TOP Time Calibration System
Progress Report

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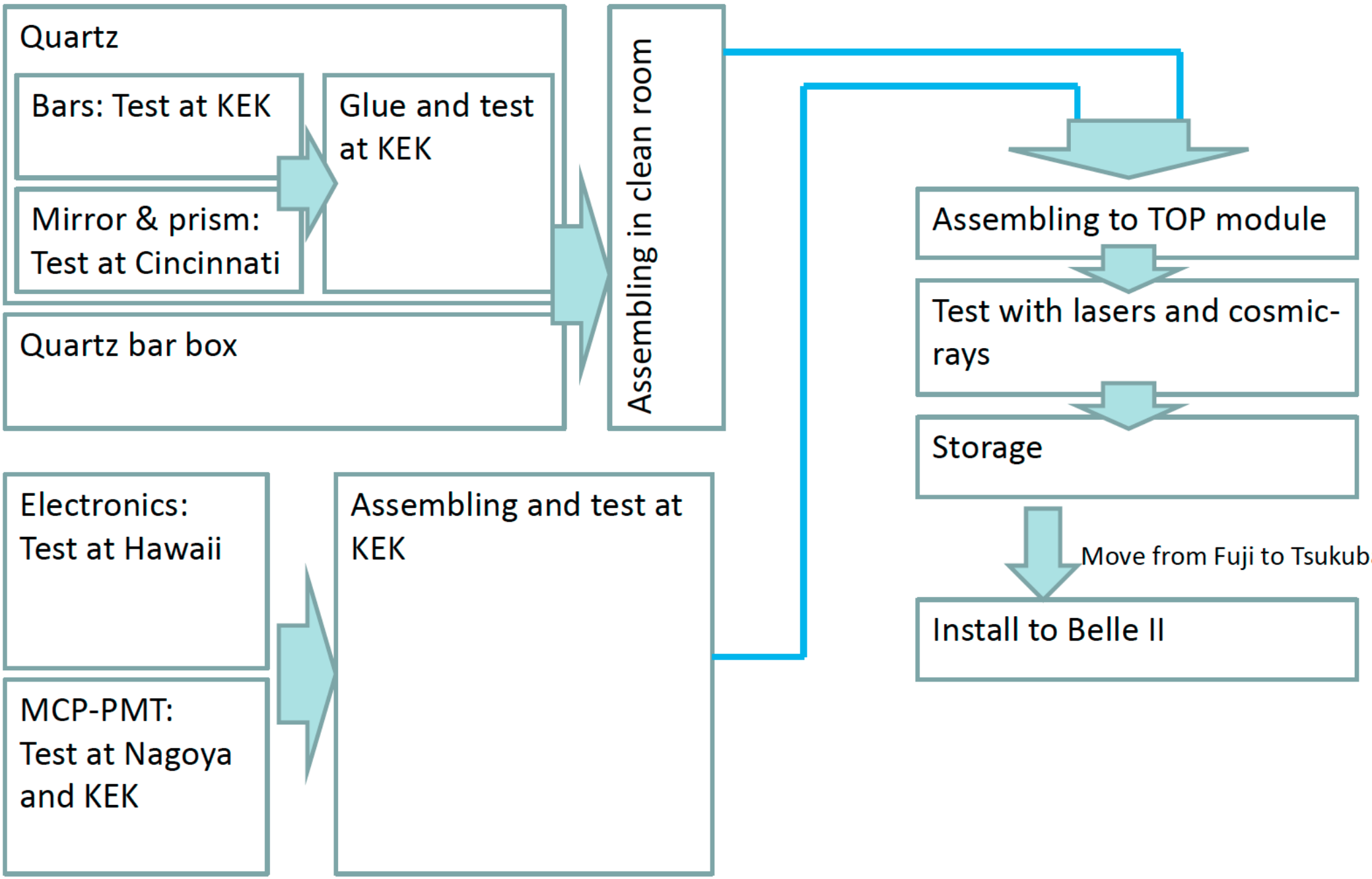
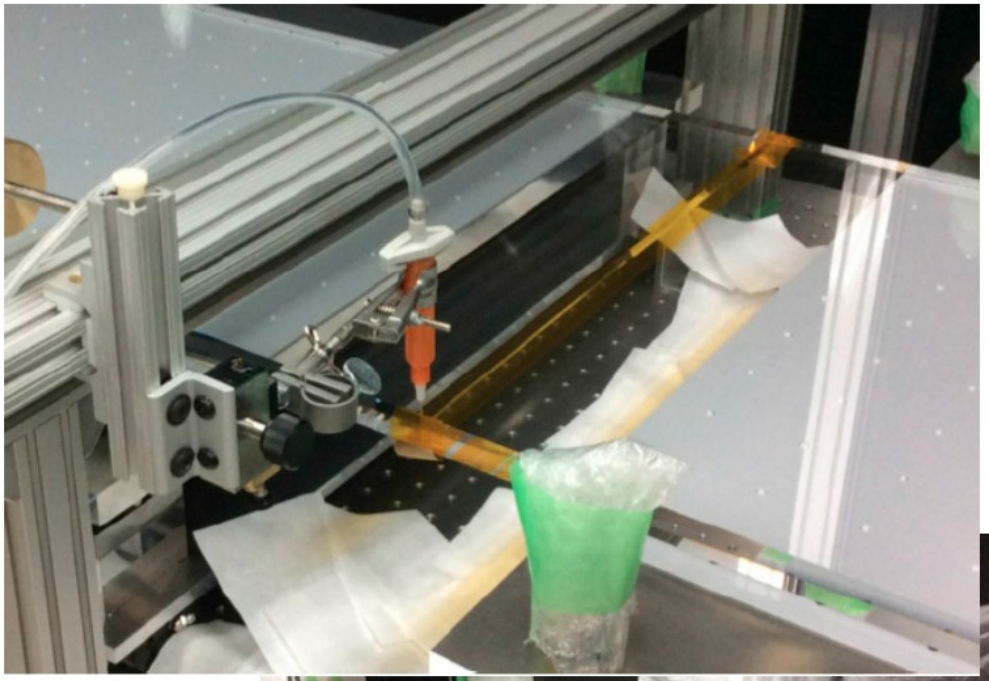
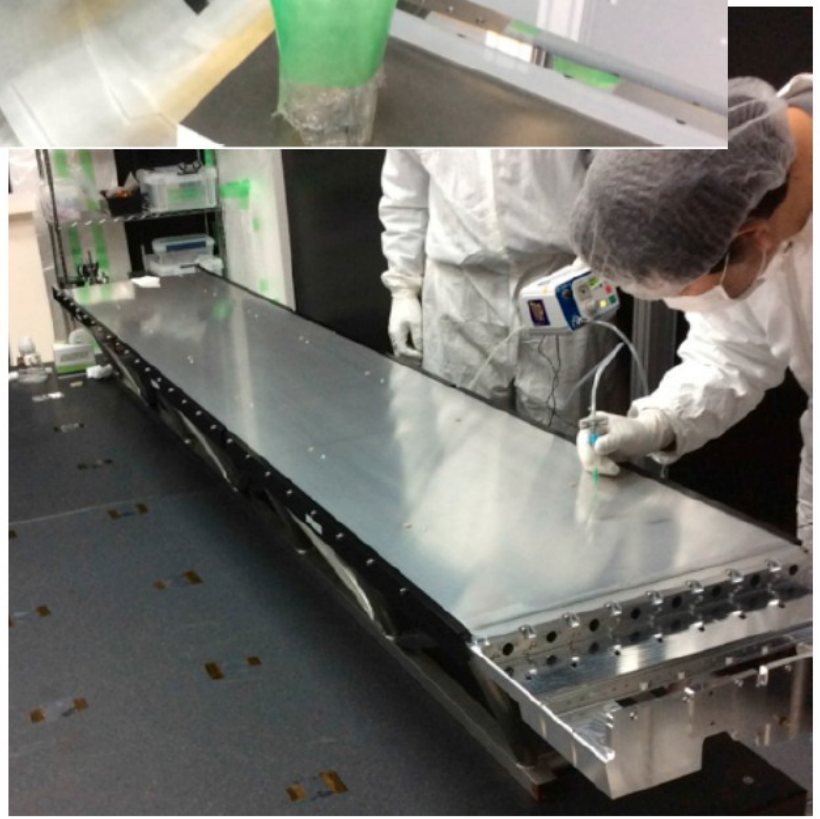
Incontro con Referee , 30/3/15 Skype

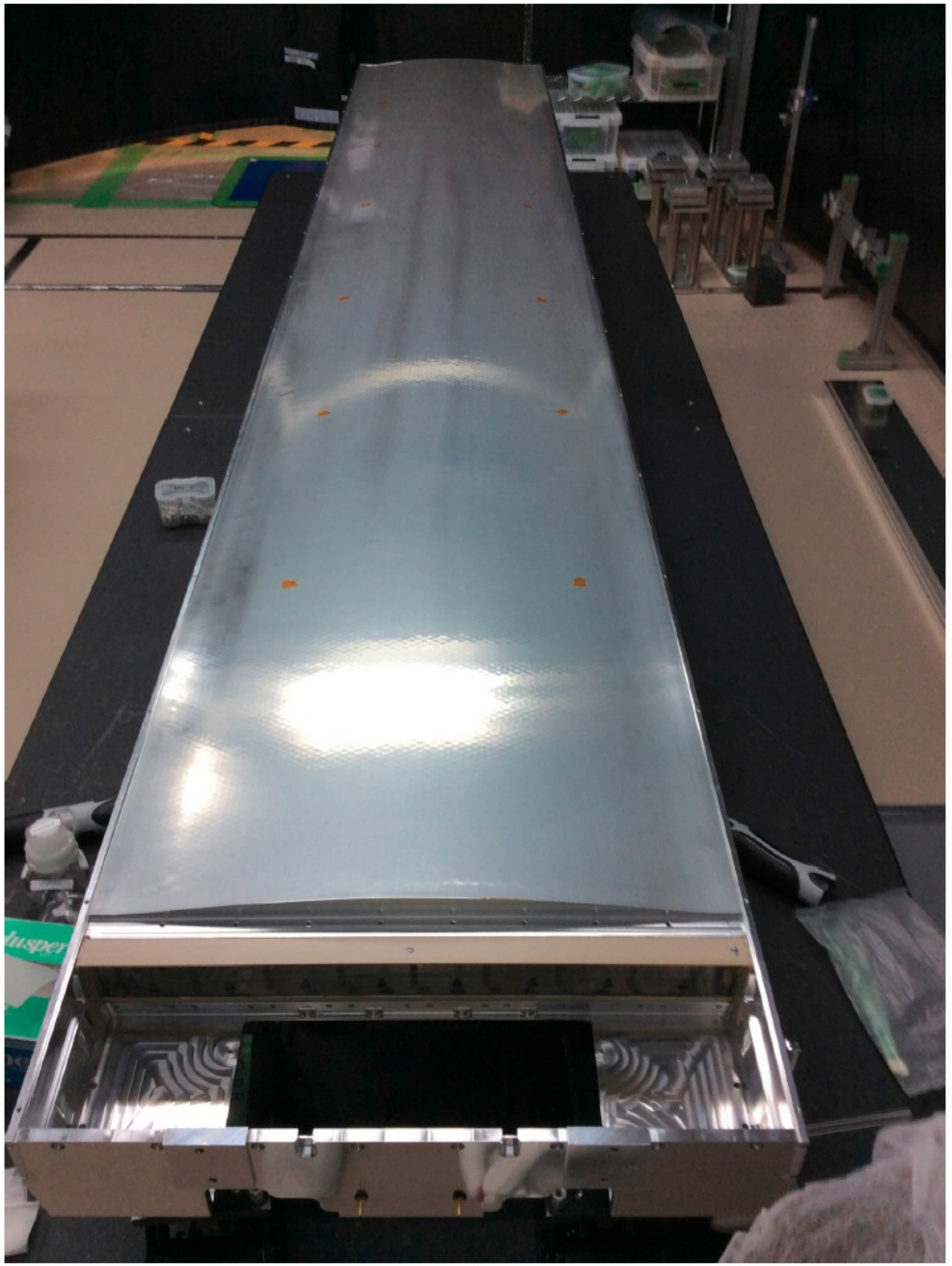
TOP modules construction flow:overview



Module 01 completato in novembre 2014



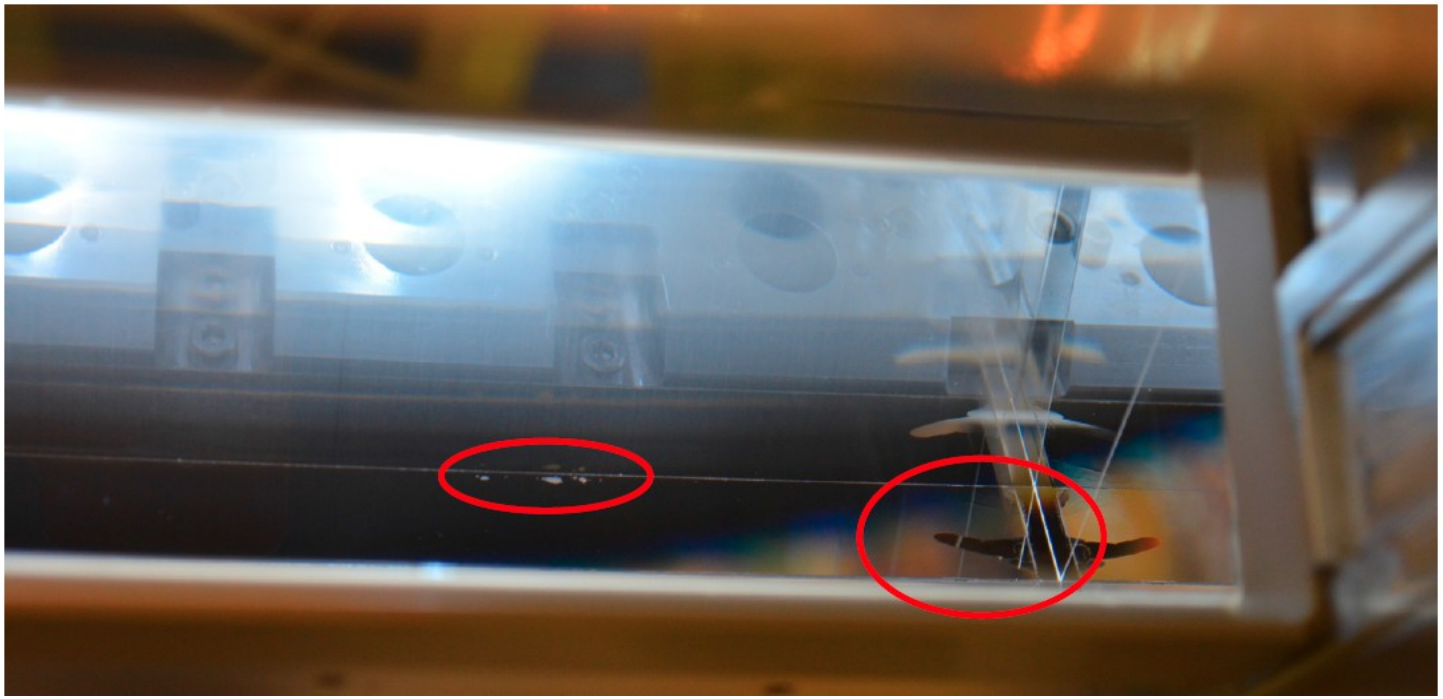




___ ma .....

Module 01 glue problems

- Found that the glue joint between prism and bar is partly failed, during the check of CCD/LED at buffer2.
- The peeled part is the side of bar, which is the side the glue was leaked and bottom side when the module was rotated.
  - Cannot identify when the failure happened after QBB assembly.

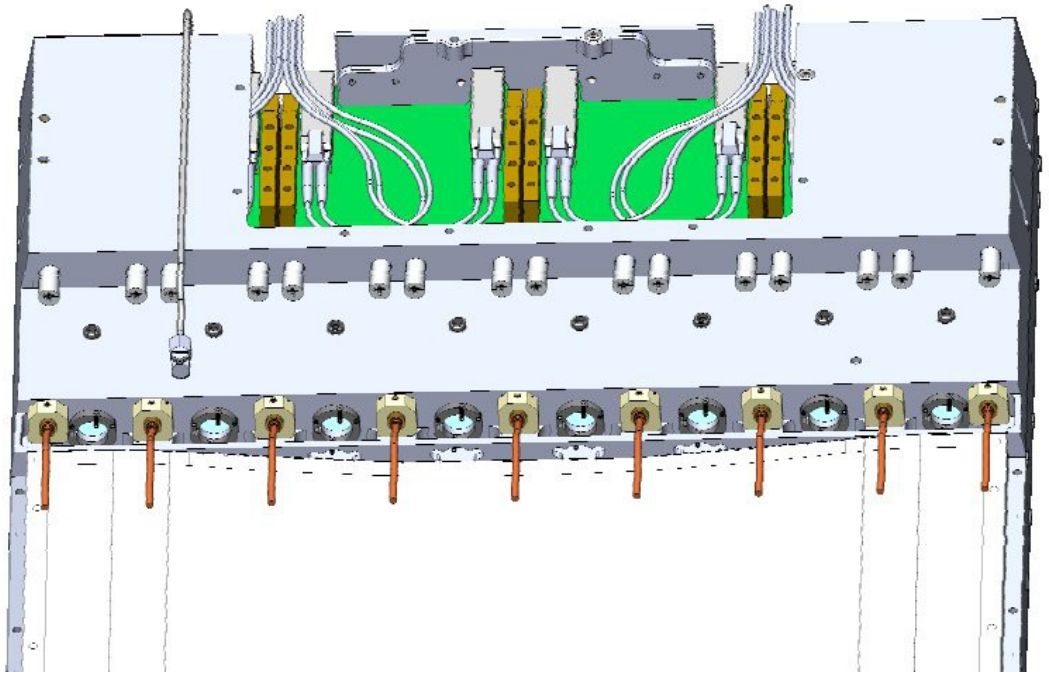


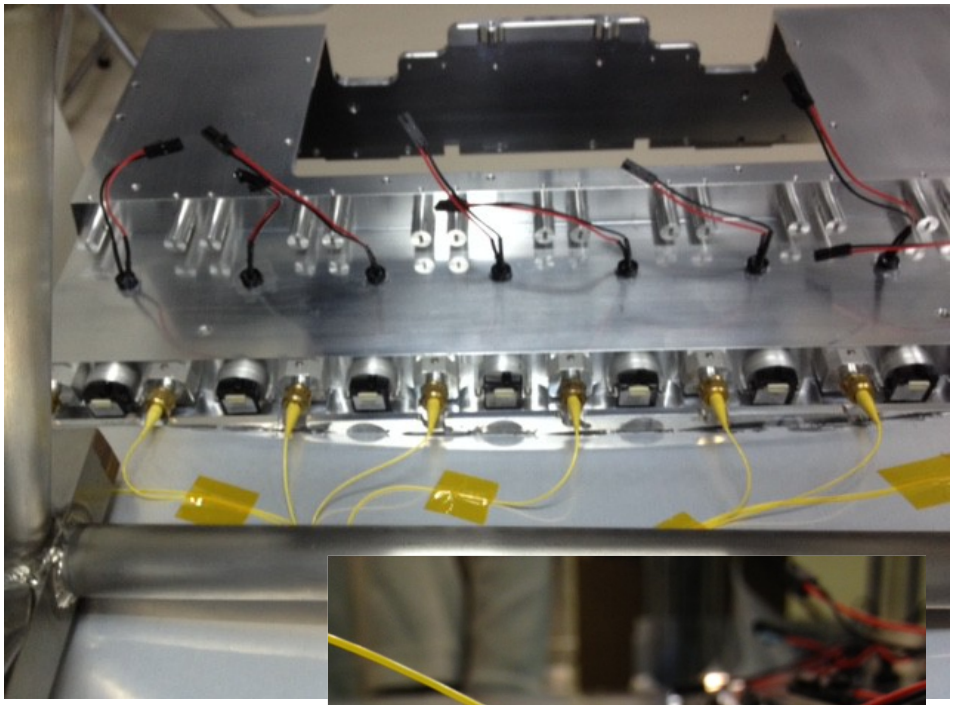
Produzione dei moduli interrotta fino a febbraio per tests sulla procedura di incollaggio.

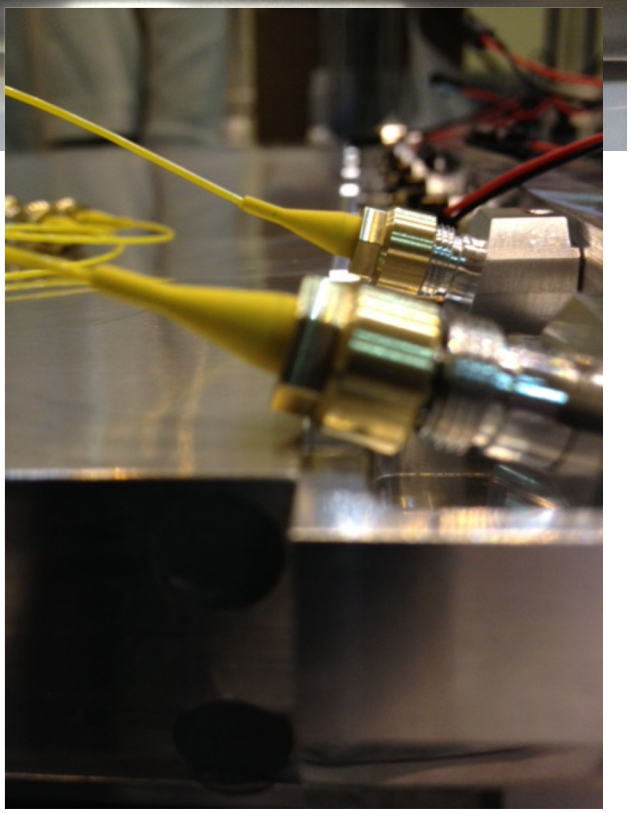
iTOP Module Construction Schedule

	Quartz Deliver → QBB Assembly		Readout Electronics
	Start	Finish	Integration Complete
Module 01	27-Dec-13	1-Nov-14	15-Feb-15
Module 02	12-Nov-14	15-Mar-15	15-Apr-15
Module 03	5-Jan-15	10-Apr-15	15-May-15
Module 04	4-Nov-14	1-May-15	15-May-15
Module 05	19-Dec-14	21-May-15	15-Jun-15
Module 06	14-Jan-15	10-Jun-15	15-Jun-15
Module 07	28-Jan-15	1-Jul-15	1-Jul-15
Module 08	11-Feb-15	21-Jul-15	21-Jul-15
Module 09	25-Feb-15	10-Aug-15	10-Aug-15
Module 10	11-Mar-15	1-Sep-15	1-Sep-15
Partial iTOP Installation		1-Oct-15	
Module 11	3-Mar-15	21-Sep-15	21-Sep-15
Module 12	8-Apr-15	10-Oct-15	10-Oct-15
Module 13	22-Apr-15	1-Nov-15	1-Nov-15
Module 14	6-May-15	21-Nov-15	21-Nov-15
Module 15	20-May-15	10-Dec-15	10-Dec-15
Module 16	4-Jun-15	1-Jan-16	1-Jan-16
Module 17	1-Jul-15	21-Jan-16	21-Jan-16
Module 18	1-Aug-15	10-Feb-16	10-Feb-16

PD parts in Module 1







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

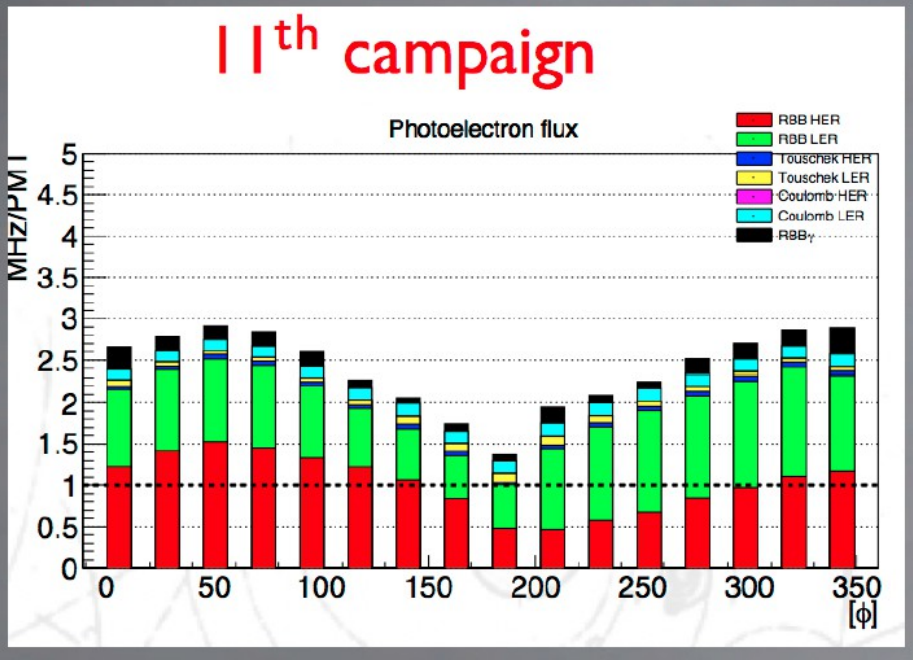
Small gas leak due to a groove out of specs

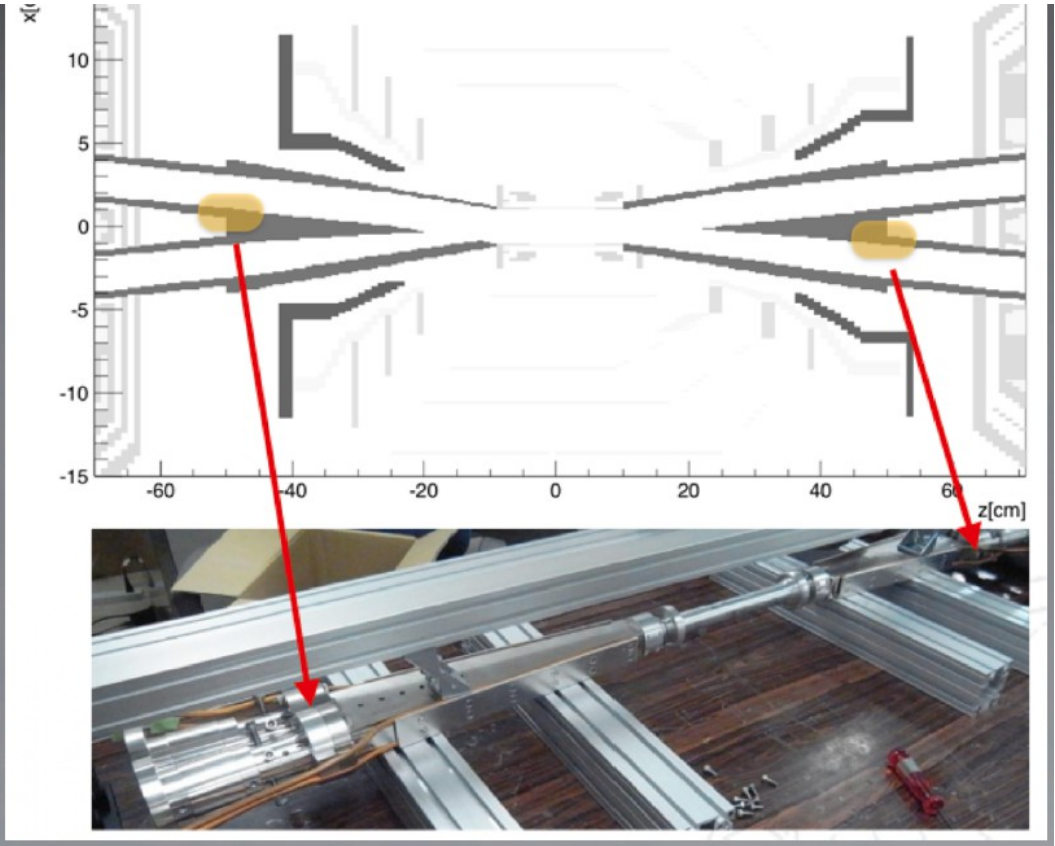
Module testing plans

- Much reduced time frame for tests with production delays
- Primary tests for every module:
  - Electronic charge injection (input node on bench, 2nd stage of amp in situ)
  - Laser test in modules (tests readout chain including MCP-PMTs)
  - Cosmic test without tracking (tests optics integrity, ensemble likelihoods)
- Cosmic rays with precise tracking for sub-set of modules
  - Fuji hall cosmic ray stand tracking is not up to task yet
    - Not clear we have manpower to get required performance
  - Serious discussions underway to do test with CDC
    - Would be ideal integration test for both detectors and DAQ
    - Leverages much work already done in CDC and DAQ groups
- Beam test is in direct conflict with module production and testing
  - Consensus forming to forego beam test entirely
  - Test would require much manpower and money (~$200k investment)
  - Likely less than 1 year to first collisions so impact is not clear
  - Integrated test with CDC is probably more impact for less effort/cost

Criticita' : eccessivo flusso di fotoni da Bhabha radiativo

- 1 C/cm^2 at 5x10^5 gain is equivalent to ~1 MHz/PMT
- Conventional style lifetime 1 C/cm^2
- ALD style lifetime >7 C/cm^2
- Source of main contribution (radiative bhabha) is very localized

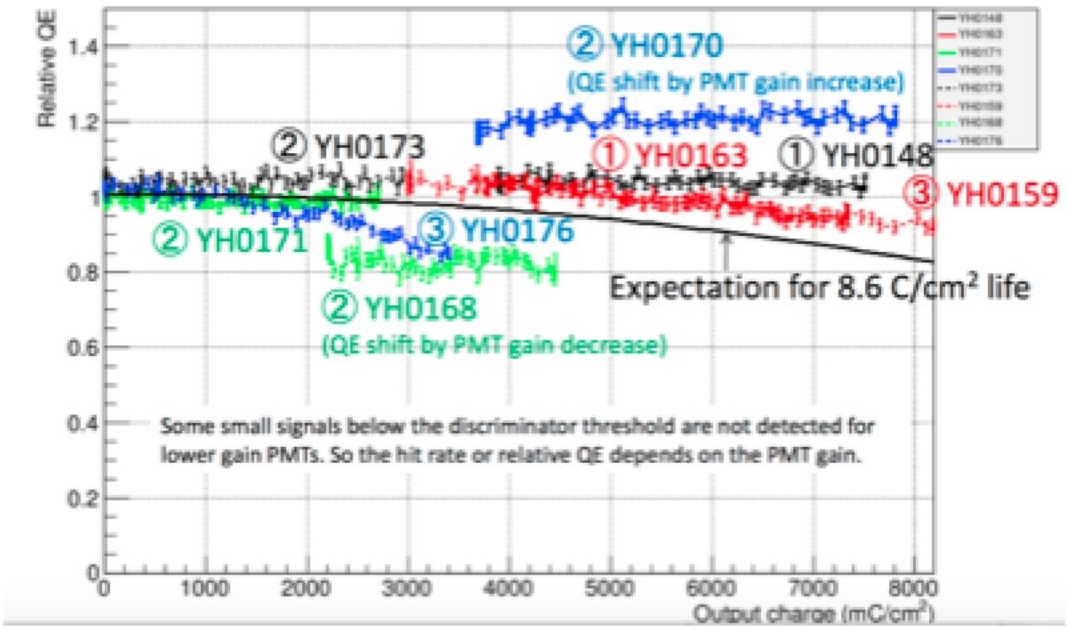




TOP group is working with machine and VXD groups to see if shielding can be added at RBB hot spots near beam pipe transition region and bellows

PMT life test

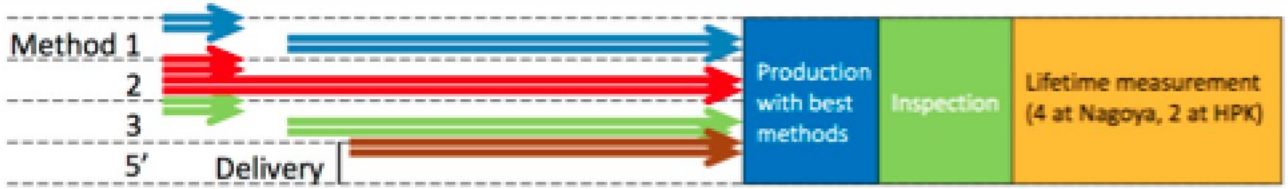
Life test result (Oct. 29)



Method	ID	Measurer	Life (C/cm²)
1	YH0152	HAMAMATSU	2.6
	YH0148	Nagoya	measuring (>7.5)
	YH0163	Nagoya	measuring (>7.3)
2	YH0169	HAMAMATSU	measuring (>6.0)
	YH0168	Nagoya	measuring (>4.5)
	YH0170	Nagoya	measuring (>7.8)
	YH0171	Nagoya	measuring (>2.7)
	YH0173	Nagoya	measuring (>3.0)
3	YH0158	HAMAMATSU	$(8)_{extrapolated}$
	YH0159	Nagoya	measuring (>8.2)
	YH0176	Nagoya	measuring $(\sim 3.6)_{extrapolated}$
4	YH0180	HAMAMATSU	3.3
	YH0181	Nagoya	3.0
	YH0182	Nagoya	(~2)
5'	YH????	HAMAMATSU	measuring
6	YH0151_1	HAMAMATSU	4.9
	YH0155	Nagoya	0.9
	YH0164	Nagoya	$(1.4)_{extrapolated}$

Original plan

	Oct.	Nov.	Dec.	Jan. 2015	Feb.	Mar.	Apr.	May.	Jun.-Aug.
Method 1		Summary of the tests	Production with best methods	Inspection	Lifetime measurement (4 at Nagoya, 2 at HPK)				
2									
3									
4									
5									
6									



Mean lifetime
Conventional: 1 C/cm²
ALD: 9 C/cm²

Production
Conventional: 272 PMT
ALD: 230 PMT

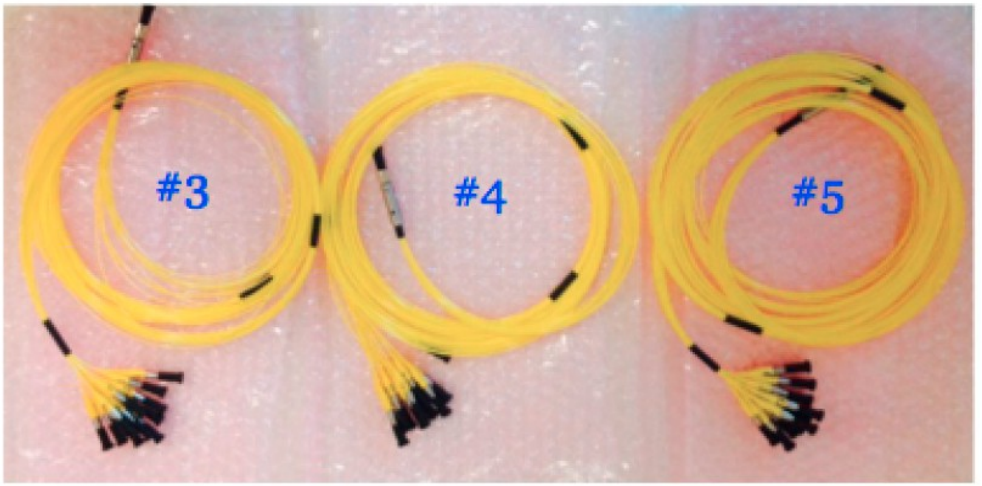
Laser calibration system update

Material procurement:

Grin lens ordered to the Go!Foton USA for the full production (150 missing lens)
Price (due to larger stock) down from 17 €/ lens to 11 € / lens

Blocks, cylinders, nuts ordered for 50% of the residual production (70 pieces)
Price (due to larger stock and wider survey) down from 187 € to 62 €
Quality to be checked for the first pieces

Fiber bundles for modules #3, #4 , #5 arrived at the lab today
Next fiber bundles to be ordered



Radiation damage tests at INFN Legnaro (PD)

Irradiation of 9 GRIN lenses at variable distance from the target

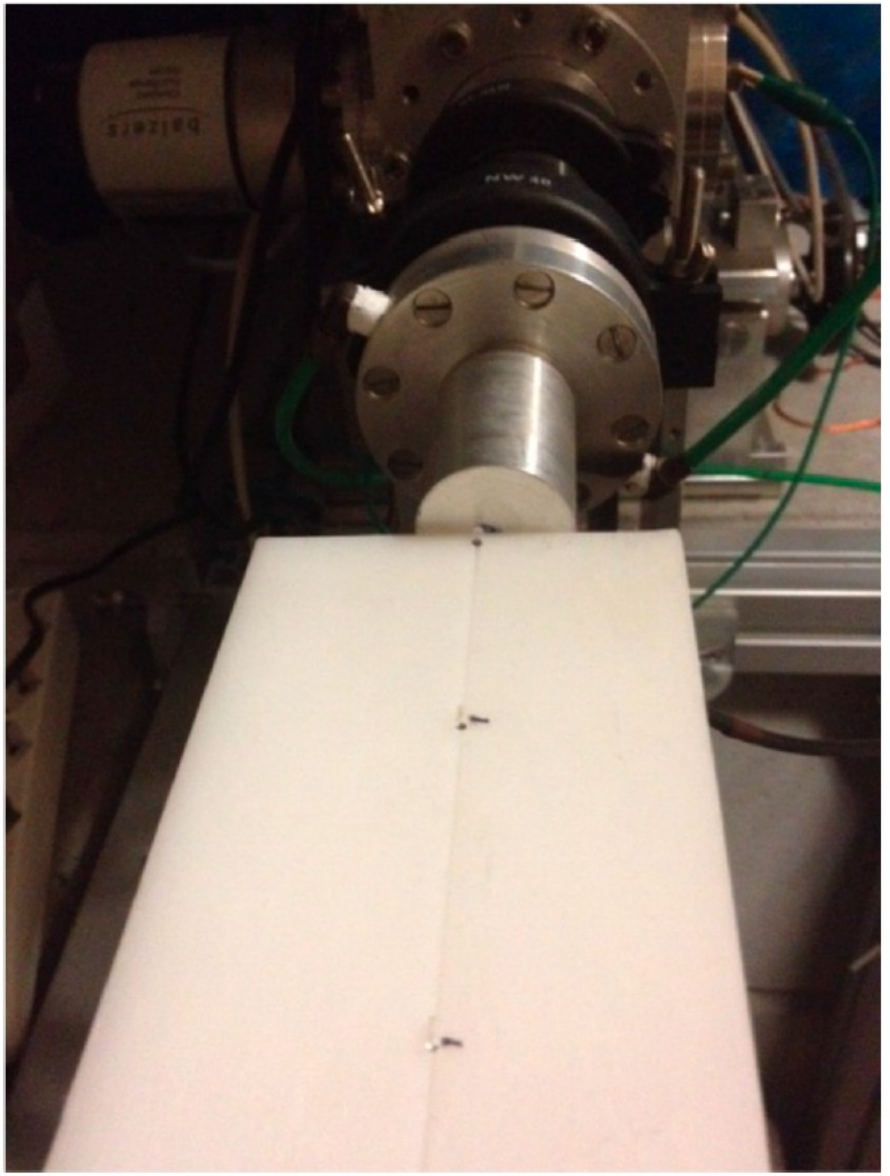
Beam: 4 MeV protons on Berillium

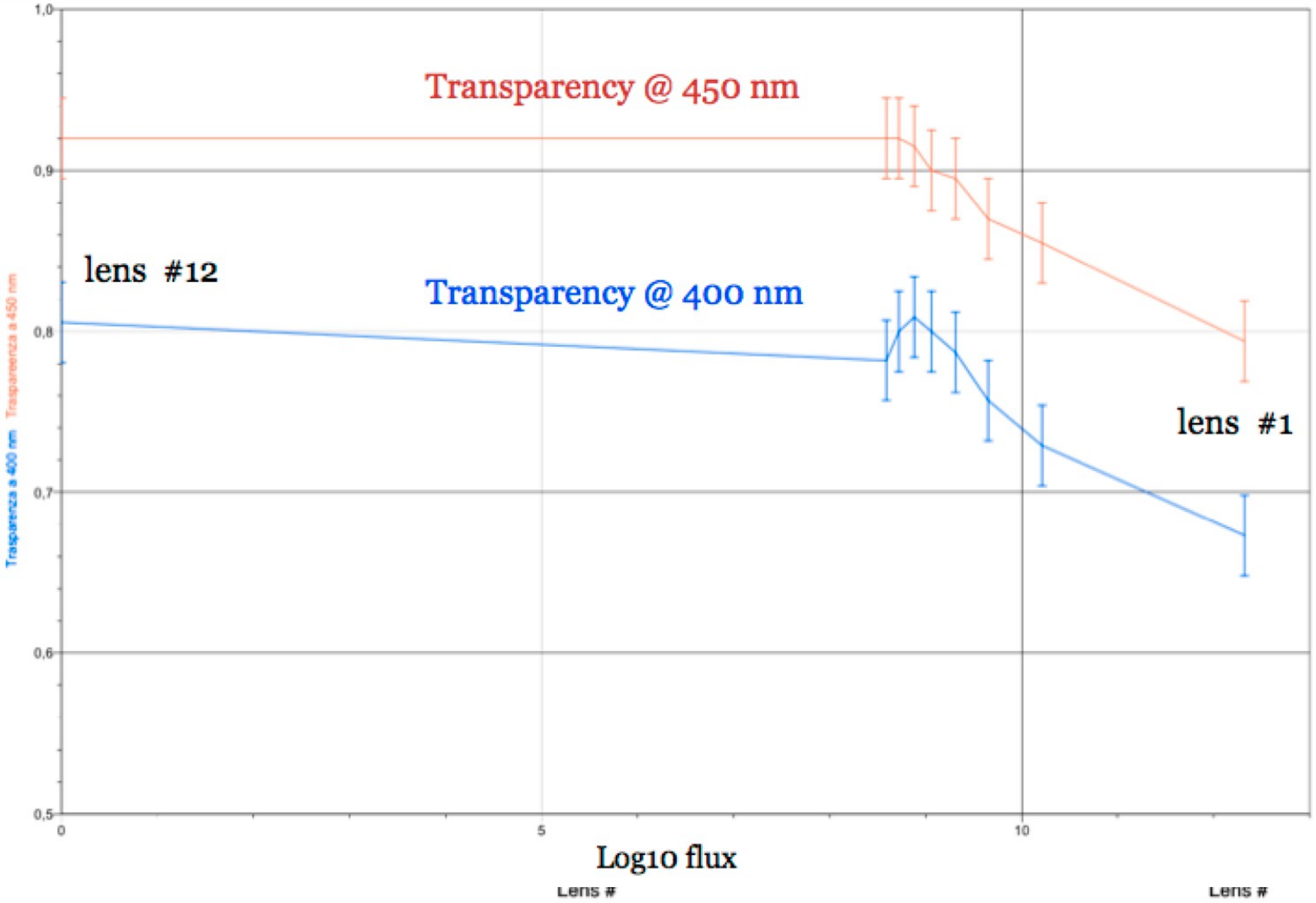
Irradiation time : 7hours

Integrated charge: 6 milliCurie

Neutron Fluence (distance dependent): 10^9 to 10^{12} n/cm^2

Analysis under way to measure Transmission and NA vs Dose

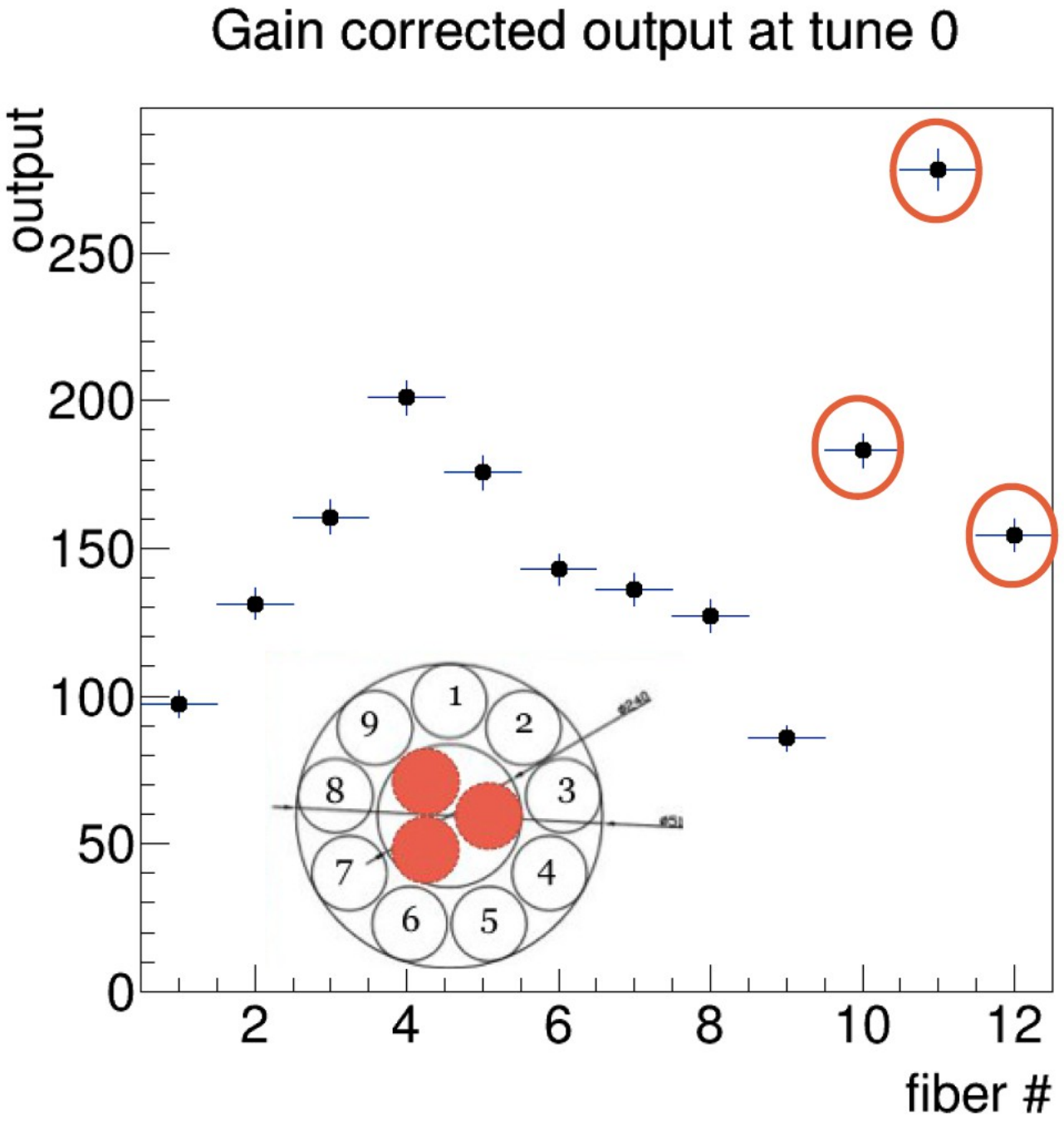



Transparency @ 450 nm
Transparency @ 400 nm
lens #12
lens #1
1,0
0,9
0,8
0,7
0,6
0,5
0
5
10
Log10 flux
Trasparenza a 400 nm
Trasparenza a 450 nm
Lens #
Lens #

Characterization of MM fibers: 2nd bundle

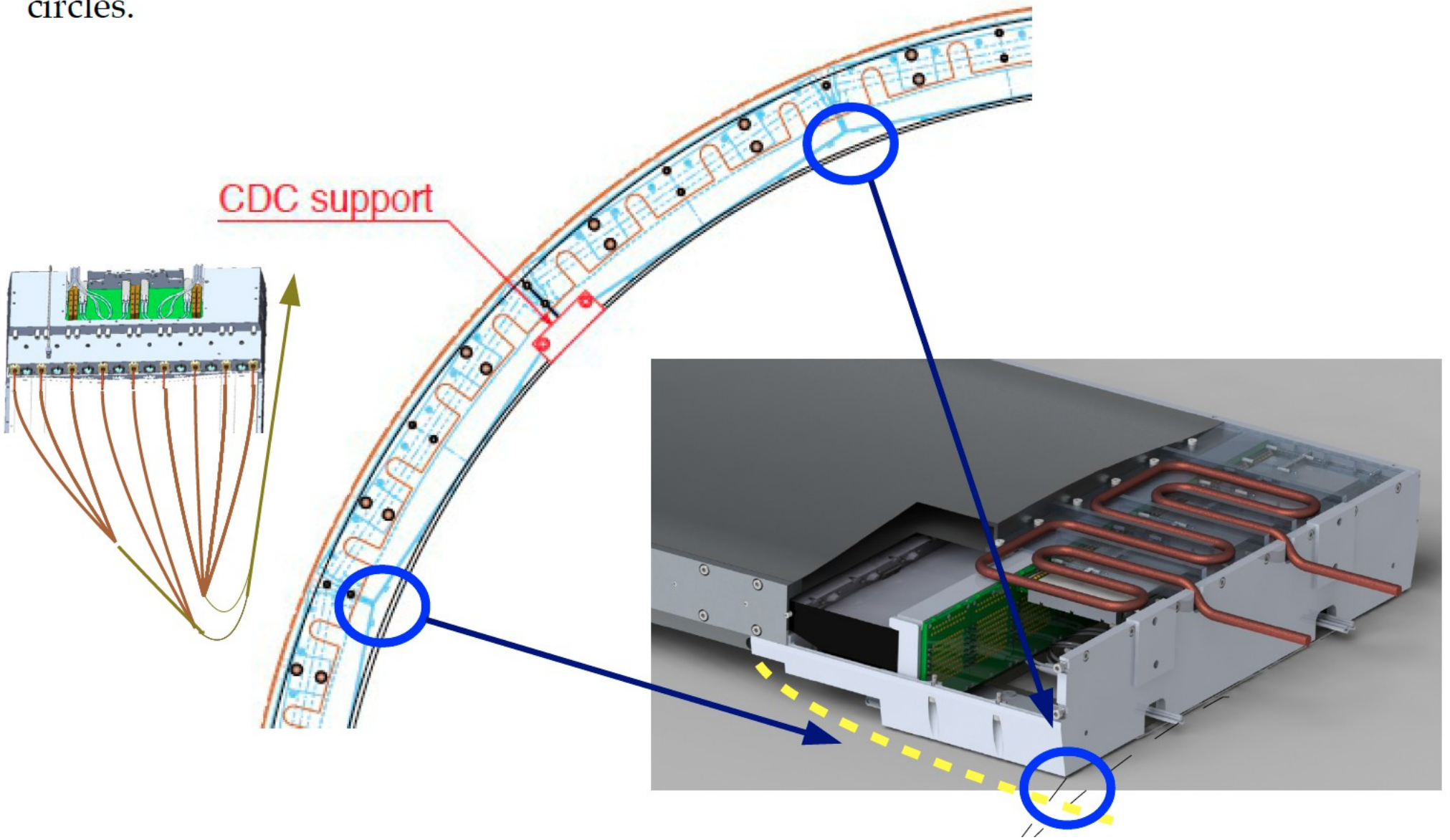
Summary of laser results

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 .

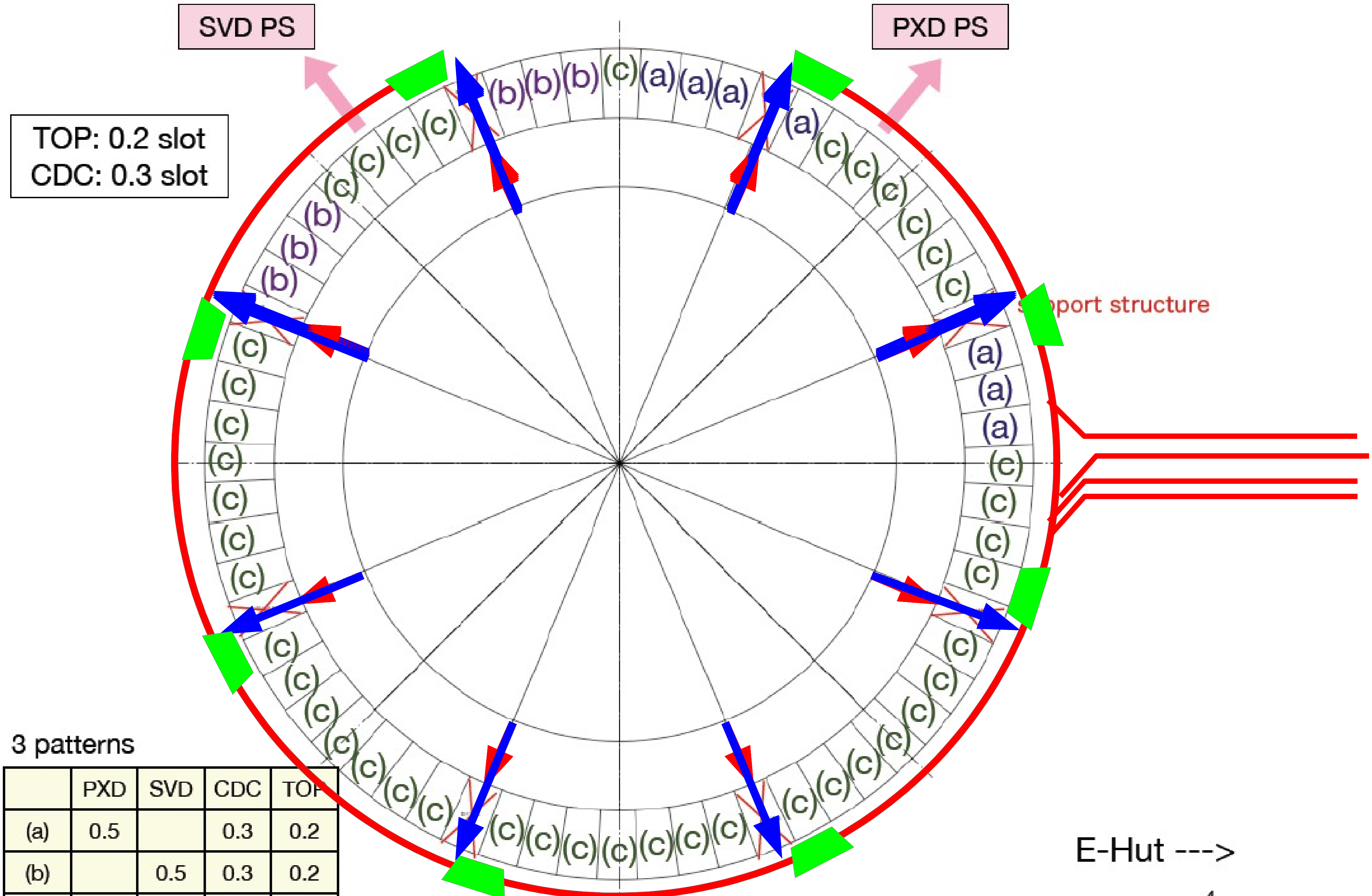


MM fiber bundle routing

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



Fiber bundle routing

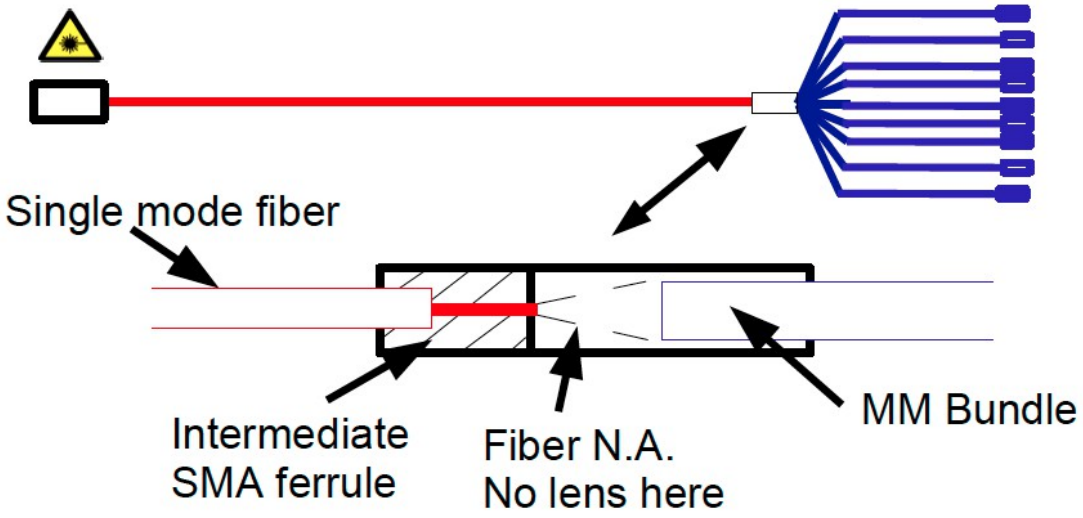


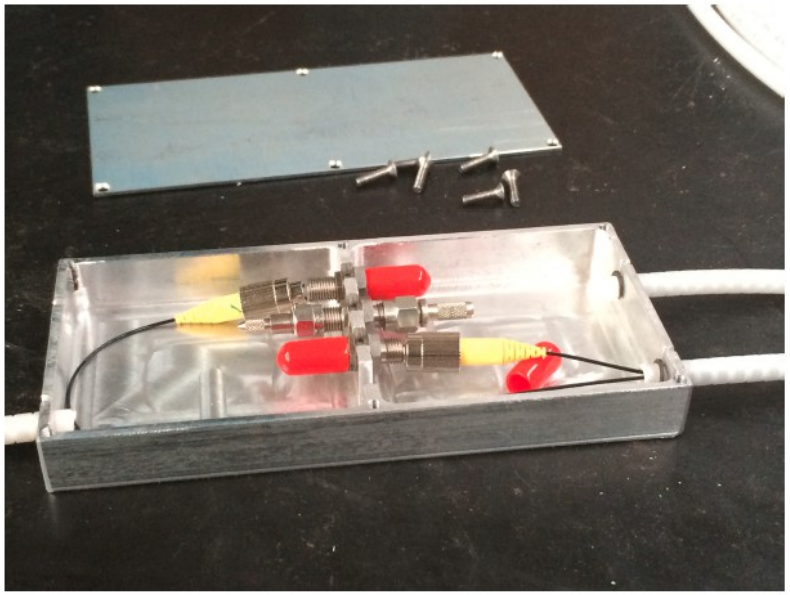
3 patterns

	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

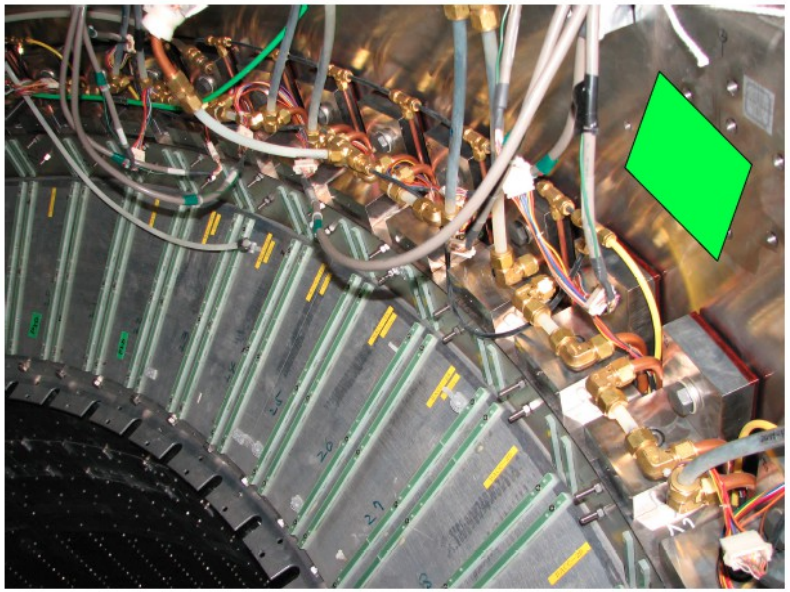
SM-MM fiber connection





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

We would like to place them on axial surface #8

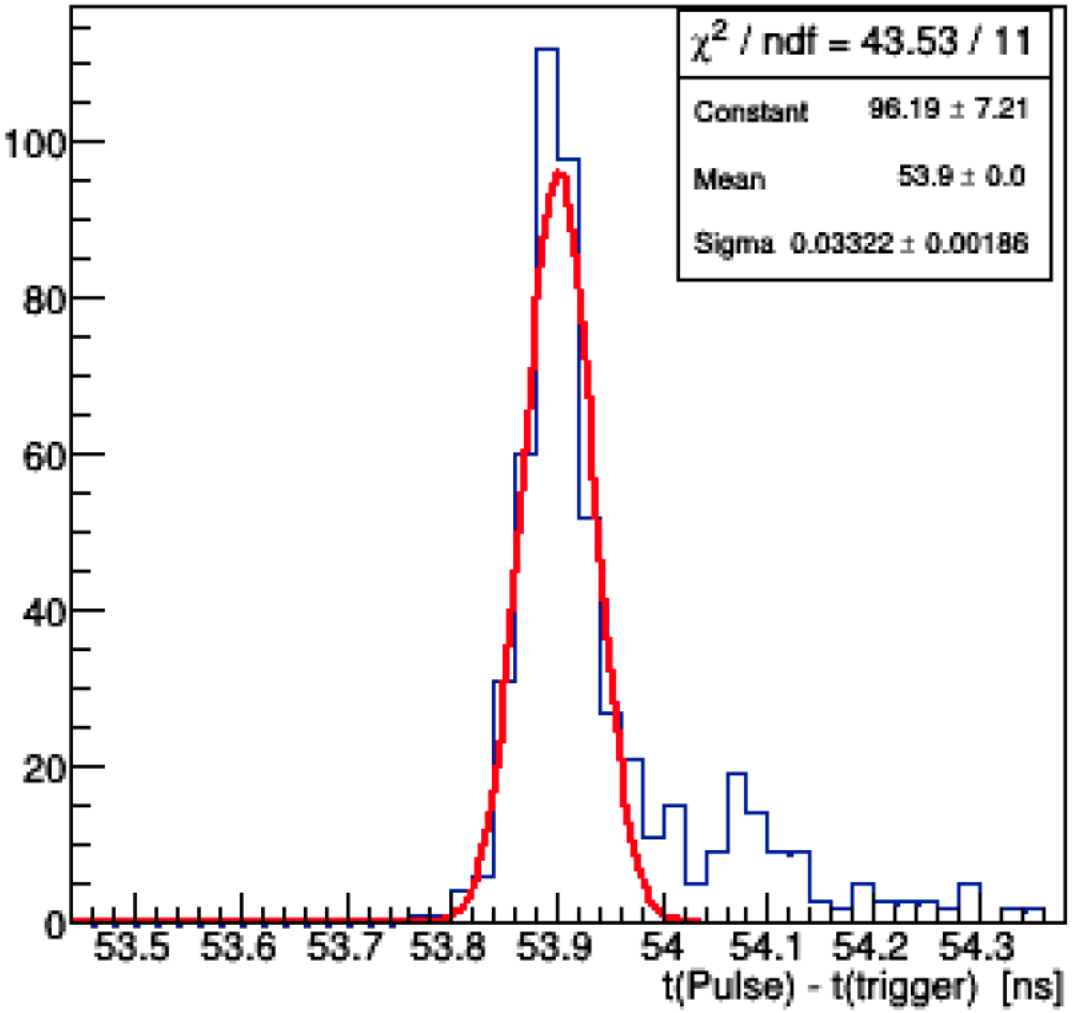


ALD-MCPPMT time resolution tests (TO)

Procurement of parts for the time calibration system: during January we received many parts for the realization of the TOF time calibration system:

- Laser source PiLas
- 2 ALD-MCPPMT
- first batch of long SM fibers (half of the total)

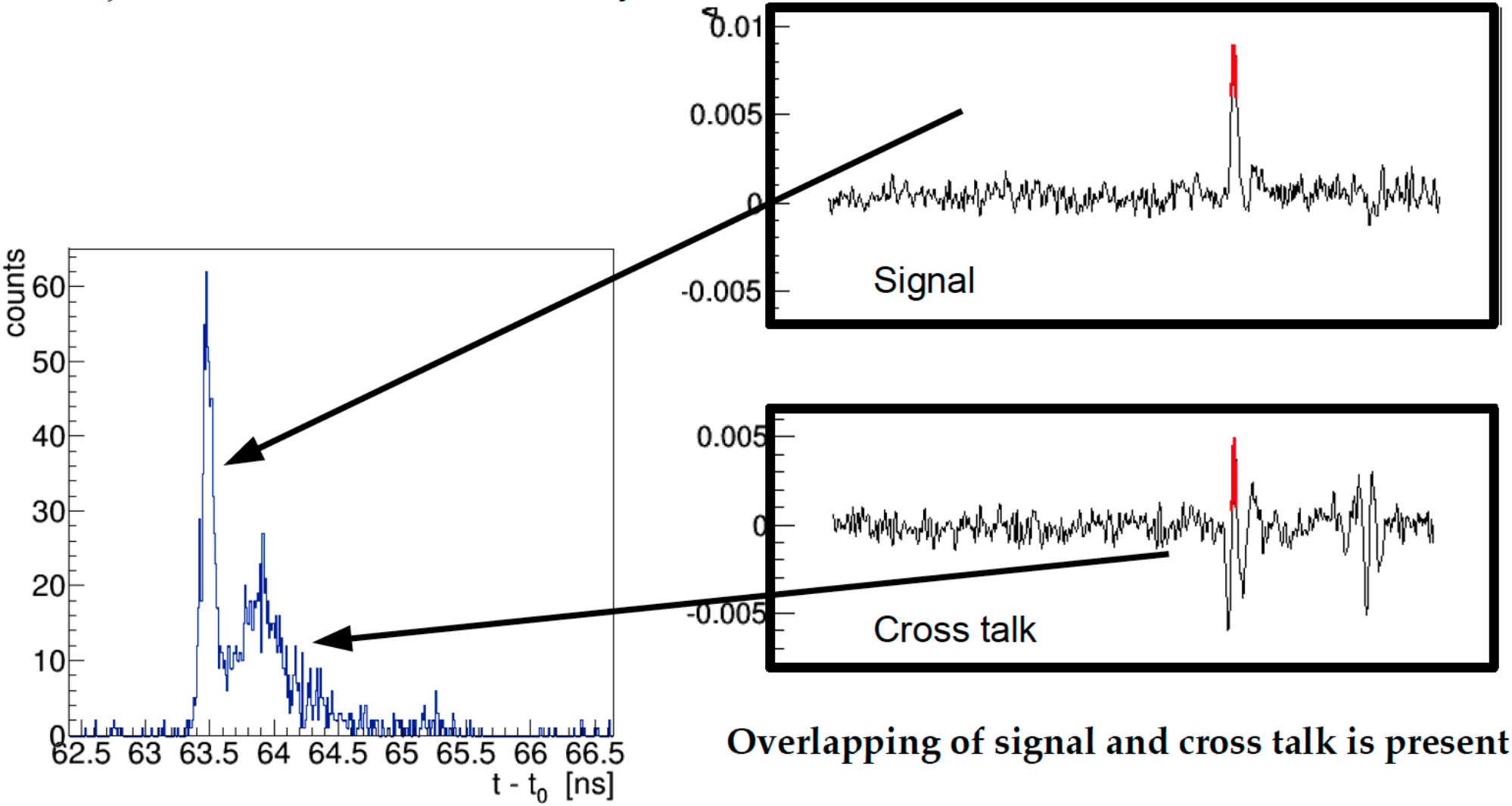
We plan to build and characterize all the system in Torino by the end of May, before shipping to Japan.



ALD-MCPPMT time resolution tests (TO)

Goal: measure the final time resolution and time offset of the SM fibers in the bundle
Measure 16 fibers simultaneously on a single PMT

Major issue: **cross talk from nearby channels**

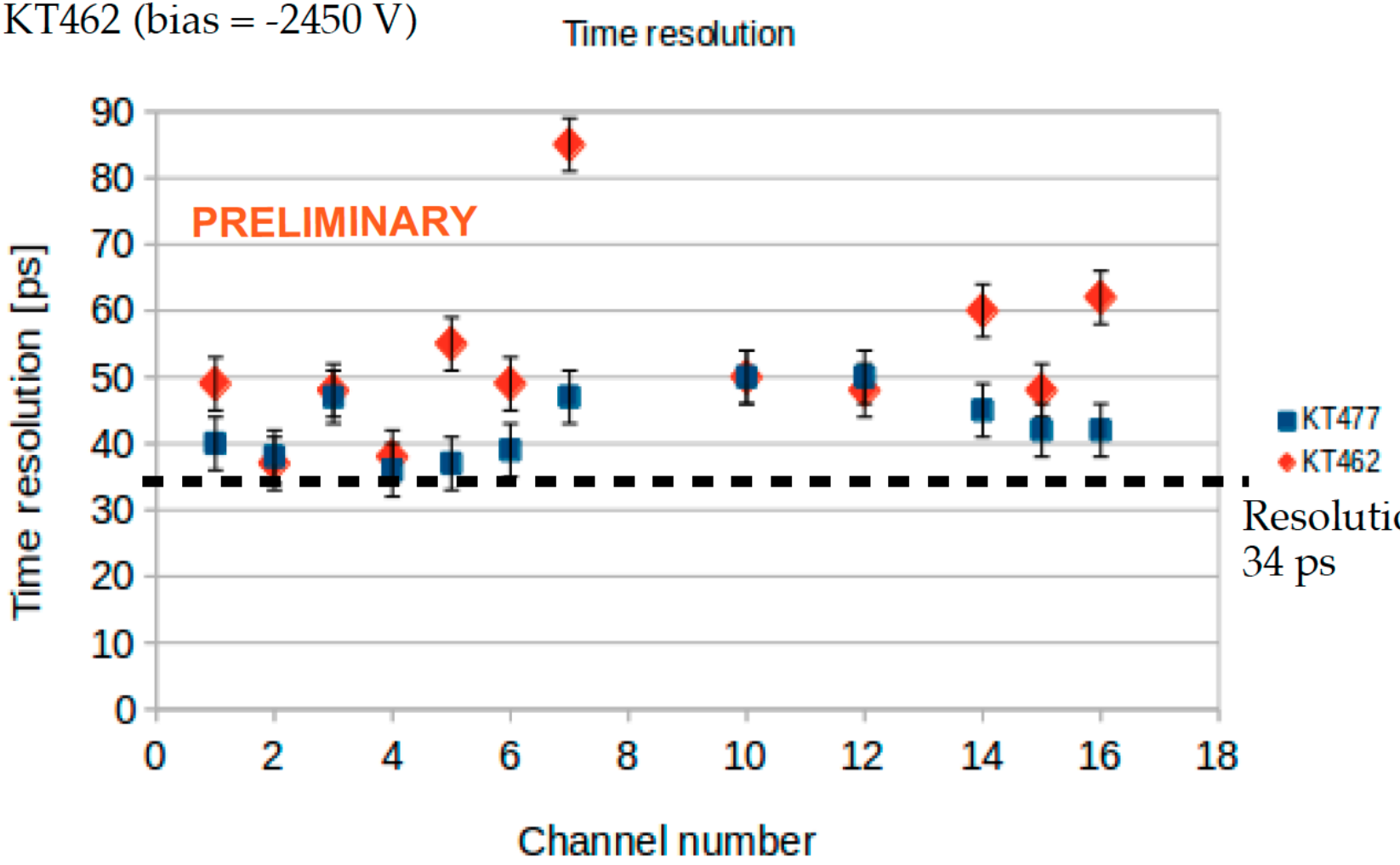


Overlapping of signal and cross talk is present

ALD-MCPPMT time resolution tests (TO)

Two ALD-PMT tested:
KT477 (bias = -2600 V)
KT462 (bias = -2450 V)

Channels 8,9 and 13 are missing due to problems on the readout board
Channel 11 is missing due to low light from fiber



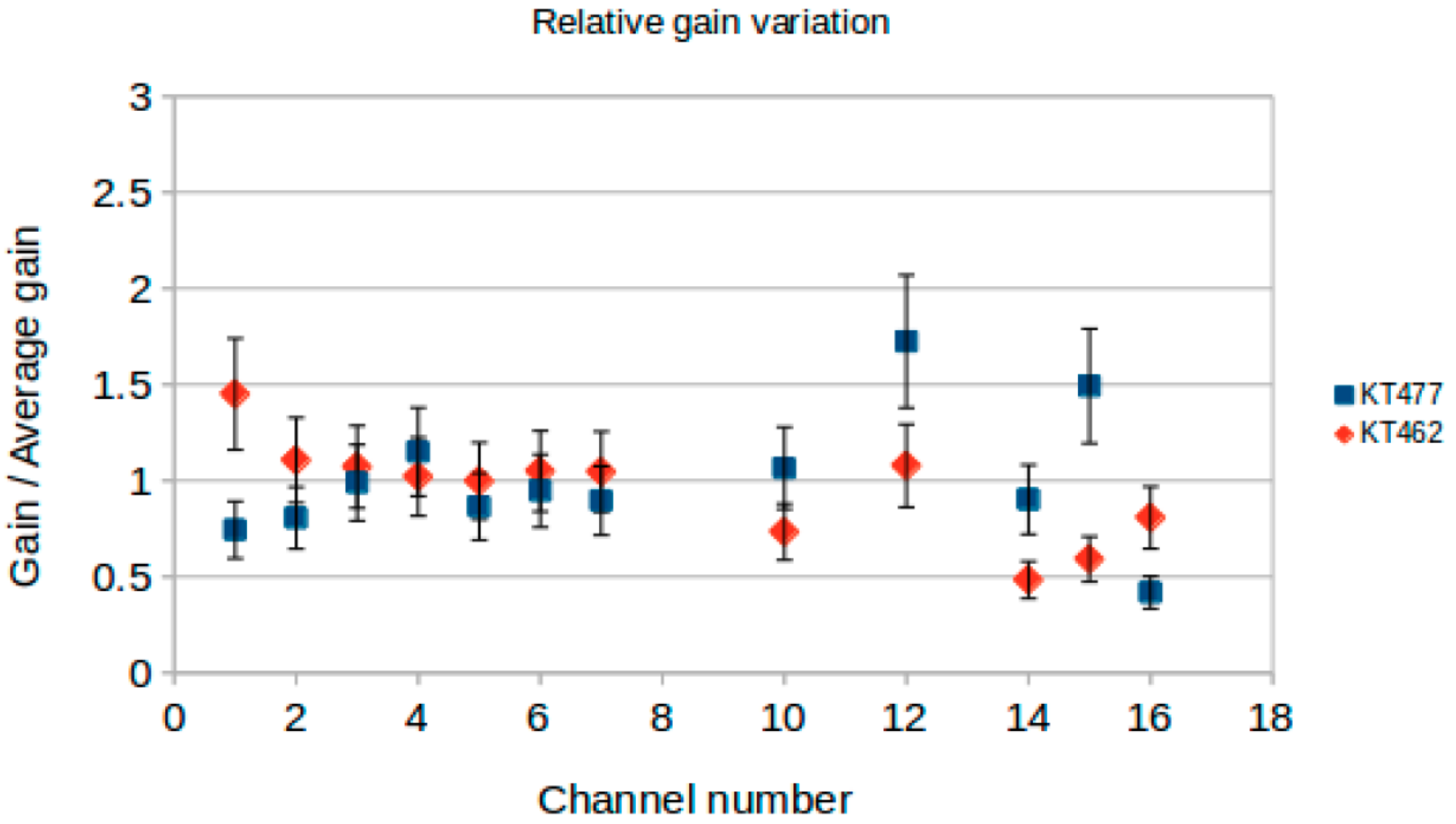
Resolution w/o cross talk
34 ps

Proper cross talk treatment is mandatory for the final test of the fibers.

ALD-MCPPMT gain spread tests (TO)

A large range of gains among the 16 anodes of MCP-PMTs are observed when operating at an average gain of 5×10^5. A factor of three range is typical for normal MCP-PMTs, while ALD MCP-PMTs can have a much larger range

Tests done at gains > 5×10^5 : further tests under way.



Situazione generale :

Ritardi sulla costruzione delle QBB per problemi di incollaggi , ora risolti

Rimane critica la questione Photon Backgrounds, sul lungo termine

Il Beam Test e' definitivamente escluso, mentre un Cosmic Ray Test in congiunzione con la CDC e' in previsione per la seconda meta' del 2015 su tutti i moduli prodotti.

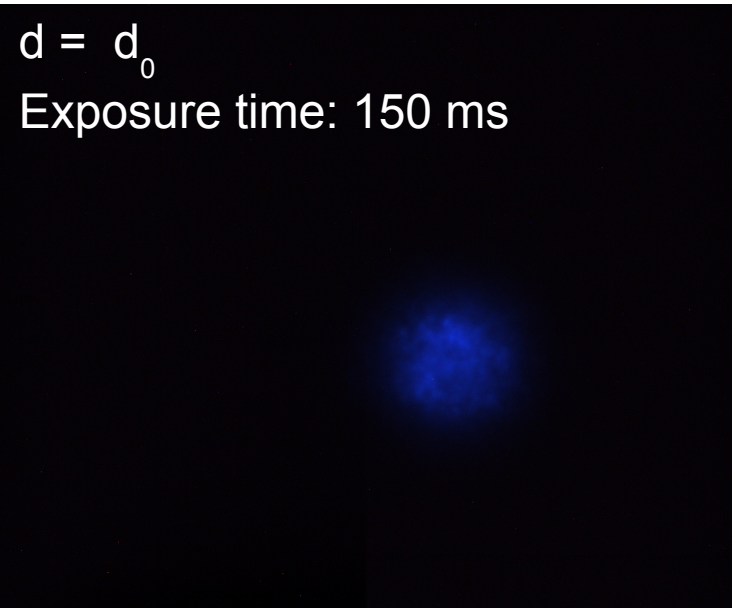
Criticita' sul fronte italiano:

- sofferenza sulle missioni estero soprattutto per PD (contiamo su Jennifer per mantenere gli impegni presi)

- importazione del PicoLaser in Giappone : overhead dell'8%(su 25 k) non calcolato lo scorso anno

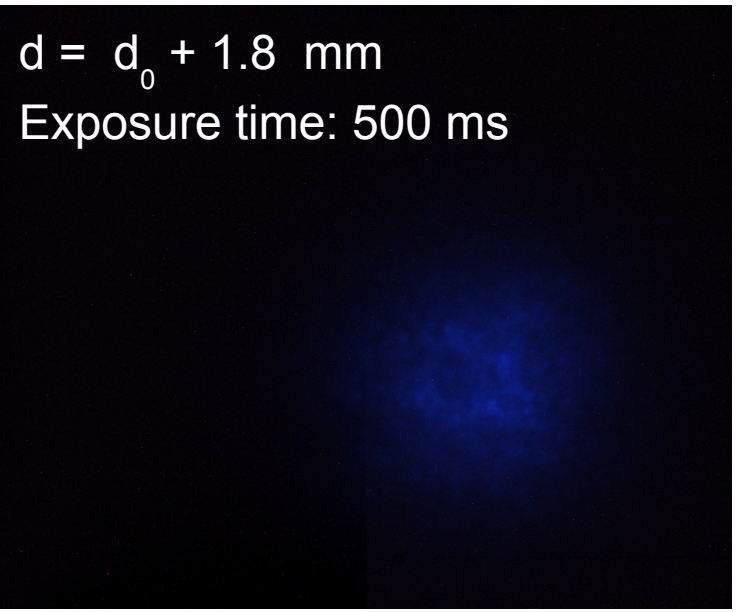
Laser – SM fiber distance optimization / 2

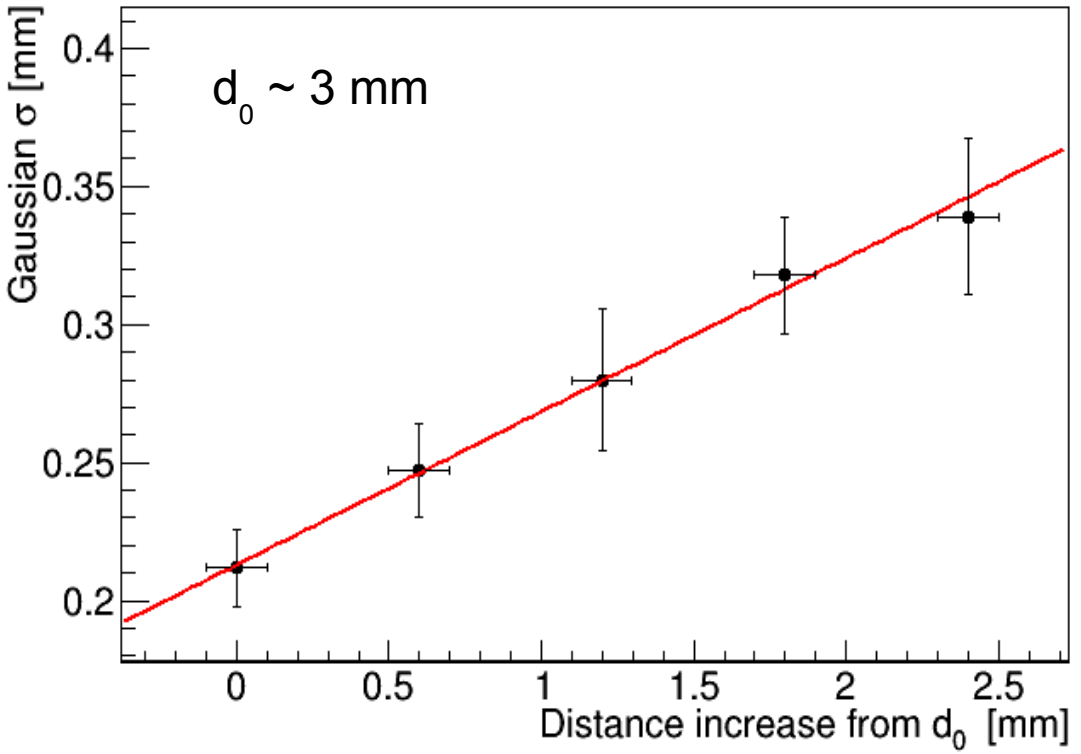
In collaboration with
Alessandro Re (INFN Torino)



2.90 mm

3.47 mm



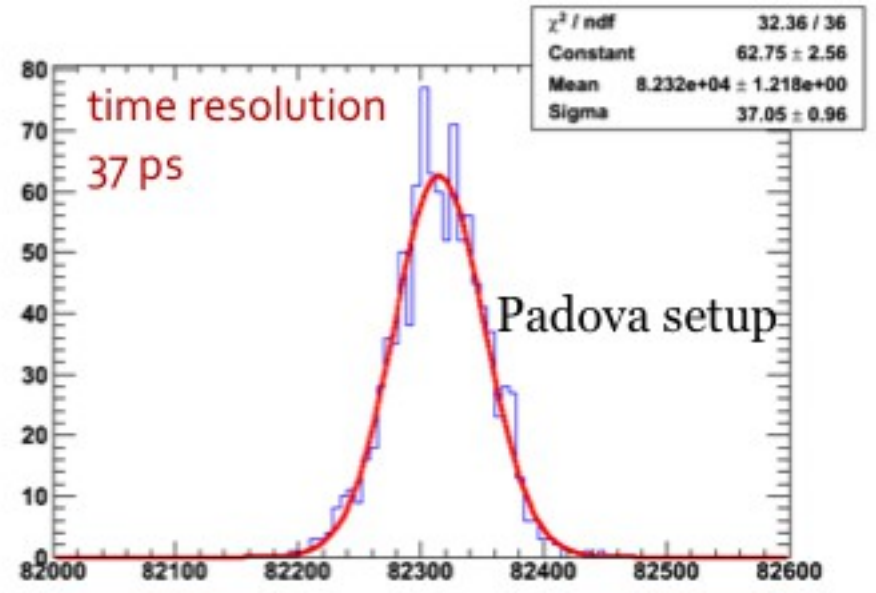


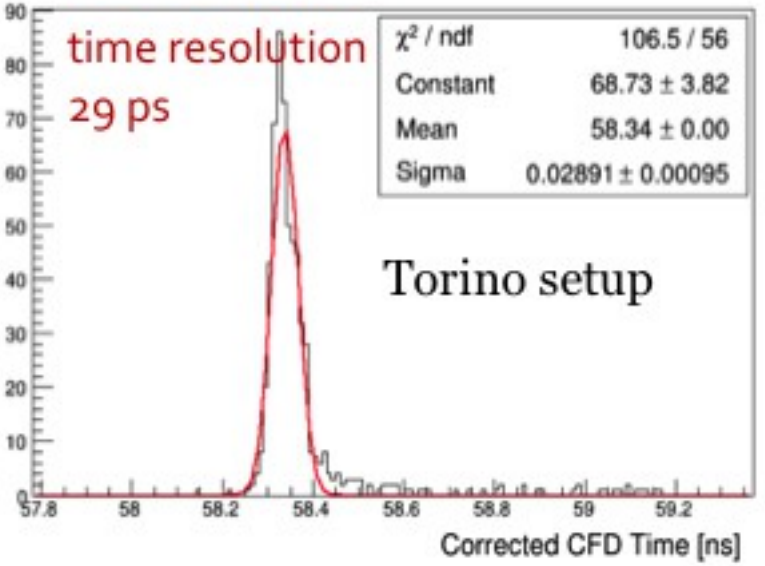
From the linear fit:
tan(Θ/2) = 0.056 ± 0.014
Θ = 0.11 ± 0.02 rad

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





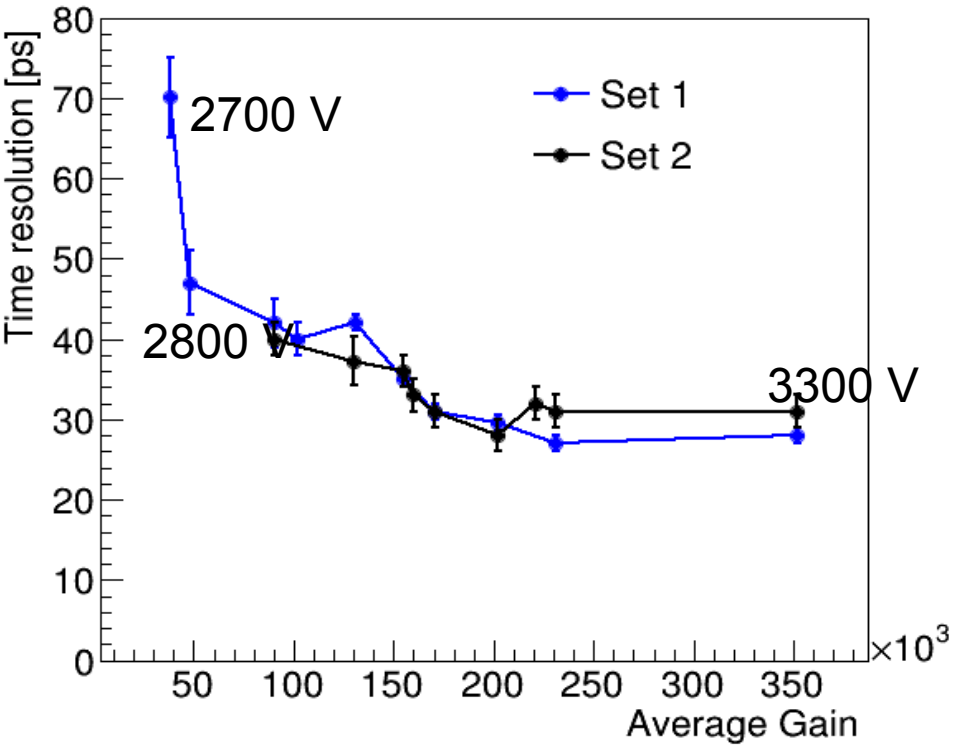
More time resolution studies

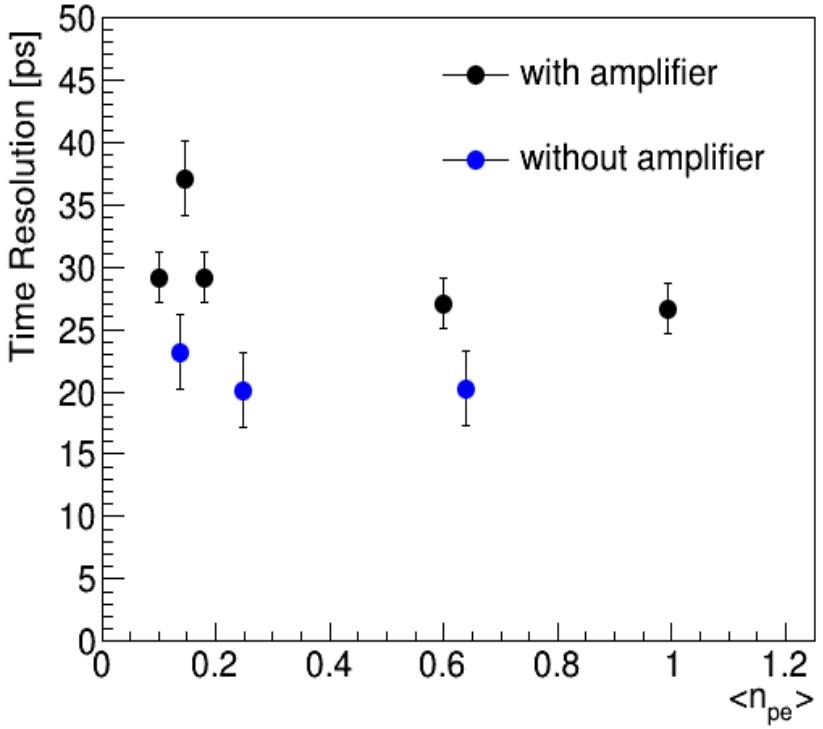
Torino, UT studied time resolution vs HV,<n_{pe}>, PMT gain, ampli.

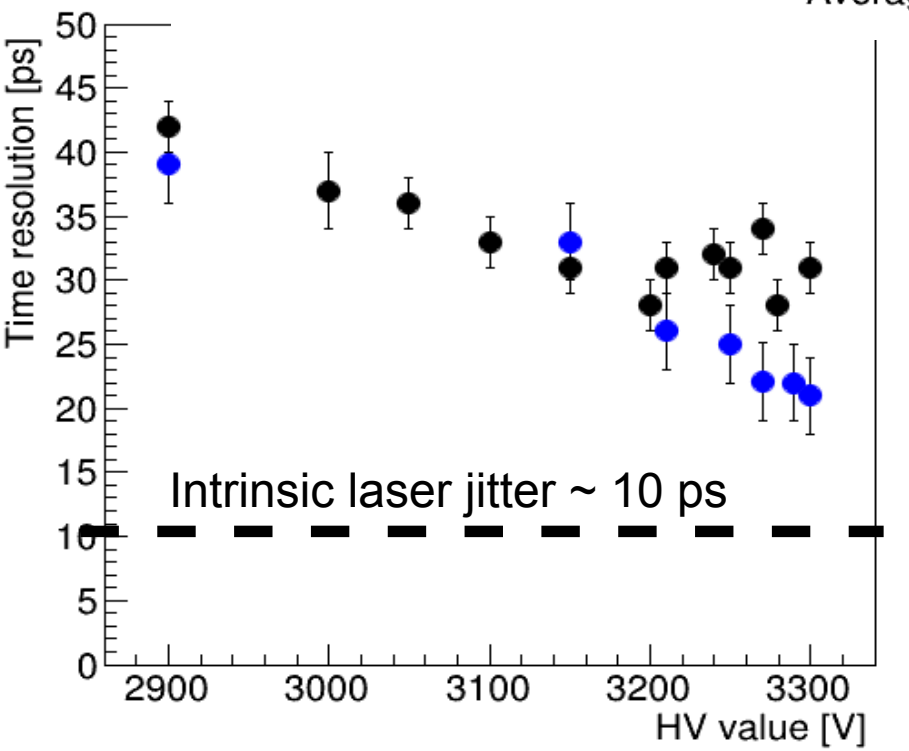
The nominal PMT operation point is at 3480 V. We have NOT operated it above 3300 V so far.

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

^ event-by-event measurement





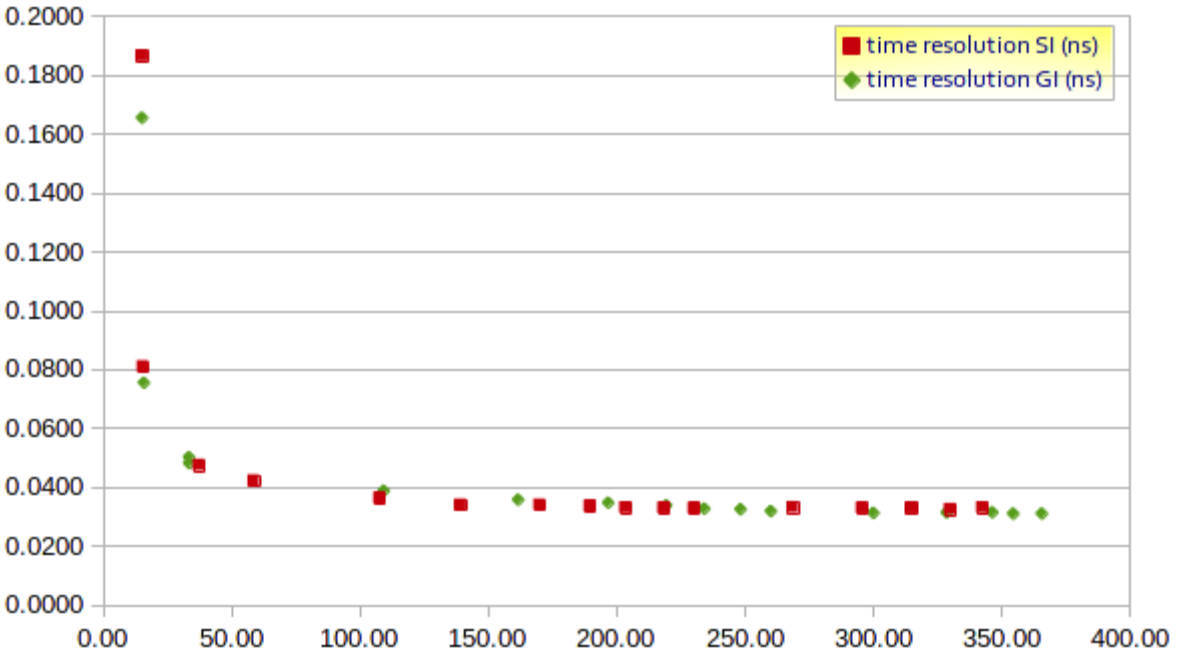


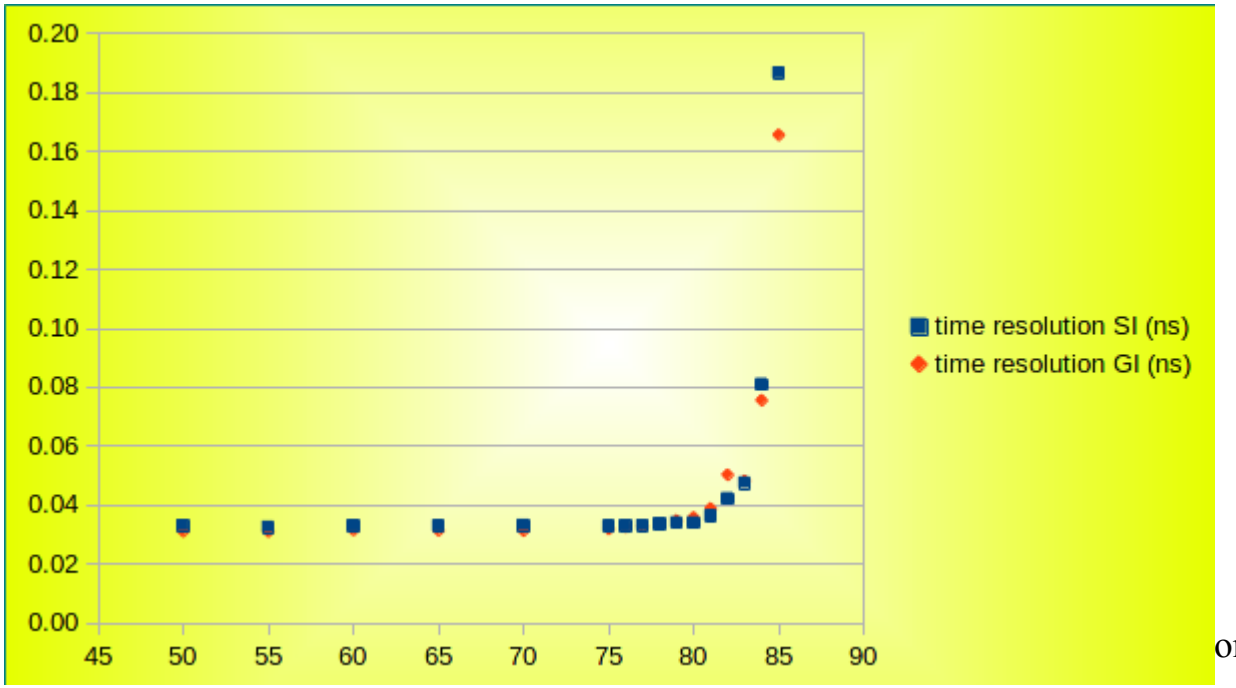
More time resolution studies

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





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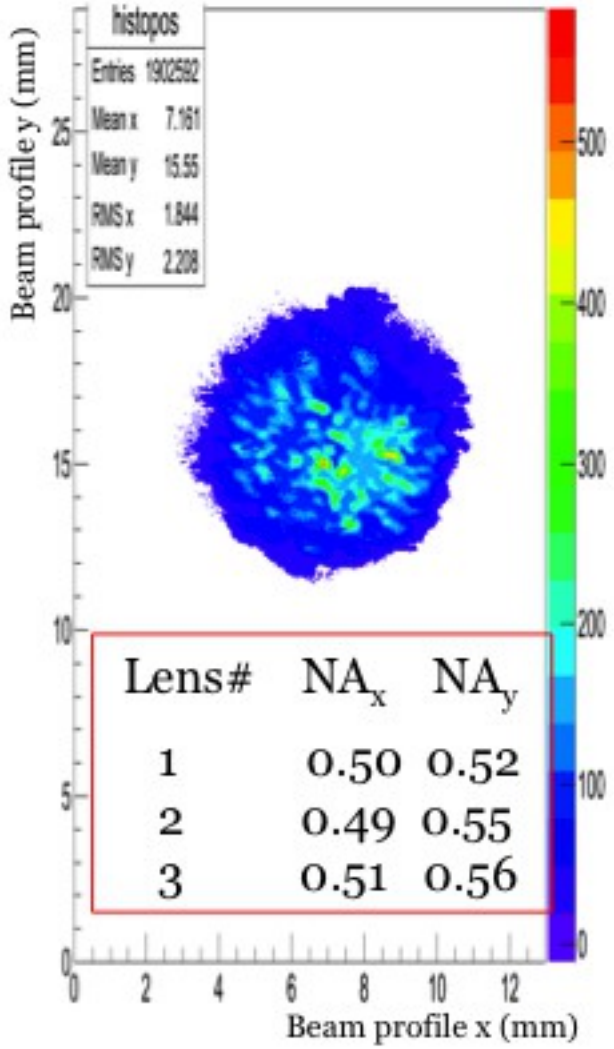
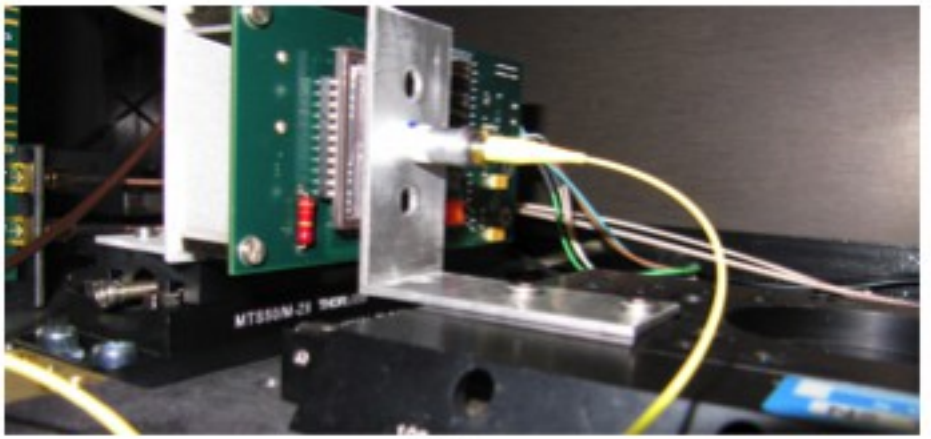
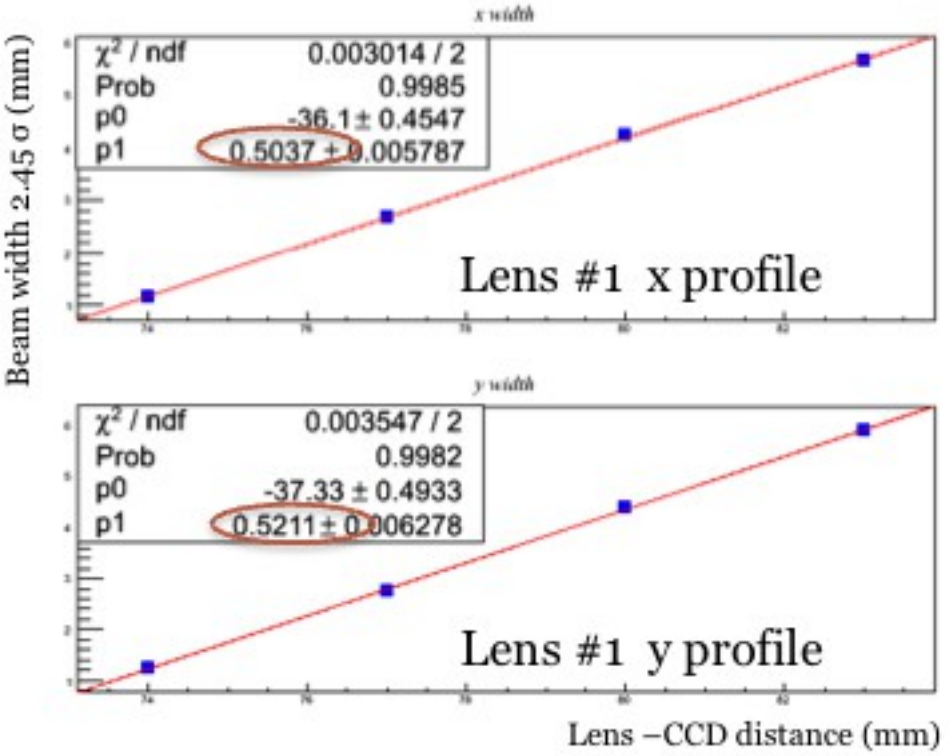
Numerical aperture measurements

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



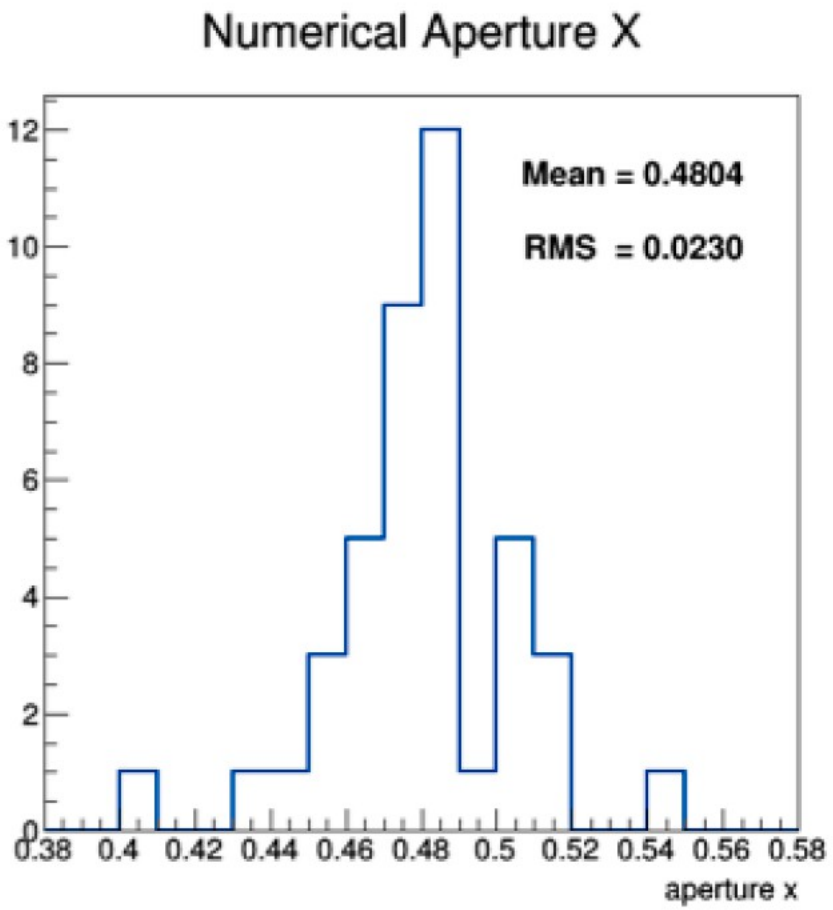
Lens#	NA_x	NA_y
1	0.50	0.52
2	0.49	0.55
3	0.51	0.56

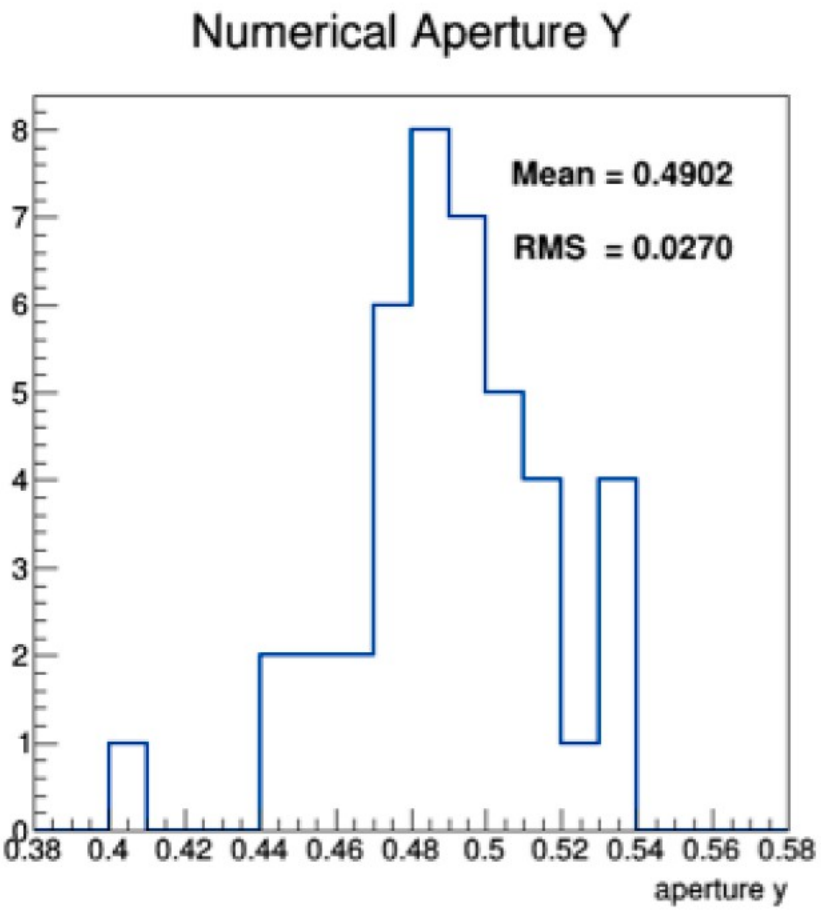




NA measurement for 42 lens without radiation:

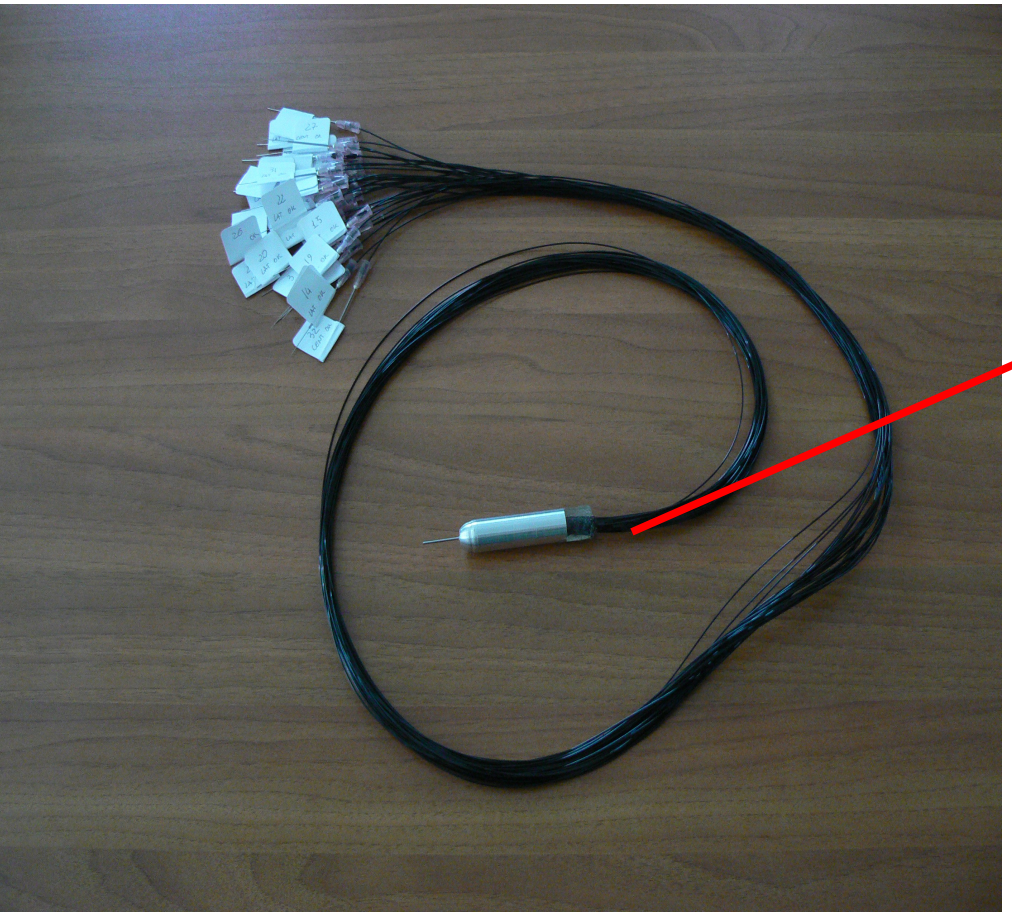
NA = 0.48 ± 0.02

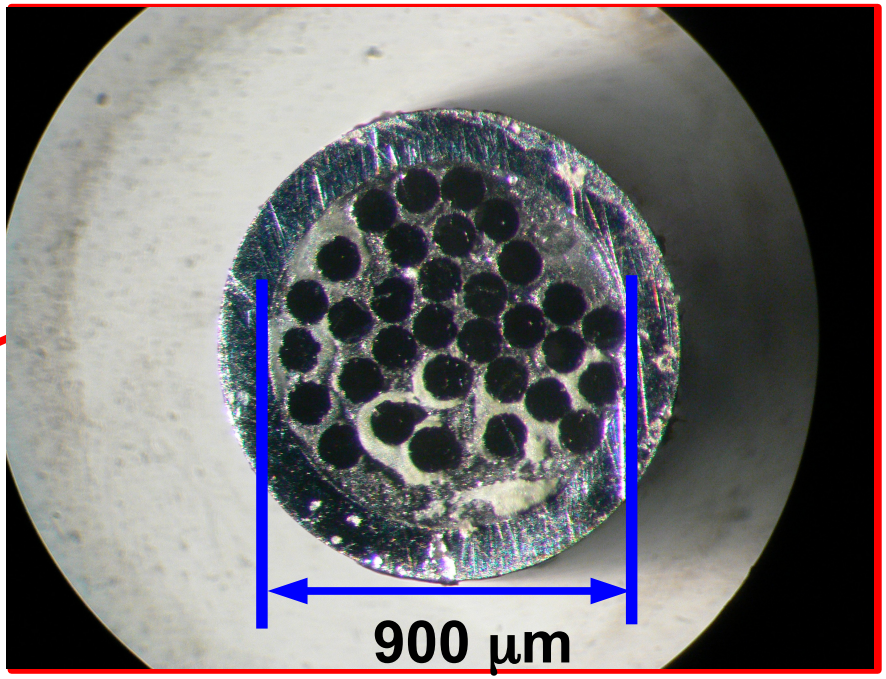




Single mode (SM) fiber bundle prototype

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}

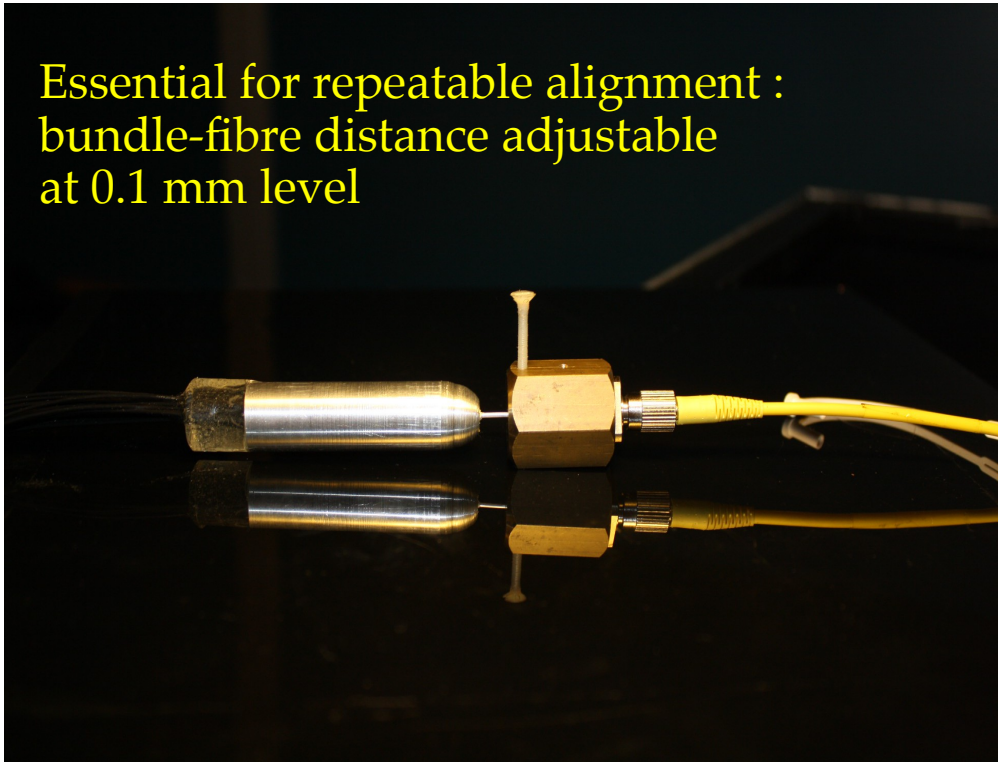
For homogeneous illumination, use only central part of the light cone:

ε_p(geo + 1σ) = ~4 x 10^{-4}

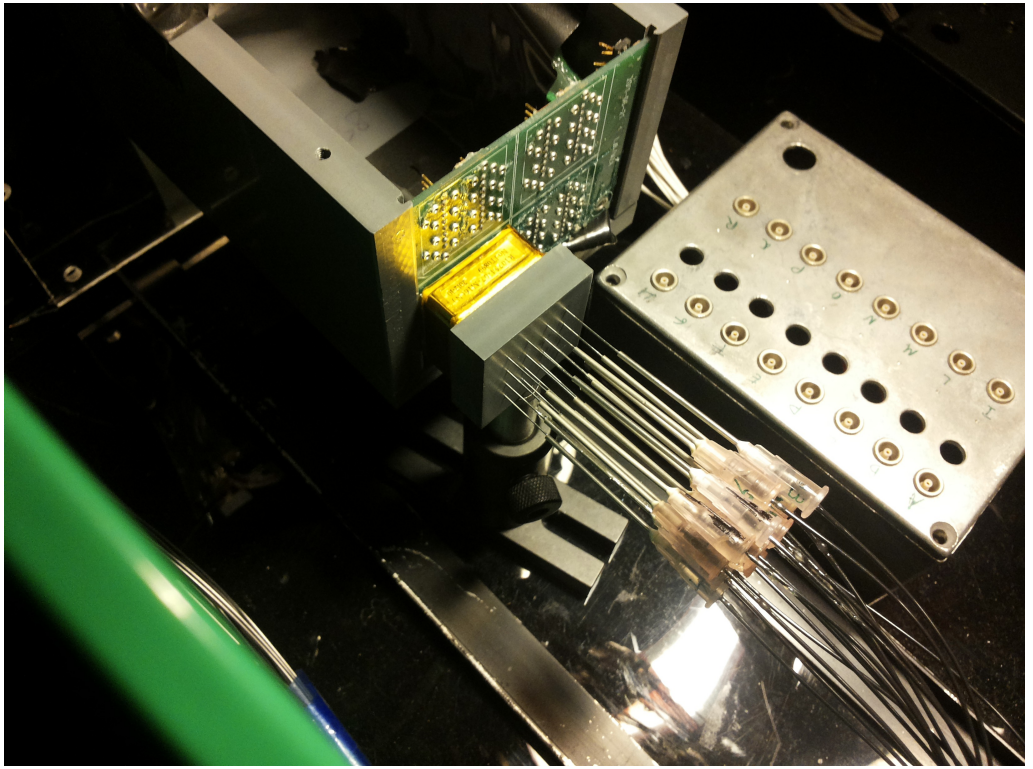
Best laser repetition rate for time resolution is 100 kHz→ 10 Hz/fiber

SM fiber Piping efficiency measurement (Torino)

Bundle-Laser alignment support



16-fibre support



16-channel readout with CAEN V1742 switched capacitor digitizer

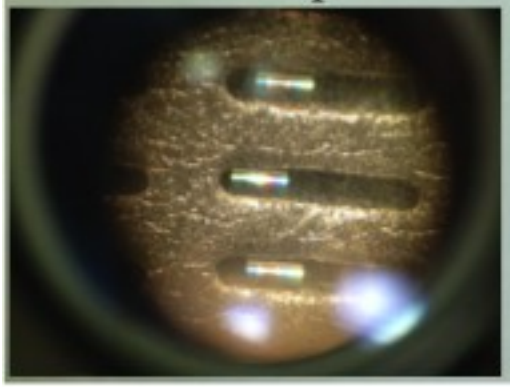
Light injection in the QBB

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



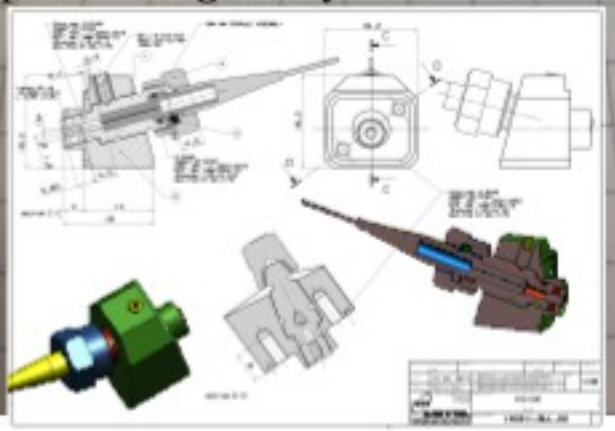
Assembling of the cylinders with the fibers

5 mm

Open washer

O-ring

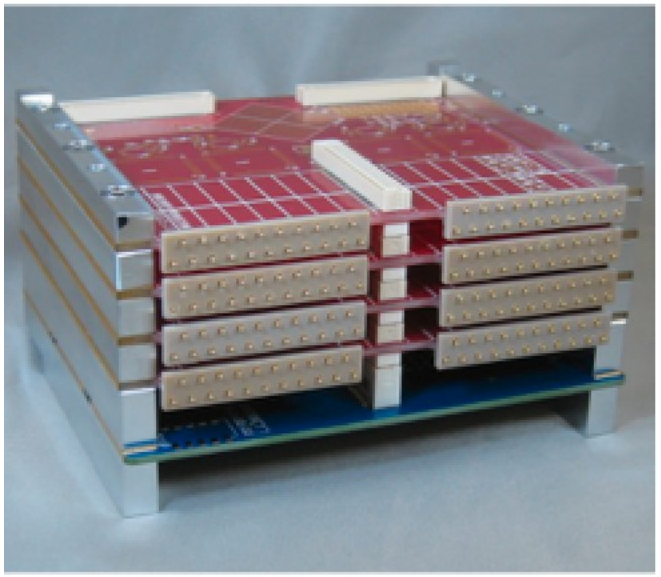
Connections between fibers, grin lens and iTOP prism designed by the PD mechanical workshop



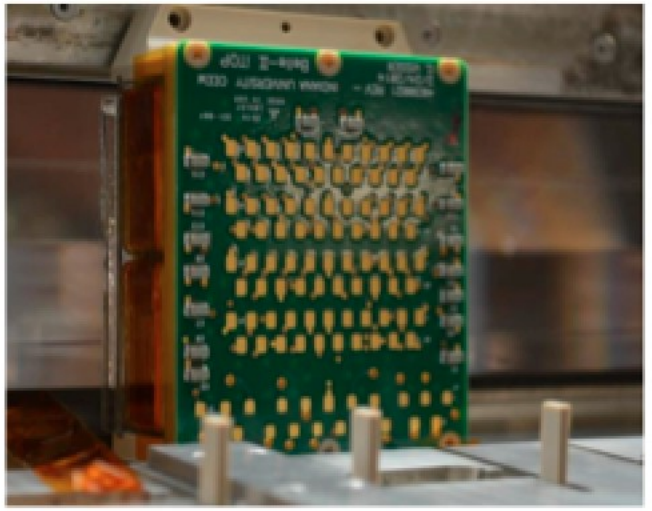
Reduced axial loading on prism

- Based on reviewer feedback and ease of making bubble-free optical joints between MCPPMTs and prism using oiled optical cookies we reduced pressure by a factor of two from ~100 kg to ~50 kg
- Assuming load is carried by forward PEEK stops, stress in quartz is 650 psi, safely below the maximum design stress of 1000 psi

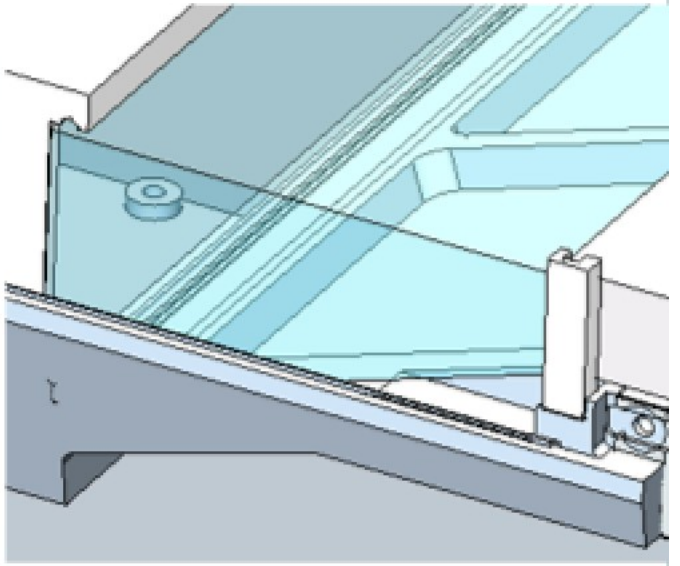
Electronics



PMT with socket



Prism

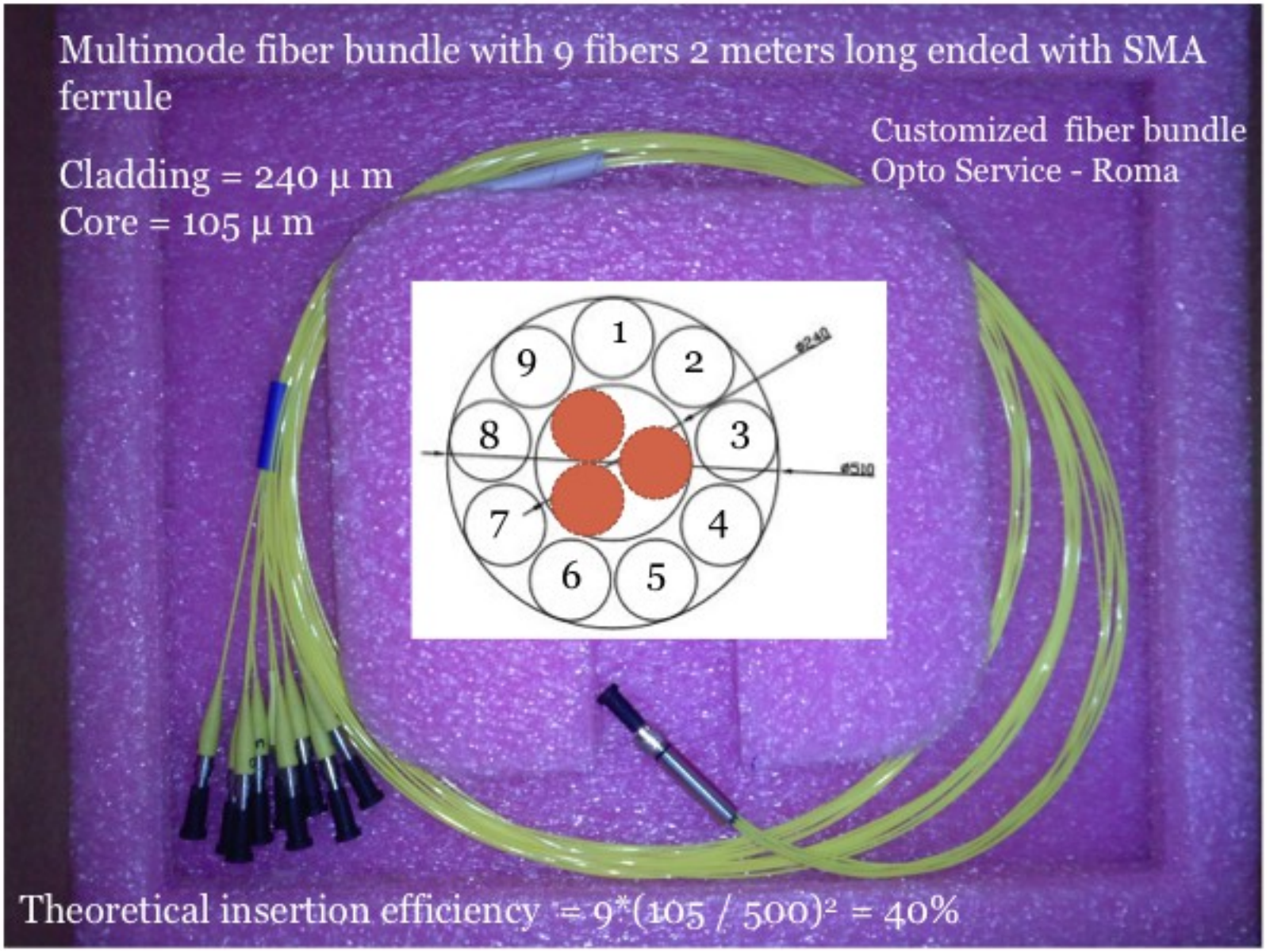


Plastic 3D print:

Blocks, cylinders and nuts can be produced with plastic material with 3D printer.

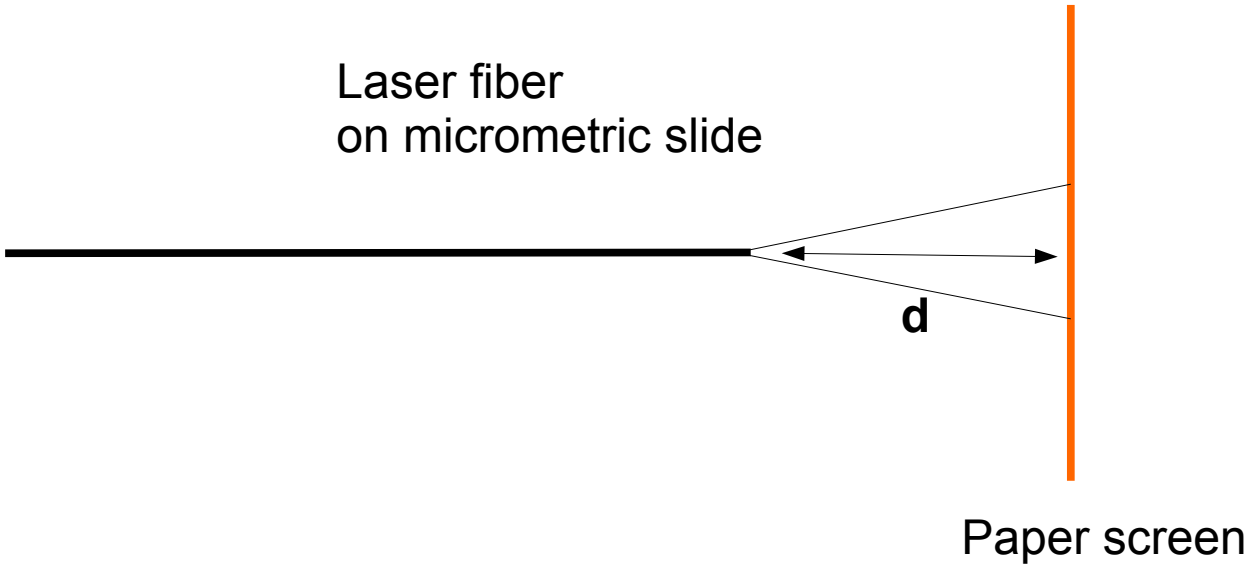
Several cylinders printed and used to measure the performance of lens radiated with neutron flux at the Legnaro INFN laboratory

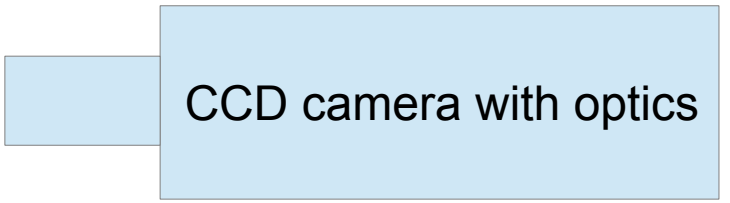
Multimode fiber bundle for Module #1



Laser – SM fiber distance optimization

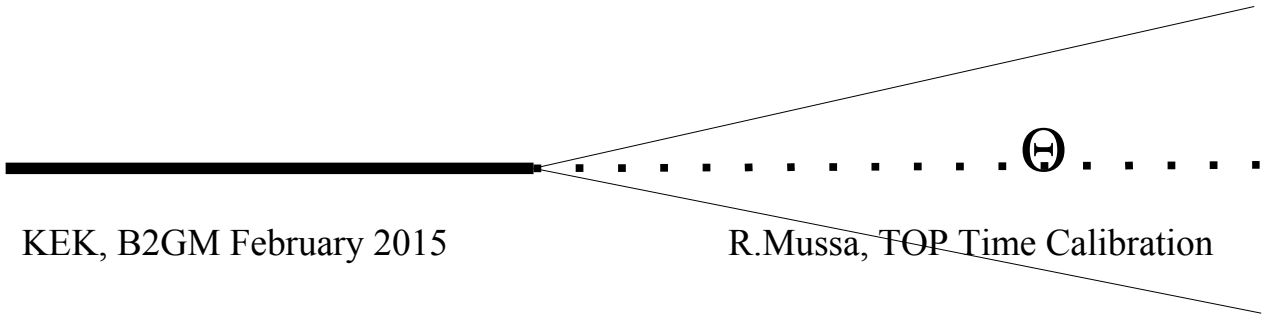
In collaboration with
Alessandro Re (INFN Torino)





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