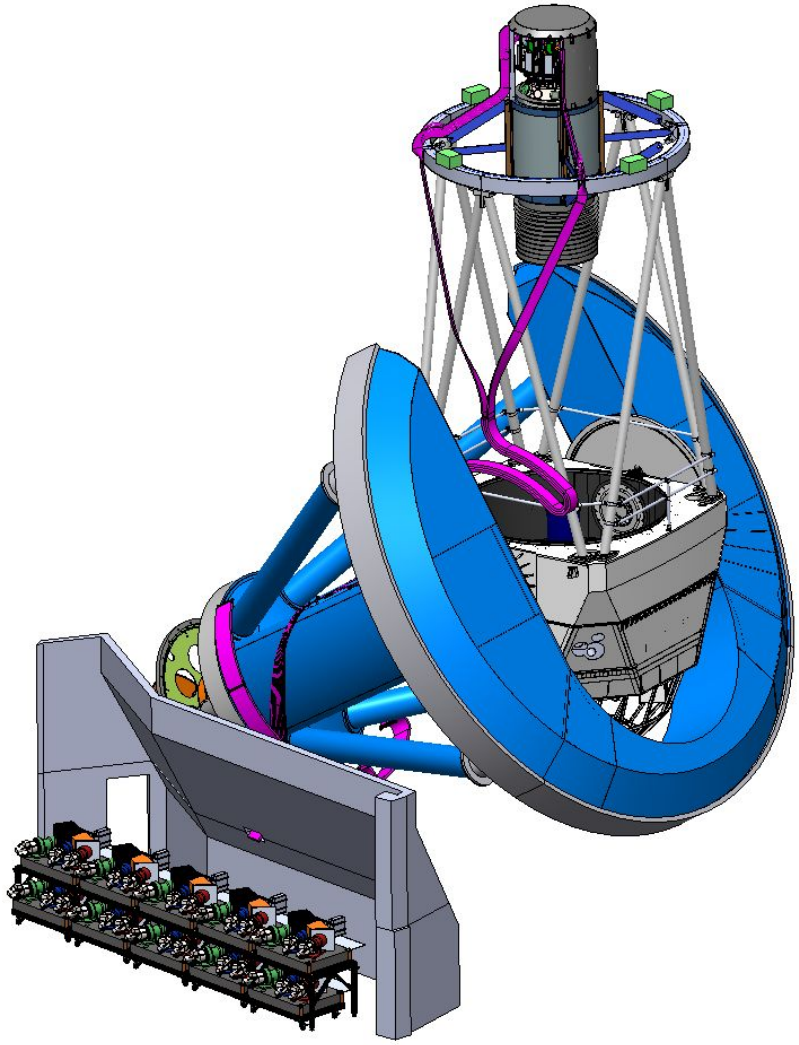


QuasarNP Status on Denali

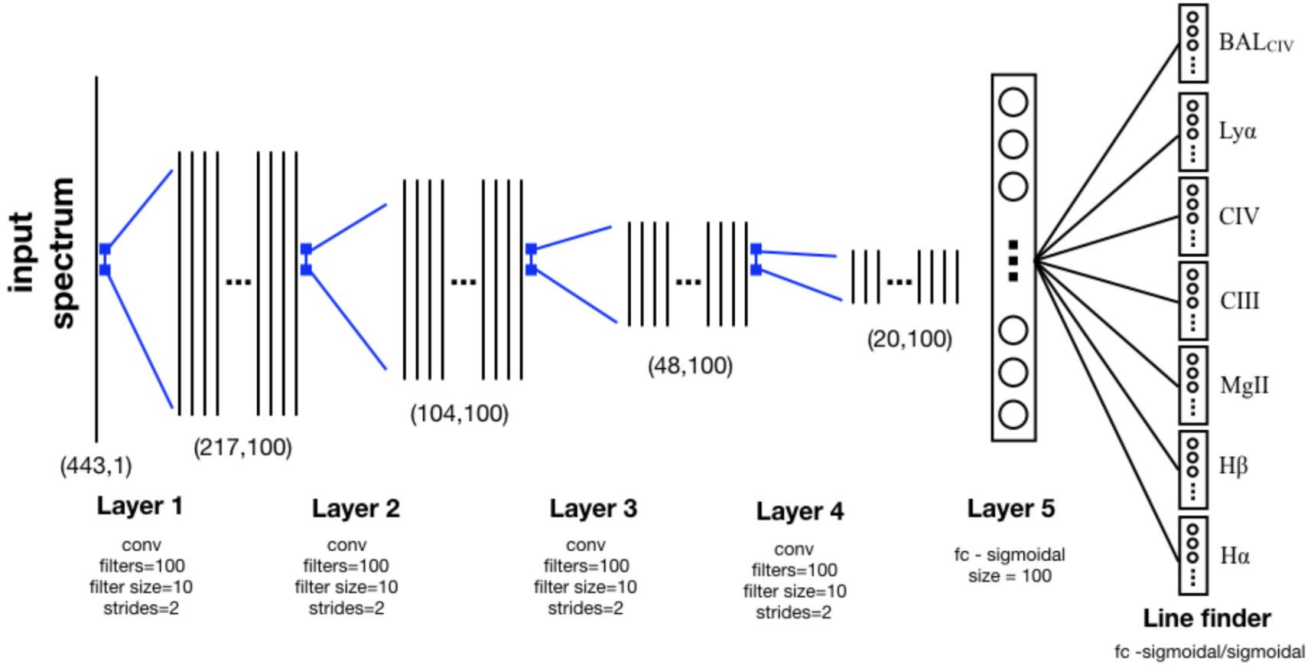
Dylan Green & David Kirkby, UC Irvine

04/15/21 DESI Research Forum

QuasarNet

- QuasarNet is a neural network that identifies quasars directly from flux-calibrated spectra.
  - http://arxiv.org/abs/1808.09955, http://arxiv.org/abs/2007.10348

- QuasarNet is designed to identify 6 Emission lines and 1 Broad Absorption Line (BAL)



QuasarNet → QuasarNP

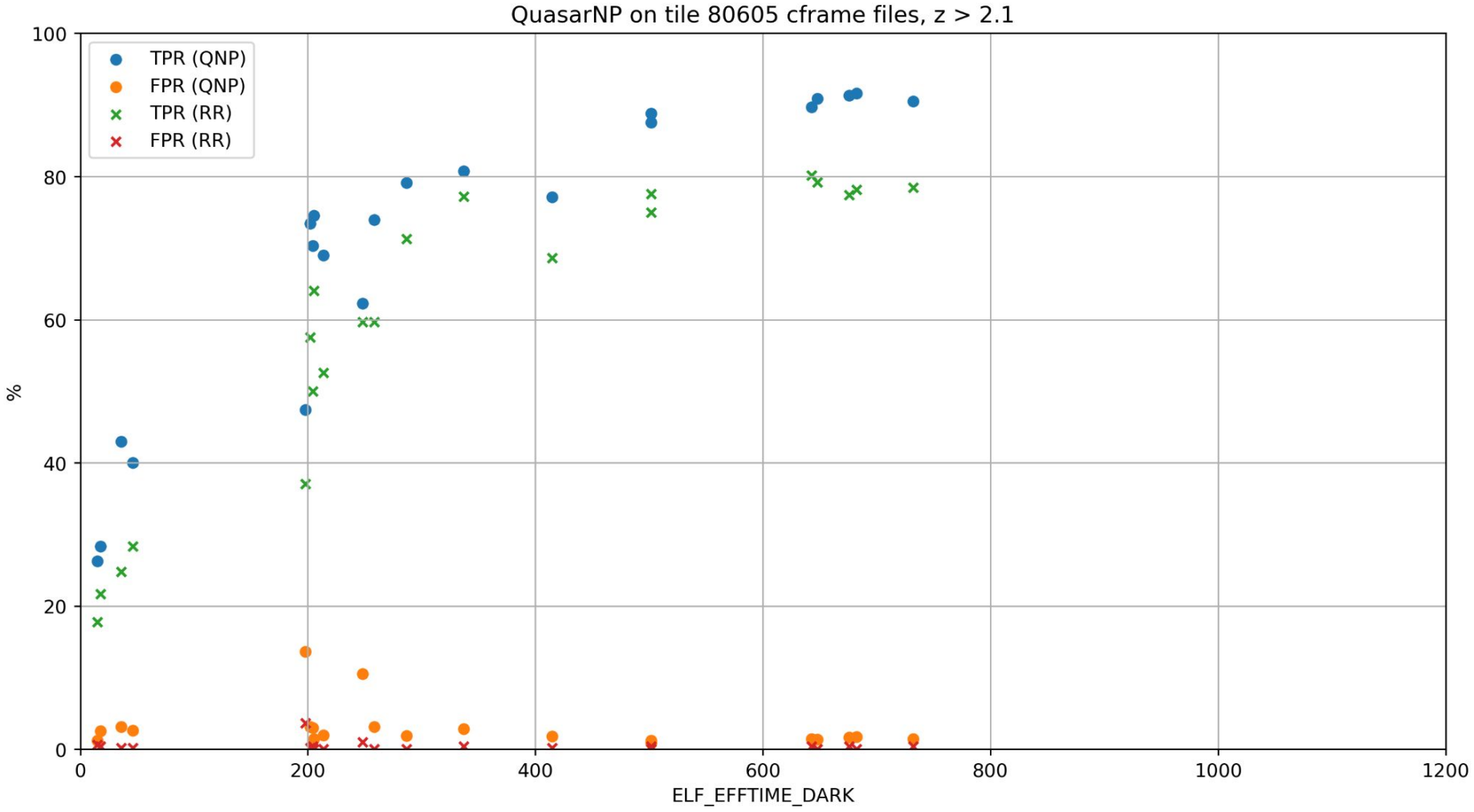
- QuasarNP is a “pure” numpy implementation of QuasarNet that runs in a standard DESI environments (without tensorflow).
  - https://github.com/desihub/QuasarNP
- We run QuasarNP on Denali single exposures of tiles with QSO VI:
  - 80605, 80607, 80609
  - ~20 exposures each with varying depth
- Plot True/False Positive Rate vs ELG_EFFTIME_DARK
  - QN positive: score > 0.4 for at least 1 line
  - RR positive: ZWARN==0 & Z>2.1
  - ELG_EFFTIME_DARK from tsnr-exposures.fits
  - RR results from SV1/redshift_comps/single_exposures/3.1/All/

Example

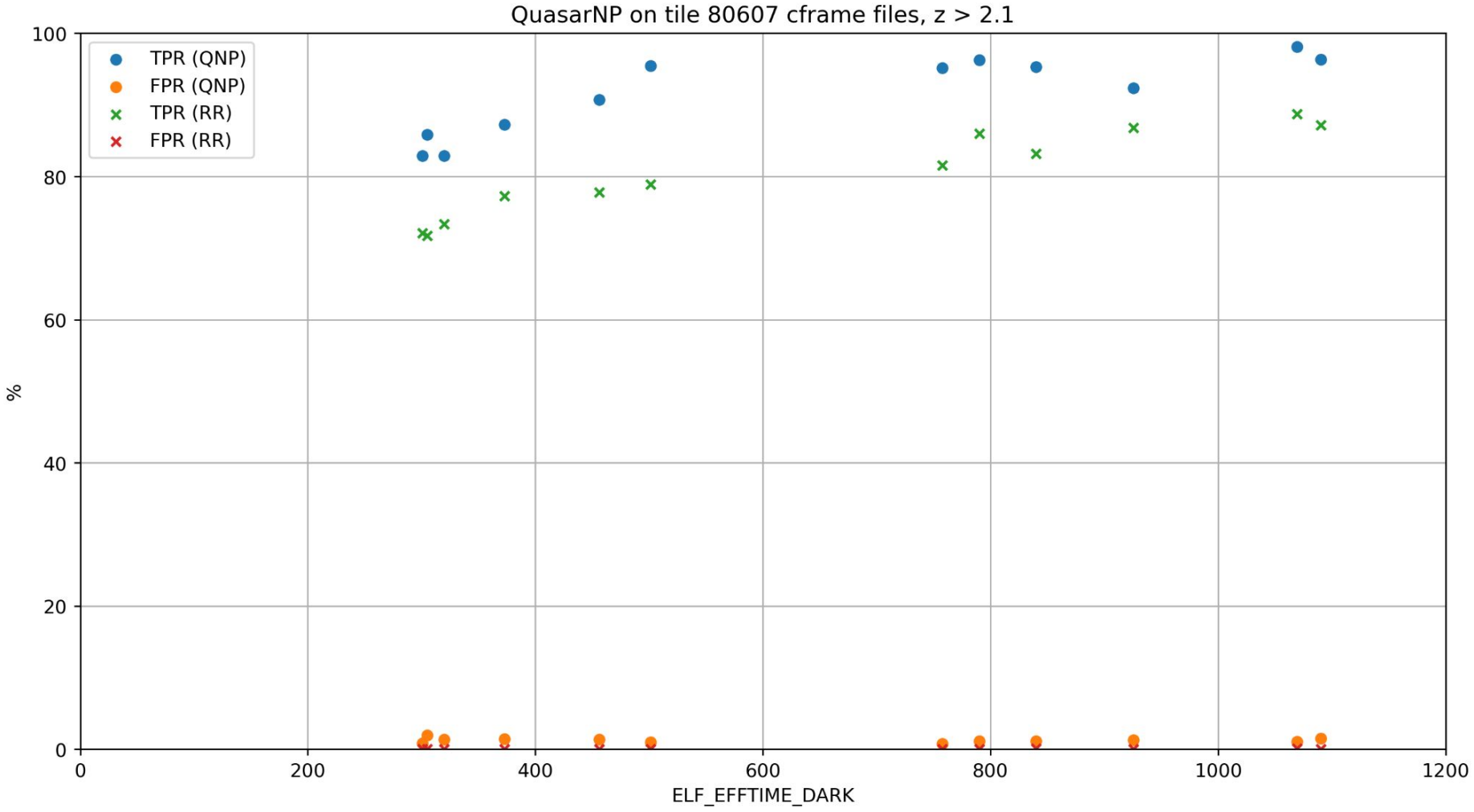
- QuasarNP code follows QuasarNet syntax
- Results in these slides run in the DESI 20.12 Environment!

```
from quasarnp.io import load_model, load_desi_exposure
from quasarnp.utils import process_preds

# Define the lines for which the model was trained
lines = ['LYA','CIV(1548)','CIII(1909)', 'MgII(2796)','Hbeta','Halpha']
lines_bal = ['CIV(1548)']

# Load the model
model = load_model("/global/cfs/cdirs/desi/science/lya/qn_models/boss_dr12/qn_train_coadd_indtrain_0_0_boss10.h5")

# Load the cframe files for a given night, exp_id
night, exp_id = "20210107", "00071246"
dir_name = f"/global/cfs/cdirs/desi/spectro/redux/daily/exposures/{night}/{exp_id}"
spec_number = 0
data, w = load_desi_exposure(dir_name, spec_number)

# Reformat data and predict
data = data[:, :, None]
p = model.predict(data)
c_line, z_line, zbest, c_line_bal, z_line_bal = process_preds(p, lines, lines_bal)

# Determine what is/isn't a quasar from the prediction
c_thresh = 0.5
n_thresh = 1
is_qso = np.sum(c_line > c_thresh, axis=0) >= n_thresh
```

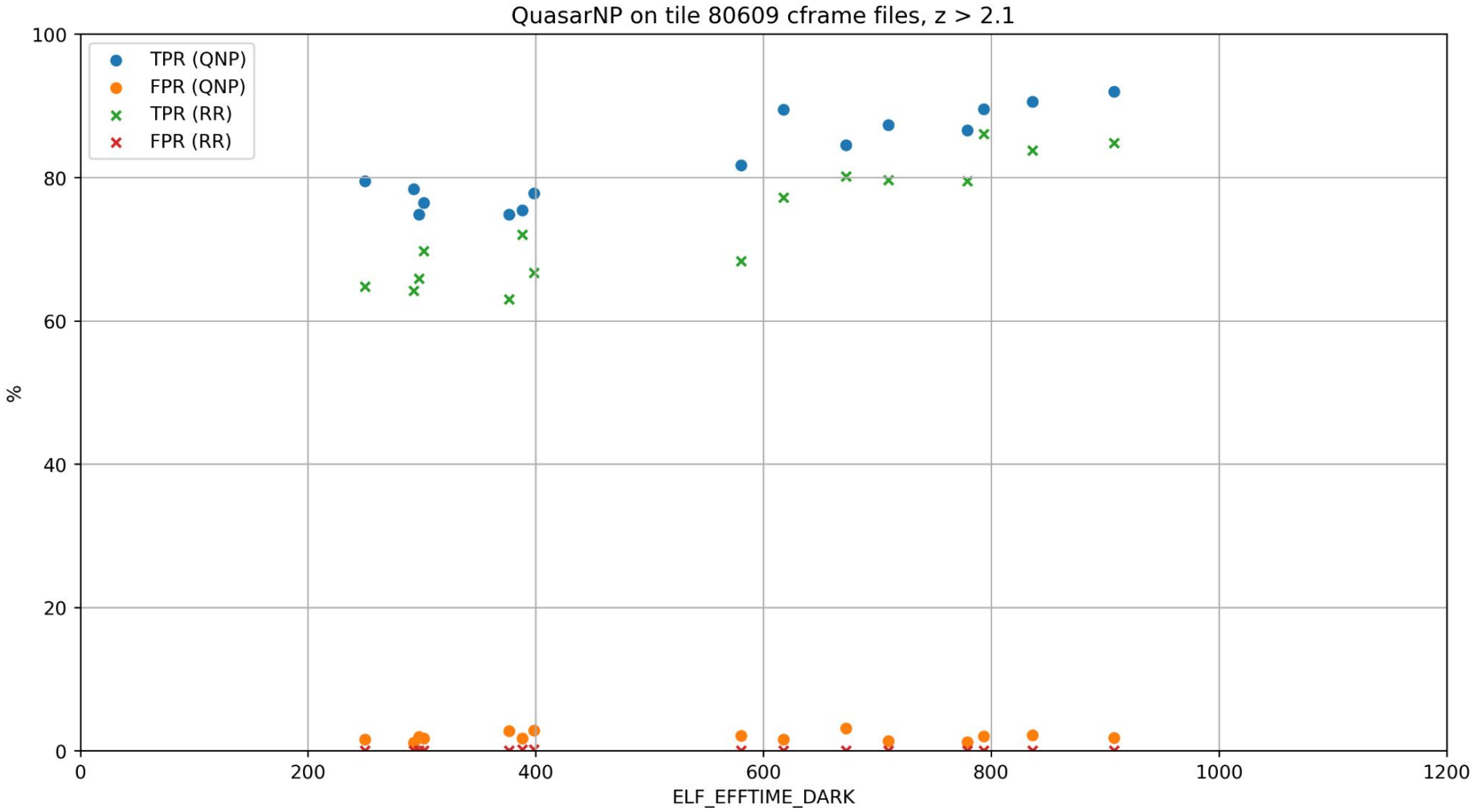
Tile #80605


QuasarNP on tile 80605 cframe files, z > 2.1
TPR (QNP)
FPR (QNP)
TPR (RR)
FPR (RR)
%
ELF_EFFTIME_DARK
0
20
40
60
80
100
0
200
400
600
800
1000
1200

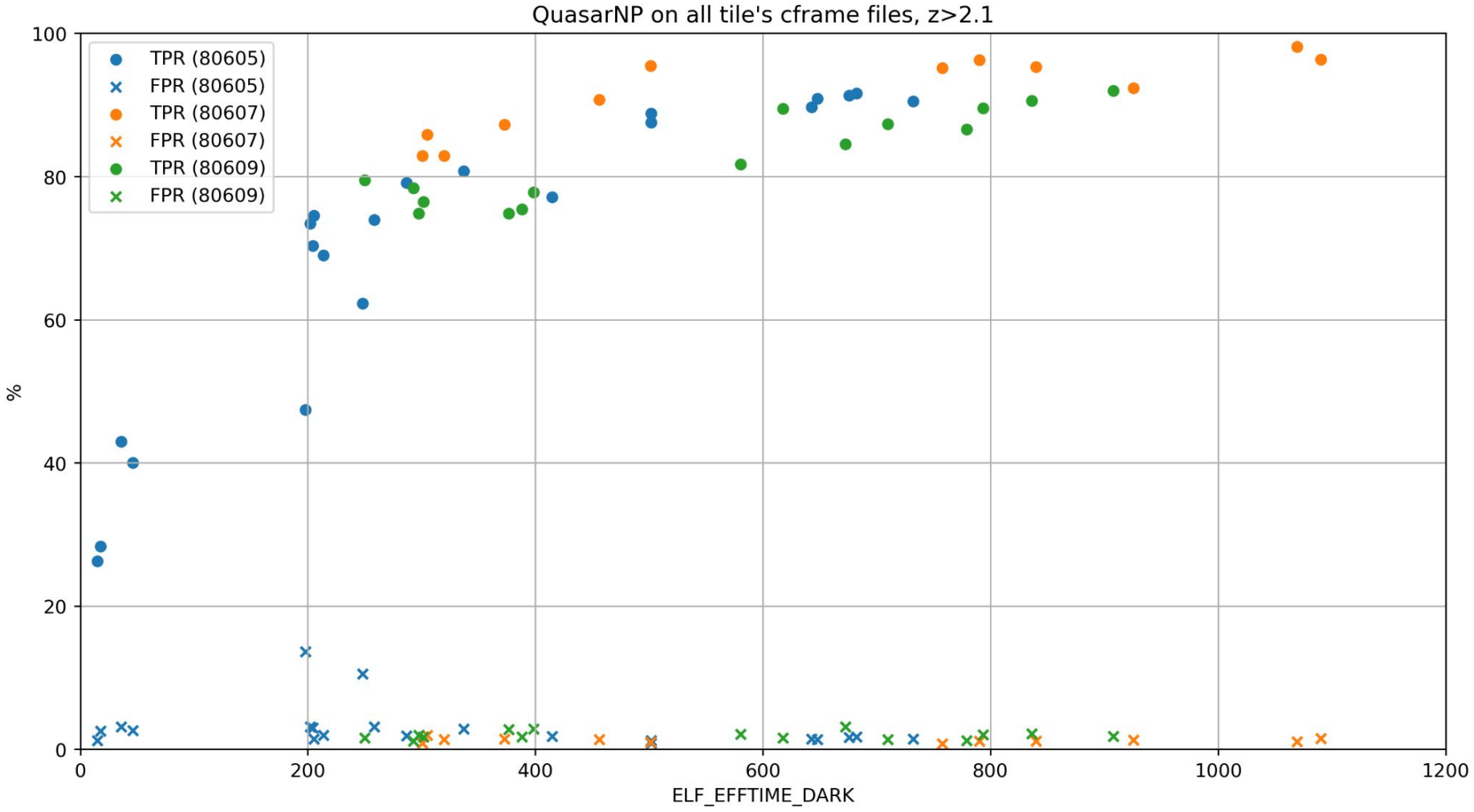
Tile #80607


QuasarNP on tile 80607 cframe files, z > 2.1
TPR (QNP)
FPR (QNP)
TPR (RR)
FPR (RR)
%
ELF_EFFTIME_DARK
0
20
40
60
80
100
0
200
400
600
800
1000
1200

Tile #80609


QuasarNP on tile 80609 cframe files, z > 2.1
TPR (QNP)
FPR (QNP)
TPR (RR)
FPR (RR)
%
ELF_EFFTIME_DARK
0
20
40
60
80
100
0
200
400
600
800
1000
1200

Combined


QuasarNP on all tile's cframe files, z>2.1
TPR (80605)
FPR (80605)
TPR (80607)
FPR (80607)
TPR (80609)
FPR (80609)
%
ELF_EFFTIME_DARK
0
20
40
60
80
100
0
200
400
600
800
1000
1200

Reobservation

- We hope to use QuasarNet as a complement to Redrock and VI to determine Lya Quasars to reobserve
- We wish to reobserve QSOs in order to increase the effective dark time of the coadds and in turn increase the signal to noise.
- Specifically want a higher SNR Lya forest
  - Thus seek high z (Z>2.1) QSOs to reobserve
- We seek to find ~70 per square degree

Purity/Completeness

- Definition below taken from Farr et al. 2020
- Questions to ask:
  - How low can we push the threshold and still have a suitably “pure” and “complete” sample?
  - How low does the threshold have to be to identify the maximum QSOs pre sq degree?

$$\text{purity} = \frac{\text{number of correctly predicted QSOs}}{\text{number of predicted QSOs}},$$

$$\text{completeness} = \frac{\text{number of correctly predicted QSOs}}{\text{number of true QSOs}}.$$

VI finds 14.7 z>2.1 QSOs per sq.deg.
(assuming 1088 QSO targets / tile averaged over the survey).

QuasarNet + RedRock selects 12.7 / sq.deg. of these (86%).

QuasarNet selects 1.5 / sq.deg. that are not found by RR.

TILEID	QSO targets	VI	VI QSO	VI z>2.1	EXPID	EFF TIME	RR	QN	RN|QN	QN unique
80605	1428	1217	485	128	74780	732s	91	105	108	17
80607	1684	1421	391	115	68664	1069s	94	104	104	10
80609	1341	1123	396	125	68337	908s	95	103	106	11

QuasarNet results are not very sensitive to choice of score threshold.

Can we recover some low-score z>2.1 QSOs with retraining?

A threshold of 0.4 selects:

- ~41 targets / sq.deg. for re-obs.
- of which ~100% are QSOs
- of which ~30% are z>2.1