Pixel Operational Experience Workshop

from Thursday, 27 January 2011 at **14:00** to Friday, 28 January 2011 at **15:05** (Europe/Zurich)
at **CERN (40-S2-B01 - Salle Bohr)**

Manage

Here is what I will cover::
- General remarks from 2011
- Our experience with SEU
- The behavior of our ROC versus time
- Our policies with beam and HV.
- Radiation damage on sensors was covered somewhere else (yesterday by Seth).

https://indico.cern.ch/getFile.py/access?contribId=4&sessionId=0&resId=0&materialId=slides&confId=178194

CMS Pixel

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General remarks from 2011 (1)

Infrastructure:

Cooling, CAEN Power System, VME electronic and computing were very stable during 2011.

- Swapped a handful of P.S. to find out that they work perfectly fine on the bench.

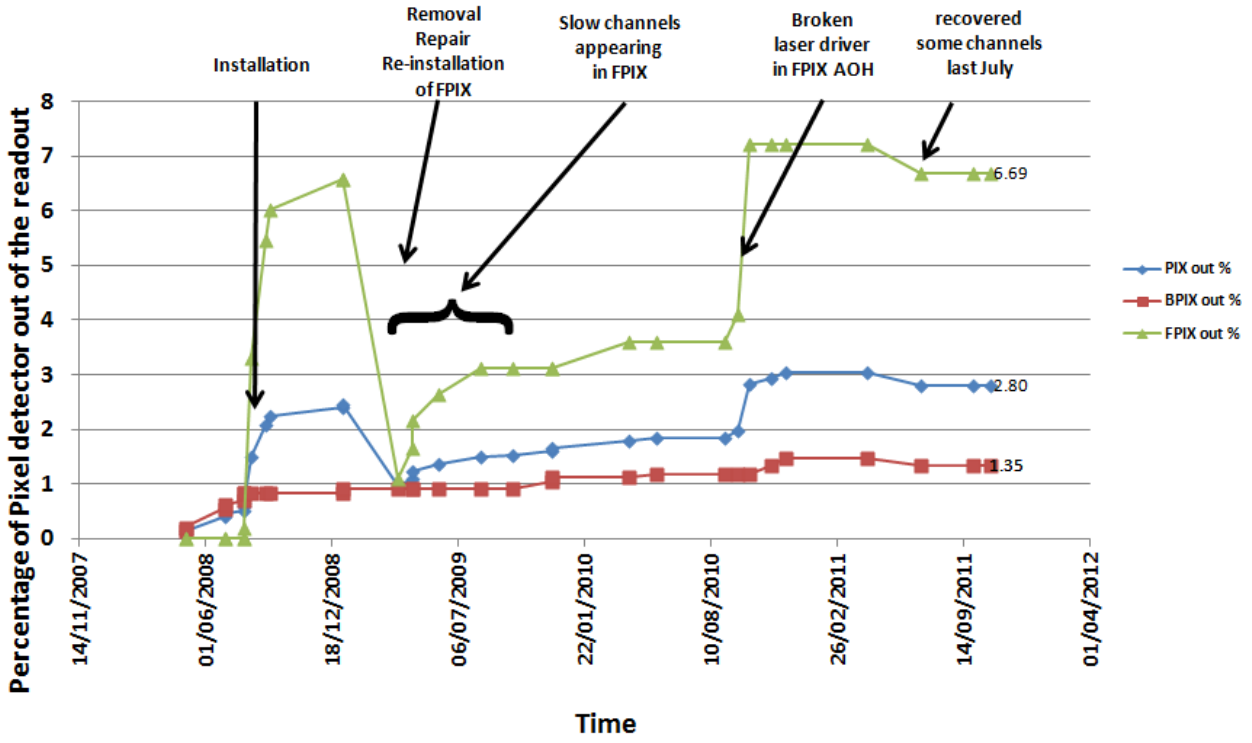
Detector (inside the magnet):

We did not loose any channel.

Actually we managed to recover a fraction of a percent.

Recovery was possible by working on more fault tolerant firmware/software.

No miracles happened (spontaneous recovery of malfunctioning modules)



General remarks from 2011 (2)

Quality of the data:

A negligible part of the data taken was declared "BAD" by offline validation due to pixel non conformity (at the per mill level).

- Dominated by period in which we were running special test with the system.
  - Still big discussion to get some ½ hour now and then to do something special with the detector during collision period. Usually these activities were limited to lumi-ramp following technical stops.

On overall the data quality is excellent.

Pixel crew presence during data taking.

Along 2011 the pixel crew has been an on-call crew.

- No longer present at the beginning of every fill
- Ready to intervene only in case of problems.

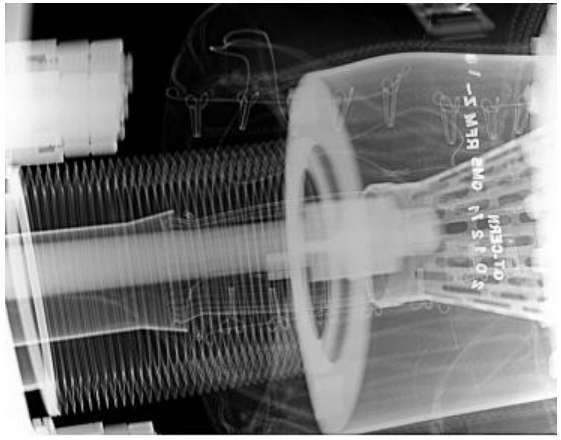
The obvious implication is that the Pixel-DQM (Data Quality Monitor) is doing its job well and presents the results to the CMS-central crew in a clear and effective format.

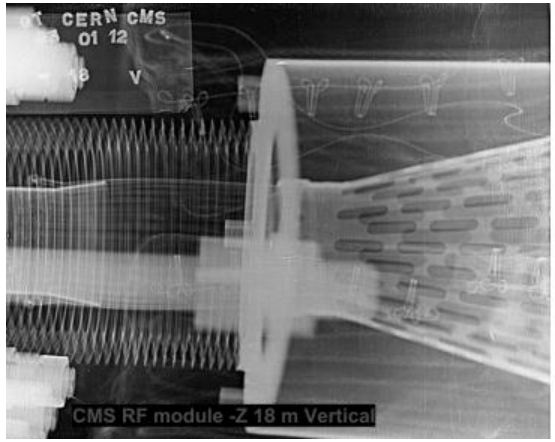
General remarks from 2011 (2)

Pixel Induced deadtime (not downtime):

Pixel is still one of the major sources of deadtime (together with trigger rules).

- In 2010 we understood and ameliorated our sensitivity to beam-gas events
  - Introduced BUSY (stop the L1 trigger) when time is needed to digest large data volume generated by multiple grazing tracks from beam-gas collision in the straight session of the beam pipe.
  - With this ameliorations in place we contribute to ~1% of the experiment dead-time.
  - We think there is little more we can do to improve this situation.
  - But “hopefully/likely” the intervention during the YETS improved the vacuum conditions at the experiment.





General remarks from 2011 (2)

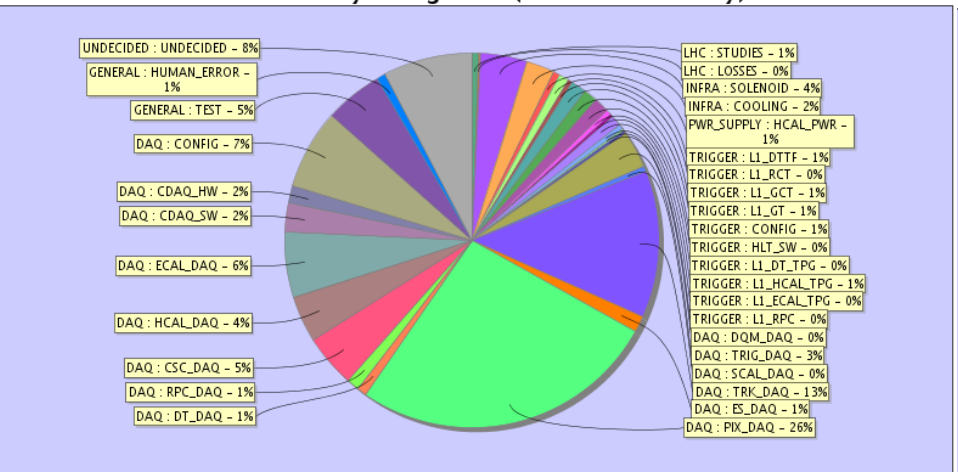
Pixel Induced downtime (not deadtime):

Pixel is still one of the sources of downtime.

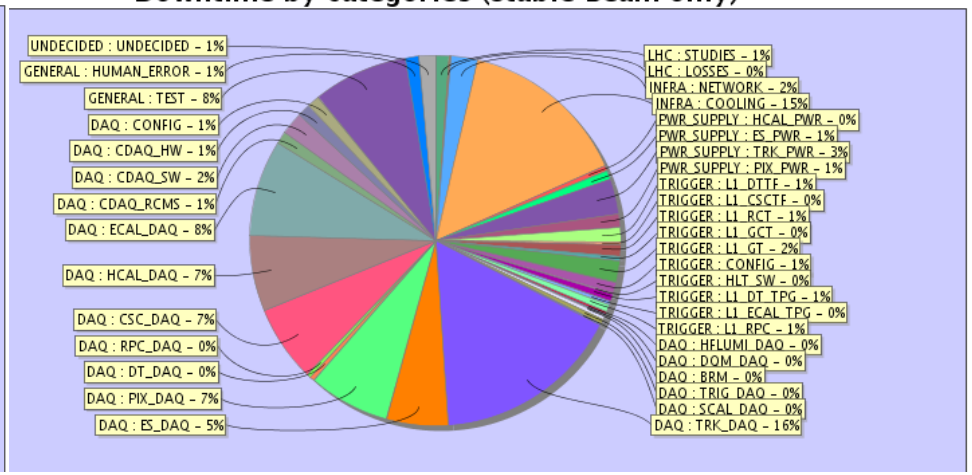
- No longer the dominant source as we were in 2010.

It soon became clear that our interruption of data taking could be explained with SEU (Single Event Upset) symptoms.

2010



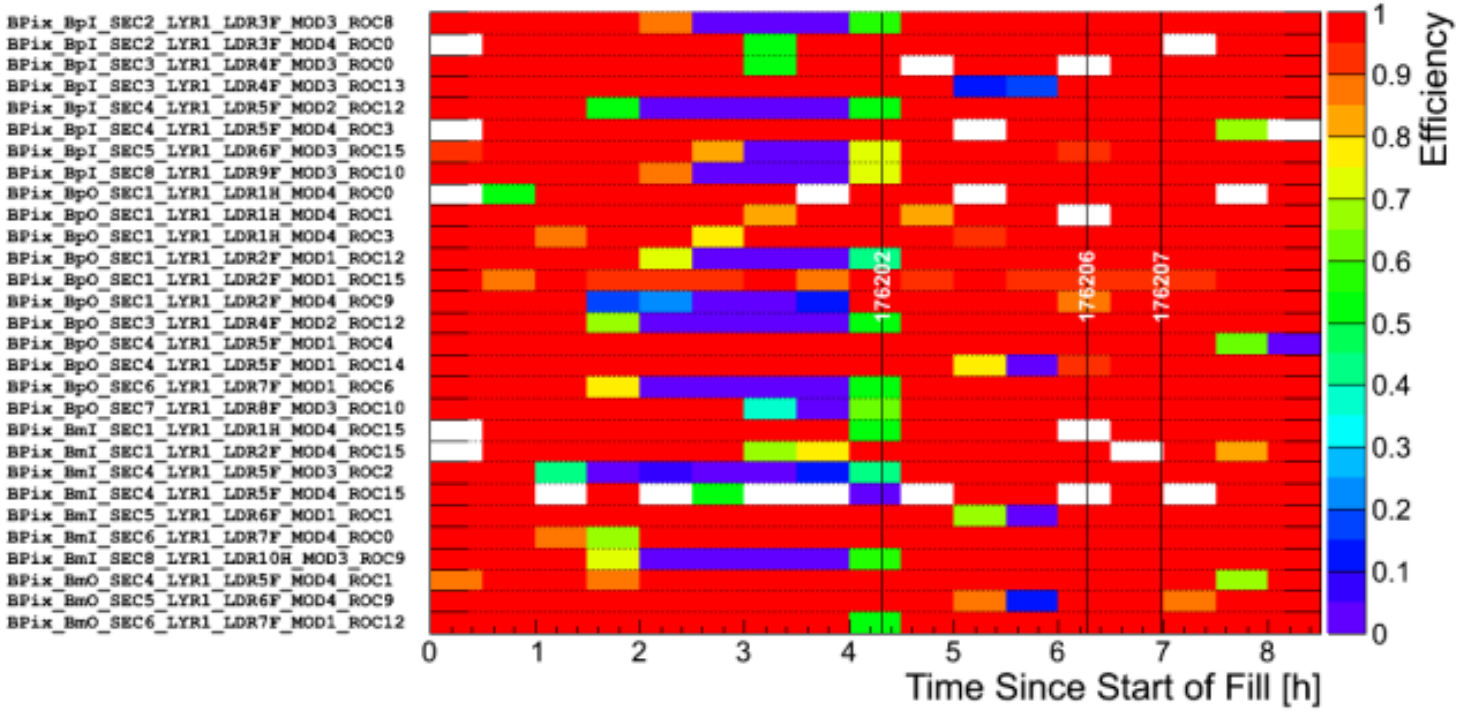
2011



SEUs for the CMS Pixel System (0)

This plot shows only the 20-30 ROCs (out of 1E4) that lost efficiency

Low Eff ROCs – Fill 2103– Layer 1



- Reconfiguring Pixel and starting a new run works on problematic ROCs

SEUs for the Pixel System (1)

SEUs are part of nature we just need to deal with them in the most efficient way.

1. There are SEUs that disturb single Pixels here and there
   - we consider them irrelevant and we do not plan any action to mitigate their effects
2. There are SEUs that disturb the functionality of single ROCs (<0.1‰)
   - No action needed but It would be nice to recover them every now and then
3. There are SEUs that stop data flowing from a whole module as they take place on the TBM (~ 1‰)
   - Action is needed.
4. There are also SEUs on the auxiliary electronic (portcards) that stop data flowing from ~1% of the detector
   - Action is needed

SEUs for the Pixel System (2)

To recover from SEUs DACs and registers need to be reprogrammed.

The information needed to reprogram our electronic is only located in the database or in cache.

→ **For the pixel system recovering from SEUs is a software action**

For 2011 we had a PAUSE/RESUME issued manually by the DAQ shifter.

The strategy for 2012 we are implementing is:

1. Disable channels that suffered a SEU automatically and count their number (Number Of Channels Inactive = NOCI).
2. If NOCI> threshold (likely a number around 2-4) raise a NEED-for-SEU-RECOVERY in Run Control.
3. Upon receive of the SEU-RECOVERY signal we reprogram all ROCs, TBM and portcards (not the single pixels).

We plan to recover also when other subsystem request a Software SEU recovery.

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SEUs for the Pixel System (3)

This plan is now implemented.

→ **Recovery time changes from ~minutes to few seconds.**

The change is due to automation.

Problem is no longer detected and dealt with by the crew but by software processes.

Further improvements in development:

- Read SEU sensitive registers and act accordingly
  - Not all programmable registers are readable

Winter (YETS) maintenance

In 2010 there were numbers flying around with 50+ fb-1 by the end of 2012.

We operated the detector with the silicon sensors at ~18 deg C during 2010 due to limitation on the environment control (humidity) on the services (cooling pipes).

Decided to lower the temperature of the coolant by as much as safely achievable. Decrease of 7.5 deg C.

It should translate in a factor of two reduction on the leakage current effectively removing any danger to run out of "juice" at the power supply (limited to 20 mA on the HV channels).

The main implication is that we had to Recalibrate the detector.

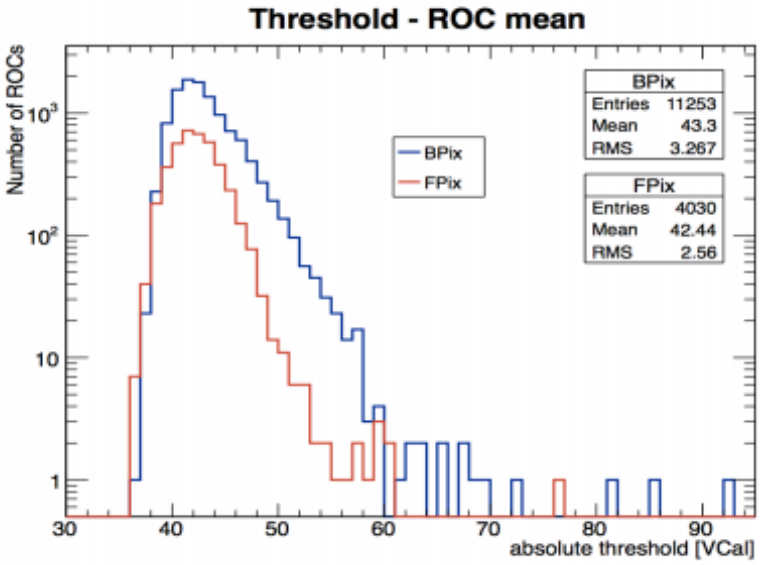
Pessimistic estimate was 2 months, done in 3-4 weeks.

Winter (YETS) recalibration

We brought the performance back to what we had in 2010

PAUL SCHERRER INSTITUT PSI

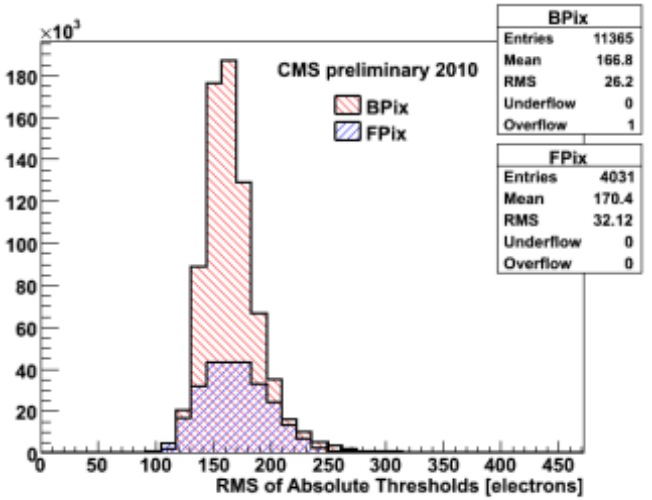
Detector Calibration Results



Average threshold is 43 dac units
= **2400 electrons**.

Like in 2010 (see a later slide).

RMS: Shows threshold uniformity



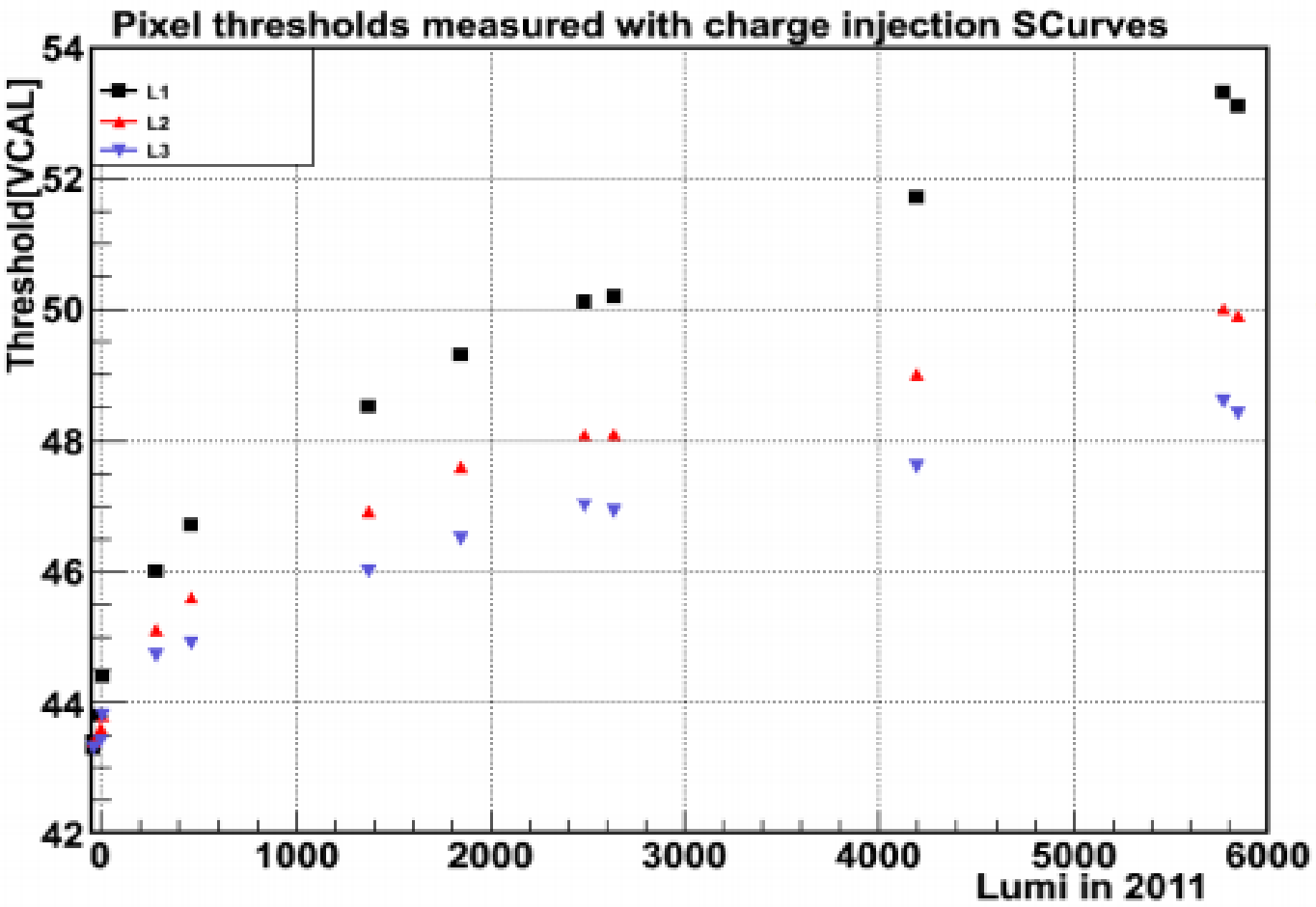
Winter (YETS) radiation damage effects

1. Increasing sensor leakage currents
2. Sensor depletion voltage: Bias scans from last year and model projections show that most likely we can keep the present bias until the end of 2012

3) SEU They will be there and growing with luminosity, hopefully the new SEU handling will minimize their effect.

4) Damage to electronics. **Might become a worry this year!**

Radiation damage on FE electronic



+9.5Vcal=620e

+6.0Vcal=390e

+4.5Vcal=300e

Radiation damage on FE electronic

The effects are accompanied by an increase in the LV Analog current.
Last year 5A now 5.5A in order to keep the same performance:

Unfortunately our Power Supplies are limited to 6A.

This implies careful monitoring of the behavior versus time.
Many believe these effects will saturate soon.

We have a “ready to deploy” emergency plan that will lower the current with the drawback of increasing the thresholds.

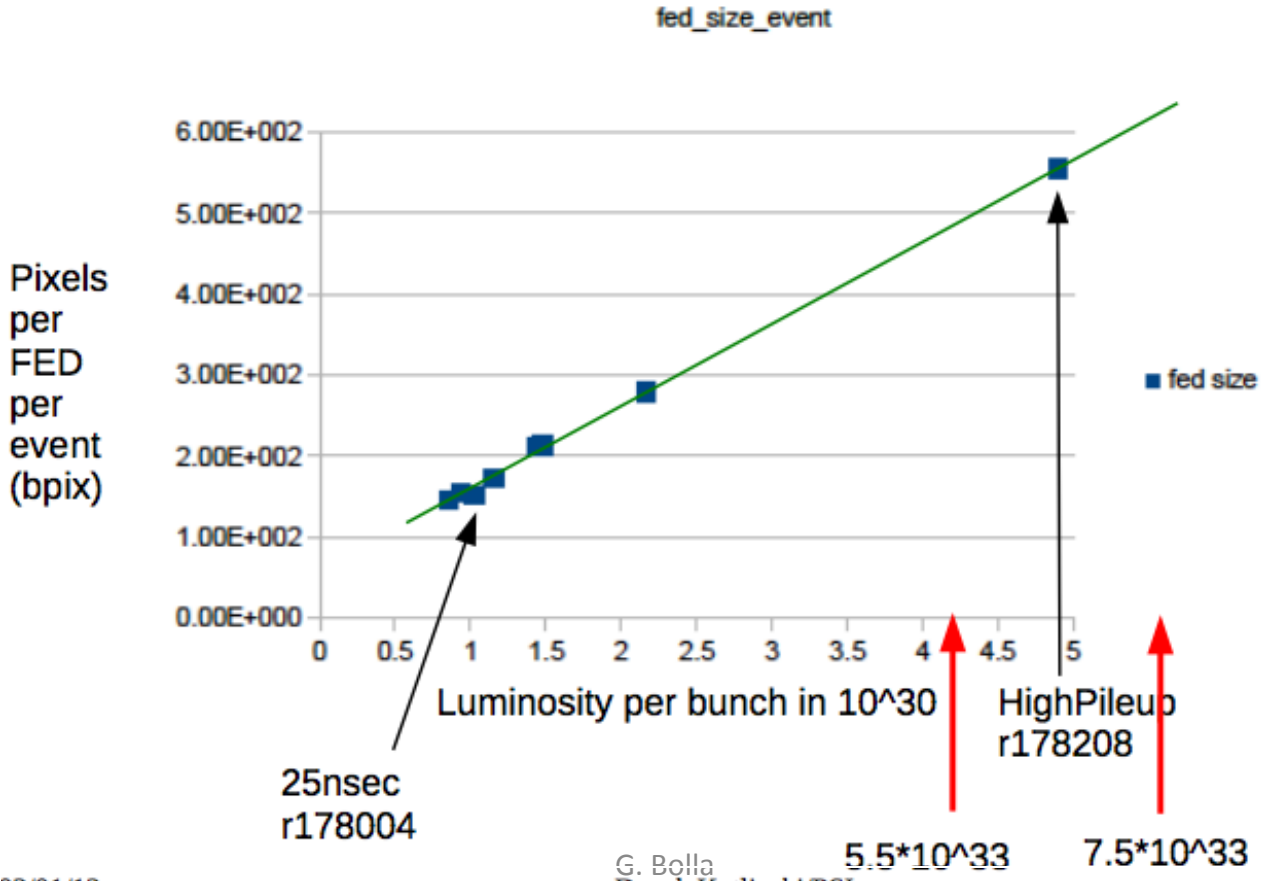
On data size and Inst. lumi

Data size is very predictable (nice linear behavior).

Pixel detector was designed and built for 25 ns, 100KHz and 1E34.

Running at 50 ns can in principle limit our capabilities by a factor of 2.

We should be OK for 2012 but likely we cannot sustain efficiently operation post LS1 still at 50 ns.



On HV and beam conditions

The decision is done by the CMS crew (no longer the pixel crew).

Necessary conditions to turn ON the Pixel HV:

Gino.Bolla@cern.ch 20/06/2011

1. The Injection Inhibit must be pressed (Green light OFF)

Figure 1. The injection Inhibit button. The left picture show the condition where the pixel HV must be OFF (Injection enabled) while the right picture show the condition where the Pixel HV can be turned ON (Injection inhibited).

2. The Stable Beam Flag Must be Green for both Beam1 and Beam2. (this flag is available at: http://op-webtools.web.cern.ch/op-webtools/vistar/vistars.php?usr=LHC1)

Figure 2. LHC page 1 bottom right detail showing the Stable Beam flags for both beams. The left picture show the condition where the pixel HV must be OFF while the right picture show the condition where the Pixel HV can be turned ON.

3. If there is a BRM shifter He/She must give a clear signal (verbal is OK) that:
   - 3.1. The beam background is acceptable.
   - 3.2. The BRM interlocks are functional and active.

   If there is NOT a BRM shifter The pixel crew should make the judgment according to these guidelines:
   - 3.3. The BRM system is functional and active (plots are being updated)
   - 3.4. BCM2 and BCM1L show a background below 20% of the abort. (see appendix A for more explanations)

Single page simple instructions:

- Injection must be inhibited.
- STABLE-BEAM flag must be present
- Three BackGround numbers must be below 20
  - Sometimes this is complicated as the BRM system has been in a continuos development mode of operation.
  - Much better in 2011 than in 2010.

On HV and beam conditions (2)

There is a continuous push to get a few seconds more of good data taking:

- We will try this year to implement a software semaphore for the conditions listed in the previous page in order to guide the decision of the crew.
- Once this semaphore is tested we could make the command automatic (not sure of the gain).
  - We do not plan to turn ON the HV before STABLE-BEAM is declared.
- We are considering riding through the beam dump with the HV ON.

I personally consider all these options irrelevant as their impact has been quantified to be 1% or less.

Ahead of us: LS1

Main Pixel goals for LS1:

- Work on the humidity control of the regions where our services are in order to allow operations with coolant temperature at nominal value (-20 deg C or lower).
  - Note that silicon sensors are ~8-9 degrees warmer than the coolant

- Extract the detector and perform maintenance.
  - The detector has to come out anyway for the installation of the new beam-pipe.
  - We think we can recover most of the 3-4 % channels that we lost.
    - Evaluation of the risk ongoing.
  - The challenge now is to get ready for such hardware oriented operation (after three years of data taking we need to train a new crew for hardware maintenance).
    - We also need to setup a lab at Cessy.