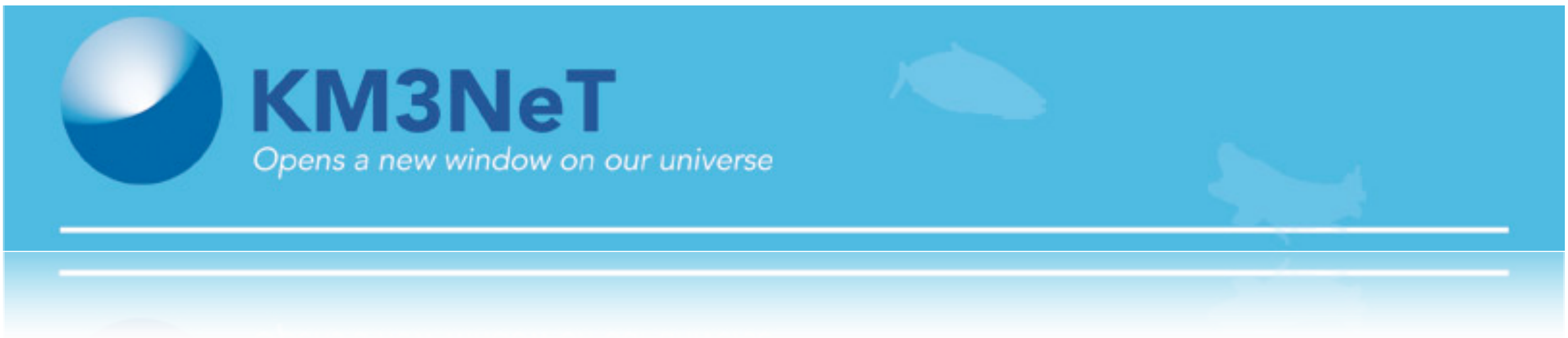
# Time Calibration Tools for KM3NeT

IFIC-Valencia, University of Sheffield, University of Leeds

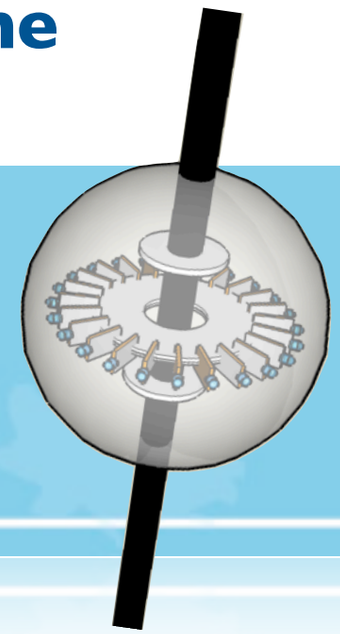


# What has been learned from pilot projects?

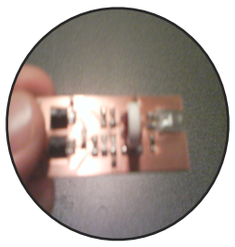
- Experience from ANTARES has shown that a system of **external sources** is very useful to **ensure** the **timing calibration of** the **detector** and measure water optical parameters
- The main use of this system is to **measure PMT** time **offsets** through intra-line calibration **with LED beacons** along the same detector line
- **Inter-line calibration** with LEDs is also possible but is **more challenging** due to movement of the lines, for this case the use of lasers could be an alternative to LED beacons
- **Synchronising** timing **offsets** between beacon elements **is cumbersome** and time consuming
- Providing **trigger** signals **introduces unwanted** electrical **noise** to system

# Proposal

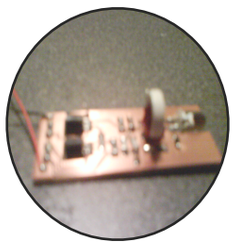
- **De-couple** the intra/inter line calibration
  - Allows a **cheap**, **basic** intra-line calibration **option** - upwards pointing, single LED pulser, housed **inside all OMs** (optimises production line efficiency)
  - **Inter-line** calibration **requires less redundancy** - side emitting sources in dedicated housing **1-2 beacons per line**



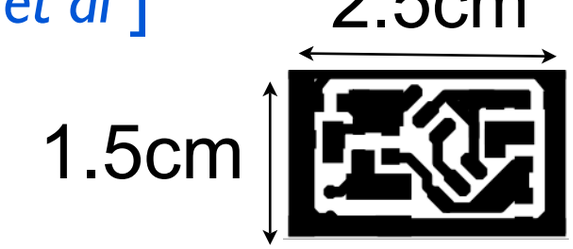
# Technology available



- The ANTARES pulser has been shown to facilitate the **transmission** of pulses **up to 200m** in situ, **using cleaved LEDs**

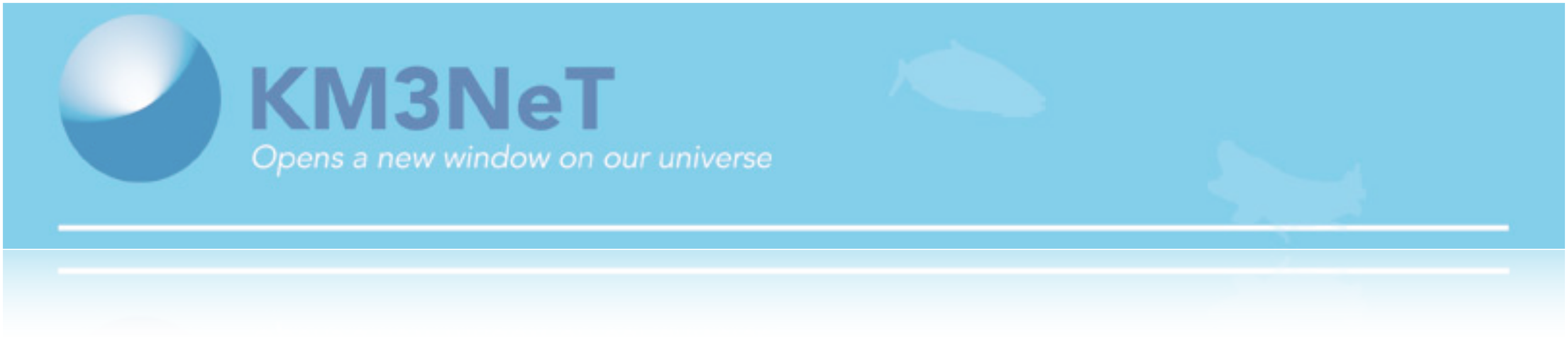


- An alternative circuit has been developed that offers at least as much light and **does not require** an **external trigger,** operating nominally at 24V, 25kHz and requiring only an On/Off interface [ doi:10.1088/0957-0233/18/1/016 Veledar *et al* ]
  - This is foreseen to be the **default solution**



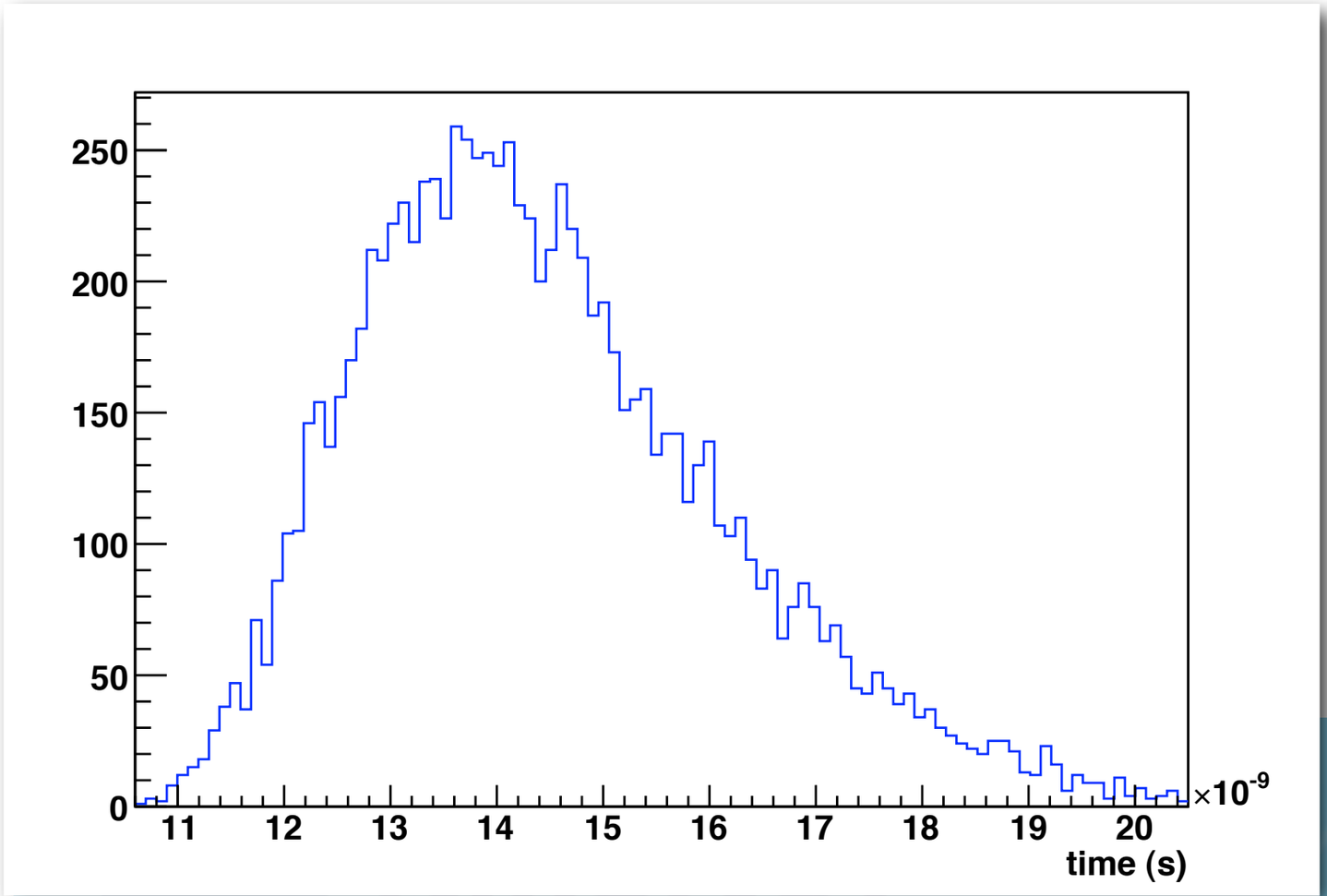
# Typical performance

- **Several transistors/LEDs** available that **offer < 2ns rise time** and equivalent or greater intensity than ANTARES pulser
- Possibility to **control frequency/intensity via** supply **voltage**
- **Variability** between LEDs and circuit tolerances **not critical** in single LED system & no need for lab-based synchronisation



# Typical performance






- 2SA1403/2SC3597 HLMP-CB15 (measured using single photon coincidence)
- pulse rise time1.78±0.14ns, FWHM ~6.8ns
- Increasing supply voltage from 24V to 48V yields from 4.5E7 to 1.5E8 γ/pulse

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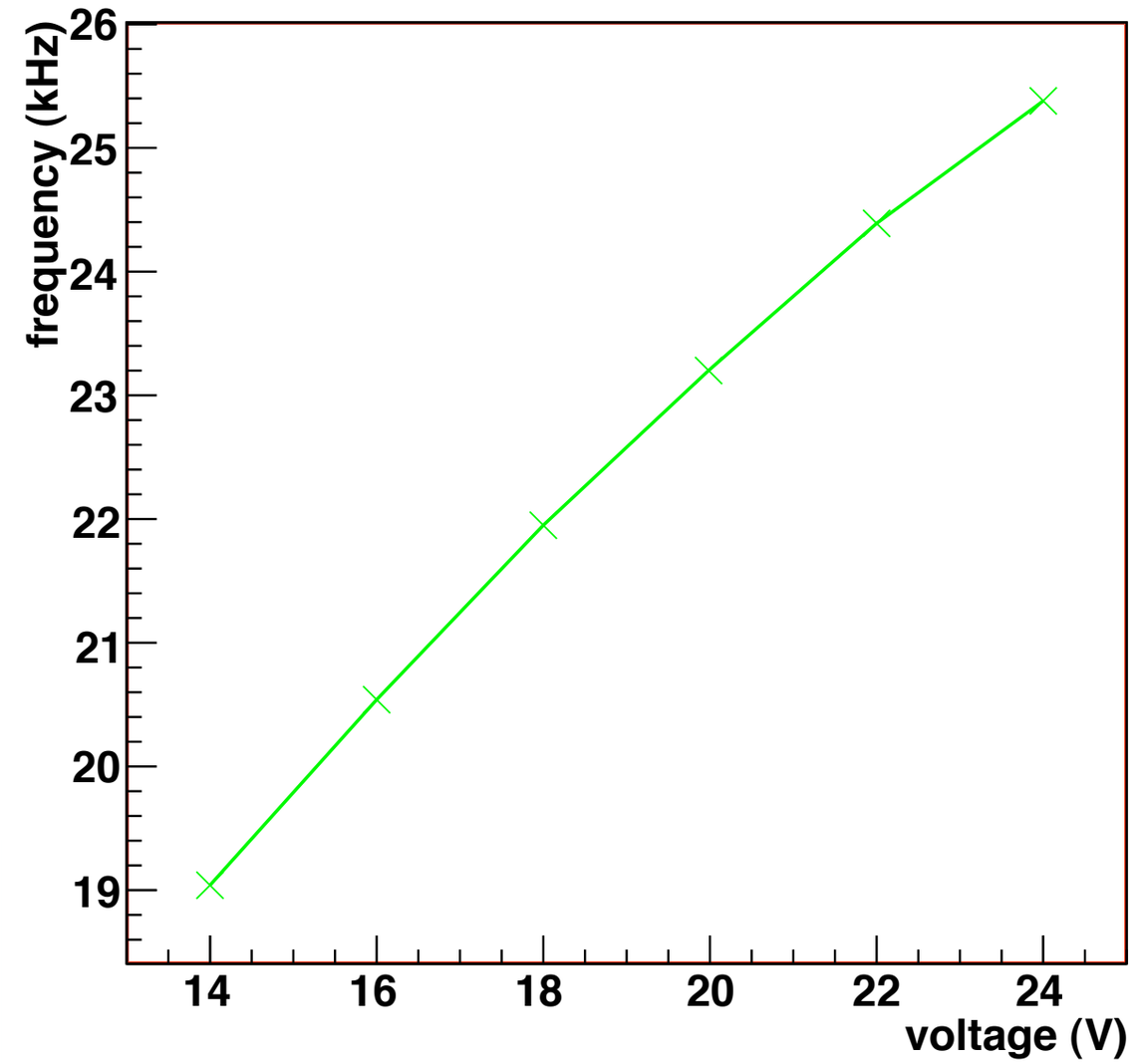
# Typical performance

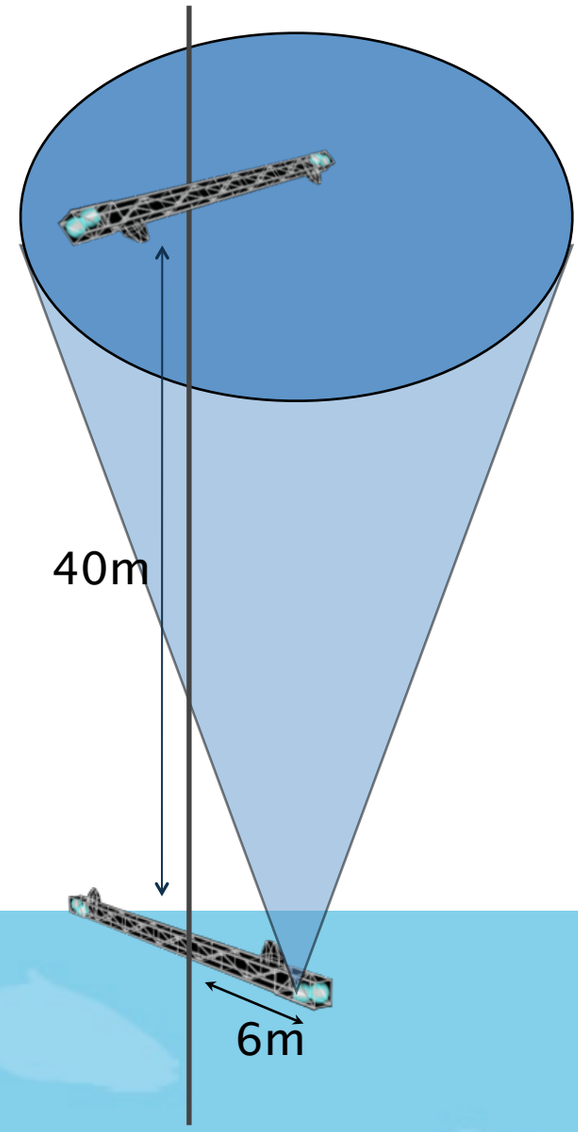
2SA1206/2SC2901

- **Frequency** of circuit oscillation as well as intensity/pulse shape **depends on** supply **voltage**
- **~15% variation** of rise times **between boards** [c.f. 15-20% LED to LED differences]



# Geometry

- A **15°**opening angle **is sufficient to illuminate OMs** above the beacon even in perpendicular arrangement (NEMO) including potential misalignment (<10°)
- Retaining lens increases received intensity by **~50x** over the cleaved LEDs...

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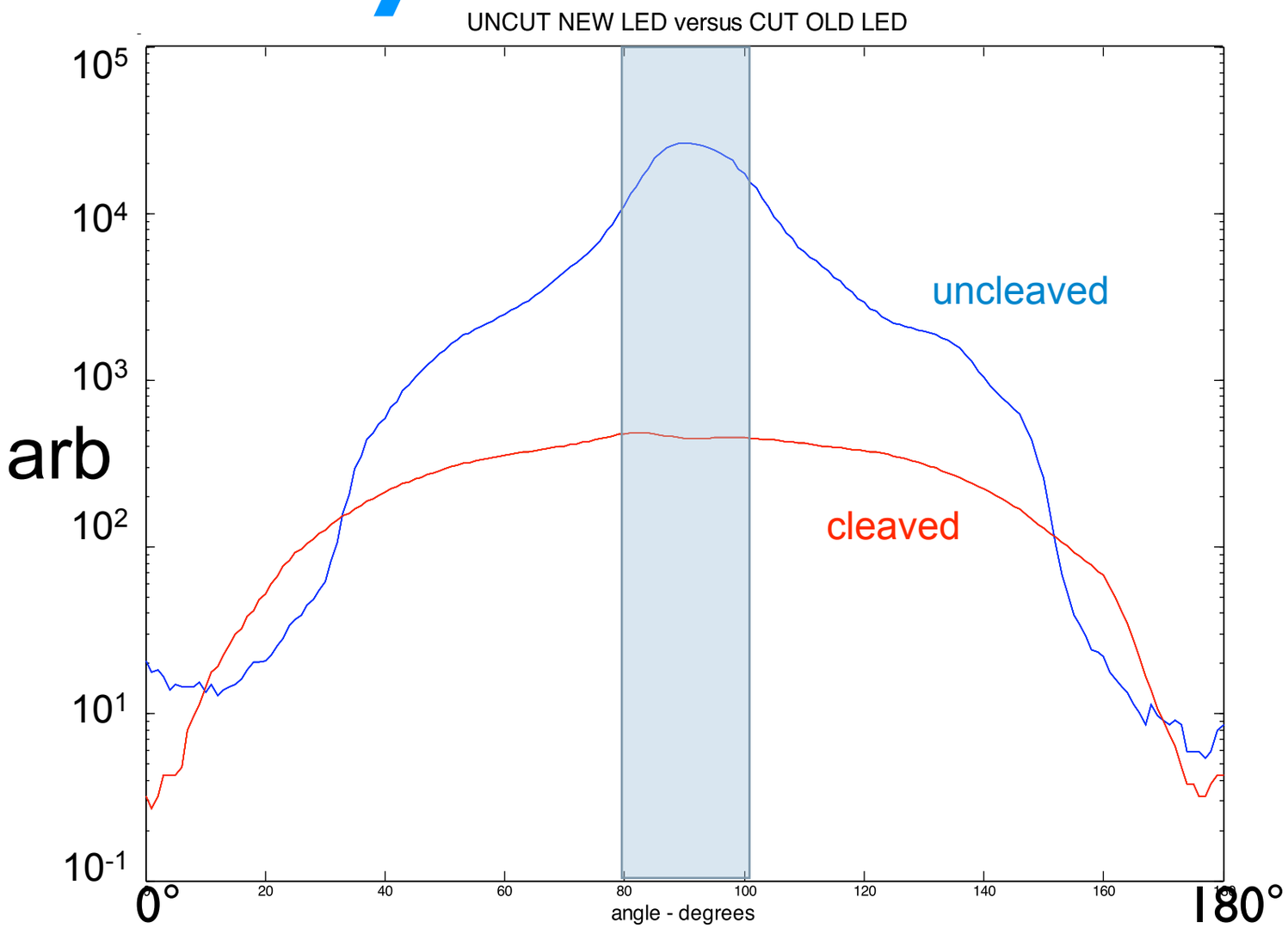
# Geometry




In the peak region (+/- 10°) non-cleaved LEDs emit ~50 times more light

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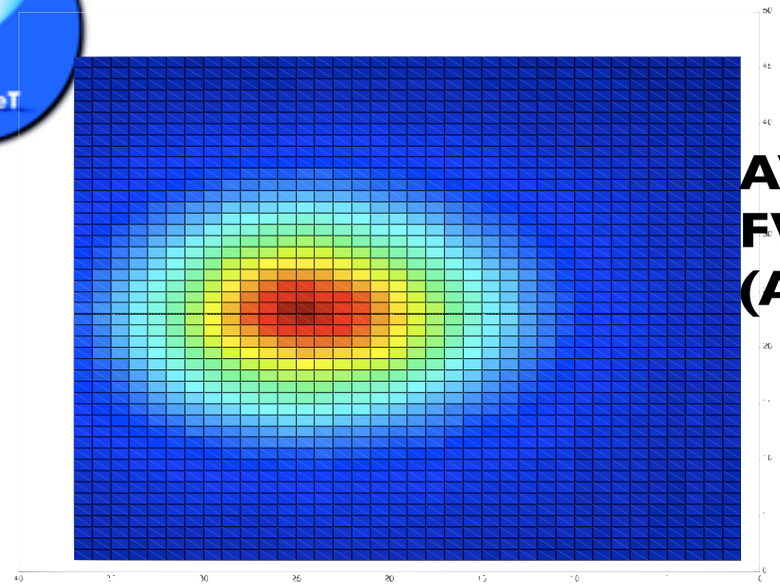
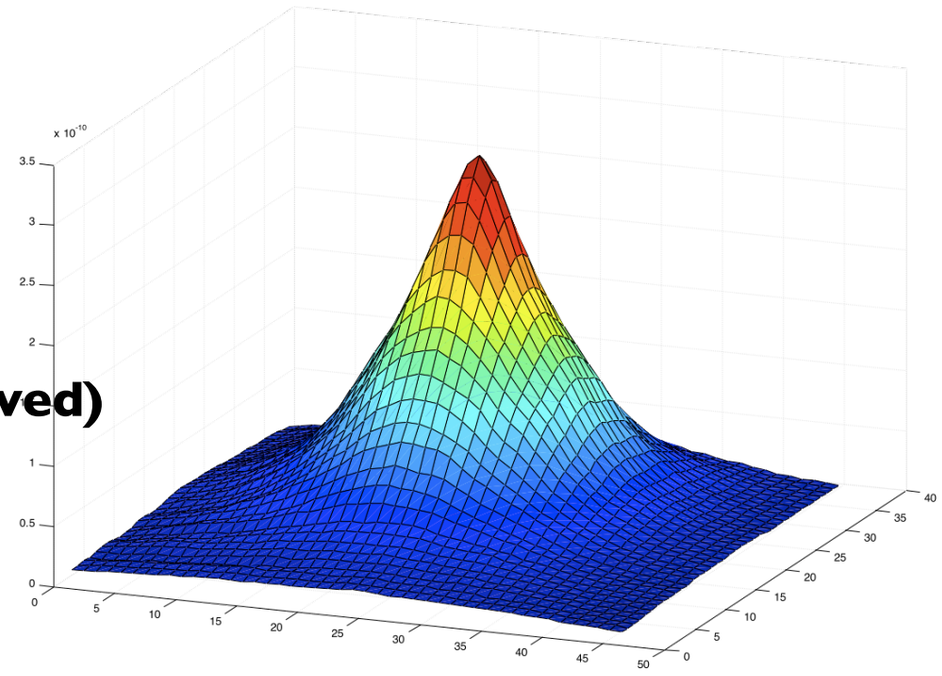
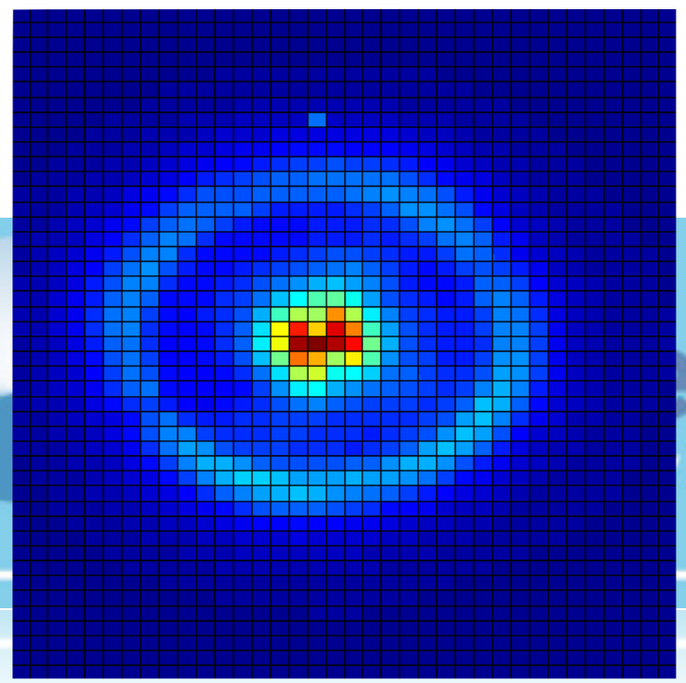
Time Calibration



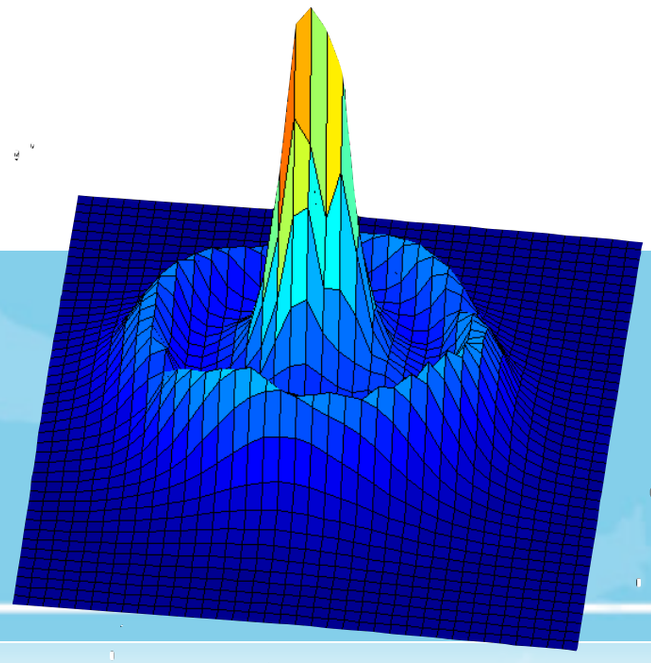
**AVAGO-CB15**
**FWHM at 15°**
**(ANTARES uncleaved)**




**Different** kinds of uncleaved **LEDs** are **under evaluation** - specifically their angular distributions and intensity

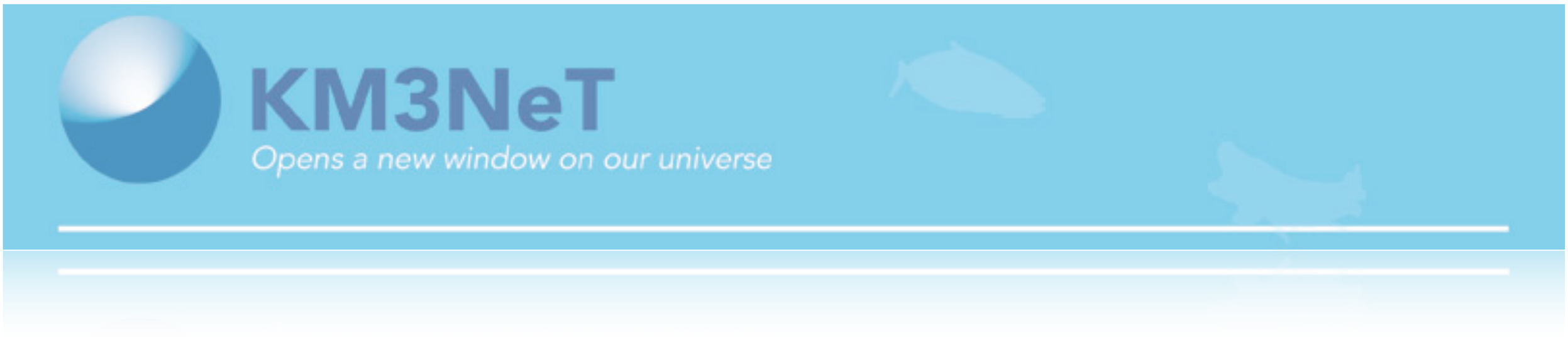


**AVAGO-CB11**
**FWHM at 7°**



# Interface with main infrastructure

- Self oscillating circuit **interface should facilitate**:
  - flashing all pulsers in tandem
  - one at a time
  - several at once
    - **i.e. pulser control system**
- 24V controllable DC power supply for in OM pulsers, 24V DC/ pulser in inter-line beacons
- Require trigger system to accept (and not reject) LED signals



# Conservative cost analysis

Two different possibilities are under evaluation for the implementation of the inter-structure calibration system

**1.- Integration in the OM**

Internal Mechanics: 50 €
Mounting and testing labour hand: 50 €
**Total <100 €/unit**
**<200 €/unit** if dedicated electronics necessary

**2.- Integration in a 13 inches glass sphere**

Glass sphere: 500 €
Internal Mechanics: 200 €
Electronics: 300 €
Testing: 100 €
Mounting and testing labour hand: 100 €
**Total <1200 €/unit**

Pulsers situated inside OMs represent most cost effective solution

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Cost estimated from ANTARES components (probably overestimated for large scale production)

# Still to study (with other WPs)

- How much light reaches PMTs in same OM?
  - may need optical shielding
  - or may want fibres to PMTs
- What is the effect of electrical noise introduced by the system?
- What is the mean charge per pulse, at large distances observed by ANTARES?
- Confirm via MC that 2ns time offset precision is still valid

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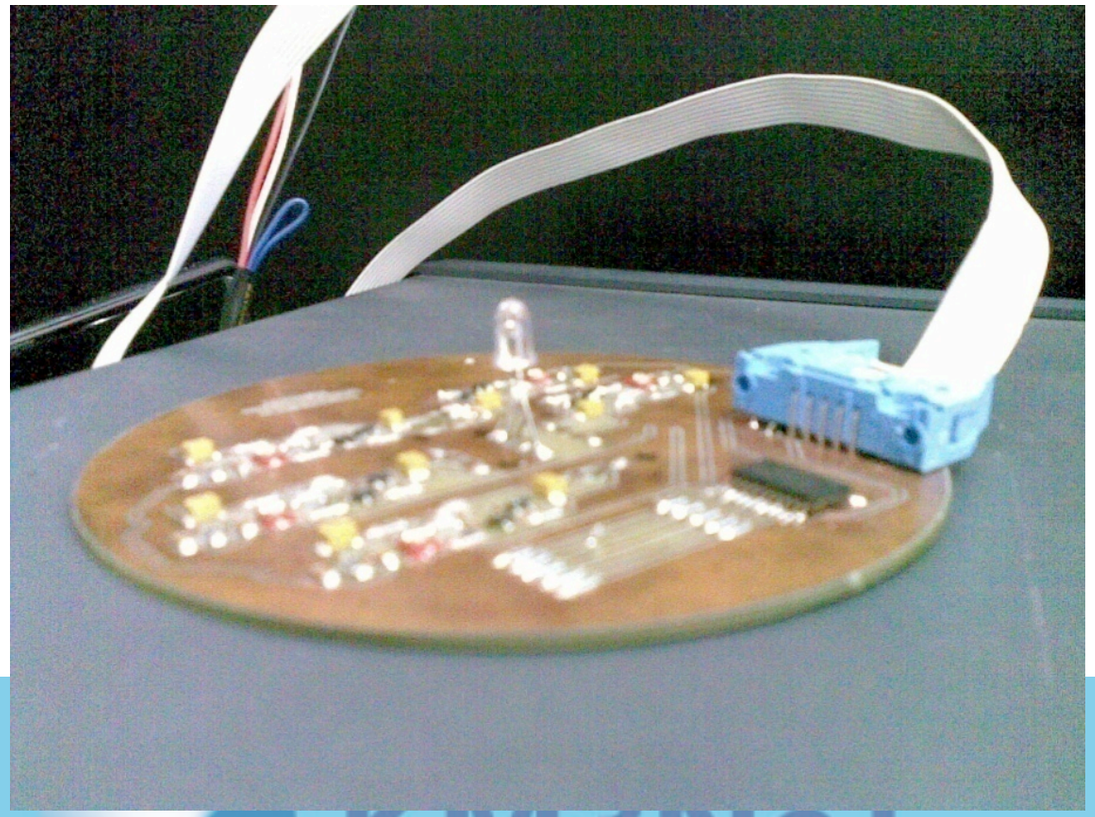
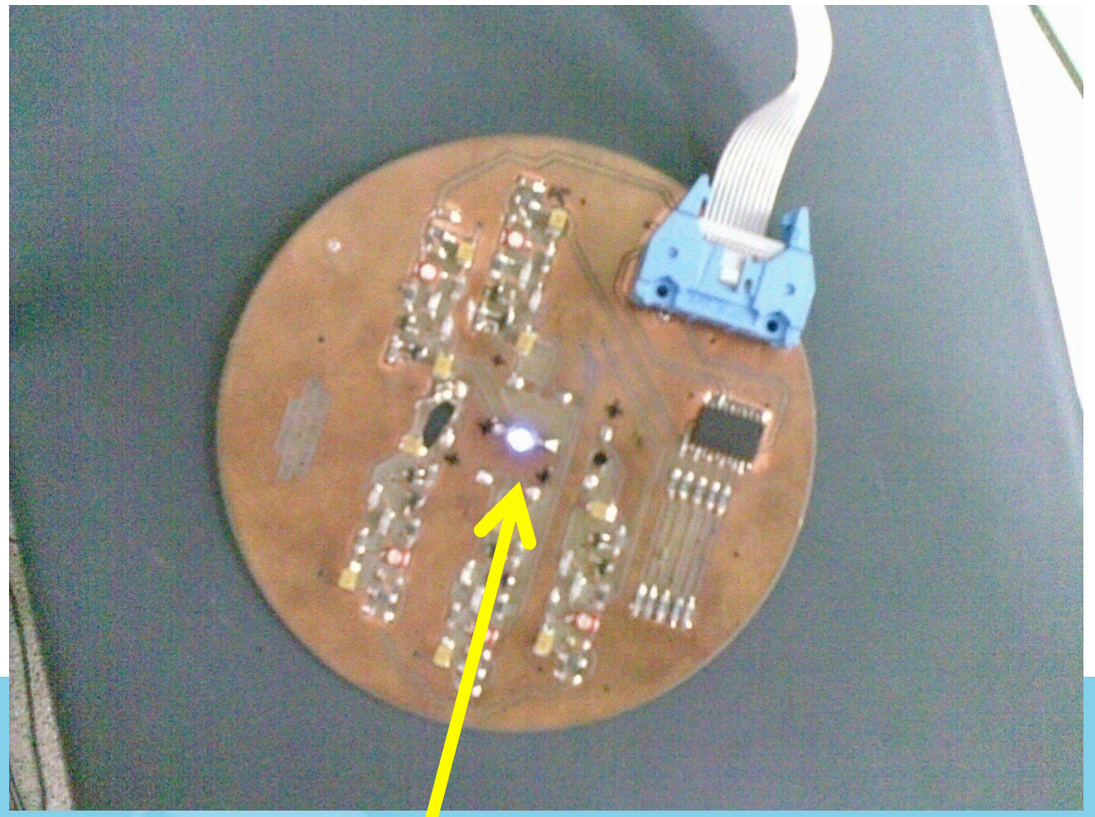
Progress can only be made in collaboration with Mechanics and OM groups

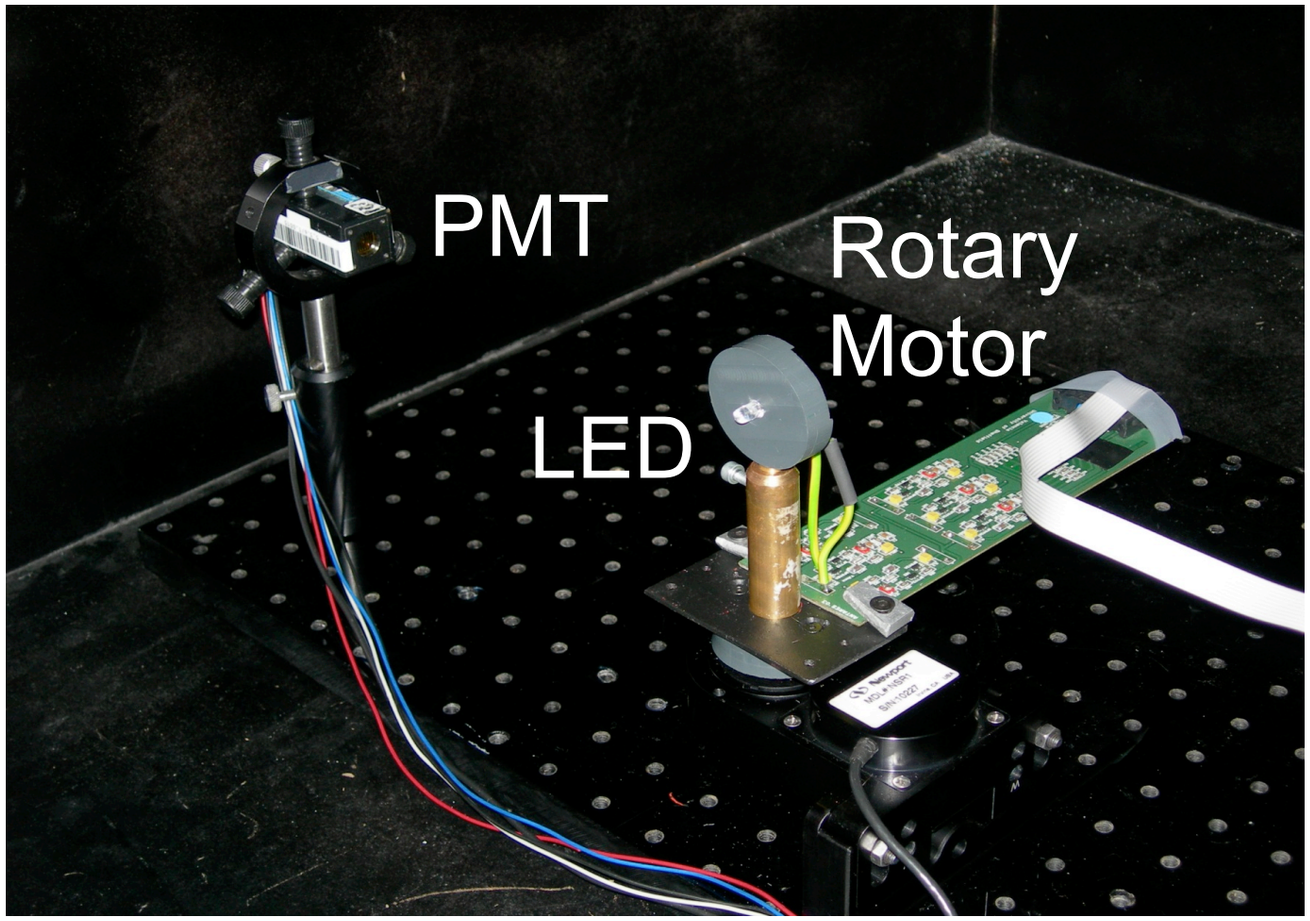
Already some preliminary electronics design under development:





# LED TEST BENCH: XY Table, measuring the 3D intensity surface

# LED TEST BENCH : Measuring the LED angular distribution

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