Physics performance of the ATLAS Pixel Detector

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On behalf of ATLAS Collaboration

Introduction

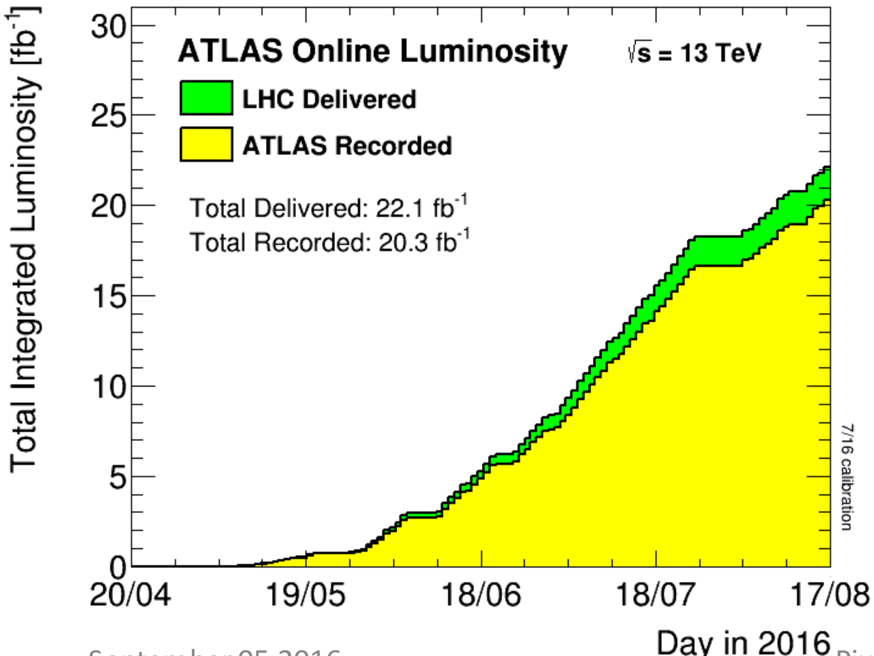
ATLAS Physics results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic

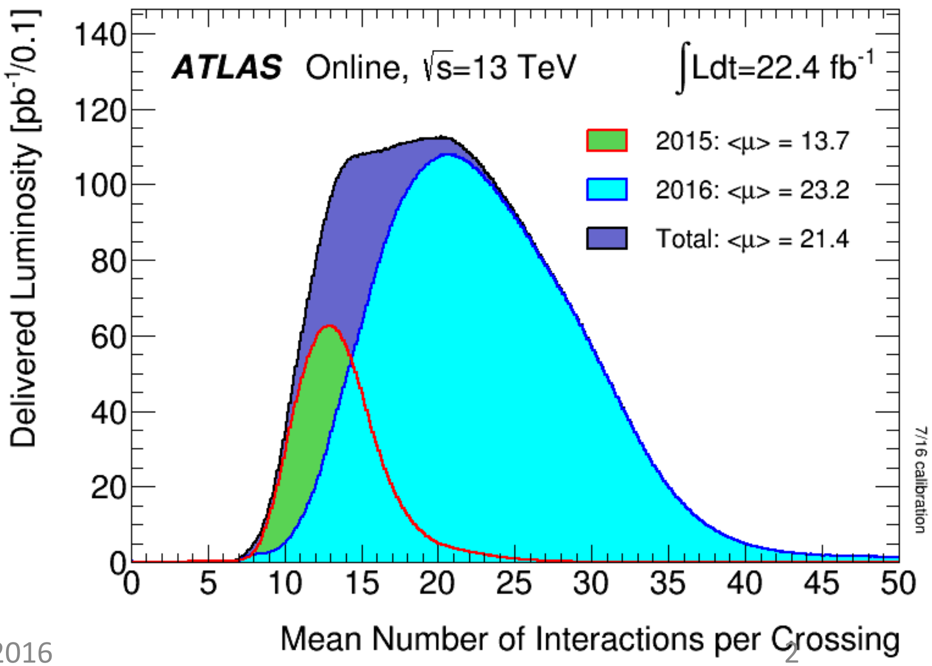
ICHEP2016 Conference Notes:

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/Summer2016-13TeV

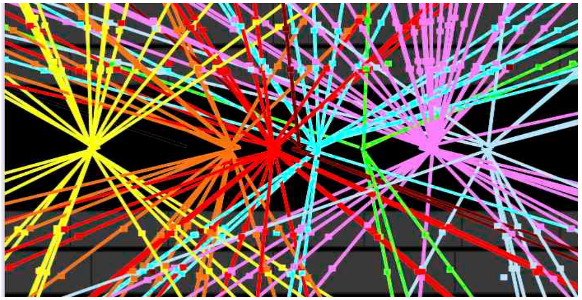
54 physics conference notes + 13 supportive notes

In this talk, I will discuss what is the impact of the Pixel to the physics analysis.





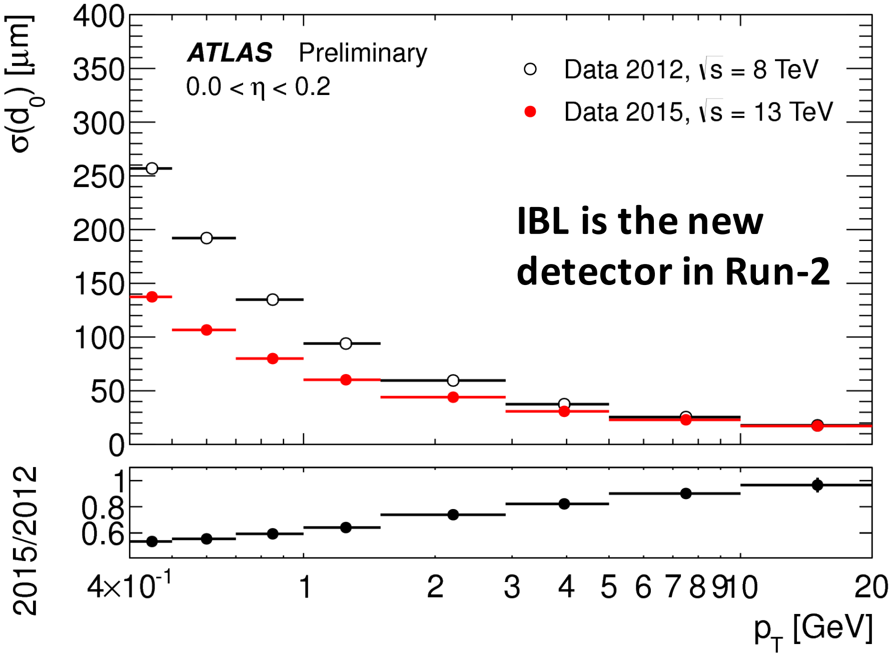
Application to the physics analysis

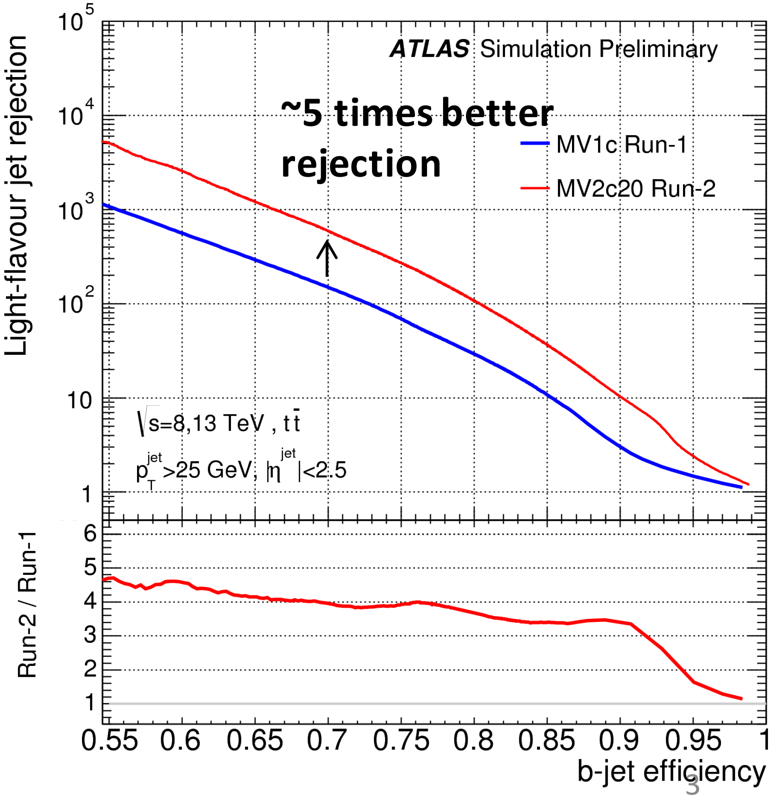


Most powerful measure of impact parameter.

=> Good separation of the interaction vertex

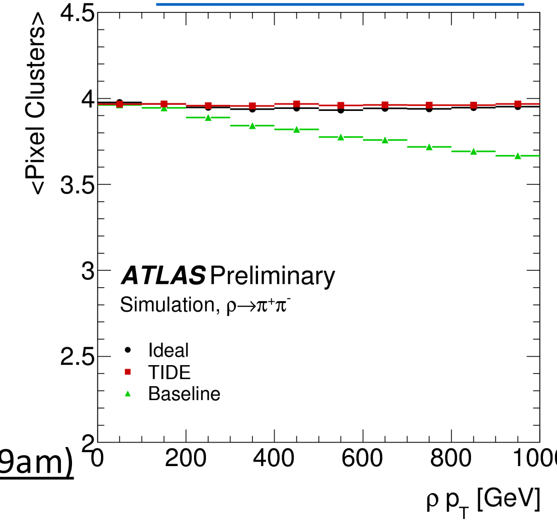
- better performance for b-jet tagging,
- pileup suppression, well-control of the Object identification (e / μ / τ / MET)





ATL-PHYS-PUB-2015-006

IBL tracking performance

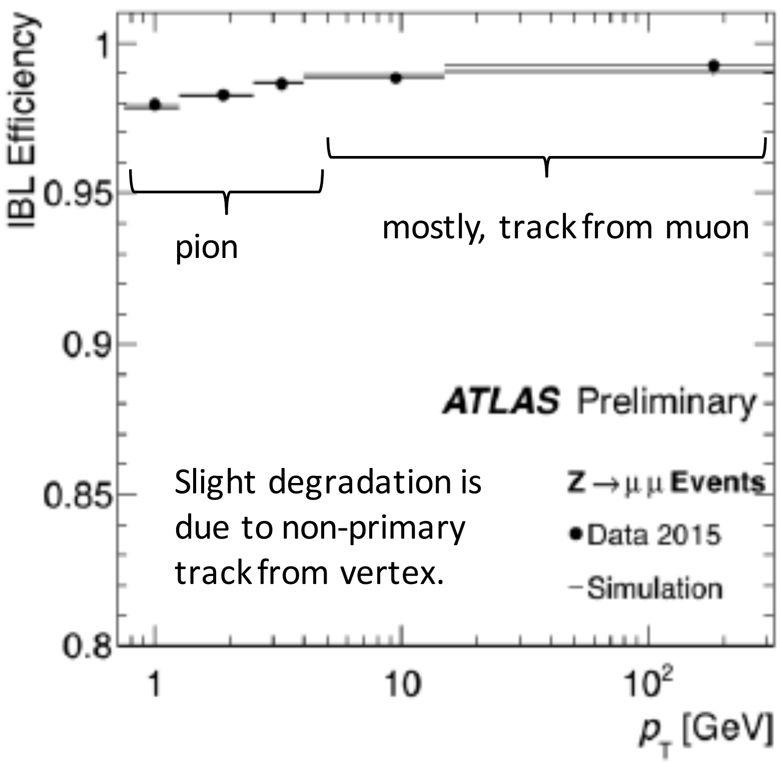


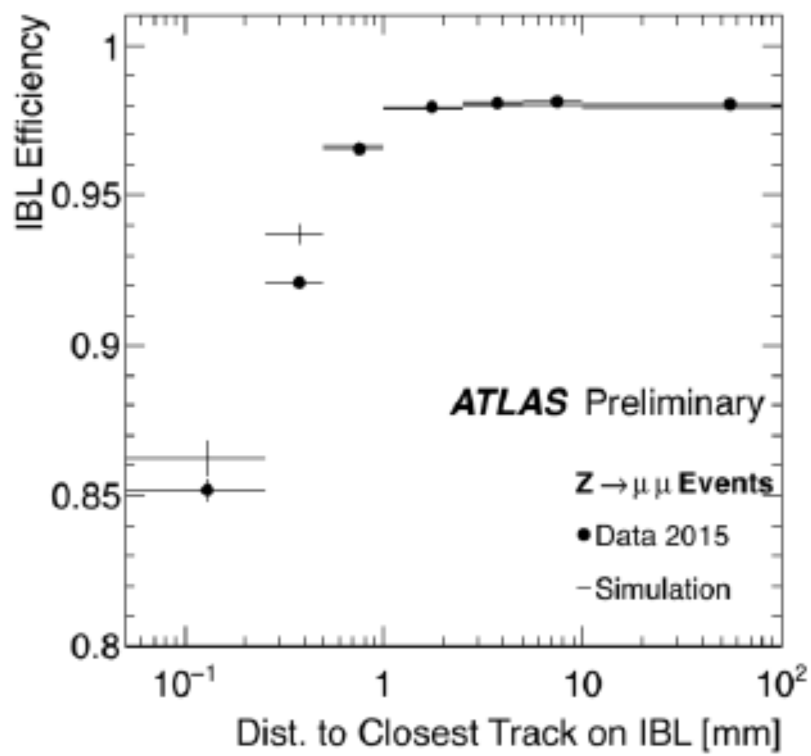
Data Z->μμ events are compared with MC.

The separation power of the merged cluster is ~0.75mm.
(50 x 250μm pixel)

The Neural Network additionally resolves cluster splitting.

(Talk is given by MANSOUR, Jason Tue. 9am)





ICHEP 2016 – ATLAS physics results

65% of the analysis uses the b-jet!!!

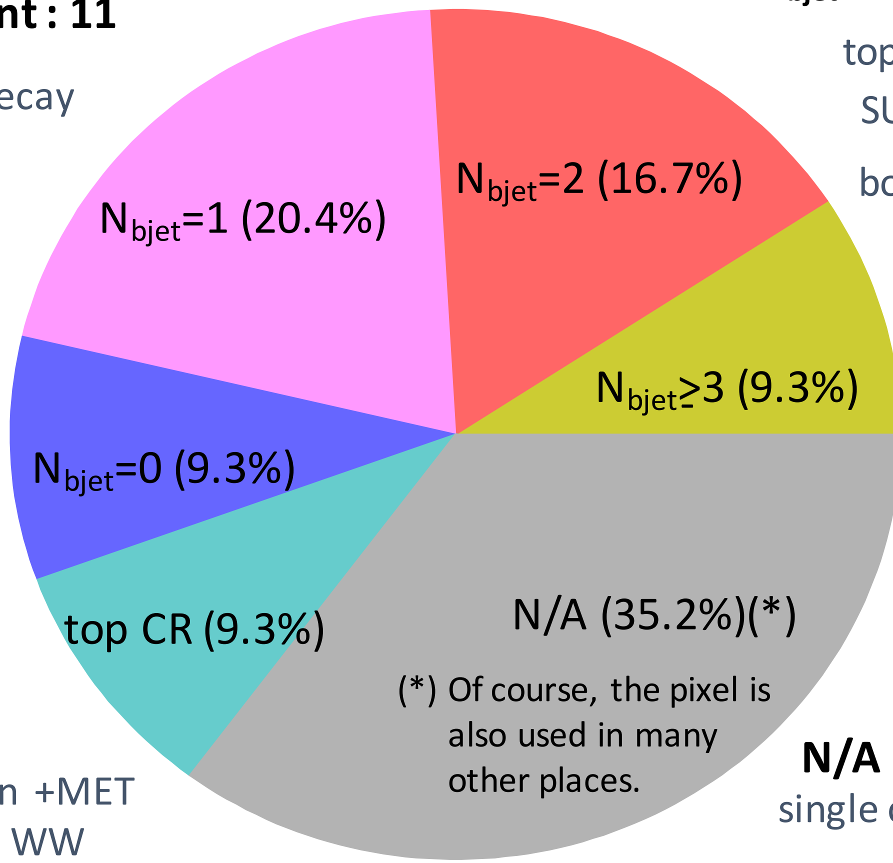
N_{bjet} =1 requirement : 11

SUSY: stop->exotic decay
single top,
MSSM Higgs, H+
ttH->multi-lepton
new bb-resonance

N_{bjet} =2 requirement : 9

top-pair : 5
SUSY: stop->dilepton

boosted / H topology: 4
H->bb, dark matter



N_{bjet} =0 (b-veto) : 5

SUSY: multi-jet
di-boson high mass
H->WW/ZZ

N_{bjet} ≥ 3 requirement : 5

multi-top topology: 5

SUSY: stop/sbottom searches,
Higgs: ttH, HH, tH+

TopCR : 5

SUSY: photon +MET
H->$\gamma\gamma$, WBS WW
+ several

N/A : 19

single object : di-jet, di-lepton,
$\gamma\gamma$ resonance,
multi-lepton

b-jet is dominant systematic uncertainty

This is natural, increasing the b-jet multiplicity, increase the systematics...

In most of the analyses, the systematics on b-jet efficiency is **DOMINANT systematics**.

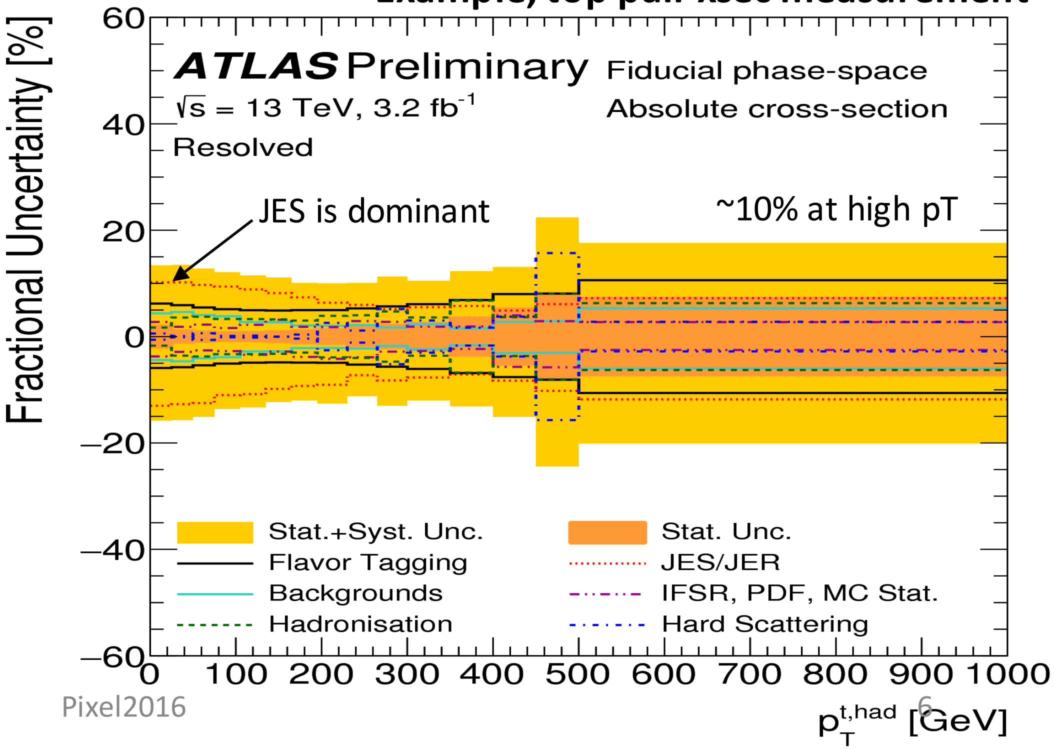
1. Jet energy scale (JES) , 2. b-jet efficiency, 3. MET (through propagation from them)

At low pT, JES is dominant, while at high pT, b-jet systematics is dominant.

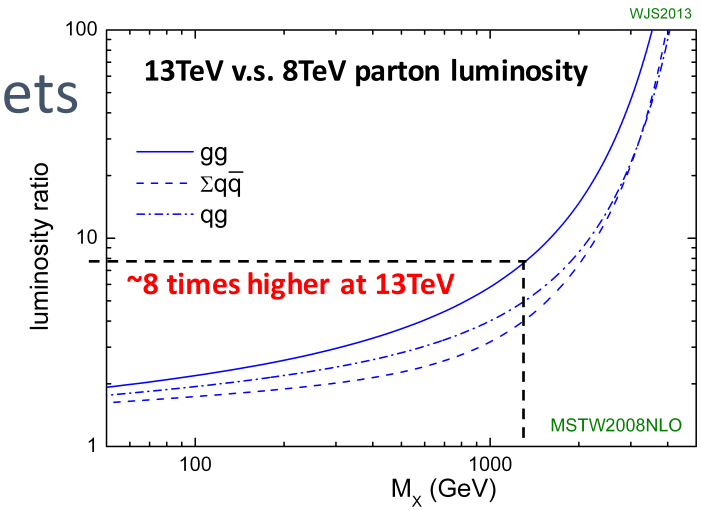
Typical order of uncertainty

Analysis	JES	b-jet
$N_{bjet} > 2$	13-25%	10-30%
$N_{bjet} = 2$	4-10%	1-15%
$N_{bjet} = 1$	2-20%	2-10%
b-veto	1-20%	~3%
top CR	12-33%	7-16%

Example, top pair xsec measurement



Search for SUSY in events with multiple b-jets



Run-1 Limit (8TeV) : < 0.44fb ($L=20.1fb^{-1}$)
[JHEP10(2014)024]

m(g~) < 1350GeV @95% C.L.

Run-2 Limit (13TeV) : < 0.87fb ($L=14.8fb^{-1}$)
[ATLAS-CONF-2016-052]

m(g~) < 1900GeV @95% C.L.

If Run-1 result is "scaled" to 13TeV collisions (that is, **no IBL**),

Simple scaling : $\sigma_{13TeV} \sim 8 \times \sigma_{8TeV}$

Scaled Run-1 limit (no IBL) reaches :

m(g~) = ~1600GeV @95% C.L.

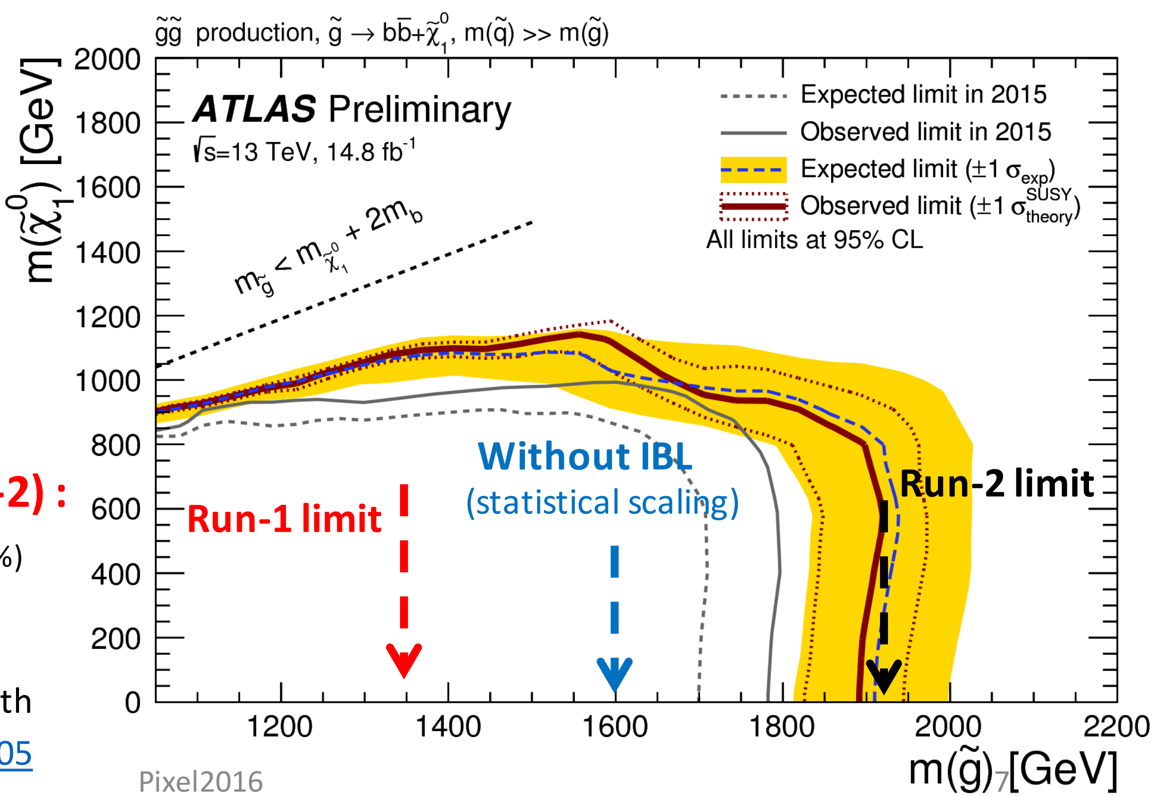
(without IBL)

Big impact on introducing IBL (Run-2) :

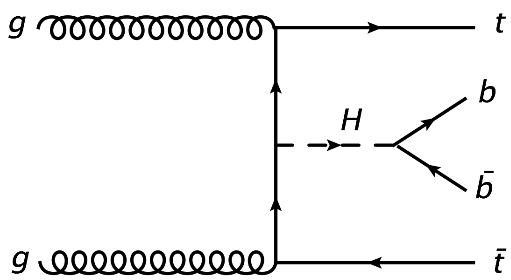
m(g~) : 1900GeV v.s. 1600GeV (%)

(plus analysis improvement)

(%) this scaling is more or less consistent with [ATL-PHYS-PUB-2015-005]



Search for Standard Model ttH->bb



More complex situation:

=> background also scales as same order of signal…

	σ_{exp} [pb]	μ	stat	syst
Run-1 (8TeV) EPJC.75(2015)349	0.133	1.2	0.8	1.0
Run-2 (13TeV) ATLAS-CONF-2016-080	0.507	1.6	0.5	1.0

consistent

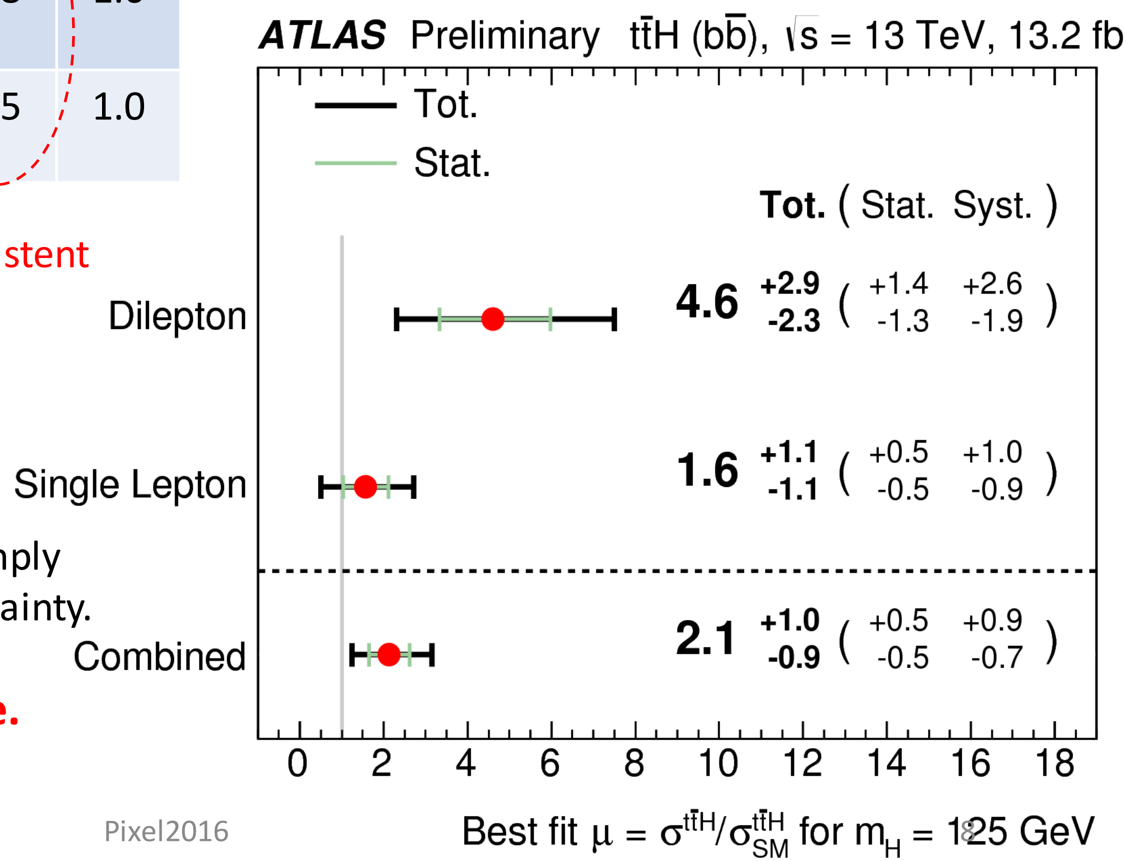
Cross section scaling, ~2.5

=> Stat. error scales by ~1.6.

Same systematic uncertainty.

So far, impact on IBL is not visible, simply because of statistics dominant uncertainty.

… but will be more visible in future.



Search for long-lived SUSY using Pixel dE/dx

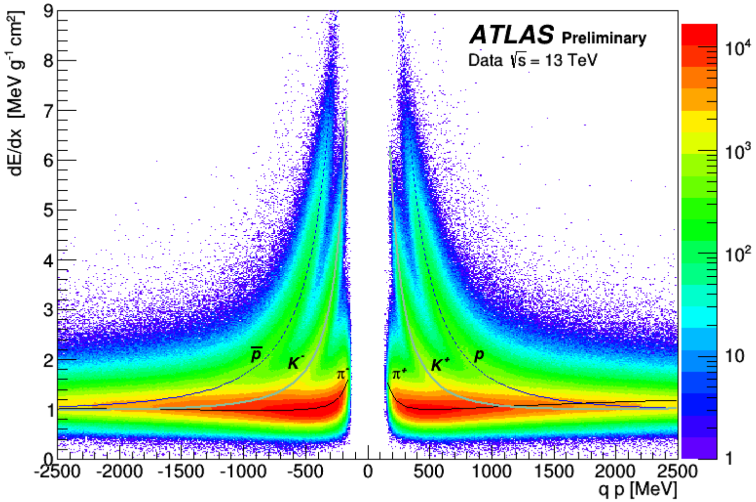
Heavy (new) particle may decay in (or outside) Pixel envelop.

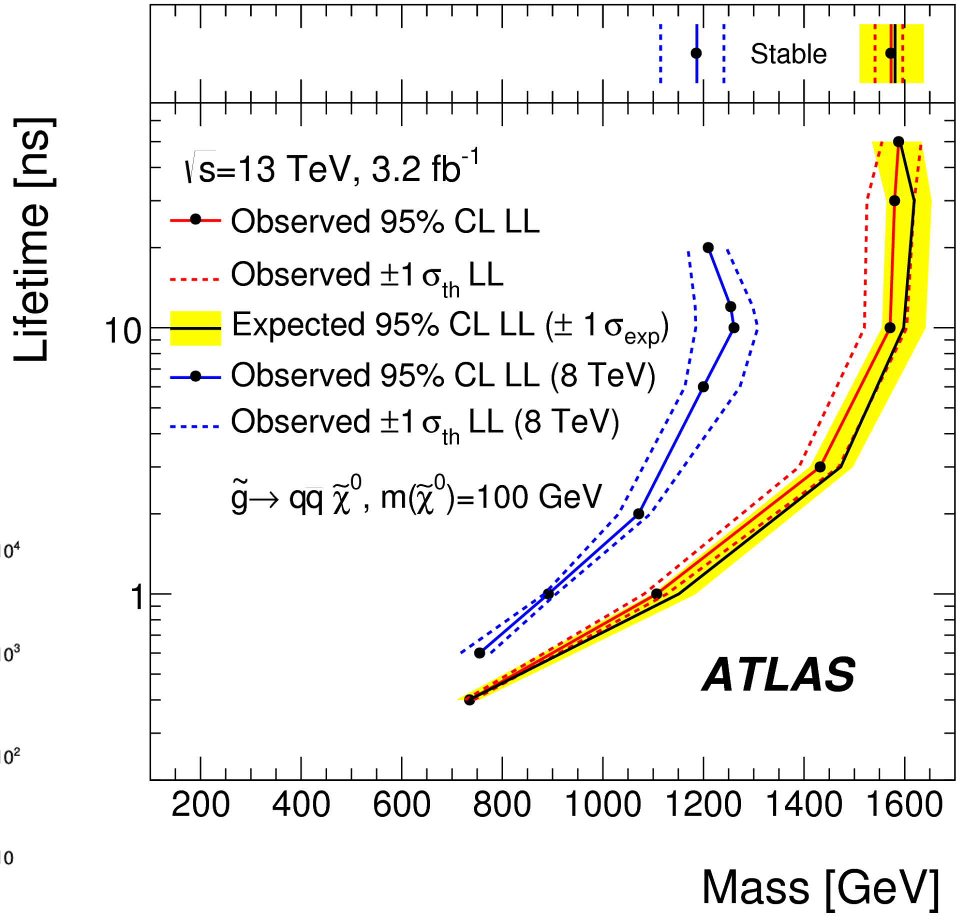
Run-1 Limit (8TeV) : m(R-hadron) < 1185GeV
EPJC.75(2015)407 @lifetime = 10ns

Run-2 Limit (13TeV) : m(R-hadron) < 1570GeV
PhysRevD.93.112015 @lifetime = 10ns

With IBL, signal yield increases by ~15%.

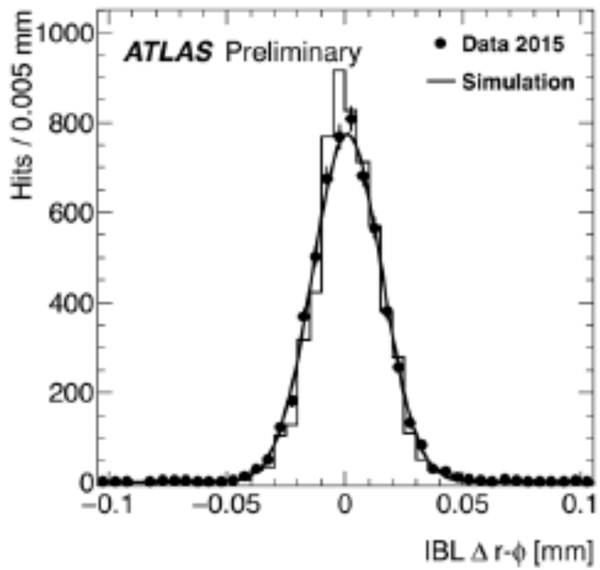
IBL helps dE/dx measurements

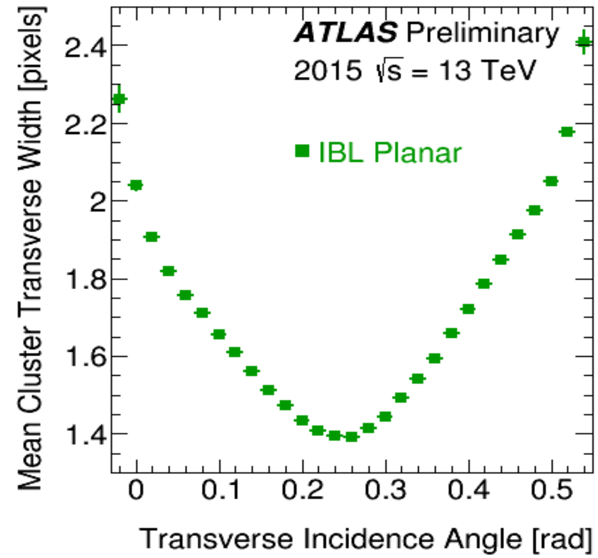




IBL/Pixel performance and MC simulation

Understanding Pixel :





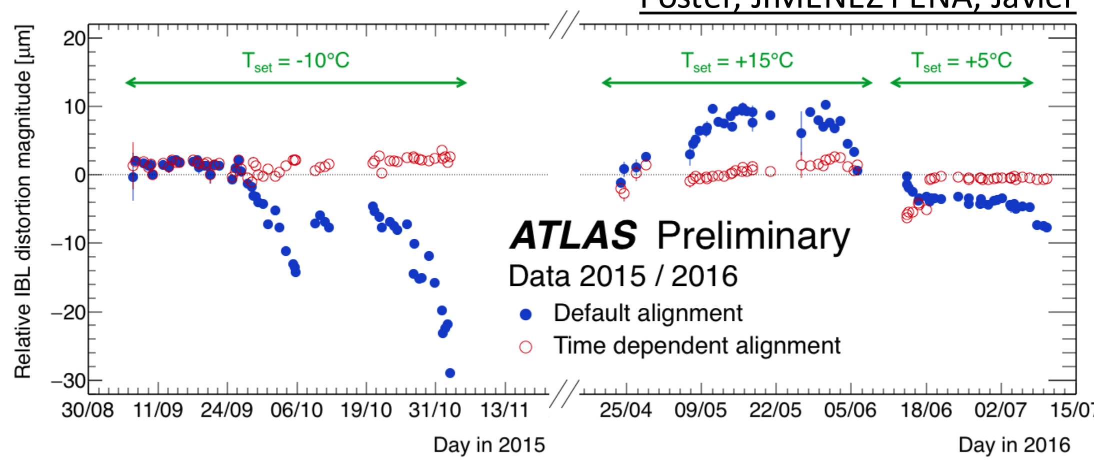
IBL is a new detector :

- Validation (MC) is not completed yet…
- Prompt (~hour order) alignment correction.
- Study new charge collection model (Bichsel model).
- 3D sensor is also interesting subject.

Other Pixel detector :

- Continuous monitoring
- Run-dependent MC
- Radiation damage simulation

Poster, JIMENEZ PENA, Javier



Summary

- The Pixel detector is the core of ATLAS detector.
- The Pixel detector is used not only just for tracking/vertexing but also object identification, pileup suppression.
- Now, ~65% physics analysis uses b-jet in their analyses.
- In some area (multiple-b-jet final state), significant improvement is seen by new Pixel detector, IBL (and improved analysis method).
- Need further improvement of the systematic uncertainty (direct connect to the object identification)

More ATLAS talks is coming for more detail aspect.

- Track reconstruction in dense environment and dE/dx measurement.
- Vertex reconstruction, future Pixel layout design for HL-LHC etc..