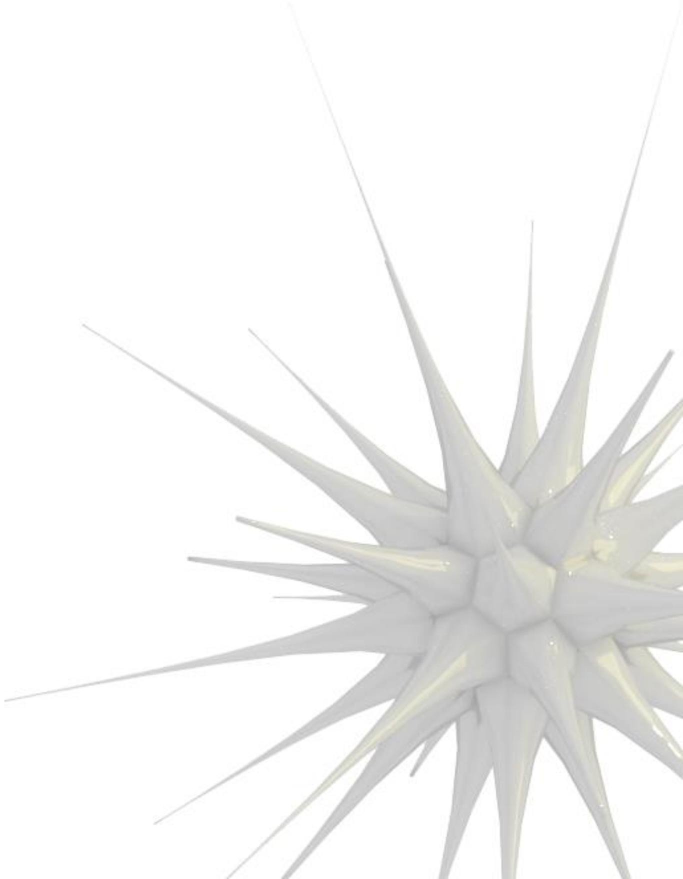
Project LIGHT TUBE

UV-A decontamination device

IP IT1403379(B1)

promete



Investigation of UV-A
ability to inactivate bacteria in water: STATIC CASE

EXPERIMENTAL SET-UP

High-energy light-emitting diode (LED):

$\lambda \in [365,370]$ nm

Viewing angle = 70 degrees

Total angle (90% of the total radiant flux) = 105 degrees

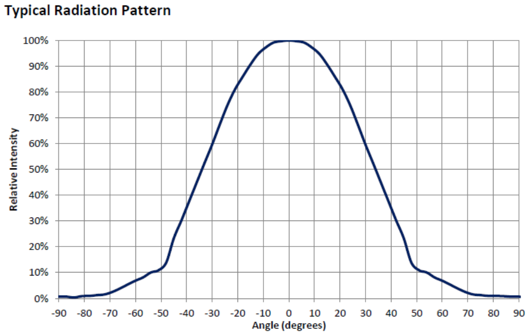
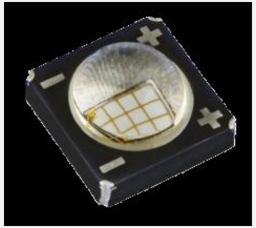


Figure 4: Typical representative spatial radiation pattern



Preliminary calibration:

We characterized the **LED intensity profile** along x and y axes, for different levels of device's intensity.

We identified **optimum measurement conditions** (distance between LED and sample 2.8cm, sample diameter 8 mm) corresponding to a **uniform light** intensity on the sample.

Detector:

photodiode with circular sensitive air, 4 mm diameter

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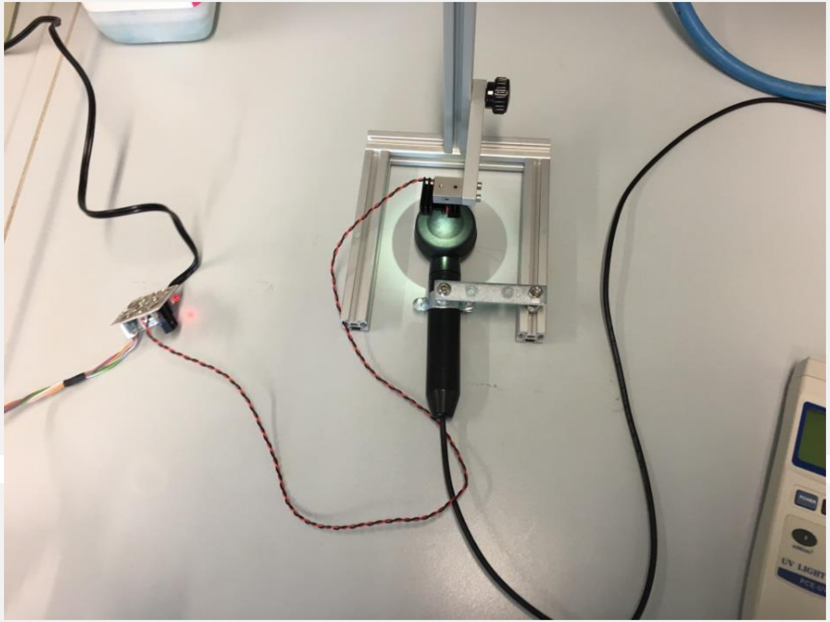
EXPERIMENTAL PROCEDURE

Irradiation tests performed on different species of bacteria:

- ***Escherichia coli DH5α*** (Gram-negative strain)
- *Bacillus Subtilis AZ54* (Gram-positive strain)
- *Bacillus subtilis PY79*
- *Pseudomonas aeruginosa PAOI*
- ***Legionella pneumophila*** *ATCC*
- *Candida albicans ATCC.*



VARIABLES

- intensity of LED source;
- exposure time to LED source;
- initial bacterial concentration.

Investigation of UV-A
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EXPERIMENTAL PROCEDURE

Inactivation level was determined by a **colony-forming assay**:

a) after UV irradiation, bacterial suspensions were diluted appropriately, plated on LB agar plates and incubated at 37_C for 18 h

b) after incubation, number of colonies was counted and log survival ratio or inactivation percentage was calculated.

ADDITIVITY TEST

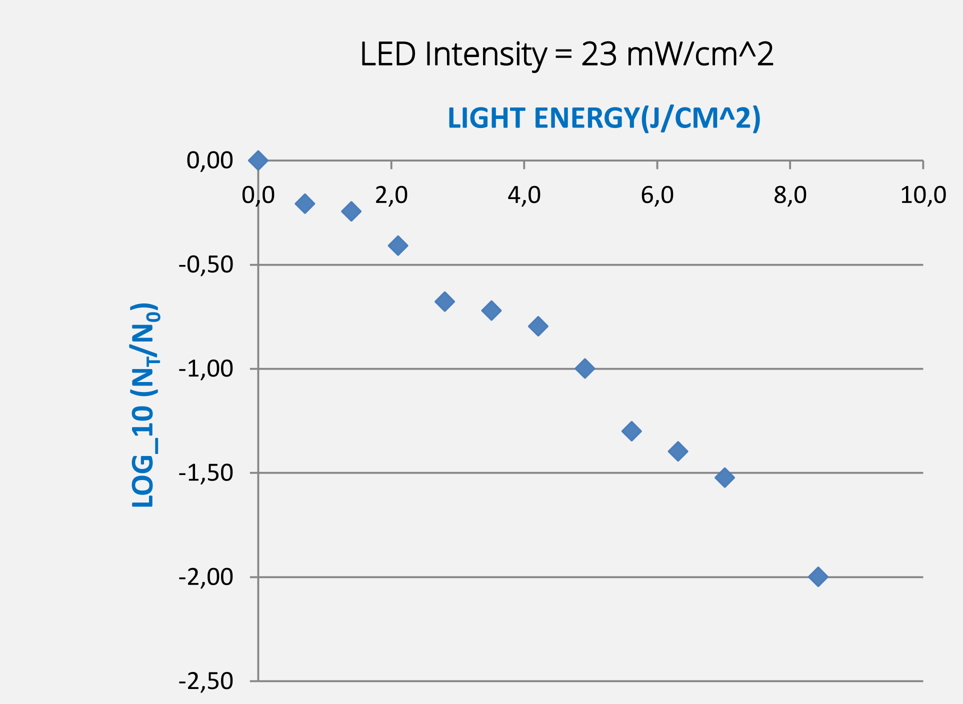
Decontamination **in flux** is obtained with the same energy of the equivalent **static device**!!

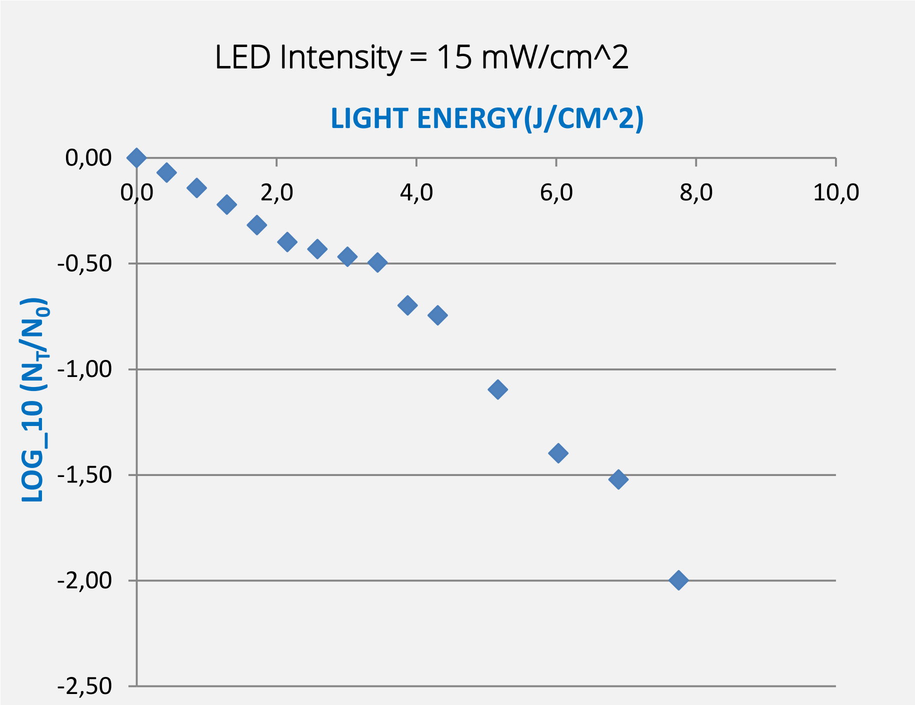
RESULTS

For all species, mortality levels of 100%.

RESULTS FOR

Escherichia coli in Concentration 10^4 CFU/ml





Mutagenicity

UVA-LED bacteria inactivation in water

Our experimental results indicate that **the decontamination effect is enhanced by water**: the same percentages of bacteria mortality are obtained with less energy in water!!!! (see A. Hamamoto results for comparison)

New water disinfection system using UV-A light-emitting diodes - A. Hamamoto et al.

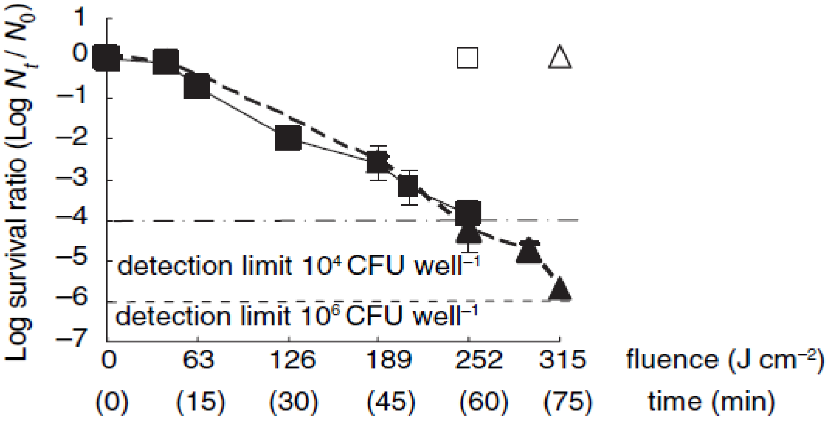


Figure 2 Ultraviolet A light-emitting diode irradiation inactivates *Escherichia coli* DH5α in a UVA dose-dependent manner. The initial number of cells was 10^4 (■) or 10^6 (▲) CFU per well[1]. Nonirradiated control samples (in the dark at 25°C) are displayed as open symbols. The data represent means ± SD (n = 5).

Comparison

UV system with Chemical debacterialization systems

UV light techniques turn out to be the most economical and easy to implement;

UV rays are highly effective in inactivating a wide range of microorganisms, including pathogens resistant to other standard chemical treatments, such as Cryptosporidium and Giardia, that are resistant to chlorination;

There are no side effects related to chemical substances as toxicity and poor-tasting;

UV disinfection eliminates or reduces the long-term costs associated with chemicals, i.e. transport and delivery, risk management and contingency planning, as well as operator training costs.

Comparison
with UV-C debacterialization systems

UV-C low-pressure mercury vapor lamps:
a. special procedures for final disposal
b. safety-conditions for installation and maintenance
c. very expensive

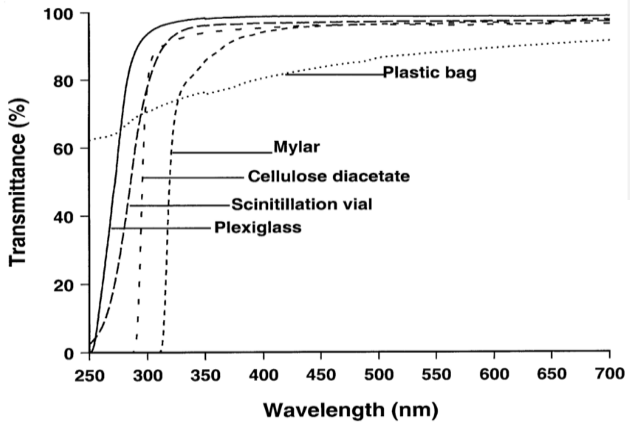
UV-A systems use, as sources of electromagnetic radiation at 365nm, solid-state Light Emitting Diode (LED) with high performance features

UV-C Dose(Log_Inactivation = 1) 3 mJ/cm^2

UV-A Dose (Log_Inactivation = 1) 5 J/cm2

LED devices are fully recyclable and do not require special disposal procedures, since they do not contain substances heavily polluting

LED technology is highly efficient and with low consumption and inexpensive operating costs. LED have a long operating life



UV-C LED versus UV-A LED:

a. Higher costs (***up 1 order of magnitude!!!***)
b. Lower Efficiency (***up 2 orders of magnitude!!!***)
c. Lower UVT (Ultraviolet Transmittance)
d. **Plexiglass** (*insoluble e inert*) or **ordinary glass** instead **quartz!!!!!!**

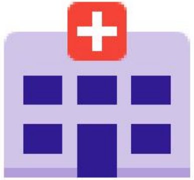
Potential applications

any situation where are required high quality standards of the water

Debacterialization systems based on UV-C radiation are still effective but they present some shortcomings.

5-10% of mortality in hospitals is due to infections that occurred there.

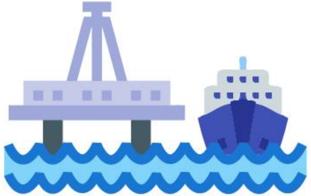
Healthcare building



Extreme environments

residential and commercial

Ship, tanker and off shore platforms



Public Institutions

Self portable kits

Application
Health Hospital Critical Environments

PROBLEM:

HIGH quality standards required for water, not guaranteed by the current procedures

Risk of public health impairment :

- users immuno-suppressed;
- biomedical use of water.

SOLUTION

UV-A decontamination device for delivery points

indentify the points of risk;

define installation, maintenance, power supply, management & operating requirements.

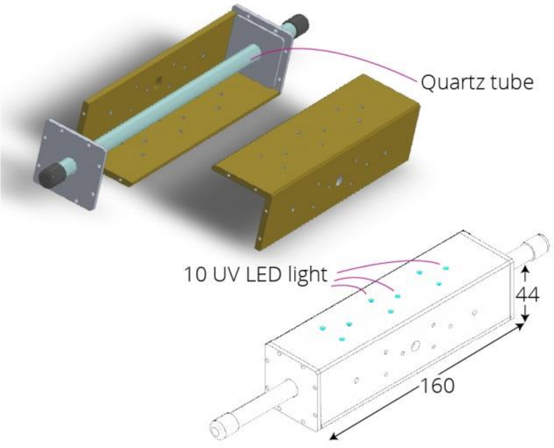
Light Tube
First Prototypal version

UV-A technology in a compact and versatile prototype, for the reduction of the bacterial load in a flowing fluid.

Features:

- **low power consumption**
- **easy maintenance**
- **in-line installation in existing distribution plants,**
- **ability to work under pressure's values in the network**

The quartz tube passes through the whole room and protrudes for connection to the hydraulic circuit. The pump speed and the power of the LEDs can be controlled.



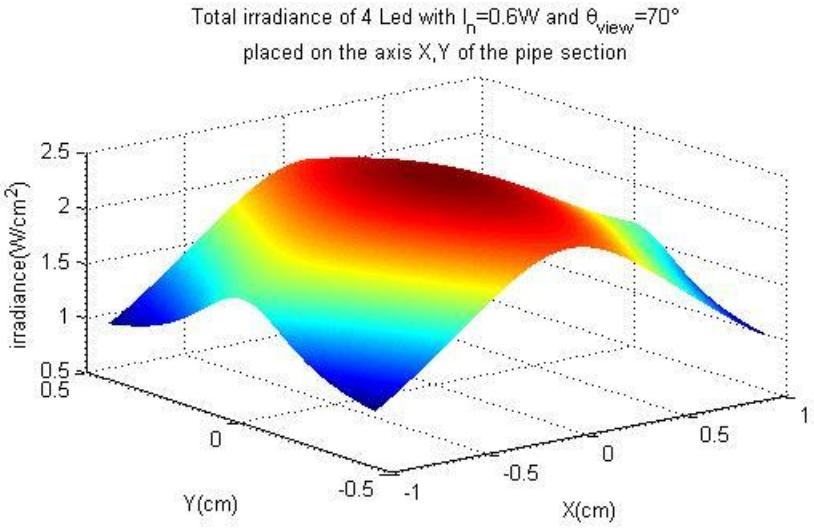
The **LIGHT TUBE** moke-up is like a filter for fluids, with action "in real time", with no need for storage or waiting times.

Italian patent IT1403379(B1)

Study of the irradiance LEDs:
cylindrical geometry

Light distribution of 4 LED

We can calculate the
LEDs geometric distribution
on the external surface of a cylinder as a function of the irradiated energy that we want to obtain.



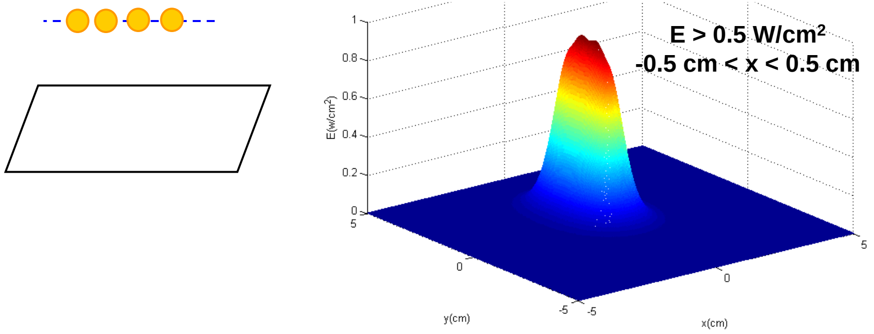
We can plan **LED sources in a pipe system**, for decontamination in flux, with a determined **number of LEDs!!**

Simulation of the energy distribution due to 4 LEDs, with **cylindrical geometry**, on the external circle ø 1“

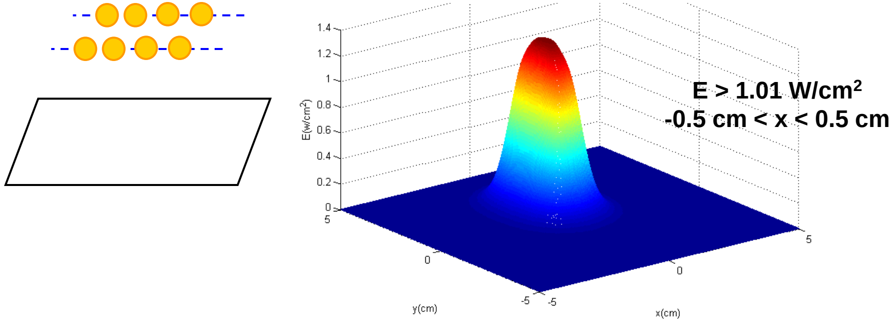
Study of the irradiance LED: flat geometry

Irradiance for *4 LED linear array* at d 0.7 cm

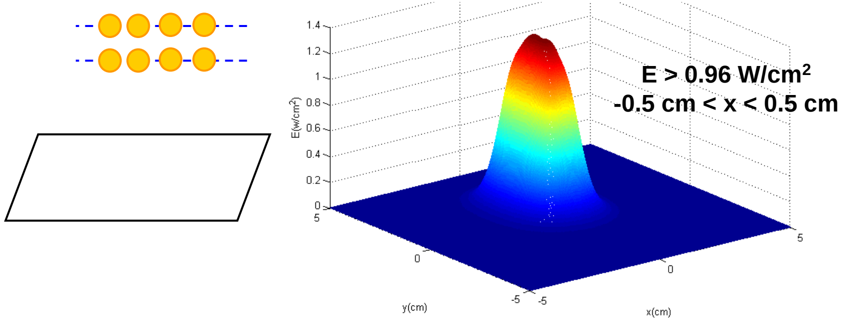
Calculation plane at 1 cm



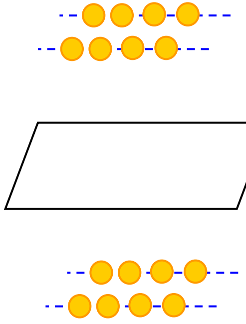
Irradiance for *2 parallel and STAGGERED linear array* OF 4 LED each - d_led 0.7cm e d_array 0.7cm - Calculation plane at 1 cm

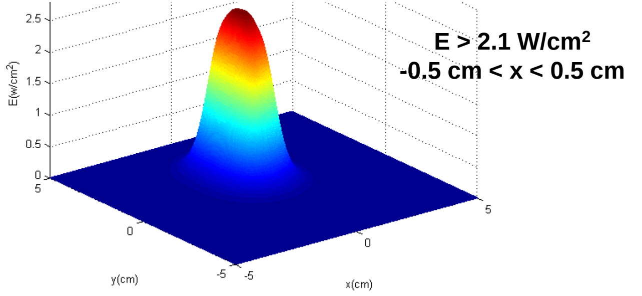


Irradiance for *2 parallel 4 LED linear array* at d_led 0.7cm e d_array 0.7cm - Calculation plane at 1 cm



Irradiance for *2 SPECULAR led MATRIX*, each of 2 parallel and STAGGERED linear array OF 4 LED - d_led 0.7cm e d_array 0.7cm - Calculation plane at 1 cm

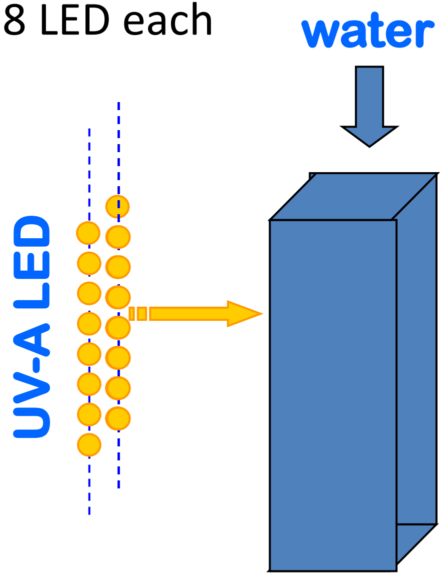




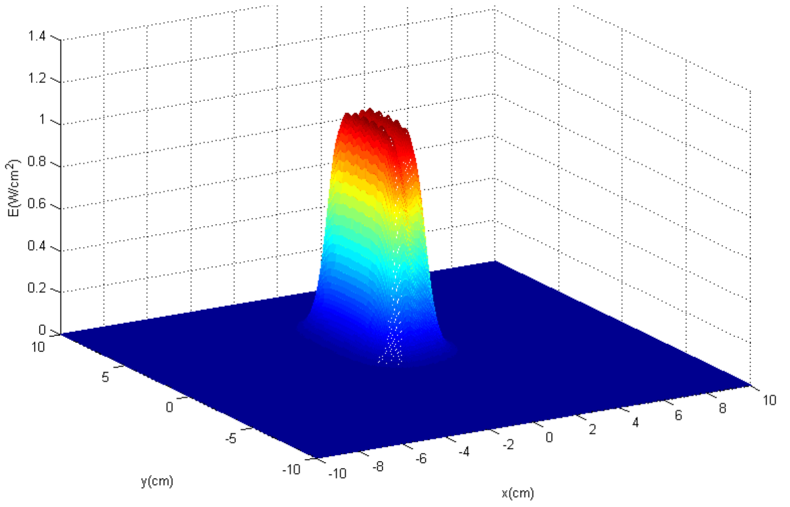
Study of the irradiance LEDs:
flat geometry

Light distribution for 16 LED

2 lines of 8 LED each



Irradiance for *2 parallel linear array* OF 8 LED each - d_led 0.7cm e d_array 0.7cm - Calculation plane at 1 cm



Simulation of the energy distribution due to 16 LEDs, with **flat geometry**, on the plane z= 1cm

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