NMI3 II FP7

Final General Assembly Meeting

Work Package 21

Detectors

Nigel Rhodes STFC ISIS

Copenhagen 16 October 2015

WP 21 Detectors

Aim: Development of Large Area Neutron Detectors for Neutron Scattering Application without using ^{3}Helium

Two technologies selected for development

Task 21.1
Development of scintillation detectors

Julich ISIS CNR

Task 21.2
Development of gas detectors based on solid 10B converter

TUM HZB BNC CEA

Observers ILL and ESS

WP 21 Detectors

Structure of Task 21.1

Task 21.1 Development of scintillation detectors

Mainly concerned with $ZnS/^{6}LiF$ scintillation detectors + WLS fibre readout

Divided into 5 sub tasks

- 21.1.1 Detector Hardware development
- 21.1.2 Electronics hardware development
- 21.1.3 Signal processing development
- 21.1.4 Evaluation of SiPM potential
- 21.1.5 Evaluation of final detectors and report

JÜLICH FORSCHUNGSZENTRUM

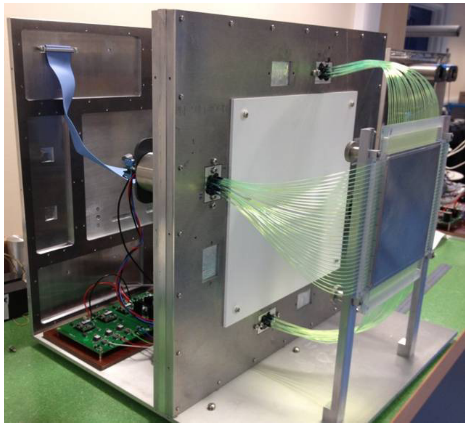
Science & Technology Facilities Council ISIS

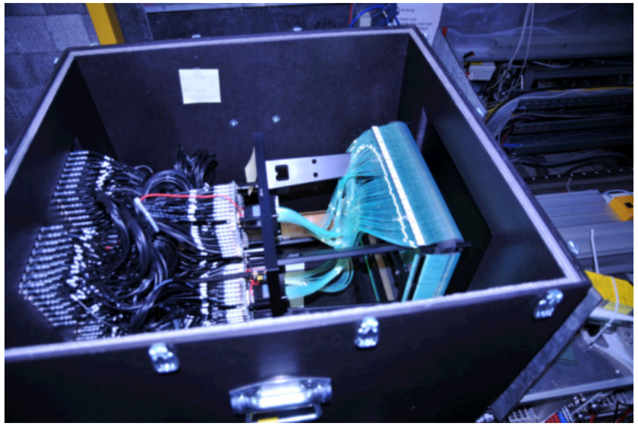
Consiglio Nazionale delle Ricerche

WP 21 Detectors

Task 21.1: Development of scintillation detectors

21.1.1 Detector Hardware development





ISIS 16 x 16 cm^2
64 fibres - pair
coded detector

ISIS 16 x 16 cm^2
64 fibres - quad
coded detector

Julich 30 x 30 cm^2
256 fibres

ISIS hardware	D 21.1
Julich hardware	D 21.2
Hardware report	D 21.3
Complete Month 24	

Choices of fibre type, fibre dye content, fibre bending, scintillator and reflector determined

ISIS detectors based on pattern recognition, Julich detectors based on centre weighted position reconstruction

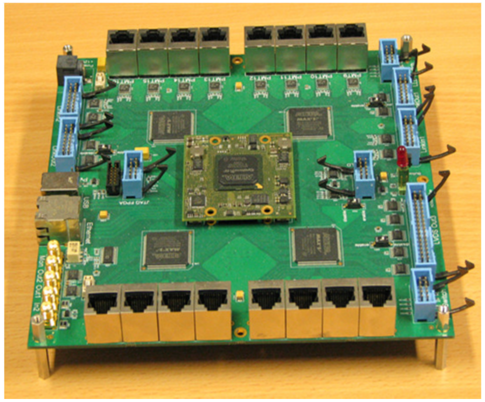
WP 21 Detectors

Task 21.1: Development of scintillation detectors

21.1.2 Electronics hardware development

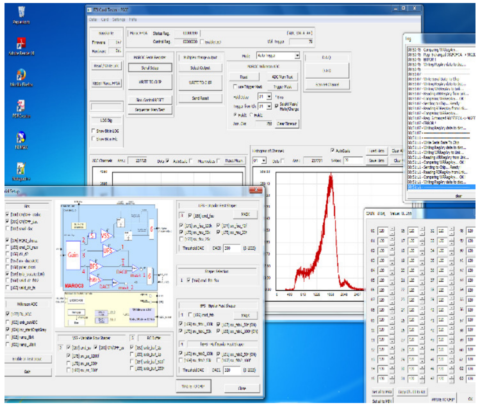
ISIS electronics

8 channel comparator

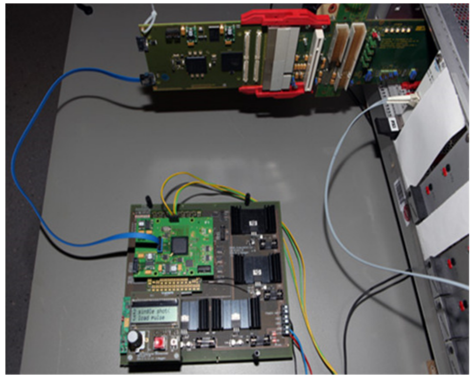


64 channel signal processing in FPGA

Julich electronics



64 channel ASIC from Omega
FPGA card with Optical or SATA link to PC
ASIC control and readout programme developed
Pulse simulator developed



FPGA readout board on test

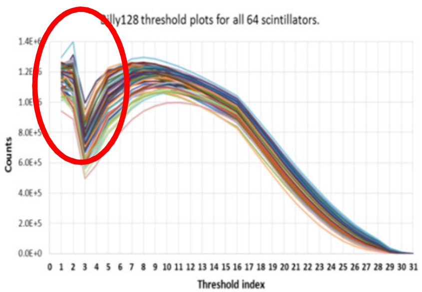
D 21.4 Month 24 Complete

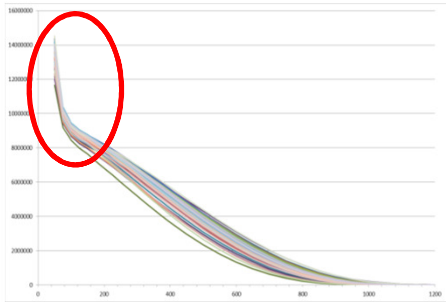
D 21.5 and D21.6 Month 36 Complete

WP 21 Detectors

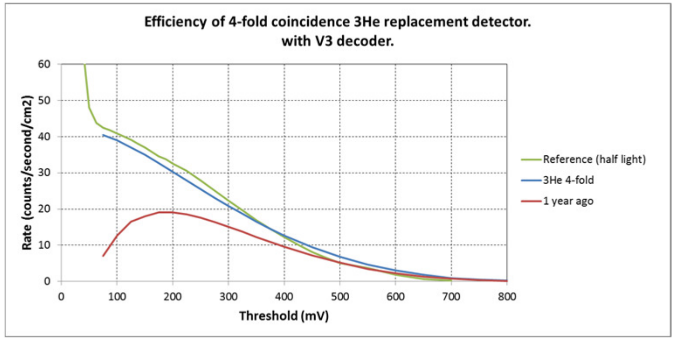
Task 21.1: Development of scintillation detectors

21.1.3 Signal processing and position reconstruction development

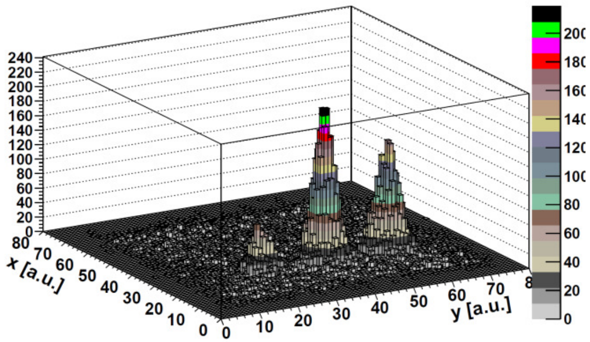




At ISIS Pair coded detector works well
Continuing to improve position algorithm



Effect of optical cross talk on MA PMT significantly reduced



At Julich Center-of-Gravity Method used for position reconstruction

B_4C-diaphram with 4mm holes and 10mm spacing accurately reproduced in detector

Intrinsic detector background yet to be determined: crucial for INS
Signal processing algorithms determine how well the detectors will perform

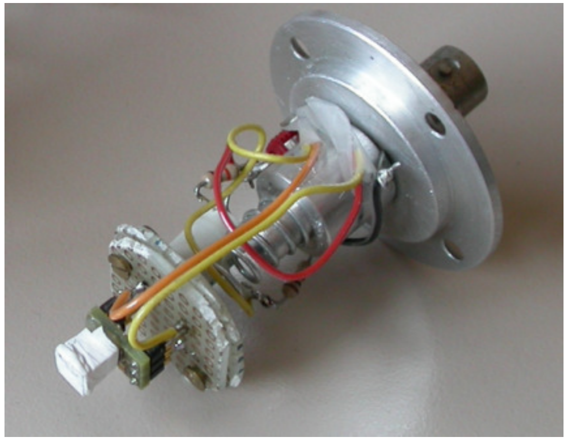
D 21.7 Month 36 Complete

WP 21 Detectors

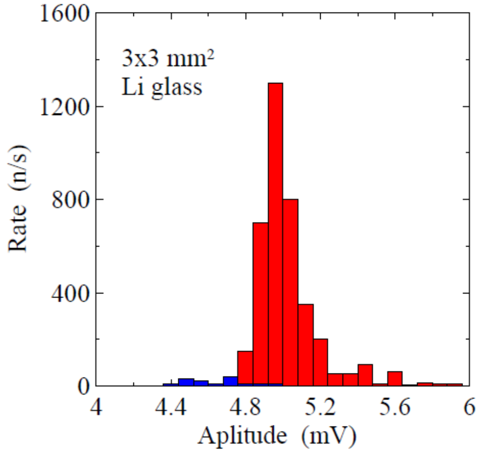
Task 21.1: Development of scintillation detectors

21.1.4 Evaluation of SiPM potential

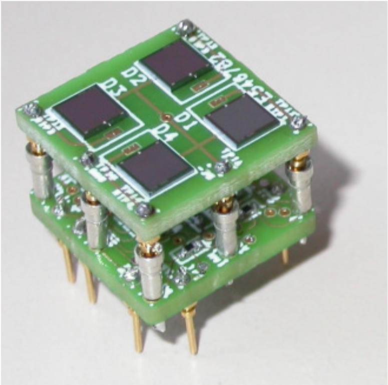
GS20 Glass scintillator coupled to a SiPM



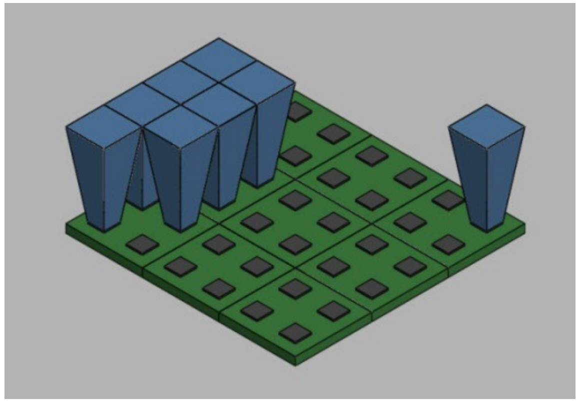
Prototype detector



Experimental Results



Stackable Electronics



Stackable Detector Concept envisaged

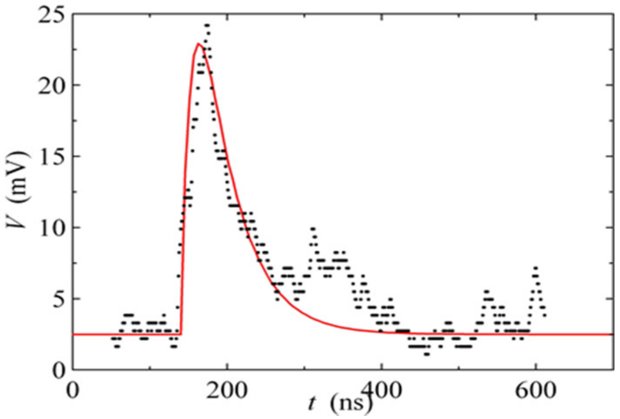
D 21.8 Interim report completed Month 24

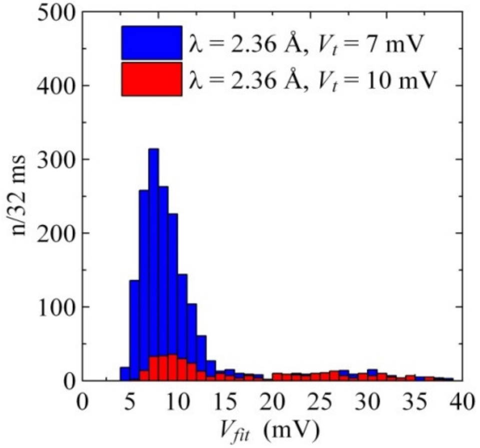
WP 21 Detectors

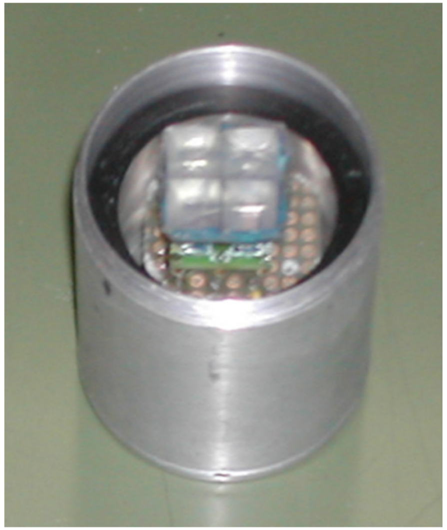
Task 21.1: Development of scintillation detectors

21.1.4 Evaluation of SiPM potential

GS20 Glass scintillator coupled to a SiPM







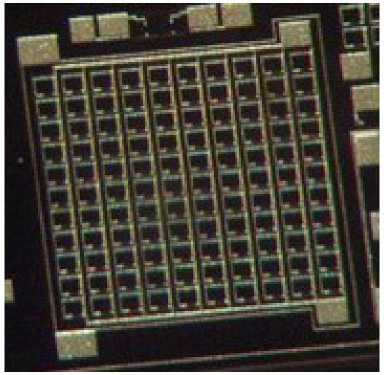
Stackable Detector

Off-line pulse shape analysis routine developed to identify neutrons

Works well with parallel light guides

Stackable detector concept realised

Evaluation of results on going



Huge commercial investment in SiPM technology

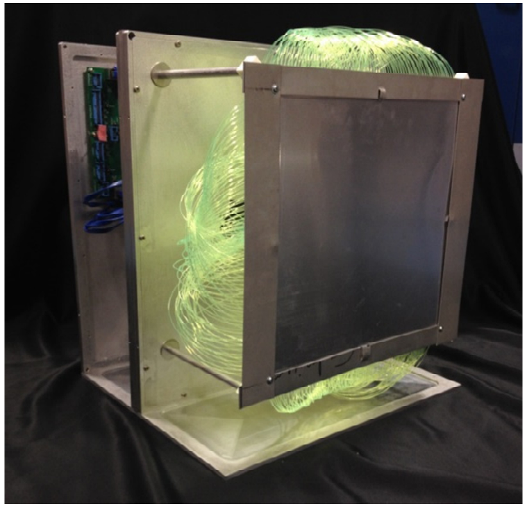
21.1.5 Evaluation of final detectors and report

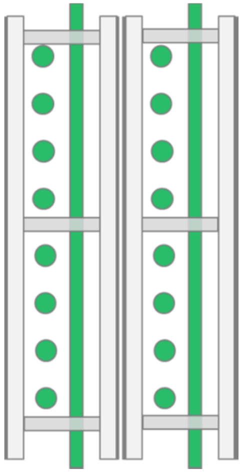
D 21.9 Due Month 48

WP 21 Detectors

Task 21.1: Development of scintillation detectors

21.1.5 Detector Performance evaluation





Built new ISIS detector for evaluation purposes
Two layers of pixels, one behind the other
Independently coded
16 x 16 pixels per layer, each pixel 20 x 20 mm^2
Four 16-channel MaPMTs

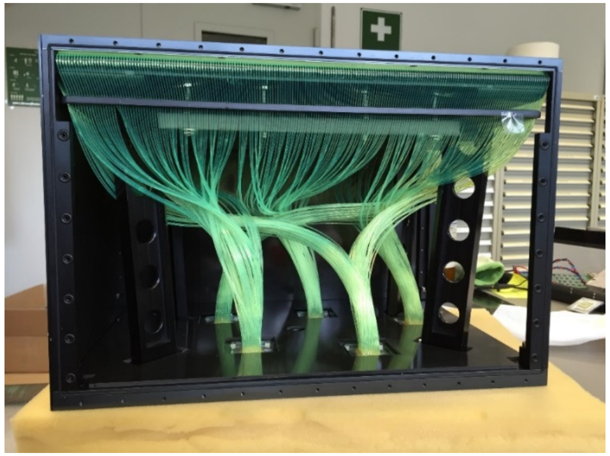
Preliminary Efficiency ~ 70% at 1 Å

Continue to evaluate to end of project.
In particular look at gamma sensitivity and intrinsic detector background

As part of tests FZJ have evaluated many ZnS/^{6}LiF samples, some giving similar efficiencies

FZJ electronics has been incorporated on test detector

The Julich the WLS fibre technology has been incorporated into a detector design for detectors for SAPHiR the high pressure instrument at FRM-2.



Detector performance results will be reported in D 21.9 Due Month 48

WP 21 Detectors

Structure of Task 21.2

Task 21.2 Development of gas detectors based on solid 10B converter

Divided into 4 sub tasks

- **21.2.1 Optimisation of substrate and ^{10}B production parameters**
- **21.2.2 Exploration of alternative production techniques**
- **21.2.3 Measurements with a test detector**
- **21.2.4 Concept study for a large area detector**
  - **a) Based on macro grooved structures with wire readout**
  - **b) Based on layered structure with micromegas readout**

HZB Helmholtz Zentrum Berlin

FRM II Forschungs-Neutronenquelle Heinz Maier-Leibnitz Technische Universität München

BNC Budapest Neutron Center

LLB Orphée Laboratoire Léon Brillouin

ILL NEUTRONS FOR SCIENCE

ESS EUROPEAN SPALLATION SOURCE

WP 21 Detectors

Task 21.2: Development of gas detectors based on solid ^{10}B

21.2.1 Optimisation of substrate and ^{10}B production parameters

Linköping solved many production issues before JRA began

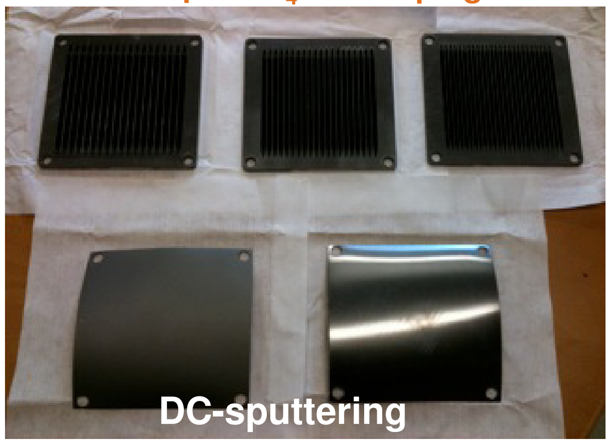
Lead role switched from HZB to TUM

TUM measured neutron performance of variety of films

Little difference between manufacturer or technique

Linköping able to supply high quality research quantities

2.5 µm $^{10}B_4C$ Linköping

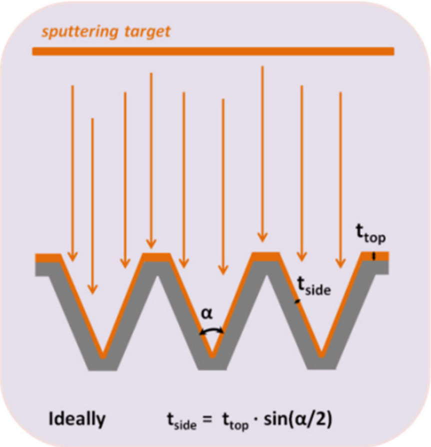


WP 21 Detectors

Task 21.2: Development of gas detectors based on solid ^{10}B

21.2.1 Optimisation of substrate and ^{10}B production parameters TUM

TUM Developed Macro structured converter



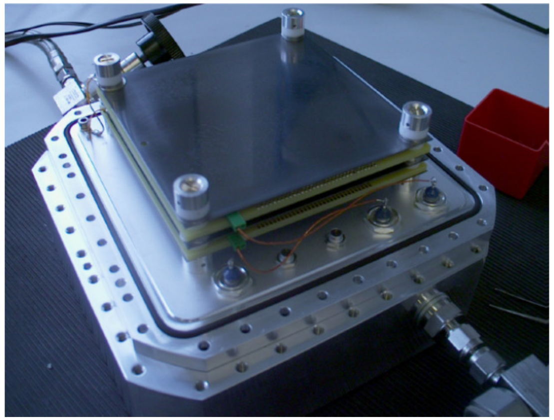
Gives 40% increase in efficiency cf flat layer

Task complete

D 21.10 Report Month 36 Complete

D 21.13 Report Month 36 Complete

21.2.3 Measurements with a test detector TUM



Measurements carried out with

Small test detector designed and built for JRA

D 21.12 Month 12 Complete

WP 21 Detectors

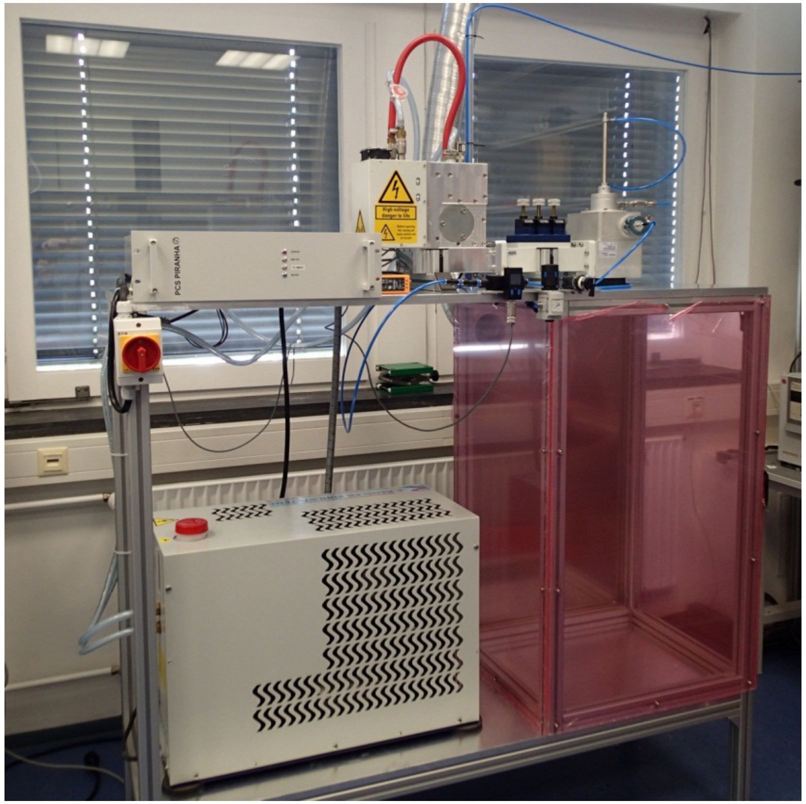
Task 21.2: Development of gas detectors based on solid ^{10}B

21.2.2 Exploration of alternative production techniques - HZB leading

Drivers:

Increase boron layer production rate: Reduce cost
Need to maintain quality and long term stability

Andriy Styervoyedov Explored a variety of alternative techniques



Powder spraying with microwave atmospheric plasma selected

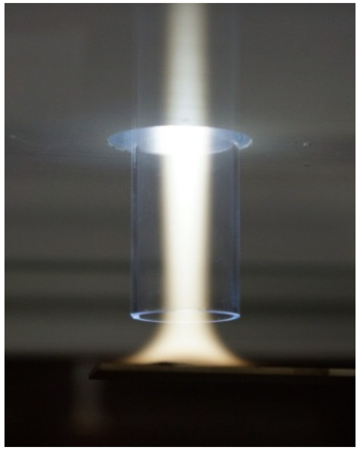
Equipment purchased and installed at HZB

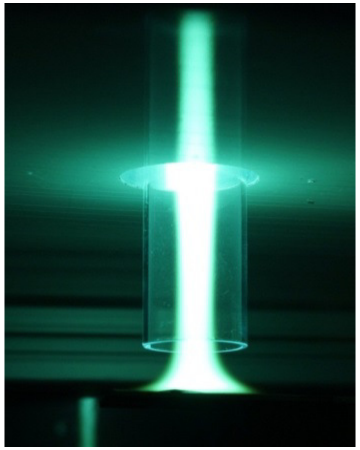
Many parameters optimised including microwave power, gas flow, particle speed, substrate temperature, etc…

WP 21 Detectors

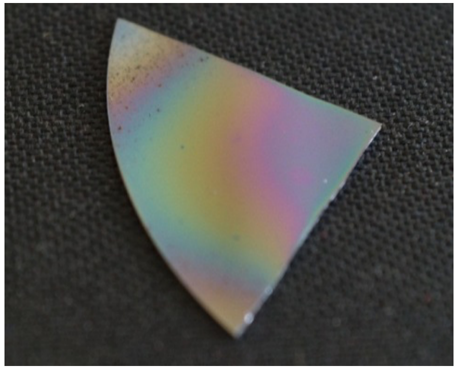
Task 21.2: Development of gas detectors based on solid ^{10}B

21.2.2 Exploration of alternative production techniques - HZB leading





The colour change signifies boron evaporation See NMI3 Video



High deposition rate achieved on silicon substrate

2D MWPC constructed using components produced at BNC

The detector works well. – see D21.11.

Attempts to deposit thin $^{10}B_4C$ layers on aluminium unsuccessful.

Needs further work in optimisation of operation parameters and possible pre treatment of aluminium surface.

Beyond scope of this project

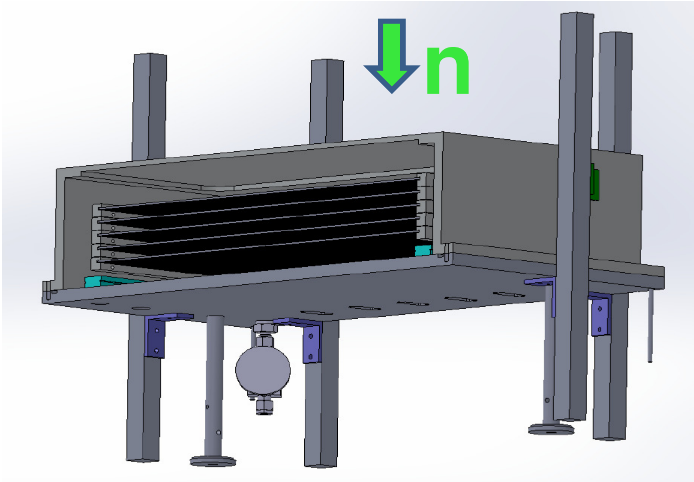
D 21.11 Status report. Month 36 Complete

WP 21 Detectors

Task 21.2: Development of gas detectors based on solid ^{10}B

21.2.4 Concept study for a large area detector

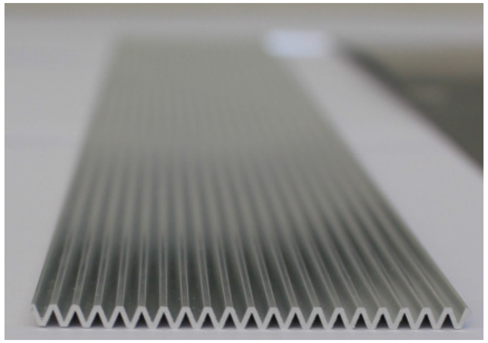
a) Based on macro grooved structures with wire readout TUM



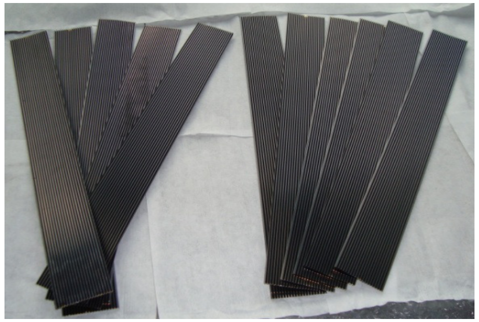
40 cm x 40 cm active area

Incorporates a stack with 3 layers of macrostructured planes (2 MWPCs) each coated with 1.4 µm $^{10}B_4C$ by magnetron sputtering.

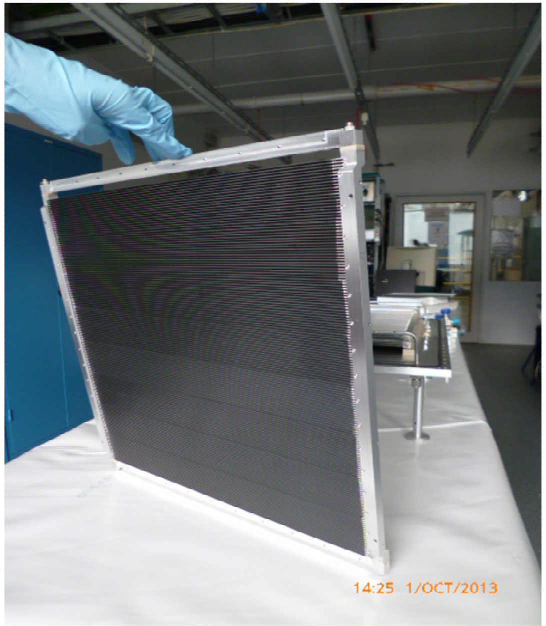
Operated in a continuous flow of Ar/CO_2 gas.



5 cm x 40 cm macrostructured plate fabricated by extrusion (MIFA, Holland).



$^{10}B_4C$-coated plates for the demonstrator (Univ. Linköping, Sweden).



Cathode panel, 40 cm x 40 cm (8 plates).

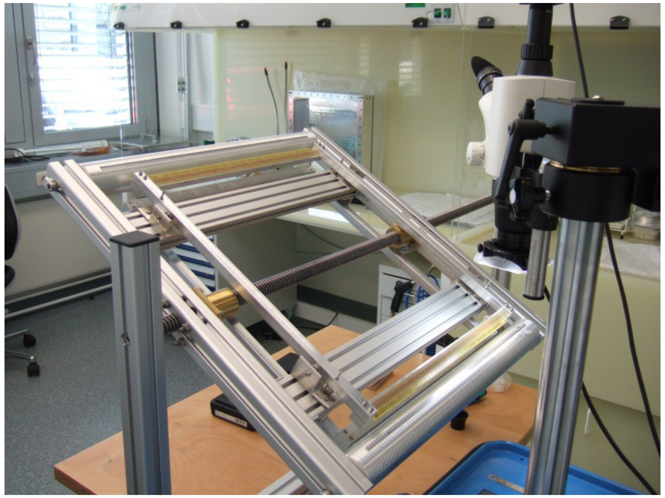
D 21.14 Month 48

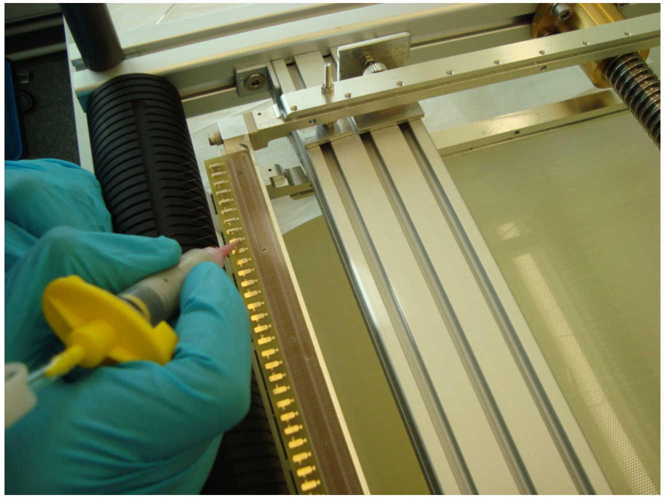
WP 21 Detectors

Task 21.2: Development of gas detectors based on solid ^{10}B

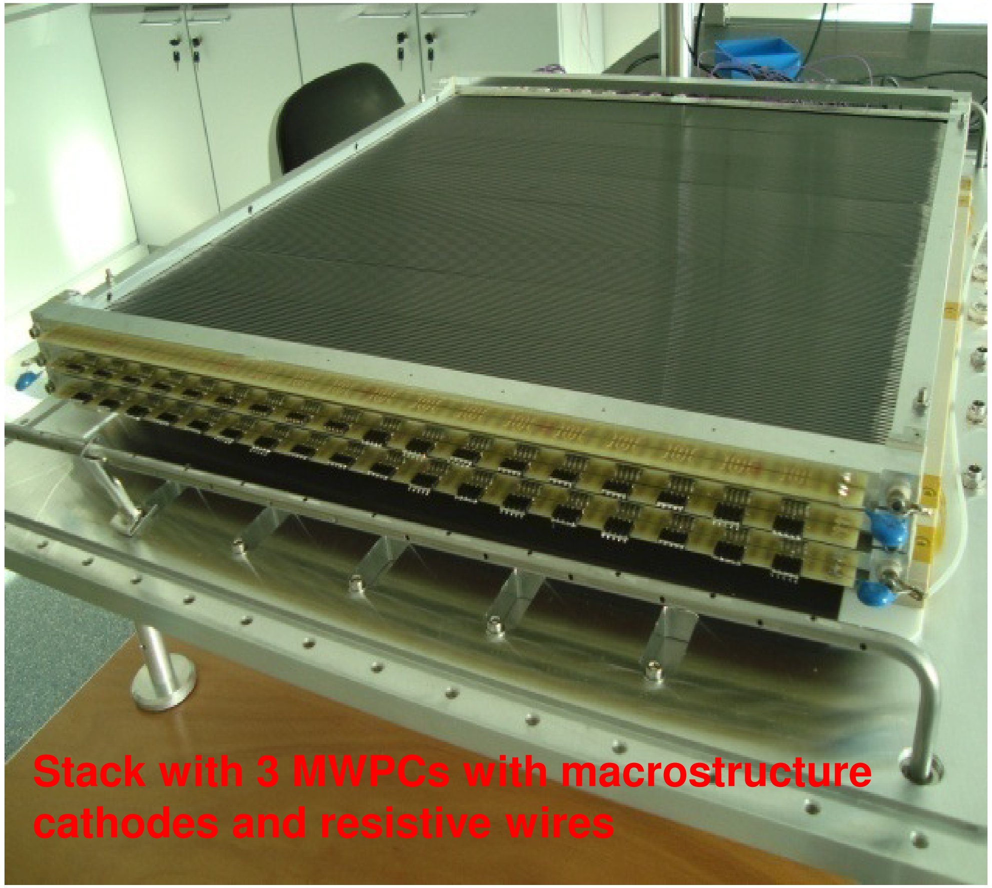
21.2.4 Concept study for a large area detector

a) Based on macro grooved structures with wire readout TUM





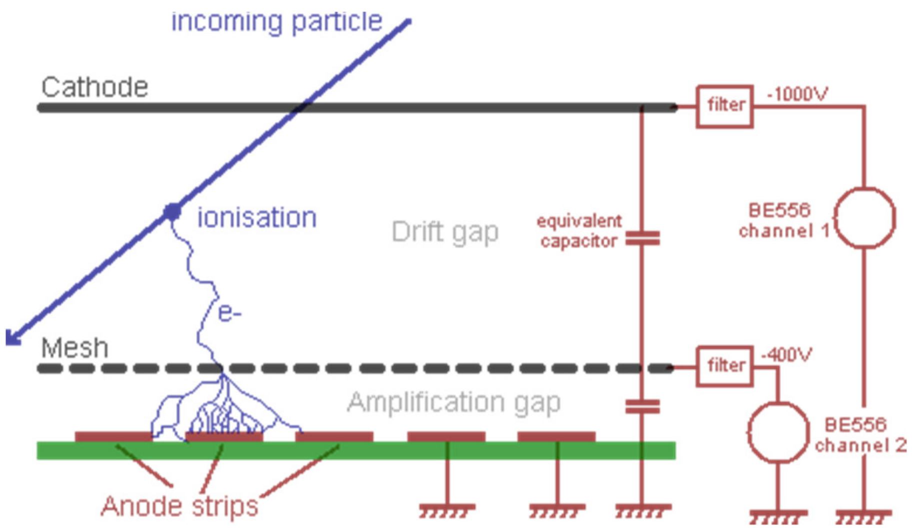
Stablohm 875 (resistive) wire Ø=17 µm 72 / plane
wire pitch = 5 mm anode - cathode distance: 7 mm



WP 21 Detectors

Task 21.2 Solid 10B Gas Detector Development

T21.2.4: Concept study for a large area detector
Based on layered structure with micromegas readout – LLB IFRU



Micromegas detector
2 region gas detector

Conversion region and Amplification region separated by a micromesh

Amplification gap is small, typically 50 µm – mesh supported on pillars

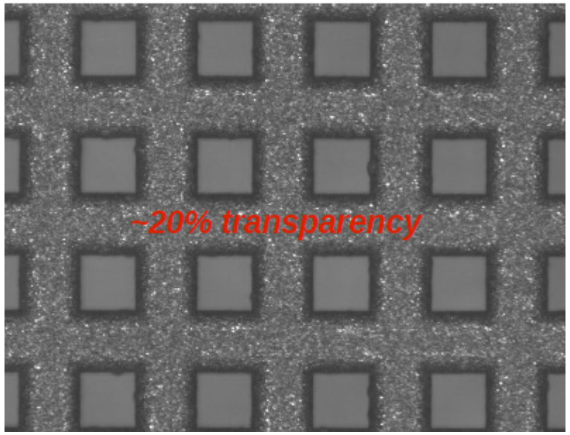
IFRU developed Bulk Micromegas technology as robust, low cost detectors for HEP

IFRU has also developed MicroBulk technology for higher detector performance applications

WP 21 Detectors

T21.2.4: Concept study for a large area detector: Micromegas

Neutron sensitivity is by coating the micromesh with enriched $^{10}B_4C$.

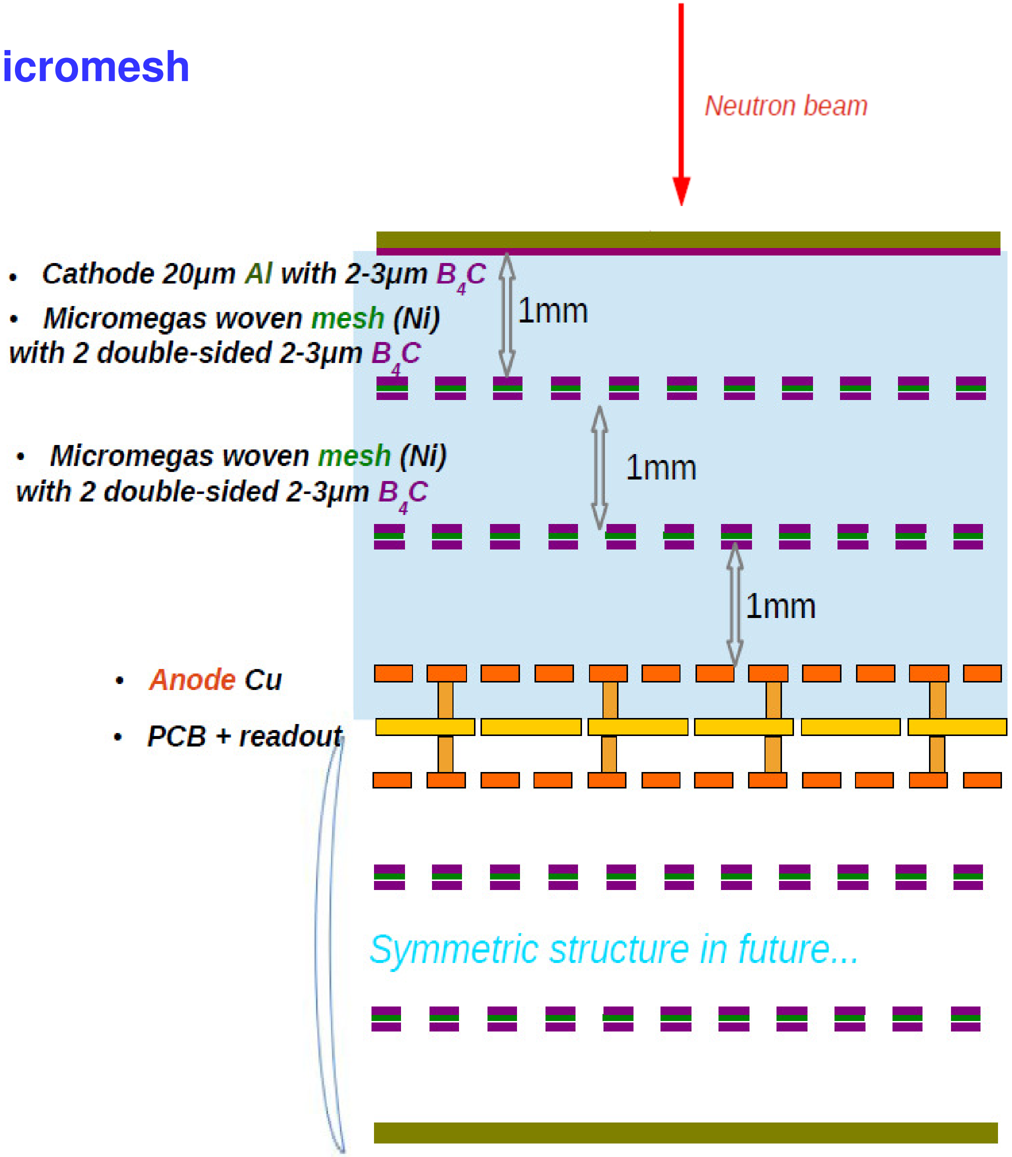


An initial design has been developed

2 micromeshes

5 layers of $^{10}B_4C$

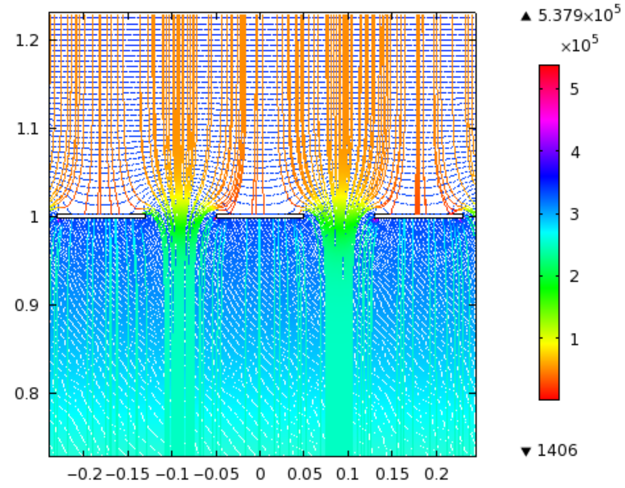
Can be symmetric in future

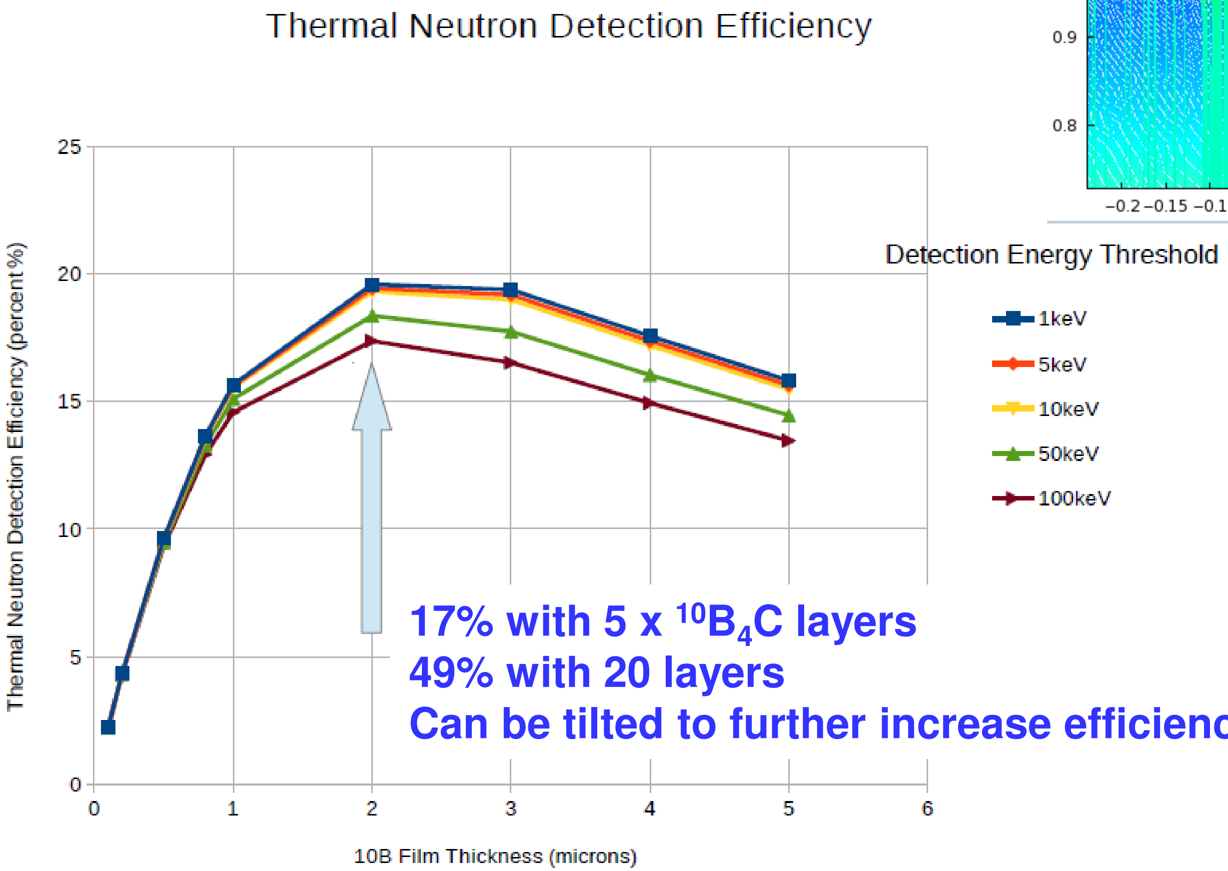


WP 21 Detectors

T21.2.4: Concept study for a large area detector: Micromegas

Simulations have been carried out to optimise
- **Electron collection efficiency**
- **B_4C layer thickness**
- **Neutron detection efficiency**



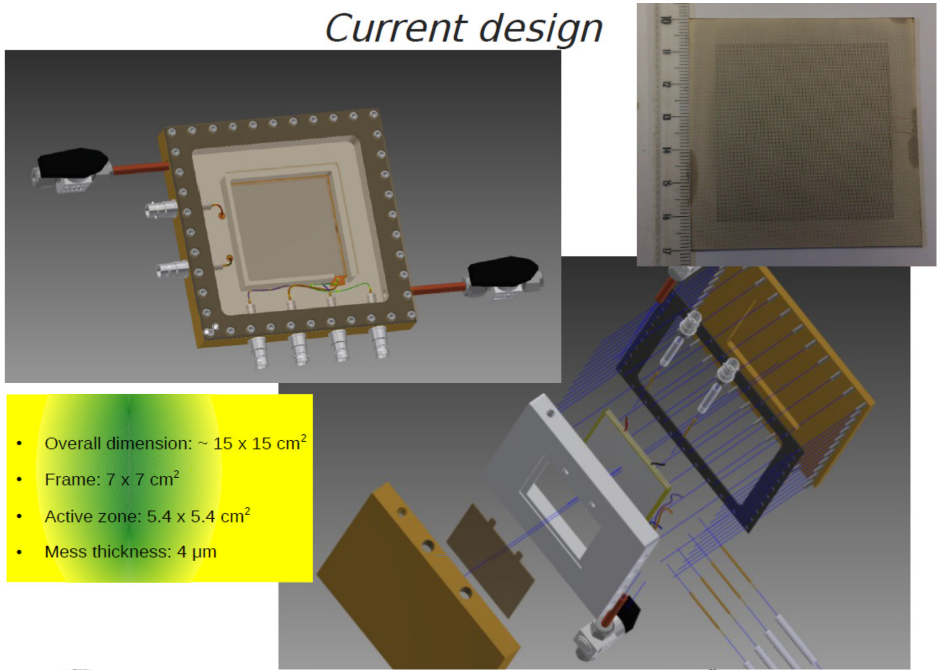


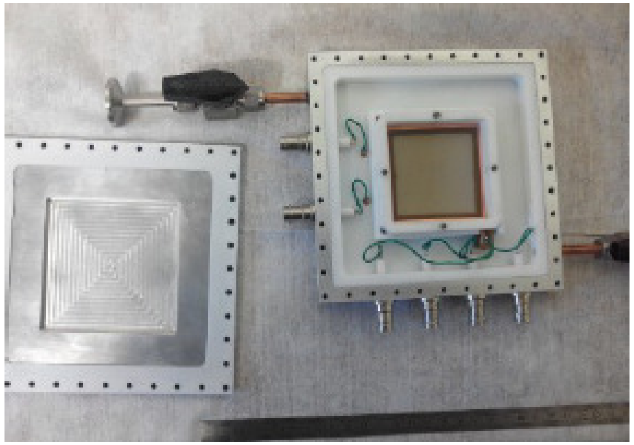
17% with 5 x $^{10}B_4C$ layers
49% with 20 layers
Can be tilted to further increase efficiency

WP 21 Detectors

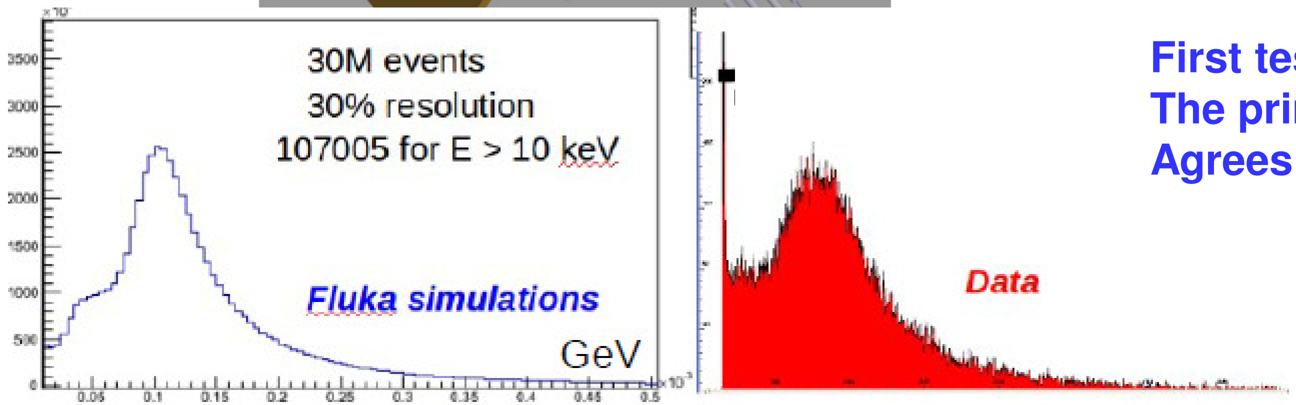
T21.2.4: Concept study for a large area detector: Micromegas

Current design





7 x 7 cm^2 test detector has been designed constructed and tested



First tests:
The principle works.
Agrees well with simulation

WP 21 Detectors

Next Detectors JRA Meeting Early December 2014 Munich

Task 21.1 Development of scintillation detectors

- 21.1.1 Detector Hardware development
- 21.1.2 Electronics hardware development
- 21.1.3 Signal processing development
- 21.1.4 Evaluation of SiPM potential
- 21.1.5 Evaluation of final detectors and report

Task 21.2 Development of gas detectors based on solid 10B converter

- 21.2.1 Optimisation of substrate and 10B production parameters
- 21.2.2 Exploration of alternative production techniques
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Complete   Ongoing   Not yet started