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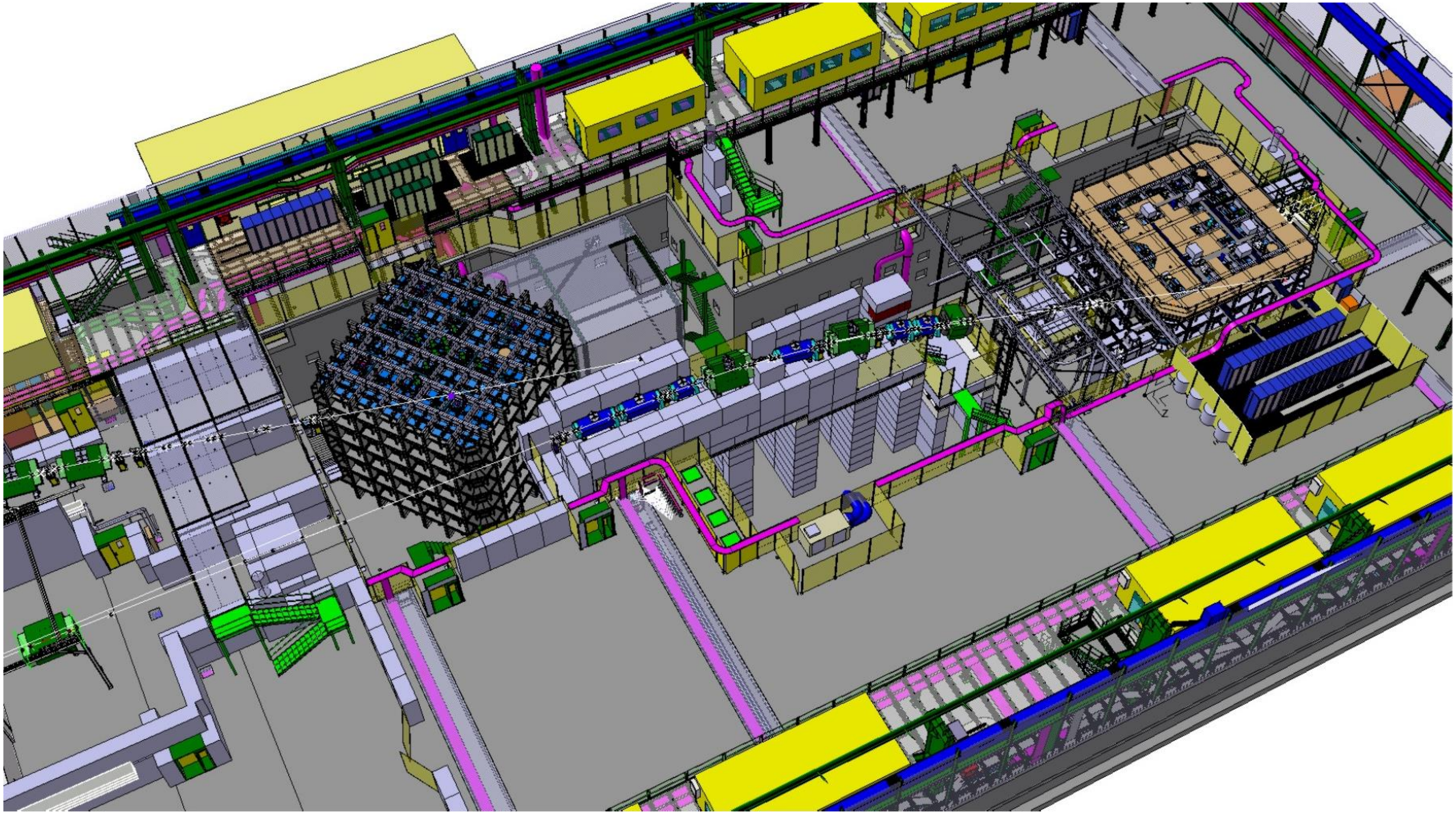
Update on the progress of the beam instrumentation for the CERN Neutrino Platform

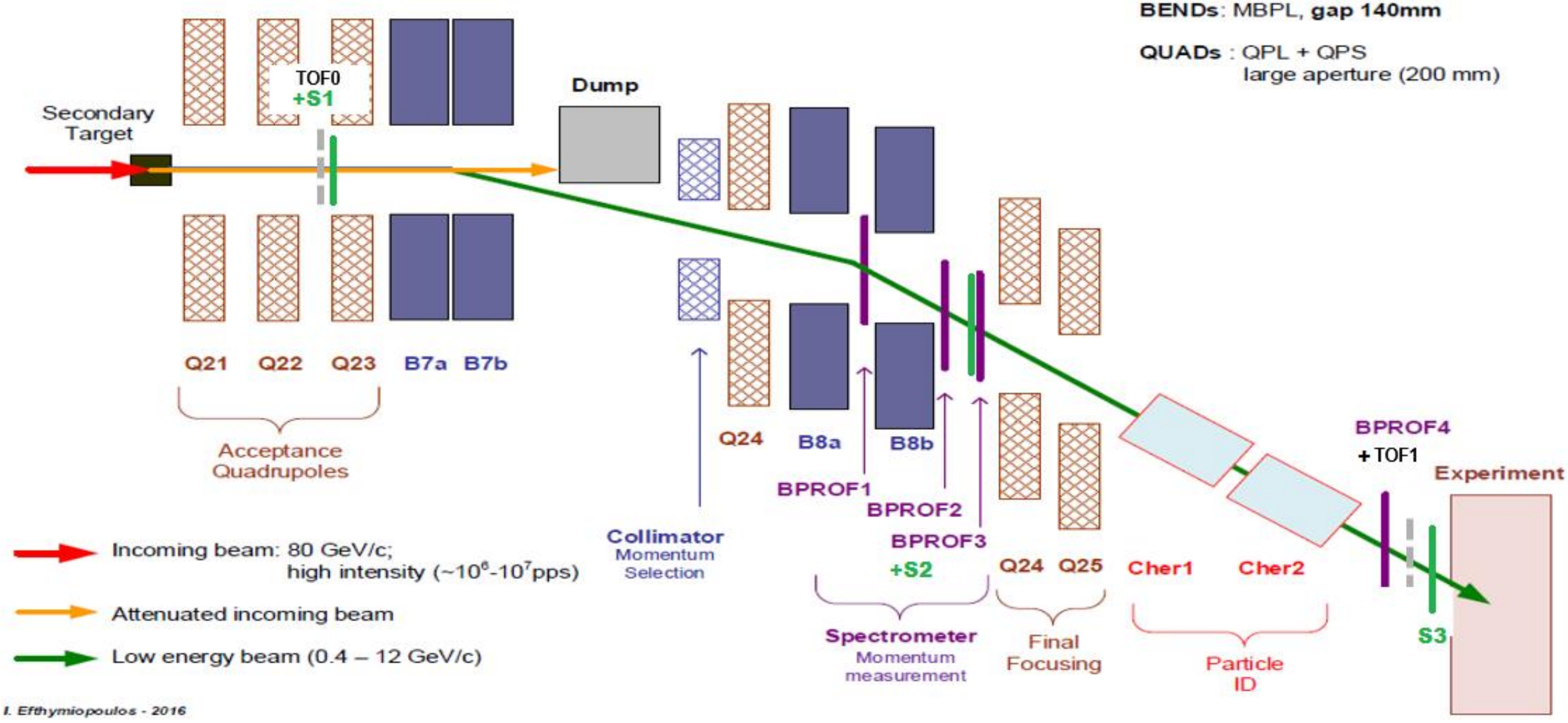
Inaki Ortega on behalf of CERN BE–BI–EA, Thomas Schneider, Jonathan Franchi, Jiri Kral, Manoel Barros and Andrea Boccardi

Summary



- Secondary beams of hadrons (p±, π±, K±) and leptons (e±, μ±) of very low energies (0.5 to 12 GeV) and intensities (10^3 particles/spill maximum).
- Individual particle detection required: profile, intensity, spectrometry, ToF.
- Large area detectors: 20 cm x 20 cm.
- First prototype ready for September 2017. Beam tests foreseen in the East Area in October/November. A total of 26 detectors ready for mid-2018.

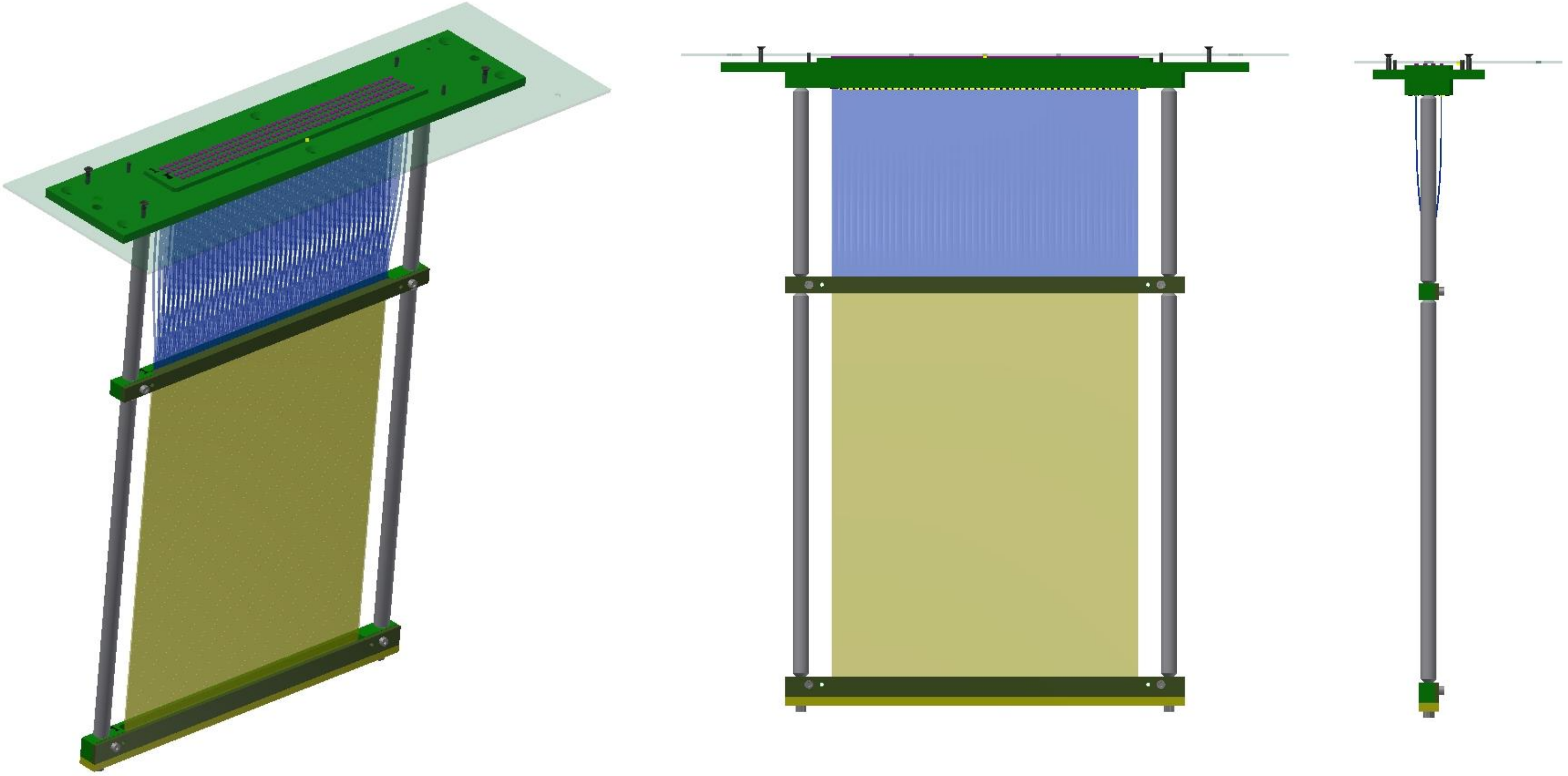
EHN1 Extension - H2 VLE Beam
Schematic Layout



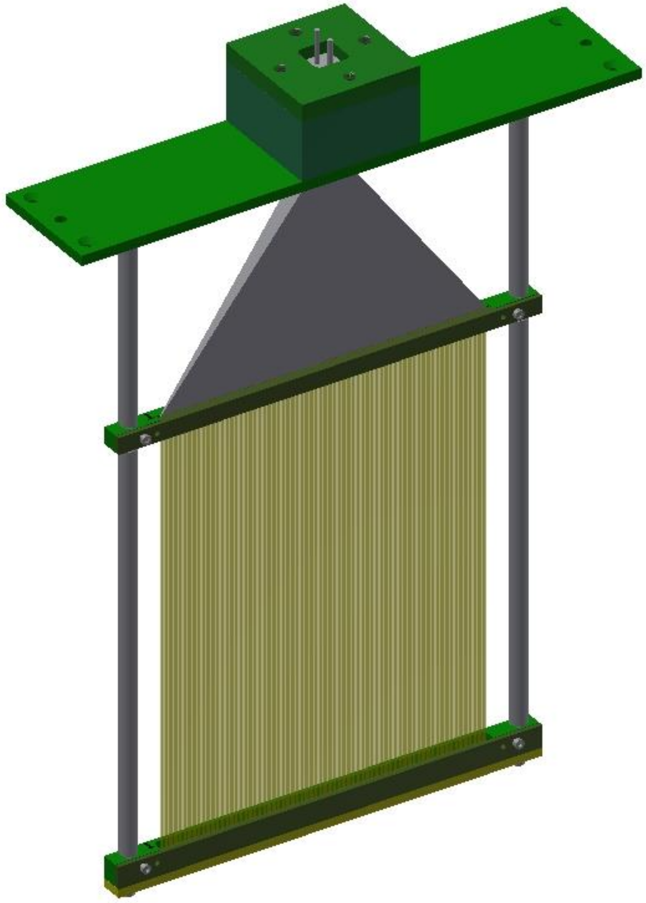
The layout for H4 is slightly different but involves an equal number of detectors.

Proposed instrumentation:

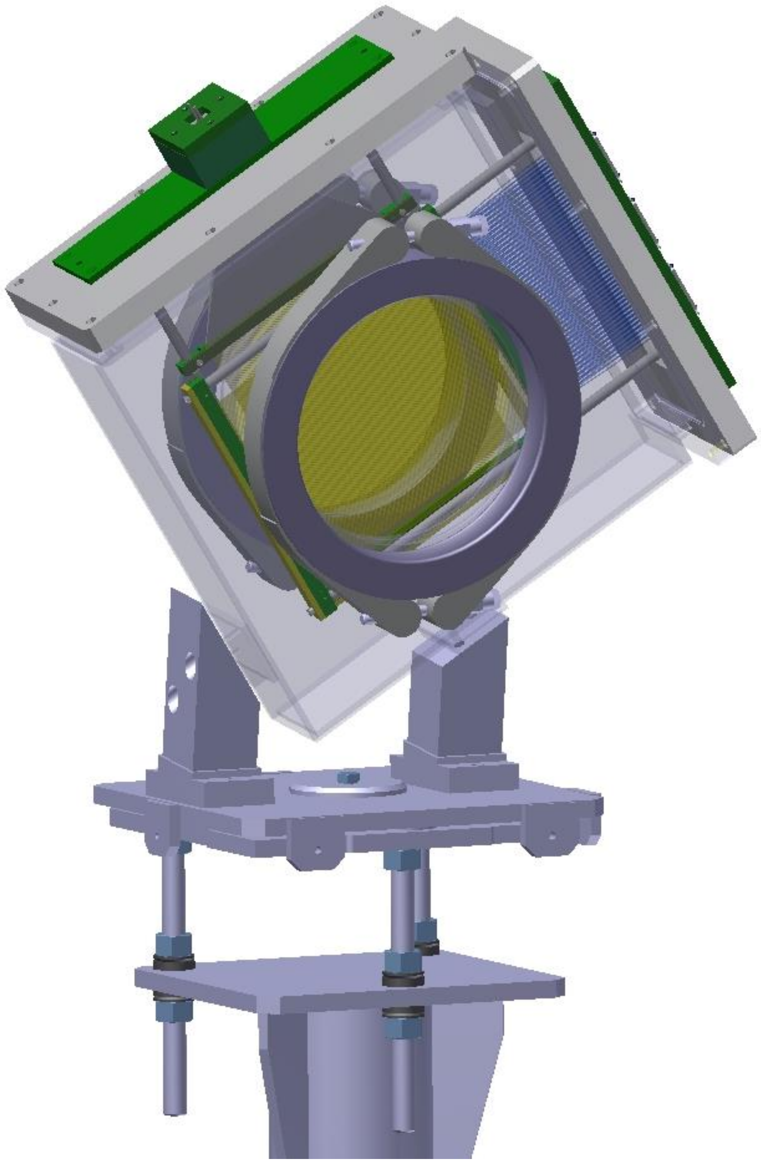
- scintillating fibres read out by silicon photomultipliers (XBPF)
- Scintillating fibres read out by photomultiplier tubes (XSCINT)



XBPF

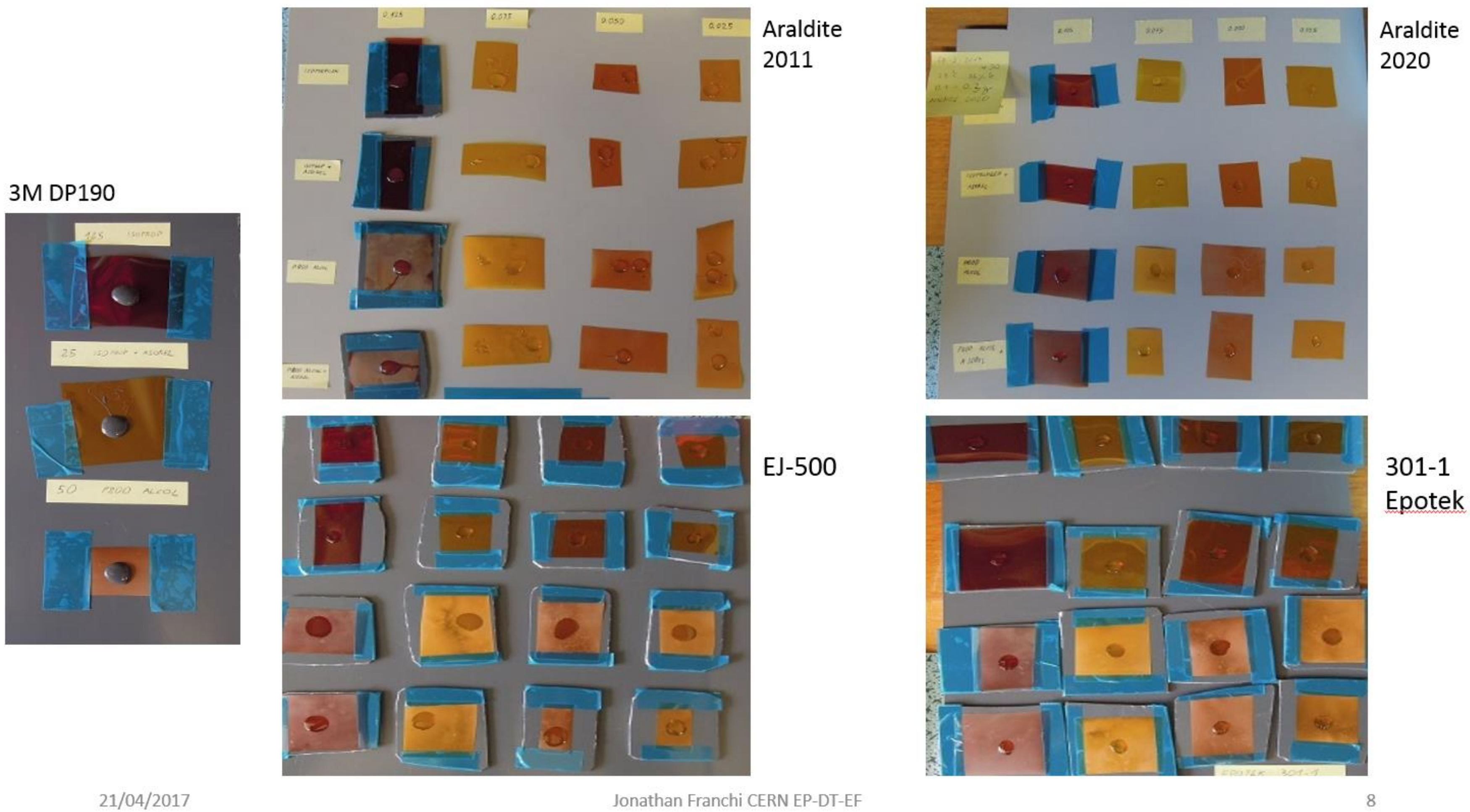


XSCINT



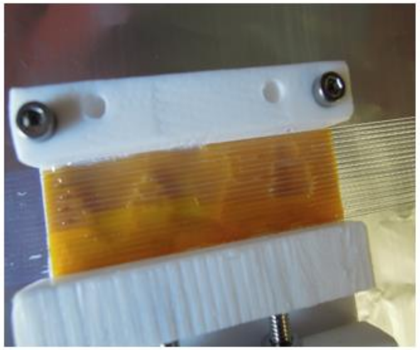
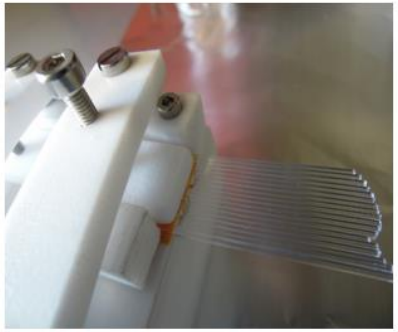
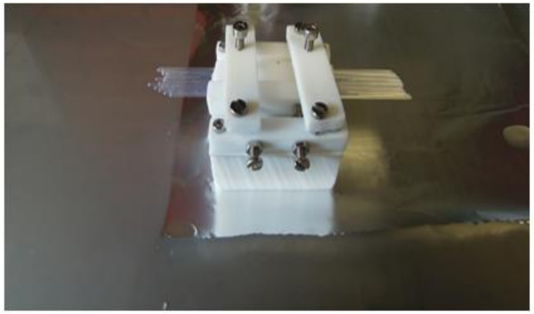
Mechanics

New technical fellow (Jonathan Franchi), under supervision of Thomas Schneider (EP-DT), has done an investigation on glues and thin foils to assemble the fibres

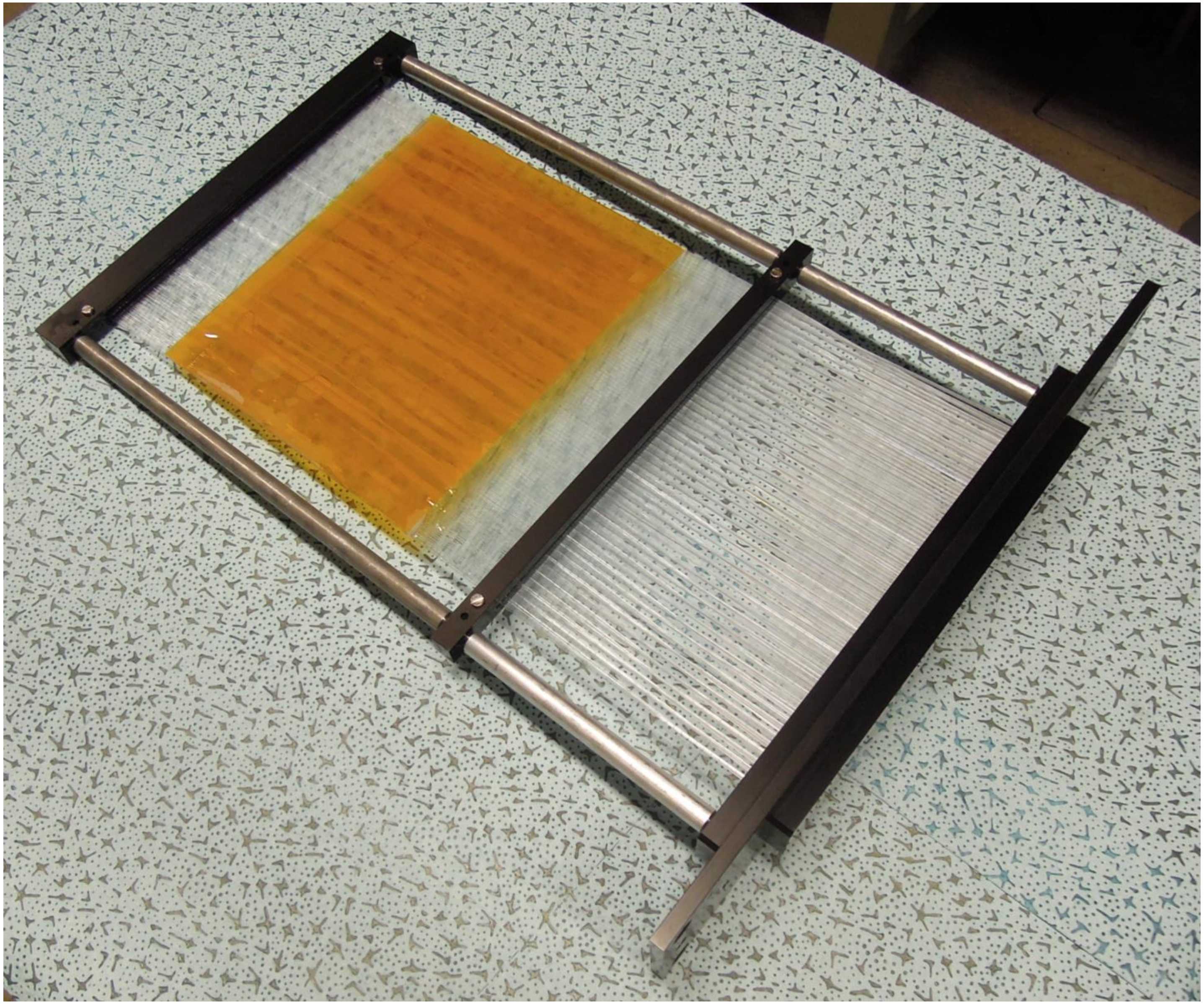


EJ-500 epoxy resin with 25µm kapton foil is the best combination

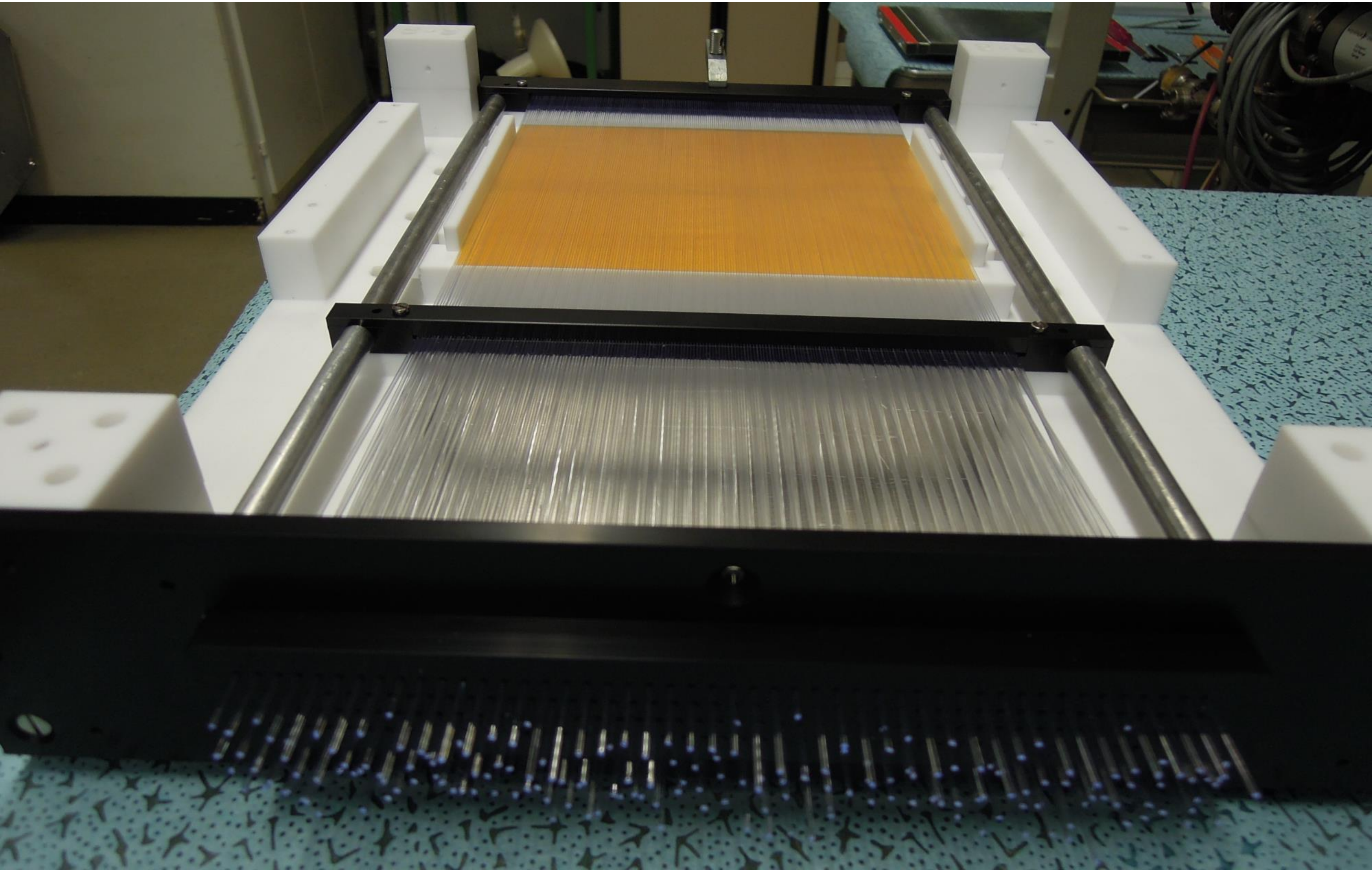
From a small prototype

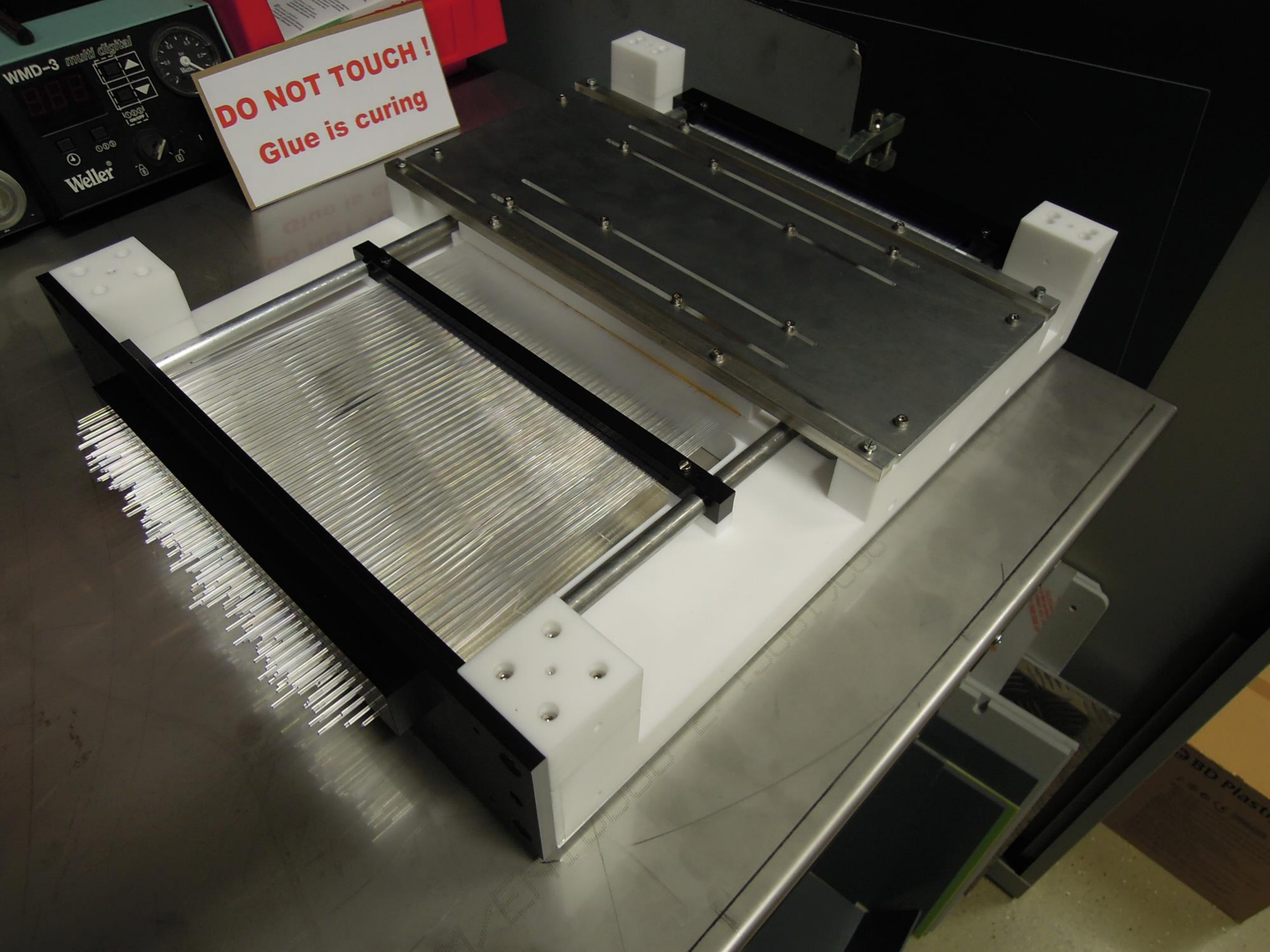





To the real size detector

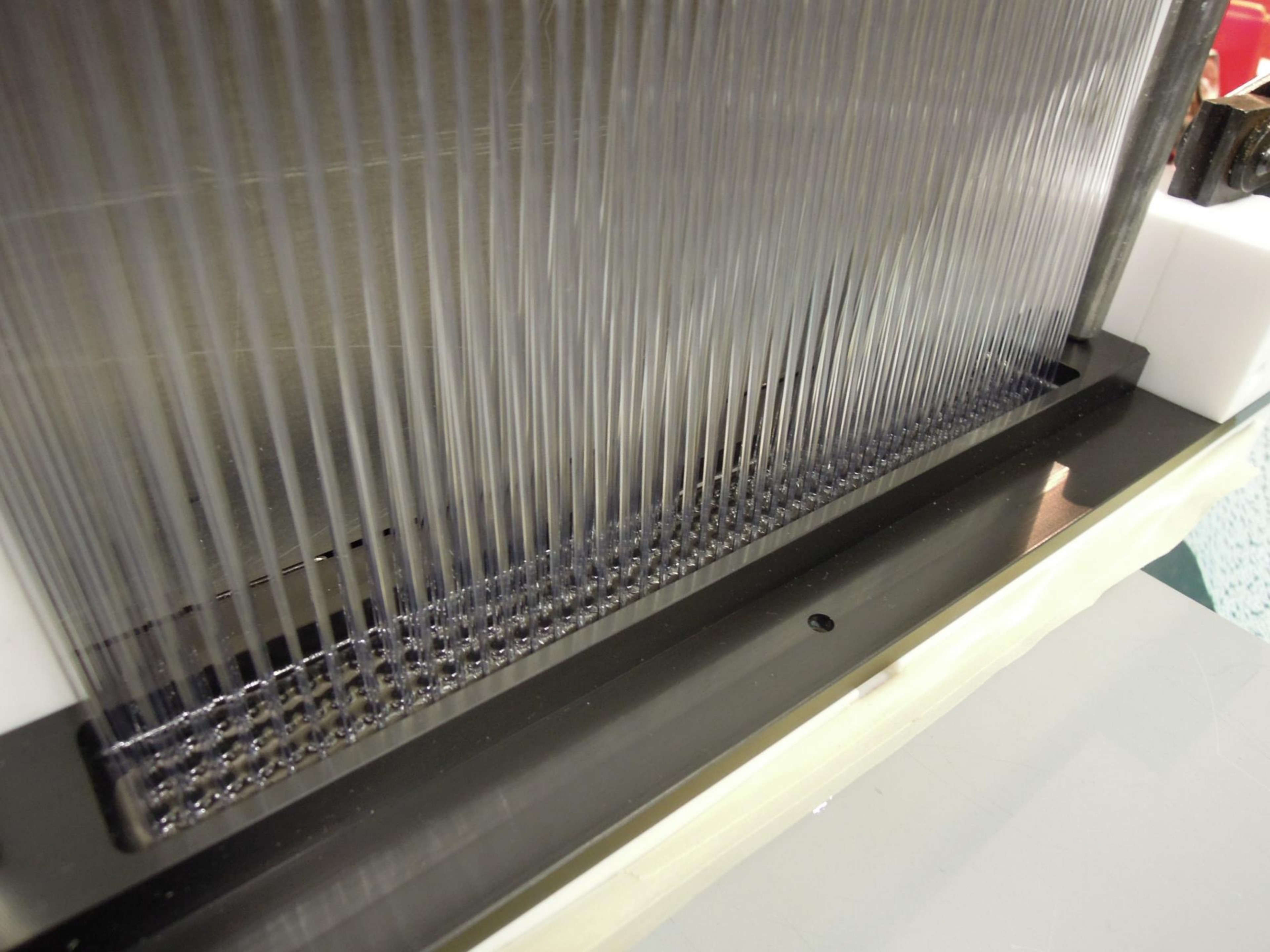


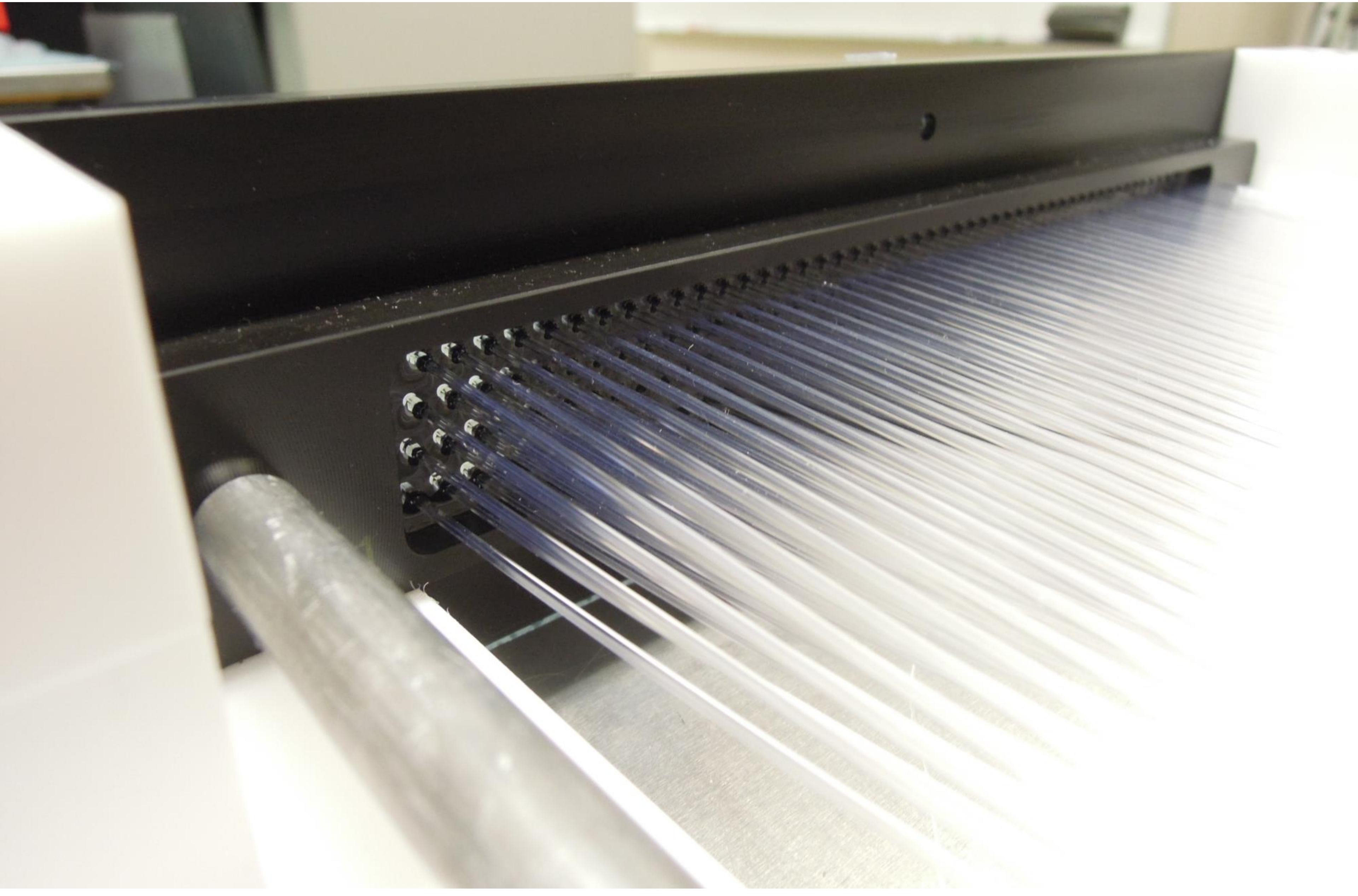
Assembly process

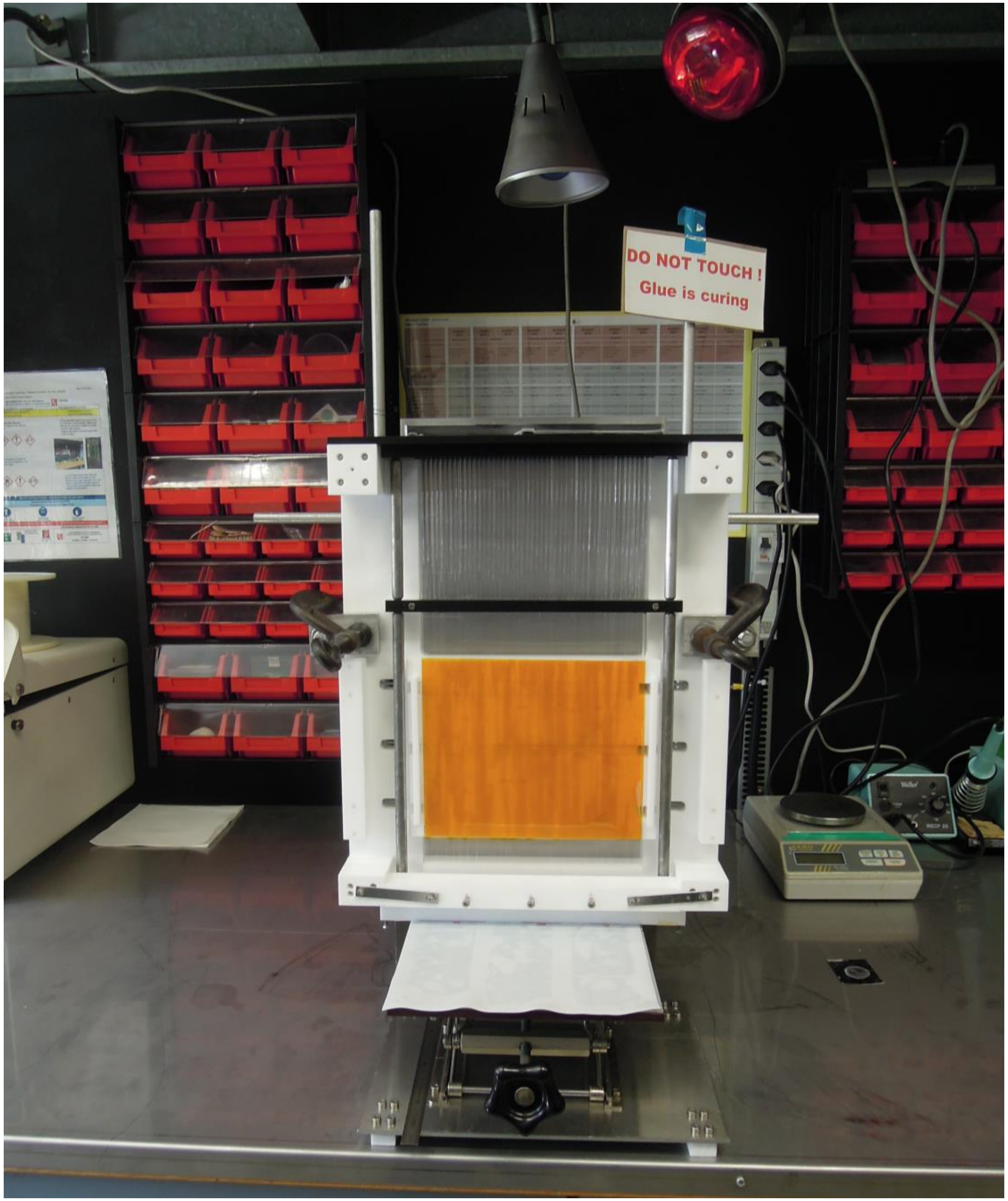


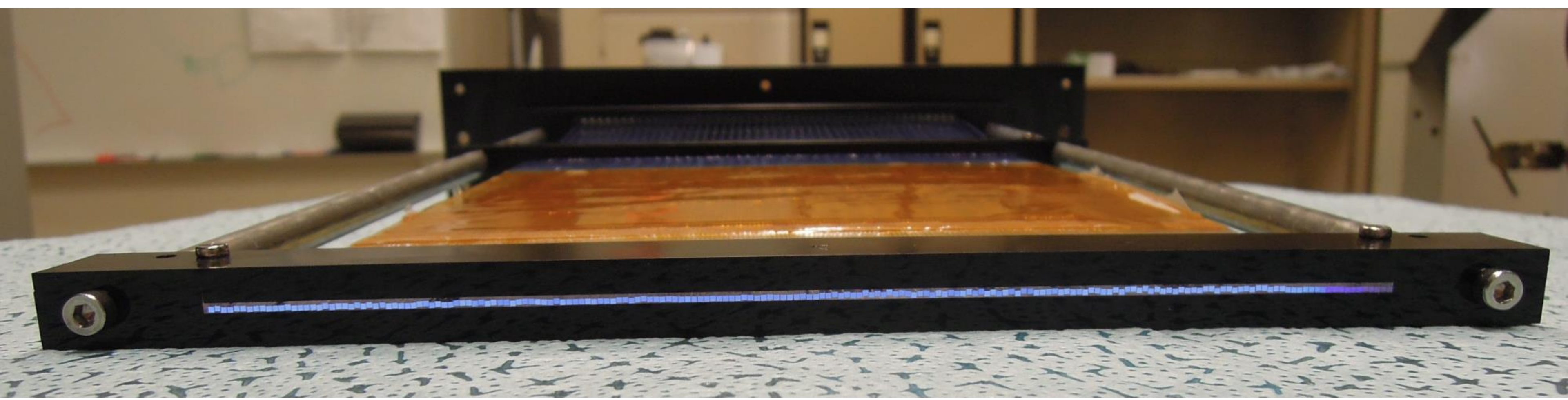

DO NOT TOUCH !
Glue is curing
WMD-3 multi digital
Weller


MAPA

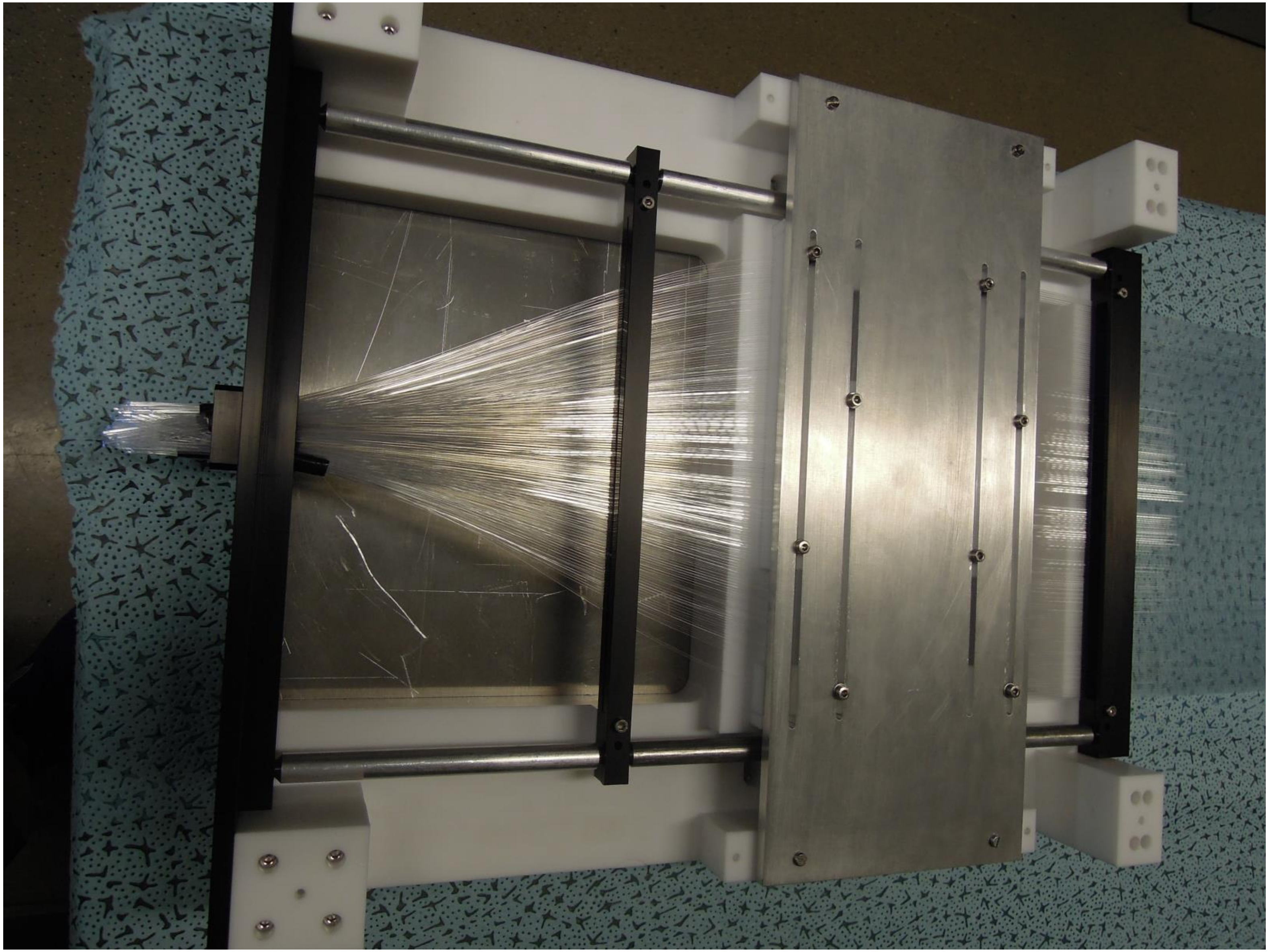





DO NOT TOUCH !
Glue is curing



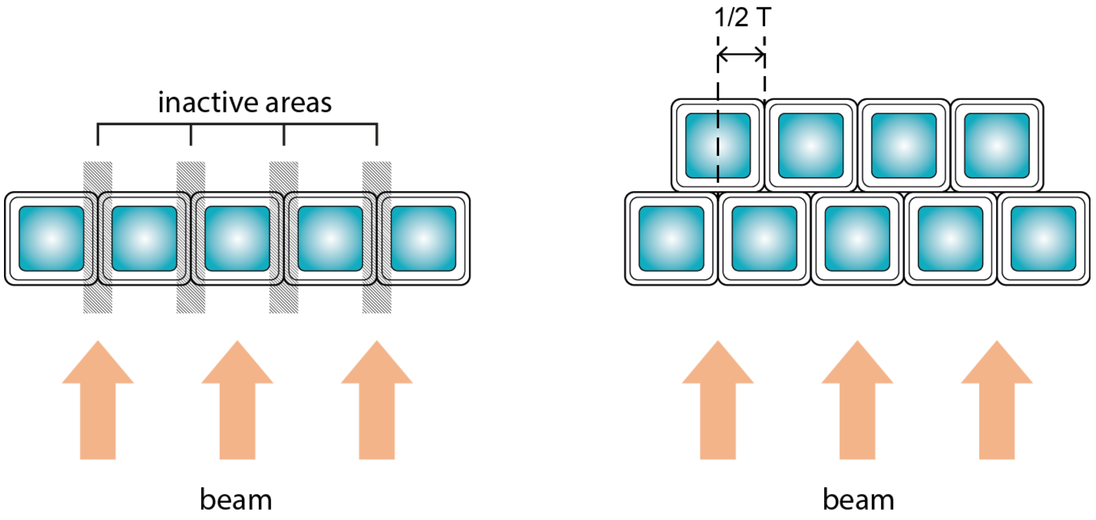
The XSCINT module is giving some problems



Possible solutions:

- Use two PMT instead of one -> half of the fibres for each
- Go for 0.5mm fibres -> less stress.

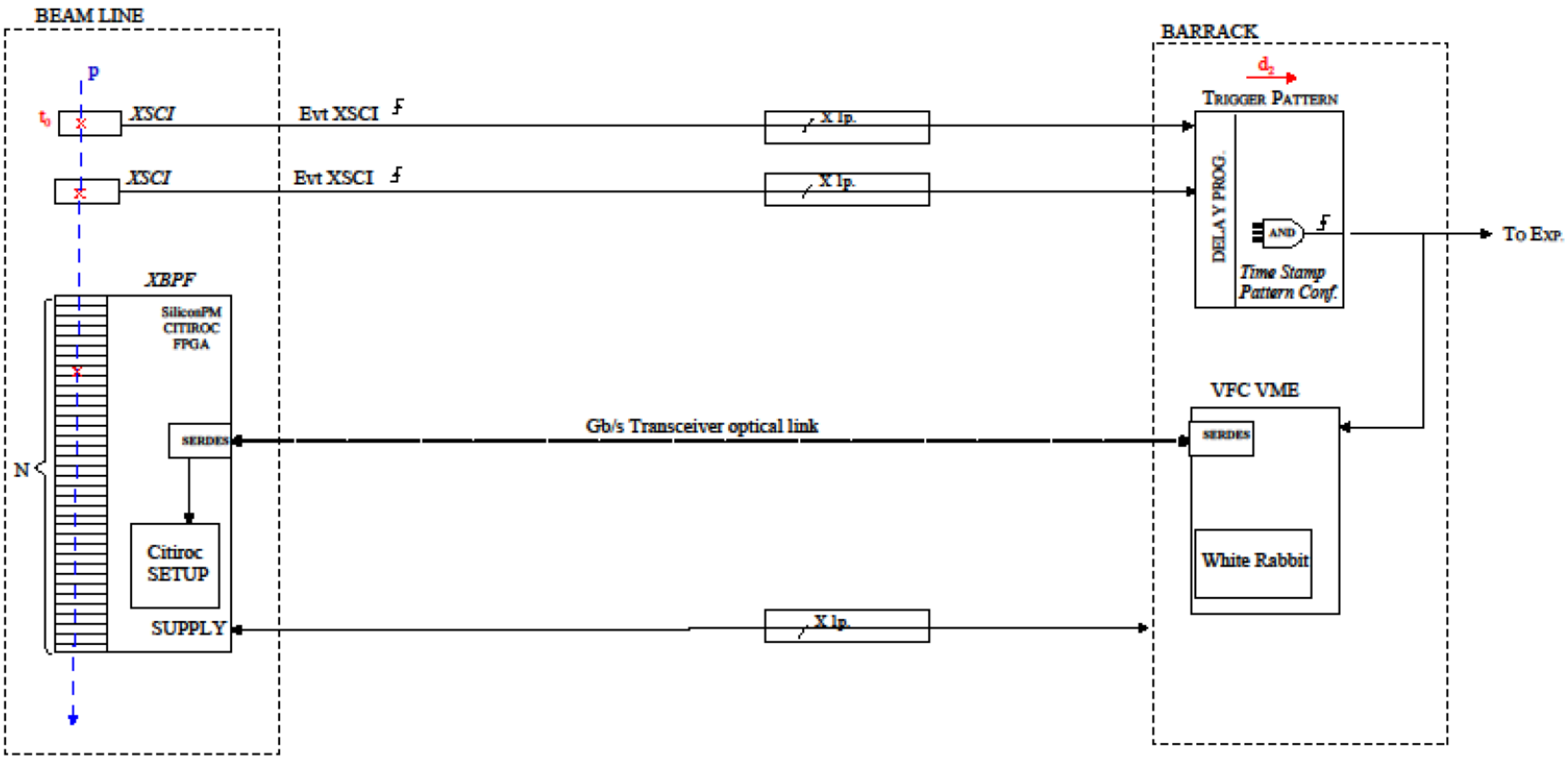
Using thinner fibres open also the research for staggered layers of fibres
-> avoid dead-space of fibre cladding and reach a higher detection efficiency while keeping the same material budget



Mechanics will foreseeably be ready for September: two XBPF and two XSCINT.

Electronics

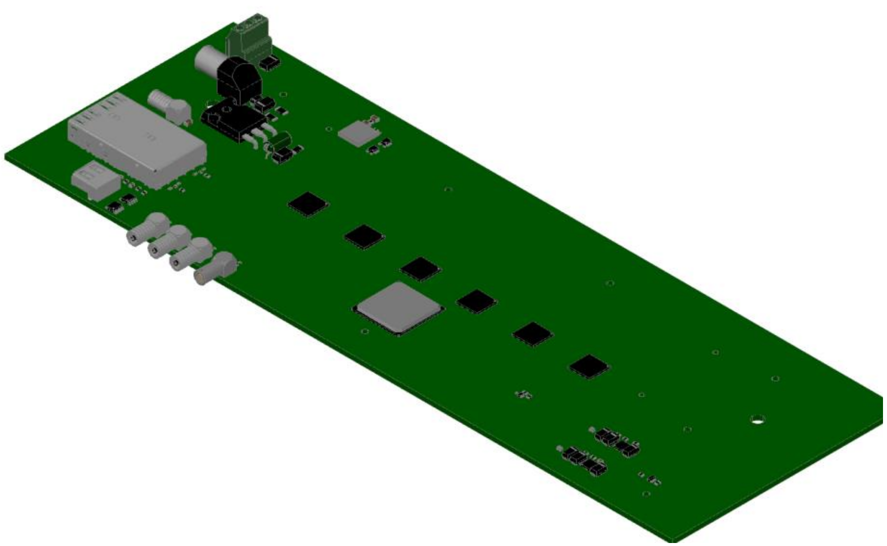
Definitive design

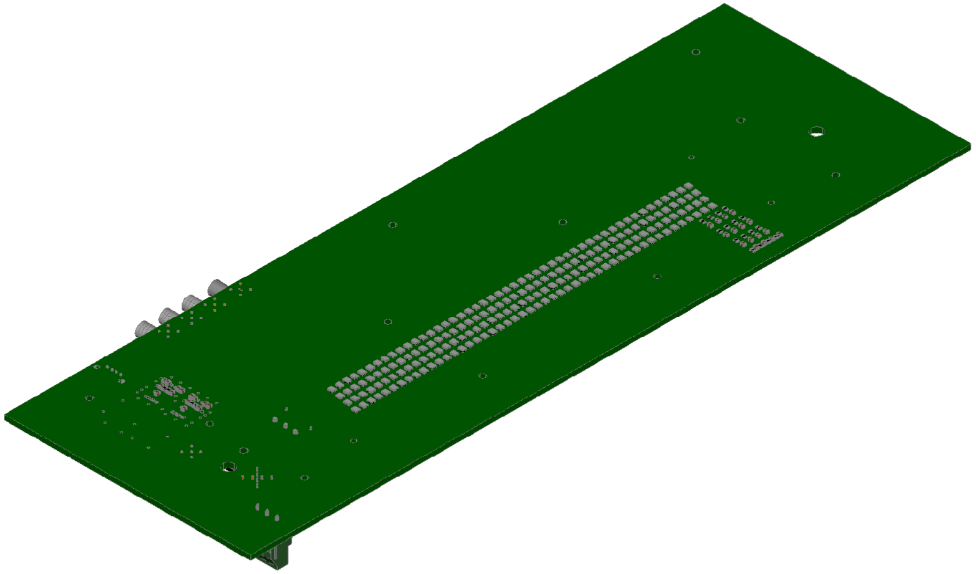


Front-end

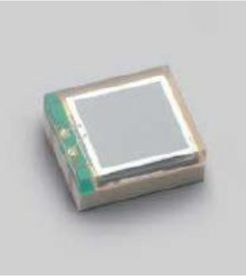
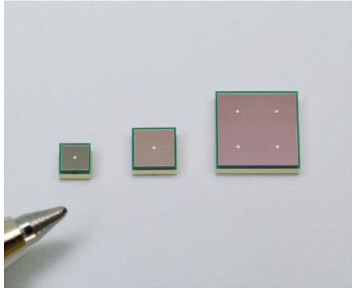
- 192 SiPM
- Integrated “HV” power source for SiPM
- CITIROC ASIC: process all 192 channels from fibre monitor & produces 192 parallel digital outputs
- Xilinx FPGA: - Reads CITIROC output & packages data
  - Encodes data & send out on Gbit link
  - Up to 1MHz data stream
- SFP module with Gbit transceiver

PCB study is being done by the electronics design office at CERN. Two boards foreseen for end of July.



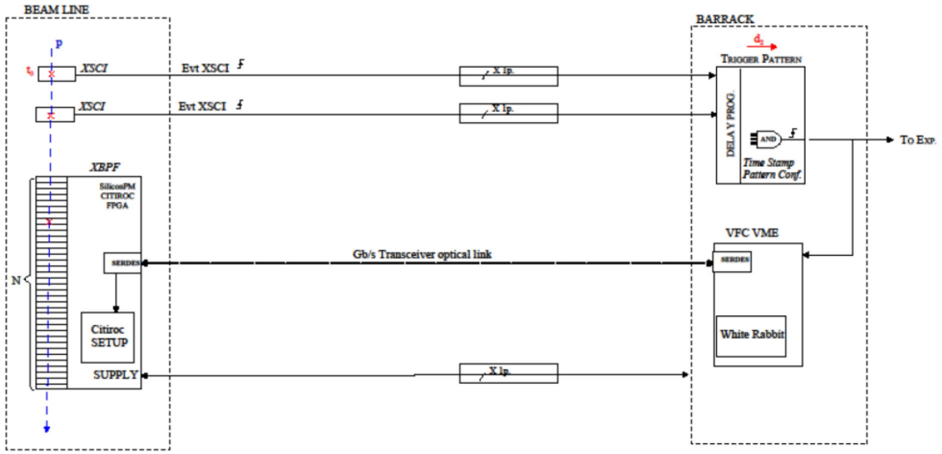


First prototype built with small area SiPM. However Hamamatsu has recently developed a SiPM with a slightly larger active area in a matrix format (8x8 = 64 channels) with a significantly lower price per channel.

Hamamatsu MPPC:	S13360-1350CS	S13360-2050VE
		
Active area:	1.3mm x 1.3mm	2mm x 2mm
Cross-talk:	1%	3%
Maximum dark count:	270kcps	900kcps

Is worth making a second prototype with the SiPM matrix.

Back-end: VFC board



- Decodes Gbit stream from front-end
- Sends control data to front-end
- Implements White Rabbit receiver -> experiment sends WR clock to timestamp the events
- Receives external trigger from scintillator coincidence system
- Creates events structure

Jiri leading the VFC work

Note about FESA class:

- A FESA class is going to be developed for September

Note about White Rabbit:

- BE-CO is lending us a WR switch for our first tests with the prototype

Event structure:

32-bit words, 1 event

Word

0 - timestamp event 32LSB
1 - timestamp event 32MSB
} from detector

2 - timestamp trigger 32LSB
3 - timestamp trigger 32MSB
} global trigger

4 - HW event ID

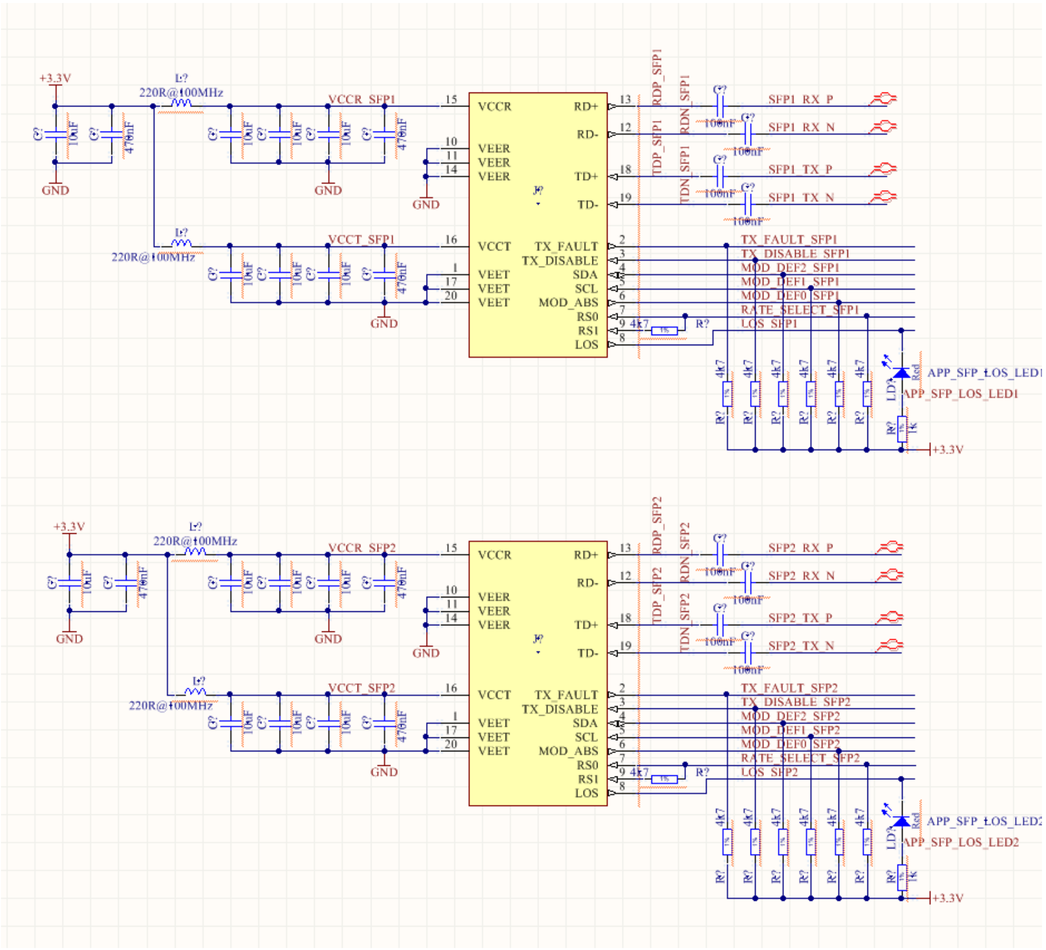
5 - Data word 0 (LSB)
6 - Data word 1
7 - Data word 2
8 - Data word 3
9 - Data word 4
10 - Data word 5
} fibre hit information

11 - ReedSolomon check symbols

12 - ReedSolomon decoder event error counts

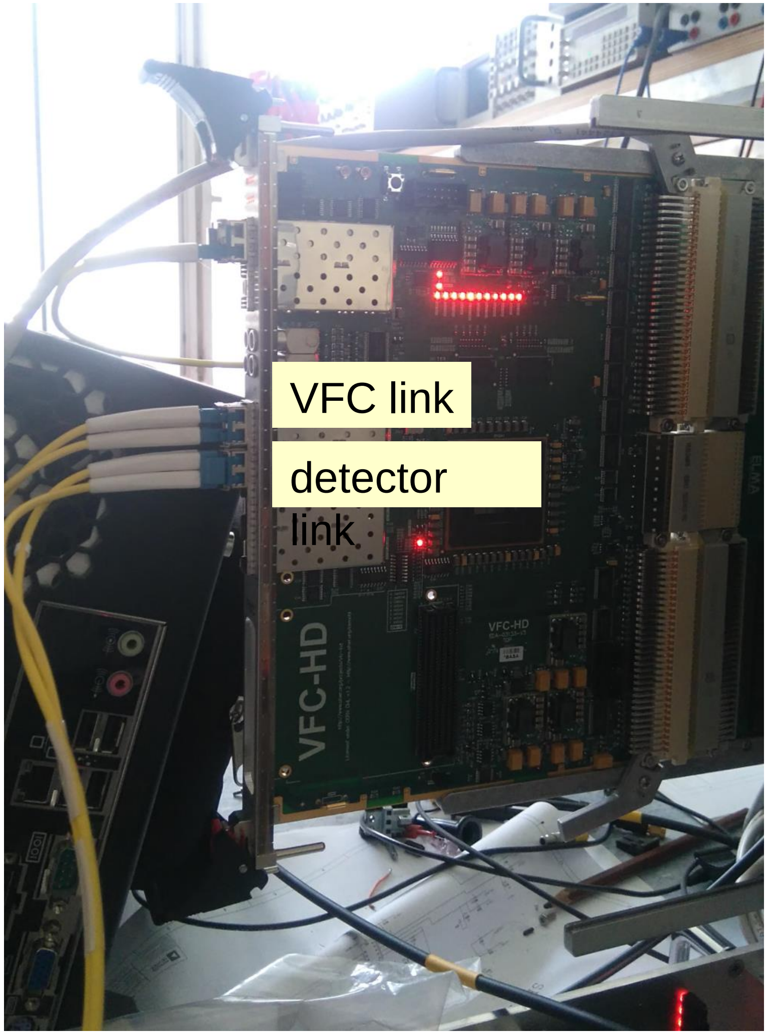
Transceiver schema

- Based on working VFC example

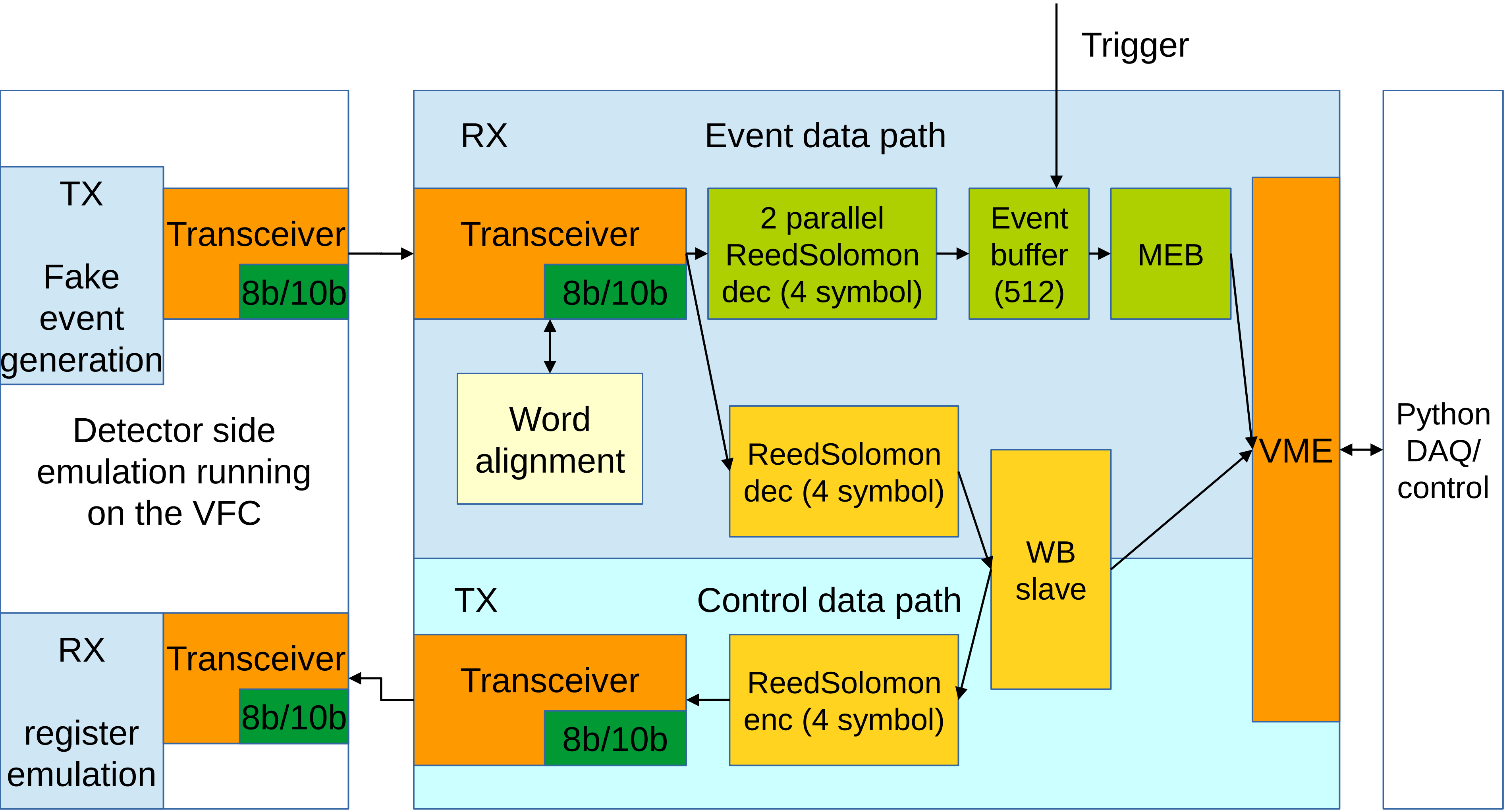


FW development platform

- Using one VFC board to read out and simulate detector side (front-end)
- 2000 Mbaud/s link at the moment
- Next step: Implement detector side code in Xilinx test board



FW structure

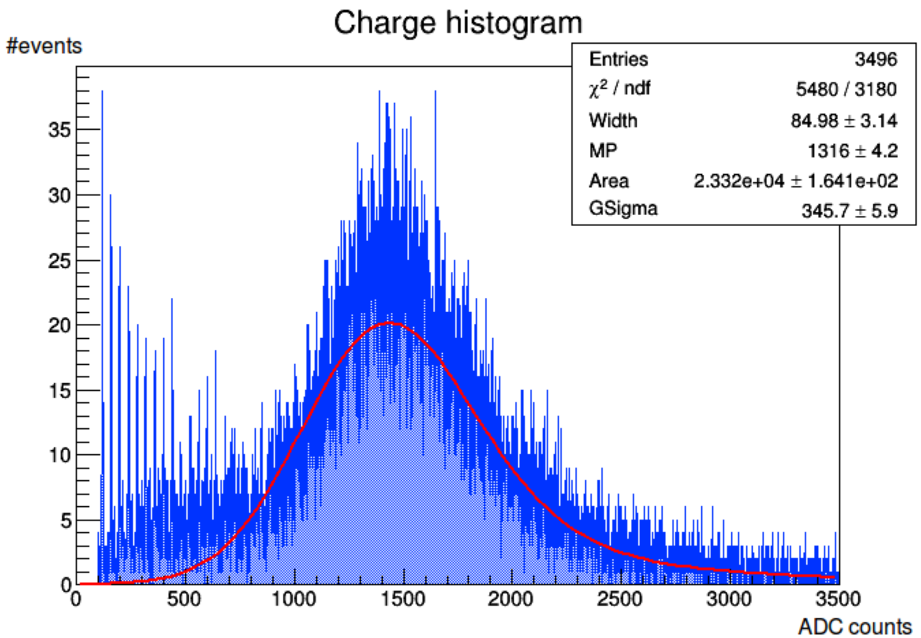


- VFC side acquiring emulated data (IRQ, Python readout), control working. Missing WhiteRabbit client
- Detector side: Work in progress

Miscellanea

- New test bench being built at BI-EA labs to calibrate the new detectors: large light-tight box of 1.2m x 0.6m x 0.7m equipped with motorised platform where to install UV-laser or radioactive source to excite the fibres.

- Question about detector efficiency due to light collected by SiPM and discriminators threshold was opened in the last TB. From tests done with similar fibre-SiPM setup:



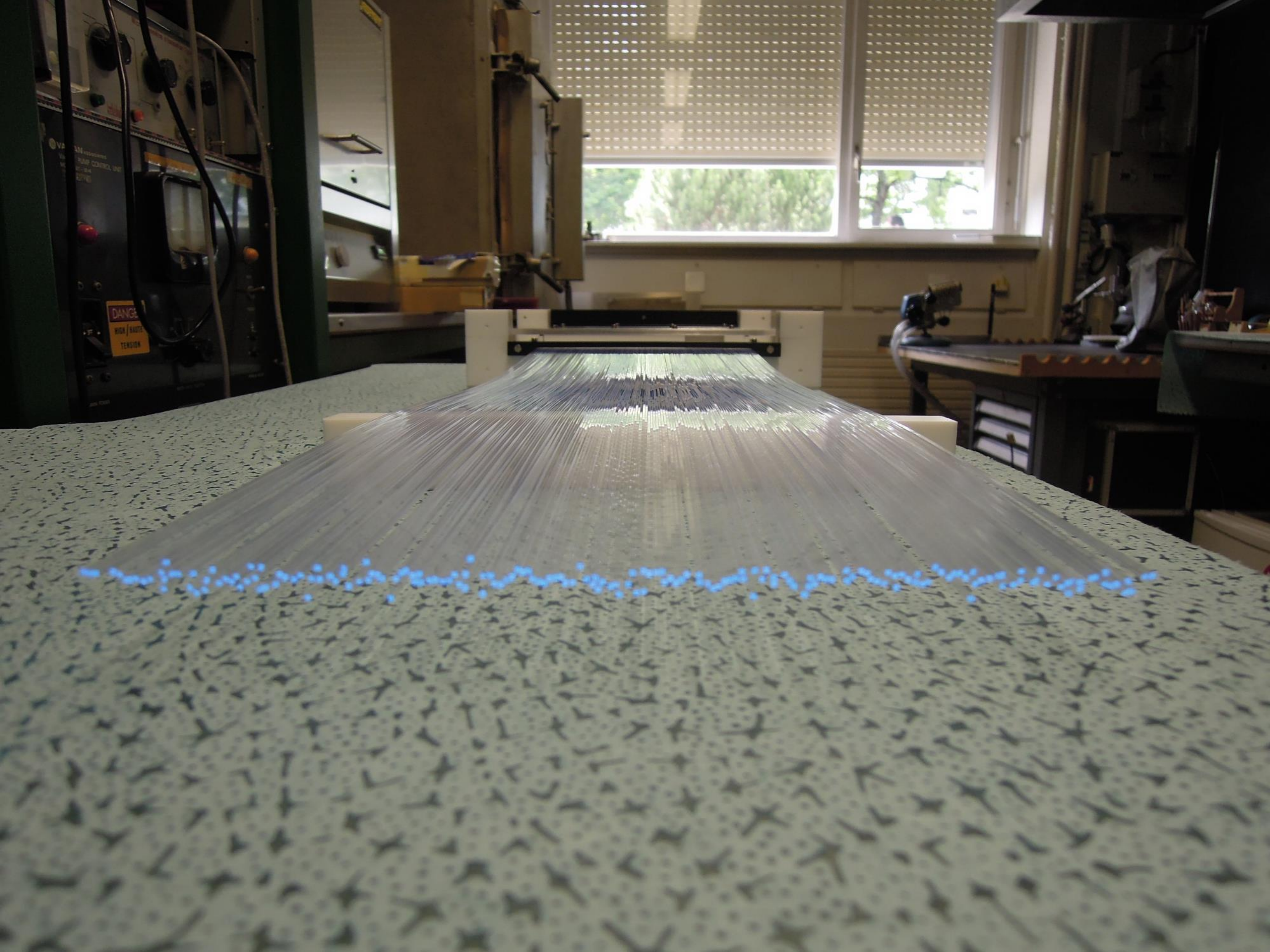
MPV = 25.5 photons
Sigma = 10.5 photons

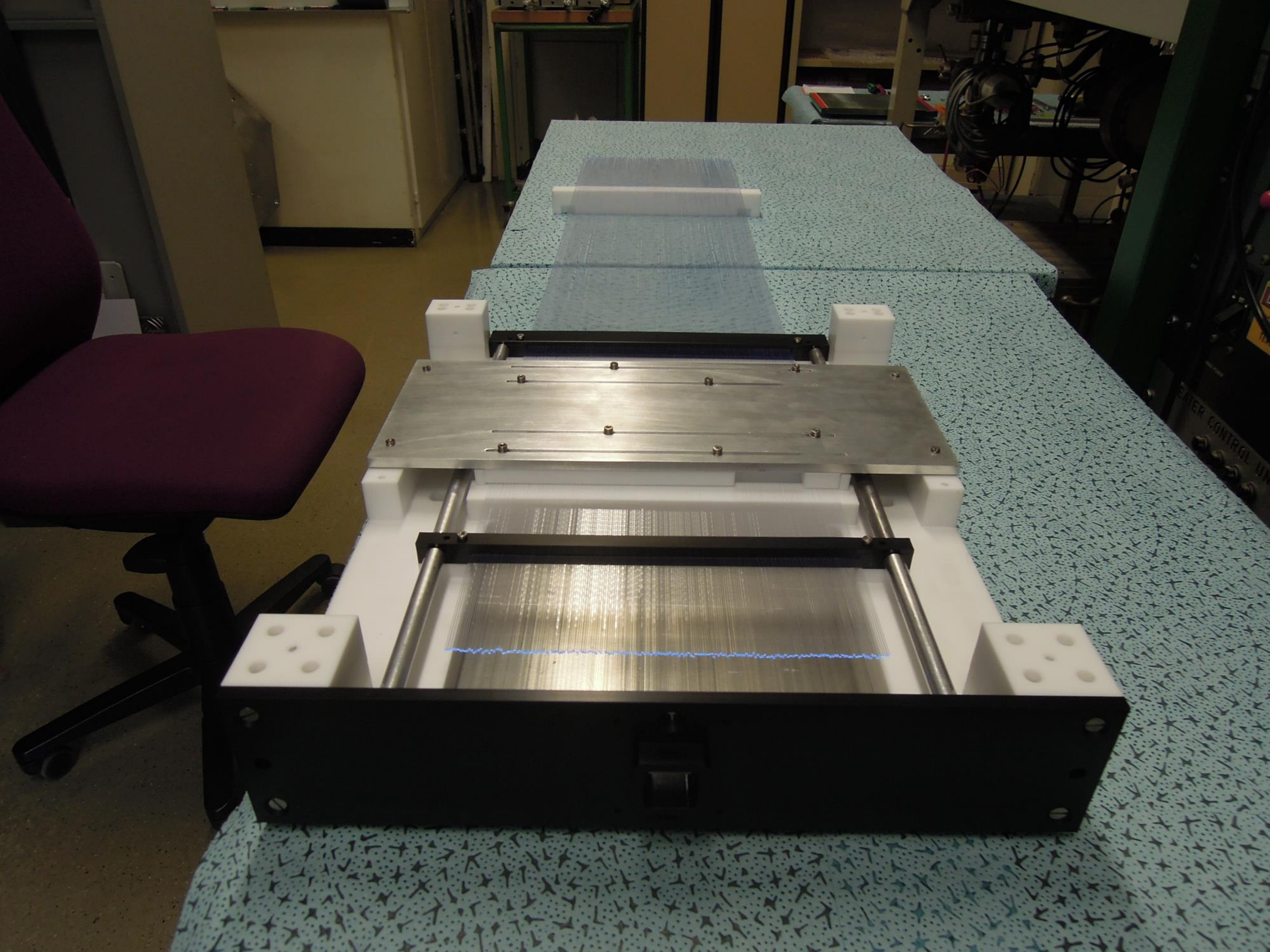
Threshold (photons)	Probability lost events (%)
0.5	1.0
1.5	1.3
2.5	1.6
3.5	2.0
4.5	2.5
5.5	3.2

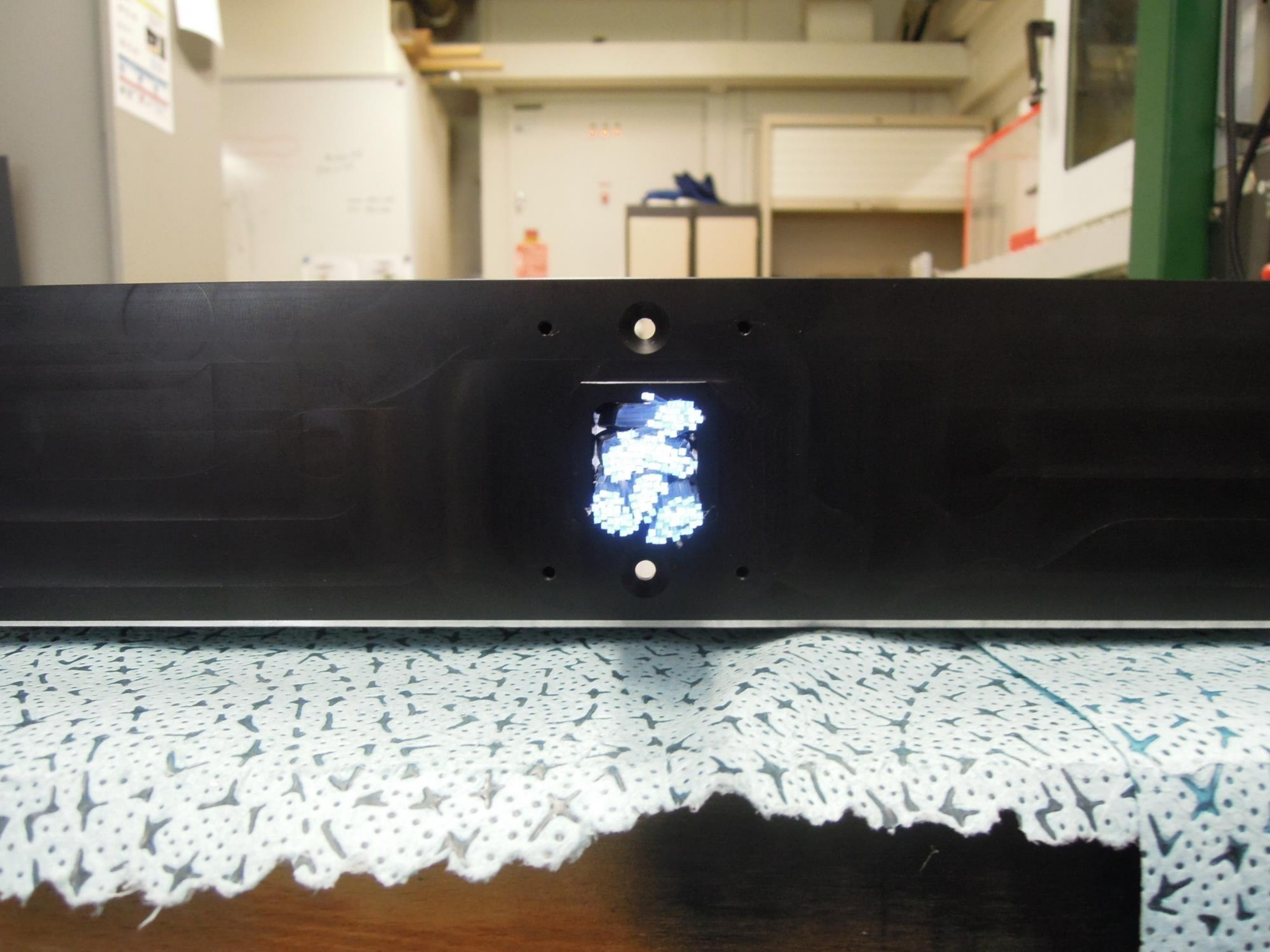
- The XSCINT could be used for Time-of-Flight measurements: the PMT used are good for timing measurements. The SVEC board that we have bought for the WR tests has a very good TDC -> Test setup being done in collaboration with Neutrino Platform physicists to study feasibility.

- Aluminium coating of scintillating fibres to avoid optical cross-talk is still under discussion. The first prototypes will be made with half of the fibres coated and other half un-coated to study the difference.

Annex: nice pictures


HIGH / HAUTE
TENSION





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