## ALFA Test Beam at DESY

# Light Yield & Uniformity of the ALFA Trigger Tiles

K.Hiller , DESY Zeuthen

DESY ATLAS meeting 25/2/2008

## The Crew

**CERN:** Ch.Joram, S.Franz, A.Mapelli

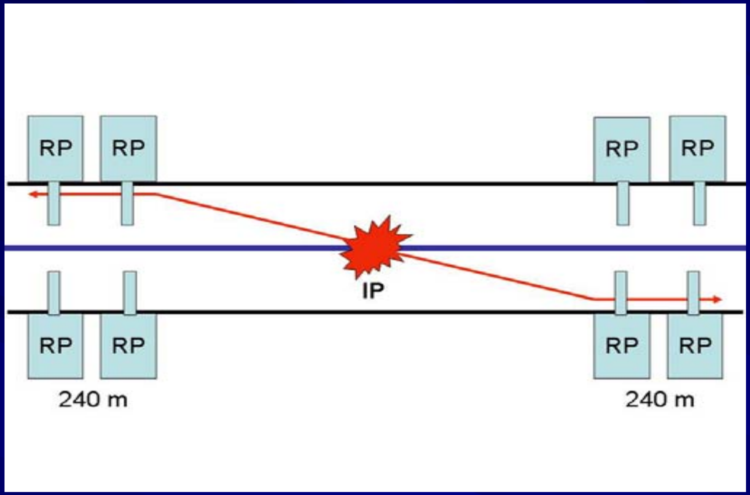
**DESY:** R.Ciesielski, I.Gregor, W.Hain, K.Hiller, U.Koetz, D.Petschull

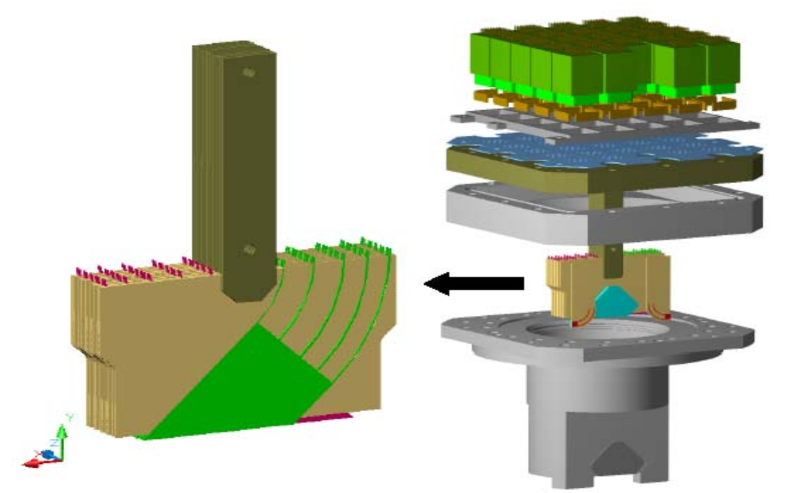
**Thanks to engineers & technicians:**

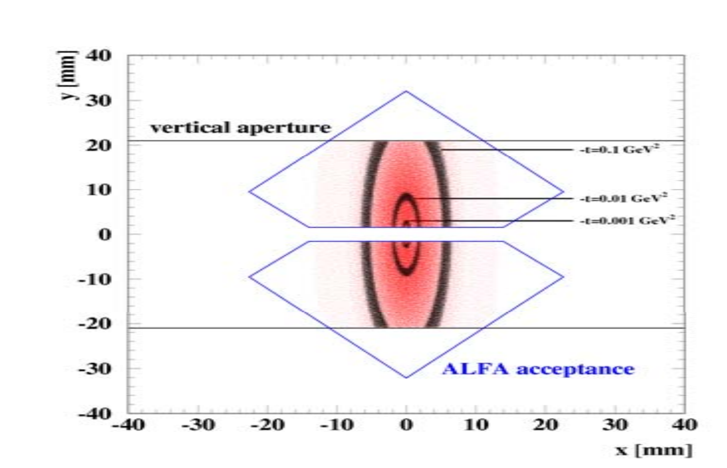
**A.Braem, A.Folley, P.Pohl**

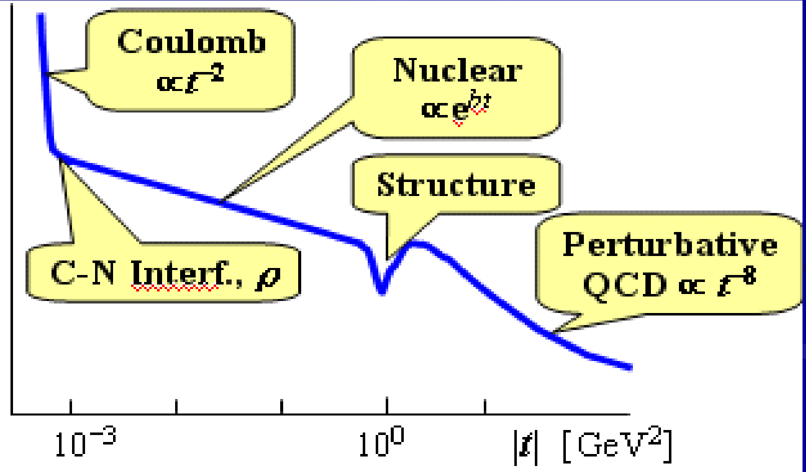
# ALFA in one Slide

**A**bsolute **L**uminosity **F**or **A**TLAS, to calibrate the LUCID detector



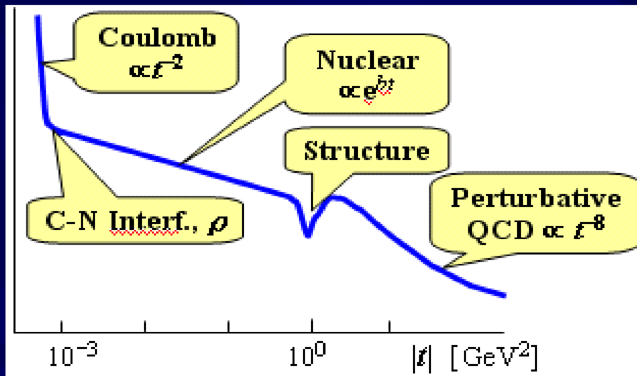





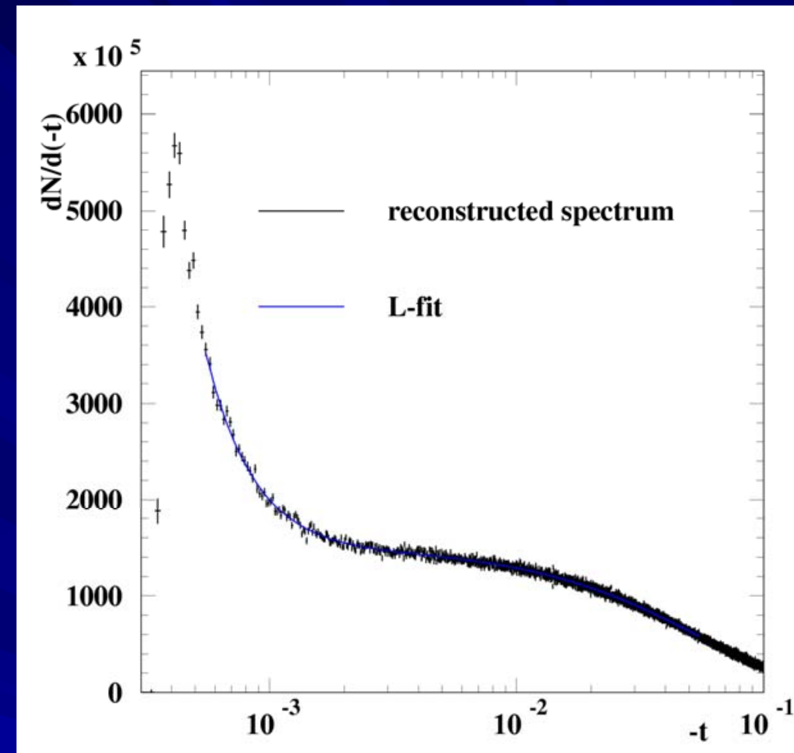




**move 1.5 mm to beam → measure interference region → $\sigma_{tot}$, b, ρ, L ± 3%**

# The Luminosity Fit




simulation
+
reconstruction




$$\frac{dN}{dt} = L\pi \left| F_C + F_N \right|^2$$

$$\approx L\pi \left| -\frac{2\alpha}{|t|} + \frac{\sigma_{tot}}{4\pi}(i+\rho)e^{-B|t|/2} \right|^2$$

**ρ = Re/Im $f_{le}$ (t=0)**
**B = exp. t-slope**
**$\sigma_{tot}$ = tot.cross section ± 1%**
**L = luminosity ± 2 %**

# Impact on the Trigger Efficiency

- fit needs well-normalized dN/dt, otherwise $\sigma_{tot}$ x L wrong
- contribution of trigger efficiency to total error should be negligible
- if trigger efficiency < 100%:

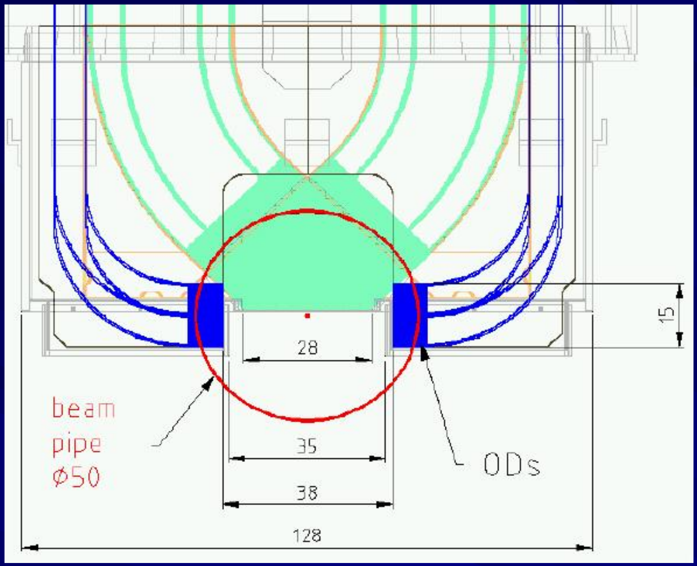
  1) differences of tile-lightGuide-PMT couplings require individual tile measurements
  2) aging effects require time-dependent monitoring

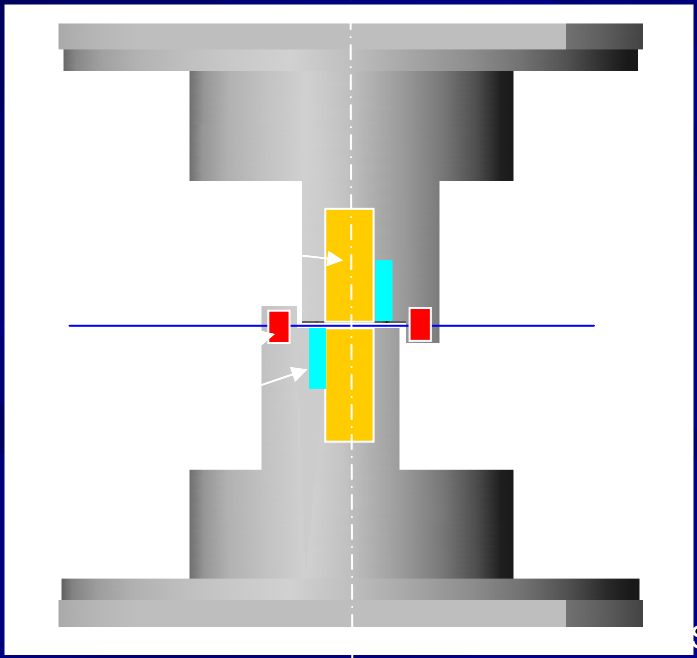
  → too much additional effort

- safe way to get ΔL ~ 3%: 100% trigger efficiency

**→ light yield across the tile size well above threshold**

# ALFA Trigger Tiles



**Main tiles:**
32 x 32 mm2, 3mm thick

To allow precise tile positioning
do not fully cover the edge by fibers
→ bundle thickness ~ 2 mm

Test bundle for main tiles 32 x 2 mm2

~ 250 fibers

**OD tiles:**
6 x 15 mm2, 3mm thick

Bundles 30° to vertical

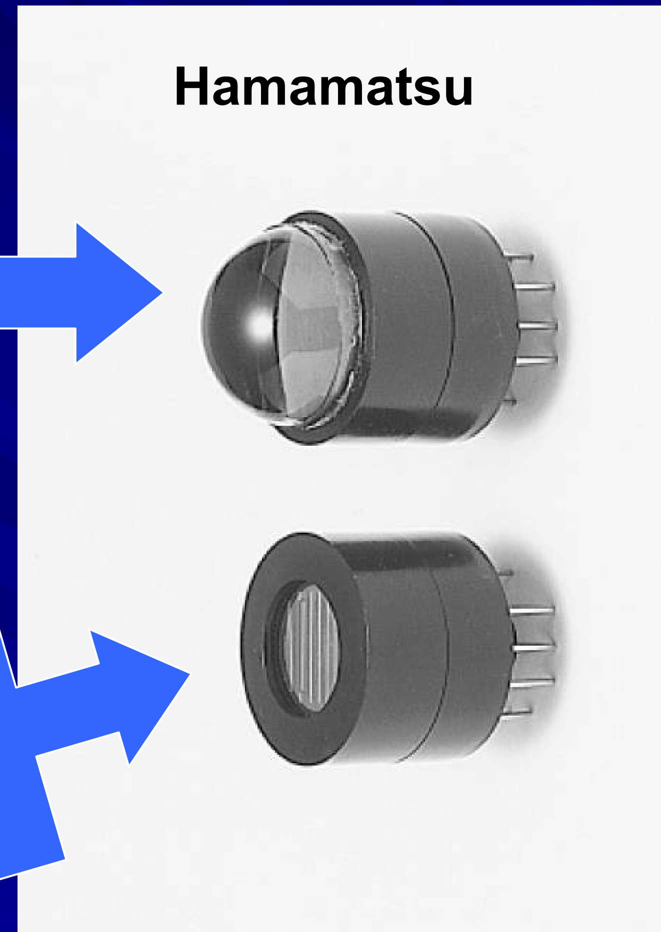
Made of 2 separate bundles
A: 5.2 x 2 mm2 → 38 fibers
B: 7.5 x 2 mm2 → 58 fiber

} 96 fibers
(45° → 112)

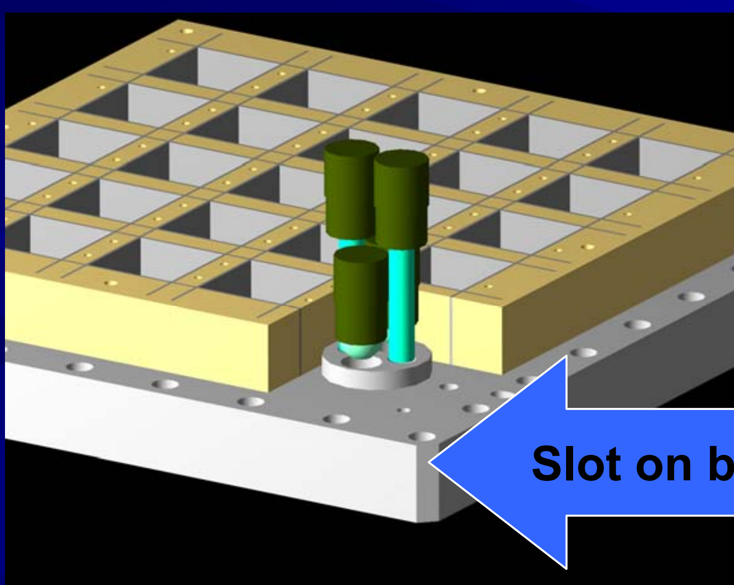
# General Readout Scheme

General R/O scheme from H1 FPS trigger tiles


Add 2 bundles
2 x 250 fibers




OD bundles
100 fibers

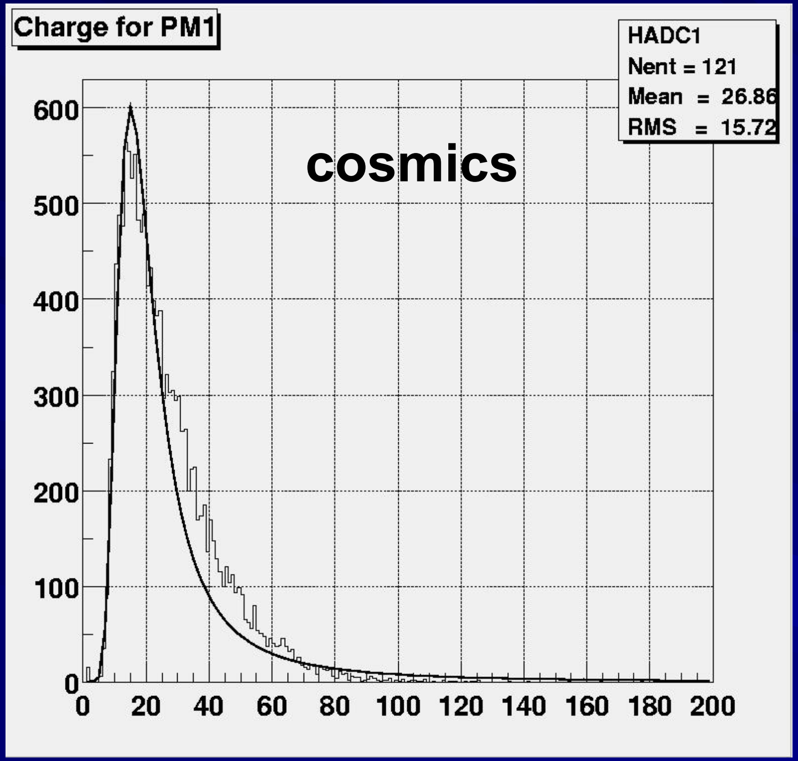


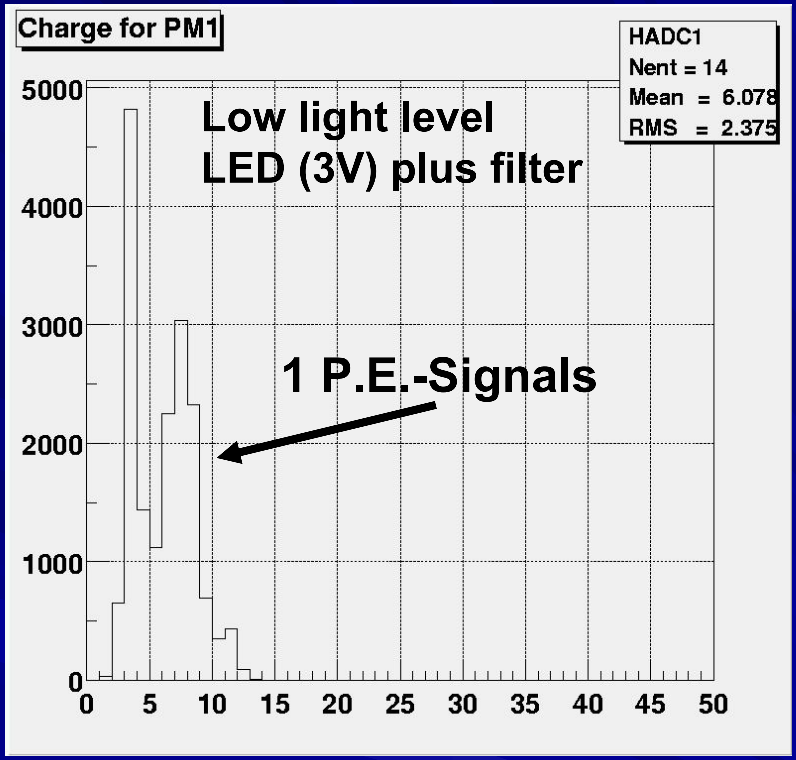
Slot on base plate

R7401 with lens D = 14mm
R7400 w/o lens D = 9mm

# H1 Trigger Tile Cosmic Data

Rough estimate of light yield of H1 trigger tiles (W.Hain, K.H.)

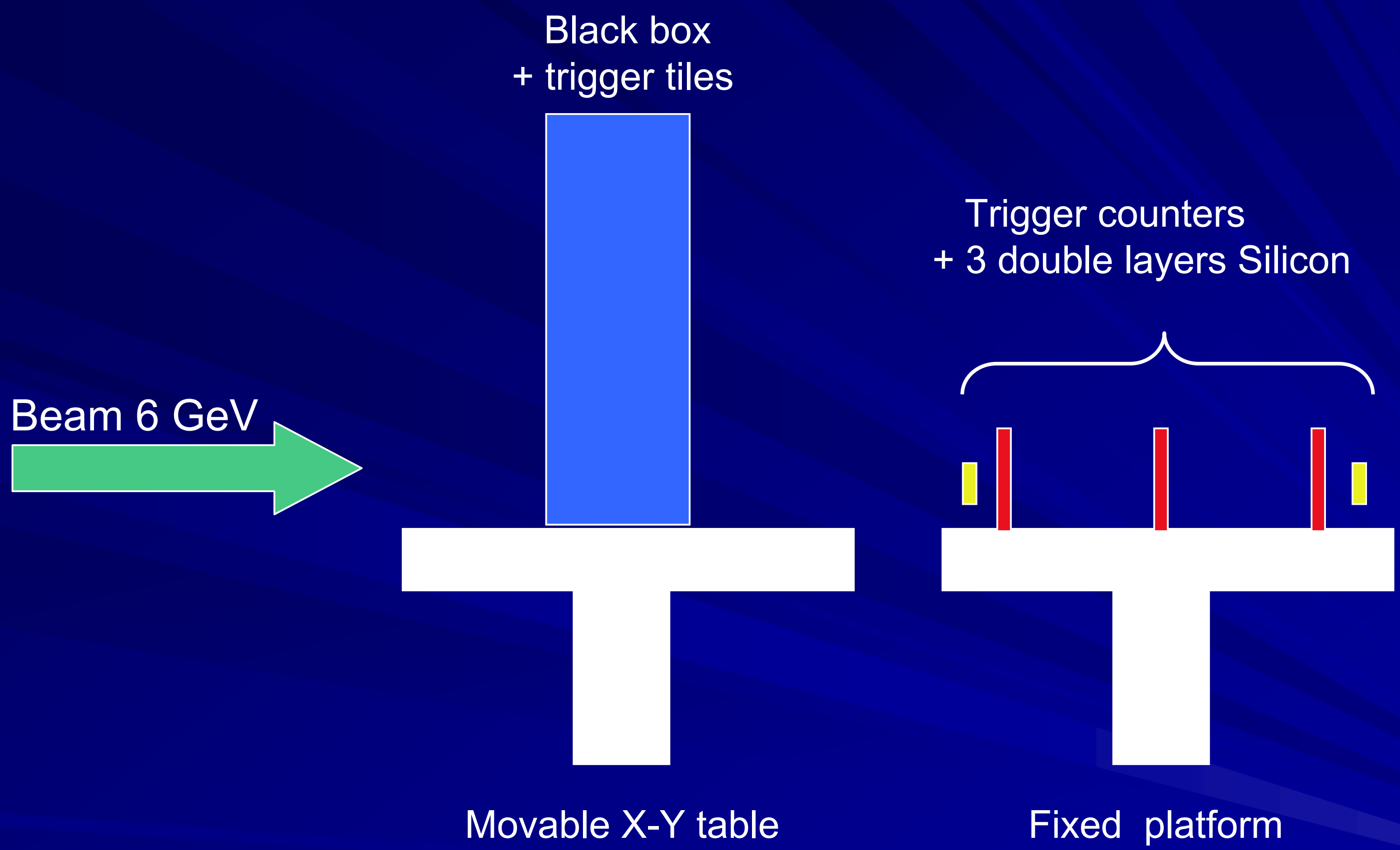


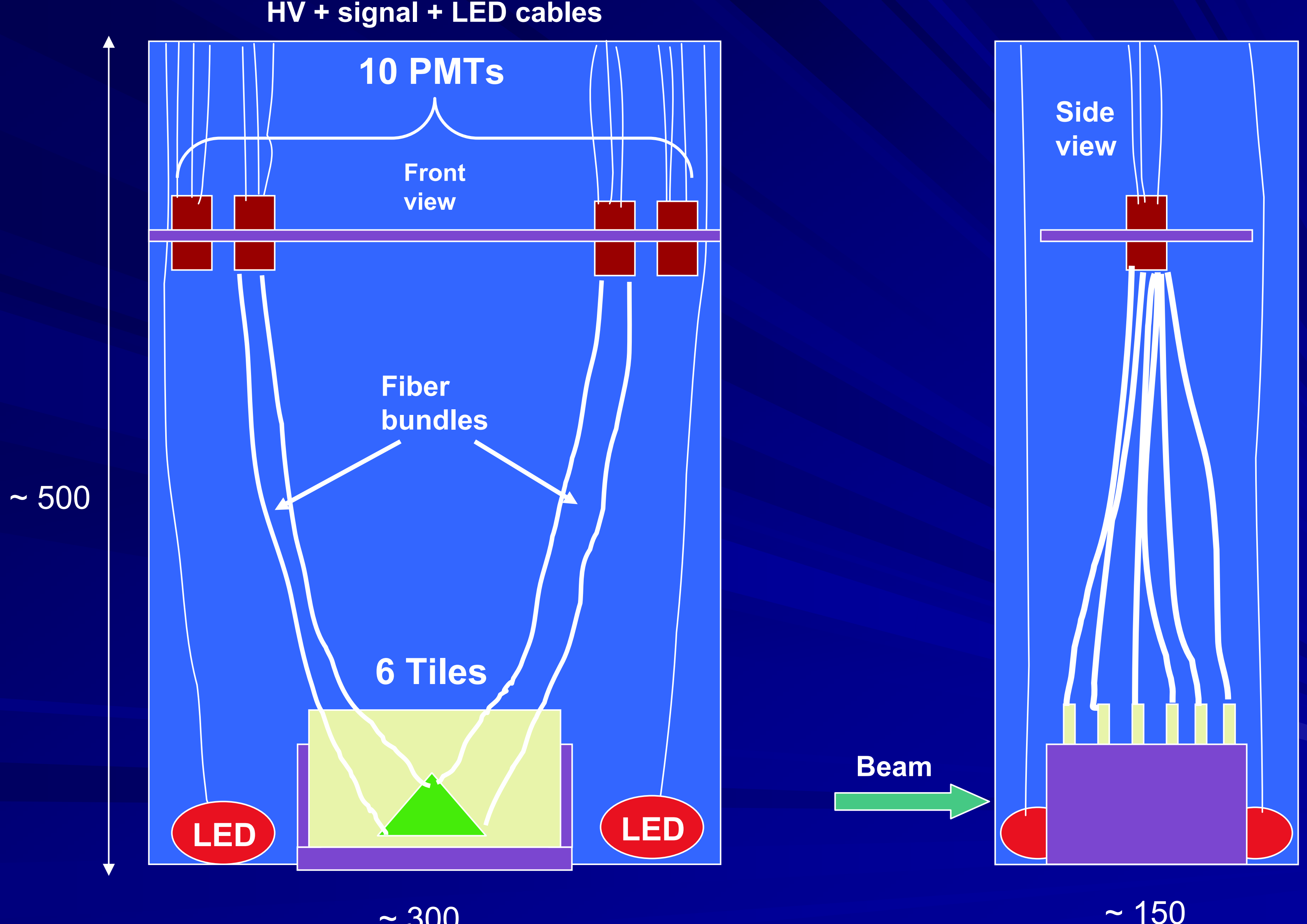

PMT0 : 5 ± 2/1 P.E. → we can expect for ALFA tiles > 10 P.E.

PMT1: 6 ± 2/1 P.E. → **sufficient for good uniformity ???**

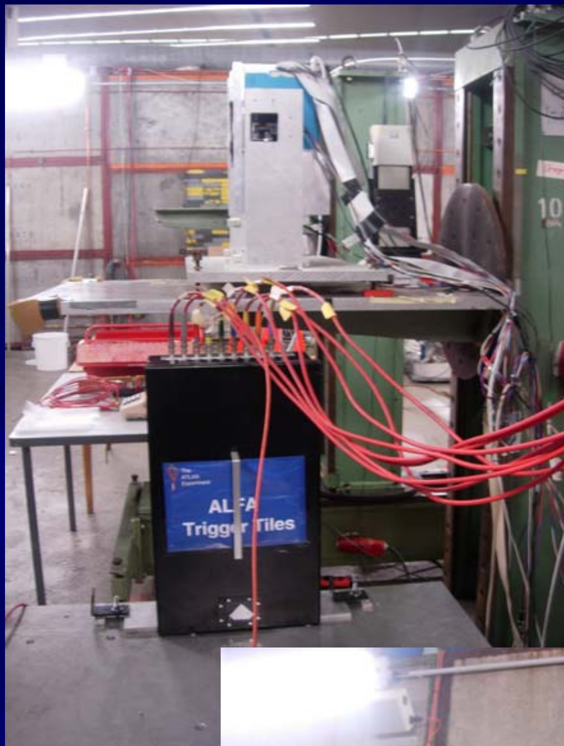
# Test Beam Set-up (1)



# Test Beam Set-up(2)

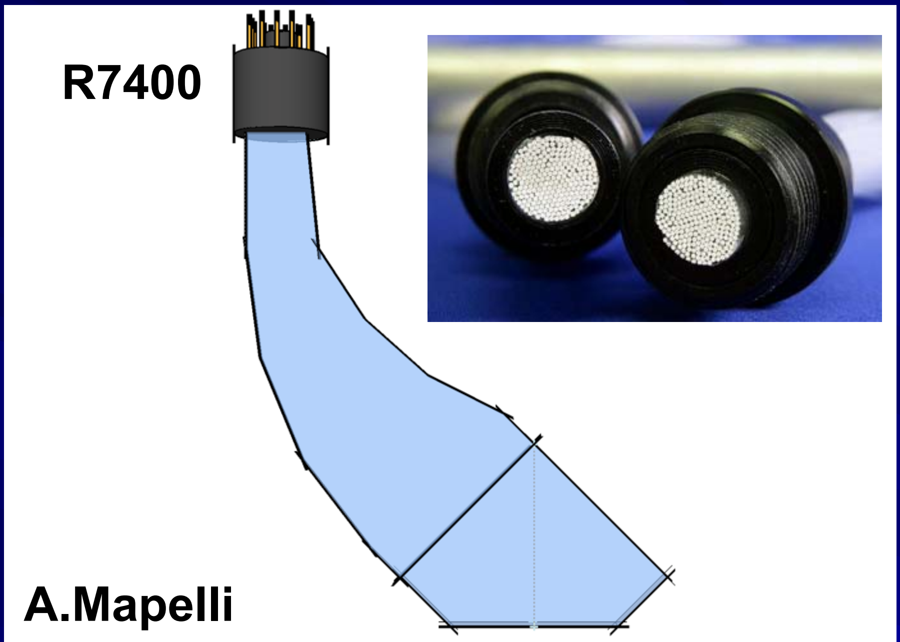


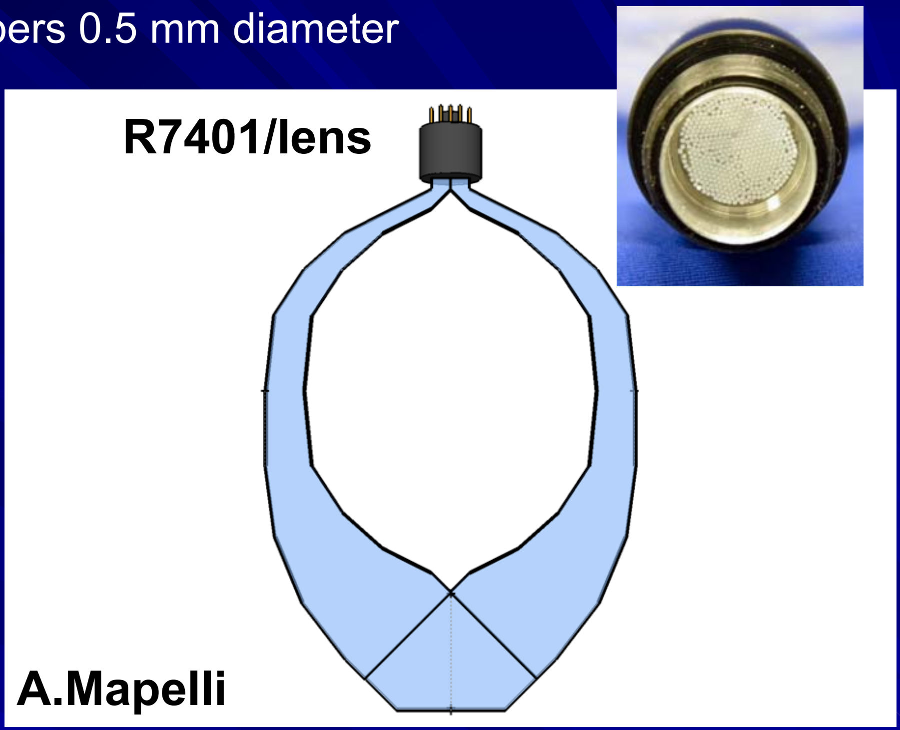
# Test Beam Set-up (3)



# Black Box Content (1)

2 bundle types: single/twin of 250/2x250 clear fibers 0.5 mm diameter




**Tile coatings:**
**1) bare tile**
**2) Aluminum edges**
**3) Aluminum full**
**4) white, reflective paint**

**5) scitill.fiber tile**

# Black Box Content (2)

| Tile# | Coating | Fiber Bundle |
|---|---|---|
| 1 | No | 2 single glued |
| 2 | Al - edges | 2 single glued |
| 3 | Al - full | 1 twin glued |
| 4 | White paint | 2 single glued |
| 5 | No | Free single or twin |
| 6 | Al - edges | Free single or twin |
| 7 | Al - full | Free single or twin |
| 8 | White paint | Free single or twin |
| 9 | Al - edge | Scint.fibers |
| 10 | Al - edge | Scint.fibers |
| 11 | Al - edge | Free single |
| 12 | No | Lucite light guide |

| PMT# | Type | age |
|---|---|---|
| 1 | R7400 | new |
| 2 | R7400 | used |
| 3 | R7400 | used |
| 4 | R7400 | new |
| 5 | R7401 | new |
| 6 | R7401 | new |
| 7 | R7400 | used |
| 8 | R7400 | used |
| 9 | R7400 | used |
| 10 | R7400 | used |
| 11 | R7400 | used |
| 12 | H1635 | used |

**5 tile coatings**
**3 PMT types**
**3 bundles / connectors**

**➔ 8 sets per 6 tiles in the black box**

**➔ 32 runs per 100.000 triggers**

| Slot# | Set#1 Tile PM/ADC | Set#2 Tile PM/ADC | Set#3 Tile PM/ADC | Set#4 Tile PM/ADC | Set#5 Tile PM/ADC | Set#6 Tile PM/ADC | Set#7 Tile PM/ADC | Set#8 Tile PM/ADC |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 2/1 + X/X | 1 1/0 + 10/3 | 1 1/0 + 10/3 | 1 1/0 + 10/3 | 2 3/0 +7/3 | 3 6/0 | 1 4/0 + 7/1 | 1 4/0 + 7/1 |
| 2 | 3 5/4 | 2 2/1 + 9/5 | 2 2/1 + 9/5 | 2 2/1 + 9/7 | 3 6/1 | 4 1/1 + 10/2 | 4 1/2 + 10/3 | 3 5/4 |
| 3 | 4 3/2 + X/X | 3 5/4 | 3 5/4 | 3 6/2 | 4 9/2 + 2/7 | 8 5/3 | 3 5/4 | 9 10/3 |
| 4 | 5 4/3 + X/X | 4 3/2 + 8/7 | 11 4/6 | 9 8/6 | 6 5/6 | 11 9/4 | 9 8/5 | 10 1/2 |
| 5 | 6 6/6 | 11 4/6 | 8 8/7 + X/X | 11 3/5 | 11 10/4 | 10 8/5 | 10 3/6 | 11 9/6 |
| 6 | 12 12/0 | | 7 6/2 | 7 5/4 | 10 8/5 | 6 3/6 + X/X | 11 2/7 | |

# Test Run Problem List

The beginning was very painful.  After 10 days and we had no reliable data …

Main problems:

- ❑ ADCs:
  we had 5 in hands, dead or dying during data taking, last ADC instable …
- ❑ Online-Computer:
  Cetia crashed if run time too long ( ~ 2 hours), exchanged against bad example,
  …  back to old Cetia
- ❑ DAQ:
  was alive, but not fully understood at the beginning
- ❑ PMTs:
  some bad/dead PMTs #2,4,7
- ❑ General status of  test beam area:
  much old stuff, reconstruction foreseen  2008 / I.Gregor

Finally, with help of DESY crew all problems could be solved, data taken …

# Silicon Tracking (1)

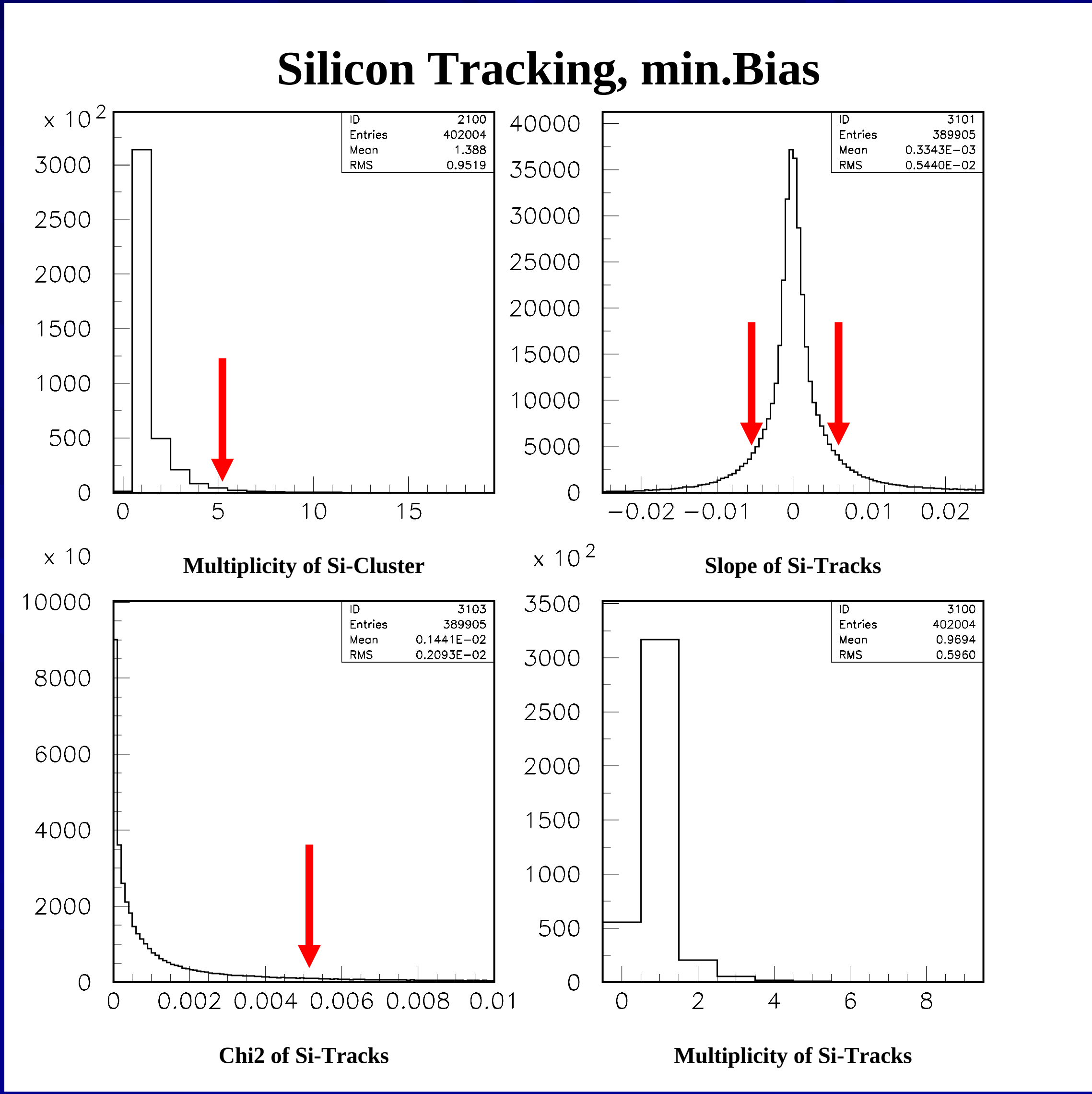
- Silicon-tracking from scratch:
  hit -finding
  clustering
  amplitude weighting
  X/Y coordinates

- track finding:
  candidates by 2 outermost planes
  confirmation by hit in middle plane
  no fine-tuning / rotations

- tracking efficiency ~ 90%

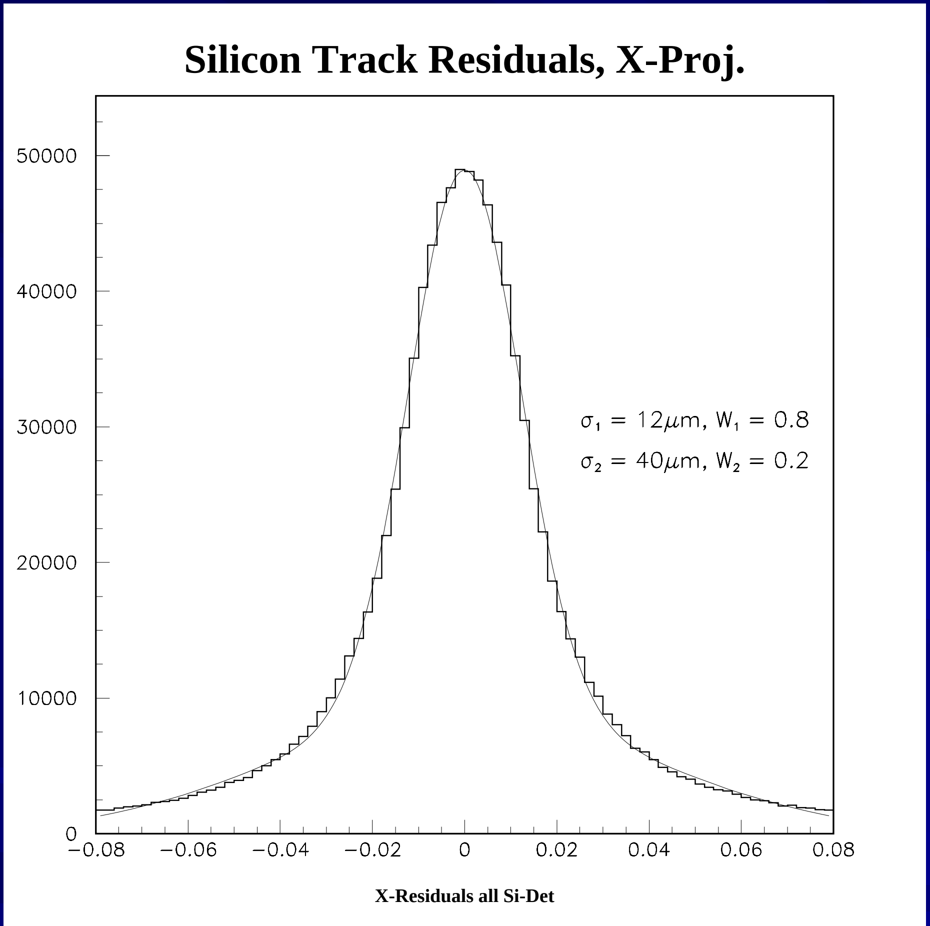
- final tracks:
  cluster# < 5
  slope < 5 mrad
  chi2 < 0.005

→ track multiplicity ~ 1
→ tracking efficiency ~ 50%

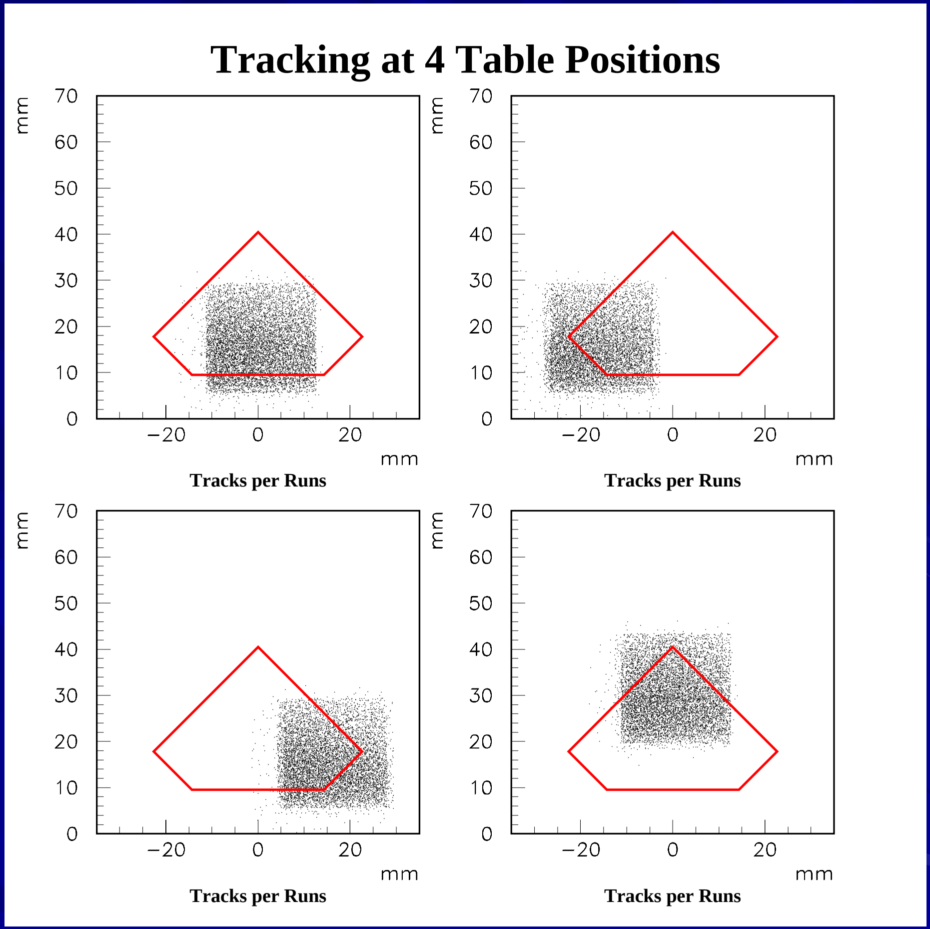


# Silicon Tracking (2)

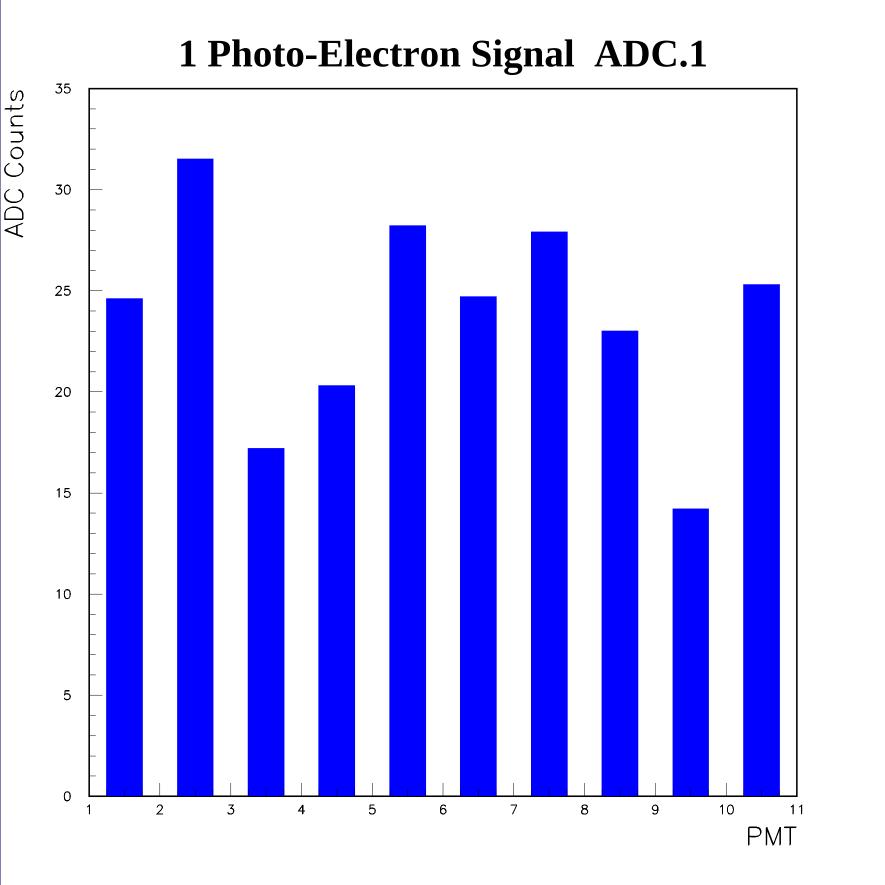
Spatial Resolution ~ 15 µm

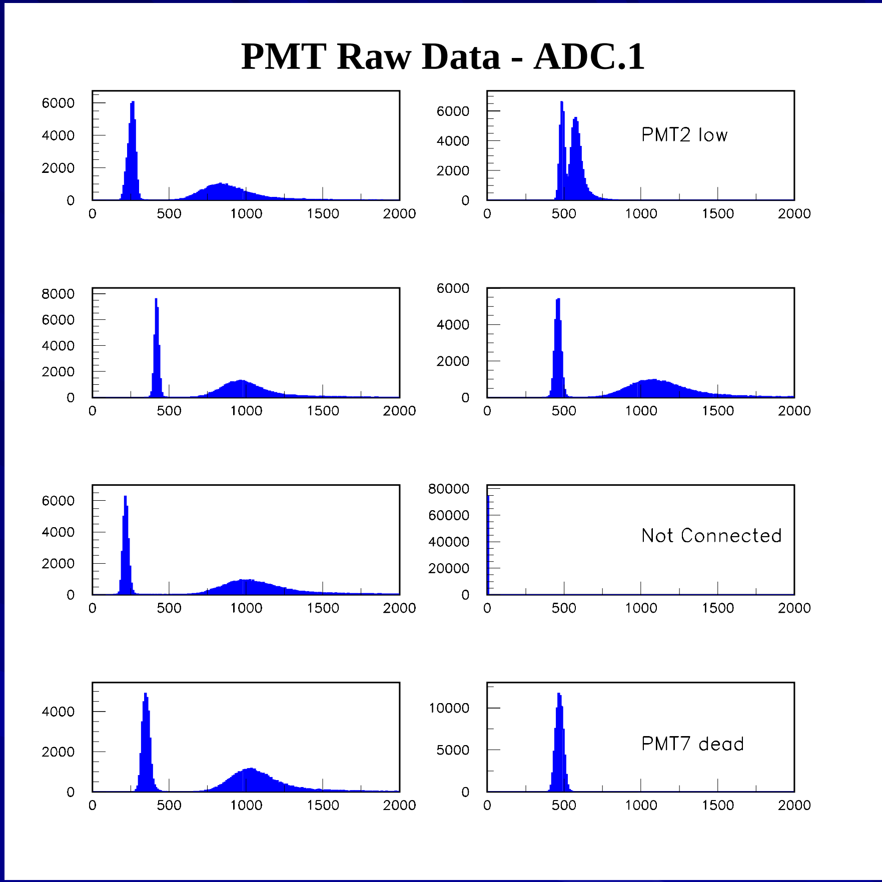



Particles traversing trigger tiles



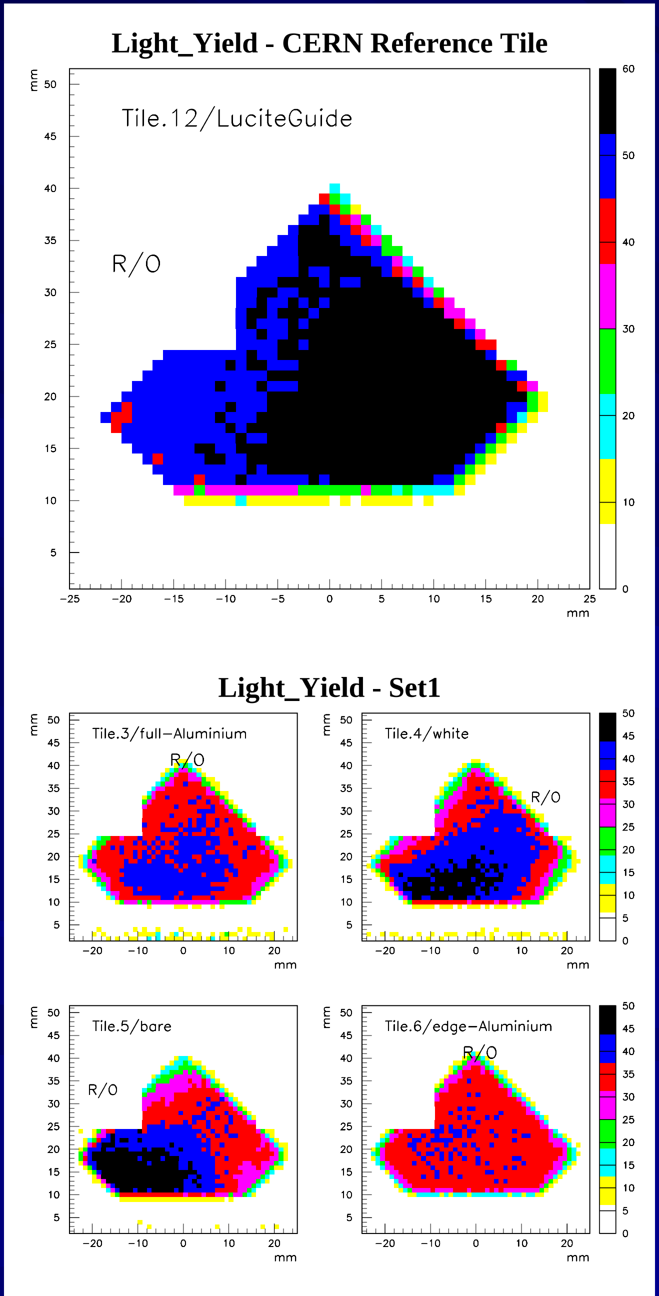
# Measurements ADC.1 – High Sensitivity (1)

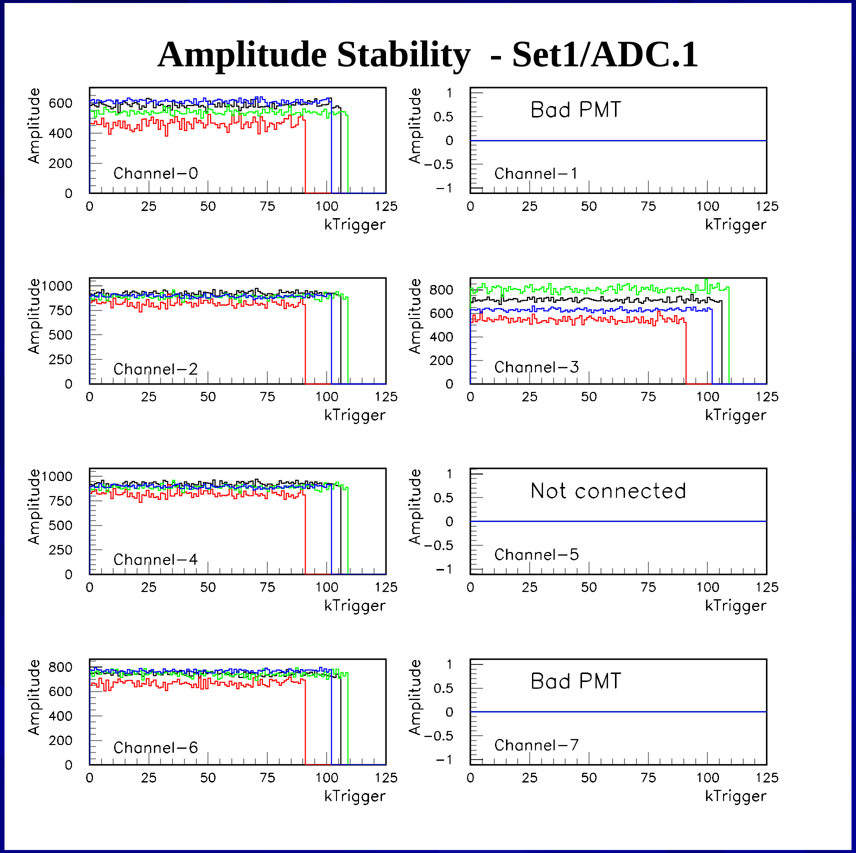



- 1 Photo-electron 20 … 30 ADC counts
- tile signals well-separated from pedestal ~ 500 … 800 ADC counts
- light yield mostly > 20 P.E.

# Measurements ADC.1 – High Sensitivity (2)

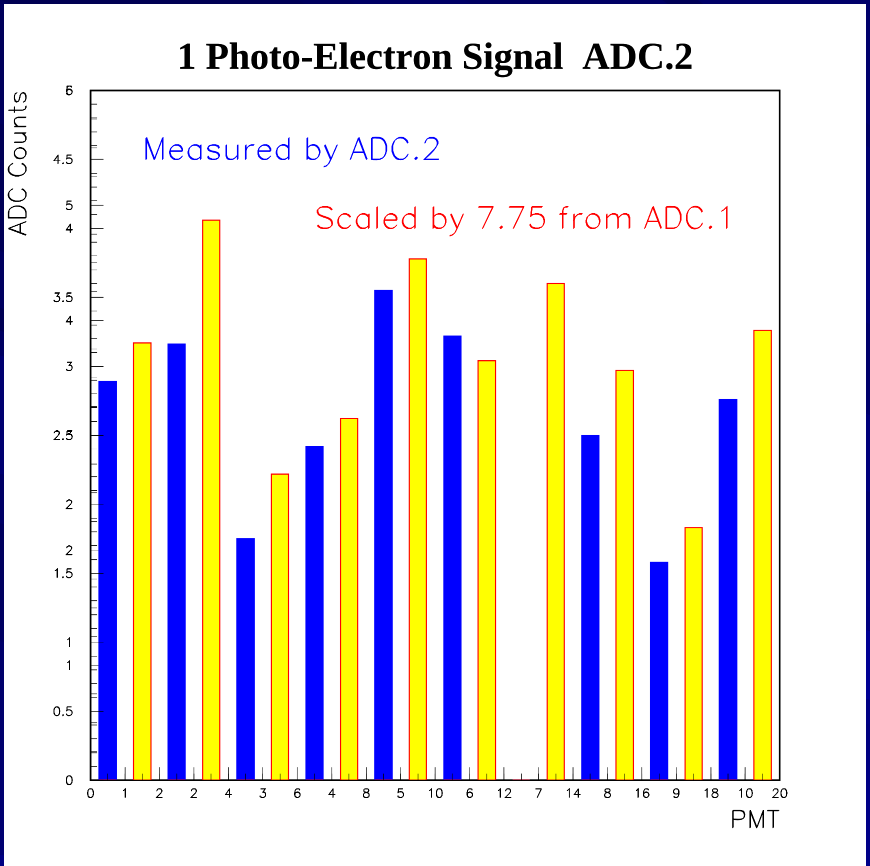


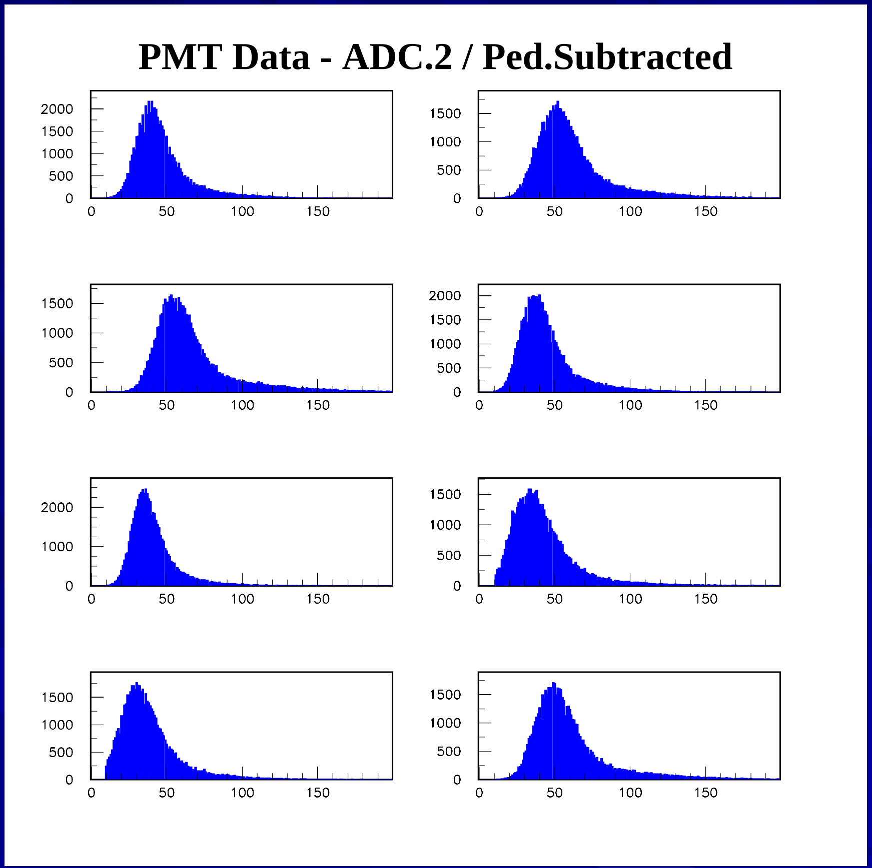




- much light
- stable data taking …
- sudden death of ADC.1 (HV cables ???)

# Measurements ADC.2 – Low Sensitivity (1)

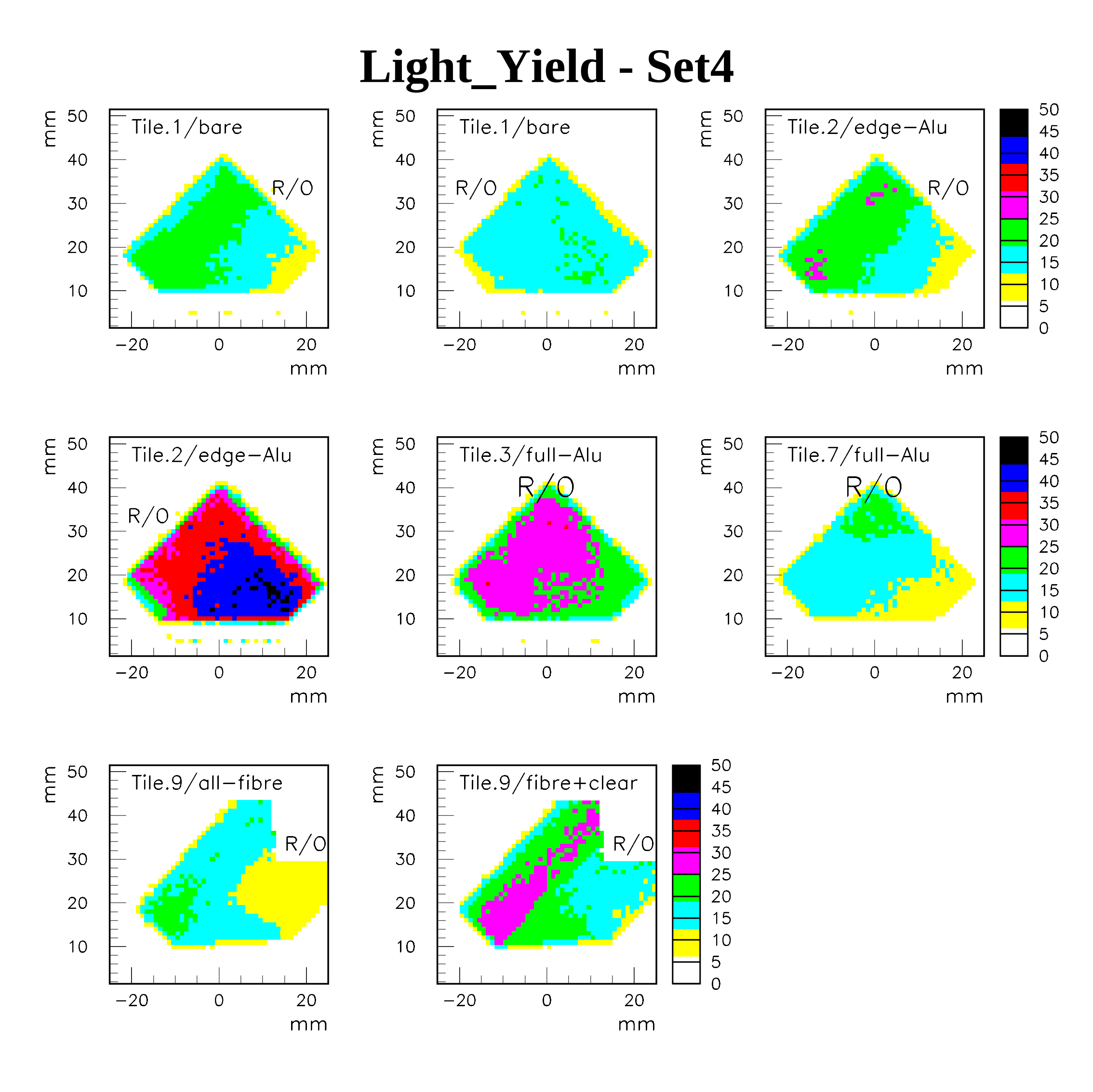
Low sensitivity: no switch for high sensitivity in the DAQ …

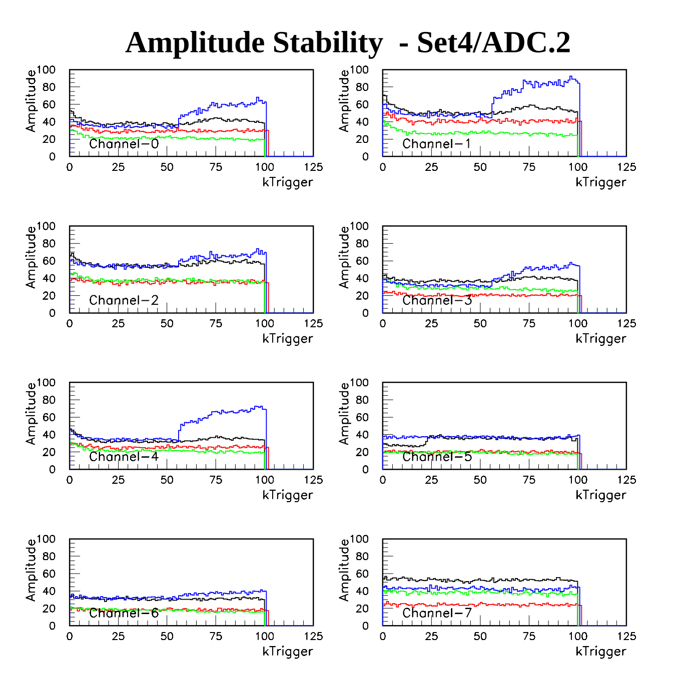



- ❑ 1 photo-electron 2 … 4 ADC counts
- ❑ calibration cross-checked by ADC.1 results
  - general agreement, ~ 14% too small, use ADC.1 extrapolation in analysis
- ❑ tile signals ~ 50 ADC counts
- ❑ → light yield ~ 20 P.E.

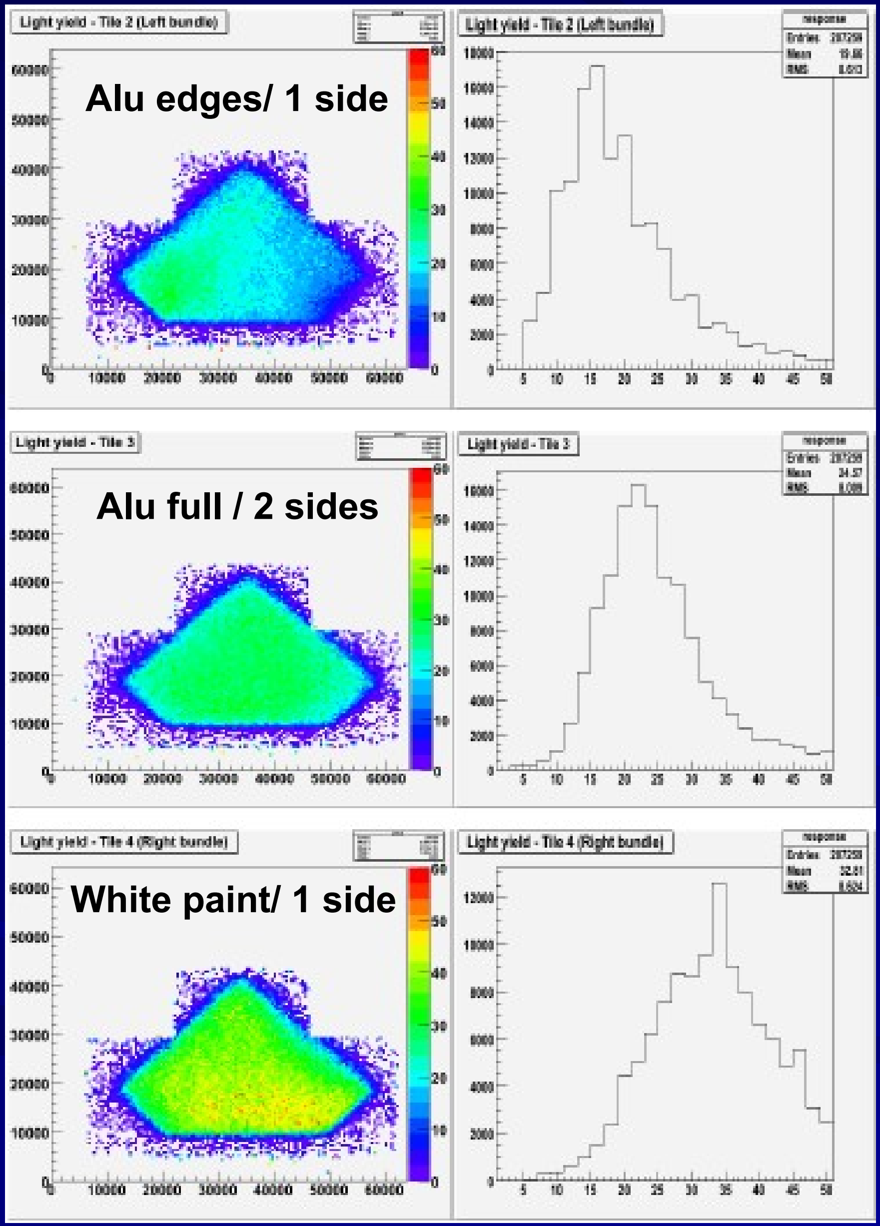
# Measurements ADC.2 – Low Sensitivity (2)



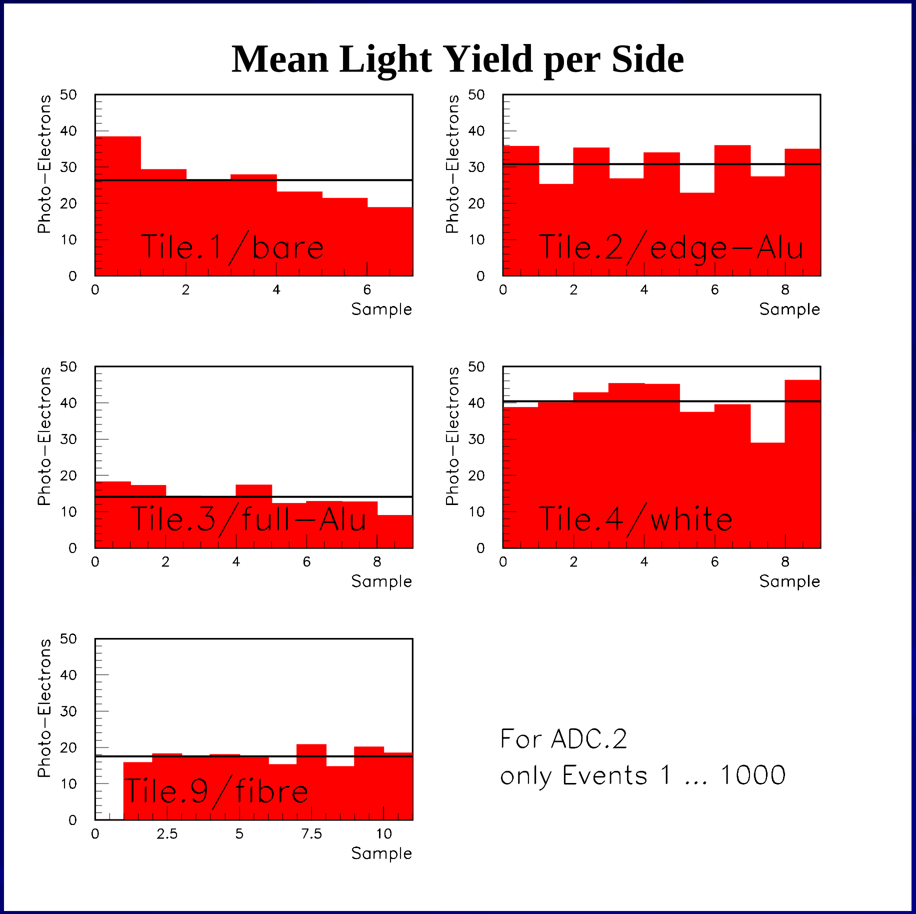

- absolute light yield degraded by instable ADC.2
- different ADC-channels influenced differently

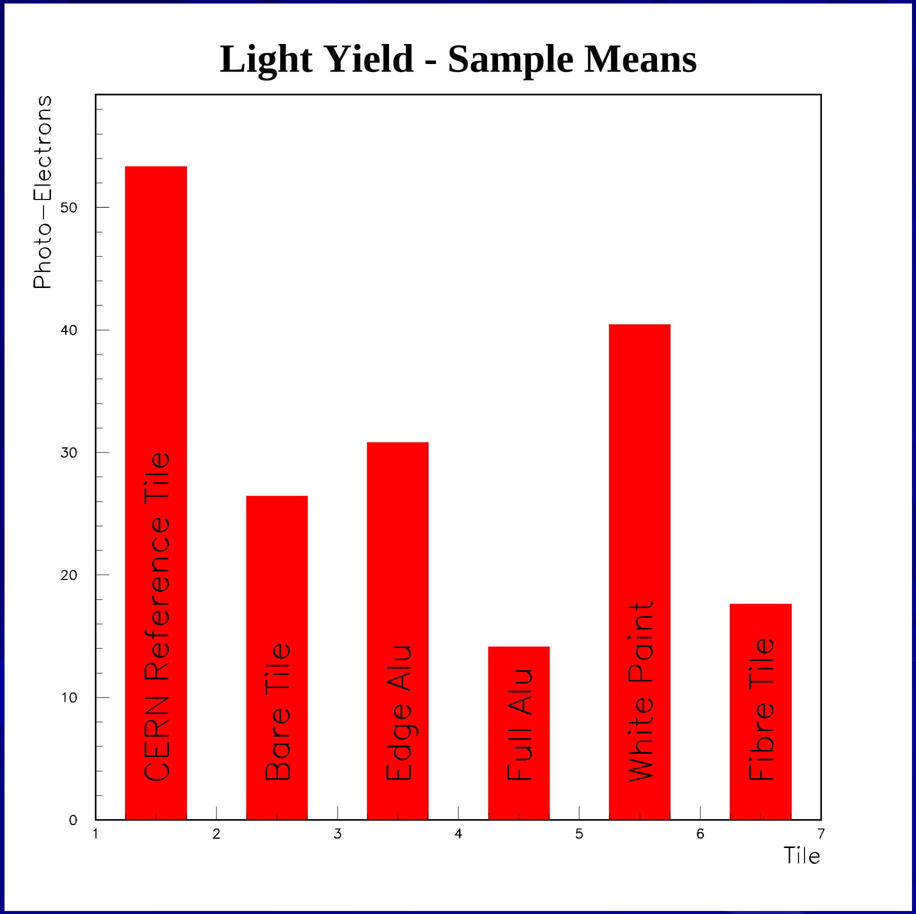
# ROOT based analysis / CERN




- in hands of S.Franz / A.Mapelli
- results are coming now
- light yield comparable with PAW analysis
- need some fine tuning and detailed run-by-run comparison
- common results will be presented on the next ALFA meeting

# Comparison of all Sets




- Instable ADC.2 prohibits precise normalization
- Estimated normalization error +- 5 photo-electrons
- Best light yield for white, reflective paint ~ 40 P.E/ side

# Summary

- light yield of 12 trigger tiles readout by 3 bundle versions and 2 PMT types measured
- instable ADC.2 inhibits precise normalization
- 32 runs with ~ 100,000 triggers each
- results indicate much light, mostly # P.E. > 20 per side
- estimated error for normalization +- 5 P.E.
- best option: white, reflective paint ~ 40 P.E. per side

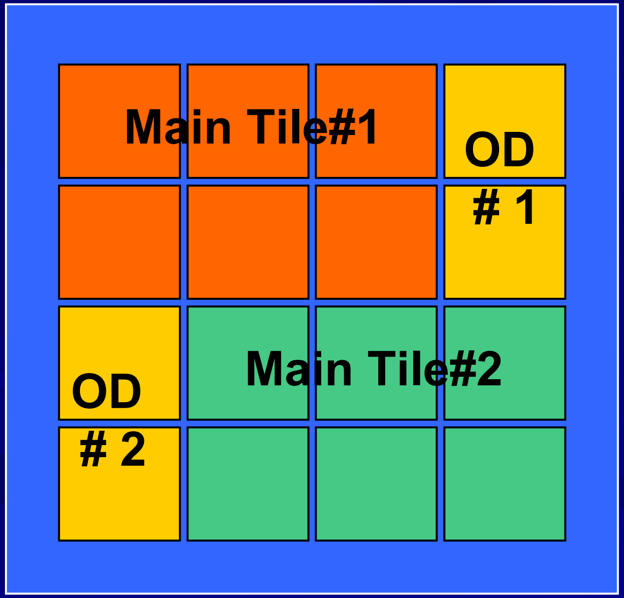
**Next to do:**

- finish ROOT based analysis of Alessandro & Sebastian
- including edge behaviour of efficiency
- final cross-check of normalization by cosmic data at CERN
- summarize the results in a short (ATLAS ?) note

# How to continue the trigger business ?

# Back to use MAPMTs for trigger purpose

Why ?
1) more then sufficient light yield: 2 x 40 P.E. (to be confirmed !)
2) complicated mechanical arrangement of single/lens PMTs
**3) main argument against MAPMTs – common noise –**
**can be excluded by internal anticoincidence pixels**




- ❑ 16 pixel a 4 x 4 mm2
- ❑ main trigger tiles: 6 pixel allow to r/o 360 fibers,
- ❑ now 2 x 250
- ❑ Total light yield reduced: 2 x 40 P.E. → 2 x 30 P.E.
- ❑ OD tiles: 2 pixel allow r/o 120 fibers, sufficient
- ❑ cross talk on % level can be discriminated

**To clarify: latency for summation of 2 x 6 pixels,**
**logical .AND. of signals plus**
**anticoincidence of OD pixels**

# Estimation of Latency

Based on discussion with Zeuthen electronician H.Henschel …

**Standard version:**
**2 single mini-PMTs**

1) analog signal sum of 2 bundles by twin bundle — 0 nsec
2) discrimination of 2 signals — ~ 2 nsec
3) logical .AND. — ~ 2 nsec
4) … plus some margin

**Latency < 10 nsec**

**Advanced version:**
**1 MAPMT 4 x 4 pixel**

1) analog sum of all pixels per bundle in parallel — ~ 2 nsec
2) discrimination of 4 signals — ~ 2 nsec
3) locical .AND. plus anti-coincidence of OD bundles — ~2 nsec

**Latency < 12 nsec**

- ❑ Summation and discrimination possible in parallel – independent from pixel number
- ❑ Difference in latency is marginal, only due to step 1) ~ 2 nsec (very rough estimate)

# A scenario for MAPMT trigger electronics

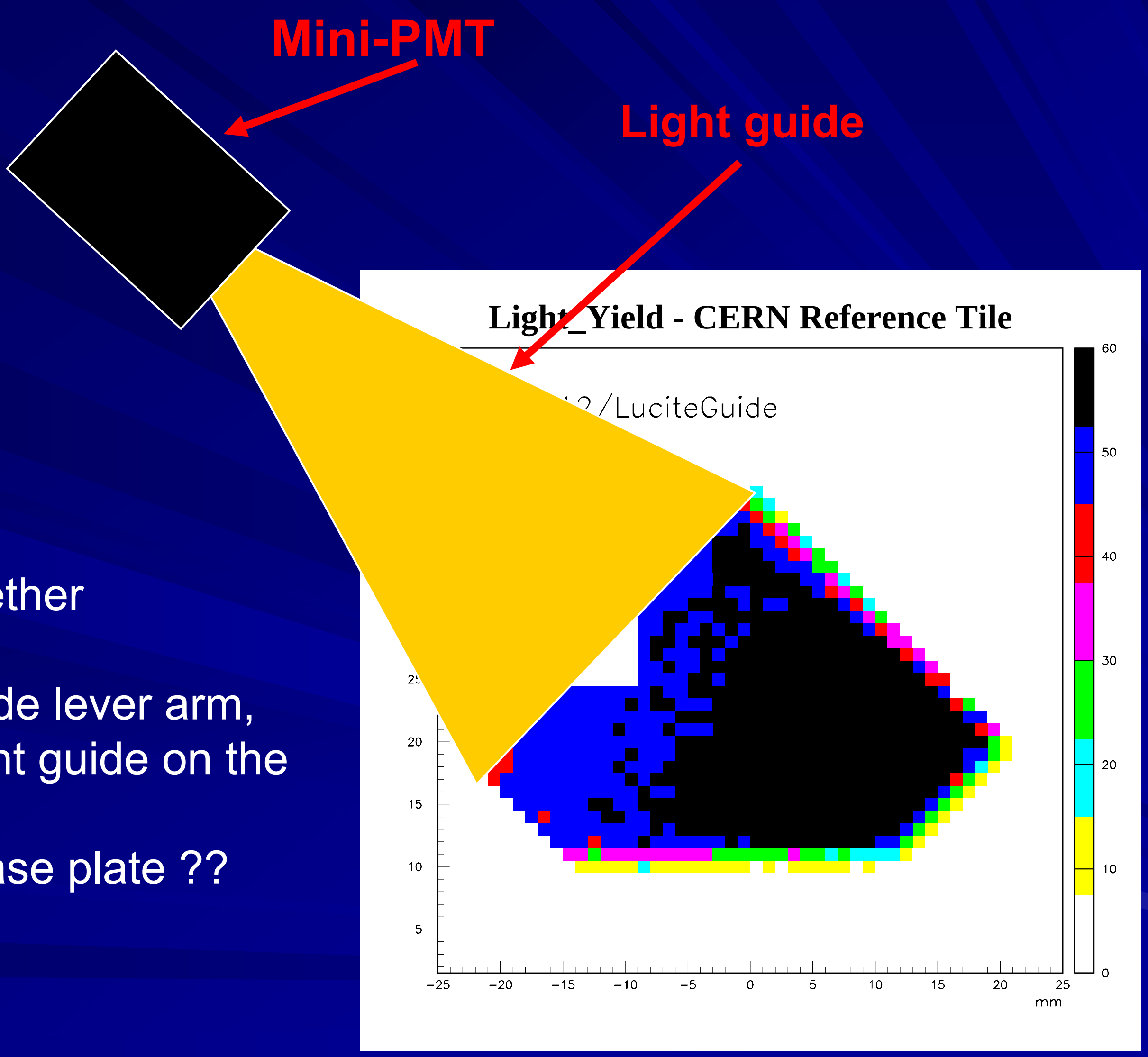
**Goal (desire ?): trigger scheme ready for test beam in July 2008**

- ❑ Test of principle with 8 x 8 pixel MAPMT, same as for fiber r/o
- ❑ produce modified fiber bundles
- ❑ prepare 2 tiles for a cosmic test at CERN
- ❑ use r/o electronics prepared for the 64-fiber detectors
- ❑ add analog pixel signals offline, simulate trigger logic, and check trigger efficiency
- ❑ time scale: cosmic test in April ???

If test of principle was successful:

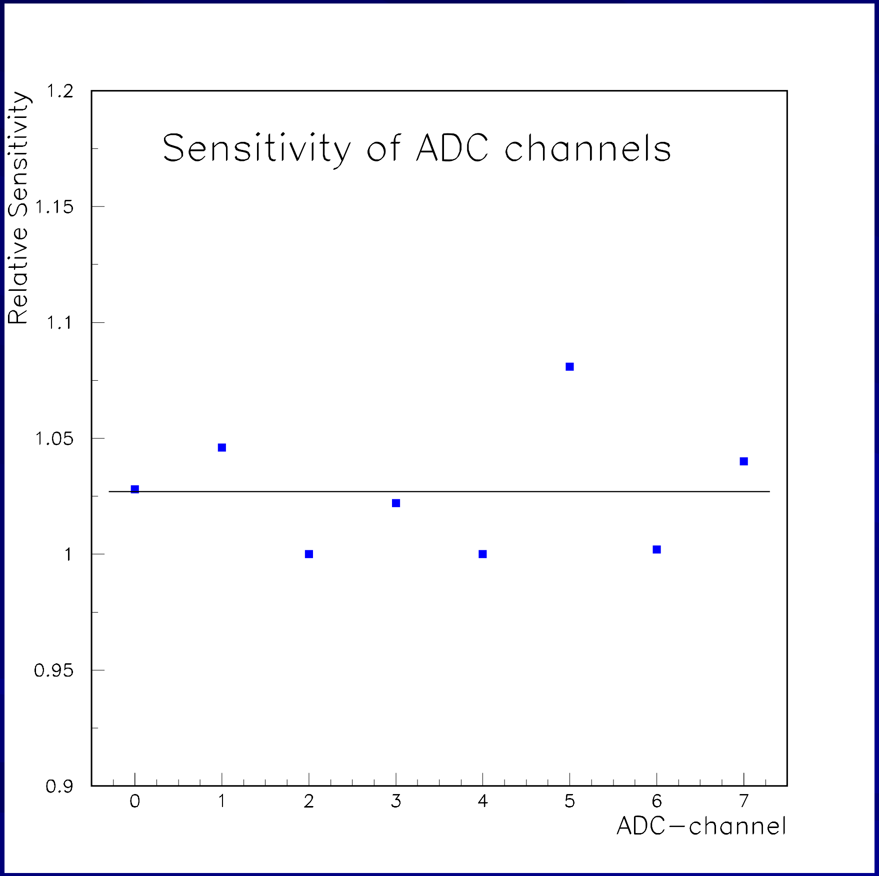
- ❑ ask Orsay group (?) to develop for the existing PMF a new layer for fast analog signal summation and the trigger logic
- ❑ if analog signal summation for 8x8 MAPMT takes too much time: can 4x4 MAPMT coupled to the present PMF ???

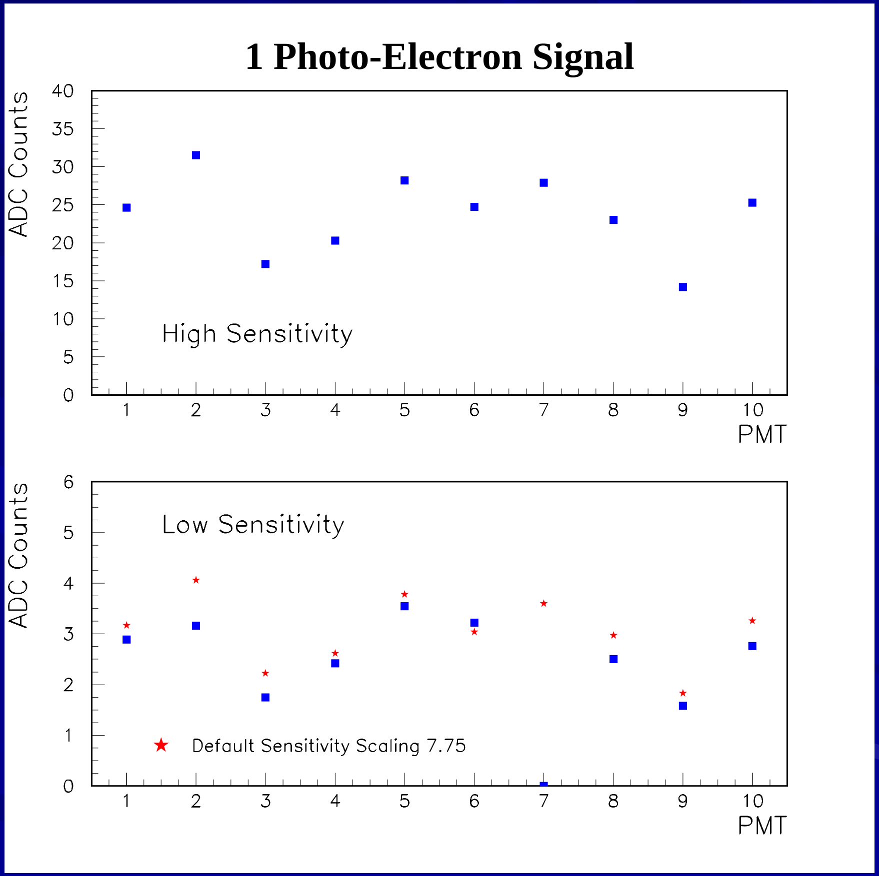
# Direct option: Lucite light guides



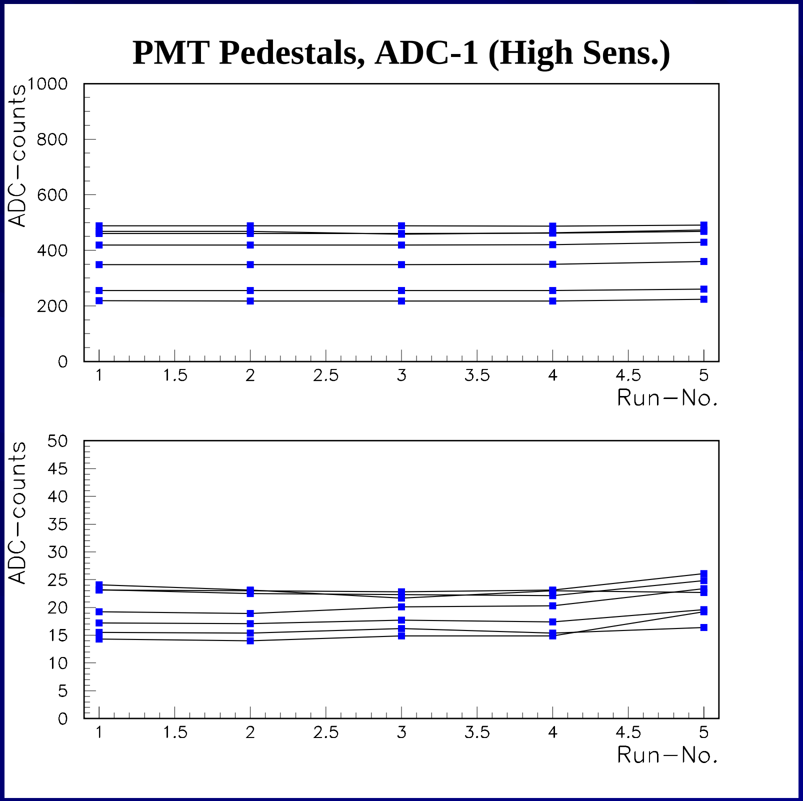

- ❑ All pieces glued together
- ❑ Rather long light guide lever arm, and no fixation of light guide on the Ti-plate
  → PMT fixation at base plate ??

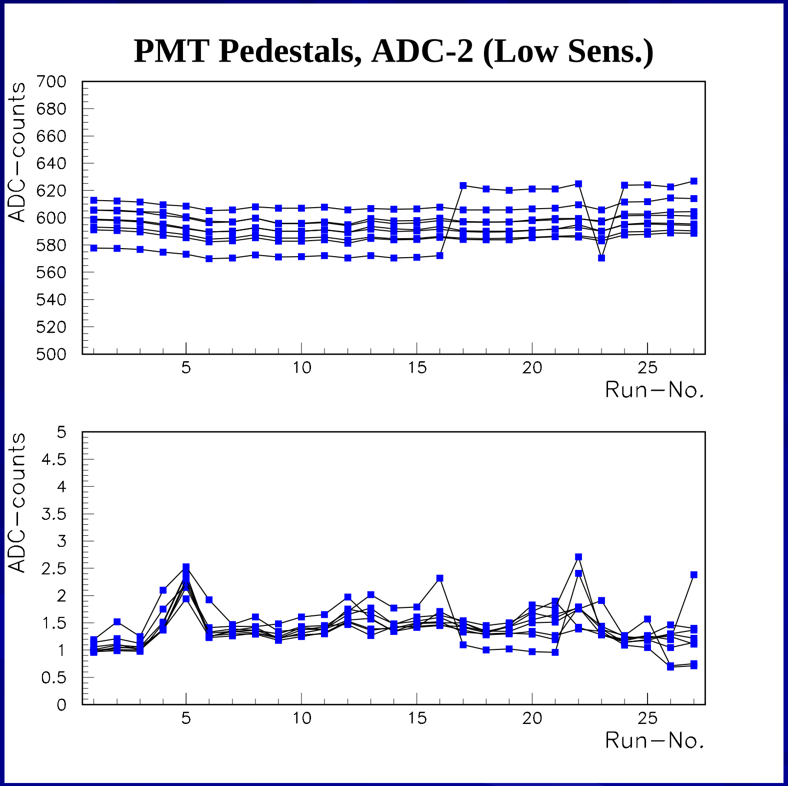
# The 1 Photo-Electron Signal



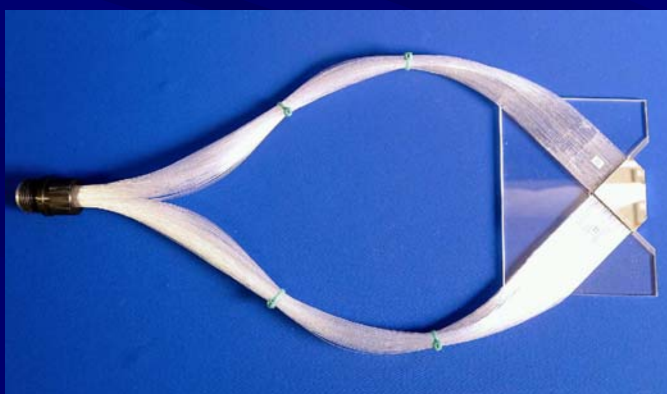
# ADC Pedestals



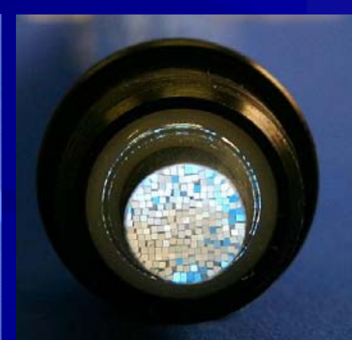



# Black Box Content (1)

White tile glued to 2 clear single bundles



Tile w/o coating glued to a twin bundle



Fiber tile with scint.fiber bundle