Study of Timing and Efficiency Properties of the Hamamatsu H-8500 Photomultiplier

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Stanford Linear Accelerator Center
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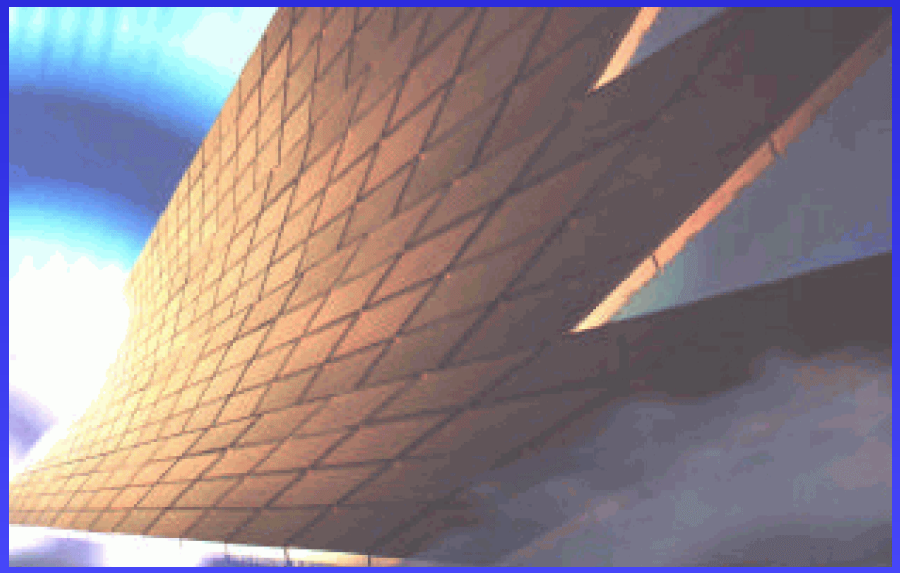
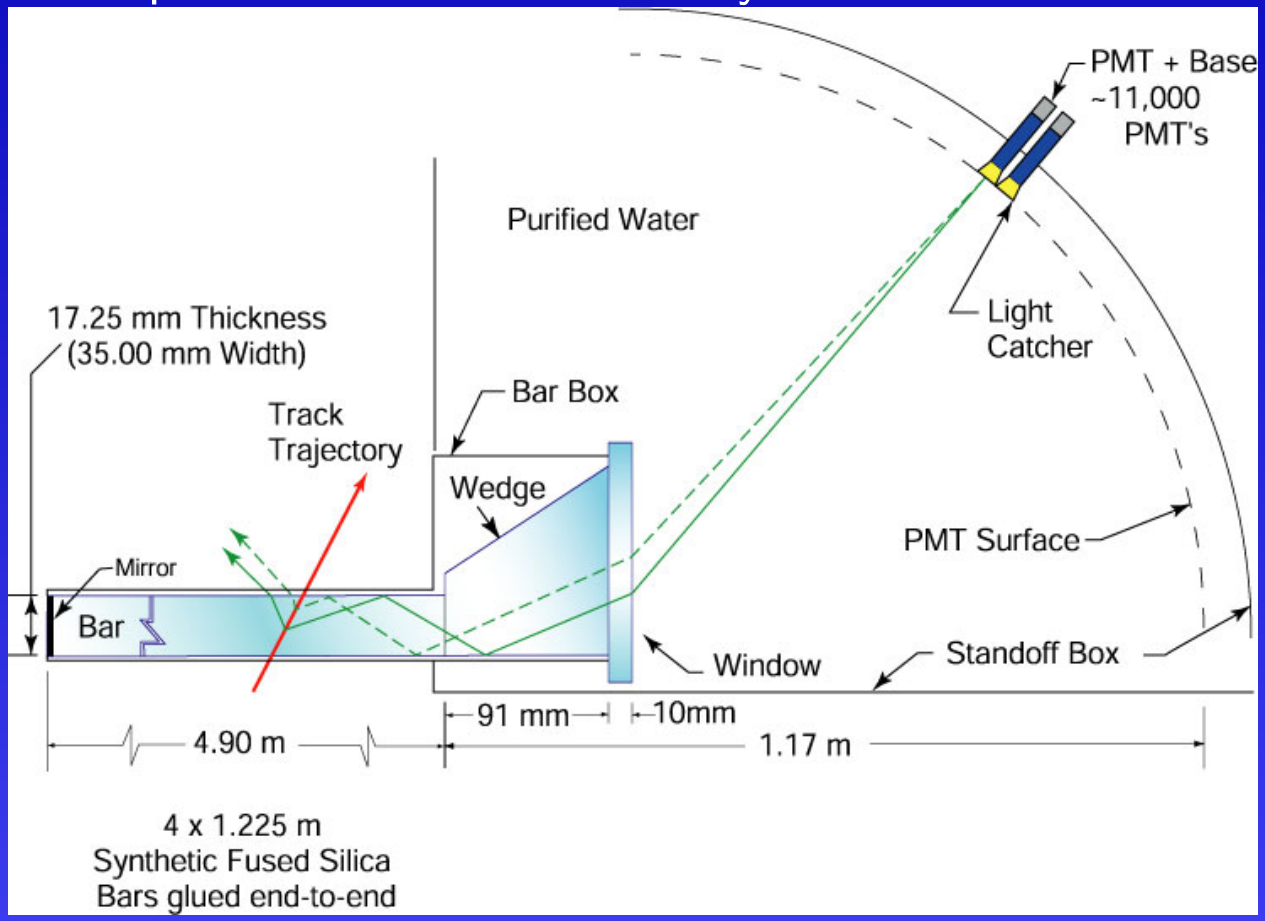
- Motivation
- Setup
- Timing Resolution
- Relative Efficiency Variations
- Conclusions and Outlook



Motivation

Using PMTs in Cherenkov detector:

DIRC particle identification subsystem in BaBar detector



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Using PMTs in Cherenkov detector:

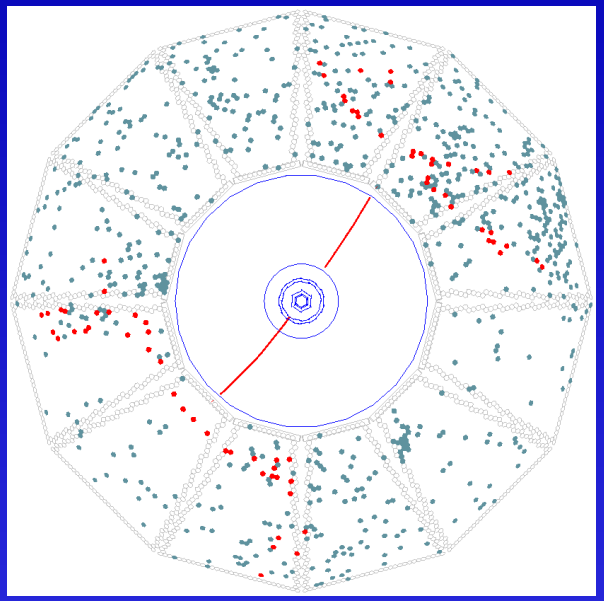
DIRC particle identification subsystem in BaBar detector

≈ 11000 EMI 9125FLB17 PMTs,

1.7 ns timing resolution, 30 mm diameter

Measuring PMT position and photon arrival time

Timing mainly used for signal vs. background separation



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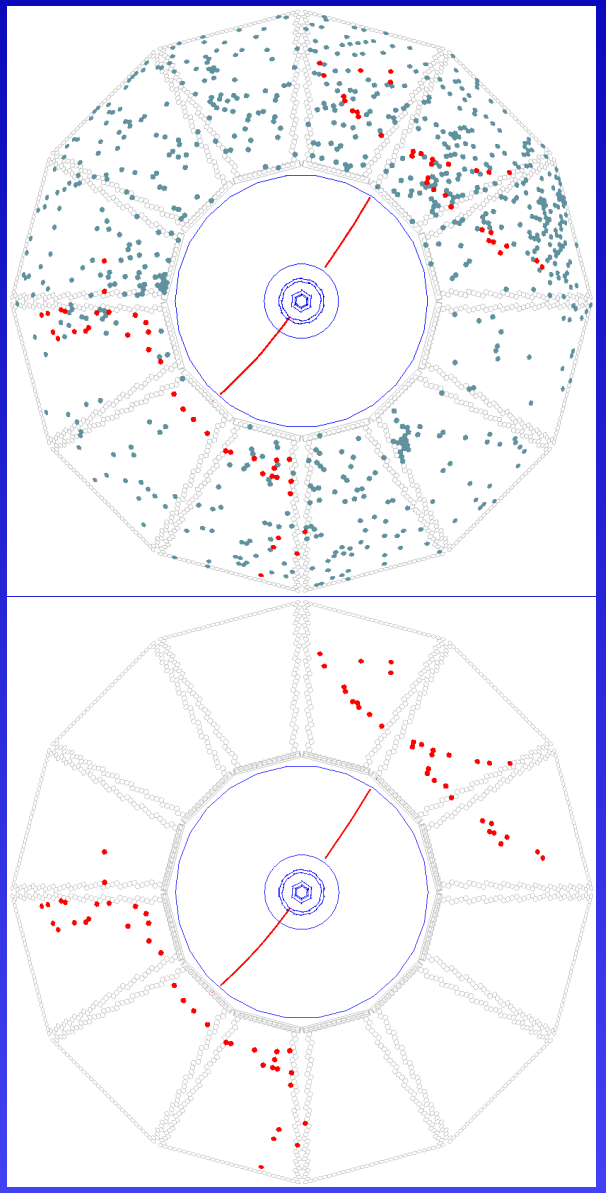

Event display without(top) and with(bottom) time cut

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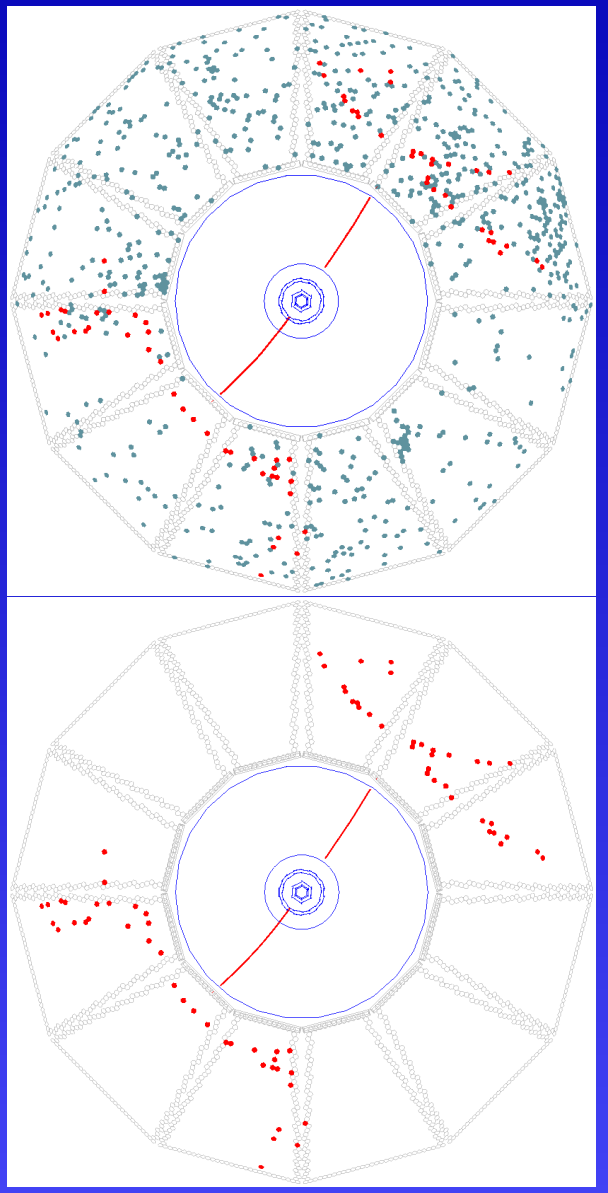
1.7 ns timing resolution, 30 mm diameter
Measuring PMT position and photon arrival time
Timing mainly used for signal vs. background separation

For better performance:

- Better timing resolution
  $\longrightarrow$ better background suppression
- Smaller PMT size $\longrightarrow$ smaller expansion region
  $\longrightarrow$ better geometric resolution
- Much better timing resolution (≈ 100 ps)
  $\longrightarrow$ correcting for chromatic uncertainty.

Looking for:

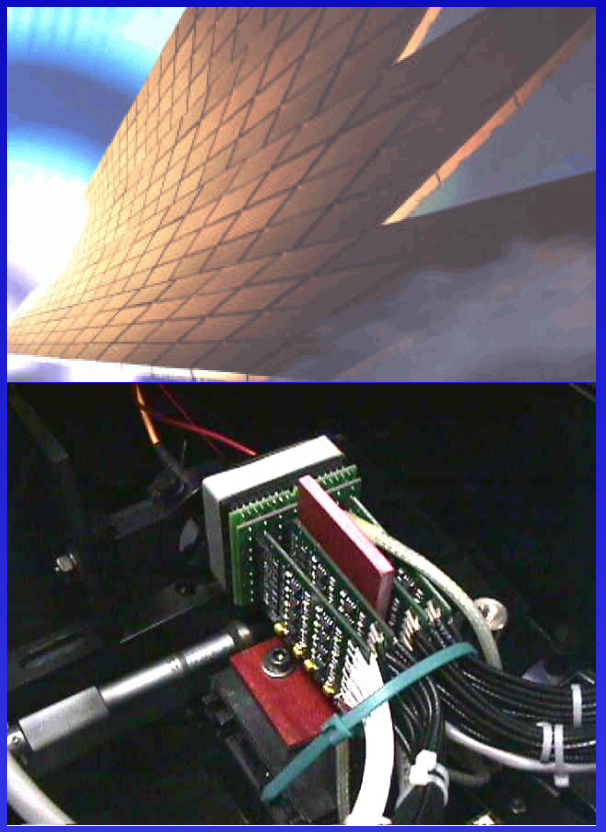
small, high efficiency PMT
with very good timing resolution



Event display without(top) and with(bottom) time cut

Motivation

Hamamatsu H-8500:
Multi-anode PMT
Geometry:
8×8 pads
size: 52 mm $\times$ 52 mm
effective area: 49 mm $\times$ 49 mm
Spectral response:
300 nm $\ldots$ 650 nm
Gain:
10^6
Cross-talk:
3%
Transit time spread:
300 ps
(all data taken from prelim. data sheet, April 2001)



setup with amplifier boards added

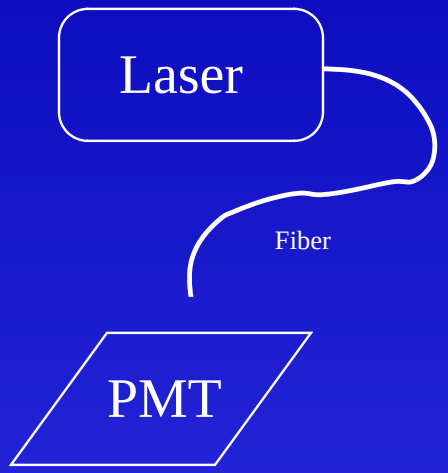
Timing Setup

Light source

- Pilas pico-second laser
- $\lambda = 635$ nm
- $\sigma_{\text{pulse}} < 35$ ps
- Operated in single photon mode

PMT

- Hamamatsu H-8500 early pre-production



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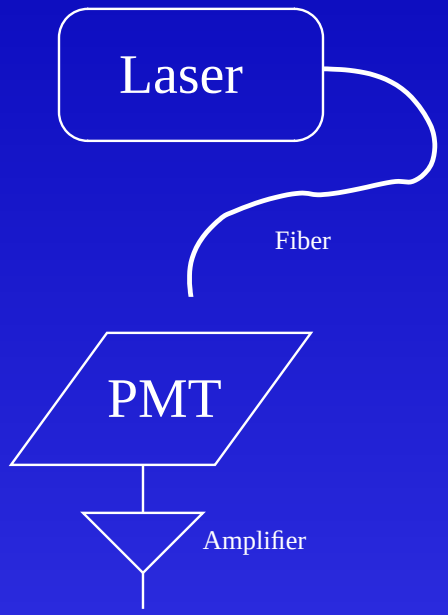
Amplifier

Elantec EL2075C, $40\times, 2$ GHz bandwidth



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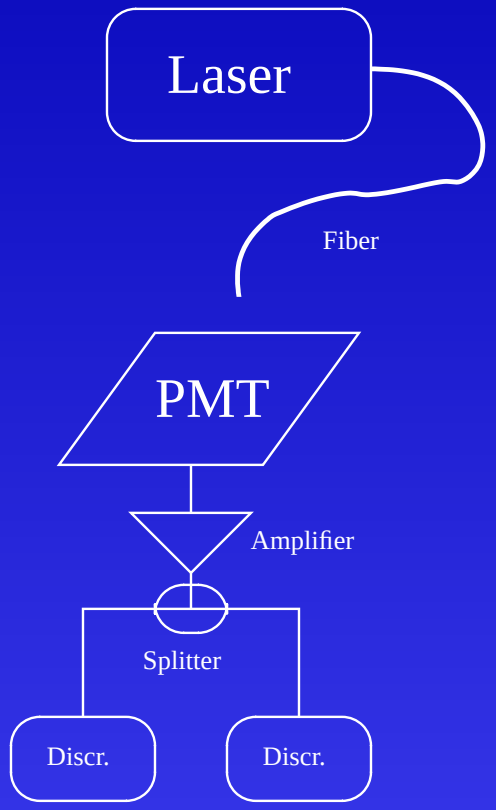
Readout

Double threshold discrimination



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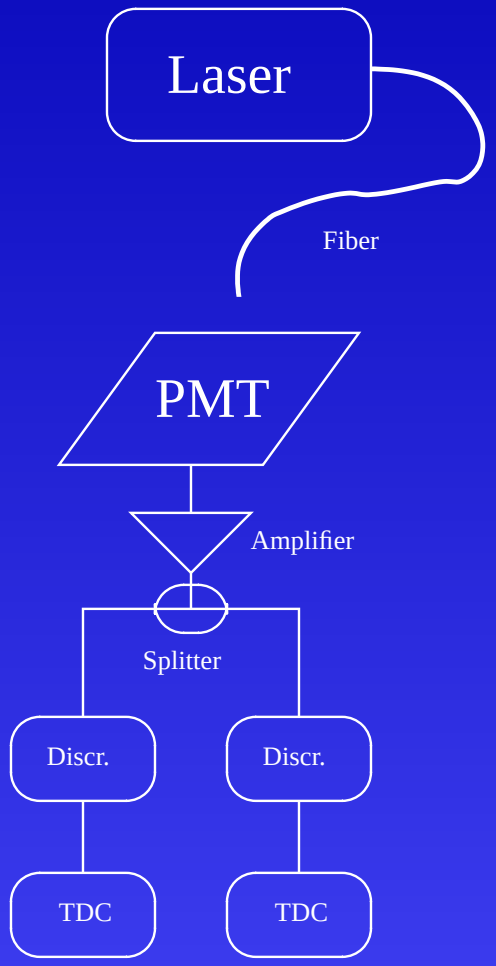
Readout

Double threshold discrimination

LeCroy 2228A, 22 ps per count TDC

CAMAC based readout



Time Distribution

Electronics timing resolution:

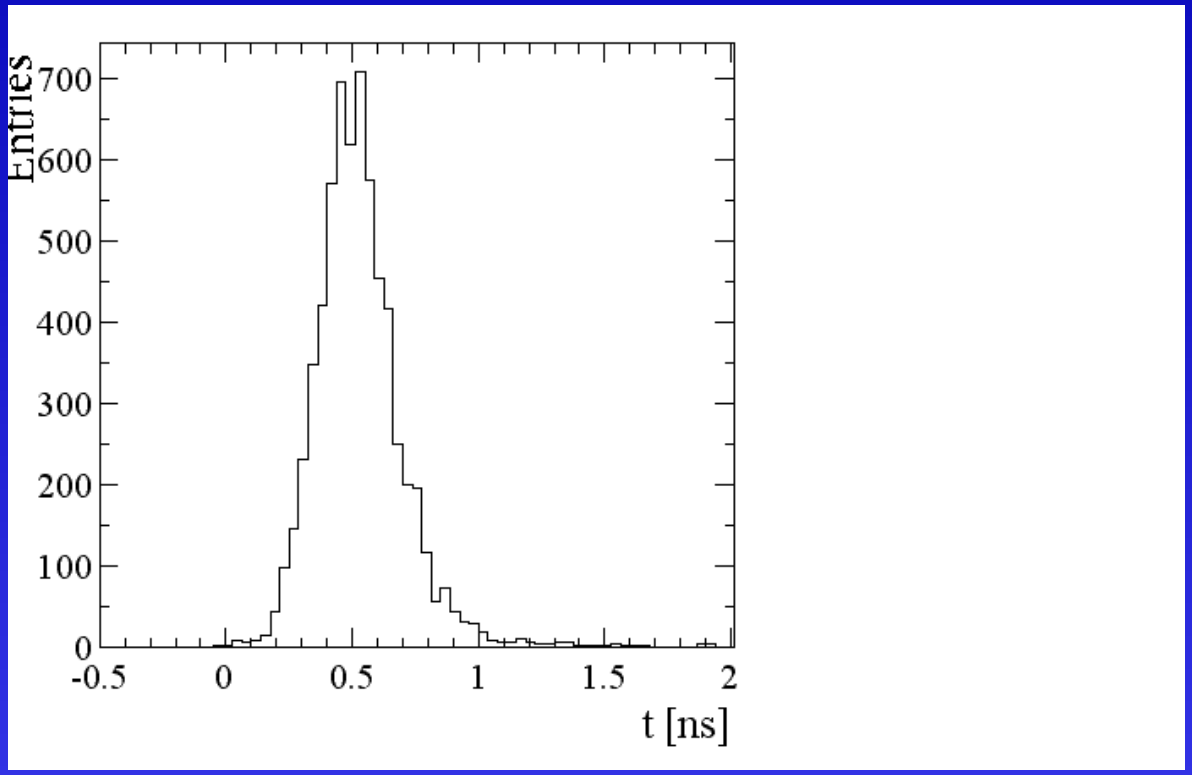
- 22 ps TDC
- 35 ps FWHM Laser

Thresholds:

- ≈ 14.8 mV, 20.8 mV

Notes:

- High amplitude signals only
- Double threshold allows for time walk correction
- No correction for laser pulse width



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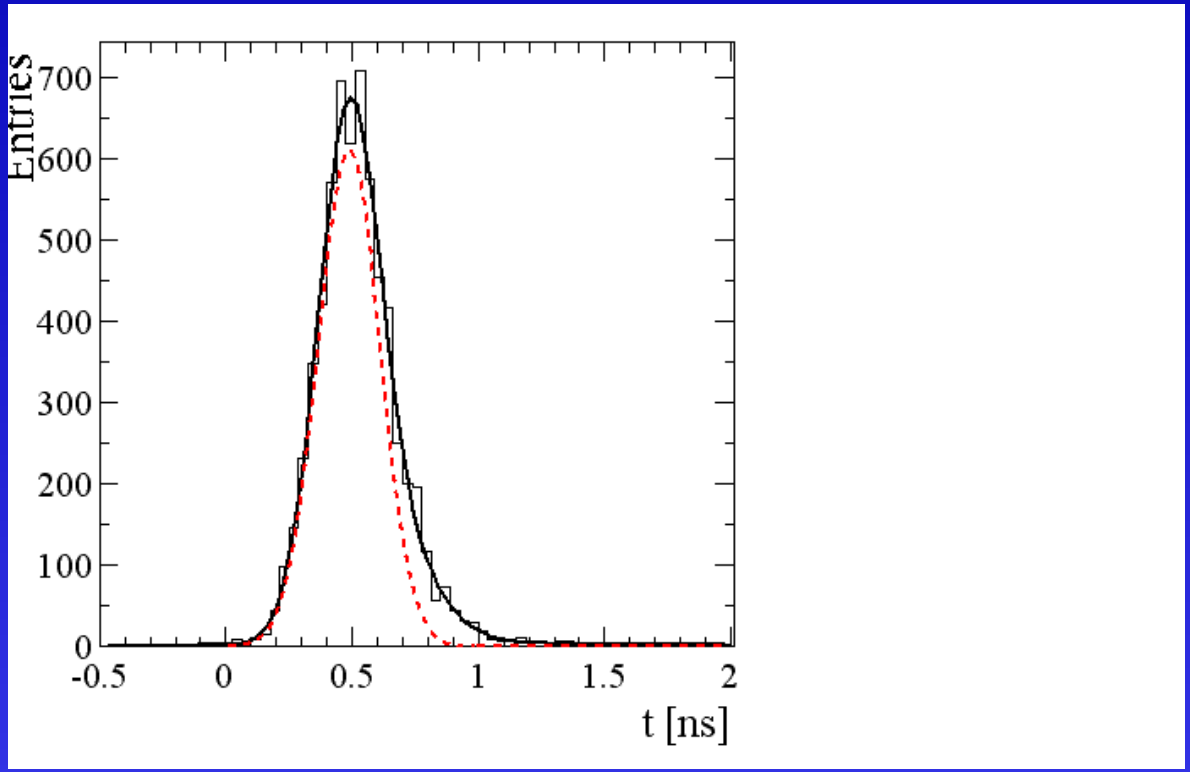
Conclusions:

Double gaussian plus 2nd order polynominal

Resolution ≈ 130 ps



Motion Controlled Setup

Light source

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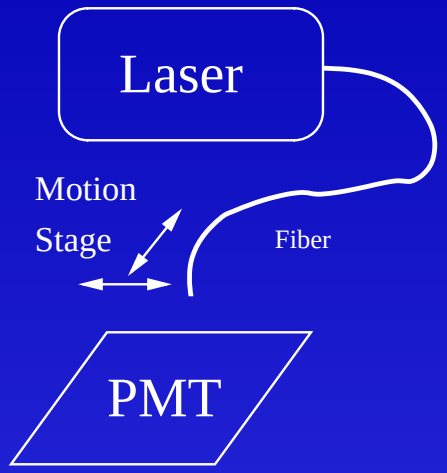
Motion Controller:

- Repeatability $< 7\ \mu$m



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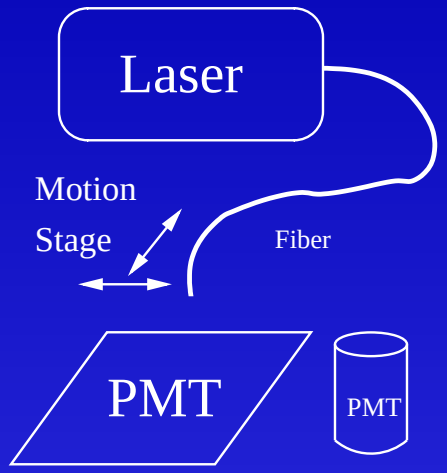
Laser Intensity Monitoring

Two standard PMTs used for calibration
(Photonis XP2262B, EMI 9125FLB17)



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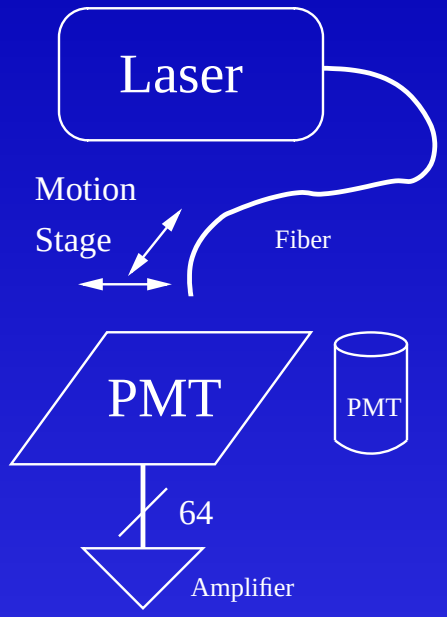

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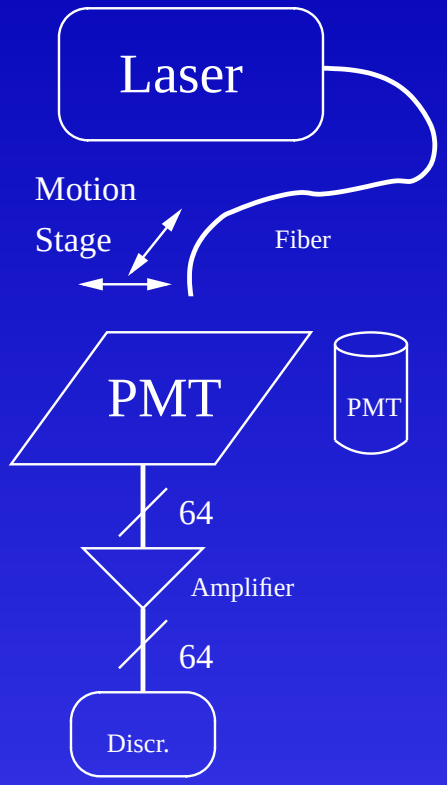

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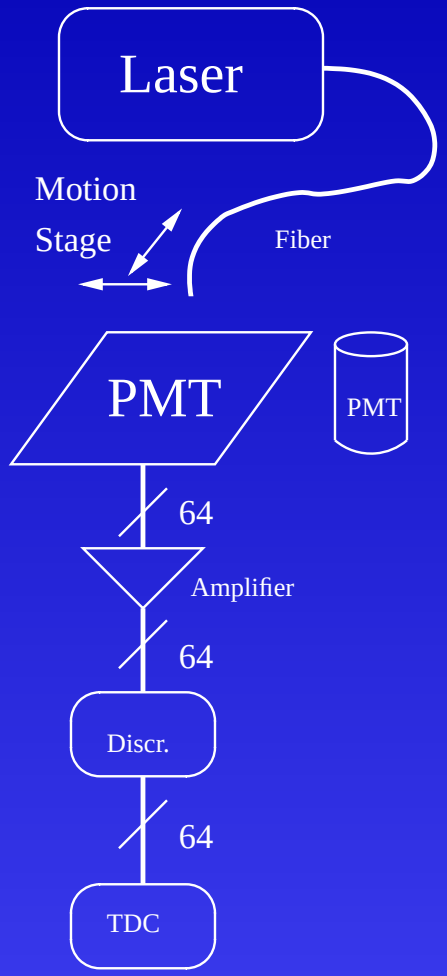
CAMAC based readout

Single threshold discrimination

500 ps per count TDC (LeCroy 2277)

connected to Linux PC

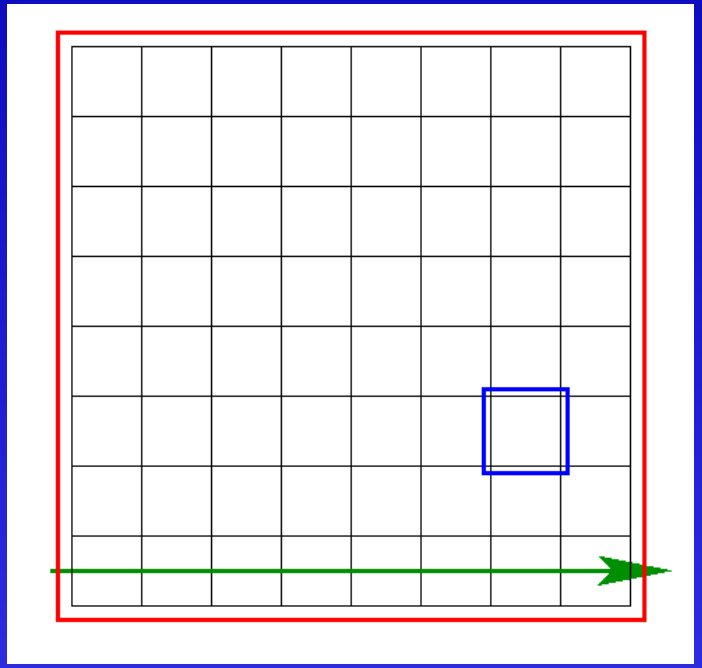


Overview of Scans

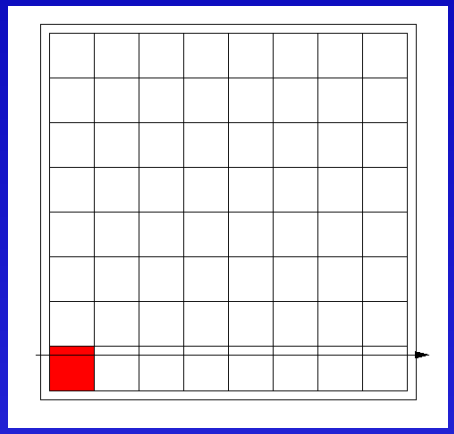
Goal: To determine
- rel. efficiency variations of pads
- rel. efficiency variations within a pad
- visible structures of PMT

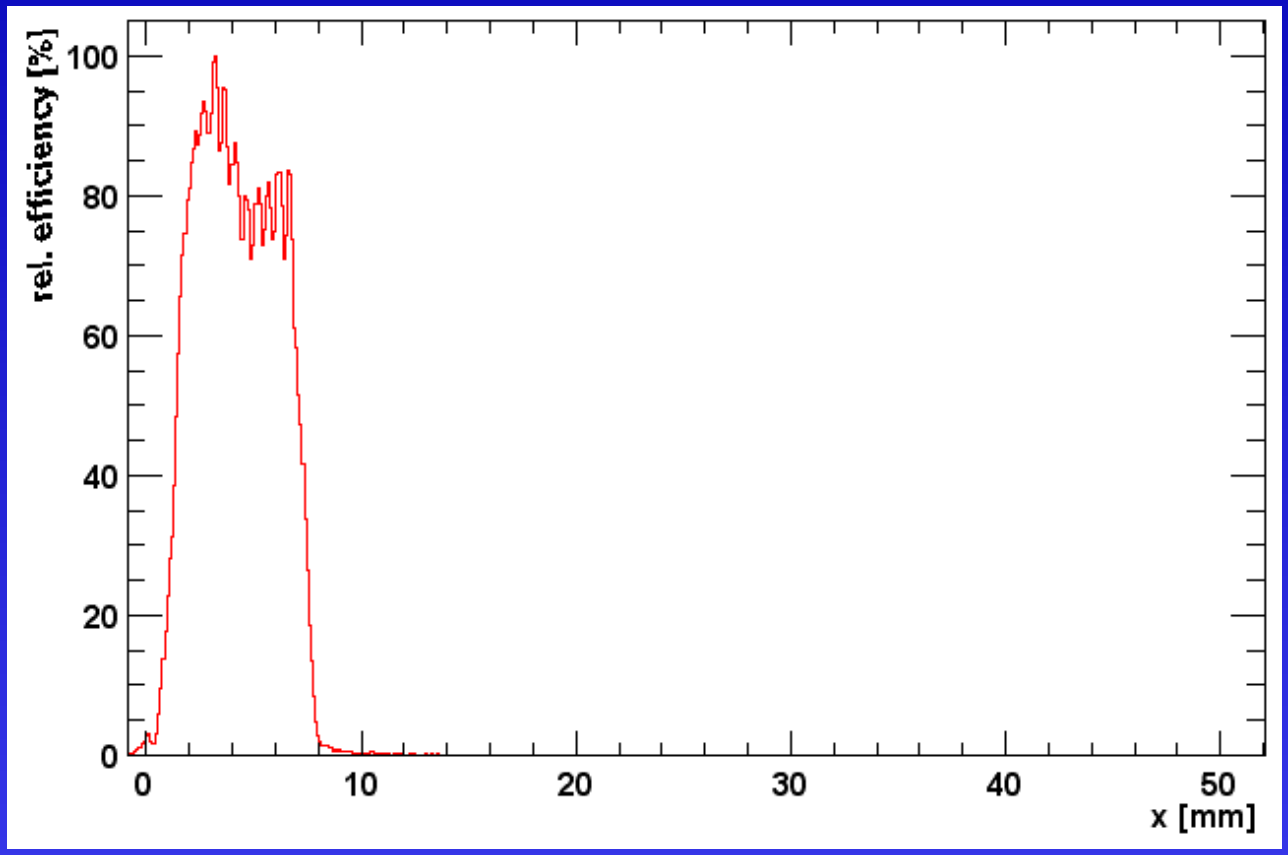
Scans:
- Across the PMT along a line
- Across the whole PMT
- Across a single pad

Note:
"Rel. efficiency" is a convolution of:
- Cathode efficiency
- Anode efficiency
- Spectral efficiency



Scan of one Line across the PMT





Scan step size:

- $100\ \mu$m

Conclusions:

- Steep pad edges
- 2 main peaks per pad, addl. microstructure
- cross talk $< 1\%$ (addl. 3% electr. x-talk)

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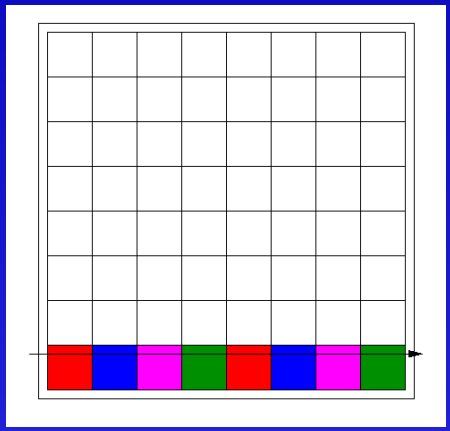

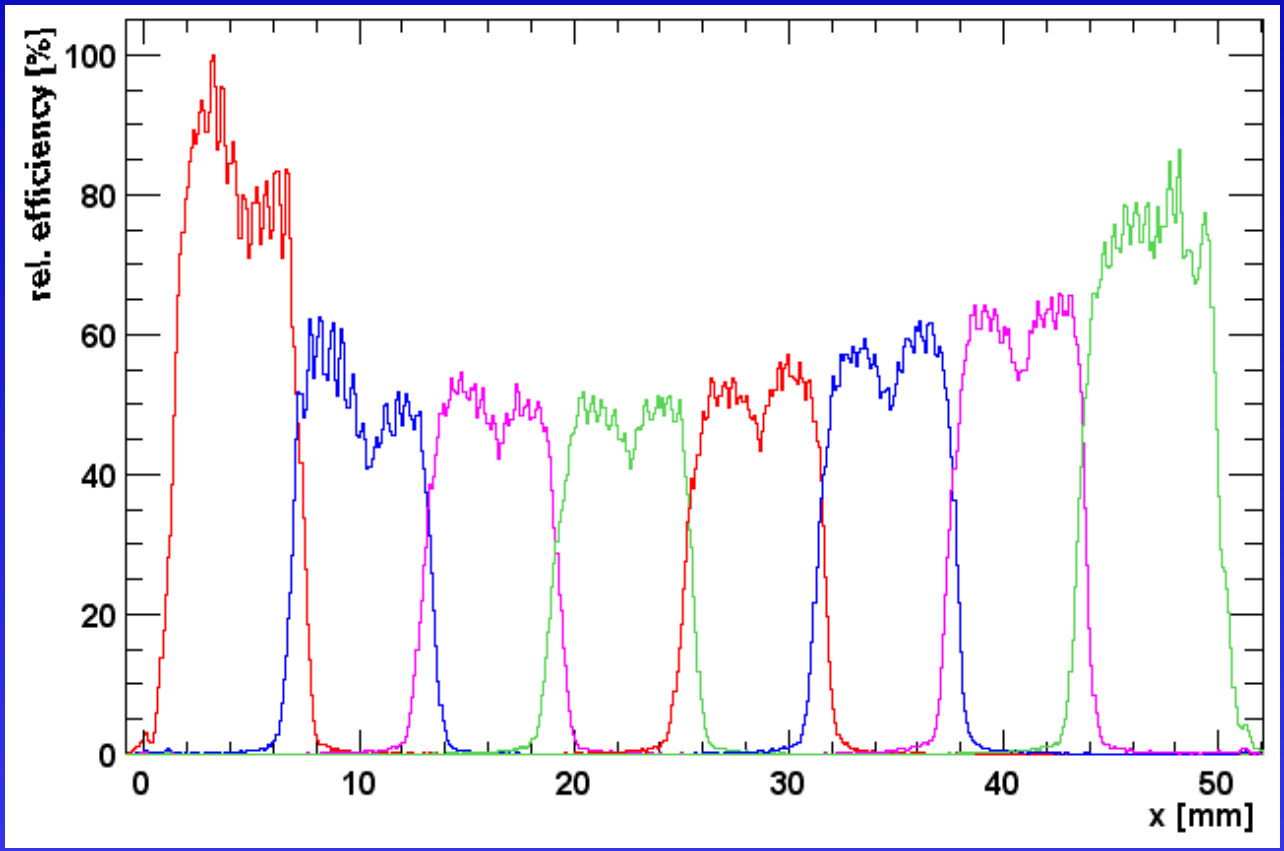

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Conclusions:

- Steep pad edges
- 2 main peaks per pad, addl. microstructure
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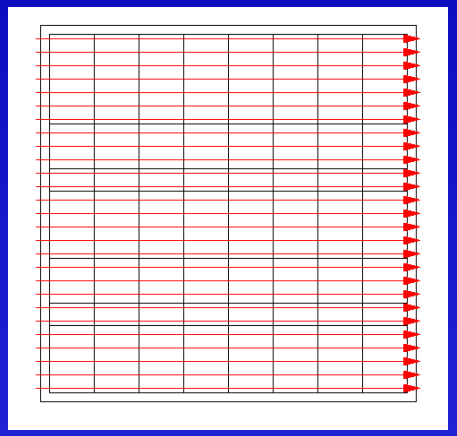
- Factor 2 to 4 difference in pad efficiency
- At pad boundary: charge sharing

Scan of full PMT

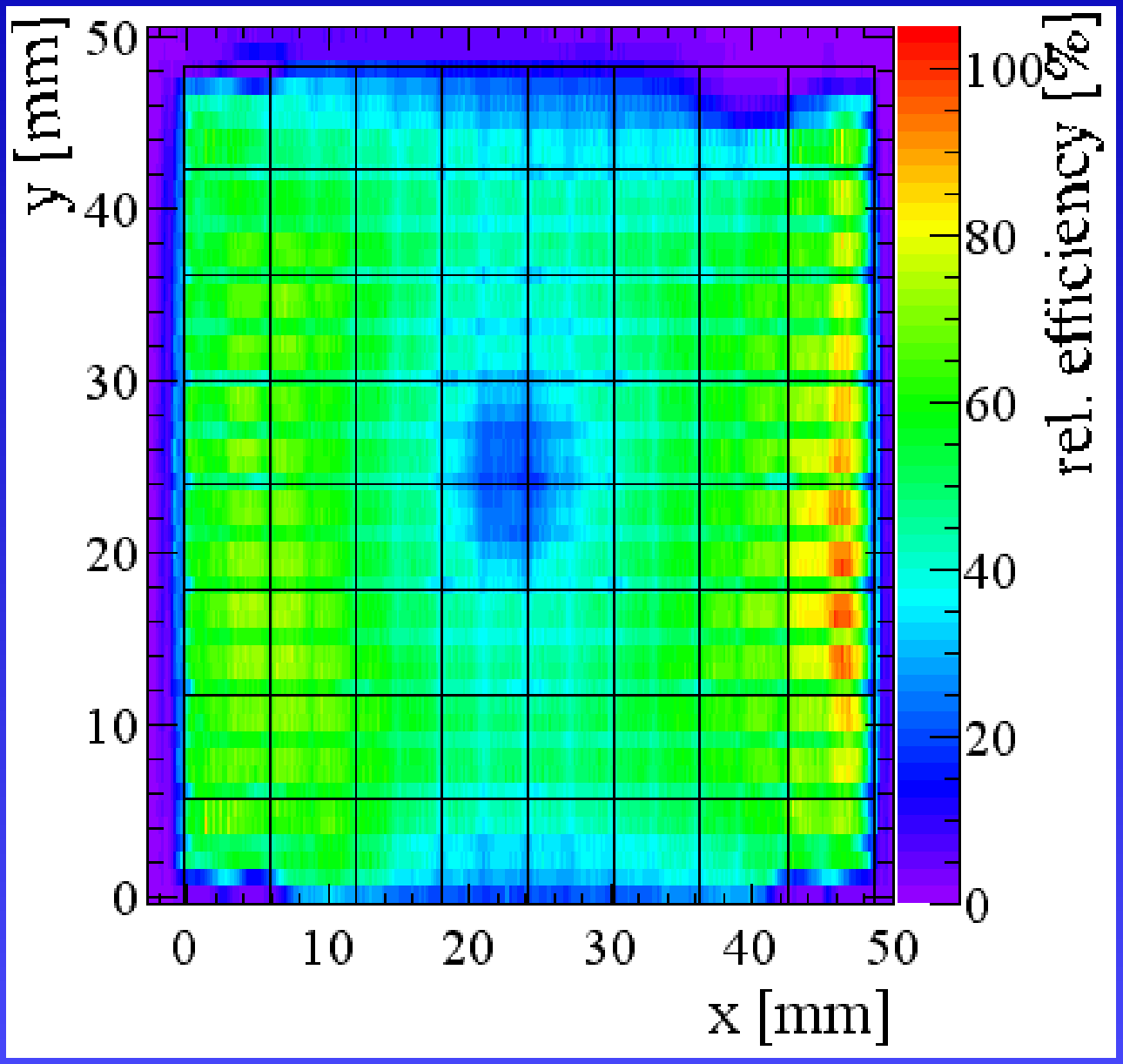


Scan step size:

- 1.0 mm vertical
- 100 μm horizontal

Conclusions:

- Strong variations of rel. efficiency (factor 2-4)



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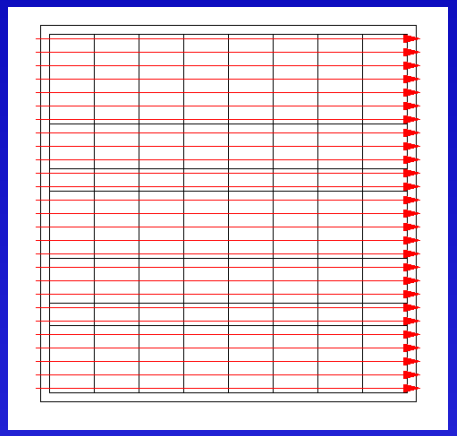
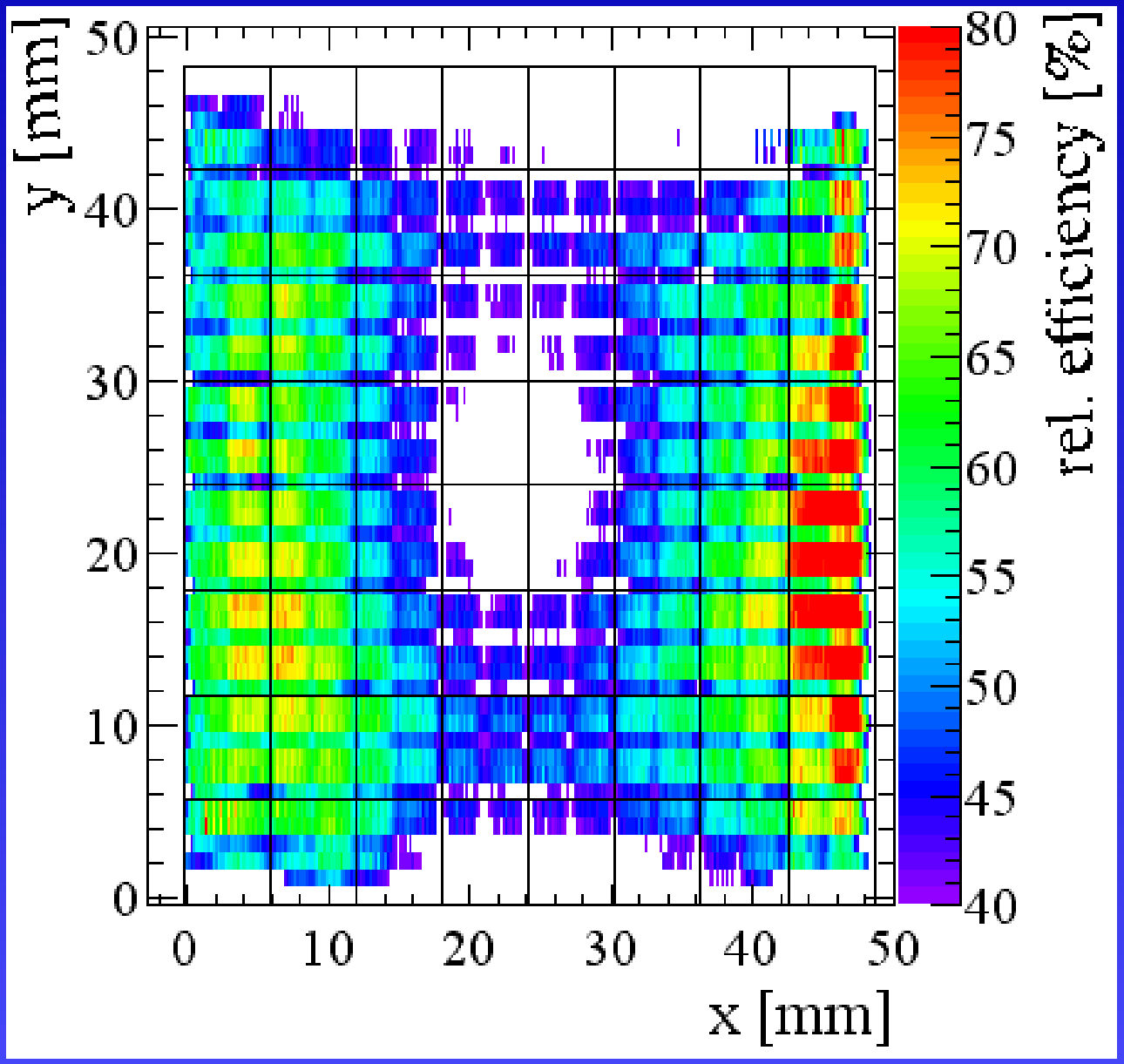


Scan step size:

- 1.0 mm vertical
- 100 μm horizontal

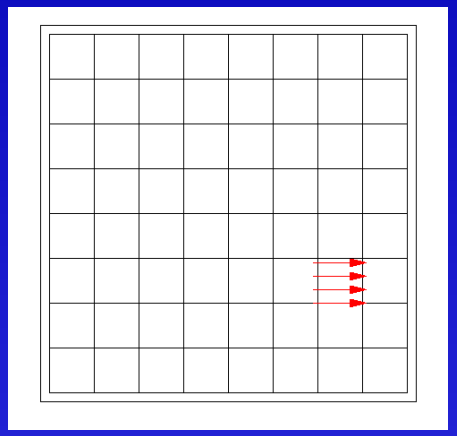
Conclusions:

- Strong variations of rel. efficiency (factor 2-4)
- Obvious pad boundaries
- Pad structure visible



Zoom into z axis

Detailed Scan of one Pad

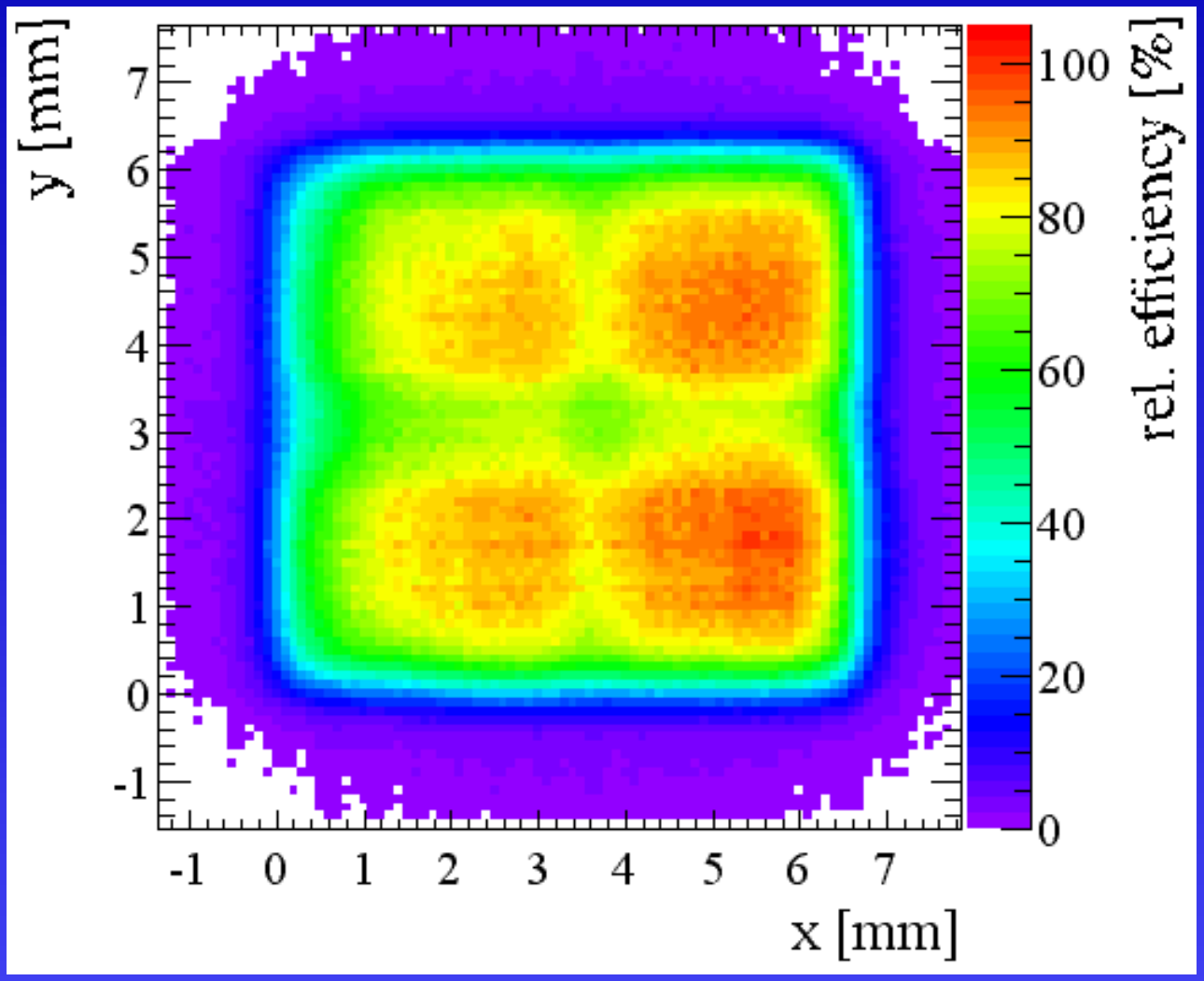


Scan step size:

- 100 μm vertical
- 100 μm horizontal

Conclusions:

- 4 high efficient regions
- Factor 2 variation within pad



Conclusions

- First look at new Hamamatsu H-8500 64-pad flat panel PMT.
- Early pre-production PMT shows good timing resolution (≈ 130 ps).
- Early pre-production PMT shows factor 2-4 rel. efficiency variations.
- Expectations for production: More uniform efficiency.

Outlook

- Repeat measurements with production-type PMT
  (Two newer PMTs are available at SLAC)
- Try different time correcting methods
  (ADC/TDC combination, constant fraction discriminator, ...)

Links

Time Setup
Time Distribution
Motion Setup
Line Scan
PMT Scan
Pad Scan
Single Threshold Time
Time Distribution

Time Distribution

Electronics timing resolution:

- 25 ps TDC

Threshold:

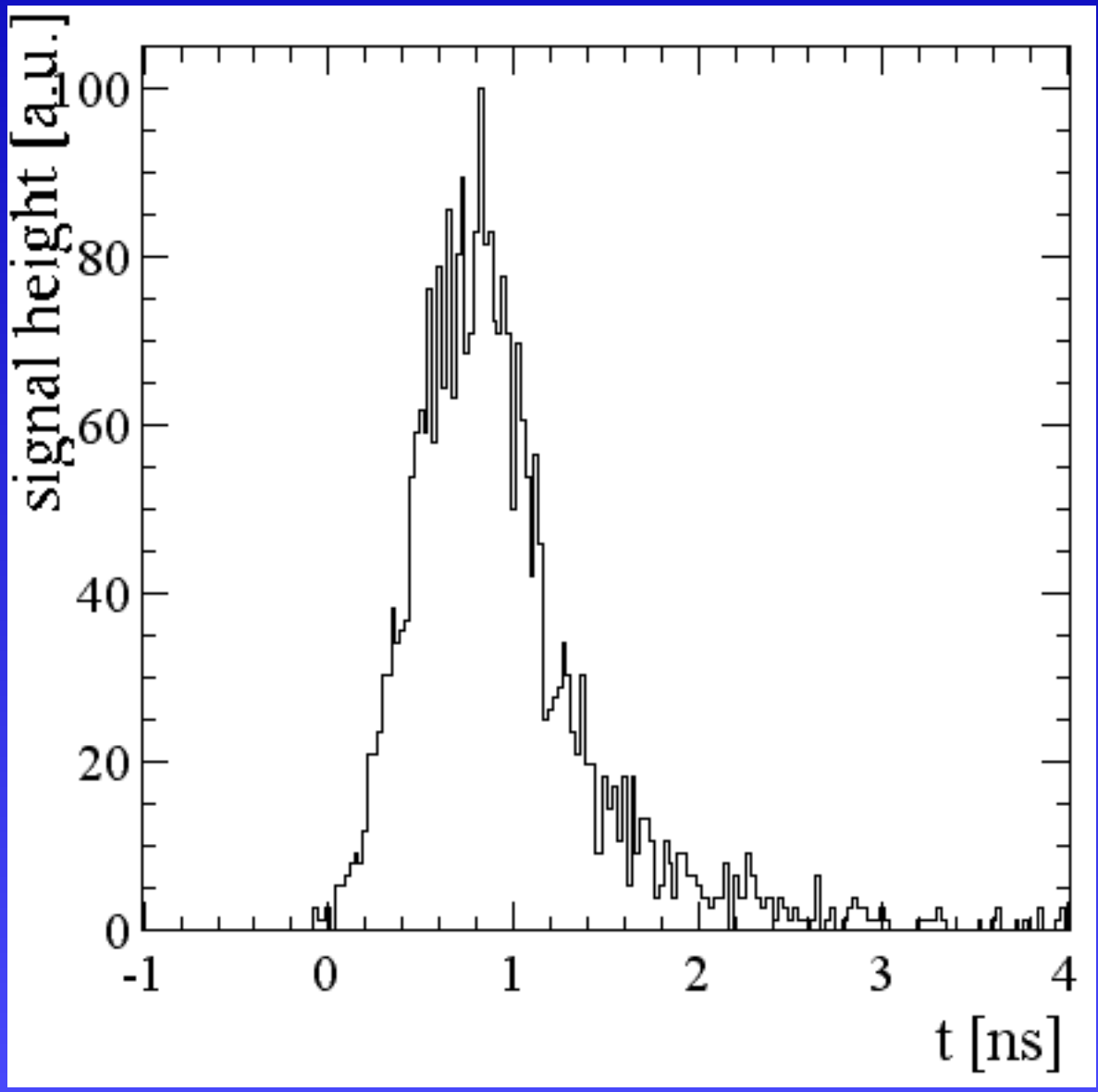
- $\approx$ 30 mV

Notes:

- More low amplitude signals
- No time talk correction
- No correction for laser pulse width

Conclusions:

- Resolution (uncorrected) Double Gaussian fit $\approx$ 300 ps(700 ps)



Time Distribution, 2D

Electronics timing resolution:
- 500 ps TDC

Threshold:
- $\approx$ 15 mV

Notes:
- Readout for two pad broken
- Resolution close to TDC resolution
- No time talk correction
- No correction for laser pulse width

Conclusions:
- Nearly uniform resolution