Verify a Single Photon Source

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Introduction

- experiment on single photon sources in 1974
- 1986 at IOGS first experimental demonstration of a source emitting single photons (Phillipe Grangier, Alain Aspect, Gérard Roger)

- Nowadays plenty of single photon sources:
    - fluorescence of the beam of sodium atoms
    - the use of ions, molecules
    - end of the 20th century: defect centers in various solid state materials

      more than 500 in diamond but three are currently used

      (Silicon - Nickel - Nitrogen)

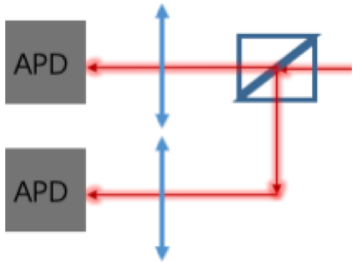
- Applications: quantum computing, cryptography, magnetometry

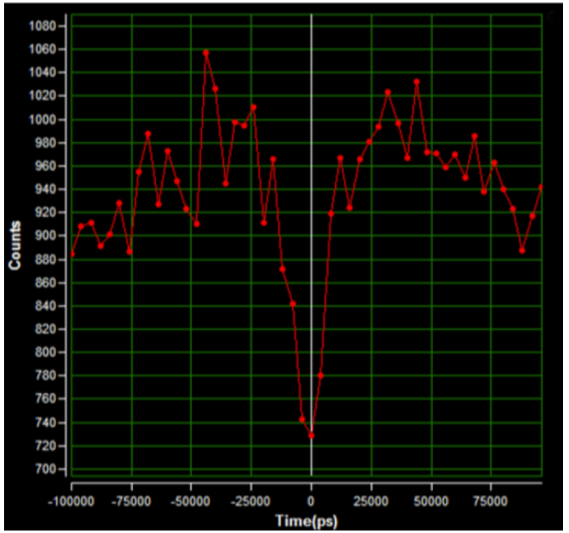
How to prove that a source is a single photon source?

Detection of single photons

- Beam splitter (50%)
- 2 detectors
- The photon goes on one of the dector

$$g^{(2)}(0) = 0$$





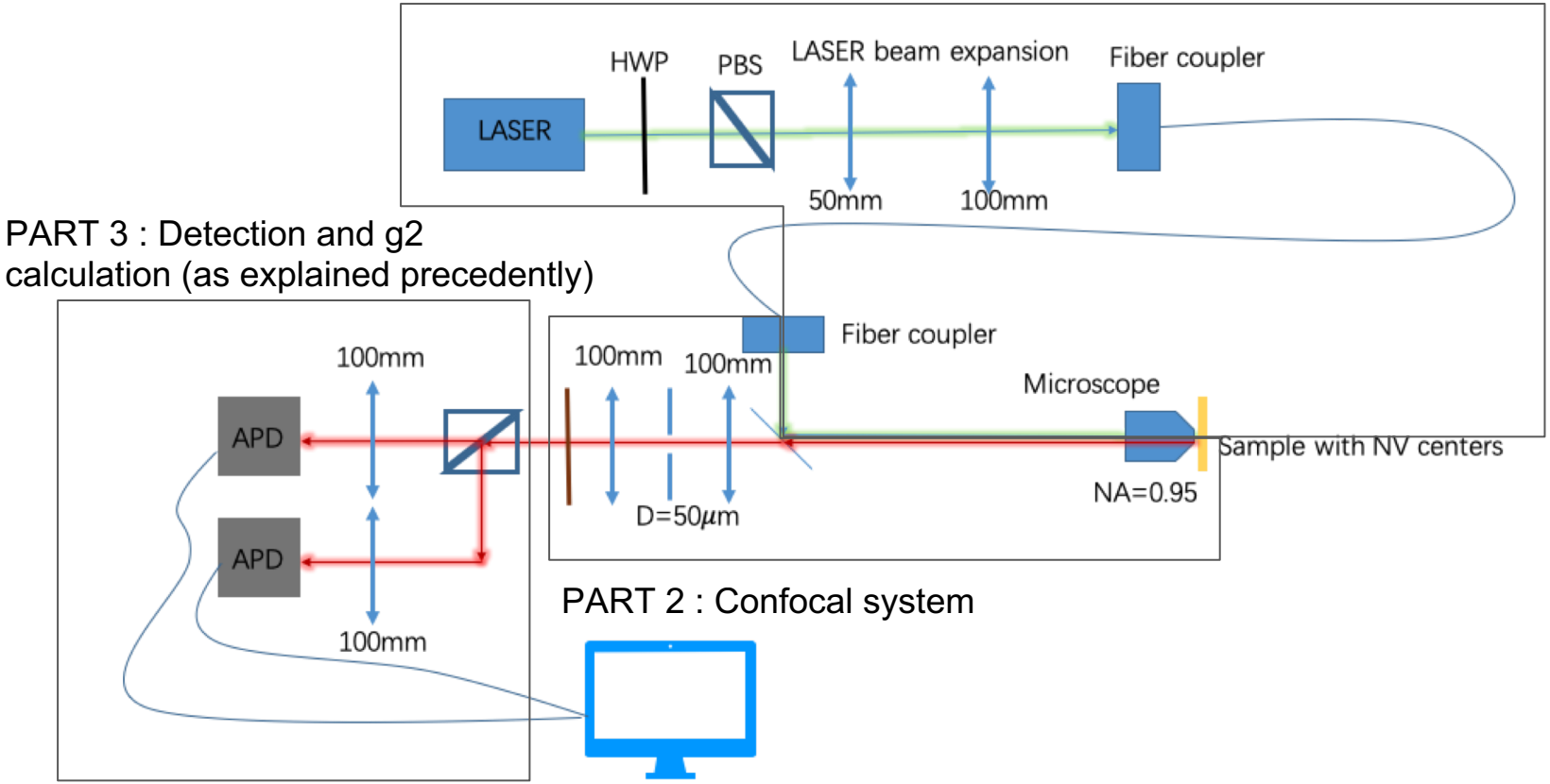
Result by Antoine Hilberer

Summary

- The experiment we worked on the entire week
- Difficulties in the experiment
- What should we buy?

The experiment we worked on the entire week

PART 1 : Laser excites the NV centers

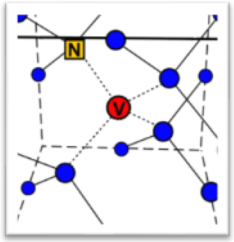


First part : *A visible Laser excites « NV centers » of a diamond*

How to choose the diamond ?

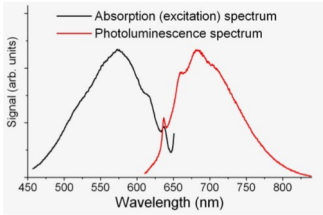
What is a NV center ?

- A NV center is a deffect in the diamond
- We need a diamond with NV centers
- There are many NV centers in type I.b Diamonds



Physical properties :

- A large spectrum of :
  Absorption in the Green
  Emission in the Red
  And they are well separated
- The life-time of an excited state is around 10 ns
- No photobleaching



How to choose the laser ?

Properties :

- Wavelength : in the green (between 500 nm et 600 nm)
- Power : 10mW continuously is enough to excite all the focalised area

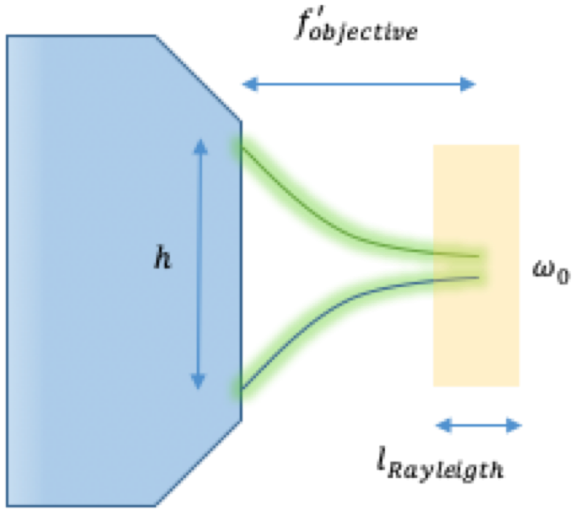
Options :

- Nd:YAG, 532 nm (this is what we used, and it is the most common)
- Argon, 514 nm

Second part : *The confocal microscope system extracts the image of a thin film of the sample*

The principle of confocal microscope: use a pinhole as spatial filter so that the expansion of field is limited. The sample is carried by a piezo. (resolution less than 10 nm)

What's the Rayleigh length of the LASER?



$$2\omega_0 = \frac{0.81\lambda}{NA} = 0.45\mu m$$

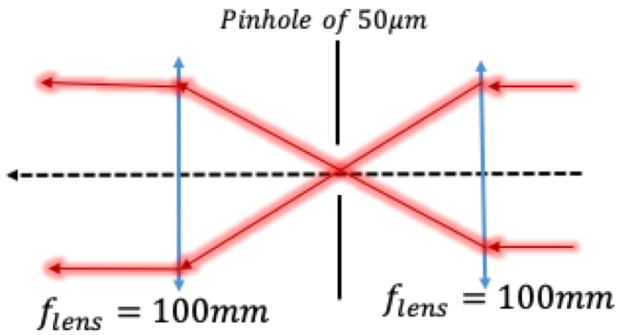
$$l_{Rayleigth} = 2 * \frac{\pi * \omega_0^2}{\lambda} = 0.6\mu m$$

This length indicates the excitation depth of the laser in the diamond.

The field depth limited by the size of the pinhole.

From the conjugation of the pinhole and sample, it is easy to find that the transversal growth:

$$g_y = \frac{f2'}{f'_{objective}} = \frac{100}{180/100} = 55.56$$



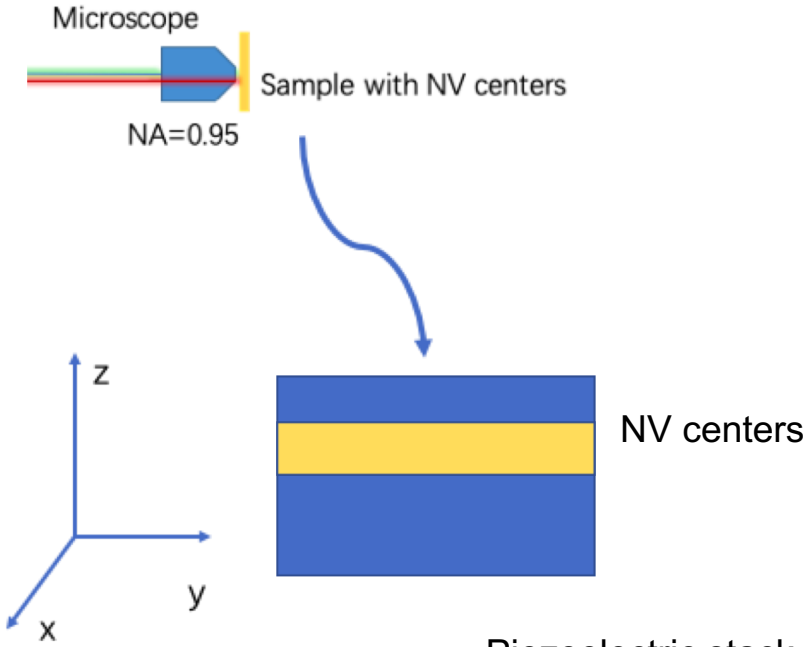
Therefore, the field depth by geometric method is shown as :

$$\Delta z = \frac{1}{g_z} * dz = \frac{1}{(g_y)^2} * dz = 0.81\mu m$$

$$\mathrm{D} = 50\mu m * \frac{1.8}{100} = 0.9\mu m > 2\omega_0$$

It is obvious that the Rayleigh length is shorter than field depth. And the pinhole is large enough for the laser spot on the sample. The pinhole here we use is just a spatial filter to filter out the ambient light.

Piezoelectric stack



Piezoelectric stack

Use a piezoelectric stack to move the sample in three dimensions.
-> change the position of light focus in the sample

However the prize of Piezoelectric stack is more than 6000 euros !!!

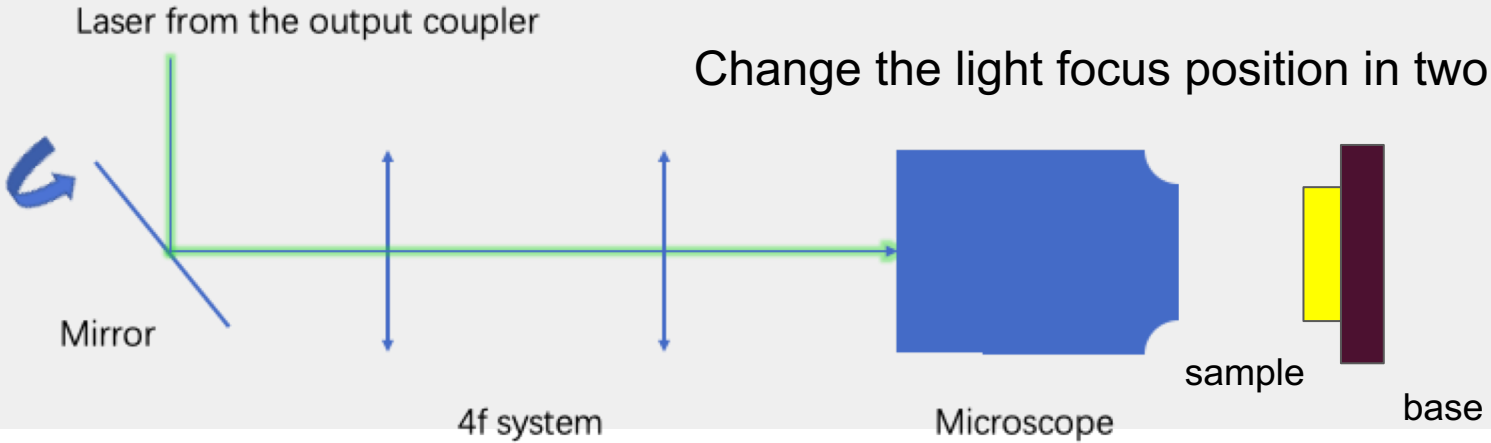
Piezoelectric stack

Another platform is not necessary

A easy replacement of piezoelectric stack -> 4f system

Change the incident angle of light into microscope

Change the light focus position in two dimension



What should we buy?

Product	Model	Quantity	Characteristics	Alternatives	Providers	Approximative price € (unit)
Laser Nd:YAG		1	532nm, 10mW	Argon, He-Ne..	IOGS, Thorlabs	
Piezo-electric scanning system	ANSz100-A6-110	1	scan in a range of approximately 20µm	Galvanometric mirrors	TRIOPTICS, Attocube	5000
Objective	1-LM590	1	gy = x100, ON = 0.95		IOGS	5000
Type I.b diamond		1				
APDs : single photon counters	SPCM - AQRH - 12737	2	Visible spectrum , ~ 15millions photons/s max		Thorlabs	4000
BNC to PC	BNC 2110	2			National instruments	500
Generator for the piezo (connected to PC)	MDT 693B	1			Thorlabs	2000
Data acquisition card	PCIe 6323	1			National instruments	1100

Schedule

Before week 52 (16th to 20th December) :

- Yijun and Ozan look for what we need
- Grégoire studies other solutions such as the galvano-mirrors
- Puyuan plans how we will set up the experiment during week 52

Week 52 :

- We gather our informations and start to set up the experiment

Week 9 (24th to 28th February) :

- Everything should be bought and we will finish the setup of experiment.

4 thursday mornings (5th to 26th march) :

- Look for improvement (such as magnetometry) and try to set up an easily repeatable experiment for IOGS