# *Aerogel light yield studies with the test beam data from 2002 and 2003*

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# Outline

- ✔ Data Samples
- ✔ Data Selection
- ✔ Light Yield evaluation
  - ▶ ring acceptance
  - ▶ photoelectron spectrum
  - ▶ ring photon yield estimator
  - ▶ uncertainties
- ✔ Light Yield momentum dependence
- ✔ Refractive index evaluation
- ✔ Conclusions

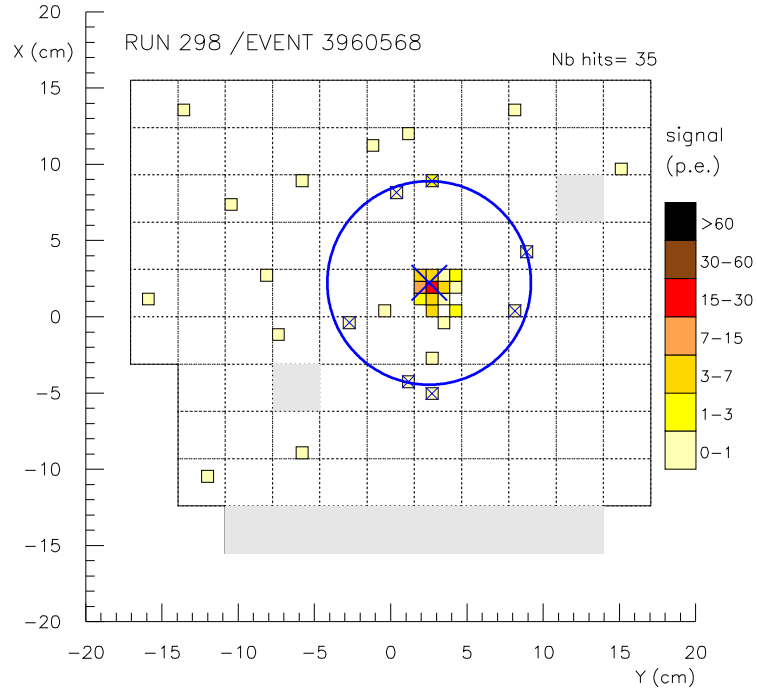
# *Light yield : data samples*

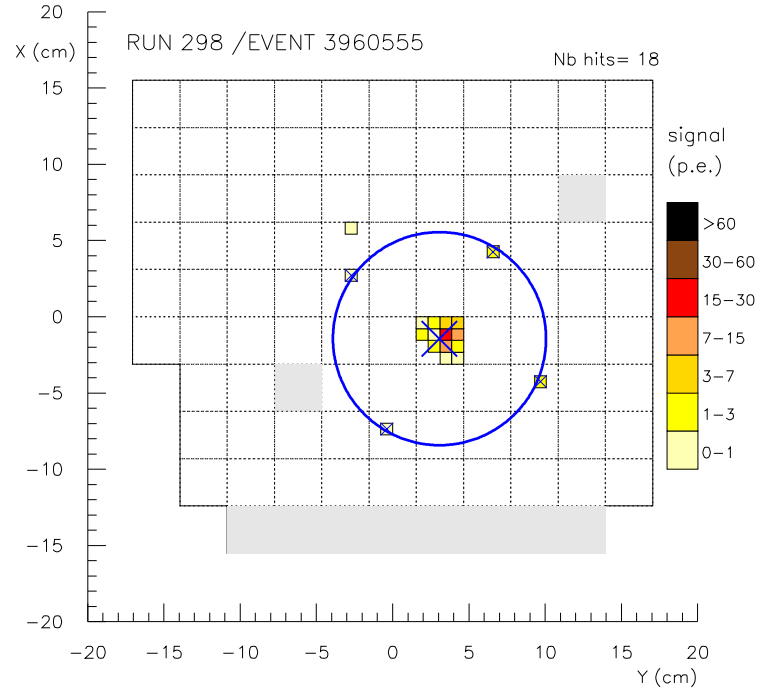
| Manufacturer | n | h (mm) | 2002 runs | 2003 runs |
|---|---|---|---|---|
| MECy01.103 | 1.03 | 3×11 | ✔ (5,7,9,13)* | |
| MECy02.103 | 1.03 | 2×11 | ✔ (5,7,9,11,13) | ✔ (158) |
| MECy02.105 | 1.05 | 2×11 | ✔ (7,9,13) | |
| CINy02.103 | 1.03 | 30 | ✔ (5,9,13) | |
| CINy02.104 | 1.04 | 30 | ✔ (5,7,9,13) | |
| MECy03.103 | 1.03 | 3×11 | | ✔ (158) |
| CINy03.105 | 1.05 | 25 | | ✔ (158) |

(*) values in GeV/c/nucleon

# Light yield : data selection

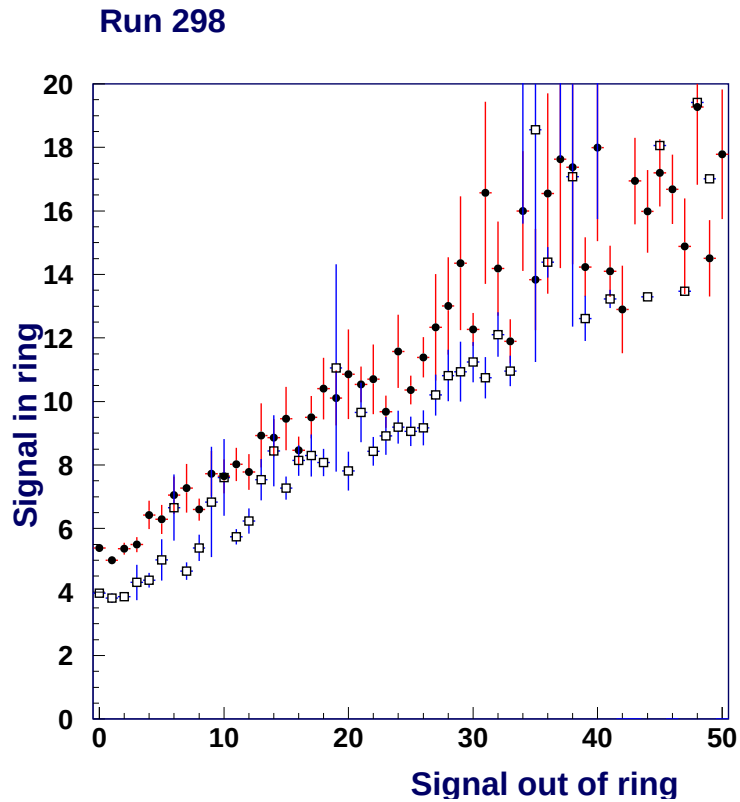
- ✔ Noisy events specially at low energy
- ✔ muon contamination ($\beta$=1)

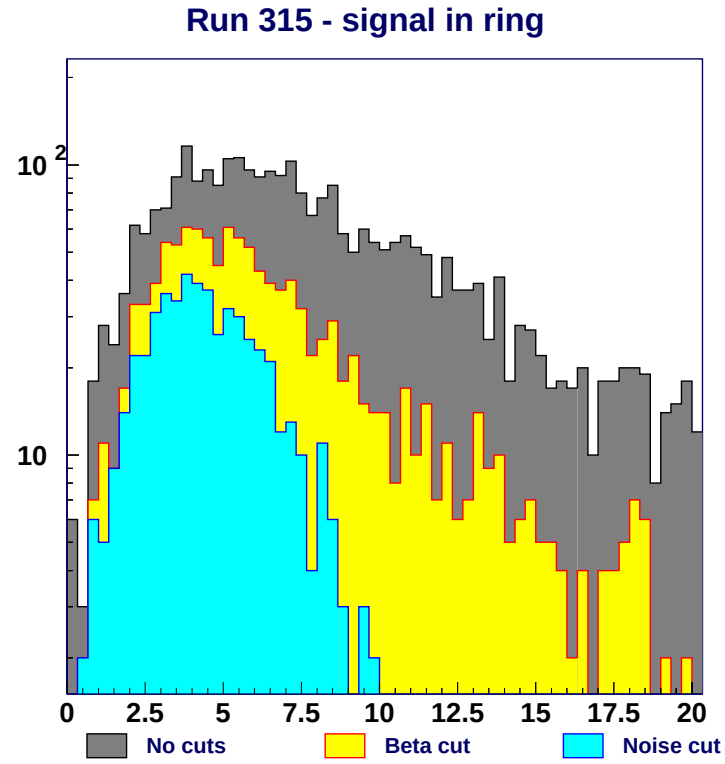


# Light yield : data selection criteria

- ✔ Signal out of the ring < 10
- ✔ $\beta = 1$



# Light yield : npe evaluation

- ✔ Mean photoelectron light yield for $\beta$=1 and full acceptance rings evaluated through a fit to the ring signal $(\mu_0)$
- ✔ It takes into account :
  - statistical fluctuation $(p_n)$
  - event ring acceptance (ring width included) $(p_i)$
  - photomultiplier gain $g(x; n, \sigma_{p.e})$

$$f(x) = \sum_i p_i \sum_{n \geq 3} \frac{e^{-\mu_i}\ \mu_i^n}{n!}\ g(x; n, \sigma_{p.e})$$

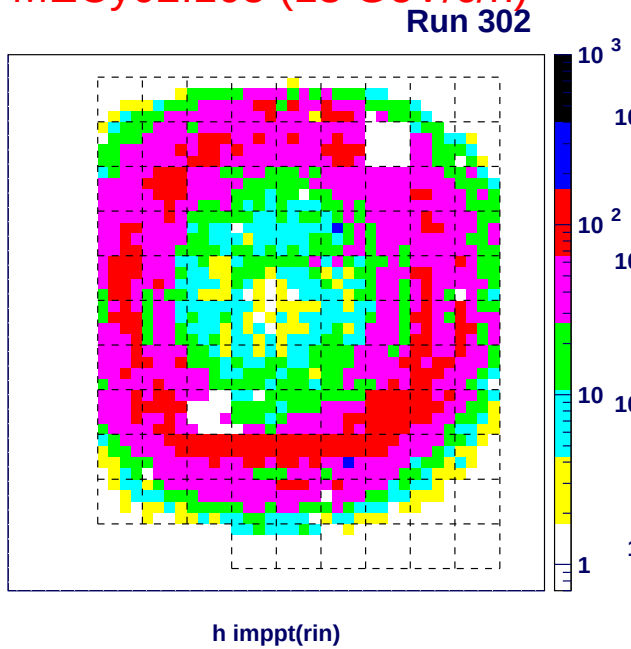
with $\mu_i = \mu_0\ p_i$

# Light yield : ring acceptance

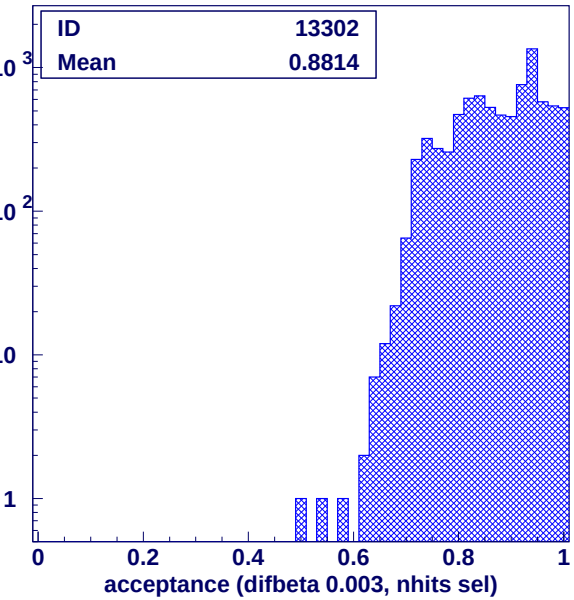
Ring acceptance evaluated for the event sample to take into account :

- ✔ dead photomultipliers
- ✔ prototype border effects in rings

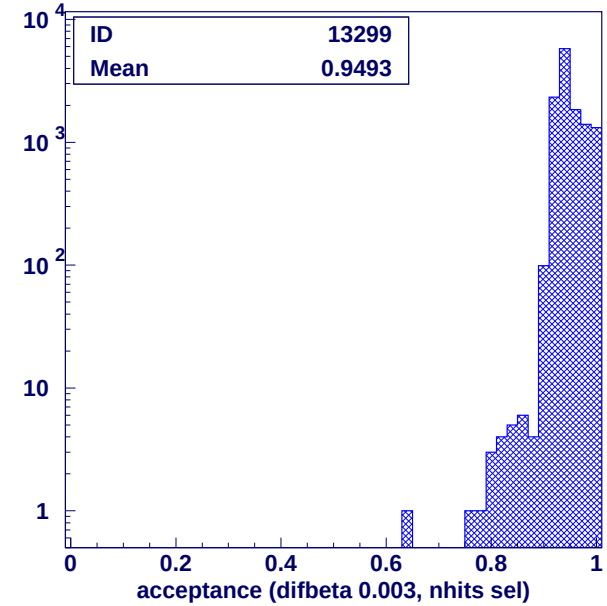
MECy02.105 (13 GeV/c/n)




MECy02.105 (13 GeV/c/n)




MECy02.103 (13 GeV/c/n)

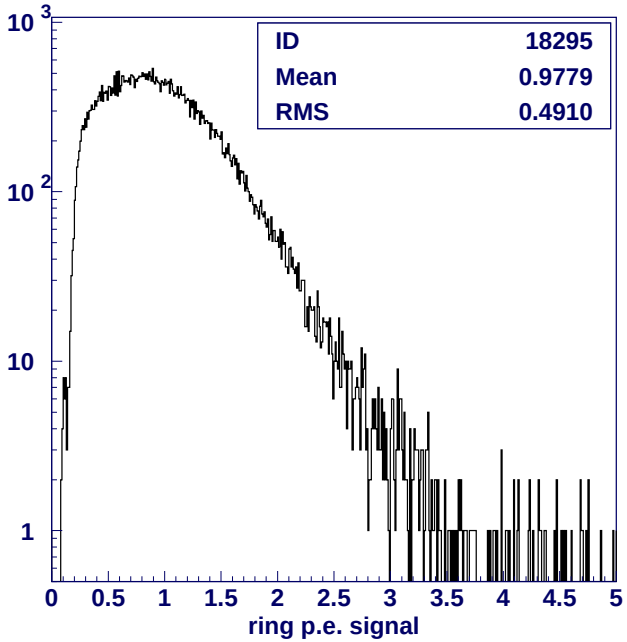


# *Light yield : photoelectron spectrum*

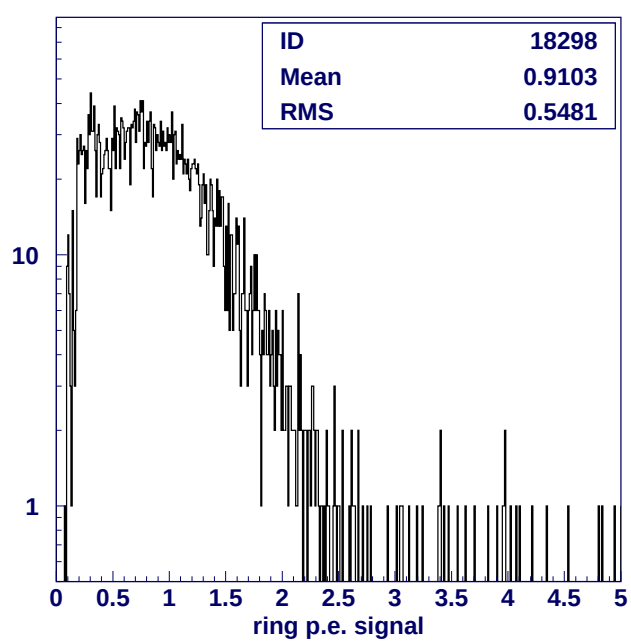
The mean photoelectron spectrum (over the cerenkov ring) at different energies.

- ✔ average gain shifted
- ✔ low energy spectra *noisy*

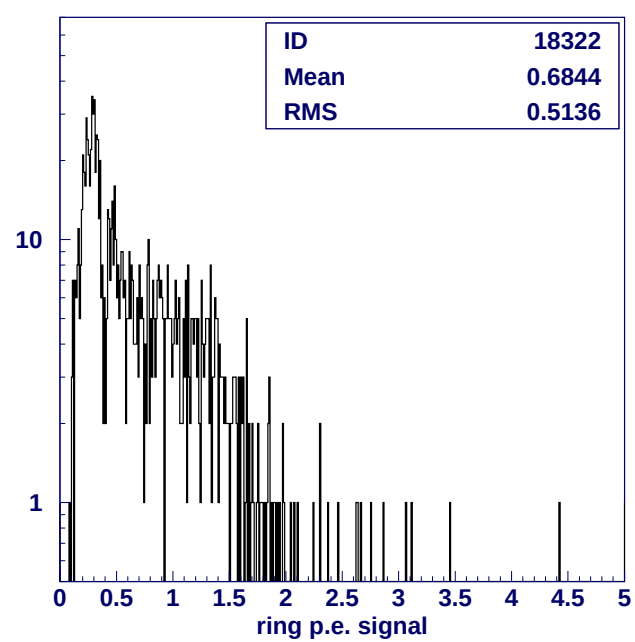
MECy02.103 (11 GeV/c/n)




MECy02.103 (5 GeV/c/n)



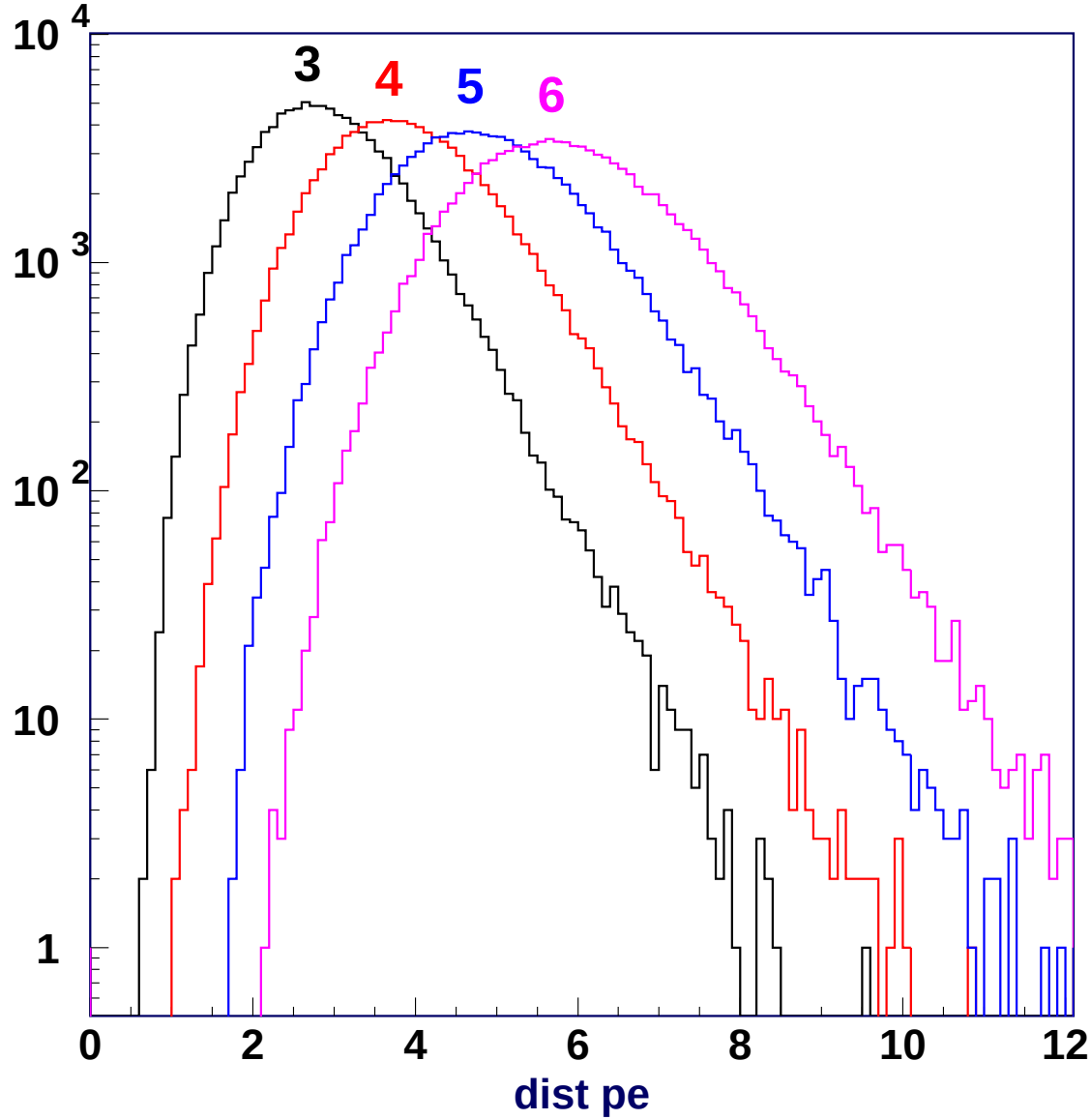

CINy02.104 (5 GeV/c/n)



# *Light yield : pmt response*

Photomultiplier response simulated

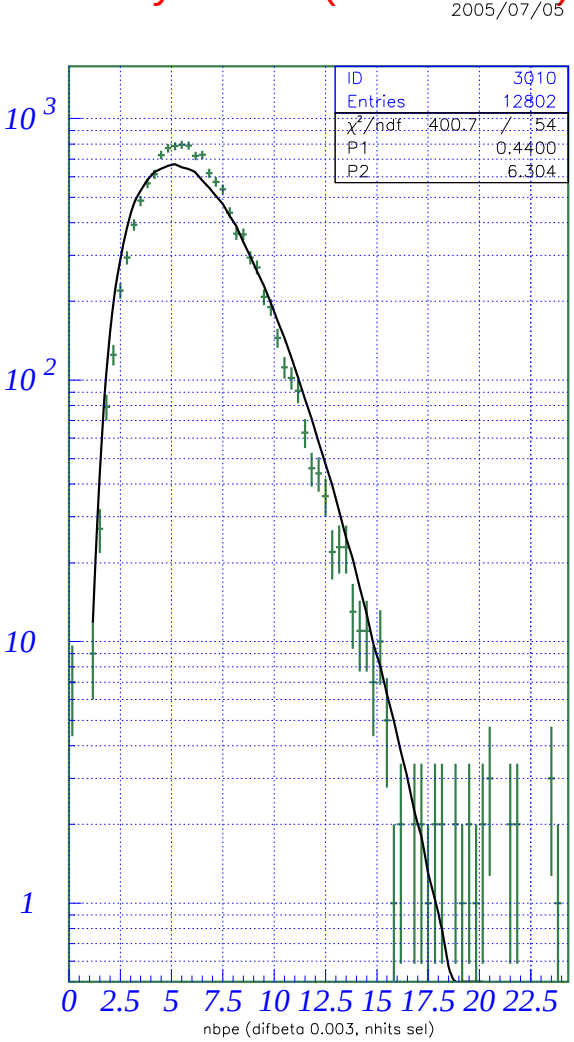
- ✔ used photoelectron spectrum gathered at high momentum (13 GeV/c)
- ✔ $n_{p.e}$ curves obtained from p.e sampling



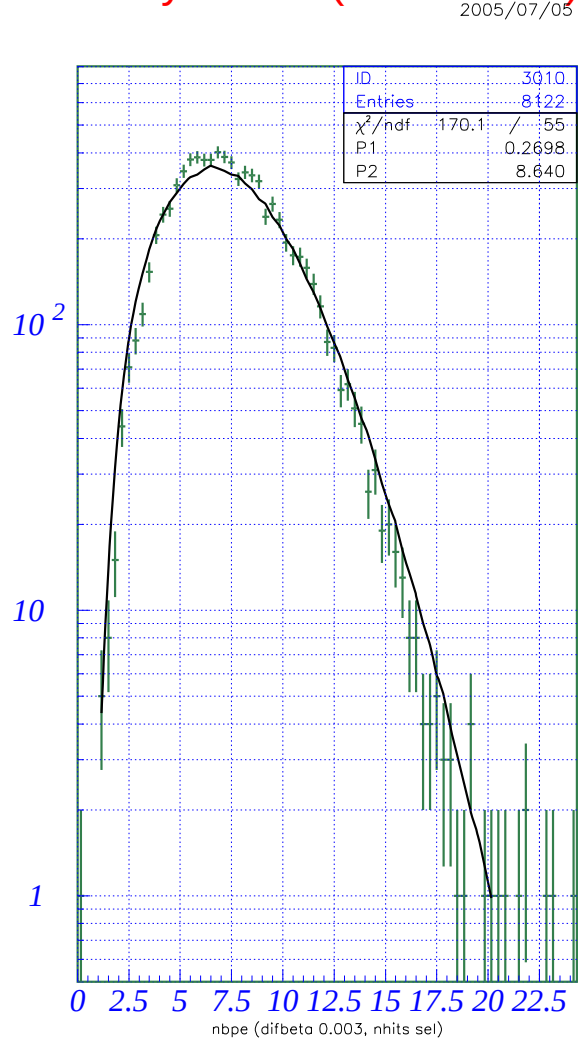
# Light yield : npe estimator

A ring signal fit is done to extract the mean number of photoelectrons

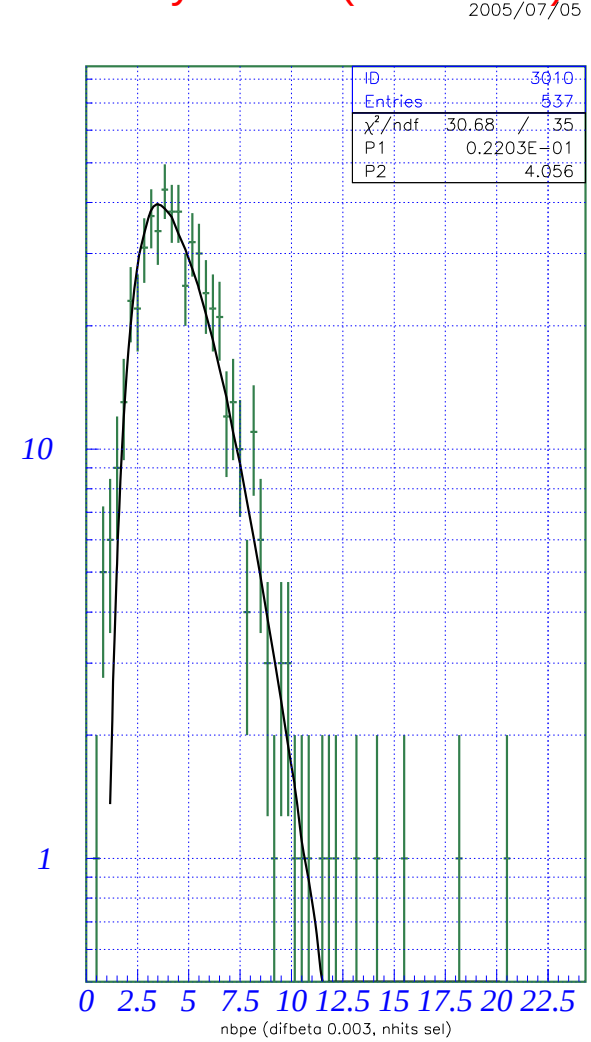
MECy02.103 (13 GeV/c/n)




MECy02.105 (13 GeV/c/n)




CINy02.103 (5 GeV/c/n)

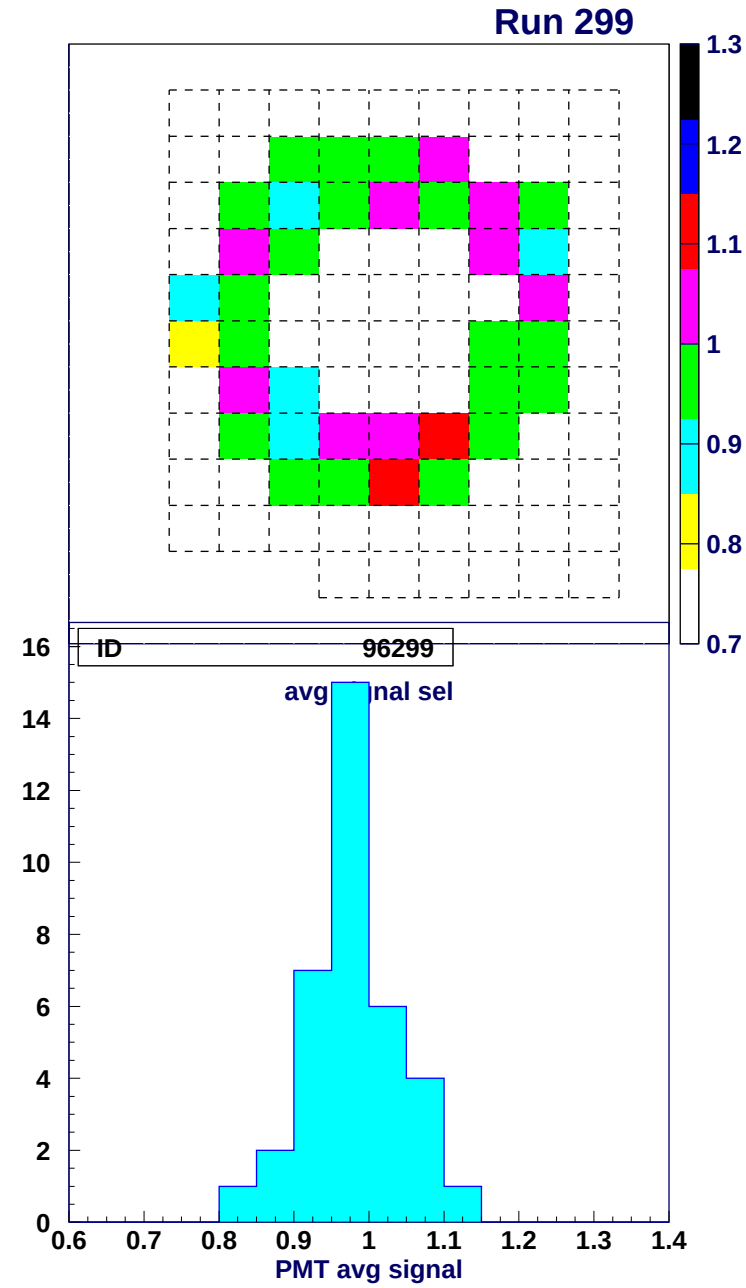


# Light yield : npe uncertainties

Uncertainties on the mean number of photoelectrons :

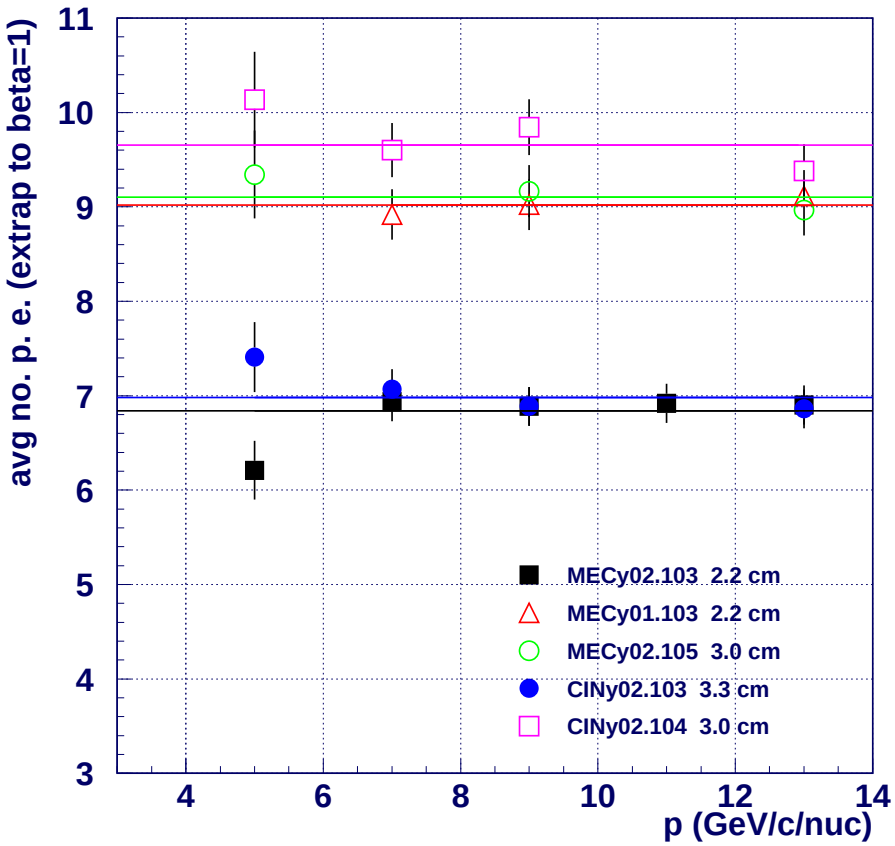
- ✔ data analysis (cuts, fit)
- ✔ acceptances
- ✔ pmt gain variations (lower than 13 GeV/c energies)

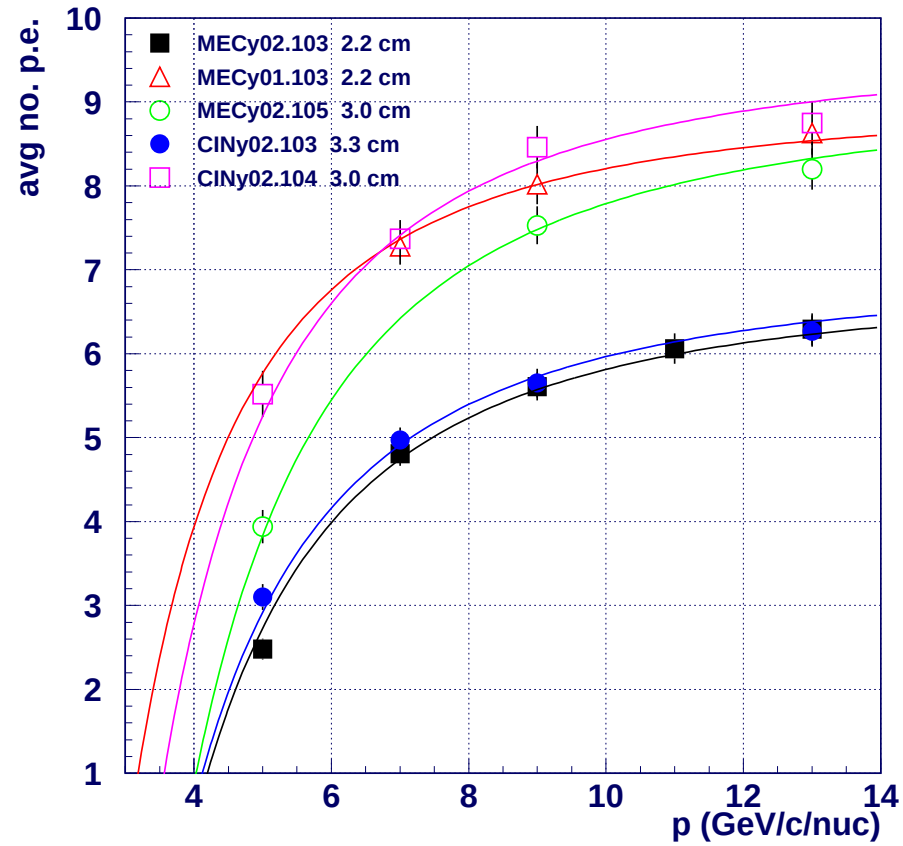
| source | error | |
|---|---|---|
| | 5 GeV/c | $>$ 5 GeV/c |
| analysis | $\sim$4% | $\sim$2% |
| acceptance | $\sim$ 1% | |
| pmt <G> | $\sim$ 1.5% | |



# Light yield : momentum dependence

$$n_{p.e} \propto sin^2\theta_c \, \ell \, Z^2 = n_0 \left[ 1 - \frac{\left(\frac{m}{p}\right)^2}{n^2 - 1} \right]$$

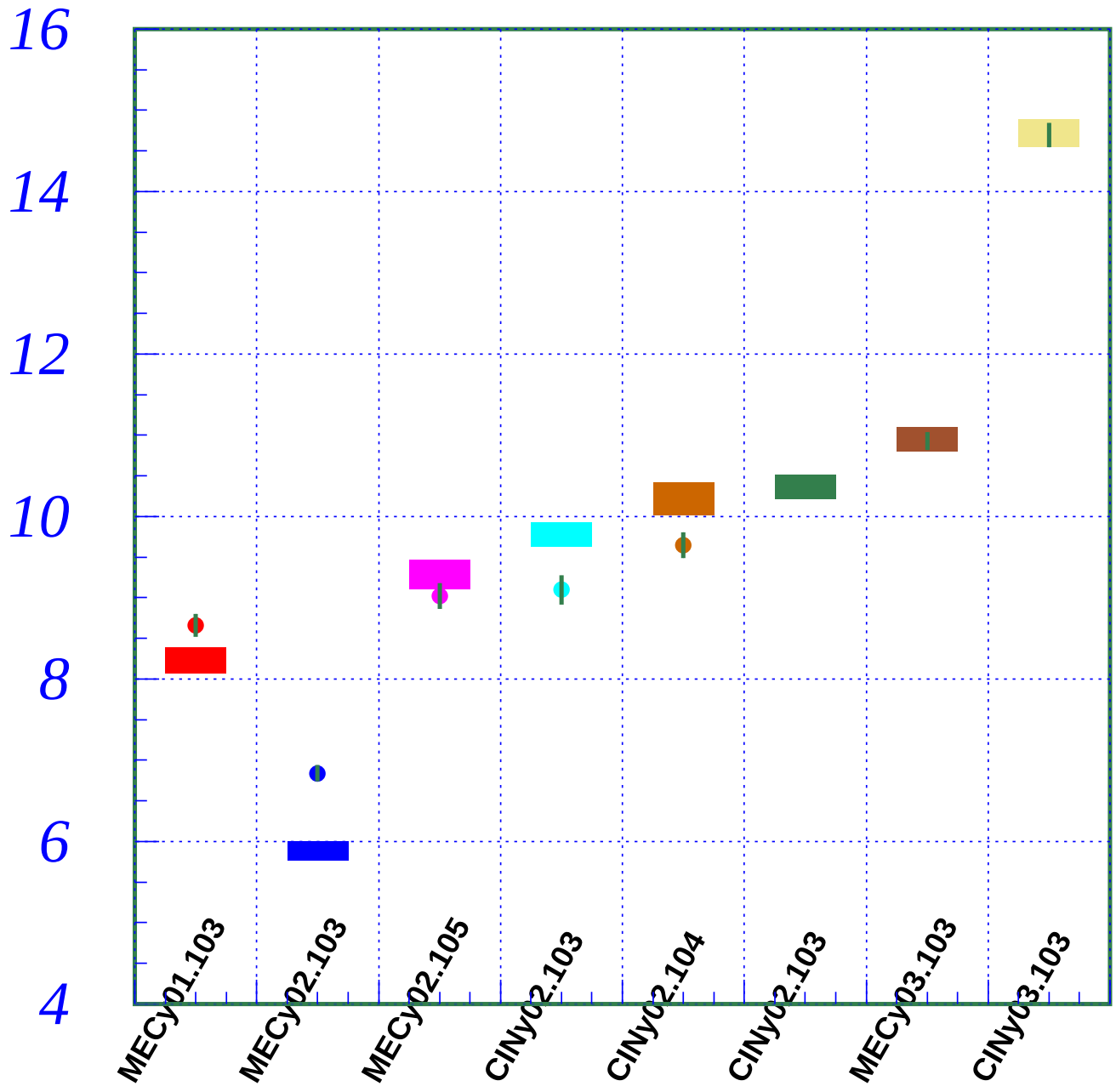


# Light yield : npe values ($\beta$=1 and full accept)

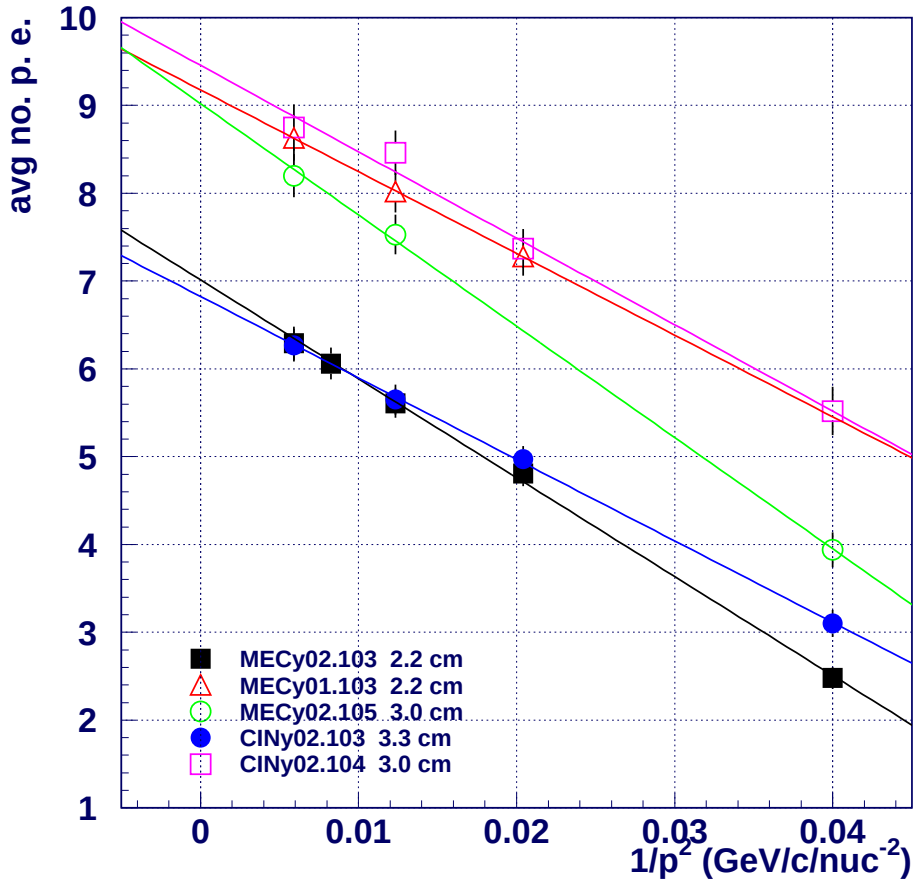
| Manufacturer | n | h (mm) | 2002 | | 2003 | |
|---|---|---|---|---|---|---|
| | | | LIP | CIEMAT | LIP | CIEMAT |
| MECy01.103 | 1.03 | 3×11 | 8.66 ± 0.14 | 8.23 ± 0.16 | | |
| MECy02.103 | 1.03 | 2×11 | 6.84 ± 0.10 | 5.88 ± 0.12 | | |
| MECy02.105 | 1.05 | 2×11 | 9.02 ± 0.16 | 9.29 ± 0.18 | | |
| CINy02.103 | 1.03 | 30 | 9.10 ± 0.18 | 9.78 ± 0.15 | 10.39±0.10 | 10.37 ± 0.15 |
| CINy02.104 | 1.04 | 30 | 9.65 ± 0.16 | 10.22 ± 0.20 | | |
| MECy03.103 | 1.03 | 3×11 | | | 10.93 ± 0.11 | 10.95 ± 0.15 |
| CINy03.105 | 1.05 | 25 | | | 14.70 ± 0.15 | 14.72 ± 0.17 |

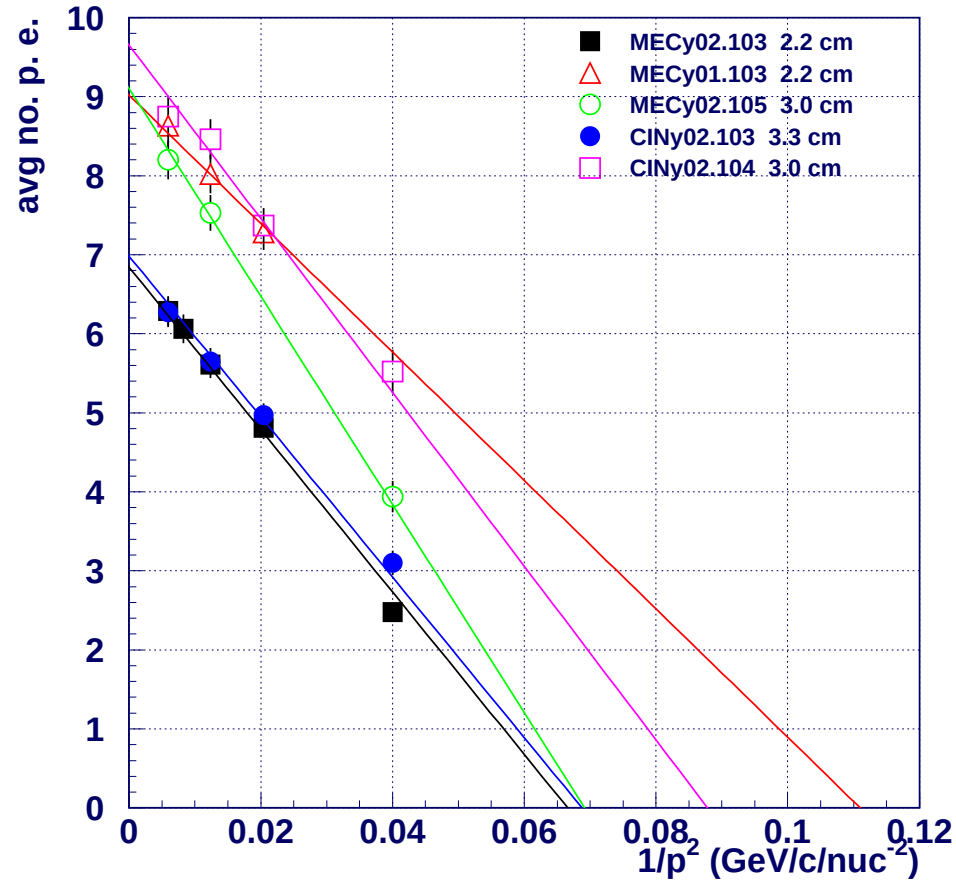
# Light yield : npe values ($\beta$=1 and full accept)



# Light yield : refractive index

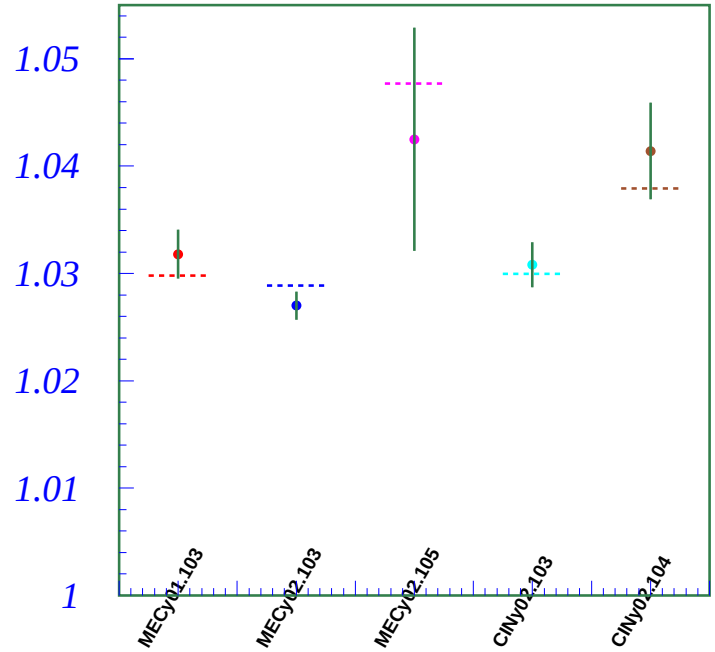
Refractive index can be derived from a fit to the data points



# Light yield : refractive index

| Manufacturer | $n_{agl}$ | fi t results | |
|---|---|---|---|
| | | $n_{fit}$ | $n_0$ |
| MECy01.103 | 1.02981 | $1.0318 \pm 0.0023$ | $8.47 \pm 0.20$ |
| MECy02.103 | 1.02888 | $1.0270 \pm 0.0013$ | $7.01 \pm 0.13$ |
| MECy02.105 | 1.0477 | $1.0425 \pm 0.0104$ | $9.18 \pm 0.35$ |
| CINy02.103 | 1.02998 | $1.0308 \pm 0.0021$ | $9.02 \pm 0.22$ |
| CINy02.104 | 1.03792 | $1.0414 \pm 0.0045$ | $9.46 \pm 0.24$ |



# Light yield : conclusions

- ✔ Test beam data from 2002 and 2003 has been analysed
- ✔ An independent method for light yield evaluation was developed, including corrections for several error sources

  muon contamination, noisy events, border effects, dead photomultipliers
- ✔ Light yield follows expected momentum dependence
  - ▶ no visible effects, depending on the incident angle, up to $\sim$ 15 degrees (LG for instance)
- ✔ The comparison with the CIEMAT results on the light yield shows :
  - ▶ 2002 : some discrepancies
  - ▶ 2003 : excellent agreement
- ✔ Independent, rough estimate of the refraction index was obtained from the light yield data
  - ▶ Estimates agree with CIEMAT results