SiPM response in situ

Trygve Buanes, Gerald Eigen

Department of physics and technology
University of Bergen

30th June 2008

Overview

- Study saturation curves from calibration scans taken in beam test periods
- Saturation curve measurement performed at ITEP before installing the SiPMs in the detector used as reference
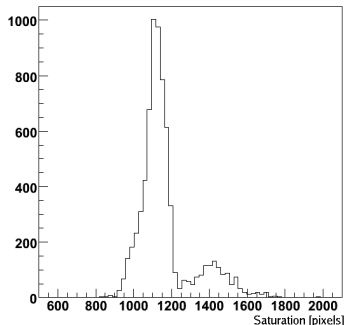- Goal is to study stability over time. Do the SiPMs deteriorate due to ageing?

Fit to ITEP data

- Rescale x-axis to yield $f'(0) = 1$

- Fit model:

$$f(x) = C\left(1 - e^{-x/C}\right)$$

- 94% of the channels yield a good fit with this simple model

Fit to ITEP data

- Rescale x-axis to yield $f'(0) = 1$
- Fit model:

$$f(x) = C \left(1 - e^{-x/C}\right)$$

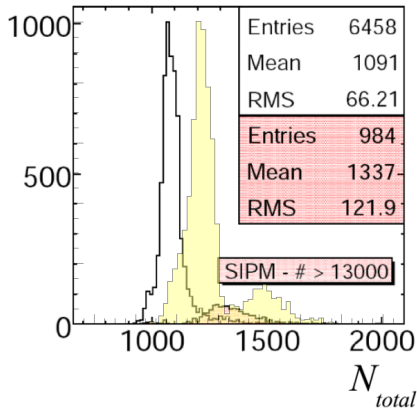- 94% of the channels yield a good fit with this simple model
- Compare to results shown by Alexander Kaplan during CALICE week at Argonne
- Shape agree, but there is a shift of ~ 100 *pixels*

Entries	6458
Mean	1091
RMS	66.21
Entries	**984**
Mean	**1337**
RMS	**121.9**

SIPM - # > 13000

N_{total}

4

Fit to in situ data

- ▶ Perform pedestal subtraction and apply gain and inter-calibration constants
- ▶ Rescale x-axis to yield $f'(0) = 1$
- ▶ Saturation curves show more variation in shape than ITEP data
  - ▶ Need a fit function with more degrees of freedom

$$f(x) = \frac{1}{g(x)} \left[\frac{(C-1)^2}{a - (b+d)(C-1)} \cdot \frac{e^{-bx} + e^{-dx}}{C - e^{ax}} - \frac{2(C-1)}{a - (b+d)(C-1)} \right]$$

  - ▶ $g(x)$ takes care of different gain setting for low and high light intensity
    - ▶ $g(x) = 1$ for low light intensity
    - ▶ $g(x) =$ free parameter for high light intensity
  - ▶ $b \leftrightarrow d$ symmetry $\Rightarrow$ arrange such that $b < d$
  - ▶ $\frac{2(C-1)}{a - (b+d)(C-1)}$ represents the saturation
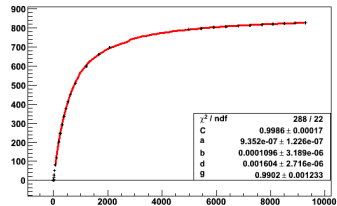
5

Fit to in situ data

- Fit model still not very satisfactory, to many bad fits
- Fit results for Run331212 (31. July 2007):

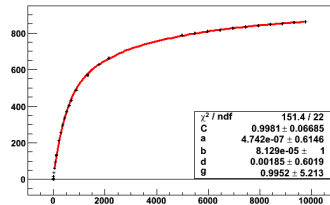|		
Total number of channels	7608	
Number of good fits	4402	58%
Failed due to dead SiPM, dead PIN etc.	939	12%
Failed due to bad fit	2267	30%

- Channels which failed due to a bad fit may be recoverable with a better fit model

Bad fits (χ^2 prob $< 10^{-8}$)
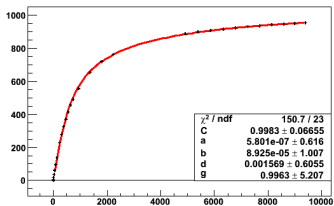
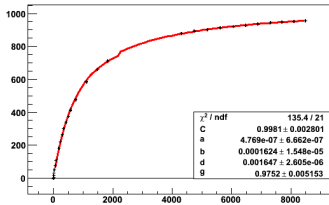**Mod11 Chip2 Chan3**

χ^2 / ndf	288 / 22
C	0.9986 ± 0.00017
a	$9.352e\text{-}07 \pm 1.226e\text{-}07$
b	$0.0001096 \pm 3.189e\text{-}06$
d	$0.001604 \pm 2.716e\text{-}06$
g	0.9902 ± 0.001233

Mod11 Chip5 Chan10

χ^2 / ndf	151.4 / 22
C	0.9981 ± 0.06685
a	$4.742e\text{-}07 \pm 0.6146$
b	$8.129e\text{-}05 \pm 1$
d	0.00185 ± 0.6019
g	0.9952 ± 5.213

Good fits

Mod11 Chip0 Chan10

χ^2 / ndf	150.7 / 23
C	0.9983 ± 0.06655
a	$5.801e\text{-}07 \pm 0.616$
b	$8.925e\text{-}05 \pm 1.007$
d	0.001569 ± 0.6055
g	0.9963 ± 5.207

Mod11 Chip1 Chan1

| χ^2 / ndf	135.4 / 21
C	0.9981 ± 0.002801
a	$4.769e\text{-}07 \pm 6.662e\text{-}07$
b	$0.0001624 \pm 1.548e\text{-}05$
d	$0.001647 \pm 2.605e\text{-}06$
g	0.9752 ± 0.005153

But most of the bad fits aren't that bad. . .

In situ data Vs ITEP data

- ► Only channels with a good fit in both data sets are included in the plot
- ► The shift is not (only) due to ageing
- ► Looks like the round fibre does not illuminate the square SiPM 100%
- ► Widening probably due to spread in fibre–SiPM separation
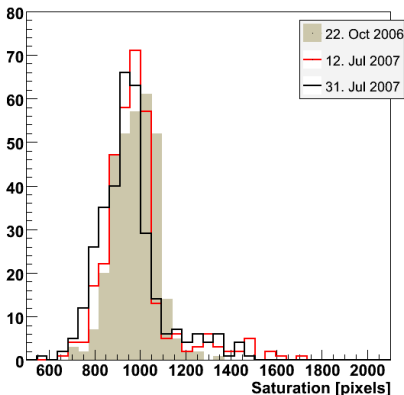 - ► Needs to be studied more to be verified
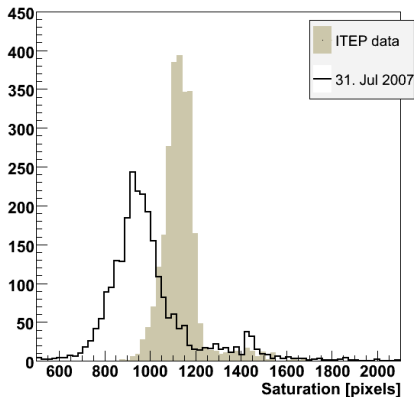
Ageing?

▶ Compare three runs to look for changes with time

▶ Only channels with a good fit in all three runs are included in the plot

Date	Mean
22. Oct 2006	976
11. Jul 2007	950
31. Jul 2007	930

Tails not included when calculating mean

▶ Too early to conclude that shift is due to ageing, but it should be studied in more detail

Conclusion

- ITEP data "better behaved" than in situ data
  - need fit model with more degrees of freedom to fit in situ data
  - fit model used for in situ data still not satisfactory
- Not very good correspondence between ITEP data and in situ data
  - but we think we know why
  - need to confirm this hypothesis
- Comparing in situ data from 2006 and 2007 show possible indication of ageing
  - to early to conclude that it is a real effect, not only systematic uncertainty
  - 2008 data should help to clarify this