

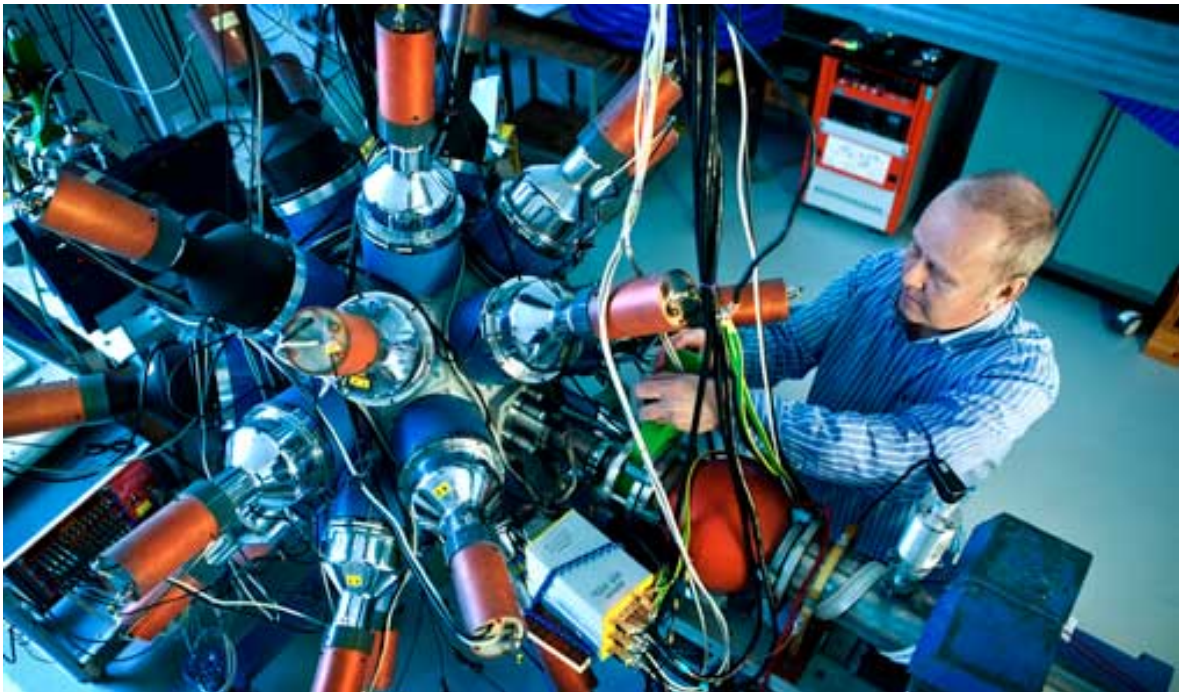
# Cool Title

## Oslo Cyclotron Laboratory

Project FYS-3180

Ina K. B. Kullmann

November 21, 2015



**Figure 1:** Magne Guttormsen working on the CACTUS/SiRi detector. From <http://www.mn.uio.no/fysikk/english/research/about/infrastructure/OCL/>

## Contents

<b>1</b>	<b>Motivation and purpose</b>	<b>3</b>
<b>2</b>	<b>Theory of experimental nuclear physics, what to measure</b>	<b>3</b>
<b>3</b>	<b>Experimental setup</b>	<b>3</b>
3.1	The Oslo Cyclotron laboratory (OCL) . . . . .	4
<b>4</b>	<b>Data analysis of experimental data and the Oslo method(?)</b>	<b>6</b>
4.1	Distinguishing particles: Particle bananas . . . . .	6
4.2	The theory of coincidence matrix . . . . .	6
<b>5</b>	<b>Choice of target/reaction (?)</b>	<b>6</b>
<b>6</b>	<b>Preparation before experiment: kin software?</b>	<b>7</b>
<b>7</b>	<b>Results/Data</b>	<b>7</b>
7.1	Raw particle-gamma coincidence matrix . . . . .	7
<b>8</b>	<b>Analyze of the dataset</b>	<b>7</b>
8.1	Final particle-gamma coincidence matrix . . . . .	7
<b>9</b>	<b>Discussion and Experiences</b>	<b>7</b>

## Abstract

abstract abstract abstract abstract abstract abstract abstract abstract abstract ab-  
 abstract abstract abstract abstract abstract abstract abstract abstract abstract abstract  
 abstract abstract abstract abstract abstract abstract abstract abstract abstract abstract  
 abstract abstract abstract abstract abstract abstract abstract abstract abstract abstract  
 abstract abstract abstract abstract abstract abstract abstract abstract abstract abstract  
 abstract abstract abstract abstract abstract

[illegible][illegible]

## 1 Motivation and purpose

The purpose of this article is to give an (brief) introduction to detectors, systems and methods used in experimental nuclear physics. Important because blablabla learning about how to prepare and conduct an experiment and most importantly analyze and interpret the possible error sources.

Will give an short introduction to the OCL In this project we will focus on the basics of how the cyclotron works and

We will choose a particular reaction and prepare as for a real experiment by calculating (....energy lost in the ...kin...). We will then use data from an earlier experiment, analyse it and discuss possible error sources(?). Will also verify/compare data with exsisting databases(?).

We will learn the terms: prompt time, particlebananas, thicknessspectra ++ (?)

Goal: particle-gamma coincidence matrix

## 2 Theory of experimental nuclear physics, what to measure

We know the energy of the beam, the Q value, the final energy of the emitted particles and their angle. We can therefore get the excitation energy of the final nucleus

introduce to a general reaction and Q val so easy to talk about siri/cactus

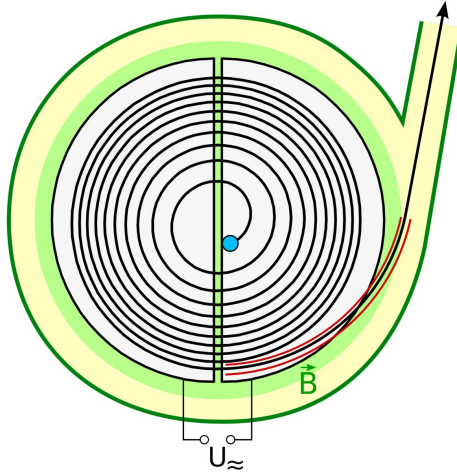
then how to /what to measure

### 3 Experimental setup

## The basic concepts of a cyclotron

A cyclotron is a particle accelerator for charged particles. The particles are accelerated with an external electric field and together with a magnetic field the particles are contained in an orbit inside the cyclotron. In nuclear physics a cyclotron is used to accelerate charged particles so that they leave the cyclotron with the desired energy. The goal is then to study nuclear reactions that occur when the particle beam is directed to a target. Different detectors are used to measure particles and  $\gamma$ -rays that are produced in the reaction.

A simple cyclotron consists of two half -cylinders placed side by side as in figure 2. Every time the particles pass between the two cylinders they are accelerated by an oscillating electric



**Figure 2:** A simple illustration of a cyclotron. The illustration is taken from <http://www.mn.uio.no/fysikk/english/research/about/infrastructure/OCL/ocl-photos/>

field. Therefore the particles increase speed and radius for every half round. Inside the cylinders the electric field is zero, but there is a magnetic field perpendicular to the plane showed in figure 2 that contain the particles in a circular orbit. When the radius of the particle beam is bigger than the radius of the cylinders the particles leave the cyclotron.

### 3.1 The Oslo Cyclotron laboratory (OCL)

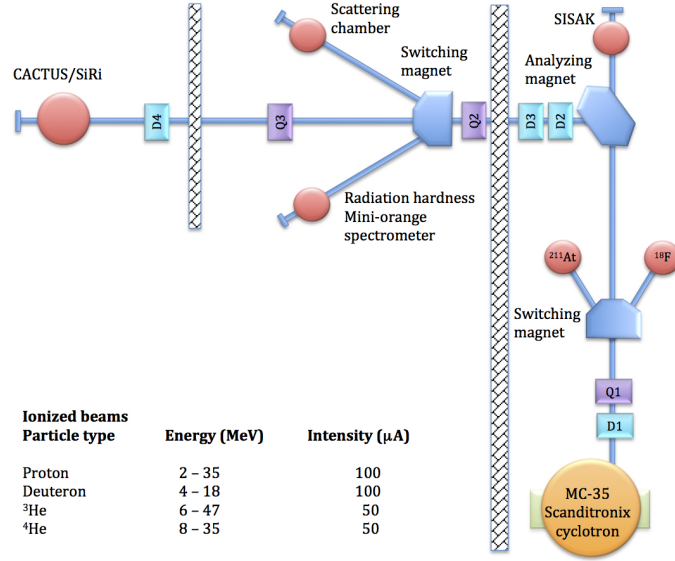
The Oslo Cyclotron Laboratory (OCL) houses the only accelerator in Norway for ionized atoms in basic research<sup>1</sup>. The accelerator is used in various fields of research for instance nuclear physics and nuclear chemistry. Other applications for the Cyclotrone are the production of isotopes for nuclear medicine. The reasearch in nuclear physics at Oslo Cyclotron Laboratory mainly focus on studying the level densities and radiative strength functions where the overall goal is to better understand the atomic nuclei.

We can see the cyclotron vault to the far right in figure 3 with the cyclotron (MC-35 Scanditronix Cyclotron) at the bottom right. The beam of the accelerated particles travels first from the cyclotron along the beam line through a switching magnet and then to a analyzing magnet. The analyzing magnet directs the beam out of the cyclotron vault and into the experimental hall by turning the beam 90 degrees. The beam then goes through another switching magnet before hitting the target chamber (CACTUS/SiRi) to the far left in figure 3. Around the target chamber there are two detectors, CACTUS and SiRi. The swiching magnets can also direct the beam to different target stations, but we will only have a closer look at the target chamber associated to the CACTUS and SiRi arrays.

#### 3.1.1 The CACTUS and SiRi detectors

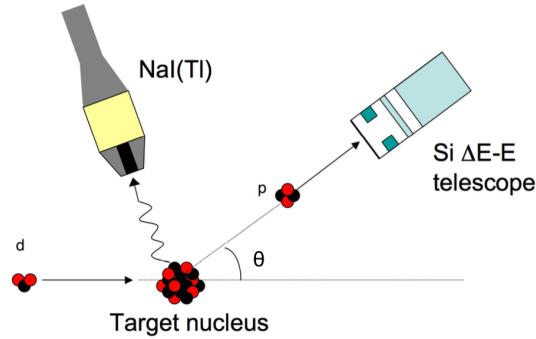
The CACTUS/SiRi detector can be used to study particle-gamma coincidences. In figure 4 we see an illustration of a particle from the beam hitting a target nucleus. After the reaction a gamma-ray and a particle is emitted in addition to the resulting nucleus beeing changed.

<sup>1</sup><http://www.mn.uio.no/fysikk/english/research/about/infrastructure/OCL/index.html>



**Figure 3:** The experimental hall of the Oslo Cyclotron Laboratory.

We see that the gamma is measured by the CACTUS detector and the emitted particle by the SiRi detector. The figure indicates that the angle between the incident trajectory and the trajectory of the emitted particle is given as  $\theta$ .

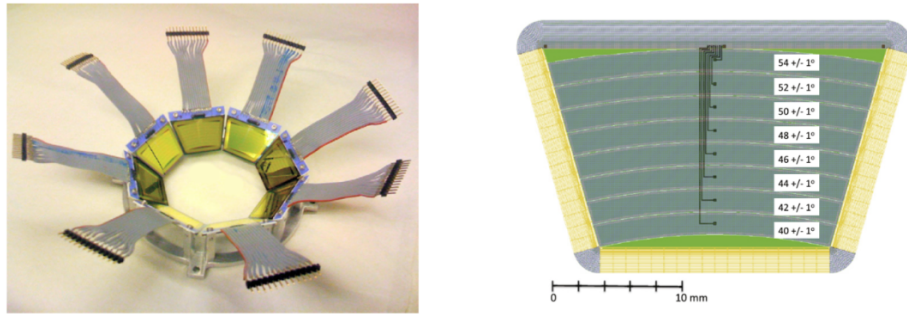


**Figure 4:** A incident particle hitting a target nucleus. The resulting emitted *gamma*-ray is detected by the CACTUS detectors and the emitted particle is detected by the SiRi detector. The angle between the incident trajectory and the trajectory of the emitted particle is given as  $\theta$ .

When looking at the front picture, figure 1, it is not hard to imagine where the CACTUS detector have gotten its name from. The CACTUS detector measures the energies of the  $\gamma$ -rays and counts the number of  $\gamma$ -rays. The detector consists of 28 NaI scintillation detectors spherically distributed around the target chamber, pointing out like a Cactus. Each of the NaI scintillation detectors measure the energy of the  $\gamma$ -radiation by using the excitation effect of the incident radiation on a scintillator material (NaI). When the scintillator is excited it

produces a signal that is then converted into an electrical signal that the electronics process<sup>2</sup>.

The SiRi-array measure the energy of a particle and consists of 8 Si detectors on a ring. Each detector is divided into 8 strips which makes it possible to also measure the angle of the particle. In figure 5 we see the Silicon Ring (SiRi) to the left and a drawing of one of the detectors on the right with the individual strips marked.



**Figure 5:** The SiRi detector used to measure the energy of a particle from a particle-gamma coincidence. The Silicon Ring (SiRi) to the left and a drawing of one of the 8 detectors on the right with the individual strips marked.

## 4 Data analysis of experimental data and the Oslo method(?)

The gamma radiation and particle(utsending) is measured with the CACTUS and SiRi detectors. The dataset consists of event files; large files where each measured parameter from each nuclear reaction is written down. There are millions of event files that have been analyzed and sorted out. —>possible to follow the experiment back to the beginning and "see" what happened.

### 4.1 Distinguishing particles: Particle bananas

### 4.2 The theory of coincidence matrix

## 5 Choice of target/reaction (?)

Choose a reaction (Si) We will calculate the parameters that are important for the experiment (with software kin) We will use data from an earlier experiment.

specifics: we are going to analyse data from a reaction which a 16MeV proton beam on a 28Si target . the goal is to get familiar with the experimental methods at OCL and the data analysis

<sup>2</sup>[https://en.wikipedia.org/wiki/Scintillation\\_counter](https://en.wikipedia.org/wiki/Scintillation_counter)

6 Preparation before experiment: kin software?

7 Results/Data

7.1 Raw particle-gamma coincidence matrix

8 Analyze of the dataset

8.1 Final particle-gamma coincidence matrix

9 Discussion and Experiences

---