

Angular selective electron detection using an MCP

Patrick Oelpmann

February 24, 2021

Contents

1	Introduction	4
2	Neutrinos	5
2.1	prediction	5
2.2	experiments to prove neutrinos	5
2.3	solar neutrino problem	5
2.4	neutrino oscillation	5
2.5	methods to determine neutrino mass	5
2.5.1	kinematics of electrons in beta decay	5
2.5.2	neutrinoless double beta decay	5
2.5.3	cosmologie	5
3	KATRIN	6
3.1	KATRIN in general and why Tritium?	6
3.2	major components	6
3.2.1	rear section	6
3.2.2	WGTS	6
3.2.3	transport section	6
3.2.4	pre Spectrometer and Main Spectrometer (MAC-E Filters)	6
3.2.4.1	working principle	6
3.2.4.2	transmission function and energy resolution	6
3.2.4.3	properties of the MAC-E filters	6
3.2.5	Detector	6
3.2.6	Monitor spectrometer	6
3.3	sources of uncertainties	6
3.3.1	Eloss, plasma, high voltage etc.	6
3.3.2	background	6
3.3.2.1	Rydberg background	6
3.3.2.2	Radon background	6
4	Test setup	7
4.1	Vacuum system	7
4.2	EGun	7
4.3	Transport section	7
4.4	Micro channel Plate	7
4.4.1	MCP filter behind the Dice	7
4.4.2	MCP detector	7
4.5	Deflection coils	7
5	Angular selective electron detection	8
5.1	Motivation	8
5.2	Measurements	8

5.2.1	Egun to zero degree	8
5.2.2	inserting MCP filter and set EGun to a combination of polar and azimuthal angle until transmission	8
5.2.3	use of deflection coils to deflect in a circle with MCP filter	8
5.2.4	dependence of the magnetic field wheather transmission through MCP filter or not	8
5.2.4.1	spikes of transmission with periodic distance	8
5.2.5	without MCP filter: varying the magnetic field at beamtube and by this there were intervals with lower countrate	8
5.2.6	Wanted to investigate the intervals with lower countrate with a filtered beam	8
5.2.6.1	varying beamtube 1 and beamtube 2 seperatly and fitting	8
5.2.6.2	many degrees of freedom and not a better result so the MCP filter will not be used again	8
5.2.7	diagonal lines by varying beamtube current and detectorcurrent without tilted MCP	8
5.2.7.1	explanantion why there are diagonal lines → channels are tilted with respect to magnetic field line	8
5.2.8	installing of a tilted flange to reduce degree of freedom	8
5.2.9	diagonal lines by varying beamtube current and detectorcurrent with tilted MCP	8
5.2.10	MCP rotated to right direction and moving of egun coil nearer to egun for higher magentic field at creation point	8
5.2.11	use of deflection coils for four quadrant pictures with deep holes .	8
5.3	Simulations with Kassiopeia	8
5.3.1	consideration of channels	8
5.3.2	pictures of the simulations	8
6	conclusion	9
6.1	proven that angular selective electron detection principle works	9
7	outlook	10
7.1	aTEF	10
7.1.1	creation in our working group	10
7.1.2	pictures of aTEF	10

1 Introduction

2 Neutrinos

2.1 prediction

2.2 experiments to prove neutrinos

2.3 solar neutrino problem

2.4 neutrino oscillation

2.5 methods to determine neutrino mass

2.5.1 kinematics of electrons in beta decay

2.5.2 neutrinoless double beta decay

2.5.3 cosmologie

3 KATRIN

3.1 KATRIN in general and why Tritium?

3.2 major components

3.2.1 rear section

3.2.2 WGTS

3.2.3 transport section

3.2.4 pre Spectrometer and Main Spectrometer (MAC-E Filters)

3.2.4.1 working principle

3.2.4.2 transmission function and energy resolution

3.2.4.3 properties of the MAC-E filters

3.2.5 Detector

3.2.6 Monitor spectrometer

3.3 sources of uncertainties

3.3.1 Eloss, plasma, high voltage etc.

3.3.2 background

3.3.2.1 Rydberg background

3.3.2.2 Radon background

4 Test setup

4.1 Vacuum system

4.2 EGun

4.3 Transport section

4.4 Micro channel Plate

4.4.1 MCP filter behind the Dice

4.4.2 MCP detector

4.5 Deflection coils

5 Angular selective electron detection

5.1 Motivation

5.2 Measurements

5.2.1 Egun to zero degree

5.2.2 inserting MCP filter and set EGun to a combination of polar and azimuthal angle until transmission

5.2.3 use of deflection coils to deflect in a circle with MCP filter

5.2.4 dependence of the magnetic field wheather transmission through MCP filter or not

5.2.4.1 spikes of transmission with periodic distance

5.2.5 without MCP filter: varying the magnetic field at beamtube and by this there were intervals with lower countrate

5.2.6 Wanted to investigate the intervals with lower countrate with a filtered beam

5.2.6.1 varying beamtube 1 and beamtube 2 seperatly and fitting

5.2.6.2 many degrees of freedom and not a better result so the MCP filter will not be used again

5.2.7 diagonal lines by varying beamtube current and detectorcurrent without tilted MCP

5.2.7.1 explanantion why there are diagonal lines → channels are tilted with respect to magnetic field line

5.2.8 installing of a tilted flange to reduce degree of freedom

5.2.9 diagonal lines by varying beamtube current and detectorcurrent with tilted MCP

5.2.10 MCP rotated to right direction and moving of egun coil nearer to egun for higher magentic field at creation point

5.2.11 use of deflection coils for four quadrant pictures with deep holes

5.3 Simulations with Kassiopeia

5.3.1 consideration of channels

5.3.2 pictures of the simulations

6 conclusion

6.1 proven that angular selective electron detection principle works

7 outlook

7.1 aTEF

7.1.1 creation in our working group

7.1.2 pictures of aTEF