Project sketch.

PhD project sketch of Christoph Eckardt at DESY

SCT digitization and $t\bar{t}H$ analysis

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Block course Spring 2014
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ATLAS EXPERIMENT

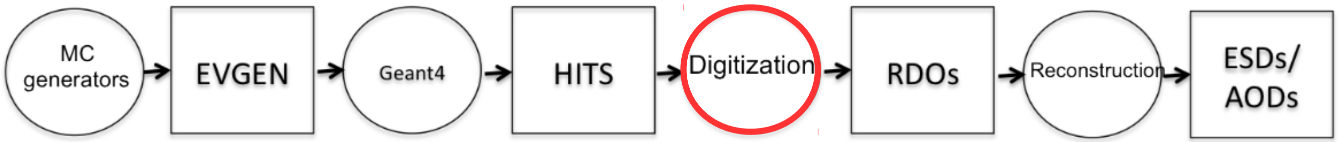
DESY

Content

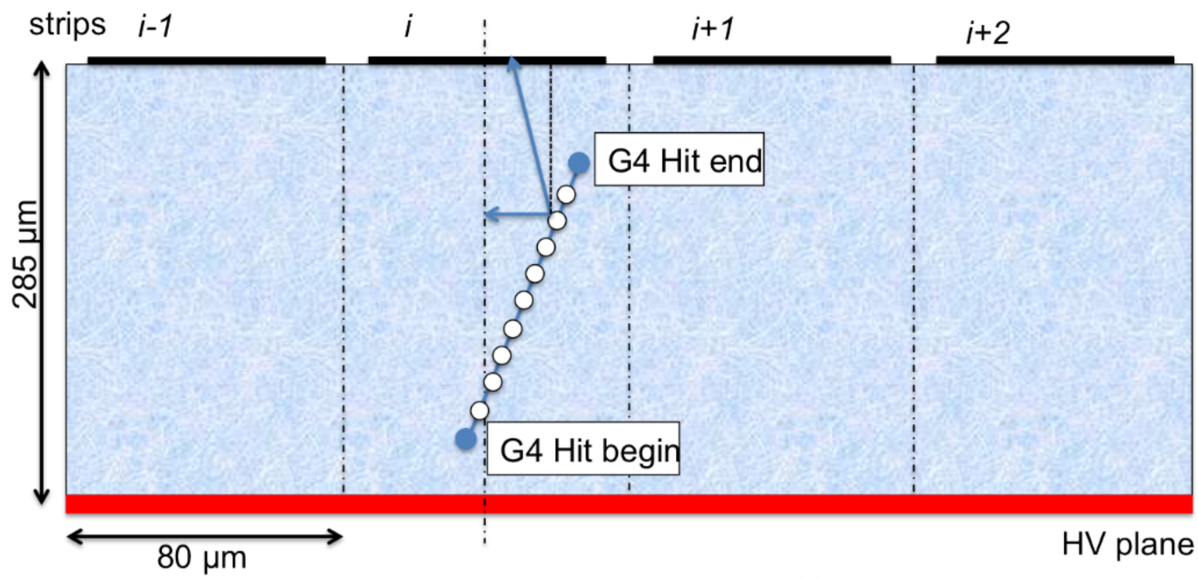
- SCT digitization
  - Digitization in a simulation process
  - Motivation
  - Goal and strategy
  - First results (work in progress)
- $t\bar{t}H$ with $H \rightarrow b\bar{b}$ search
  - Discovery of the Higgs
  - Motivation and Goals
  - Present ATLAS analysis (8TeV)
  - Possible improvements
- Summary

SCT digitization.

Digitization

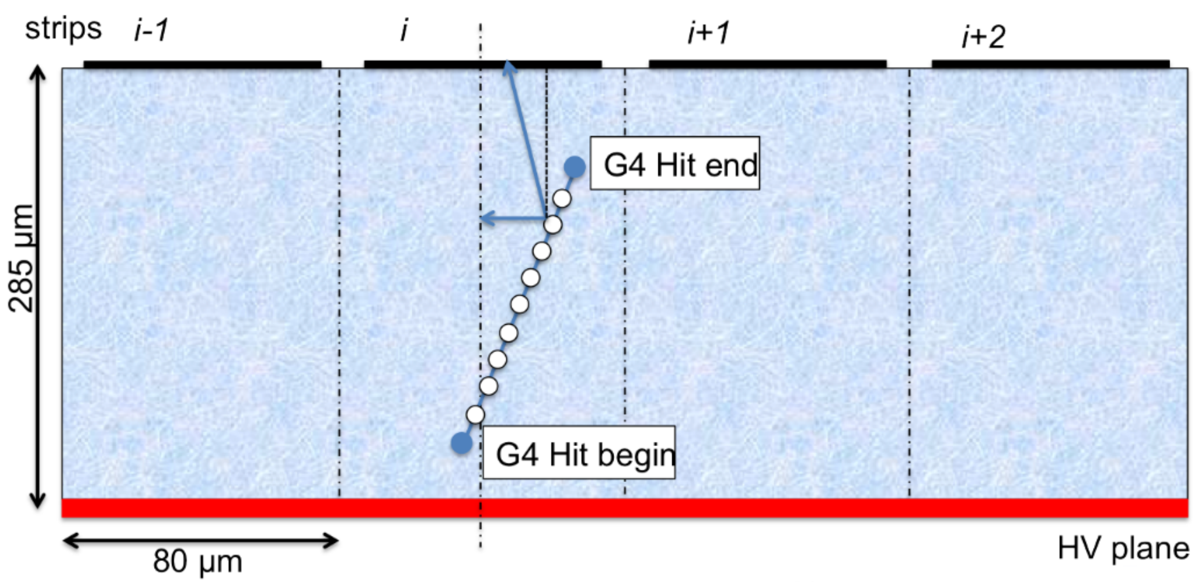


- Digitization process is part of simulation chain
- Realistic simulation of the detector response (charge collection)
  - Generation of electron-hole pairs and drift in electric field
  - Diffusion and deflection of electron-hole pairs due to magnetic field (Lorentz shift)
  - Crosstalk and noise



Motivation

- SCT is near to the beam pipe in the ATLAS detector system
- Radiation increases because of higher luminosity in Run-II
→ more damage
- Depletion and noise of the modules will change
- Impact on tracking



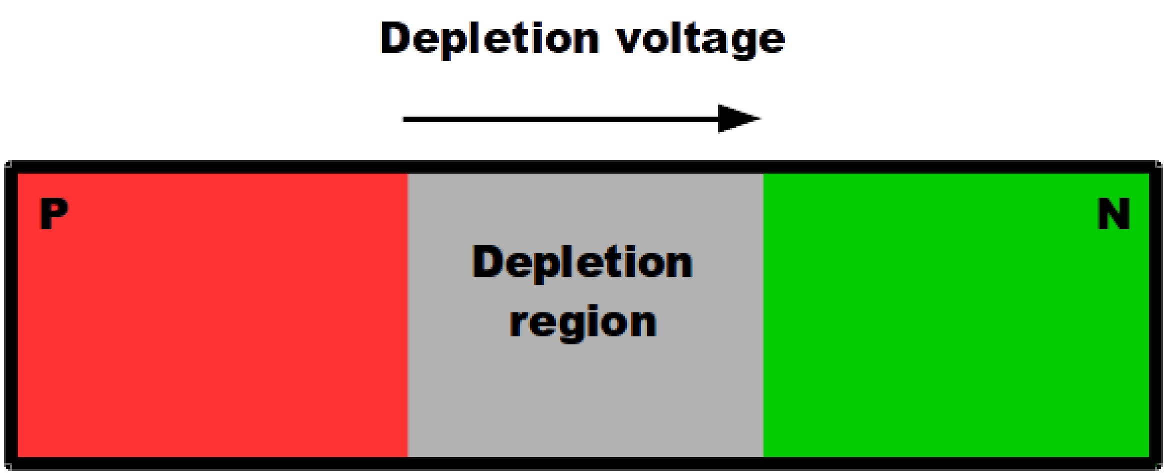
Analysis

- Goal:
  - Simulating and studying the performance of SCT digitization code in case of radiation damages
  - Comparison with data from Run-I

- Strategy:
  - Variation of different variables in the SCT digitization code

Analysis

- Variables:
  - **Depletion voltage**: potential difference, which is formed across the junction
  - **Bias voltage**: opposite sign to DV → if BV > DV: fully depleted module
  - **Noise**: background effects (controlled by Condition DB for each module)
  - **Gain**: gain factor (controlled by Condition DB for each module)
  - **Threshold**: strips above the 1 fC readout threshold are further used (clustered/reconstructed to hits/tracks)



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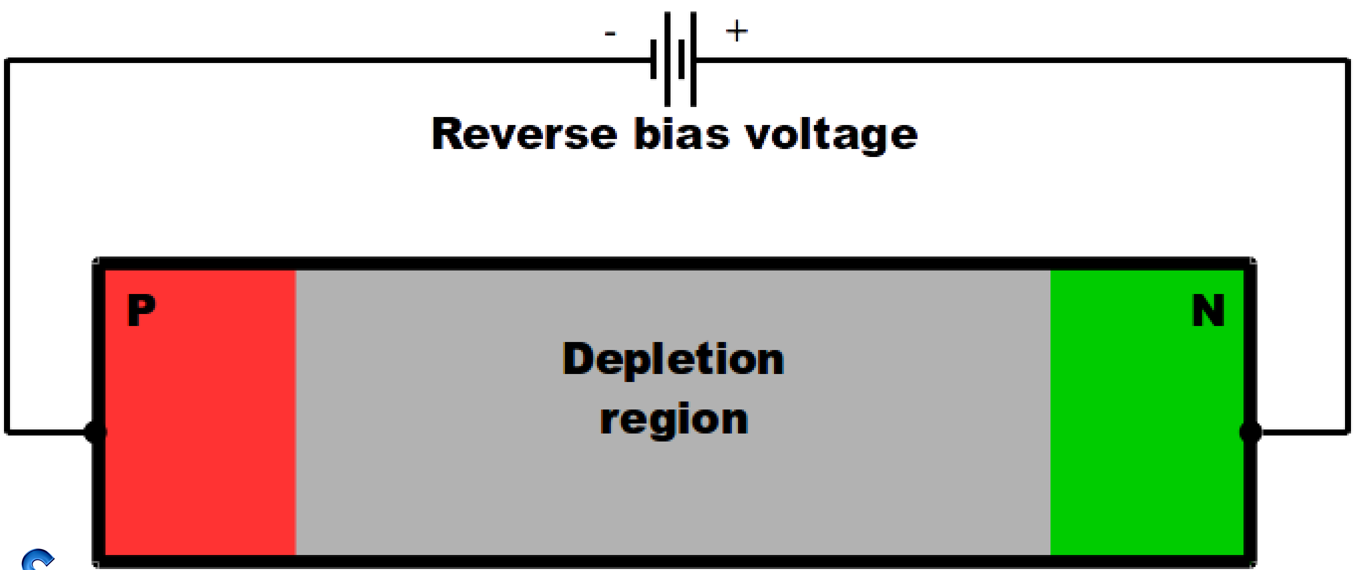

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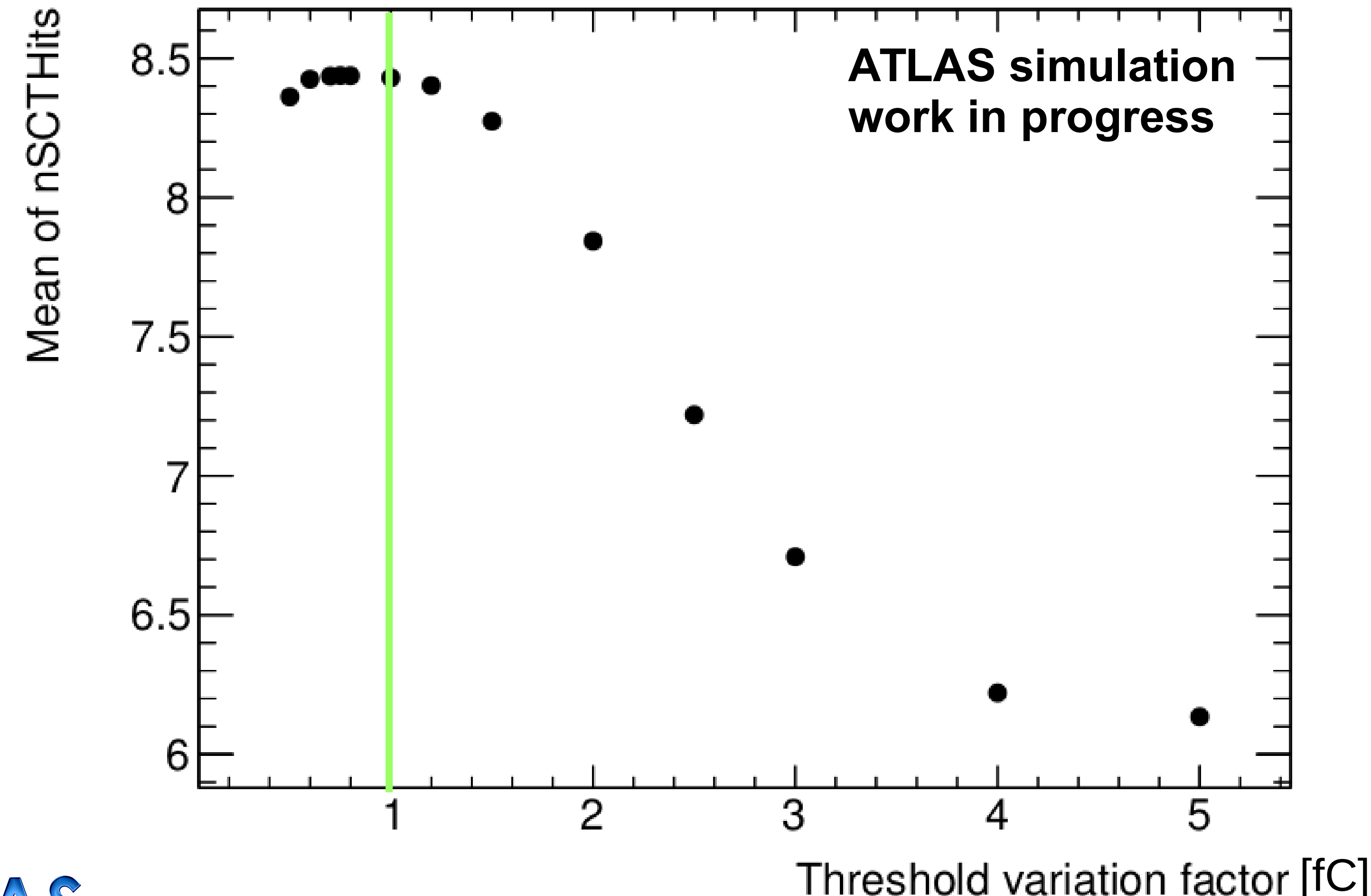
First results – threshold scan

- Varied the **threshold** factor in the SCT digitization code (default: 1.0)
- Shown is the mean of the number of SCT hits per track



First results – threshold scan

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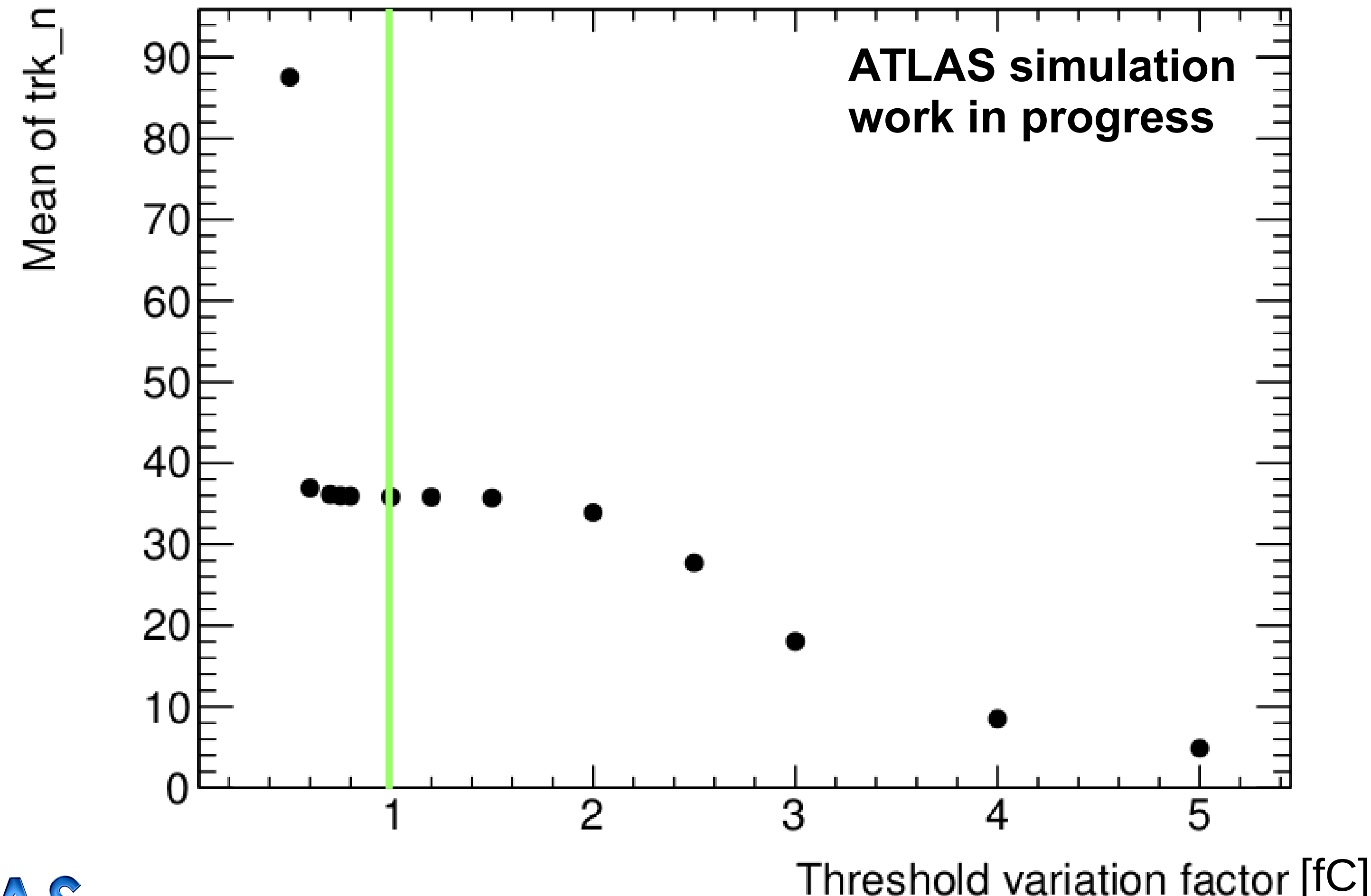
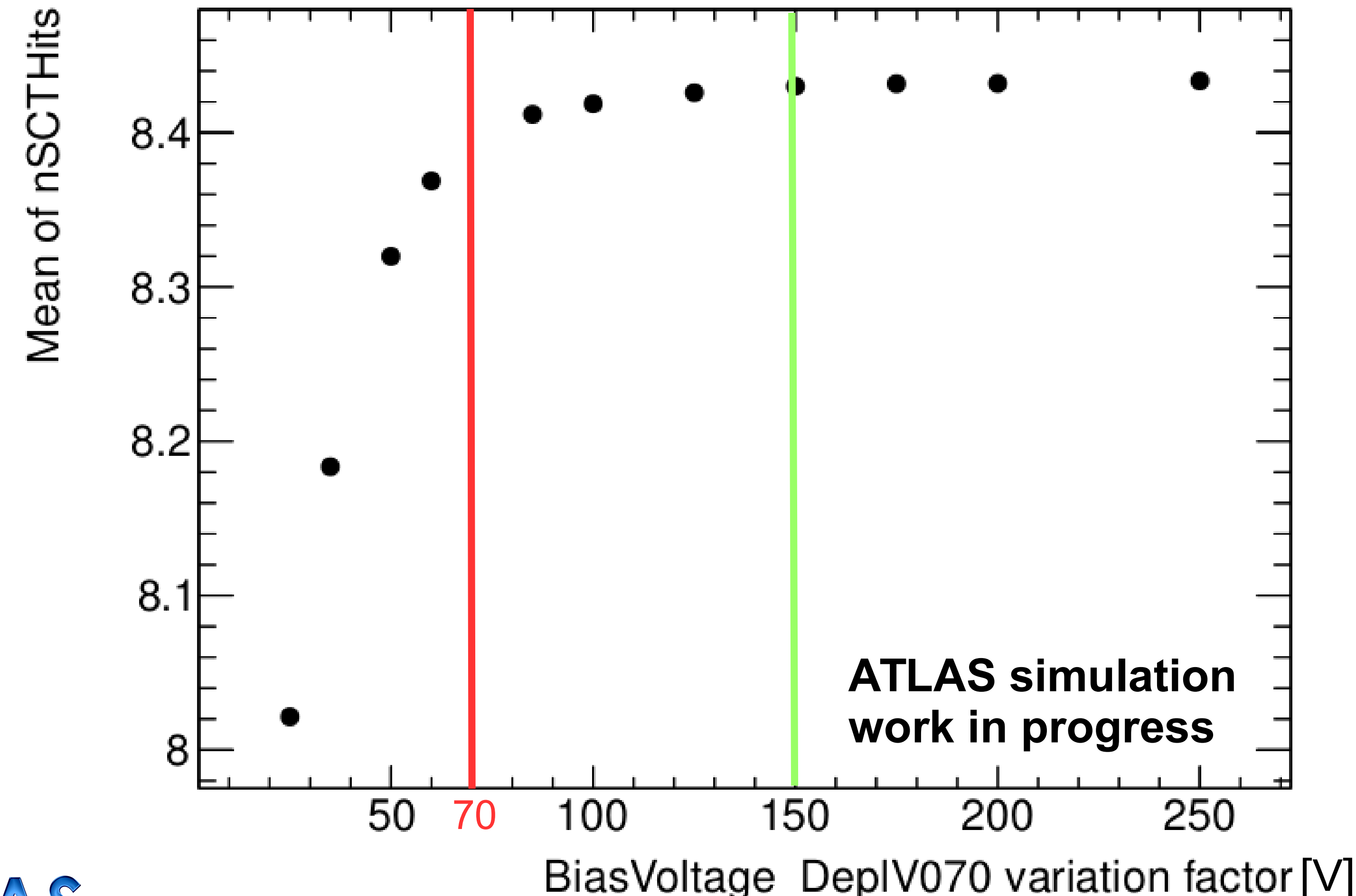


First results – variation of bias voltage

- Varied the **bias voltage** in the SCT digitization code (default: 150V), while depletion voltage (material property) is 70V
- Shown is the mean of the number of SCT hits per track



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First results – variation of bias voltage

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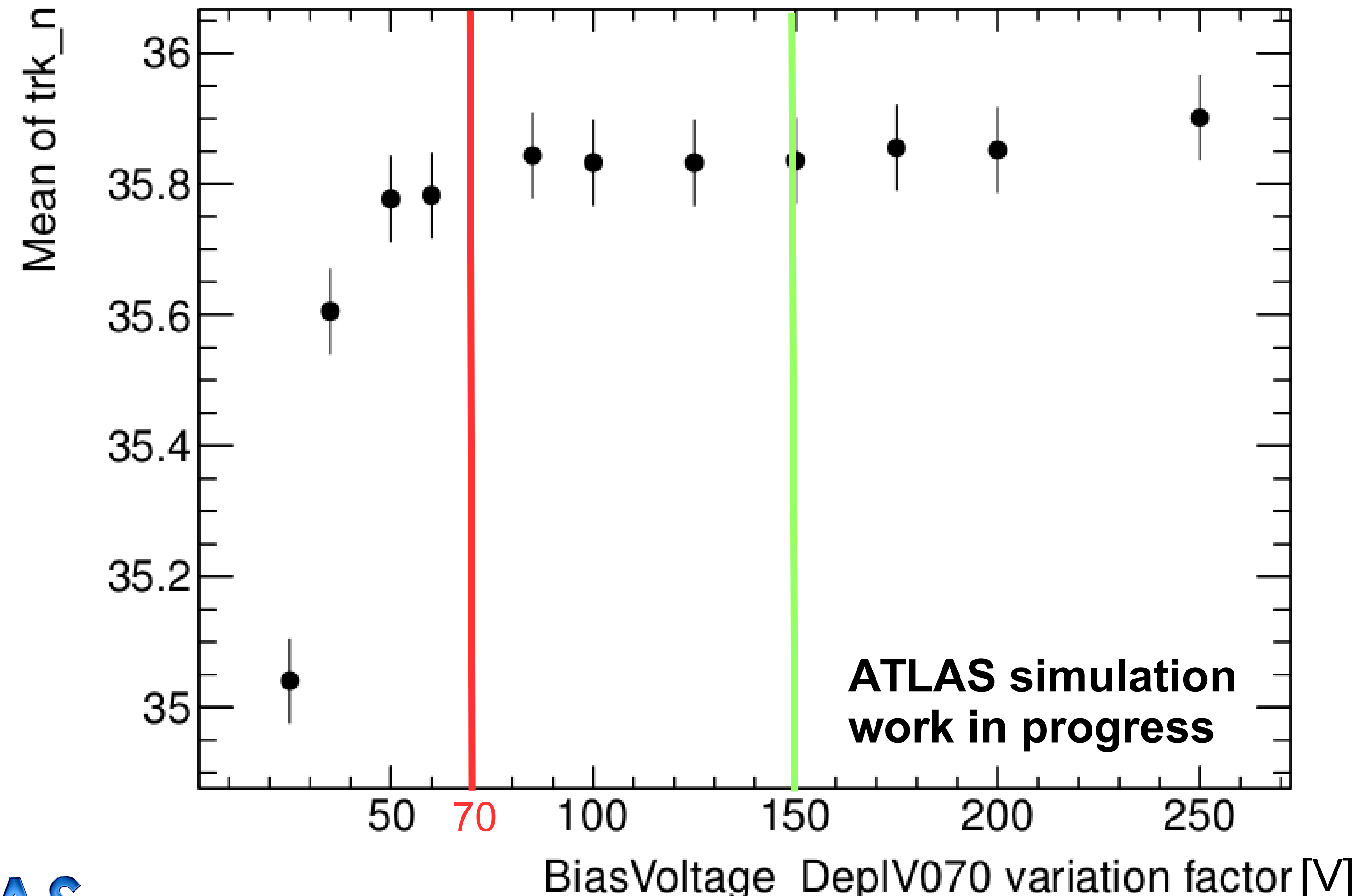


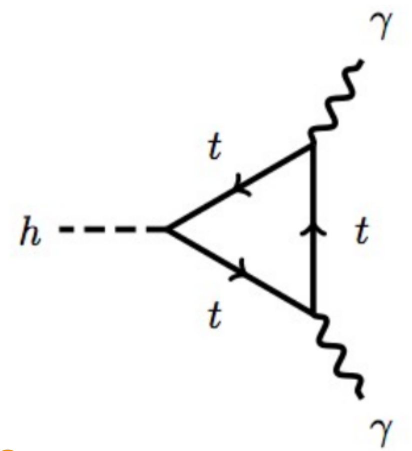
$t\bar{t}H$ analysis.

Discovery of the Higgs boson

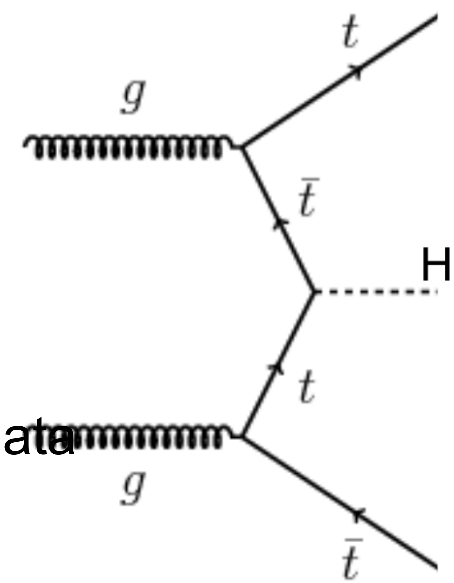
- Discovery of the Higgs boson in 2012 by ATLAS and CMS
  - $H \rightarrow \gamma\gamma$
  - $H \rightarrow ZZ^* \rightarrow 4\ell$
  - $H \rightarrow WW^* \rightarrow \ell\nu\ell\nu$
  - $H \rightarrow \tau\tau$
- Nobel prize 2013: Englert and Higgs
- Current knowledge:
  - Mass of 125.5 ± 0.6 GeV
  - 0^+ Spin favoured
  - Couplings to bosons

Motivation and goals

- Couplings to fermions are not measured
  - 4σ evidence for $H \to \tau\tau$ (new)
  - 3σ evidence for $H \to b\bar{b}$ from Tevatron and CMS
  - indirect access via $H \to \gamma\gamma$
- $H \to t\bar{t}$ is impossible because of $m_H < 2m_{top}$

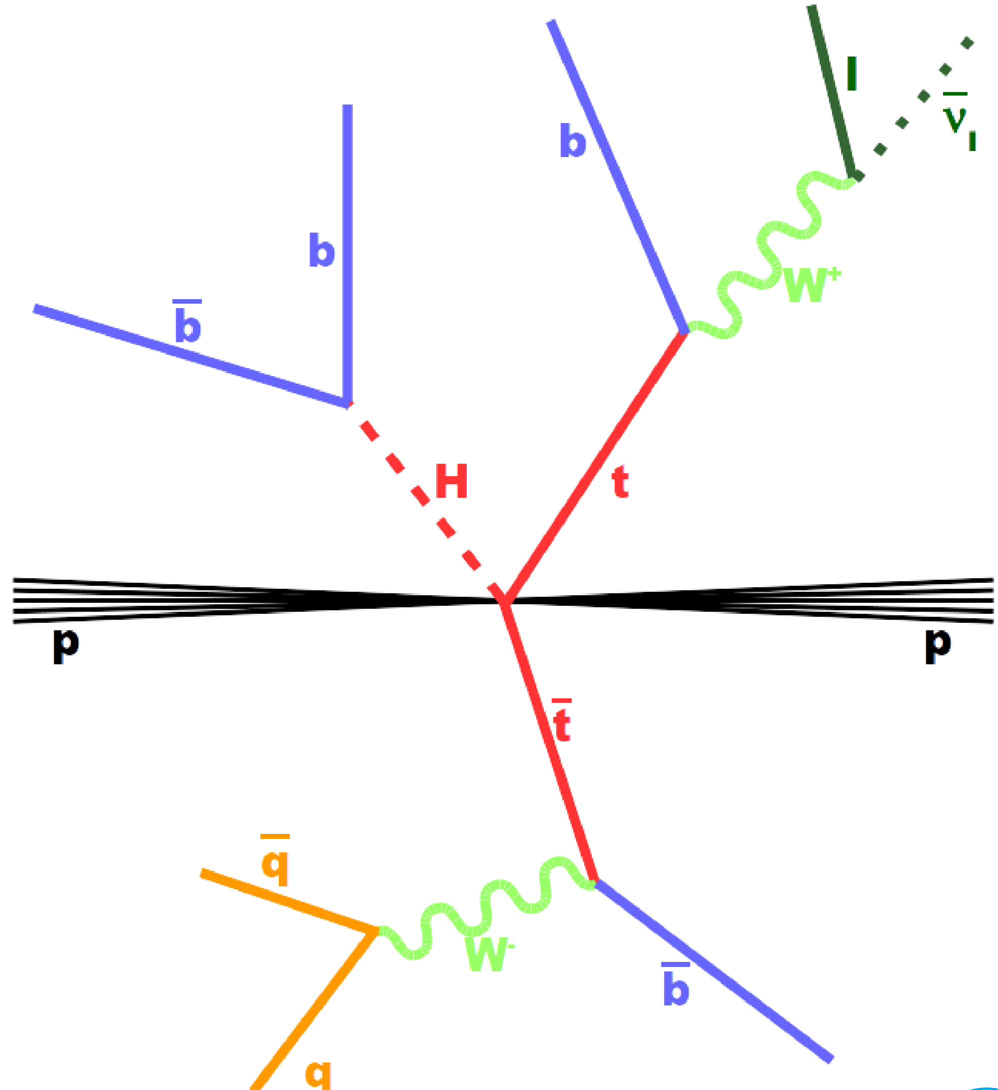


- **Measurement of top-pairs in association with a Higgs boson with $H \to b\bar{b}$**
  - access to tH and Hb Yukawa couplings (λ_{tH} close to 1)
  - Present analysis:
    - 7 TeV: ATLAS-CONF-2012-135
  - Project: try to improve results with 13 TeV data



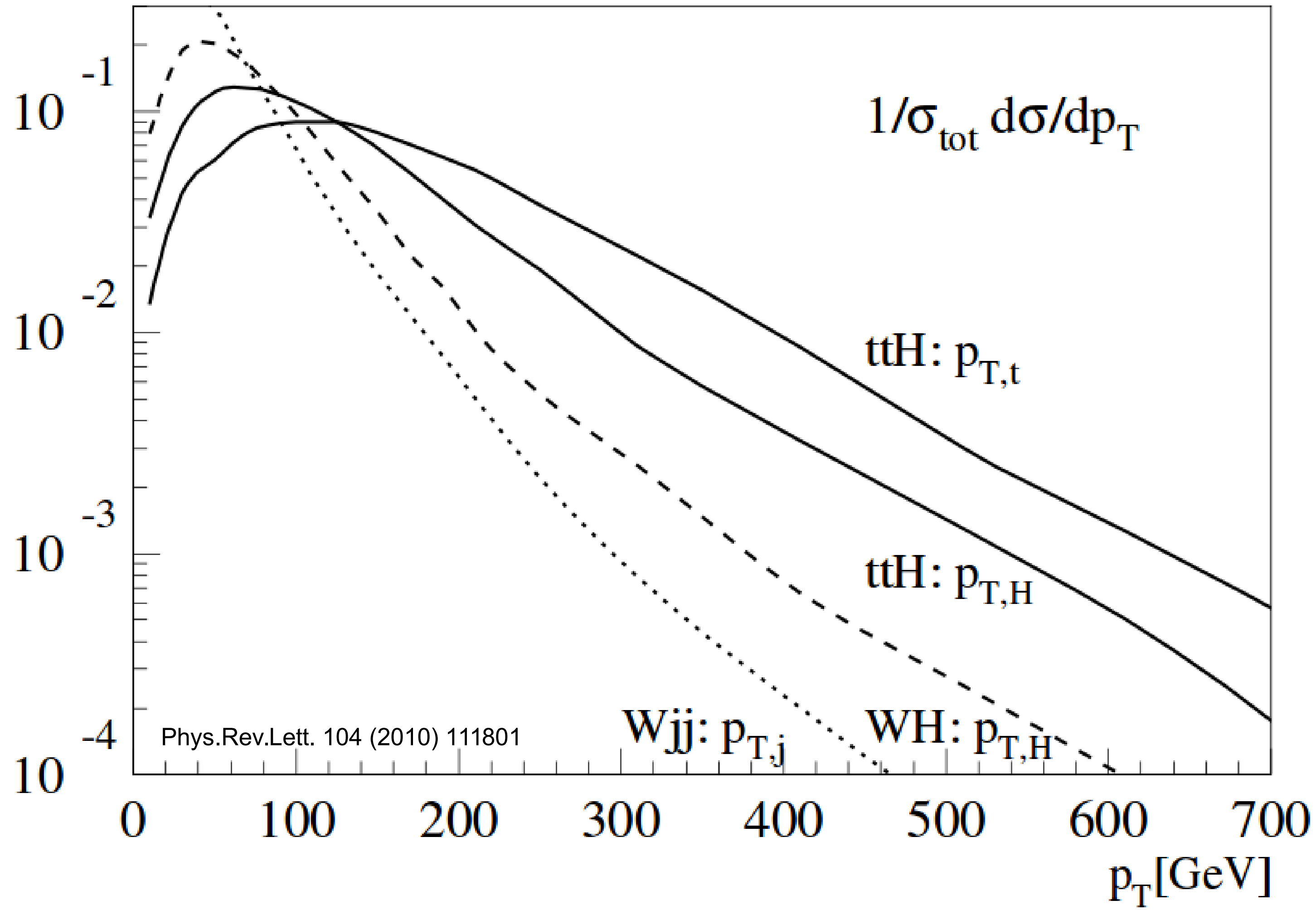
Search topology

- Signature:
  - high p_T lepton
  - missing transverse energy
  - $\geq$ 6 jets and $\geq$ 4 b-jets
- Very complex final state
- Backgrounds
  - $t\bar{t}+b\bar{b}$ (irreducible)
  - $t\bar{t}V$ (W/Z) (irreducible)
  - $t\bar{t}$+light jets (reducible)
  - others: W+jets, Multijet



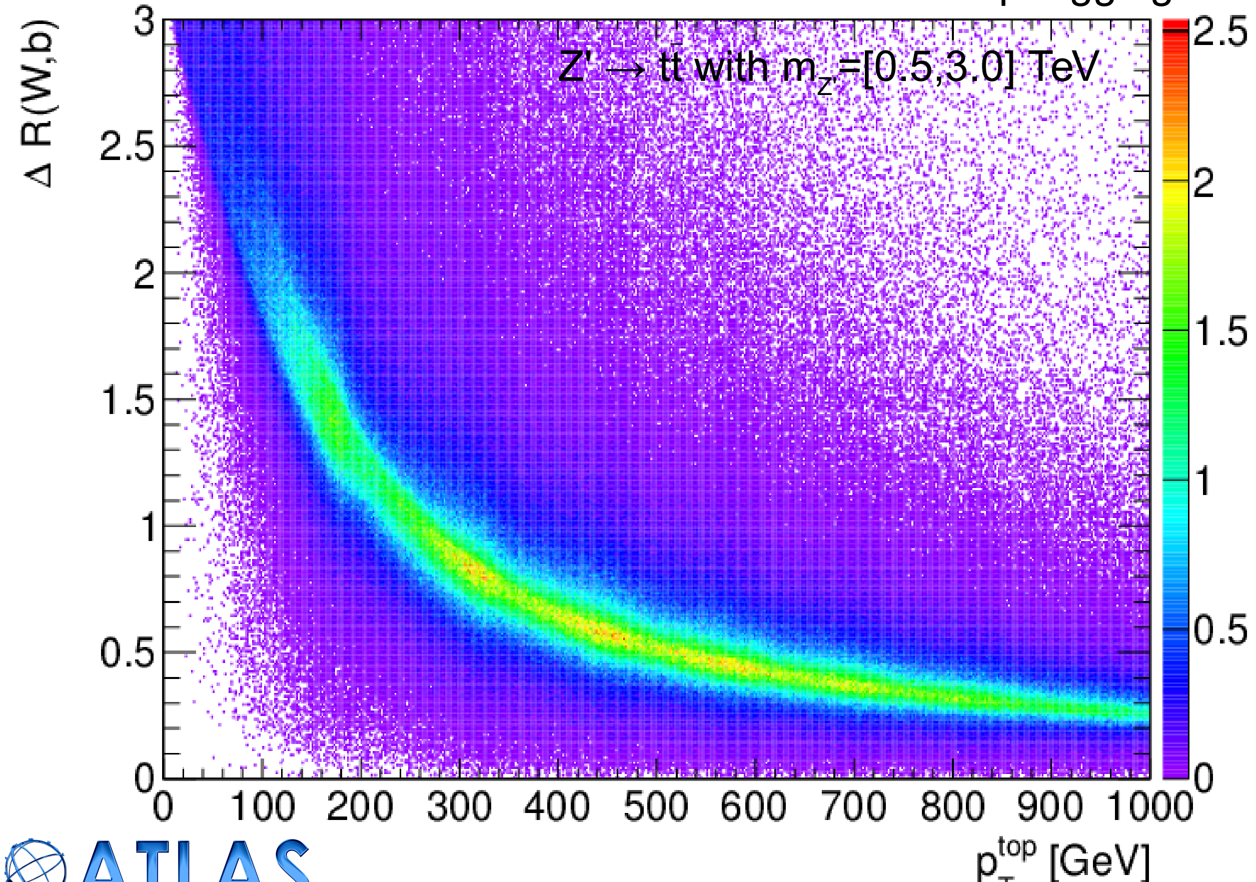
Possible improvements

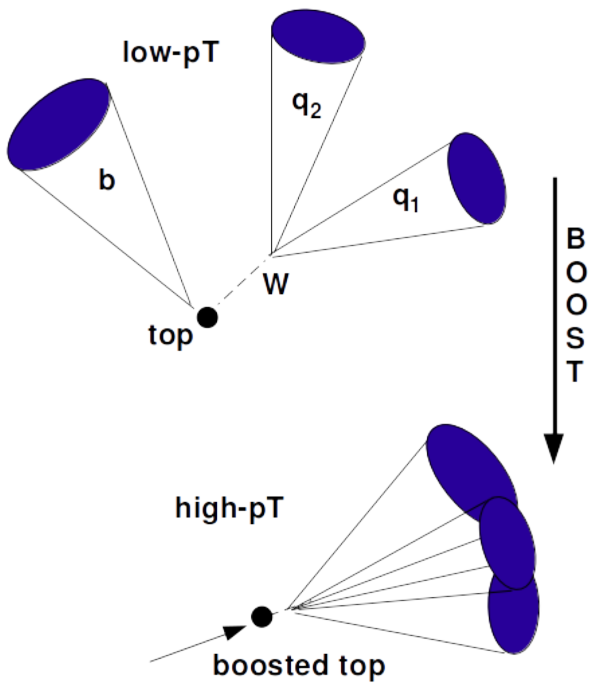
- Usage of boosted objects?



Possible improvements

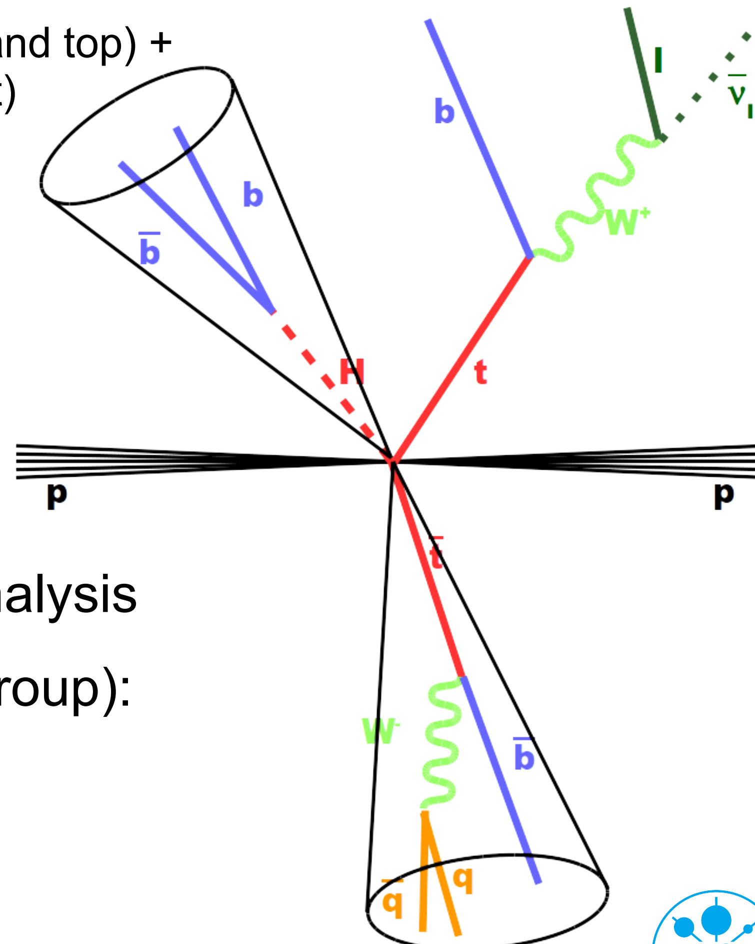
- Usage of boosted objects
  - Rule of thumb: $\Delta R < 2m/p_T$
  - Experience with boosted tops in our group
  - Worked on $t\bar{t}$ resonances and used top tagging techniques





Possible improvements

- Usage of boosted objects
  - Less background
  - Reduce combinatorics by confining decay products
  - Cleaner environment, e.g. two fat jets (H and top) + lepton + missing energy + narrow jet (b-jet)
  - $S/\sqrt{B}$~3-5 expected for 100 fb^{-1} @ 14 TeV
    (Phys.Rev.Lett. 104 (2010) 111801)
- Techniques
  - Substructure of jets
  - Top tagging (like HEPTopTagger)
  - Higgs tagger
- Combine this approach with resolved analysis
- Goals for this year (whole boosted $t\bar{t}H$ group):
  - Simulate full analysis (INT note)
  - Be ready for 13 TeV data



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Summary.

- SCT digitization
  - Understand and simulate radiation damage of the SCT detector
  - Timescale: first half year
- $t\bar{t}H$ analysis
  - Study the topology in case of high p_T objects in $t\bar{t}H$ events
  - Use Top tagging and Higgs tagging techniques
  - Timescale:
    - First year: prepare analysis framework and simulate analysis
    - Following years: Use first ATLAS data with 13 TeV