Can Dwarf Galaxies Host the First Stars in the Universe?

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- Andrew Benson (Carnegie Observatories)
- Mike Shull (CU-Boulder)

- Long Yan Yung (USF student, see poster at this workshop)
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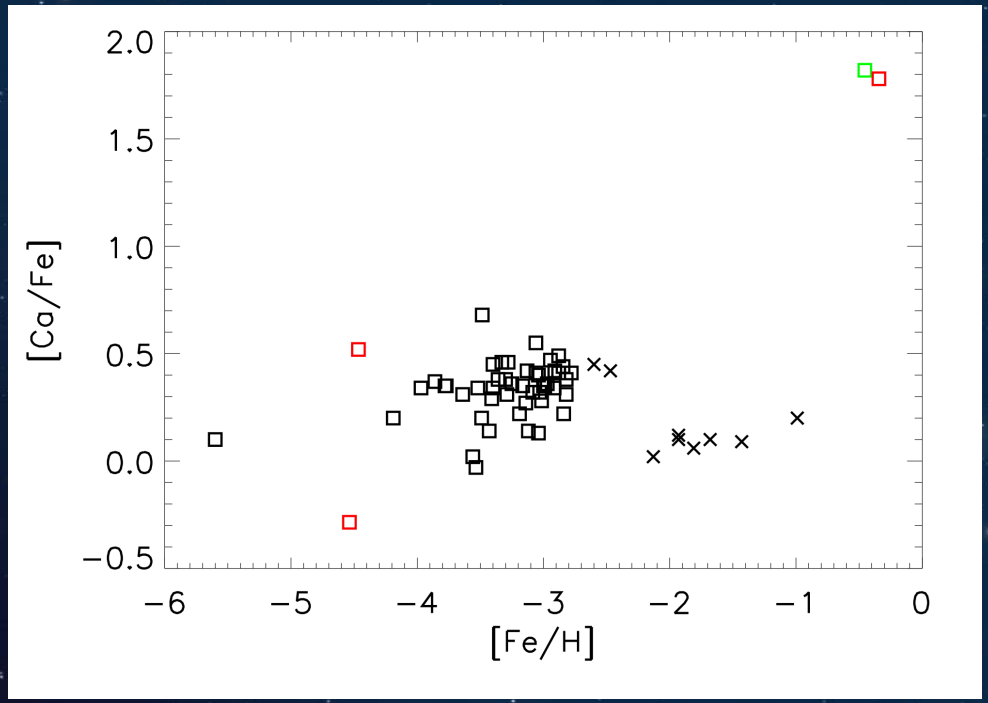
The 99 (47?) percent…

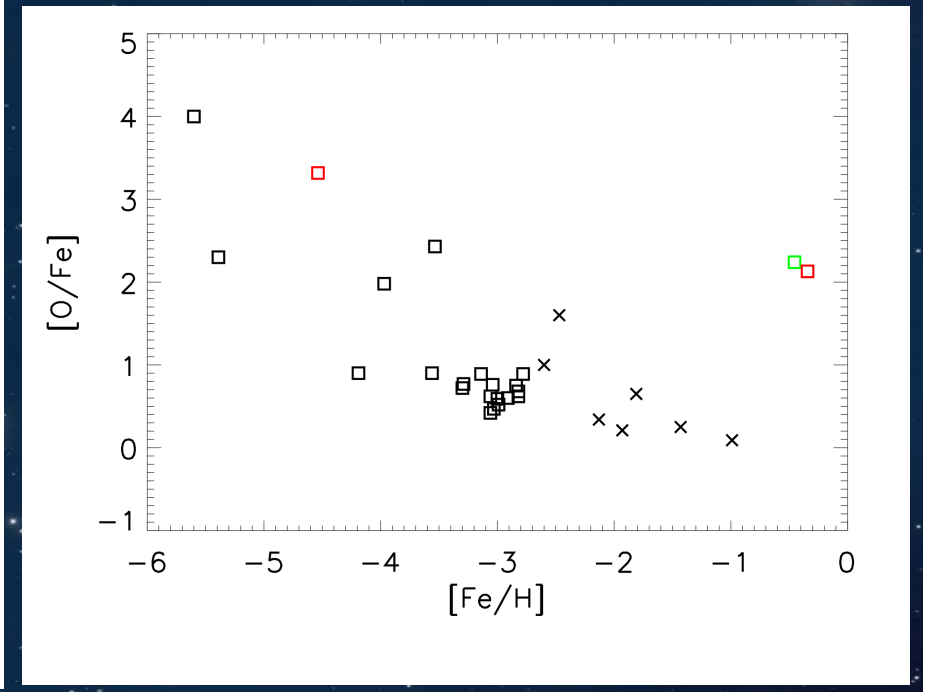
- Could these systems have hosted the first stars, and be cosmological survivors of galaxy assembly and reionization?

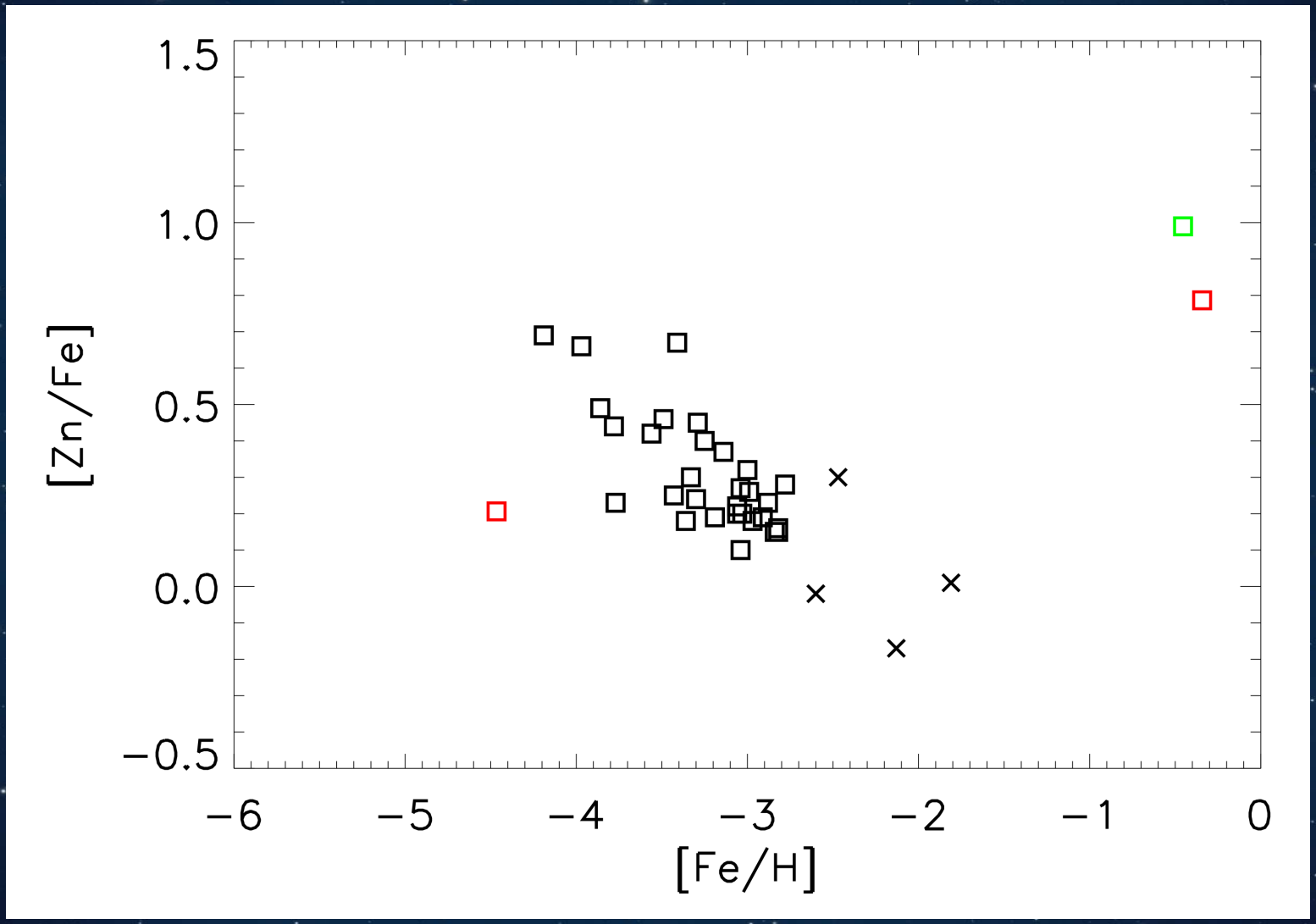
- How important were they for reionization, and cosmic metal enrichment? What are the observed patterns relative to other local universe systems?

Metal abundance trends in dwarfs:

- Increasingly clear that local gas-poor dSph systems, many of them very old, have similar relative metal abundance patterns to those in very metal-poor Galactic halo stars (Frebel 2012, Brown et al. 2012, and others)

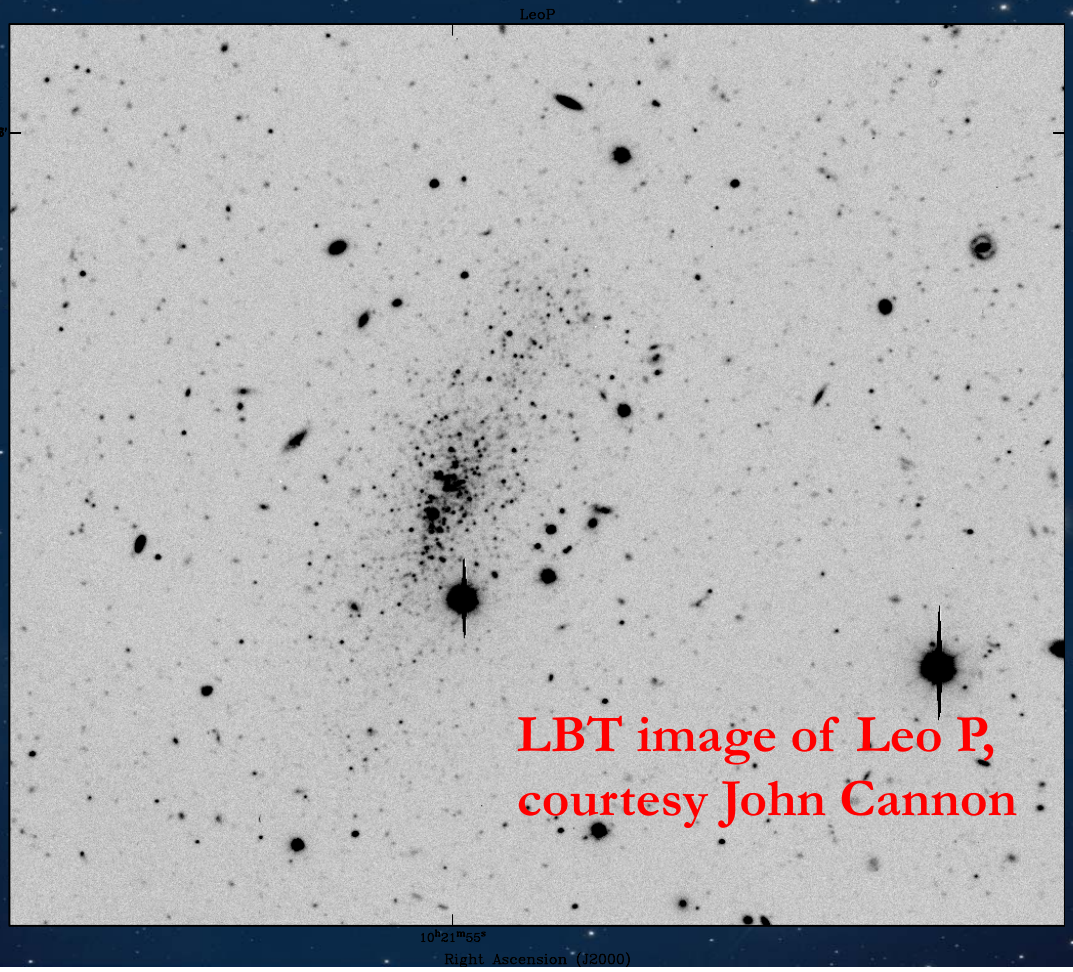





1.5
1.0
0.5
0.0
−0.5
[Zn/Fe]
−6
−5
−4
−3
−2
−1
0
[Fe/H]

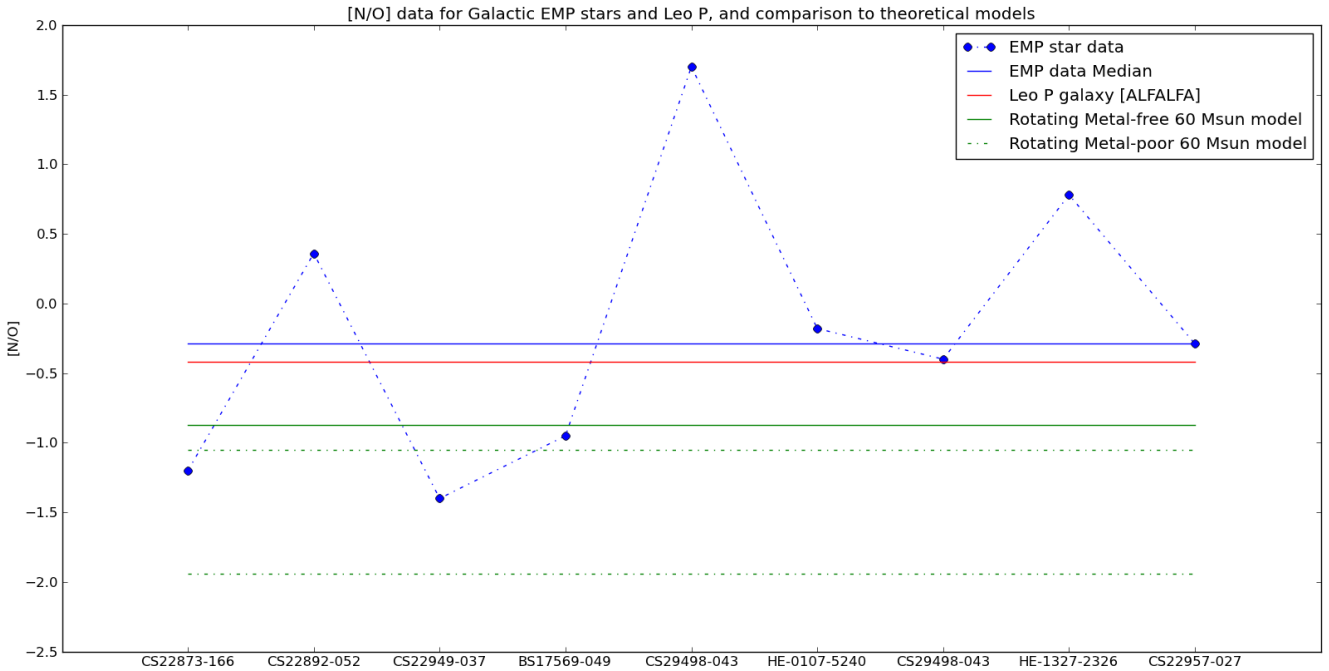
Bringing ALFALFA into this:

- Recent discovery of very metal-poor gas-rich dwarf irregular galaxy Leo P with followup spectroscopy on KPNO and LBT/ MODS (Skillman et al. 2013)

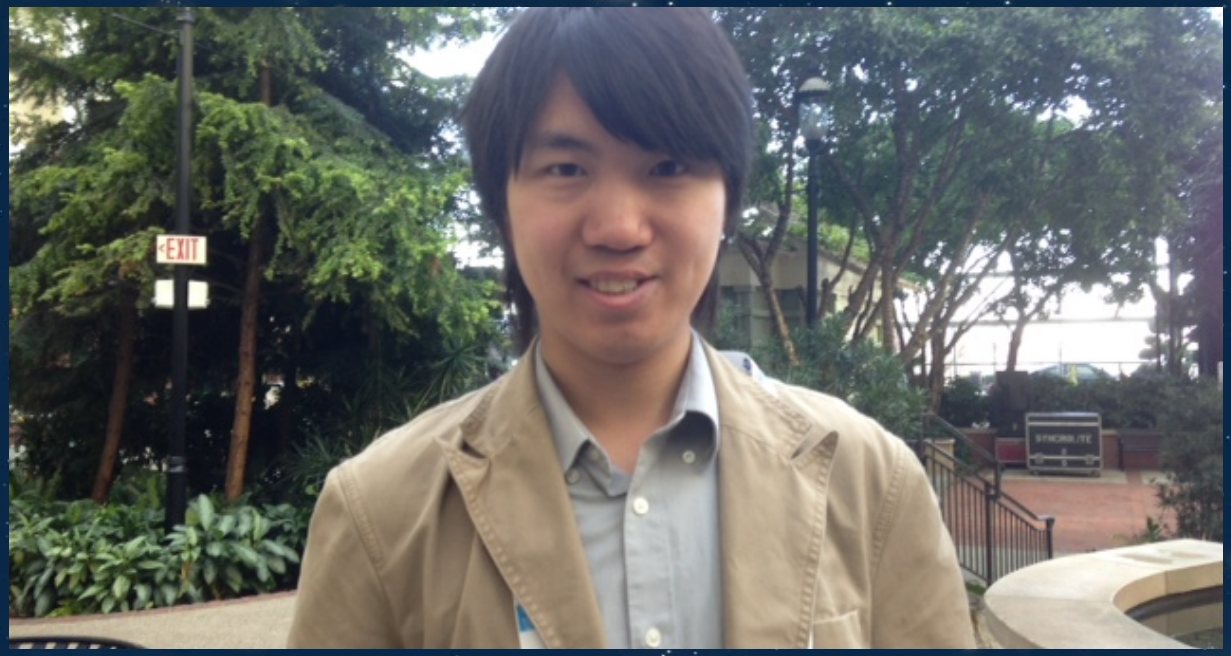


LBT image of Leo P, courtesy John Cannon

- Many local dSph galaxies show similar abundance trends as the EMP halo stars, and strikingly close mean values for many commonly measured elements between the two datasets.
- A close match in [N/O] values between Leo P and the median EMP star data (*caveat:* nebular vs stellar metal abundances)

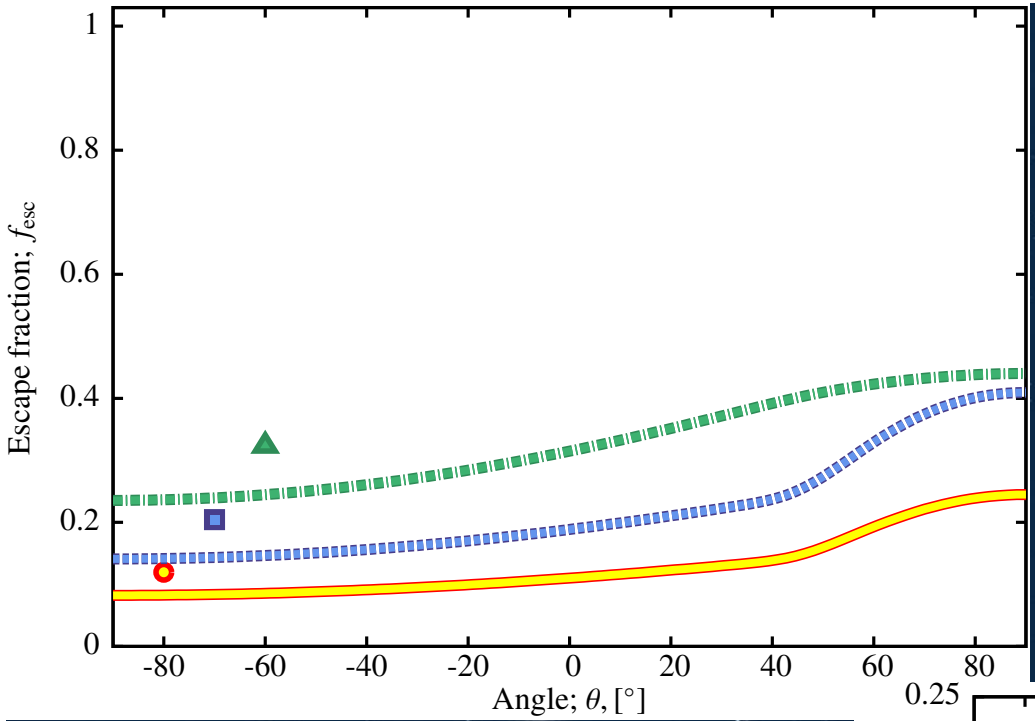


For more details, please see poster by Long Yan Yung at this workshop



Escape fraction from dwarf galaxies

- The escape fraction of ionizing radiation f_{esc} is a critical parameter in cosmological studies, theoretical and observational
- Determines the reionization/thermal history of universe (IGM and CMB), and affects the viability of detecting high-z sources
- Observational measurements of low-z galaxies indicate an escape fraction of H-ionizing radiation, f_{esc} (H) ~ 1% to a few percent. For sources at z~3 (LBGs or otherwise), this can be higher.
- Theoretical calculations have ranged from < 1% to 100%, with strong variations with galaxy or source properties, and higher values coming from numerical simulations of dwarf galaxies.

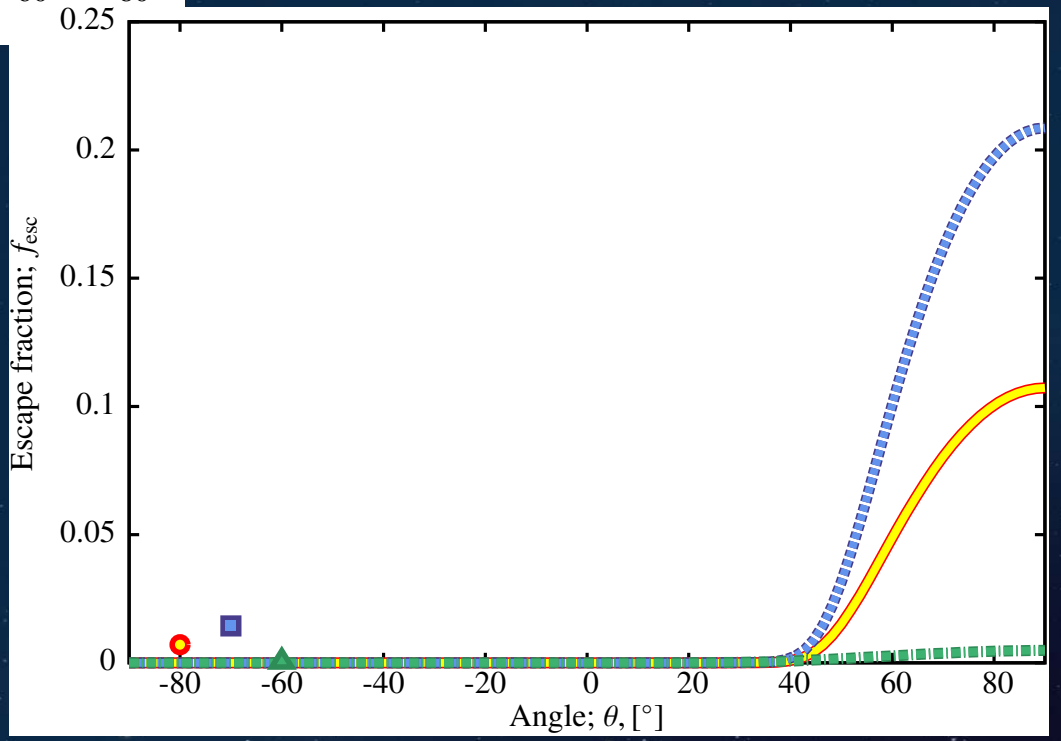


Benson, Venkatesan & Shull 2013

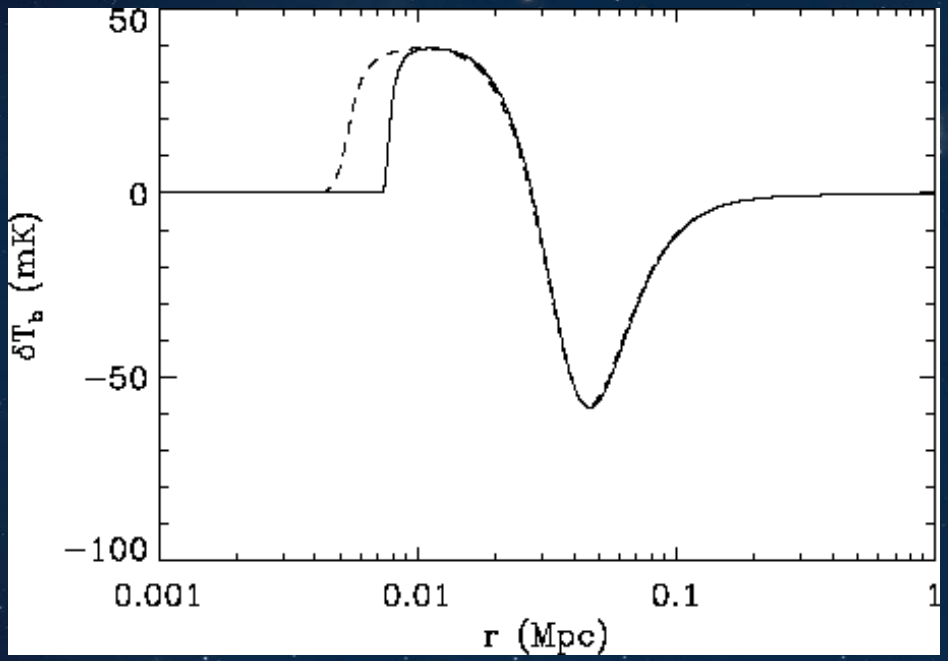
YELLOW: H I
BLUE: He I
GREEN: He II

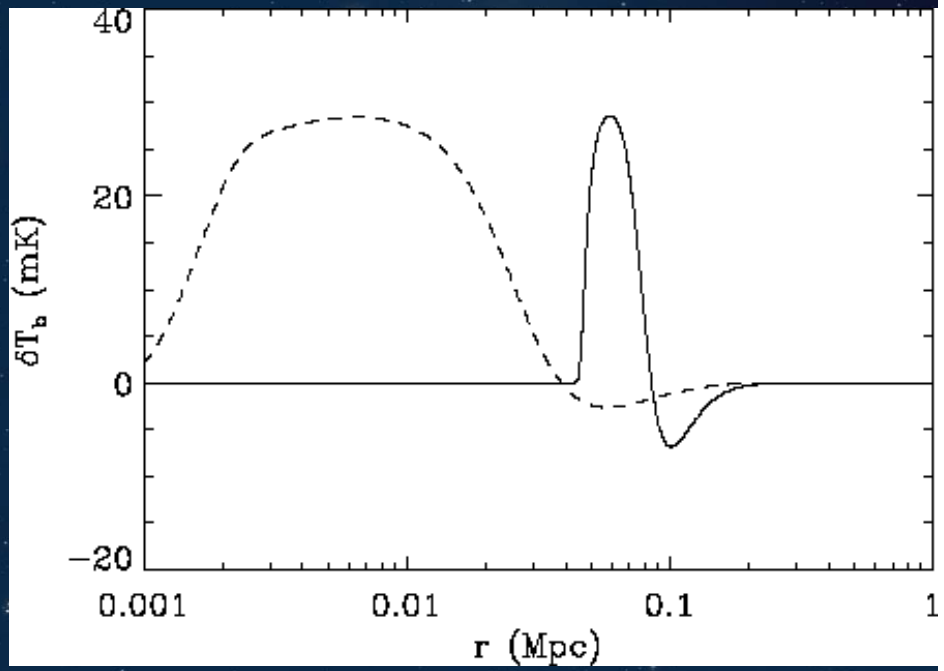
Beta gas density profile within NFW halo
10^4 AGN off center by 100 pc

CLUMPING:
Cloud overdensity 10,
filling factor 20%, size 30 pc
WITH X-RAYS (TOP)
NO X-RAYS (BOTTOM)



21 cm radio signals





- 21 cm Brightness Temperature shown
- **Solid**: full spectrum, **Dashed:** Xrays only.
- LEFT: 10^5 M_{sun} stars, 10^6 M_{sun} BH at t = 0.1 Myr, at z=20
- RIGHT: 10^6 M_{sun} stars ONLY at t = 1 Myr, at z=10

Technical Development: Sites

PAPER Green Bank ***Slide courtesy Aaron Parsons (Berkeley)*** PAPER South Africa