Impact of filter design on LSST photo-z

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Introduction

- Constraints on filter are very strict (slope, leakage ...),
- It could be difficult to make filters with such constraints
  → costly filter.

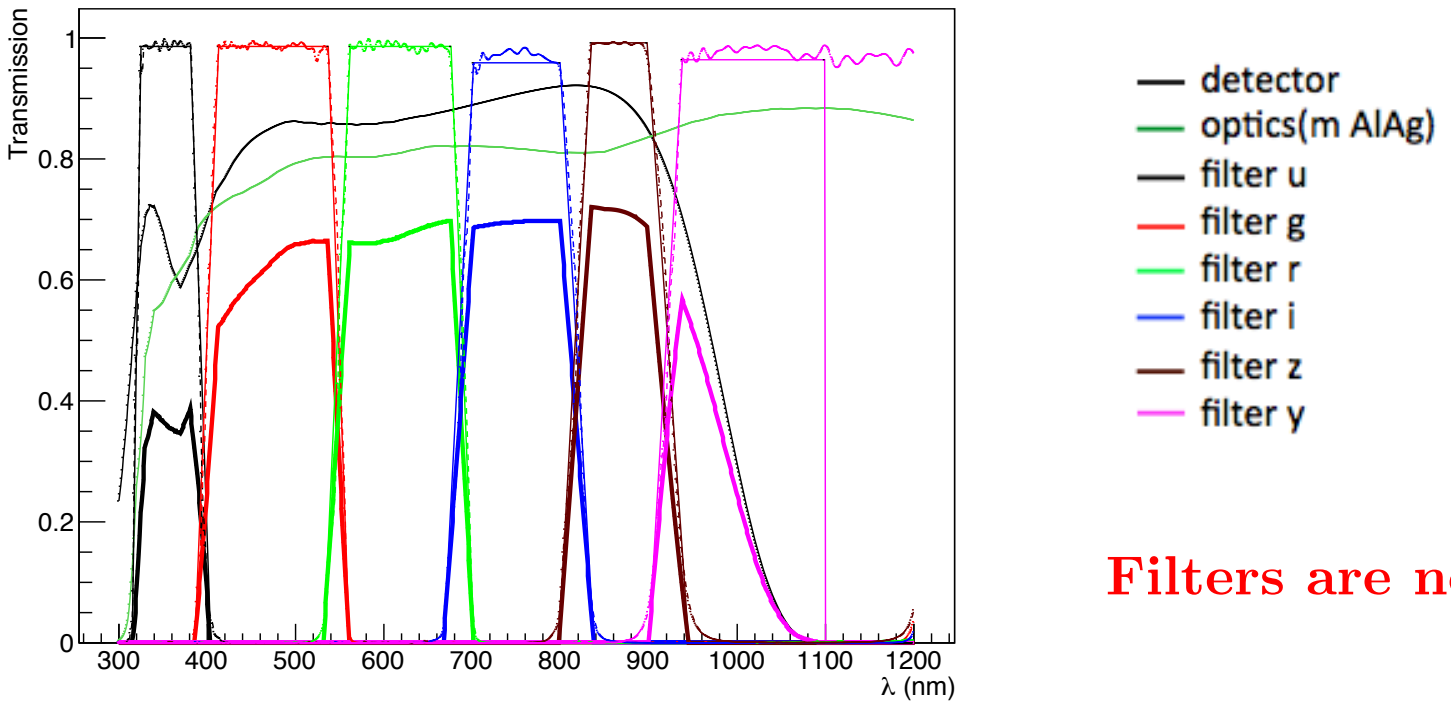
⇒ **What happen on photo-z if those constraints are not reach ?**

⇒ **Can we relax the filter shape constraints ?**

Contents

Filters modeling

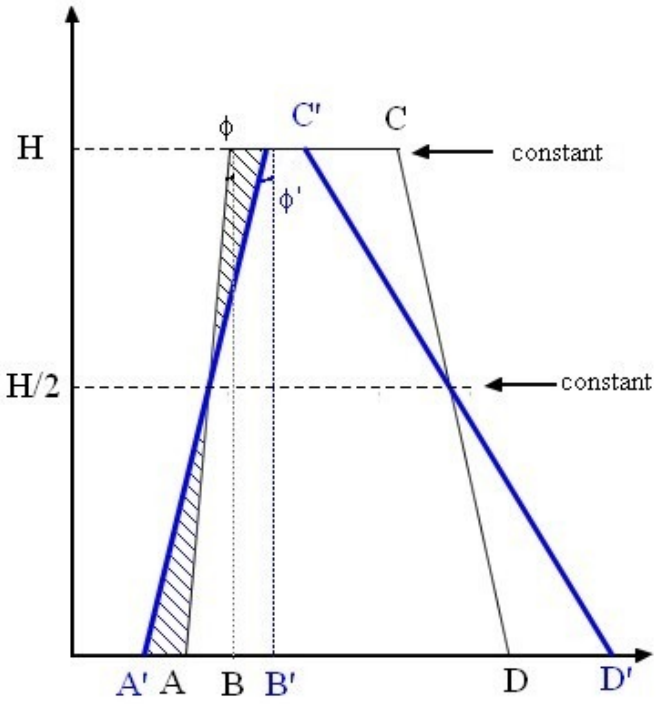
- Reference Filters :
  - http ://ssg.astro.washington.edu/elsst/magsfilters.shtml ?filterinfo
  - we use y4 filter for y band.
- Construction of six modeled filters :
  - filter ≡ trapezoidal function fitted on LSST filters,
  - we neglect plateau's oscillations and tails on edge.



Filters are not symetrics

Filter slope modification : Constant integral

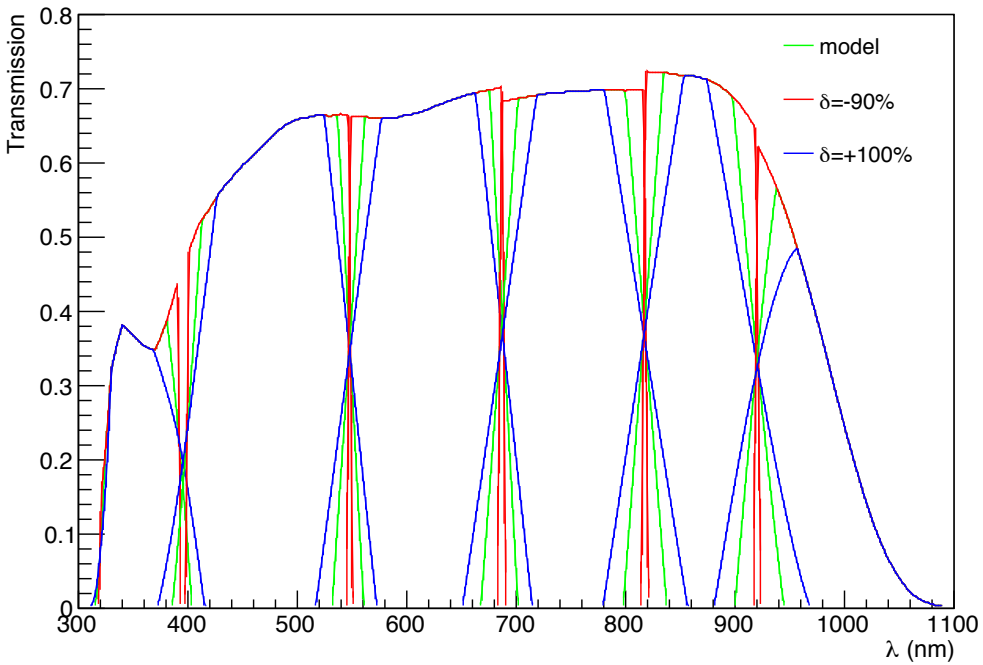
Filters modification - Constant integral



- Integral = constant,
- Symmetrical modification :
  - A'B' = $(1+\delta)$AB,
  - C'D' = $(1+\delta)$CD.

→ Slope : $tan(\phi') = (1+\delta)tan(\phi)$

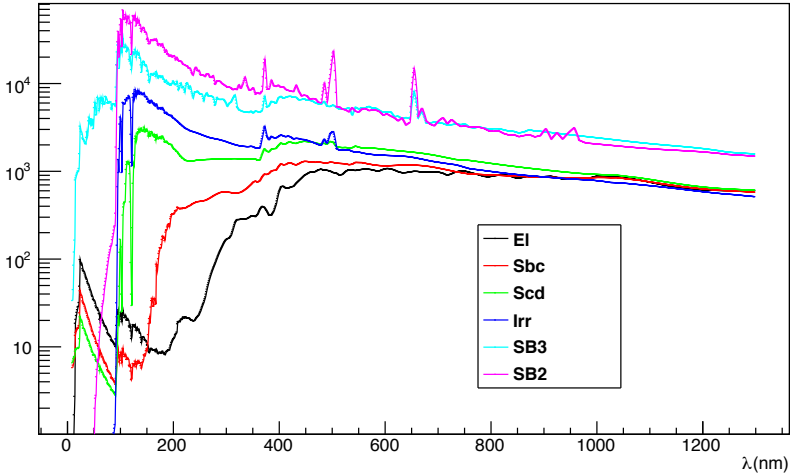
- Analysis made for : $\delta = \{-90\%, -50\%, 0, +50\%, +100\%, +200\%, +300\%\}$
- for each analysis, each filter are modified with the same δ.

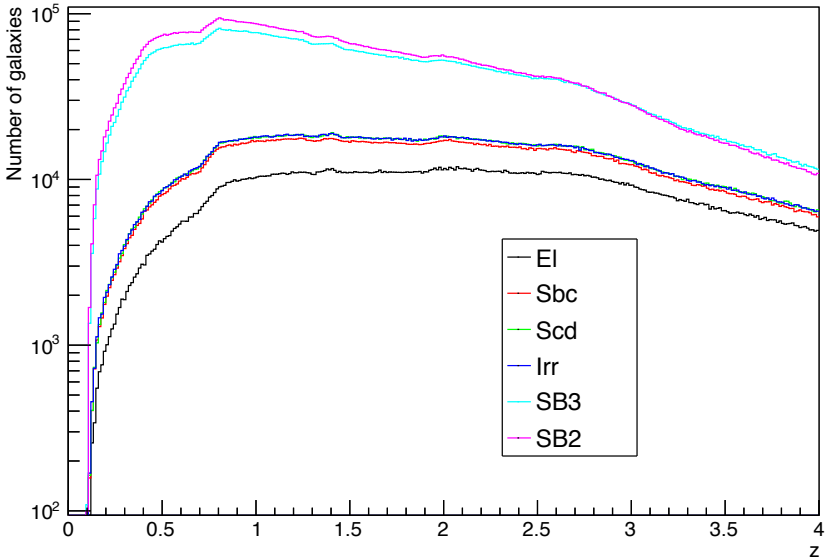


- Integral of final throughput transmission is not a constant.

Photo-z reconstruction :

- 51 galaxies spectral type interpolated between 6 main SED.
  - main spectral type : El, Sbc, Scd, Irr, SB3, SB2.

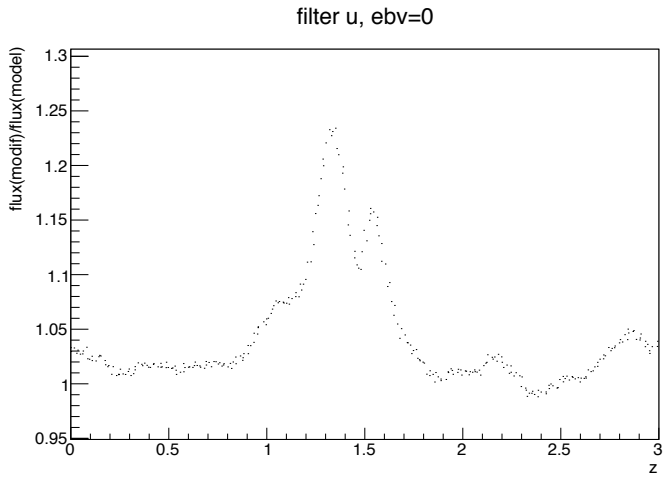


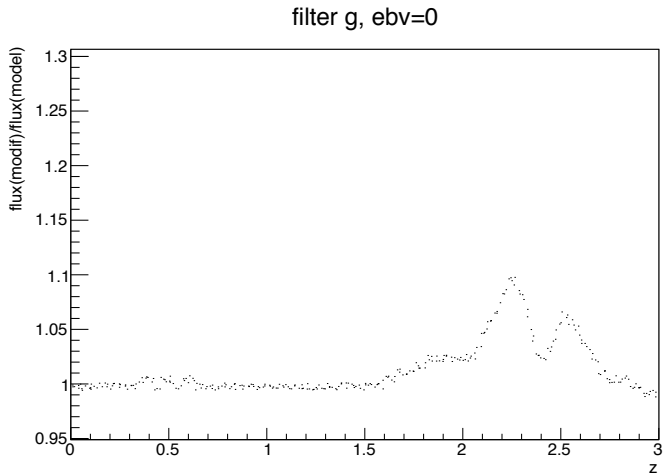


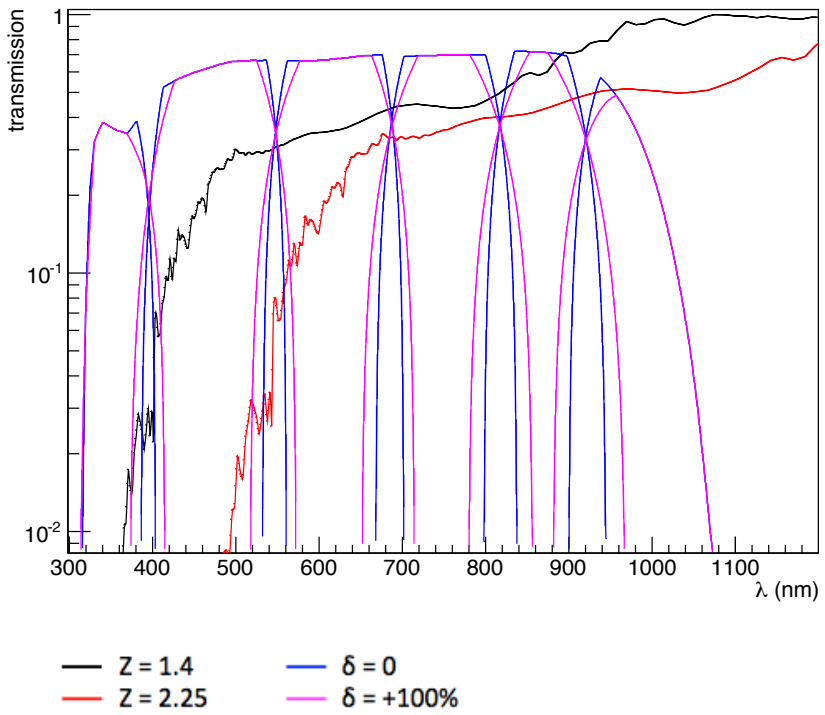
- template fitting method,
- **Quality cut :** LikelihoodRatio (LR) ⇒ discrimination between good and outliers ($\frac{z_p - z_s}{1+z_s} > 0.15$) galaxies.
- **Gorecki & al** : *arxiv :1301.3010*

Flux variation : flux($\delta = +100\%$)/flux($\delta = 0\%$)

- overall change are smaller than a few % for each filter and spectral type.
- Sbc galaxies : change up to 30% at $z \sim 1.5$ in u filter.





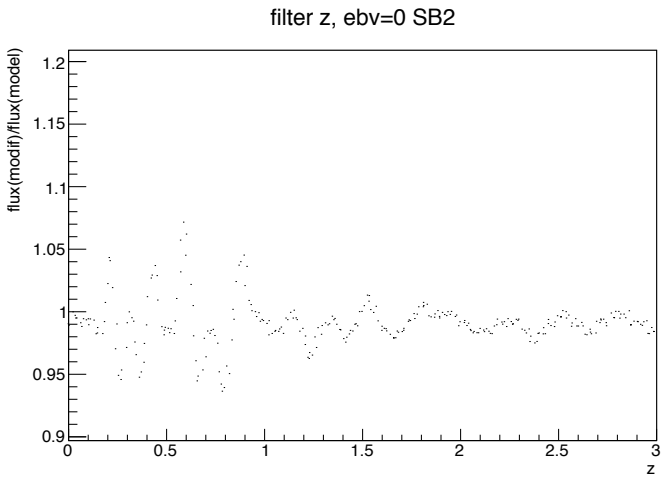


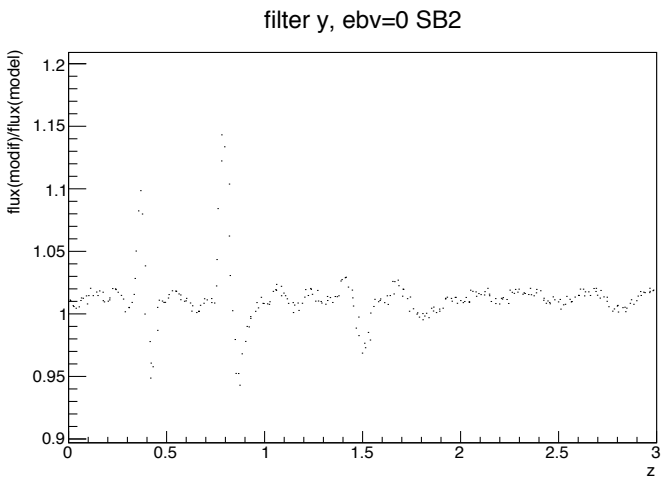
SED : arbitrary scale.

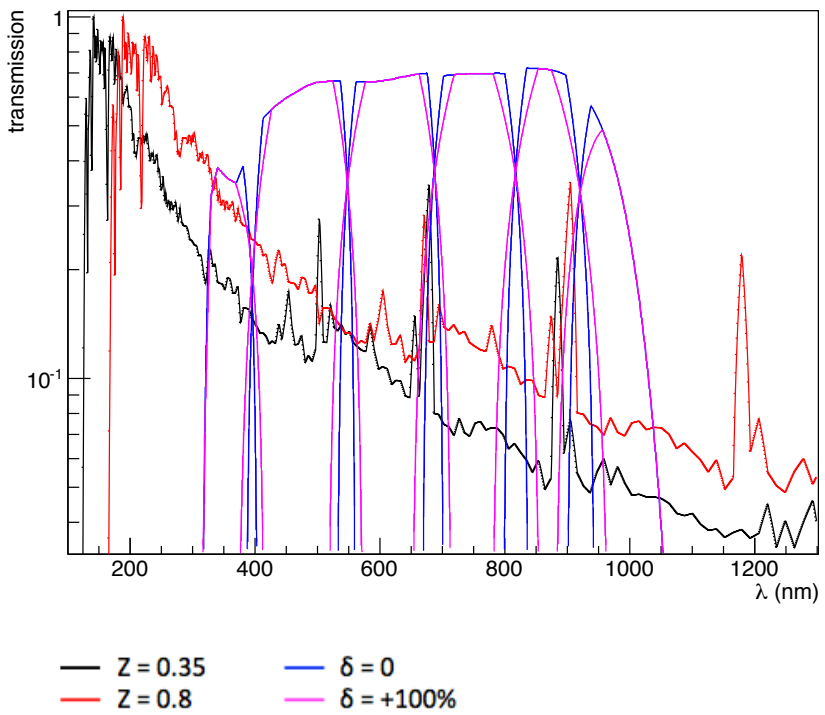
- Sbc are not the main spectral type ⇒ few effet are expected on photo-z.

Flux variation : flux($\delta = +100\%$)/flux($\delta = 0\%$)

- overall change are smaller than a few % for each filter and spectral type.
- SB2 galaxies : change up to 15% at $z \sim 0.35$, $z \sim 0.8$ in y filter.





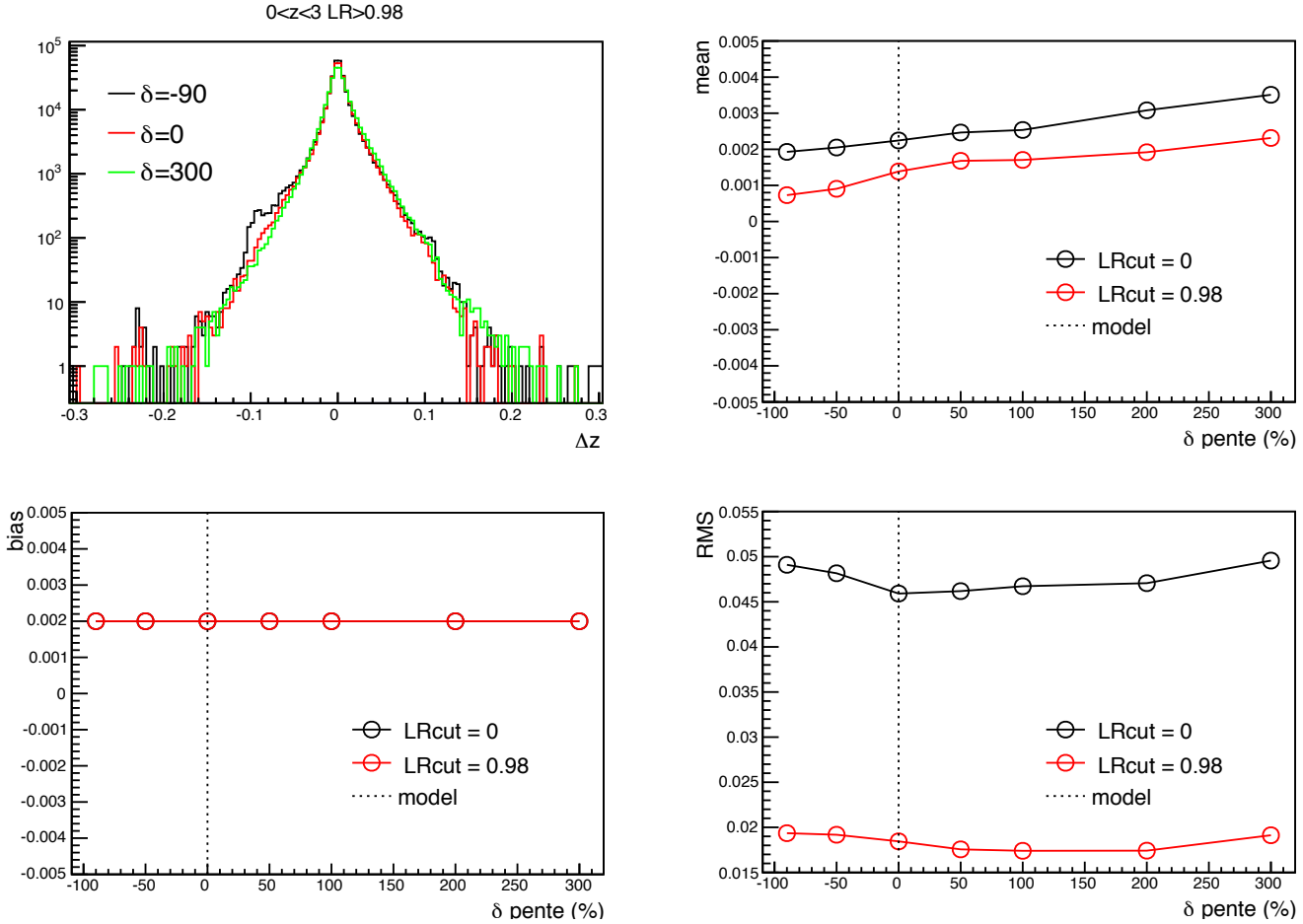


SED : arbitrary scale.

- Change compensate each other ⇒ few effet are expected on photo-z.

Photo-z performances : Δz as a function of δ

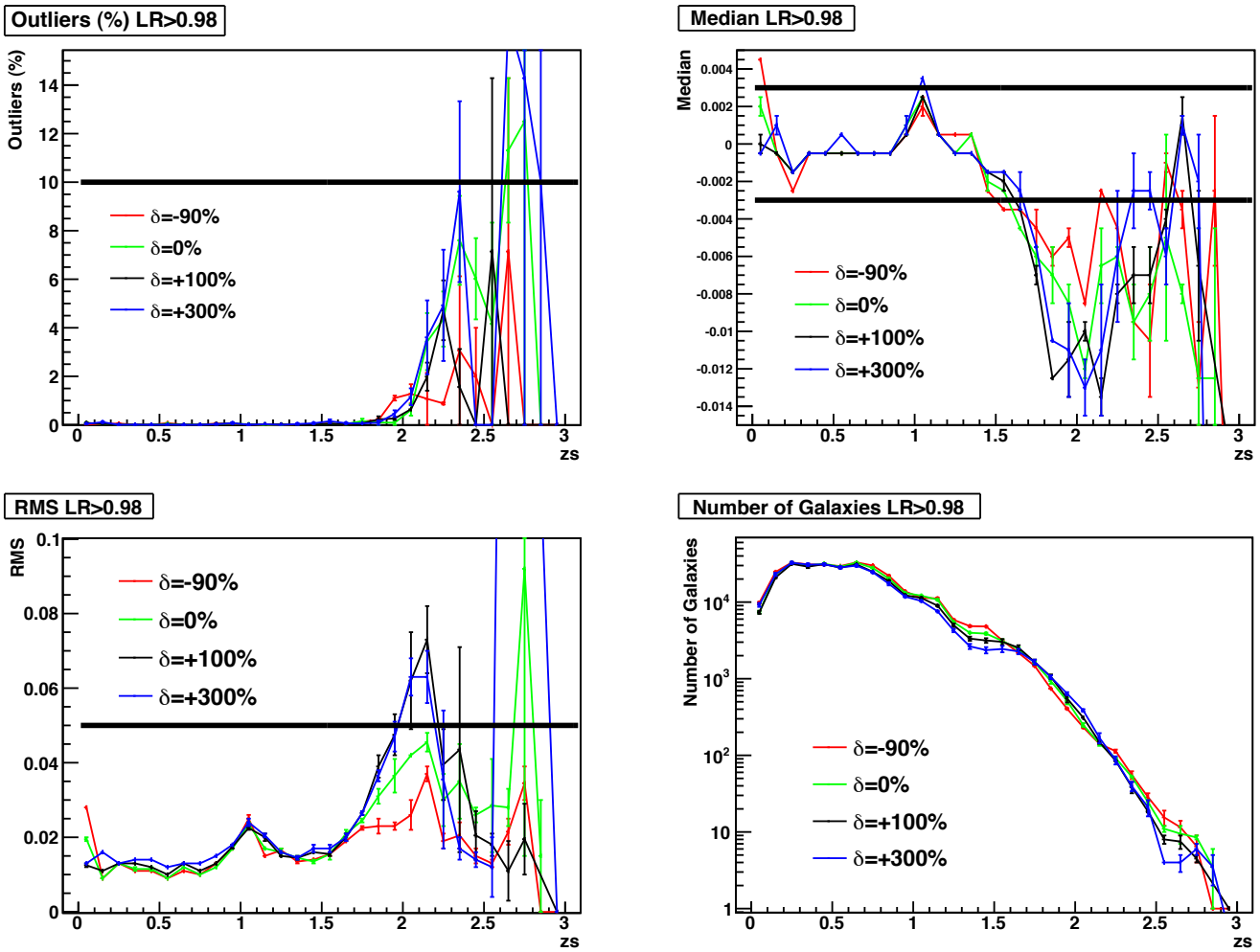
- We keep only galaxies observed in 6 filters (S/N>5).
- $\Delta z = \frac{z_p - z_s}{1+z_s}$,



⇒ We don't observed an impact of changing slope on the photo-z performancies.

Photo-z performances : as a function of z_s

- Galaxies S/N>5, in 6 filters.



- Outliers galaxies : $|\frac{z_p - z_s}{1+z_s}| > 0.15$

$\Rightarrow$ We don't observed important impact except for :

- $z > 2$,

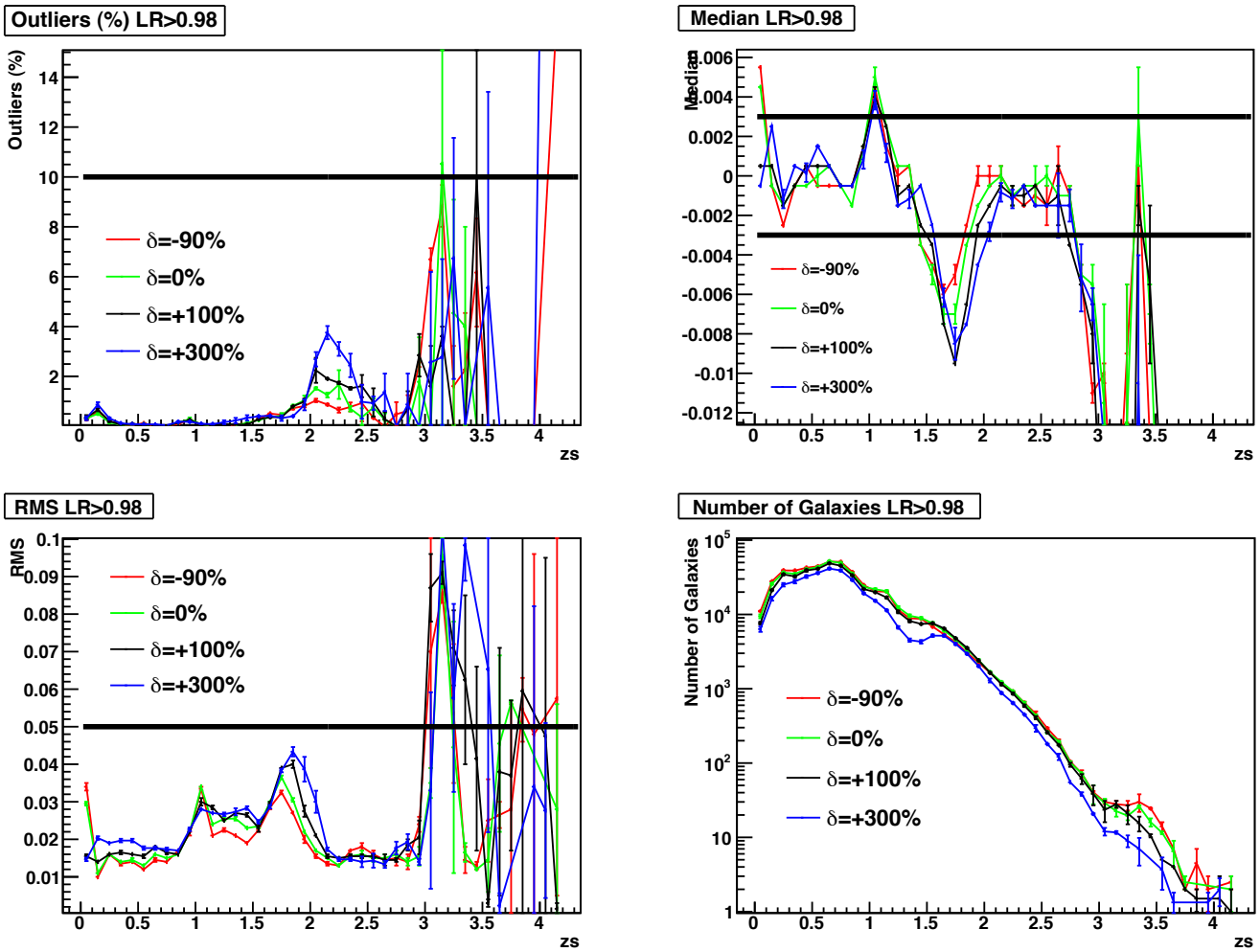
$\rightarrow$ need more statistics.

- $z \sim 0.1$!

$\rightarrow$ starburst galaxies.

Photo-z performancies : as a function of z_s

- Galaxies S/N>5, in 5 filters.



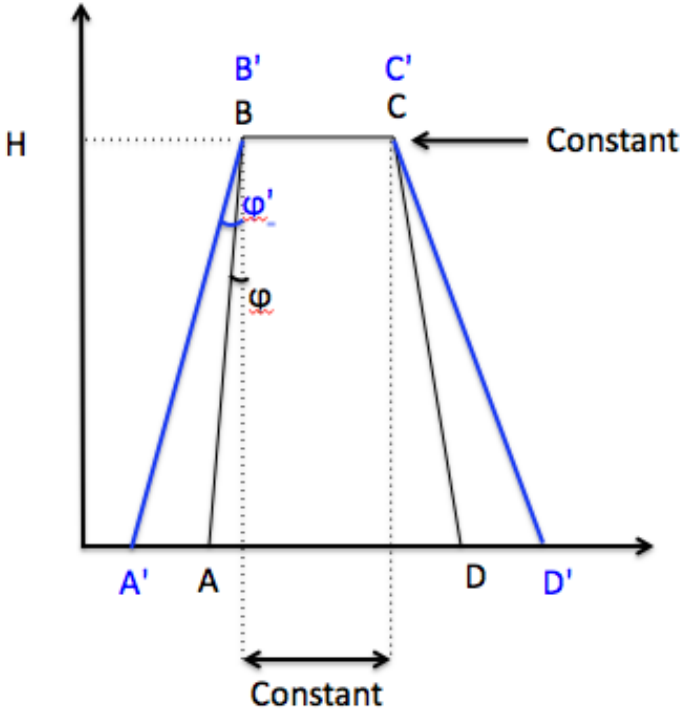
⇒ no visible impact on photo-z for z<3, if $\delta < +300\%$,

⇒ exception for $z \sim 0.1$,

⇒ less observed galaxies when δ increases.

Filter slope modification : Non constant integral

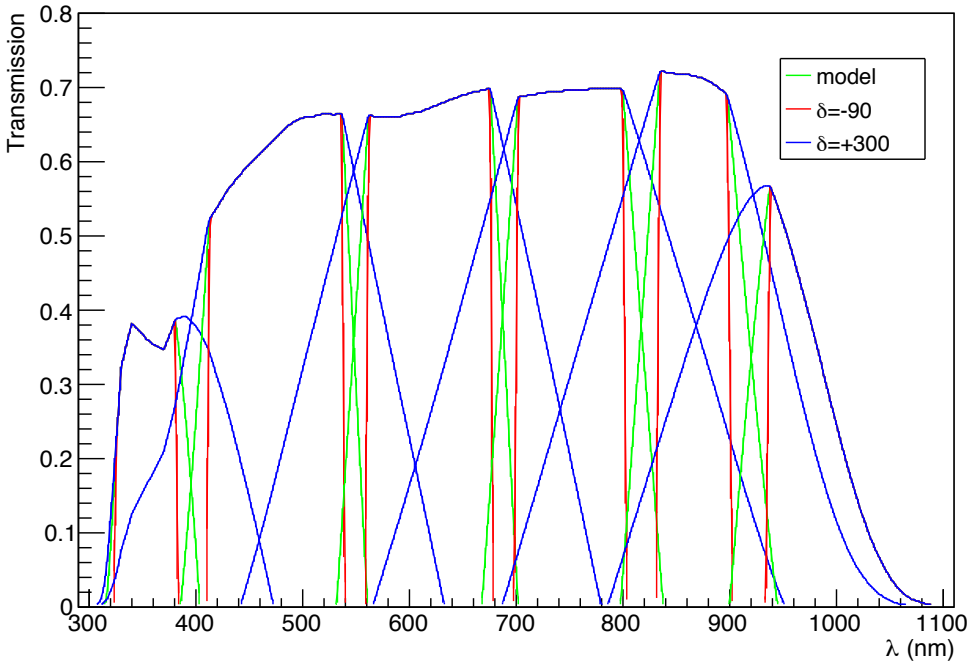
Filter modification : non constant integral



- Symmetrical modification :
  - A'B' = AB + δAB,
  - C'D' = CD + δCD.

→ Slope : $tan(\phi') = (1+\delta)tan(\phi)$

- $\delta = \{-90\%, -50\%, 0, +50\%, +100\%, +200\%, +300\%, +400\%, +500\%\}$.

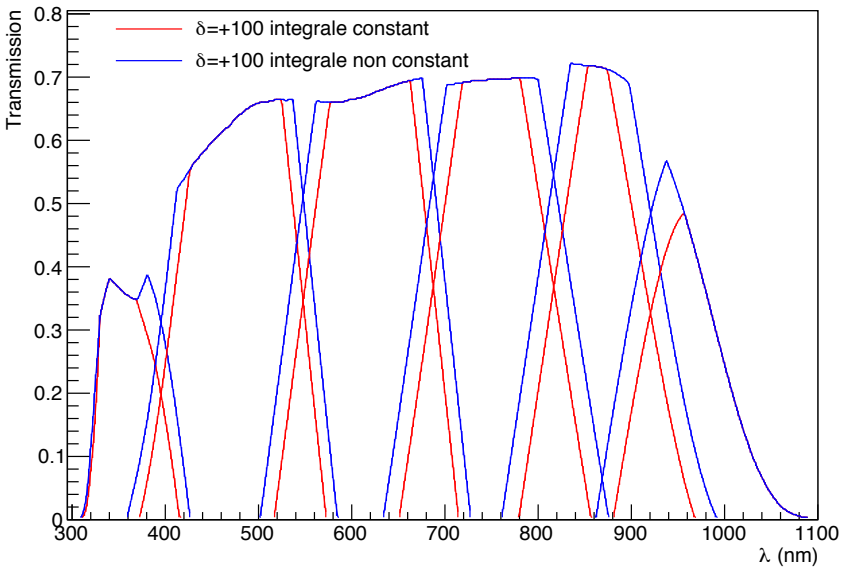


- when δ increases, z filter overlap y filter.

Filter : integral constant vs non constant

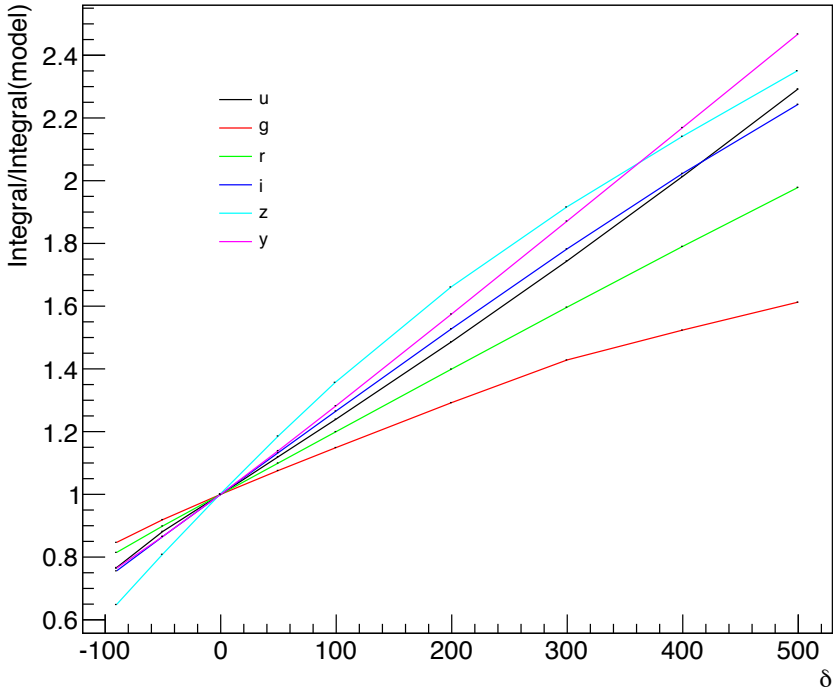
$\delta = 100\%$:

integral constant vs non constant :



- same $\delta \leftrightarrow$ same slope as before.

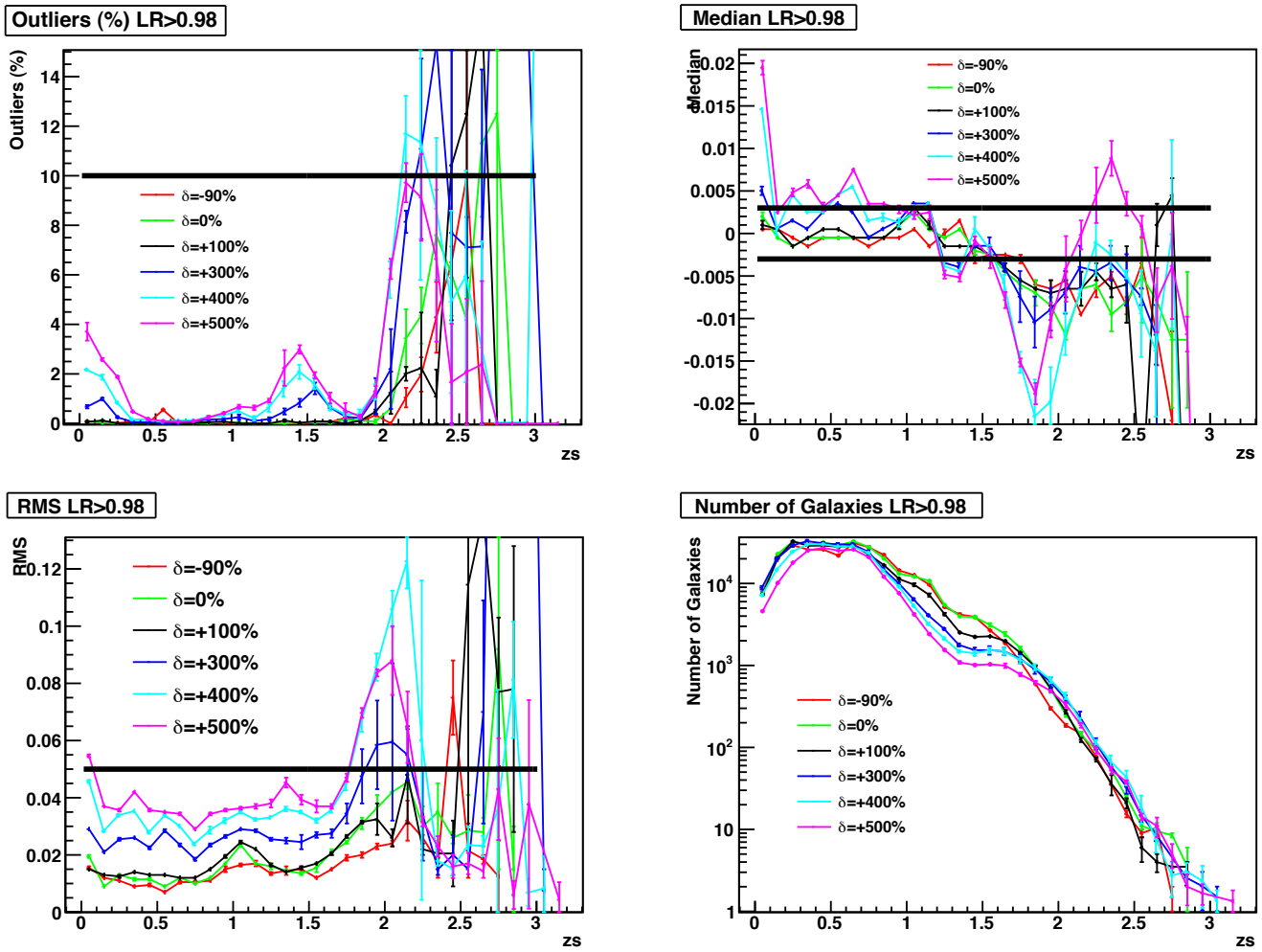
- Filter integral depends of optics and detector,



- we expect more galaxies when δ increases.

Photo-z performancies : as a function of z_s

Non constant integral - galaxies observed in 6 filters



⇒ visible effect for $\delta \geq 300\%$,

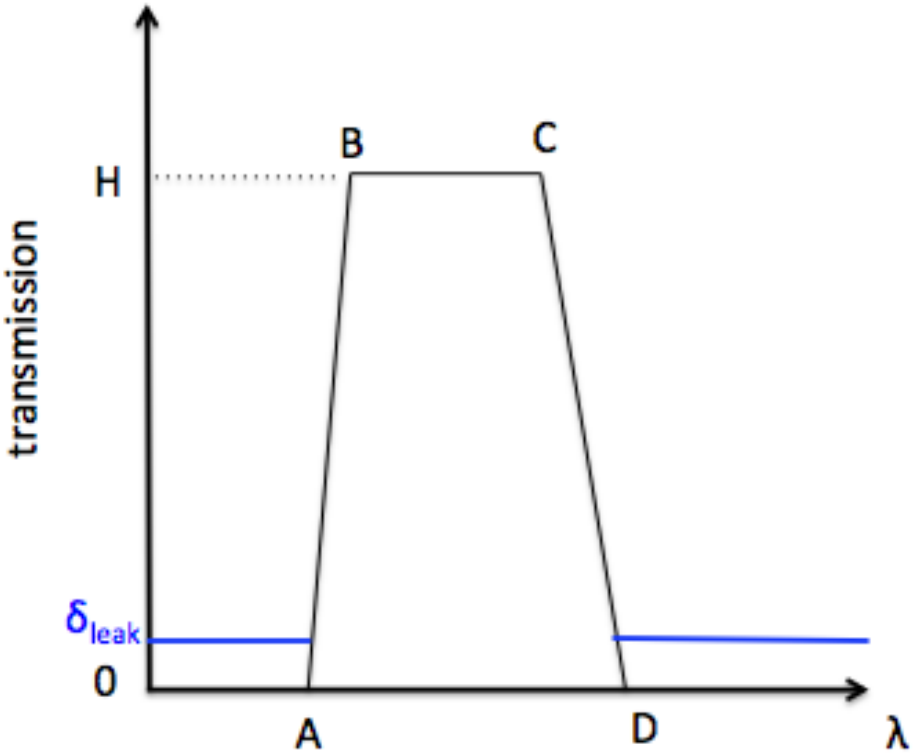
⇒ less galaxies when δ increase :

⇒ due to the quality cut.

Filter leakage

Filter leakage

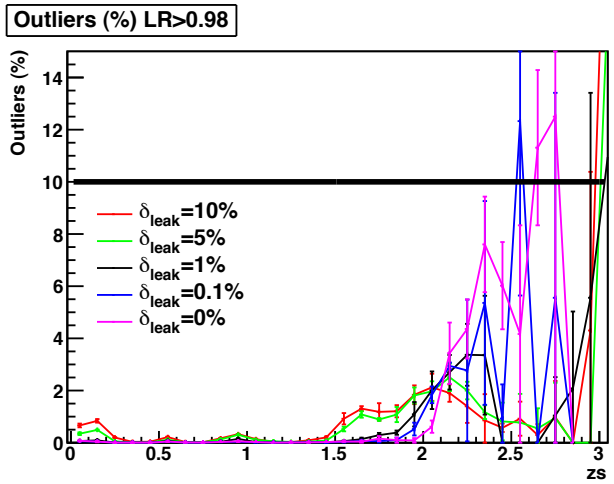
- Constraints on filters :
  - *Filter R&D : Filter design study result summary, 23/08/2012,*
  - filter leakage should be $< 0.1\%$ H.
- Modification :
  - from model filter ($\delta = 0$),
  - $\delta_{leak} \in \{0, 0.1, 1, 5, 10\}$ in %H.

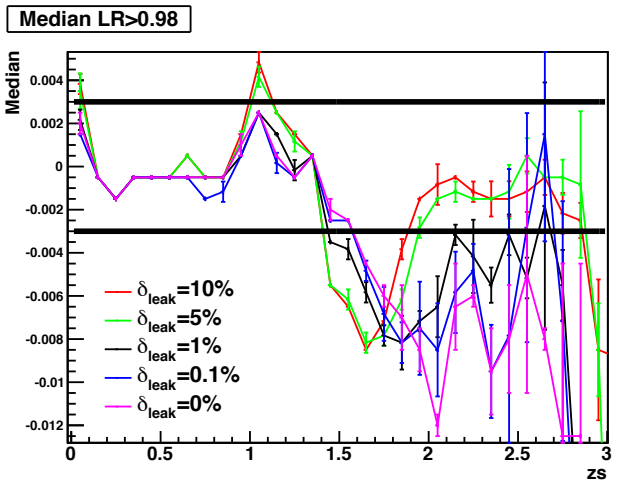


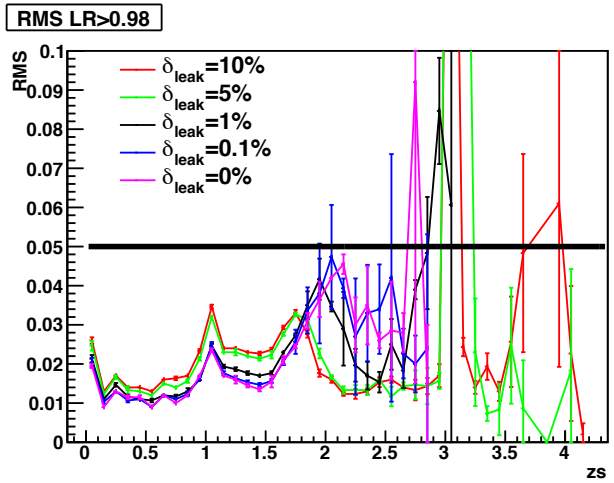
- Leakage impact (in weavelenth range) will be limited by optics and detector throughput.

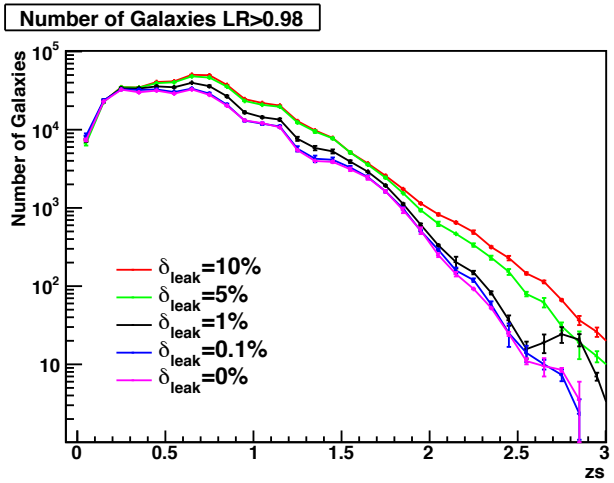
Photo-z performancies

- Galaxies with S/N>5 in 6 filters,
- Leakage only in u filter.









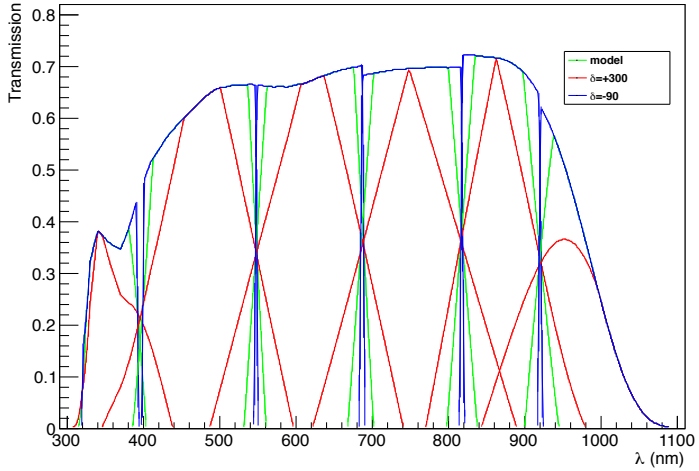
⇒ no visible effect if $\delta_{leak} < 1\%$,

⇒ we obtain similar result if we consider leakage in all filters.

Conclusion and perspectives

Conclusion

- We modified filter slope keeping :
  1. integral value,
     plateau's height,
     half maximum value.
  2. plateau's height,
     plateau's width.



- No visible impact for z<3 if $\delta \leq +300\%$,
- $z \sim 0.1$: still to be understood.
- If leakage in UV filter $< 1\%$ peak : no visible effect on photo-z reconstruction.
- All those studies are done considering all filters are well known.

Perspectives

- Similar study using *Poletta & al (2006)* SED library,
- Study in more detail filter leakage.
- What could be a "realistic" filter ?
  → difficulties to reach slope constraints ? leakage ? precision in transmisson mesurement ?

Annexes

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Integral constante

δ maximum possible value

- B'C' must be $> 0 \Rightarrow$ maximum value for δ :

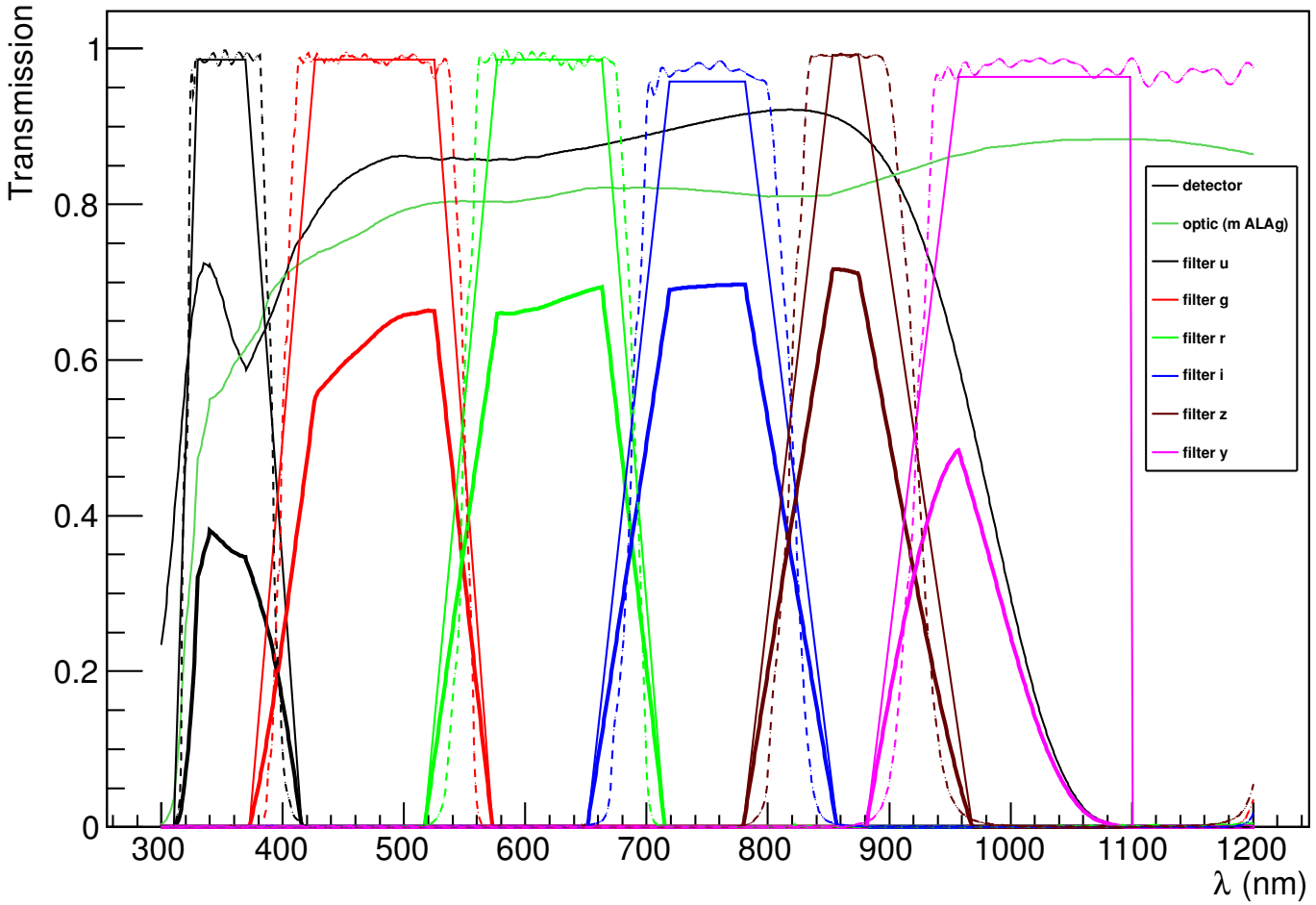
$$\delta_{max} = 2\left(\frac{BC}{AB + DC}\right).$$

- maximum possible value for each filter :

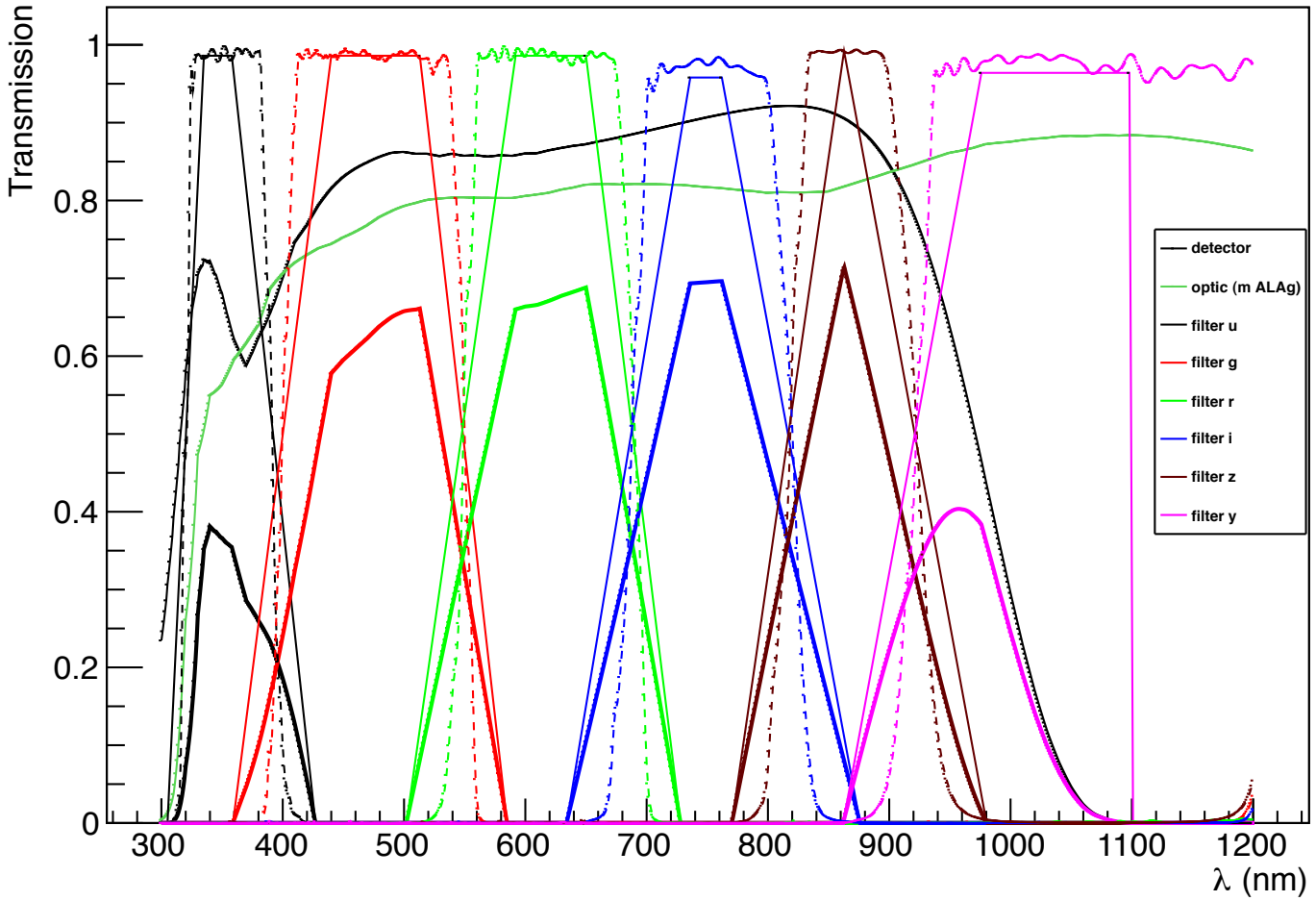
filter	u	g	r	i	z	y
δ_{max}	339%	486%	407%	272%	150%	/

- If $\delta > \delta_{max}$ then $\delta = \delta_{max}$ for concerned filter.
  - $\delta = 200\% \Rightarrow$ maximal value for z,
  - $\delta = 300\% \Rightarrow$ maximal value for z and i.

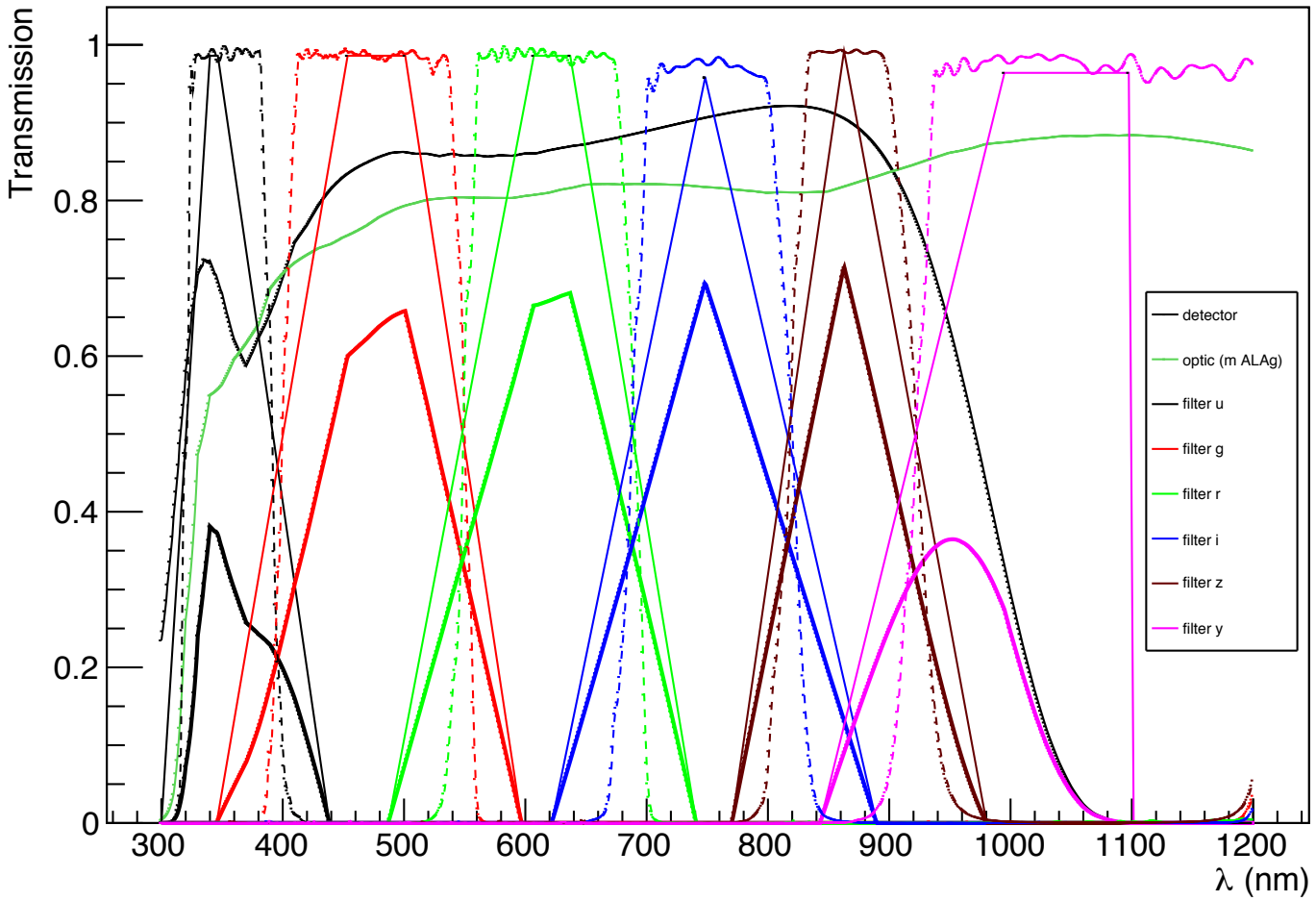
Filter : $\delta = +100\%$



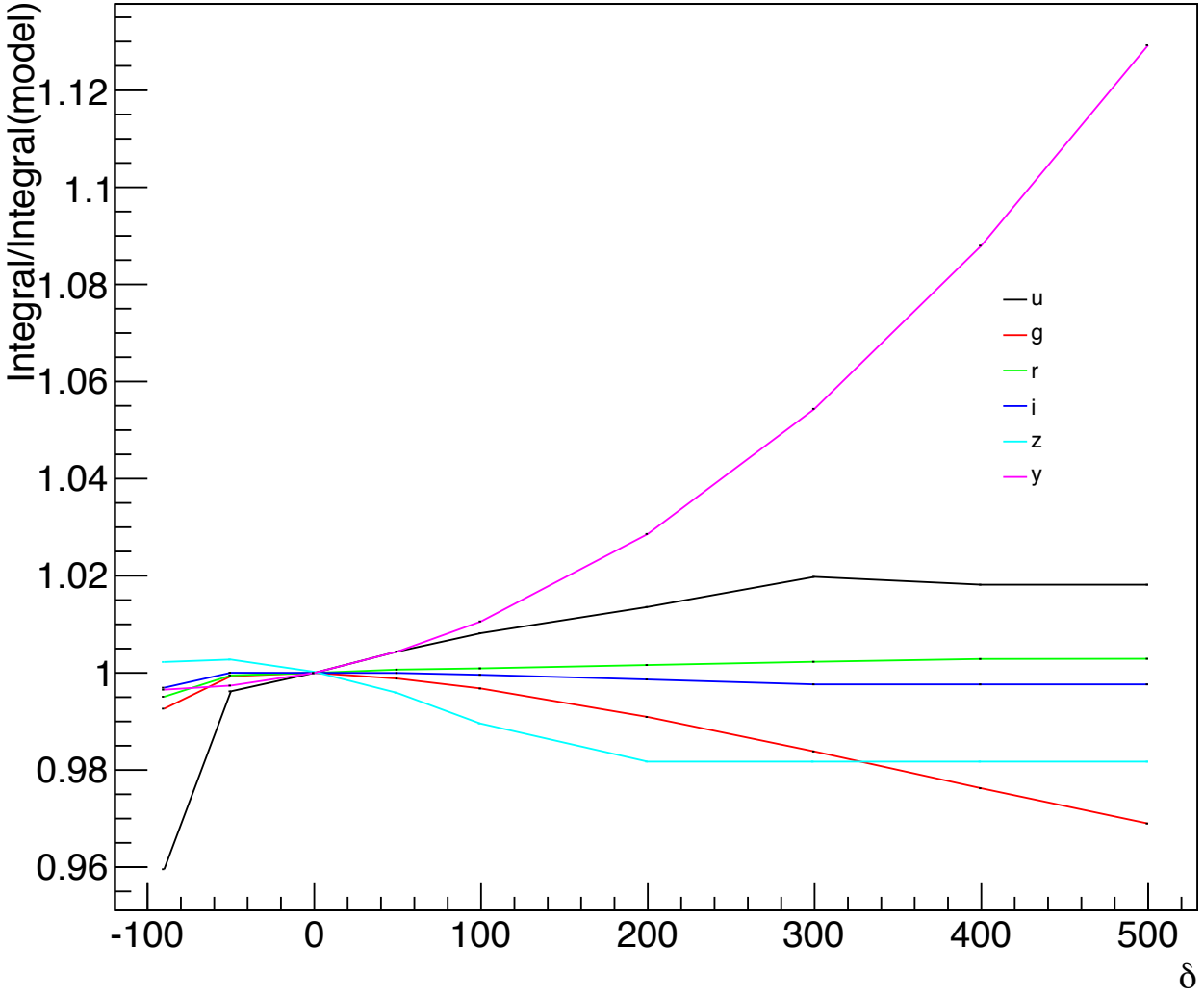
Filter : $\delta = +200\%$



Filter : $\delta = +300\%$

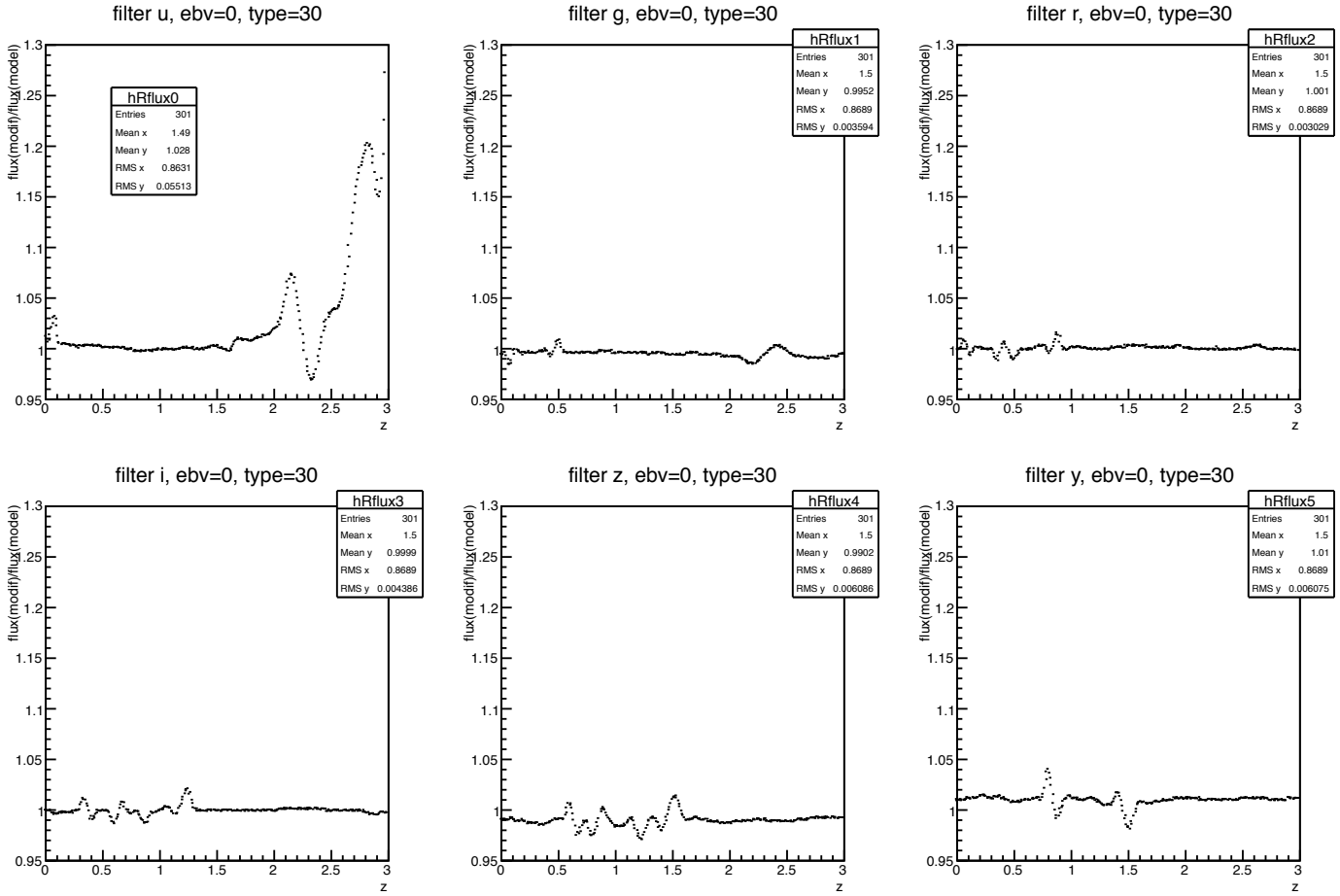


Filter's integral



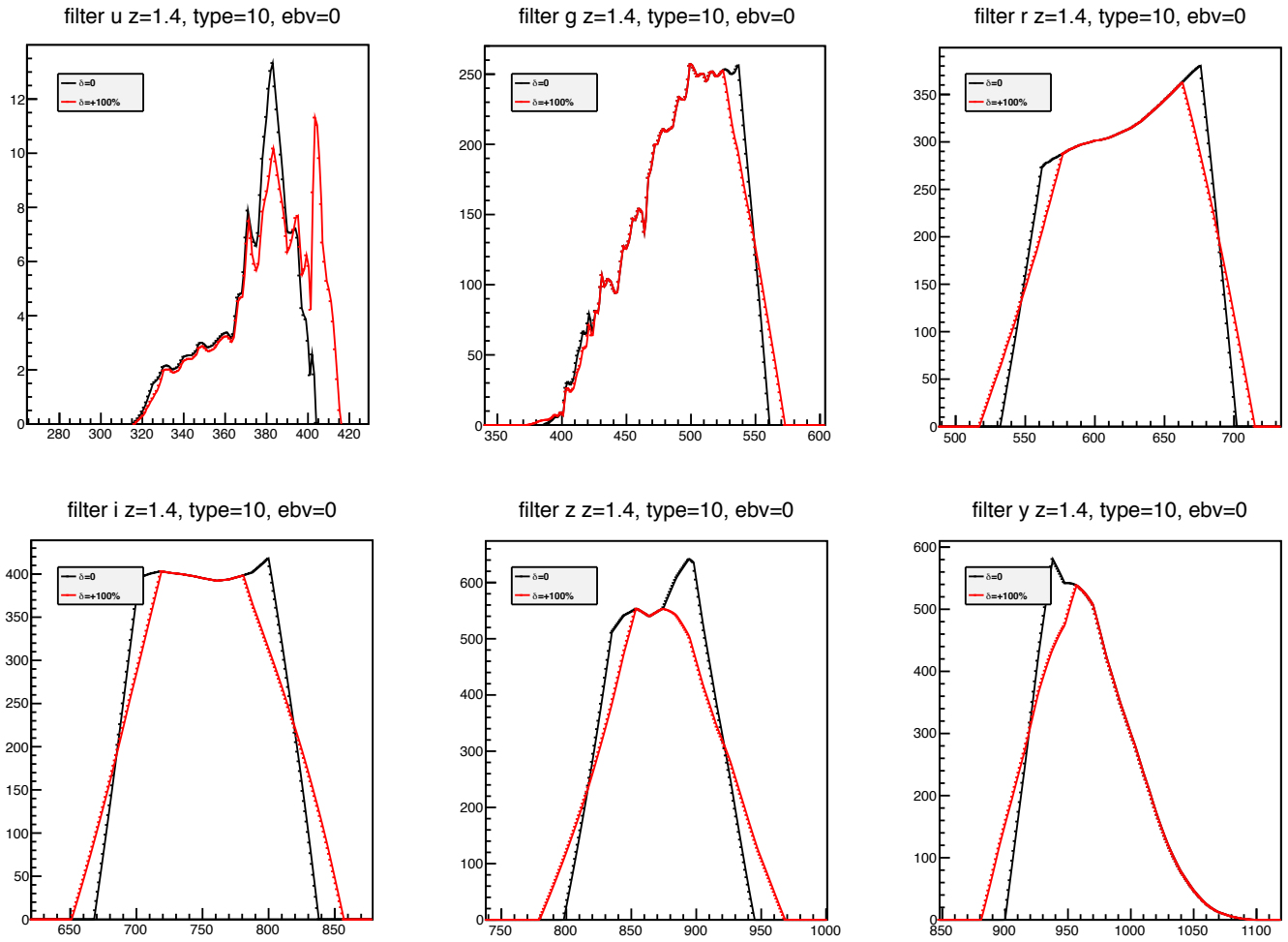
Ratio between flow : flow($\delta = +100$)/flow($\delta = 0\%$)

Irregular galaxies



Effective flow : $\delta = +100$ vs $\delta = 0\%$

Spiral Galaxies (Sbc)

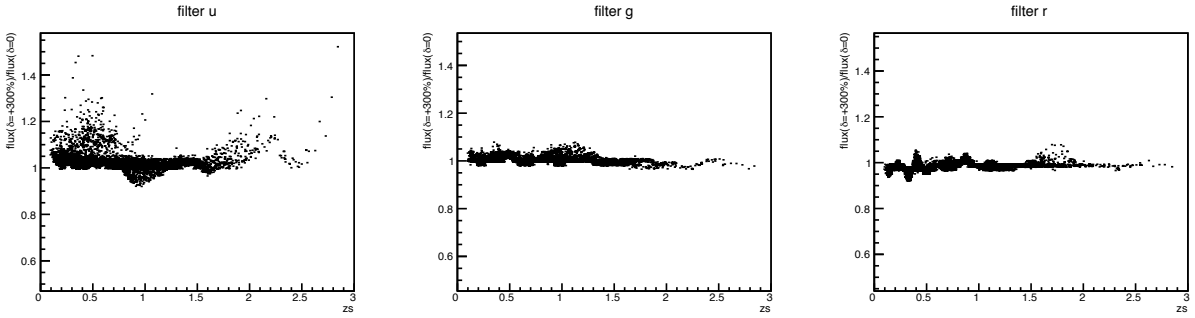


Comparison between galaxies

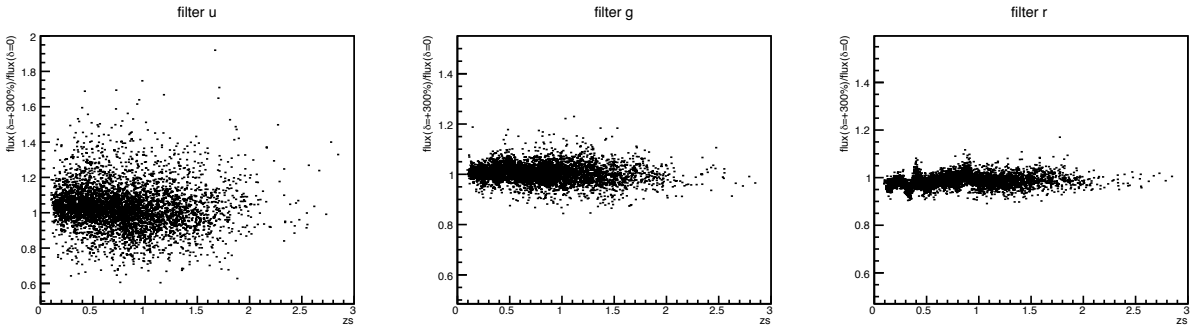
Effect on flow : flow($\delta = +300$)-flow($\delta = 0$) vs z_s

Analyse on 5000 1st galaxies : $\sim$ 4800 galaxies.

f_{theo} :



f_{obs} :



Magnitudes and flow :

- $m_i theo = MA + MD + k$,
- σ_{m_i}(theo) (- in figure),
- $f_{theo} = F0_i * 10^{-0.4 m_i}$
- σ_f,
- f_{obs} : gaussian,
- $m_i(obs) = -2.5 * ln\left(\frac{f}{F0_i}\right)$
- σ_{m_i}.

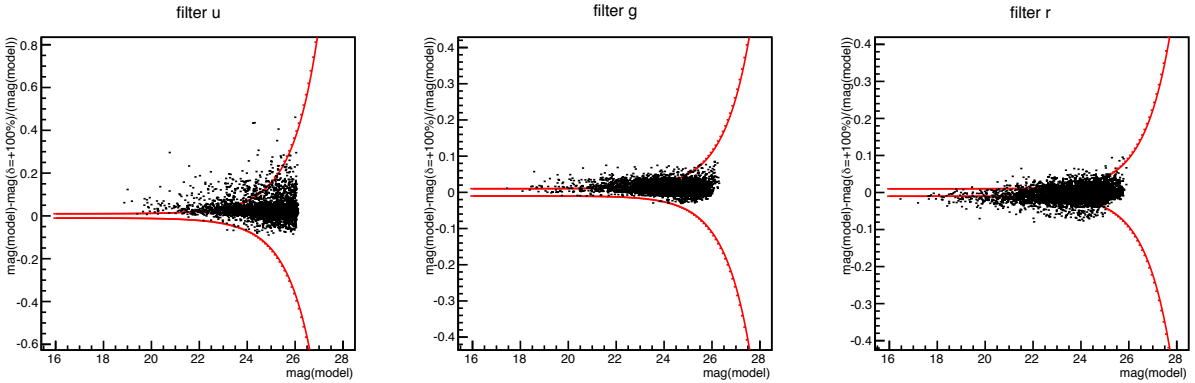
$\Rightarrow$ Effect is dominated by the statistic.

Comparison between galaxies

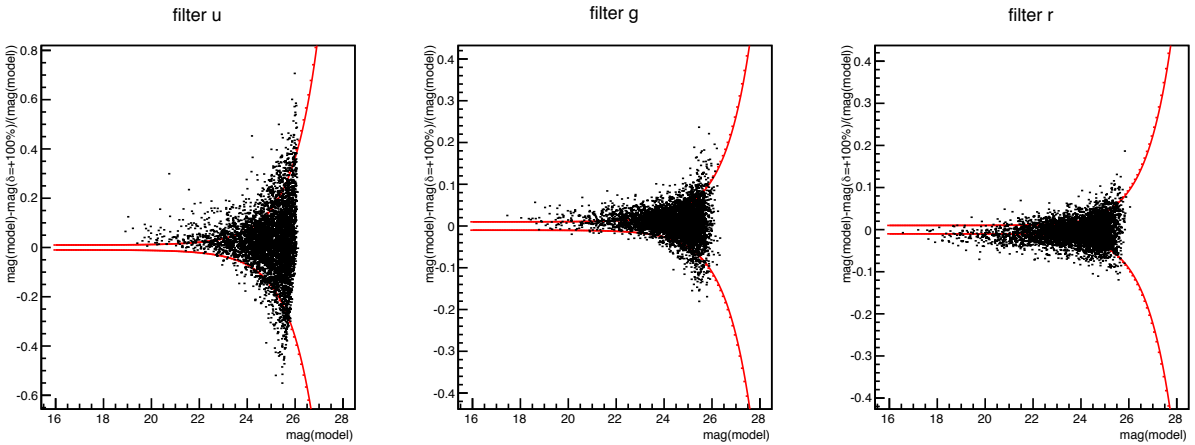
Effect on magnitudes : mag($\delta = 0$)-mag($\delta = +300$) vs mag($\delta = 0$)

Analyse on 5000 1st galaxies : $\sim$ 4800 galaxies.

m_{theo} :



m_{obs} :

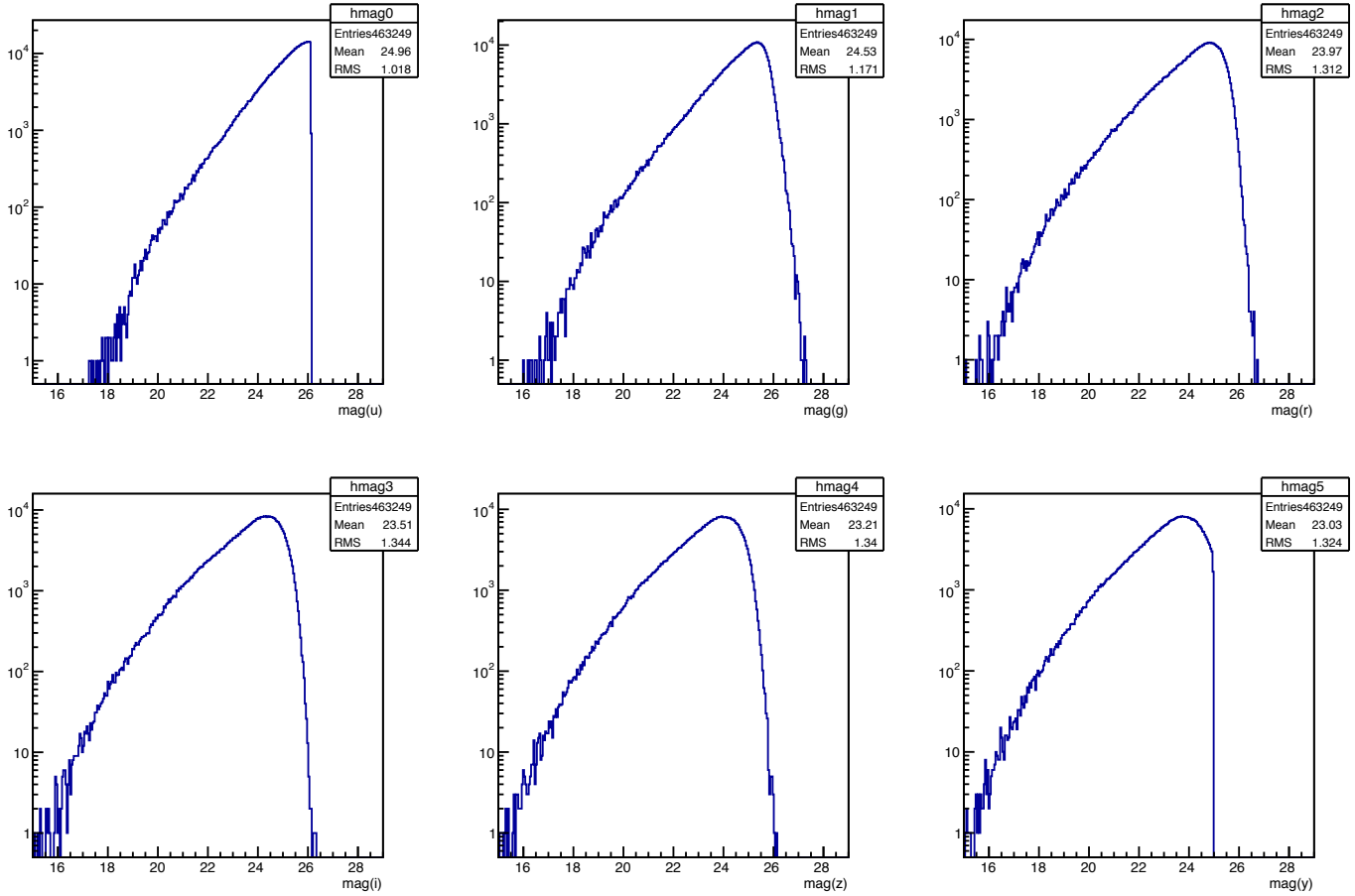


Magnitudes calculation :

- $m_i theo = MA + MD + k$,
- σ_{m_i}(theo) (- in figure),
- $f = F0_i * 10^{-0.4 m_i}$
- σ_f,
- f_{obs} : gaussian,
- $m_i(obs) = -2.5 * ln\left(\frac{f}{F0_i}\right)$
- σ_{m_i}.

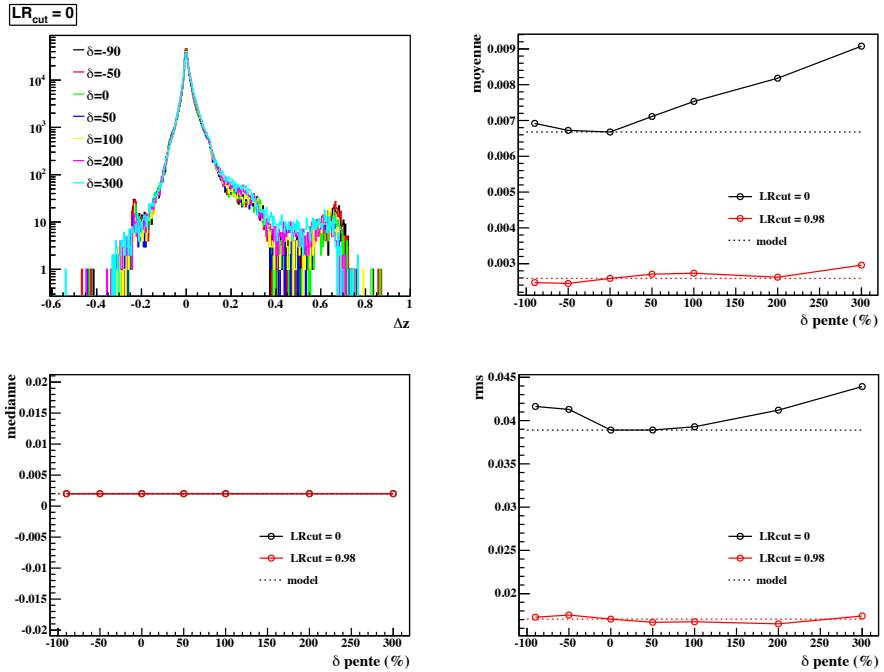
$\Rightarrow$ Effect is dominated by the statistic.

Magnitude distribution

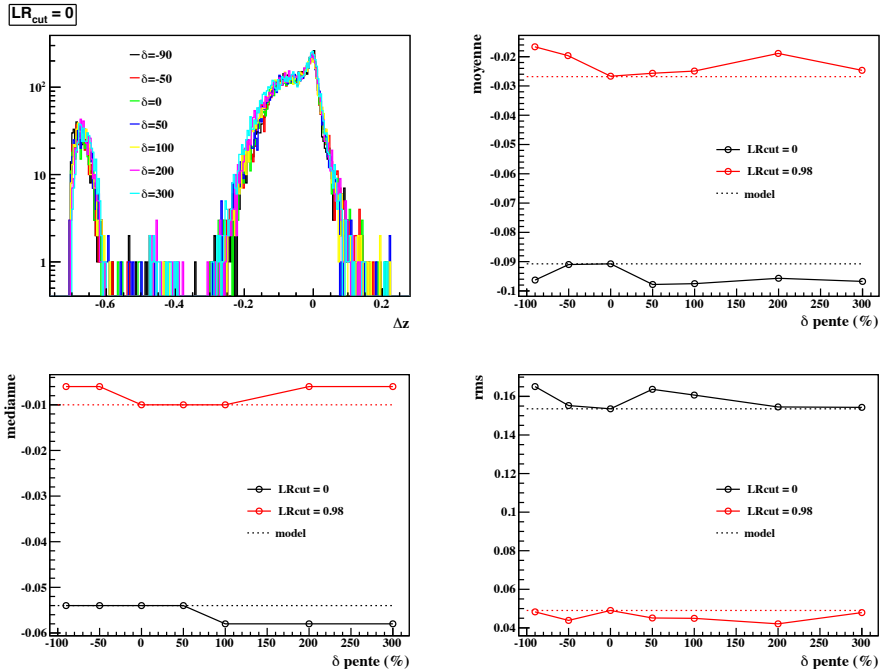


Distribution Δz

$0.5 < z < 1.5$

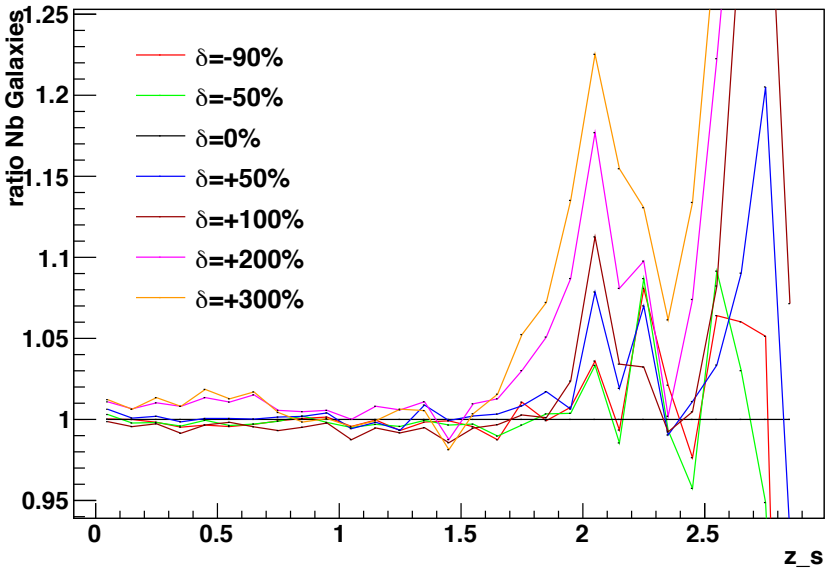


$2 < z < 2.5$



Number of galaxies

$LR_{cut} = 0$



$LR_{cut} = 0.98$

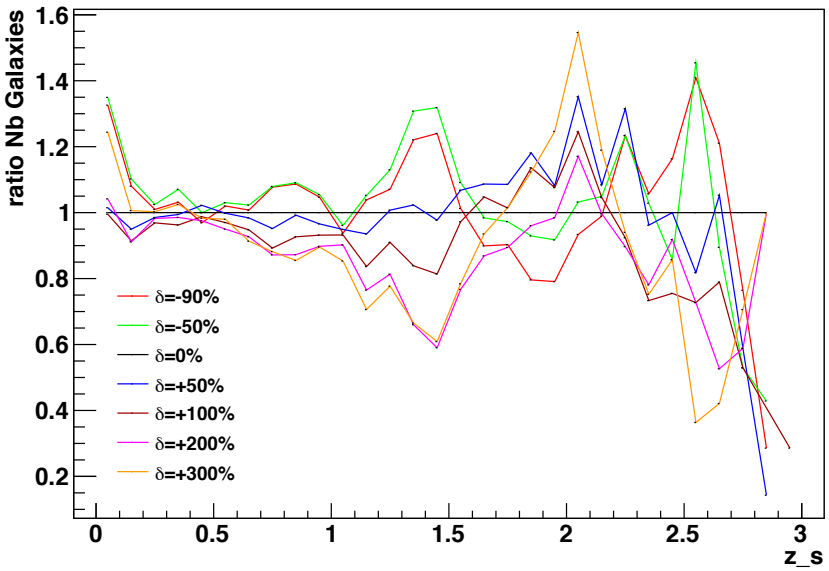
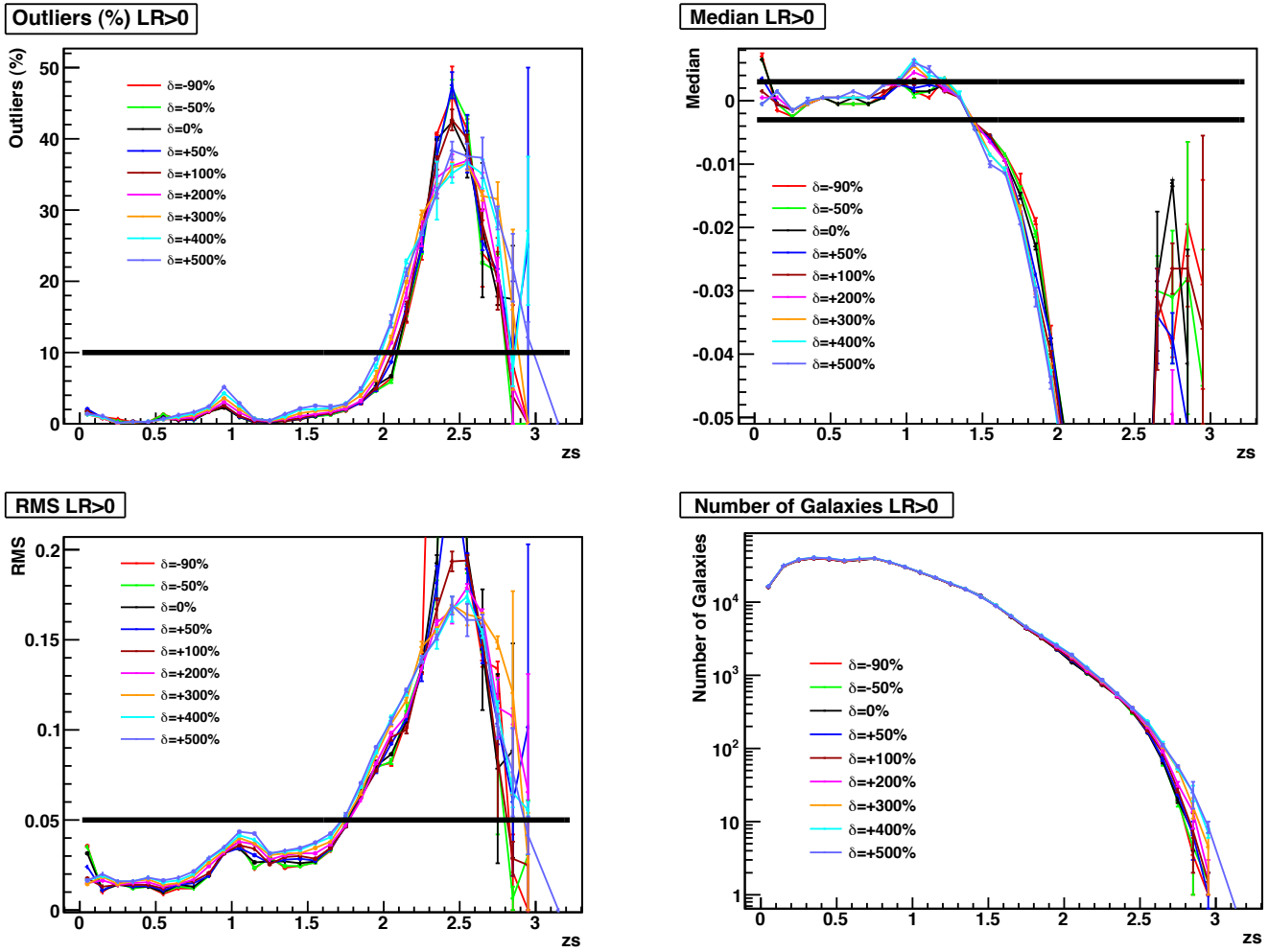
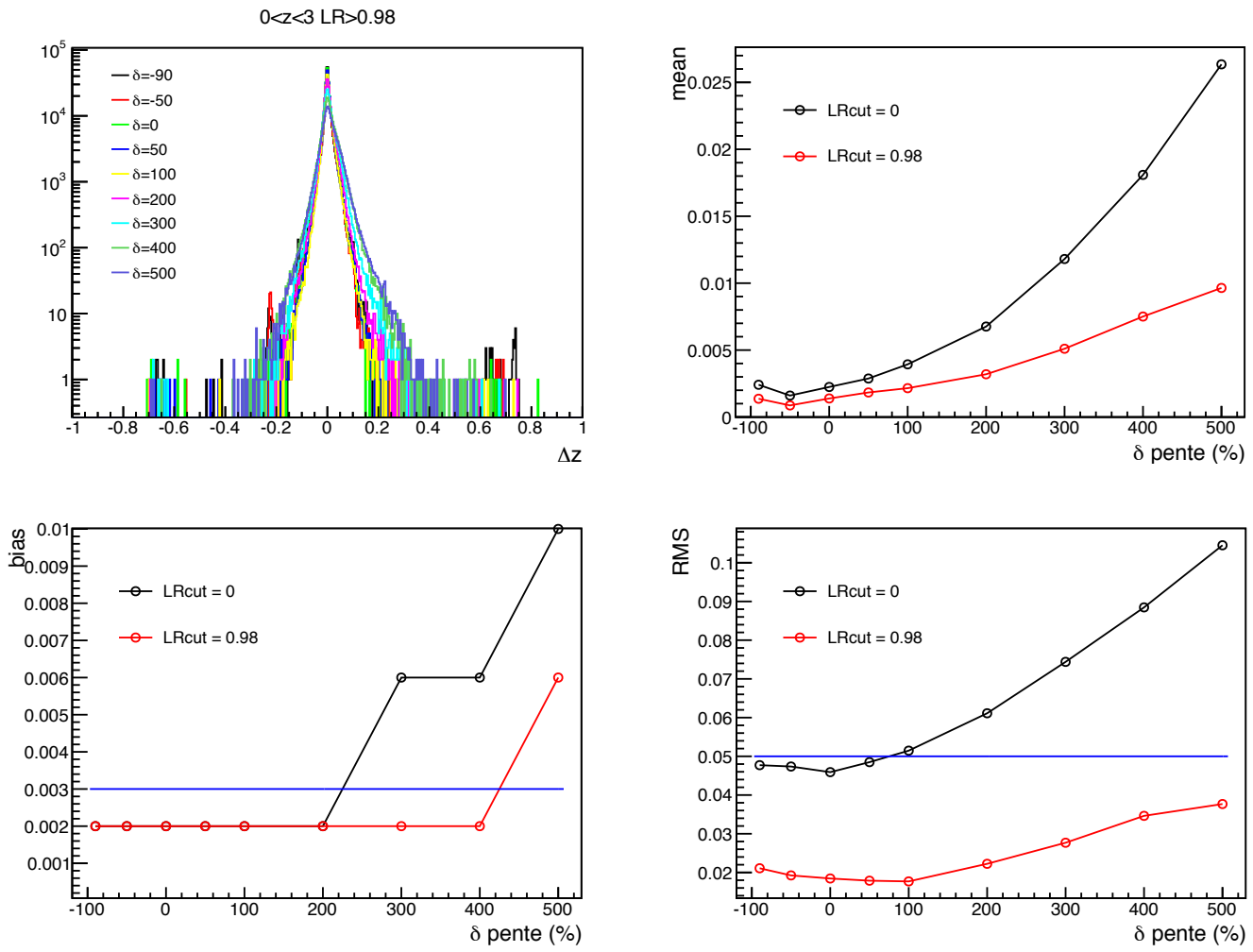


Photo-z reconstruction, $LR_{cut} = 0$



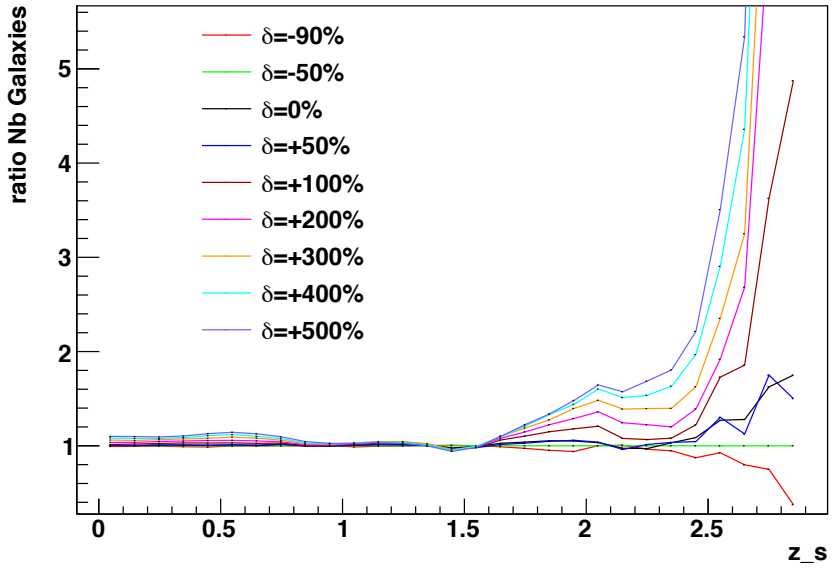
Integral non constante

Δz distribution



Number of galaxies

$LR_{cut} = 0$



$LR_{cut} = 0.98$

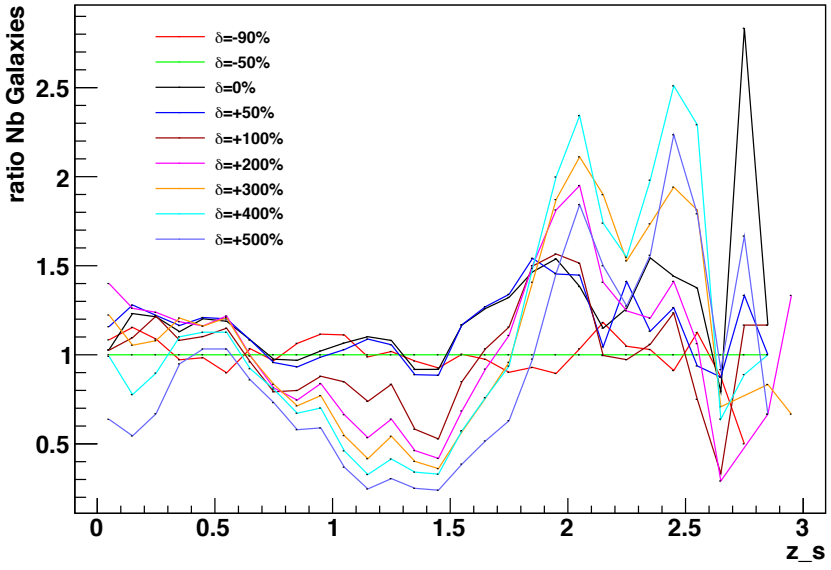
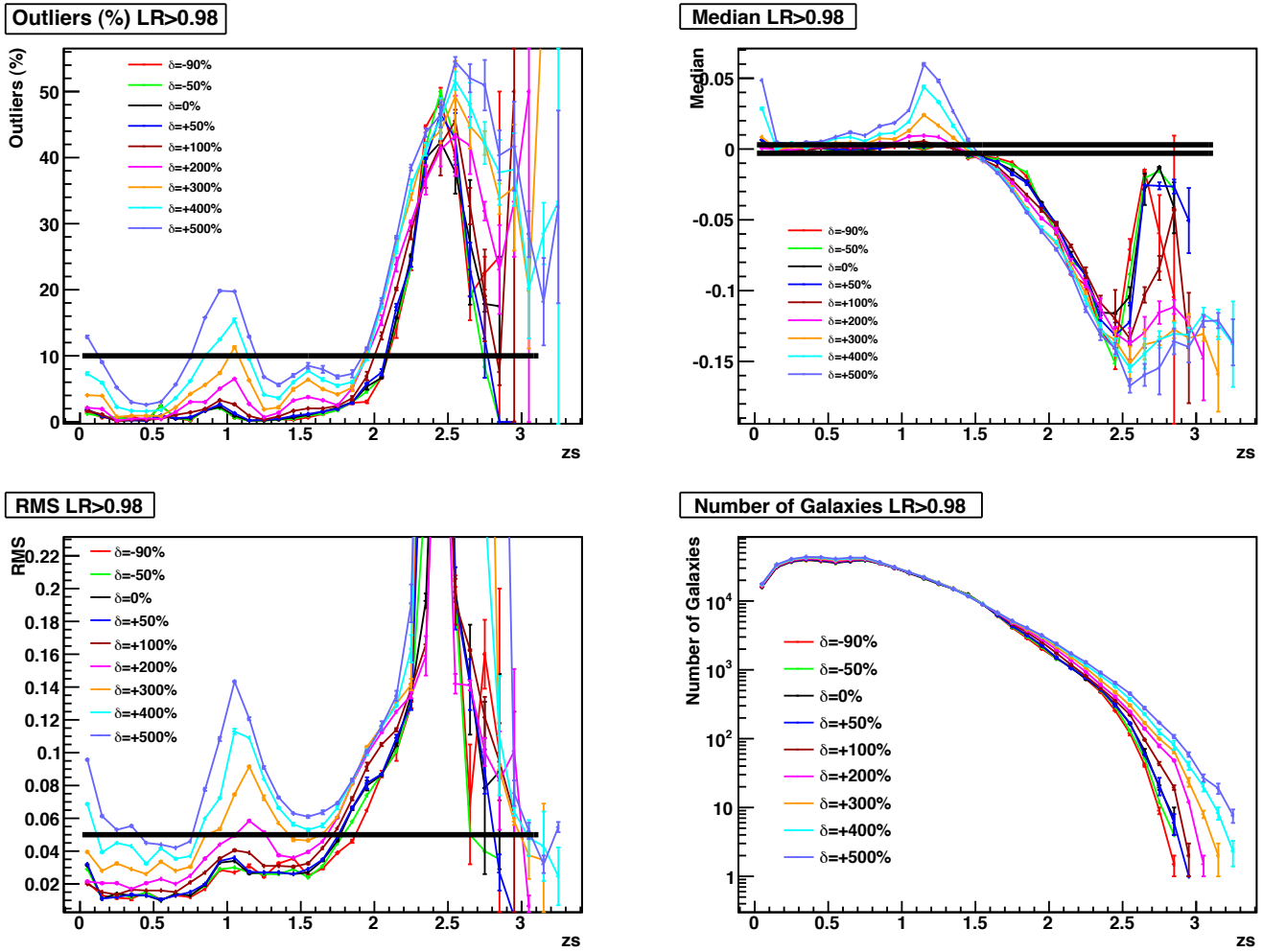
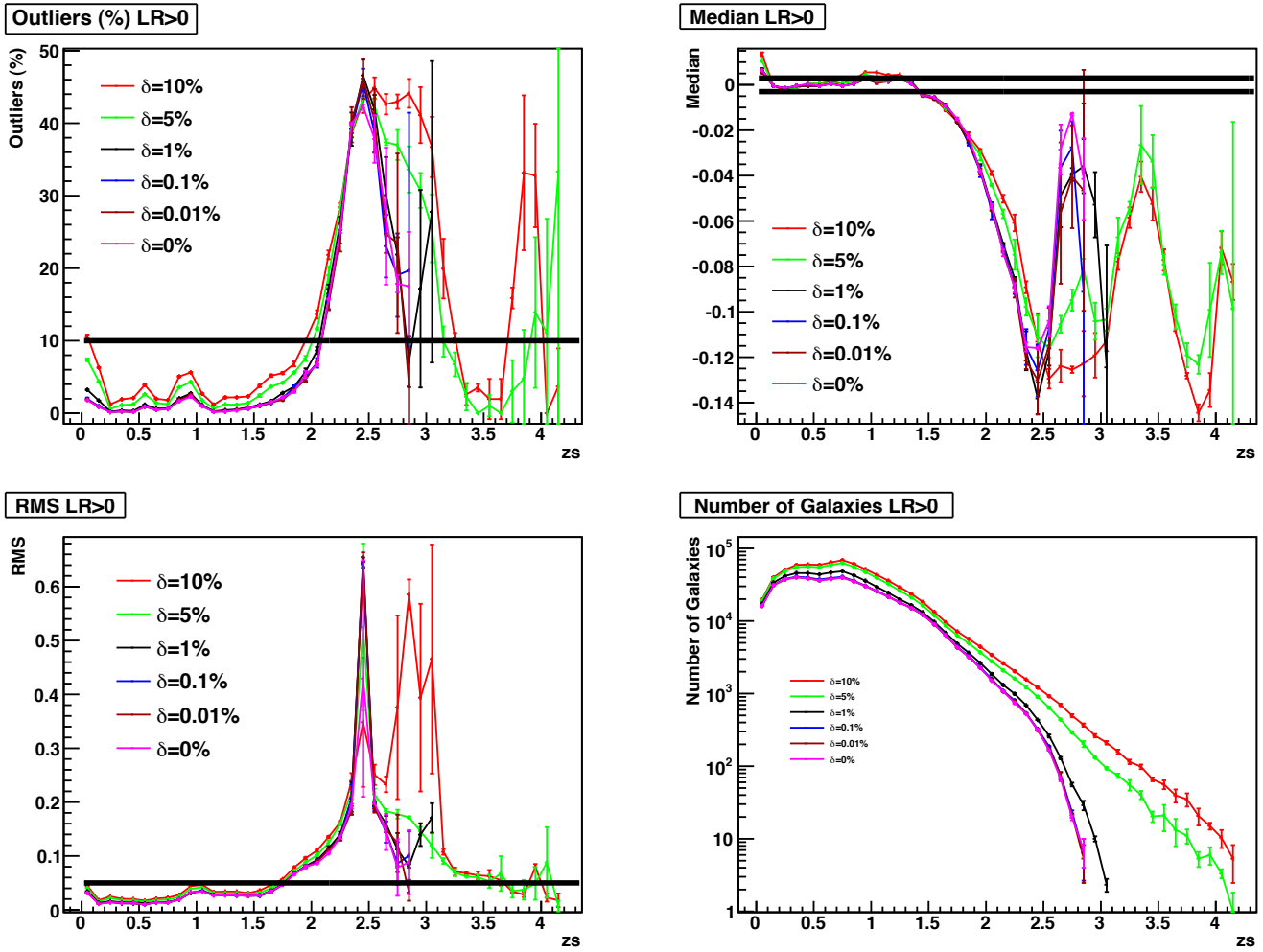


Photo-z reconstruction, $LR_{cut} = 0$

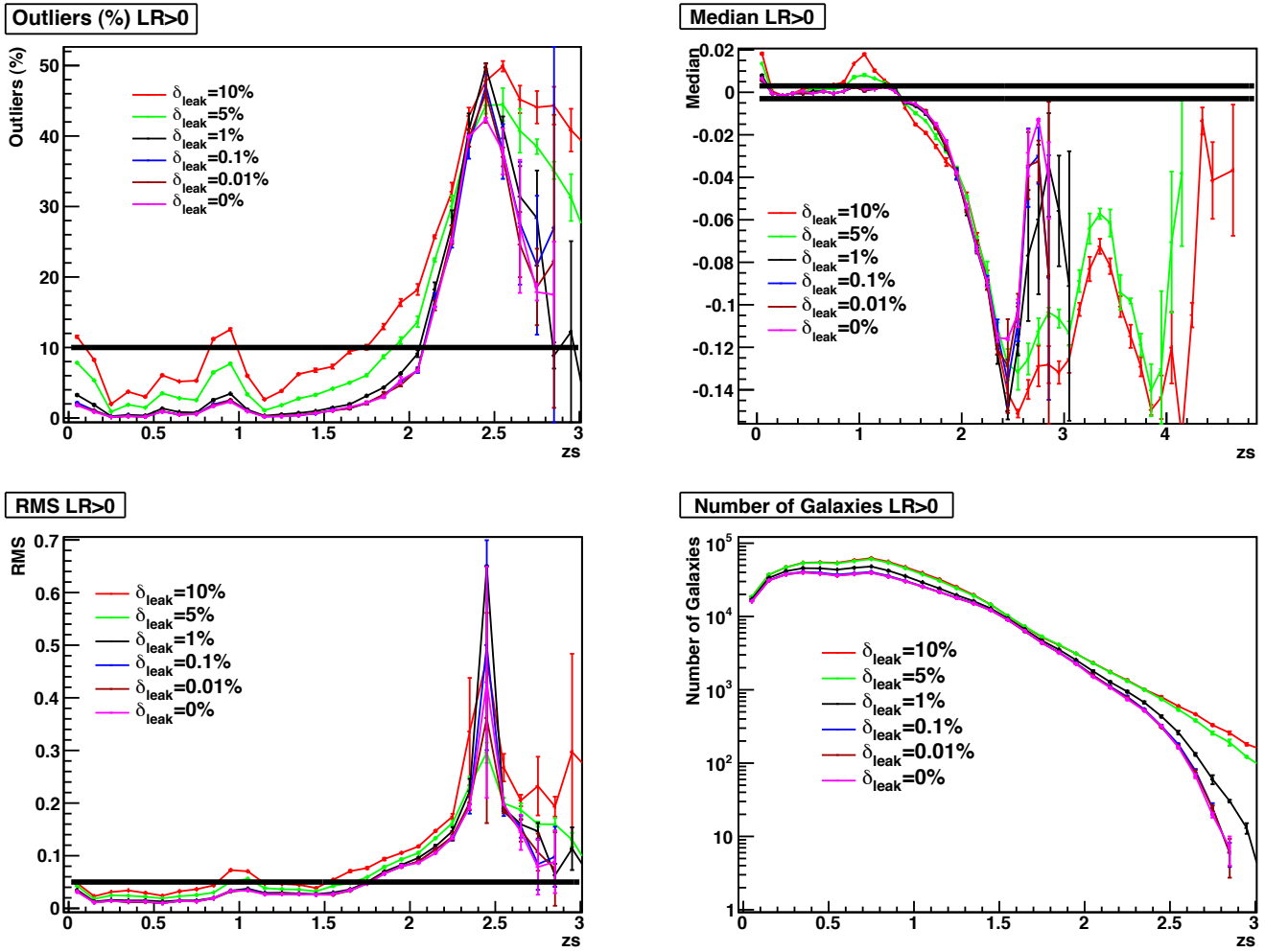


Leakage

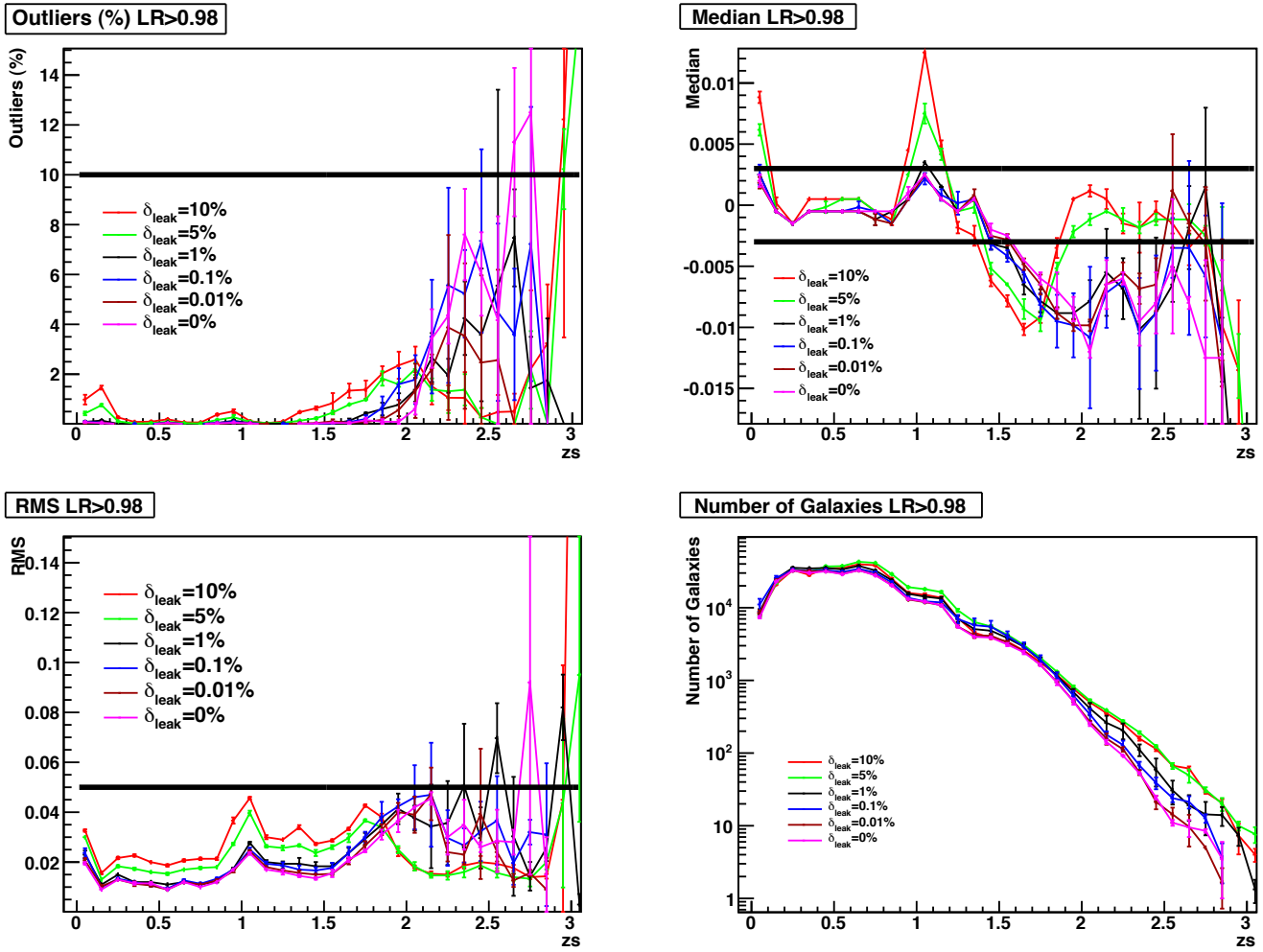
UV filter's leakage, $LR_{cut} = 0$



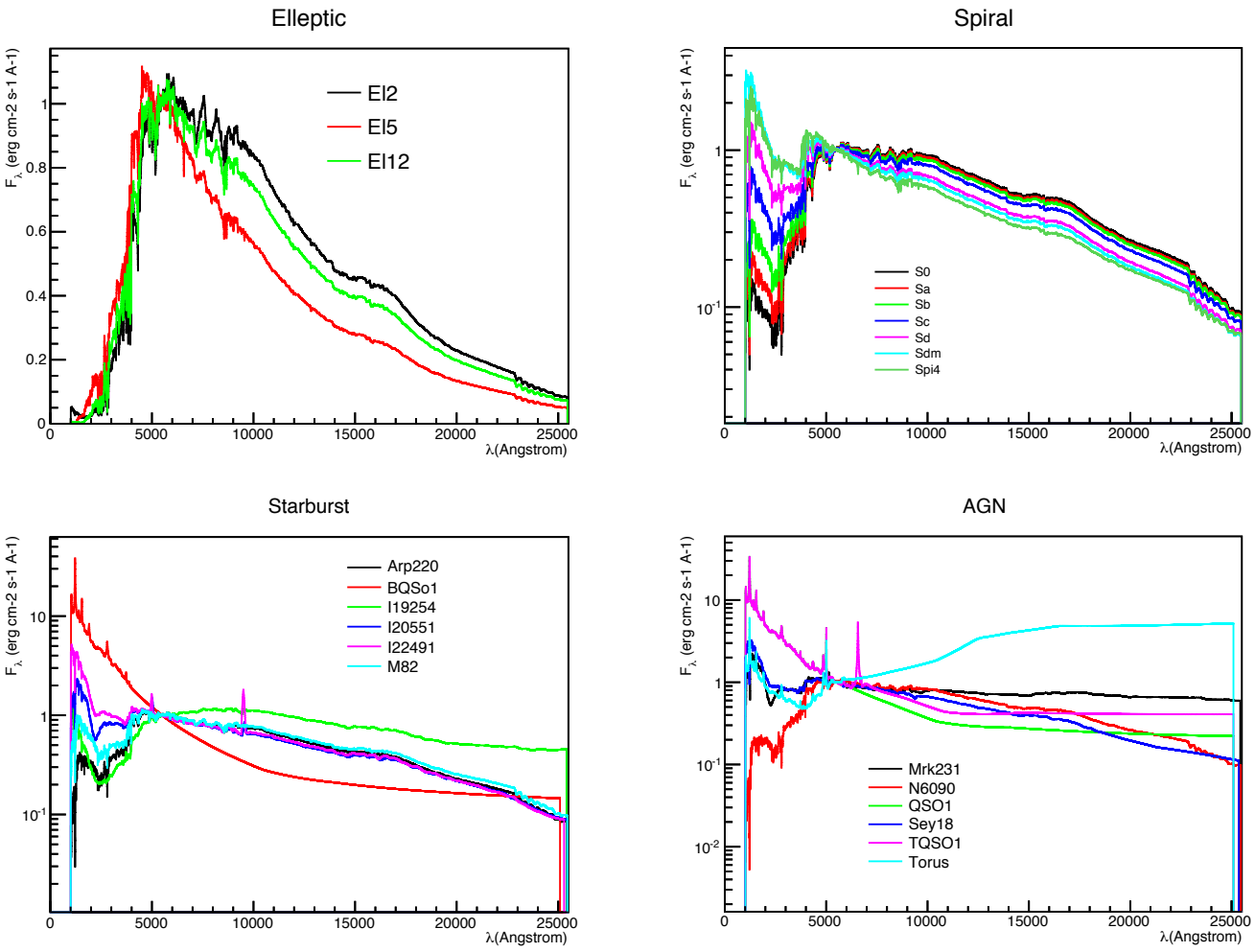
Leak in all filter, $LR_{cut} = 0$



Leak in all filter, $LR_{cut} = 0.98$



Poletta SED


Elleptic
El2
El5
El12
Spiral
S0
Sa
Sb
Sc
Sd
Sdm
Spi4
Starburst
Arp220
BQSo1
I19254
I20551
I22491
M82
AGN
Mrk231
N6090
QSO1
Sey18
TQSO1
Torus
F_λ (erg cm-2 s-1 A-1)
λ(Angstrom)