TOP
Progress Report

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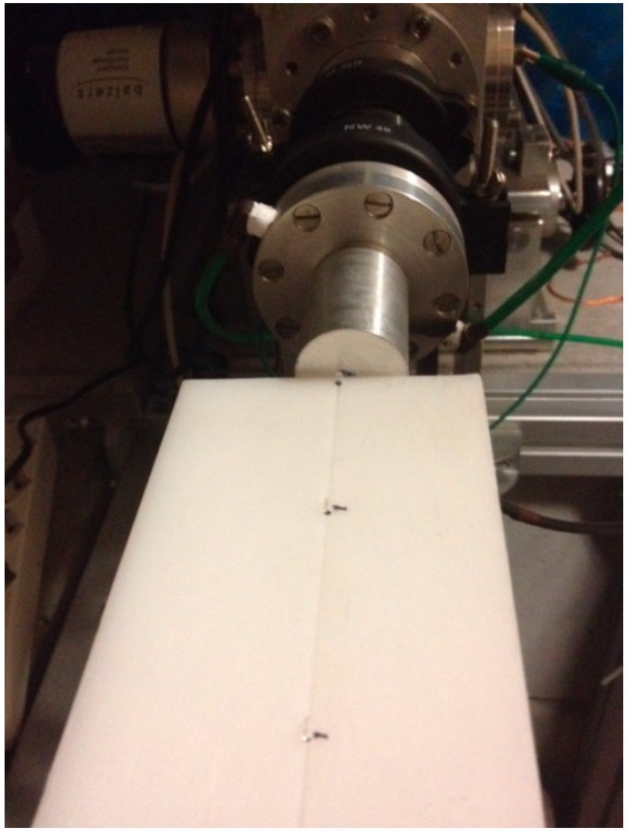
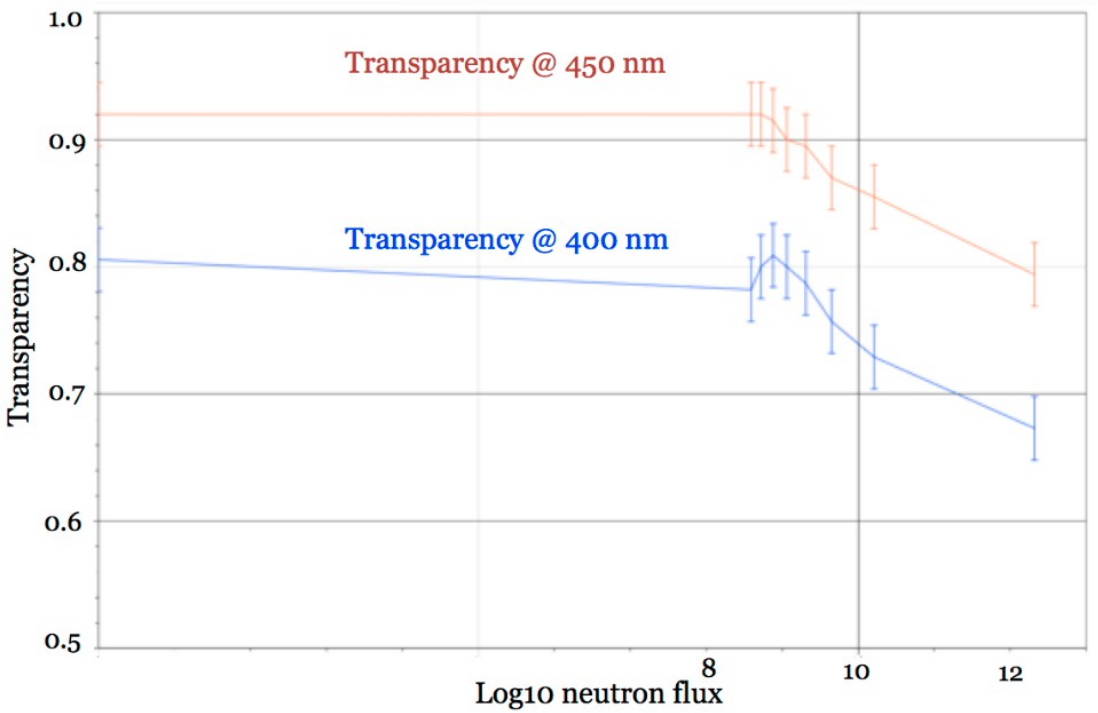
Belle-2 Italia 3rd Meeting LNF, 21-22/5/ 2015

Radiation damage tests at INFN Legnaro (PD)





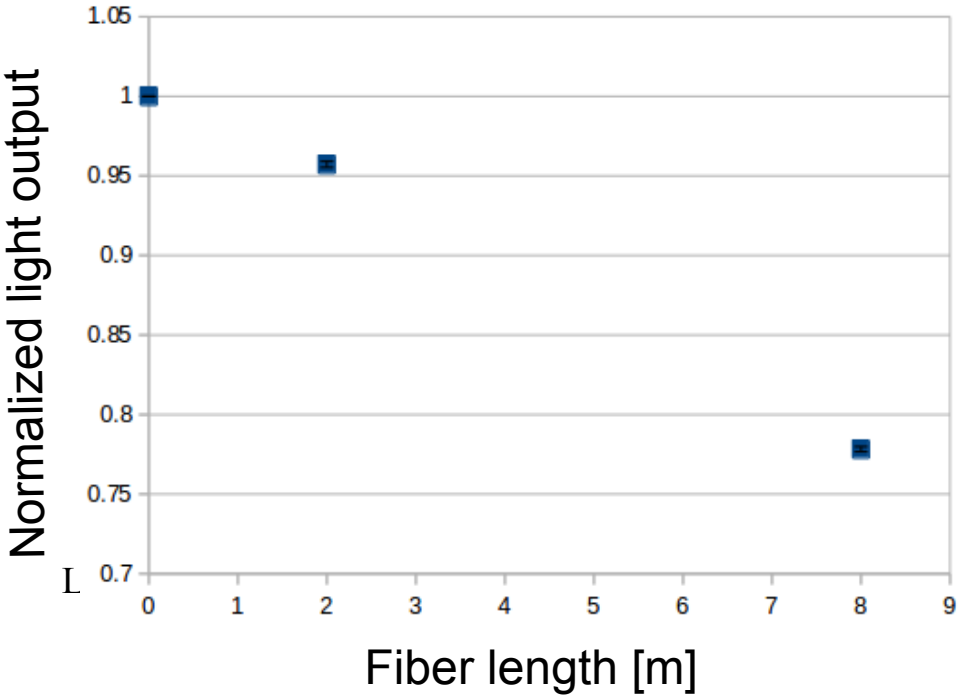
Irradiation of 9 GRIN lenses at variable distance from the target
Beam: 4 MeV protons on Berillium
Irradiation time : 7hours
Integrated charge: 6 milliCurie
Neutron Fluence (distance dependent): 10^9 to 10^{12} n/cm^2
Negligible loss in transmission expected for the whole duration of experiment (equivalent to a flux of 0.25 10^9 n/year*N_y)

Attenuation in graded index fibers (PD+TO)

New multimode fibers from Padova tested with CCD setup in Torino

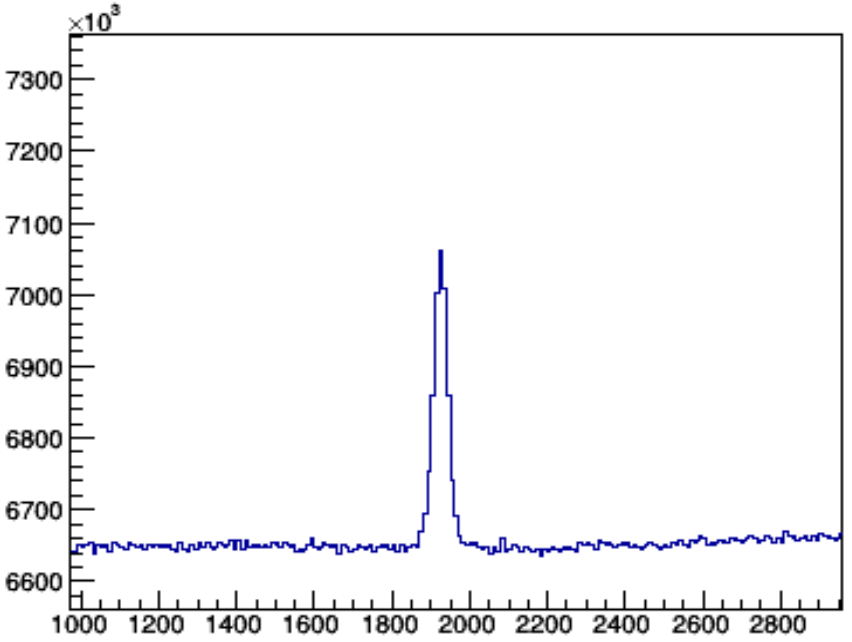
Graded Index; Cladding = 240 μ m; Core = 65 μ m; length=2,8 m
Single Fiber Efficiency = 1.6% (lower than in MM bundle #1)
Never tested with 405 nm light by producing company
Light time spread < 1 ps/m

Attenuation measurements done with CCD setup in Torino



L P Time C

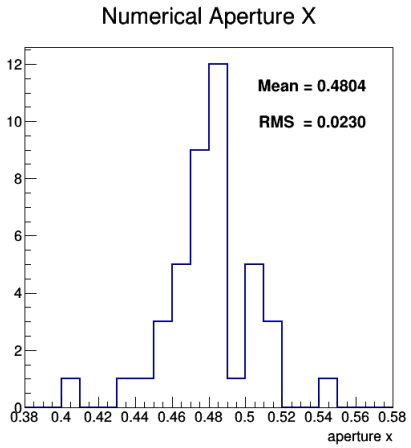
Light profile

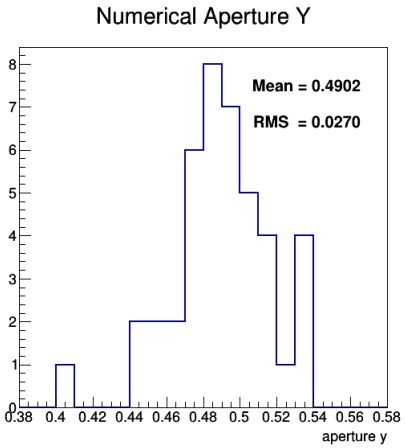


Characterization of GRIN lens cylinders (PD): aperture

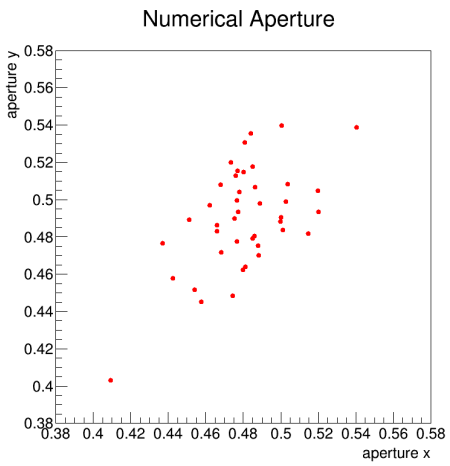
N.A. measured on the first 42 pieces varying CCD – cylinder distance in four 2 mm steps
The 2D images were fitted with Gauss(X)*Gauss(Y) PDF

1D apertures in X,Y

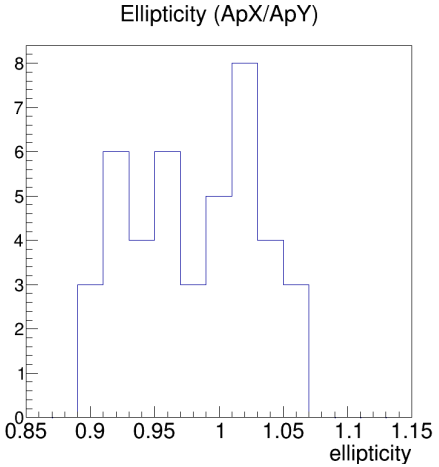


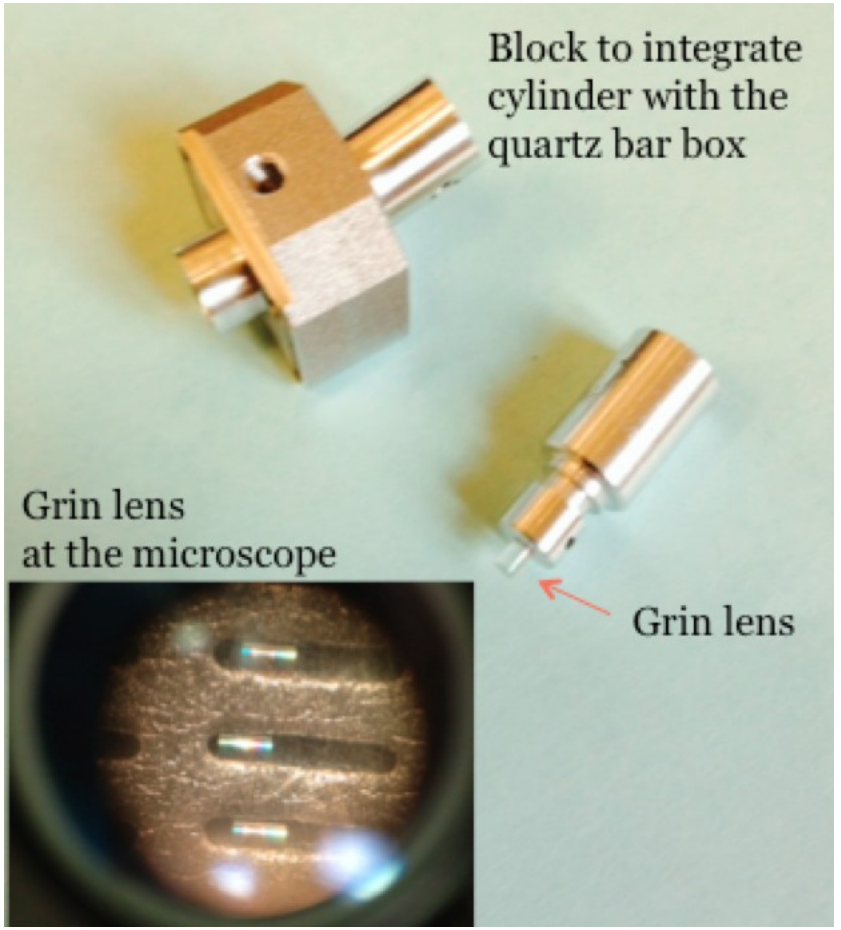


Correlation



Ellipticity

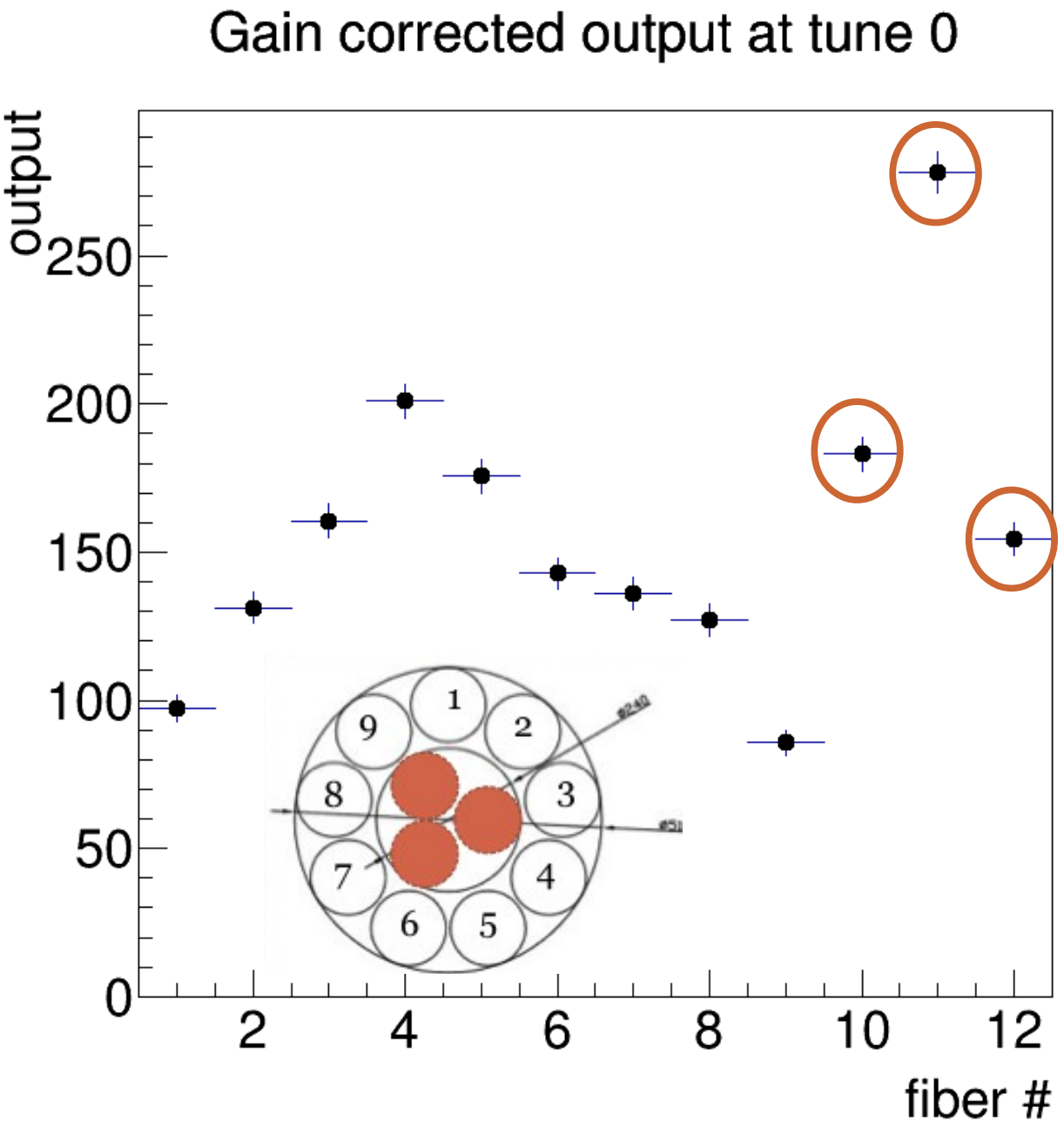




Characterization of MM fibers: 2nd bundle

Summary of laser results

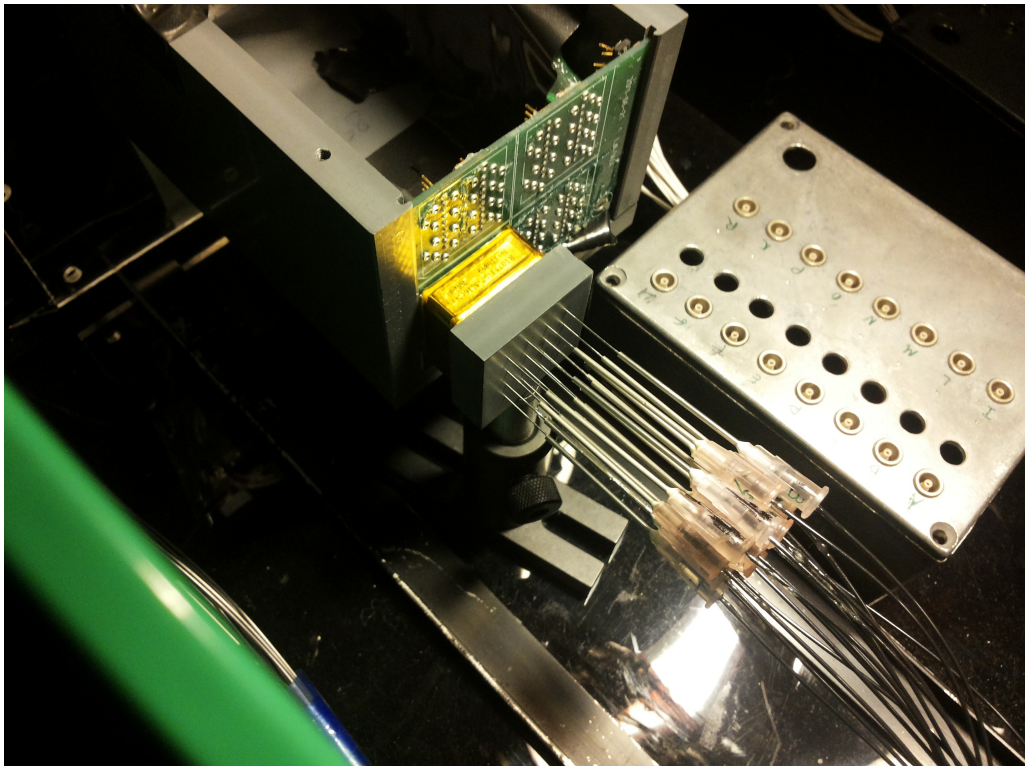
The 3 inner fibers (also shorter), in ch 10-12 are expected to have higher light output.
Excluding 10-12 a 2x change between minimum and maximum is observed .



Test setup for Tsukuba Hall installation

The final light distribution system has to be tested in Tsukuba hall after its placement on the detector.

- Check of the fiber light distribution
- Measurement of the time spread on each SM fiber
- Measurements of the relative delay on each fiber



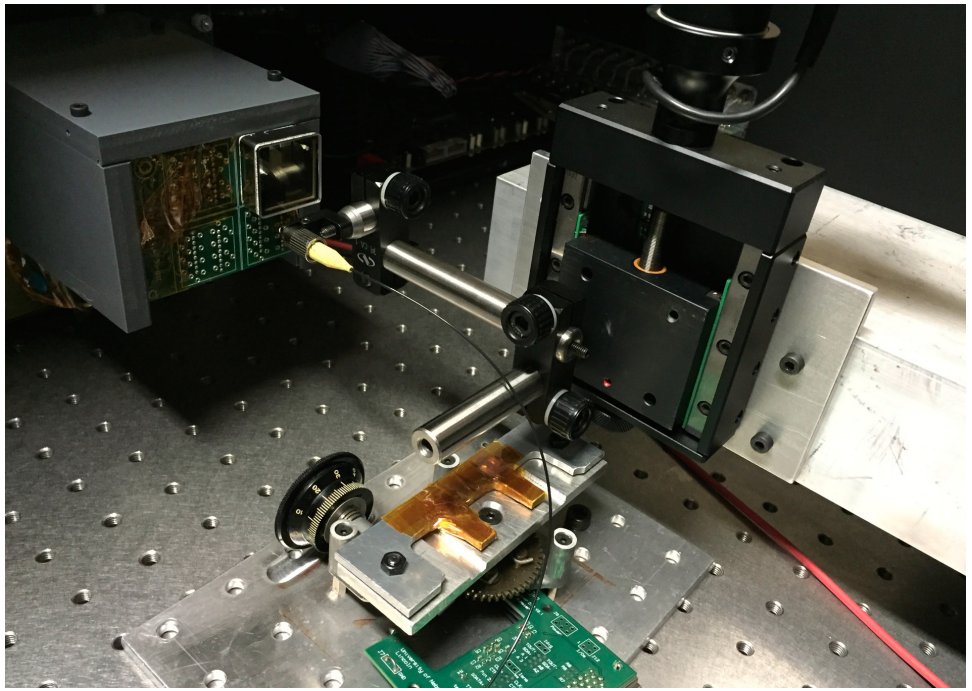
Tasks:

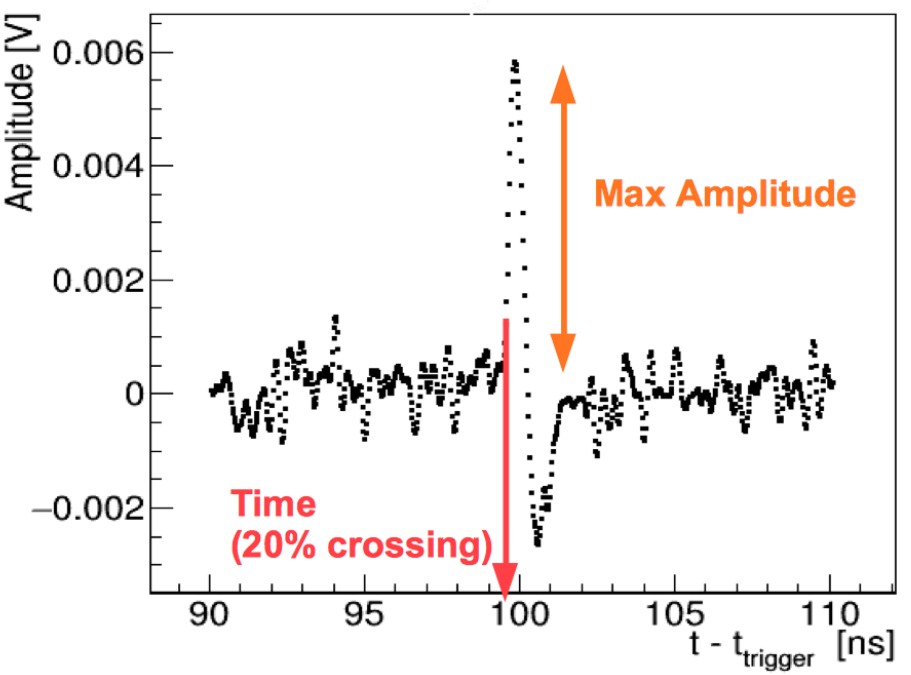
- Full characterization of the readout ALD-MCPPMT
- Characterization of the DAQ system (CAEN V1742, 1 GHz BW and 5 GS/s)

ALD-MCPPMT characterization (TO)

Two ALD-MCPPMTs in Italy: KT447 and KT462

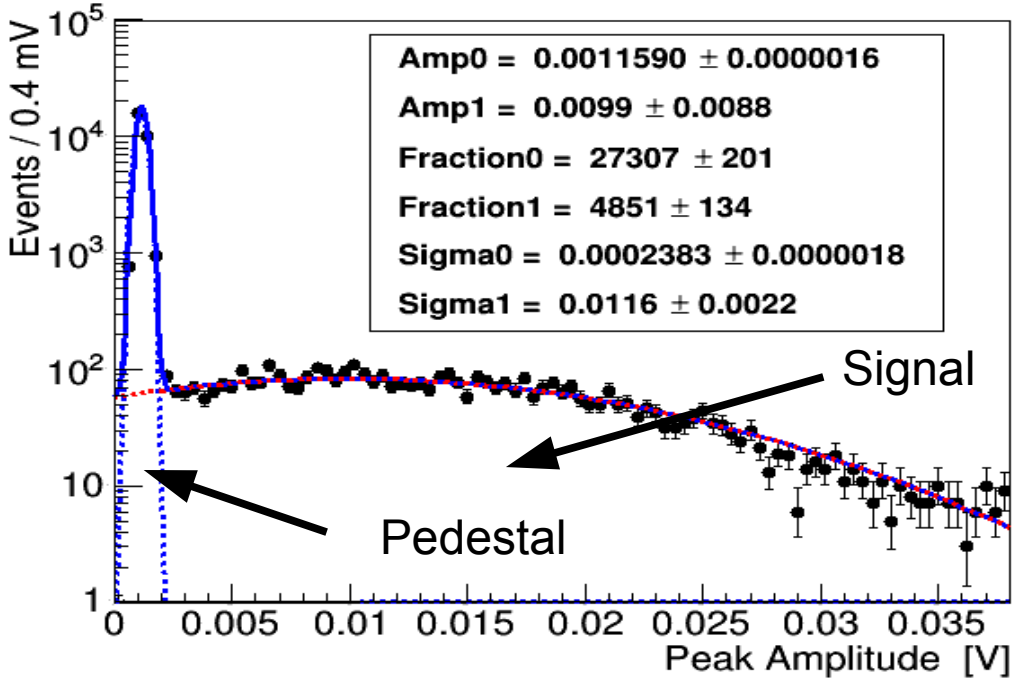
- Test is done using a 2.5 GHz, 40 GS/s scope
- 3D motorized slide is used for scanning through all the channels





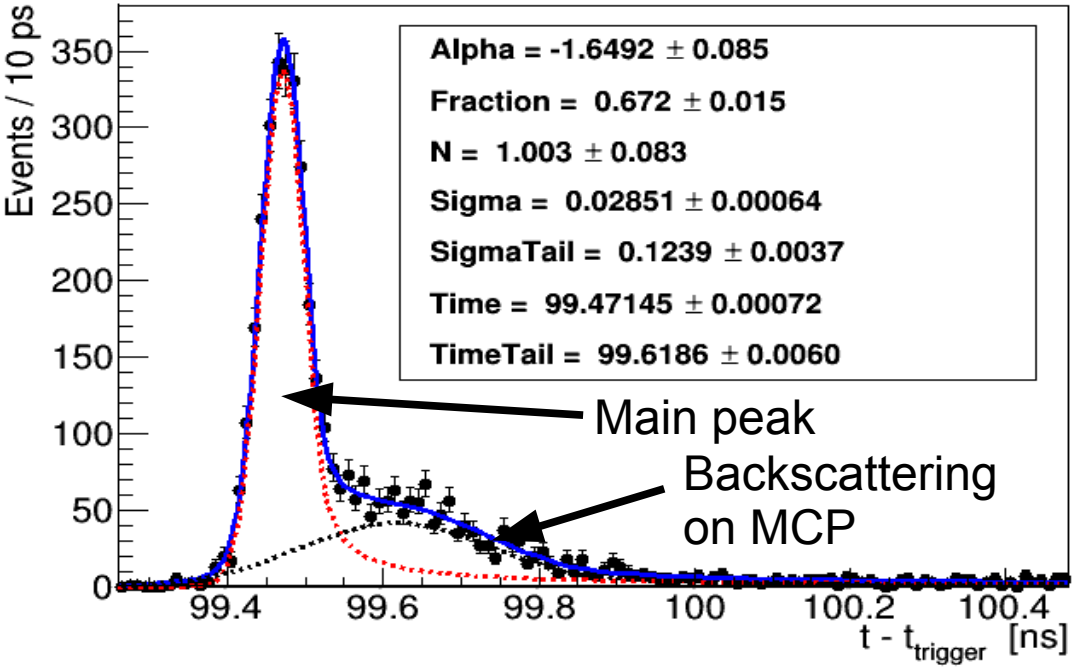
Typical signal pulse (inverted)

ALD-MCPPMT characterization (TO)



Single photon regime
KT447, Channel 3, Max HV

Avg pedestal amplitude: 1.1 mV
Pedestal gaussian fluctuation: 0.2 mV
Signal events: 4851 ± 134
Pedestal events: 27307 ± 201
Avg signal amplitude: (10 ± 9) mV



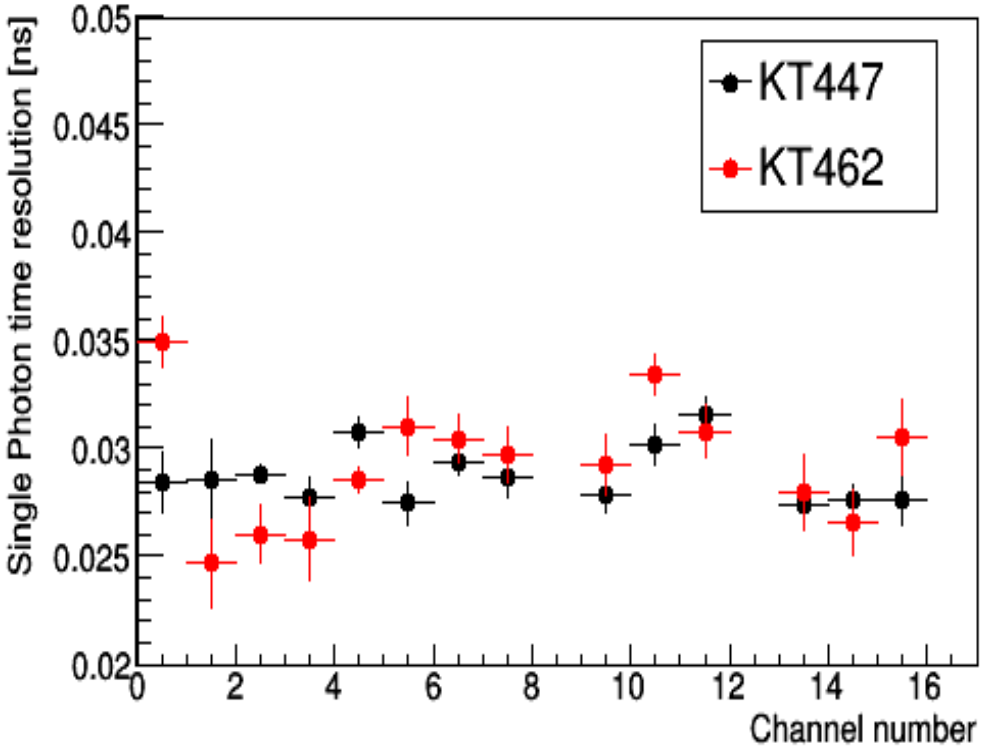
Single photon time resolution: 28.5 ps

Main peak position: (99.472 ± 0.001) ns
- correlated to the fibre length
- stat. error only

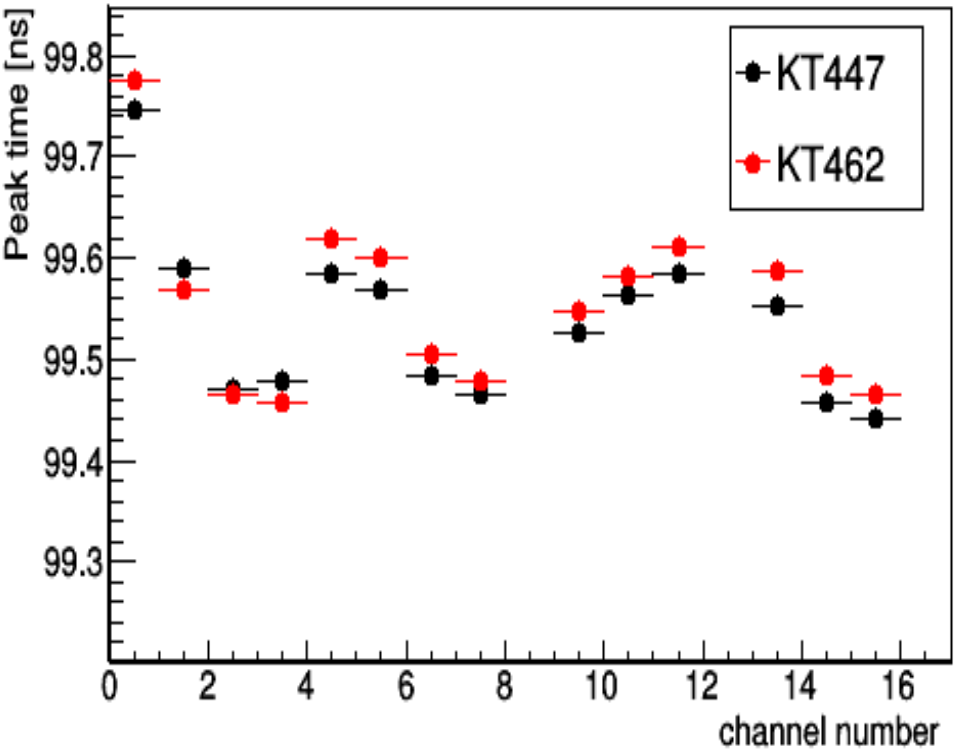
ibration

ALD-MCPPMT comparison

Channel 9 and 13 are missing due to problems on the readout board connectors



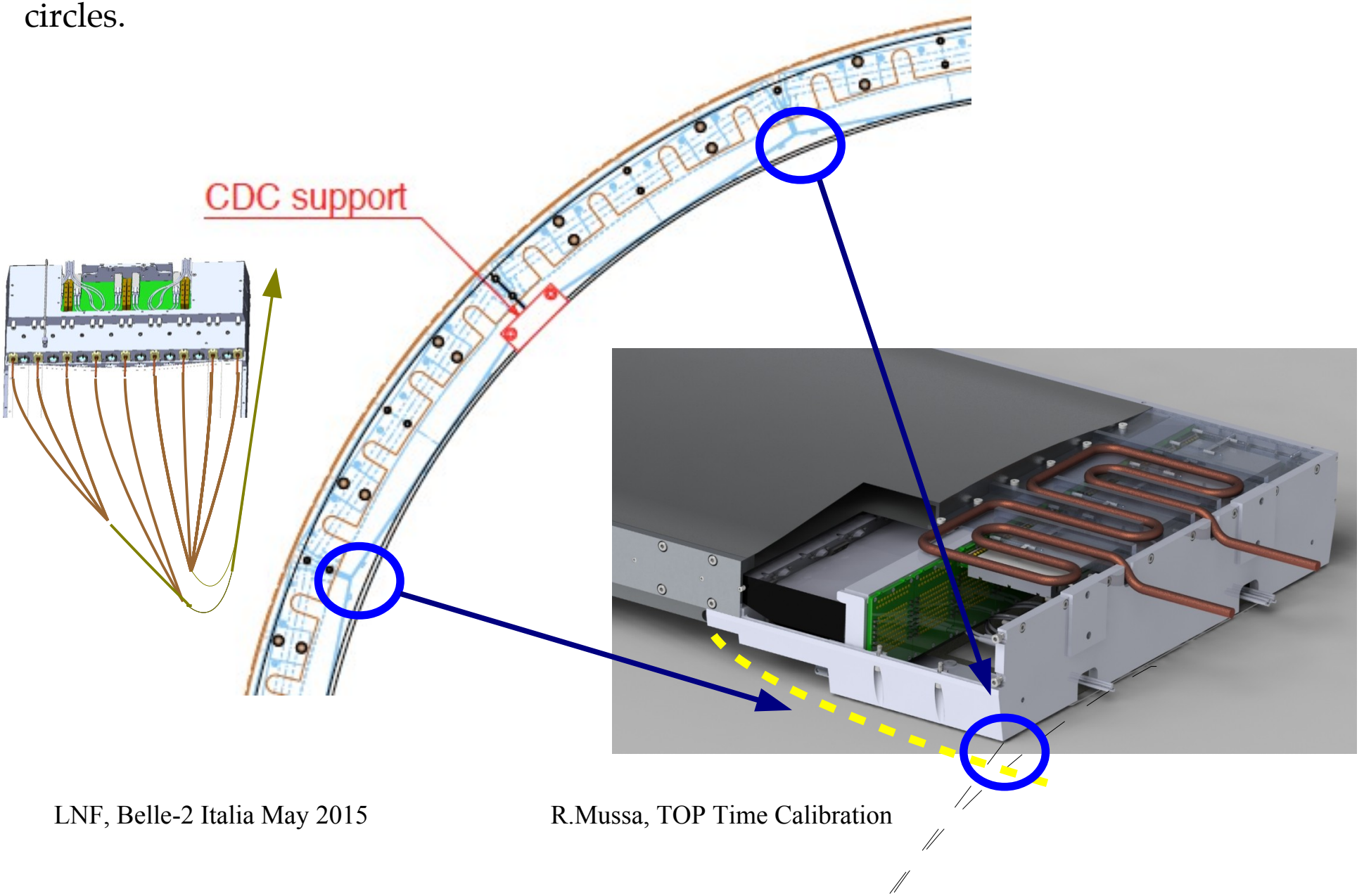
Single photon time resolution: 25 – 35 ps



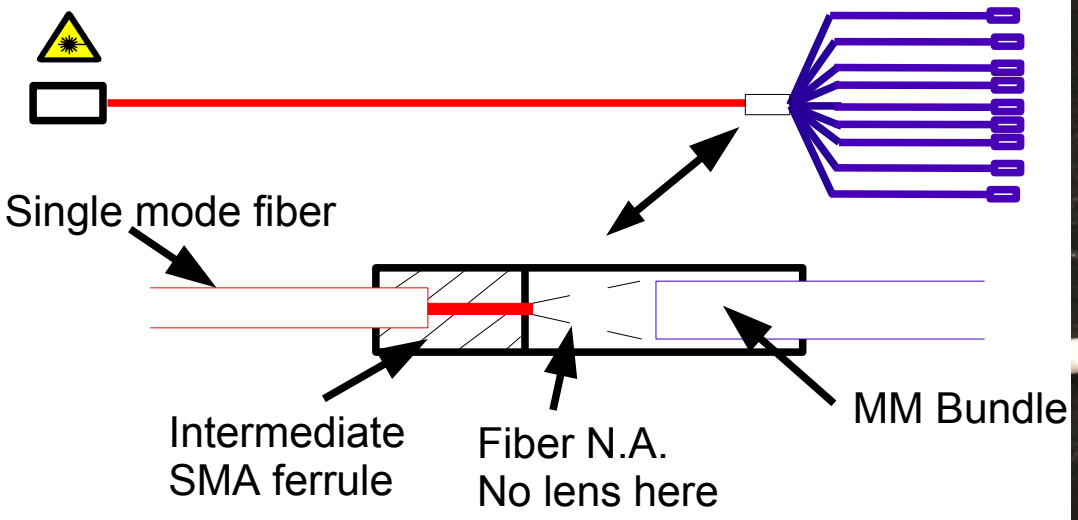
Channel-by-channel differences are due to differences in the cabling lengths for each channel;
PMT-PMT offset due to different fiber positions

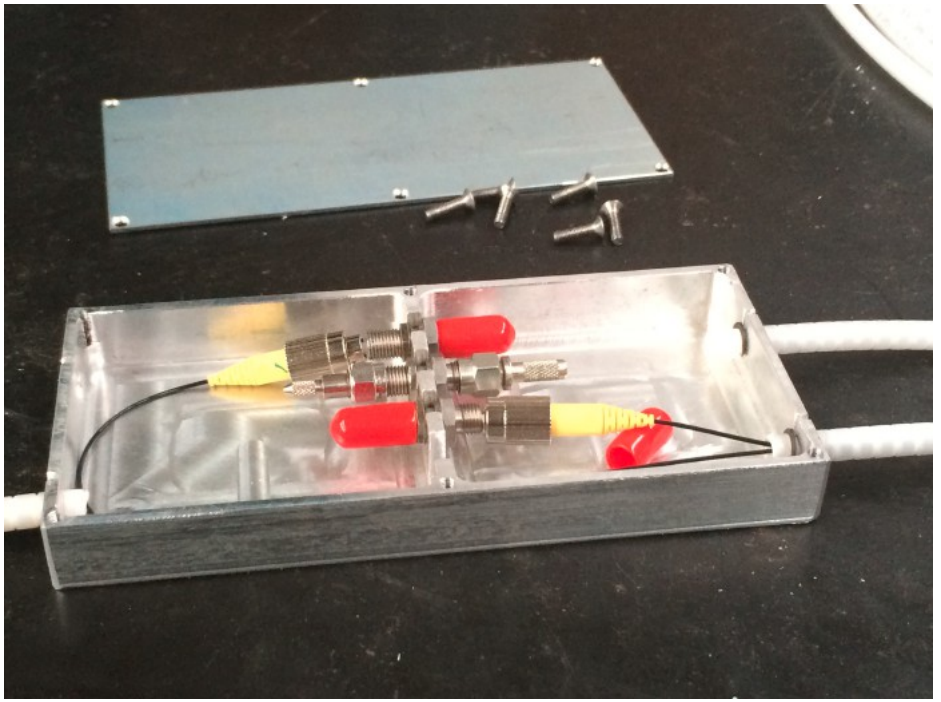
MM fiber bundle routing

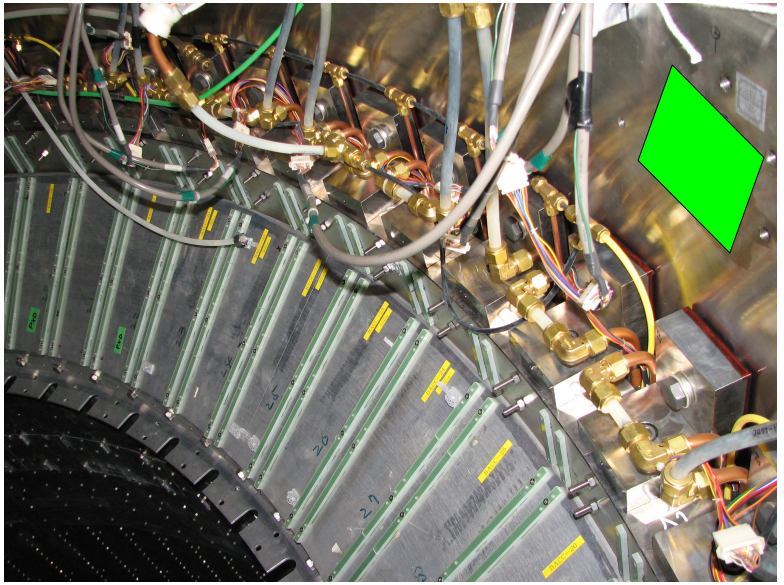
The MM fiber bundles from each pair of modules will exit the detector in the points indicated by the blue circles.



SM-MM fiber connection

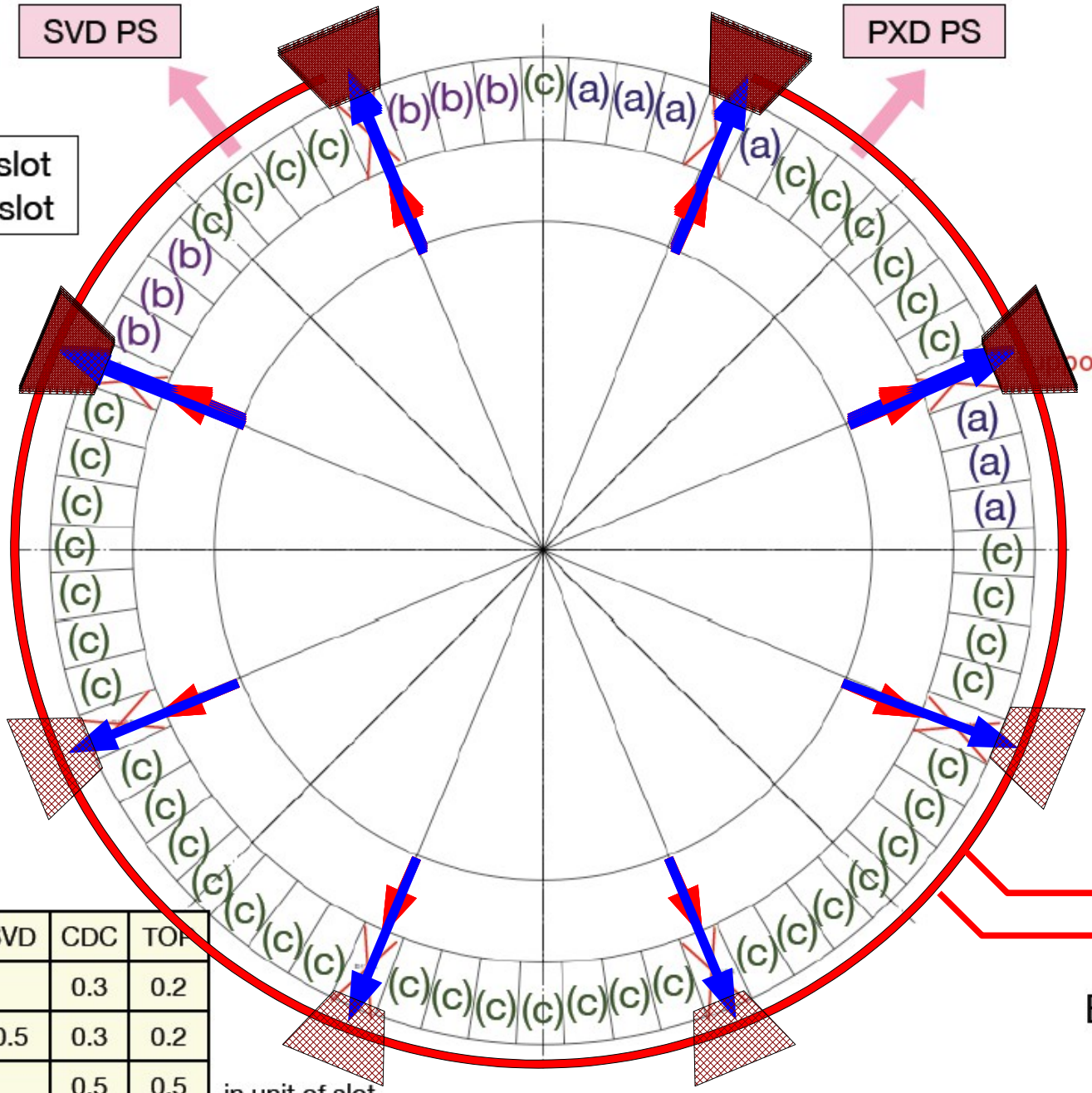






Connector boxes (8):
- 3 SM fibers in (1 spare)
- 2 MM bundles out

Fiber bundle routing



3 patterns

	PXD	SVD	CDC	TOP
(a)	0.5		0.3	0.2
(b)		0.5	0.3	0.2
(c)			0.5	0.5

in unit of slot

TOP modules production

	Mechanical Assembly		Electronics Integration
	Start	Finish	Complete
Module 01	Oct 2014	Nov 2014	Feb 2015
Module 02	Mar 2015	April 2015	
Module 03	April	April	
Module 04	May	May	
Module 05	June	June	
Module 06	June	July	
Module 07	July	Aug	
Module 08	Aug	Sept	
Module 09	Sept	Oct	
Module 10	Oct	Oct	
Module 11	Nov	Nov	
Module 12	Nov	Dec	
Module 13	Jan 2016	Jan 2016	
Module 14	Jan	Feb	
Module 15	March	March	
Module 16	March	April	
Module 17	April	May	
Module 18	May	May	

Module assembly: QBB-04 is being completed, after FPCP QBB-05 gluing will start.

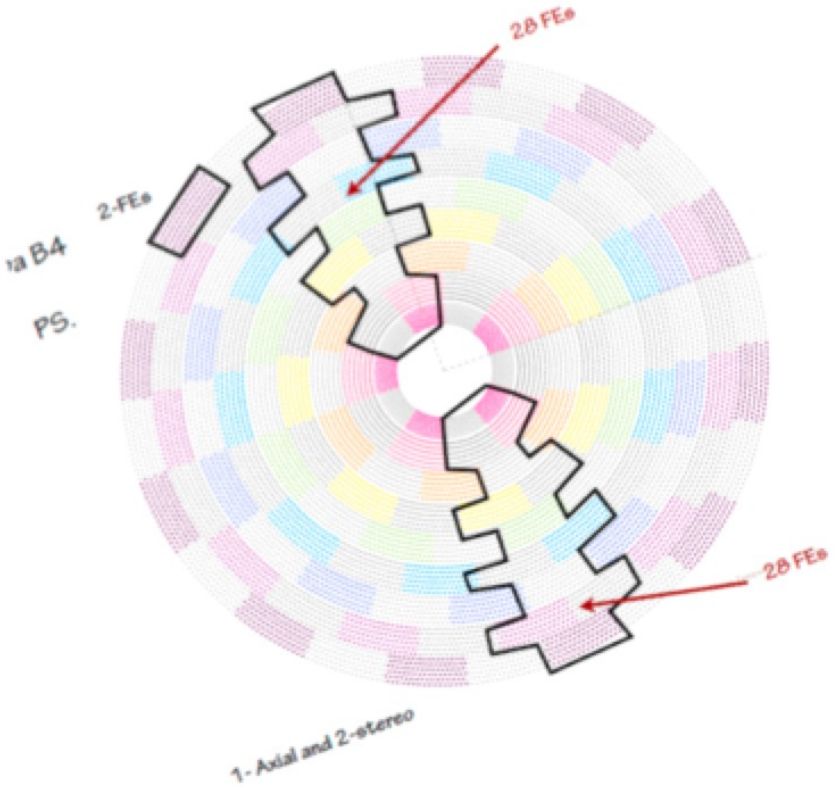
Readout problems on the Belle-2 link between FE and HLSB boards (same for CDC,ECL,TOP) prevents start of all final module tests.

¾ of Cylinders + GRIN lenses assembled
5 MM bundles available (3 mounted)
Not ordered yet: 2/3 MM, ½ SM fibers.

TOP+CDC Test Stand

TOP module at r=165cm:
~ 45cm away from the CDC

CDC readout configured to read cosmic rays :



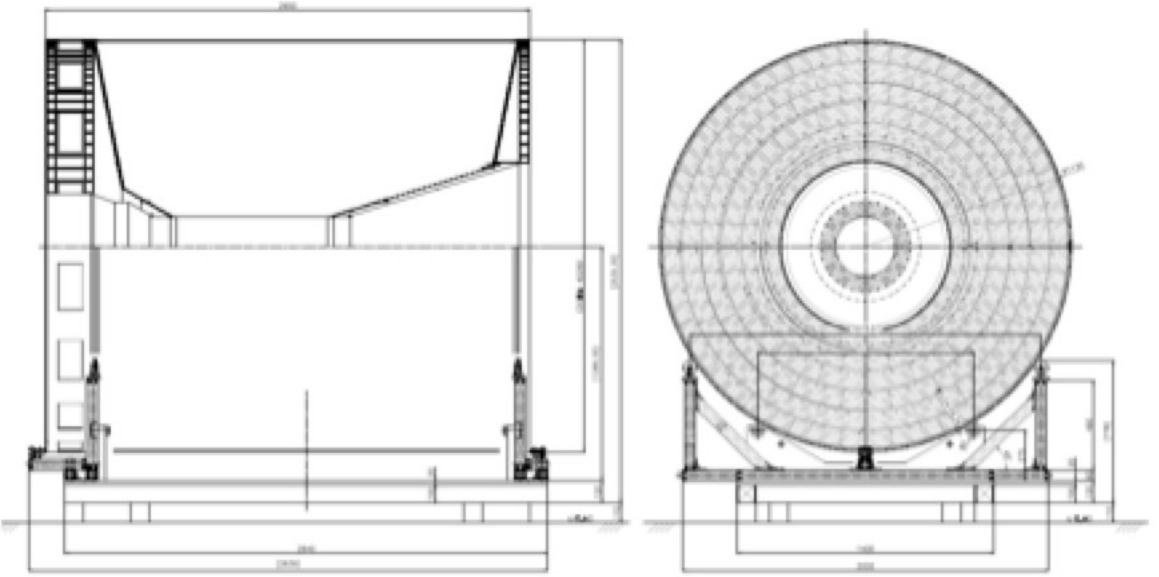


Figure 2: Two-dimensional CAD drawings of the CDC on top of the support stand in the Tsukuba Hall alcove (provided by Kohriki-san).

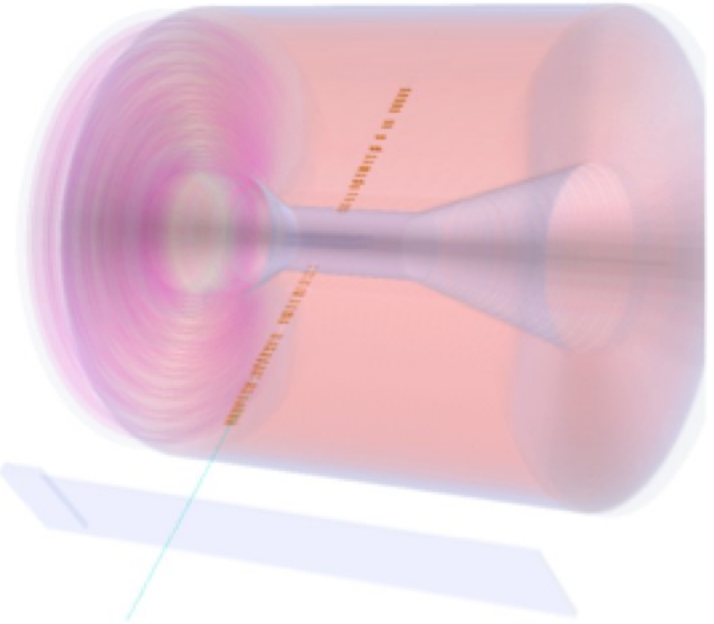


Figure 3: A GEANT4 simulation of a high energy cosmic ray muon passing through the CDC and then a TOP module located on the side of the CDC. Two scintillators and a lead absorber are located in the center of the CDC.

TOP+CDC Test Stand

TOP module at r=165cm:
~ 45cm away from the CDC

Requirements: no large scatter between the two segments in the CDC ($\Delta\varphi<5$ mrad, $\Delta\theta<10$ mrad) and a dE/dx in relativistic rise region (dE/dx>90).

Smooth momentum cut on the muon spectrum to get 1-2 mrad angular resolution and ~1 mm impact position resolution.

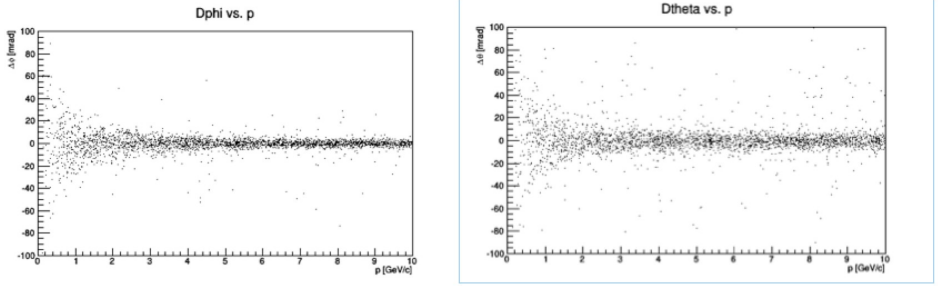
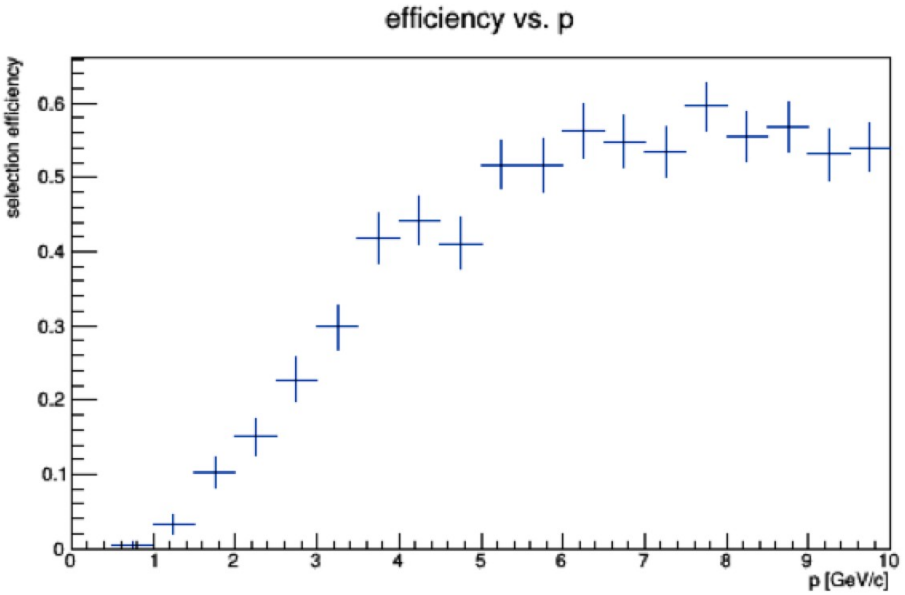
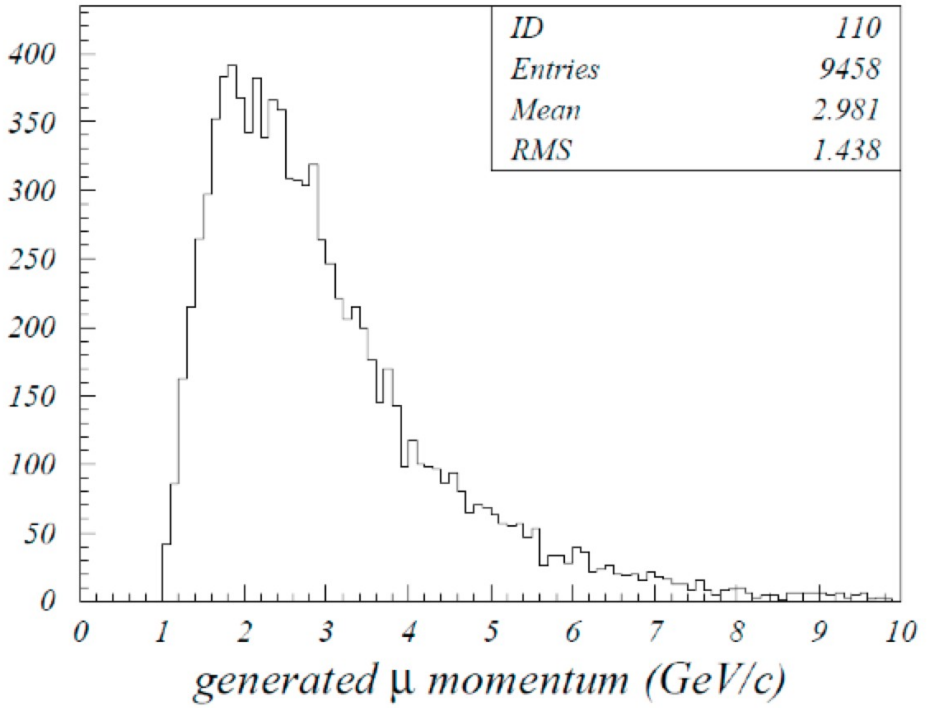


Figure 5: Expected φ and ϑ resolutions vs momentum in the CDC

Expect 500 k cosmic muons in one month with these cuts..





Sommario

Ad oggi, 4 QBB sono pronte.

Componenti TimeCal system in casa: PiLas, MM fibers+ parts per 4+1 moduli, cilindretti per 12 moduli, SM fibers+spares per 8 moduli

Caratterizzazione dei due ALD-MCPPMT completata a TO, ora si tratta di mettere insieme il setup per testare le fibre durante installazione.

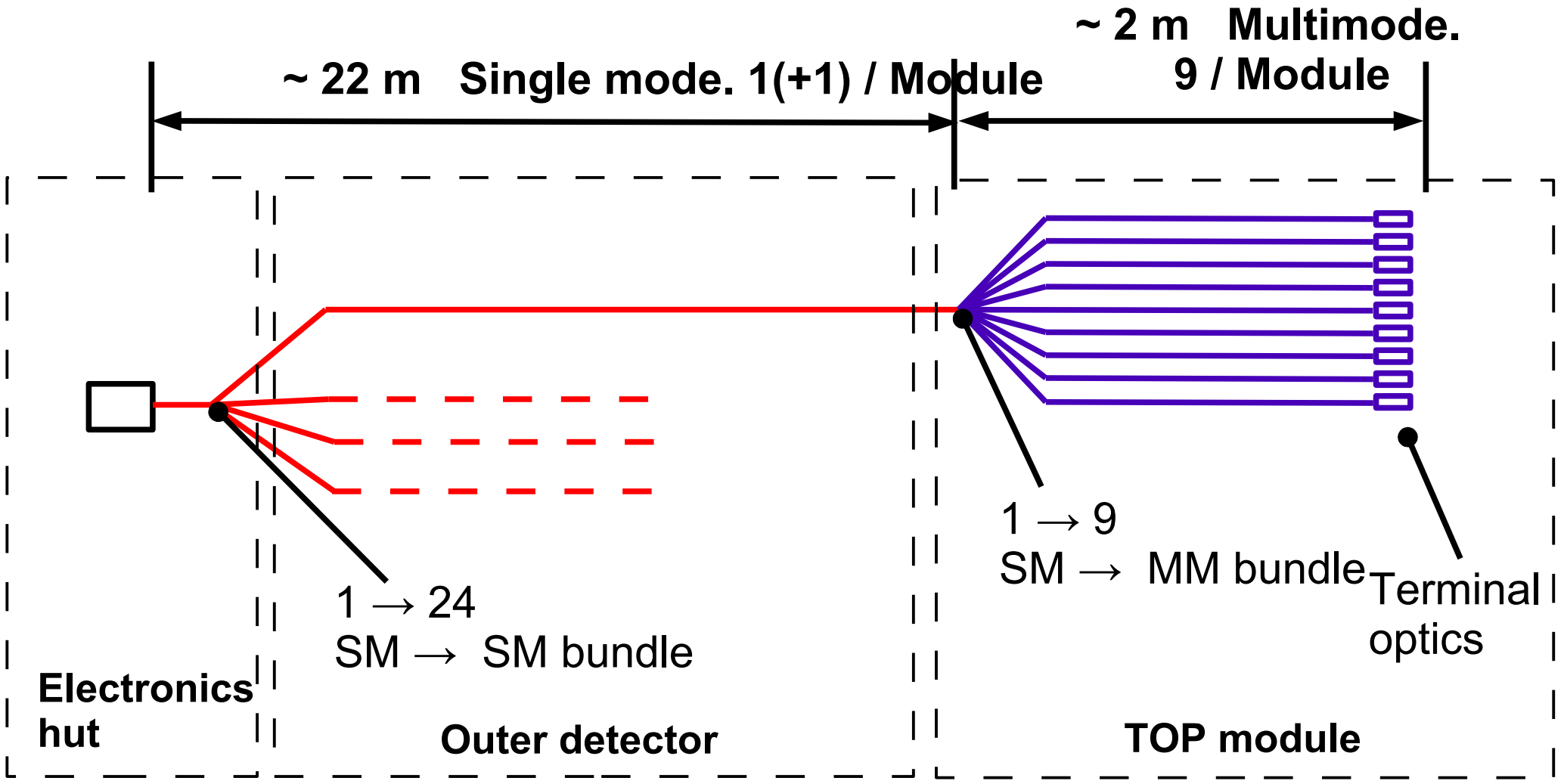
Tests di irraggiamento a LNL : componenti OK

Un problema sulla catena di readout sta bloccando l'inzio dei tests dei moduli completi a Fuji Hall.

A Tsukuba Hall, il test congiunto CDC-TOF dovrebbe partire a settembre

Belle-2 note in preparation sul time calibration system.

Light distribution



Tasks in Torino

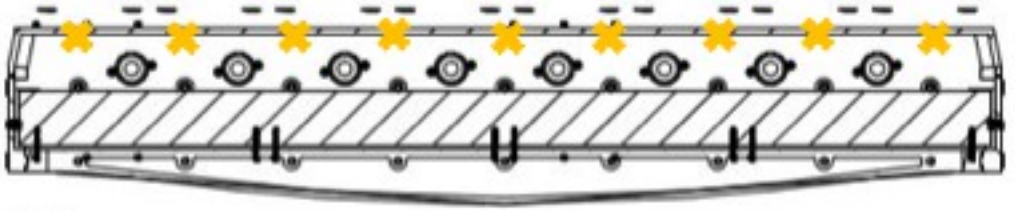
→ Time resolution of the calibration system
→ SM → SM bundle
→ MC simulation

Tasks in Padova

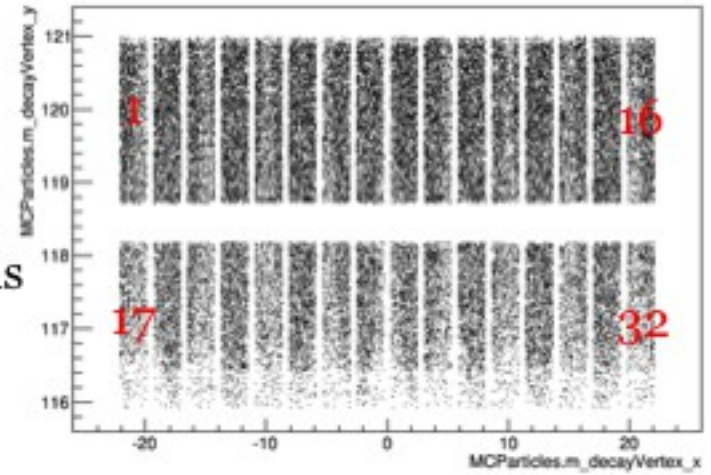
→ SM → MM bundle
→ Terminal optics
→ Light injection mechanics
→ Radiation tests

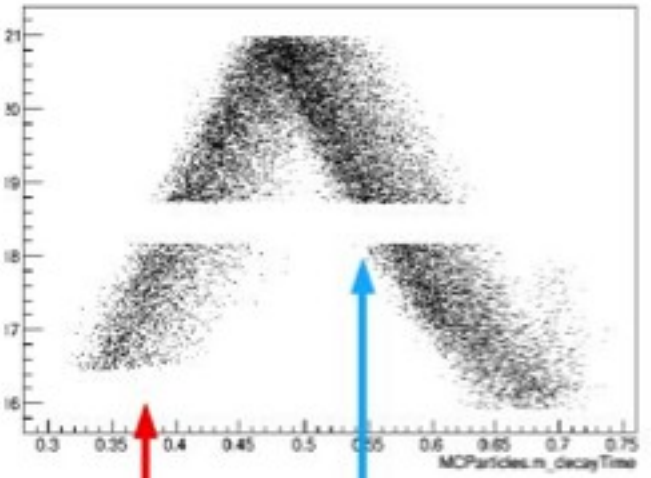
Light injection in QBB

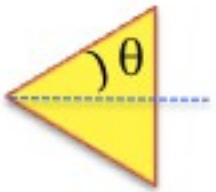
- 9 light points
- close to the edge of the box
- azimuthal angle ~~15°~~ 17°
- NA = 0.5 (sin θ)

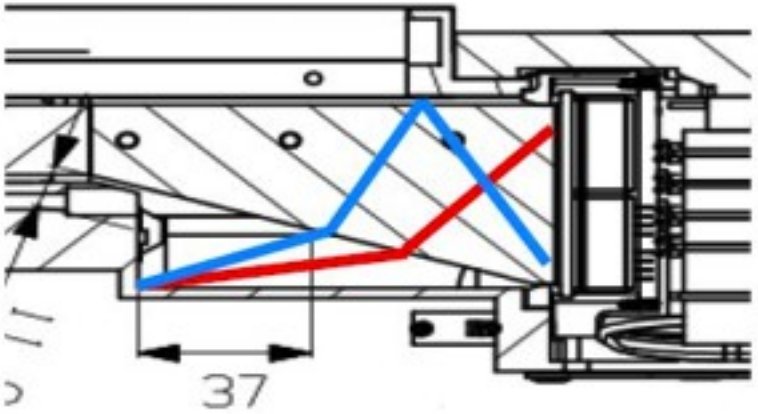


32 PMT
16 ch /PMT
512 channels







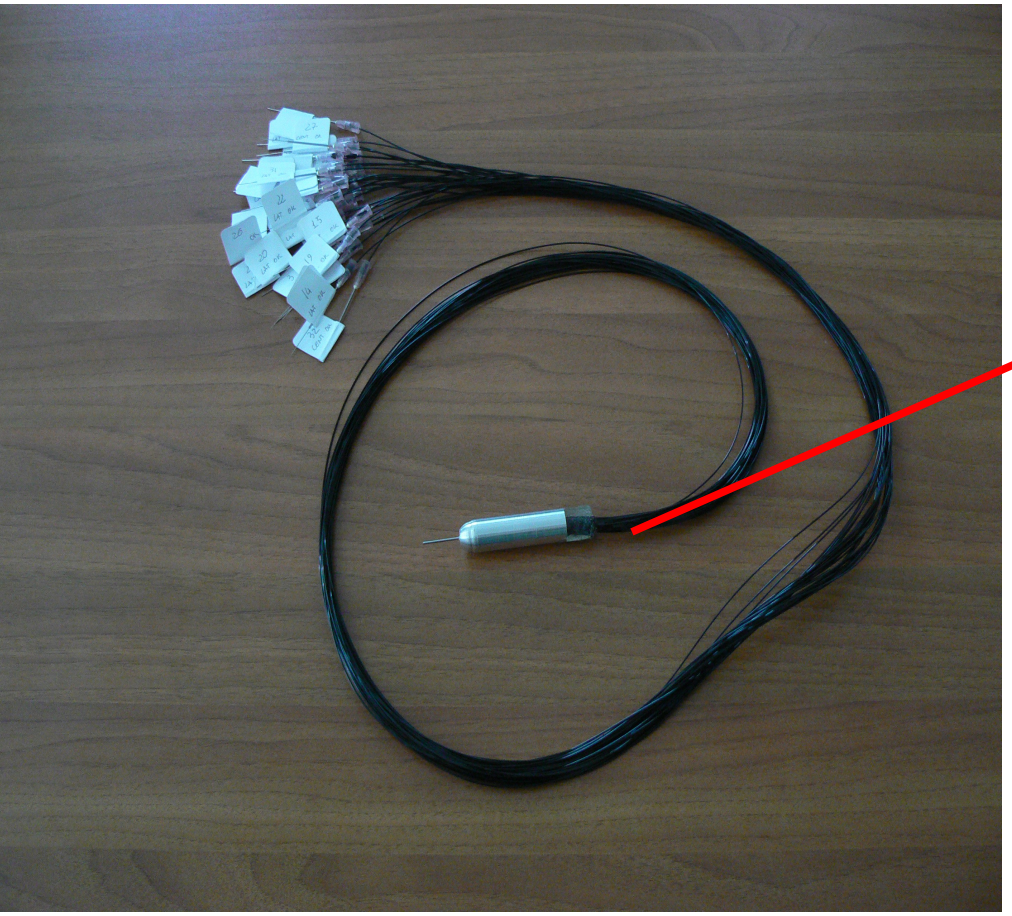


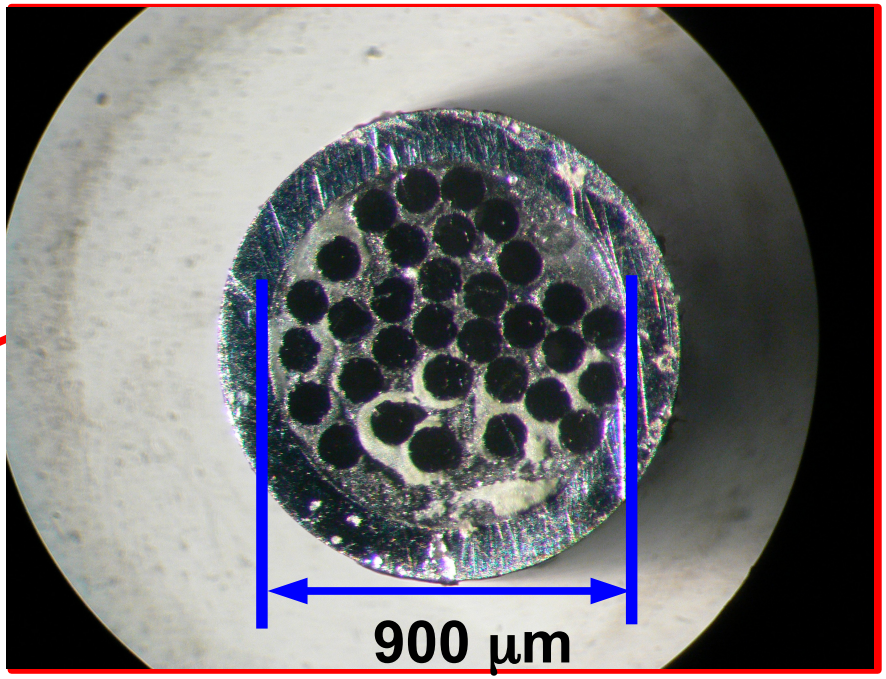
Single reflection

Direct Photons

Single mode (SM) fiber bundle prototype

32 OZ-Optics fibers, 1.5 m long, in one bundle
(Oscar Brunasso, Torino INFN workshop)





Bundle's head hosting 32 fiber cores

Core radius = 2 μm

Bundle radius = 450 μm

Piping Efficiency: ε_p(geo) = 6.3 x 10^{-4}

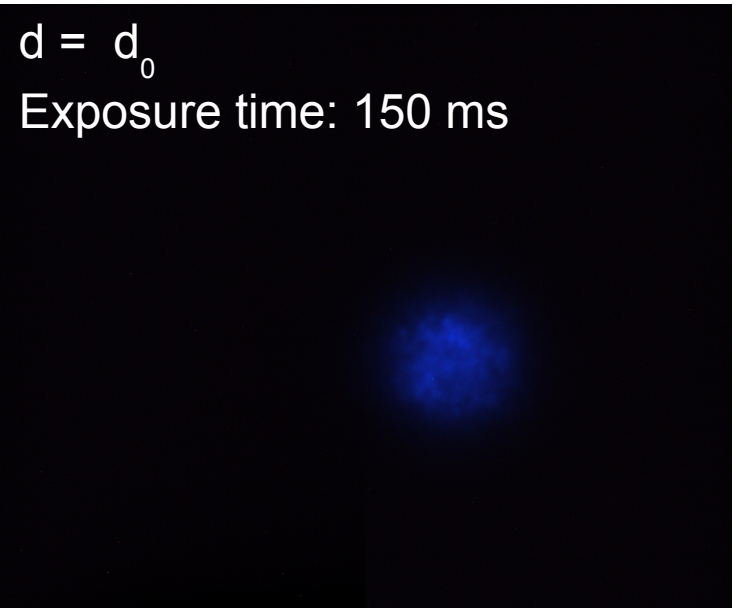
For homogeneous illumination, use only central part of the light cone:

ε_p(geo + 1σ) = ~4 x 10^{-4}

Best laser repetition rate for time resolution is 100 kHz→ 10 Hz/fiber

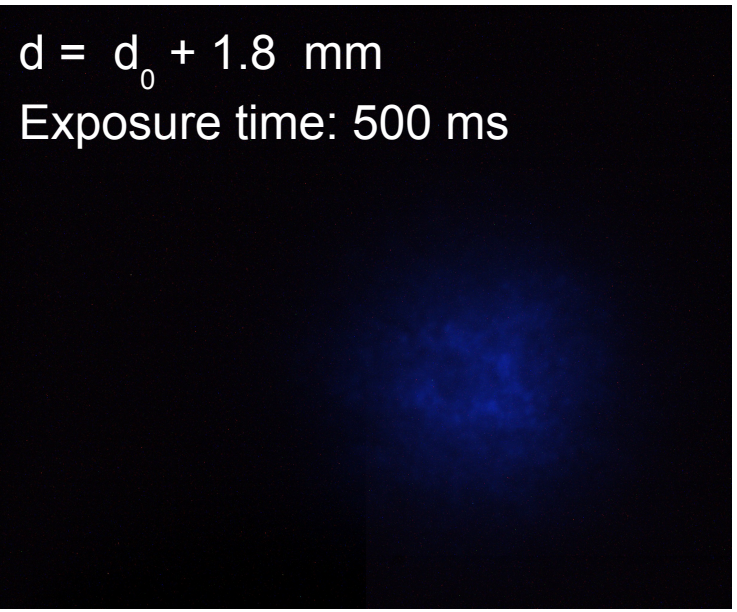
Laser – SM fiber distance optimization / 2

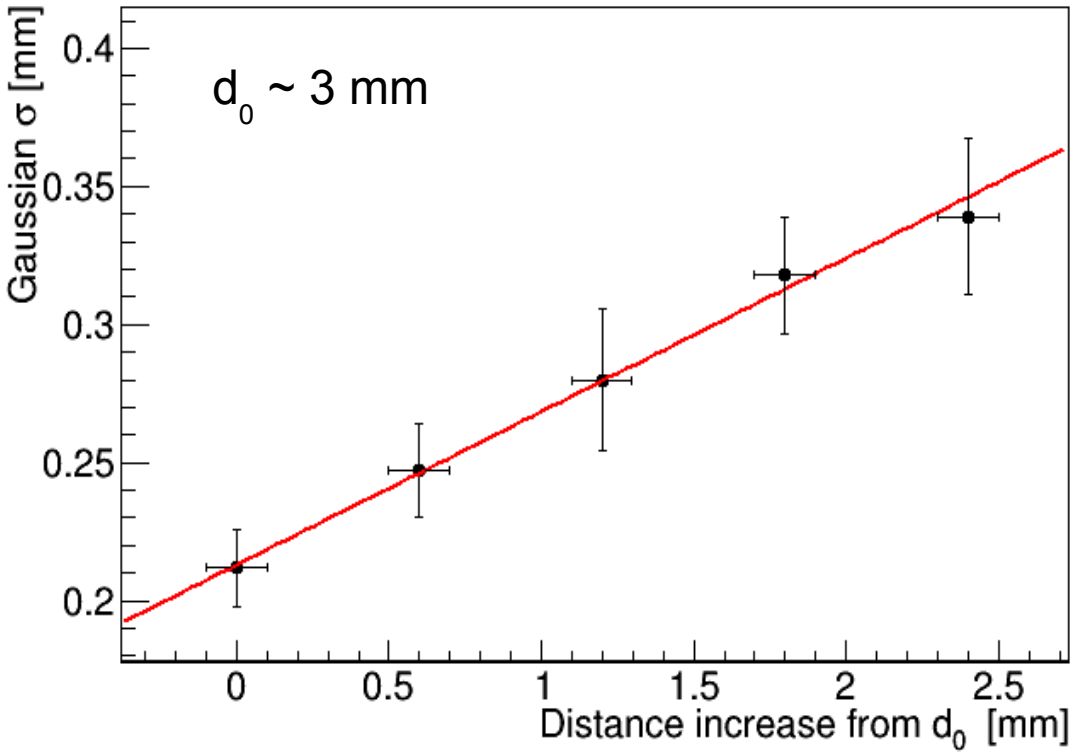
In collaboration with
Alessandro Re (INFN Torino)



2.90 mm

3.47 mm



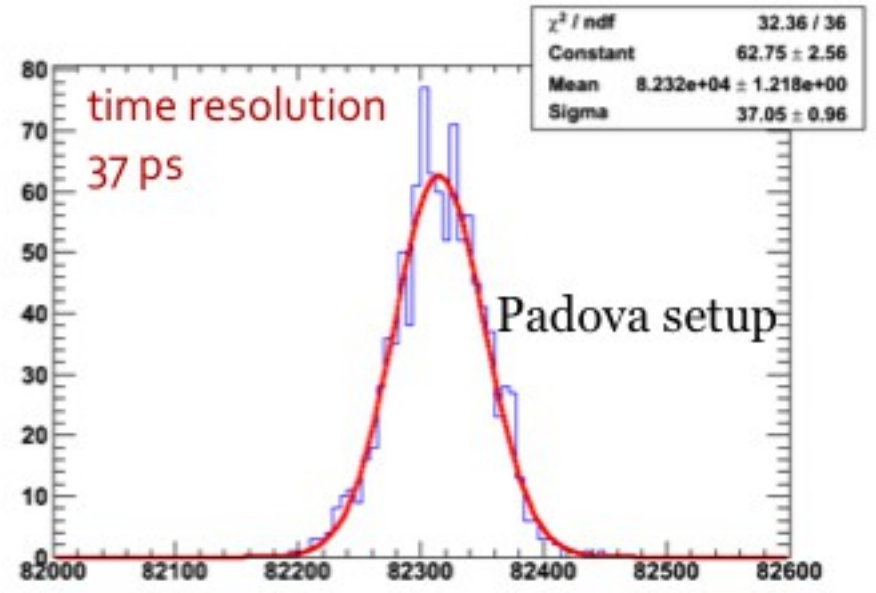


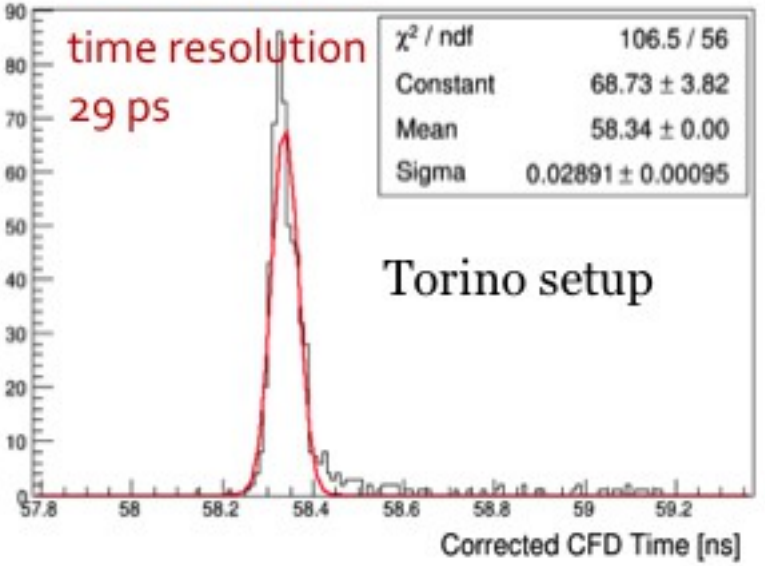
From the linear fit:
tan(Θ/2) = 0.056 ± 0.014
Θ = 0.11 ± 0.02 rad

For a 0.450 mm radius bundle:
1O illumination with fiber at ~ 8.0 mm

Time resolution measurements

- LASER: Advanced Laser Diode Systems PiLas 405 nm $t_{res} < 40$ ps
- AMPLI: Padova TI development board based on TI THS4303 gain 5
  Torino prototype board of the iTOP ampli with two output channels
- ADC: CAEN digitizer V1742 (5 GS/s)
- SCOPE: LeCroy WaveRunner 625zi (20GS/s)
- Time reconstructed by signal shape with offline constant fraction discriminator





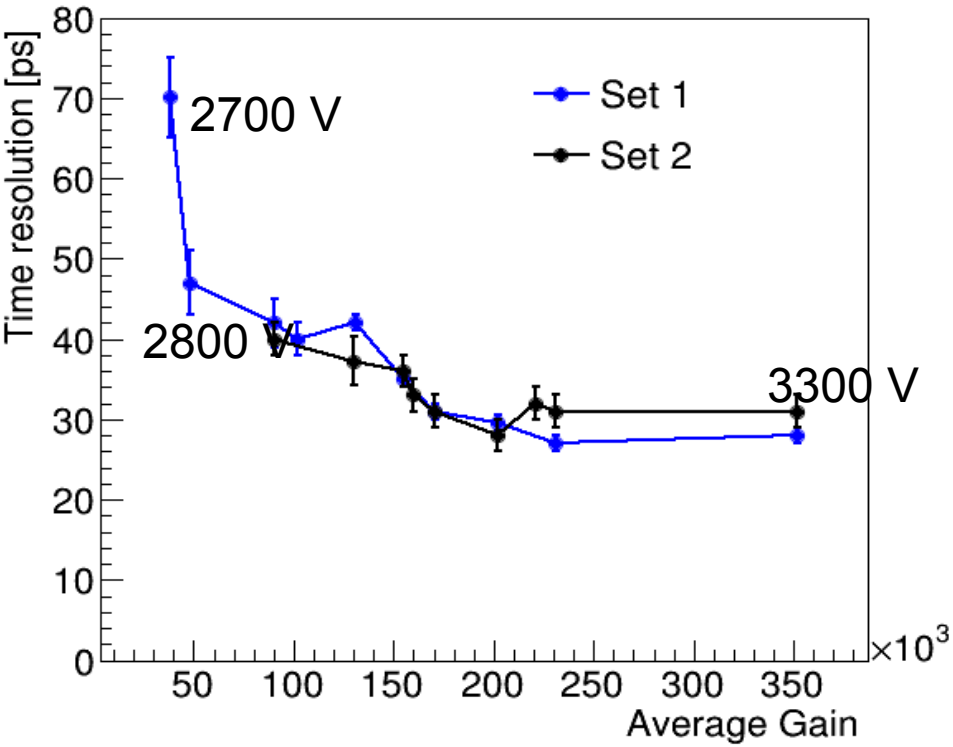
More time resolution studies

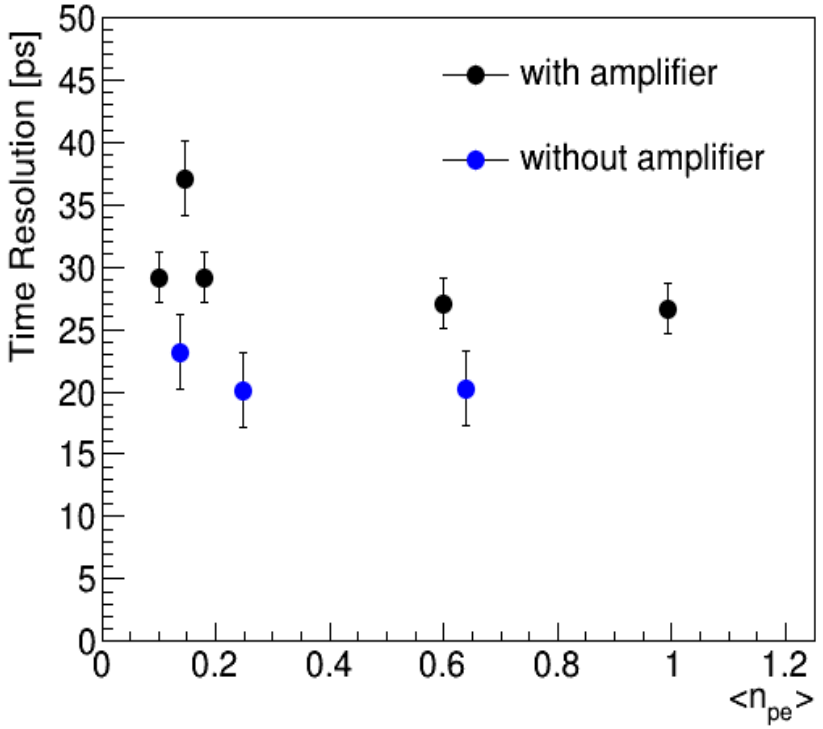
Torino, UT studied time resolution vs HV,<n_{pe}>, PMT gain, ampli.

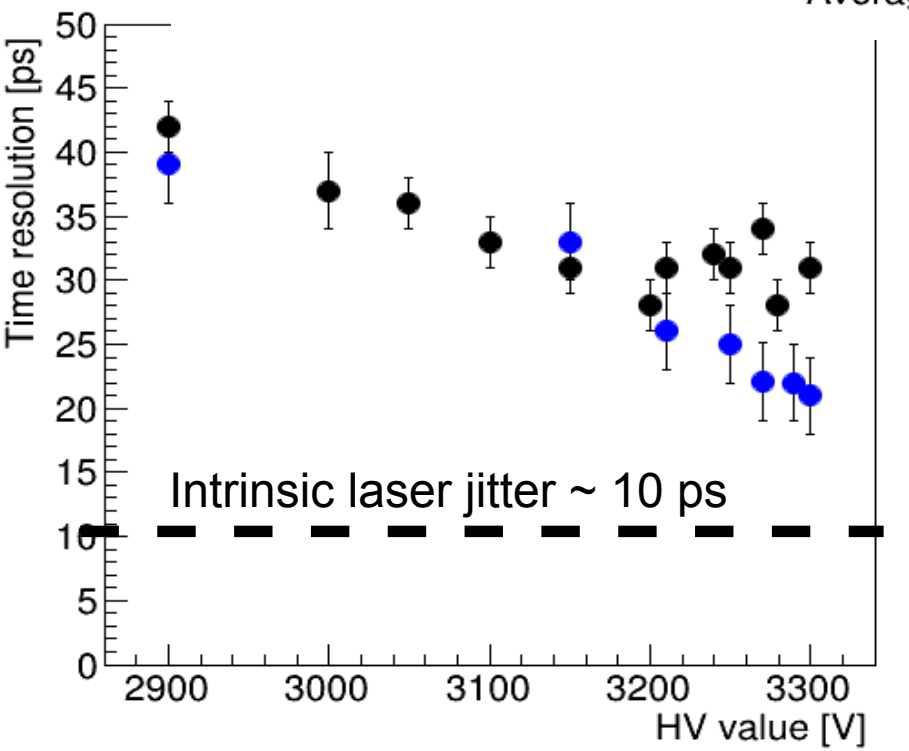
The nominal PMT operation point is at 3480 V. We have NOT operated it above 3300 V so far.

The gain is determined using dark count events and fitting the signal peak

^ event-by-event measurement





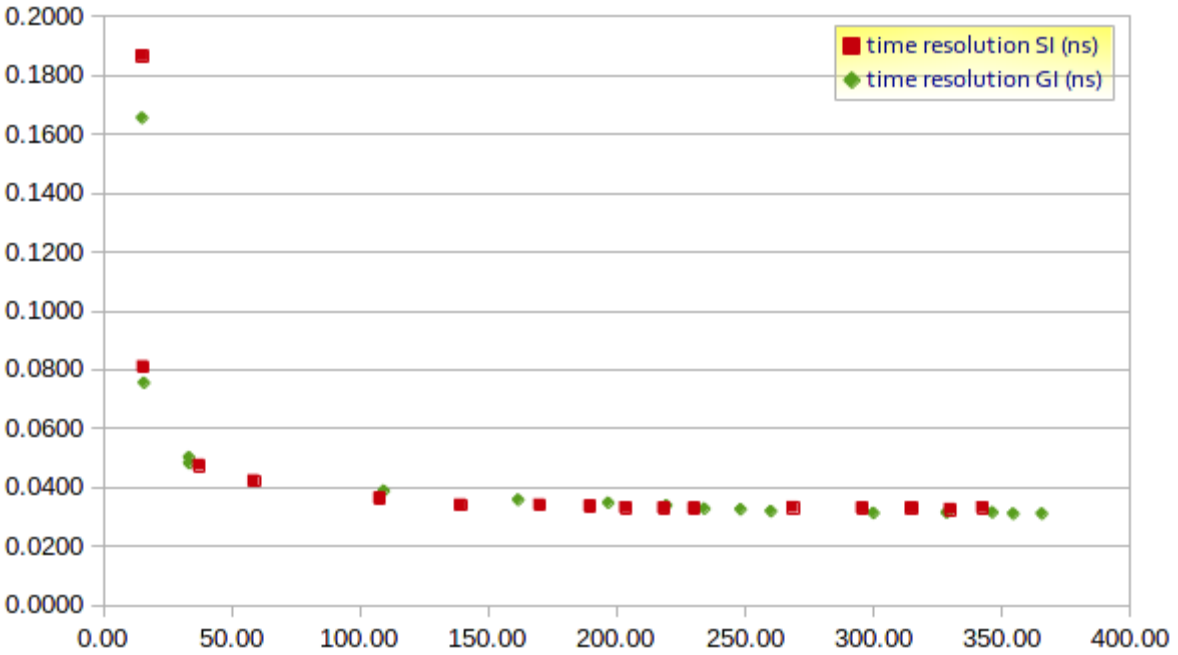


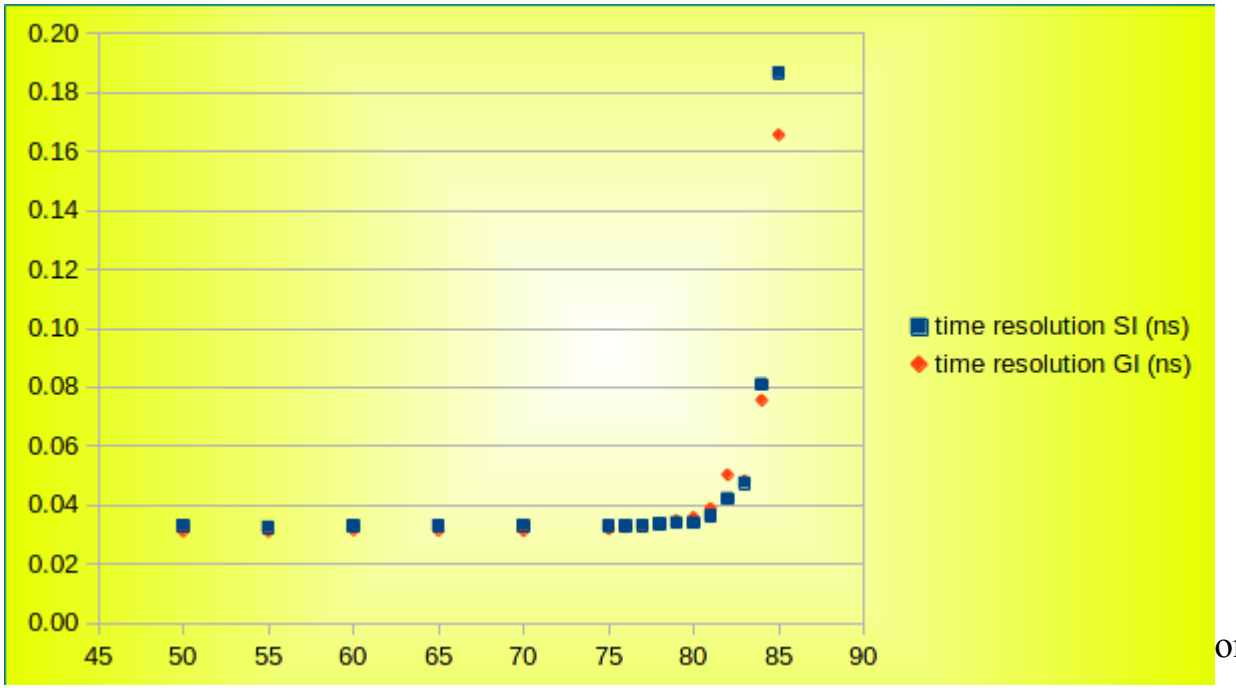
More time resolution studies

Padova: RS studied time resolution vs signal amplitude (arb.units, left) and Laser tune (below) with Step Index and Graded Index MM fibers

Indiana 2ch test board was used

MCPPMT operated at nominal voltage

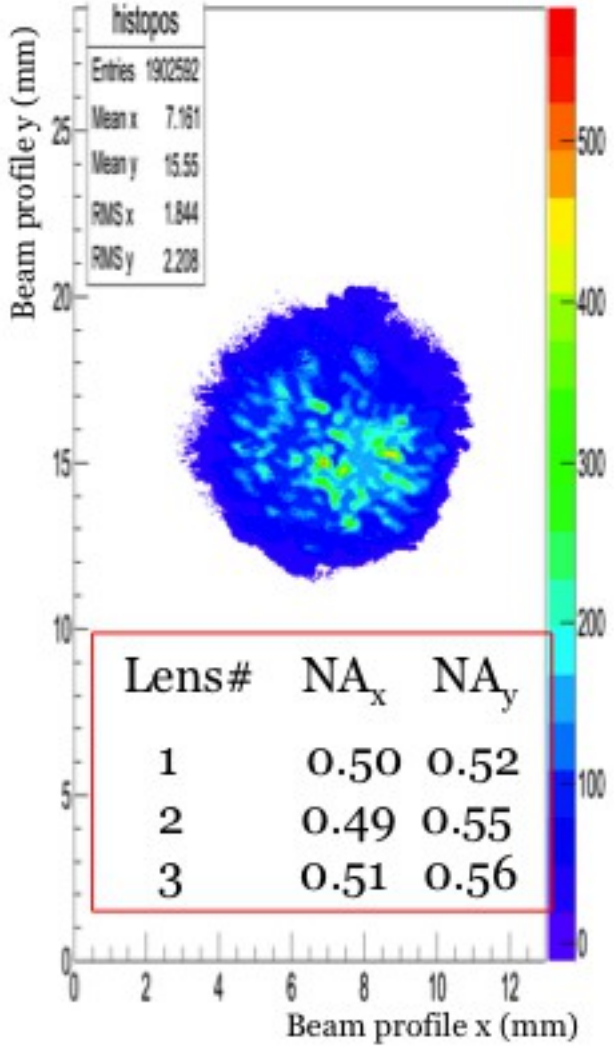




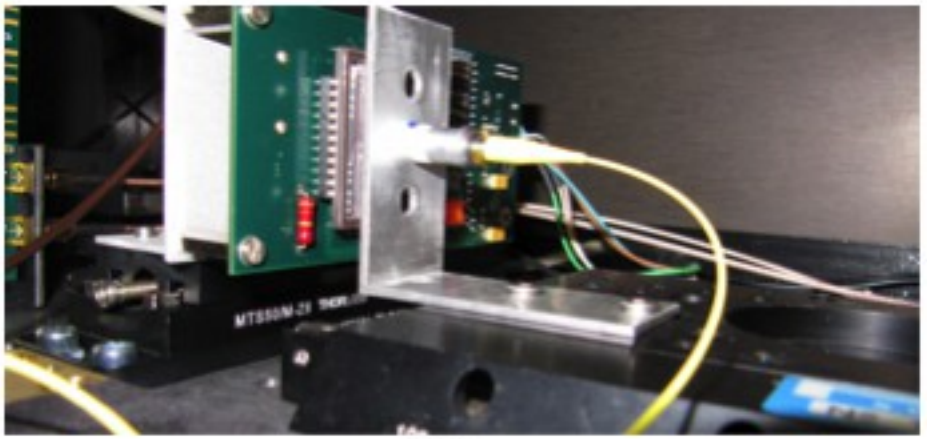
on

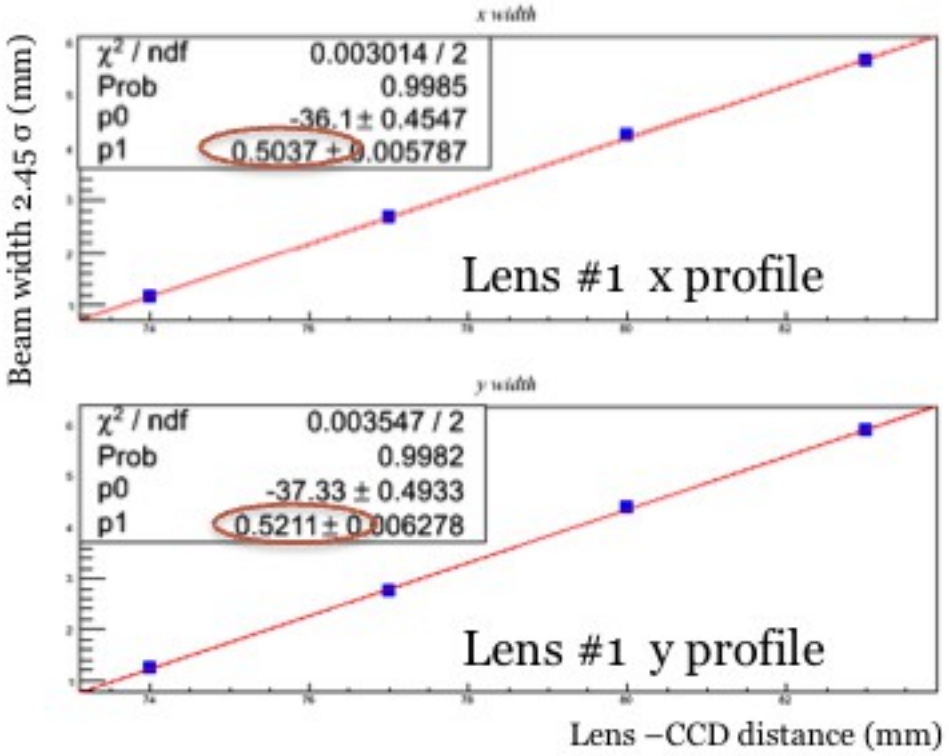
Numerical aperture measurements

Setup for NA measurement with CCD
Multimode fiber with grin lens NA=0.6



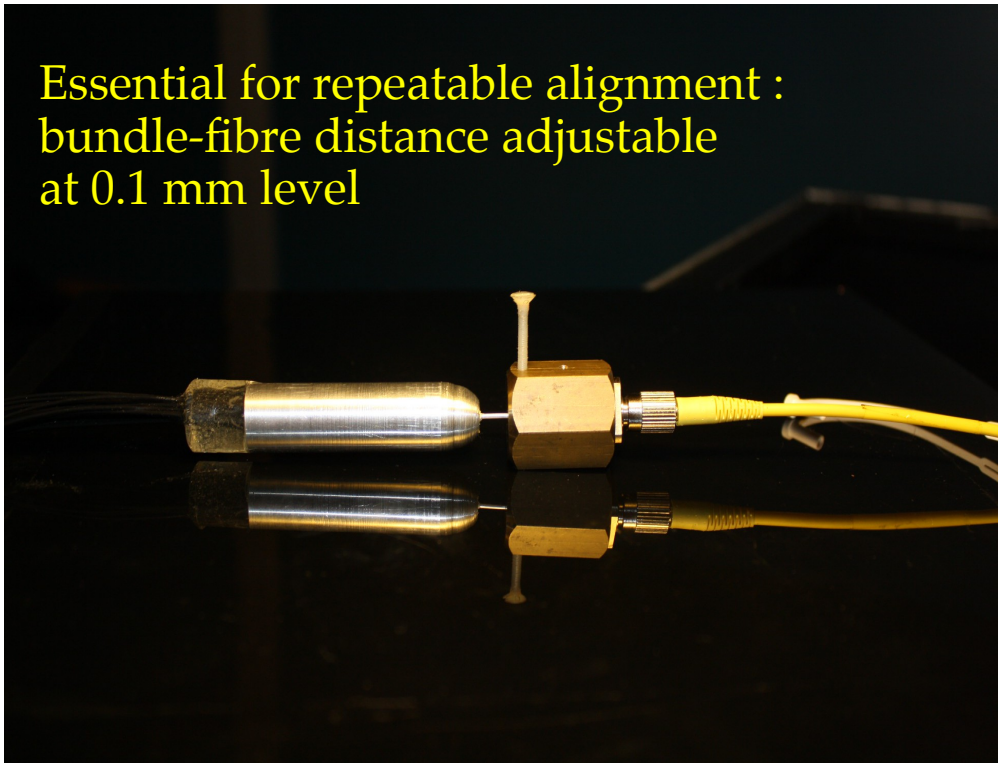
Lens#	NA_x	NA_y
1	0.50	0.52
2	0.49	0.55
3	0.51	0.56



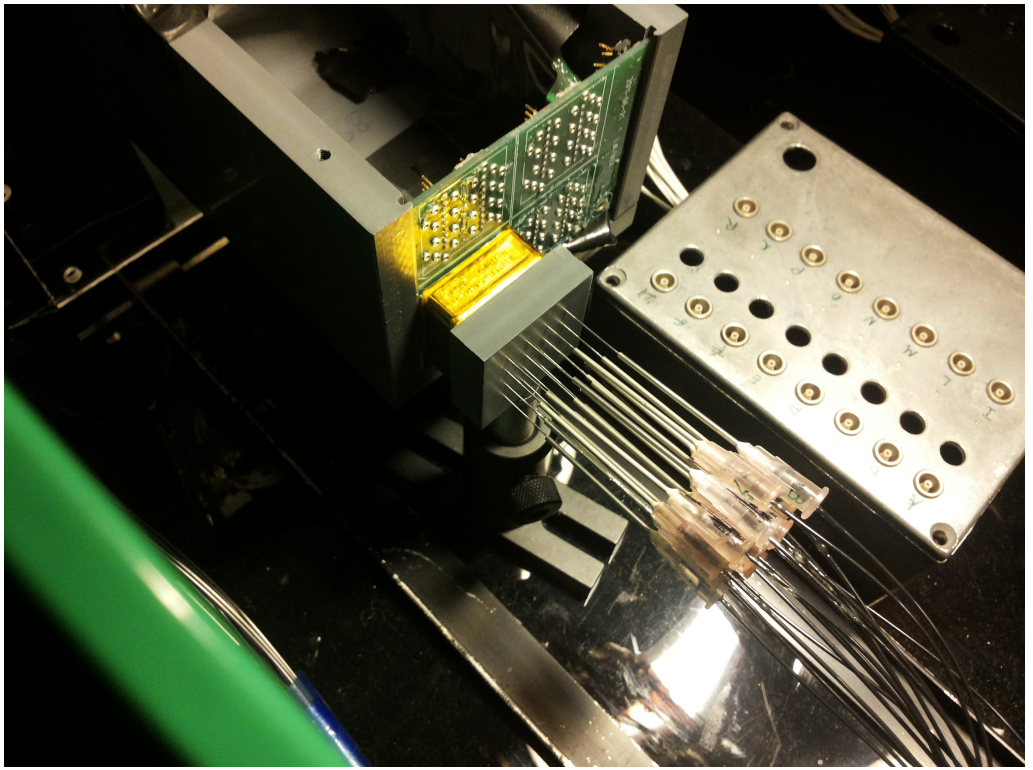


SM fiber Piping efficiency measurement (Torino)

Bundle-Laser alignment support



16-fibre support



16-channel readout with CAEN V1742 switched capacitor digitizer almost ready

^ long delay due to discharges in the PMT
support board: 15/16 channels OK, we had to disconnect the channel whose signal pin is closest to 3.4kV pin

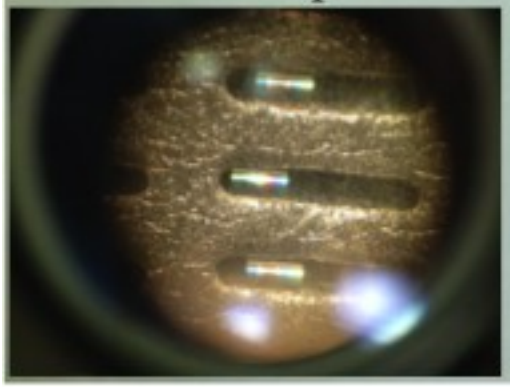
Light injection in the QBB

Spread the light with a grin lens implemented at the end the fiber

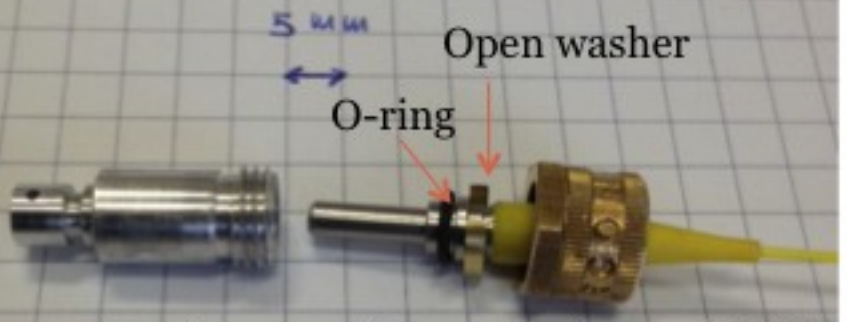
Block to integrate cylinder with the quartz bar box

Grin lens

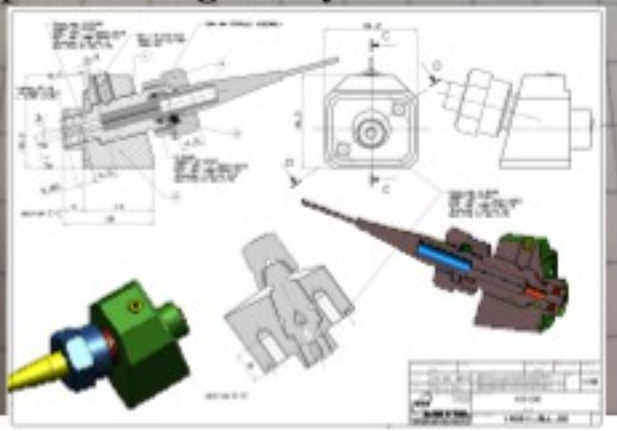
Grin lens at the microscope



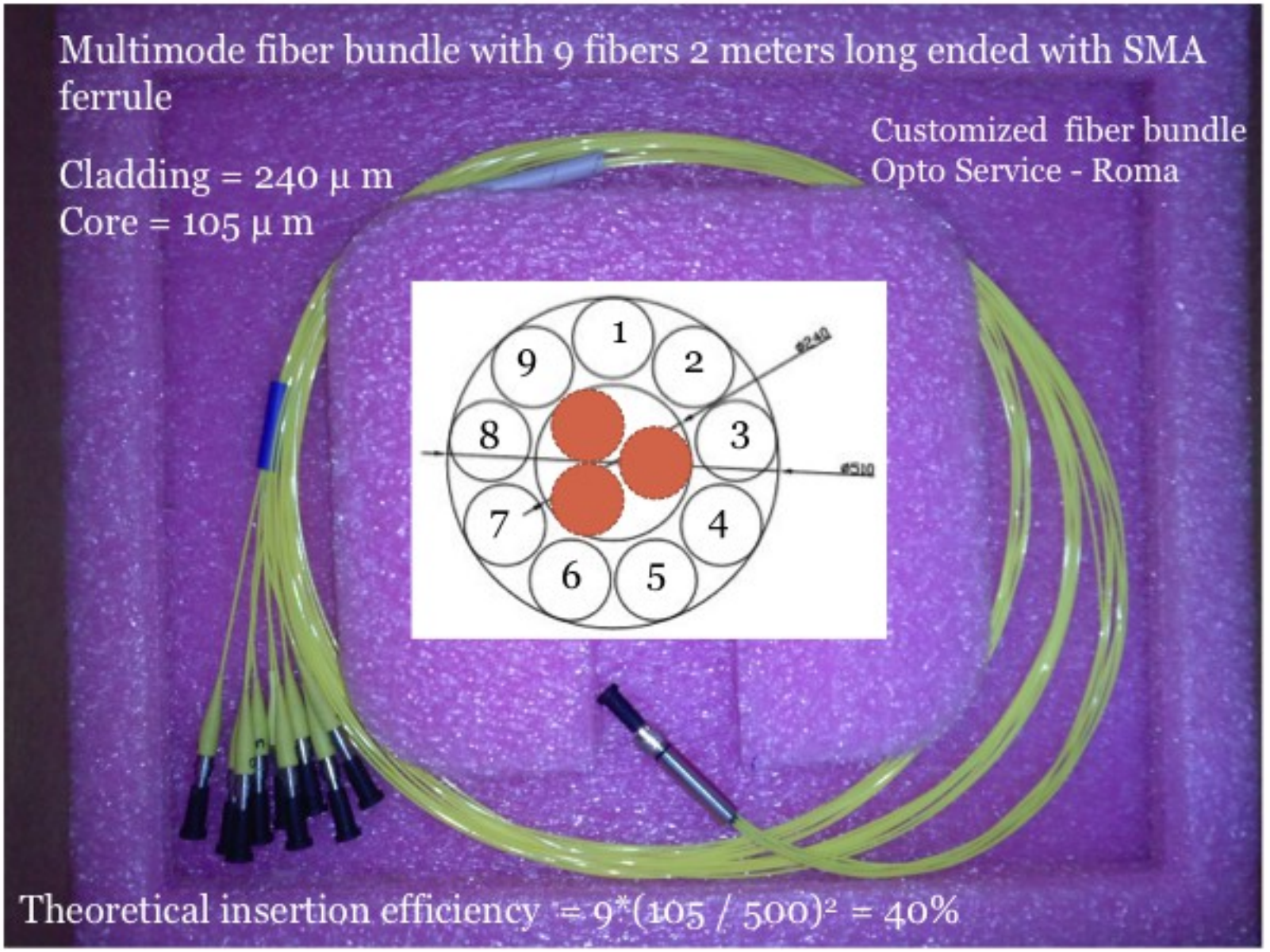
Assembling of the cylinders with the fibers



Connections between fibers, grin lens and iTOP prism designed by the PD mechanical workshop

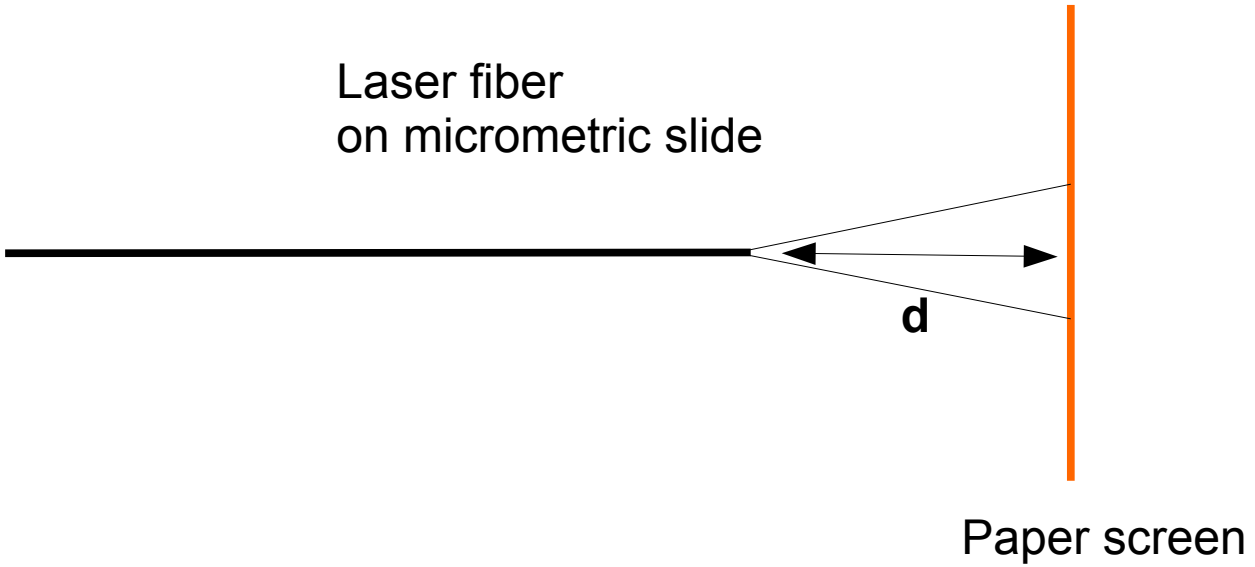


Multimode fiber bundle for Module #1



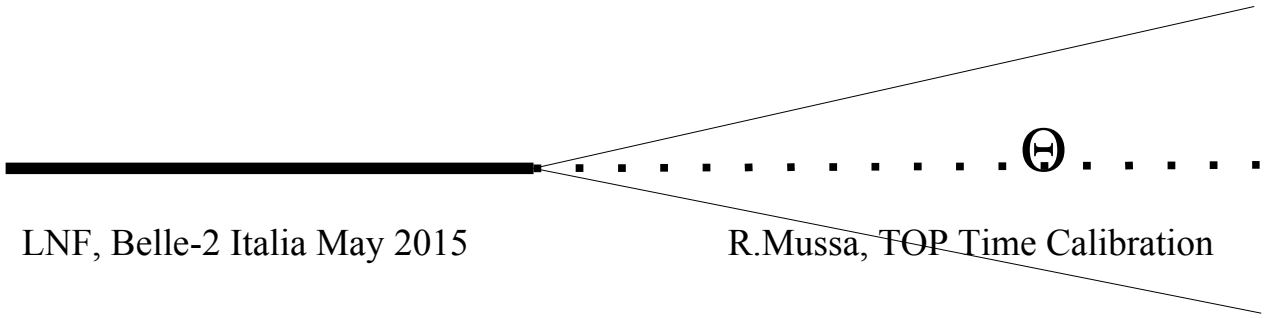
Laser – SM fiber distance optimization

In collaboration with
Alessandro Re (INFN Torino)



CCD field of view: **3.47 x 2.90 mm**
Pixel size on screen = 1.4 I m

Start from $\mathbf{d_0}$ **~ 3 mm**
Increase $\mathbf{d_0}$ of fixed amounts Δ**d = 0.6 ± 0.1 mm**
Fit the light distribution as function of **d**

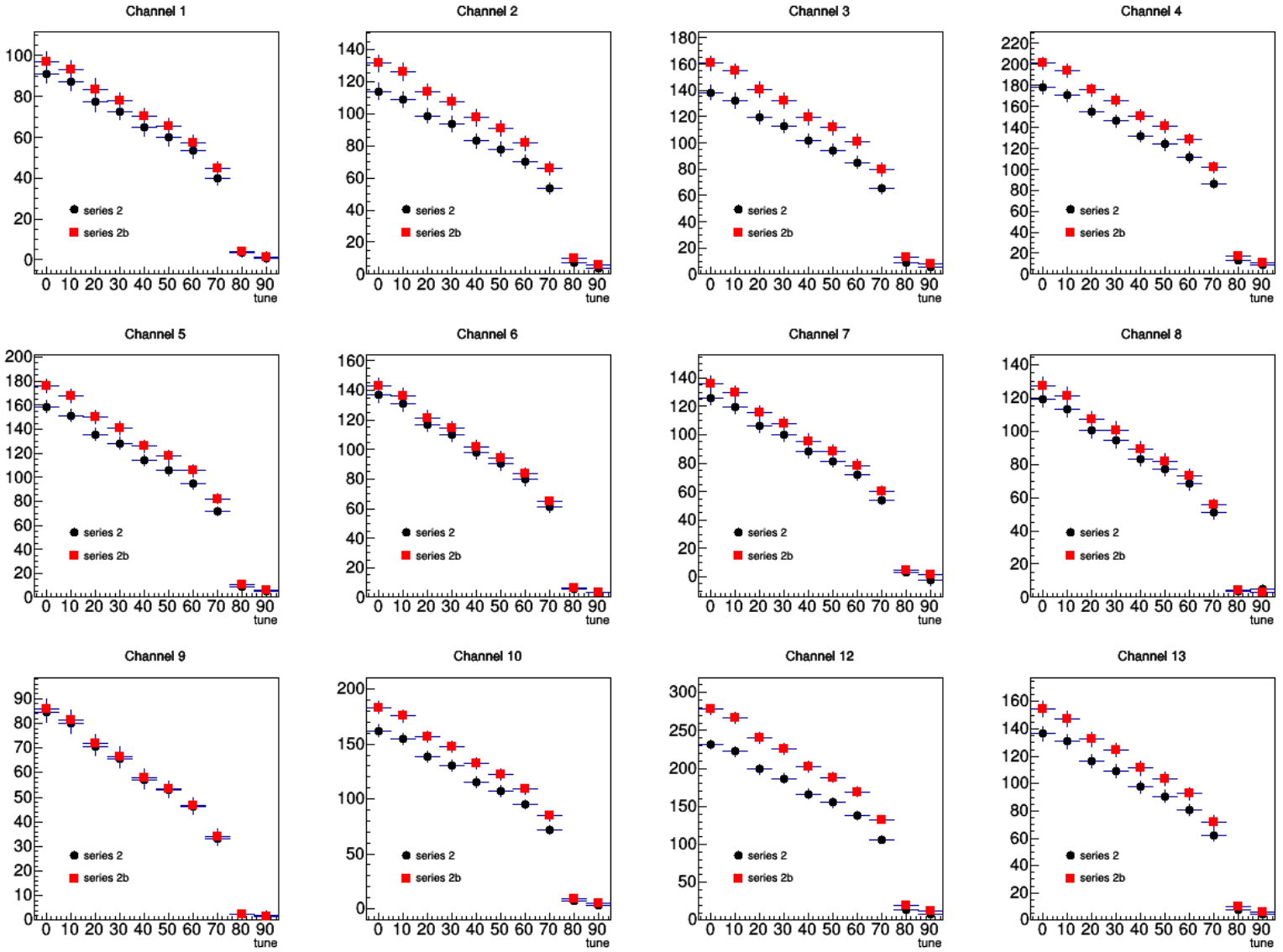


The light distribution after the fiber is gaussian. We define the light cone as the region within 1 Ofrom the beam axis

Θ Is the full angle at the cone vertex

Characterization of MM fibers (PD) : 2nd bundle

The second MM bundle was fully characterized in PD+LNL , using:
- PiLas
- monochromator

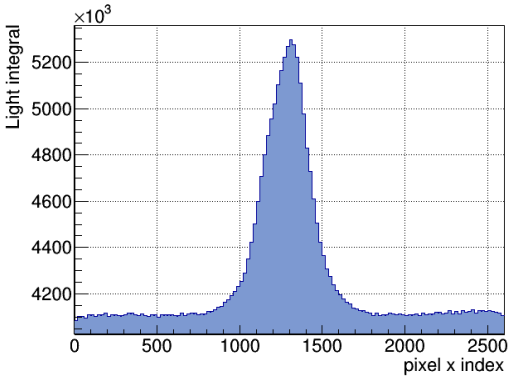


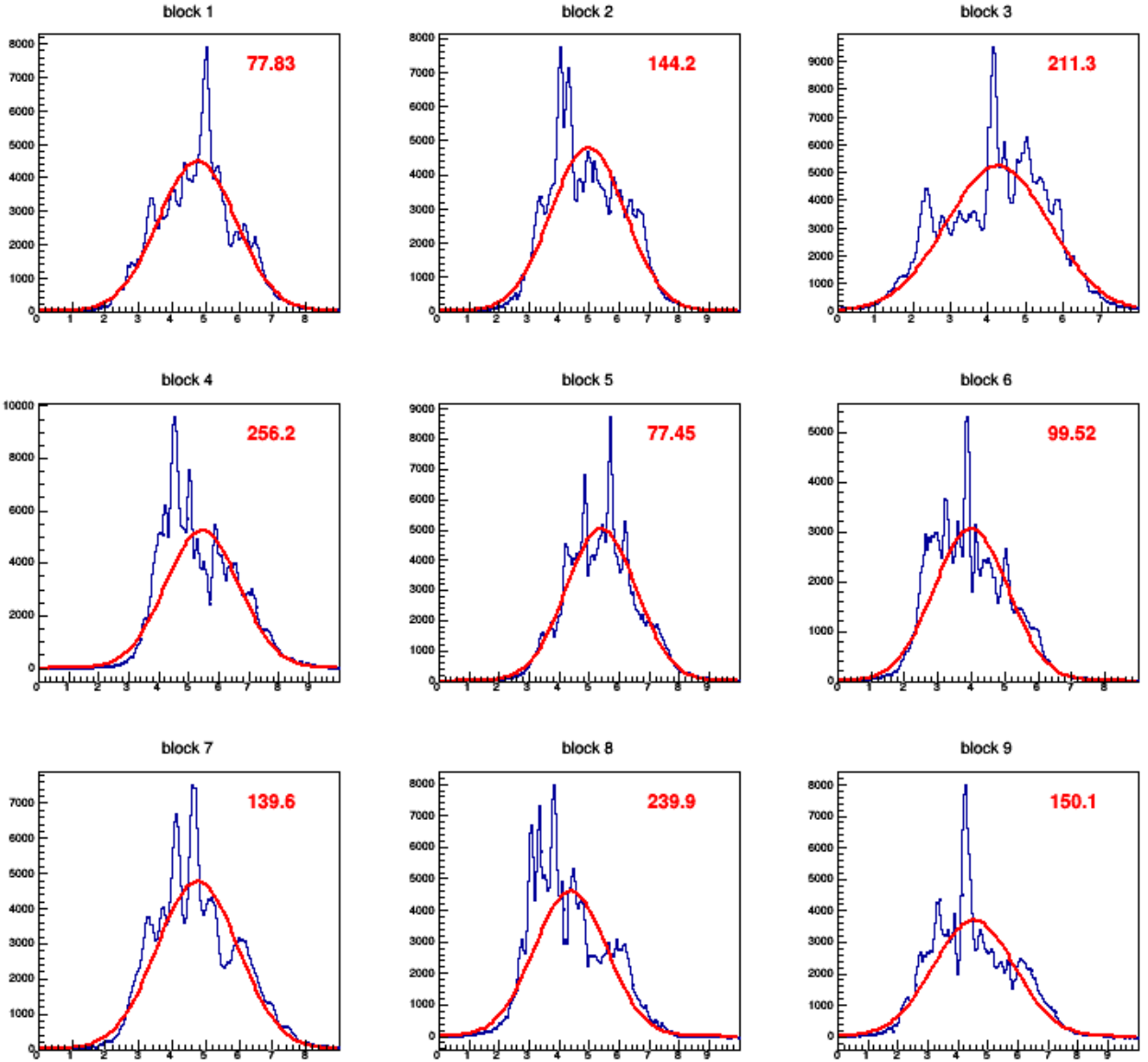
Characterization of GRIN lens cylinders (PD): profile

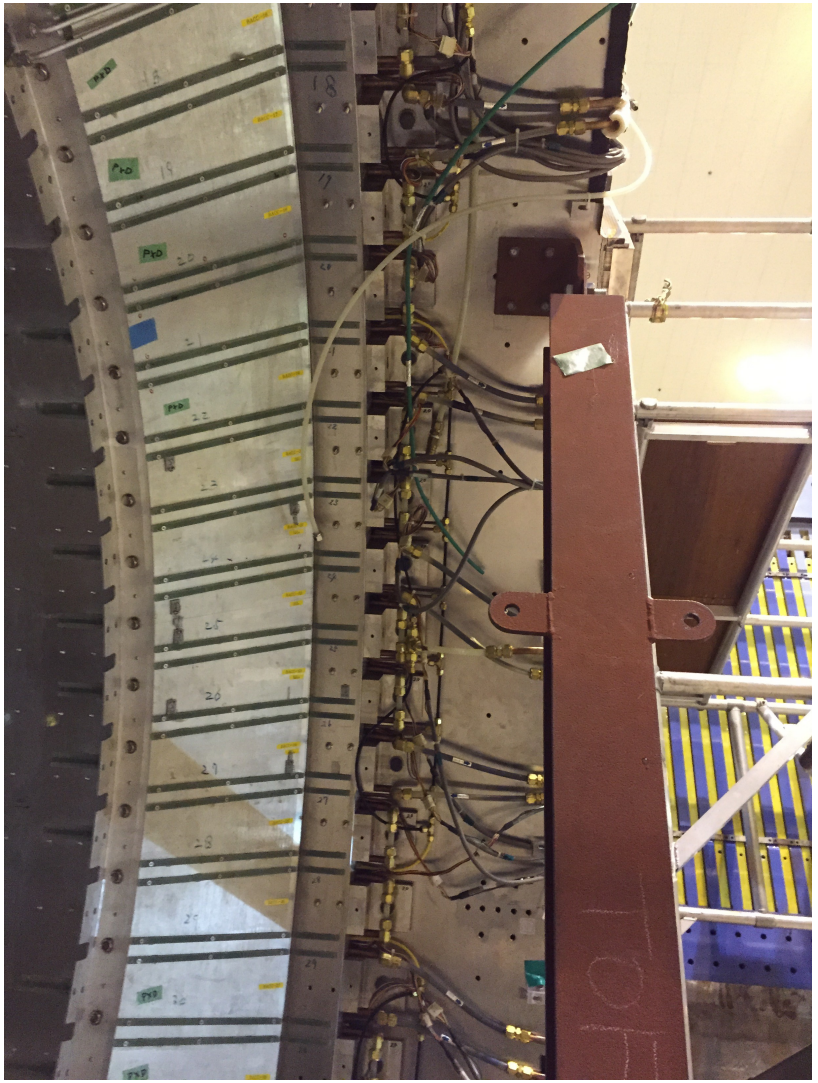
Each profile is a slice of 10 pixels in y : clear spikes are observed in most profiles . (only 9/42 lenses

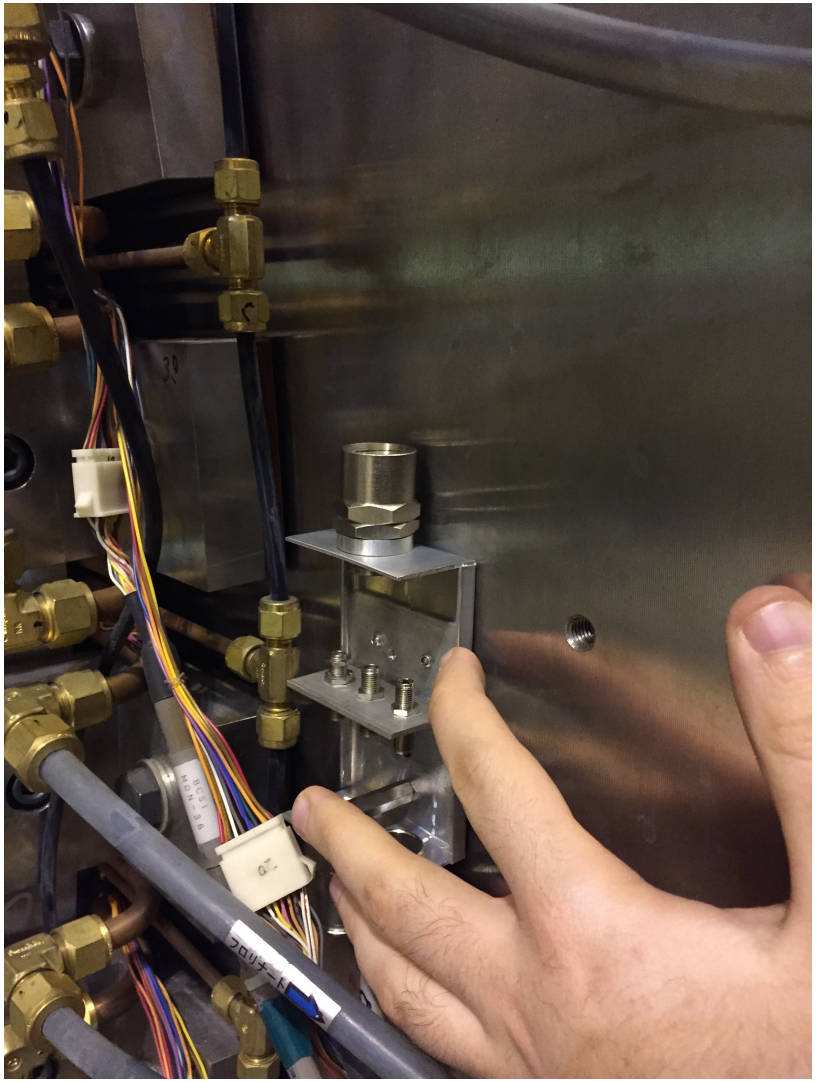
The laser beam profile without lens was measured in Torino and was much smoother.

Dust on lens surface?



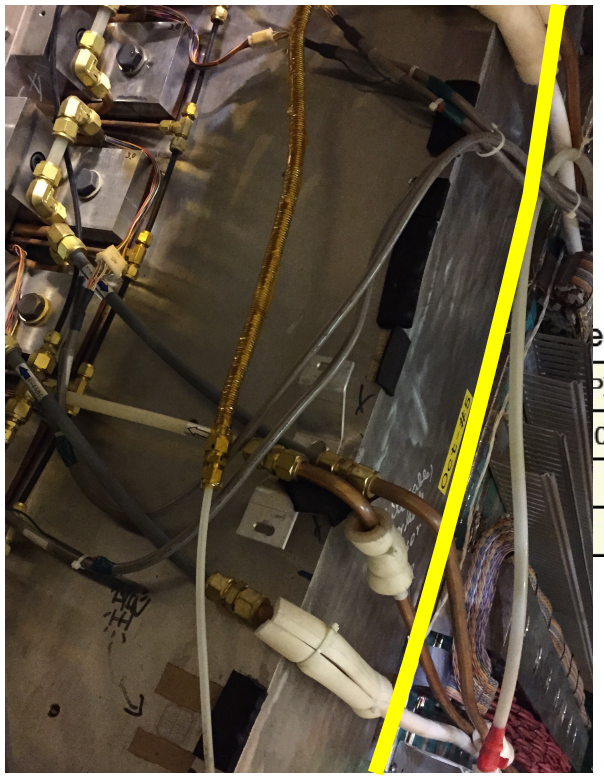


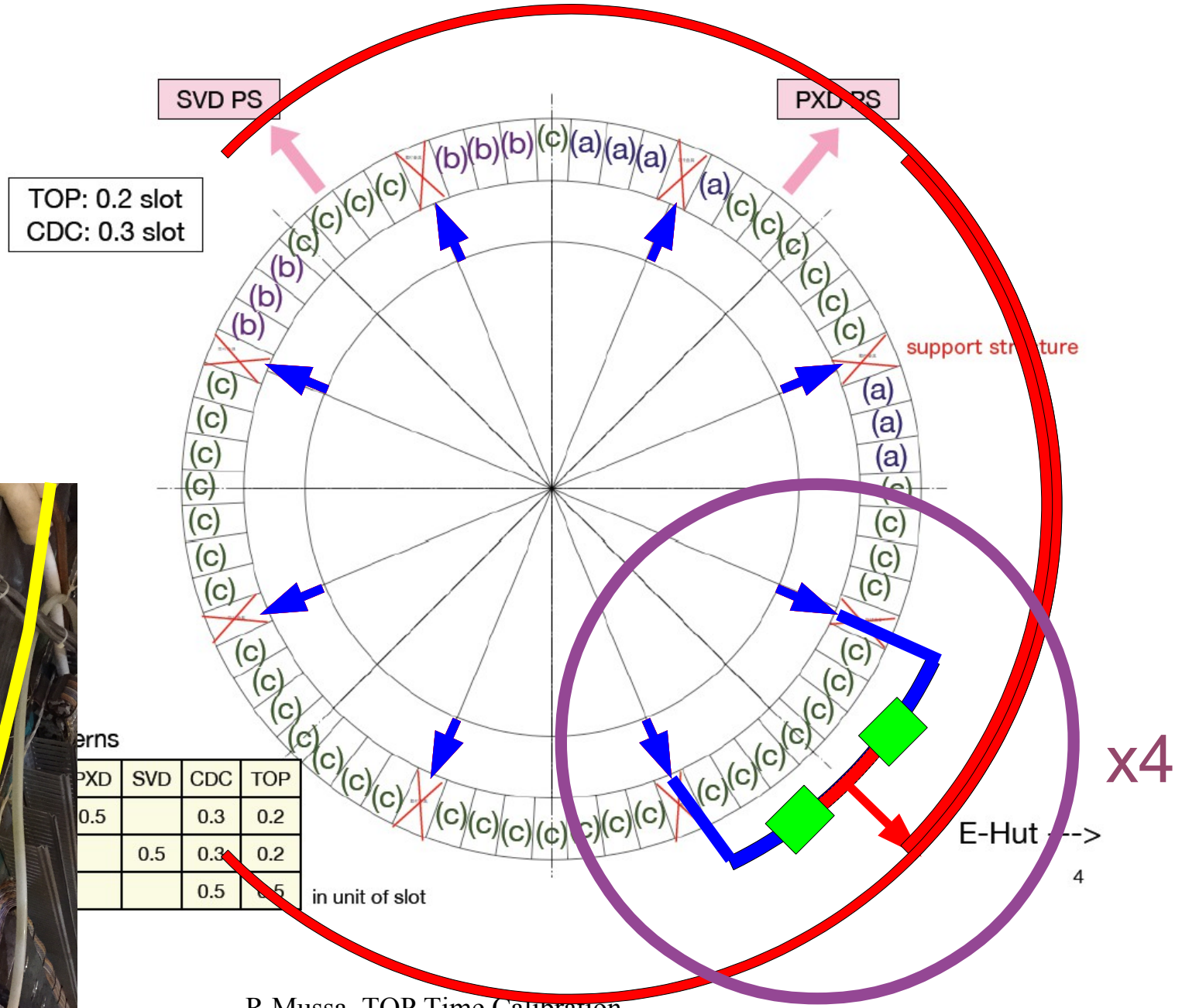




Fiber bundle routing

To avoid the routing in zone 8, we should run fibers on the back of the cryostat, but we need 4 nodes to take the fibers to the TOP



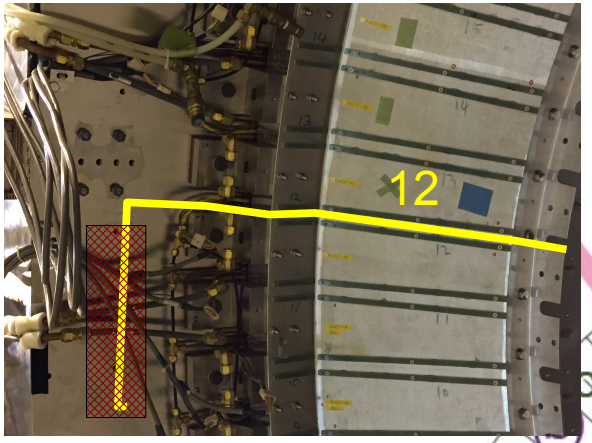


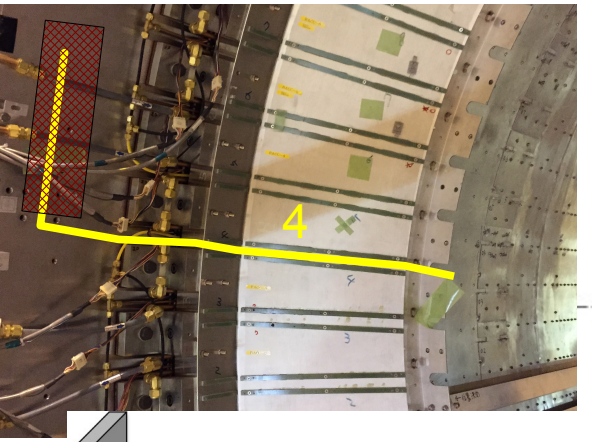
erns

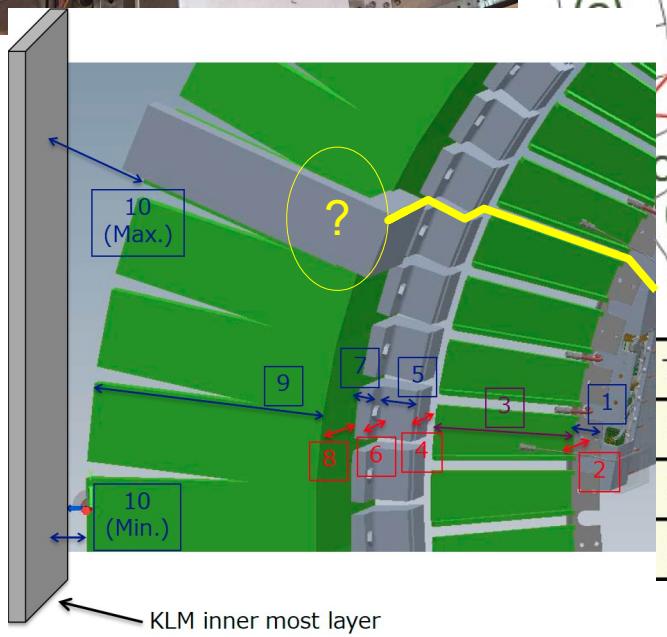
PXD	SVD	CDC	TOP
0.5		0.3	0.2
	0.5	0.3	0.2
		0.5	0.5

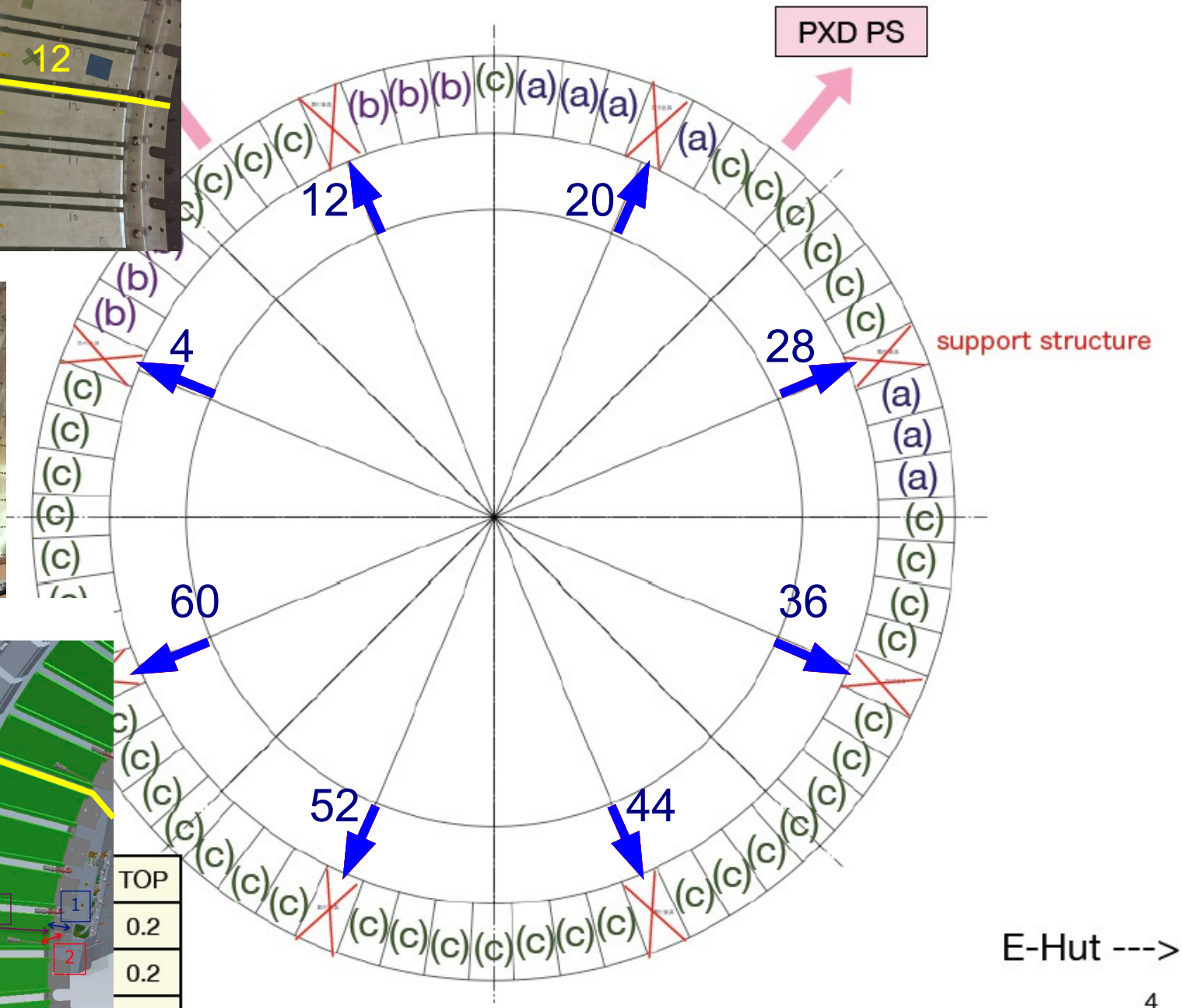
in unit of slot

Fiber bundle routing







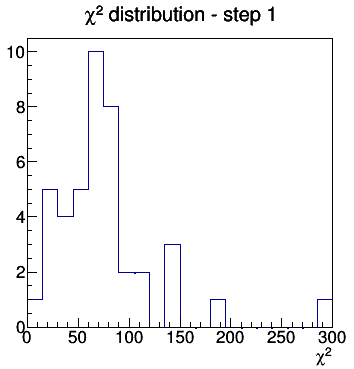


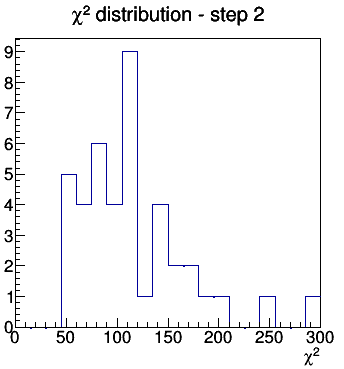
TOP
0.2
0.2
0.5

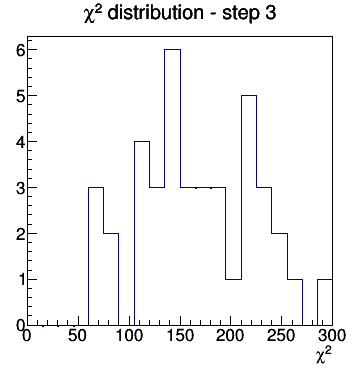
in unit of slot

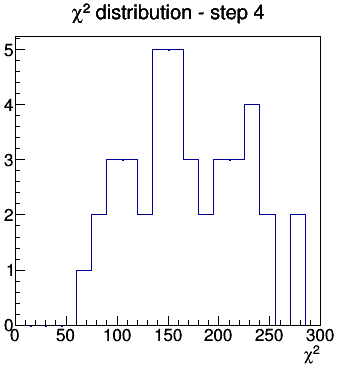
Characterization of GRIN lens cylinders (PD): profile

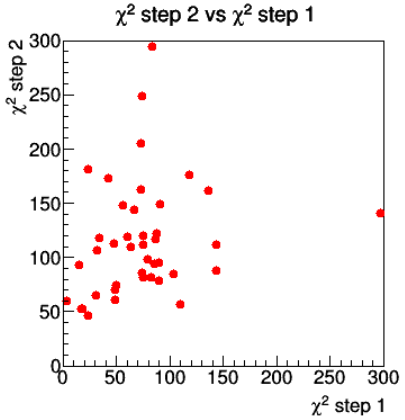
The average χ^2 increases with distance
Correlation between χ^2 at different distances is observed for each lens.

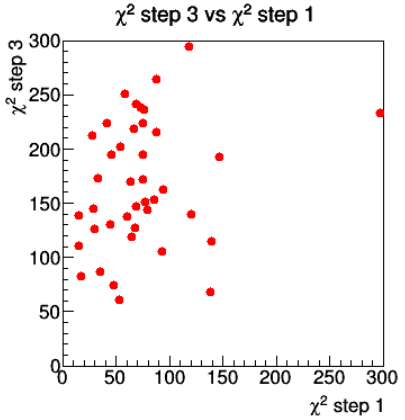


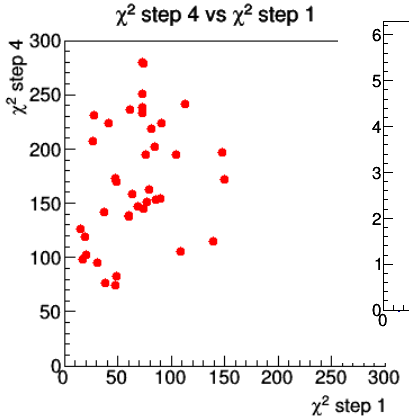


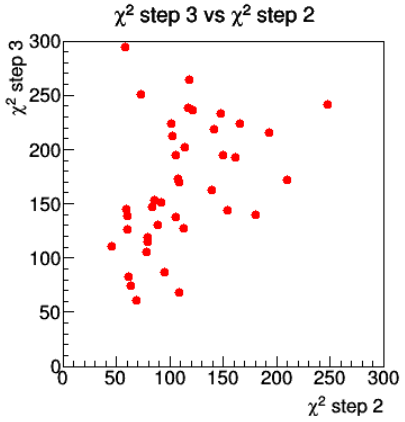


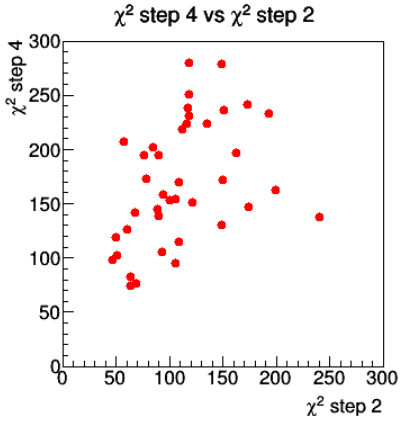


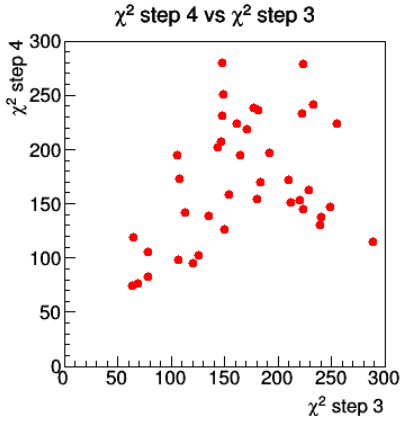




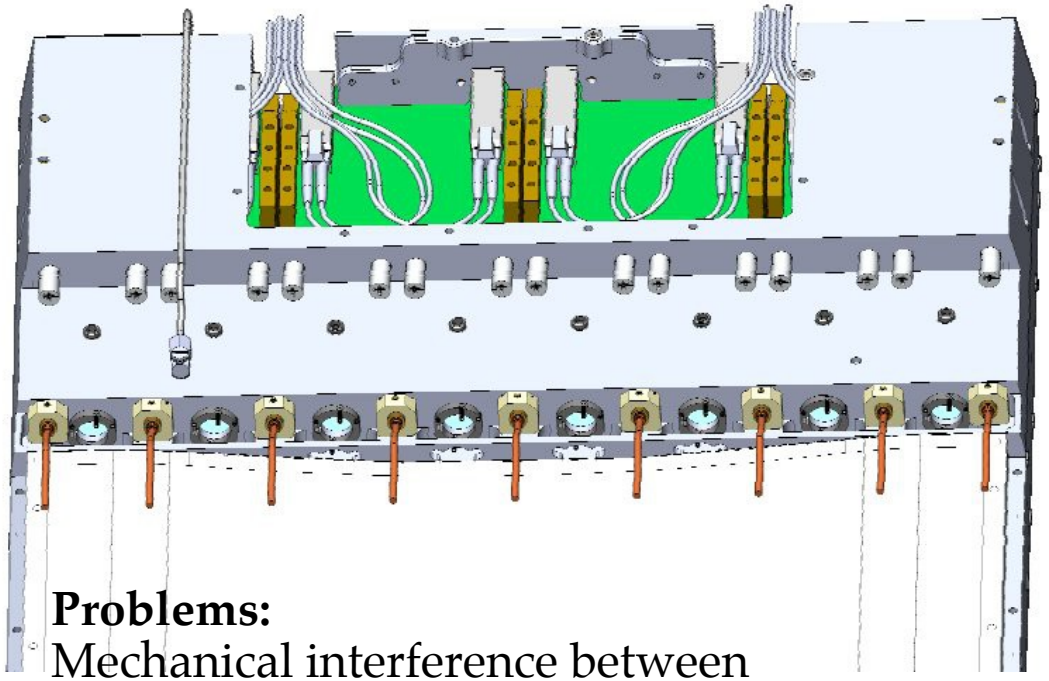


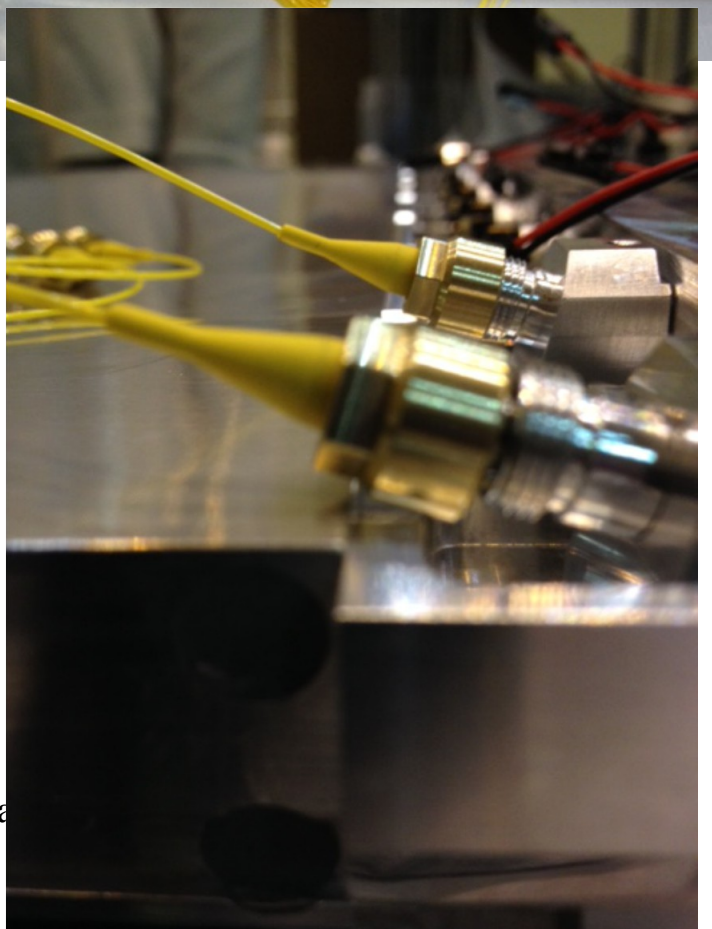






Module 1 Integration





Problems:
Mechanical interference between the supports and the honeycomb
→ change injection angle from 15° to 17°
Need a couple of changes on box design:
- neck hole diameter : 7.6 to 8.0 mm
- screw hole diameter : 2.9 to 3.1 mm