ECAL and the SLHC

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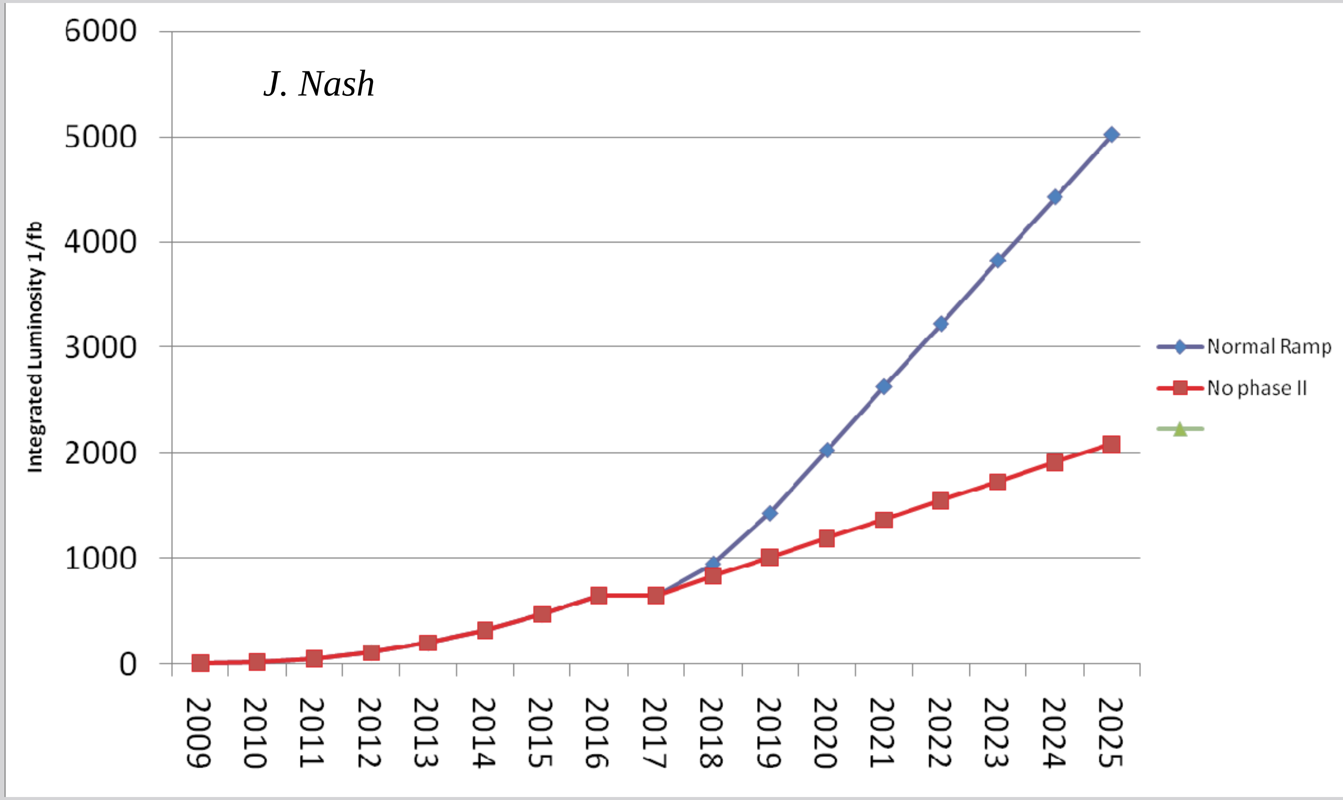
With input from F. Nessi-Tedaldi.

Luminosities at SLHC



Peak L = 10^{34} $cm^{-2}s^{-1}$ at LHC
Peak L = 10^{35} $cm^{-2}s^{-1}$ at SLHC

Int L = 500 fb^{-1} at LHC
Int L = 5000 fb^{-1} at SLHC

Dose rate at SLHC = 10 x TDR, integrated dose at SLHC = 10 x TDR

Radiation levels

Approximate radiation levels and fluences, rescaled from the ECAL TDR for 3500 fb-1 at $10^{35}cm^{-2}s^{-1}$:

in front of crystals:

- η=2.0: $5x10^{13}$ fast hadrons/cm2
- η=2.9: $4x10^{14}$ fast hadrons/cm2

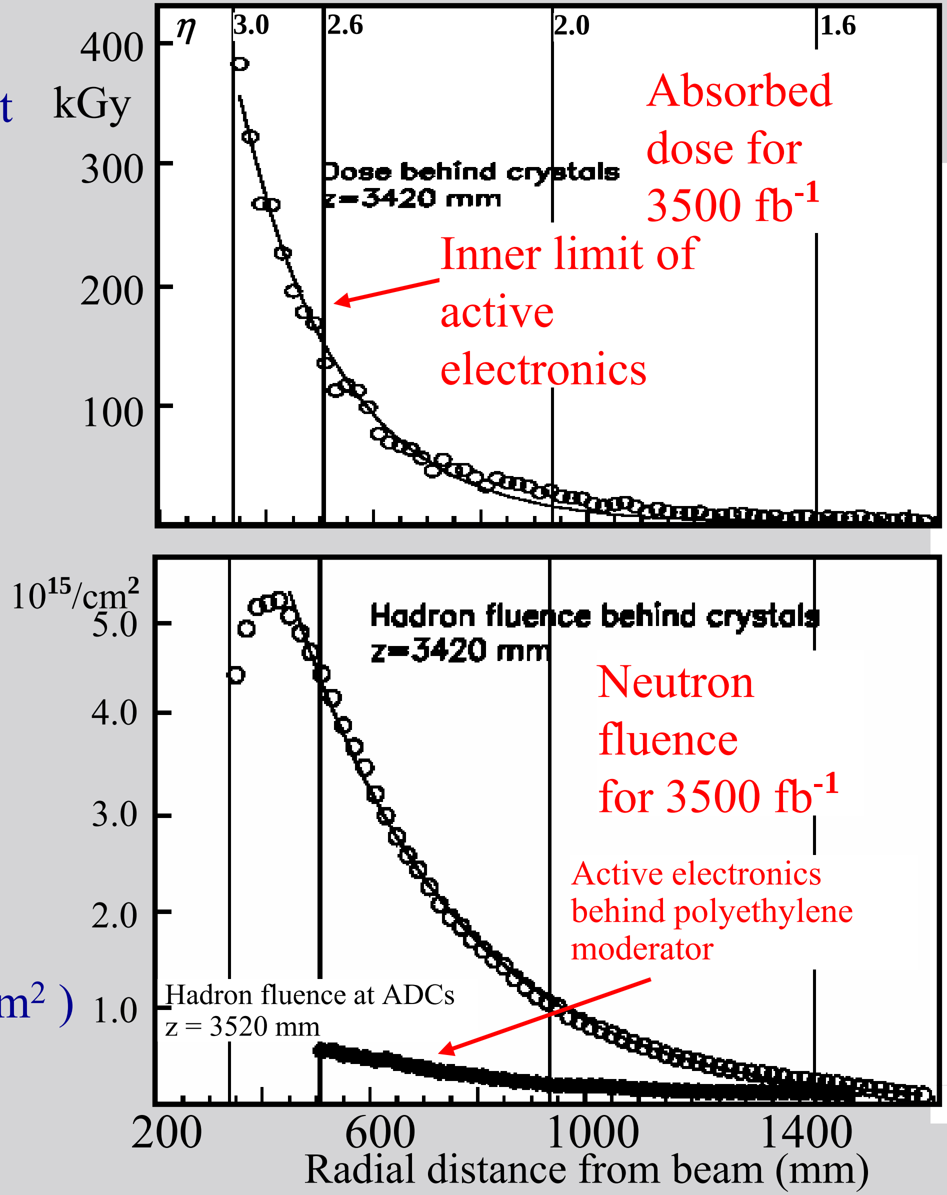
at shower max →crystals :

- η=2.6: 570 kGy, 50 Gy/h
- η=2.9: 1400 kGy, 140 Gy/h

behind crystals →VPT, HV/LV cables, fibers, HV pcbs:

- η=2.6: 150 kGy, 20 Gy/h
- η=3.0: 370 kGy, 50 Gy/h

max $5x10^{15}$ hadrons/cm^2 (mostly 1 MeV neutrons, with max $3x10^{14}$ charged hadrons/cm^2)



R.M. Brown, mini-workshop on EE@SLHC, 15-APR-08

Changes in $PbWO_4$ Due to Radiation

Radiation and particle fluxes change the crystals light output and light output uniformity.

The reduction in light output is due to the variations in the transmission

The scintillation mechanism is not changed by radiation.

Reduced Light Output → effect on Energy-resolution stochastic term and increases the effect of the electronic noise.

Change in Uniformity → effect on Energy-resolution constant term, especially in the front half of the crystals (Front-Non-UniFormity, FNUF)

Activation → This significantly limits what can be done to and around components in the endcaps.

Light Output Loss from Ionizing Radiation

◆ Measurements indicate that at LHC and SLHC, the scintillation mechanism is not affected. But the light transmission (LT) is reduced. This is quantified as an induced absorption coefficient μ_{IND}:

$$\frac{LT(\lambda)}{LT_0(\lambda)} = e^{-\mu_{IND}(\lambda)L}$$

◆ Ionizing radiation causes a damage by forming color centers: this damage reaches an equilibrium at a level proportional to the dose rate.

◆ At SLHC, the dose rate will reach ~140 Gy/h at $\eta = 2.9$.

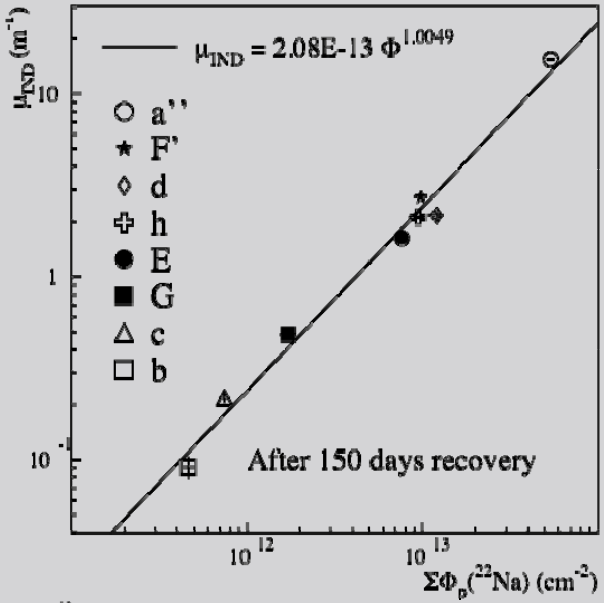
◆ Throughout the EE, the damage from ionizing radiation is expected to saturate with Light Output losses reaching 40%-60% (based on ^{60}CO irradiations at ~200 Gy/h).

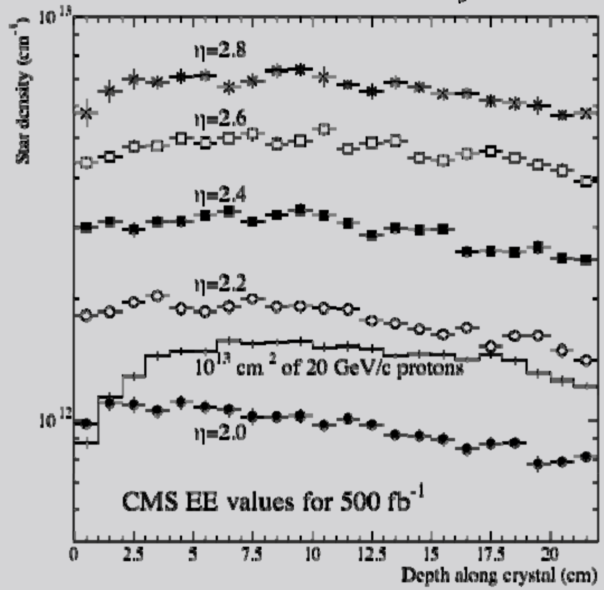
◆ Reduction in the transmission of light can be monitored with the laser light that is injected into the crystals. We have shown that this can have a stability of ~0.1%.

Light Output Loss from Hadron Interactions

◆ Interacting hadrons cause a permanent reduction in the light transmission.

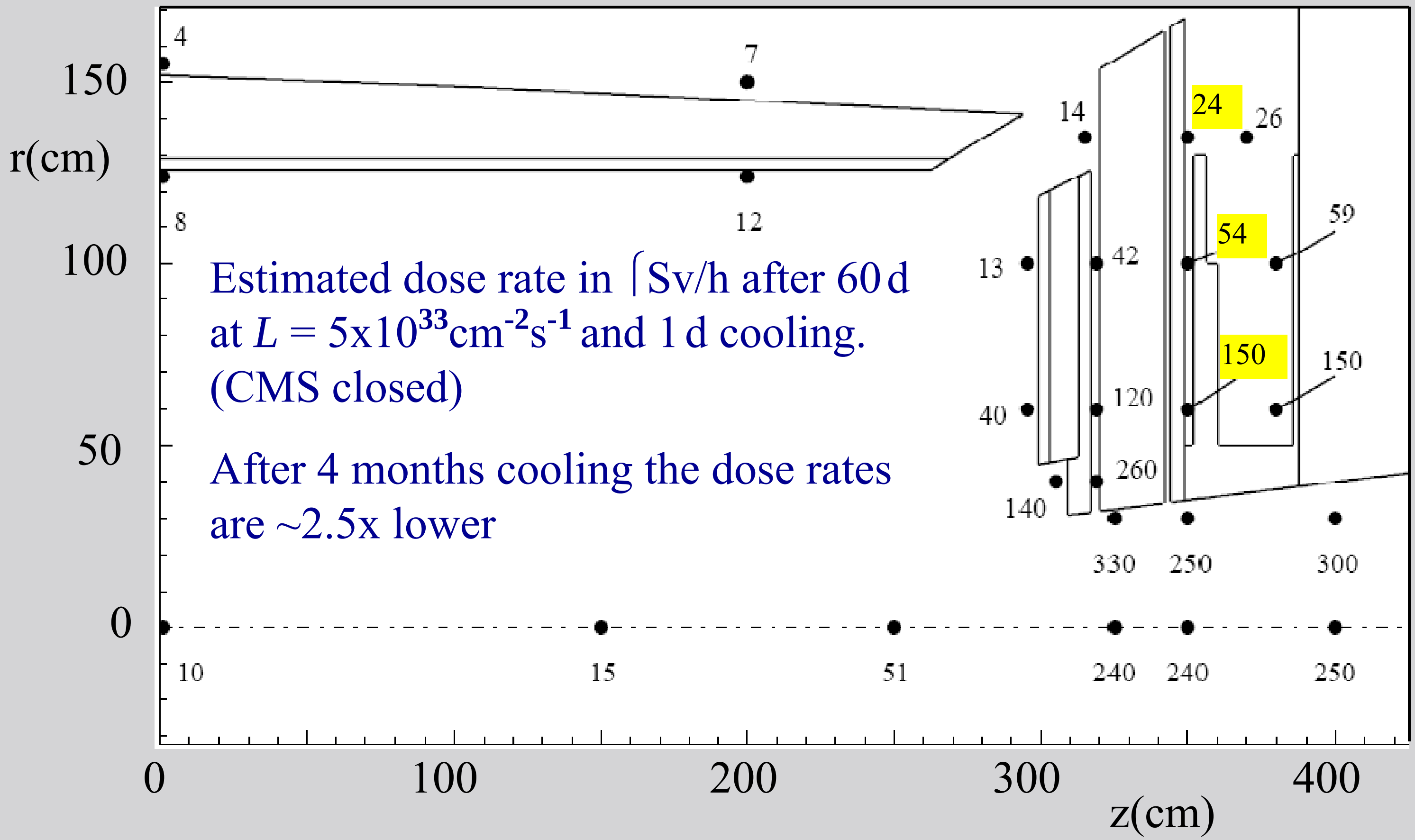
◆ The high dE/dx of heavy fragments from nuclear interactions. It is cumulative and nearly permanent on a time scale of years. Data from over 2 orders of magnitude in fluence, up to $5x10^{13}$ $/cm^2$ (i.e. $\eta \approx 2.0$ at SLHC).





Reality

Activation



Occupational dose limits:

- 1 mSv/wk
- 15 mSv/yr

If assume induced activity levels at SLHC ~10xLHC . It takes ~10 hours to receive the annual dose limit after high luminosity running

Summary

- *There are some (mostly) well understood effects that we can expect to happen to the crystals and the photodetectors as we go to higher luminosity.*
- *We need to investigate the consequences of these changes on the physics capabilities of CMS operating at the SLHC.*
- *At this meeting we will be discussing possibilities for the detector upgrade- what we know and what we don't know.*
- *The preshower occupies 20 cm in front of the detector.*
- *Any changes that we propose must be driven the physics requirements of the detector.*