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Variable Objects in SNLS

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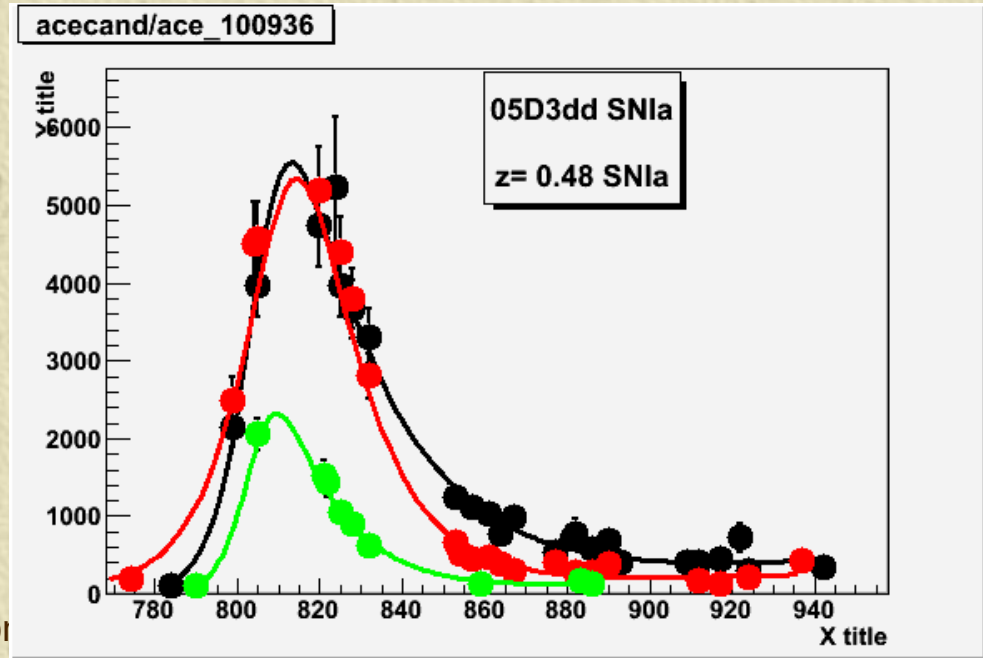
Variable Objects in SNLS

- The SNLS DataSet
- Detection of all true variable objects (ACE)
- Classification of all Variable objects

The SNLS DataSet

- 4 Deep field :
  - Each lunation : (20 days)
    - 5 to 3 epoch in 4 filters (griz)



The goals and requirements

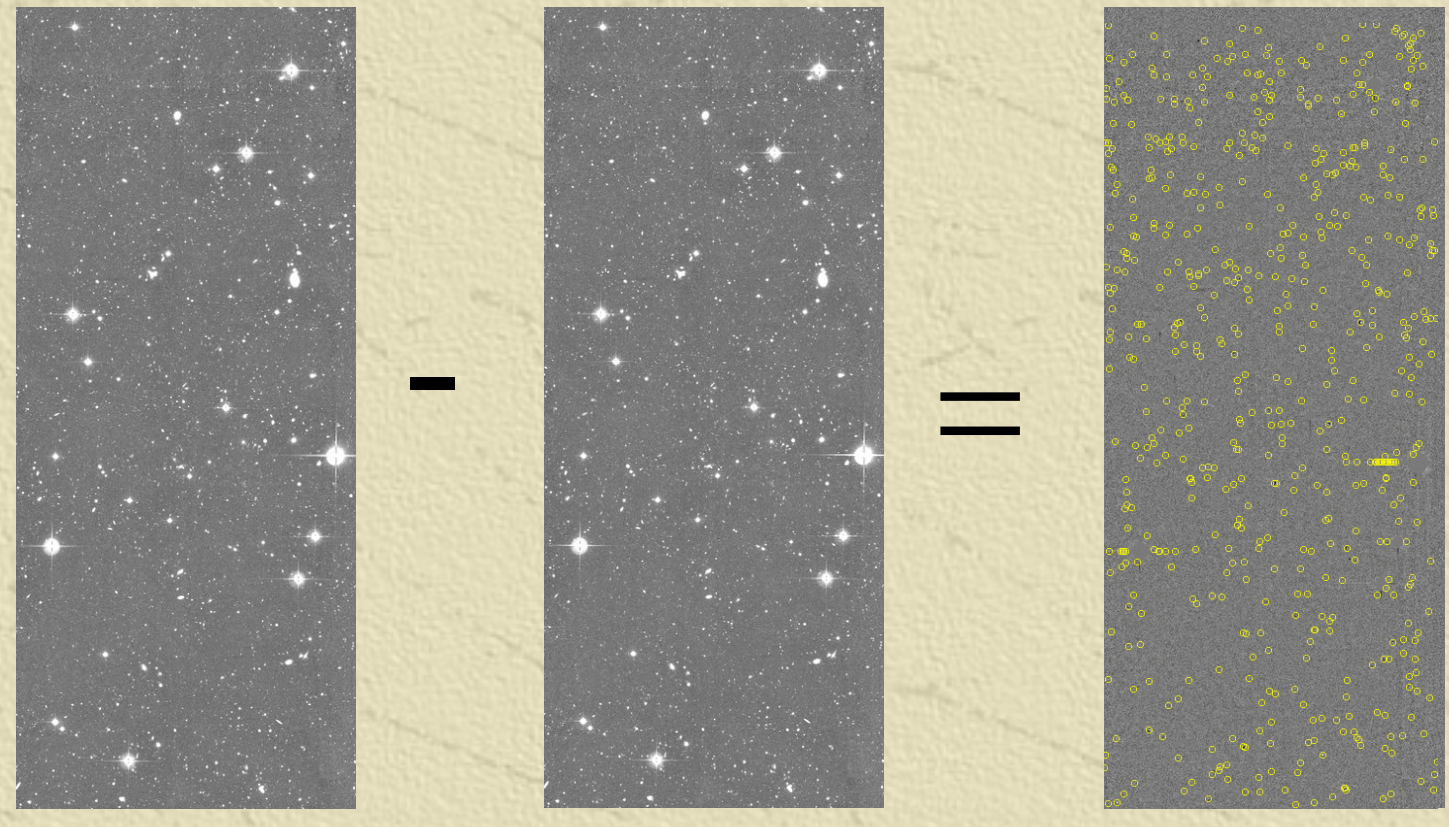
- Goals
  - Real time SN detection for spectroscopic follow-up
  - Reprocessed SN detection
  - Supernovae rate
  - SN selection bias studies for cosmology (malquist,…)
  - SN identification bias studies for cosmology (contamination,…)
- Requirements
  - No Human scanning nor specific post-selection/identification
  - Work on real time data
  - Work on reprocessed data (offline)
  - Permit selection efficiency determination
  - Standalone photometric identification (controlled by spectro follow-up)

ACE : Principle

- Part I : Perform image subtraction on each night from deep reference image
  - Variable PSF convolution (a la Alard)
- Part II: 'Computer scanning' procedure to select the 'true' PSF-like variations
- Part III: Construct true variable objects from set of consecutive true fixed position variations.
  - Multicolor lightcurve

ACE : Part I

Ref Sub New



20 000 000 Detections per year !!!

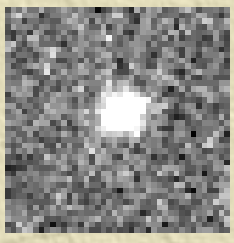
PartII: The ‘computer scanning’ method

- Identification of Good/Bad Detections with shapelets
- Neural network training phase
- Results

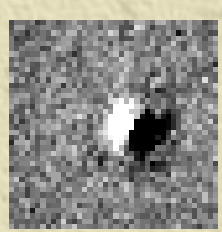
Shape analysis of detections

Shapelet decomposition

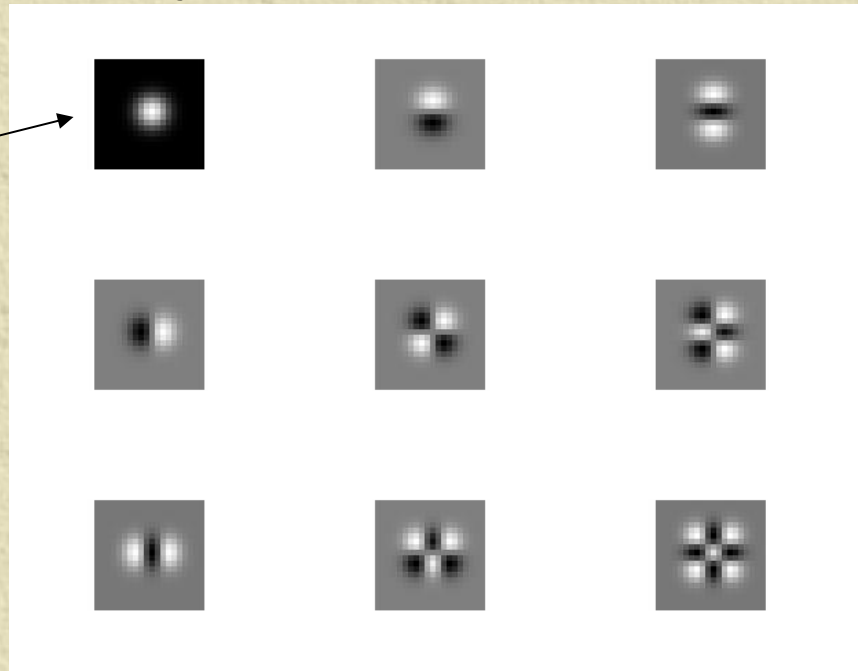
- Project each detection vignet on the 16 first functions of a cartesian shapelets base. 16 coefficient then determine the shape.
- A standard 2D gaussian image (A standard point like object image) will project on the first function only !



GOOD

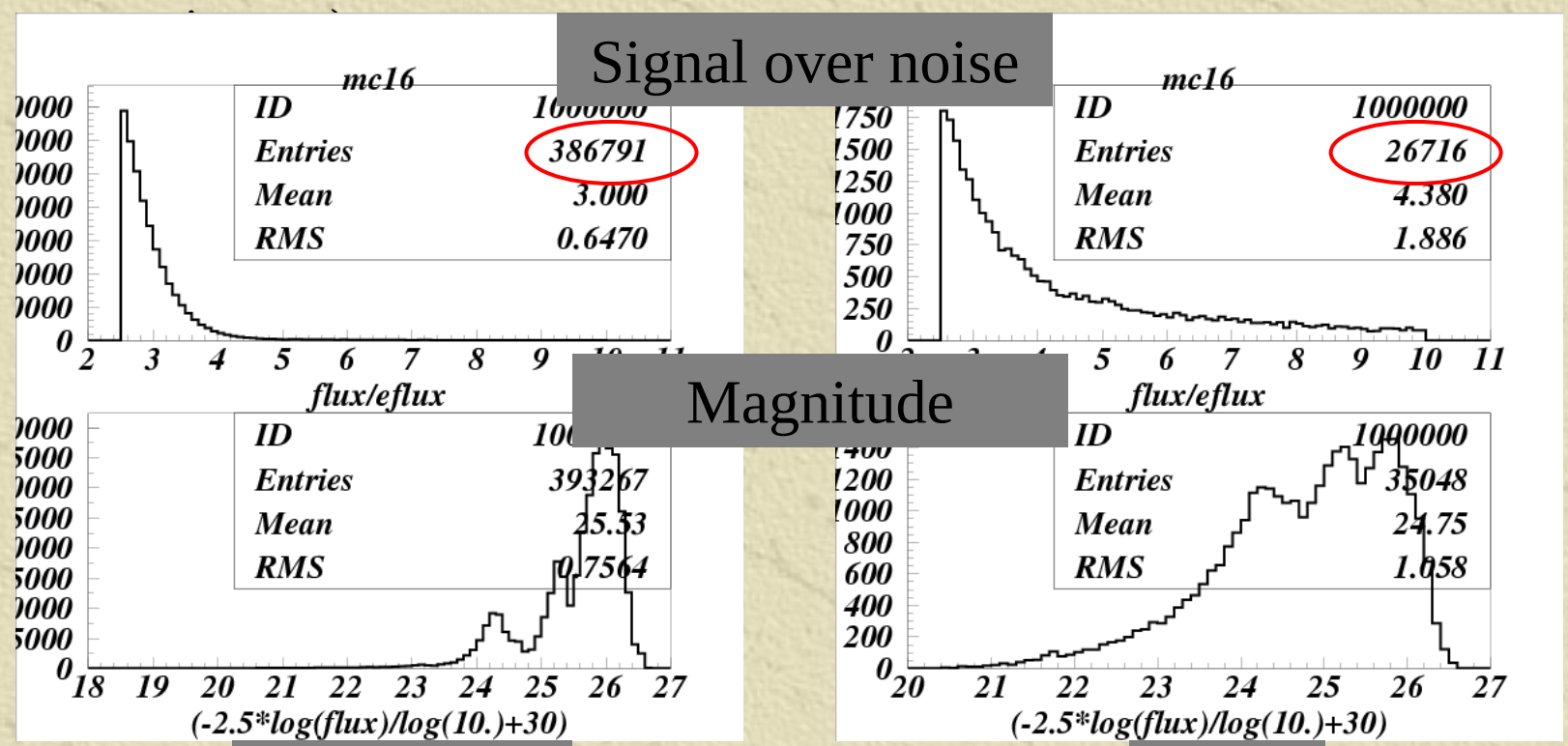


BAD !



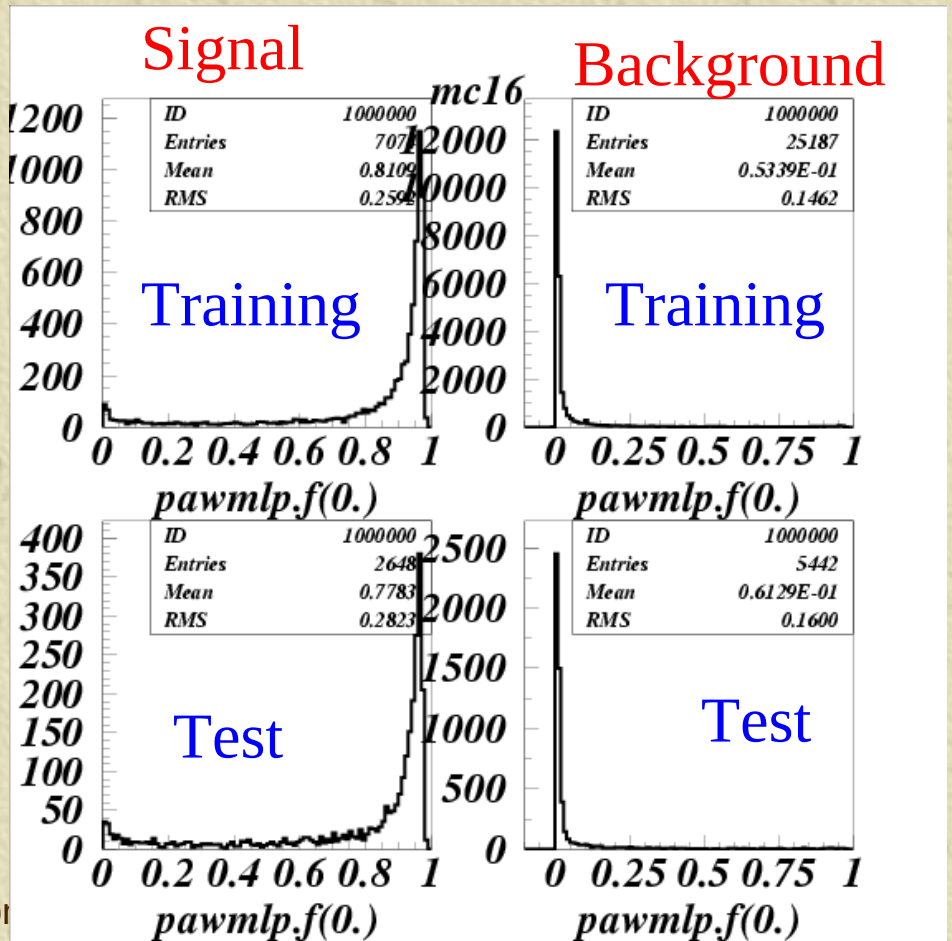
Neural Net training

- Detection samples
  - Background = from true images (back + small part of signal)
  - Signal = from Simulation (PSF-like variation added on true



Neural Net training

- Train on half of detetction/ Test other half
  - Input 127000 Bgd / 16000 Sig of detections SoN>5
  - Result of NN output :



EFF/rej = 92. /15 SoN>8

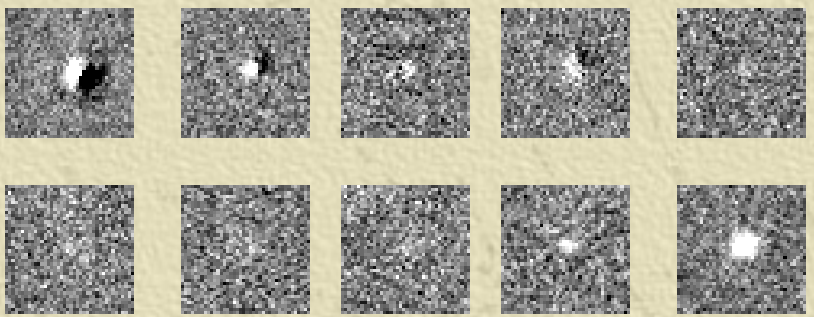
EFF/rej = 89 /8 SoN>5

EFF/rej = 46 /2.8 5>SoN>3

Computer Scanning : Result

Good & bad detections according to the NN

Bad



Good

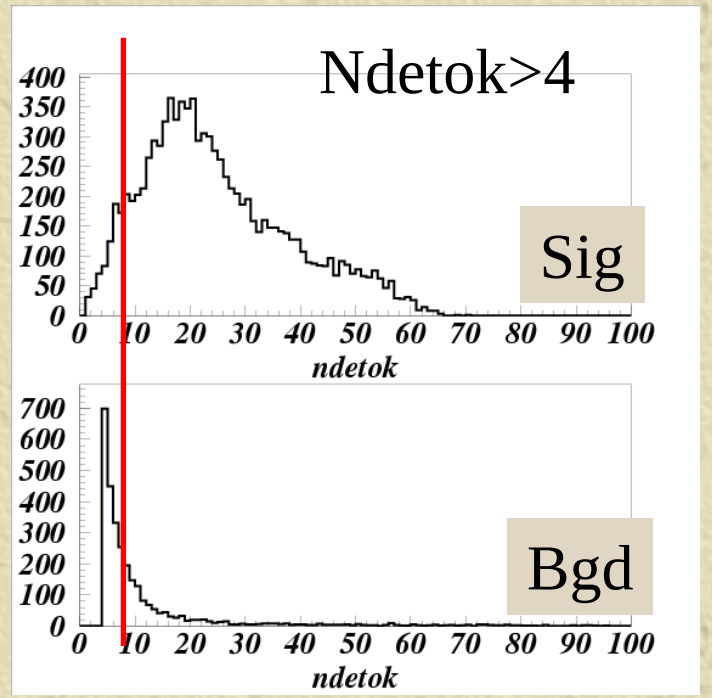
From bad events

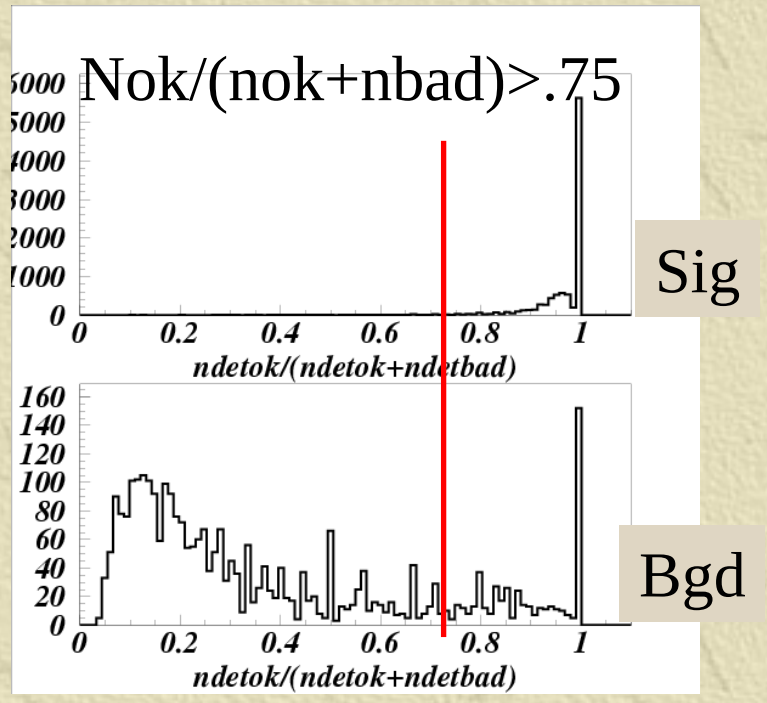
From good events

ACE Part III
Construction of variable point-like objects

- Enter all detections in a database
  - (5.10^6 /field*semester)
- Variable object (event) is created if at least one good det exists
  - Constructed epoch after epoch + backward search when event created.
- Selection of good point-like events
  - Number of good and bad dets : Ndetok,Ndetbad

Selection of good point like events





All events with at least 5 good detections and less than 25% bad

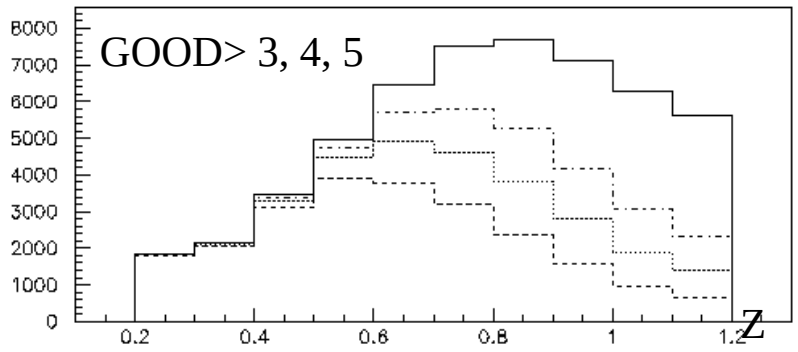
Study of variable object selection

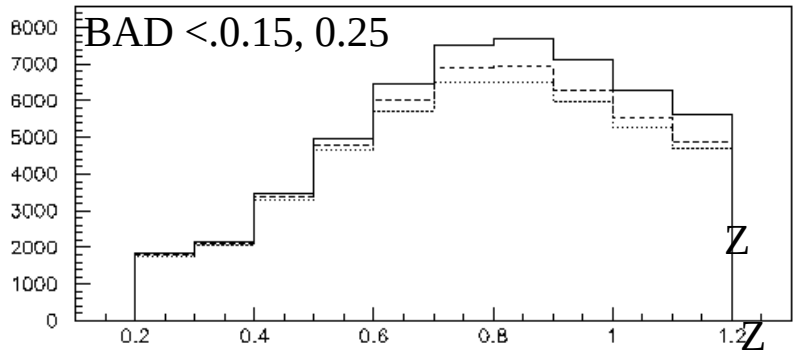
- Selection from good/bad detections

Full monte carlo of SNIA

CUT1 =
GOOD >4
(id 3 for lightcurve
+ 2 for color …)

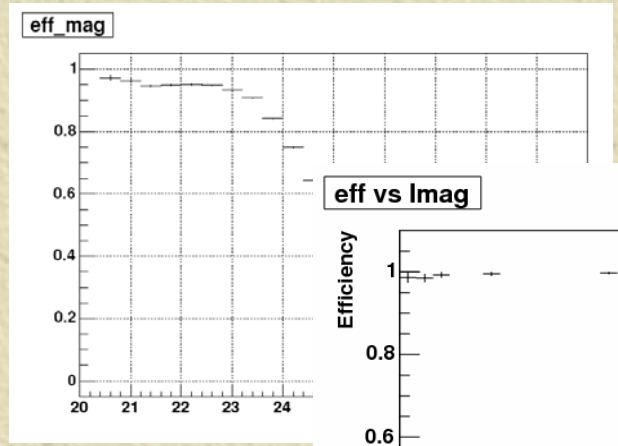
CUT2 =
BAD < 0.25 (GOOD+BAD)

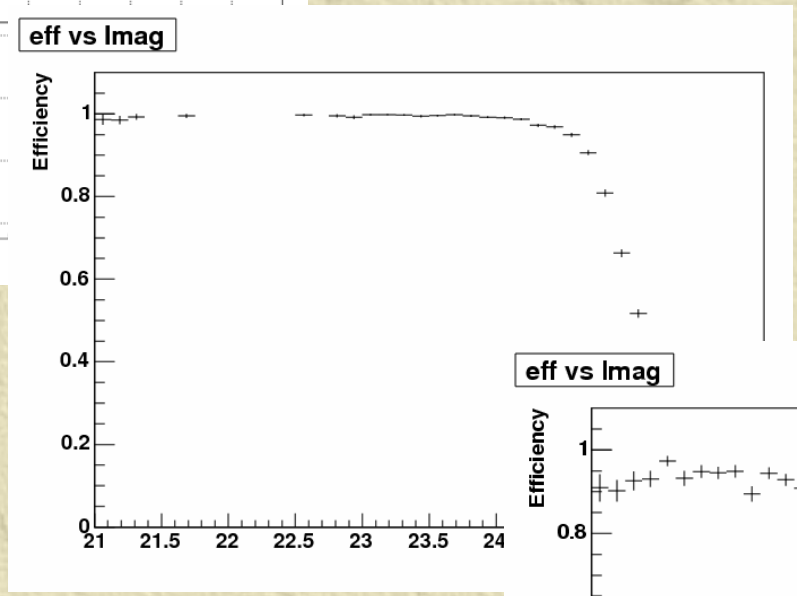


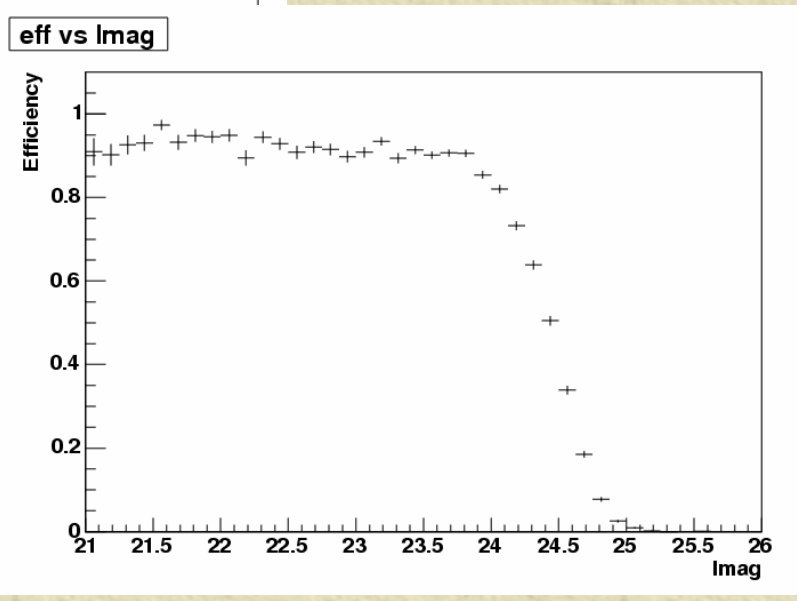


HUMAN SCANNING OF RESULTS:
NO BAD CAND FOUND
-> BGD = percent level ?

High efficiency result





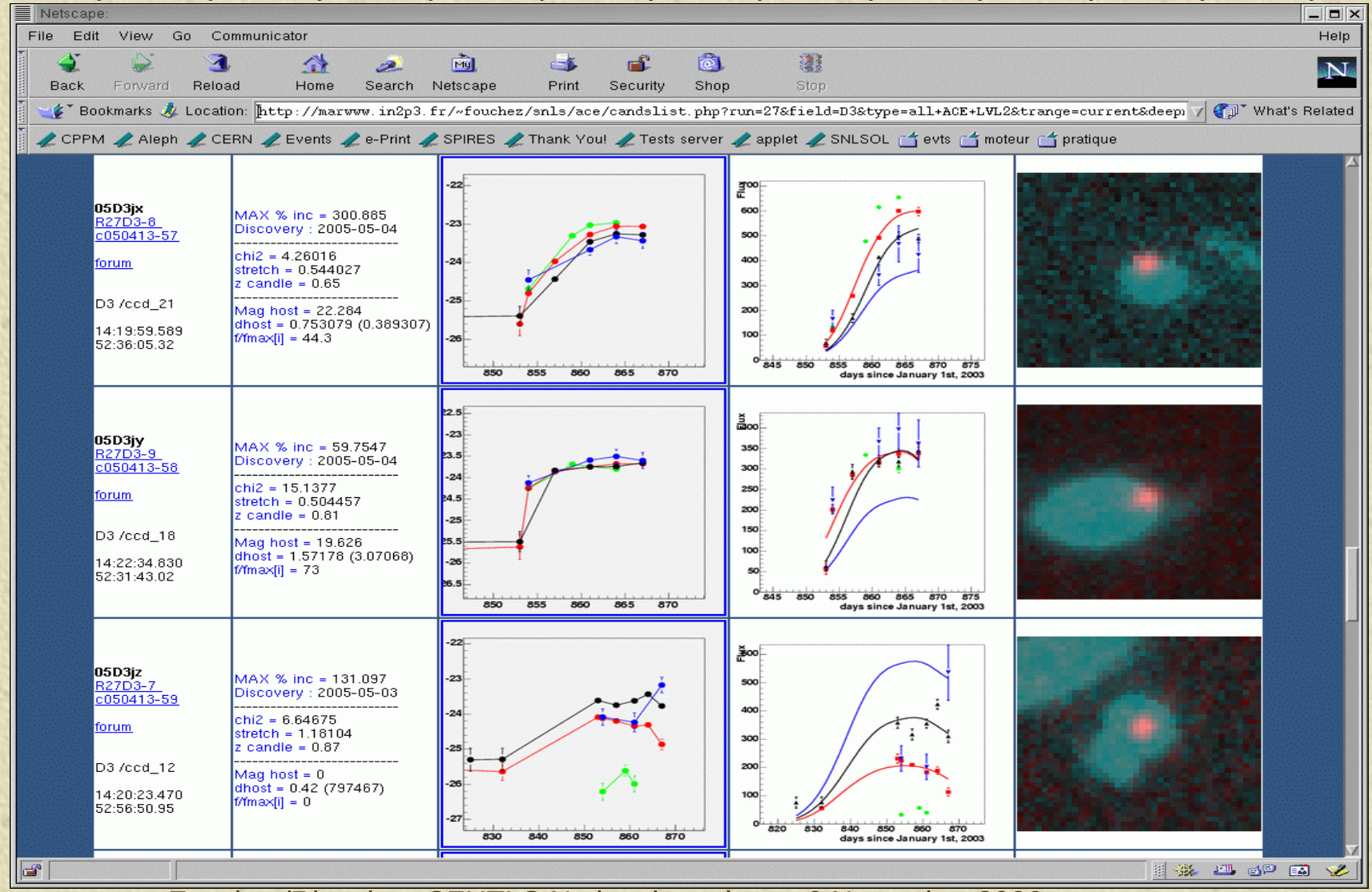


Almost 100% up to magnitude limit cut

Summary Automatic Candidate sElection

- In one fully automated PATH
  - Construct candidate events from set of subtracted images to reference
    - Use all color filters
  - Select good variable object on a first step
  - Select good Snia events in a second step
- Selection is based on well defined and adjustable cuts, no pre-post human intervention
- Reasonably fast (<24H for a field*semester)
- Can be used on true image, MC images, real time or offline reprocessing

First Application
French RealTime Detection pipeline

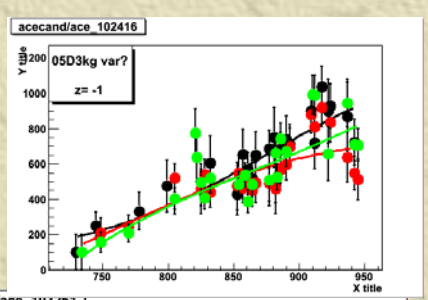


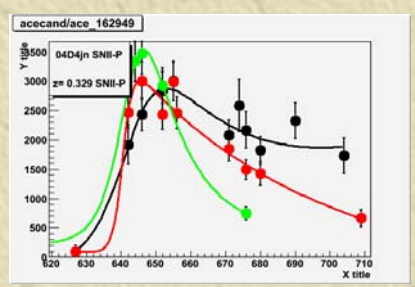
Second Application: Classification/identification of variable objects

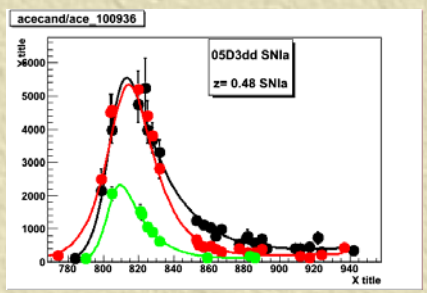
- DATA Set = Season 1+2 on 4 Deep fields, all reprocessed for image subtraction (same image input as the one use for precise photometry, full simulation of fqke run in parallel)
  - After ACE running : Number of ‘true’ Variable objects = 2780
  - Spectro information on 310 objects
  - CFHT Photometric catalog
- Examples of Lightcurves …

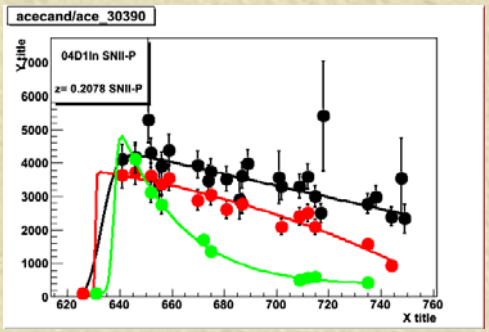
Classification/identification of variable objects

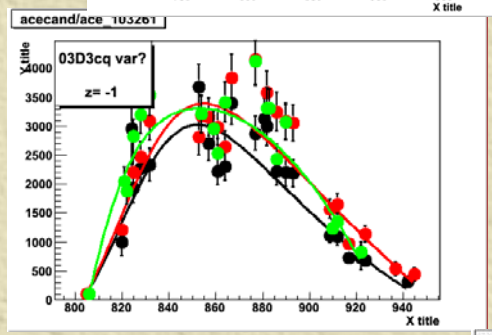
- Examples of Lighcurves:

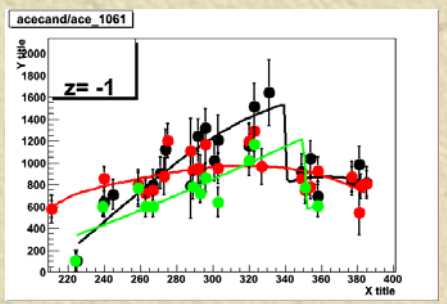


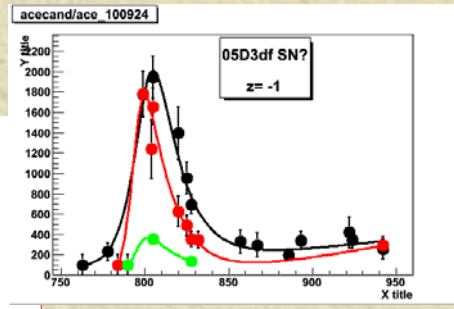


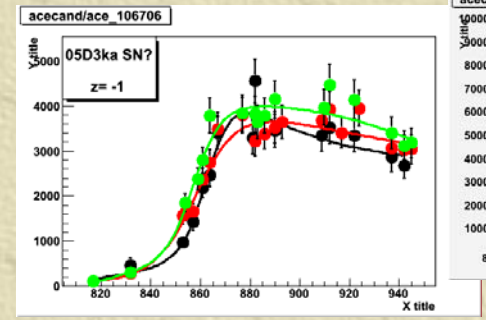


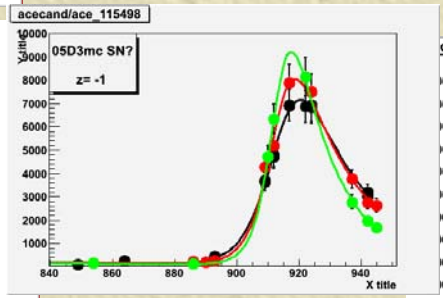


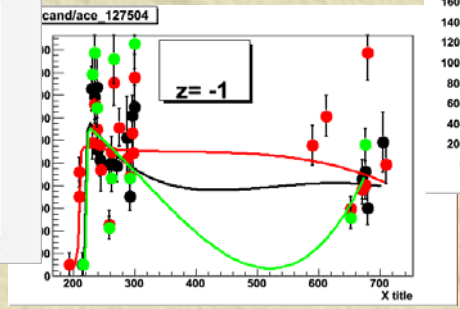












Classification/identification of variable objects « First attempt »

- The Lightcurve Shape classification

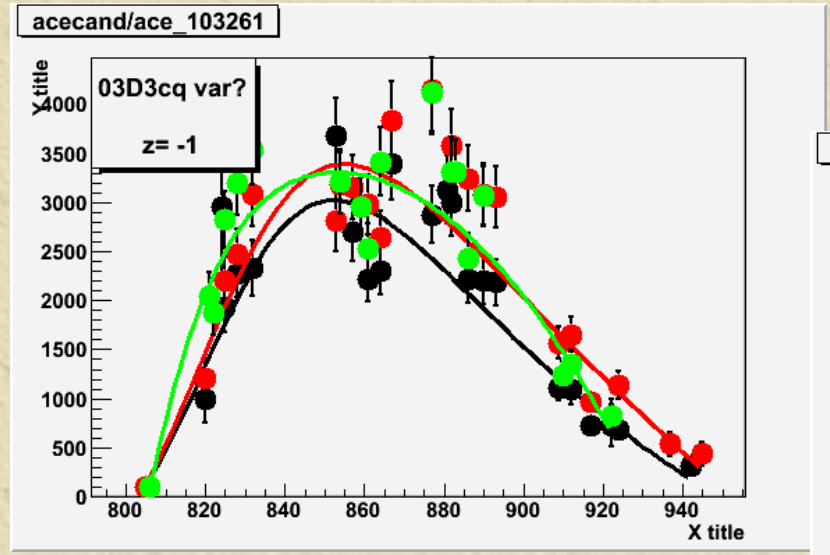
- Very Fast Variation
- Slow variation (slow rise)
- Fast rise - slow drop : plateau like
- Fast rise – fast Drop : SNI like

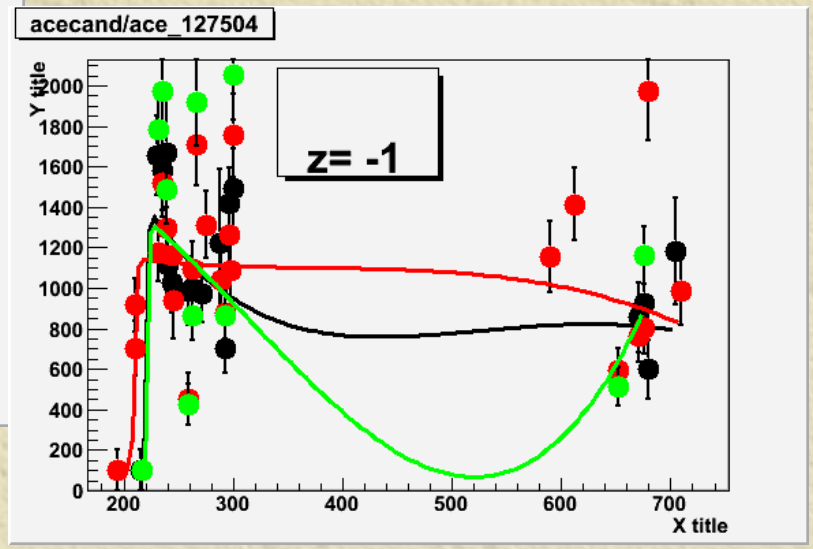
Very Fast Variation

Try to fit a ‘Skewed Normal’ Distribution

(cut on Chi2)

(landau curve+polynomial)

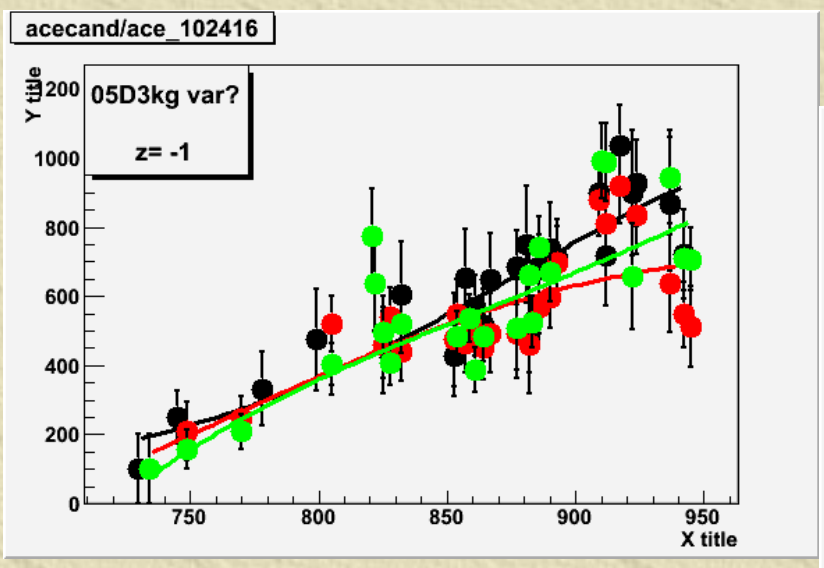


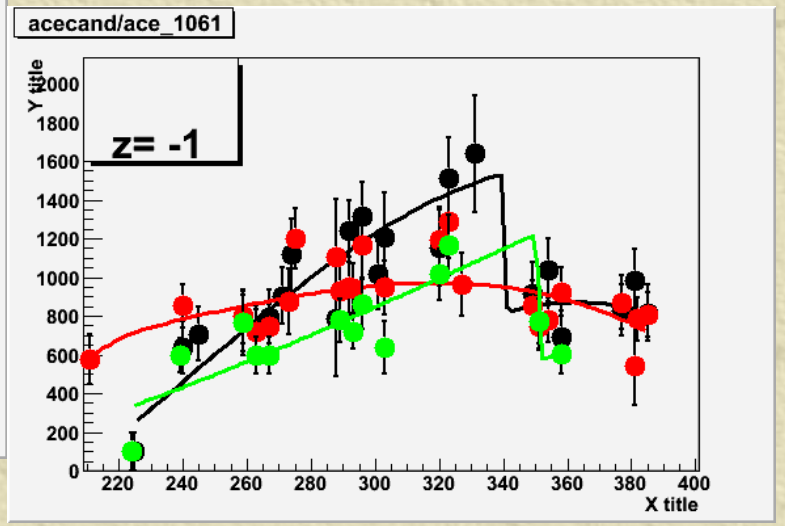


Slow variation

Cut on Δmag-10

$= mi_{max} - mi_{magmax-10days}$

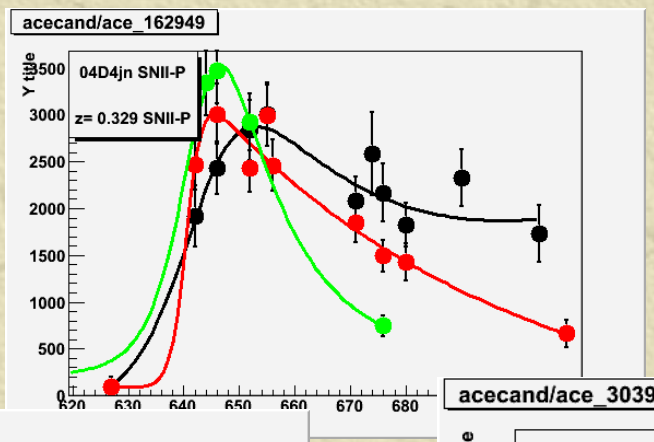


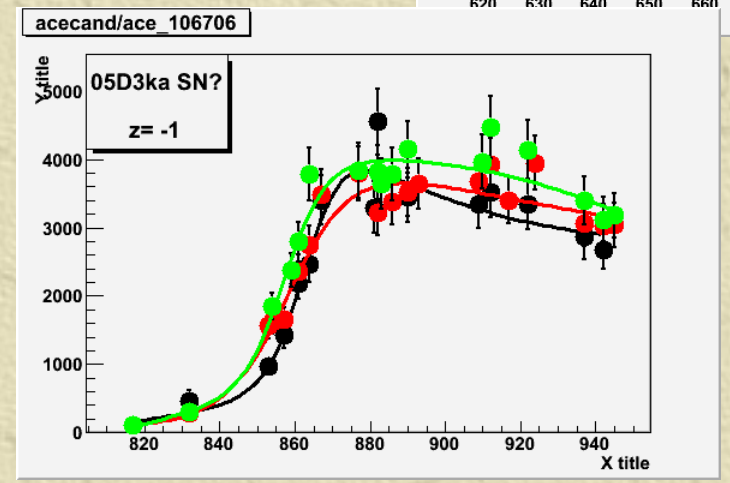


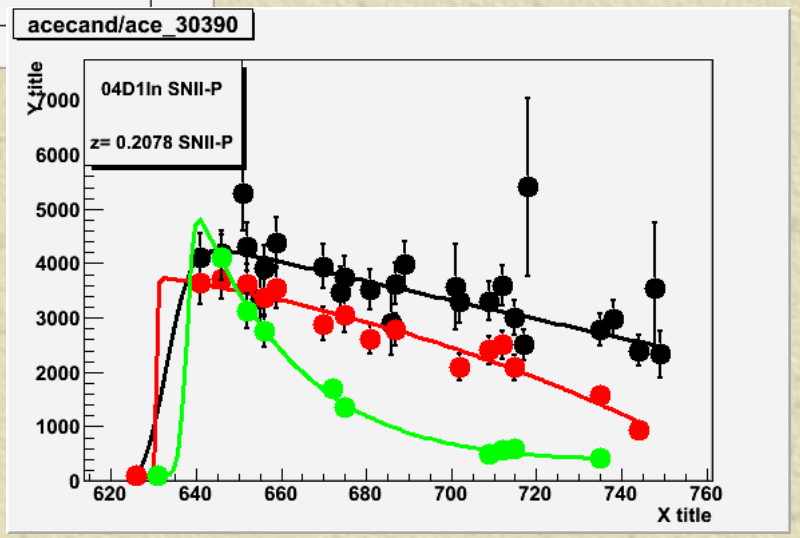
Fast rise Slow Drop

Cut on Δmag+20

$= mi_{max} - mi_{magmax+20days}$



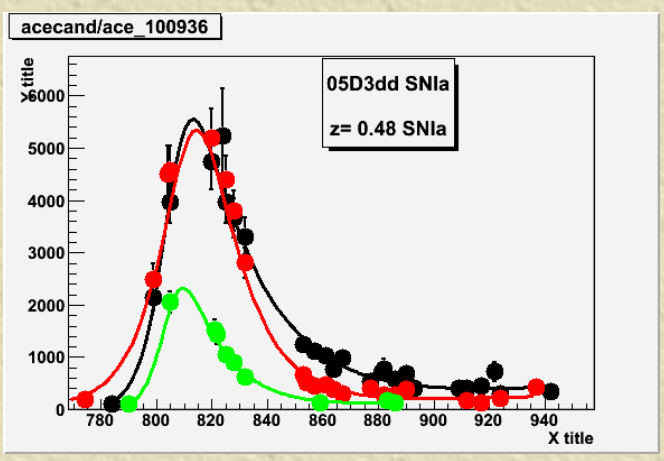


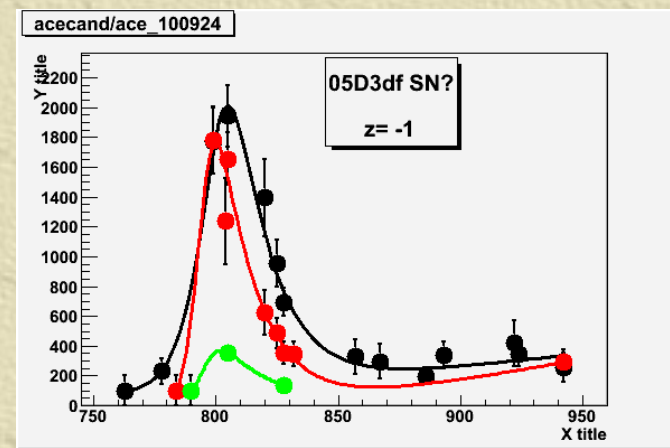


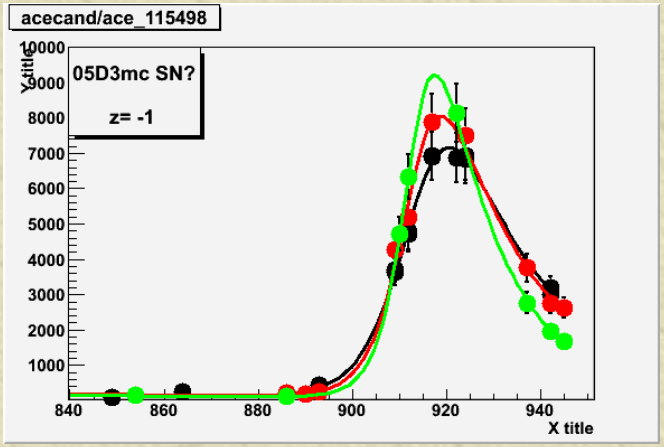
Fast Rise Fast Drop

Cut on Δmag+20

and Δmag-10

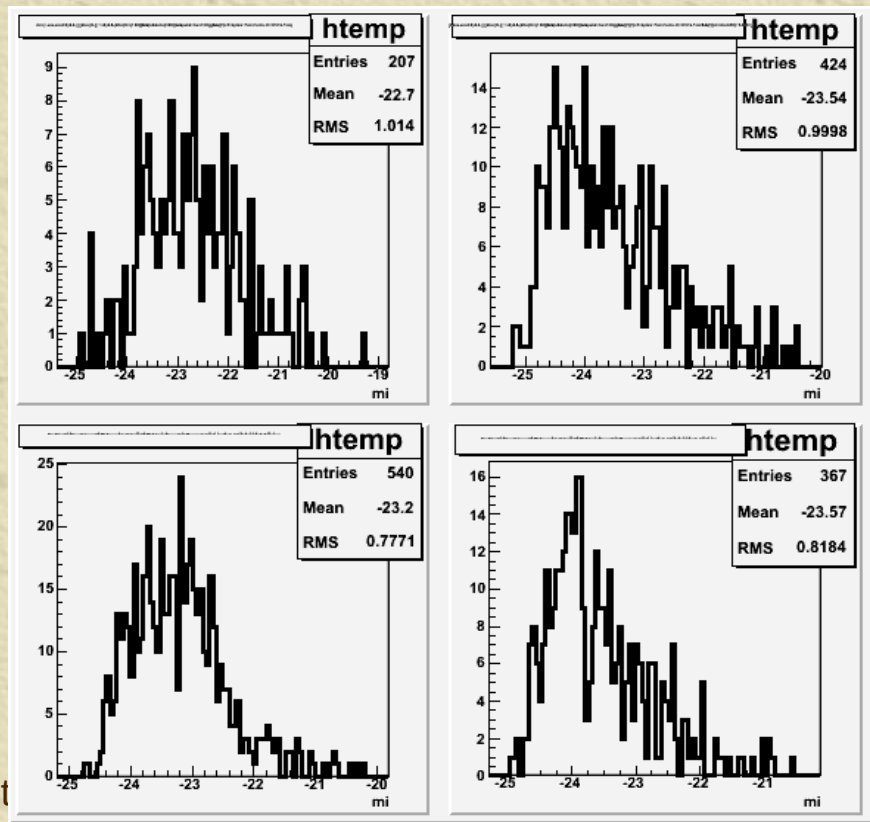




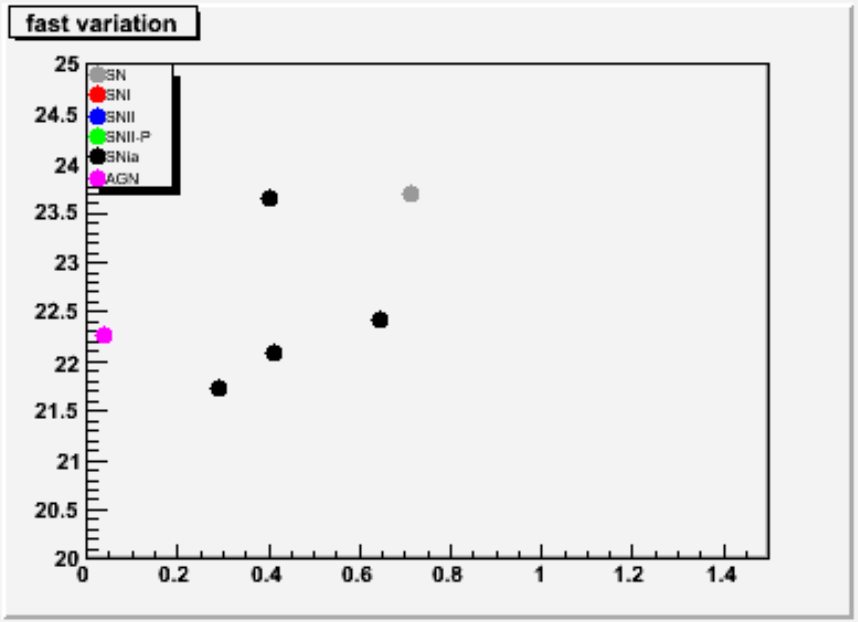


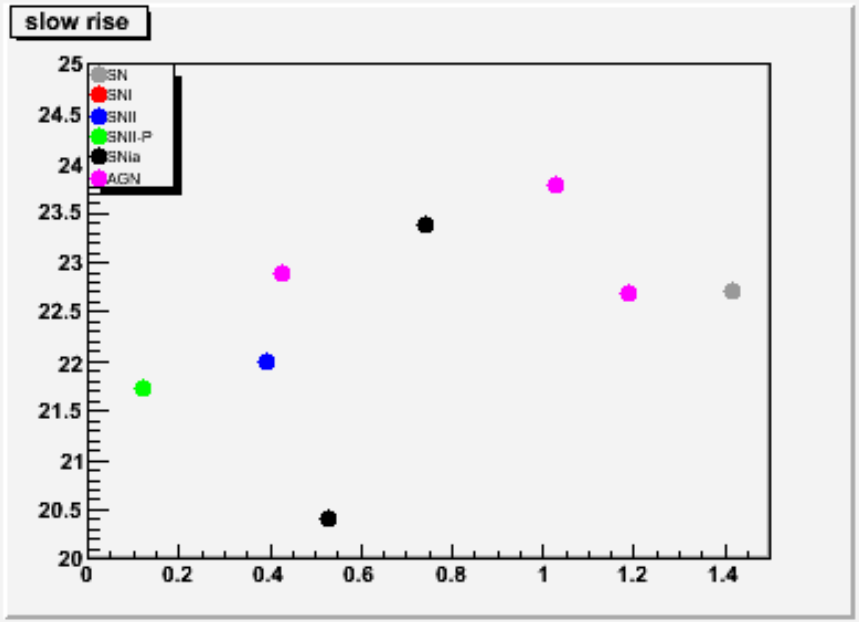
What are thoses objects ?

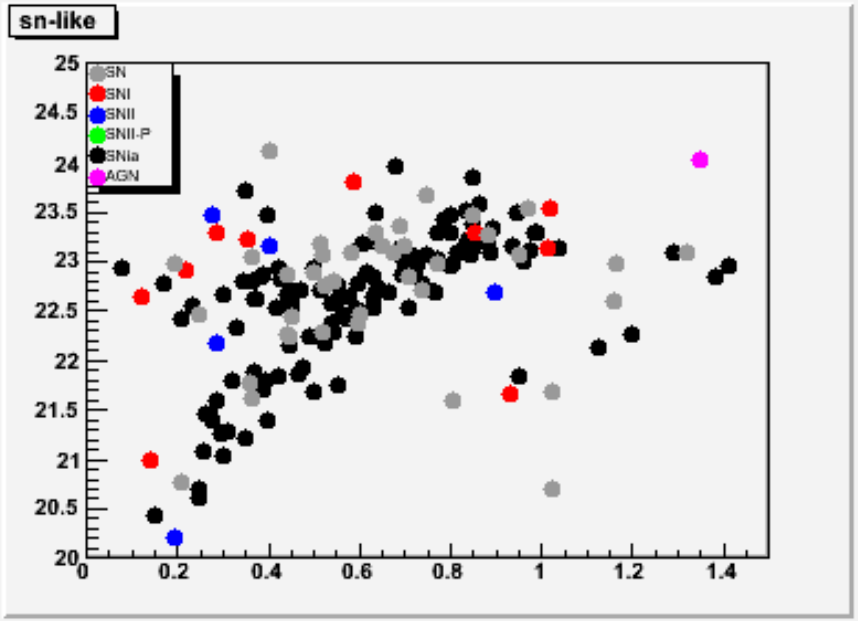
- Star and AGN candidates = Very Fast or Slow?
  - 600
- SNIIP = Slow drop ?
  - 550
- SNI, SNII = Fast Drop ?
  - 400

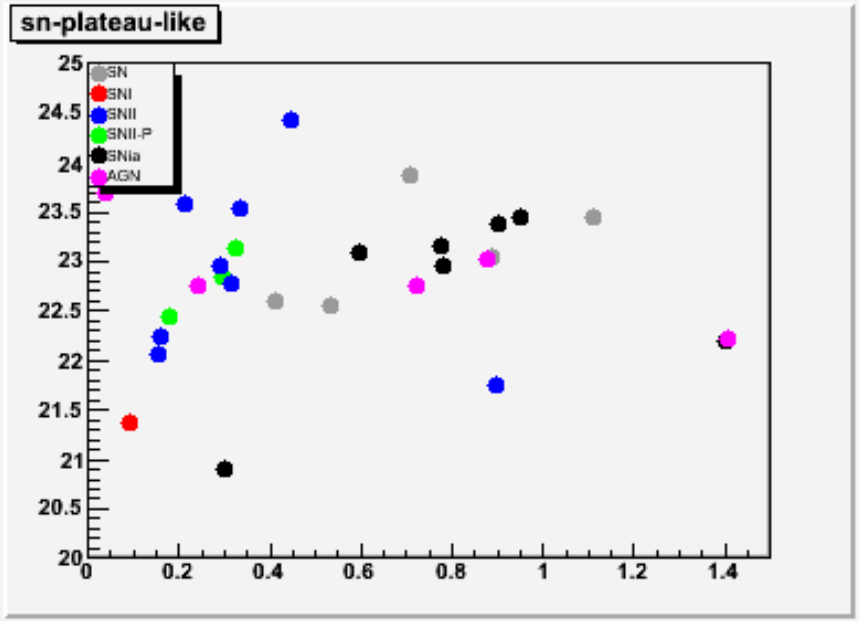


m_i

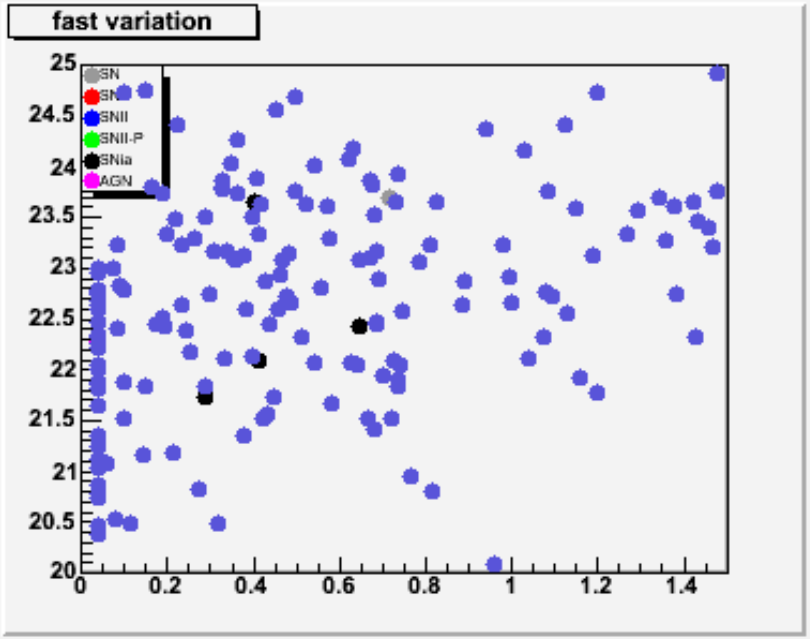

fast variation
SN
SNI
SNII
SNII-P
SNIa
AGN
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
0
0.2
0.4
0.6
0.8
1
1.2
1.4

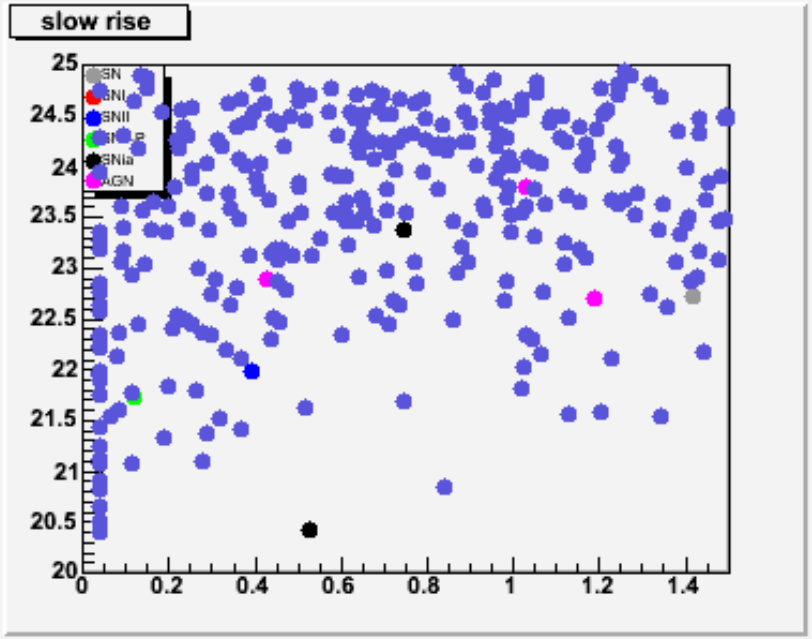

slow rise
SN
SNI
SNII
SNII-P
SNIa
AGN
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
0
0.2
0.4
0.6
0.8
1
1.2
1.4

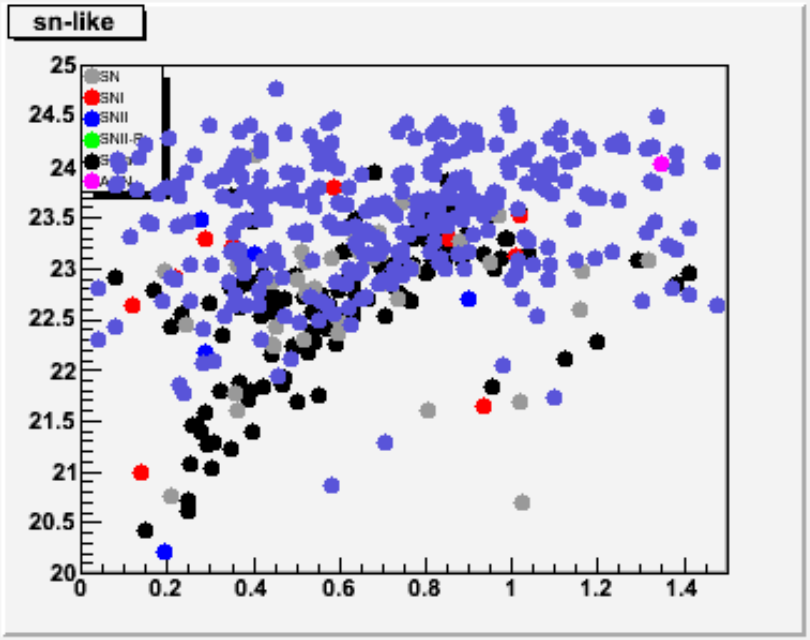

sn-like
SN
SNI
SNII
SNII-P
SNIa
AGN
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
0
0.2
0.4
0.6
0.8
1
1.2
1.4

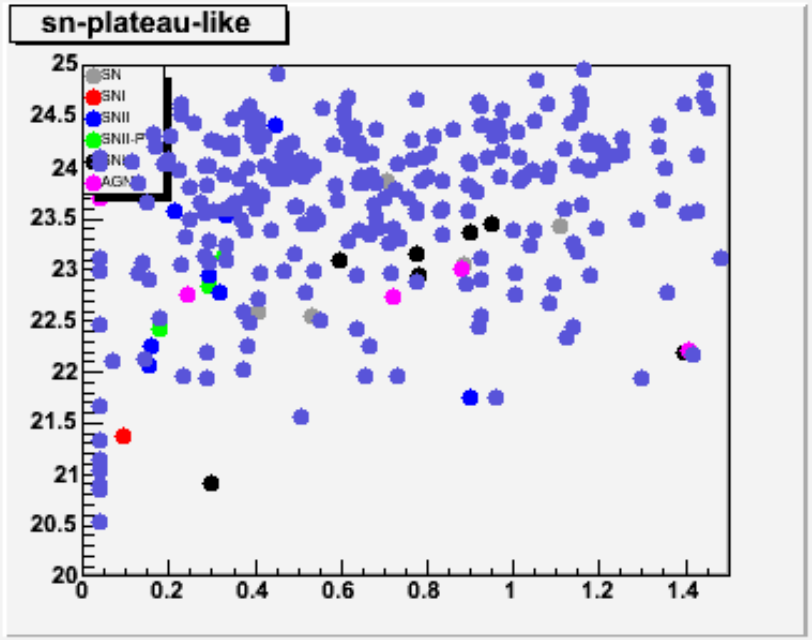

sn-plateau-like
SN
SNI
SNII
SNII-P
SNIa
AGN
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Z

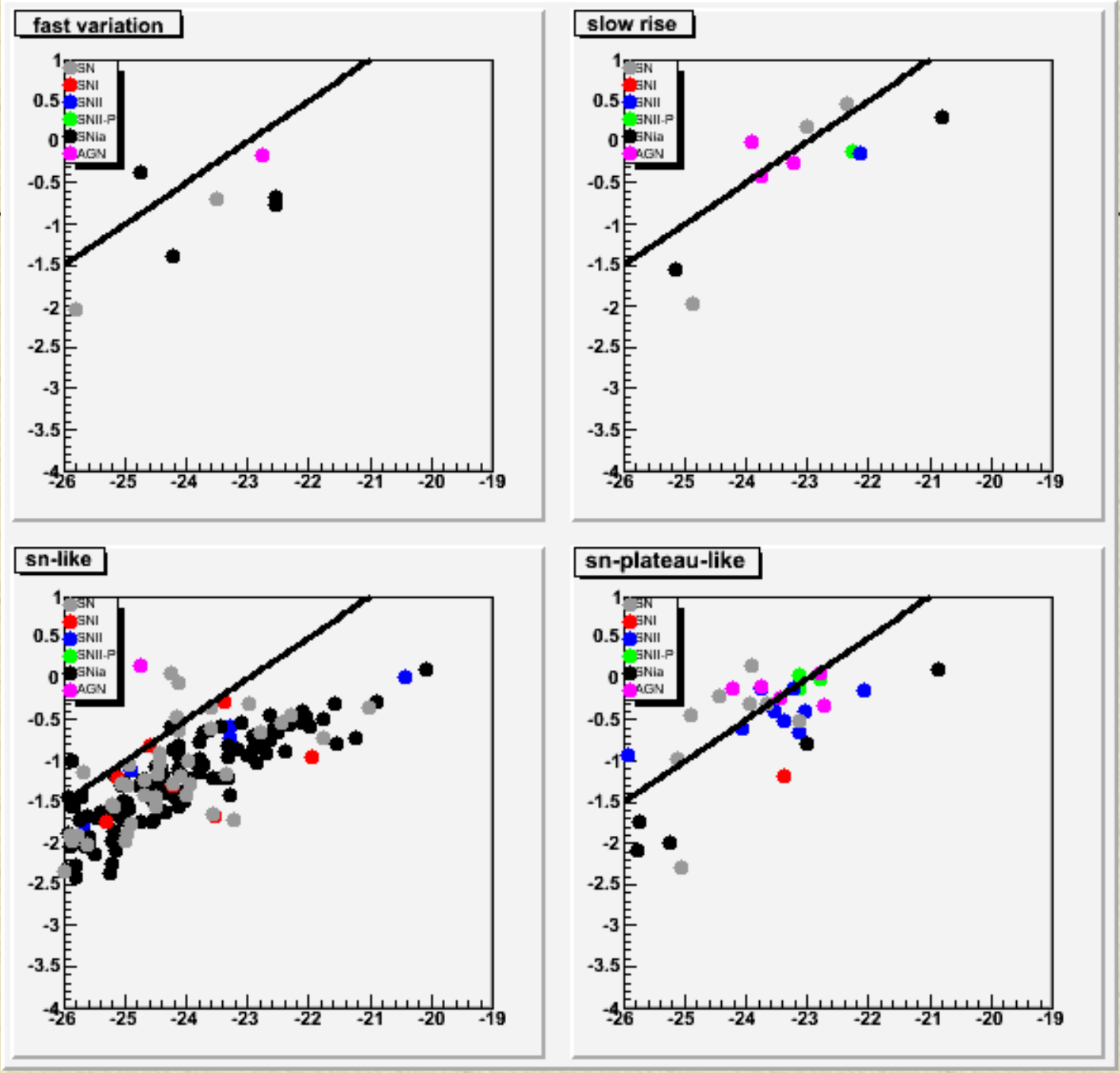

fast variation
SN
SNI
SNII
SNII-P
SNIa
AGN


slow rise
SN
SNI
SNII
SNII-P
SNIa
AGN

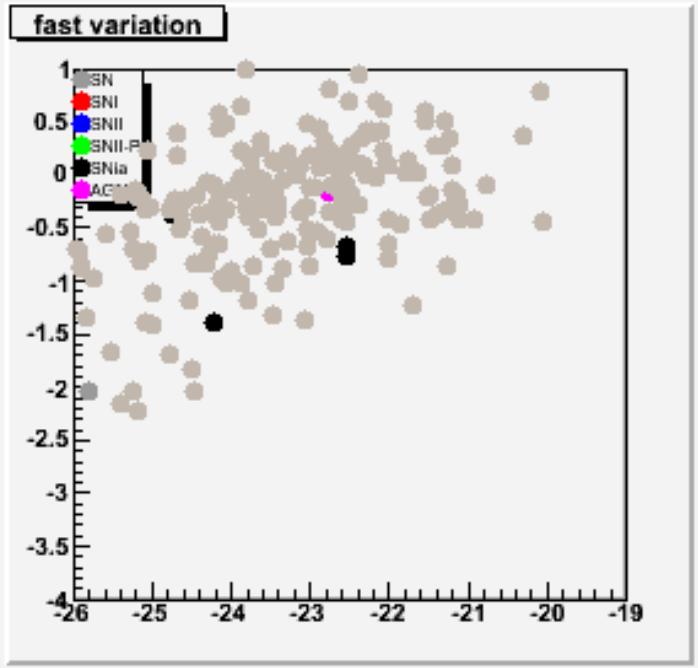

sn-like
SN
SNI
SNII
SNII-P
SNIa
AGN

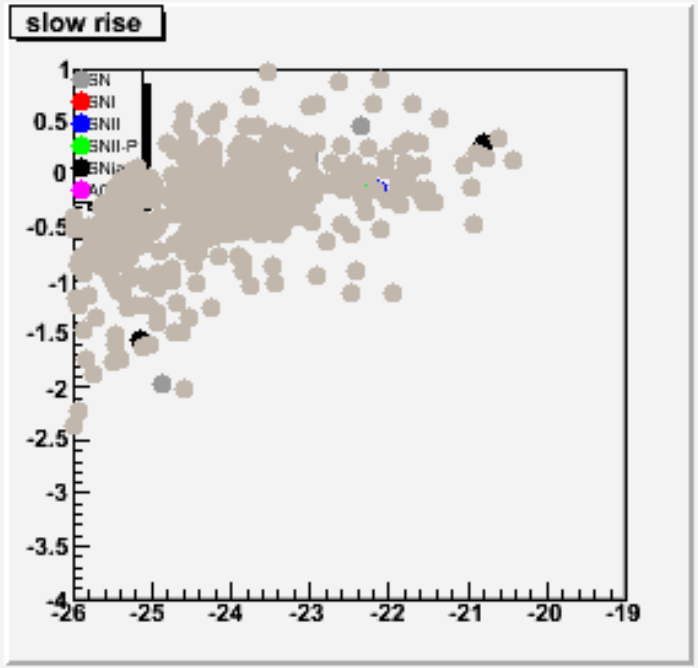

sn-plateau-like
SN
SNI
SNII
SNII-P
SNIa
AGN

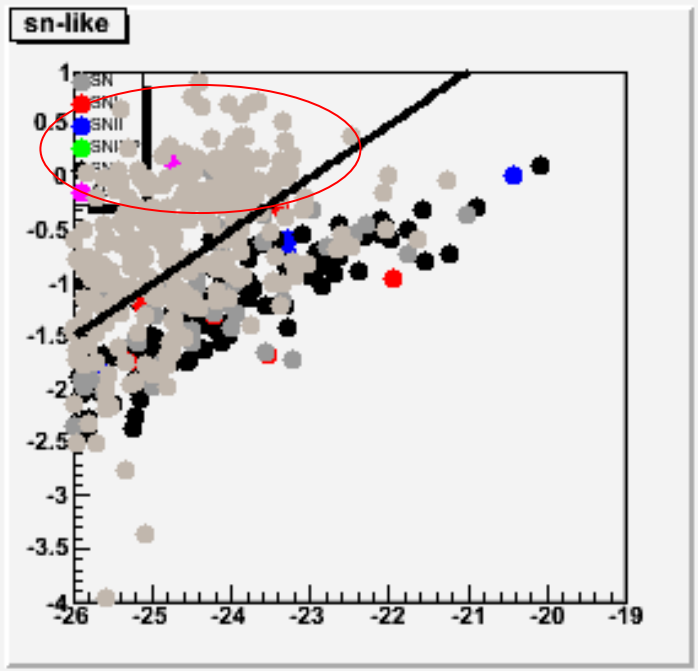
m_g-m_r

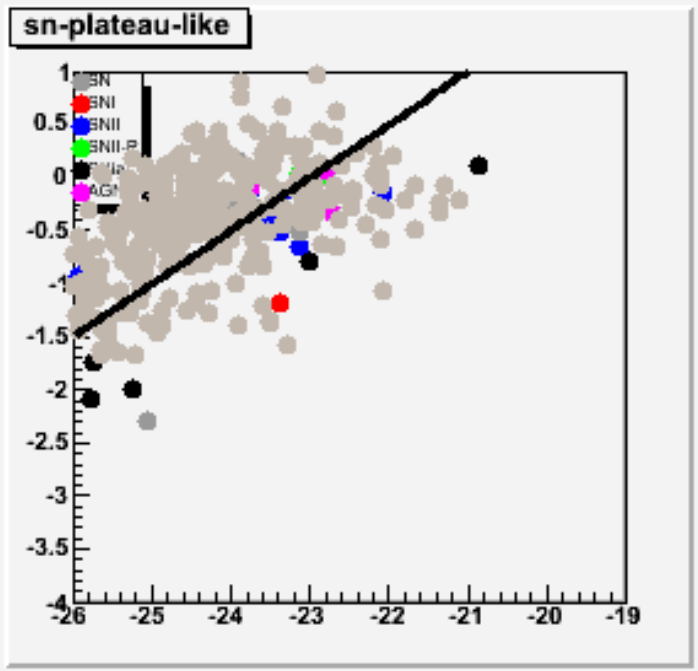

fast variation
slow rise
sn-like
sn-plateau-like
SN
SNI
SNII
SNII-P
SNIa
AGN
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-26
-25
-24
-23
-22
-21
-20
-19

m_g


fast variation
SN
SNI
SNII
SNII-P
SNIa
AGN
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-26
-25
-24
-23
-22
-21
-20
-19


slow rise
SN
SNI
SNII
SNII-P
SNIa
AGN
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-26
-25
-24
-23
-22
-21
-20
-19


sn-like
SN
SNI
SNII
SNII-P
SNIa
AGN
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-26
-25
-24
-23
-22
-21
-20
-19


sn-plateau-like
SN
SNI
SNII
SNII-P
SNIa
AGN
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-26
-25
-24
-23
-22
-21
-20
-19

Conclusions

- ACE shows now to be a well tuned and controled tool for variable object selection.
- About 10 times more Objects than spectred SNIa have been found
- SN like objects are probably twice (or more) numerous than Spectred SN
- Future : Use more precise methods for Class selection
  - use of Spectral template for known class : ex SALT for SNIa (already check on real time and will be used for rate computation) can be probably very powerfull for SN type separation
  - Special strategies for AGN/Stars ?

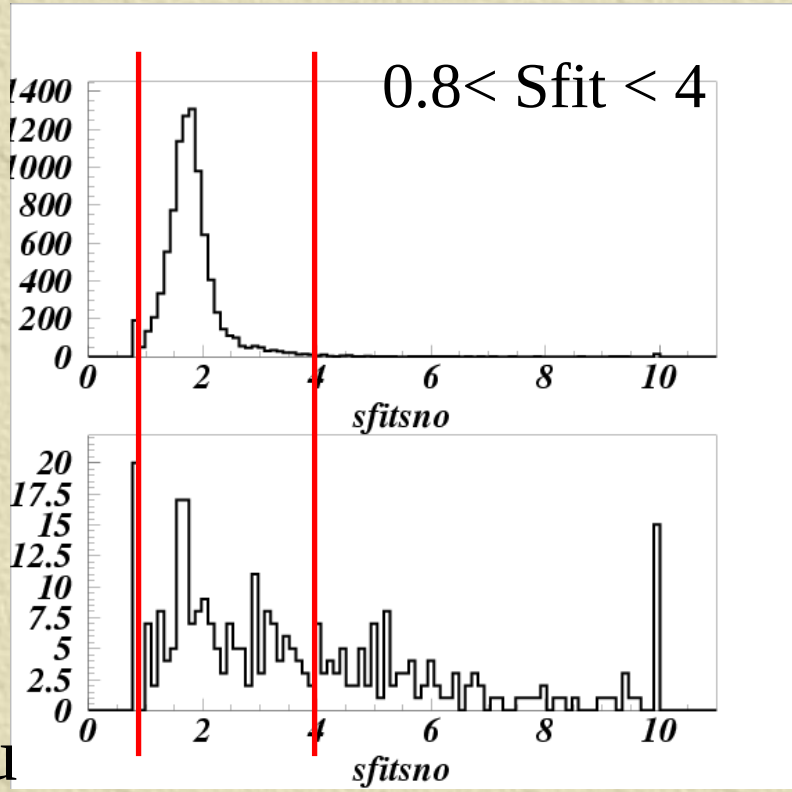
Detection of SNIa-like objects

- Preliminary/simple/Poor man etc …

- Select against AGN/Variable stars : multipeaks
- Select against IIP : plateau
- Select against CC : color

Selection of SNIA like events

- width of lightcurve Sfit
  - Strech like
    - ‘gaussain’ fit
    - S=1 if IA z=0



- No second peak nor plateau
  - Max in i after/before 40 days/ max i
- color

Study of variable object selection

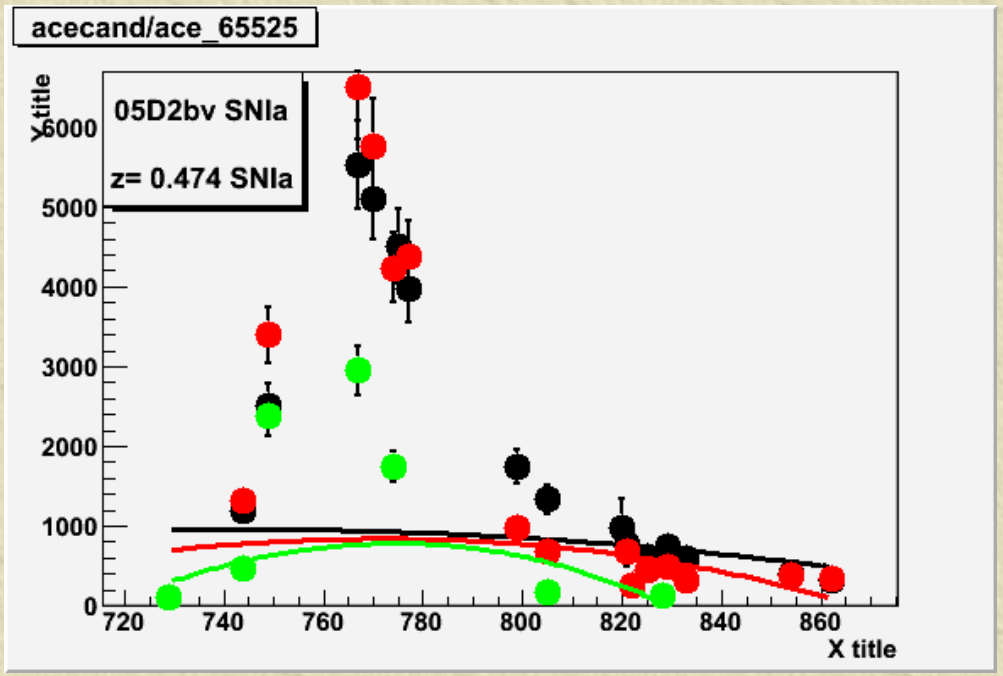
- Selection from good/bad detections

Can we go lower in significance ?

GOOD = 1,2,3,4 N= 400000, ? ? ?

HUMAN SCANNING OF RESULTS:
MANY BAD CAND FOUND/
FEW POSSIBLE GOOD CAND
ALL UNSIGNIFICANT

Z


acecand/ace_65525
05D2bv SNIa
z= 0.474 SNIa
Y title
X title
0
1000
2000
3000
4000
5000
6000
720
740
760
780
800
820
840
860