CMS Noise Experience During Commissioning

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2008-2009 Running Periods

Expected CMS to have been running at this time

- Operational data with beam would have been more interesting
- Will have to wait a few weeks longer

However, CMS has been taking cosmic ray data during 2008 and 2009

- Both magnet on and magnet off
- Different detector configurations
- Accumulated several 100 million events during each period

	2008	2009
B = 0	325 * 10^6	156 * 10^6
B = 3.8 T	238 * 10^6	323 * 10^6

This data already gives us valuable information about detector performance

Noise …

Varieties of noise appearing during commissioning:

- **Intrinsic: persistent feature of the measuring instrument itself**
  - Ex: shot noise, I/f noise, will show up as pedestal width
- **Sporadic: occasional response of measuring instrument**
  - Ex: internal discharges
- **Induced noise- interaction with external systems**
  - Synchronous noise is subset
- **Oscillations**

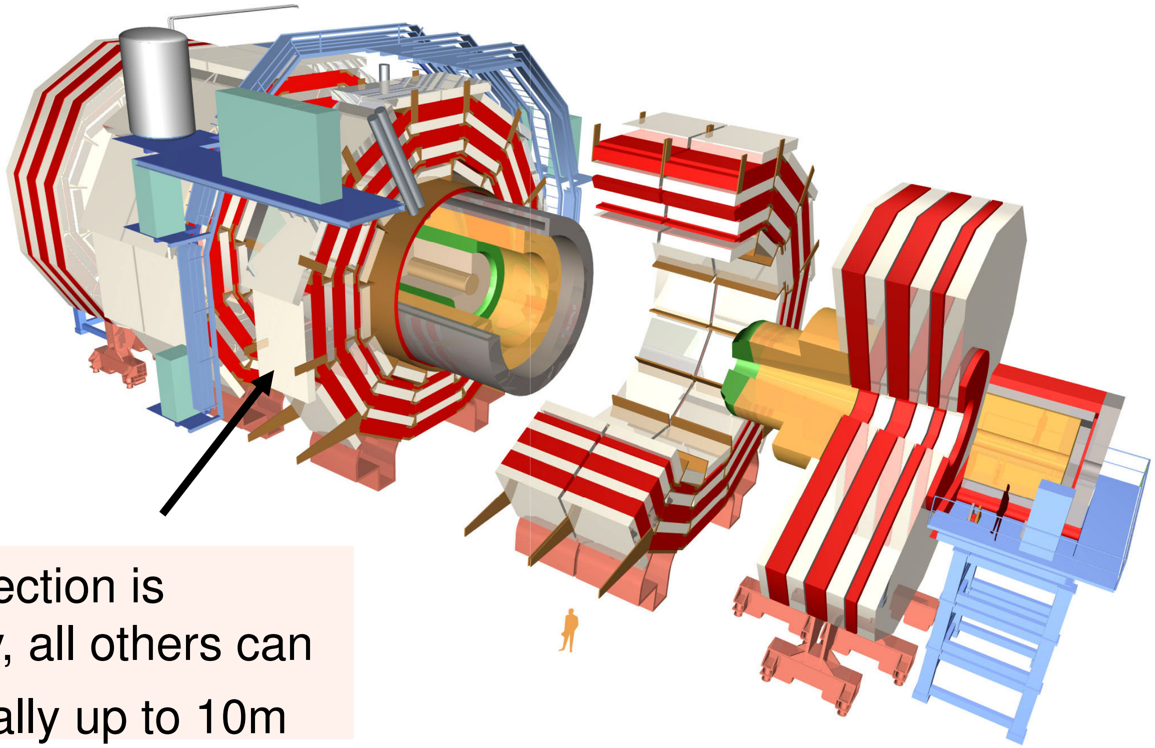
Primary concern here is system-level behavior, interaction with infrastructure

- **Subdetectors will present detailed overviews**
- **Many subdetectors worked out internal noise issues prior to cosmic ray running- will not cover that here**
- **This is meant to serve as a snapshot of experiences during commissioning phase**

The CMS Detector

CMS is segmented longitudinally into 13 sections

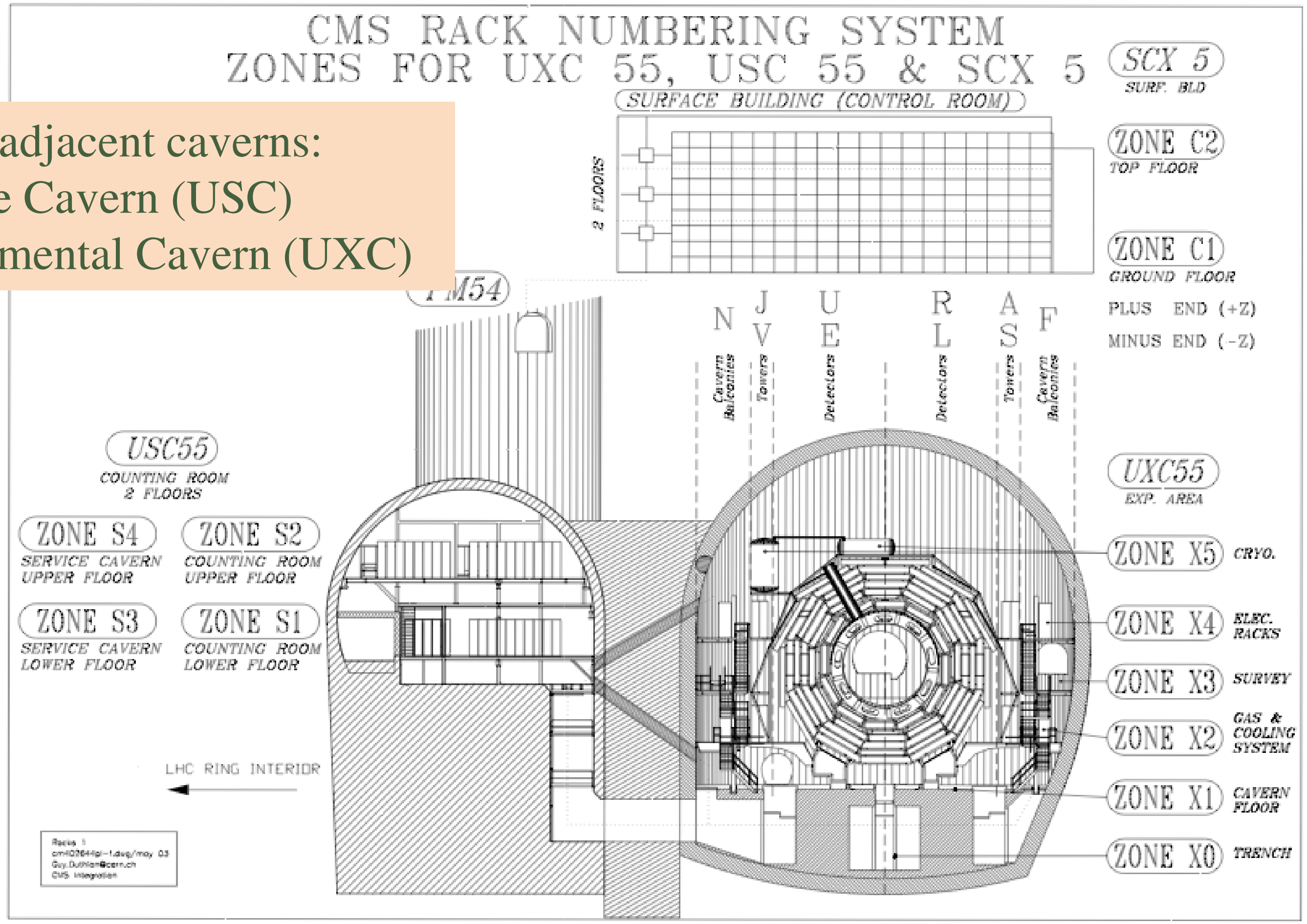
- **Central section holds cryostat containing solenoid, is fixed to cavern floor**
- **Other sections are movable, allowing up to 10m free travel**



Central section is stationary, all others can move axially up to 10m

CMS Caverns

CMS located in two adjacent caverns:
Underground Service Cavern (USC)
Underground Experimental Cavern (UXC)



Connection Paths…

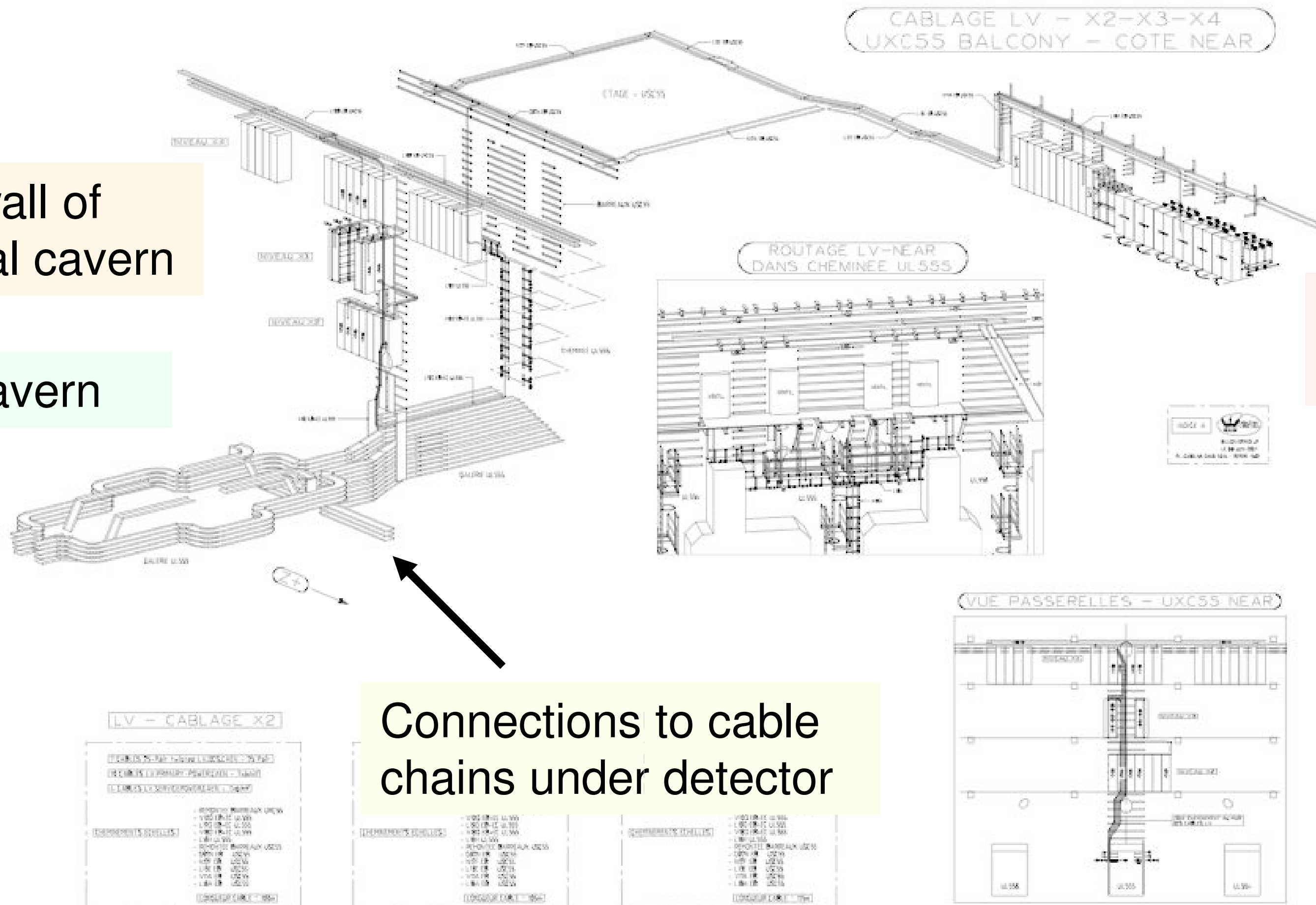
Cabling paths between safe area and experimental cavern are shared with other detector cabling

- **Detector readout systems use fiber-optic cabling**
- **Power system cables run through dedicated cable trays**

Connections- Near Wall

Near-side wall of experimental cavern

Experimental cavern

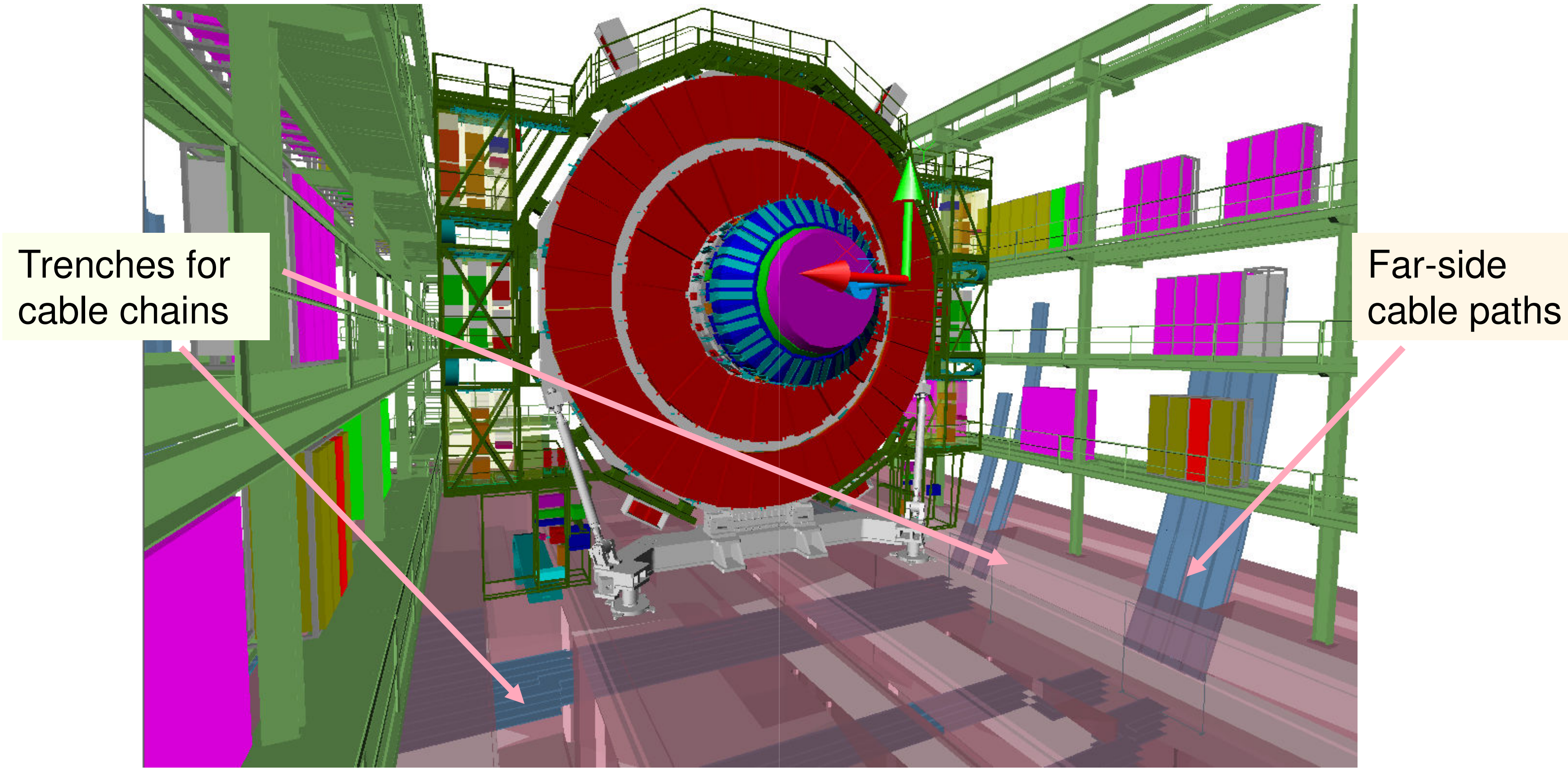


Safe area electronics

Connections to cable chains under detector

Connections to Detector

All cables to the 12 movable sections of the detector pass through cable chains located in trenches under the detector



Power Distribution

On-detector LV system is powered by 2 MVA UPS

- UPS unit is installed on surface
- Will provide 2 minutes autonomy for on-detector systems

UPS powers bank of 6 isolation transformers in USC

- Transformers divided by subsystem, detector region
- Each transformer feeds one or more power distribution cabinets
- Transformers are a mix of 230V and 380V units
- Active PFC applied at distribution cabinet level

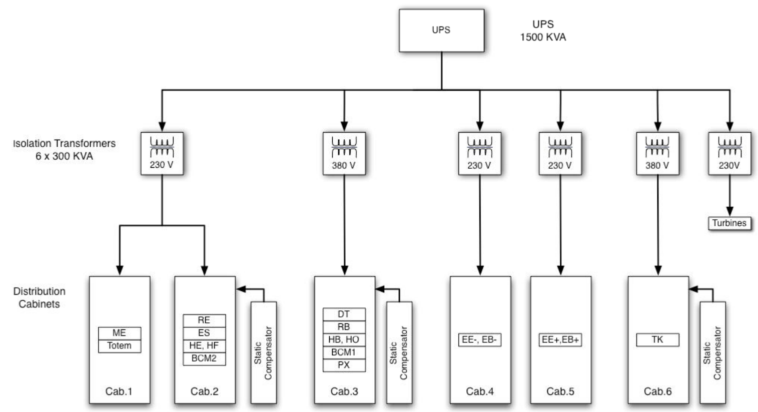
Power distribution in USC for CMS Detector LV

Power figures updated 31 Oct 06
Layout updated 07 Nov 06

Transformers 230 & 380V, allocated by subdetector,adjacent subdetectors wherever possible
No distinction between EE & EB
HCAL & BCM partitioned between barrel & endcap

System	Pwr. Req (KVA)	Cables
PX	21	4
TK	262	40
ECAL	400	48
ES	35	6
HCAL	30	10
DT	117	20
RB	40	10
RE	28	8
ME	110	20
BCM / TOTEM	10	3 / 2
Turbines	126	?
Tot.	**1179**	**171**

System	Pwr. Req (KVA)	Cables
EB	317	36
EE	83	12
HB	8	2
HO	8	4
HE	8	2
HF	6	2



Transformer

	Cab.1 / Cab.2	Cab.3	Cab.4	Cab.5	Cab.6
Power (KVA)	197	194	200	200	262
Utilization (%)	66	65	67	67	87
Spare (KVA)	103	106	100	100	38

Cables

	Cab.1	Cab.2	Cab.3	Cab.4	Cab.5	Cab.6
# Power Cables	22	20	40	24	24	40

Distribution

	Cab.1	Cab.2	Cab.3	Cab.4	Cab.5	Cab.6
# Circuit Breakers	22	20	40	24	24	40
# Wiener PFC Bin	7	0	0	12	12	0

Observations …

In general, CMS subdetectors have not reported any significant noise issues during cosmic-ray running

- **Pixels- intrinsic noise of 335 e compared to signal 11k-22k depending on charge sharing (1.5%- 3%). No particular issues during commissioning**
- **Tracker- once tracker entered cosmic ray running, no reports of any significant noise issues**
  - Collected 3.6 Million tracks
  - S/N ratio ~ 20 in deconvolution mode
- **ECAL- Total number of noisy channels is low**
  - Barrel - 65 noisy channels out of 61200 (~0.1%)
  - Endcaps - 7 noisy channels out of 14648 (~0.05%)
  - Roughly equal split between hot channels and high pedestal values

HCAL

HCAL- has observed 3 kinds of noise:

- **HPD ion feedback: <8 hits in single HPD**
  - Observed ~6 Hz/HPD @ 20 GeV threshold
- **HPD discharge: >8 hit in single HPD**
  - ~0.15 Hz/HPD @ 10 Gev threshold
- **RBX noise: hits in more than one HPD**
  - Between 4 and 7.5 Hz @ 20 GeV threshold
- **Noise rates are low, expect no impact on physics**

Endcap CSCs- noise performance of anode front-end boards has been very good

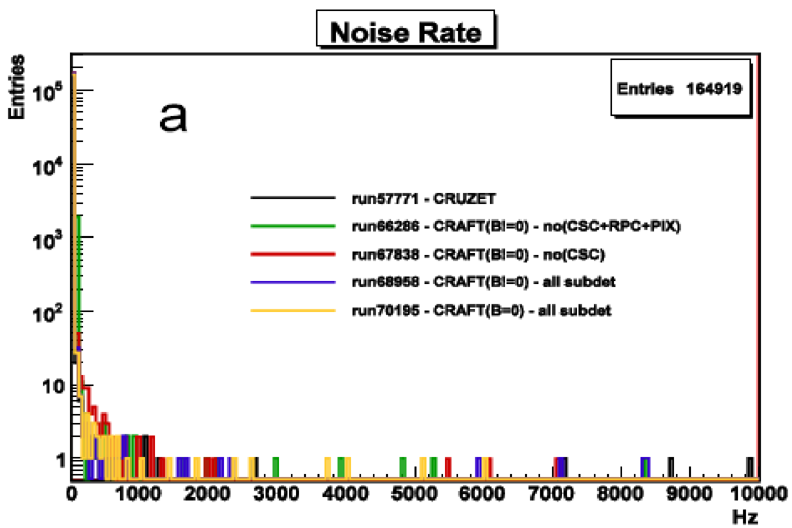
- **Intrinsic noise measured at 1.4 fC, with max at 1.6 fC**
- **Compare to nominal thresholds of 20 fC**
- **Number of noisy AFEB boards below 0.1% (8 out of 11166)**
- **Additional observations of sporadic noise bursts traced to welding work being done in the CMS cavern, not features of CSC electronics**

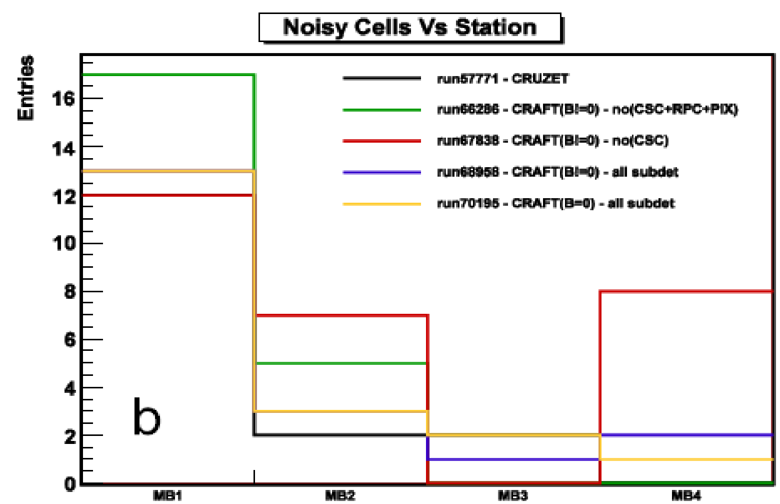
Barrel Muon Drift Tubes

Muon Drift Tubes: studying low-level coherent noise

- **Noisy cells: rate > 500 Hz, not associated with cosmics**
  - Compare with expected LHC background of 1-10 kHz / cell
  - 20-30 noisy cells avg. out of 172000 total
  - Discriminator thresholds 30 mV, ~ 10 fC
- **Occurrences sporadic, can be separated by hours or days**
- **Not dependent on magnetic field**
- **Affect innermost chambers the most, weighted to one end of detector**

Average noise rate ~ 4 Hz, expect minimal impact on operation





Trigger Rate Bursts

During 2008 cosmic-ray running, observed bursts in trigger rate of barrel muon RPCs

- Would last for minutes
- Trigger rate of 1 kHz and above, nominal had been 200 Hz

Trigger rate bursts began when CMS magnetic field was turned on

- Bursts disappeared when field was ramped down
- Only small group of chambers was affected
- Affected chambers were in same area

Projector lights in cavern had become unstable

- Lights would cycle between ON state and unstable OFF state
- Trigger-rate spikes would occur during OFF states

A projector light was found on balcony in front of high-rate RPCs

- Once light was turned off, trigger-rate bursts disappeared
- Rest of cosmic-ray running was done without projector lights

Lights in a Magnetic Field

Investigated magnetic-field effects on lights used in cavern

- **Local field can exceed 1 Kilogauss**
- **Found unstable lights in these regions**

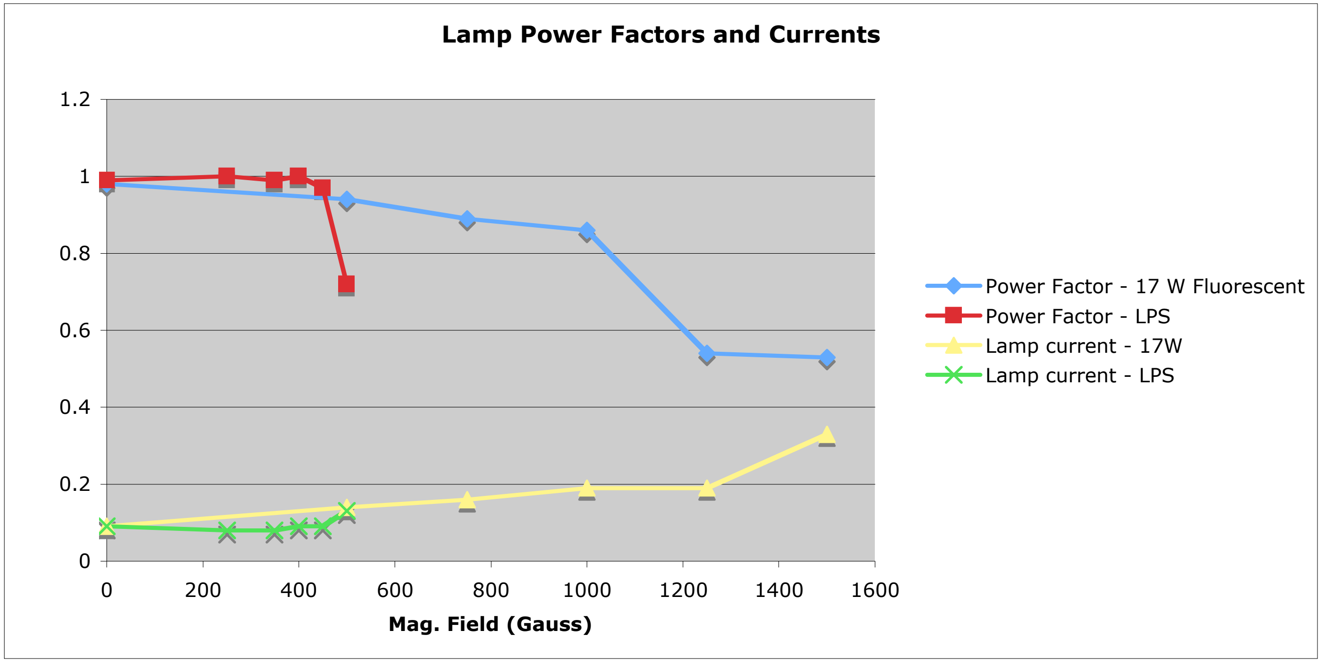
Found two different modes of failure

- **Fluorescent lights: ballast saturation**
  - Lamp current increases until voltage drop across lamp triggers starter, lamp power cycles
  - Lamp aging dramatically accelerated
  - Use of electronic ballast is not a cure, has inductive components. Also, switches at 40 kHz
- **Mercury-vapor & low-pressure sodium**
  - Lamp itself is sensitive to magnetic field
  - Sensitivity is direction-dependent
  - Can mitigate effects by selective orientation of lamp in magnetic field

Fluorescent vs. LPS

Compared magnetic field tolerance of fluorescent and low-pressure sodium (LPS) lights

- Power factor appears to be best indicator of lamp instability
- Plot shows lamp current and power factor for each light as function of magnetic field
- LPS light fails at 500 Gauss, fluorescent operates up to 1 KG



This test used worst-case orientation for LPS light

- Best-case orientation gave stable operation to 1.2 KG
- Would have to know local orientation of field in cavern in order to mount lights for highest magnetic-field tolerance

Clearly, not the final solution. We will need a better lighting design in the future.

Summary

By the time of CMS cosmic ray running, many individual detector noise issues had been resolved, subdetectors operated well in the final CMS assembly

Exceptions involved infrastructure:

- Welding & grinding
- Projector lamps and fluorescent lights in magnetic field
- May yet see effects of cooling plant motors

No effect has been observed from magnet power supply

With beam things may change

Preparing to instrument infrastructure for monitoring

- Not the usual technique, but can make debugging easier in future

Subdetector groups are preparing analysis tools for improved understanding and monitoring of noise