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WP 28 / T2

SiPM coupled advanced fibre detectors

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Overview

„Proof of Concept“ detector: Beam Monitor
Crossed Fibre Layers

First Configuration : Square Organic Fibres
electron beam dimensions / electron veto in photon beam

Second Configuration : Round Inorganic Fibres
photon beam dimensions

- Diploma Thesis
  milled fibres vs. commercial fibres
  TPC Start Detector, SiPM readout
- Bachelor Thesis
  YAG(Ce) Fibre with SiPM readout (Prag meeting)
- Diploma Thesis
  fibre hodoskop as beam monitor or fibre/SiPM test stand,
  build from organic and inorganic fibres (this meeting)

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Overview

- Sensor Selection
  lighyield /SiPM PDE / noise / rate stability
- Detector Design
  electronics/mechanics
- In Beam Performance
- Further Measurements
  temperature dependence of gain/noise
- Outlook
  inorganice fibres

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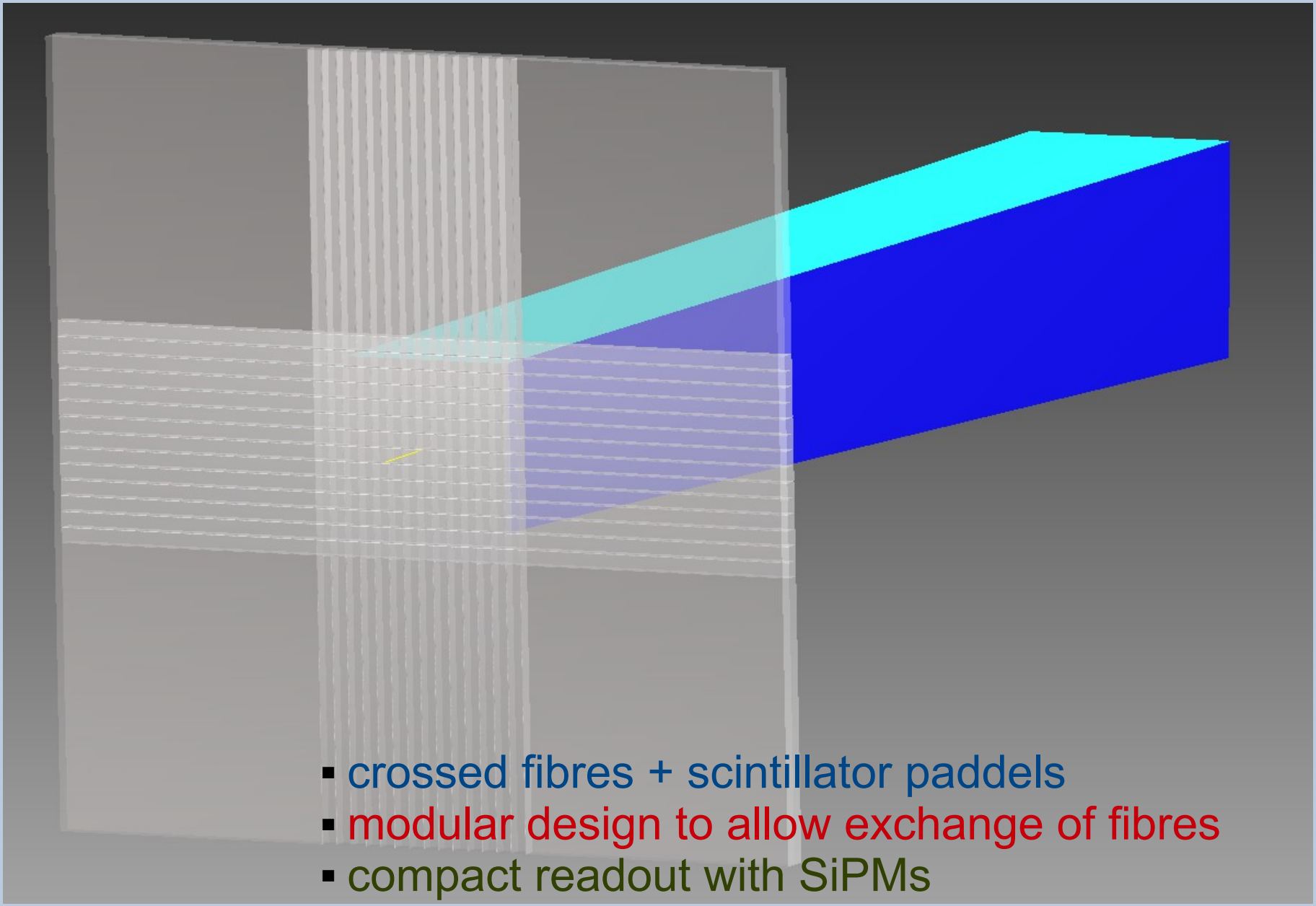
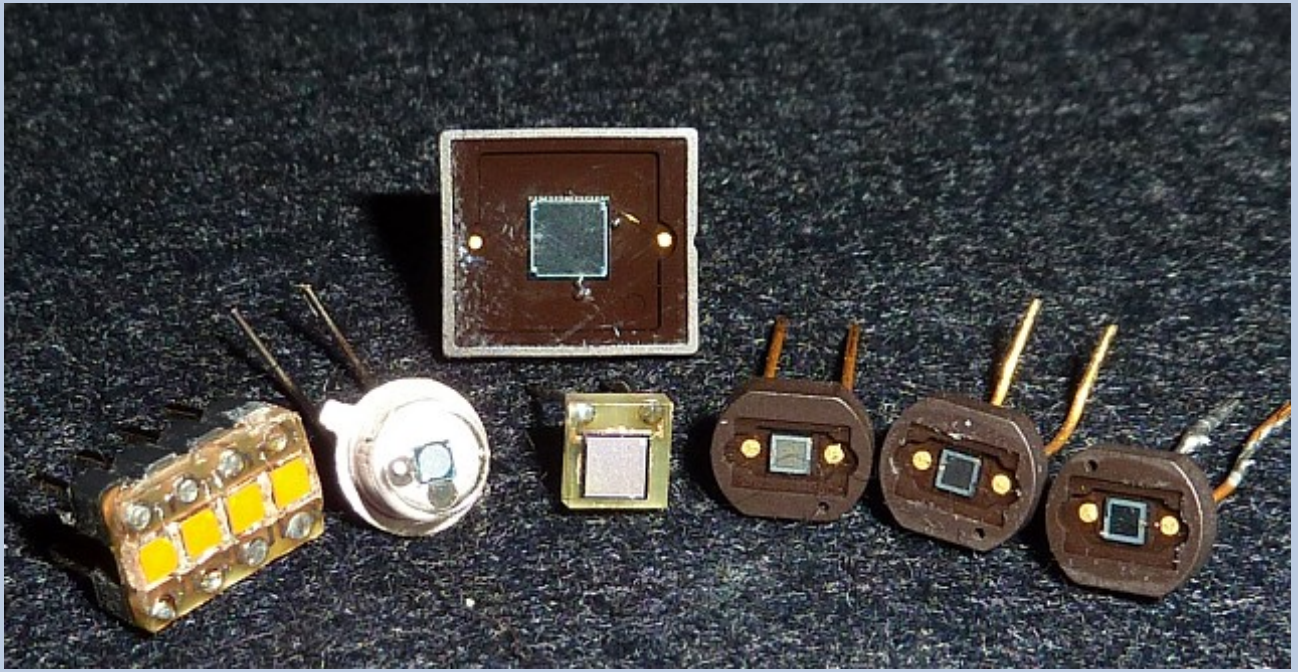
Detector Concept



- crossed fibres + scintillator paddels
- modular design to allow exchange of fibres
- compact readout with SiPMs

Selection of SiPM



SiPM	Photonique			Hamamatsu S10362-11-			SensL
	0701BG	0611B4MM	Array	25C	50C	100C	MIcro3035
Operating Voltage	31 V	36 V	20 V	70 V	70 V	70 V	28 V
active Area	1 mm^2	4,4 mm^2	1 mm^2	1 mm^2	1 mm^2	1 mm^2	8,1 mm^2
Pixels	556	1700	556	1600	400	100	3640
Fill Faktor	$\geq$ 70 %	$\geq$ 70 %	$\geq$ 70 %	30,8 %	61,5 %	78,5 %	-
Gain	$4 \cdot 10^5$	$0,6 \cdot 10^5$	$4 \cdot 10^5$	$2,75 \cdot 10^5$	$7,5 \cdot 10^5$	$2,4 \cdot 10^6$	$1 \cdot 10^6$
PDE	40 %	25 %	$\geq$ 10 %	25 %	50 %	65 %	20 %
λ bei max. PDE	560 nm	440 nm	560 nm	440 nm	440 nm	440 nm	490 nm
Darkrate	1,6 MHz	2,9 MHz	1,5 MHz	600 kHz	800 kHz	1000 kHz	10 MHz
Rise Time	$\leq$ 0,7 ns	$\leq$ 0,7 ns	$\leq$ 5 ns	$\leq$ 0,3 ns	$\leq$ 0,3 ns	$\leq$ 0,3 ns	$\leq$ 5 ns

plus some more, i.e.

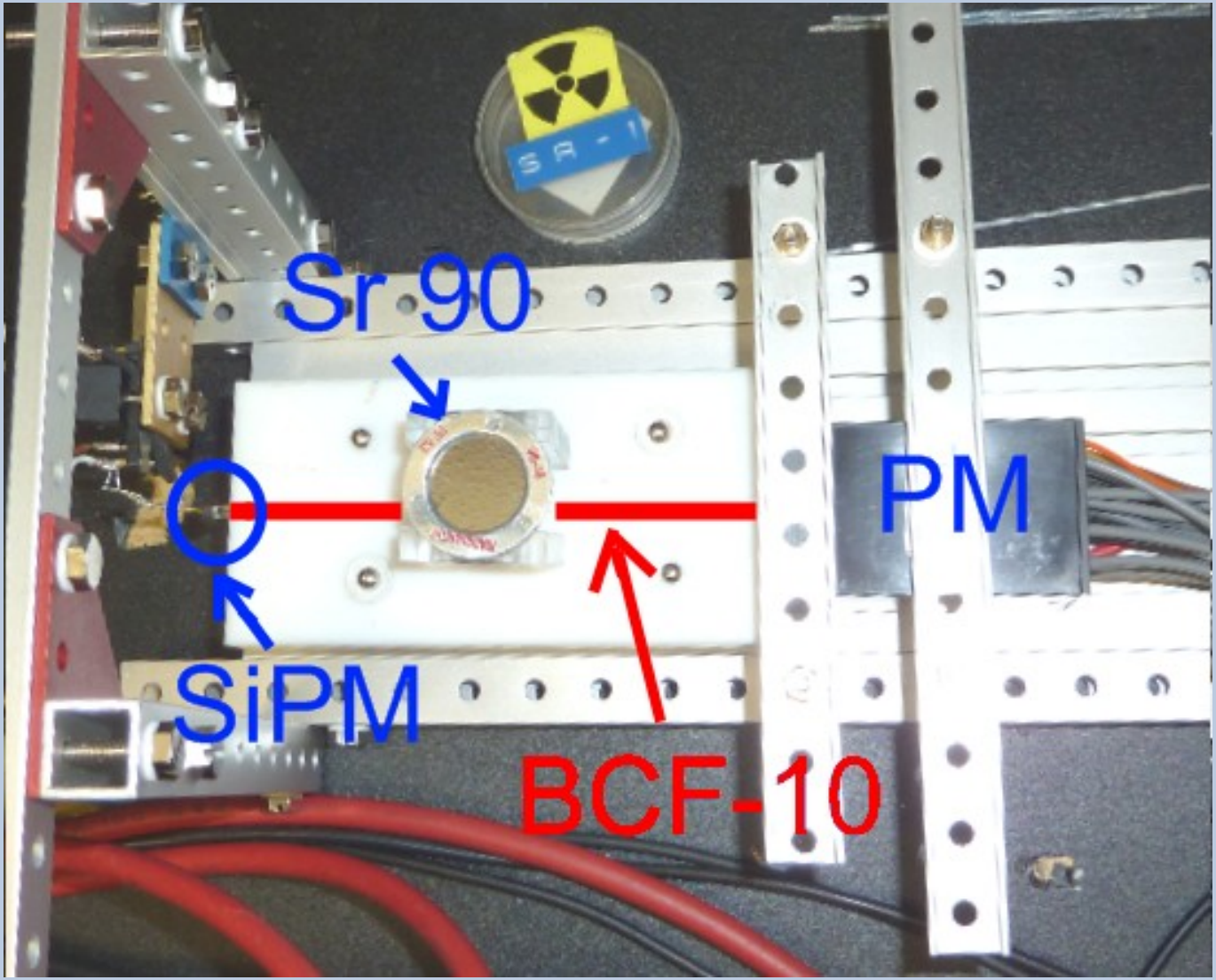
Photonique
- 2.2 x 2.2 red enhanced,

- some older MEPhI/Pulsar Prototypes

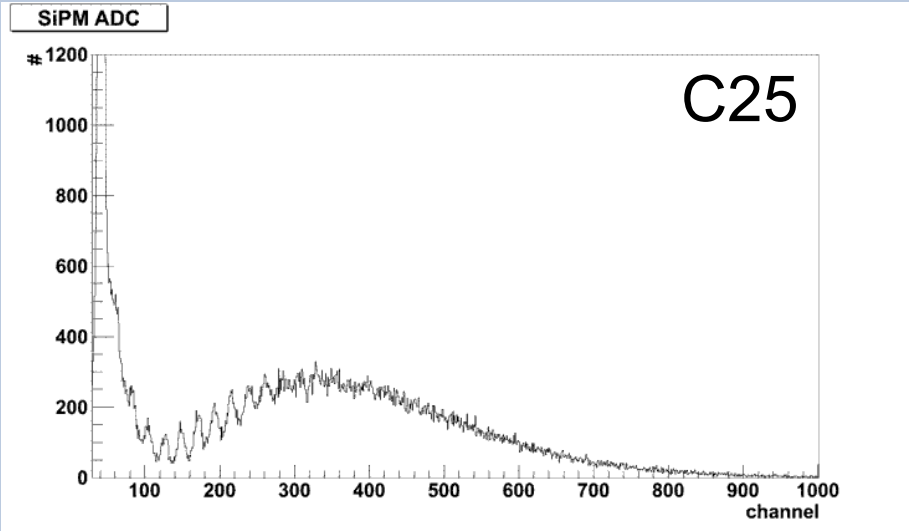
PDE / Lightyield Measurement

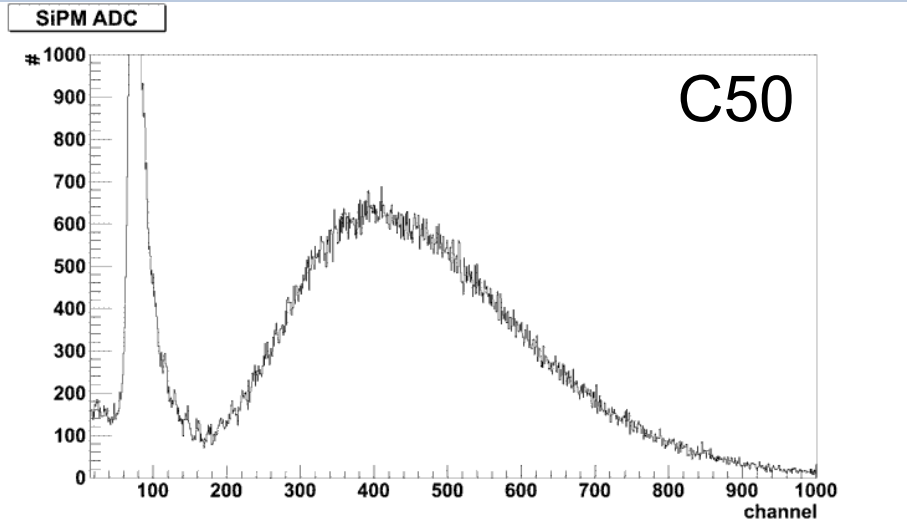
1st crucial question: occupancy of the sensor

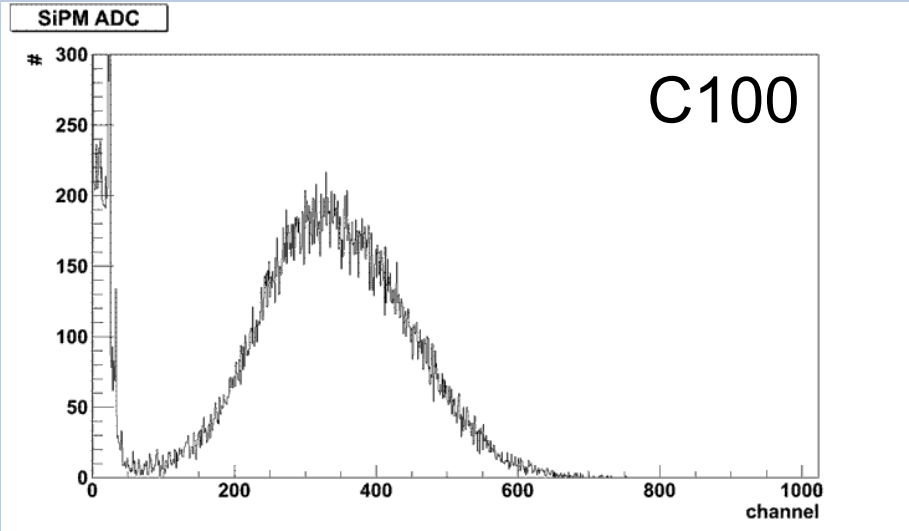
- depending on lightyield and global PDE (inc. FF)



Hamamatsu PDE / Lightyield



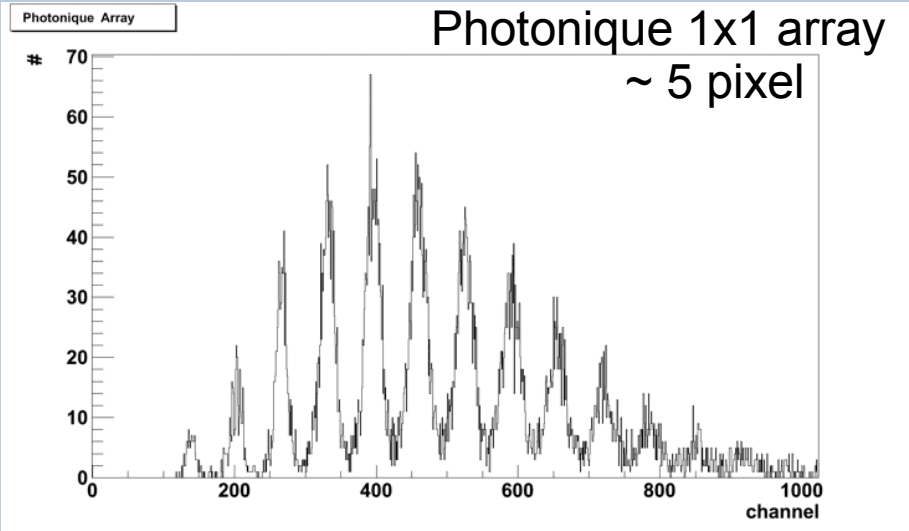


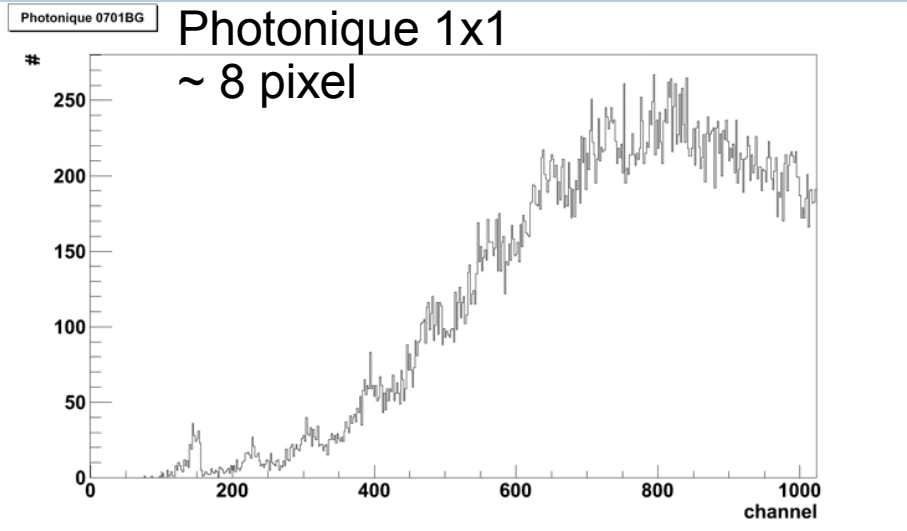


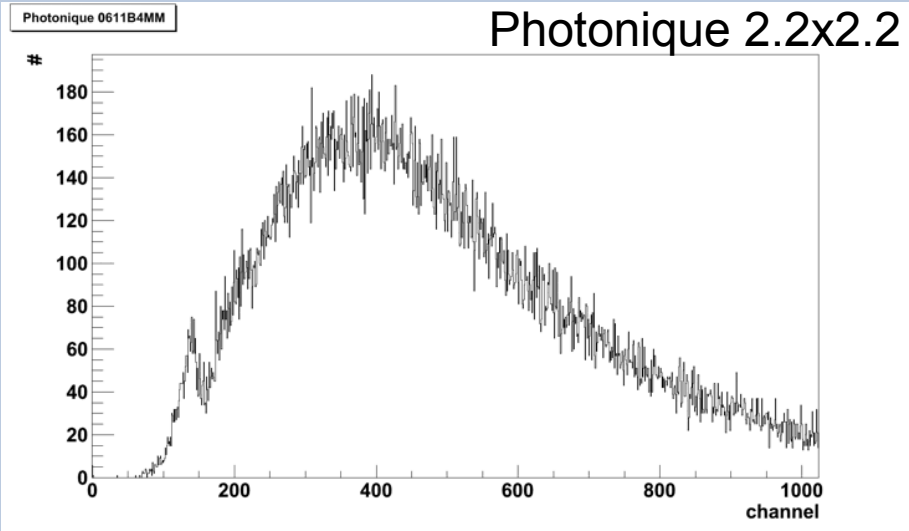
Model	# Pixel	Fillfactor	Pixels Hit
C25	1600	30,8%	~15
C50	400	61,5%	~22
C100	100	78,5%	~35

sensors cover 25% of fibre endface
PDE-peak matches fibre spectrum

Photonique PDE / Lightyield





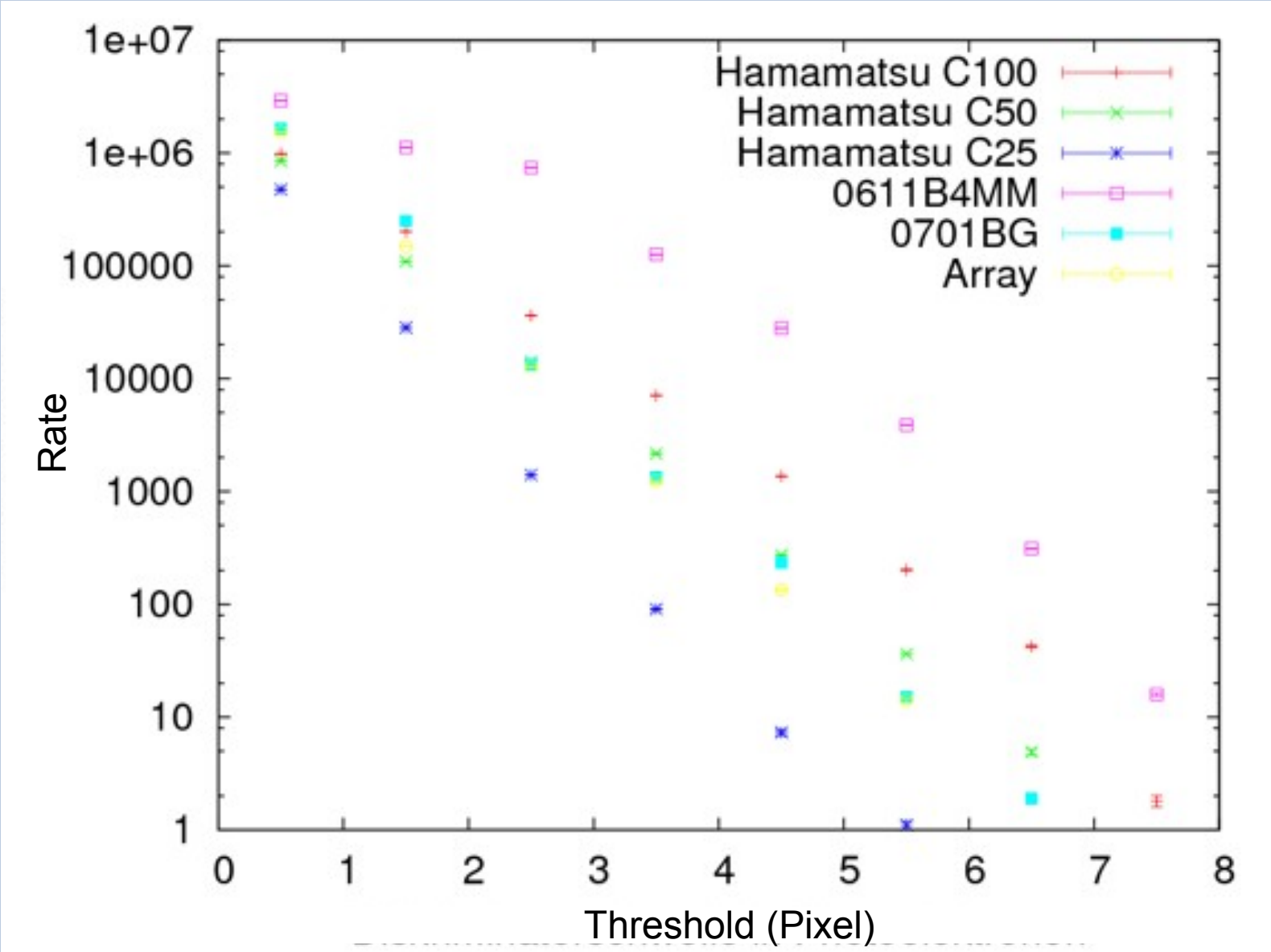


Model	# Pixel	FF*PDE	Pixels Hit
array	556	>10%	~5
1x1	556	40%	~8
2x2	1700	25%	~7?

PDE-peak in green, > 50% loss for blue
measured efficiency 50% of Hamamatsu

Dark Counts

- measured at lab temperature



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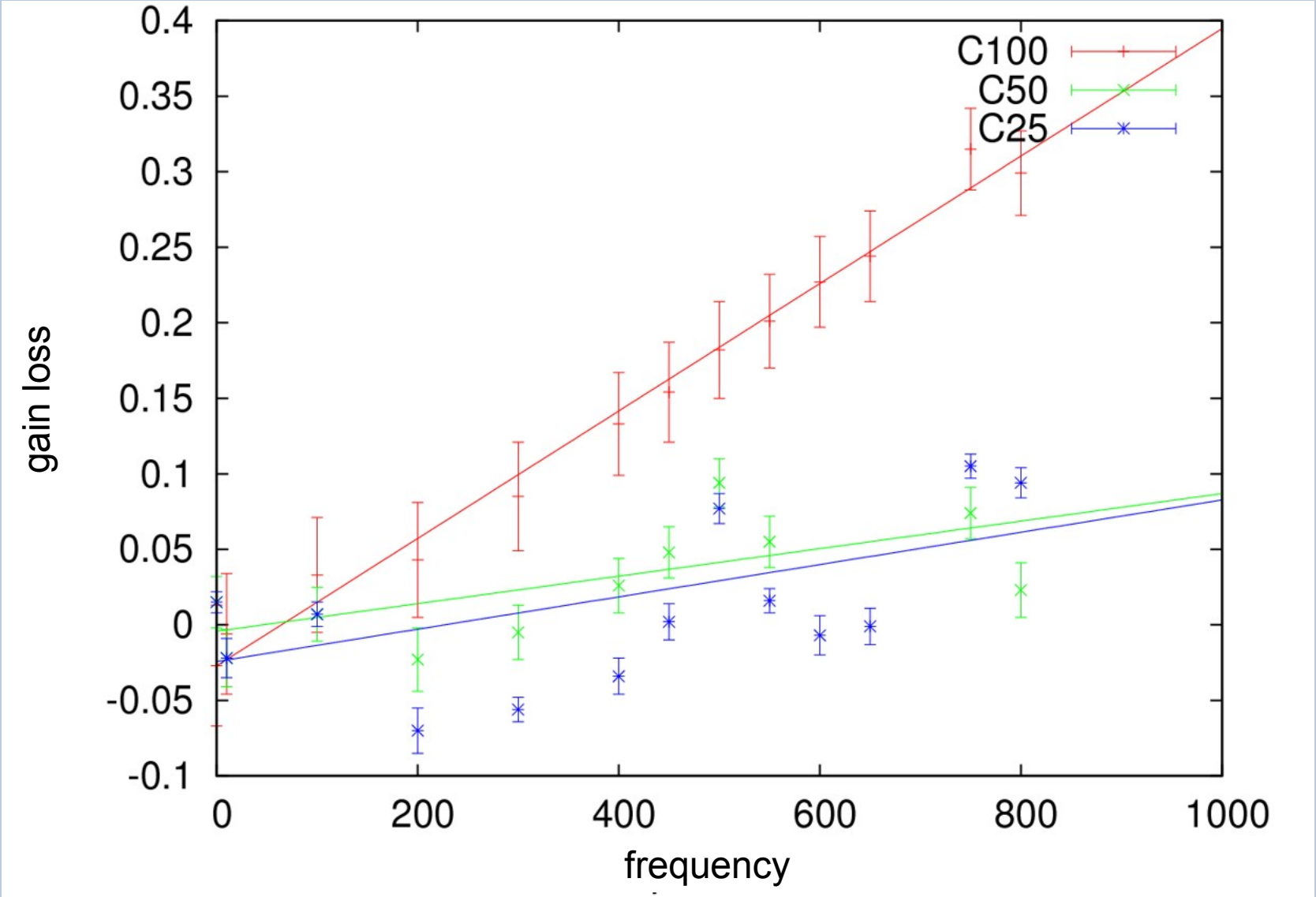
Rate Stability

- LED-pulser tuned to expected lightyield
- normalized on 10 Hz and reference PMT

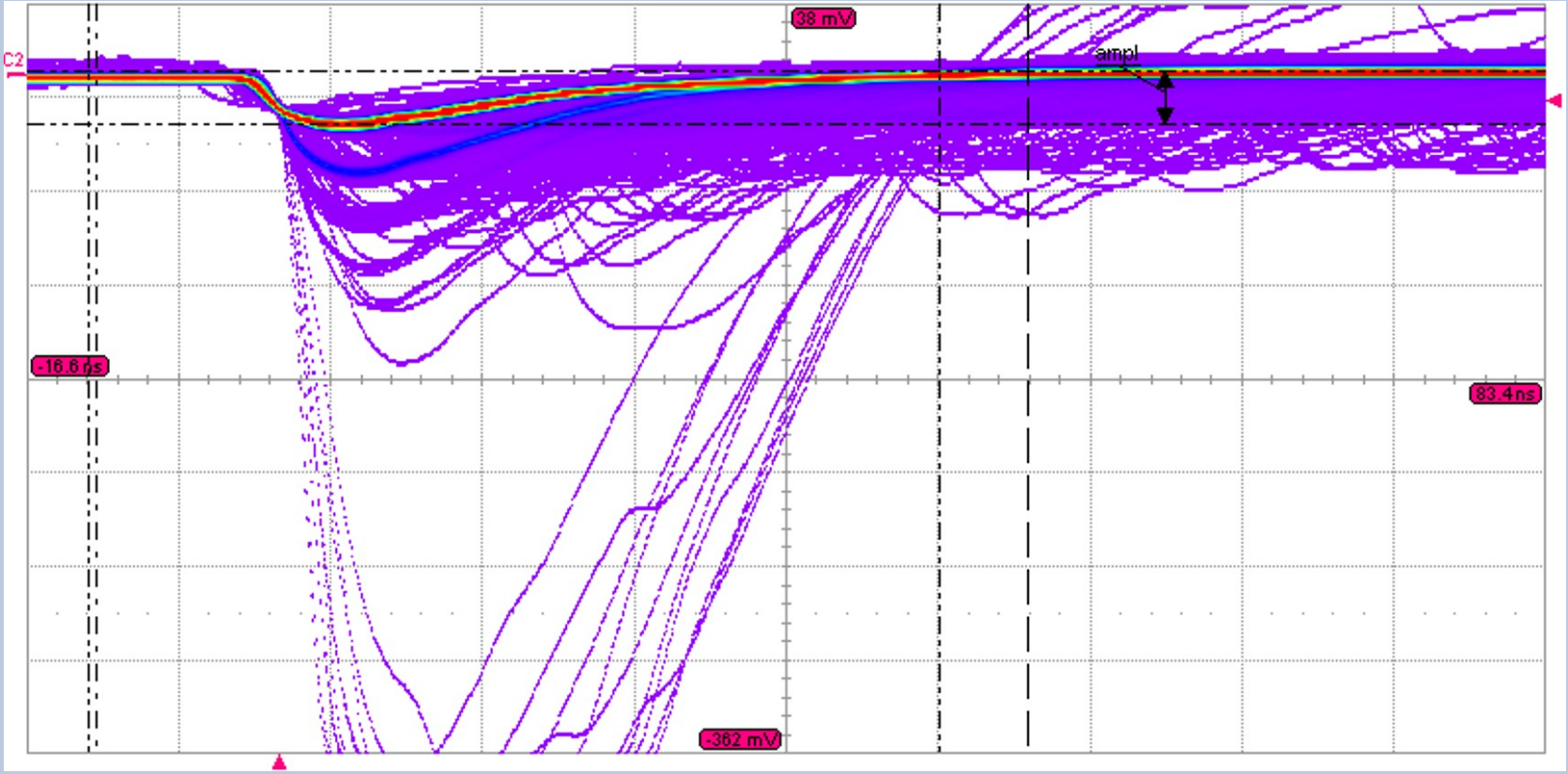


Results

Hamamatsu MPPC C50 (400 Pixel) @ Bicron BCF10

performance at lab temperature:

- Signal > 10 Pixel (~22 / MIP)
- Noise <10 Hz at 6,5 Pixel
- Gain <10% up to 1 MHz



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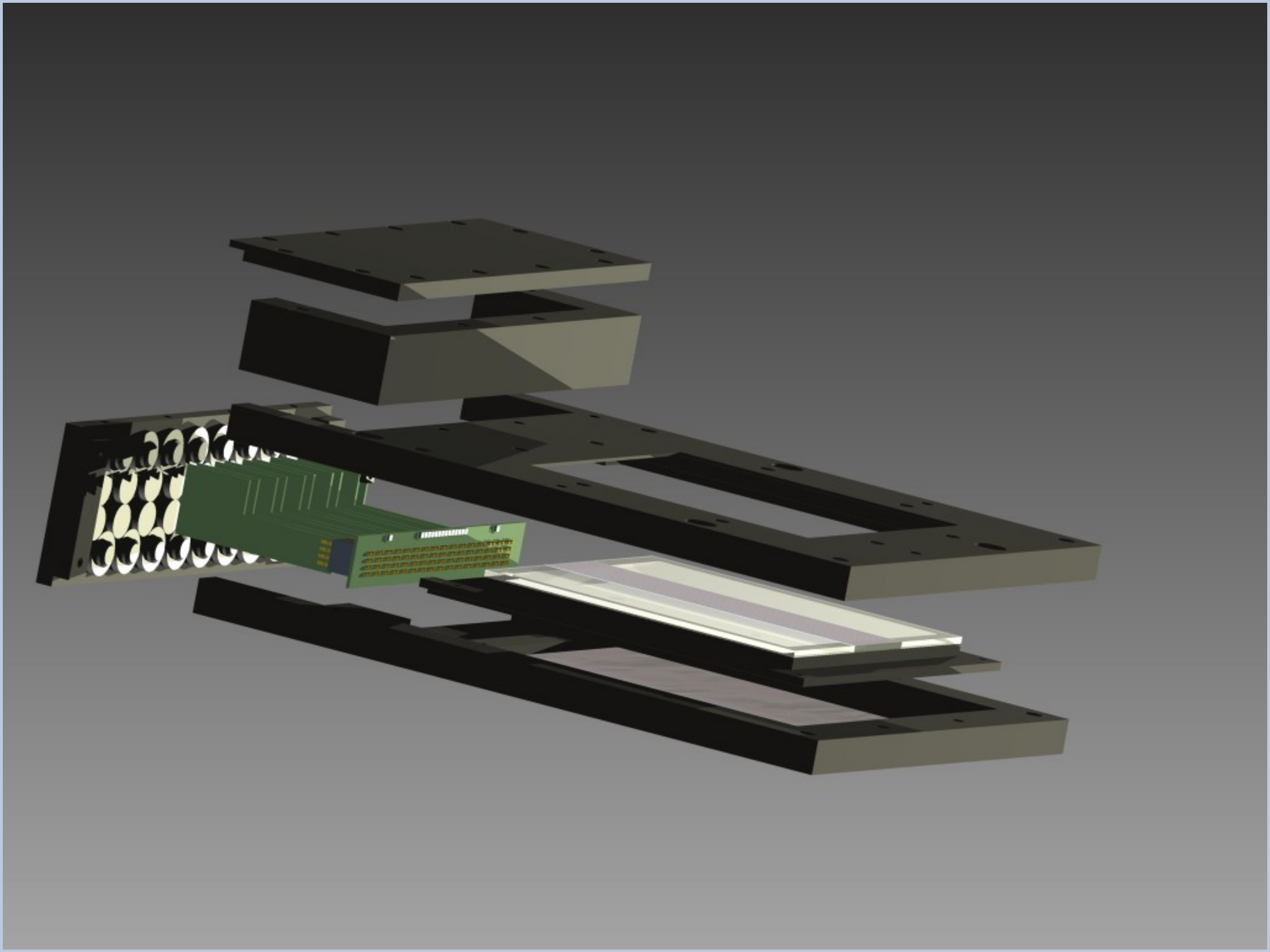
Detector Design



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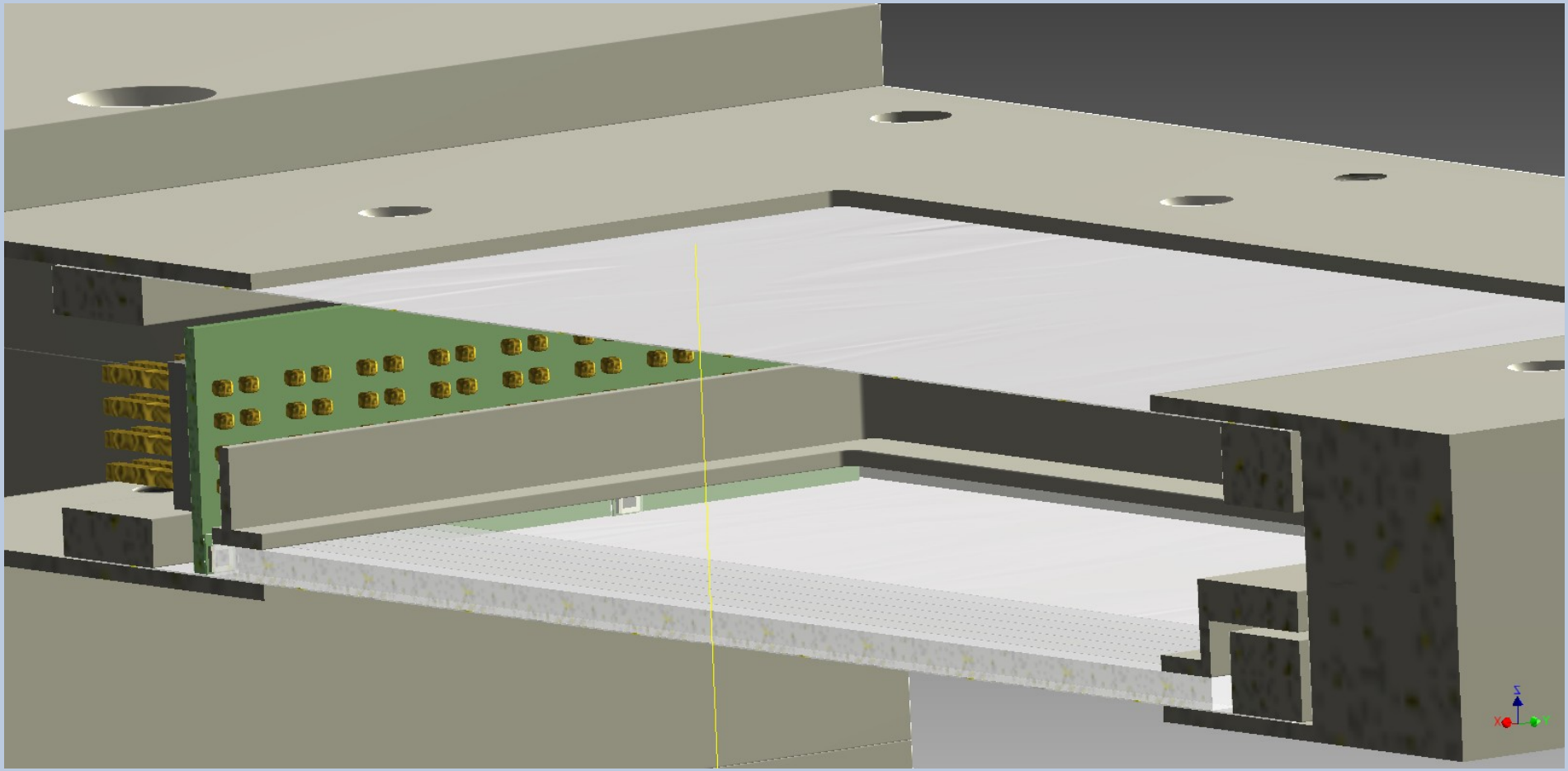
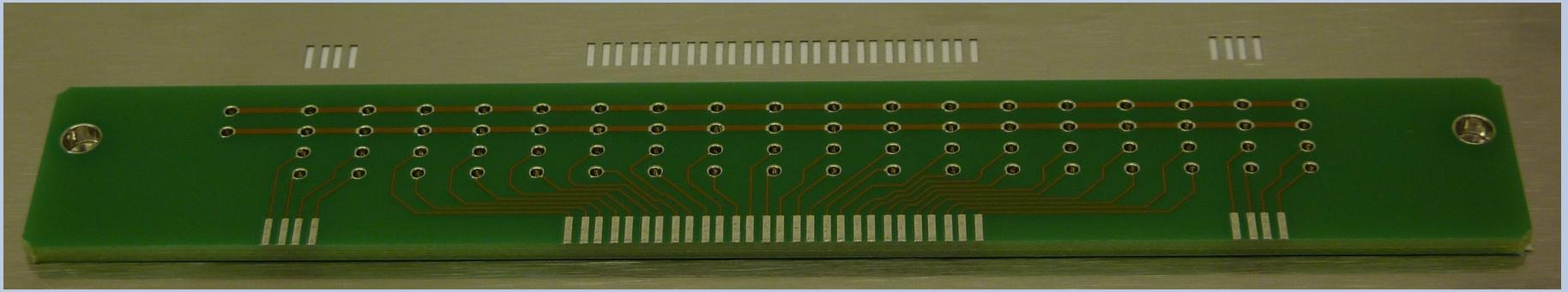
Detector Design

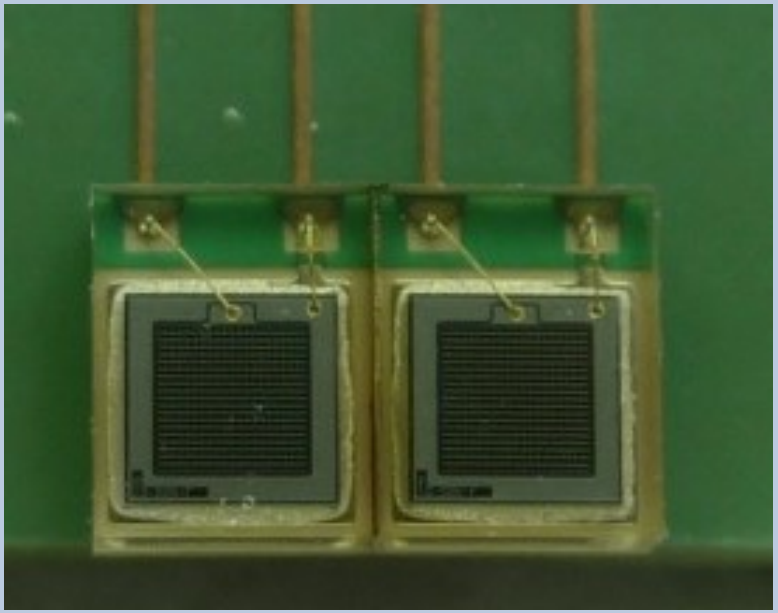
- compact & robust
- light- and EM-shielded
- 2 mm distance between two modules

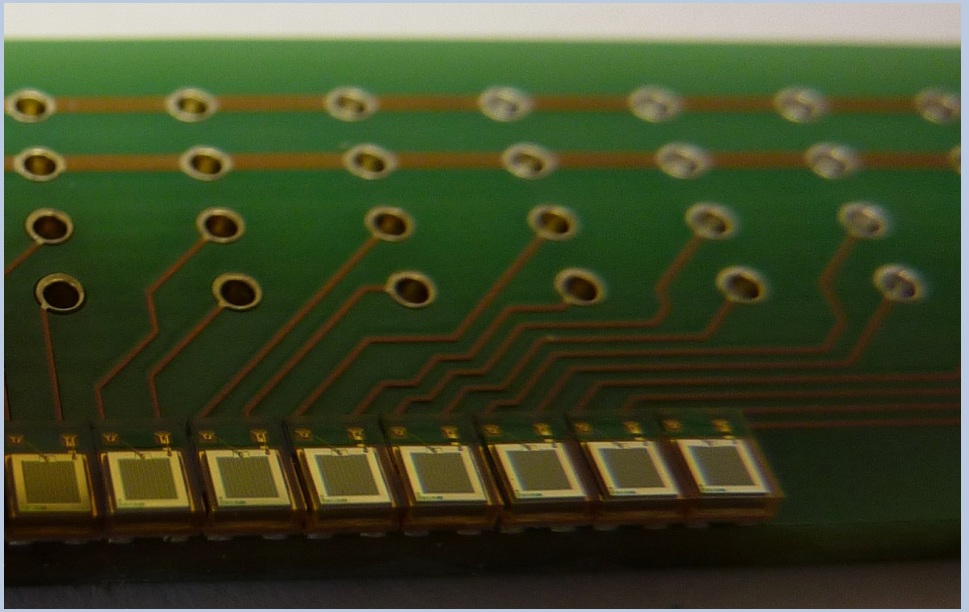


SiPM Board

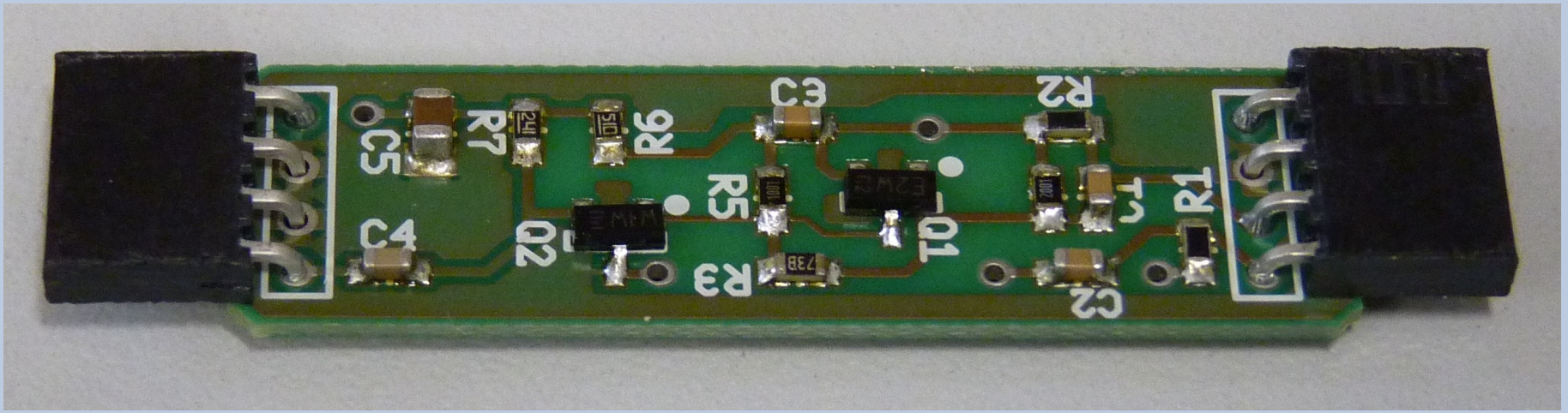
- common ground connection close to all sensors
- distribution of PreAMP LV
- reflow soldered SiPMs with 2 mm pitch



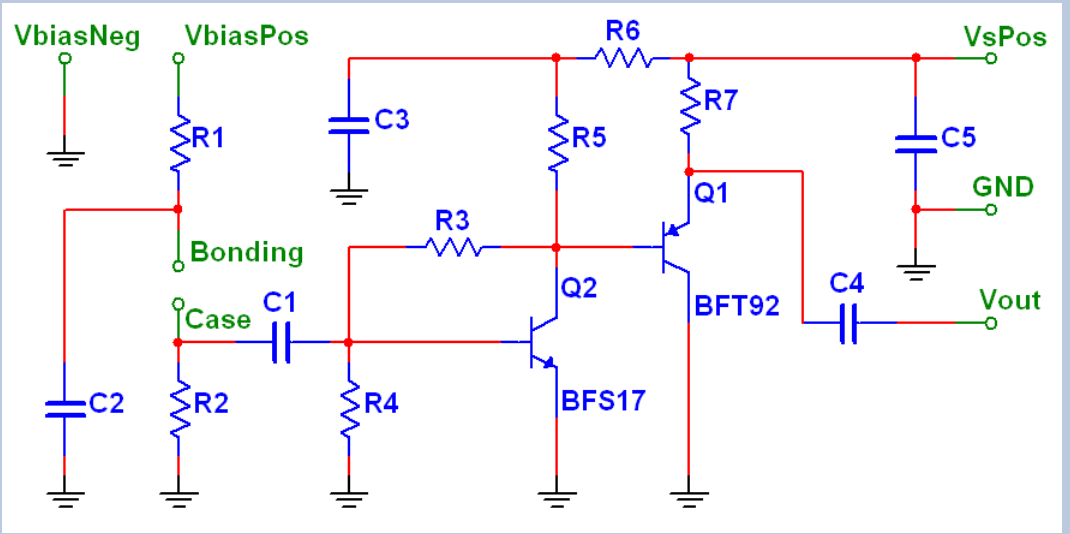




PreAMP



- individual, interchangable PreAMPs
- 10V supply via SiPM board
- individual bias supply
- ~ 50x gain output



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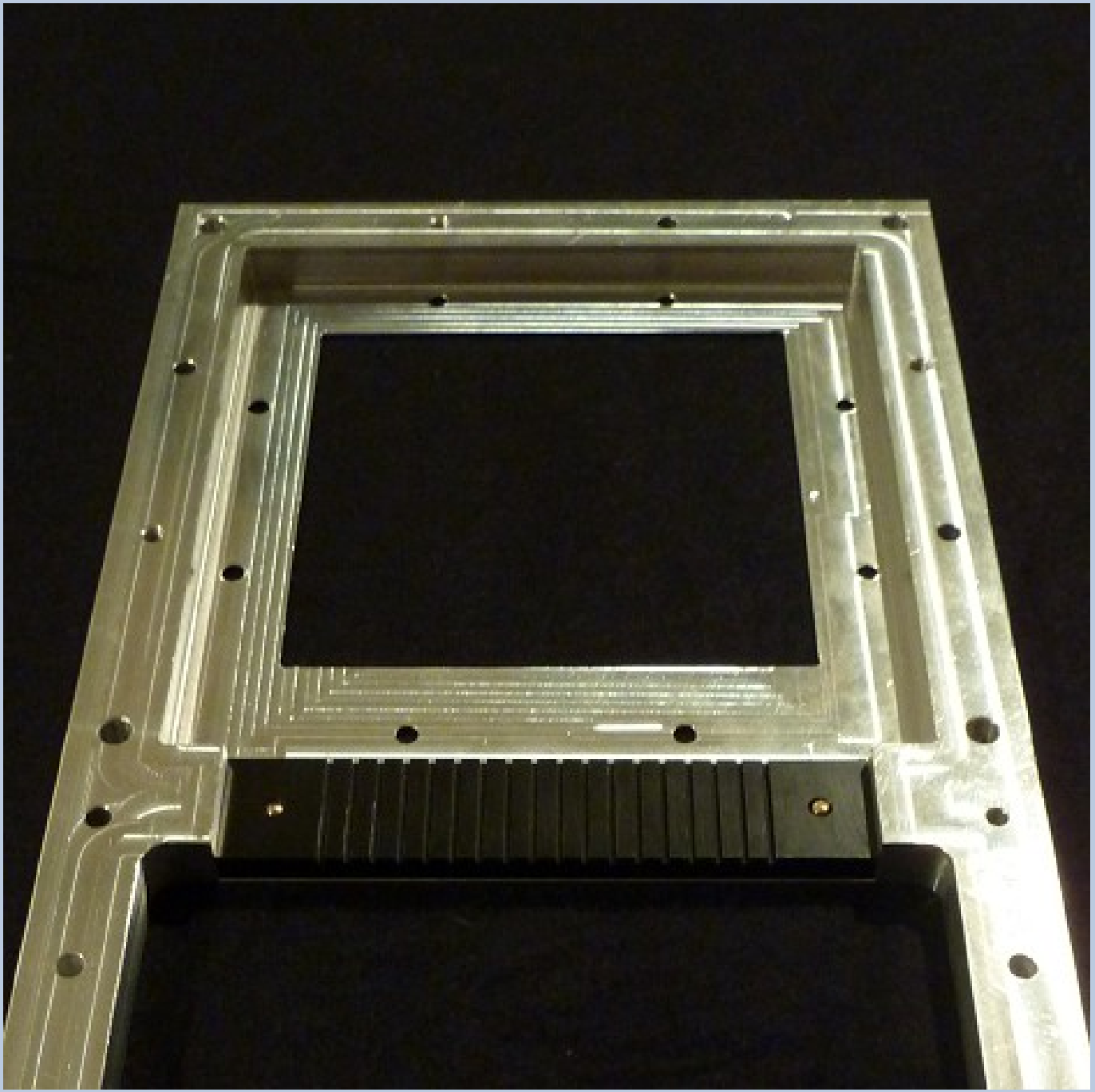
Base Frame



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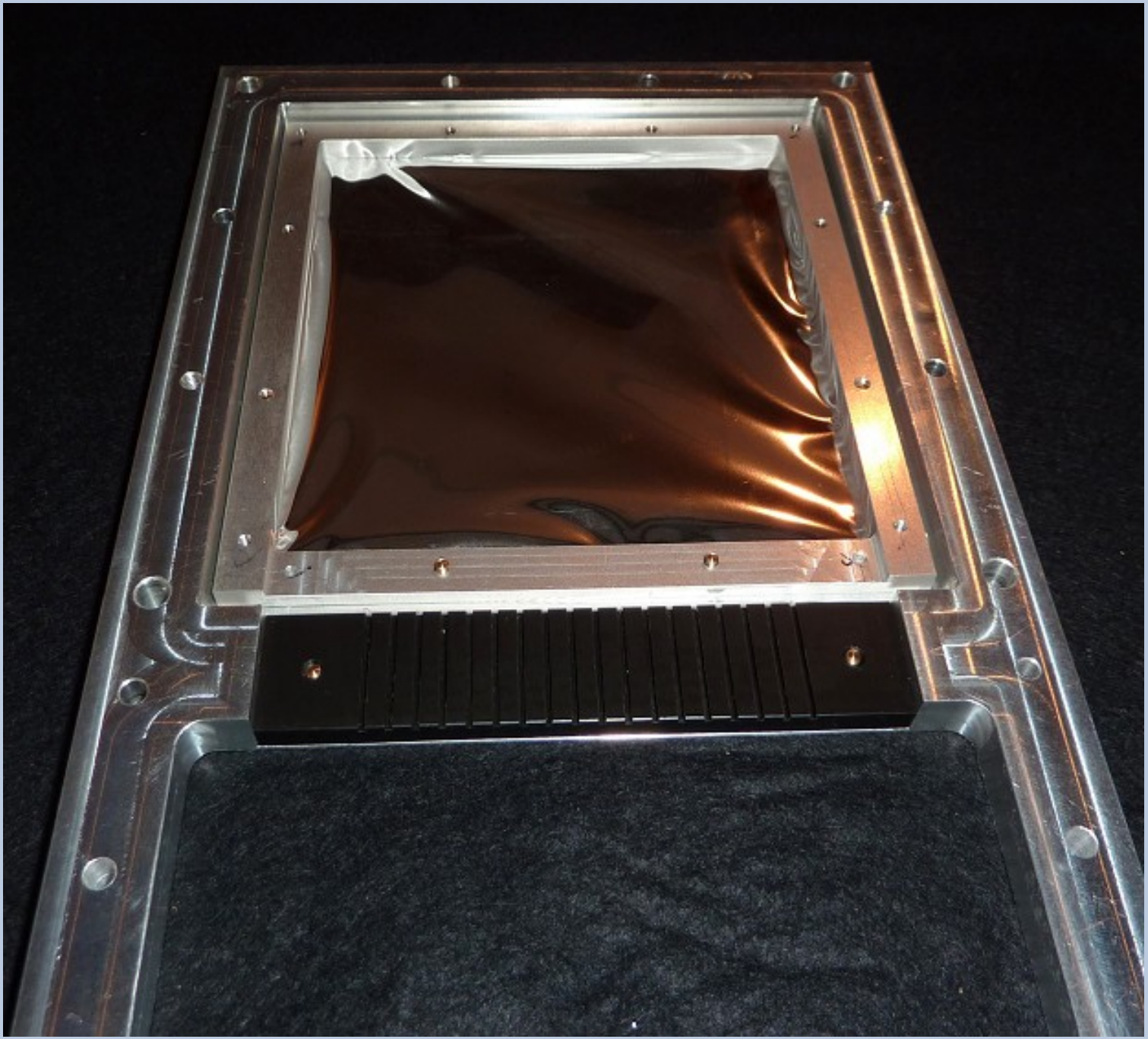
Light / EM Shield, Fibre Frame



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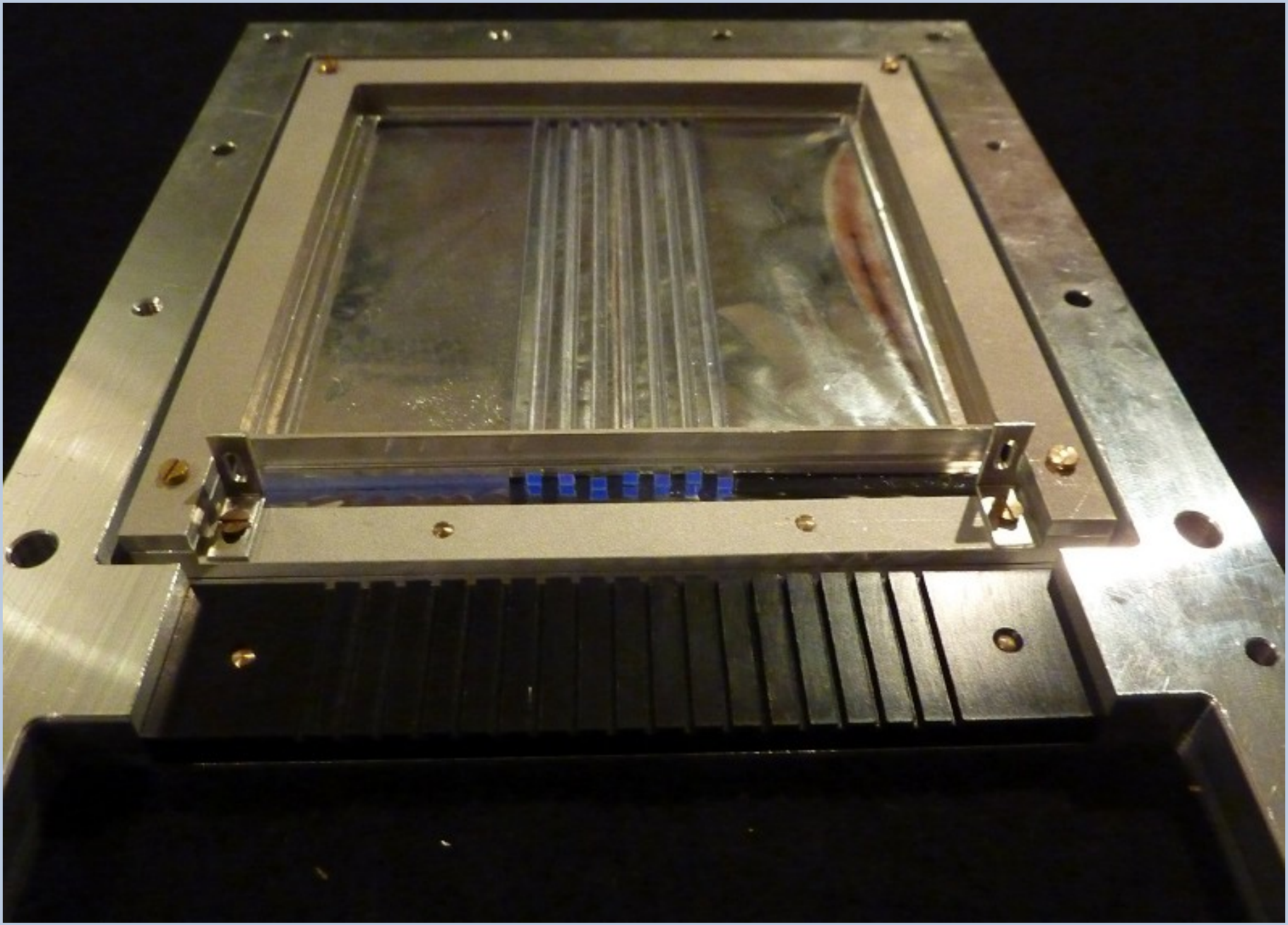
Detector Material / Sensor Holder



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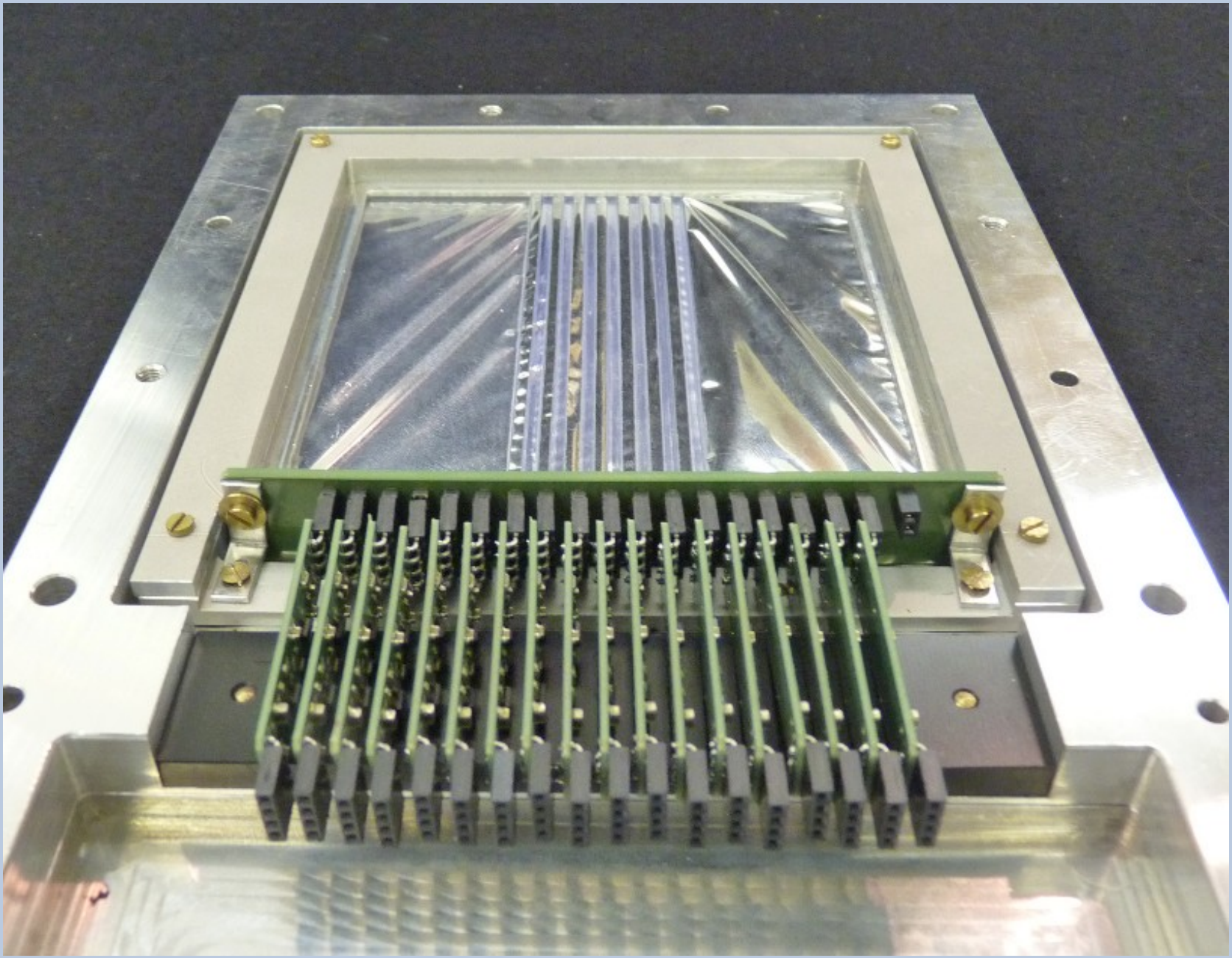
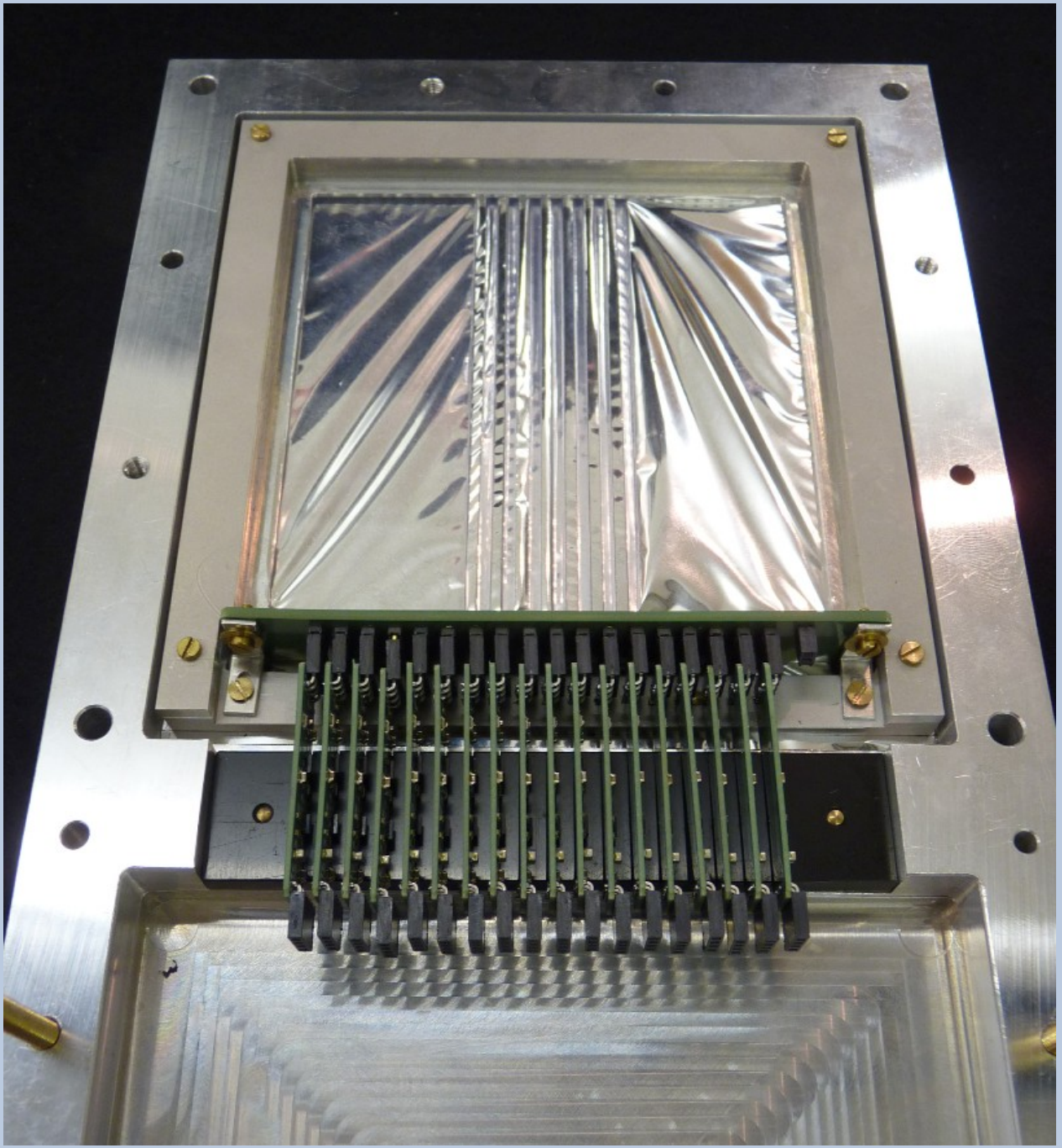
Sensors / PreAMPs





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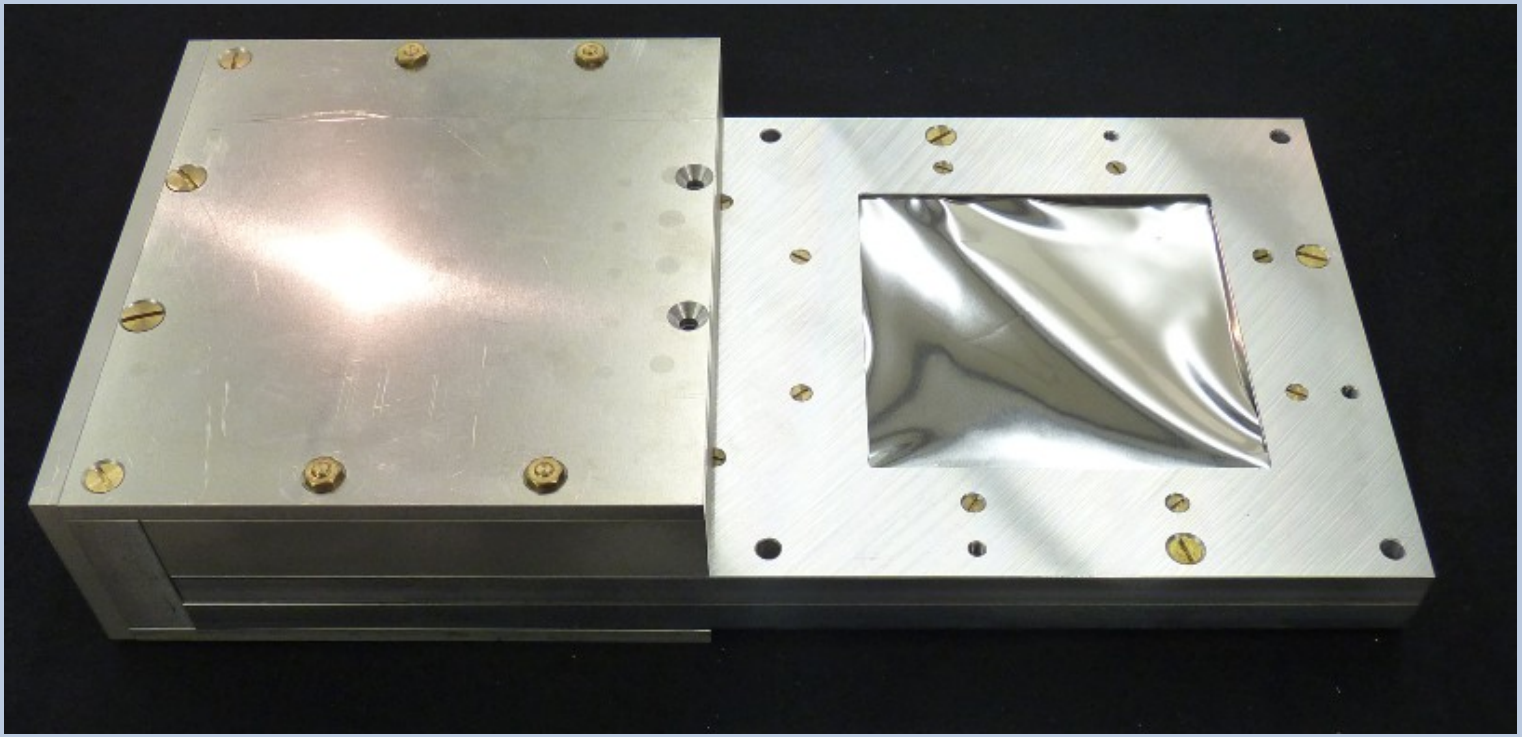
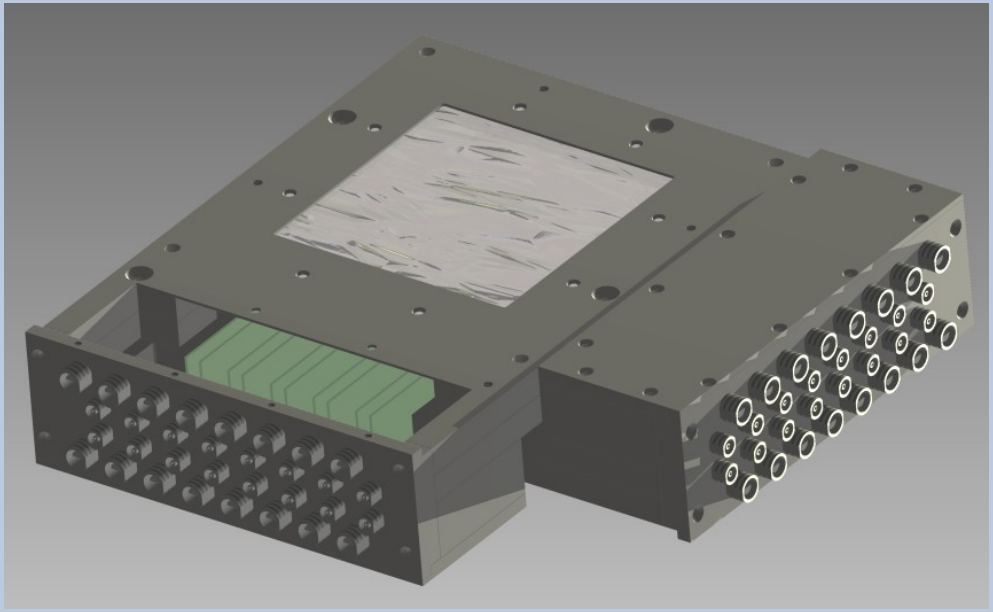
First Detector Module





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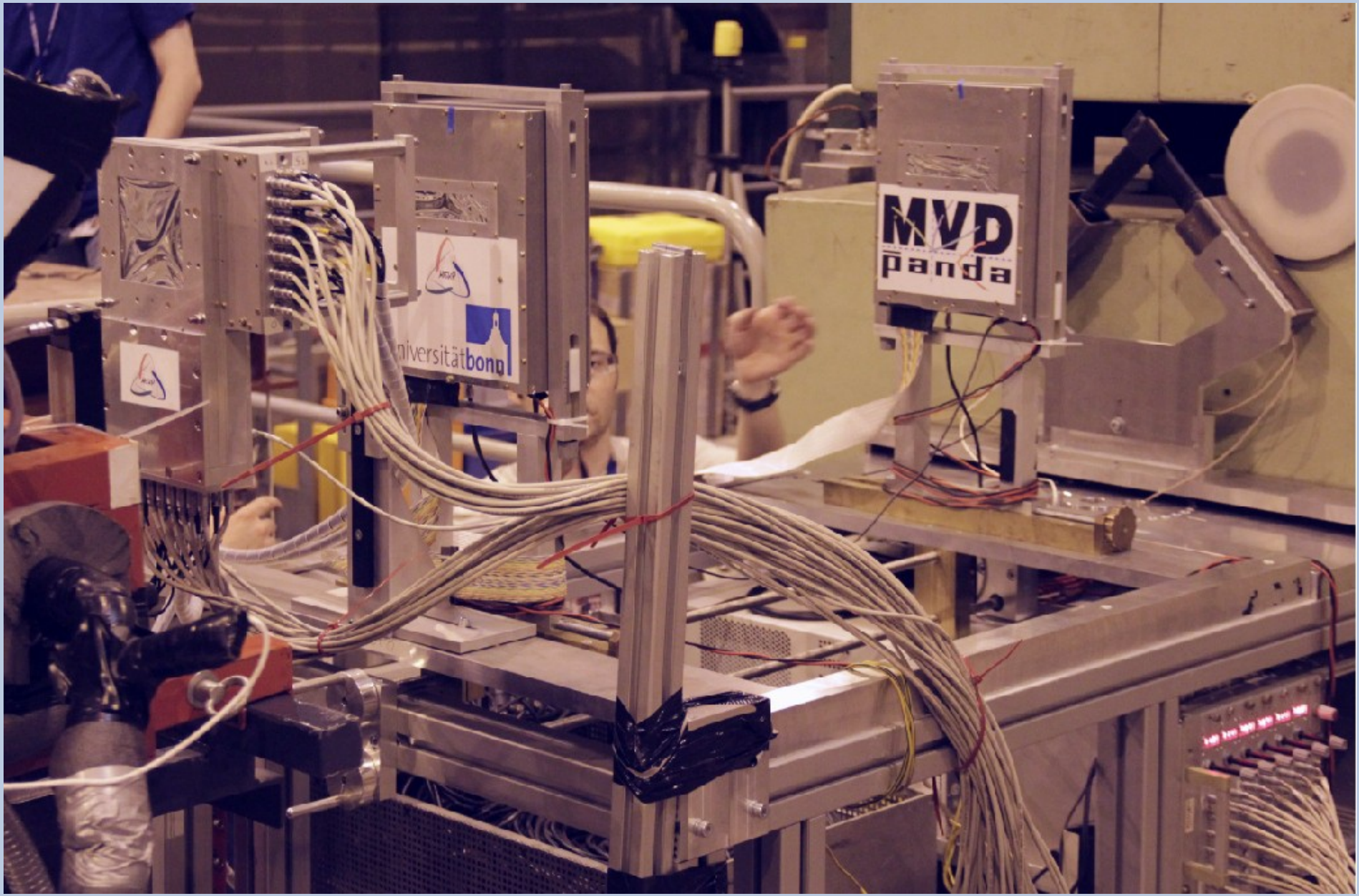
Performance at CERN



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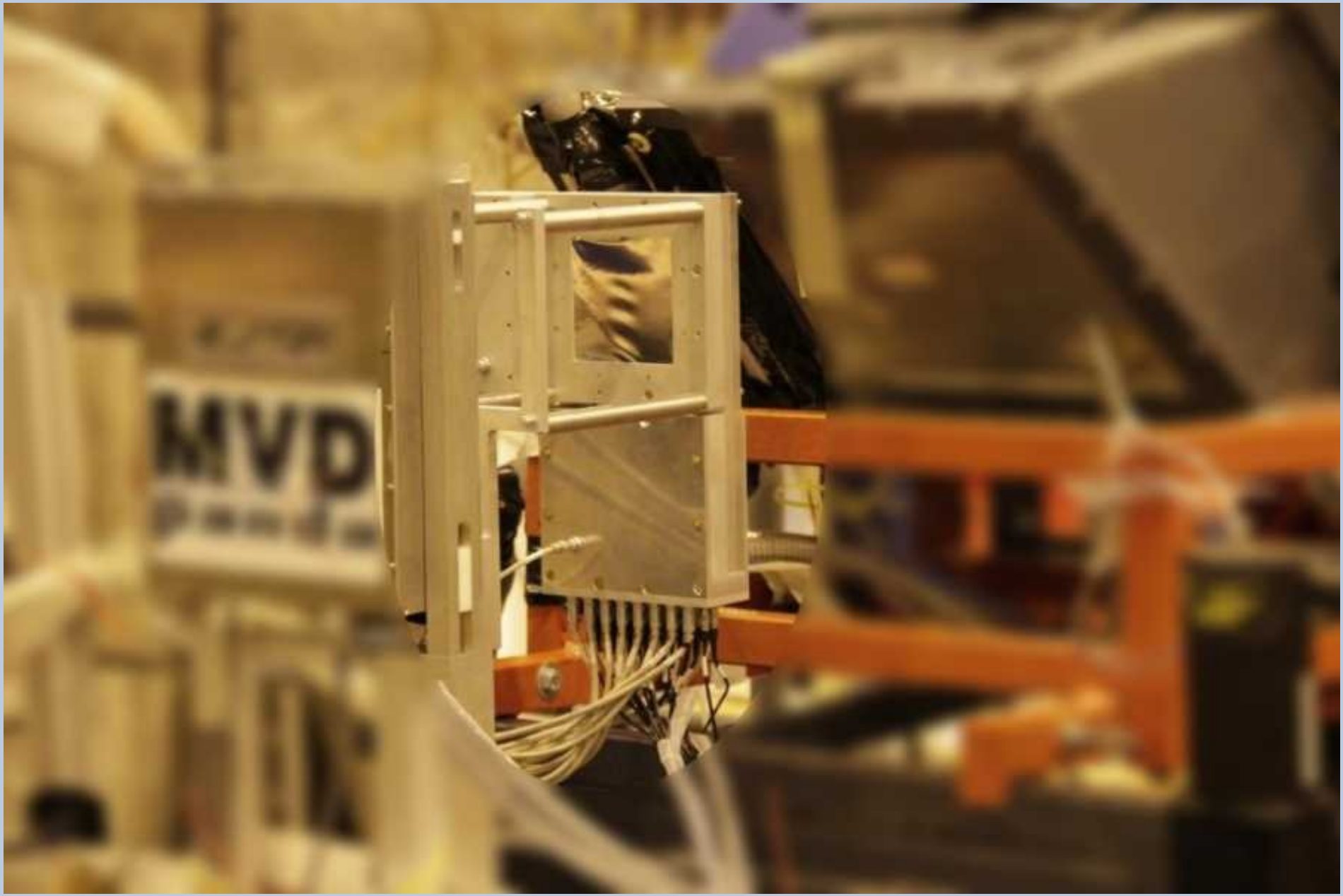
Performance at CERN



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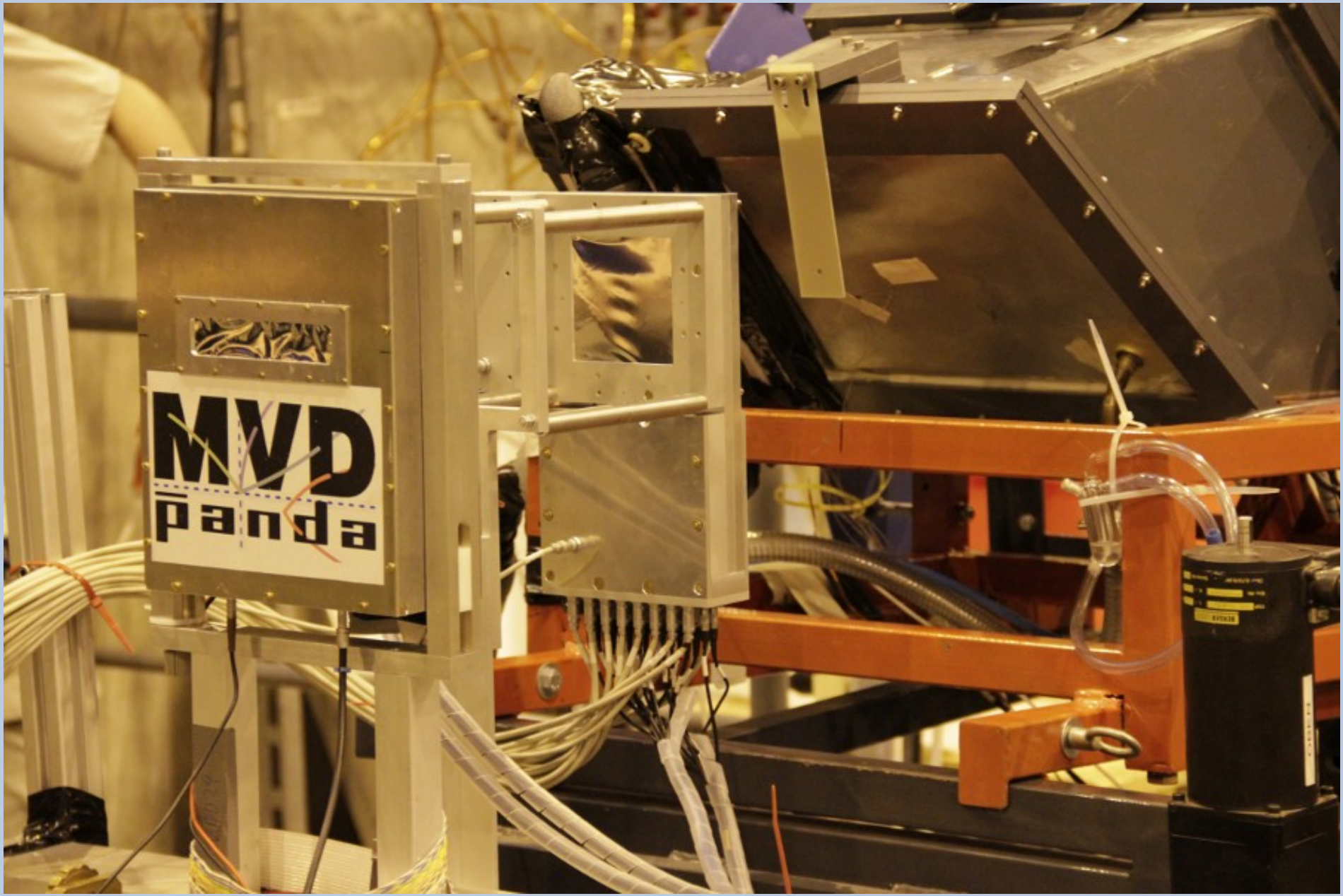
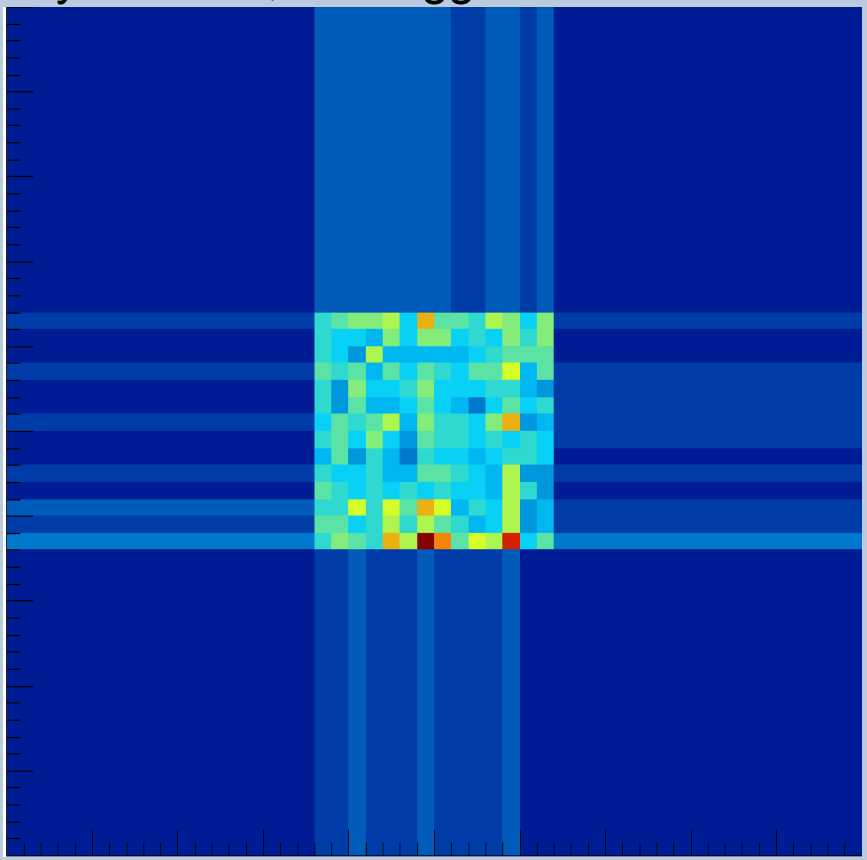
Performance at CERN



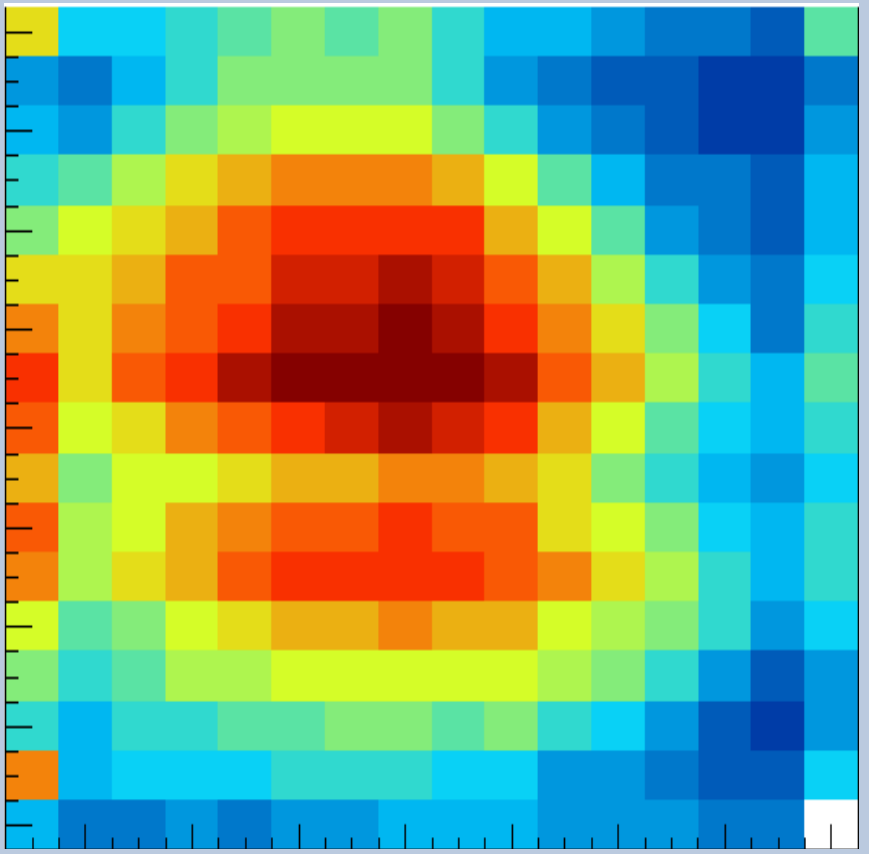
Performance at CERN

myon-beam, self trigger



- good performance
- simple and easy to use, robust detector

positron-beam, external trigger



- siginificant temperature drift:
  observed during 10 K thunderstorm drop
  - SiPM V_{Br}
  - Bias Supply
  - PreAMP, ...

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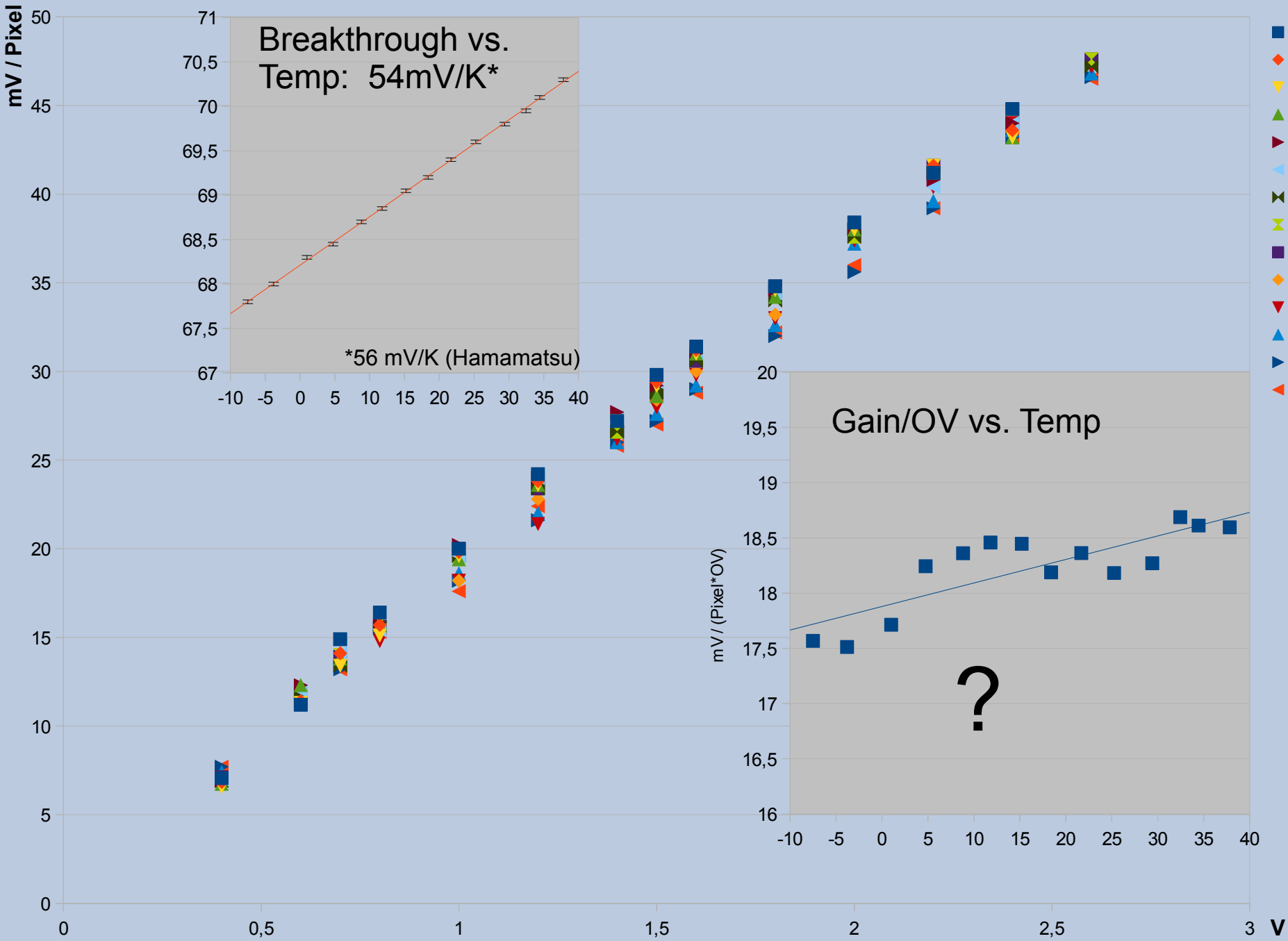
Gain vs. OV : ~18,5 mV / (V · Pixel)



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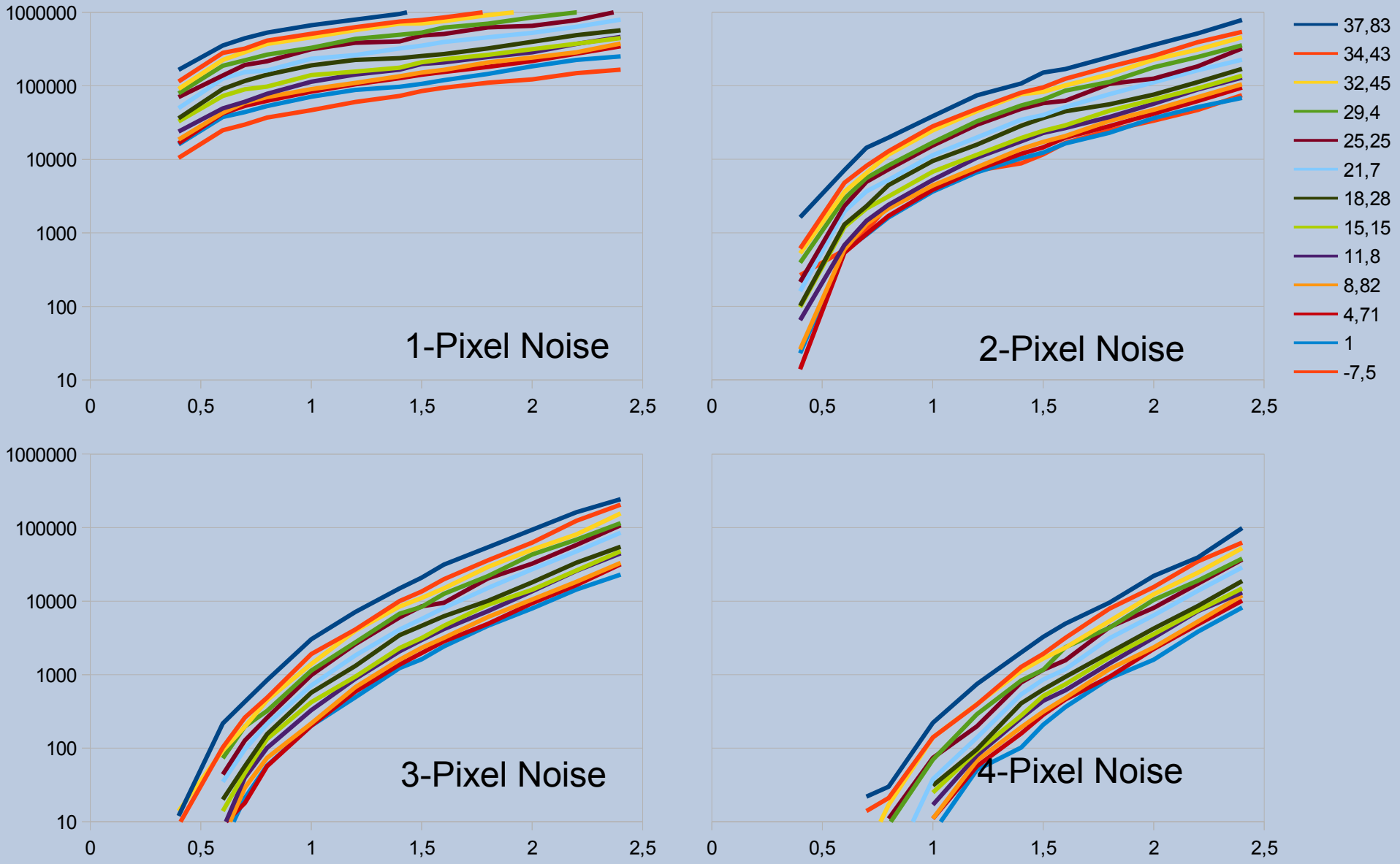
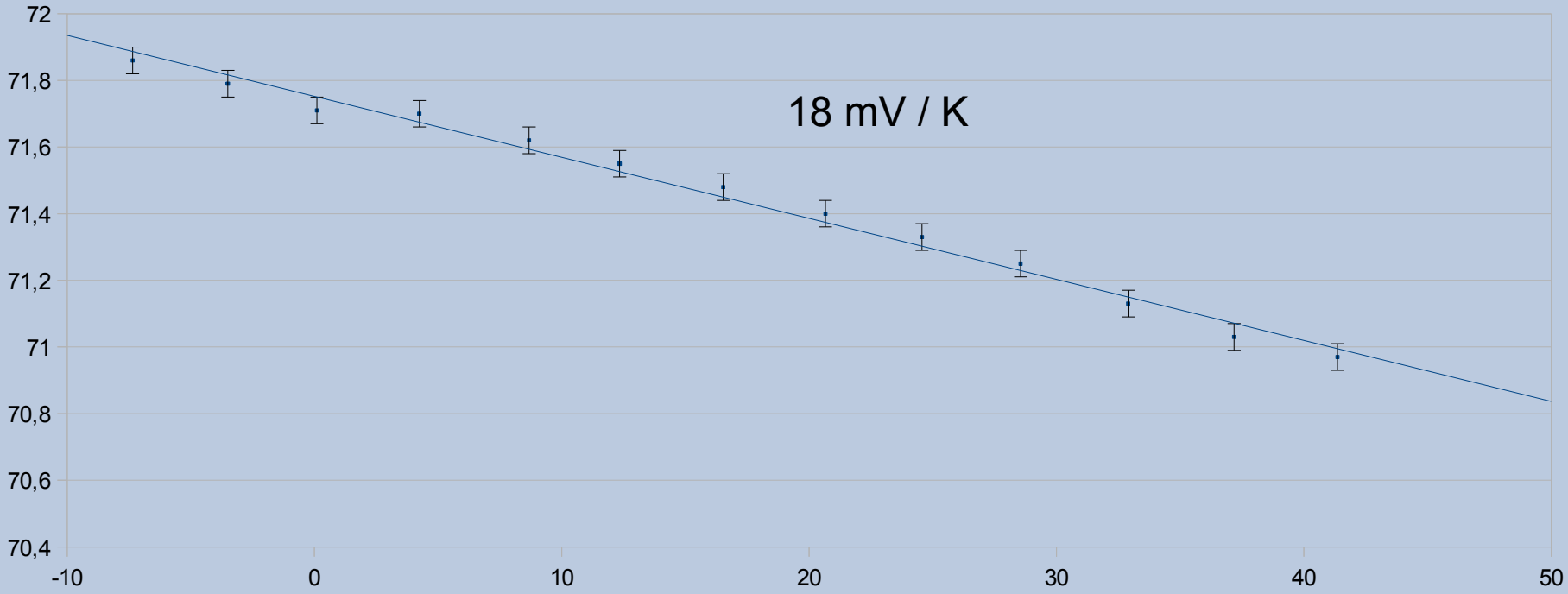
SiPM- Noise vs. OV

~ 1 Order of Magn. / 40 K (dep. on OV)



Bias Powersupply



- drift enhances (32%) breakthrough effect
- responsible component identified

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Roadmap

Detector:
temperature control for SiPM, AMP and PS
data analysis

Detector Cosmetics:
smaller connectors, differential output, ...

Inorganic Fibres:
installing fibres
taking data

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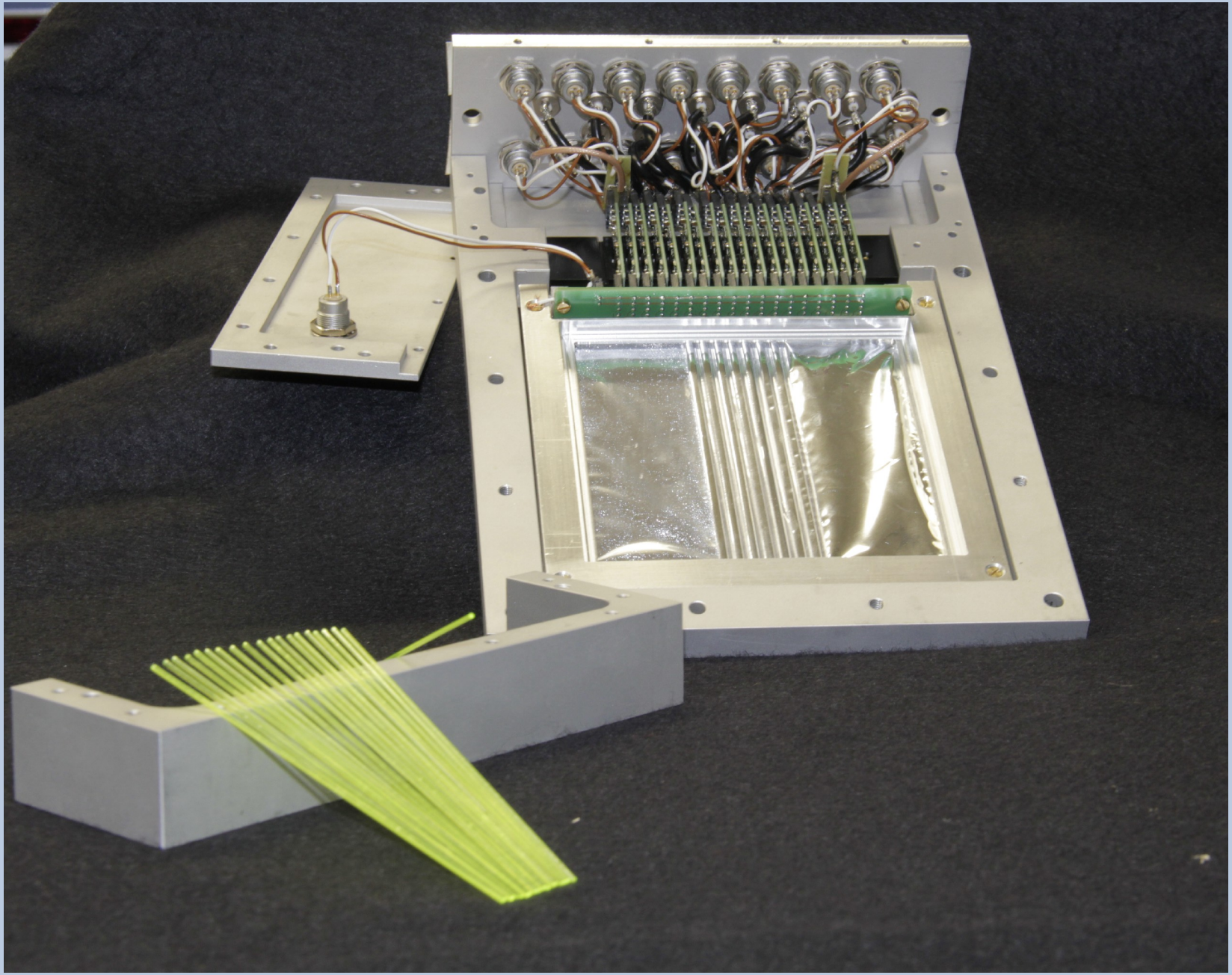
1 mm Round LUAG Fibres, 10 cm Long



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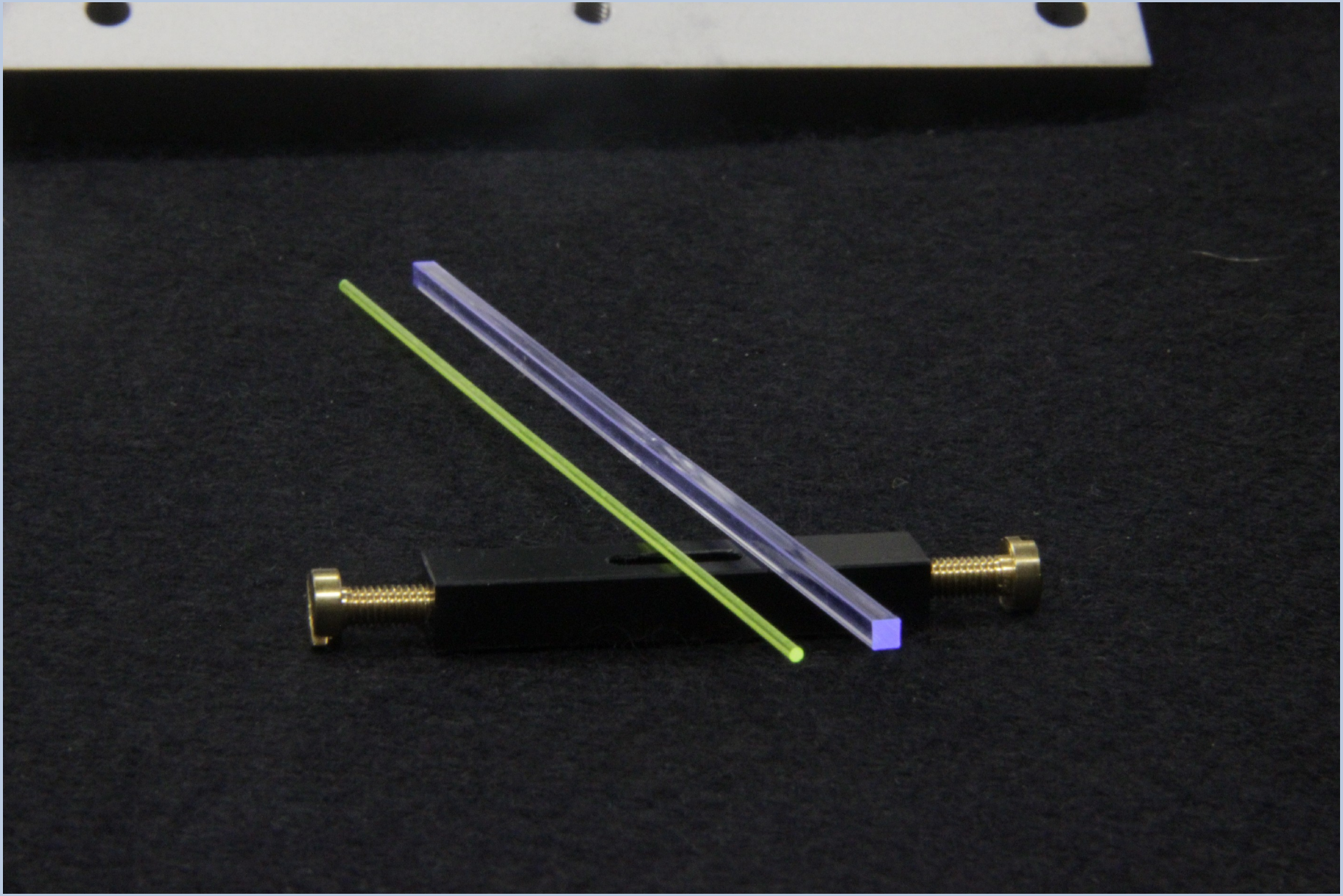
Fibres



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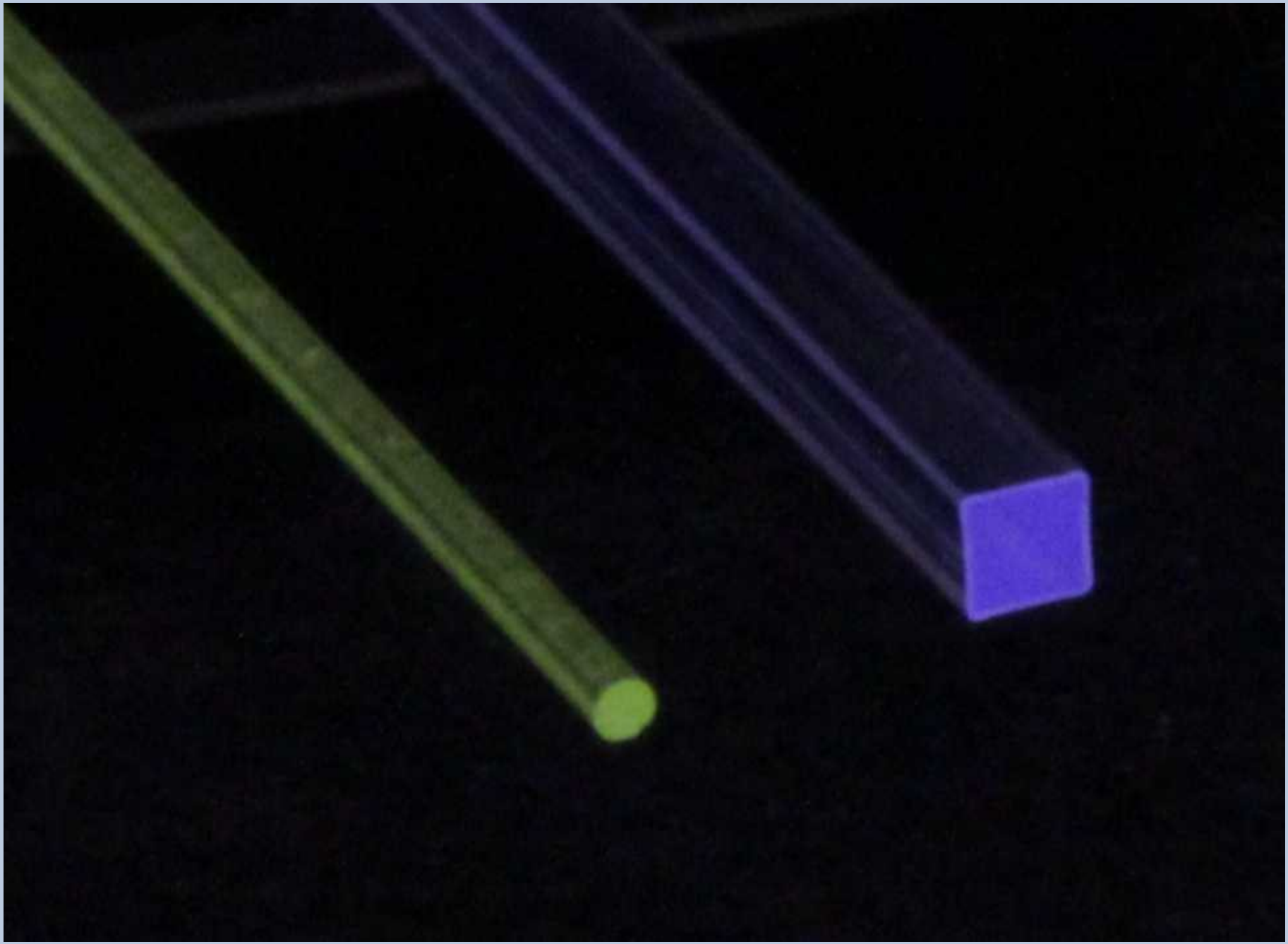
Fibre Closeup



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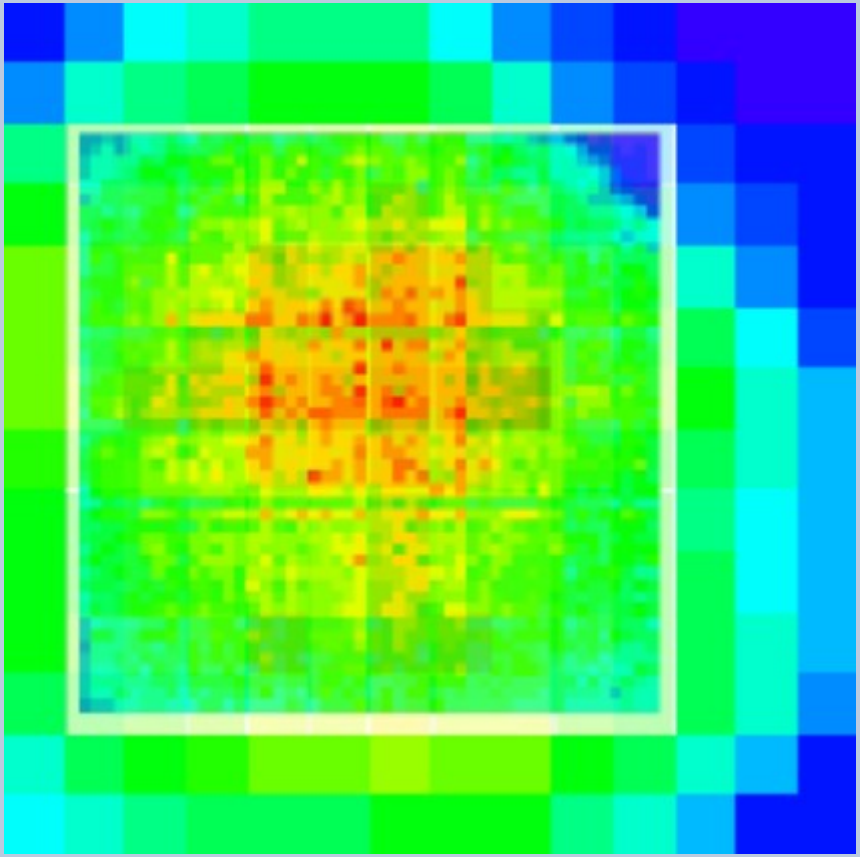
Detector Matching

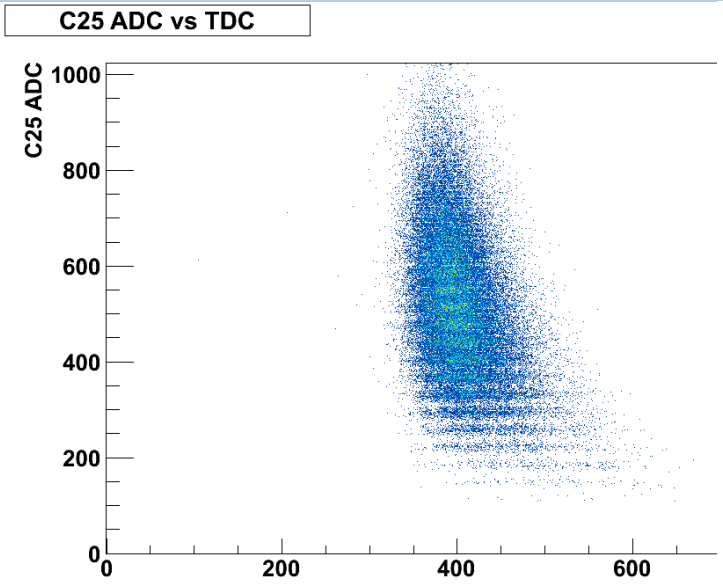
Large Area: Fibre Detector

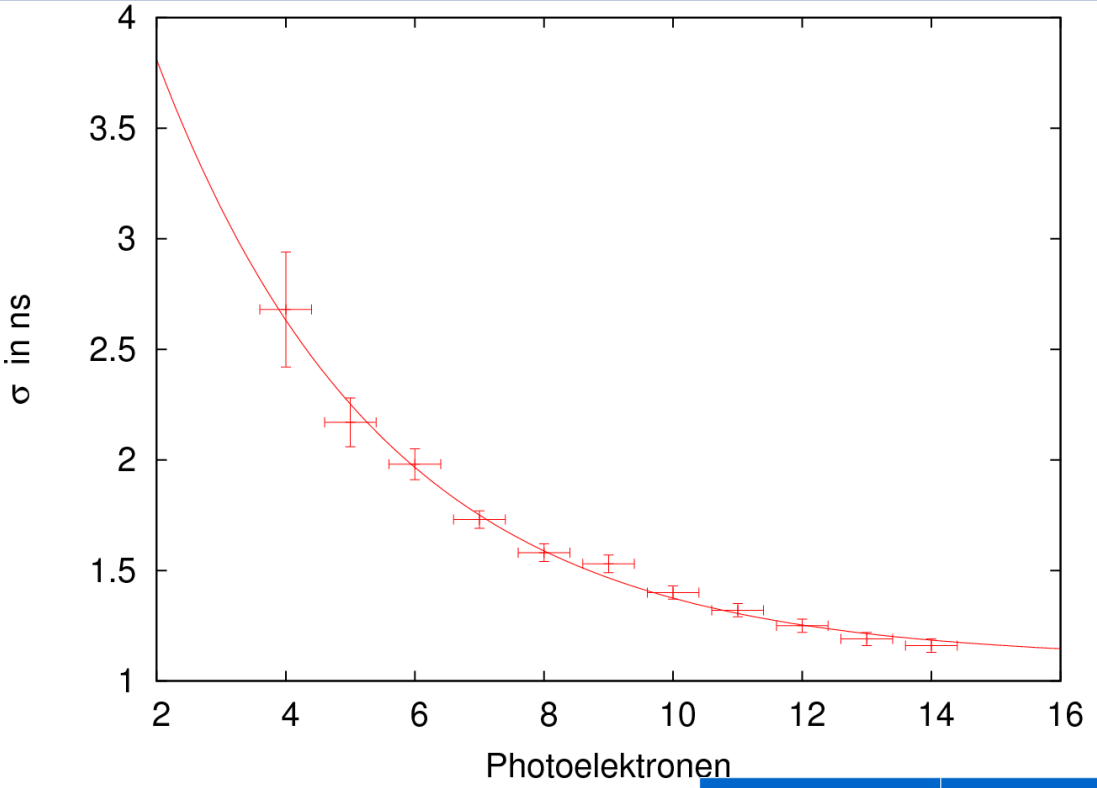


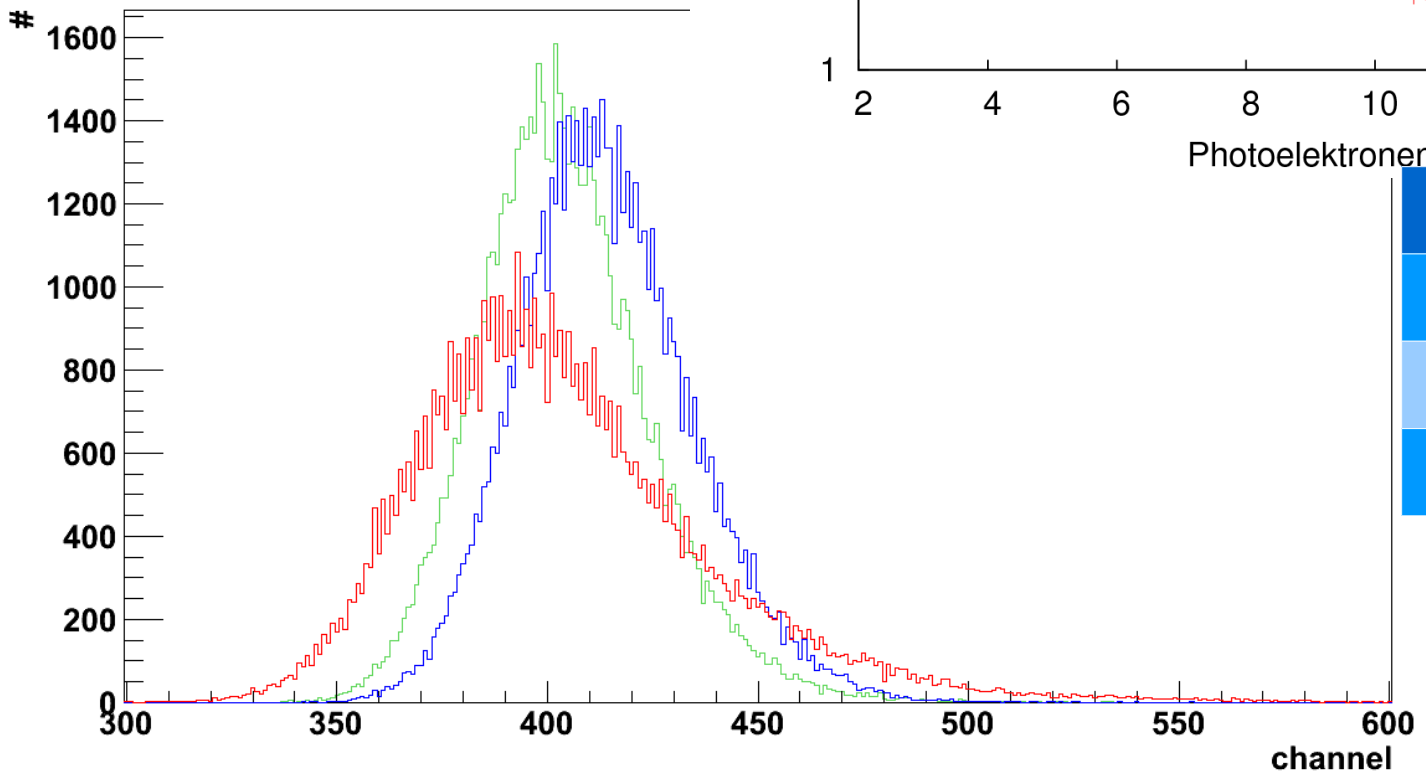
Center: Silicon Strip Detector

*different colour scale

Time Resolution







Model	Sigma
100 C	0,90 ns
50 C	0,94 ns
25 C	1,28 ns

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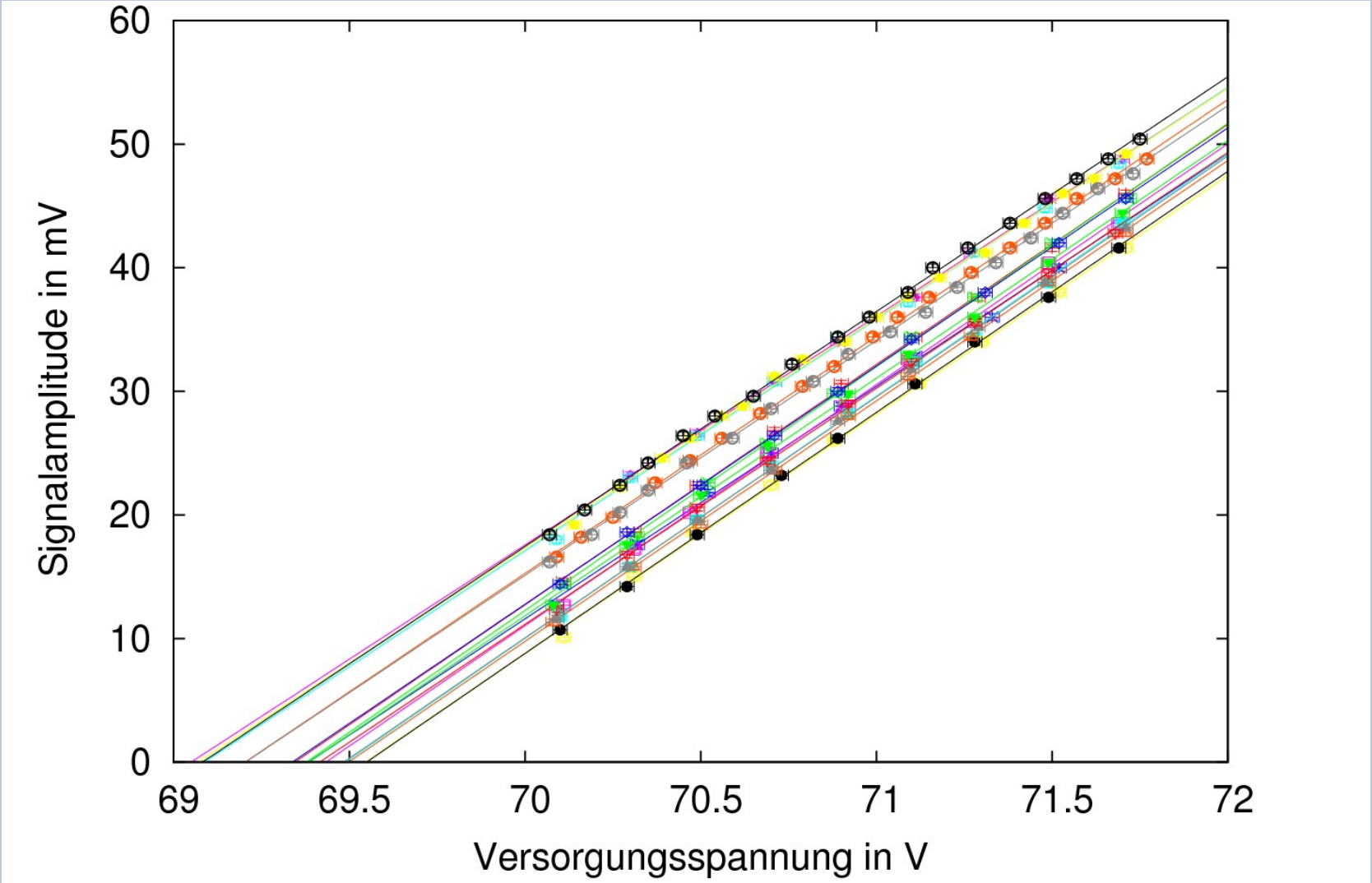
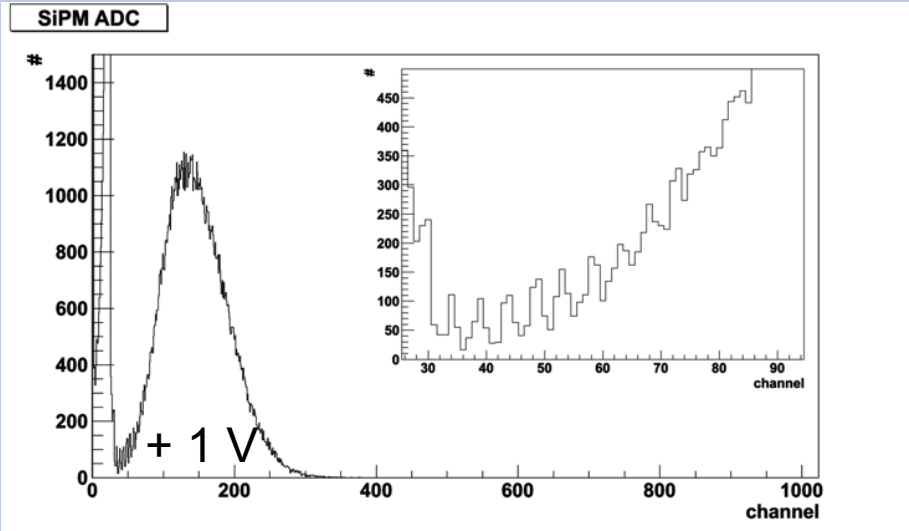
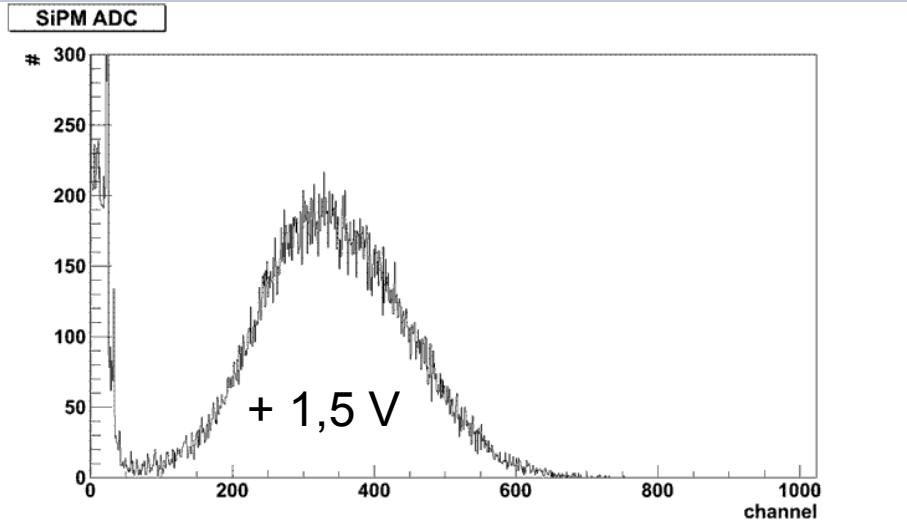
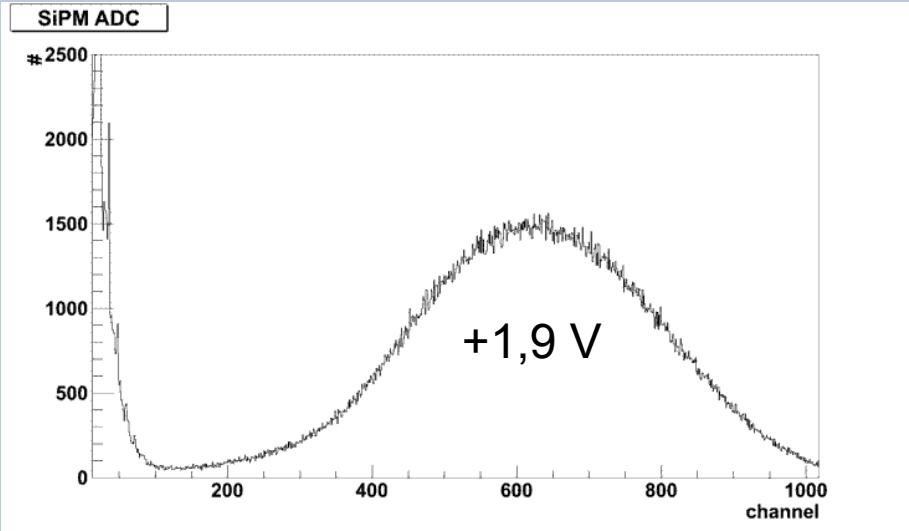
Breakthrough Determination

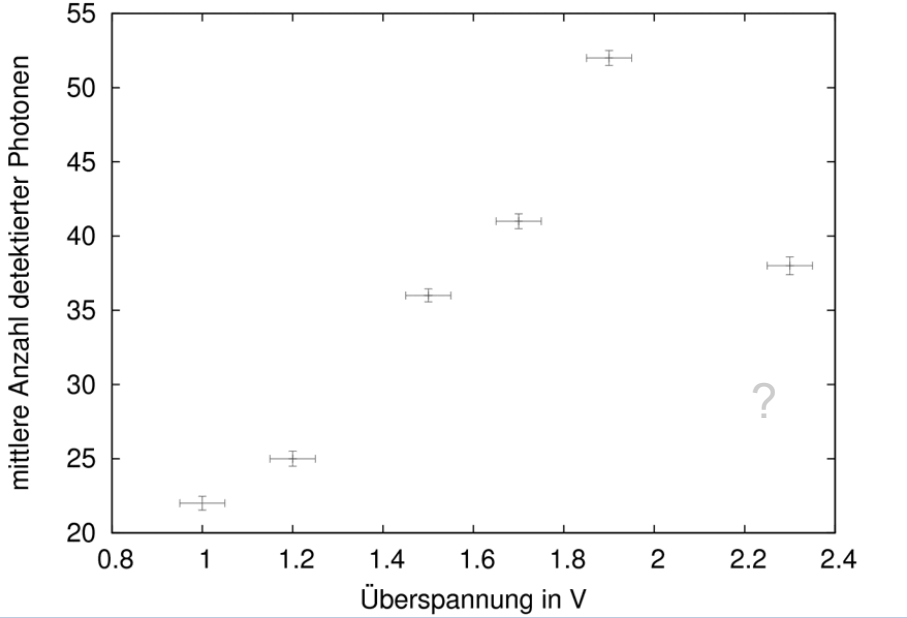


Overvoltage Determination







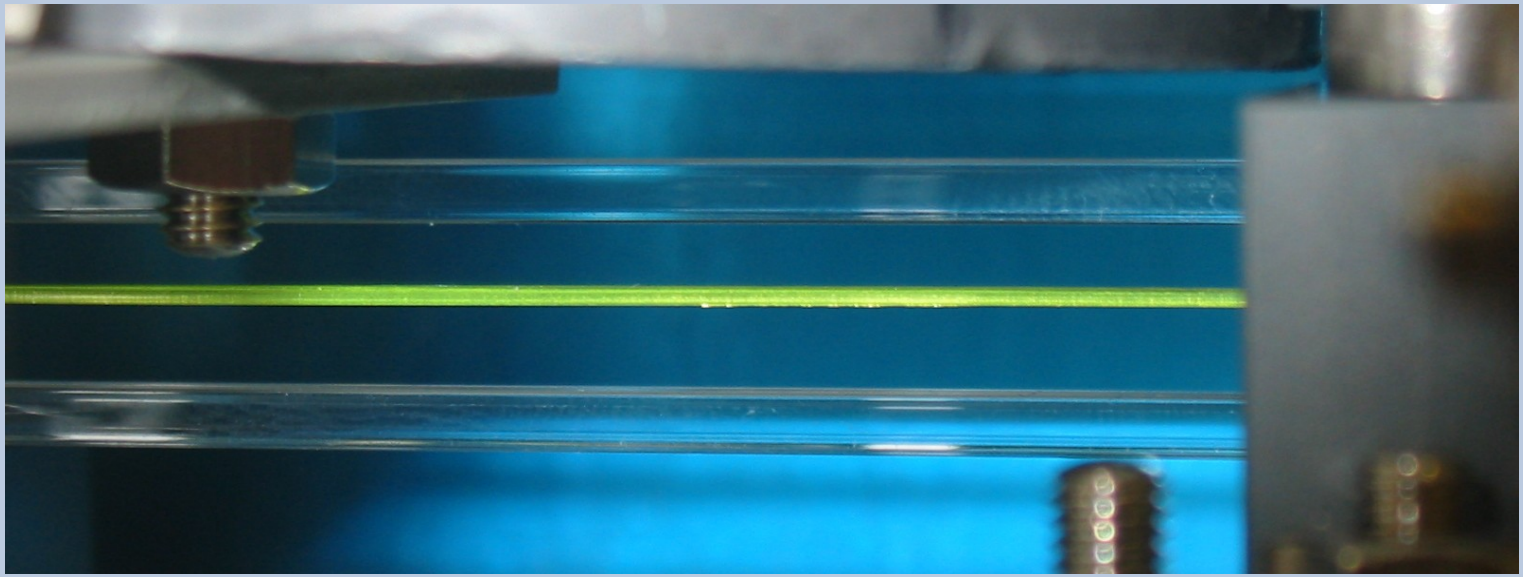


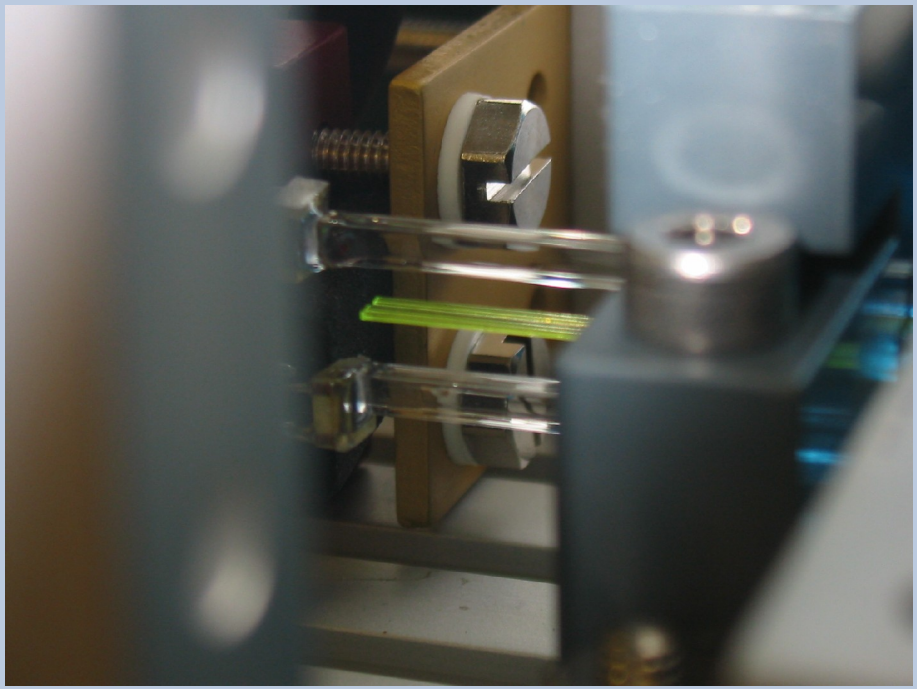
1st Inorganic Fibre Tests

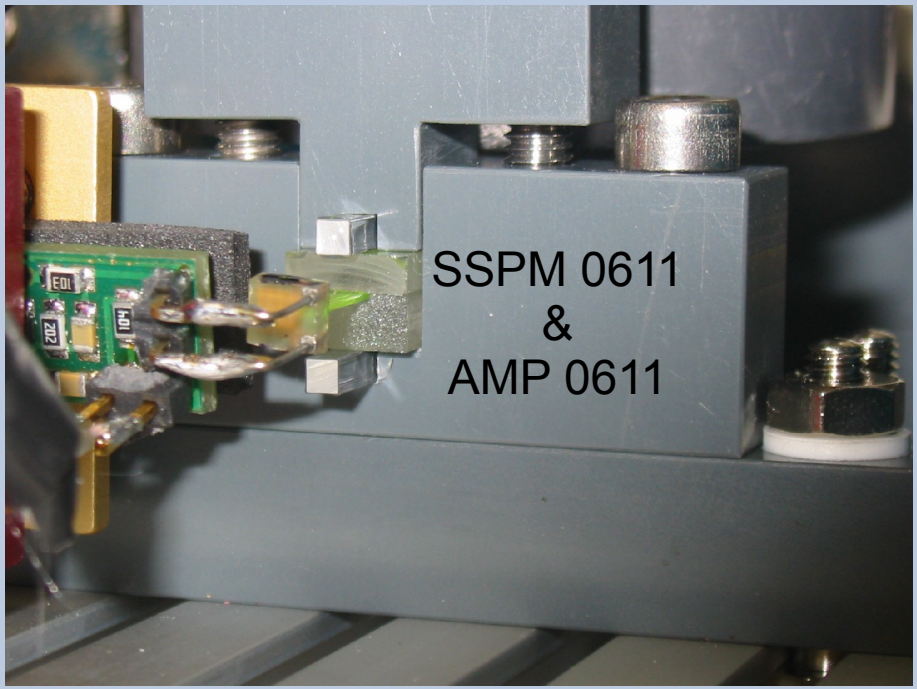
BCF12

YAG : Ce

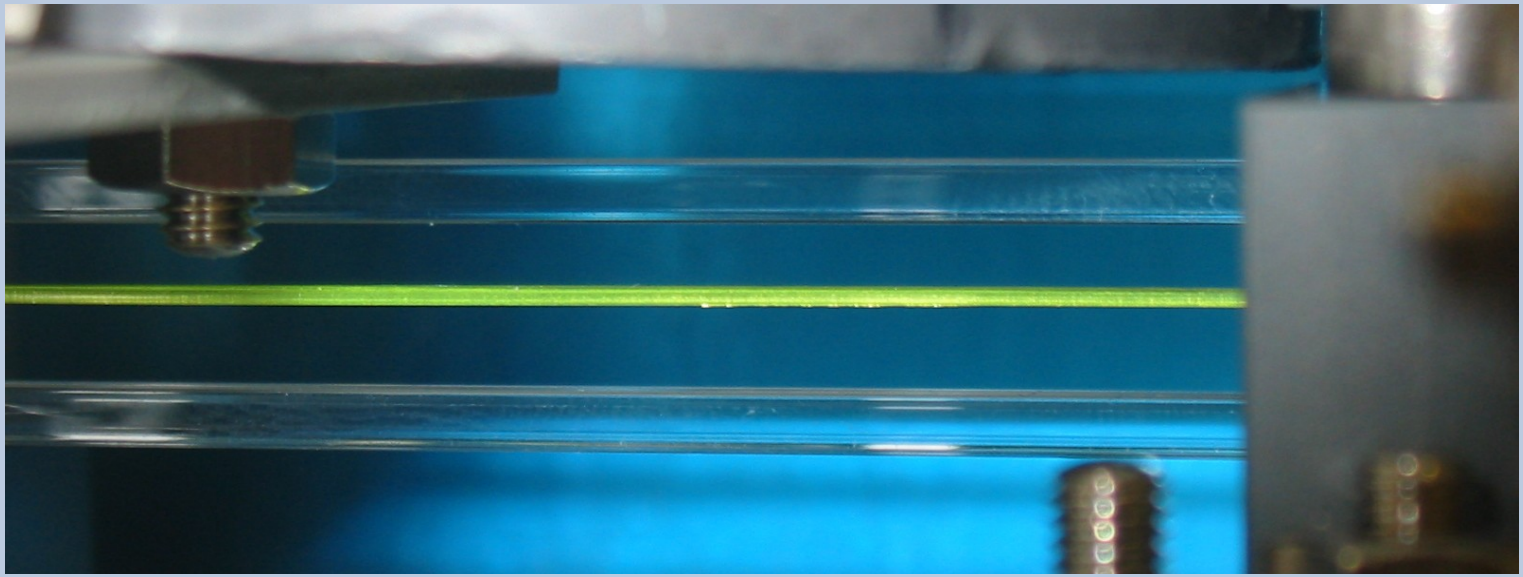
BCF12





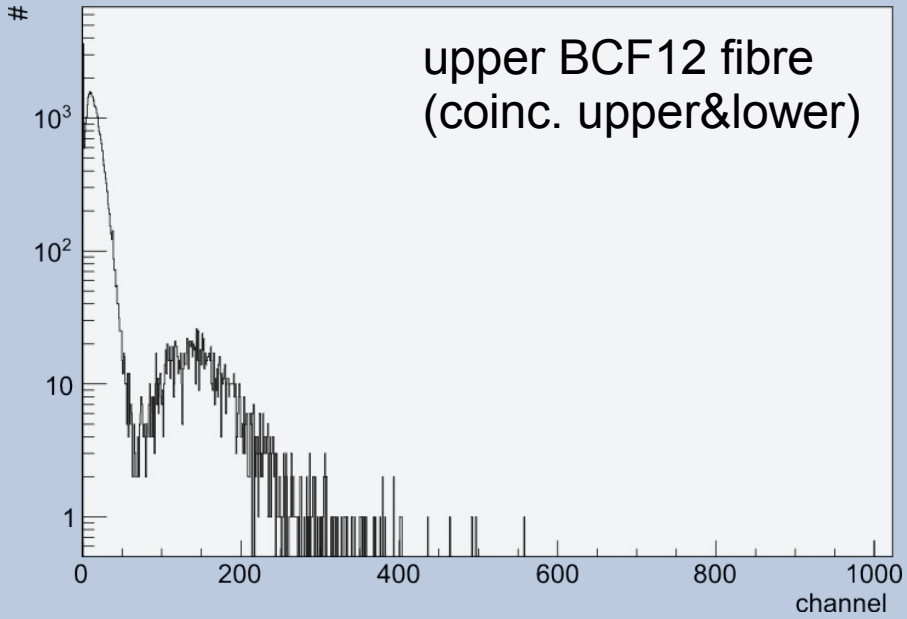


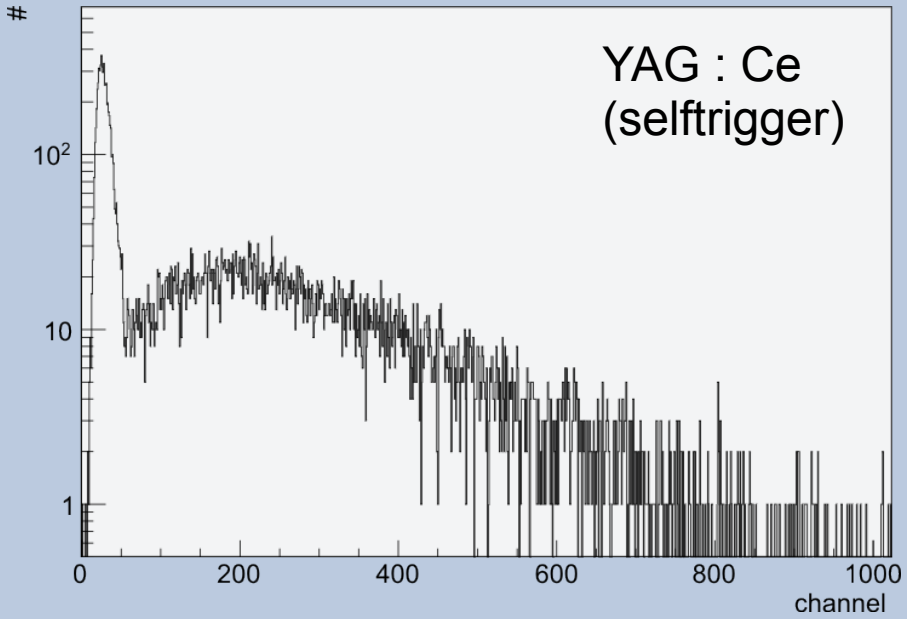
Expected Response



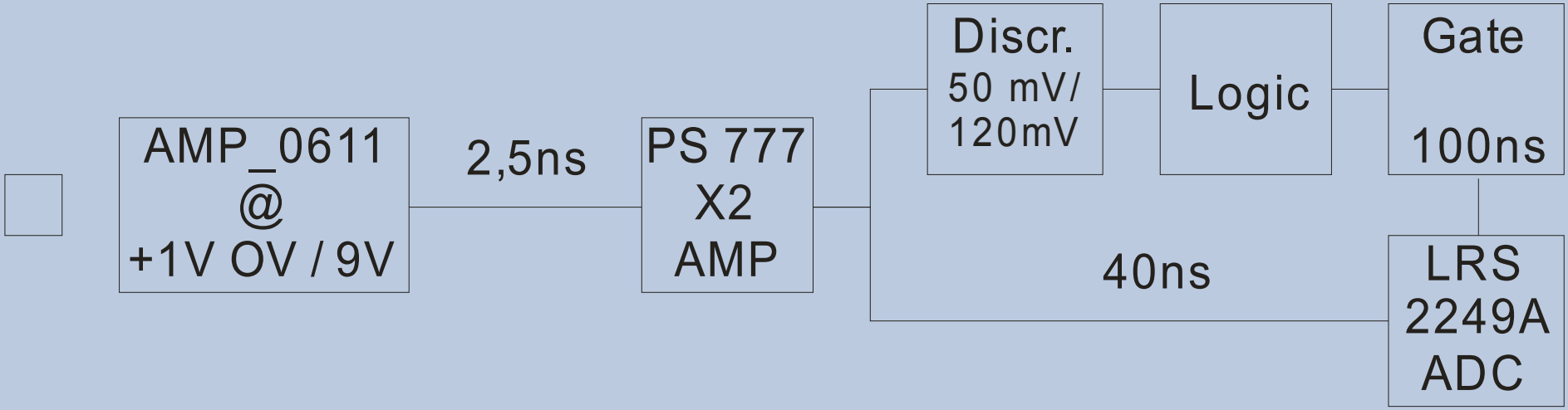
2 mm square organic (i.e. BCF 12 MC)		0,5 mm round inorganic YAG : Ce
1,8 - 2,6 MeV * cm / g	Material	1,4 - 2,4 MeV * cm / g (*)
1,9 - 2,7 MeV / cm	1,05 g/cm³ Density 4,57 g/cm³	6,4 - 11,0 MeV / cm
0,38 - 0,55 MeV	2 mm Thickness ~ 0,35 mm	0,22 - 0,38 MeV
3024 - 4368 Ph	8k Ph/MeV Lightyield 12k-25k Ph/MeV	2911 - 9597 Ph (**)
221 - 319 Ph	>7,3% Trapping Eff. ~ 5%	146 - 480 Ph
55 - 80 Ph	25% PDE @ λ 18%	26 - 86 Ph
	Coupling	

Measured Response

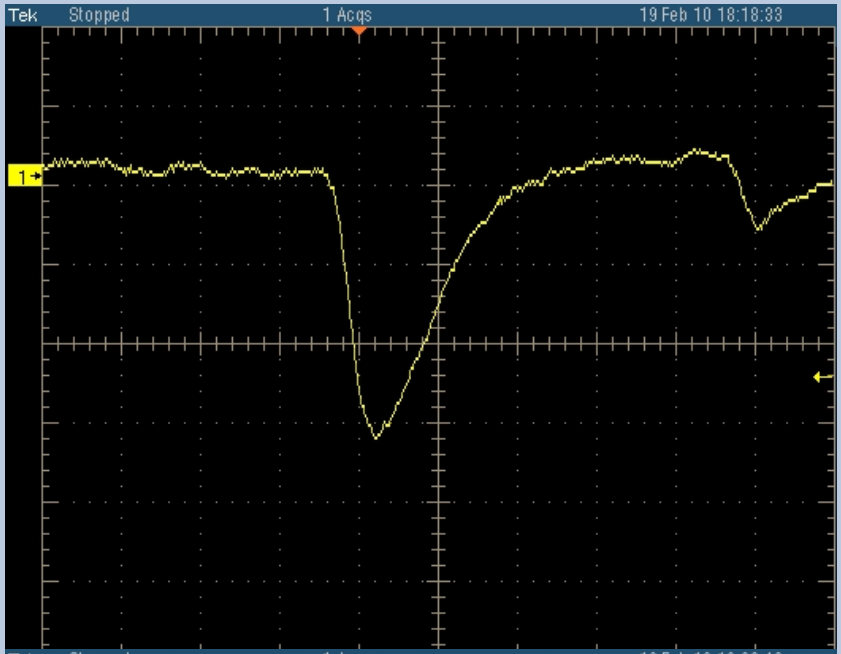




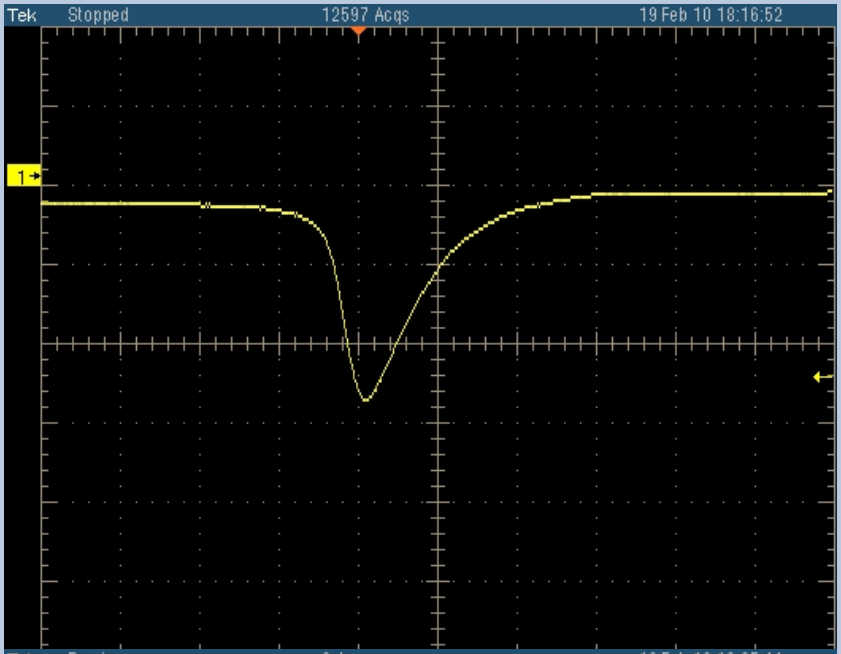
~20 Ph / 100 Ch



Pulse Form



2 AMPs
&
8m Cable



Noise

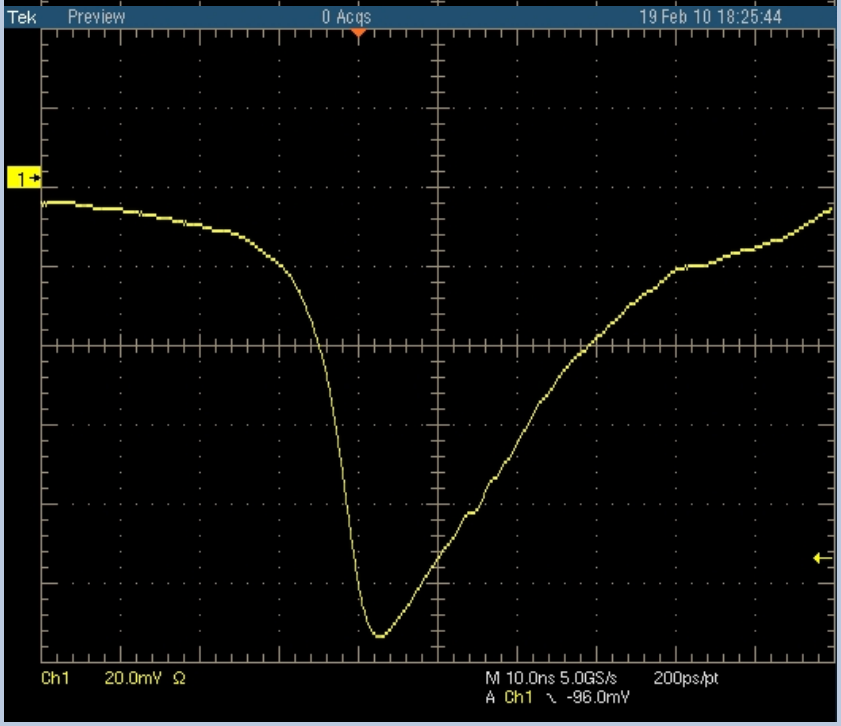
4 ns
Rise

13 ns
Decay

YAG : Ce

13 ns
Rise

42 ns
Decay



TPC Start Detector

inorganic scintillating fibres (abandoned spring 2009)

- bright, but... high Z →
  - high photon conversion propability
  - large proton scattering angle

two layers of ~300 square (2 mm) plastic scintillator fibres (MC)

- small scattering angle
- ~ 20 photoelectrons at 30 cm
- fibre tests finished