CALICE Meeting
CERN 20.05.11

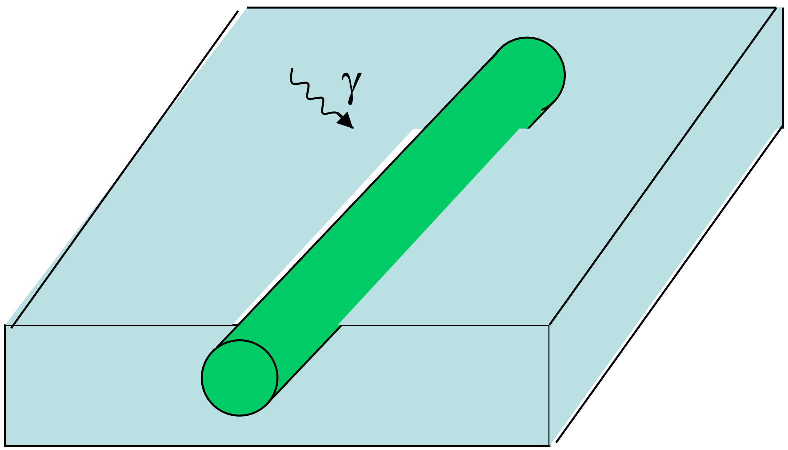
Saturation Studies at ITEP

(very preliminary results)

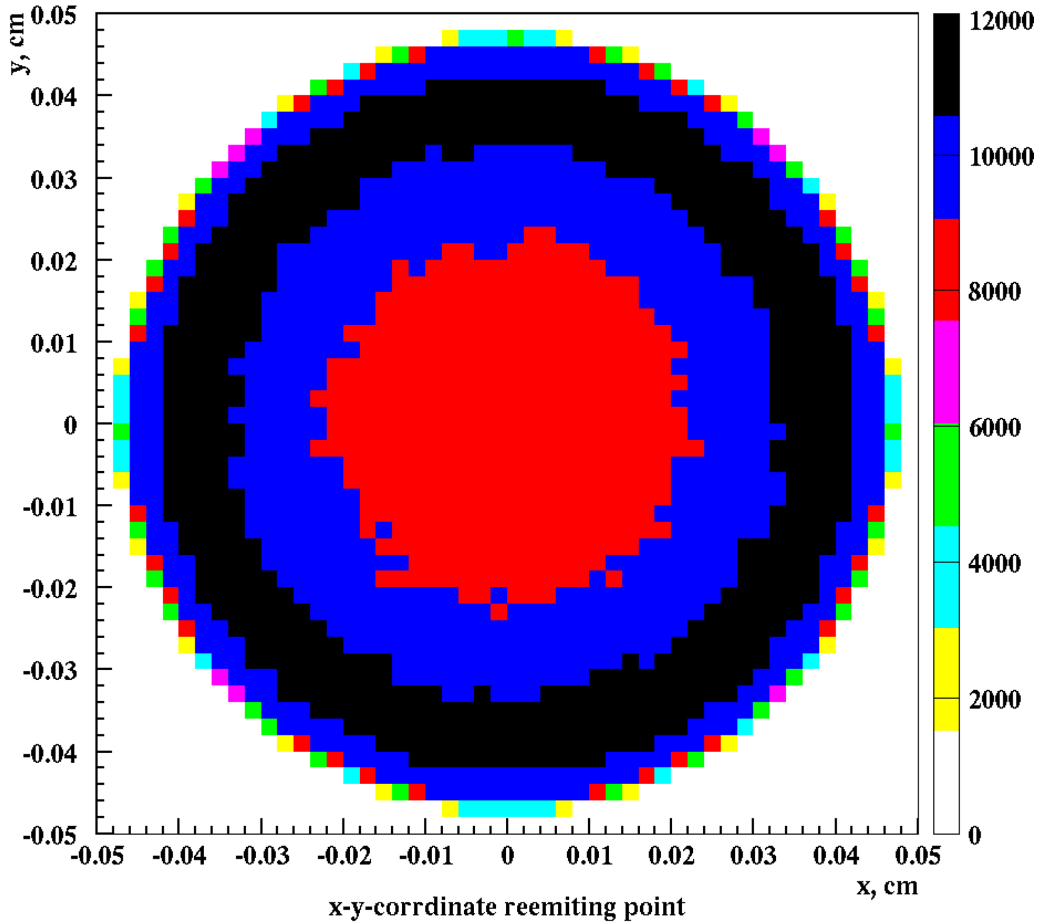
M.Danilov

Saturation of SiPM response in scintillator tile readout

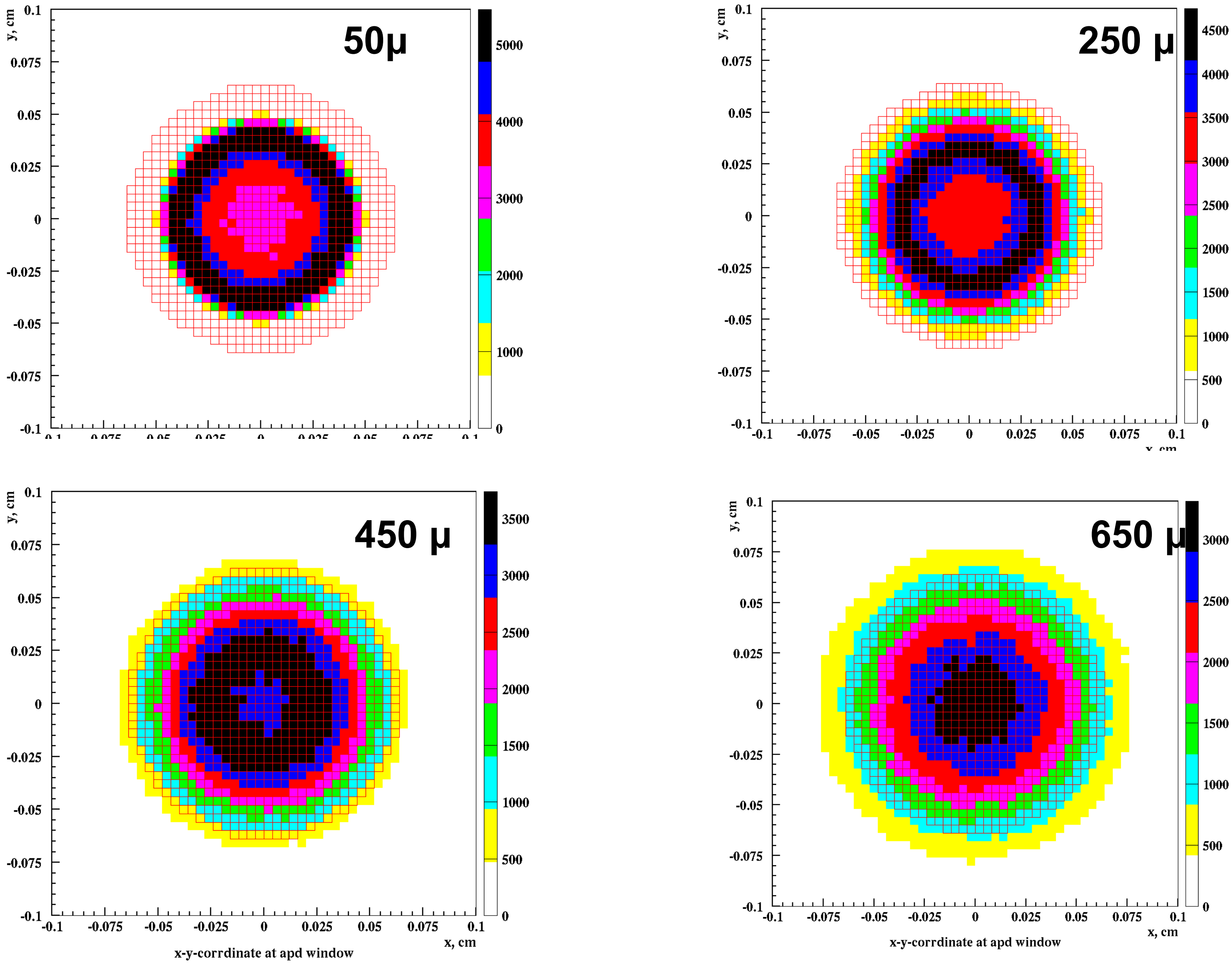
Simulation of light collection in WLS fiber



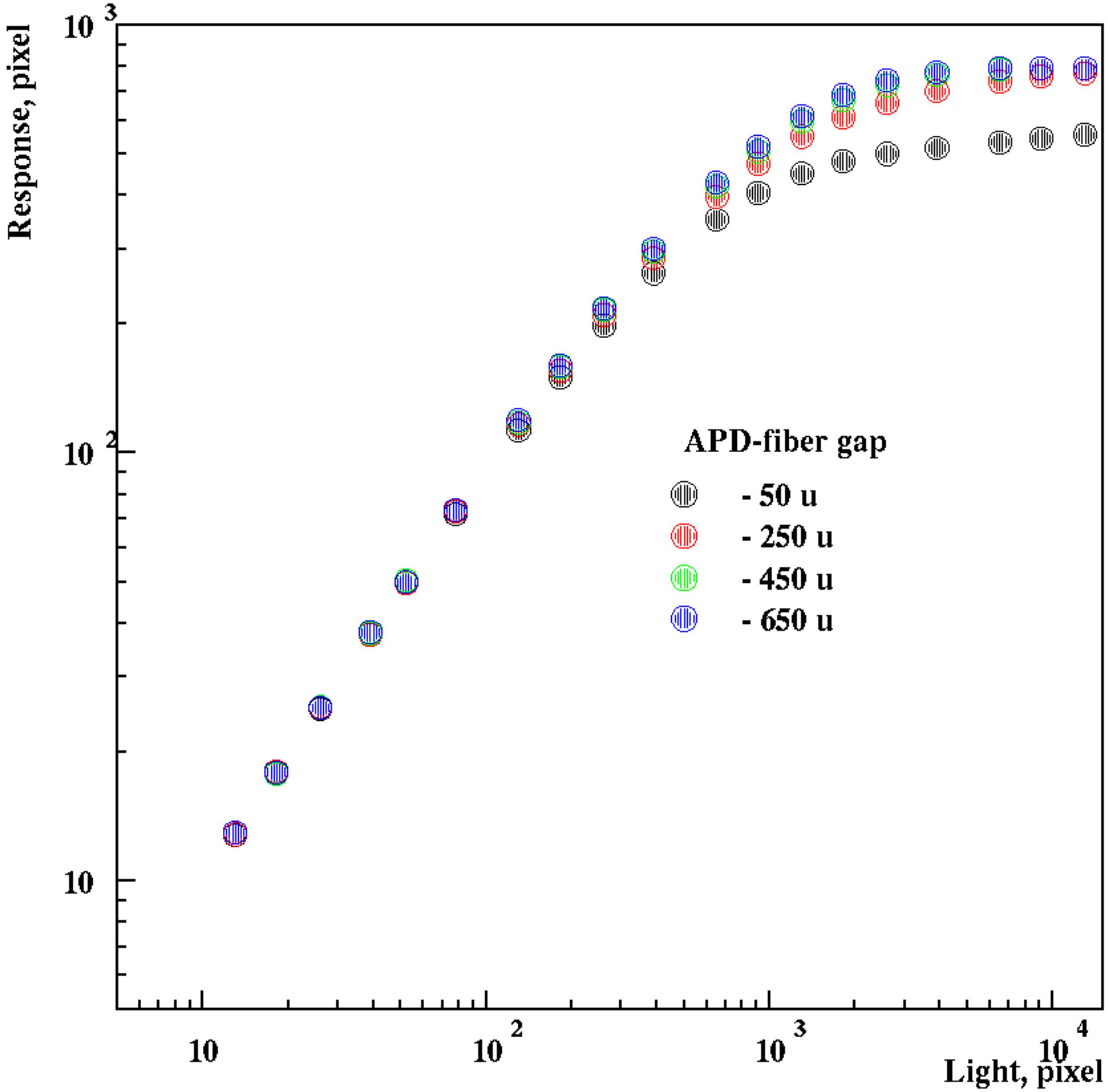
Distribution of absorption points in WLSF



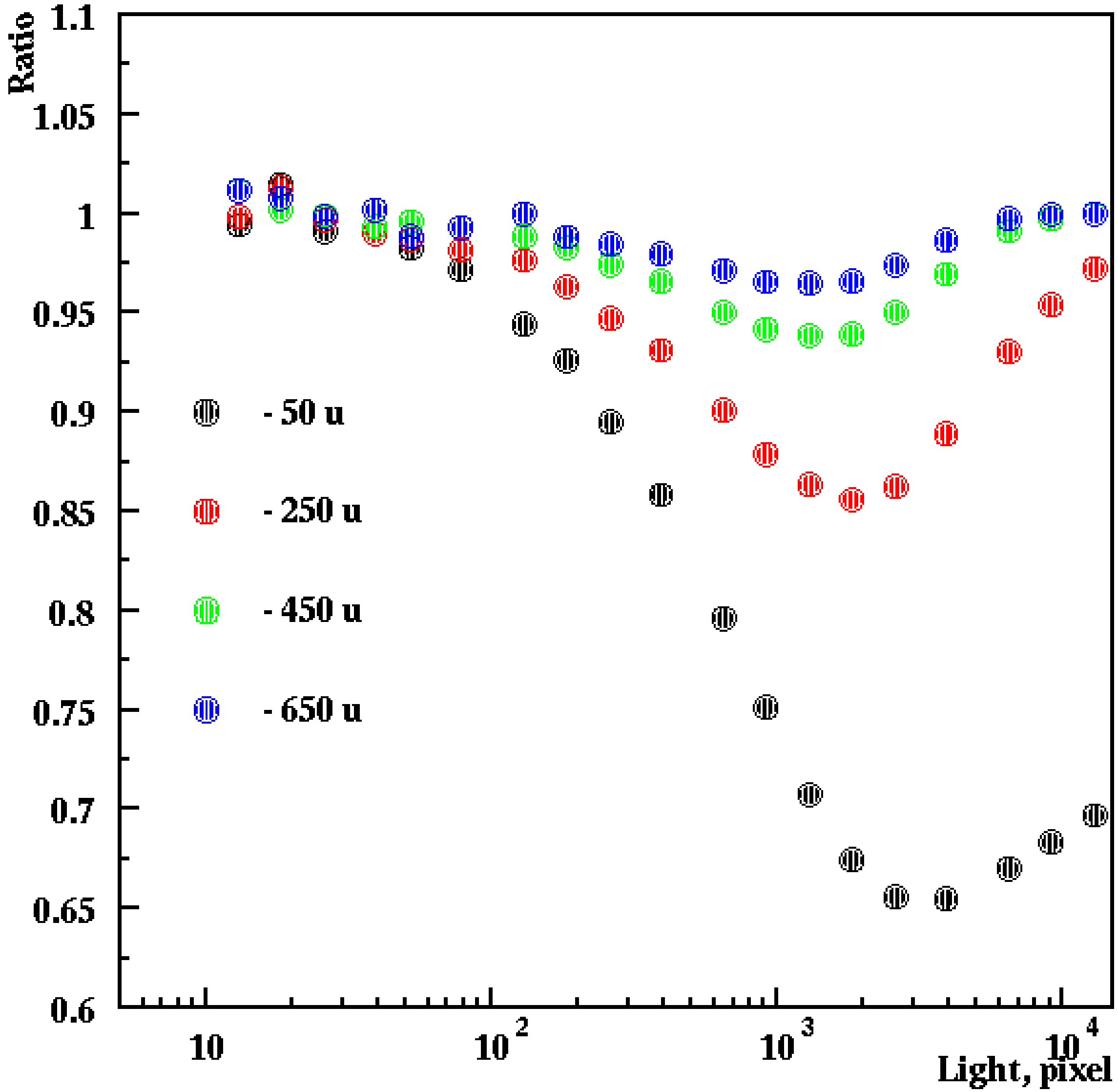
Distribution of light at SiPM surface at various SiPM-fiber distances



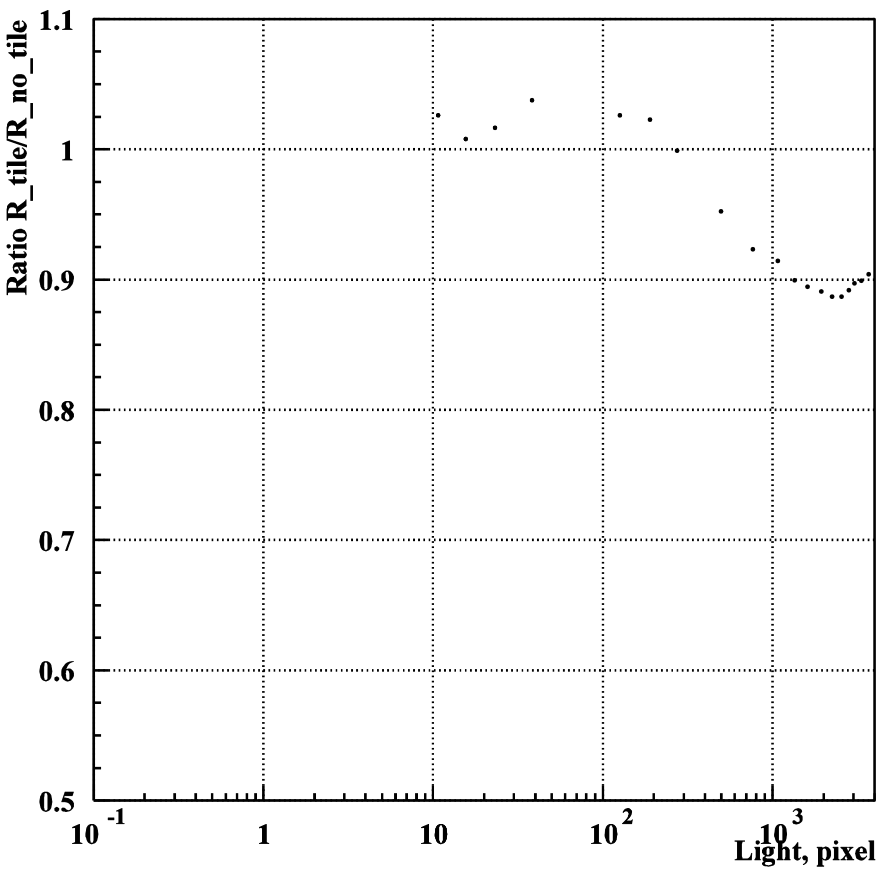
Saturation curves (MC)

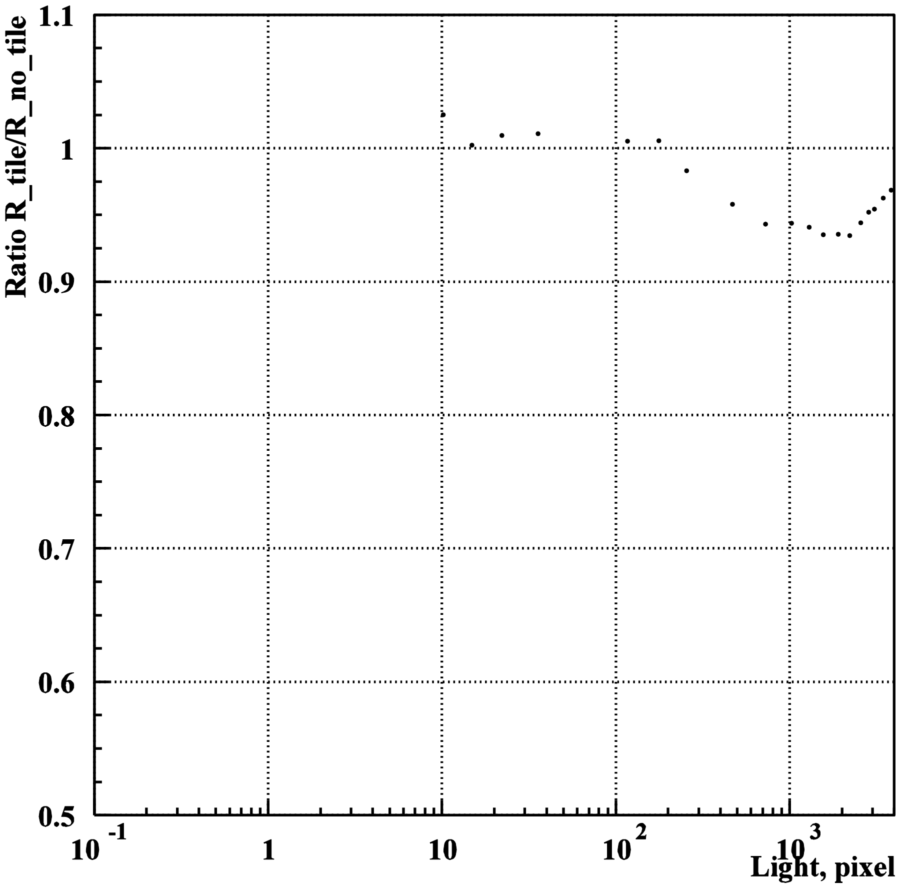


Ratio of saturation curves for SiPM in tile and uniformly illuminated one

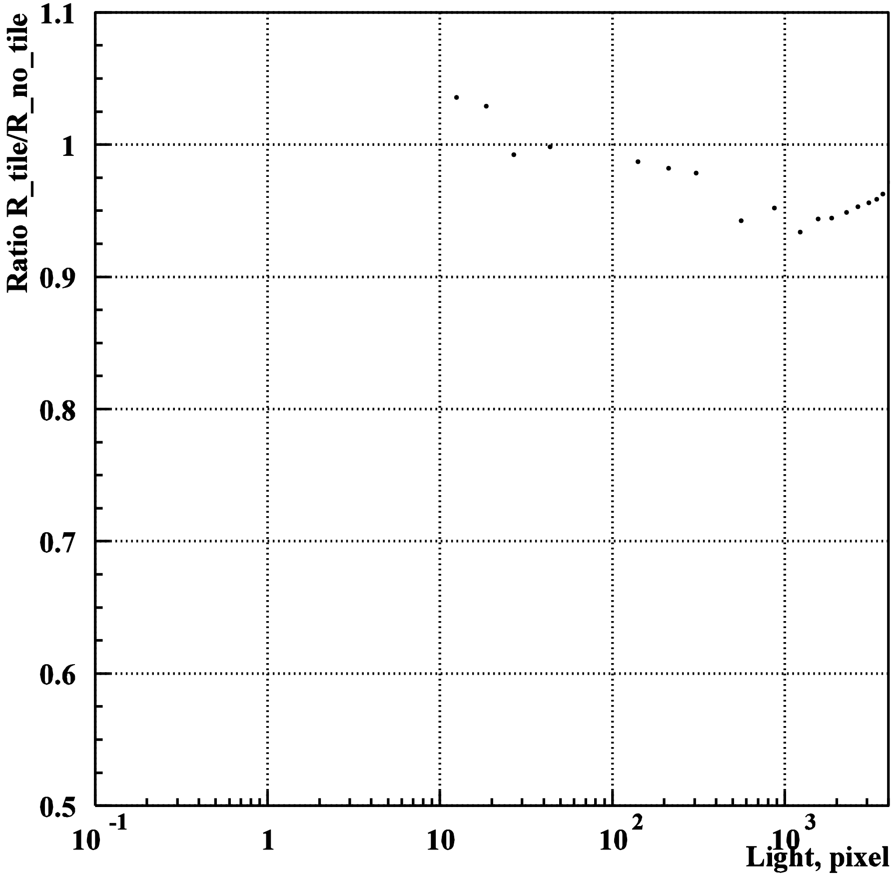


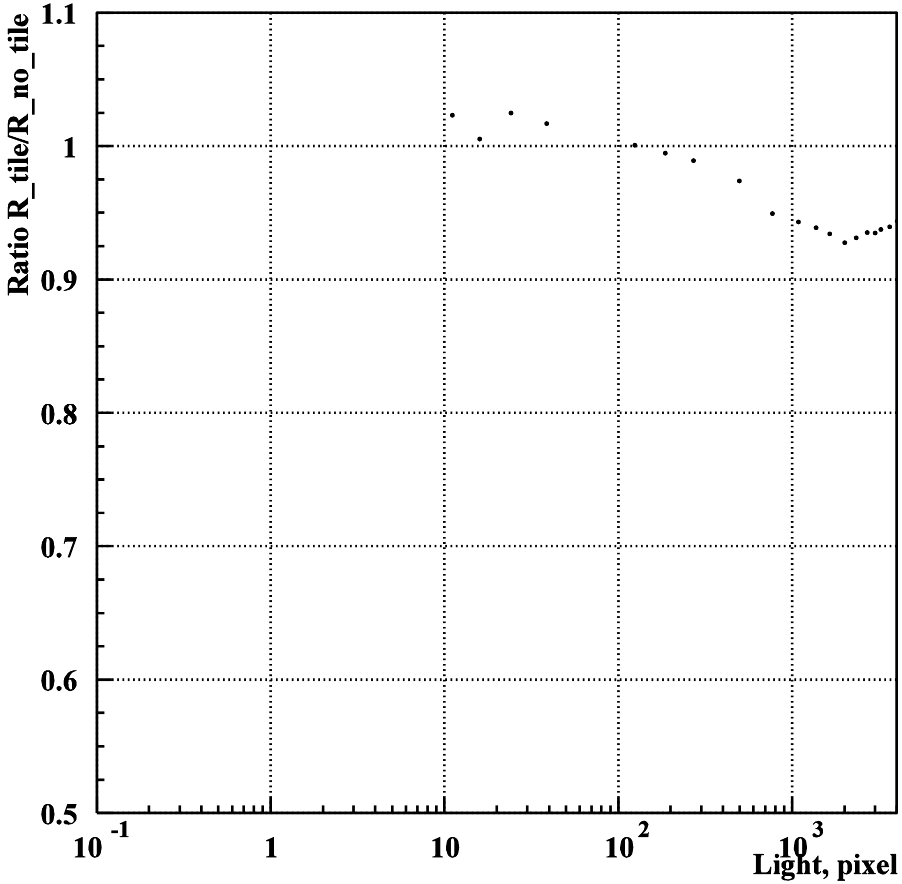
Ratio of SiPM saturation curves illuminated by a fiber in tile and illuminated with uniform light



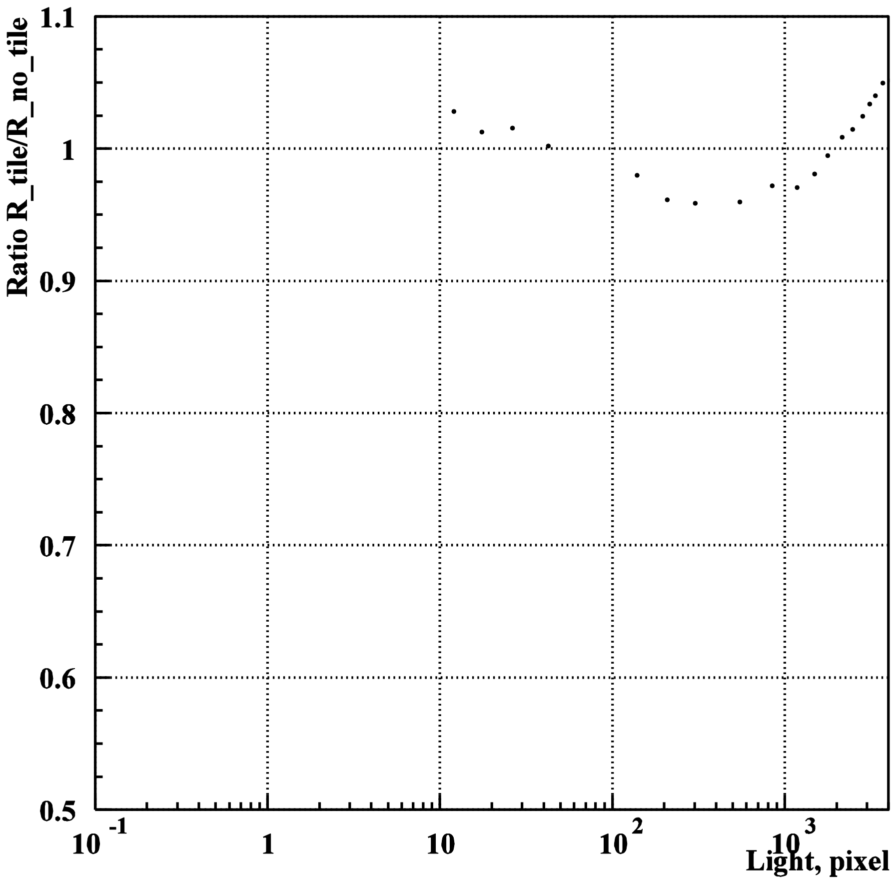


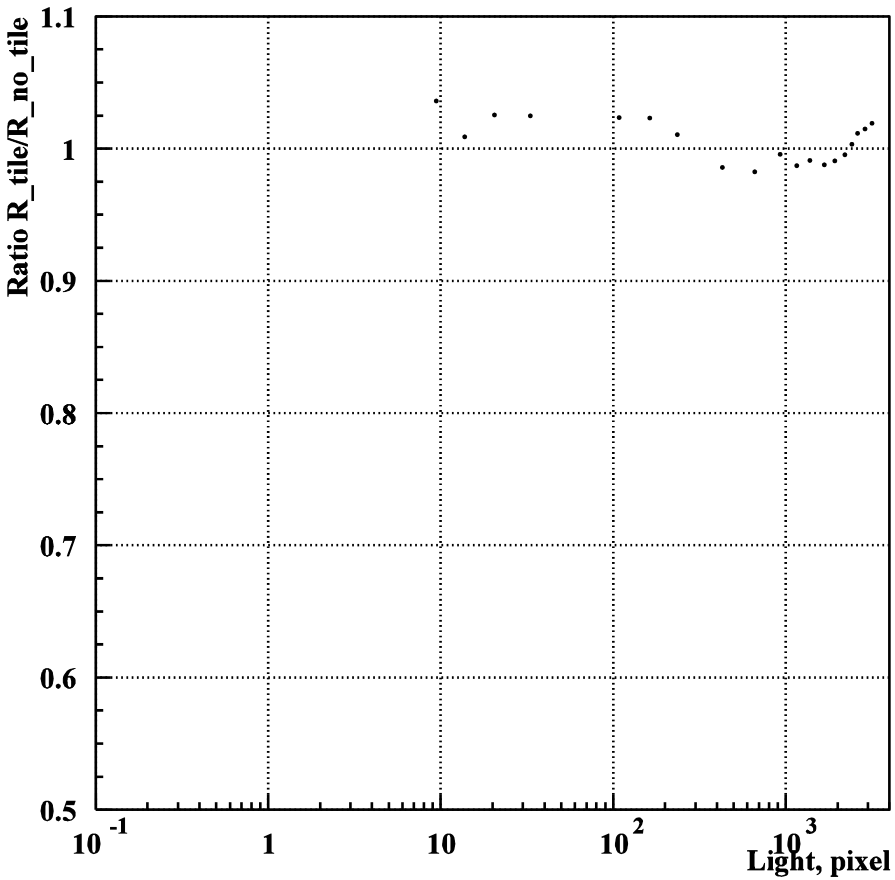
Ratio of SiPM saturation curves illuminated by a fiber in tile and illuminated with uniform light





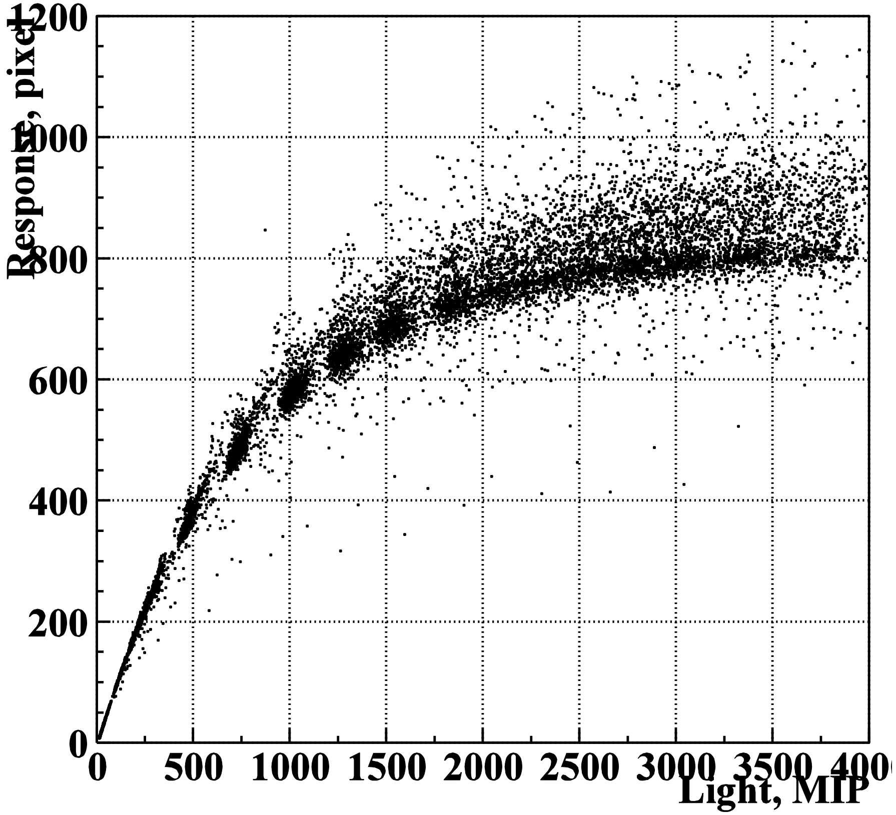
Ratio of SiPM saturation curves illuminated by a fiber in tile and illuminated with uniform light (examples)

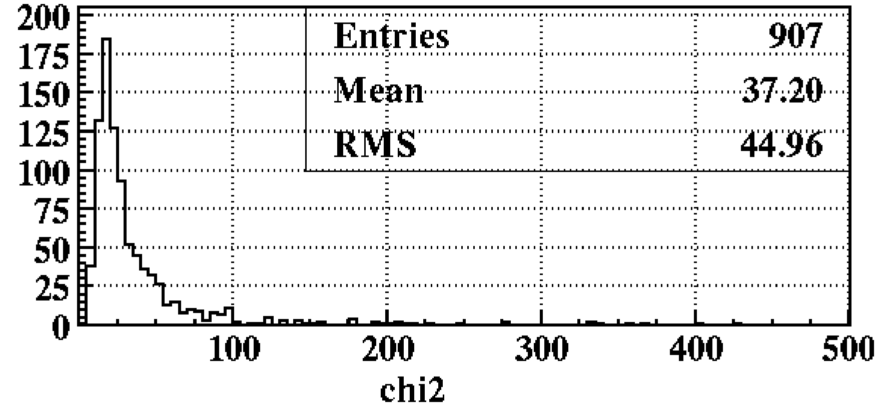


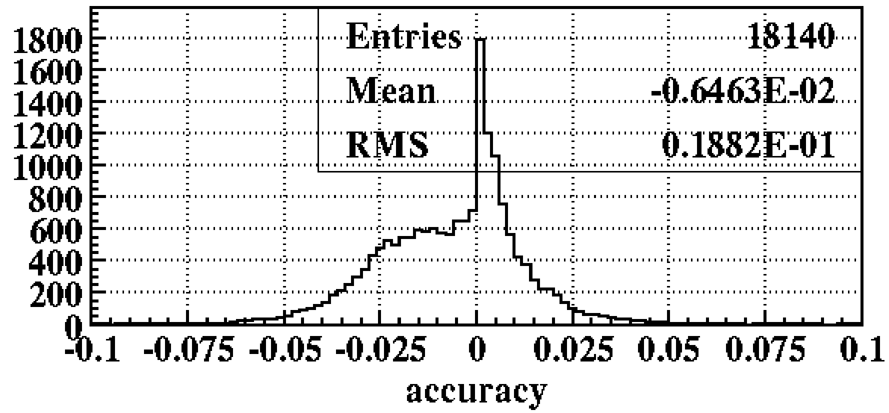


Data are quite similar to MC simulation

Saturation curve measured for uniform illumination of SiPM







Light (pixels)

Fit with simple formula: N*(1-e-x/N) is quite good σ~2%

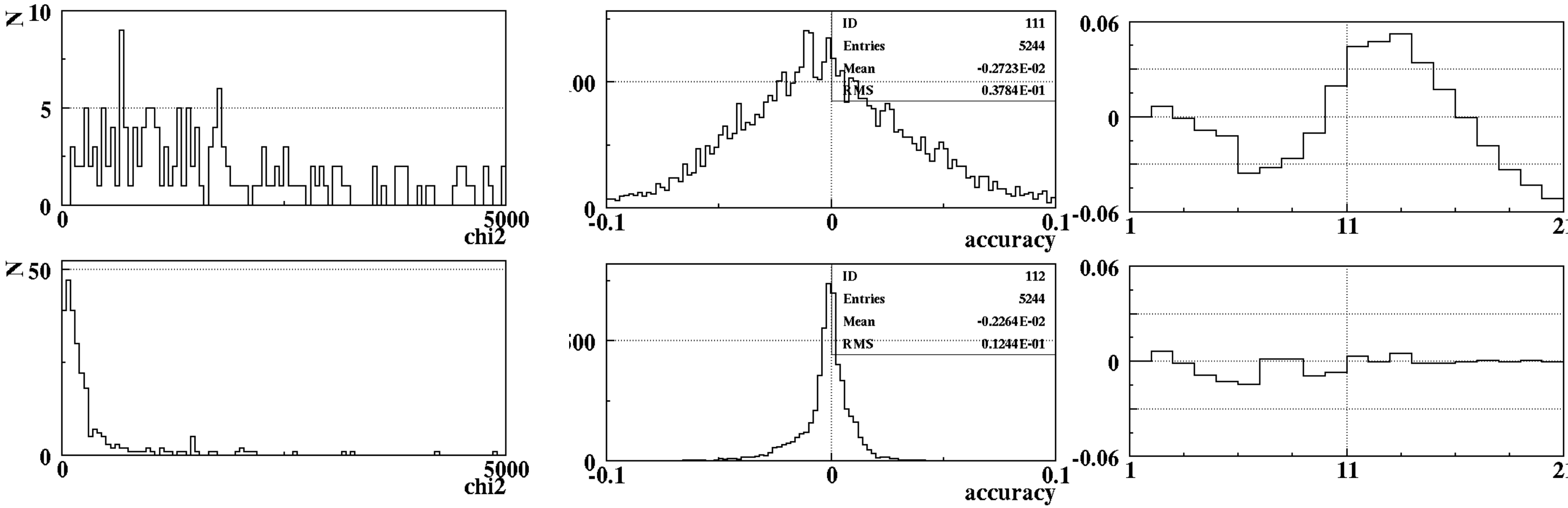
Fit of saturation curves measured in tile

Top - $N*(1-e^{-x/N})$

Bottom - $N*(1-e^{-x/N})*(1+a*x+b*x^2+c*x^3)*(1+d*x+f*x^2)$; $30 < x < 300$

$N*(1-e^{-x/N})*(1+a*x+b*x^2+c*x^3)$; $x < 30; x > 300$

Deviation from fit

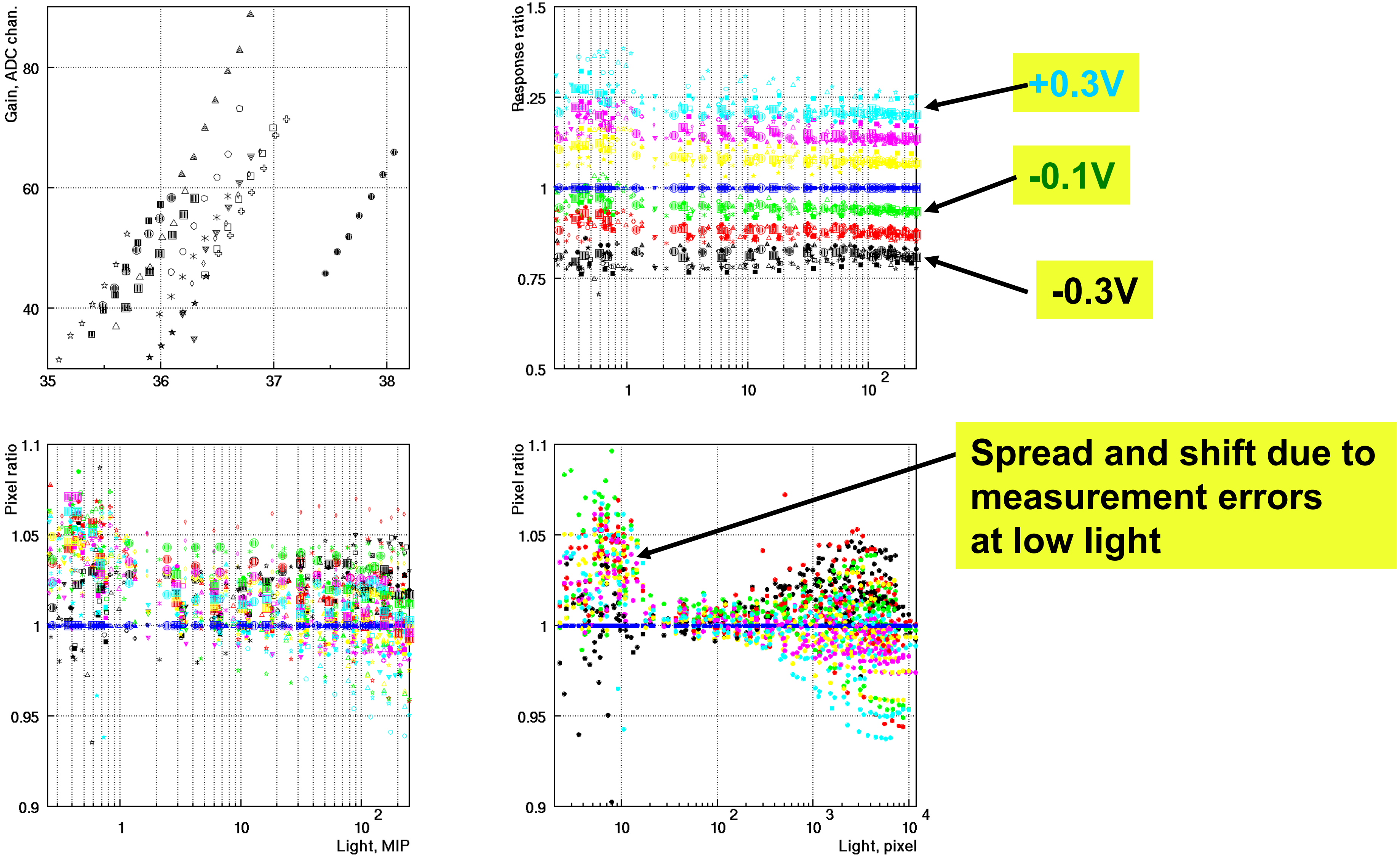


Light in log scale
10~ 30MIP
20~ 300MIP

One parameter fit is may be acceptable

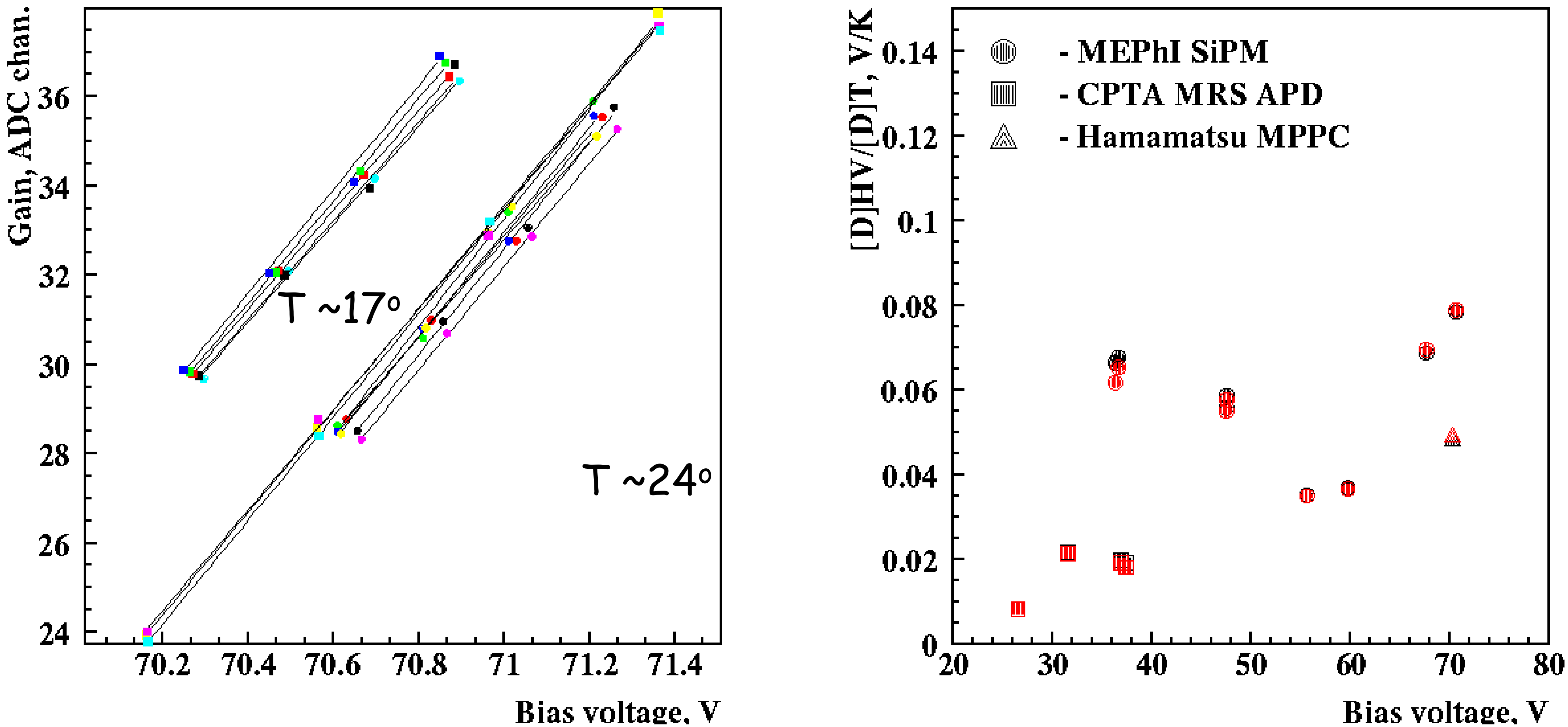
Six parameter fit is very good: σ~1%

Saturation curve is stable within ~5% for HV variation of ±0.3V equivalent to huge T variation of ±15 degrees



Temperature sensitivity of breakdown voltage

$V_{bd}=V_{bd}(T_0)-dV_{bd}/dT*(T-T_0)$ $Gain=F(V_{bias} - V_{bd})$



CPTA SiPMs have much smaller T sensitivity than MEPhI and Hamamatsu SiPMs

VERY preliminary studies of required dynamic range

Treatment of hits above M_{limit} =90(100) MIP

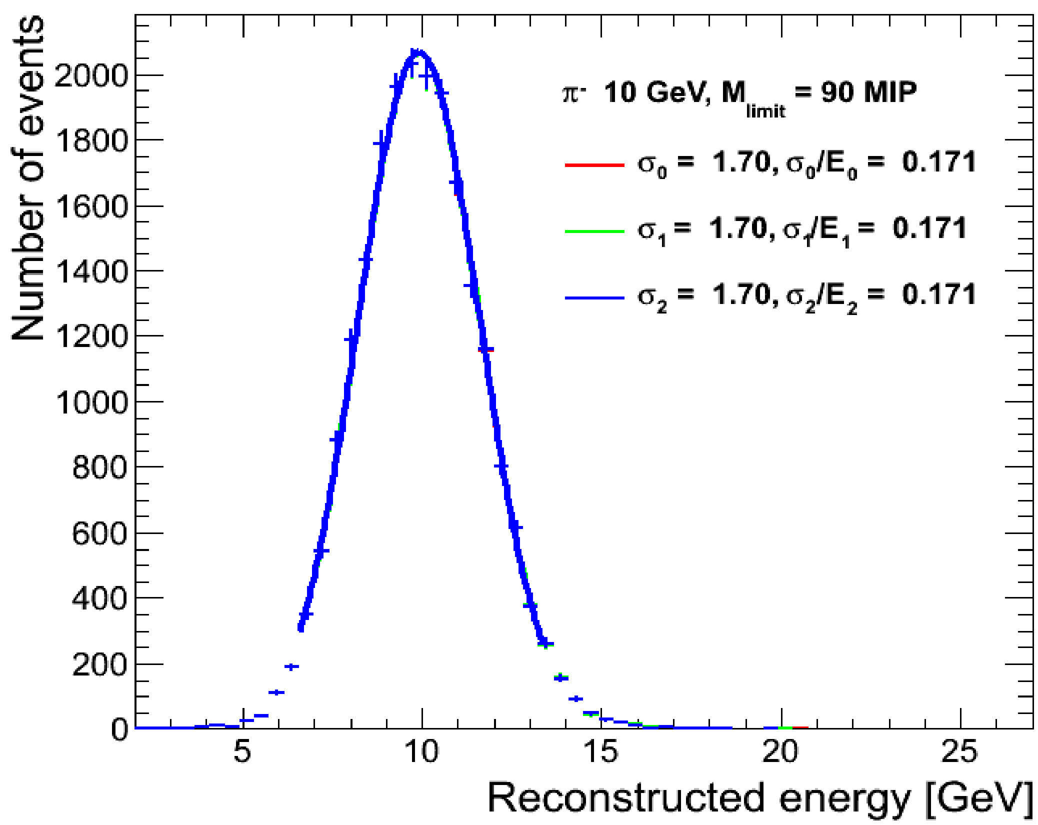
- Showers contained in AHCAL (start in the first 5 AHCAL layers)
- $E_{reco} = E_{ECAL} + E_{HCAL} + E_{TCMT}$
- CALICE software v04-01, em scale, e/pi = 1.19
- Mean E and sigma σ derived from Gaussian fit
- Data: π^- at 10, 40 and 80 GeV from CERN 2007 test beam

Method 1: if $e_{hit} \geq M_{limit}$ then e_{hit} is replaced by the mean for the hits above M_{limit} for given energy.

Method 2: if $e_{hit} > M_{limit}$ then $e_{hit} = M_{limit}$

No changes in resolution for 10 GeV

- Fraction of events with $e_{hit} \geq 90$ MIP ~0.2%
- Fraction of events with $e_{hit} \geq 100$ MIP <0.1%



σ_0, E_0 – initial

σ_1 , E_1 – from method 1

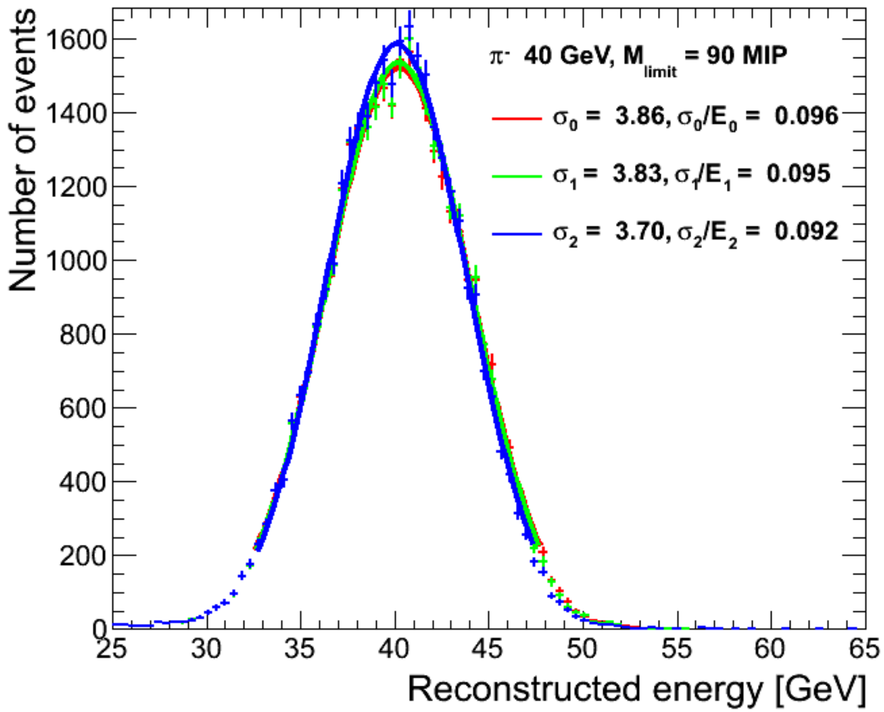
σ_2 , E_2 – from method 2

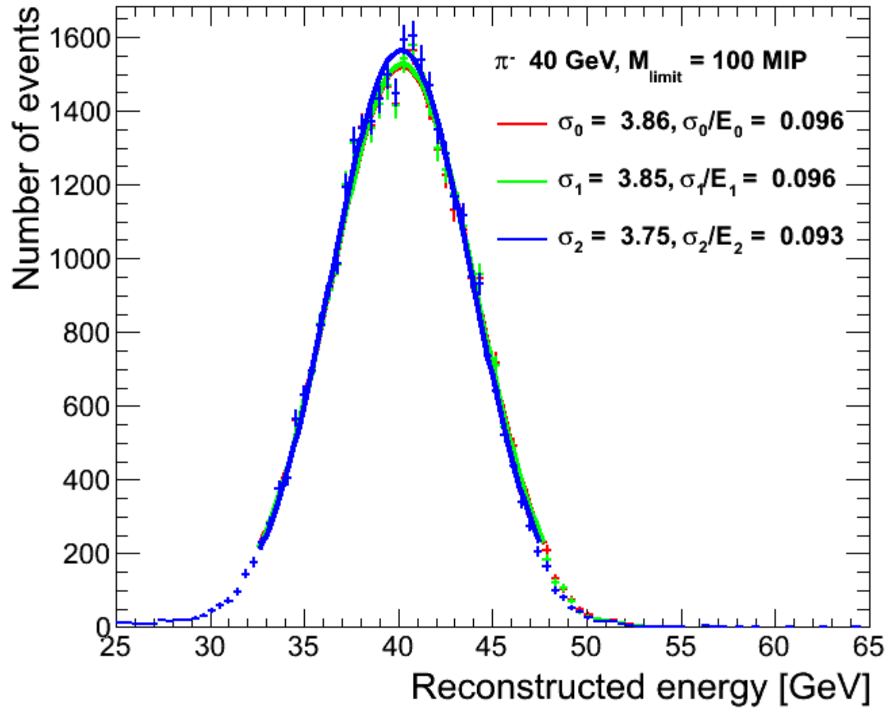
Improvement for 40 GeV

Fraction of events with:

$e_{hit} \geq 90$ MIP: ~12%

$e_{hit} \geq 100$ MIP: ~8%





Method 1: rel. improvement ~1%
Method 2: rel. improvement ~4%

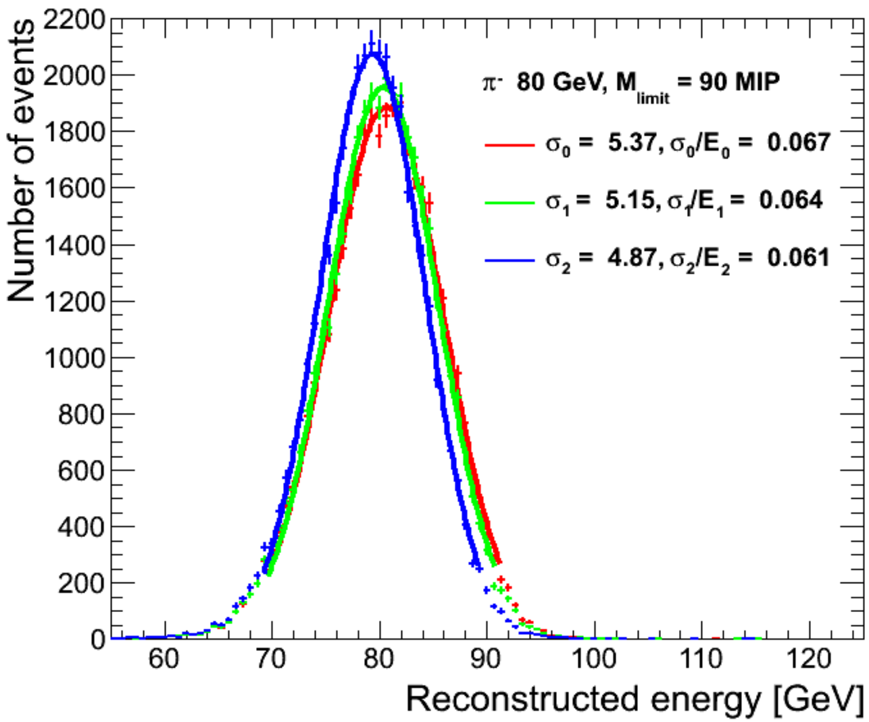
Method 1: rel. improvement ~0.3%
Method 2: rel. improvement ~3%

Shift of mean value < 0.3%

Improvement for 80 GeV

Fraction of events with:

$e_{hit} \geq 90$ MIP: ~45%



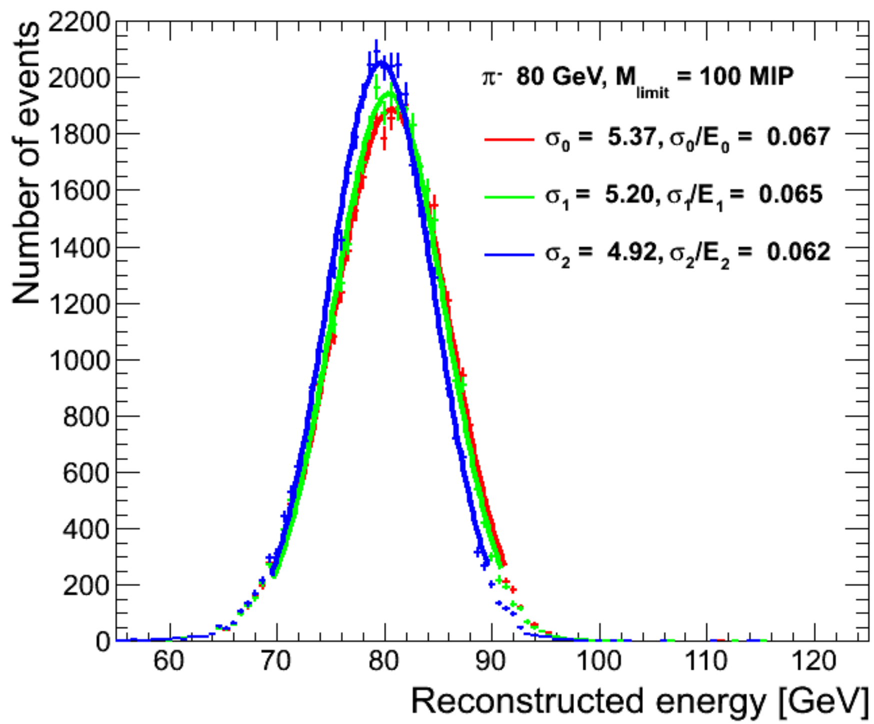
Method 1: rel. improvement ~4%

Shift of mean value ~0.4%

Method 2: rel. improvement ~8%

Shift of mean value ~1.6%

$e_{hit} \geq 100$ MIP: ~36%



Method 1: rel. improvement ~3%

Shift of mean value ~0.3%

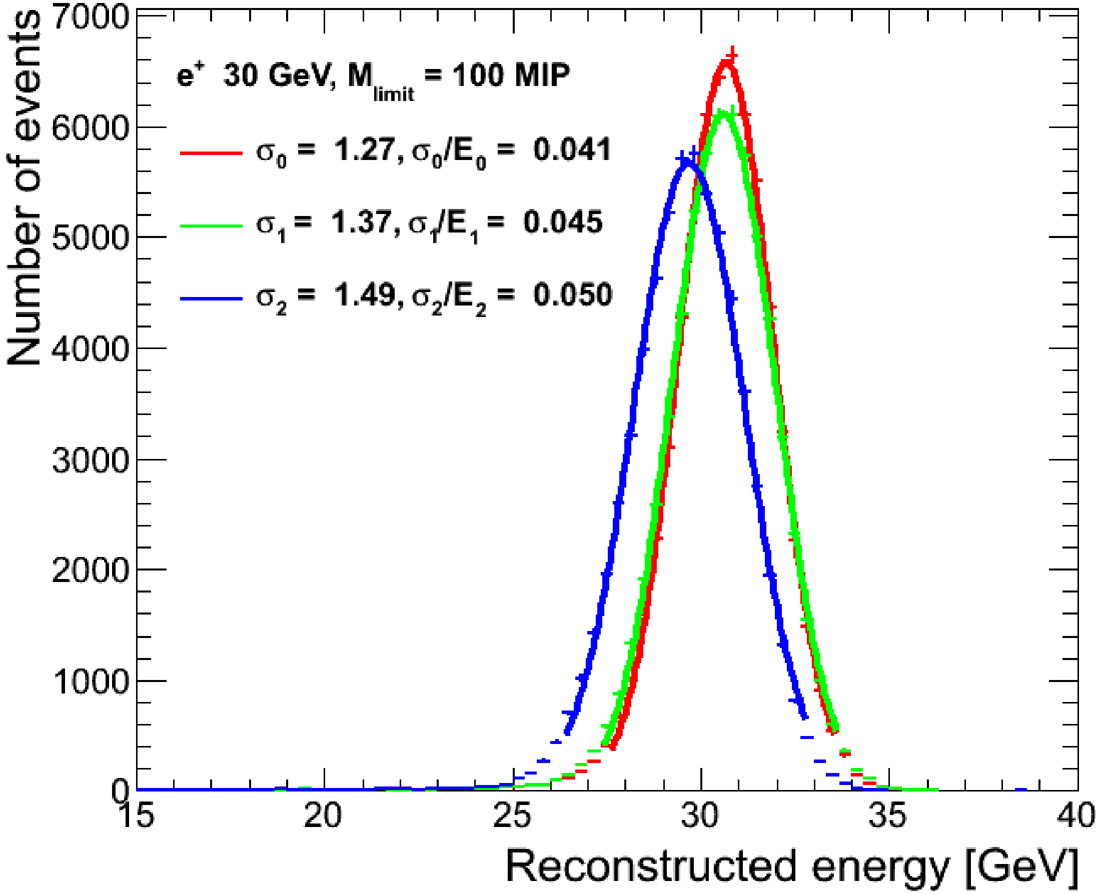
Method 2: rel. improvement ~7%

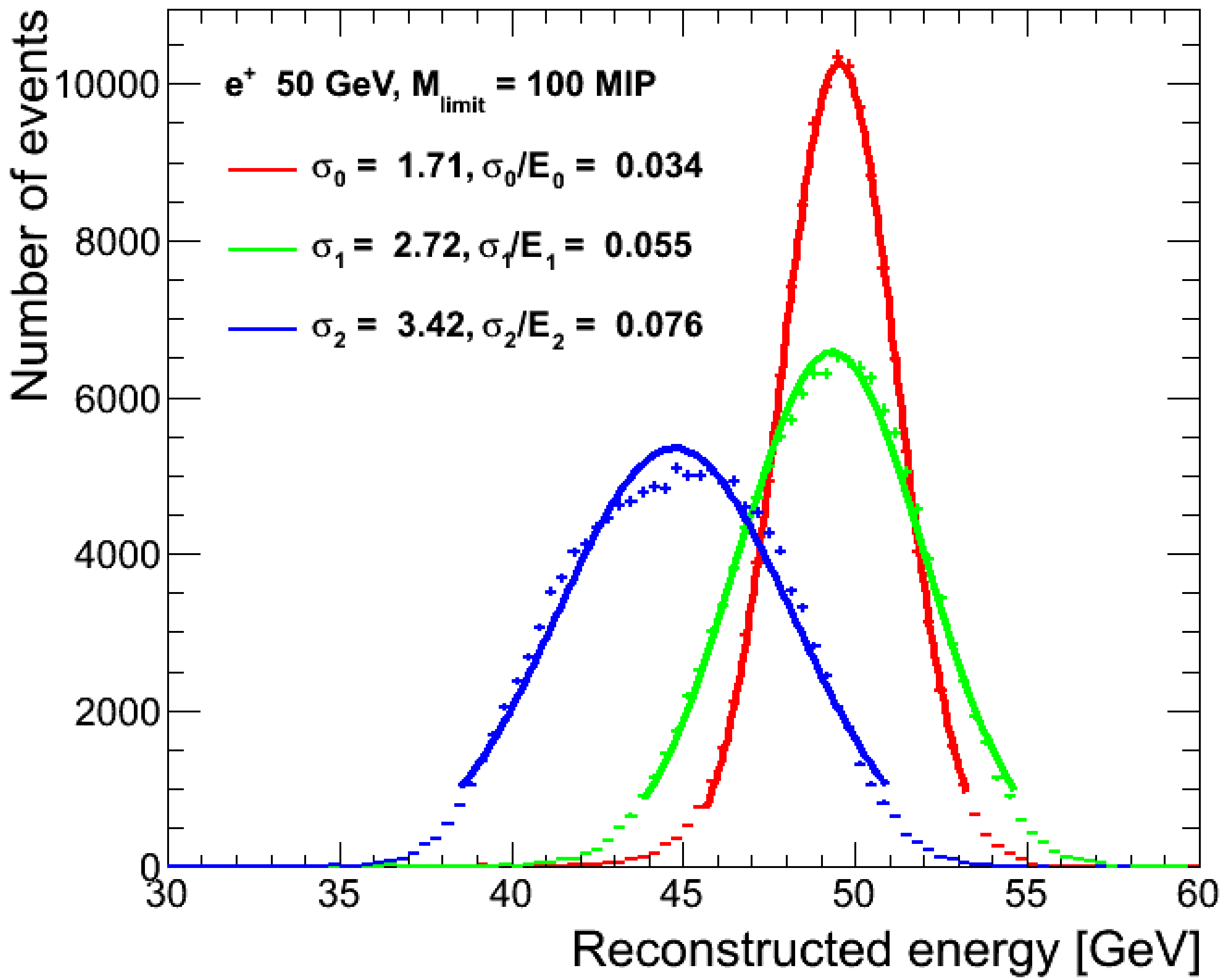
Shift of mean value ~1.3%

Looks promising but there are many questions

Why mean value changes slightly for method 1?
Is improvement in method1 due to suppression of e/m parts of shower?
There are 80 GeV runs with no improvement (but also without deterioration)

There is 10% (60%) deterioration of resolution for 30 (50) GeV positrons





e+ 50 GeV, M_limit = 100 MIP
σ0 = 1.71, σ0/E0 = 0.034
σ1 = 2.72, σ1/E1 = 0.055
σ2 = 3.42, σ2/E2 = 0.076
Number of events
Reconstructed energy [GeV]
0
2000
4000
6000
8000
10000
30
35
40
45
50
55
60

Conclusions

1.Saturation of CPTA SiPMs in tiles depends on many factors (distance to fiber, shift, SiPM parameters like X-talk, efficiency, etc) but can be well described by a 6 parameter fit function.

May be more simple fit function can be found (but it is not important)

2. Saturation curve dependence on T is very small for CPTA SiPMs (CPTA SiPMs have much smaller Vbd T sensitivity than other SiPMs)

If changes in T are compensated by bias V adjustment saturation curve should not change at all.

3. Very preliminary studies of the required dynamic range indicate that 100MIP dynamic range is sufficient for hadron showers up to 80GeV, however there are still many questions.