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ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS



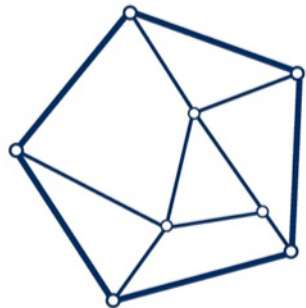
**Australian
National
University**

DASH

Deep Learning for Spectral Classification in OzDES

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Australian National University



Australian Government
Australian Research Council



**DARK ENERGY
SURVEY**



- › 5-year 100-night spectroscopic survey on the AAT
- › Follow up on the transients from the international DES deep fields
- › On track to observe 5000 SN host galaxy redshift with spectra
- › Monitoring 771 AGN out to $z \sim 4$ for reverberation mapping



The Anglo-Australian Telescope. Credit: J. Calcino



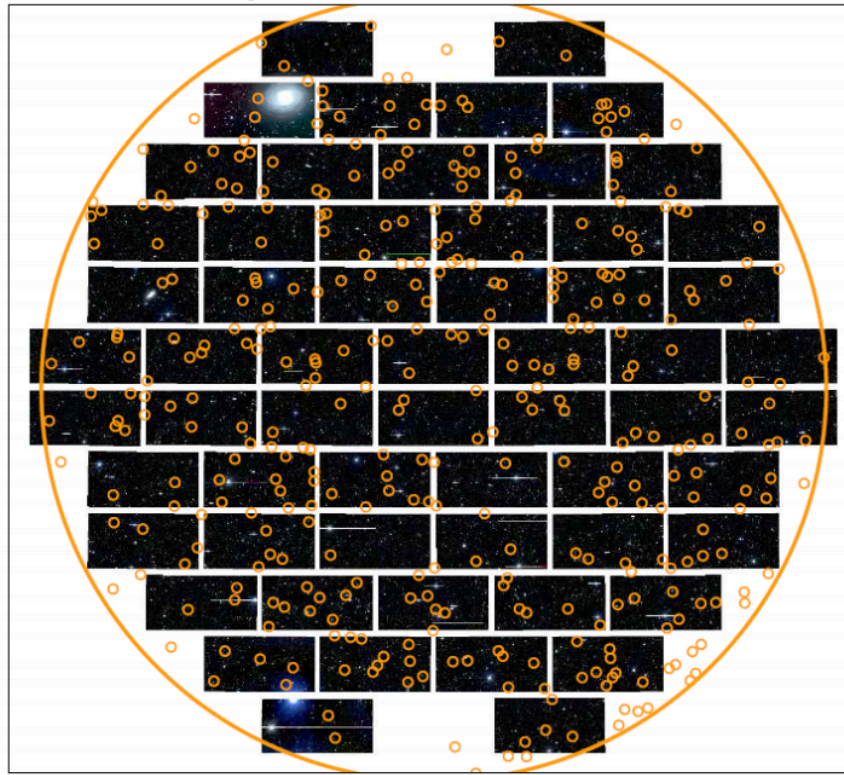
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OzDES

DECam and 2dF a perfect match

DECam Image

392 2dF Fibres



2.1 degrees

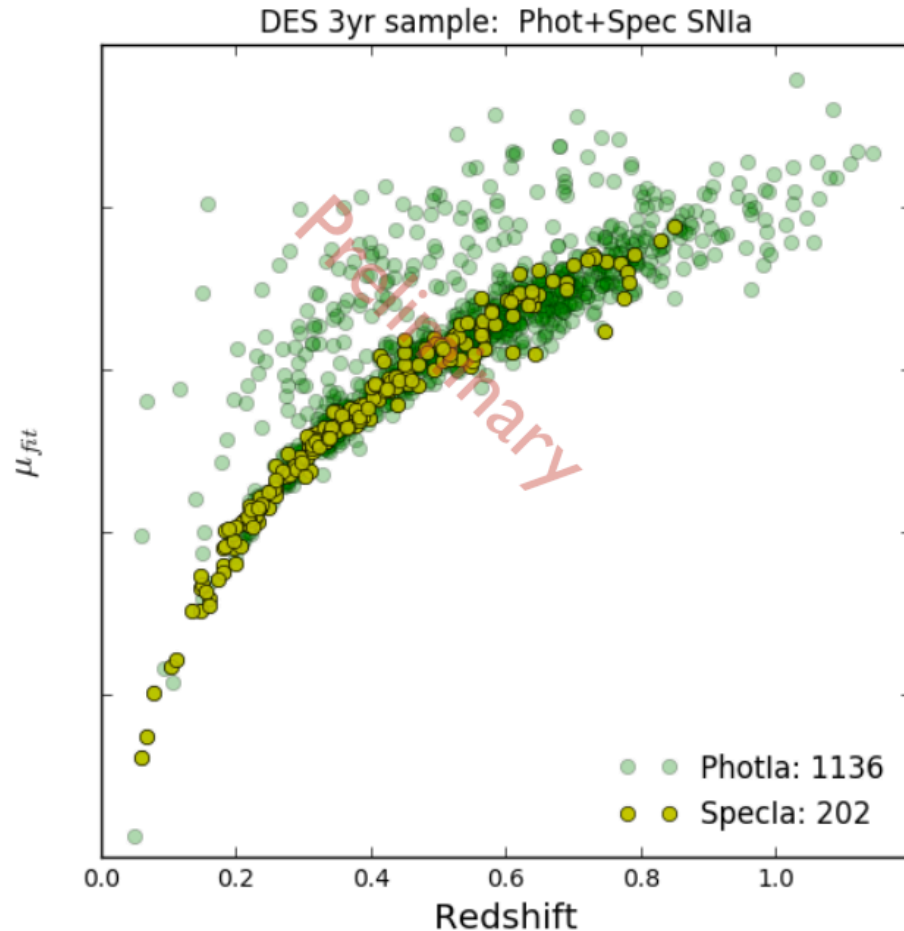
From Yuan++ (2015)





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OzDES – Data release coming soon!



Largest SN sample from a single instrument ever!

Extends to higher redshifts

200+ spectroscopically confirmed SNe Ia

From the first 3 years

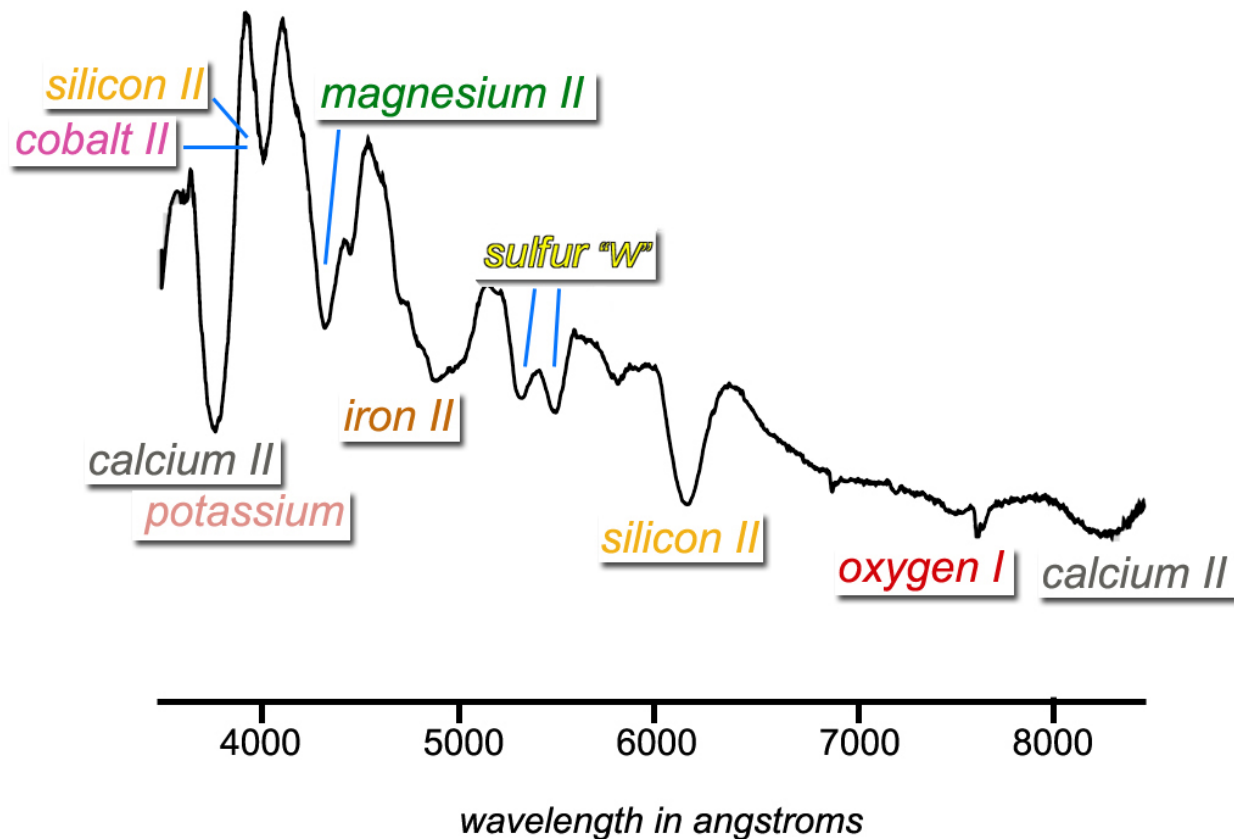
AAT is the largest single source of confirmed SNe

Credit: Chris D'Andrea



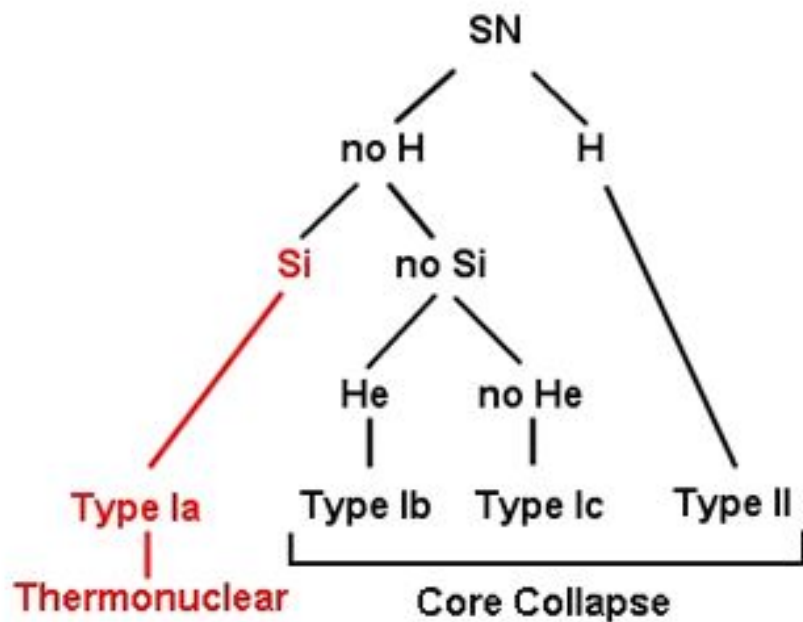
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What type of SN is this?





Supernova Types



SNIa: Ia-norm, Ia-91T, Ia-91bg, Ia-02cx, Ia-csm, Ia-pec

SNIb: Ib-norm, Ibn, IIb, Ib-pec

SNIc: Ic-norm, Ic-broad, Ic-pec

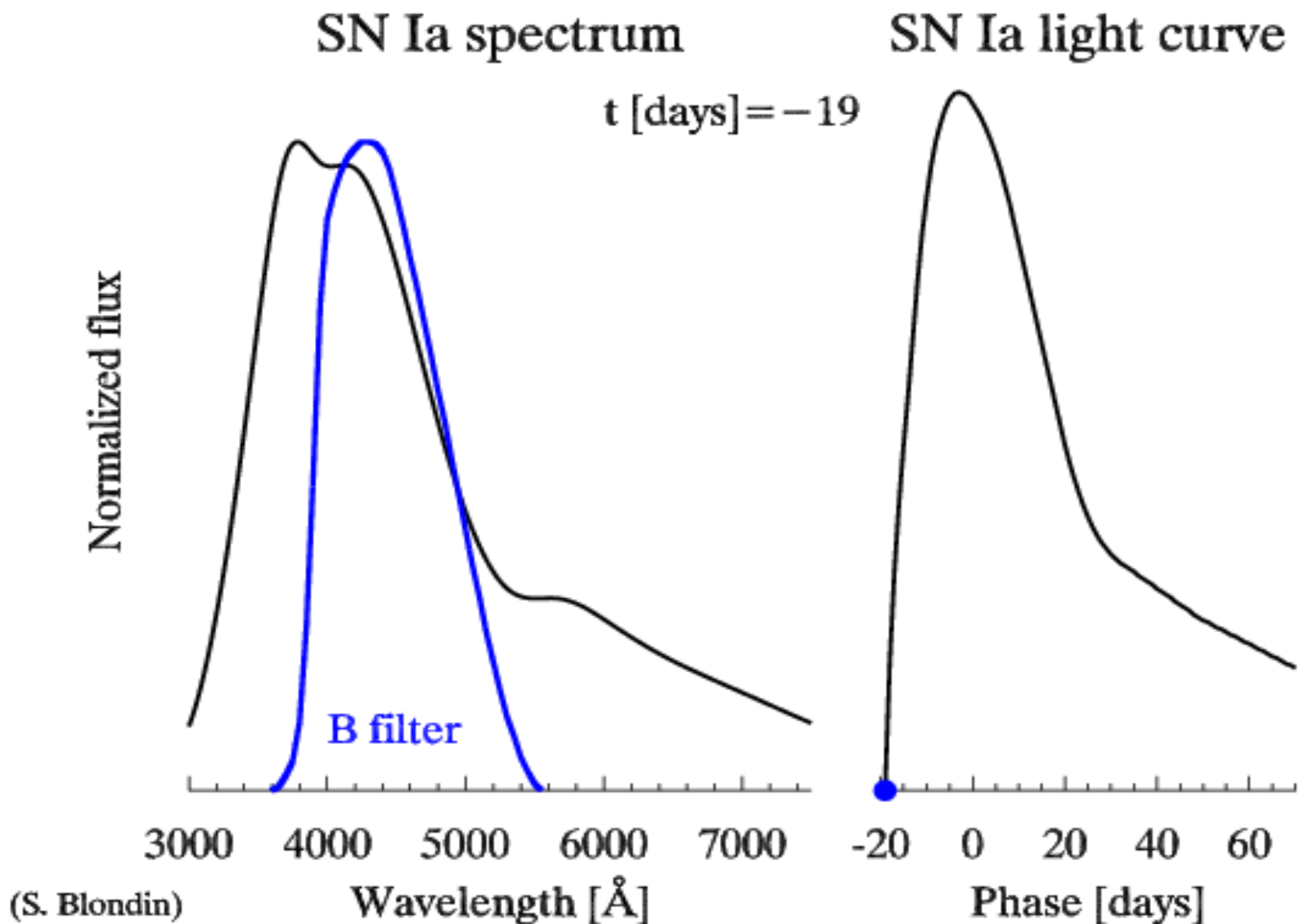
SNII: IIP, IIL, II_n, II-pec



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Why is this a difficult problem?

Age



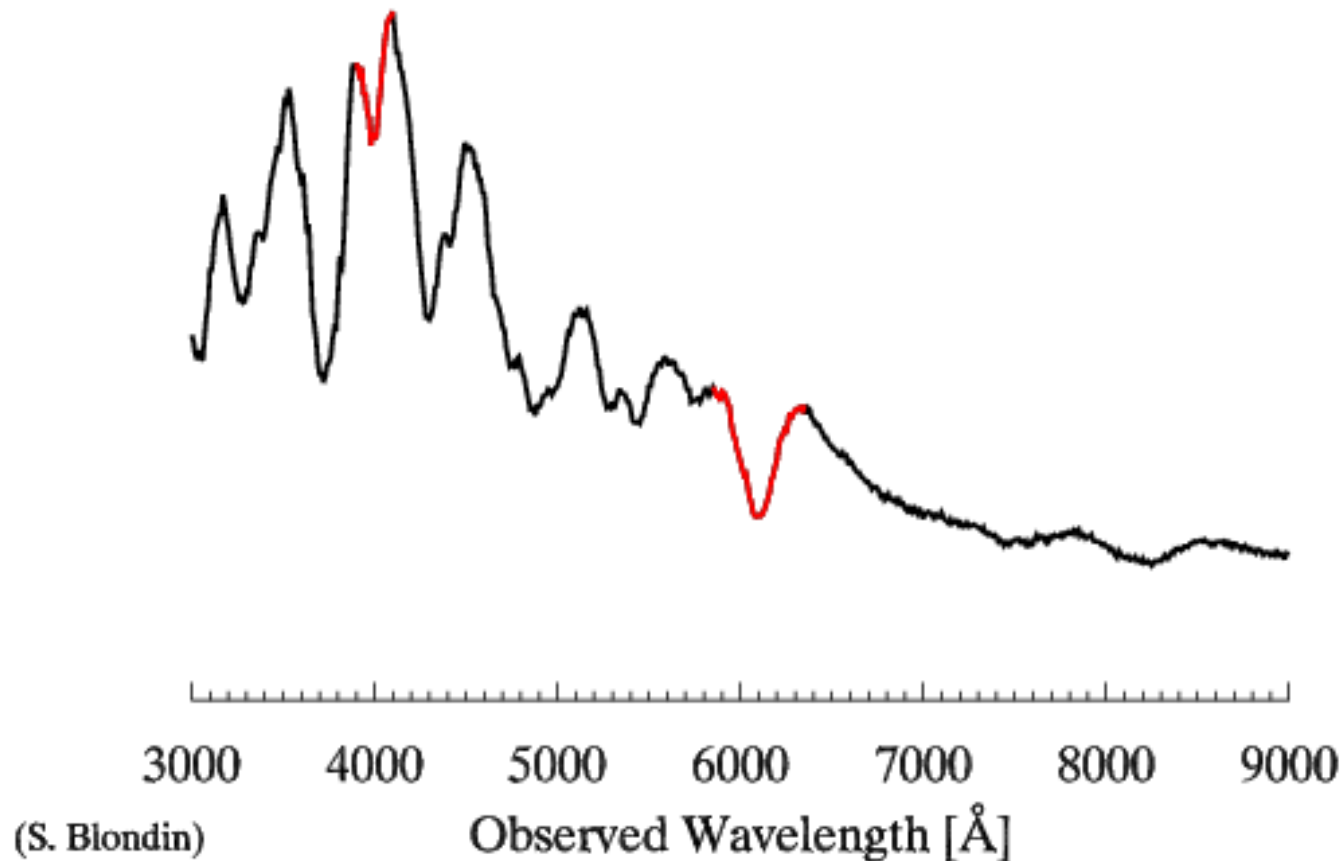


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Why is this a difficult problem?

Redshift and Noise

A Type Ia Supernova at $z = 0.00$

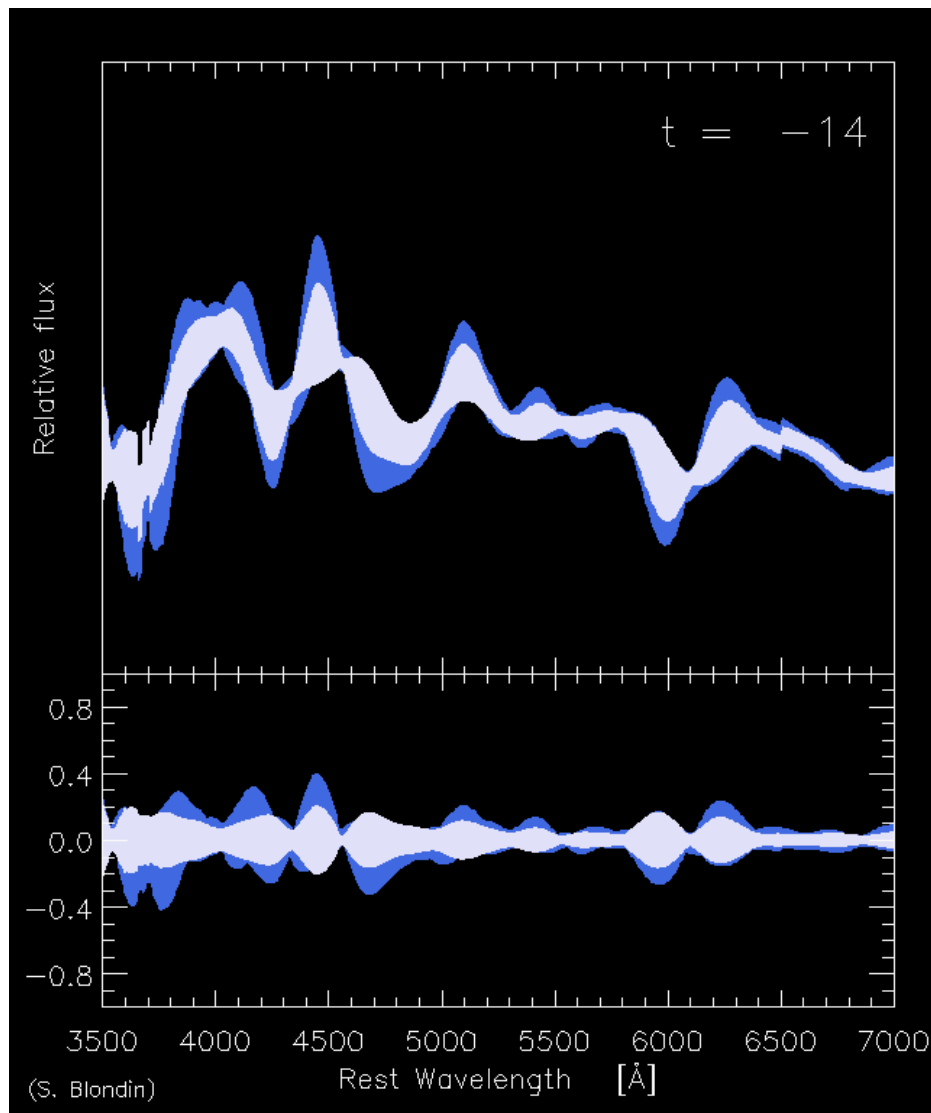




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Why is this a difficult problem?

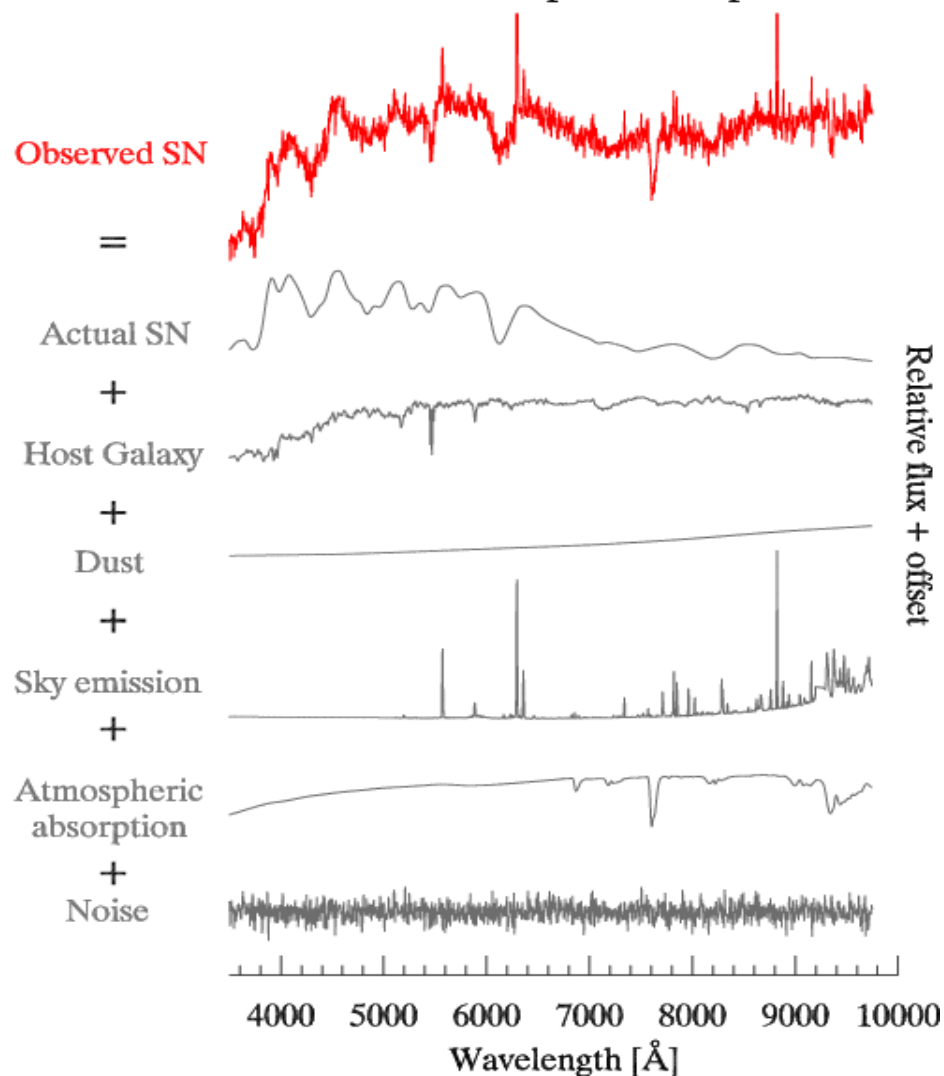
Variations in data





What do we observe?

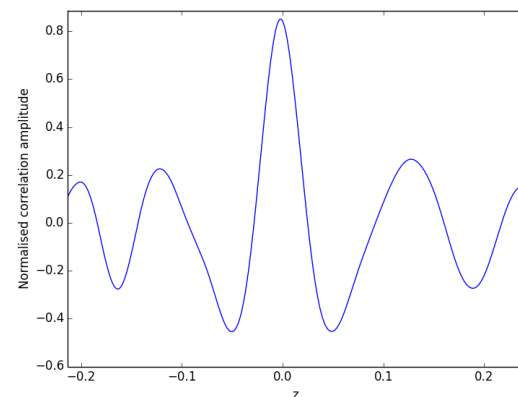
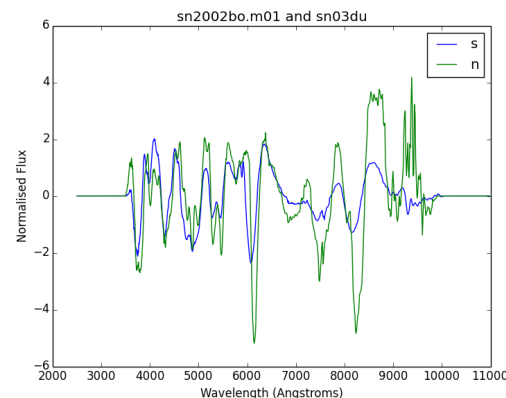
An Observed Supernova Spectrum





Previous classification methods

- › Currently classification is slow, labour-intensive, and can take tens of minutes for a single supernova spectrum
- › All rely on iterative template matching processes (cross-correlations or chi-squared minimisations)
 - Computation **time increases linearly with the number of templates**
 - Can only compare to **one template at a time** (rather than the aggregate set of each SN type)
- › Chi-squared minimisations are **slow**
- › **Not autonomous**: requires a lot of human-input



Design Decisions

How DASH improves

› Speed

- **Autonomously** classify several spectra at once
- **Significantly faster** (example: 250 classified spectra in 18 seconds)

› Accuracy

- DASH classifies based on **features instead of templates**
 - Uses aggregate set of templates rather than a single template
- Softmax regression probabilities

› Precision

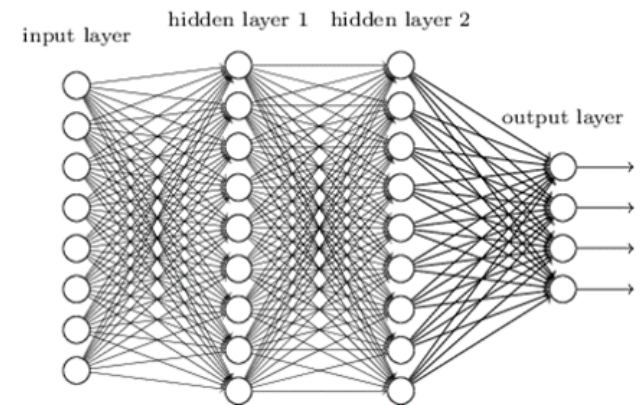
- **More specific classification** including age and specific type

› Installation and ease of use

- Graphical interface and **python library**
- Very simple installation and use

Why Deep Learning?

- › Era of big data!
- › Deep Learning has had success in a range of new Big Data problems:
 - Image, speech, language recognition. Beating grandmasters at Chess and Go
- › Accuracy improves with number of template (does not affect computation time)
- › Training process is separate to testing
- › Only need to train once. Then only need the trained model instead of the entire template set.
- › Train based on the aggregate set of all templates in a particular SN bin
- › Disadvantages
 - Deep learning is often position invariant, which makes redshifting difficult.
 - Softmax probabilities are relative, not absolute measures

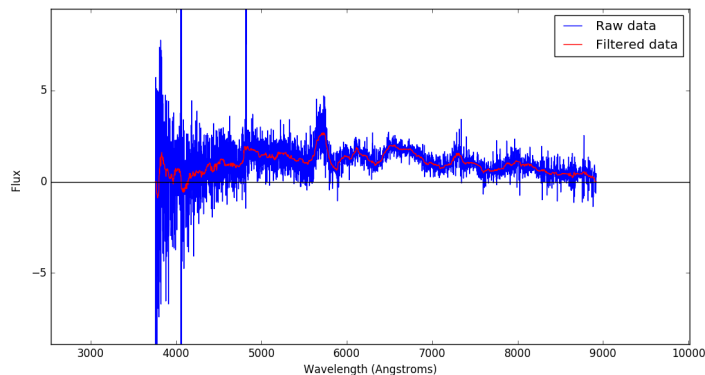




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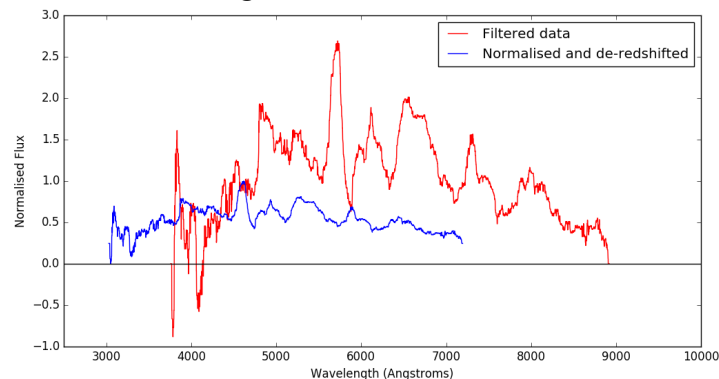
Pre-processing spectra

1. Low pass median filtering



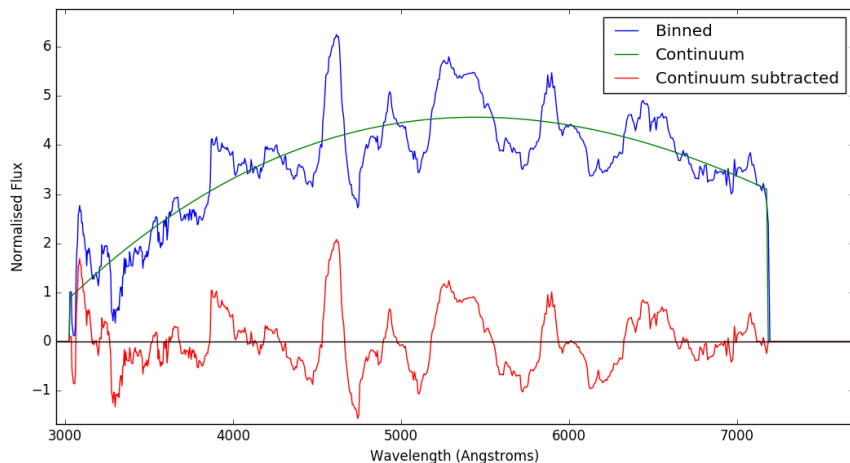
2. Normalising

3. De-redshifting



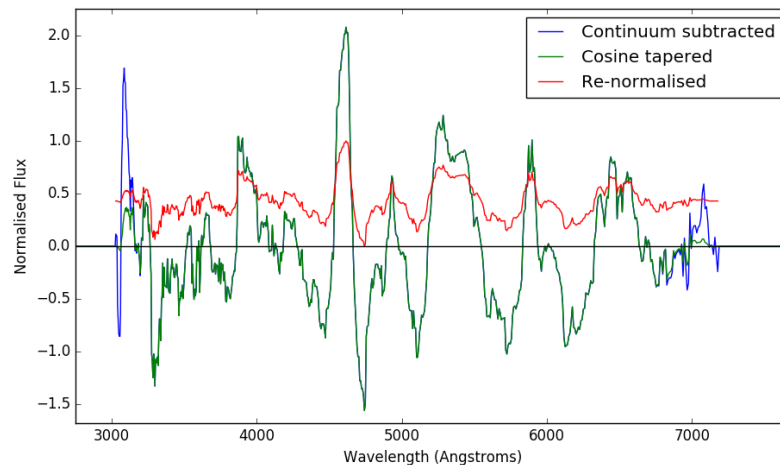
4. Continuum modelling with spline interpolation

5. Continuum subtraction



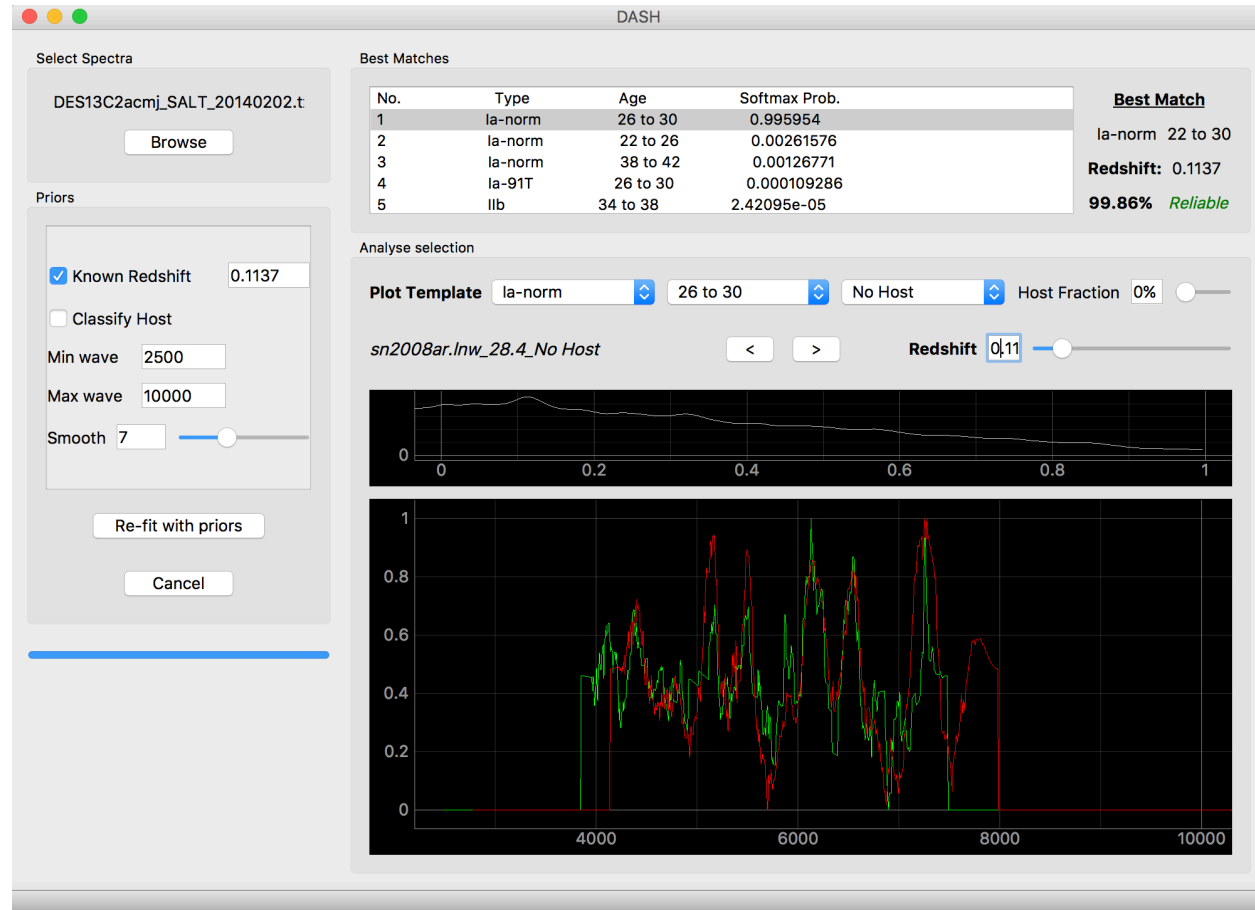
6. Log-wavelength-binning

7. Apodising edges




```
pip install astrodash
```

- › Python 2/3
- › Operating Systems:
Linux/Mac/Windows
- › Available open
source at:
<https://github.com/daniel-muthukrishna/DASH>
- (Paper in preparation)



- › **Type:** Correct broad type (i.e. Ia, Ib, Ic, II) identified by the matching algorithm.
- › **Subtype:** Correct subtype (i.e. Ia-norm, Ib-pec, Ib-norm, etc.) identified.
- › **Type and Age:** Correct broad type and the correct age bin identified by the matching algorithm.
- › **Subtype and Age:** Correct subtype and the correct age bin identified.

Criteria	Correctly Classified
Type	99.2%
Subtype	96.0%
Type and Age	95.7%
Subtype and Age	93.3%

- › Supernovae are the most powerful probe for probing the nature of dark energy
- › DASH makes use of a convolutional neural network with Tensorflow
- › Over 100 times faster and more precise than previous methods because it classifies based on aggregate features instead of individual templates
- › Two interfaces:
 - Graphical interface, Python library
- › Easy installation
 - pip install astrodash
- › Open Source
 - <https://github.com/daniel-muthukrishna/DASH>
- › Currently being tested by OzDES for implementation in the Y5 run