European Organization for Nuclear Research

ATLAS Experiment

Mohammed V – AGDAL University

Faculty of Sciences , Rabat

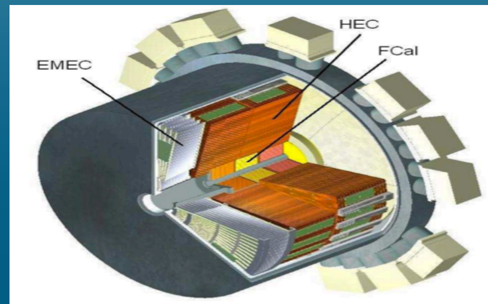
The ATLAS Liquid Argon Calorimeter: Luminosity Determination using the Currents of the High-Voltage System

Nacim HADDAD
Emmanuel Monnier
Rajaa Cherkaoui El Moursli
Hass Abouzeid

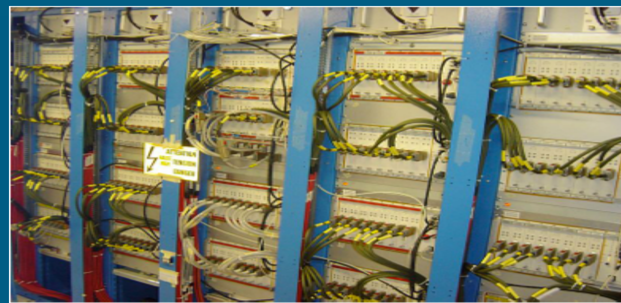
Introduction (1)

- « **Minimum Bias** » Events from soft collisions between two protons, particles (often π^0/π^+) in the final state have a low transverse momentum and important longitudinal momentum → Pions are ionized in the inner detector to give a large flux of photons through the electromagnetic calorimeter (FCAL in particular).

> *The induced particle flux intensity is directly proportional to the interaction rate → Luminosity*



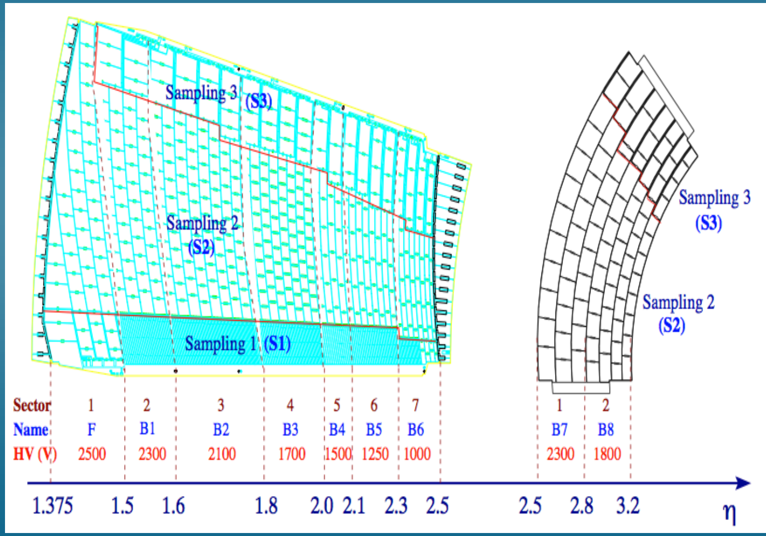
- « **High Voltage System(HV)** » The current injected to compensate for ionisation losses from minimum bias events is correlated to the flux, → Luminosity !!



> *The LAr group offers an official luminosity measurement from reading the current induced by the FCAL high voltage system (HV)*

Introduction (2)

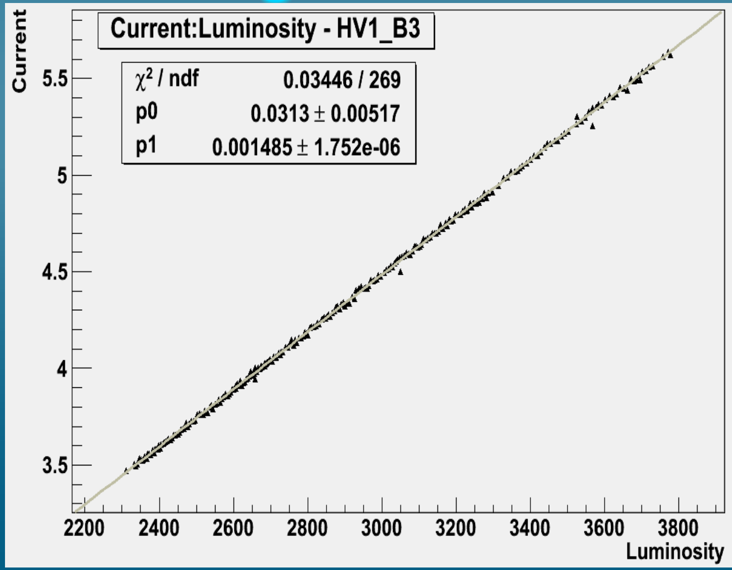
My work consists in extracting the current injected by the EMEC high voltage system to measure the luminosity.



Work Plan :

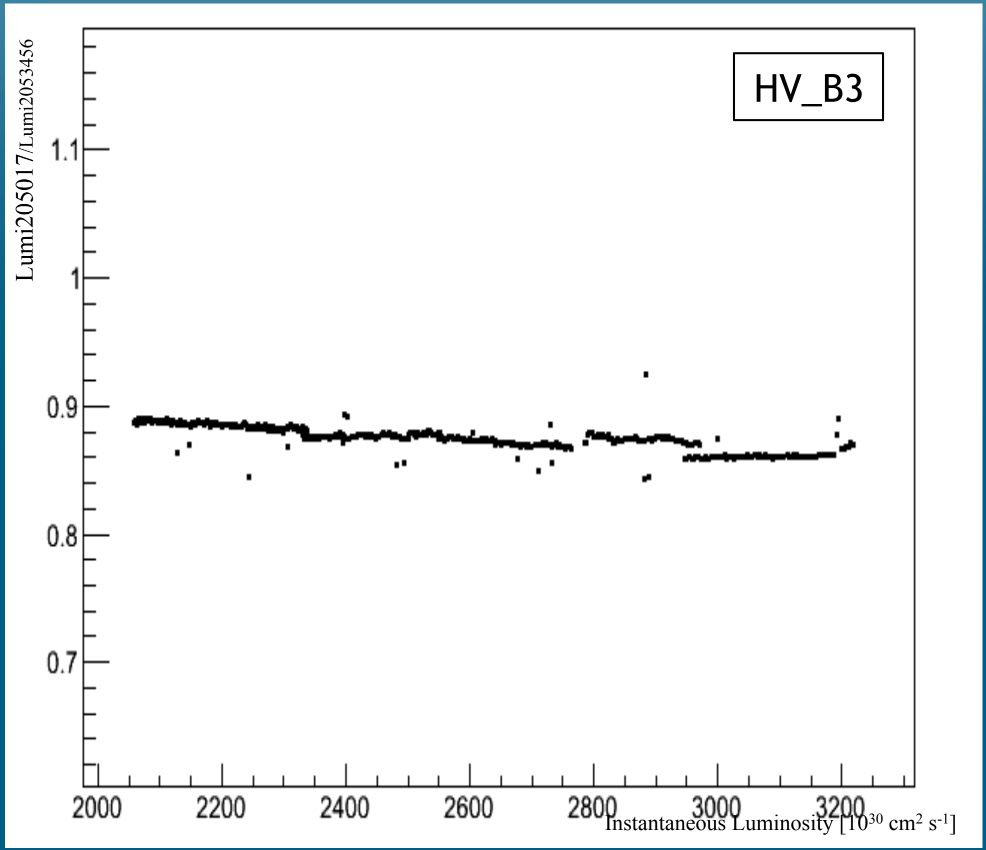
- Select properly the HV channels (correspond to the same type of HV zone)
- Extract the good Run (Use the Good Run List [GRL])
- Luminosity Algorithm (Beam Condition Monitor [BCM])
- BCM Calibration → Van der Meer

The first results



Extracted fit parameters from the relationship:

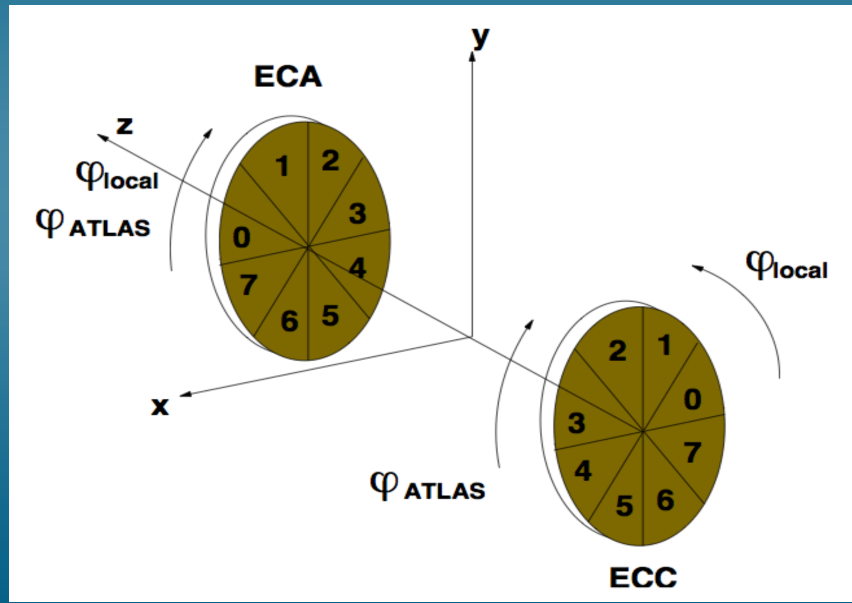
<u>*Current = **a** . Luminosity + **b***</u>



Not good Distribution !!
We need a distribution
around 1

Selection of HV lines

- « EMEC (A ou C)» is composed by 8 modules (ECA0, …, ECA1), each module is composed by an outer wheel (1.375<η<2.5) and an inner wheel (2.5<η<3.2).



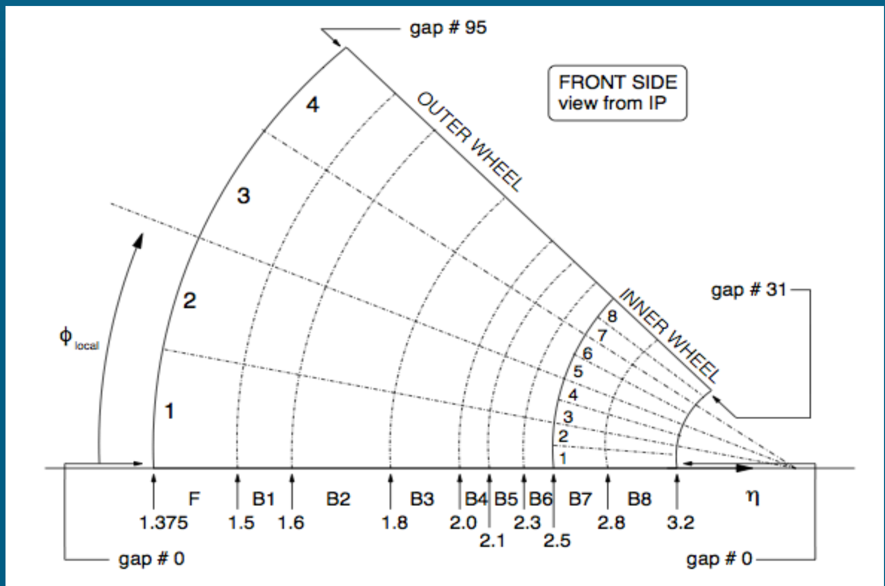
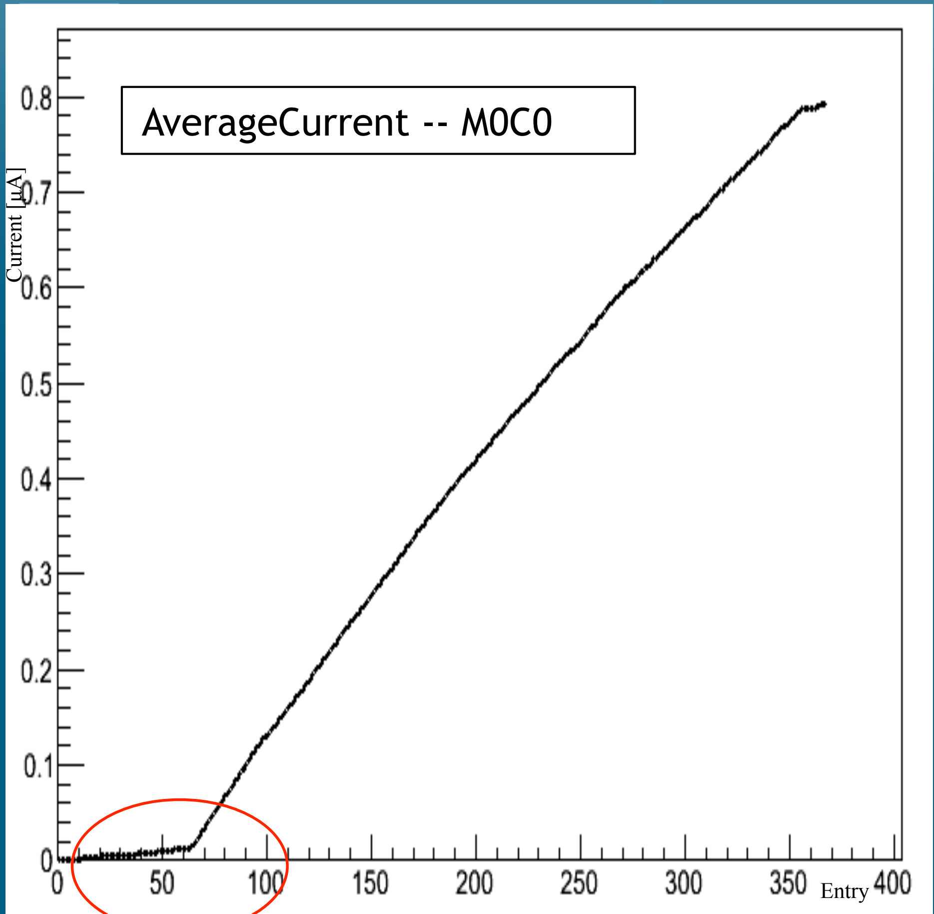


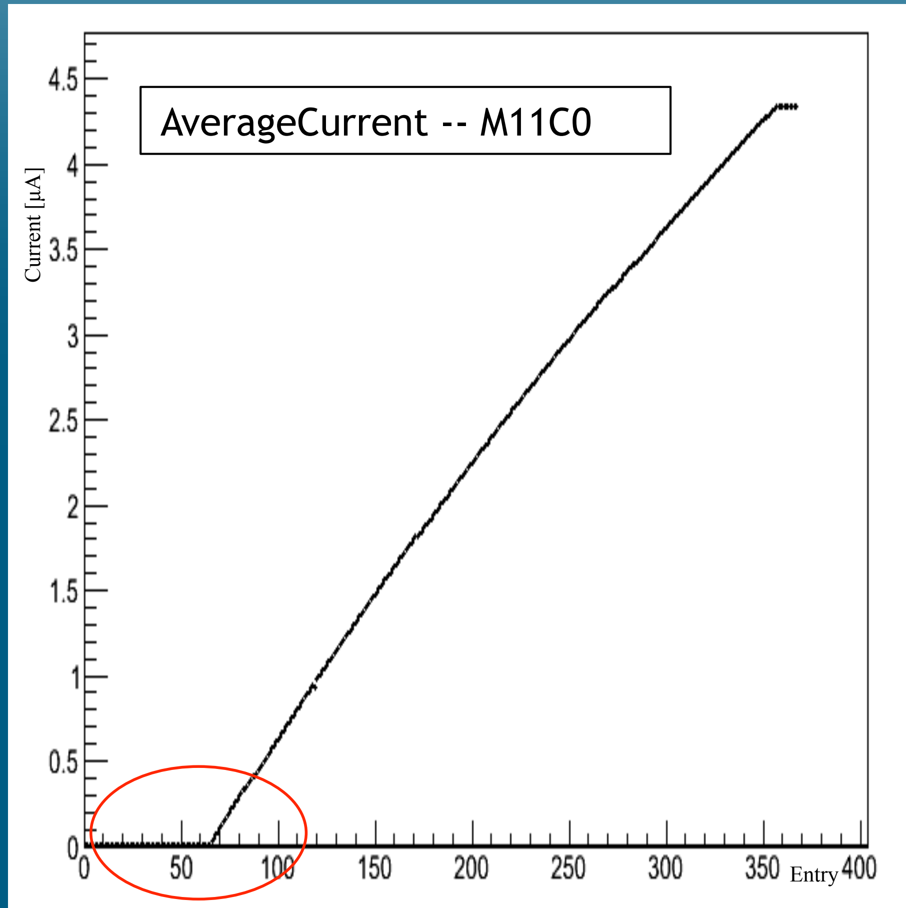
Figure 3: *Schematic view loocking from the interaction point*

- « Secteur HV» is defined as a 1 η sector [F, B1, …, B8] and 1 ϕ sector [OW with 4 ϕ sector and IW with 8 ϕ sector] with 2 side HV [HV1, HV2].

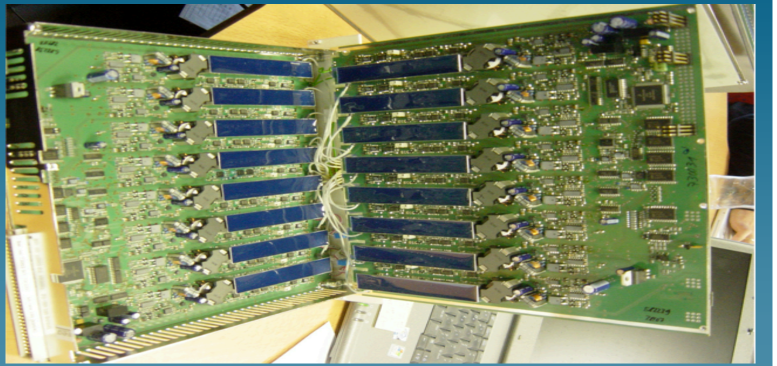
Selection of HV lines

- Select the noisy channels based on their means current.





Selection of HV lines



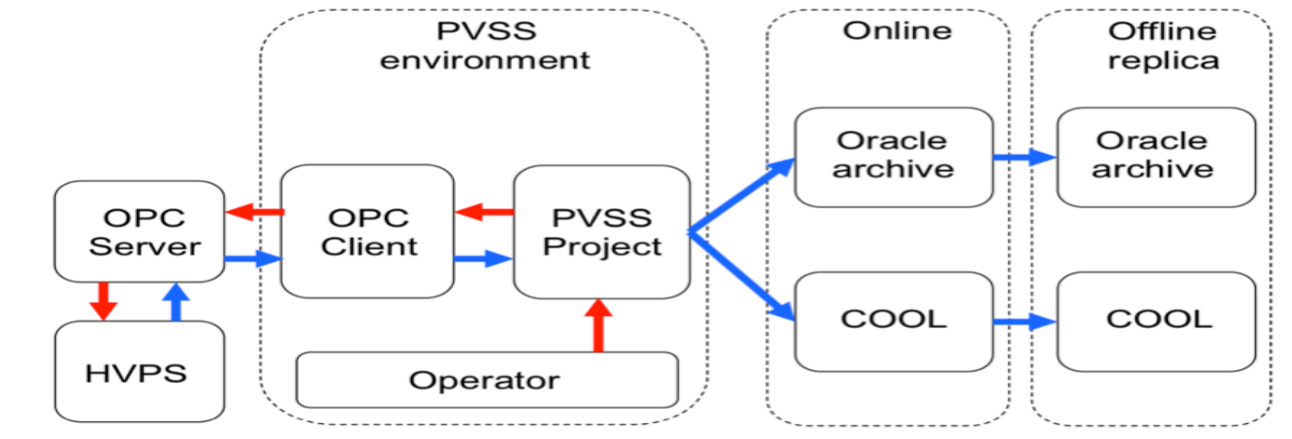
« High Voltage System (HV) » A selection of values is archived in the Online Oracle database for each module HV, The online database contents are subsequently replicated to an offline database outside the technical network → « Cool » :

ATLLARHVx :Myy.Czz.R.I$_{meas}$

- EMEC–A : $x = 1$, $y \in [0, 47]$, $z \in [0, 15]$

Module — Channel — Read — Current

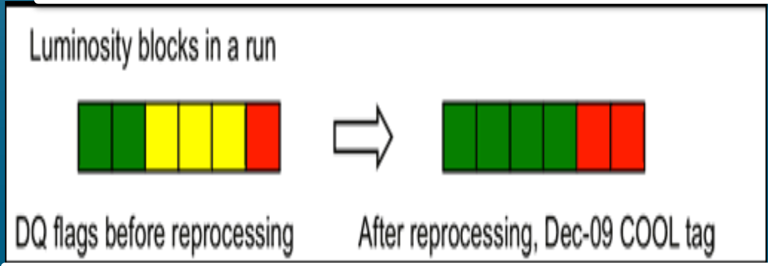
EMEC–C : $x = 2$, $y \in [100, 147]$, $z \in [0, 15]$



Good Run List (GRL)

« **Good Run List** » To define a good dataset we need Data Quality (DQ) information, as assessed by the DQ group

✓ The approach to using DQ information in a physics analysis is through the use of dedicated lists of runs and luminosity blocks ➔ **Good Run List(GRL)**

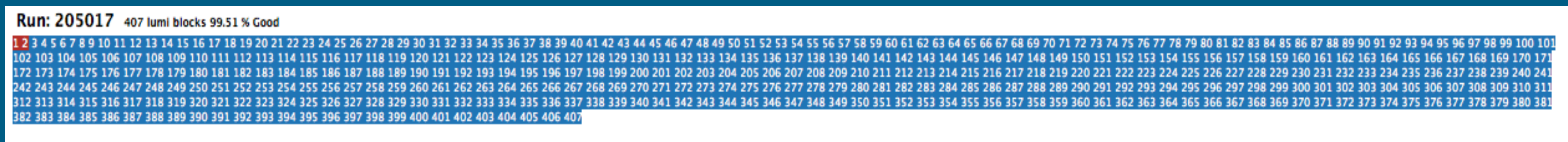


« **Luminosity Blocks** » is the unit of time for data-taking, and lasts about two minutes (in our case 1 minute)

✓ For my work, I use Good Run List officially pre-calculated
➔ http://atlasdqm.web.cern.ch/atlasdqm/grlgen/

Extract a new Run reference (Run 205017).

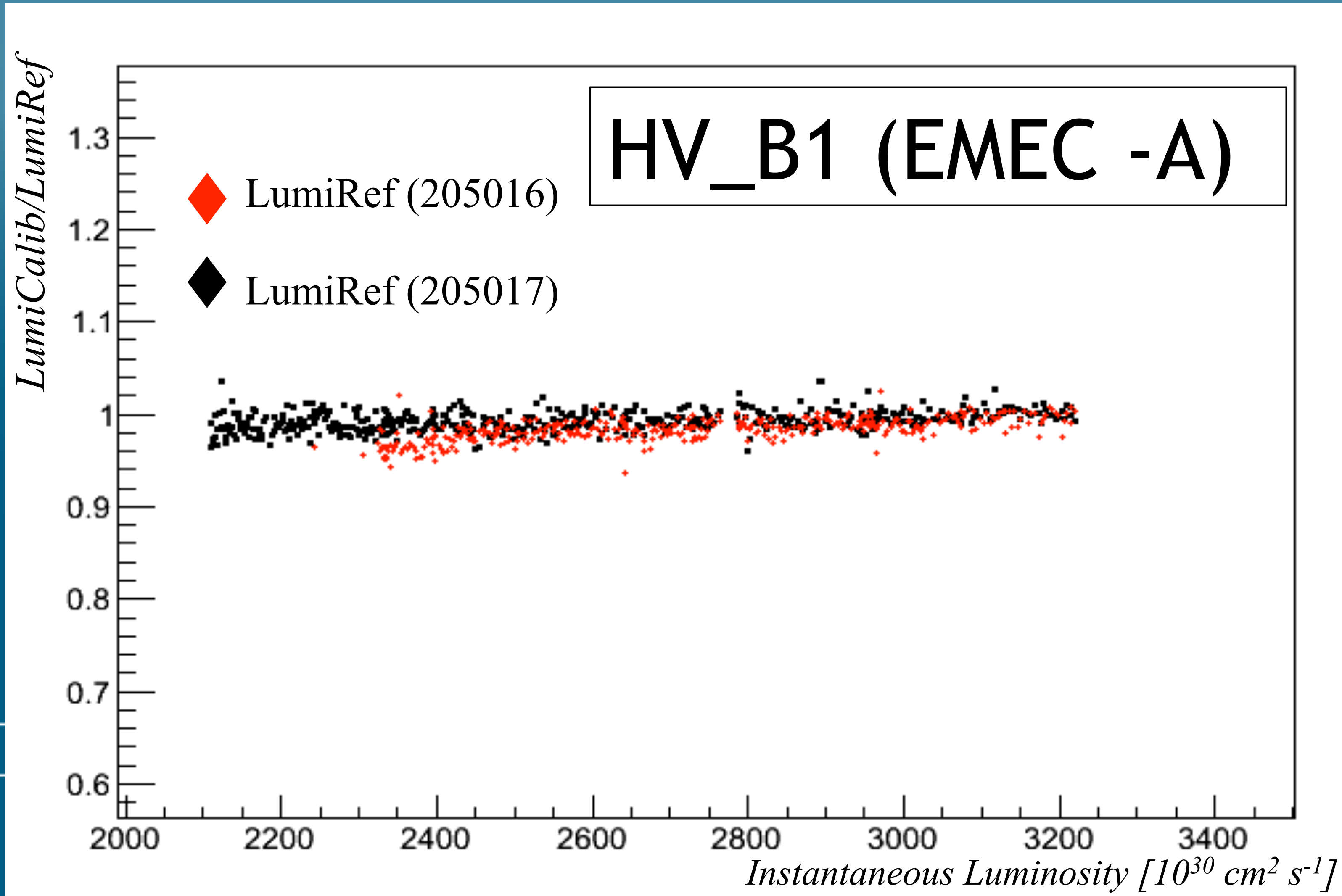
http://atlasdqm.web.cern.ch/atlasdqm/grlgen/All_Good/data12_8TeV.periodAllYear_HEAD_DQDefects-00-01-00_PHYS_StandardGRL_All_Good.xml#205017



Run: 205017 407 lumi blocks 99.51 % Good

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101
102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171
172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241
242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311
312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381
382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407

The results


HV_B1 (EMEC -A)
LumiRef (205016)
LumiRef (205017)
LumiCalib/LumiRef
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
2000
2200
2400
2600
2800
3000
3200
3400
Instantaneous Luminosity [10^30 cm^2 s^-1]

Conclusion

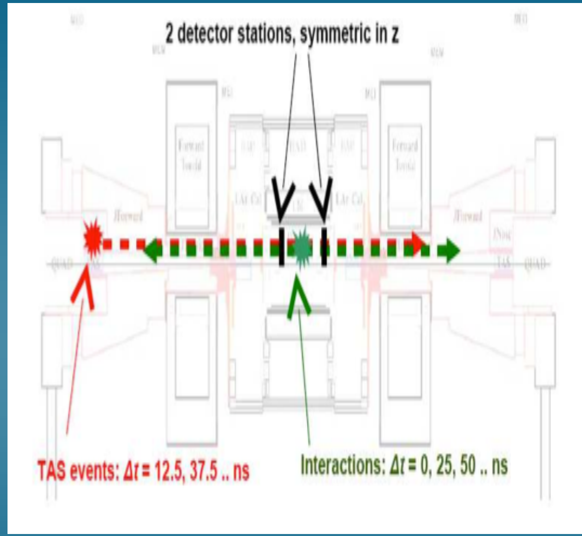
✓ I have started to select the good HV channels (the same type of HV zone) … Using Good Run List (GRL) gives a good result compared to the use of normal Run …

- Calibration with BCM and LUCID Algorithm !!
  Work in Progress (See Backup)

Backup

Beam Condition Monitor (BCM)

« Beam Condition Monitor (BCM) » is designed to detect such incidents and trigger an abort before they happen. It consists of two stations (forward and backward) of detectors each with four modules



By matching their rate measurements with the BCID, the LUCID and BCM detectors are able to provide a bunch- by-bunch luminosity determination.

Algorithm name	Description
LUCID Event_OR	A/C inclusive OR
LUCID Event_AND	A/C coincidence
LUCID Event_A	A exclusive OR
LUCID Event_C	C exclusive OR
BCM Event_OR	A/C inclusive OR , horizontal sensors
BCM Event_AND	A/C coincidence , horizontal sensors
BCM Event_OR_V	A/C inclusive OR , vertical sensors
BCM Event_AND_V	A/C coincidence , vertical sensors

During the 2010 and 2011 data-taking periods, the ATLAS luminosity algorithms were calibrated using dedicated :

van der Meer

http://www-f9.ijs.si/~margan/Atlas/BCM/jinst8_02_p02004.pdf

Van Der Meer calibration (1)

« Van Der Meer » The principle is to measure simultaneously the luminosity, beam currents, and collision rates

✧ The luminosity:

$$\mathcal{L} = \frac{\mu n_b f_r}{\sigma_{inel}}$$

μ et σ_{inel} *are not a directly measurable quantity*

✧ Their Ratio :

$$\frac{\mu}{\sigma_{inel}} = \frac{\mu_{vis}}{\varepsilon \sigma_{inel}} = \frac{\mu_{vis}}{\sigma_{vis}}$$

With μ_{vis} is the observed number of collisions per bunch crossing

✧ So, The luminosity :

$$\mathcal{L} = \frac{\mu_{vis} n_b f_r}{\sigma_{vis}} \quad + \quad \mathcal{L} = \frac{n_b n_1 n_2}{2\pi \Sigma_x \Sigma_y}$$

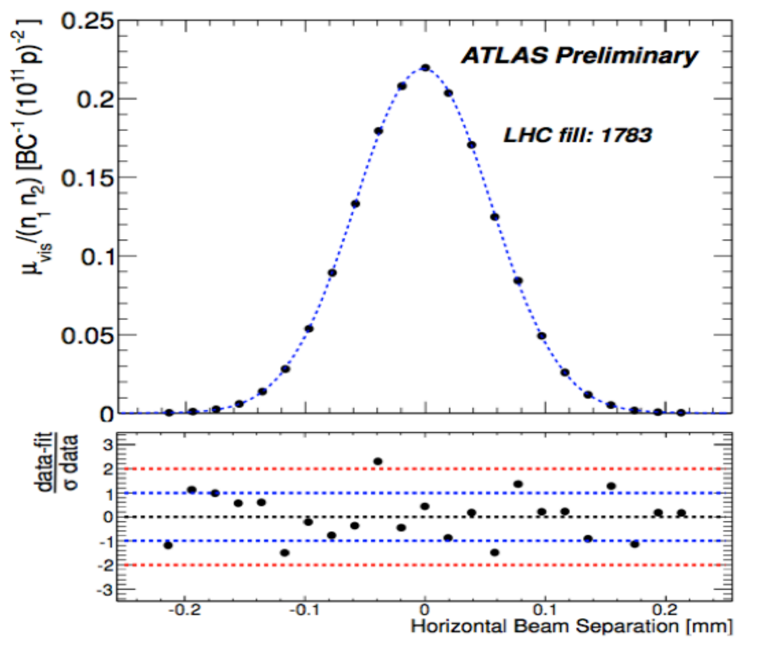
Another expression of luminosity using the machine parameters

$$\mu_{vis}^{MAX} = \frac{\mathcal{L}_{MAX} \sigma_{vis}}{n_b f_r} = \frac{n_1 n_2 \sigma_{vis}}{2\pi \Sigma_x \Sigma_y}$$

$$\sigma_{vis} = \mu_{vis}^{MAX} \frac{2\pi \Sigma_x \Sigma_y}{n_1 n_2}$$

So The peak rate (see Slide 14) μMax can then be compared to the measured luminosity and the visible cross-section

Van Der Meer calibration (2)



The Remaining calculations is to convert the rate of visible events into visible number of interactions and finally into instantaneous luminosity.

- With the BCM algorithm.:

EventOR inclusive

(follows a Poisson distribution)

$$P_{EventOR} = \frac{N_{OR}}{N_{BC}} = 1 - \exp\left(-\mu\varepsilon^{OR}\right) = 1 - \exp\left(-\mu_{vis}^{OR}\right)$$

- The visible number of interactions :

$$\mu_{vis}^{OR} = \ln\left(1 - \frac{N_{OR}}{N_{BC}}\right)$$

$$\mathcal{L} = \frac{\mu_{vis} n_b f_r}{\sigma_{vis}}$$