QFib Test Beam

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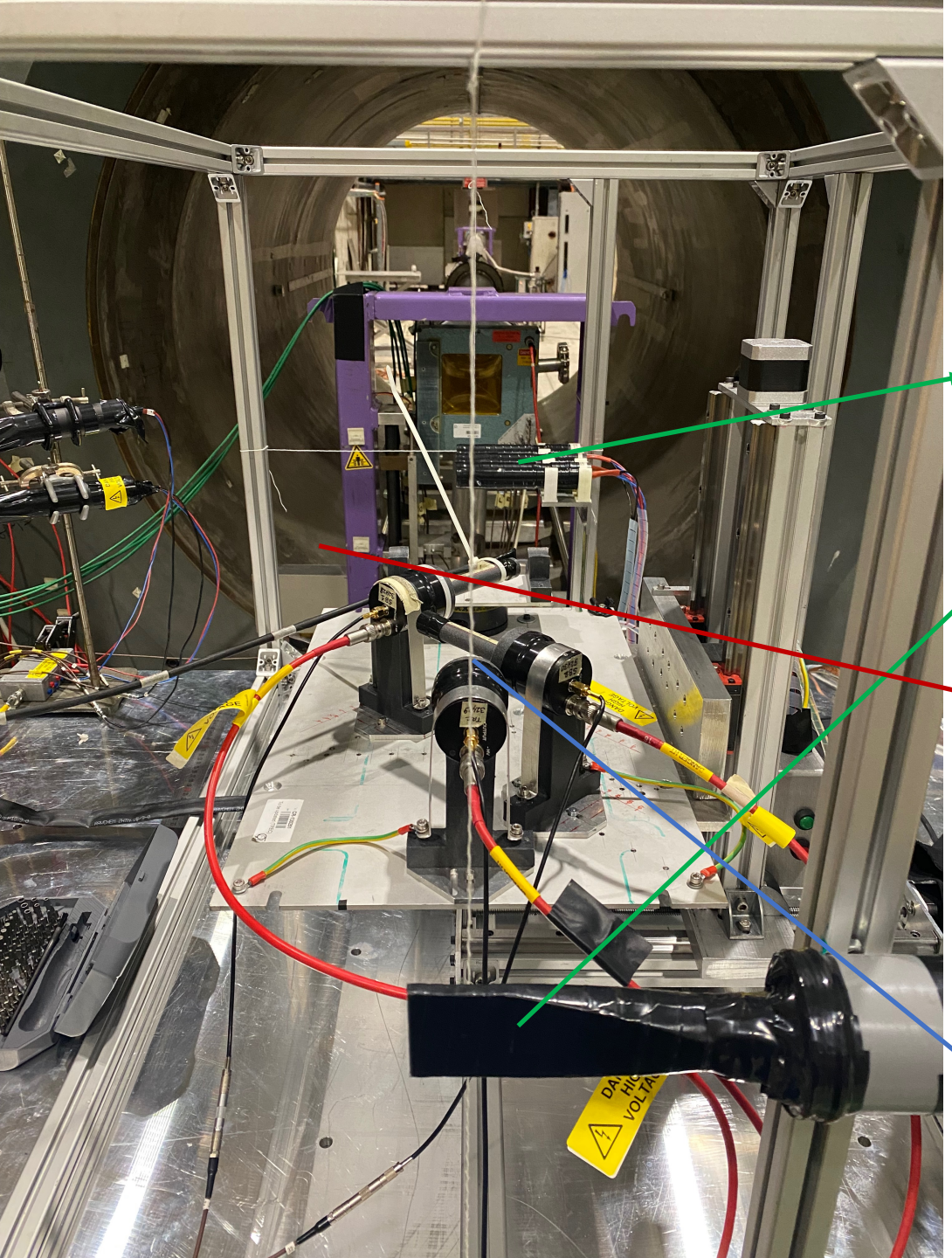
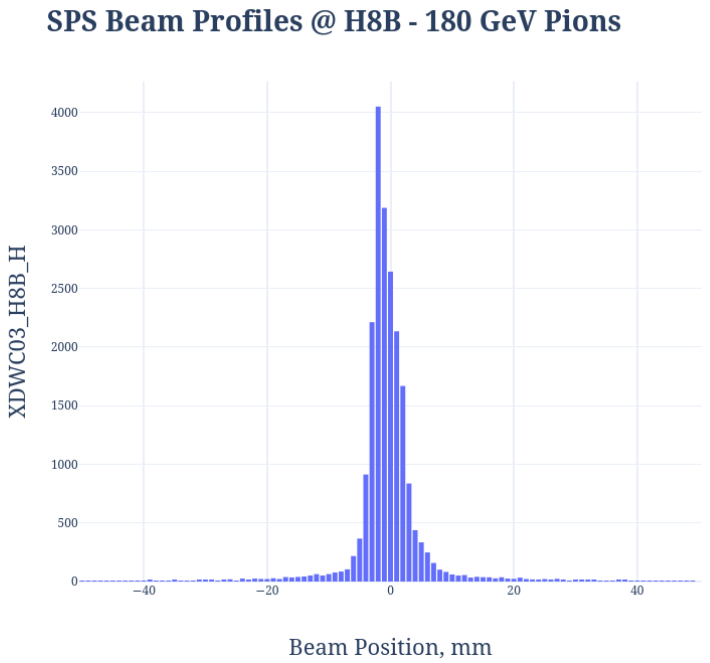
QFib Test Beam Setup

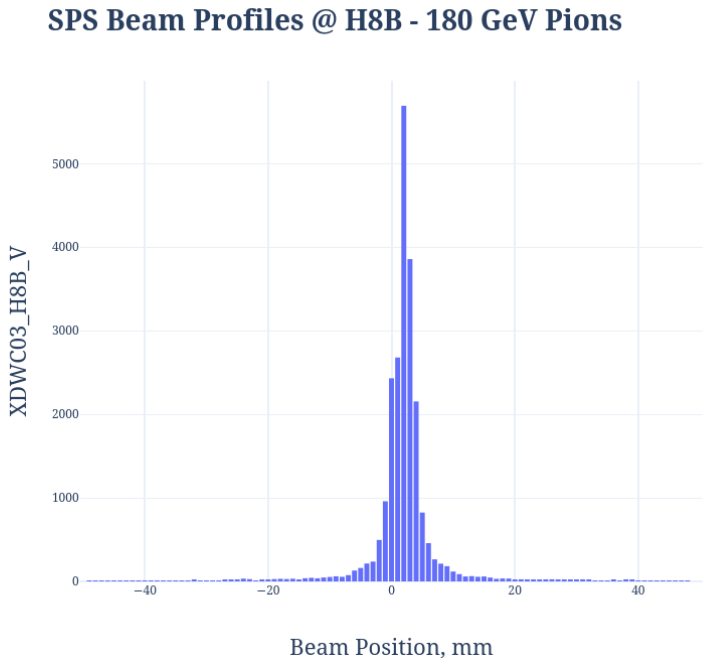


Beam defining counters
Beam defined as 5mm diameter or $10x10mm^2$ according to combination of coincidence of beam counters

DUT: Detector Under Test
- 1.5m long HF-PPP fibers + MCP-PMT/PMT
- 2.5m long HF fiber bundle + MCP-PMT
- 12cm Polymicro fiber bundle + MCP-PMT
- 8cm Polymicro High NA fiber bundle + MCP-PMT
- 12cm Polymicro fiber array(7x7) + MCP-PMT

TRS: Time Reference System
SB1-2: MCP-PMT + Qbar doublets (two $5x5x100mm^3$), 45^o to the beam
TRC: MCP-PMT + Qblock ($12x12x25mm^3$)/UVT Plexi ($12x12x20mm^3$), Head on





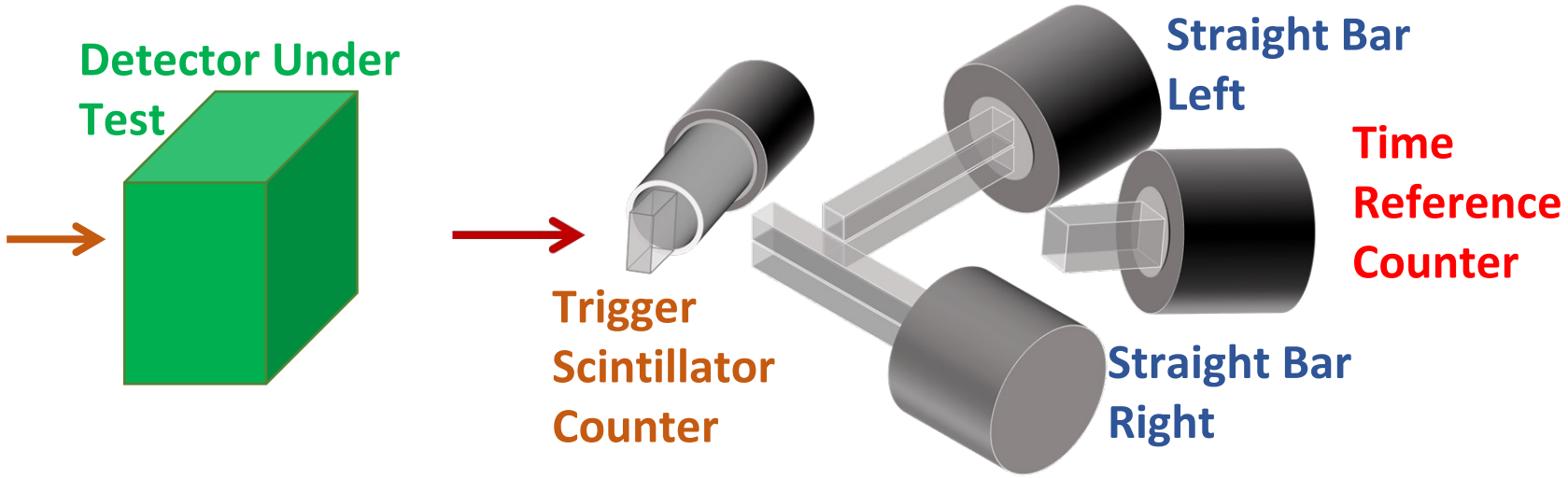
Data Taking Conditions

- 100, 120, 140, and 180 GeV pion beams were available.
- Mainly 180 GeV pion beam was used.
- In total, 57 Runs and 29 Scans were taken.
- More than 61.5 Million events were taken.

- TRS calibrated with the scans.
- Attenuation and time resolution in the different fibres were investigated

Time Reference System (TRS)

TRS consist of three quartz Cherenkov counters



Apparatus: Quartz Bars and Block + MCP (KATOD)

- 2 (identical) Slant (45°) Bars (SBL-R)
- 1 Head-on Block (0°) Time Reference Counter (TRC)

Measuring simultaneously ToF between each pair of the 3 counters, in hypothesis of independent measurements (no covariance):

$$\sigma_{12}^2 = (\sigma_1^2 + \sigma_2^2) \quad ; \quad \sigma_{13}^2 = (\sigma_1^2 + \sigma_3^2) \quad ; \quad \sigma_{23}^2 = (\sigma_2^2 + \sigma_3^2)$$

time resolution for each counter can be obtained.

After calibration the TRC (was/can be) used with DUTs

List of available fibers and dimensions

Module	Type	Core	(μm)	Clad	(μm)	Buffer	(μm)	OH−(ppm)
PPP-HF	FSHA	Silica	(300)	Polymer	(320)	Acrylate	(345)	~700
" "	FIA	Silica	(200)	F-Silica	(240)	Acrylate	(500)	<1
" "	IN	Silica	(300)	F-Silica	(316)	Polyimide	(345)	~1200
HF	FSHA	Silica	(600)	Polymer(?)	(630)	Acrylate	(800)	~500
200m roll	JTFLH	Silica	(600)	Polymer(?)	(630)	Acrylate	(950)	~???
High NA	FSU	Silica	(330)	AF(Teflon)	(350)	???	(400)	~???

For PPP-HF module:

FSHA- and FIA-type manufactured by Polymicro Inc. (USA)

IN-type fibers manufactured by INFOS (Russia)

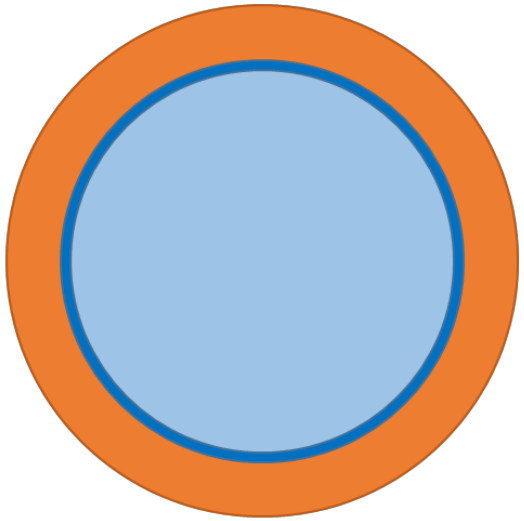
For HF modules:

FSHA-type manufactured by Polymicro Inc. (USA)

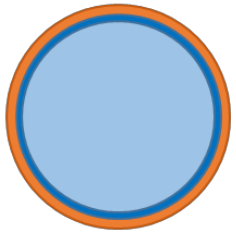
We are also testing plastic clear fibers' bundles (from Kuraray)

Assemblies of fused silica bars and rods (from HERAEUS) will be tested soon

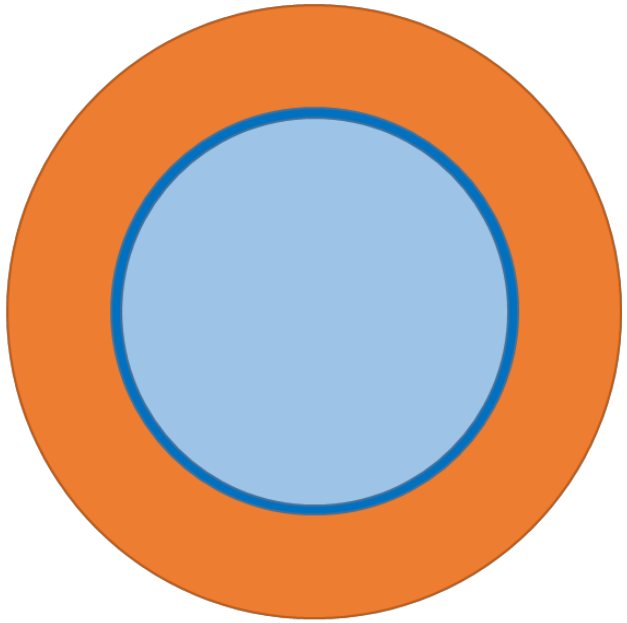
Polymicro (MOLEX) Fibers tested



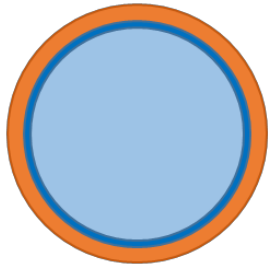
HF： FSHA600630800 (OH- 500ppm)



PPP-HF： FSHA300320345 (OH- 700ppm)

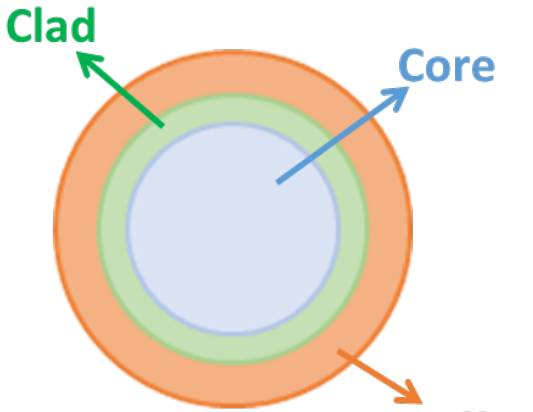


JTFLH600630950 (OH- ??? ppm)
(≈ 200m spool)

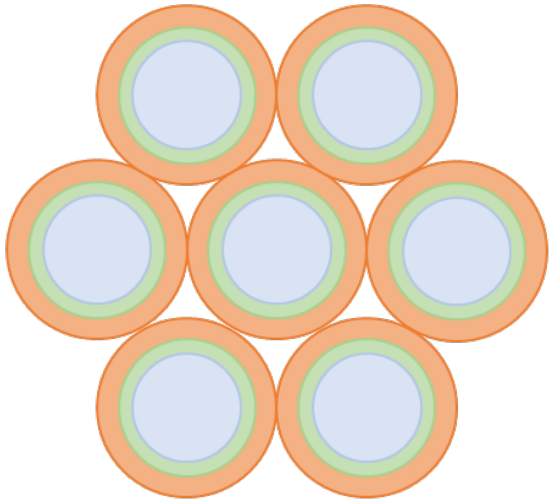


High N-A： FSU330350400 (OH- ???ppm)
(≈3m)

Fibers' Assemblies

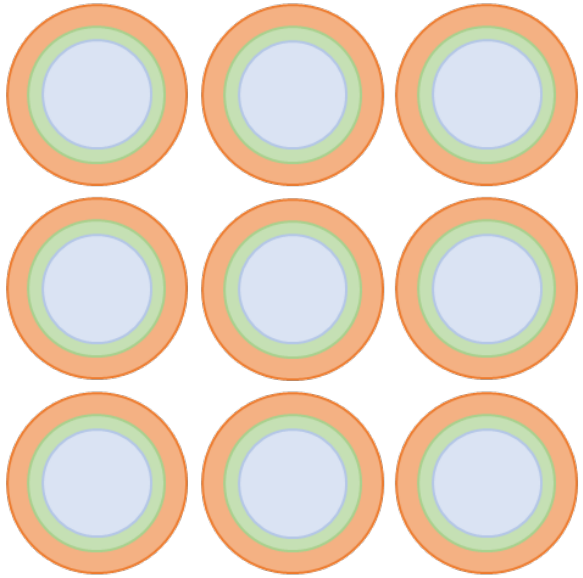


Fiber's Structure

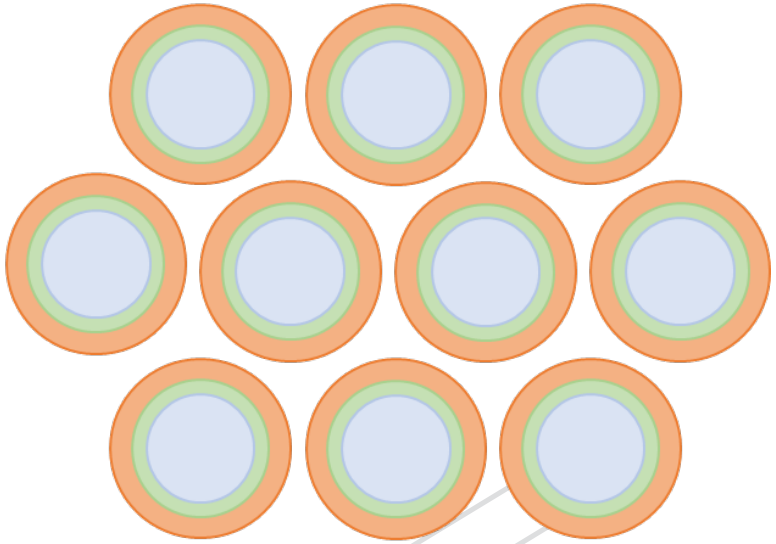


Fibers' Bundle
(dense packing)

Fibers' Arrays



"Regular" Array

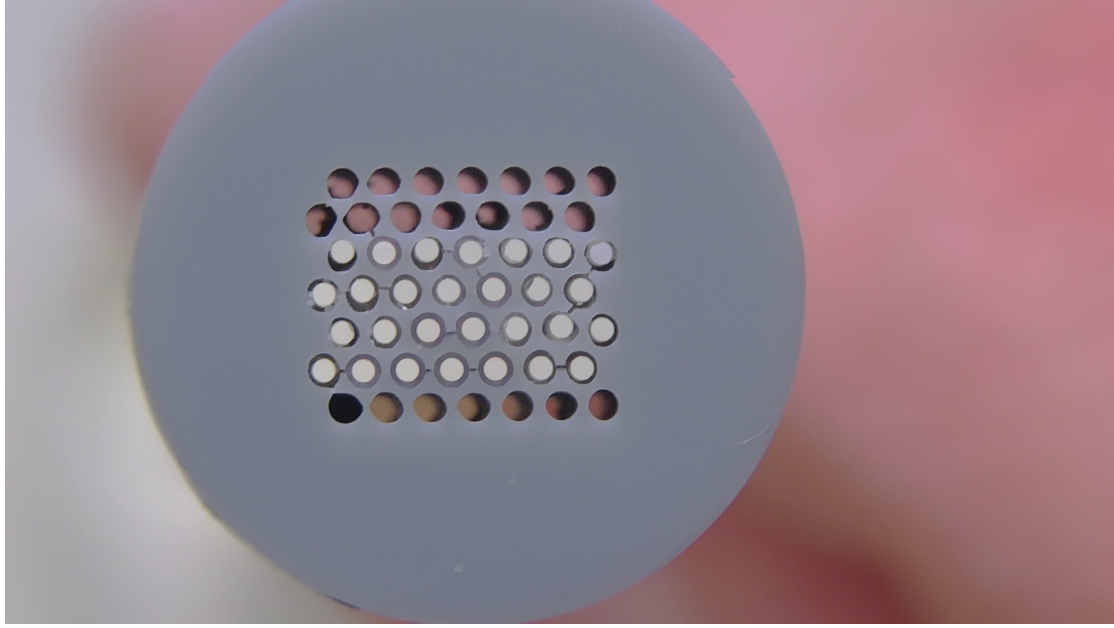


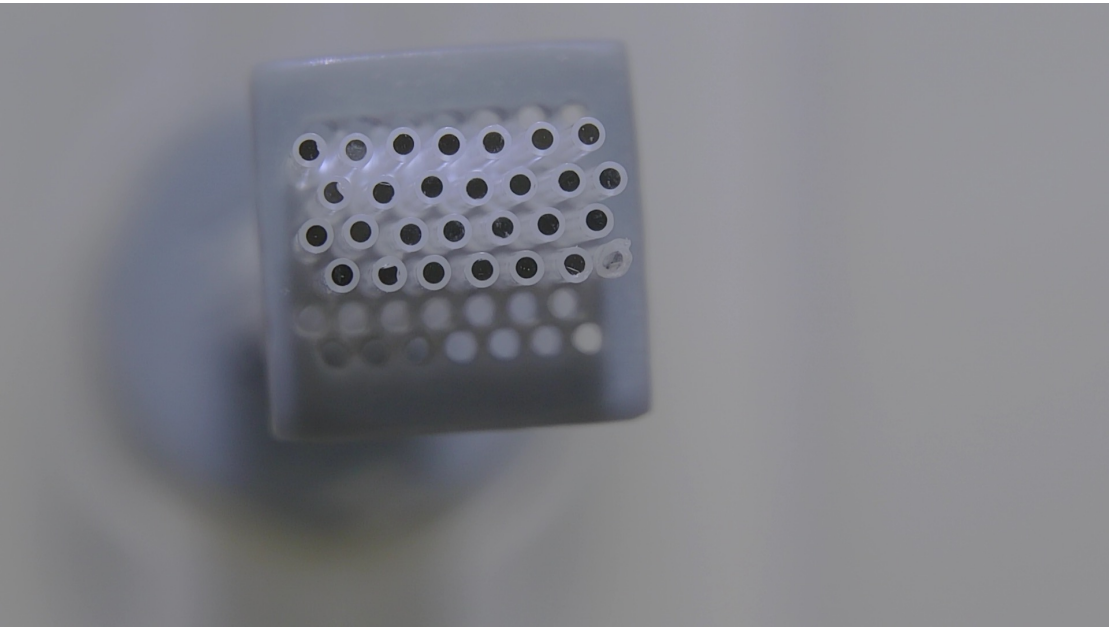
"Staggered" Array

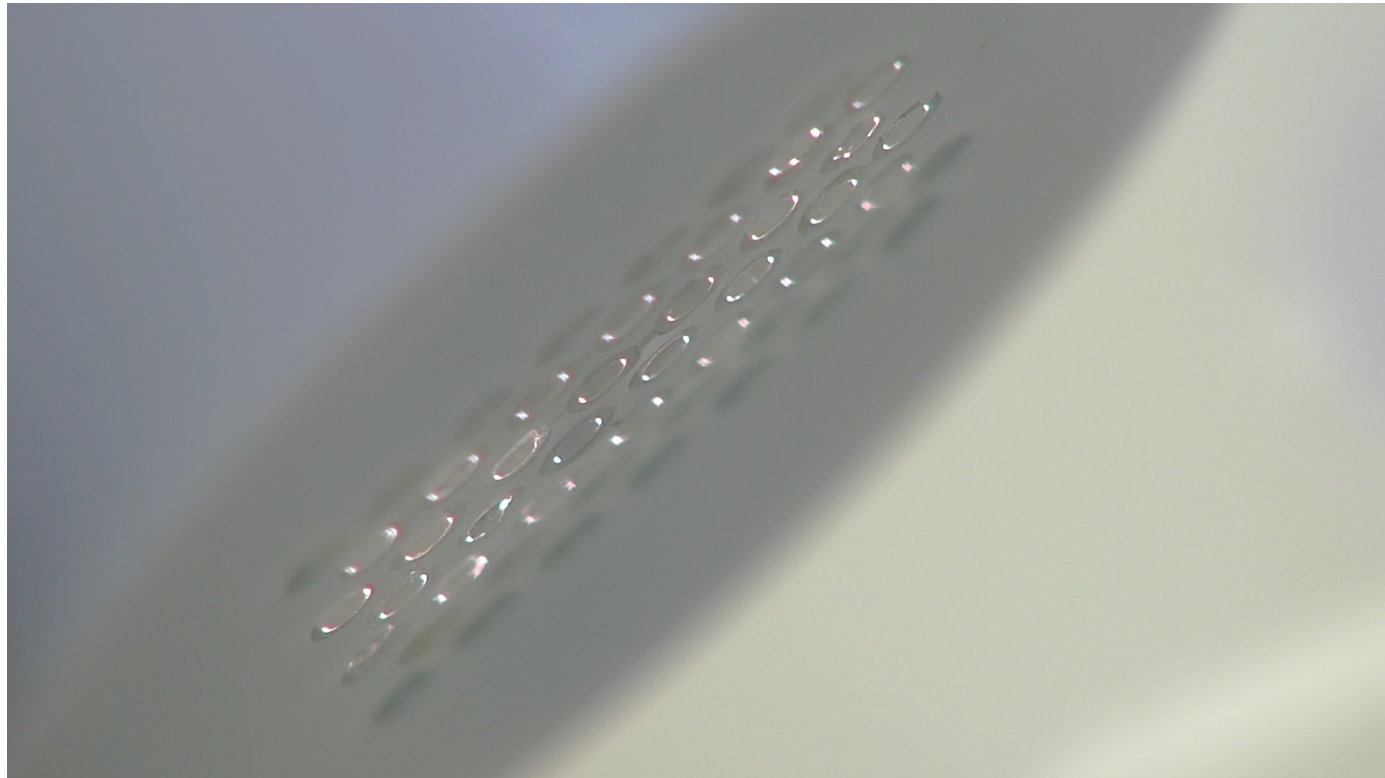
Optical Inspection

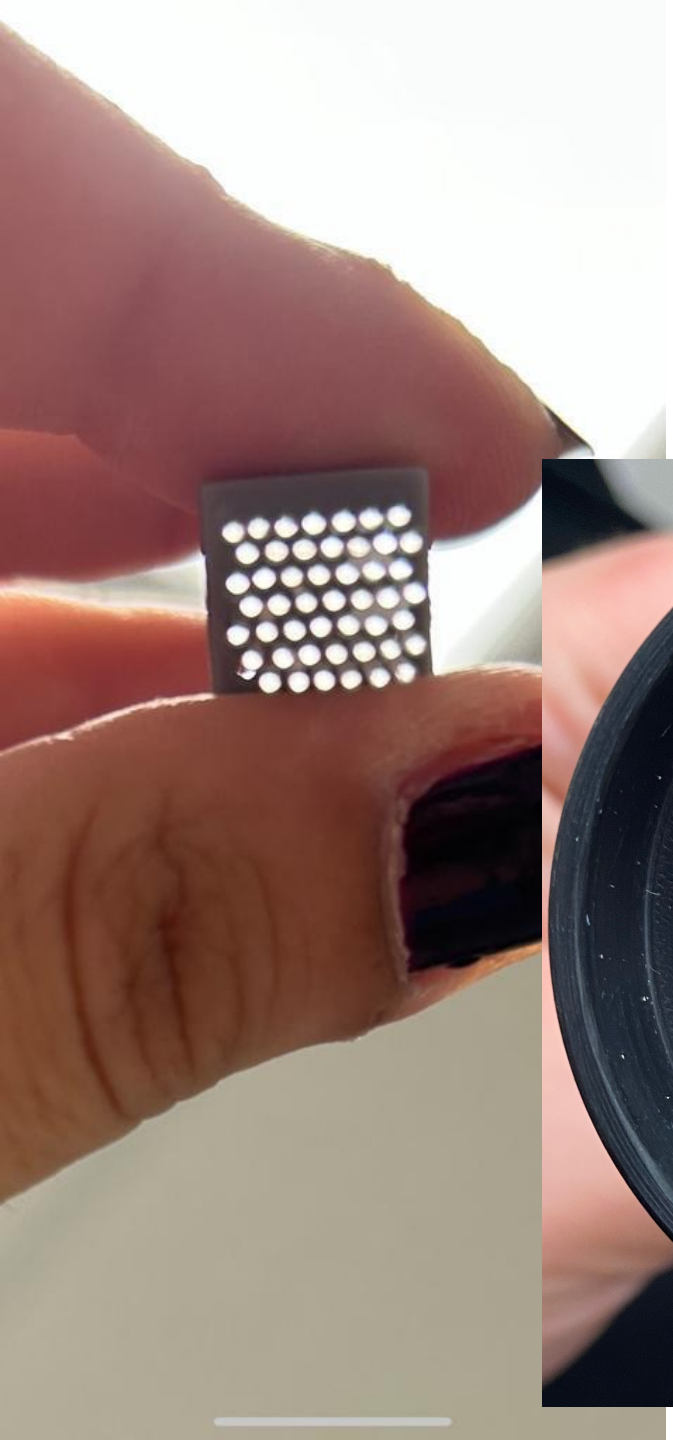
Polymicro JTFLH600630950

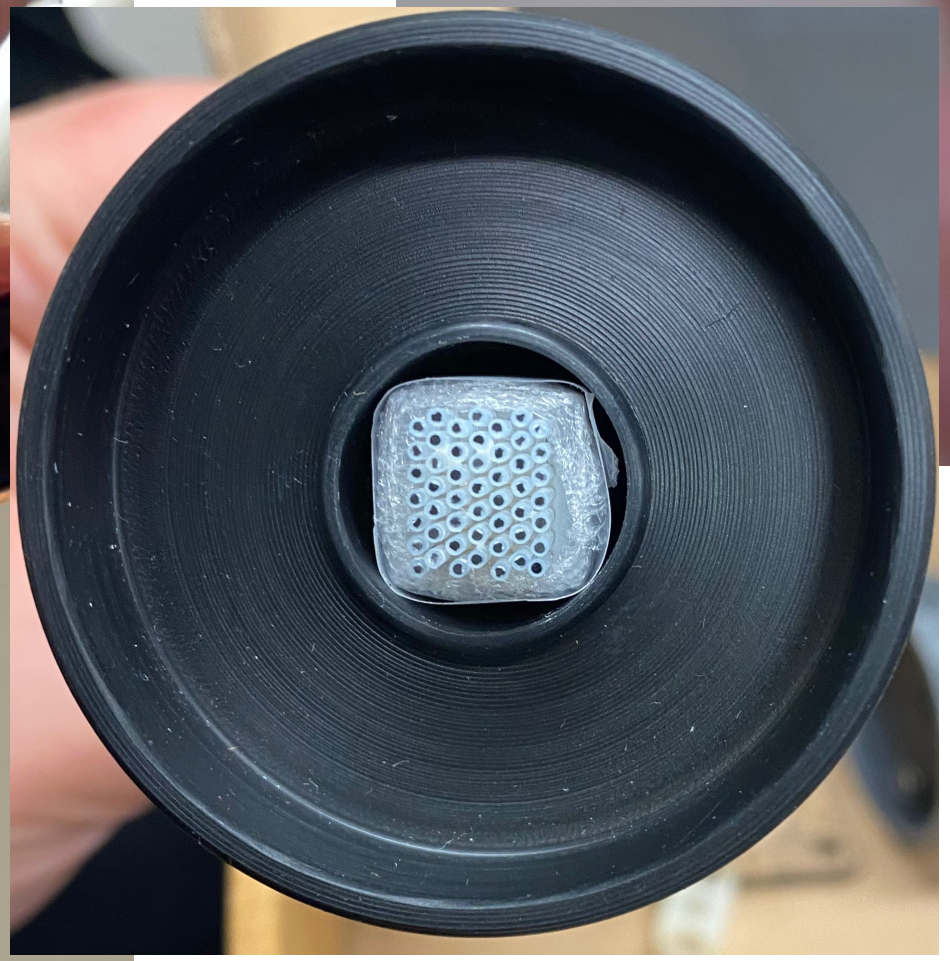
- Thanks to R. Stefanovitch, fibers were cut by 12 cm
- Thanks to Buse Duran, all fibers were *polished by hand*
- brought together in different configurations
- Array or Bundle

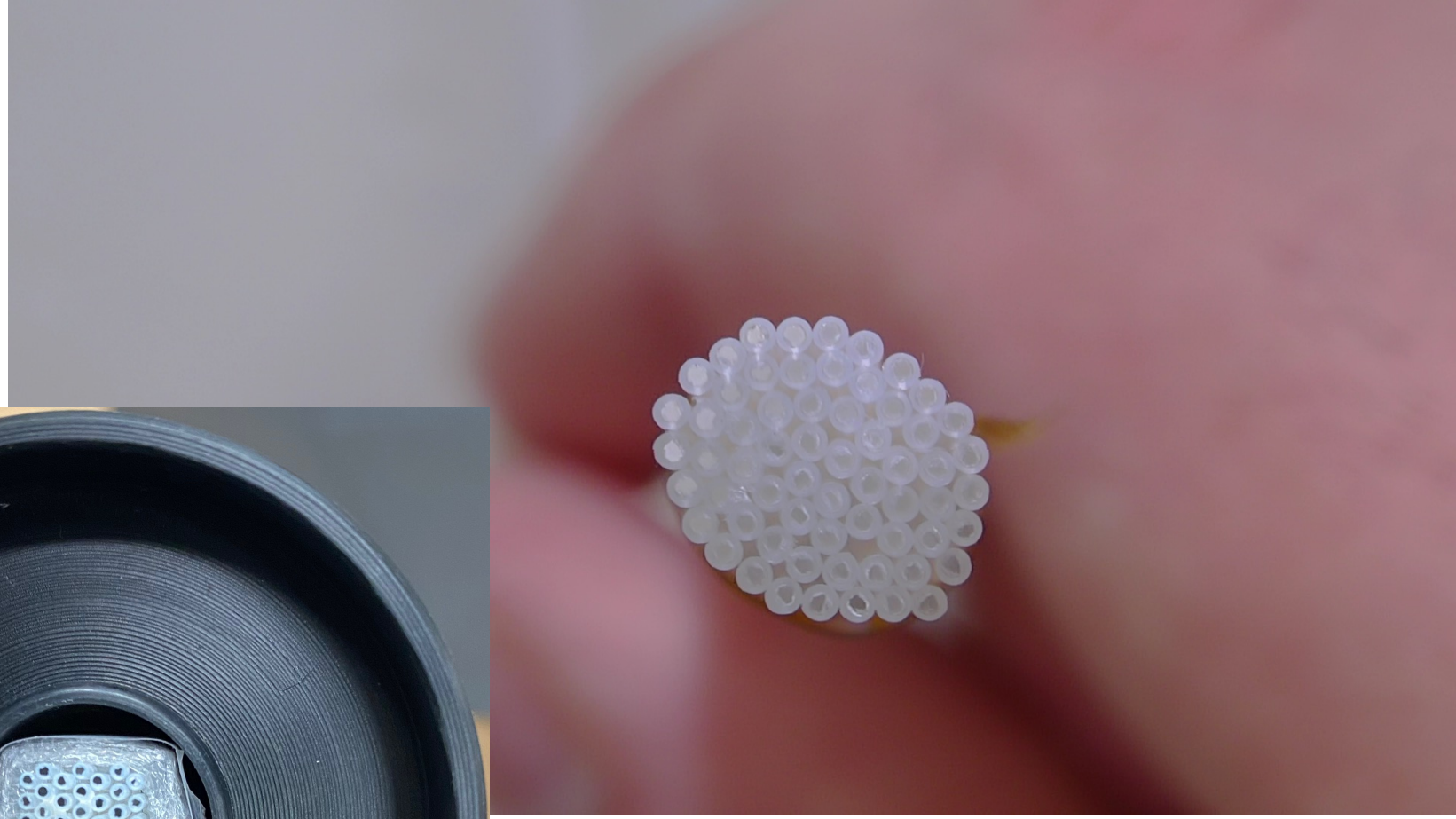










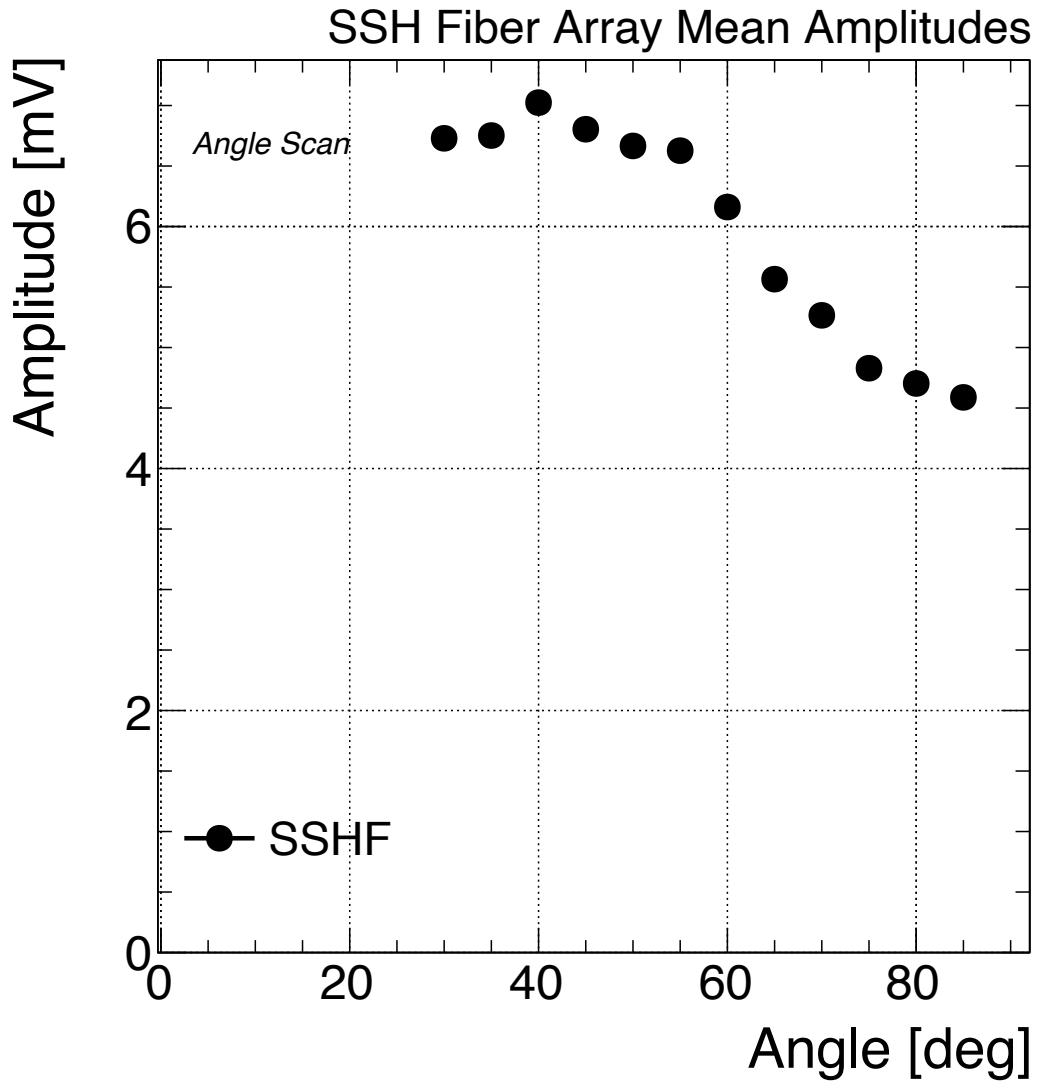


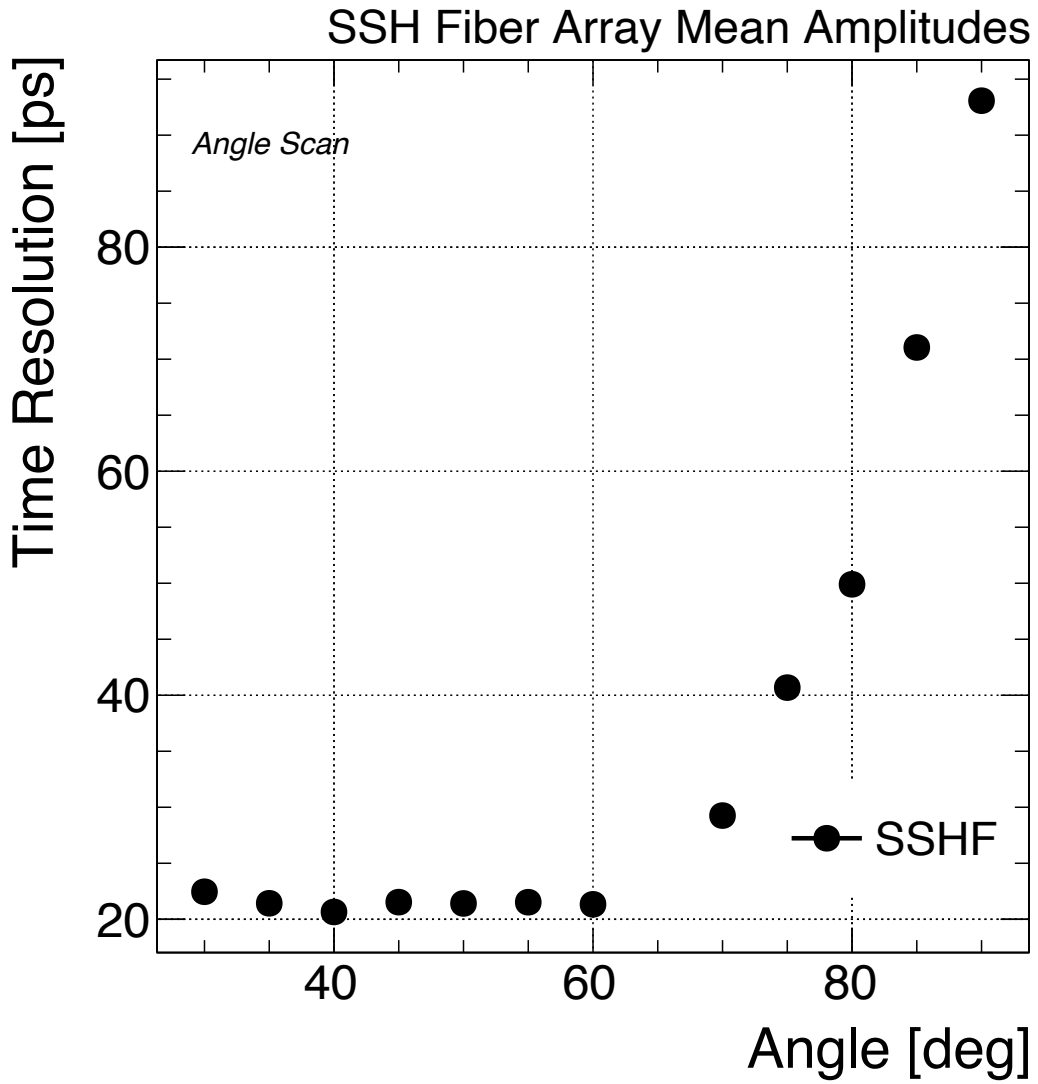
7x7 12cm Polymicro Fiber (SSHF- Array)
JTFLH600630950

Conditions for 12th Scan;

- 7x7 12cm Poly-Micro Fiber with Si-pad
- SSHF- Array
- Fiber stands 5.5 cm and 7 in a row.

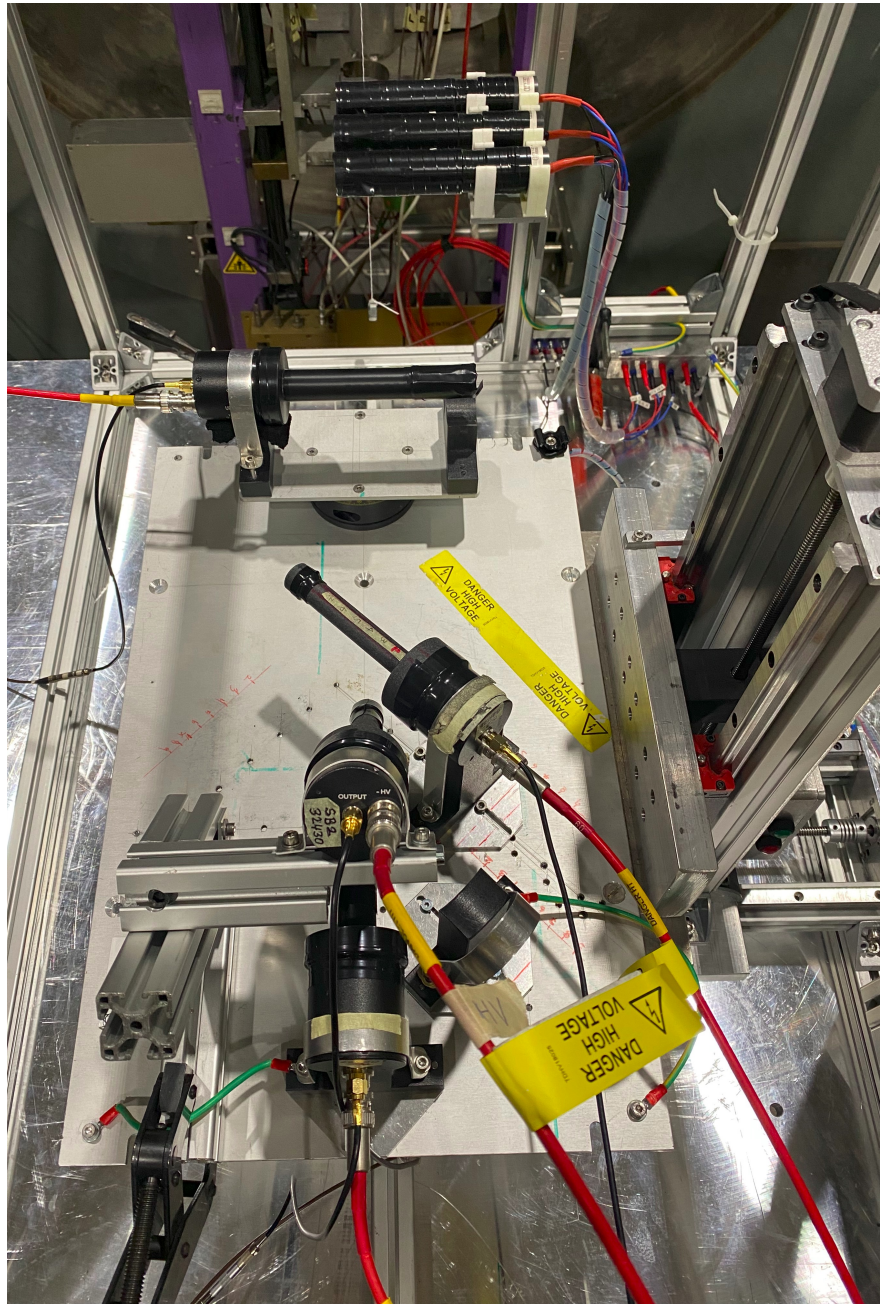
Angle Scan





12cm Polymicro Fiber (SSHF- Bundle)

JTFLH600630950

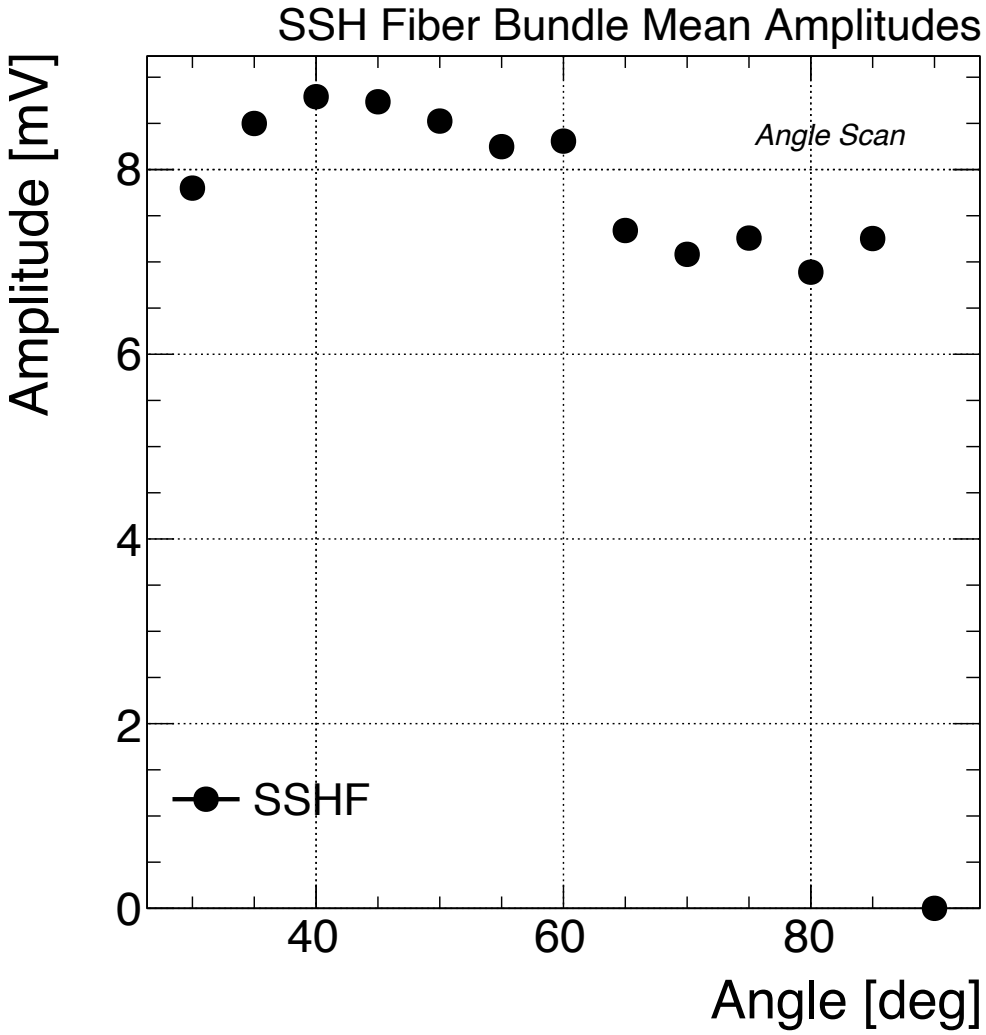


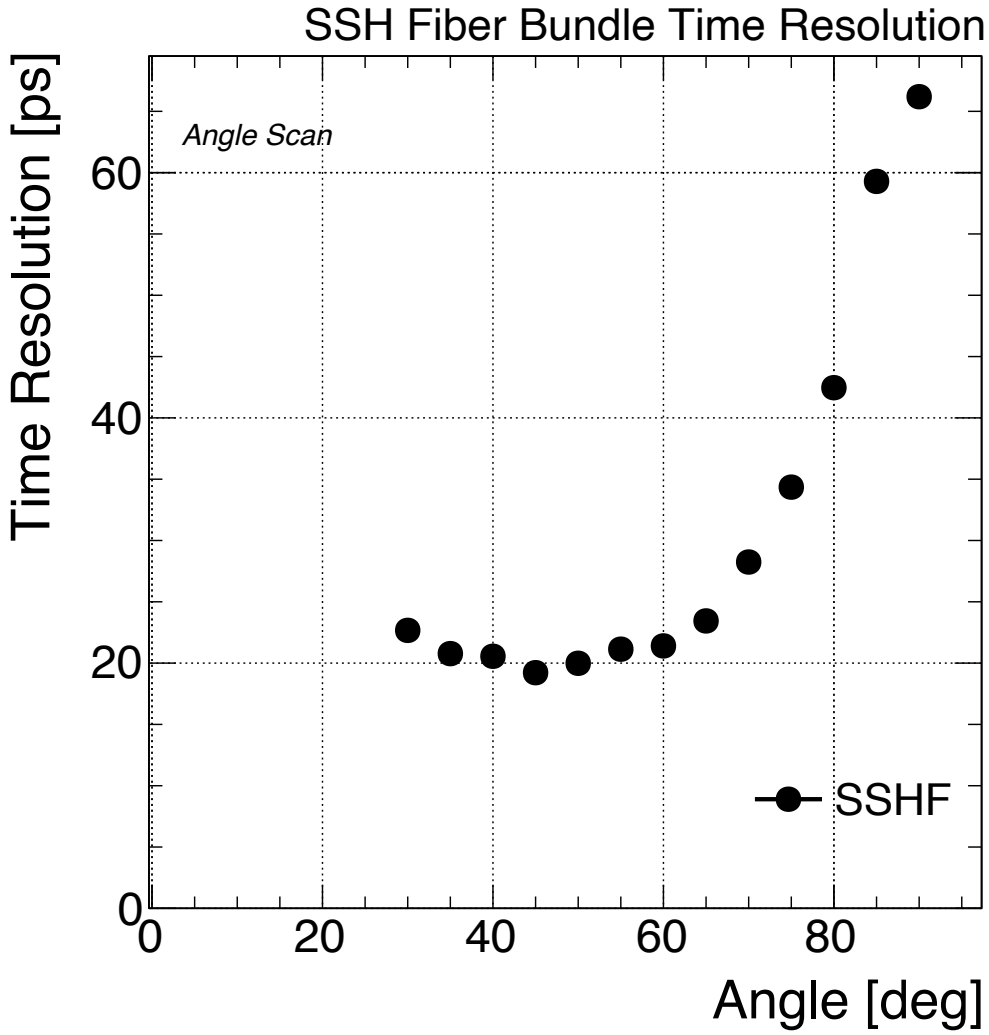
Angle Scan

SSHF- Bundle

- Fibers are more compact and more fibers were broth together, so the amplitude is higher than the fiber array

For both cases (fiber array or bundle), 90degree configuration could not be read out because of the critical angle. Created Cherenkov photons go out from the fiber.



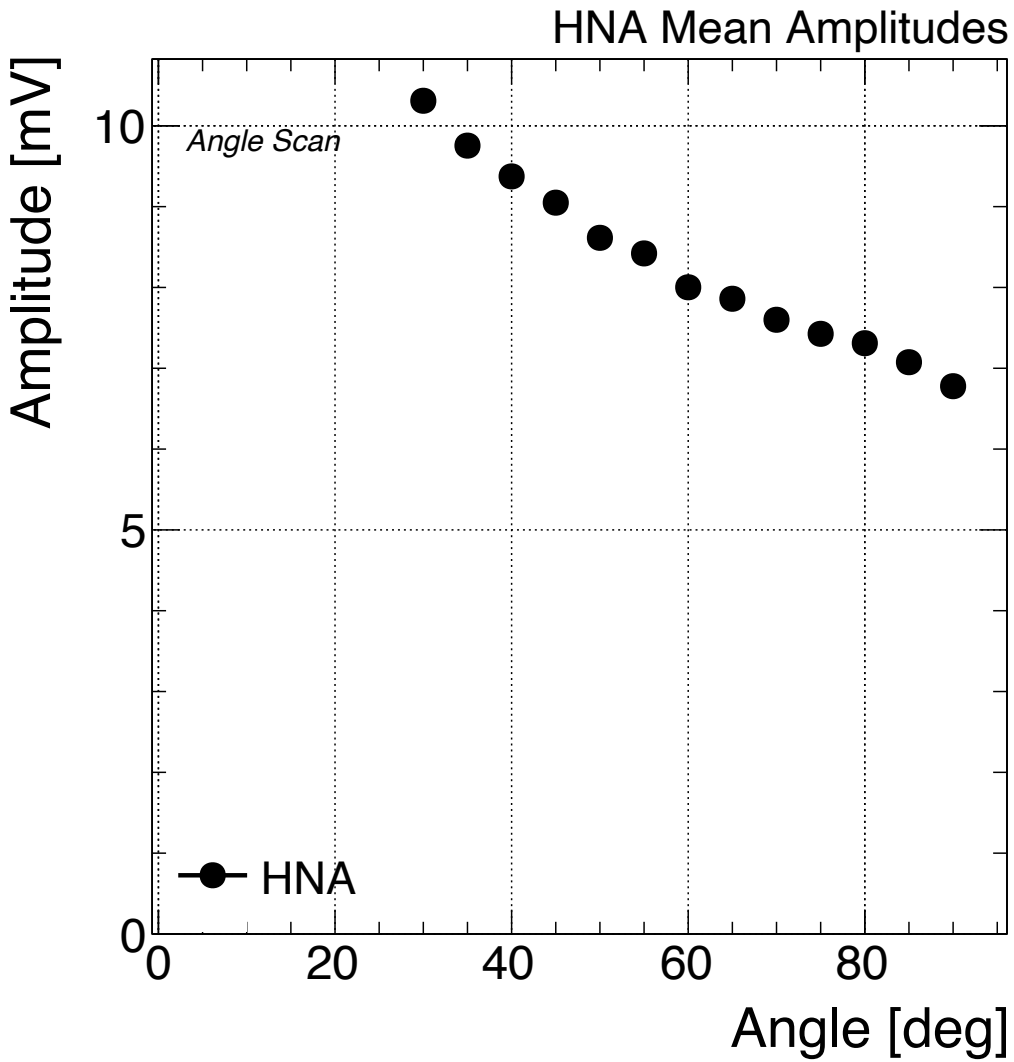


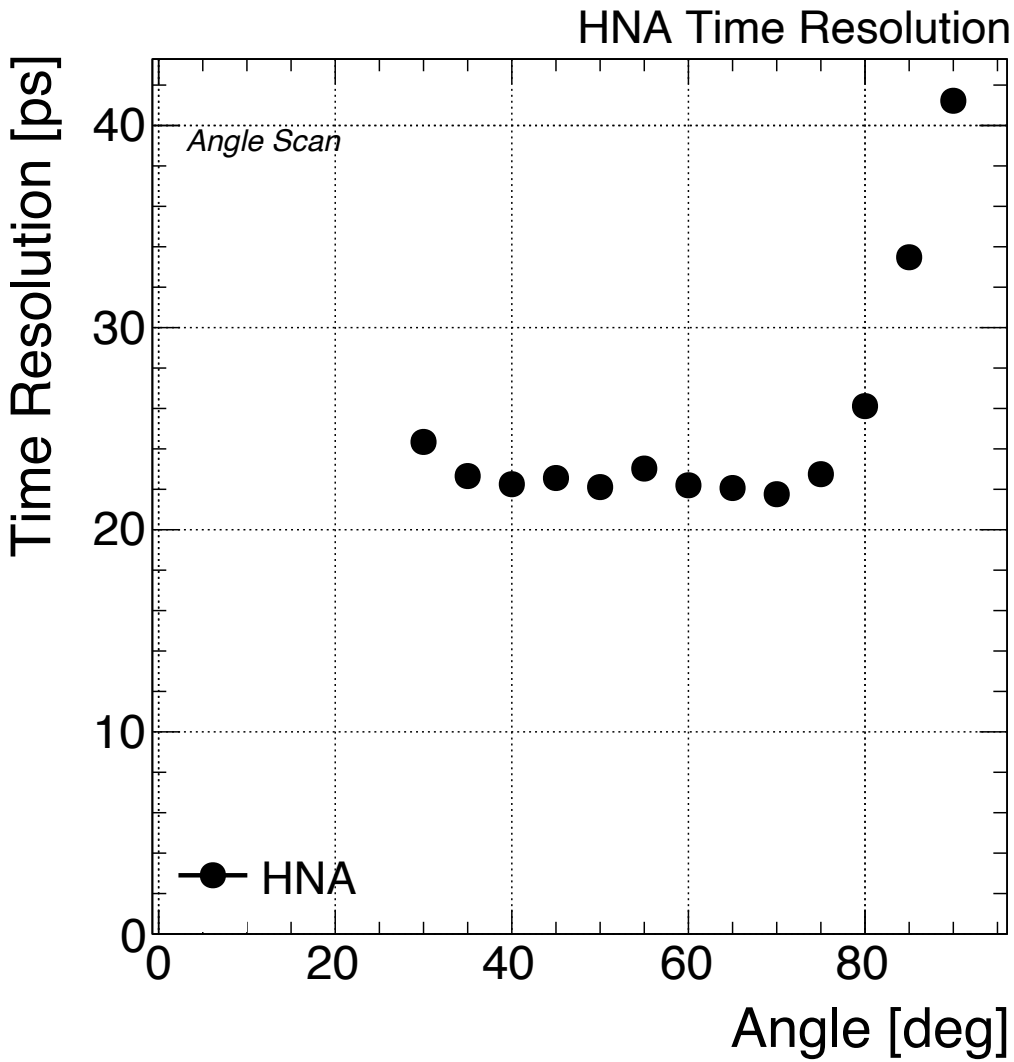
Angle Scan

High NA- Bundle

- 74 x 8 cm HNA fiber bundle
- Using same HV and MCP, amplitudes are better than other fibers. Even though effective thickness slightly small than the other types!!!

Even 90-degree configuration gives very good results!!!!

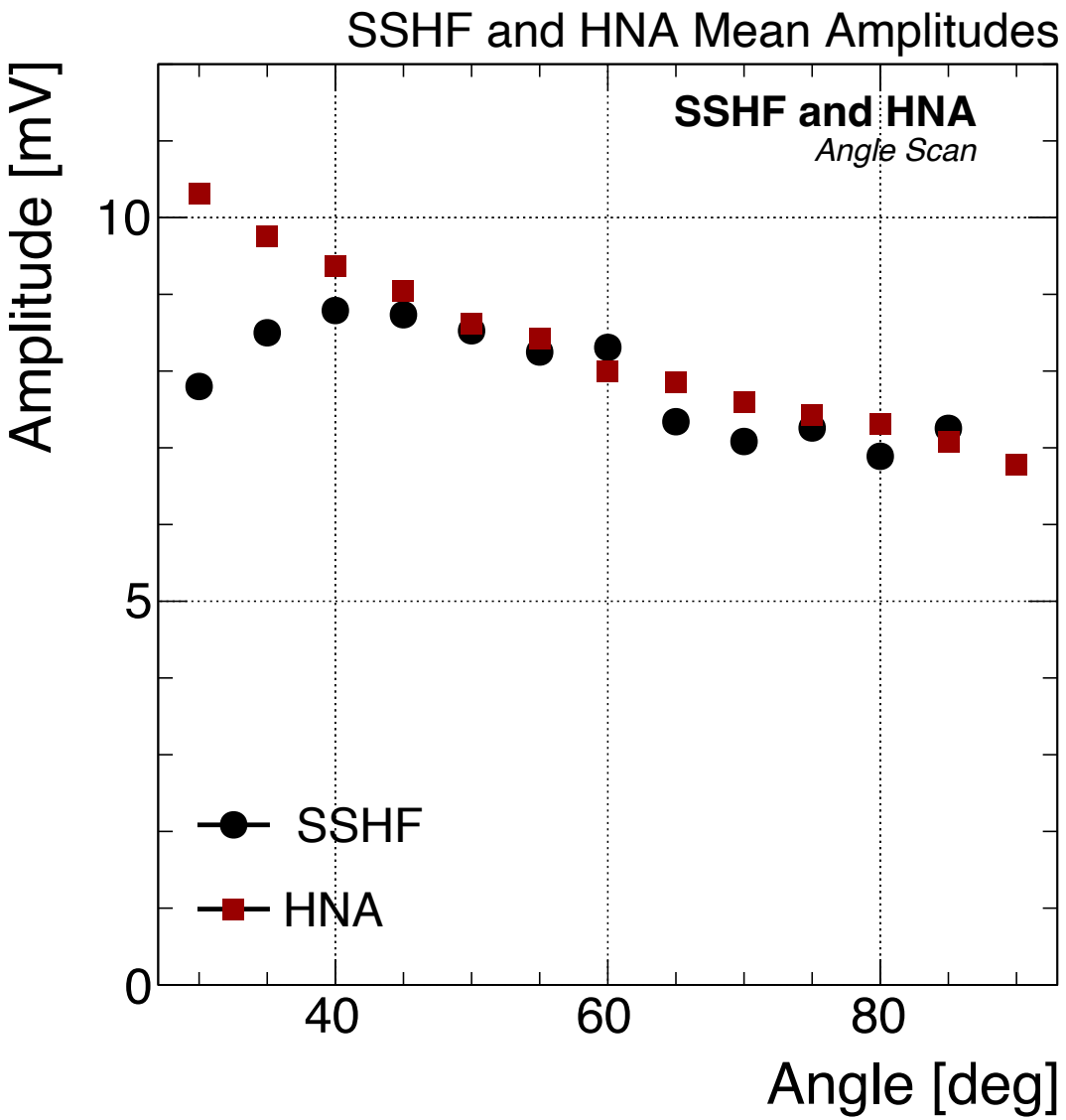


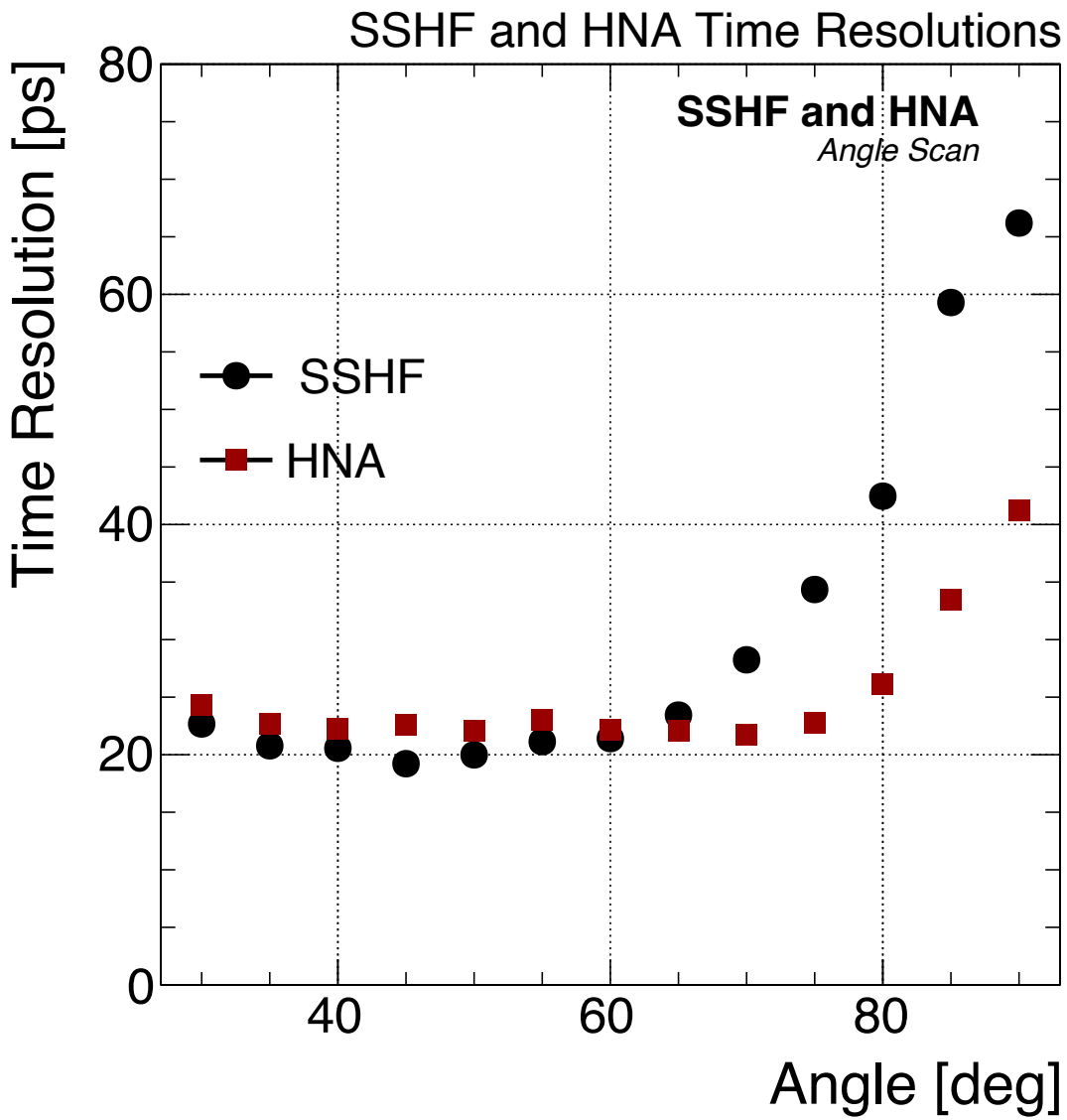


Short Segment HF like Fiber (SSHF) Bundle
JTFLH600630950

vs

High NA Fiber Bundle
FSU330350400

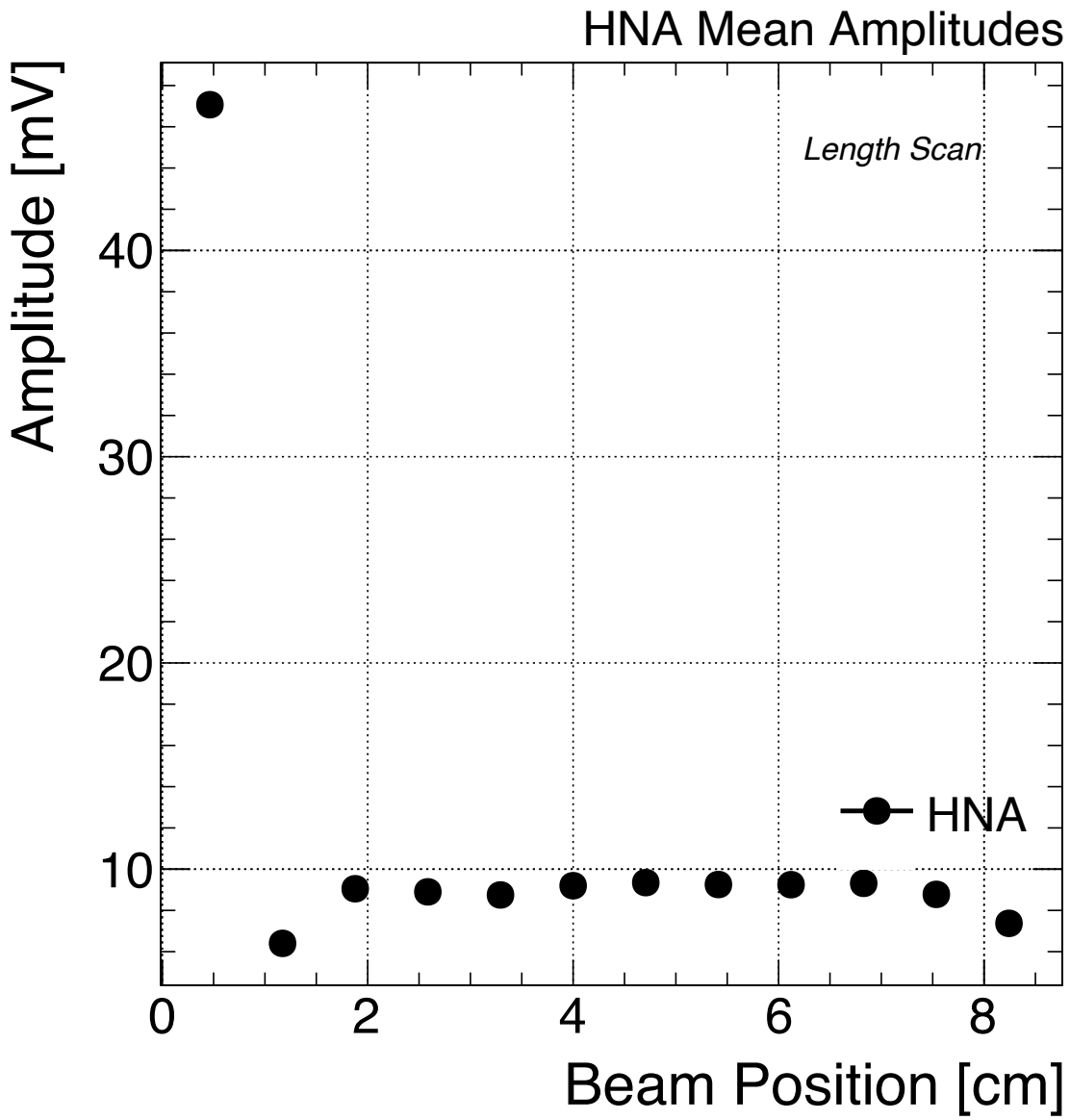


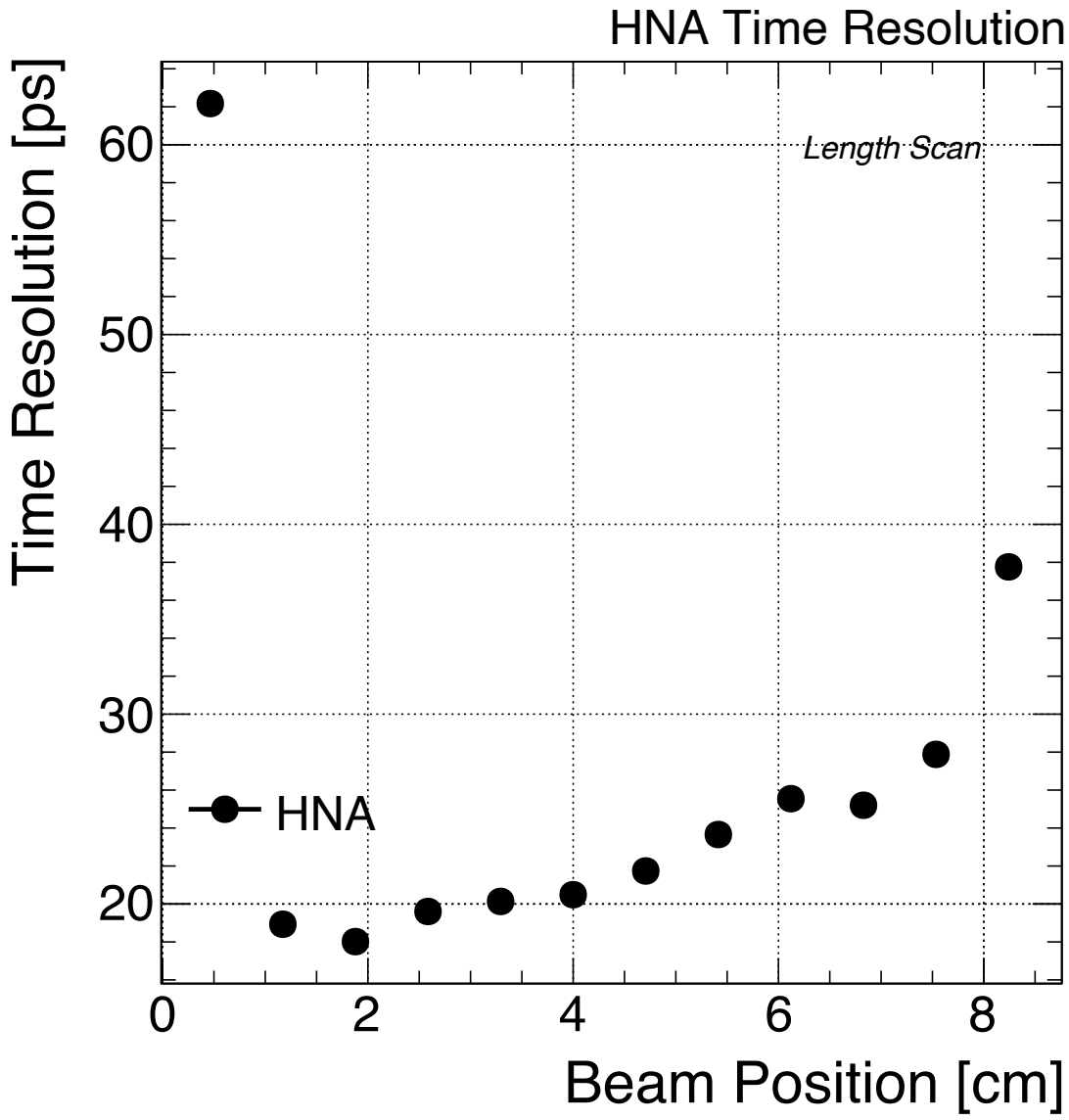


High NA- Bundle

- 74 x 8 cm HNA fiber bundle
- **Length Scan at 45 degree**

Amplitude of the HNA fibres is quite stable along the full-length (8cm)
And time resolution varies between 20 -30 ps

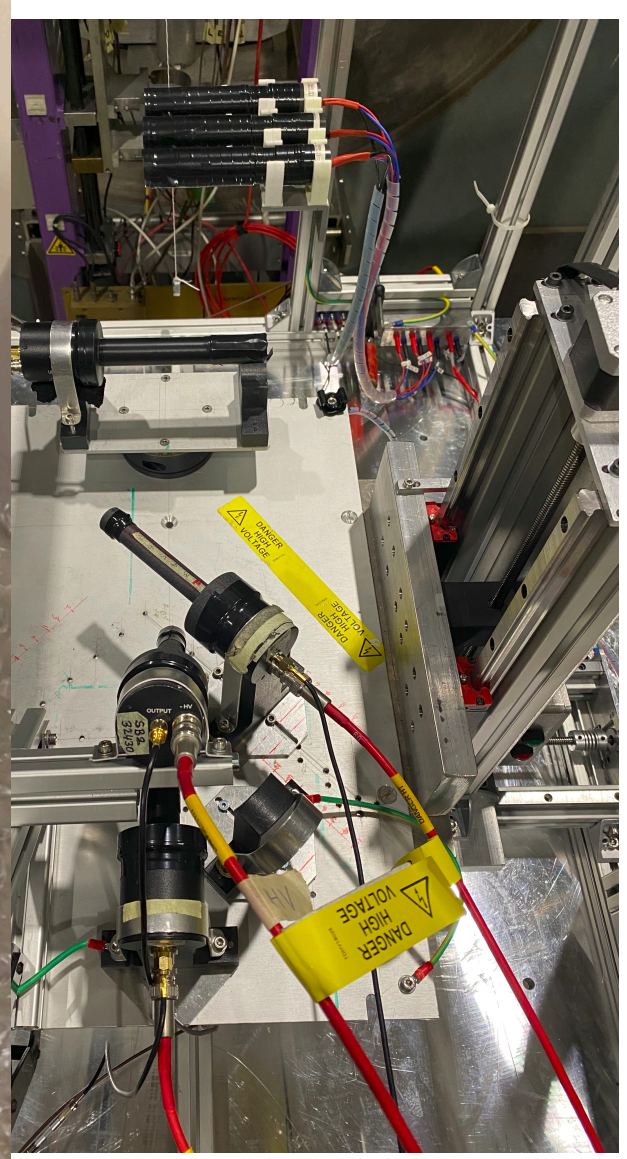


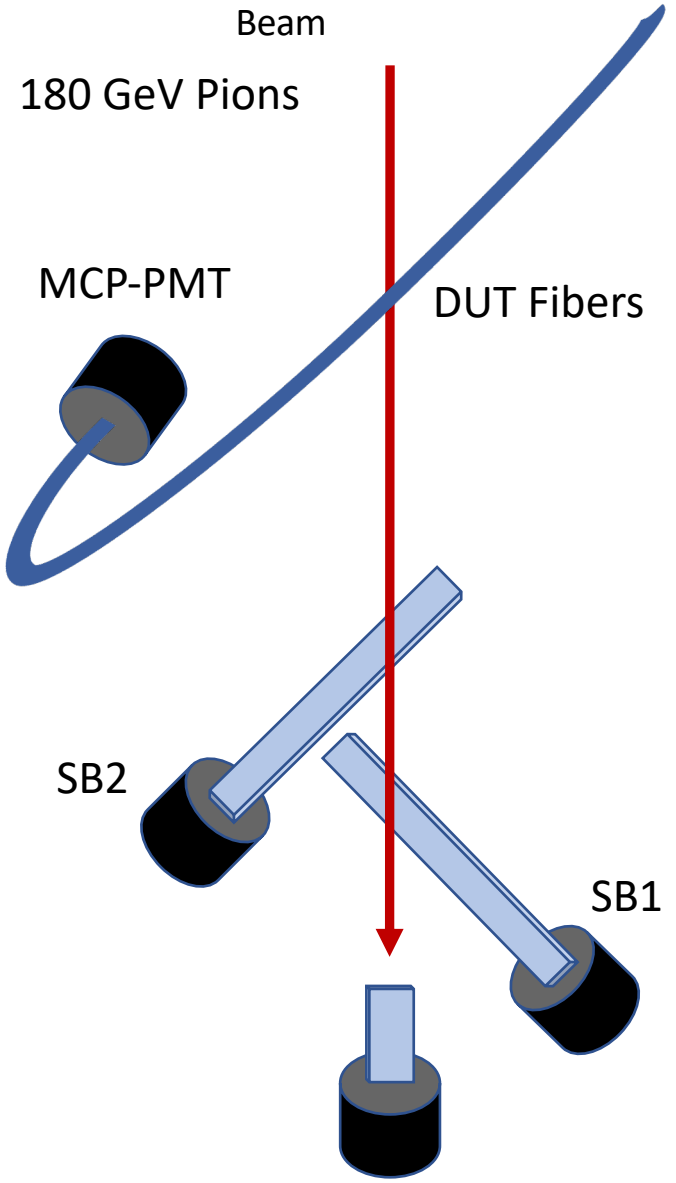


T
b
c

P
c

A

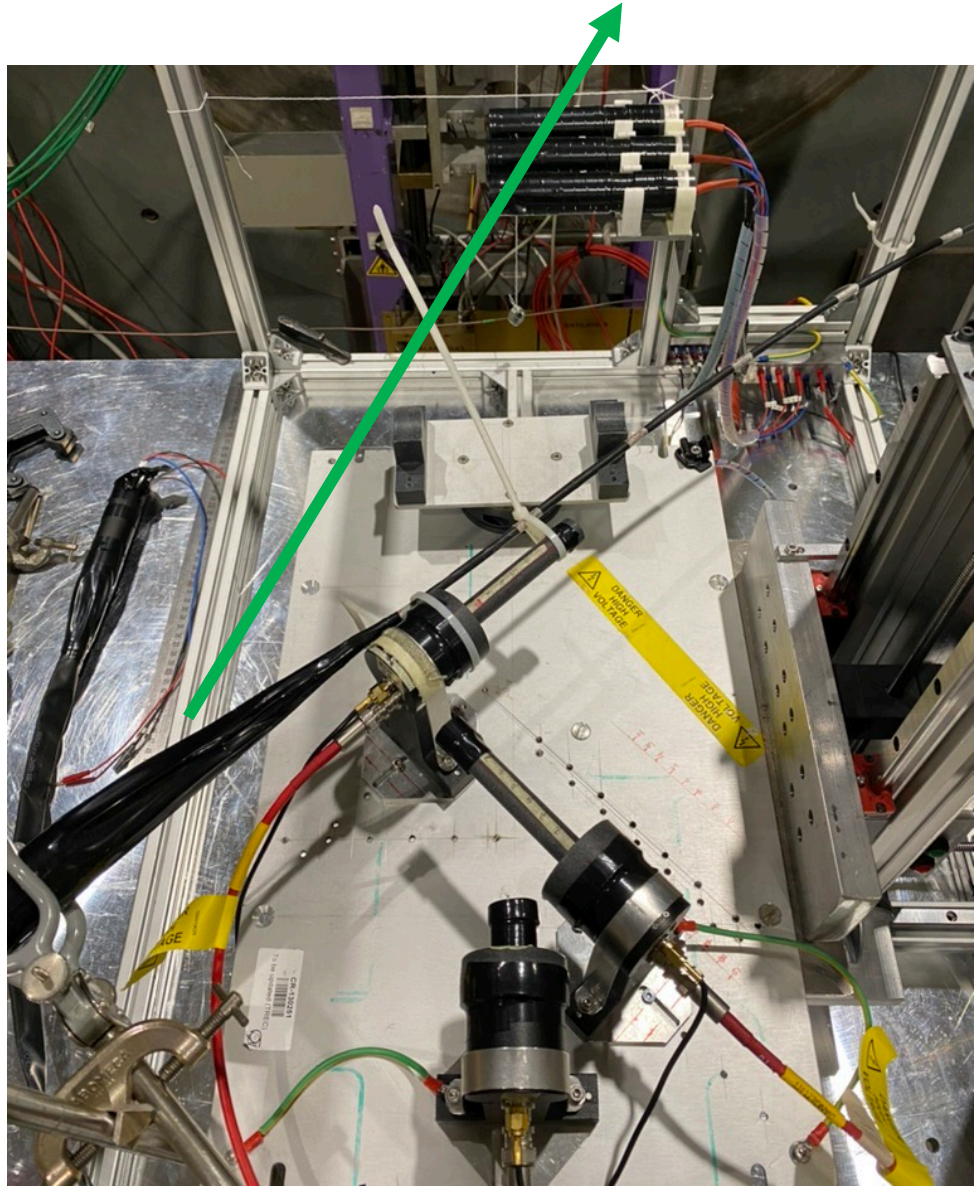




TRC – With 12x12x25mm^3 QBlock

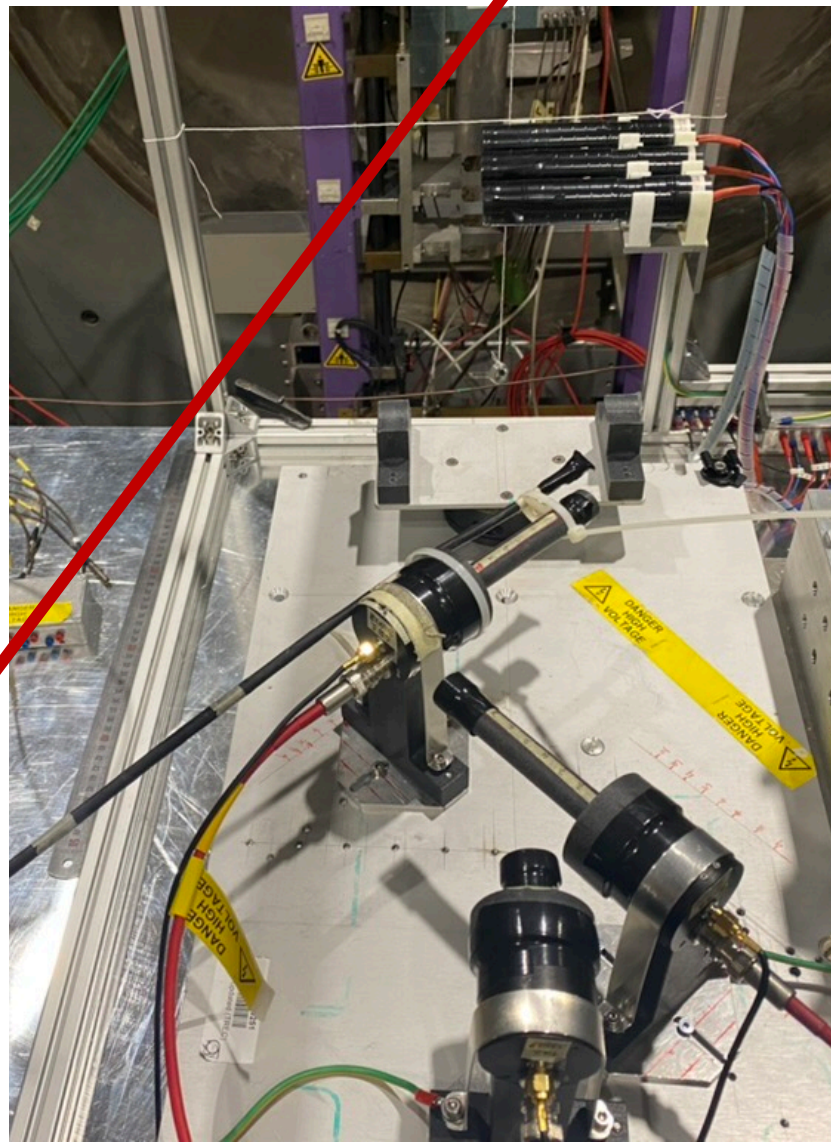
PPP (HF PreProduction Prototype) Fibre bundle

With Hamamatsu R7525



1.5 m long PPP fibers attached to the different PMTs

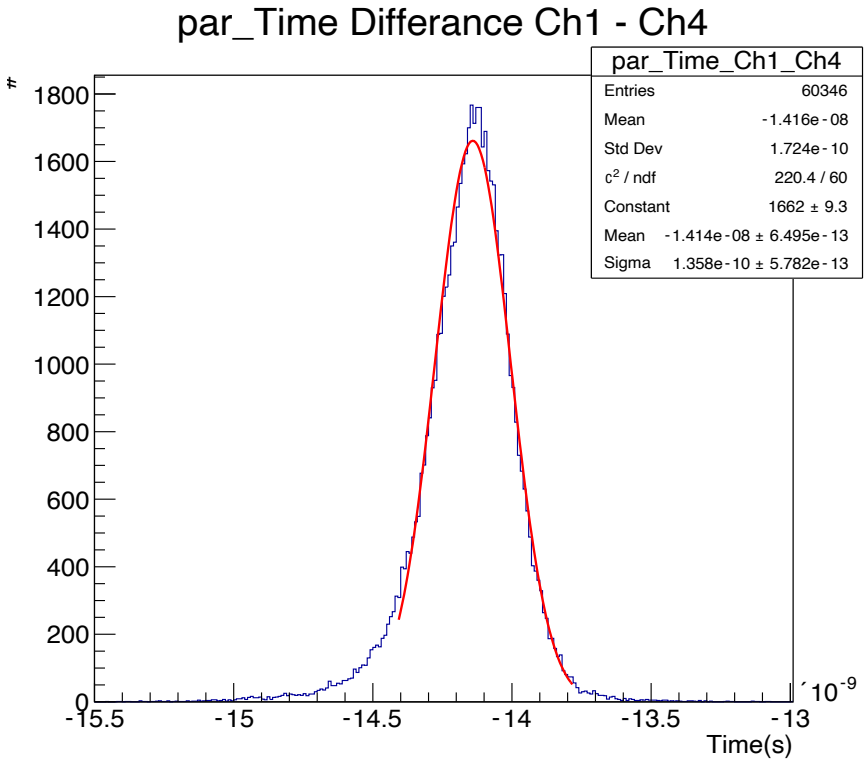
With MCP-PMT



Time resolution of HF-PPP fiber 20 cm away from the photodetector

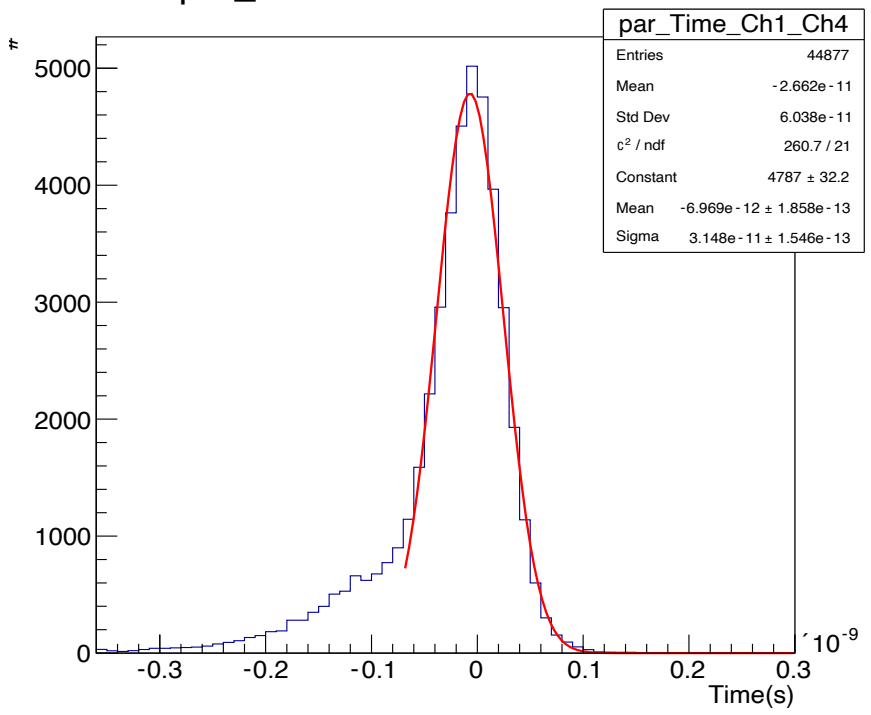
HF-PPP + R7525

135.8 ps



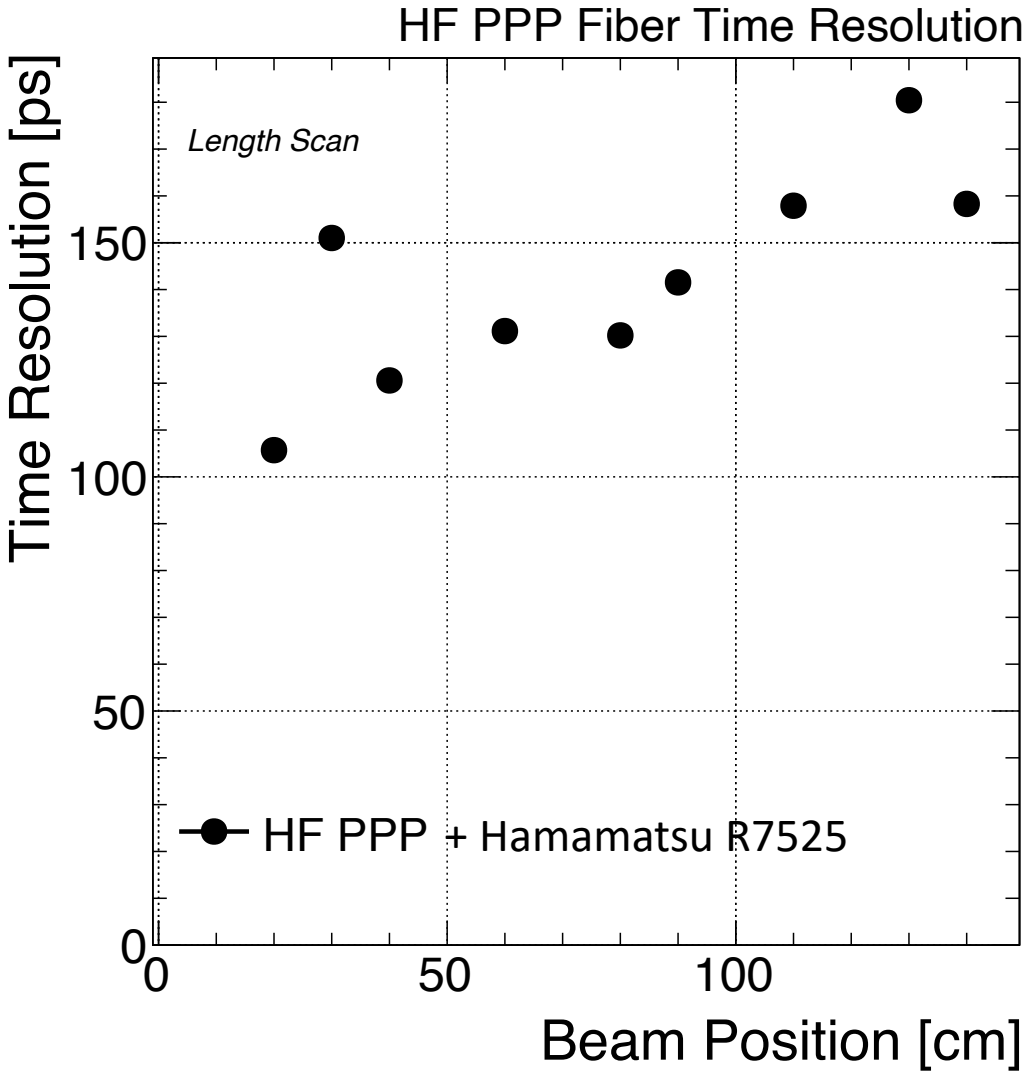
HF-PPP + MCP-PMT

31.48 ps

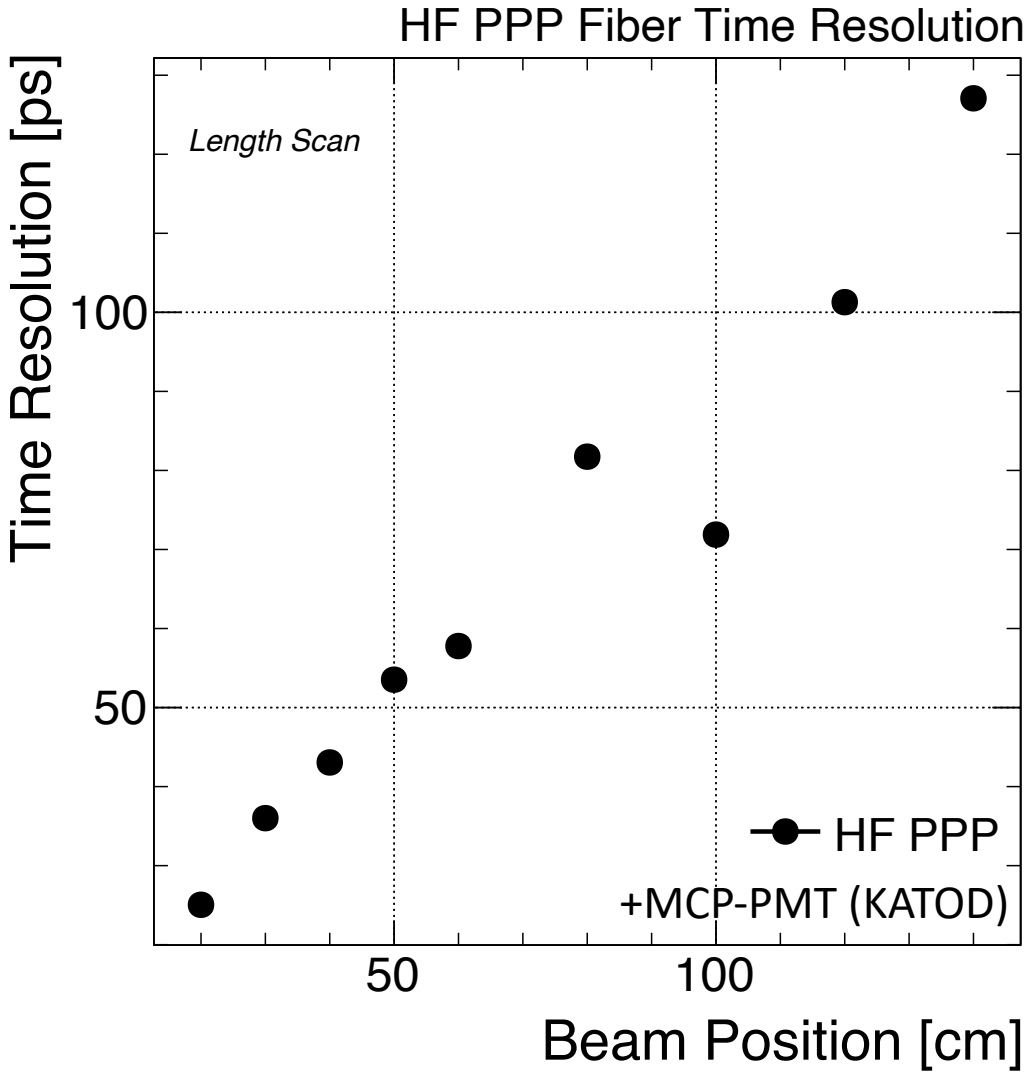


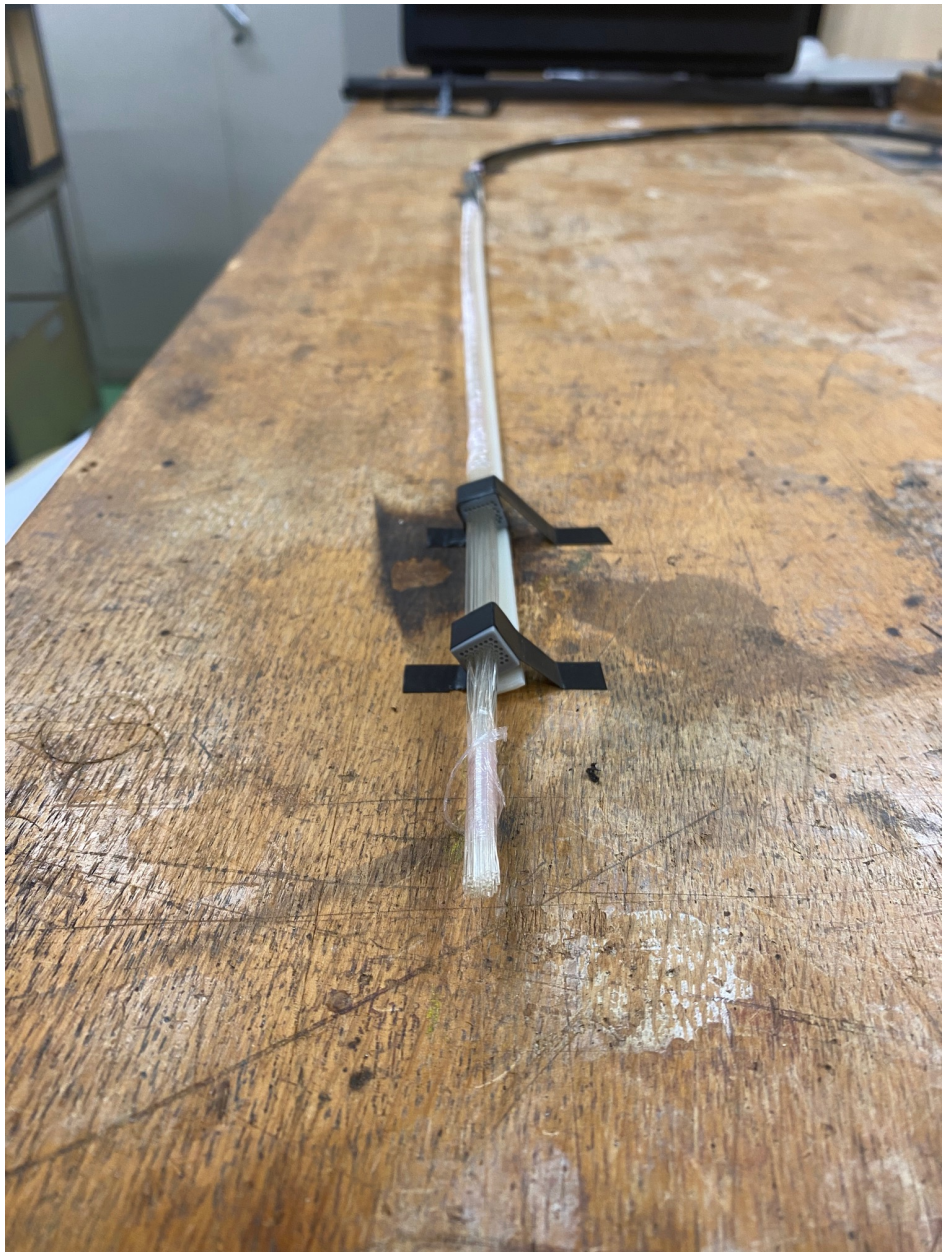
The time resolution of HF-PPP fiber along 1.5 m with different PMTs

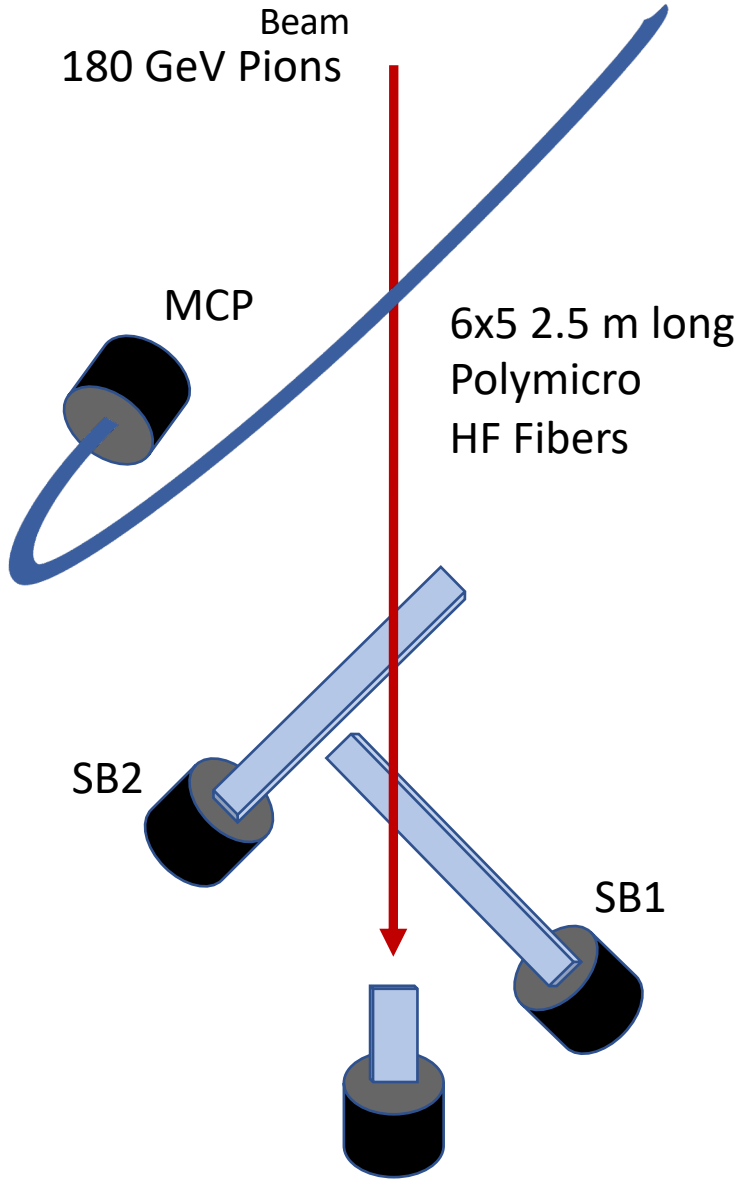
Hamamatsu
R7525



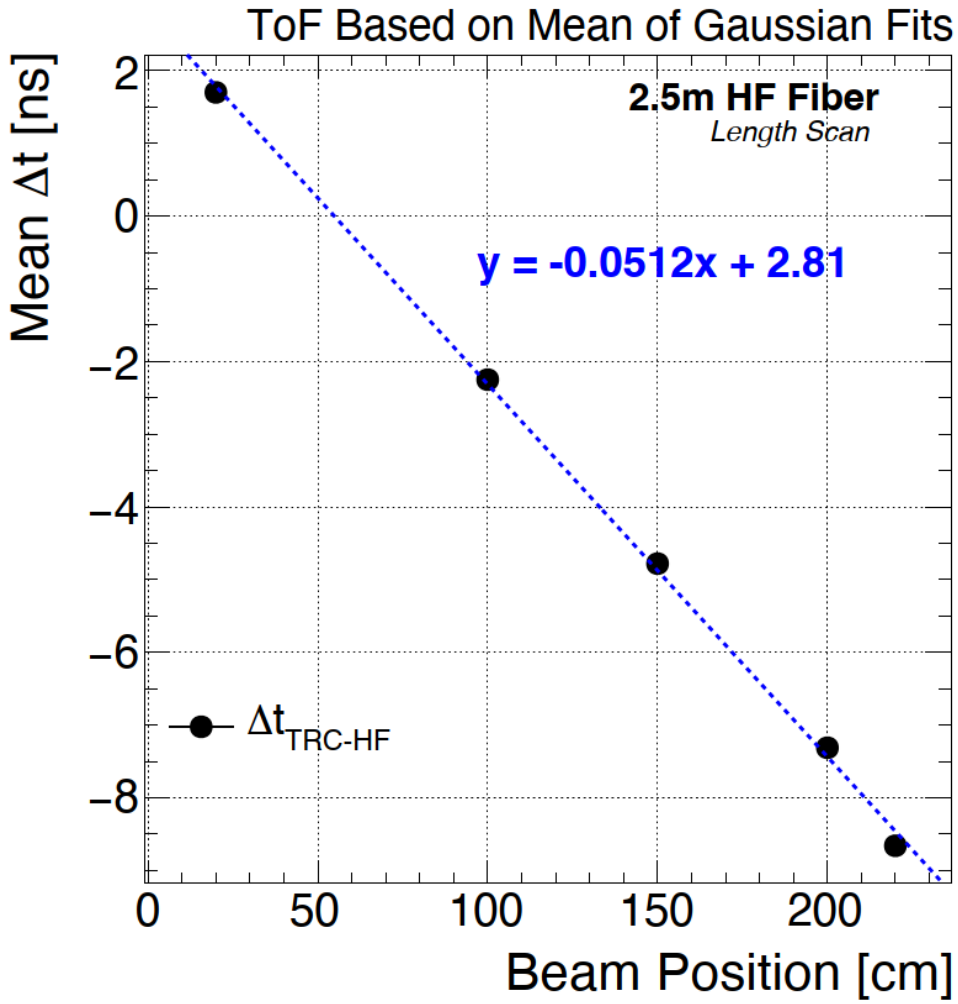
KATOD UFK-5G-2D
MCP-PMT

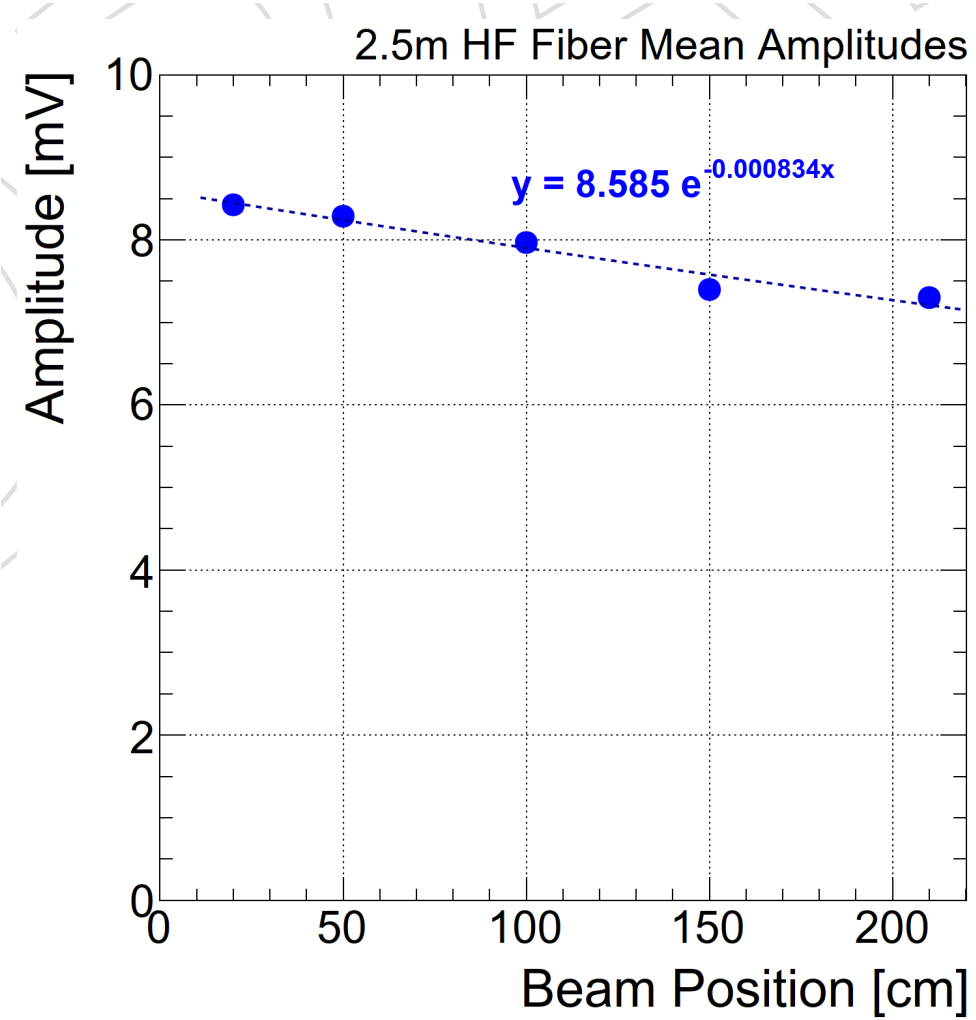






TRC – With 12x12x25mm^3
QBlock


ToF Based on Mean of Gaussian Fits
2.5m HF Fiber
Length Scan
y = -0.0512x + 2.81
Δt TRC-HF
Mean Δt [ns]
Beam Position [cm]
2
0
−2
−4
−6
−8
0
50
100
150
200


2.5m HF Fiber Mean Amplitudes
y = 8.585 e -0.000834x
Amplitude [mV]
Beam Position [cm]
10
8
6
4
2
0
0
50
100
150
200

Time resolution along the 2.5 m HF fiber bundle