Trigger Detector Upgrade

TDR Editorial Meeting
CERN, June 12, 2013

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on behalf of the team preparing the Trigger Detector chapter

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Preliminary content of TDR trigger chapter

- The purpose of Trigger Detector Upgrade
- Required functionality, latency and compatibility with current trigger
- Proposed readout scheme (requirement to follow TOF readout)
- Space envelope on the C side (A side not critical)
- The baseline for T0 upgrade
  - Description, properties, simulations, test results, etc.
- Redundancy and additional funcionality
  - The baseline for V0 upgrade
- First cost estimate and timetable
- List of participating institutes
- Conclusions

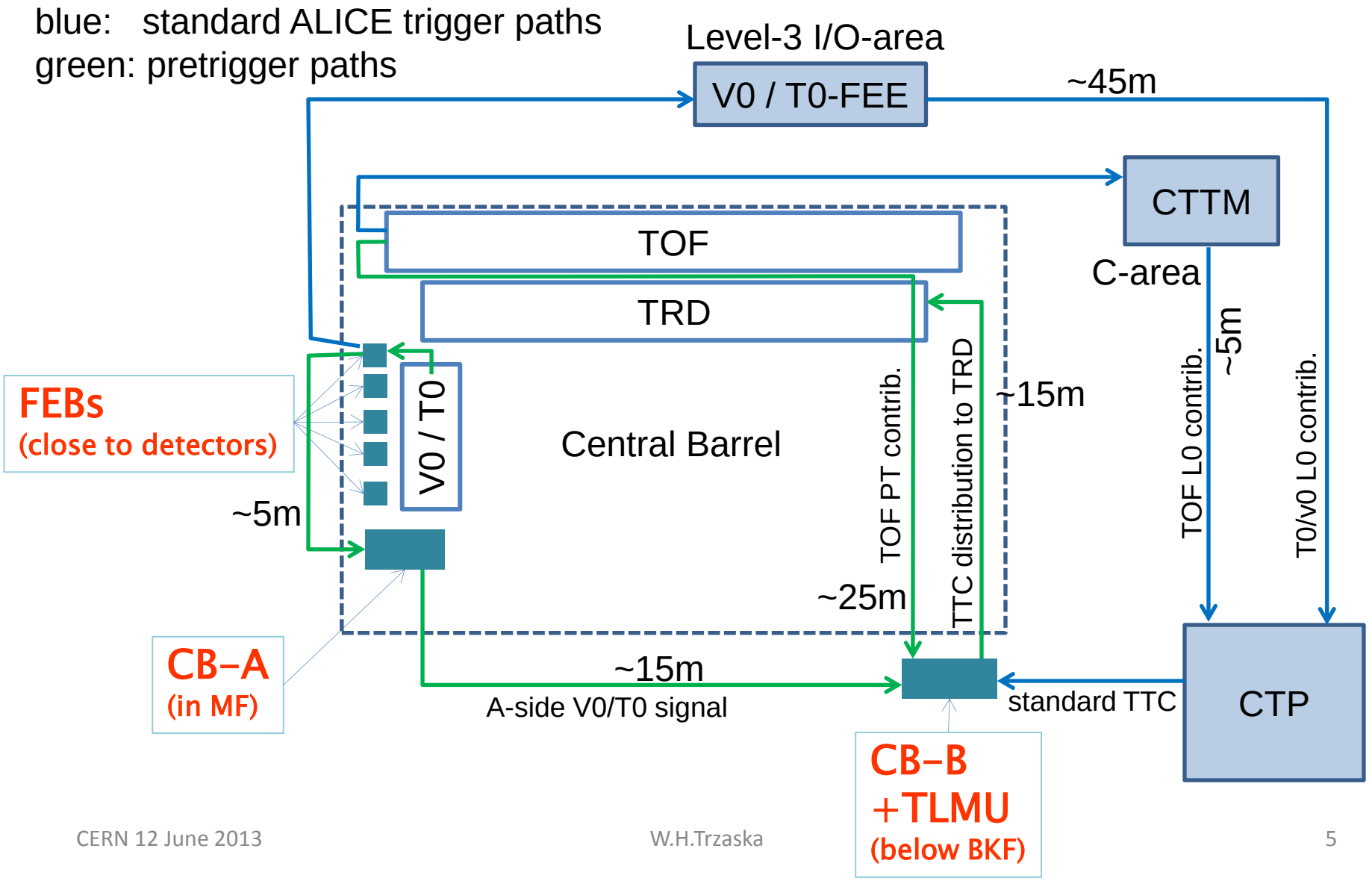
The purpose of Trigger Detector upgrade

- To provide ALICE with a reliable, efficient and flexible trigger detector capable to deal with the increased luminosity and bunch crossing frequency of the upgraded LHC.
- To fit into reduced **space envelope** imposed to accommodate MFT – the new forward detector.
- To maintain the functionality and performance that was secured by T0 & V0 detector.
- To increase robustness of the trigger and minimize aging phenomena observed during 2009 – 2012 running period.
- To reduce trigger generation **latency**.
- To eliminate or substantially reduce after-pulsing
- To provide **common readout** architecture compatible with that of the ALICE TOF detector.
- To updated and refine the front-end electronics.

Additional functionality requested of the upgraded T0 trigger detector

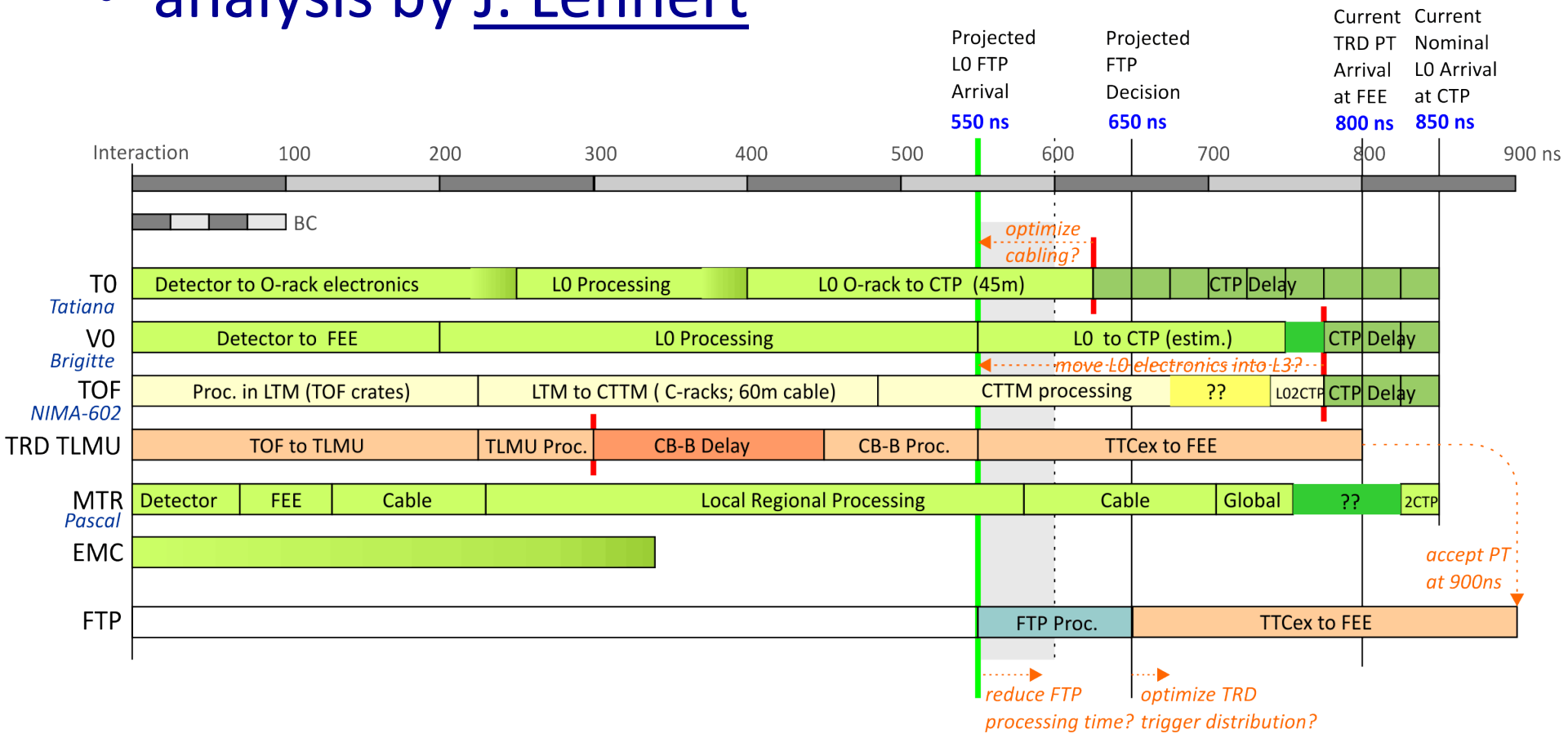
- Monitor LHC beam conditions,
- Measure the luminosity,
- Reject beam-induced backgrounds
- to measure basic physics quantities
  - Particle multiplicity
  - Centrality
  - Event plane of nucleus-nucleus collisions (V0 equivalent)

Latency reduction is to be implemented already during LS1 (chart from K. Oyama)



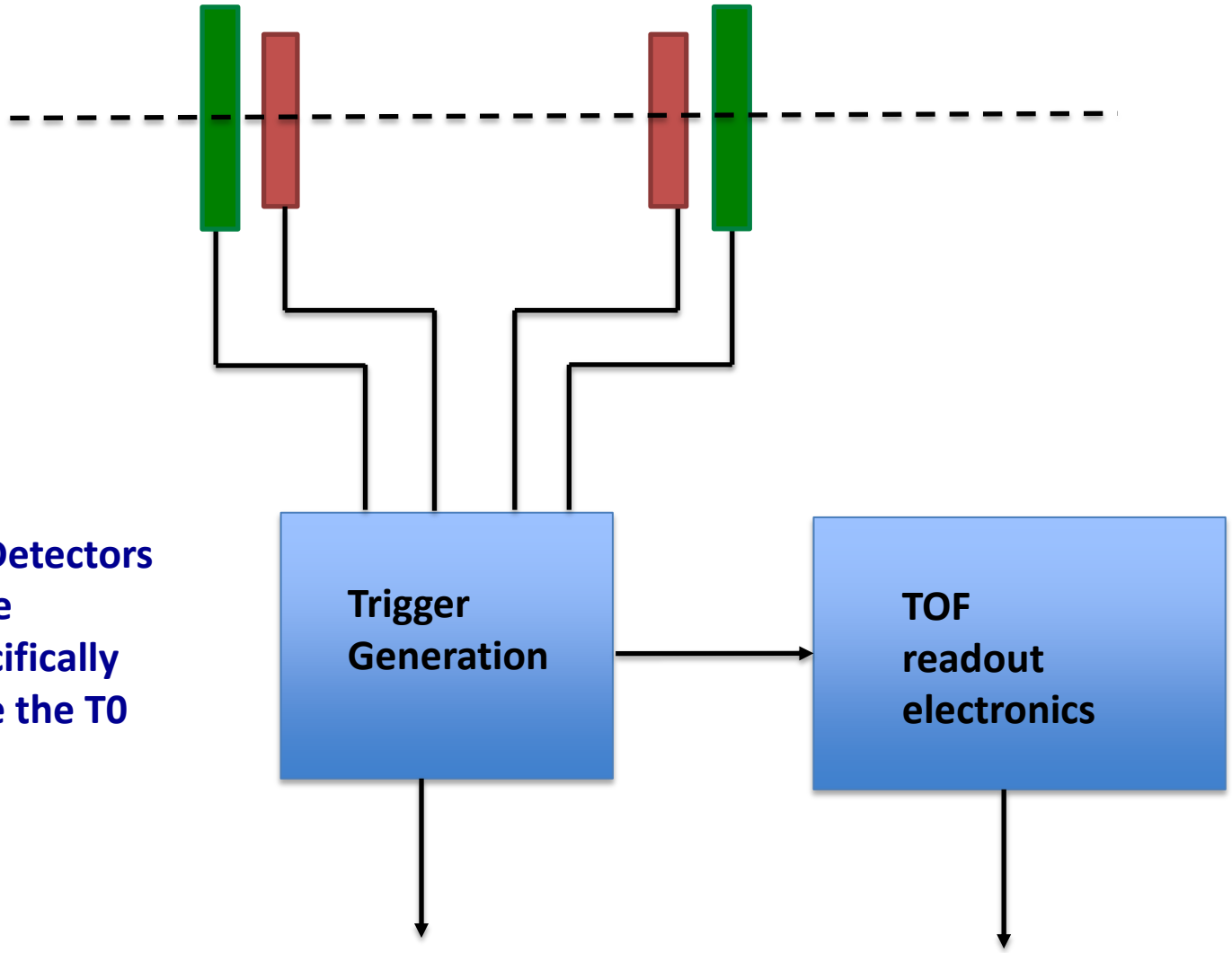
Individual L0 contributor detector timing

- analysis by J. Lehnert



Common readout of Trigger Detectors

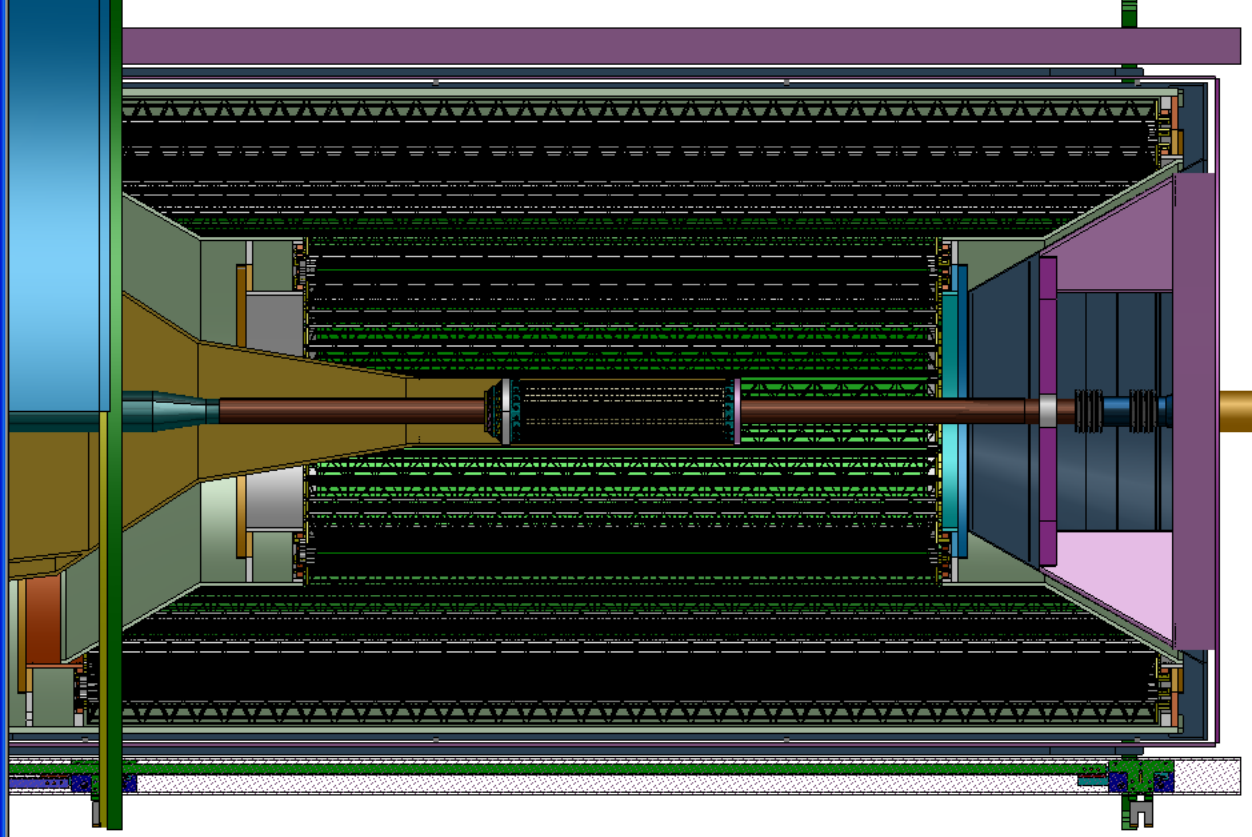
as proposed by **W. Riegler**

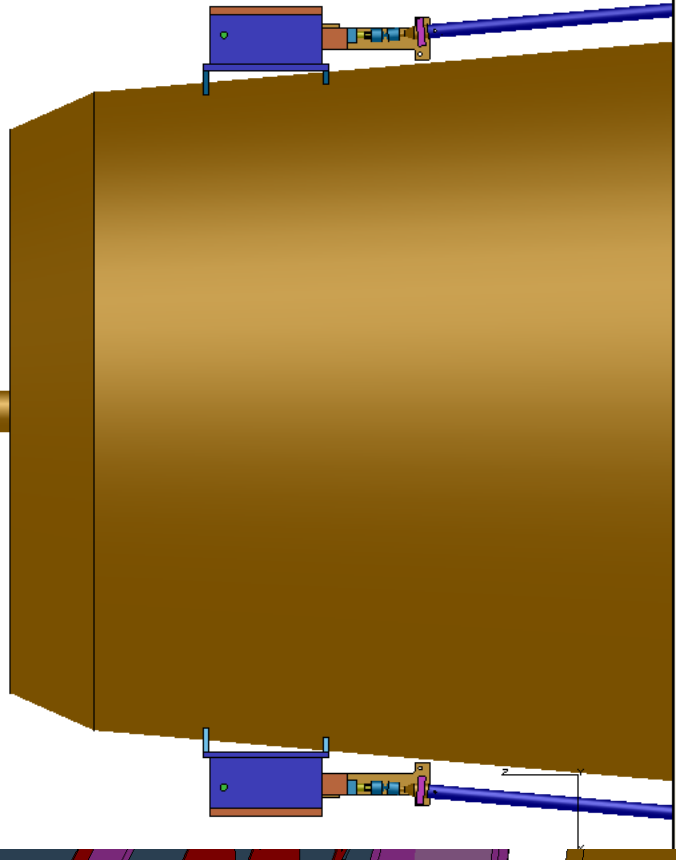


Interaction Trigger Detectors Should use the same electronics and specifically the TOF readout like the T0 does presently

Space envelope on the C – side (status from 24/05/2013 from G.Corrado)

- The present ‘cavity’ between the absorber and ITS cage has a outer radius of 330 mm and a depth of 149 mm.
- This area will however still change a lot due to the pending MFT integration and final ITS layout, so we have to stick to an outer enveloping radius of 250 mm and a depth of 100 mm for the moment, which fits with the present T0 proposal.
- The inner enveloping radius will depend on the question whether we want to place the detector on the absorber or on the ITS mechanics, which would make it removable/serviceable without moving the TPC.
- In case it is sitting on the absorber, an inner enveloping radius of 50mm is feasible.
- In case it is sitting on the ITS cage, a minimum inner radius of 60 mm must be assumed.

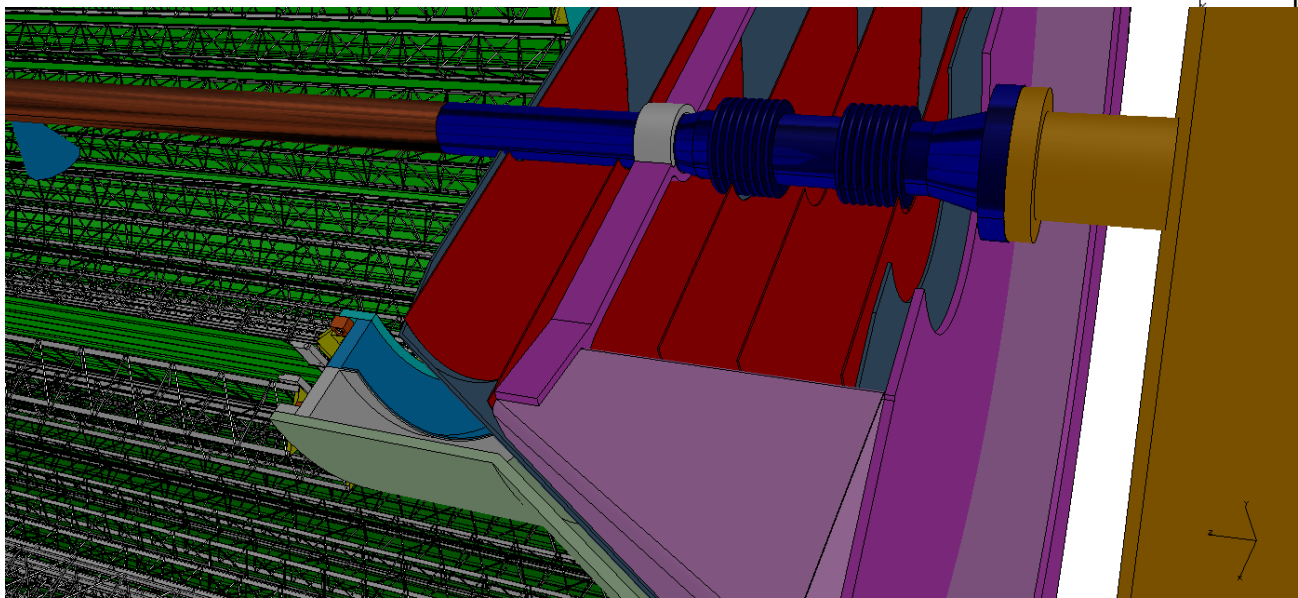


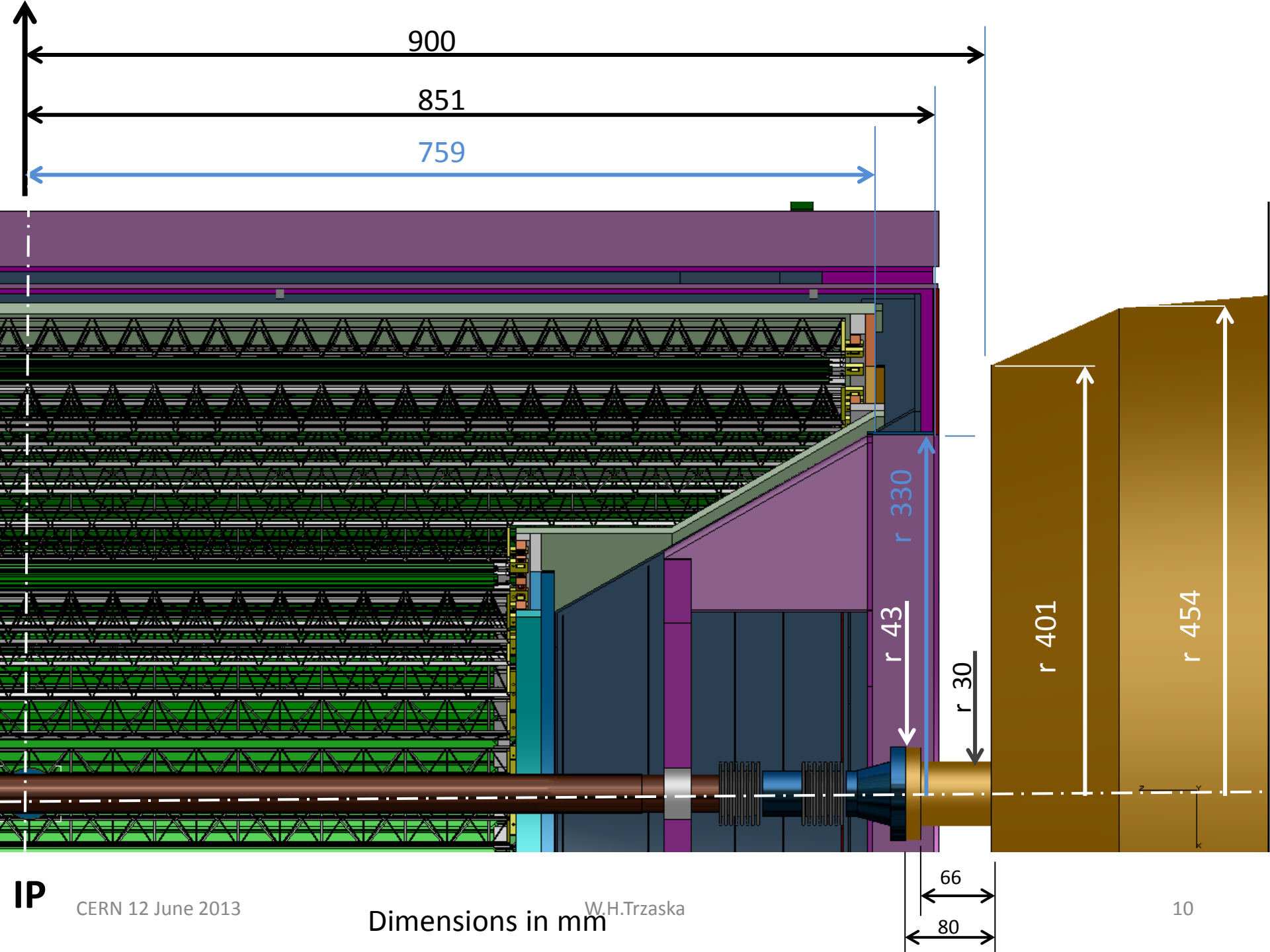


Trigger detectors C-side nominal envelope

ALICE

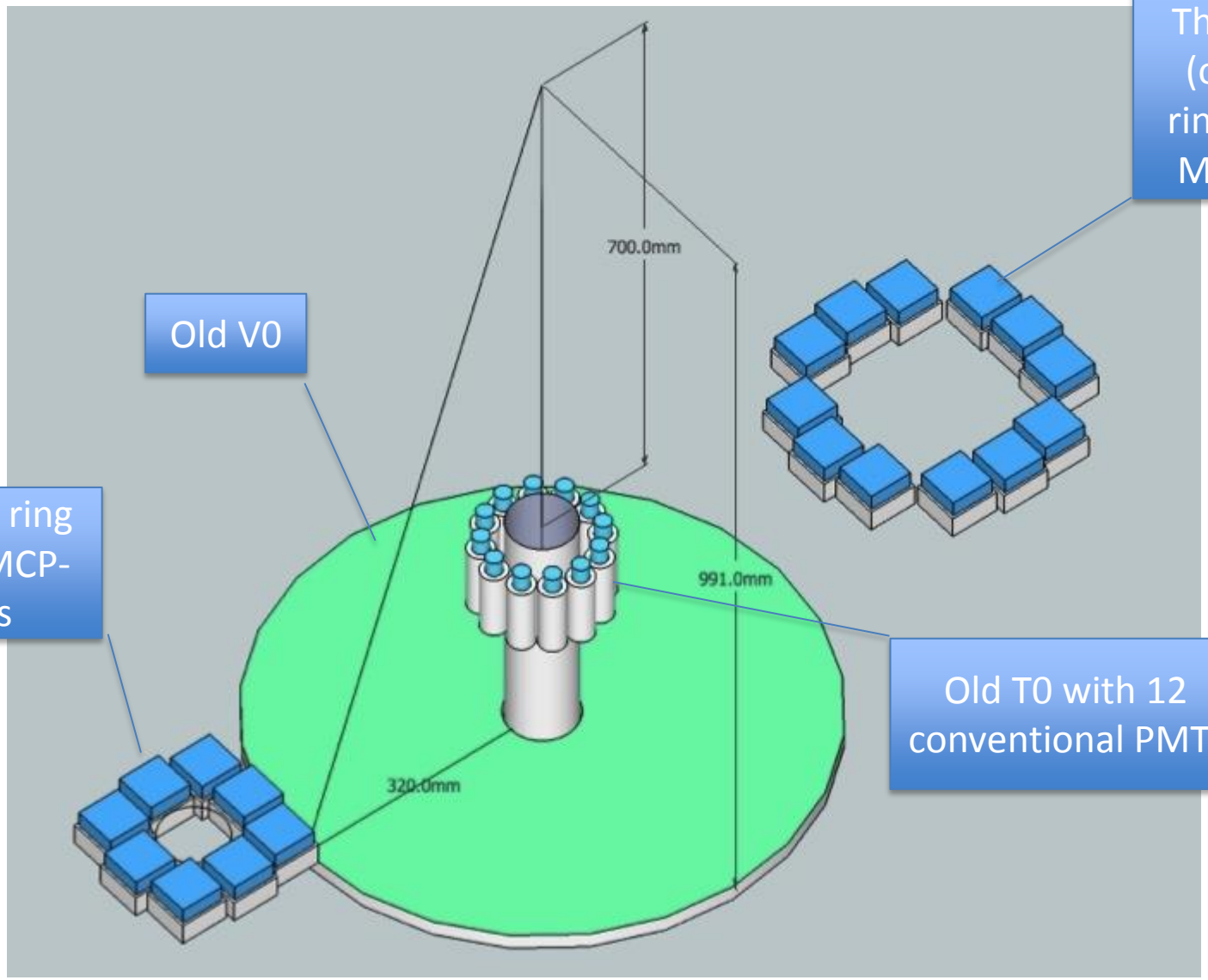
CERN 12 June 2013



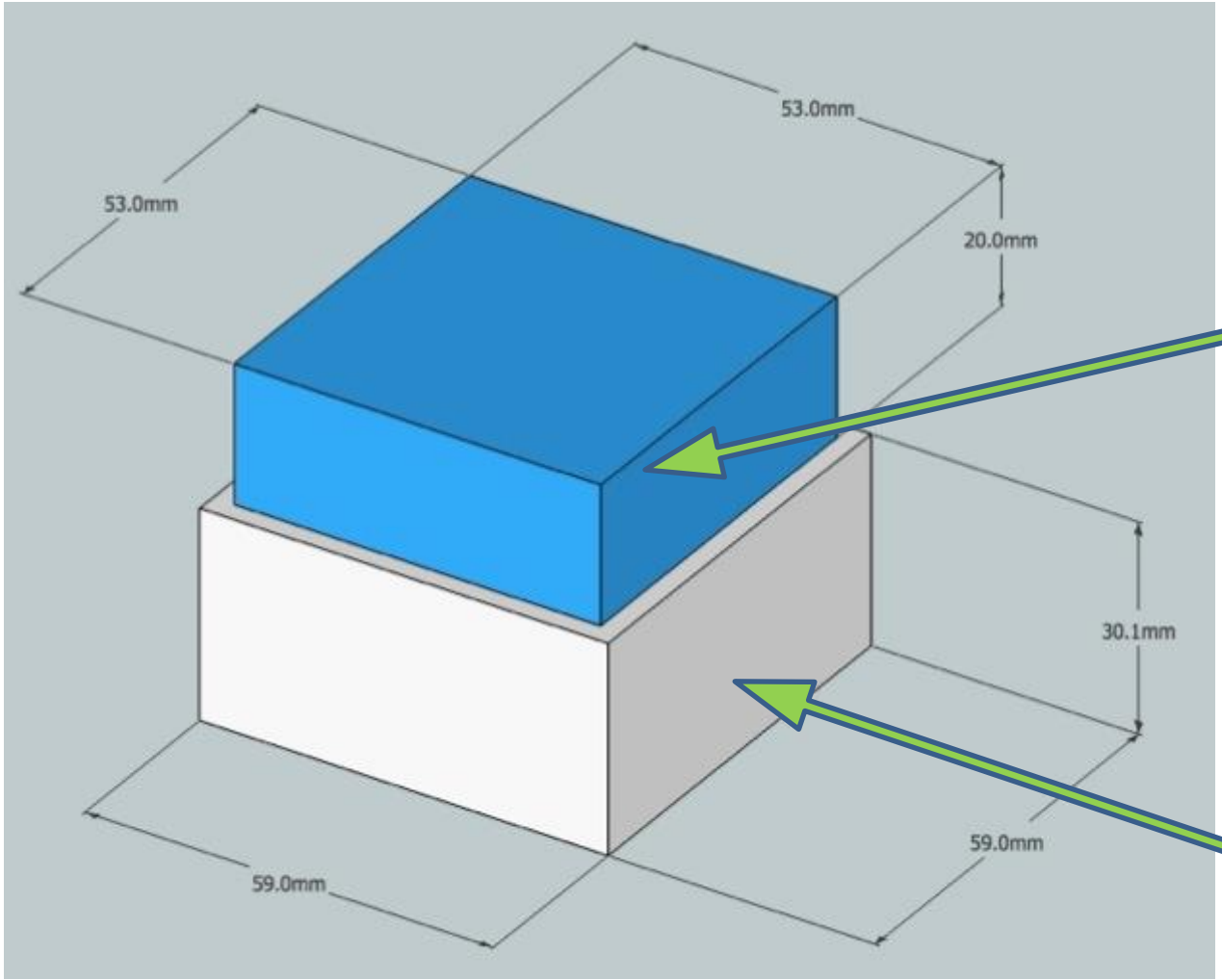


Dimensions in mm

The proposed Trigger Detector



Dimensions of the new detector unit



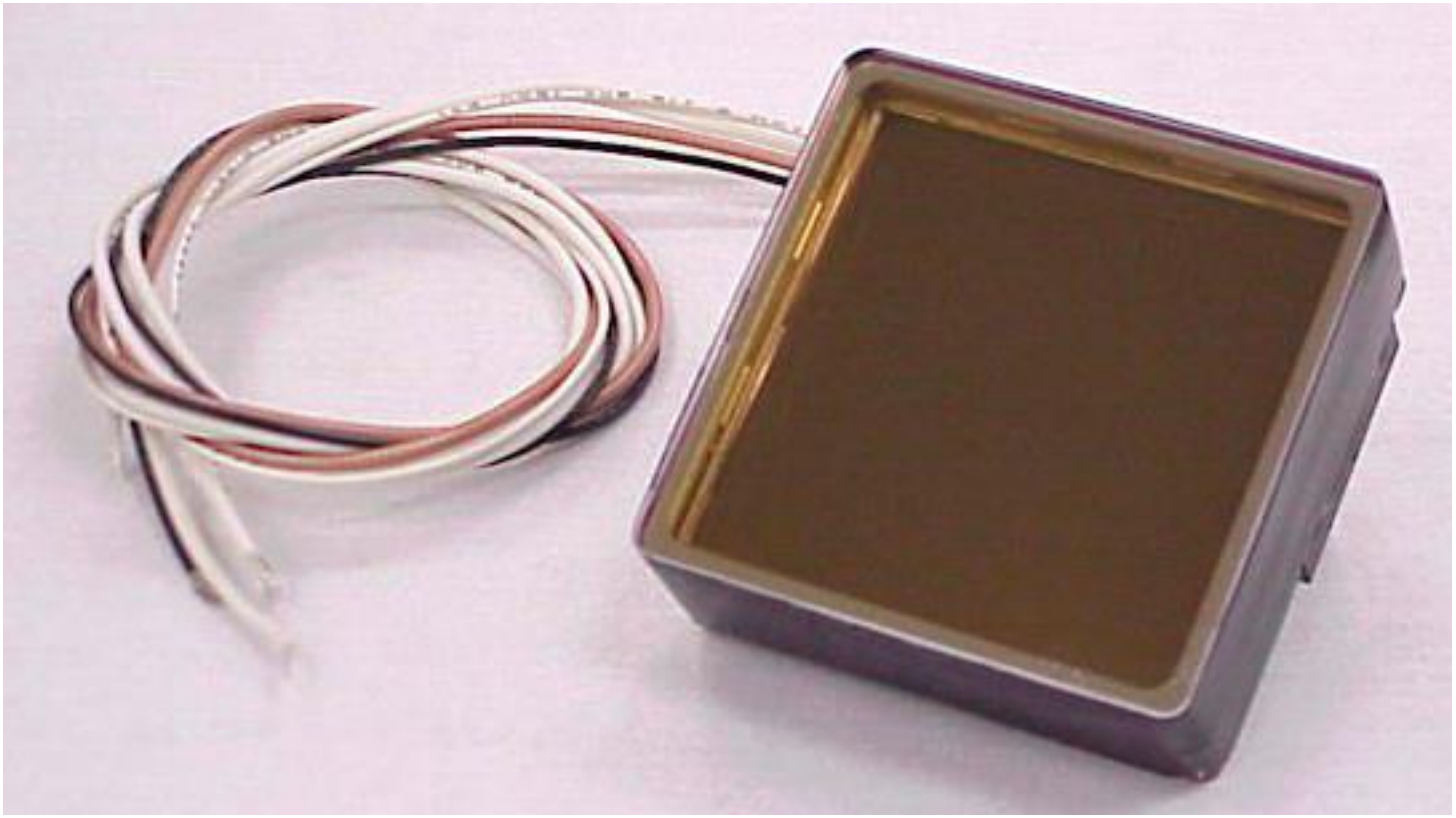
New T0 Quartz radiator

Active Area: 53 × 53 mm²
Thickness: 20 mm

Will be made from a high purity, synthetic, fused silica material SUPRASIL®1 manufactured by the Heraeus Company, Germany

MCP – PMT

Photonis PLANACON® **XP85012**

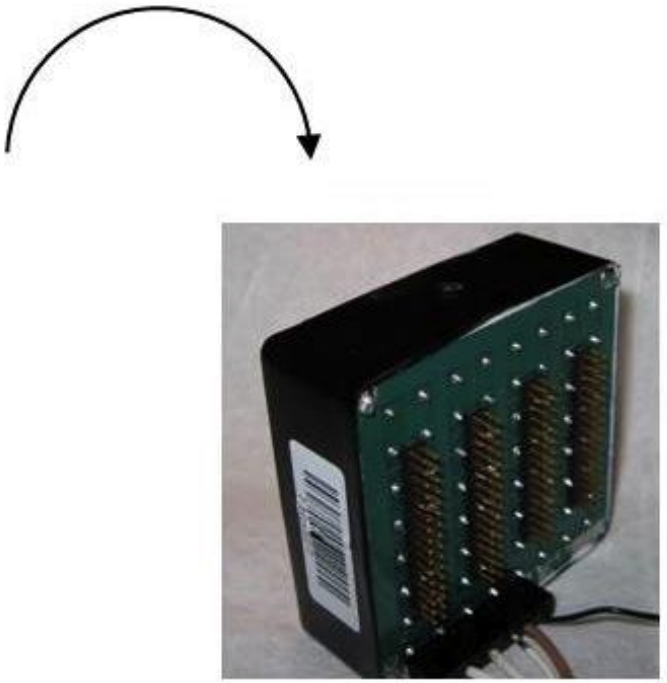


Cost (2012): **XP85012/A1-Q - $8,830**

XP85012

PLANACON®

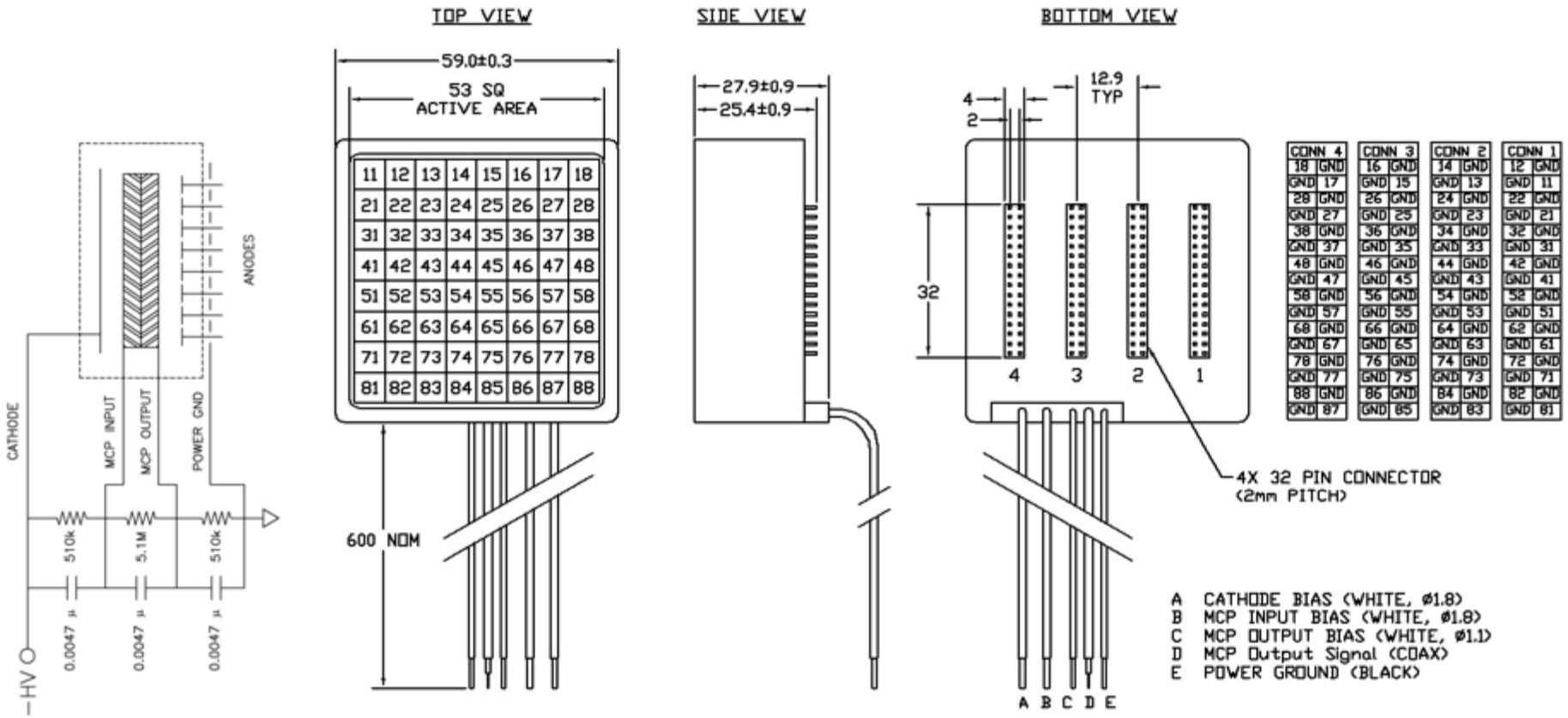
Window-side

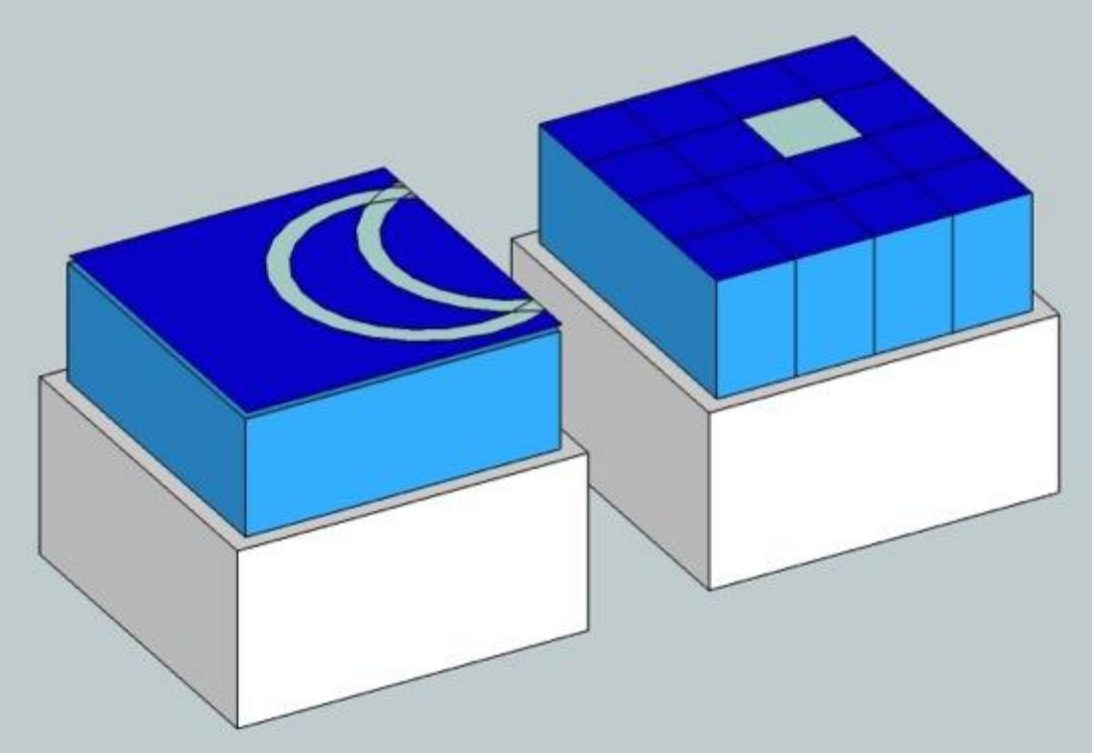


Back-side

Overall thickness ~30 mm

The anode of **XP85012** is **subdivided** into **64** units. This feature, together with fragmented radiator, could be used to **improve performance** and add **tracking ability** to T0



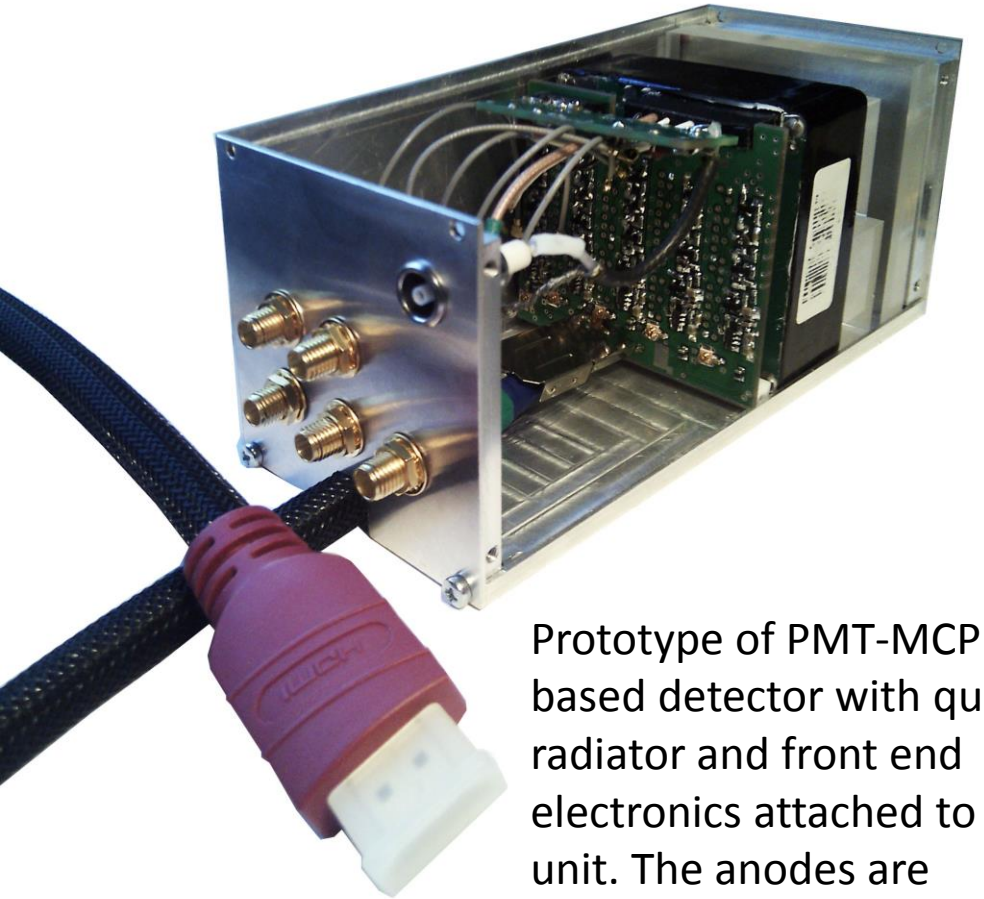


Solid vs. fragmented quartz radiator

In case of a **solid radiator** the Cherenkov ring of light generated by a MIP spreads over a large surface of the light sensitive element. To register that diffused light, **higher amplification (HV)** is required.

The inner walls of a **fragmented radiator** reflect the light and contain it within the sub-unit of the radiator. As a result the light intensity falling on the MCP surface is higher. Therefore **lower amplification (HV)** is needed.

Thickness estimate of the new T0 module



Prototype of PMT-MCP based detector with quartz radiator and front end electronics attached to the unit. The anodes are divided into 4 groups with individual amplifiers.

~15 mm – optical fiber

~20 mm – Quartz

~30 mm – PMT-MCP

~20 mm – FEE

~15 mm – cabling

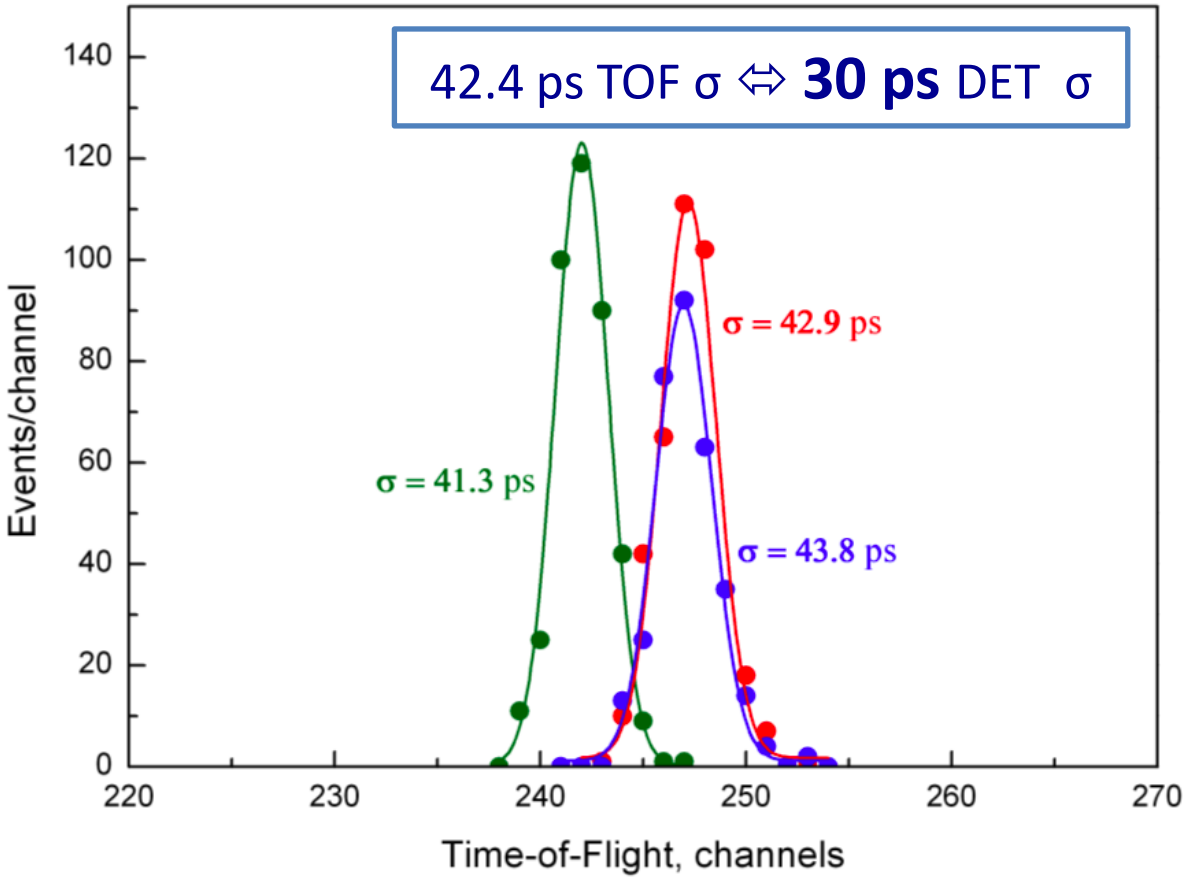
TOTAL = ~100 mm

Latest information on the **ongoing R&D**

- Properties of Photonis PLANACON® XP85012
  - Time resolution
  - After pulses
  - Simulations
  - etc.
- Choice and properties of quartz material
- Shape optimization of MCP-PMT modules
  - Price and availability
  - Performance

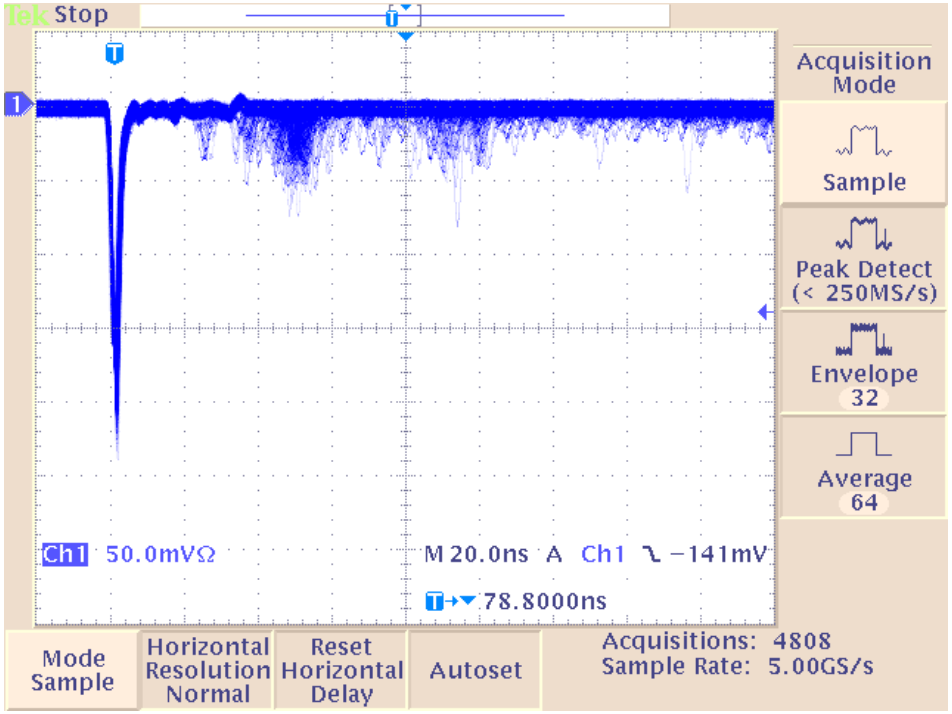
Time resolution at the level of 30 ps

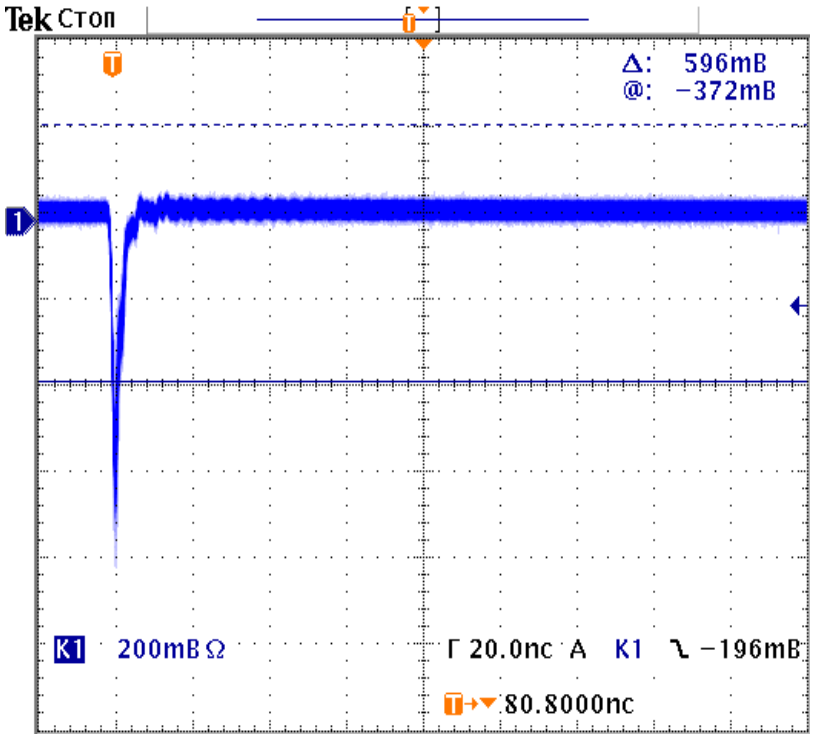
has been proven by several groups developing MCP-PMT detectors



Measured TOF resolution obtained with cosmic rays for various pairs of MCP-PMT detector prototypes

After-pulses are suppressed in MCP-PMT





PMT

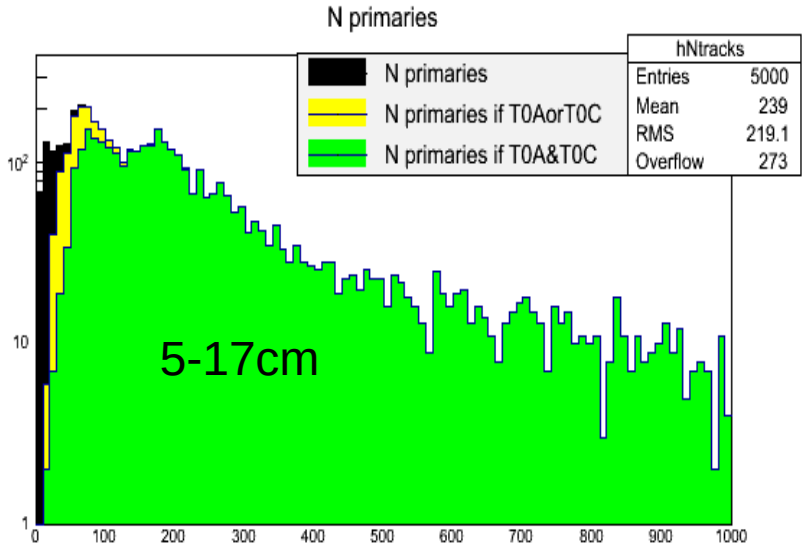
(used currently by T0)

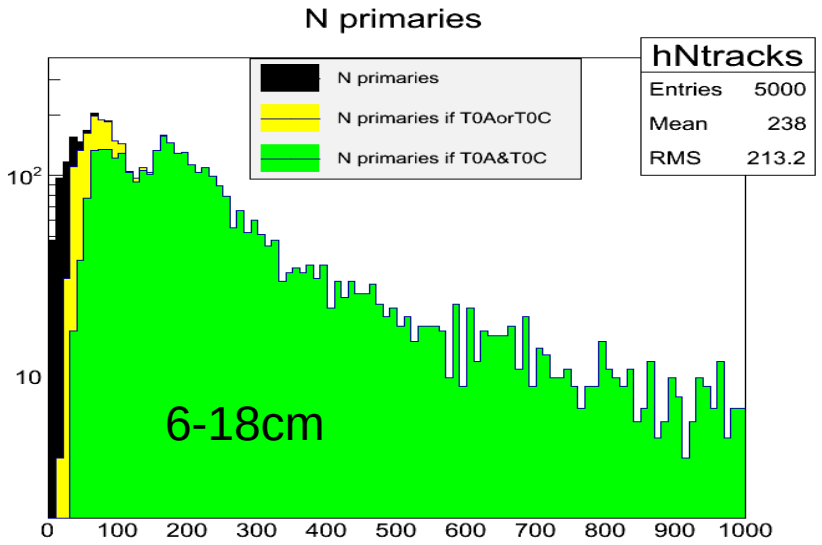
MCP-PMT

(proposed for T0 upgrade)

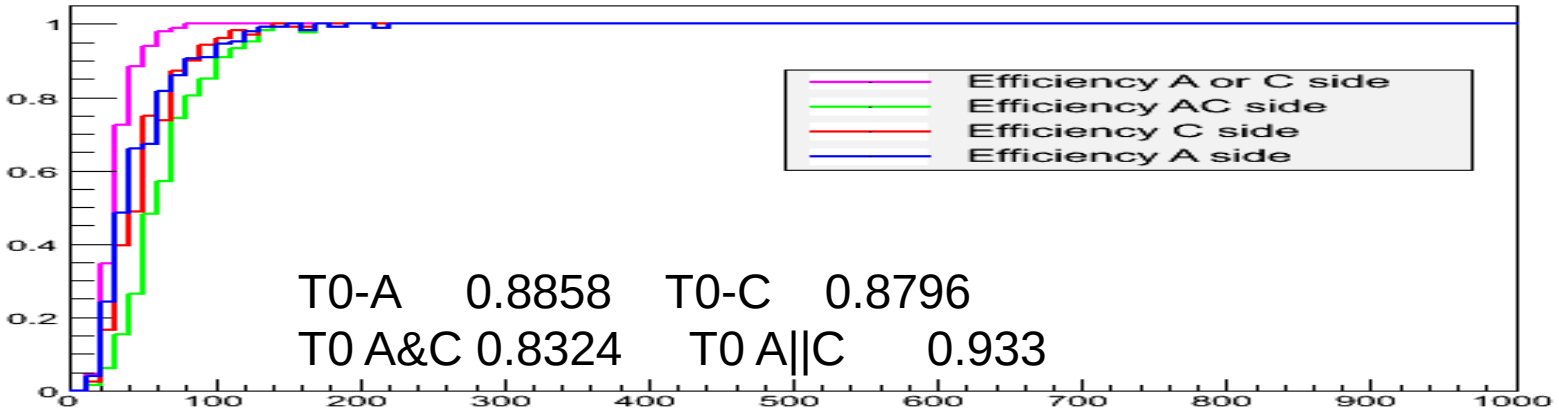
Simulation environment (ideal geometries)

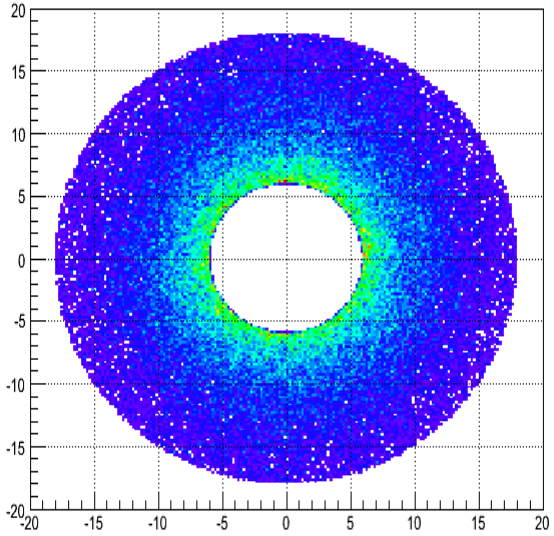
Aliroot trunk 29 May 2013
Generator PYTHIA6 14TeV
5000 events
V0 place : Z position detector face -90cm, 340cm
T0 place -75cm, 375cm
Air ring size 5 -17 cm
6 – 18 cm

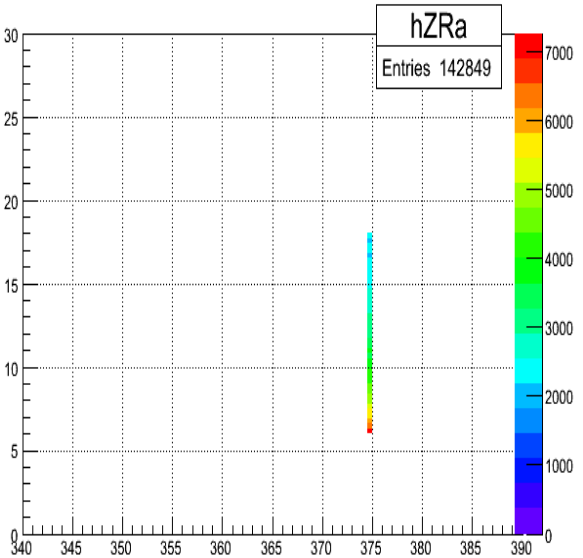


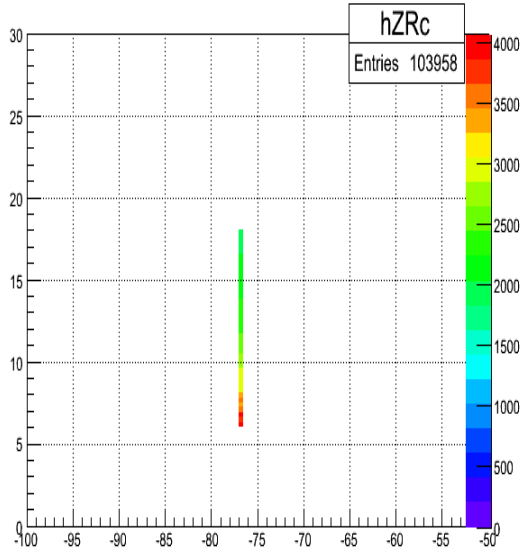


Radius 6 — 18 cm; T0 place; pipe upgrade









Comments on the **input options for MC** simulations

- **Intrinsic efficiency** of the new MCP-PMT based module is **~100%** for MIPs entering perpendicular to the surface of the radiator.
- The **geometric coverage** of the quartz radiator (the ratio of its surface to outline of the module) is $(53mm/59mm)^2$ = **80%**. The need for a mechanical support will reduce it a little **~73%**.
- **Side coating** of the quartz would reduce (if needed) the sensitivity to the entrance angle of MIPs.
- **Front coating** (black or highly reflective) will control the sensitivity to particles traveling in the opposite direction

T0 Efficiencies [%] for ideal geometries

	A (340cm)	C (-90cm)	A&C	A||C
old pipe	88	88	83	93
Pipe upgrade	88	88	83	93

Ring 5 -17cm (V0 place)

	A	C	A&C	A||C
old pipe	89	88	83	94
pipe upgrade	88	87	82	93

Ring 6-18cm (V0 place)

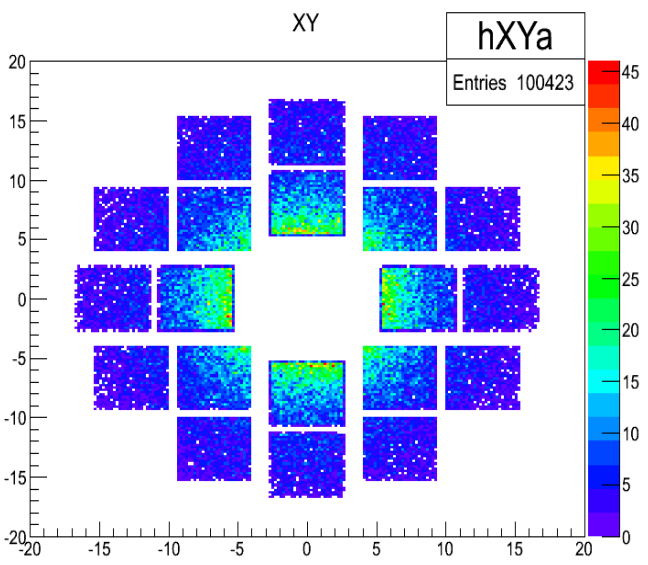
	A (375cm)	C (-75cm)	A&C	A||C
old pipe	89	89	84	94
Pipe upgrade	88	88	83	93

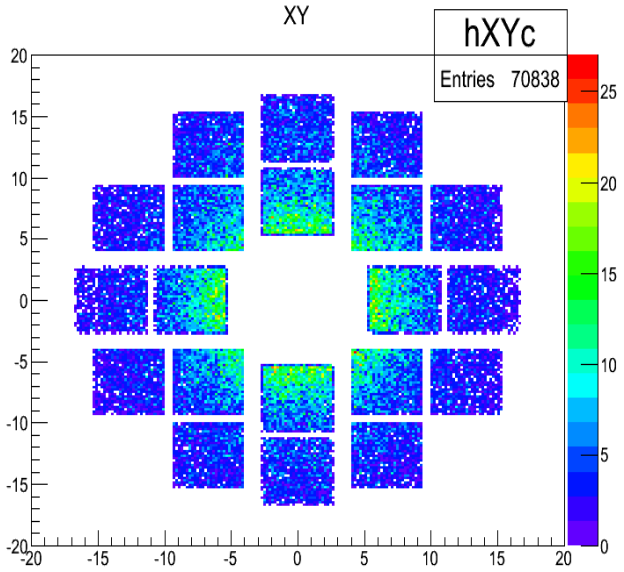
Ring 5 -17cm (T0 place)

	A (375cm)	C (-75cm)	A&C	A||C
old pipe	88	89	83	93
Pipe upgrade	88	88	83	93

Ring 6-18cm (T0 place)

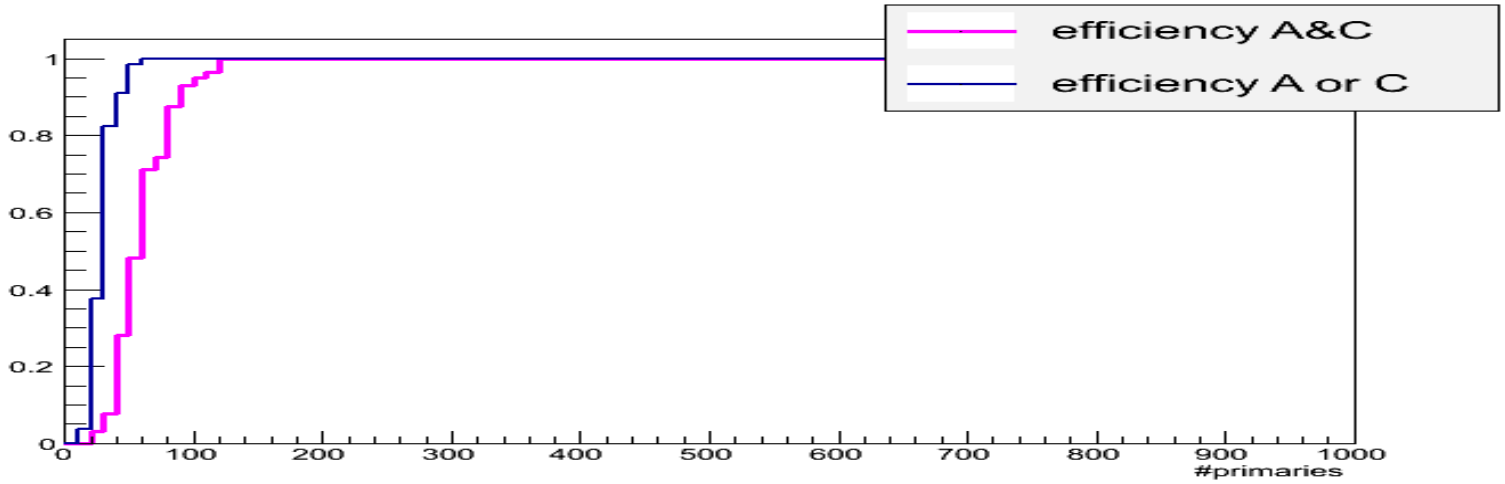
MCP placed around new beam pipe at inner radius 6cm and Z T0-A=373cm Z T0-C=-70cm





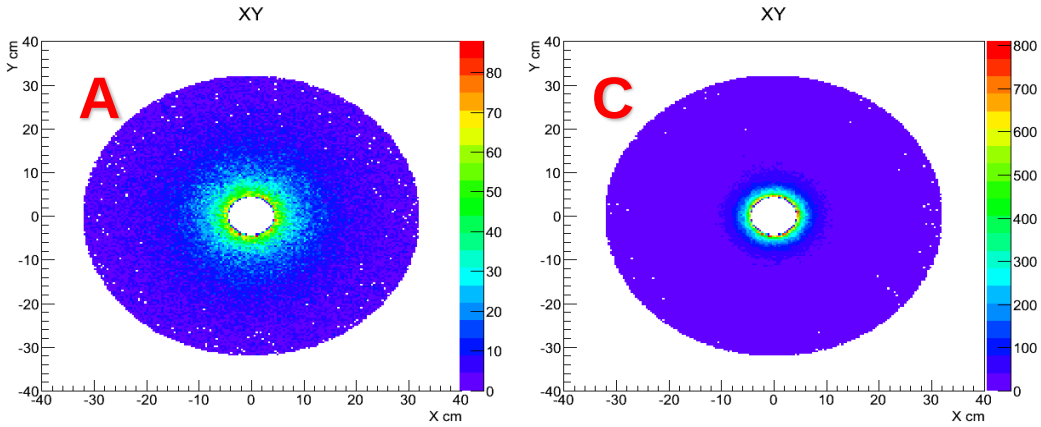
	T0A[%]	T0C[%]	T0A&C[%]	T0AorC[%]
Old pipe	86	86	80	92
New pipe	88	86	80	93

“VZERO” place and size



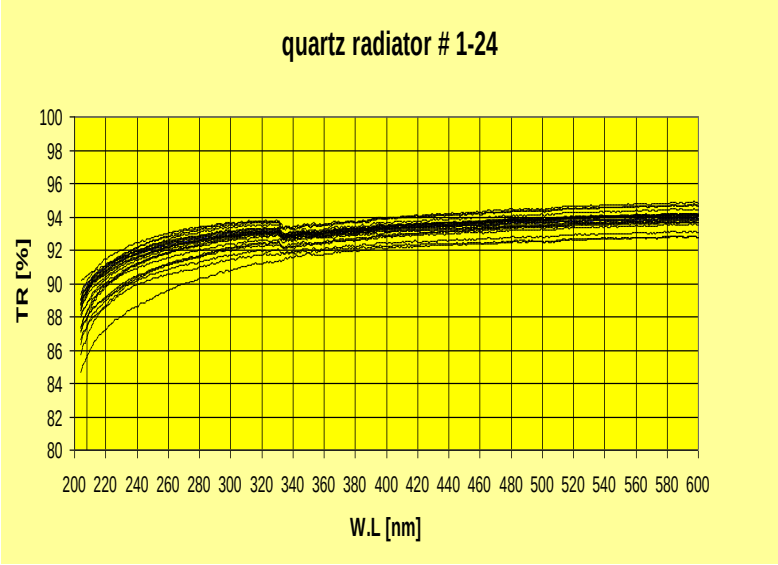
V0 A&C 0.85 **(T0 83%)**

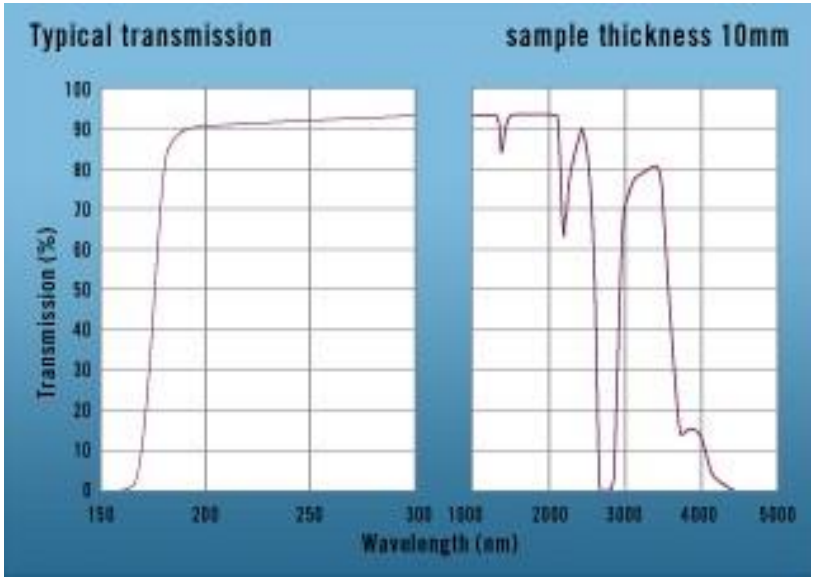
V0 A||C 0.95 **(T0 93 %)**



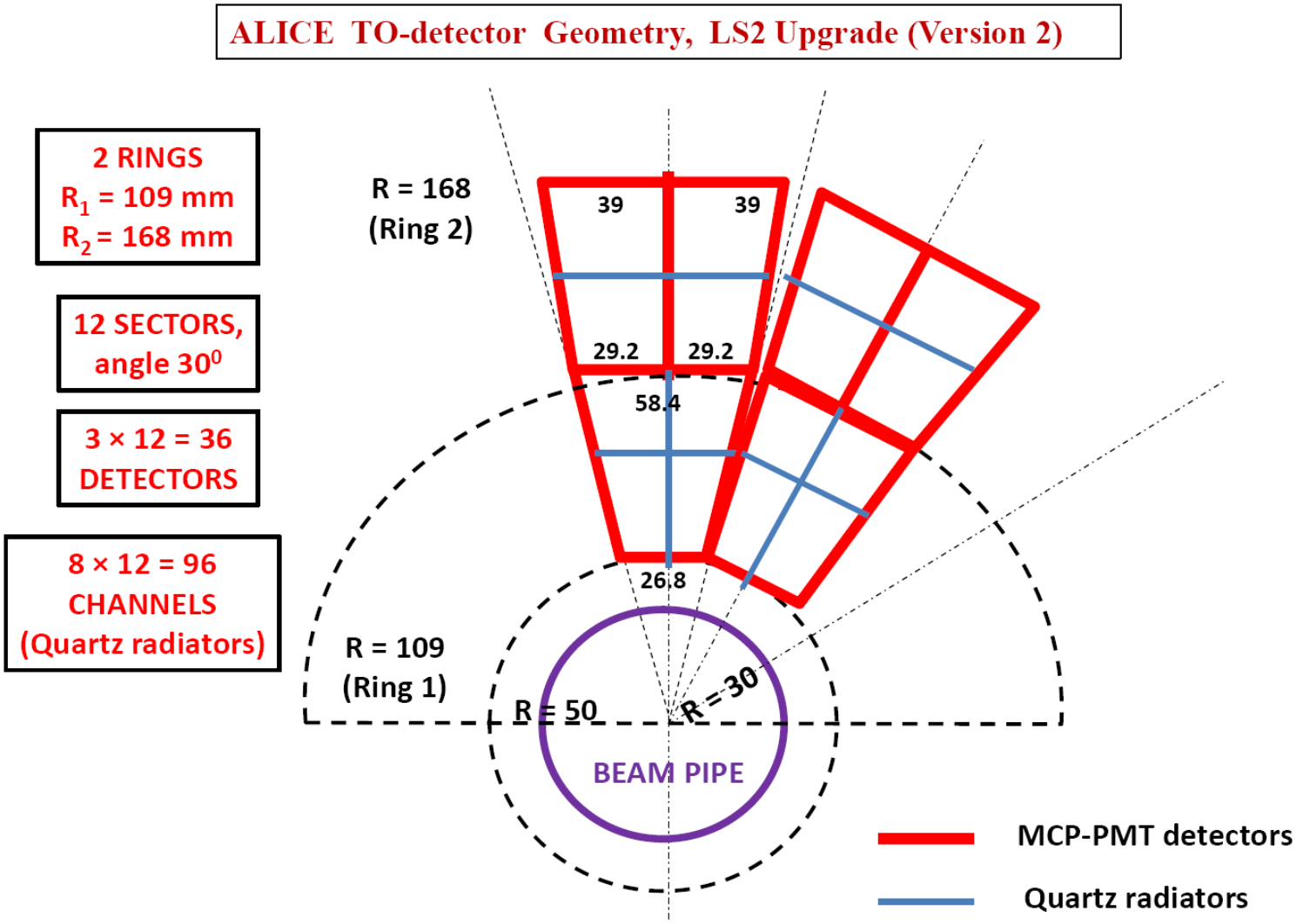
Choice of **quartz suppliers**

- QUARTZ KU-1 (Gus-Khrustalnyi, Russia)
- SUPRASIL® 1 (Heraeus Company, Germany)





Option with **non-square MCP-MPT** units



Cost estimate

- The most expensive items are the new MCP-PMT units currently valued at $8500 each (tax free). Therefore we get:
  - **For the single ring option**: 2 x 8 + 4 spares = 20 units @ ~10 k€ each = ~**200 k€**
  - **For the two ring option**: 2 x 20 + 10 spares = 50 units @ ~10 k€ each = ~**500 k€**
- Quartz material ~500€/kg + processing
- The main cost to modernize the electronics will be the labor cost for R&D of the new PCBs

Redundancy

- One of the strong points in the old trigger was partial functional overlap between T0 and V0
- It would be desirable to maintain at least partial redundancy also in the upgraded trigger.
- The natural choice for the second detector would be a modified plastic scintillator based system with the readout part complying with the TOF standard.

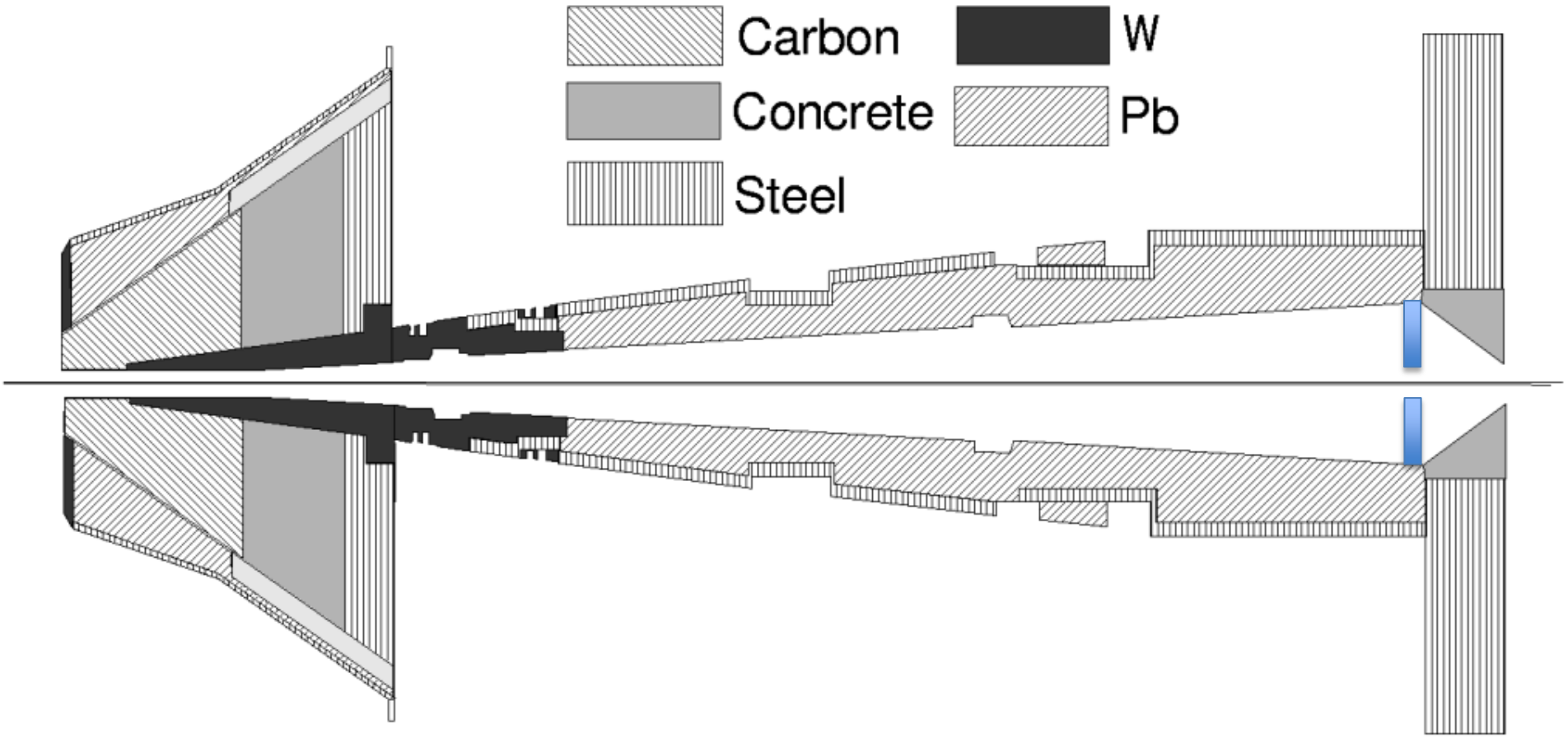
Information provided by G. Herrera Corral

V0 UPGRADE

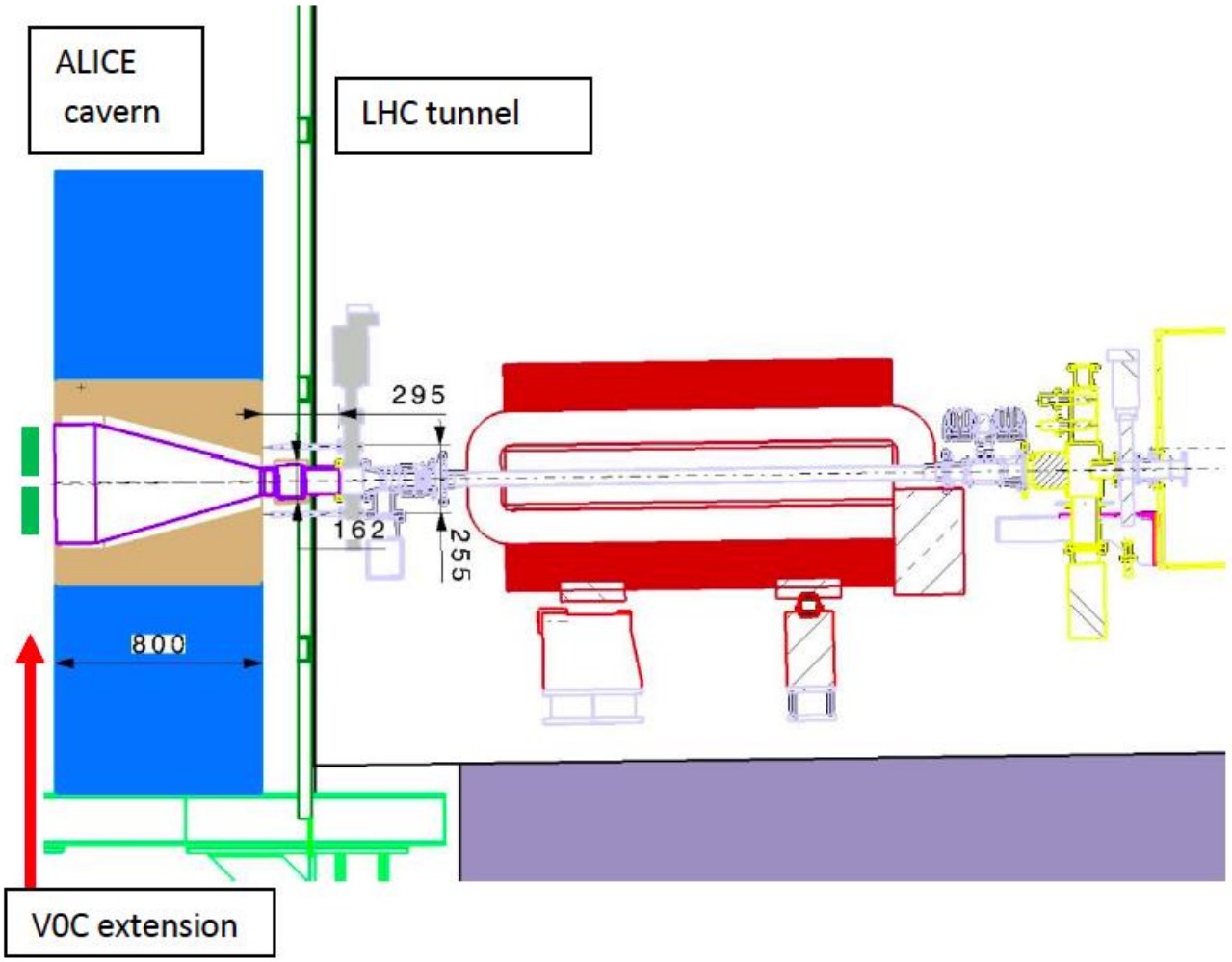
Pseudo-rapidity coverage of the new design

Ring	New V0A		New V0C	
	η_{max}/η_{min}	$\theta_{max}/\theta_{min}$	η_{max}/η_{min}	$\theta_{max}/\theta_{min}$
V0C extension 18 m from IP ⇨			-6.0/-4.9	
			-4.9/-4.5	
acceptance hole			-4.5/-3.7	
0	5.1/4.5	0.7/1.3	-3.7/-3.2	177.0/175.3
1	4.5/3.9	1.3/2.3	-3.2/-2.7	175.3/172.4
2	3.9/3.4	2.3/3.8	-2.7/-2.2	172.4/167.5
3	3.4/2.8	3.8/6.9	-2.2/-1.7	167.5/159.8
4	2.8/2.2	6.9/12.7	Additional ring on V0A	

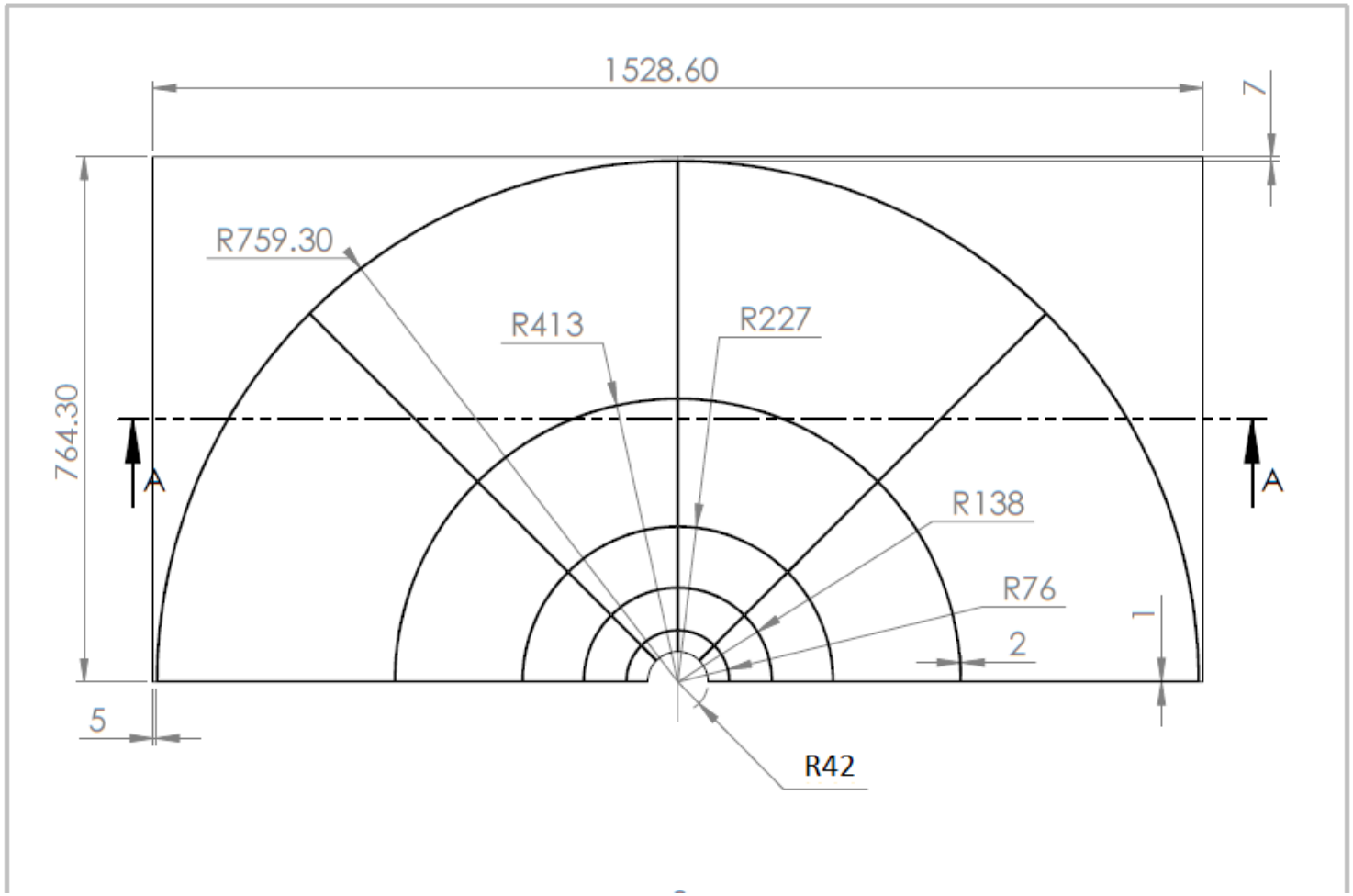
Proposed new location on C-side



Proposed new location on C-side

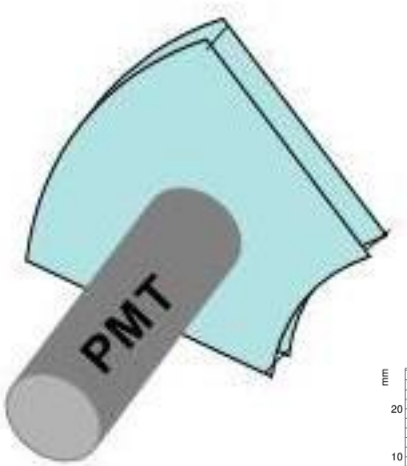


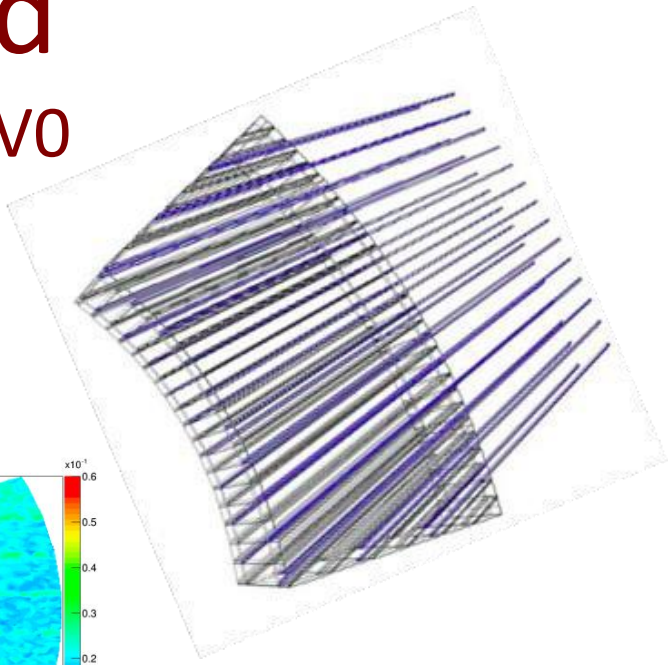
Five rings design for the New V0A

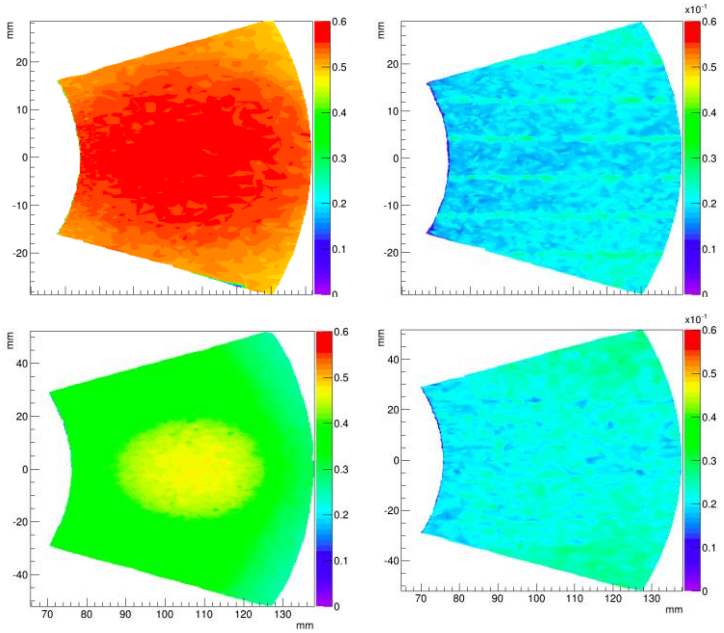


New vs. Old

light collection for V0







Preliminary list of contributors

(please help me to keep the list up to date)

- Members of the T0
  - **Finland**
    - Jyväskylä / HIP (W.H.Trzaska – Project Leader)
  - **Russia**
    - INR/Russian Academy (T.Karavicheva – Deputy PL)
    - MEPhI
    - Kurchatov Institute
- Members of V0
  - **Mexico**
    - CINVESTAV, UAS (G. Herrera Corral)
    - Puebla
    - UNAM
- Members of FMD
  - **Denmark**
    - Niels Bohr Institute (B. Nielsen and I. Bearden)
- New members
  - **USA**
    - Chicago State University (E. Garcia)