Two (DL) CANDELS morphology catalogs

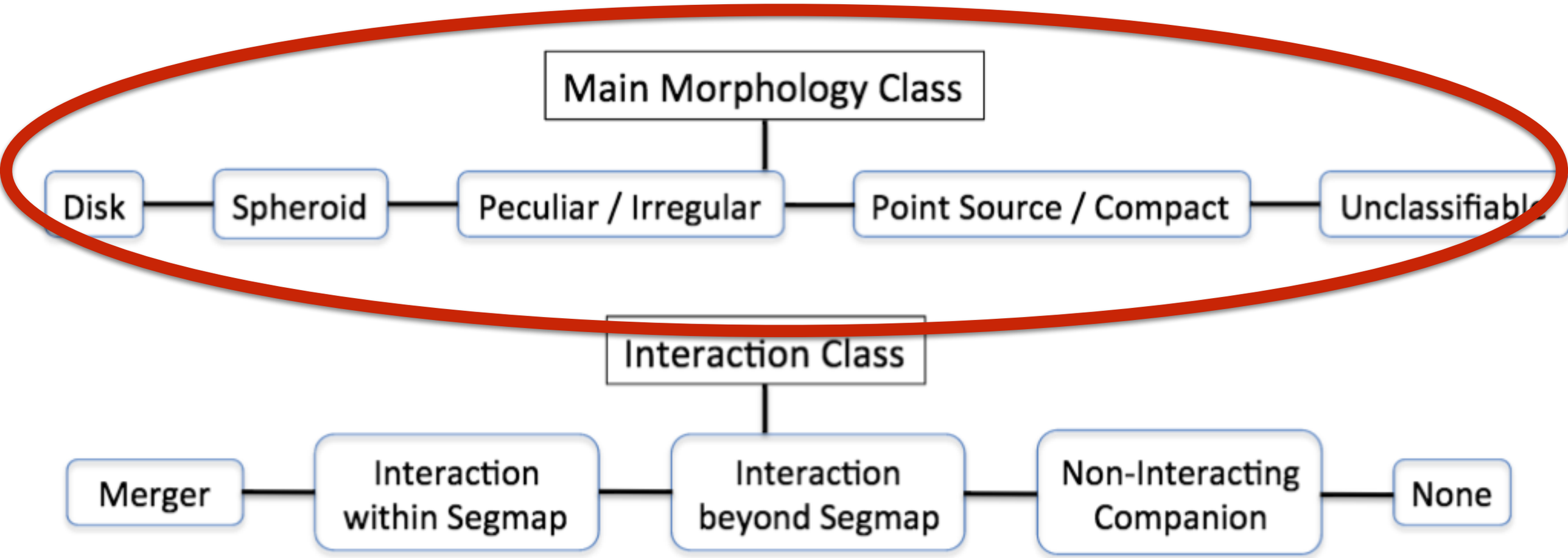
Marc Huertas-Company

E. Daddi, P. Pérez-González, **P. Dimauro**, M. Bernardi, F. Caro, D. Koo, S. Faber, J. Primack, G. Barro, D. Tuccillo, S. Mei, G. Snyder, J. Lotz, C. Lee, A. Dekel, S. Lapiner, B. Haussler et al.

CANDELS meeting 2017

I - “Visual” morphologies

CANDELS visual classification tree



Kartaltepe+14

— Classification of galaxies in GOODS-S with **H<24.5**

— Each galaxy is classified by 3-5 experts

— Fractions for ~8000 galaxy in GDS

— Classification done in F160 (+F125,F105)

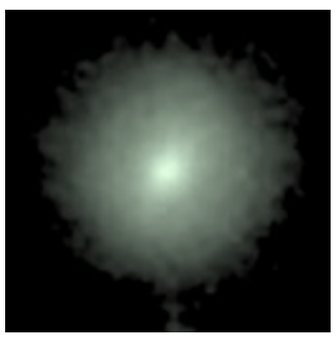
CONVNET for CANDELS

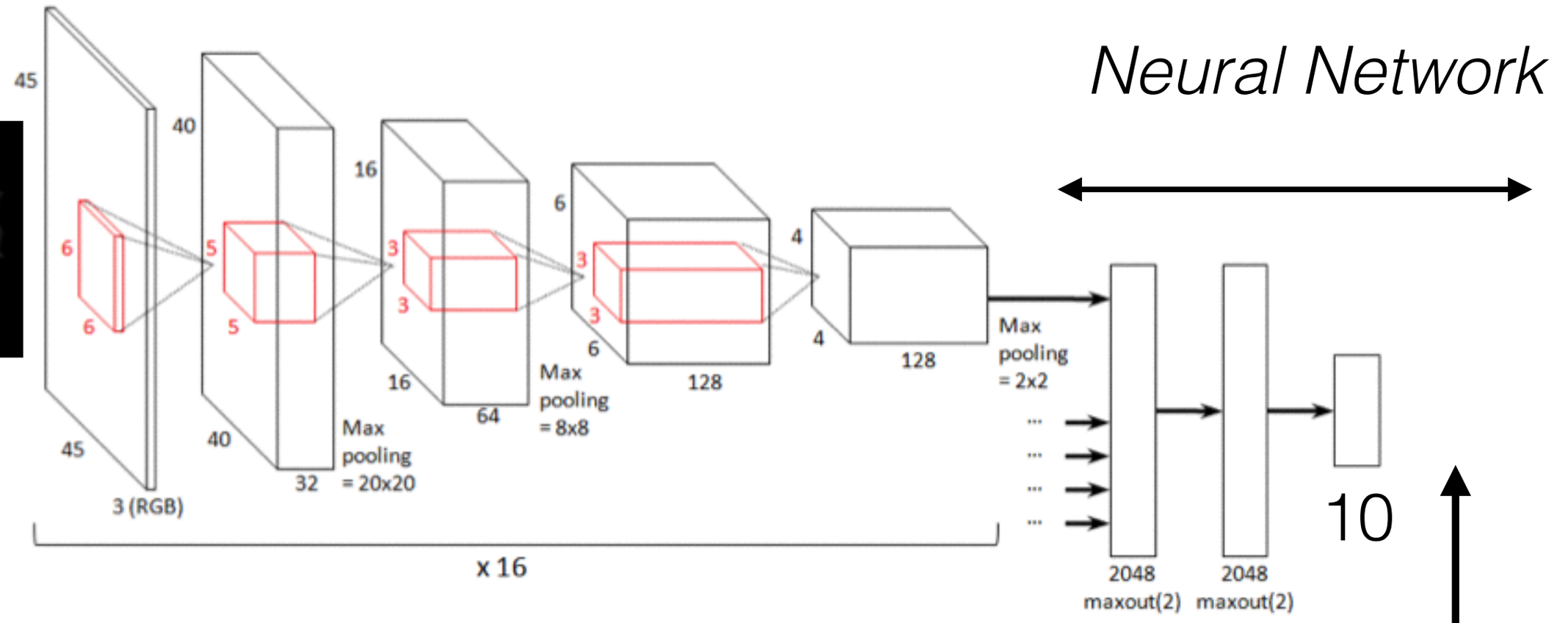
[Dieleman+15, MHC+15b]

- **TRAIN**: ~50.000 redundant galaxies in GDS (~10 days)
- **CLASSIFY**: GDN, COSMOS, UDS, GDS (~8h/field)

Feature learning

Neural Network

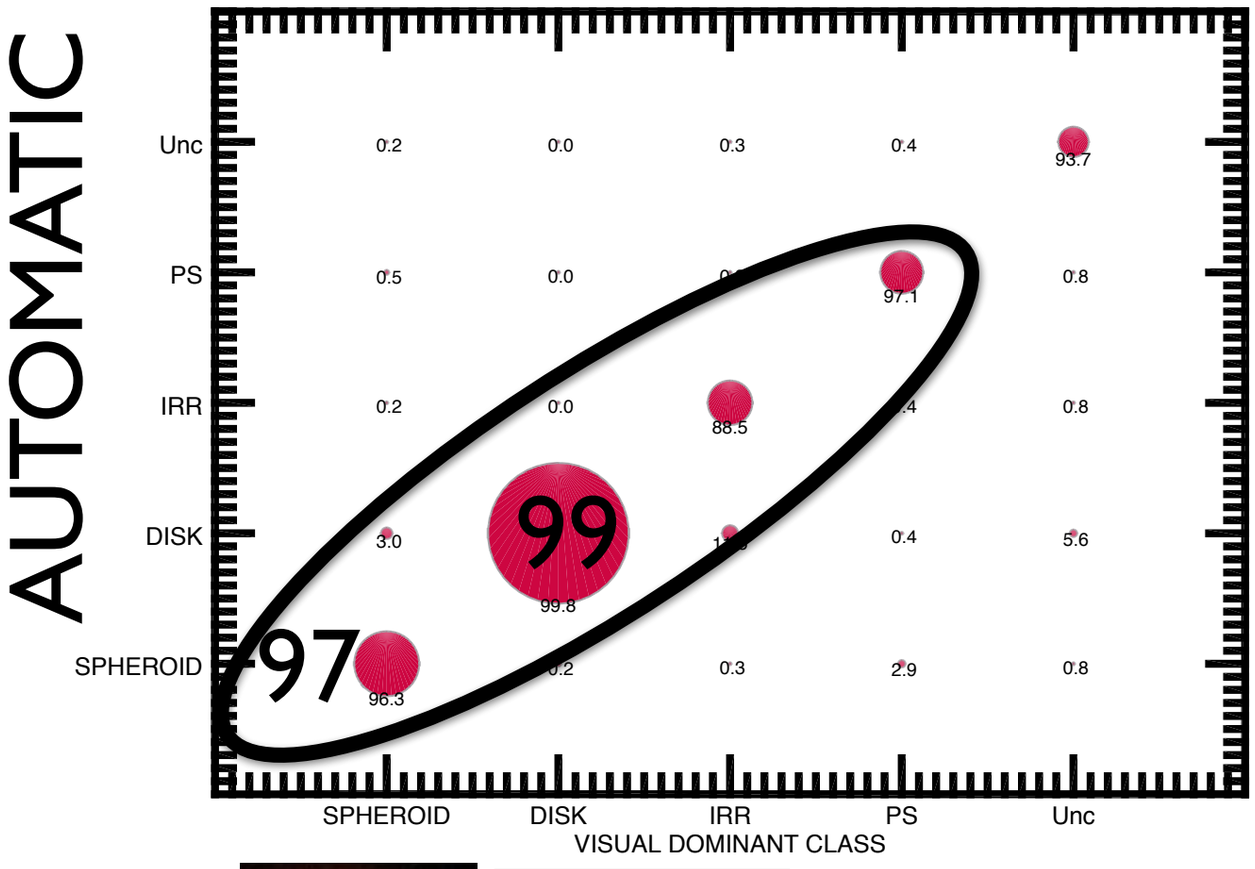




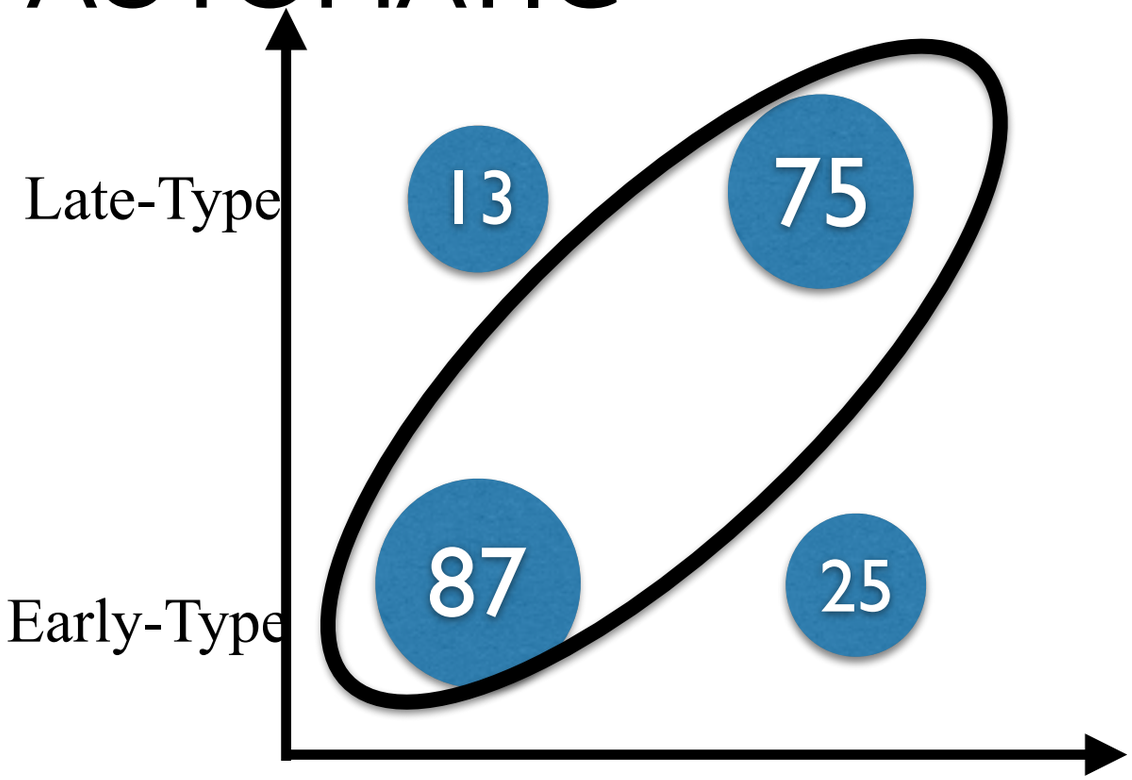
***INPUT**: RGB JPEG GDS snapshots*

***OUTPUT**: 10 probs.*

DEEP-LEARNING APPLIED TO MORPHOLOGY



VISUAL

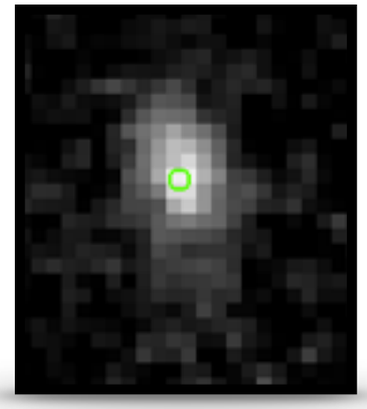


MHC+15b

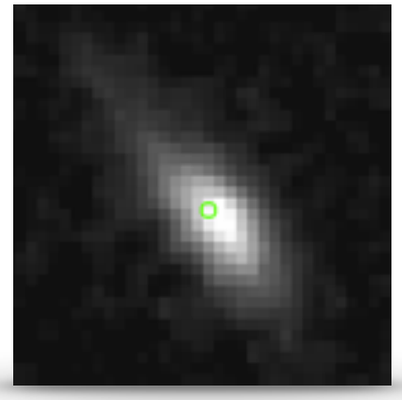
Catastrophic “errors”

fsph_v > 0.7 and fsph_a < 0.3 or fsph_v < 0.3 and fsph_a < 0.7

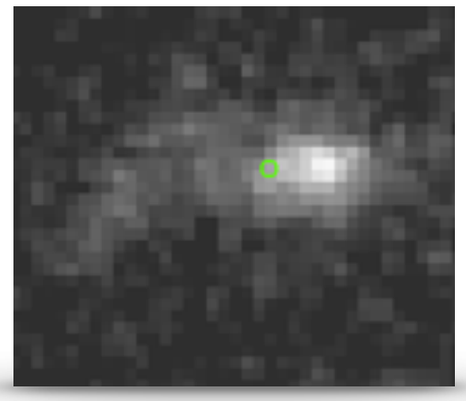
~15/8000=0.2%



fsph=0.82 / 0.25
fdisk = 0.5 / 0.76
firr = 0.0 / 0.22



fsph=0.8 / 0.25
fdisk = 0.75 / 0.95
firr = 0.0 / 0.0



fsph=0.76 / 0.11
fdisk = 0.6 / 0.66
firr = 0.39 / 0.53

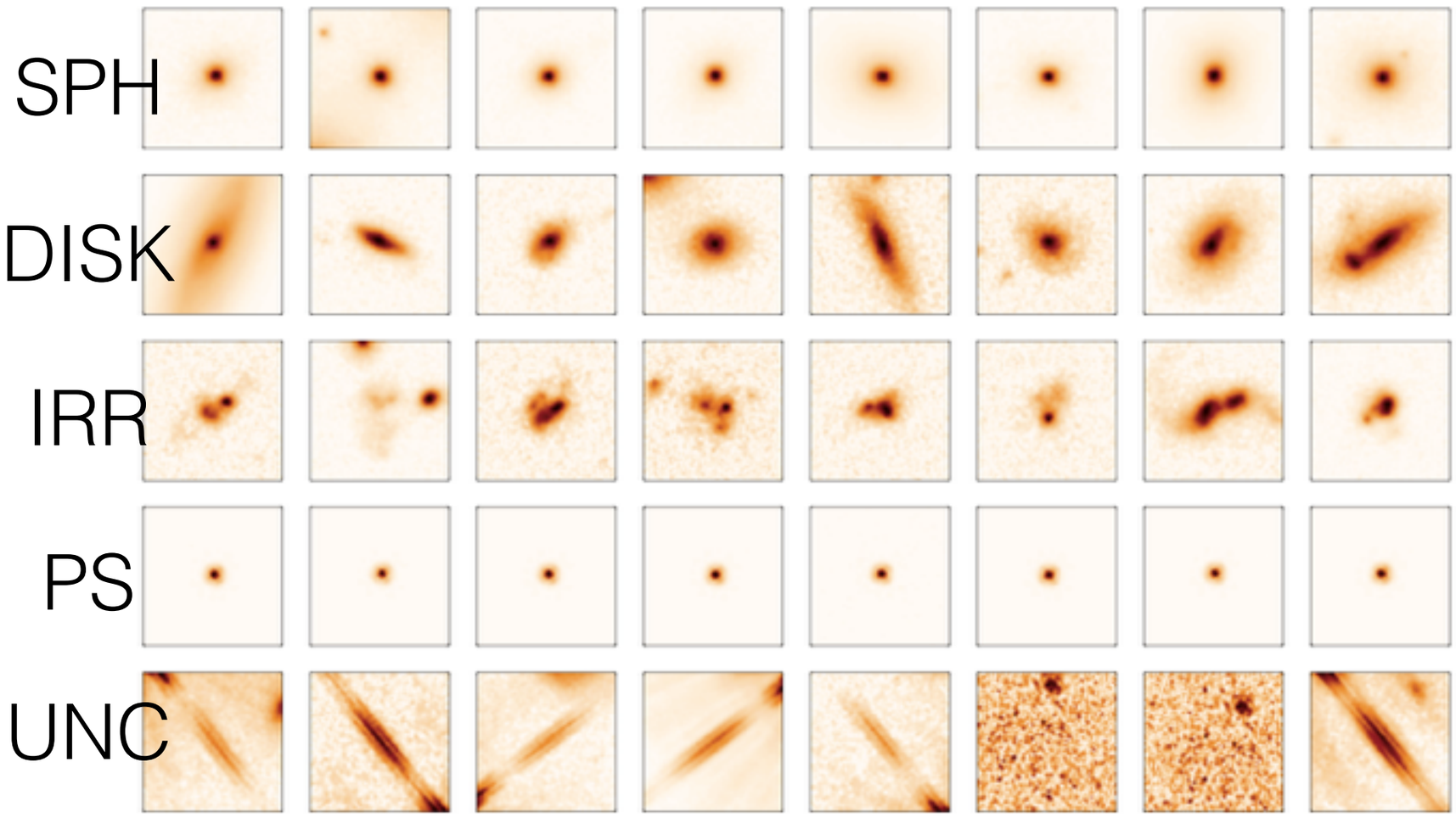
VISUAL / AUTO

Summary of catalog

- ~ **50.000** galaxies in **5 CANDELS fields** (GDN, GDS, COSMOS, UDS, EGS)
- 10 probabilities (fractions for each galaxy)
- **H < 24.5**
- **<z>= 1.25**
- Optical rest-frame morphology at 1<z<3
- Complete @ Mstar>10^10 Msol @ z~3

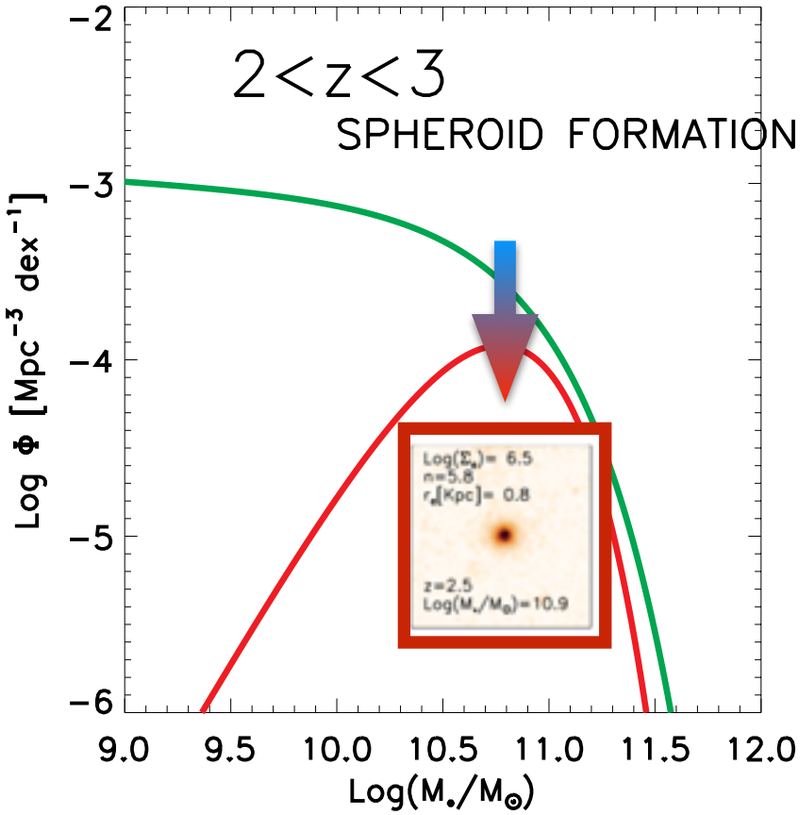
Available @ Rainbow Database

http://rainbowx.fis.ucm.es/Rainbow_navigator_public/



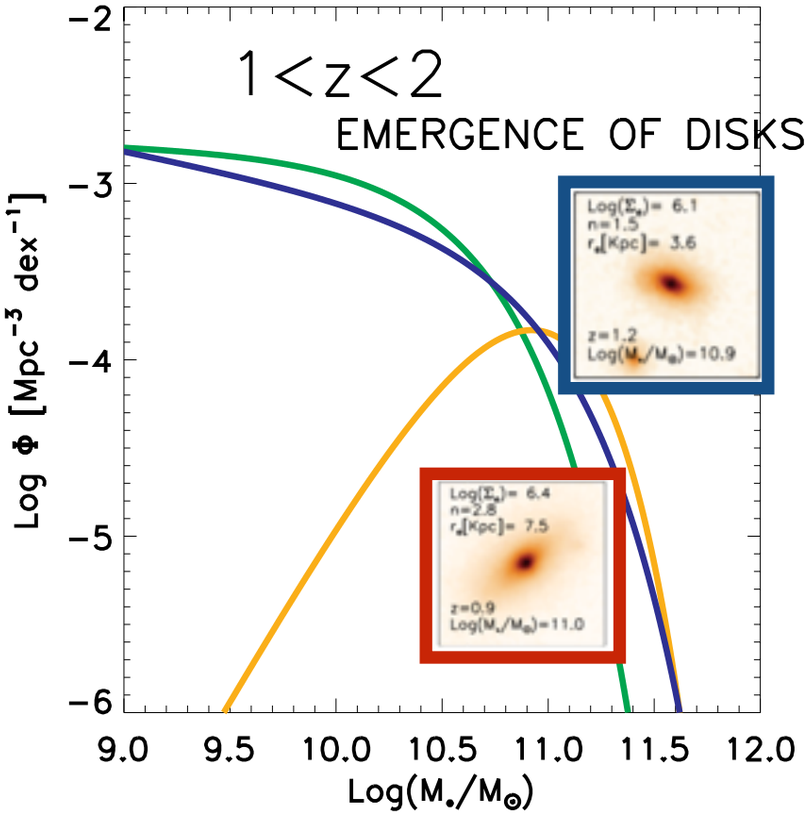
MHC+15b

CORE SPHEROID FORMATION



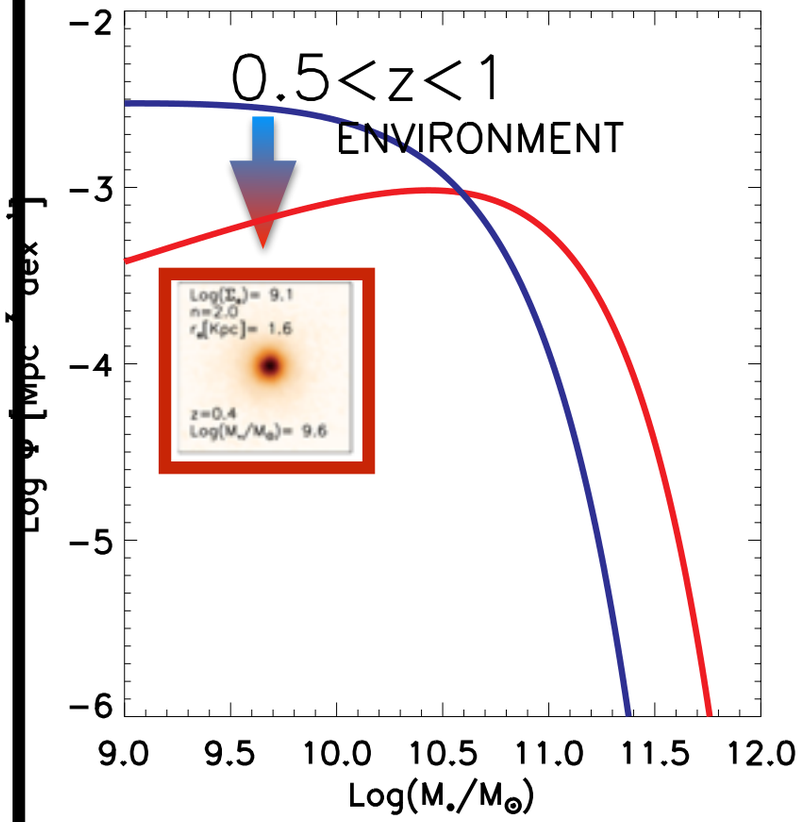
Violent quenching:
Rapid spheroid formation
Violent quenching
Fast gas consumption
Compact and dense remnant (Dekel+,Barro +13)

EMERGENCE OF PASSIVE DISKS



Gentle quenching:
Normal disks dominate (disk stabilization)
"Quiet" quenching that preserves the disk - see Peng+15

LOW MASS END: ENVIRONMENT

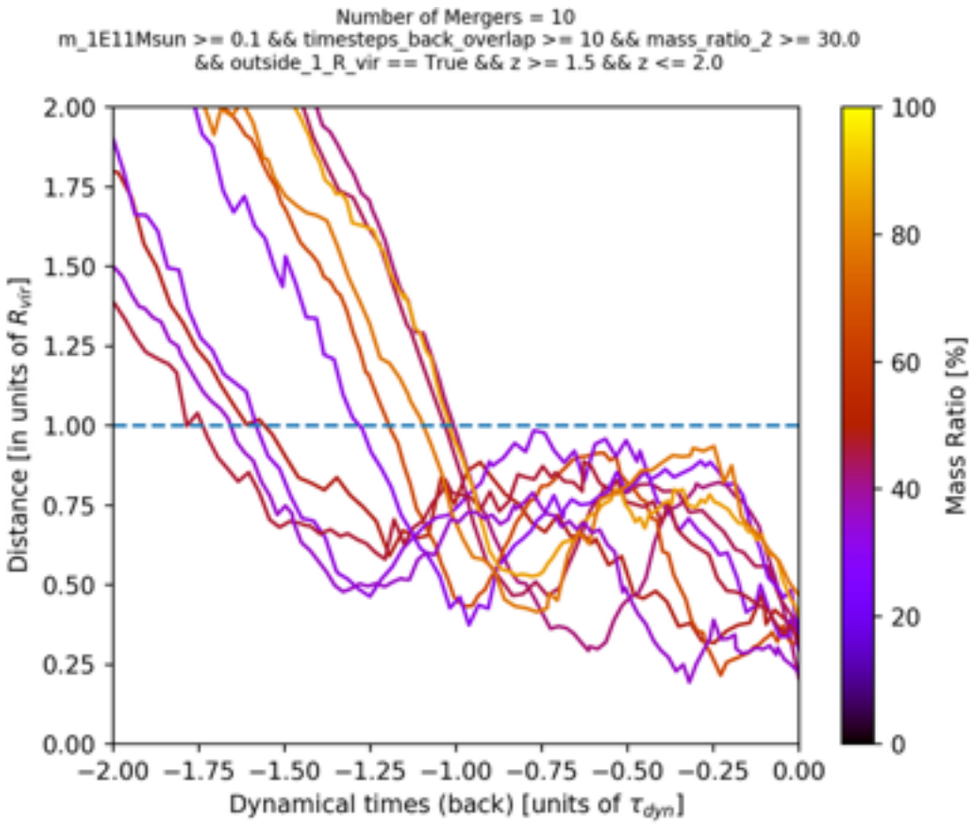


Environment quenching
dominates at the low mass end
Disks statistically destroyed - Ram-pressure?

MHC+15a,16

Coming soon? mergers…

Horizon AGN hydro sim → **Mock images** → Deep Learning



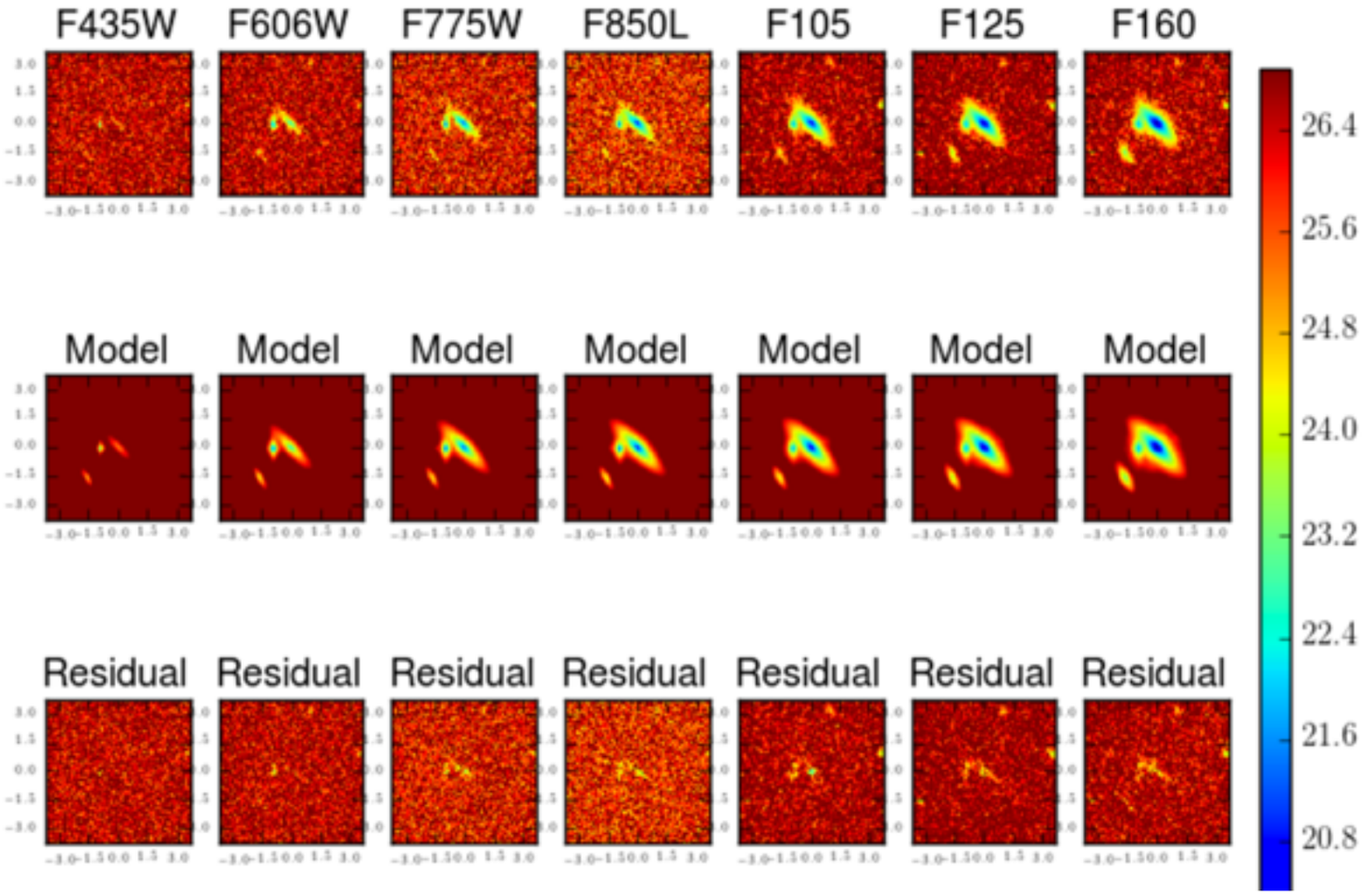
→ Deep Learning →

Merger properties:

- mass-ratio
- stage
- timescale

II - Bulges and disks

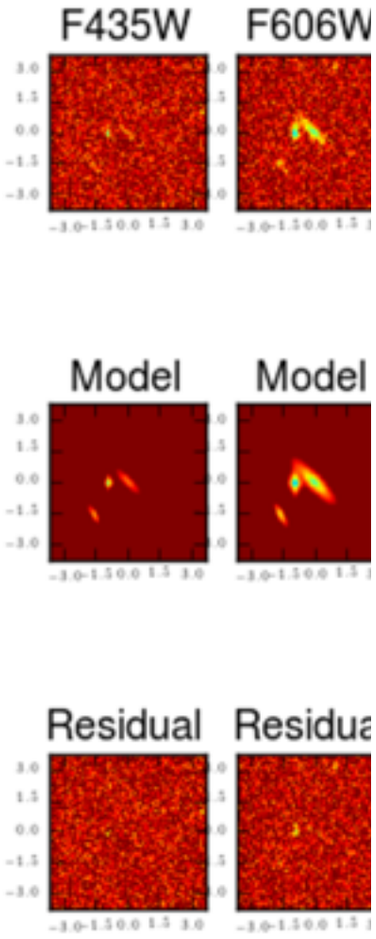
GALFITM catalogs
in 7 -4 bands

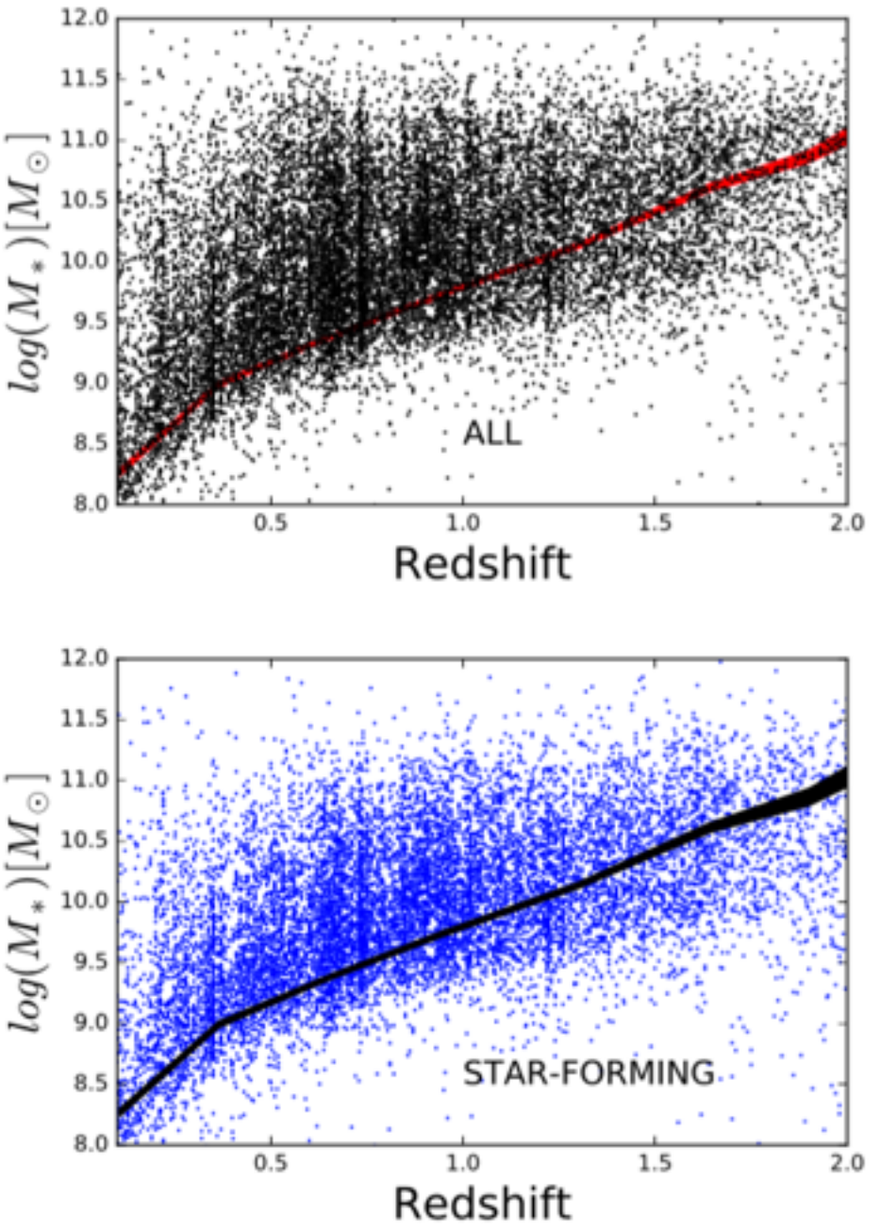


Very similar to Boris' catalogs

Dimauro,MHC+17a

GALFITM catalogs
in 7 -4 bands





H<23!

Very similar to Boris' catalogs

I7a

MODEL SELECTION

1 component?

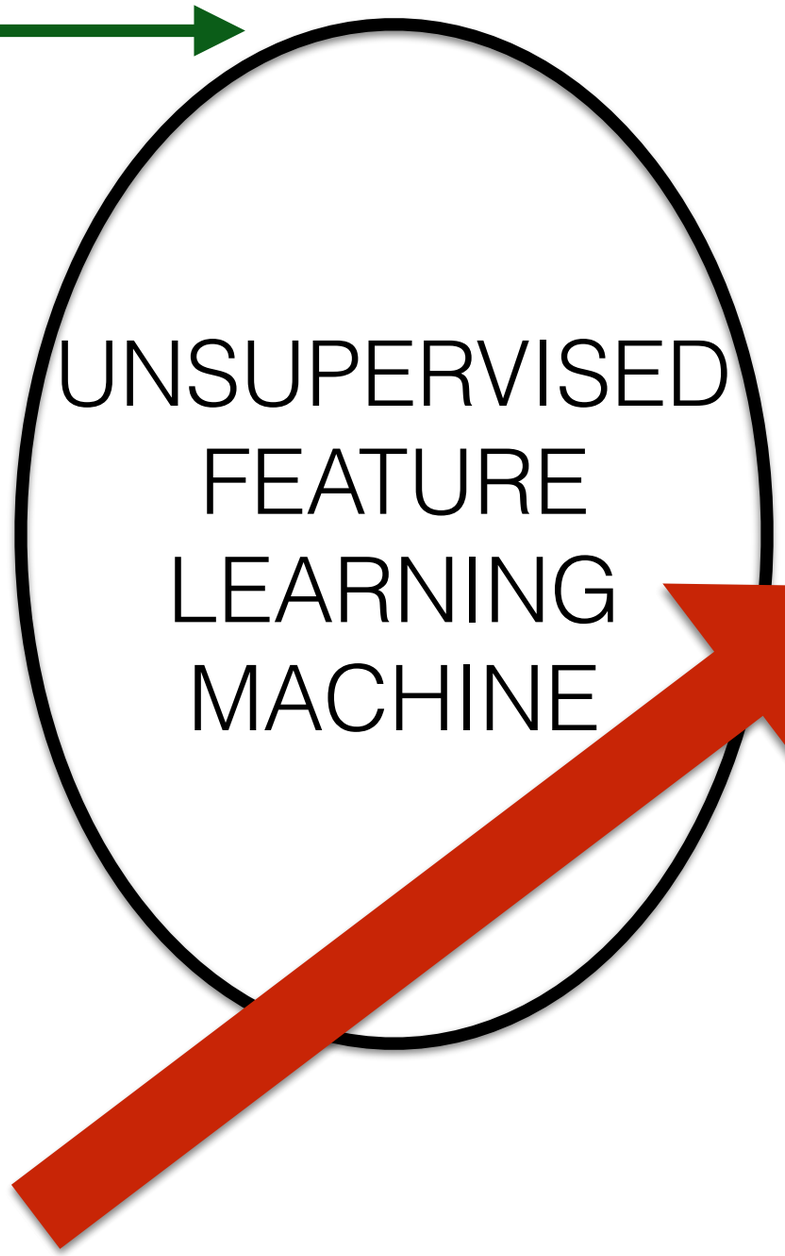
2 components?

MODEL SELECTION WITH DL

TRAINING:

simulations of analytic profiles with PSF, noise effects

(no limits on the size)



2 component (B+D)

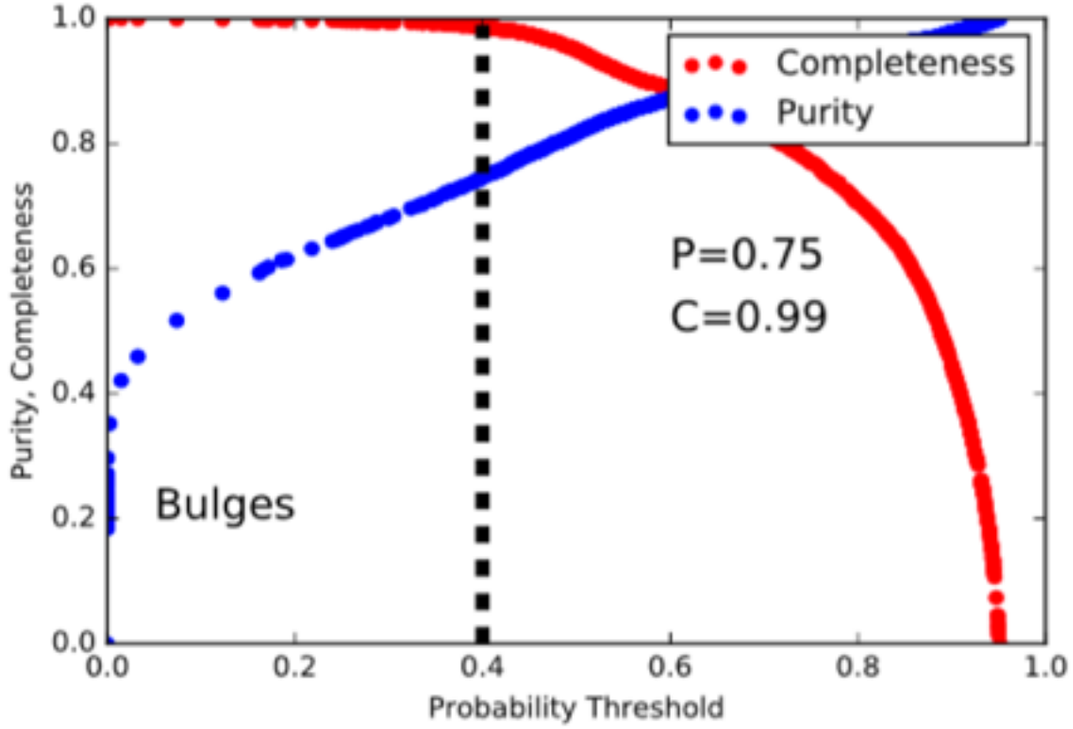
1 component disk

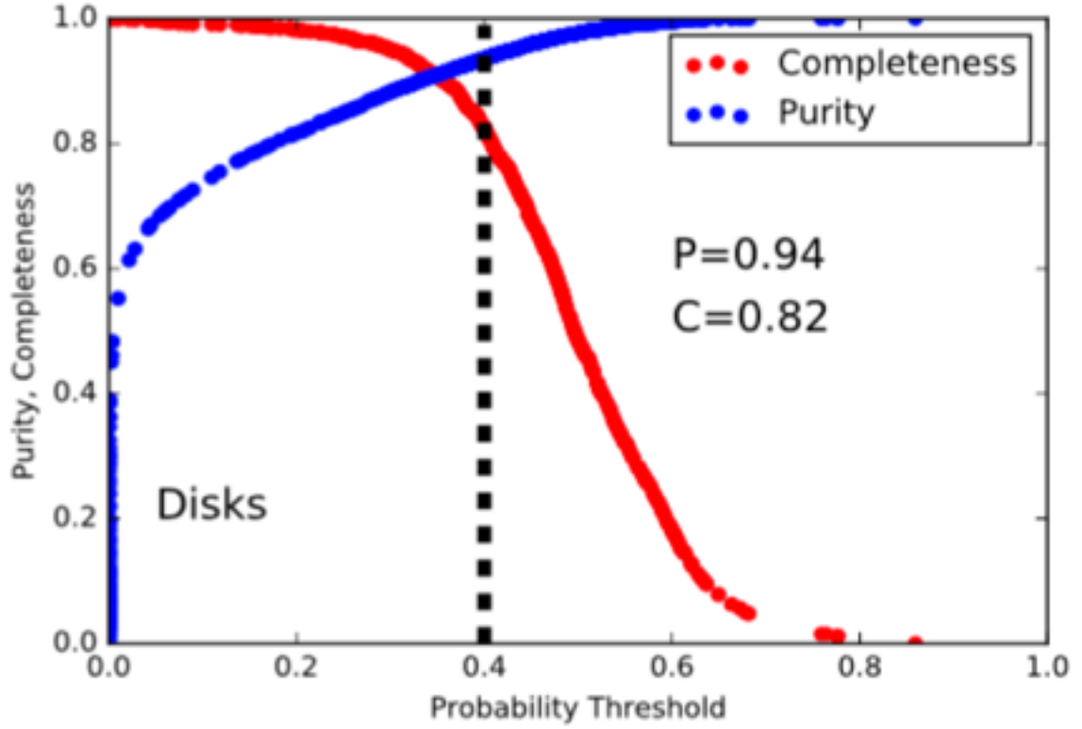
1 component bulg

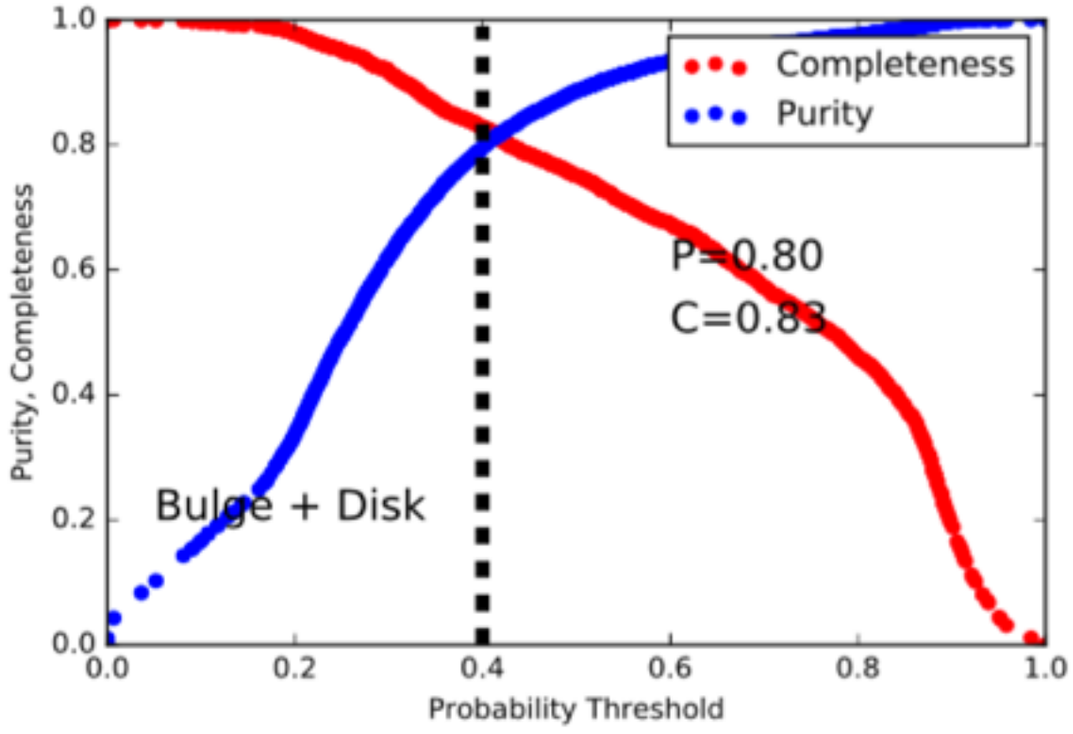
2 component (PB+D)

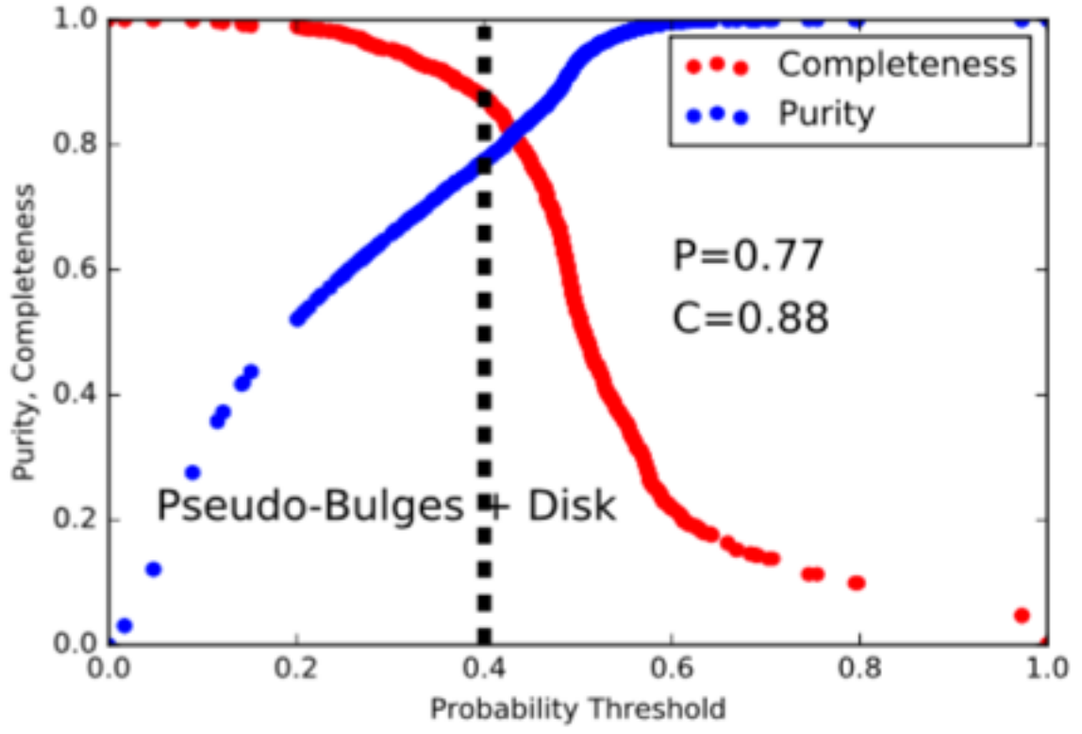
DATA:

HST deep field observations CANDELS


Completeness
Purity
P=0.75
C=0.99
Bulges
Purity, Completeness
Probability Threshold
0.0
0.2
0.4
0.6
0.8
1.0


Completeness
Purity
P=0.94
C=0.82
Disks
Purity, Completeness
Probability Threshold
0.0
0.2
0.4
0.6
0.8
1.0


Completeness
Purity
P=0.80
C=0.83
Bulge + Disk
Purity, Completeness
Probability Threshold
0.0
0.2
0.4
0.6
0.8
1.0


Completeness
Purity
P=0.77
C=0.88
Pseudo-Bulges + Disk
Purity, Completeness
Probability Threshold
0.0
0.2
0.4
0.6
0.8
1.0

Pure n=1 model 1-C

Pure n>2 model 1-C

Sersic+Exp model (n>2)

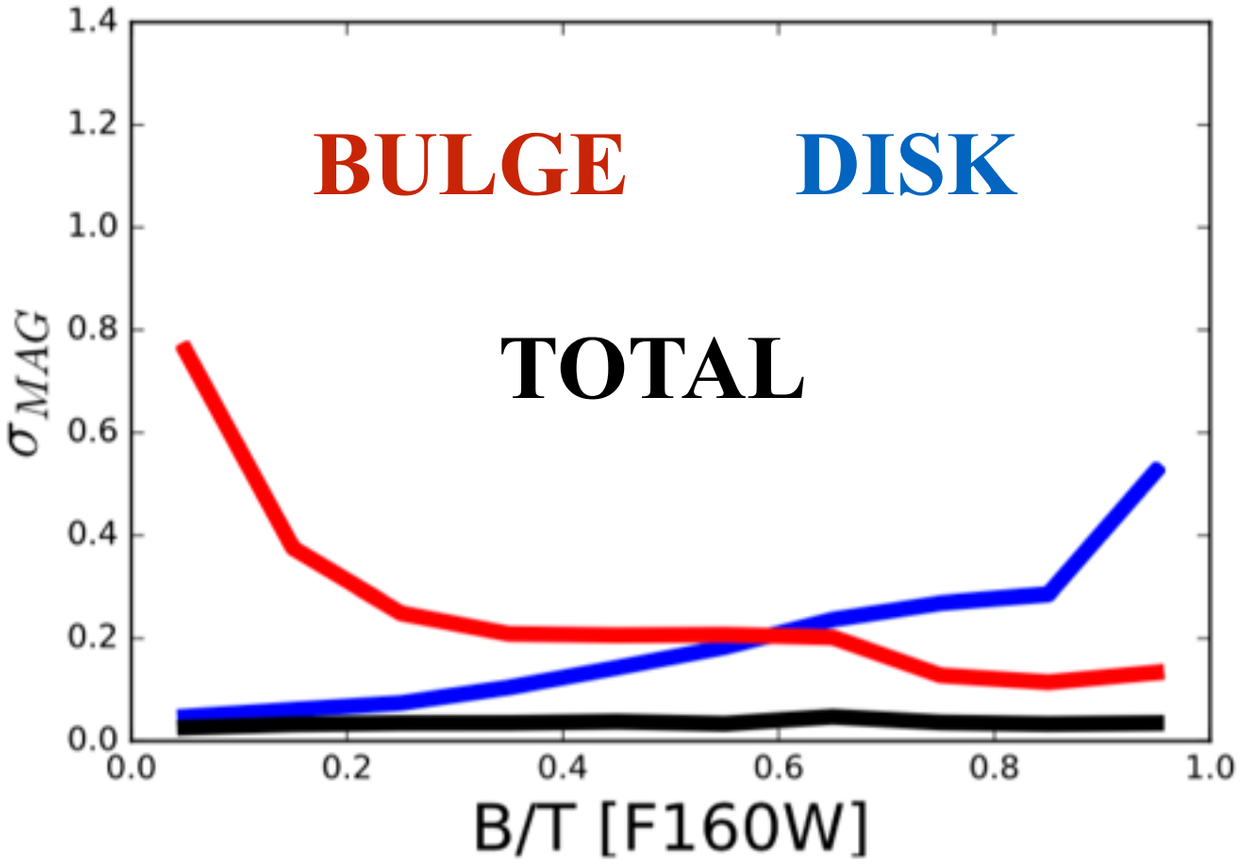
Sersic+Exp model (n<2)

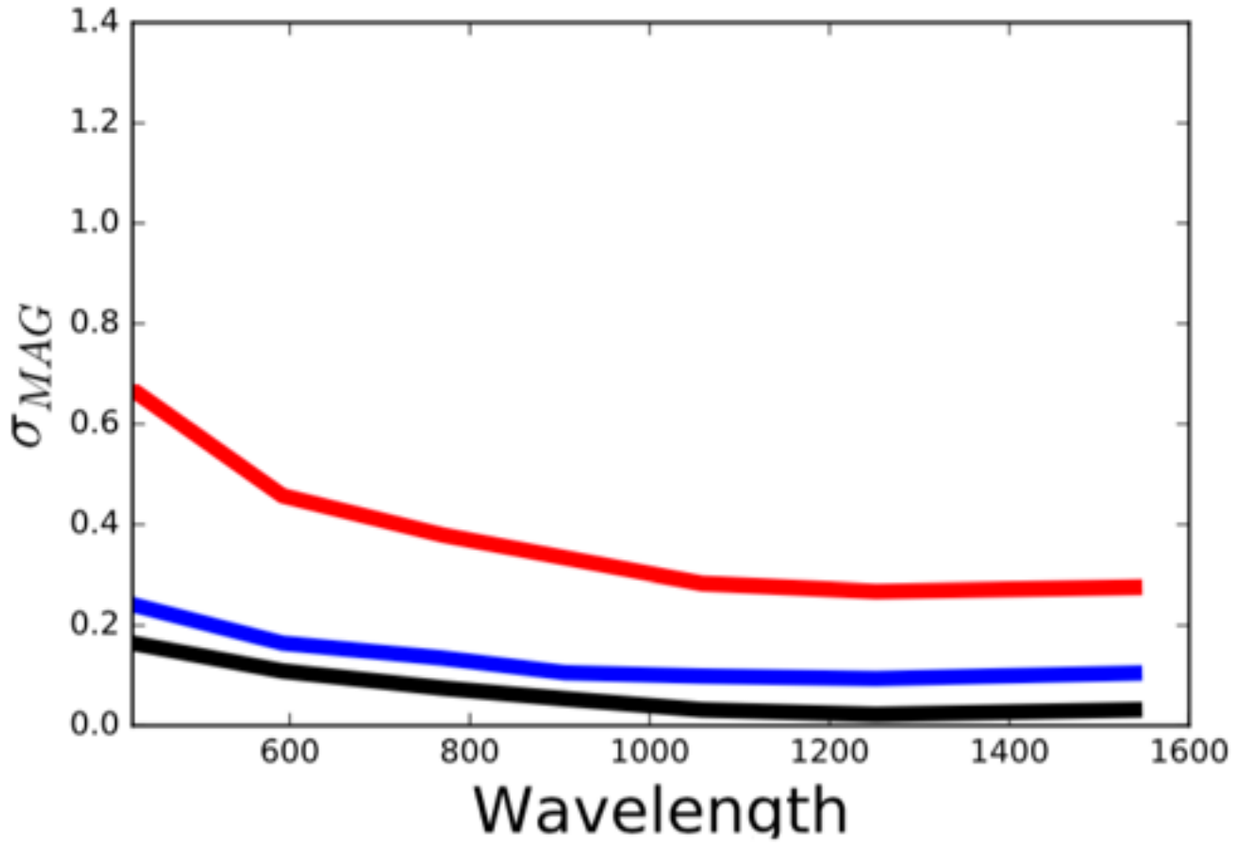
No model (6%)

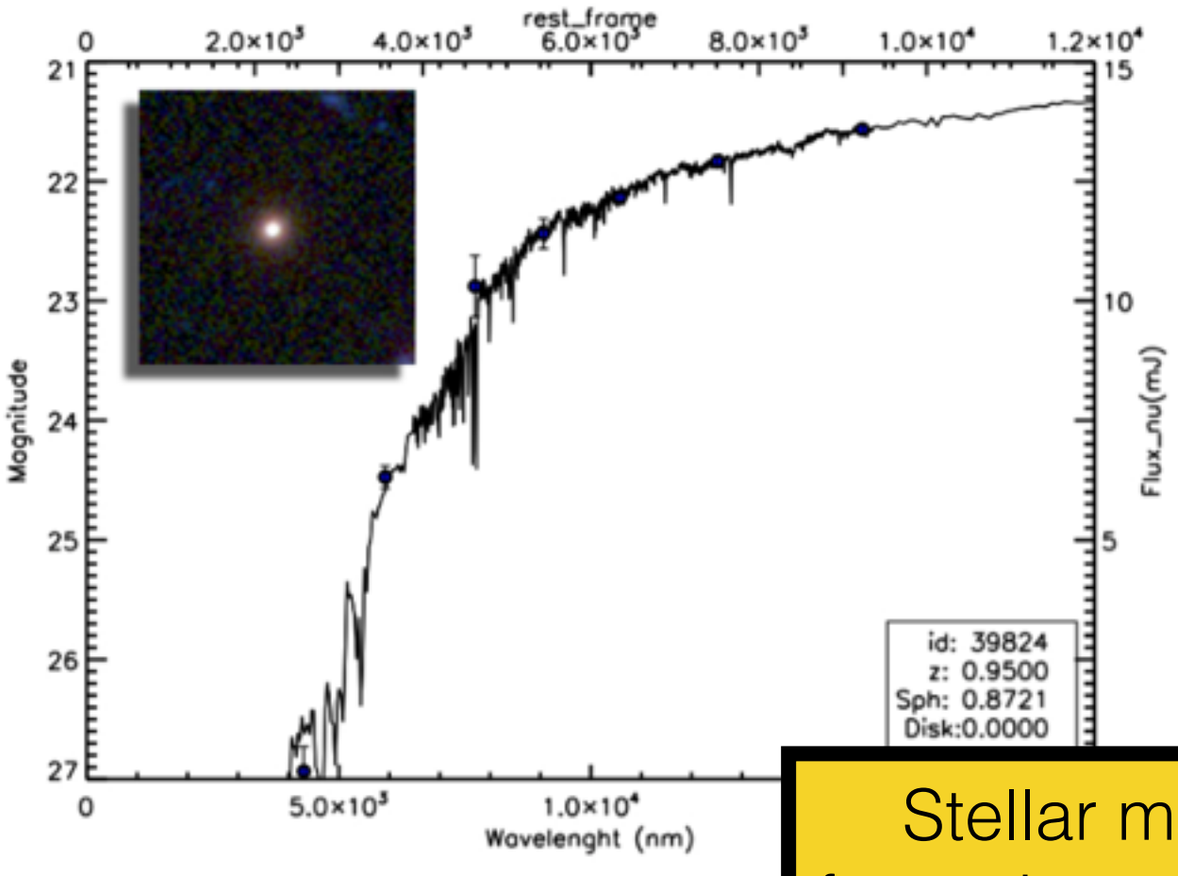
INDIVIDUAL ERROR ESTIMATE

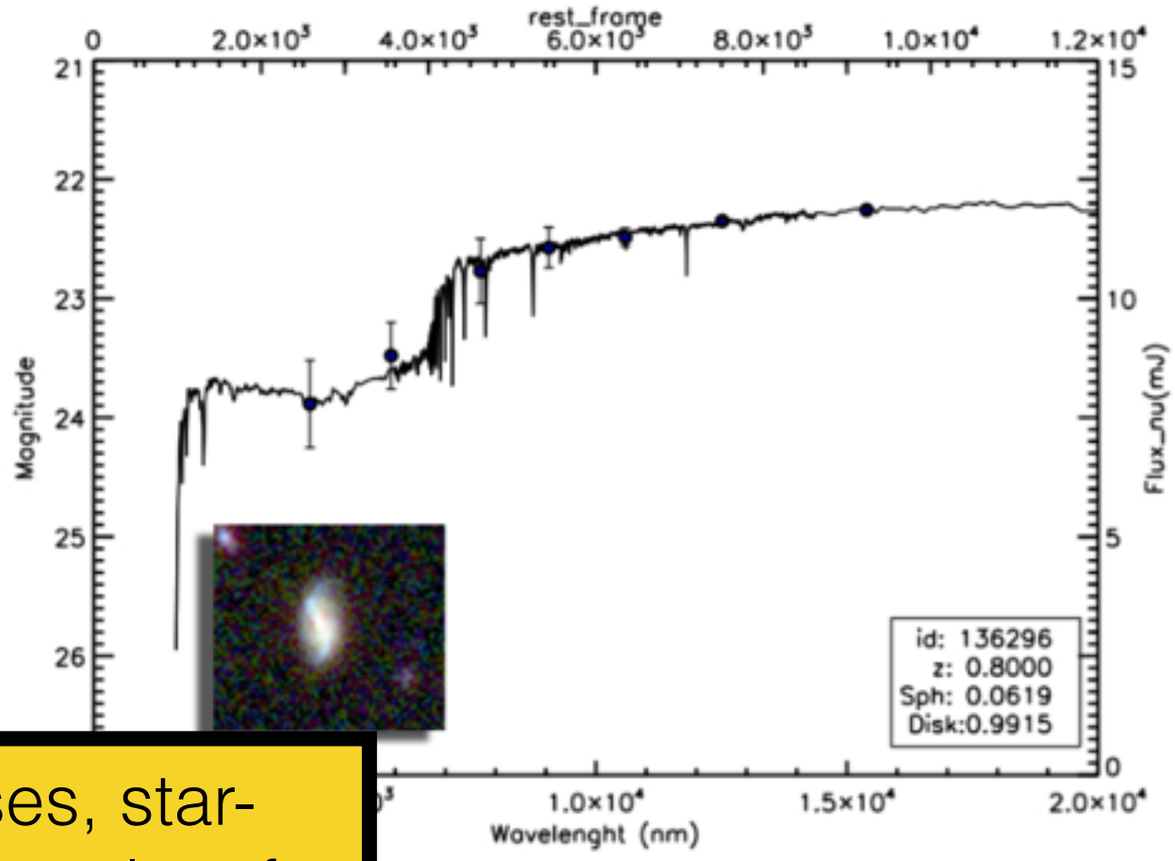
$$\mathbf{p^{2C}} = \left(\frac{m}{\sigma_m}, \frac{log(n_b)}{\sigma_{log(n_b)}}, \frac{log(R_d)}{\sigma_{log(R_d)}}, \frac{log(R_e)}{\sigma_{log(R_e)}}, \frac{BT}{log(BT)}, f_{sph,disk,irr}\right)$$

(van der Wel+12)

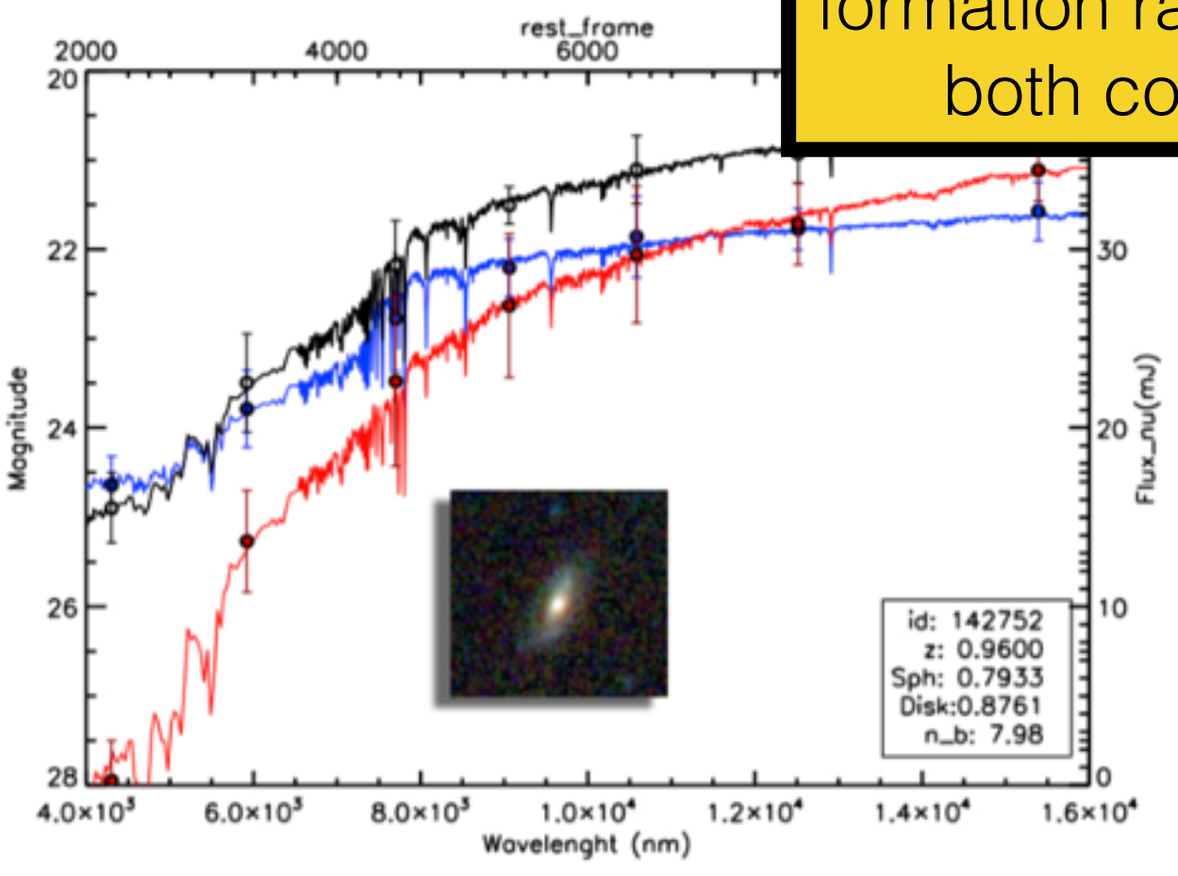


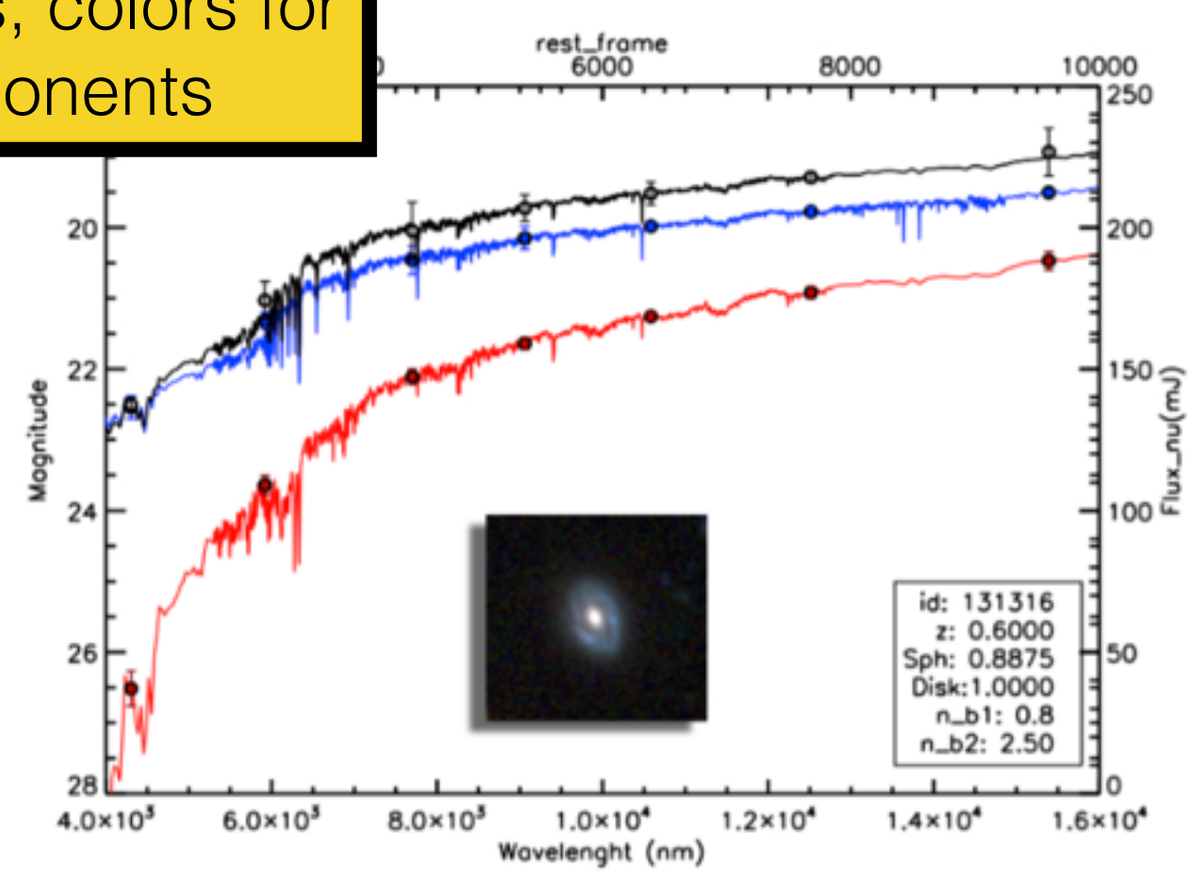






Stellar masses, star-formation rates, colors for both components



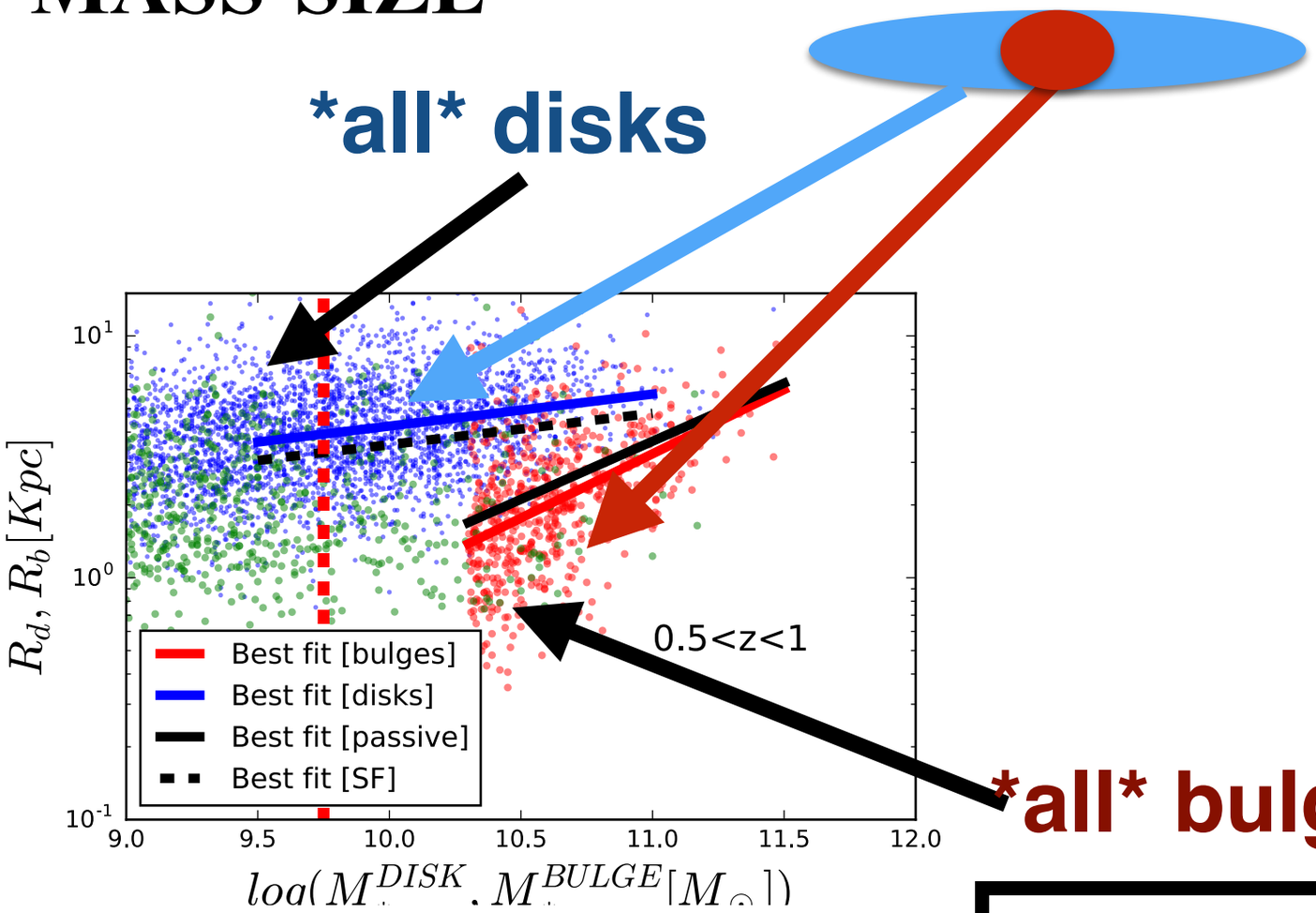


Summary of catalog

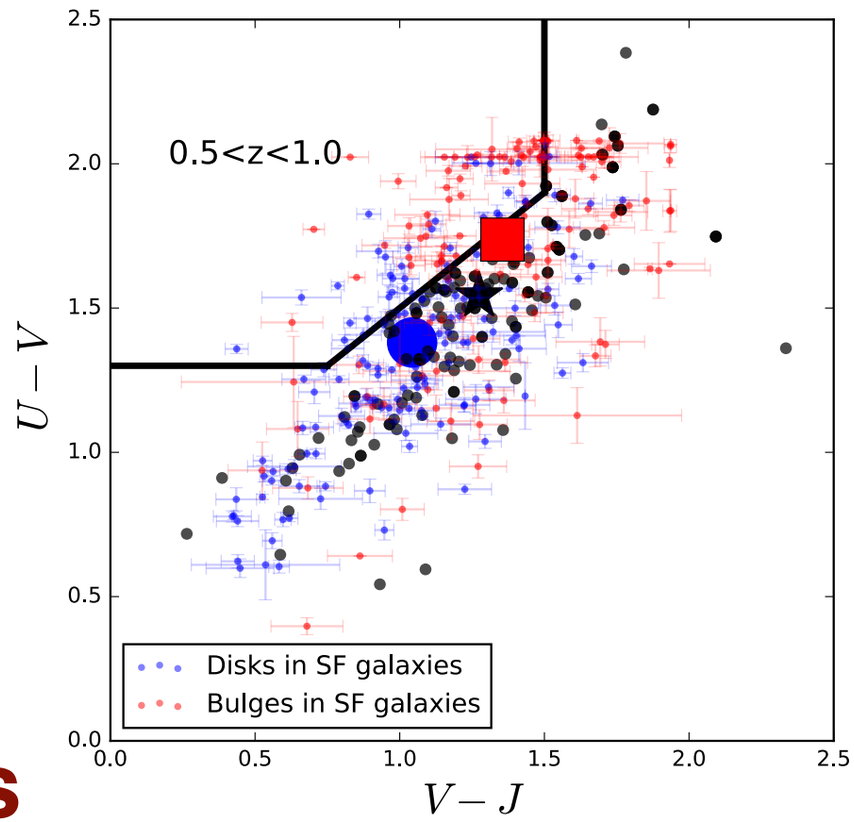
- Service and Sersic+Exp in 5 fields, 4-7 bands - 0.06”/pixel
- ~ 17.000 galaxies, H<23, z<2, **3 different setups**
- **Probability of “best” model using deep-learning**
- **Individual error estimates on the different structural parameters**
- **Stellar population properties of bulges and disks (Mstar, SFRs, UVJ…)**

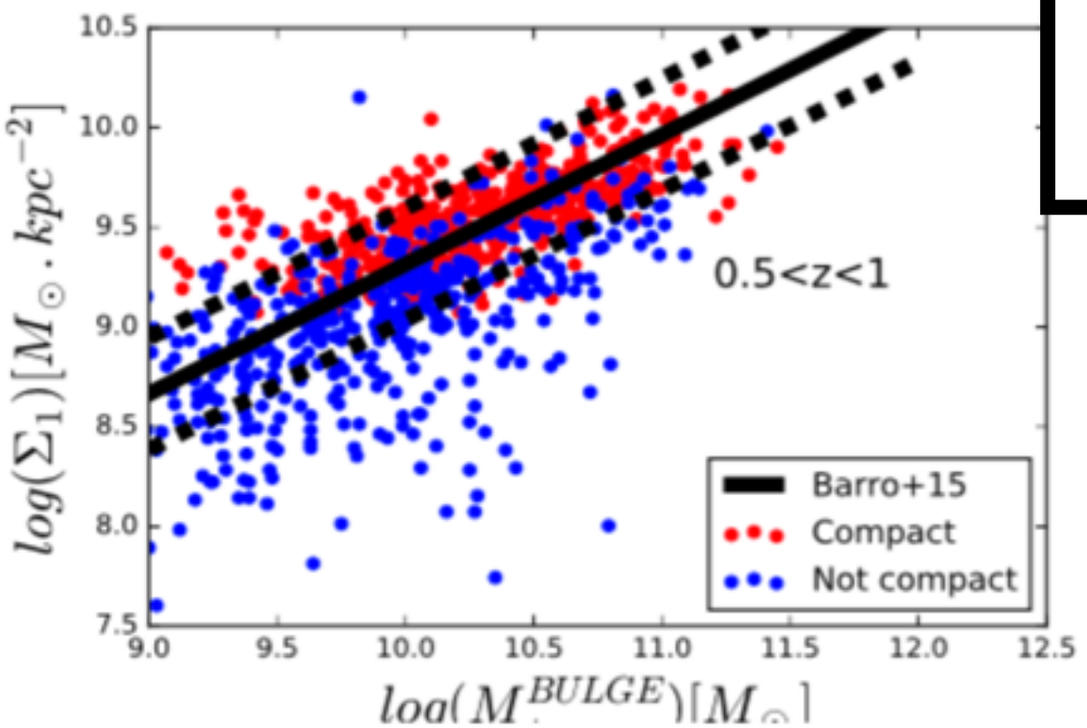
https://lerma.obspm.fr/huertas/form_CANDELS

MASS-SIZE



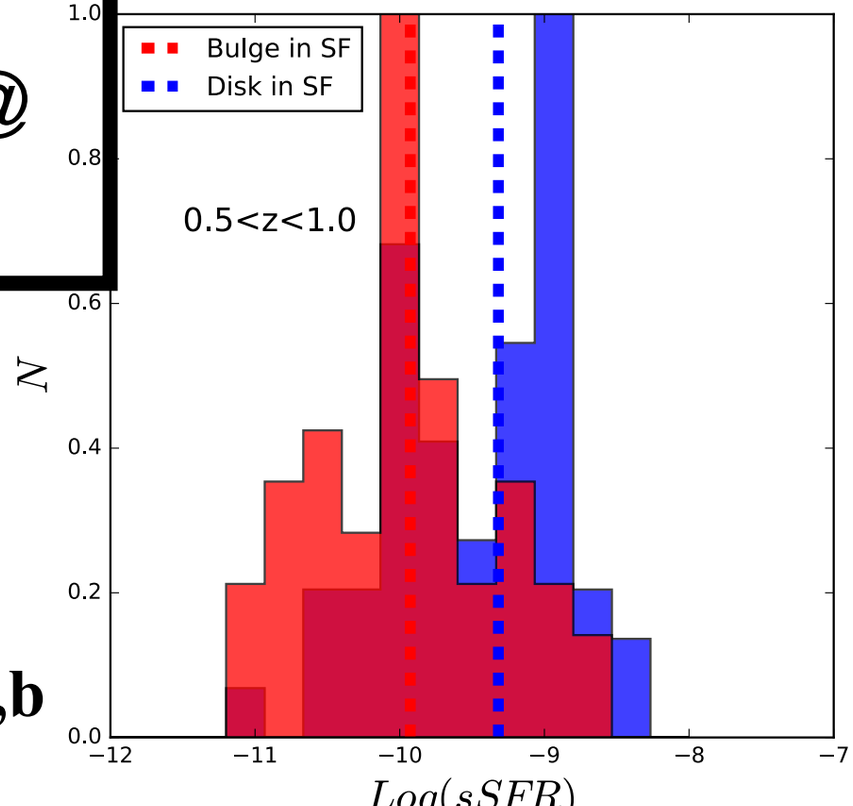
COLORS





Talk on Monday @ 1:40pm

Dimauro+17a,b
MHC+17

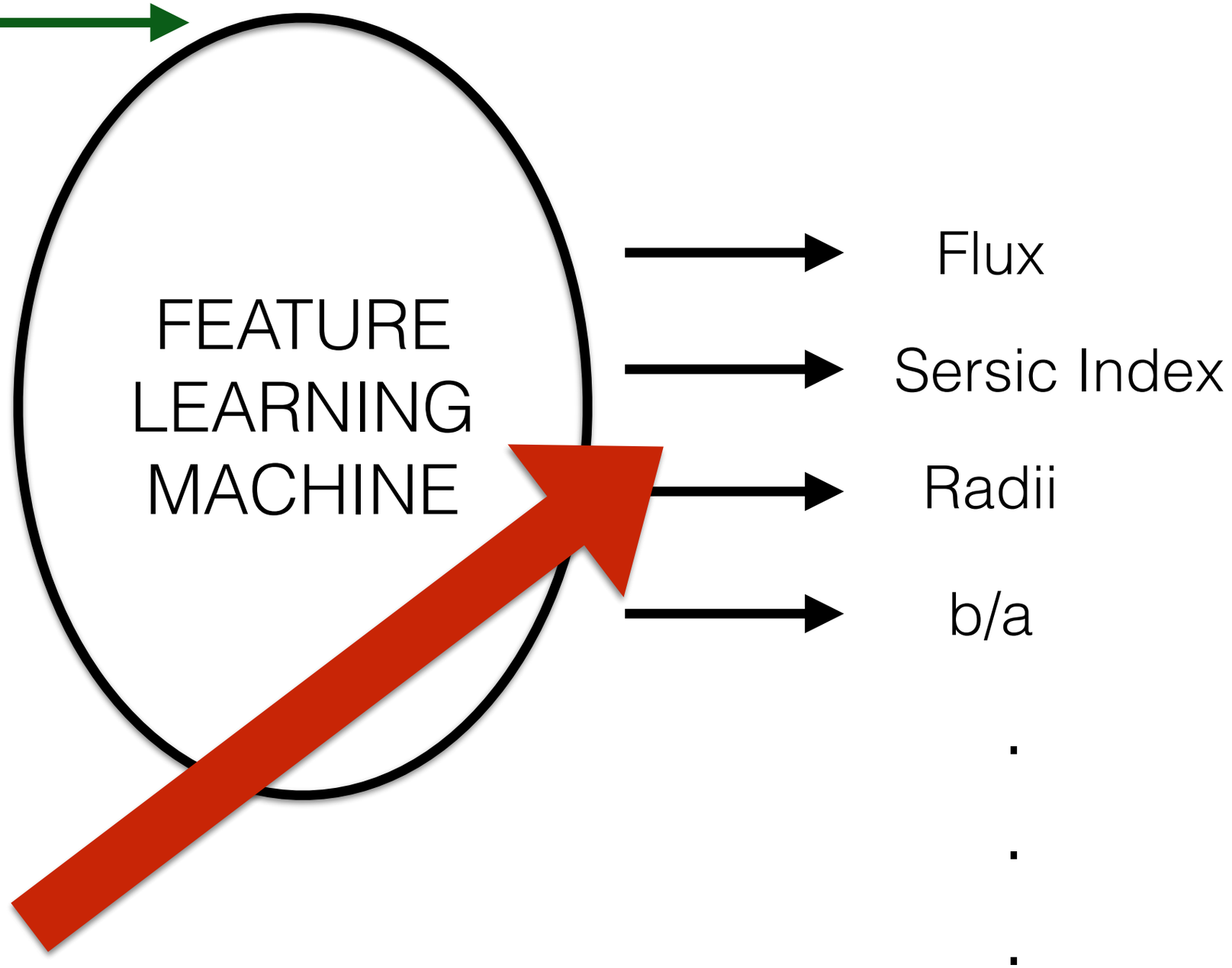


For future … Galfitting with deep-learning…

TRAINING:

simulations of analytic profiles with PSF, noise effects

(no limits on the size)

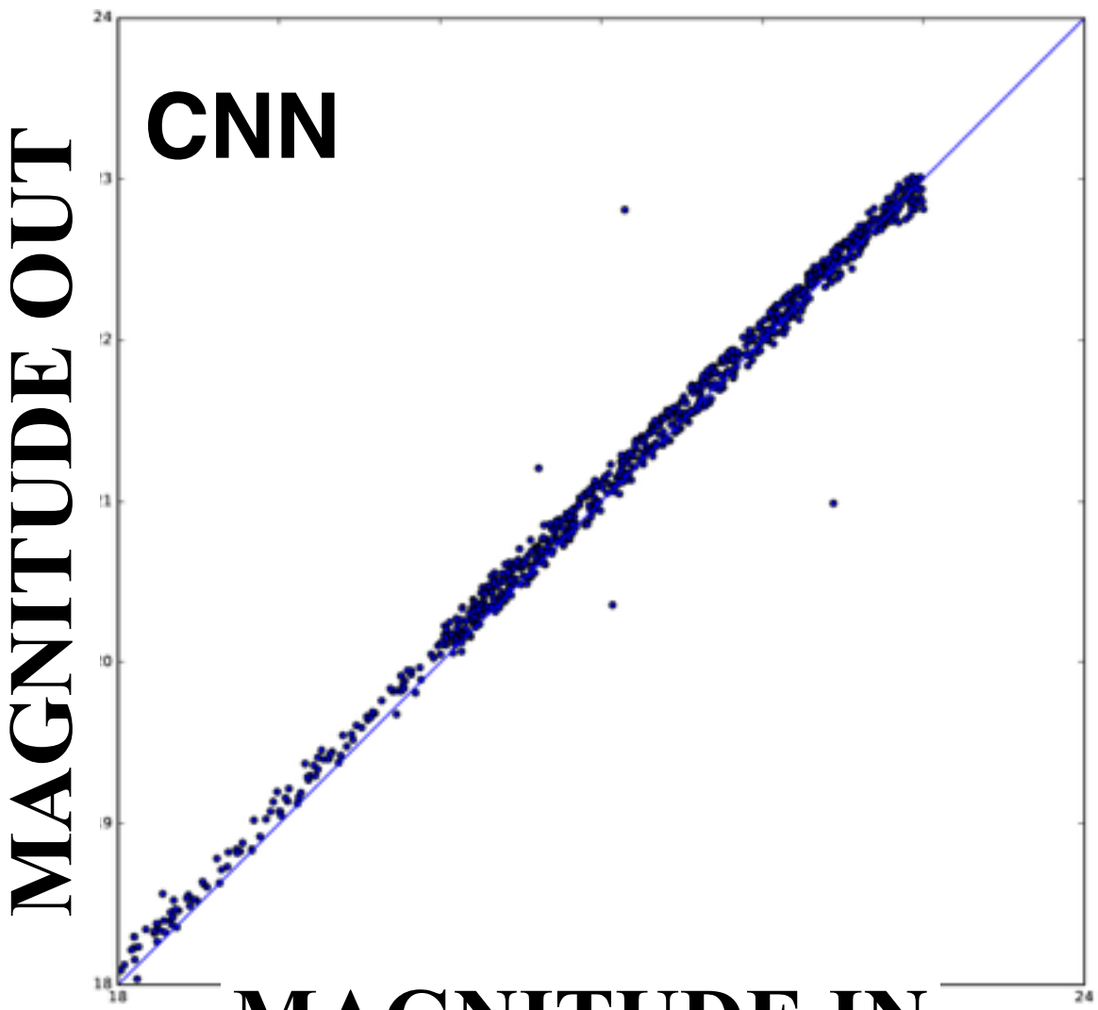


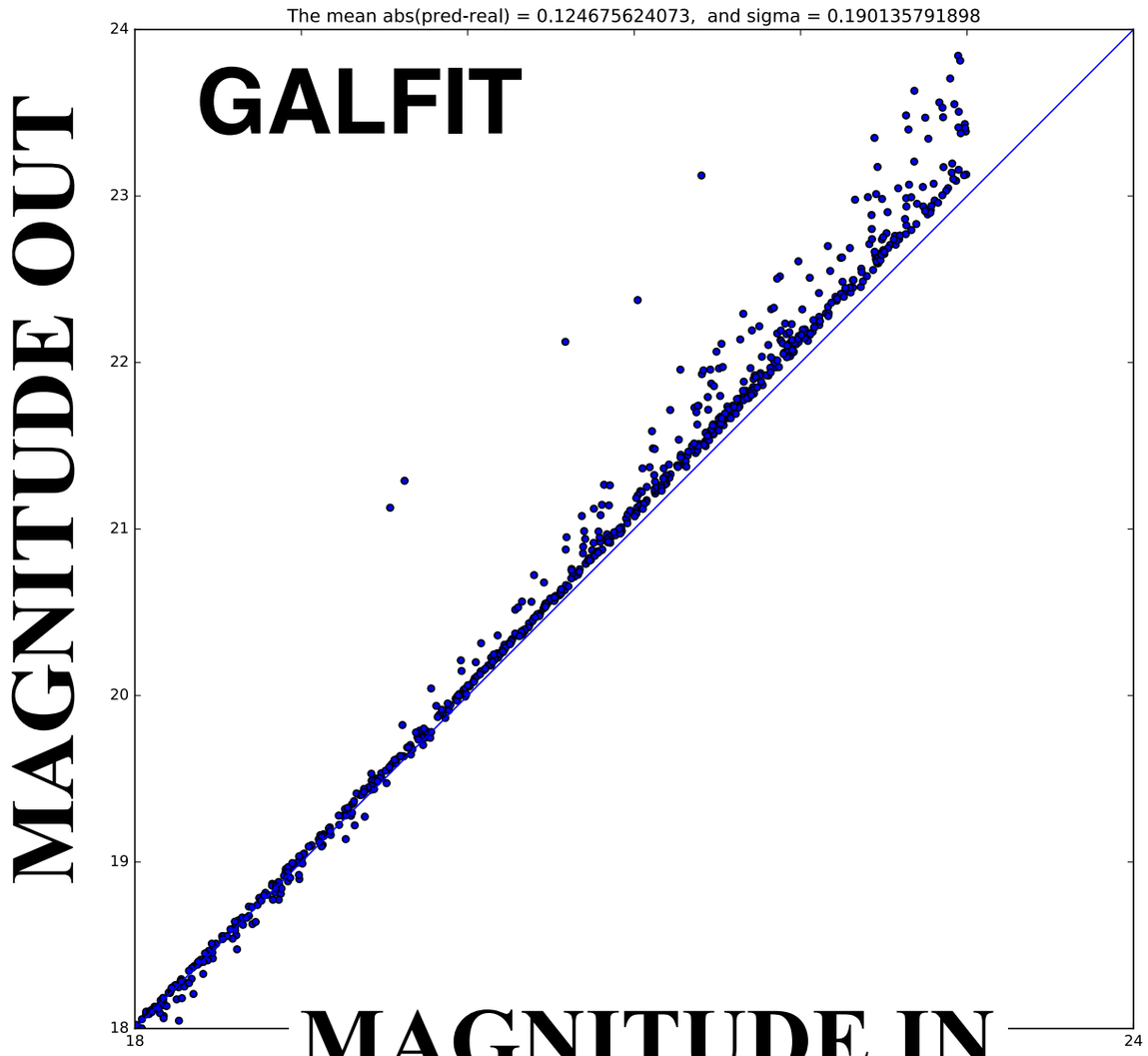
DATA:

HST deep field observations CANDELS

ON SIMULATIONS

TUCCILLO, HUERTAS-COMPANY et al.

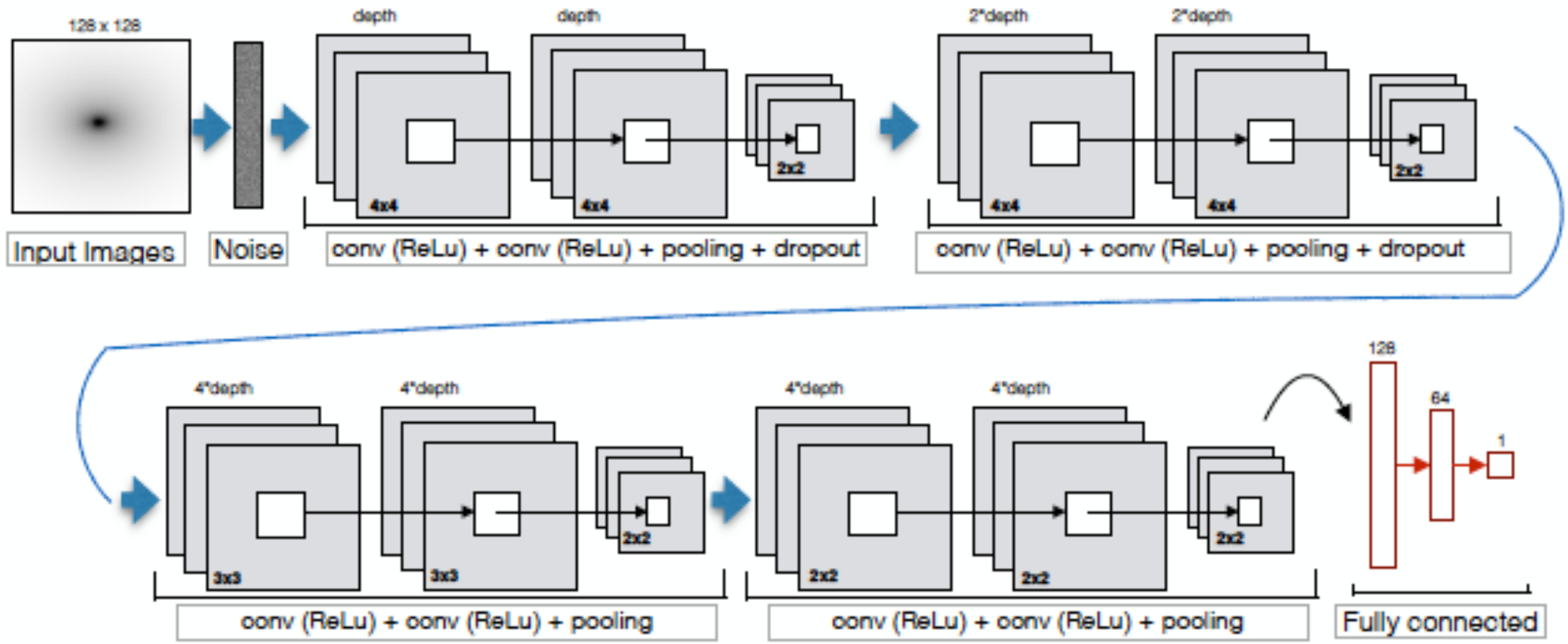




VERY SIMILAR RESULTS ON THE SAME SIMULATIONS, BUT CNNs are several orders of magnitude faster [**3.5 hrs vs. <1 sec for ~1000 objects**]

ON SIMULATIONS

TUCCILLO, HUERTAS-COMPANY et al.



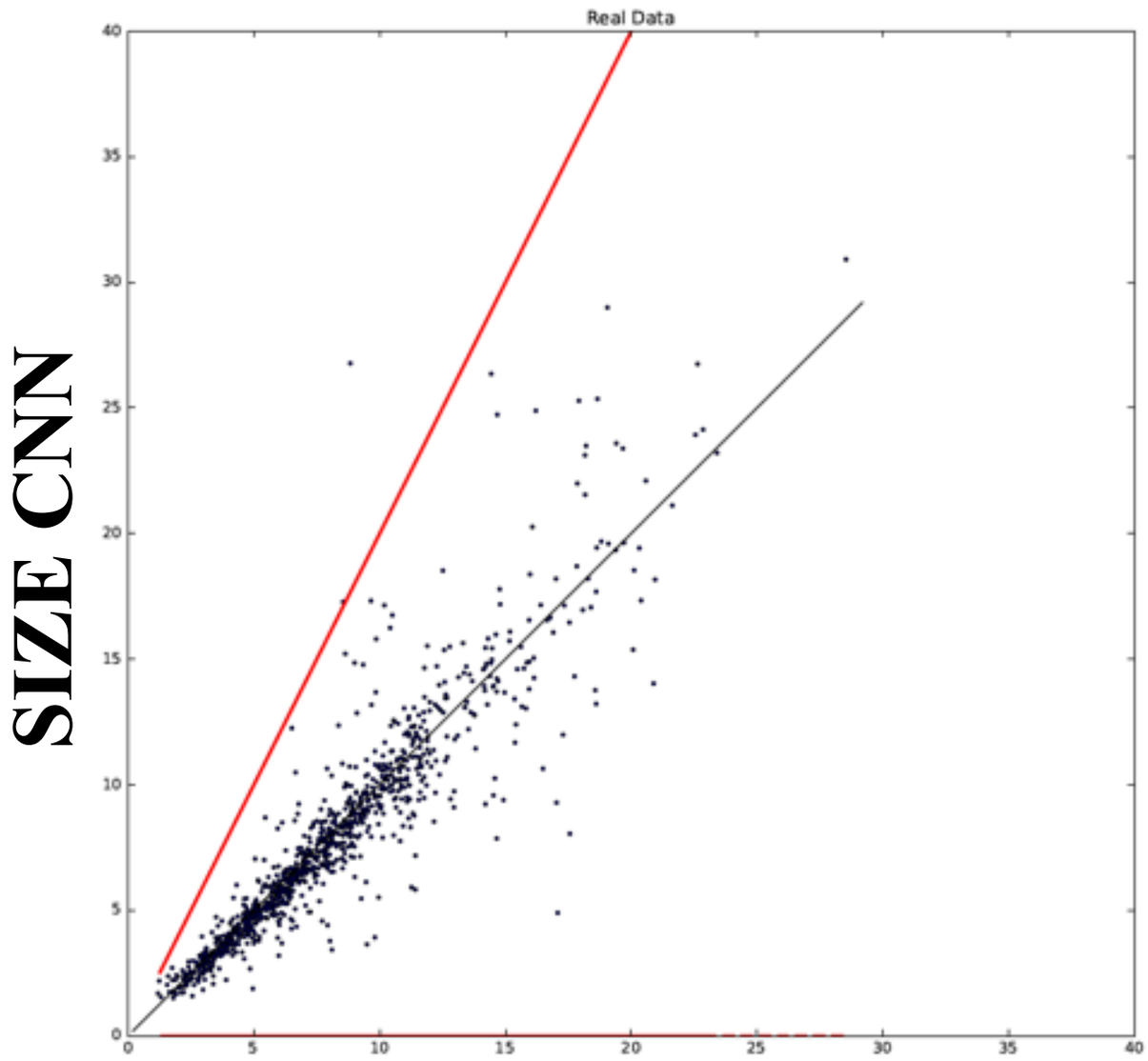
MAGNITUDE IN

MAGNITUDE IN

VERY SIMILAR RESULTS ON THE SAME SIMULATIONS, BUT CNNs are several orders of magnitude faster [**3.5 hrs vs. <1 sec for ~1000 objects**]

FUTURE: POTENTIALLY OPENS THE DOOR TO FIT A SMALL SUBSAMPLE OF GALAXIES AND THEN RUN ON CNNs VERY FAST

but..
PSF variations etc…



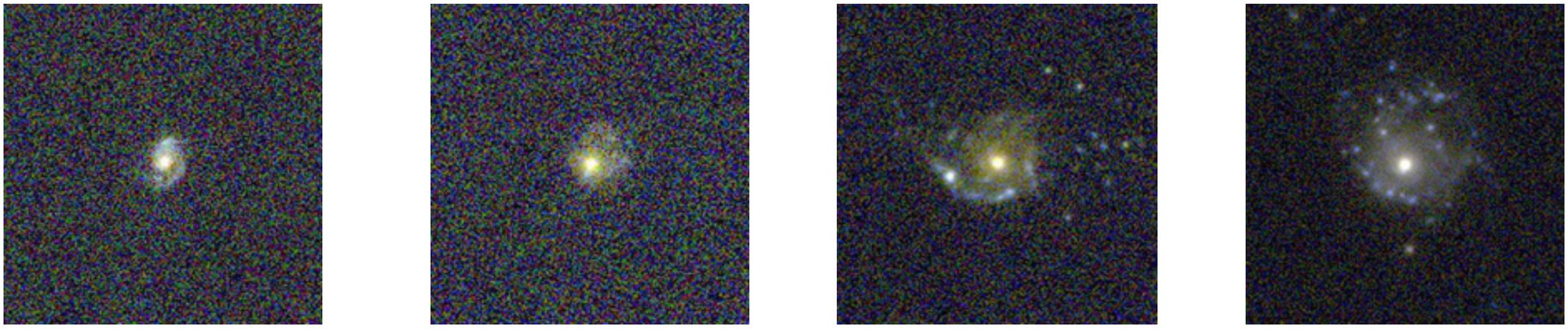
III - 3D sizes?

VELA hydrodynamic simulations

Ceverino, Dekel, Primack+15

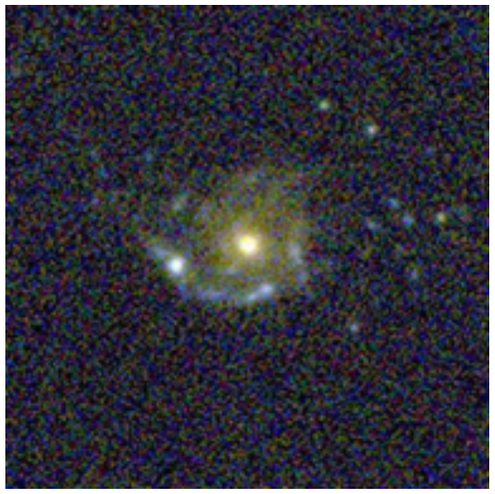
35 high res (~20pc) zoom-in simulations
hydroART
radiative and supernovae feedback
stops at z=1 - Mh=10^11-2.10^12

mock images [sunrise]
Tstep ~ 200Myrs
10 projections
HST / JWST like

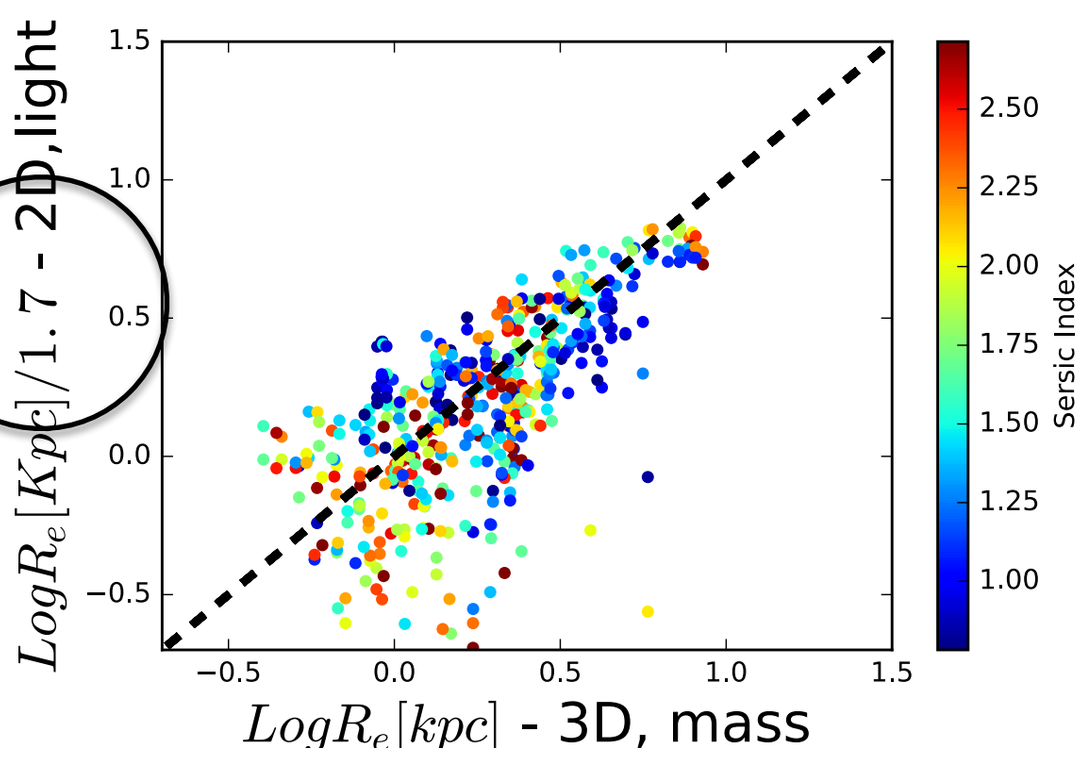


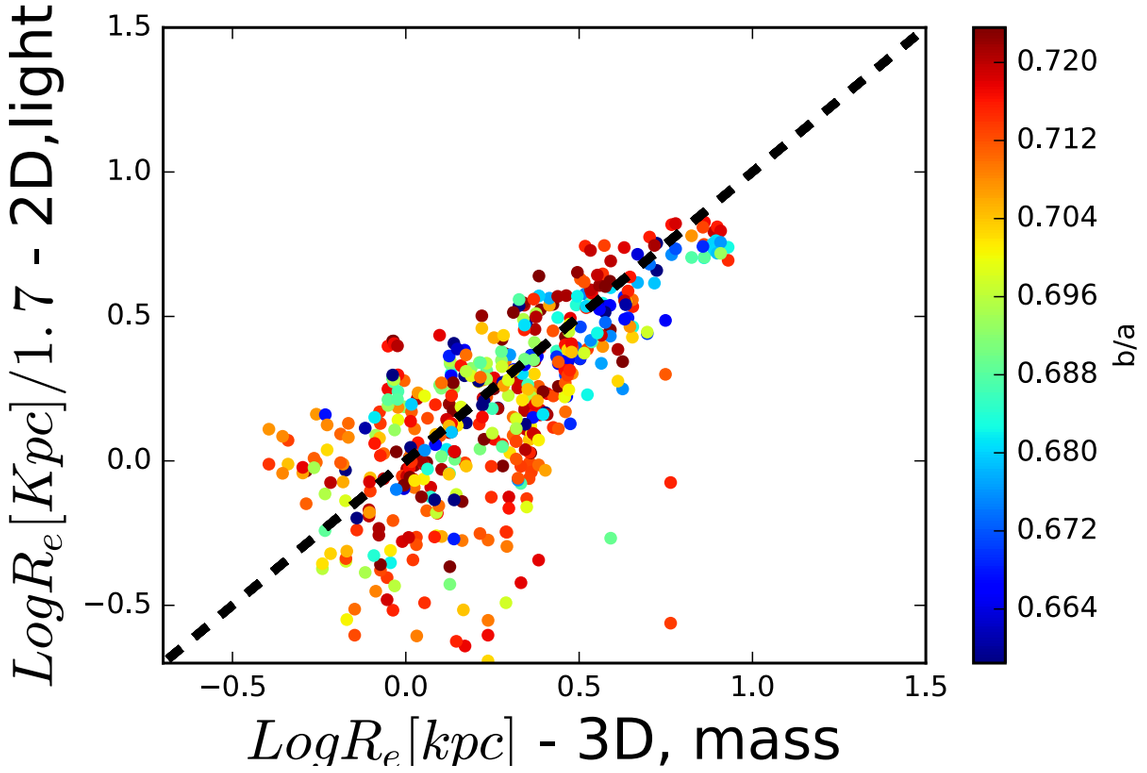
[G. Snyder, J. Lotz et al.]

mock image



$$R_3D = f(Re, b/a, n \ldots ?)$$





?