UPPSALA UNIVERSITET

ATLAS EXPERIMENT

ATLAS Activities at Uppsala University

Pedro Sales de Bruin on behalf of the Uppsala University ATLAS group

Group overview

Faculty Staff
- Richard Brenner
- Arnaud Ferrari
- Elin Bergeås Kuutmann
- Tord Ekelöf (senior)

Engineers
- Nils Bingefors
- Lars-Erik Lindquist
- Leif Gustafsson

Researchers / postdocs
- Mattias Ellert
- Pedro Sales de Bruin

PhD Students
- Joakim Gradin (50% Grenoble, just graduated)
- Max Isacson
- Mikael Mårtensson
- Myrto Asimakopoulou
- Petar Bokan (50% Göttingen)

Activities and Responsibilities

Analysis Activities

- LQ, $hh \rightarrow 2b2\tau$
- $H^+ \rightarrow tb$ (editor Elin)
- $\mathrm{H}^+ \rightarrow \tau\nu$ (editor Arnaud)

Performance activities

- Data quality trigger monitoring
- Tau reconstruction validation
- Tau DAOD contact
- Tau trigger performance

HL-LHC detector development

- Hardware-based track trigger (HTT)
- HTT project lead (Richard)
- 60 GHz wireless transfer
- Strip modules for ITk

Grid/computing

- DAST and DCOS shifts
- ARC grid middleware

Advanced Resource Connector

- The Advanced Resource Connector (ARC) is a general purpose, lightweight, open source portable grid middleware that has been in use since 2002

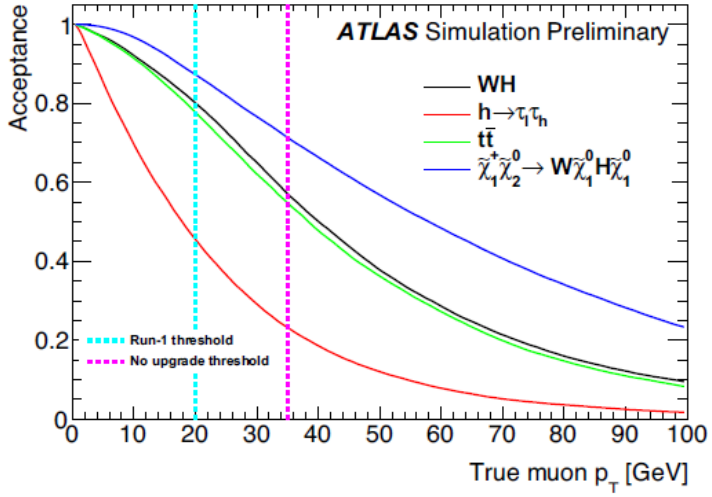
- Allows for reliable, production-quality, scalable implementation of grid services

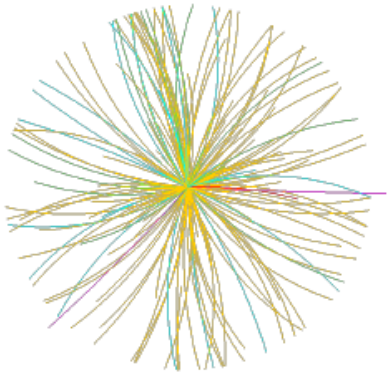
- Recent developments include:
  - ARCHERY: a new resource discovery mechanism
  - Plans to form a community to maintain Globus toolkit (used primarily for GridFTP)
  - Event-driven job processing
  - Configuration clean up

HL-LHC

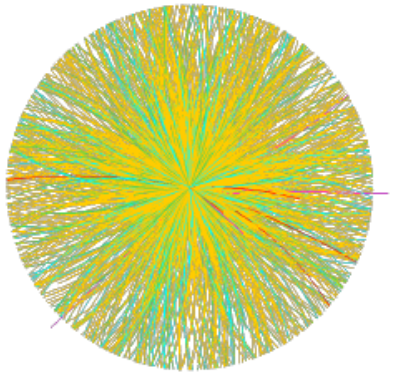
- About 200 pile-up events expected for the HL-LHC with $\mathcal{L}_{inst} = 7.5 \times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Much of the gain from the higher luminosity will be lost if trigger thresholds have to increase to cope with higher rates

EPJ Web Conf., 150 (2017) 00008

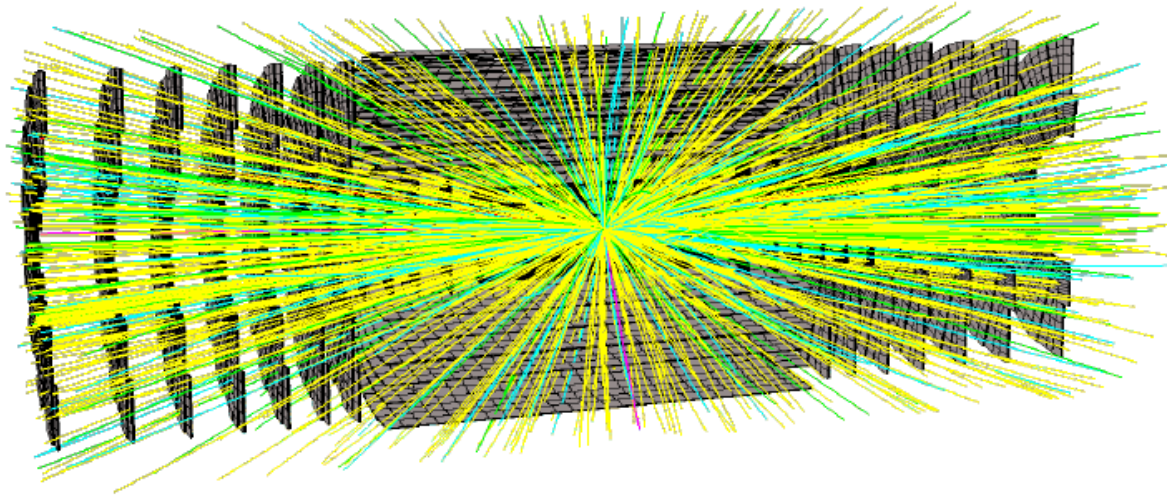




pile-up 23

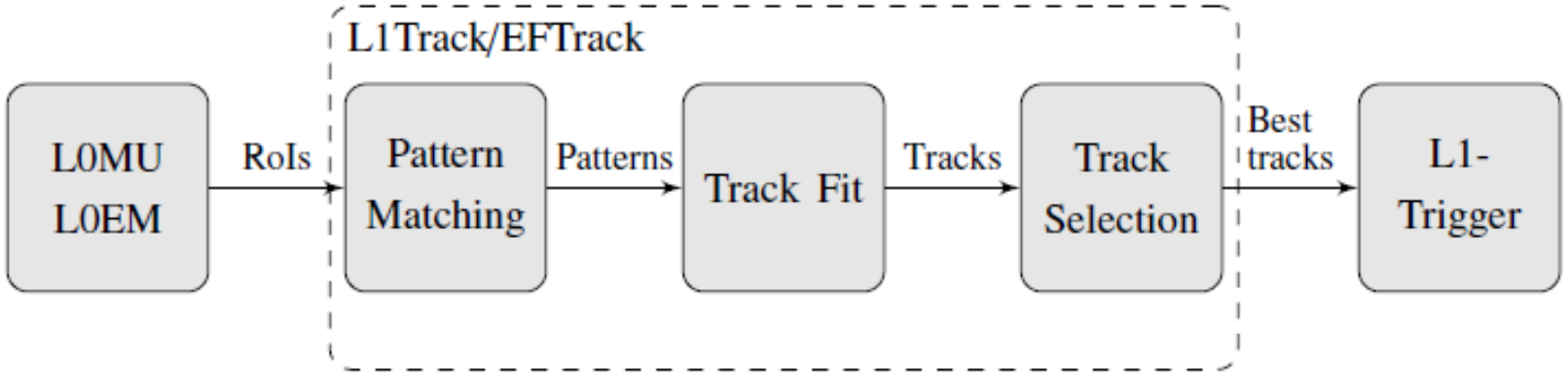


pile-up 200



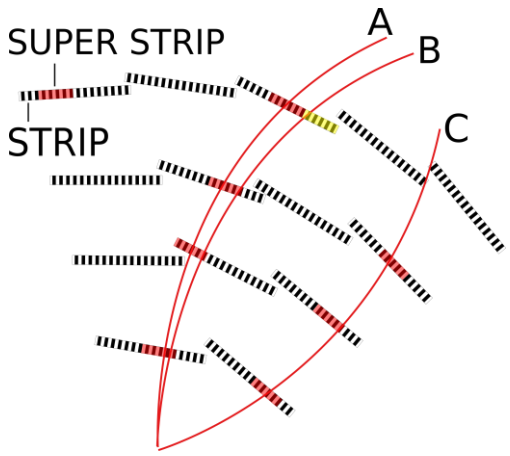
Hardware-based Track Trigger

- Solve this with a hardware-based track trigger that exploits extremely good tracking resolution to increases signal-to-background ratio
- Impossible to apply tracking algorithms to full detector, so use RoIs seeded from EMCalo and MS
- Description and performance studies available in upcoming ATLAS TDAQ TDR

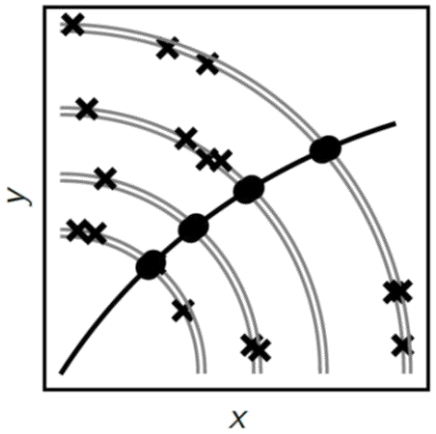


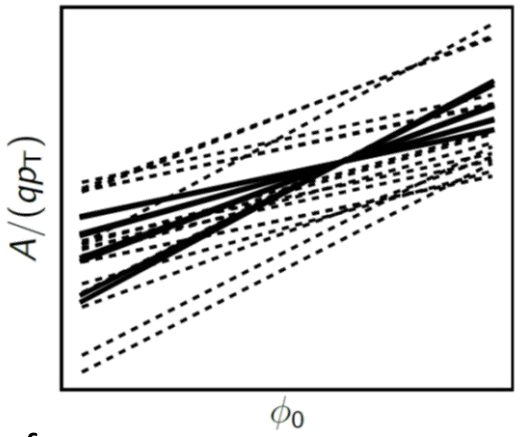
Hough Transform X AM pattern matching

- Two tracking strategies tested: associative memory (AM) pattern matching and Hough Transform of track hit space
- AM pattern matching consists of running parallel comparisons of the detector hits to patterns stored in the chip's pattern bank
- The Hough transform sweeps over the RoI and maps back the 8-bit hit information to retrieve information on the track's polar coordinates $\left(A\frac{qB}{p_T} = \frac{\phi_0 - \varphi}{r}\right)$



AM pattern matching



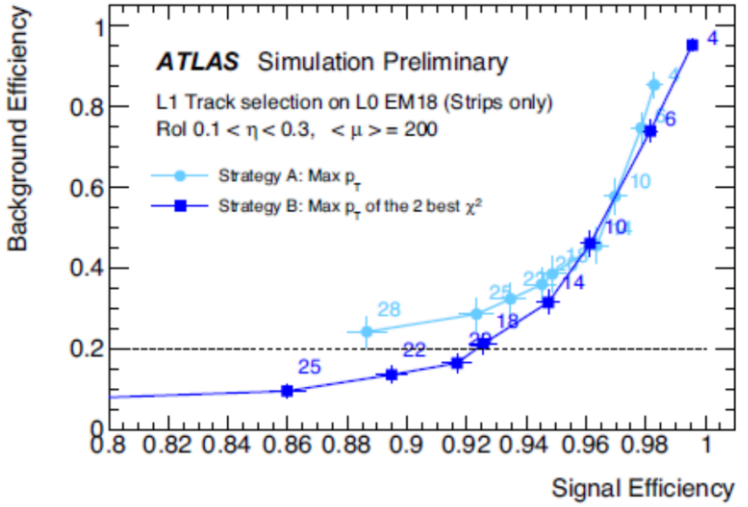


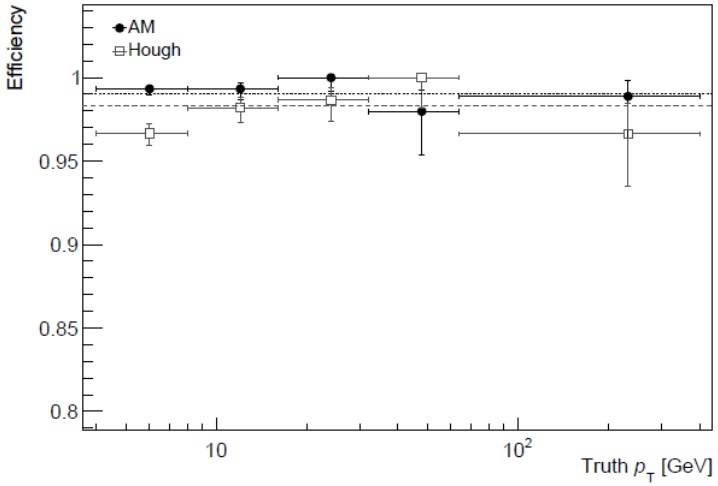
Hough Transform

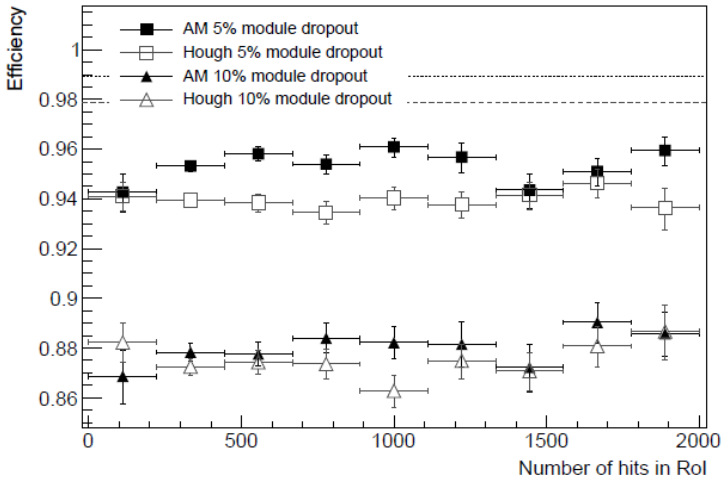
*J. Gradin. M. Mårtensson, R. Brenner

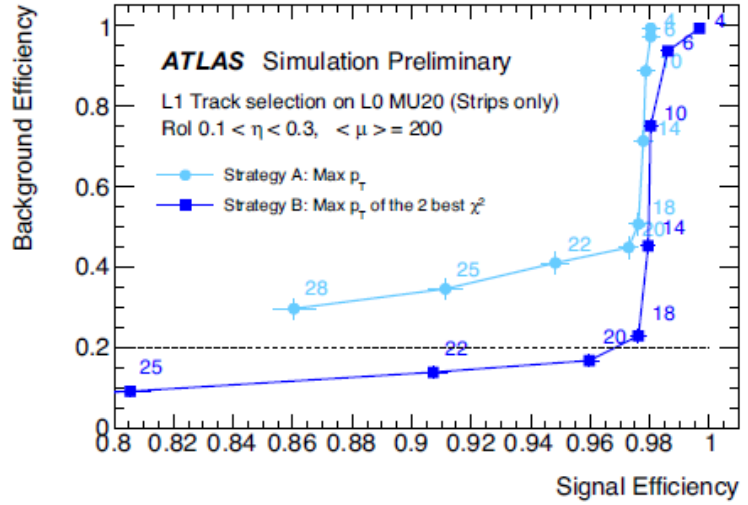
Hough Transform X AM patter matching (2)

- AM pattern matching performs a bit better (>99% efficiency versus ~98% for Hough transform)
- Robustness against module failure scenarios also tested
- Studies of HTT efficiency for τ identification ongoing (M. Mårtensson, M. Asimakopoulou)
- Results described in arXiv:1709.01034 and proceedings



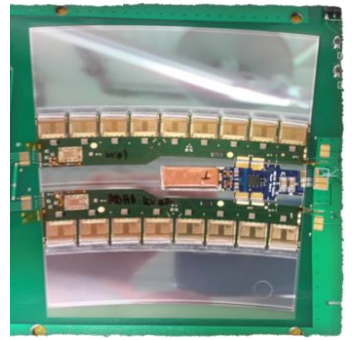


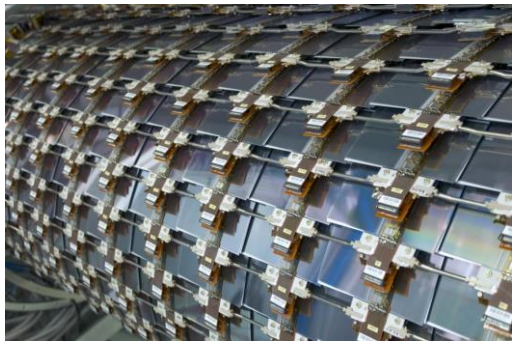


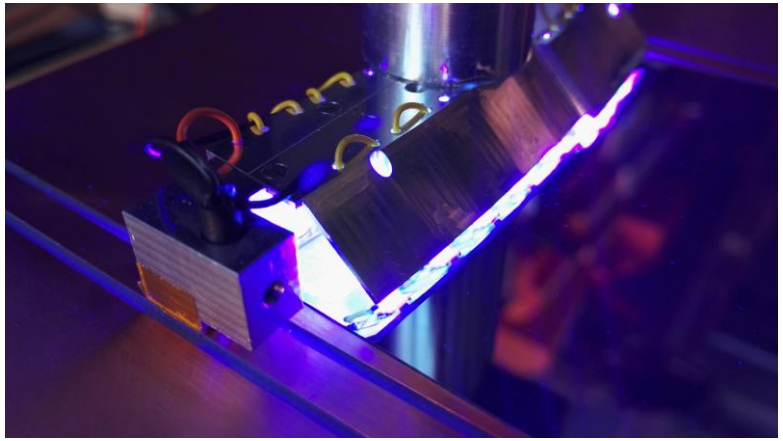


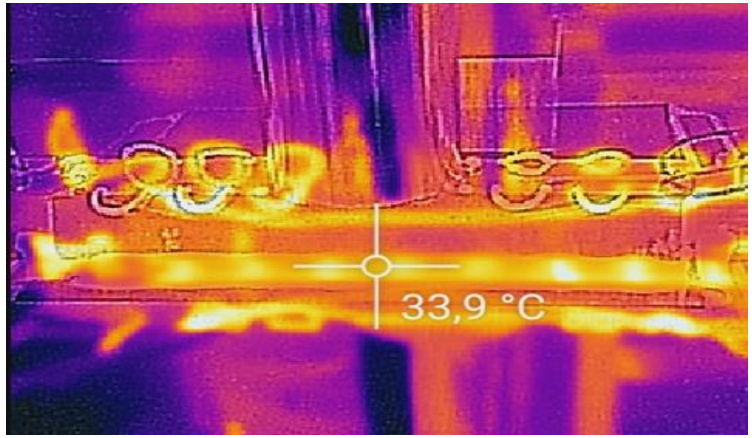
Large silicon tracker

- Module production for current ATLAS SCT was done in-house in Uppsala
- The quantity of modules to be delivered for ITk strips for ATLAS Phase II is ~4 larger than for SCT
- Industrialisation of assembly method to allow for large scale production in industry
- Quality Control will be done at University labs in Uppsala, Lund and NBI



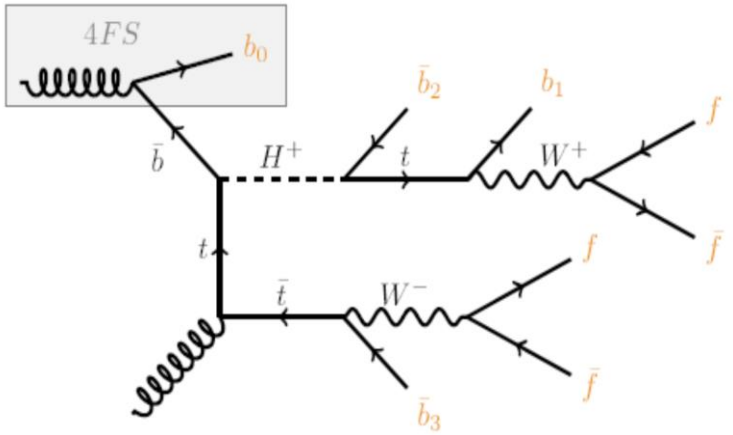


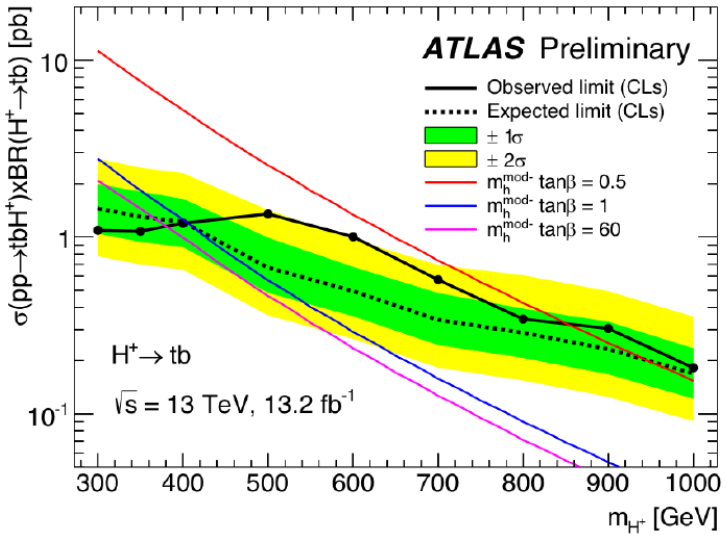




$H^+ \rightarrow tb$

- Latest results:
  - $H^+ \rightarrow tb$ (13 TeV), ATLAS-CONF-2016-089, Aug 2016
  - *Charged Higgs boson searches with the ATLAS detector* (PoS)
- Needed in all SUSY models, e.g. 2HDM. H^+ to tb dominates at high mass in almost all models and is mostly sensitive at low $\tan\beta$
- Work in progress, aim for end-of-year publication using 2015+2016 data
- Uppsala contributions:
  - Main analyzers for dilepton (J. Gradin) and l+j (M. Isacson) final states, with tasks including BDT training, background estimation, interpretation…
  - Note and paper editing (E. Bergeås Kuutmann)

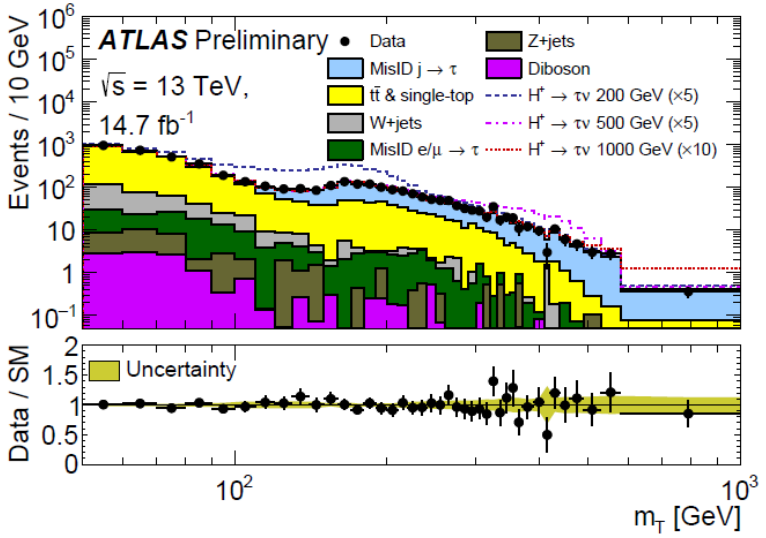


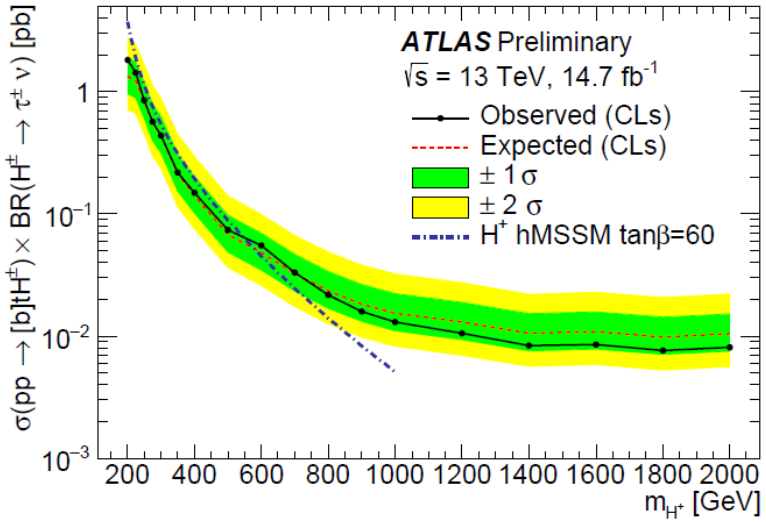


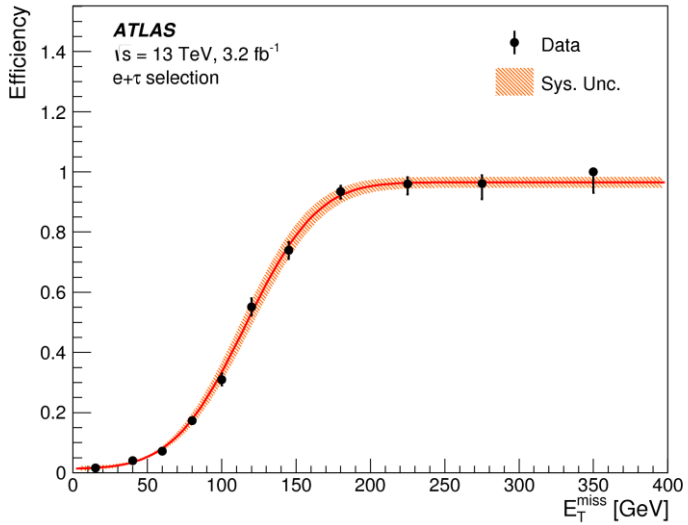
ATLAS-CONF-2016-089

$H^+ \rightarrow \tau\nu$

- Dominant mode for $m_h < m_{top}$, with good sensitivity for entire mass range
- Work in progress, aiming for end-of-year publication using 2015+2016 data
- Uppsala contributions:
  - MET trigger scale factors (M. Asimakopoulou)
  - Paper editor (A. Ferrari)





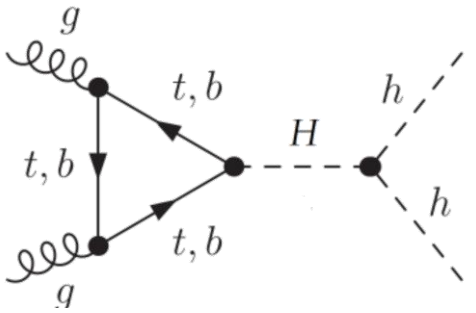


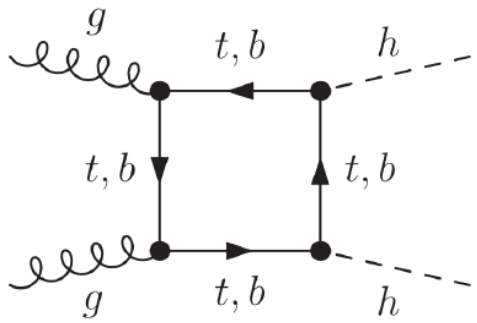
ATLAS-CONF-2016-088

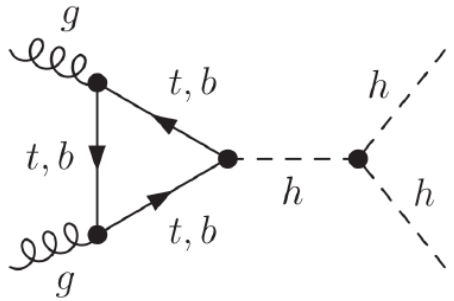
Phys. Lett. B 759 (2016) 555-574

$hh \rightarrow bb\tau\tau$

- See Petar's talk for more details
- Work in progress, aim for end-of-year publication using 2015+2016 data
- Uppsala contributions:
  - Main analyzers for $bb\tau_{had}\tau_{had}$ channel (P. Bokan, PSB)
  - HL-LHC prospects analysis (P. Bokan)
  - Note editing (PSB, HL-LHC prospects)
- Recently started joint effort with U. Göttingen to gauge viability of both boosted and SM non-resonant $hh \rightarrow WW\tau\tau$

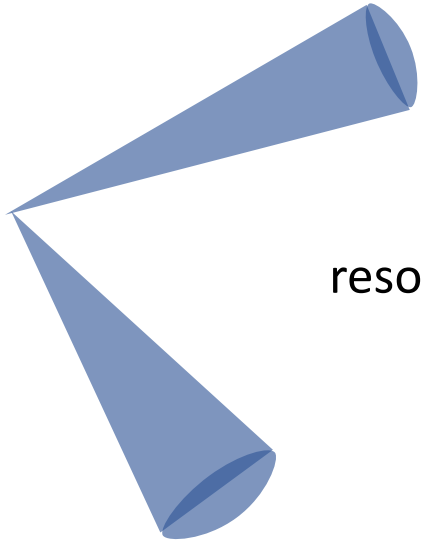


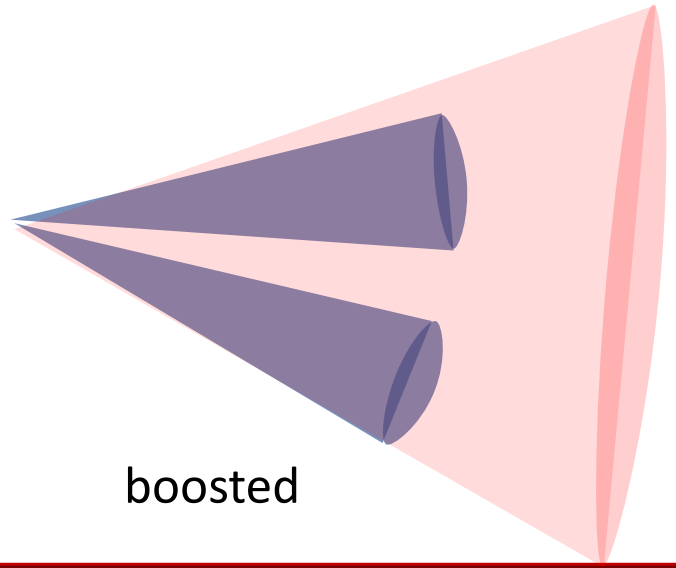




$hh \rightarrow bb\tau\tau$ (boosted)

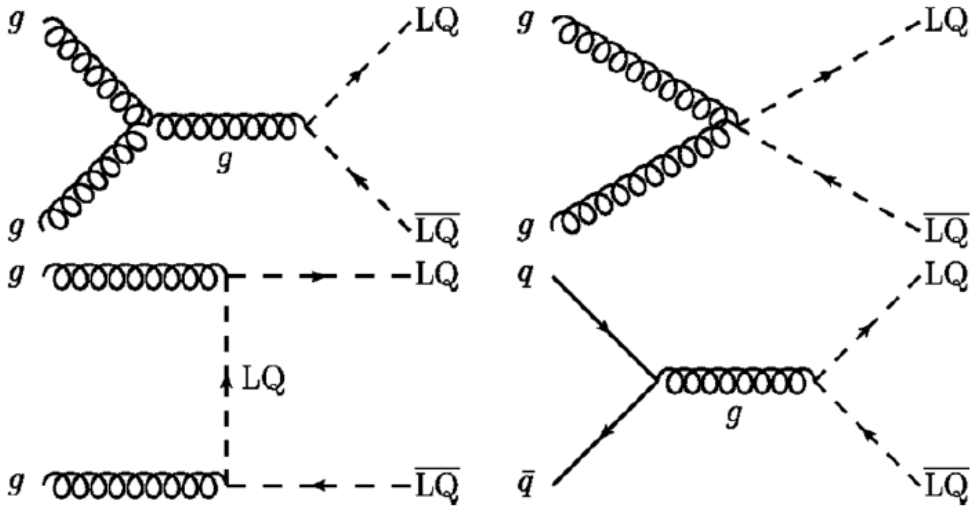
- Search for di-Higgs production from high-mass resonances in the boosted regime (1-3 TeV)
- Makes use of boosted reconstruction techniques to identify and reconstruct $\tau\tau$ and bb pairs
- Majority of background is multijet, need robust data-driven background estimation methods
- Work in progress, aiming for publication next year
- Uppsala contributions:
  - Main analyzer for $bb\tau_{had}\tau_{had}$ (P. Bokan)
  - Started development of $bb\tau_{lep}\tau_{had}$ channel (M. Asimakopoulou)





$LQ \rightarrow b\tau b\tau$

- Re-working of di-Higgs analysis into a search for pair-production of a 3rd gen. leptoquark decaying to $b\tau$
- Attractive solution to deviations in B^0 decays measured in Babar, Belle and LHCb
- Work in progress, aiming for end-of-year publication using 2015+2016 data
- Uppsala contributions:
  - Main analyzers $b\tau_{had}b\tau_{had}$ channel (M. Mårtensson, PSB)



Summary

- HEP group at Uppsala University involved in a wide range of activities:
  - Data quality, performance and operations
  - Grid computing
  - Upgrade
  - BSM searches

- Several exciting searches ongoing and expected to conclude soon, with more efforts just starting

Thank you

BACKUP

$hh \to bb\tau\tau$ - more details

$\tau_{lep}\tau_{had}$		$\tau_{had}\tau_{had}$	
Single lepton trigger SLT	Lepton tau trigger LTT	Single tau trigger STT	Di-tau trigger DTT
1 e/μ and 1 medium τ of oppostite sign		2 medium τs of opposite sign	
$p_T^{e/\mu} > 25, 27$ GeV	$18\text{ GeV} < p_T^{e} <$ SLT threshold	$p_T^{lead\,\tau} > 100, 140, 180$ GeV	$p_T^{lead\,\tau} > 40$ GeV
(for 24, 26 GeV triggers)	$15\text{ GeV} < p_T^{\mu} <$ SLT threshold	(for 80, 125, 160 GeV triggers)	$p_T^{sub1\,\tau} > 30$ GeV
$p_T^{\tau} > 20$ GeV	$p_T^{\tau} > 30$ GeV	$p_T^{sub1\,\tau} > 20$ GeV	
≥ 2 central jets		≥ 2 central jets	
$p_T > 45, 20$ GeV	$p_T > 80, 20$ GeV	$p_T > 45, 20$ GeV	$p_T > 80, 20$ GeV
			$p_T > 45, 20$ GeV (2015 data)
$m_{\tau\tau}^{MMC} > 60$ GeV		$m_{\tau\tau}^{MMC} > 60$ GeV	

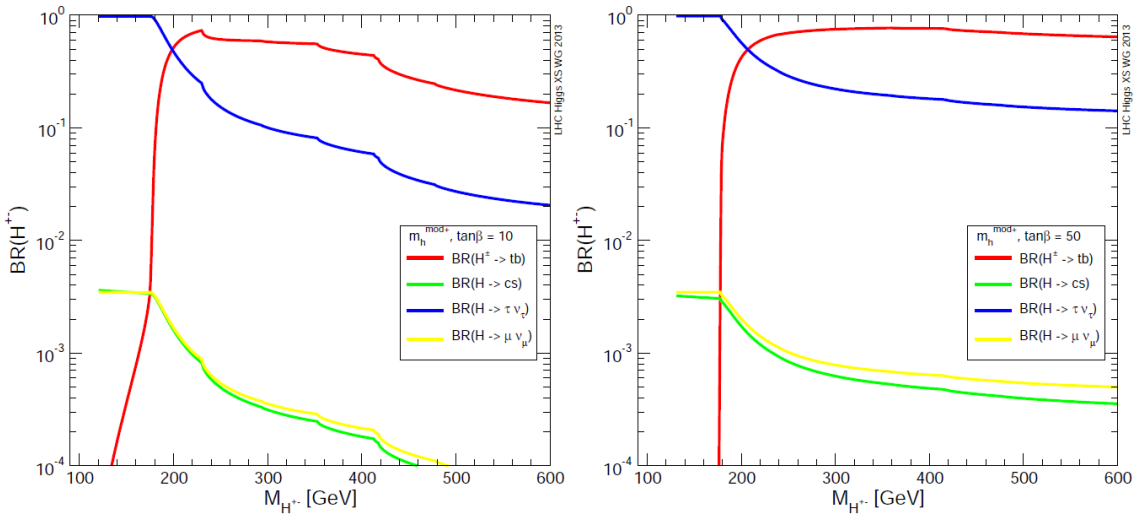
- **Signal region (SR): events with exactly 2 b-tagged jets.**
- A **Boosted Decision Tree** classification is applied to the SR.
- Events with 0, 1 b-jets, high transverse mass and "same-sign" events are used to define the control/validation regions.

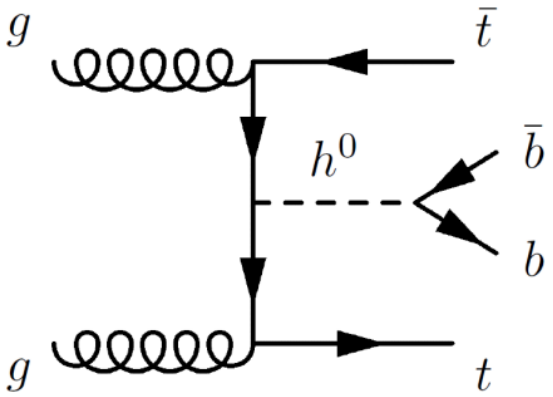
*P. Bokan

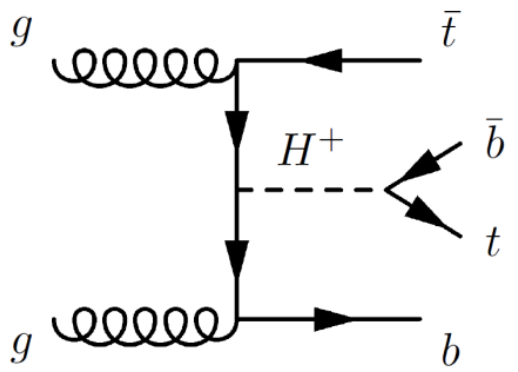
$H^+ \to tb$

- H⁺ to $\tau\nu$ important at high tanβ
- H⁺ to tb dominates at high mass in almost all models and is sensitive at low tanβ
- Same final state as $tth \to tt(bb)$

Handbook of LHC Higgs Cross Sections: 3, arXiv:1307.1347





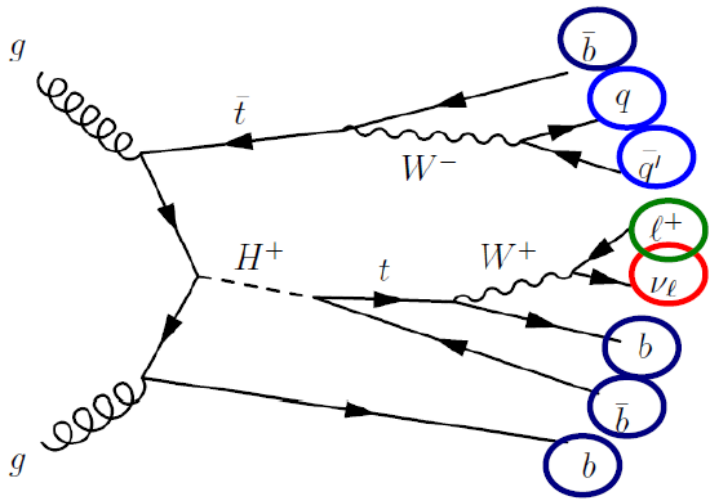


$H^+ \to tb$ – more details

$H^+ \to tb$ searches

13.2 fb^{-1} @ 13 TeV
ATLAS-CONF-2016-089

- Looking at the **ℓ+jets** final state.
  Basic selection:
  1 *e* or *μ* (p_T>25 GeV),
  ≥4 jets (p_T>25 GeV)
  of which ≥2 *b*-tagged (70% eff).
- Most challenging background: ***tt̄+bb̄***.
- Various signal and control regions (SR, CR) based on jet and *b*-jet multiplicity:



	2b	3b	≥4b
4j	CR	CR	
5j	CR	SR	SR
≥6j	CR	SR	SR

- Training BDTs for each m_{H+} and SR to suppress background ($t\bar{t}$+≥1*b* for m_{H+}≤500 GeV, all $t\bar{t}$ backgrounds for m_{H+}>500 GeV).

$H^+ \to tb$ – more details

$H^+ \to tb$ searches

ATLAS-CONF-2016-089

- Simultaneous profile likelihood fit of SR and CR.
  Fitted variable: BDT output in SR, H_T^{had} (scalar sum of p_T of all jets) in CR.
  $t\bar{t}$+≥1c, $t\bar{t}$+≥1b normalisation freely floating in fit.
- Major systematic uncertainties:
  $t\bar{t}$+heavy flavour modelling; b-tagging, jet energy scale and resolution.
- No significant excess found.
- CLs limits:
  Model-independent as a function of m_{H+}
  Interpreted in MSSM m_h^{mod-}
  (e.g. Carena et al EPJC73 (2013) 2552 arXiv:1302.7033;
  LHCHiggsXSWG YR4, arXiv:1610.07922).