Aalto University
School of Electrical
Engineering

PhOto LED

FISHEYE CAMERA METHOD

for spatial non-uniformity corrections in luminous flux measurements with integrating spheres

Alexander Kokka
Stakeholder training
Roskilde, 28.8.2019

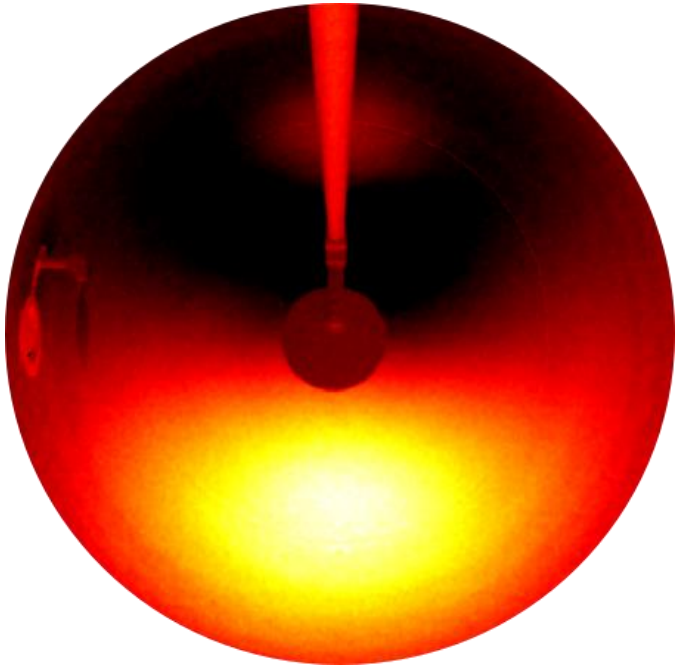
Motivation

- A more convenient way to
  - *apply spatial non-uniformity corrections in luminous flux measurements with integrating spheres*
    - by quickly measuring the angular intensity distribution of the lamp under test

Fisheye camera method

Content

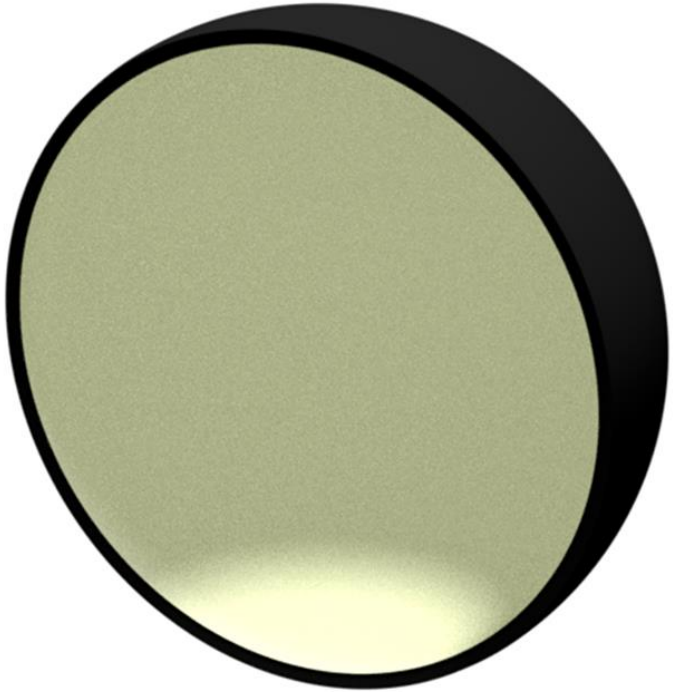
- Spatial-non uniformity correction
  - *Concept*
  - *Traditional method*
- Fisheye camera method
  - *Principal*
  - *Benefits*



Processed fisheye camera photograph of an integrating sphere

Ideal integrating sphere

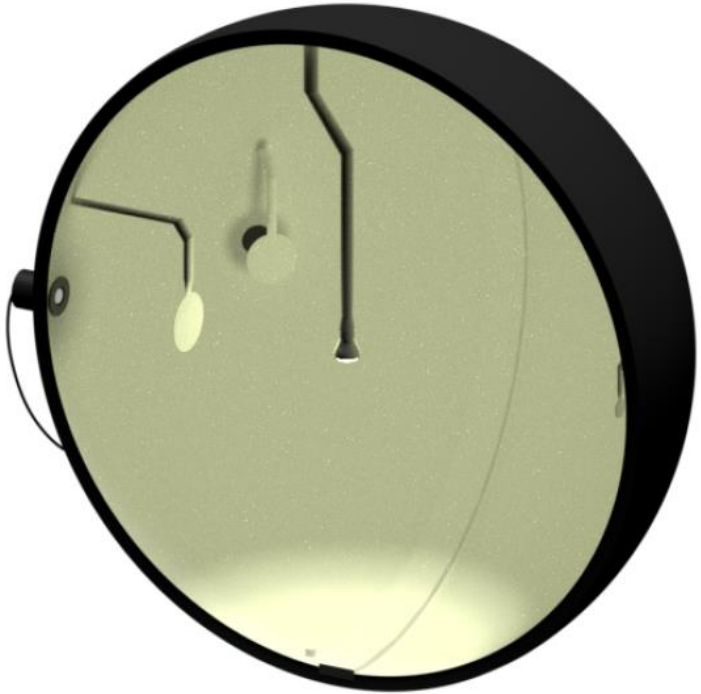
- Uniform spatial responsivity
- Luminous flux can obtained from the ratio of photometer signals of
  - *Device under test* (DUT)
  - *Luminous flux standard lamp*



Cross section of an ideal integrating sphere with a directional light source

Actual integrating spheres

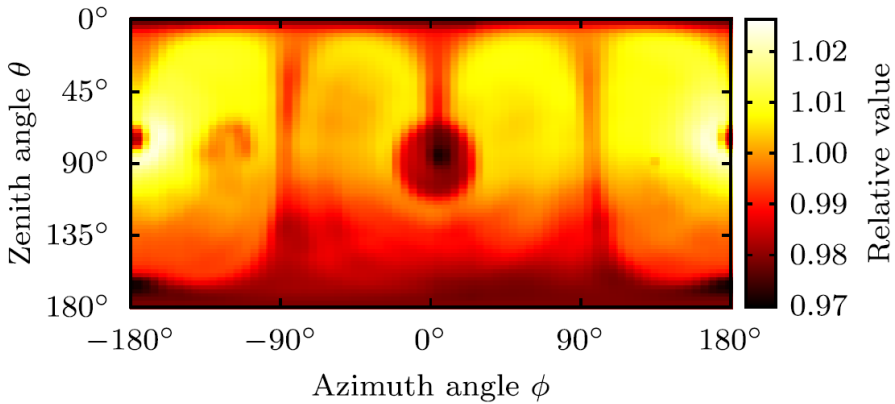
- Spatially non-uniform
  - *Baffles*
  - *Seams*
  - *Holders*
  - *Contamination*
- Mismatch of the angular distributions of the
  - *Device under test*
  - *Luminous flux standard lamp*



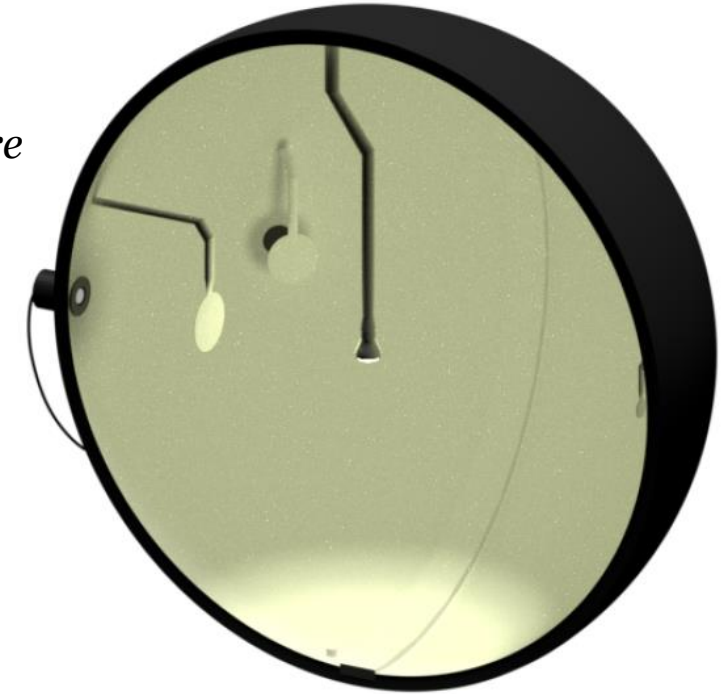
3D model of the sphere at Aalto University

Spatial responsivity of the sphere

- Obtained using a sphere scanner
  - *Rotating spotlight at the center of the sphere*
  - *Photometer signals recorded to create a sphere map*



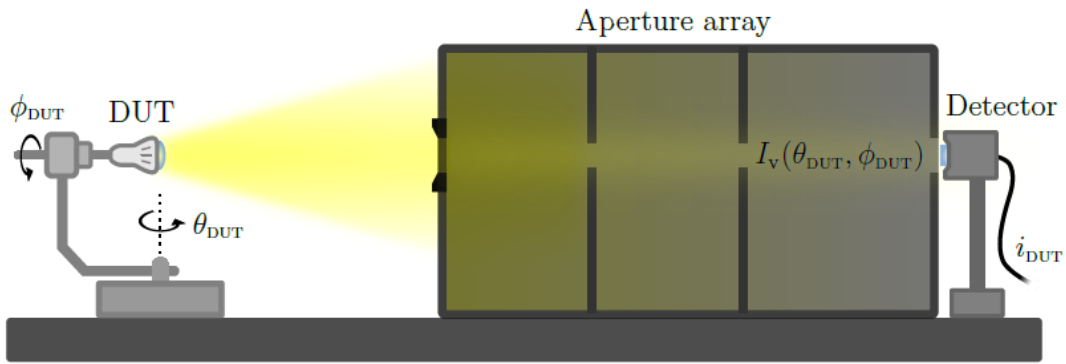
Spatial responsivity map of the same sphere



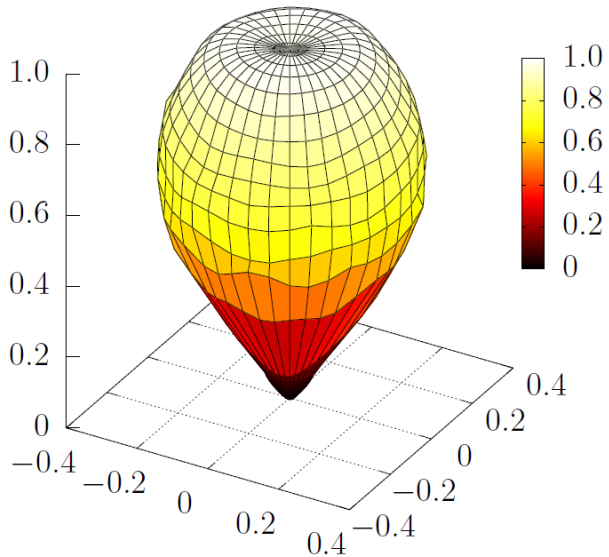
3D model of the sphere at Aalto University

Relative angular intensity distribution

- Traditionally obtained using a goniophotometer
  - *Time consuming*
  - *Resource intensive*



Goniophotometer at Aalto University



Example of an angular intensity distribution

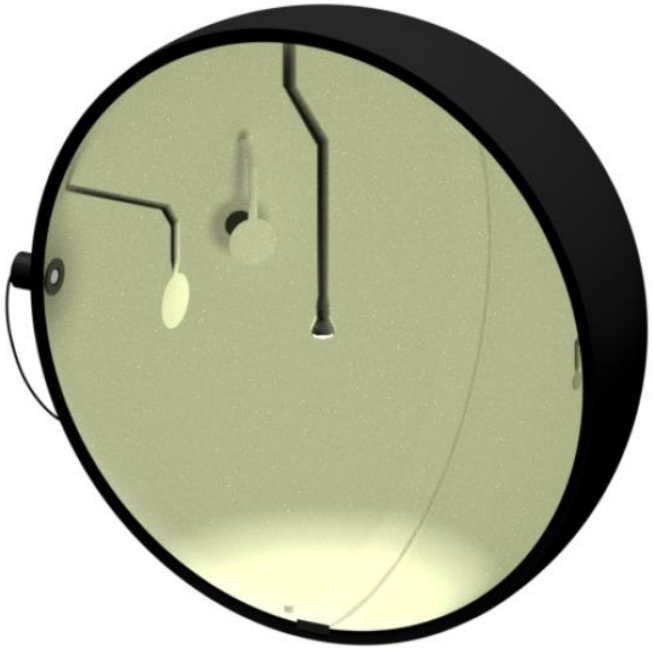
Aalto University
School of Electrical
Engineering

PhOto
LED

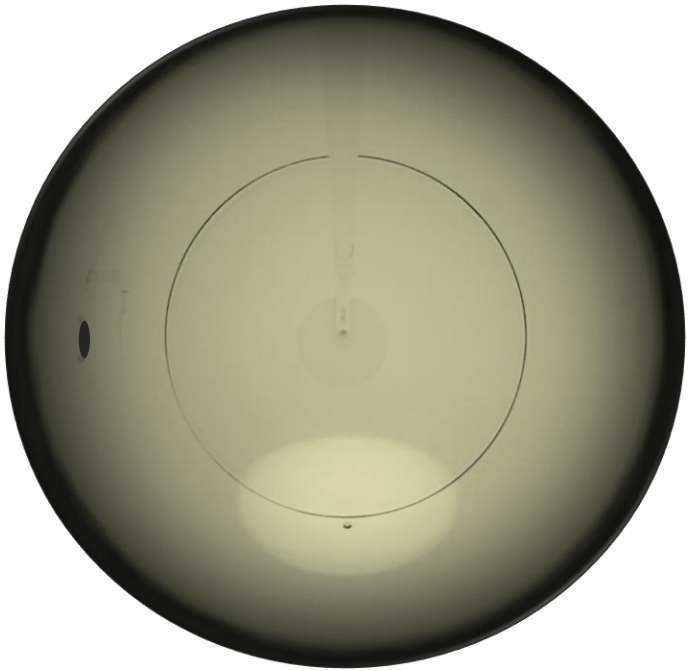
Fisheye camera method

Fisheye camera method

- Fisheye camera + integrating sphere

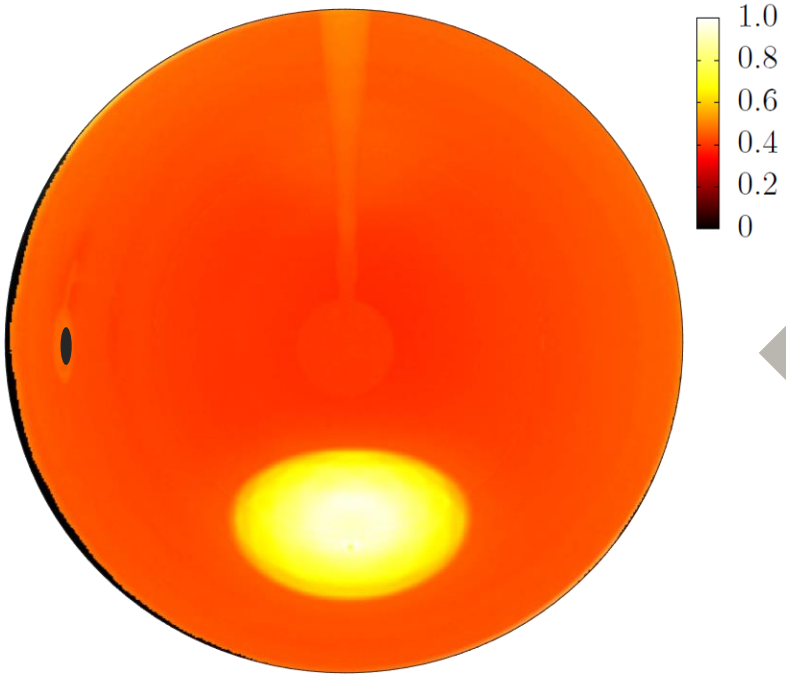


Integrating sphere

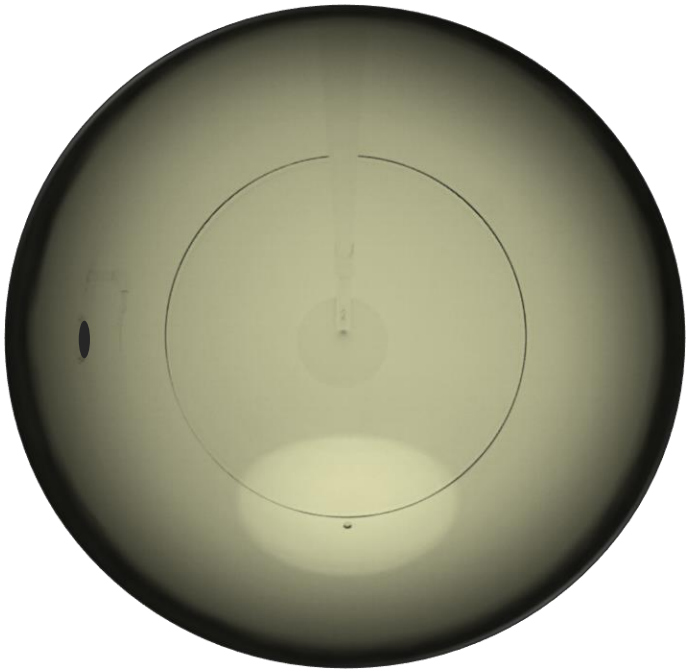


Fisheye camera photograph

Image processing

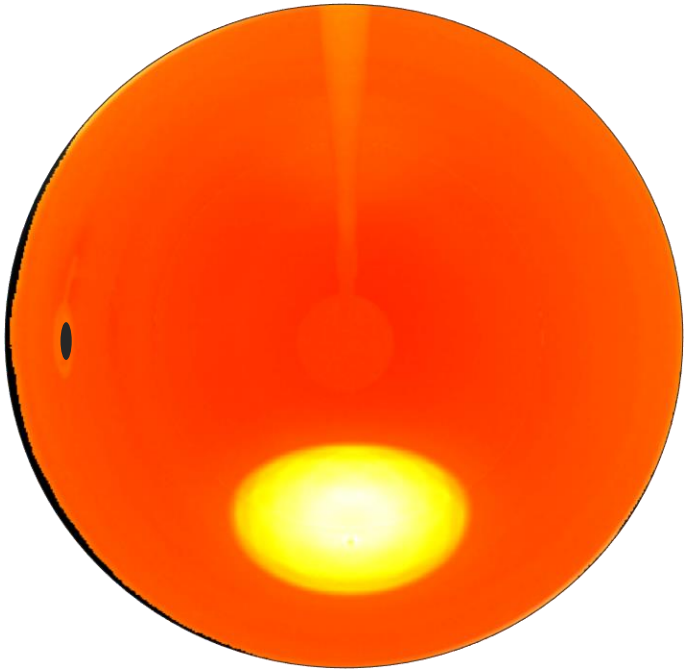


Processed image shown with a colormap



Fisheye camera photograph

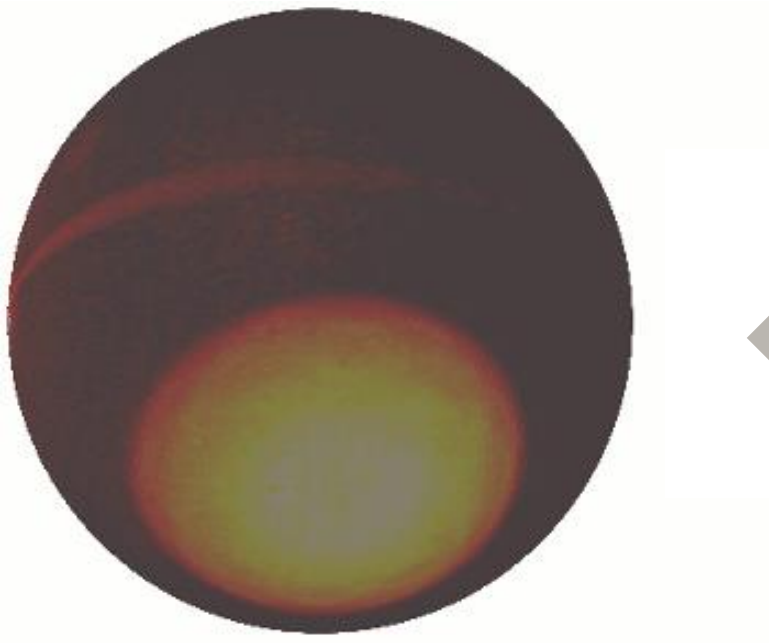
Image backprojection



Processed image with a colormap

Backprojected fisheye camera image

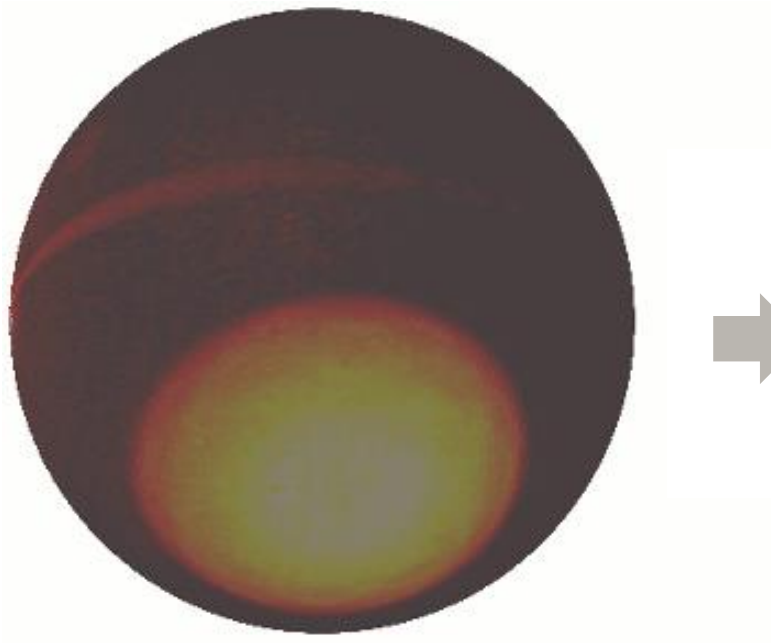
Image backprojection



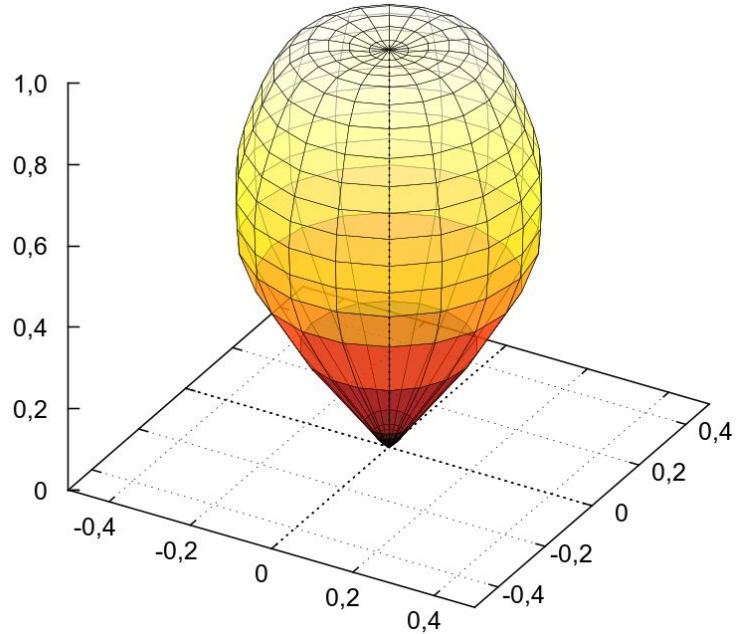
Diffuse light level subtracted

Backprojected fisheye camera image

Relative angular intensity distribution

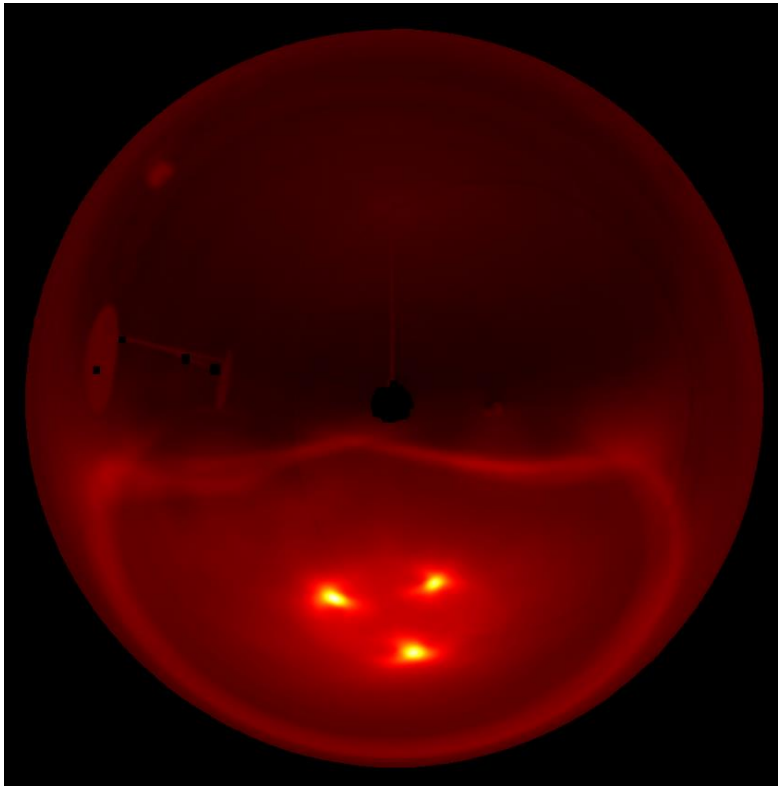


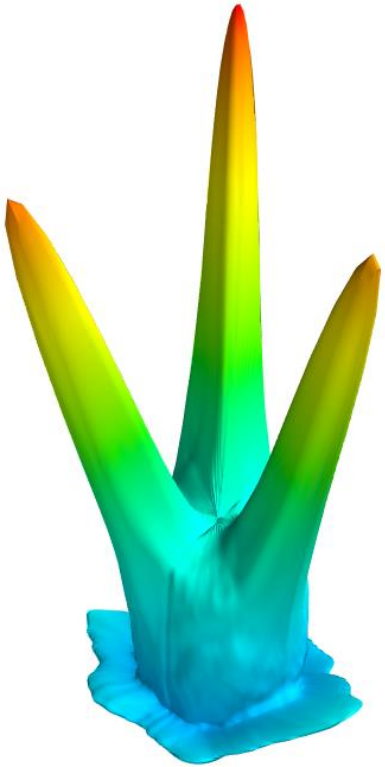
Diffuse light level subtracted



Distance to the sphere center plotted as a function of intensity

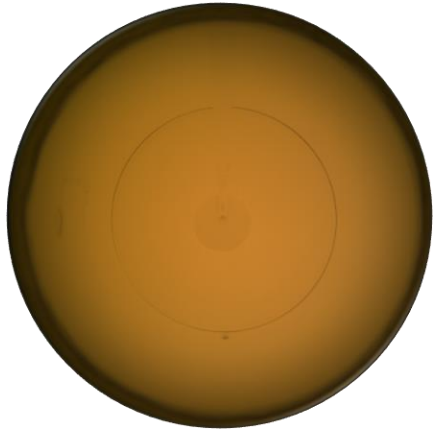
Example

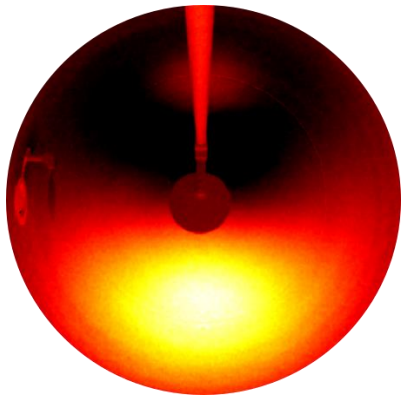


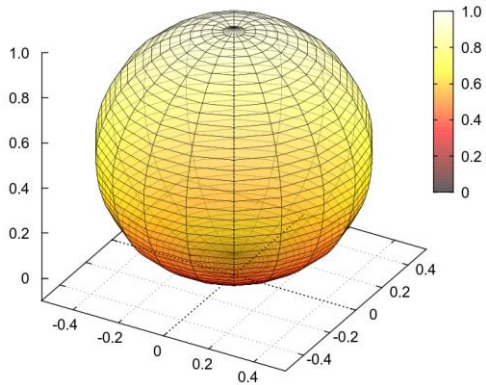


Summary

- Fisheye camera method for spatial non-uniformity corrections
  - *Quick: spatial correction obtained in minutes*
  - *Compact: camera, sphere adapter and software*
  - *Convenient: existing ports of the sphere can be used*

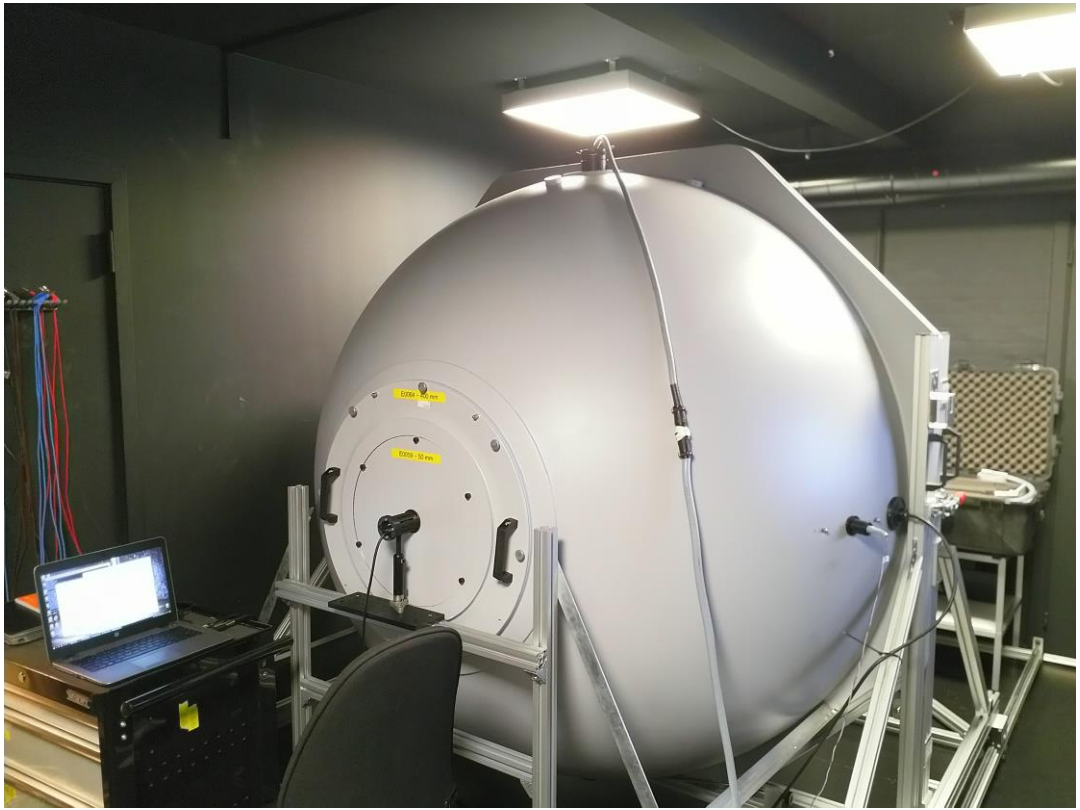






Spatial non-uniformity correction

Sphere lab at DTU



Aalto University
School of Electrical
Engineering

PhOto
LED

Alexander Kokka
alexander.kokka@aalto.fi

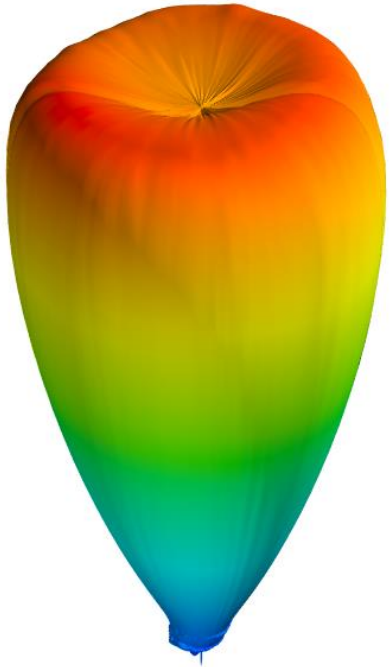
photoled.aalto.fi

DUT 1

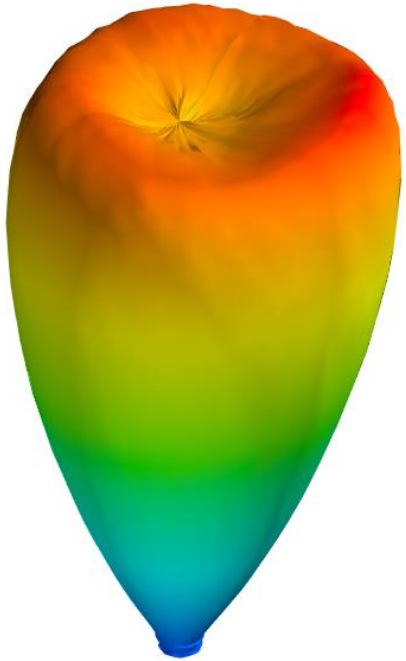
Fisheye camera

Goniophotometer

DUT 2

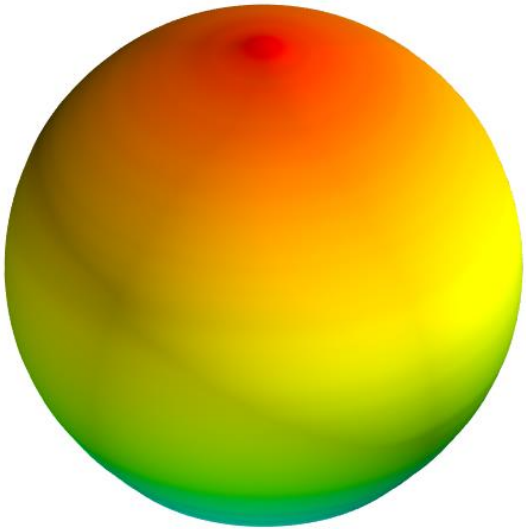


Fisheye camera

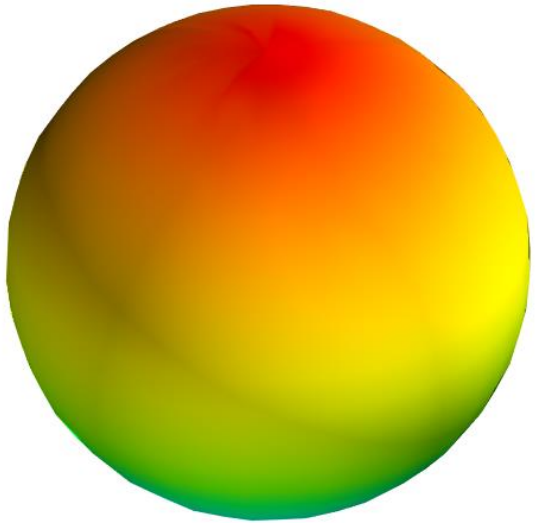


Goniophotometer

DUT 3

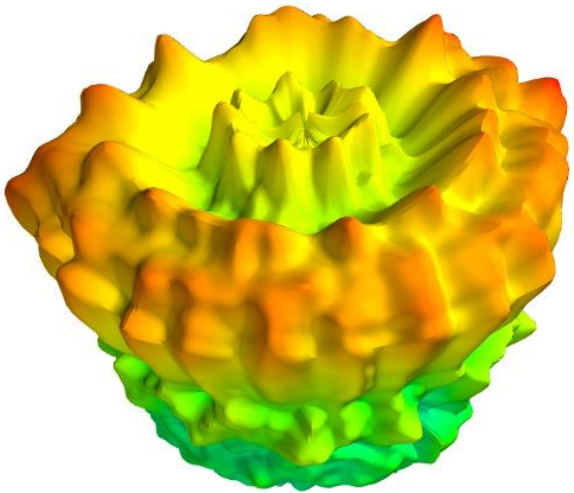


Fisheye camera

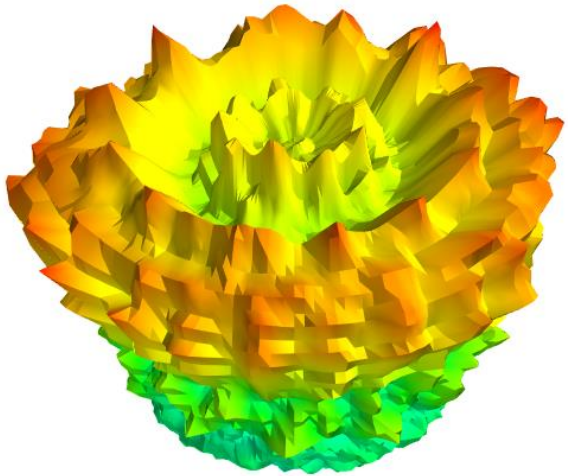


Goniophotometer

DUT 4

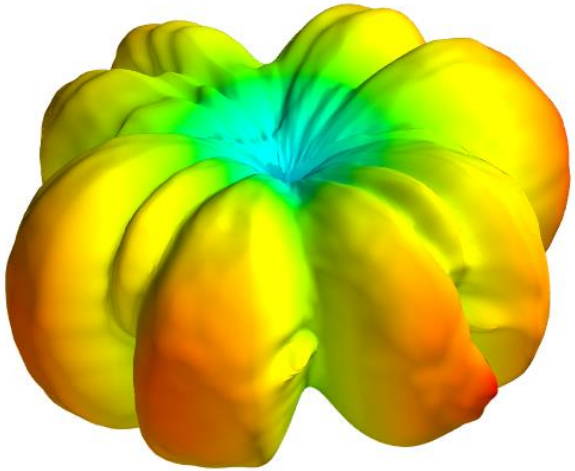


Fisheye camera

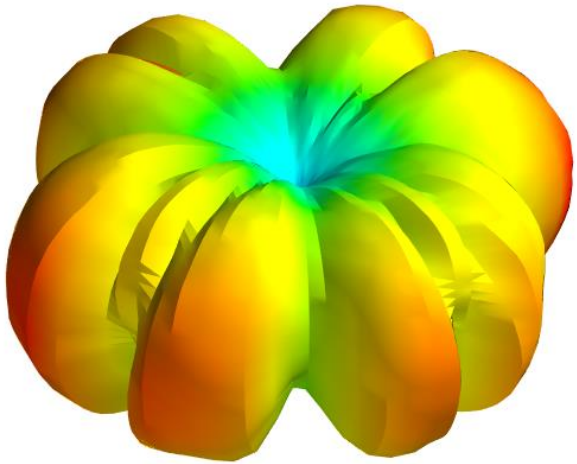


Goniophotometer

DUT 5

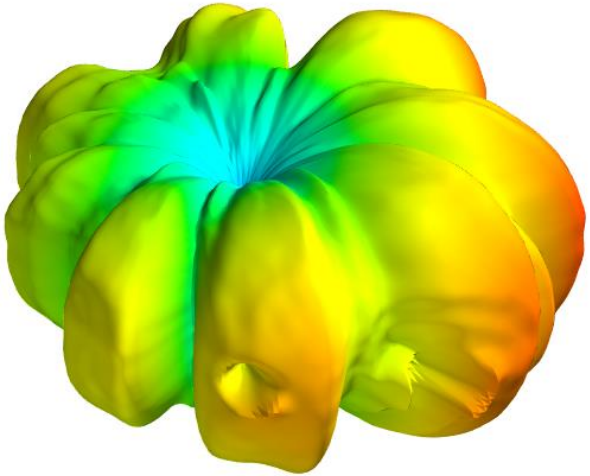


Fisheye camera

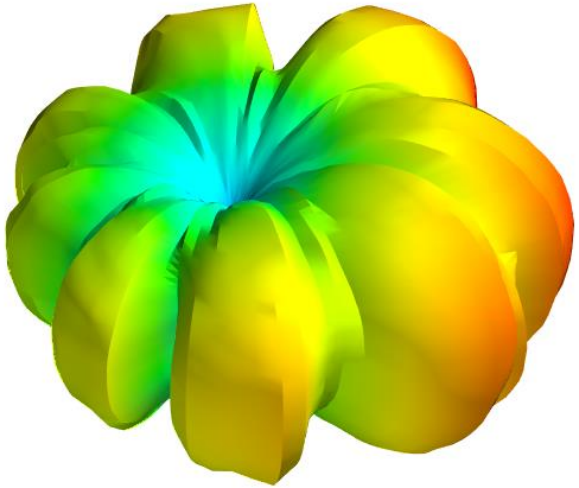


Goniophotometer

DUT 6



Fisheye camera



Goniophotometer

Aalto University
School of Electrical
Engineering

PhOto
LED

Details available in the following publications:

https://doi.org/10.1088/1681-7575/aa7cb7

https://doi.org/10.1088/1681-7575/ab17fe