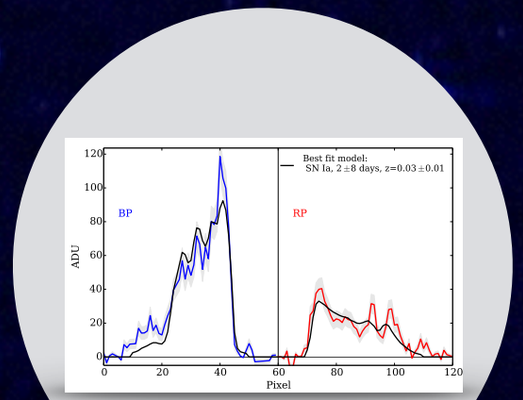
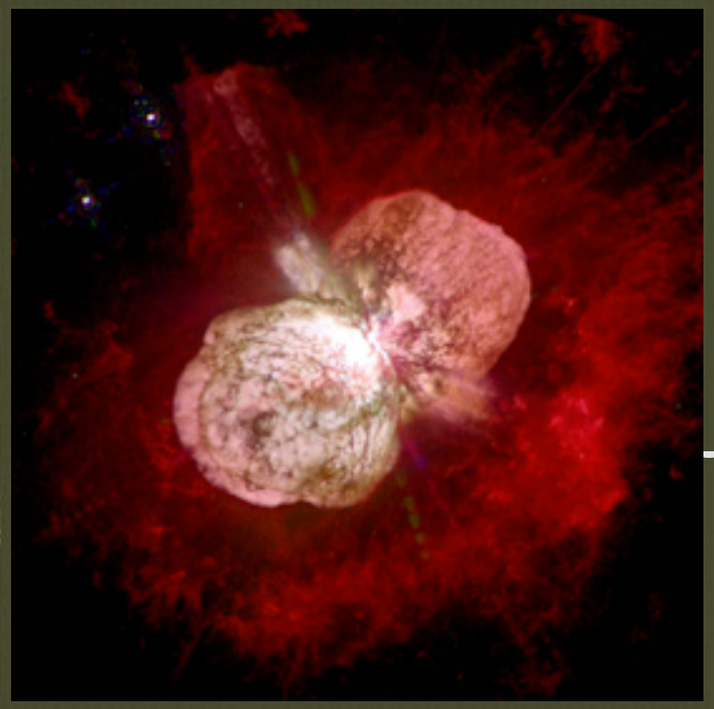


(Nuclear) Transient detection/characterisation with Gaia

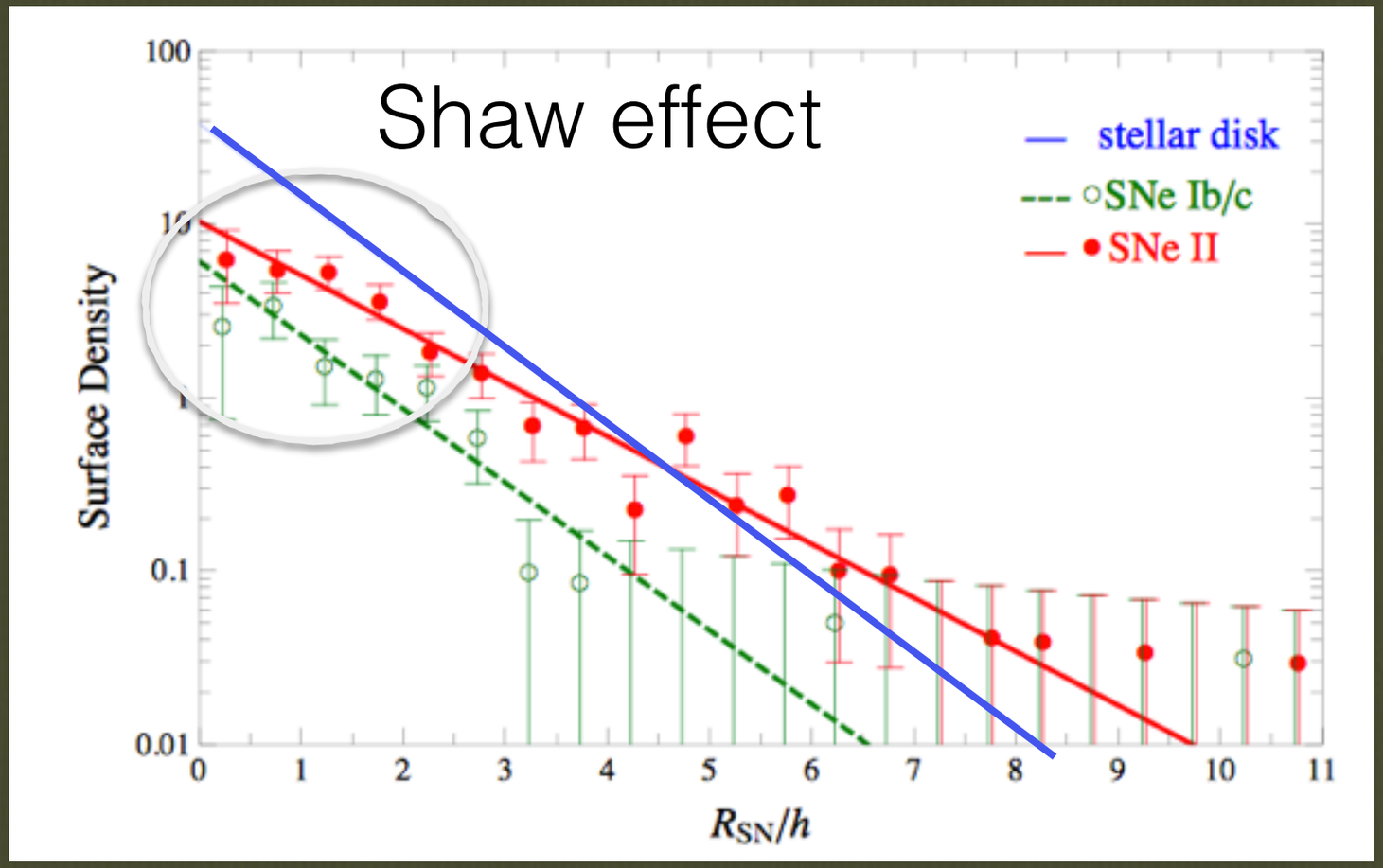
Gaia Science Alerts workshop, 11th November 2015

Nadejda Blagorodnova (Caltech)
& Gaia Science Alerts DPAC team



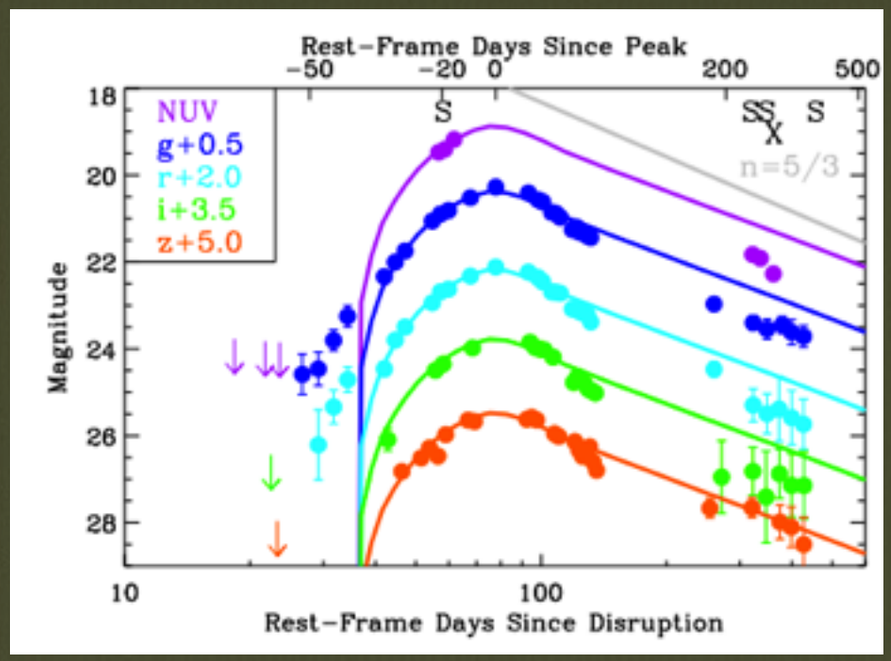
Nuclear Supernovae

- Lack of CCSN in central regions:
  - Different IMF?
  - Intrinsically fainter?
  - Dust?
  - Metallicity?
  - Bias in ground-based surveys?

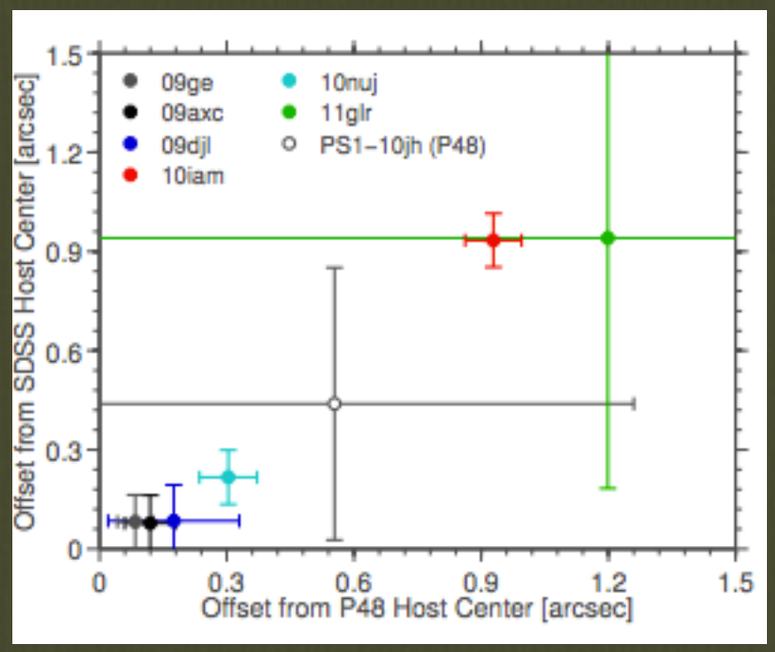


Hakobyan et. al, 2008

Tidal Disruption

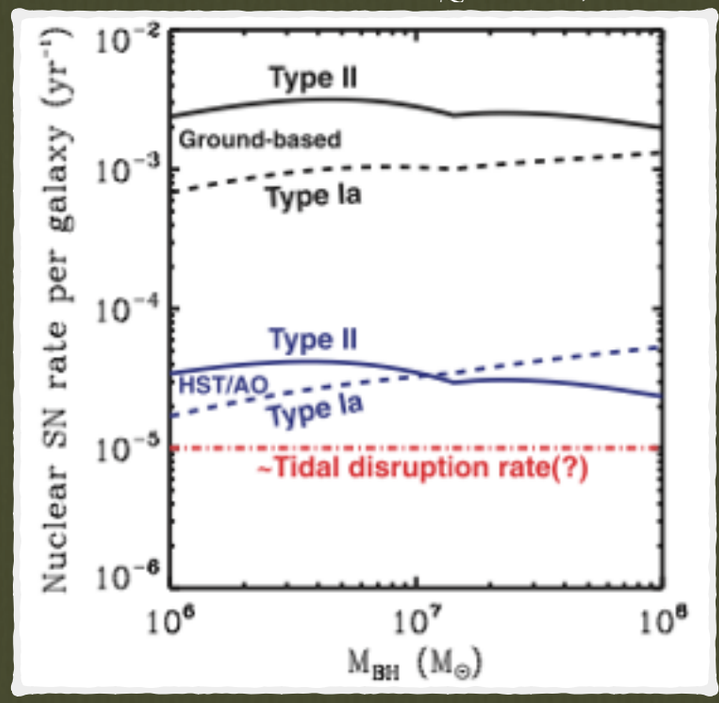


Gezari et. al., 2012



Arcavi et. al., 2014

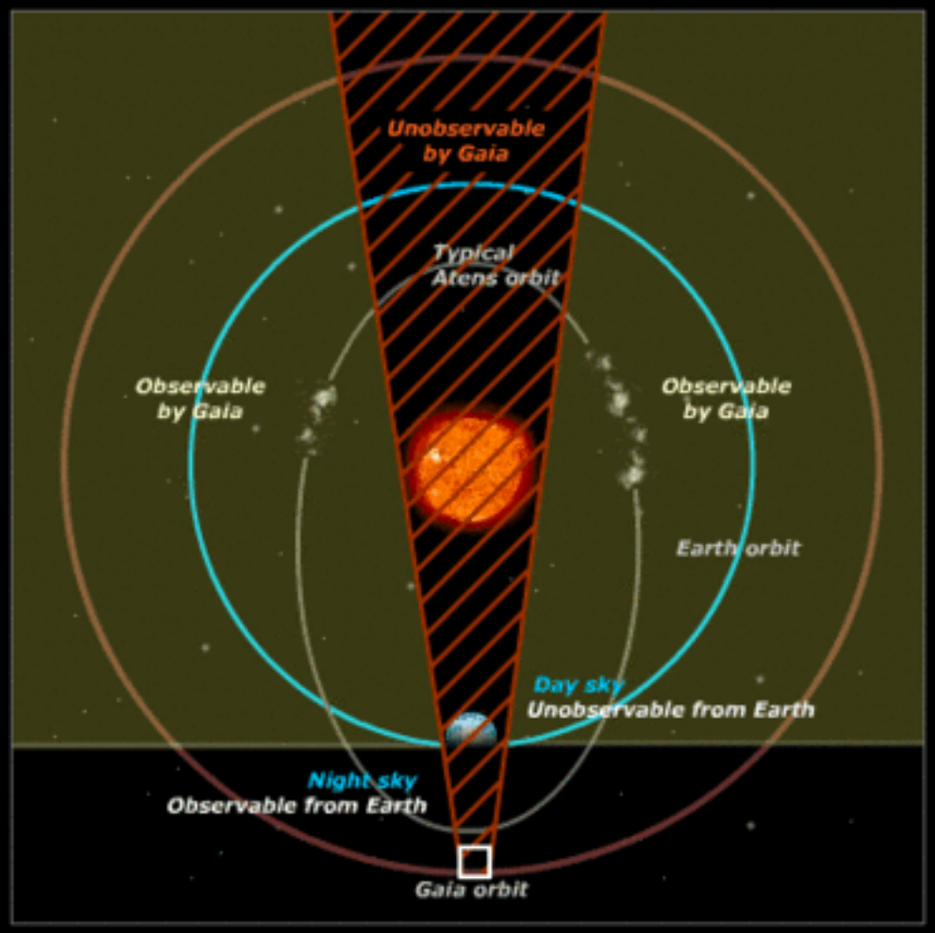
Strubbe and Quataert, 2012



- ☐ **SMBH population for non-active galaxies: mass, spin**
- ☐ **Accretion disk geometry in SMBH**

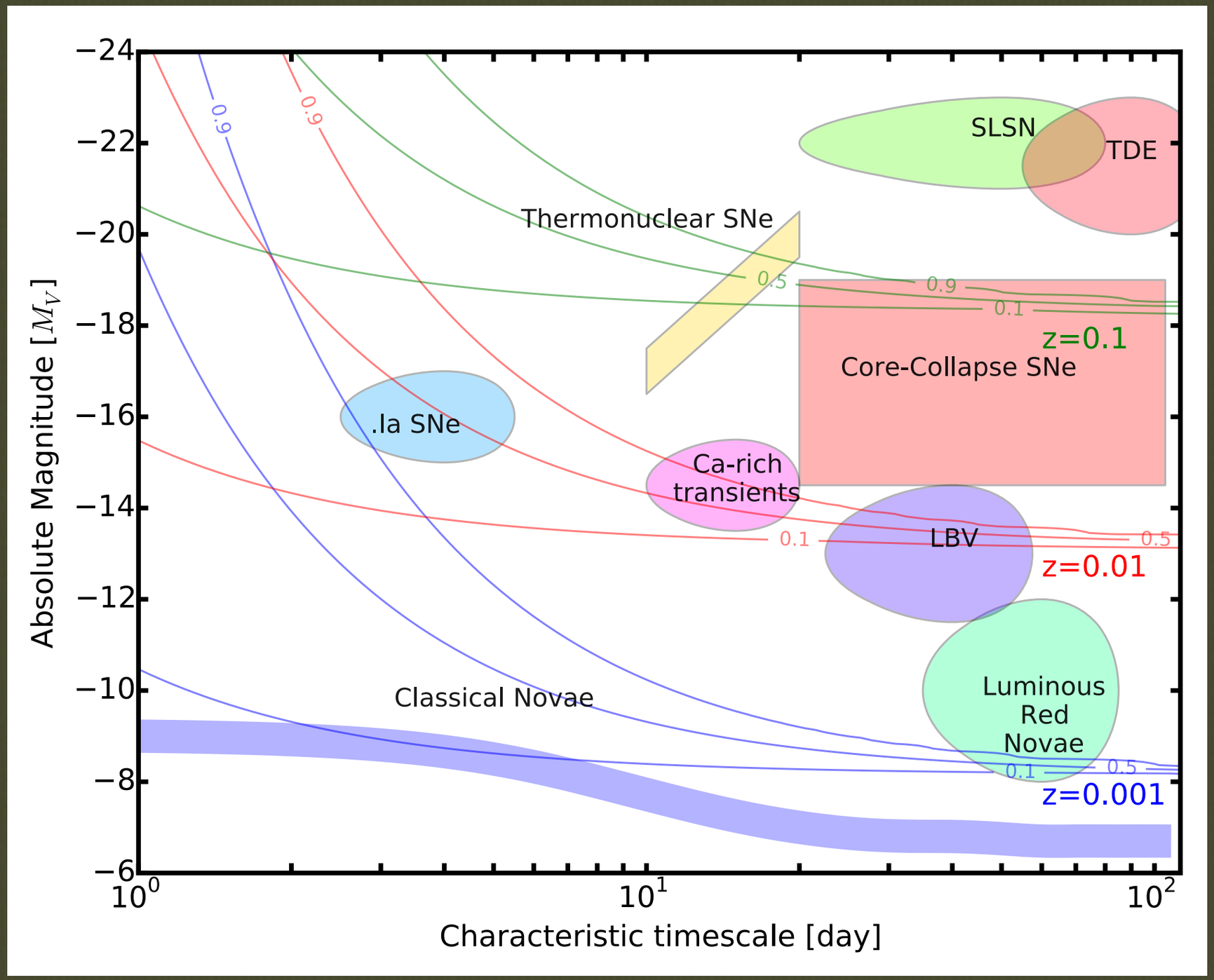
Sun

Earth


Unobservable by Gaia
Typical Atens orbit
Observable by Gaia
Observable by Gaia
Earth orbit
Day sky
Unobservable from Earth
Night sky
Observable from Earth
Gaia orbit

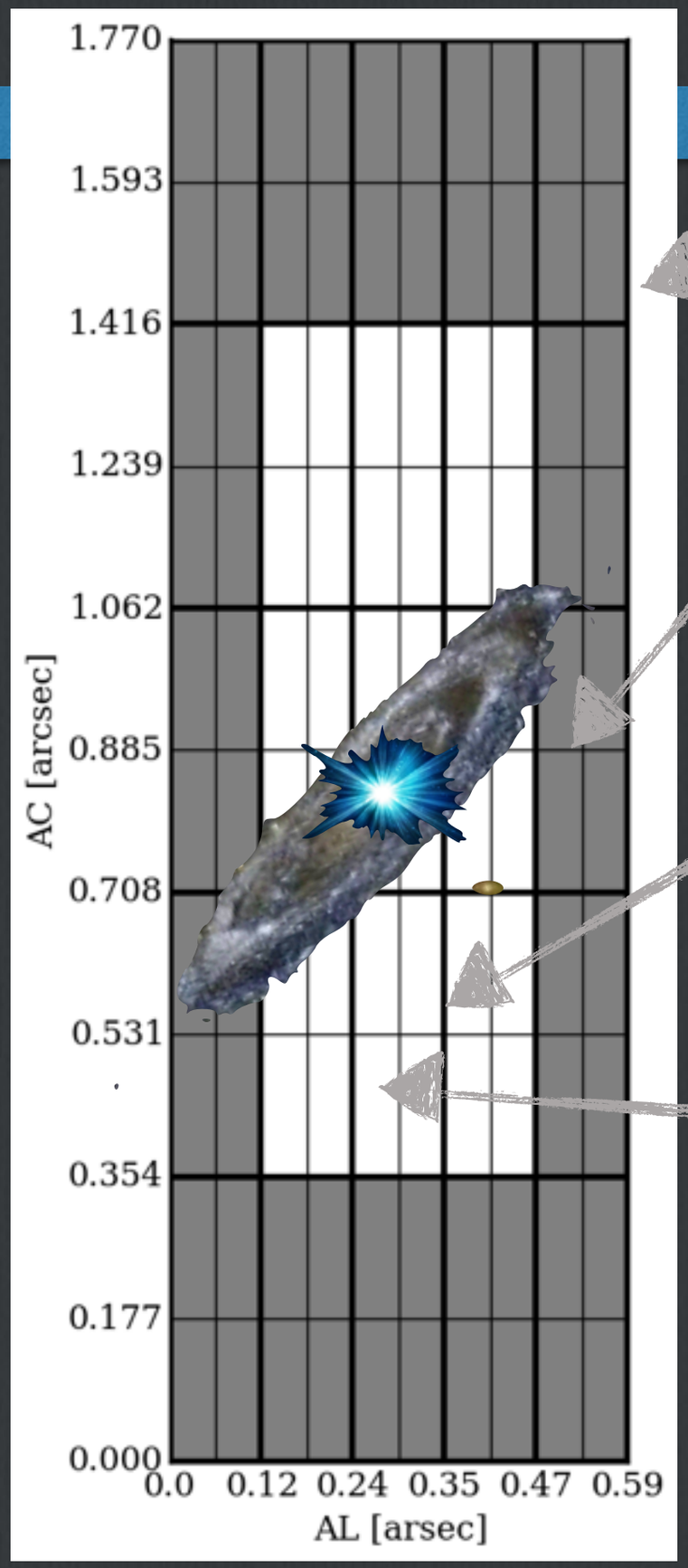
L2

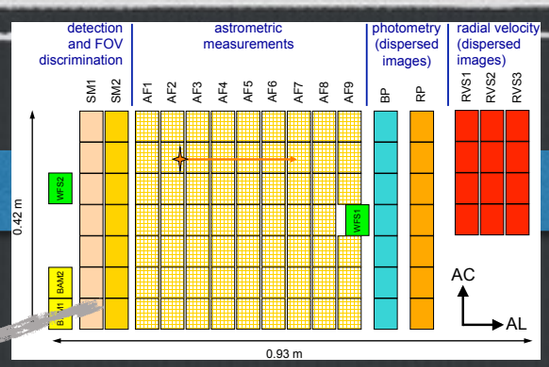
Gaia parameter space



Limiting mag:
20.5mag
Cadence:
~35d

Original diagram in Kasliwal et. al, 2011





Scan motion

Background estimation:

- 5th lowest value of 16 samples

Flux estimation:

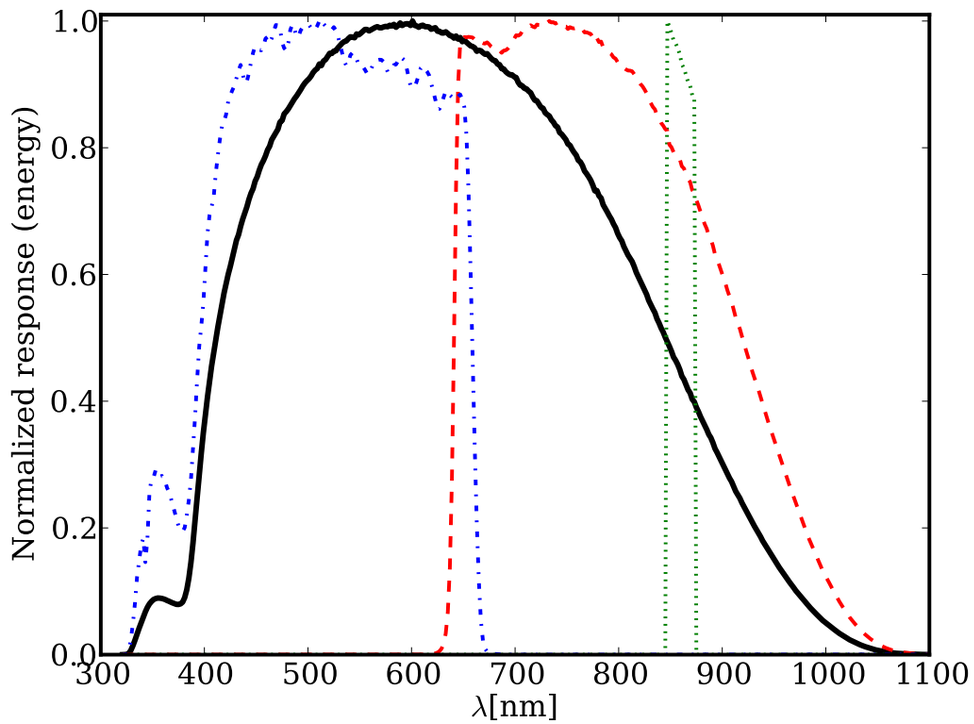
- Central 3x3 - background

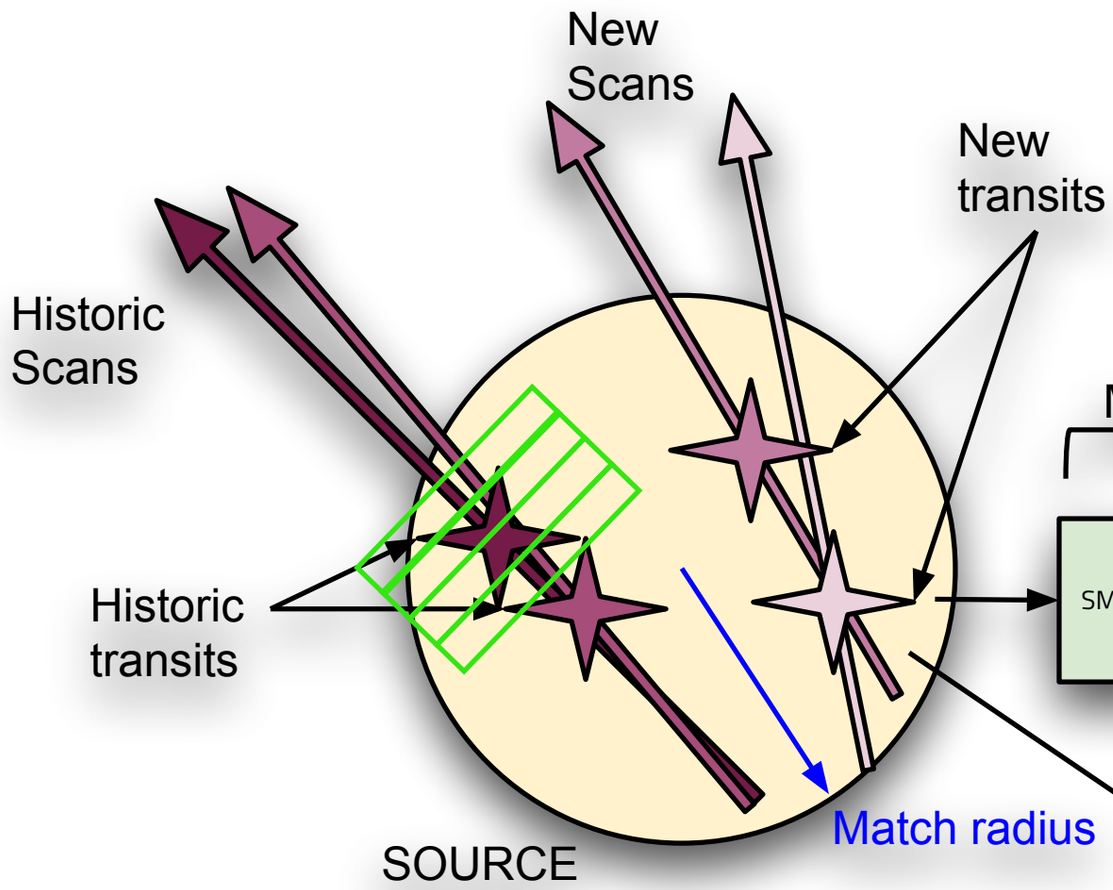
Source detection:

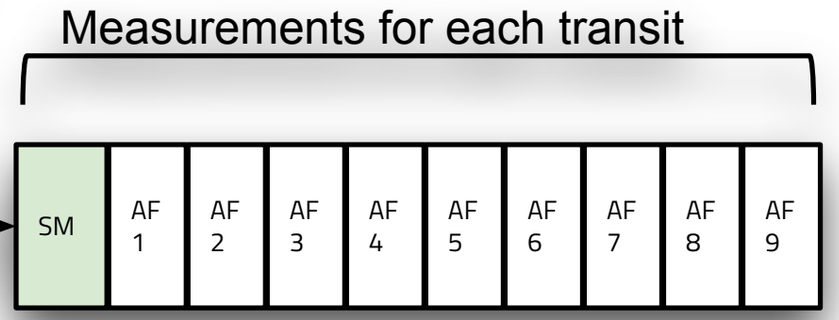
- Flux
- Geometry 3x3 window

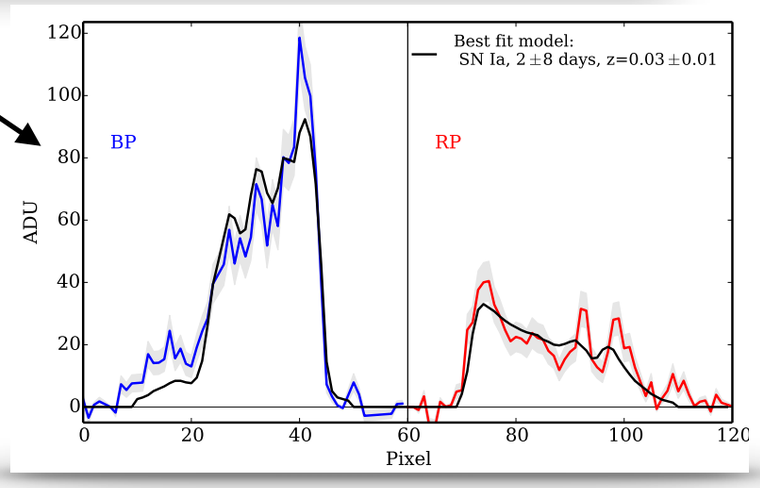
Details in De Bruijne et. al. 2015

The catalogue…









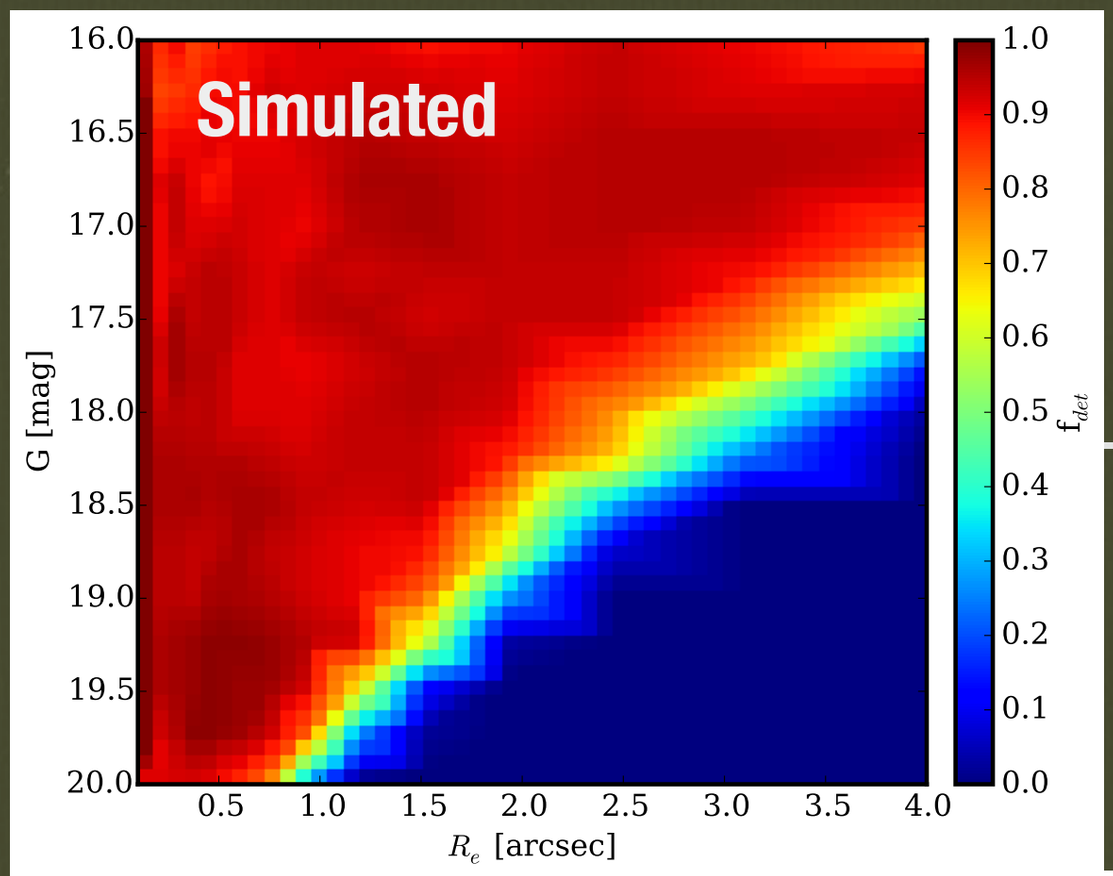
The Gaia Sky

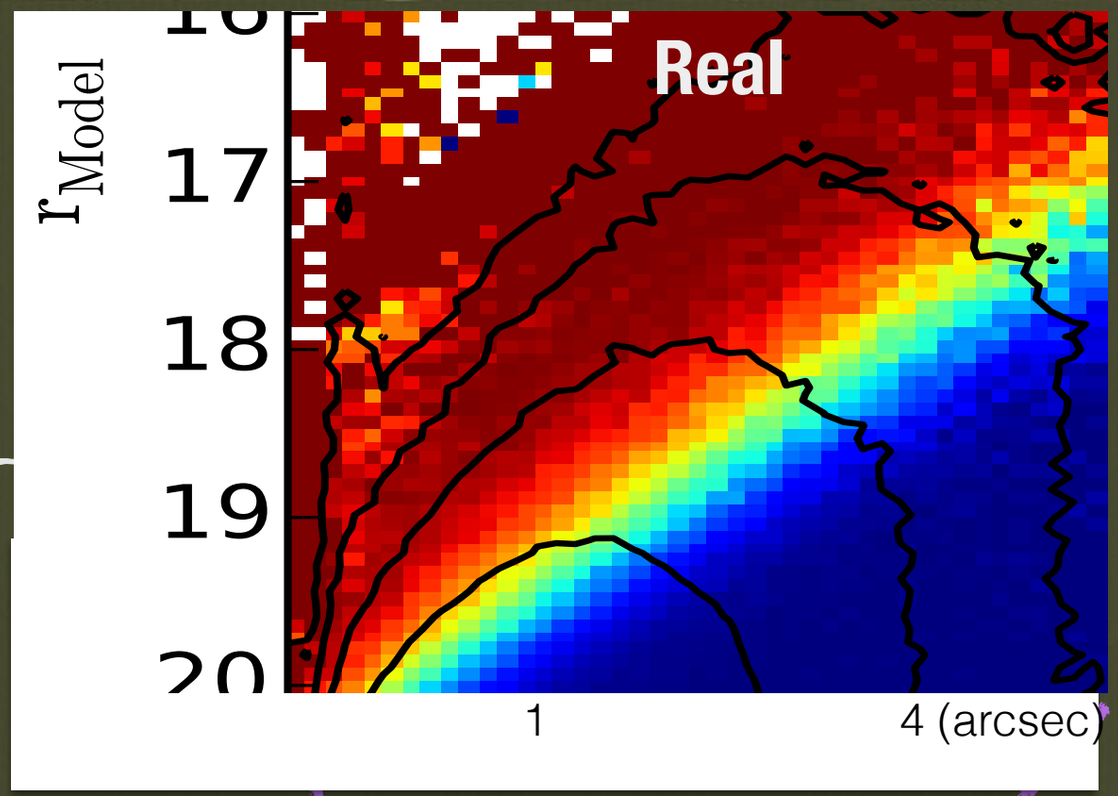
Simulated view of R136 (Jos de Bruijne and Guido de Marchi)

GIBIS: Gaia Instrument and Basic Image Simulator

Simulation parameters:

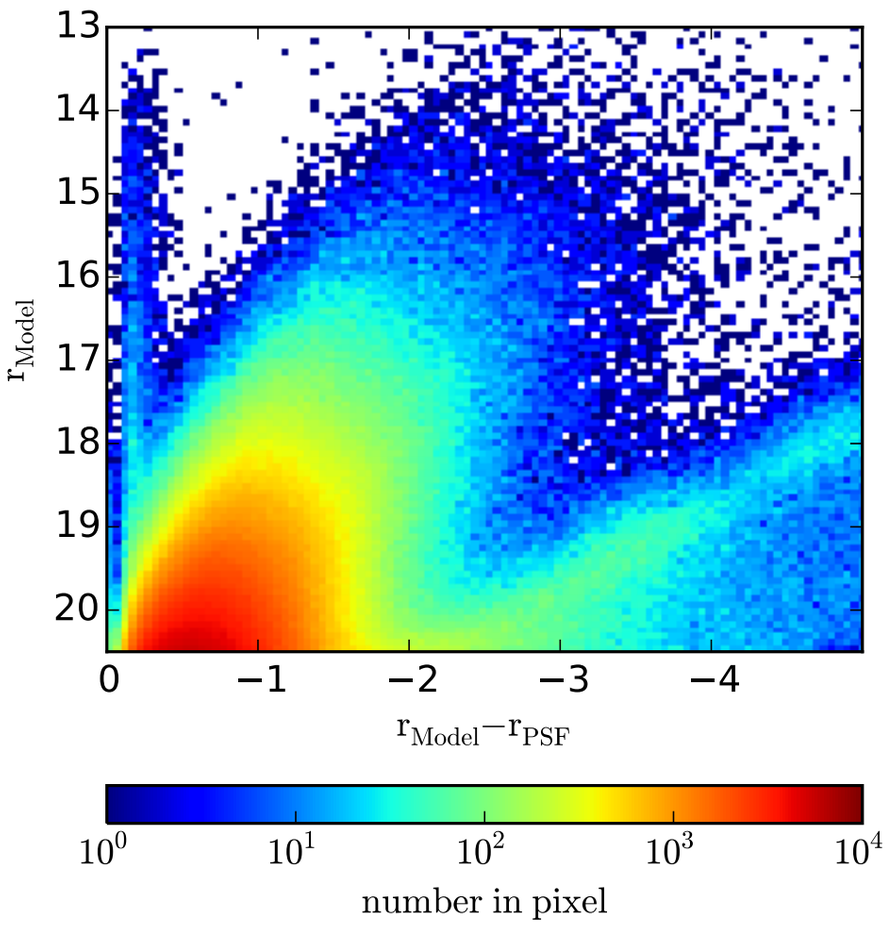
- Bulge mag
- Bulge radius
- SN mag
- Angular separation

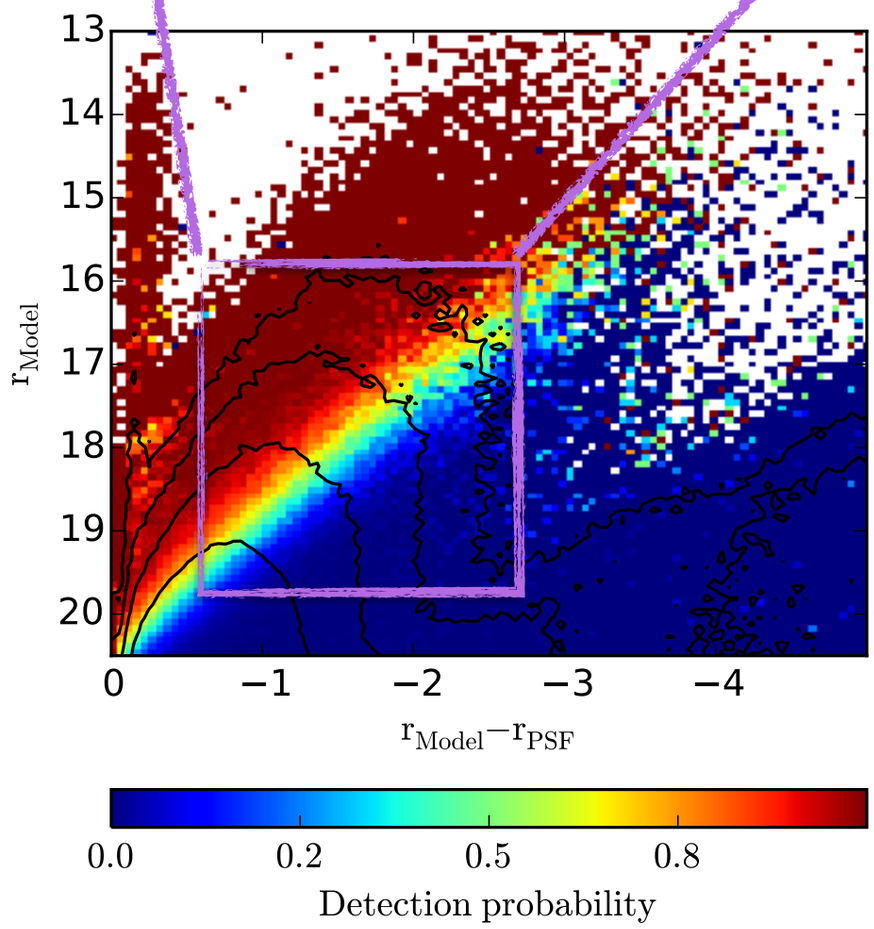




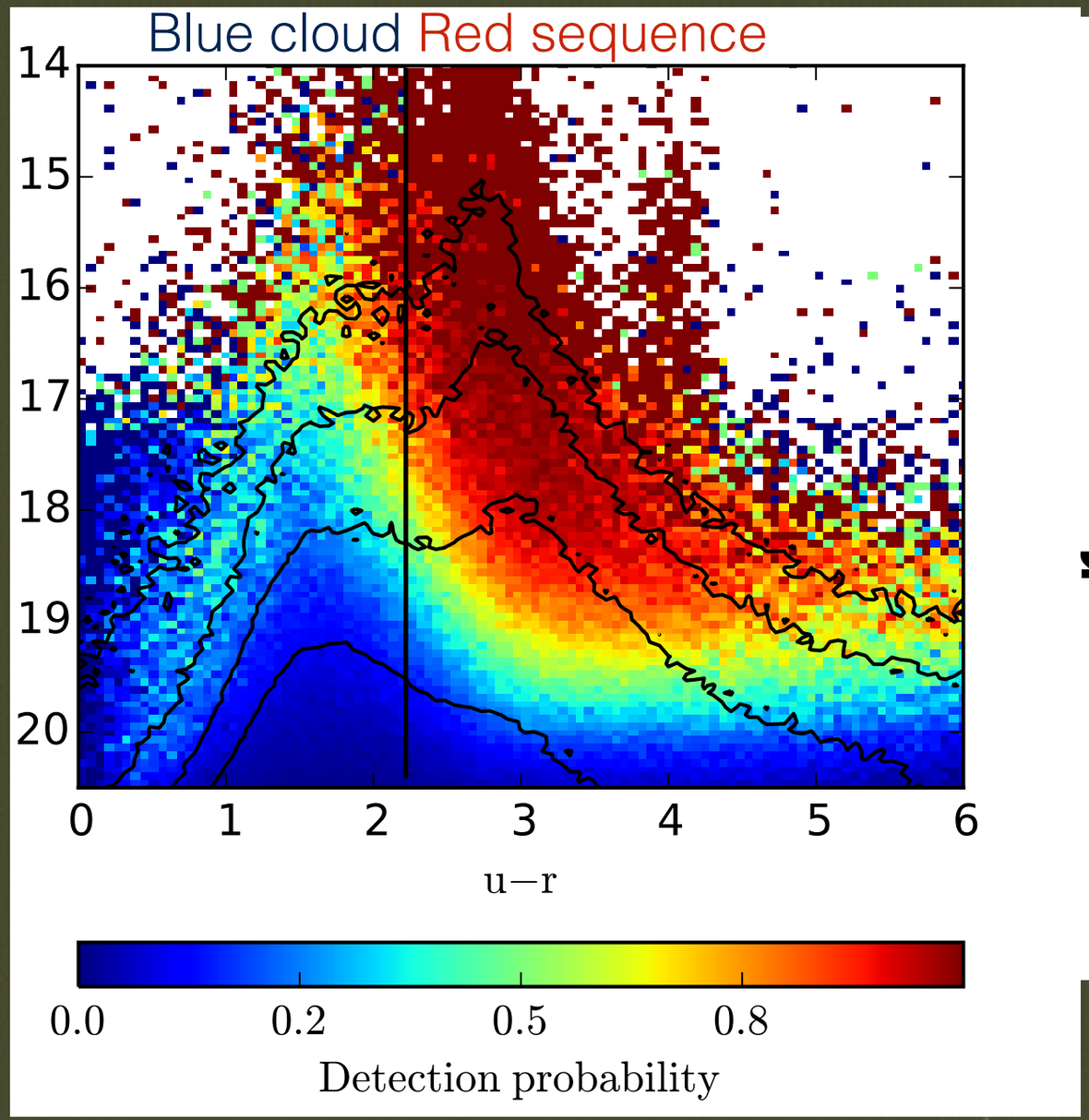
1.3M from SDSS mag< 20

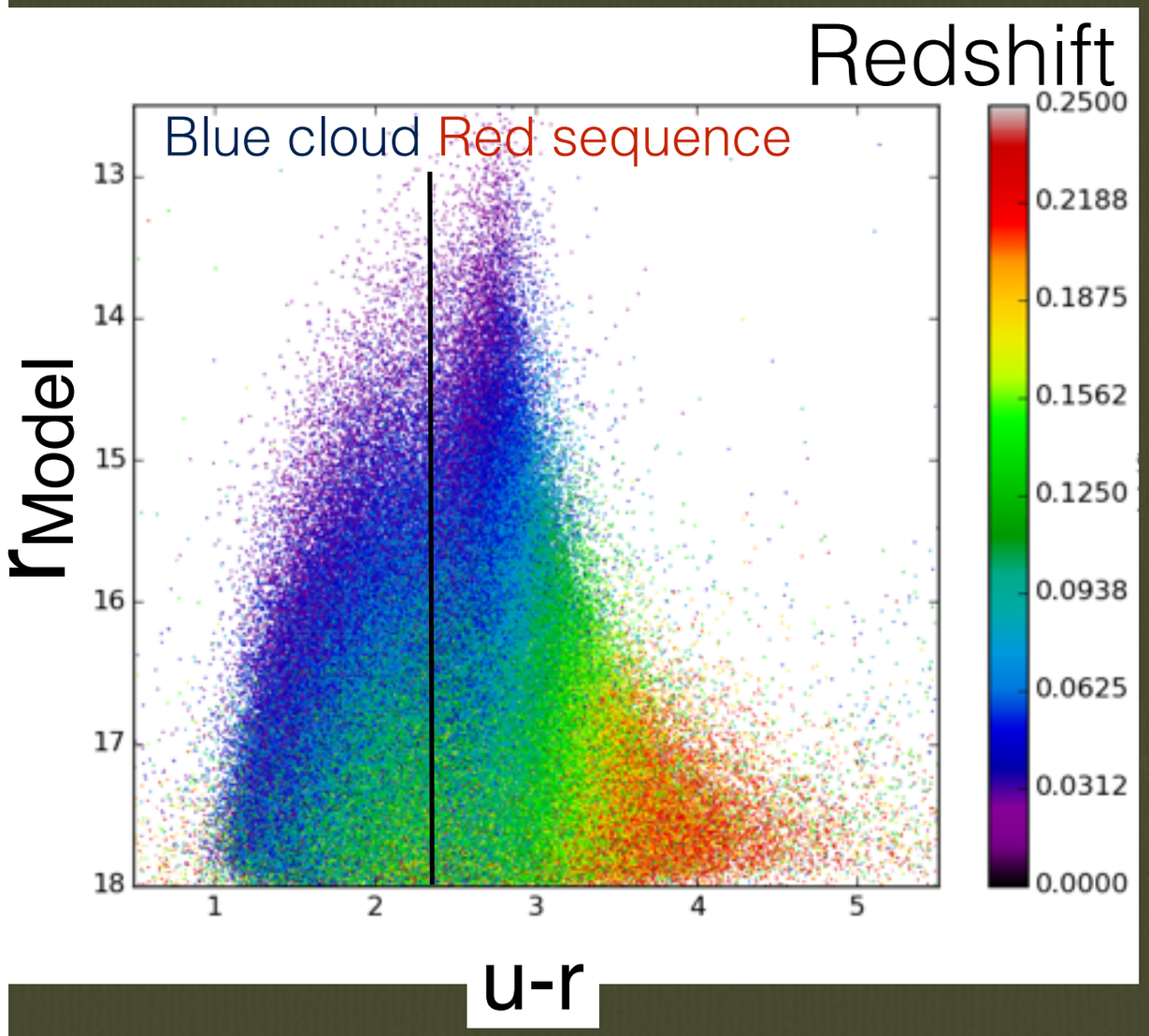
~25% galaxies detected



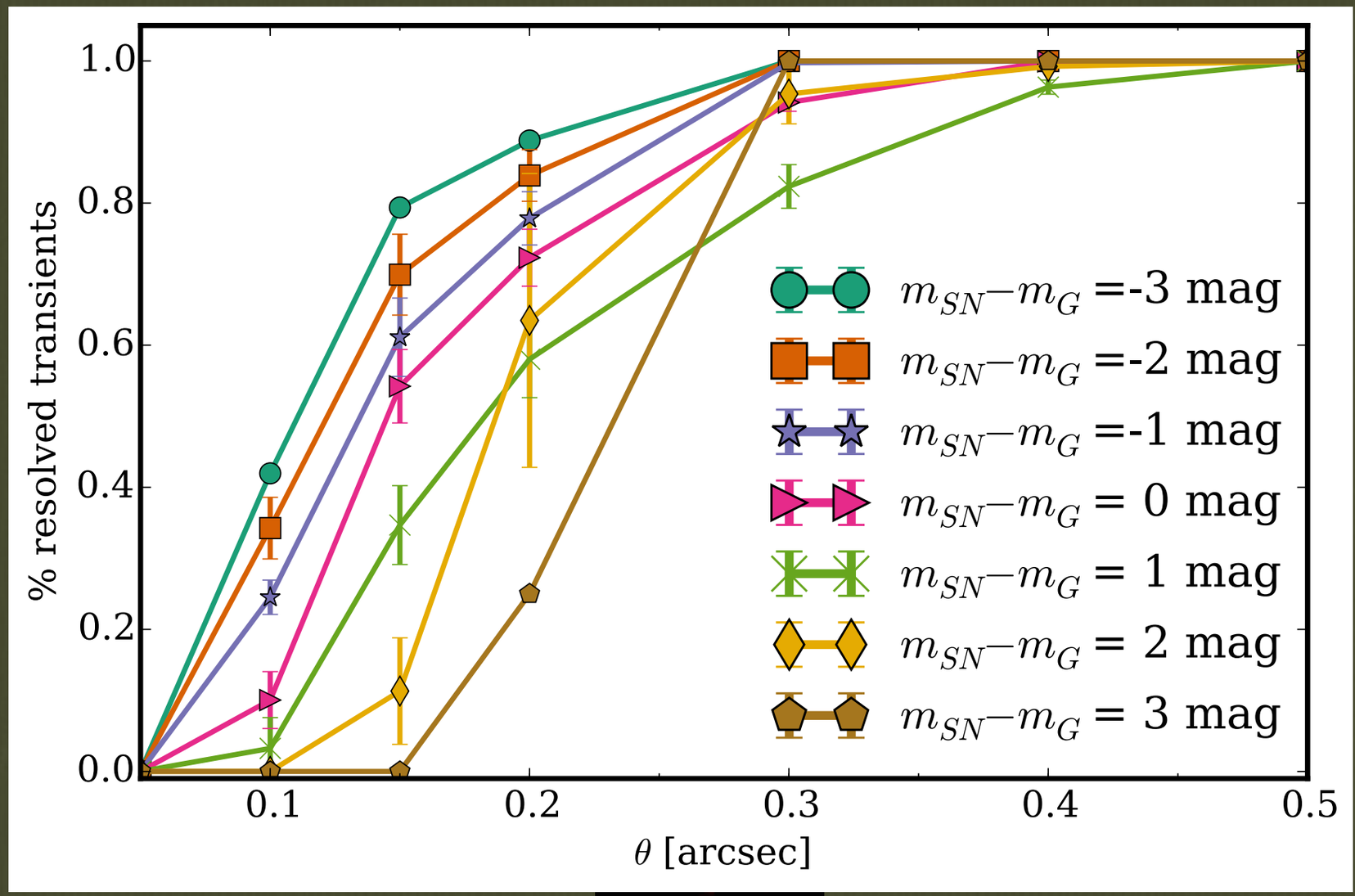


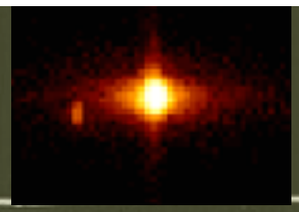
What galaxies are detected?





% resolved in function of magnitude difference bulge-SN



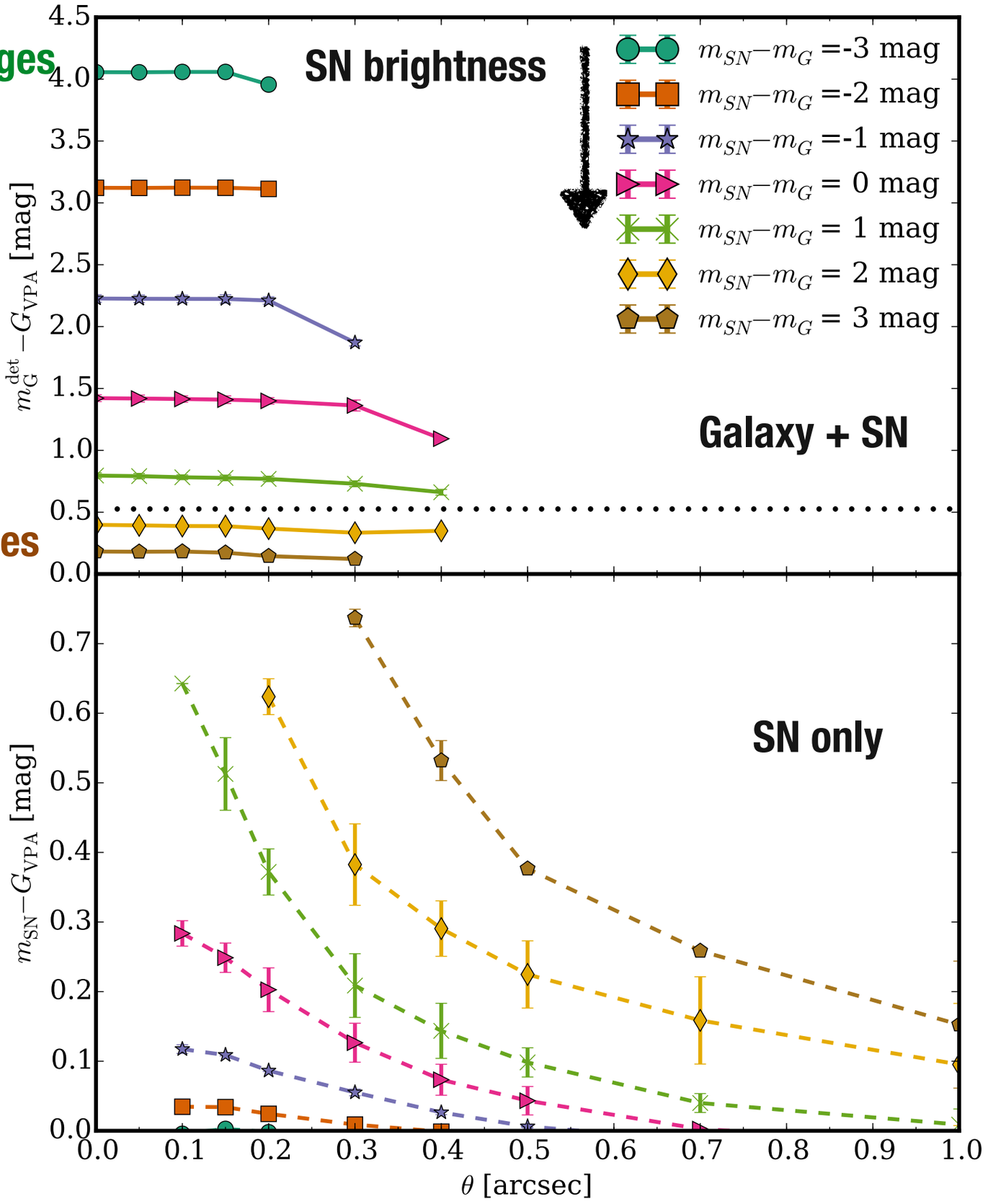


Blagorodnova et. al. 2015

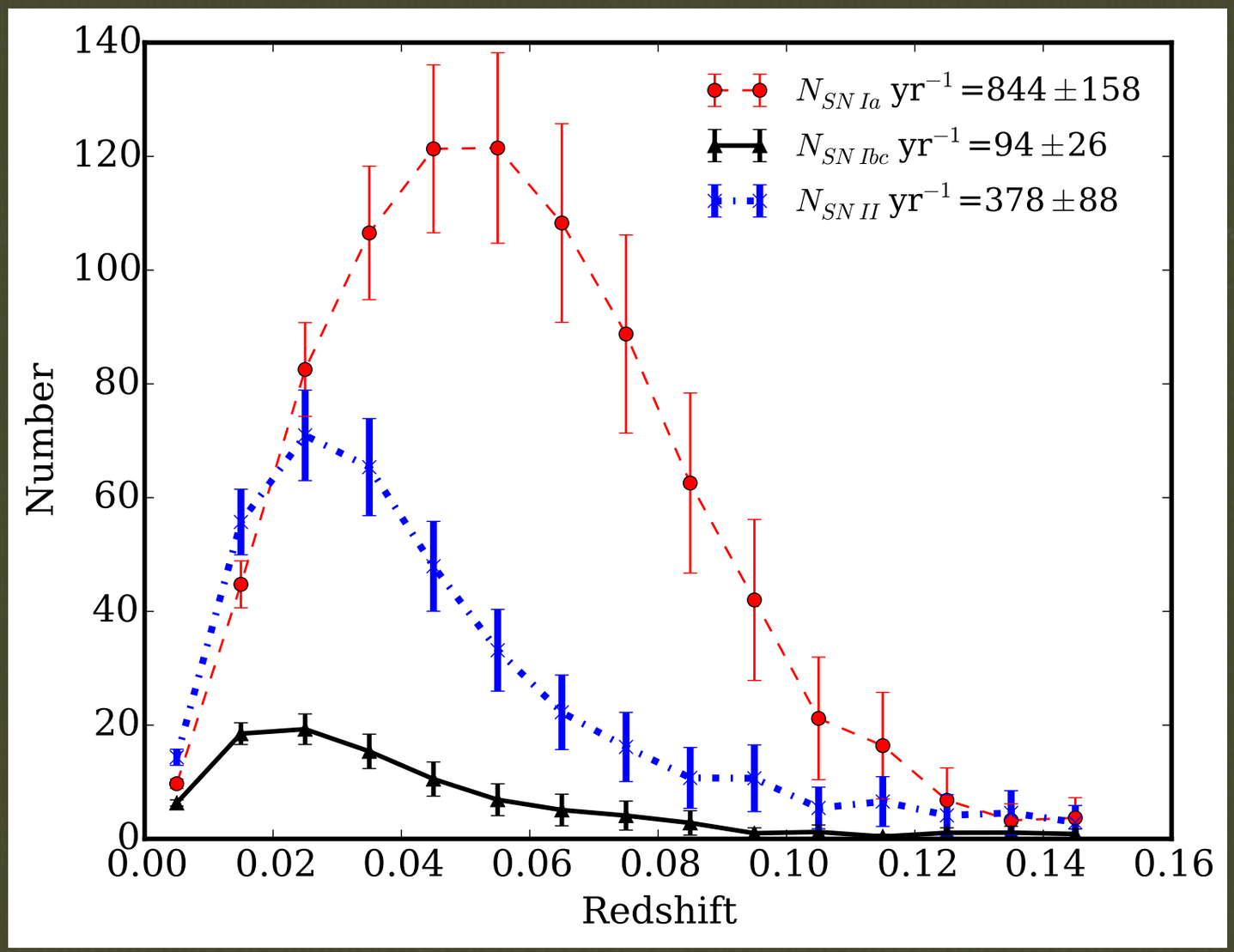
Simulation for bulges with Re=1 arcsec

Fainter bulges

Brighter bulges



Expected number of SNe. Limiting Magnitude=19

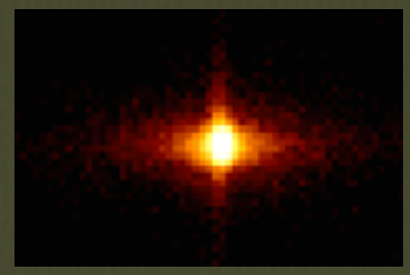


Blagorodnova et. al. 2015

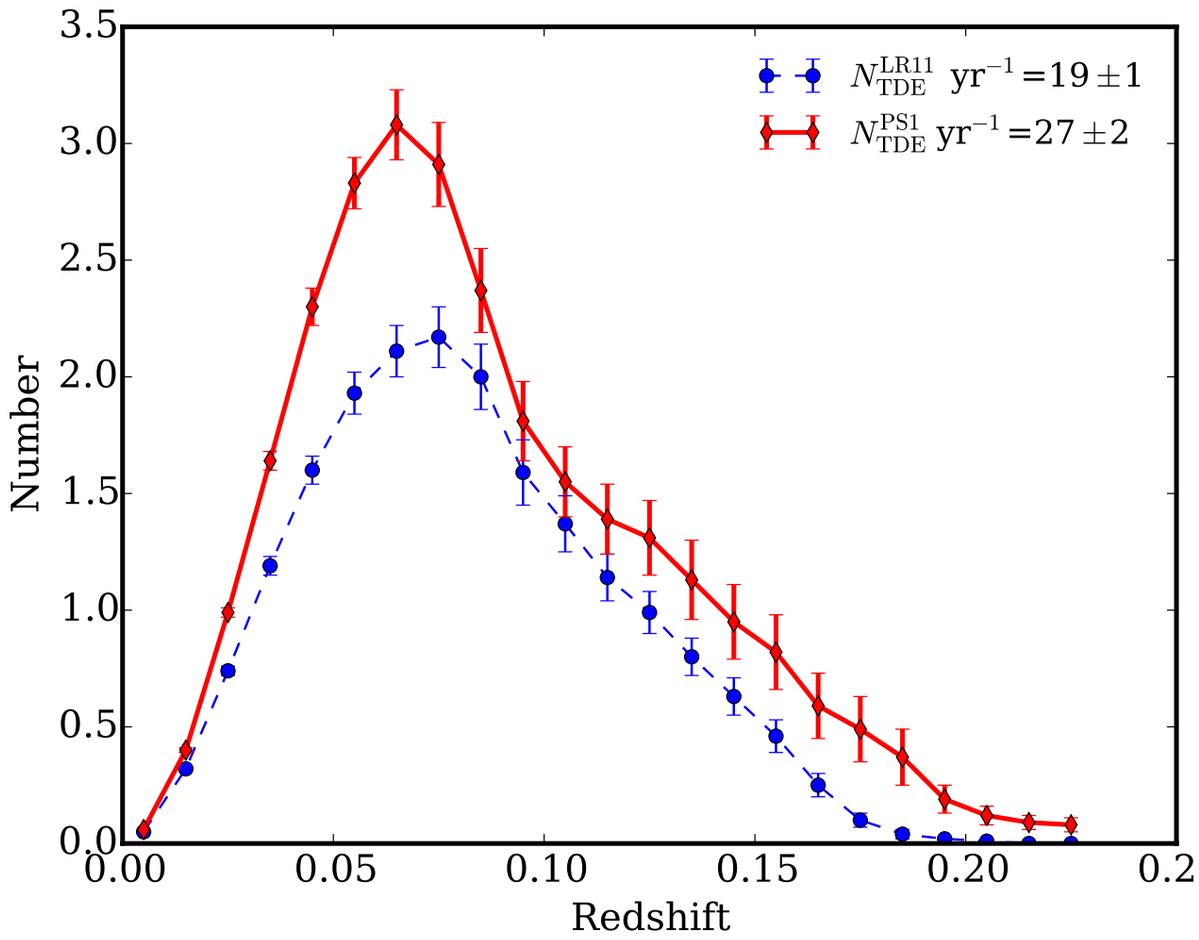
Orphan in Gaia:

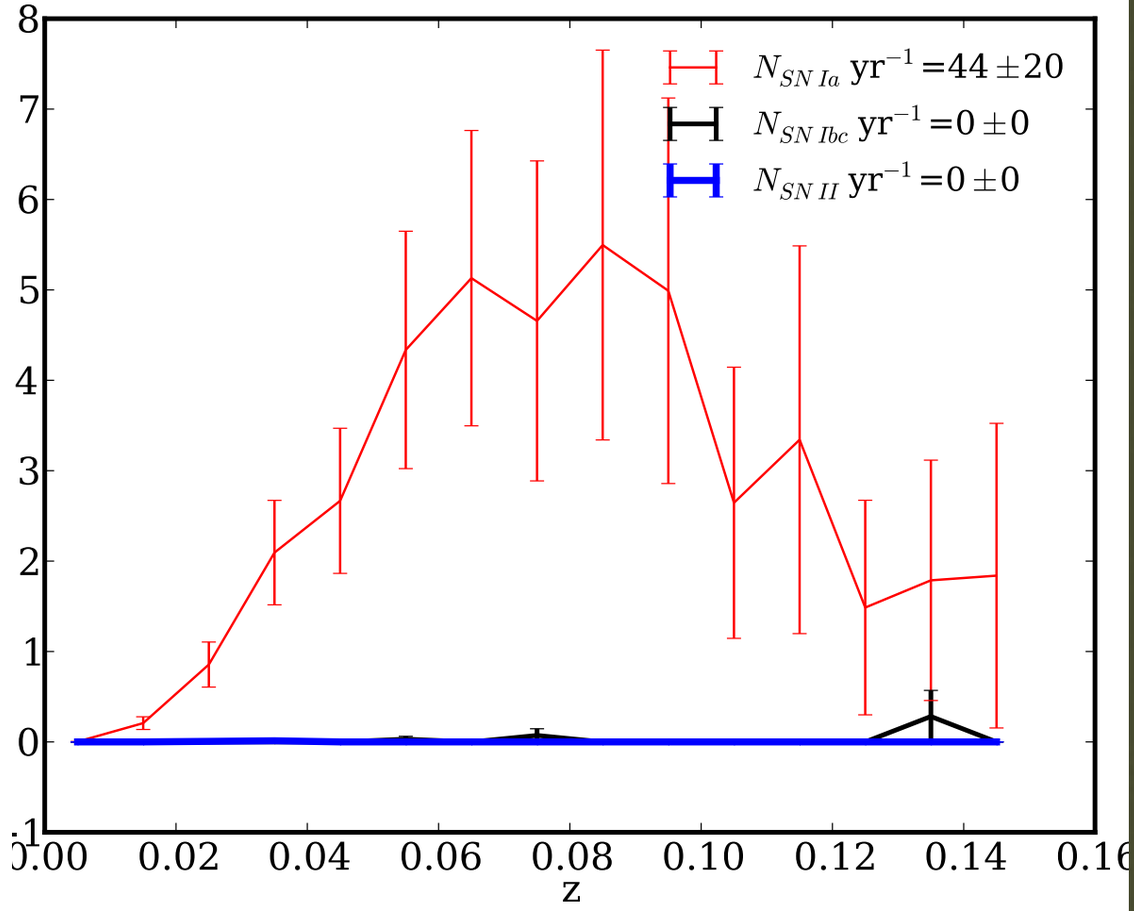
75% SN Ia
90% CCSN

TDE vs. SN - nuclear case



m_{lim} = 19mag, Δm=0.5mag

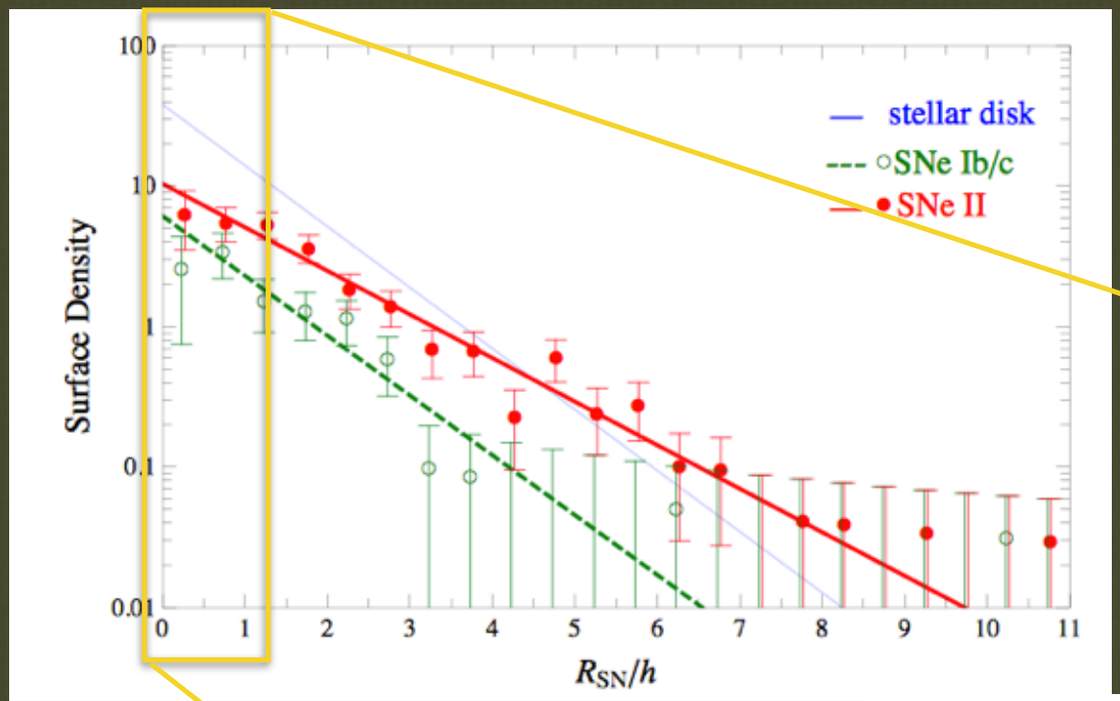




Detected TDE ~ Detected unresolved SN

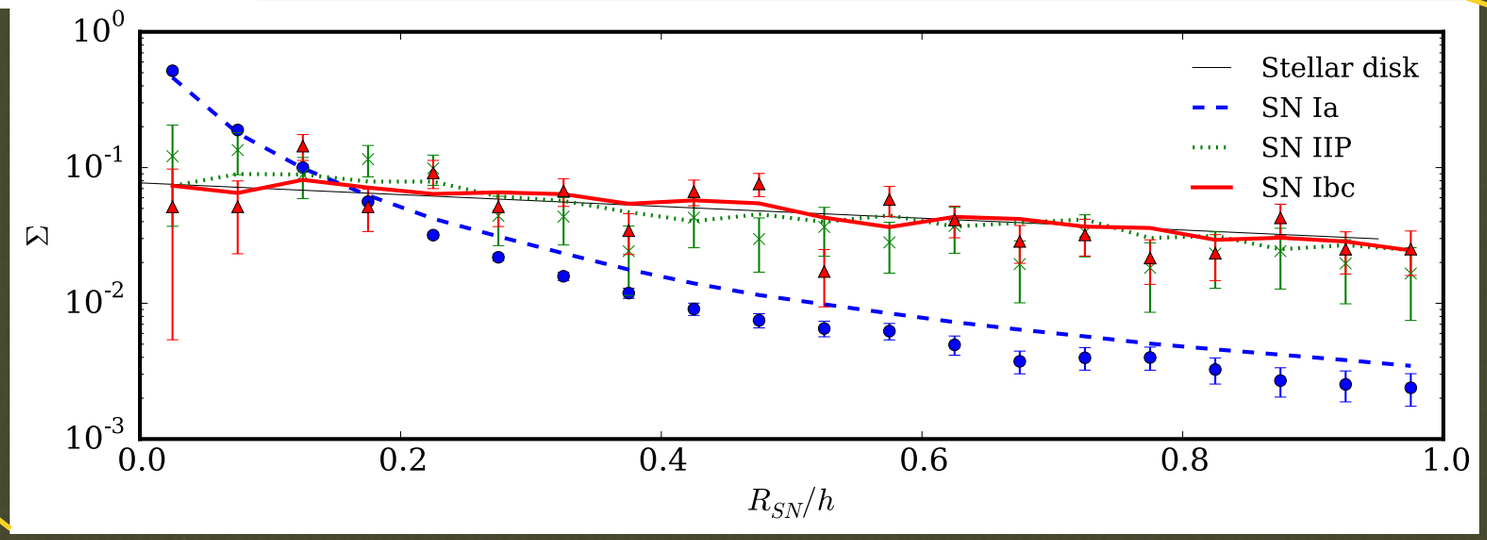
-> Low contamination!

SN density distribution



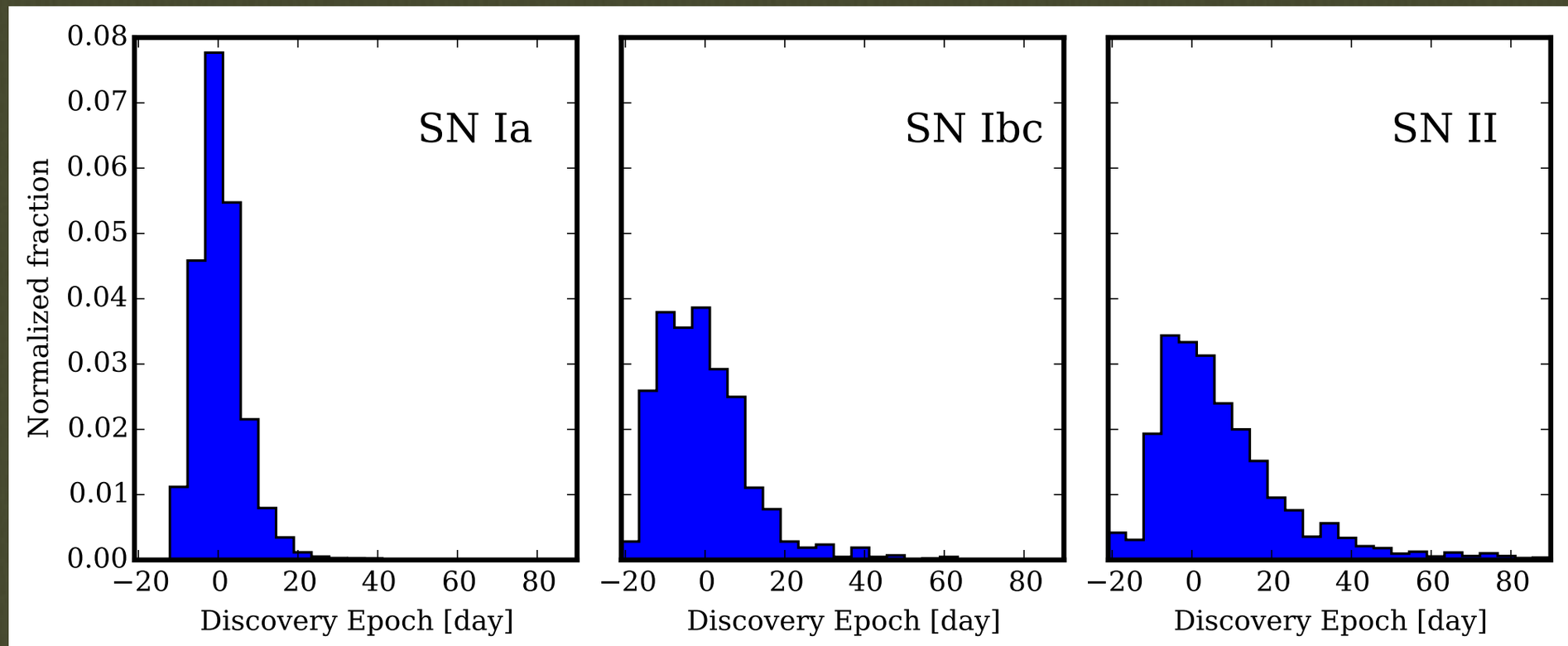
Hakobyan et. al, 2008

No noticeable decrease in the number of detections close to nucleus



Blagorodnova et. al. 2015

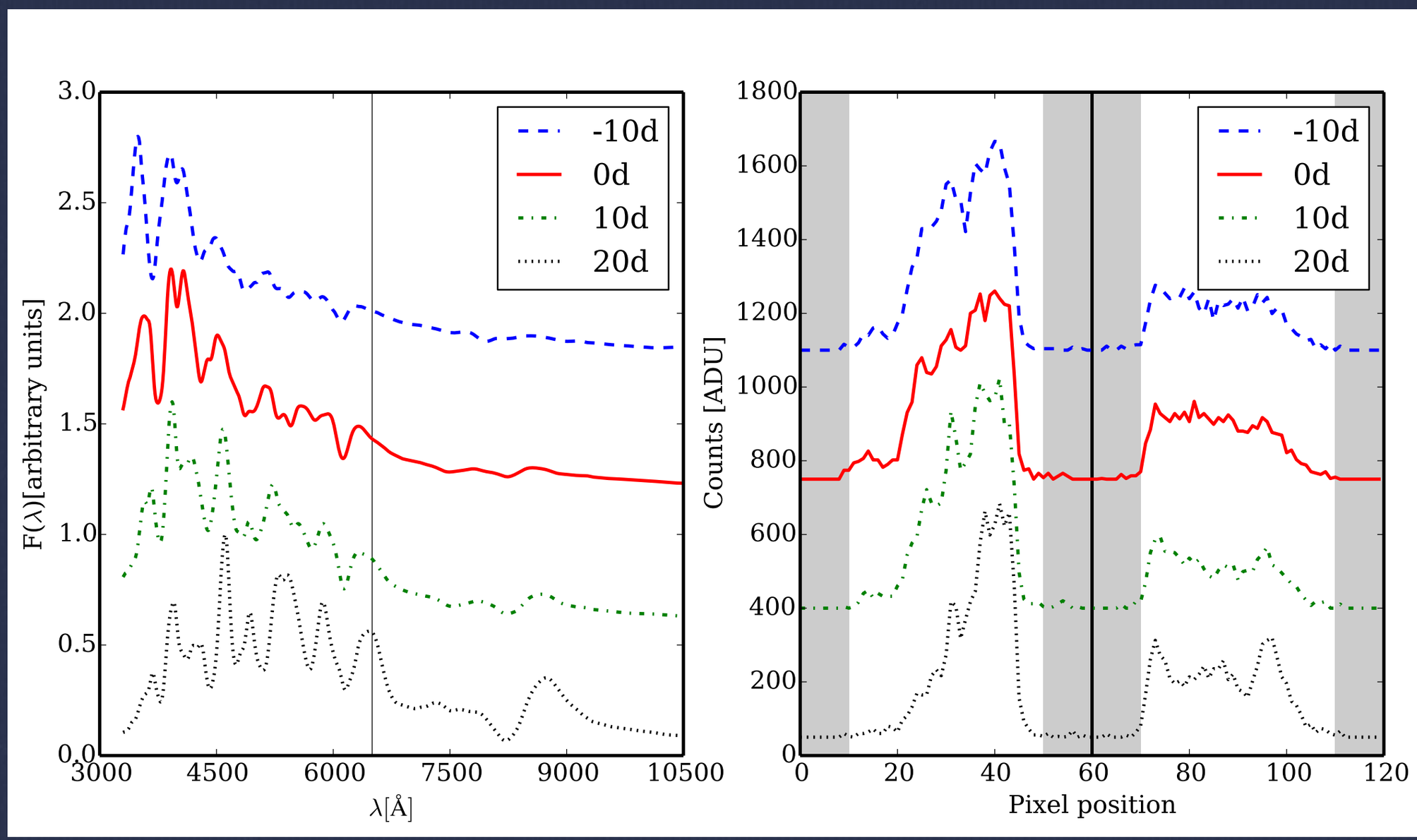
SN epoch at discovery



Existing low resolution spectra for classification!

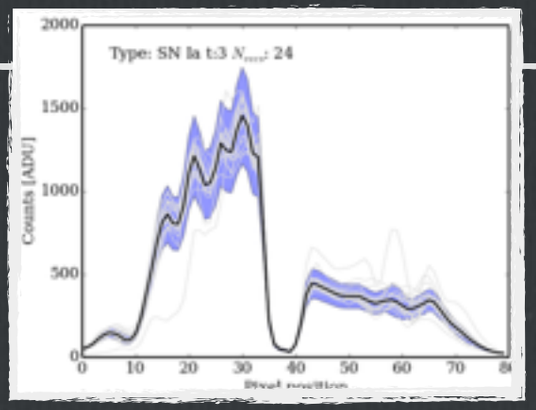
Gaia Transient Classification

Blue **Red**

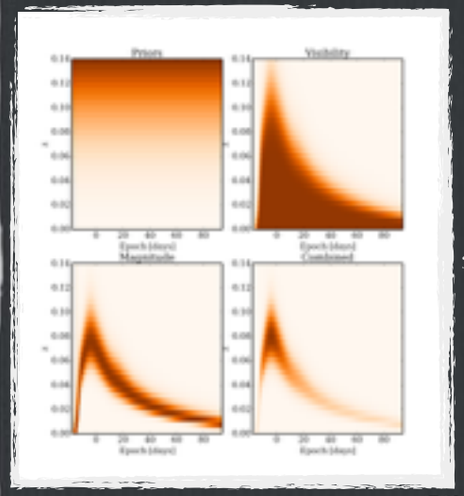


SNIa templates from Hsiao et. al 2007

GSTEC-Gaia Spectrophotometry Transient Event Classifier

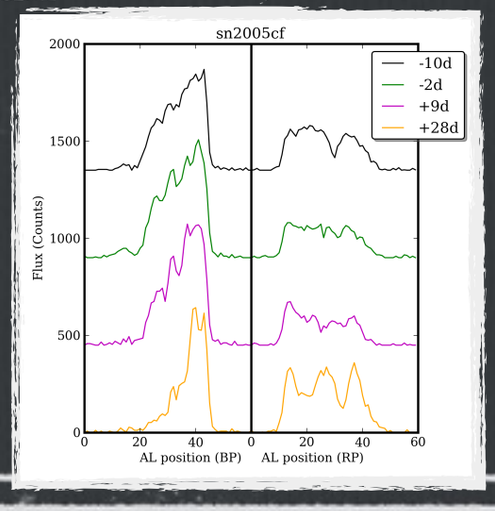


Spectral libraries



Priors

Input spectra

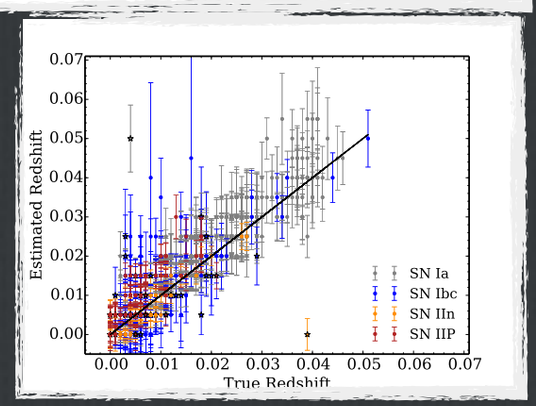


GS-TEC

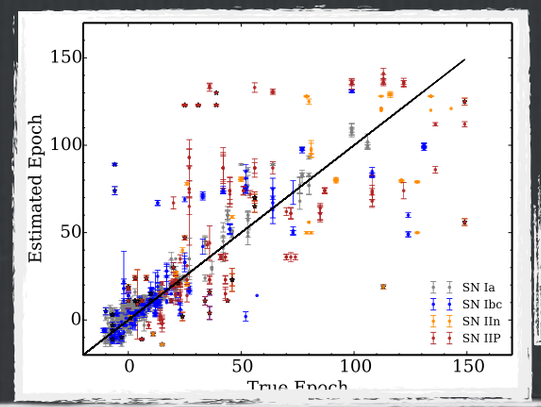
$$P(M|D, m_G, \mathbf{v}) = \frac{P(D, m_G, \mathbf{v}|M)P(M)}{\int P(D, m_G, \mathbf{v}|M)P(M)dM}$$

Blagorodnova et. al. 2014

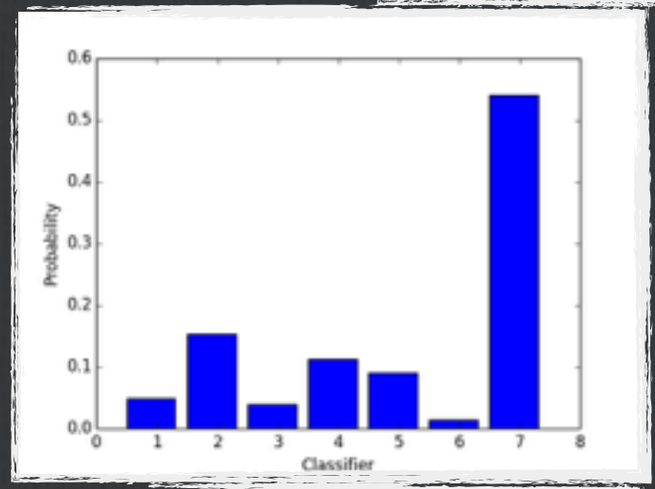
z



epoch

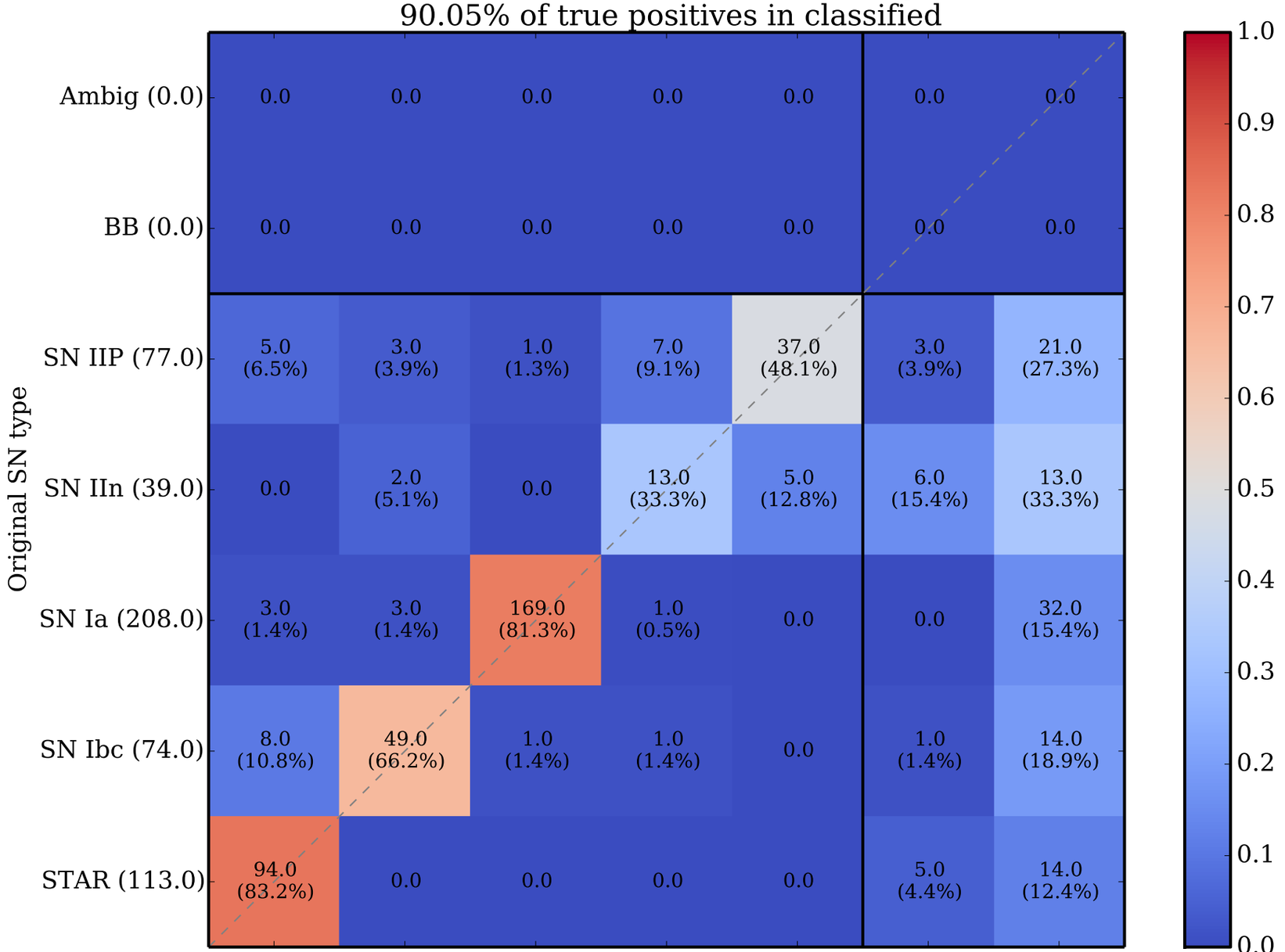


P(type)

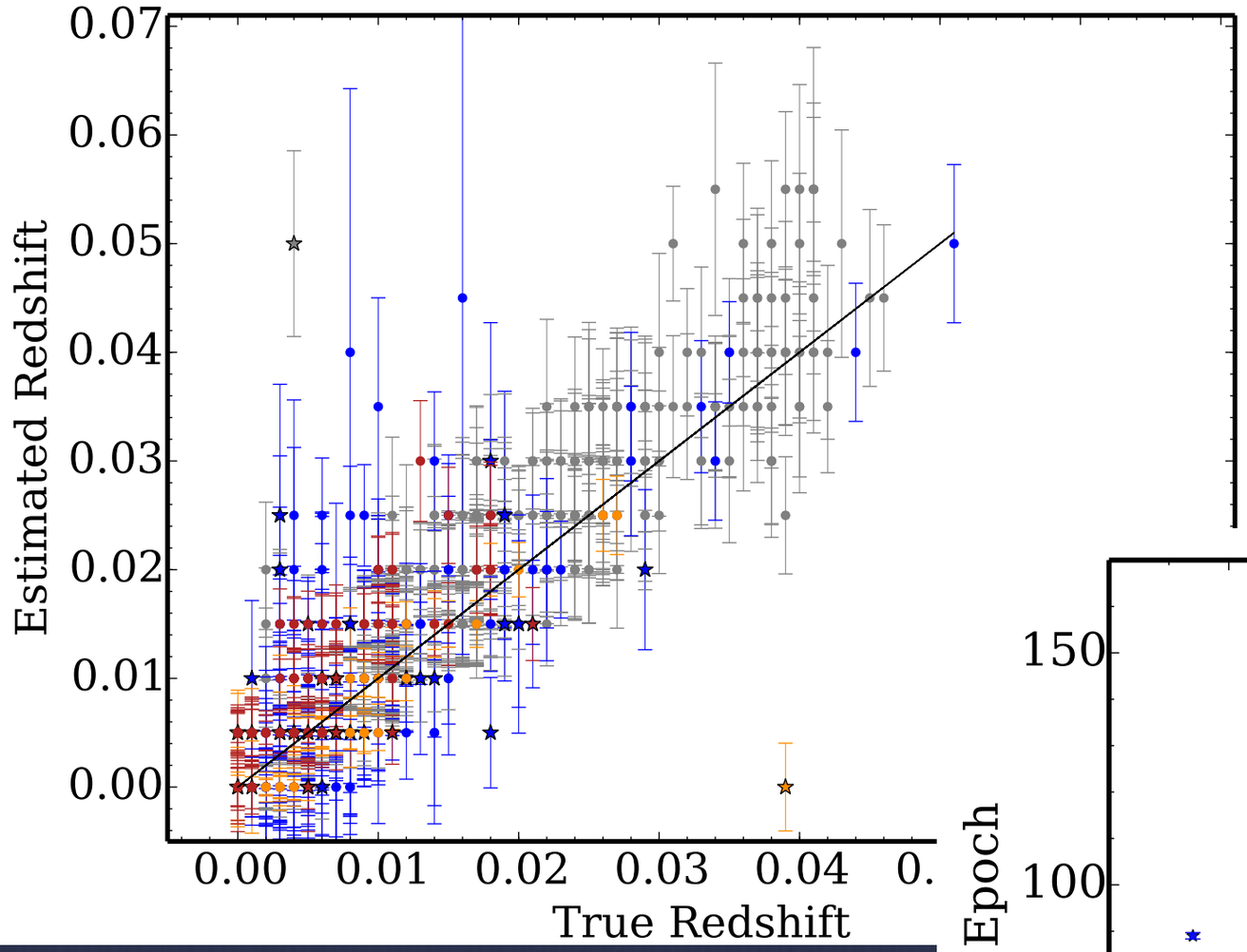


Confusion Matrix for G=18mag.
21.33% unclassified (BB or Ambig)
90.05% of true positives in classified

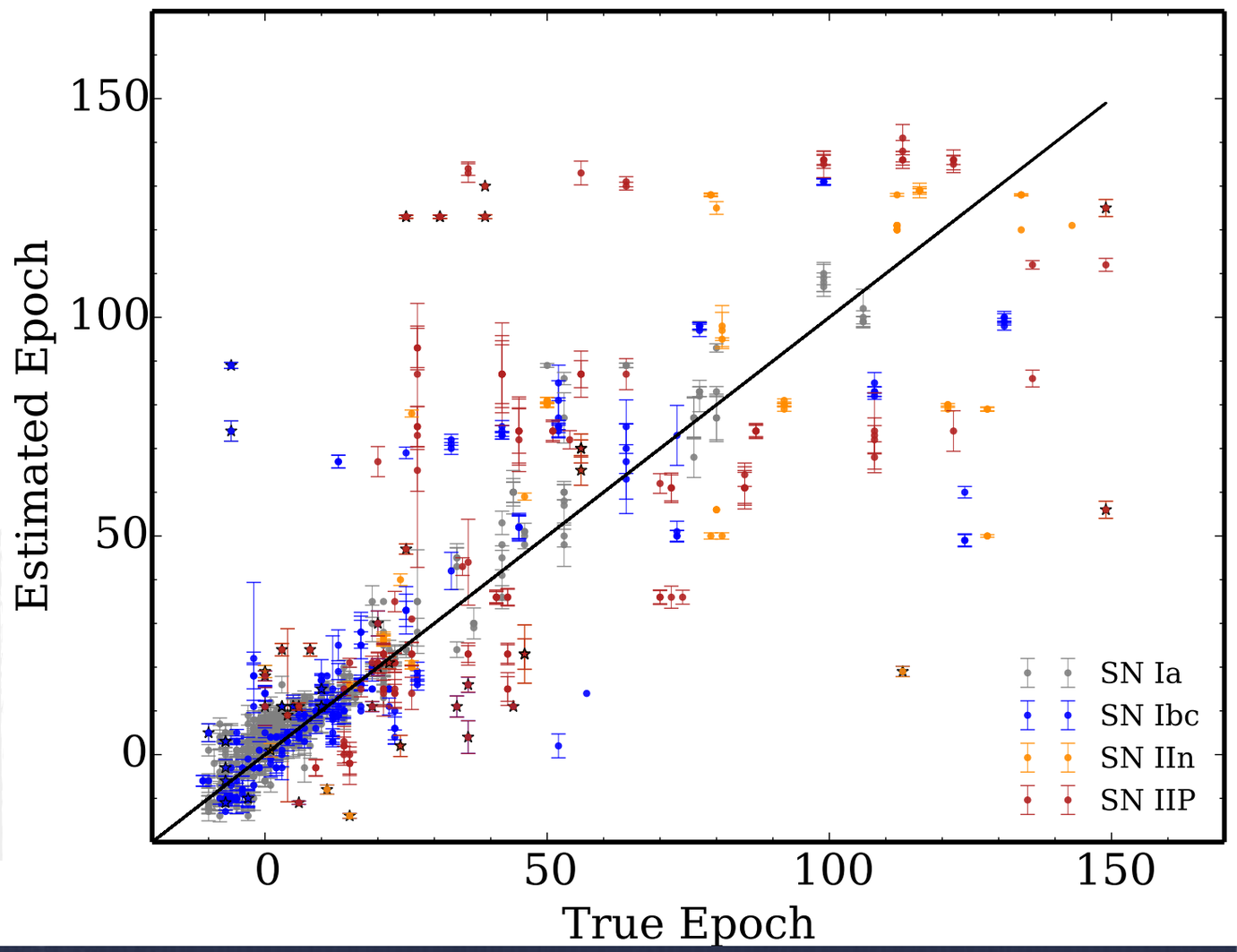
Original SN type \ Predicted type	STAR	SN Ibc	SN Ia	SN IIn	SN IIP	BB	Ambig
Ambig (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB (0.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SN IIP (77.0)	5.0 (6.5%)	3.0 (3.9%)	1.0 (1.3%)	7.0 (9.1%)	37.0 (48.1%)	3.0 (3.9%)	21.0 (27.3%)
SN IIn (39.0)	0.0	2.0 (5.1%)	0.0	13.0 (33.3%)	5.0 (12.8%)	6.0 (15.4%)	13.0 (33.3%)
SN Ia (208.0)	3.0 (1.4%)	3.0 (1.4%)	169.0 (81.3%)	1.0 (0.5%)	0.0	0.0	32.0 (15.4%)
SN Ibc (74.0)	8.0 (10.8%)	49.0 (66.2%)	1.0 (1.4%)	1.0 (1.4%)	0.0	1.0 (1.4%)	14.0 (18.9%)
STAR (113.0)	94.0 (83.2%)	0.0	0.0	0.0	0.0	5.0 (4.4%)	14.0 (12.4%)



Redshift estimation



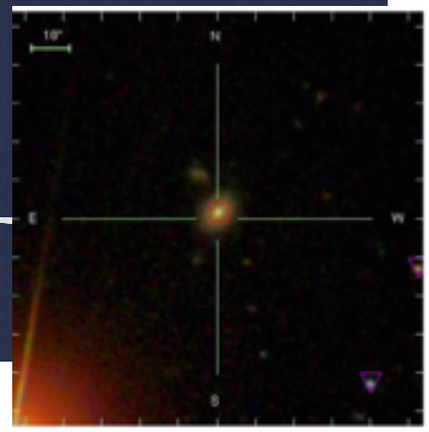
Epoch estimation

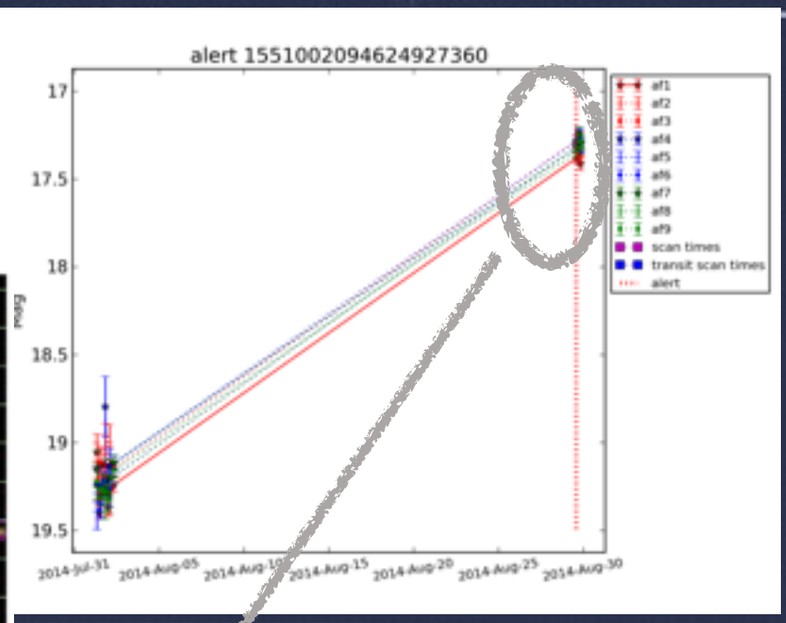


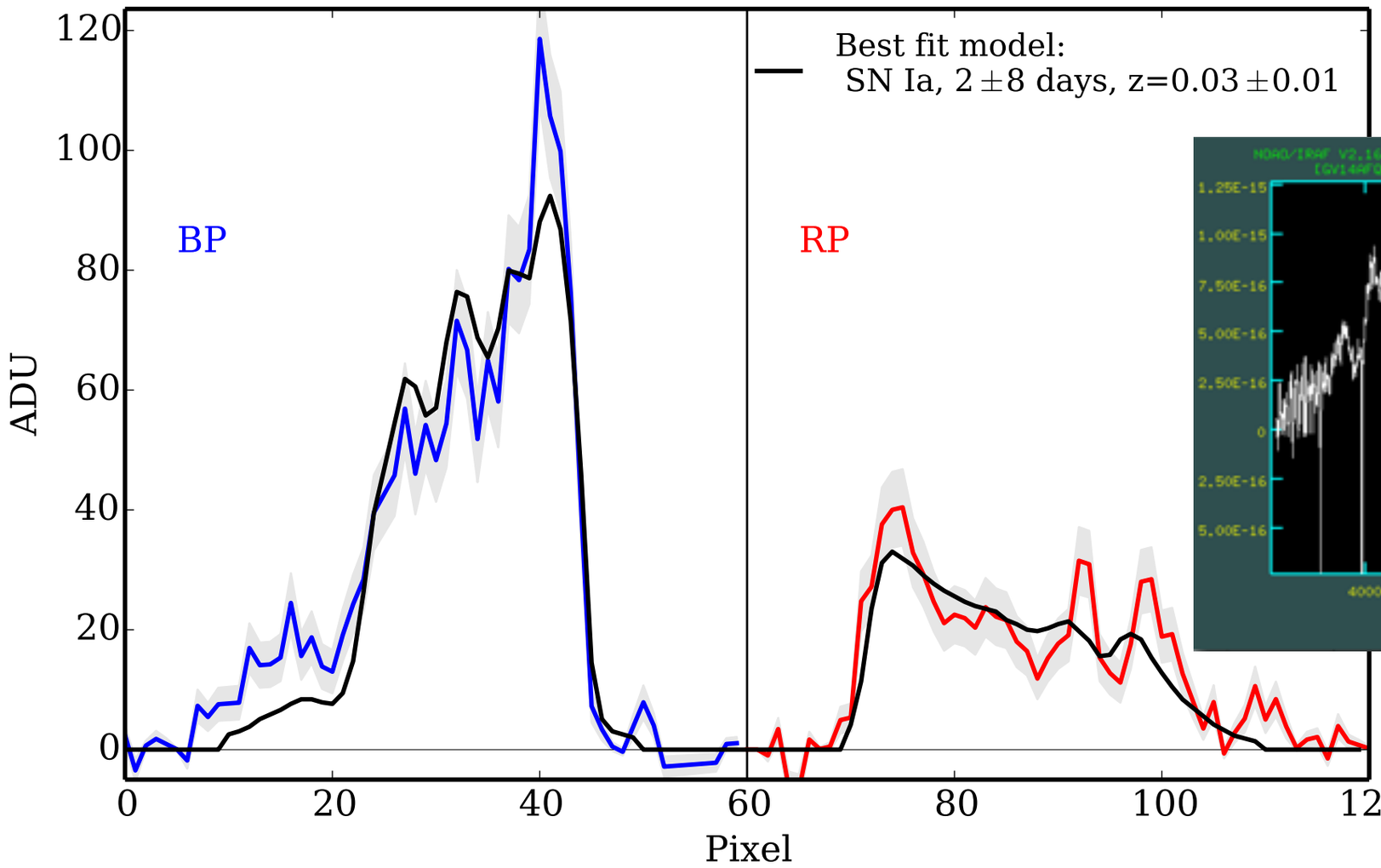
Blagorodnova et. al, 2014

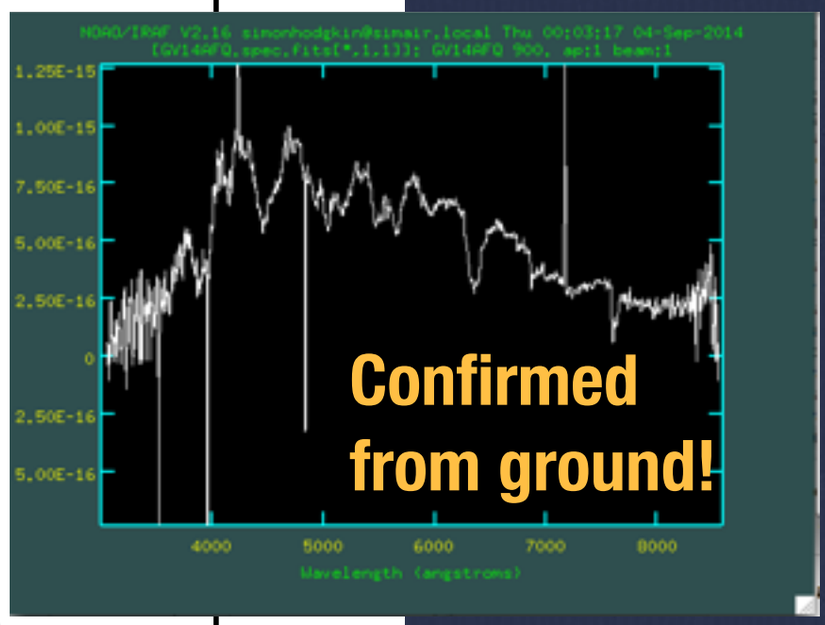
First Gaia SN BP/RP classification!

Identification of the first Gaia SN as SN Ia at z=0.03!

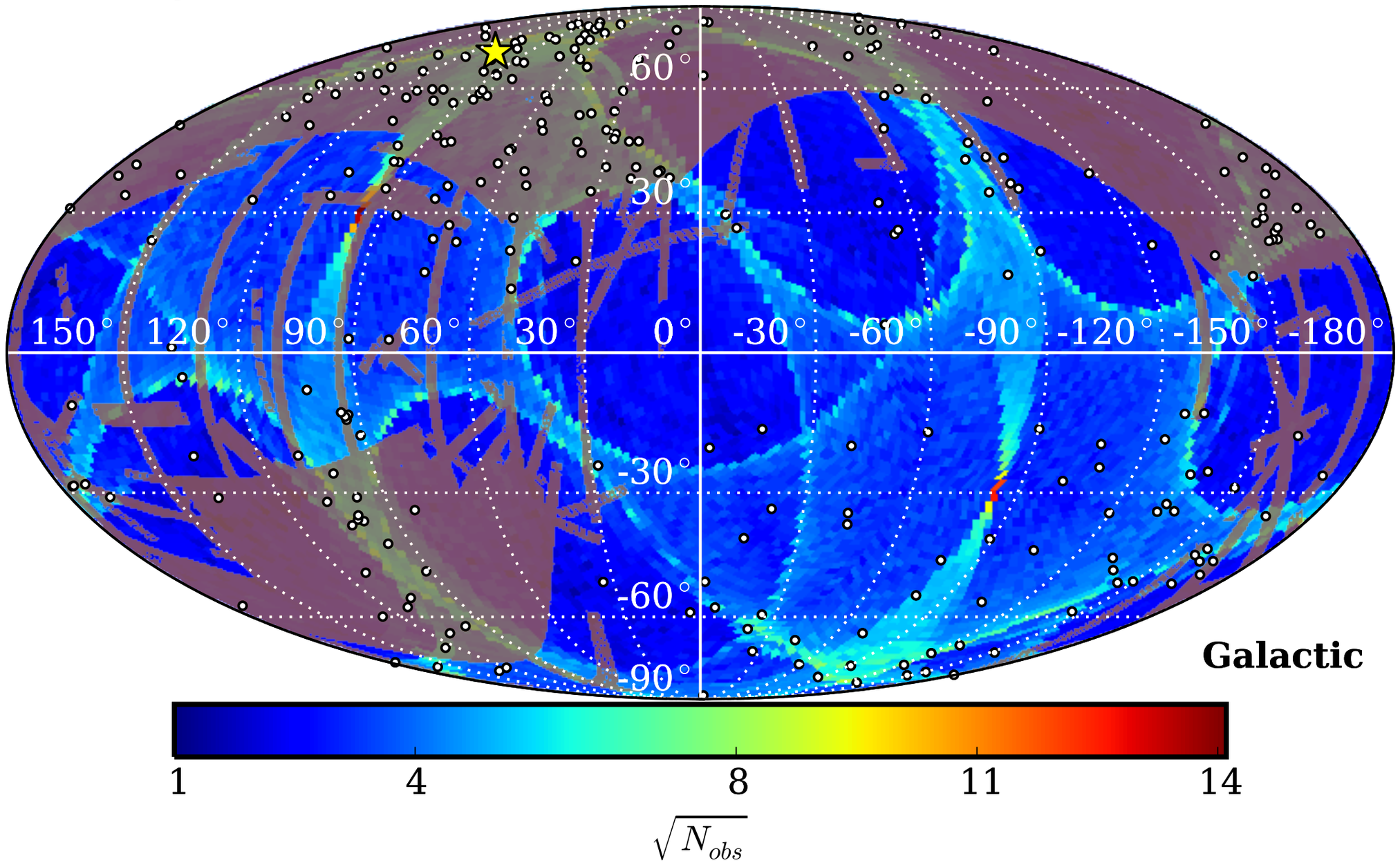








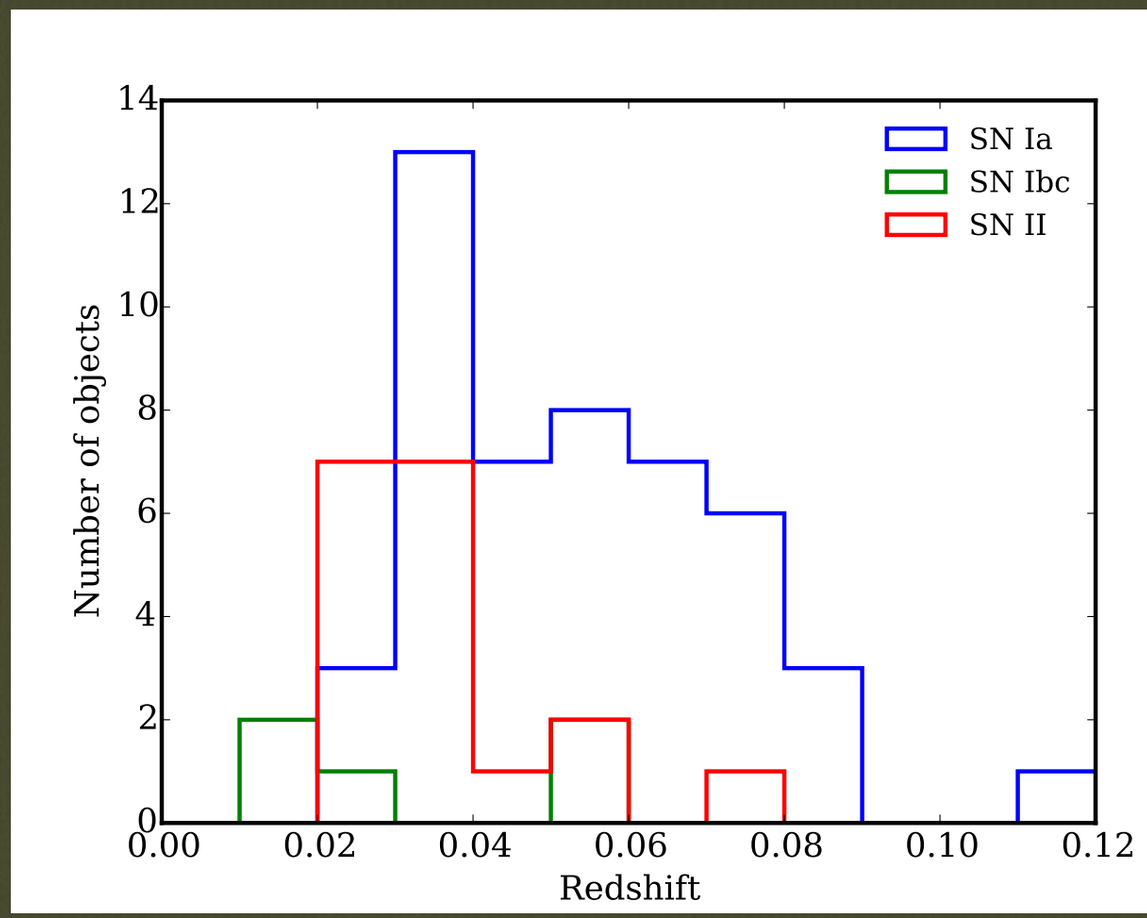
Gaia14aaa

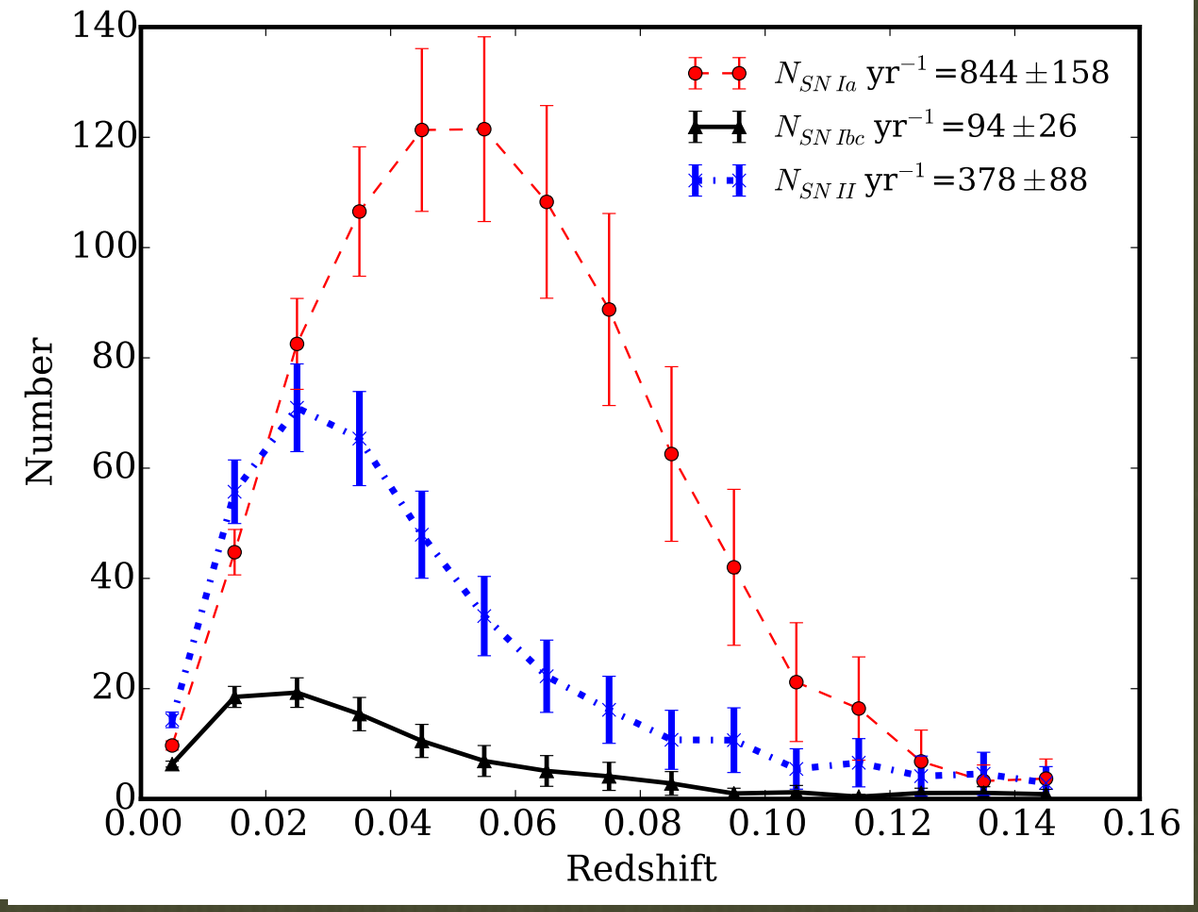


Density of observations until June 2015

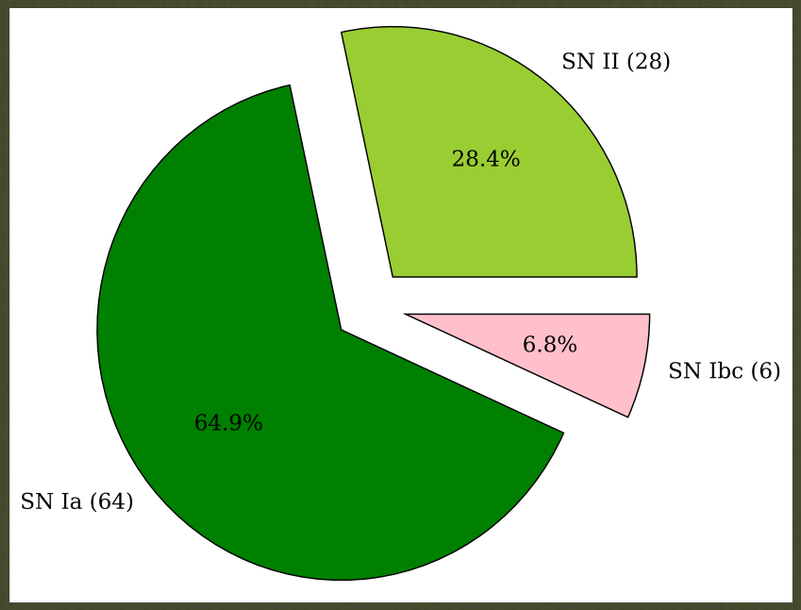
Gaia Alerts (so far)

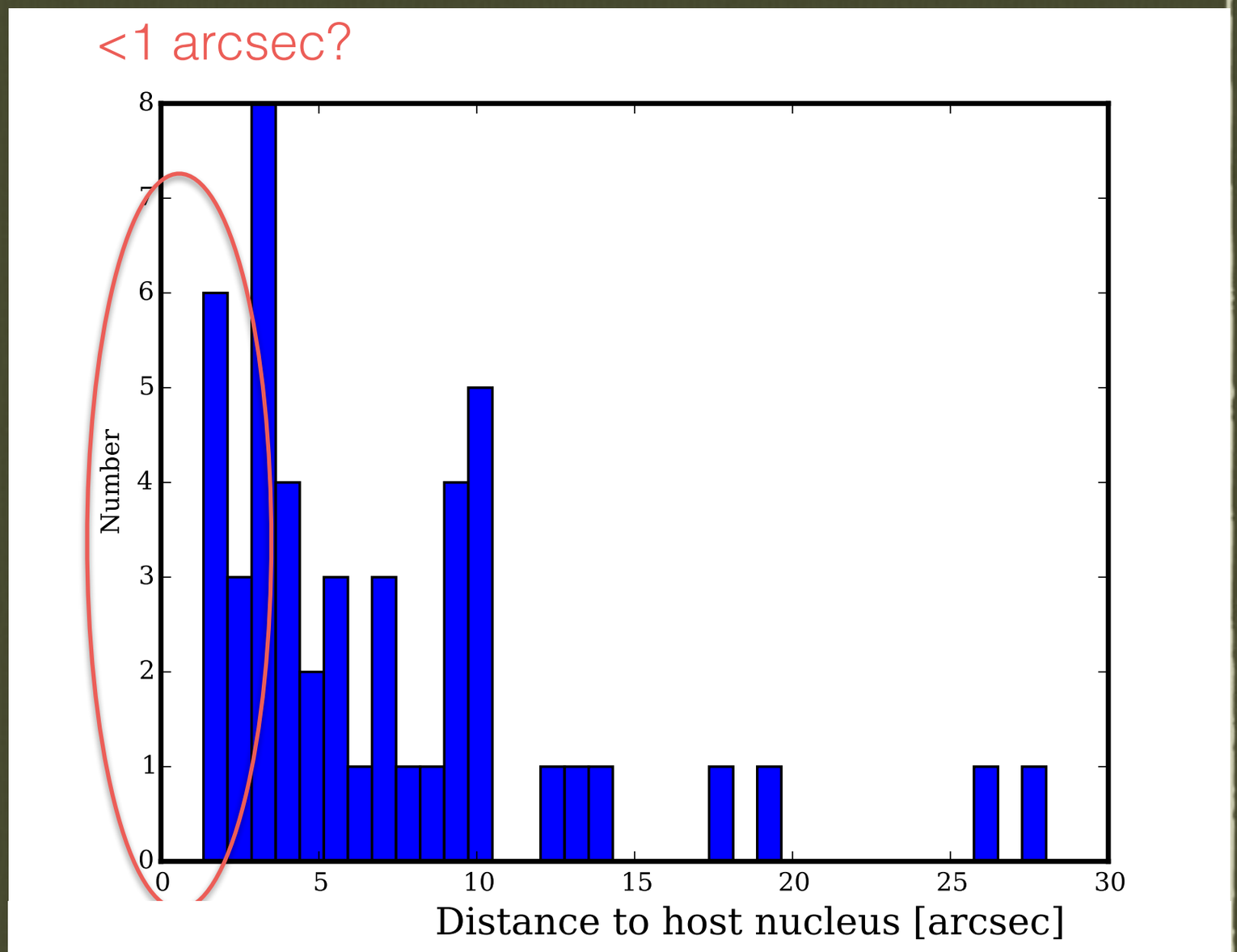
- 275 published alerts until June 2015
- 98 spectroscopically confirmed SN



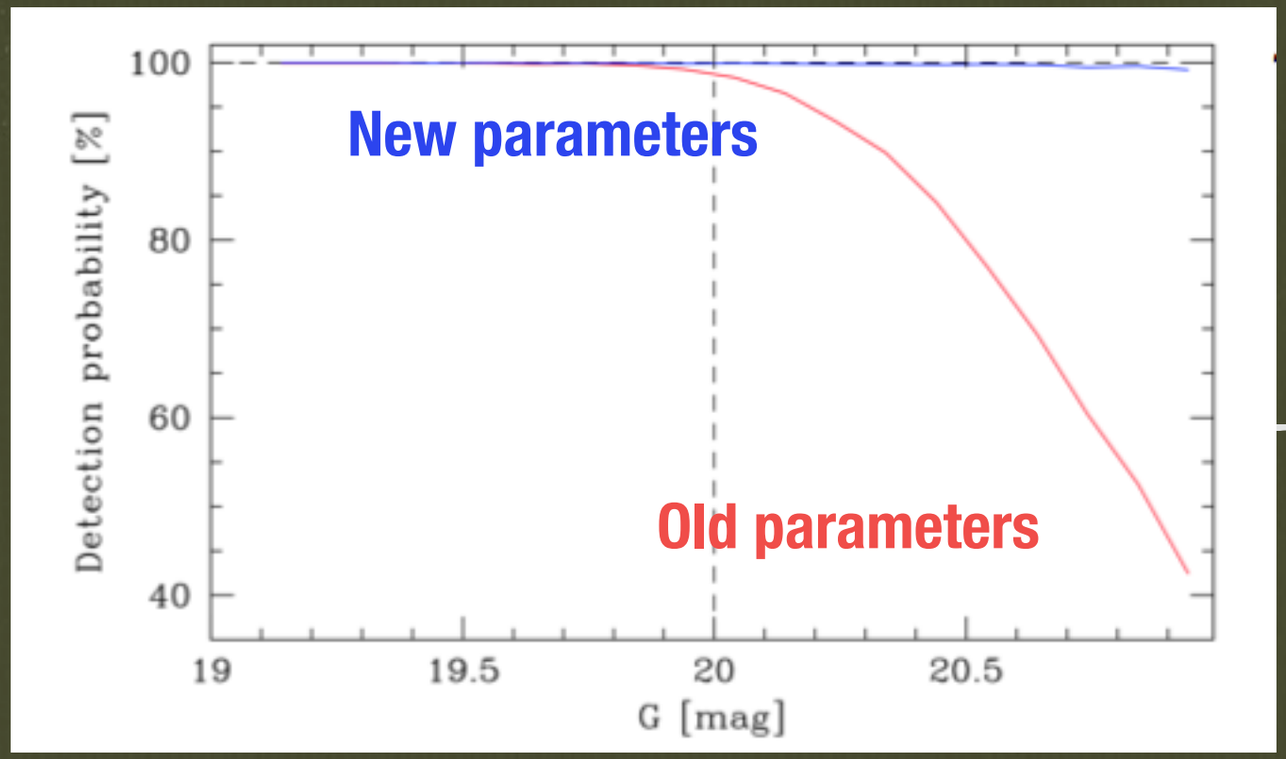


Gaia Alerts (so far)

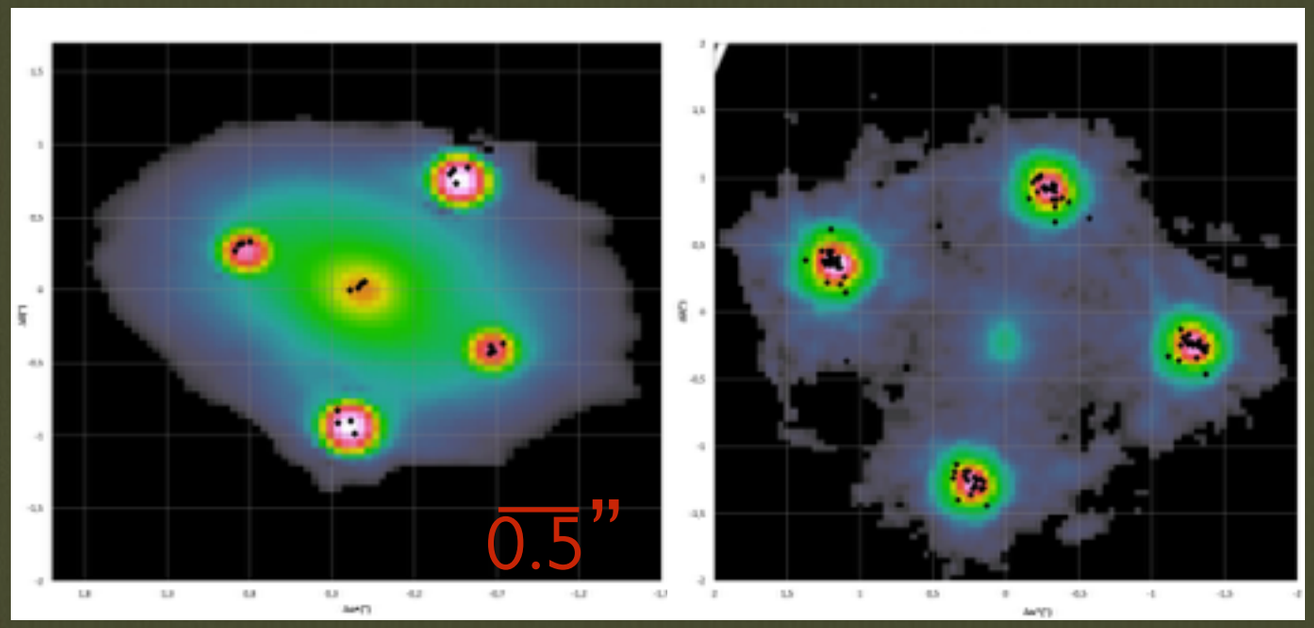




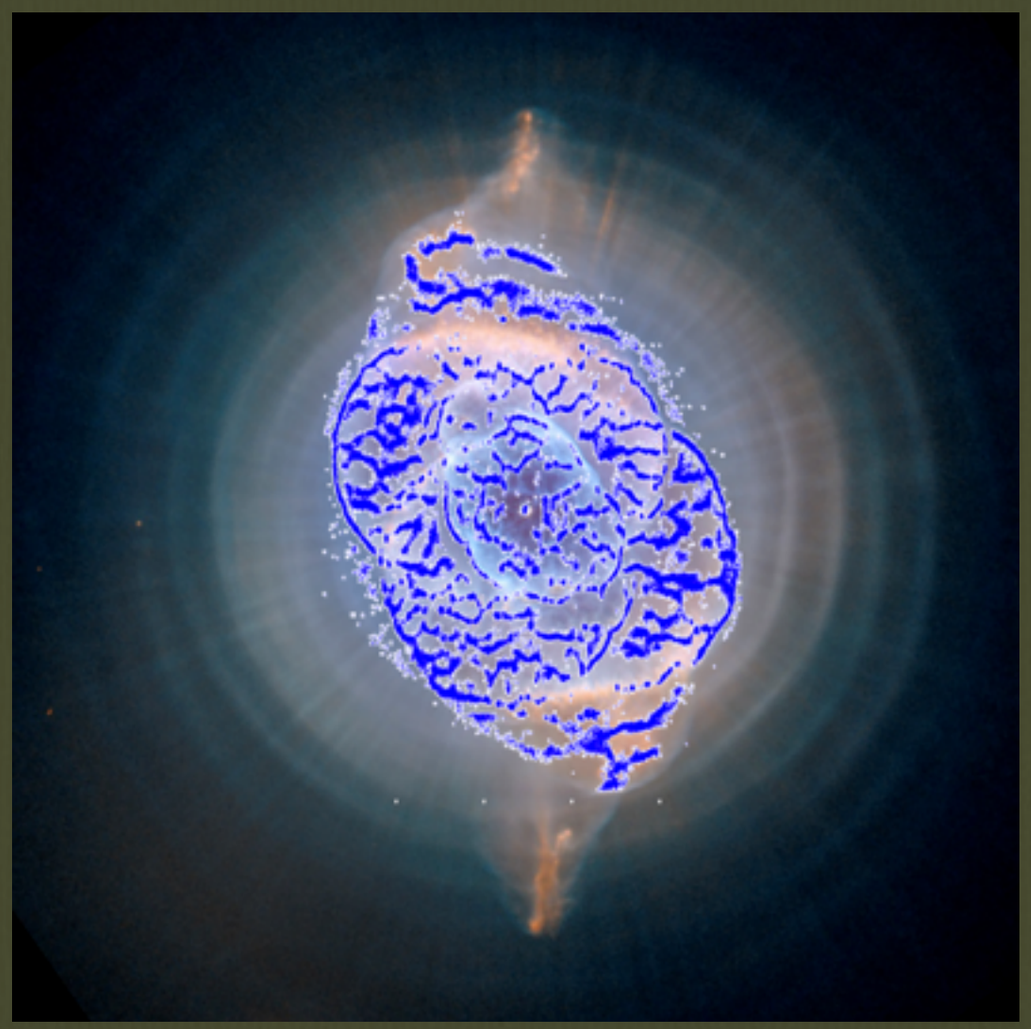
On-board parameters



De Bruijne et. al, 2015



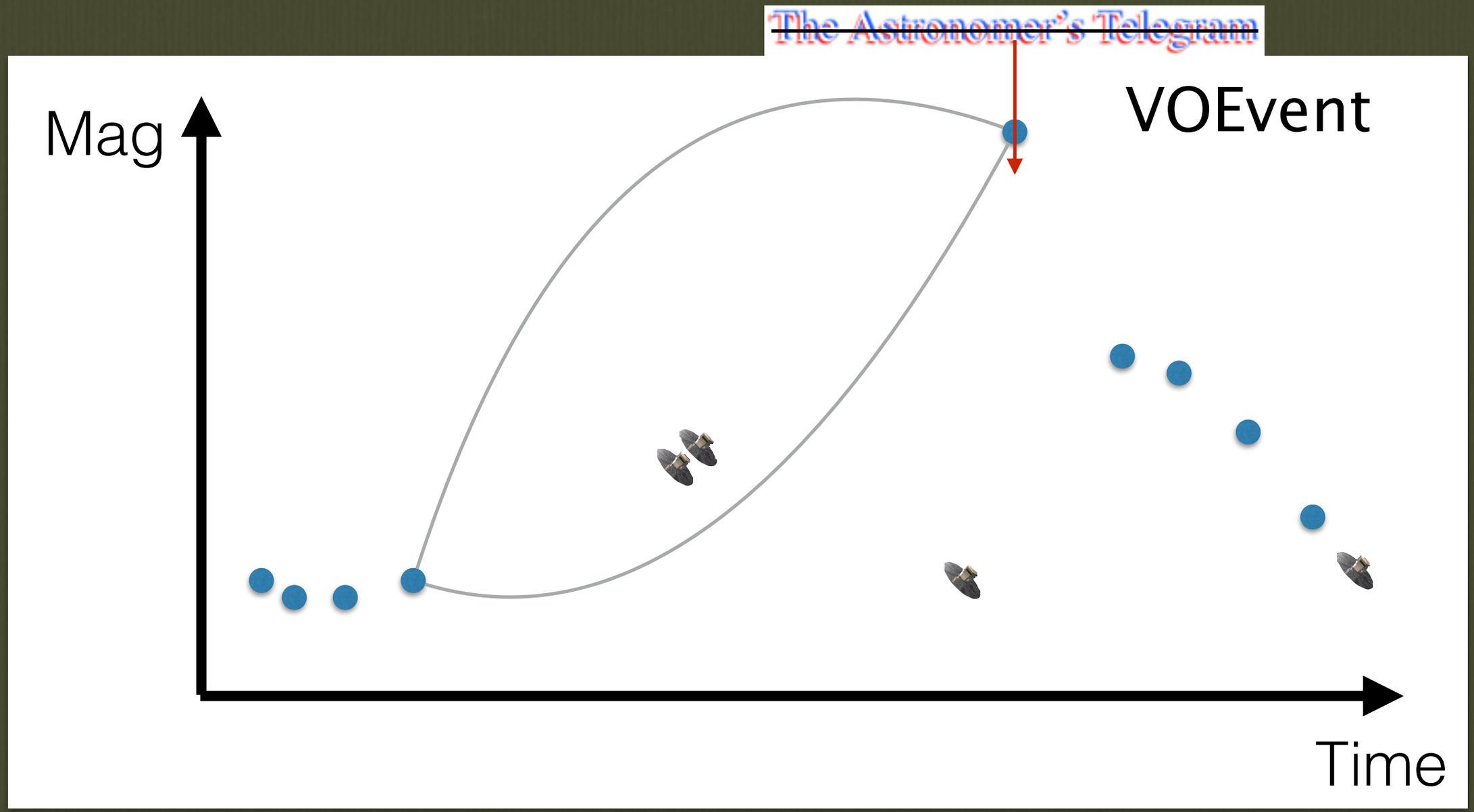
http://www.cosmos.esa.int/web/gaia/iow_20150409



http://www.cosmos.esa.int/web/gaia/iow_20141205

Validation phase and improvements

Dream… watch-list?



Conclusions

- **Gaia is a** suitable tool for high-accuracy measurements of slow-rising transients.
  - FREE low-resolution classification.
    - Observations close to the Sun.
    - Observations on low-profile days.
- Change in on-board detection parameters has **increased** the **number of “fake” detections**.
- **Currently**, changes in pipeline focus on **cleaning the sample and approaching the nucleus!**

Thank you!

Gaia DPAC
Data Processing & Analysis Consortium

&

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