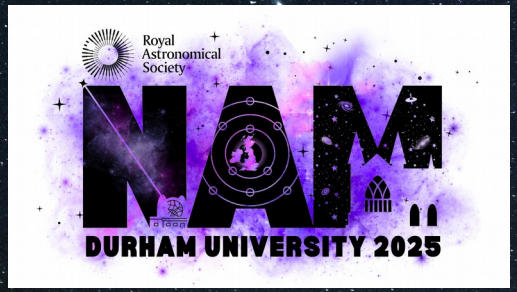
# Direct emission and absorption line metallicities of a GRB host galaxy at z=4.28

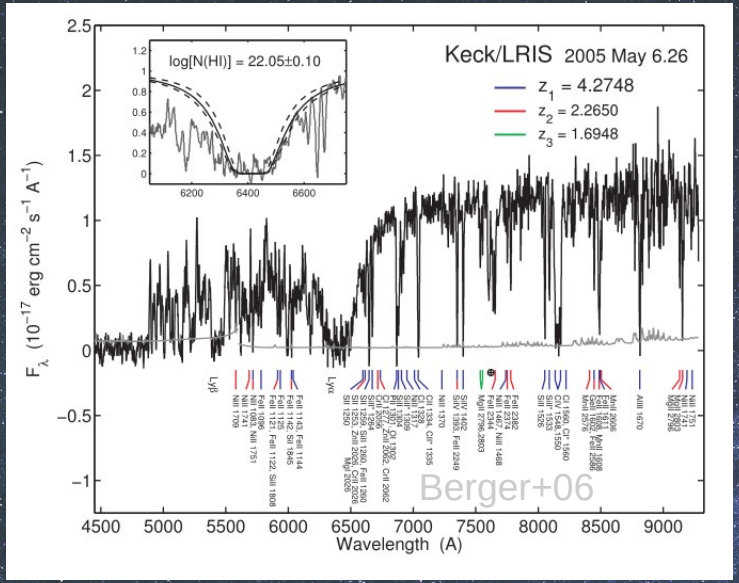
Anne Inkenhaag, Patricia Schady, Phil Wiseman, Rob Yates, et al.



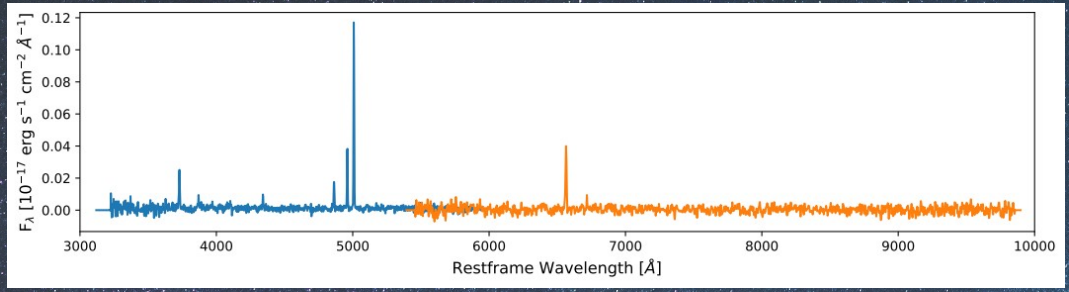

arXiv:2506.08114

UNIVERSITY OF BATH

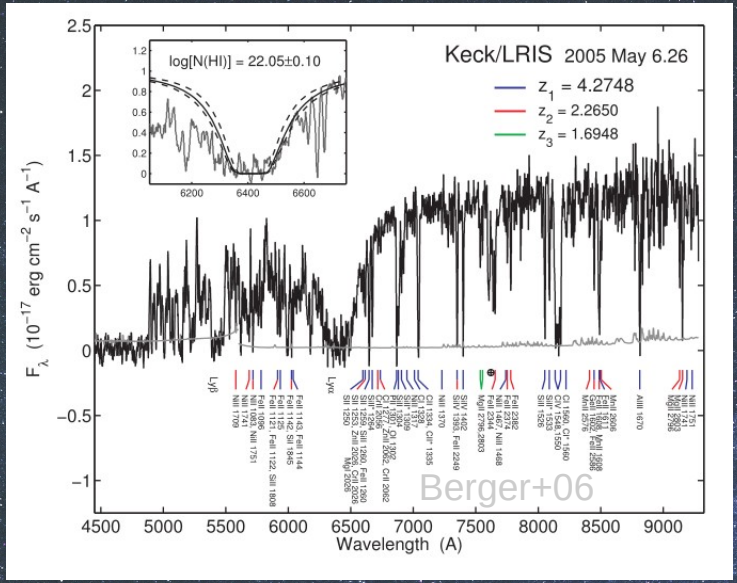
# Absorption



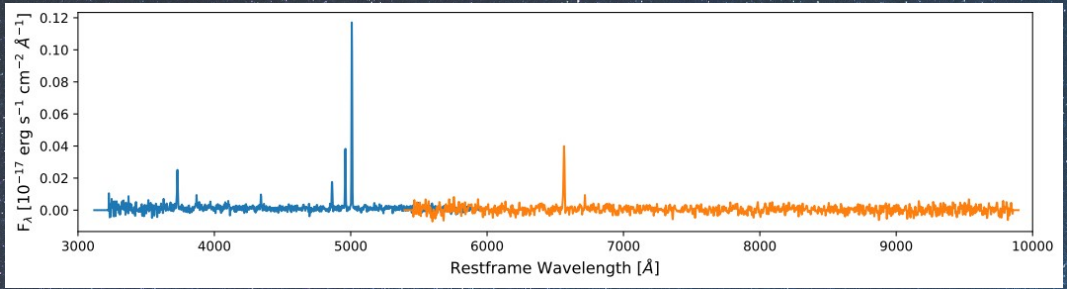

# Emission



# Absorption

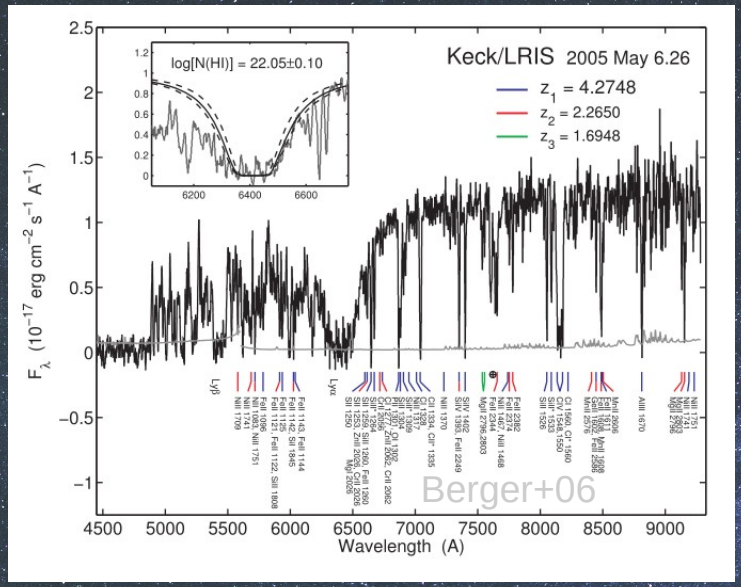



# Emission




**Neutral/cool gas**
Clouds along ling of sight
Not flux limited

# Absorption

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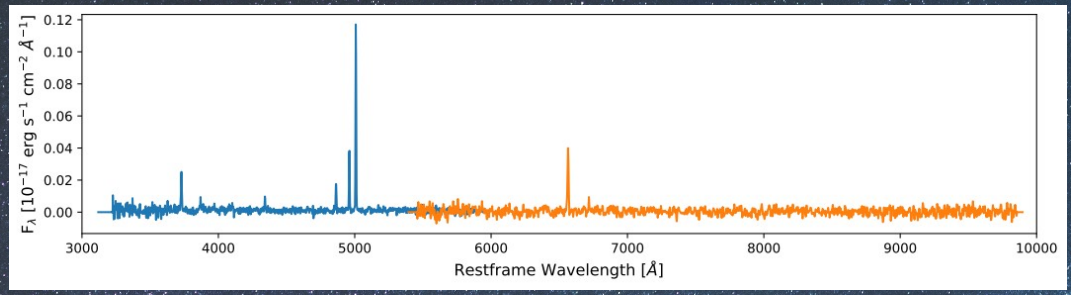
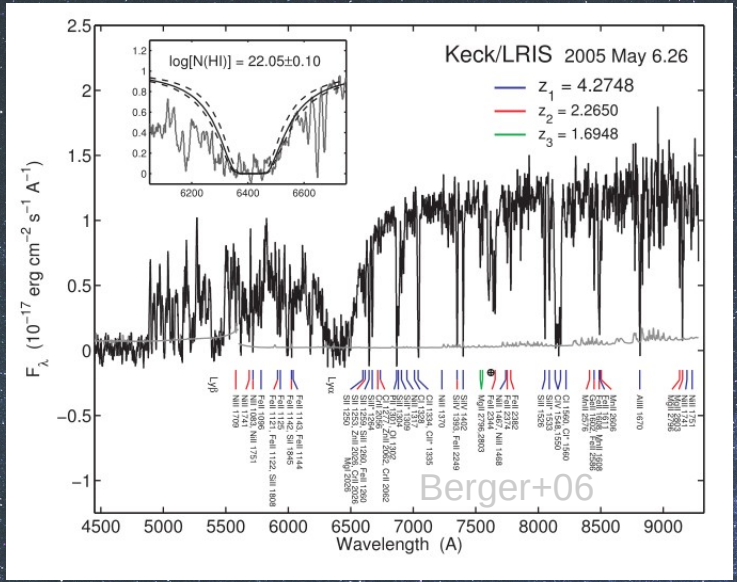



**Ionised/warm gas**
Integrated spectrum
Flux limited

## Absorption

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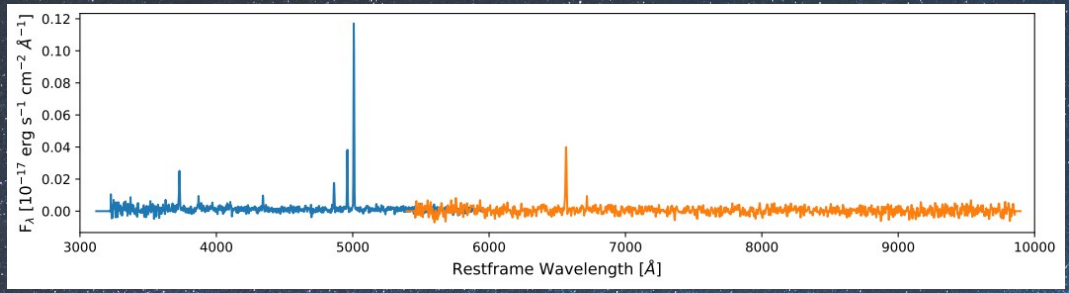
Clouds along ling of sight
Not flux limited

## Emission

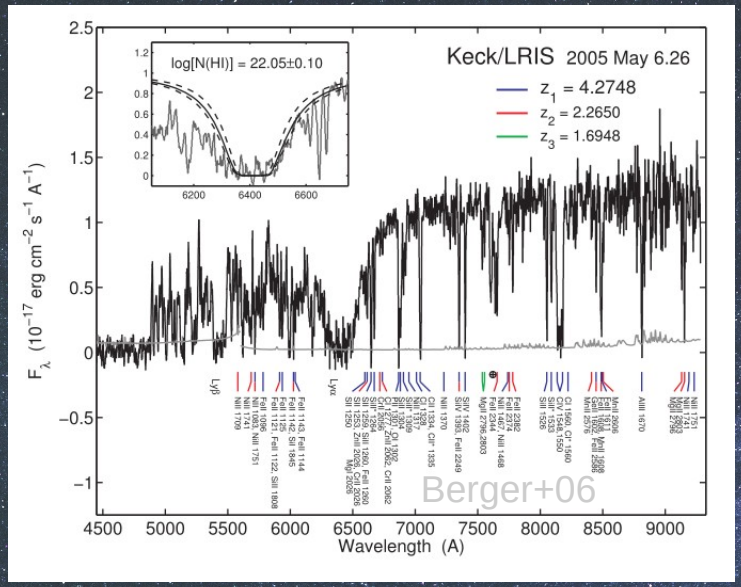



**Ionised/warm gas**
Integrated spectrum
Flux limited

**Te-based**

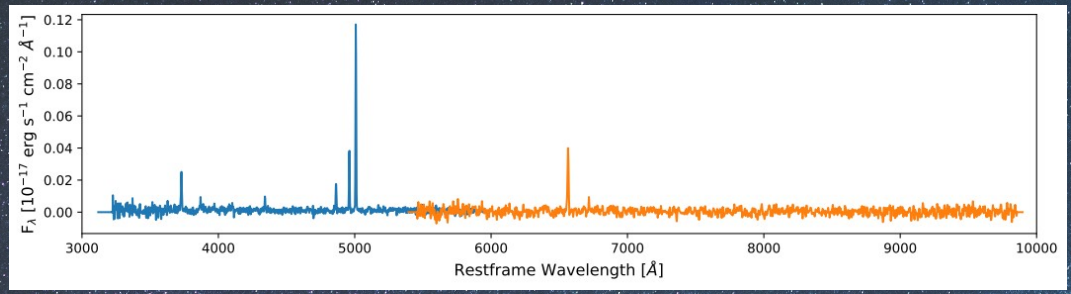
Least model dependent
Auroral lines are dim

# Absorption




**Neutral/cool gas**
Clouds along ling of sight
Not flux limited

# Emission




**Ionised/warm gas**
Integrated spectrum
Flux limited

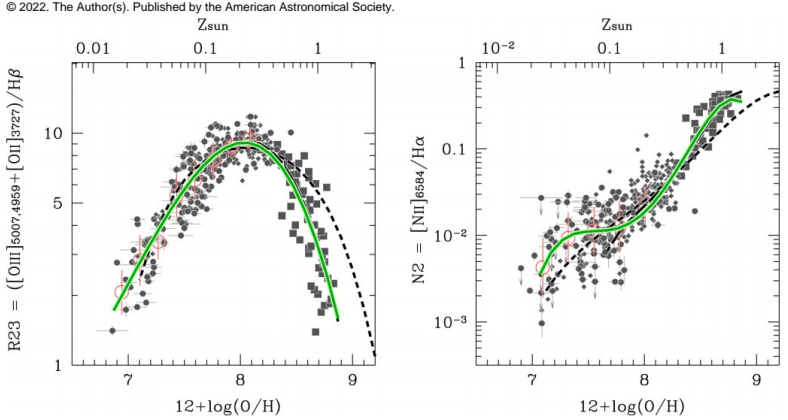
**Te-based**

Least model dependent
Auroral lines are dim

**Strong line diagnostics**

Model dependent
Many options

Figure 3. from
Kimihiko Nakajima et al 2022 Astrophys. J. Suppl. 262 doi:10.3847/1538-4365/ac7710
https://dx.doi.org/10.3847/1538-4365/ac7710


Nakajima+2022

Figure 4. from
Kimihiko Nakajima et al 2022 Astrophys. J. Suppl. 262 doi:10.3847/1538-4365/ac7710
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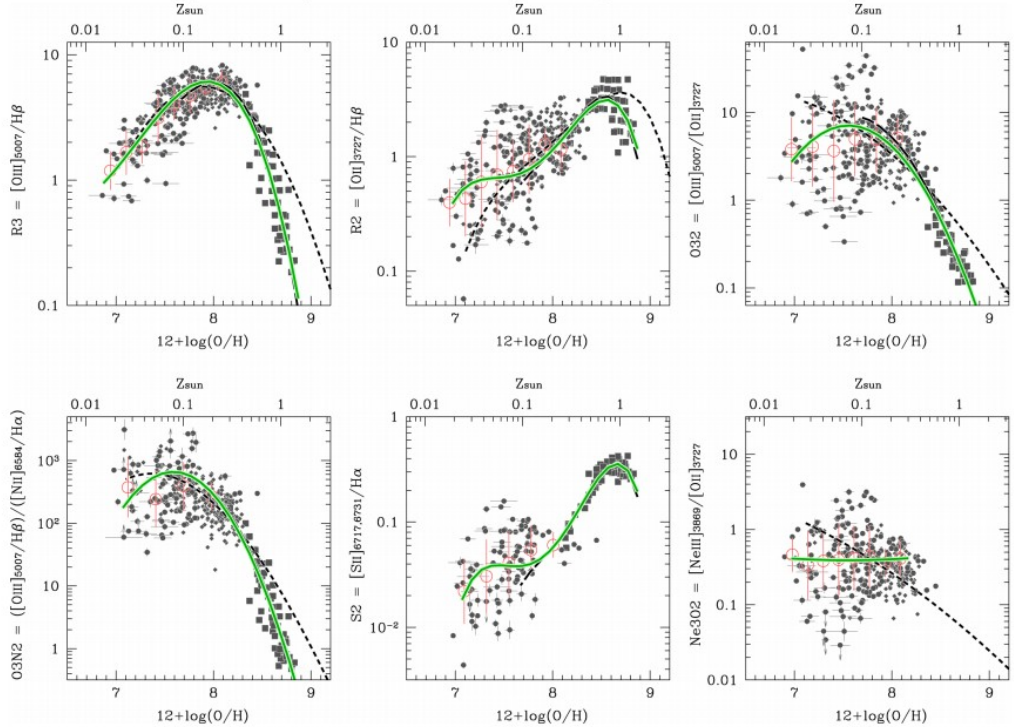
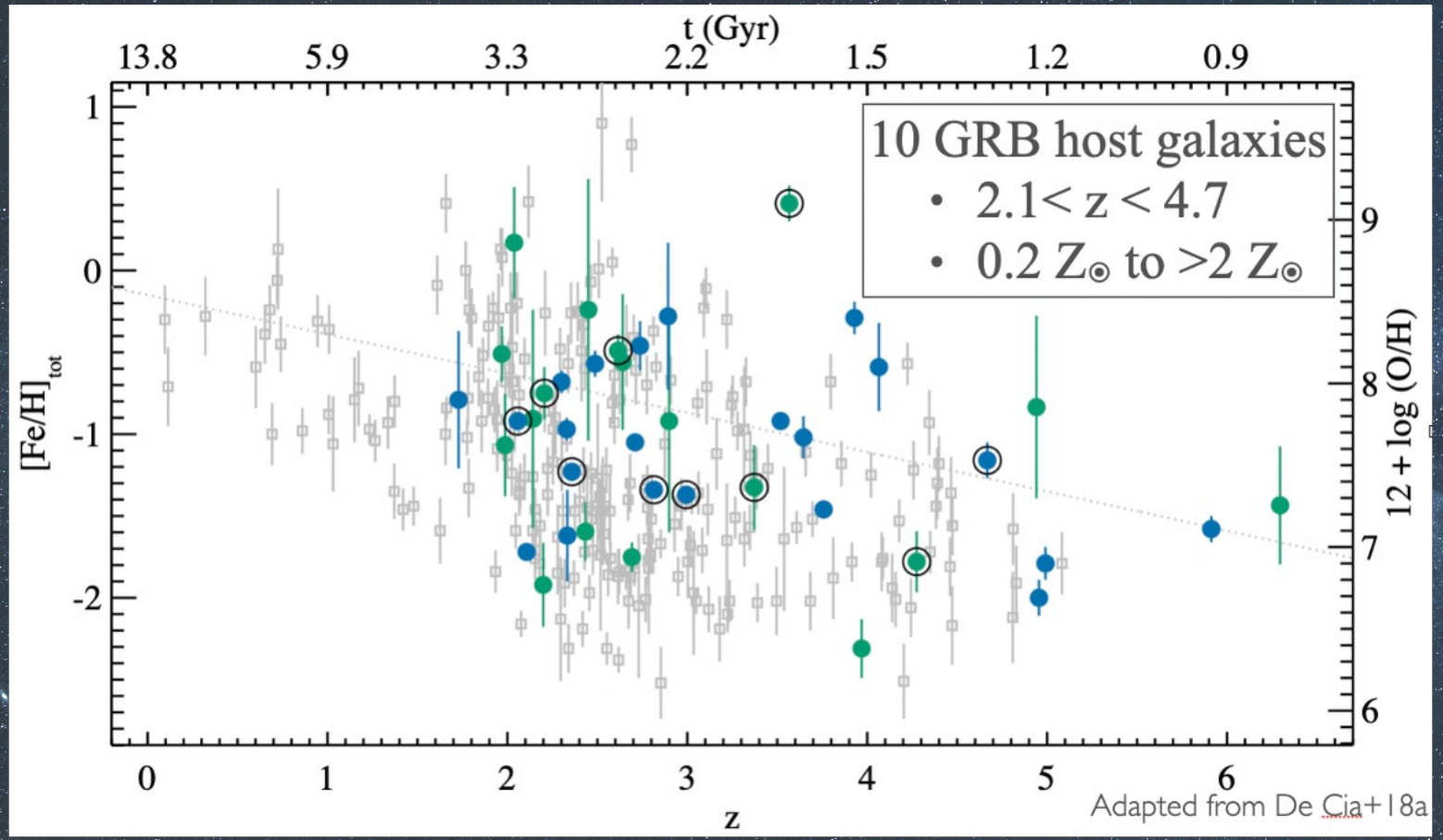
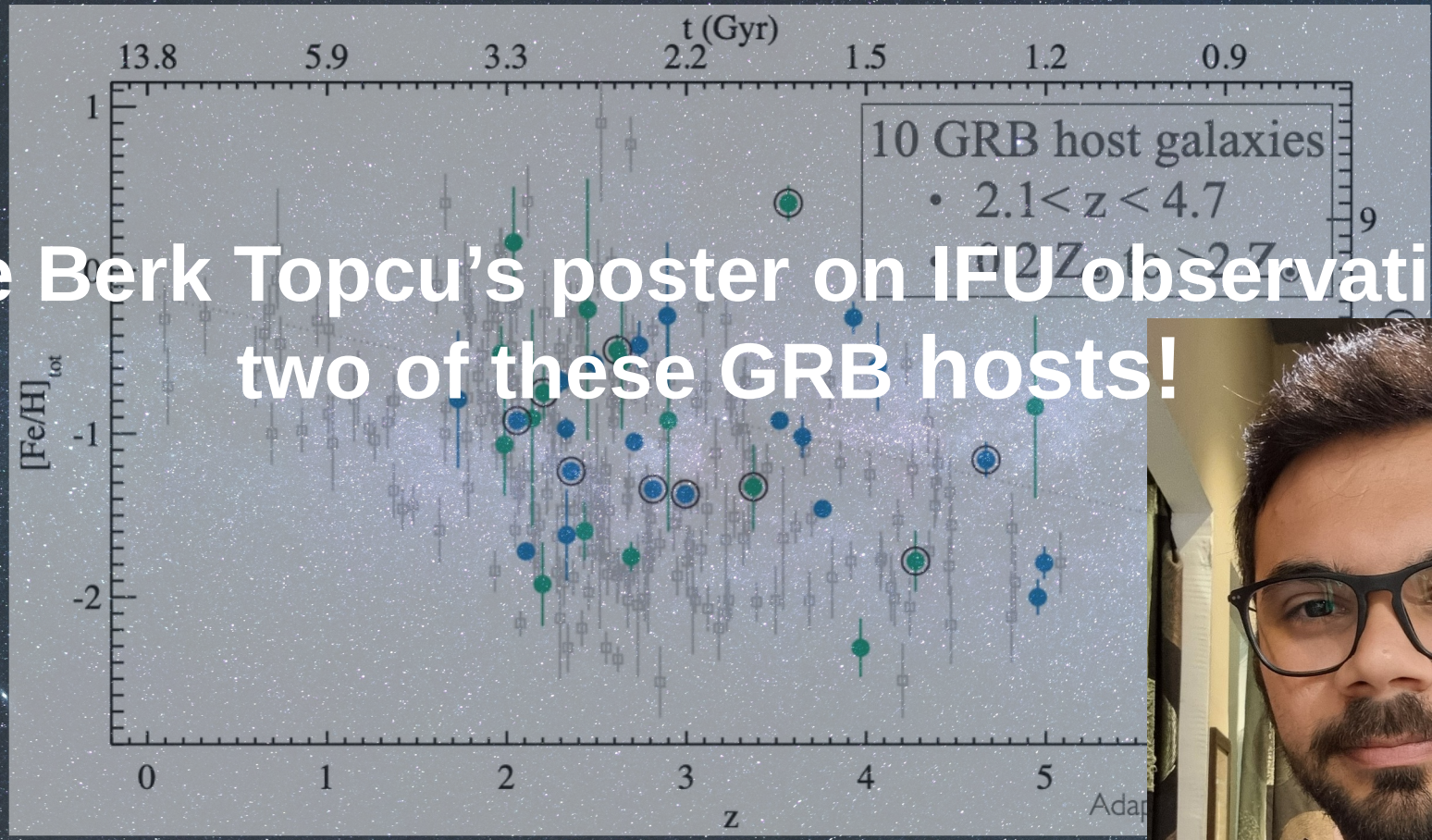
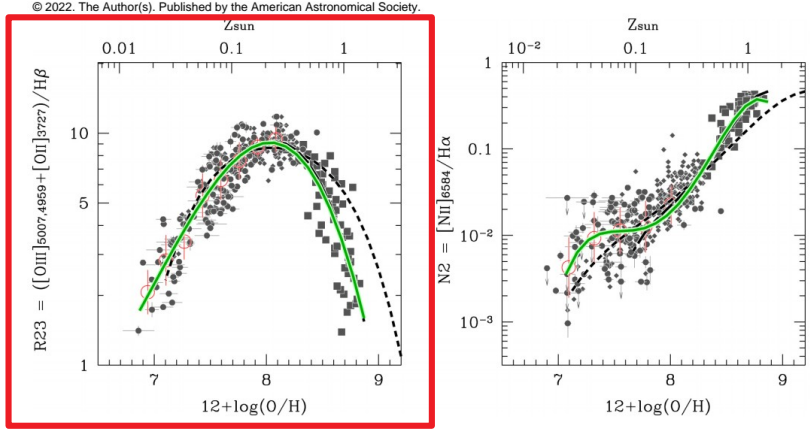



t (Gyr)
13.8
5.9
3.3
2.2
1.5
1.2
0.9
10 GRB host galaxies
• 2.1< z < 4.7
• 0.2 Z⊙ to >2 Z⊙
[Fe/H]tot
12 + log (O/H)
z
Adapted from De Cia+18a




# Go see Berk Topcu's poster on IFU observations of two of these GRB hosts!

Figure 3. from
Kimihiko Nakajima et al 2022 Astrophys. J. Suppl. 262 doi:10.3847/1538-4365/ac7710
https://dx.doi.org/10.3847/1538-4365/ac7710


Nakajima+2022

Figure 4. from
Kimihiko Nakajima et al 2022 Astrophys. J. Suppl. 262 doi:10.3847/1538-4365/ac7710
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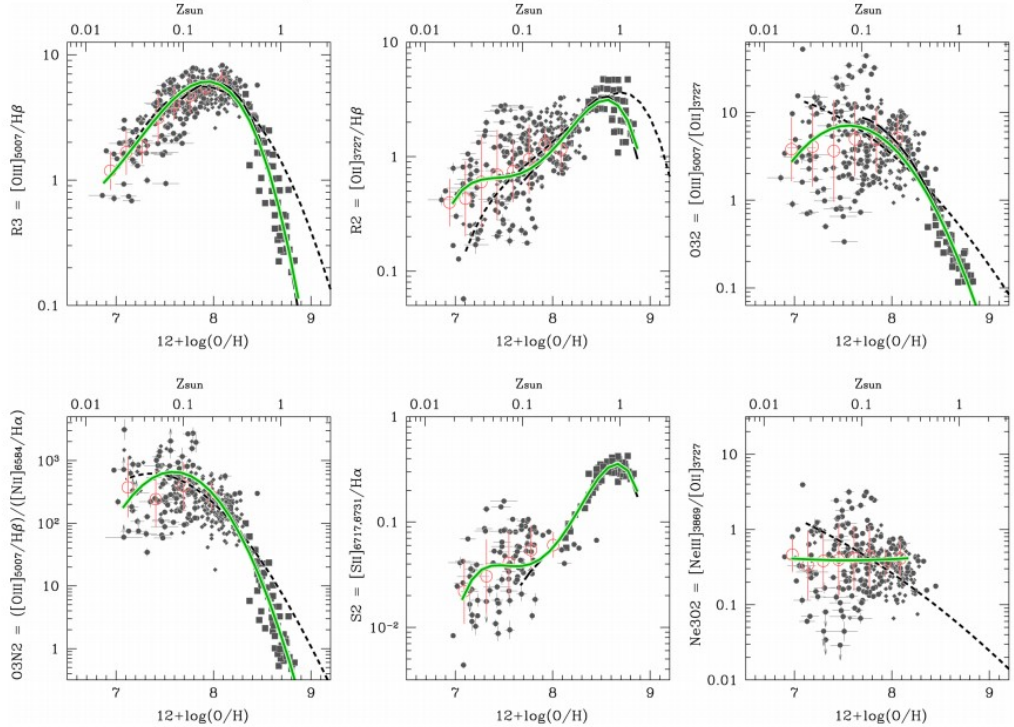
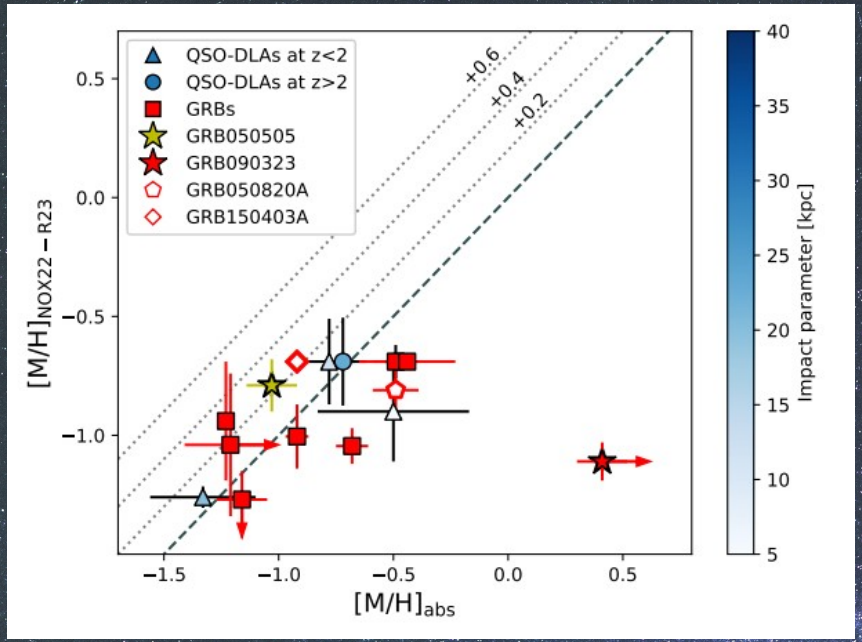
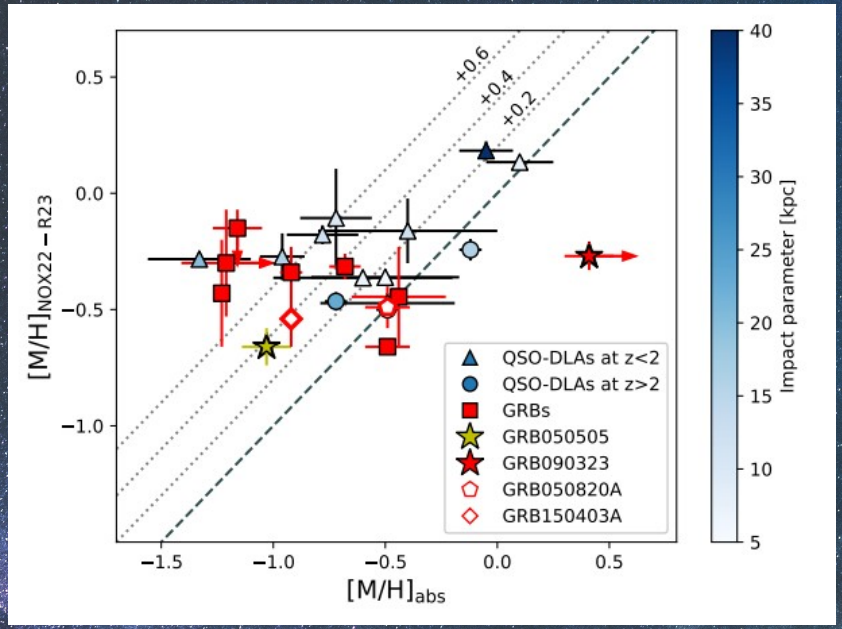



QSO-DLAs at z<2
QSO-DLAs at z>2
GRBs
GRB050505
GRB090323
GRB050820A
GRB150403A
+0.6
+0.4
+0.2
[M/H]NOX22 − R23
[M/H]abs
Impact parameter [kpc]


QSO-DLAs at z<2
QSO-DLAs at z>2
GRBs
GRB050505
GRB090323
GRB050820A
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+0.6
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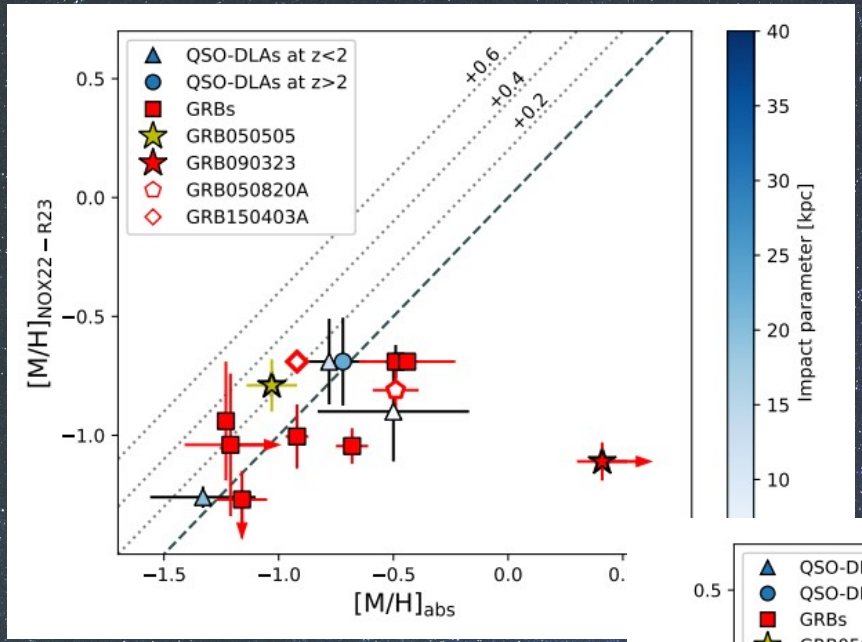
Impact parameter [kpc]


QSO-DLAs at z<2
QSO-DLAs at z>2
GRBs
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+0.6
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[M/H]NOX22 − R23
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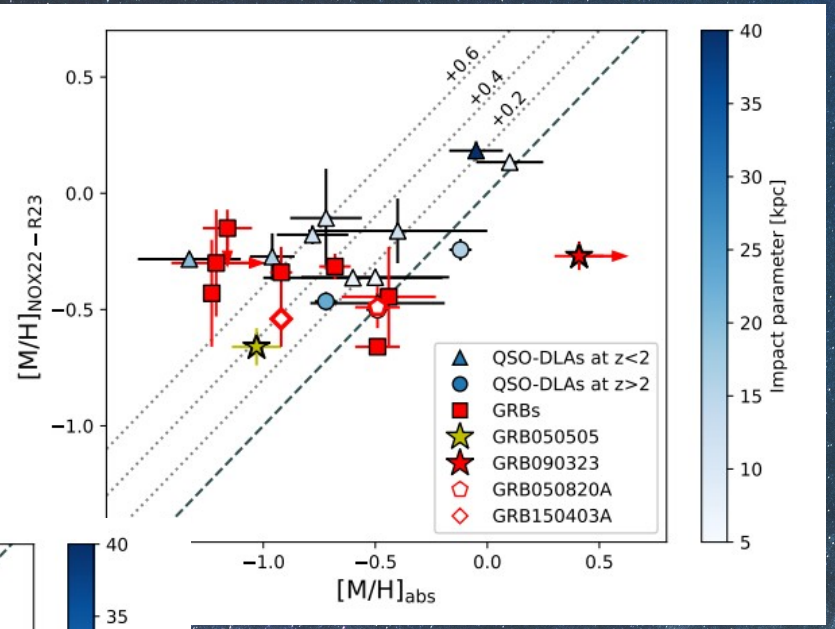
Impact parameter [kpc]


QSO-DLAs at z<2
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GRB090323
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+0.6
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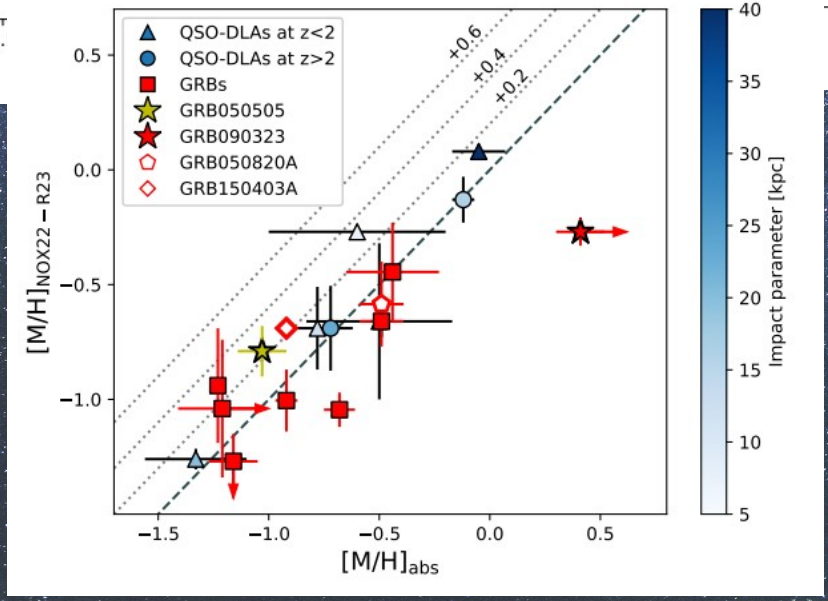
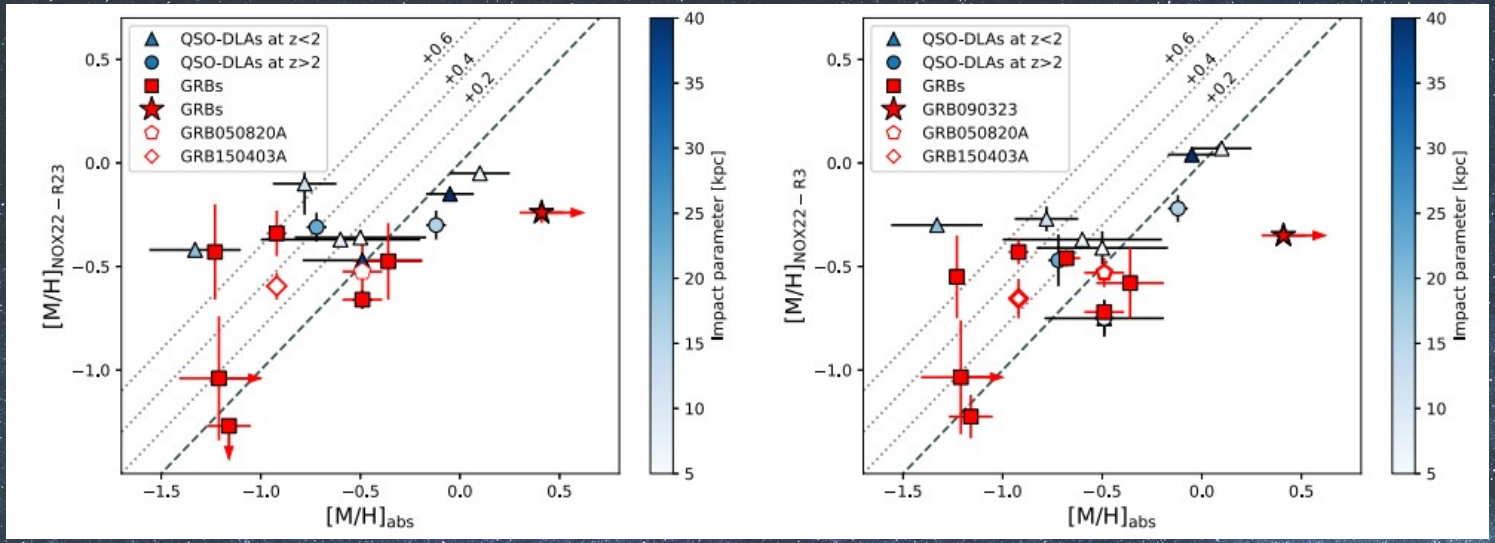

QSO-DLAs at z<2
QSO-DLAs at z>2
GRBs
GRB050505
GRB090323
GRB050820A
GRB150403A
+0.6
+0.4
+0.2
[M/H]NOX22 − R23
[M/H]abs
Impact parameter [kpc]



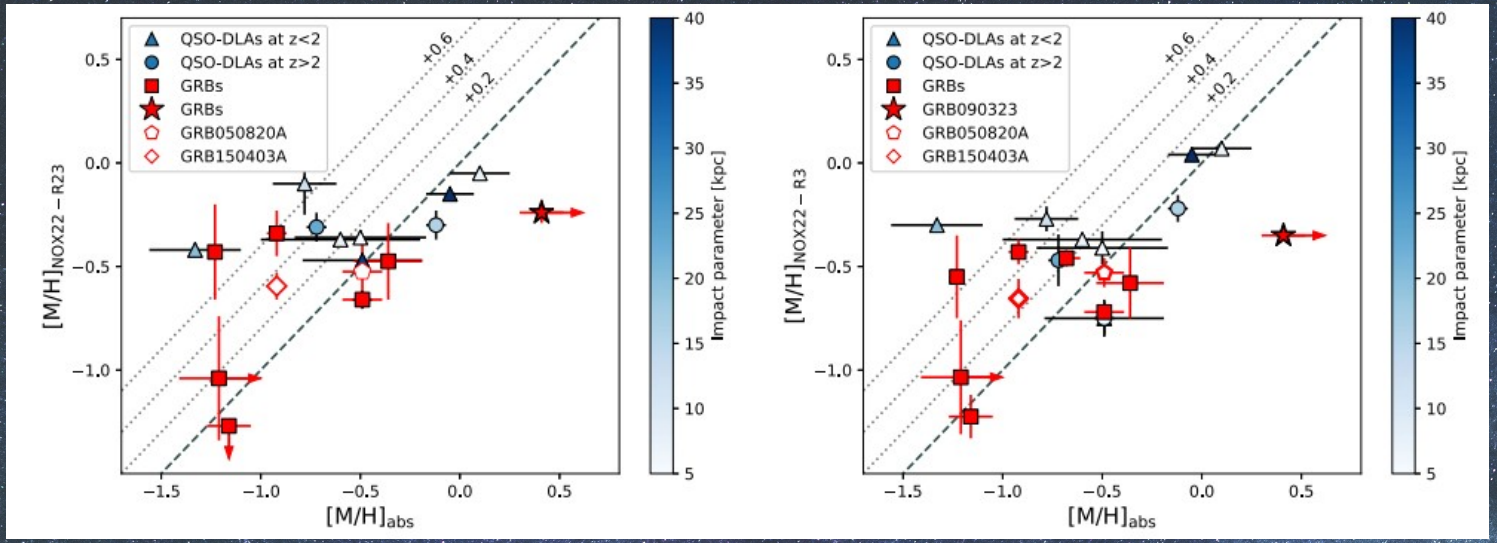

Schady+24

Calibrations not correct?

Zabs & Zem probing different part of the galaxy?

Calibration sample not representative?

Zabs and Zem are actually different?




Schady+24

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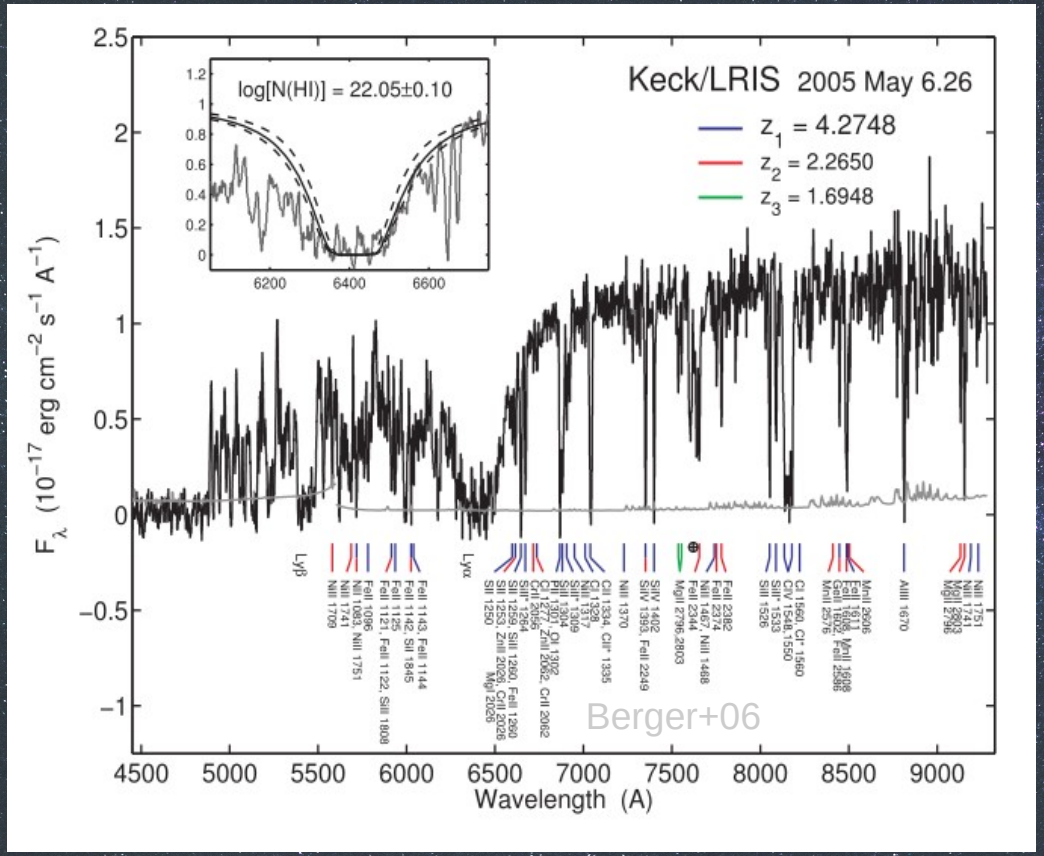
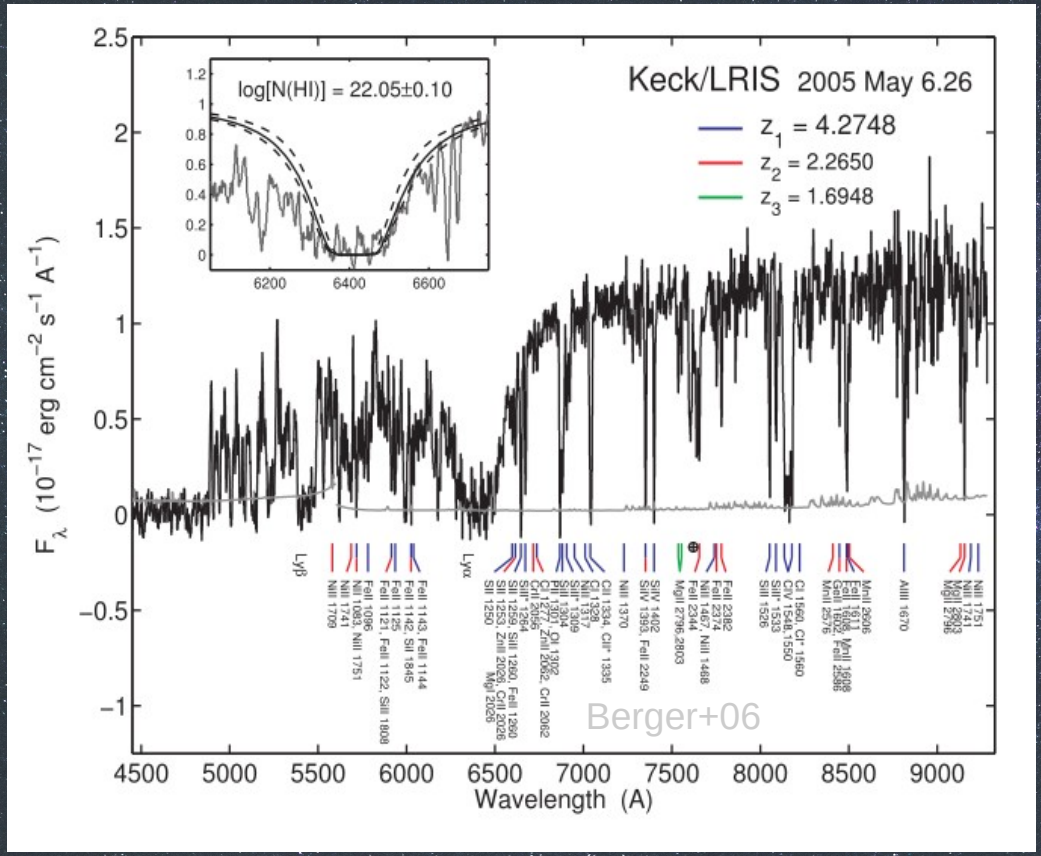
# GRB050505

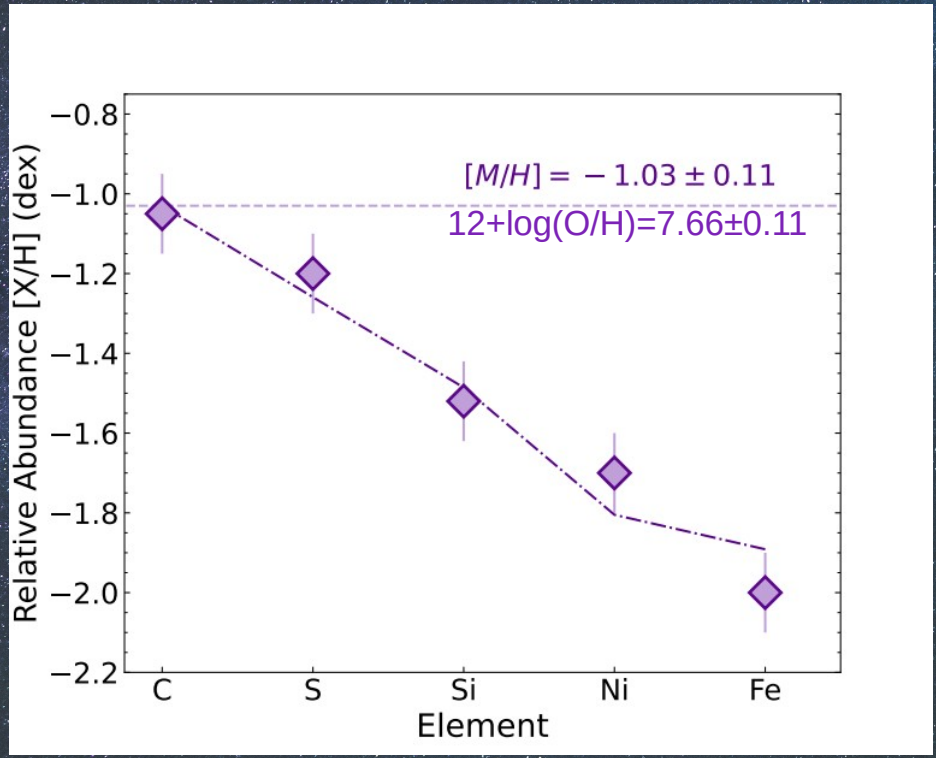



12+log(O/H) > 7.5

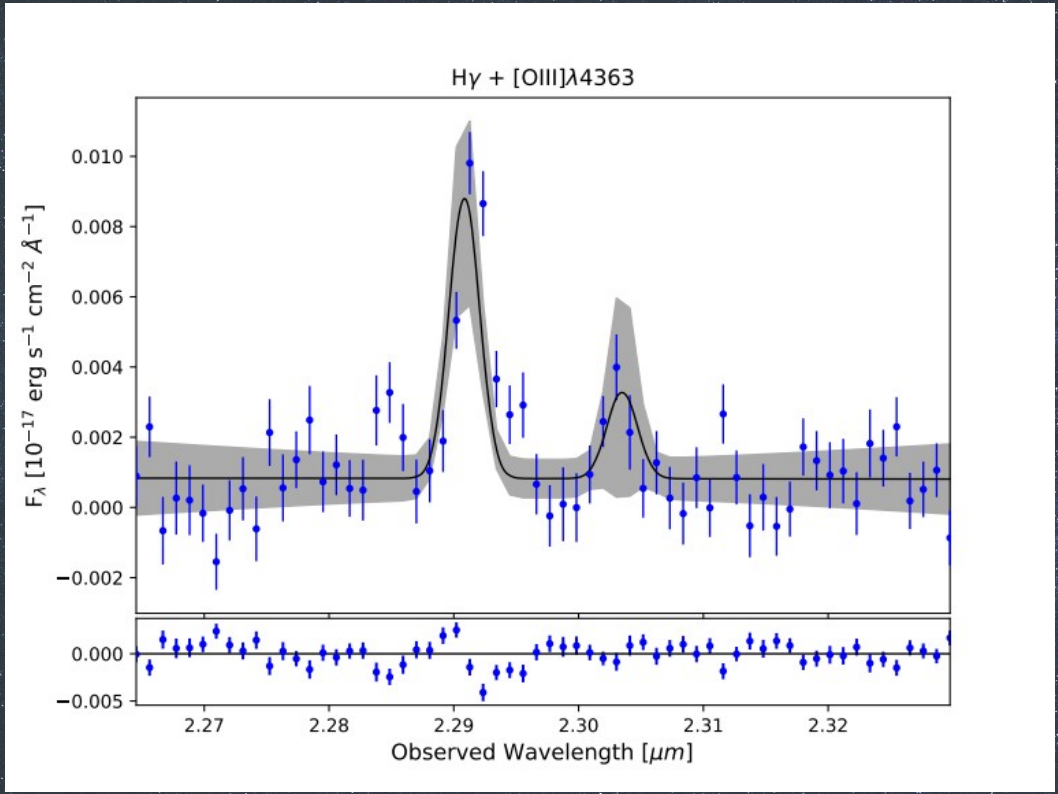
# GRB050505




12+log(O/H) > 7.5

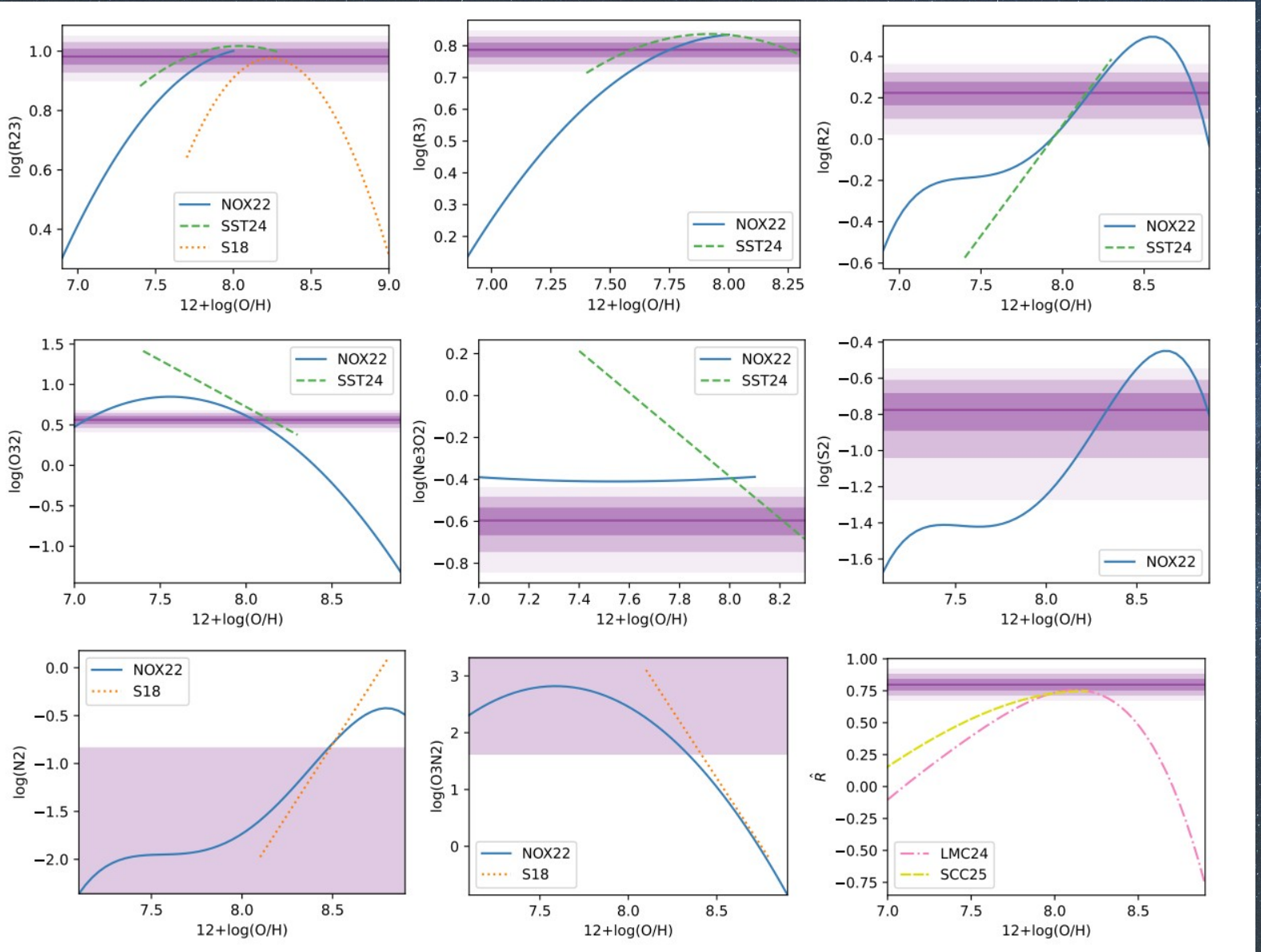


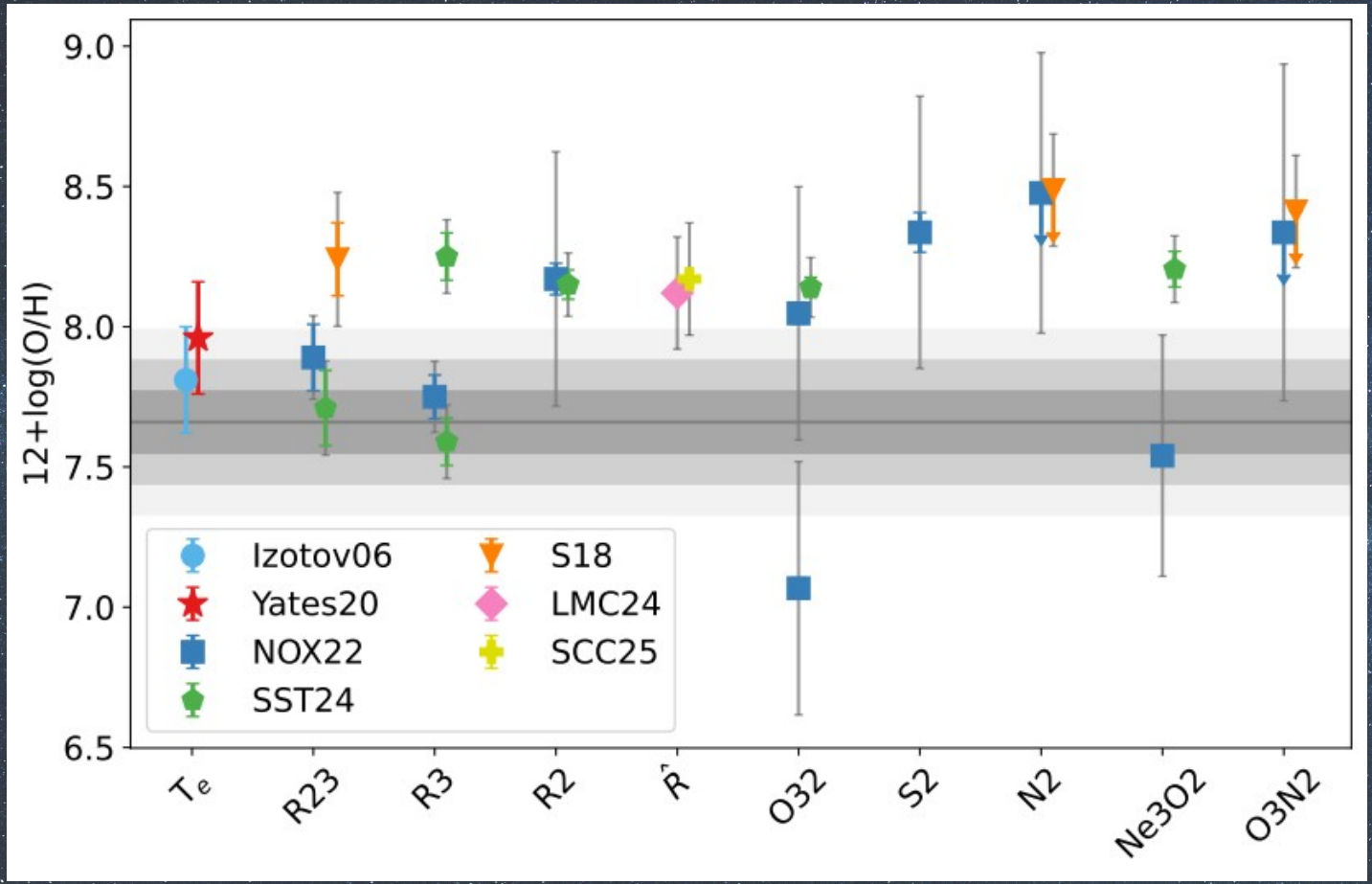
# GRB050505




Two zone ionisation model

Various models for relation between Te([OII]) and Te([OIII])


log(R23)
12+log(O/H)
NOX22
SST24
S18
log(R3)
log(R2)
log(O32)
log(Ne3O2)
log(S2)
log(N2)
log(O3N2)
$\hat{R}$
LMC24
SCC25


9.0
8.5
8.0
7.5
7.0
6.5
12+log(O/H)
Izotov06
Yates20
NOX22
SST24
S18
LMC24
SCC25
$T_e$
R23
R3
R2
$\hat{R}$
O32
S2
N2
Ne3O2
O3N2

# Take Home Messages

Efficient mixing

Use R23 or $T_e$-based metallicity

N=1, we need more data

arXiv:2506.08114