LED PULSERS AS LIGHT SOURCES

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LED Pulsers

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

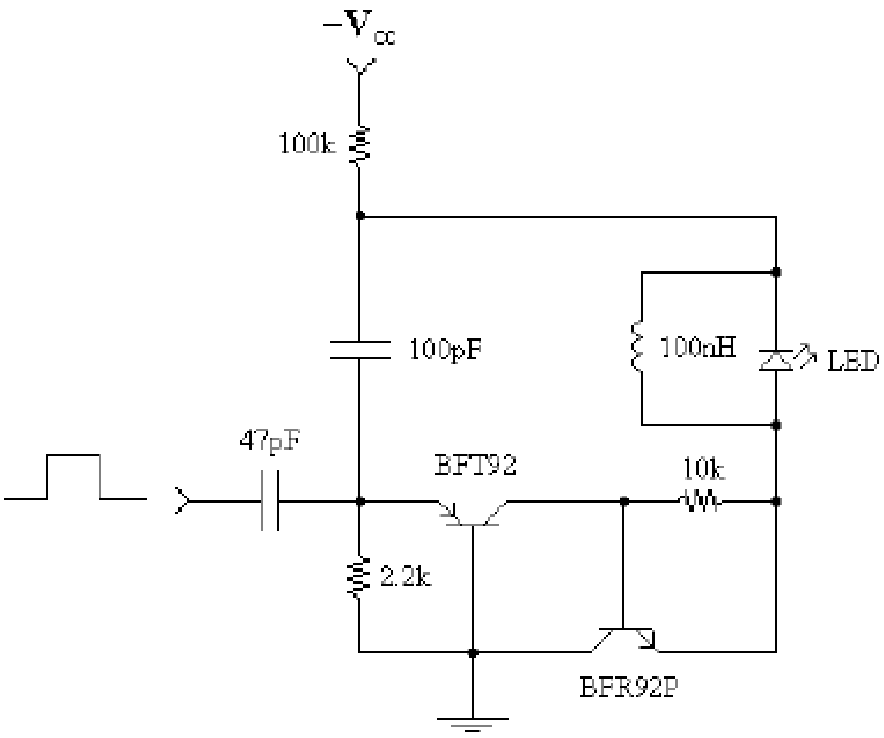
- Advantages
  - Cheap per channel cost. (~£10 for LED and basic driver electronics)
  - Compact device possible
  - Stable wavelength distribution ~ 10 nm spread
  - Wide range of wavelengths available
  - ~1-2 ns pulses.
  - Simple coupling to fibres
- Disadvantages
  - Higher current requirements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

ANTARES Beacon

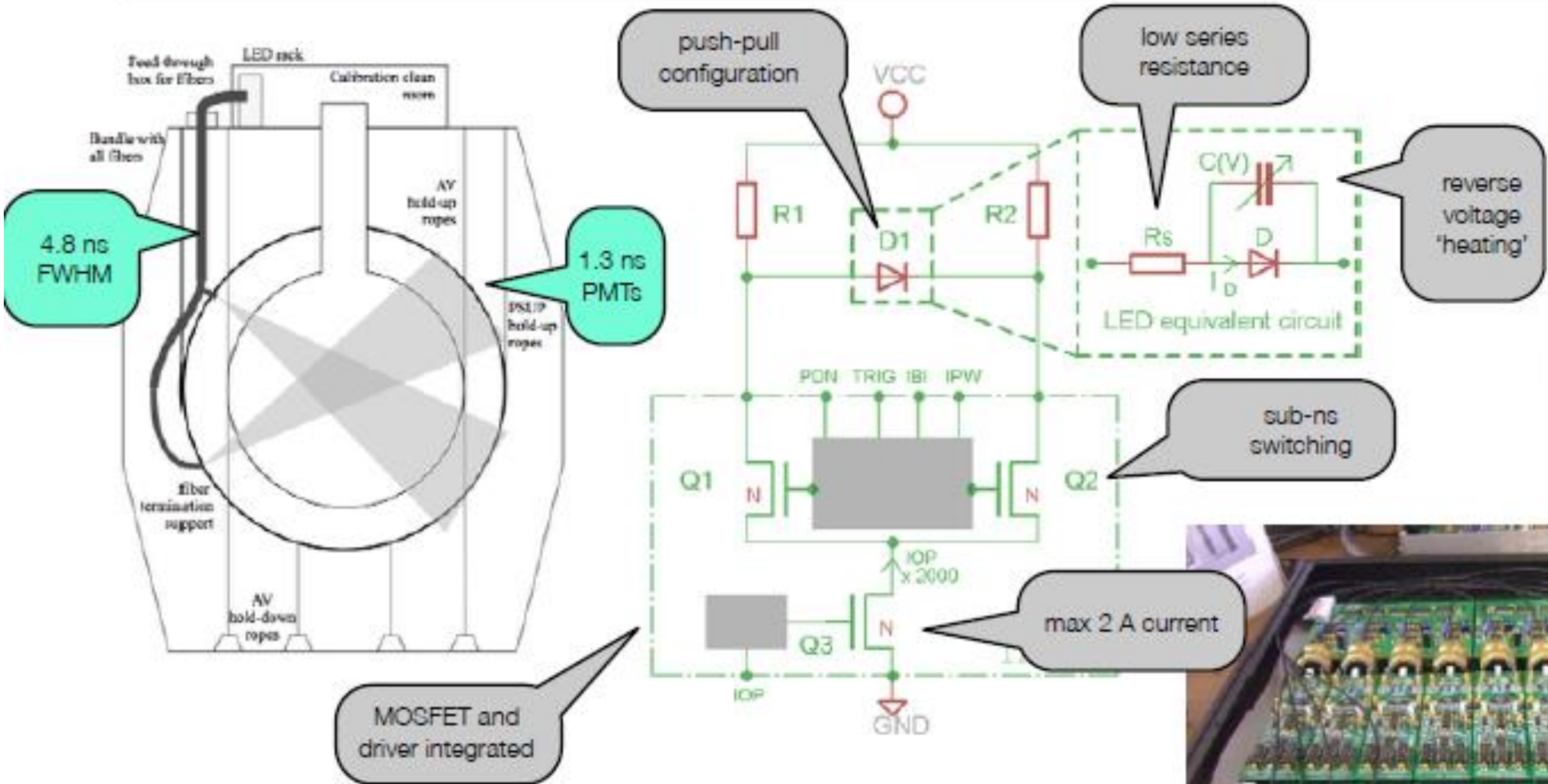
- Developed to provide a light source on each ANTARES photo-module.
- Permanently deployed.
- Can flash single or multiple LEDs at once, depending on calibration required
  - Different systems to do this.

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

Updated LED drivers for HK

- We plan to develop an updated driver circuit for HK exploiting what we’ve learn from ANTARES and SNO+
  - Include the best of both systems with new improvements
  - Update electronics to more modern standards, use FPGAs for example

- Need to finalise targets for
  - Pulse width
  - Number of photons
  - Decision on number of LEDs to drive simultaneously (>1?)

- Plan to develop a prototype by December 2014
  - Bridging funds to do this secured.

Possible uses for LED

- Embedded light source on PMT support
- Potted in a diffuser ball as an isotropic light source
- As a beacon on other calibration sources
- As the light source for a “muon source”.
- Plan to develop calibration devices using LED prototypes as part of UK HK proposal.

Embedded Light Sources

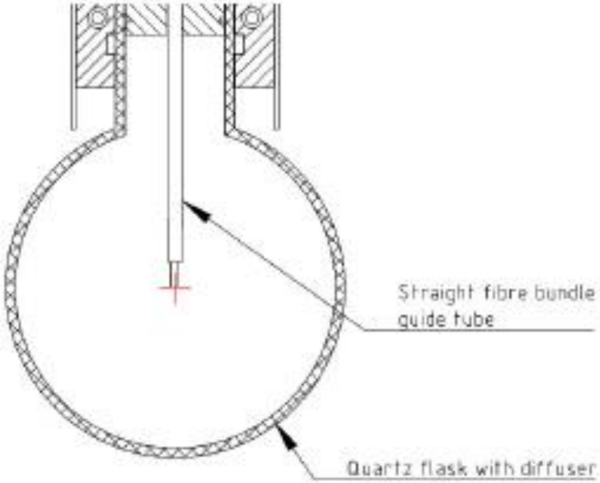
- Source for embedded light source in HK PMT support
  - Similar to SNO+ fibre system.

- Could be deployed as a fibre system as in SNO+
- Alternatively could be deployed directly in detector
  - Particularly interesting if we have “wet-end” electronics.

- Useful for measuring/monitoring
  - PMT timing
  - Attenuation/extinction
  - Scattering

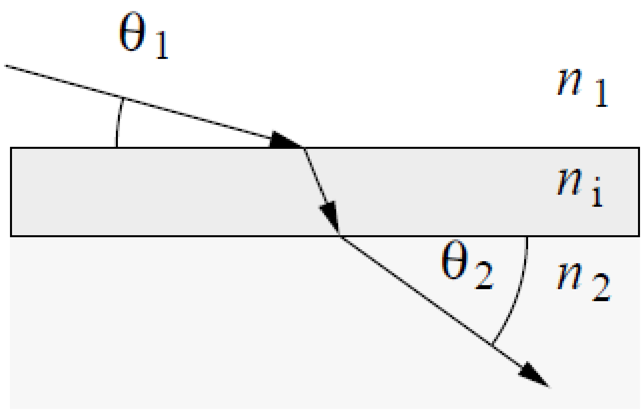
For an isotropic source

- Adapt the laserball design from SNO.
  - Fibre in the centre of a quartz ball filled with beads potted in a gel.
  - Provides isotropic light.
- Replace fibre with LEDs.
  - Will be more isotropic as the light from a LED is more isotropic than from a fibre.
- Can potentially stay in the detector
  - Can run calibrations without running the laser system.



A fake 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.

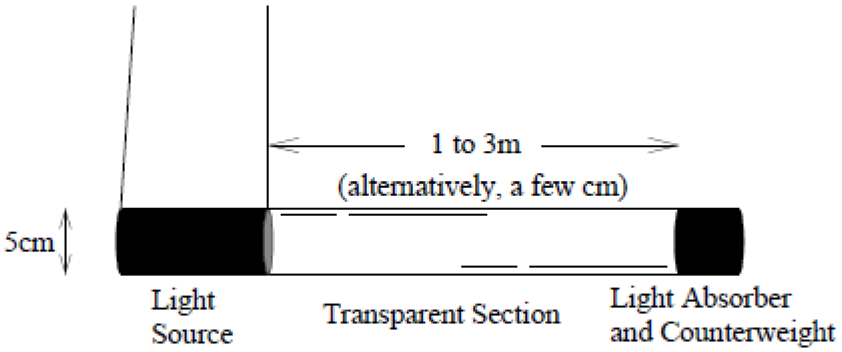


$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

independent of n_i

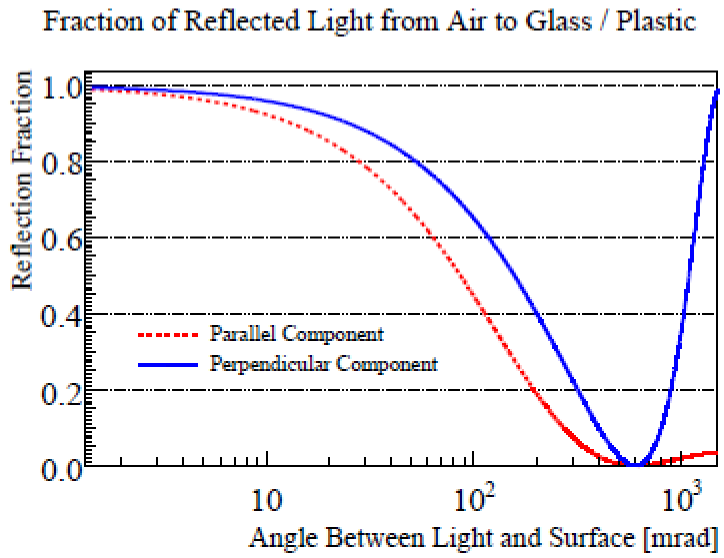
As $\theta_1 \rightarrow 90^\circ$ $\sin(\theta_2) \rightarrow 1/n_c$

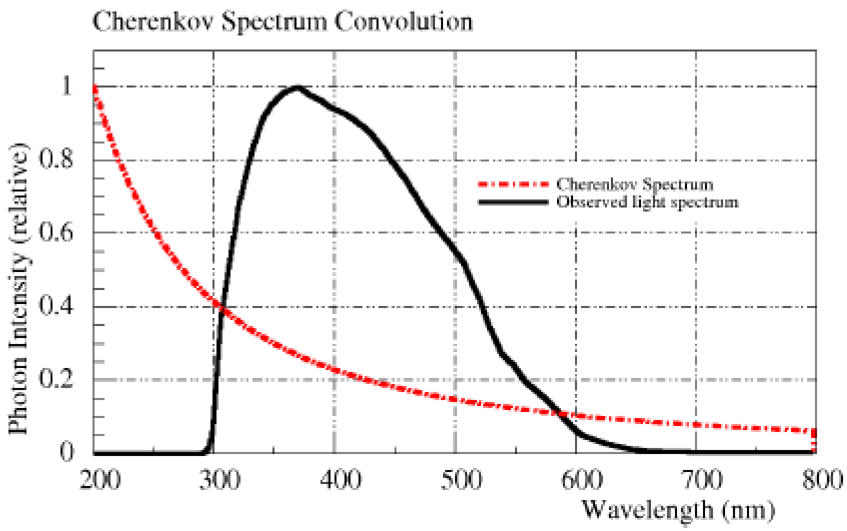
Light emitted at Cherenkov angle.



Plans for muon source

- We plan to pursue this as an R&D project in the UK
- Produce a short source for testing.
- Use multiple LEDs to “cover” range of Cherenkov spectrum
- Plan to
  - Test angular distribution
  - Tune LED intensity
  - Test light deployment and absorption methods.





Source Beacon

- LED source is small and compact and could be attached to any calibration source.
  - Or to the source deployment system
- Can therefore use as a beacon to determine the position of the source in the PMT co-ordinate system.
  - Collect multiple pulses – determine mean PMT time for direct light.
  - Reconstruct position of LED
  - Determines source position independent of source effects.
- Could also act a as light source for a camera system if one is deployed.
  - Flash LED at a high rate.

Conclusions

- LEDs are a viable light source for a water Cherenkov detector
  - Can provide ns scale light pulses
  - Cheap to produce if multiple sources needed

- Multiple calibration sources and aids can produced

- Aim to produce a HK prototype LED driver in 2014
- Produce LED based calibration sources as part of UK HK proposal