Future use of silicon photomultiplier for KAOS at MAMI and PANDA at FAIR

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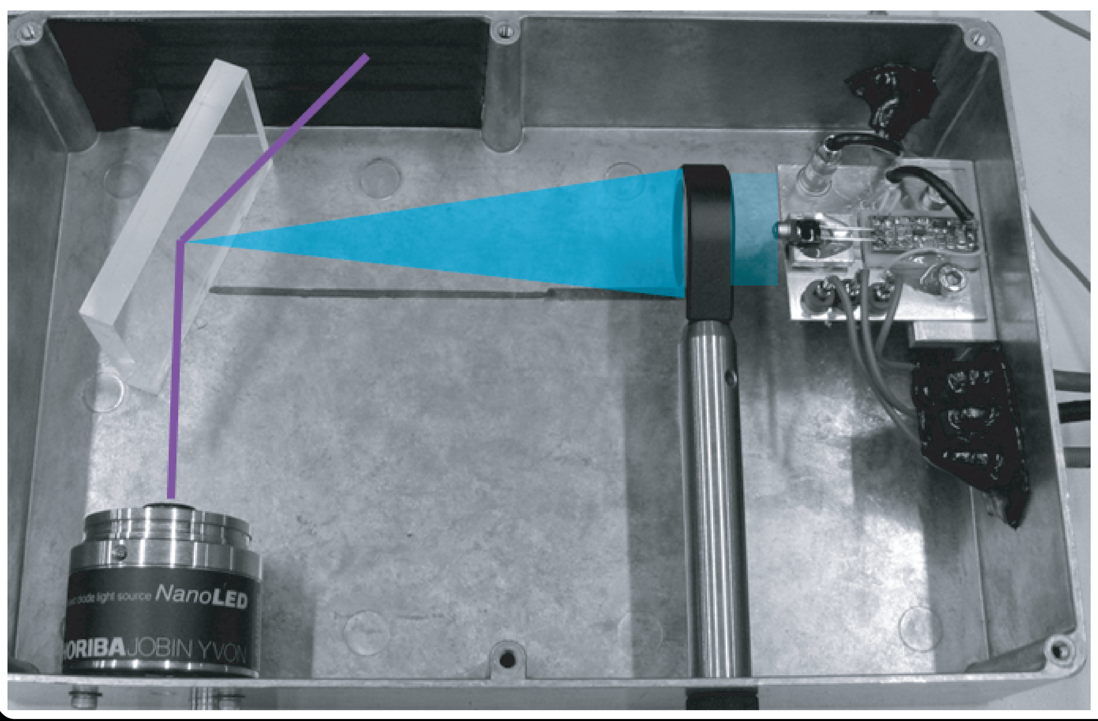
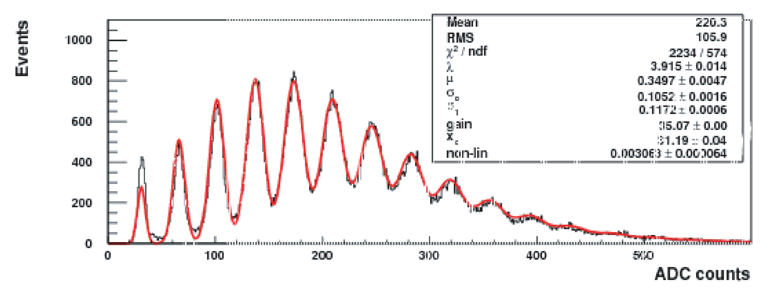
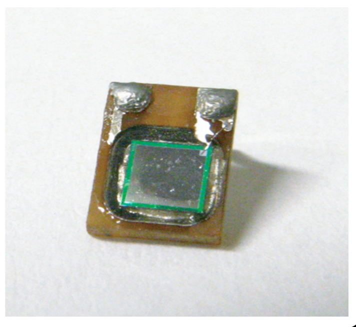
SiPM CHARACTERISATION FOR LOW LIGHT YIELD APPLICATIONS



Pulse-height spectrum from a fibre exited by ^{90}Sr and read out by a SiPM.





SiPM/FIBRE ASSEMBLIES

SiPM technology is evolving very fast and one of the main performance improvements is the progressive reduction of the dark count rate. This new situation makes scintillating fibre tracking detectors read-out by SiPM an interesting and realistic option. To fully exploit the good timing properties of SiPM, the output of SiPM/fibre assemblies has to be increased well above the noise level.

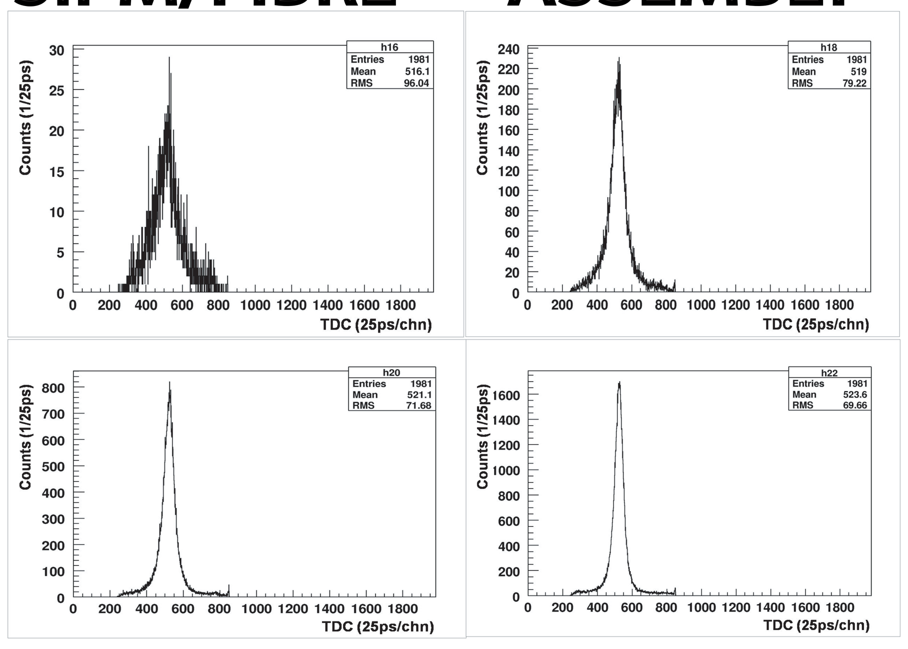
SiPM IN THE PANDA EXPERIMENT

A small fiber barrel read-out by SiPM has been discussed as an option for a time-of-flight start detector in PANDA and as the active target for the hypernuclear Physics programme. Such a detector might be also used as a time reference for the DIRC detector or for track deconvolution of the time projection chamber. For PANDA the time resolution is a main issue.

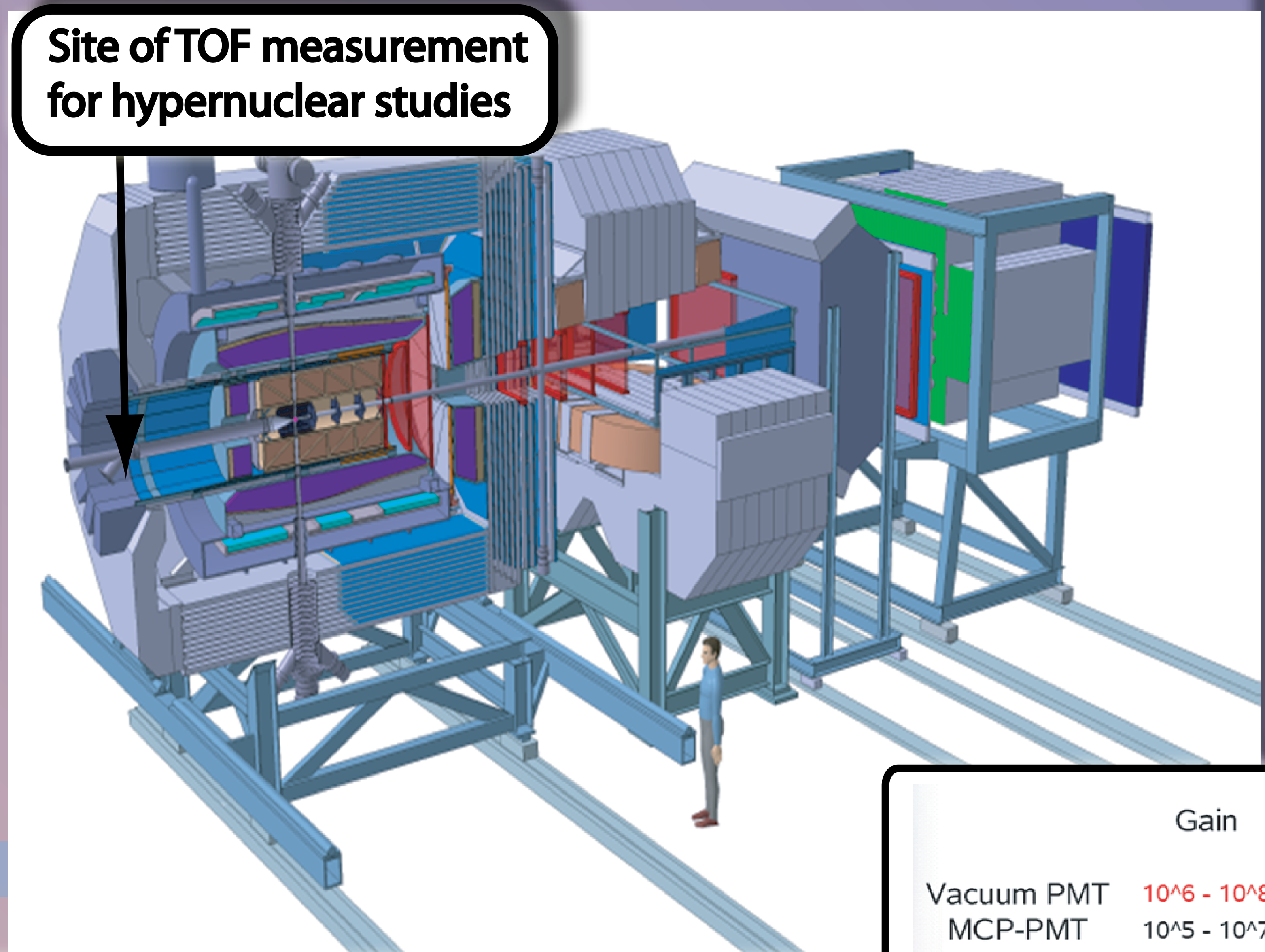
Requirements for a DIRC photodetector:

- dt < 100 ps
- dy ~ 1-2 mm
- dx ~ 5 mm
- single photon counting
- magnetic field immunity
- effective area > 70%

TIME RESOLUTION OF AN SiPM/FIBRE ASSEMBLY



Measured left/right time differences with a 2m long SiPM/fibre set-up. For the 4 spectra the pixels N = 1,...,4 from the pulse height spectrum were selected.

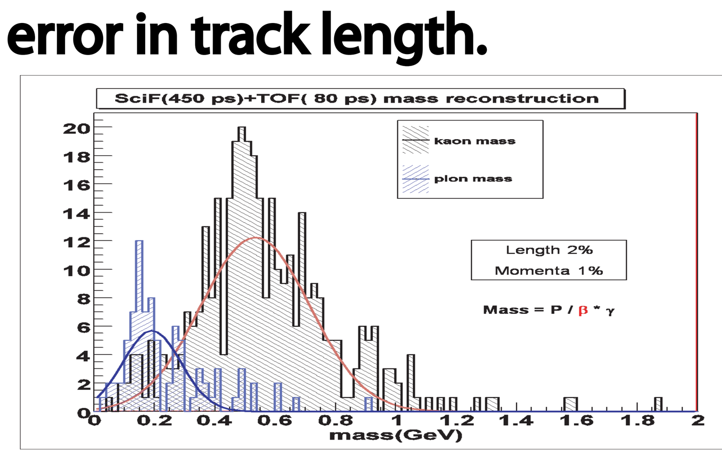


	Gain	Max. B-field	Dark Count	Max. Rate
Vacuum PMT	10^6 - 10^8	< 0.05 T	< 100 Hz	10^7 Hz
MCP-PMT	10^5 - 10^7	2 T	~ 10 kHz	10^6 - 10^7 Hz
SiPMT	10^5 - 10^6	Prob. High	~ 1 MHz / pixel	Prob. Low

	TTS	Efficiency	Lifetime	Price
Vacuum PMT	> 350 ps	~ 20 %	> 1000 C/cm^2	\$500 – 1500
MCP-PMT	< 50 ps	~ 15 %	< 1 C/cm^2	\$1500 - 10000
SiPMT	~ 100 ps	<< 15 %	Prob. High	~ \$100 / mm^2

TIME-OF-FLIGHT PARTICLE ID IN PANDA

Simulated kaon/pion separation in the PANDA hypernuclei programme using a fibre start counter and a barrel stop counter with 80 ps and 450 ps time resolution. Calculated with 1% momentum resolution and 2% error in track length.

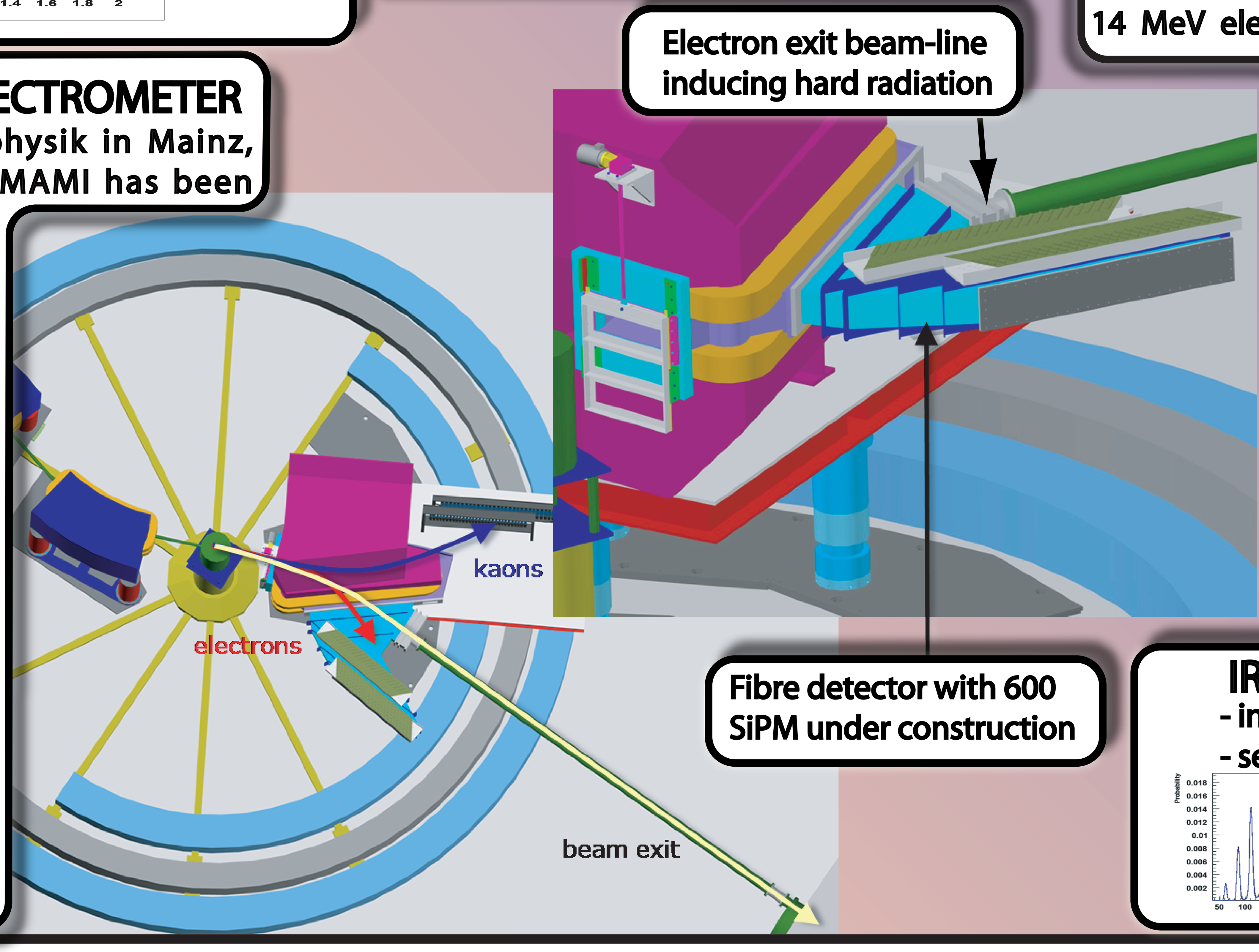


PARTICLE DETECTION EFFICIENCY OF LONG FIBRES WITH SiPM

Threshold (no. of pixels)	Efficiency
1	91 %
2	76 %
3	56 %
4	35 %

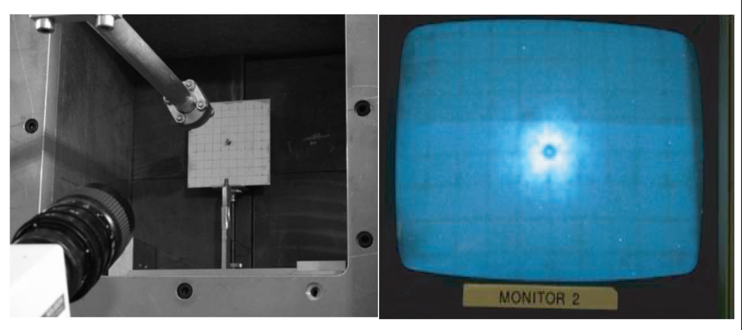
SiPM IN THE KAOS SPECTROMETER

At the Institut für Kernphysik in Mainz, Germany, the microtron MAMI has been upgraded to 1.5 GeV electron beam energy. A large fibre detector set-up is under development for the KAOS spectrometer, covering an active area of 2000 × 300 mm². SiPM have been suggested as a possible candidate for a two-sided read-out for the long fibres in horizontal direction. We concluded that a 4 mm² double cladding fibre with 4 mm² SiPM read-out can be used as tracking detector.



IRRADIATION SET-UP

14 MeV electrons were used to irradiate a sample of SSPM-0701 BG-TO18 diodes. The beam current was 10 nA.



Electrons crossed a 0.3mm thick aluminum window at 15cm distance from the SiPM. Fluences ranged from 0.31 to 3.8 × 10¹⁰ electrons/mm².

IRRADIATION EFFECTS

- increase in leakage current
- severe loss of gain uniformity