Crosstalk studies on the LHCb Vertex Locator Modules

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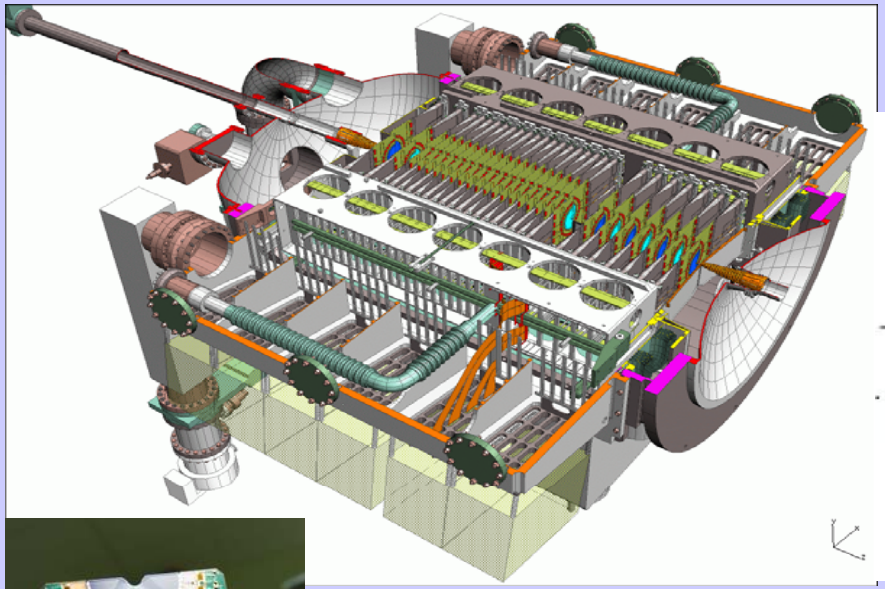
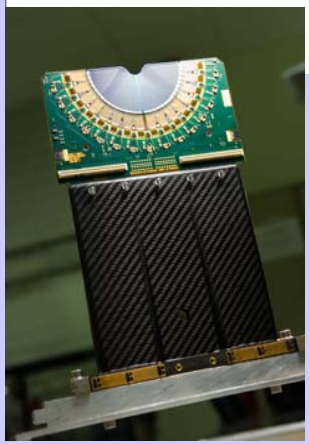
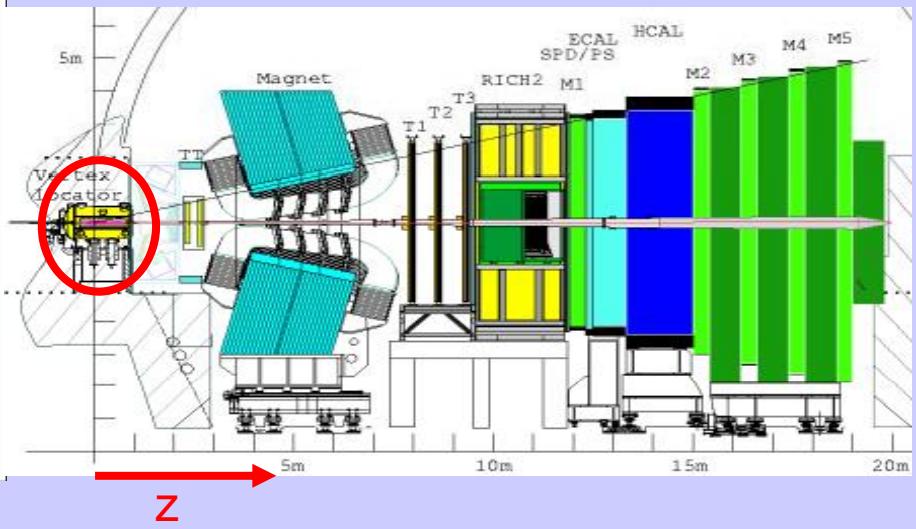
Overview

- LHCb Vertex Locator (VeLo)
- Testbeam overview
- Crosstalk analysis

LHCb VeLo






5m
Magnet
TT
T1
T2
T3
RICH2
M1
ECAL
SPD/PS
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z

Testbeam

- Data taken with 6 production modules
- Cooling and electronics used in final experiment
- Check response of modules
- My analysis: Crosstalk

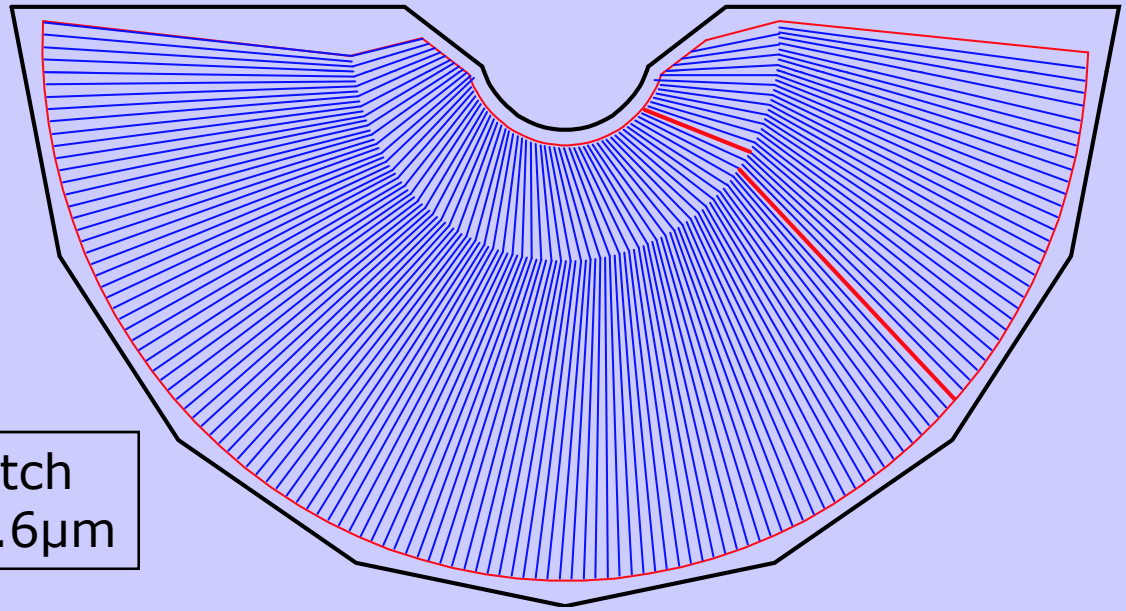
Crosstalk analysis

- Fraction of two strip clusters
- Ratio of charge
- Crosstalk

- Zero suppressed data
- Zero degree tracks
- Clusters on tracks
- Look at *R* and ϕ sensors separately

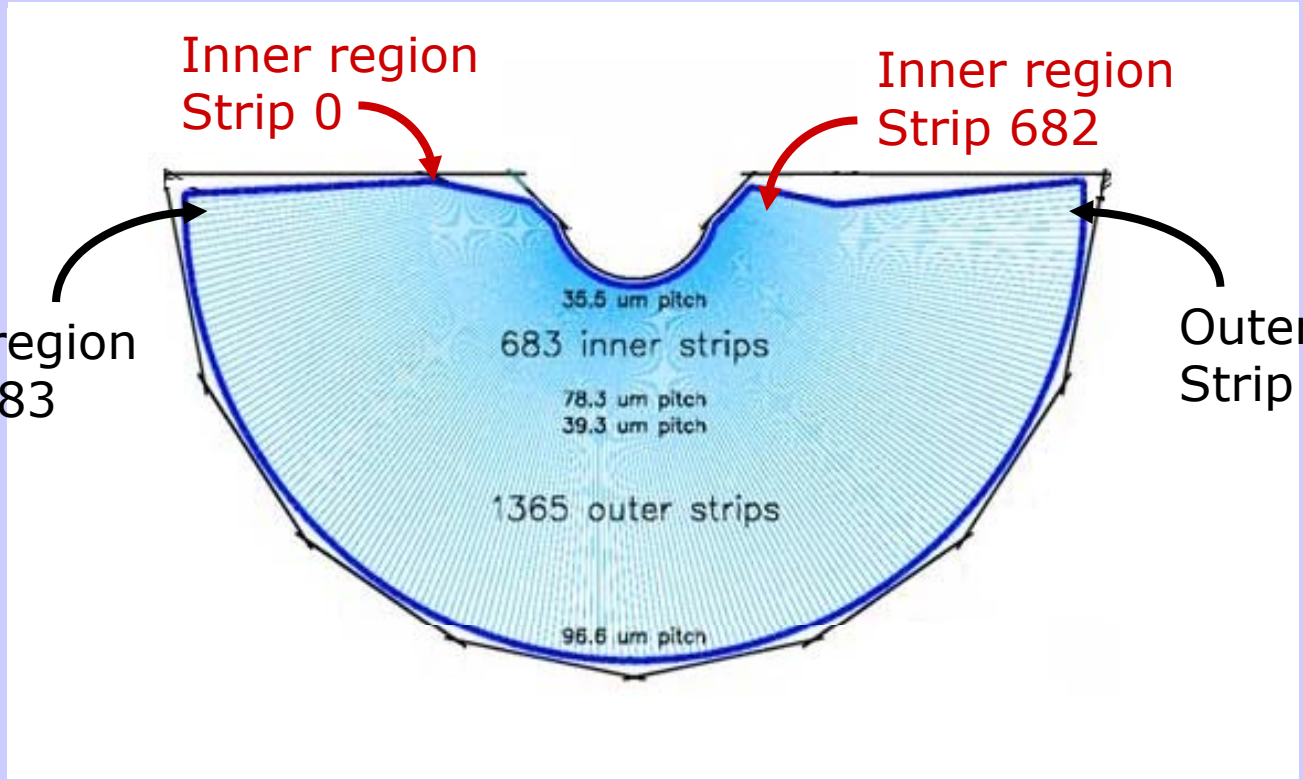
Phi sensor

Inner strip pitch
35.5μm – 78.3μm

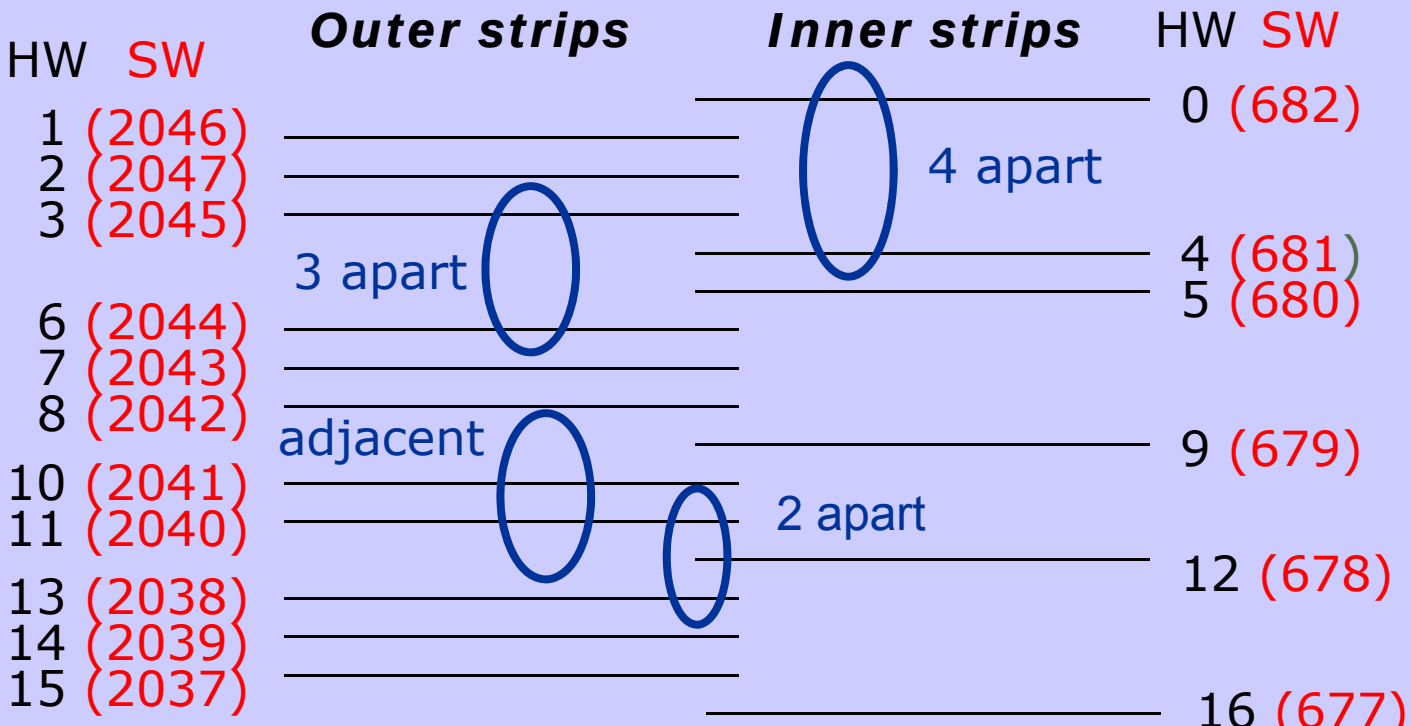


Outer strip pitch
39.3μm – 96.6μm

Phi sensor readout – software strip



Phi sensor readout - Hardware channel



Crosstalk in hardware channel

Readout trace

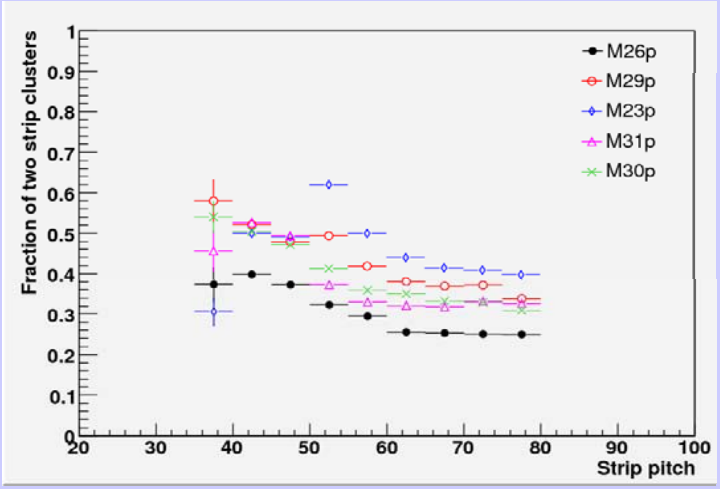
- Oscilloscope trace of chip readout
- Output in voltage and time

Data from chip

Header information

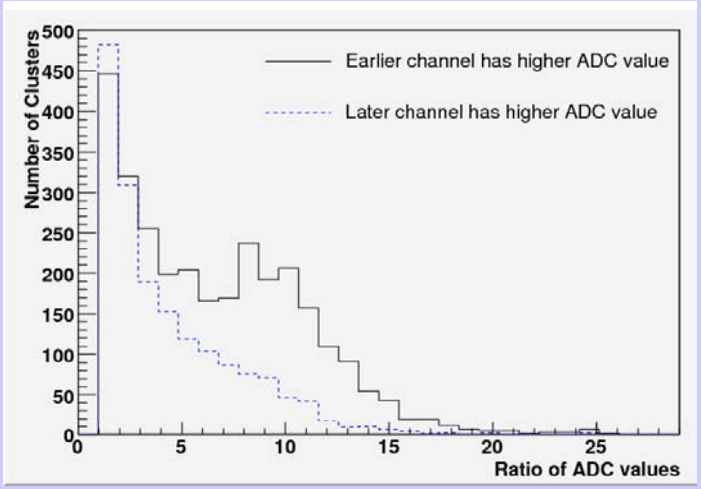
Fraction of two strip clusters

- Fraction of two strip clusters as a function of strip pitch
- Expect similar fractions of two strip clusters in each sensor

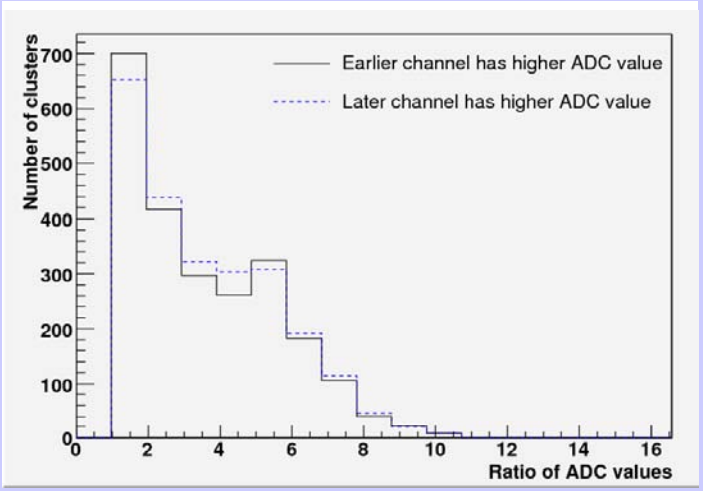


Measuring crosstalk

- Look at two strip clusters
- Look at ratio of charge
- Divide data into categories
  - Earlier > Later
  - Later > Earlier
- Comparison between testbeam data and simulation
- Data found to be asymmetric



Data shows asymmetry



No asymmetry in simulation

Simulation accounts for crosstalk on sensor but not in cables

Crosstalk simulation

- Simulate testbeam events in MC
- Add noise and smear simulation (hardware channel order)
- Re-cluster (software strip order)
- Compare results to data

Smearing data

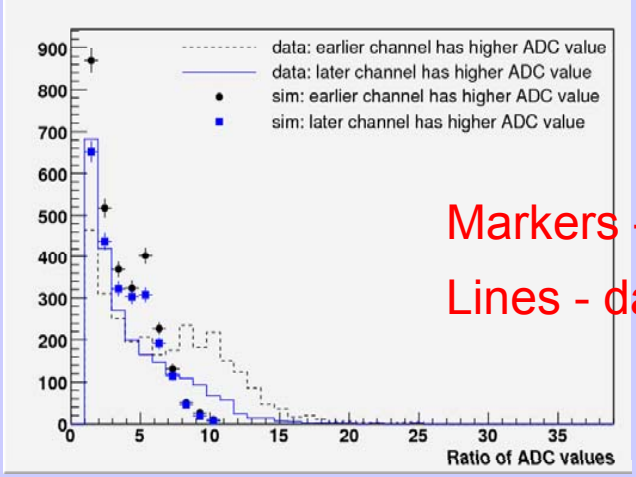
- To model crosstalk
- Smearing formula:

$$adc_{new} = adc_i \times \frac{1}{1+\sum f+\sum g} + \sum adc_{i-j} f_j + \sum adc_{i+j} g_j$$

- Negative f & g values → charge sucked in from strip earlier (later) in readout scheme
- Positive f & g values → charge dispersed strip earlier (later) in readout scheme

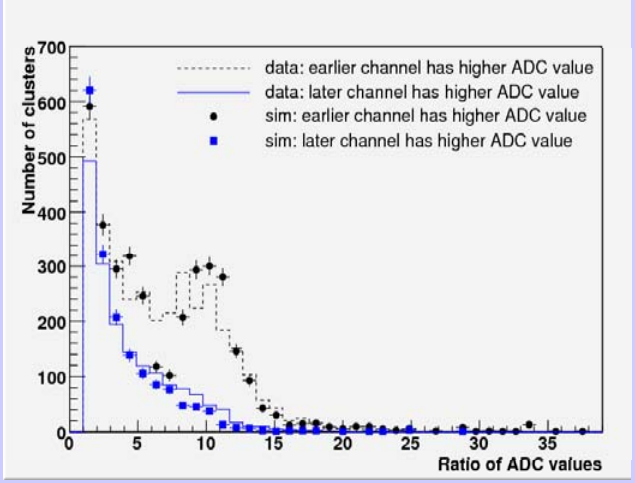
ϕ sensor data

- Data for channels adjacent in the readout scheme



Markers - simulation

Lines - data

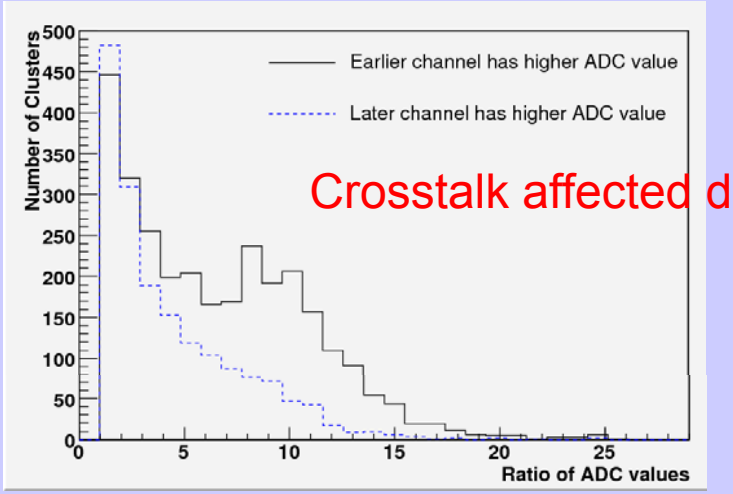


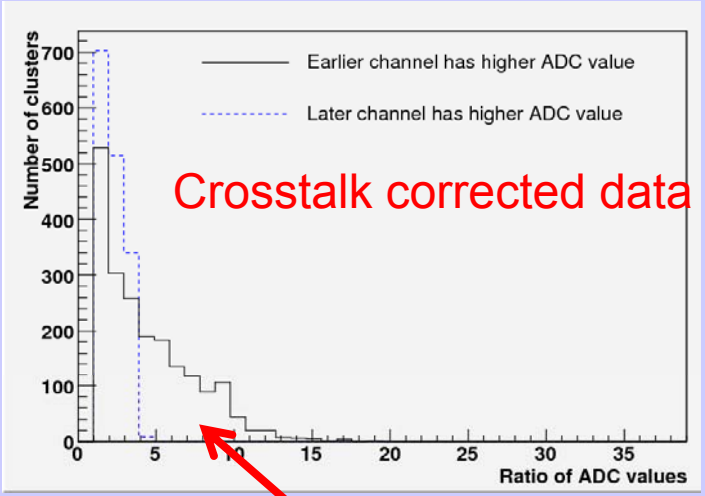
f = 0.02 ± 0.01

g = -0.26 ± 0.01

Data Correction

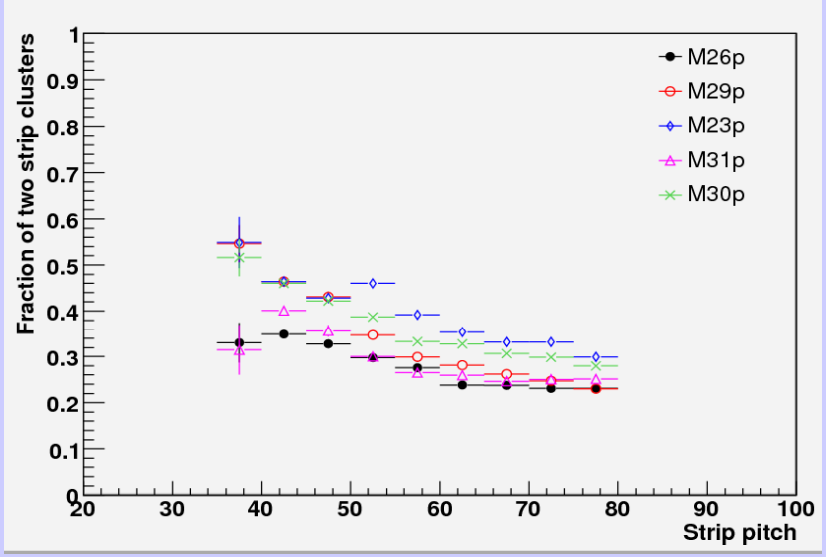
- Reverse effect of smearing on data





- Process not perfect; “fake” one and three strip clusters not considered

- Fraction of two strip clusters as a function of strip pitch for crosstalk corrected data



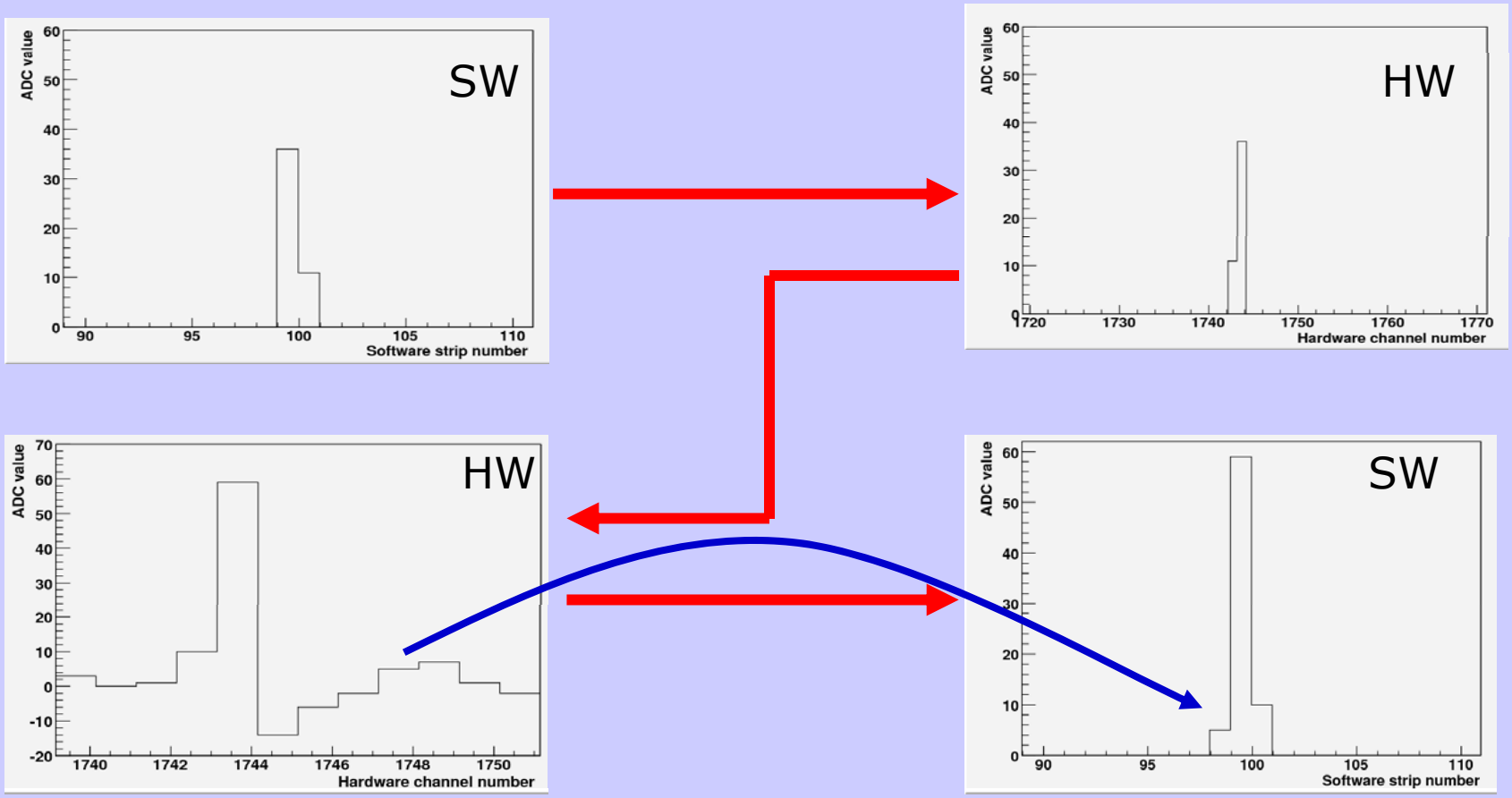
- At 70μm difference between sensors has been reduced to 10%

Conclusion

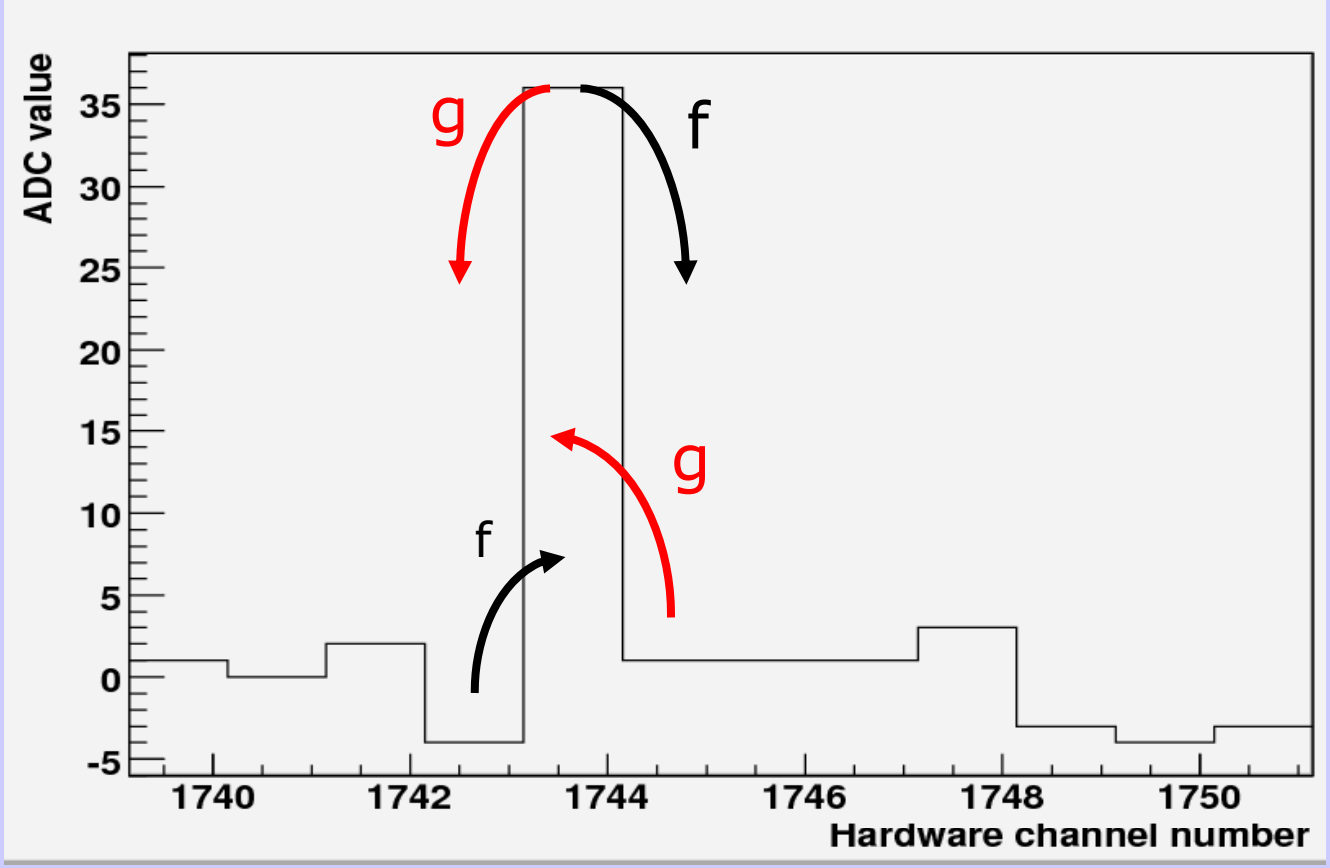
- Method developed for identifying, quantifying and correcting for crosstalk seen in VeLo module testbeam data
- Crosstalk expected to be less of an issue in the experiment
- Analysis to be re-run using real data

Back up slides

Crosstalk simulation



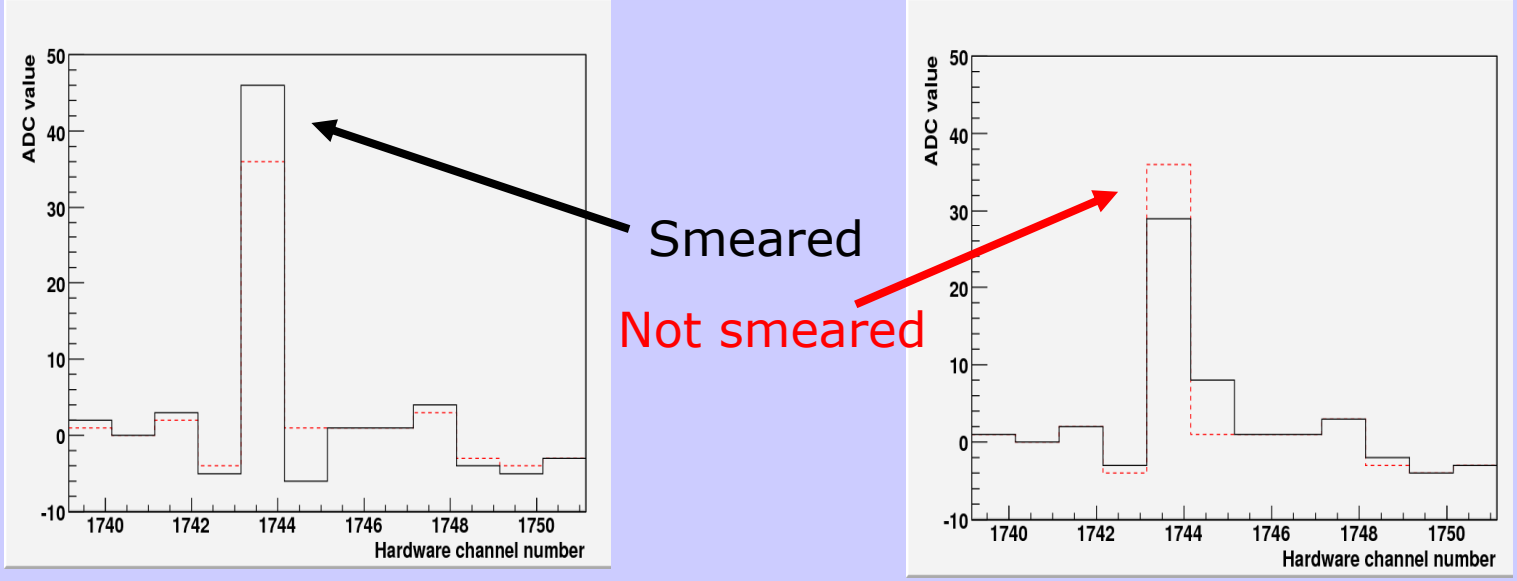
Effects of f & g



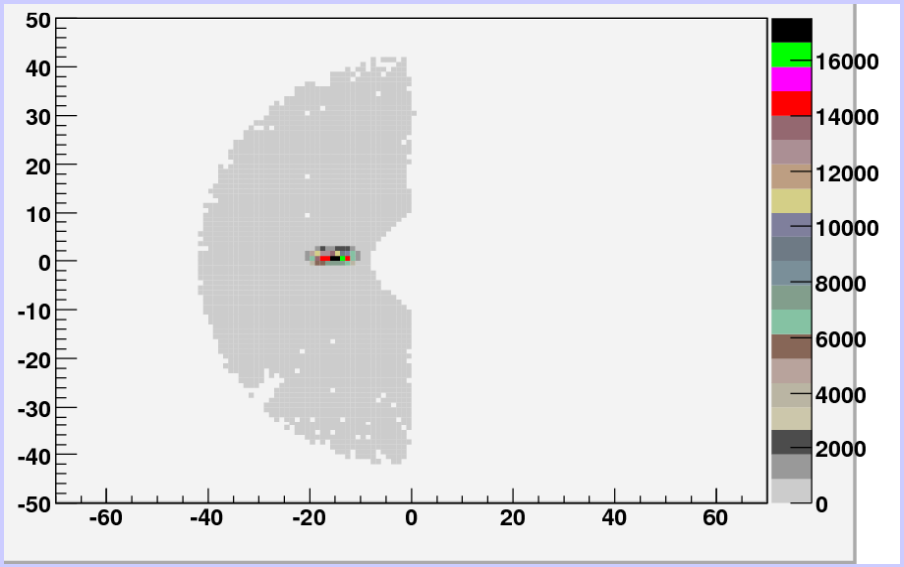
Effect of f

- Negative f
- f=-0.2

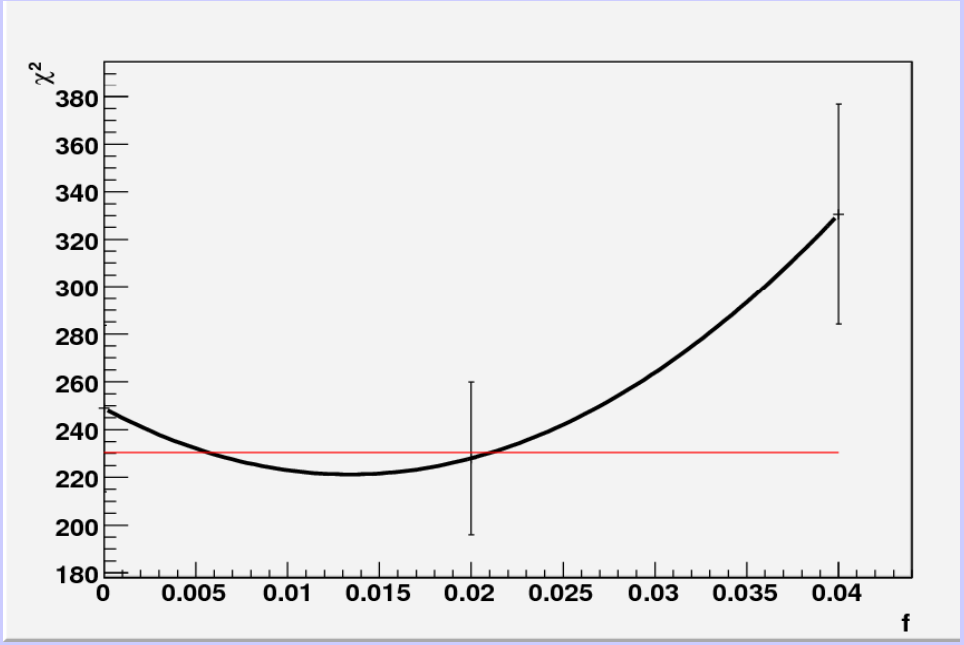
- Positive f
- f=0.2



Beam position on sensor



χ^2 fit


χ²
380
360
340
320
300
280
260
240
220
200
180
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
f

Results - ϕ sensors

Module	f1	g1	f2	g2	f3	g3	f4	g4
M26	-0.15 ±0.01	-0.28 ±0.01	0.1 ±0.01	-0.02 ±0.02	0 ±0.01	-0.04 ±0	-0.03 ±0	-0.08 ±0.01
M29	0.02 ±0.01	-0.26 ±0.01	0.05 ±0.01	-0.1 ±0.01	-0.03 ±0.08	-0.04 ±0.01	-0.04 ±0.01	-0.08 ±0.01
M23	0.03 ±0.01	-0.22 ±0.02	0.04 ±0.01	-0.12 ±0.02	-0.01 ±0	-0.12 ±0.01	-0.04 ±0.01	-0.02 ±0.01
M31	0.1 ±0.02	-0.44 ±0.01	0.04 ±0.01	0 ±0.02	0 ±0.02	-0.02 ±0.01	-0.02 ±0.02	-0.06 ±0.02
M30	-0.16 ±0.01	-0.3 ±0.01	0.08 ±0.01	-0.04 ±0.02	0 ±0.01	-0.05 ±0.01	0 ±0.01	-0.01 ±0
Mean	-0.03	-0.3	0.06	-0.03	-0.03	0.05	-0.03	-0.04
rms	0.1	0.07	0.02	0.07	0.04	0.03	0.01	0.04
χ^2	2.7	4.38	0.15	3.33	0.39	1.25	0.06	1.27

Results – *R* sensors

Module	f	g
M26	0.04±0.02	-0.34±0.01
M29	0±0.01	-0.28±0.01
M31	0.1±0.02	-0.44±0.01
M30	0.08±0.02	-0.35±0.01
Mean	0.06	-0.34
rms	0.04	0.06
χ^2	0.41	3.17

- 12% one strip clusters converted into two strip clusters
  - 630700 one strip clusters
  - 75684 clusters are actually two strip clusters
- 5% of three strip clusters converted into two strip clusters
  - 8000 three strip clusters
  - 400 three strip clusters are actually two strip clusters