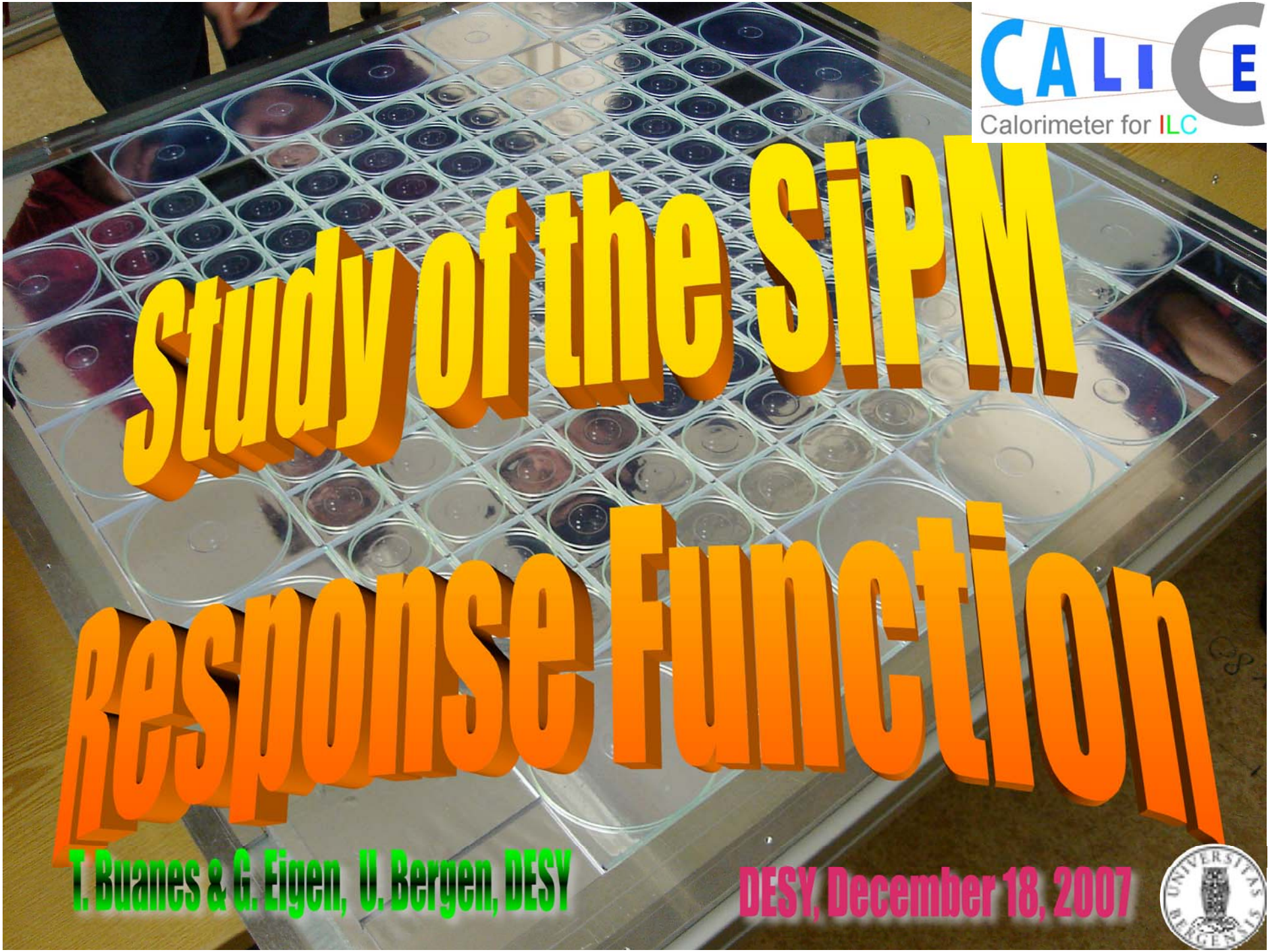

CALICE
Calorimeter for ILC

Study of the SiPM Response Function

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DESY, December 18, 2007

Introduction

- We have an elaborate LED/PIN based monitoring system that records changes in the SiPM response due to voltage and temperature changes

- If we manage to parameterize the SiPM response by an analytic function, we need to measure the full SiPM response curve only once and then record just a few values during a run to correct for changes
  ➔ this would simplify the monitoring system considerably

- We have analyzed the SiPM response curves taken during the 2006 test beam program in August and in October (2 runs each) to study shapes, saturation points,

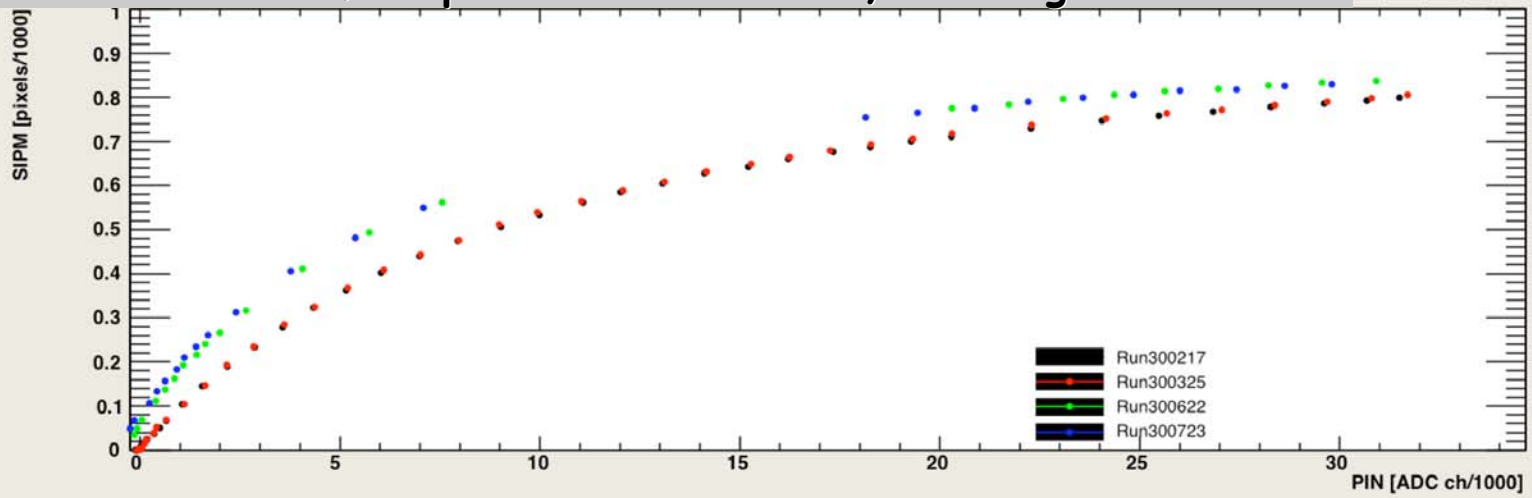
Analysis Procedure

- Use run type ahcPMVcalibScan and extract SiPM & PIN diode values from LCIO files
- After pedestal subtraction, we apply gain corrections and take intercalibration into account
- The pedestal subtraction is based on pedestal events from beam events that were taken shortly before or after a Vcalib run
- We calculate for each Vcalib value an average of the SiPM & the PIN respone and plot the SiPM vs PIN correlation
  (➔ "uncorrected" SiPM response curve)
- We rescale PIN values to force the initial slope to be one and to start at a common origin (➔ "corrected" SiPM response curve)
- We compare the 4 runs from August & October for all modules 3-15 (we have left out modules 1 &2)

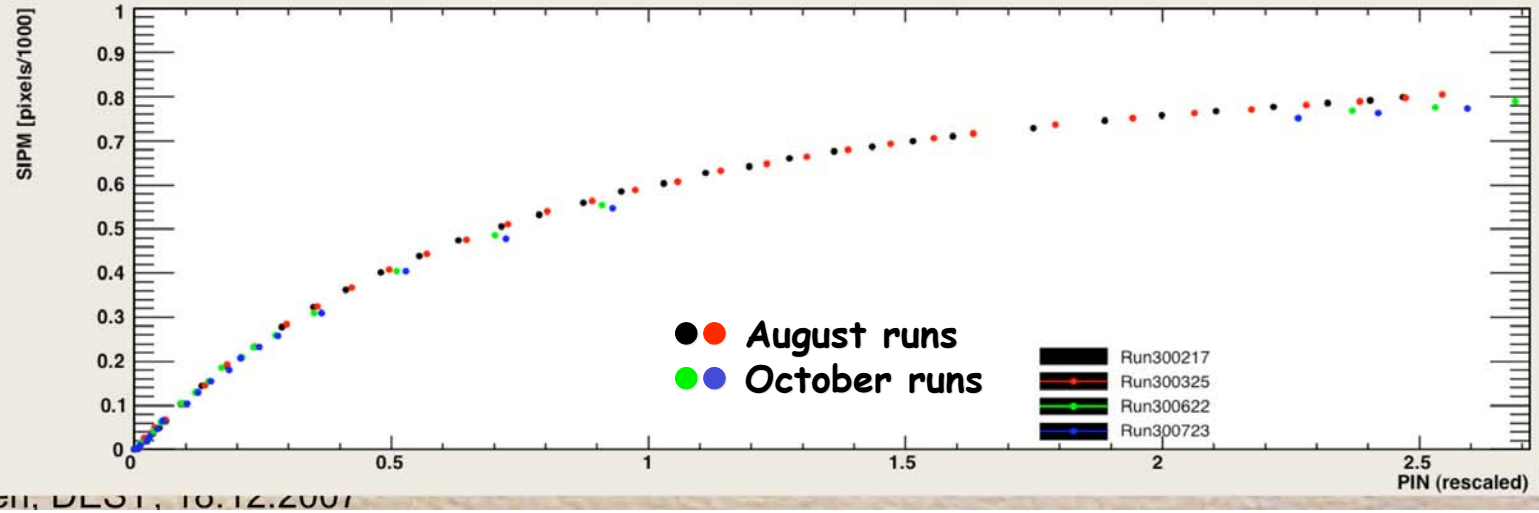
Saturation Curves for Module 13, 5-6

- Compare 4 runs from August & October

Saturation curve after pedestal subtraction, PIN & gain correction



Saturation curve after adjustment to common origin with slope one

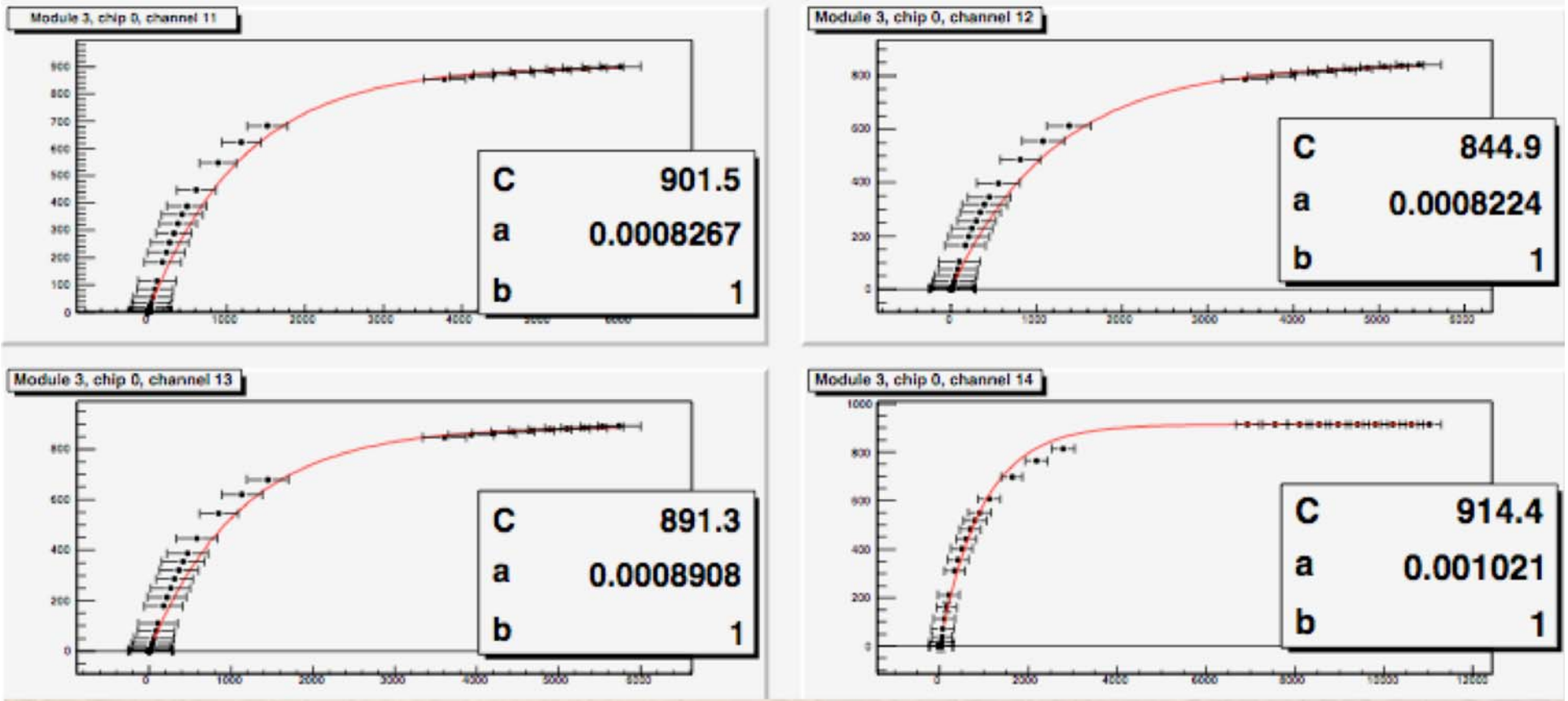


Parameterize SiPM Response Functions

- The SiPM response curves all have a similar shape
- Thus, we like to represent them by an analytical function
  - find a function with a few free parameters
  - fit all SiPM response curves to this function
  - determine the free parameters from the fit and plot their distribution
- We have focused on the function: $f(x) = C\left(1 - \exp(-ax)\right)$
  - free parameters are a and C
    - C represents saturation point
- We will also try other functions

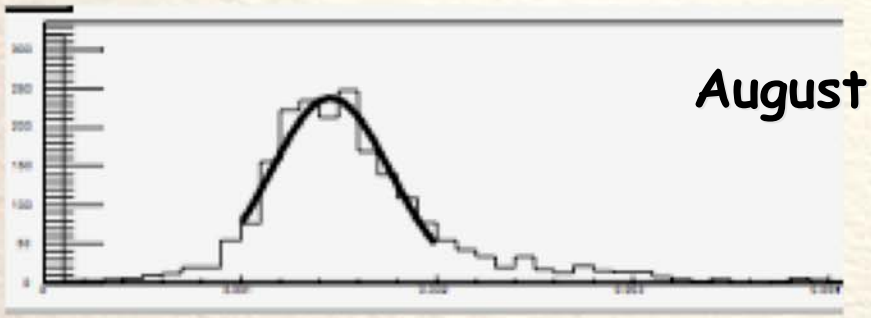
Fits of SiPM Response Functions

- The SiPM response curves are consistent with $f(x) = C\left(1 - \exp(-ax)\right)$

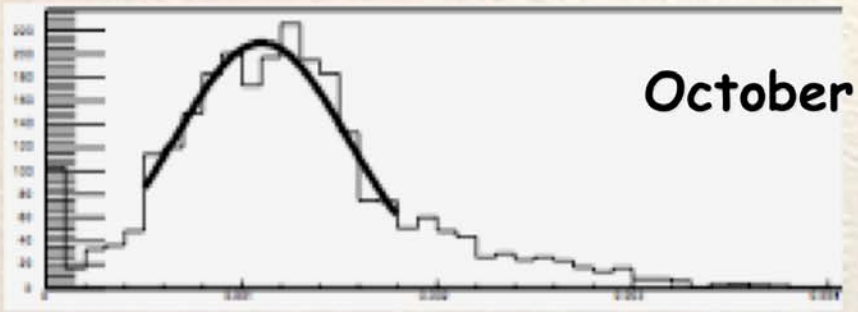


Distribution of Slope in Exponential

- Compare August & October runs for parameter a



- $a=0.00146\pm0.00001$
- $\sigma_a=0.00030\pm0.00001$

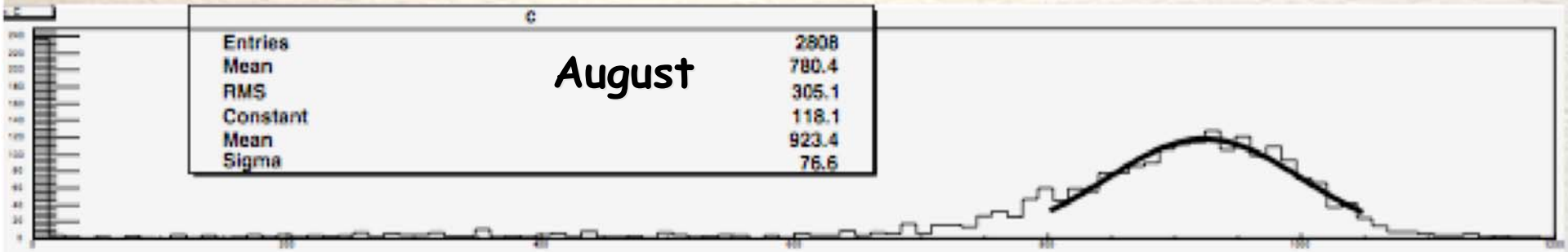


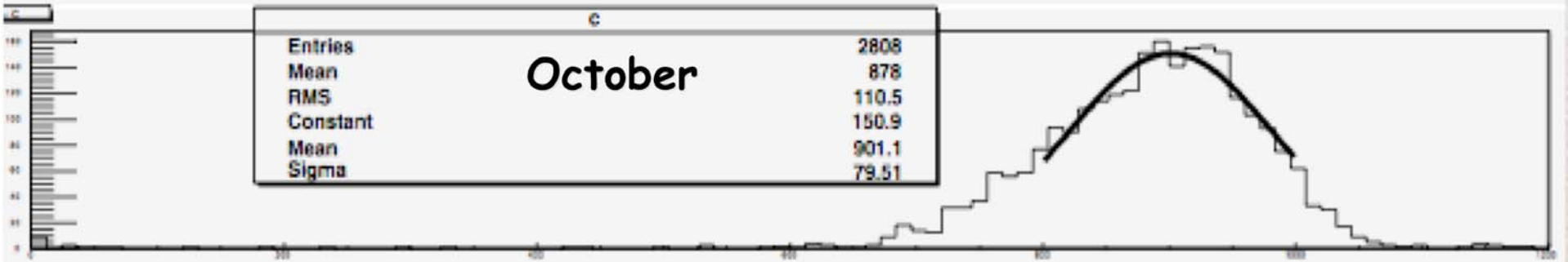
- $a=0.00110\pm0.00001$
- $\sigma_a=0.00045\pm0.00002$

- Distributions are asymmetric with tail on high side, but core fits to a Gaussian
- For the October run the mean seems to be 50% lower while the width is 86 % higher
- In August runs about 200 fits do not converge

Spread of SiPM Response Curve Endpoints

- For both August runs mean is higher but width too
- For August runs the endpoints are slightly higher but the width is slightly higher too

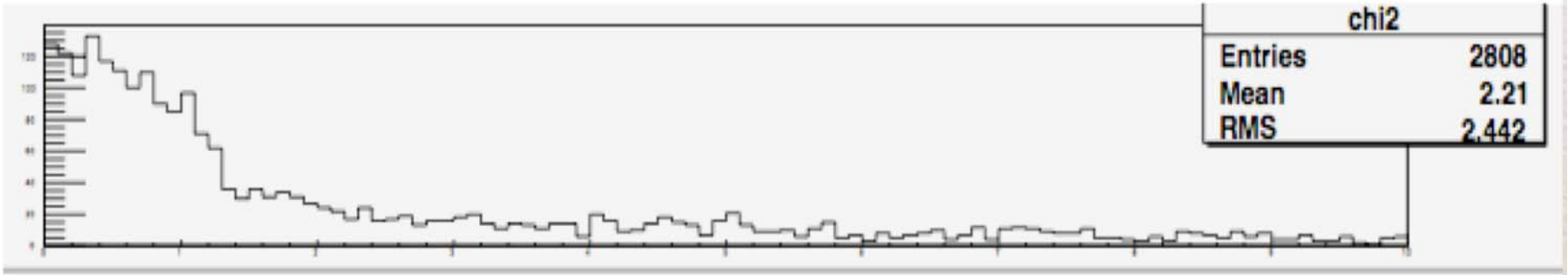




- August: C=923±2 pixels, σ_C=77±3 pixels
- October: C=901±3 pixels, σ_C=79±5 pixels

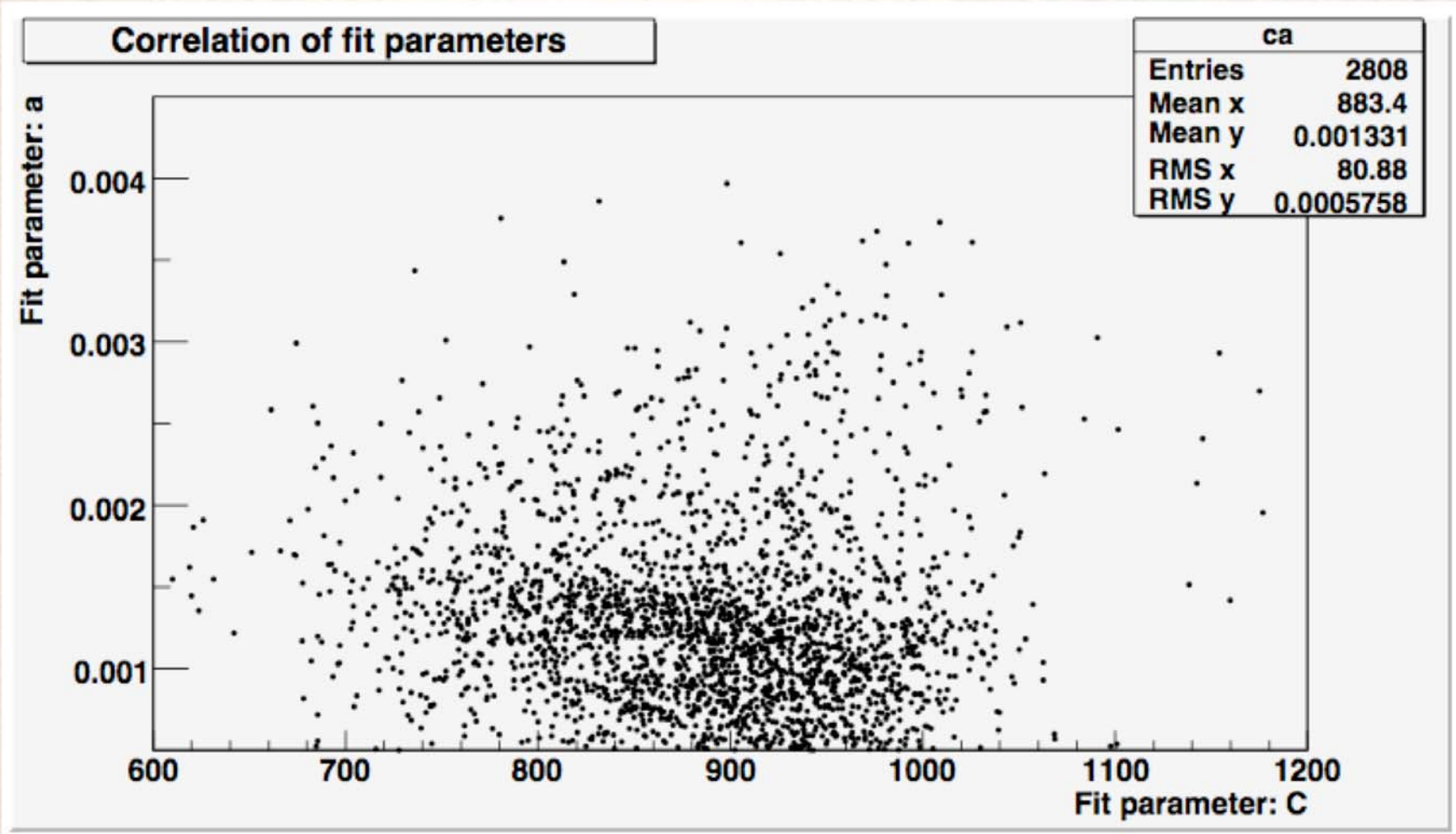
Spread of SiPM Response Curve Endpoints

- For the August runs the χ^2 is lower, but 200 fits did not converge, for the October runs it is just a few



Correlation between Fit Parameters

- There seems to be some correlation between the parameters



Conclusion and Outlook

- Results from August and October runs are consistent
- Parameterizing the SiPM response with the function $C\{1+\exp(-ax)\}$ yields a good description
  ➔ further improvements may be gotten by fine tuning the functional form (e.g. introducing fixed coefficient x^b, with $b \neq 1$
- Saturation is observed around 900 pixels, distribution has a width of 80 pixels
- Slopes are typically around 0.0011 with width of 0.00045 (broader for October runs)
- We will test our procedure on the runs from the 2007 test beam

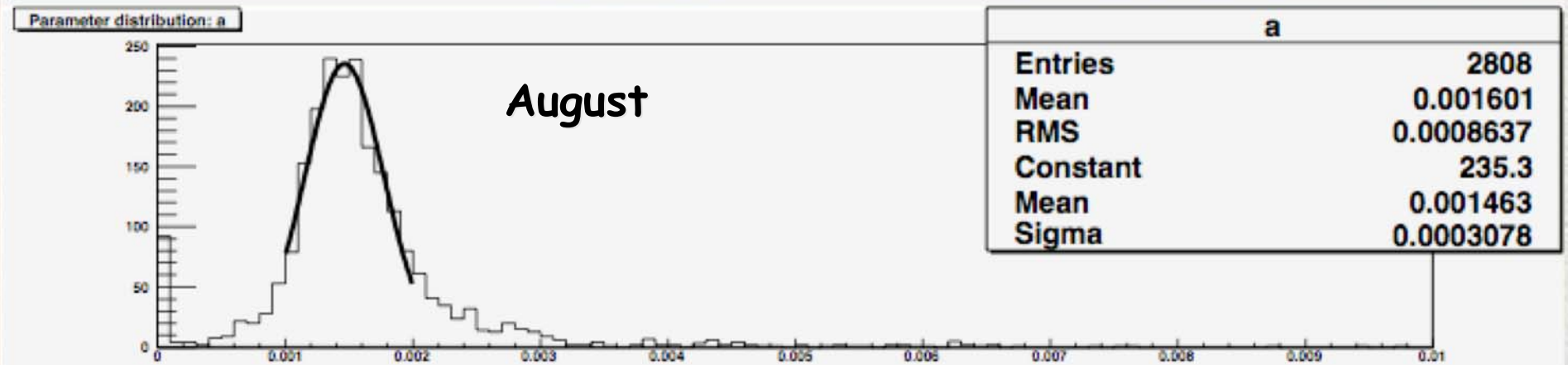
Acknowledgments

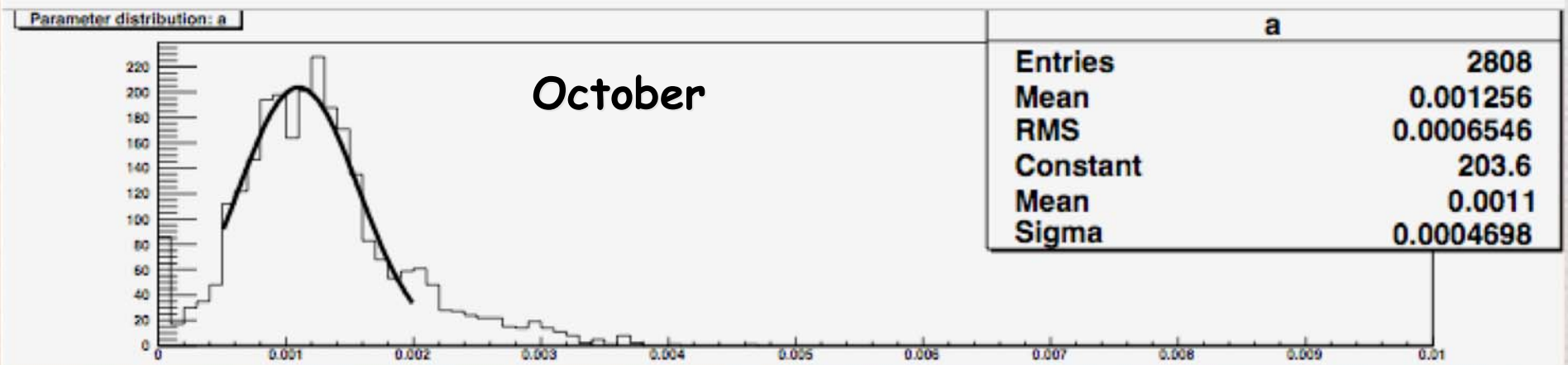
- This work was conducted in collaboration with the DESY AHCAL group, in particular we would like to thank S. Schaetzel for his help in setting us up to performing these studies

Backup Slides

Distribution of the Exponential Slope

- Compare August & October runs for parameter a





- For the October run the mean seems to be 25% lower while the width is 50% higher

Spread of SiPM Response Curve Endpoints

- For both run periods the shapes look similar
- For the August runs the endpoints are slightly higher but the width is slightly higher too