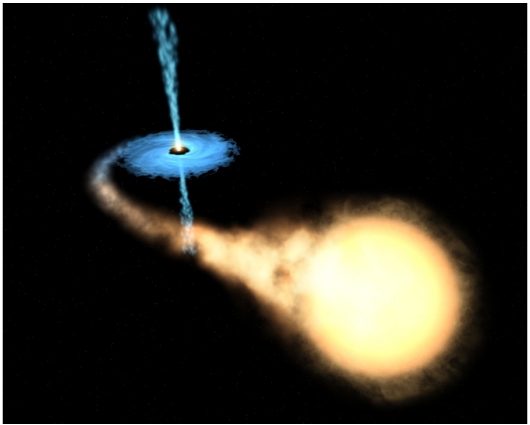
In Death:

- Shock Heating
- Cosmic Ray Heating
- Metal Enrichment
- More Ionization

The Myriad Effects of the First Stars on the IGM

Afterlife:

- X-ray Heating
- X-ray Ionization



ESA, NASA, and Felix Mirabel

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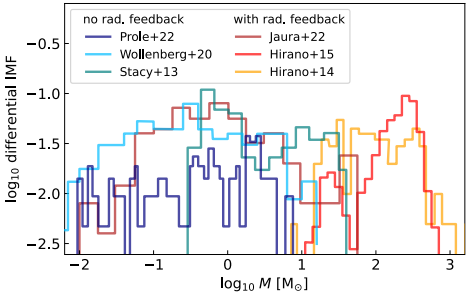
Uncertainties in the Mass Distribution of the First Stars

Theoretical Uncertainty:



Klessen and Glover 2023

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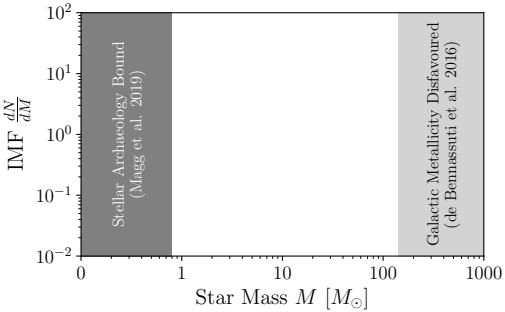
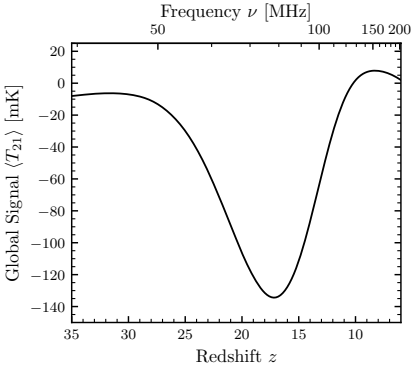
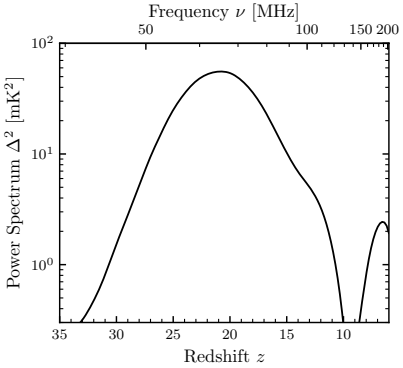


Impacts of the First Stars IMF on the 21-cm Signal

Effects Included:





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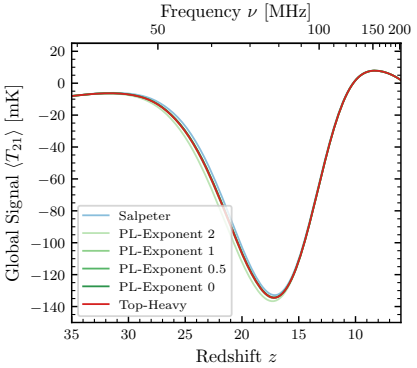
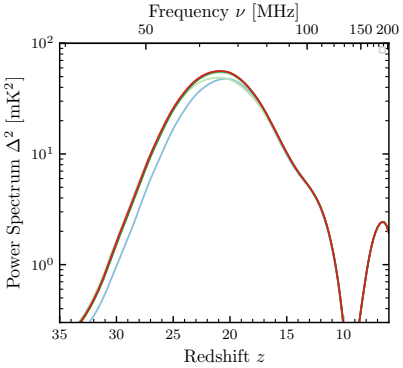
Effects Included:

- Lyman Emission

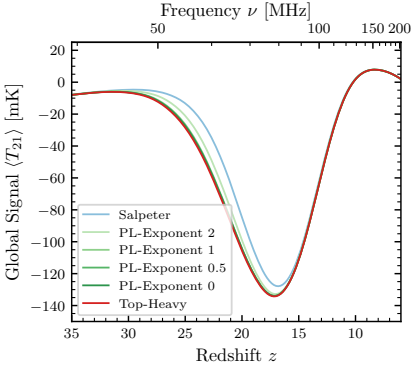


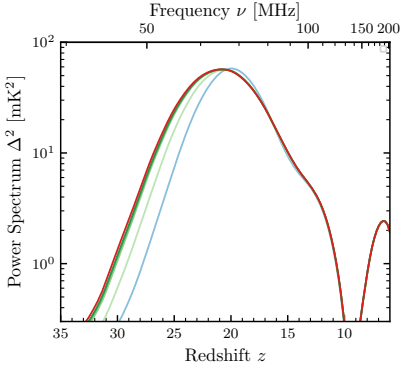


Impacts of the First Stars IMF on the 21-cm Signal

Effects Included:

- Lyman Emission
- Finite Lifetimes





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Effects Included:

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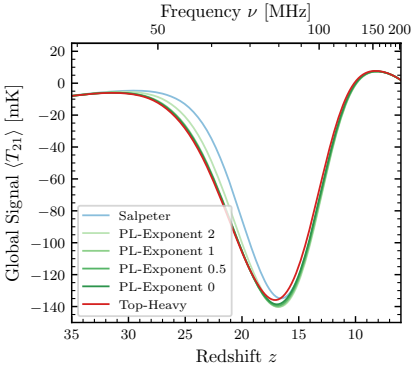

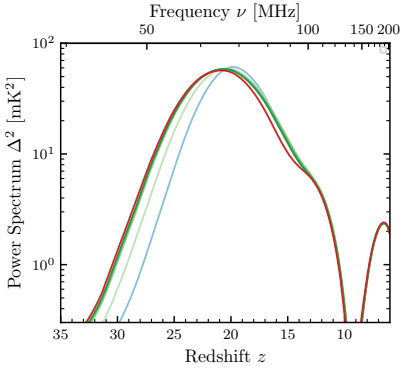

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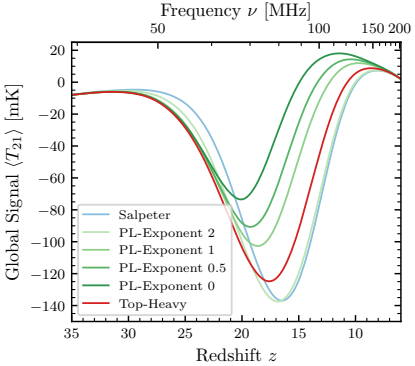

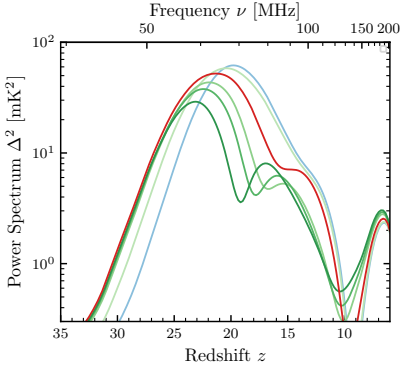

Are these Impacts Measurable?

Challenges:

By what?

Foregrounds and Experimental systematics

Degeneracies with other astrophysics

Quantifying distinguishing power in an interpretable way

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Consider the different scenarios from de Lera Acedo et al. 2022

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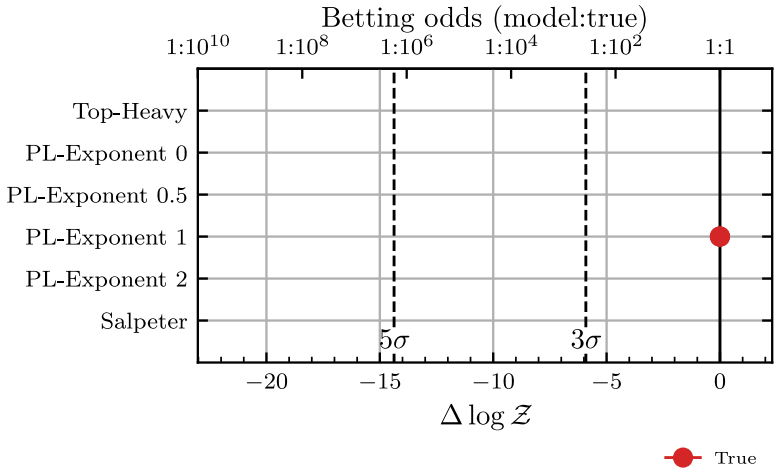
Bayesian approach, marginalizing over astrophysics

Are these Impacts Measurable?

Challenges:	Methodology:
By what?	Forecasts for REACH
Foregrounds and Experimental systematics	Consider the different scenarios from de Lera Acedo et al. 2022
Degeneracies with other astrophysics	Bayesian approach, marginalizing over astrophysics
Quantifying distinguishing power in an interpretable way	Use nested sampling and Bayes' ratio, $\Delta \log(\mathcal{Z})$

Probing the Pop III IMF with REACH



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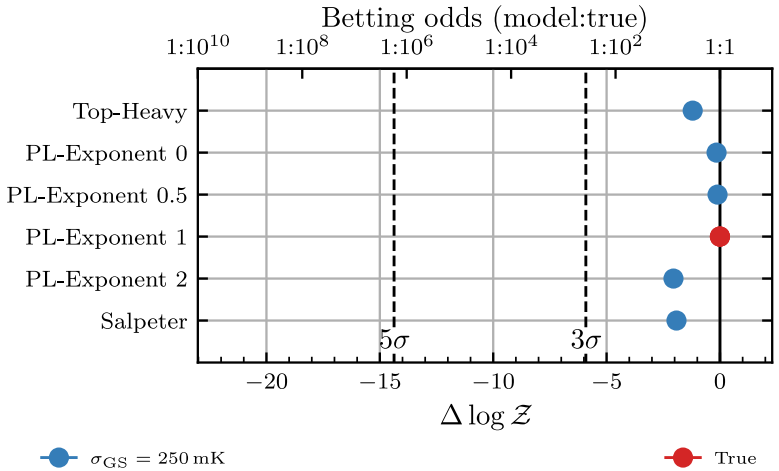

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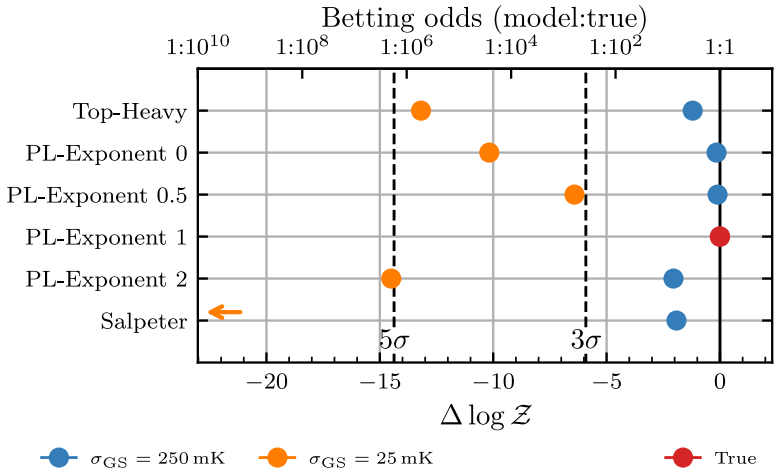

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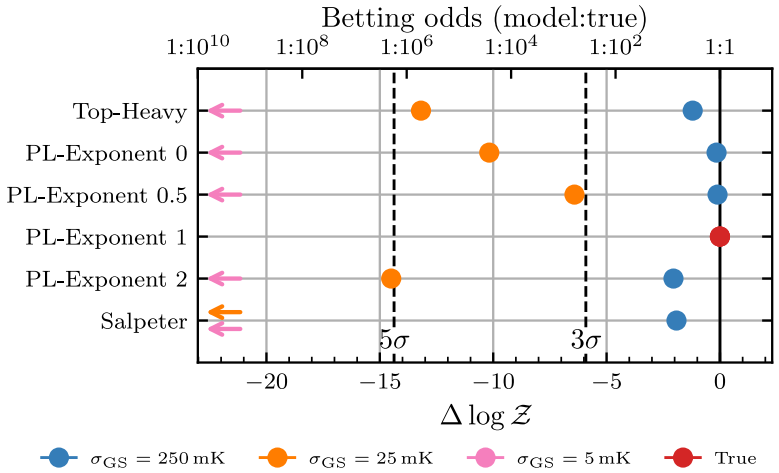

Summary of our Findings

- The **initial mass function of the first stars has a strong impact on the 21-cm signal** from cosmic dawn to the beginnings of the epoch of reionization
- A **Bayesian analysis** allows us to see what mass function is favoured by a data set while rigorously accounting for uncertain astrophysics
- Applying this to the forecast **REACH** fiduciary sensitivity of **25 mK**, we find a **3** σ **detection** of the correct mass function
- Pre-print paper coming soon, with forecasts for SKA1-LOW and joint analyses too