Effects of Blending on Cosmic Shear in DES and LSST

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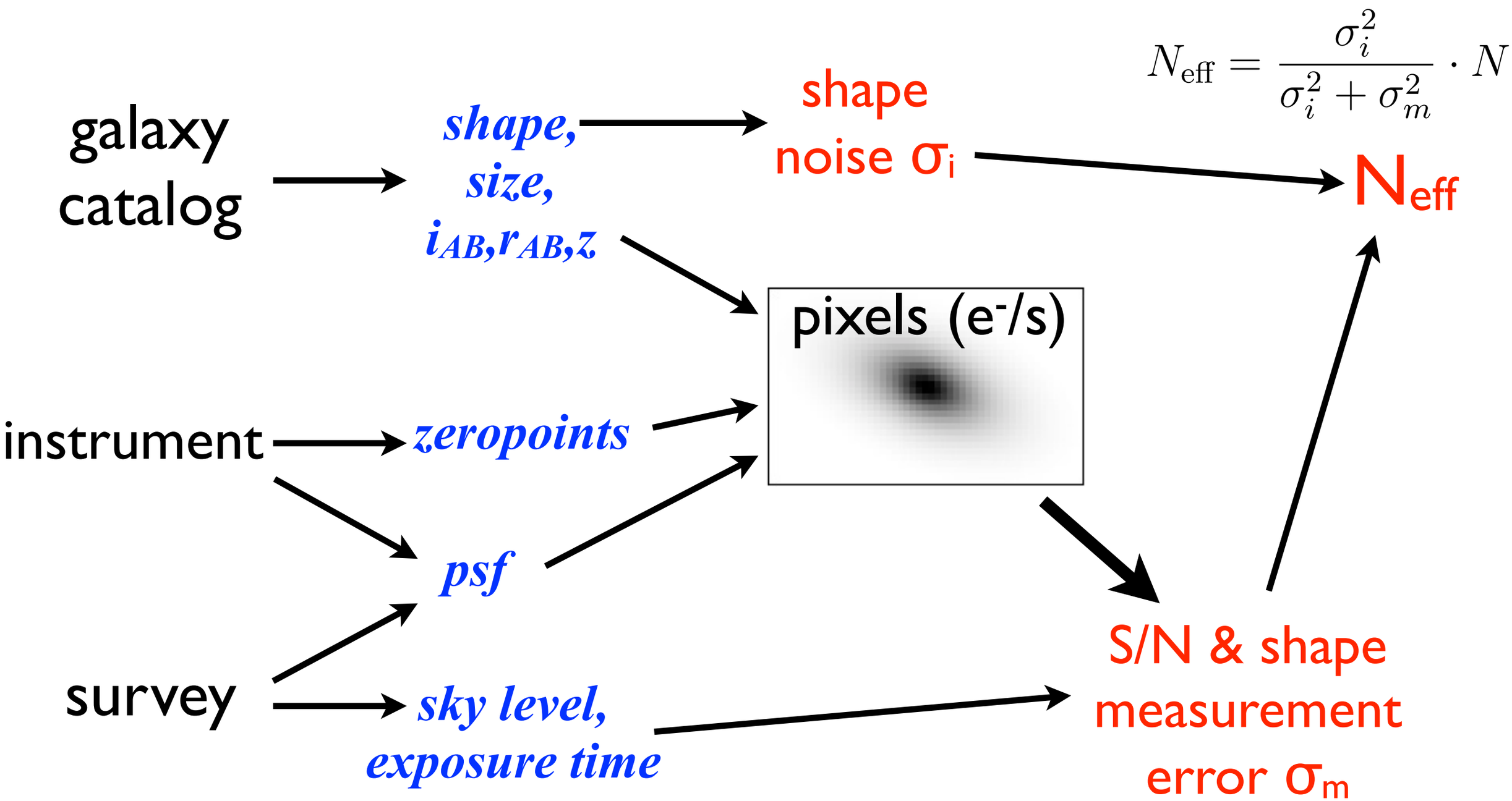
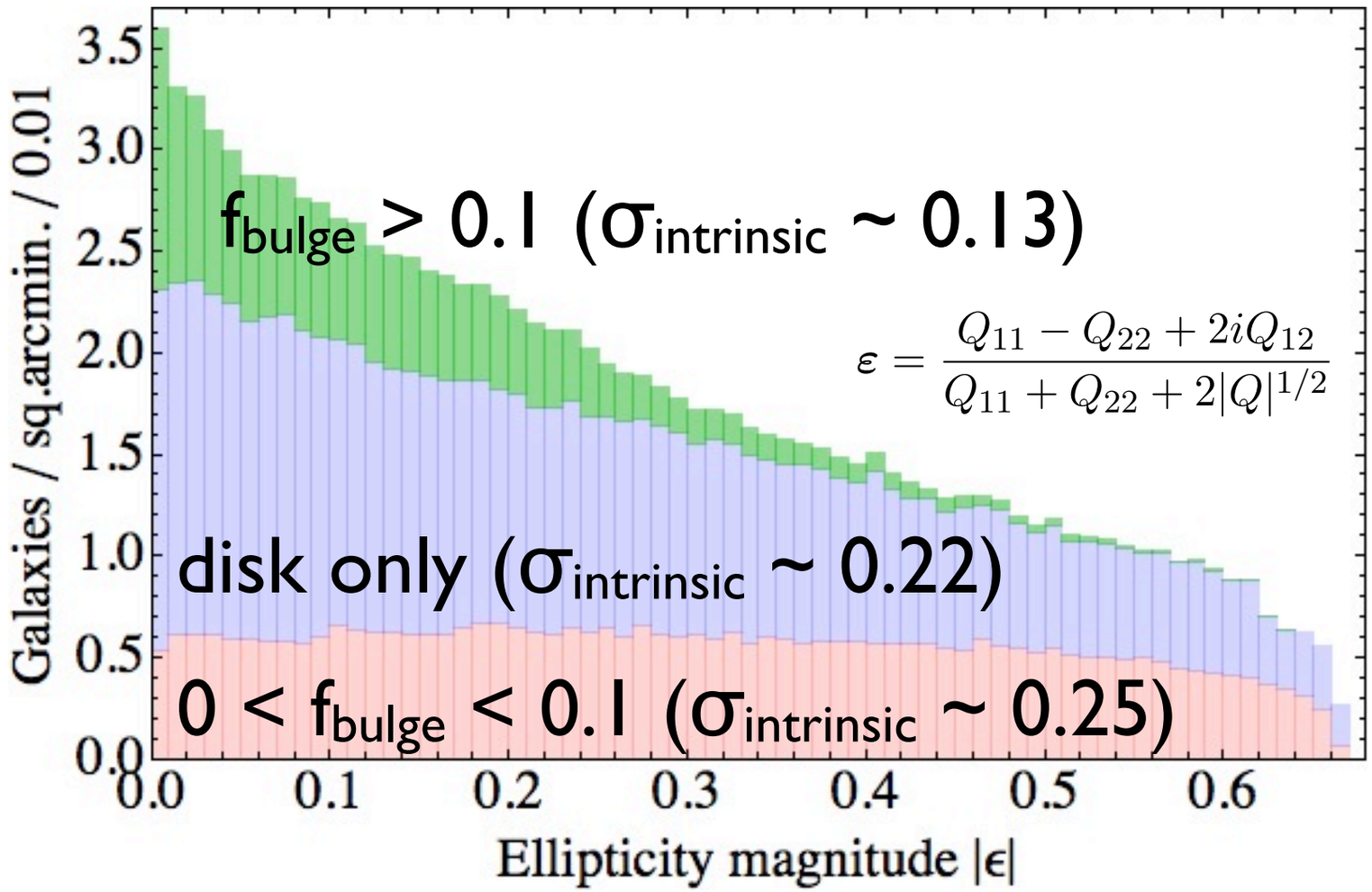
4 Dec 2013
LSST DESC Meeting, Pittsburgh

- Current shape measurement algorithms assume that galaxies do not overlap.
- Stage-IV lensing surveys probe higher surface densities, but with more overlaps.
- Are we ready to take advantage of the full LSST depth? (LSST/DES signal ~ 28)
- Where should we focus our effort in further developing photo-z and shape measurement algorithms?

First Pass: analyze galaxies independently

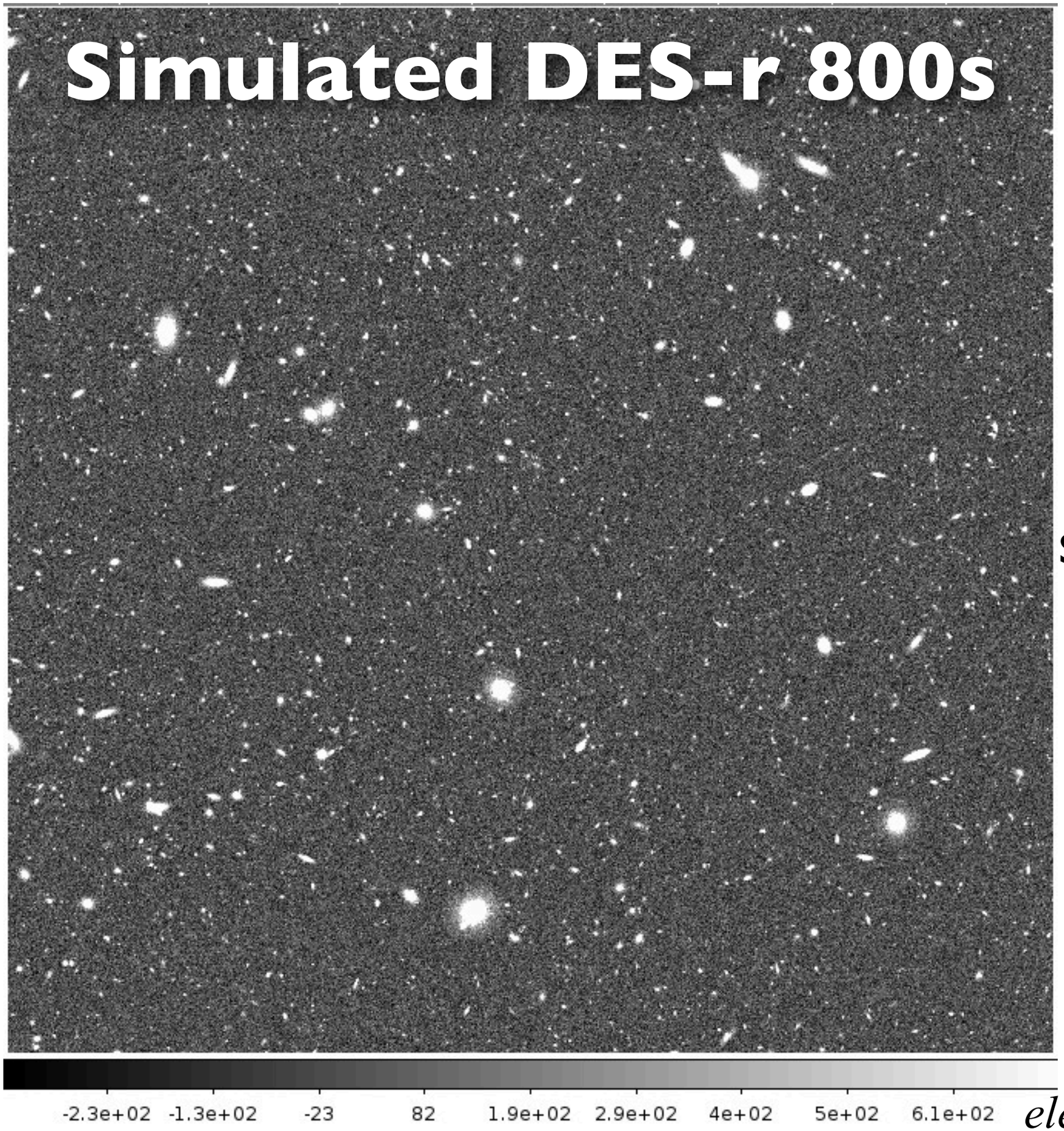


LSST CatSim



Survey	Effective Area(m^2)	Pixel Size(")		Exposure Time (s)	Sky Brightness (mag/arcsec^2)	Med. Seeing (FWHM ")	Zero Point
CFHTLS	8.022	0.185	i	4300	20.3	0.64	10.0
			r	2000	20.8	0.71	13.5
DES	10.014	0.263	i	1000	20.1	0.79	12.5
			r	800	21.1	0.79	16.8
LSST	33.212	0.200	i	6900	20.0	0.67	41.5
			r	6900	21.3	0.70	55.8

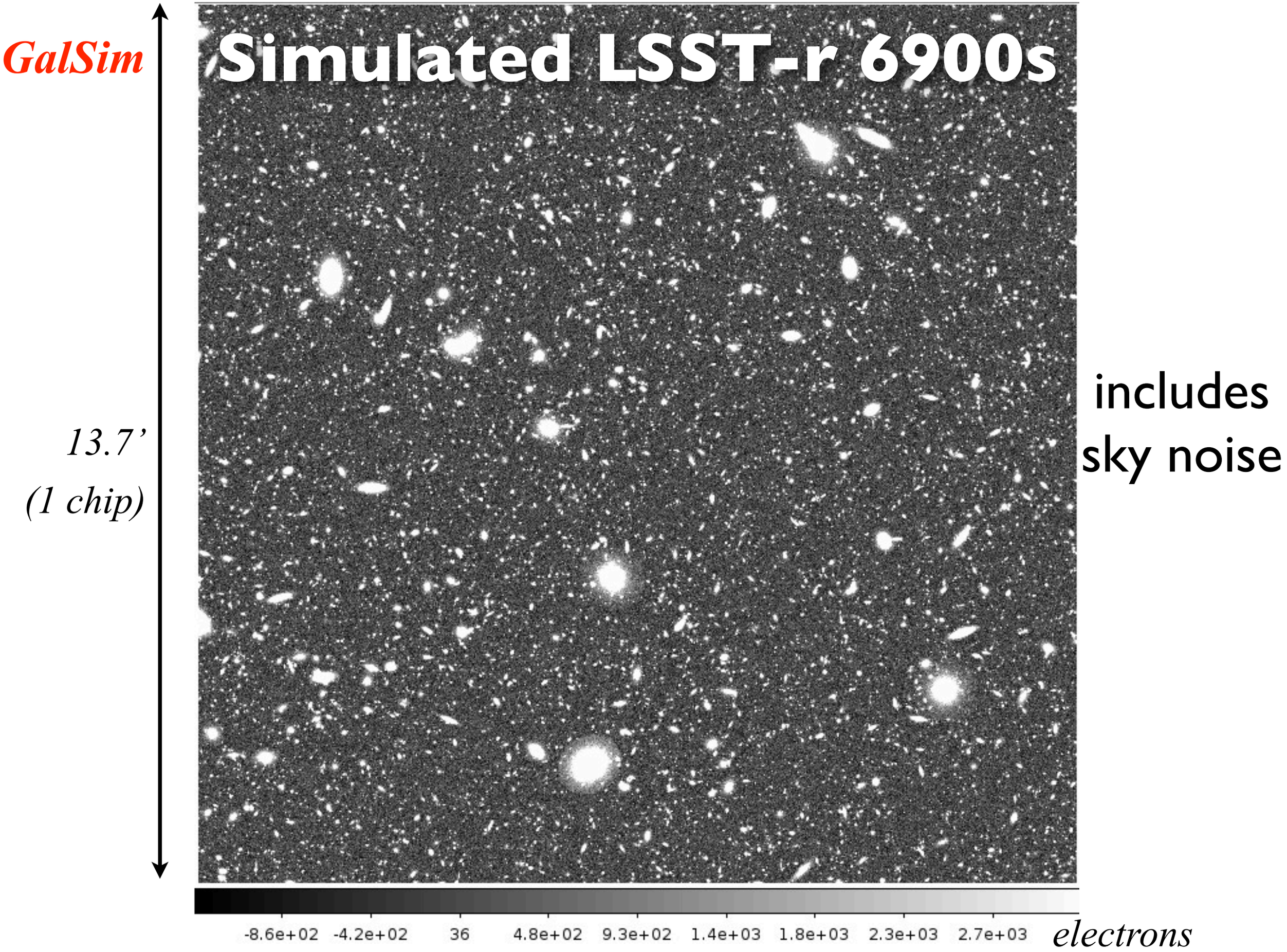
GalSim



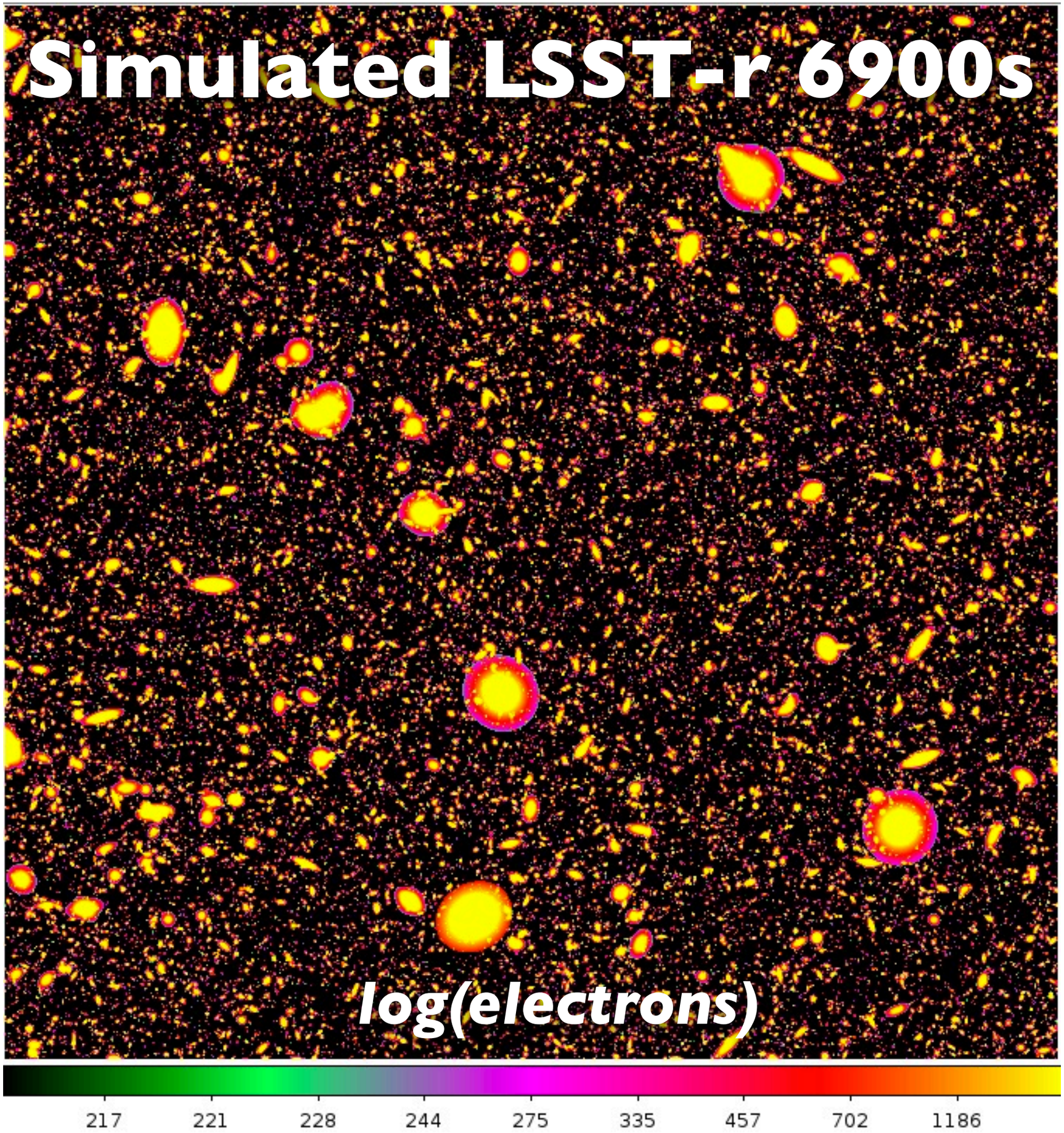
13.7'

includes sky noise

electrons


GalSim
Simulated LSST-r 6900s
13.7'
(1 chip)
includes
sky noise
-8.6e+02
-4.2e+02
36
4.8e+02
9.3e+02
1.4e+03
1.8e+03
2.3e+03
2.7e+03
electrons

GalSim

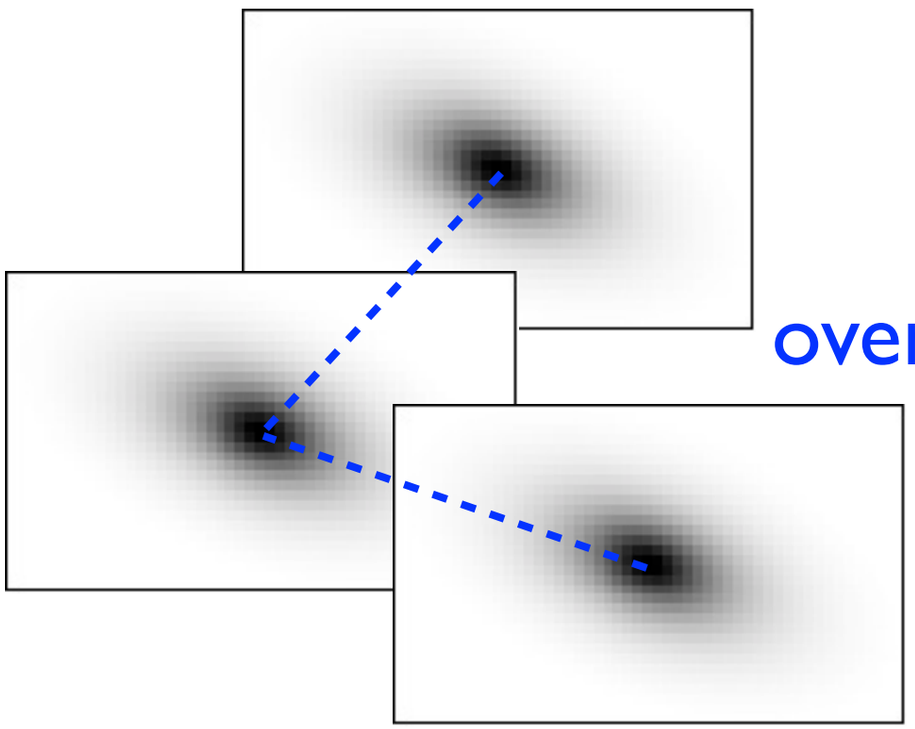


no noise!

sqrt(sky)/2

5sqrt(sky)

Second Pass: quantify effects of overlaps



overlapping? → group size

overlapping? → redshift purity → *photo-z ok?*

overlapping? → shape confusion → *reduced N_{eff}*

- each galaxy's footprint = pixels where its detected signal > sqrt(full-depth sky)/2
- two galaxies are overlapping if their footprints have any pixels in common

Preview of results

- Predicted effective galaxy surface densities*:
  - LSST: N_{eff} ~ 23 (r), 18 (i) / sq.arcmin.
  - DES: N_{eff} ~ 8.0 (r), 5.5 (i) / sq.arcmin.

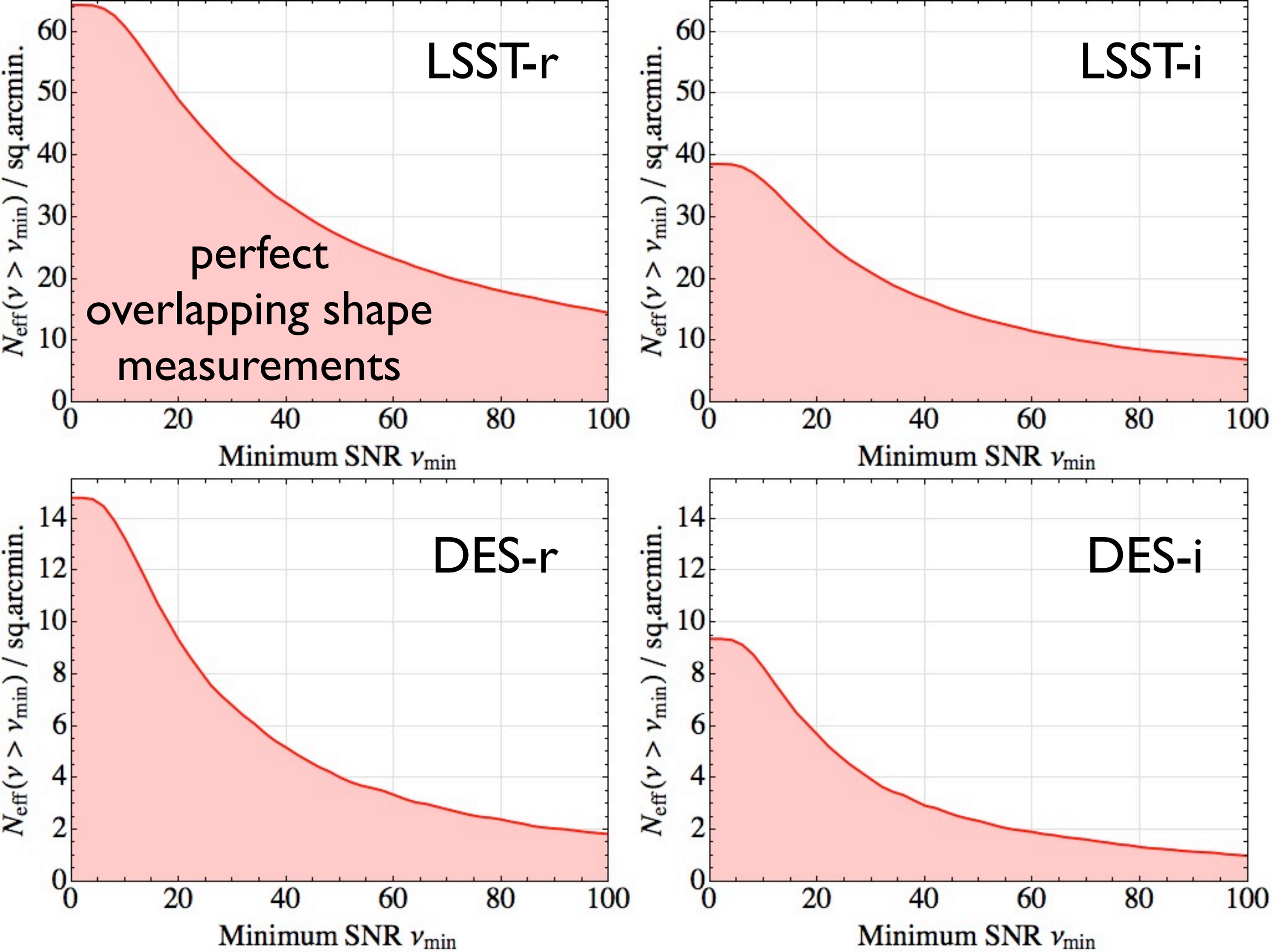
x3

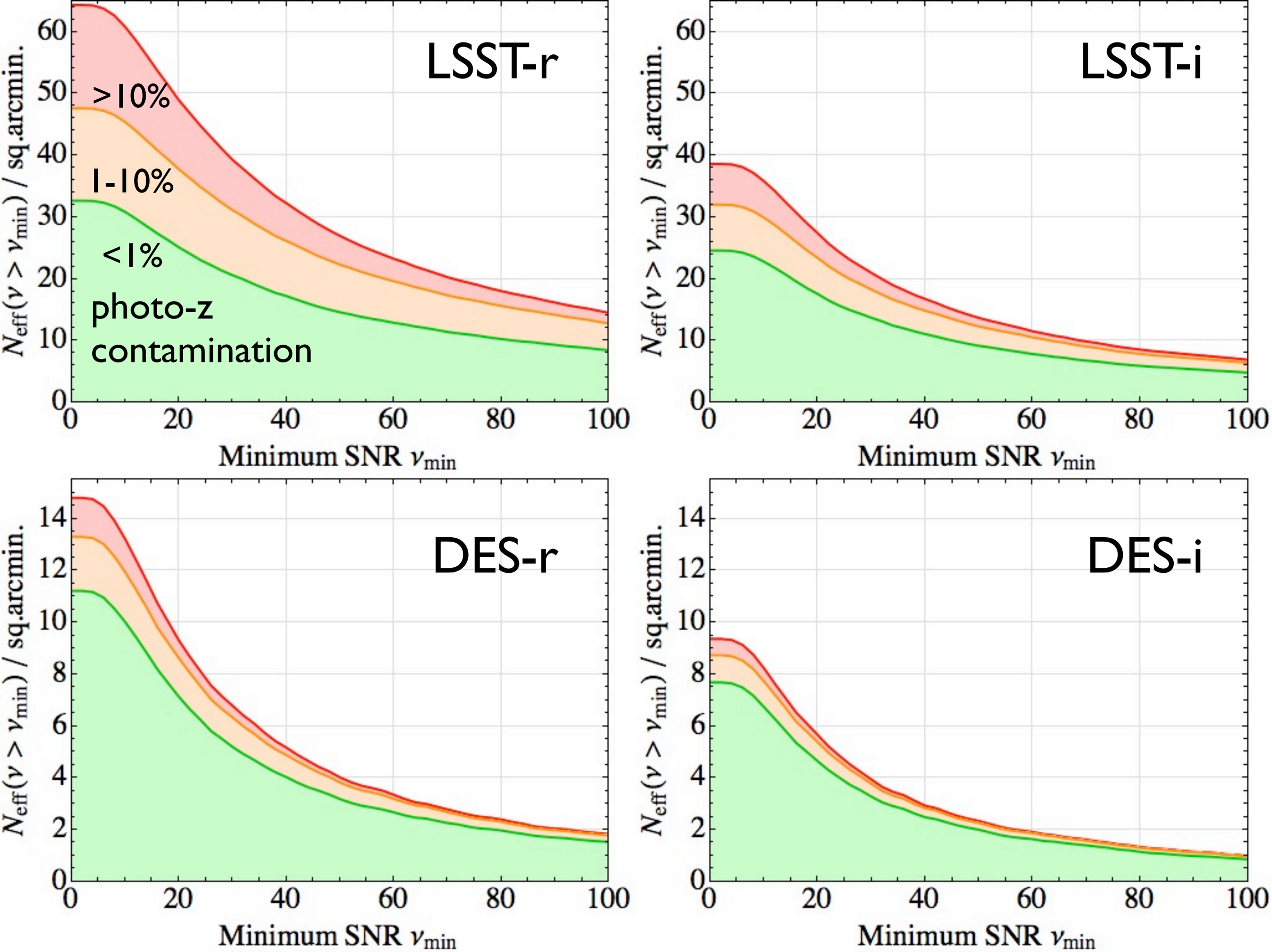
- LSST cosmic shear signal is concentrated at:
  - S/N > 10
  - σ_{gal} / σ_{psf} ~ 0.5 - 1.5
  - z-contamination ~ 1%

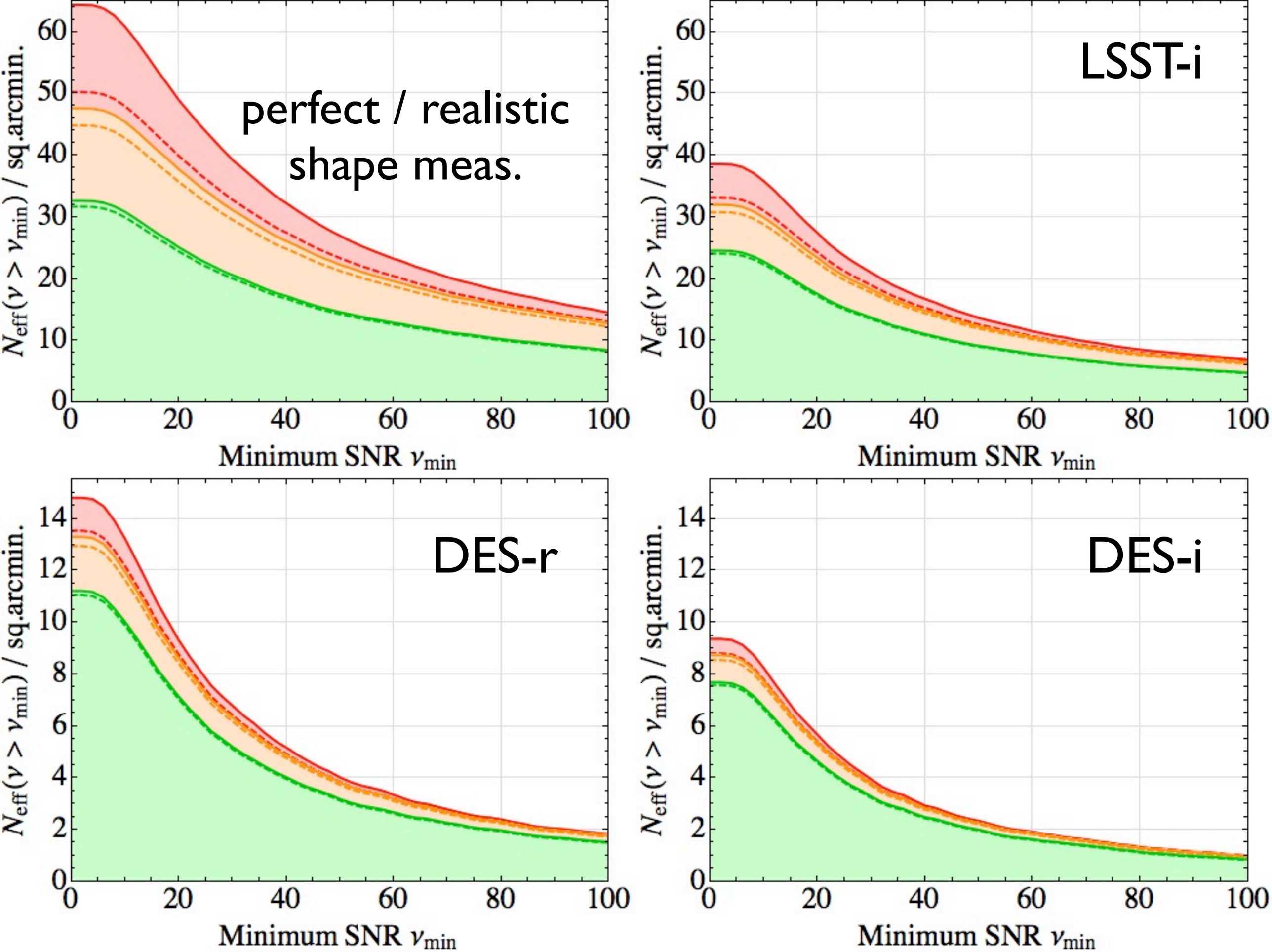
focus effort here!

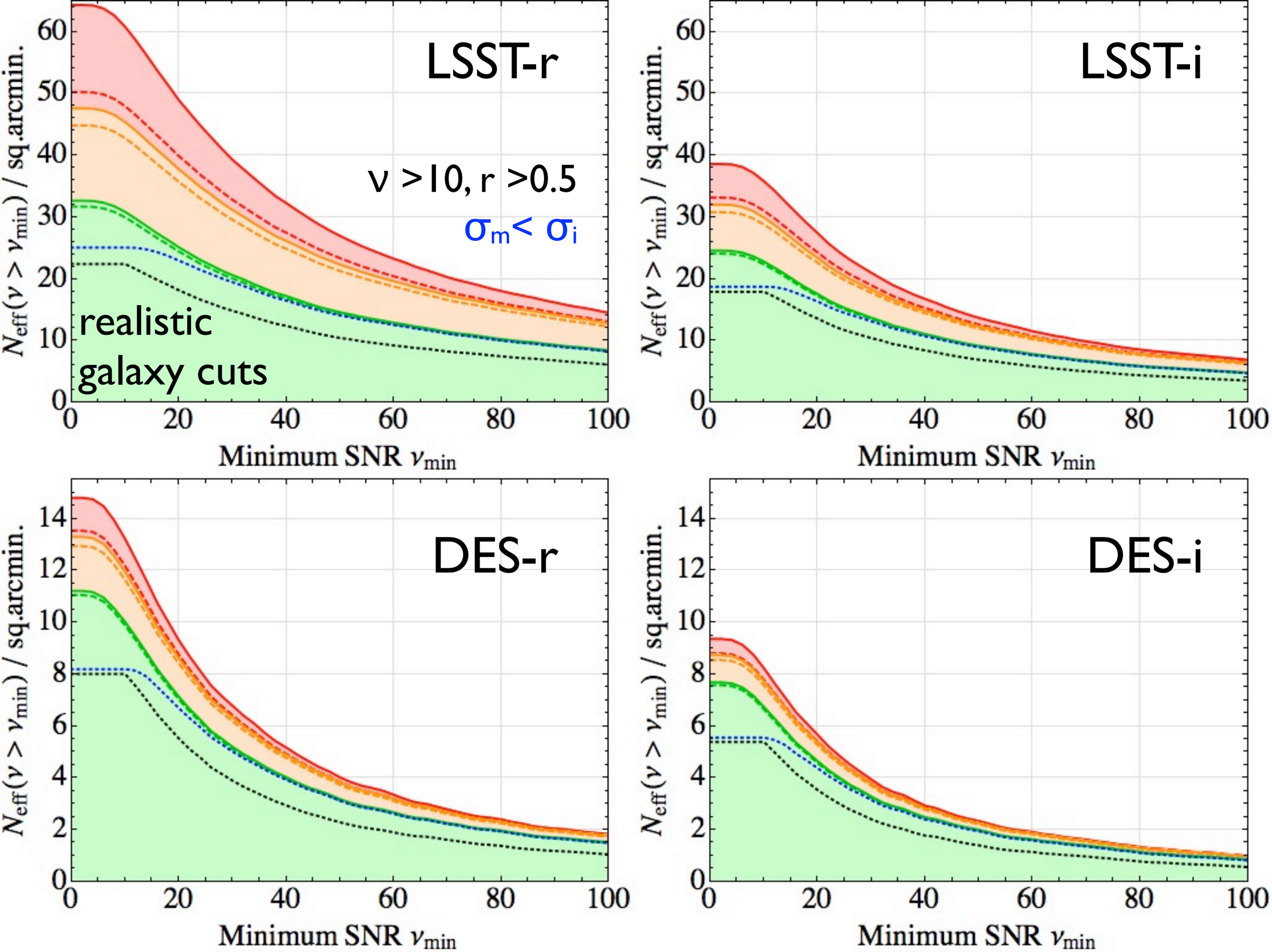
  - <z> ~ 1.1(r) , 1.0 (i) and i < 27.0, r < 26.5

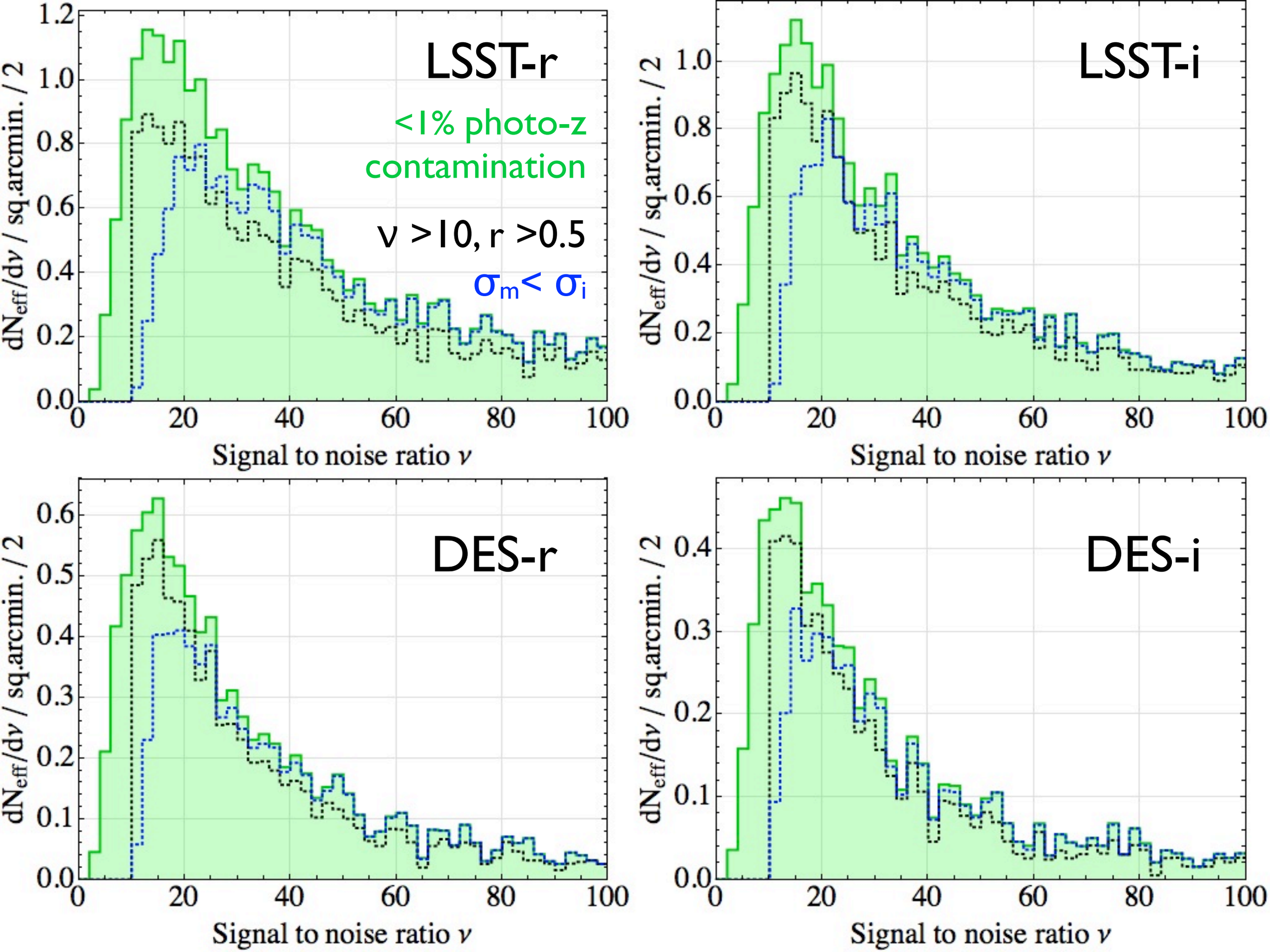
* ~15% masking for stars not included

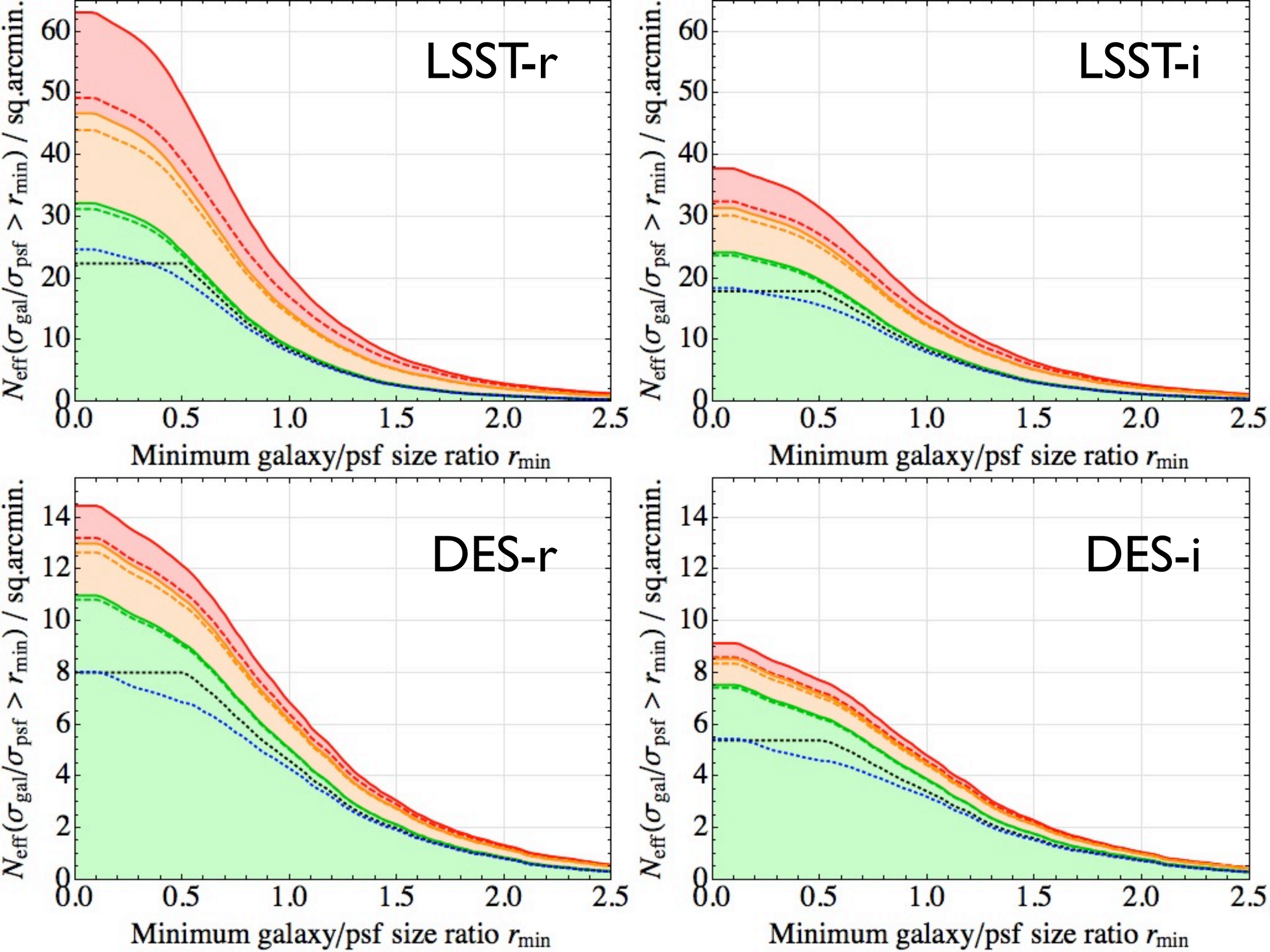

LSST-r
LSST-i
DES-r
DES-i
perfect
overlapping shape
measurements
$N_{\rm eff}(\nu > \nu_{\rm min})$ / sq.arcmin.
Minimum SNR $\nu_{\rm min}$
0
20
40
60
80
100
10
30
50
2
4
6
8
12
14

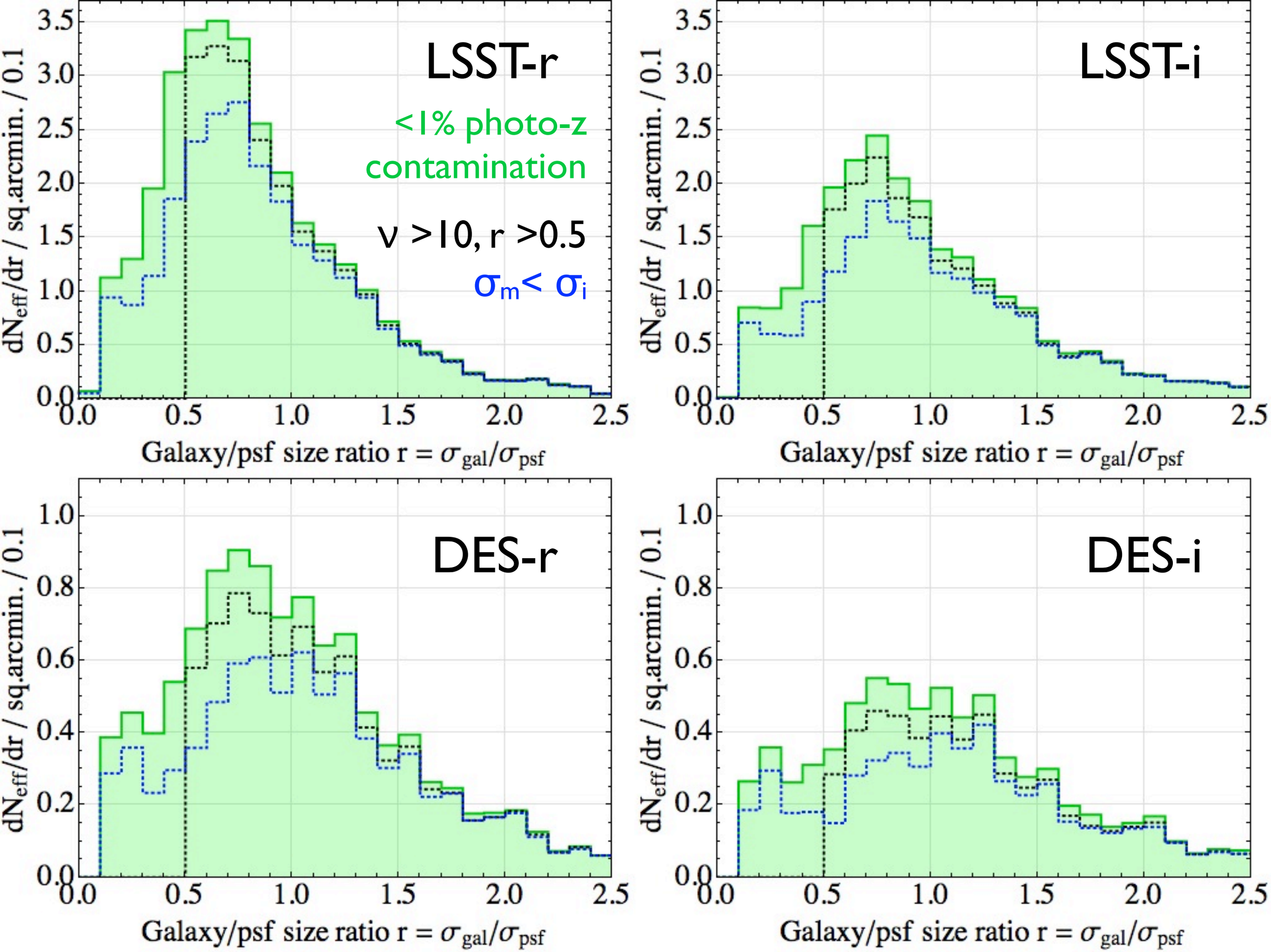

LSST-r
LSST-i
DES-r
DES-i
>10%
1-10%
<1%
photo-z
contamination
$N_{\rm eff}(\nu > \nu_{\rm min})$ / sq.arcmin.
Minimum SNR $\nu_{\rm min}$

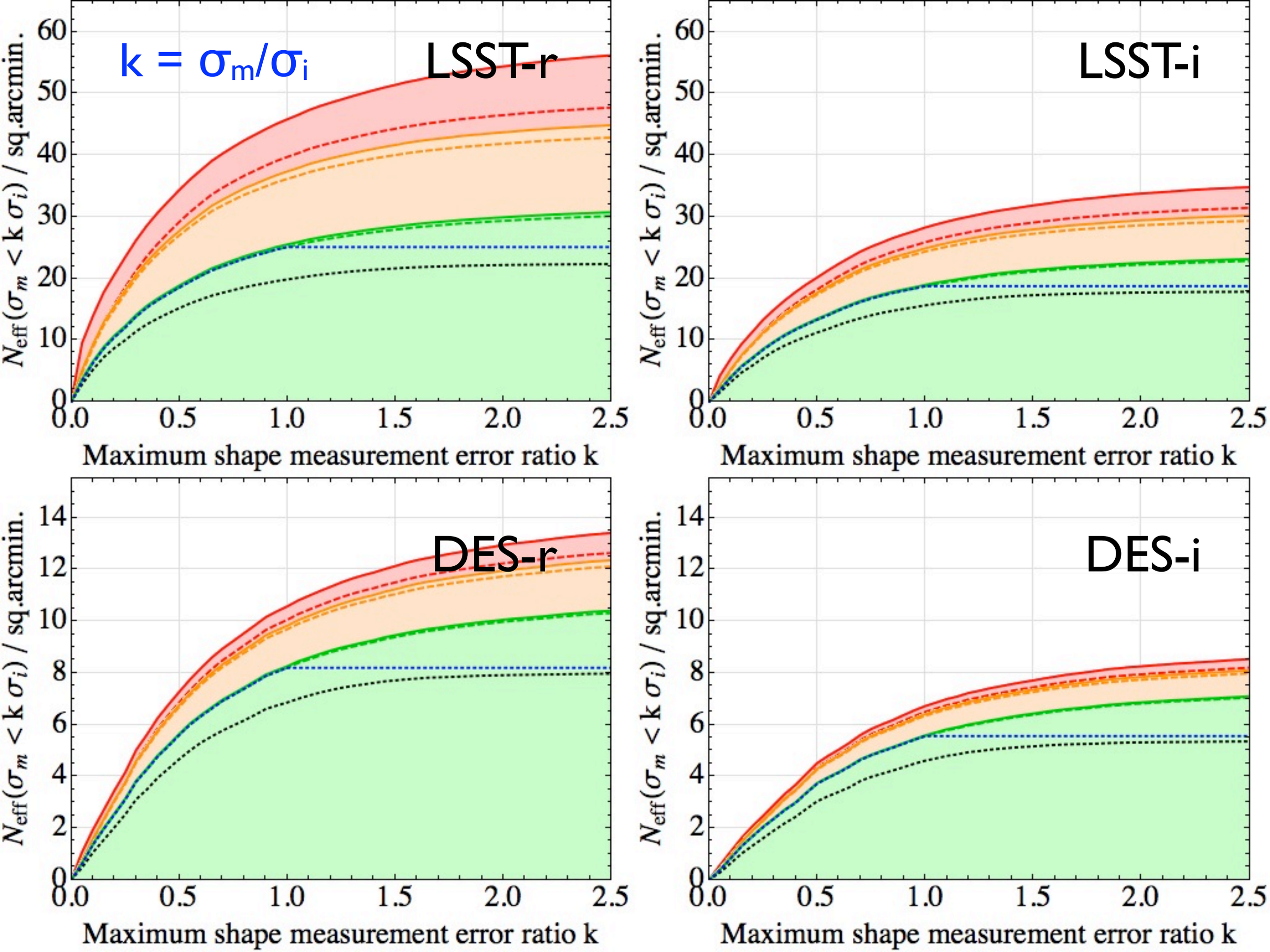

perfect / realistic
shape meas.
LSST-i
DES-r
DES-i
$N_{\rm eff}(\nu > \nu_{\rm min})$ / sq.arcmin.
Minimum SNR $\nu_{\rm min}$
0
20
40
60
80
100
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14

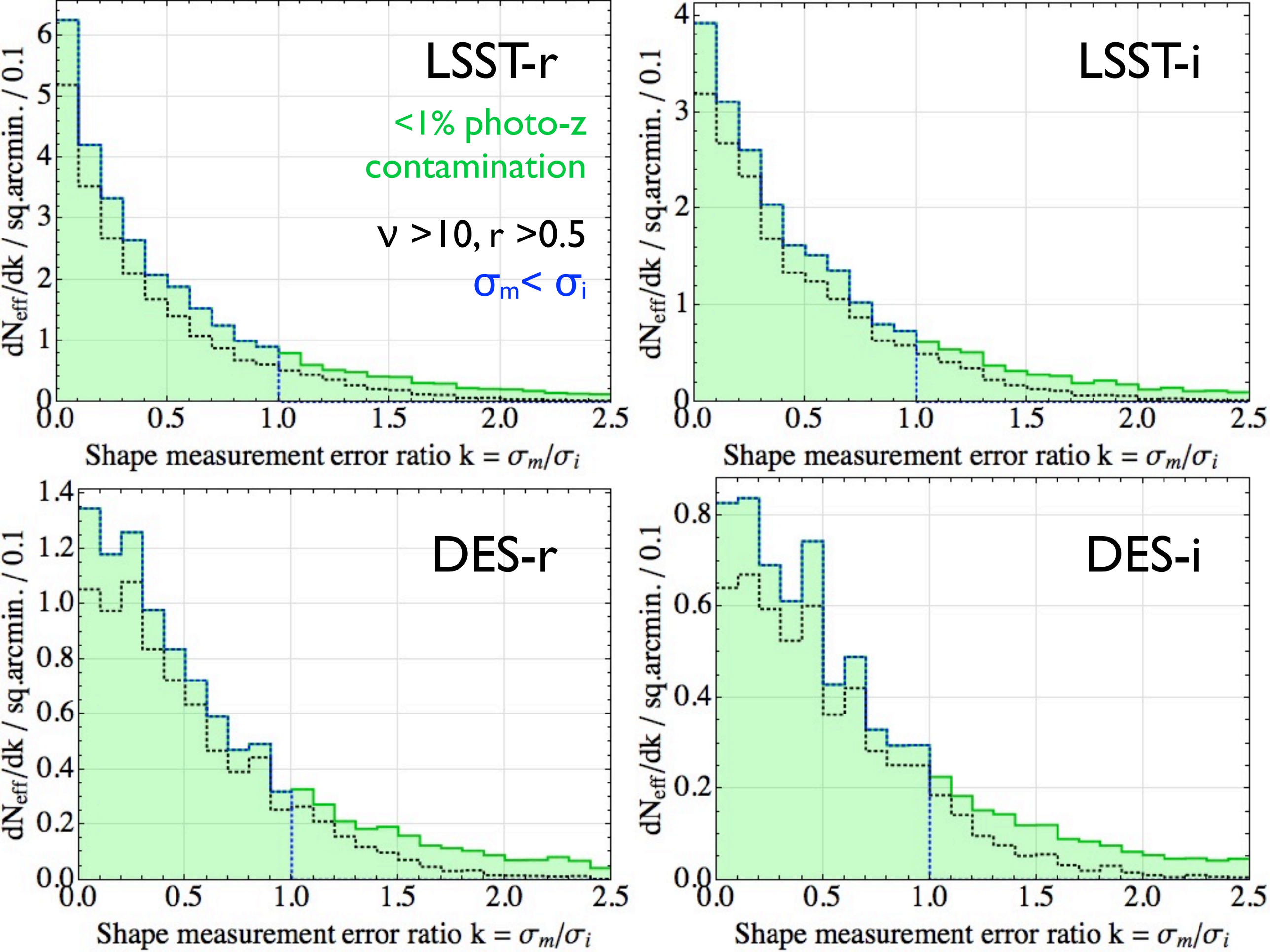

LSST-r
LSST-i
DES-r
DES-i
ν >10, r >0.5
σm< σi
realistic
galaxy cuts
$N_{\rm eff}(\nu > \nu_{\rm min})$ / sq.arcmin.
Minimum SNR $\nu_{\rm min}$

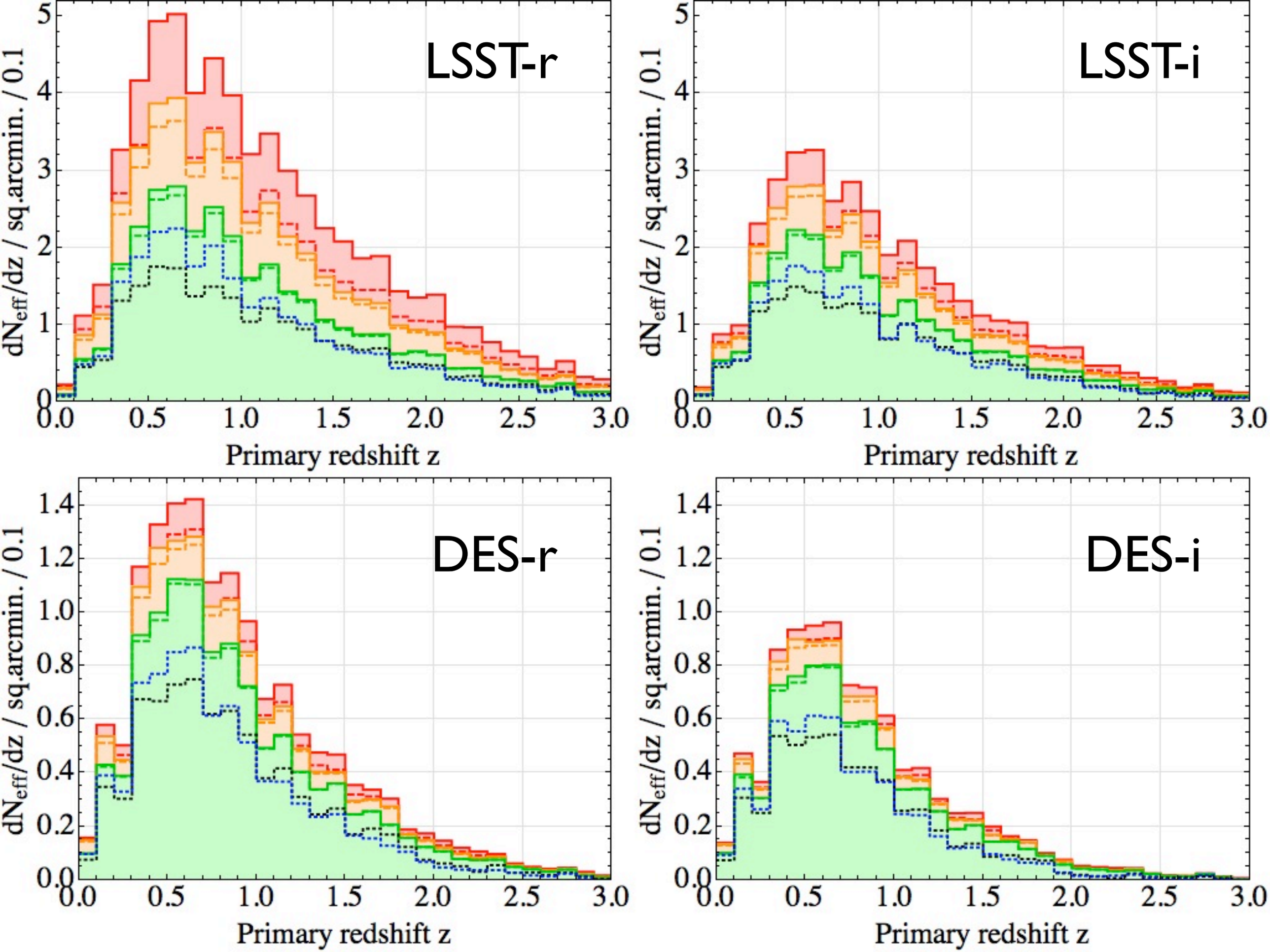

LSST-r
<1% photo-z
contamination
ν >10, r >0.5
σm< σi
LSST-i
DES-r
DES-i
dNeff/dν / sq.arcmin. / 2
Signal to noise ratio ν

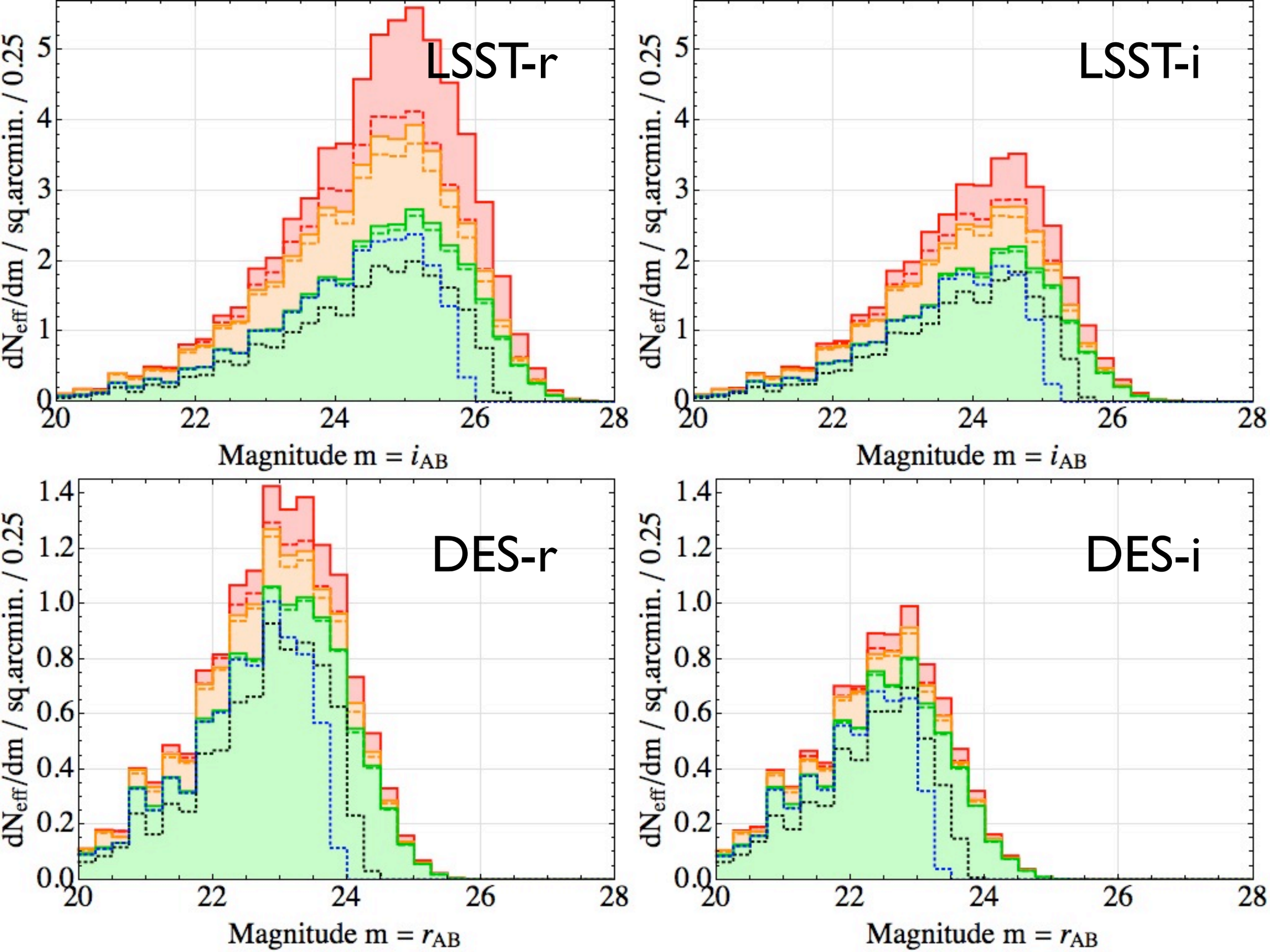

LSST-r
LSST-i
DES-r
DES-i
$N_{\rm eff}(\sigma_{\rm gal}/\sigma_{\rm psf} > r_{\rm min})$ / sq.arcmin.
Minimum galaxy/psf size ratio $r_{\rm min}$
0.0
0.5
1.0
1.5
2.0
2.5
0
10
20
30
40
50
60
2
4
6
8
12
14

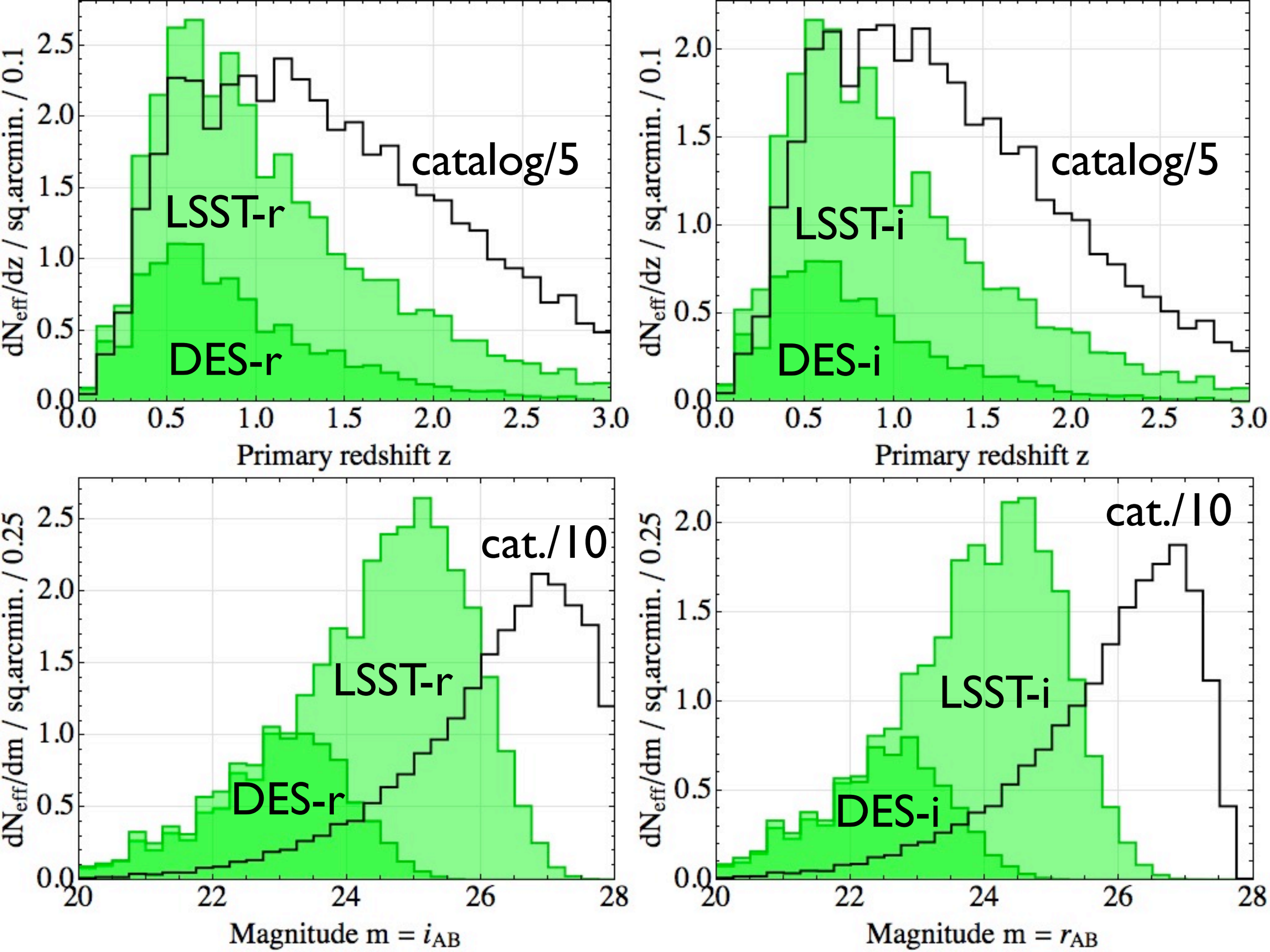

LSST-r
<1% photo-z
contamination
ν >10, r >0.5
σm< σi
LSST-i
DES-r
DES-i
dNeff/dr / sq.arcmin. / 0.1
Galaxy/psf size ratio r = σgal/σpsf

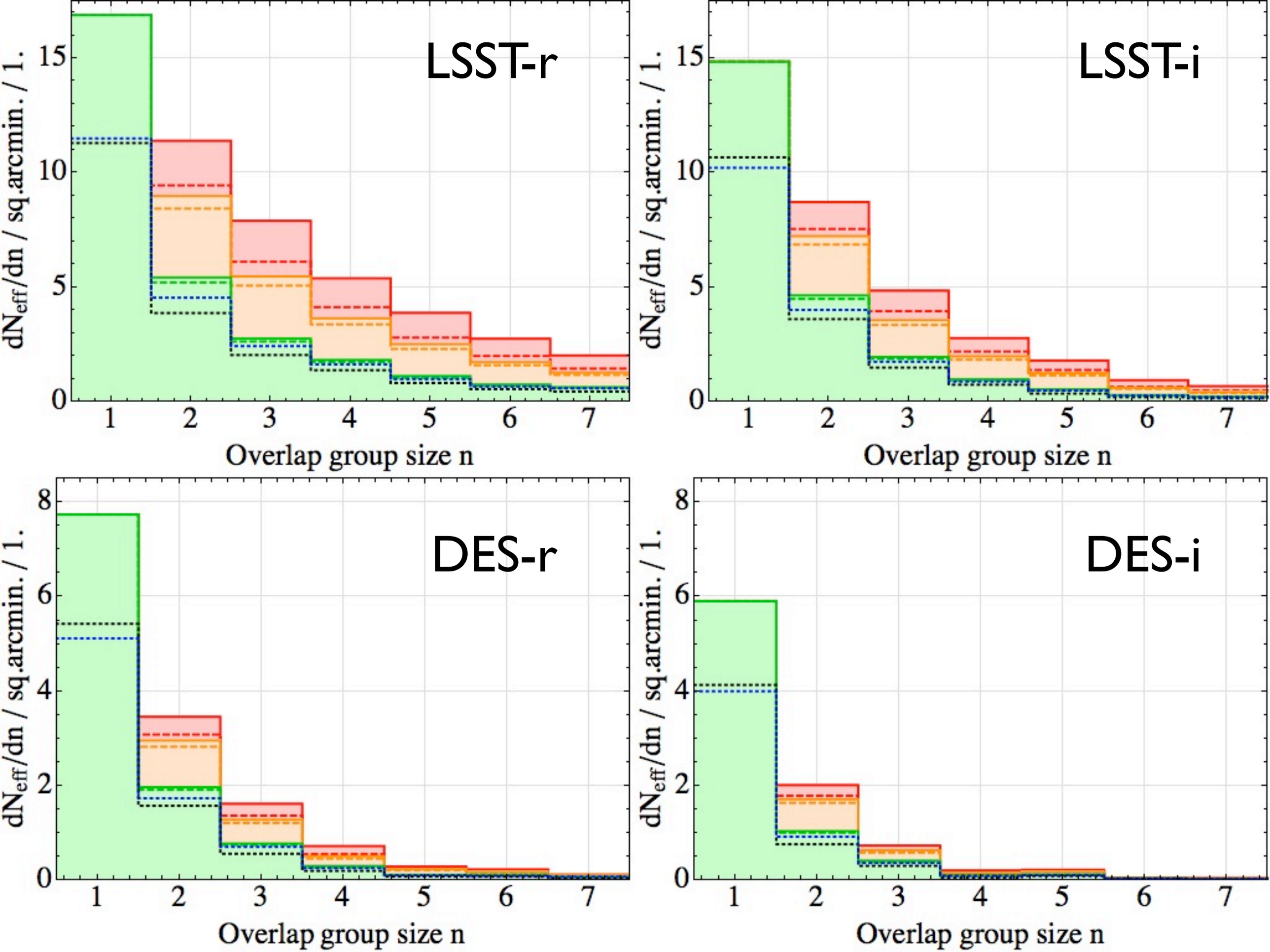

k = σm/σi
LSST-r
LSST-i
DES-r
DES-i
Neff(σm < k σi) / sq.arcmin.
Maximum shape measurement error ratio k
0.0
0.5
1.0
1.5
2.0
2.5
0
10
20
30
40
50
60
2
4
6
8
12
14


LSST-r
<1% photo-z
contamination
ν >10, r >0.5
σm< σi
LSST-i
DES-r
DES-i
dNeff/dk / sq.arcmin. / 0.1
Shape measurement error ratio k = σm/σi


LSST-r
LSST-i
DES-r
DES-i
dN_{eff}/dz / sq.arcmin. / 0.1
Primary redshift z
0.0
0.5
1.0
1.5
2.0
2.5
3.0


LSST-r
LSST-i
DES-r
DES-i
dN_{eff}/dm / sq.arcmin. / 0.25
Magnitude m = i_{AB}
Magnitude m = r_{AB}


catalog/5
LSST-r
DES-r
dN_{eff}/dz / sq.arcmin. / 0.1
Primary redshift z
catalog/5
LSST-i
DES-i
dN_{eff}/dz / sq.arcmin. / 0.1
Primary redshift z
cat./10
LSST-r
DES-r
dN_{eff}/dm / sq.arcmin. / 0.25
Magnitude m = i_{AB}
cat./10
LSST-i
DES-i
dN_{eff}/dm / sq.arcmin. / 0.25
Magnitude m = r_{AB}


LSST-r
LSST-i
DES-r
DES-i
dN_eff/dn / sq.arcmin. / 1.
Overlap group size n

Redshift contamination from overlaps

- Overlaps with $|\Delta z| < 0.1$ are considered harmless (e.g., from satellites)

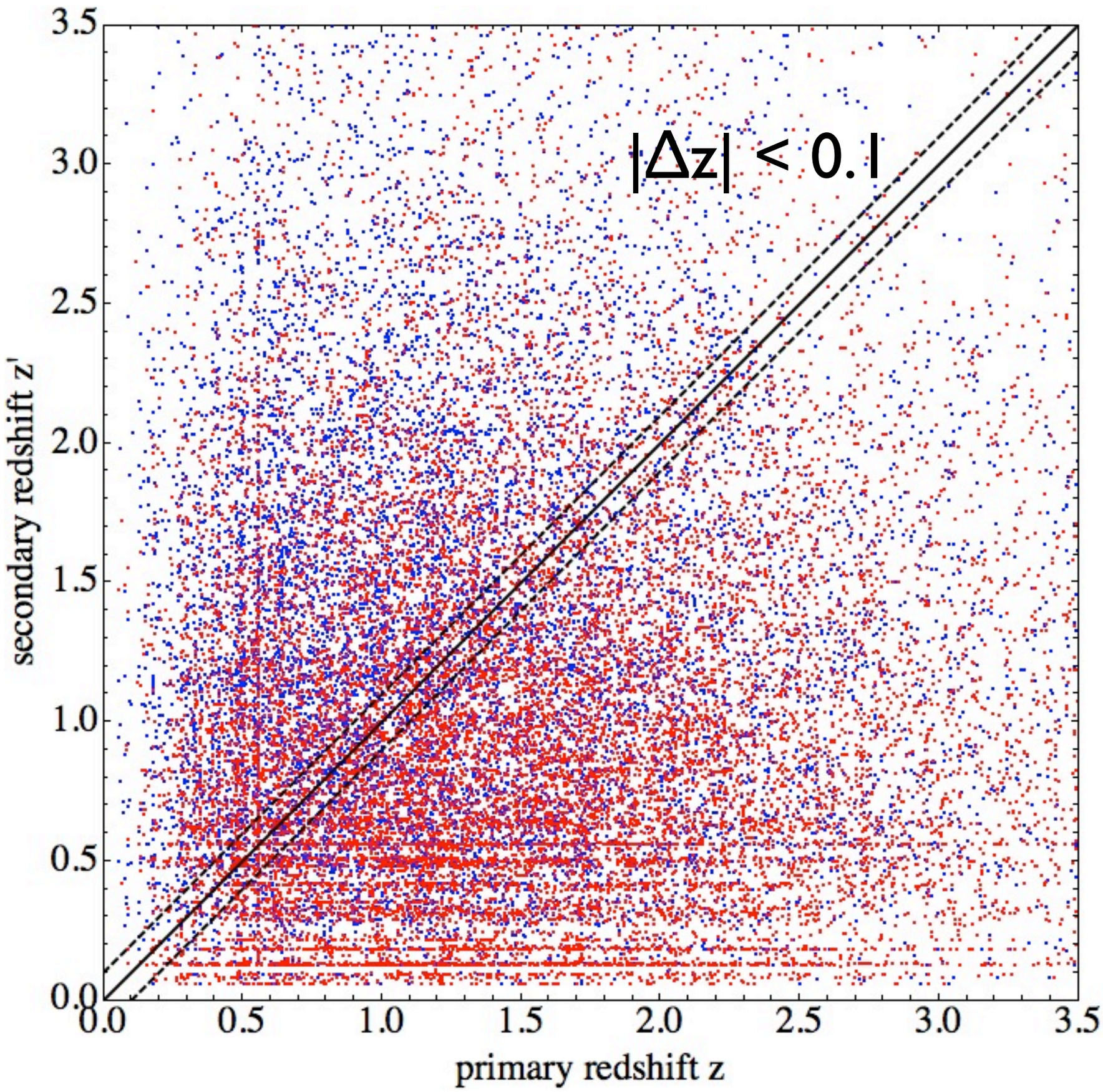
- Measure fraction of galaxy's weighted* flux due to overlapping galaxies with $|\Delta z| > 0.1$

- Fraction measures redshift contamination:

  - > 10% is unusable for photo-z

  - 1-10% is "challenging"

* flux of secondary galaxy weighted with primary galaxy's profile.

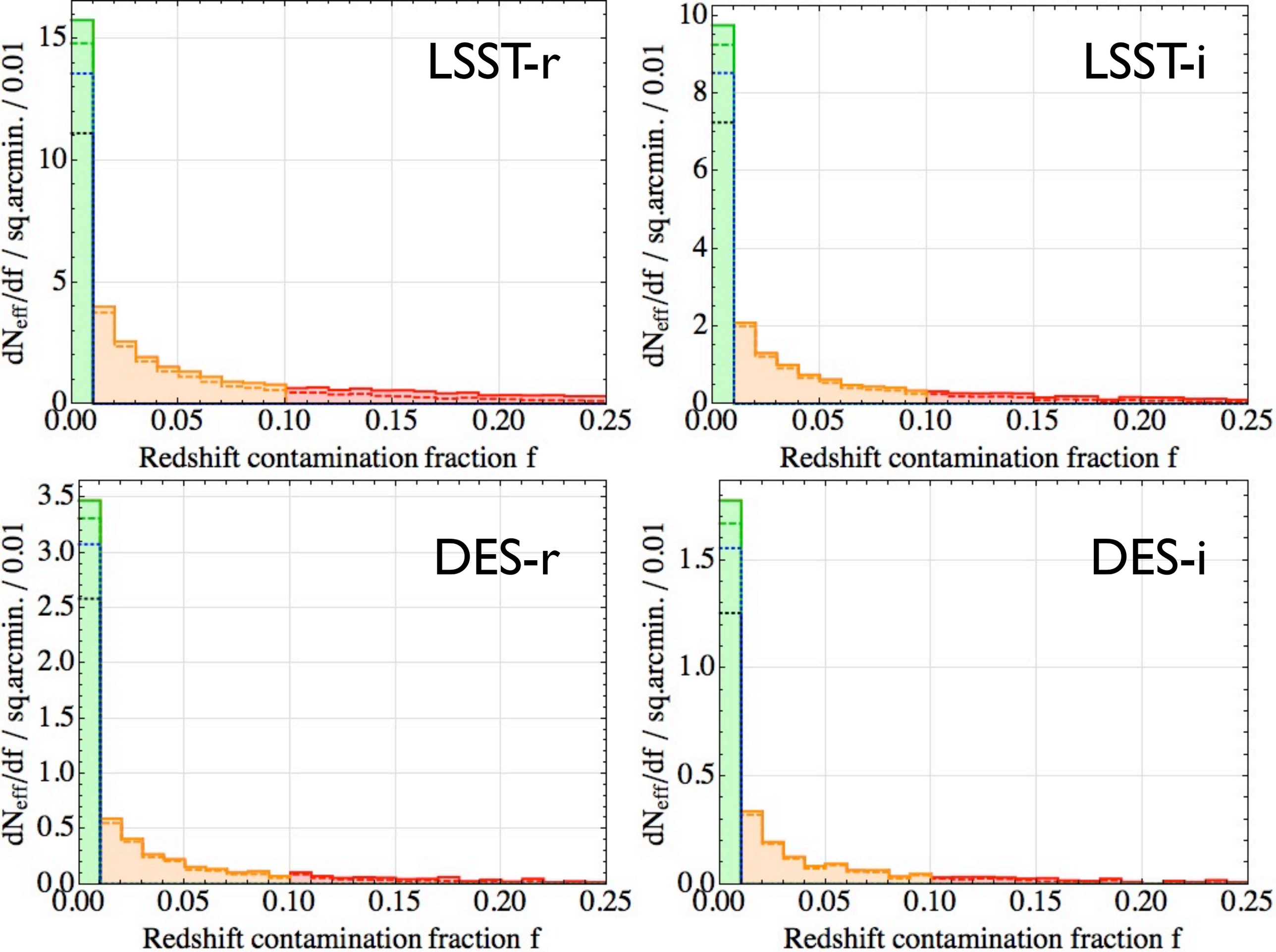


LSST-r

redshift contamination:

1-10%

>10%


LSST-r
LSST-i
DES-r
DES-i
dN_eff/df / sq.arcmin. / 0.01
Redshift contamination fraction f
0.00
0.05
0.10
0.15
0.20
0.25

Comparison with other N_{eff} estimates for LSST

- LSST Science Book: N_{eff} ~ 40 / sq.arcmin.
- Chang++ 2013: N_{eff} ~ 31 / sq.arcmin.
  - $\sigma_m < \sigma_i$ (k = 1), simple geometric treatment of overlaps.
- This work: N_{eff} ~ 23 (r), 18 (i).
  - $\sigma_m < \sigma_i$, redshift contamination < 1%

Next steps

- validate / improve input galaxy catalog
- model effects of stars on overlaps
- estimate systematic biases on shape measurement and photo-z due to overlaps
- focus limited CPU on best 20% of seeing?
- paper draft in progress...

Summary of results

- Predicted effective galaxy surface densities*:
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x3

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* ~15% masking for stars not included