Servizi Base per BelleII

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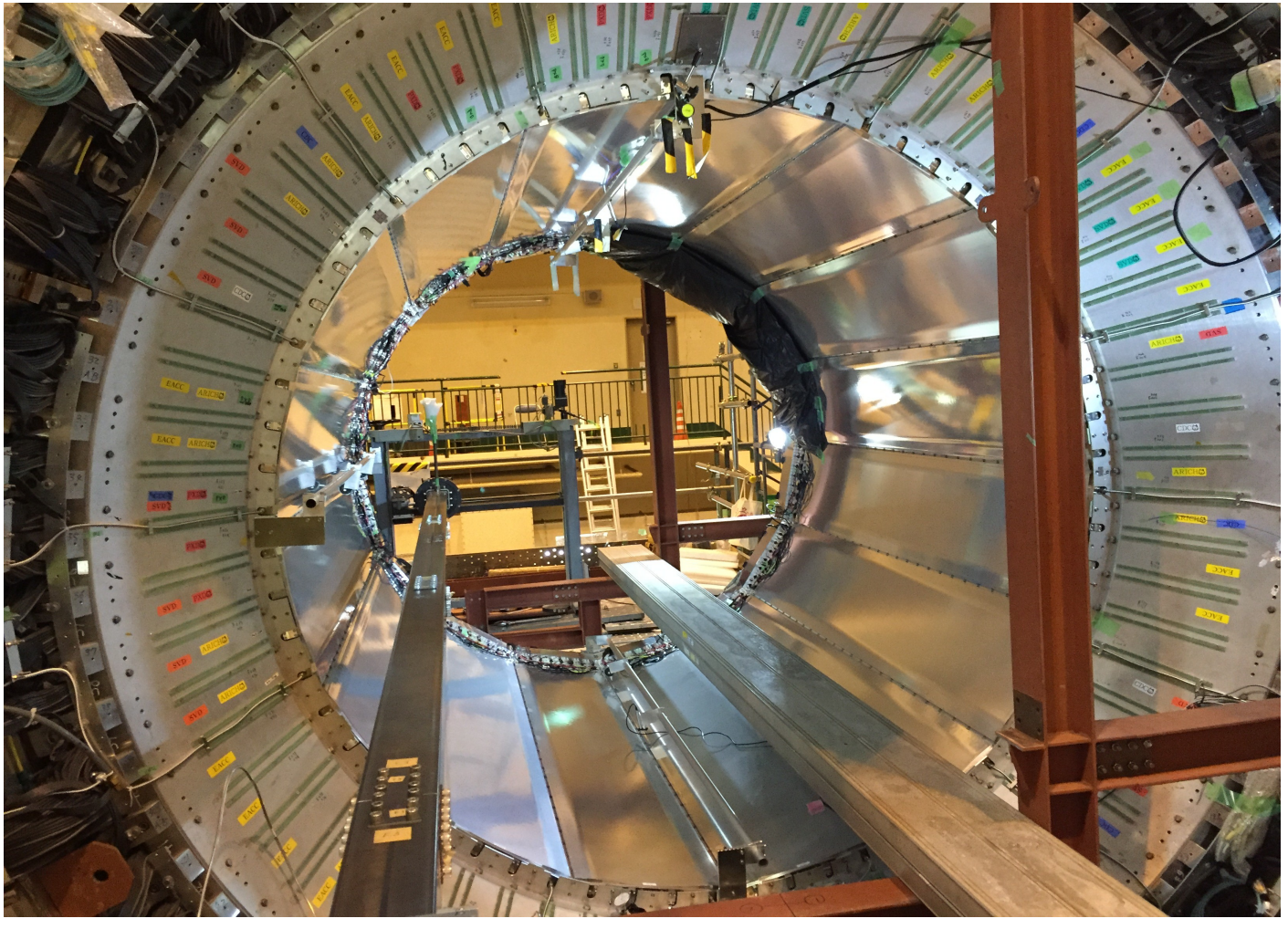
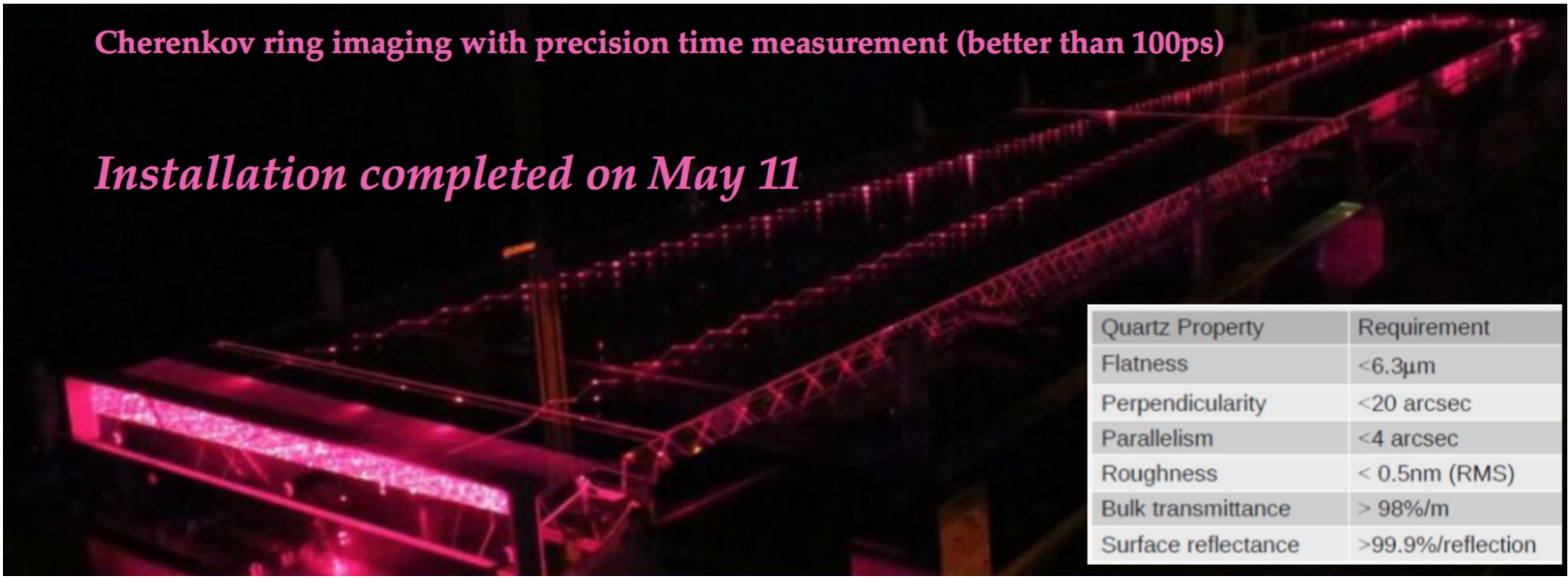


The TOP on BelleII

Good news first: the TOP installation is done

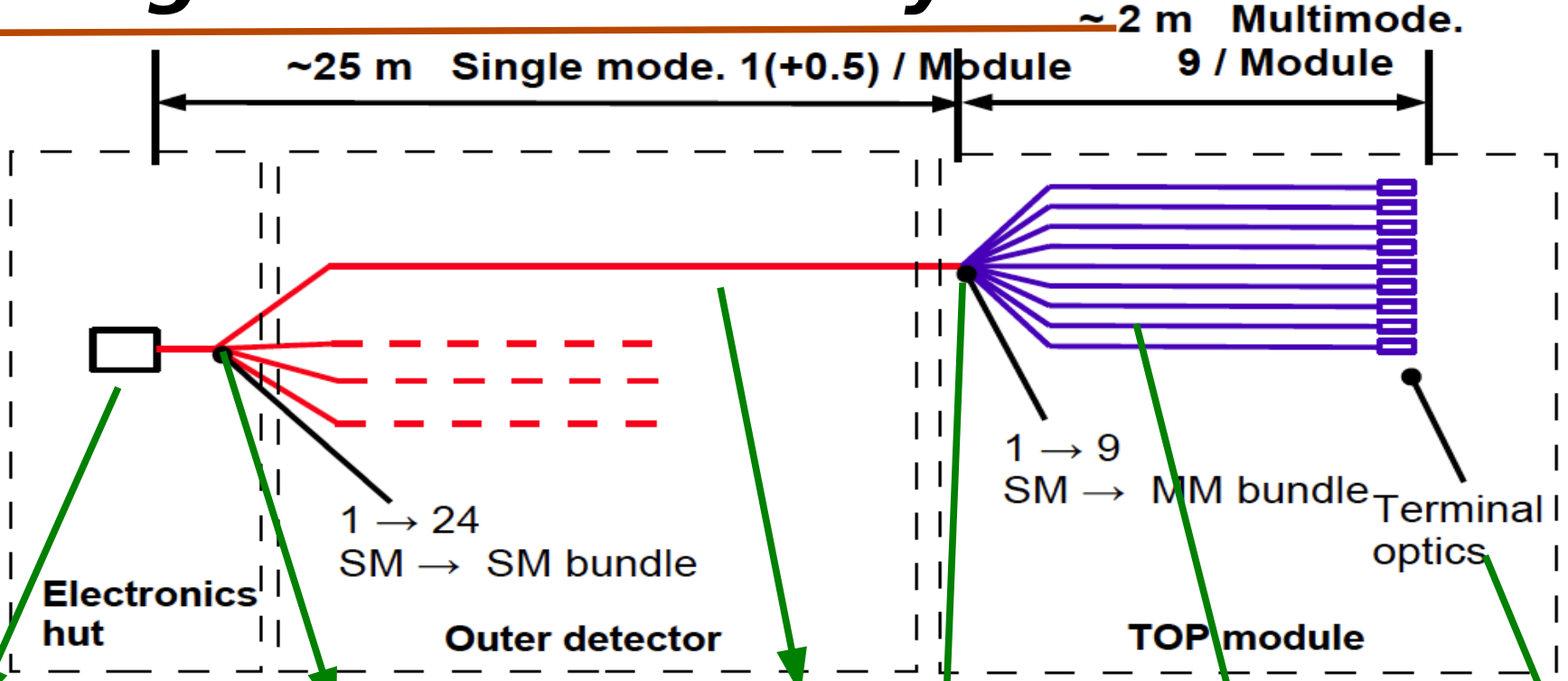
Four months-long effort by 20+ people shifting at KEK (~10 people constantly on the field)

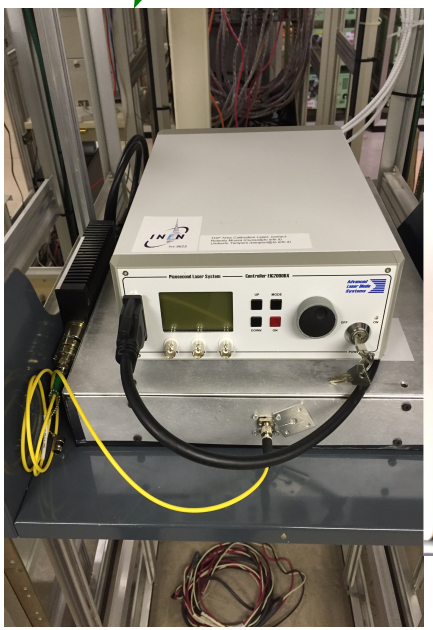


Quartz Property	Requirement
Flatness	<6.3μm
Perpendicularity	<20 arcsec
Parallelism	<4 arcsec
Roughness	< 0.5nm (RMS)
Bulk transmittance	> 98%/m
Surface reflectance	>99.9%/reflection

Now the effort is on debugging and calibration of the front end electronics, and integration in the global DAQ

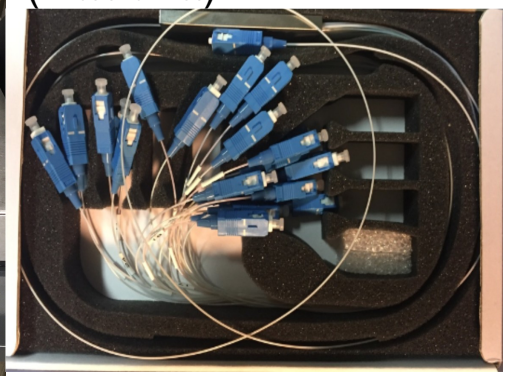
TOP light distribution system



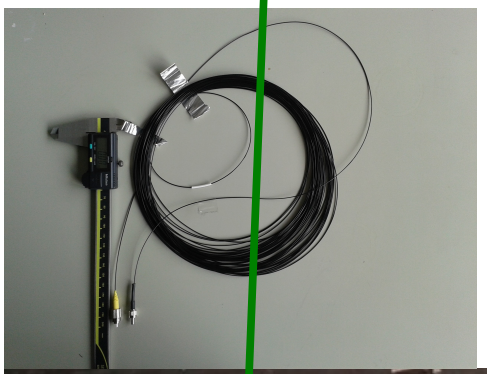


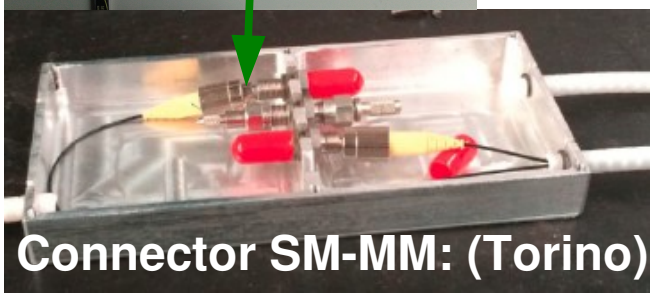
PiLas laser (Torino)

NEW: Splitter 1-24 via Planar Light Circuit (Padova)



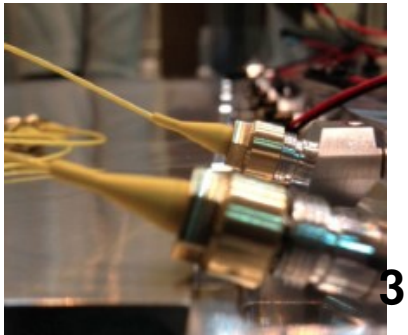
SM fiber (Torino)



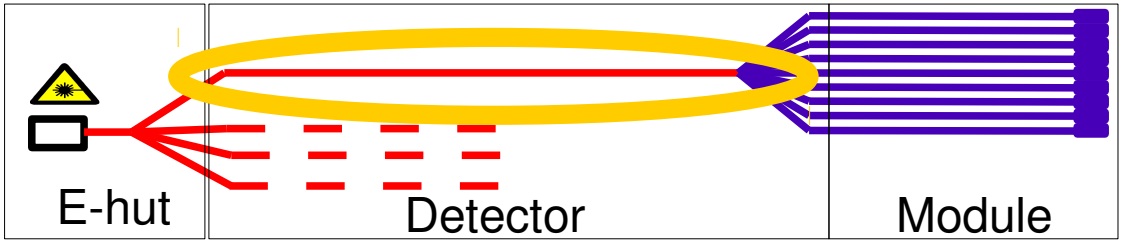


Connector SM-MM: (Torino)

GRIN Lenses (Padova)

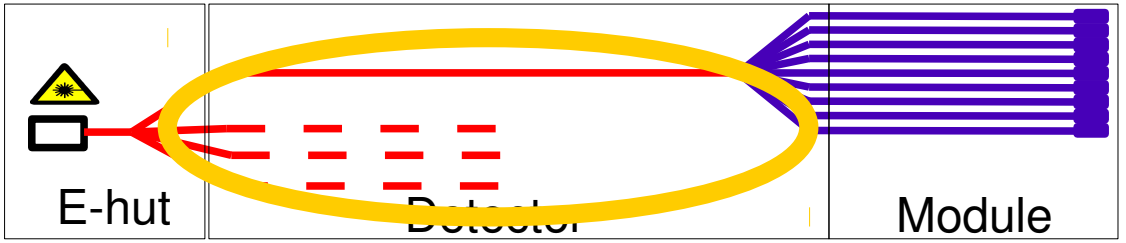


Fiber bundle preparation



Bundles are protected by 6.2mm diameter miniflex tubing. Bundles were assembled in Fuji Hall, exploiting the large space to avoid entanglement of fibers.

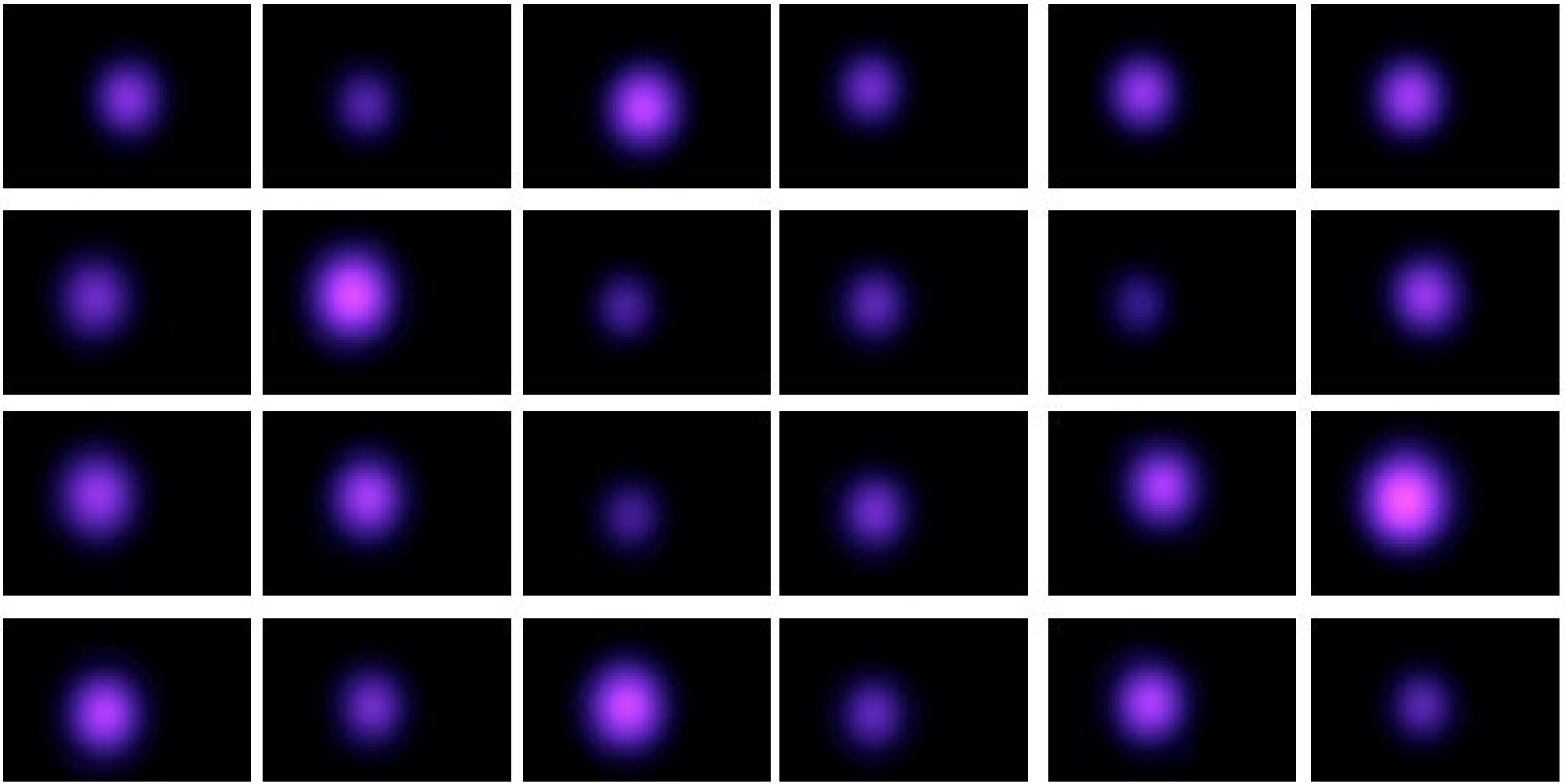
Fiber test on detector



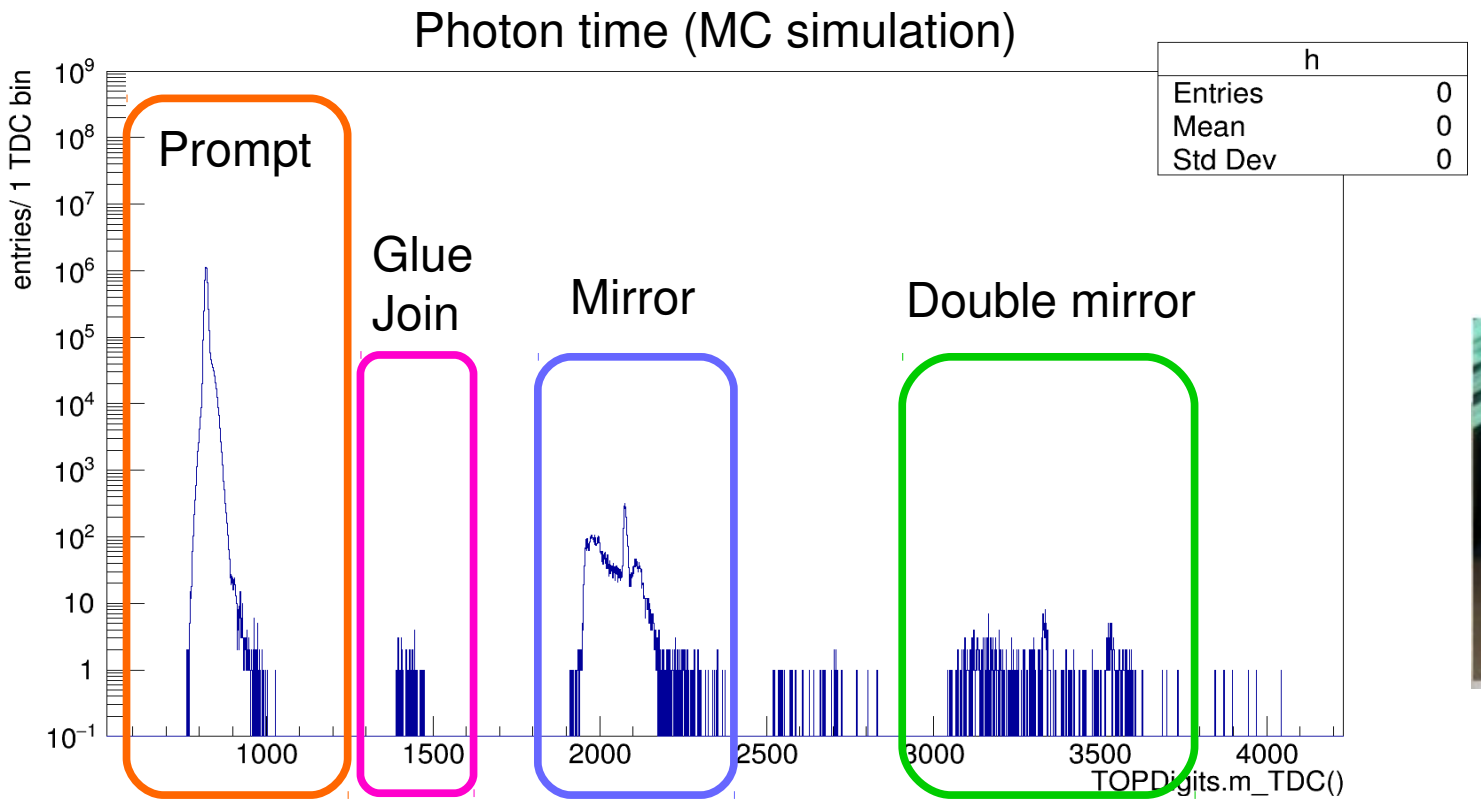
The laser is directly connected to each fiber (no PLC) to check the integrity after the installation

→ **No damaged fibers**

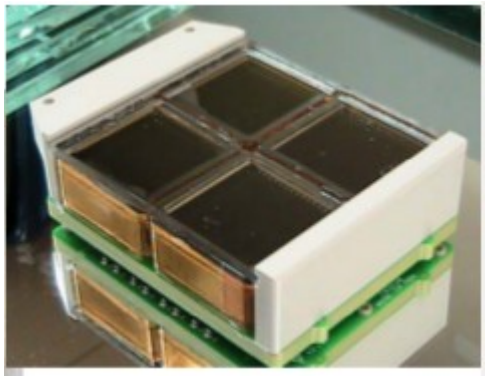
→ **fluctuations in light yield are due to the SM-SM connection**

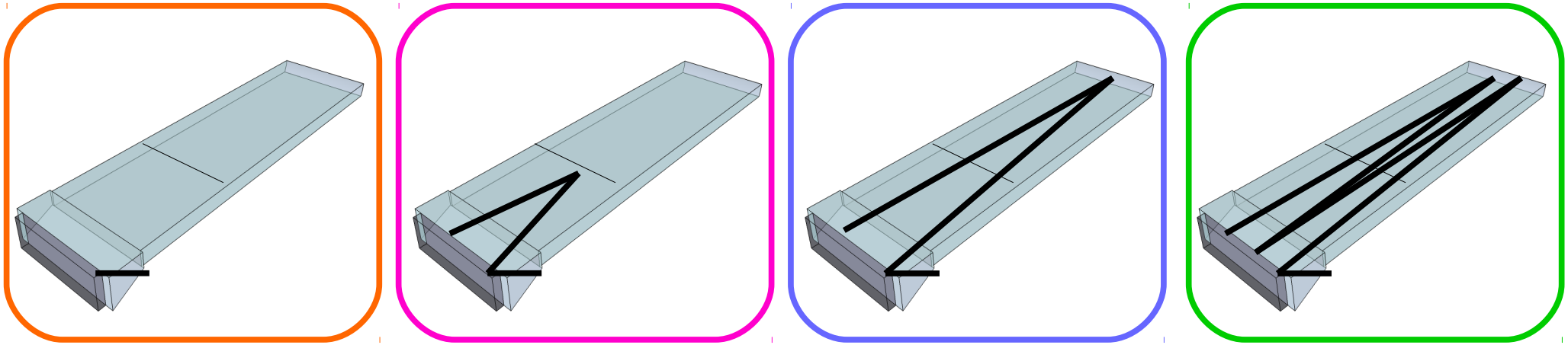


Laser: TOP tomography with time



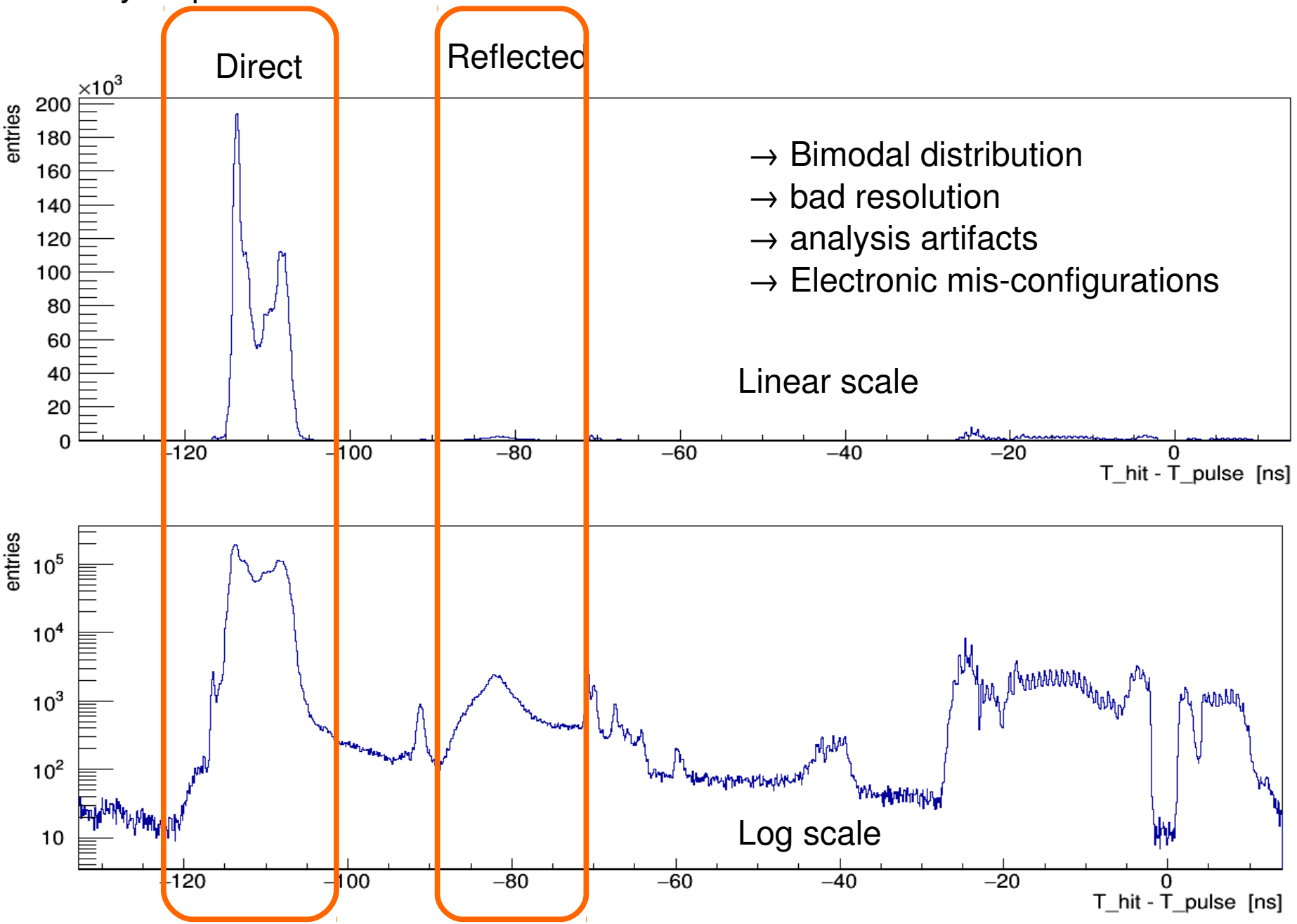
PMTs are quite reflective...





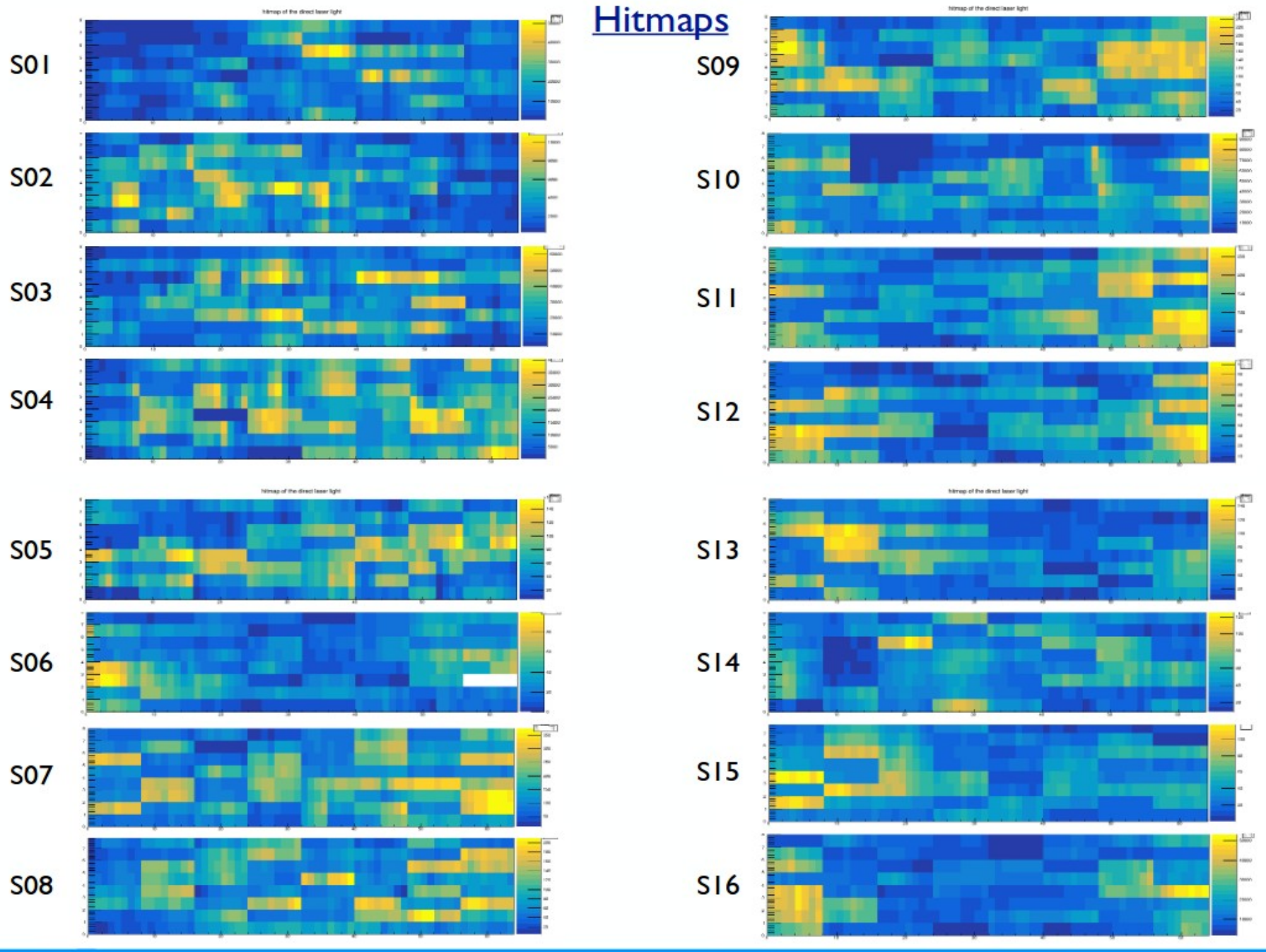
TOP tomography: real data

Reality is quite different from the ideal MC

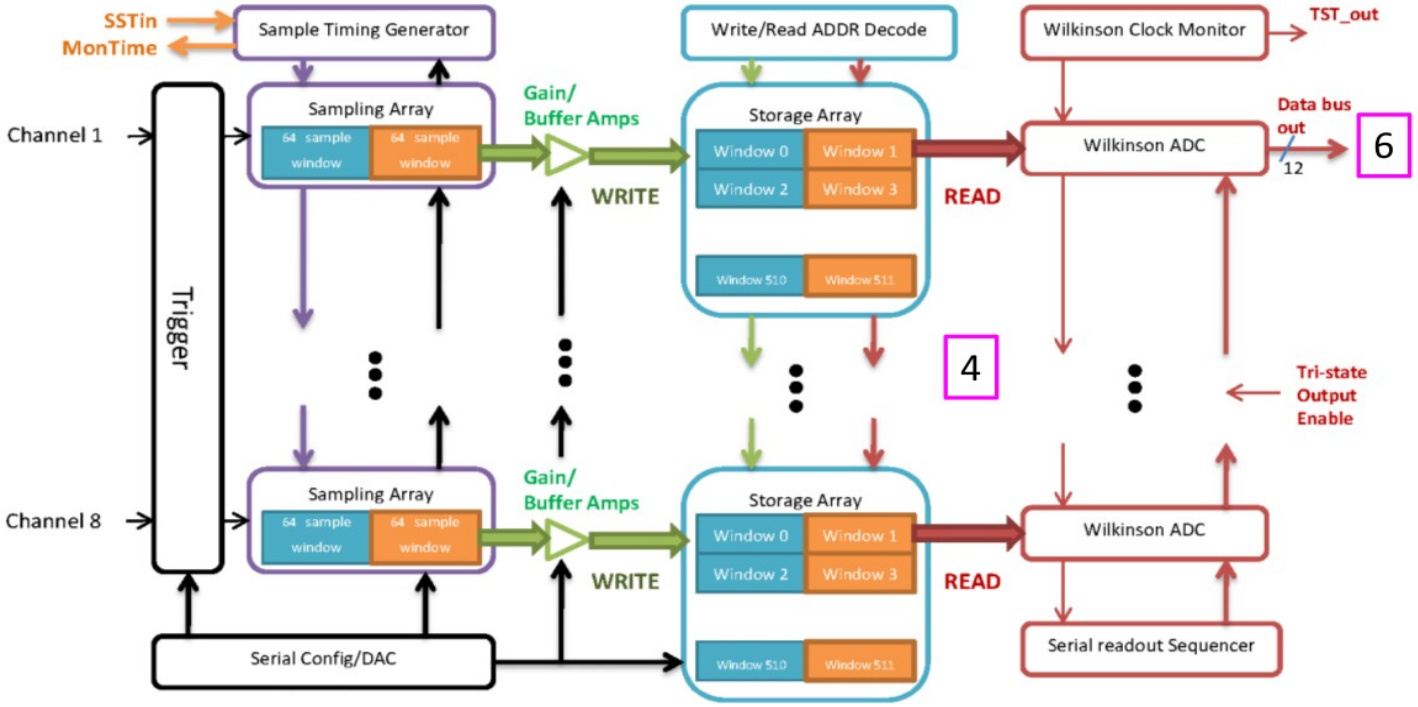


Family picture

Hitmaps. All asics and fibers are OK!



To be done: FEE calibration



Lots of features are still missing

→ fast feature extraction
→ time alignment
→ data corruption
→ time sampling calibration

IRS3X is basically an 8-ch, miniaturized scope controlled by a FPGA

1) Full waveform mode: acquire a fixed number of samples after the trigger
   → For debugging. Insane data packet size

2) Feature-extraction mode: analyze the traces on the FPGA and same only the hit informations
   → target operation mode, still under development

Debugging setup in Torino

One full boardstack, 2 MCP-PMT

Similar (but not identical) setups only in Hawaii and Pacific northwest national laboratories (PNNL)

Goal: deconvolve laser effects form electronics ones

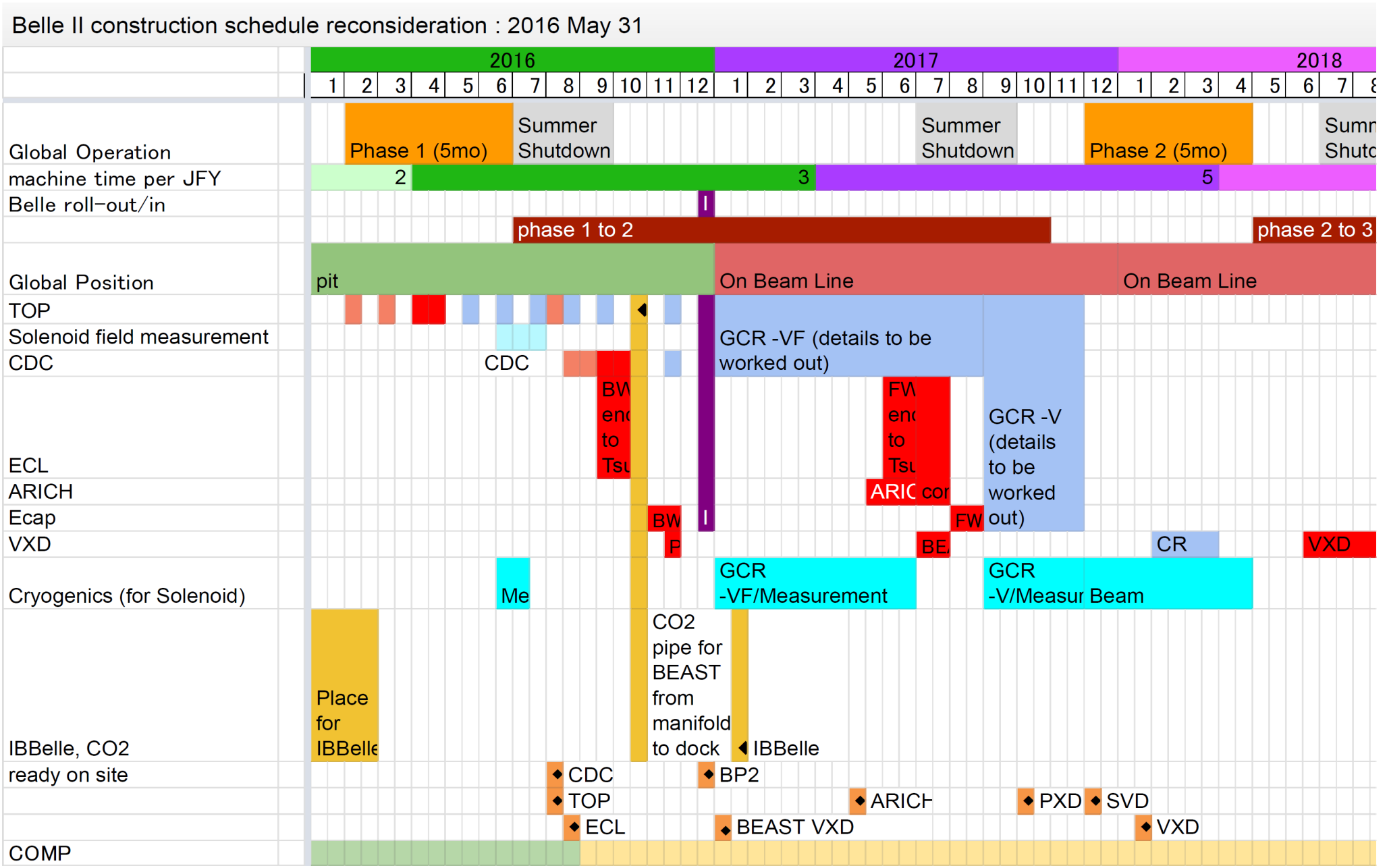
Requirements to complete the setup

Electronics:
F. Rotondo, 3 months

Mechanics:
O. Brunasso, 2 months

Backup

Schedule


Belle II construction schedule reconsideration : 2016 May 31
2016
2017
2018
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
Global Operation
Phase 1 (5mo)
Summer Shutdown
Summer Shutdown
Phase 2 (5mo)
machine time per JFY
2
3
5
Belle roll-out/in
phase 1 to 2
phase 2 to 3
Global Position
pit
On Beam Line
On Beam Line
TOP
Solenoid field measurement
GCR -VF (details to be worked out)
CDC
CDC
ECL
GCR -V (details to be worked out)
ARICH
Ecap
VXD
CR
VXD
Cryogenics (for Solenoid)
GCR -VF/Measurement
GCR -V/Measur
Beam
IBBelle, CO2
Place for IBBelle
CO2 pipe for BEAST from manifold to dock
IBBelle
ready on site
CDC
BP2
TOP
ARICH
PXD
SVD
ECL
BEAST VXD
VXD
COMP

Testing workflow

Pre-installation test

Run coordinator: B. Fulsom (PNNL)

Fuji staging area

→ First power-up
→ electronics and data fibers tests
→ light tightening
→ 24+ hrs of cosmics

Tsukuba Staging area

→ 20 hrs of cosmics
→ 4+ hrs of laser

In situ test

Run coordinator: U.T. (Torino)

→ **Detector commissioning**
  → Cabling test
  → 24+ hrs of laser
  → 3+ days Cosmic with custom scintillator trigger
→ laser system commissioning

Developments

→ FW upgrade tests
→ simultaneous readout
→ real-life operations

Commissioning status

Laser runs

→ Timing well understood
→ High rate

Cosmic rays

→ Very good illumination
→ miserable rate

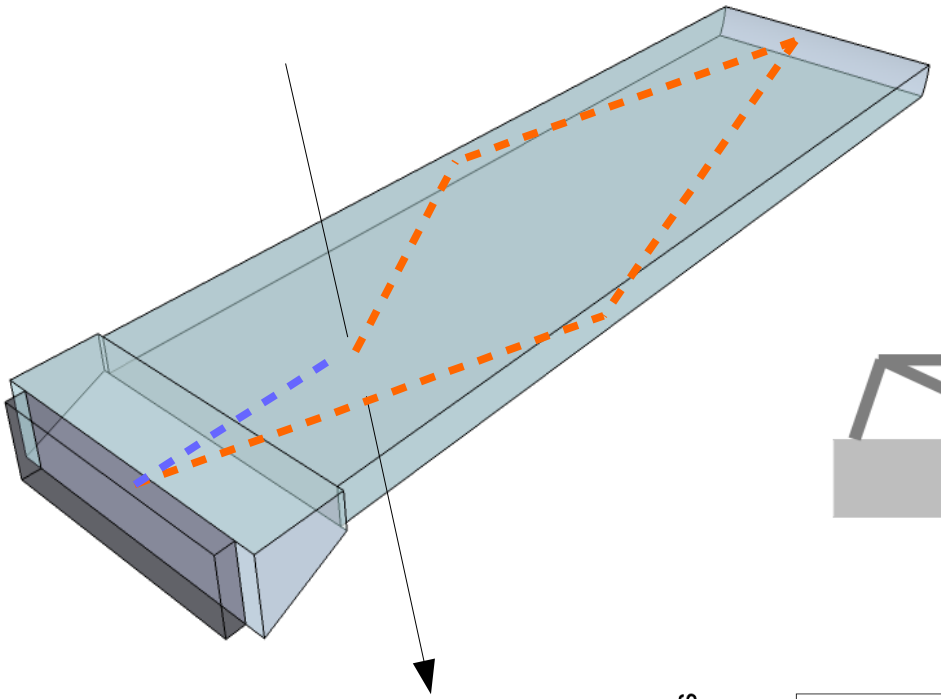
Goals

→ Mechanical integrity of all the modules → Cabling checks (HV, fibers, triggers...)	**Done / almost done**
→ Time calibration → Fast, online feature extraction → SW interlock	**Ongoing**
→ DAQ stability and reliability → Trigger capabilities → Event building	**On the critical path**

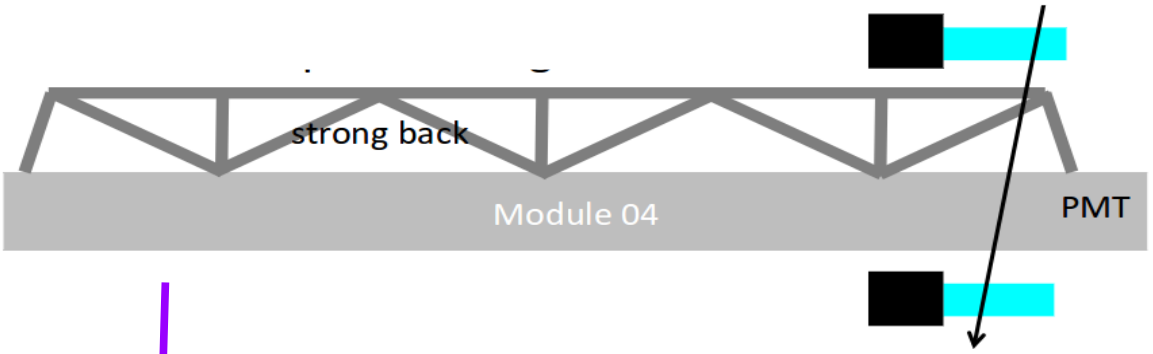
Many items: this talk will be Italy-biased...

CRT commissioning

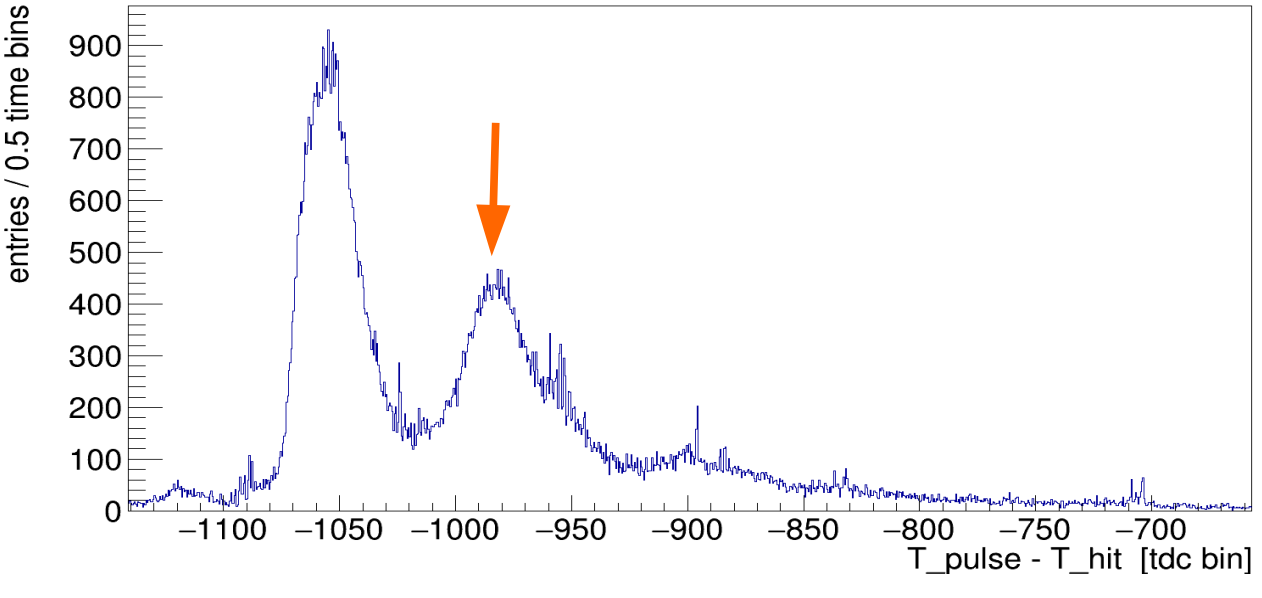
In the staging areas



Trigger provided by two Belle TOF scintillators
~ 30 x 20 cm



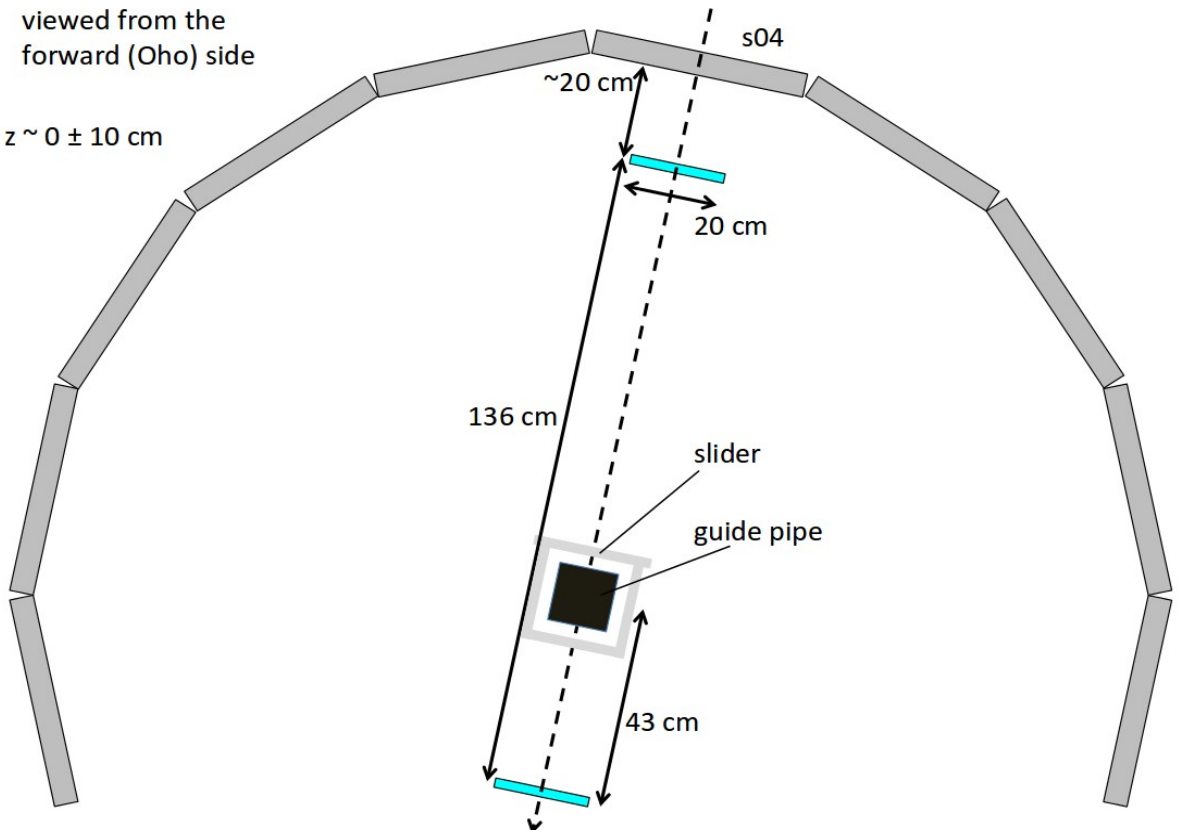
Large direct and reflected light yield, but poor timing

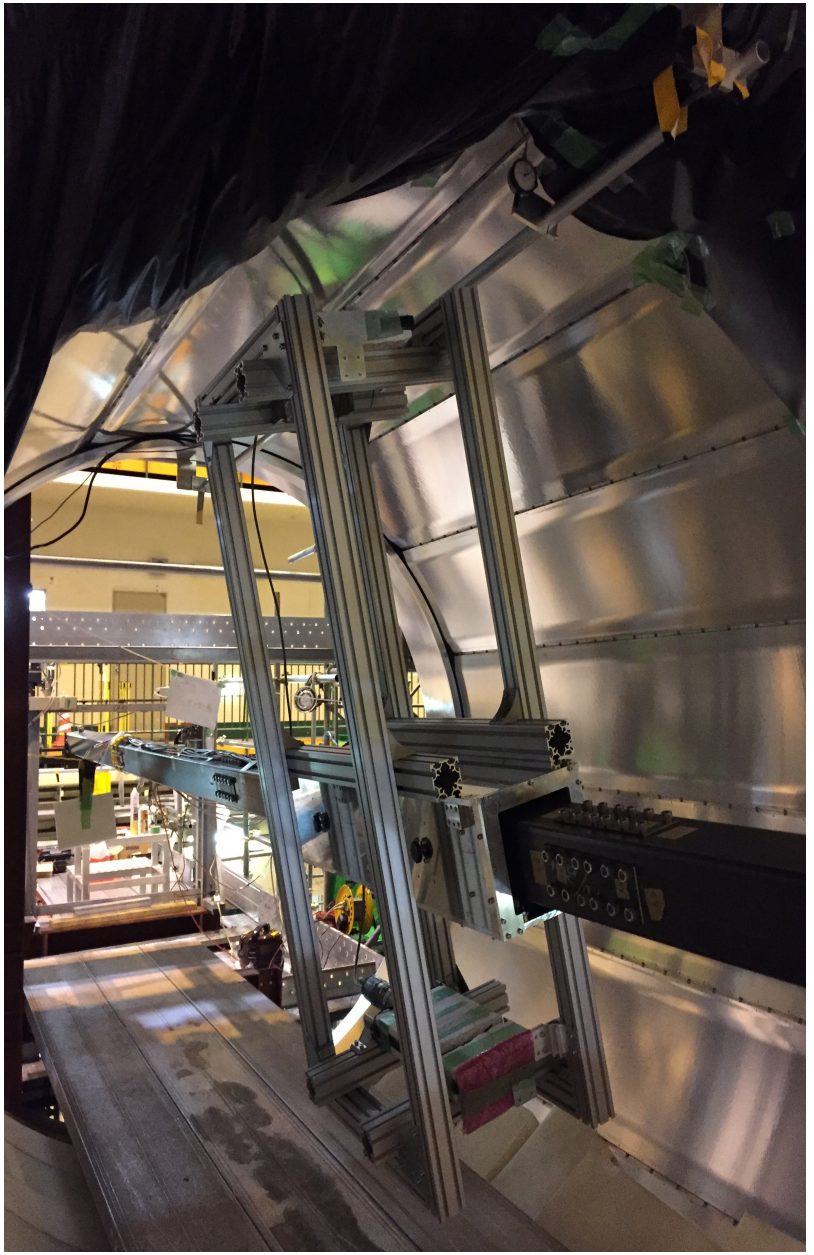


CRT commissioning

On the detector

KLM trigger was asked long ago, but it is not ready yet
→ home-made scintillator trigger (Nagoya)
→ this is a very serious issue for us





Two modules (back-to-back) at once
→ 0.15 – 0.05 Hz, β ~ 1

Timing

IRS3X is basically an 8-ch, miniaturized scope controlled by a FPGA

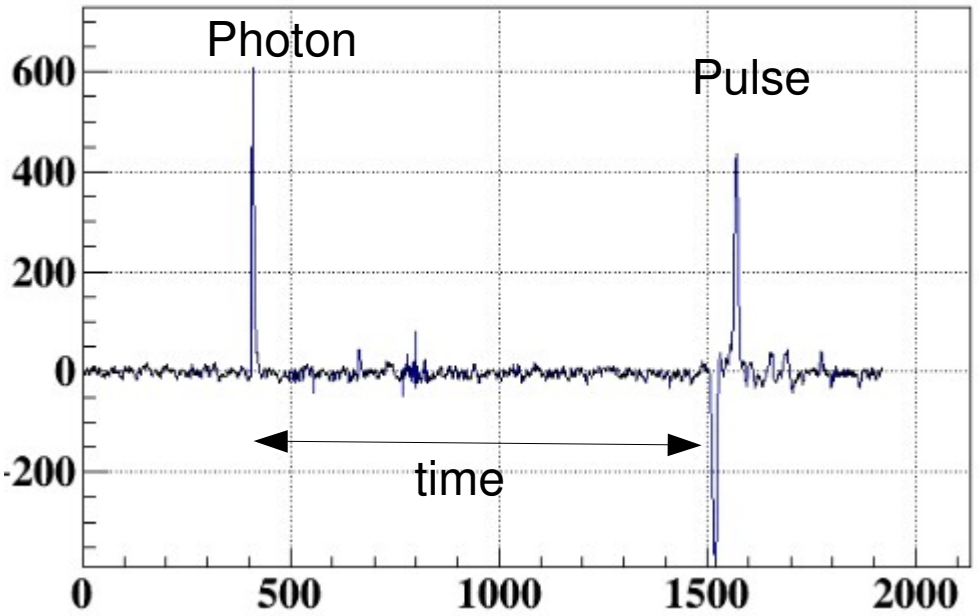
1) Full waveform mode: acquire a fixed number of samples after the trigger
   → For debugging. Insane data packet size

2) Feature-extraction mode: analyze the traces on the FPGA and same only the hit informations
   → target operation mode, still under development

How to make timing

1) Final operation mode: RF clock

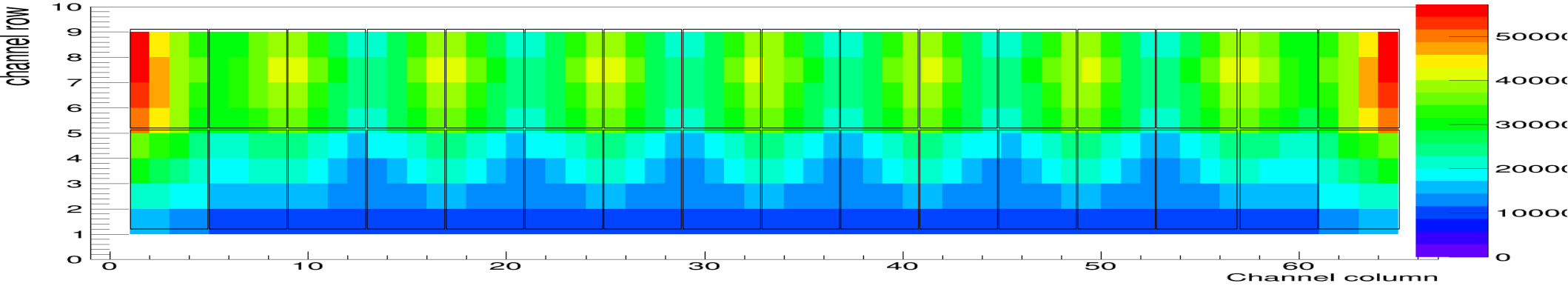
2) Commissioning:
   → When a trigger comes, inject a pulse on one asic channel
   → record both the PMT signal and the pulse
   → use the pulse timing as reference



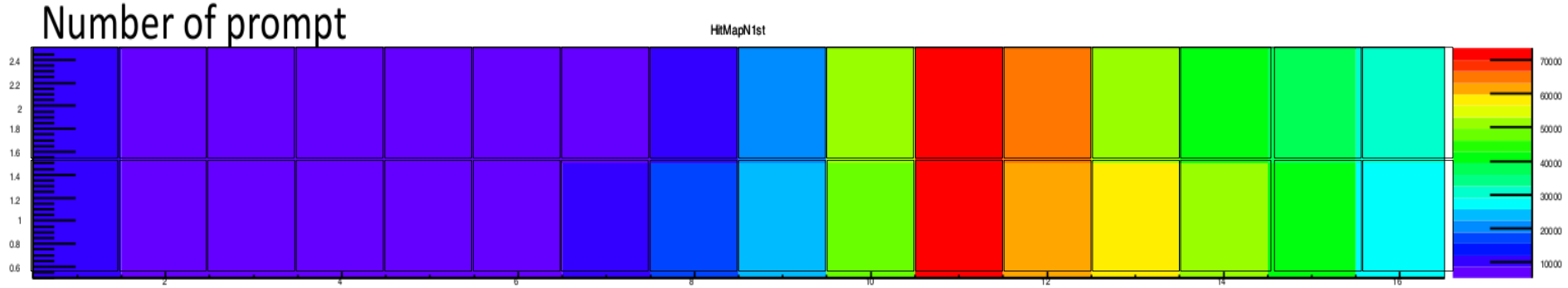
Commissioning with laser

Reminder:
→ one bundle (9 light sources) per module
→ flashing in front of the PMTs

Occupancy from MC simulation....



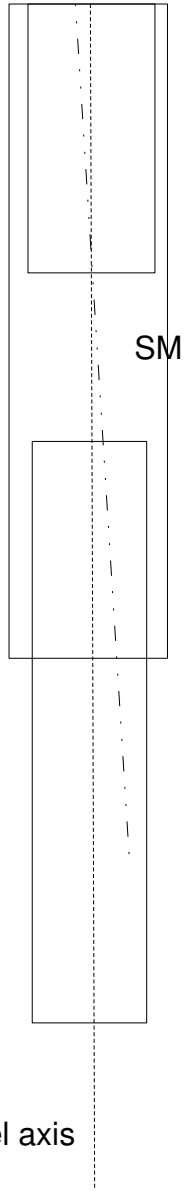
Reality of the very first laser run...



Very first laser run
→ why such large inhomogeneities?

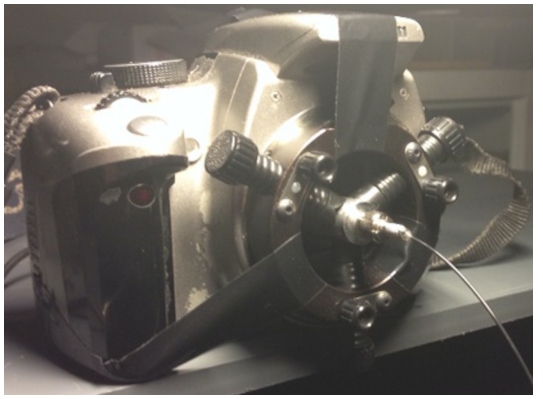
Origin of the inhomogeneities

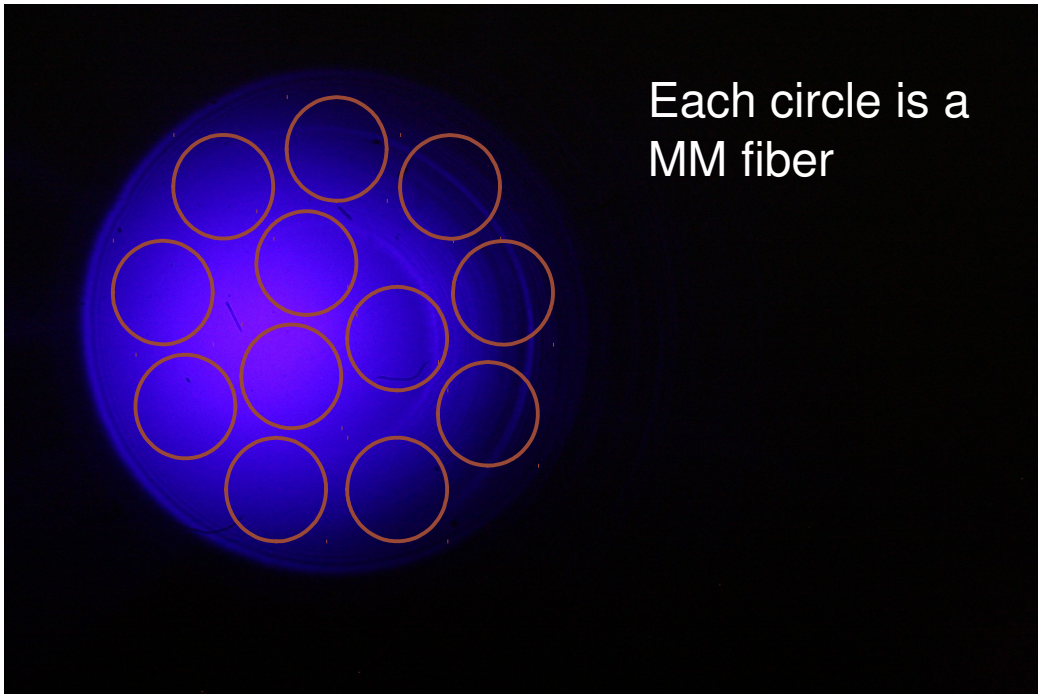
The light is flashed over the final MM bundle form few mm distance in a cilindrical connector



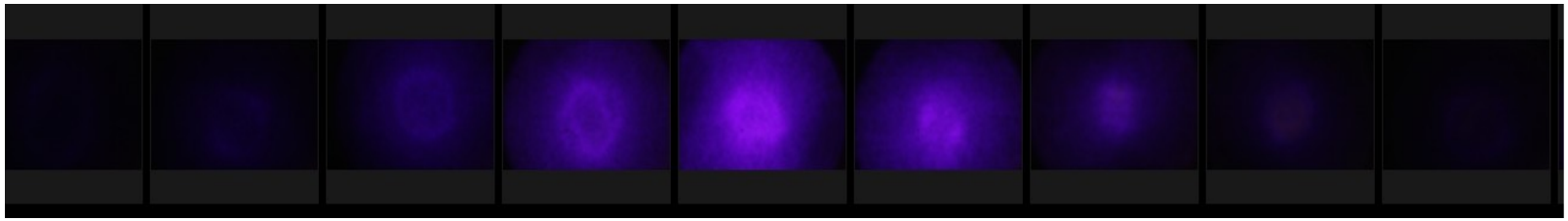
SM fiber not aligned with the connector axis
→ Not homogeneous light distribution!

High-tech beam profiler in Torino



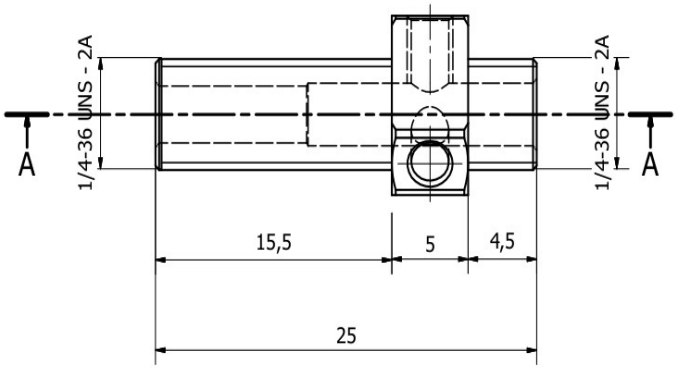


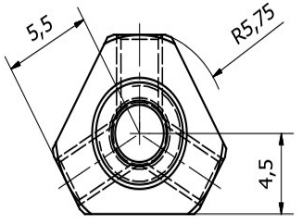
Light modulation on a MM bundle

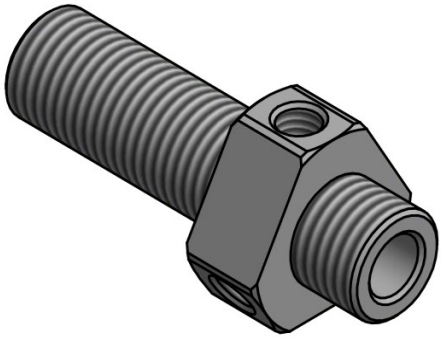


Flat-fielders

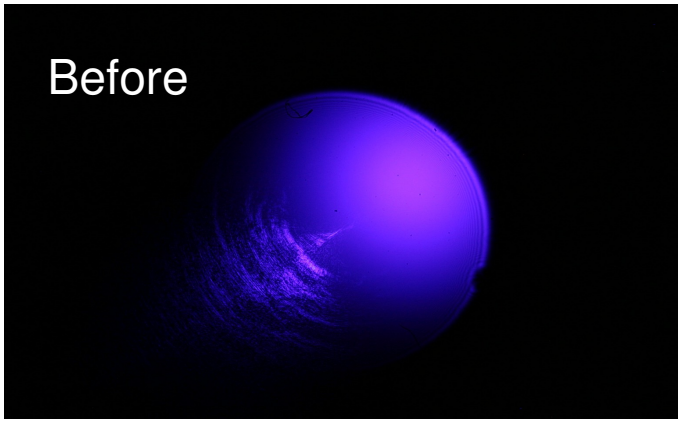
Flat fielder from Padova

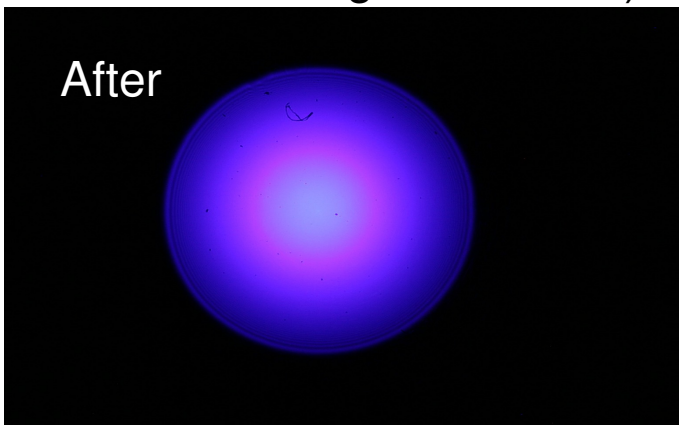




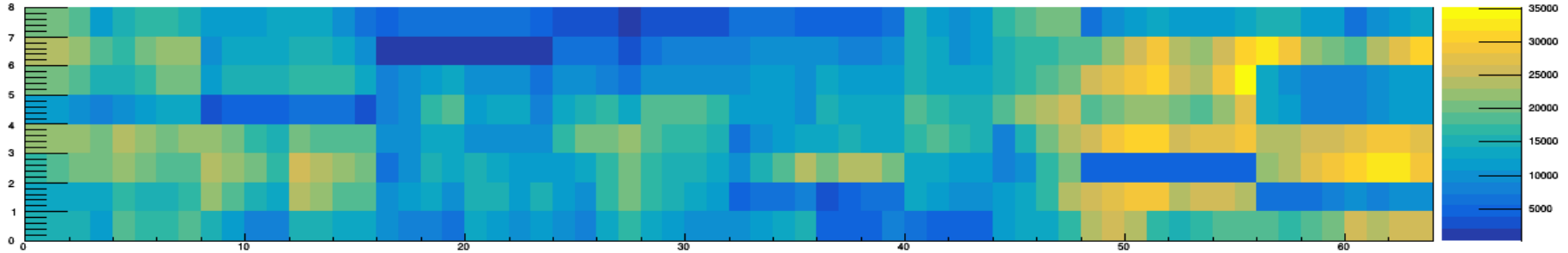


A quite dramatic example (and proof of Ezio's alignment skills)



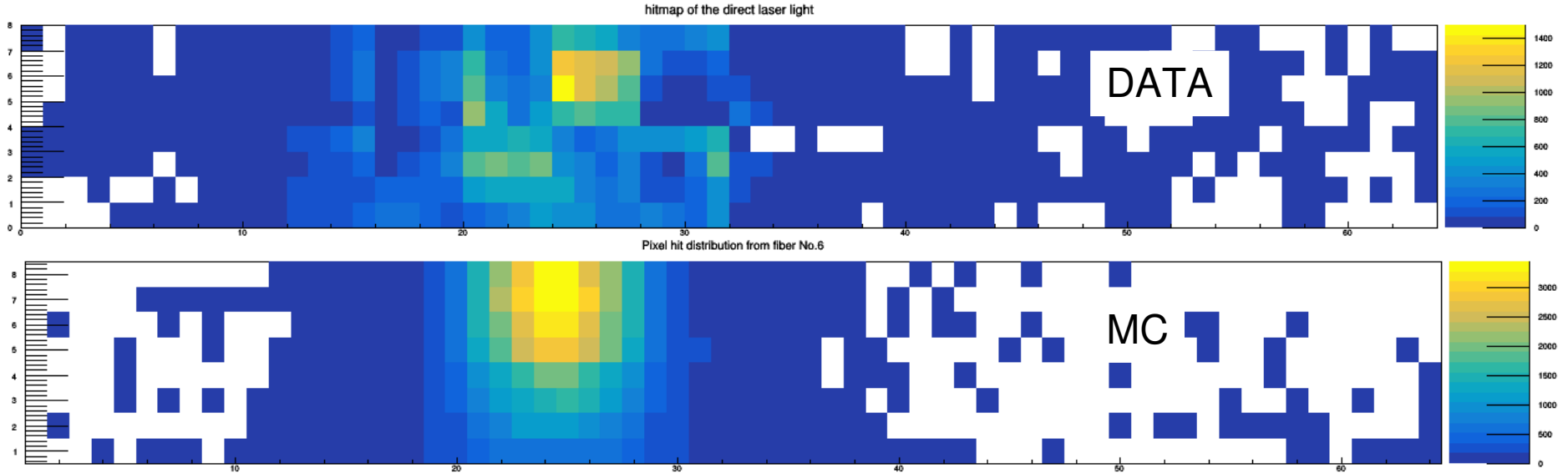


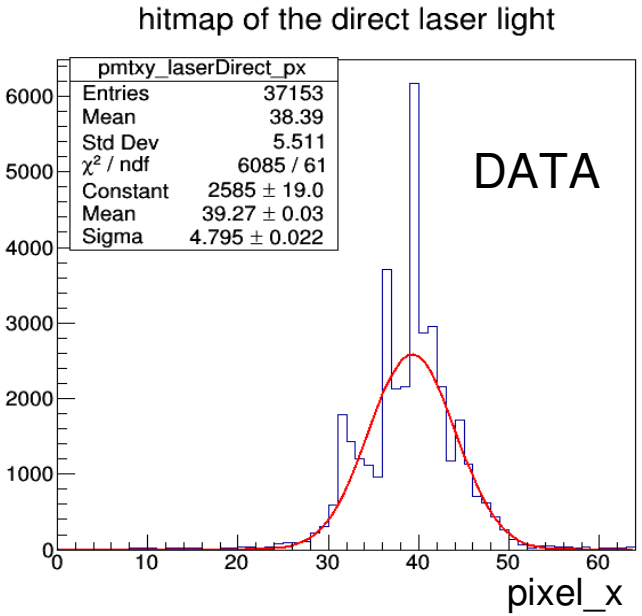
Residual inhomogeneities reduced by a factor of 10

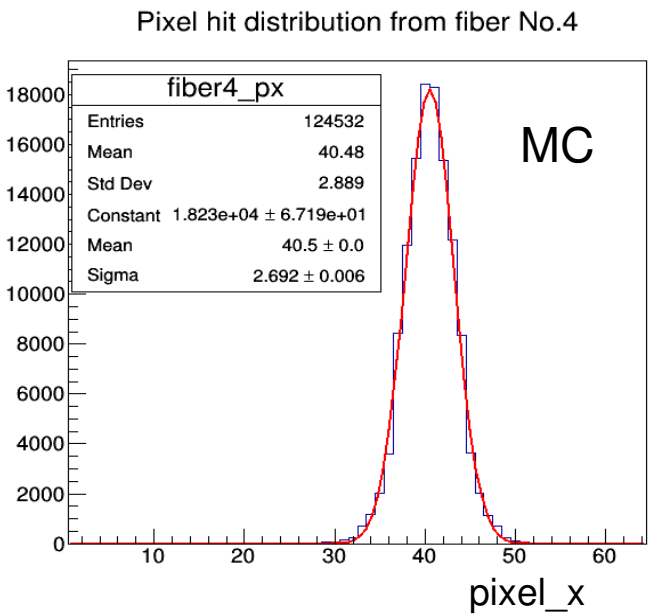


Data-MC comparison

We have a set of single-spot laser data taken on module 07 to make data-MC comparison





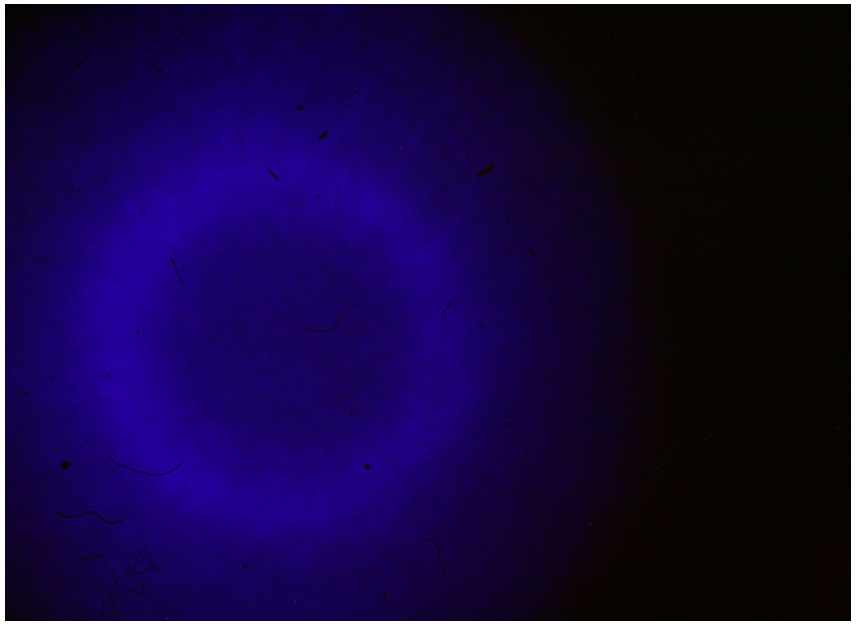


Quite different light spot Shape

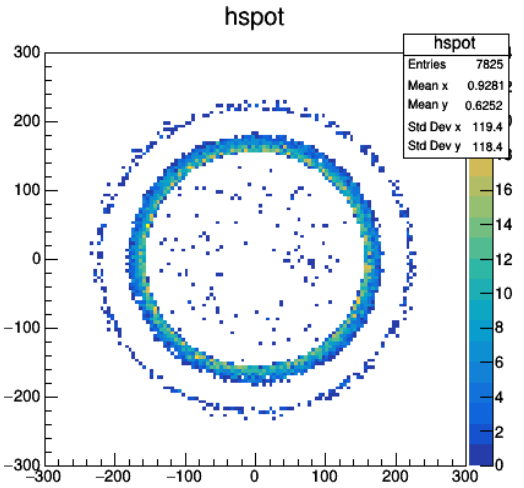
→ no Q.E. correction
→ no gain correction

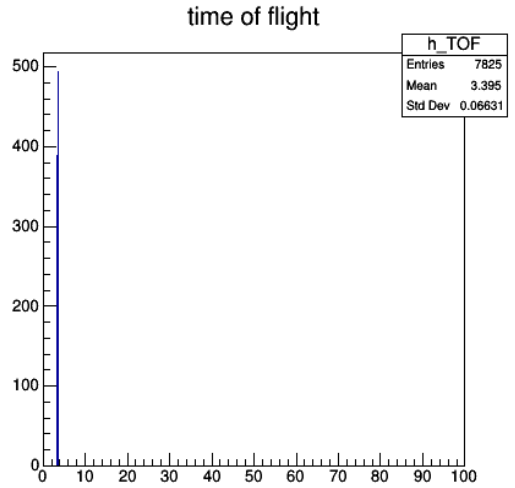
Ring-like structures

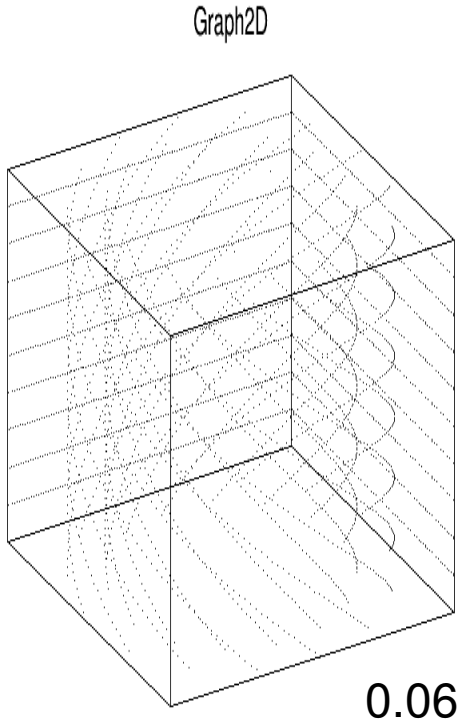
MC: Gaussian spot
Data: Not gaussian at all!



Simulation (UT's private code, to be released)







Light trajectory inside the fiber

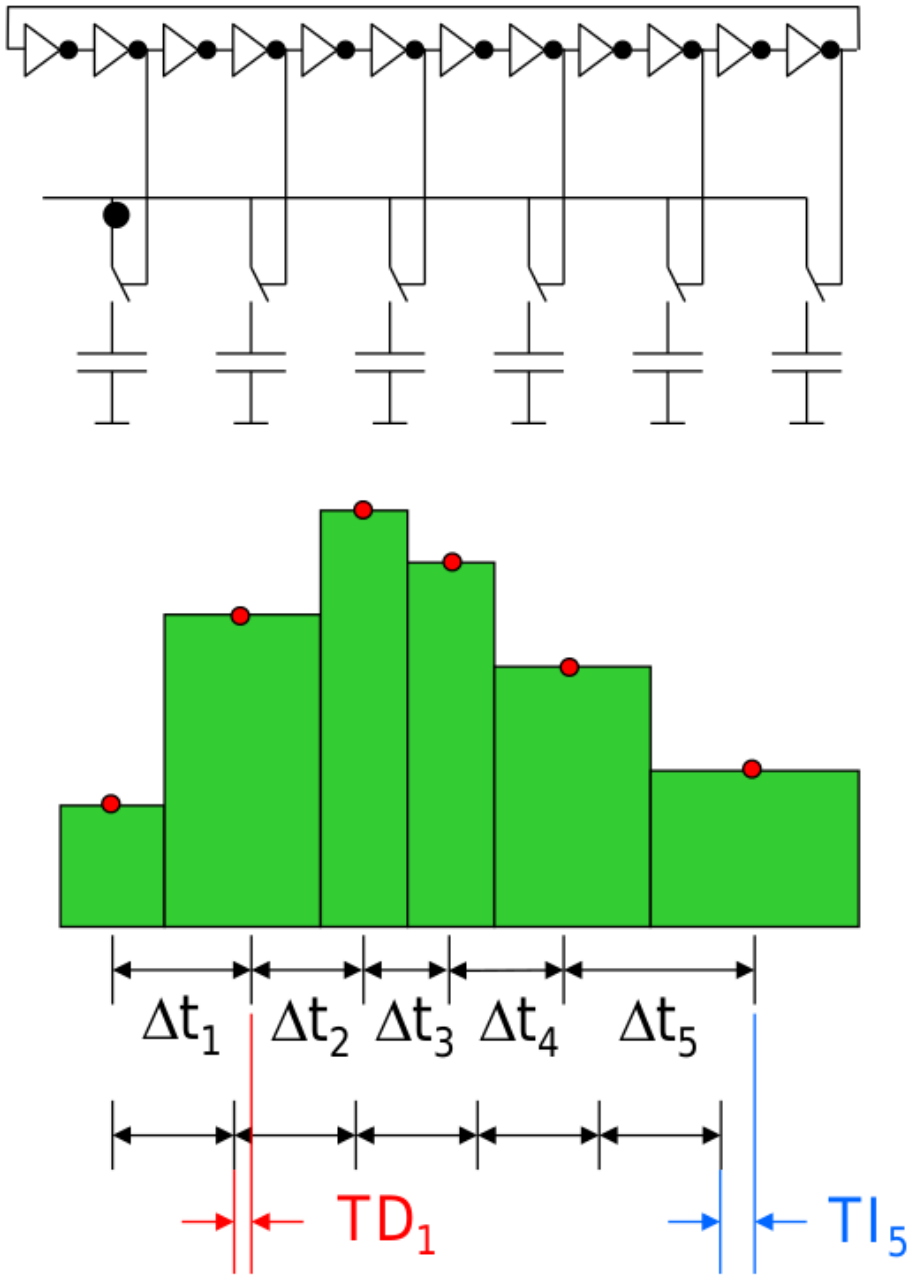
100 mm

0.06 mm

The light is entering the MM fiber from a narrow, non-zero angle
→ helicoidal propagation
→ ring-like spot

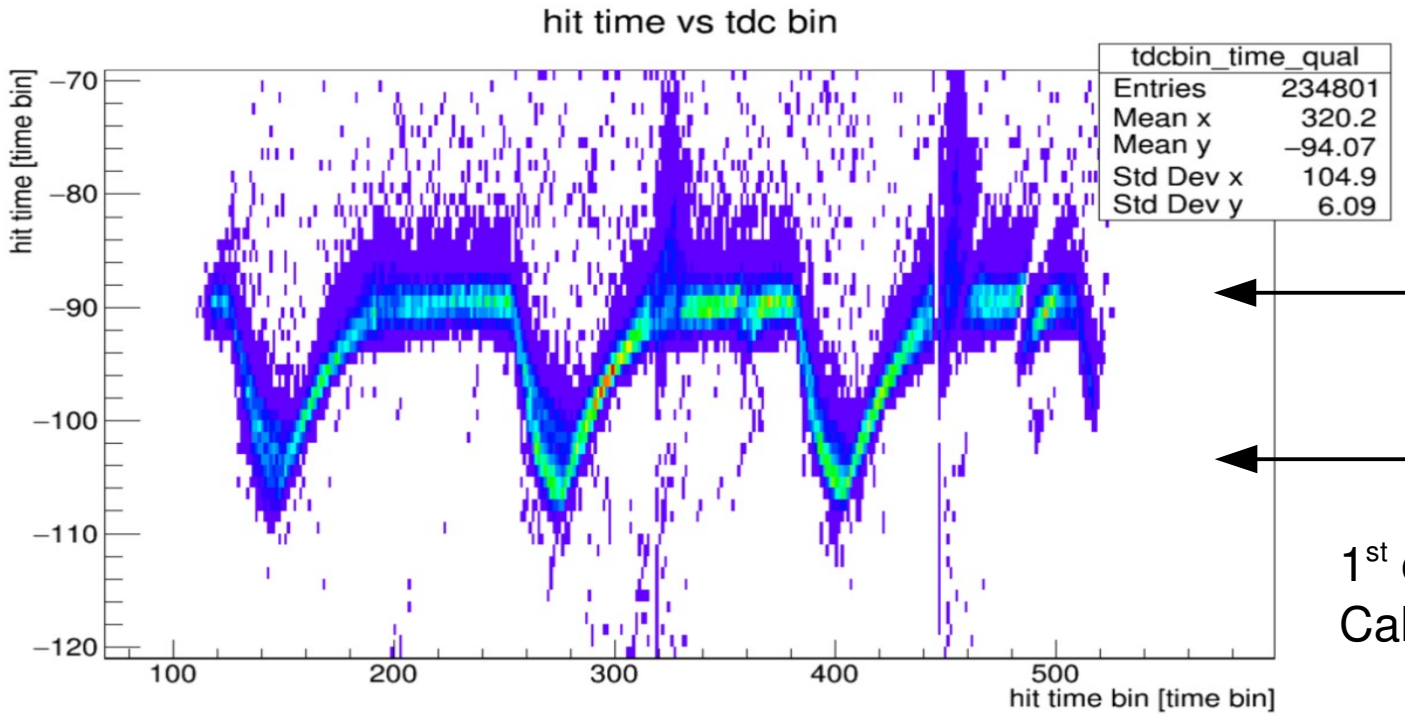
Still to be included in the simulation

TOP readout: Time base calibration



- Inverter chain has transistor variations
  → Δt_i between samples differ
  → "Fixed pattern aperture jitter"
- "Differential temporal nonlinearity"
  $TD_i = \Delta t_i - \Delta t_{nominal}$
- "Integral temporal nonlinearity"
  $TI_i = \Sigma \Delta t_i - i \cdot \Delta t_{nominal}$
- "Random aperture jitter" = variation of Δt_i between measurements

Time base calibration from laser



T_pulse- T_hit

Position of the hit in the trace

The two peaks of the bimodal distribution

1st order, channel-by-channel Calibration

→ Make all the time bin equally spaced

After the channel-by-channel time bin correction:

→ channel intercalibration (time alignment)

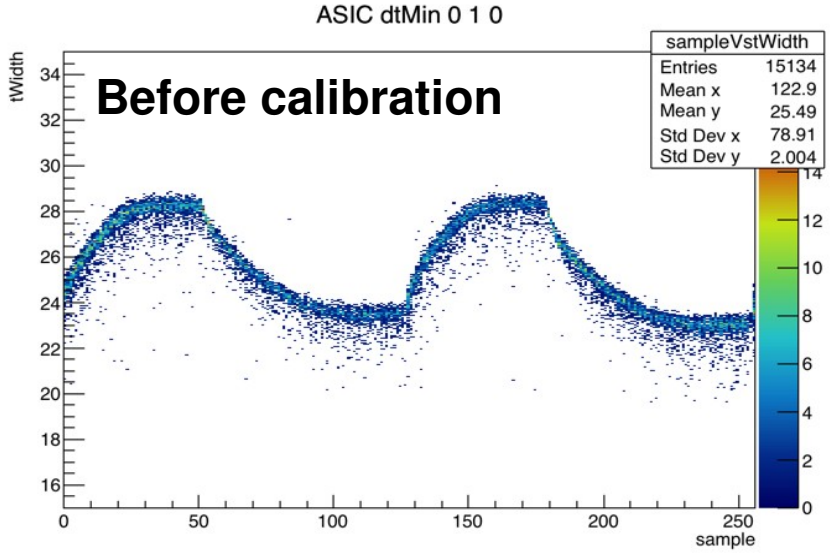
→ module intercalibration (time alignment)

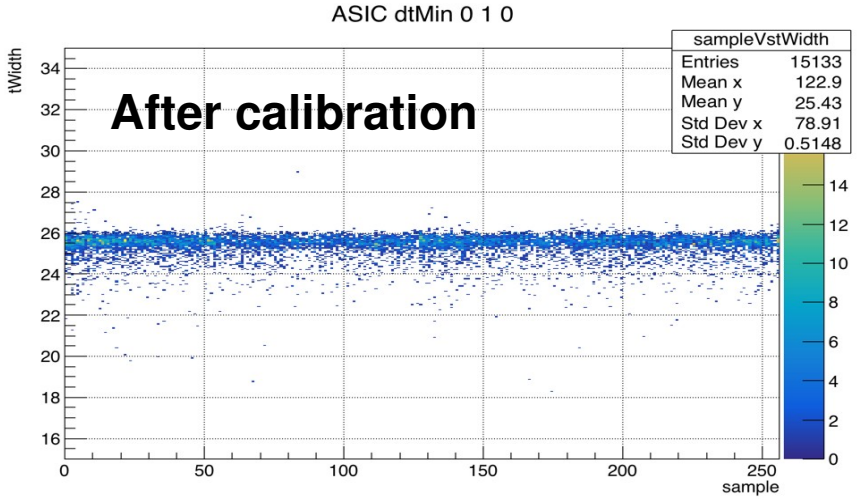
Time base calibration from laser

The laser is the primary system for the time-base calibration

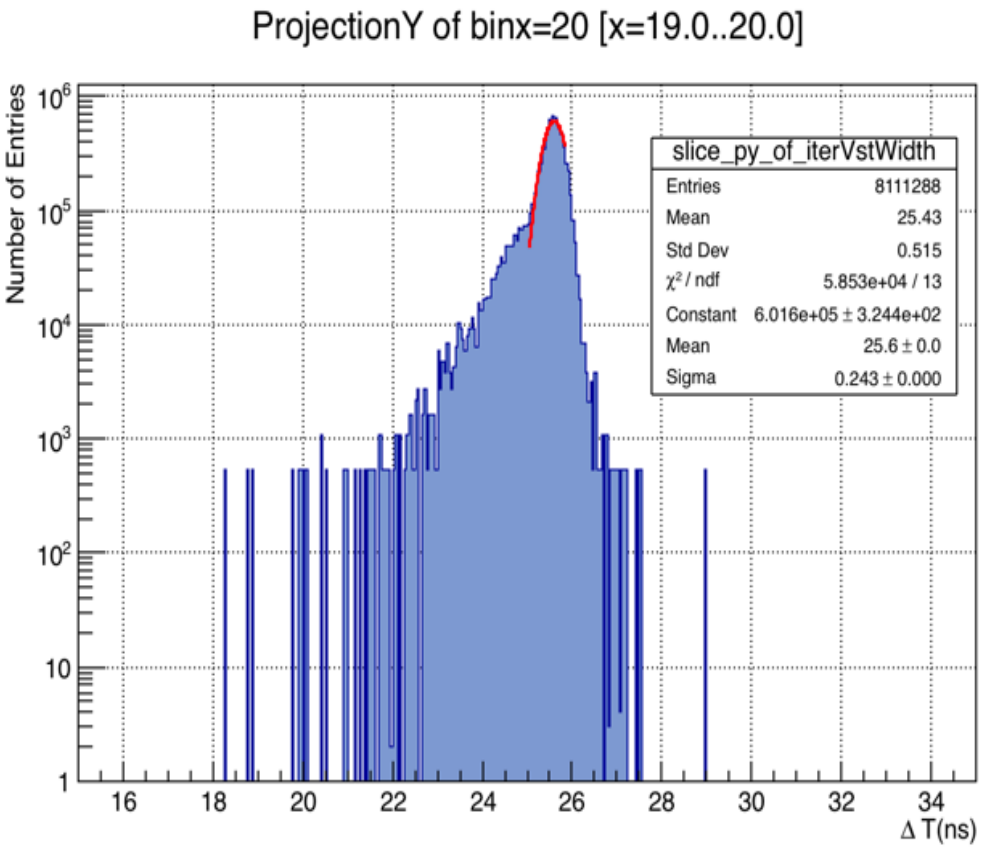
Minimization is not trivial
- → clean hit selection
- → fast hit finding
- → iterative method: must converge in the right place

Hawaii – Torino – Wayne State joined effort





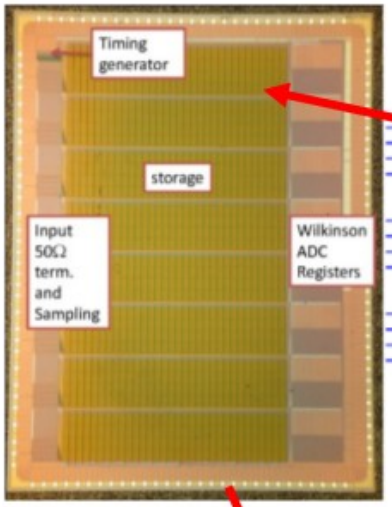
1 ns → 250 ps (goal: < 80 ps)

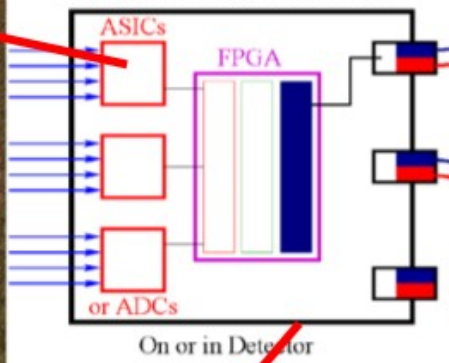


TOP DAQ

Waveform sampling ASIC

64 DAQ fiber transceivers

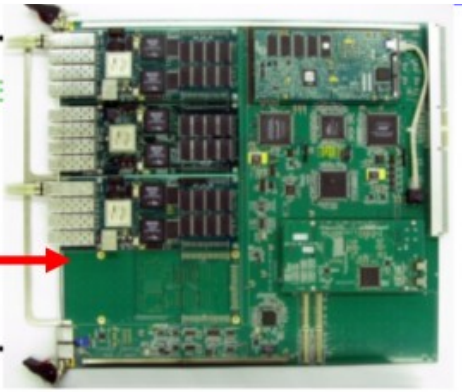




Giga-bit Fiber Transceiver Links

COPPER

FINESSE



64 FINESSE
16 COPPER

Global Decision Logic

2x UT3 Trigger modules

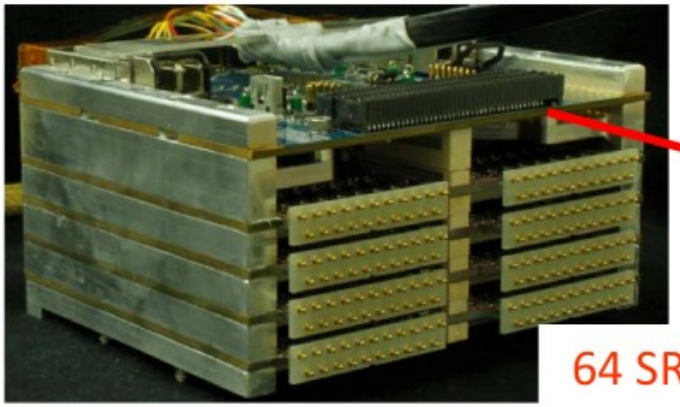
Clock/Event Timing Distribution

FPGA firmware consists of 3 parts:
1) ASIC/ADC driver (common)
2) Trigger feature extract (subdet. specific)
3) Unified DAQ transport protocol

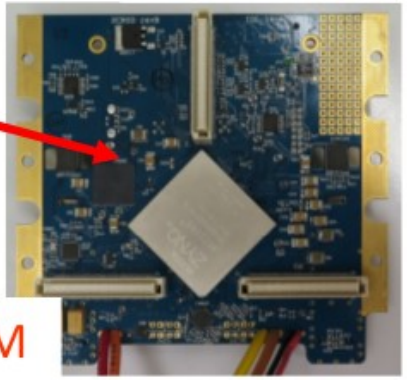
8k channels

1k 8-ch. ASICs

64 "board stacks"



Low-jitter clock



64 SRM

Clock, trigger, programming module (FTSW)

8 FTSW

Firmware development

Main issues

→ **Manpower**

1 (2) person is working on this from PNNL (Hawaii)

→ **Feature extraction (Hawaii - PNNL)**

Full waveform → hits

64x15x 512 words / event → ~8x50 words / event

10 Hz → 10 kHz

→ **Soft reboot (Hawaii - PNNL)**

A large fraction of problems is now solved with hard reboot

→ long operation time

→ not really a solution

→ **DAQ integration (Hawaii – PNNL - KEK)**

→ We cannot run the copper at its full speed

→ We experience tranfser rate slowing down during data taking

What can be done in Italy

→ **A full FE boardstack is in Torino**

→ no way to get a copper / FTSW

→ FW development is still possible

Software development

Two different frameworks, sometimes overlapping

top (M. Staric)
→ Intended for final data analysis
→ MC simulation is analyzed with it
→ Coherent, simple, but unsuitable for debugging

topcaf (M. Barret, J Strube, U.T.)
→ Intended for full waveform analysis
→ Developed at PNNL, changed at least 3 generations of mantainers
→ Large overlappings with top
→ Needs to be improved!

Some examples:
→ New dT calibrator (Hawaii - Torino – Wayne state) : **1 hr/run → 5 mins / run**
→ New hit finder (Torino) : **3 hrs/run → 10 mins / run**
→ Improved calibration pulse selection (Torino – PNNL): **efficiency +100%**

Conclusions

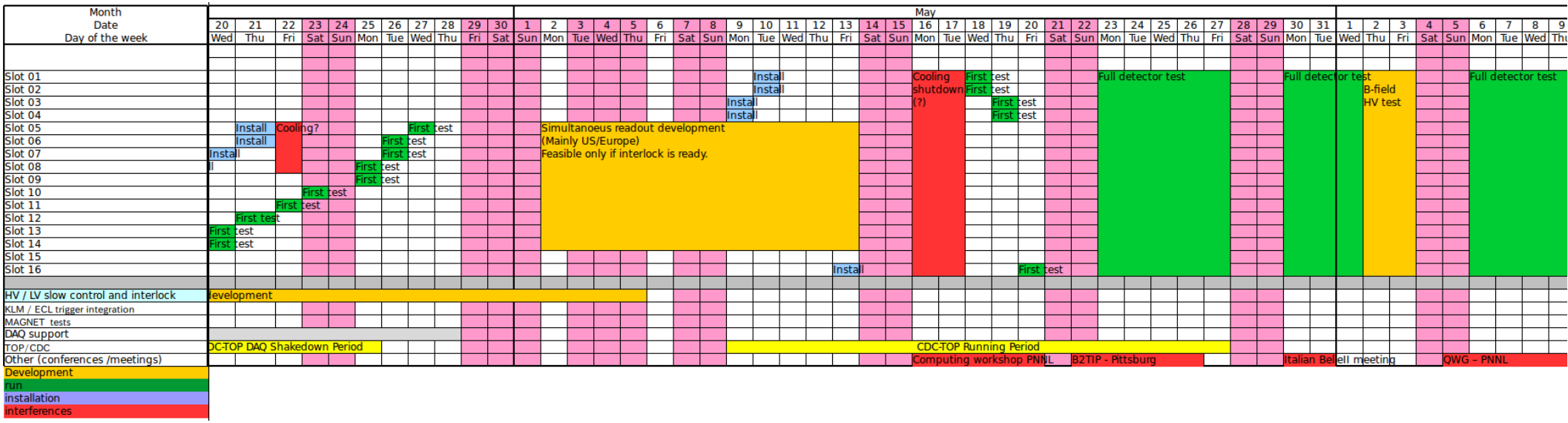
TOP commissioning is going well
→ No dead channels
→ all modules have comparable performances

Some items are on the critical path
→ feature extraction
→ time calibration
→ KLM cosmic trigger
→ Software

B-field test form June 15th
→ No access to the detector

CDC goes in in August
→ No more room for HW replacing and Recabling

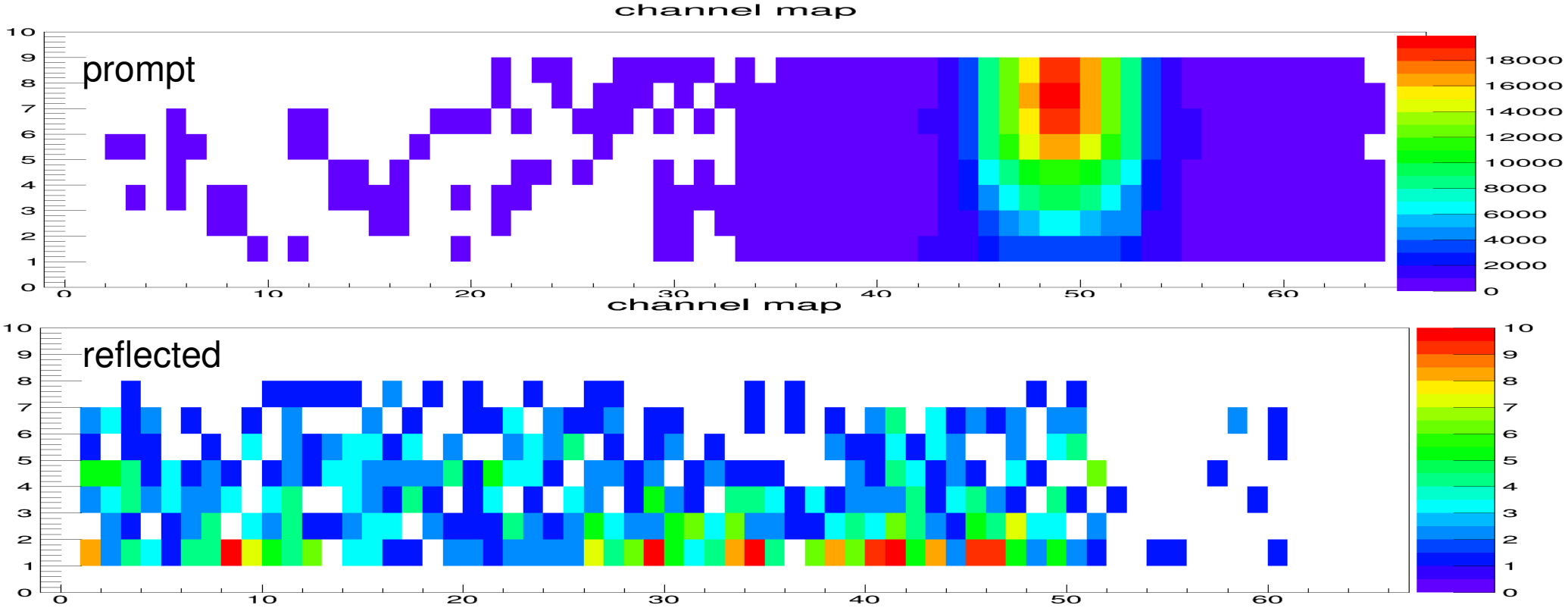
HW must be commissioned within the next 2 weeks



Testing schedule won't fit any slide...
https://belle2.cc.kek.jp/~twiki/bin/view/Detector/TOP/WebHome

Tracking down the reflected spot

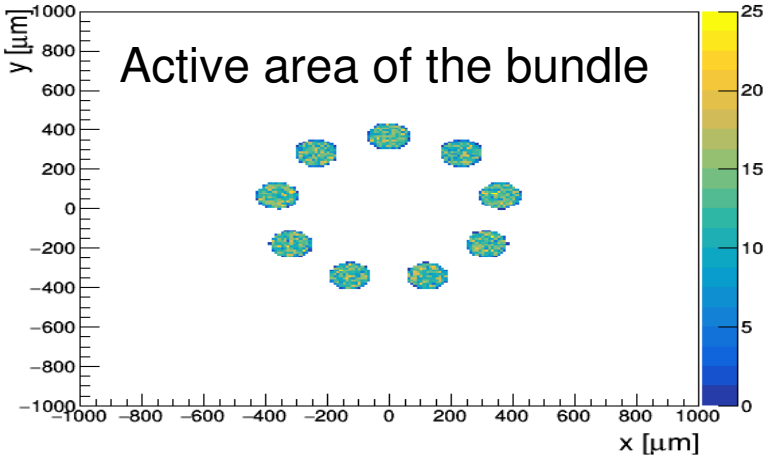
MC with one single source out of nine

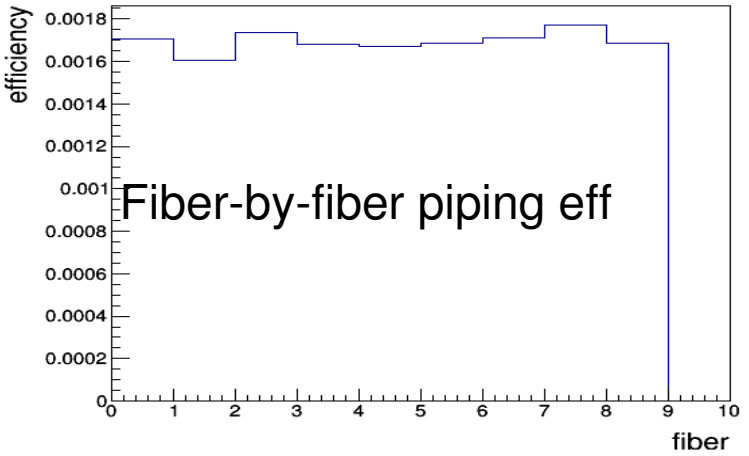


Channel-by-channel ratio may not be the best observable

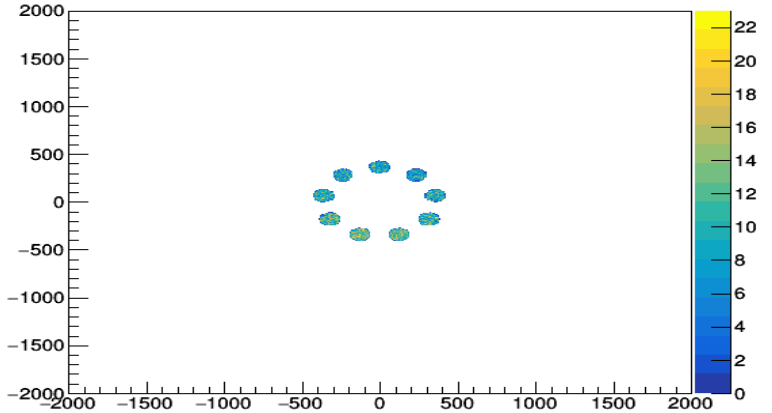
→ can we build a look-up table to predict the reflected pattern based on the direct one?

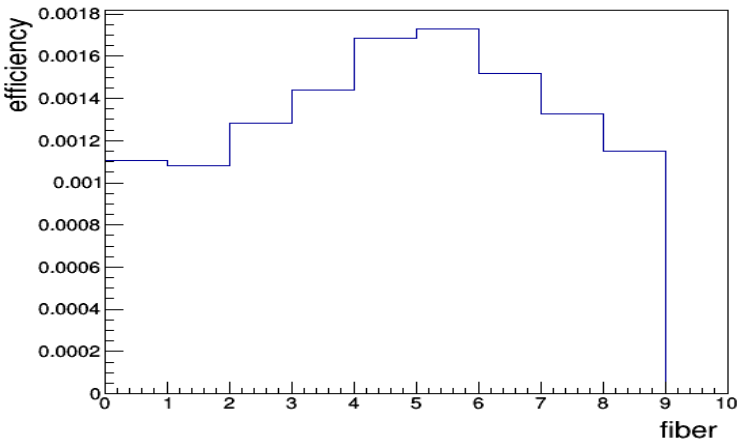
Origin of the inhomogeneities: toy MC



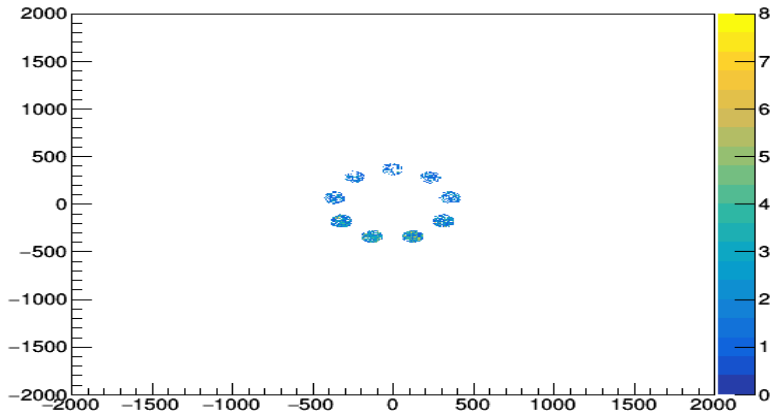


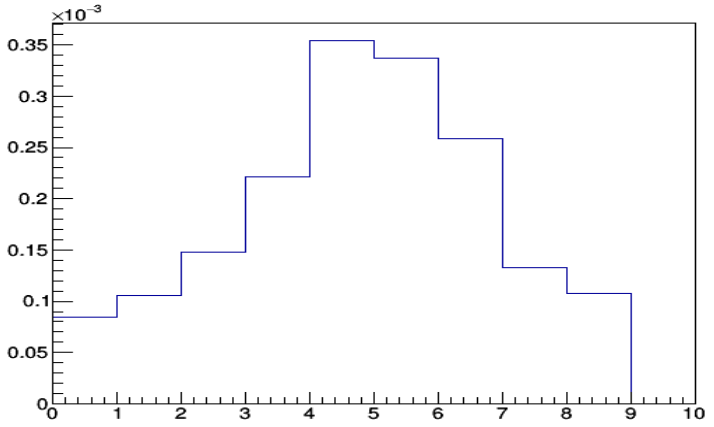
Tilt = 0°





Tilt = 5°





Tilt = 15°

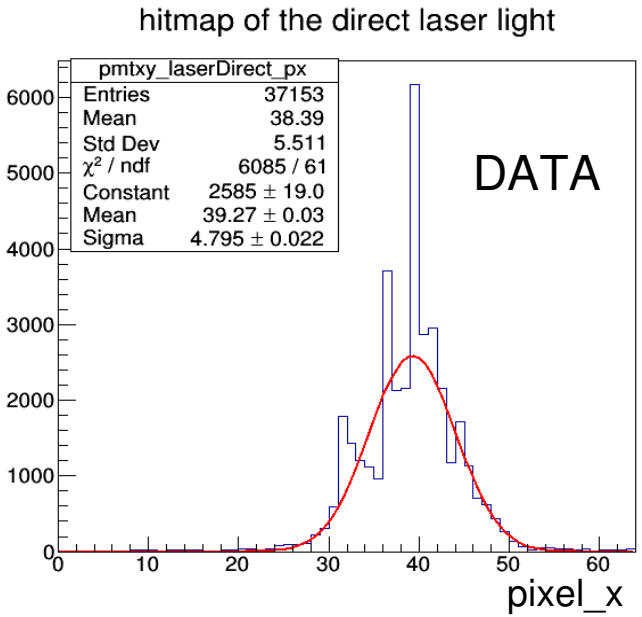
Is it realistic?

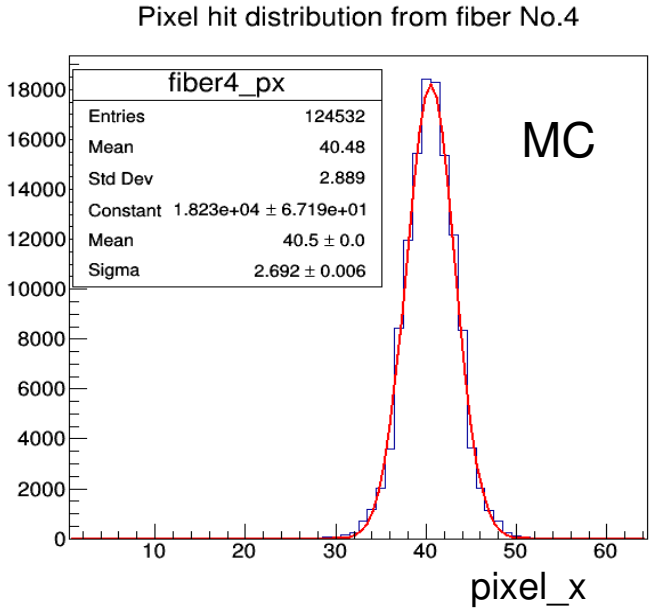
Alignment survey

We compare the gaussian fit of the x and y projections of the hit maps

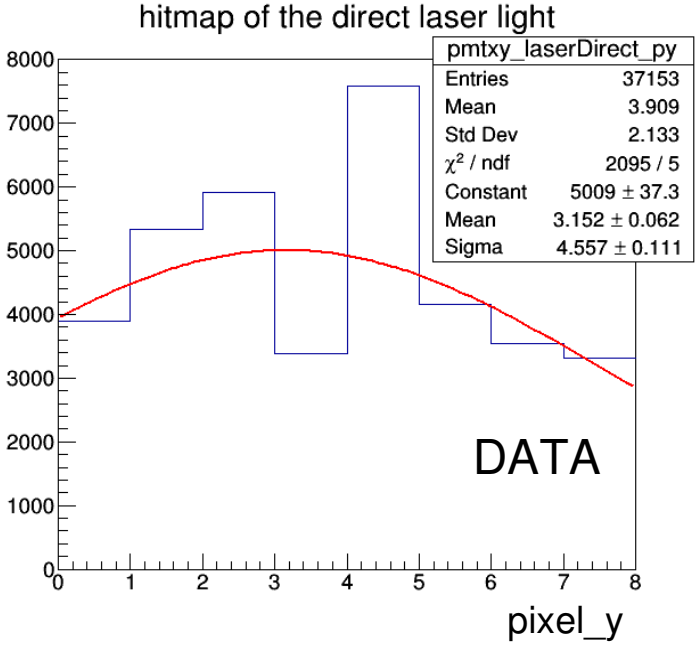
→ Maximum position

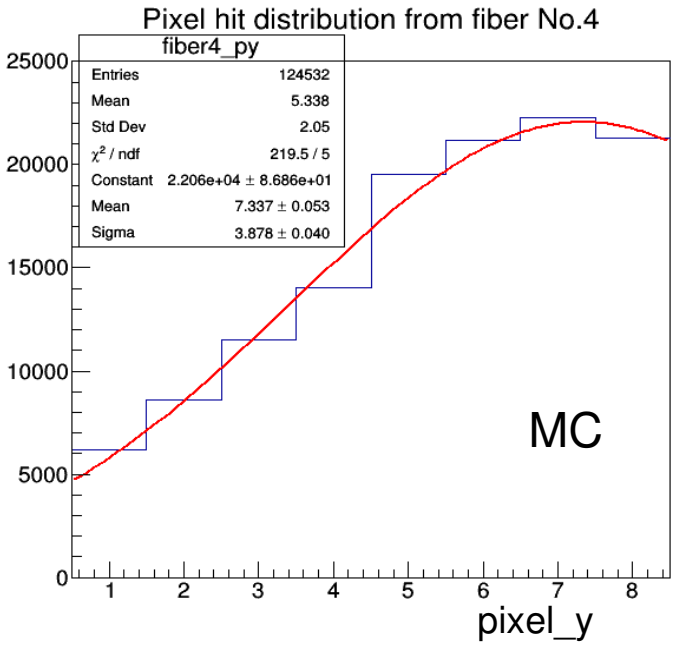
→ spot size (x only)





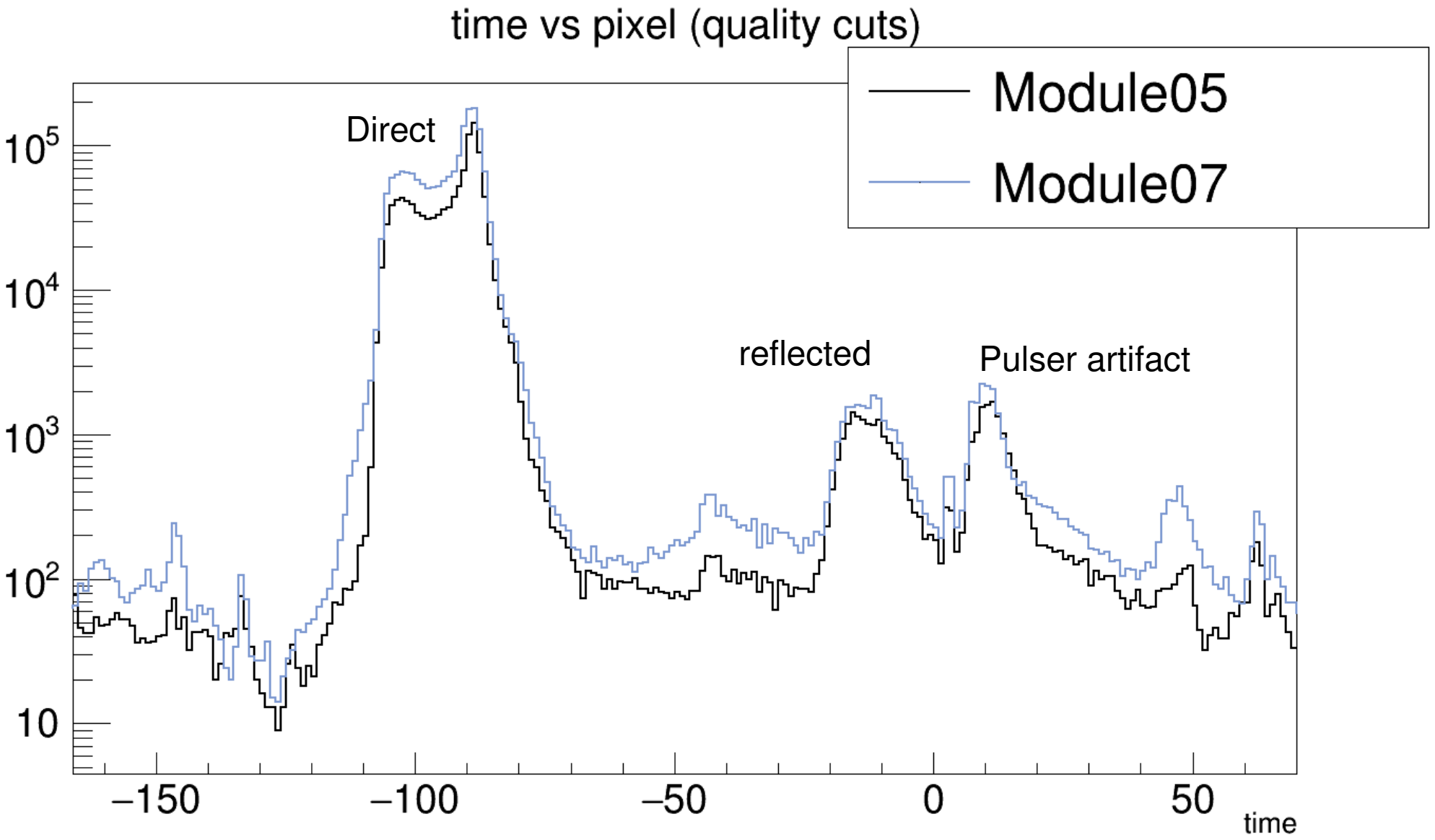
Projection x





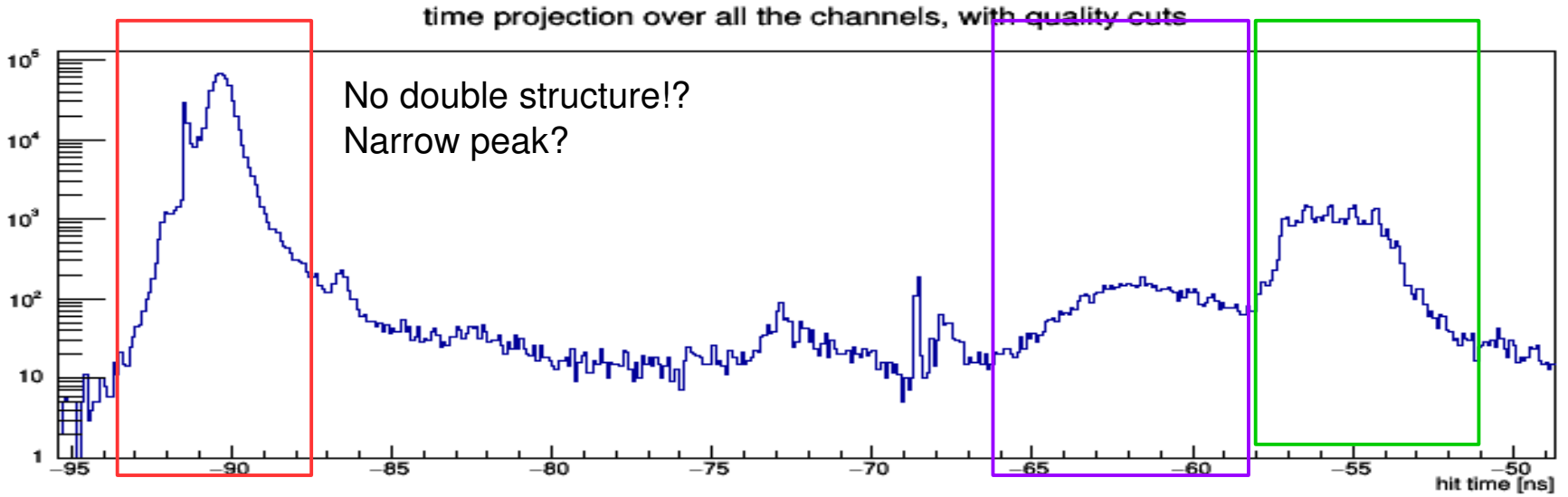
Projection y

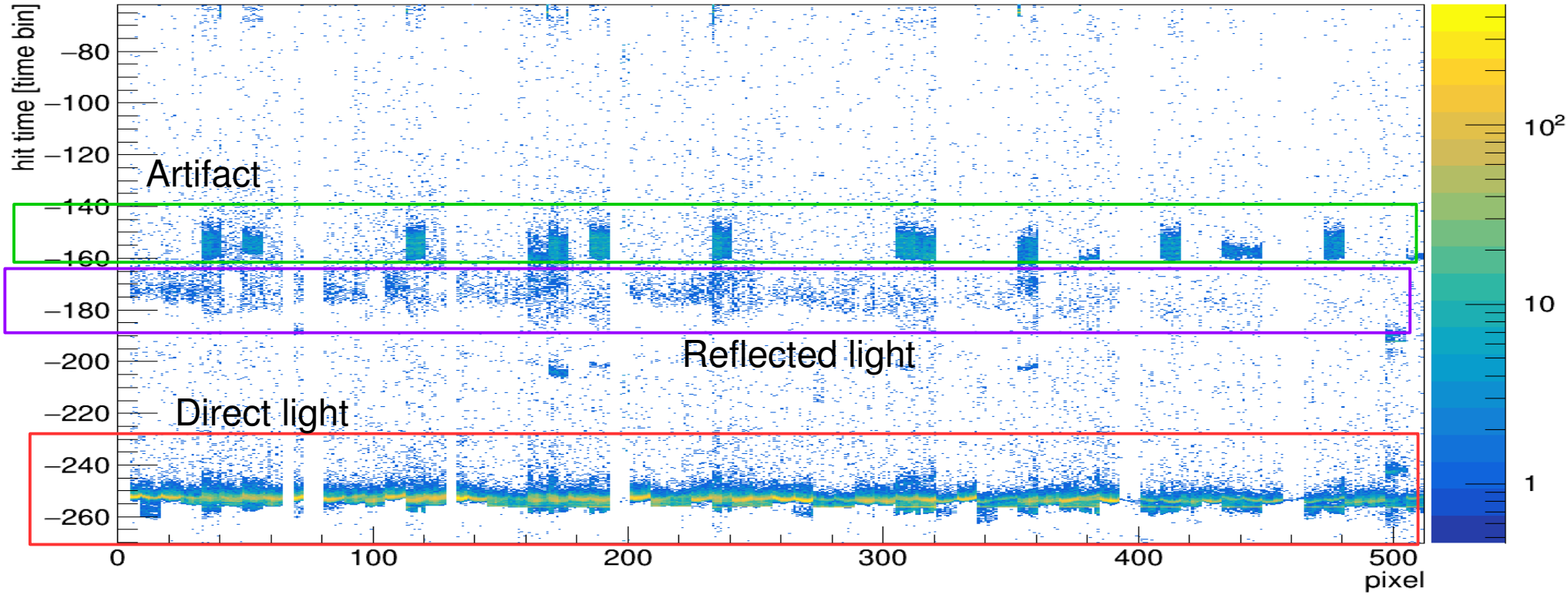
Timing


time vs pixel (quality cuts)
Module05
Module07
Direct
reflected
Pulser artifact
10^5
10^4
10^3
10^2
10
−150
−100
−50
0
50
time

Timing (II)

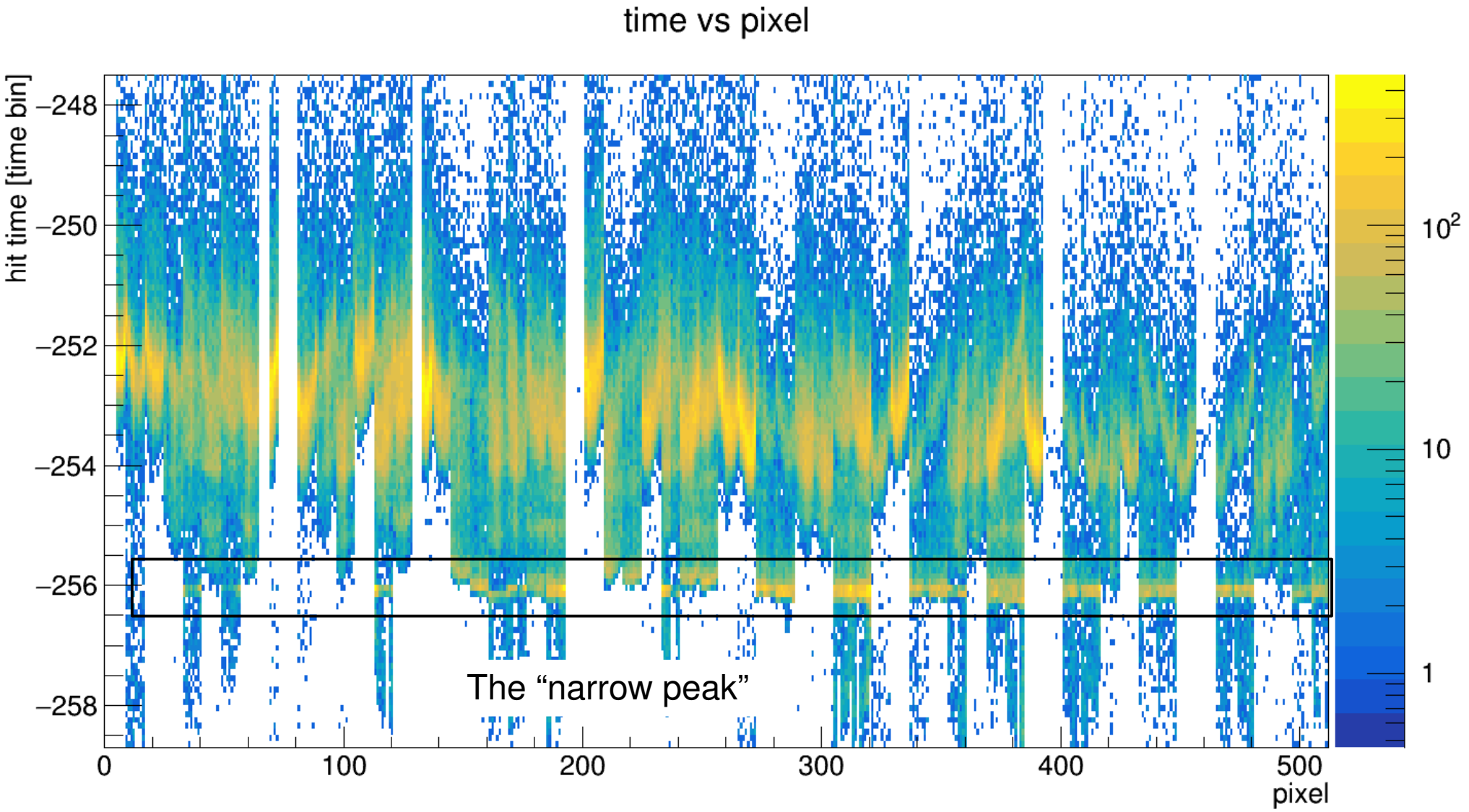
Zoom in the laser light region





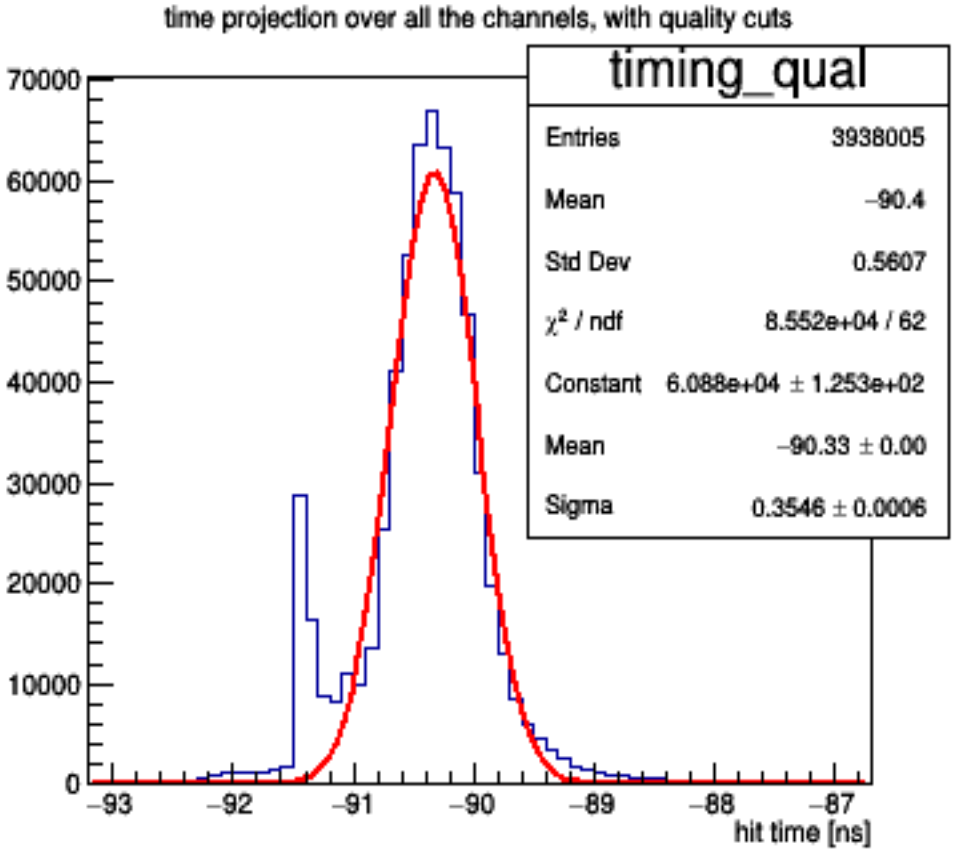
Timing (III)

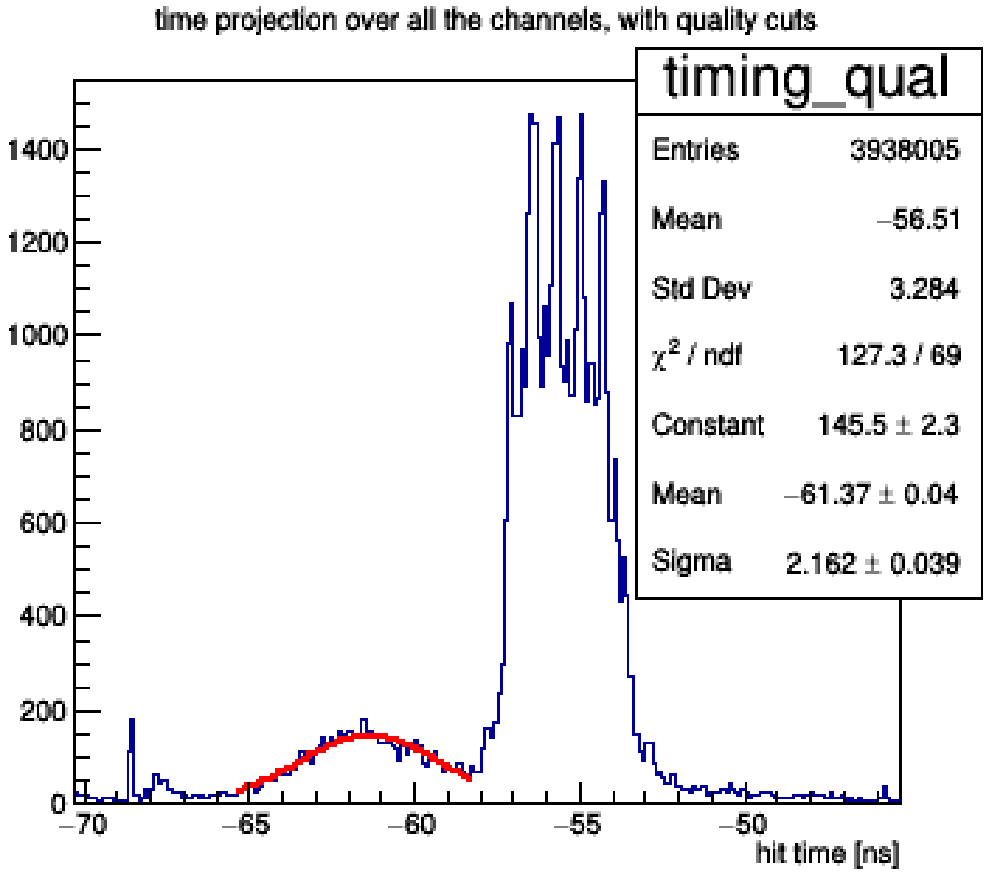
Even finer zoom: direct laser light only



Timing: all channels

Integrating over all the channels (assuming 1 time bin = 0.357 ns, which is not correct probably)

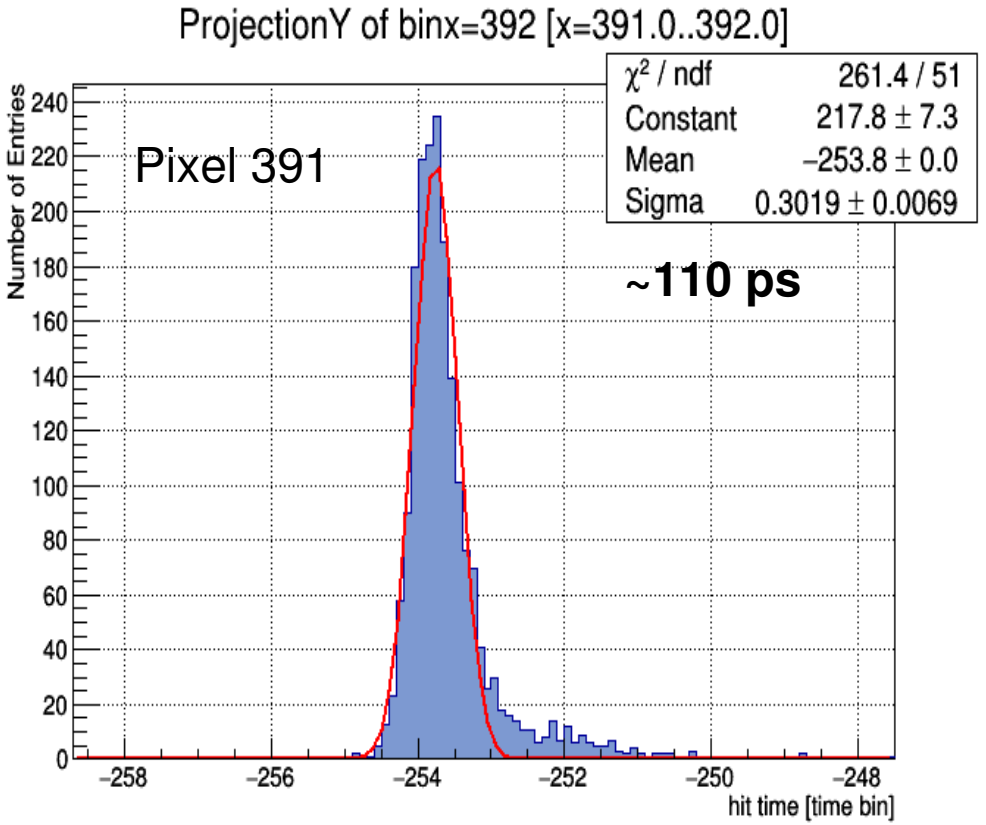


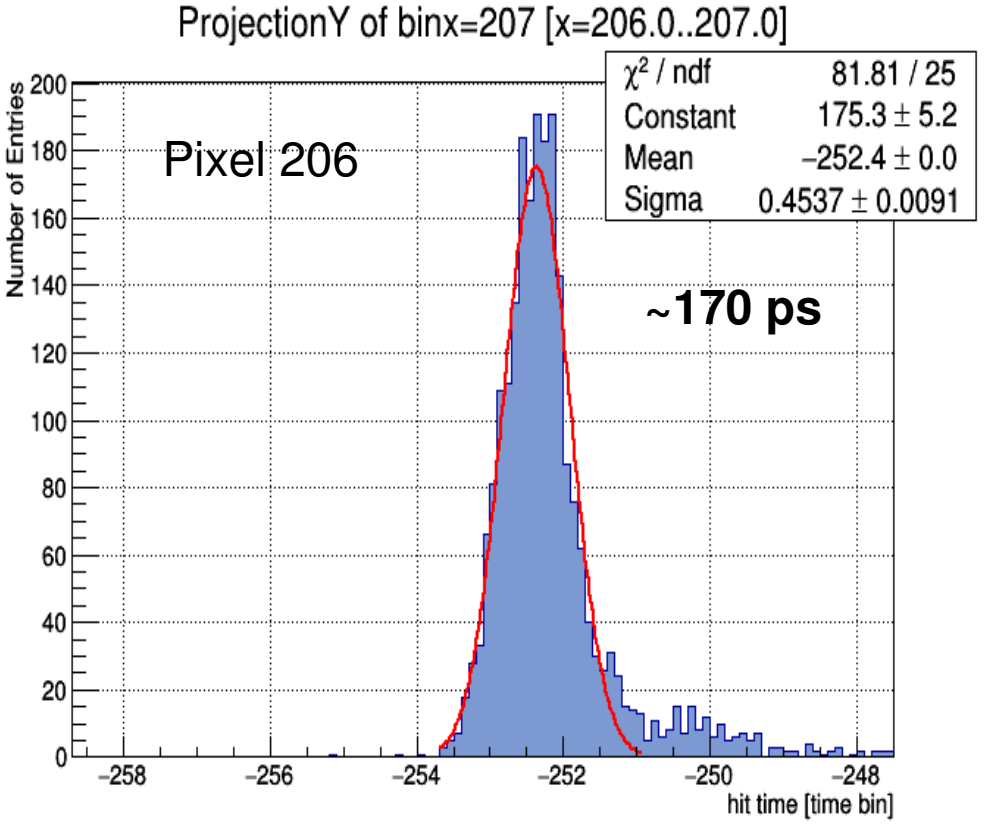


Direct light resolution: ~350 ps (360 assuming time bin = 0.370 ns)

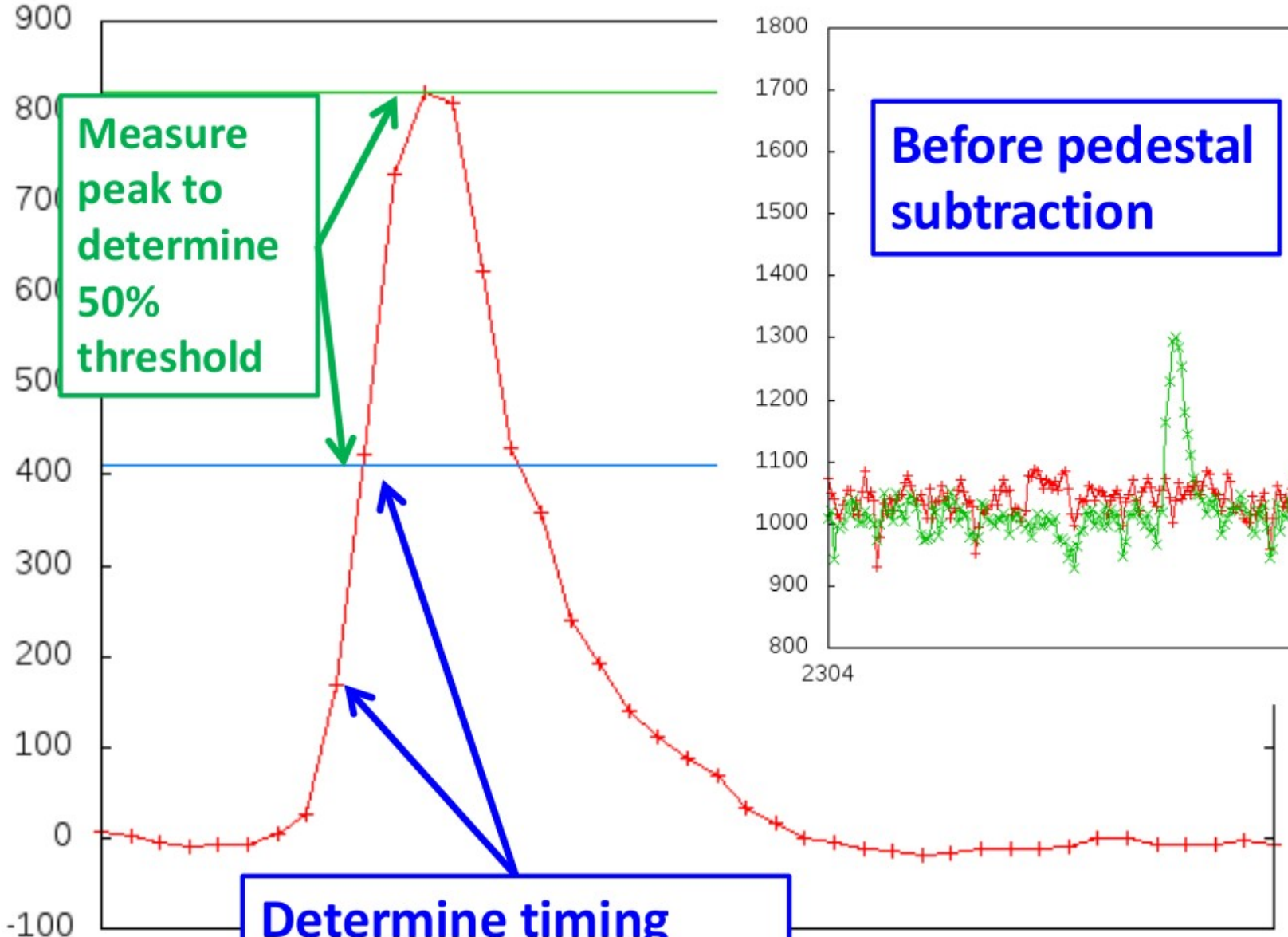
Timing: single channel

Some single channel time distributions



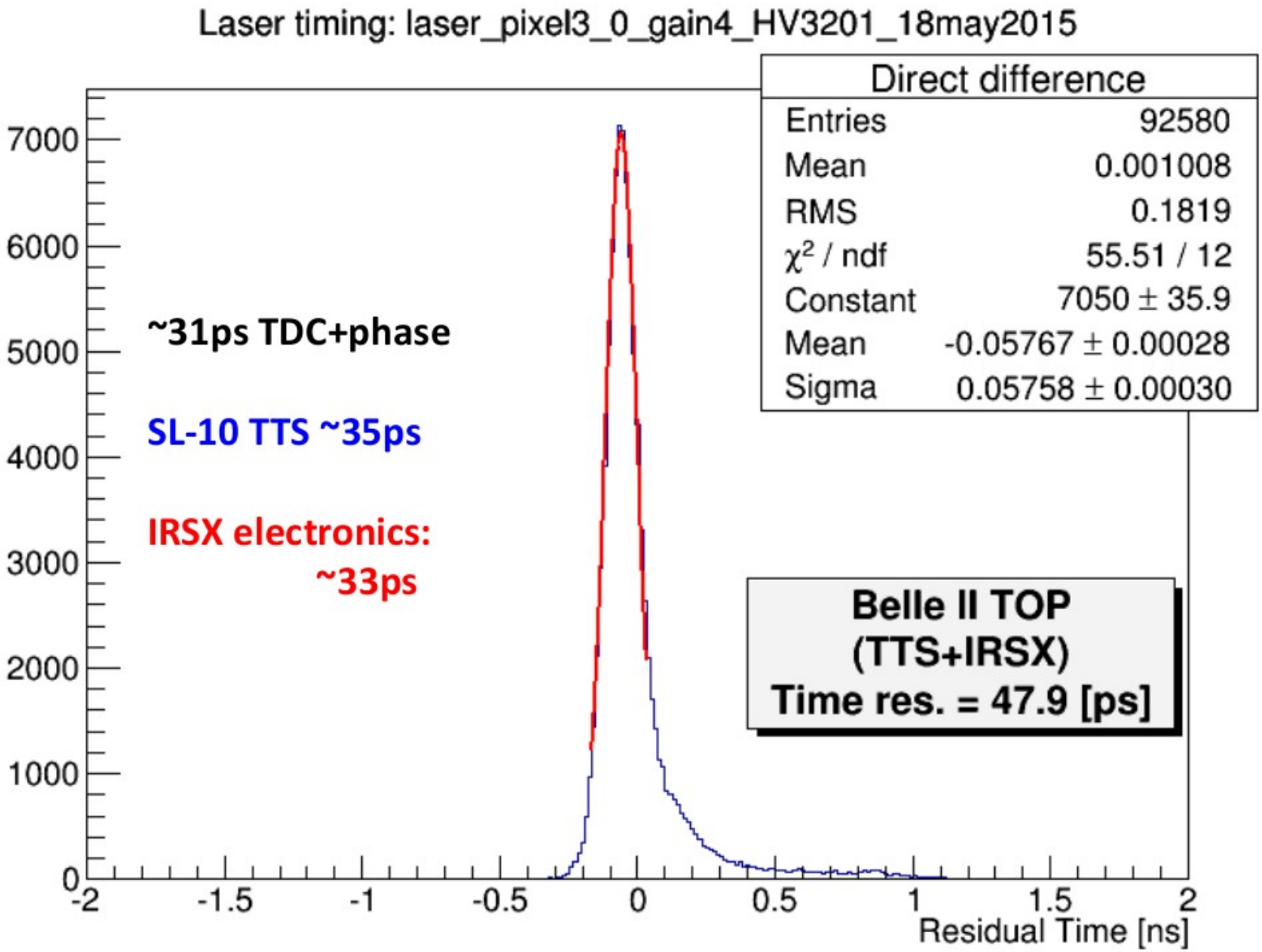


1. Ped subtract & 50% CFD

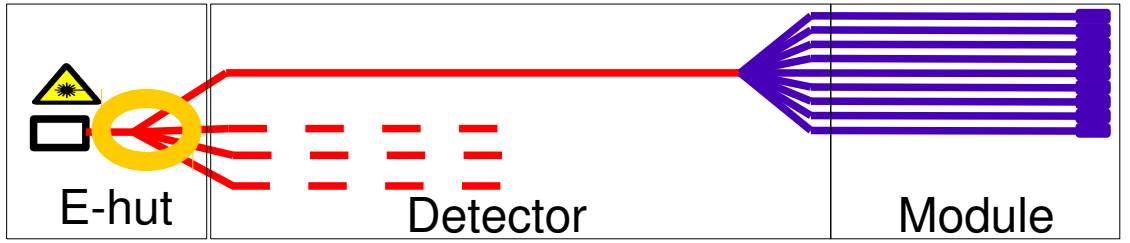


Default samples are ~ 0.37ns/point

Example laser timing Residual



PLC splitter

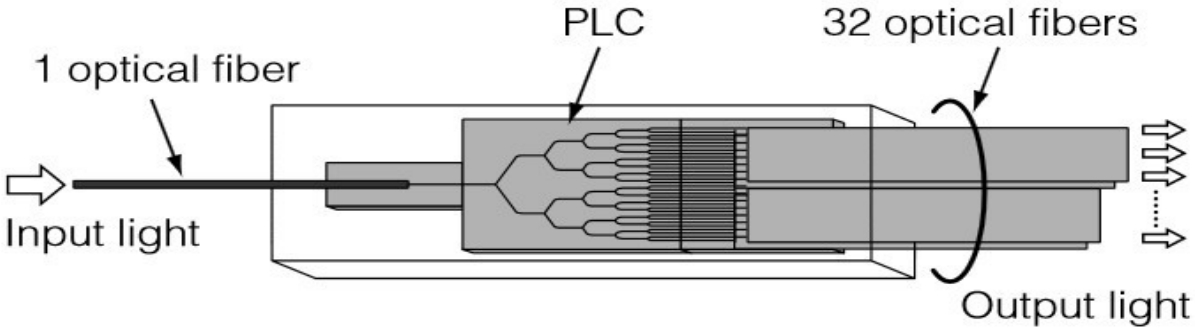


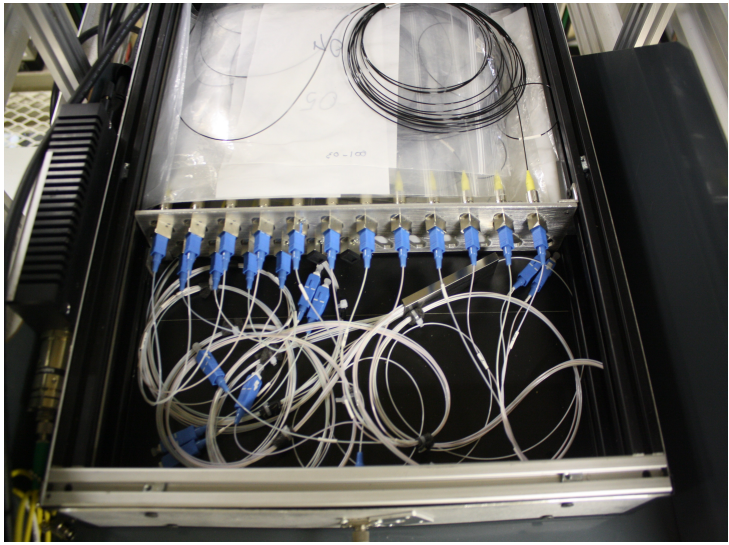
Planar lightwave circuit

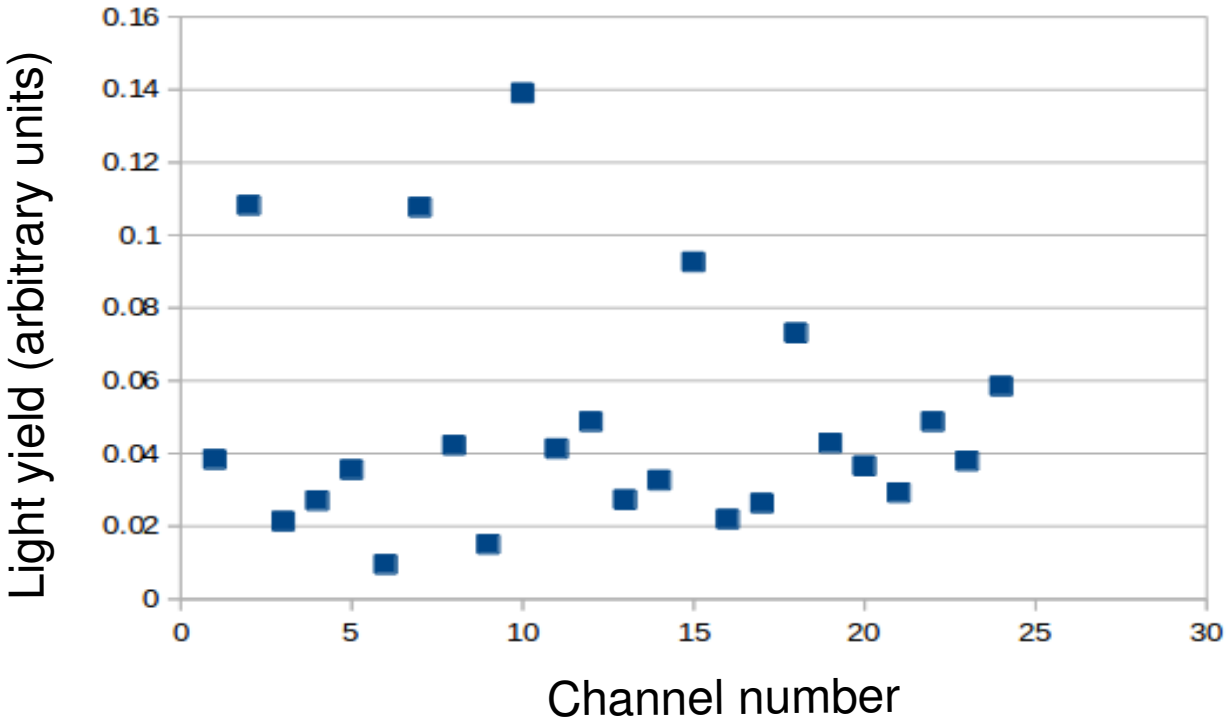
→ tree of Y shaped, micrometric light guides

→ Construction technology similar to electronic semiconductors

→ Splitting efficiency ~ 1-2% per channel **(only ~50% light loss due to splitter!)**

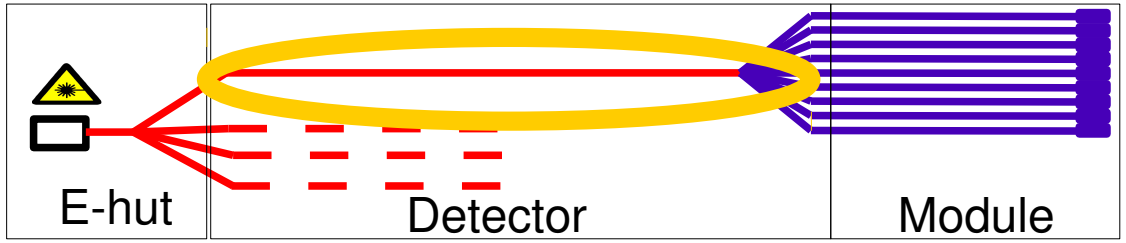




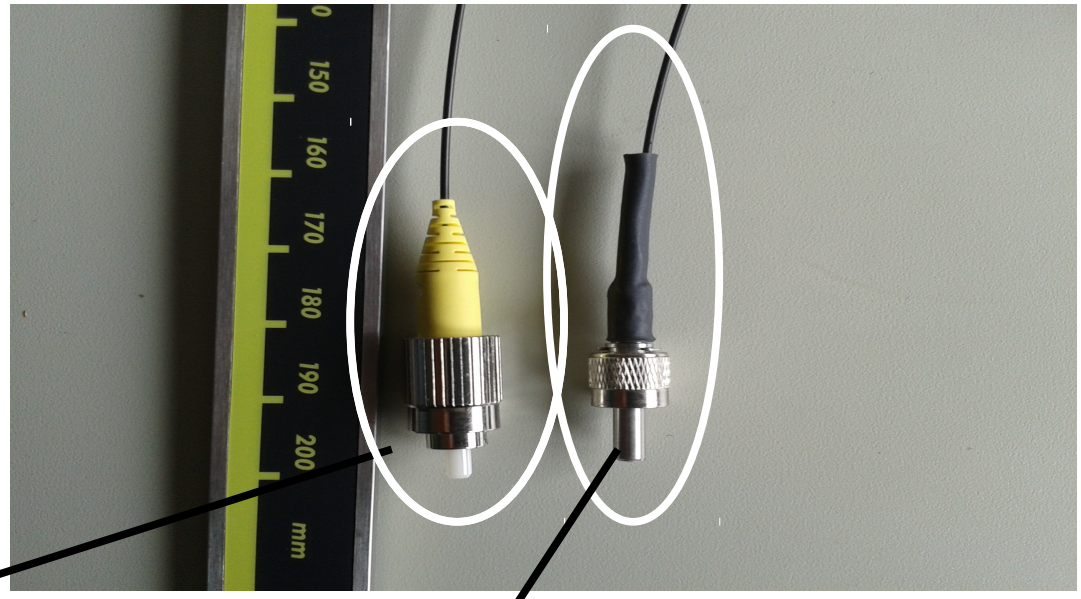


Good uniformity of the light output from each channel from tests both in Padova (with CCD) and in Torino (single photon counting on PMT)

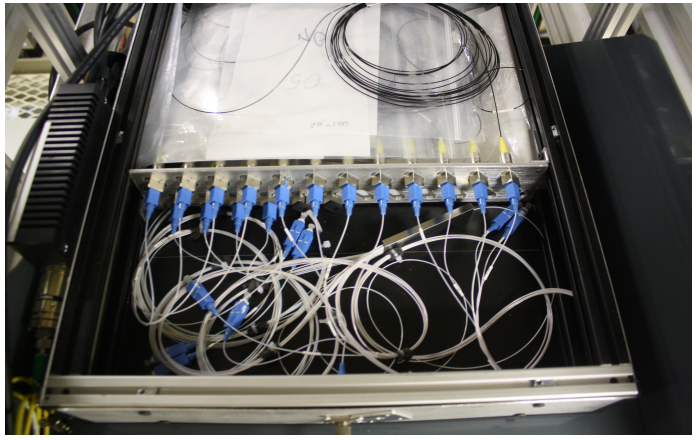
Single Mode fibers testing



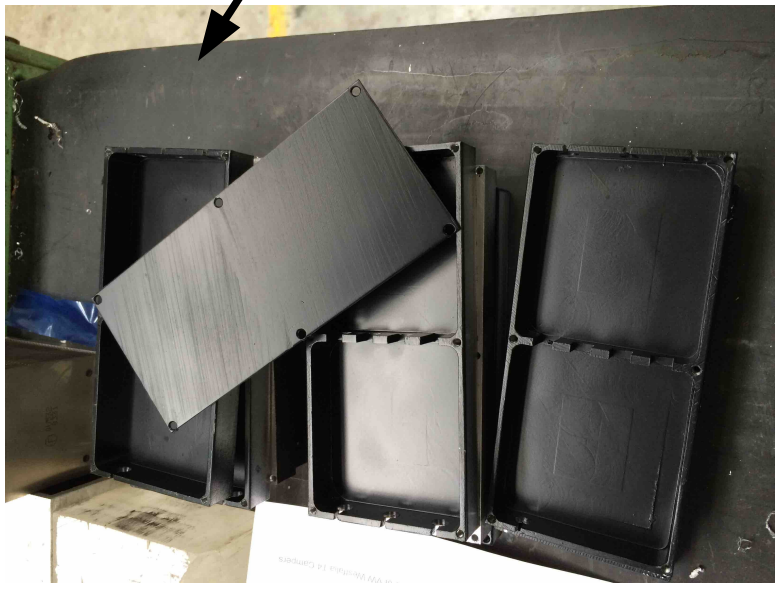
24 (16 + 8 spares), 27-m long single mode fibers prepared By O. Brunasso in Torino



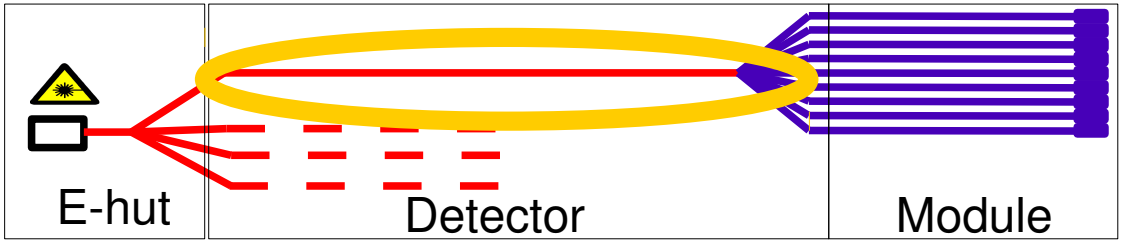
FC connector to the PLC via an SC-FC adapter



SMA connector to the Multi-mode bundle in the calibration connector boxes fixed on the detector

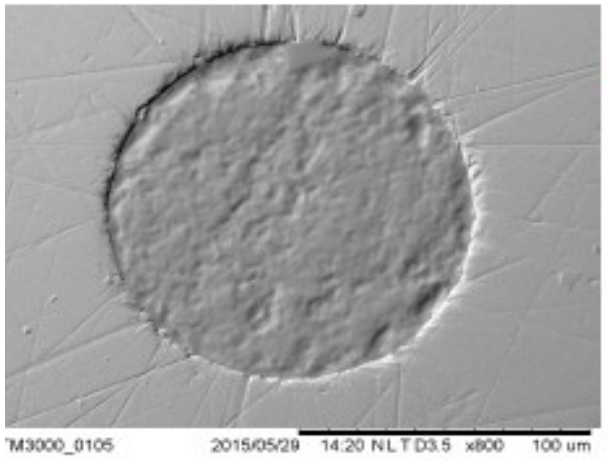


Single Mode fibers testing

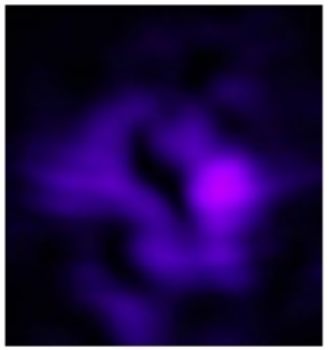


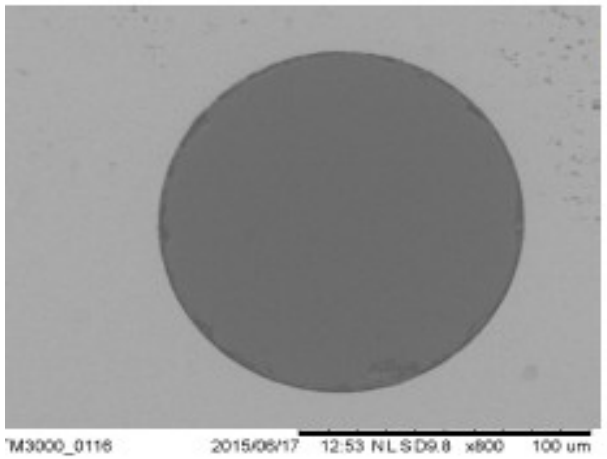
Connector polishing

A bad polishing of the fiber connector was observed in Torino using the SEM
→ A diffraction pattern is produced in the beam spot profile seen on a commercial CCD



BAD



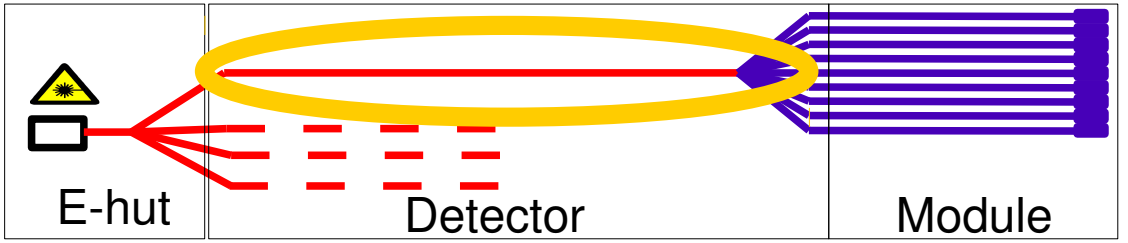


GOOD

All the 24 fibers are tested on each size using 401nm light in Fuji F1

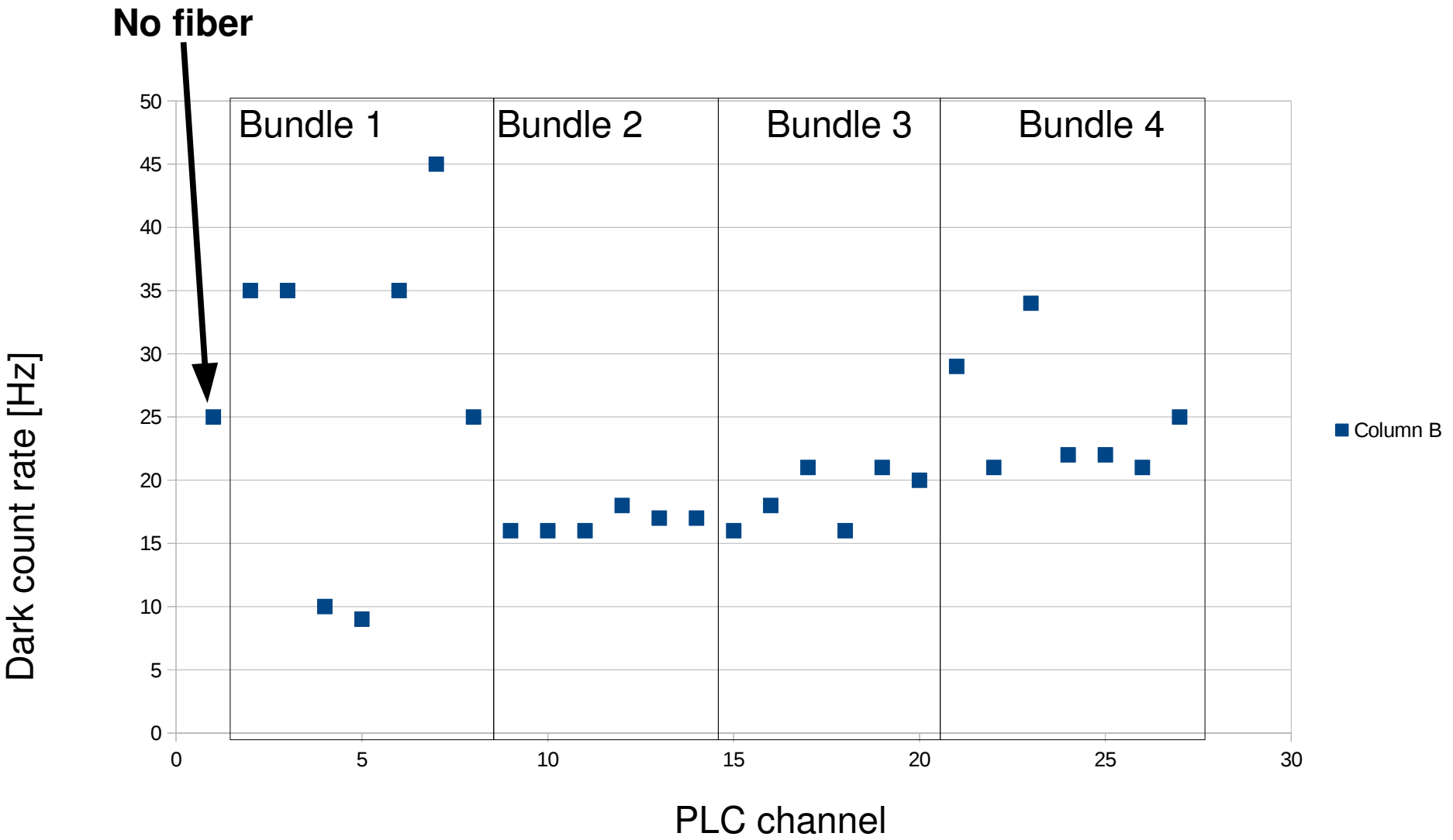
No bad polishing on any connector was found

Single Mode fibers testing

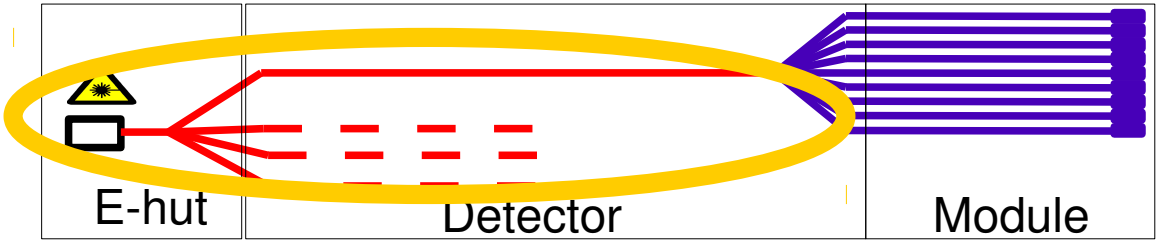


Coating integrity

Dark count rates are taken connecting to the PMT eah SM fiber, leaving it exposed to white light



Single Mode fibers testing

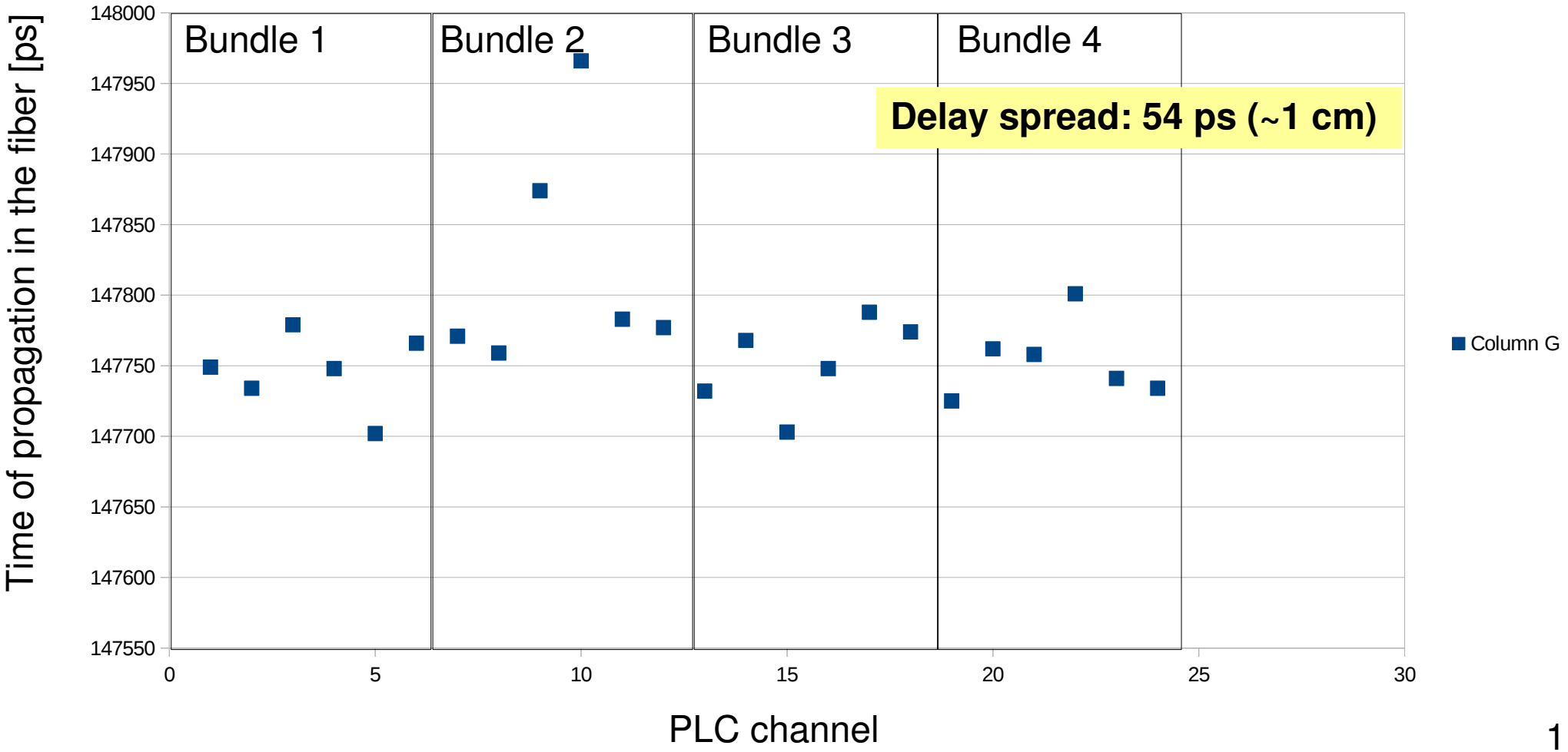


Delay

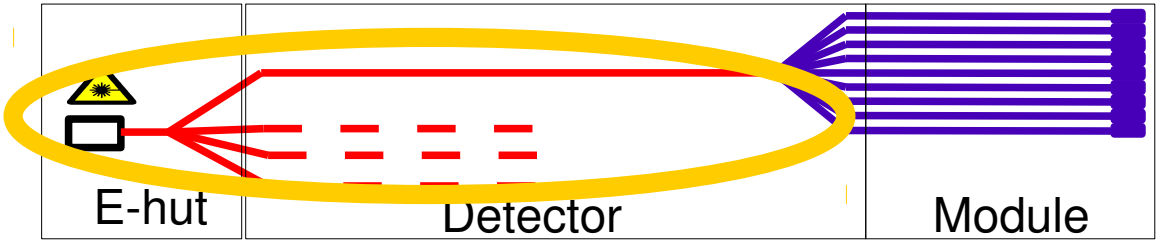
24 fibers connected to the PLC to have 4 similar fibers in each bundle

→ **test of the system AS IT IS ON THE DETECTOR**

→ outlier are left as spare fibers



Single Mode fibers testing

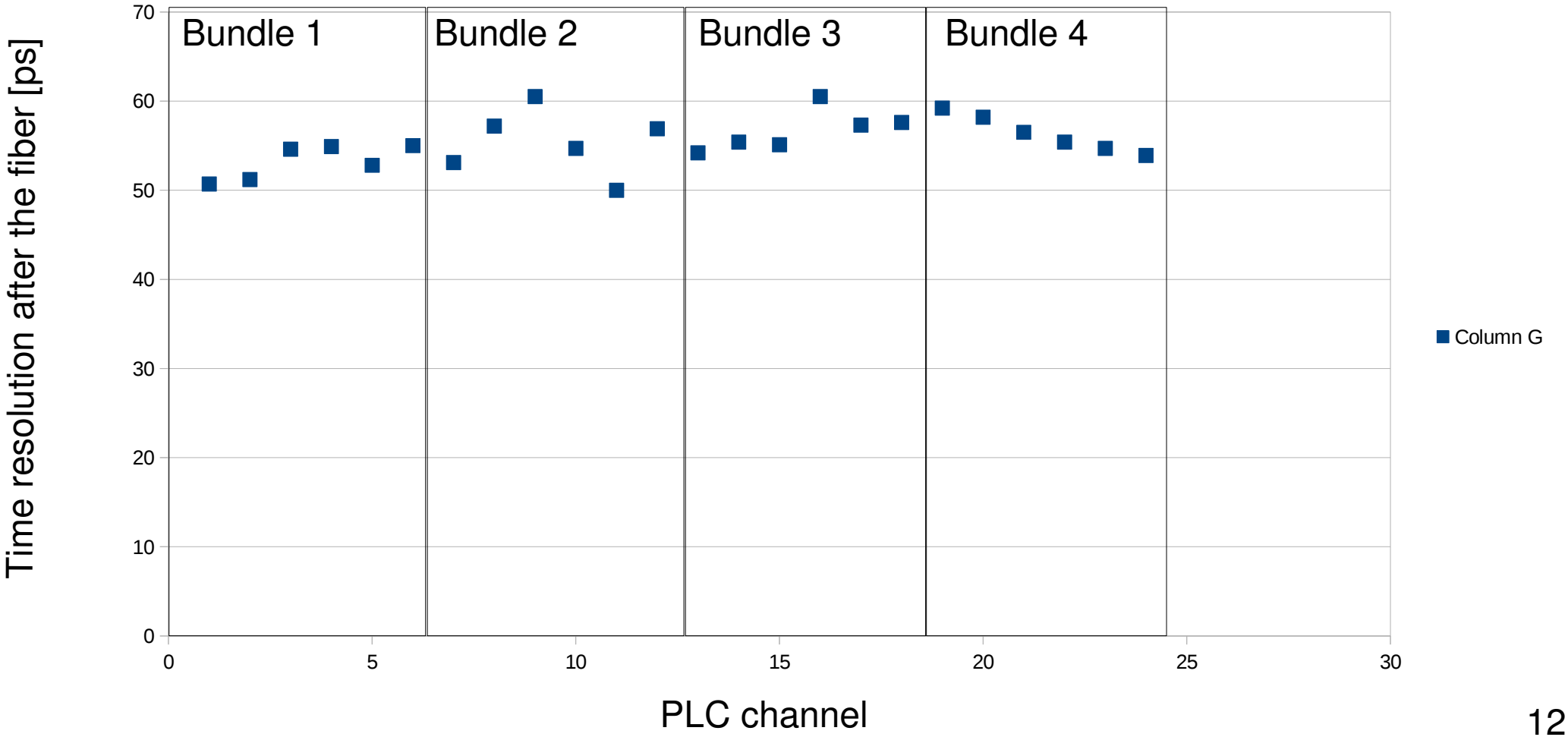


Single Photon time resolution

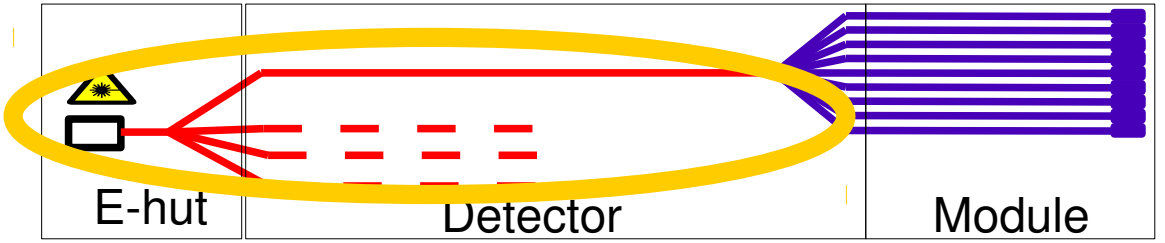
Time resolution is slightly worst than the one obtained in Torino

→ Different DAQ

→ Lower PMT gain



Single Mode fibers testing



Transmission efficiency

Comparison between single photon counting on each fiber, normalized to the countings from the laser only