The extended He II λ4686 emission in the extremely metal-poor galaxy SBS 0335-052E seen with MUSE

Kehrig et al. 2018

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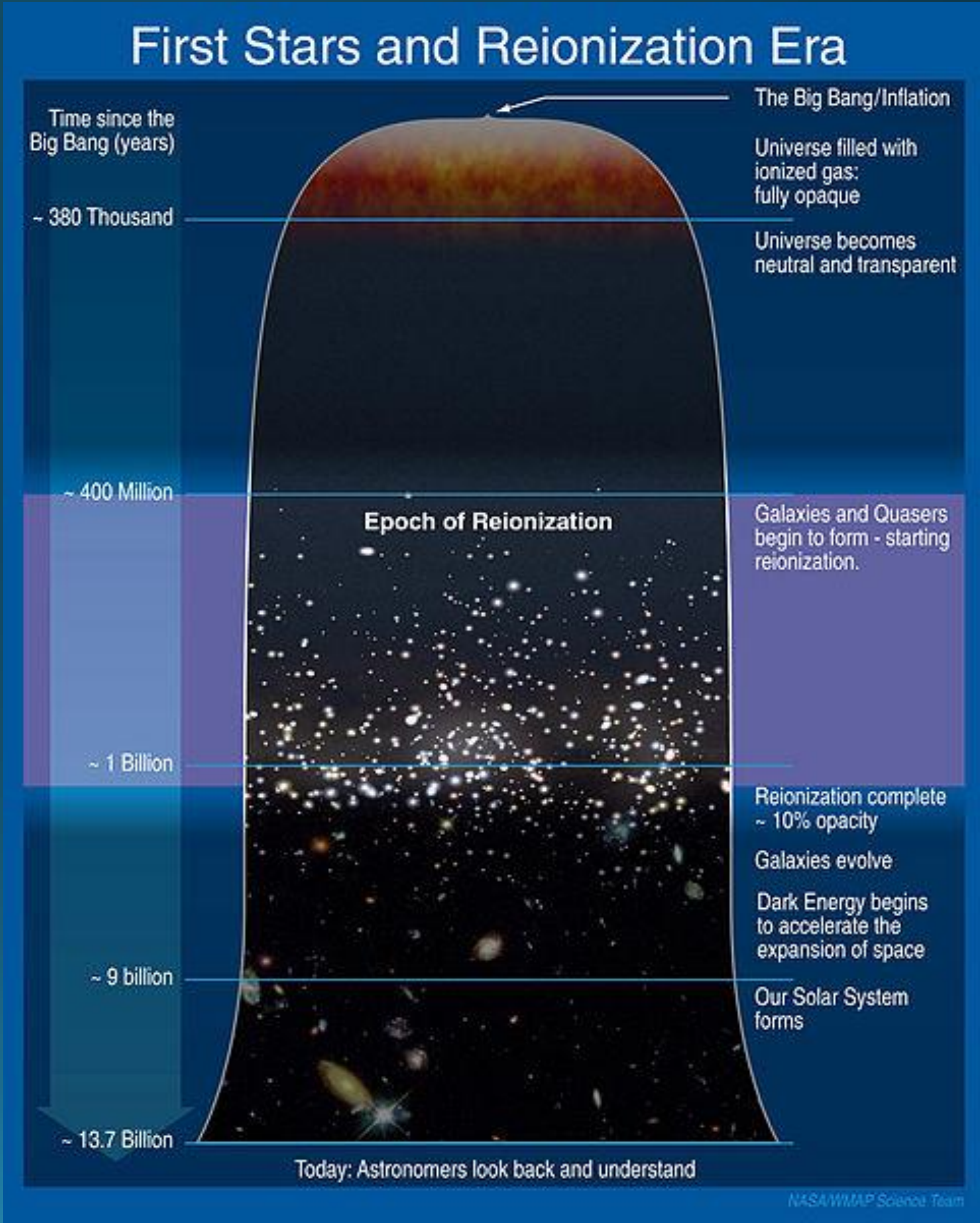
Grace Olivier

Epoch of Reionization

First stars and quasars started ionizing the hydrogen in the universe.

These Pop III stars would be very low metallicity (Z ~ 0).

He II at 1640 Å and 4686 Å is an indicator of low metallicity.



SBS 0335-052E

What is it?

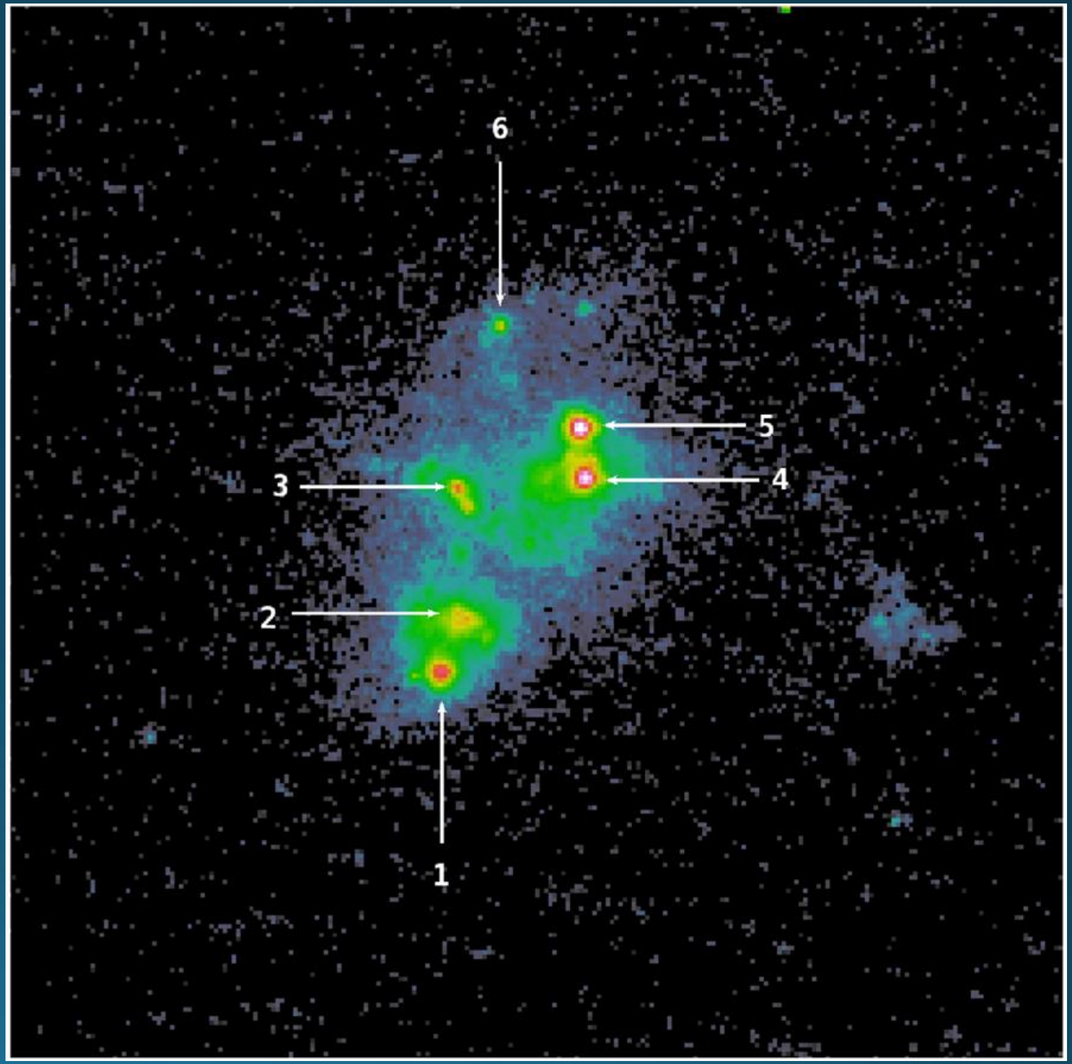
- Starburst-y galaxy first discovered in 1990.

Where is it?

- 54 Mpc away.

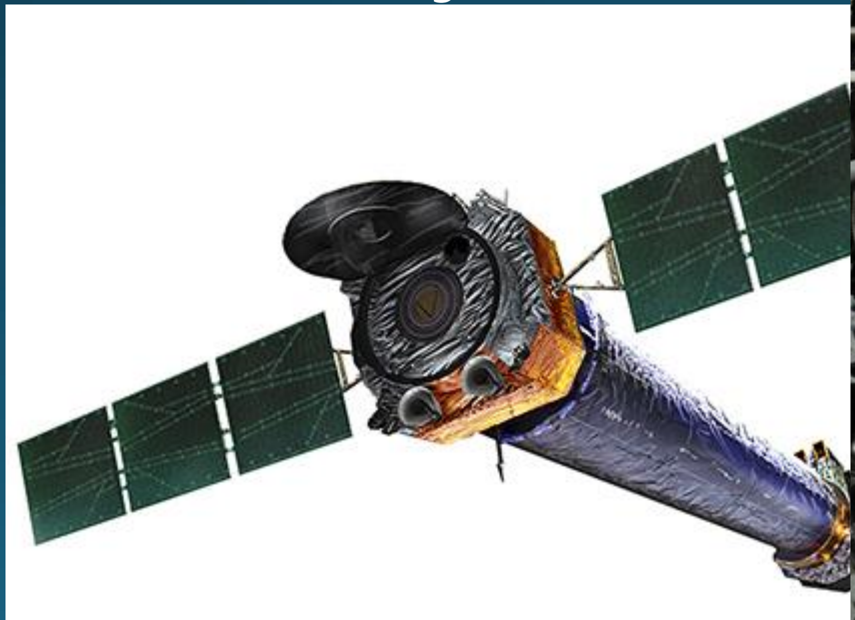
Why do we care?

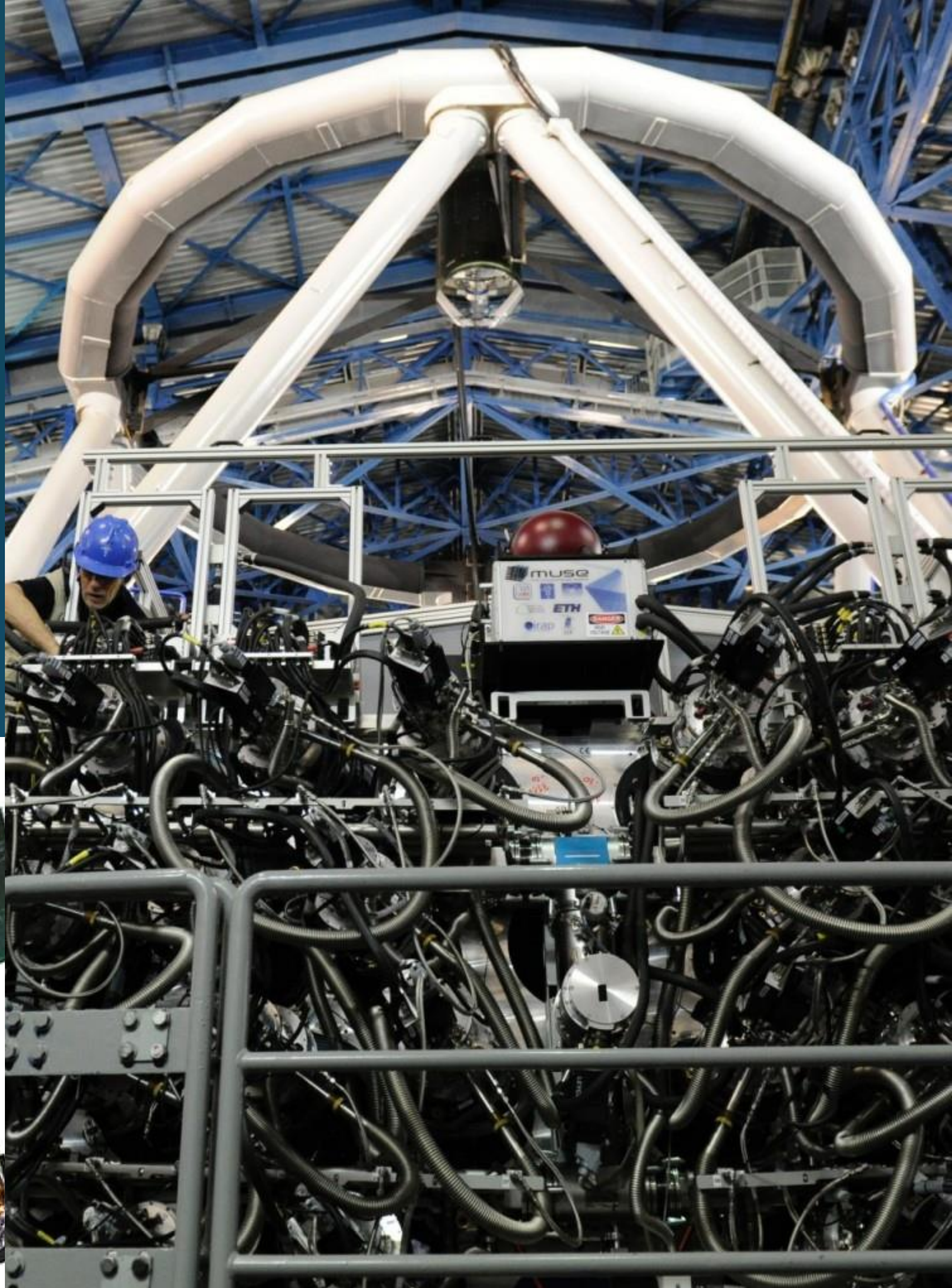
- Has nebular He II emission.
- Extremely low metallicity (Z ~3-4% Z_{Sun}).
- **Excellent local analog of EoR galaxy.**



MUSE & *Chandra*

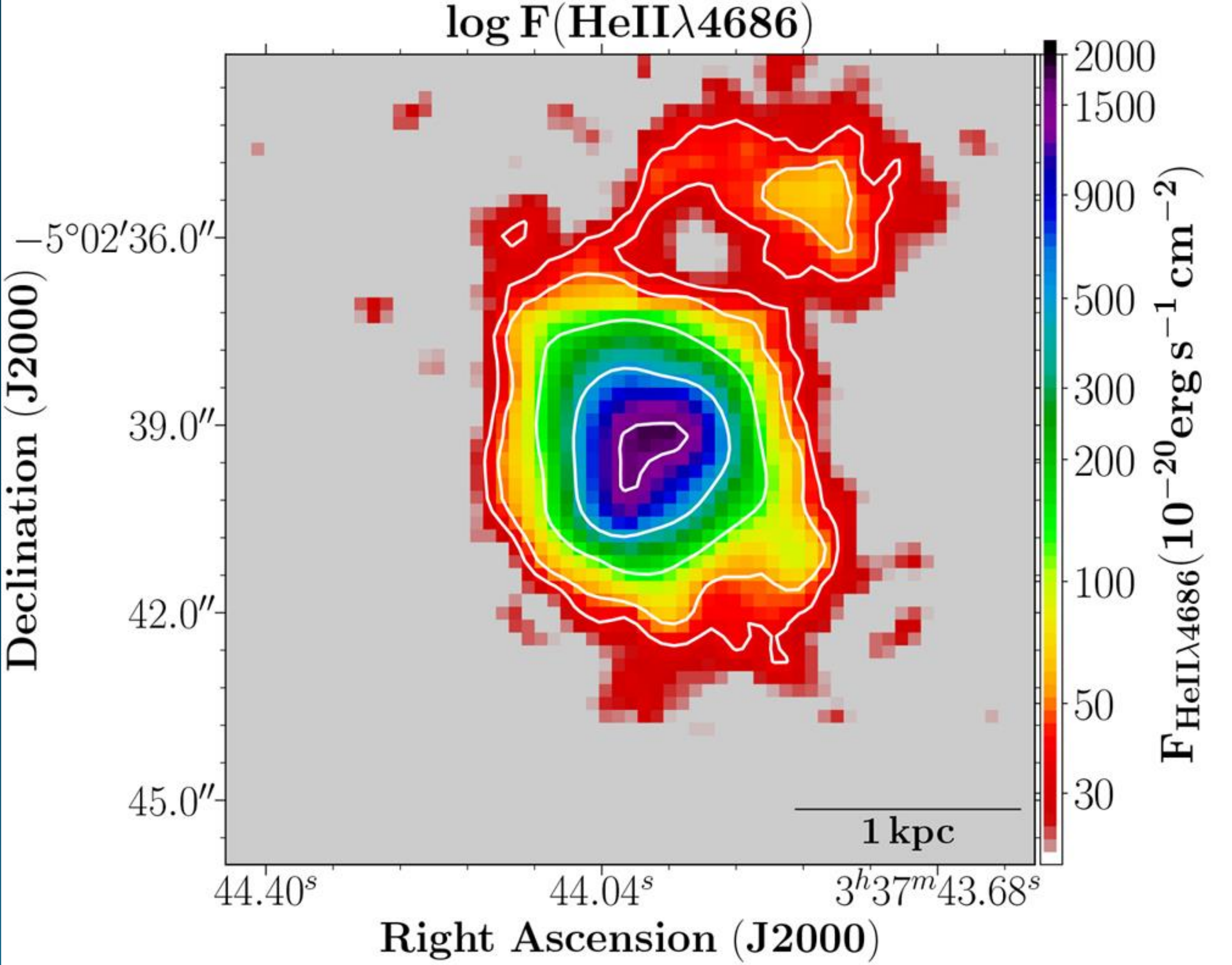
- MUSE on VLT (Image credit: R. Bacon)
  - 4600-9366 A
  - R =2988
- *Chandra X-ray Observatory* (Image credit:NASA/CXC/SAO & J.Vaughan)
  - 0.6-5.0 keV





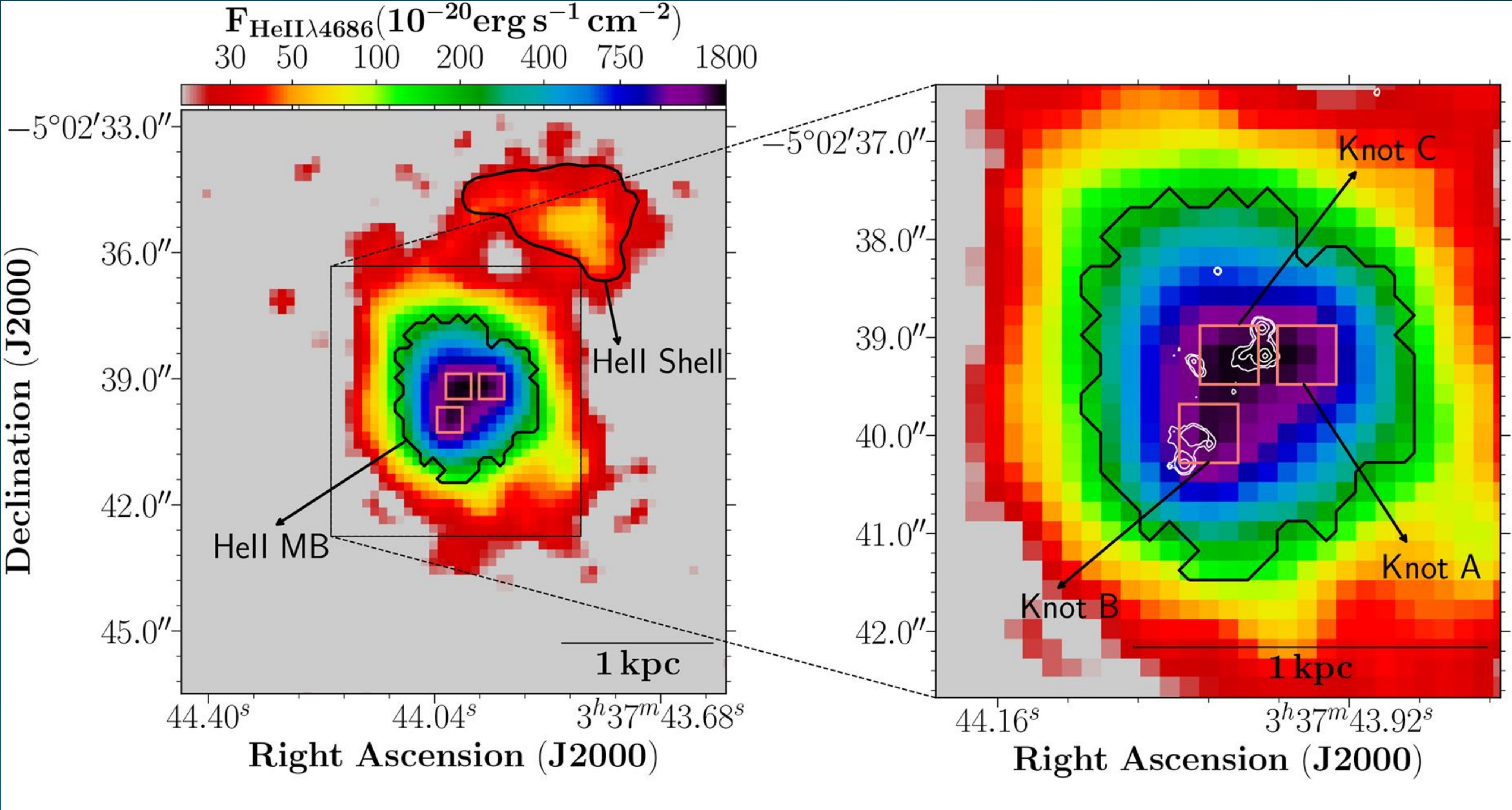
Why MUSE?

Spatially resolved He II.



Why MUSE?

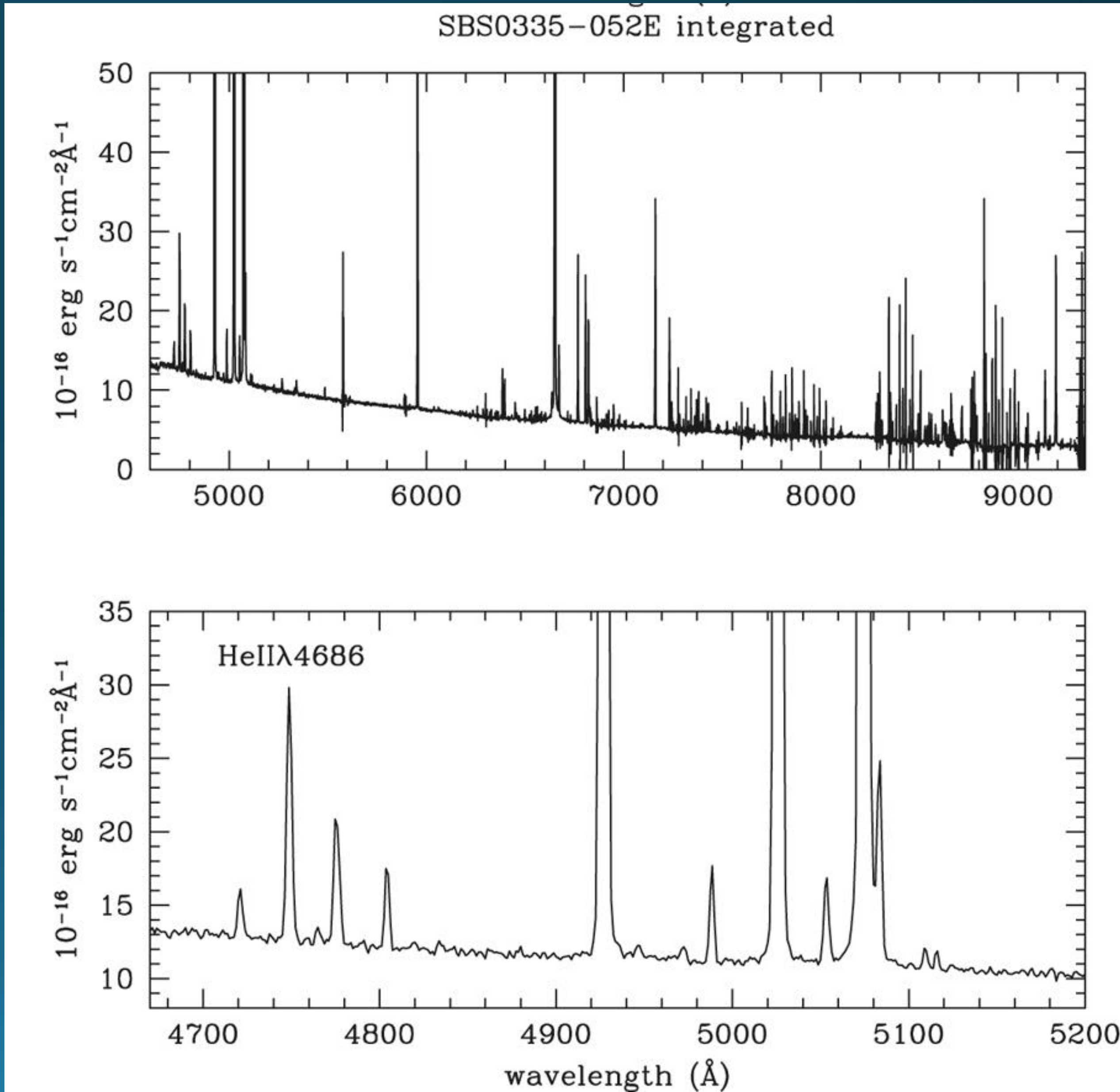
Shape of the He II emission



Why MUSE?

Using this integrated spectrum they calculate Q(He II).

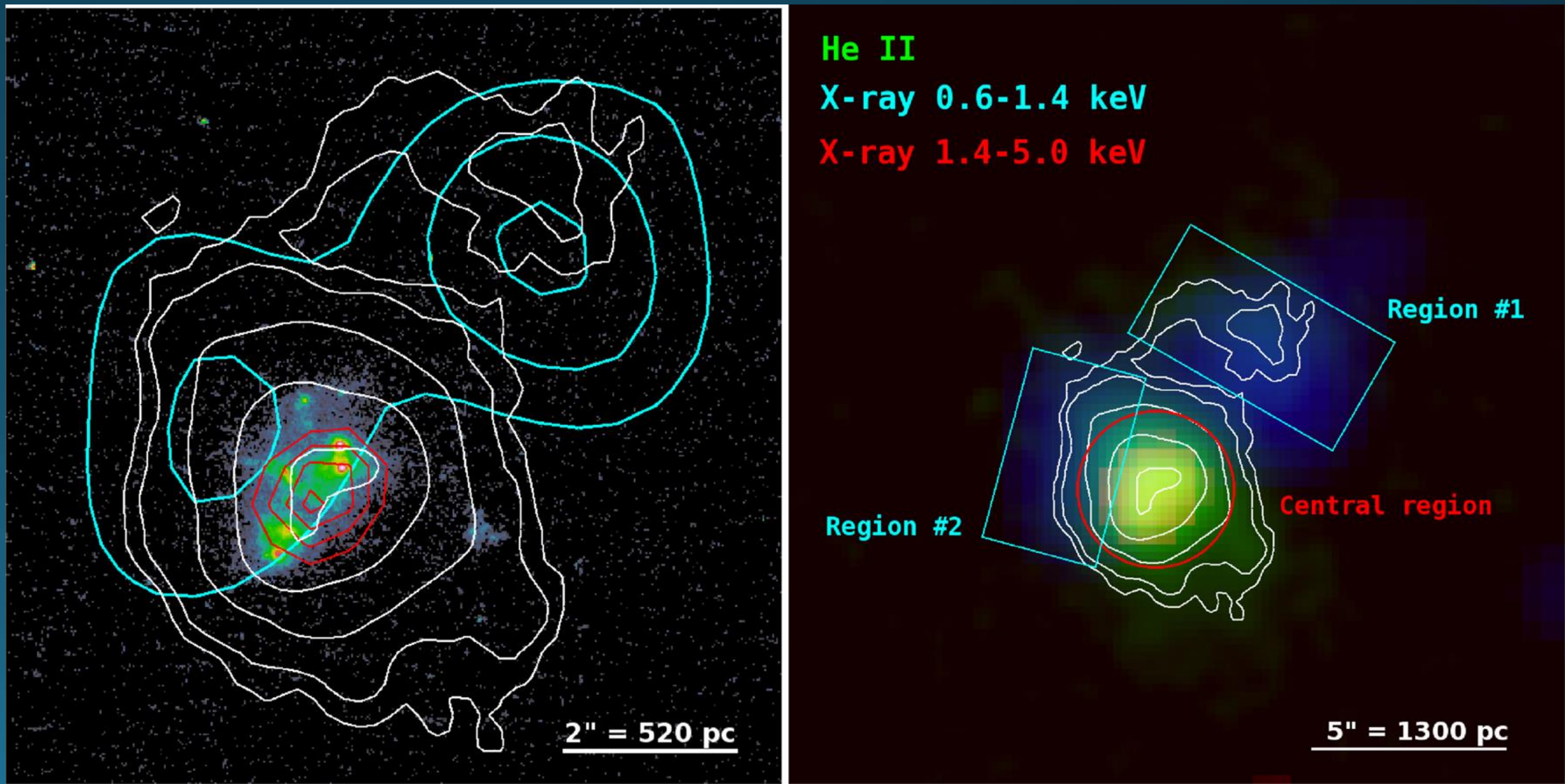
Q(He II) = 3.17 x 10^{51} photons/s



Origin of the Emission

X-ray emission

- Hard X-rays: (1.4-5.0 keV) near SSCs – Q(He II) = 1.6 x 10^{36} phot/s
- Soft X-rays: (0.6-1.4 keV) near shell – Q(He II) = 2.5 x 10^{35} phot/s



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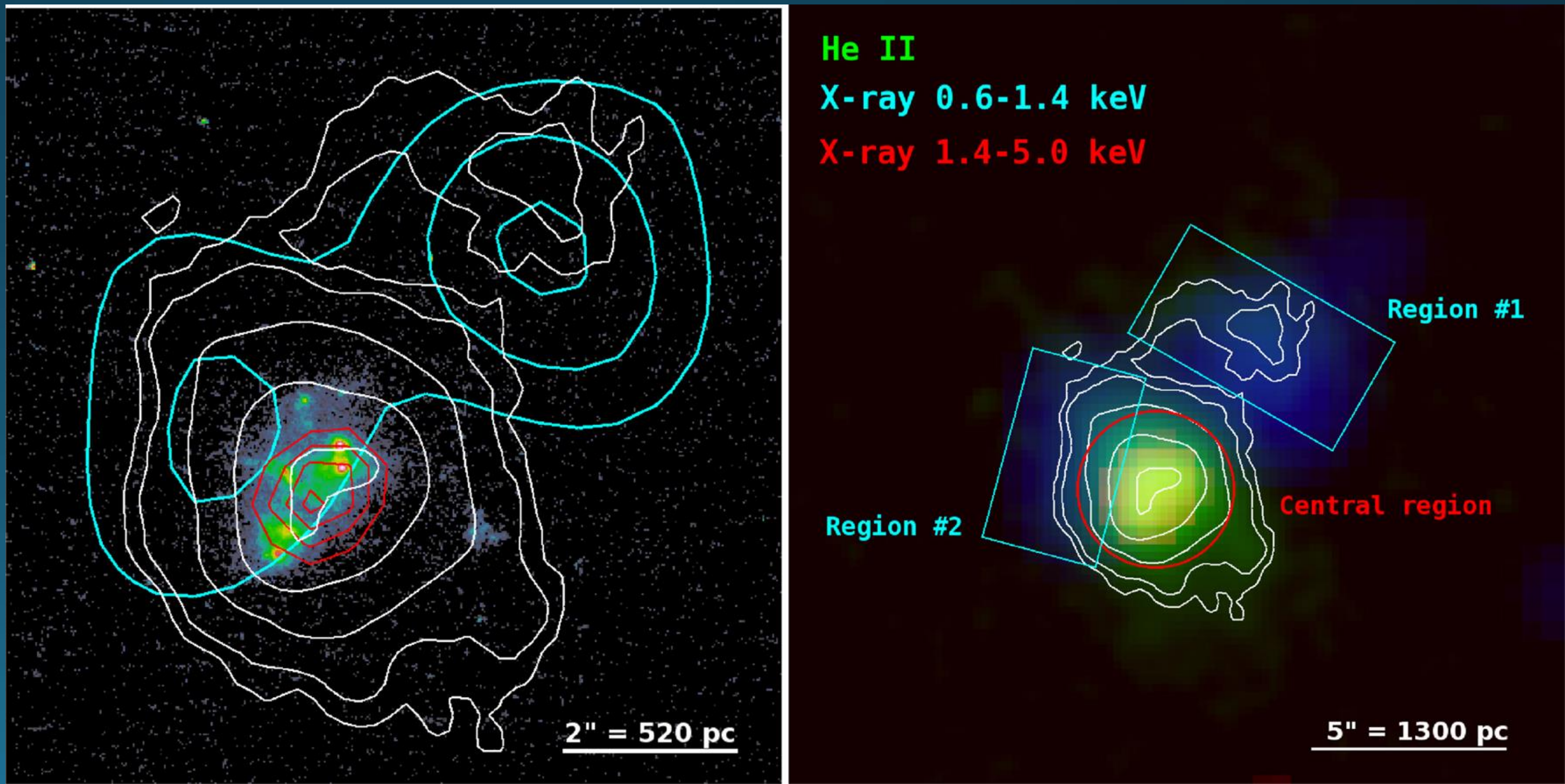

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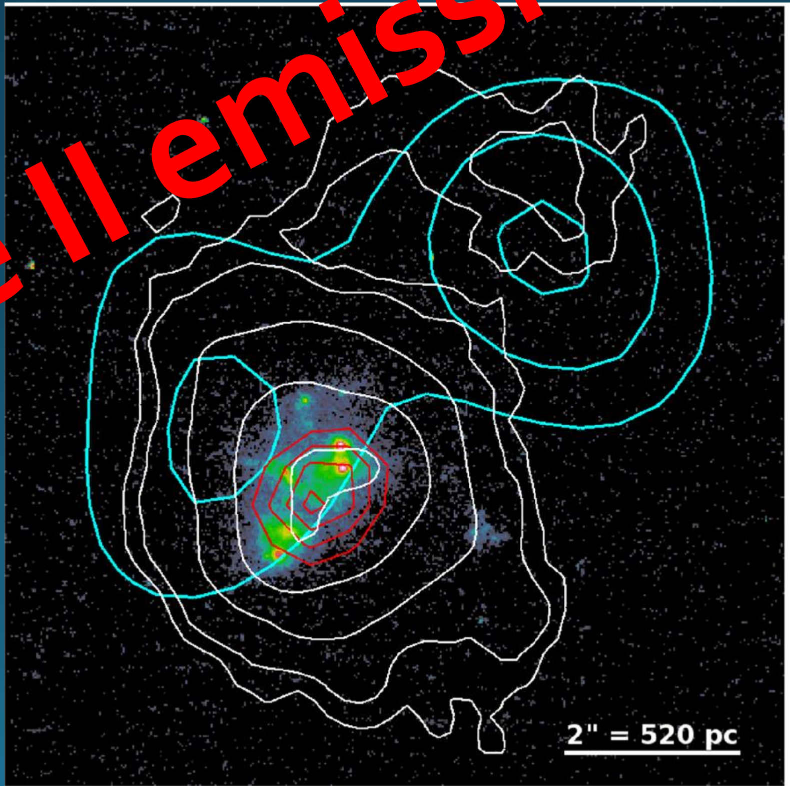
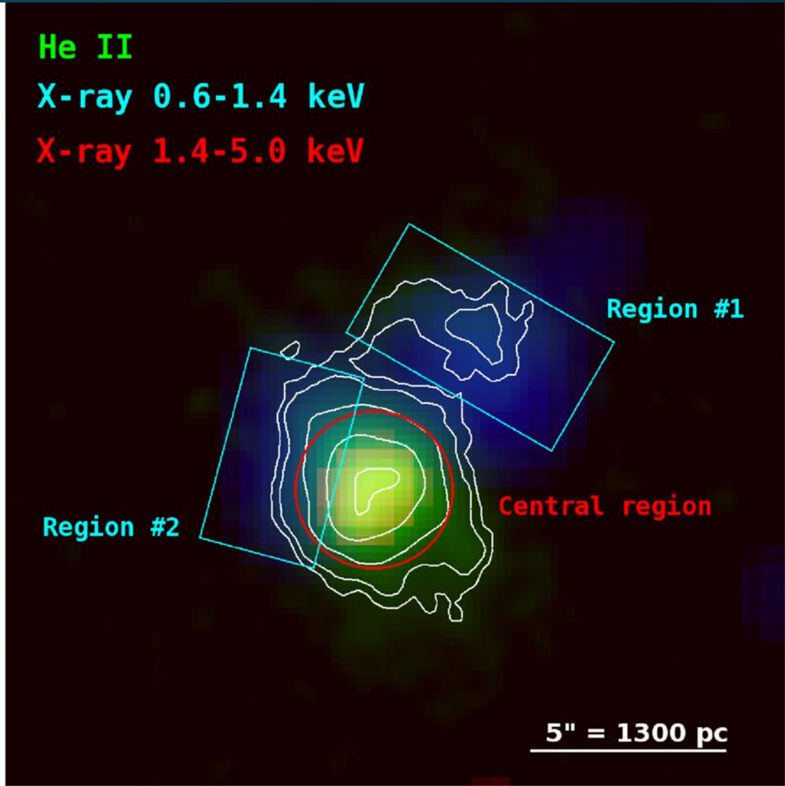
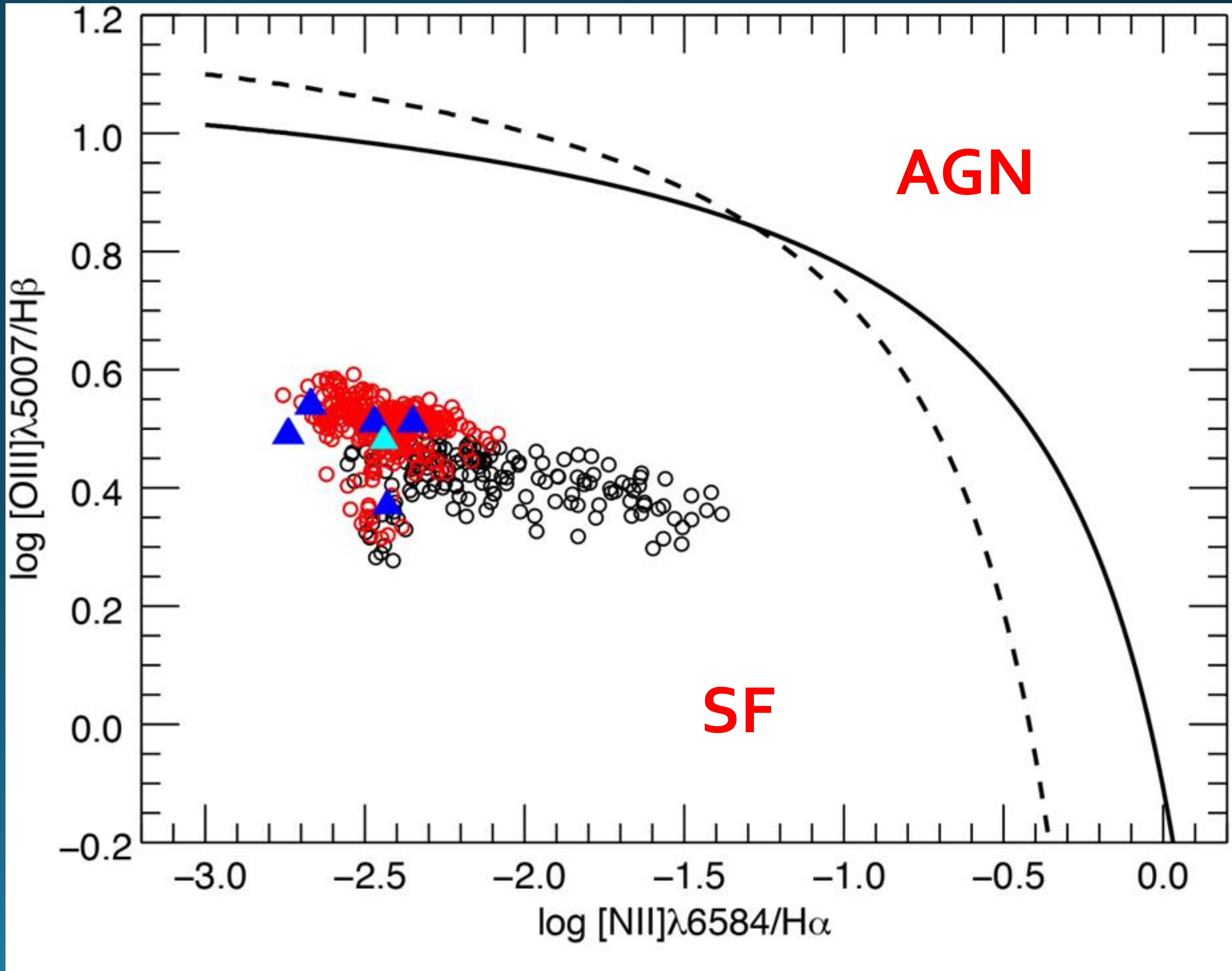
X-rays ≠ He II emission budget





Origin of the Emission

- Line Ratio Diagnostics
  - BPT diagram for every spaxel.
  - Solidly star-forming.



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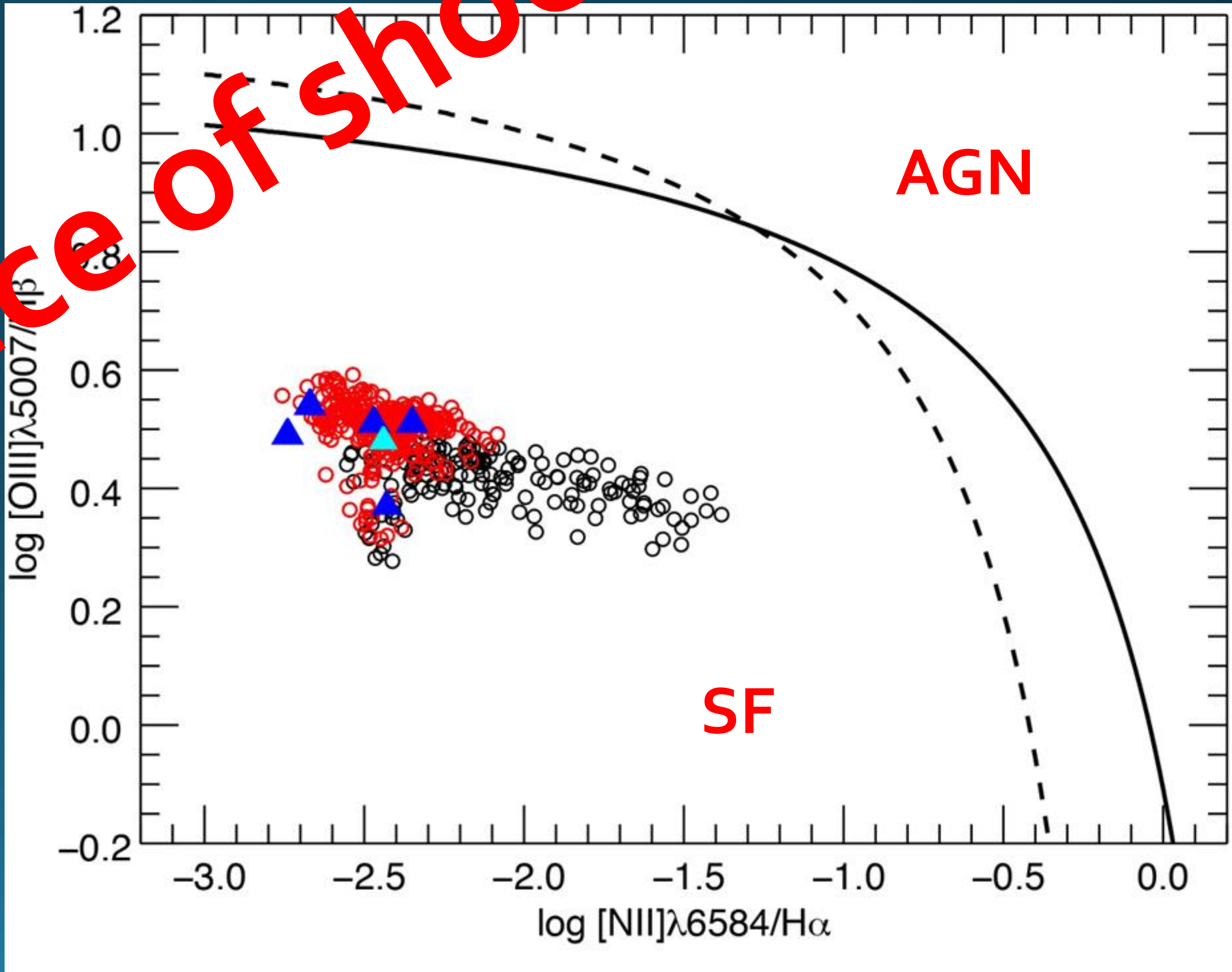
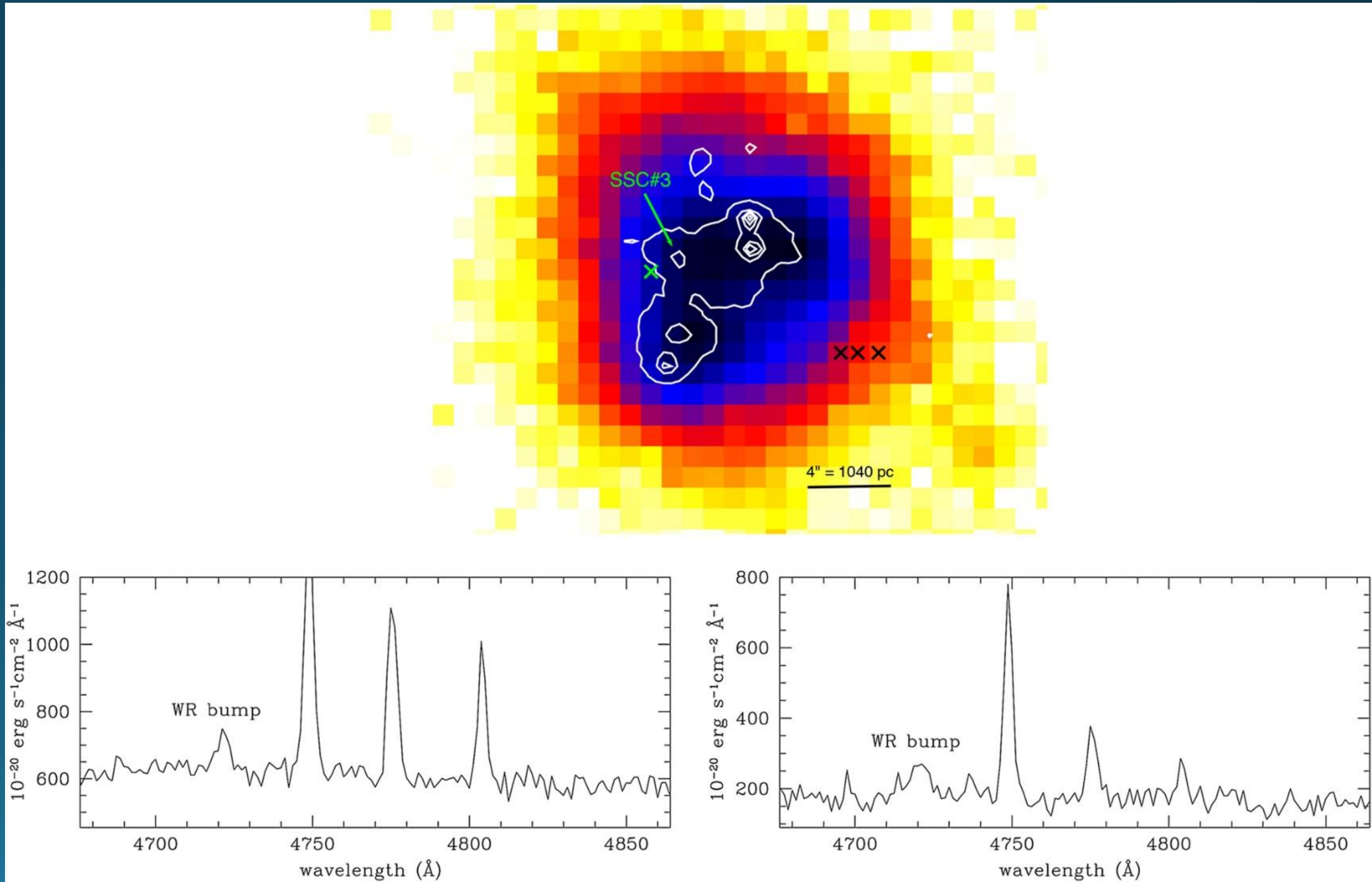


Origin of the Emission

- Hot Ionizing Stars Continua
  - Wolf-Rayet stars
    - Discovered new knot of 7
    - Q(He II) = 4.4 x 10^{48} phot/s
    - ~7000 WRs needed



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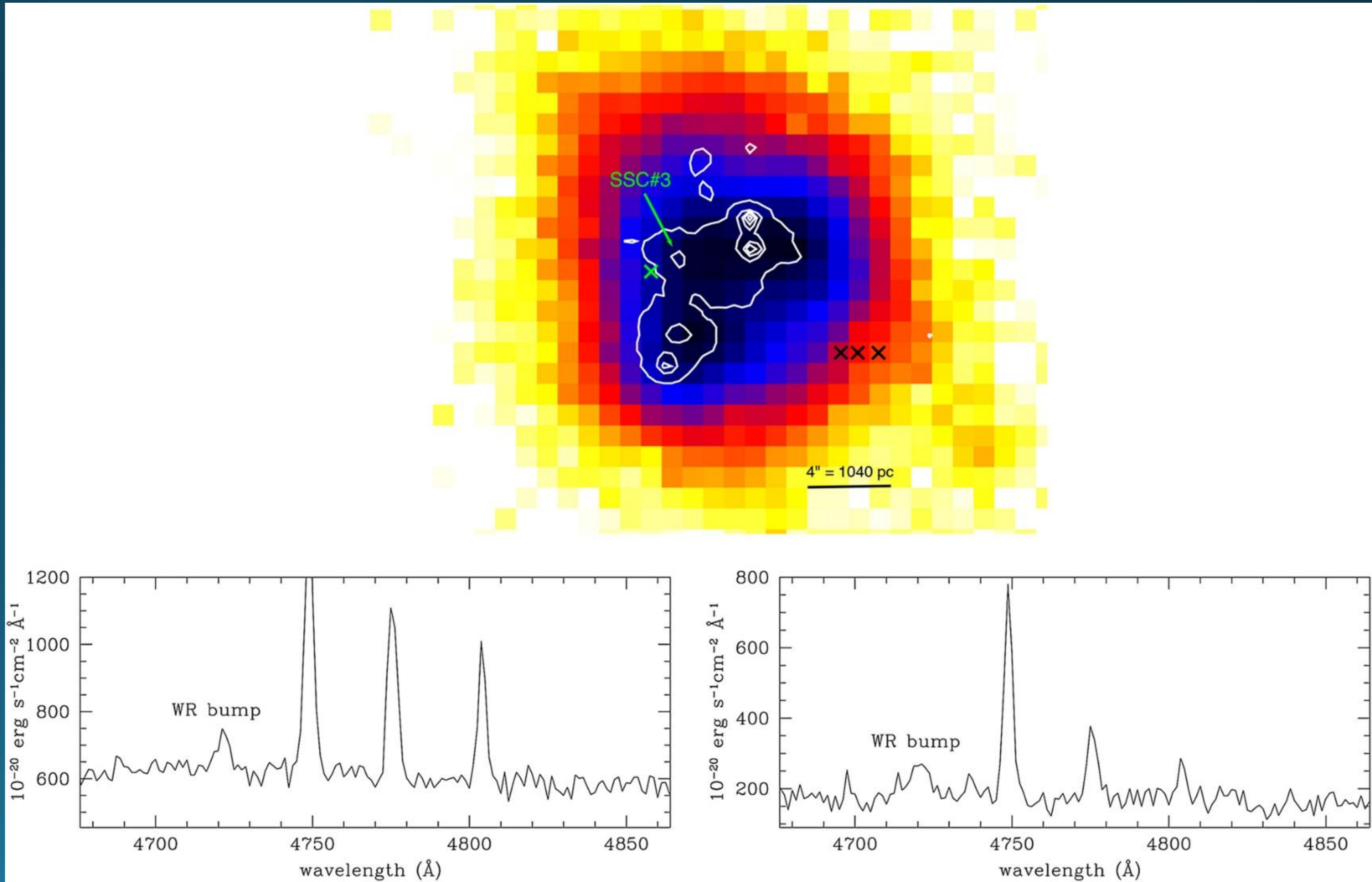
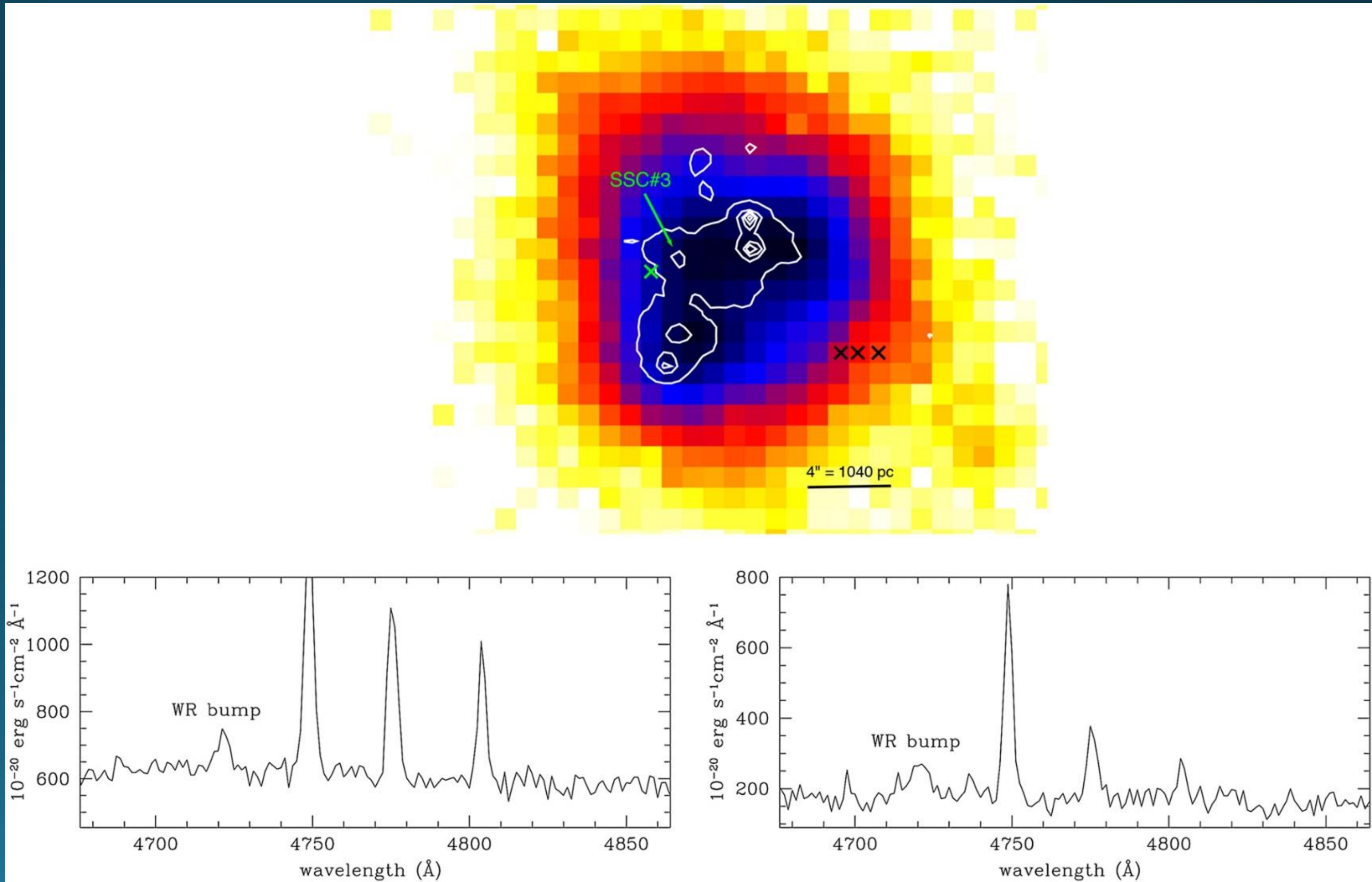


Origin of the Emission

Hot Ionizing Stars Continua

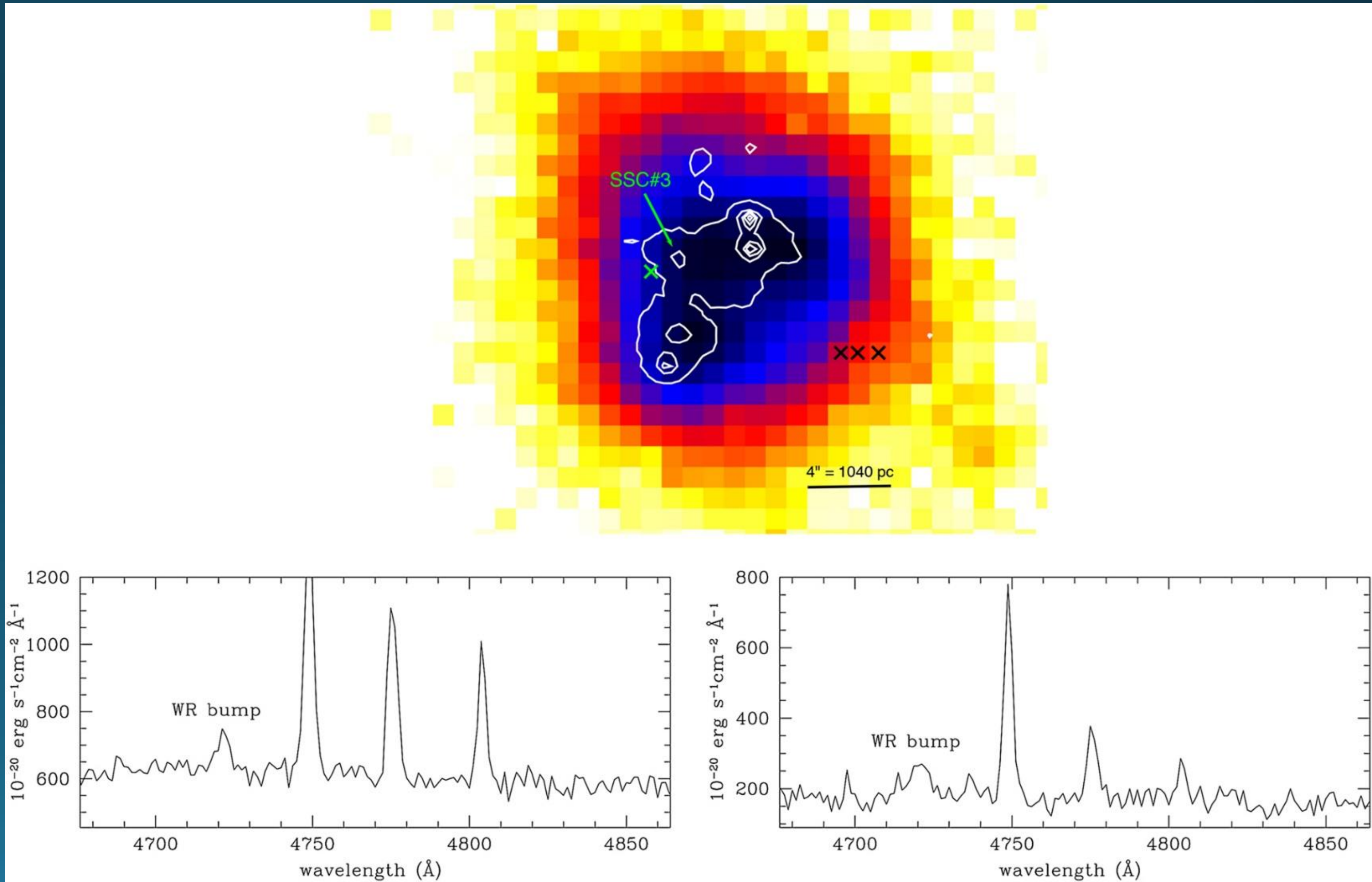
- ~~Wolf-Rayet stars~~
- Single stars
  - Non-rotating
    - Need:
      - 150 M_{Sun} : 16,000
      - 300 M_{Sun} : 360



Origin of the Emission

Hot Ionizing Stars Continua

- ~~Wolf-Rayet stars~~
- Single stars
  - ~~Non-rotating~~
  - Rotating
    - Need:
      - 294 M_{Sun} : 430
    - With Z=0 stars:
      - 150 M_{Sun} : 230



Origin of the Emission

- Hot Ionizing Stars Continua
  - ~~Wolf-Rayet stars~~
  - ~~Single stars~~
  - Binary Population and Spectral Synthesis (BPASS)
    - Scaling masses to stellar mass in SSCs, no 5% Z_{Sun} models account for Q(He II)
    - **BUT,** 0.05% Z_{Sun} models do:
      - Top-heavy IMFs with masses up to 100 and 300 M_{sun} work!

Origin of the Emission

Hot Ionizing Stars Continua

- ~~Wolf-Rayet stars~~
- ~~Single stars~~
- ~~Binary Population and Spectral Synthesis (BPASS)~~

No stellar models with correct metallicity work.

Conclusions

- SBS 0335-052E is one of the best local analogs of EoR galaxies.
- Extreme He II emission:
  - Q(He II) = 3.17 x 10^{51} photons/s
  - Not from X-ray emitting gas.
  - Not from shocks or AGN like features.
  - It is likely from continuum emission from massive stars.
    - Unfortunately only very low metallicity (Z =0.05% Z_{Sun}) models match this emission.
    - Unlikely that extreme low metallicity stars are in a Z ~ 3-4% Z_{Sun} galaxy.

Comments

All models for extremely low metallicity are theoretical extrapolations.

The models necessary for this study don’t exist yet.

Epoch of Reionization galaxies are a main science driver for many next generation telescopes like JWST and ELT. Understanding local analogs is the first step.