

First results from newly installed Forward Shower Counters in LHCb



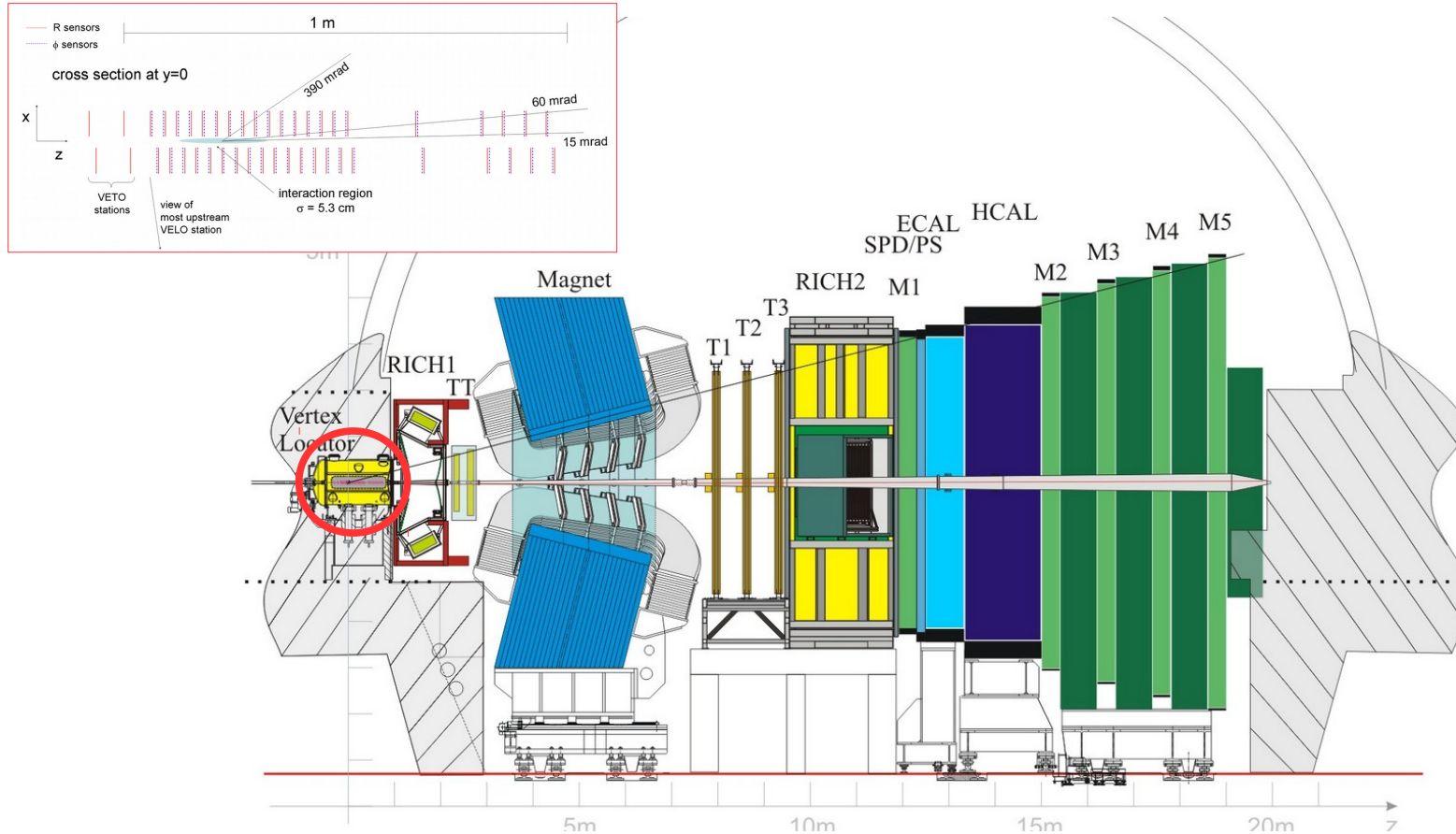
Paolo Gandini
University of Oxford
on behalf of the Herschel group



LHC Working Group on Forward Physics and Diffraction

27th October 2015

LHCb Detector



Fully instrumented: $2 < \eta < 5$
 Some sensitivity: $-3.5 < \eta < -1.5$

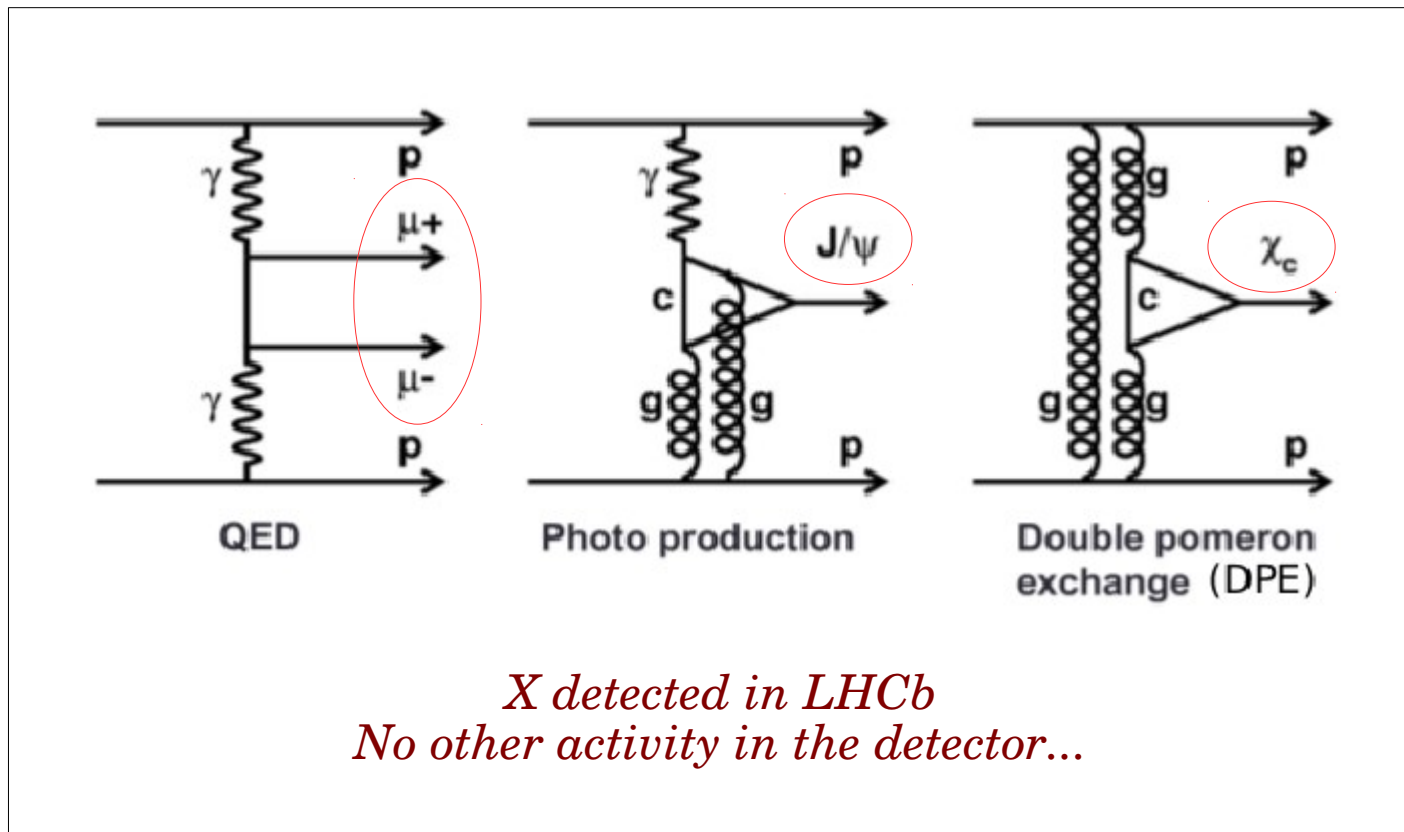
- **Forward spectrometer**
- Good Vertex measurements (Velo)
- Precise Tracking (Velo+TT+T)
- Excellent PID up to 100GeV (Rich1&Rich2)
- Versatile Trigger (L0+Hlt1+Hlt2deferred)

CEP @ LHCb

- **Low pile-up environment** → LHCb very well suited to studies of CEP production
- What do we look for (typically) ?

$pp \rightarrow p + X + p$ (rapidity gaps and protons intact)

- Colourless objects in QCD, Very low P_T objects, Clean experimental environment
- **Rich Physics:** Photon-Pomeron, Double-Pomeron, Photoproduction, Glueballs, Exotica

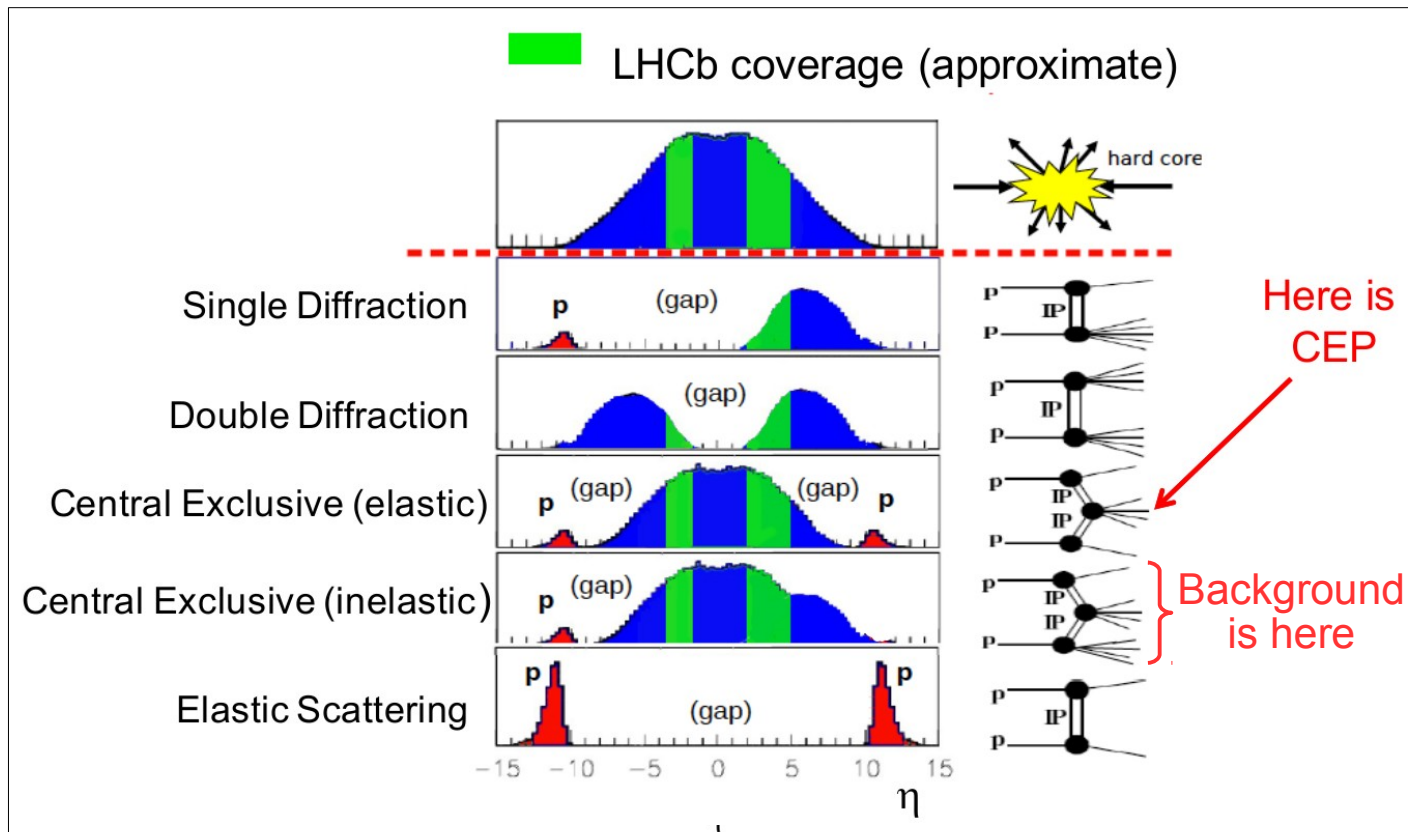


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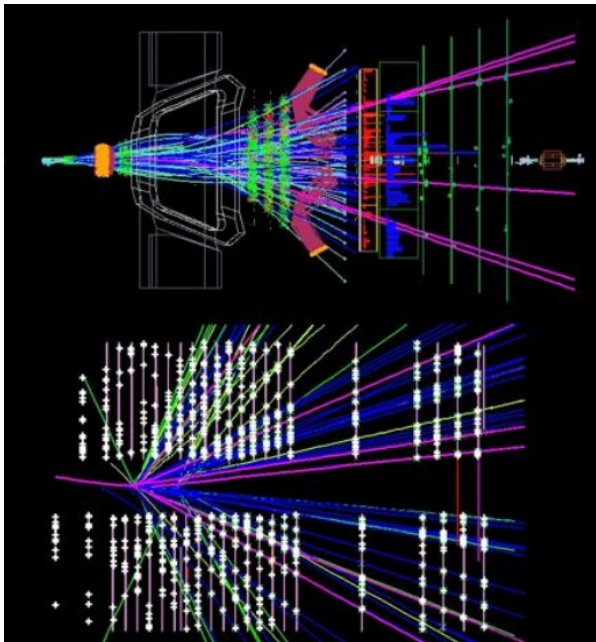
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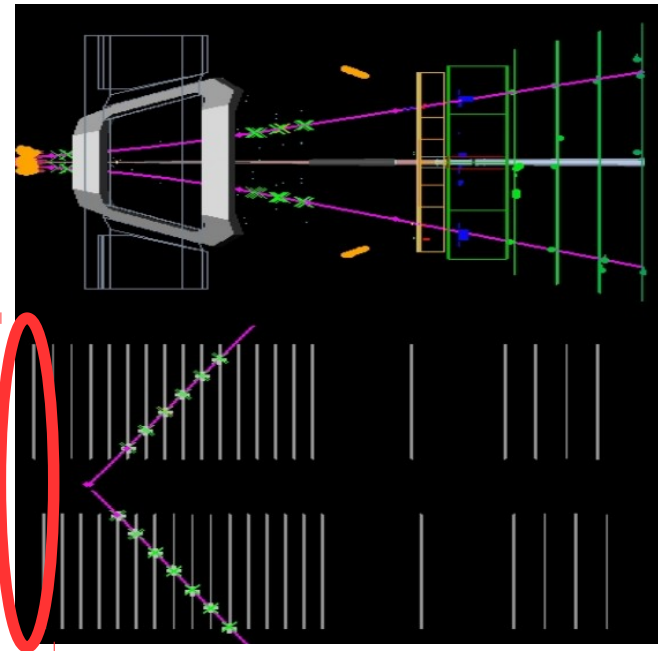
Experimentally...

- How do we select / trigger these events?
- Protons \rightarrow escape in the beampipe
- Events with low activity in detector
- Look at backwards tracks in the VELO (some η coverage)
- Size of detectable gaps is critical

Typical Event



CEP-like event: 2muons



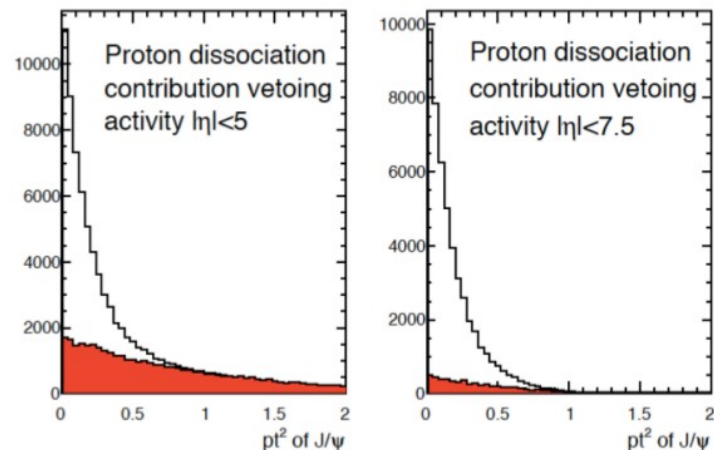
Backgrounds?

- The irreducible backgrounds to the analyses are dominated by inelastic backgrounds
- Undetectable events where the proton breaks up in the forward direction (inside beampipe)
- Currently we fit CEP/nonCEP fractions via PT distributions
- Main source of systematic uncertainty

Updated measurements of exclusive
 J/ψ and $\psi(2S)$ production
 cross-sections in pp collisions at
 $\sqrt{s} = 7$ TeV

Correlated uncertainties expressed as a percentage of the final result	
ϵ_{sel}	1.4%
Purity determination (J/ψ)	2.0%
Purity determination ($\psi(2S)$)	13.0%
* ϵ_{single}	1.0%
*Acceptance	2.0%
*Shape of the inelastic background	5.0%
*Luminosity	3.5%
Total correlated statistical uncertainty (J/ψ)	2.4%
Total correlated statistical uncertainty ($\psi(2S)$)	13.0%
Total correlated systematic uncertainty	6.5%

Estimate of potential
 benefit of vetoing
 particles up to $\eta < 7.5$

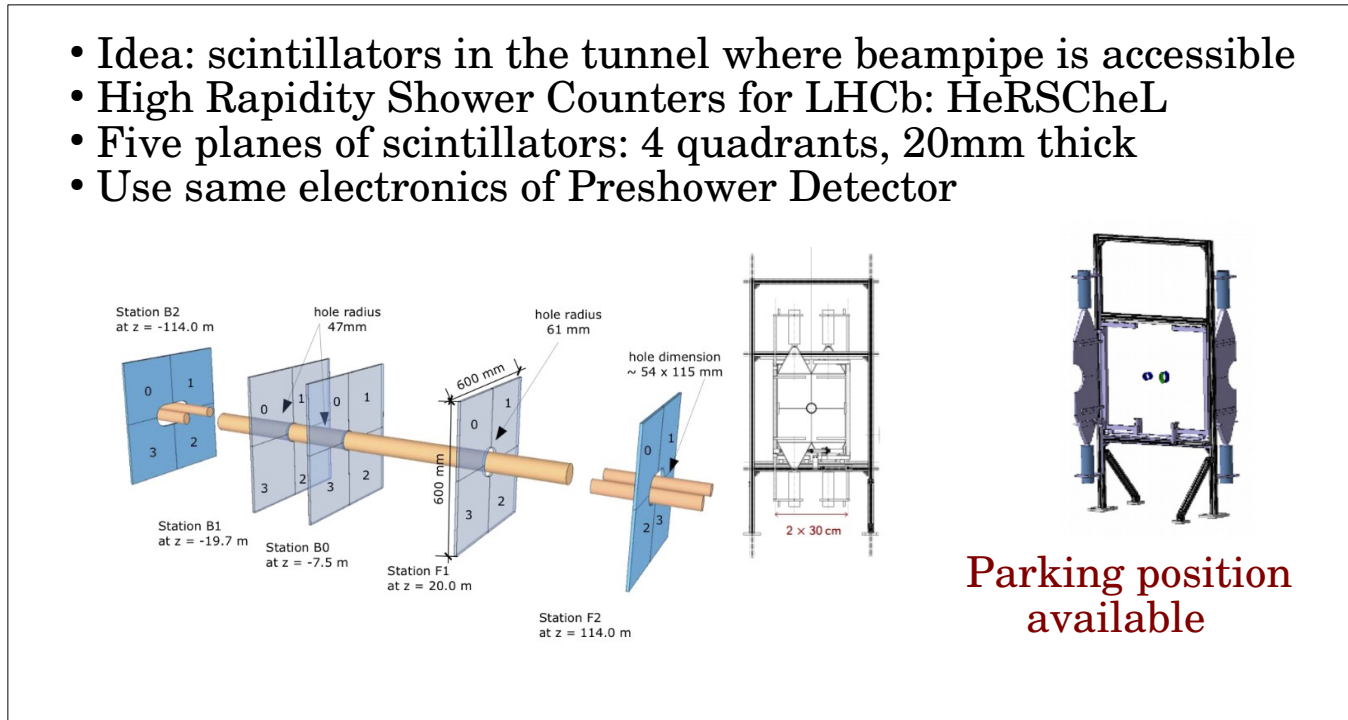


CERN-PH-EP-2013-233
 LHCb-PAPER-2013-059

Herschel Detector

- New detector installed for Run2 → Increase η coverage in the forward region

- Idea: scintillators in the tunnel where beampipe is accessible
- High Rapidity Shower Counters for LHCb: HeRSChel
- Five planes of scintillators: 4 quadrants, 20mm thick
- Use same electronics of Preshower Detector



15mm thick plastic scintillator glued to fishtail light guides

PMT: Hamamatsu R1828-01, 51mm, anode current limit $\sim 200\mu A$

Customised high rate base.

Calibration with cosmics, 1 mip ~ 170 photo-electrons.

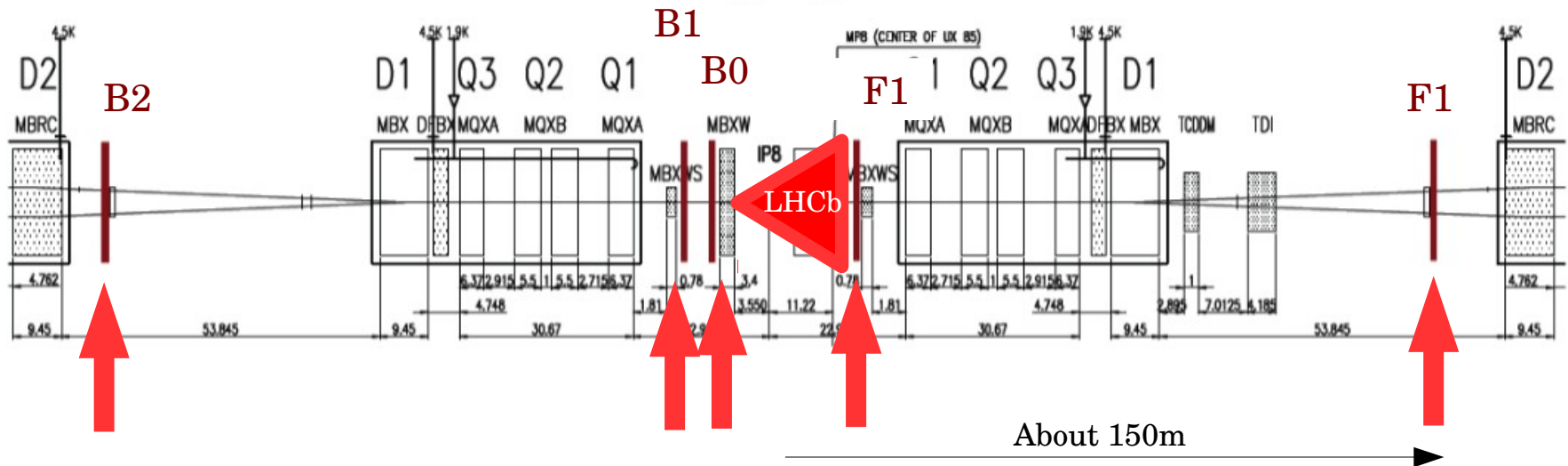
LED calibration at different HV.

Pneumatic motion system to retract scintillators from high fluence region.

Herschel Detector

- New detector installed for Run2 → Increase η coverage in the forward region

To get an idea on distances



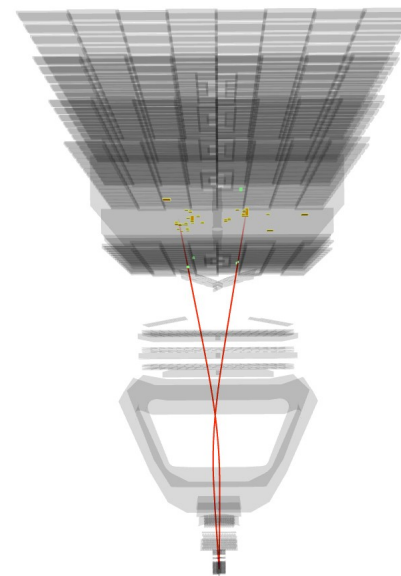
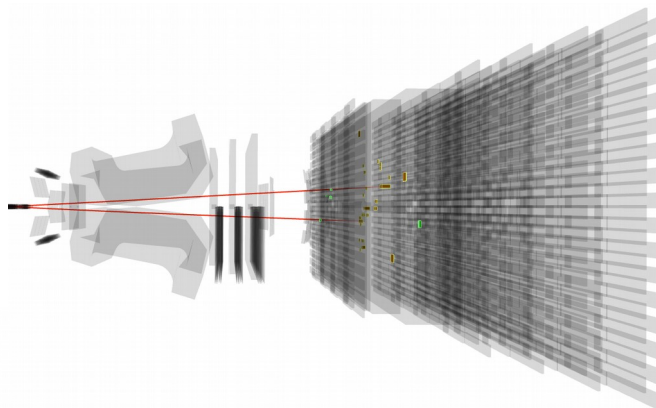
- Fully operational and running
- Fully integrated in LHCb DAQ → Work ongoing towards integration in L0
- Can be used to VETO forward activity
- Can be included at Trigger level → maximise trigger efficiency and lumi

Summer Data (2015)

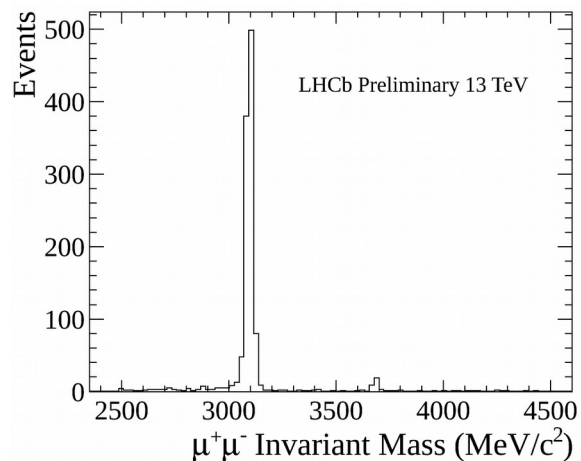


DiPion event consistent with CEP

Event 92298607
Run 157027
Mon, 06 Jul 2015 01:53:50

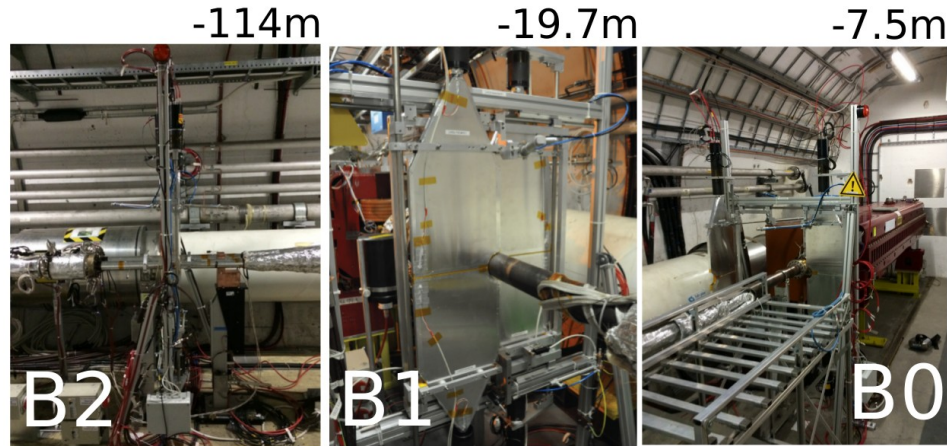


Nice signal of exclusive-like J/ψ

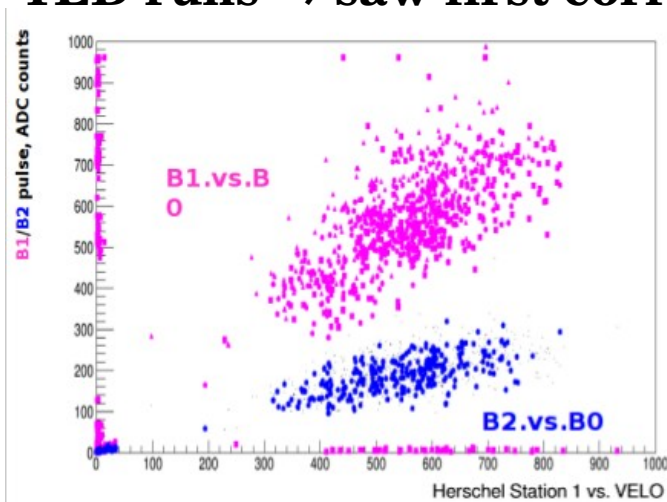


History so far (1) – last Forward Phys workshop

- Installation finished in December 2014

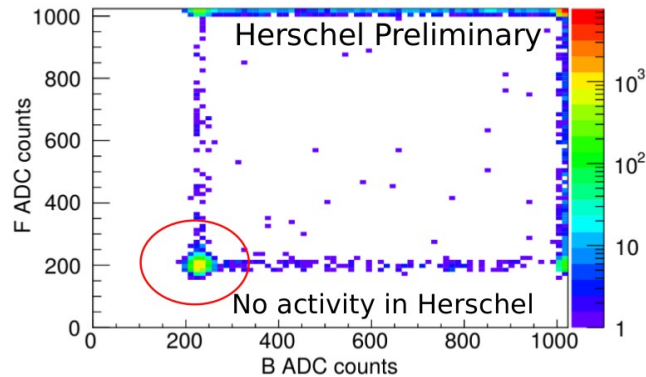


- Commissioning
- **TED runs** → saw first correlations



History so far (2)

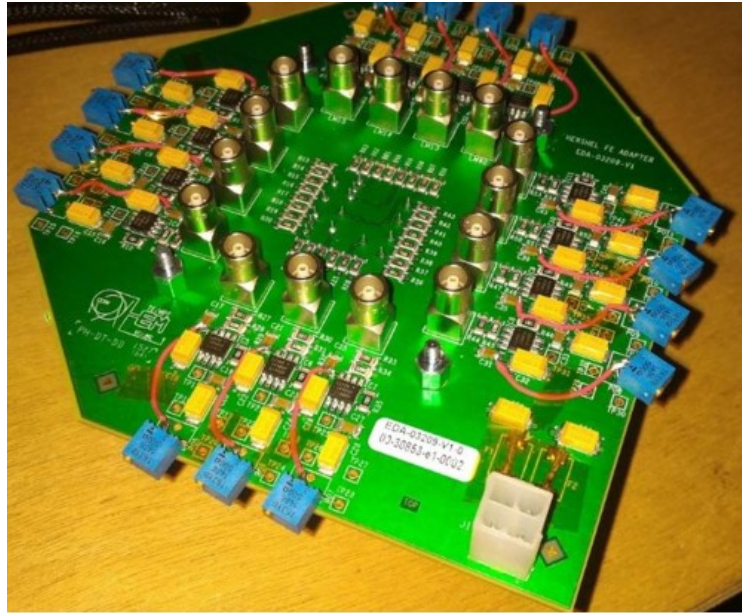
- 50 ns Intensity Rump → Herschel included in LHCb global running first time
- Adaptor Board: Simple adaptation of signal from PMT (AC coupling) to adapt our 0V baseline signal to the -2V baseline input of the VFE
- Used for TED, Calibration runs, 50ns intensity ramp up.
- Correct readout only on the rst bxID of a train.



50ns ramp
(high voltage very high)
Maximum ADC counts seen in
quadrants of F side VS B side.
Herschel run from 50ns data
taking.

- Commissioned all scripts and tools
- Improved grounding (Noise was at the level of PMT pedestal)
- We realized noise was correlated between channels → new connections of spare channels for CM suppression

History so far (3)

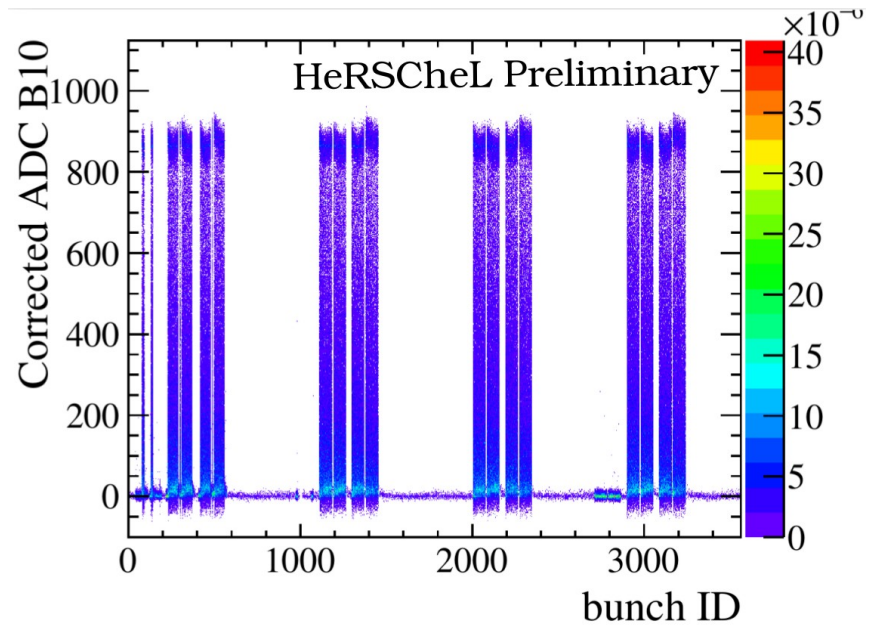
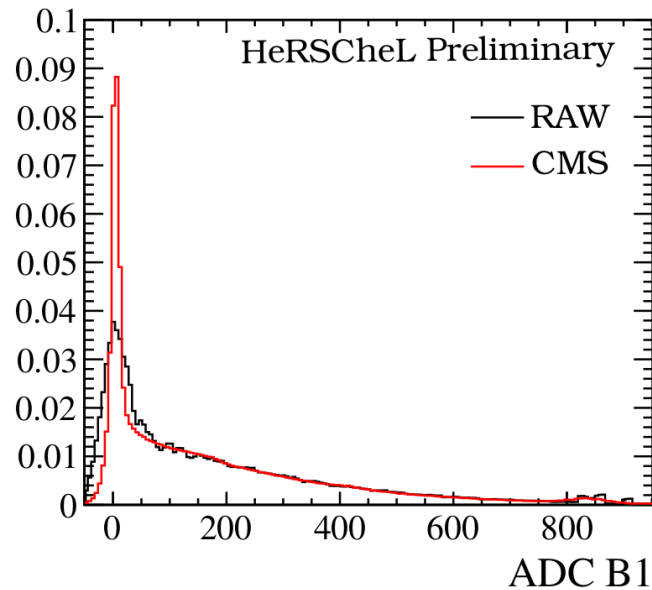


- **New adaptor board installed end July**
- A factor of 10 current attenuation → avoid saturation regime of FE
- Able to read every BXID (stable response along the train)
- Noisier, to be improved in 2016 data taking
- Part of the noise can be corrected via CM subtraction
- In use for 25 ns data (all 2015)

Common Mode Suppression

~1.8 nb⁻¹ of pp collision on Hlt2 selected events

- HV settings:
 - B0, B1 ~ 4 ADC/mip
 - B2, F2 ~ 5 ADC/mip
 - F1 ~ 2 ADC/mip

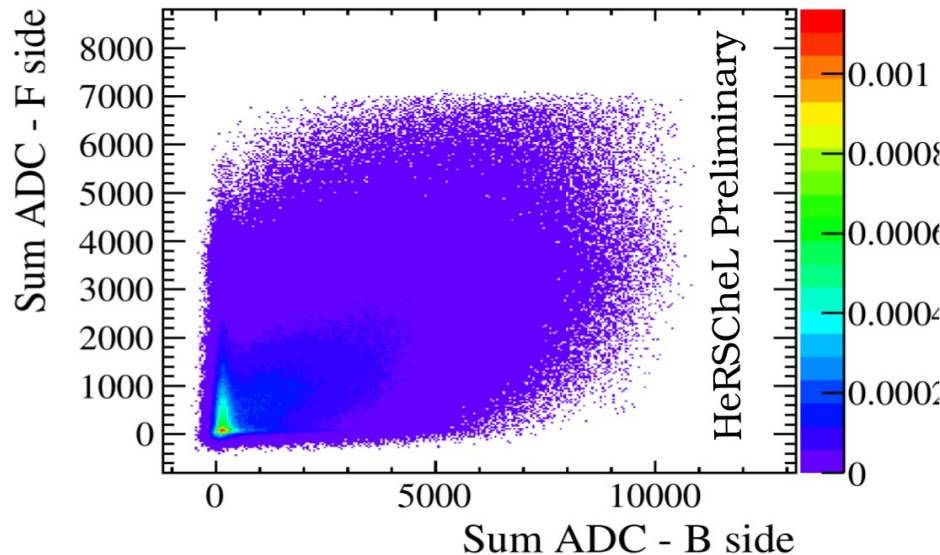


A look at Data: Herschel Only

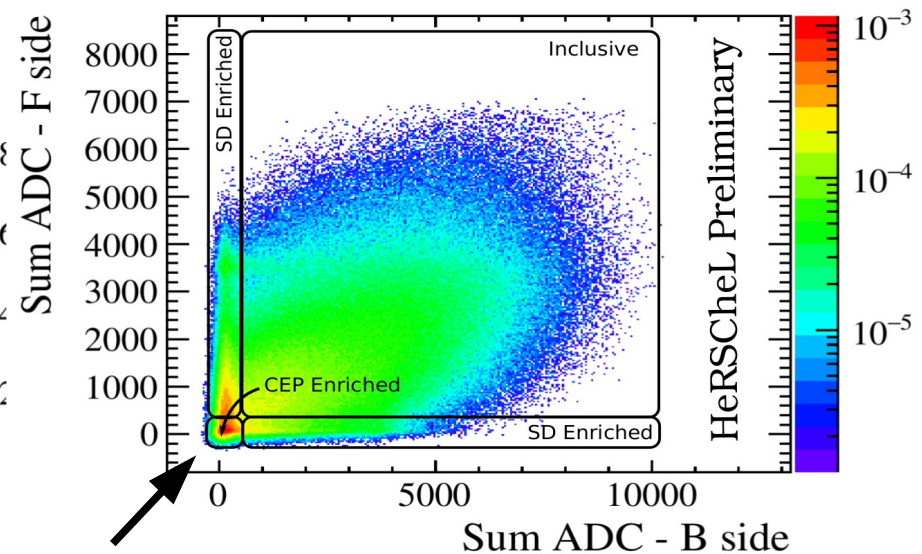
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Mixture of triggered events
compatible with B,D decay and events triggered by our CEP triggers.

Linear plot



Log plot

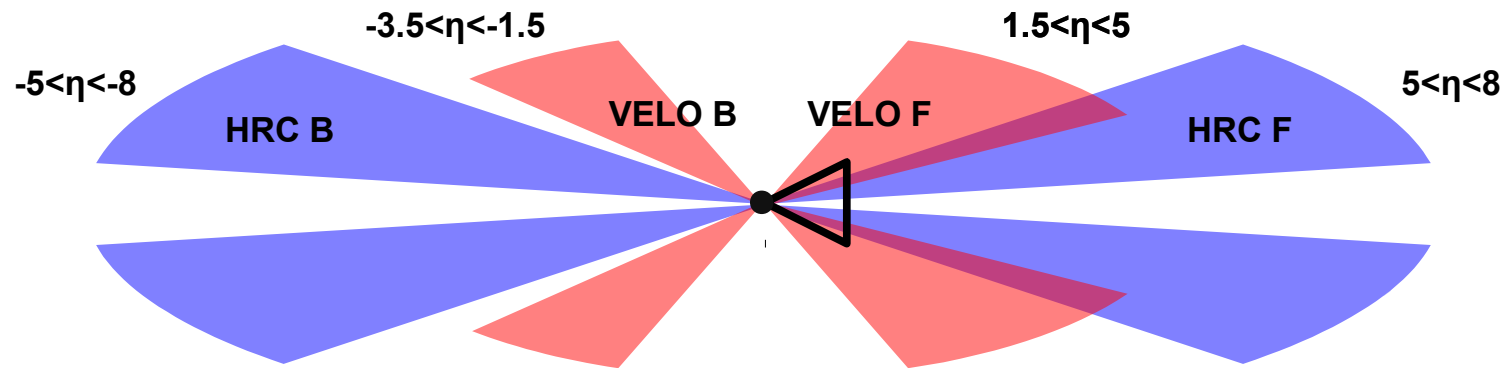
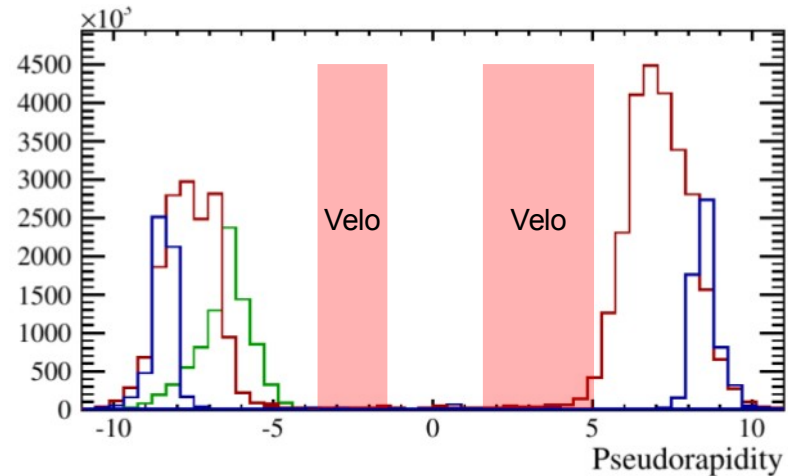


We can identify clearly
the various “classes” of events

Herschel vs Velo coverage

Velo Coverage : **backwards** $-3.5 < \eta < -1.5$ and **forward** $1.5 < \eta < 5$

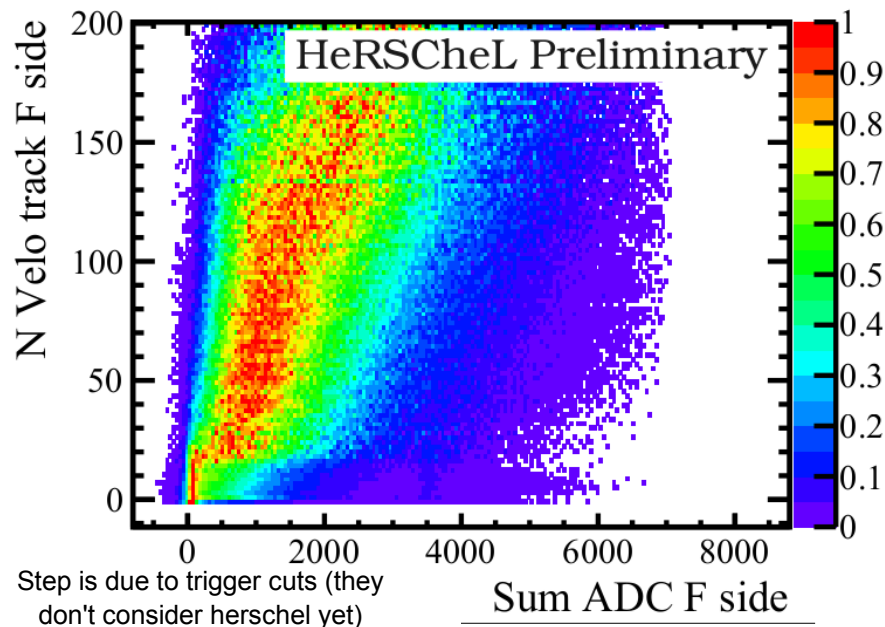
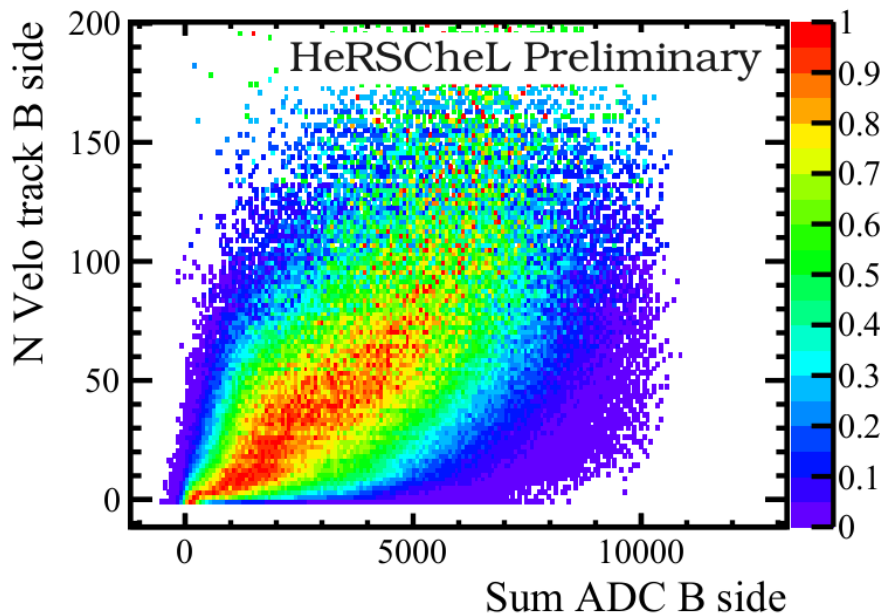
Simulation (Pythia8)
Pseudorapidity of primary particles
creating showers detected by Herschel.
Entries are weighted by energy deposit.



A look at Data: with LHCb

~1.8 nb⁻¹ of pp collision on Hlt2 selected events

Correlate with VELO tracks in LHCb
We should see a correlation between activity in tracker and Herschel
Can look backward and forward parts

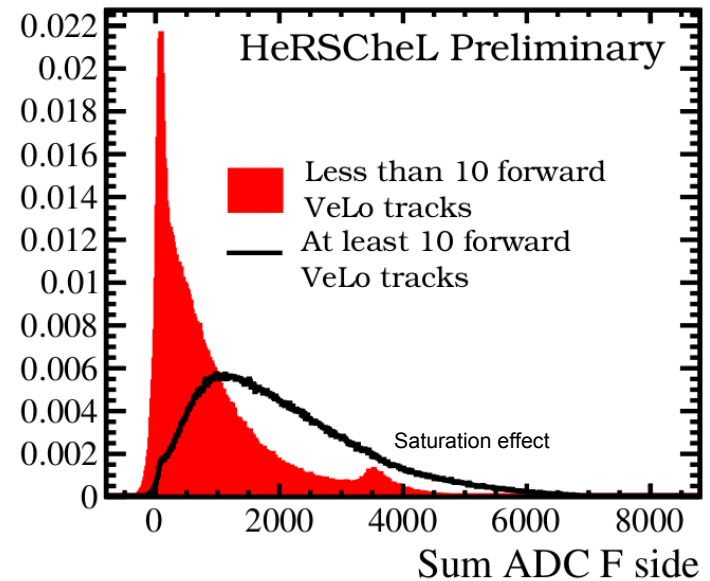
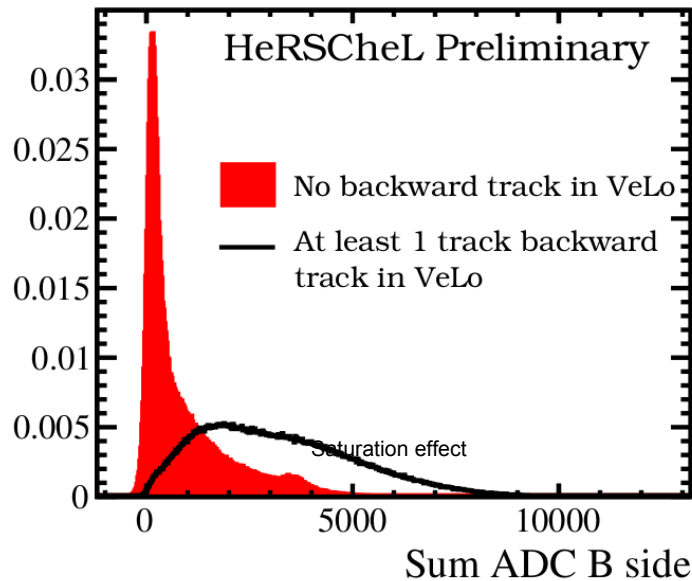


A look at Data (LHCb)

~1.8 nb⁻¹ of pp collision on Hlt2 selected events

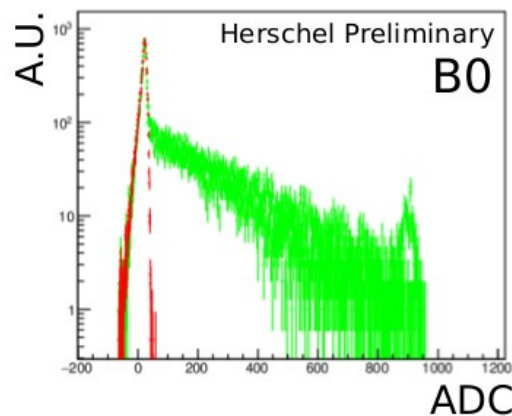
Correlate with VELO tracks in LHCb
We should see a correlation between activity in tracker and Herschel
Can look backward and forward parts

(essentially same plot but 1D)

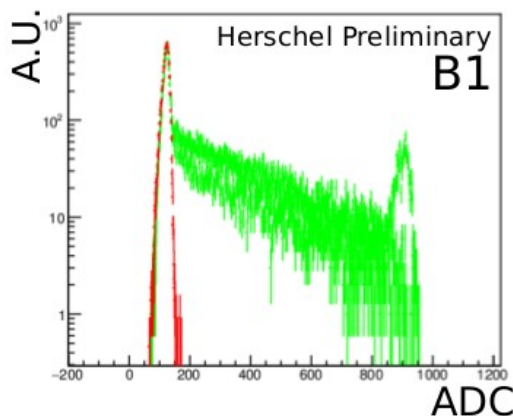


A look at Data

- We can check the response of Herschel in collision
- This type of study allows us to check how CEP should look like in Herschel

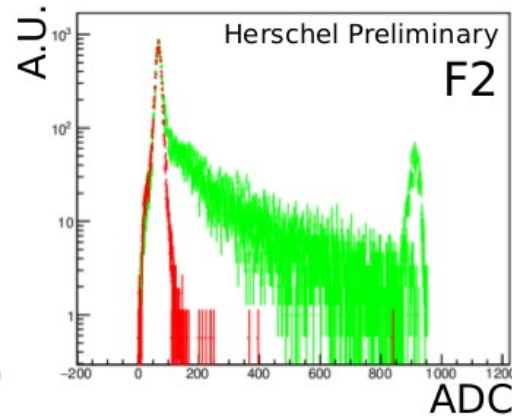
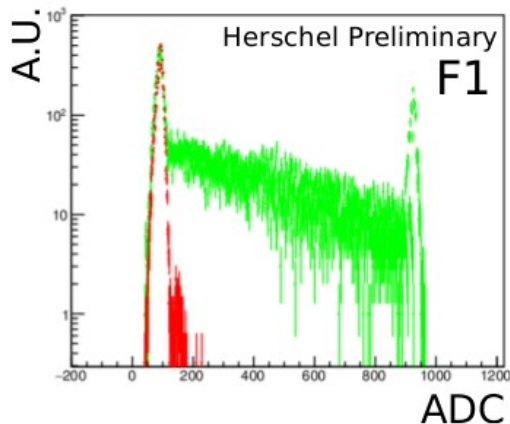
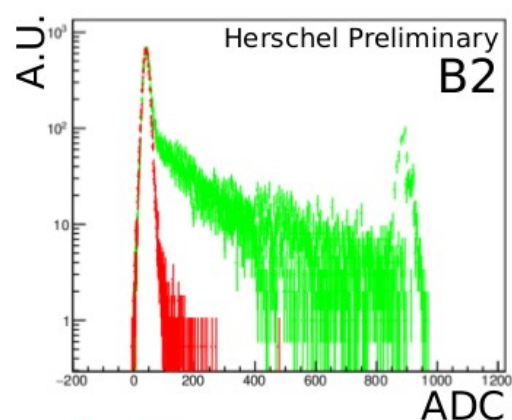


Random trigger on bb crossing



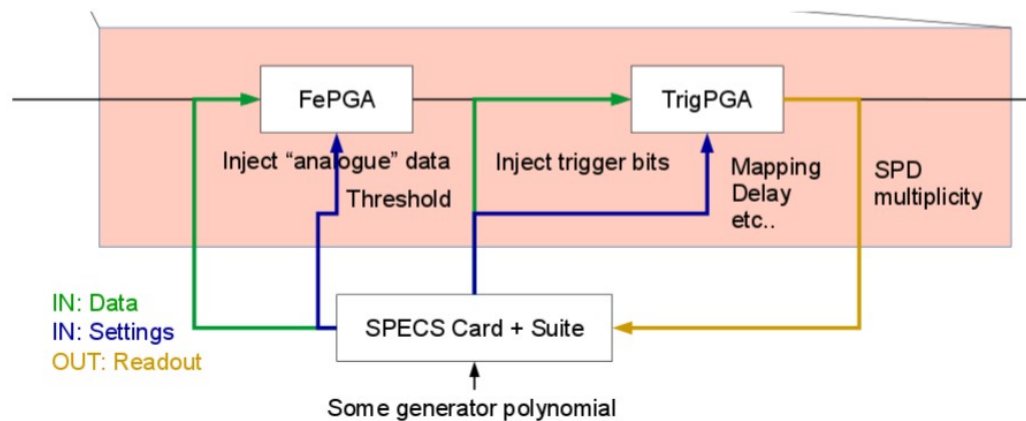
First empty crossing after a bb train

How signal should look like (considering the bunching)



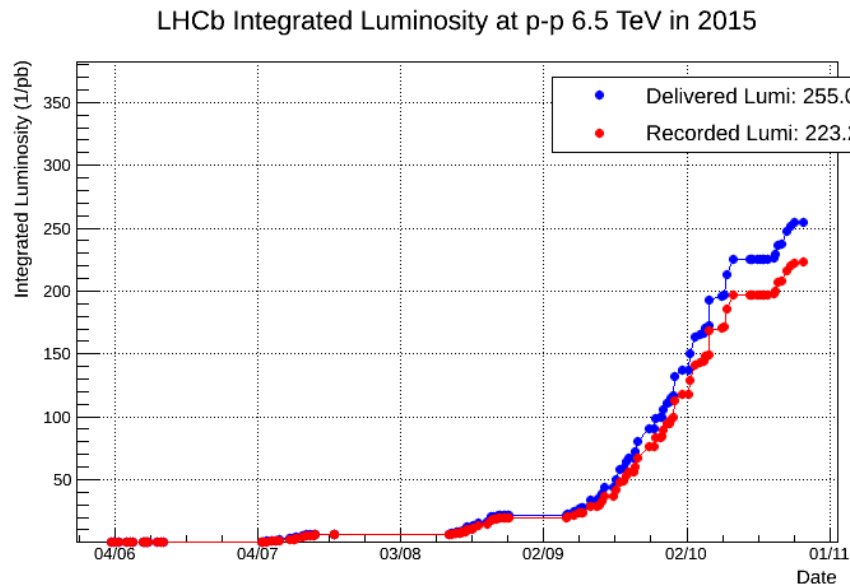
Herschel in L0 trigger

- Work ongoing for the integration in the hardware trigger
- Veto on Herschel activity would allow to relax other cuts
- Need the number of channels above threshold on F and B side in the L0.
- Reuse PS/SPD FE SPD CB
- On the front end board FPGA dedicated → need to reprogram it
- Validation on-going, checking all the communications
- Should be ready for 2016



Outlook

- LHCb CEP program is quickly expanding
 - Charmonium, Double-Charmonium and Bottomonium results published so far...
 - Included dedicated loose triggers for RunII
 - Herschel is fully operational and running
- CEP $J/\Psi, \Psi(2S)$ 2014 J. Phys. G. 41 055002
CEP $J/\Psi J/\Psi$ 2014 J. Phys. G. 41 115002
CEP $\Upsilon?$ arXiv:1505.08139
- Special loose L0 threshold to allow calibration of detector
 - **>200pb-1 on tape in 2015 with Herschel included in LHCb**
 - Working towards automation of most procedures



As this morning
(most of it with Herschel in)