Emission from the Circum-Galactic Medium:

Predictions of Multi-Wavelength Observables from zoom-in Cosmological Simulations

RAMONA AUGUSTIN (ESO/LAM)

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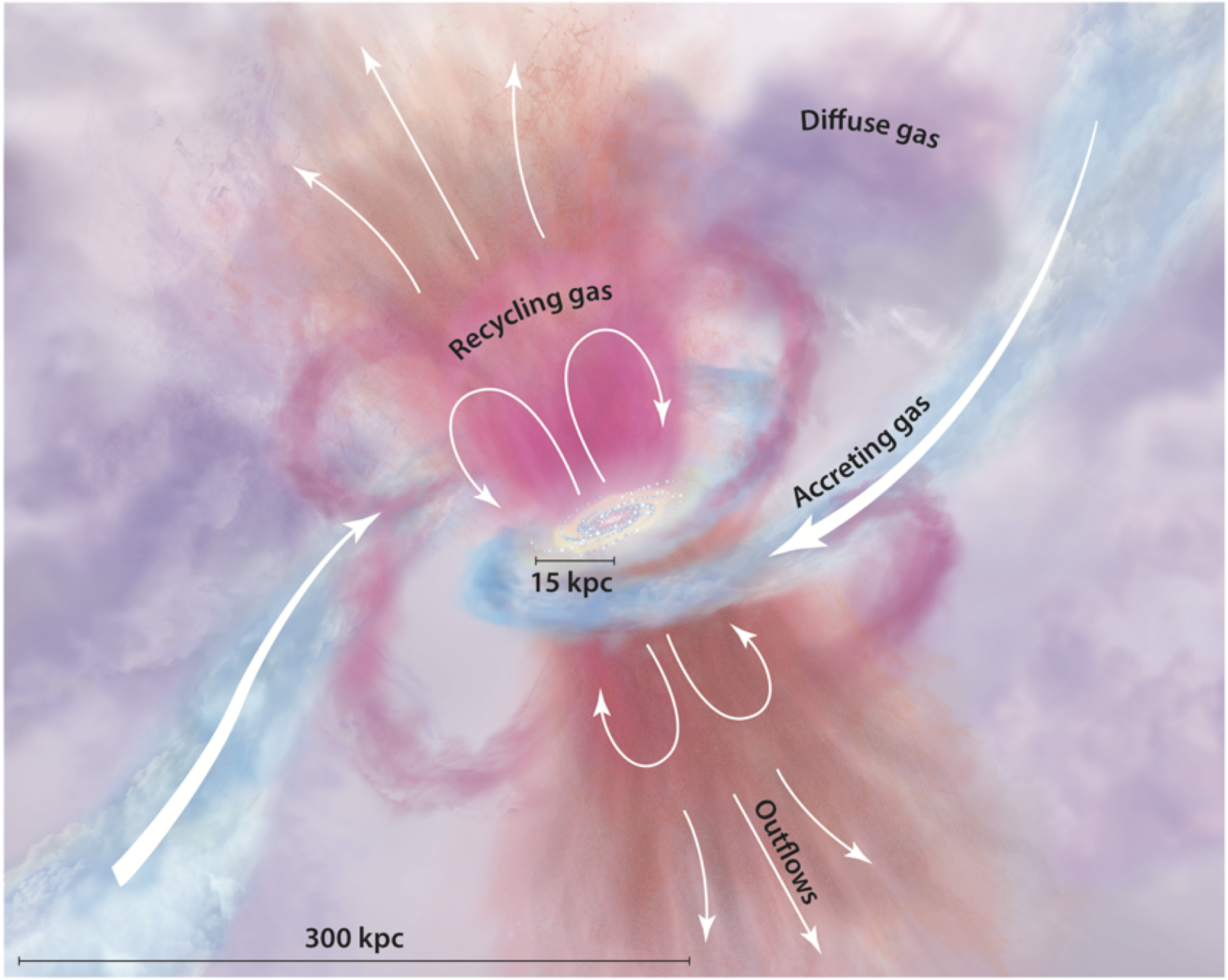
31.08.2018 – IAU – FM2: WARM AND HOT BARYONIC MATTER IN THE COSMOS

The Circum-Galactic Medium



Tumlinson et al. 2017

Two ways of investigating the CGM

Absorption

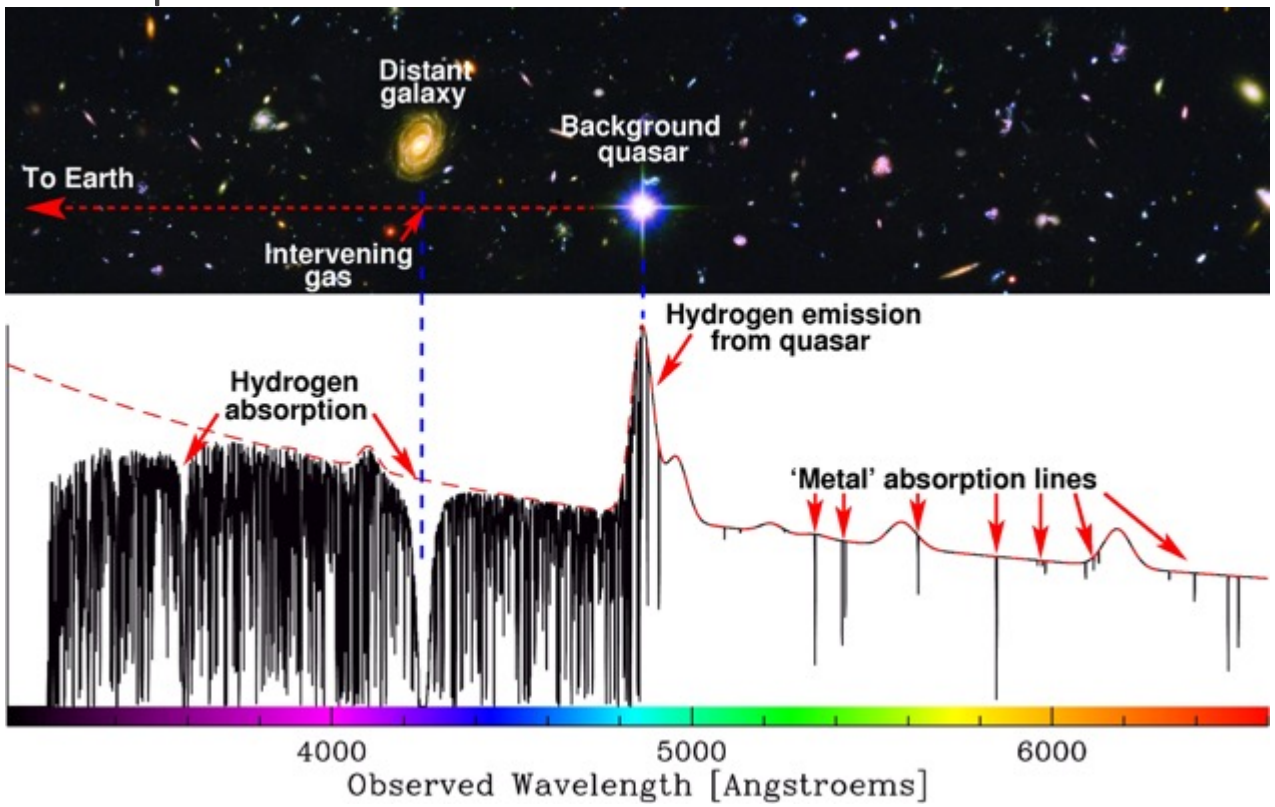


Figure: http://www.hs.uni-hamburg.de/jliske/qsoal/qsoabs.jpg

Emission

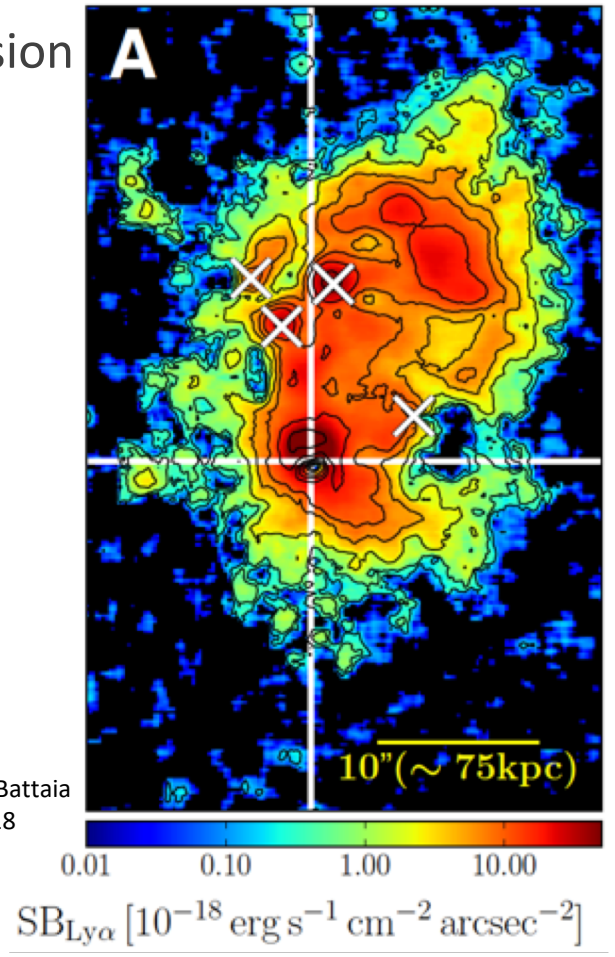
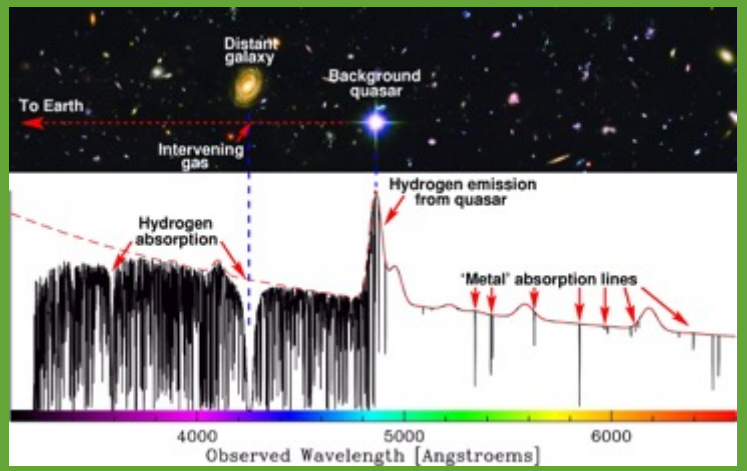


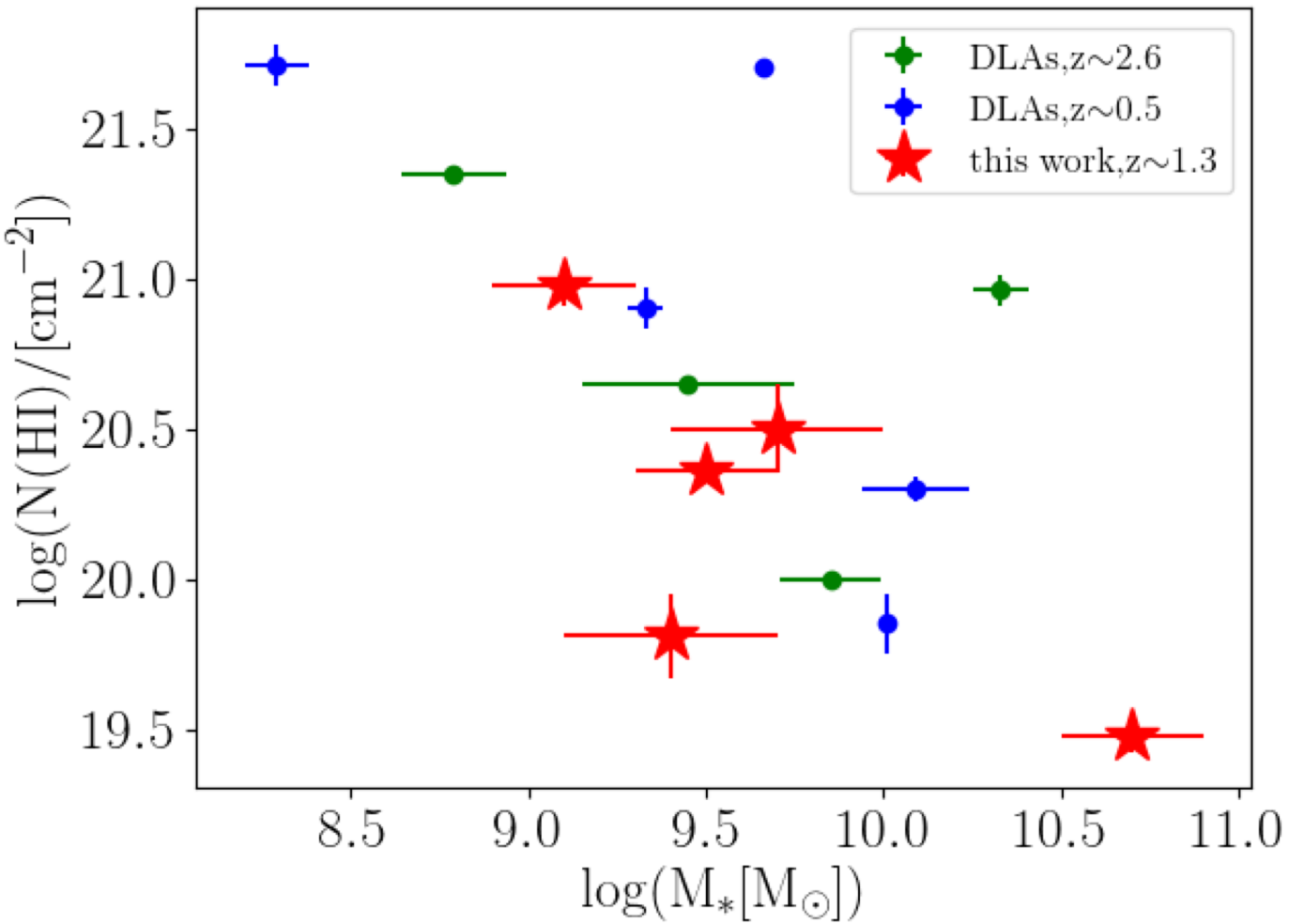
Figure: Arrigoni Battaia et al. 2018



Detections in Absorption:

e.g. DLA galaxies:
Christensen et al. 2014
Krogager et al. 2017
Augustin et al. 2018

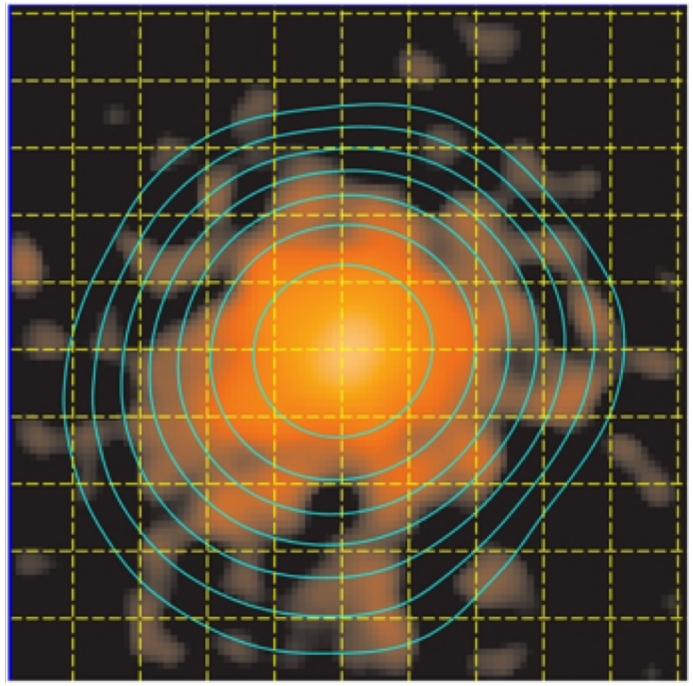
See also Poster by
A. Hamanowicz



Detections in Emission

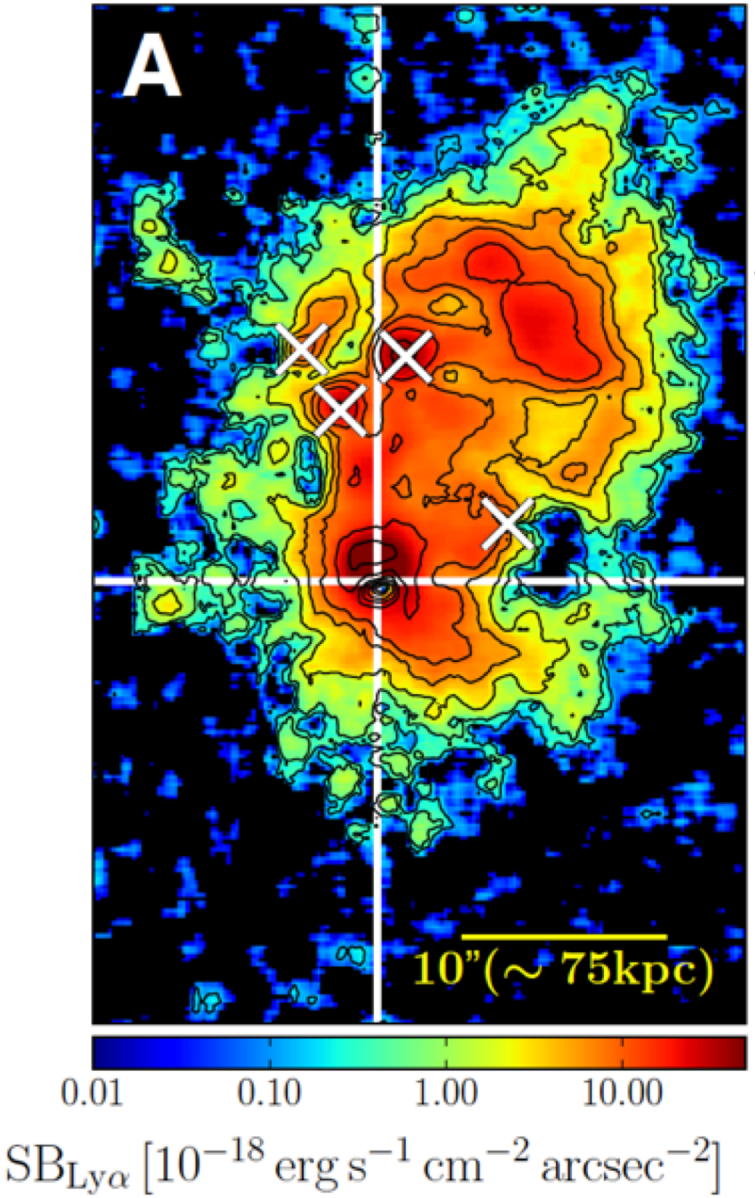
Stacking:

e.g. Steidel et al 2011



Line emission maps using **narrow band images** (from IFU data) of the extended emission around quasars:

e.g. Cantalupo et al. 2014; Martin et al. 2014; Borisova et al. 2016; Arrigoni Battaia et al. 2015, 2016, 2018



Challenges in observing the CGM

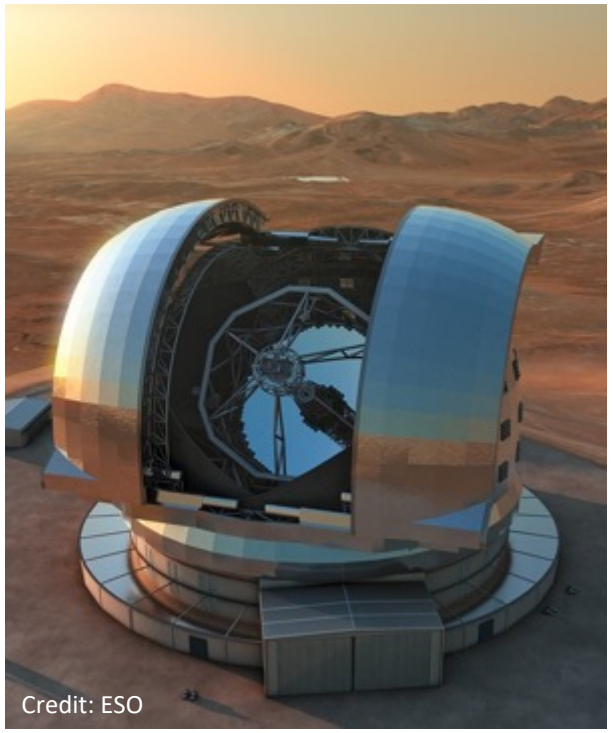
Low redshift → UV

Need Satellite or Balloon missions like FIREBall-2

Credit: P. Balard (LAM)

High redshift → faint

Need big telescopes and sensitive detectors → ELT/Harmoni



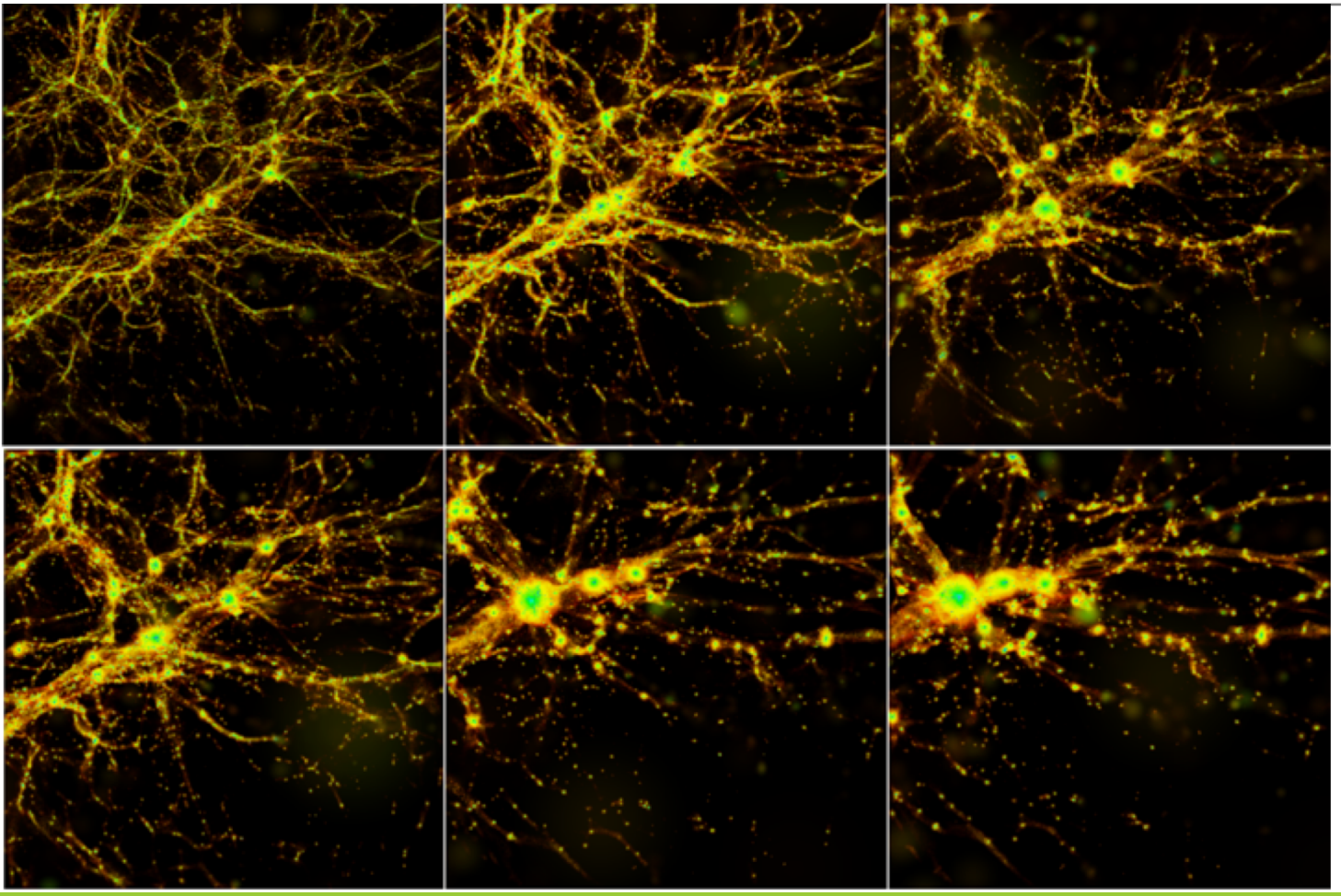
Credit: ESO

High temperatures → X-Ray

Need satellite missions like Athena

Credit: MPE, ESA and Athena Team

Cosmological zoom-in simulations



RAMSES Adaptive Mesh Refinement

Cosmological simulations down to z=0

~ 1.3 Mio CPU hours

Based on simulations from Frank et al. 2012

Zoom-in on a large cubic region with a box length of 13.92 Mpc/h.

Non-thermal supernova (SN) feedback (Teyssier et al. 2013)

'on-the-fly' self-shielding for $n_{HI} > 0.01$at/cc

Maximum resolution of 380 h^{-1} comoving parsecs

Collaborators: S. Quiret, B. Milliard, C. Peroux, D. Vibert, J. Blaizot, Y. Rasera, R. Teyssier, S. Frank, J.-M. Deharveng

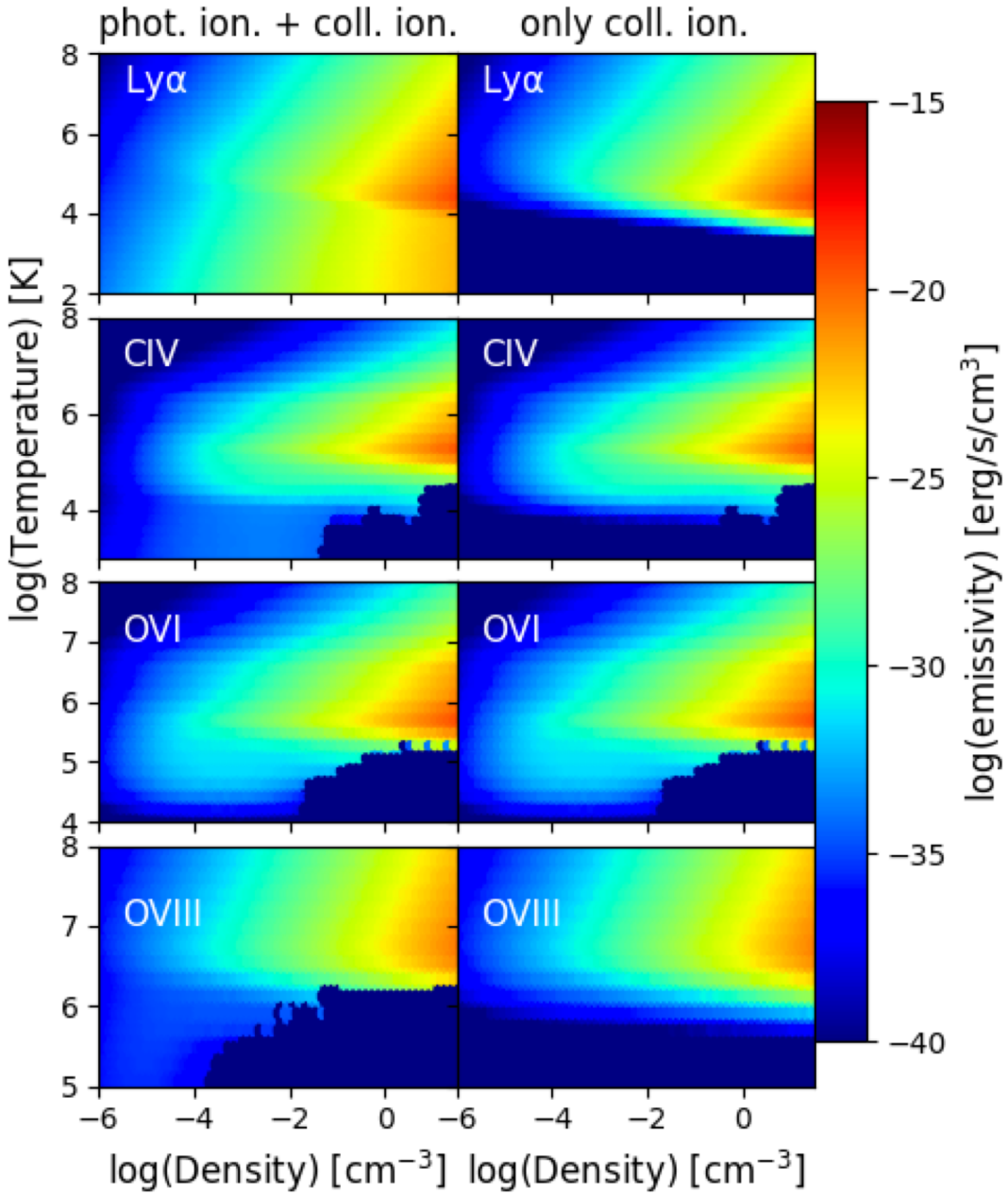
CLOUDY Model

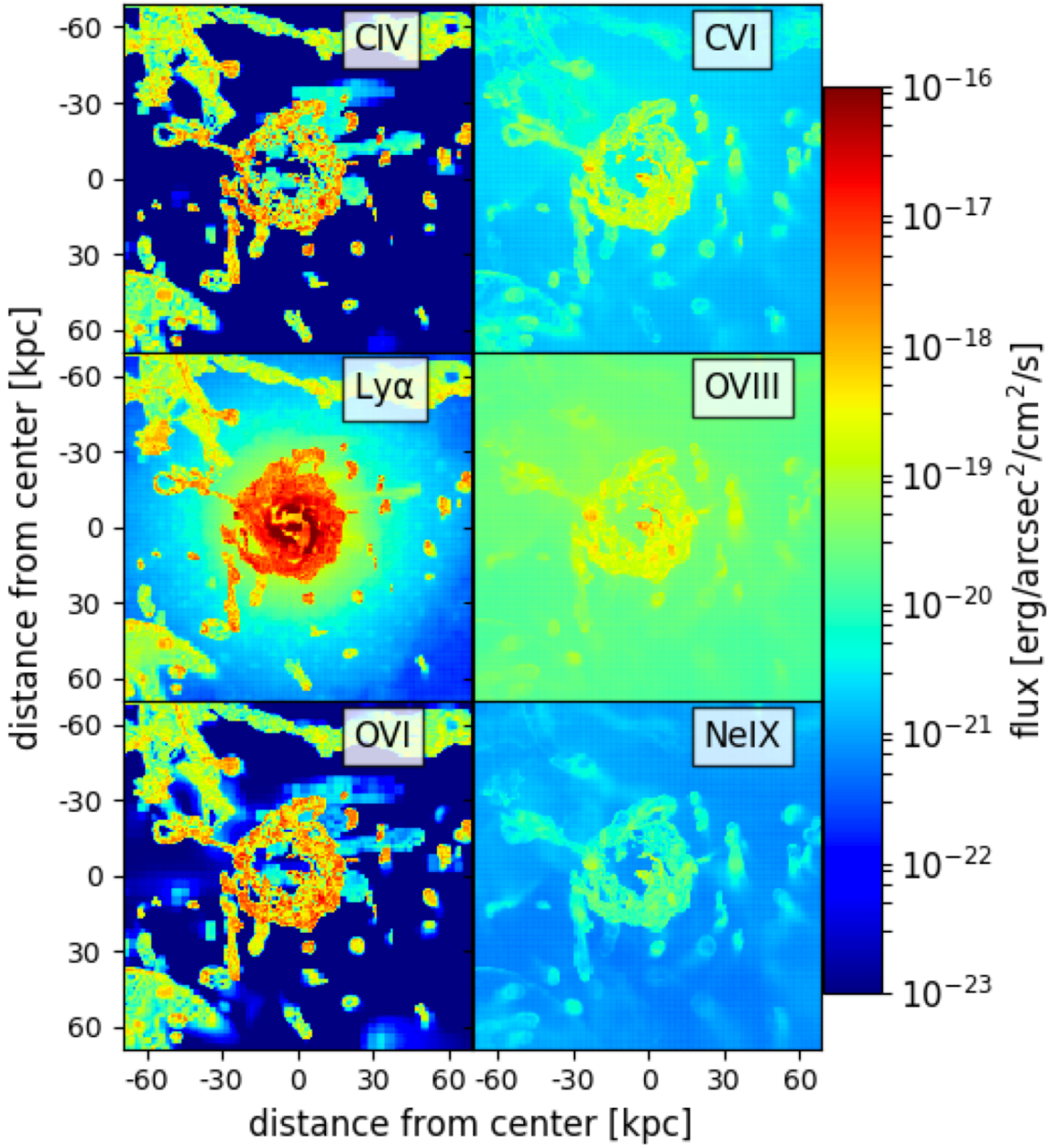
- Photoionization + collisional ionisation

  →low density / high temperature gas

- only collisional ionisation

  → self shielded gas with high density / low temperature





Line Emission

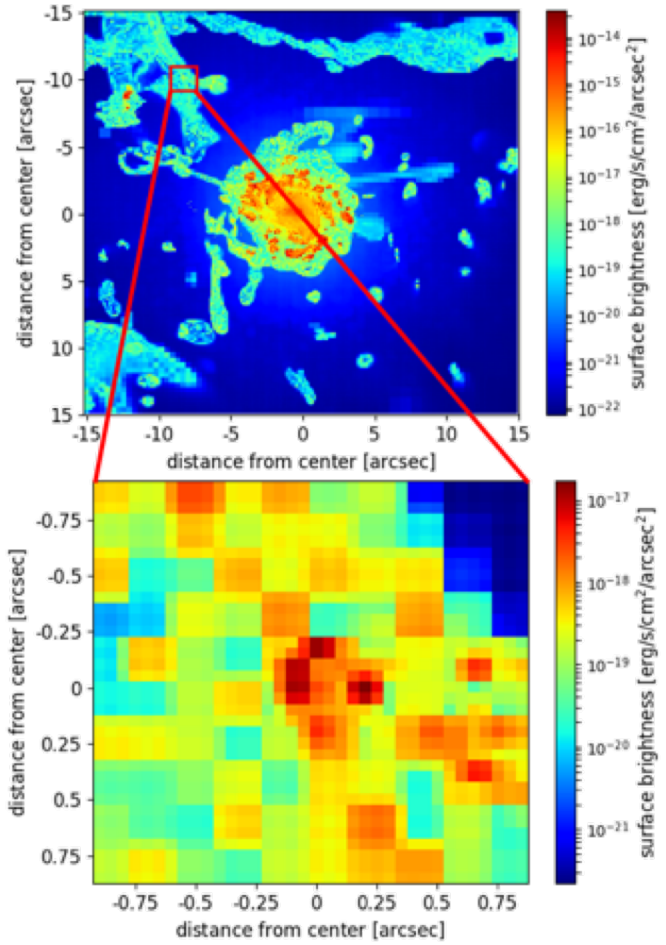
Lya brightest ”cold” emission line

OVIII brightest “hot” emission line

cool gas clumpy

hot gas more homogeneous and extended

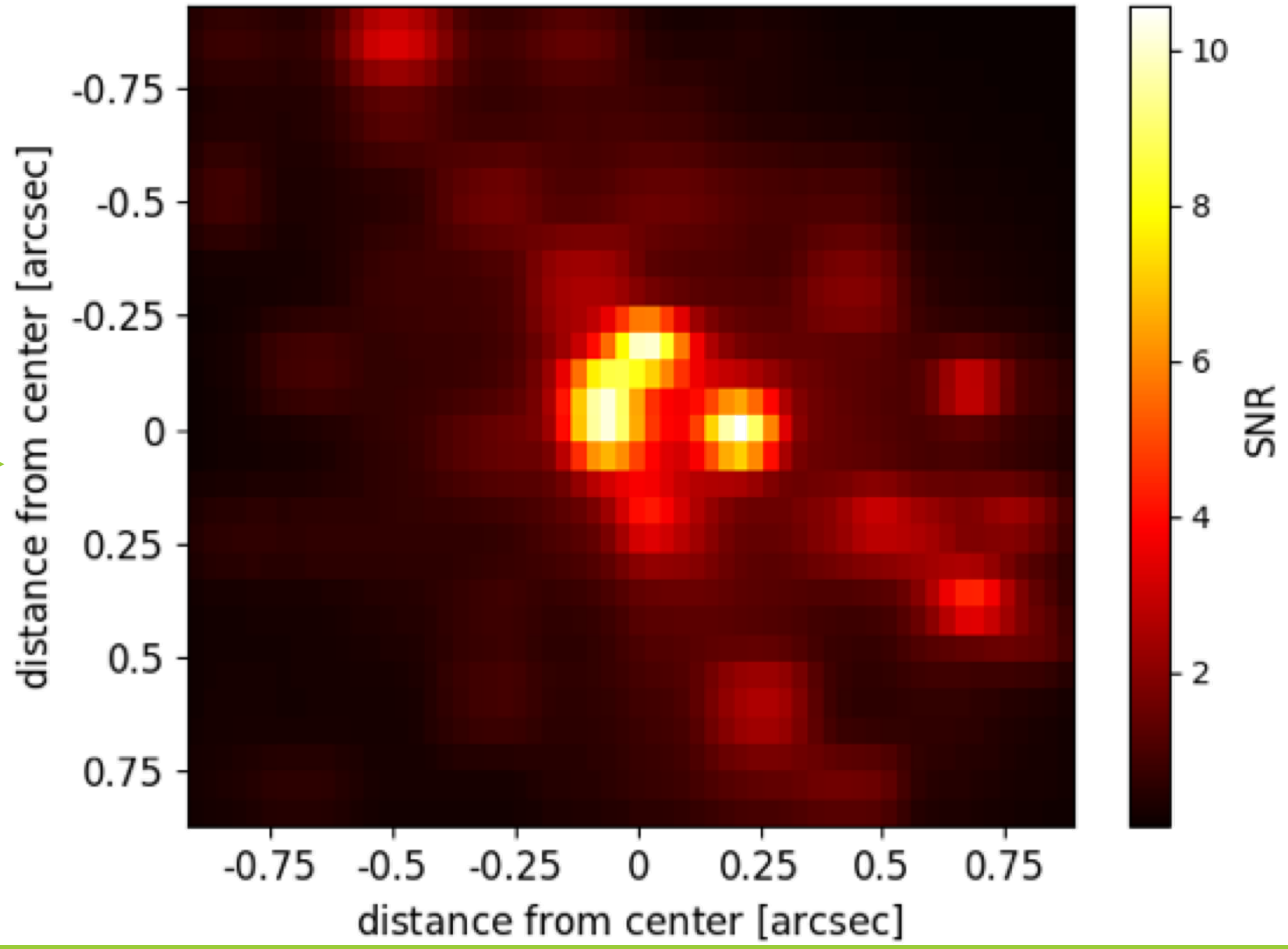
ELT/HARMONI Simulator HSIM

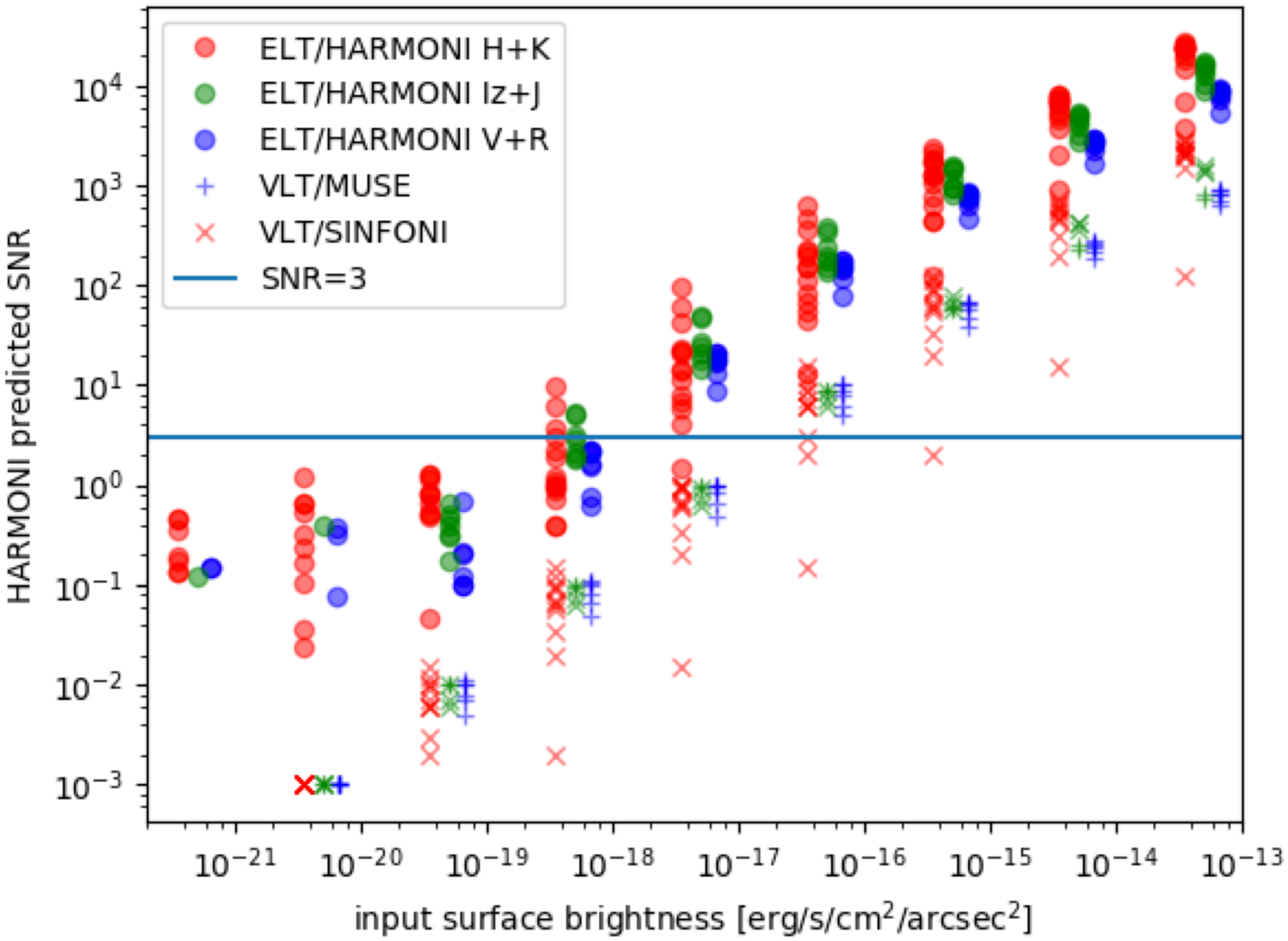


Instrument
Atmosphere
Telescope
+
Data Reduction

Collaborators:
C. Péroux, N. Thatte,
M. Pereira-Santaella,
L. Routledge,
S. Zieleniewski

HSIM credit:
Zieleniewski et al. 2015





SNR – input surface brightness

UV observations with FIREBall-2

UV multi-object spectrograph on a balloon (~300 targets)

Designed to discover and map the faint emission from the CGM at low redshifts (0.3-1)

To be launched from Fort Sumner, New Mexico in September 2018

Narrow window around 2000 Å

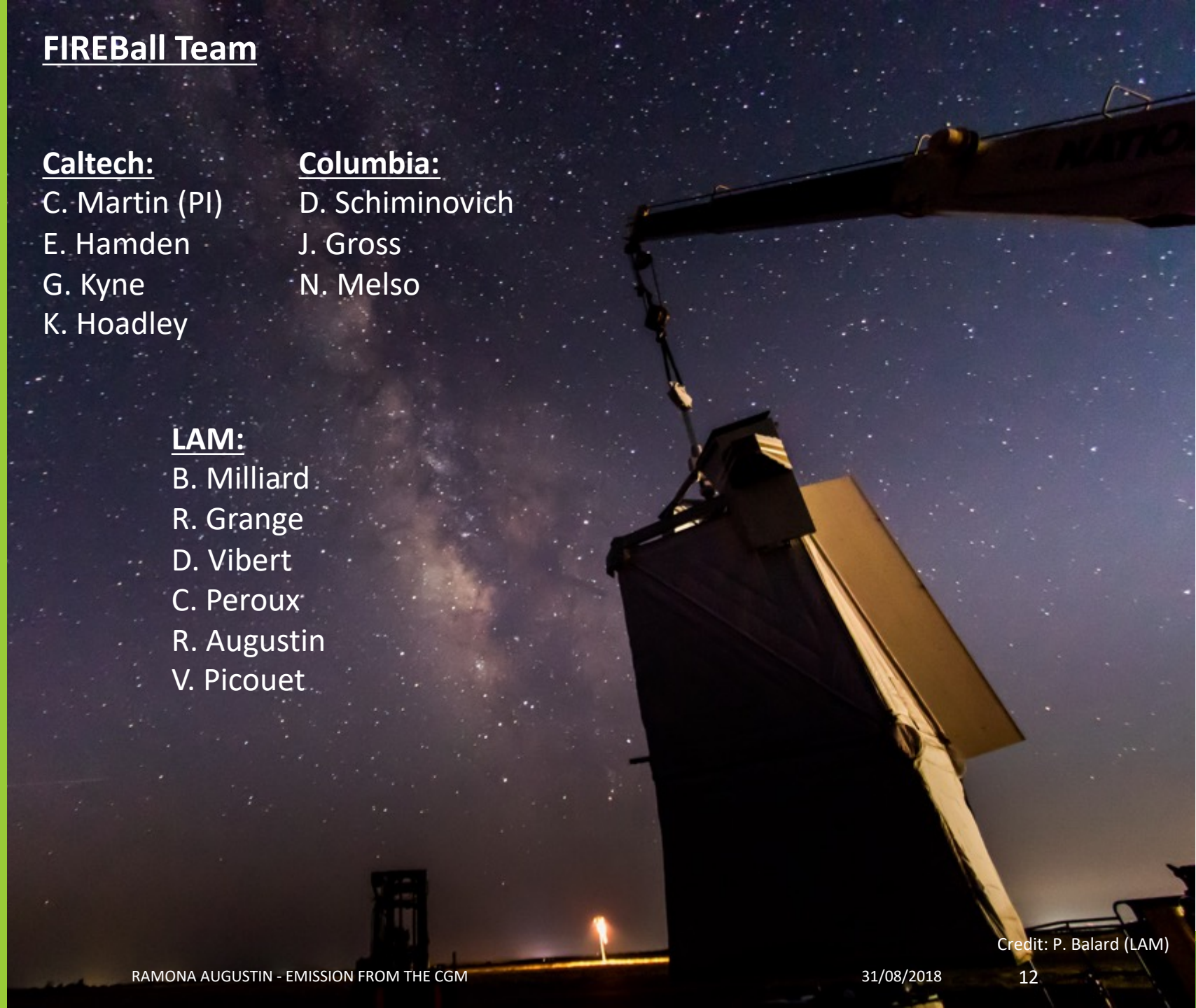
- CIV at z=0.3
- Lyα at z=0.7
- OVI at z=1.0

FIREBall Team

Caltech:
C. Martin (PI)
E. Hamden
G. Kyne
K. Hoadley

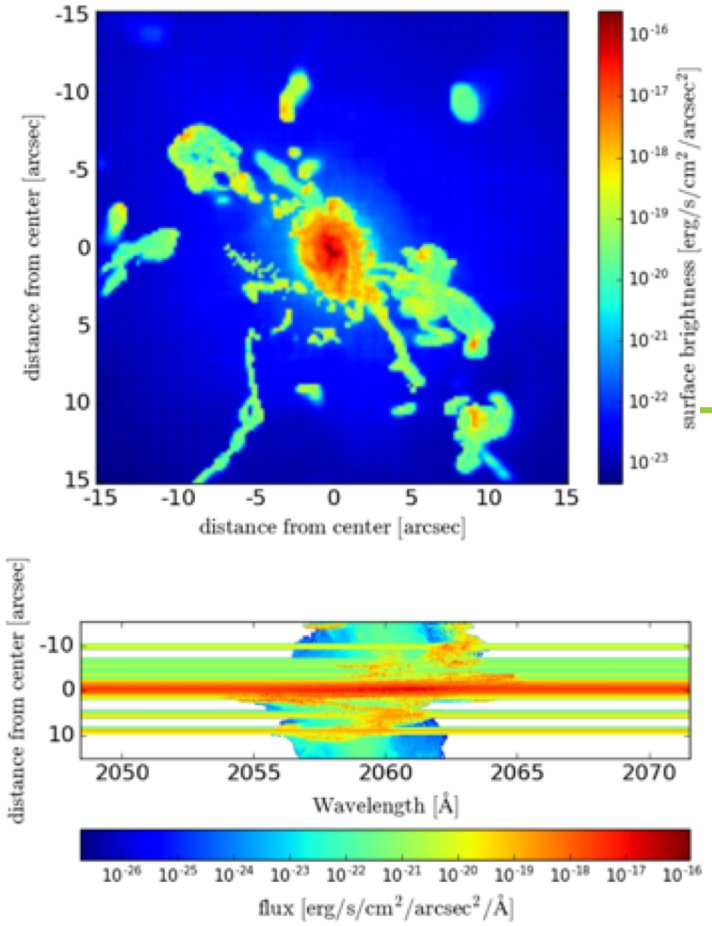
Columbia:
D. Schiminovich
J. Gross
N. Melso

LAM:
B. Milliard
R. Grange
D. Vibert
C. Peroux
R. Augustin
V. Picouet



Credit: P. Balard (LAM)

FIREBall Instrument Model (IMO)



Instrument
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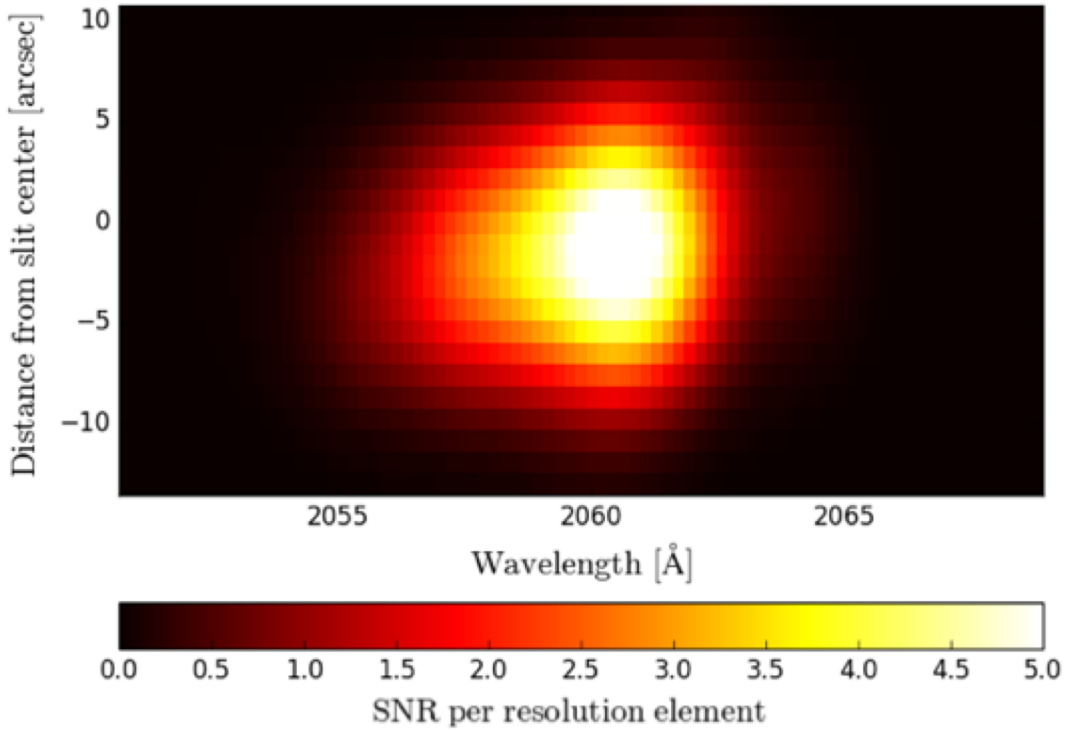
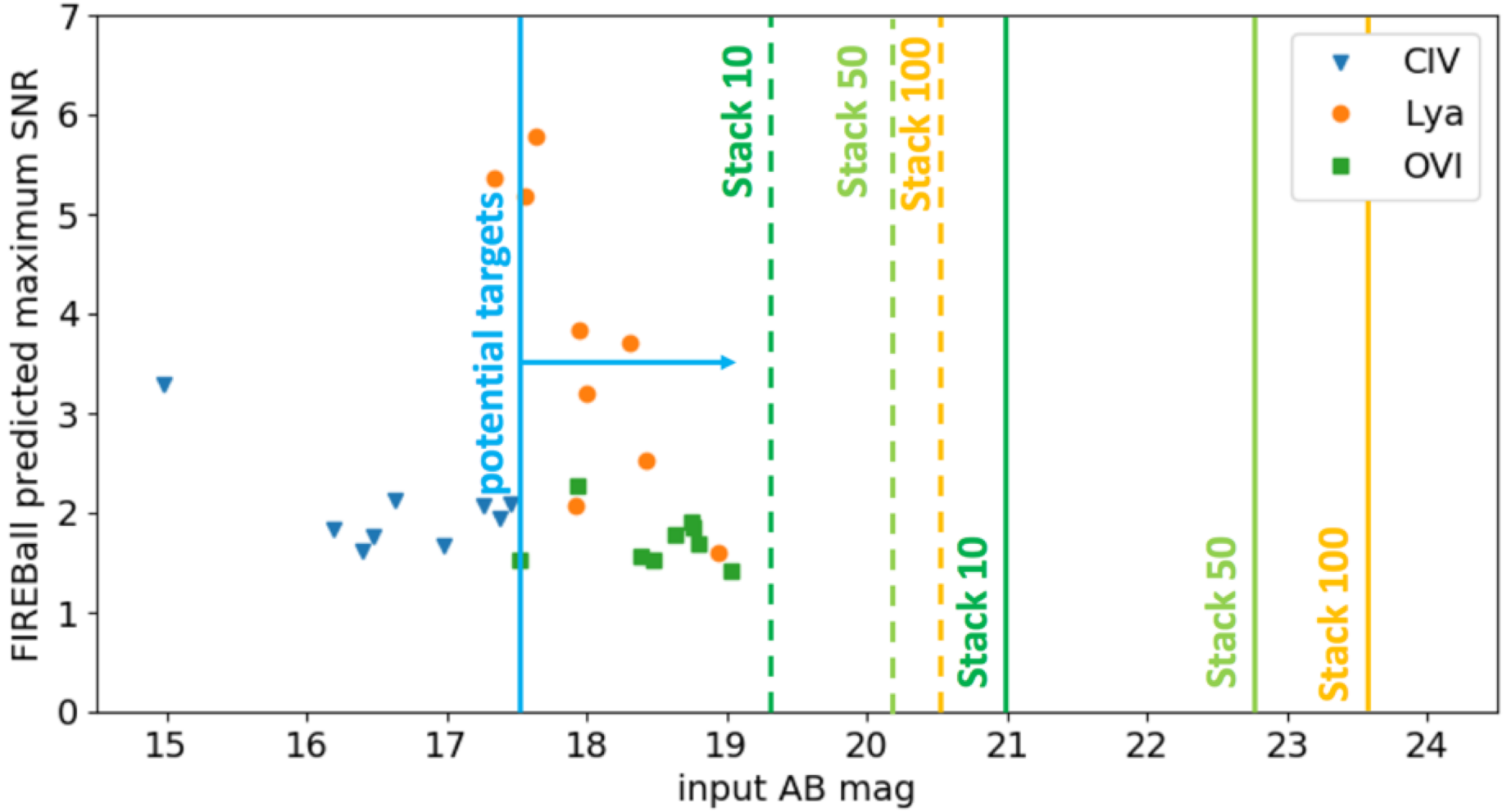


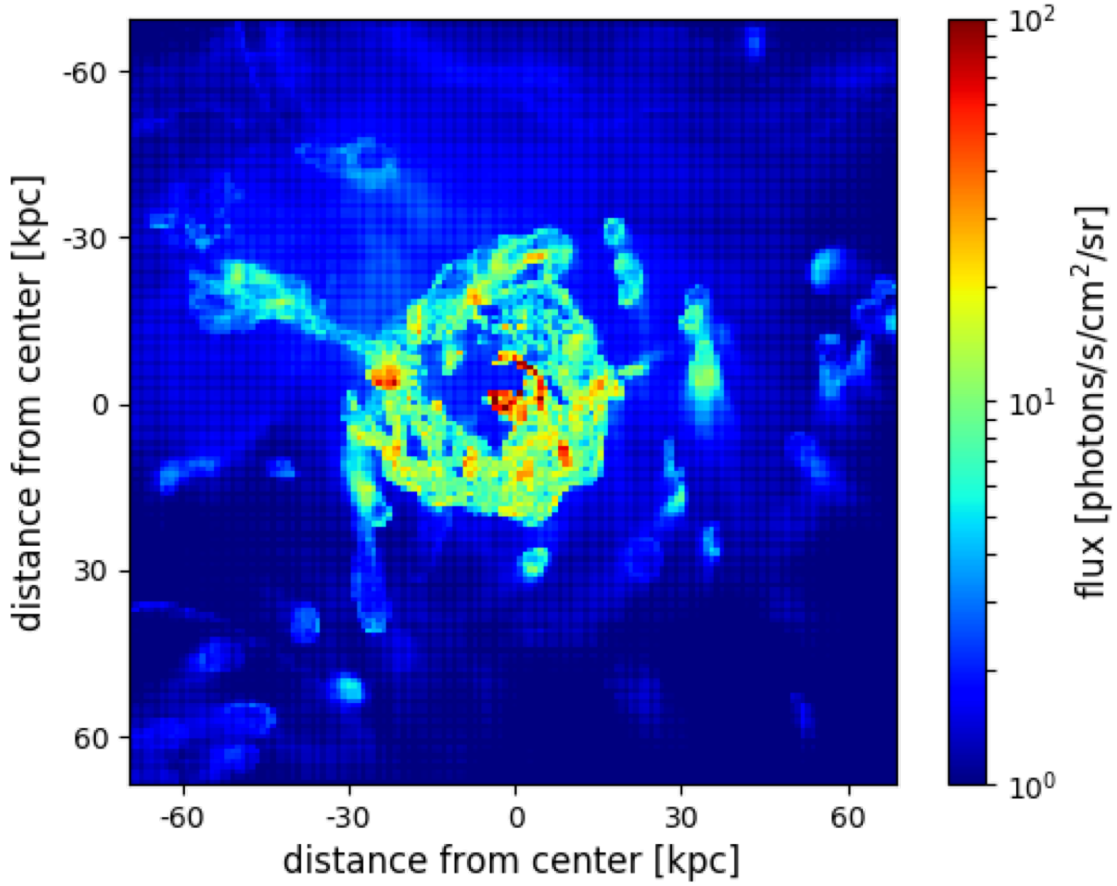
Collaborators:
S. Quiret, C. Péroux,
B. Milliard, D. Vibert,
V. Picouet, C. Martin,
E. Hamden

FIREBall IMO credit:
Mège et al. 2015



Signal of the emission from the CGM

Next step: SNR analysis for ATHENA X-IFU

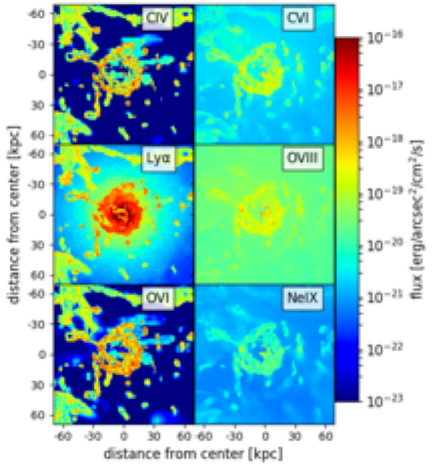


Summary and Conclusions

Augustin et al.
to be submitted

Cosmological zoom-in simulations with the AMR RAMSES code + Emission model from CLOUDY

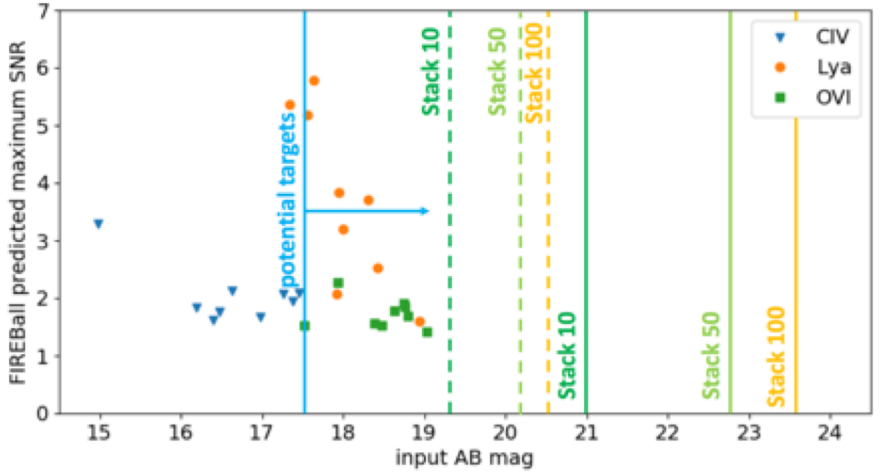
→Post-processing of simulated galaxy halos to create mock observations



Use simulated observations as input for the instrument model of FIREBall-2

→Results:

- Bright QSOs observable
- Fainter Lyα: Stacking
- Metal lines not observable



Use simulated observations as input for HSIM

→Results:

- At least one order of magnitude more sensitive than MUSE/SINFONI
- 'Sweet spot' around z~1-2