Test of a 1 m^2 MICROMEGAS prototype in a muon beam

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Outline

Set-up

Detectors

- Telescope
  - 4 Gassiplex chambers
  - 3 scintillators
- 1 m^2 prototype
  - 4 ASUs with 24 HR2
  - 1 ASU with 24 HR2b

Trigger

- Coincidence PM
  + READY of 2 acquisitions
- Delay of 1 μs to m^2

Rates

- Beam: 150 GeV/c muons
  100–500 kHz over 5×5 cm^2
- Acq. rate $\sim$ 100 Hz

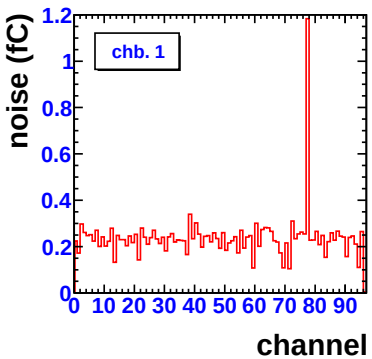
Gassiplex telescope (I)

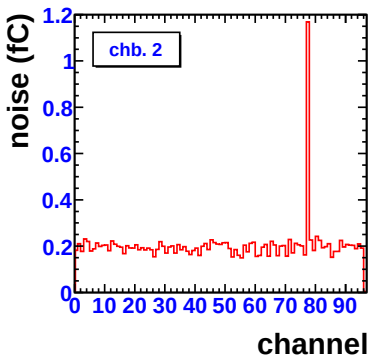
Readout chain

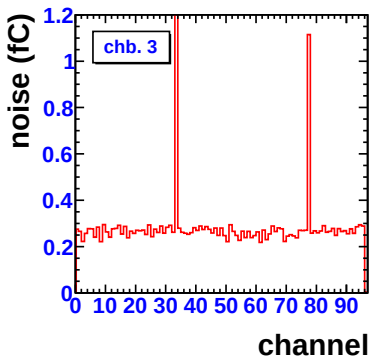
1. pad
2. preamp-shaper
3. ADC-sequencer
4. PC-LabView

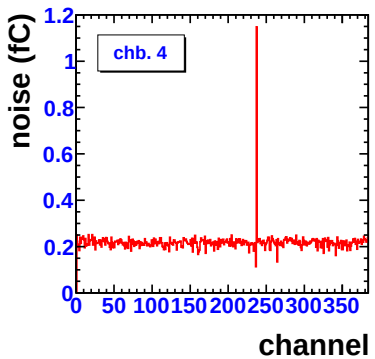
Low noise conditions

1. 0.24 ± 0.04 fC
2. 0.20 ± 0.02 fC
3. 0.27 ± 0.03 fC
4. 0.22 ± 0.02 fC





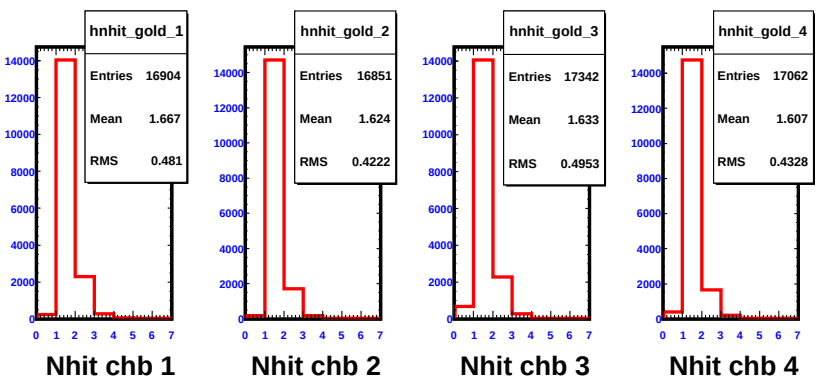




Gassiplex telescope (II)

Thresholds

- 1 threshold/channel
  $\rightarrow$ uniform noise proba.
- Hardware (VME) cut at 2 σ
  $\rightarrow$ increase acq. rate



Performance

- Track finding algo.
  $\rightarrow$ remove noise hits
- Perf. compatible with previous measurements

chb.	**thr.** (fC)	ϵ	**m**
1	0.48	98.5	1.19
2	0.40	98.8	1.14
3	0.54	96.0	1.18
4	0.44	97.6	1.14

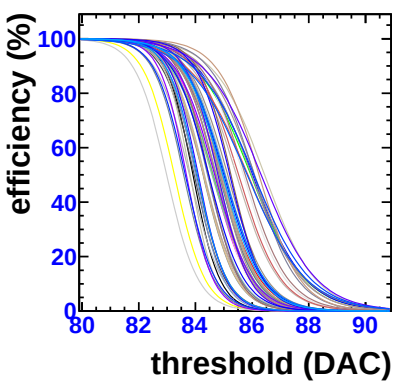
Hardroc2 prototype

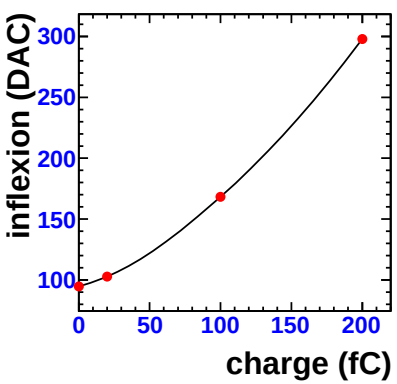
Thresholds

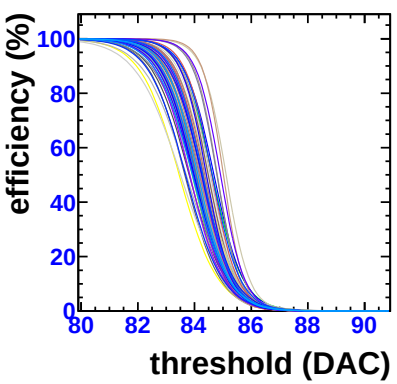
- LAPP calibration:
  $\rightarrow$ Scurve & preamp. gain
- 1 channel: $thr \sim 6$ fC at 5σ
- 64 channels of a chip:
  common DAC thr. $\rightarrow$ 12 fC

Pedestal alignment

- 10 % of signal shaped:
  MPV $\sim$ 2–3 fC
- Align Scurve:
  tune indiv. preamp. gains
- HR2-HR2b $\rightarrow$ 12-6 fC

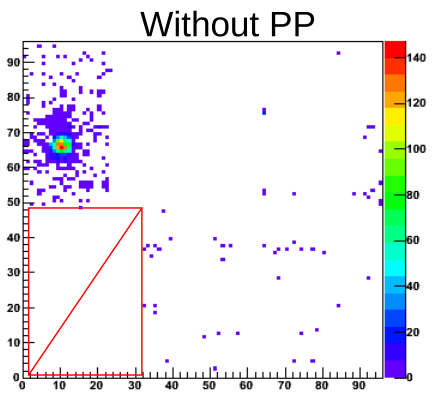


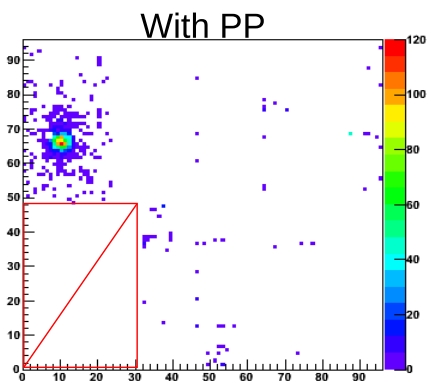




Collected triggers

- Beam on all ASUs
  most data ASU-HR2b
- Run @ 420 V
  - 1 chip with $\neq$ *thr.*
  - 160 k triggers
- Run @ 410 V
  - 4 chips - fixed *thr.*/chip
  - 400 k $\times$ 4 triggers
- Power-pulsing
  - 1 chip @ 410 V, fixed *thr.*
  - 20 k $\times$ 2 (ON/OFF)





Event selection in telescope

Track extrapolation

- 1 cm^2 segmentation
- 1 m separation

Straight tracks

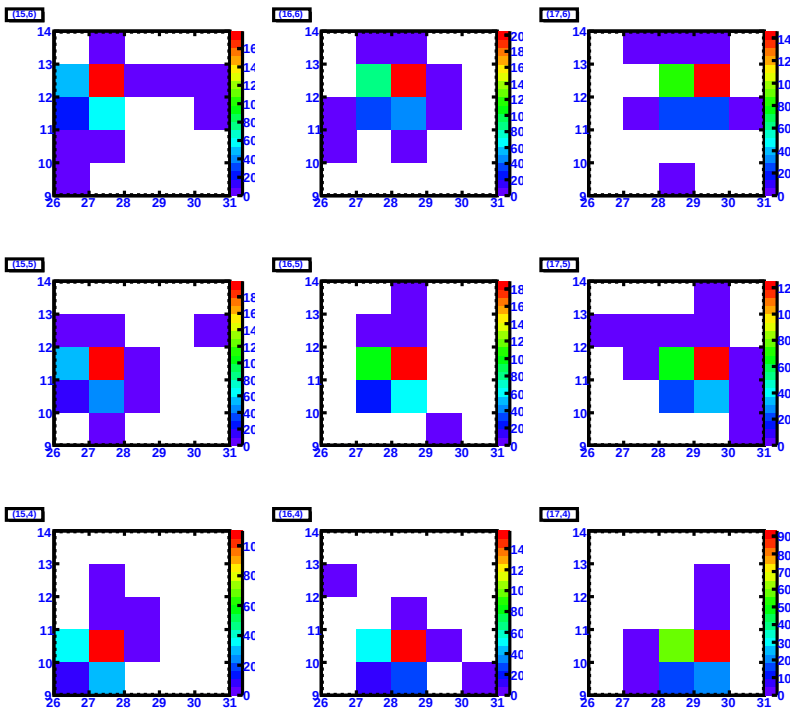
- Aligned $Q_{\max.}$ in $\neq$ chb.:
- $X_1 = X_4$ AND ($X_2 = X_4$ OR $X_3 = X_4$)

After selection

- $\sim$ 60 % of all triggers
- Hits in m^2 fit in 3$\times$3 cm^2

Hit pattern in m^2 prototype for various straight track positions in telescope

Also provide offset



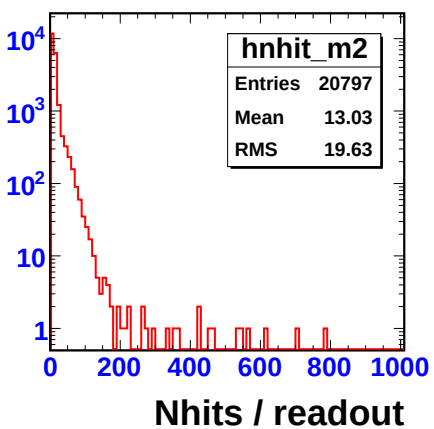
Hit selection in prototype

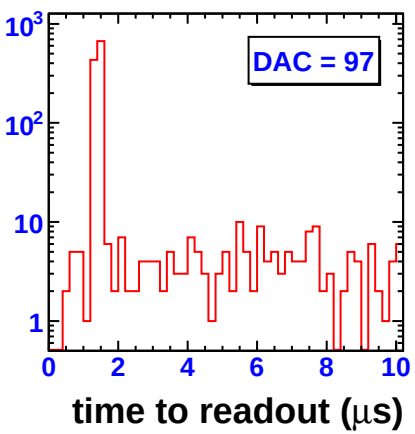
Number of hit/readout

- 127-event depth memory
  $\rightarrow$ possibly large N_{hit}
- Sparks, noise burst...
- Reject if more than 400 hits

Time of hits

- Hardroc2 & DIF provide
  - time of hits & readout
- Delay of 1 μs
  - Reject noise hits
  - Measure noise proba.





Performance

Efficiency ϵ

- Complement to 1 of proba. of no hits

Multiplicity m

- Weight sum of proba. of i hits ($i \neq 0$)

Noise probability η

- Counts hits out of trigger

Formulae

$$\epsilon = 1 - \epsilon_0$$

$$m = \sum_{i=1}^{9} i \cdot \epsilon_i / \epsilon$$

$$\epsilon_i = p_i/(1-\eta) - p_{i-1} \cdot \eta/(1-2\eta)$$

$$p_i = N_i/N_t$$

$$\eta = 2 \cdot \frac{1}{t_1 - t_0} \sum_{t_0}^{t_1} N_t$$

$$t_0 = 2\ \mu s$$
$$t_1 = 80\ \mu s$$

Errors

Probability p_i of i hits

- Measuring N_i in N_t trials
  $\rightarrow$ Binomial error

Probability η of noise hits

- Noise proba. is small
  $\rightarrow$ Poisson error

Formulae

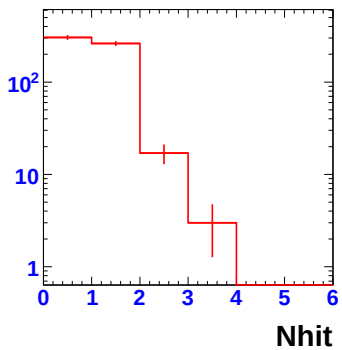
$$\sigma^2_{p_i} = \sigma^2_{N_i}/N_\mathrm{t} = N_\mathrm{t}(1-p_i)p_i/N_\mathrm{t}$$

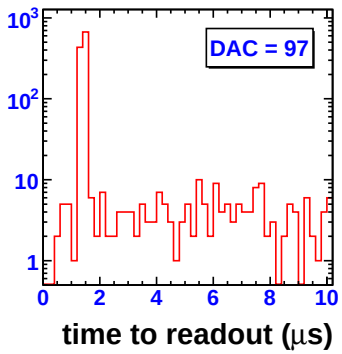
$$\sigma^2_\eta = \sqrt{\eta}$$

$$\sigma^2_{\epsilon_i} = ...(cf.tech.note)$$

$$\sigma^2_\epsilon = \left(\frac{1}{1-\eta}\right)^2 \sigma^2_{p_0} + \left(\frac{p_0}{(1-\eta)^2}\right)^2 \sigma^2_\eta$$

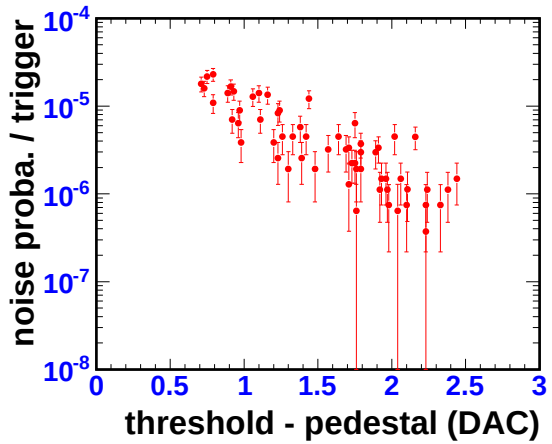
$$\sigma^2_m = \left(m\frac{\sigma_\epsilon}{\epsilon}\right)^2 + \frac{k^2}{\epsilon}\sum_{i=1}^{9}\sigma^2_{\epsilon_\mathrm{i}}$$



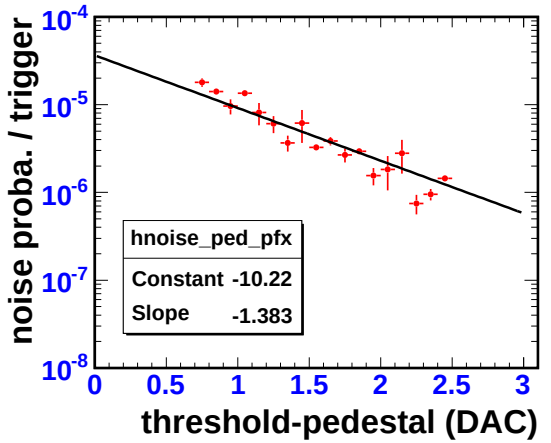


Noise probability

Proba. per channel



Profile along x-axis

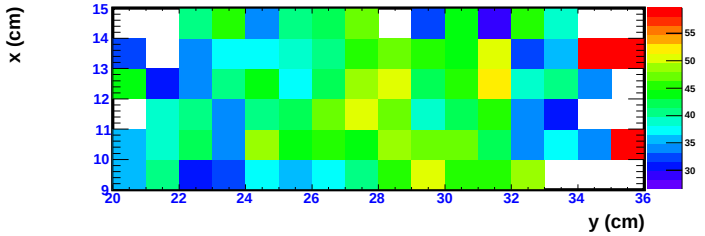


- With global threshold just above pedestals $\eta \sim 10^{-5}$ for single channels
- In 3×3 pad regions $\eta \sim 10^{-4}$, compared to $\epsilon \sim 10^{-1}$ $\rightarrow$ negligible contribution

Efficiency and multiplicity - 420 V (I)

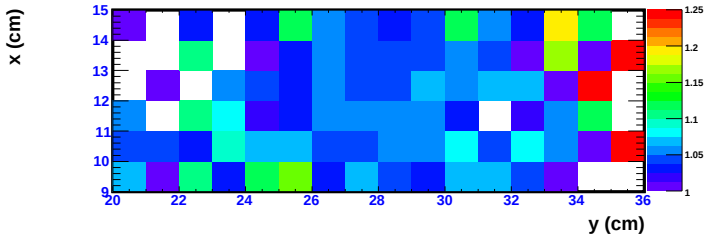
Run @ 420 V

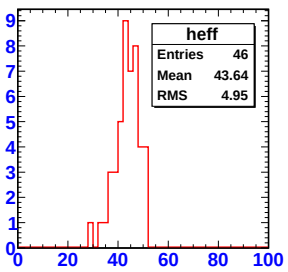
- High gas gain (10^4)
- Low (thr): ΔDAC $\sim$ 1–2

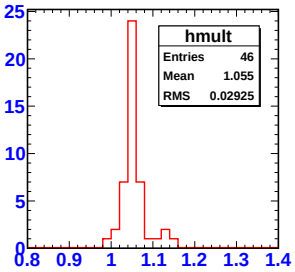


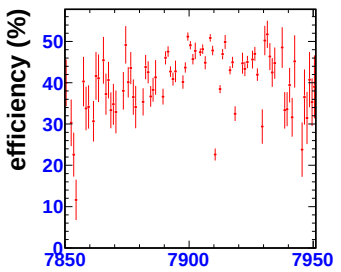
Best performance

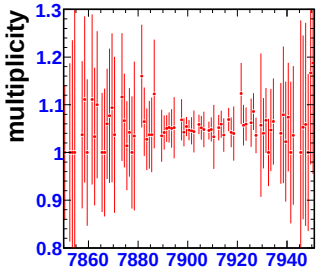
ϵ (%)	σ_ϵ (%)	m	σ_m
43.8	5	1.06	0.03











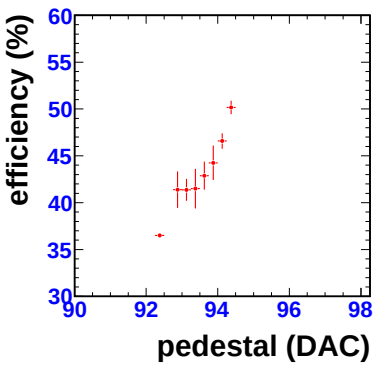
Trend with threshold - 420 V (II)

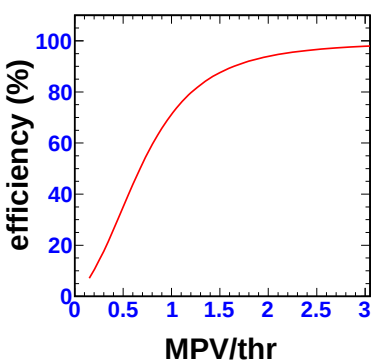
At DAC = 95

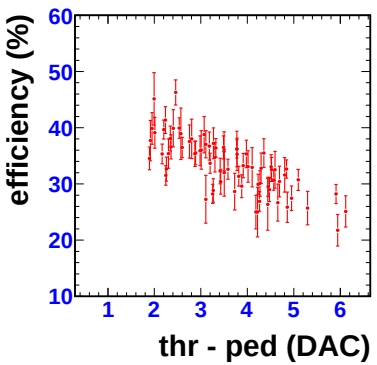
- 80 k triggers
- Gassiplex-like trend
  $\rightarrow$ $MPV/thr \sim 0.6$
- With MPV of 3 fC
  $\rightarrow$ effective *thr* $\sim$ 5 fC

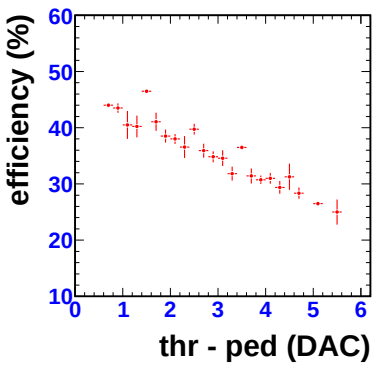
At DAC = 95,96,97,98

- 20 k triggers / DAC
- Different chip *thr*
  $\rightarrow$ difference *thr-ped*
- 25 % eff. drop
  $\rightarrow$ 5 fC *thr* variation









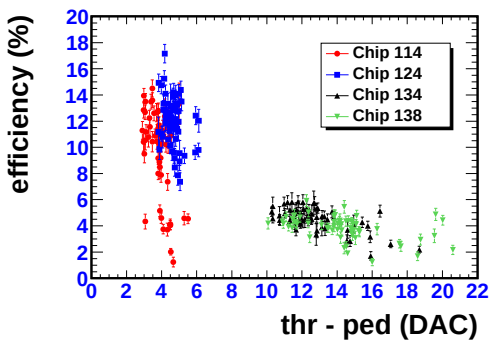
Efficiency and multiplicity - 410 V (I)

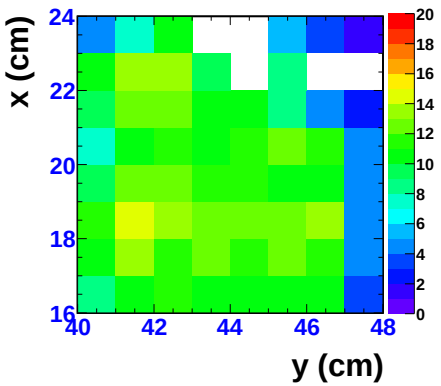
Trend with threshold

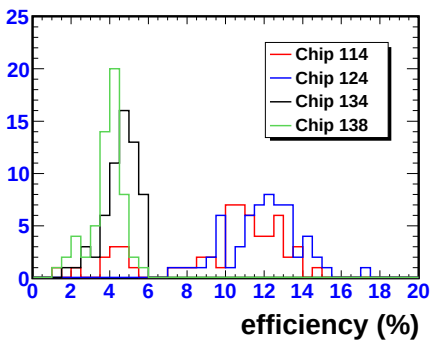
- Gassiplex compatible
- Chip 114
  - A few points off
  - On ASU edge
  - Noisy channels

Performance

chip	thr_{DAC}	ϵ	σ_ϵ	m
114	4	11.2	1.7	1.07
124	5	11.9	1.9	1.06
134	12	4.5	0.9	1.09
138	12	3.8	0.9	1.08







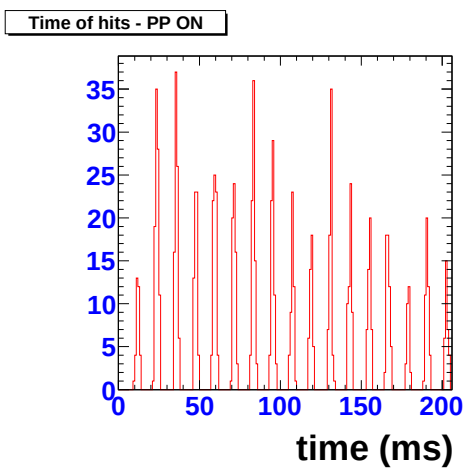
Effect of power-pulsing (I)

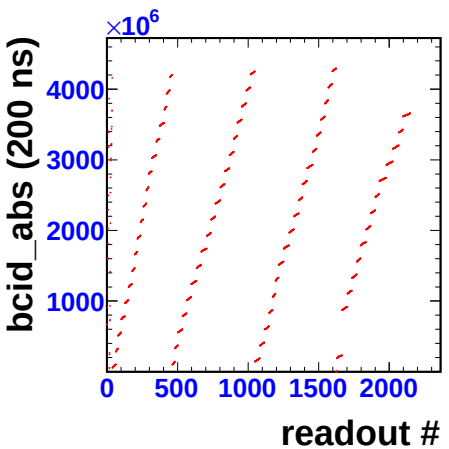
Conditions

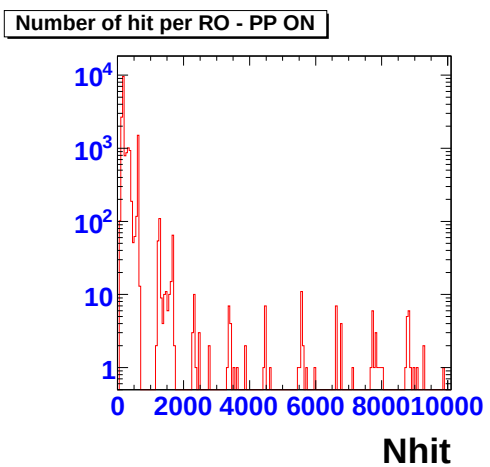
- Pulse analog part all chips
  - 10/2 ms OFF/ON
  - about 7.5 A (all ASU)
  - VETO trigger when OFF
- Chip 124, 410 V

Observations

- Peaks in hit time
- Counter $\text{BCID}_{ABS`q}$ reseted!
- Burst of hits when switch on Power stable after 15 μs







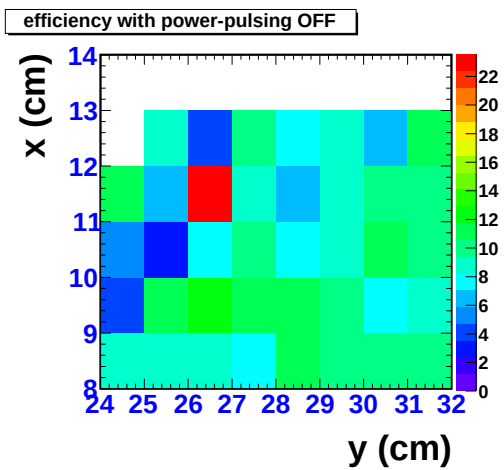
Effect of power-pulsing (II)

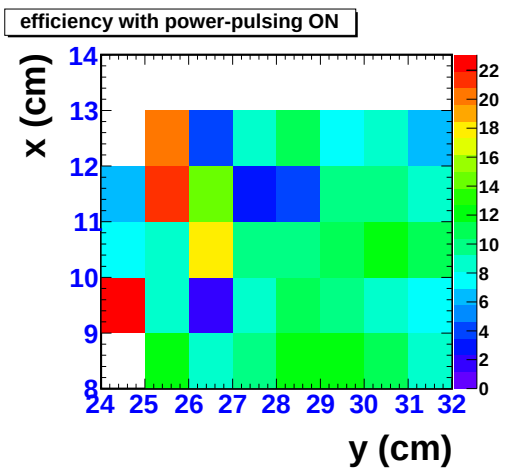
Conditions

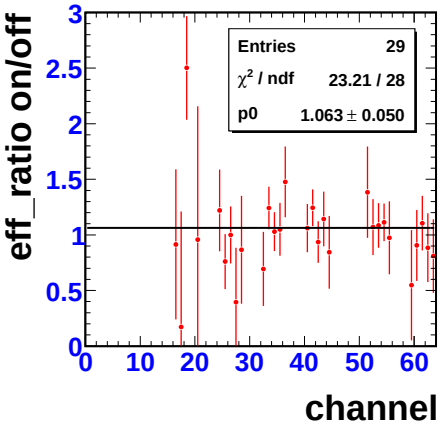
- Pulse analog part all chips
  - 10/2 ms OFF/ON
  - about 7.5 A (all ASU)
  - VETO trigger when OFF
- Chip 124, 410 V

Efficiency

- Cutting on $\sigma_\epsilon \leq 5$ %
  - OFF: (8.7 ± 0.4) %
  - ON: (9.3 ± 0.6) %
  - Channel-to-channel ratio: ON/OFF: (1.06 ± 0.5) %
  - $\rightarrow$ no significant effect







Preliminary conclusions

Efficiency

- Decent performance achieved despite HR2 short shaping
  - Maximum efficiency of 40–45 %

Power pulsing

- Prototype operates in power-pulsing with 2/10 ms ON/OFF
  - Data suggest no effect on efficiency

Others

- Significant progress in hardware and off-line tools
  - Telescope, calculation mehod, analysis framework...
  - Useful for 2011 TB