

A synthetic mirror of DES Y6:

Balrog-ing 5000 deg<sup>2</sup> of the sky

Dhayaa Anbajagane

on behalf of the Balrog team

arxiv:2501.05683



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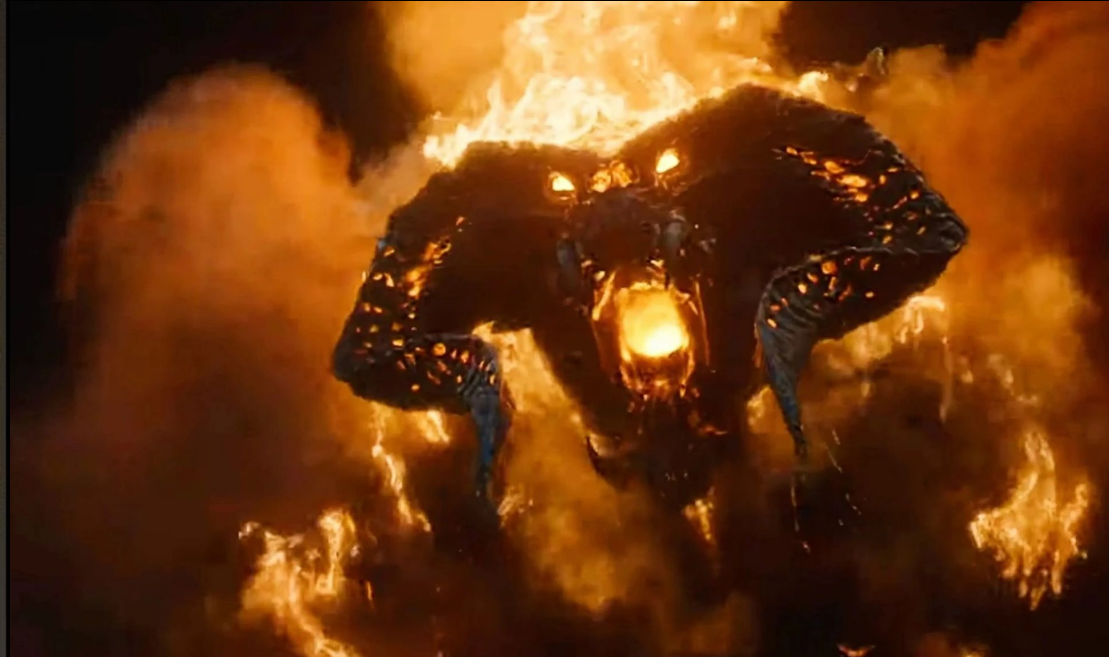
arxiv:2501.05683

# The Lord of the Rings: The Fellowship of the Ring

2001 · PG-13 · 2h 58m

IMDb RATING

★ 8.8/10  
1.9M



The Lo

2001 · PG-13

[Submitted on 29 Jul 2015 (v1), last revised 28 Jan 2016 (this version, v2)]

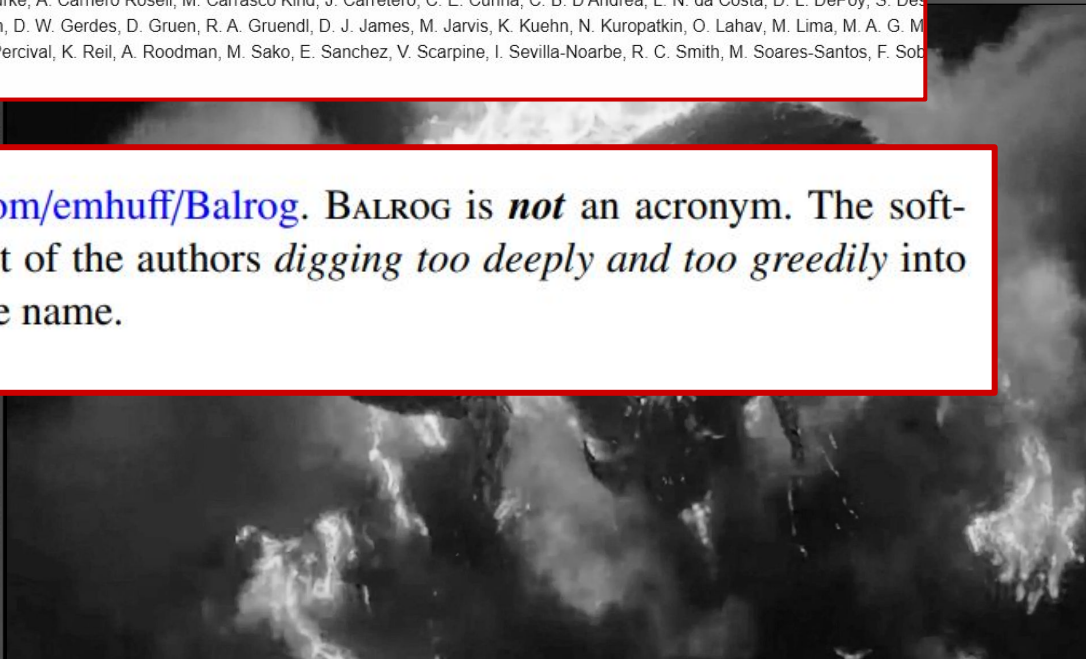
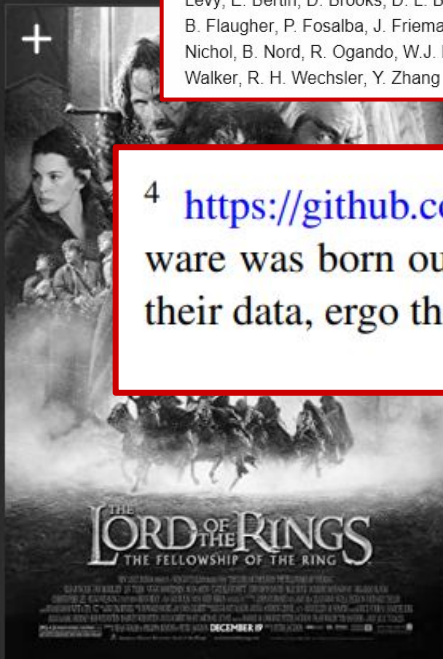
## No galaxy left behind: accurate measurements with the faintest objects in the Dark Energy Survey

E. Suchyta, E. M. Huff, J. Aleksić, P. Melchior, S. Jouvel, N. MacCrann, M. Crocce, E. Gaztanaga, K. Honscheid, B. Leistedt, H.V. Peiris, A. J. Ross, E. S. Ry-  
Lévy, E. Bertin, D. Brooks, D. L. Burke, A. Carnero Rosell, M. Carrasco Kind, J. Carretero, C. E. Cunha, C. B. D'Andrea, L. N. da Costa, D. L. DePoy, S. Des-  
B. Flaugher, P. Fosalba, J. Frieman, D. W. Gerdes, D. Gruen, R. A. Gruendl, D. J. James, M. Jarvis, K. Kuehn, N. Kuropatkin, O. Lahav, M. Lima, M. A. G. M-  
Nichol, B. Nord, R. Ogando, W.J. Percival, K. Reil, A. Roodman, M. Sako, E. Sanchez, V. Scarpine, I. Sevilla-Noarbe, R. C. Smith, M. Soares-Santos, F. Sob-  
Walker, R. H. Wechsler, Y. Zhang

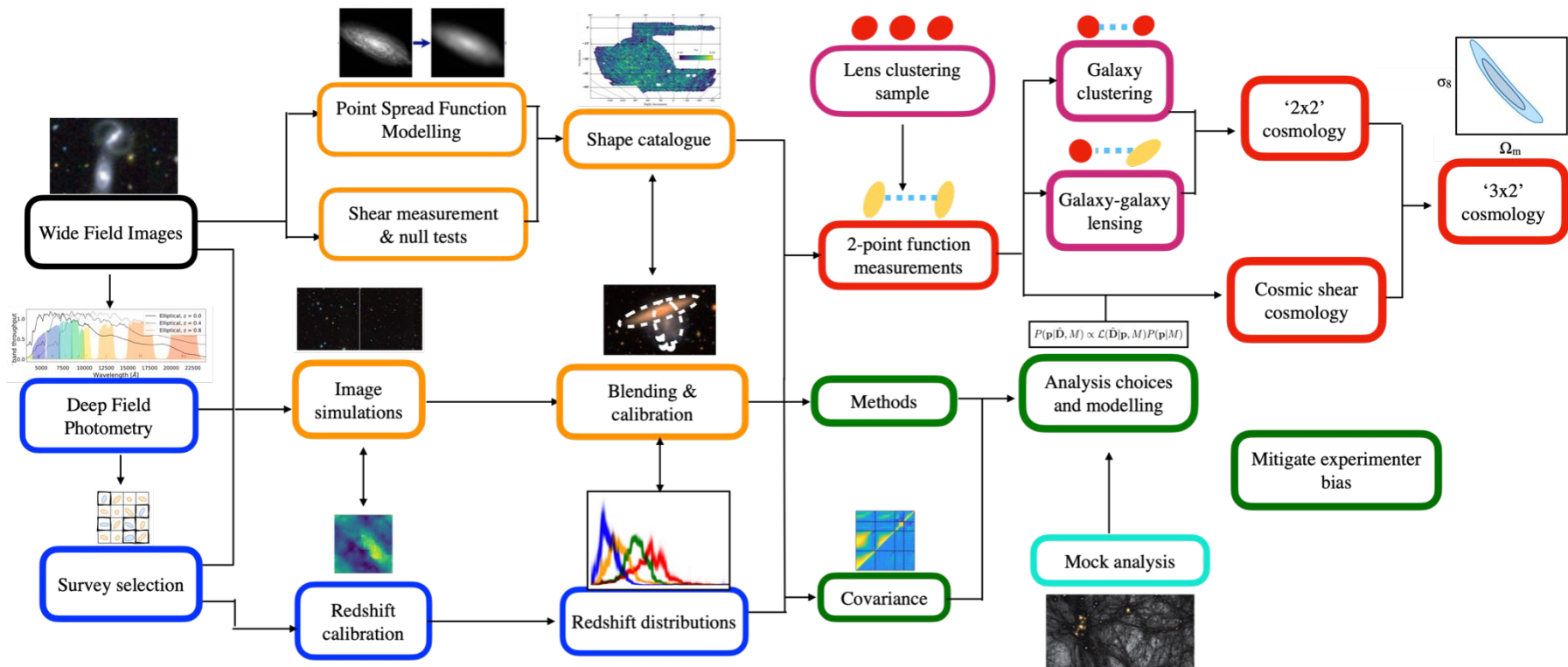
IMDb RATING

★ 8.8/10  
1.9M

4 <https://github.com/emhuff/Balrog>. BALROG is *not* an acronym. The soft-  
ware was born out of the authors *digging too deeply and too greedily* into  
their data, ergo the name.



# The DES 3x2pt cosmology pipeline

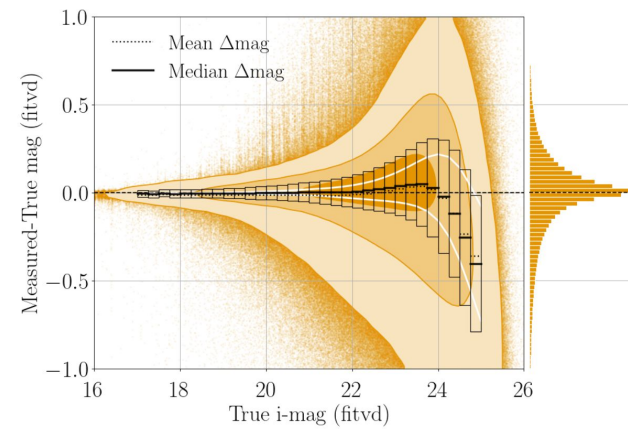


$$P(x_{\text{meas}} \mid x_{\text{true}})$$

Photometric biases

$$P(x_{\text{meas}} | x_{\text{true}})$$

Flux errors



Cosmological  
information

$$P(\Sigma | x_{\text{meas}}) \propto$$

$$\int P(x_{\text{meas}} | x_{\text{true}})$$

Transform observable into  
raw measurement

$$\times P(x_{\text{true}} | \Sigma, \dots)$$

Connecting models with  
observables



Photo-z estimates

$$P(m_{\text{meas}} | m_{\text{true}})$$

Survey depth

$$P(\text{SNR}_{\text{meas}} | m_{\text{true}})$$

$$P(x_{\text{meas}} | x_{\text{true}})$$

Shear calibration

$$P(\mathbf{e}_{\text{meas}} | \mathbf{e}_{\text{true}}, \kappa, \dots)$$

Magnification

$$P(S | m_{\text{true}}, \kappa)$$

Star/galaxy classification

$$P(\text{MASH} | m_{\text{true}}, T_{\text{true}}, m_{\text{lim}}, \dots)$$

Photo-z estimates

$$P(m_{\text{meas}} | m_{\text{true}})$$

Survey depth

$$P(\text{SNR}_{\text{meas}} | m_{\text{true}})$$

$$P(x_{\text{meas}} | x_{\text{true}})$$

Shear calibration

$$P(\mathbf{e}_{\text{meas}} | \mathbf{e}_{\text{true}}, \kappa, \dots)$$

Magnification

$$P(S | m_{\text{true}}, \kappa)$$

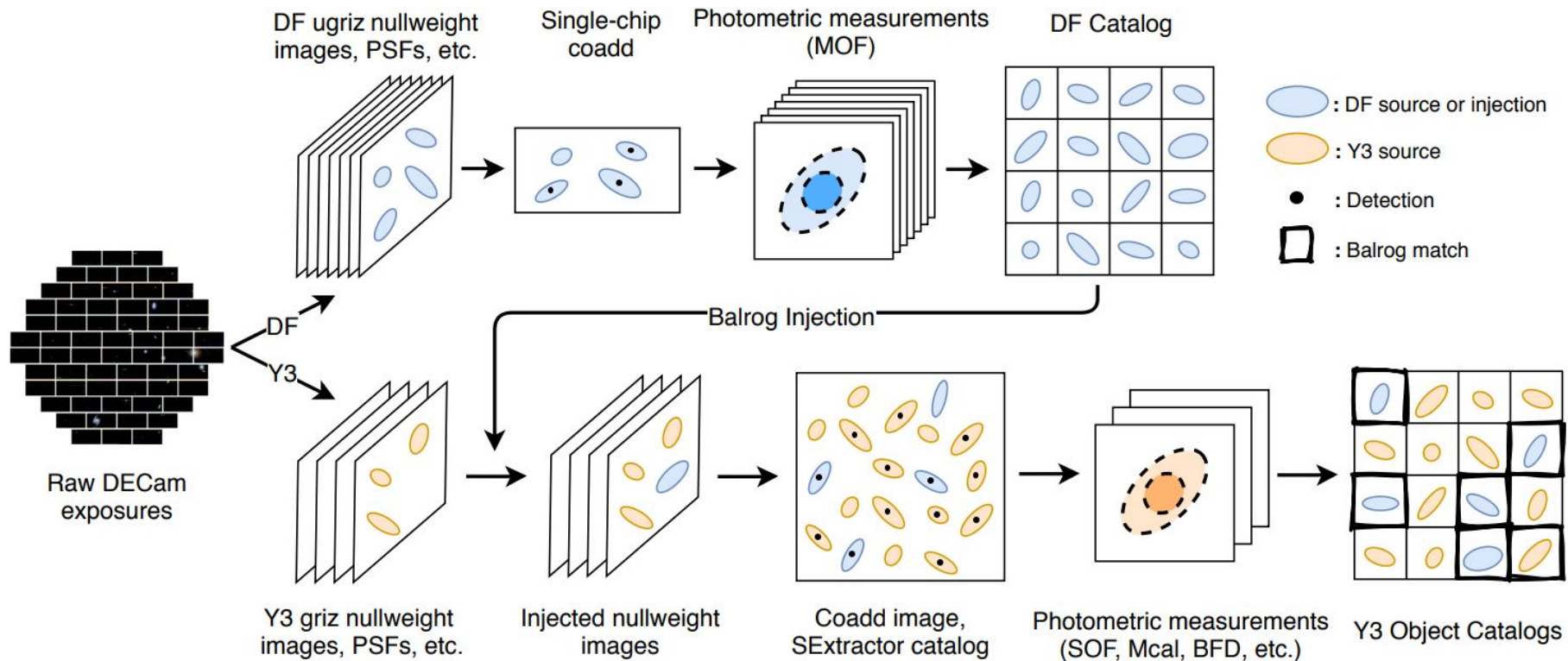
Star/galaxy classification

$$P(\text{MASH} | m_{\text{true}}, T_{\text{true}}, m_{\text{lim}}, \dots)$$

How do we estimate this?

$$P(x_{\text{meas}} \mid x_{\text{true}})$$

# The Balrog SSI pipeline



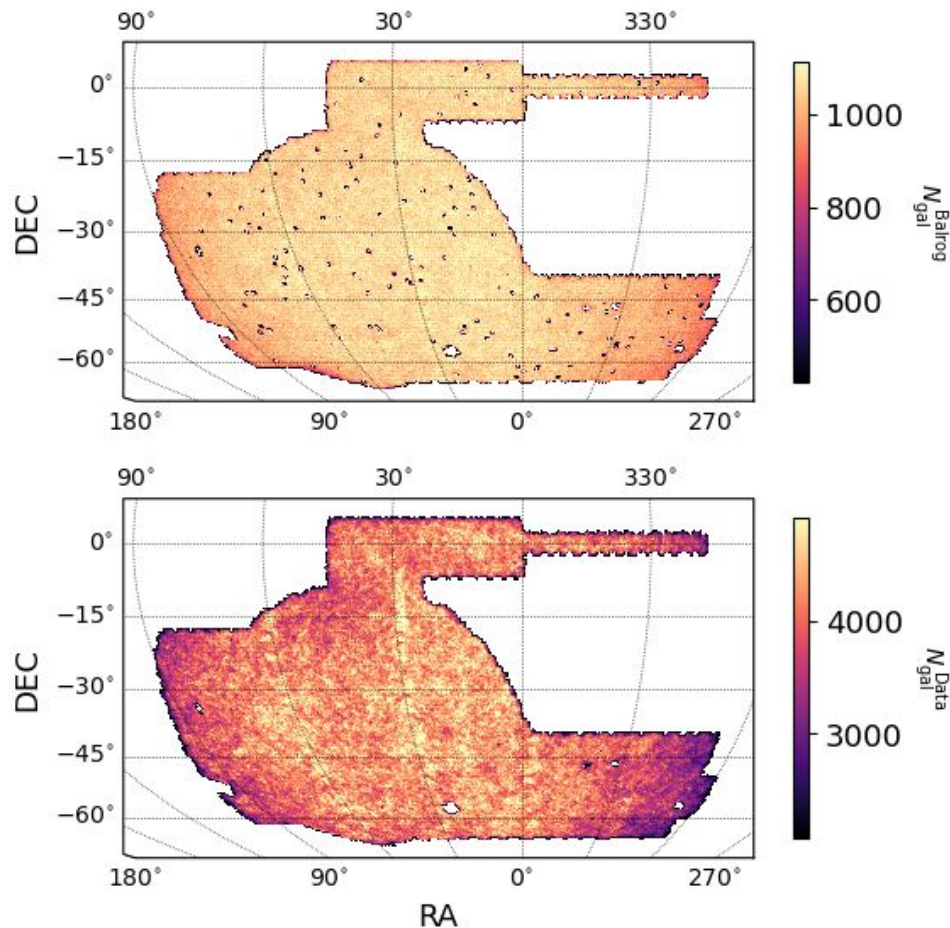
# Balrog in DES Y6

150 million synthetic sources  
across 5,000 deg<sup>2</sup>

Includes all source/lens  
catalogs used in DES 3x2pt

*Metadetection, BFD  
RedMaGic, Maglim*

*sof/fitvd*



... by evading the law a tiny bit

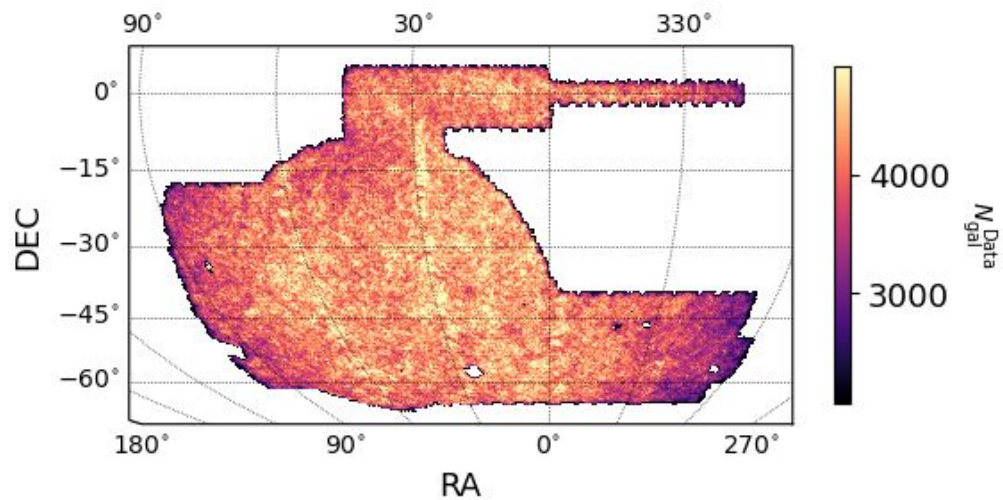
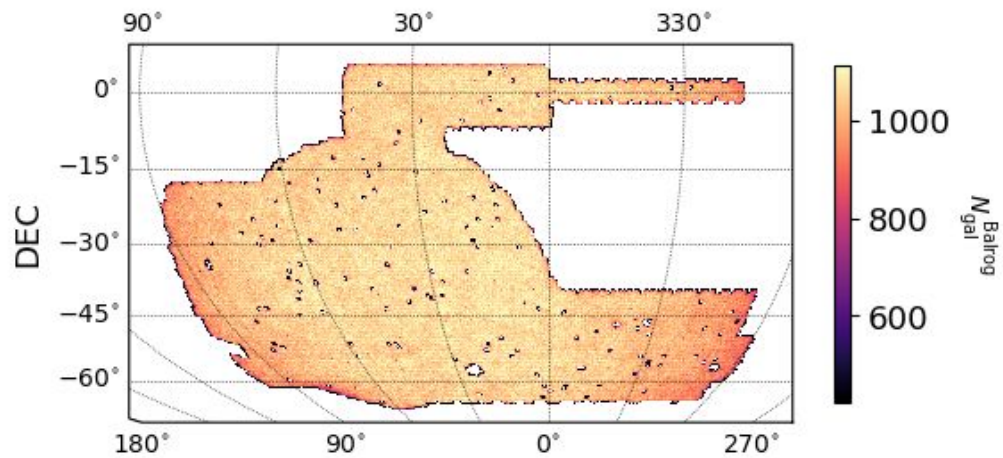
Do you know this person?

ANBAJAGANE, DHAYAA

UNIVERSITY OF CHICAGO

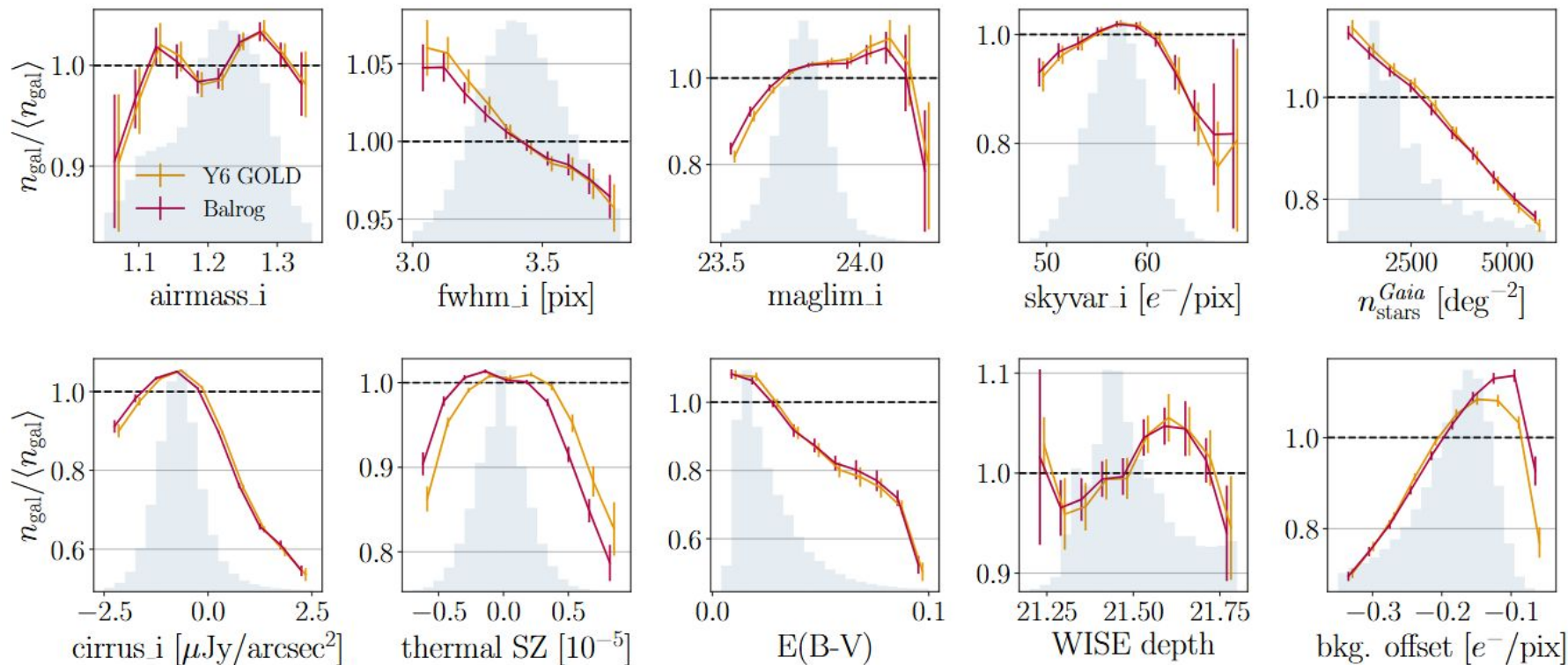
Email: [dhayaa@uchicago.edu](mailto:dhayaa@uchicago.edu)

Their batch usage looks a bit strange.



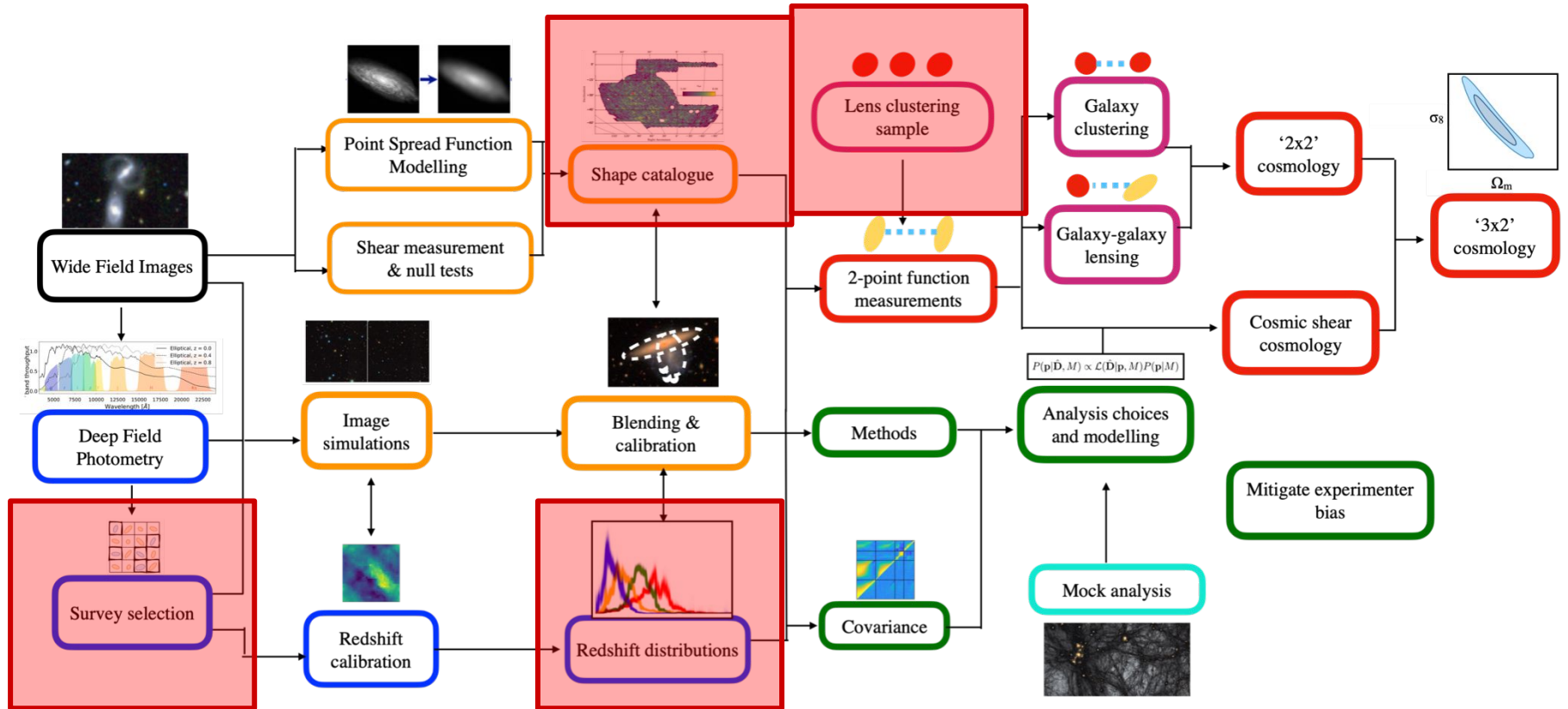
What do we gain from having all this area?

# Correlations of galaxy selection and observing conditions

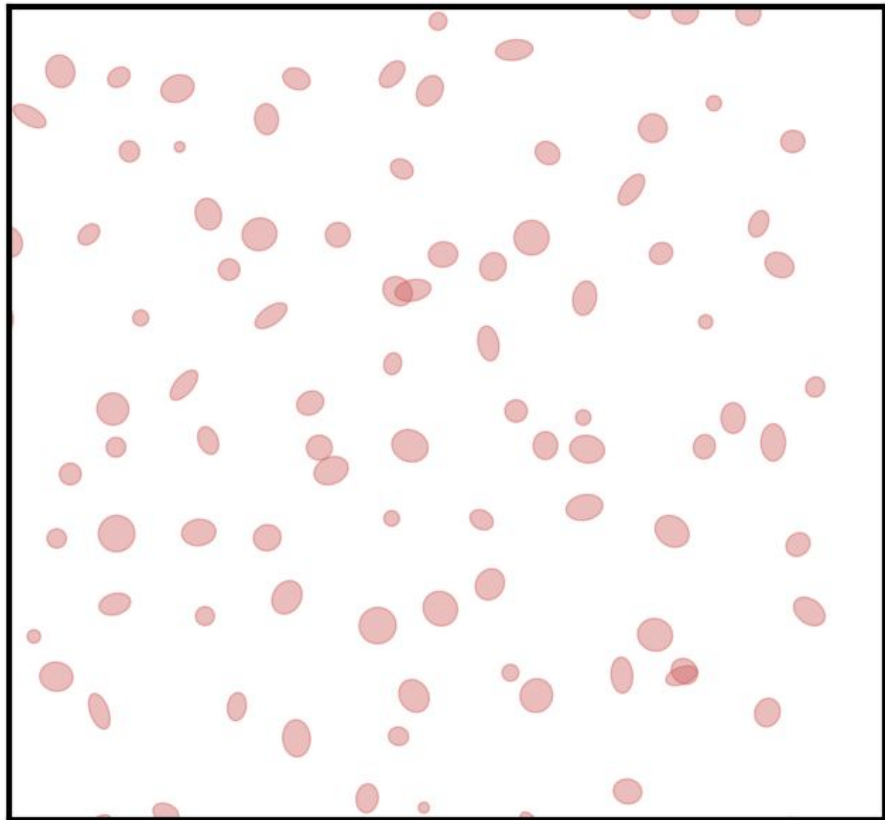




# (some) uses of the Balrog catalog

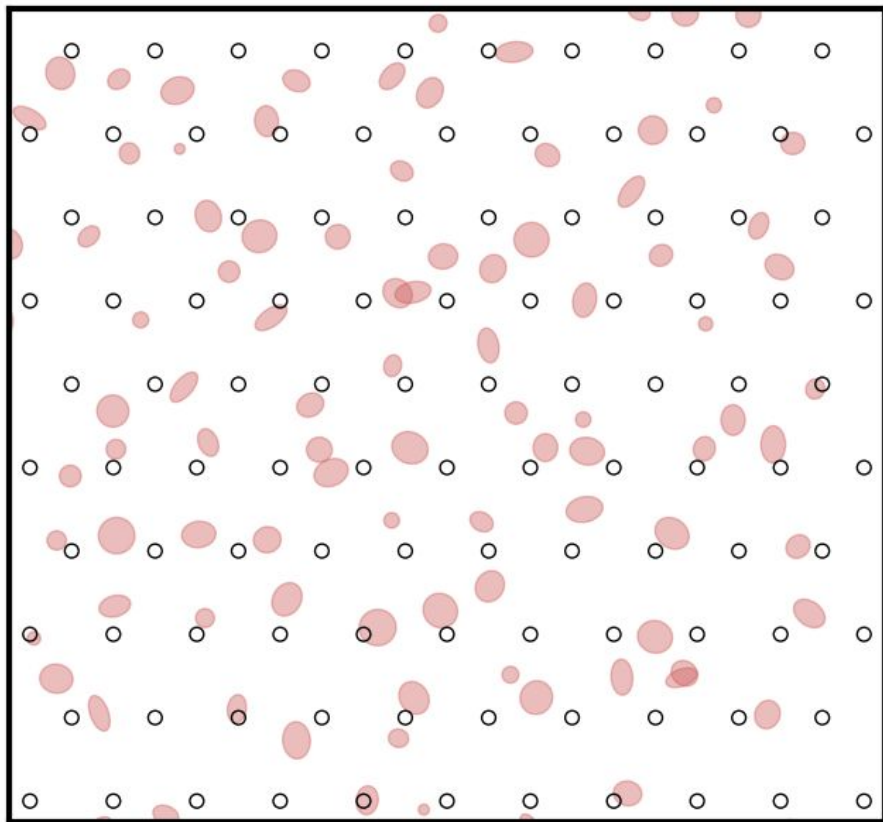


## An optimal way to SSI



Real sources

## An optimal way to SSI

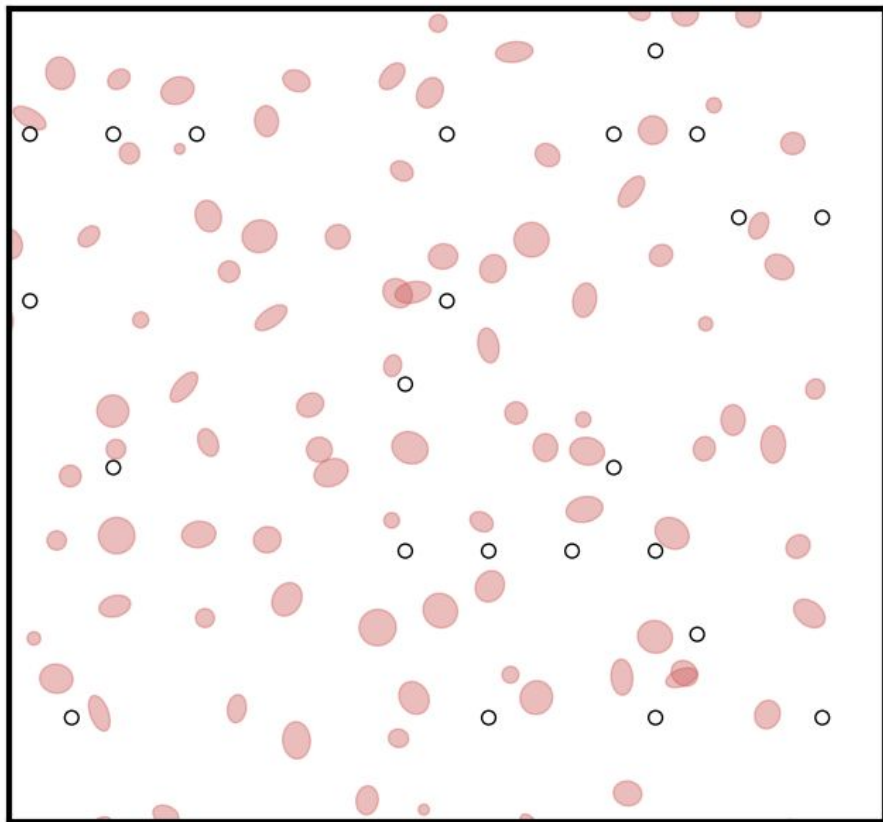


Real sources



Injections

## An optimal way to SSI



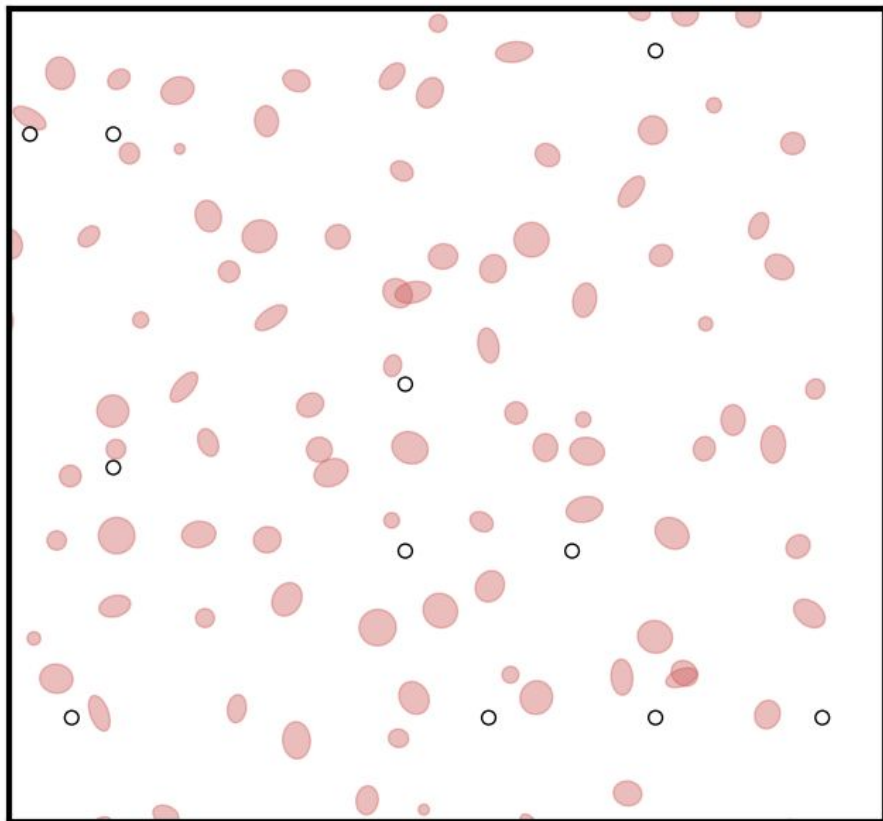
Real sources



Injections

Detections

## An optimal way to SSI



Real sources

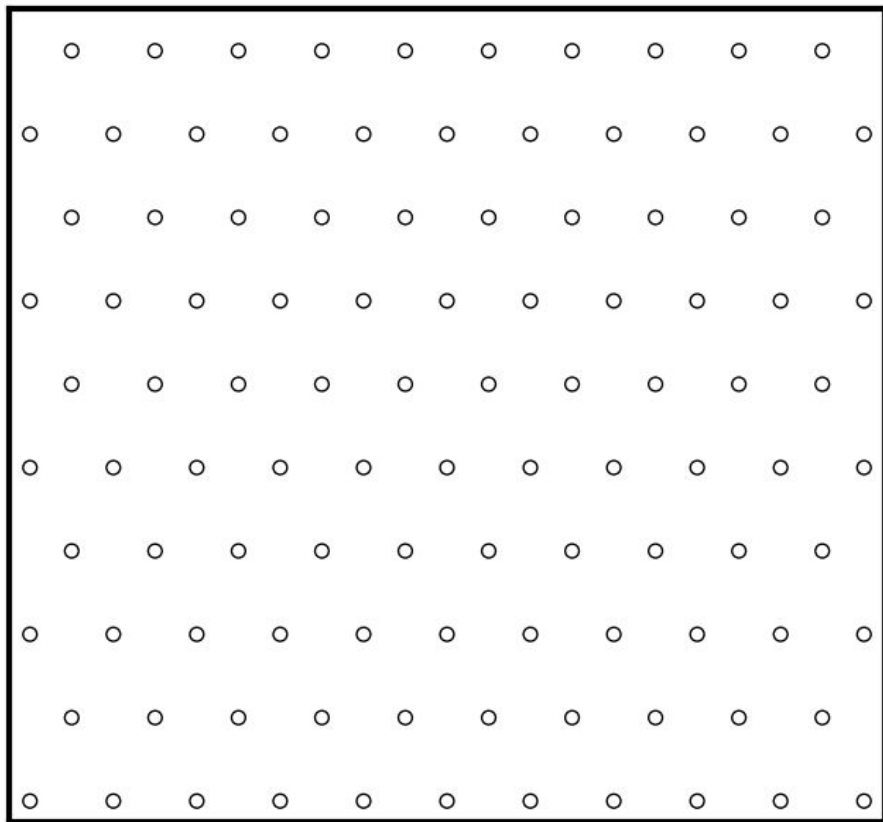


Injections

Detections

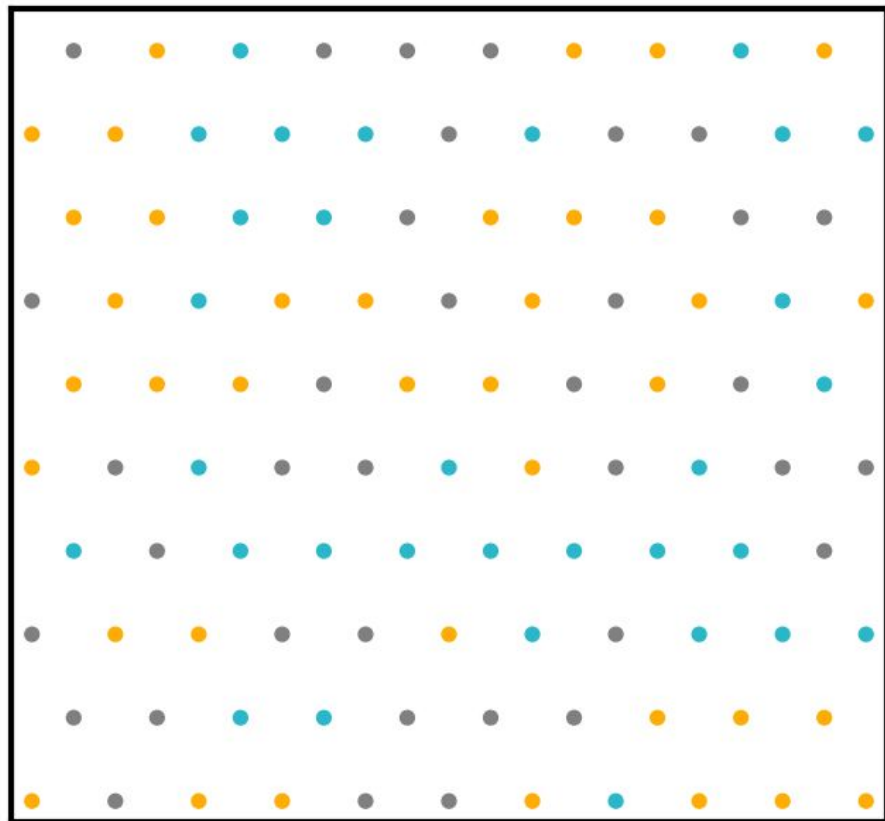
Selections

## An optimal way to SSI



○ All injections

## An optimal way to SSI



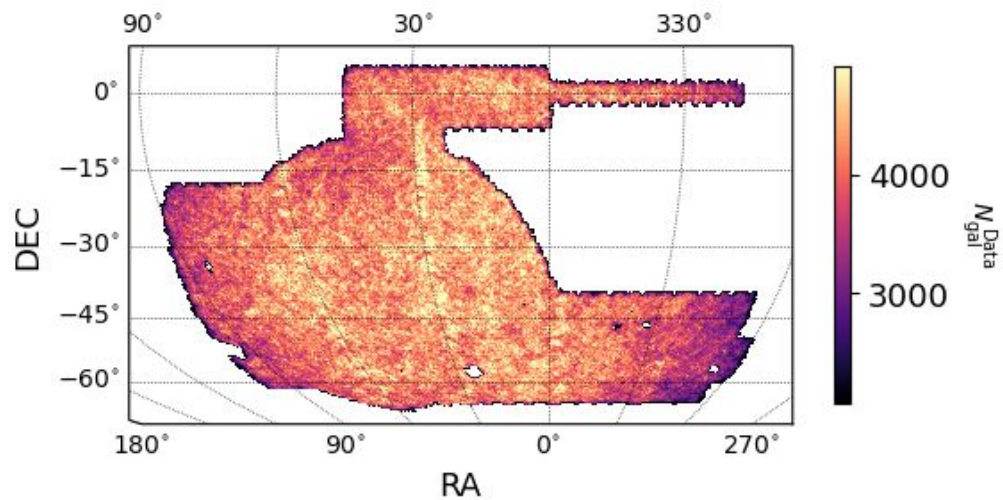
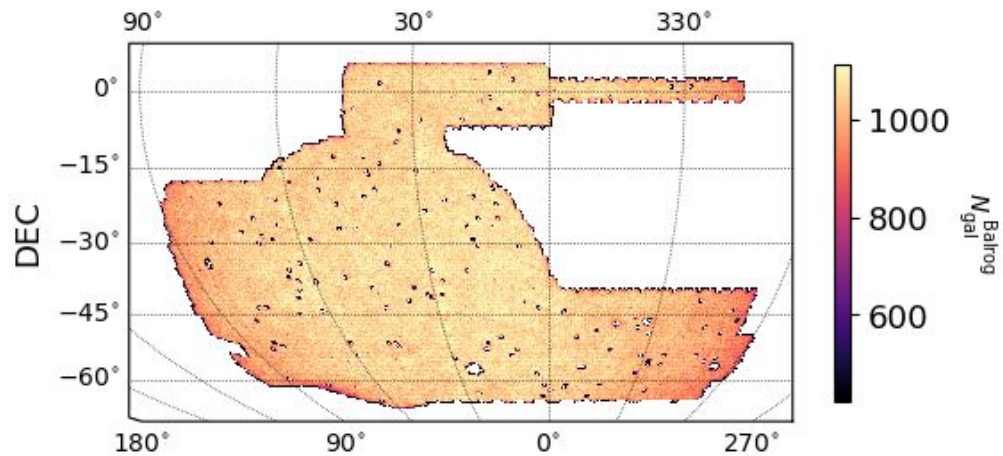
LSS injections (12x)



WL injections (4x)



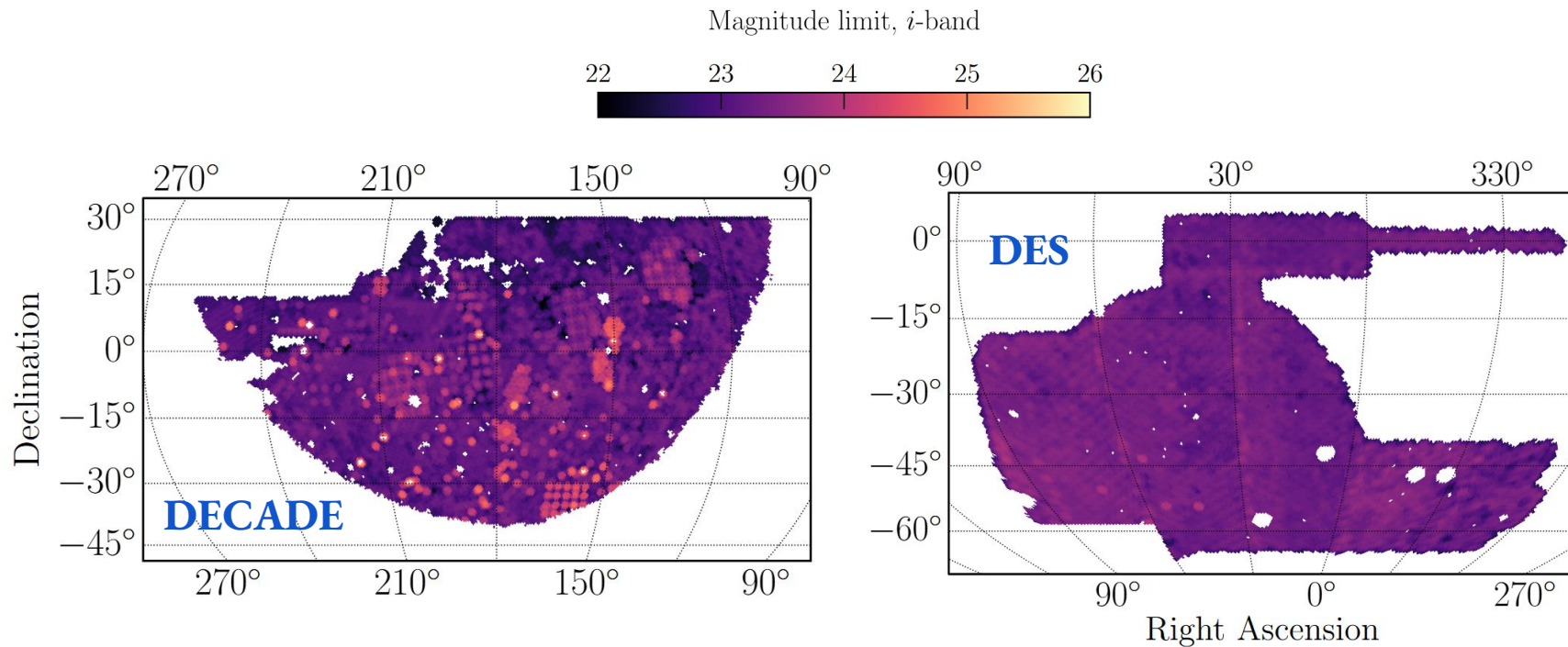
"Fid" injections



What can SSI do for us  
moving forward?

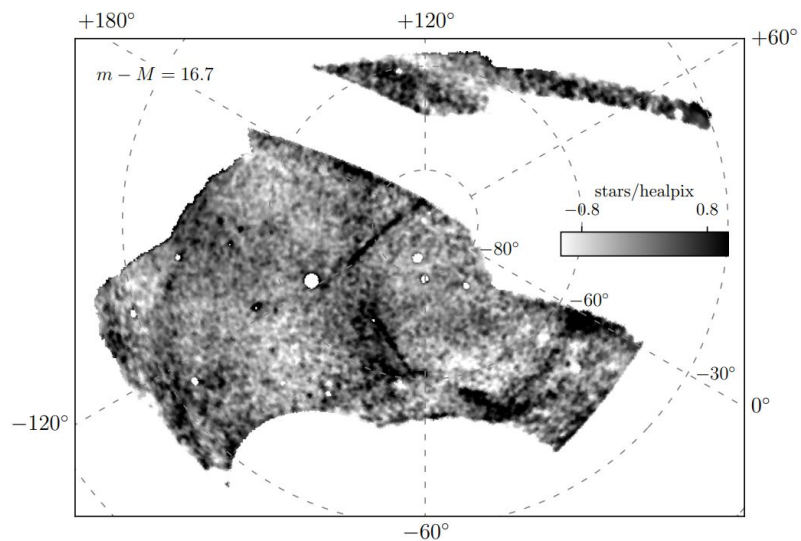


# Balrog-ing for more “flexible” data

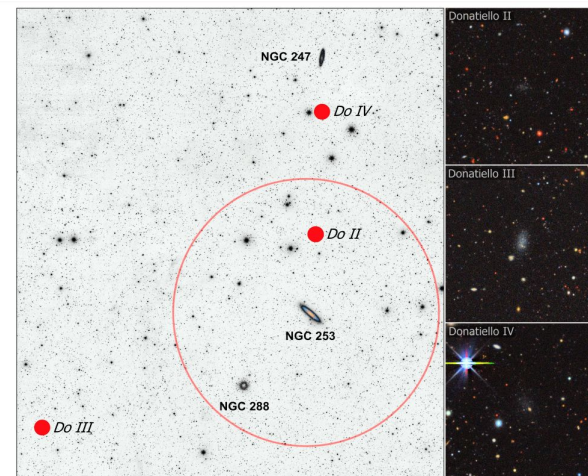


# Balrog-ing for other probes

## Stellar Streams



## Dwarf galaxies in the LV



# Balrog-ing across surveys

## **OpenUniverse2024: A shared, simulated view of the sky for the next generation of cosmological surveys**

OpenUniverse, The LSST Dark Energy Science Collaboration, The Roman HLIS Project Infrastructure Team, The Roman RAPID Project Infrastructure Team, The Roman Supernova Cosmology Project Infrastructure Team, A. Alarcon,<sup>1</sup> L. Aldoroty,<sup>2</sup> G. Beltz-Mohrmann,<sup>3</sup> A. Bera,<sup>4</sup> J. Blazek,<sup>5</sup> J. Bogart,<sup>6</sup> G. Braeunlich,<sup>7</sup> A. Broughton,<sup>6</sup> K. Cao,<sup>8</sup> J. Chiang,<sup>6</sup> N. E. Chisari,<sup>9</sup> V. Desai,<sup>10</sup> Y. Fang,<sup>2</sup> L. Galbany,<sup>1,11</sup> A. Hearin,<sup>3</sup> K. Heitmann,<sup>3</sup> C. Hirata,<sup>8</sup> R. Hounsell,<sup>12,13</sup> B. Jain,<sup>14</sup> M. Jarvis,<sup>14</sup> J. Jencson,<sup>10</sup> A. Kannawadi,<sup>2</sup> M. K. Kasliwal,<sup>15</sup> R. Kessler,<sup>16,17</sup> A. Kiessling,<sup>18</sup> R. Knop,<sup>19</sup> E. Kovacs,<sup>3</sup> R. Laher,<sup>10</sup> K. Laliotis,<sup>8</sup> C. Lin,<sup>2</sup> I. Lopes,<sup>20</sup> A. Mahabal,<sup>15</sup> R. Mandelbaum,<sup>21</sup> J. Masiero,<sup>10</sup> S. Mau,<sup>22</sup> C. Meehan,<sup>2</sup> J. Meyers,<sup>6</sup> B. Moraes,<sup>20</sup> R. Paladini,<sup>10</sup> A. Pearl,<sup>23</sup> A. Plazas Malagon,<sup>6</sup> B. Rose,<sup>24</sup> D. Rubin,<sup>25</sup> B. Rusholme,<sup>10</sup> A. Santos,<sup>26</sup> N. Šarčević,<sup>27</sup> D. Scolnic,<sup>2</sup> M. A. Troxel,<sup>2\*</sup> N. Van Alfen,<sup>5</sup> S. Van Dyke,<sup>10</sup> C. W. Walter,<sup>2</sup> T. Wu,<sup>2</sup> M. Yamamoto,<sup>2</sup> Y. Yan,<sup>28</sup> and T. Zhang<sup>23</sup>

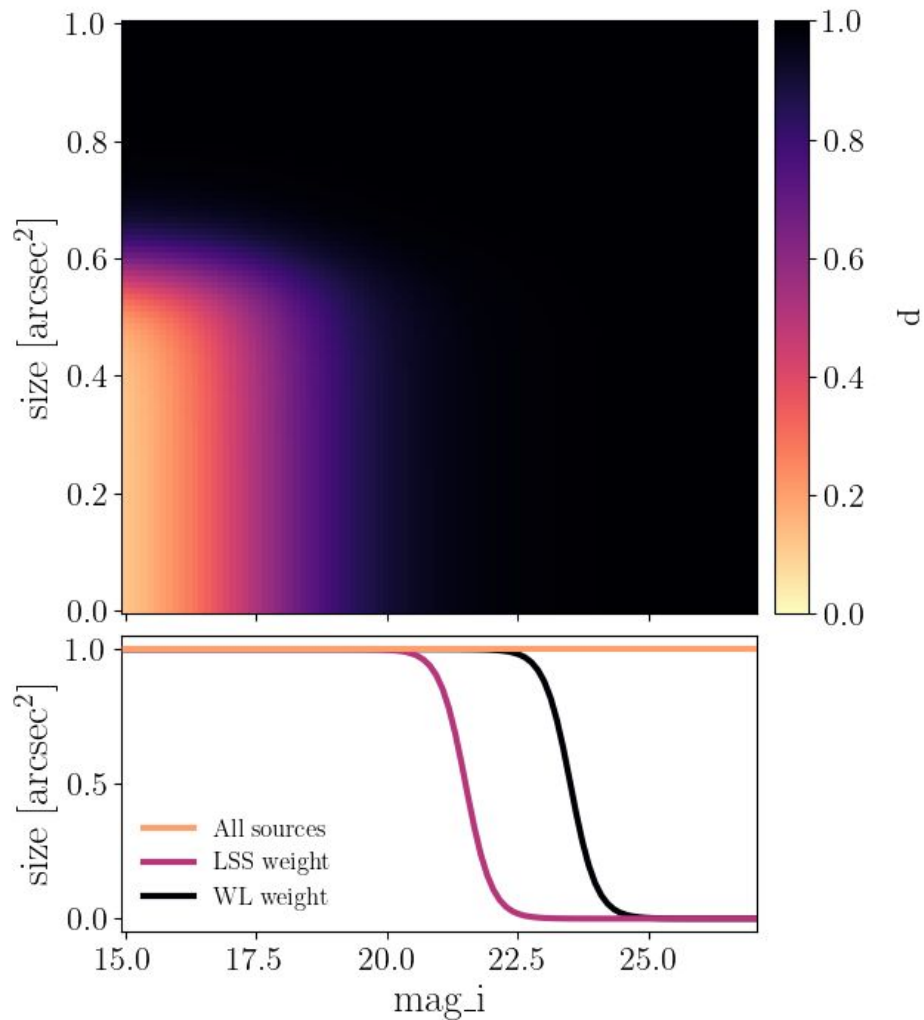


Extra Slides

# Weighted injections

Increases the injection rate for  
most relevant objects

But still injects from  
representative sample of objects



# Many other use cases!

