Q-FIB
TEST BEAM 2024

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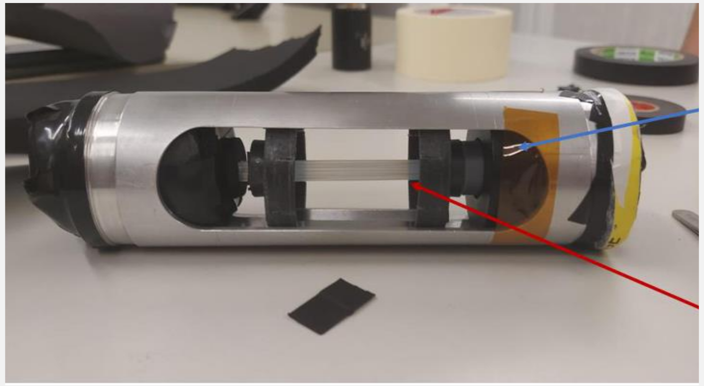
MOTIVATION

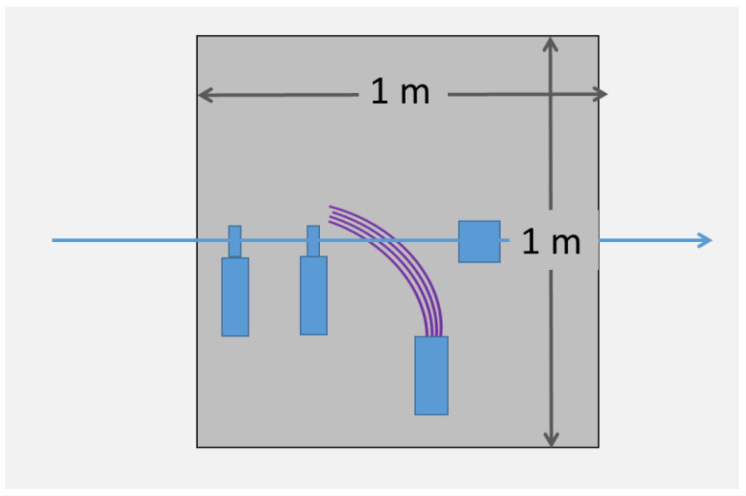
Generic R&D for a fast detector with excellent timing (30-20 ps), position (<1mm), high rate and high radiation resistance, optimized for the very forward regions (h > 6) of LHC and HL-LHC, FCC, but also for high-rate fixed target experiments.



Quartz bar + MCP-PMT counters achieve time resolutions **close to 25ps** with the bar at 45^o wrt incident particle (beam) (with particles along the bar long. axis, the resolution is **below 10ps)**

In 2024 we would like to test UFK-5G-2D-16 or/and R7600-M16 PMT **(16 ch.)** and new fibers (FSUA330350400; high N.A.) from Polymicro, as well as longer fibers (up to 2m: FSHA600630800, used in HF calorimeters).

With these tests we'll have all information needed to design a full scale prototype of large-h, rad-hard, timing preshower detector for HL-LHC or FCC.



BEAM AND SETUP

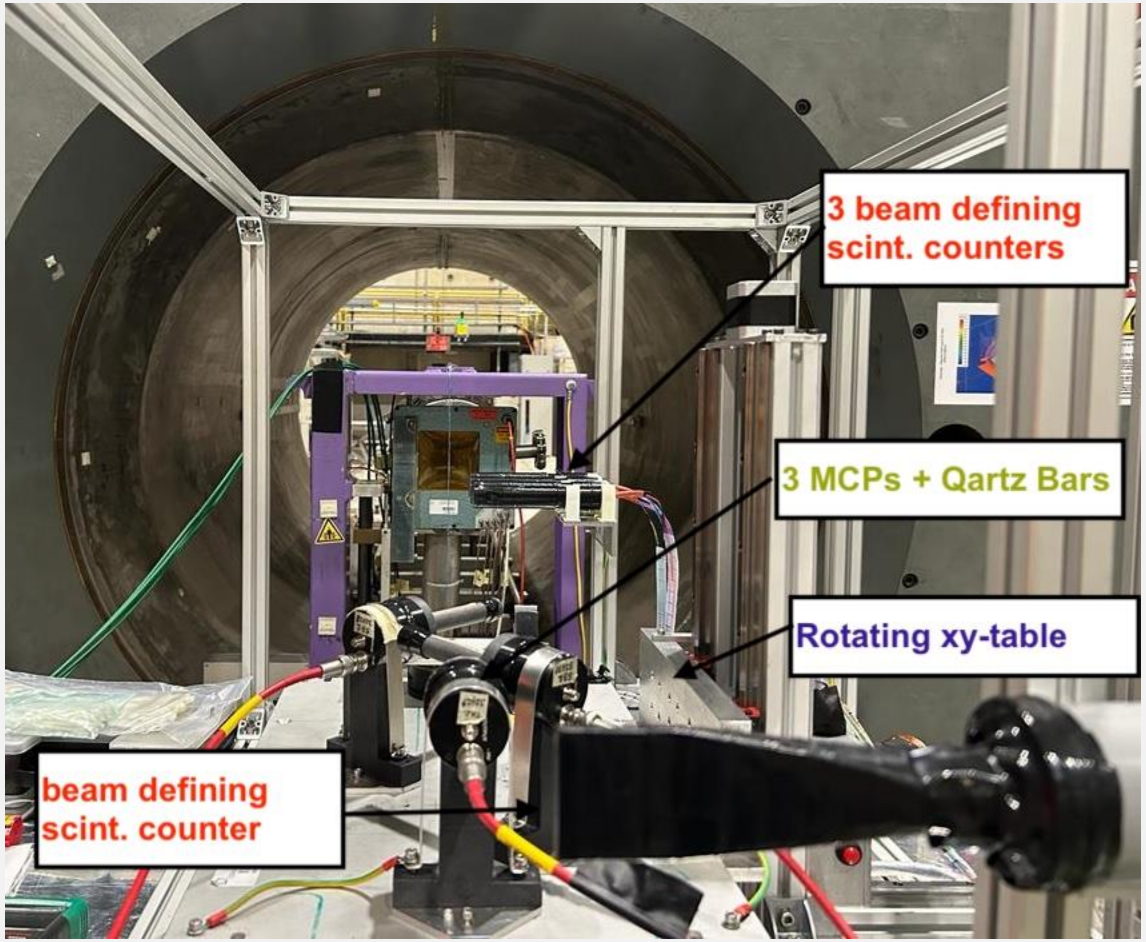
- **Particle and Energies**
  - Electron, Muon @ 100-180 GeV

- **Beam Condition**
  - Polarity: any
  - Intensity of 10 [kHz]
  - Beam Size [mm] < 10x10
  - Beam Spot Size of ~1.5 cm radius
  - 1x1 cm Scintillators will be used for triggers
  - Normally transparent;
    - occasionally absorbing (f.e. calorimeter...)

- **Setup for Beam**
  - Overall space needed 1mx1m
    - Beam defining counters(s)
    - Fiber arrays(s) + PMTs
    - Multichannel PMTs
  - Moving table needed. No fixed installation
  - Not heavy (< 10 kg in total)
  - Equipment
    - DSO WR LeCroy
    - Power Supply
    - DAQ PC

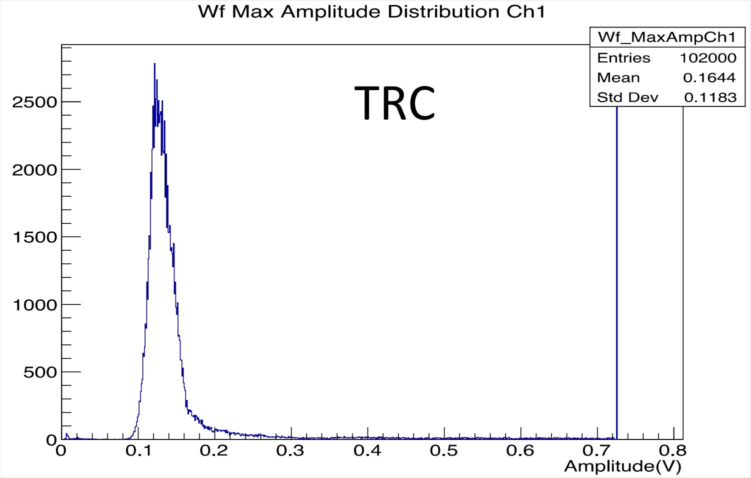
Test of a (10 mm x 10 mm) module including X and Y planes made of 4 layers of 1mm diameter quartz fibers.
The fibers extend by 50cm to reach multipixel photodetectors (16 channel PMT or SiPM array).

SETUP

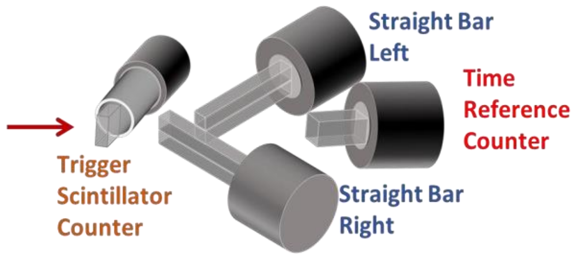


Intrinsic time resolutions

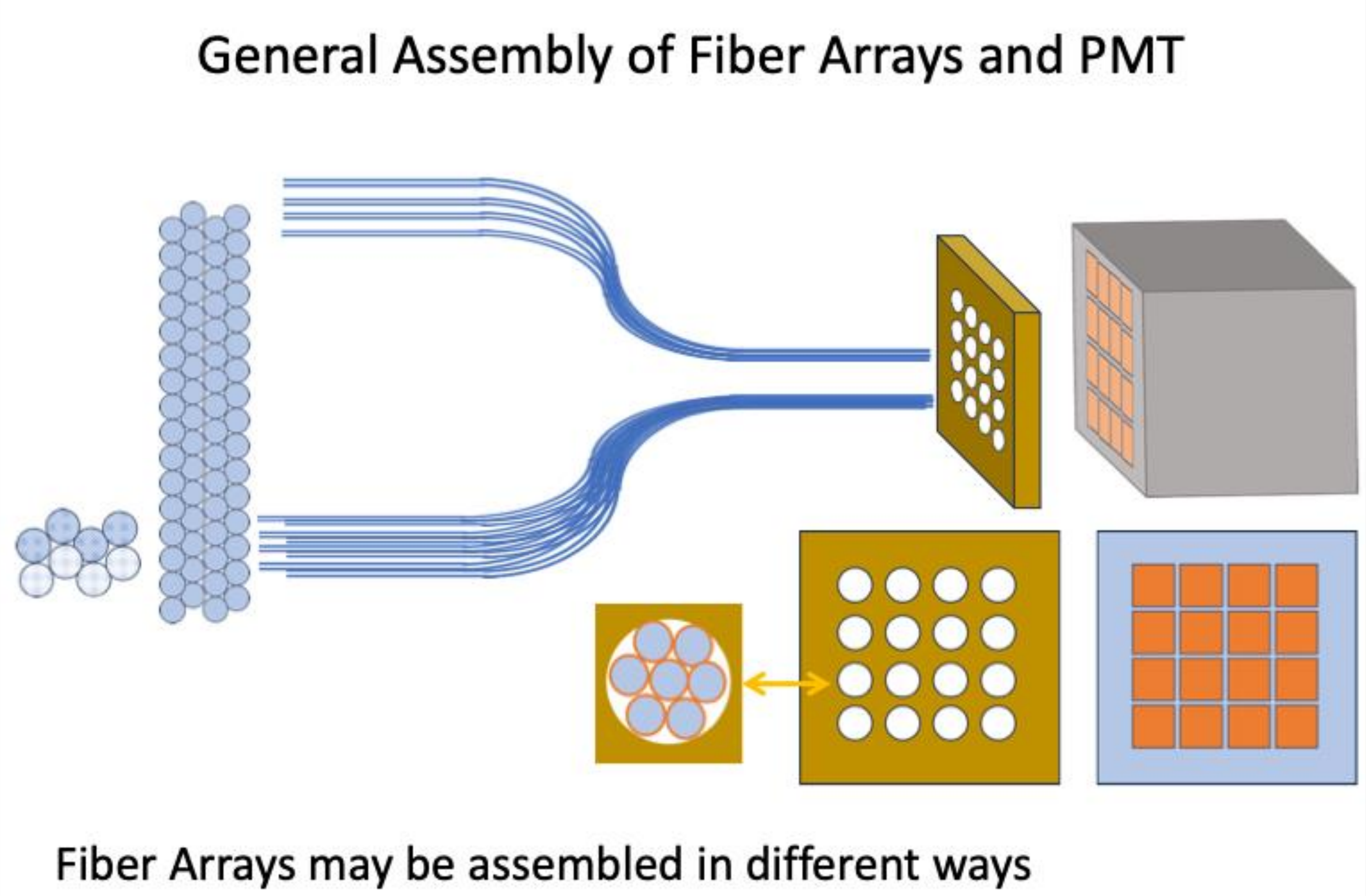
- Sigma1(TRC) →7.14 ± 2.19 ps
- Sigma2(SB1) →19.44 ± 0.80 ps
- Sigma3(SB2) → 22.65 ± 0.72 ps



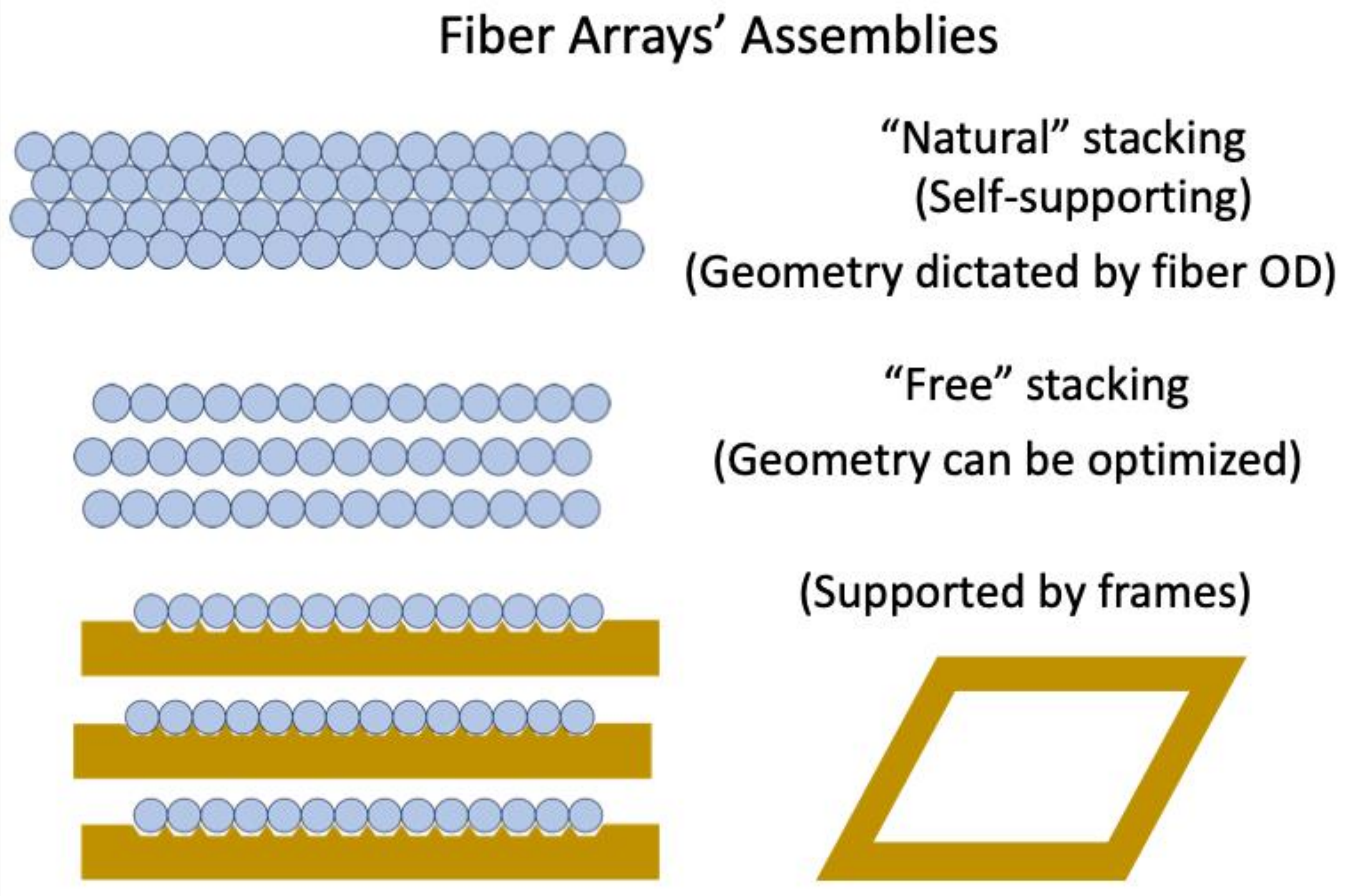
TRS consist of three quartz Cherenkov counters



SETUP

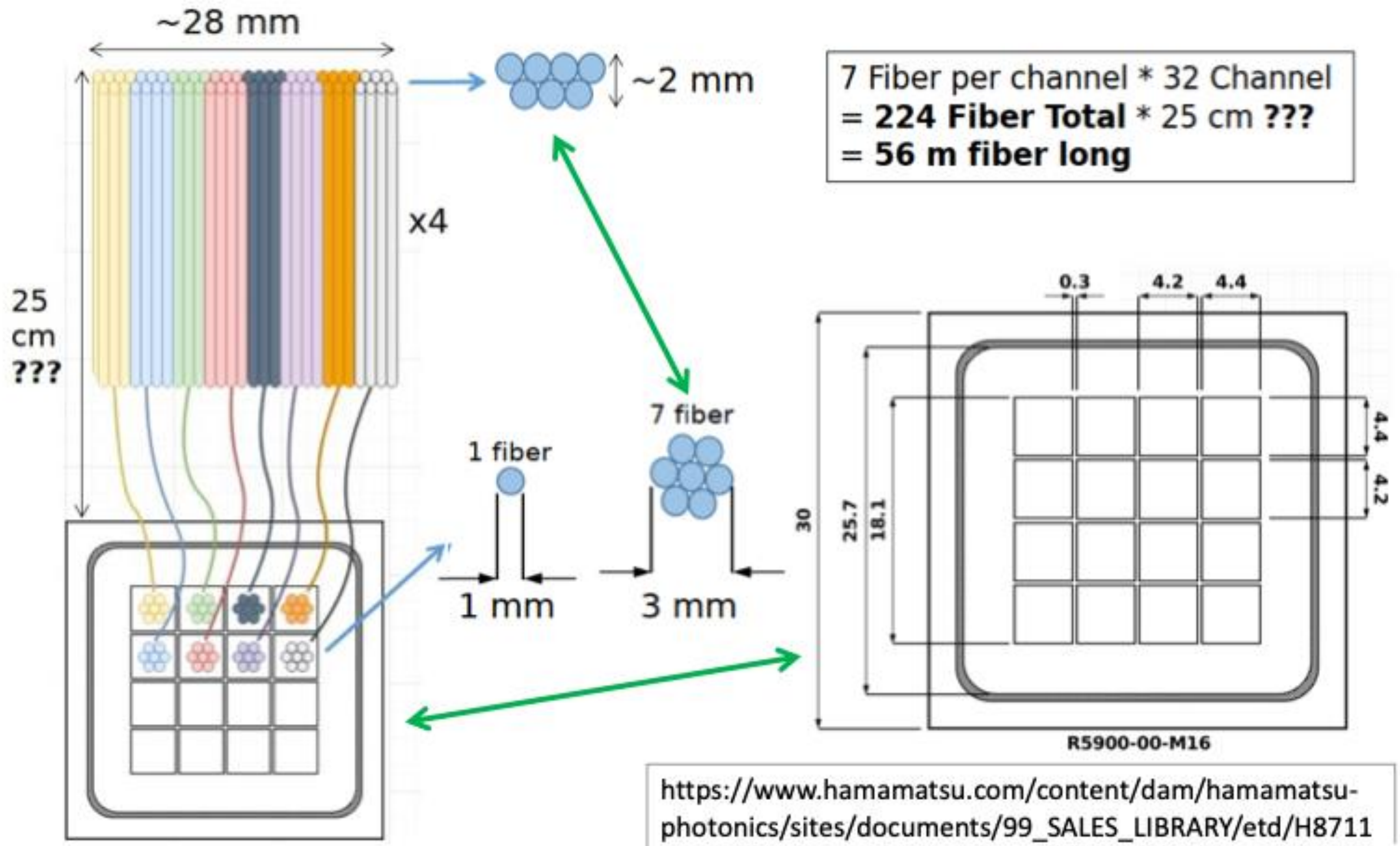

General Assembly of Fiber Arrays and PMT
Fiber Arrays may be assembled in different ways

SETUP


Fiber Arrays' Assemblies
"Natural" stacking
(Self-supporting)
(Geometry dictated by fiber OD)
"Free" stacking
(Geometry can be optimized)
(Supported by frames)

SETUP

Sketch OP et al. , July 1st, 2024



7 Fiber per channel * 32 Channel
= **224 Fiber Total** * 25 cm **???**
= **56 m fiber long**

https://www.hamamatsu.com/content/dam/hamamatsu-photonics/sites/documents/99_SALES_LIBRARY/etd/H8711_TPMH1320E.pdf

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Measuring time with high precision in particle physics

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ABSTRACT

Time measurements with sub-nanosecond time resolution (aiming at values of few picoseconds) are of paramount importance for a wide variety of applications. In the field of particle physics, measuring with increasing precision the time taken by a particle to travel between two points (Time-of-Flight, ToF) gives information on the particle' (relativistic) velocity, contributing to identifying the type of particle (Particle Identification Detectors, PID). Among this category of detectors are also Cherenkov counters, based on the emission of light when a charged particle travels in a transparent medium with a velocity exceeding the light velocity in that medium. Here we discuss a special category of ToF counters using the properties of Cherenkov light to determine the passage of the particles through the detectors with unprecedented precision. Results obtained with test beams are described and analysed, demonstrating the excellent timing resolution that can be obtained. Such detectors may be used to provide a 'precision time reference' for calibrating other types of timing detectors. Other applications are, for instance, time-tagging of 'pile-up' events in high-luminosity Large Hadron Collider (LHC), and identification of events with anomalous timing properties (for instance, long-lived particles, LLP).

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