LED based powerful nanosecond light sources for calibration systems of deep underwater neutrino telescopes

B.K. Lubsandorzhiev
Institute for Nuclear Research
Moscow Russia
University of Tuebingen
Tuebingen Germany
Ultra Bright Blue LEDs

S. Nakamura, NICHIA 1993

Single quantum well

InGaN/GaN structure
Ultra bright LEDs emission kinetics

Fast LEDs (Nichia «old», G-nor, YolDal)

Intermediate LEDs

Slow LEDs

Nichia «old» and «new» LEDs

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NSPB500S NICHIA CHEMICAL

«old» - 1.8 ns width
«new» - 4ns width $\tau \sim 10$ns

KINGBRIGHT L7133NBC
slow L7113PBC

«old» - 1.8 ns width
«old» - 4.5 ns width $\tau \sim 16$ns
G-nor GNL3014BC

The fastest LED
0.6 ns width!
Without tail!
• Drivers with single LEDs provide 1 ns width (FWHM) light pulses with up to $10^9$ photons per pulse.
• How to increase light yield keeping emission kinetics fast?

• To assemble LEDs in a matrix.
• Problems: Light emission kinetics of the whole matrix?
• LEDs in the matrix should be selected thoroughly.
• They should be identical in their emission kinetics and intensity
• If several drivers - they should electronically tuned
Nearly identical (in emission kinetics, spectrum and light intensity) LEDs are selected for the matrix. The light pulses of individual LEDs coincide with each other with an accuracy of $\leq 50$ ps.
Matrix of LED drivers

Each LED of the matrix has its own driver based on avalanche transistor. LEDs and their drivers are thoroughly tuned to be identical in timing and intensity. The light pulses of individual drivers coincide with each other with an accuracy of $\leq 50$ ps.
LED stability and life time

Pulse width (left, ns) and light yield (right, a.u) vs the total number of pulses
Driver’s parameters temperature dependences

Pulse width (left, ns) and light yield (right, a.u) vs temperature

Temperature coeff. - 0.14%/C in the range of -3 ÷ 45 C
Cluster of n matrixes of ultra bright blue LEDs

light pulses with $\geq 10^{11}$ photons per pulse with 1-2 ns width
High power LEDs

$10^{11} - 10^{12}$ photons per pulse
6-10 ns width
CONCLUSION

• Ultra bright blue LEDs give excellent opportunities to design powerful, fast light sources for calibration systems of astroparticle physics experiments based on Cherenkov and scintillation techniques

• Using matrixes of ultra bright blue LEDs it’s possible to have light sources with 1-2 ns width (FWHM) and intensity of up to $10^{10}$ photons per pulse and even more, and with a cluster of matrixes - $10^{11}$ photons per pulse.
• New ultra high power blue LEDs allow to have light sources intensity of $\geq 10^{12}$ photons per pulse with a single LED but their emission kinetics relatively slow - $\sim 5$-10 ns (FWHM).

• Powerful light sources based on ultra bright blue LEDs have very high long-term stability and very long life time.

• They are powerful, fast, stable, reliable, cheap and very simple in operation.

• They are in many respects very good competitor to laser systems.