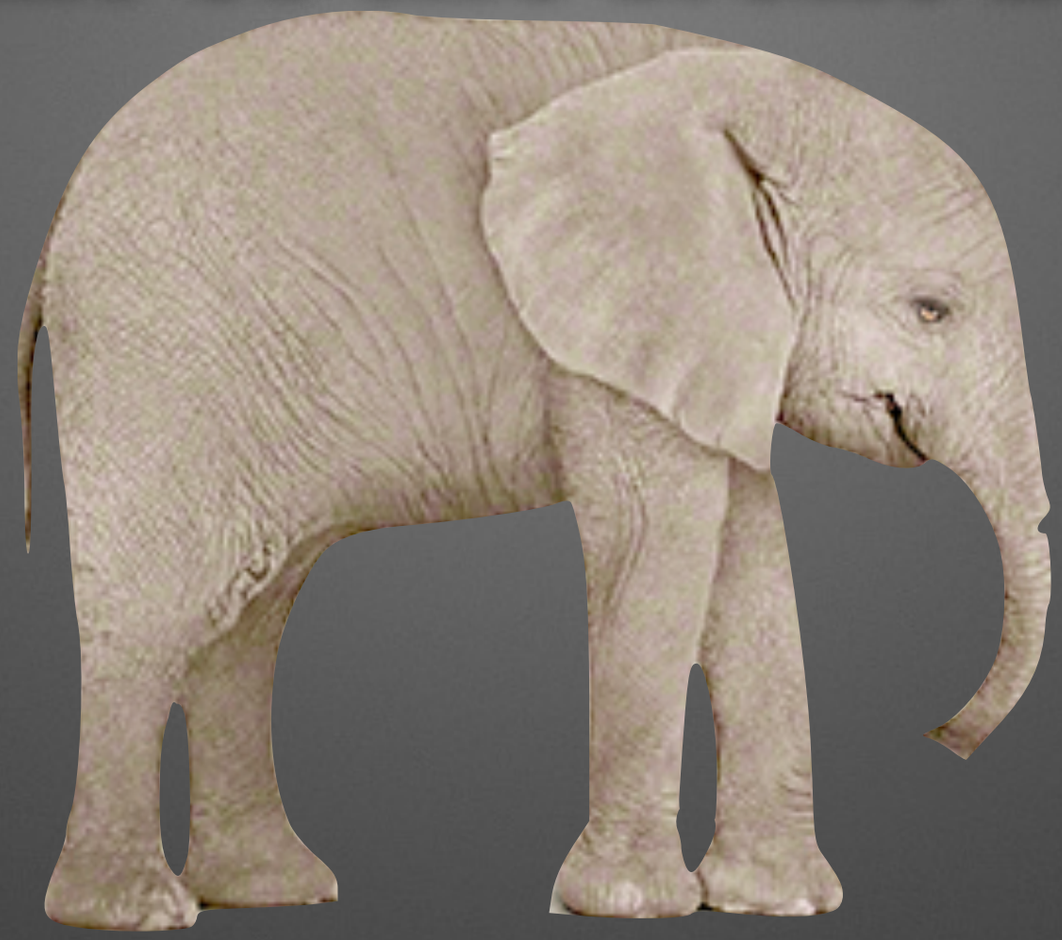
In Pursuit of the Next Big Thing



Adam A Miller
JPL/Caltech

2016 Hubble Symposium
15 March 2016

Jet Propulsion Laboratory
California Institute of Technology

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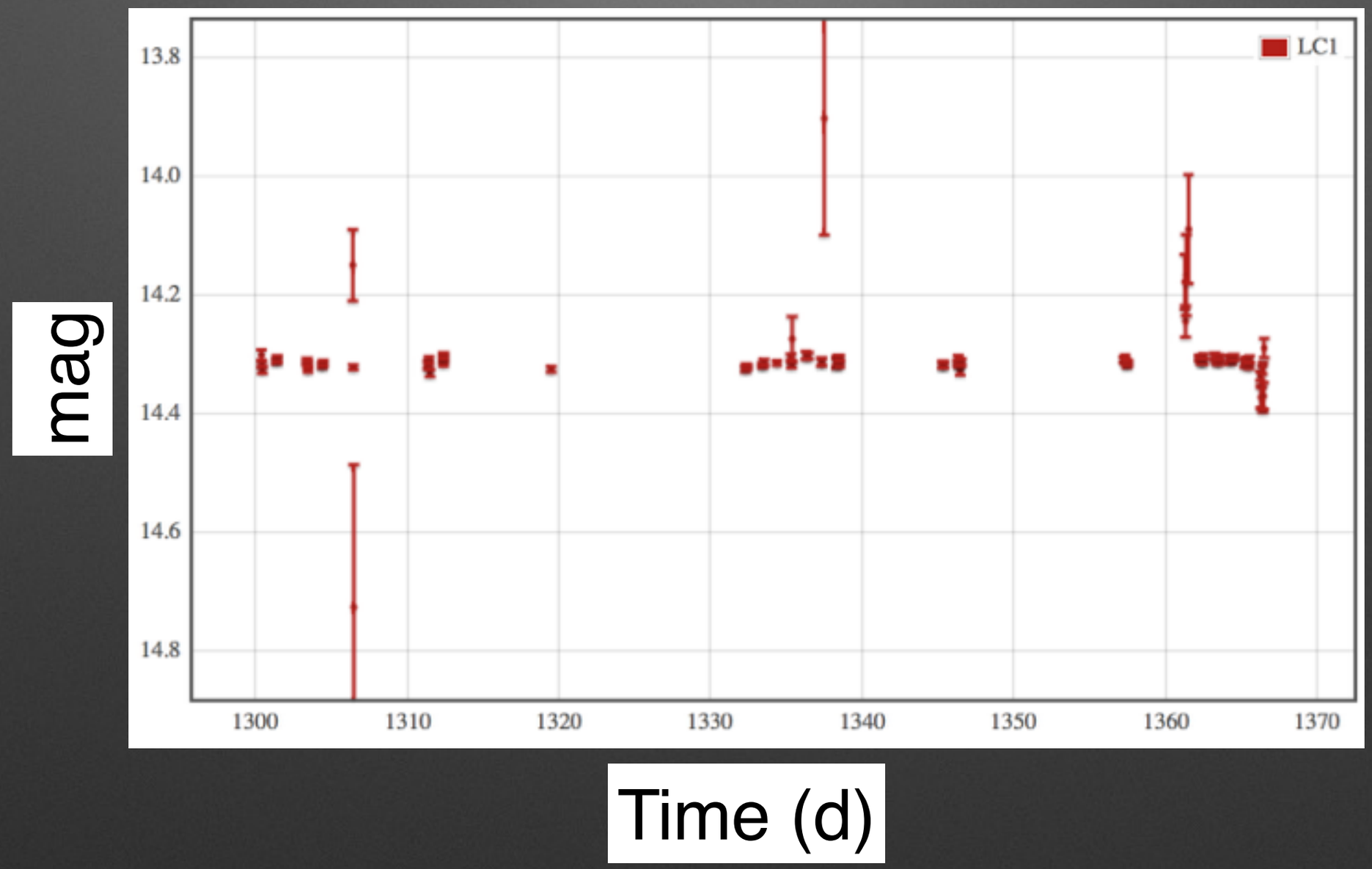
It’s much easier to teach an astronomer
about machine learning,
than it is to teach astronomy
to a data-miner.

— Sanjay Chawla, Prof. Statistics

Heteroskedastic Errors



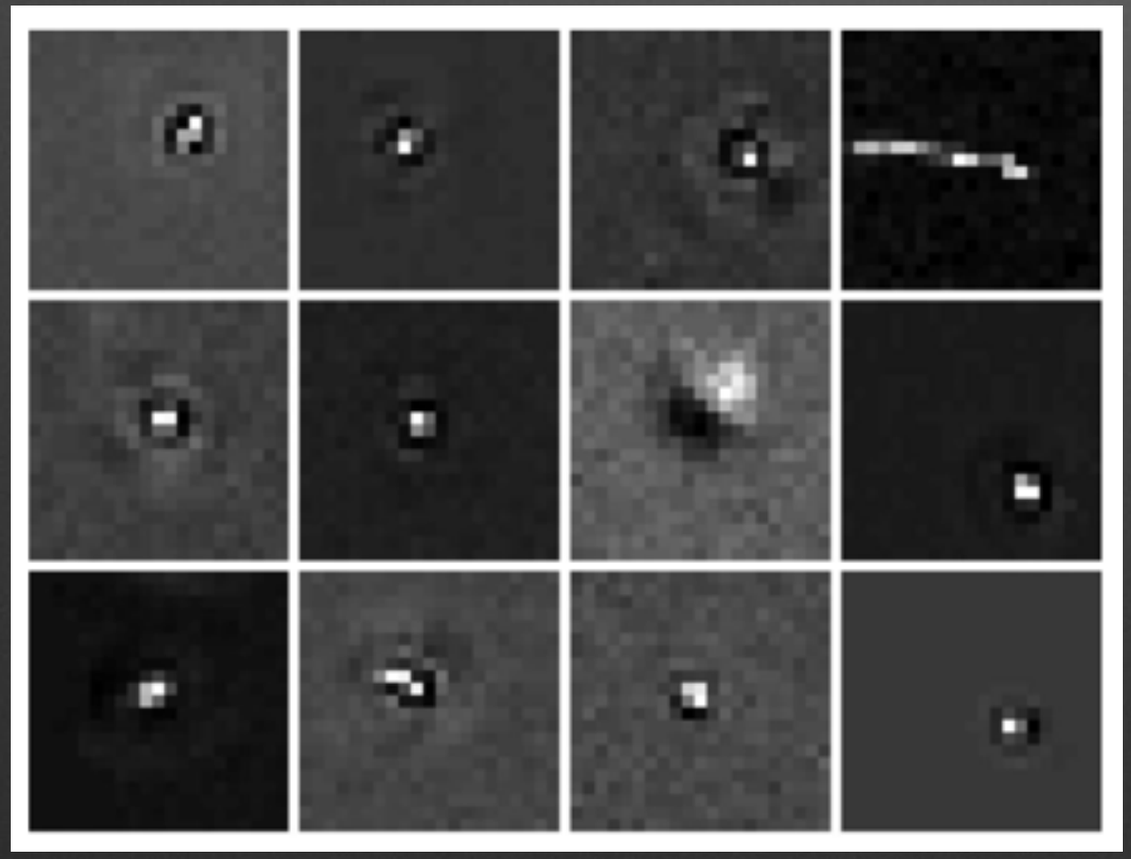
Faint Objects

Faint Objects

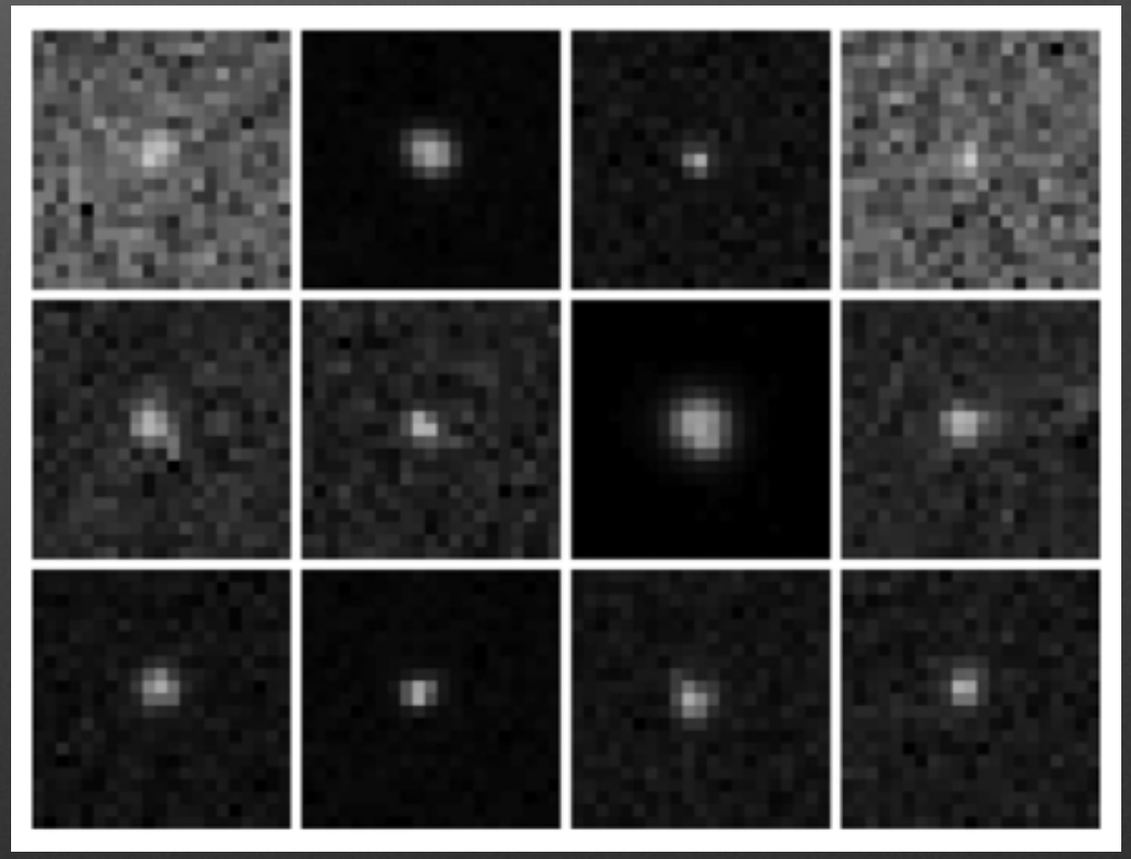
ML success: Real-Bogus

- PTF - 1M transient candidates/night
- ~1k real variable sources/night
- Lots of human hours needed (wasted?) filtering candidates

1M of these



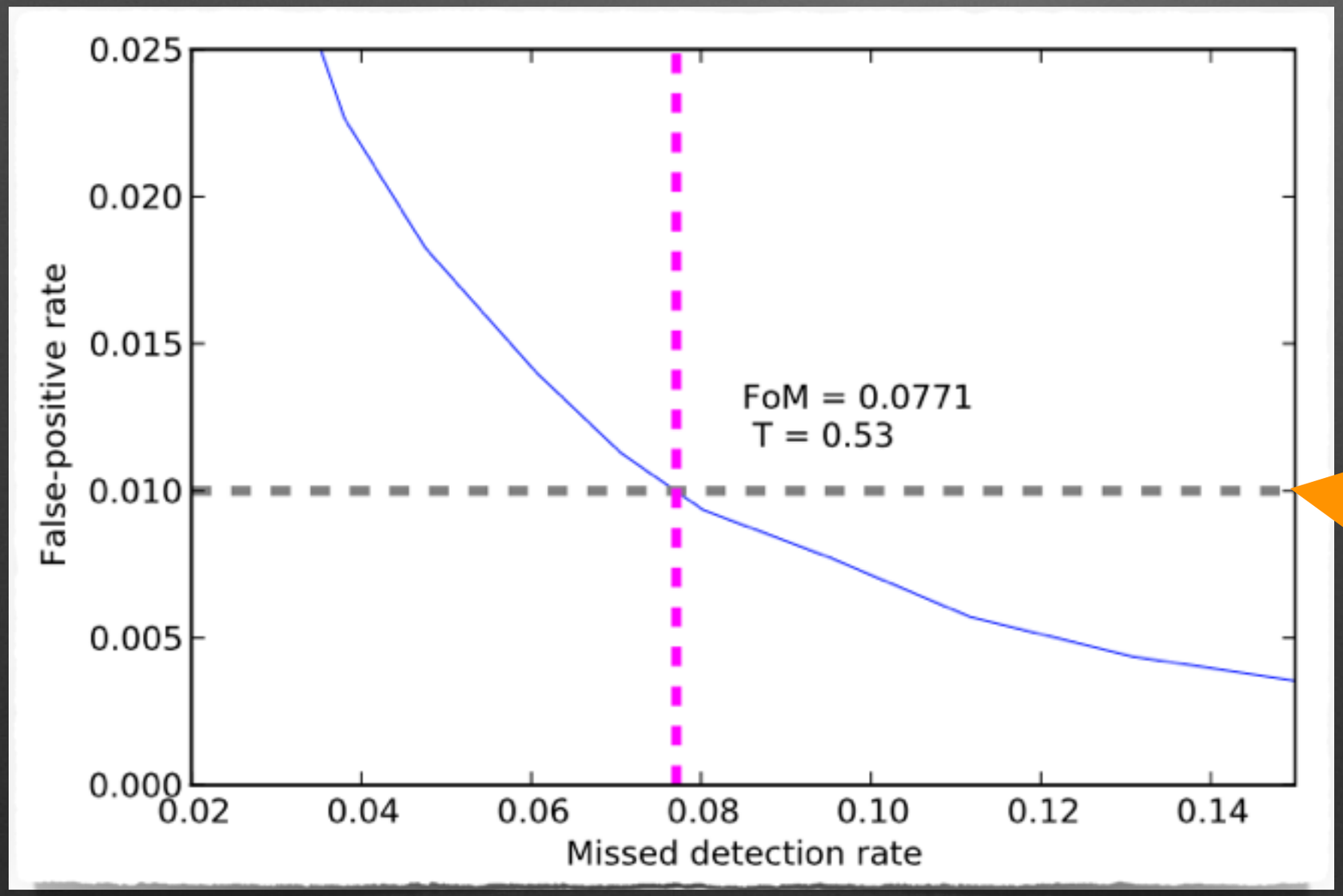
only ~1k of these



Brink+13

ML success: Real-Bogus

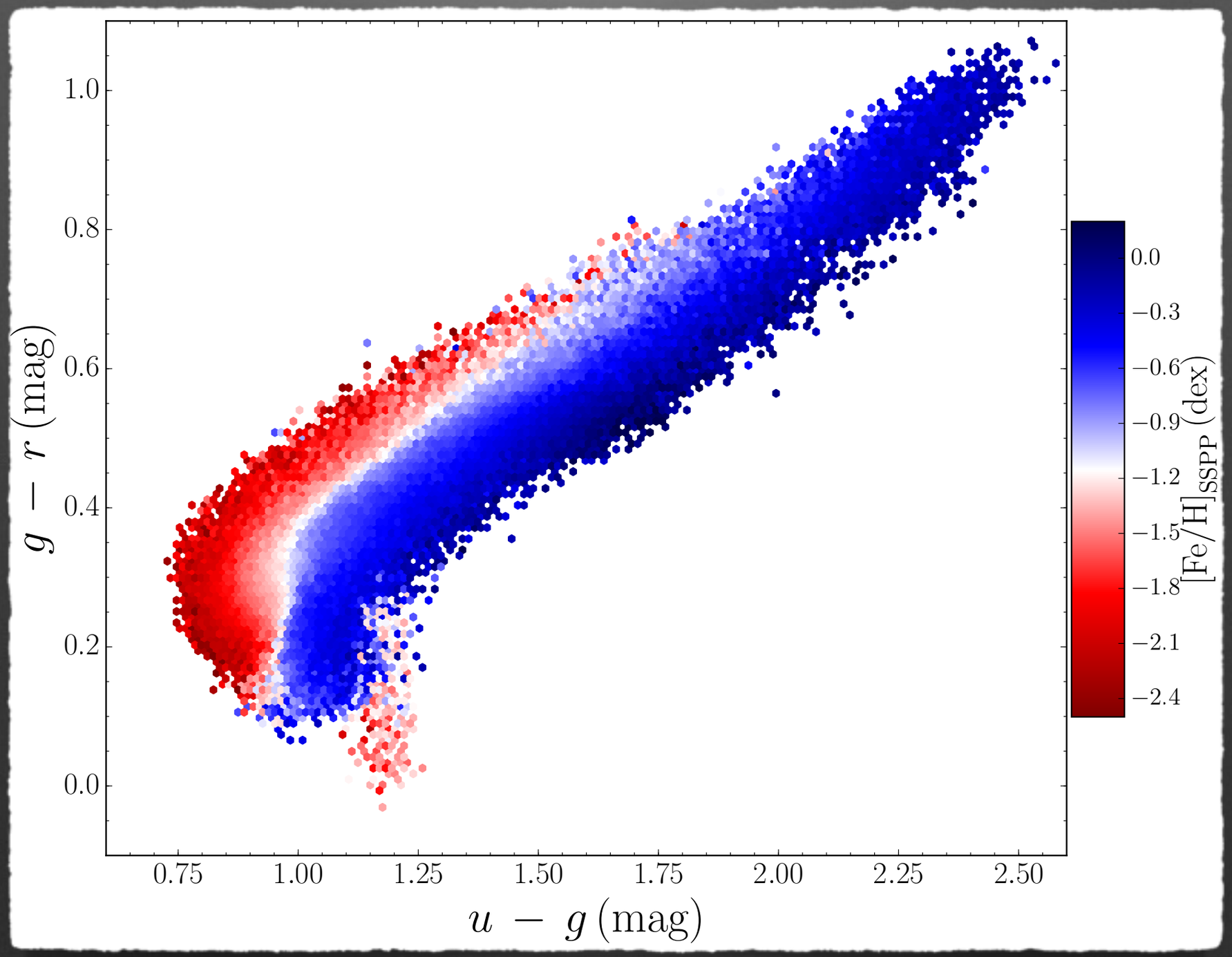
- Determine acceptable N_{cand} for human vetting
- Optimize model to detect max(real) within N_{cand}



Model tuned for ~1% FPs

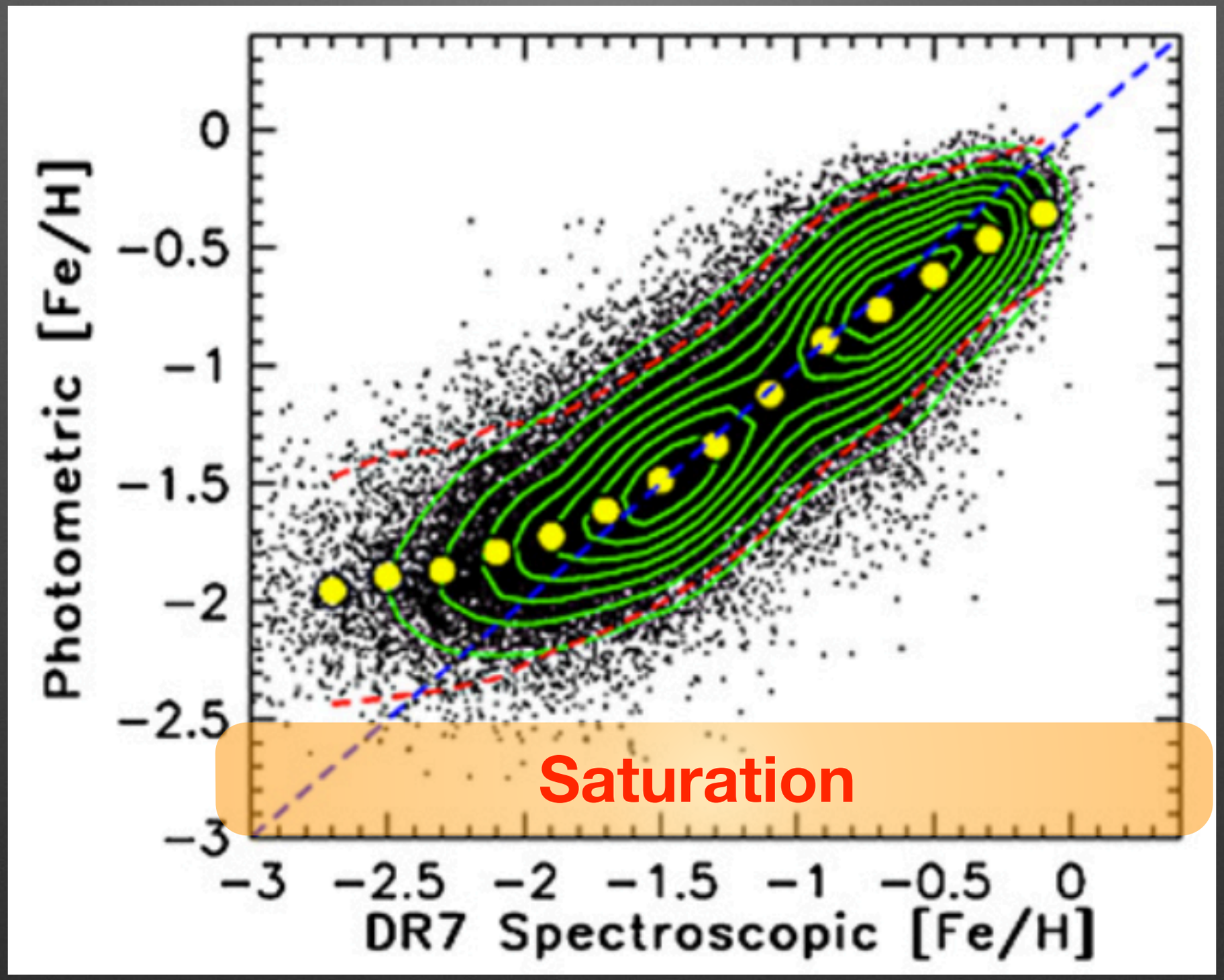
Brink+13

ML success(?): EMP stars



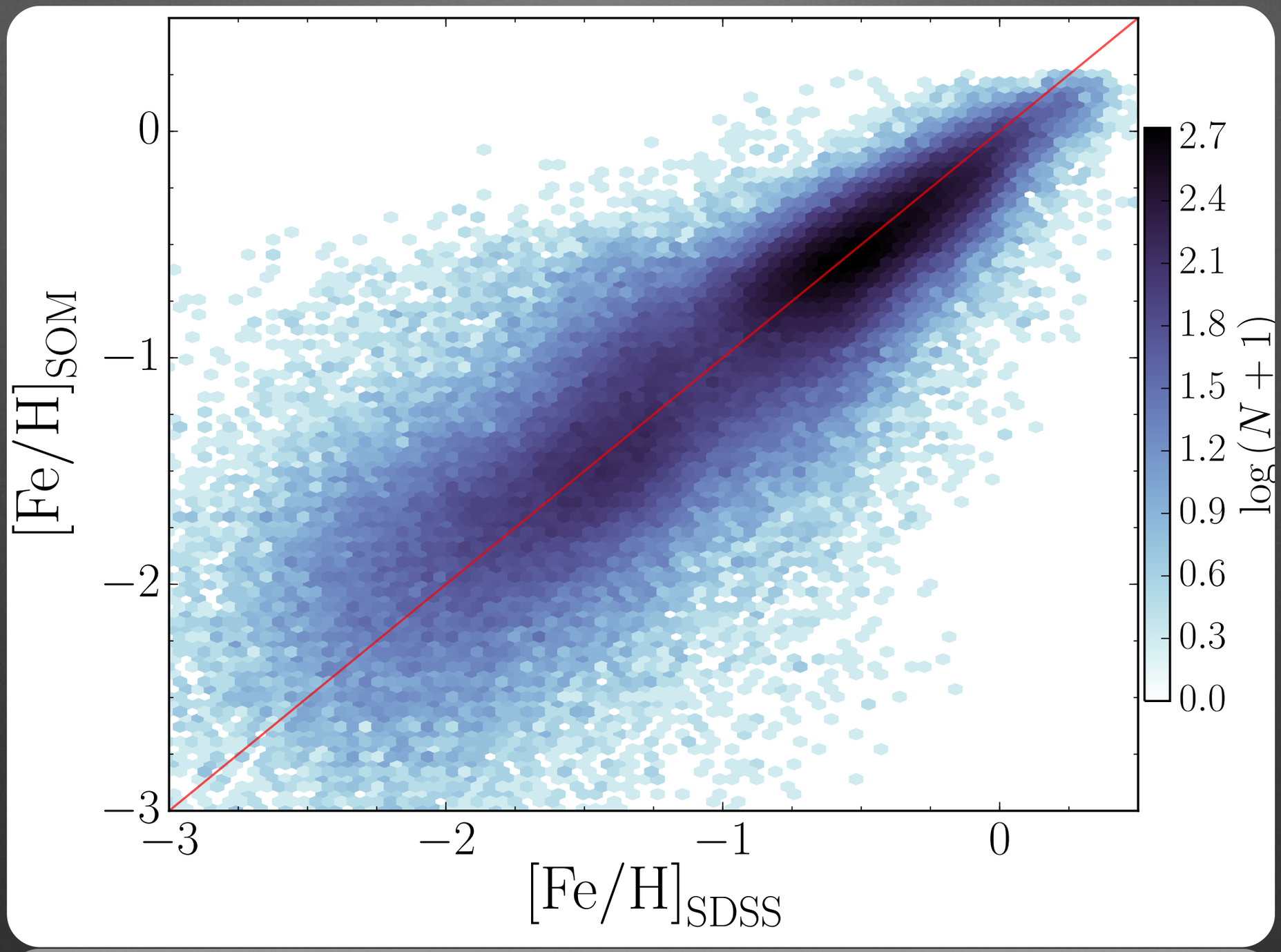
Miller 15

ML success(?): EMP stars



Bond+10

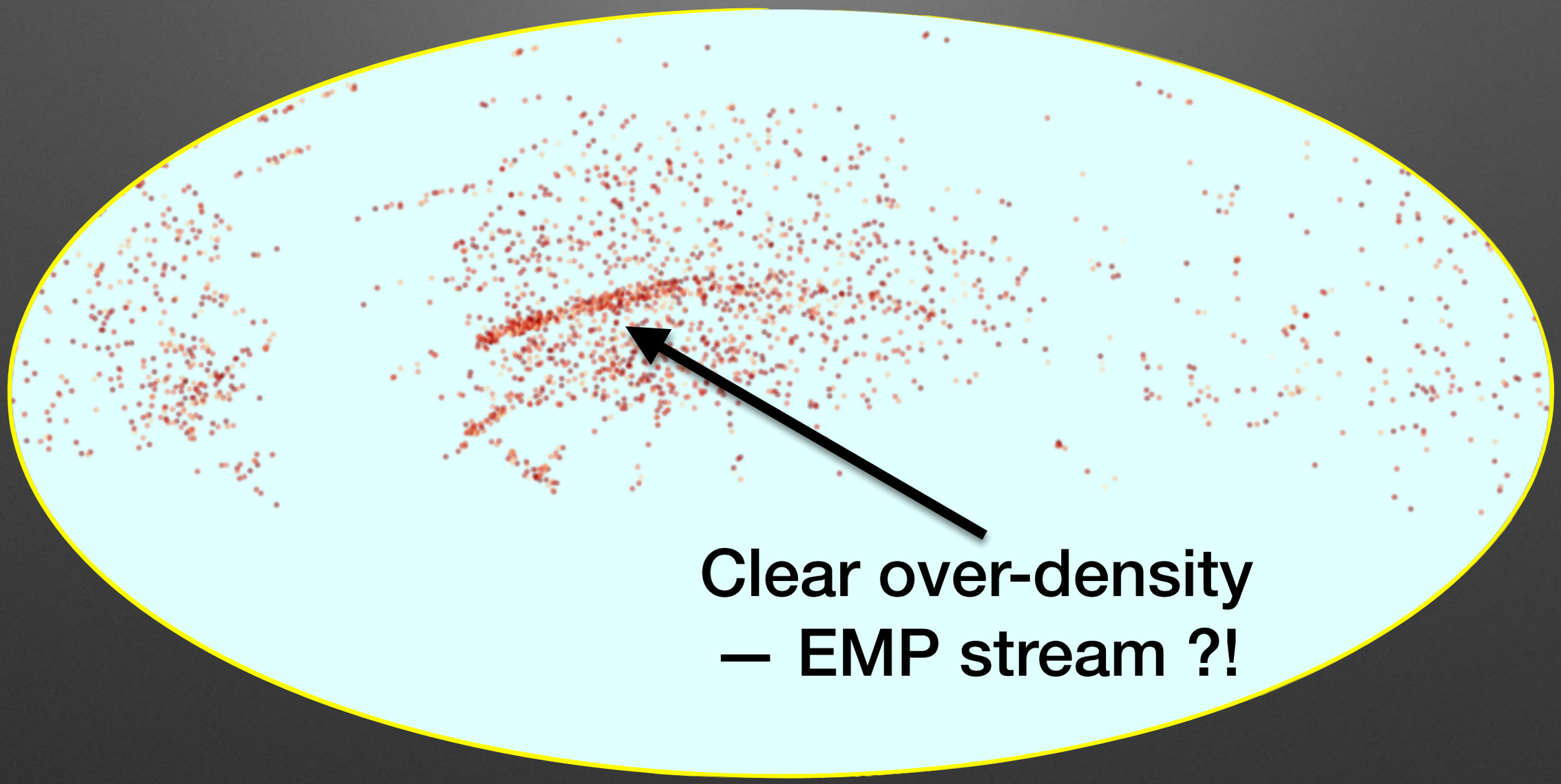
ML success(?): EMP stars



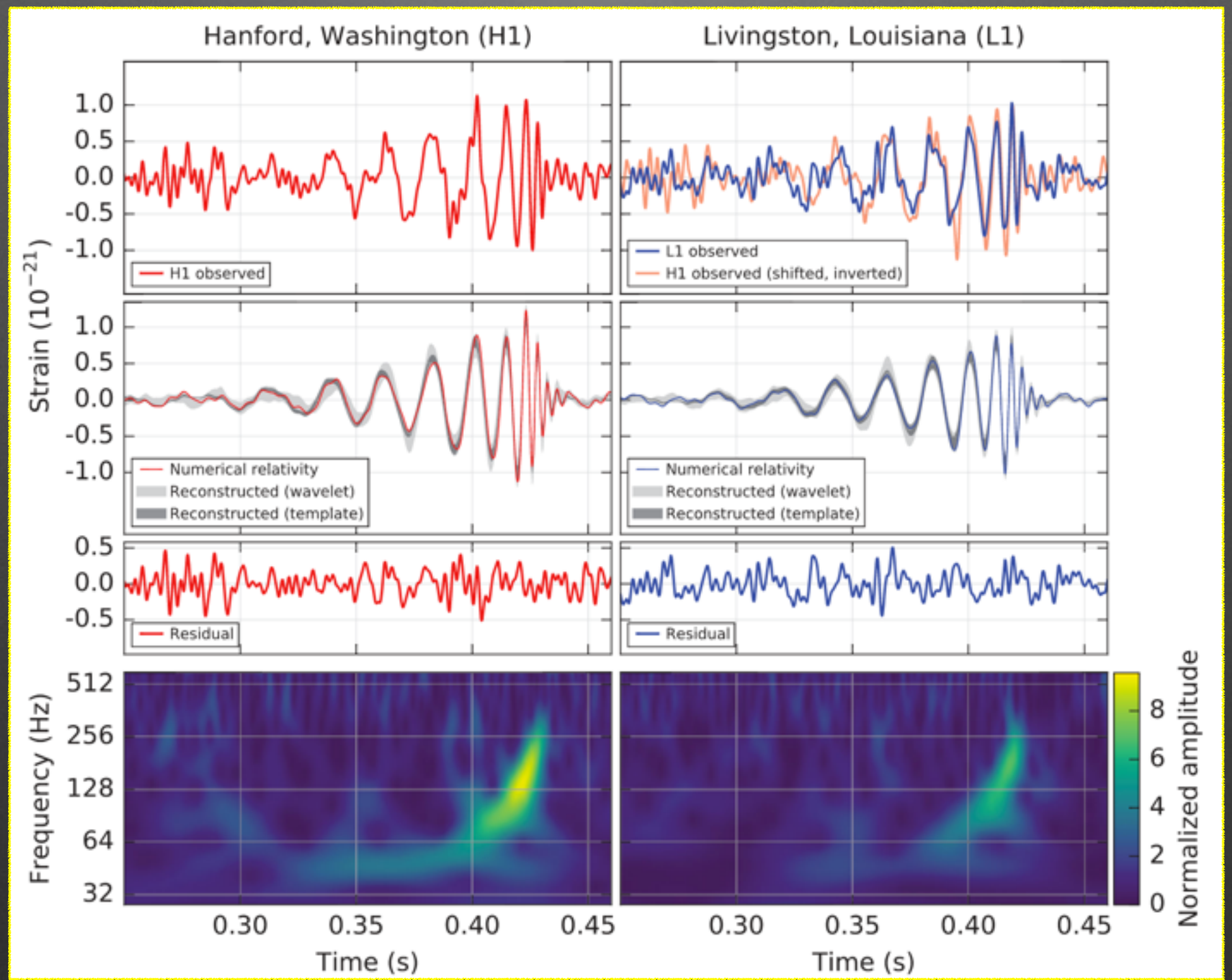
Miller 15

ML success(?): EMP stars

Map location of highest confidence EMP candidates

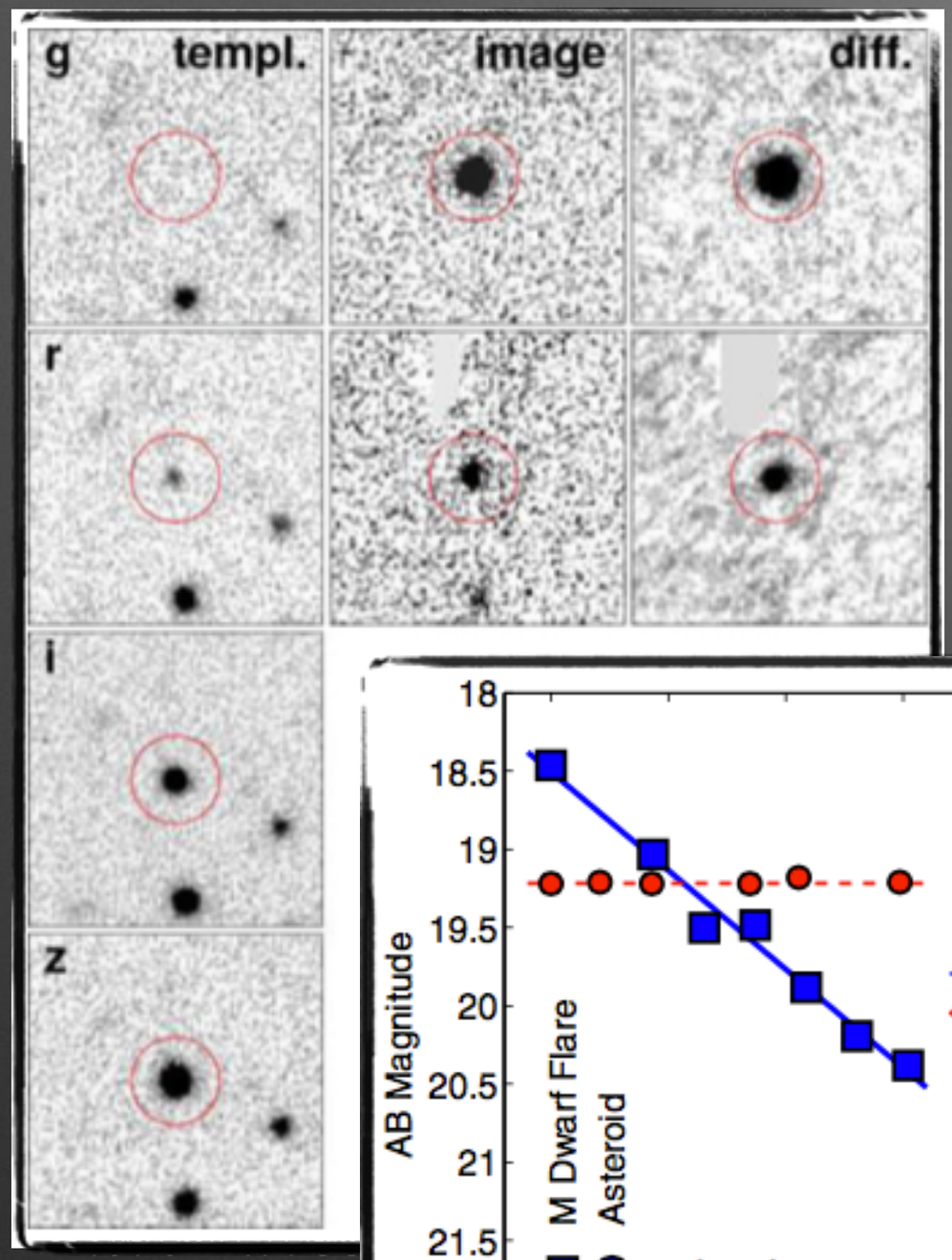


ML success(?): star/galaxy separation

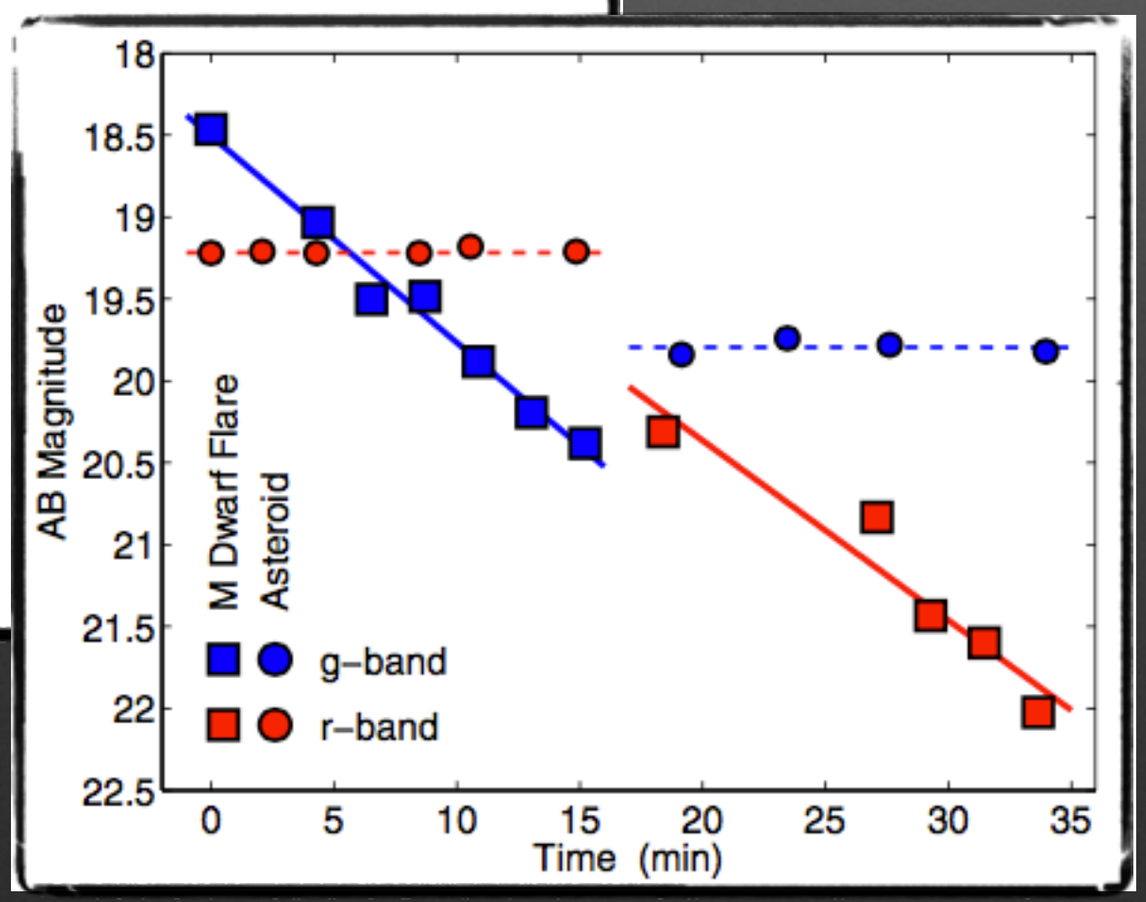


LVC+16

ML success(?): star/galaxy separation



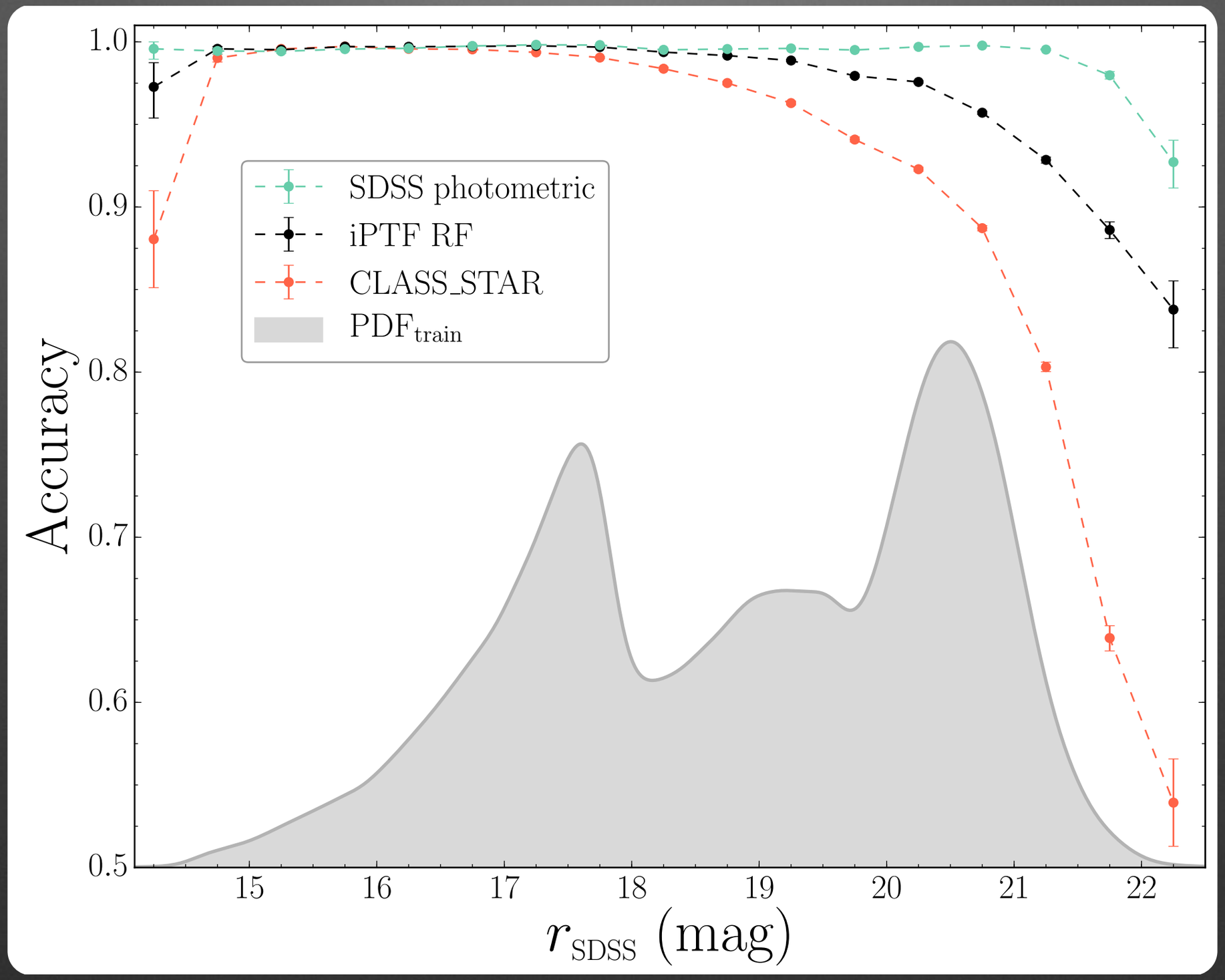
- Fast transients dominated by M dwarf flares
- Most likely false positive when searching for GW-EM



s/g model eliminates FPs

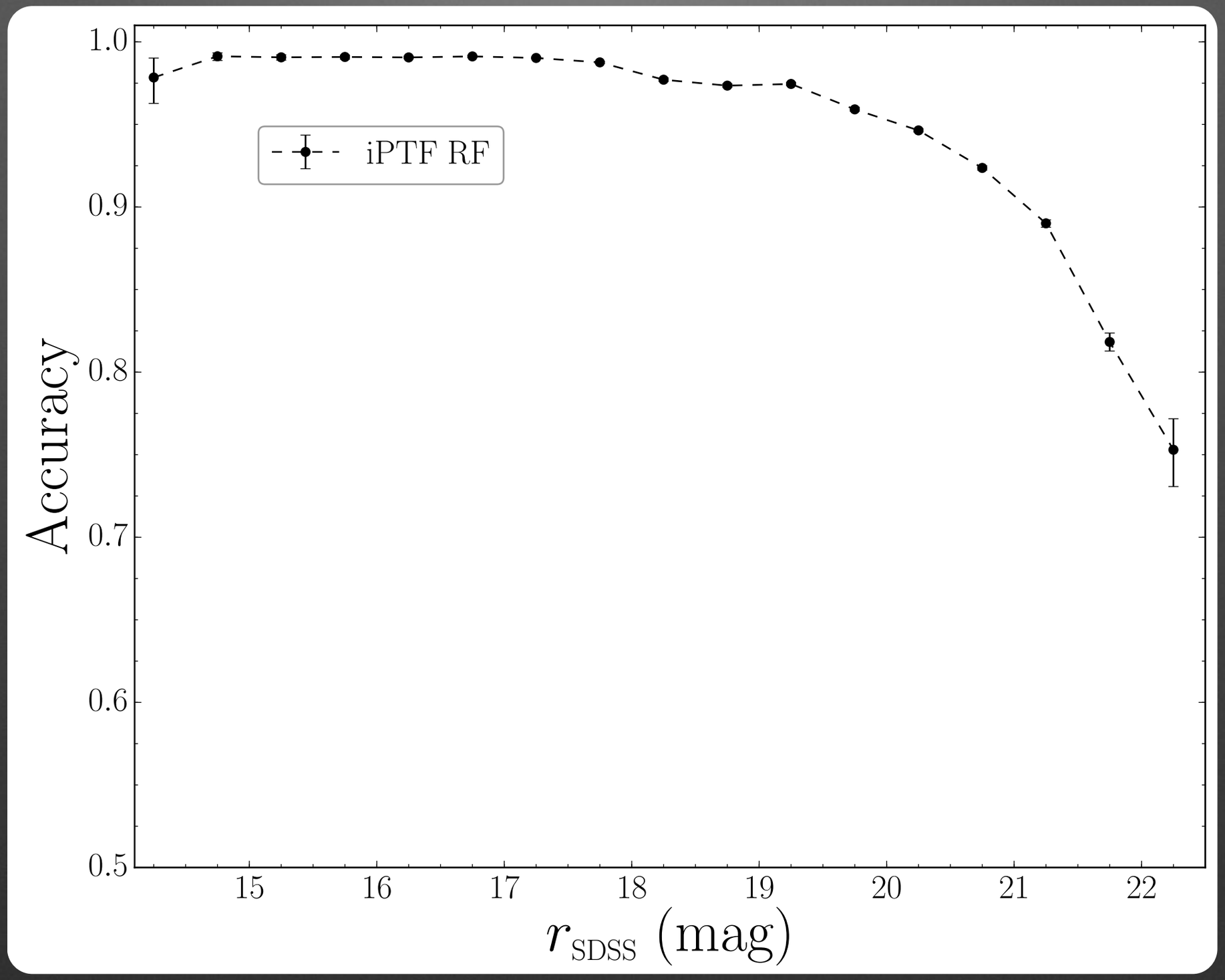
Berger+13

ML success(?): star/galaxy separation



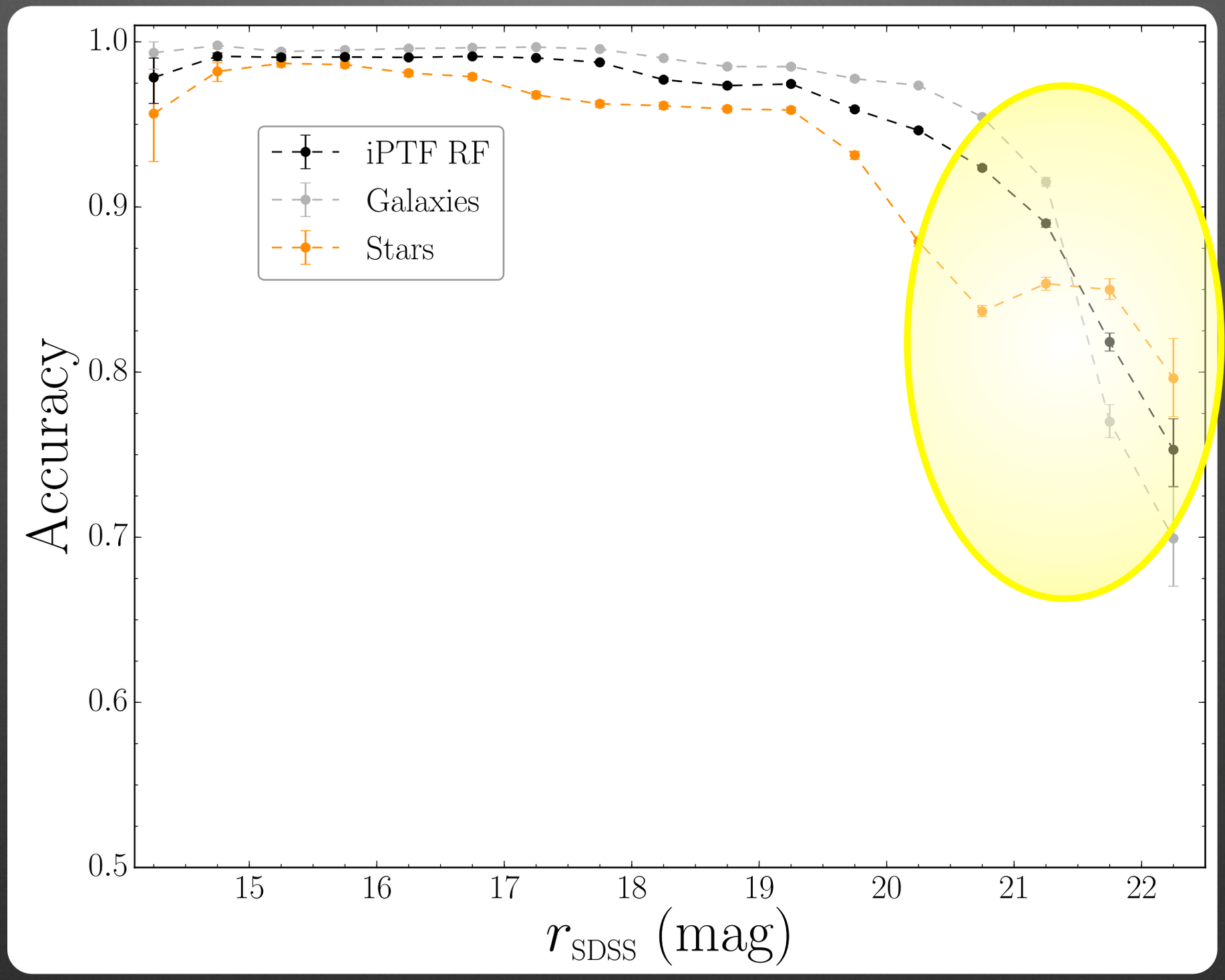
Kulkarni, AAM 16

ML success(?): star/galaxy separation



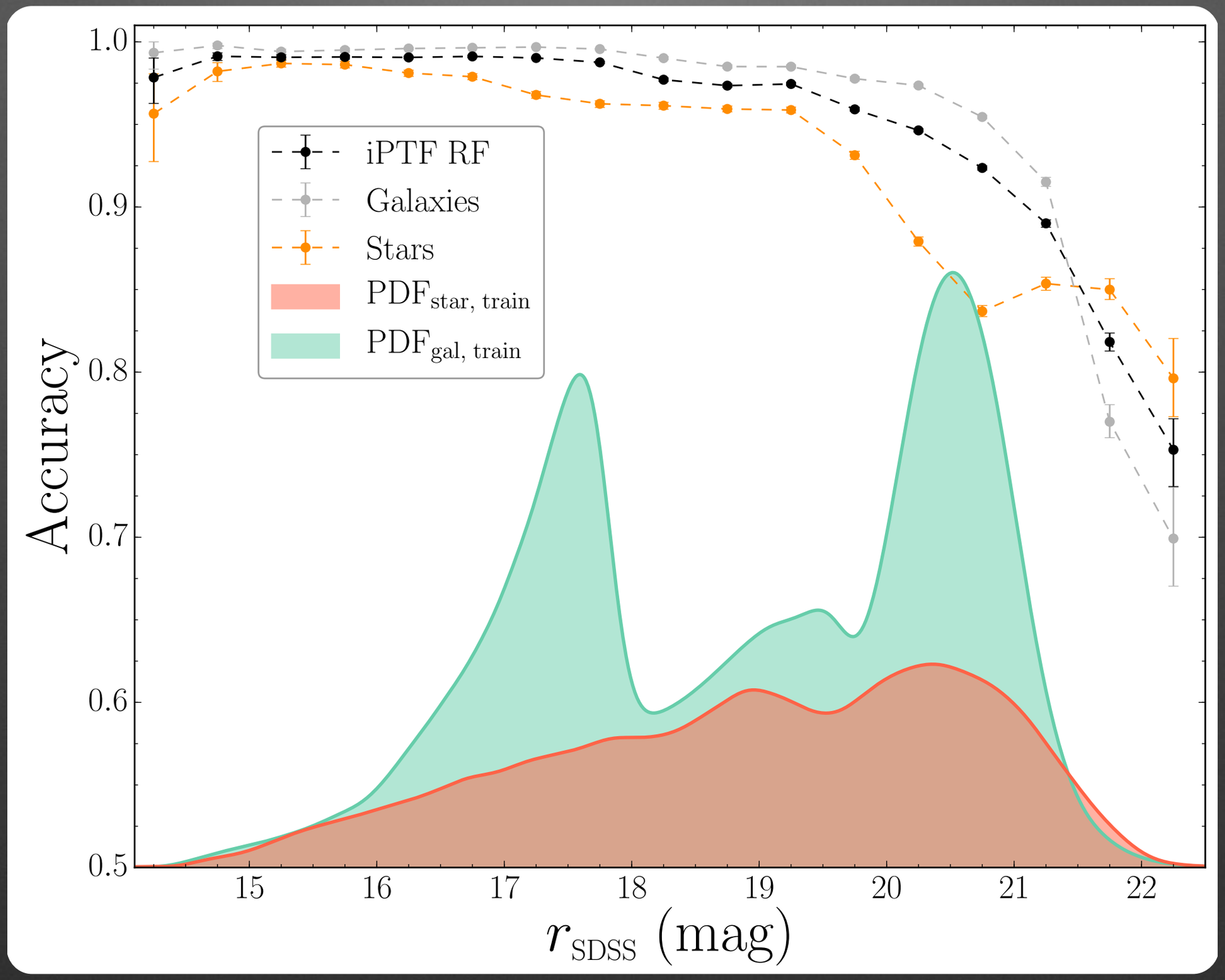
Kulkarni, AAM 16

ML success(?): star/galaxy separation



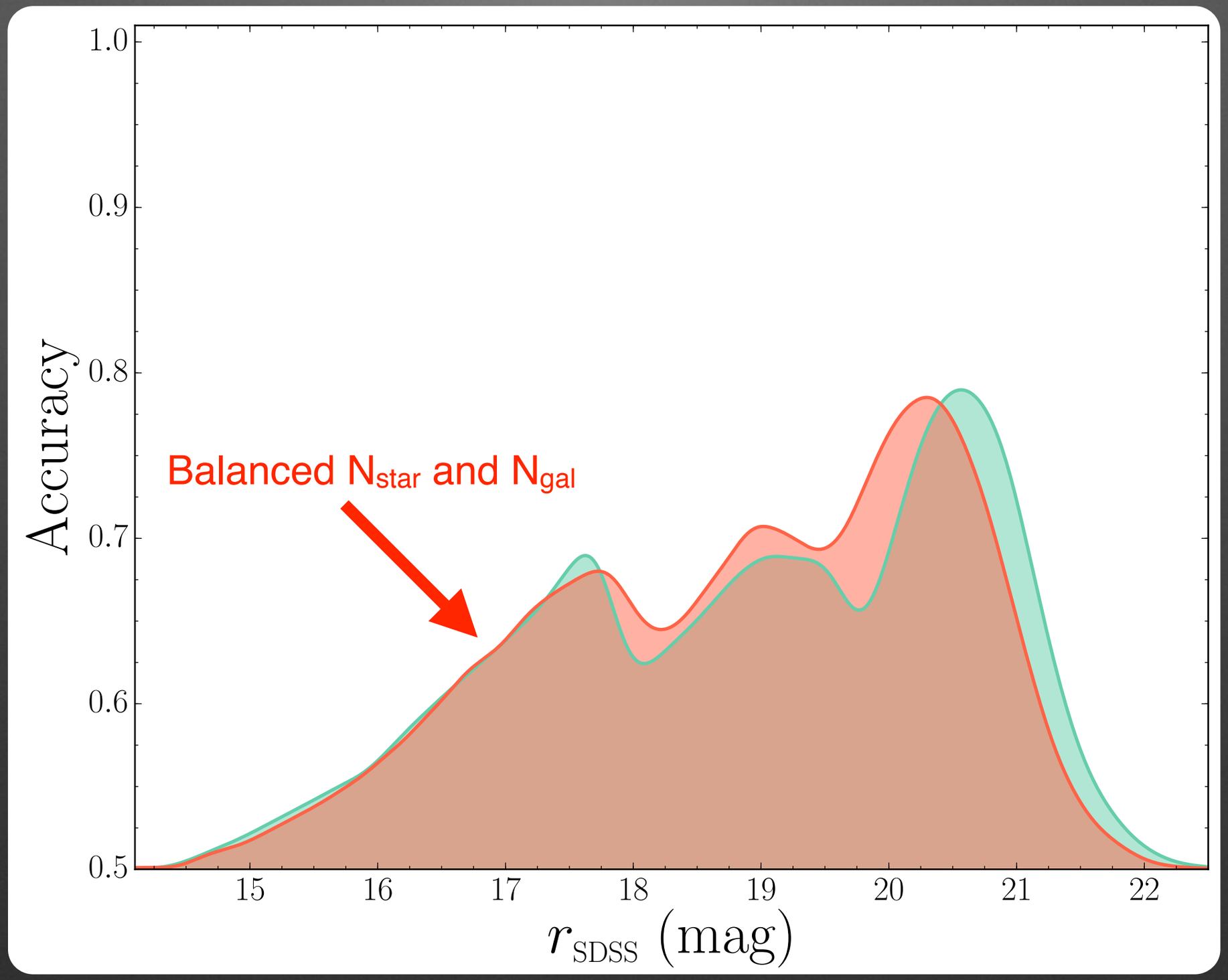
Kulkarni, AAM 16

ML success(?): star/galaxy separation



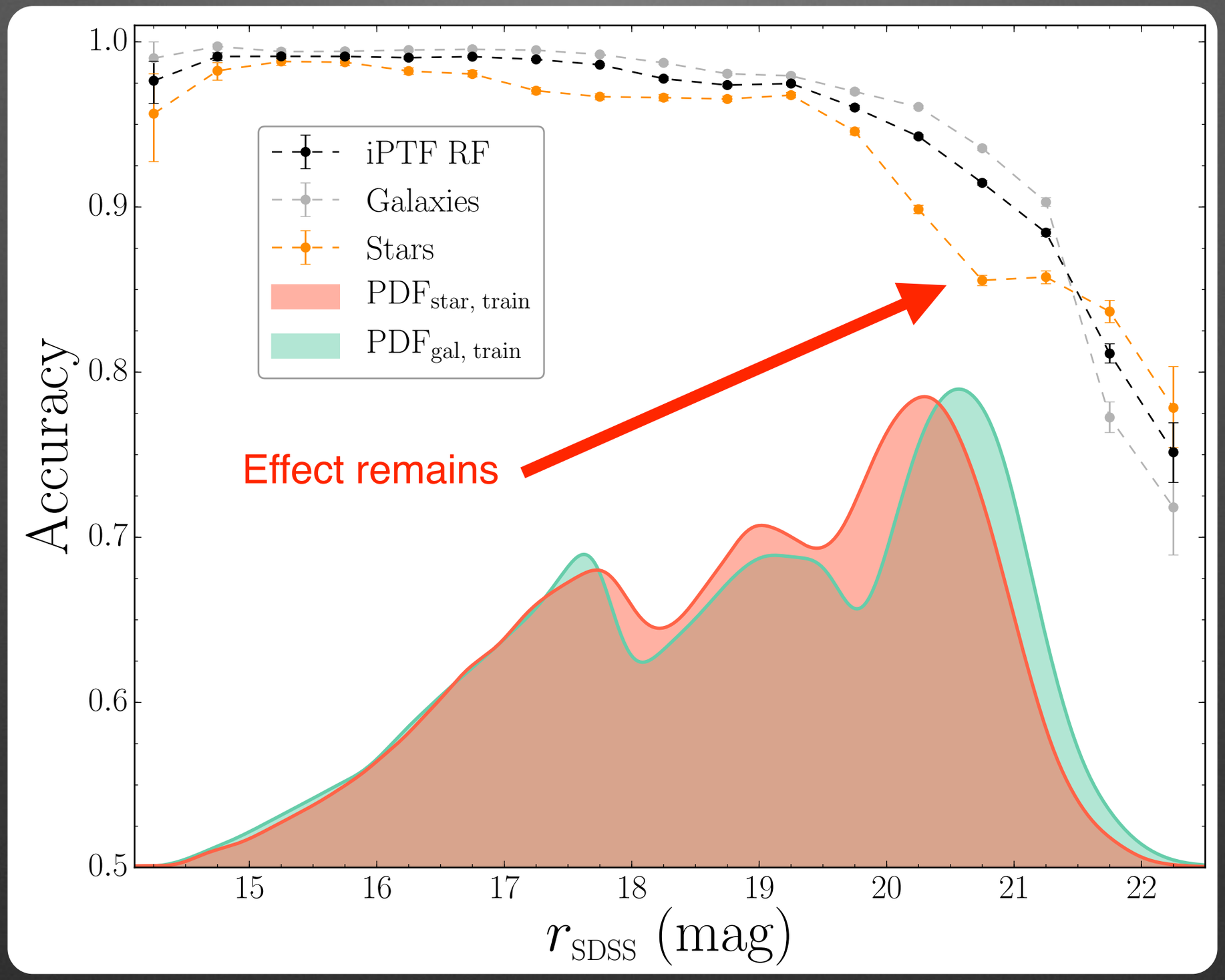
Kulkarni, AAM 16

ML success(?): star/galaxy separation



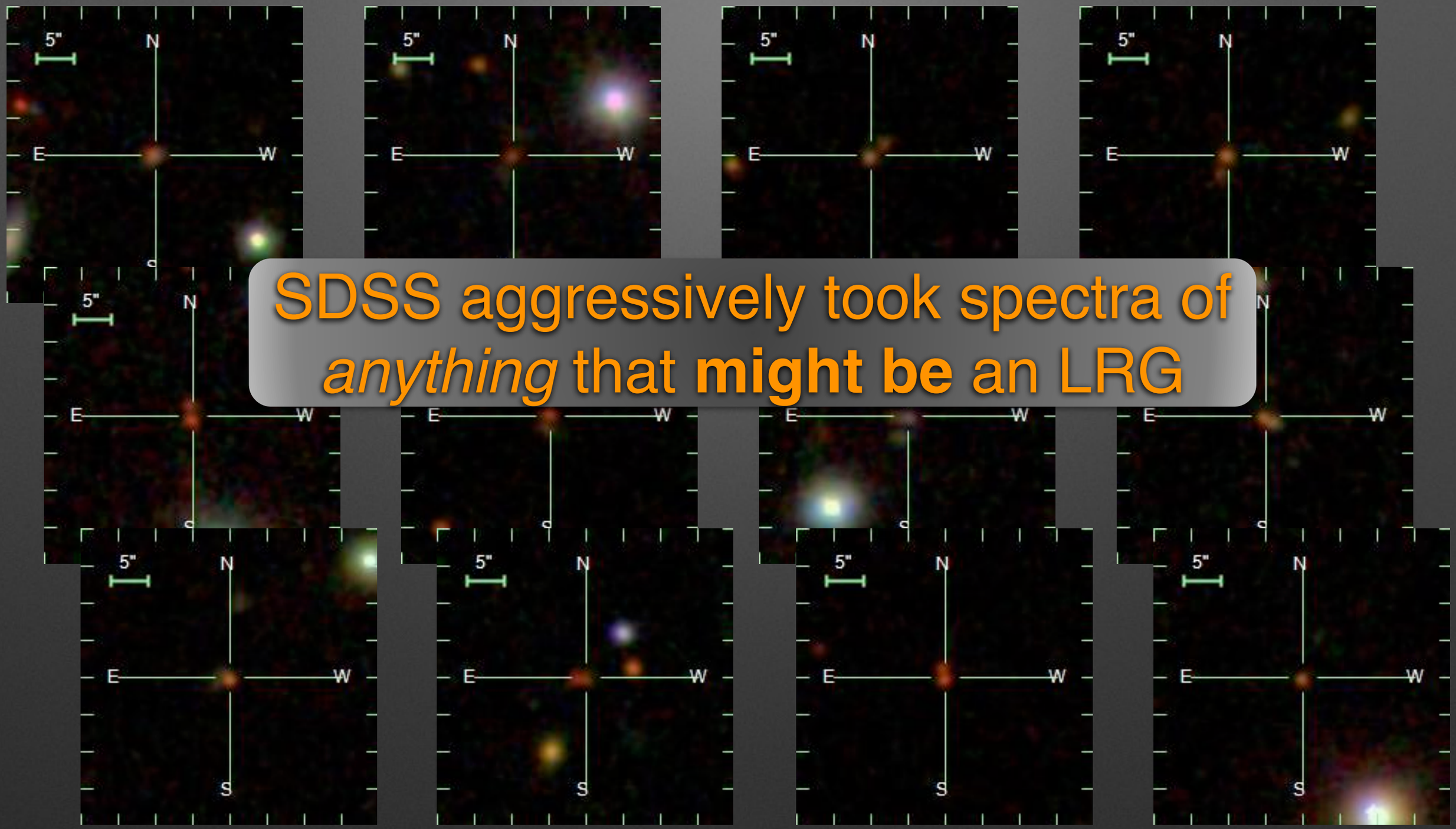
Kulkarni, AAM 16

ML success(?): star/galaxy separation



Kulkarni, AAM 16

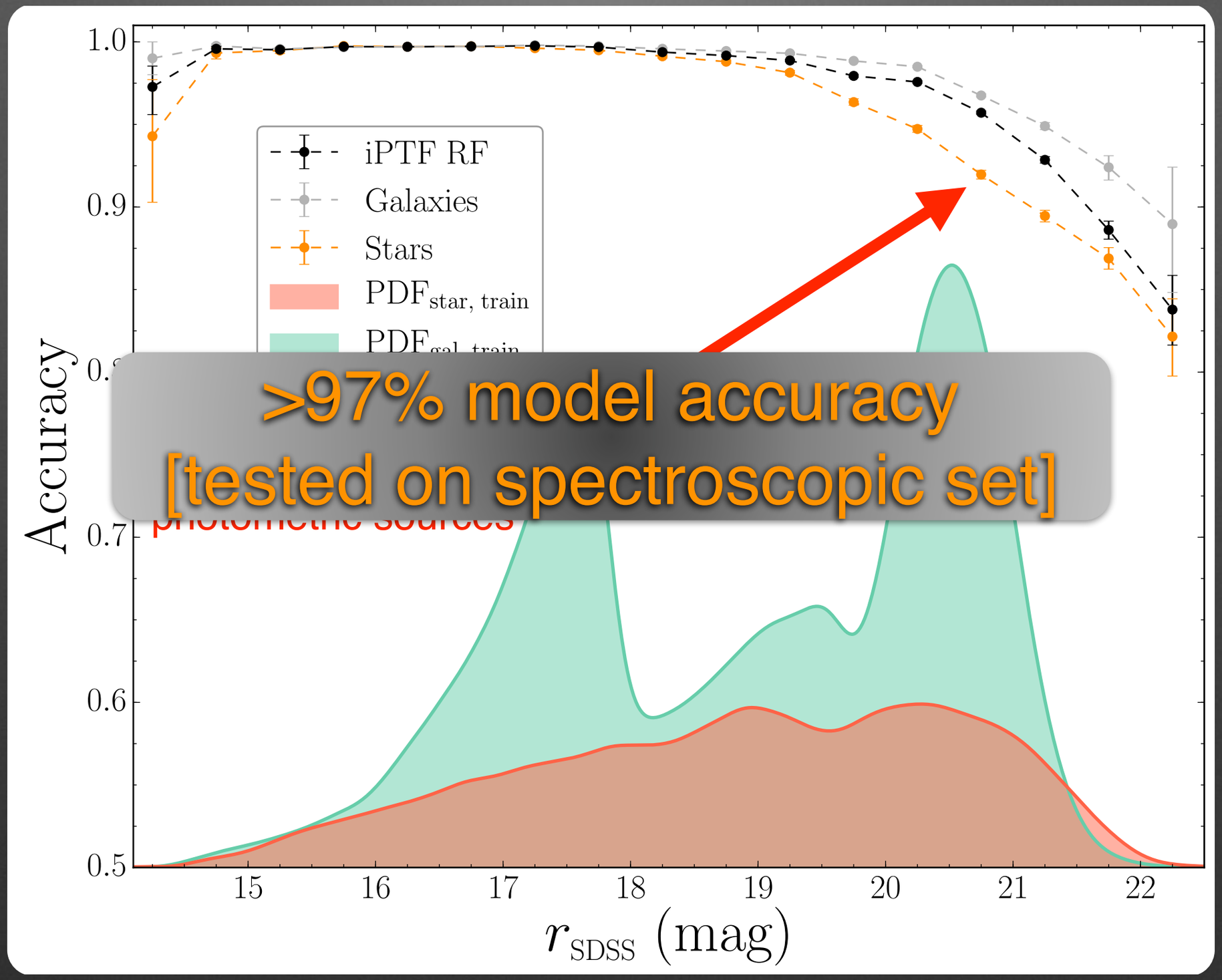
ML success(?): star/galaxy separation



SDSS aggressively took spectra of *anything* that **might be** an LRG

(C) SDSS

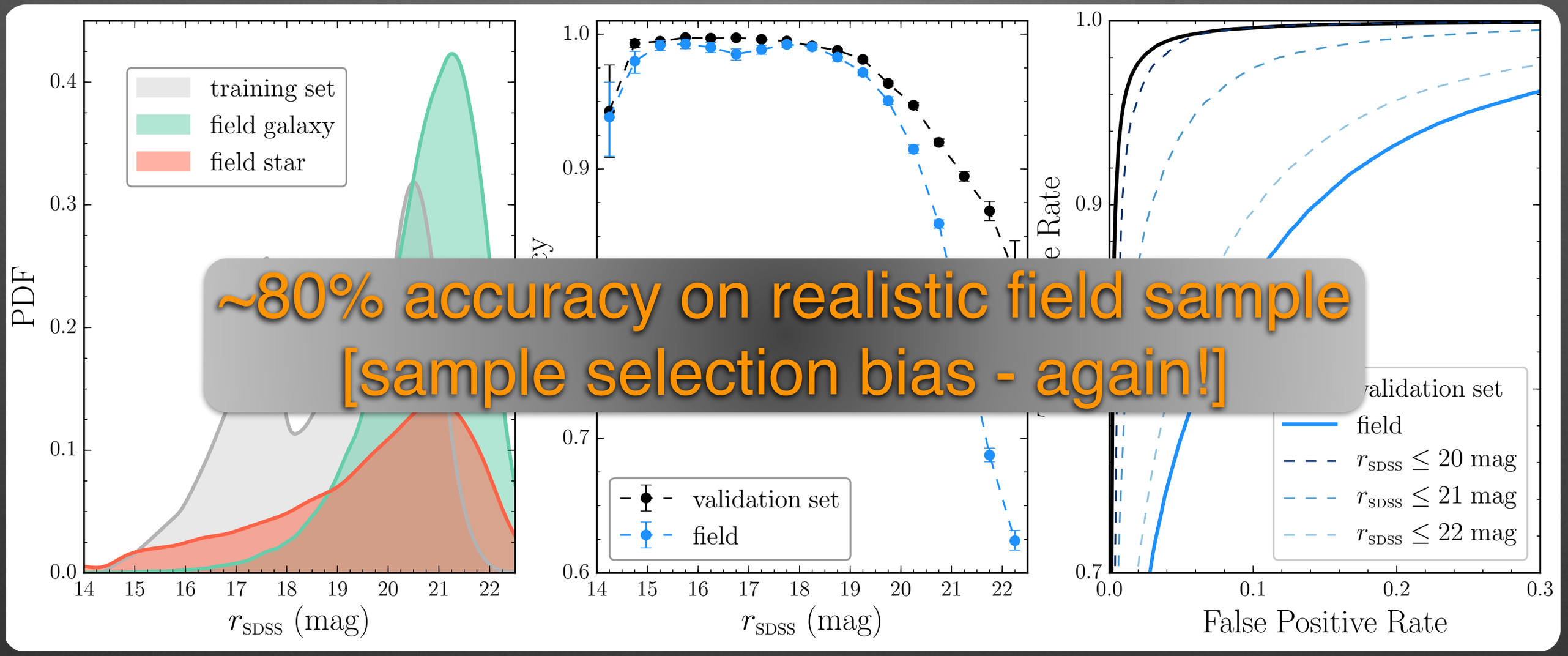
ML success(?): star/galaxy separation



>97% model accuracy
[tested on spectroscopic set]

Kulkarni, AAM 16

ML success(?): star/galaxy separation

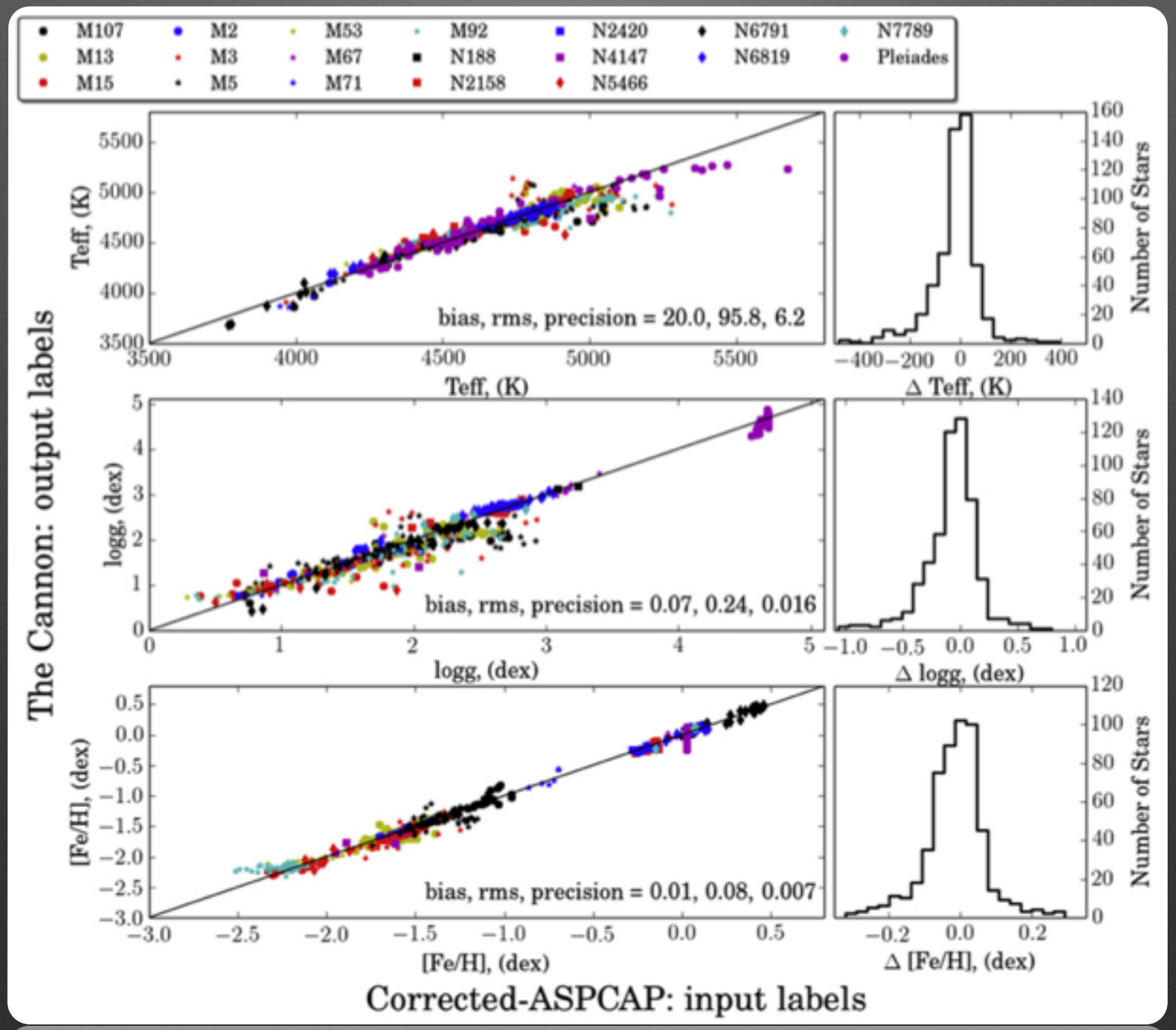


~80% accuracy on realistic field sample
[sample selection bias - again!]

Kulkarni, AAM 16

ML-like success: The Cannon

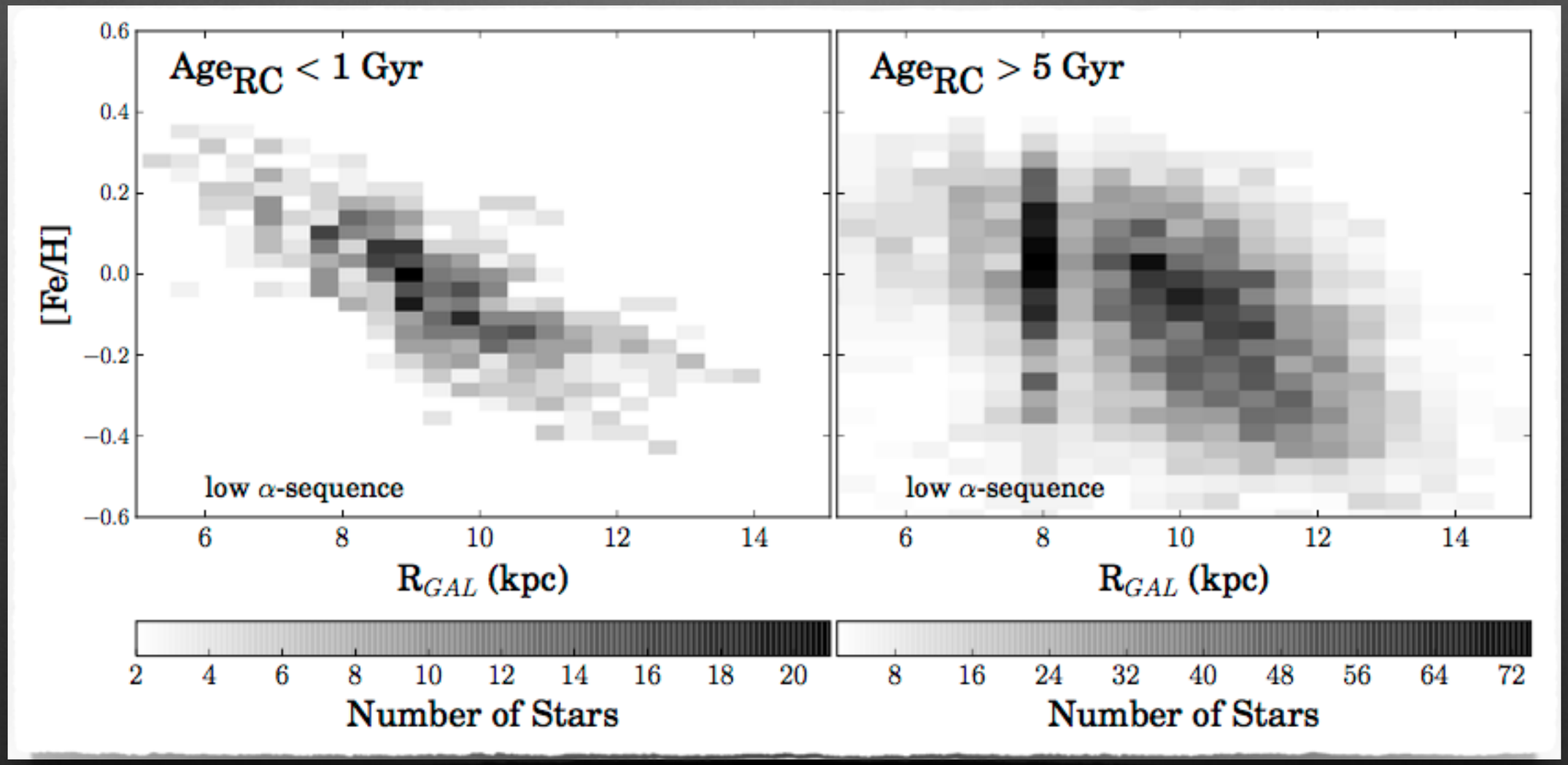
- ML-inspired data-driven method to analyze APOGEE spectra (Ness+15)
  - ➡ T_{eff}, log g, [Fe/H], abundances, also M_*, age (! - for RGs) (Ness+16)



Ness+15

ML-like success: The Cannon

- Direct evidence for stellar migration in the Milky Way (Ness+16)



Ness+16

Conclusions

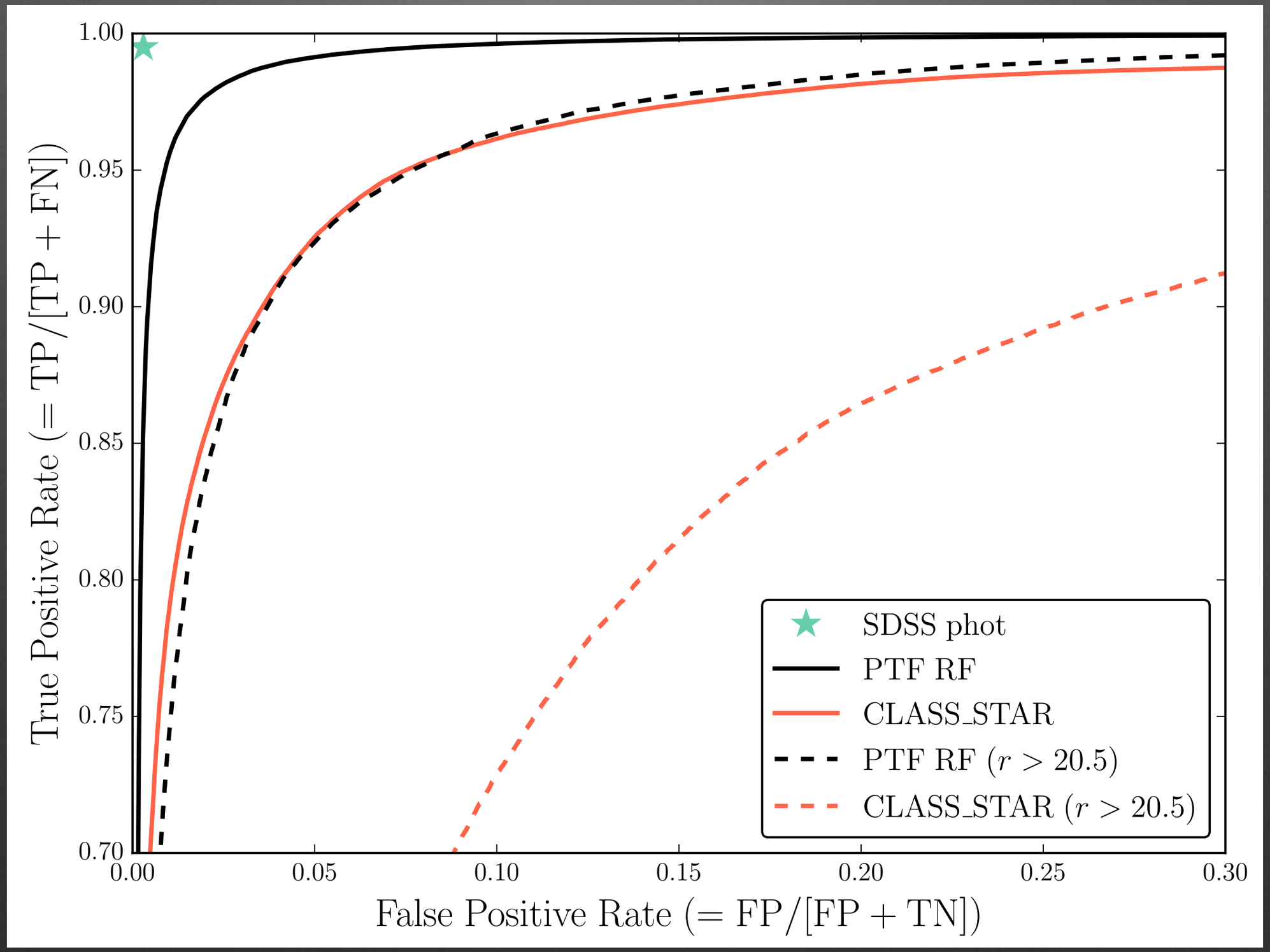
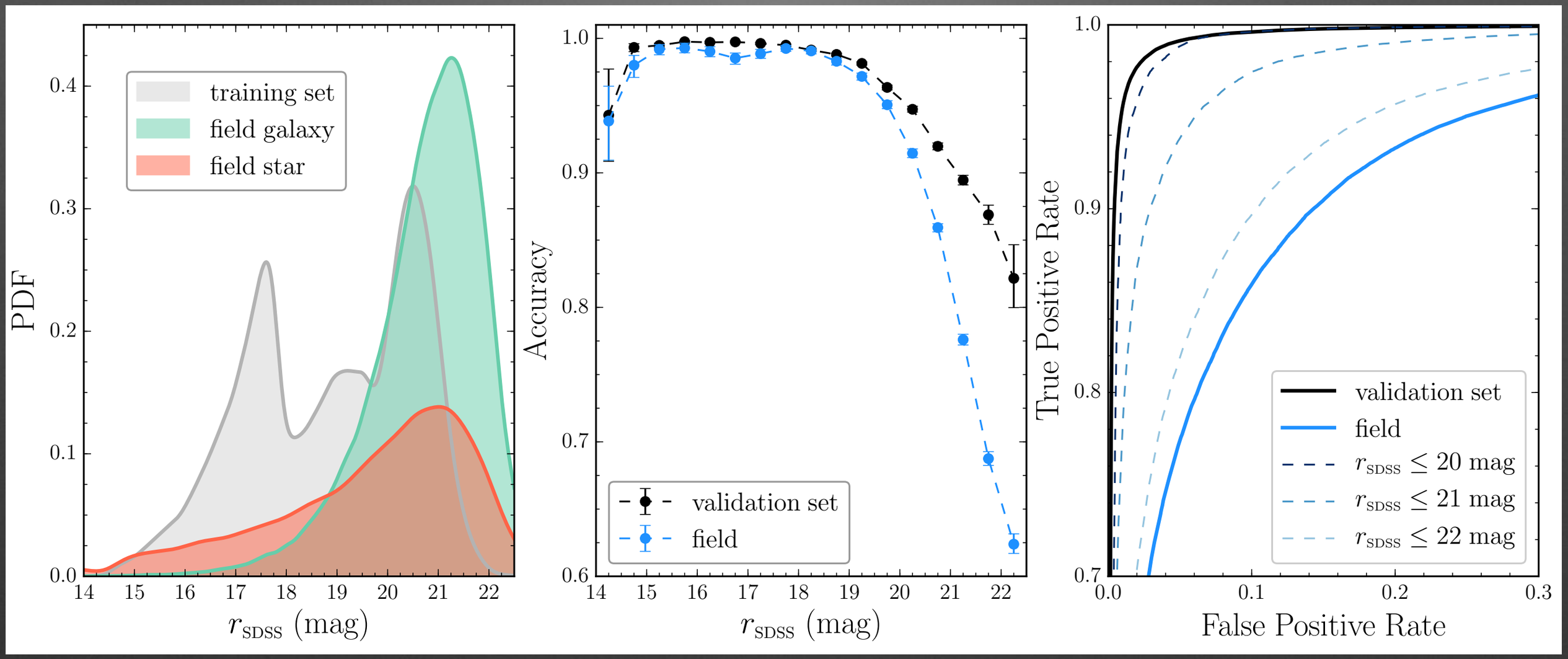
- Data-driven solutions are a necessity for ever-growing wide-field surveys (ZTF, LSST, etc)
  - ➡ e.g. real-bogus for transients
- Off-the-shelf ML algorithms are rarely plug+play for astro
  - ➡ nasty systematics (heteroskedastic errors & targeting bias)
  - ➡ e.g., small calibration errors in SDSS for EMP discovery
  - ➡ e.g., SDSS LRG bias
- Specific targets for one-off projects most likely to succeed
  - ➡ properly account for and propagate (non-ML like) uncertainties
  - ➡ e.g., The Cannon - measuring ages for >10k giants

Awwwwwwwww

SNAP!

You just asked a dope question!

Dope Question Time



Dope Question Time