



Hands on with MINERVA

Lecture 3

Kate Shaw

International Centre for Theoretical Physics

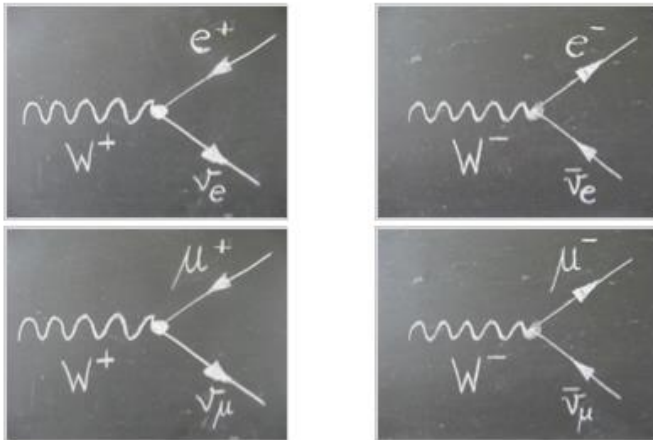
INFN Udine/ICTP ATLAS Group

5th Egyptian School of High Energy Physics, Zewail City, Cairo

14th – 19th November 2015

Analysis

- **Search for W^+ and W^- bosons using the ATLAS Detector**

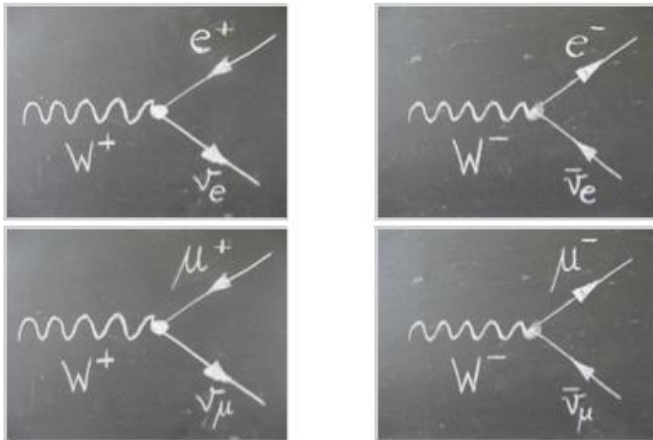


What is the final state?

How does ATLAS detect these event?

Analysis

- **Search for W^+ and W^- bosons using the ATLAS Detector**

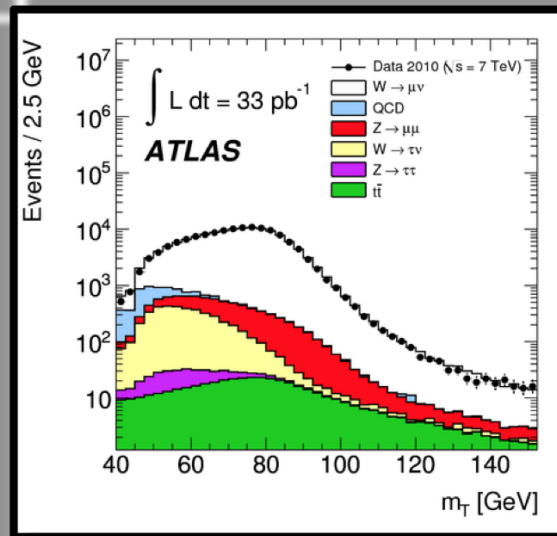
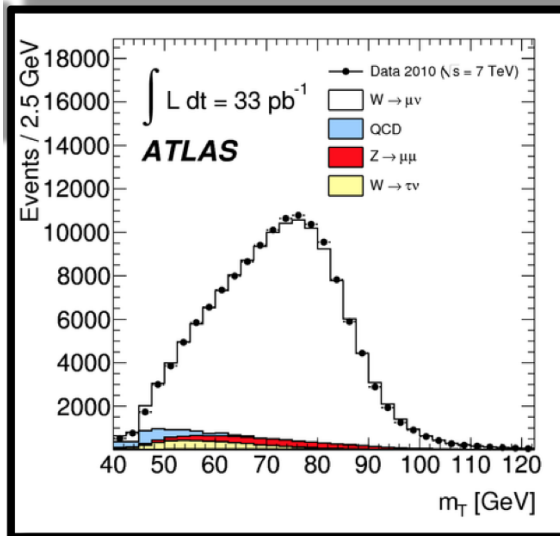
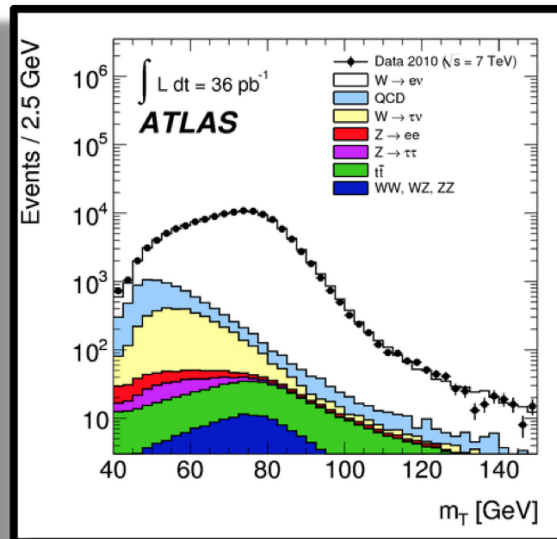
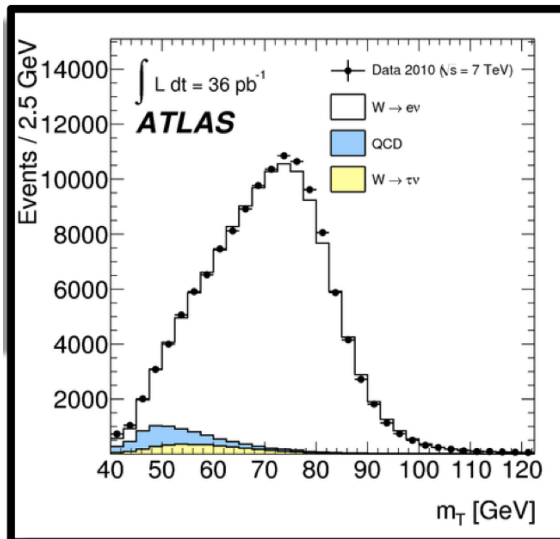


- **Whats your signal?**
- **What are the backgrounds?**
- **What cuts do we need to isolate the signal?**

Physics Analysis

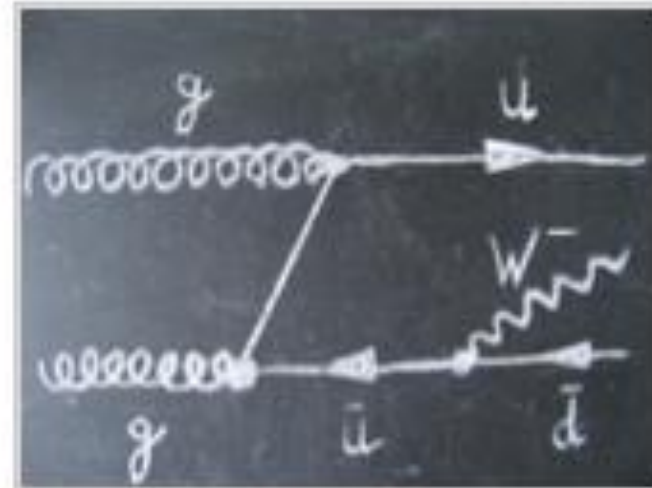
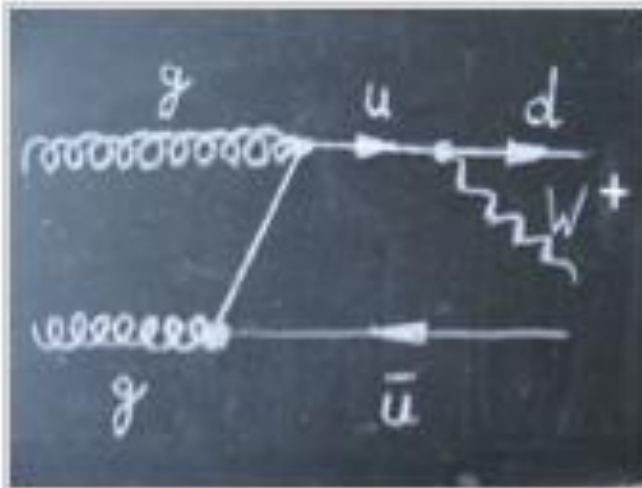
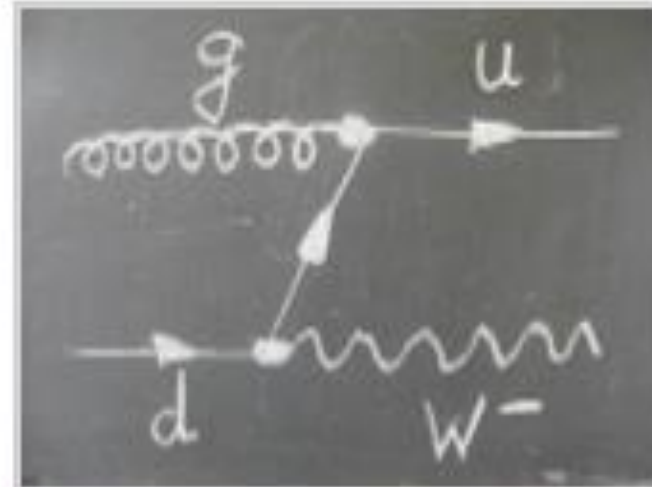
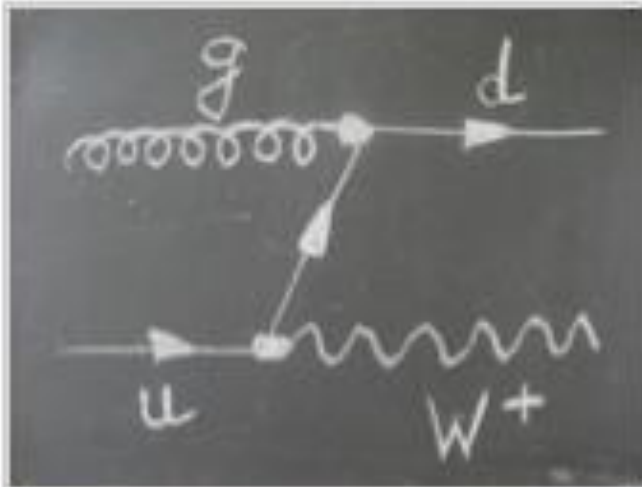
- **TODAY: We will look at events using the event display teaching program: MINERVA**
 - **Each event we apply cuts to see if the event is signal or background, and count them**
- **In analysis: We use C++ and ROOT to loop over thousands/millions of events**
 - **The code loops over the events and applies the cuts**
 - **Ones that pass as signal are then put into histograms**
 - **Do for the Monte Carlo simulation (SIGNAL, backgrounds)**
 - **Do for the data – does it fit?**

Physics Analysis

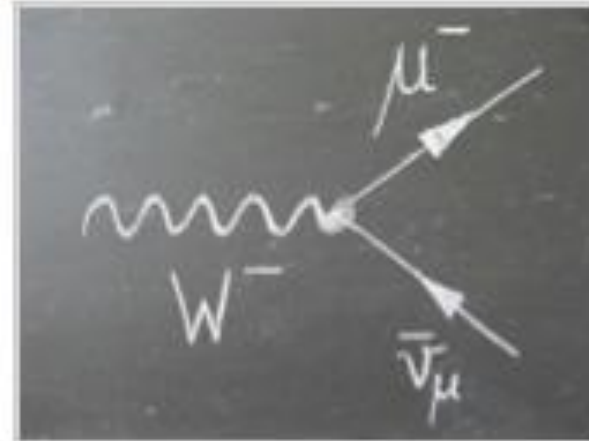
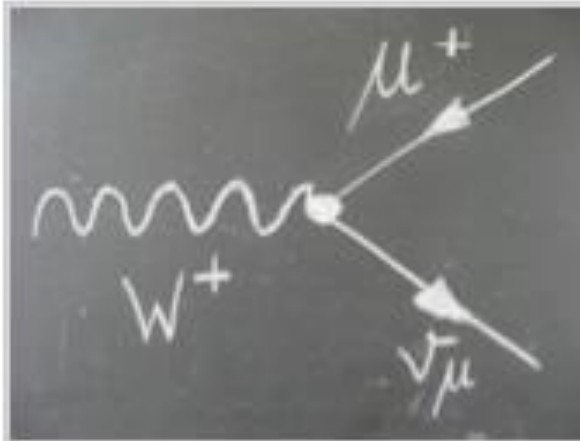
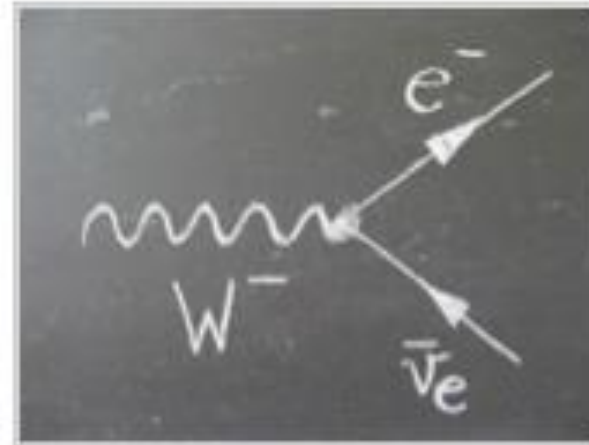
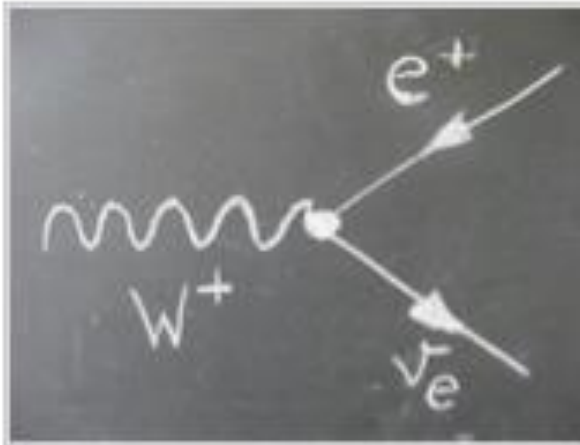


W Production

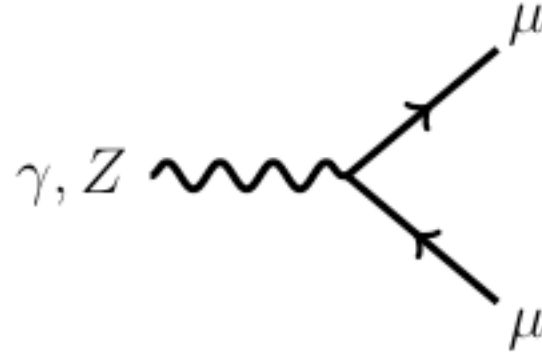
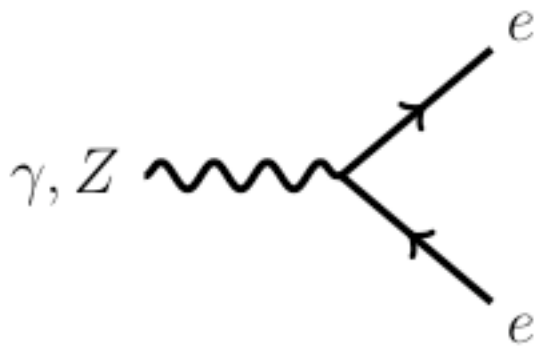
Production of different W particles



W decay

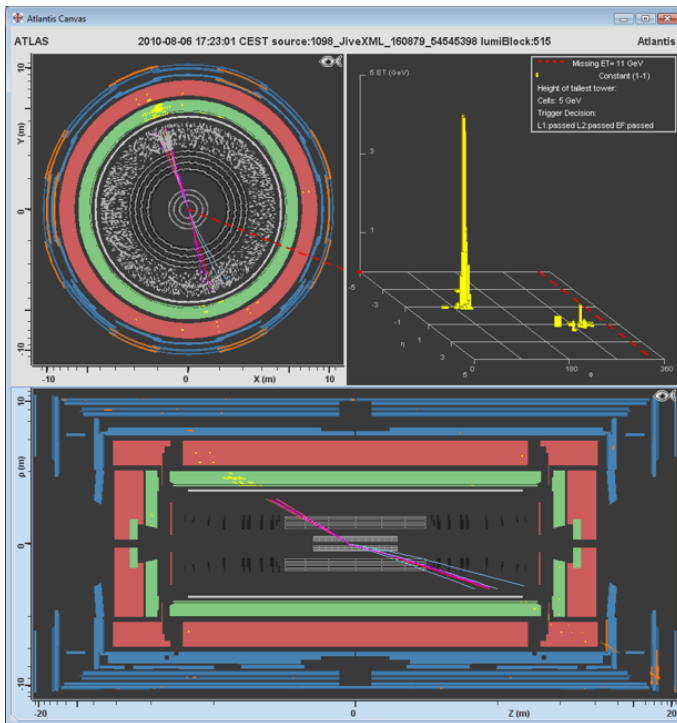


Background



$Z \rightarrow \mu^- + \mu^+$ (or $Z \rightarrow e^- + e^+$)

there is **TWO OPPOSITELY CHARGED Leptons** (either an electron or a positron or a muon or an anti-muon),



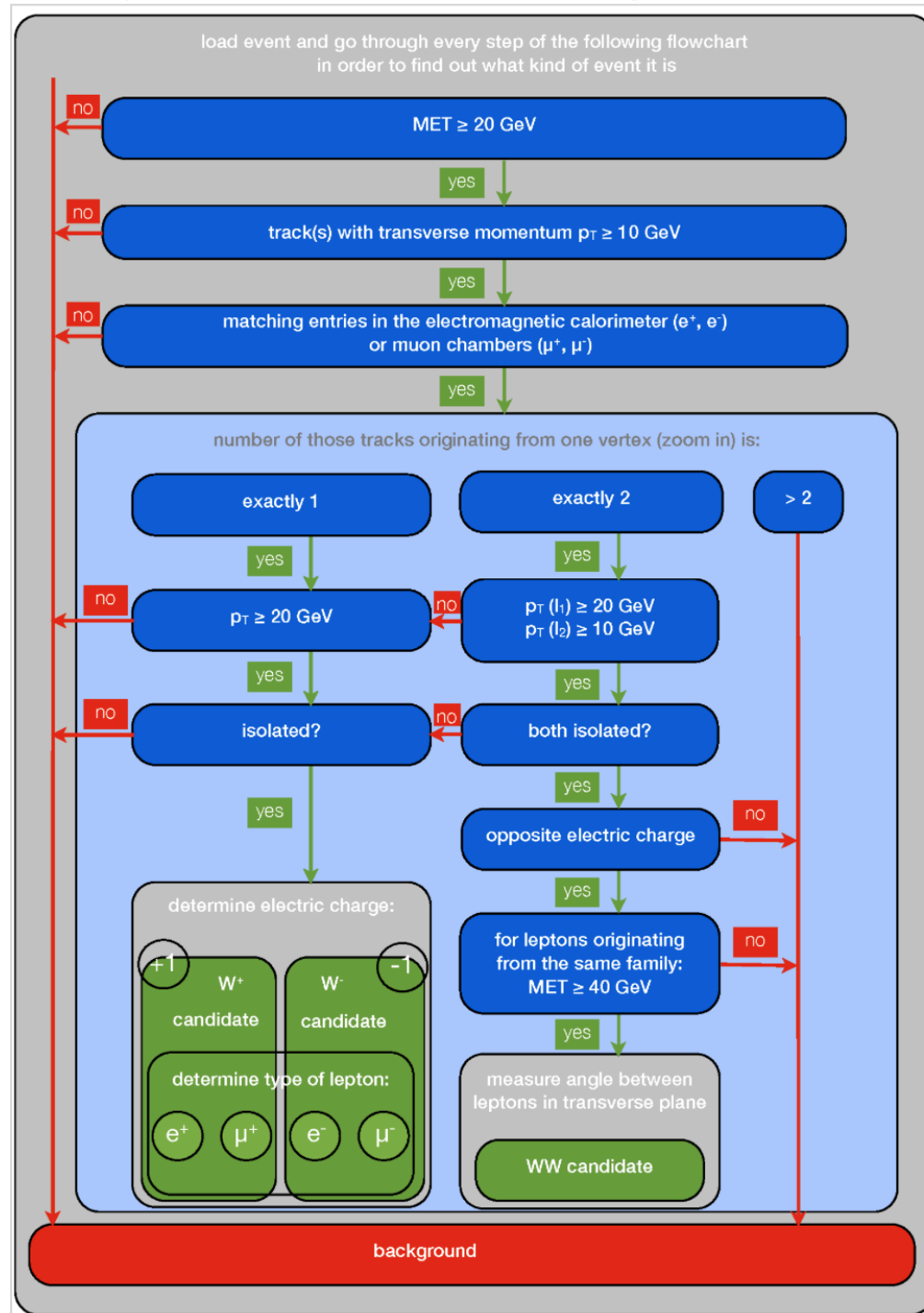
Multiple Jets

there are multiple jets (collections of hadrons particles)

CUTFLOW

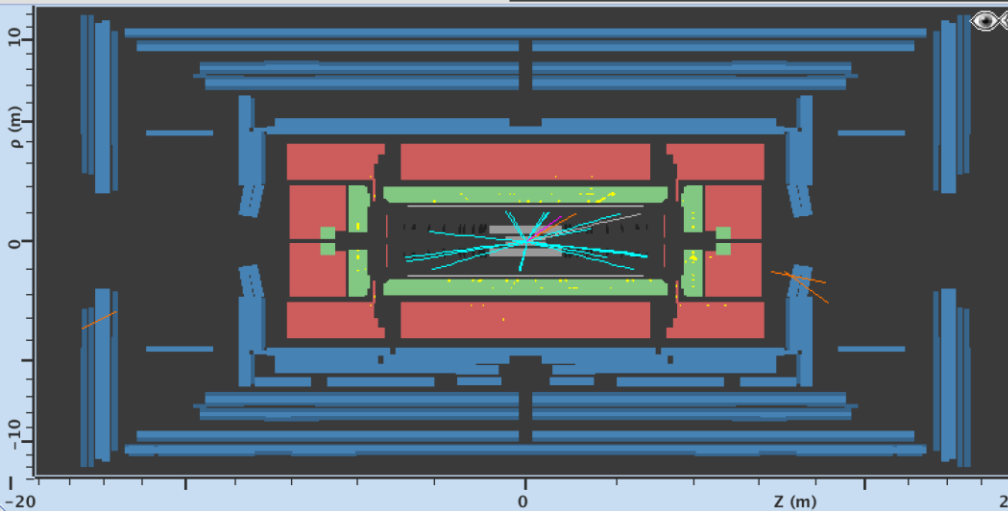
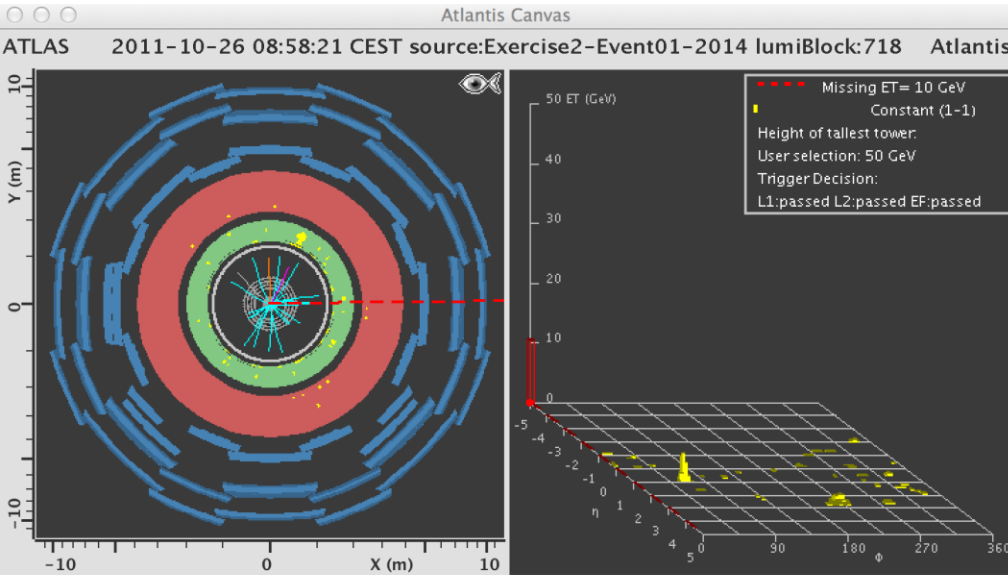
Isolates
W -> lepton + neutrino events

What do WW events look like?



Learning MINERVA

In DIR: minerva2014/events/exercise2-2014.zip



Atlantis GUI

File Preferences Lists Reset Demo Previous Next Help

ateshaw/Documents/Physics/Outreach/minerva2014/events/exercise2-2014.zip

Event Data

W 1 2 1 2 B 3 4

Cuts

InDet

Name	Value
<input checked="" type="checkbox"/> Pt	> 1.0 GeV

001_JiveXML_105200_190249.xml (10520000190249)

Exercise2-Event01-2014.xml (1916350047567557)

InDetTrack index: 67
PT=1.811 GeV
 $\eta = 1.659$
 $\Phi = 144.897^\circ$
Px=-1.481 GeV
Py=1.041 GeV
Pz=4.583 GeV
Charge = 1

Exercise

▪ **Use the link online:**

http://kjende.web.cern.ch/kjende/en/wpath_exercise2.htm

▪ **There are 10 events to look at – each of a different type**

▪ $W^+ \rightarrow e^+ + \nu_e$

▪ $W^- \rightarrow e^- + \nu_e$

▪ $W^+ \rightarrow \mu^+ + \nu_\mu$

▪ $W^- \rightarrow \mu^- + \nu_\mu$

▪ $WW^- \rightarrow l^+ + \nu_l + l^- + \nu_l$

▪ **Background from jets, $Z \rightarrow e^+e^-$, $Z \rightarrow \mu^+\mu^-$**

▪ **Load up events from “exercise2.zip” in ATLANTIS (OPEN)**

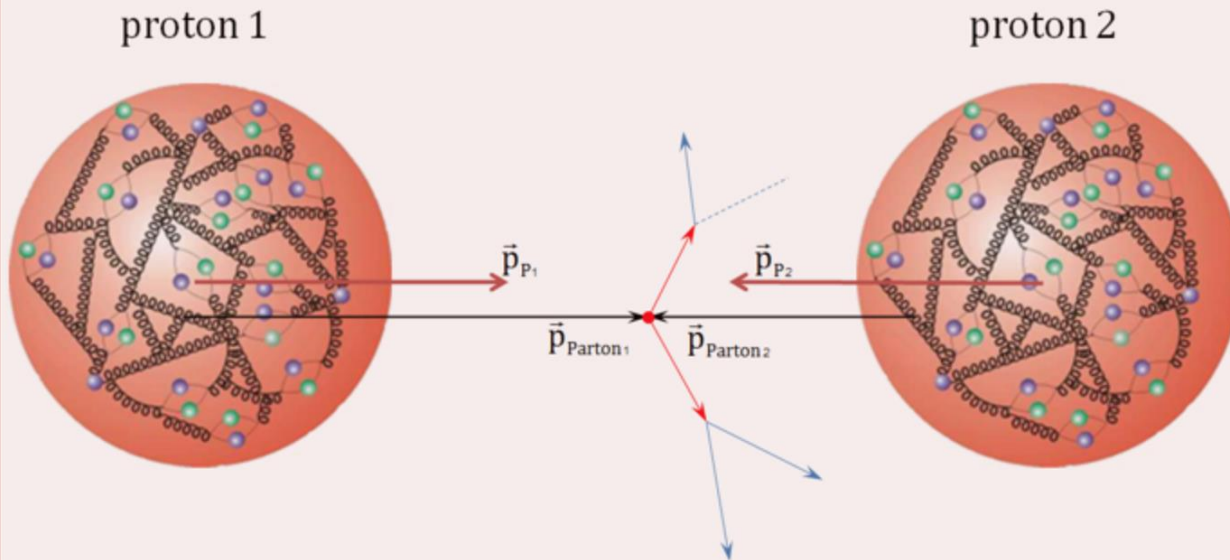
▪ **In DIR: minerva2014/events/exercise2-2014.zip**

▪ **Distinguish between background and signal events!**

▪ **Aim to correctly identify all of them**

Proton Structure

Interactions of constituents of the colliding protons, the so called partons (quarks, gluons)



\vec{p}_{P_1} ... momentum proton 1

\vec{p}_{P_2} ... momentum proton 2

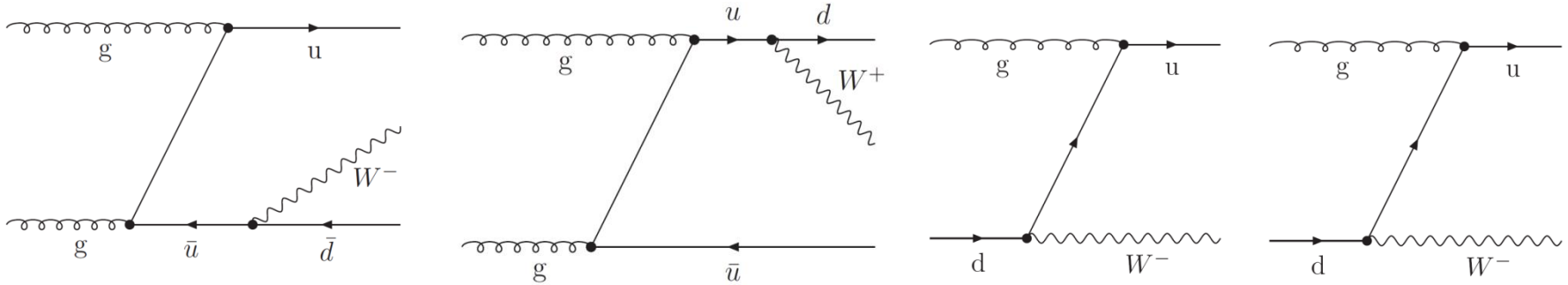
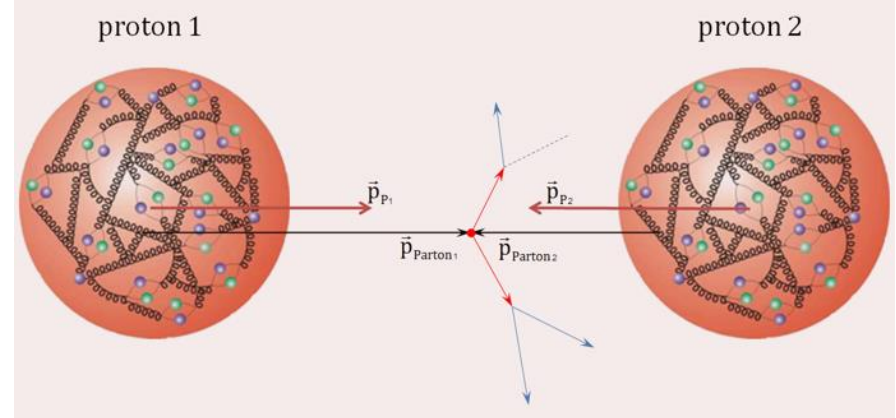
• interaction vertex

\vec{p}_{Parton_1} ... momentum parton 1

\vec{p}_{Parton_2} ... momentum parton 2

Proton Structure

- **Proton does not react as a whole**
- **Different methods of production of**



- **Decays – 1/3 of the time W decays into a lepton and neutrino (electron, muon or tau)**
- **Protons are complicated at high energies!**

Proton Structure

Comparison with results of the ATLAS collaboration (from 2011):

Measurement of the $W \rightarrow l\nu$ and $Z/\gamma^ \rightarrow ll$ production cross sections in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector **

Search for the Standard Model Higgs boson in the $H \rightarrow WW() \rightarrow l\nu l\nu$ decay mode using 1.7 fb⁻¹ of data collected with the ATLAS detector at $\sqrt{s} = 7$ TeV **)*

*) Authors: The ATLAS Collaboration (Submitted on 5 Dec 2011): <http://arxiv.org/abs/1109.5141.pdf>

***) Authors: The ATLAS Collaboration (24 Aug 2011): ATLAS-CONF-2011-134

	W → ... + ν				Background	WW+0J cand.
	positron	electron	antimuon	muon		
Total	77885	52856	84514	55234.0	21930.0	469
Total W+/W-	number of W+	162399	number of W-	108090		
W+ / W-	1.50 ± 0.01					