SINE2020 Mid-term Review

Brussels, 4 July 2017

WP 9
WP Detectors

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This project is funded by the European Union (GA no. 654000)

Explanations of the work carried out

1. Objectives
2. Work carried out so far
3. Expected impact
4. Deviations / Problems encountered

This project is funded by the European Union (GA no. 654000)

1. Objectives

AIMS

Develop neutron detectors for reflectometry applications relevant to the ESS

- **Spatial resolution 1 – 3 mm**
- **Time resolution better than 100 µs**
- **Local instantaneous rate capability of several kHz/mm^2**

Evaluation of the latest silicon PMs and scintillator readout devices for MuSR, particularly with regard to rate capability and fast timing applications

TASKS

- **Task 9.1: Involvement of industry and the wider European neutron and muon detector communities in detector development**
- **Task 9.2: Development of scintillation detectors with high rate capability for reflectometery**
- **Task 9.3: 3He based microstrip gas chamber with a novel 2D readout**
- **Task 9.4: Emergent Detector Technologies for neutron scattering and muon spectroscopy**

This project is funded by the European Union (GA no. 654000)

2. Work carried out

TASK 9.1:

Involvement of industry and the wider European neutron and muon detector communities in detector development (All)

- **Invite manufacturers of critical detector componenents to selected RTD meetings**
- **Invite would-be manufactureres of detectors to selected RTD meetings**

  Stimulate transfer of detector requirements to industry

First extended RTD meeting in 13-14 June - Deliverable 9.1

  Representatives from 6 compnies attended - KPI W9.1

  A mixture of firms building detectors and building components for detectors

- **Invite detector persoannel from groups outside RTD to participate in RTD meetings**

  Promotes exchange and disemmination of information

UMB and ENEA have given invited talks at the Abingdon RTD meeting

Prof. Paulo Fonte gave an excellent overview of RPC detectors at the Coimbra meeting

UMB and JCNS gave invited talks at the PSI RTD meeting

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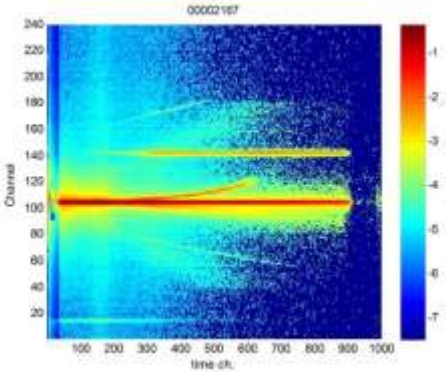
2. Work carried out

TASK 9.2:

Development of scintillation detectors with high rate capability for reflectometry

- **9.2.1 ZnS scintillation detector with WLS fibre readout (STFC)**

768 pixels
0.5 x 60 mm^2

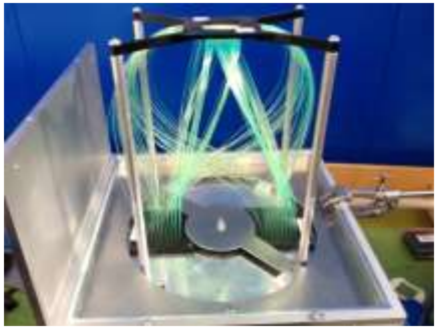


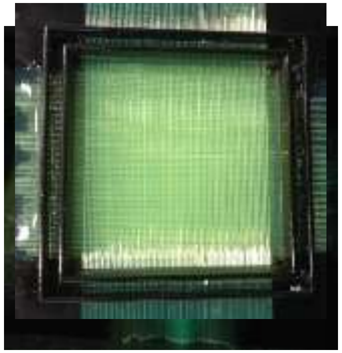
192 PMT pixels, but most of the data goes into just two PMT pixels

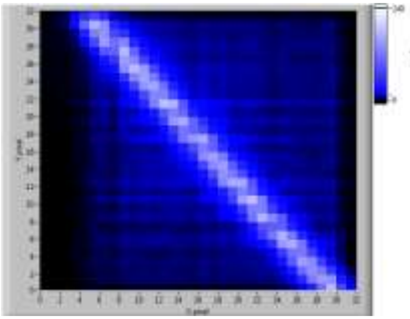
Distribute data high intensity data across all PMTs rather than just a few

Adjacent horizontal and vertical pixels deliberately coded to different PMTs

0.7 mm^2 resolution
Need to eliminate ghosting







4096 pixels 0.5 x 0.5 mm^2 First detector hardware Deliverable 9.1

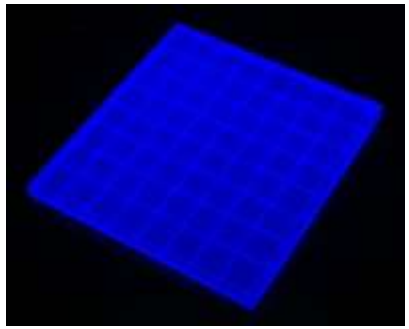
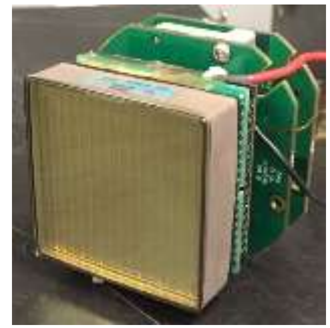
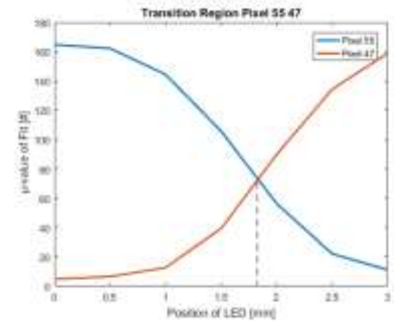
This project is funded by the European Union (GA no. 654000)

2. Work carried out

- **9.2.2 Scintillation detector with direct PMT readout (FZJ)**

  Use of Li glass scintillator drectly coupled to PMT for high light collection

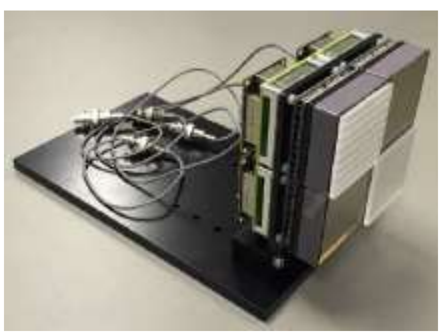
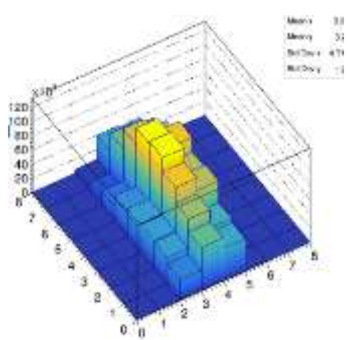
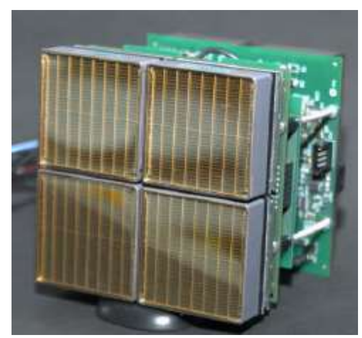
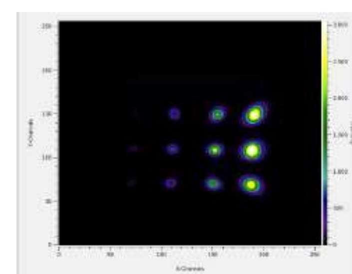
  64 channel H8500 PMT gives 6 x 6 mm intrinsic resolution

Transparent scintillator grooved and grooves filled with refelector

Rosmap electronics used for evaluation

Fast electronics system in development

High Rate Mode 6 x 6 mm2 resln.

Anger Mode 0.7 mm FWHM resln.

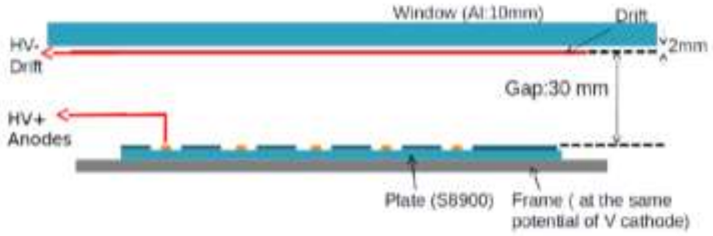
2. Work carried out

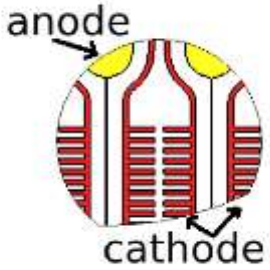
TASK 9.3:

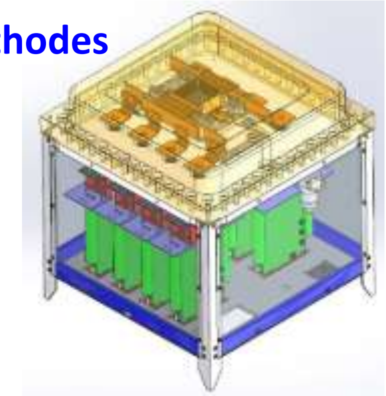
Development of a 3He based microstrip gas chamber with a novel 2D readout (ILL)

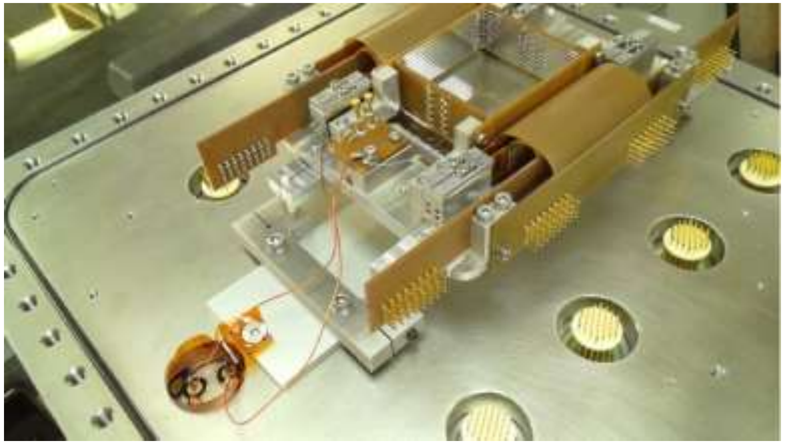
The microstrip gas chamber is intrinsically a 1D position sensitive device

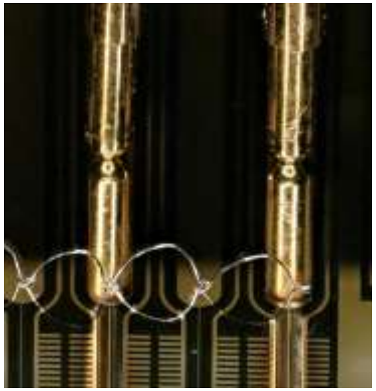
The proposal is to make it 2D position sensitive by laying down resistive cathodes

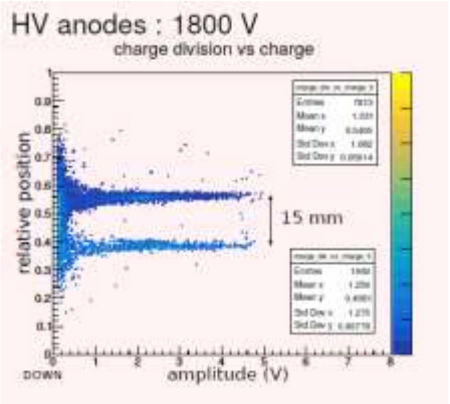












Active area 64 x 76 mm²

Wire bonding of anodes solved sparking issue

FWHM < 2 mm

2. Work carried out

TASK 9.4:

Emergent Detector Technologies for neutron scattering and MuSR

- **9.4.1 $^{10}B_4C$ coated Resistive Plate Chambers for Position Sensitive Neutron Detectors**
- **9.4.2 Silicon Photomultipliers for Neutron scattering**
- **9.4.3 Silicon Photomultipliers for MuSR**
- **9.4.4 Micromegas detectors**

Irina Stefanescu et al. (EDG) keep us up to date with progress at the ESS

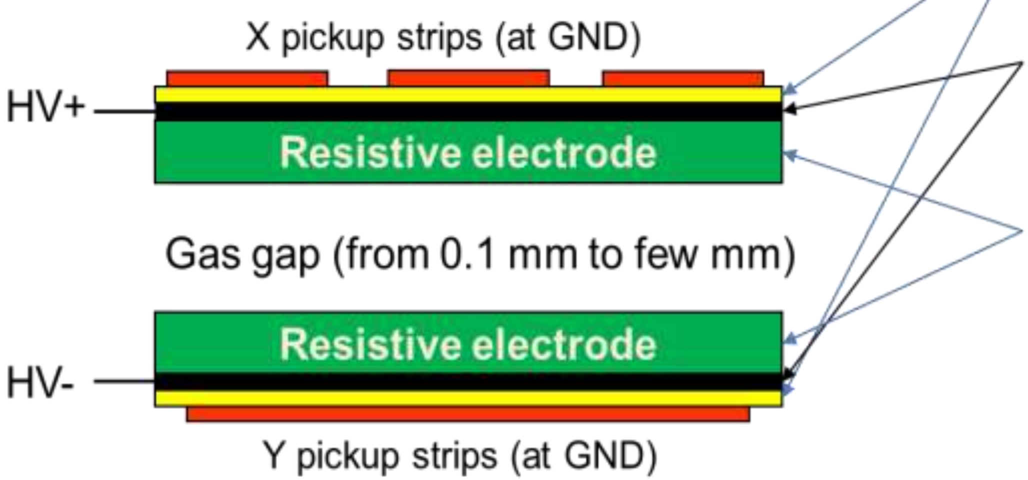
Particularly with regard to the detector development and the ESS detector performance requirements

$^{10}B_4C$ coatings for tasks 9.4.1. and 9.4.4 carried out at ESS

This project is funded by the European Union (GA no. 654000)

Task 9.4.1 Development of neutron sensitive resistive plate chamber (RPC) (LIP)

Typical RPC Structure



High resistivity layer (e.g. PET)

HV distributed trough a medium resistivity layer (e.g. Graphite or resistive Ink) transparent to the induced signals

Resistive electrodes
(e.g. **glass**, bakelite,ceramics)

"Standard" gas mixture:

$C_2H_2F_4$ (tetrafluoretane or R134a)

1 to 10% SF_6 (sulphur hexafluoride)

0 to 5% C_4H_{10} (isobutane)

RPCs:

Gas detector developed in the early 1980's as a low-cost alternative to large scintillator planes

This project is funded by the European Union (GA no. 654000)

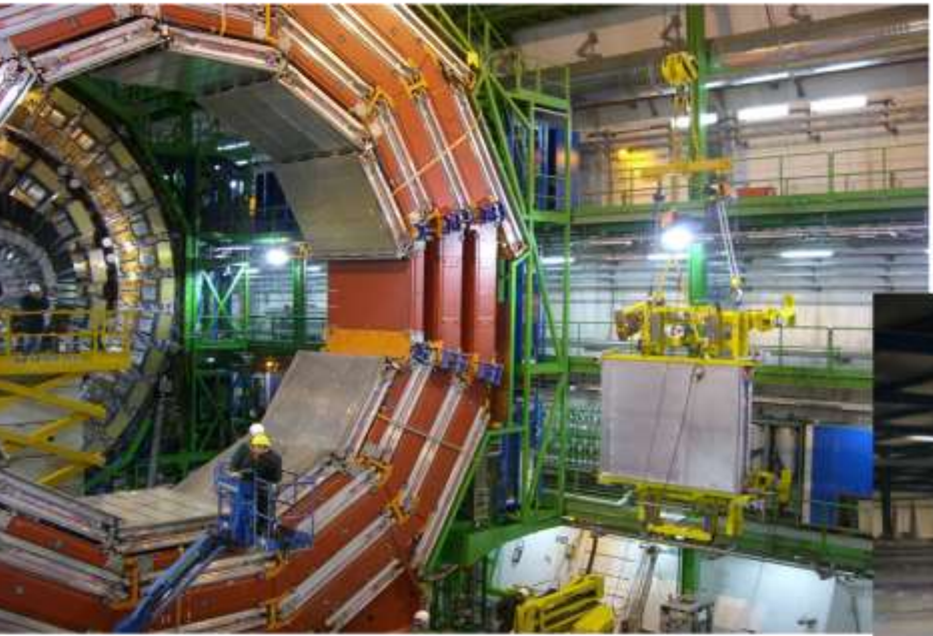
2. Work carried out

Task 9.4.1 Development of neutron sensitive resistive plate chamber (RPC)

RPCs are used in many physics experiments

ATLAS@CERN
CMS@CERN
HARP@CERN (TOF)
ALICE@CERN (TOF)
HADES@GSI (TOF)
FOPI@GSI (TOF)
STAR@RHIC (TOF)
BELLE@KEK
OPERA@LNF
ARGO@Tibet
Etc.

CMS Trigger: (2953 m^2)



ARGO: (6700 m^2)

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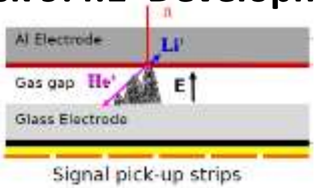
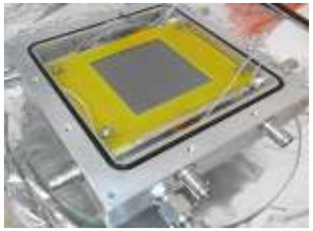
2. Work carried out

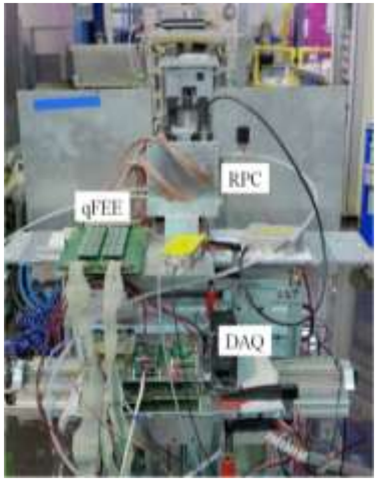
Task 9.4.1 Development of neutron sensitive resistive plate chamber (RPC)



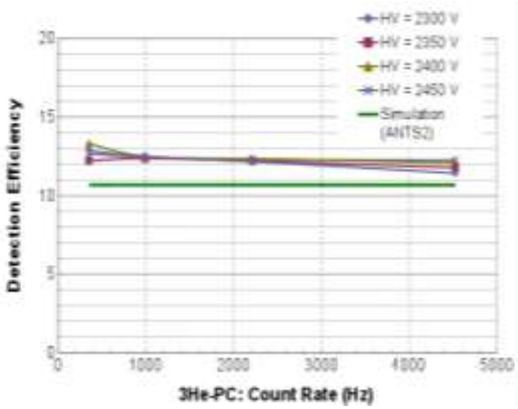
1 layer 2 µm $^{10}B_4C$



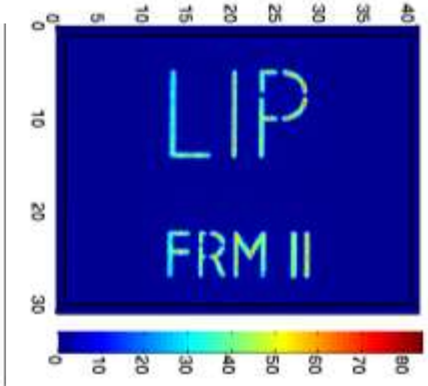
Active area 70 x 70 mm²



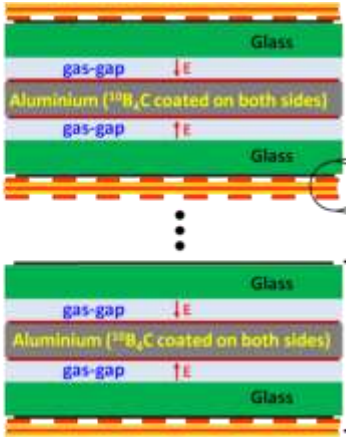
Tested at TREFF FRM II



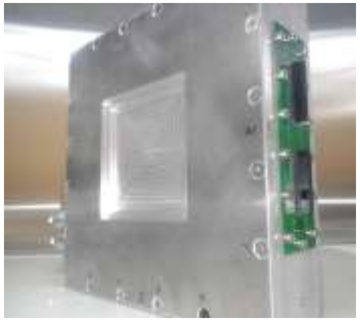
Efficiency 12.5% at 4.7Å



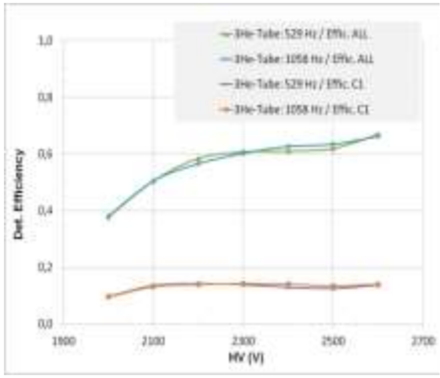
Resolution 236 µm FWHM



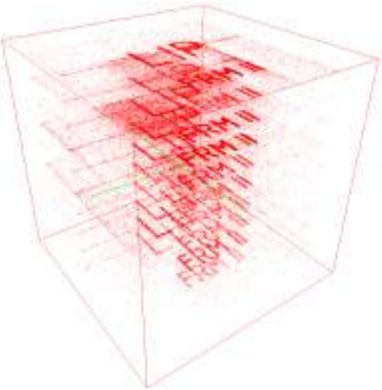
10 double gap RPCs
23 µm $^{10}B_4C$



$^{10}B_4C$ coatings provided by the ESS



Efficiency 60% at 4.7Å



Resolution ~300 µm FWHM

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2. Work carried out

Task 9.4.2 Development of SiPM based detectors for neutron scattering (PSI)

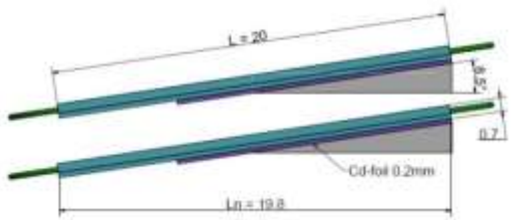
ZnS:Ag/^{6}LiF scintillator with WLS fibre coupled to SiPMs

SiPMs: Small Good QE Low power Insensitive to magnetic fields

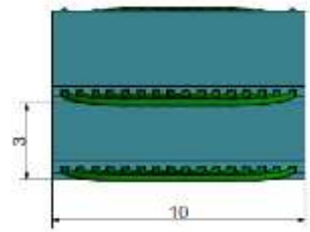
But High dark counts

Two different methods of achieving 2D position resolution are being investigated

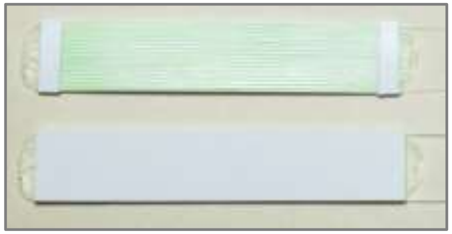
a) **2D pixelated detector**



light collection from pixel with single fiber



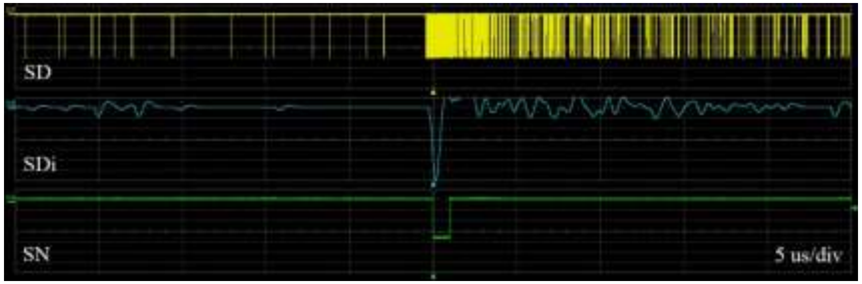
Individual pixels, this design: (3 × 10) mm^2



0.25 mm dia. fibres embedded in scintillator

Detection efficiency 50% at 1 Å

Rate = several kHz in one column/row



Extraction of neutron signal from SiPM noise solved previously by PSI

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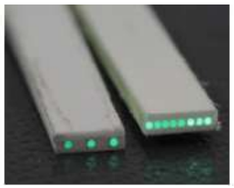
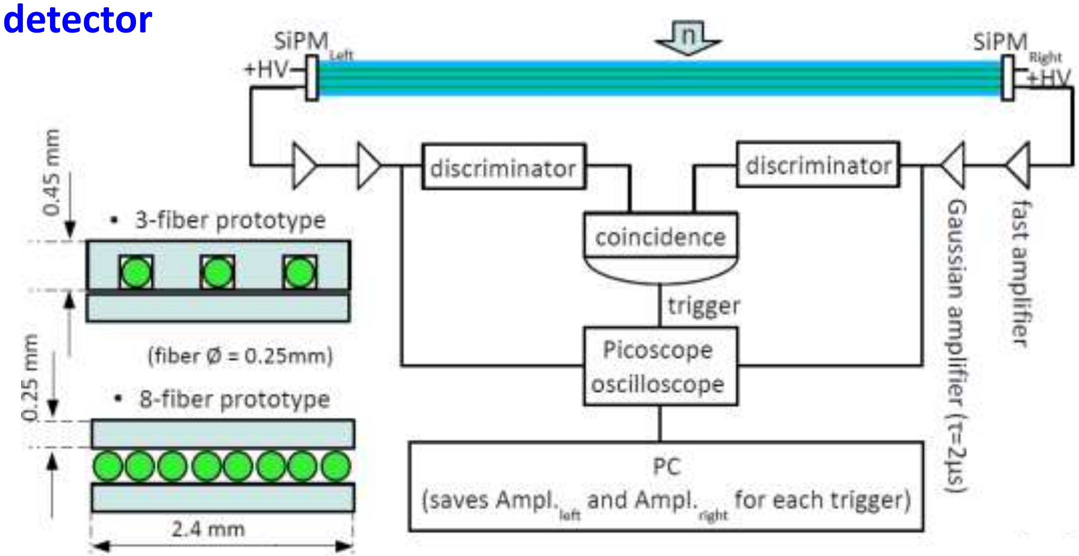
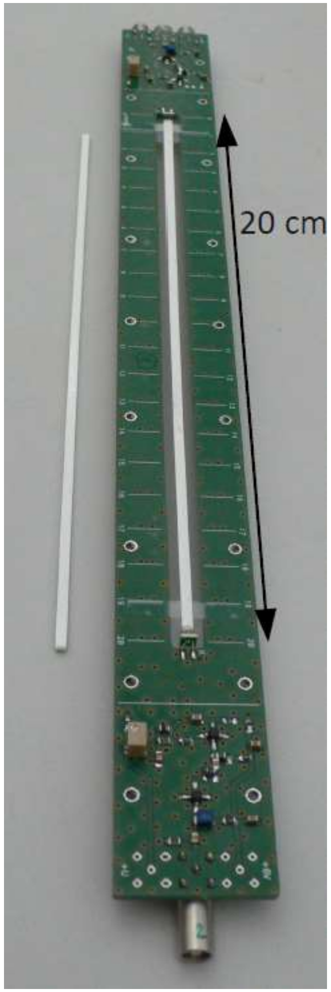
2. Work carried out

Task 9.4.2 Development of SiPM based detectors for neutron scattering

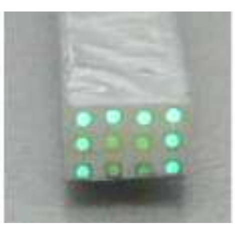
b) Light sharing detector

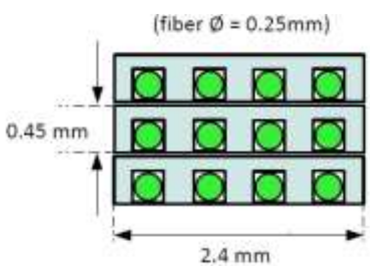






200 mm long fibres short attenuation length developed by Kuraray. A-B/A+B to find positon.. Currently 13 mm.





Careful fibre selection
New structure
New gluing procedure
New scintillator developed with Sintacor
Expect LY at least x 2 → improved resolution

Development of low cost readout electronics and DAQ system being considered

This project is funded by the European Union (GA no. 654000)

2. Work carried out

- **Task 9.4.3 Silicon Photomultipliers and other scintillation readout devices for µSR (ISIS + PSI)**

First half of the task has concentrated on SiPMs

Systematic testing of emerging commercial SiPMs D9.8, M 24 (new series every few months)

Continuous source requires excellent timing resolution

Pulsed source requires excellent dead time (many positrons per detector per pulse)

Three pronged approach

Testing of scintillation detector with SiPM on muon beam line

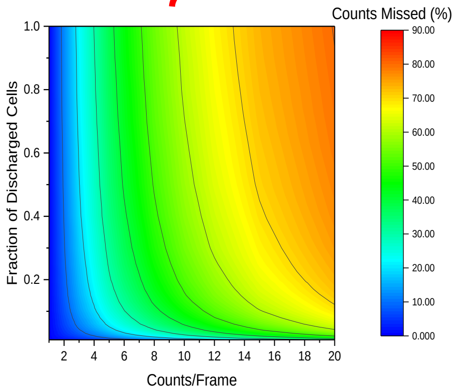
Testing of SiPM with laser response

Modeling of detector response

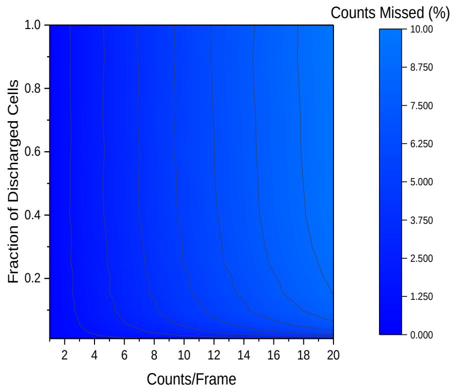
SensL 50µm

Differentiated signal

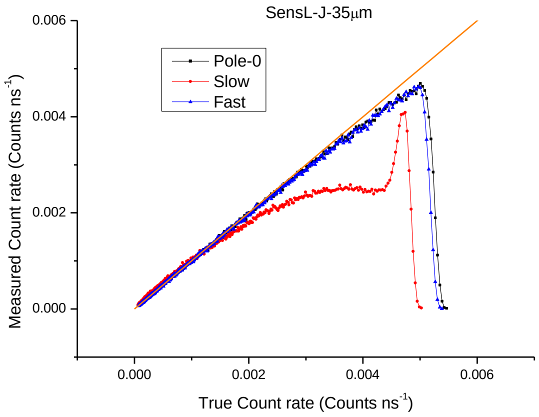
SensL 50µm



2 counts per frame
10% dead time



20 counts per frame
10% dead time



Mostly about the signal processing electronics

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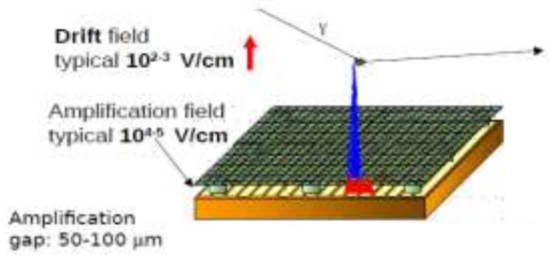
2. Work carried out

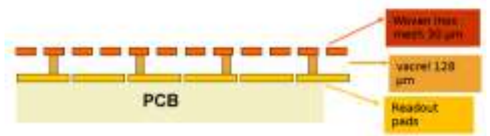
Task 9.4.4 Development of Micromegas Detectors for neutron scattering (CEA)

Micromegas detectors are one of the family of micro pattern gas detectors

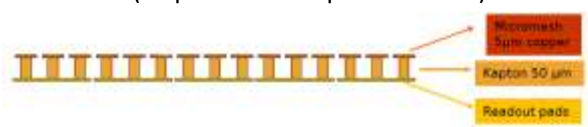


Gas gain takes place between grid and readout plane

Bulk



Microbulk (Dupont™ Cu-Kapton-Cu foils)

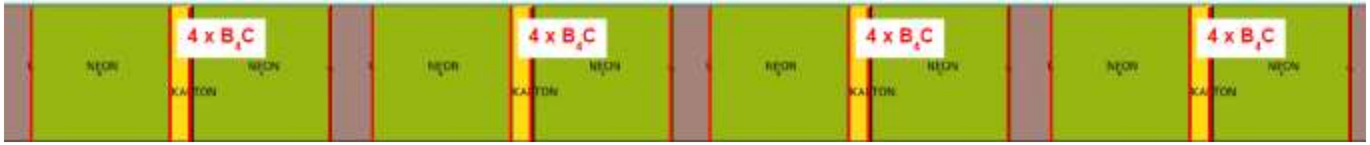


Two technology options

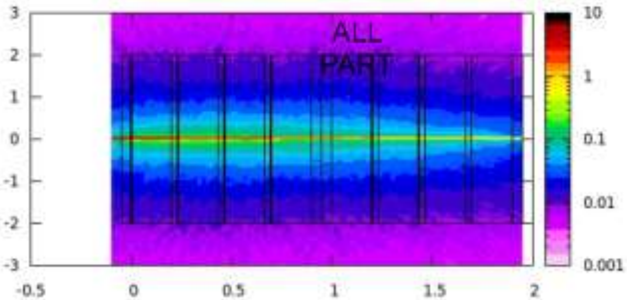
Drift electrode and grid coated with $^{10}B_4C$

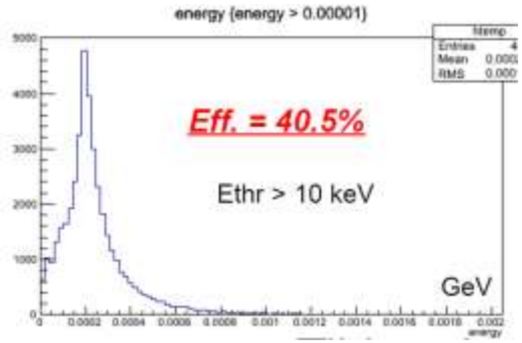
No PCB layer in microbulk detector

Allows stacking

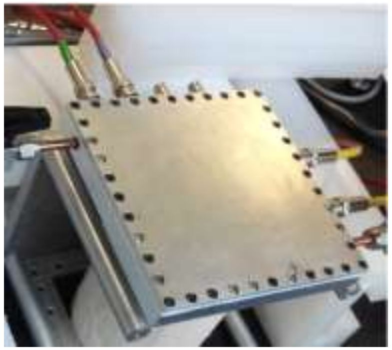


Stack of 4 pairs of micromegas detectors





Simulations show 40% efficiency at 1.8 Å



Prototype 15 x 15 cm^2 detector waiting for coatings

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This work seeks to develop new detector technology of the neutron scattering and MuSR communities.

This is enabling technology whitout which facilities like the ESS will not be able to realise their full scientific potential.

Although aimed specifically at reflectometry, the technologies explored here may benefit other aspects of neutron scattering, eg powder and siggle crystal appications.

Most of the technology is very specific to neutron scattering, but some asspects may be of interest to the wider detector community.

2d position resolution from WLS fibre using light attenuation of the fibre

Improving rate capability of RPCs

Training of fixed term PDRAs who may then take up positions in other scientiific areas

Ill, Psi, CEA and Lip all have fixed term PDRas working in WP9

technis to provide the Research facilities with high performance, cost effective detectors which allow the potential of the science programmes at these facilities to be realised.

The scientific output of facilities like the ESS far out weigh the

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4. Deviations / Problems encountered

- The lead for task 4.3.1 “Silicon Photomultipliers for MuSR” has changed from PSI to ISIS

  Elevezio Monrenzoni retired and Stephen Cottrell has assumed this role

  There is no perceived impact of this change

- The first extended RTD meeting which involved industry representatives was delayed.

  I was involved in organising another conference in March (ICANS)

  The meeting took place on 13 – 14 June

  Facilities continue to interact with industry on an individual basis and not dependent on this meeting for progress.

  There is no perceived impact of this change

- LIP have requested an additional €30k

  Change in Portuguese regulations required LIP to change PDRA from a grant to a work contract, incurring higher costs

  Propose to transfer costs from STFC

  STFC holding €40k on behalf of all partners to cover costs associated with task 9.1

  Non funded partners attending meetings have provided their own cost

  Industries provided their own costs in attending the extended meeting