Preparation for the test-beam and status of the ToF detector construction
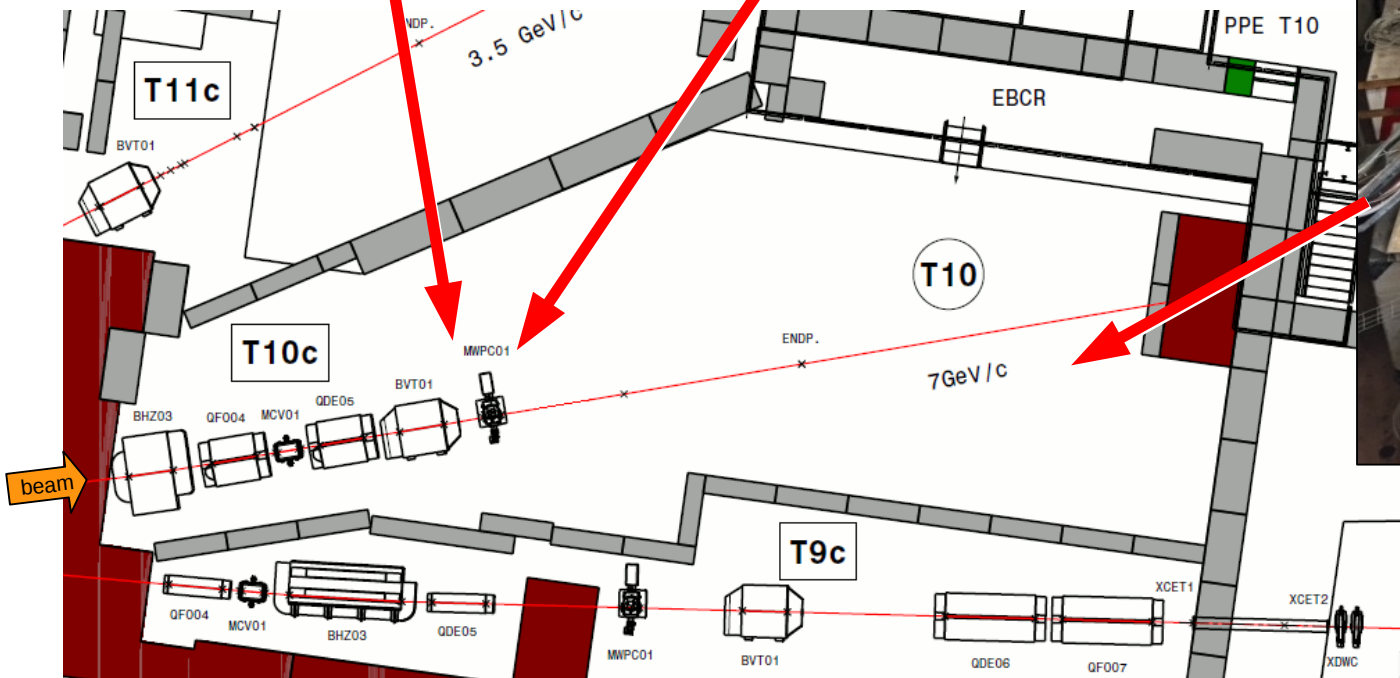
C.Betancourt, A.Korzenev*, P.Mermod

HPTPC-ToF meeting
May 3, 2018
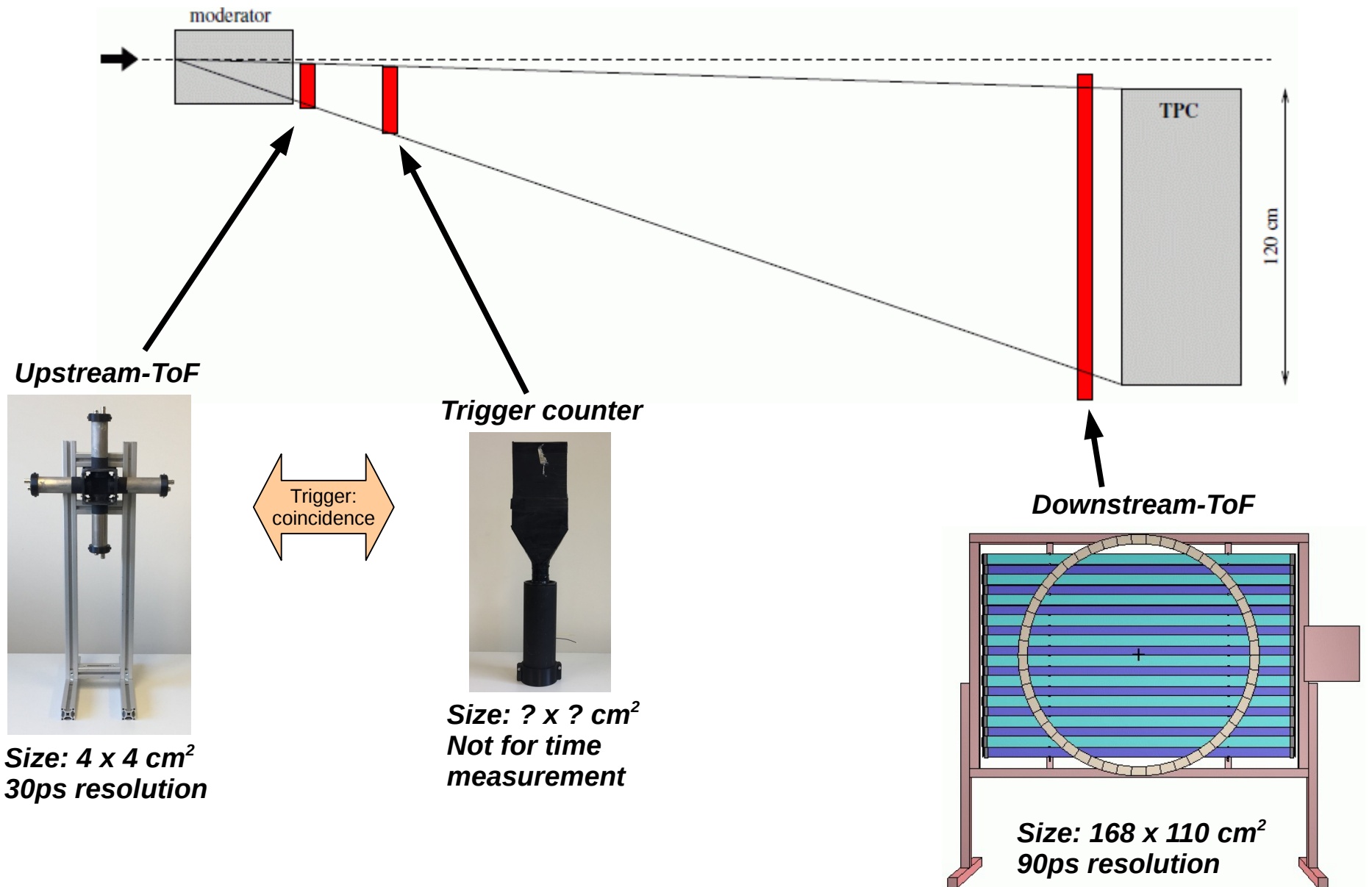
ToF and trigger

- Channels of the ToF DAQ system are self-triggered
- Does TPC require a trigger?
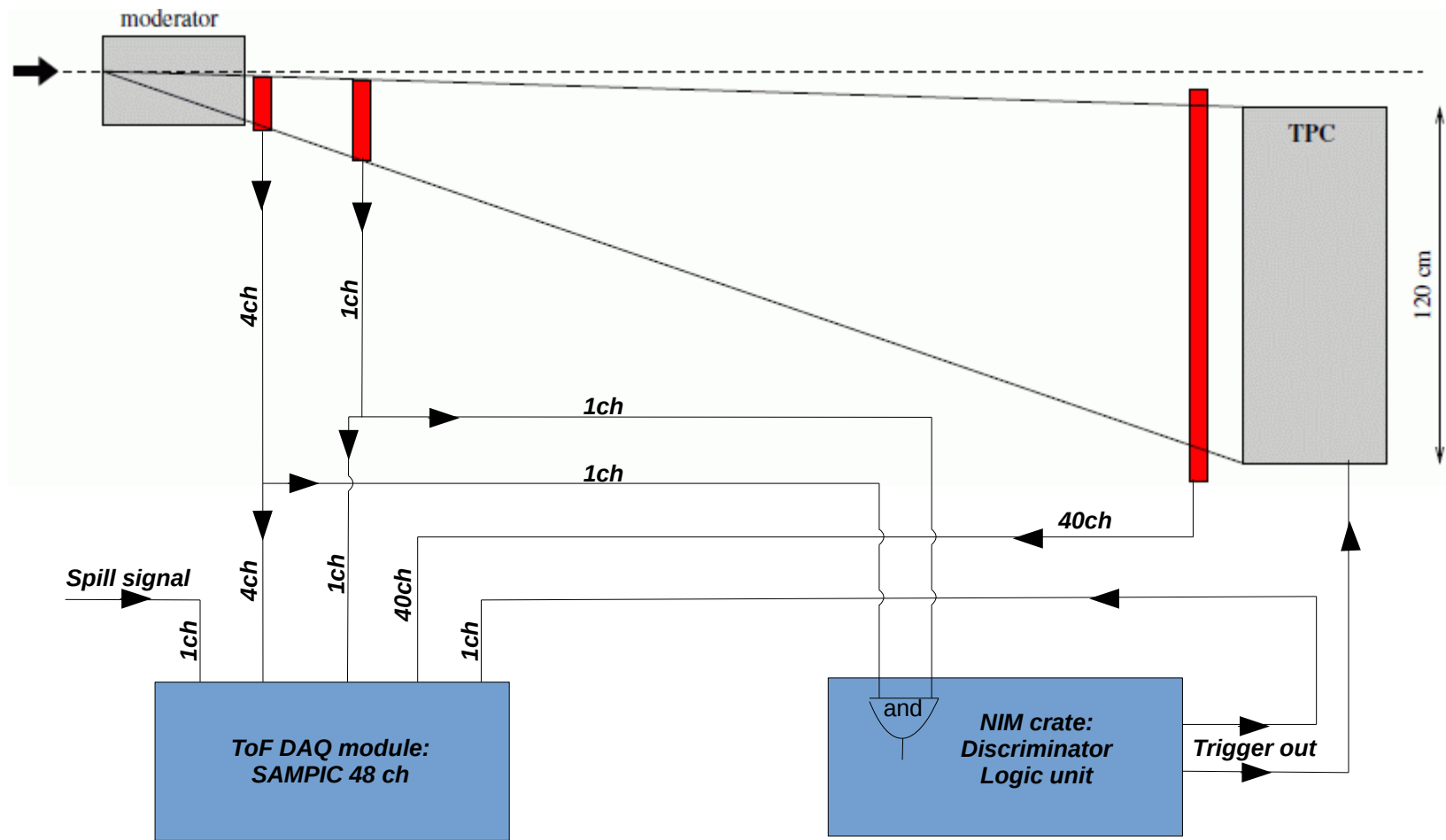- If yes, which counters will form the trigger?

East Hall, T10

Which counters form the trigger?

moderator

TPC

120 cm

Upstream-ToF

Trigger: coincidence

Trigger counter

Downstream-ToF

Size: 4 x 4 cm²
30ps resolution

Size: ? x ? cm²
Not for time
measurement

Size: 168 x 110 cm²
90ps resolution

4

Decoupling of trigger and ToF-DAQ systems

DAQ system of ToF

- Waveform digitizers: WaveCatcher vs SAMPIC
- Data analysis: upstream counter as an example

PS user schedule for 2018

- ▶ sFGD : 25 June - 11 July / T9
- ▶ TPC : 22 August - 5 September / T9
- ▶ HPTPC : 2 August - 5 September / T10

- ● SHiP combined: 3 Oct – 16 Oct / T10
- ● SHiP combined: 15 Oct – 21 Oct / T9

7

DAQ system based on analog memory SCA

SAMPIC

WaveCatcher

- 16ch SAMPIC chip. AMS CMOS 0.18 μm. All channels independent/self-triggered
- Sampling frequency 0.8 – 10.2 GS/s
- Up to 150 kHz signal rate
- Sampling depth is 64 samples
- Dynamic range 1 V
- **Module with 48 ch will be used in the test-beam of HPTPC**
- Proposed for the readout of TD SHIP and ToF ND280 upgrade.
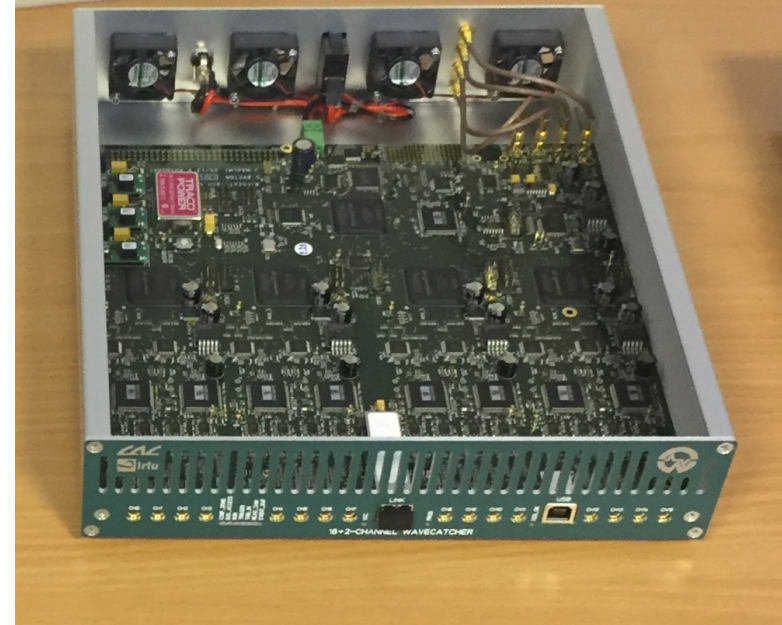
- 2ch SAMLONG chip. AMS CMOS 0.35 μm.
- Sampling frequency 0.4 – 3.2 GS/s
- Up to 1 kHz signal rate
- Sampling depth is 1024 samples
- Dynamic range 2.5 V
- **Module with 16+2 ch will be used for sFGD and atmTPC test-beams**
- Very suitable for test-beams

Waveform recorded by SAMPIC and WAVECATCHER

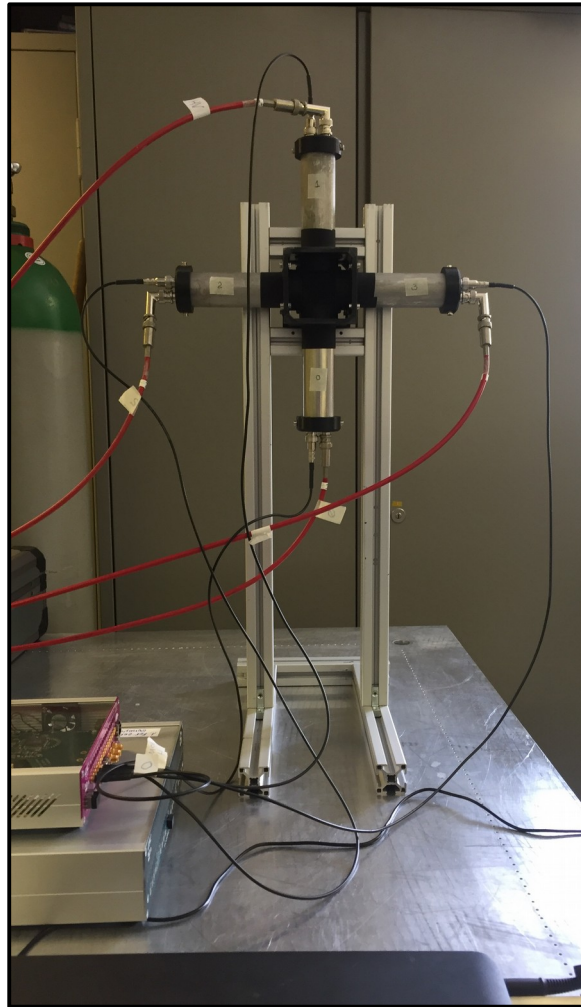**WAVECATCHER**

1024 x 313 ps (1/3.2 GHz) = 320 ns

SAMPIC

with respect to a reference time

ToT information (signal width) is also provided

64 x 313 ps (1/3.2 GHz) = 20 ns
64 x 625 ps (1/1.6 GHz) = 40 ns
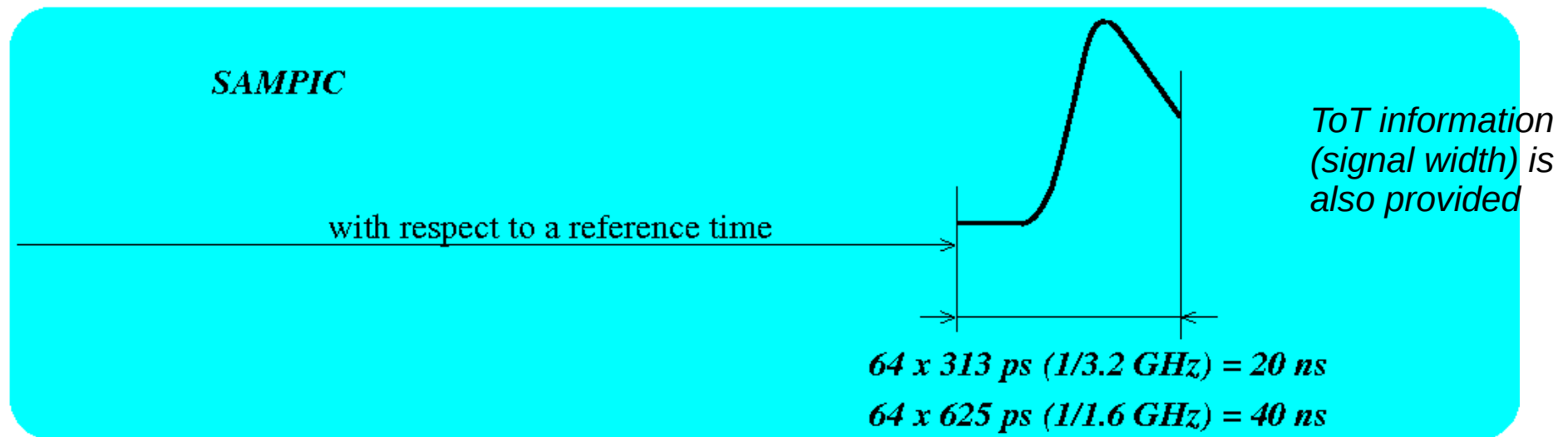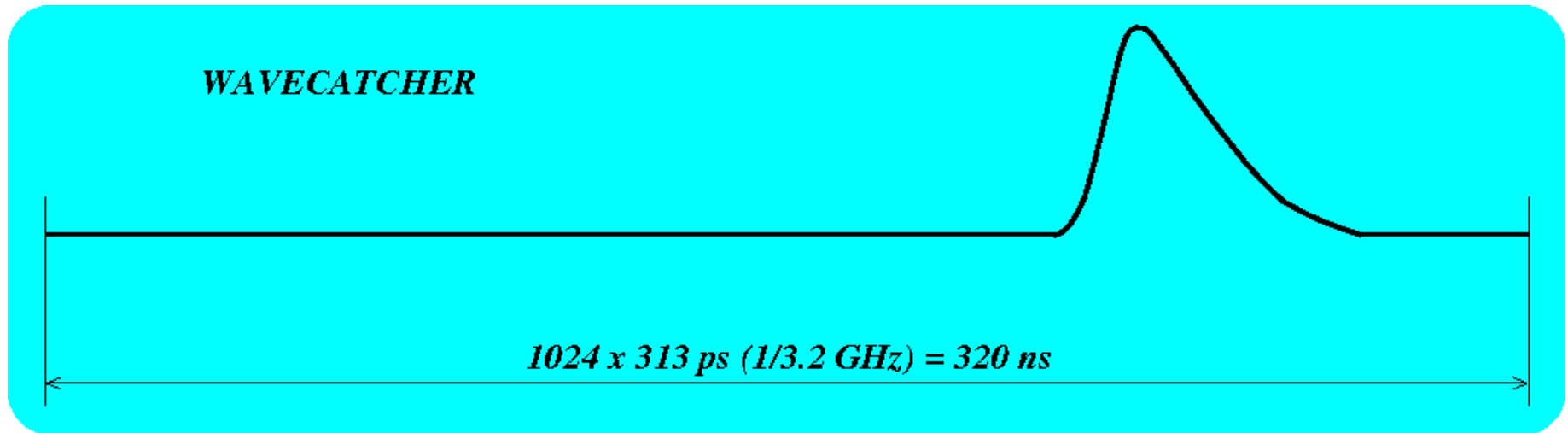
Was used in the 3.2 GS/s mode

Upstream ToF counter

Side view

Front view

Plastic scintillator: EJ-228 (BC-418)

5 / 40 / 40
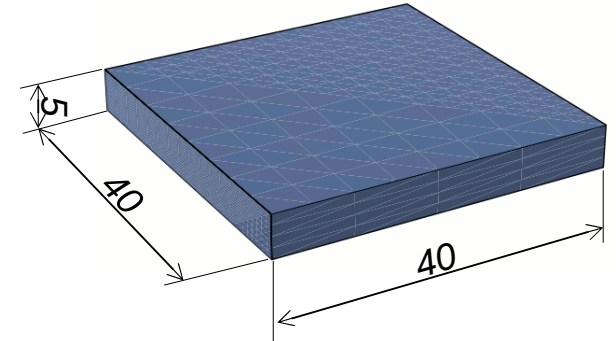
Rise time = 0.5 ns, decay time = 1.4 ns

Max emision in 391nm, N_γ per 1 MeV e- = 10k

4 cm

PMT: 1" R4998, H6533 MOD

PMT : R4998
WITH HA TREATMENT

MAGNETIC SHIELD CASE (t= 0.8 mm)

$\varnothing 31 \pm 0.5$
$\varnothing 26 \pm 1$
$\varnothing 20$ MIN

1 MAX.

120 ± 0.8
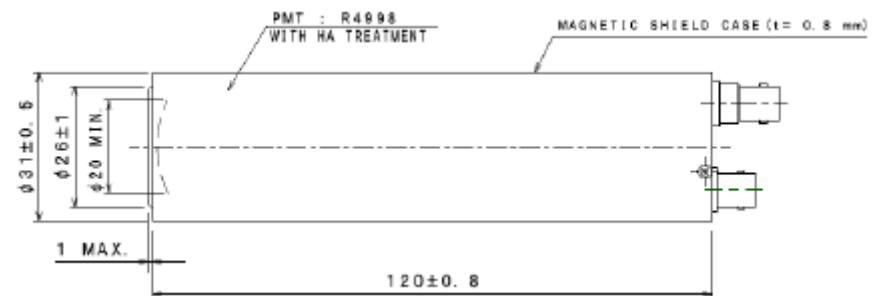
10-stages, rise time = 0.7 ns, TTS = 0.16 ns

Transit time = 10 ns, Gain = 5.7 x 10^6

Has been assembled (in b. 595) and calibrated

10

Analysis of the ^{90}Sr data
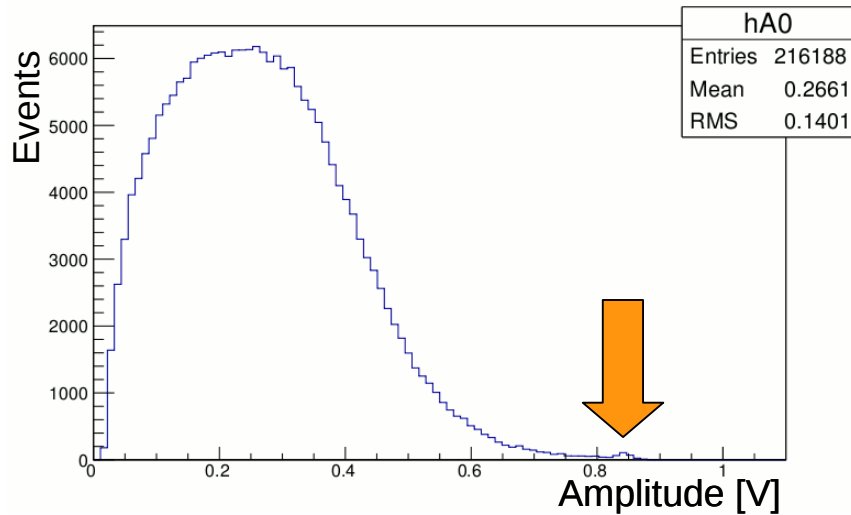
- ^{90}Sr β-source have been used to calibrate the response of PMTs
- Amplitudes are equalized
- Dynamic range of SAMPIC is 1V

- Event rate falls exponentially with Δt
- There are no events at first 2 μs => deadtime of the SAMPIC readout

11
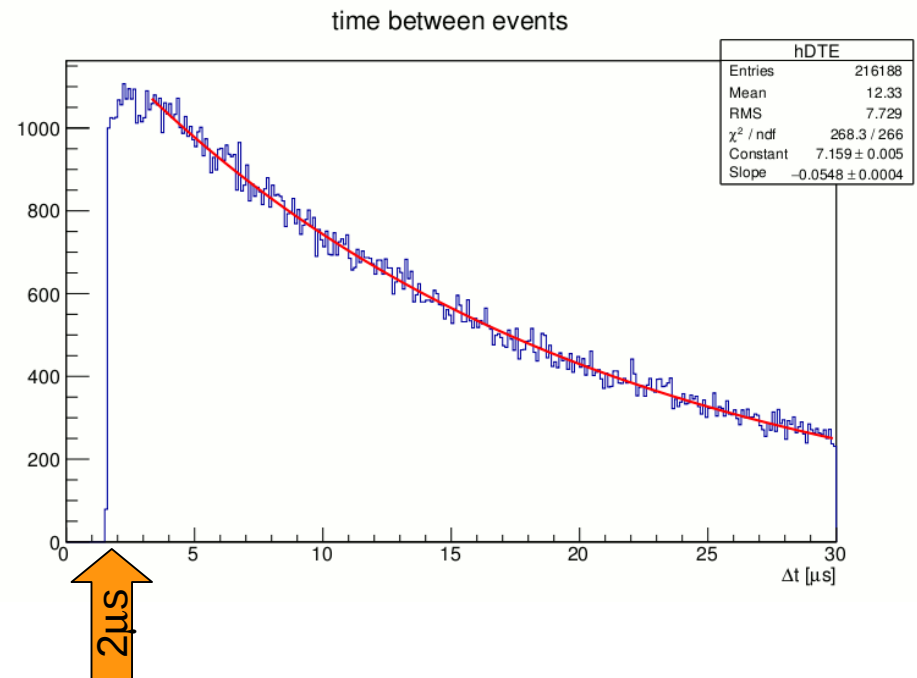
DAQ program of SAMPIC

Time resolution of the 4-PMT counter

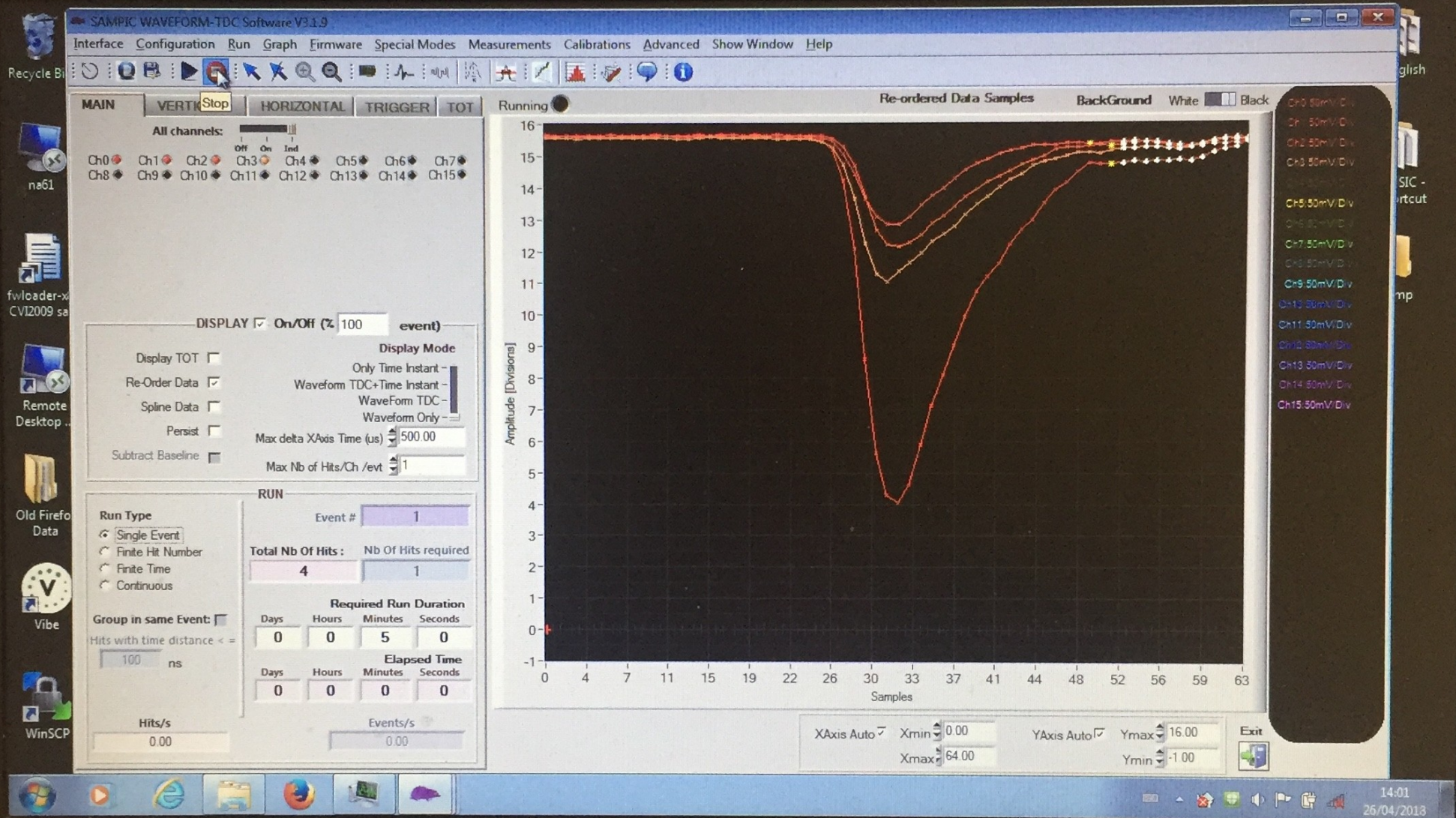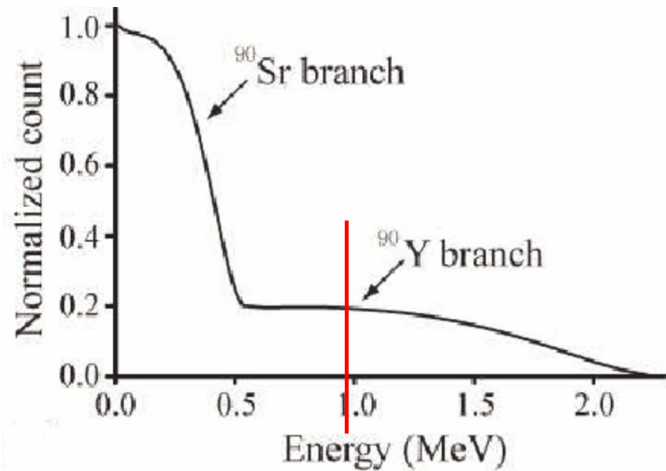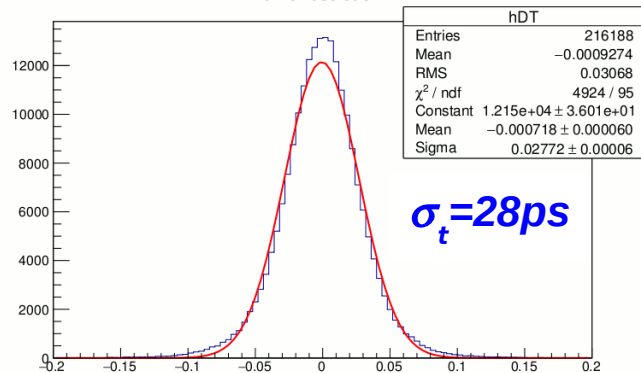- Digital CFD technique to determine time
- Energy deposition in PVT: 2 MeV/cm
  - Only a fraction of e⁻ can go through
  - Non-gaussian tails
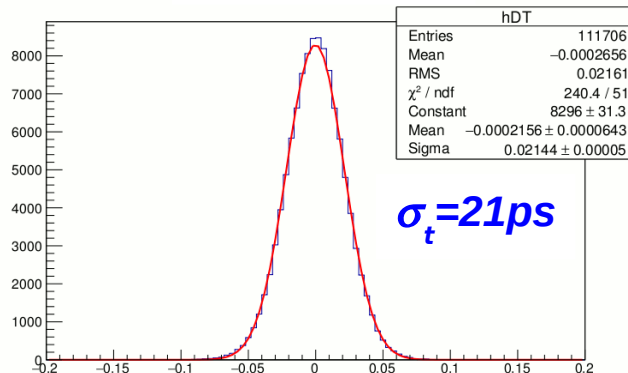- Time resolution can be measured by looking at the relative time of PMTs

$$t_{trig} = \frac{t_1 + t_2 + t_3 + t_4}{4} \quad \rightarrow \quad \delta t_{trig} = \sigma\left(\frac{(t_1 + t_2) - (t_3 + t_4)}{4}\right)$$
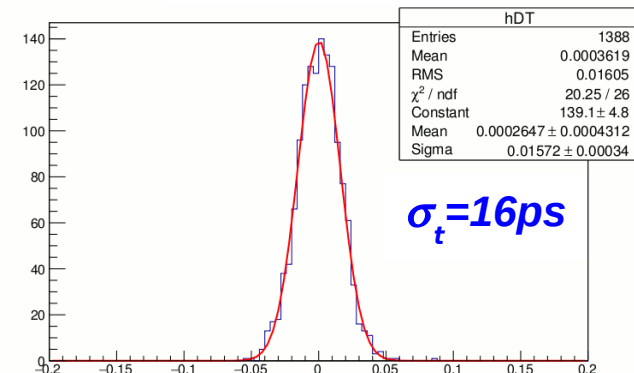
Without A cut

time resolution		
	hDT	
Entries		216188
Mean		−0.0009274
RMS		0.03068
χ^2 / ndf		4924 / 95
Constant		$1.215e+04 \pm 3.601e+01$
Mean		$−0.000718 \pm 0.000060$
Sigma		0.02772 ± 0.00006

$\sigma_t = 28ps$

$A_{min} > 200mV$

	hDT	
Entries		111706
Mean		−0.0002656
RMS		0.02161
χ^2 / ndf		240.4 / 51
Constant		8296 ± 31.3
Mean		$−0.0002156 \pm 0.0000643$
Sigma		0.02144 ± 0.00005

$\sigma_t = 21ps$

$A_{min} > 500mV$

|	hDT	
Entries		1388
Mean		0.0003619
RMS		0.01605
χ^2 / ndf		20.25 / 26
Constant		139.1 ± 4.8
Mean		0.0002647 ± 0.0004312
Sigma		0.01572 ± 0.00034

$\sigma_t = 16ps$
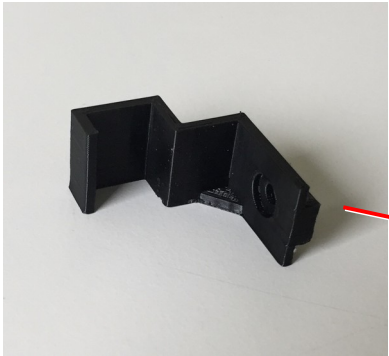
13

Status of the downstream ToF construction

- Goal is to assemble the detector by the 1-st week of July
- All t0's to be calibrated with the light pulser system in the lab in July
- To be fully operational by August 1-st (test-beam of HPTPC)

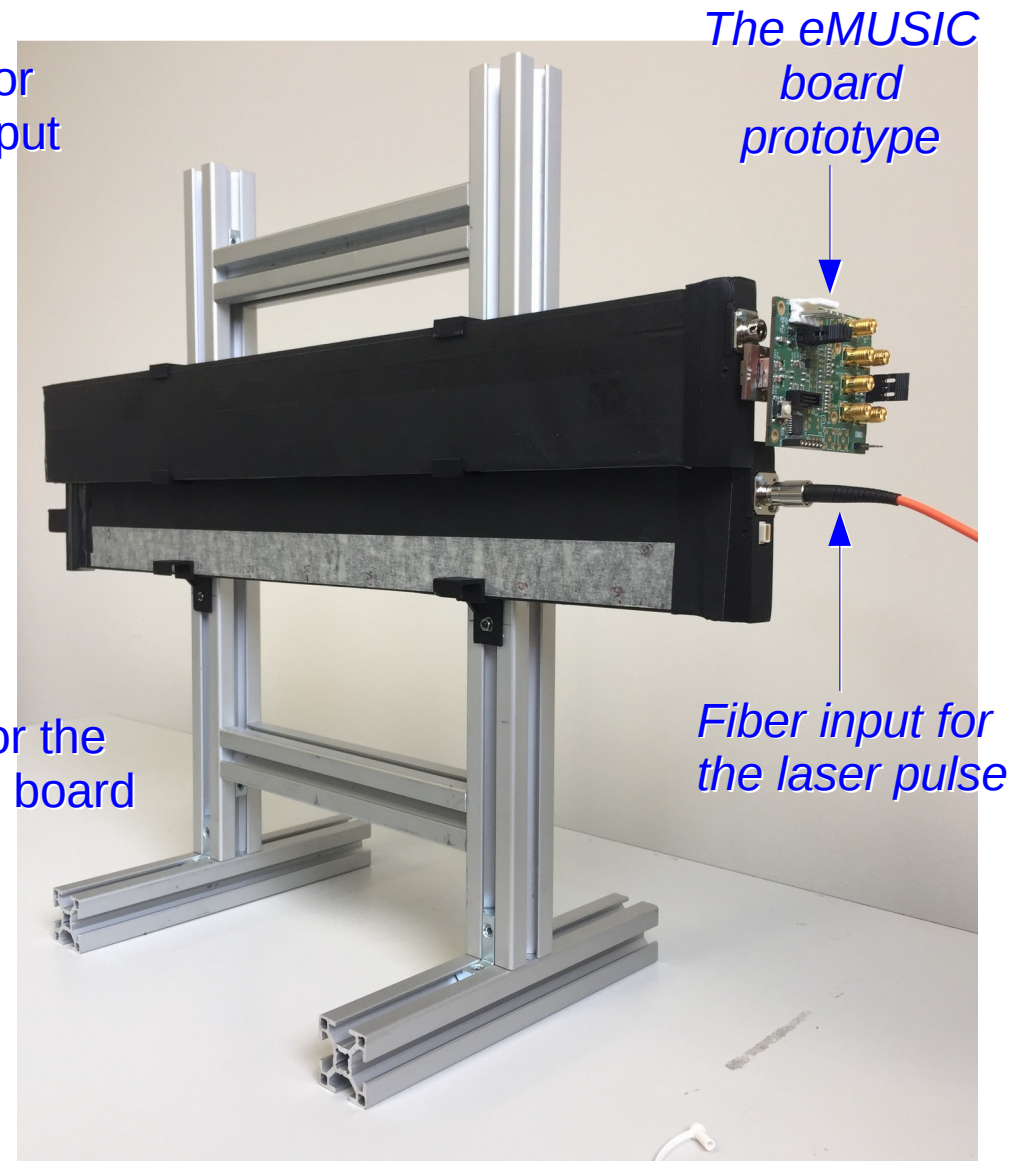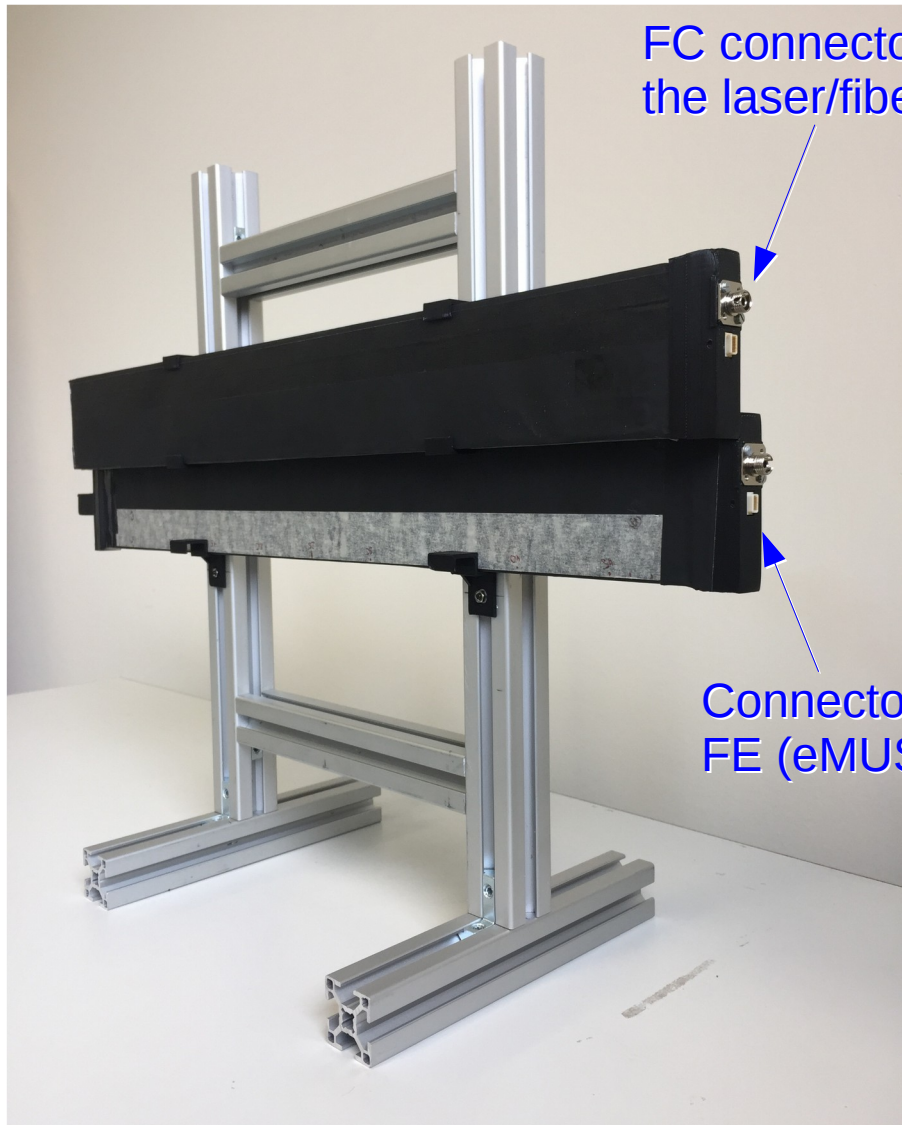# Timing detector prototype with 20 bars
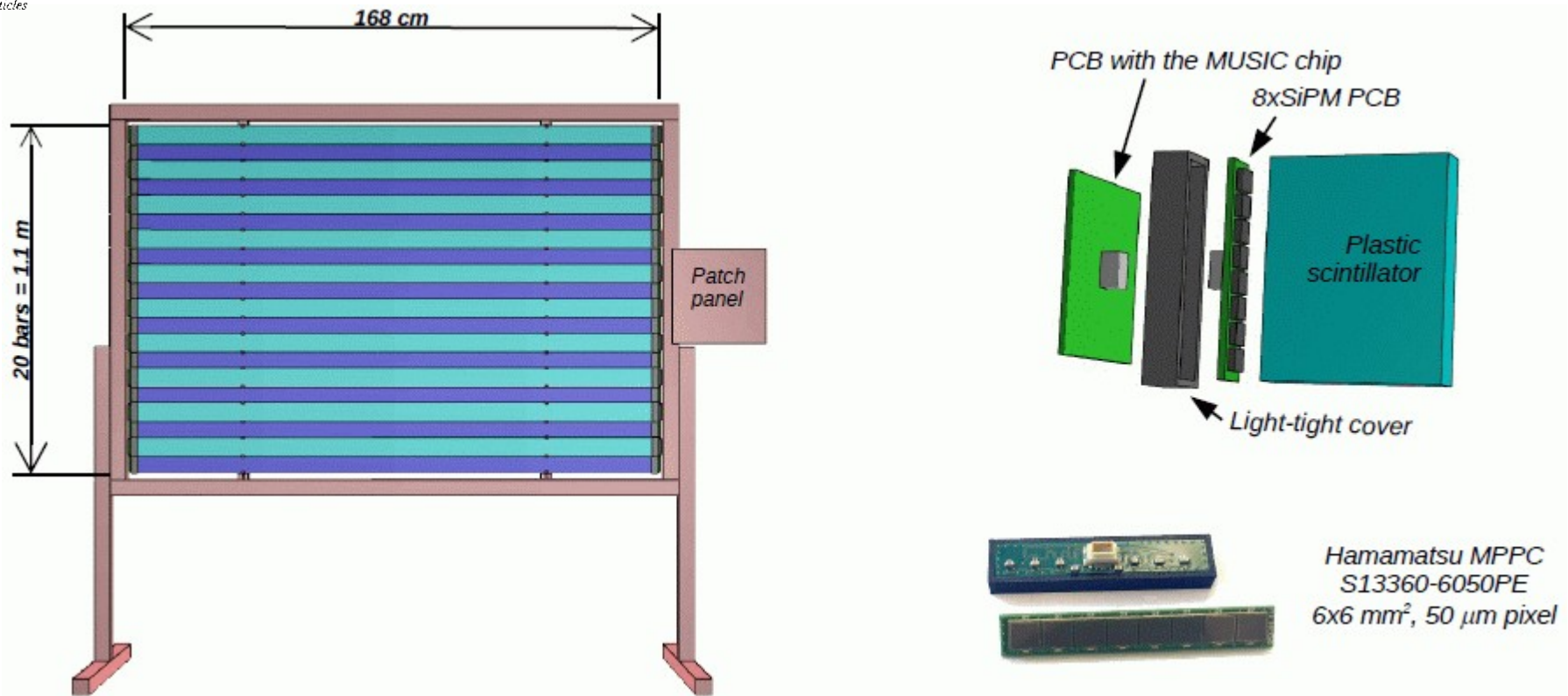
- Goal is to assemble the prototype by the 1-st week of July
  - SiPMs (320 pcs) will arrive by June 18
  - Prototype of FE (MUSIC board) has been tested. Possibly 1-2 weeks delay for the 40 PCBs
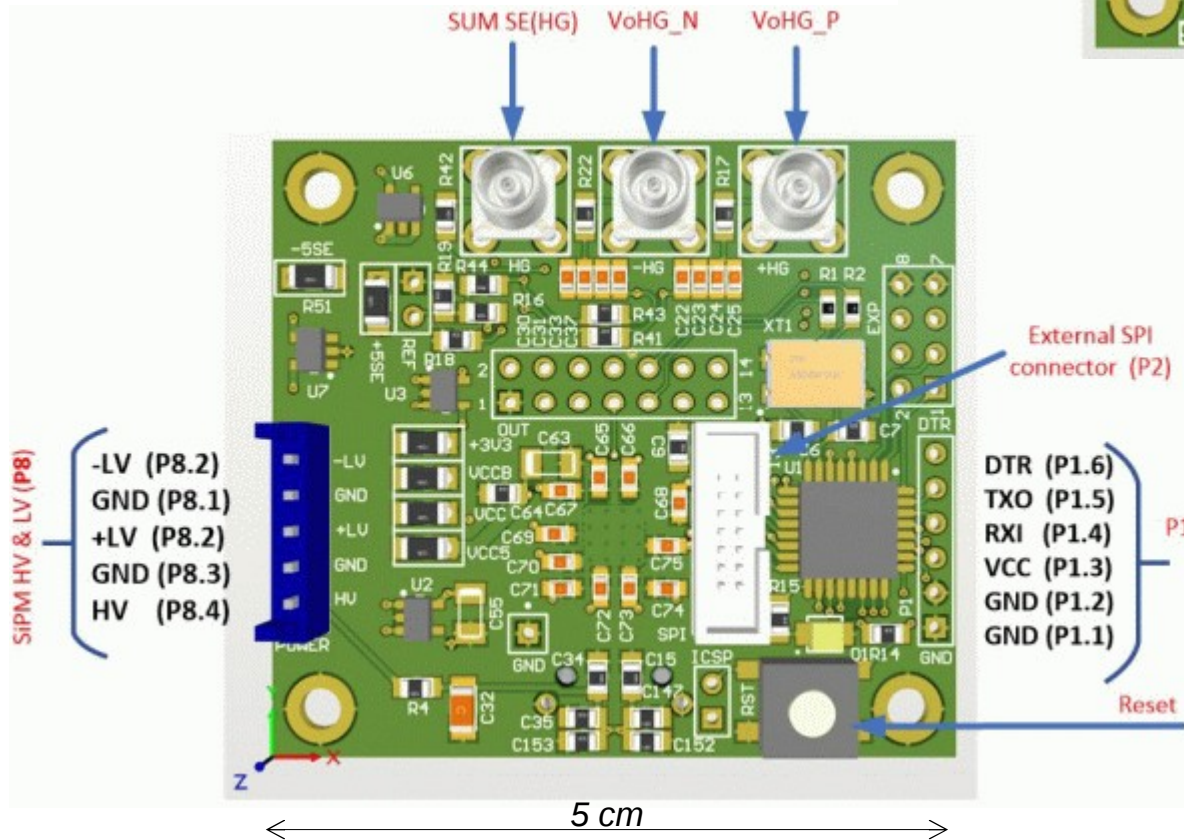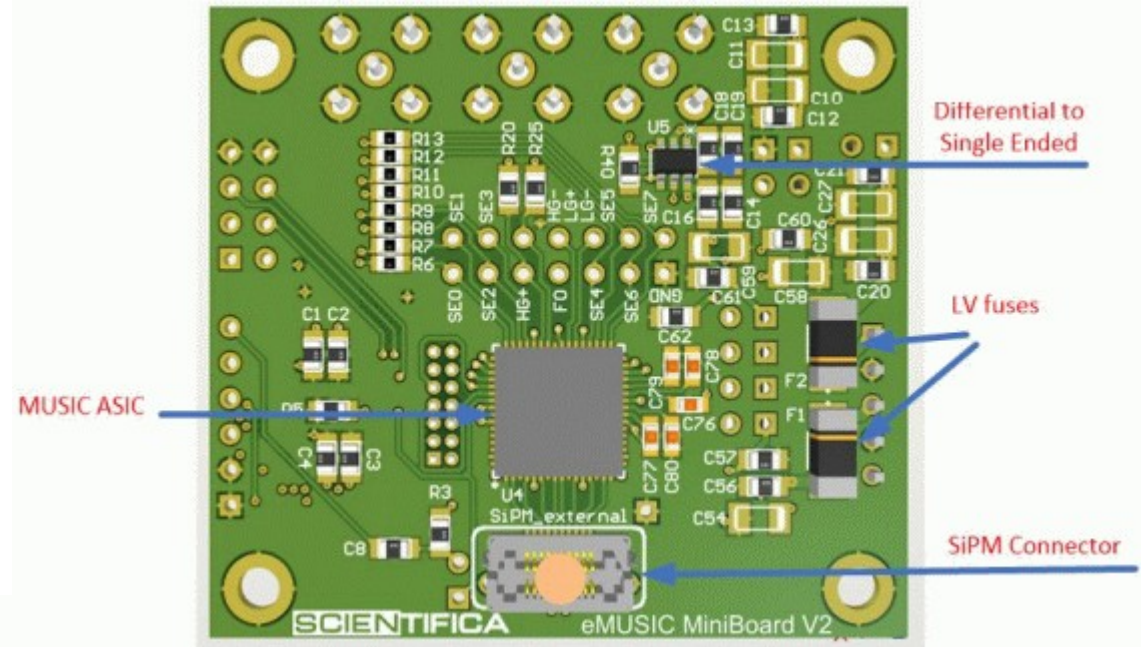
The bar fixation method

Hooks are printed at our 3D printer

MUSIC board and laser input

FC connectors for the laser/fiber input

Connectors for the FE (eMUSIC) board

The eMUSIC board prototype
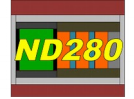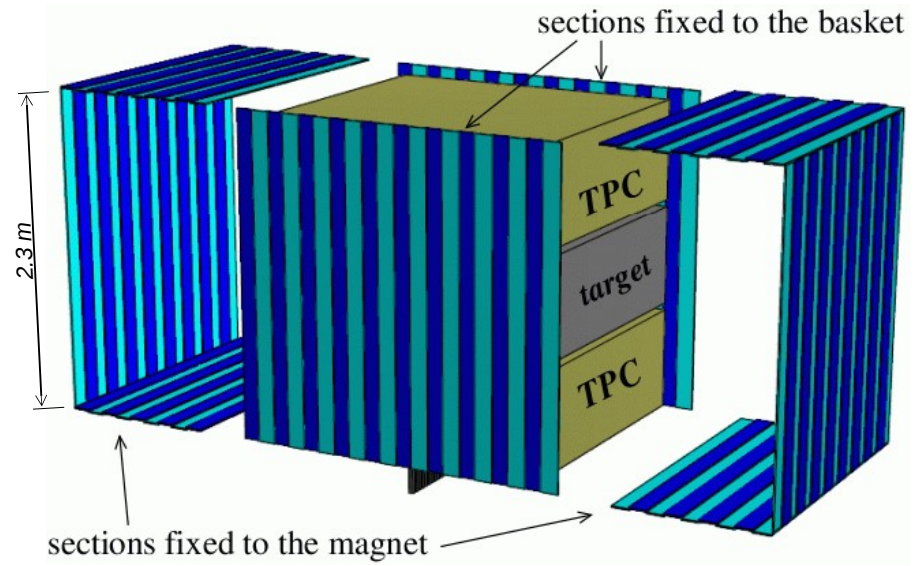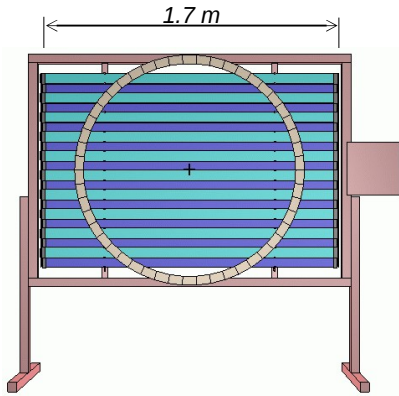
Fiber input for the laser pulse

- ASIC: Multiple Use SiPM Integrated Circuit (MUSIC)

- ASIC provides analog outputs of 8 individual SiPMs and also the sum

- Tunable pole-zero cancellation for the SiPM recovery time

- Individual offsets and overall gain can be configured

Differential to Single Ended

MUSIC ASIC

LV fuses

SiPM Connector

SUM SE(HG)   VoHG_N   VoHG_P

SiPM HV & LV (P8)

-LV (P8.2)
GND (P8.1)
+LV (P8.2)
GND (P8.3)
HV (P8.4)

External SPI connector (P2)

DTR (P1.6)
TXO (P1.5)
RXI (P1.4)   P1
VCC (P1.3)
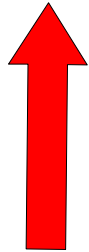GND (P1.2)
GND (P1.1)

Reset

5 cm

- Communication to MUSIC either directly (SPI connector) or via micro-controller

- Micro-controller can talk to PC via UART interface (USB) and can store all settings and calibration values for SiPMs

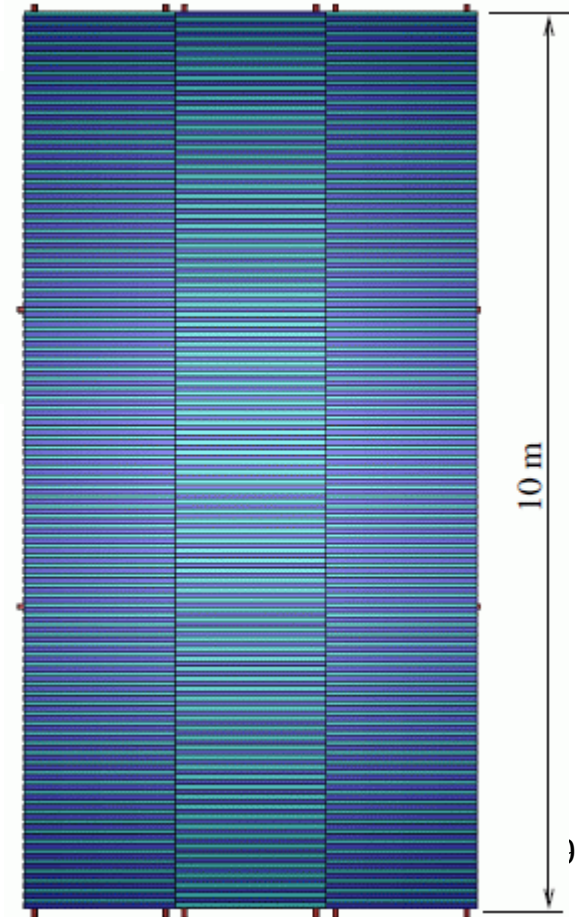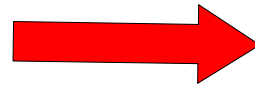- 3 options for the analog output

18

Prototype Summer 2018

1.7 m

sections fixed to the basket

2.3 m

TPC

target

TPC

ND280

ND280

ND280 upgrade 2020

sections fixed to the magnet

The technology will be applied (proposed) for the following protects

SHiP
Search for Hidden Particles

year 2024

10 m

Summary & remarks

- Trigger system to be defined
- 20 bar prototype to be assembled by July (SHIP+ND280 projects)
  - To be tested and calibrated in July
  - To be used for tof in August
- I will be alone available from the ToF team in August
  - HPTPC shifters have to know how to start/stop a ToF run and copy files
 - Will you analyze the ToF data? I can provide the raw data decoding code and Sr data for the upstream counter

backup

Test-beam scheme for T9
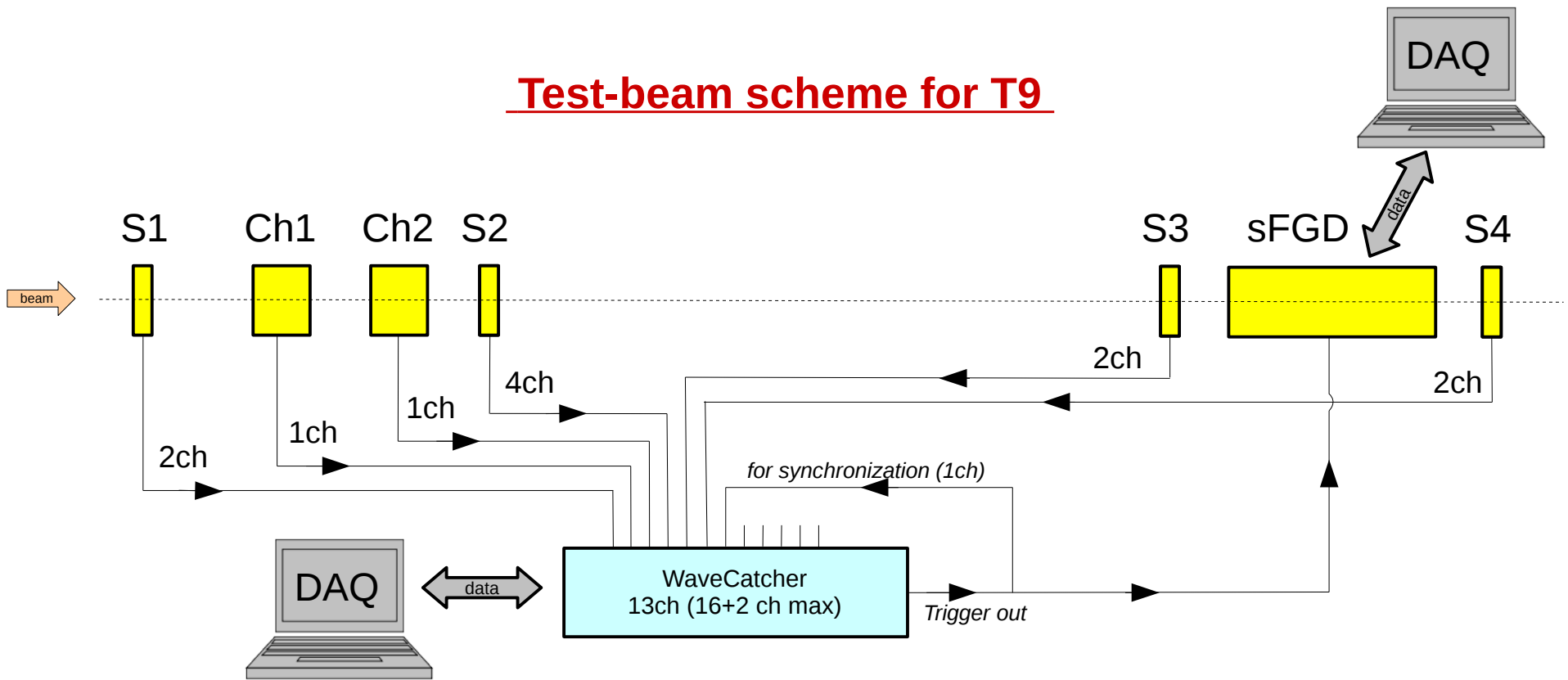
- Two independent DAQ systems: WaveCatcher & BabyMIND (sFGD)
  - Synchronized via trigger signal from WaveCatcher
  - Data to be merged offline
- WaveCatcher system:
  - Coincidence between beam scintillator counters
  - PID via ToF + 2 signals from Cherenkov counters
  - Assurance for a single particle within 320 ns time window
- BabyMIND system: detector under study
  - Self-triggering system. WaveCatcher signal goes to one of channels

Trigger: WaveCatcher
S1 and S2 and S3 (8ch)
S1 and S2 and S3 and S4 (10ch)

22

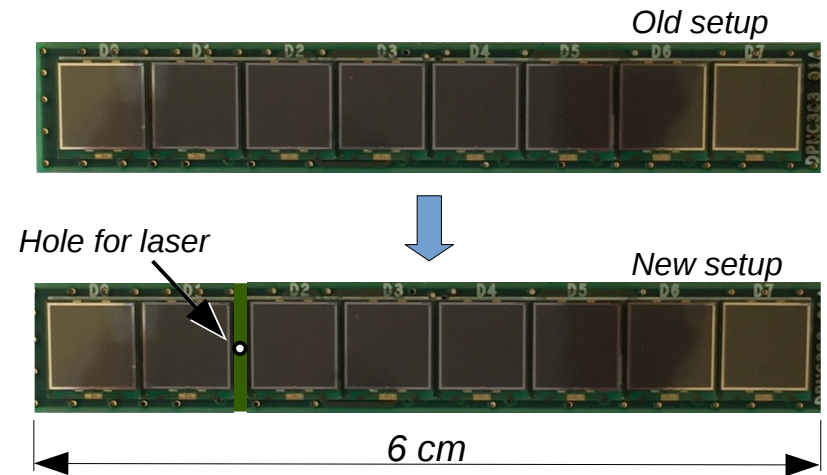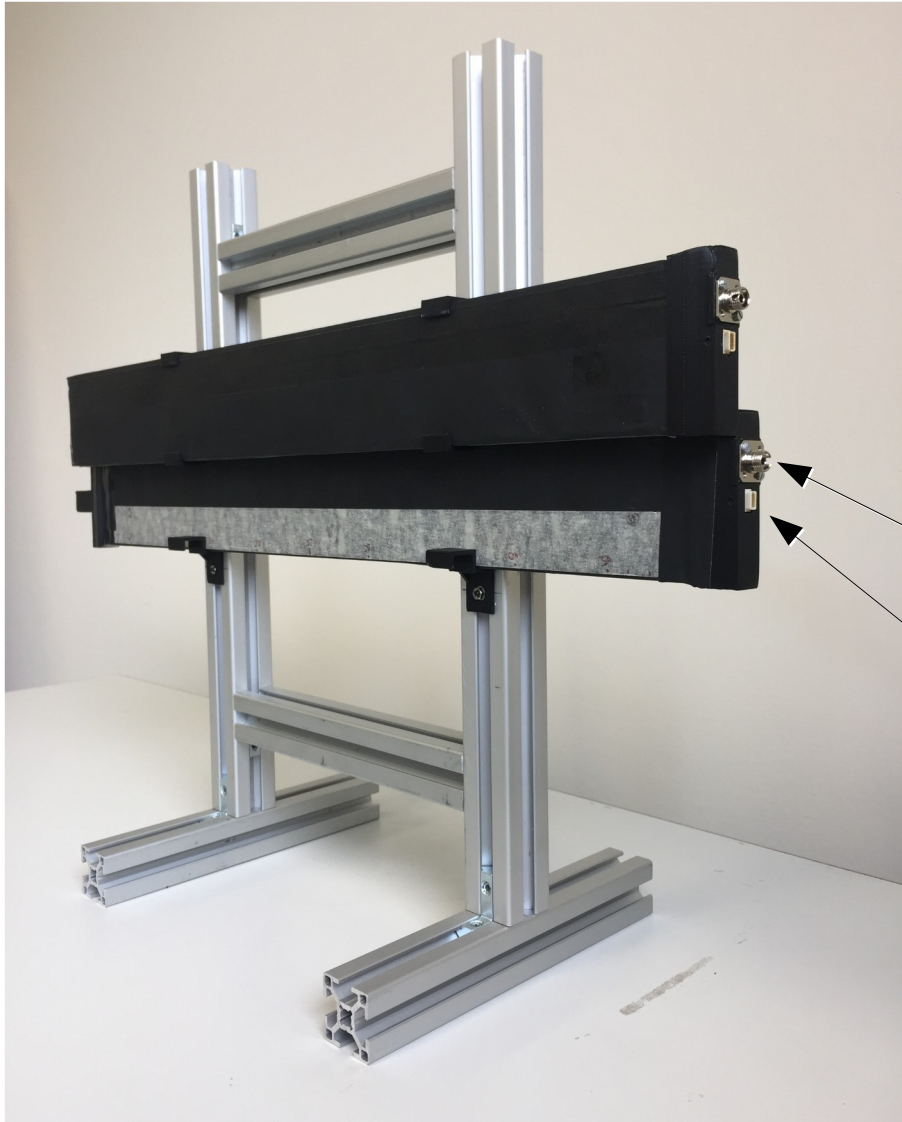# ToF and trigger system for the SuperFGD test-beam in June 2017

S1

S2
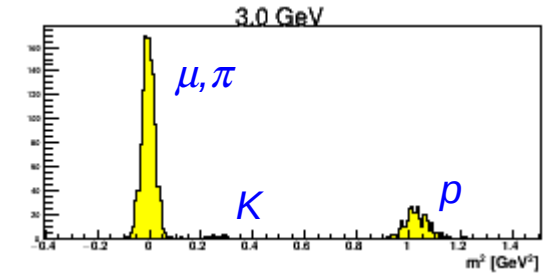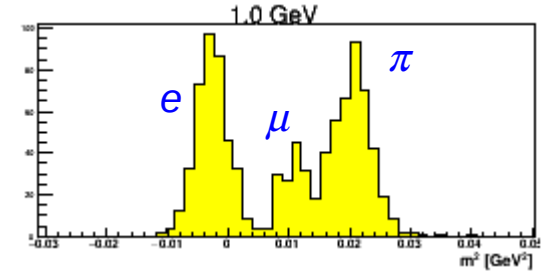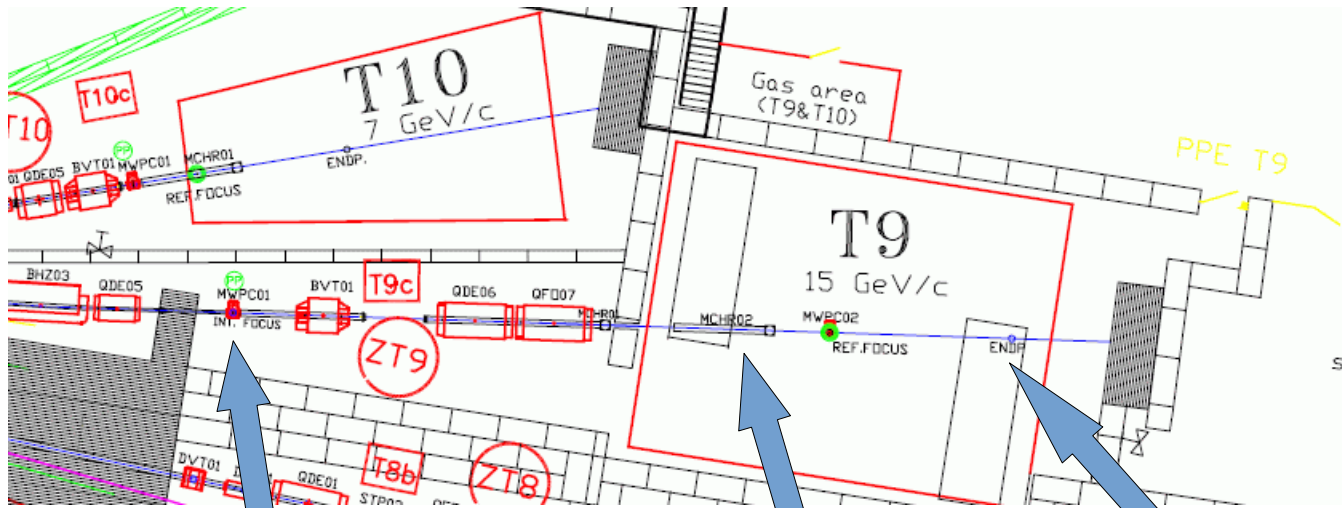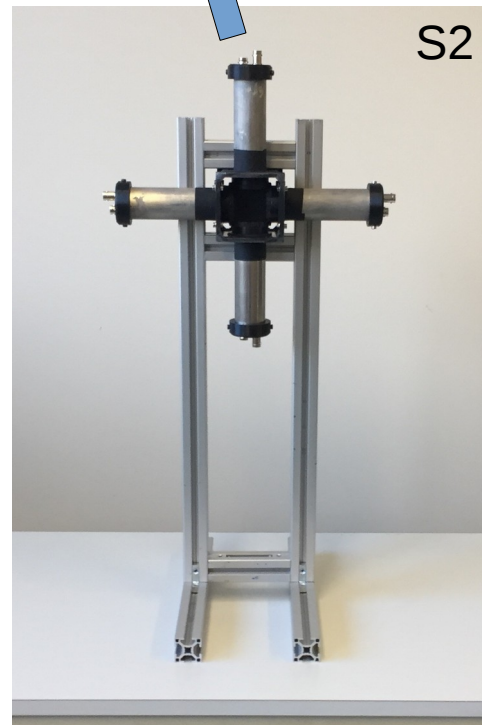
S3,S4

2 bars:
50x6x1 cm³
δt = 60 ps

To be set
up- and
downstream
of SuprFGD

SiPM-array and connectors

Old setup

Hole for laser

New setup

6 cm
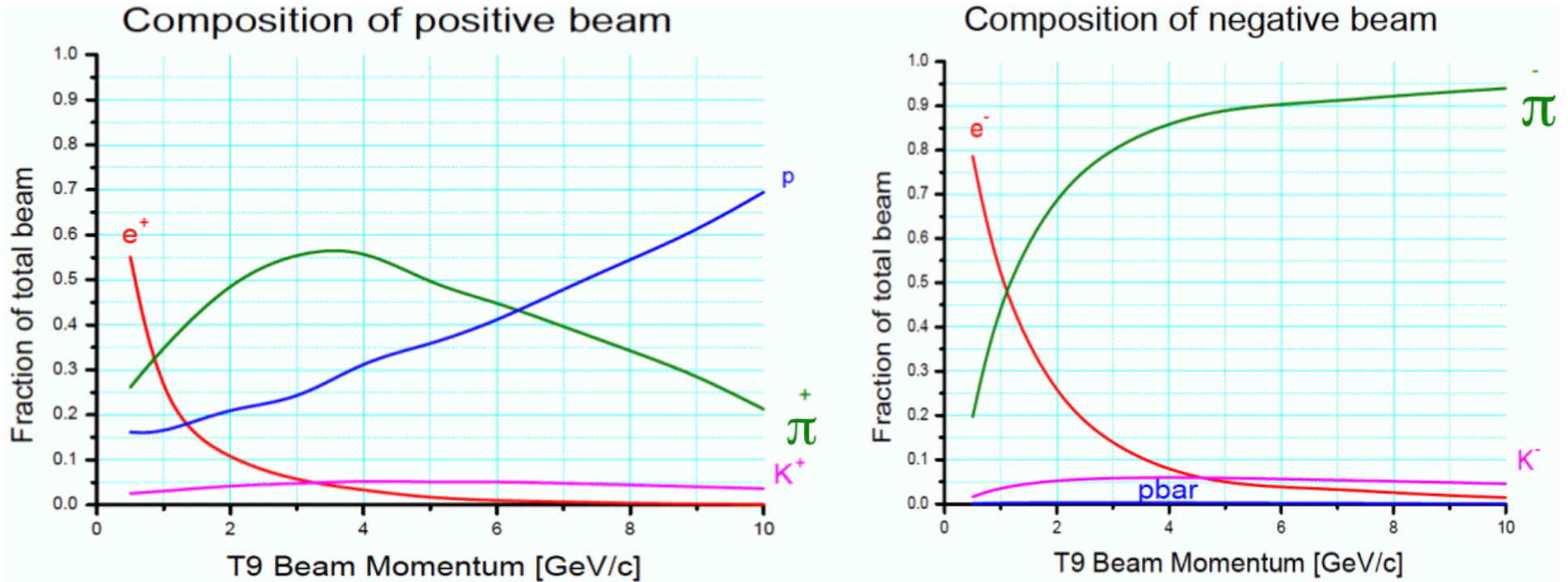
FC connectors for the laser/fiber input

Connectors for the MUSIC board

Beam composition at T9 (with electron enriched target)

- ToF cannot distinguish between $(e,\mu,\pi) \leftrightarrow K \leftrightarrow p$ up to 6 GeV/c
- Cherenkov detector: $e^\pm \leftrightarrow$ all_the_rest
- Efficiency ($\neq$100%) and purity ($\neq$100%) of identification can be calculated by looking at the mass spectrum of ToF and Cherenkov