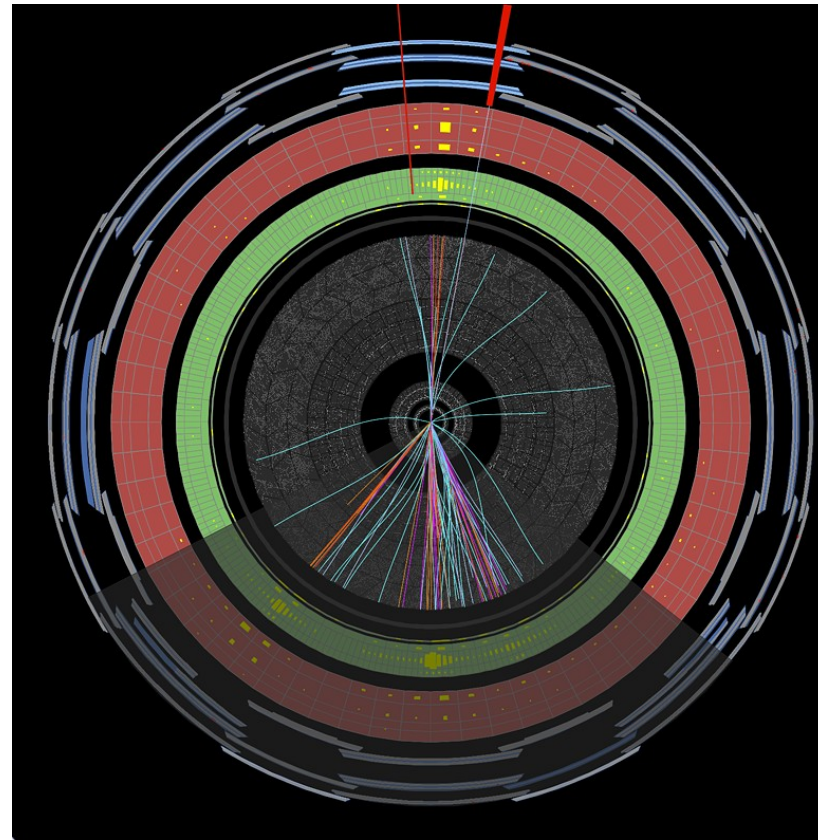




Boosted top quarks

Marcel Vos
(IFIC, CSIC/UV, Valencia, Spain)

Red española del LHC
IFT Madrid, 09/05/2017



Early days – can we use jet substructure?

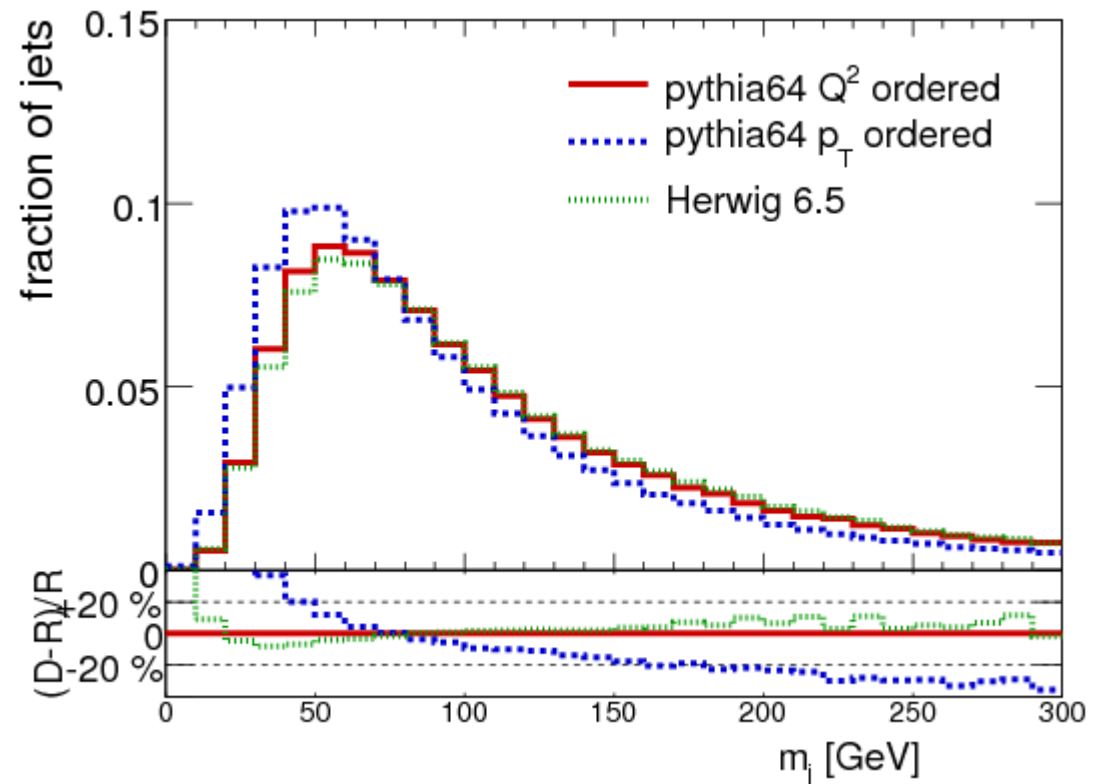
M. Seymour, Z Phys. C (1994)

J. Butterworth, PRL100 (2008)

First BOOST report, arXiv:1012.5412

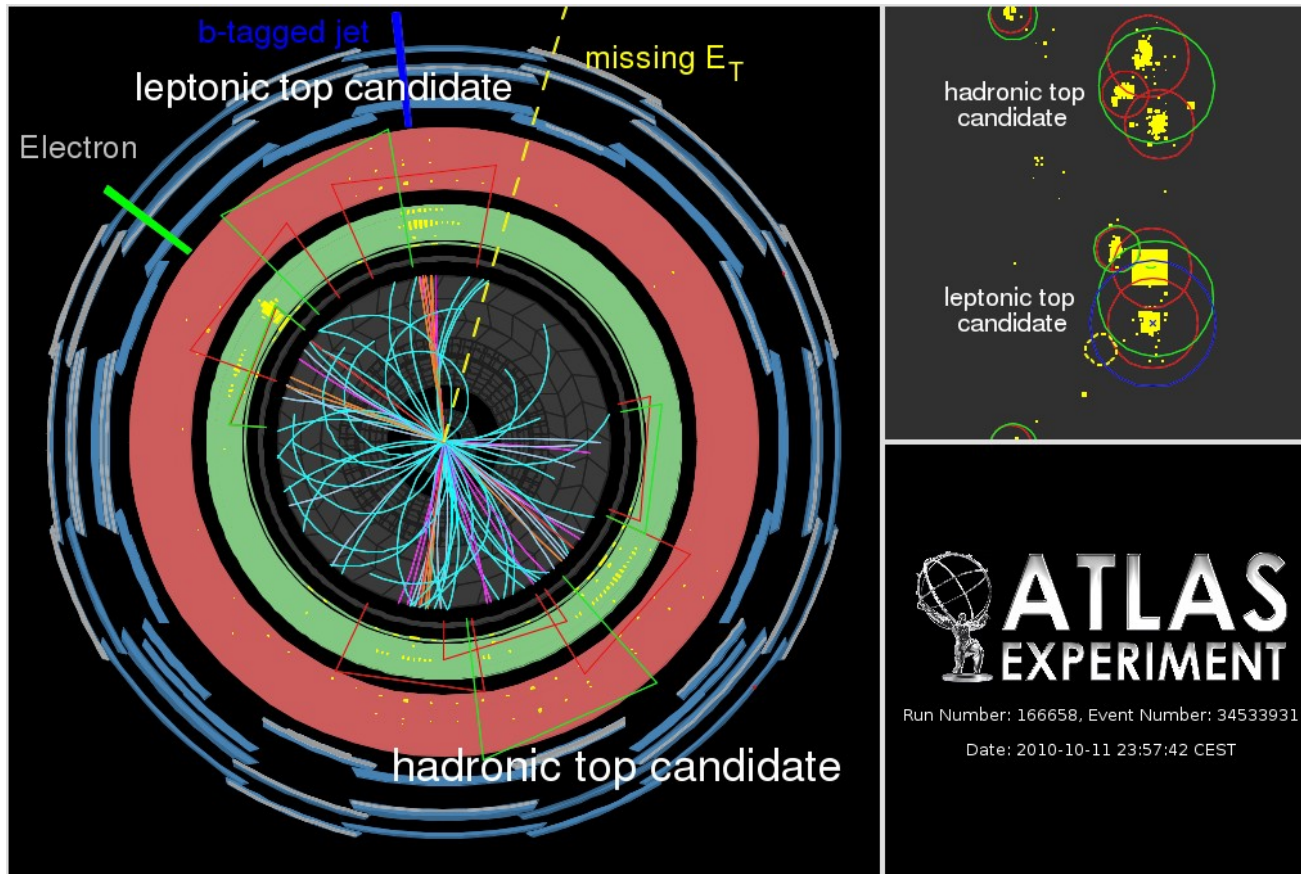
Boosted objects:
multi-prong hadronic
decay forms single jet.

Use **grooming**
techniques to clean up
and **jet substructure**
analysis to distinguish
from background



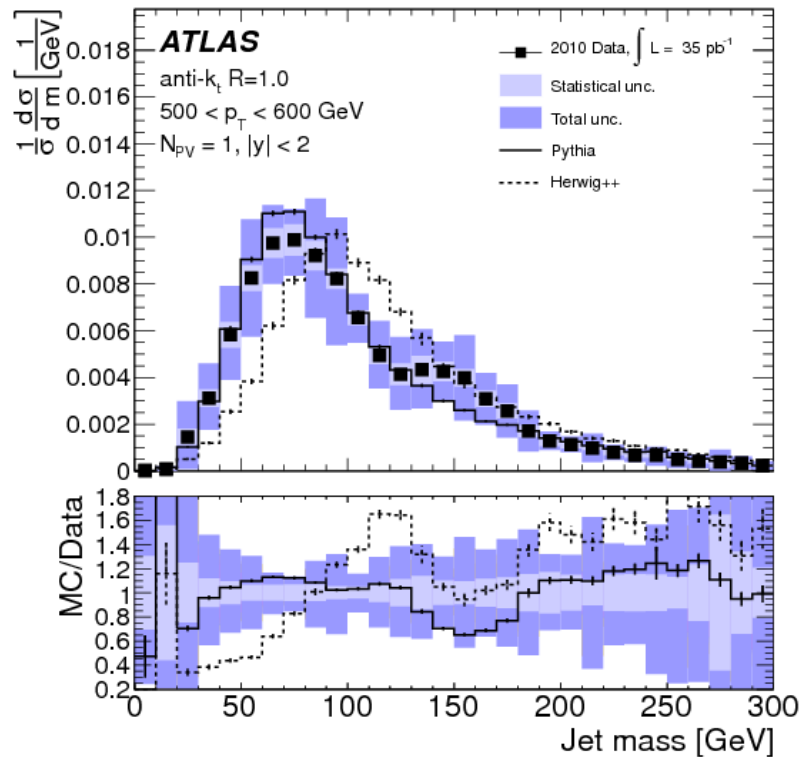
First boosted object candidates

M. Villaplana,
BOOST2011,
Princeton



Certified top quark pair events selected by standard “resolved” selection (purity $\sim 75\%$)
Hadronic top decay captured in a fat jet ($R=1$)

Can we measure jet substructure?



Fat jet mass measurement ANNO 2011

QCD multi-jet background

No pile-up ($N_{pV} = 1$)

Jet Mass is extremely sensitive to “soft stuff”

Generators struggling to reproduce shape

Unexplained artefact at 150 GeV

ATLAS jet mass paper, JHEP1205 (2012)

→ IFIC + UCL + SLAC

First boosted analysis, JHEP1209 (2012)

→ Ph.D. thesis M. Villaplana/E. Oliver

QCD jet mass is proportional to p_T

→ cuts on jet substructure inevitably shape background

BOOST '12

BOOST2012 report, EPJC74 (2014)

Boost 2012

Valencia, July 23rd-27th
Centro cultural Bancaja, Plaza Tetuan, Valencia

Programme

We aim to “boost” the physics potential of high-energy collider experiments developing new techniques for boosted objects – decays of energetic top quarks, gauge and Higgs bosons and non-hadronic jets.

Scientific committee:

- Jon Butterworth (UCL)
- Tancredi Cuhil (CERN)
- Chris Hill (Ohio State University)
- Muge Karagöz (U. Oxford)
- Tilman Plehn (U. Heidelberg)
- Sal Rappaport (Johns Hopkins/Fermilab)
- Andrea Rizzi (INFN and University of Pisa)
- Albert de Roeck (CERN/U. Antwerpen)
- Garvin Salam (CERN/Princeton/LPTHE)
- Mike Seymour (U. Manchester)
- Ariel Schwartzman (SLAC)
- Jesse Thaler (MIT)
- Marcel Vos (IFIC Valencia)
- Ivy Wacker (MIT)
- Lun Tao Wang (U. Chicago)

Local organizing committee:

- Fabrizio Tesi
- Enric Olivet
- José Salt
- Miquel Vilaplana
- Marcel Vos (chair)
- Karim Elabbar
- Antonio Gonzalez de la Hoz

Local sponsors:

- CSIC
- GENERALITAT VALENCIANA
- IFIC
- CPAN
- VINCENT BÒ VALENCIA

<http://ific.uv.es/~boost2012>

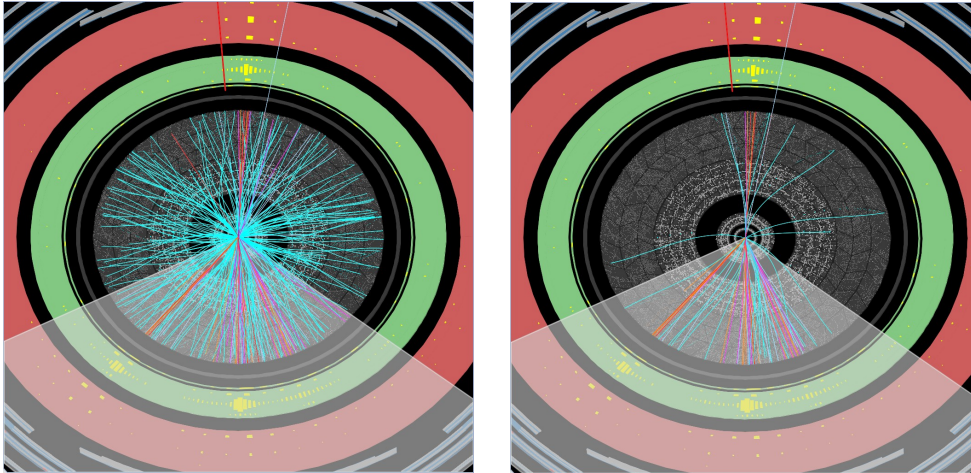
Who's afraid of pile-up?

Trimming: Krohn, Thaler & Wang '09

Pruning: Ellis, Vermilion & Walsh '09

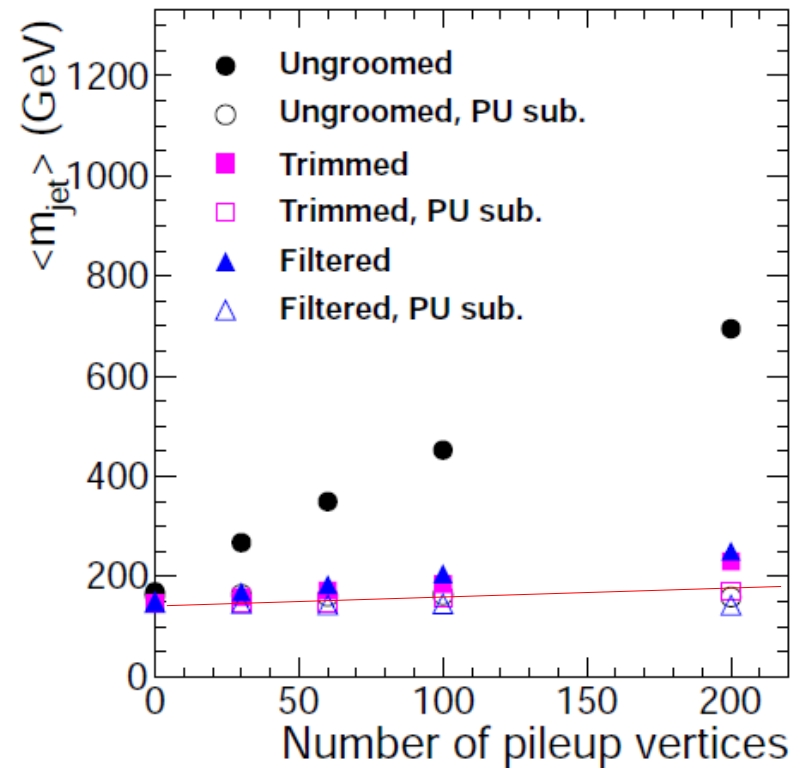
Filtering: Butterworth, Davison, Rubin & Salam '08

Area subtraction, Cacciari, Salam, PLB659 (2008!)



Combination of grooming and pile-up subtraction restores the scale and reduces impact on resolution

BOOST2012 report, EPJC74 (2014)



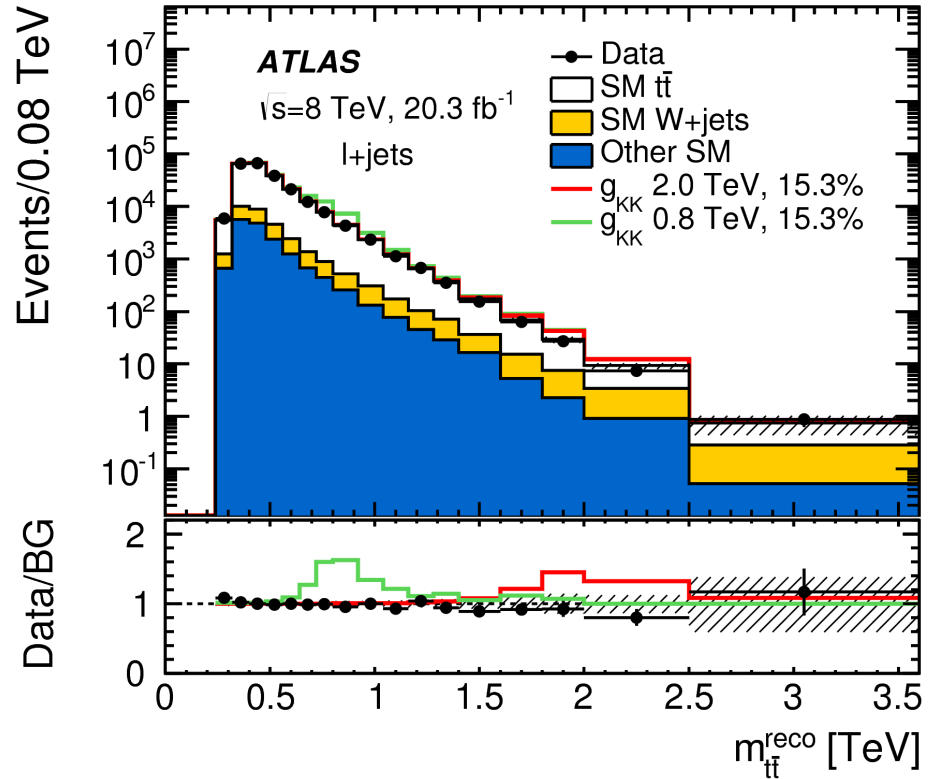
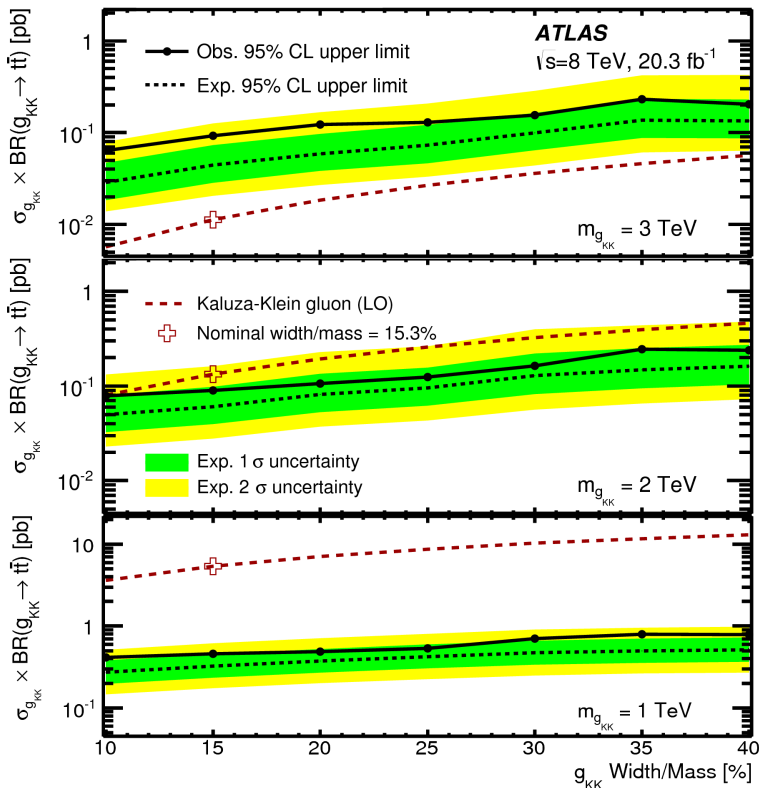
Performance OK for foreseeable future

Next phase: constituent-level subtraction note (IFIC/Harvard)

ATLAS $t\bar{t}$ resonances

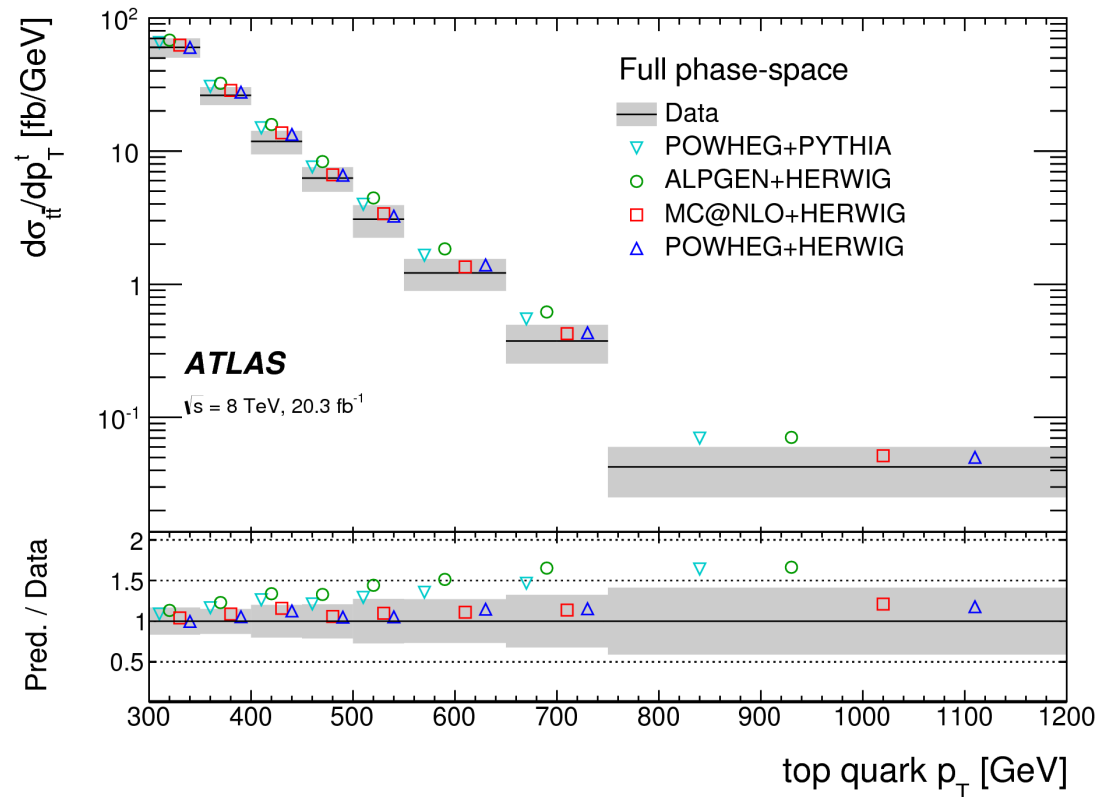
JHEP08 (2015)

Combined boosted and resolved
 Good control over normalization
 Mass resolution $\sim 10\%$



Maintain a decent sensitivity even for very broad resonances

Differential cross-section



arXiv:1510.03818

Boosted l+jets selection and reconstruction

Cross-section versus top quark p_T up to 1 TeV

Extreme phase-space corners of “bread-and-butter” physics may not be modelled flawlessly by (envelope of) MC → SUSY & Exotics

3/fb at 13 TeV → ATLAS-CONF-2016-040

Charge asymmetry

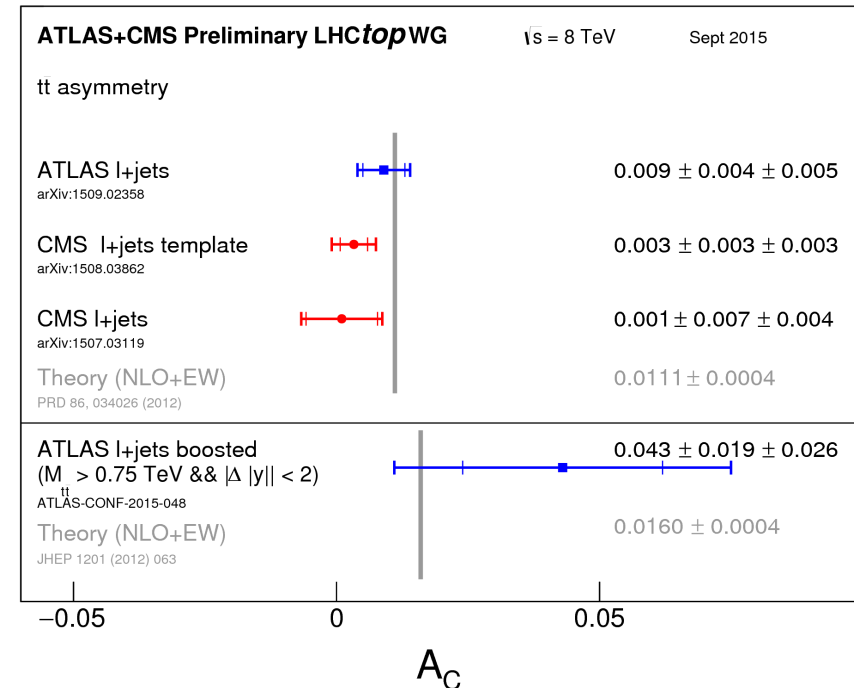
Even if Tevatron excess is evaporating, and the QCD effect is tiny at the LHC, the charge asymmetry for high mass $t\bar{t}$ pairs ($m \sim 1$ TeV) remains a very interesting object

- SM prediction 1-2% (small enough to ignore)
- Sensitive to new physics effects
- Precision is poor today, but will improve dramatically

Boosted reconstruction yields correct sign for Δy in 88% of events and is nearly immune to experimental uncertainties

2012 measurement is limited by statistics and modelling

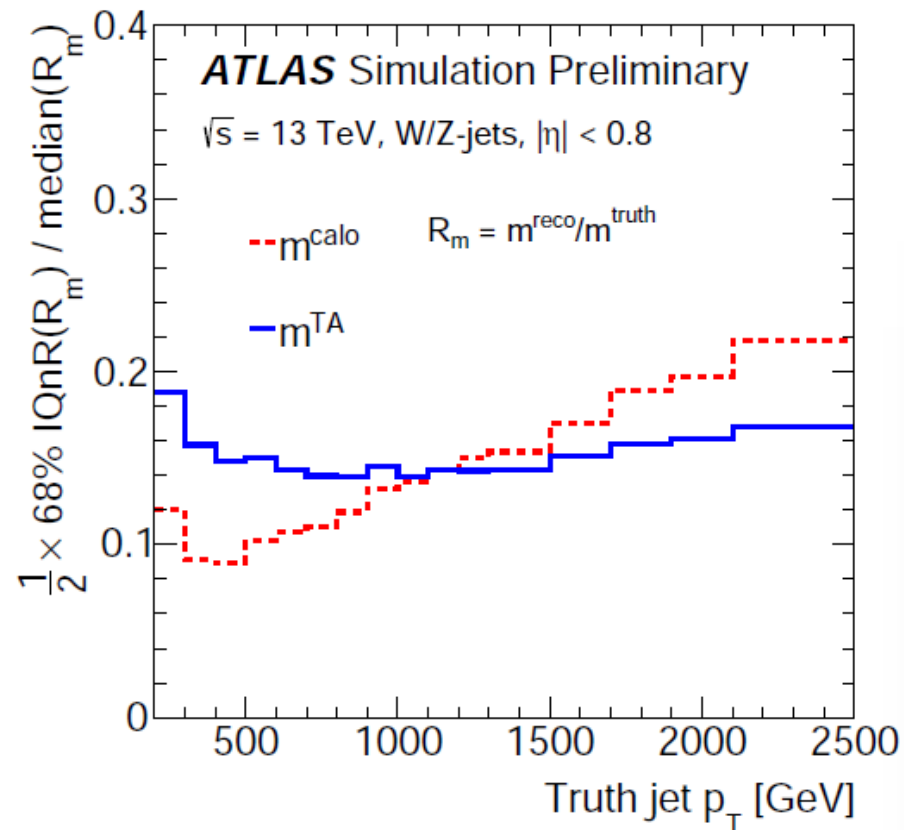
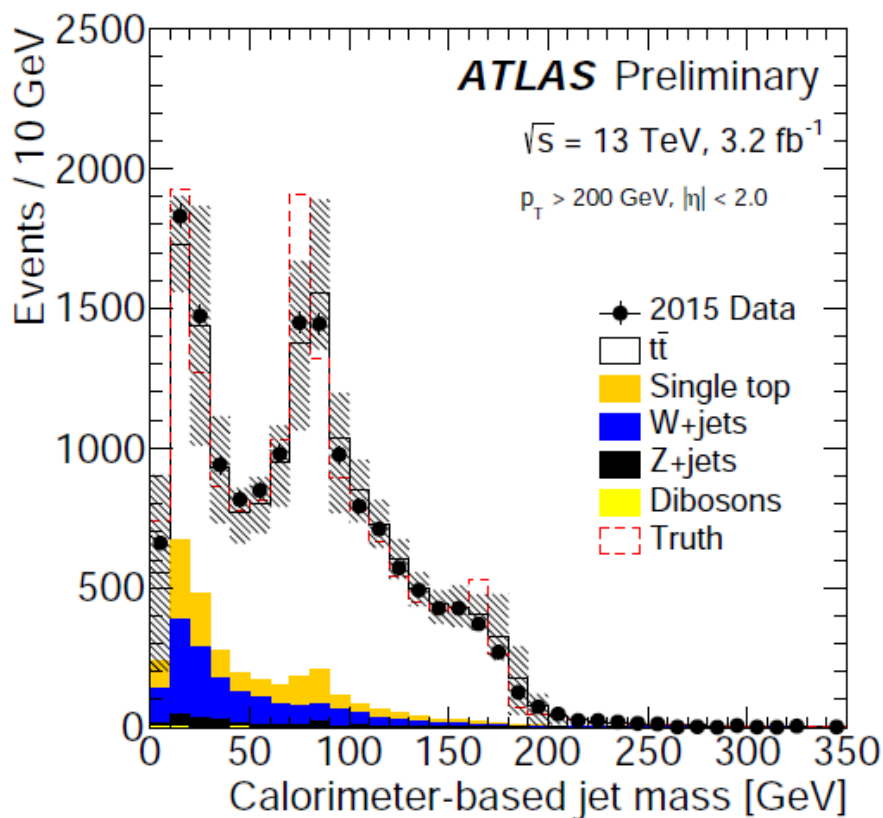
*PhD thesis Viki Sánchez
Analysis IFIC+Michigan University*



Jet mass performance

Davide Melini & Javier Aparisi
+ Ben Nachmann (LBL)

Track-assisted and composite jets



Use W and top mass peaks to
constrain jet mass response in situ

ATLAS-CONF-2016-040

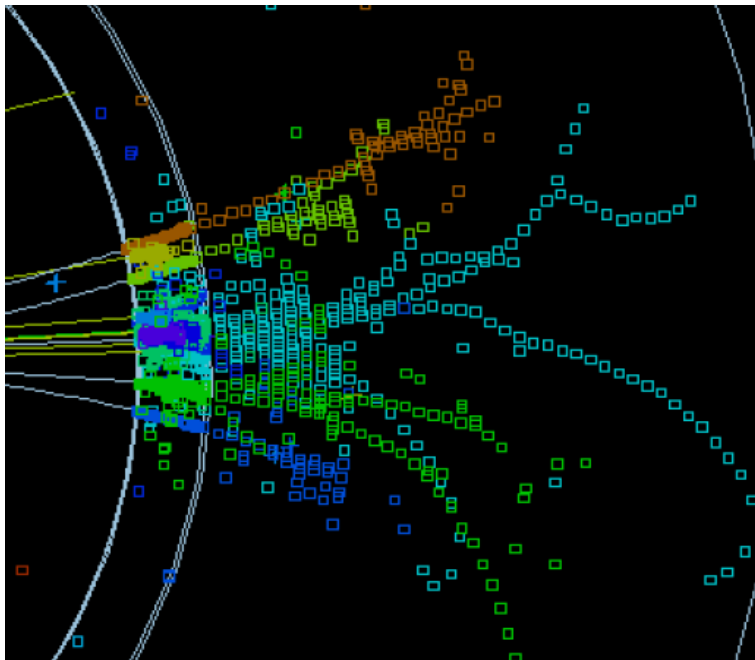
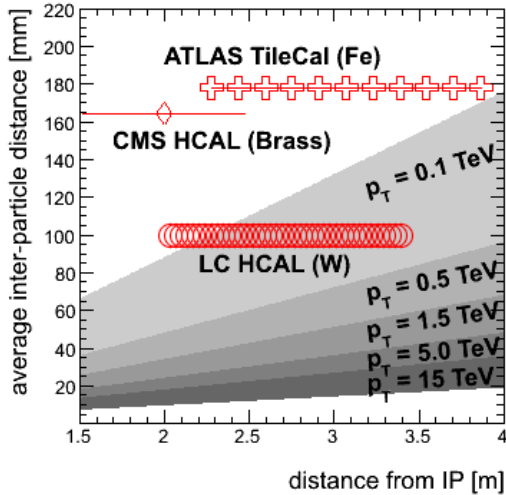
→ 2015/6 Large- R jet performance paper

Beyond the LHC – jets at future colliders

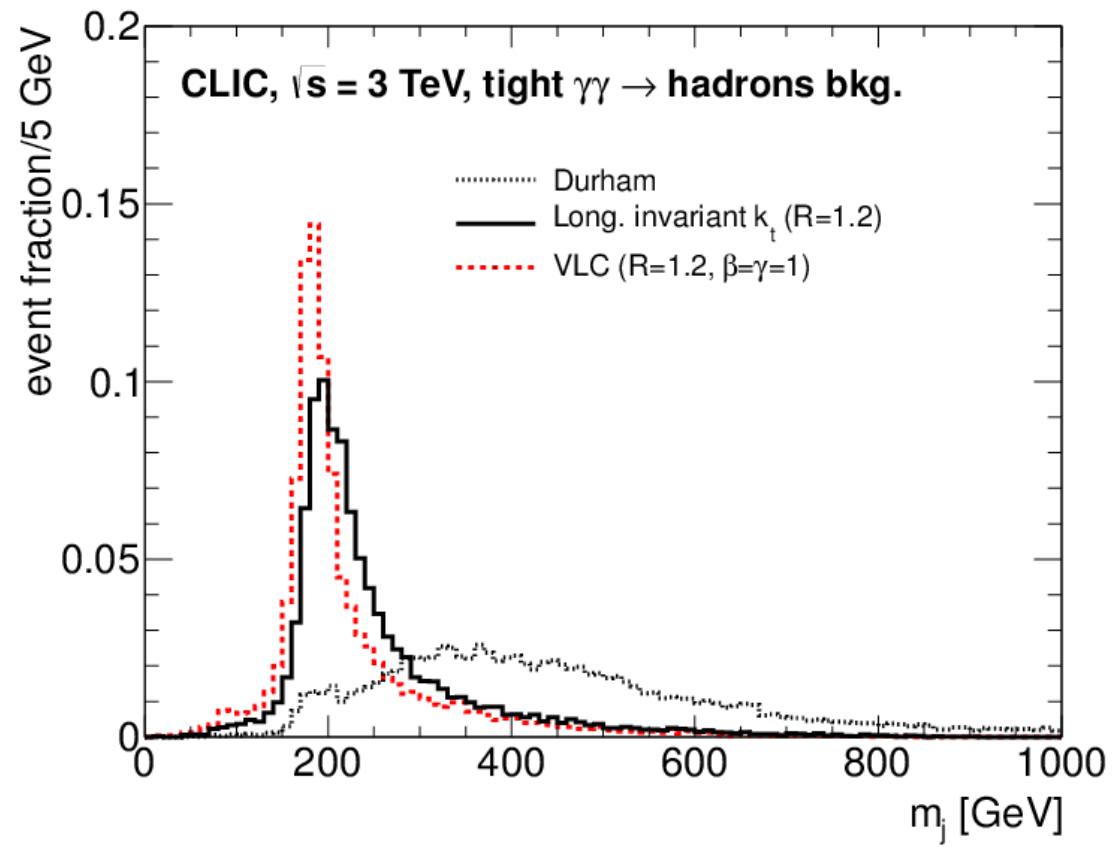
Theses Nacho García,
Martín Perelló

Boosted objects, highly granular calorimeters and jet algorithms

ILC /CLIC top jet mass resolution, including realistic background
→ background mitigated by jet algorithm of arXiv:1404.4294



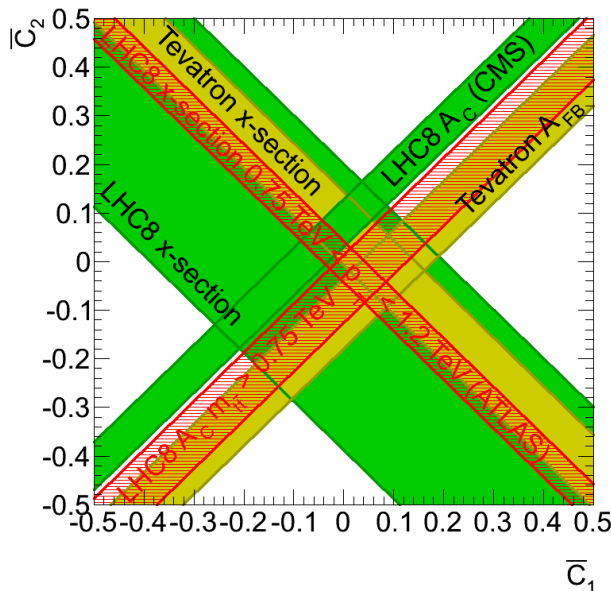
Marcel Vos, boosted top quarks



Beyond the LHC – top physics



This year's edition: CERN, 6-8 June 2017



Impact on **BSM physics** of Tevatron and LHC measurements

← *M. Perello, M.V., arXiv:1512.07542*

PhD thesis M. Perelló (LC) & J. Aparisi (ATLAS)
EFT interpretation of top measurements
(with G. Durieux, C. Zhang)

Summary

IFIC boosted top quark team

Staff: M.V., J. Salt, S. Gonzalez de la Hoz

Previous PhD students:

M. Villaplana, E. Oliver, V. Sánchez, I. García

High-profile pioneering work: first jet mass, first boosted object search

+ first charge asymmetry measurement in boosted regime

+ jets & substructure at future colliders

Current PhD students:

D. Melini (top mass + in-situ), M. Perelló (LC + EFT), J. Aparisi (in situ + EFT),