Research of supersymmetry in the 0 lepton channel with ATLAS detector at LHC

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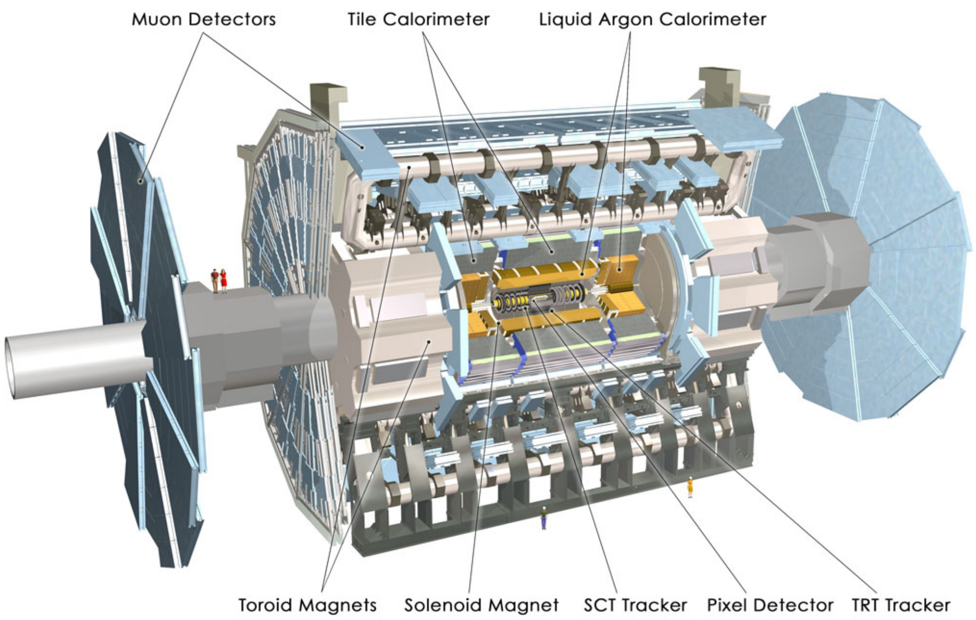
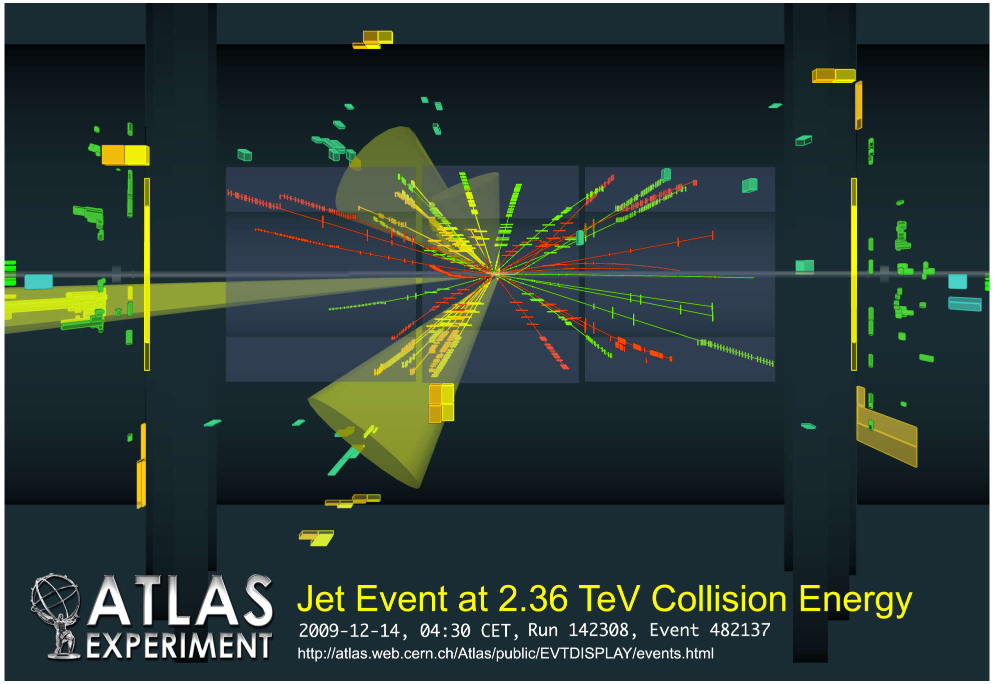
ATLAS experiment at LHC (CERN)



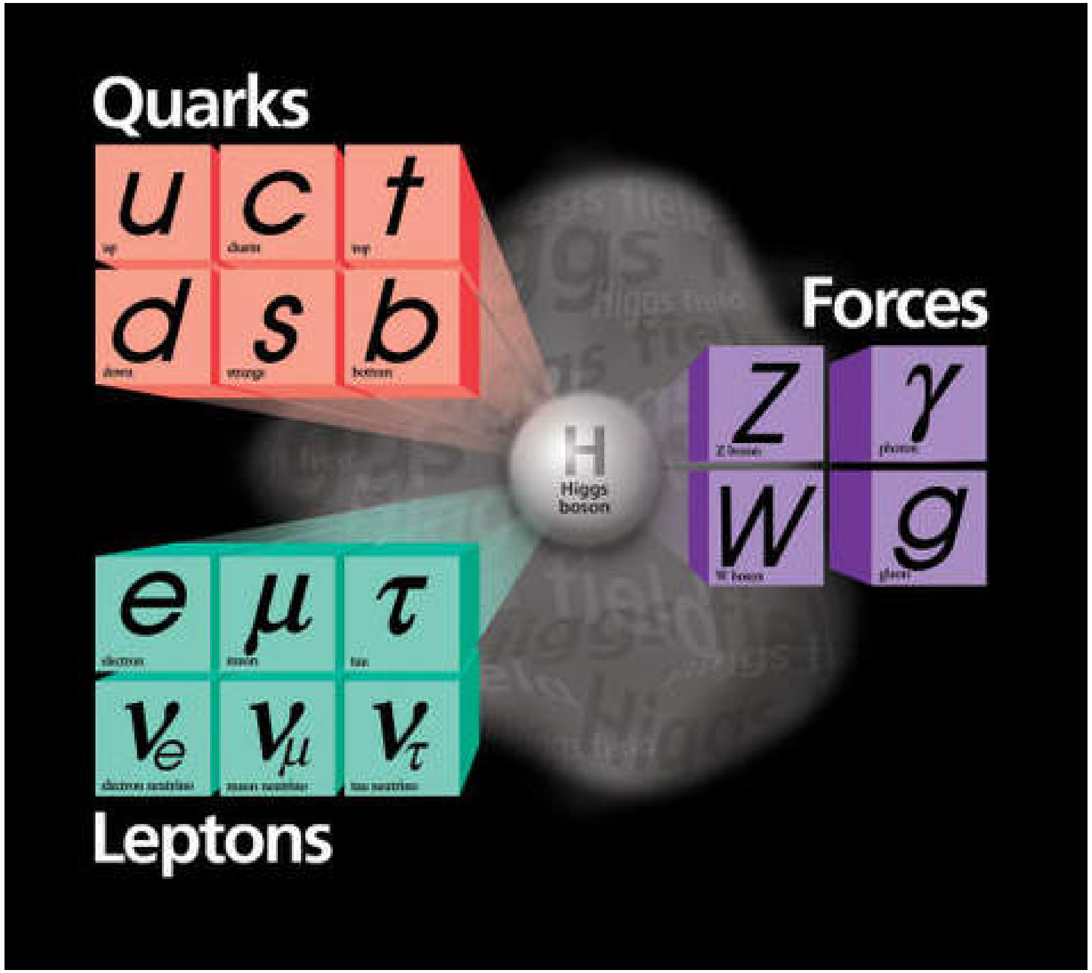
ATLAS experiment



Collision of two protons with the ATLAS detector

1. Research of **supersymmetry**
2. **Jet energy scale**
3. **Jet energy resolution**

Standard Model of particle physics



Standard Model particles :
quarks - leptons - gauge bosons - Higgs boson

<u>**Standard Model issues:**</u>

- No candidate for **gravitation**
- Don't explain the origin of the **neutrinos mass**
- Don't explain the **matter-antimatter asymmetry**
- No candidate for **dark matter**
- **hierarchy** problem

Supersymmetry and MSSM

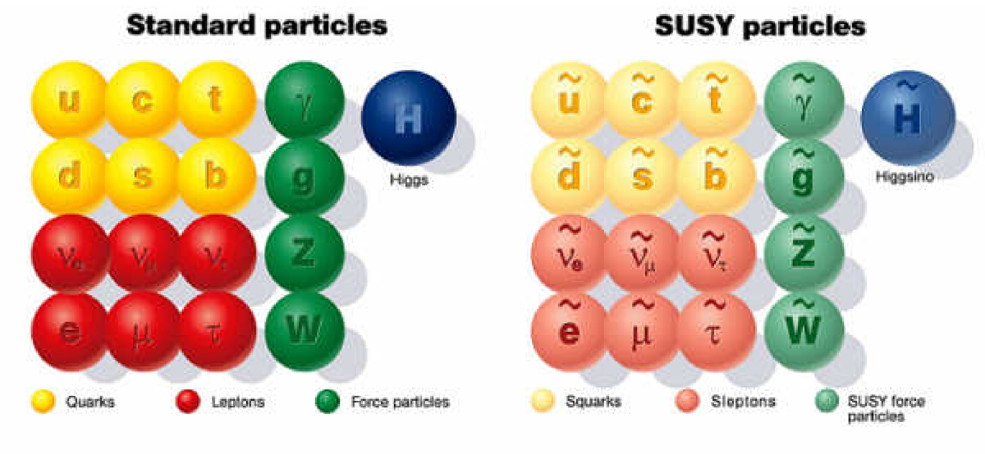
The supersymmetry:

- Unifiy the boson and the fermions
- Predict the existence of new particles

The MSSM:

- The MSSM is the minimal model with supersymmetry
- Symmetry breaking (4 neutralinos and 2 charginos)
- Conservation of the R-parity

The MSSM

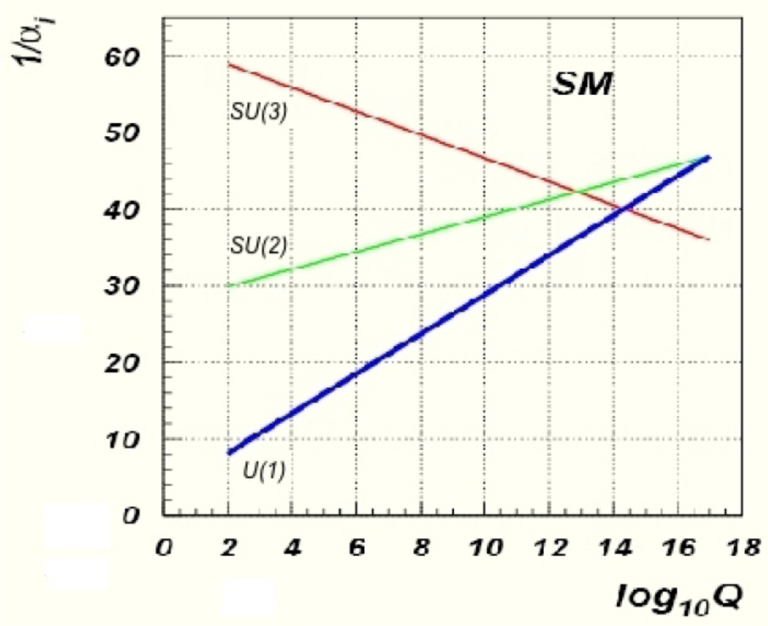


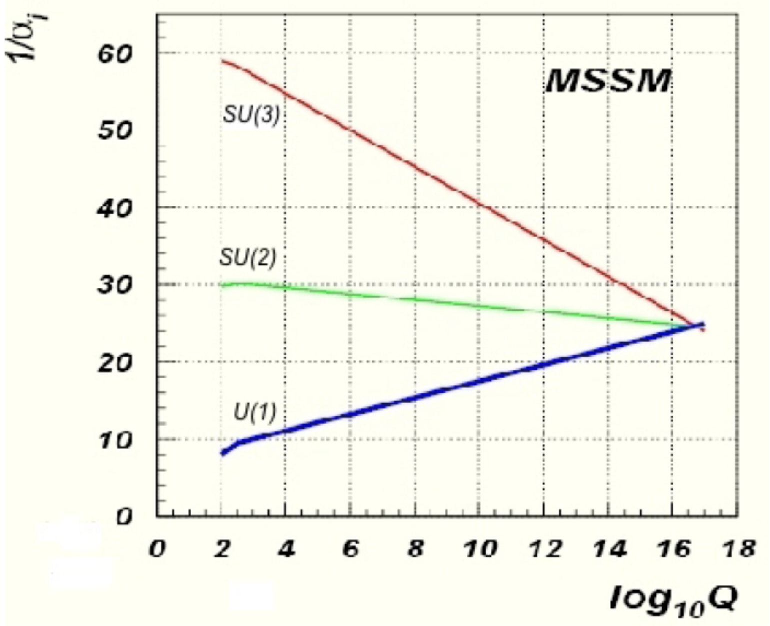
- quark $\longleftrightarrow$ squark
- lepton $\longleftrightarrow$ slepton
- higgs $\longleftrightarrow$ higgsinos
- bosons de jauges $\longleftrightarrow$ jauginos

MSSM

- New particle correction compensate the SM correction
  $\rightarrow$ fix the hierarchy problem
- Unify the runing coupling constant
- Provide a candidate for dark matter (neutralino)

Unification of runing coupling constant



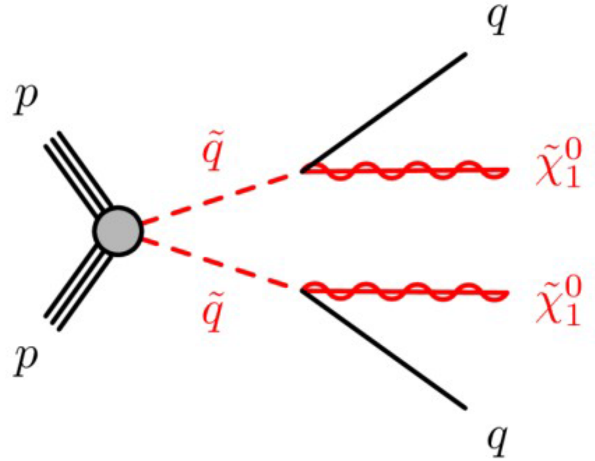


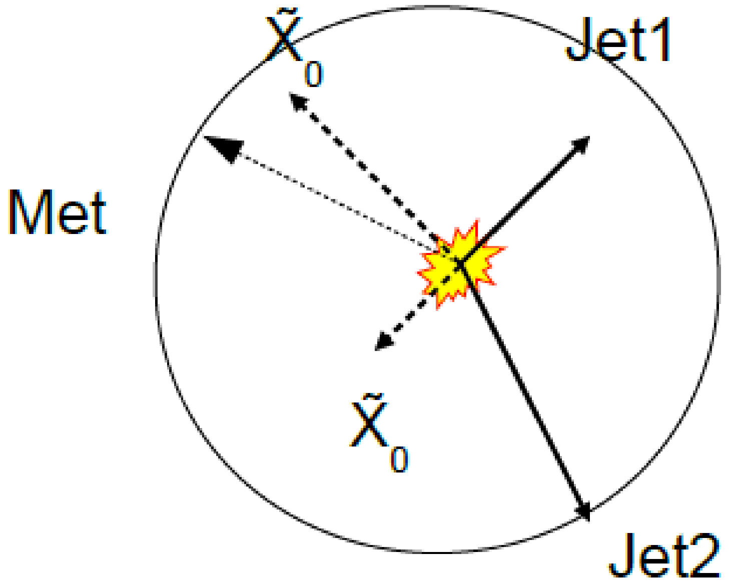
Research of squarks and gluinos

- $\tilde{\chi}^0$ is the ligthest supersymmetric particle
- Neutralinos can't be detected (weak interaction)
- $\overrightarrow{Met} = -\sum \overrightarrow{p_T}$

$\rightarrow$ Need a good p_T^{jet} measurement for MET reconstruction

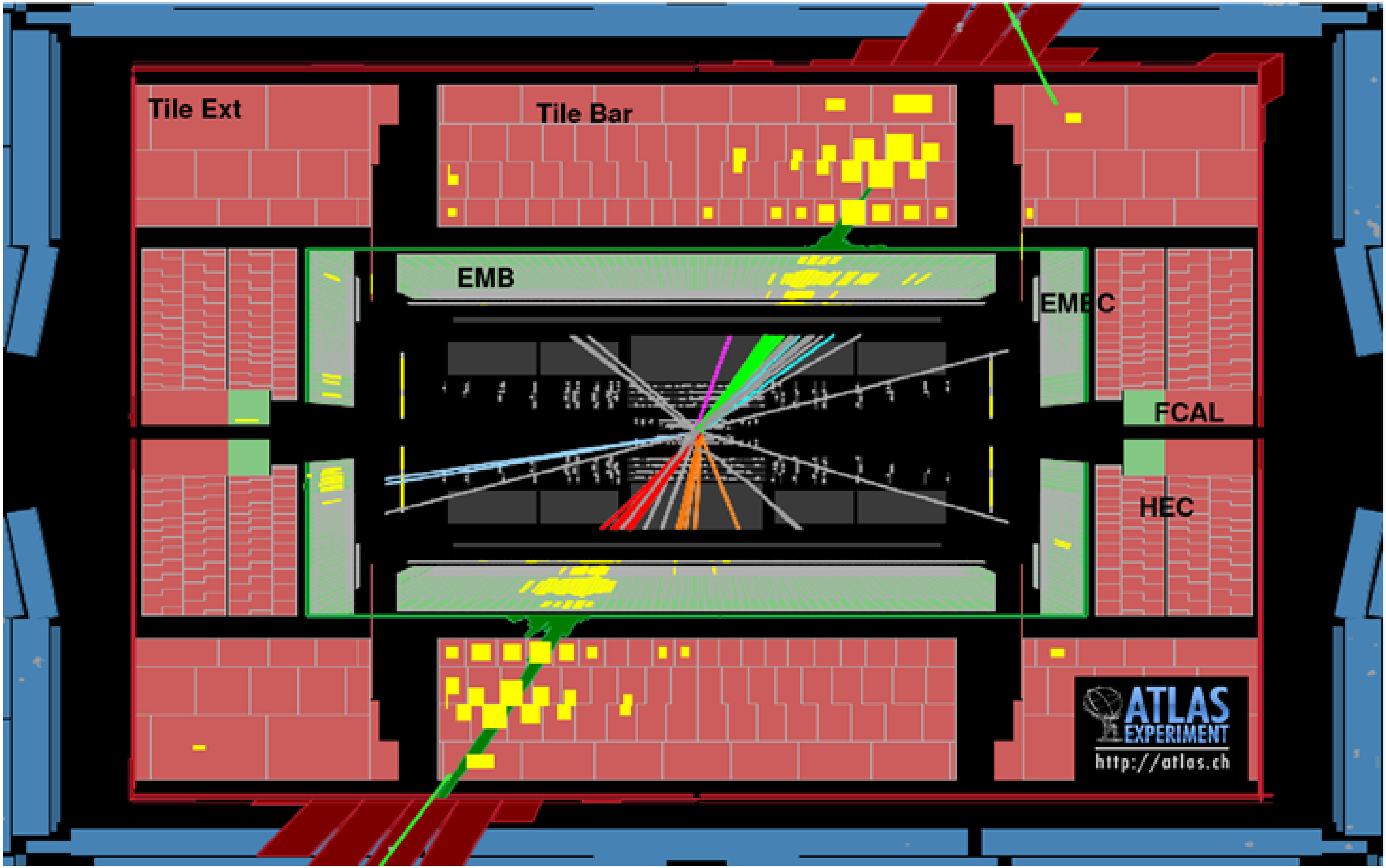
$pp \rightarrow \tilde{q}\tilde{q} \rightarrow q\tilde{\chi}^0, q\tilde{\chi}^0$





Jets energy scale

Reconstruction des jets



Event display

Jet reconstruction and calibration

Reconstruction:

- A jet is a collection of objects generated by the hadronization of a parton
- Reconstructed from calorimeter cells (topo-cluster)
- Topo-culsters are calibrated (EMTopo, LCTopo, EMPFlow)
- They are merged in a radius R=0.4

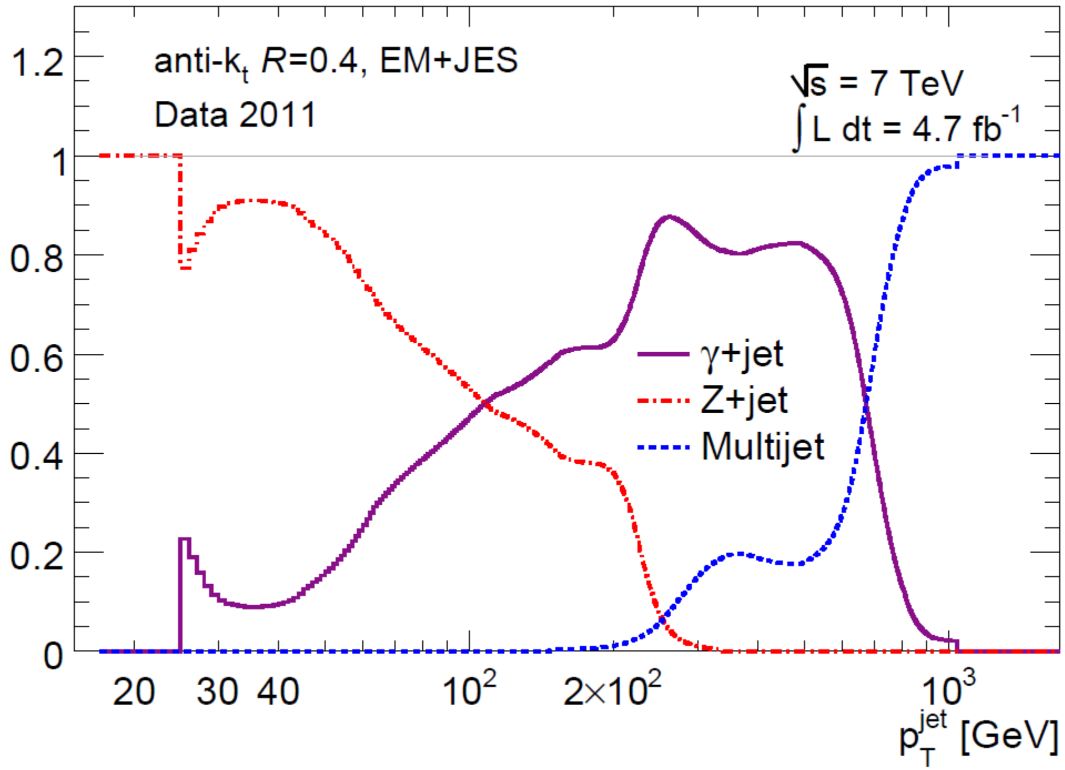
Jet calibration:

Corrections based on MC are applied to correct:

- Non compensation of the calorimeter
- Dead material
- Pile-up
- Energy leakages

JES with $\gamma + jets$ events

- Corrections based on data
- Comparison between a jet and a referance object
- Severals in-situ methods are applied
  - Di-jets events (relative calibration in η)
  - Z+jet/γ+jet
    - Absolute calibration based on a reference objects (Z or γ)
    - For central jets
  - Multi-jet for high p_T



$\longrightarrow$ This methods are combined for the final JES

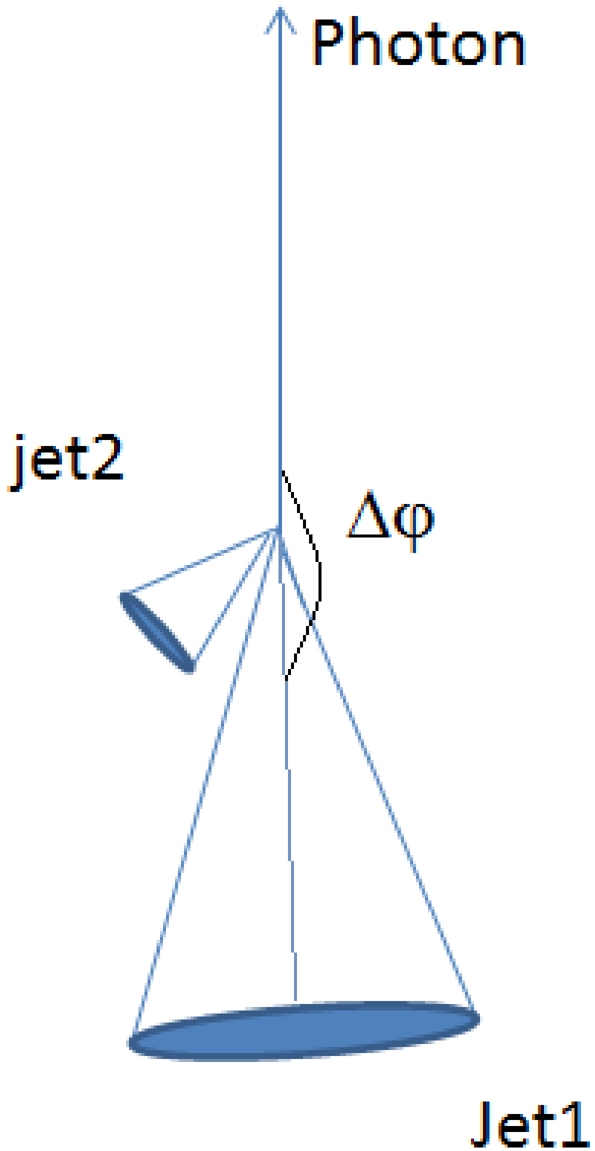
JES with $\gamma + jets$ events

- Using the $\sqrt{s} = 13\,TeV$ data.
- Select events with γ and jet back to back
- Project the γ transverse momentum on the jet axis:

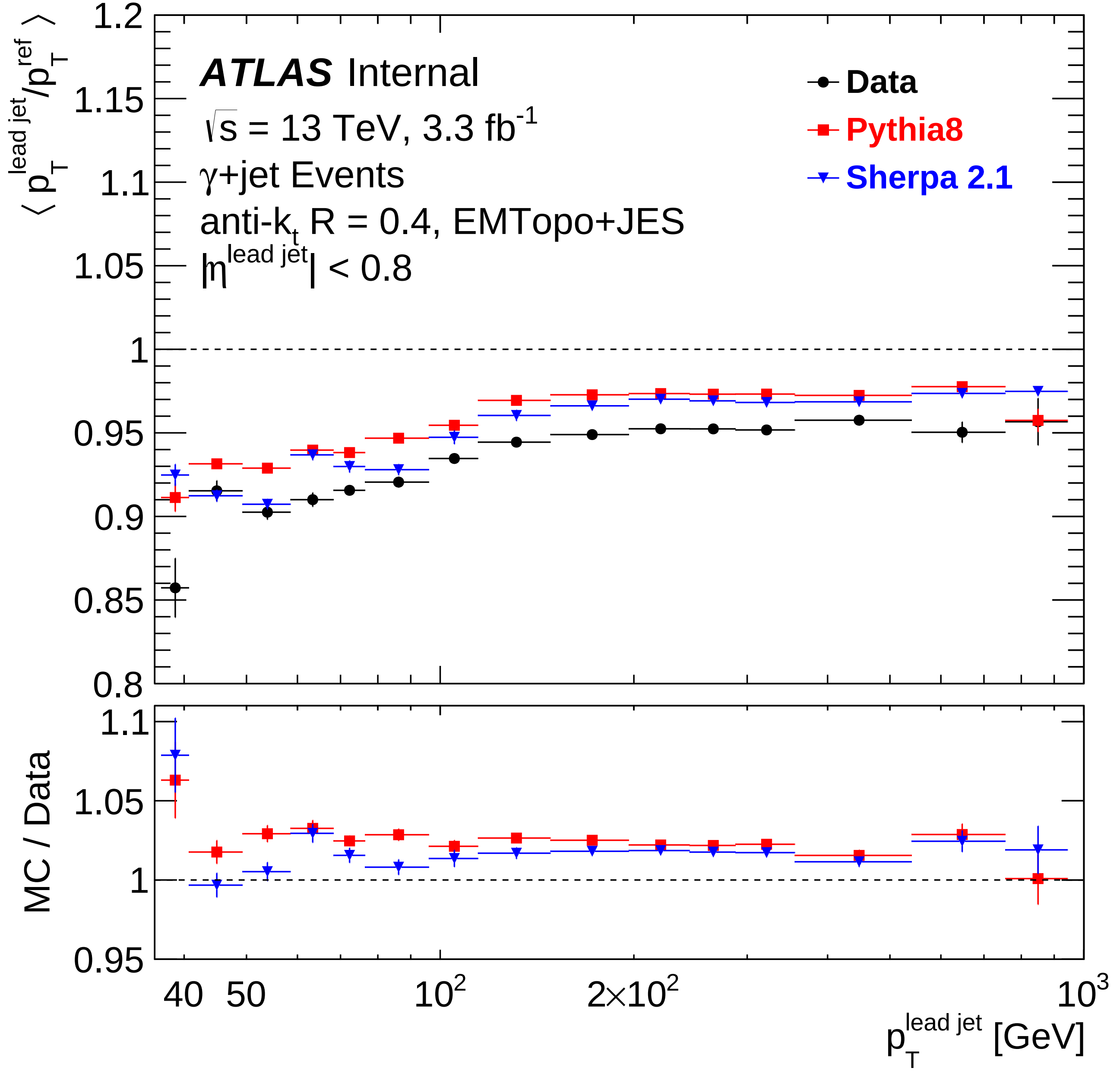
$$p_T^{Ref} = p_T^{\gamma} \times |\cos(\Delta\Phi)| \qquad (1)$$

- Comparison between $p_T^{leadjet}$ and p_T^{Ref} in differents regions of p_T:

$$\mathcal{B} = \frac{p_T^{jet}}{p_T^{Ref}} \qquad (2)$$



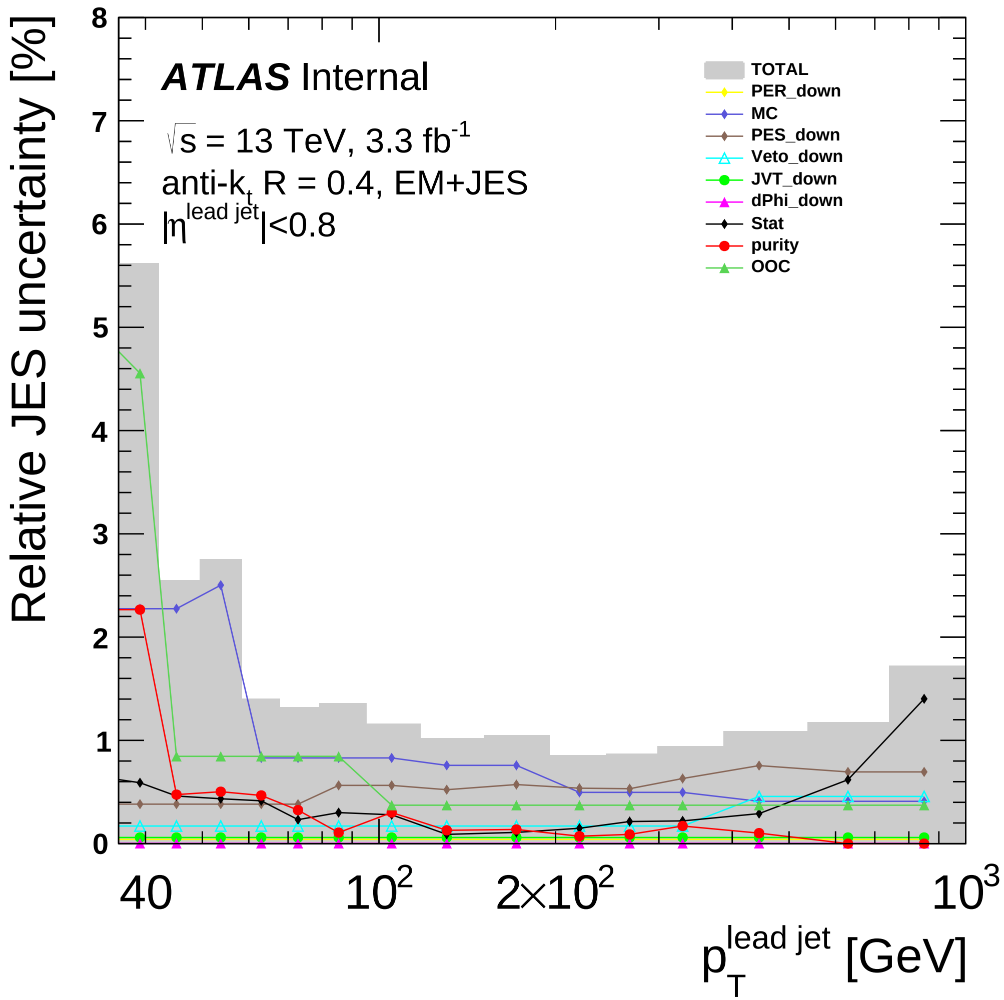
γ+jets


ATLAS Internal
√s = 13 TeV, 3.3 fb-1
γ+jet Events
anti-kt R = 0.4, EMTopo+JES
|ηlead jet| < 0.8
Data
Pythia8
Sherpa 2.1
⟨pTlead jet/pTref⟩
MC / Data
pTlead jet [GeV]
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
1.1
1.05
1
0.95
40
50
10^2
2×10^2
10^3

Combination with the in-situ methods

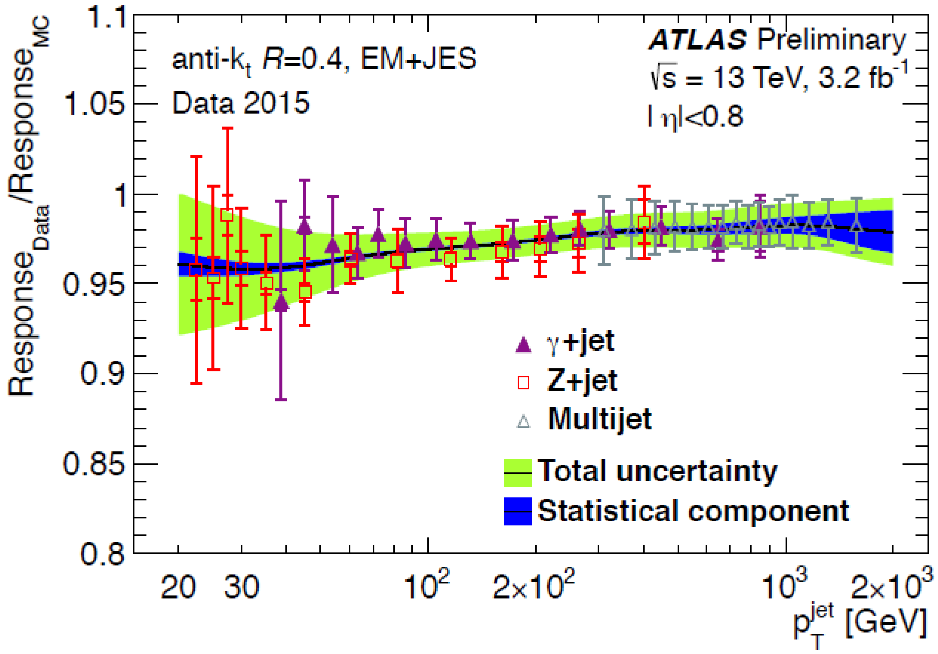
Uncertainties on:

- Generator
- Topology
- Pile-up
- Photon calibration (PES, PER)
- Purity of the photon selection
- Statistical error
- Out-of-cone

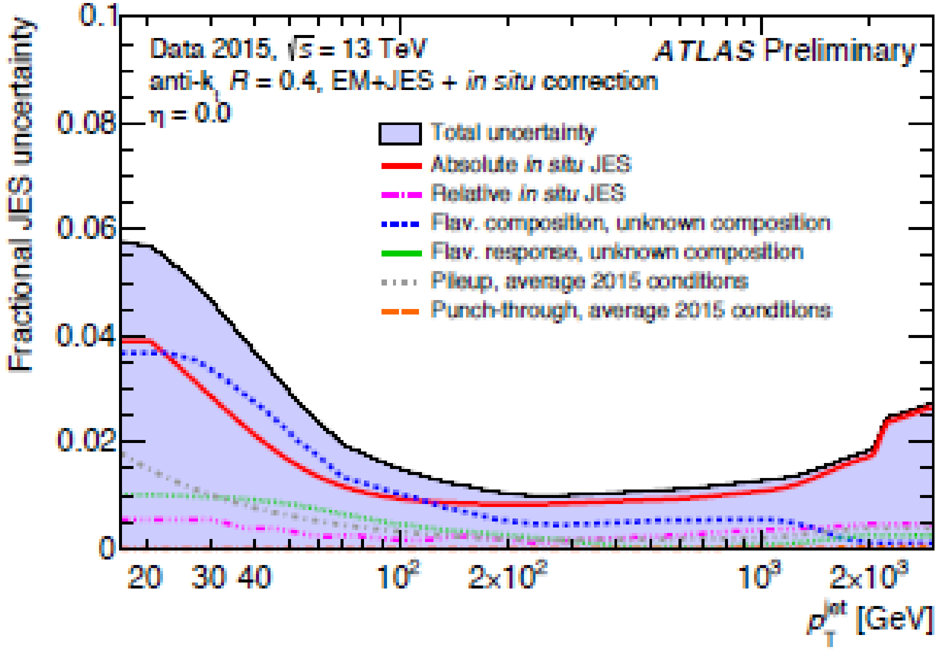


Combination with the in-situ methods

Combined calibrations



Combined uncertainties



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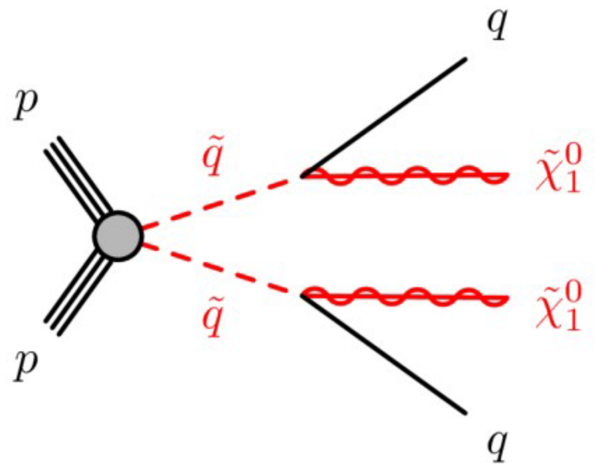
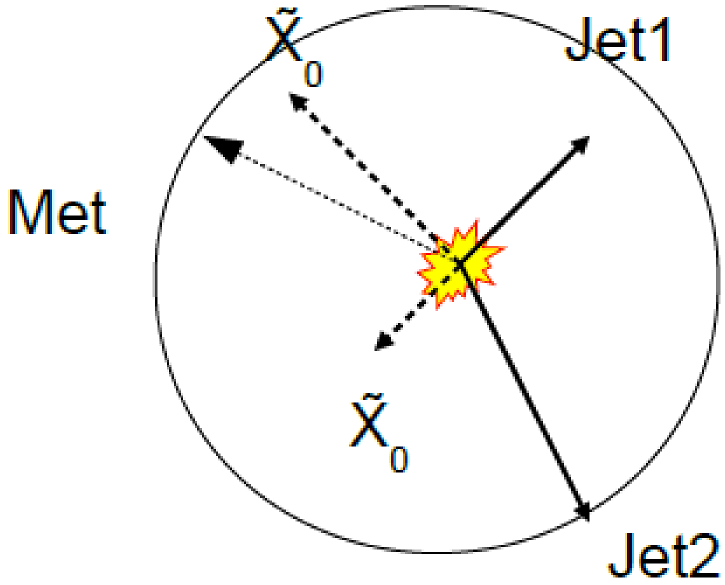
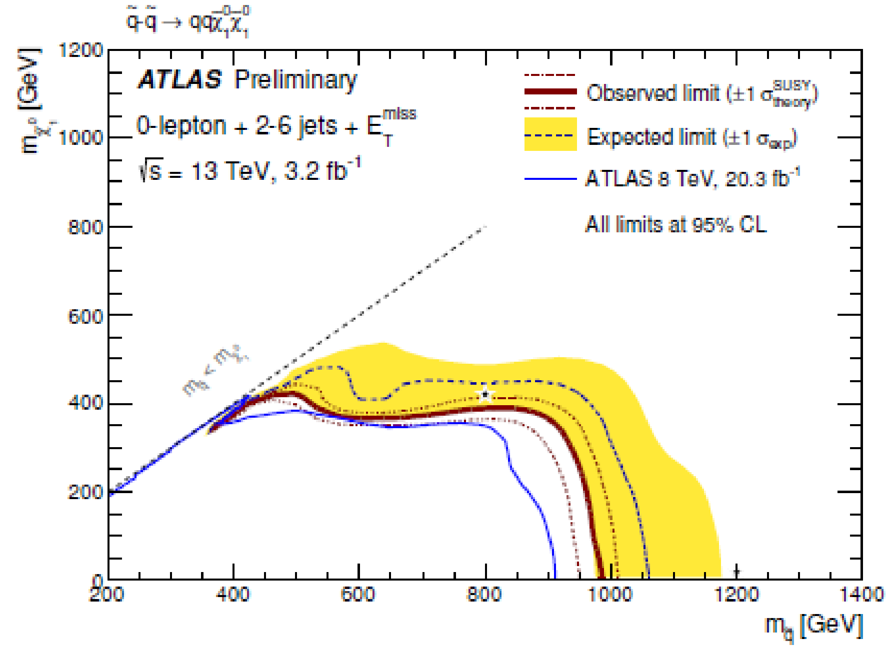


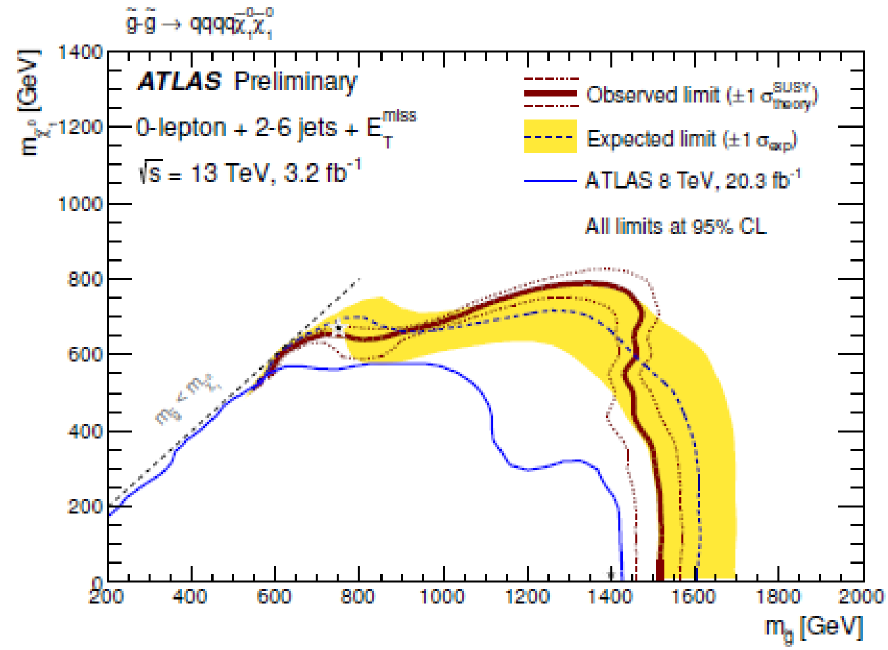


Squarks and gluinos exclusion plots

Requirement	Signal Region						
	2jl	2jm	2jt	4jt	5j	6jm	6jt
E_T^{miss} [GeV] >	200						
$p_T(j_1)$ [GeV] >	200	300	200				
$p_T(j_2)$ [GeV] >	200	50	200	100			
$p_T(j_3)$ [GeV] >	–			100			
$p_T(j_4)$ [GeV] >	–			100			
$p_T(j_5)$ [GeV] >	–				100		
$p_T(j_6)$ [GeV] >	–					100	
$\Delta\phi(\text{jet}_{1,2,(3)}, E_T^{miss})_{min}$ >	0.8	0.4	0.8	0.4			
$\Delta\phi(\text{jet}_{i>3}, E_T^{miss})_{min}$ >	–			0.2			
$E_T^{miss}/\sqrt{H_T}$ [GeV$^{1/2}$] >	15		20	–			
Aplanarity >	–			0.04			
$E_T^{miss}/m_{eff}(N_j)$ >	–			0.2	0.25		0.2
m_{eff}(incl.) [GeV] >	1200	1600	2000	2200	1600	1600	2000

→ **Optimize the signal selection** for 2016 data





Conclusion

Conclusion:

- Worked on the JES in 2015/2016
- Provided the γ+jet calibration and uncertainties to the collaboration
- Currently finalizing the JER results
- Working on the signal selection for the SUSY 0 lepton analysis
- Plan to work on the Z+jet background estimation

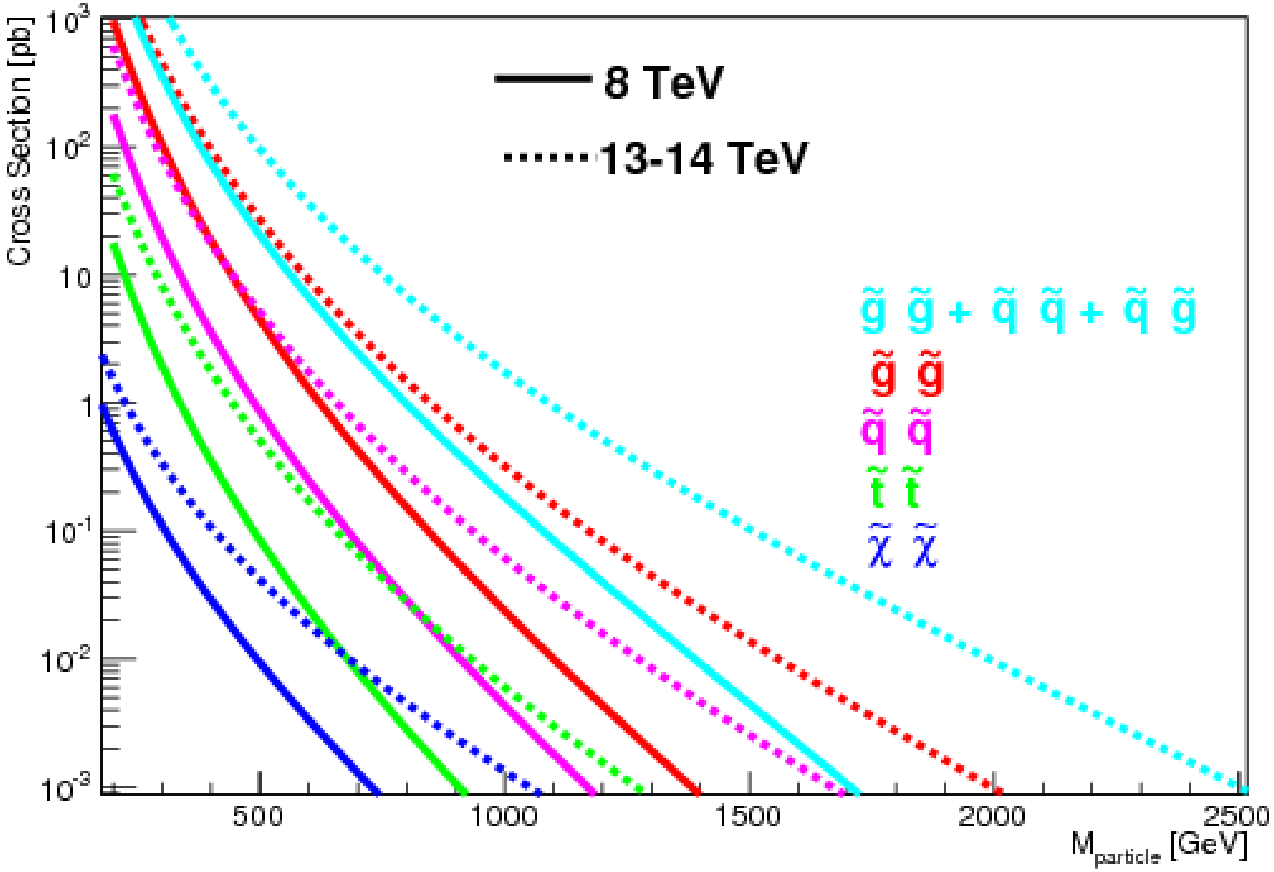
Thank you for your attention !

BACKUP

Background

- W+jet
- Z/γ+jet (planning to work on this in 2016)
- Diboson
- top
- Multi-jet

Production cross section - Run 1/Run 2



→ Higher cross section at $\sqrt{s} = 13\,TeV$ than at $\sqrt{s} = 8\,TeV$

→ L $= 20.3\ fb^{-1}$ in 2012 at $\sqrt{s} = 8\,TeV$

→ L $= 3.2\ fb^{-1}$ in 2015 at $\sqrt{s} = 13\,TeV$

→ expect L $= 20\ fb^{-1}$ in 2016 at $\sqrt{s} = 13\,TeV$