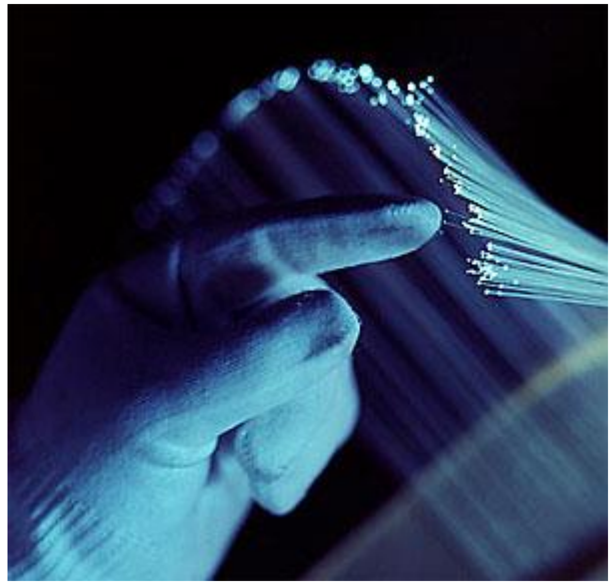
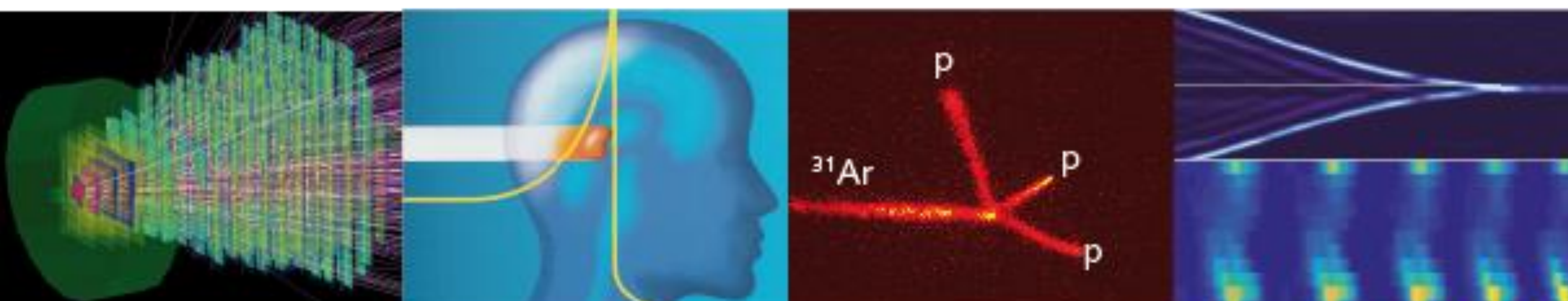
Scintillating Fiber Tracker @ GSI - DL



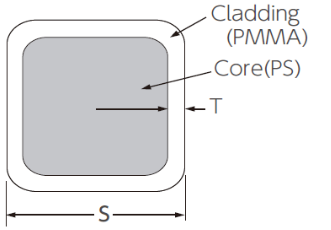


Google

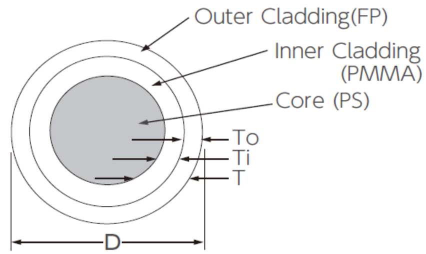

Kellogg's
Nutrition™
FIBER
TRACKER
SEE HOW YOUR FOOD CHOICES CONTRIBUTE TO
YOUR FIBER INTAKE FOR THE DAY!

Scintillating Fiber Tracker – What is it?

Single Cladding	Multi-Cladding (M)



Cladding Thickness : T=2% of S
Numerical Aperture : NA=0.55
Trapping Efficiency : 4.2%



Cladding Thickness[2)]: T=2%(To)+2%(Ti)
=4% of D
Numerical Aperture : NA=0.72
Trapping Efficiency : 5.4%

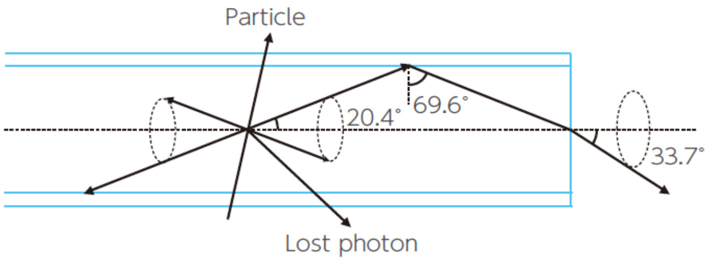
The scintillating fibers have two roles:

1. act as scintillator
(scintillating dye is expected to be radiation hard)
2. transport the light to the PM (Si / MA)
(attenuation length is an issue , radiation hardness)

Cladding and Transmission Mechanism

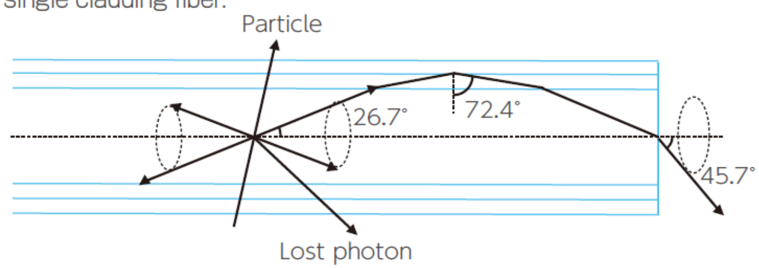
Single cladding

Single cladding fiber is standard type of cladding.



Multi-cladding

Multi-cladding fiber(M) has higher light yield than single cladding fiber because of large trapping efficiency.
Clear-PS fiber of this cladding has extremely higher NA than conventional PMMA or PS fiber, and very useful as light guide fiber.
Multi-cladding fiber has long attenuation length equal to single cladding fiber.



Not a new technology

THE REVIEW OF SCIENTIFIC INSTRUMENTS VOLUME 31, NUMBER 10 OCTOBER, 1960

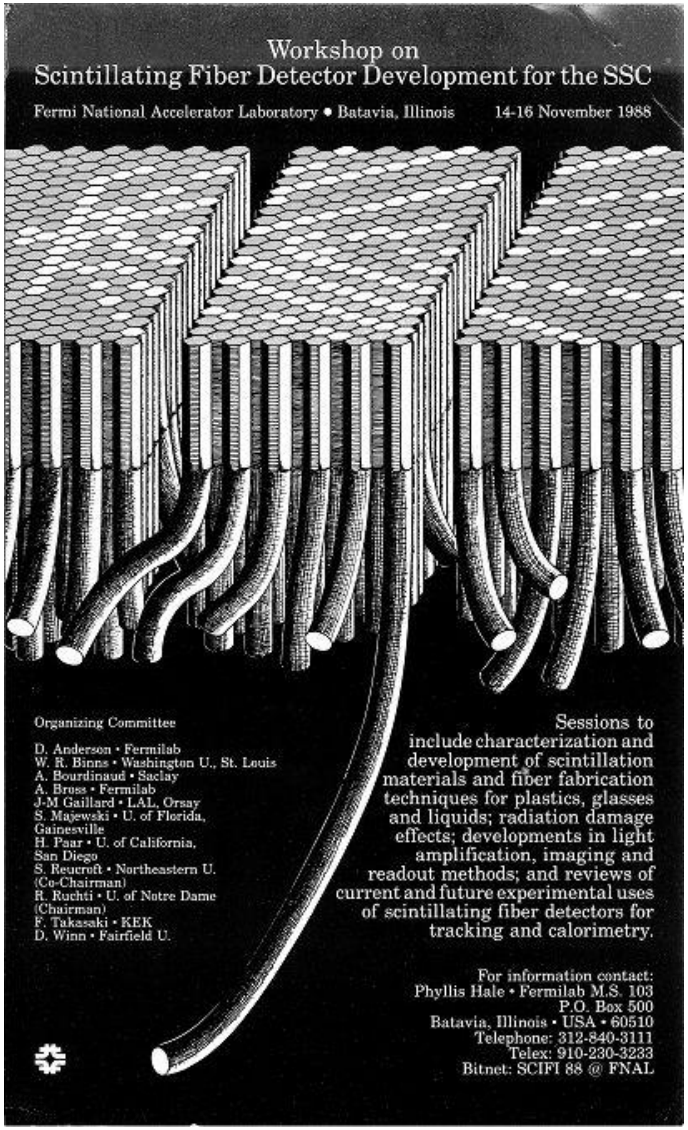
Some Considerations on Luminescent Fiber Chambers and Intensifier Screens

L. REIFFEL AND N. S. KAPANY
Physics Division, Armour Research Foundation, Chicago 16, Illinois
(Received April 21, 1960; and in final form, June 1, 1960)

Many examples from the past

N·H ELSEVIER Nuclear Instruments and Methods in Physics Research A 402 (1998) 67–74
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

A large-area scintillating fibre detector for relativistic heavy ions

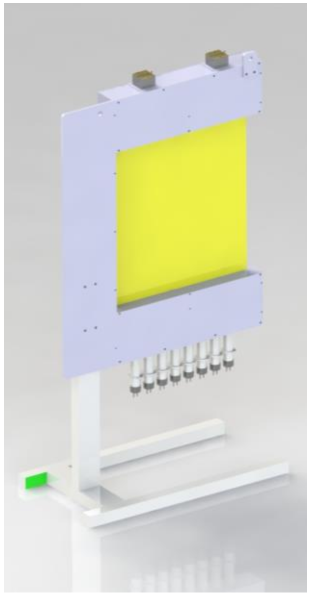


But new developments needed

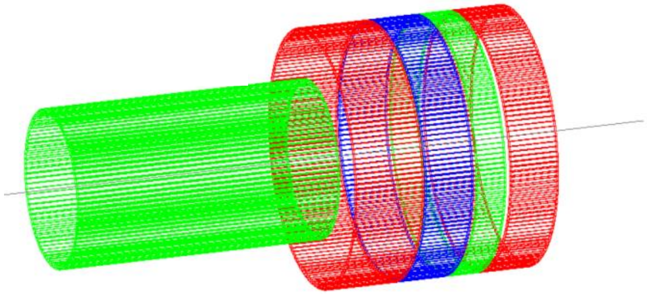
Scintillating fiber trackers using MultiAnode / SiPM photodetectors are an interesting alternative to other technologies

- resolution as good as Silicon strip detectors
- fast detectors
- big progress for operation in radiation environments
- flexible geometry: various detector shapes are possible (plane, cylindrical, cuts, etc...)
- no high voltage (if SiPMs below 100V), no gas

But many aspects still at the stage of R&D ...



- production @ DL started in 2011 by J. Hehner
- revived mid 2017



Prospects for future applications

Two kinds of position detectors

1) tracking detectors (event-by-event)

R3B -> details later

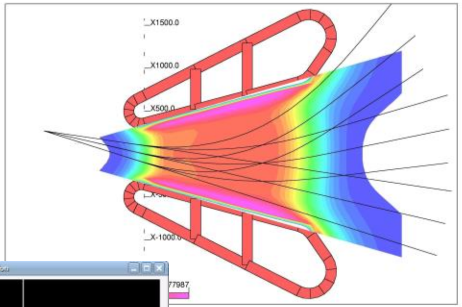
SuperFRS -> synergy with R3B

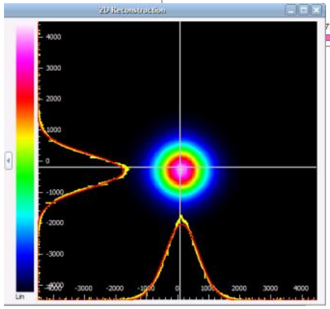
AsyEOS II -> Krakow Barrel (KRAB)

2) Beam Profile Monitors („integrated“)

„Therapy“ -> QBERT colab. with SuperFRS

-> prototype for HIT



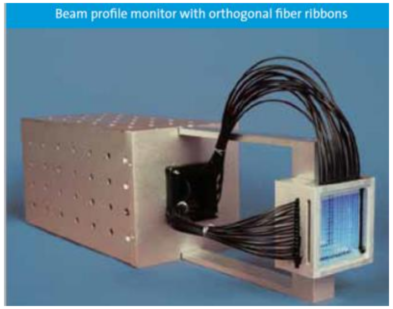


What is available in the market

SAINT-GOBAIN CRYSTALS

Types of Fiber Assemblies Available

- Single ribbons as wide as 300mm and as long as 3200mm
- Multilayered ribbons up to 4 layers



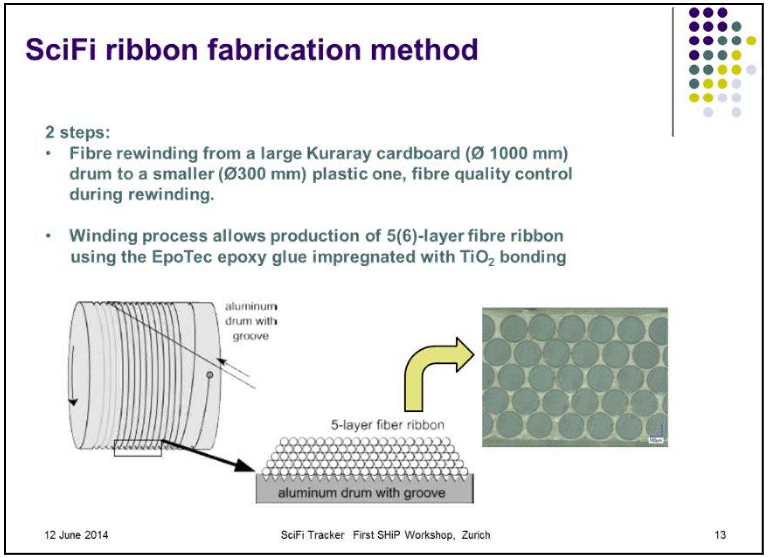
Features/Benefits

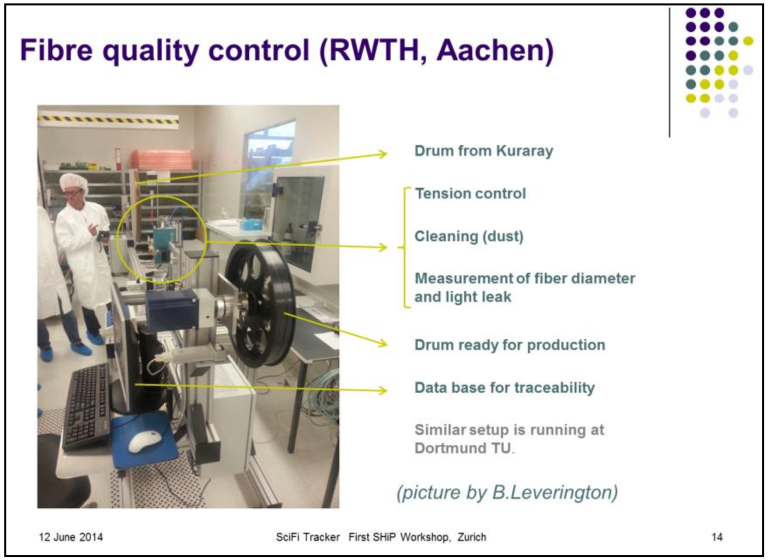
Flexibility to conform to surface shape, yielding geometries superior to those of other types of detectors. Examples are detectors for monitoring pipes or barrels.

LHCb

https://twiki.cern.ch/twiki/bin/view/LHCb/FibreMatsModules

LHCb - Fiber Tracker

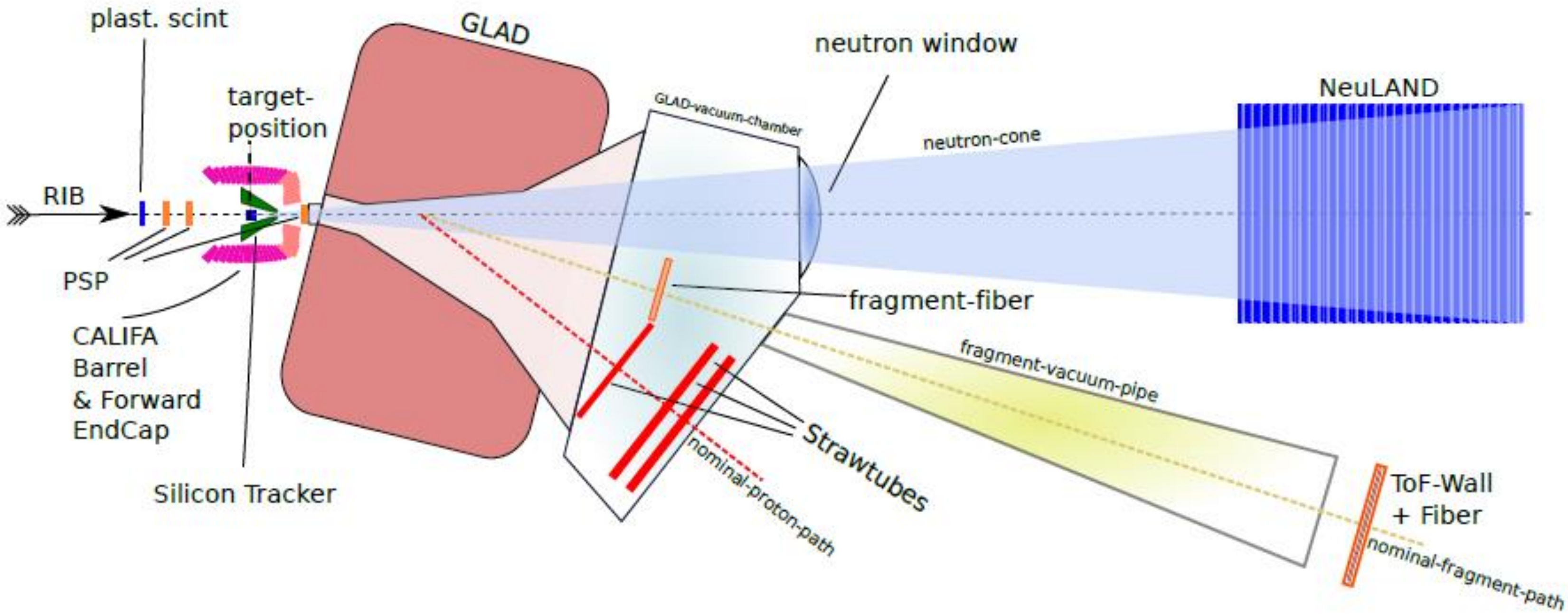




Differences of our "productions" to LHCb one

- size / shape not fixed
- glueing only part of the fiber-mat since free fibers are needed to sort them into mask

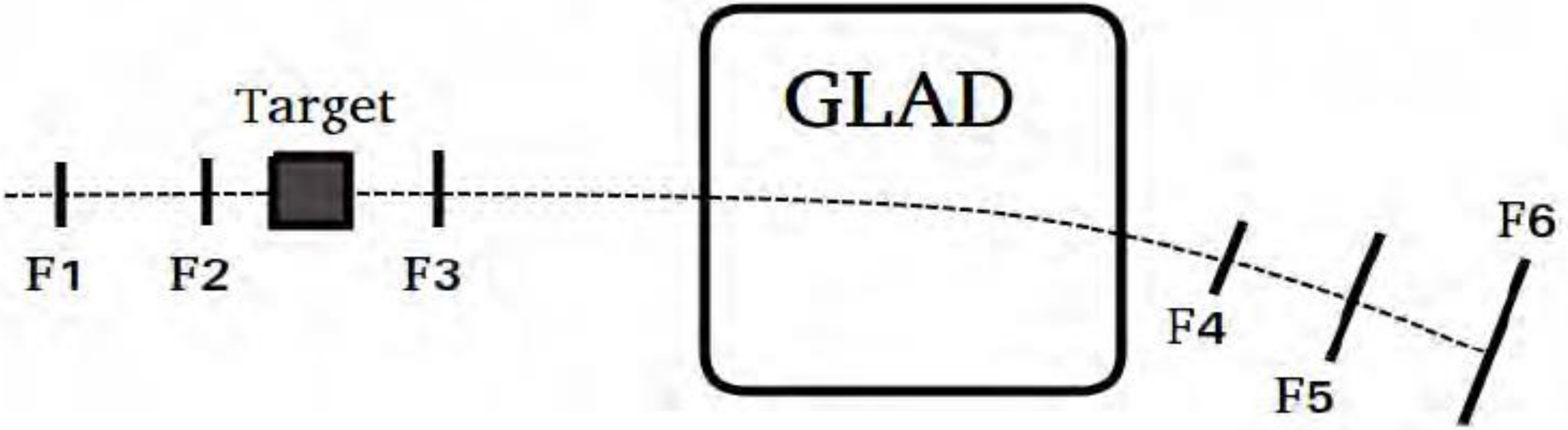
R3B - Setup



plast. scint
GLAD
neutron window
target-
position
GLAD-vacuum-chamber
NeuLAND
neutron-cone
RIB
PSP
fragment-fiber
CALIFA
Barrel
& Forward
EndCap
fragment-vacuum-pipe
Strawtubes
Silicon Tracker
nominal-proton-path
ToF-Wall
+ Fiber
nominal-fragment-path

R³B - Setup 2019

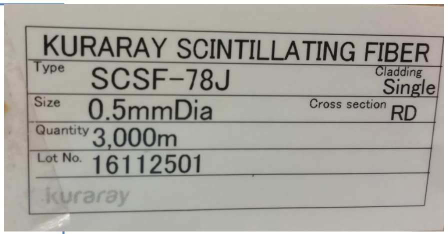
- Fiber1+2: 5 x 5 cm², 2 x 256 quadratic 210 µm fibers.
- Fiber3: 10 x 10 cm², 2 x 512 quadratic 200 µm fibers (in progress).
- Fiber4: 30 x 40 cm², 2048 round 200 µm fibers.
- Fiber5: 25 x 40 cm², 2048 quadratic 200 µm fibers.
- Fiber6: 50 x 50 cm², 1024 round 500 µm fibers.
- 3 Old GFIs: 50 x 50 cm², 512 quadratic 1 mm fibers.

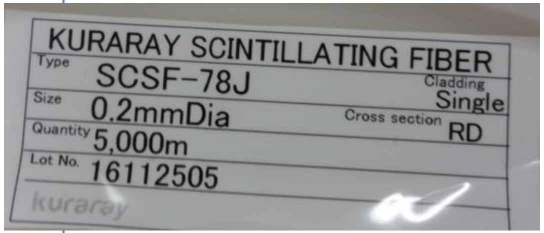


R3B - Fiber Tracker

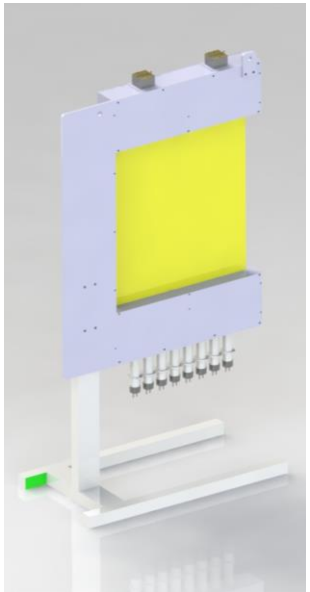
Material used:
- 10mu Pokalon foil
- EPO-TEK 301-2 glue
- Kuraray Fiber
- Araldite 2018
- QSil 216 for light coupling
- Hamamatsu H9500 MAPMT
- Hamamatsu PMT R9779 (NeuLAND)

main criteria material budget and its homogenity



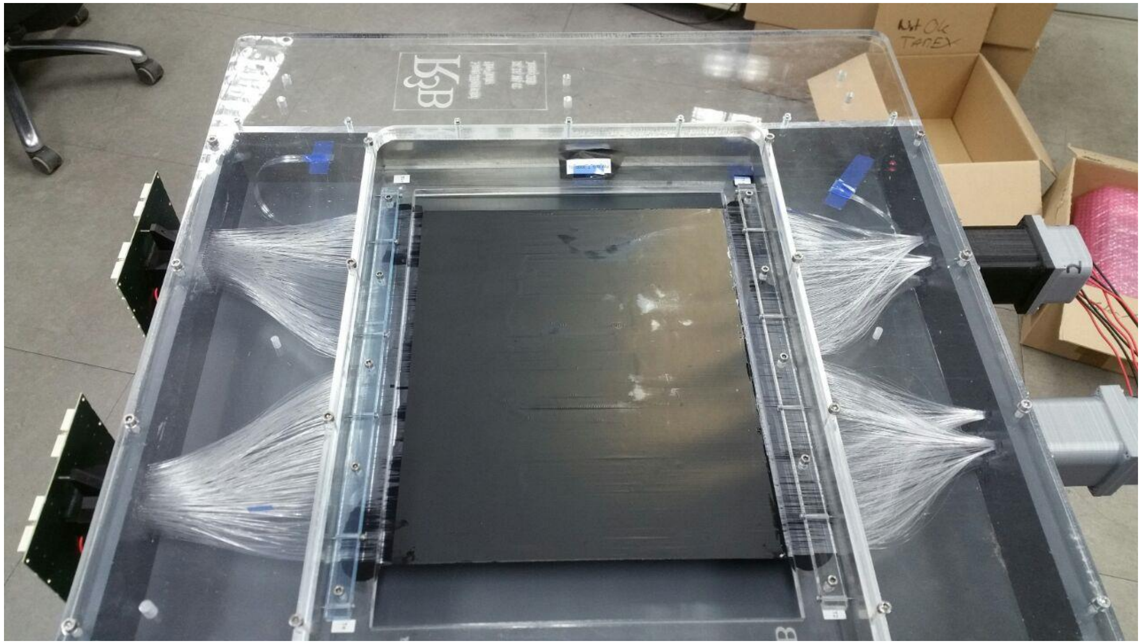


operated in vauum	yes	
Maximum active area	50 x 50	cm2
Maximum allowed length in beam direction	10	cm2
Position resolution	200	mu
Positioning	/	
Time resolution	/	
Maximum rate capability	3	kHz/mm2
Dynamic range	p - U	



Fiber4 Detector

- 0.2 mm thick and round plastic-scintillator fibers.
- 2048 fibers, total dimension of the detector 30 x 40 cm^2.
- 4 fibers bundled to one anode of MAPMT, 4 single PMT on the other side to distinguish the fibers.



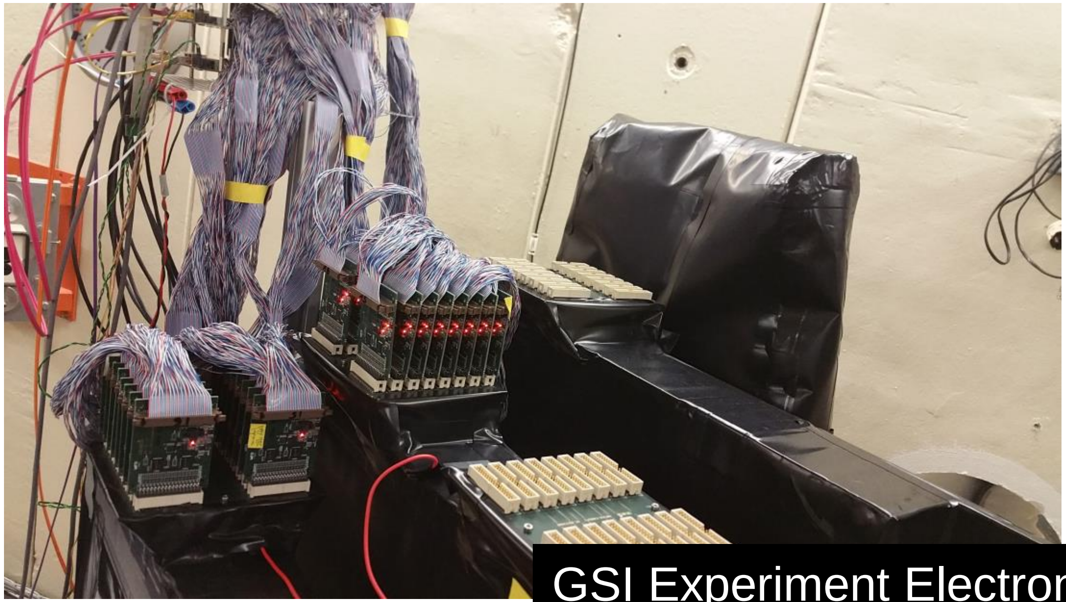
Fiber Readout (Prototype)

- Hamamatsu H9500 MAPMTs
- 16 “PADI boards” and 1 “Clock-TDC” board for 1 MAPMT

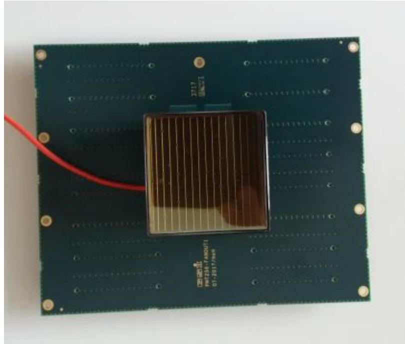
Clock-TDC (128 channel FPGA TDC, 250 ps rms leading edge and ToT multi hit TDC) Xilinx Kintex 7

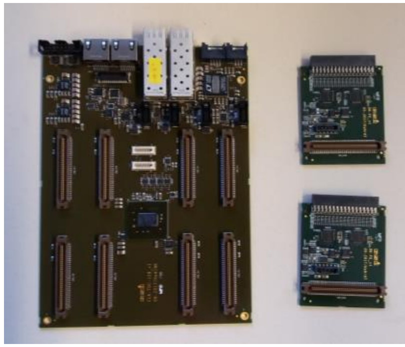
PADI, an Ultrafast Preamplifier - Discriminator ASIC

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 61, NO. 2, APRIL 2014



GSI Experiment Electronic (EE)



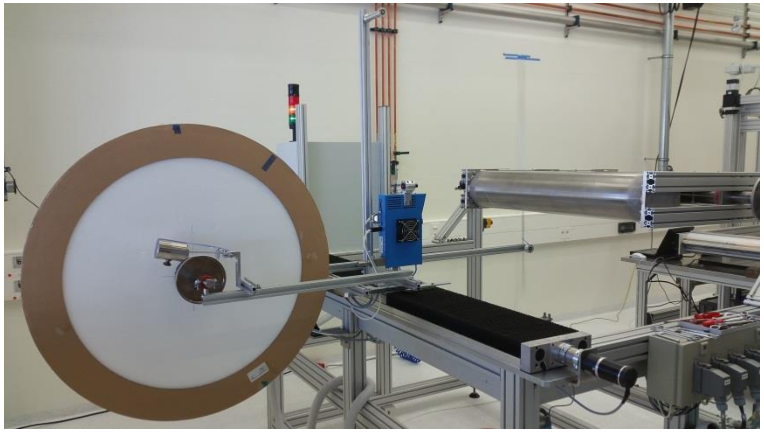


Infrastructure @ GSI - DL

- winding machine from same company as LHCb ones, however not same type and for different application

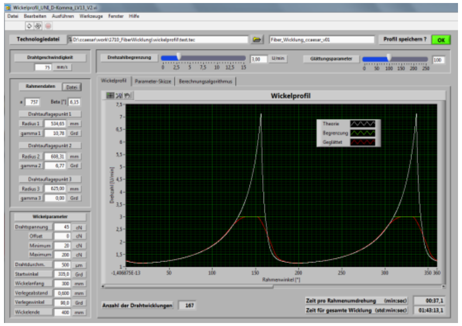
Standard usage at DL:

1. wires with small diamter < 100µm
2. but large steps ~mm
3. comb is used to fix position



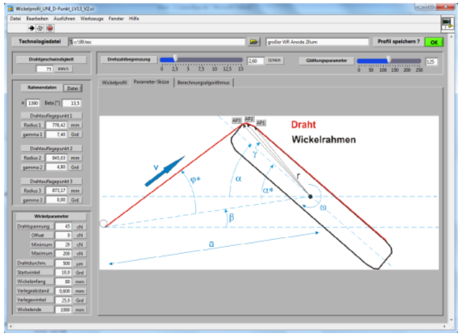
- winding to a frame instead of a wheel is a challenge
  - angular velocity has to be tuned
  - tension does not fix fiber to surface completely

  only fixed at ‚2‘ points



At the moment a fully automatic winding is unfortunately not pssible (not at all? see next slide)

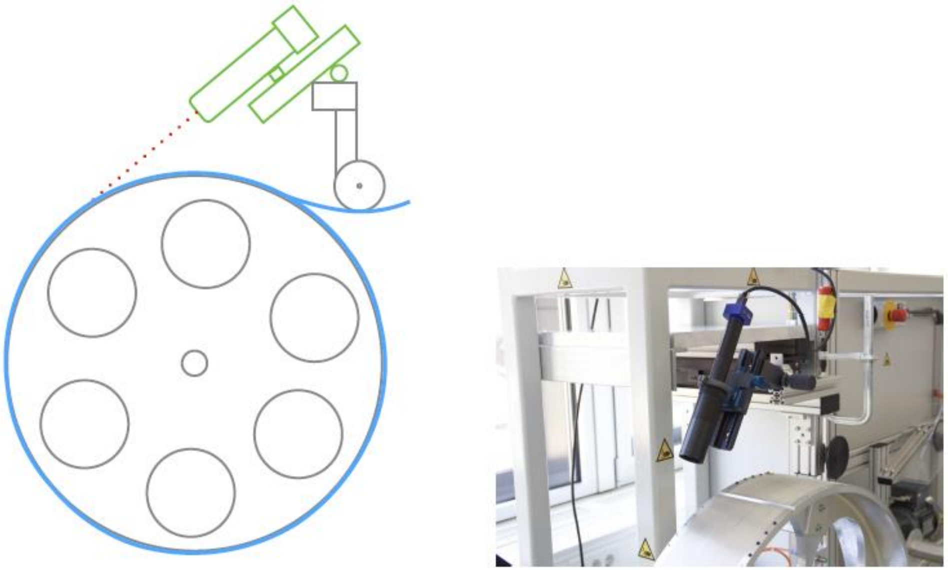
But we are in contact with STC-Elektronik GmbH to improve the ‚machine‘



- Fiber Tracker (side remark)

(a) (b)

Figure 3.38: Two different defects which can occur during the winding process. In (a) the current fibre jumped in the wrong threat and leave an empty space. (b) shows a fibre lying in the wrong layer.

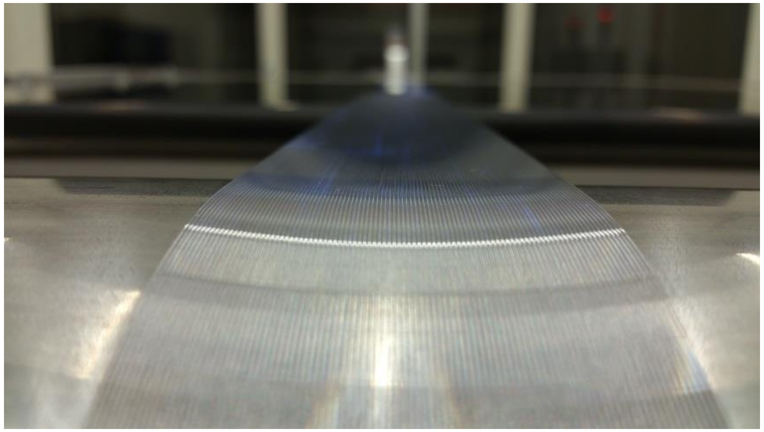


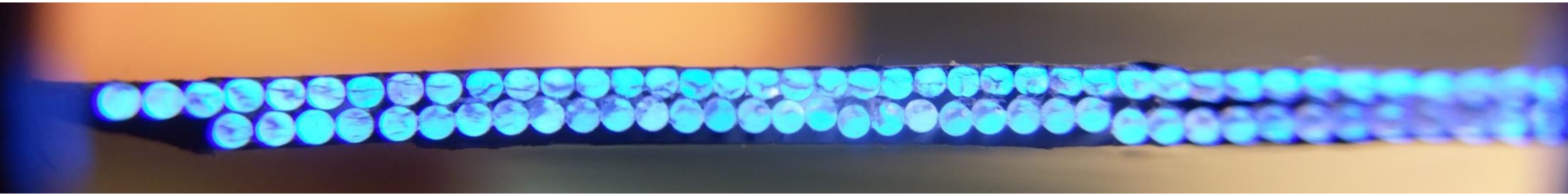
(a) (b)

Figure 3.39: Left: Scheme of the camera setup on the winding maschine. The camera (green) will be placed on the same slide as the positioning spool and look tangential on the wheel. Right: Camera setup mounted on the winding machine.

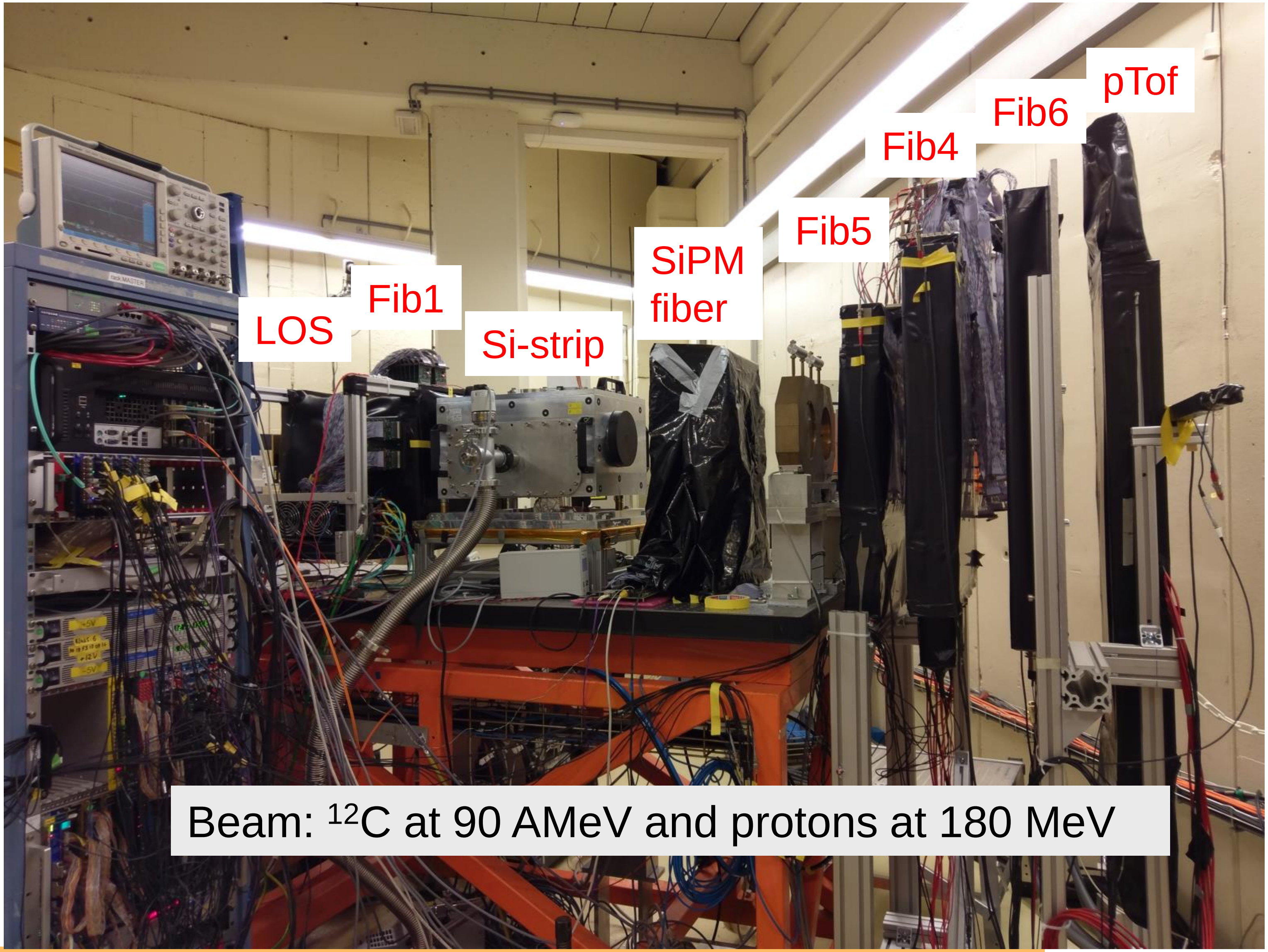
test with 2 layers on frame

- placing fibers by hand seems in general feasible (costs a lot of time)
- gluing procedure not fully fixed yet
- fibers seem to be not well aligned in mat, although they are on the ‚roll'.





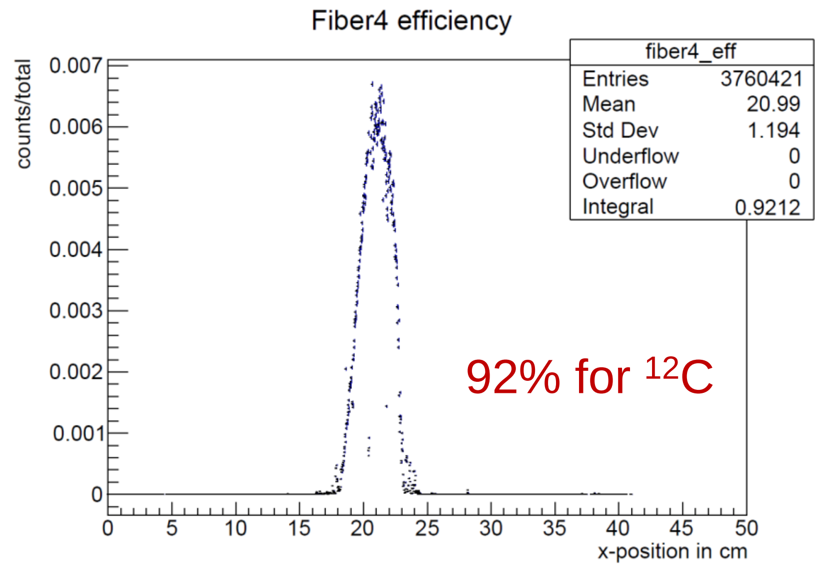
Test Beam @ KVI

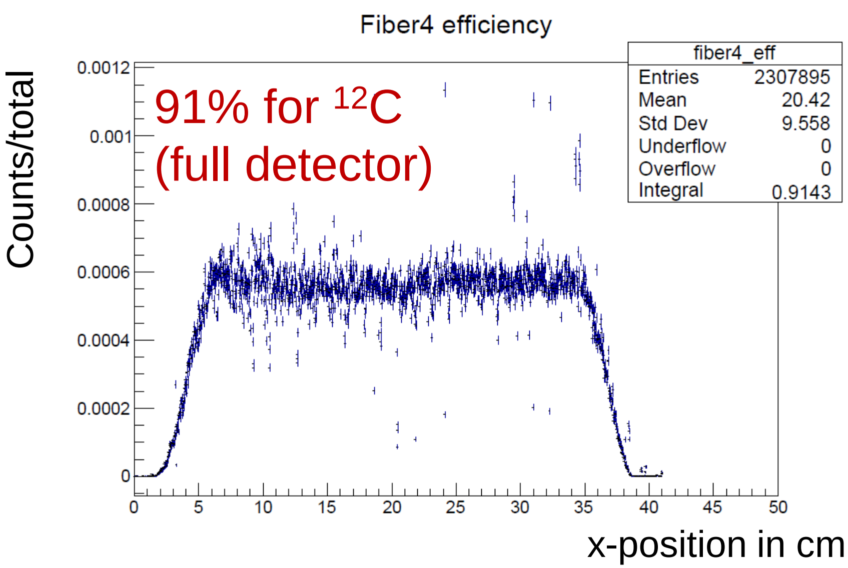


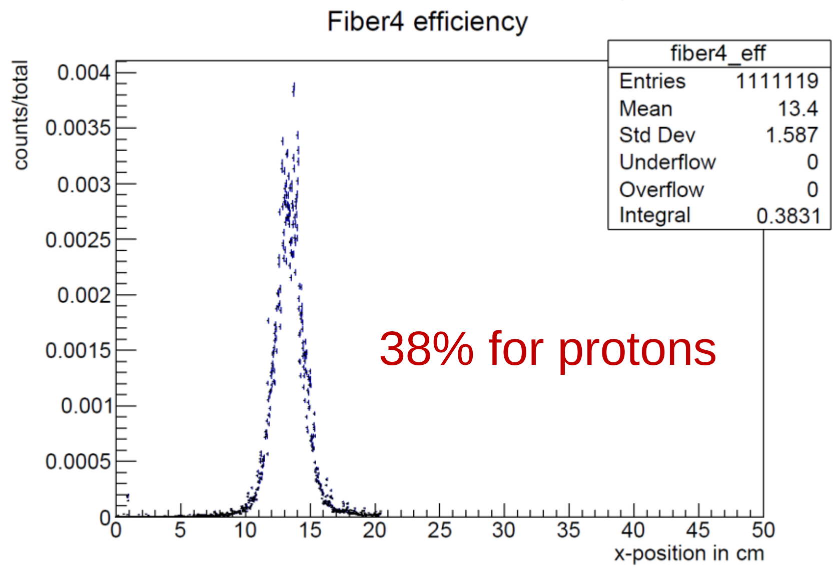
Beam: ^{12}C at 90 AMeV and protons at 180 MeV

Fiber4 efficiency

- Fiber efficiency is 92 % for ^{12}C beam and 38 % for protons





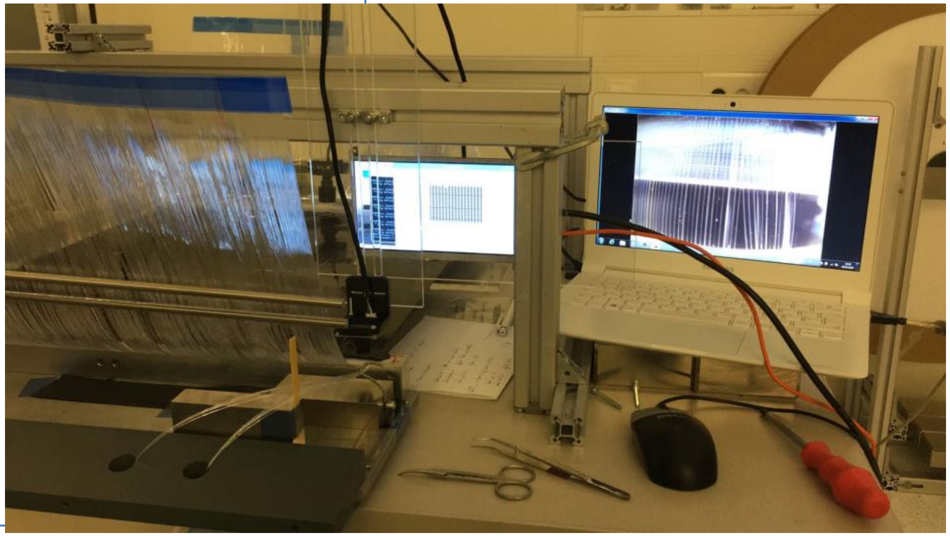


Summary & Outlook

DONE
proof of principle:
single layer planar detectors can be produced ‚fast'
200mu/500mu; square/round up to 50x50 cm2

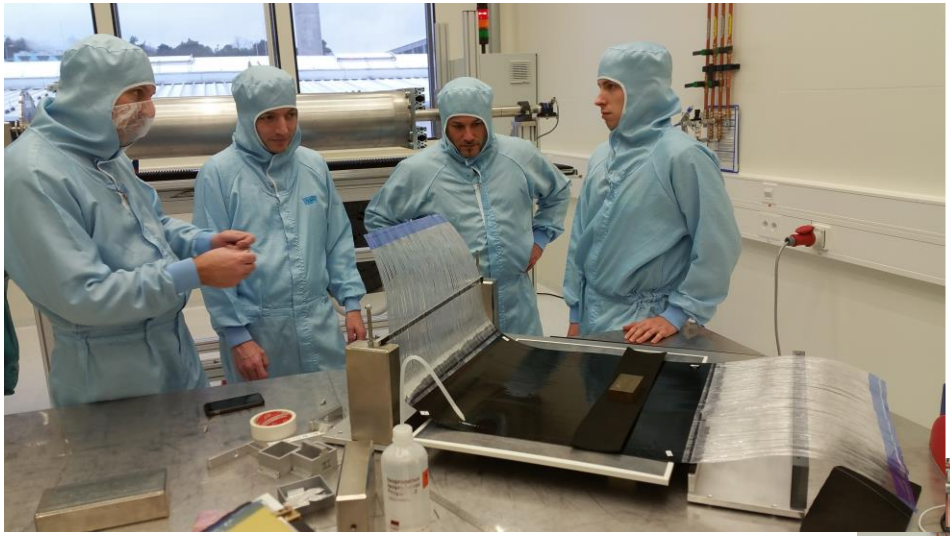
ToDo

- real QA
- optimize infrastructure
- more advanced productions
  - multi layer
  - other shapes
- optimitze readout
  - SiPMs
  - dedicated PCB
- investigate rad. hardness
- investigate outgasing



Working - Group

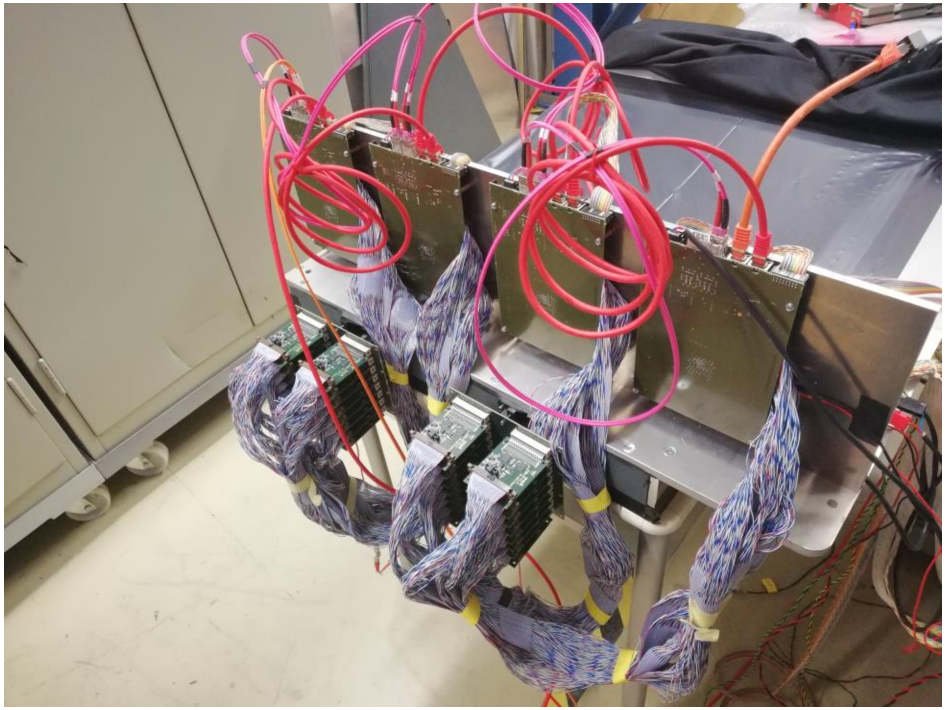
DL: Jörg Hehner, Christoph Caesar
R3B: Deniz Savran, Michael Heil, Daniel Körper, Bastian Löher

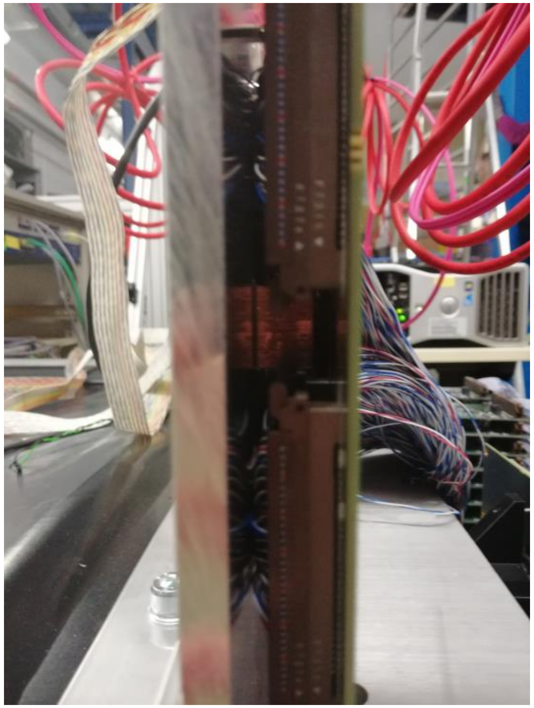



THE END

Tests in vacuum

- PADI boards tested in vacuum without cooling.
- Clock TDC gets too hot without cooling.
- FPGA is hottest part on PCB. Passive cooling with copper block pressed against Alu board is sufficient.
- Full system has been tested!

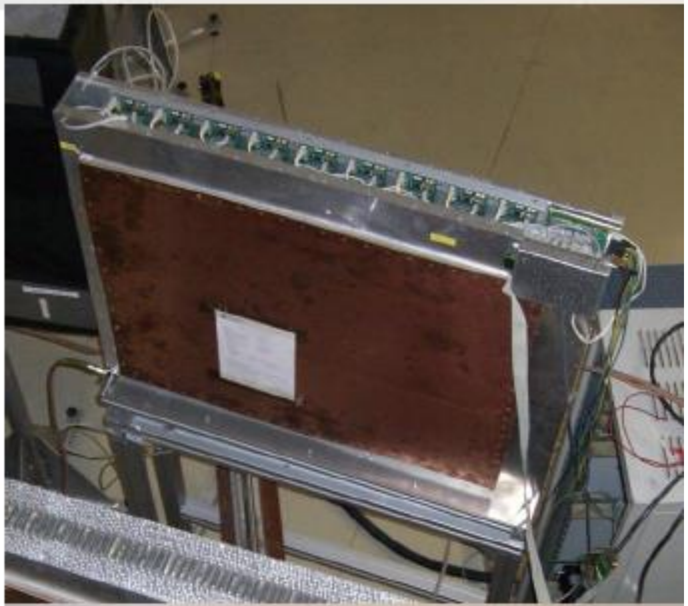




detector outgassing is mainly due to the glue that fixes the fibers

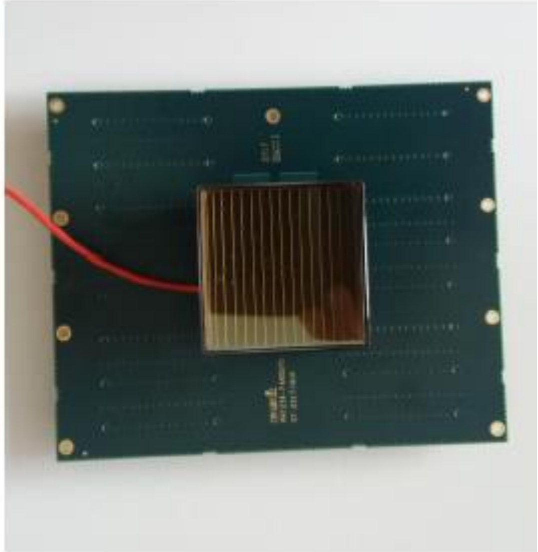
PDCs and clock TDC electronics

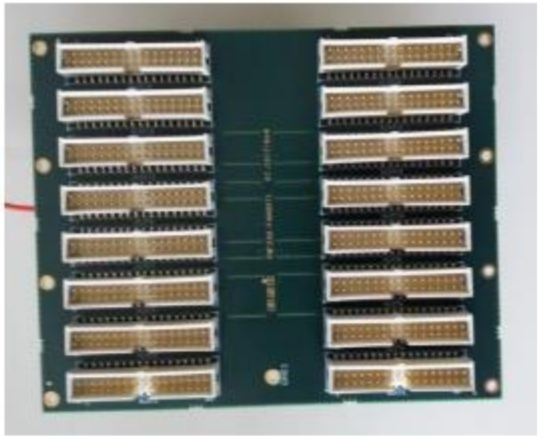
- A new read-out based on PADI and clock-TDC has been designed by the GSI electronics department (Nikolaus Kurz, Henning Heggen, Shizu Minami).
- The PADI is suited for small signal amplitudes of the PDCs (> 3 mV) .
- The clock frequency is 250 MHz with 8 phases (later maybe 16 phases).
- First tests show that times and ToTs can be measured with an RMS of 200-320 ps.



Usage of clock TDC for fiber detectors

- With the help of a converter board, the PDC read-out can also be used for MA-PMTs and MMPCs.
- For the current read-out the costs are about 15 € per channel.
- The costs could be reduced for a dedicated fiber read-out board approaching 5 € per channel (one single board with no connectors between PADI and clock-TDC).
- But then all electronics will be in vacuum and we need cooling in vacuum (has to be tested). For access to the electronics the vacuum has to be broken which could results in long beam-time breaks.
- PADI could possibly work in vacuum without cooling (has to be tested) but then one needs many feedthroughs for the LVDS signals.

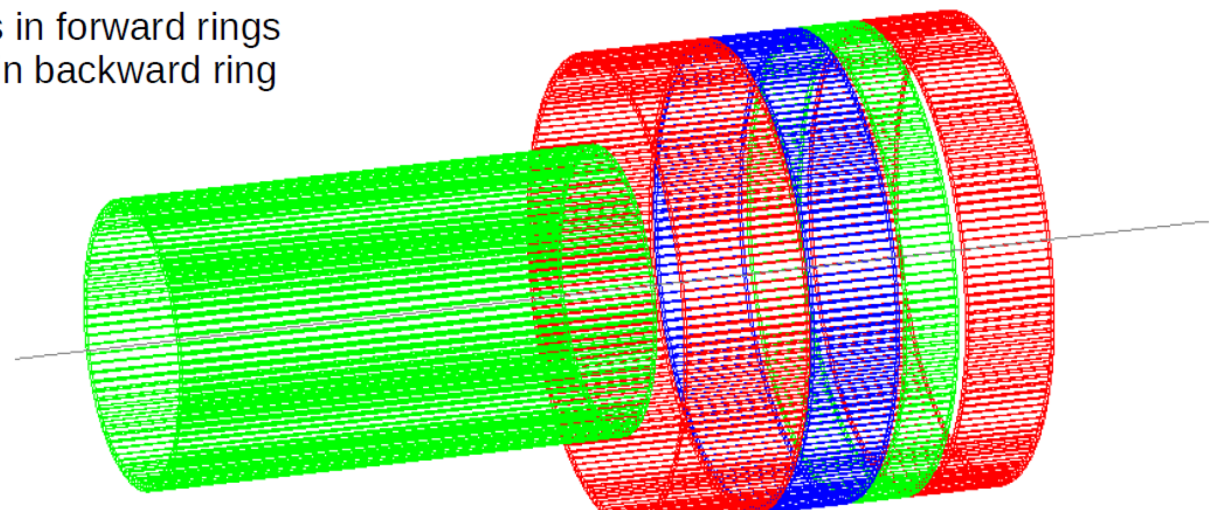




KRAkow Barrel (KRAB)

Trigger/Reaction Plane detector around the target:

- 5 rings of 4x4 mm^2 fast scintillating fibers (e.g. BCF-20) read out by SiPMs
- covers angles from 30° to 165°,
- segmentation assures more or less uniform count rates for Au+Au at 1 AGeV,
- geometrical efficiency ~95%
- ~10% of charged particles involved in multihits,
- ~5% multihit probability
- sufficiently large for radioactive beams
- sufficiently small and lightweight not to disturb neutrons
- min radius - 6 cm,
- max radius - 12 cm
- length 43 cm
- 180 segments in forward rings
- 90 segments in backward ring
- 810 channels

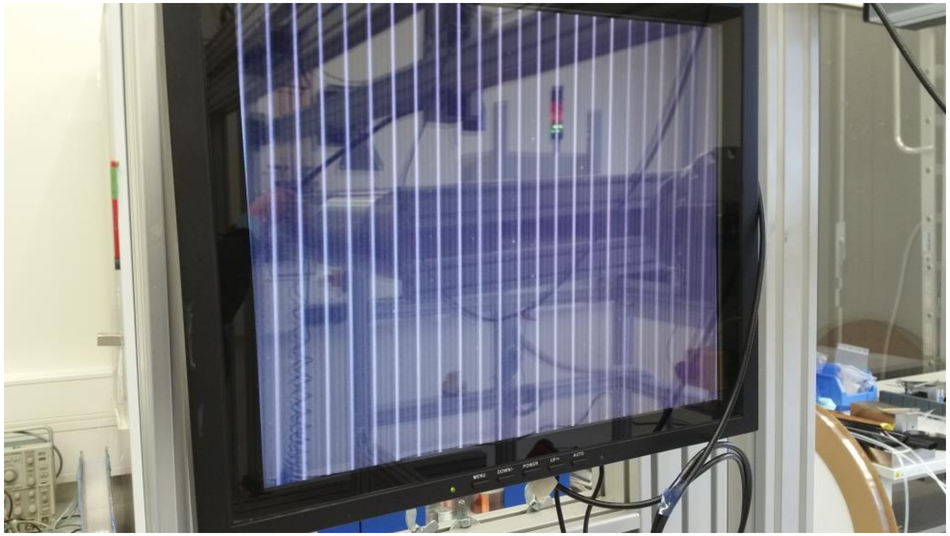


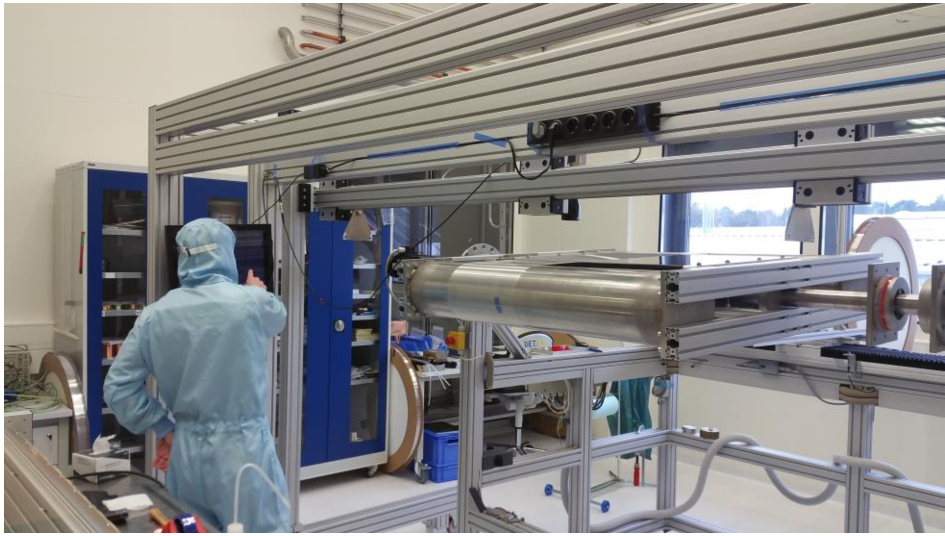
NUSYM17, GANIL
Caen, 4-7.09.2017

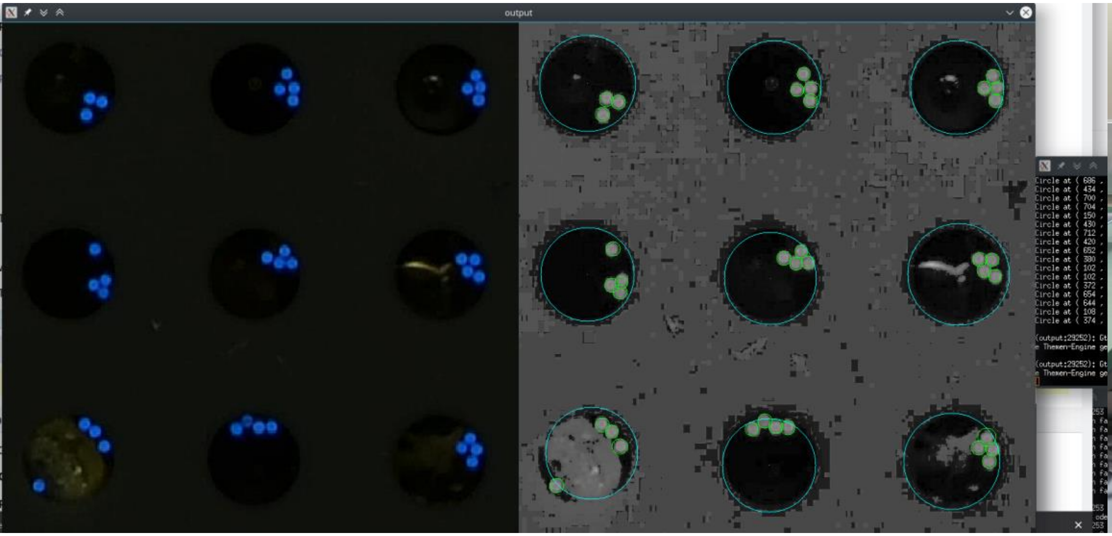
Work supported by Polish Ministry of Science and Higher Education, grant No. DPN/N108/GSI/2009 and by Polish National Science Center, contract Nos. UMO-2013/10/M/ST2/00624, UMO-2013/09/B/ST2/04064

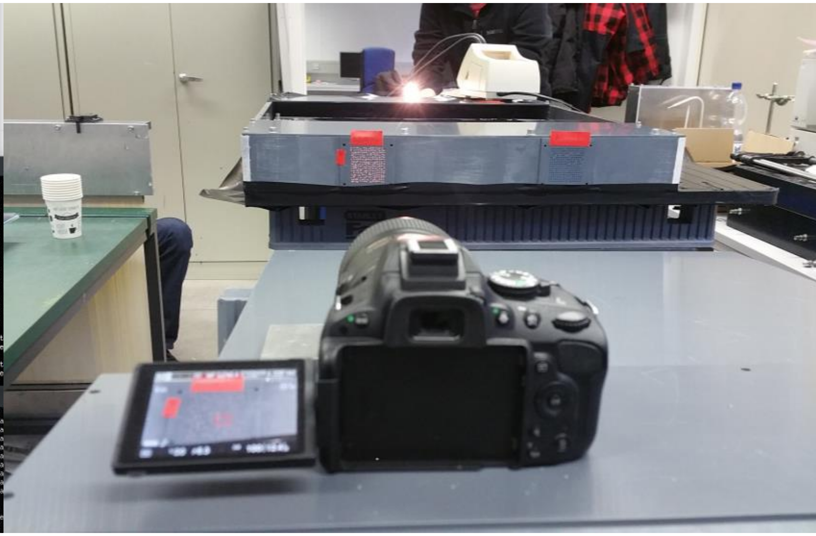
Jerzy Łukasik
IFJ PAN Kraków, Poland

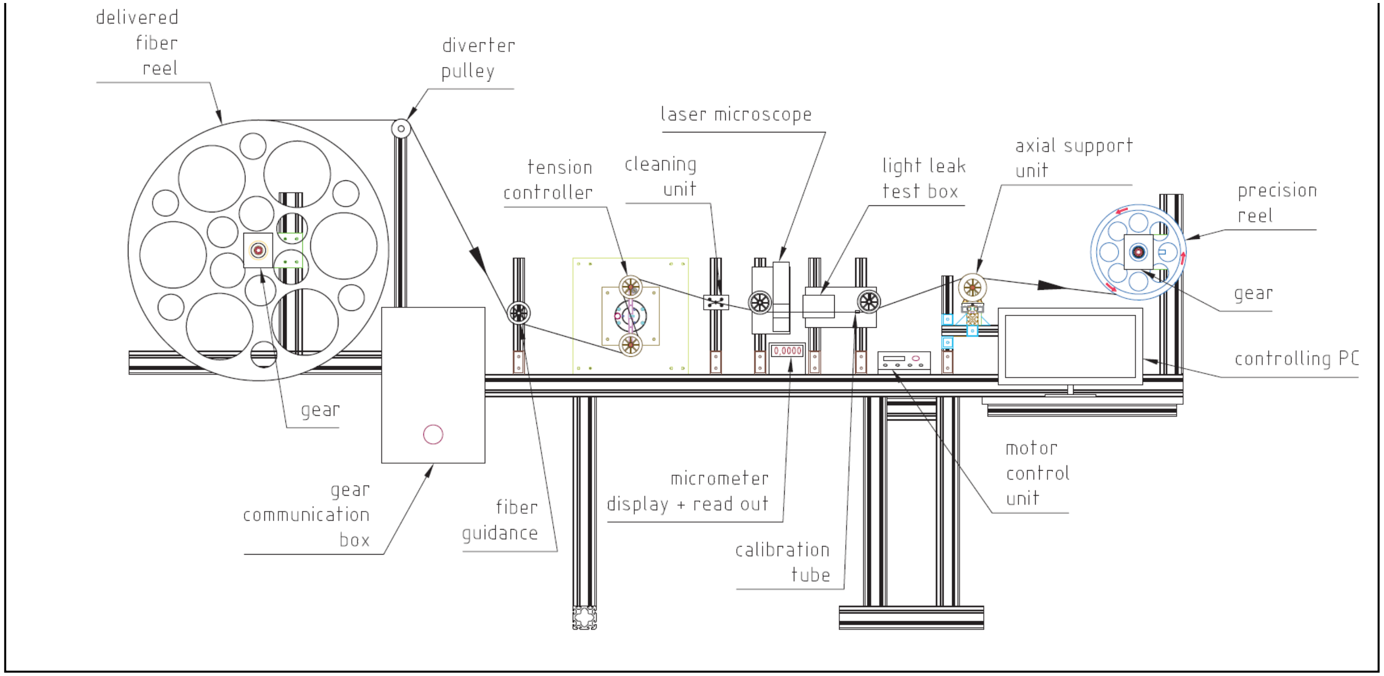
QA ...











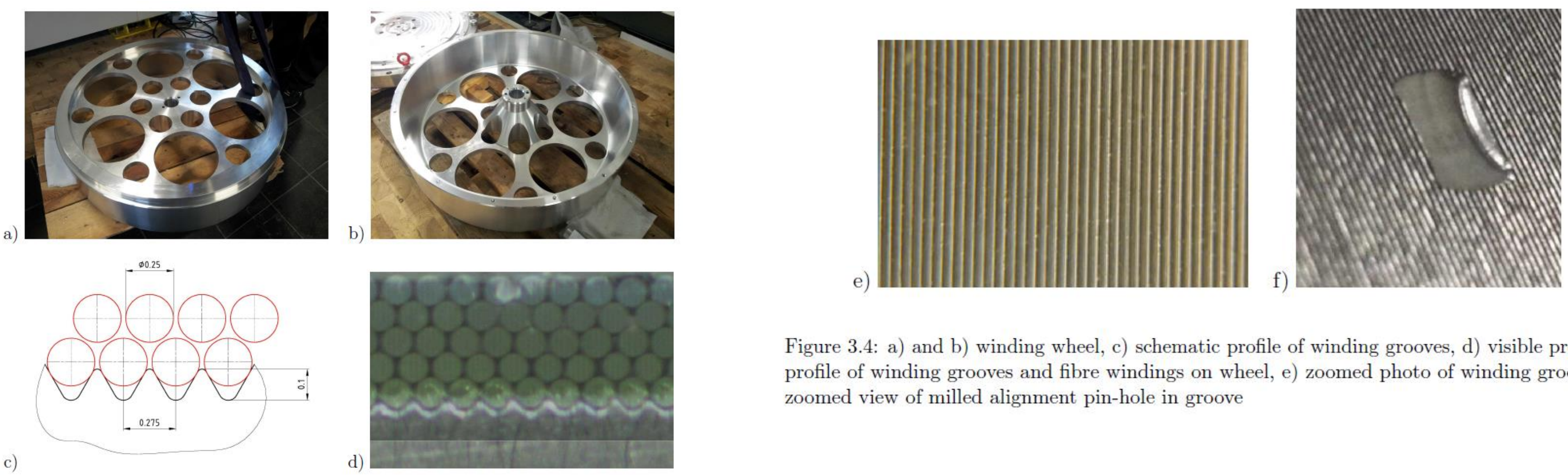
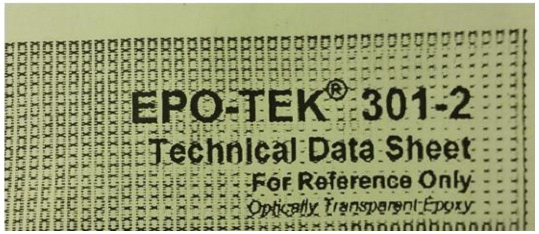
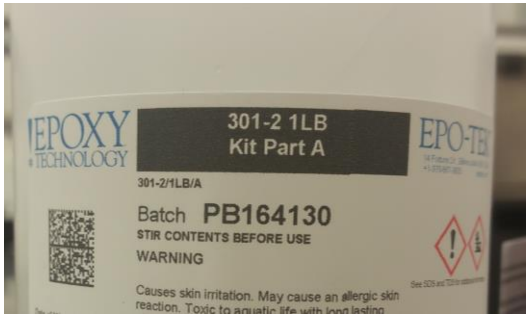
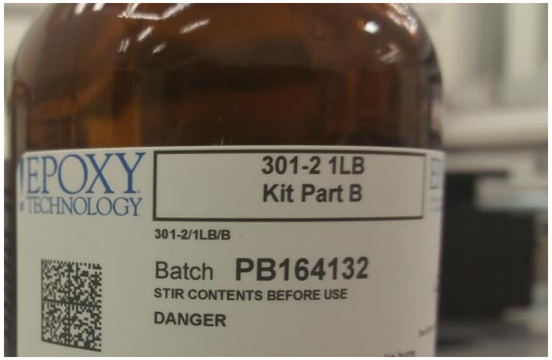


Figure 3.4: a) and b) winding wheel, c) schematic profile of winding grooves, d) visible produced profile of winding grooves and fibre windings on wheel, e) zoomed photo of winding grooves, f) zoomed view of milled alignment pin-hole in groove

The used glue is a two component epoxy glue (Epotek Epoxy 301-2). So in this step the resin and hardener of the epoxy plus titanium dioxide (20% by weight) are needed. This glue is non outgassing and has a potting time of 8 h. For measuring the right amount of each component scales and syringes are used. To guarantee a smooth mixing of the three components a special mixing machine under vacuum is assumed. Afterwards, the mixer has to be cleaned with isopropanol.





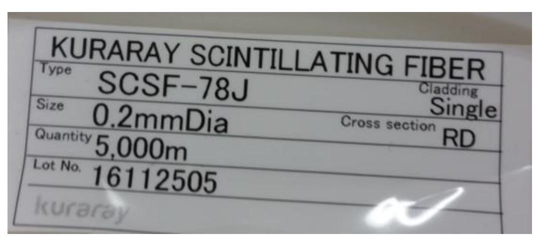


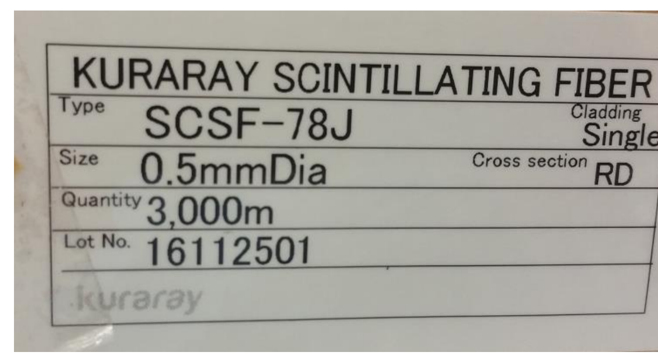
Titanium only as EMA!?

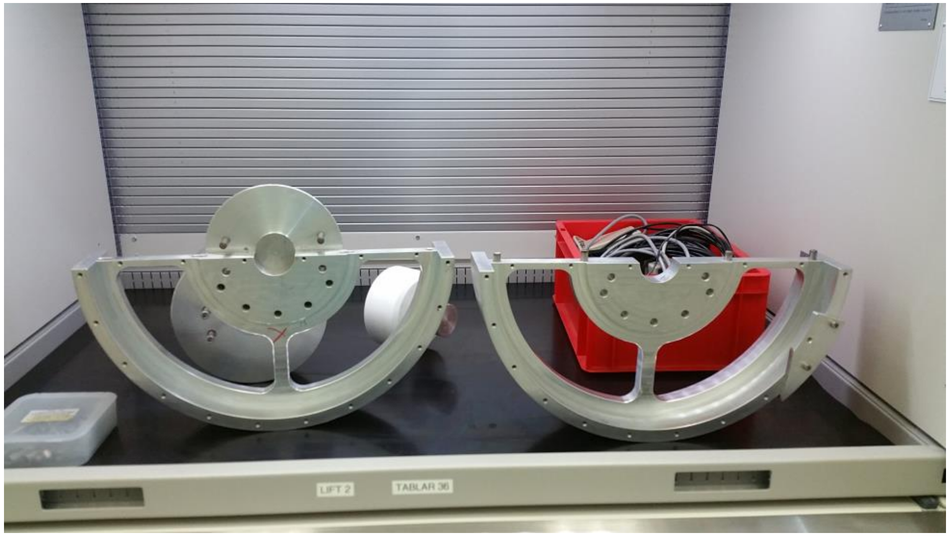
EMA (Extra Mural Absorber) – White or black coatings may be applied to the outer fiber surface primarily to eliminate crosstalk among closely packed fibers. Our coatings are typically 10 to 15 microns thick.An EMA coating decreases the overall signal intensity obtained from a fiber, irrespective of its length. This effect is greatest with black EMA, as well as with short fibers. The coating can interfere with useful light-piping in the cladding. Black EMA applied at the near end of fibers can be used to flatten out position dependent response. White EMA is used in the construction of short fiber imaging bundles.

10mu Pokalon Folie Polycarbonat (PC) mit Leit-Russ Füllung von Lofo:

Das Material Pokalon, das in der Vergangenheit durch die Firma Lofo High Tech Films GmbH angeboten wurde, ist zukünftig über die Dr. Dietrich Müller GmbH zu beziehen.



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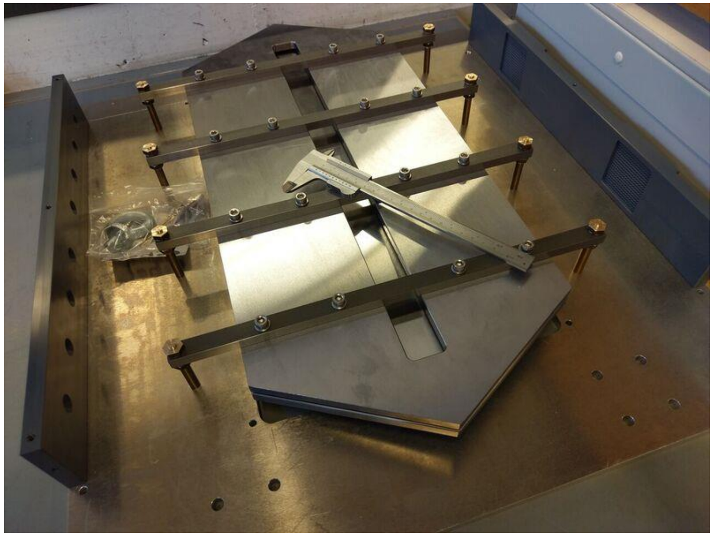

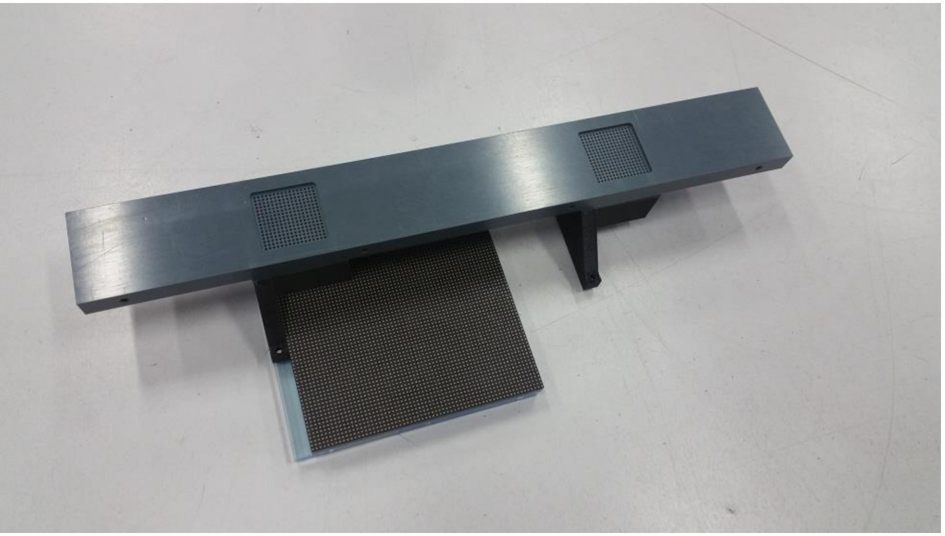

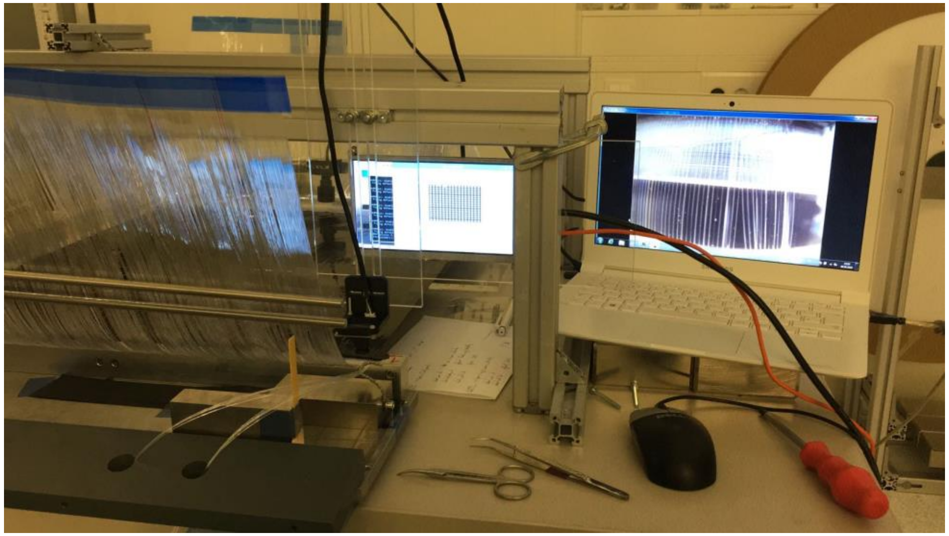

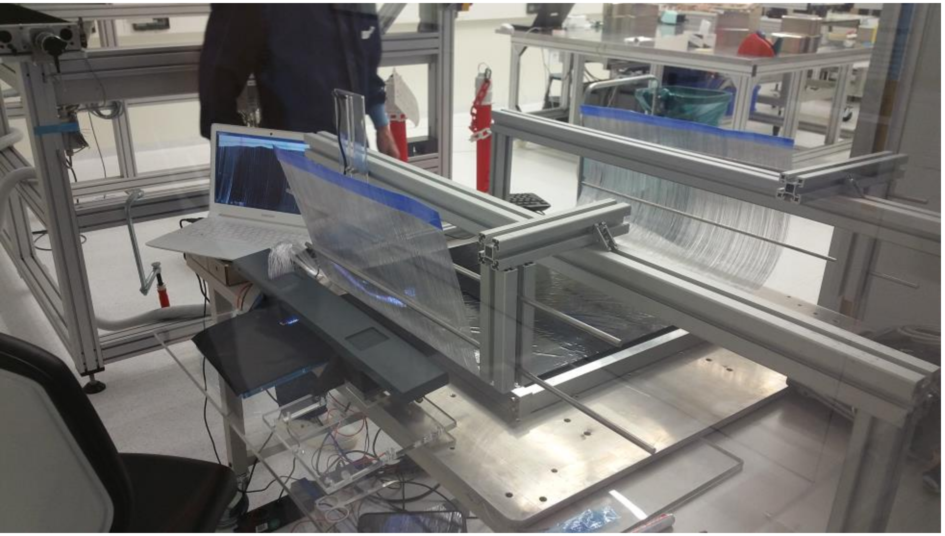

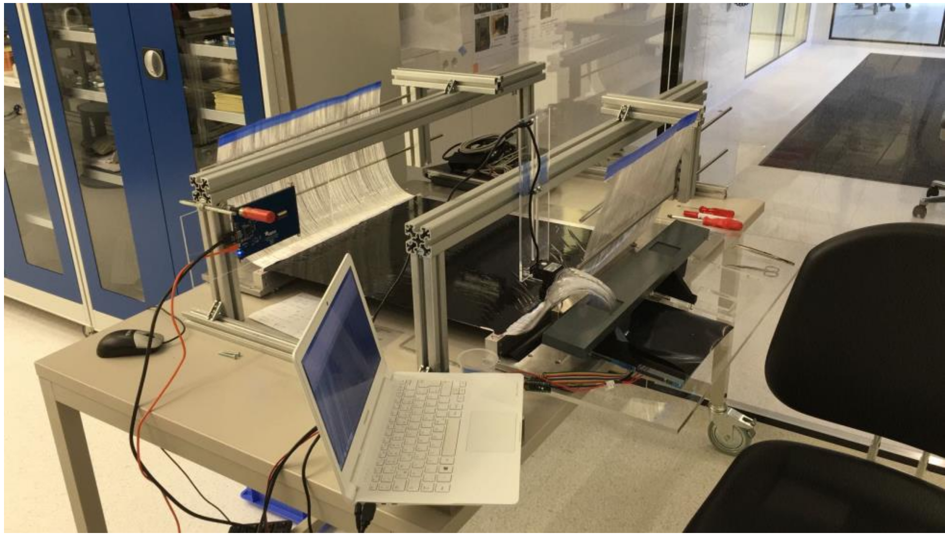

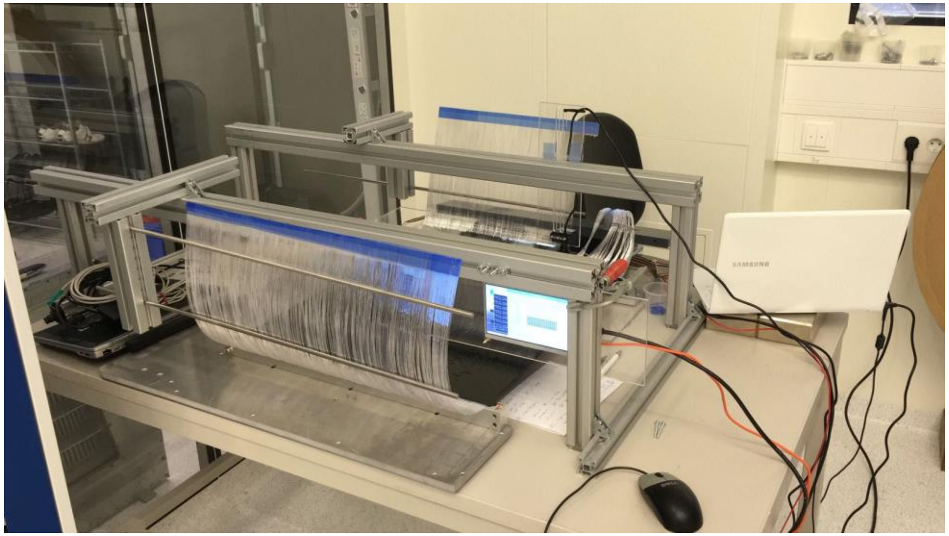

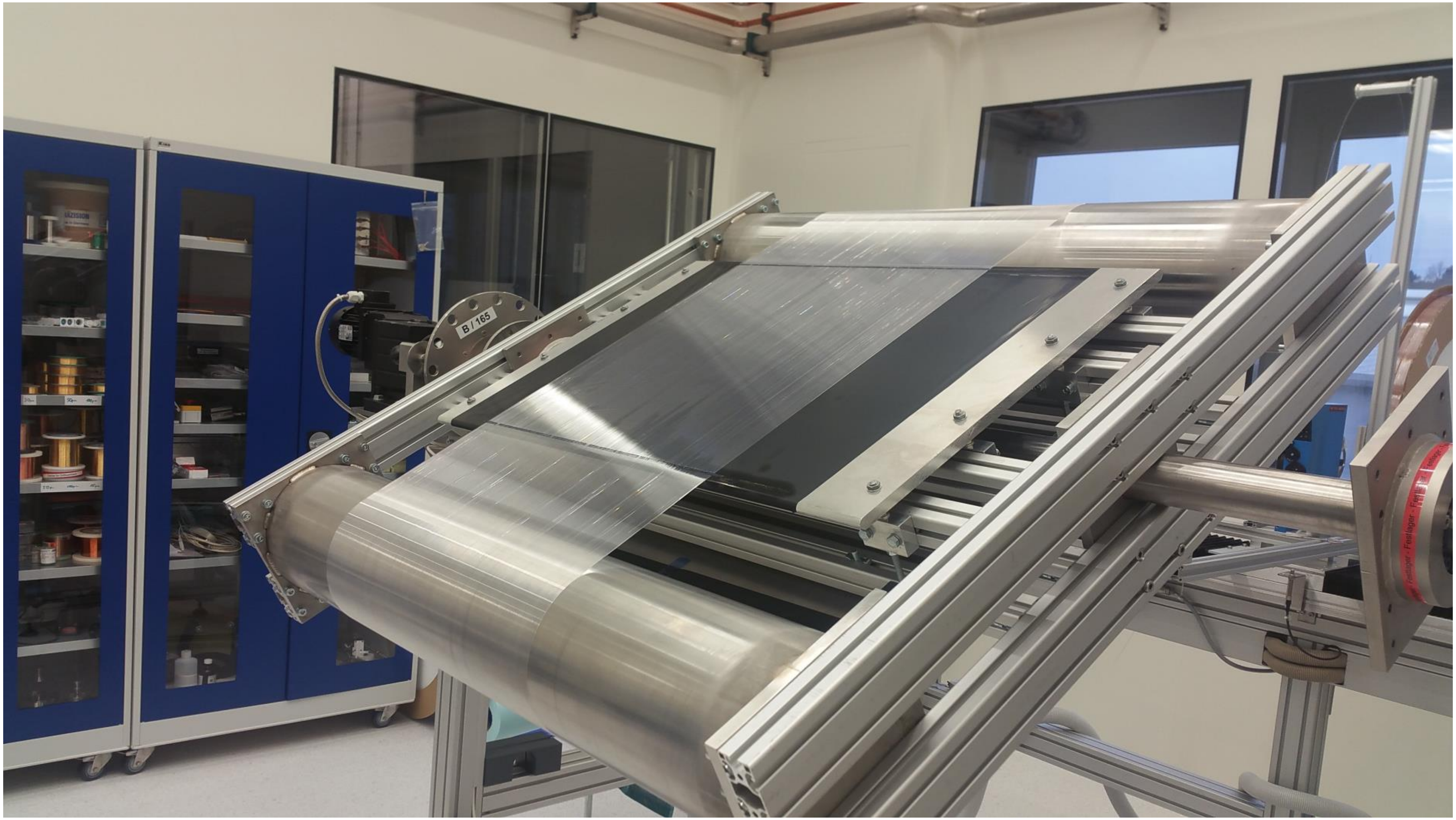
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