Development of multi-PMT optical modules for IceCube

Lew Classen • 06. October 2011

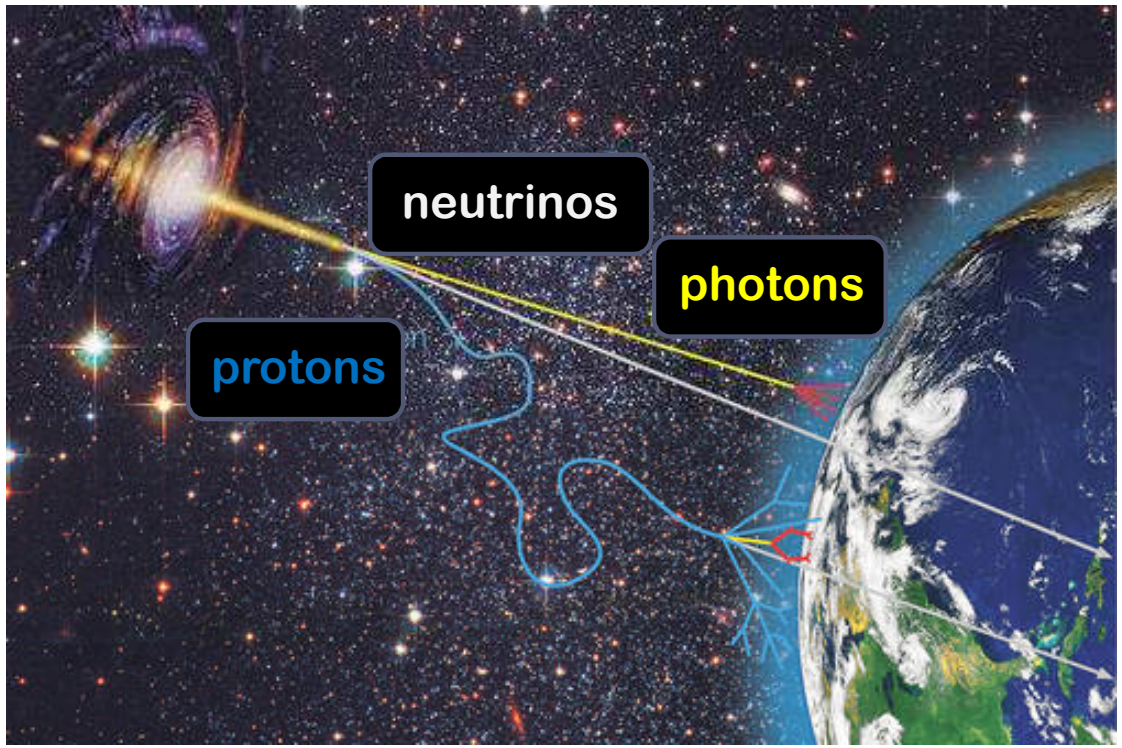
Erlangen Center for Astroparticle Physics

Topics

- neutrino astronomy
- multi-PMT modules
- first measurements

Why Neutrinos?

- initial motivation: **cosmic ray** mystery
- **charged particles** affected by magnetic fields (lose information about origin)
- **photons** absorbed (by dense matter or extragalactic background light)
- **neutrinos** stay unaffected
- point to direction of source

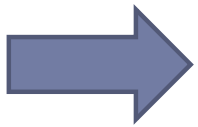


Spiering / DESY

“new eyes” on the universe

Further Goals …

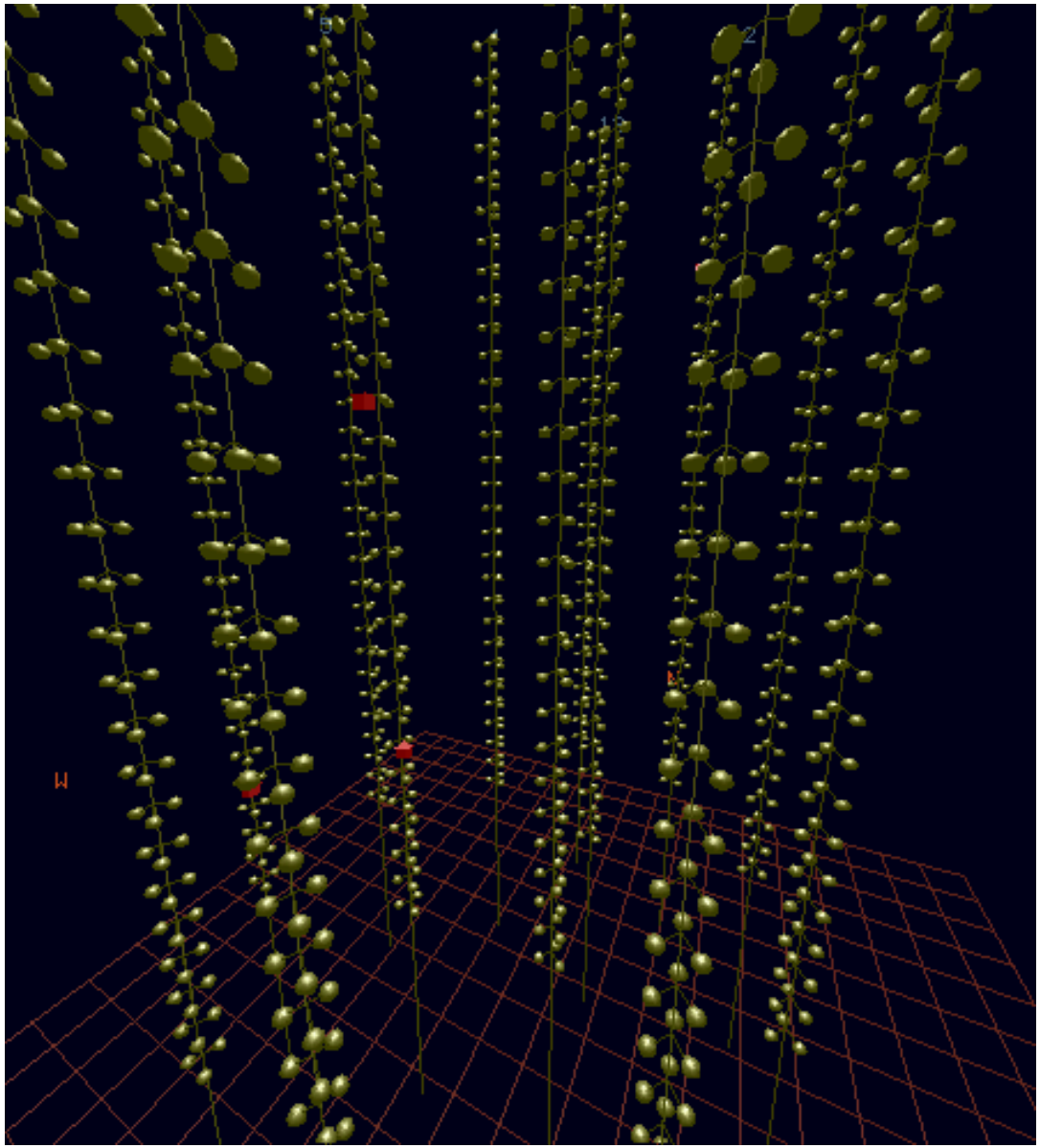
- multi-messenger astrophysics (“new eyes”)
- analysis of gamma ray bursts
- probing dark matter (WIMP annihilation)
- mesurement of neutrino background
- unknown neutrino sources



Good reasons to study neutrinos!

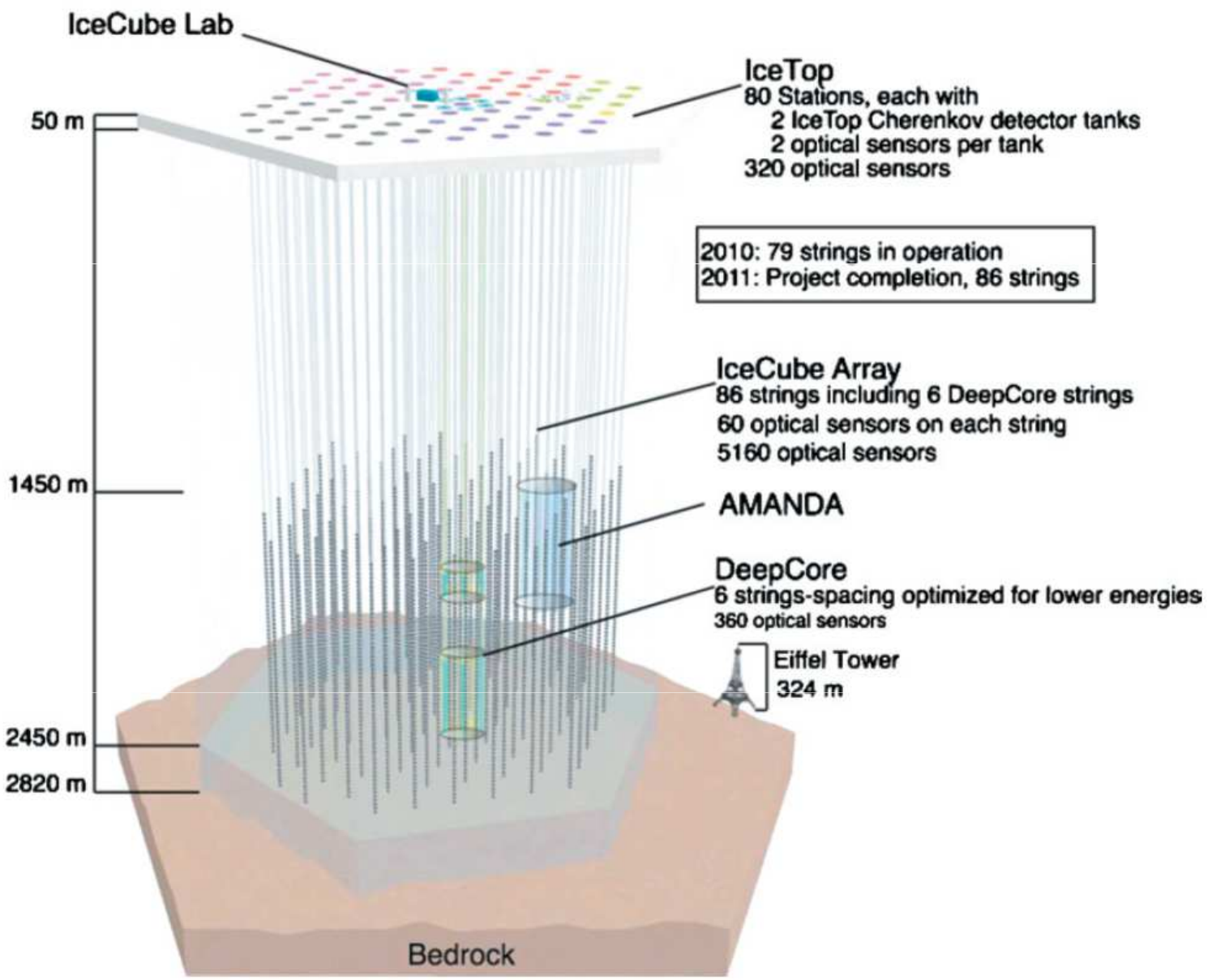
Neutrino Detection

- neutrino interaction in matter (charged or neutral current)
- secondary particles faster than local c
- emission of Cherenkov light
- detection by optical modules
- reconstruction of trajectories and energies



ANTARES Collaboration

IceCube



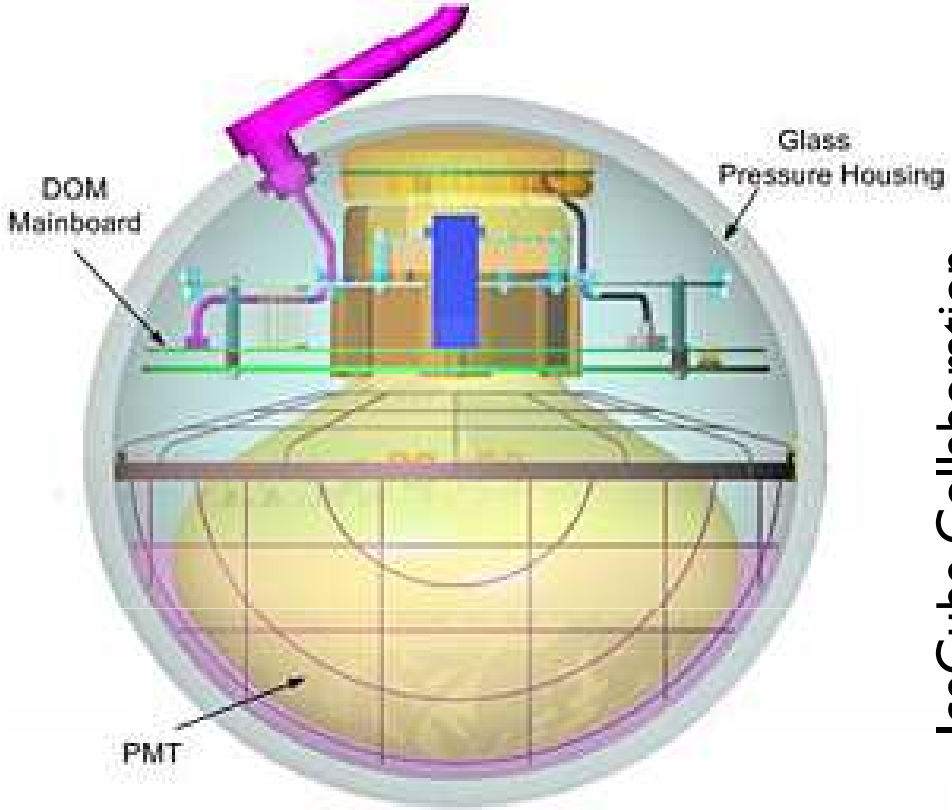
IceCube Collaboration

Topics

- multi-PMT modules

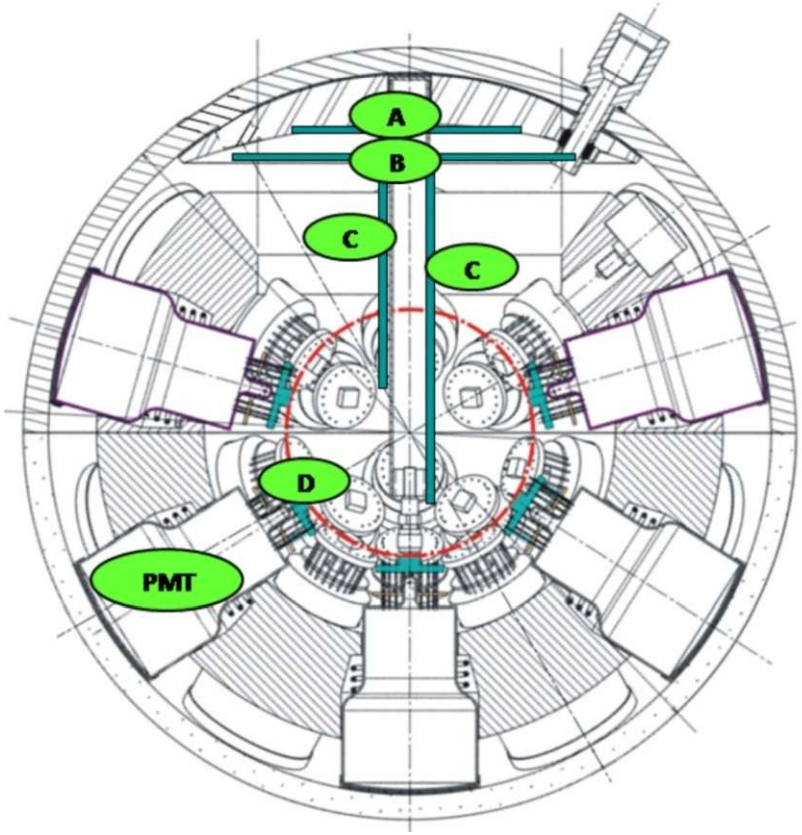
single vs. multi-PMT

Digital Optical Module (IceCube)



IceCube Collaboration

multi-PMT module (KM3Net)



Katz 2010

13" sphere	17" sphere
1 × 10" PMT	31 × 3" PMTs

Advantages of Multi-PMT Design

- increase of **sensor area** (about three times)
- bigger angle of signal **acceptance** (nearly 4 π)
- improved determination of **photon number** (from number of hit PMTs)
- **direction sensitivity**

Kooijman 2010

superior to single PMT modules

Multi-PMT for IceCube

- expected energy limit of DeepCore: ~10 GeV
- energy limit using multi-PMT modules: ~10 MeV!

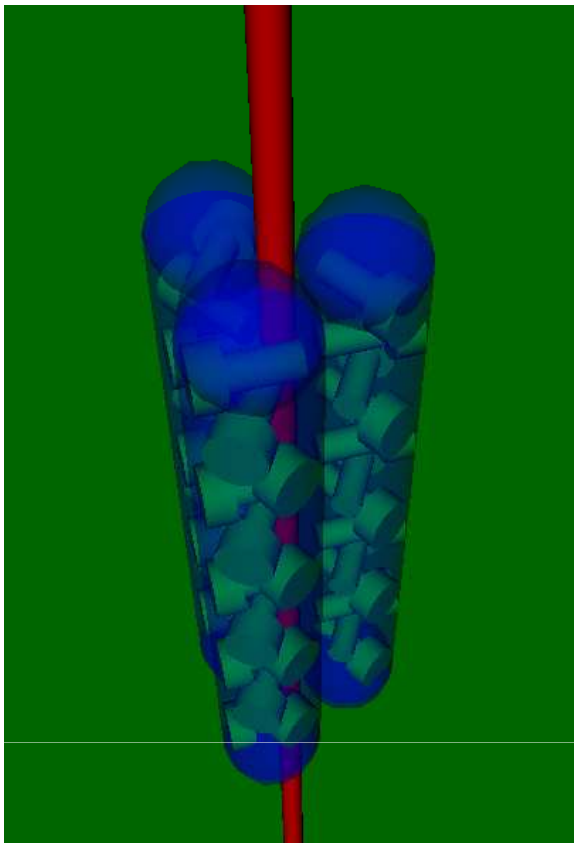
BUT…

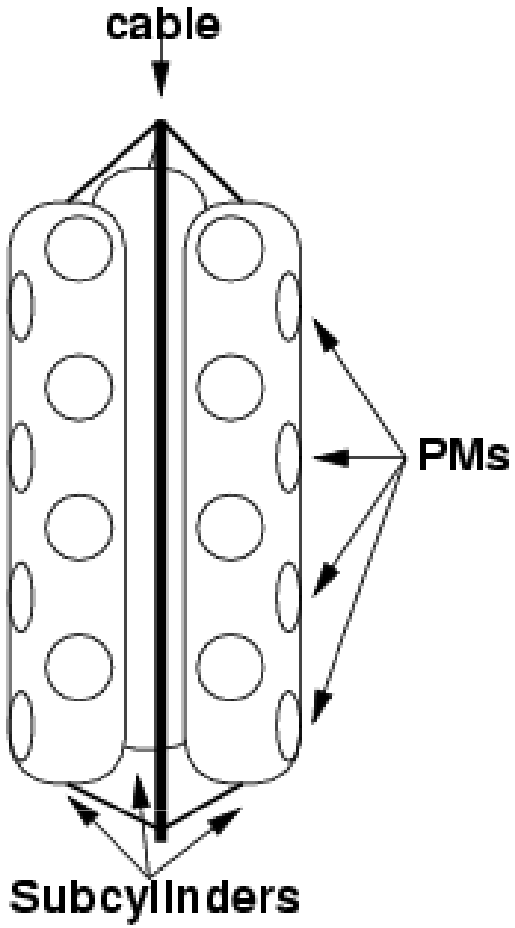
- multi-PMT modules designed and tested for KM3NeT
- housed inside 17 inch glas sphere
- maximum diameter of IceCube modules: 13 inch!

→ **development and test of new module layout**

Possible New Design

- review of abandoned KM3NeT layout





KM3NeT Collaboration

cylindrical modules

Topics

- first measurements

Photomultipliers

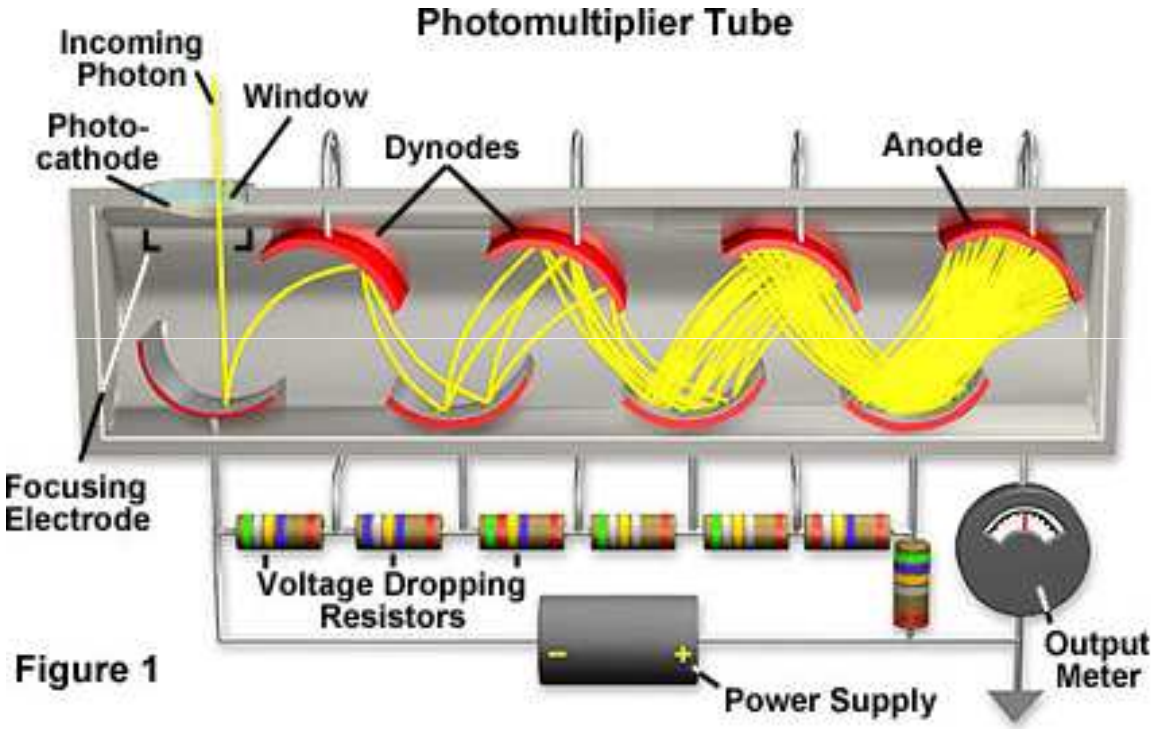


Figure 1

HAMAMATSU

test of PMT prototypes and analysis of important characteristics

Photomultipliers

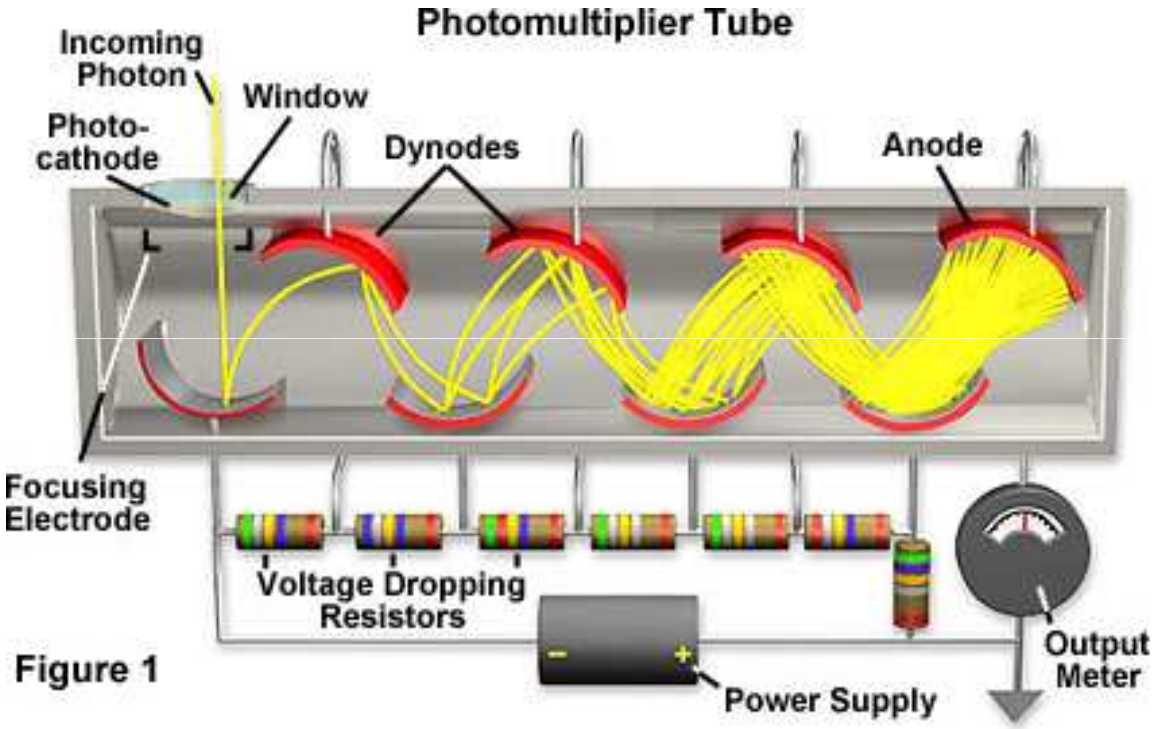


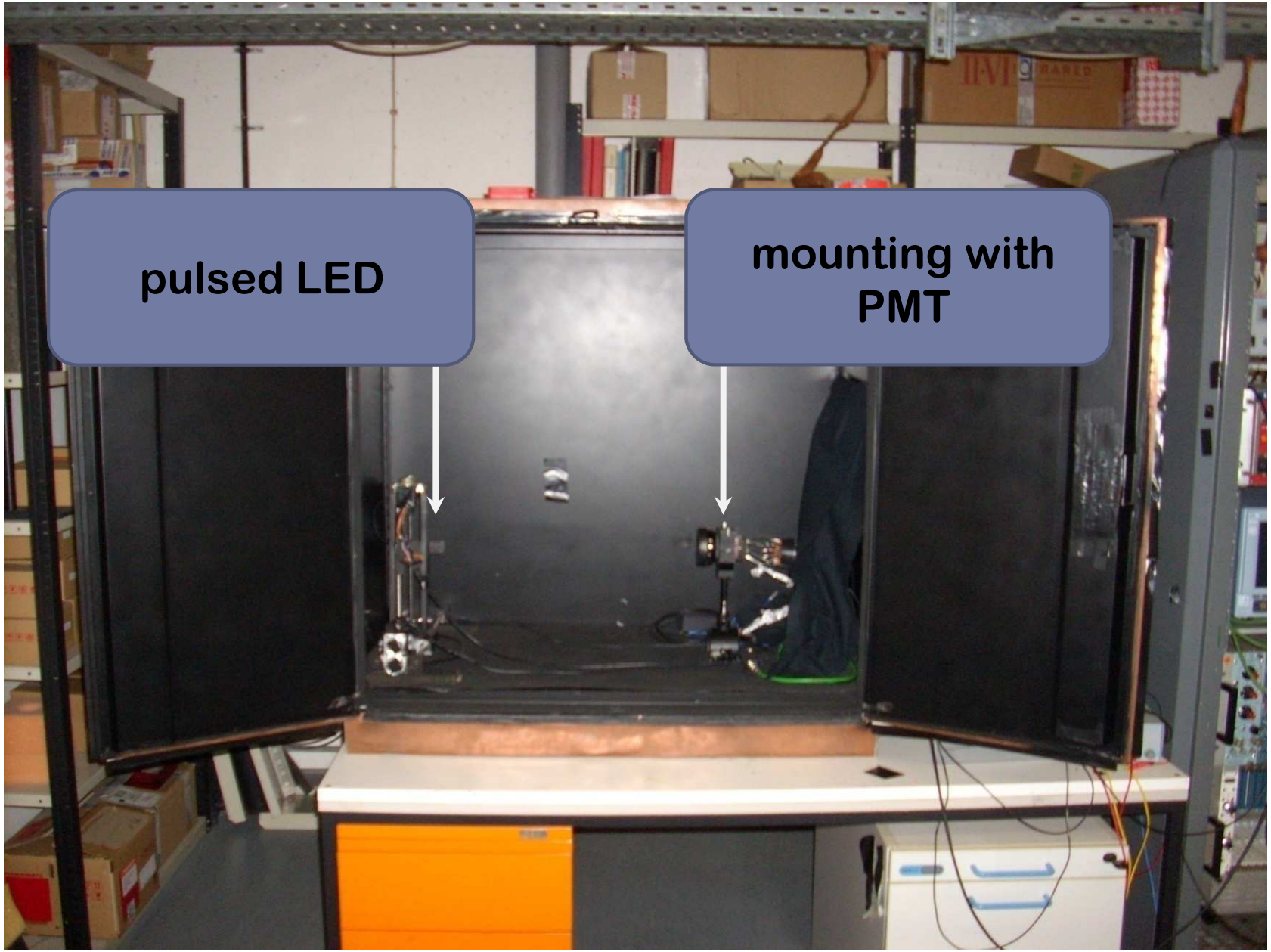
Figure 1

HAMAMATSU

- test of PMT prototypes and analysis of important characteristics
- first: amplification factor of single electron signal

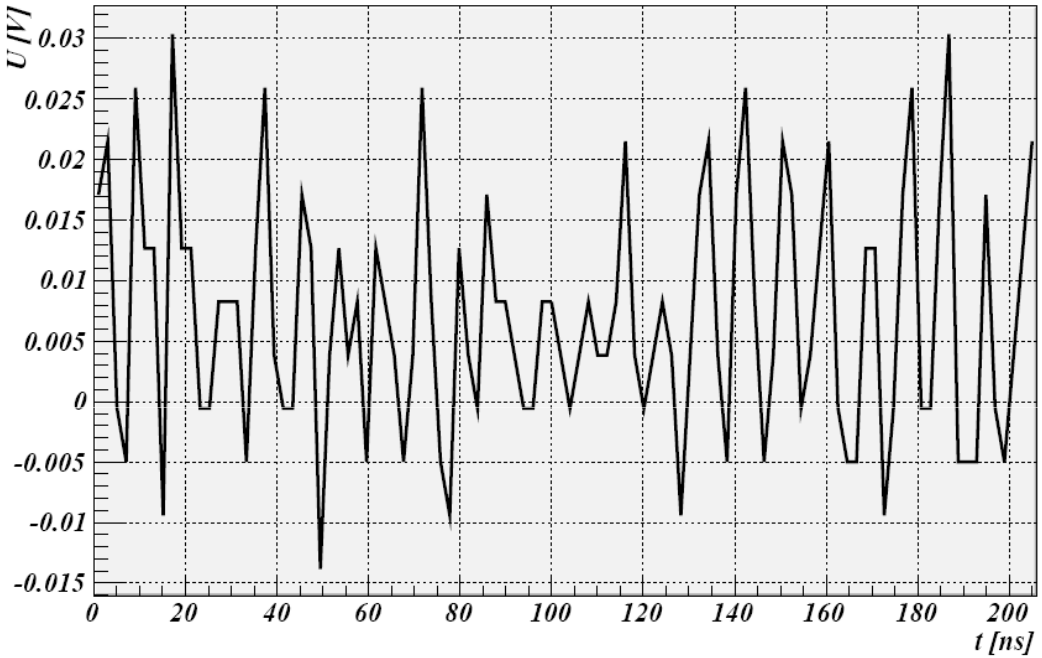
Experimantal Set Up

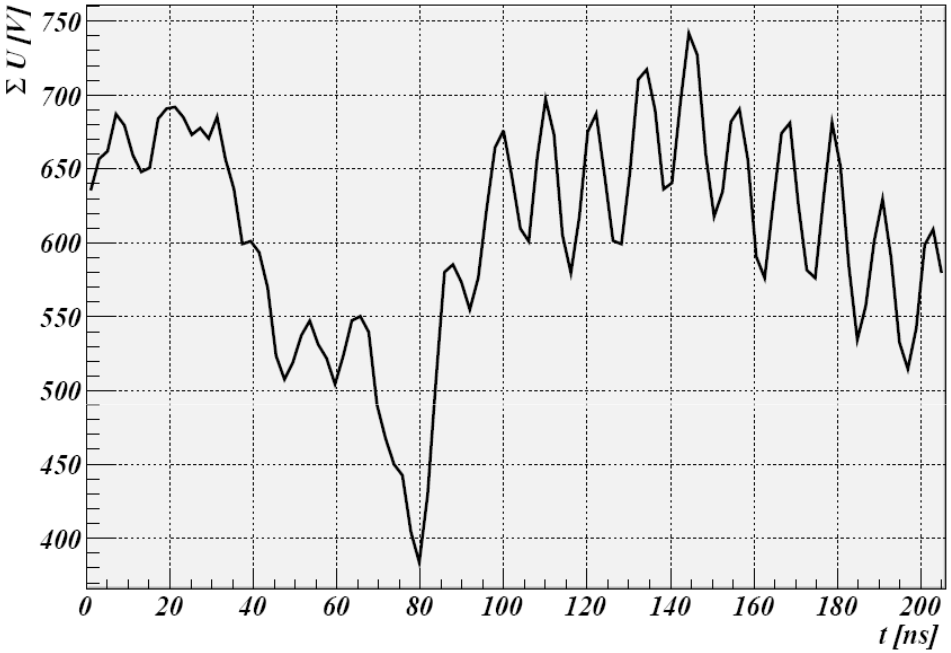
Experimantal Set Up



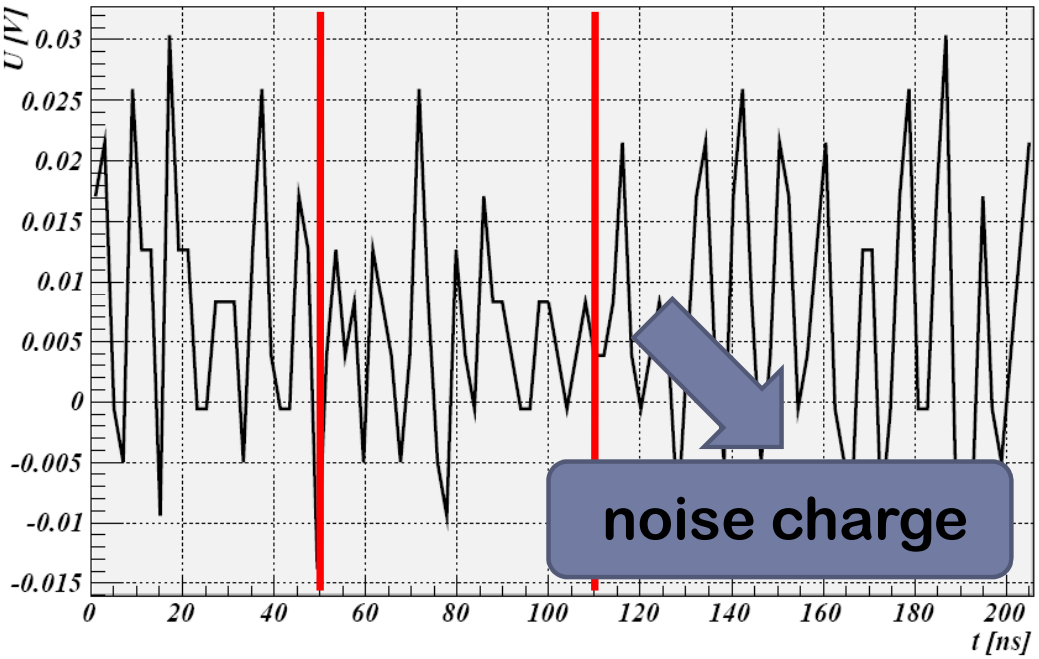
Gain Measurement

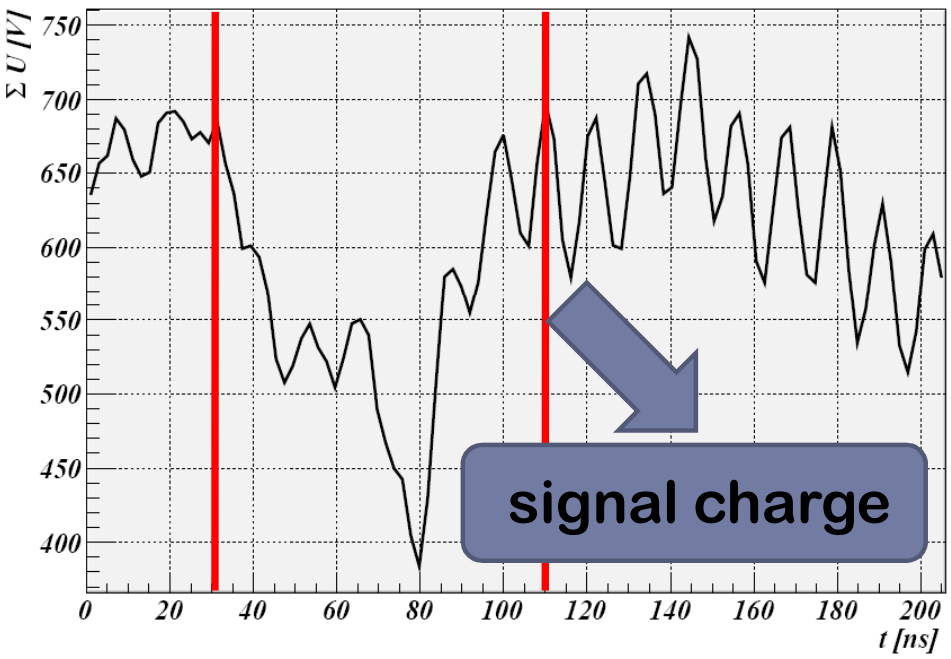
- "observation" of pulsed LED (synchronised with LED frequency)
- record of voltage-time loop (waveform)
- mostly noise, sometimes signal





Gain Measurement



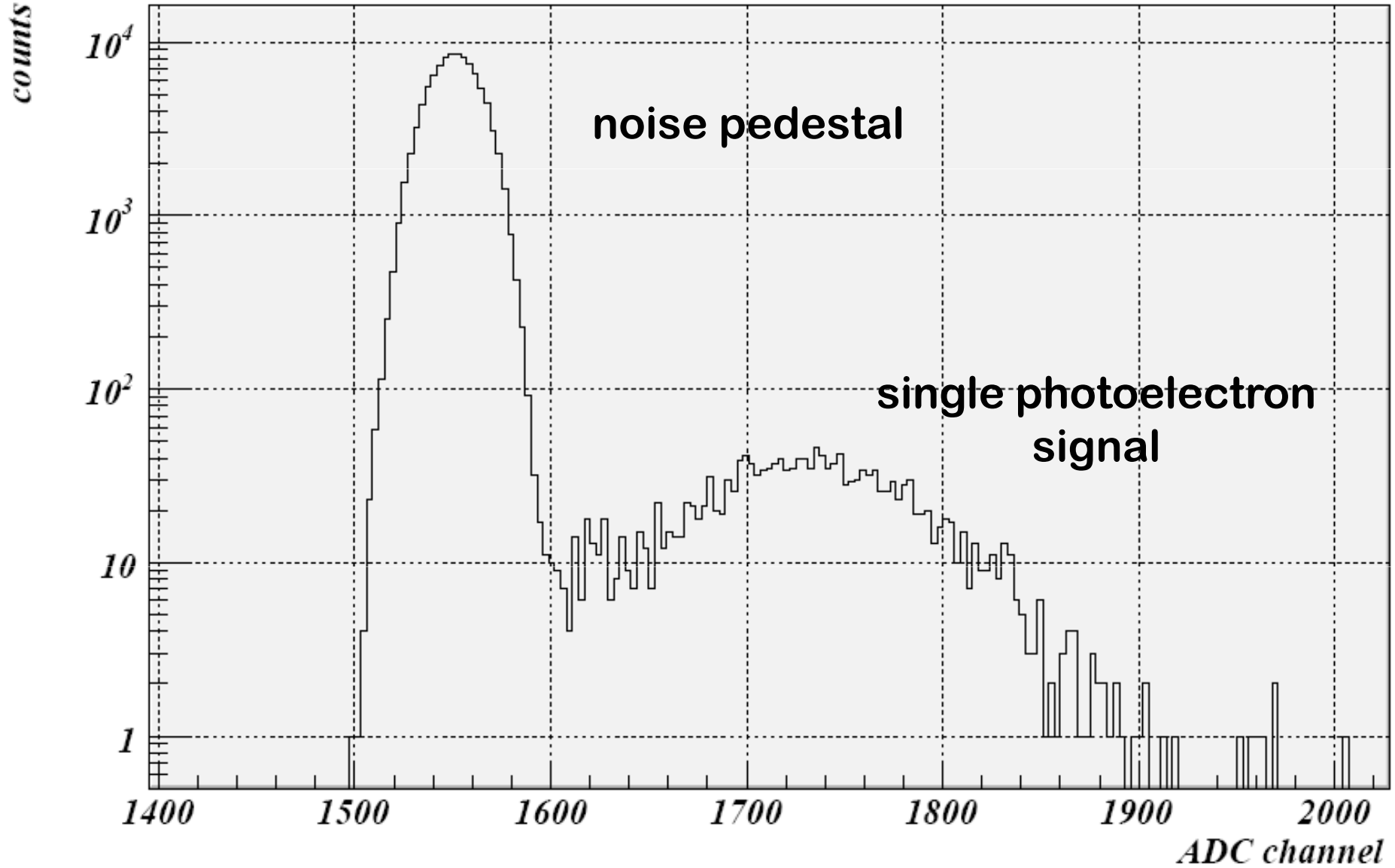


- identify signal timerange
- calculate current, integrate area

derieve charge distribution

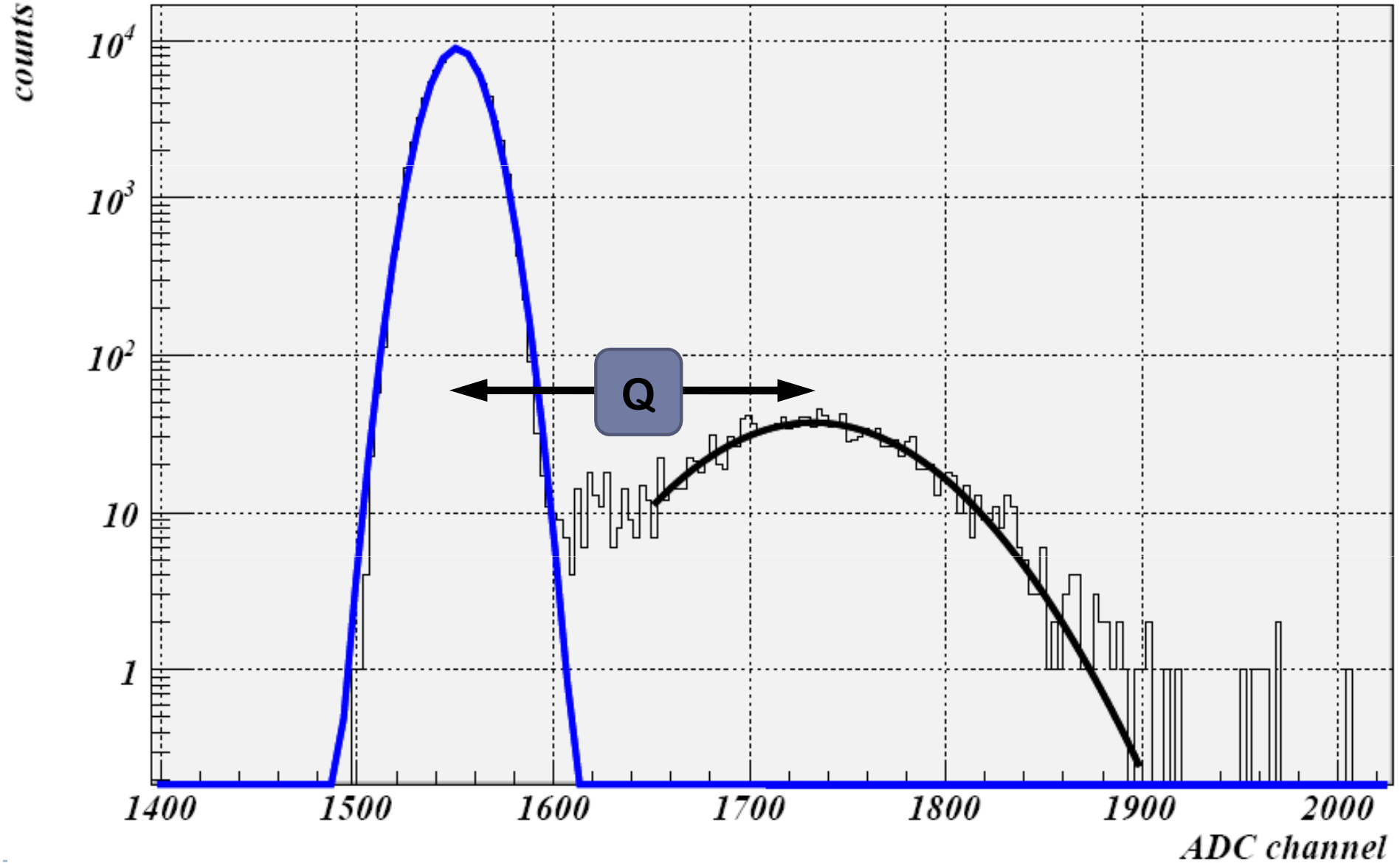
First Results

- distribution of integrated charges



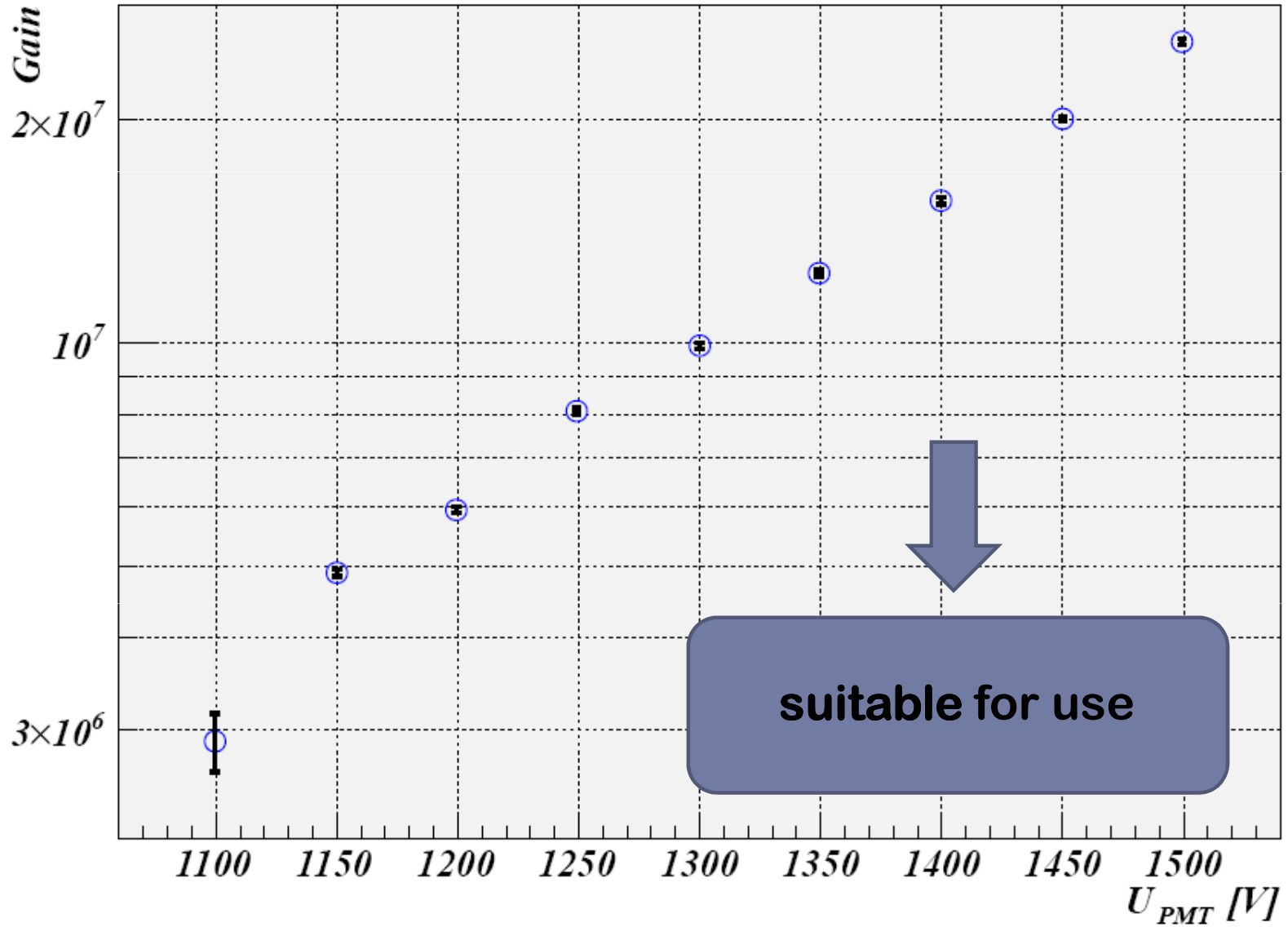
First Results

- fit of distributions, calculate real charge at last dynode



First Results

- single electron gain for different PMT voltages



Coming Soon …

- measurement of further characteristics

  - quantum efficiency
  - arrival time spread
  - …


Thank you very much for
your attention!