

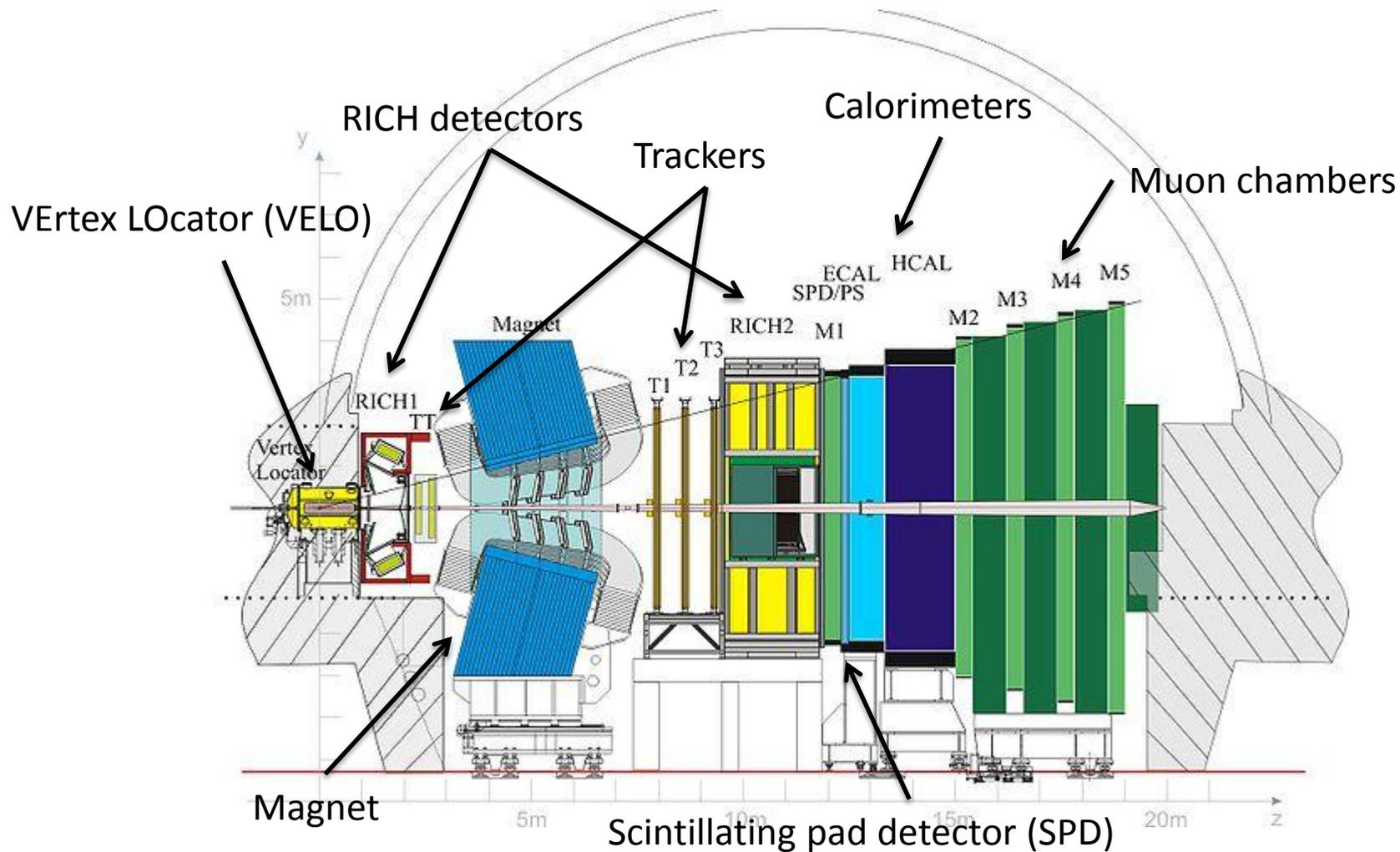
VELO DQM and Central Exclusive Dimuon Production at LHCb

Ciarán Hickey (University College Dublin)

Outline

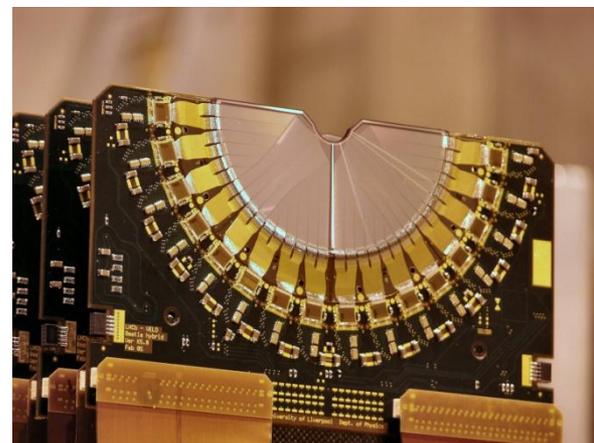
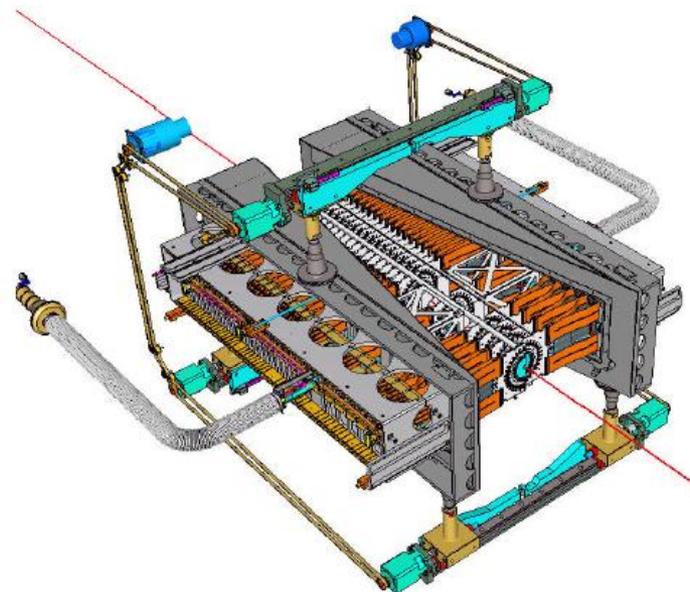
1. Brief introduction to LHCb and the VErtext LOcator (VELO)
2. Update of VELO DQM TWiki and GUI
3. Analysis of central exclusive dimuon production at LHCb

The LHCb Experiment



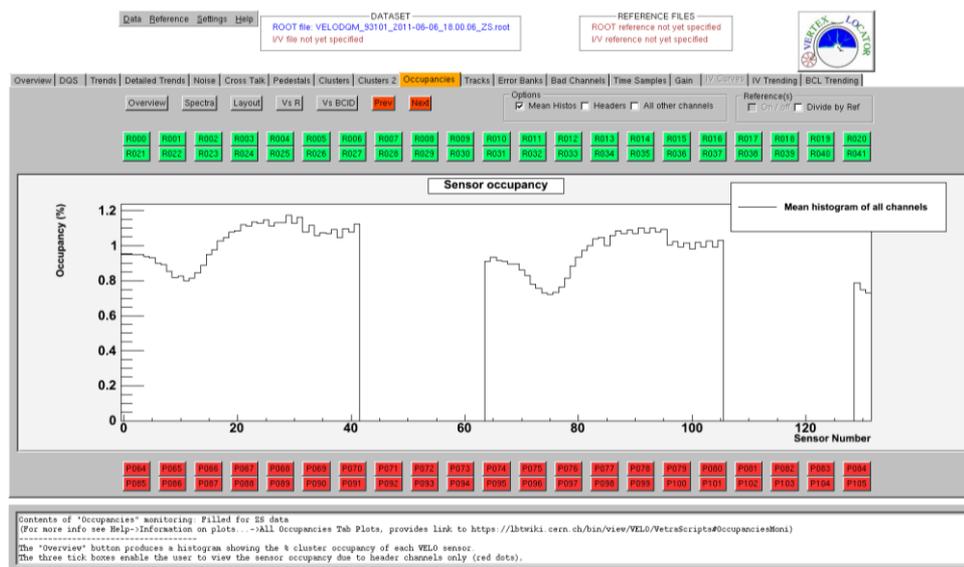
The VELO detector

- Silicon strip detector made up of 2 retractable halves of 21 modules each
- Each module has both an r and ϕ sensor
- Needed to precisely locate both primary and secondary vertices



VELO Data Quality Monitoring

- A number of macros are used to produce plots detailing VELO performance during a run.
- The plots are usually (and most easily) accessed from the VELO monitoring GUI.



Update to VELO GUI TWiki page

- There are 16 tabs in the GUI using a total of 20 macros
- Updated/wrote documentation for each macro including:
 - A summary of plots produced by the macro
 - Usage
 - Ideal behaviour
 - Examples of ideal and bad plots
 - Known problems

Update to the monitoring GUI

Data Reference Settings Help

DATASET
 ROOT file: VELODM_93101_2011-06-06_18.00.06_NZS.root
 I/V file not yet specified

REFERENCE FILES
 ROOT reference not yet specified
 I/V reference not yet specified

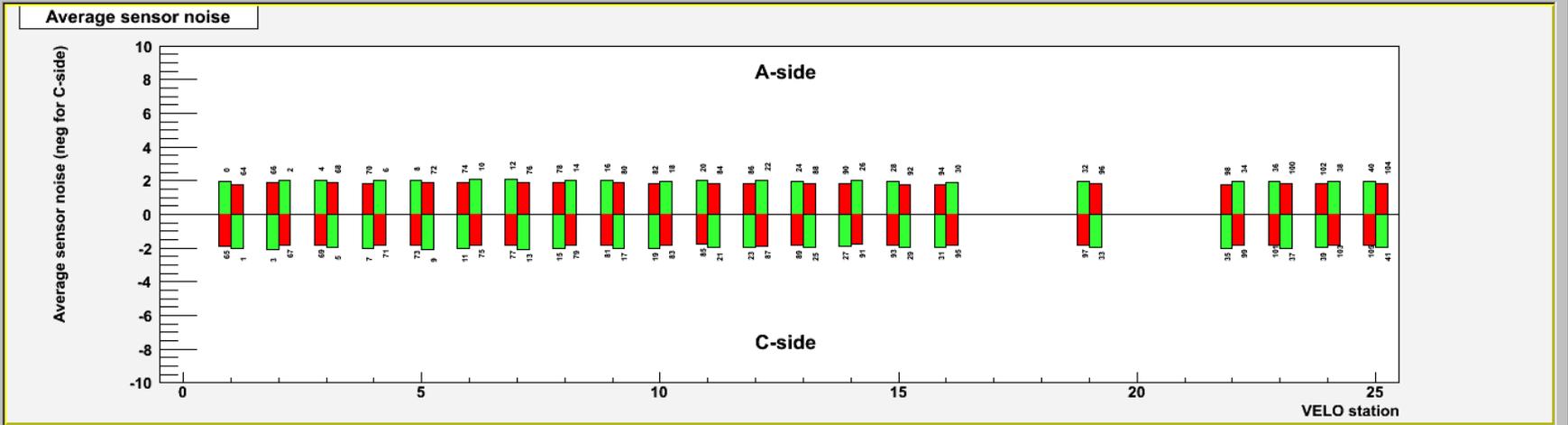


Overview DQS Trends Detailed Trends **Noise** Cross Talk Pedestals Clusters Clusters 2 Occupancies Tracks Error Banks Bad Channels Time Samples Gain *IV Curves* IV Trending BCL Trending

VELO layout R/Phi summary Link noise TP noise **Prev** Next

Sensor options
 ADC CMS Diff

R000 R001 R002 R003 R004 R005 R006 R007 R008 R009 R010 R011 R012 R013 R014 R015 R016 R017 R018 R019 R020
 R021 R022 R023 R024 R025 R026 R027 R028 R029 R030 R031 R032 R033 R034 R035 R036 R037 R038 R039 R040 R041



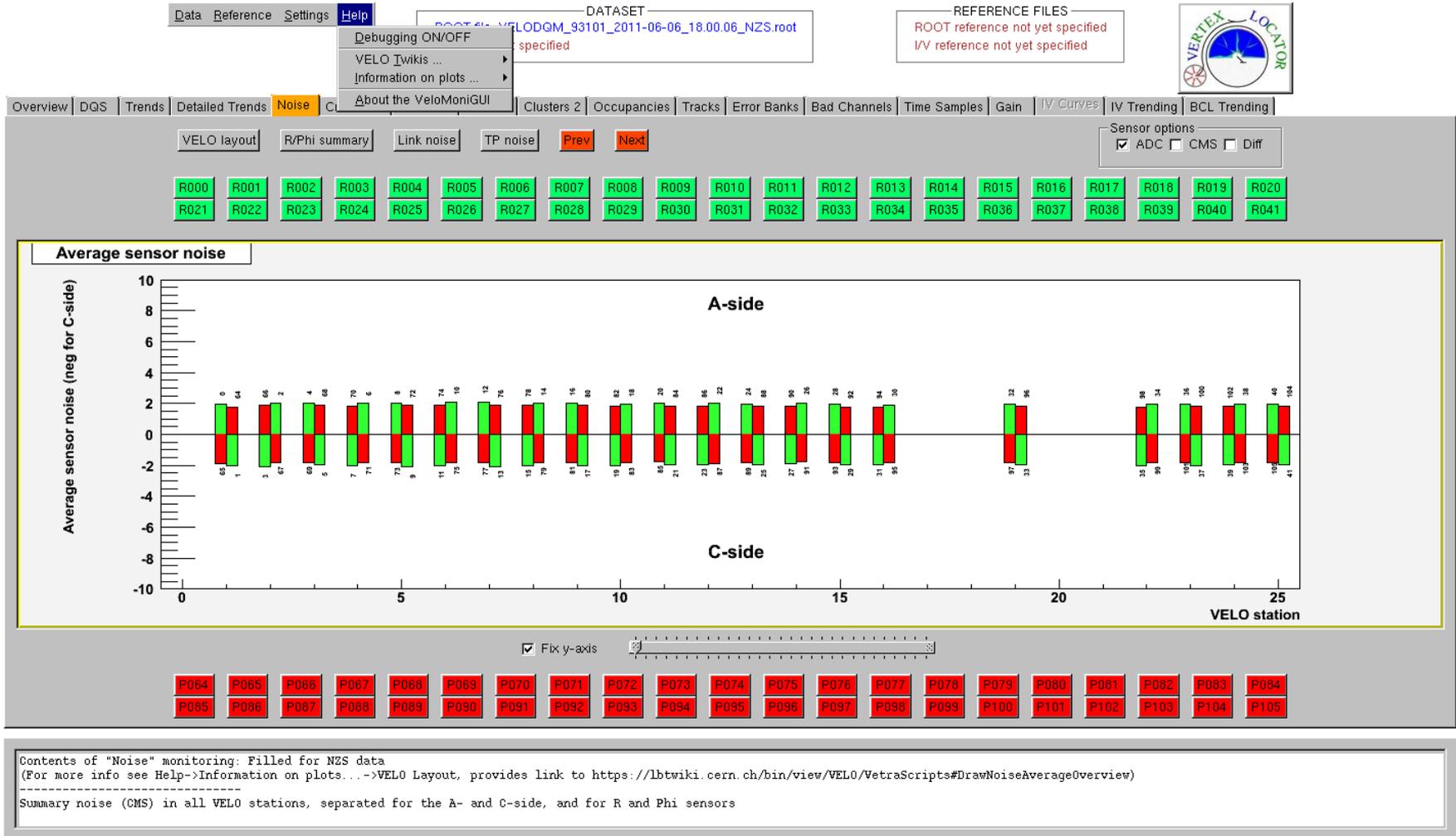
Fix y-axis

P064 P065 P066 P067 P068 P069 P070 P071 P072 P073 P074 P075 P076 P077 P078 P079 P080 P081 P082 P083 P084
 P085 P086 P087 P088 P089 P090 P091 P092 P093 P094 P095 P096 P097 P098 P099 P100 P101 P102 P103 P104 P105

Contents of "Noise" monitoring: Filled for NZS data
 (For more info see Help->Information on plots...->VELO Layout, provides link to <https://lbtwiki.cern.ch/bin/view/VELO/VetraScripts#DrawNoiseAverageOverview>)

 Summary noise (CMS) in all VELO stations, separated for the A- and C-side, and for R and Phi sensors

Update to the monitoring GUI



Update to the monitoring GUI

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Overview DQS Trends Detailed Trends Noise C...
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Average sensor noise
 Average sensor noise (neg for C-side)

Sensor options:
 ADC CMS Diff

General Tabs:
 Overview Tab
 DQS Tab
 Trends & Detailed Trends Tabs
Noise Tab:
 VELO Layout
 R/Phi Summary
 Link Noise
 IPNoise
 Individual Sensor Noise
 Noise vs. Voltage
Cross Talk Tab:
 Beetle header cross talk
 Beetle header cross talk 2D & 1D
Pedestals Tab:
 Pedestal Summary Plots
 Individual Channel Pedestals
Clusters Tab:
 All Clusters Tab Plots
Clusters 2 Tab:
 All Clusters 2 Tab Plots
Occupancies Tab:
 All Occupancies Tab Plots
Tracks Tab:
 All Track Summary Plots
 IP Resolution Plots
Error Banks Tab:
 Overview and Distribution Plots
Bad Channels Tab:
 Bad Channels Plots
Time Samples Tab:
 All Time Samples Plots
Gain Tab:
 All Gain Plots
IV Curves Tab:
 All IV Curve Plots

Contents of "Noise" monitoring: Filled for NZS data
 (For more info see Help->Information on plots...->VELO Layout, provided in the file: /ch/bin/view/VELO/VetraScripts#DrawNoiseAverageOverview)
 Summary noise (CMS) in all VELO stations, separated for the A- and C-side

Update to the monitoring GUI

drawNoiseAverageOverview.C macro

Summary

This gives an overview of the average sensor noise in the VELO layout. It plots the average sensor noise for every sensor, with the A-side above the y-axis and the C-side below the y-axis. The R sensors are coloured green and the Phi sensors are coloured red. It's also possible to check noise histograms before and after Common-Mode Suppression (CMS).

Usage (with NZS file)

In the GUI:

In the "Noise" tab, click on "VELO layout". There are check boxes in the upper left corner for ADC and CMS noise histograms.

In stand alone mode:

In ROOT, run as follows:

```
>.L drawNoiseAverageOverview.C
drawNoiseAverageOverview( "myinputfile.root" )
```

This script is also used by the monitoring GUI to display the very same histograms it produces in standalone. The drawNoiseAverageOverview.C macro produces a single plot. The macro needs as input a file with NZS data produced by the [NoiseMon](#) algorithm in the Velo/VeloDataMonitor package, containing the directory: structure/Vetra/Noise/ADCCMSuppressed/TELL1_NNN/ and Vetra/Noise/DecodedADC/TELL1_NNN/ with histograms RMSNoise_vs_ChipChannel and RMSNoise_vs_Strip.

Ideal Behaviour

Ideally the noise should be around 2 (for summer 2011) with all of the sensors having roughly equal noise. If there is a sensor missing (see bad plots below) or if one or more of the sensors has unusually high noise compared to the rest then this should be reported in the e-log.

Ideal plots



Update to the monitoring GUI

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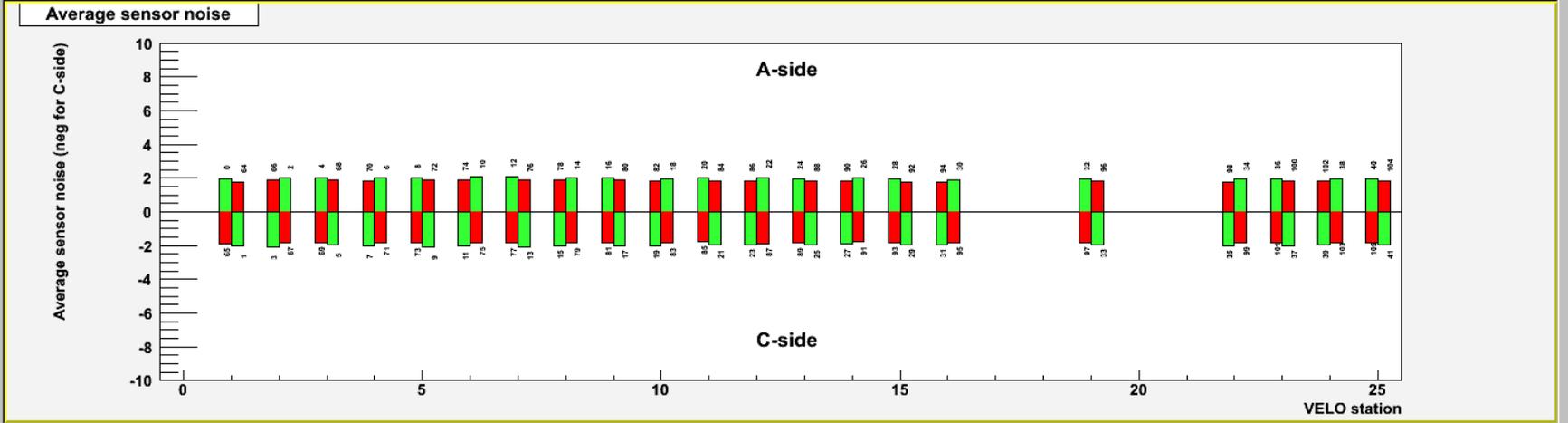


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P064 P065 P066 P067 P068 P069 P070 P071 P072 P073 P074 P075 P076 P077 P078 P079 P080 P081 P082 P083 P084
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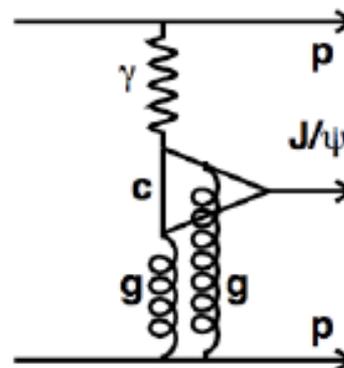
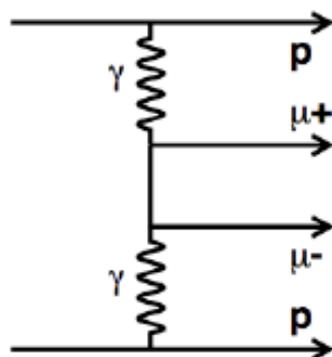
Summary noise (CMS) in all VELO stations, separated for the A- and C-side, and for R and Phi sensors

3. Analysis of Central Exclusive Dimuon Production at LHCb

(carried out with G.P. McGread, University of Cambridge)

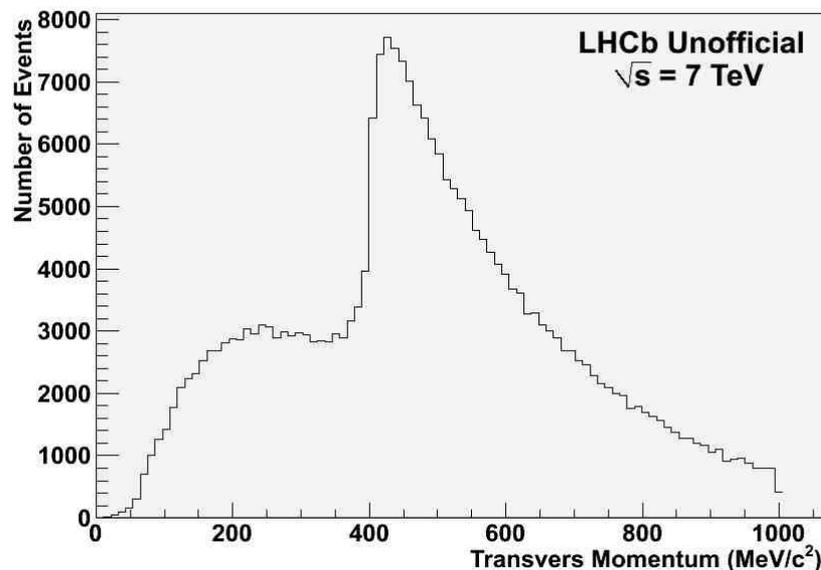
What is central exclusive dimuon production?

- Central = Particles are produced far from the beam line
- Exclusive = Class of reactions whereby the colliding particles remain intact. Additional particles are produced by photon and/or gluon propagators, i.e. $A + B \rightarrow A + X + B$
- Dimuon = Two muons, a $\mu^+\mu^-$ pair, are produced
- At LHCb we are studying: $p + p \rightarrow p + \mu^+\mu^- + p$
- Examples:



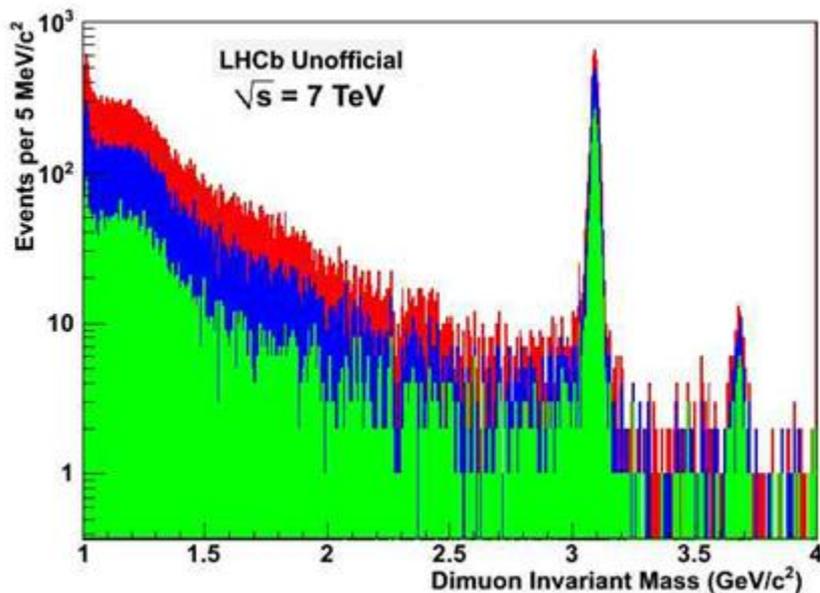
Online cuts to the data

- Hardware Trigger Settings:
 - Less than 10 SPD hits.
 - Single muon with a transverse momentum, $p_t > 400 \text{ MeV}/c^2$ or two muons both with $p_t > 80 \text{ MeV}/c^2$.
- Software Trigger Settings:
 - Invariant mass of dimuon candidate is $> 1 \text{ GeV}/c^2$ and its $p_t < 900 \text{ MeV}/c^2$ or its mass is $> 2.7 \text{ GeV}/c^2$.

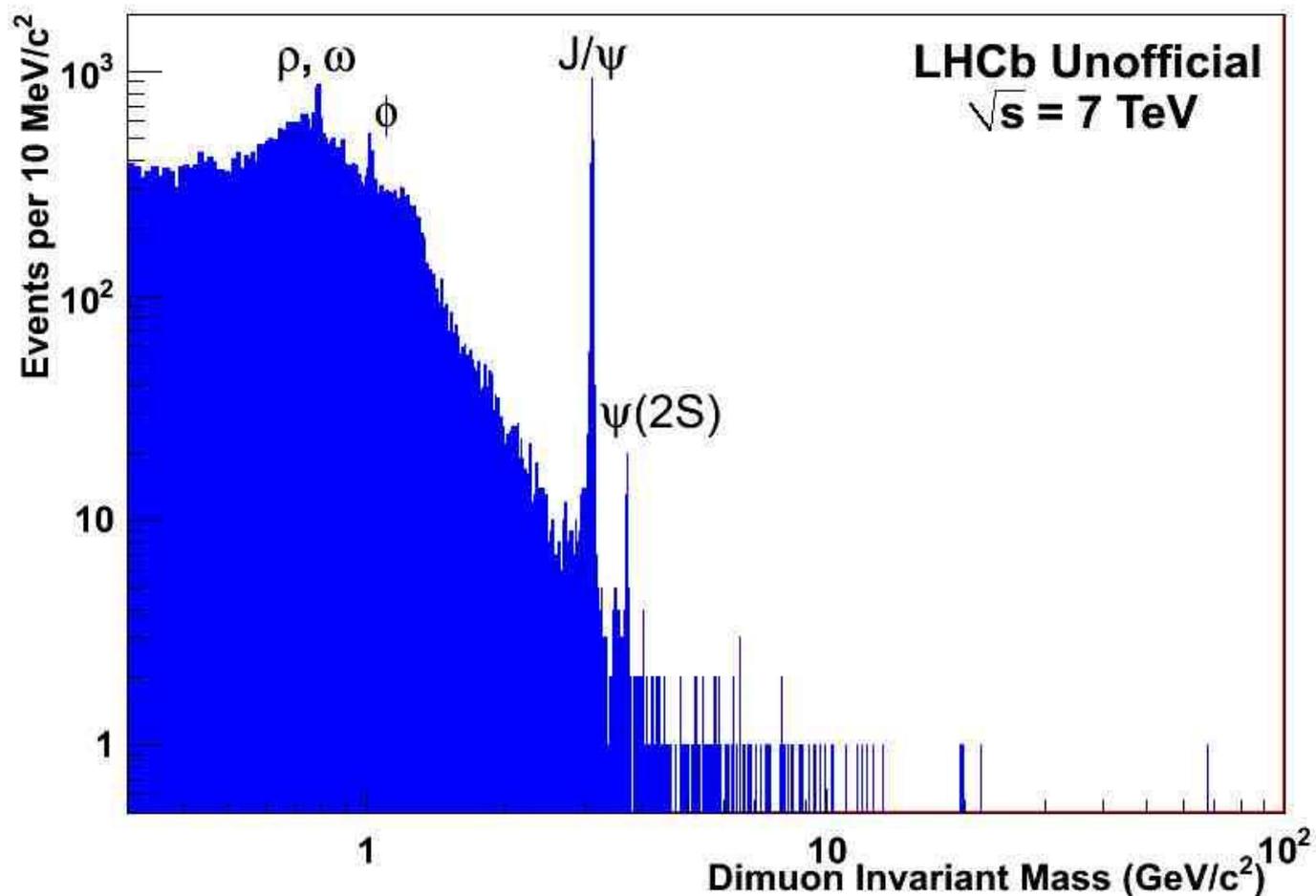


Offline cuts

- Red = All dimuon candidates passing the triggers
- Blue = Required that; the number of long tracks = 2, number of backward tracks = 0 and the pseudorapidity is in the range $2 < \eta < 4.5$
- Green = Additional requirement that the total number of tracks = 2

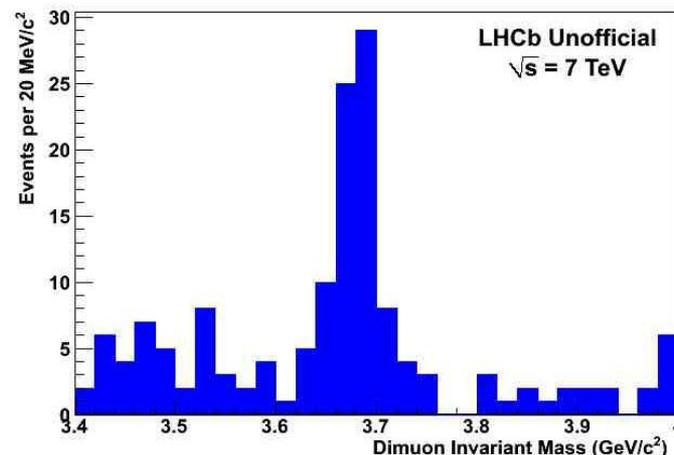
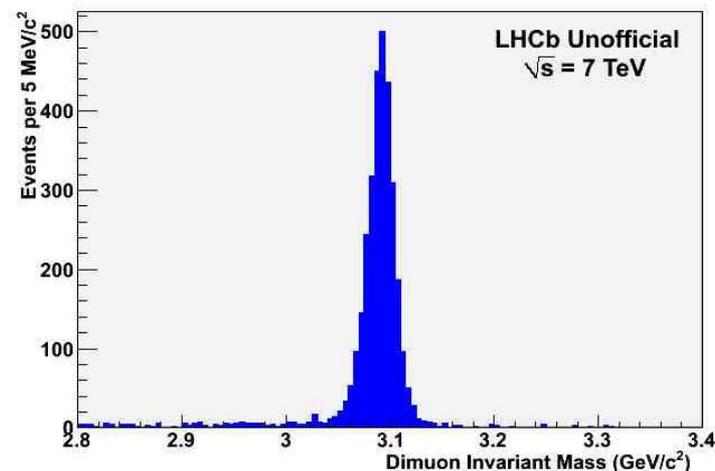


Dimuon Invariant Mass Spectrum



Invariant Mass Distributions of J/ψ and $\psi(2S)$

- J/ψ :
 - Gaussian fit gives mean of $3090.9 \pm 0.3 \text{ MeV}/c^2$
 - PDG value of mass is $3096.916 \pm 0.011 \text{ MeV}/c^2$
- $\psi(2S)$:
 - Gaussian fit gives mean of $3678 \pm 3 \text{ MeV}/c^2$
 - PDG value of mass is $3689.09 \pm 0.04 \text{ MeV}/c^2$



Conclusions

- We can see clear signals of $\psi(2S)$, J/ψ , ϕ and ρ , ω from 2011 LHCb data.
- More analysis needed in order to determine the exclusivity of these events.
- It is also necessary to calculate the efficiencies, purity, effective luminosity and background so that the cross sections can be calculated, $\sigma = (pN)/(\epsilon L_{\text{eff}})$.
- Special thanks to Dr. Ronan McNulty, Stephen Farry and Gráinne McGread.