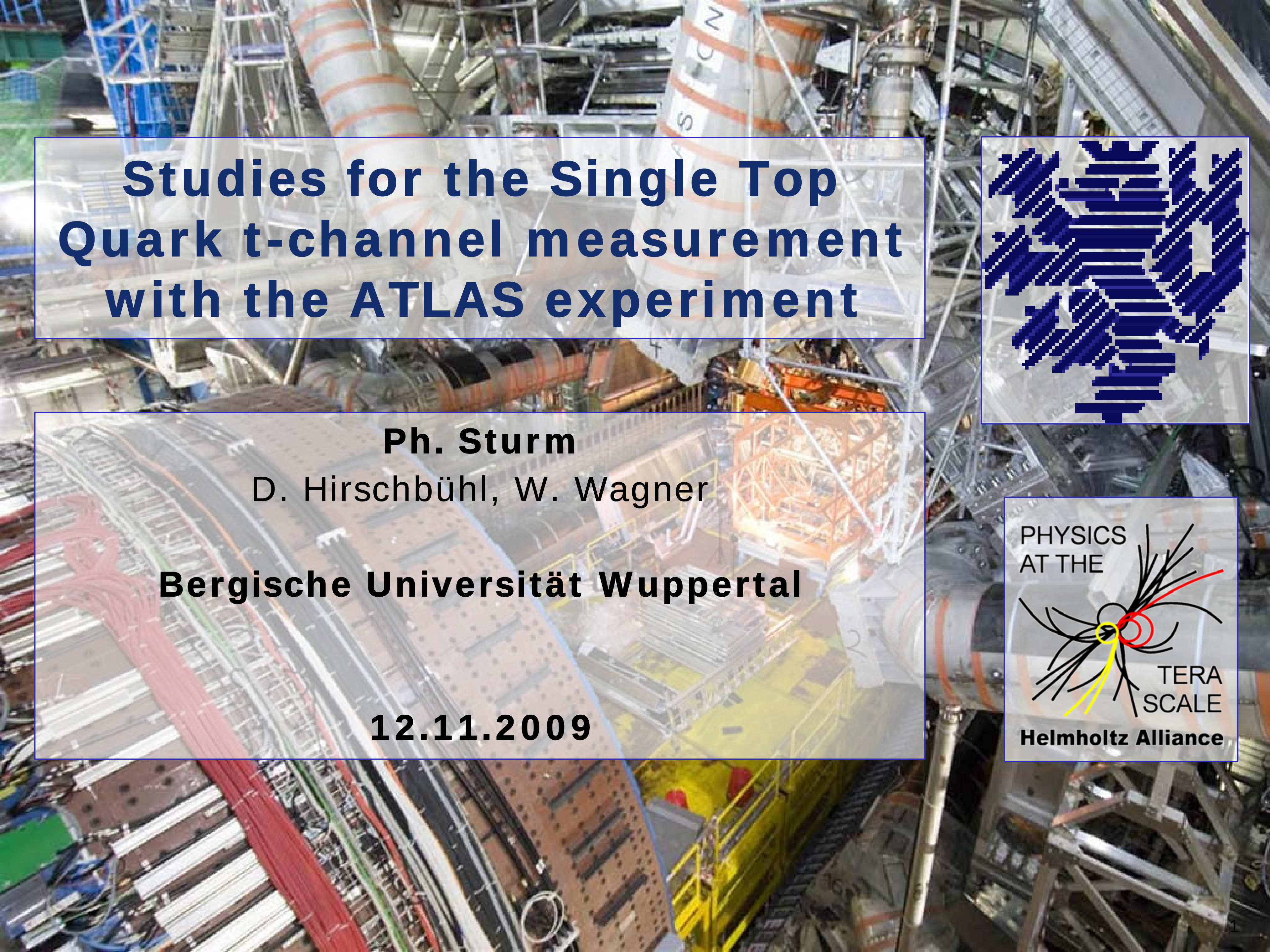

Studies for the Single Top Quark t-channel measurement with the ATLAS experiment

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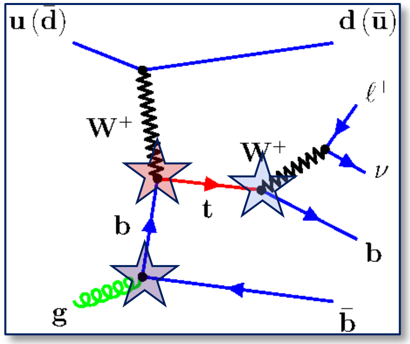
12.11.2009

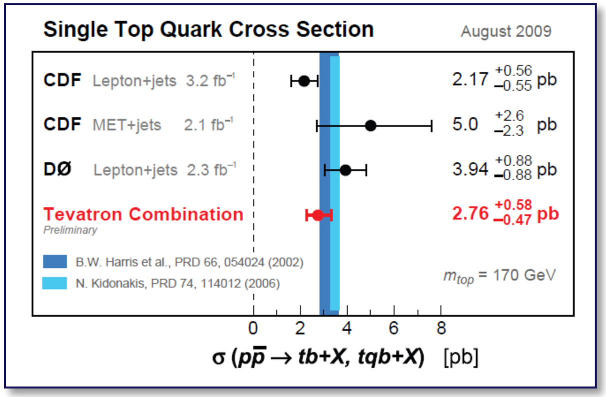
PHYSICS AT THE TERA SCALE

Helmholtz Alliance

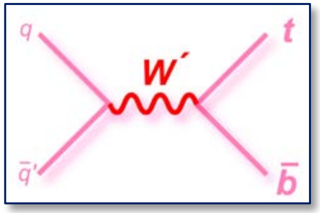
Single Top Quark Production

- Test of V-A structure of W_{tb} coupling
- Direct measurement of $|V_{tb}|^2$
- Test of the b-quark pdf

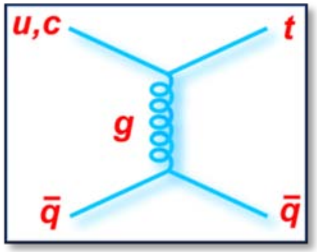




- Sensitive to new physics (4th generation, couplings, production modes, loop effects)
- Background for physics searches beyond the standard model



heavy W', charged H,...

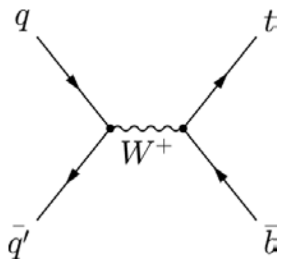


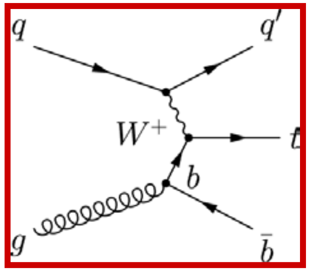
FCNC

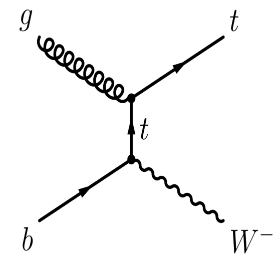
- confirmation of the Tevatron discovery

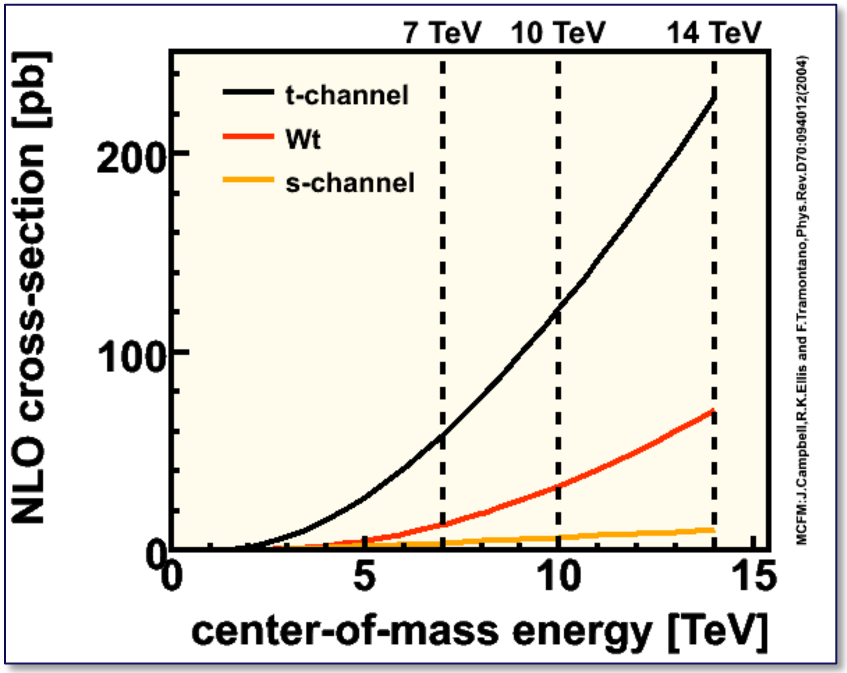
Single Top Quark Production

s-channel	t-channel	associated production









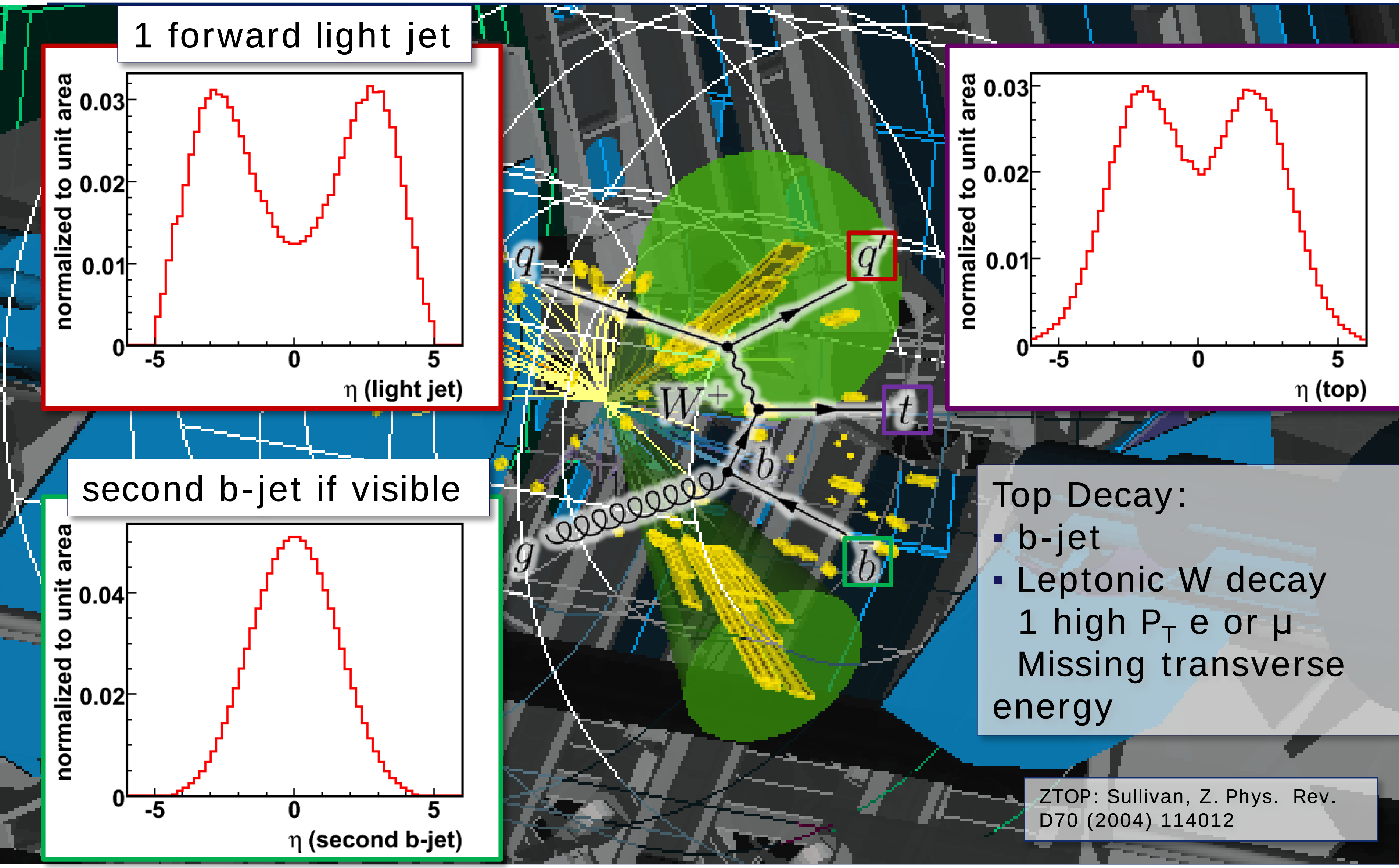
√s	s-channel	t-channel	Wt
1.96 TeV	0.88	1.98	0.094
7 TeV	**3.1**	**65**	**10.6**
10 TeV	5.2	135.7	26.5
14 TeV	10.7	247	56

Exciting at the LHC @ 14 TeV:

- t-channel x-sec rises by factor ~120
- W+jets x-sec rises by factor ~10
- High luminosity

t-channel production is the most promising channel for first data (<1/fb)

Event Topology



Top Decay:

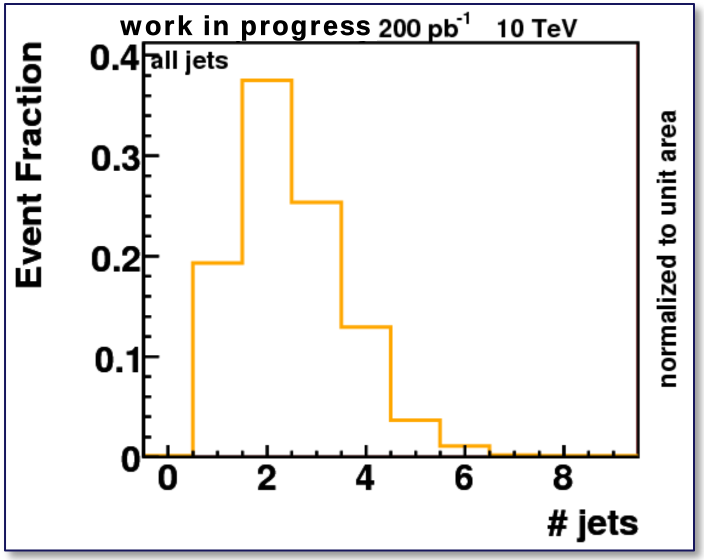
- b-jet
- Leptonic W decay
  1 high P_T e or μ
  Missing transverse energy

ZTOP: Sullivan, Z. Phys. Rev. D70 (2004) 114012

t-channel Event Selection

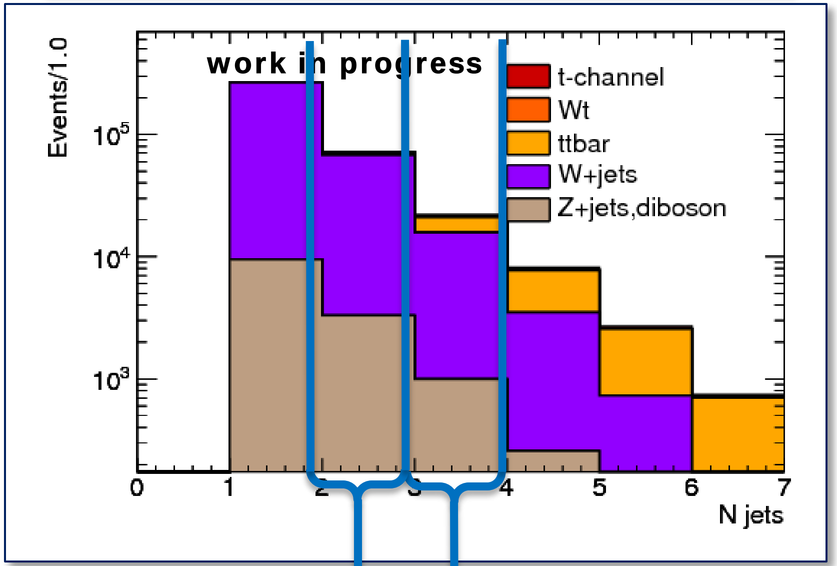
- Trigger
  - 15 GeV Muon or Electron
- Lepton selection (electron / muon):
  - p_T > 20 GeV/c
  - $|\eta|$< 2.5, electron not in crack region
  - isolated in ΔR < 0.2
- Jets
  - ATLAS Cone 0.4 jet finder
  - p_T > 30 GeV/c²
  - $|\eta|$< 5
- b-tagging
  - JetProb e_b= 45%, rej. = 93
- Overlap removal
  - 1. select electrons
  - 2. remove overlapping jets ΔR < 0.2
  - 3. remove muons overlapping with jets ΔR < 0.3

- Exactly one lepton
- 2 or 3 jets
- 1 b-tagged jet
- $E_{T,miss}$ > 20 GeV

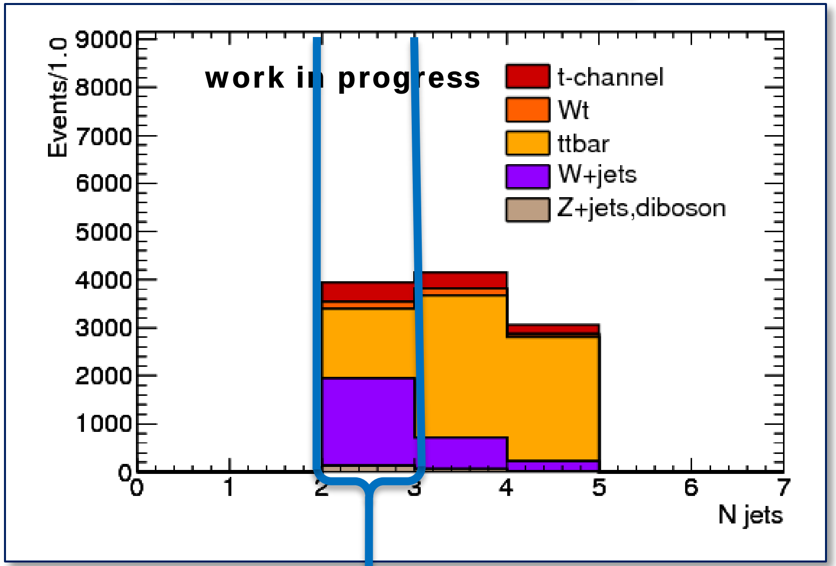


Analysis Strategy

Before b-tagging (pretag)



After b-tagging

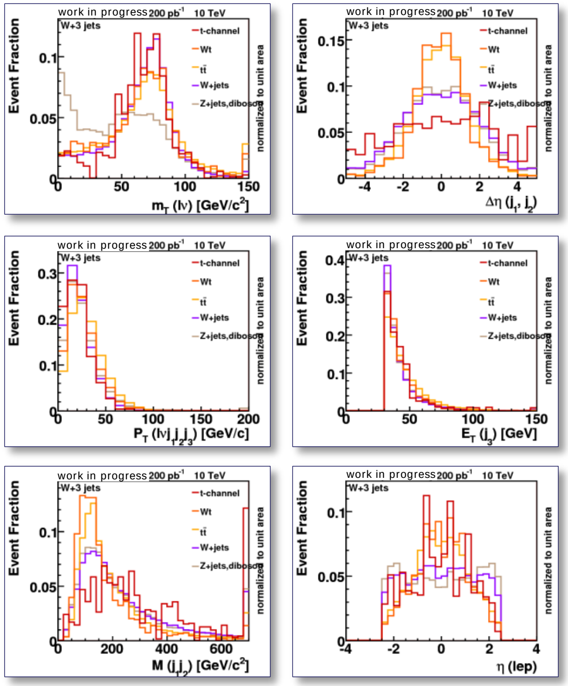


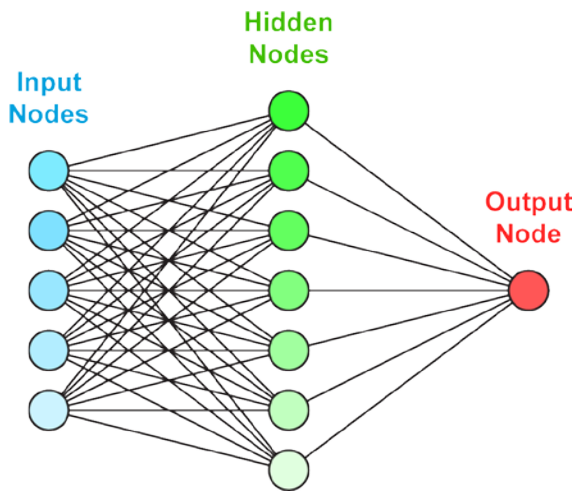
Validation of NN techiques

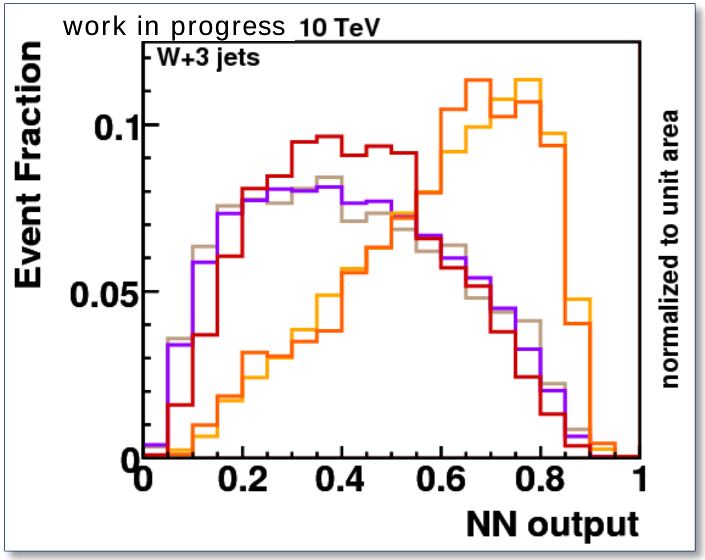
Normalization of tt and W+jets background using neural networks

Extraction of t-channel cross section using neural networks

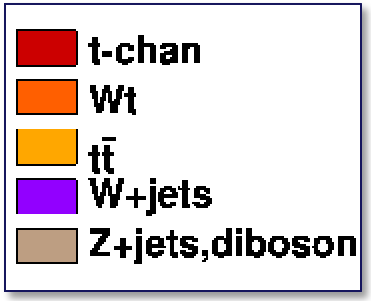
Neuronal Network Techniques for the background estimation





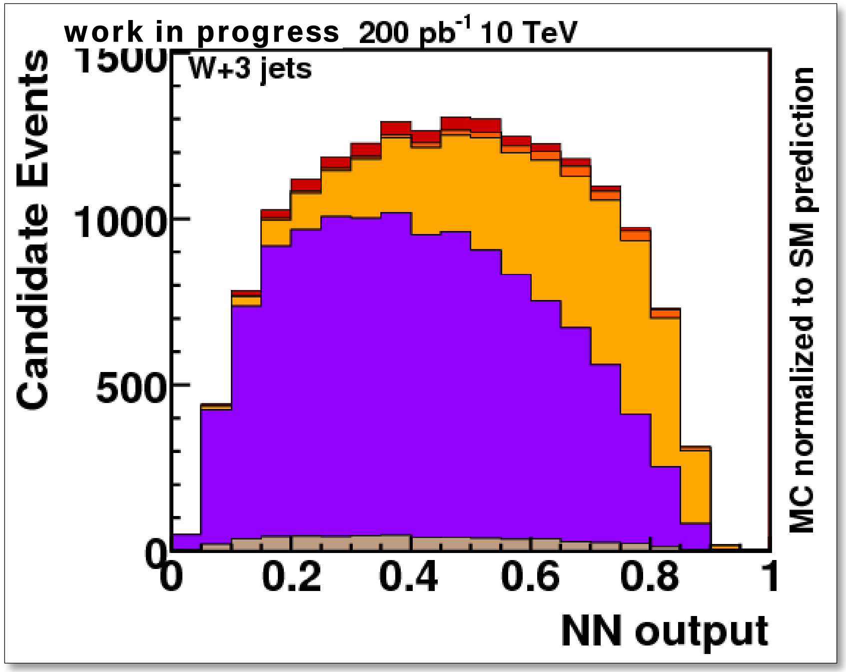


- Feed forward NN (NeuroBayes) with variable preprocessing
- Events with 3 jets, no b-tag information
- Trainingsample W+jets and tt (50% / 50%)
- 10 input variables, 15 hidden nodes

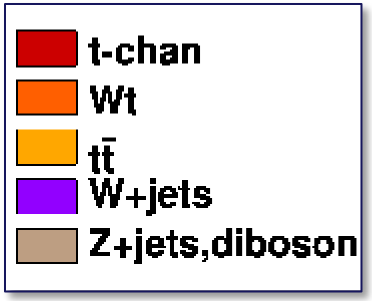


Determination of tt and W+Jet fractions in the 3 jet dataset

Process	
W + jets	68%
Z + jets, diboson	5%
tt	24%
Wt/t-channel	3%

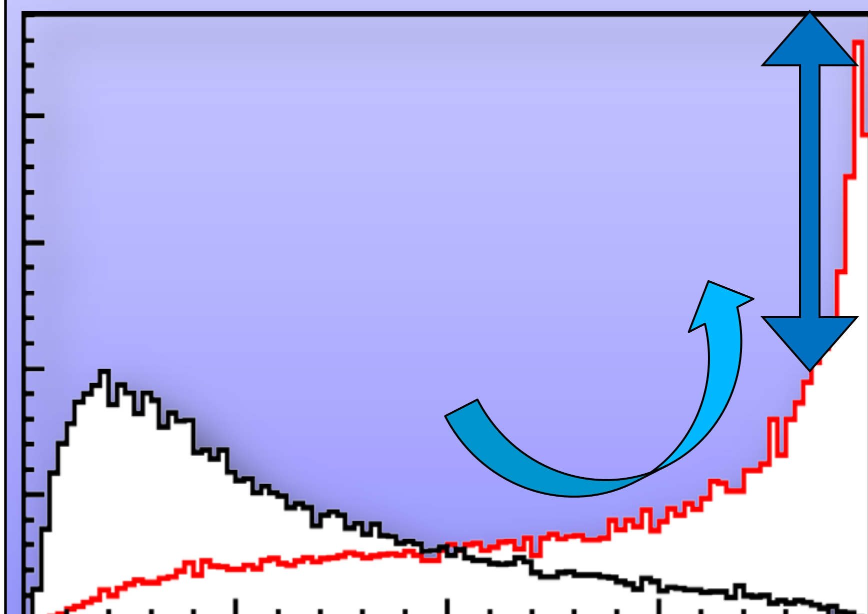


- Binned Log Likelihood Fit of NN output to (pseudo)-data
- Determination of tt and W+jet fraction $\beta=\sigma_{Fit}/\sigma_{SM}$
- Fix Wt & t-channel
- Z + jets: Gaussian constrain of 20%



Sensitivity and Systematic Uncertainty on the Background Estimation

- Determine fit sensitivity with pseudo experiments
- Statistical uncertainty is given by the RMS of the β distribution
- Systematic uncertainties by the shift of the β-mean
  - Shape of the NN output distribution
  - Rate of the Number of expected events

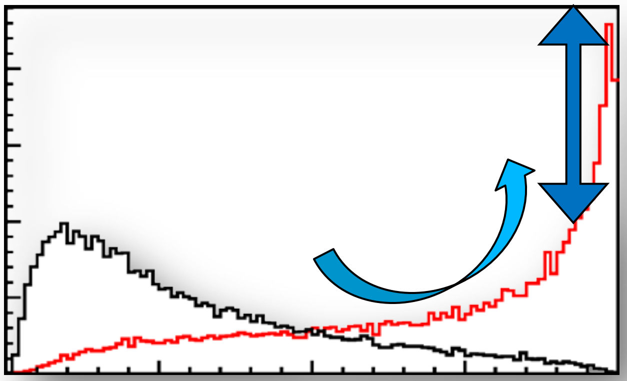


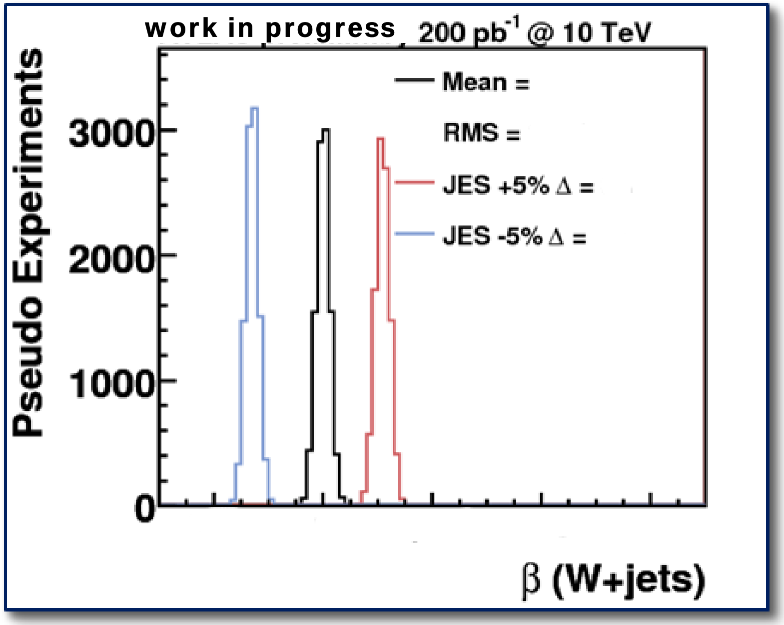
- Important Systematic Uncertainties are:
  - Jet Energy Scale
  - PDF Uncertainty
  - ISR/FSR
  - W+Jets Q^2-Scale

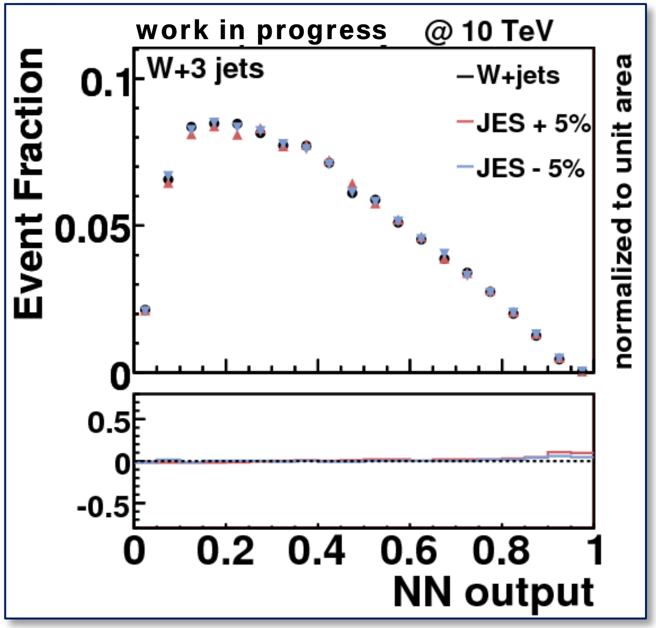
Uncertainties e.g. JES

- JES uncertainty: ~O(±10%)
- Shape uncertainty: ~ O(±2%)
- Acceptance change: ~ O(±10%)

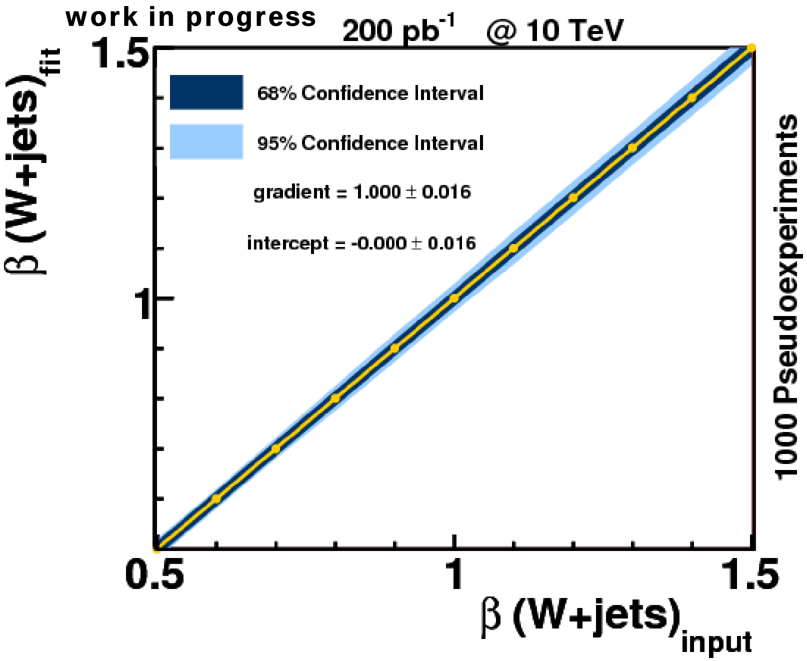
- Shape of NN robust against shape effects of the JES

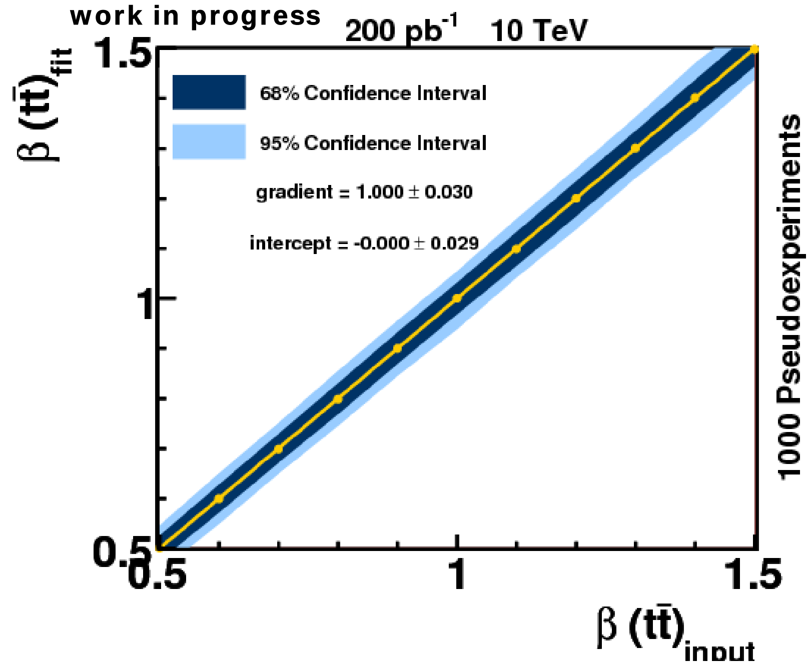






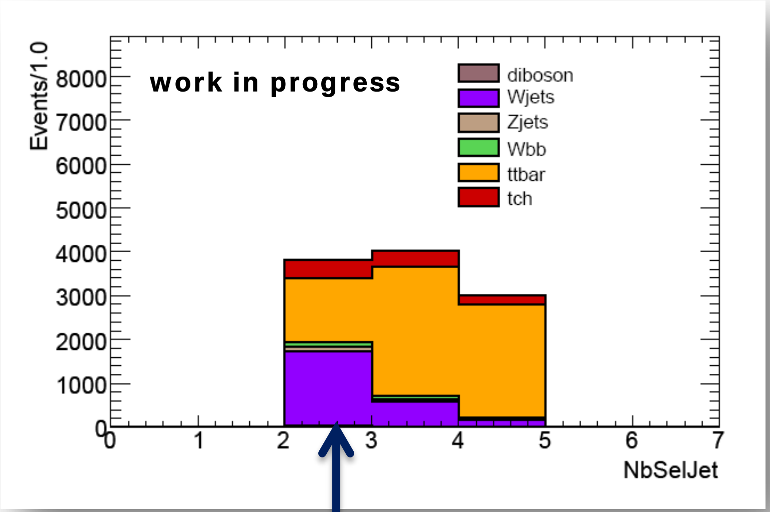
Linearity of the Method





- Check if fit returns the assumed cross section in the pseudo-data
- Vary input cross section σ_{SM} and repeat fit
- Expect linear response

Crosssection Measurement



- 2 Jets with 1 b-tagged jet
- Train neural network to separate single top from background
- Training with angular varaibles, invariant masses
- Binned likelihood fit to NN distribution to determine event rate

Use events with 2 jets and one b-tagged jet

Validation of the NN techniques

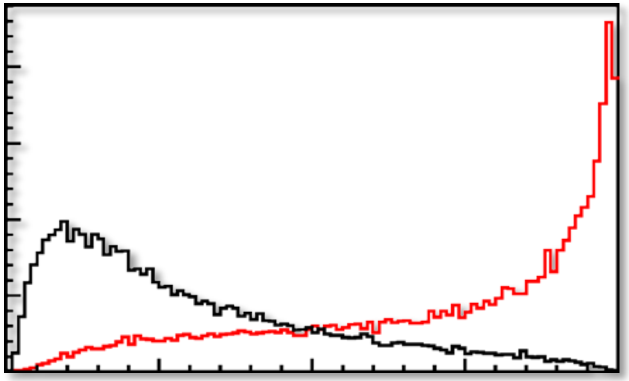
- Plan: Measure t-channel cross section with NN
- Need Validation of NN techniques:
  - For this exercise we use a NN trained with events with 2 jets and at least 1 btag

Validation of input variables and correlations
- Events with 2 jet 0 tag
- Each lepton type separately

Choose well modeled ones

This exercise uses 10 input variables for the NN.

Train network



Validation of NN output
- Events with 2 jet 0 tag
- Slice & Dice 2 jet 0 tag
- Output itself

Conclusion & Outlook

Aim for the first LHC data:

- Develop data driven techniques to measure the W+Jets and tt background form the sidebands
- Data driven estimate of the QCD contribution
- Explore NN techniques for the analysis – develop methods to validate the MVA methods with data
- Study of systematic uncertainties
- With enough integrated luminosity measurement of the single-top t-channel cross section