Type Ia supernovae detection with the J-PAS observatory

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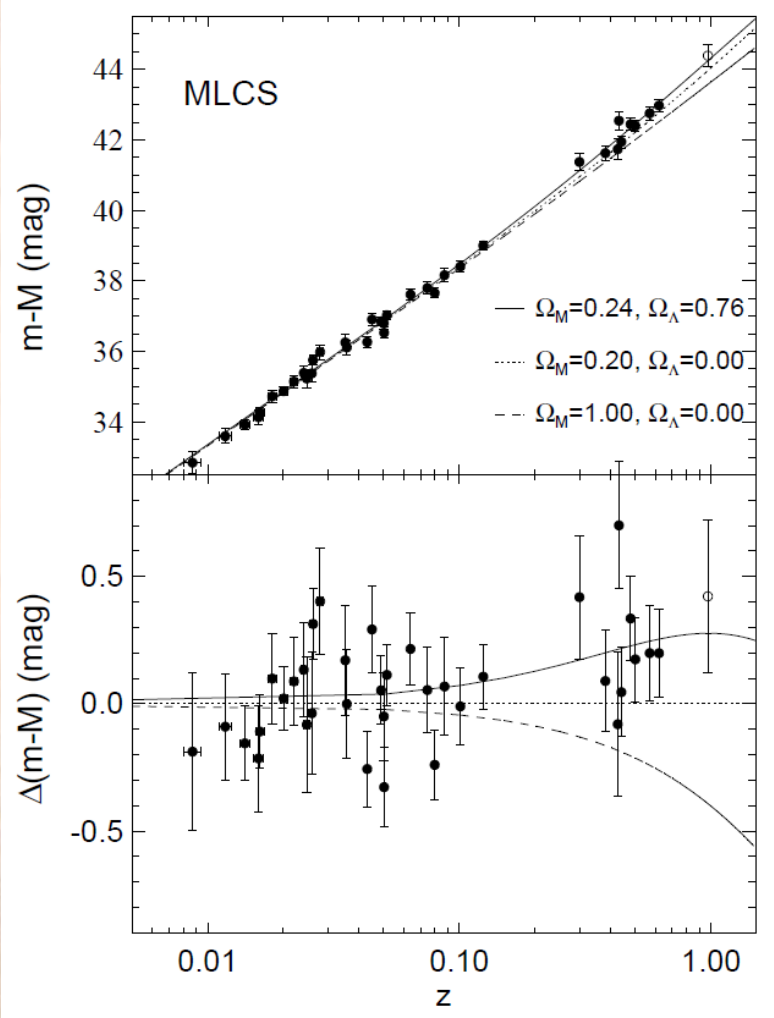
VI WORKSHOP CHALLENGES OF NEW PHYSICS IN SPACE

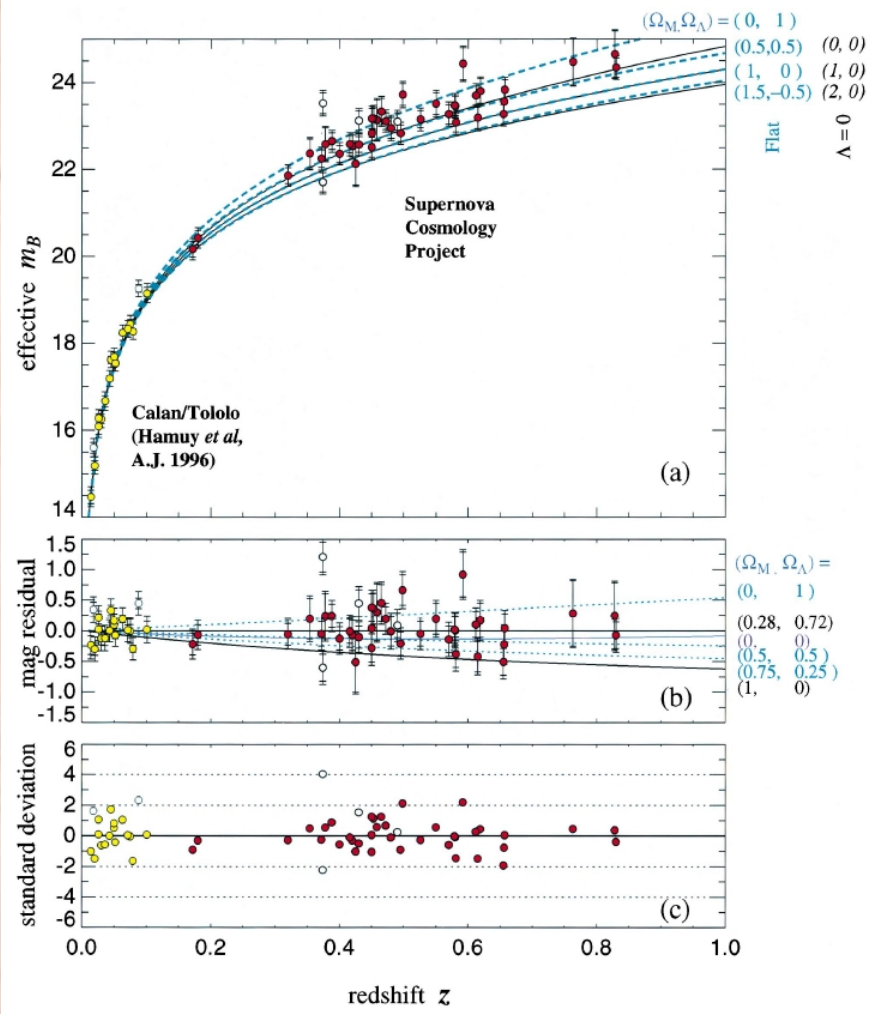
Summary

- **Challenges with type Ia SNe;**
- **The J-PAS observatory;**
- **SN detection pipeline;**
- **Discussion.**

Dark Energy



Riess *et al., 1998*

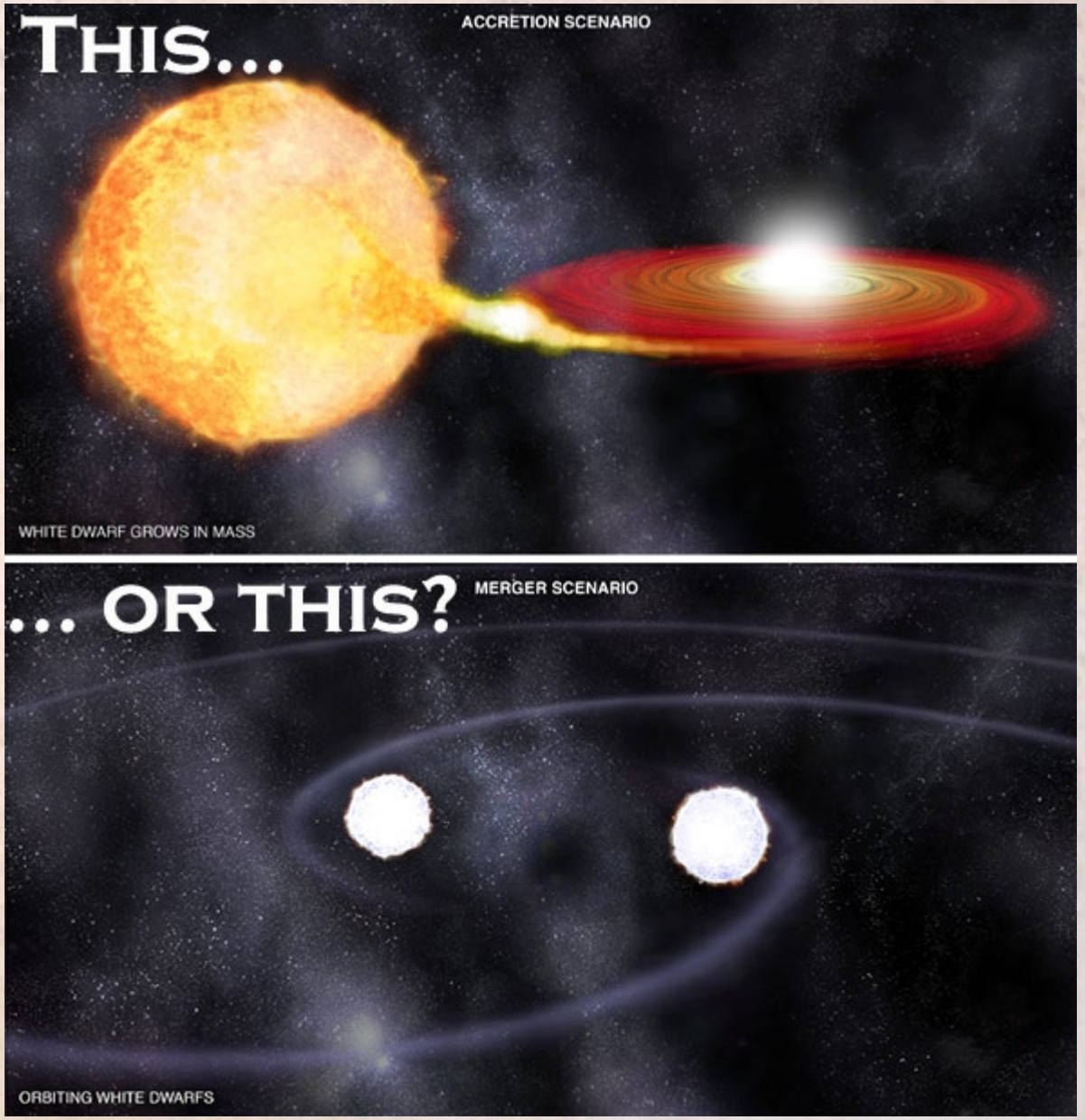


Perlmutter *et al., 1999*

Open questions

- **Nature of the progenitor;**

Progenitor – SN Ia

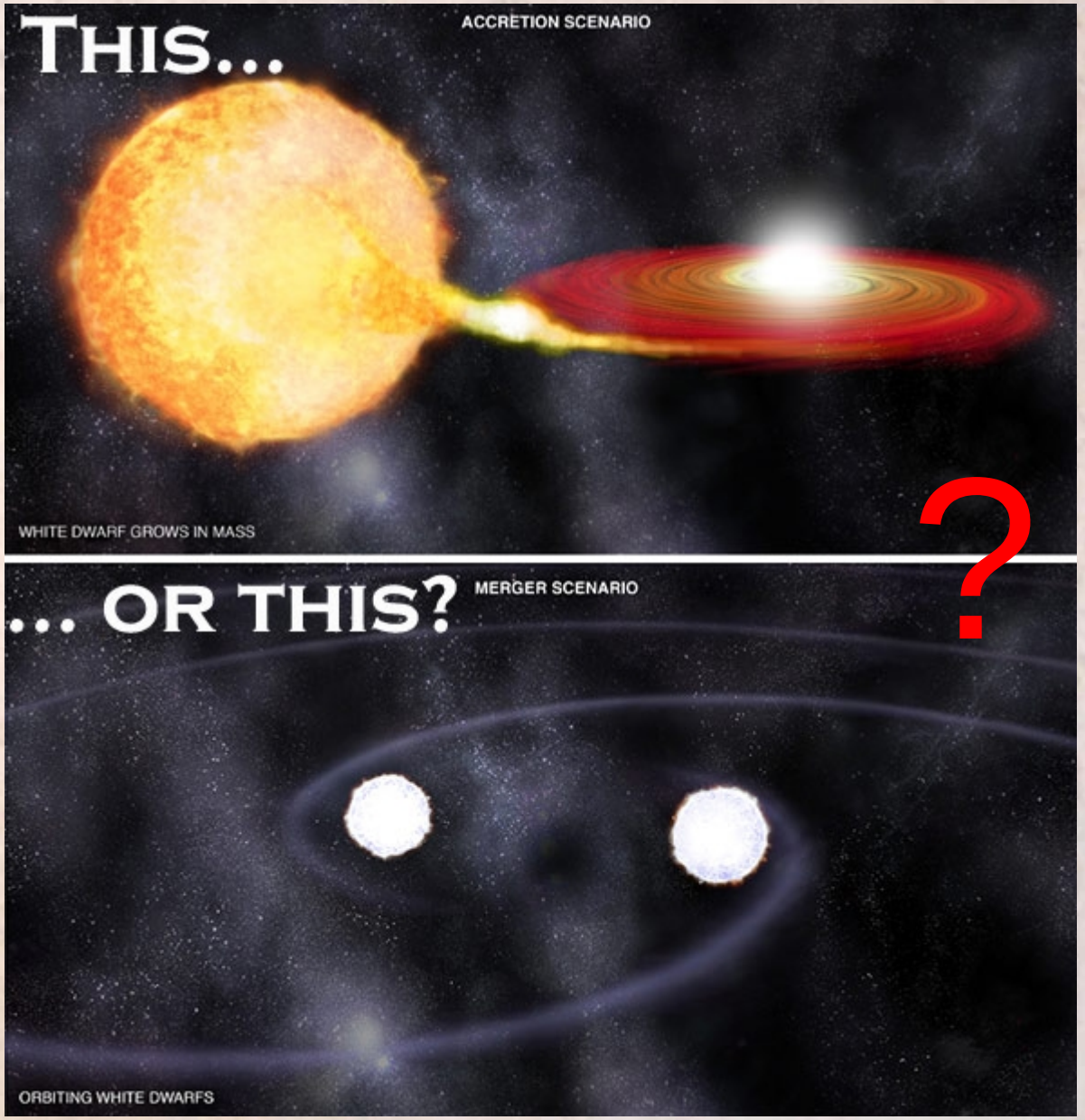


Single degenerate

Double degenerate

http://blogs.discovermagazine.com/badastronomy/tag/type-ia-supernovae

Progenitor – SN Ia



Single degenerate

Double degenerate

http://blogs.discovermagazine.com/badastronomy/tag/type-ia-supernovae

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- **Explosion mechanism;**

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Open questions

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- **Explosion mechanism;**
- **Possibility of evolution;**
- **Influence of dust extinction;**

Open questions

- **Nature of the progenitor;**
- **Explosion mechanism;**
- **Possibility of evolution;**
- **Influence of dust extinction;**
- **Etc**

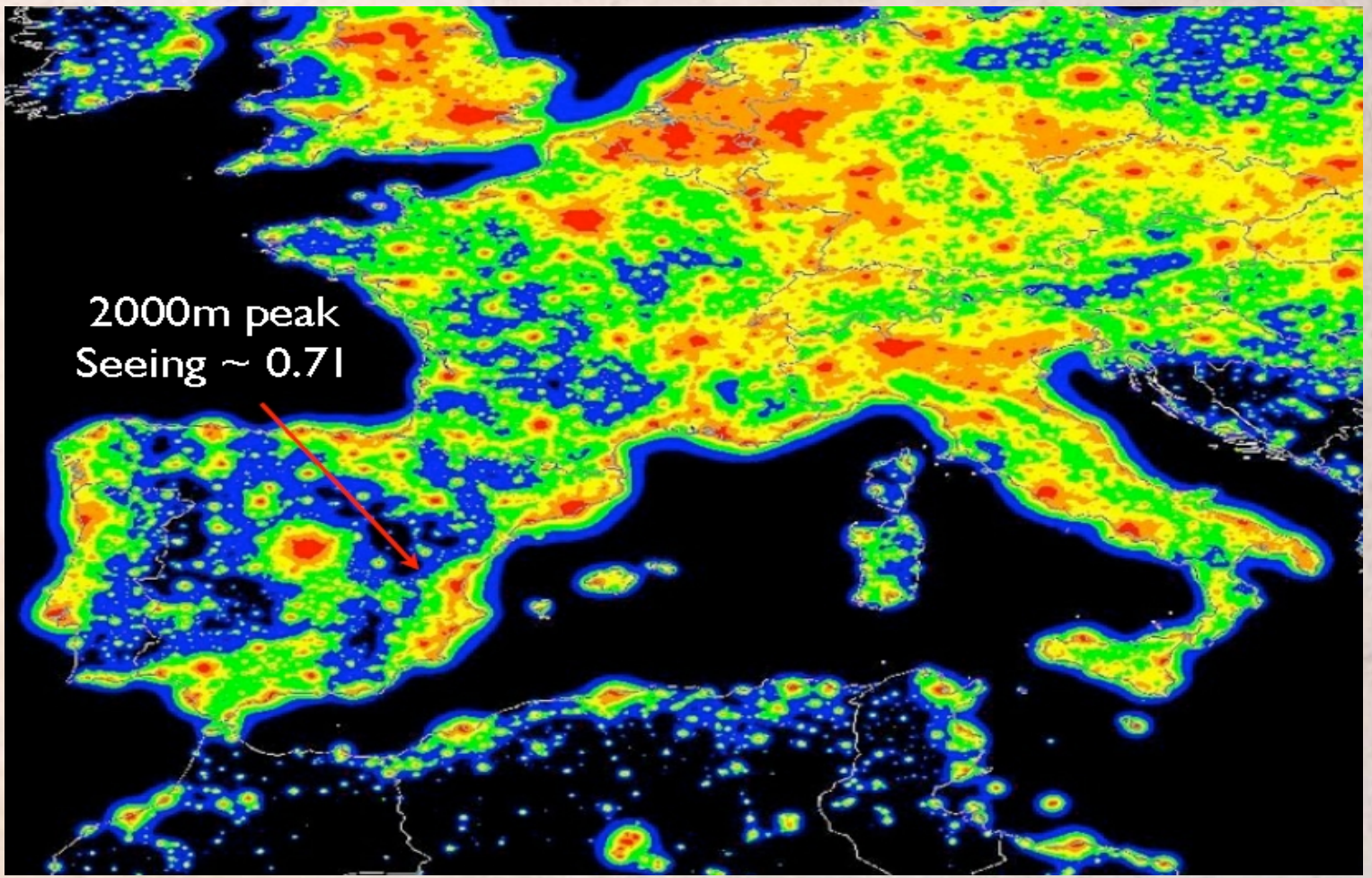
J-PAS Observatory

J-PAS

- **Spanish-brazilian collaboration;**

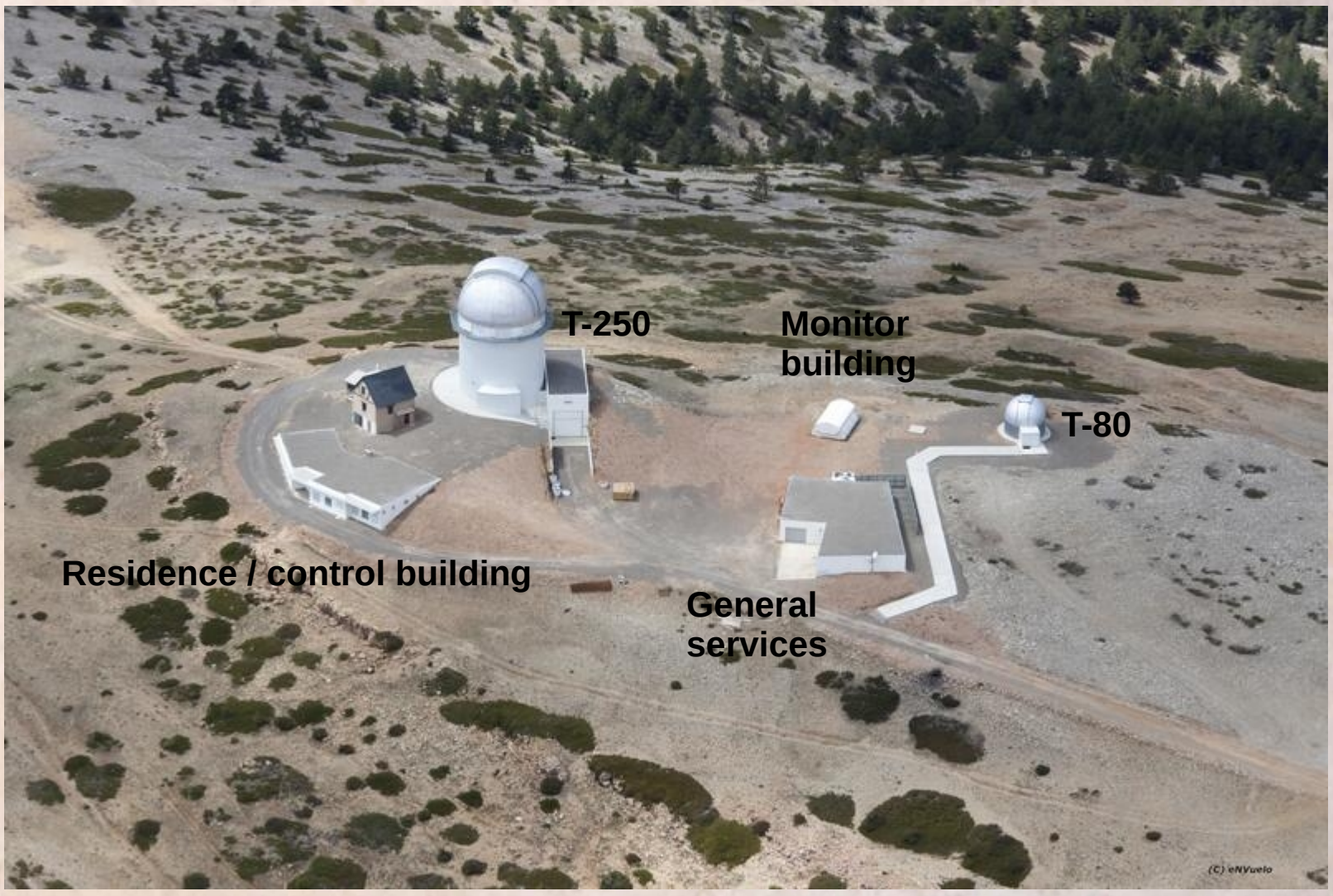
J-PAS

- **Spanish-brazilian collaboration;**
- **Under construction at Sierra de Javalambre, Spain;**


2000m peak
Seeing ~ 0.7l

Before

After...


T-250
Monitor building
T-80
Residence / control building
General services
(C) eNVuelo

J-PAS

- **Spanish-brazilian collaboration;**
- **Under construction at Sierra de Javalambre, Spain;**
- **2 telescopes (T-80 and T-250);**

Telescopes

T-80 (1.7 degrees FoV)

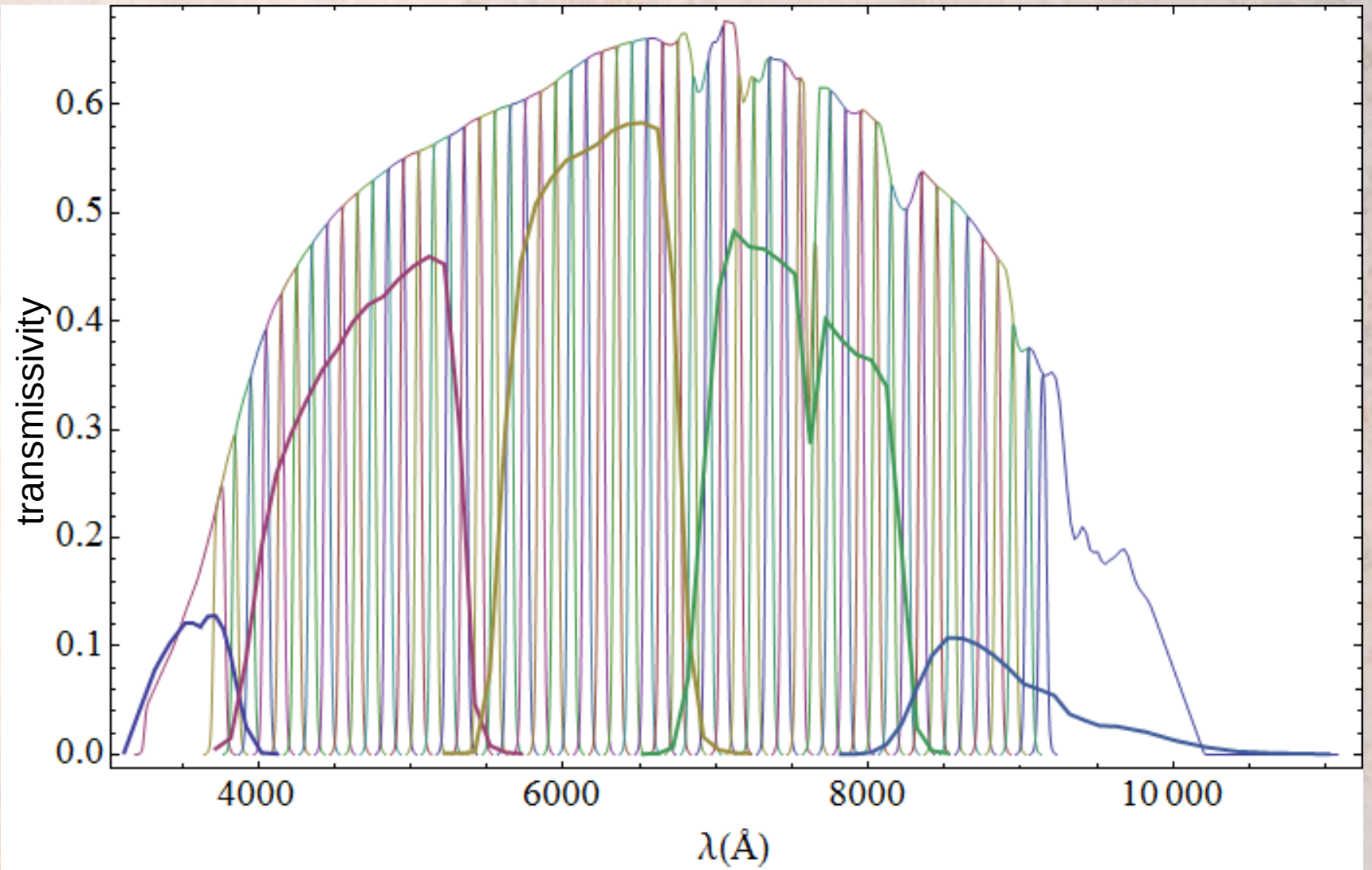
T-250 (3 degrees FoV)

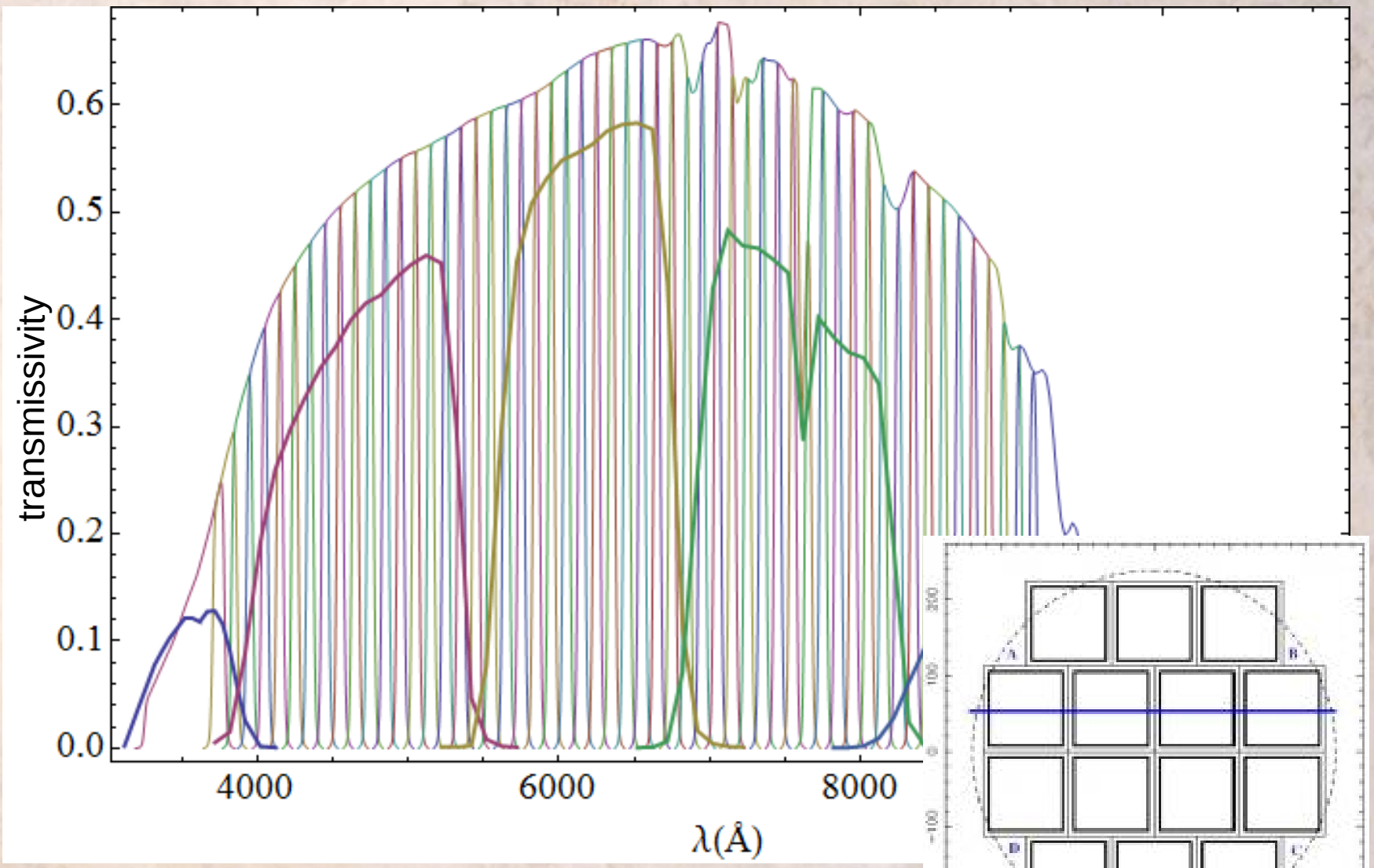
J-PAS

- **Spanish-brazilian collaboration;**
- **Under construction at Sierra de Javalambre, Spain;**
- **2 telescopes (T-80 and T-250);**
- **Main observable: radial BAO;**

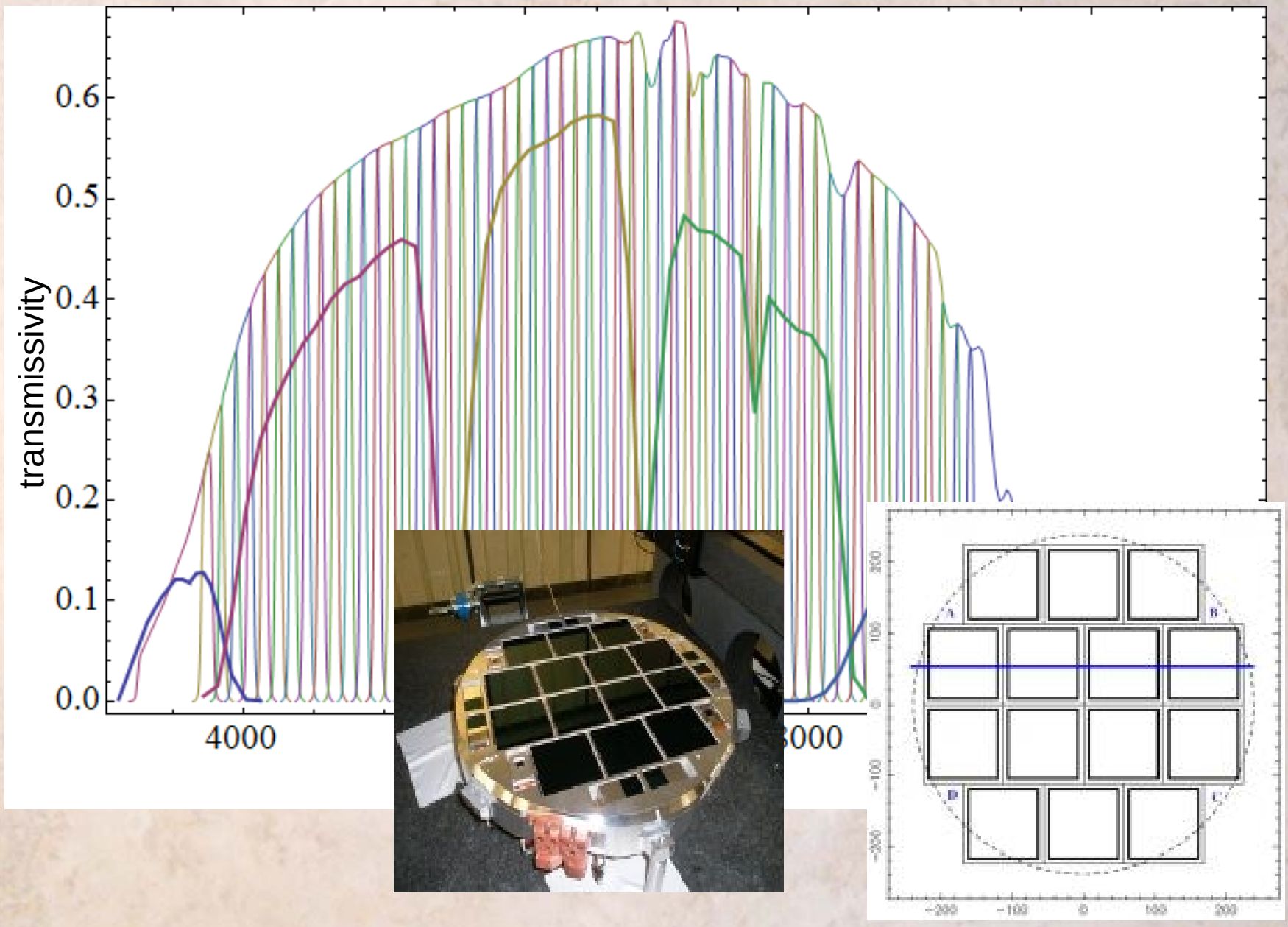
J-PAS

- **Spanish-brazilian collaboration;**
- **Under construction at Sierra de Javalambre, Spain;**
- **2 telescopes (T-80 and T-250);**
- **Main observable: radial BAO;**
- **56 narrow band filters;**


transmissivity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
4000
6000
8000
10 000
λ(Å)


transmissivity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
4000
6000
8000
λ(Å)

A
B
C
D
200
100
0
-100
-200
-200
-100
0
100
200


transmissivity
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4000

Expected improvements with J-PAS

More precise redshift measurements: $\sigma_z = 0.005\ (1+z)$.

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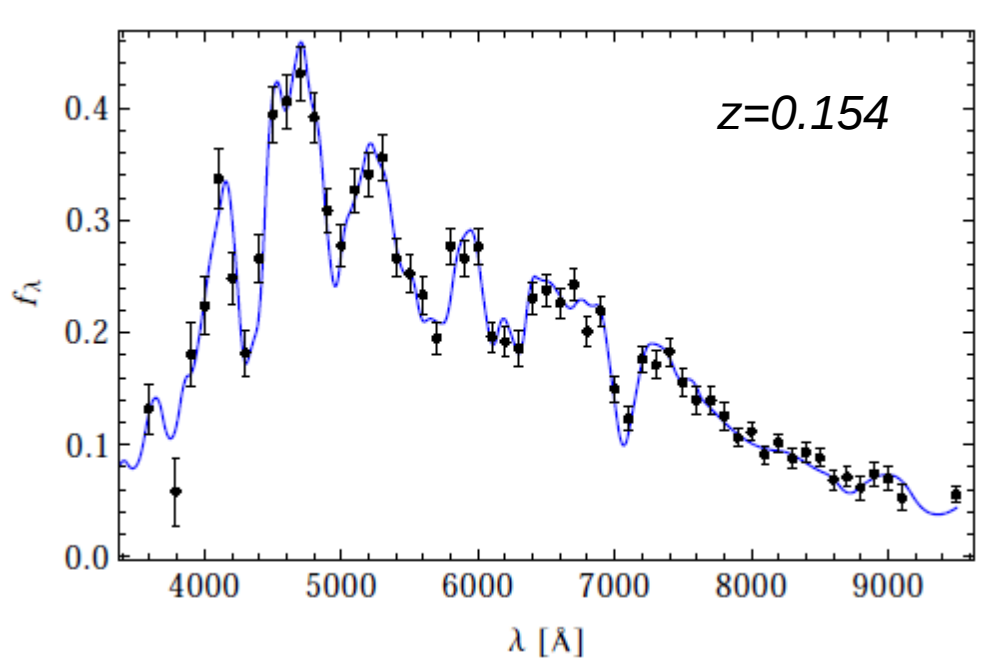
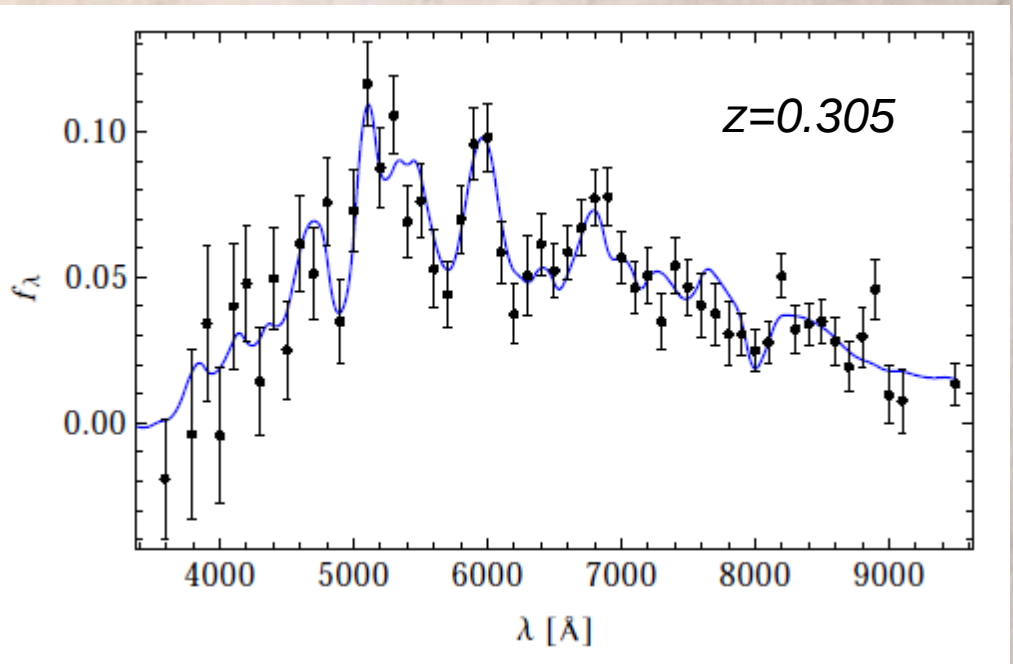
More precise redshift measurements: $\sigma_z = 0.005\ (1+z)$.

Possibility to distinguish spectral features.

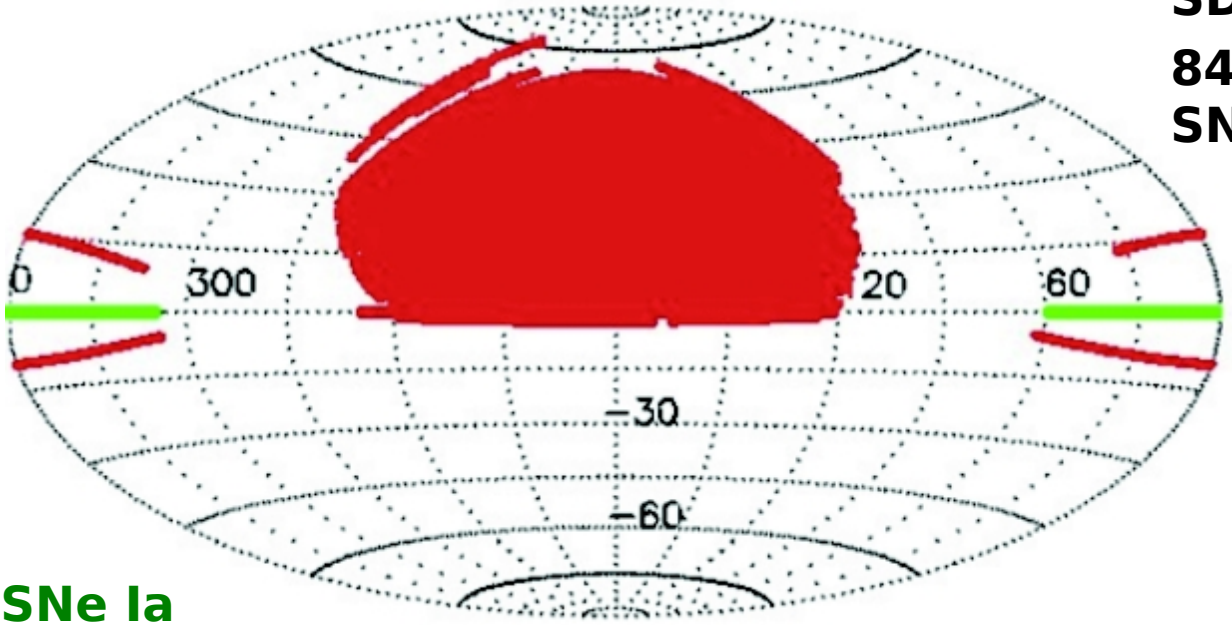




SDSS

8400 deg²

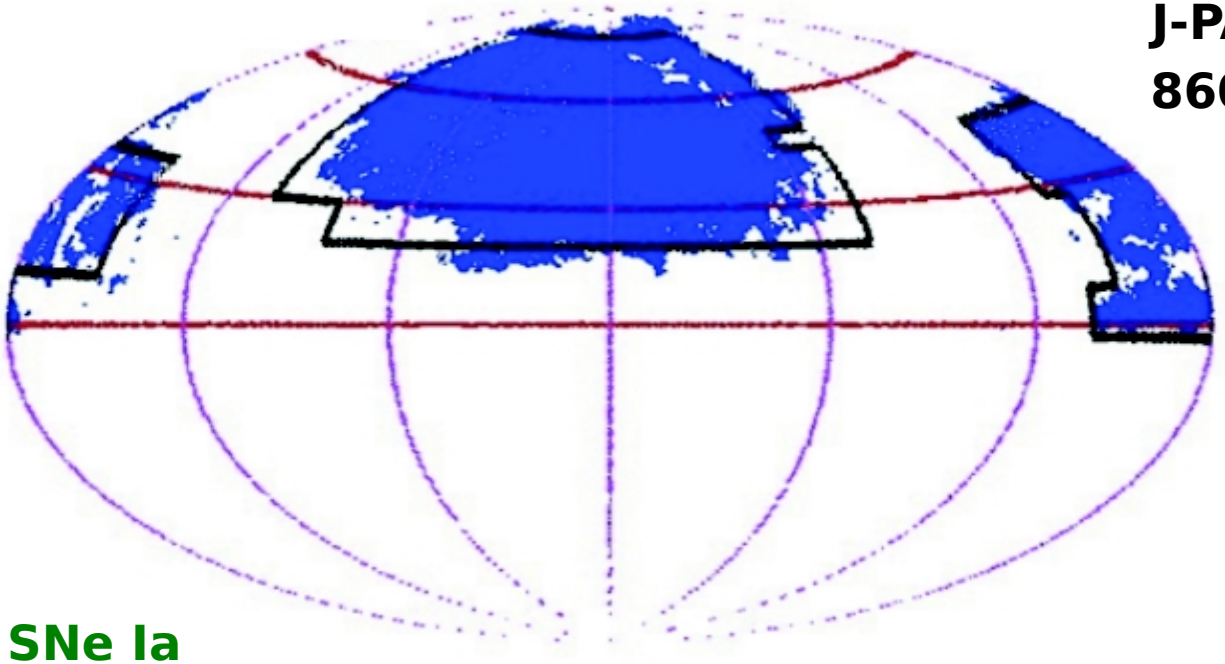
SNe Ia: 250 deg²



~500 SNe Ia

J-PAS

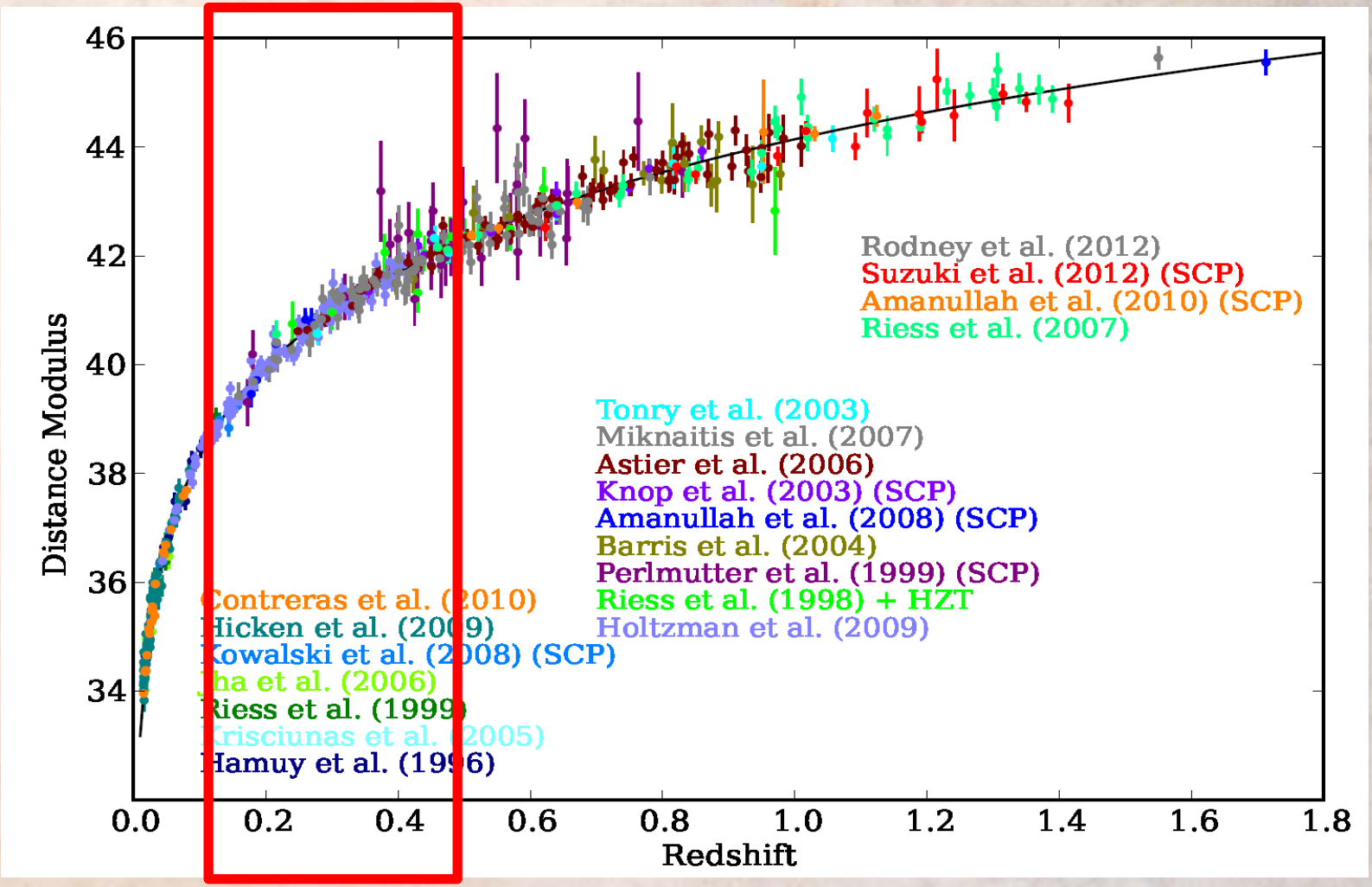
8600 deg²



~6000 SNe Ia

Expected improvements with J-PAS

Rubin et al. ApJ 763 (2013)



J-PAS

Expected improvements with J-PAS

- **Better typing;**
- **Better determination of occurrence rate;**
- **Host galaxy properties:**

  Metallicity
  Stellar mass
  Star formation rate
  Morfology

- **Progenitor (*single* or *double degenerate*?)**

Pipeline for supernova detection

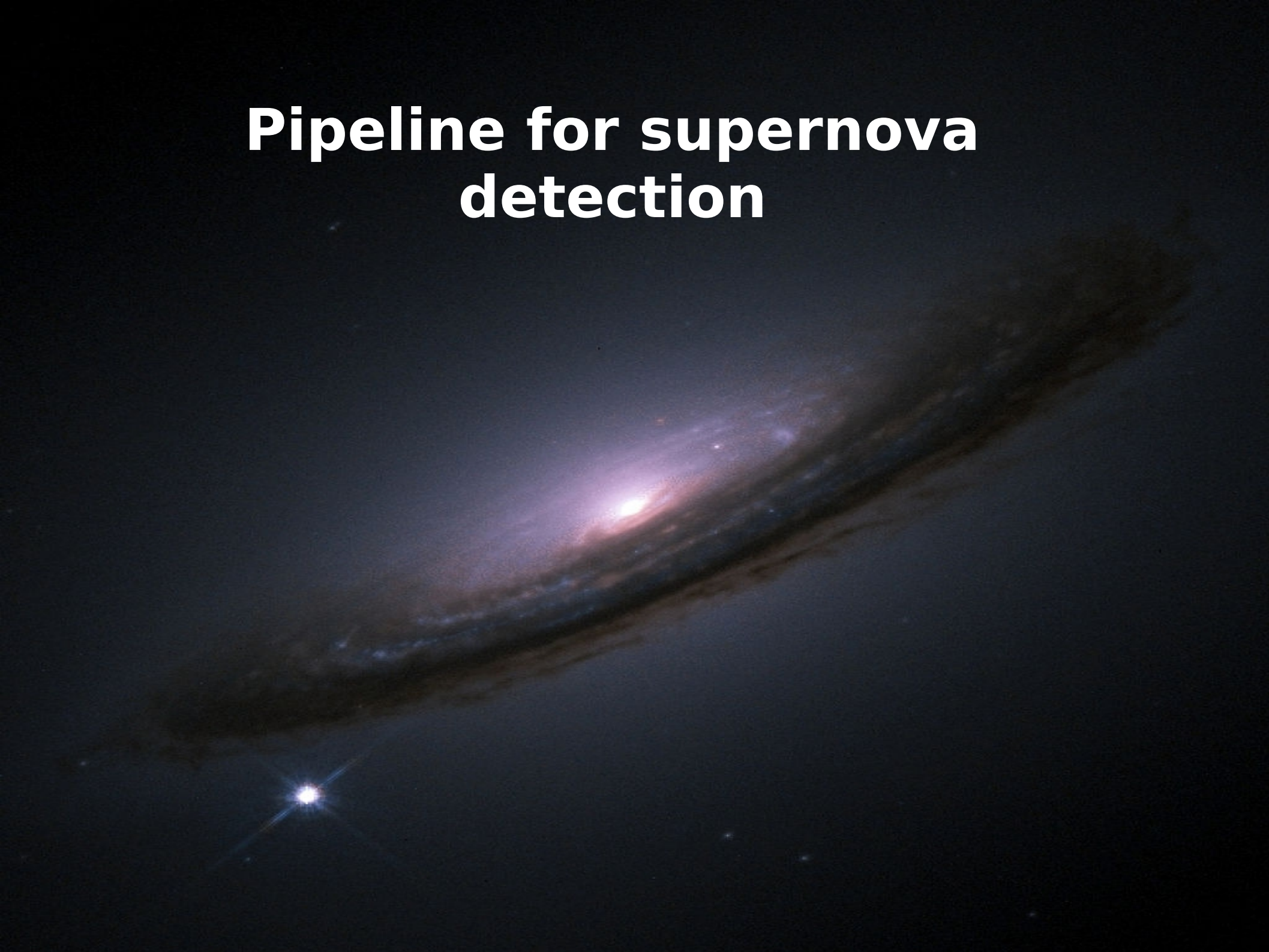


Image Subtraction

Transient events: image subtraction!

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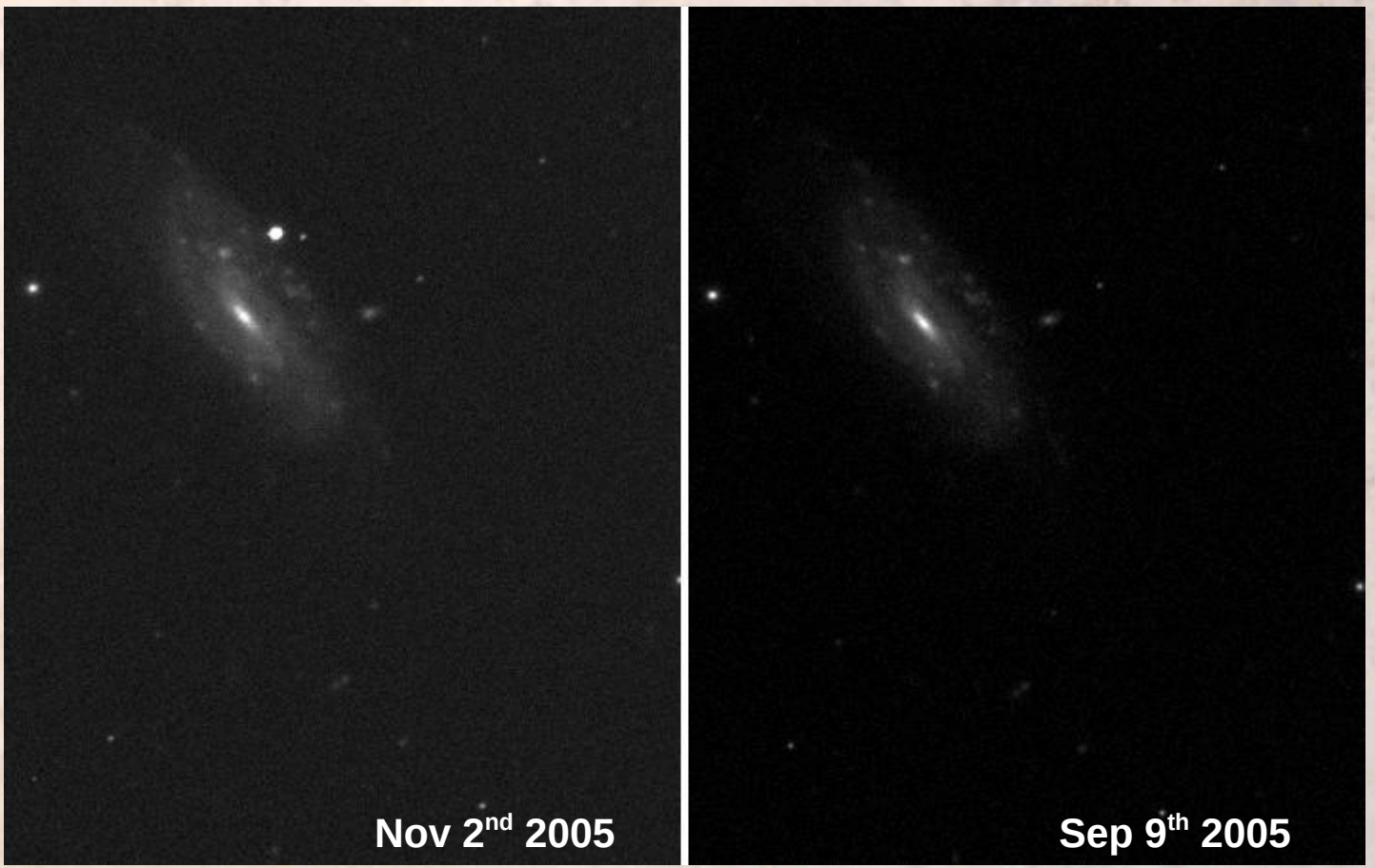

Image Subtraction

***H**igh **O**rder **T**ransform of **P**SF **AN**d **T**emplate **S**ubtraction*
http://www.astro.washington.edu/users/becker/hotpants.html

J-PAS and J-PLUS surveys

J-PAS

J-PAS: ~800 SN Ia/year

- 56 filters
- Strategy:

1 exp – 1 month – 1 exp – 1 month – 1 exp

J-PLUS

J-PLUS: ?? Much less

- 12 filters
- Strategy:

1 exp – 7d – 1 exp – 7d – 1 exp – 7d – 1 exp

Pipeline steps

(1) Choose images – template and source;

Pipeline steps

(1) Choose images – template and source;

(2) Align images;

Pipeline steps

(1) Choose images – template and source;

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(3) Perform subtraction;

Pipeline steps

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(4) List remaining objects;

Pipeline steps

(1) Choose images – template and source;

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(4) List remaining objects;

(5) Reduce list of candidates;

List of SN candidates

# of candidates depend on area and filter

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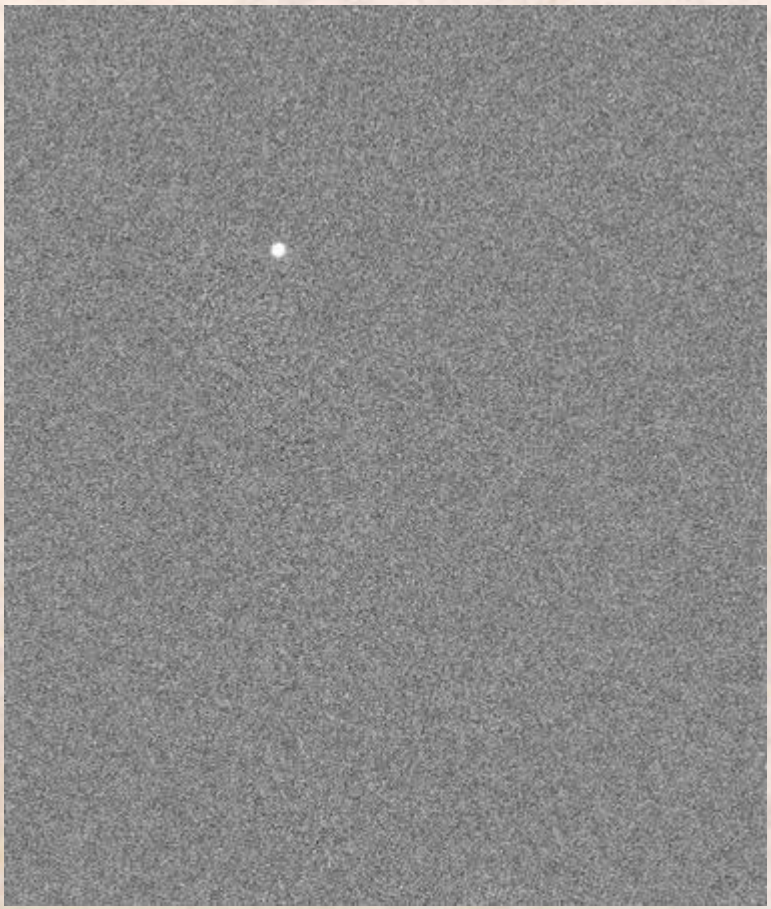
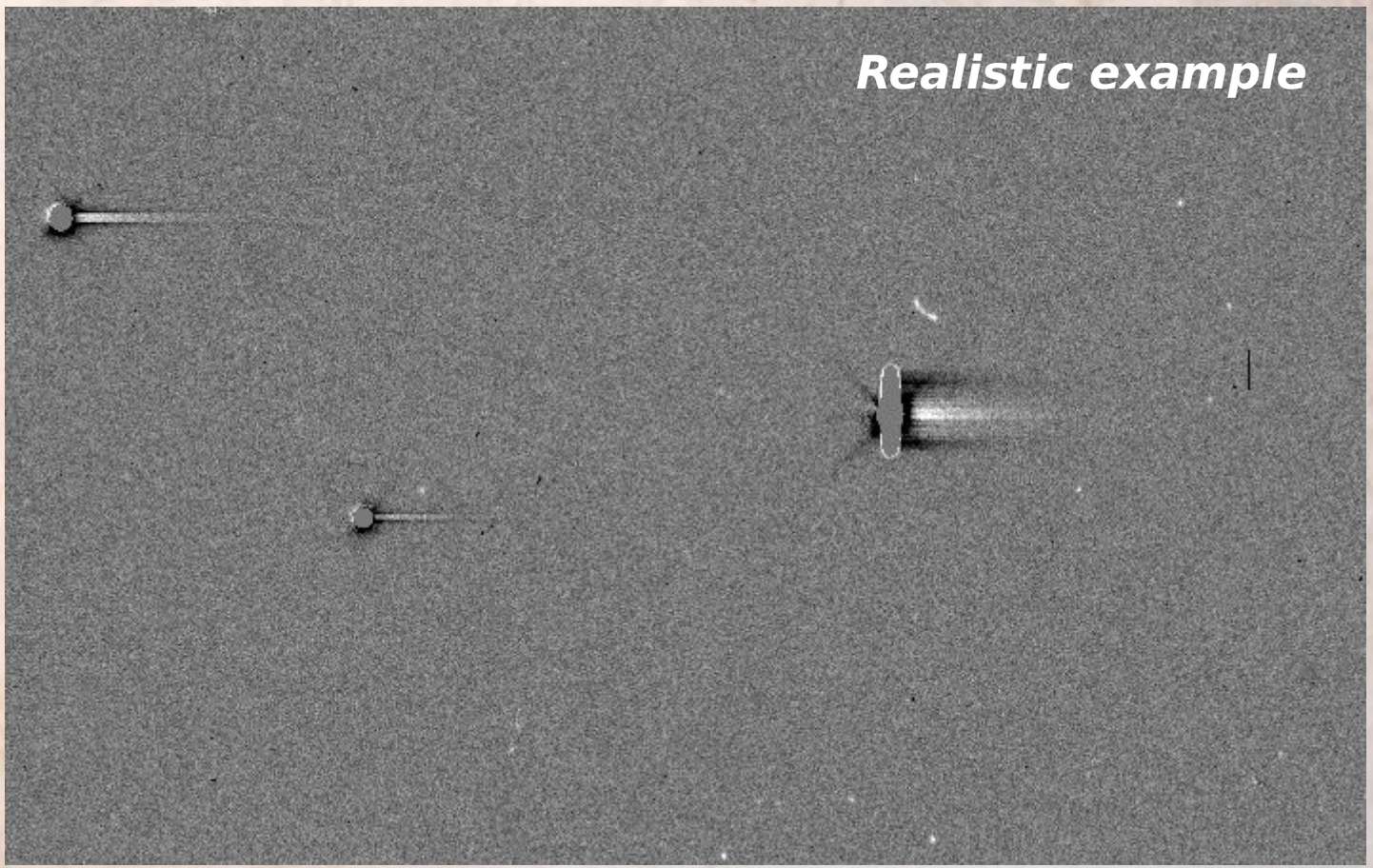


List of SN candidates

of candidates depend on area and filter



Tests with images from other surveys

SDSS

(0.16º X 0.22º)

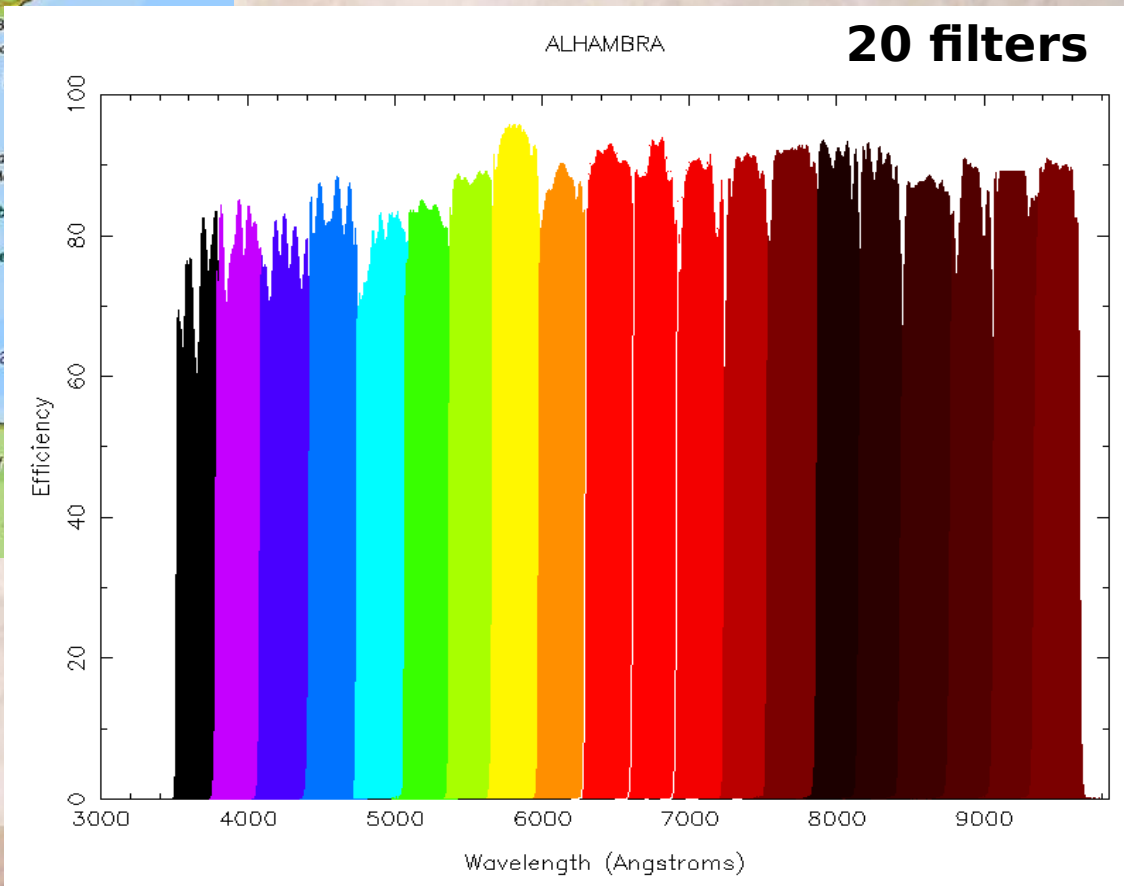
Filter	# candidates
u	50
g	43
r	45
i	172
z	26

ALHAMBRA

Advanced Large, Homogeneous Area Medium Band Redshift Astronomical Survey

Calar Alto Observatory

20 filters



Tests with images from other surveys

SDSS

(0.16º X 0.22º)

Filter	# candidates
u	50
g	43
r	45
i	172
z	26

ALHAMBRA

(0.25º X 0.25º)

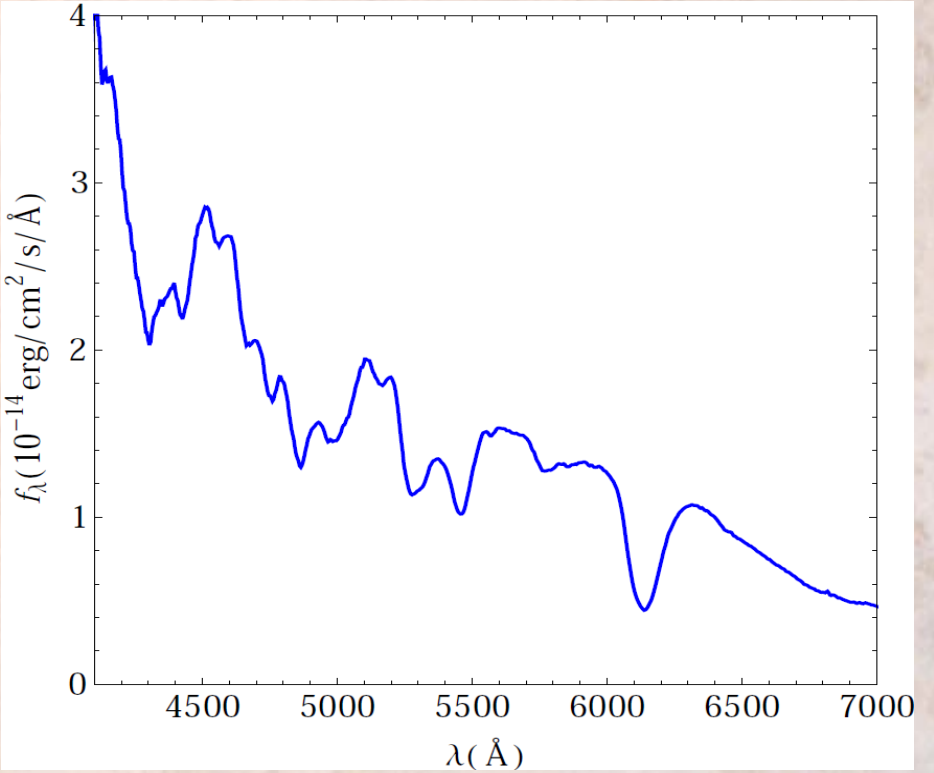
Filter	# candidates
489 nm	950
551 nm	501

Reducing the number of candidates

1. Demand coincidence between different filters:

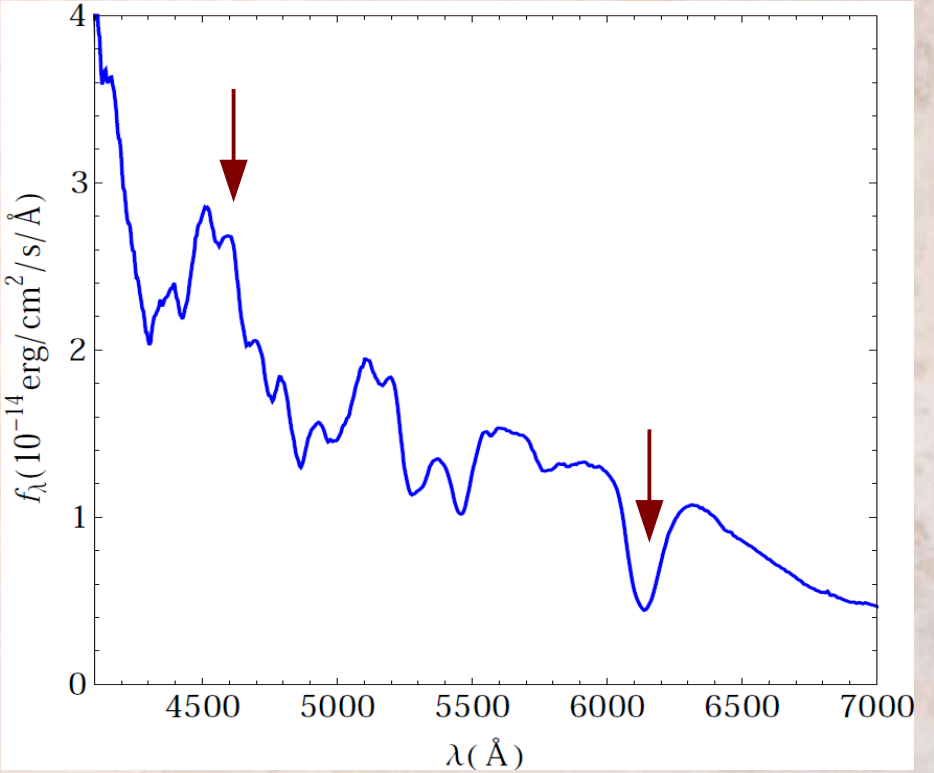
Cosmic rays, fast moving objects and bad pixels.

Reducing the number of candidates



Typical SN Ia spectrum

Reducing the number of candidates



Typical SN Ia spectrum

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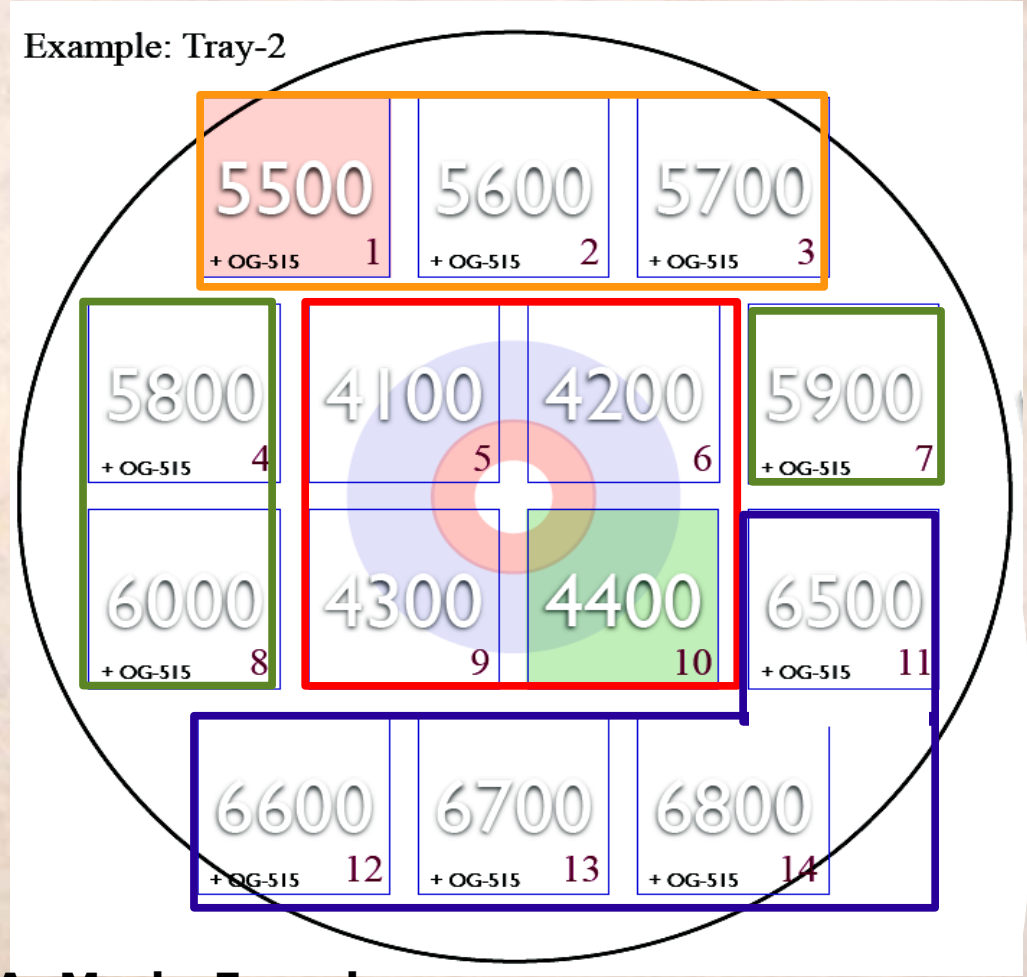
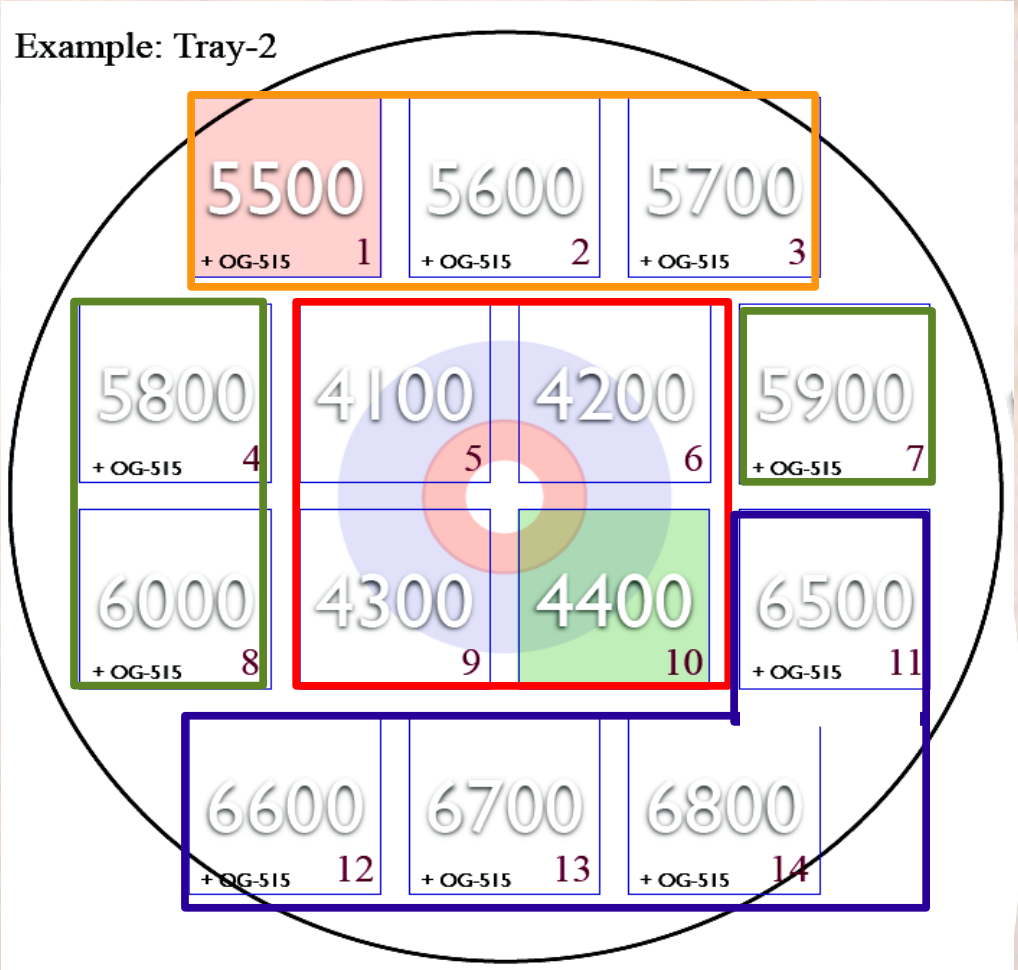
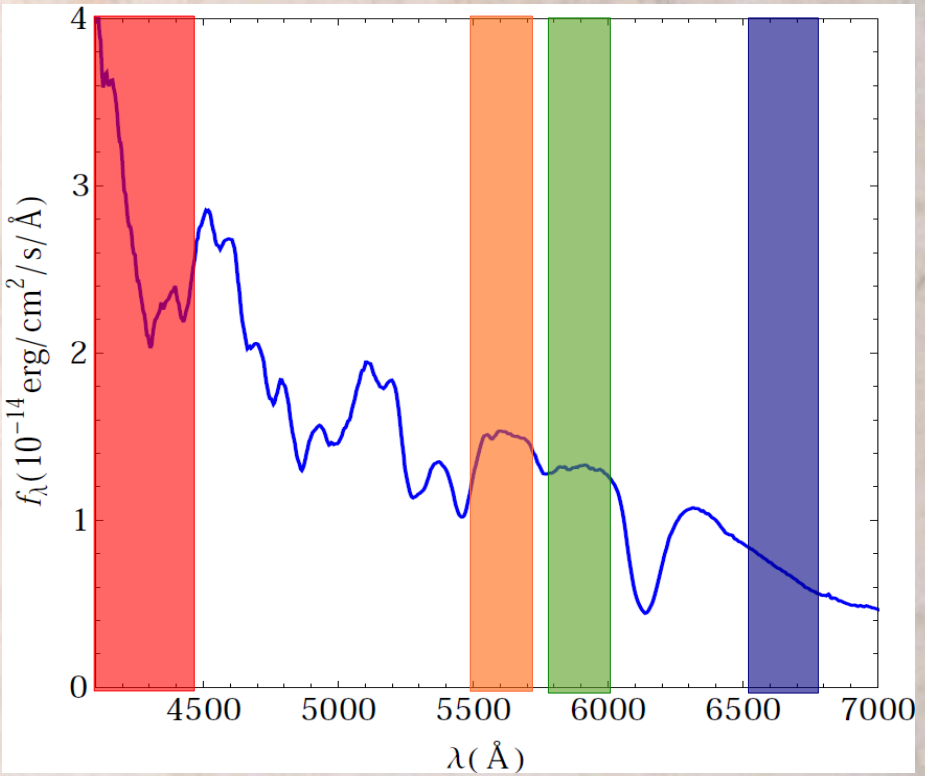


A. Marin-Franch

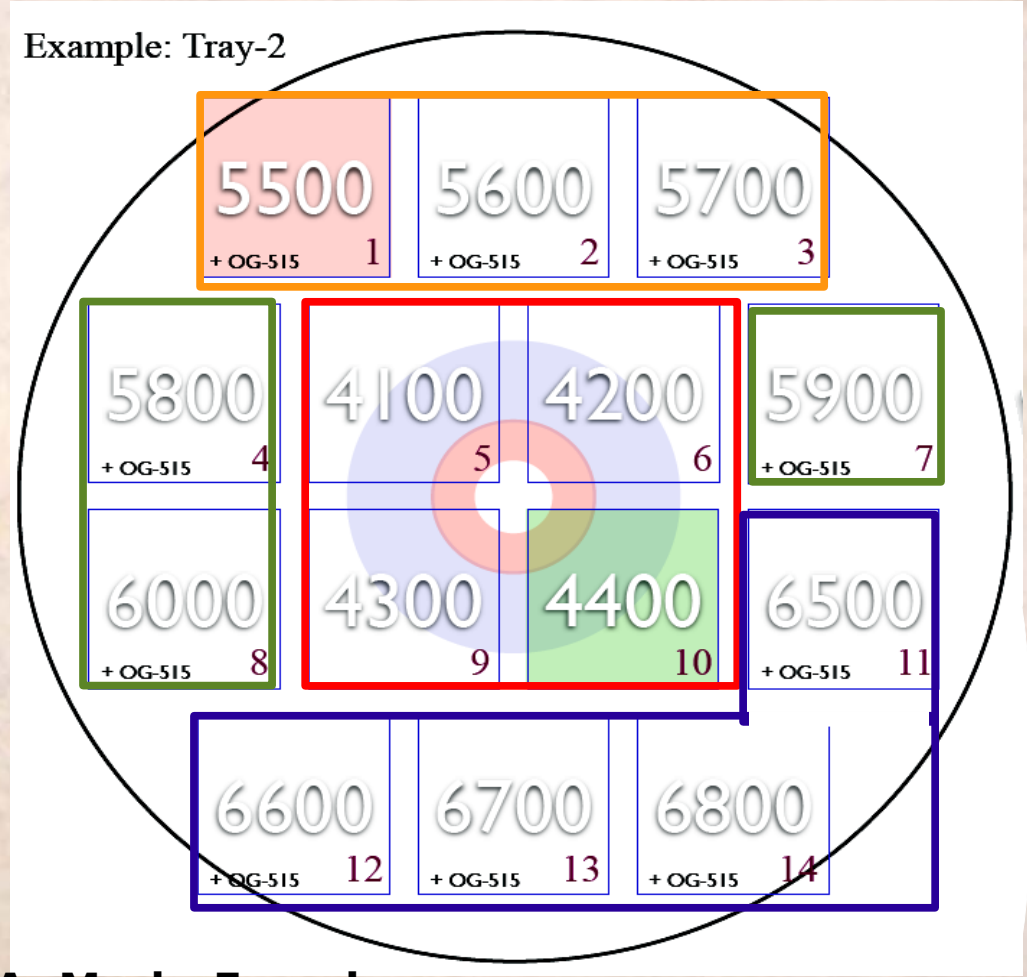
Reducing the number of candidates

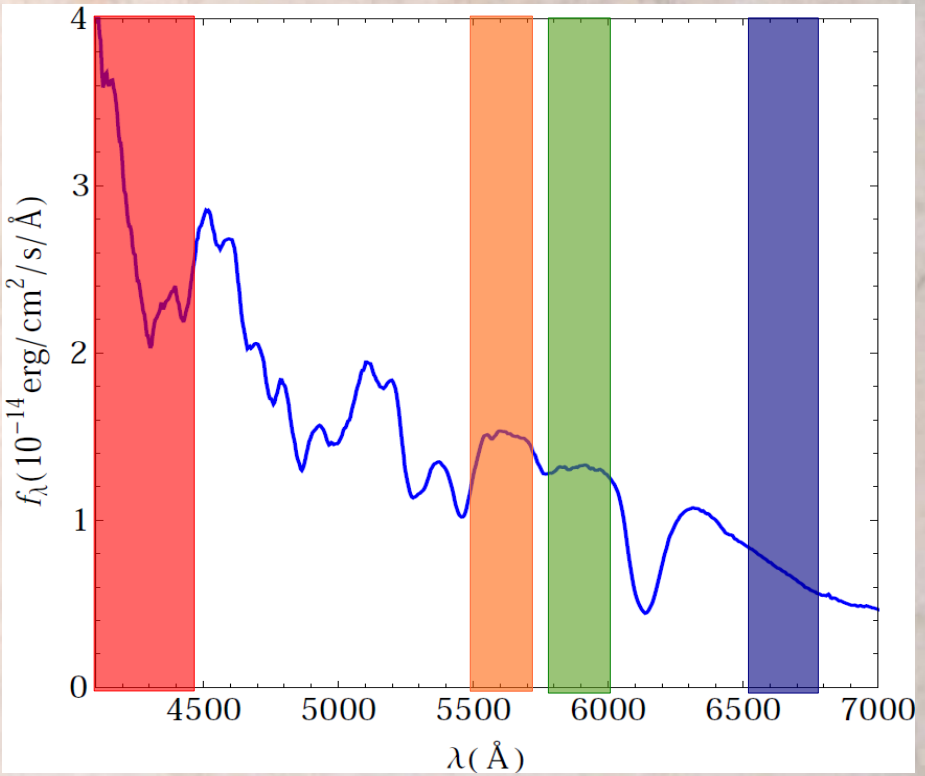




A. Marin-Franch

Reducing the number of candidates





A. Marin-Franch

Eliminates ~90% of the candidates.

Reducing the number of candidates

1. Demand coincidence between different filters:

Cosmic rays, fast moving objects and bad pixels.

2. Analyze shape:

SNe must have the PSF shape.

Eliminates objects with irregular shape.

Reducing the number of candidates

1. Demand coincidence between different filters:

Cosmic rays, fast moving objects and bad pixels.

2. Analyze shape:

SNe must have the PSF shape.

Eliminates objects with irregular shape.

3. Exclude known transient objects.

Tests with images from other surveys

SDSS

(0.16º X 0.22º)

Filter	# candidates
u	50
g	43
r	45
i	172
z	26

1 candidate:

SN 2005hk

ALHAMBRA

(0.25º X 0.25º)

Filter	# candidates
489 nm	950
551 nm	501

4 candidates:

SNLS 08D2dr

SNLS 07D2ke

2 Stars

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For each filter!

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For each filter!

All steps are automated

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For each filter!

All steps are automated

Pipeline steps

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(5) Reduce list of candidates;

For each filter!

All steps are automated

(6) Do cosmology with SNe.

Discussion

All open questions require further investigation;

J-PAS observatory expected to bring improvements in the field :

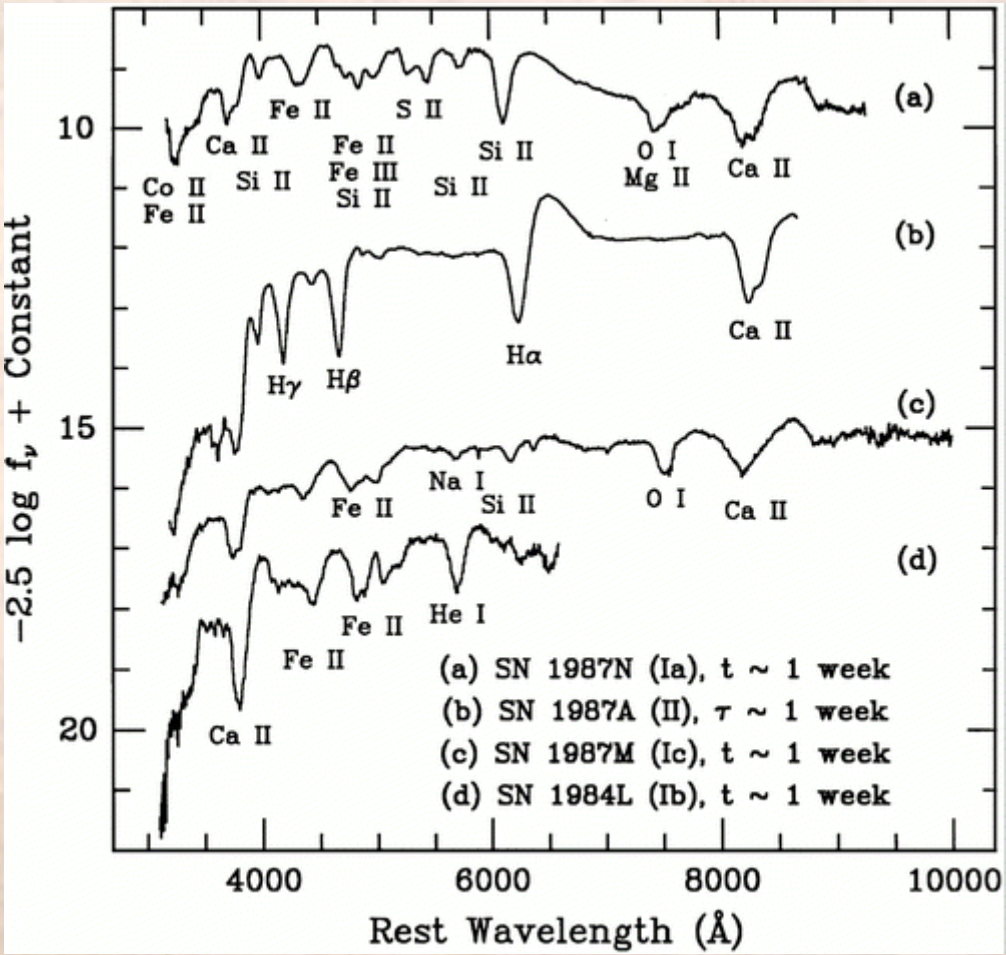
- **Big area: many SNe,**
- **Many narrow band filters: better redshift and spectral features;**

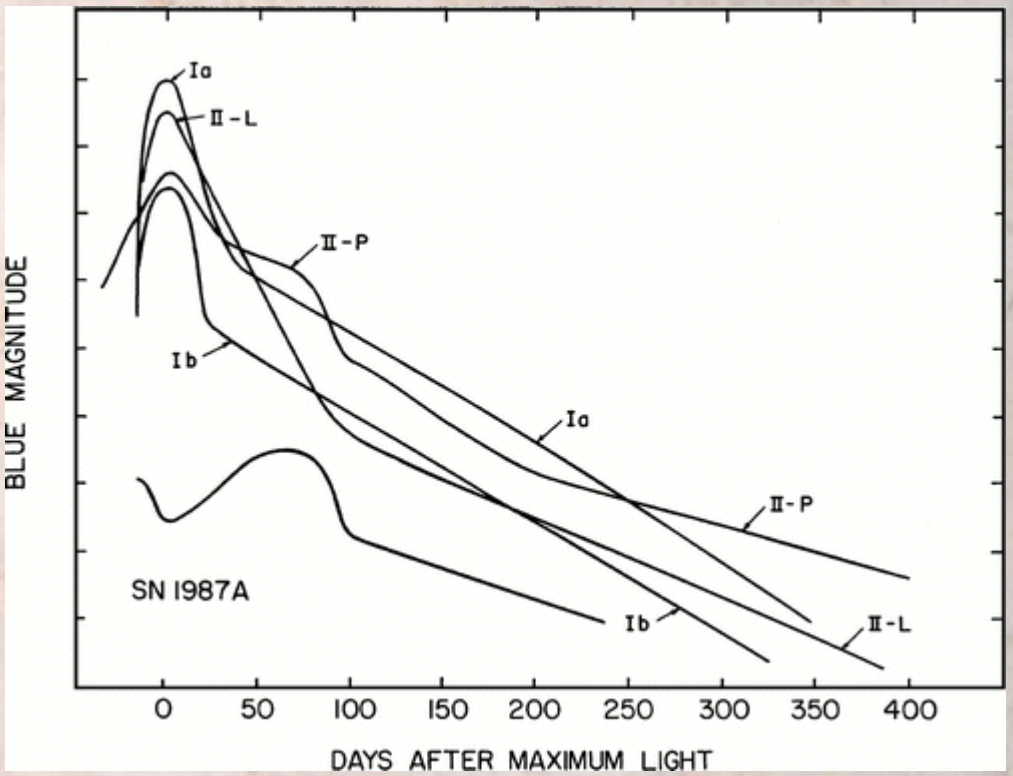
Image subtraction pipeline working well;

J-PLUS survey starting, new images to test the performance of our pipeline.

Thank you

Espectro e curva de luz





A. Filippenko, *ARA&A* 35 (1997)