Semileptonic top pair decays $t\bar{t} \rightarrow b\bar{b}q\bar{q}\ell\nu$ with the CMS detector

A. Floßdorf, B. Hegner, J. Mnich, **Ch. Rosemann**

DESY Hamburg

15.03.07 HERA and the LHC Workshop

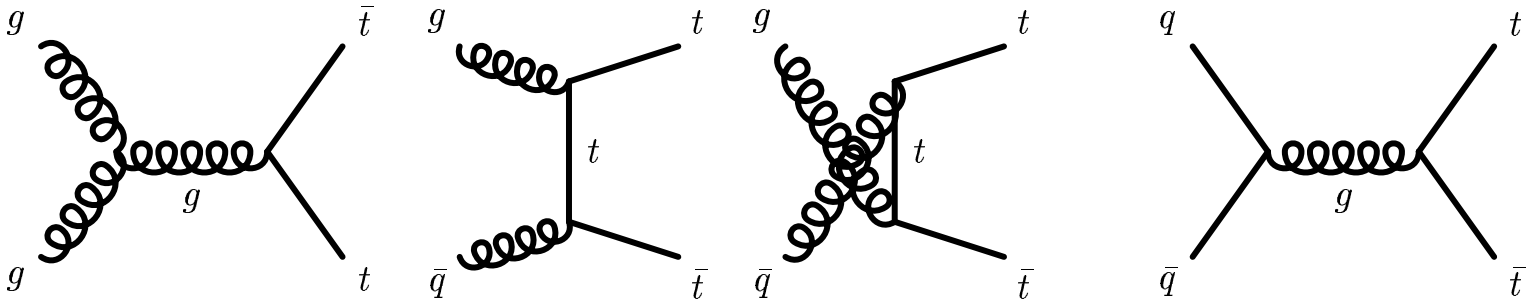
Talk Overview

Emphasis: Selection Development

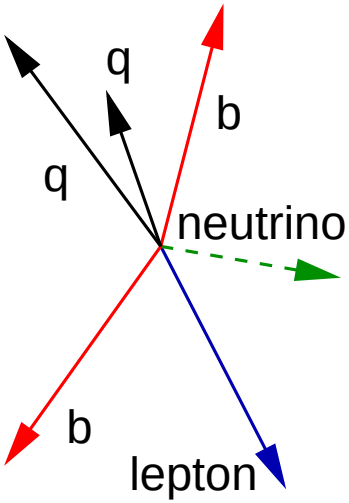
1. Motivation
2. Simulation and Reconstruction
3. Selection

Semileptonic $t\bar{t}$ decays – $t\bar{t} \to b\bar{b}q\bar{q}\ell\nu$

Production 90% $gg \to t\bar{t}$ and 10% $q\bar{q} \to t\bar{t}$ in pp at 14 TeV



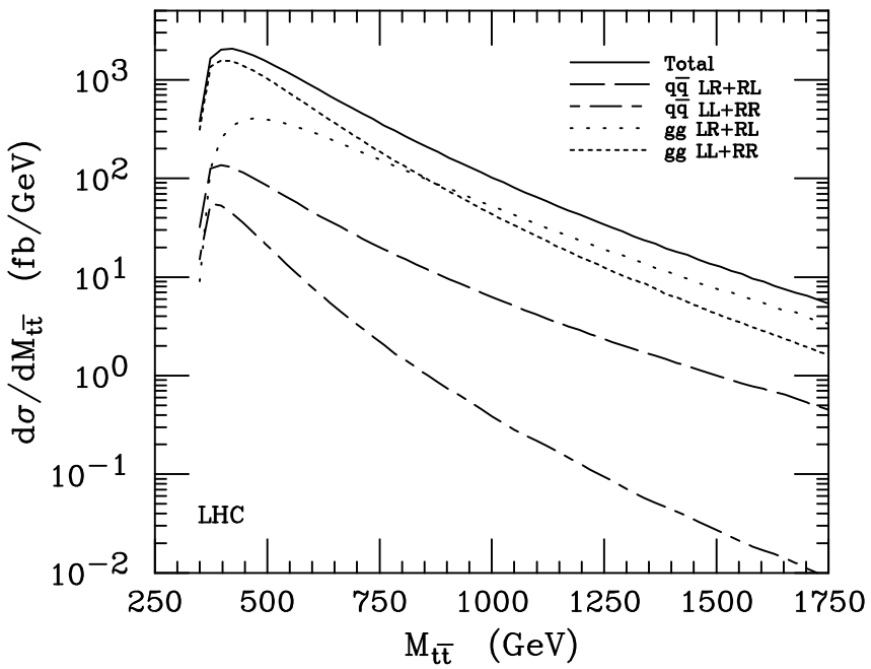
Decay $t \to bW \approx 100\%$, that is $t\bar{t} \to WWb\bar{b}$

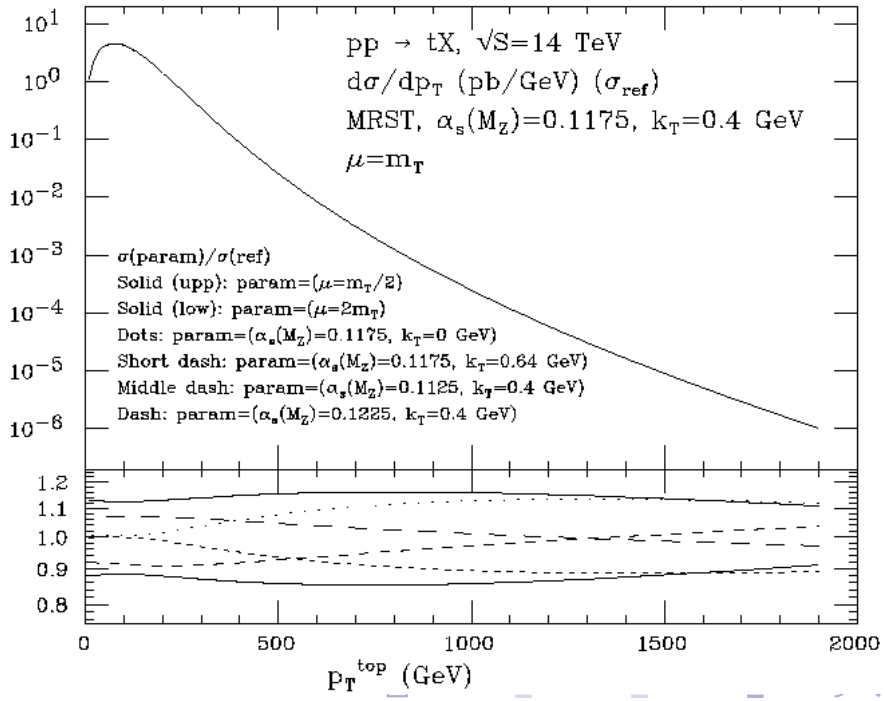


- search for (exactly) one electron or muon
- at least four jets
- two jets with high *b probability*
- missing transverse momentum/energy

Motivation – The Standard Model and more

- Top quark most unknown known particle (quantum numbers, exact mass,...)
- Special connection to EWSB (e.g. Yukawa coupling $G_{top} \approx 1$)
- Differential distributions especially sensitive

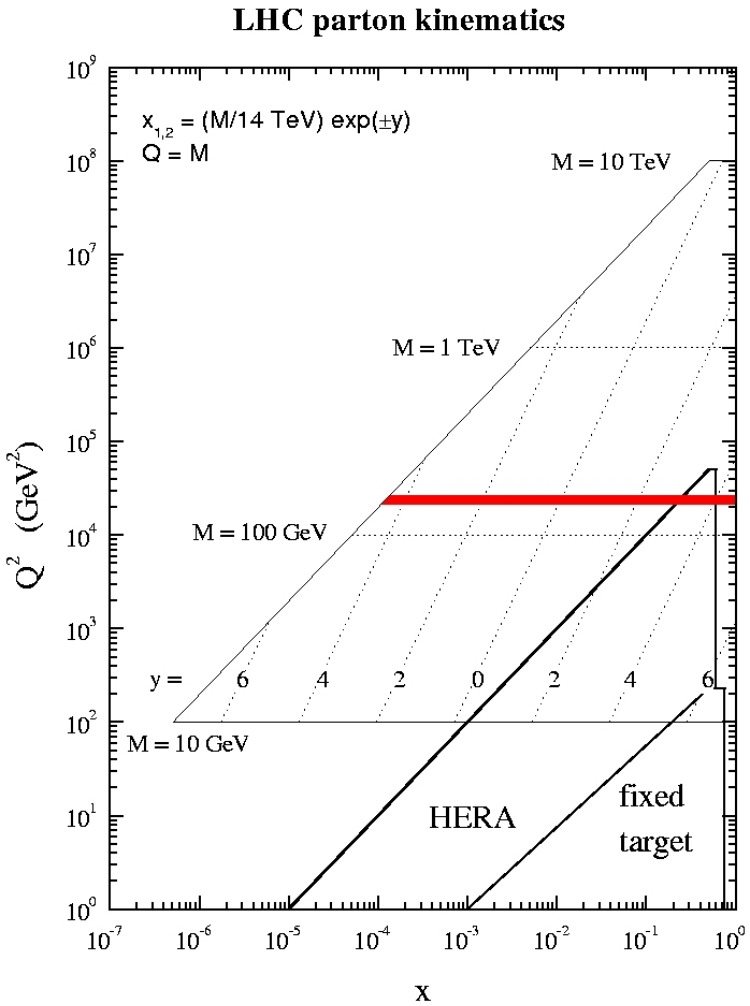




Motivation – The detector

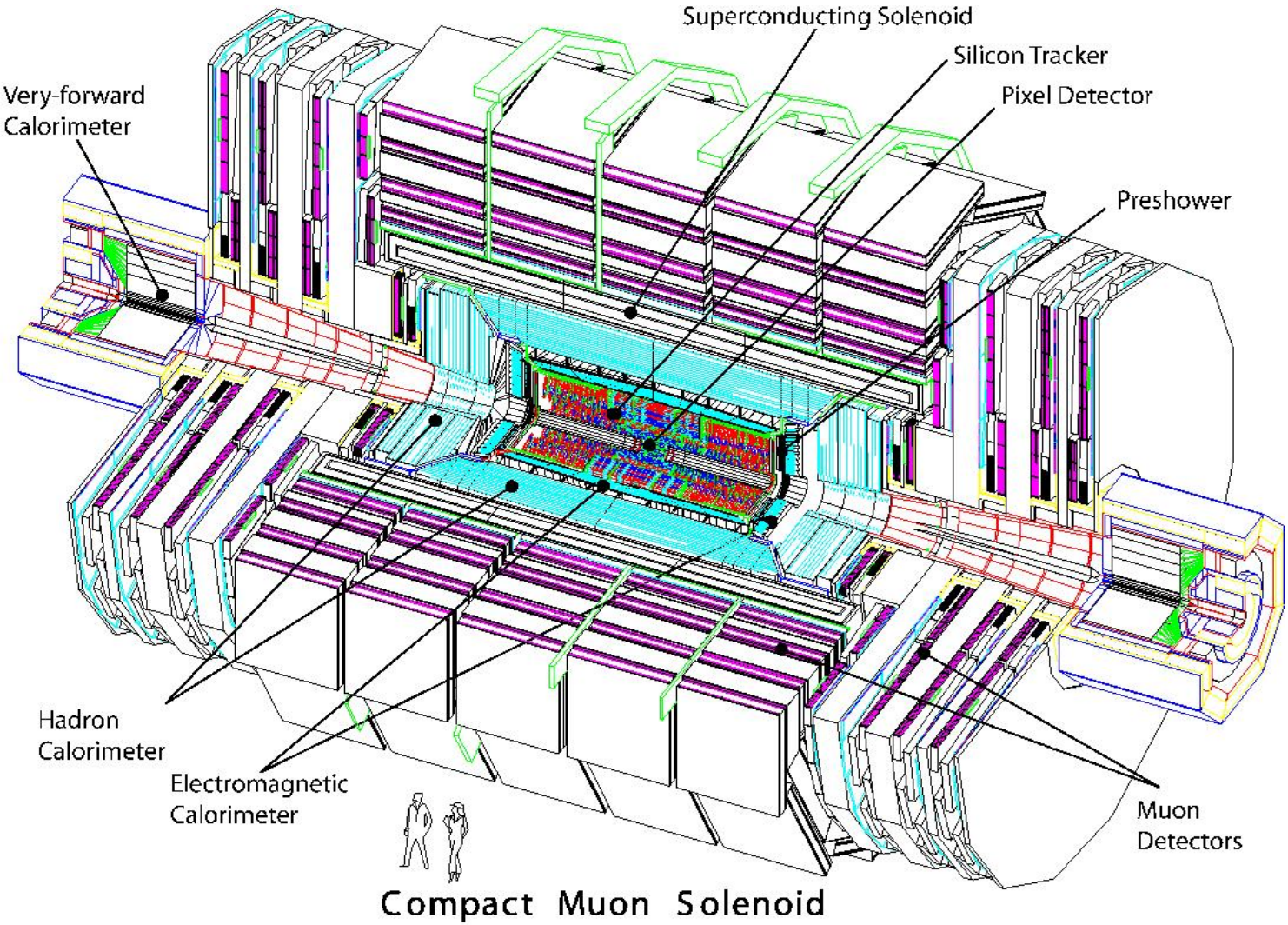
- Interplay of all detector components
  - Vertex detector especially for b-tagging
  - Tracker and Ecal for electron reconstruction
  - Muon system and tracker for muon reconstruction
  - ... and of course for jets (Calorimeters and tracking)
- $t\bar{t}$ decays as benchmark or calibration process
  e.g. jets of W decays for energy scale
- But: definitely not tasks for the first day

Motivation – Parton Density Functions

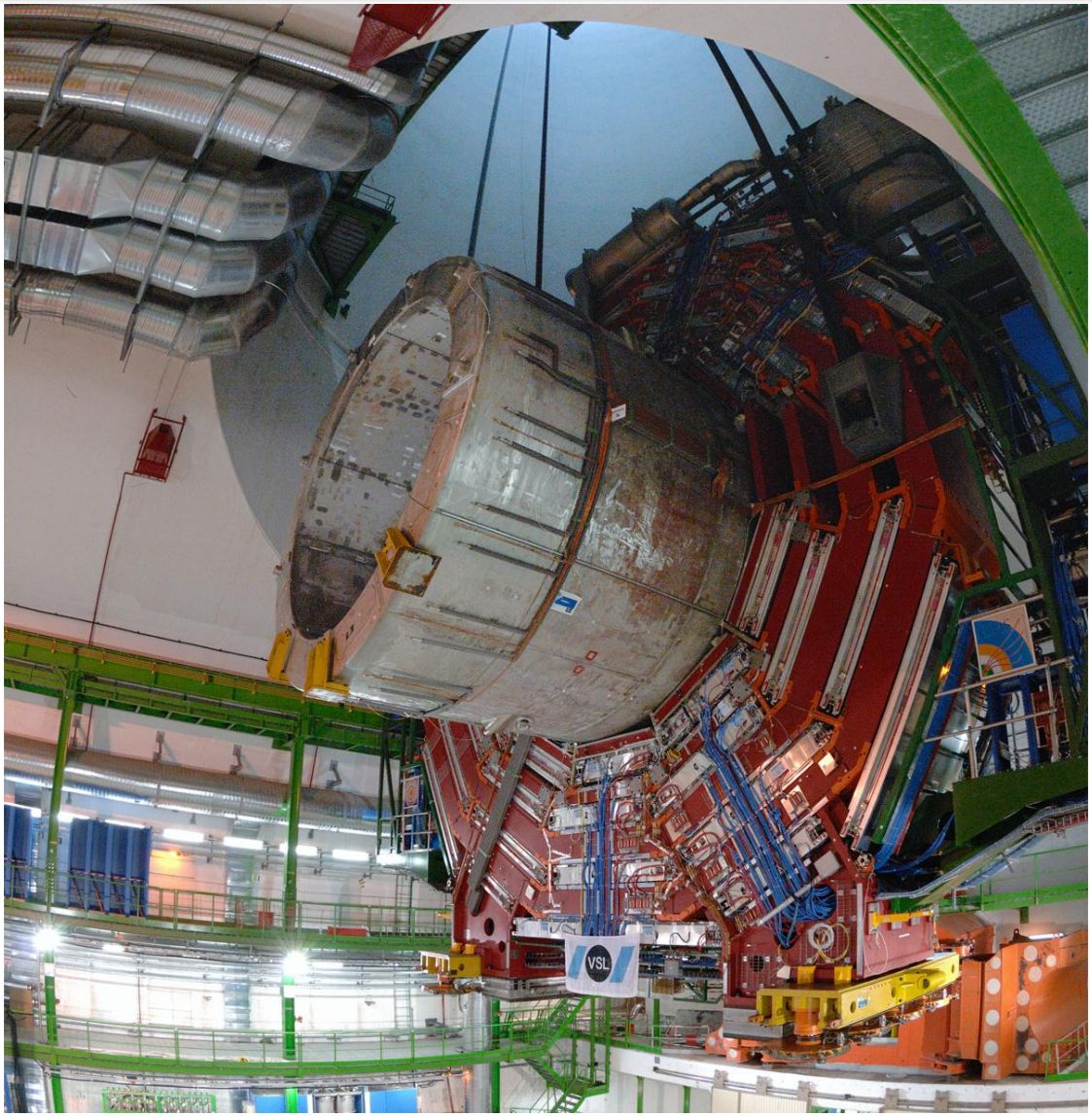


- Gluon pdfs of utmost importance
- Symmetric production threshold $x_0 = \frac{2m_{top}}{\sqrt{s}} = 0.025$
- Test of QCD
- In particular: experimental test at high Q^2
  DGLAP vs. CCFM vs. ?

The CMS detector



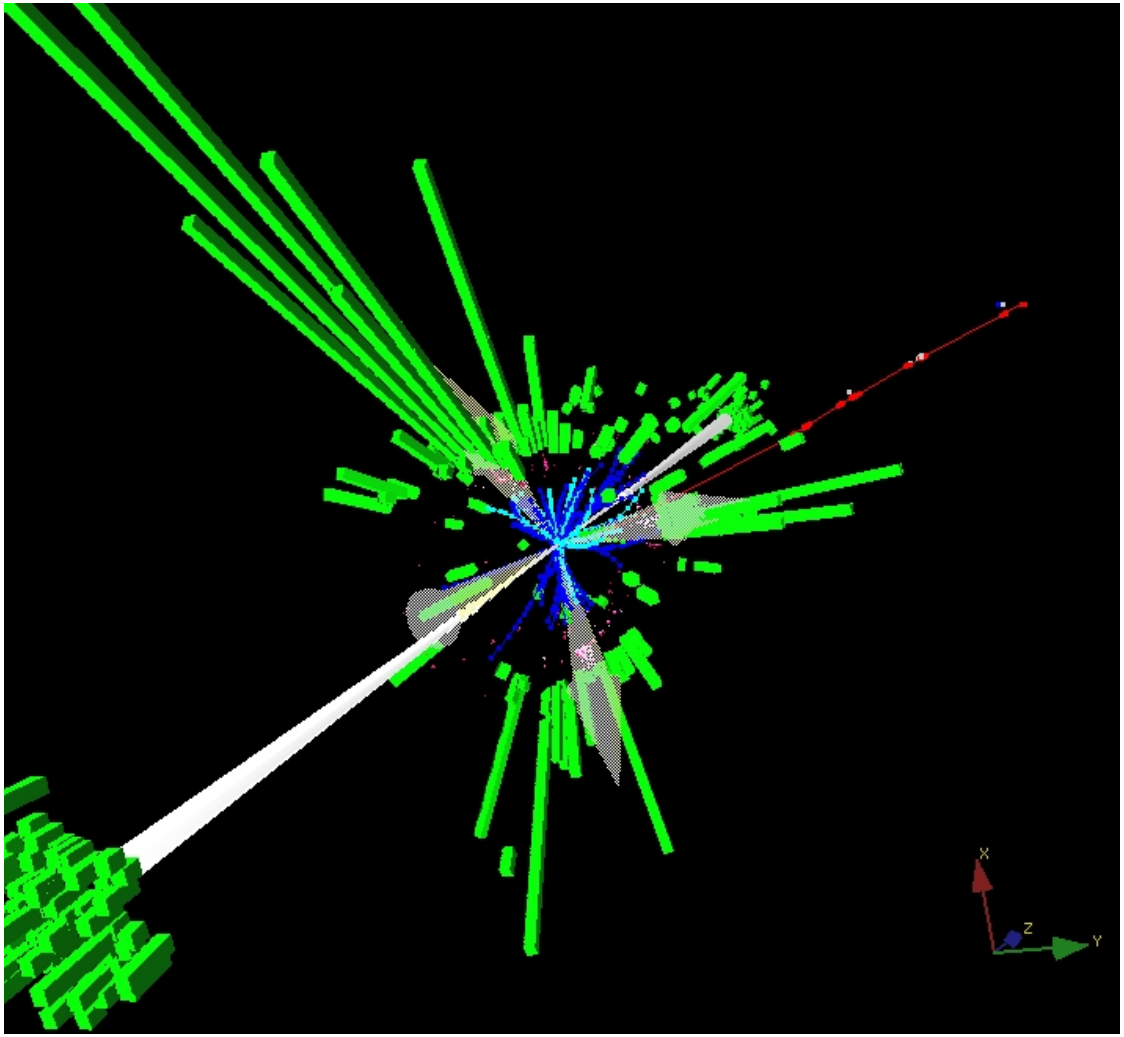
Simulation and Reconstruction



Reminder:

- No LHC yet
- No CMS yet
- No real data
- Only simulation
- Old CMS framework
- Pythia6 + Geant4 + Reco

Signal event display $pp \rightarrow t\bar{t} \rightarrow \mu\nu b\bar{b}q\bar{q}$ (simulated)

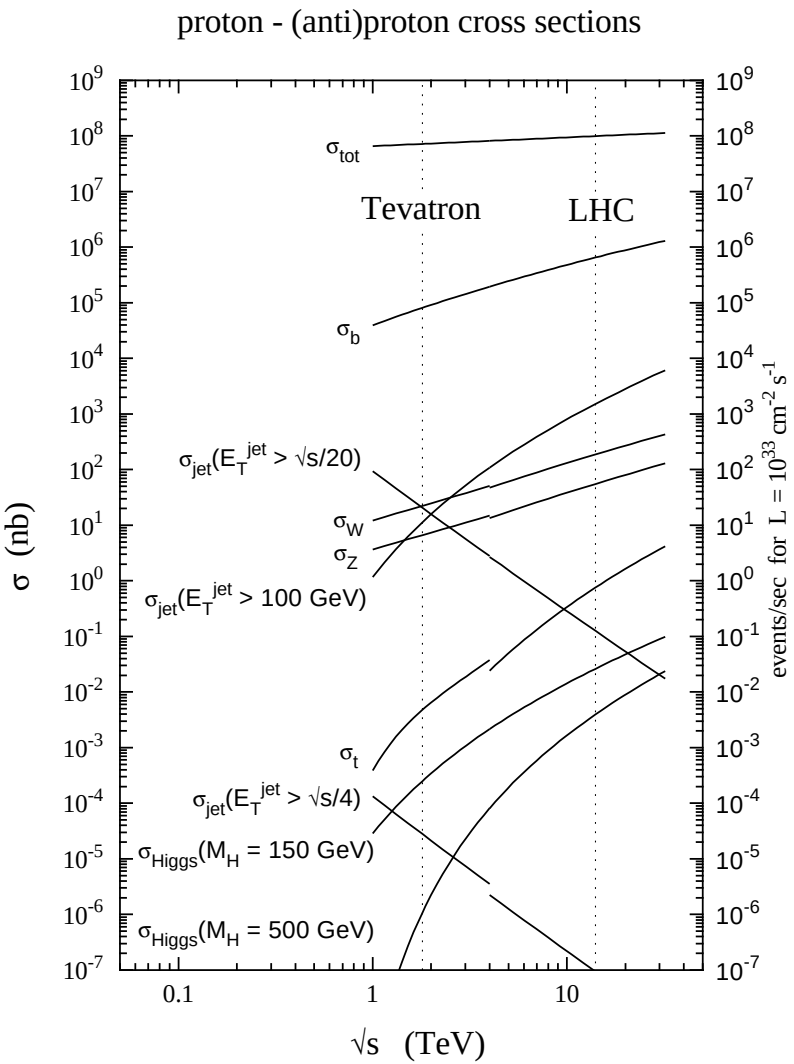


Chain:

1. Hits, ADC counts
2. Tracks, Cluster
3. Jets, Electrons, Muons, ...

(Legend:
green: Clusters
blue: Tracks
red: Muon
white arrows: Jets)

Event rates

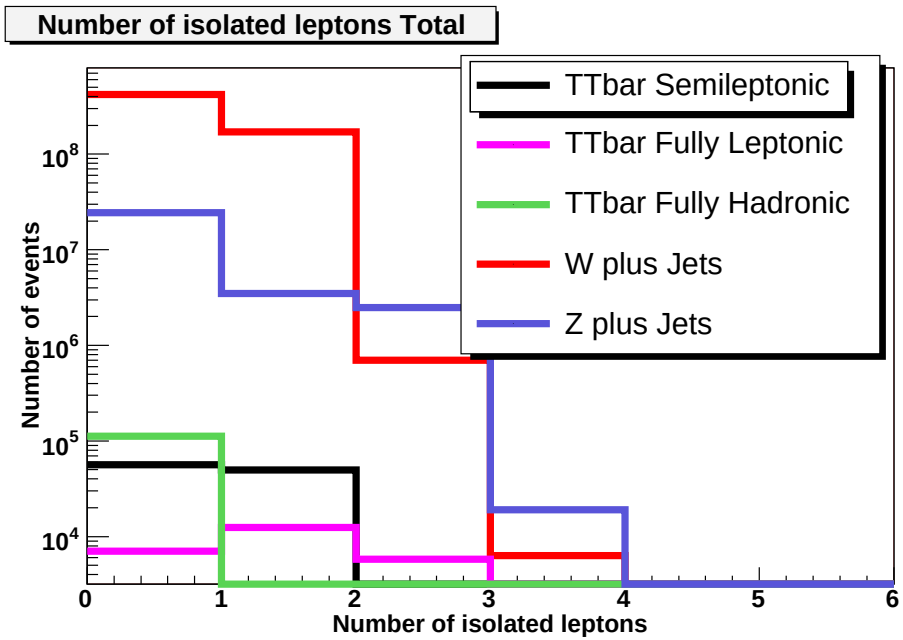


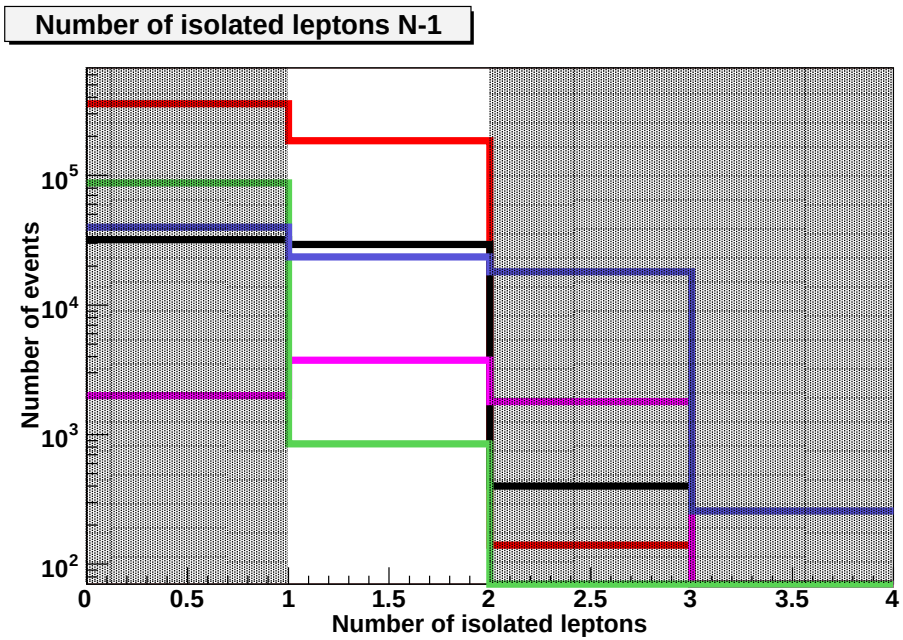
Background processes:

- W+Njets ($W \rightarrow \ell\nu$), N $\geq$ 4
- Z+Njets ($Z \rightarrow \ell\bar{\ell}$), N $\geq$ 4
- Di-Boson WW, ZW, ZZ
- ”QCD” (dijet, multijet)

Preselection: Exactly one isolated lepton

- Lepton:
  - Electron: candidate with Likelihood Ratio $>$ threshold
  - Muon: *globally* reconstructed muon
- Isolation (in cone with radius $\Delta R < 0.2$):
  - Tracks ($n \leq 2$, $\sum_p \leq 1.1 p_\ell$)
  - Calorimeter ($\sum_E \leq 1.1 E_\ell$)

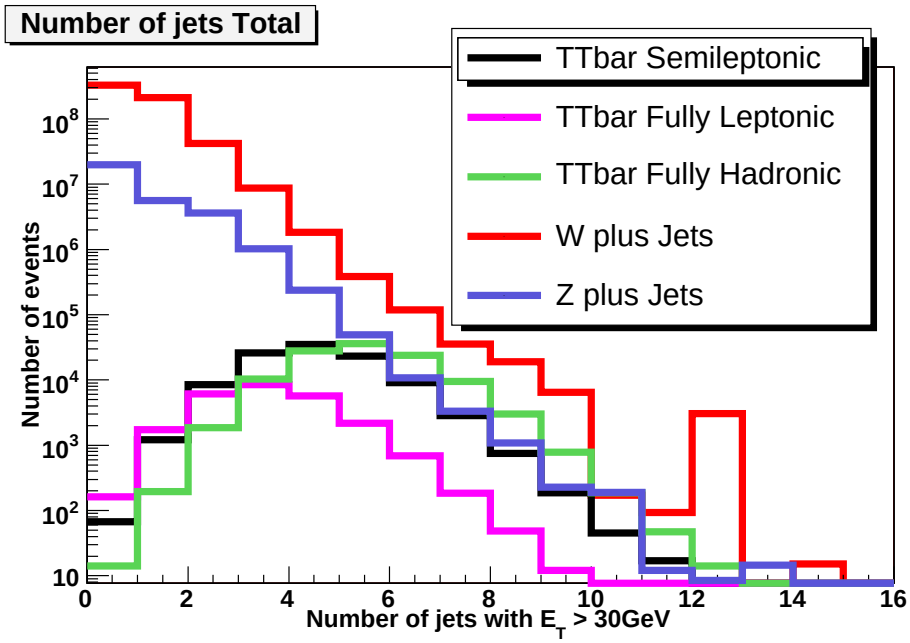


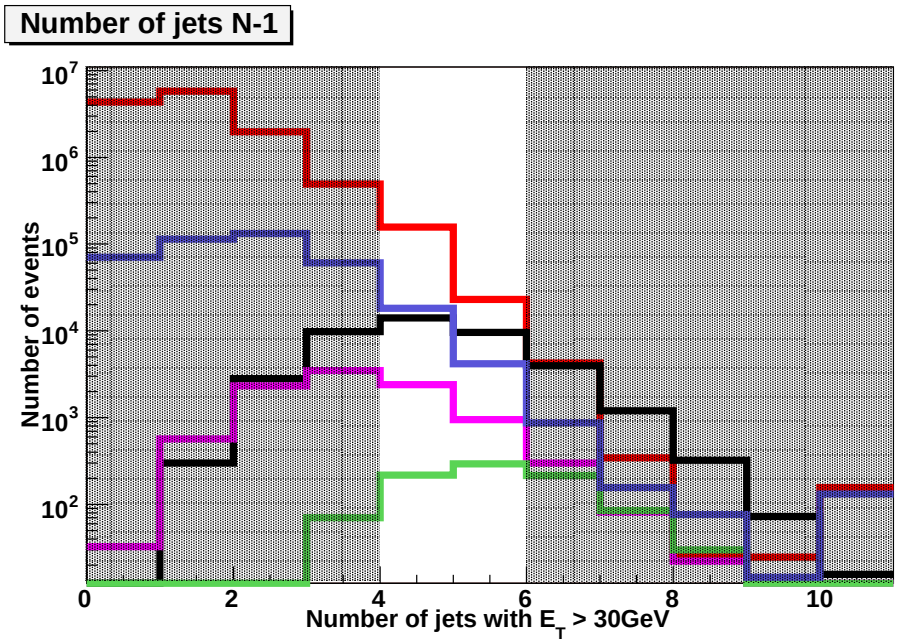


(QCD not shown)

Preselection: 4 or 5 jets

- Iterative Cone $\Delta R = 0.5$ with e/γ calibration
- energy threshold: only jets with $E_T > 30\,\text{GeV}$

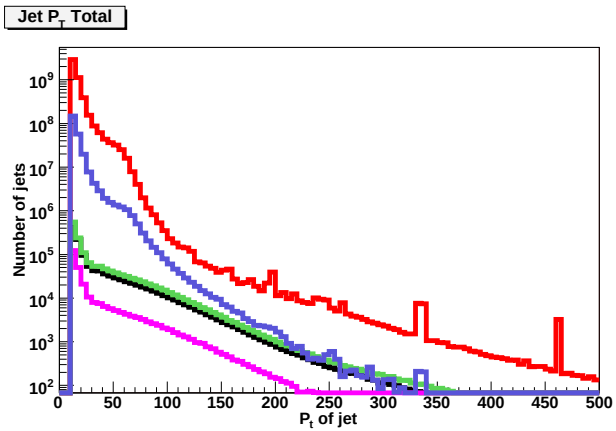


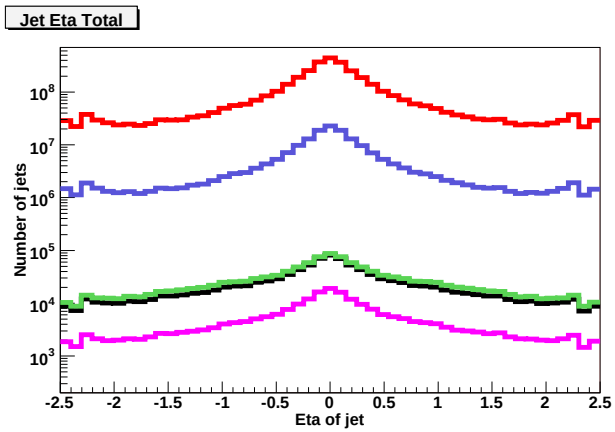


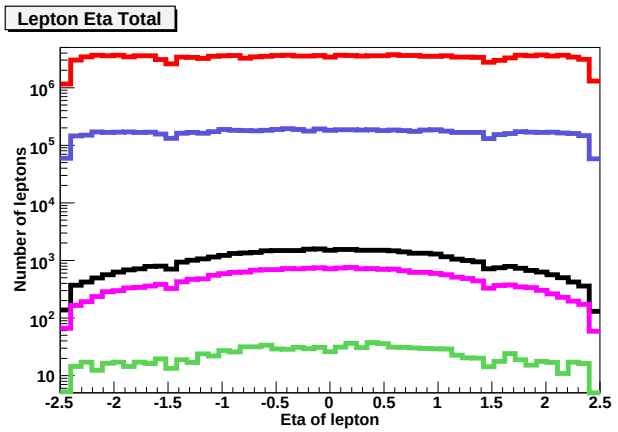
(QCD not shown)

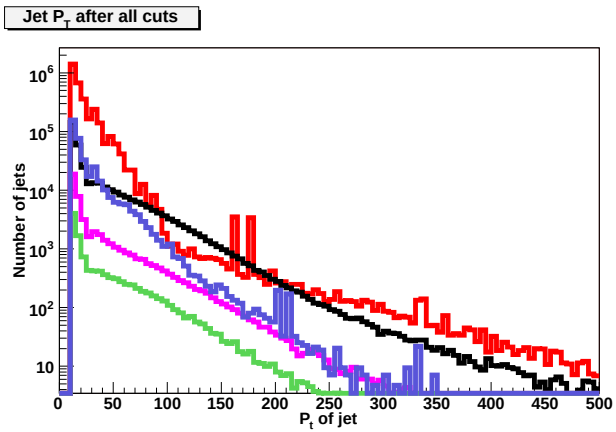
Basic principle: Acceptances and Corrections

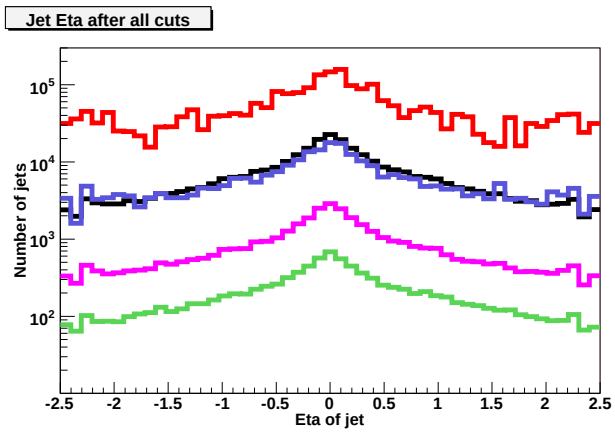
After preselection S:B $\approx$ 1:10 (85% W+jets), $\epsilon_{signal} = 28\%$

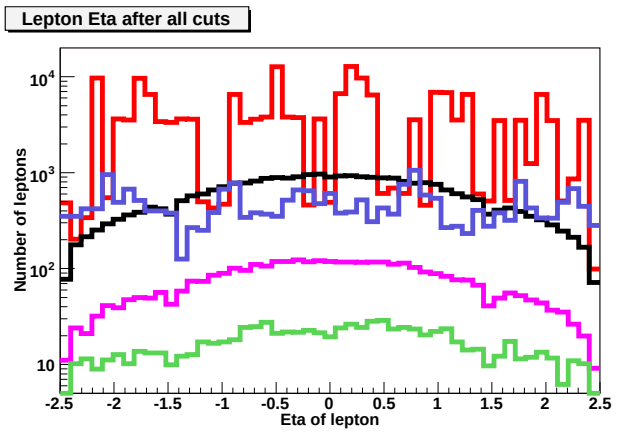






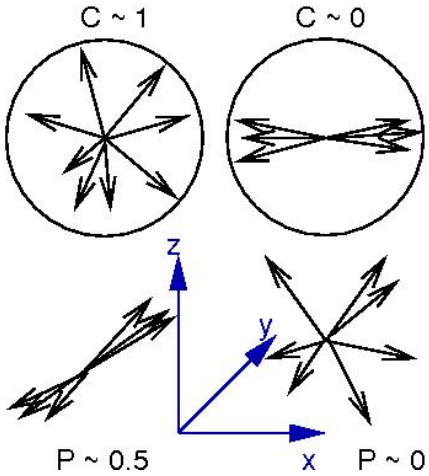


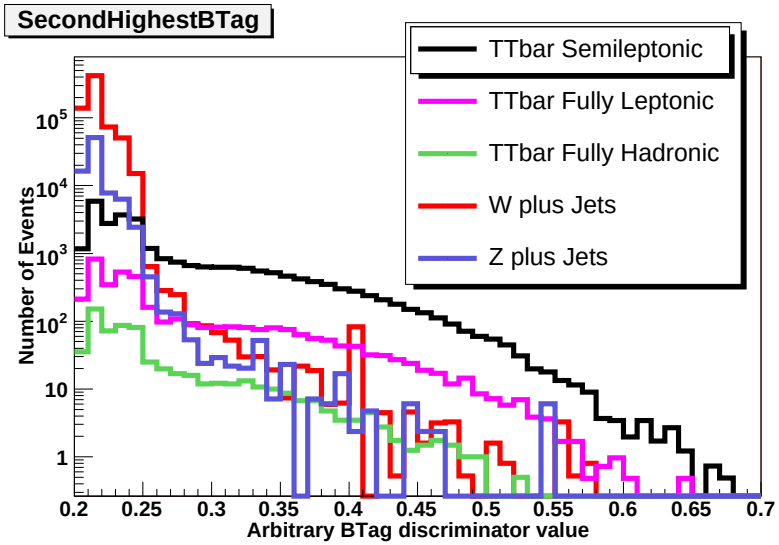


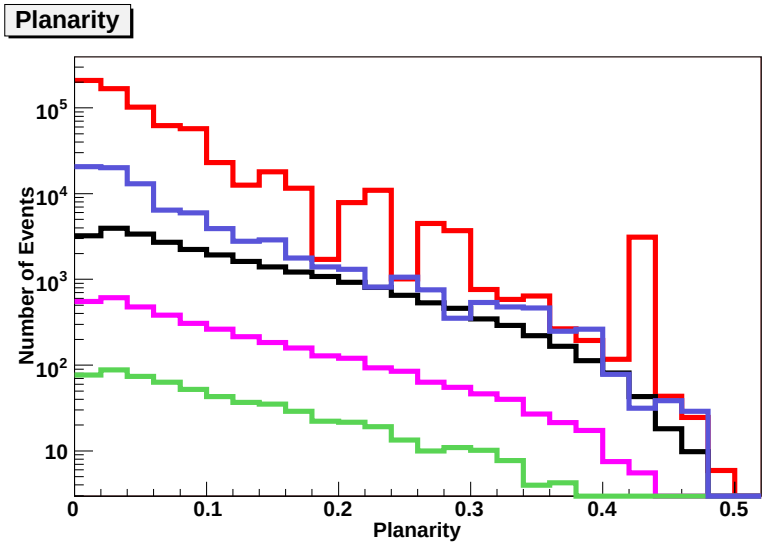


Selection Variables

- B-Tagging
  - 1st or 2nd highest discriminator value
- Event Shape variables
  - Circularity
  - (A)Planarity



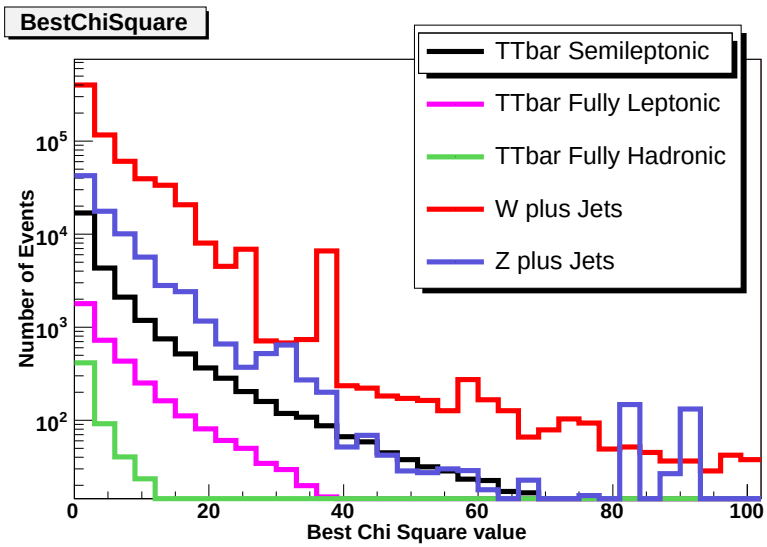


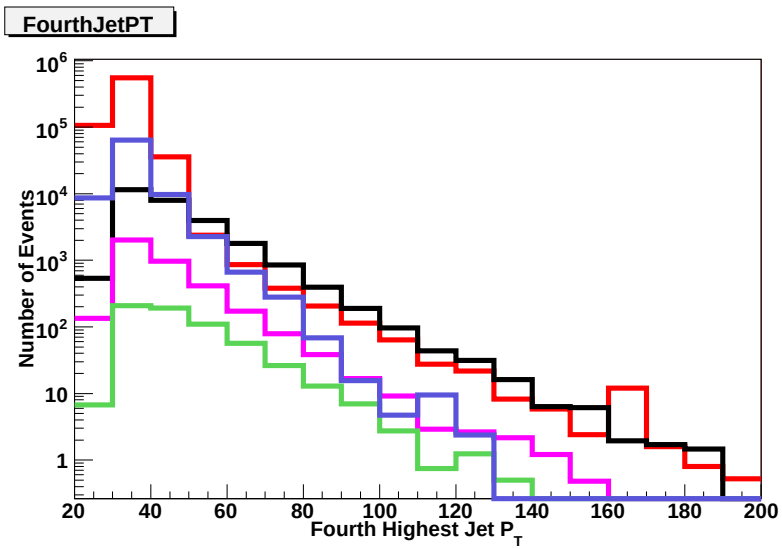


(QCD not shown)

Selection Variables

- Kinematics and Topology
  - Result (χ^2) of a kinematic fit
  - p_T of the n*th* jets (or ratios)
  - Angular correlations (MET, lepton, jets)





(QCD not shown)

Systematic errors

Main Systematics:

- Background uncertainties:
  - Shapes of W and Z plus Jet production (missing higher order calculations)
  - ”QCD” will be extracted from data
  - Event Pile-Up
  - Underlying Event
- Indirectly: Jet energy scale
- B jet fragmentation

Summary and Outlook

Summary:

- Powerful test of theory and experiment
- Currently promising results,
  e.g. small acceptance corrections
- 10% signal efficiency seem possible

Outlook:

- Change of reconstruction framework (the third...)
- Check possible alternatives for acceptance corrections
- Create the differential distributions

Backup: Jet energy preselection cut