

# **SGLUONS AT THE LHC :** **A first look**

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✧ **INTRODUCTION**

✧ **SIGNATURES**

✧ **CONCLUSION**

# INTRODUCTION

**MSSM**

Model :  $\{g_\mu, \tilde{g}\} + \{\tilde{g}', \sigma\}$

Spin : 1 ,  $\frac{1}{2}$        $\frac{1}{2}$  , 0

**the sgluon !**

- Color-octet scalar
- susy particle N=2
- R-parity = +1

**Sgluon** can be single or **pair** (this work) **product** at the LHC with **large cross section** and **promising topologies** for LHC studies... as said befor by Eva Popanda.

MC simulations are performed to estimate discovery potential. **PYTHIA** (decay, hadronization, I-FSR) is used with an **extern process generator** (sgluon pair production) plus a **detector smearing technique**... (sgluon angular distribution provided by Eva).

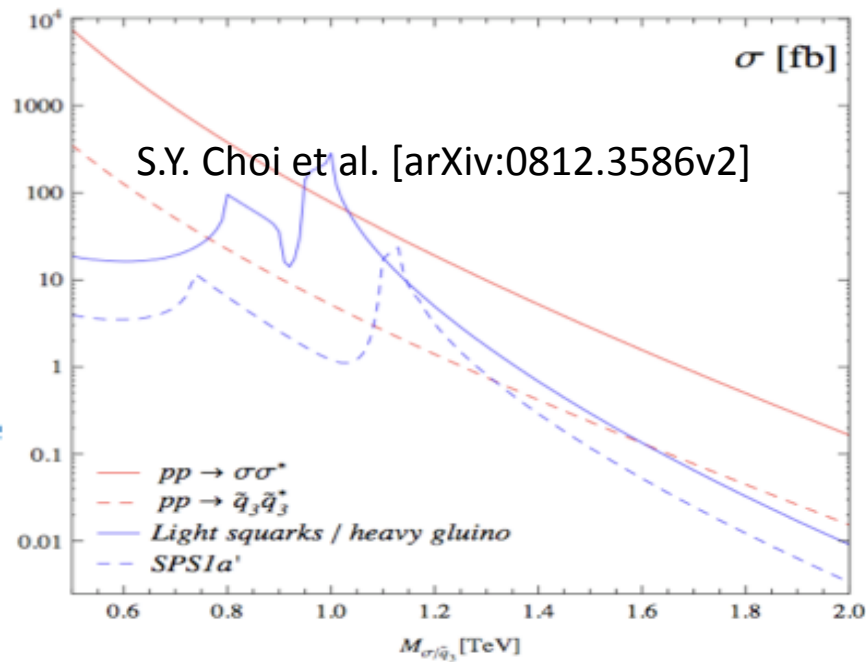
This work was motivated by the following theoretical papers :

- ✓ T. Plehn, T. Tait : Seeking Sgluons (2008) [arXiv:0810.3919v1]
- ✓ S.Y. Choi et al. : Color-octet scalars of N=2 supersymmetry at the LHC (2009) [arXiv:0812.3586v2]
- ✓ C. Kilic et al. : Searching for Multijet Resonances at the LHC (2009) [arXiv:0810.554v2]

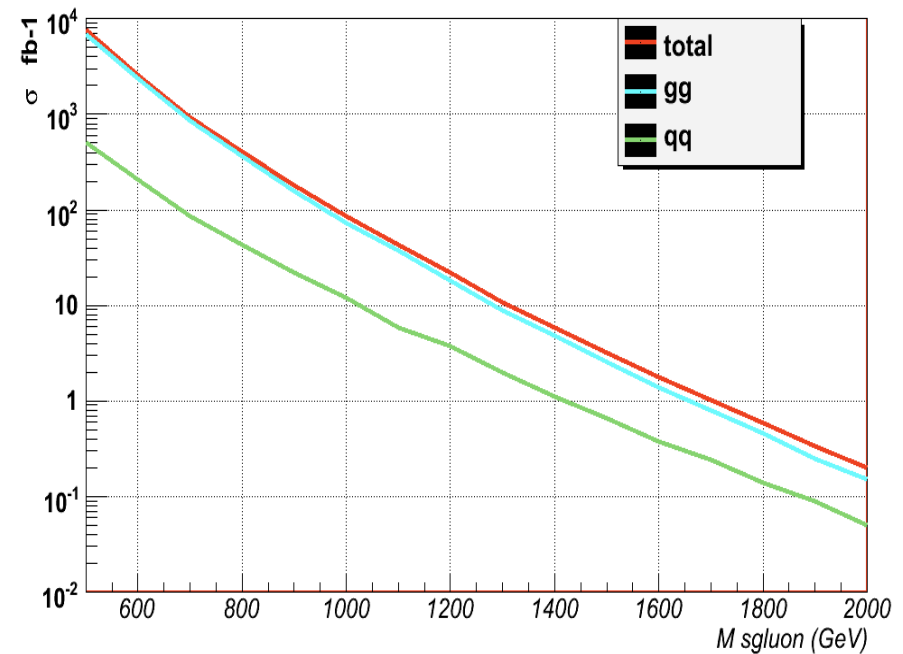
# Generator validation

Need to validate our generator : first test is the cross section.

Theory

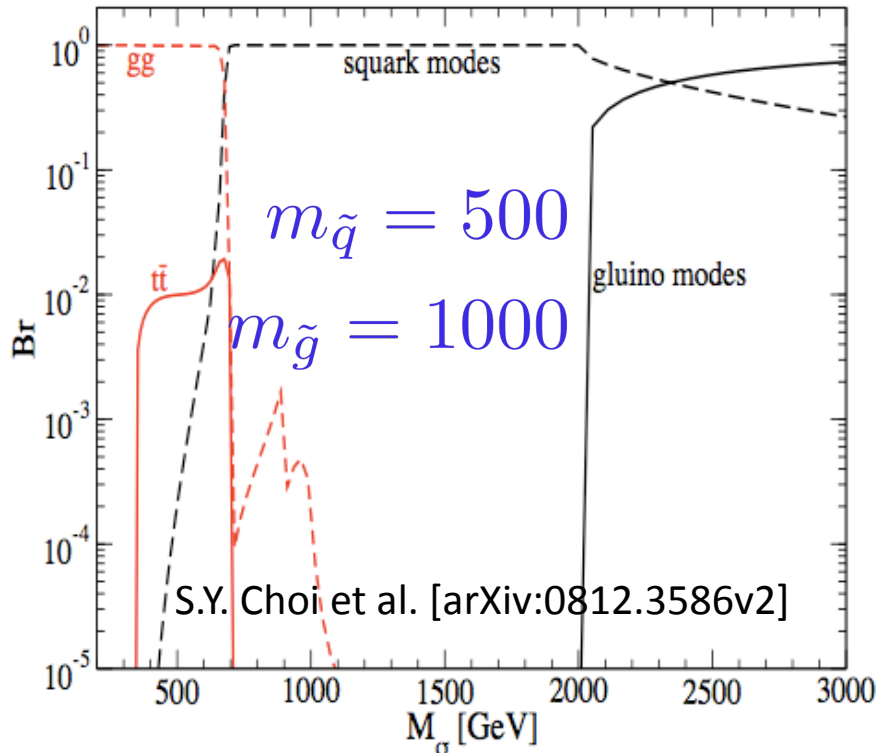


PHYTIA's result with ISR



- Good agreement for cross section.
- Large cross section for low mass sgluon.
- Main contribution from gluon fusion.

# Sgluon decay and signatures



Standard **Missing Et and jets** susy search :

Decay depends on the masses :

$\cancel{E}_T$   
&  
jets

Pair of gluinos : 8 jets and 4LSP

$$\tilde{g} \rightarrow \tilde{q}q \quad \tilde{q} \rightarrow q\tilde{\chi}_1^0$$

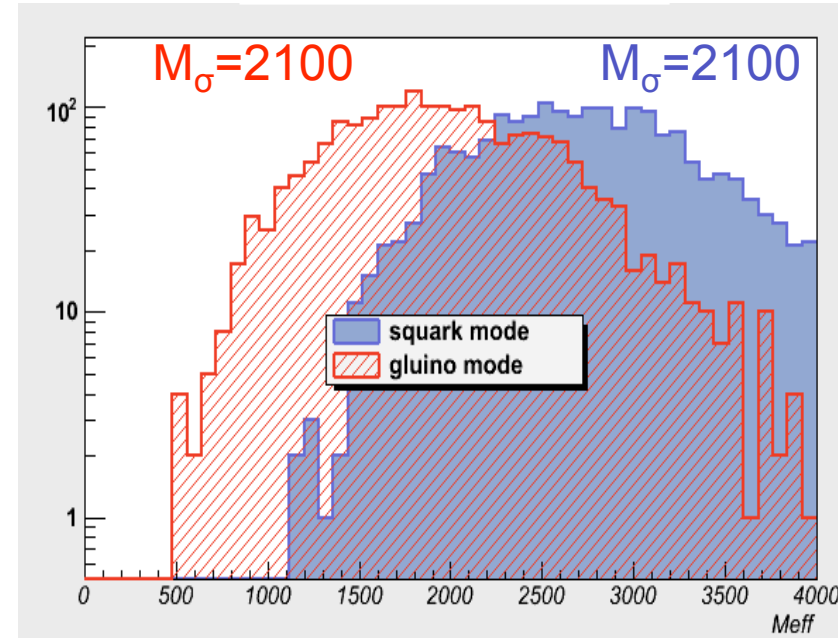
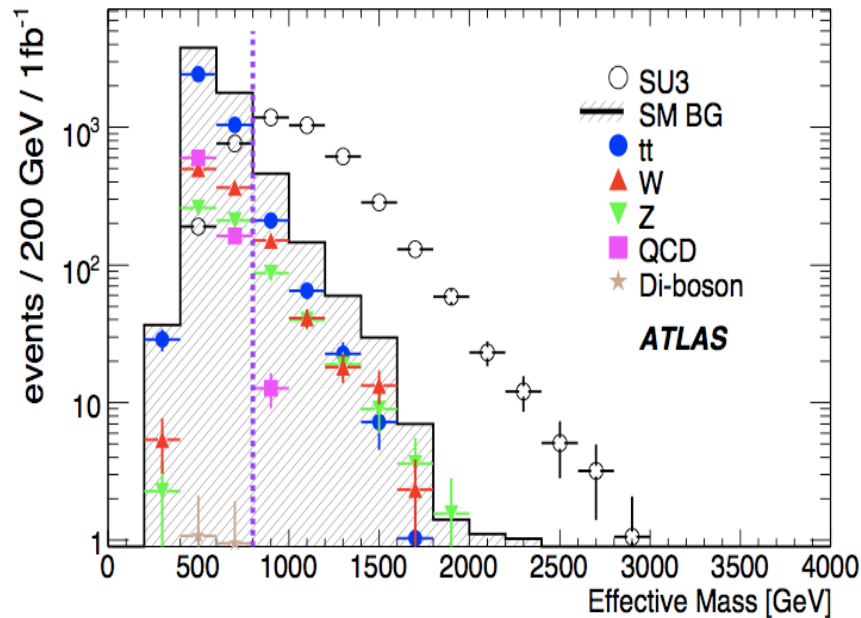
Pair of squarks : 4 jets and 4LSP

$$\tilde{q} \rightarrow q\tilde{\chi}_1^0$$

Pair of gluons : multijet resonance

- 4 jets  $p_T > 100, 50, 50, 50$  GeV
- $M_{\text{eff}} = \text{MissEt} + \sum p_T(4 \text{ jets}) > 800$
- $\text{MissEt} > 0.2 * M_{\text{eff}}$  and  $S_T > 0.2$
- No electrons, no muons
- $\Delta\Phi(\text{jet}, \text{MissEt}) > 0.2$

# Squark and gluino modes



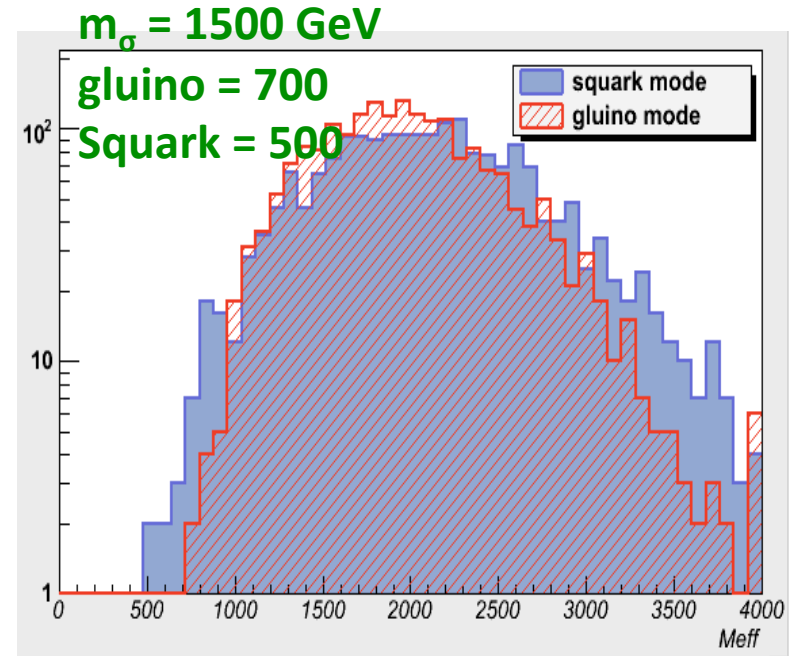
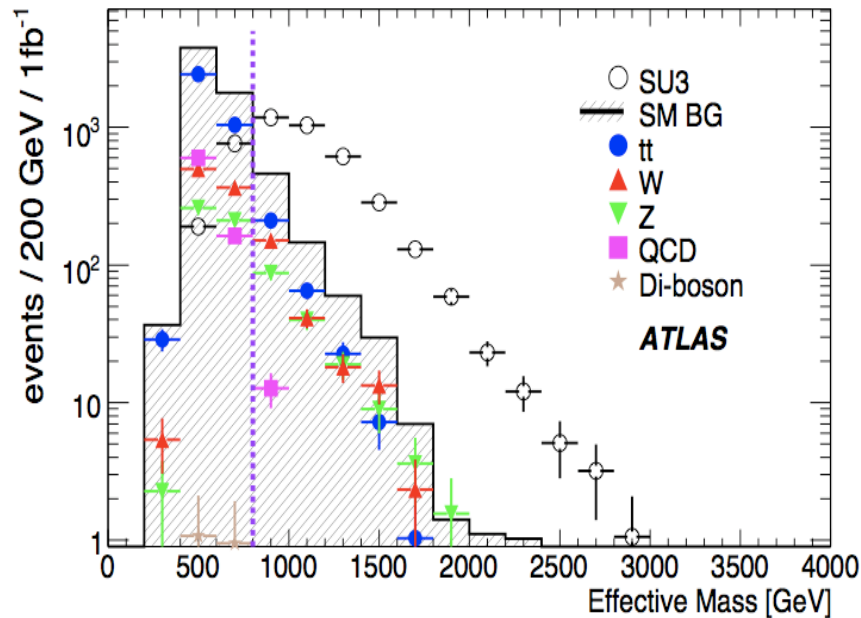
For the scenario of the Br ratio plot :

	Efficiency	S/vB (100 fb <sup>-1</sup> )
$\tilde{q}$ 500 GeV	$M_\sigma = 1100$	39 %
	$M_\sigma = 1500$	35 %
$\tilde{g}$ 1 TeV	$M_\sigma = 2100$	36 %
	$M_\sigma = 2300$	39 %

- here background (B) is SM
- Standard **selection very sensitiv**
- But **low cross section at high mass**

$$\text{Efficiency} = \frac{\text{\#evt after cuts}}{\text{\#evt before cuts}}$$

# Squark and gluino modes



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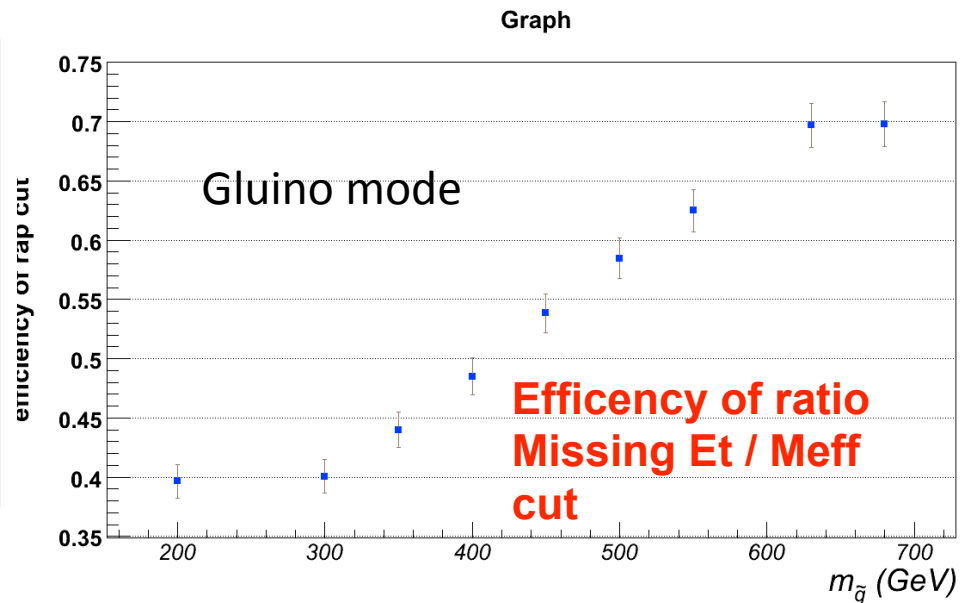
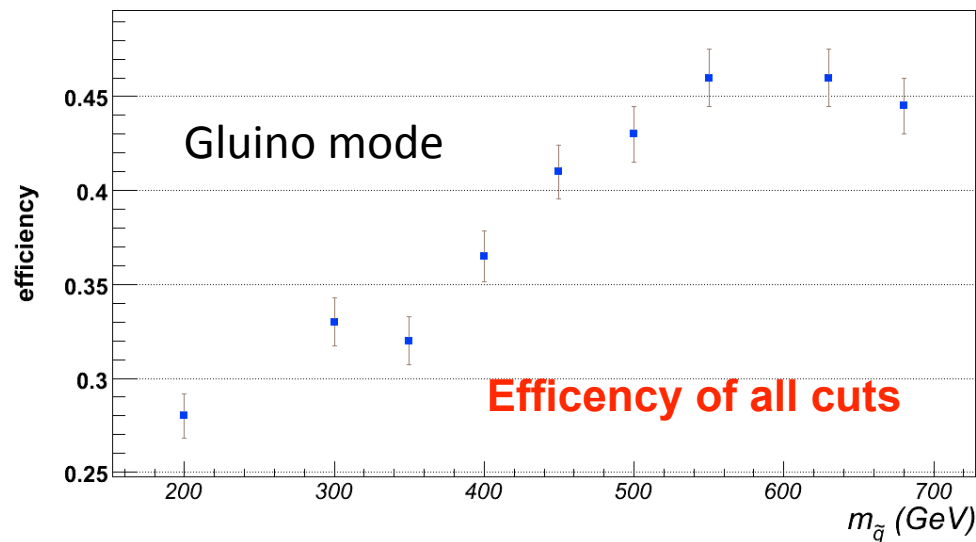
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# Squark and gluino modes

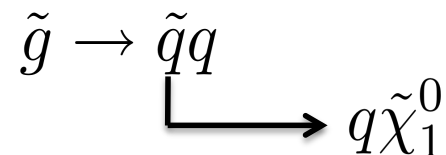
Does the efficiency (of previous cuts) depend on squark and gluino masses in the cascade decay ?

Gluino and squark masses determine the ratio  $E_T / M_{eff}$  and the **sphericity** of the event :



- Efficiency increases with squark mass

- Missing  $E_T$  increases with squark mass.



- Opposite for the sphericity.

# Glauino mode : susy low mass point

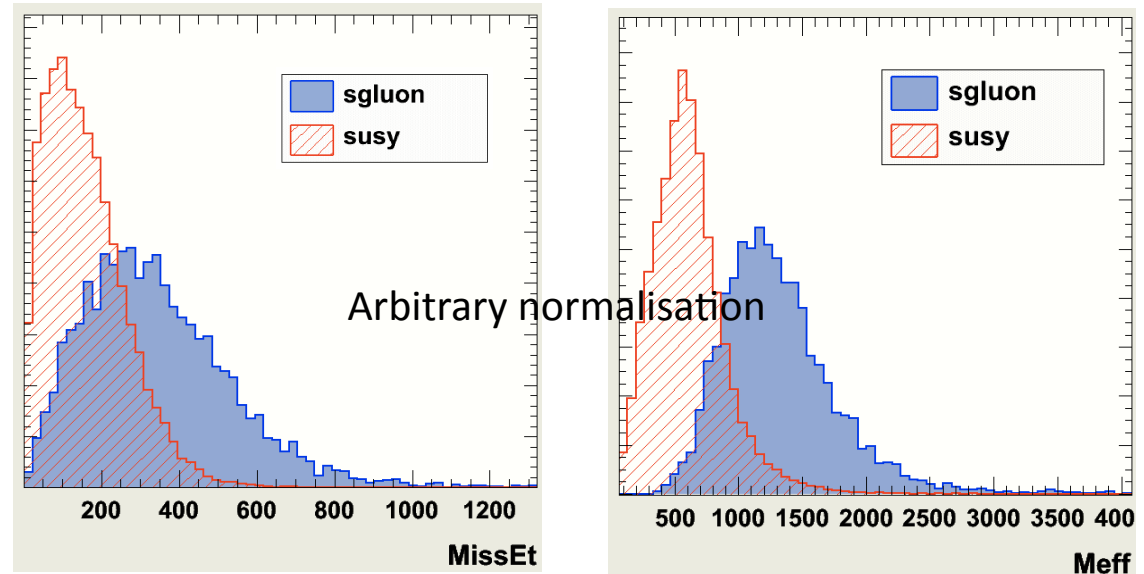
**Pair of gluinos : 8 jets and 4LSP**

$$\tilde{g} \rightarrow \tilde{q}q \quad \tilde{q} \rightarrow q\tilde{\chi}_1^0$$

- Gluino mass = 413 GeV
- Squark mass = 400 GeV
- LSP mass = 60 GeV
- **Sgluon mass = 830 GeV**

## Cuts (GeV) :

- Meff > 1257
- MissEt > 389
- Jet1 > 141
- Jet2 > 141
- Jet3 > 97

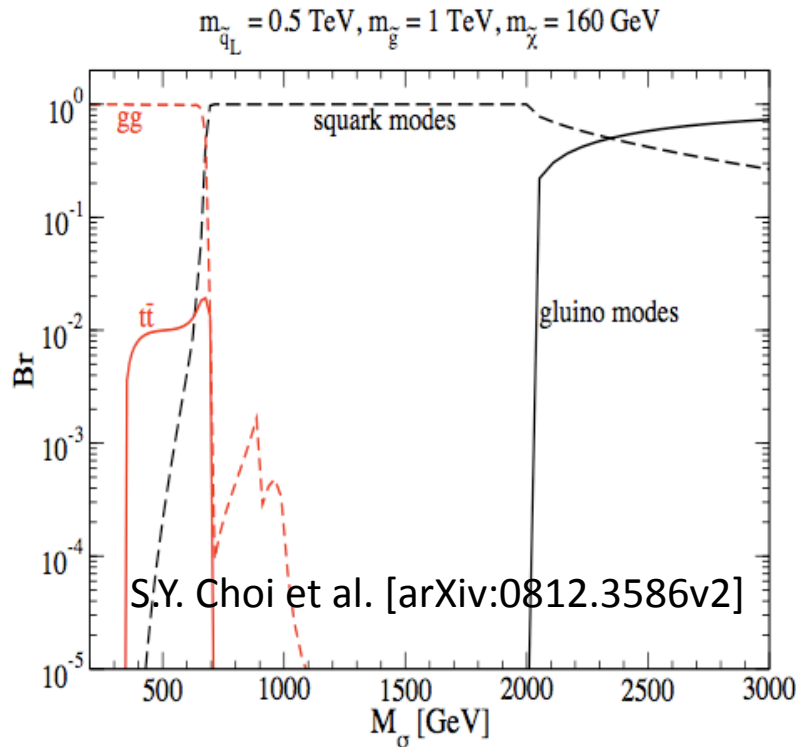


	<b>Cross section</b>	<b># of events for 1fb<sup>-1</sup></b>
<b>Sgluon</b>	350 fb	<b>52</b>
<b>SUSY</b>	240 000 fb	<b>320</b>

Despite small cross section **the signal is large for high jet's and missing energy.**



# Gluon mode : multijets resonance



Apply the cuts of Kilic et al. paper :

- Cuts (GeV)**
- 4 Jets Pt > 250
  - $\Delta R$  > 0.5
  - $|\eta|$  < 2
  - $\chi^2$  < 50

- Sgluon can decay into two gluons.

$$\sigma\sigma \rightarrow gggg$$

- R-parity conservation BUT **NO Missing  $E_T$** .
- **Reconstruction of sgluon mass** possible.

Kilic et al. investigate color octet scalar : hyperions

⇒ Similar final state.

⇒ I use their estimation of QCD background obtained with COMIX and SHERPA.

Pair the four hardest jets in all possible ways and discard the event if there is no pairing in which the invariant masses of the two pairs are within 50 GeV of each other.

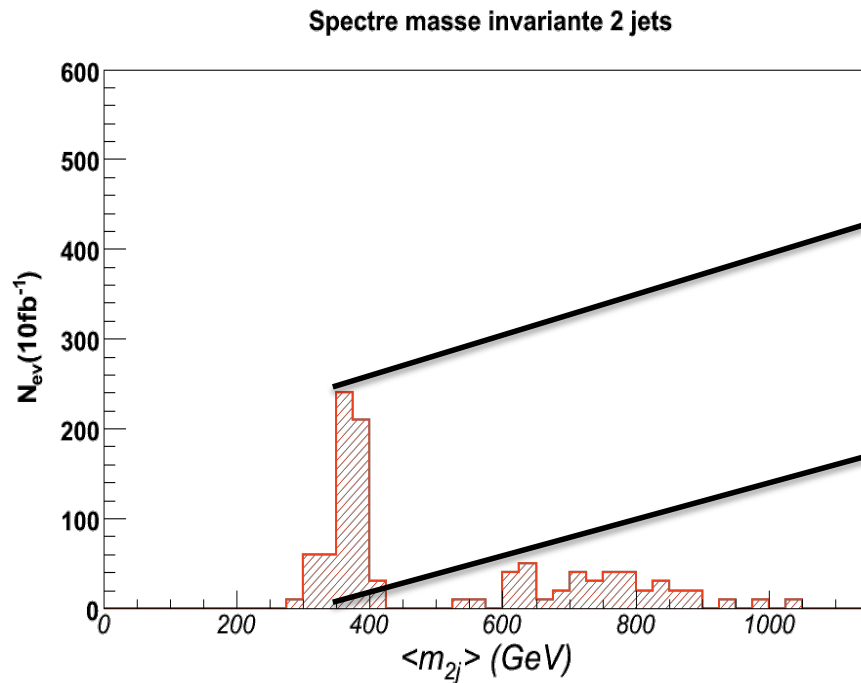
Thanks to  $\sin^2\theta$  distribution of  $\sigma\sigma$ .

# Gluon mode : Results

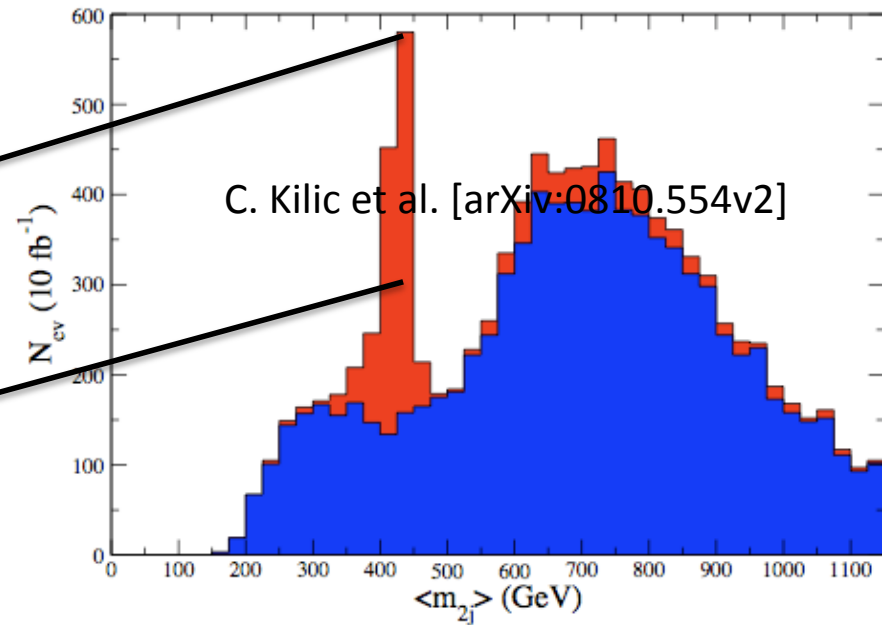
Example for  $m_g = 400 \text{ GeV}$ ,  $\sigma = 27 \text{ pb}$ .

After cuts and pairing for  $10 \text{ fb}^{-1}$  :

Cuts (GeV)		
▪ Jet 4 Pt	> 250	(0.4 pb)
▪ $\Delta R$	> 0.5	(0.2 pb)
▪ $ \eta $	< 2	(0.2 pb)
▪ $\chi^2$	< 50	(0.1 pb)



BkG :  $1 \text{ pb} \pm 1$  from [arXiv:0810.554v2]



The mass peak is clearly distinguishable from the background.

# Conclusion

- Sgluon is a colored susy particle which can be pair product at the LHC with large cross section.

⇒ Theoretical models exist.

- Sgluon can decay into :

⇒ a pair of gluinos

or

⇒ a pair of squarks

Missing Et and jets channel ⇒ standard susy analysis is sensitiv.

- Sgluon can also decay into

⇒ a pair of gluons

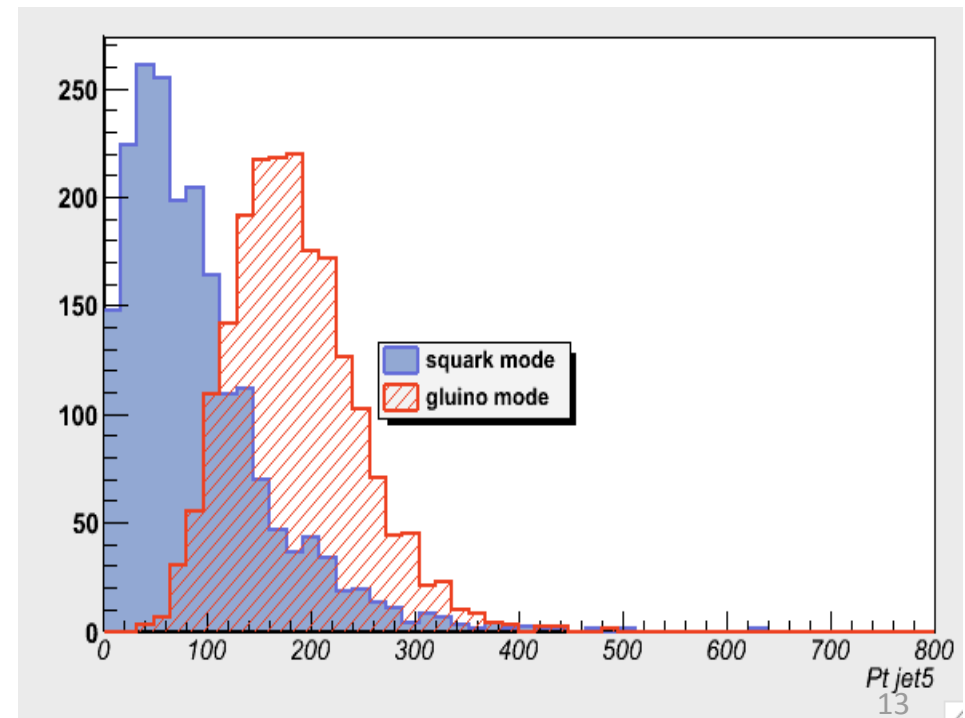
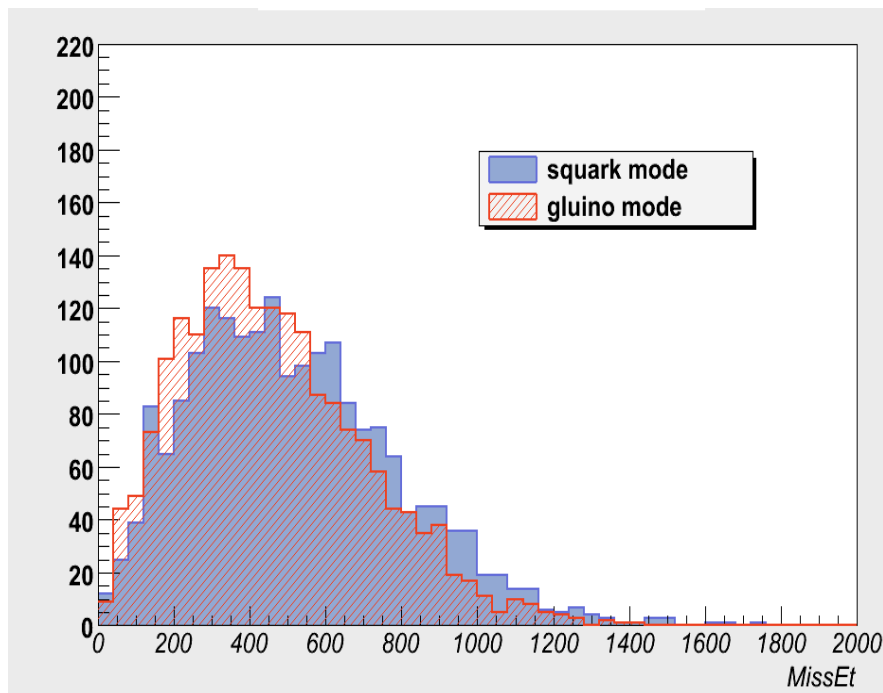
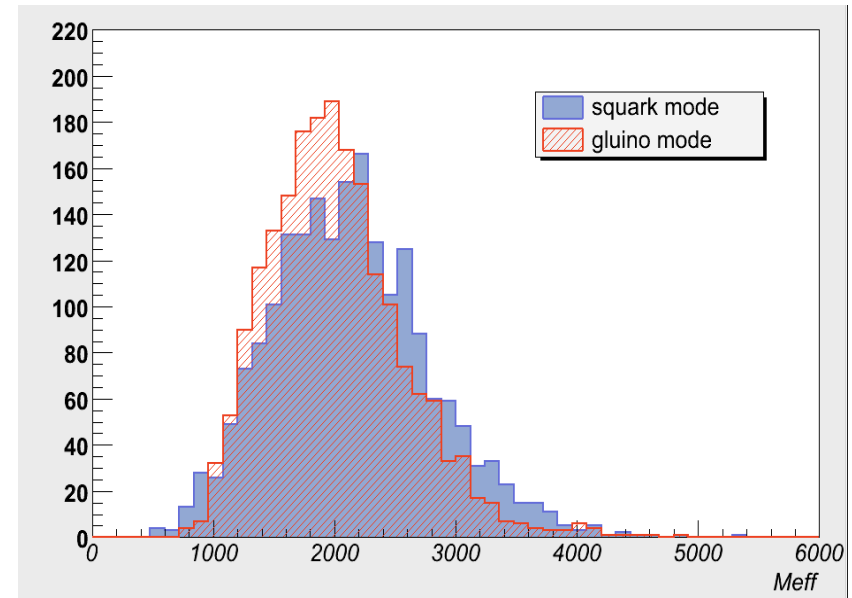
Multijets resonance in the QCD background ⇒ This have been done for hyperions by Kilic et al. ⇒ promising chanel with mass reconstruction.

- Future work : coherent simulation of signal and background (QCD).

# BACKUP

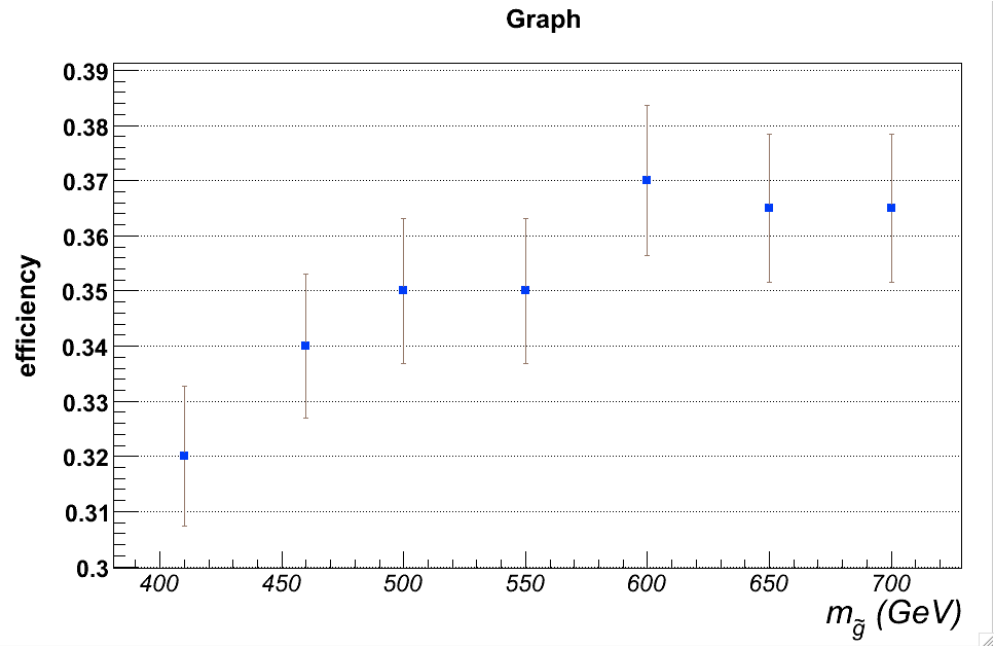
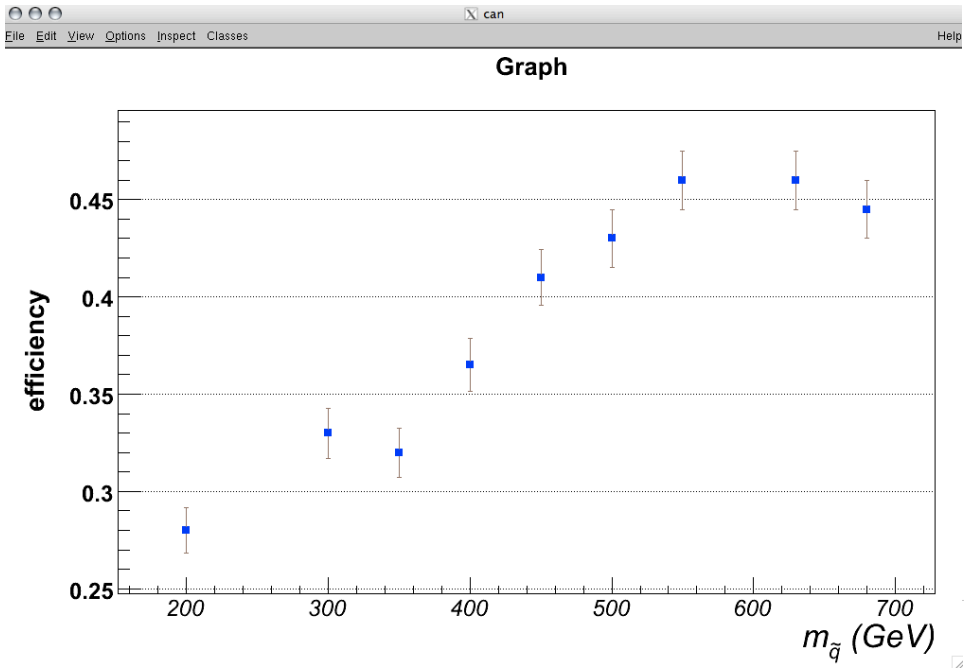
## Squark and gluino mode for $M_{\text{sgluon}} = 1500$

Difference appears for  
 $P_{t\text{jet}5}$  and it doesn't  
contribute to  $M_{\text{eff}}$ .



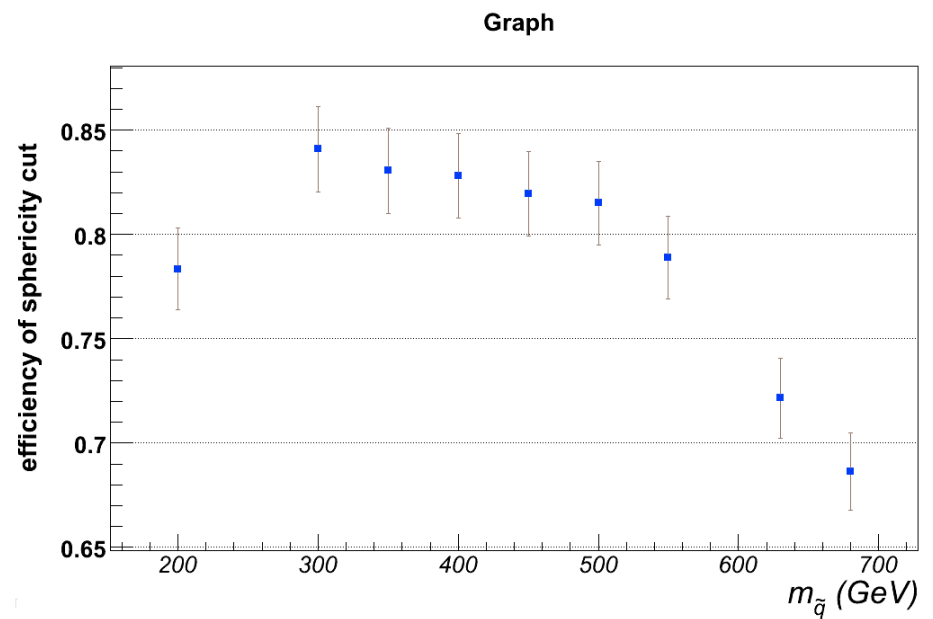
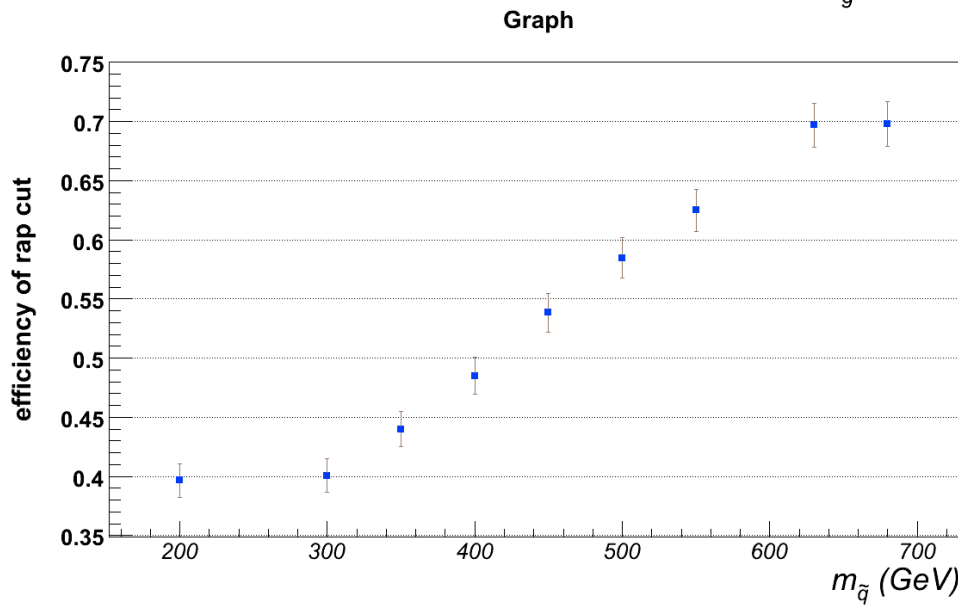
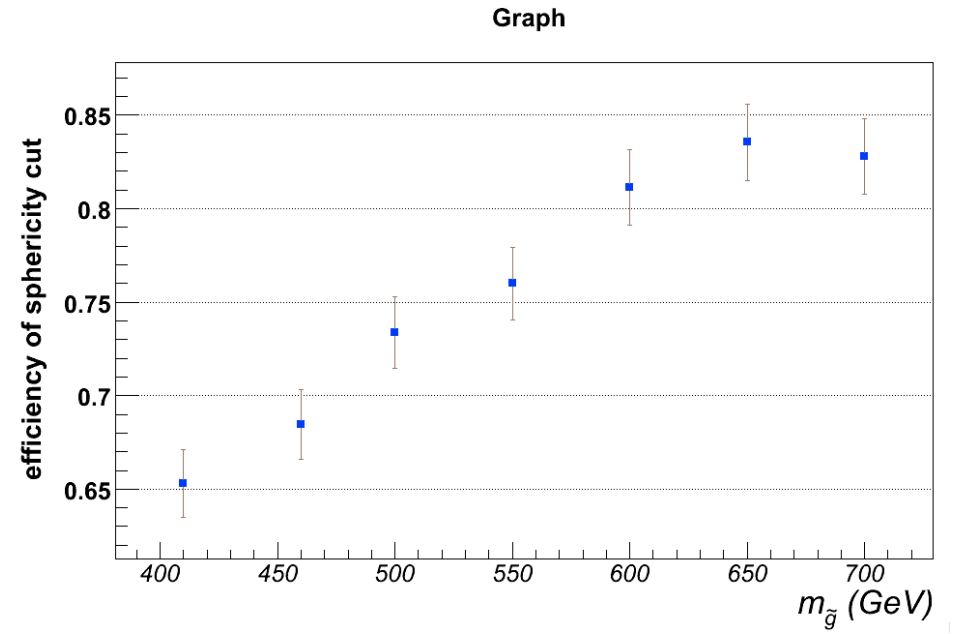
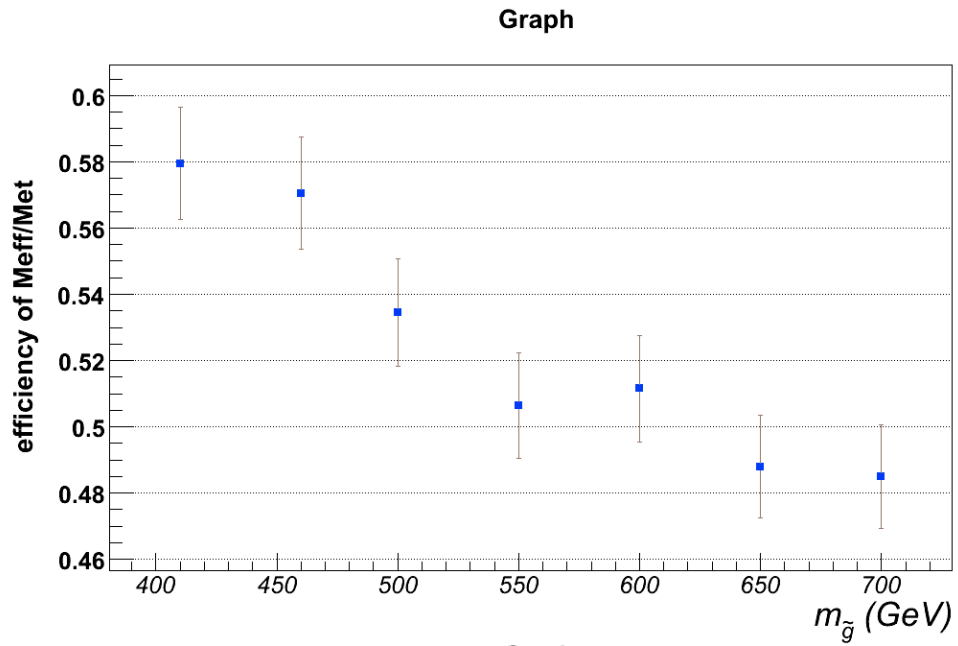
# Le CANAL gluino gluino : 8jet +4LSP

Efficiency de SCS fonction de mass des squark



D'où vient ce comportement ???

# Efficiency vient des coupures sur sphericity et rap



Explication par la cascade.

# Gluon mode : Results

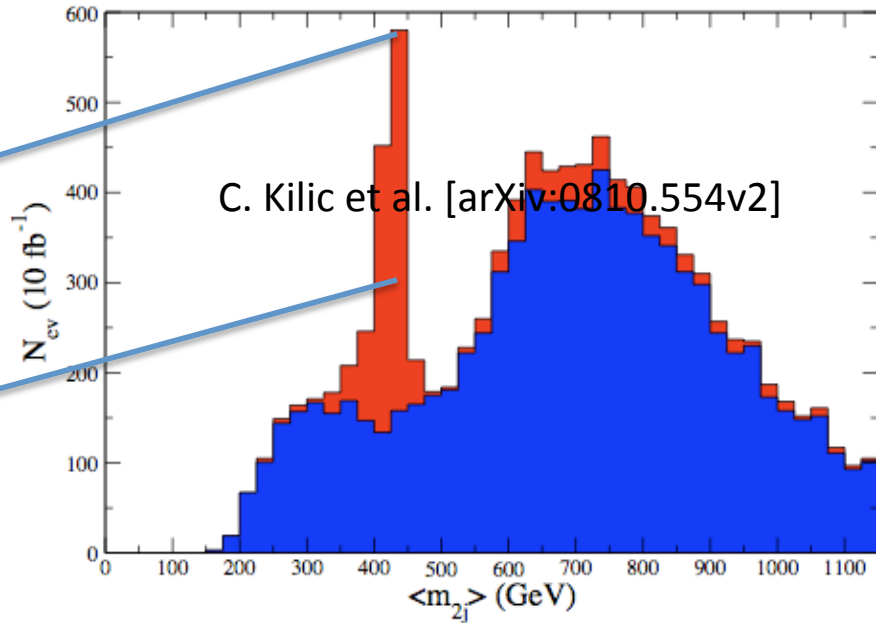
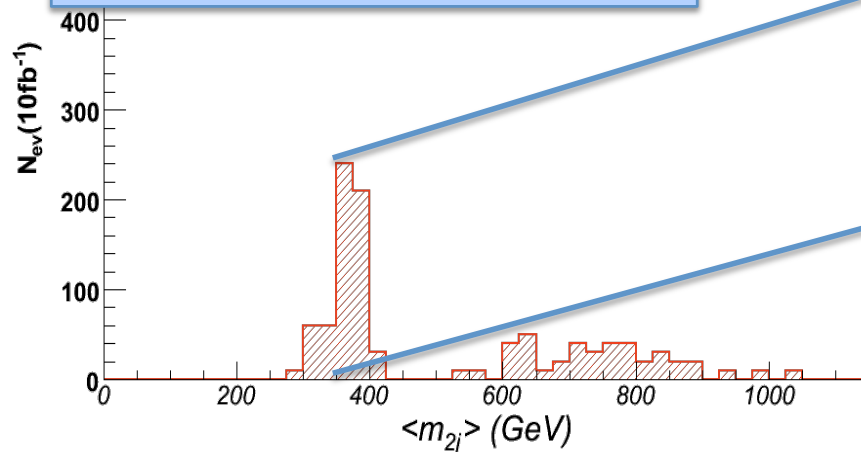
Example for  $m_g = 400$  GeV , X-section = 27 pb .

After cuts and pairing for  $10 \text{ fb}^{-1}$  :

Bining : between 350 and 400  
signal = 440  
background 320  
 $S/\sqrt{B}=25$   
If background  $2*320$   
 $S/\sqrt{B}= 16$

Cuts (GeV)		
▪ Jet 4 Pt	> 250	(0.4 pb)
▪ $\Delta R$	> 0.5	(0.2 pb)
▪ $ \eta $	< 2	(0.2 pb)
▪ $\chi^2$	< 50	(0.1 pb)

BkG :  $1 \text{ pb} \pm 1$  from [arXiv:0810.554v2]



C. Kilic et al. [arXiv:0810.554v2]

The mass peak is clearly distinguishable from the background.



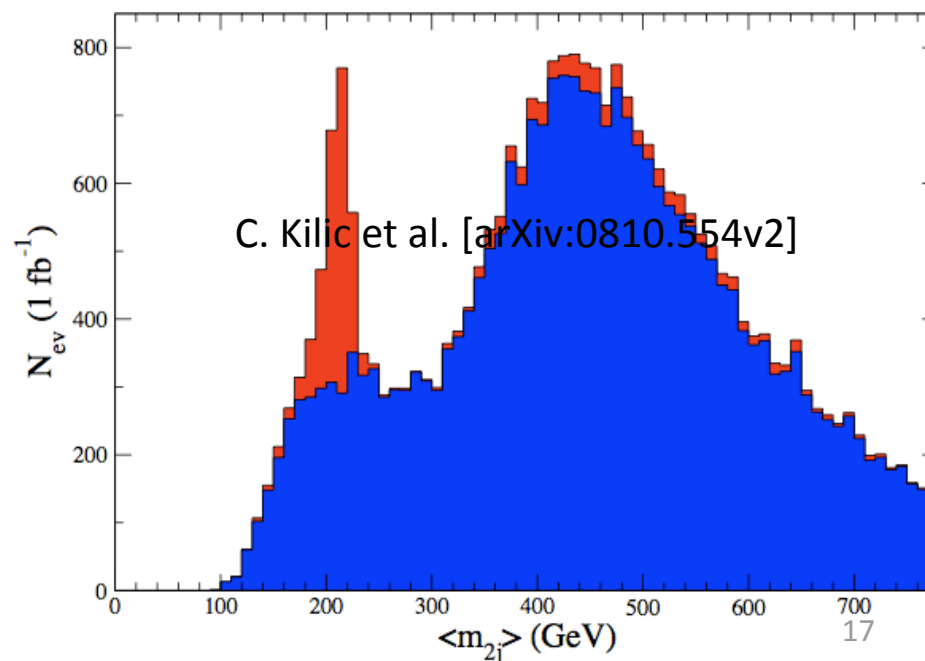
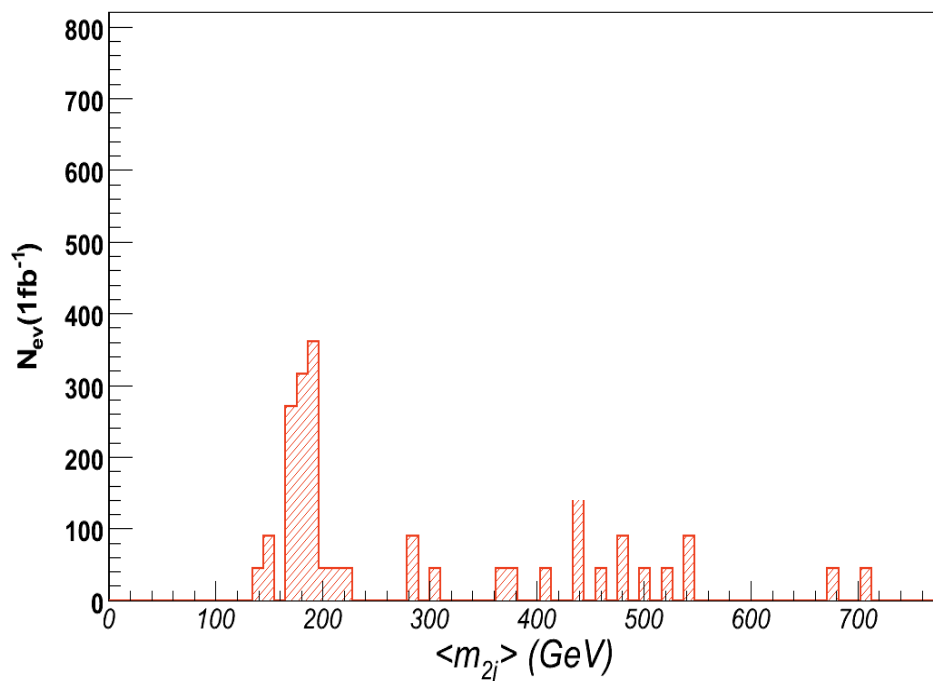
# Gluon mode : multijets resonance

Mass peak in QCD background : **select high Pt jets**. **Exemple for  $m_g = 200$  GeV :**

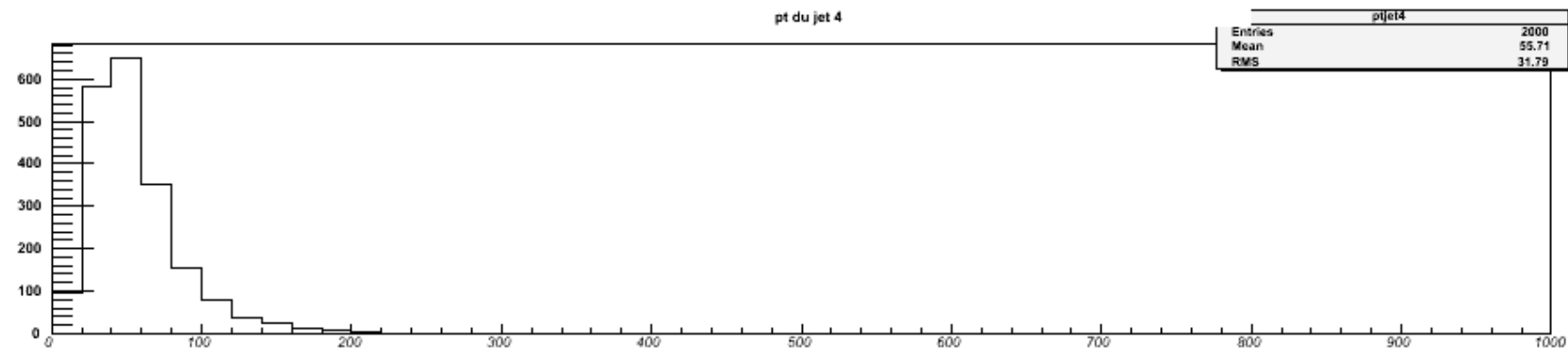
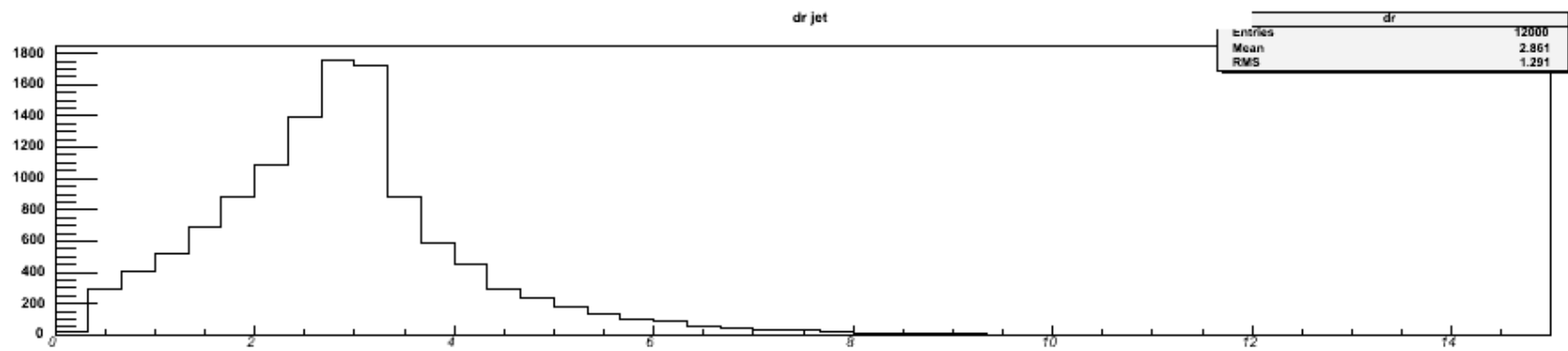
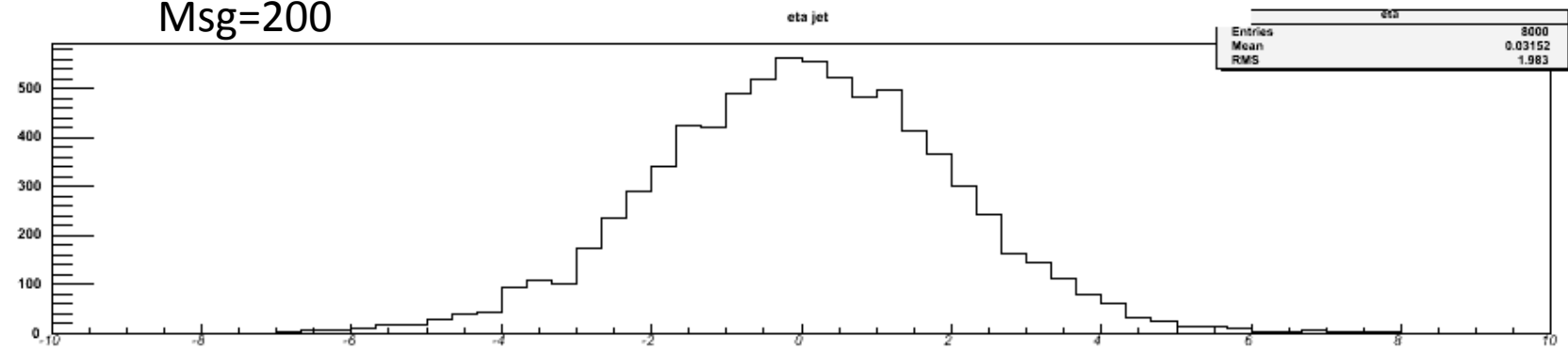
Cuts (GeV)		
▪ Jet 4 Pt	> 150	(16 pb)
▪ $\Delta R$	> 0.5	(7.5 pb)
▪ $ \eta $	< 2	(7 pb)
▪ $\chi^2$	< 50	<b>(3 pb)</b>

$$\int \mathcal{L} dt = 1 \text{fb}^{-1}$$

**BkG : 22 pb** from [arXiv:0810.554v2]

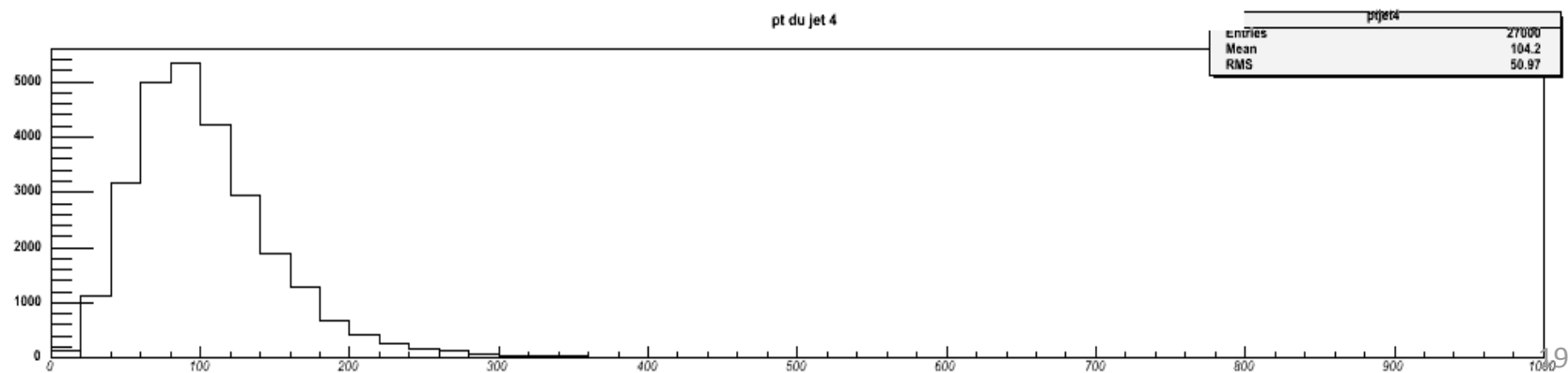
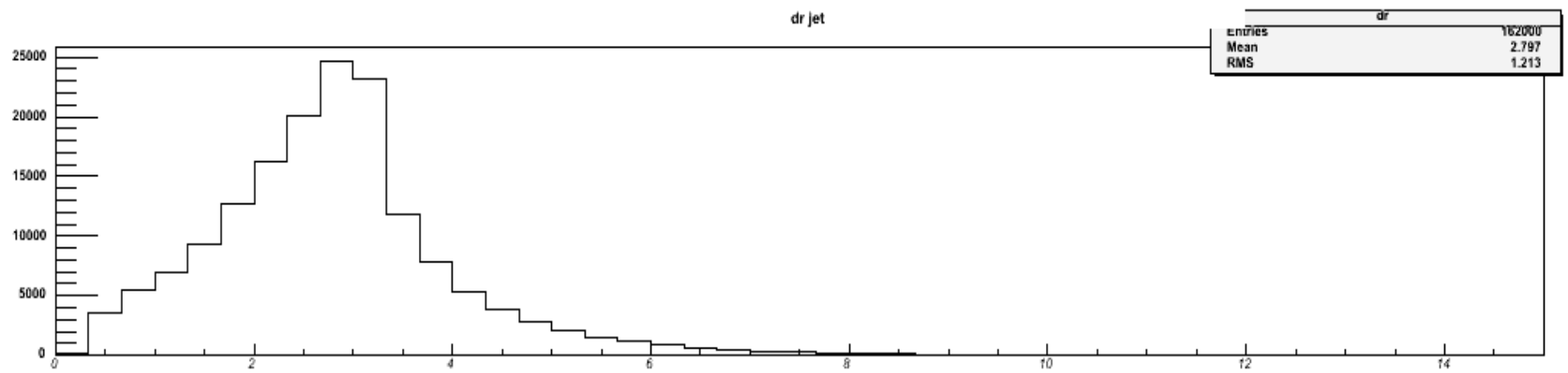
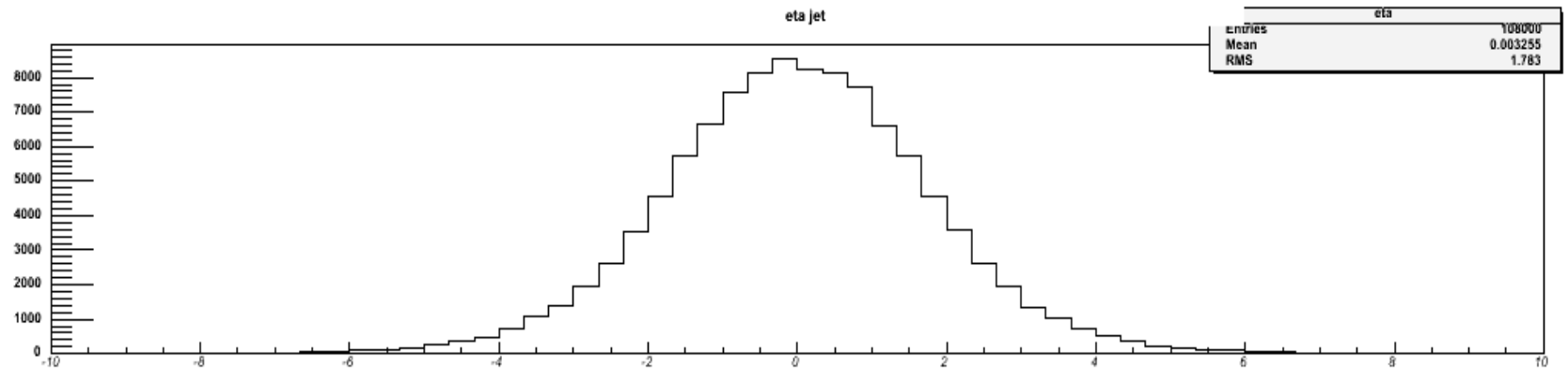


# Canal gg pour Msg=200



# Canal gg avec Msg=400

## Cut flow;



# CANAL t $\bar{t}$ bar

