LEDs as Pulsed Light Sources

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LED Pulsers

- Use an LED rather than a laser as a light source.

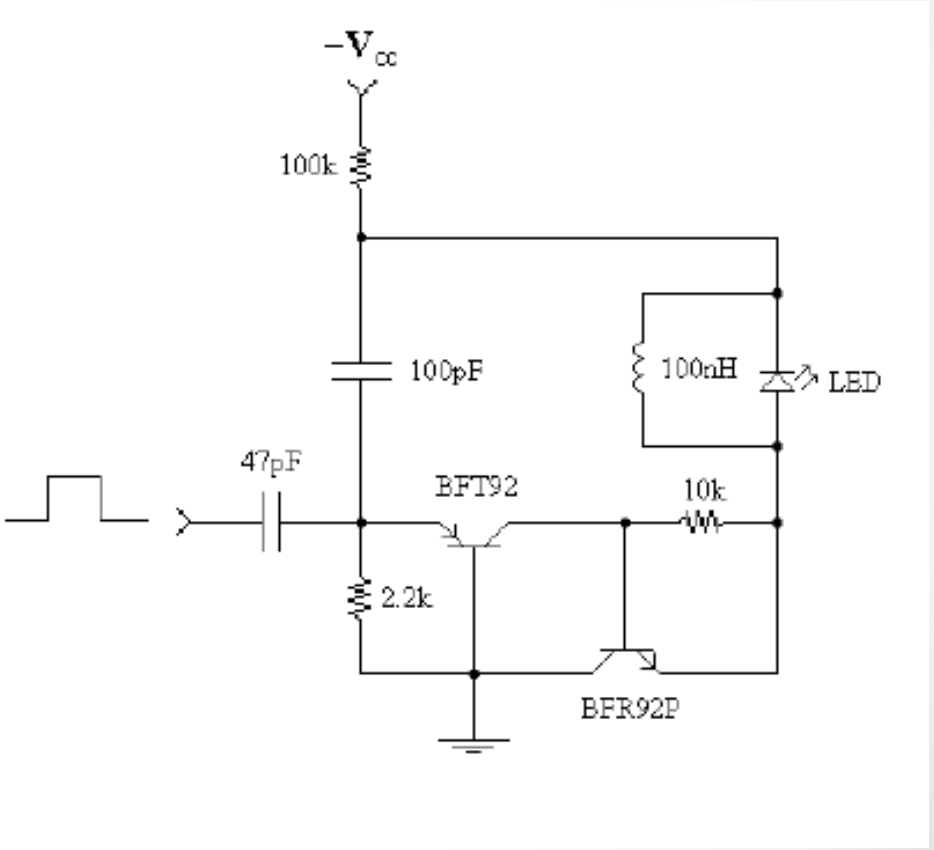
- Advantages
  - Cheap per channel cost. (~£10 for LED and basic driver electronics)
  - Compact device possible
  - Stable wavelength distribution ~ 10 nm spread
  - Wide range of wavelengths available
  - ~1-2 ns pulses.
  - Simple coupling to fibres
- Disadvantages
  - Higher current requirements
  - Large light loss into fibres.
- Questions
  - Can we produce the required dynamic range?

ANTARES Beacon

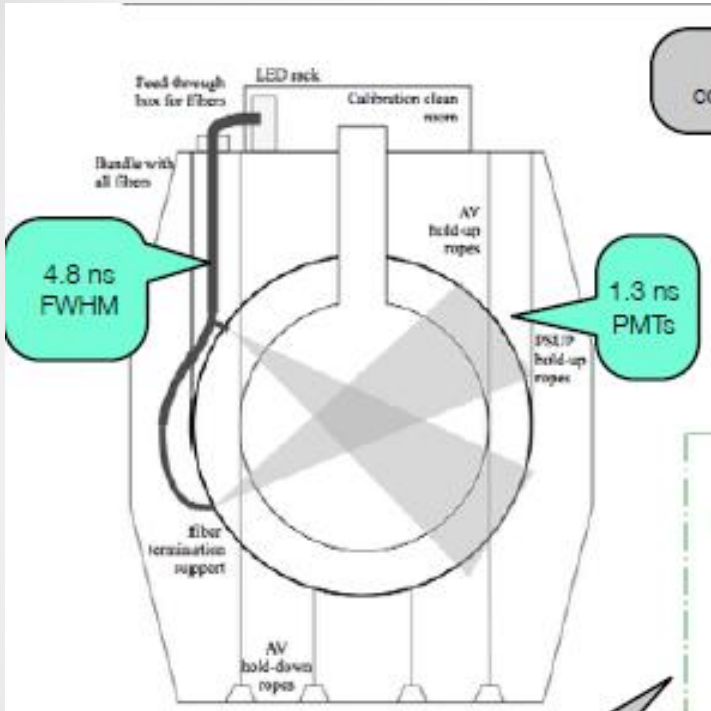
- Developed to provide a light source on each ANTARES photo-module.
- Permanently deployed.
- Can flash single or multiple LEDs at once, depending on calibration required
  - Different systems to do this.
- Not fibre coupled.

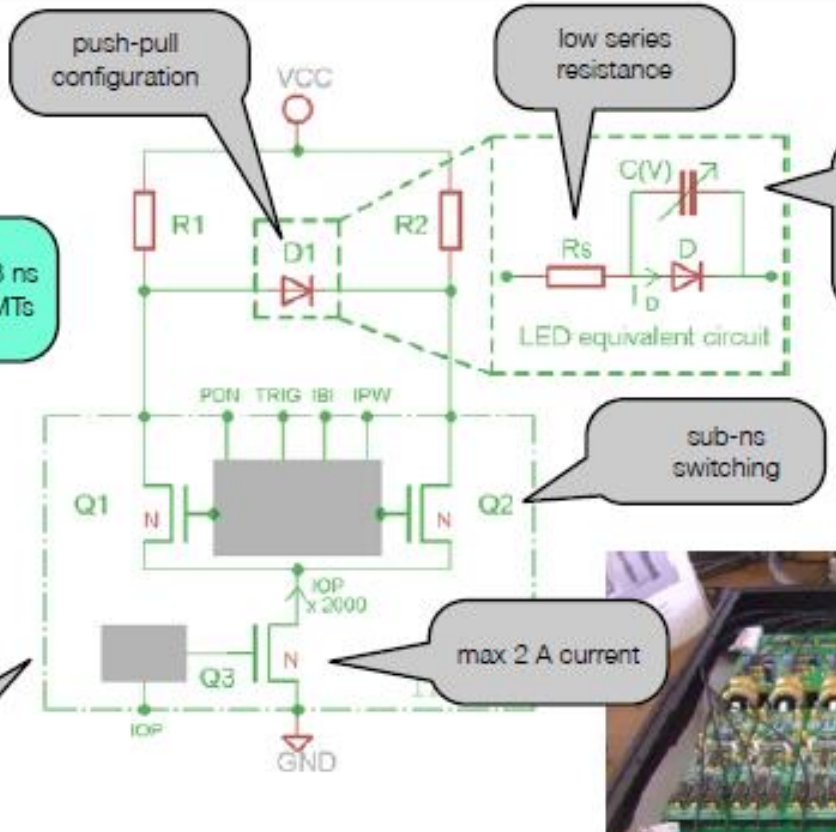
Basic design of ANTARES system

- Use a modified Kapustinki design.
- Discharge a capacitor into LED.
- Uses a fast 2 transistor switch.
- Inductor to "sweep out" charge.
  - Reduced tail.



LEDs in SNO+





Original design requirement (LED end):
- > **10^6 photons per pulse**
- – **1 ns optical pulse width**

Later additional requirement (wet end):
10^3 photons per pulse (stable) at **1 pulse per second** repetition rate

LEDs for HK

- We propose that LEDs form part of the HK calibration system.
- General light source for optical calibration
- Using fibres can build an automated system with can illuminate every PMT with known pulses.
  - PMT calibrations and water quality monitoring without source deployment.
  - Useful given 10 optically separated compartments in HK
- Uniquely able to measure scattering with such as system.
- Light source for a psedo muon light source.

UK Proposal to STFC

- In May we submitted our proposal for funding for the next 3 years.
- WP4 is calibration
  - Neil McCauley (Liverpool) – Manager
  - Lee Thompson (Sheffield) – Deputy Manager
- Liverpool, Sheffield, Warwick, Imperial College, Edinburgh and Queen Mary will contribute.

WP4

- WP 4.1 – Fibre Coupled LED Pulsers
  - LED Drivers
  - LED Fibre Coupling and Housing
- WP 4.2 – Fixed point diffuser
  - Light injection into detector from fibre
- WP 4.3 – Pseudo Muon Light Source
  - Muon Calibration device

Requests

- 1.5 Post Docs for 2 years from Sep 2015
- Engineering Support
- Hardware

- Most money turns on from Sep 2015 if approved
- Proposal being considered by STFC.

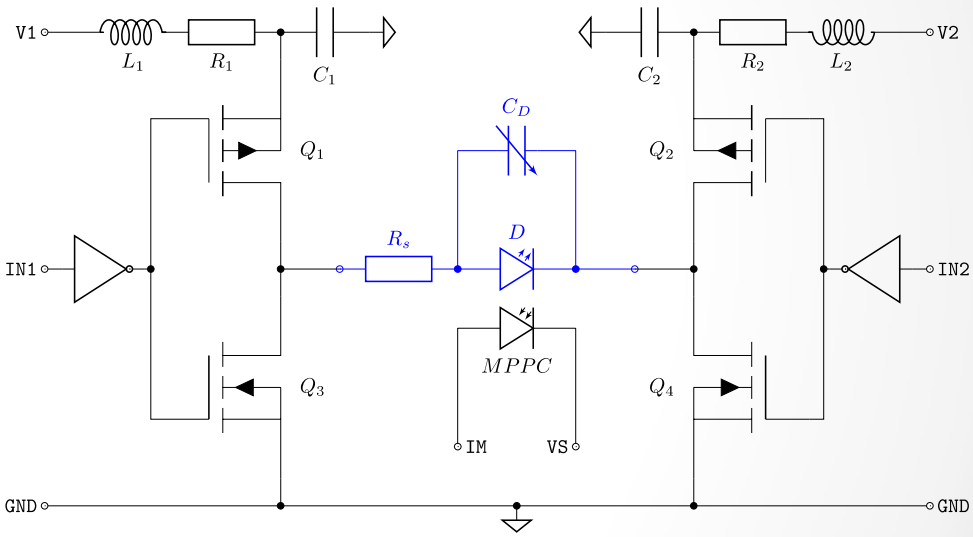
LED Driver Status

- Starting preparation of prototype circuit.
  - Will contain 2 driver circuit types
  - Quad Mossfet
  - Modified Kapustinsky
- Final circuit design in preparation for manufacture.

- Plan to control using FPGAs to provide detailed control of the circuits and their properties.
  - Part of a phase 2 prototype once circuit performance has been established.

Driving LEDs

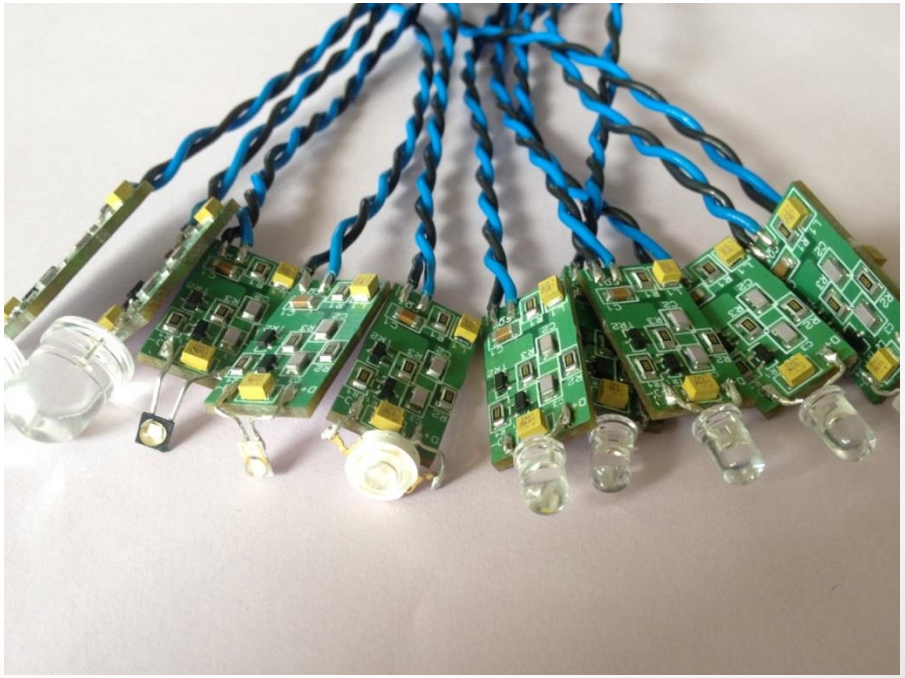
- Quad Mossfet design
- Drive large currents with swift voltage change.
- Co-ordinate raising and lowering voltages at either end of the LED to produce a fast high current pulse.
- Dual Mossfets are used in DC-DC converters for solar panels
  - Some are suitable for high frequency.



LED Testing

- We have started testing a sample of LEDs in the lab at Sheffield.
  - Not all LEDs will pulse, we need to identify suitable candidates.
  - Currently using ANTARES pulser, also plan to test SNO+ pulser.

- Testing underway:
  - Results soon



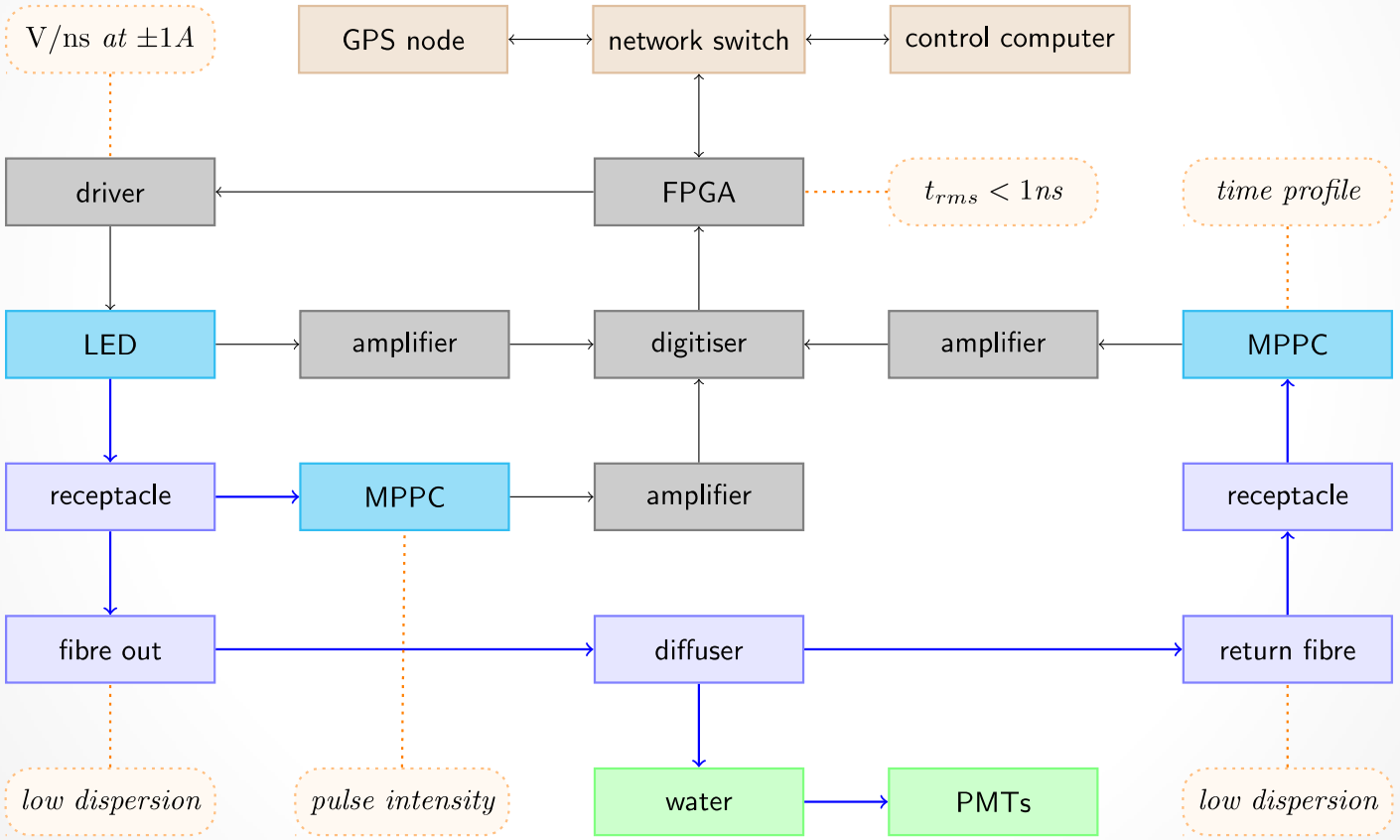
LED – Fibre coupling

- We need to use graded index fibre
  - More expensive
  - Smaller core
- Dispersion using step index fibre would be ~14 ns over 100 m.
  - Too large for HK.
- Need to investigate:
  - coupling with these fibres due to small core (~60 μm diameter).
  - Actual dispersion of pulses over a long distance
  - Angular profile and timing correlation.

Monitoring Ideas

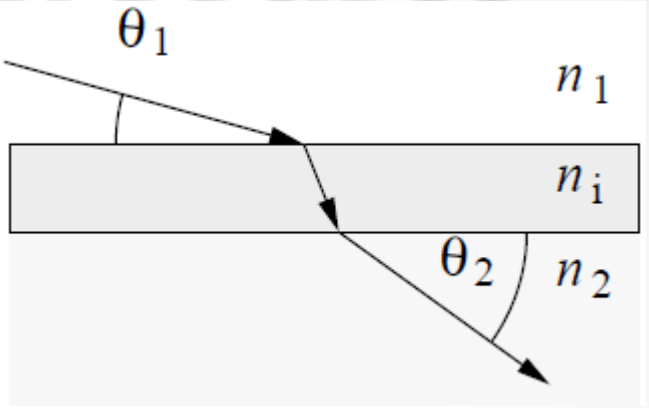
- We want to monitor light output pulse by pulse
- Two ideas under consideration
  - Instrument the LED – fibre coupling housing
    - Direct monitoring of light that does not make it into the fibre
    - Pulse by pulse intensity.
  - Return fibre
    - Allows pulse timing measurement including fibre effects.
    - Monitoring of a small number of photons.
- Starting to consider the design
  - Readout for MPPCs to be included in prototype circuit.

Overall system



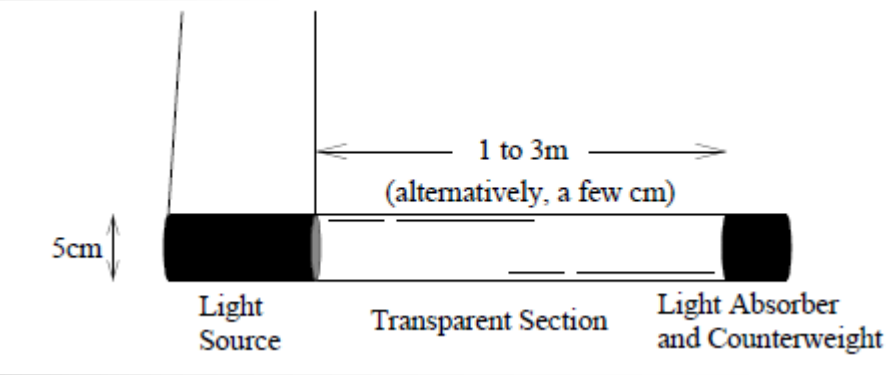
A psedo muon source

- A source to simulate muons and test reconstruction.
- A narrow transparent tube with a light source producing almost parallel light at one end.
- Light emitted at the Cherenkov angle.



As $\theta_1 \rightarrow 90^\circ$ $\sin(\theta_2) \rightarrow 1/n_c$

Light emitted at Cherenkov angle.



Summary

- Calibration forms a part of the HK grant request in the UK.
  - Should hear the result of this application over the summer.
- Work is starting on the development of the LED driver for HK.
  - Circuit design
  - LED testing