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

B.K.Lubsandorzhiev

Institute for Nuclear Research

Moscow Russia

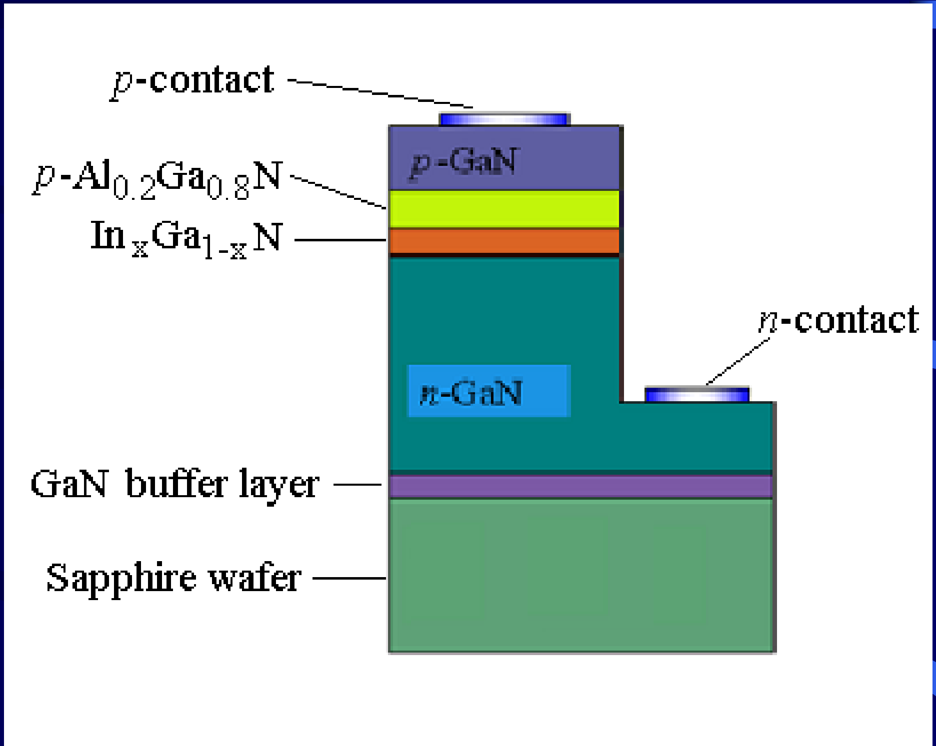
University of Tuebingen

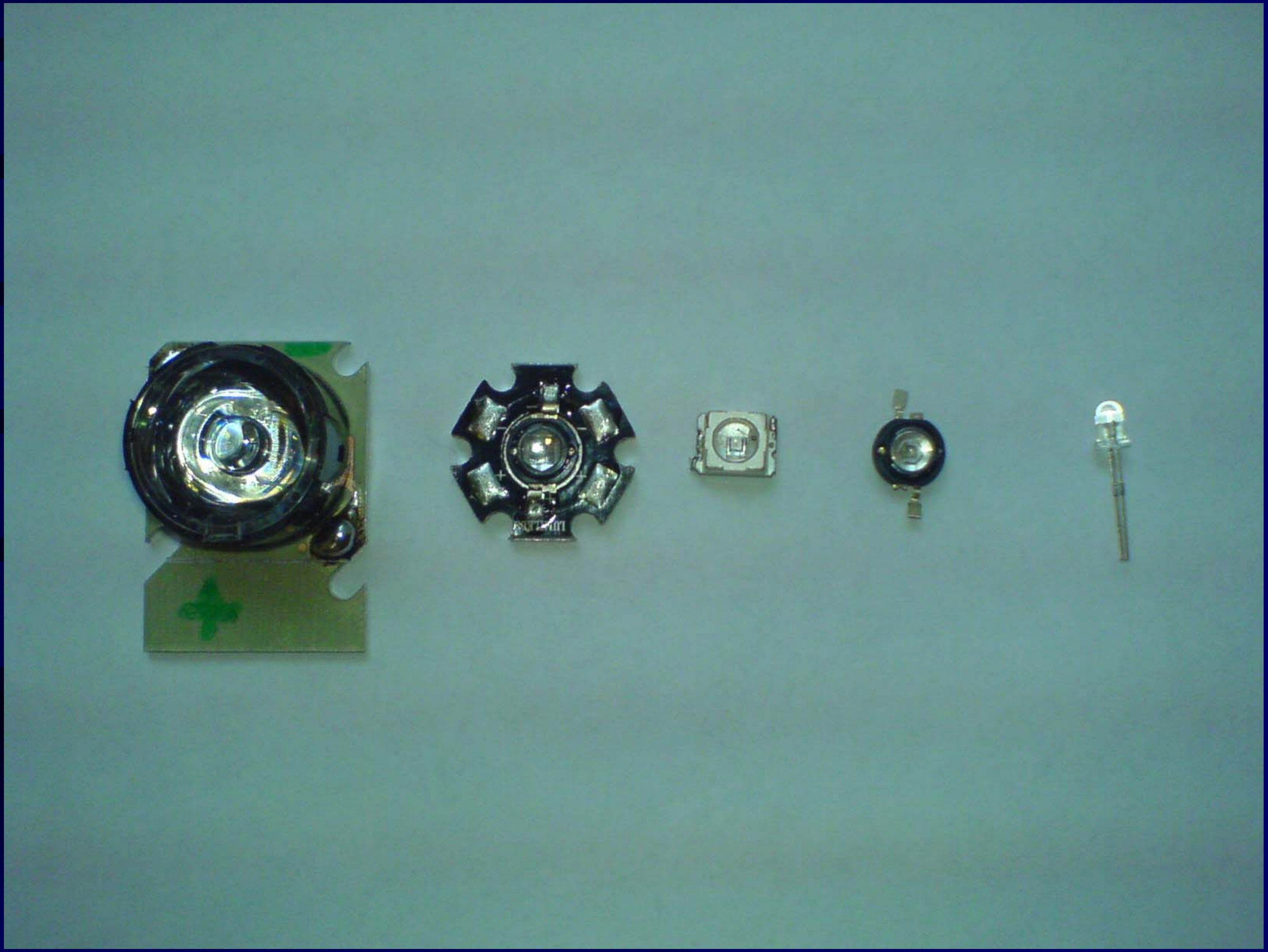
Tuebingen Germany

Ultra Bright Blue LEDs

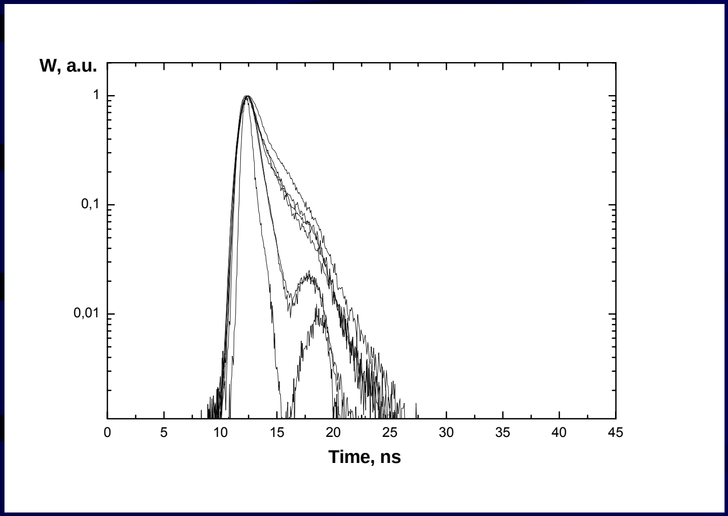
S.Nakamura NICHIA 1993

Single quantum well
InGaN/GaN structure

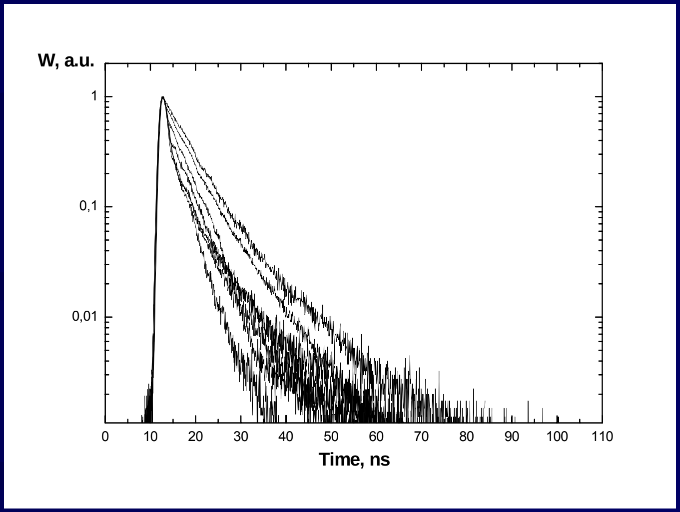




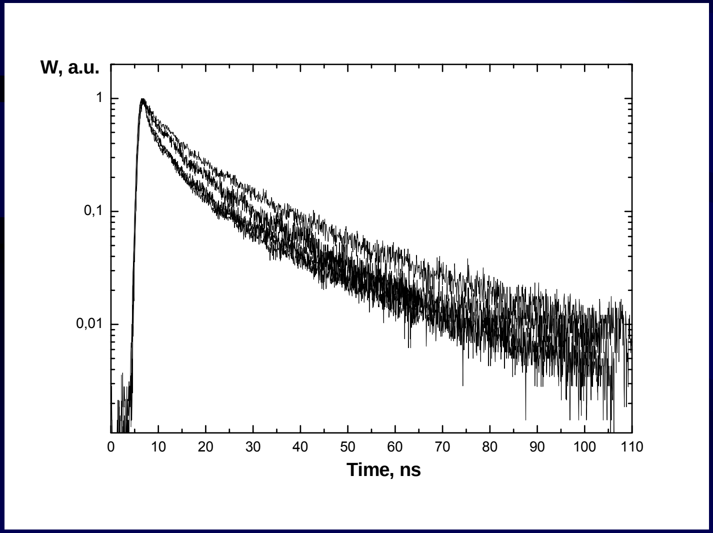
Ultra bright LEDs emission kinetics



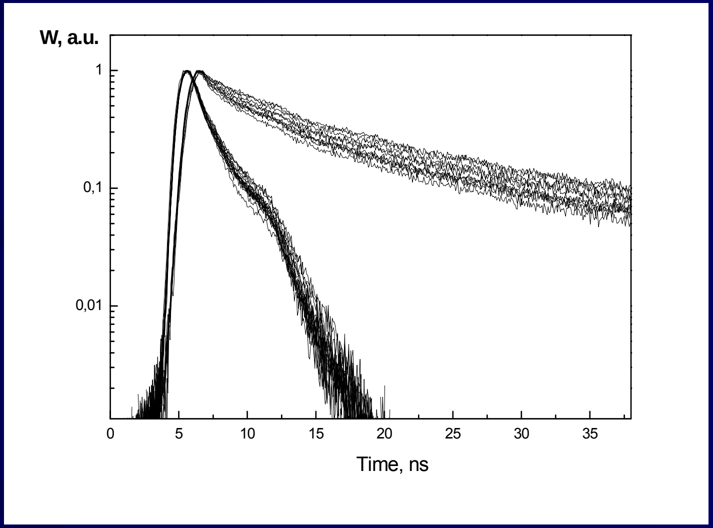
Fast LEDs(Nichia «old», G-nor, YolDal)



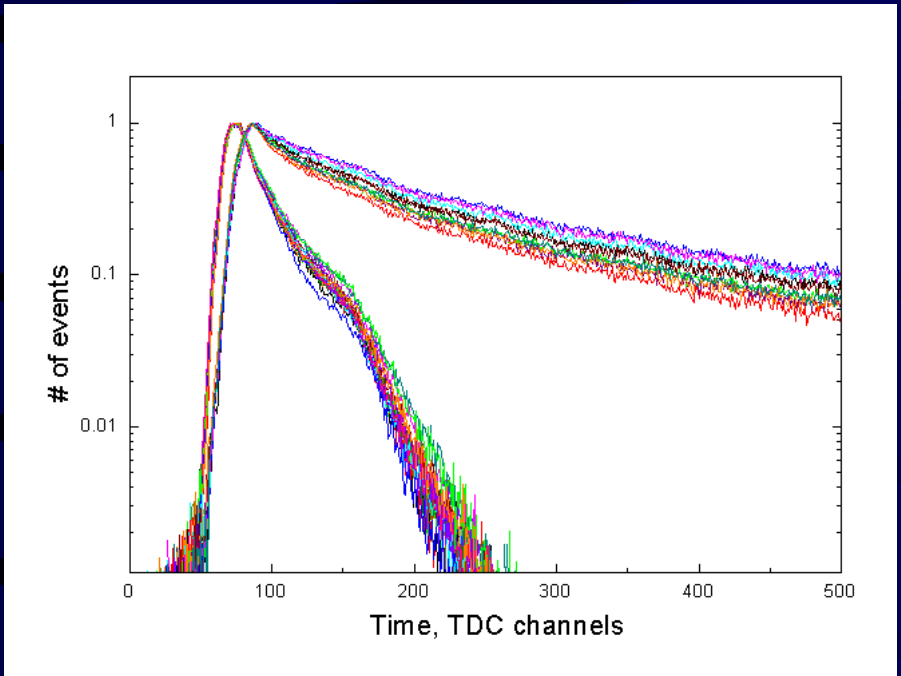
Intermediate LEDs

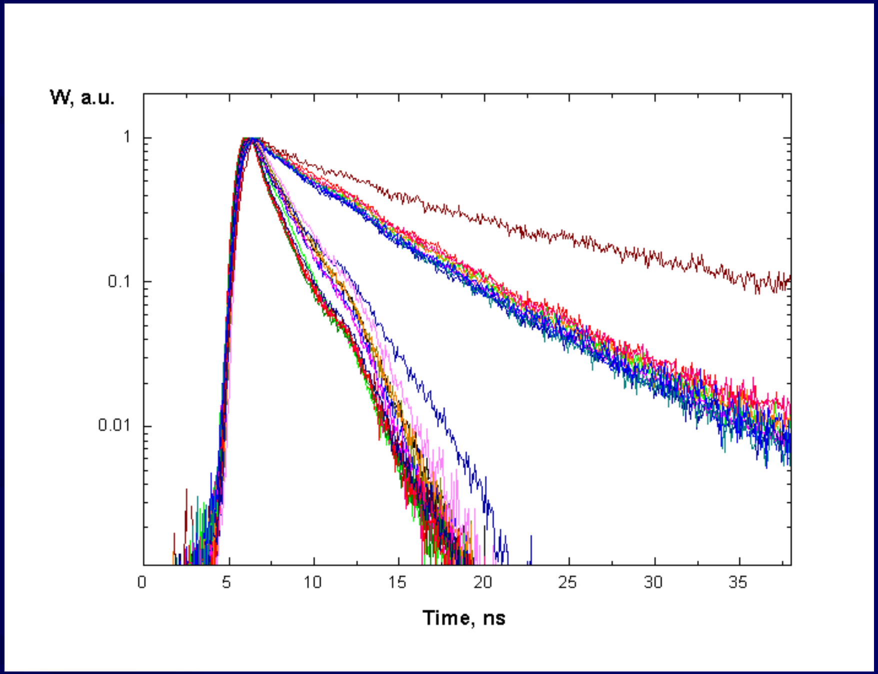


Slow LEDs



Nichia «old» and «new» LEDs





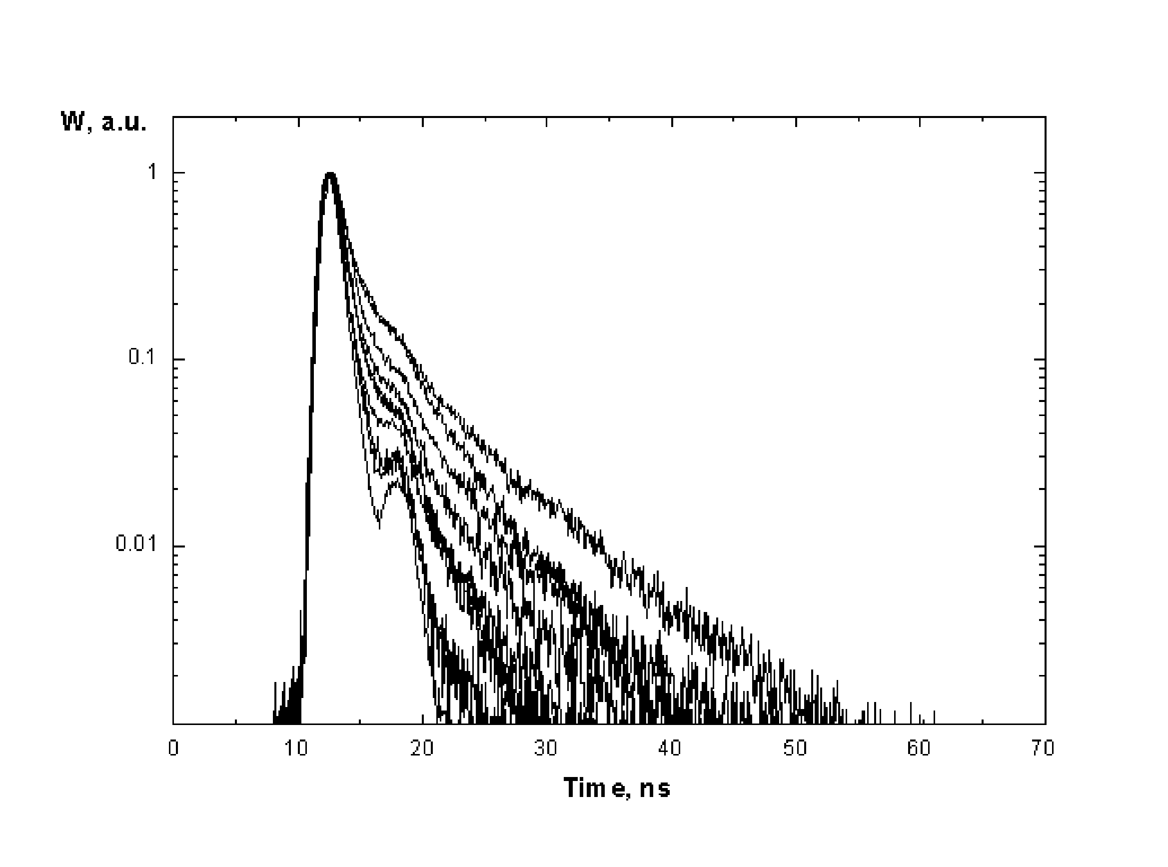
NSPB500S NICHIA CHEMICAL

«old» - 1.8 ns width
«new» - 4ns width τ~10ns

KINGBRIGHT L7133NBC
slow L7113PBC

«old» - 1.8 ns width
«old» - 4.5 ns width τ~16ns

G-nor GNL3014BC

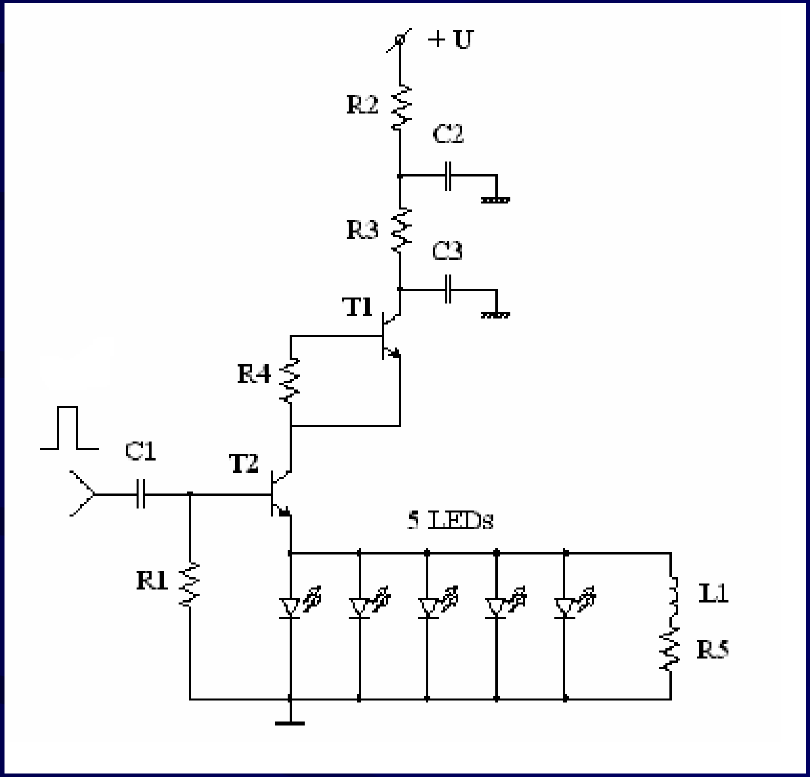


The fastest LED
0.6 ns width!
Without tail!

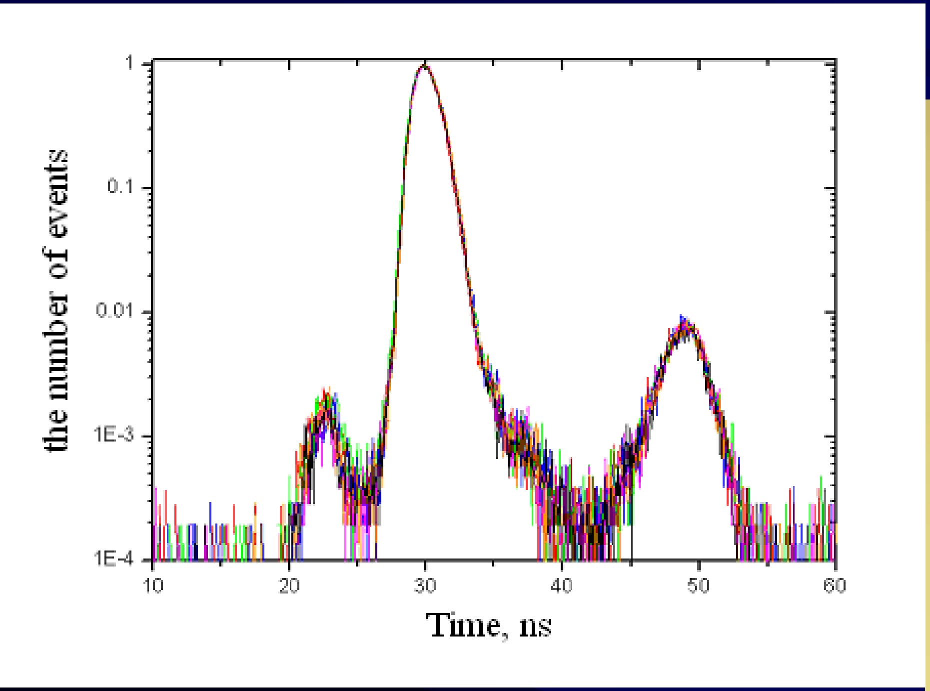
- Drivers with single LEDs provide 1 ns width (FWHM) light pulses with up to 10^9 photons per pulse.
- How to increase light yield keeping emission kinetics fast?

- 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

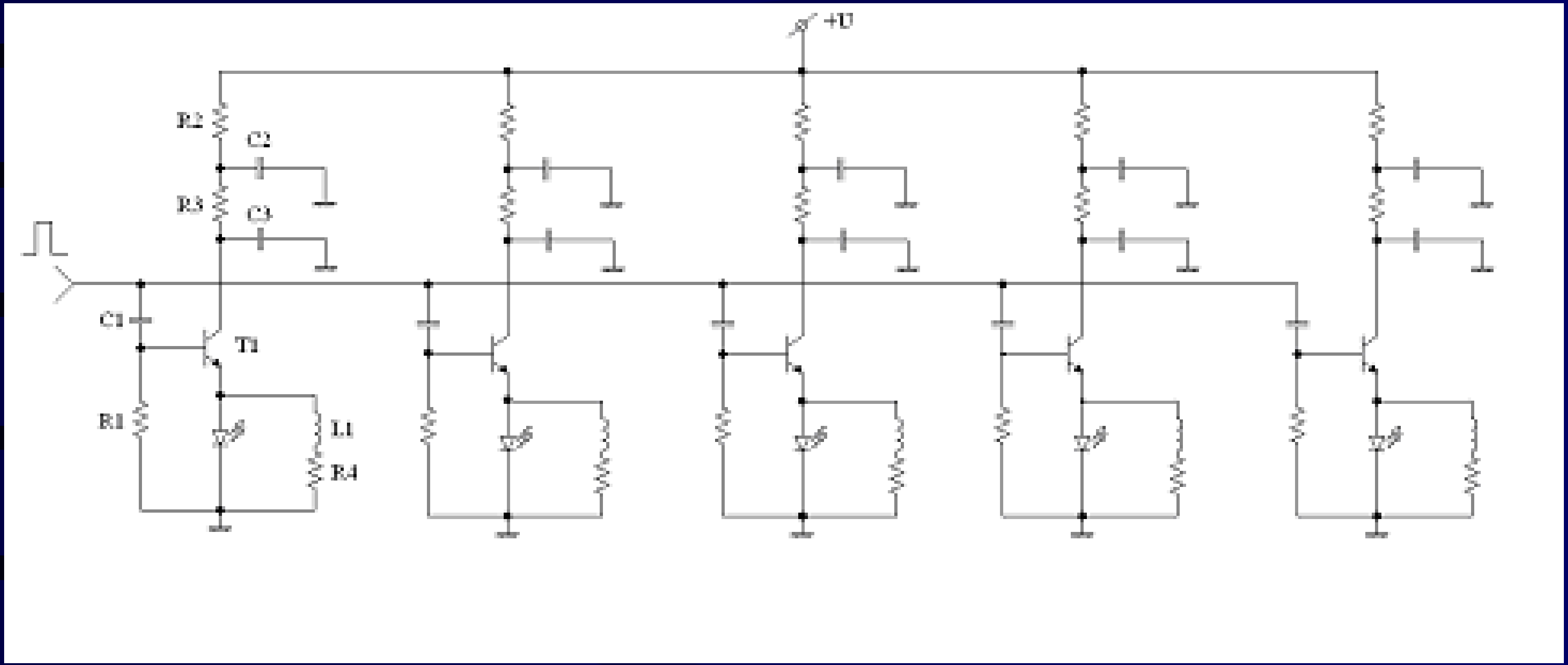
LED Matrix. One driver for a Matrix of LEDs



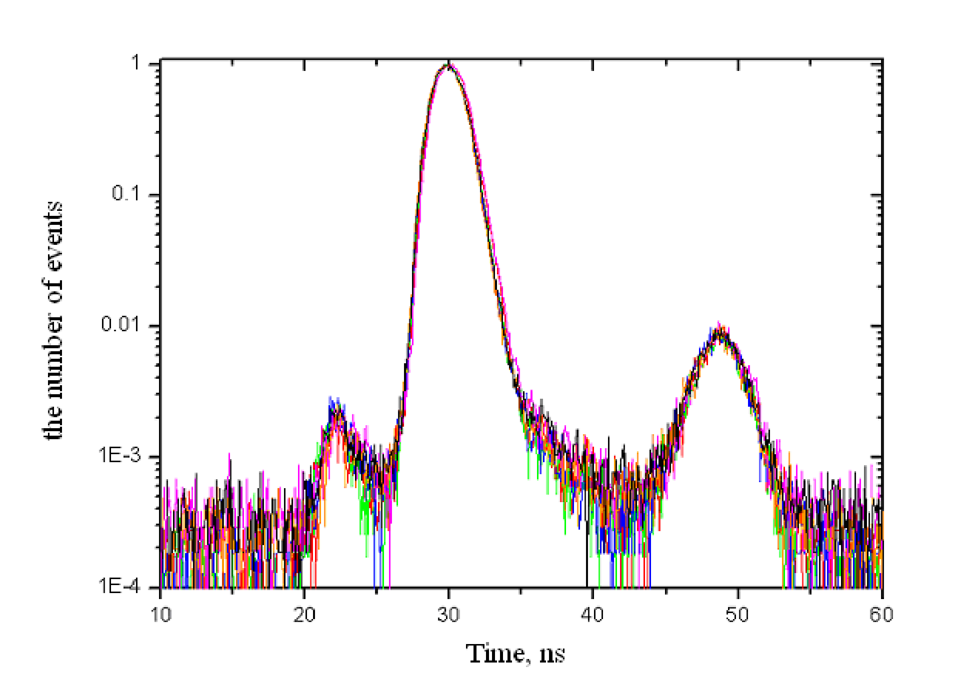
Nearly identical (in emission kinetics, spectrum and light intensity) LEDs are selected for the matrix. The light pulses of individual LEDs coincide with each other with an accuracy of ≤50 ps.


the number of events
1
0.1
0.01
1E-3
1E-4
10
20
30
40
50
60
Time, ns

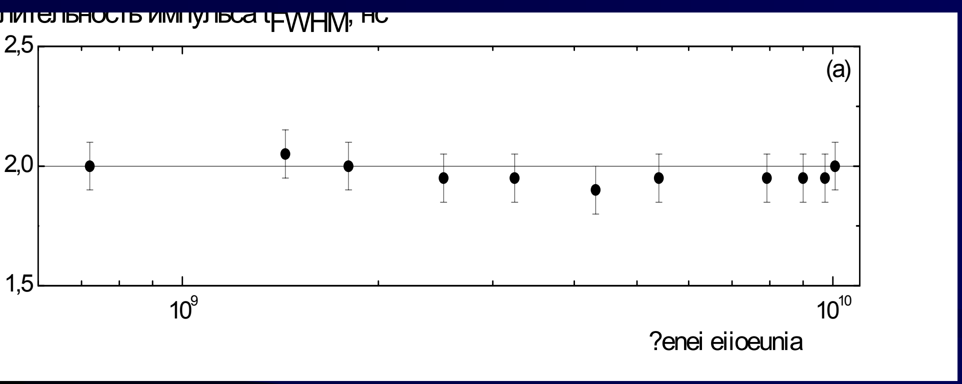
Matrix of LED drivers

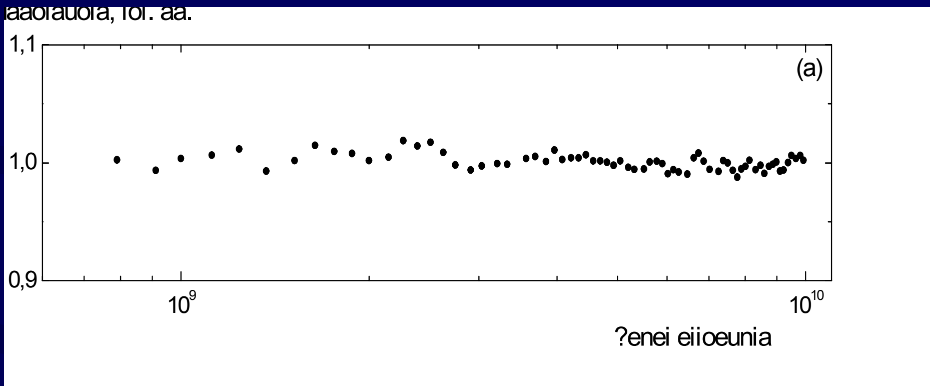


Each LED of the matrix has its own driver based on avalanche transistor. LEDs and their drivers are thoroughly tuned to be identical in timing and intensity. The light pulses of individual drivers coincide with each other with an accuracy of $\leq$50 ps.


1
0.1
0.01
1E-3
1E-4
the number of events
10
20
30
40
50
60
Time, ns

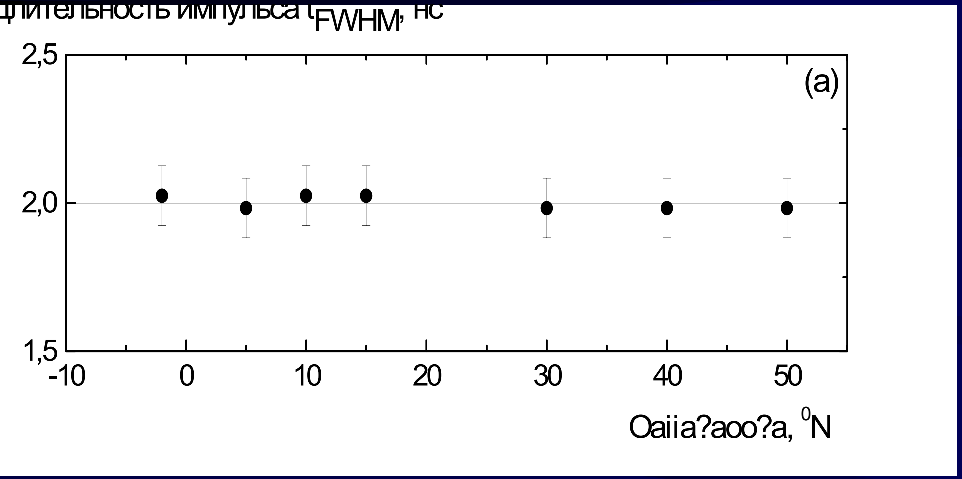
LED stability and life time

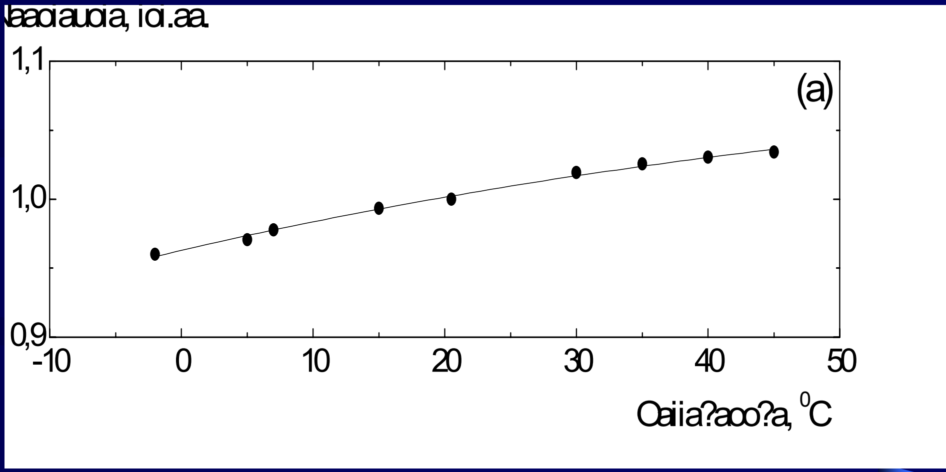




Pulse width (left, ns) and light yield (right, a.u)
vs
the total number of pulses

Driver's parameters temperature dependences

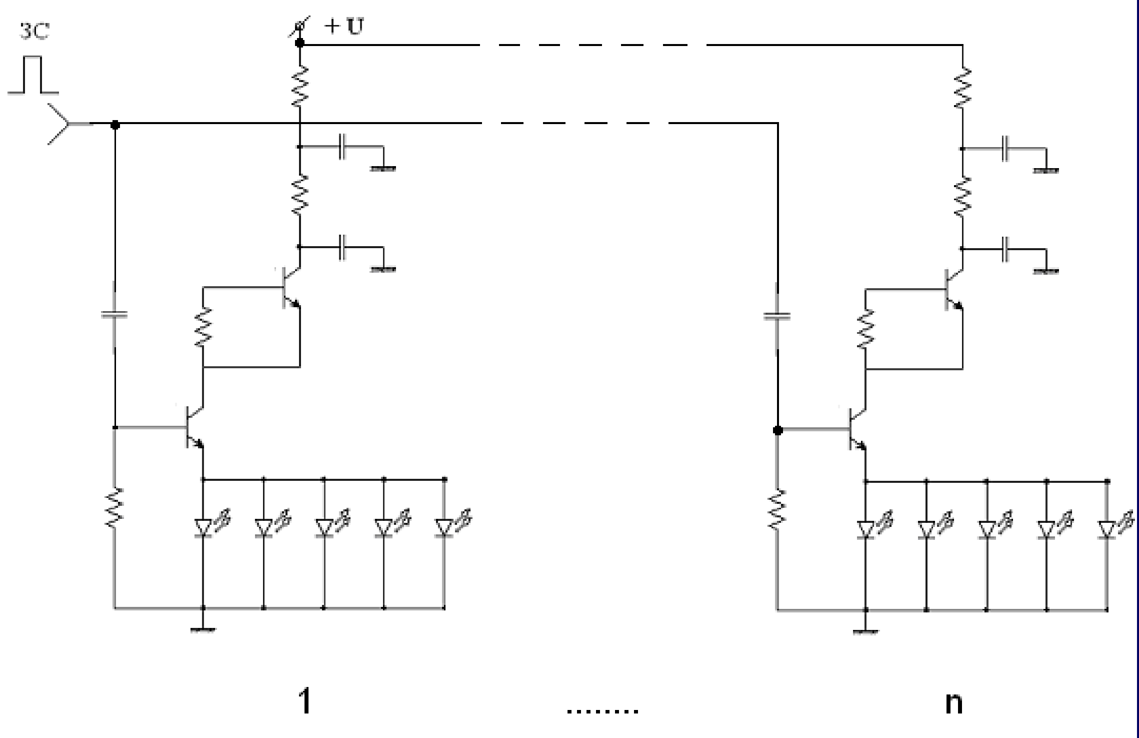




Pulse width (left, ns) and light yield (right, a.u)
vs
temperature

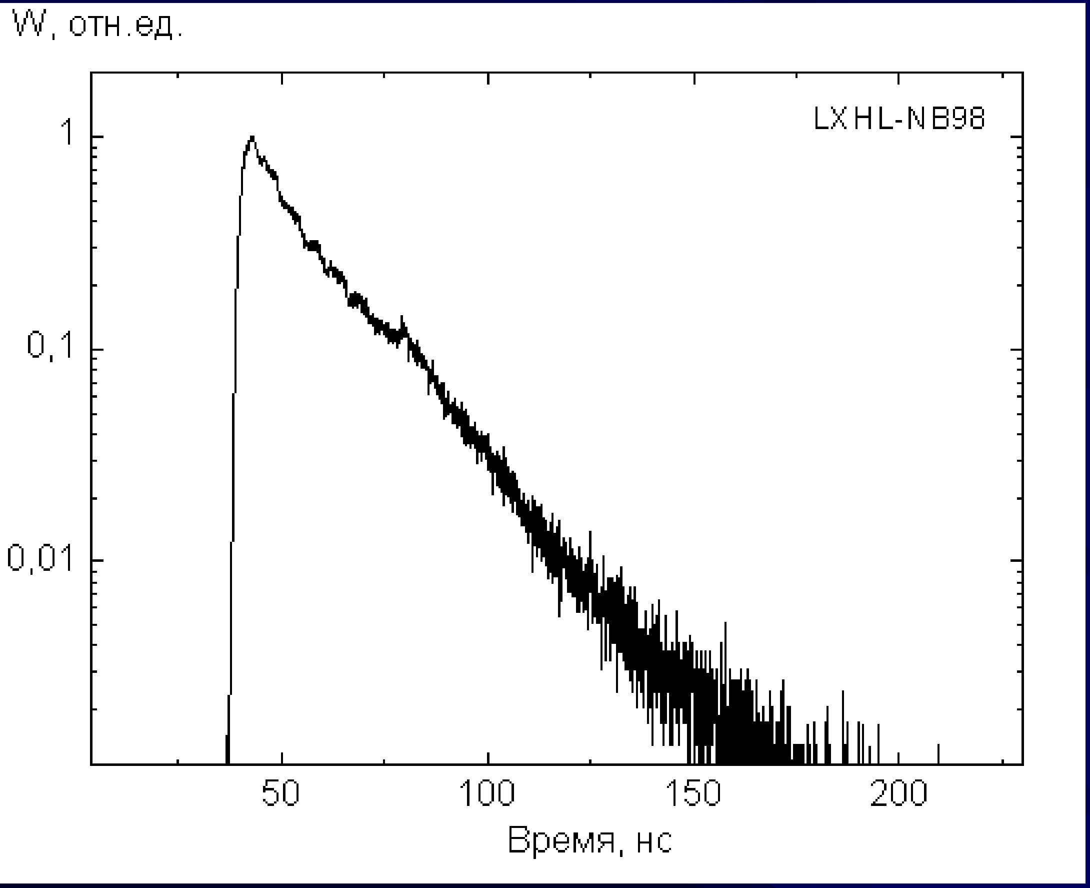
Temperature coeff. - 0.14%/C in the range of -3 ÷ 45 C

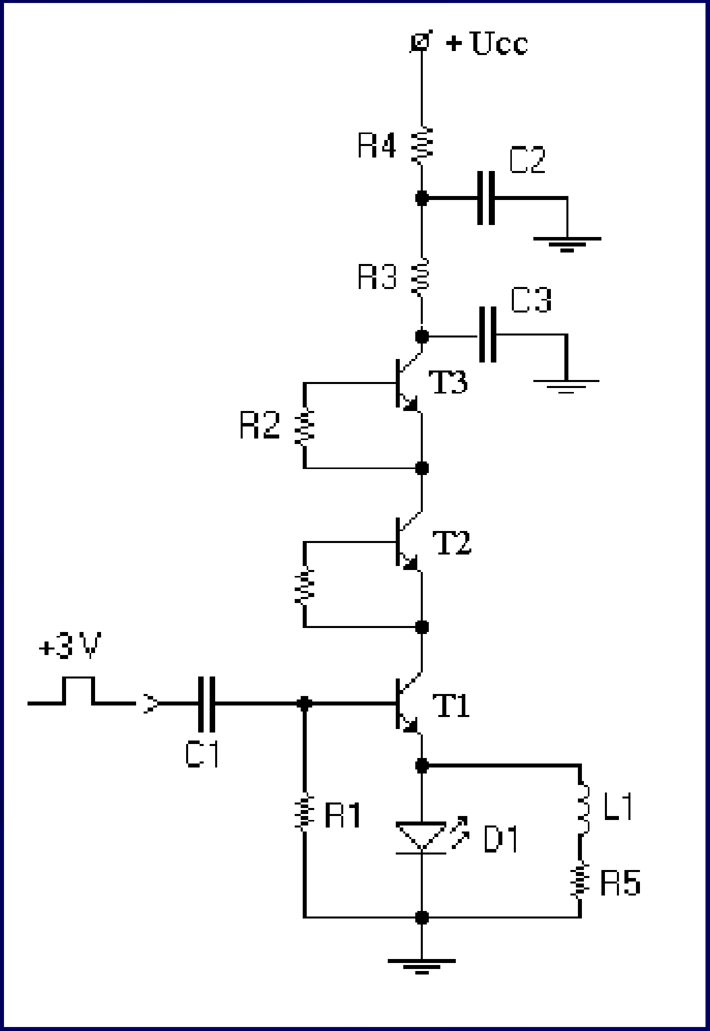
Cluster of n matrixes of ultra bright blue LEDs



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 - ~5-10 ns (FWHM).
- Powerful light sources based on ultra bright blue LEDs have very high long-term stability abd 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.