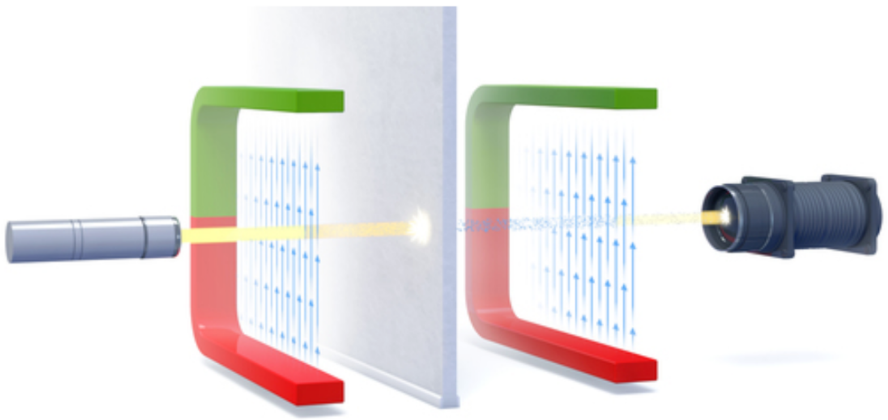
Any Light Particle Search II

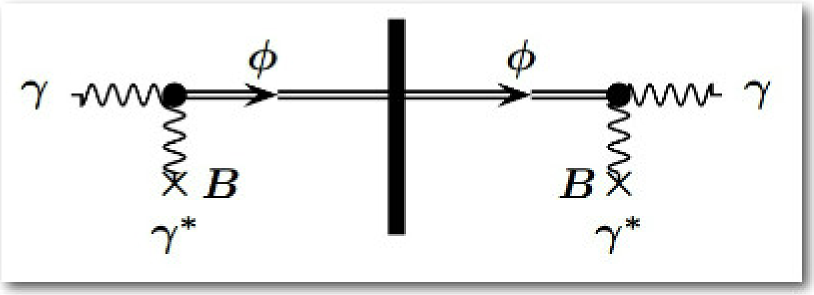
Shutter Box light Tightness Measurements

Light shining through a wall

The principle of a light-shining-through a wall experiment

Light from a strong laser, is shone into a magnetic field. Laser photons can be converted into a WISP in front of a light-blocking barrier (generation region) and reconverted into photons behind that barrier (regeneration region).



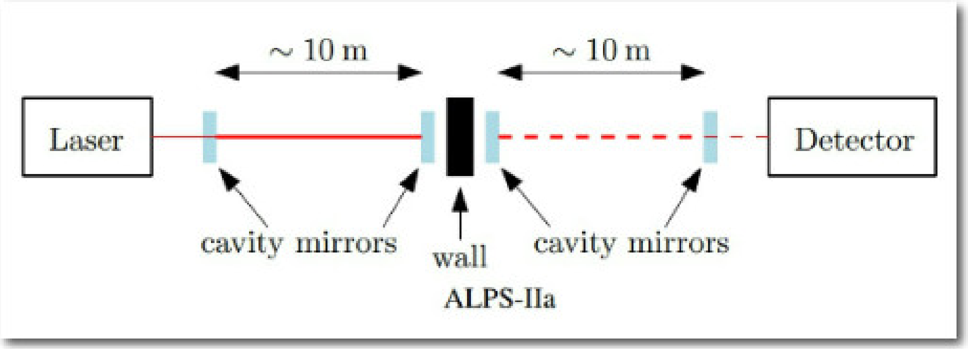


HELMHOLTZ ASSOCIATION

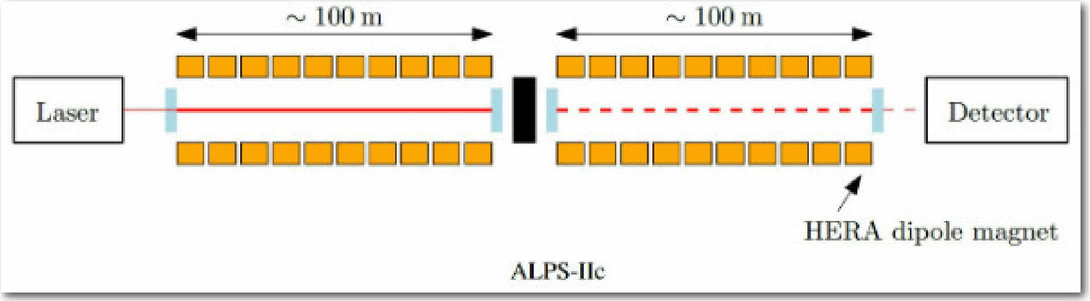
DESY

Stages of the expermient

ALPs-IIa: 10 m cavities without the HERA superconducting dipole magnets to test the optical subsystems related to maintaining the dual resonance of the PC and RC as well as single photon detection schemes at the output of the RC.



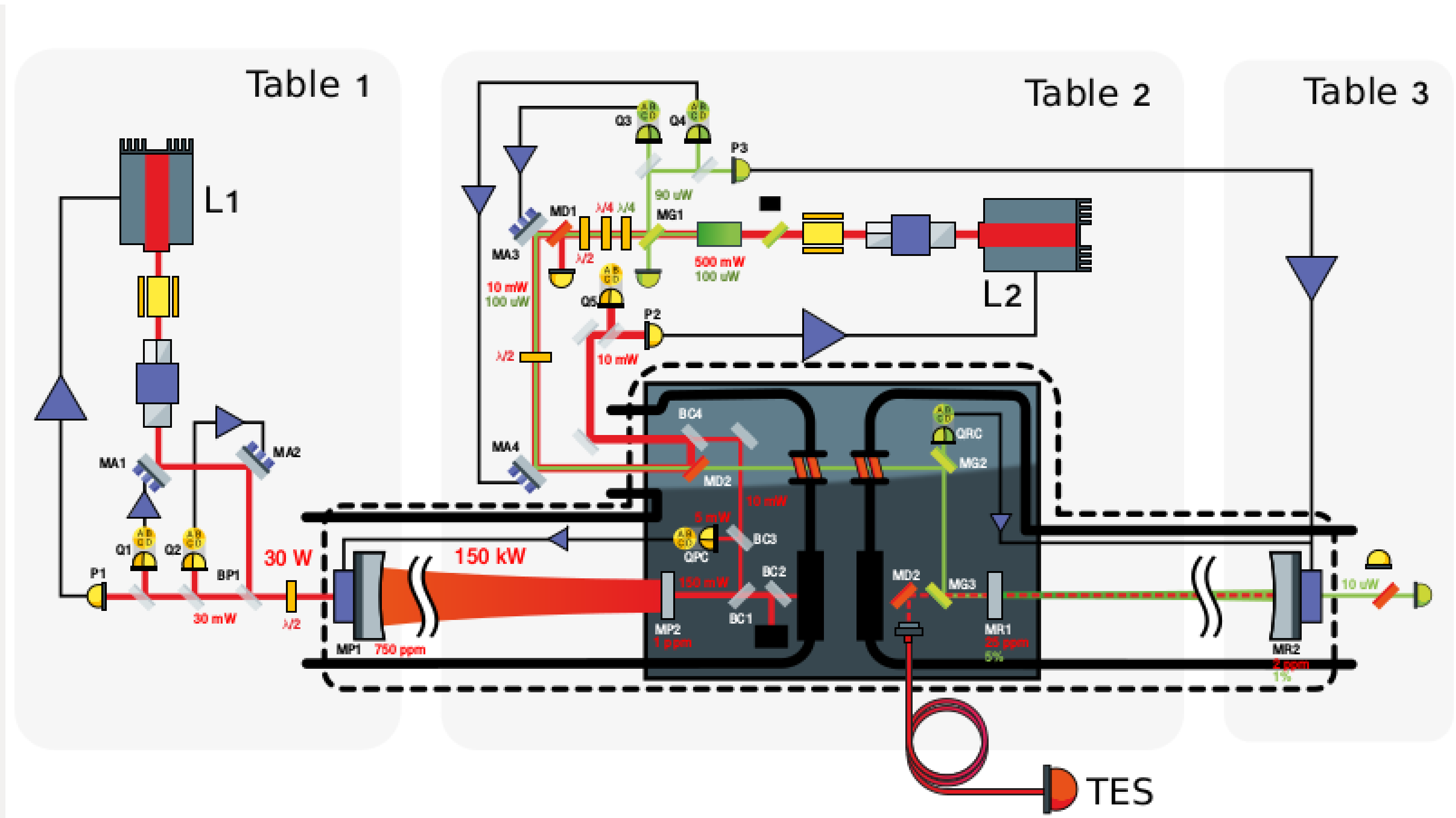
ALPs-IIc: represents the full scale experiment using 100 m cavities with light propagating through high magnetic fields using a 5.3 T HERA superconducting dipole magnets.



HELMHOLTZ ASSOCIATION

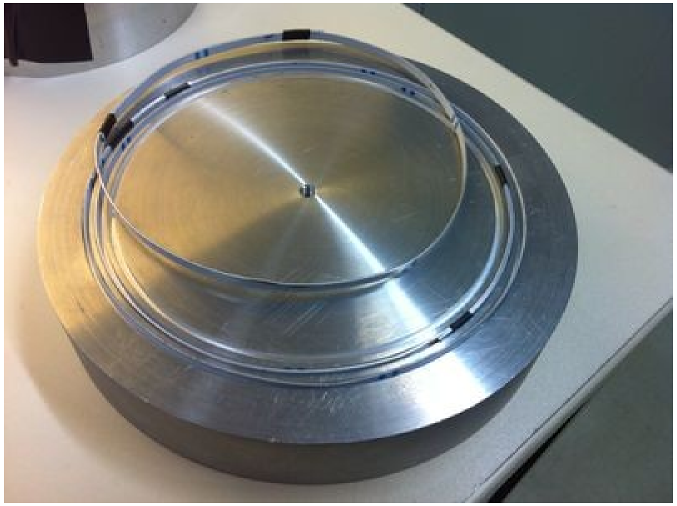
DESY

Optical Setup



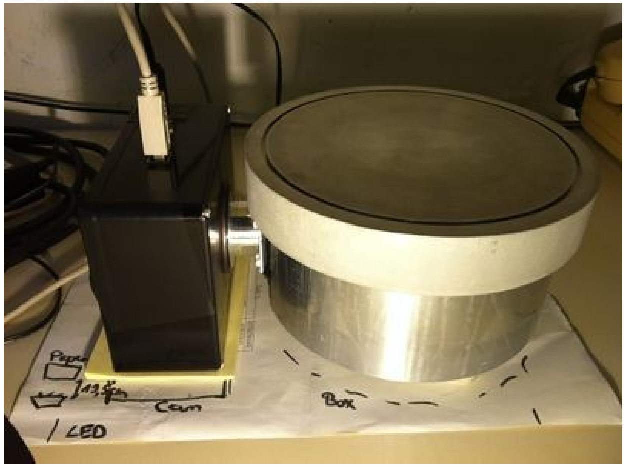
Light tightness measurements Setup

shutter box



Shutter box's ground plate

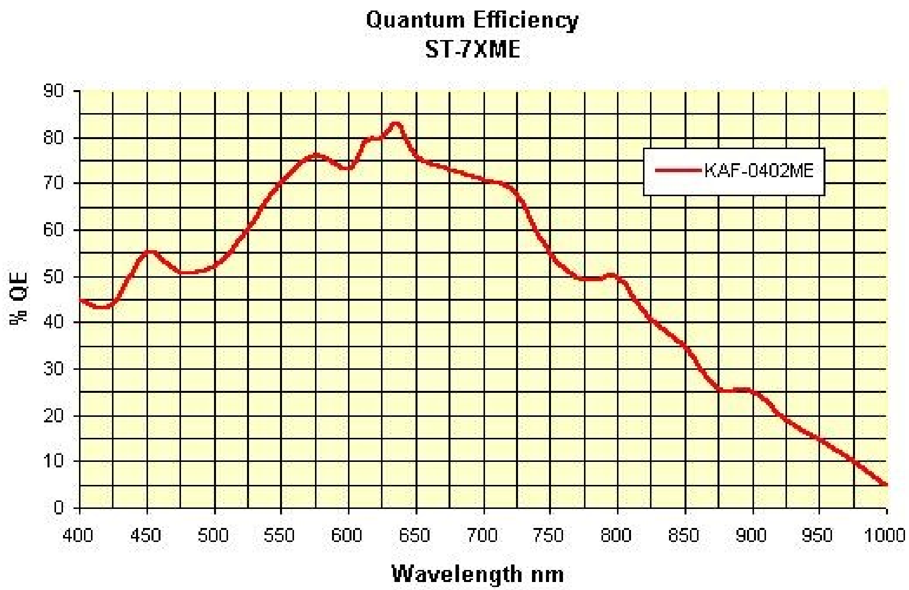
Camera-Box Connection



Setup for the the light tightness measurements with the SBIG CCD.

SBIG ST 402-ME CCD camera

- The SBIG camera has a Kodak KAF- 0402 chip (no anti-blooming effect included) to detect light,
- the camera has 360.000 pixel with a pixel array 765 x 510 pixels at 9 microns square.
- The dark current is 1 e-/p/sec at 0 ºC,
- the A/D gain is 1.5e- /ADU. With a full well capacity 100,000 electrons.

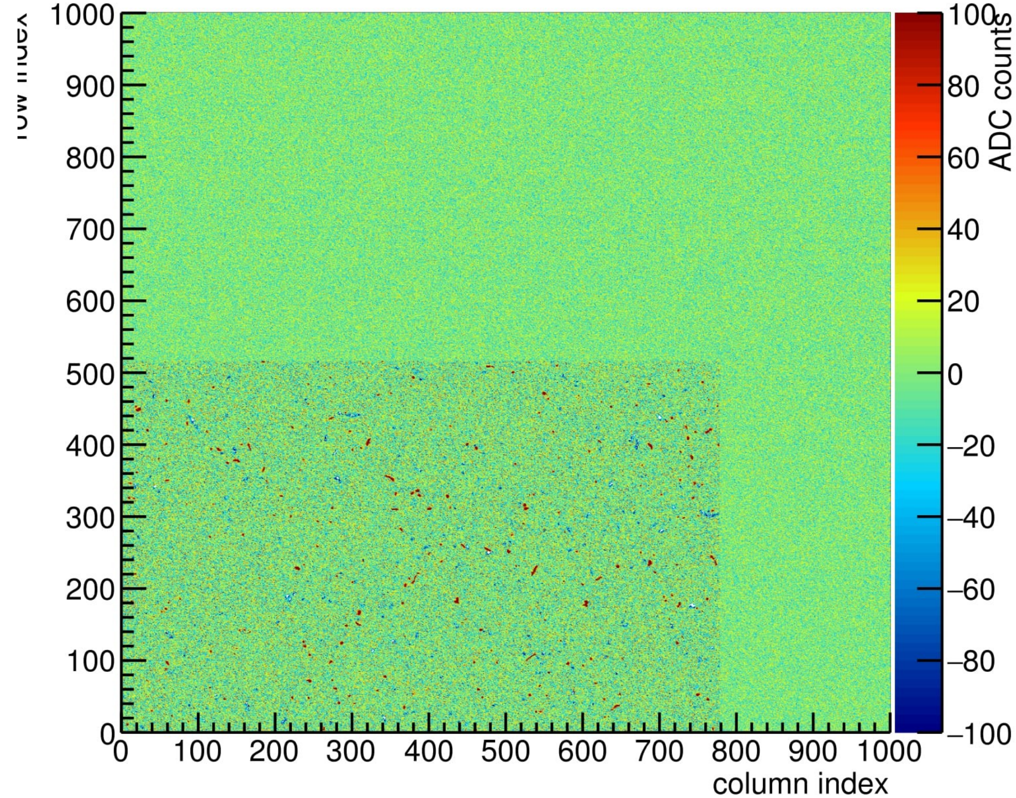


Analysis

- To analyse the pictures, the signal value for each pixel is summed up to get a total ADU (analog to digital units) value.

- The signal is affected by different types of noises;
  - read-out noise
  - Dark current
  - hot pixels
  - cosmic muons

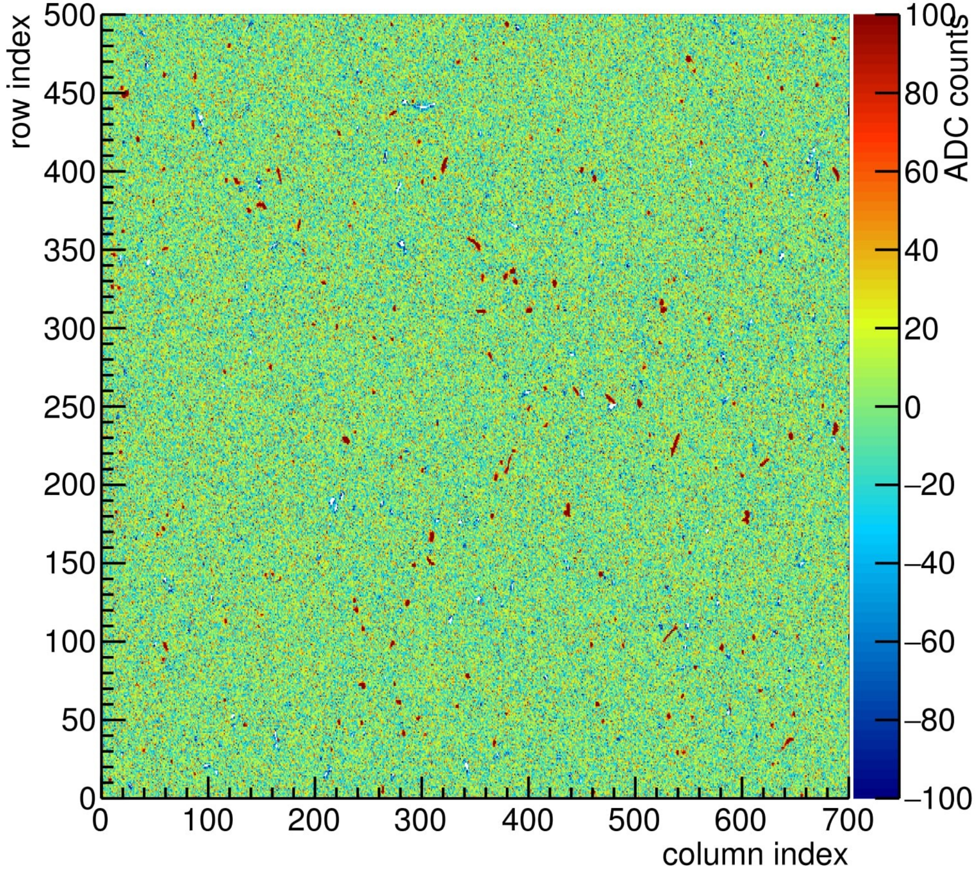
- Only the area 510x765 pixels is an active region “exposed to light “the rest is virtual pixels but used to determine the readout noise and pure fluctuations of the pixels.



Analysis

- To estimate readout noise , we subtract each active column (exposed row) by the mean of its corresponding virtual column ”.

- the total light leakage in the setup can be estimated by the ADU difference between a shutter open frame “light frame” and a shutter closed frame “Dark frame” .



Measurements

- Three sets of measurements were taken with different exposure times, with the room light off,with 3 O-rings installed in the grooves, and the light source at a distance 4 cm from the shutter box.

- Measurement set 1 : 10 light frames and 10 dark frames with exposure time 1800 sec.

  ADUs/pixel/sec : $0.1189 \cdot 10^{-3} \pm 0.52 \cdot 10^{-3}$

- Measurement set 2 : 50 light frame and 50 dark frame with exposure time 600 sec.

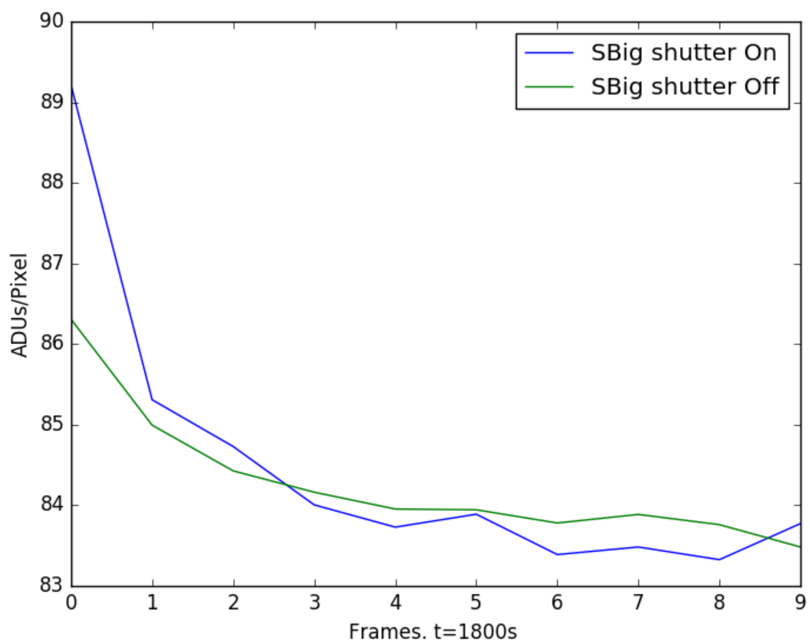
  ADUs/pixel/sec: $-3.6 \cdot 10^{-5} \pm 0.27 \cdot 10^{-3}$

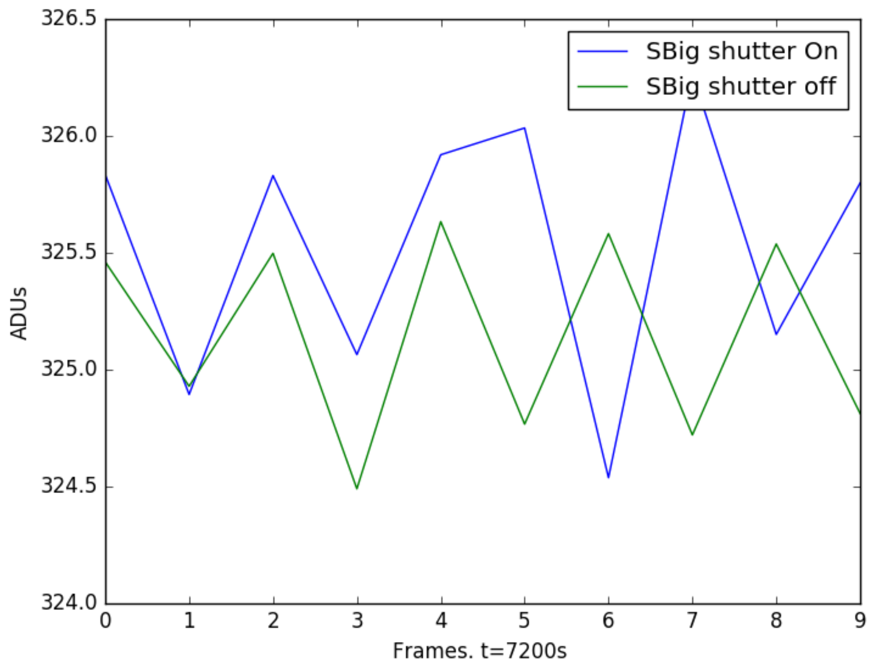
- Measurement set 3: 10 light frames and 10 dark frames with exposure time 7200 sec.

  ADUs/pixel/sec: $5.4 \cdot 10^{-5} \pm 0.1 \cdot 10^{-3}$

Measurements

- The first set of measurements showed an increase in the first couple of frames but wasn’t observed in the other following frames. Which can be due to the camera thermalization working temperature, the camera chip works at 0 degrees and cools down within a minute but the chip surroundings causing the readout noise may need longer time to cool.



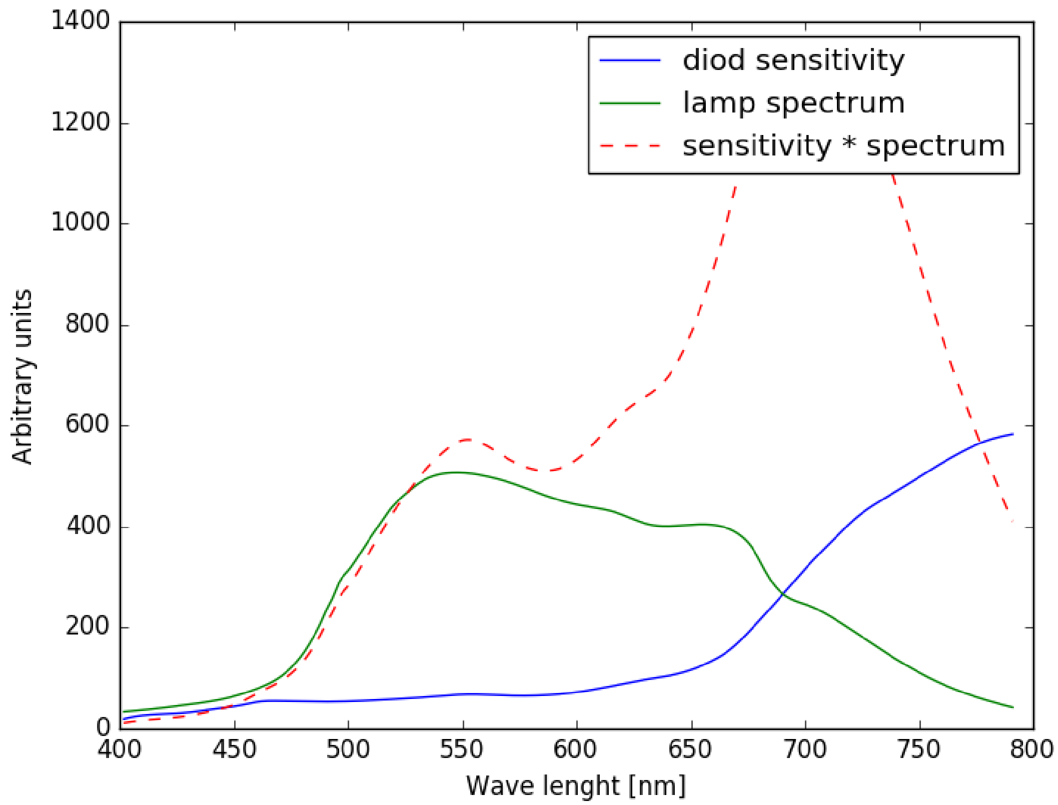


HELMHOLTZ
ASSOCIATION

DESY

Measurements sensitivity

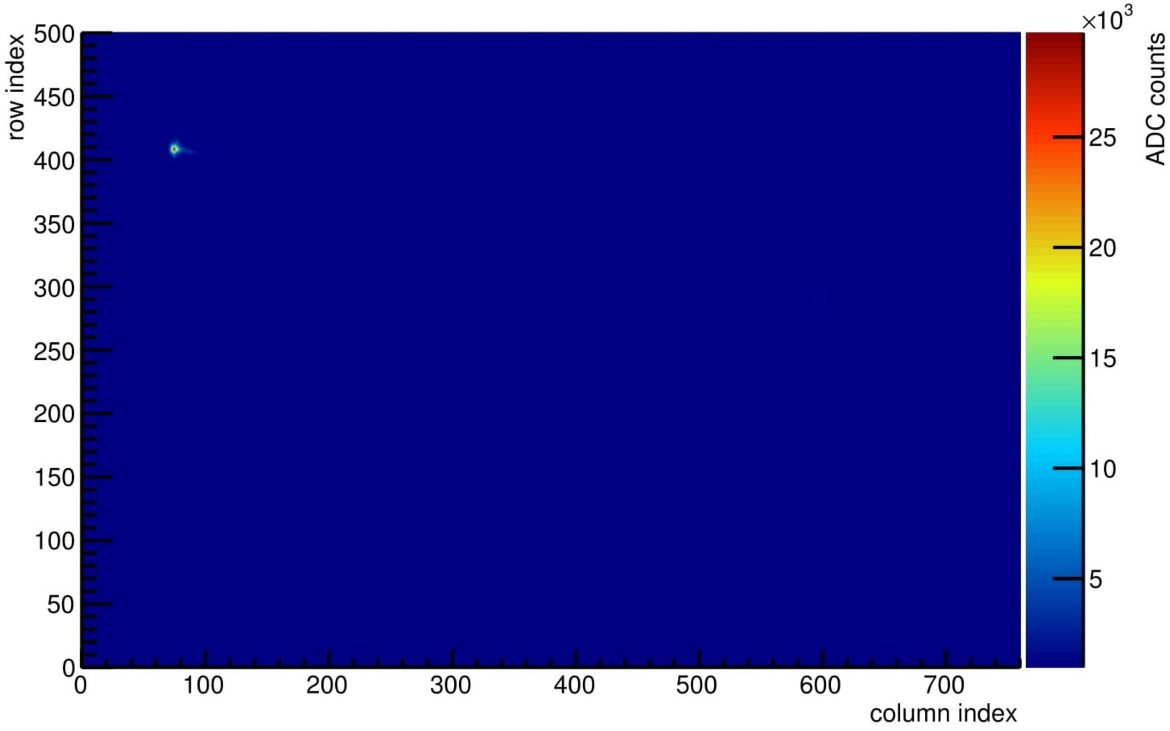
- using the data from the SBIG quantum efficiency ε(λ)and the OSL lamp spectrum S(λ)the sensitivity, the efficiency of the CCD to a known spectrum of the OSL lamp “integrating the QE of over the spectrum range 400:800 nm “ was calculated to be around 68%
- in terms of the number of ADUs per sec the SBIG gain= 1.5 e^- / ADU, the pixel size = 9 microns square and efficiency . The sensetivity was found to be around 161 **γ/sec/cm²**



Detection Efficiency of SBIG CCD for (1064 nm) light

The setup of the detection efficiency measurements is IR laser , and SBIG CCD, a Narrow bandpass filter1064±8 nm has been installed in a front of the laser to purify IR light. And to focus a laser beam a lens has been used . Two Neutral density ND filters with unknown attenuation A 1 and A 2 .

- for the measurements; 4 sets of measurements was taken with room light off and laser on and off .

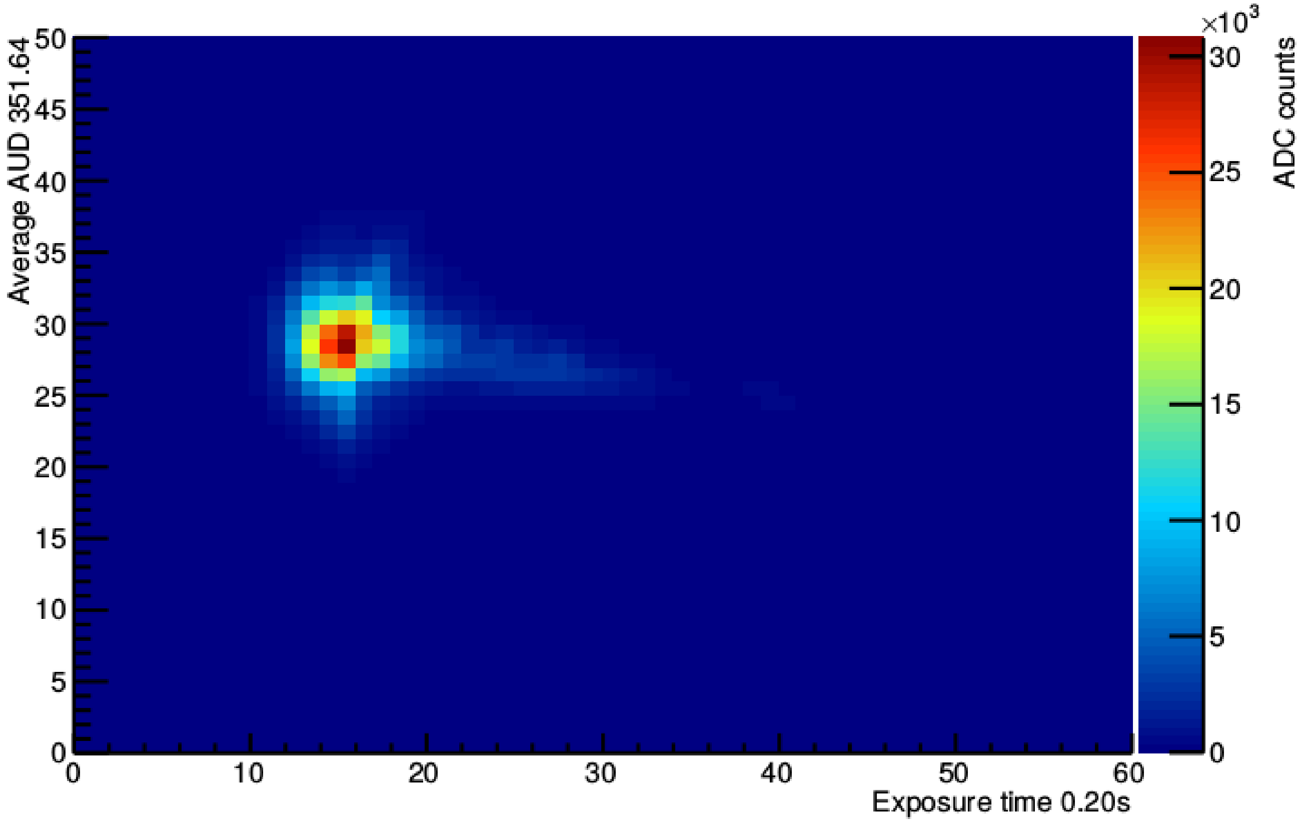


HELMHOLTZ
ASSOCIATION

DESY

Detection Efficiency of SBIG CCD for (1064 nm) light

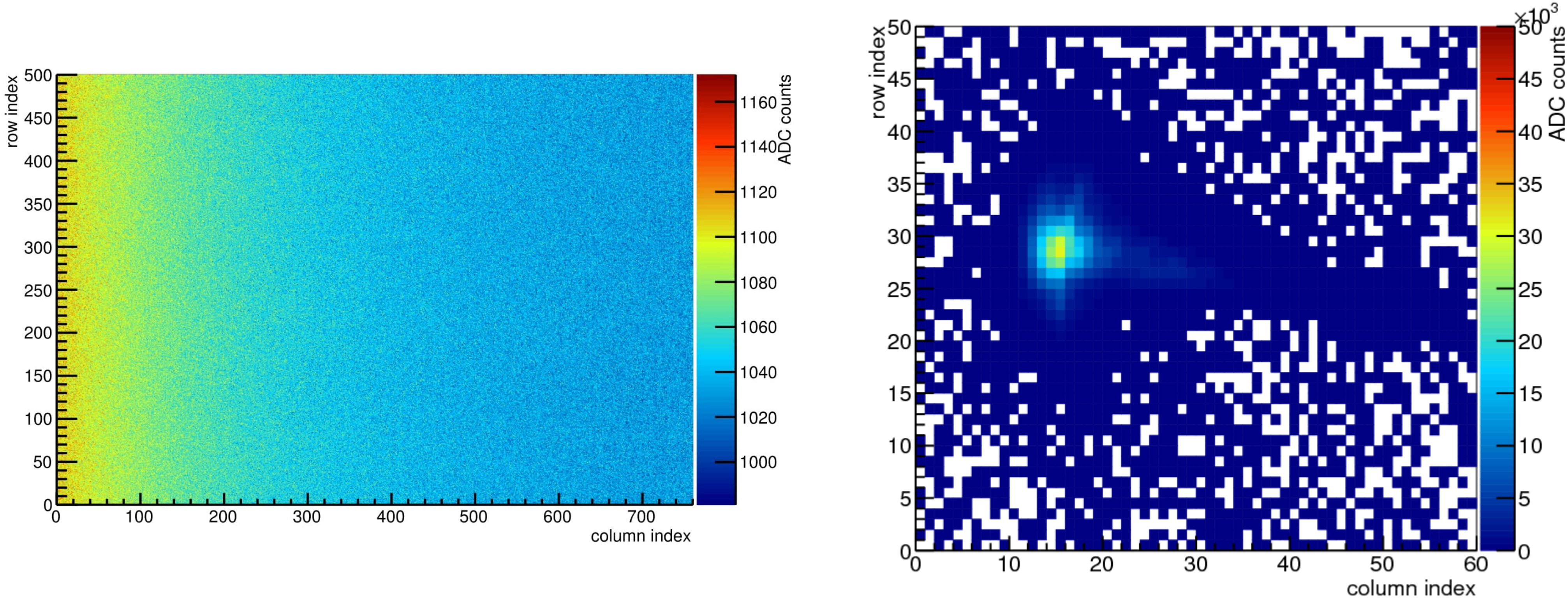
- for the analysis the laser on frames were cut so we get the beam region only, and then subtractedfrom the laser off frame to get the ADUs counts of the beam region.



HELMHOLTZ ASSOCIATION

DESY

Detection Efficiency of SBIG CCD for (1064 nm) light



HELMHOLTZ ASSOCIATION

DESY

Detection Efficiency of SBIG CCD for (1064 nm) light

-Measuring the number of photons per second sent by the laser Nγ . Where λ = 1064 nm and the measured power of laser

Nγ= Plaser /Eγ,(1064 nm) = 1.872451909*10**13/(1.2398/1.064)= 1.6*1013 γ/sec

- The SBIG efficiency ε is calculated using the following equations,

Nγ. A1 . ε = Nd1

Nγ . A2 . ε = Nd2

Nγ. A1 A2 . ε = Nd3 [3]

- Calculating attenuation factors of the two filters.

A_1= Nd3/ Nd1= $6.01*10^{-5}$

A_2 =Nd3/Nd2 = $1.07*10^{-3}$

- Calculating CCD efficiency

ε = Nd2/ Nγ/A_2 = 0.00531

the quantum efficiency of the camera chip is expressed in terms of electrons, but in the previous calculations the camera efficiency is expressed in terms of photons per second per cm square ,We can recalculate it using known gain. However Efficiency of the camera, which gives ADUs from photons is indeed more convenient for measurement.

HELMHOLTZ | ASSOCIATION

DESY

Conclusion

- the light tight measurements done shows that the shutter box lid connection with the 3 O-rings is light tight compared to the sensetivity value.

Acknowledgment

[1] Any Light Particle Search II,Technical Design Report.

[2] Aaron Spector, ALPS II technical overview and status report.

[3] Malina Reitmeyer, Report on light tightness measurements for the shutter box of the ALPS II

experiment. April 2016.