ALICE Fast Interaction Trigger detector for the future
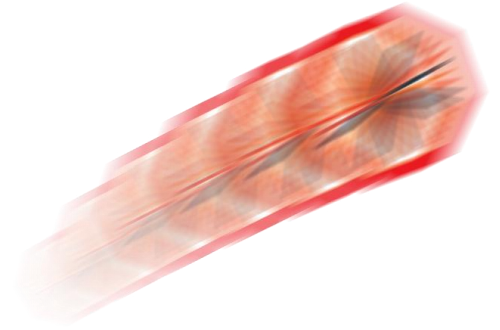
T.Karavicheva for the ALICE Collaboration,
INR RAS, Moscow

Outline

- **ALICE Forward trigger detectors**
  - Current V0/T0 detectors
- **F**ast **I**nteraction **T**rigger (**LS2**)
  - Required functionality
  - FIT = T0-Plus & V0-Plus
  - system description
- **Open/ongoing issues**
  - Reliability and lifetime
  - Radiation hardness / location of FEE
- **FIT** schedule

ALICE: the dedicated heavy-ion experiment at LHC
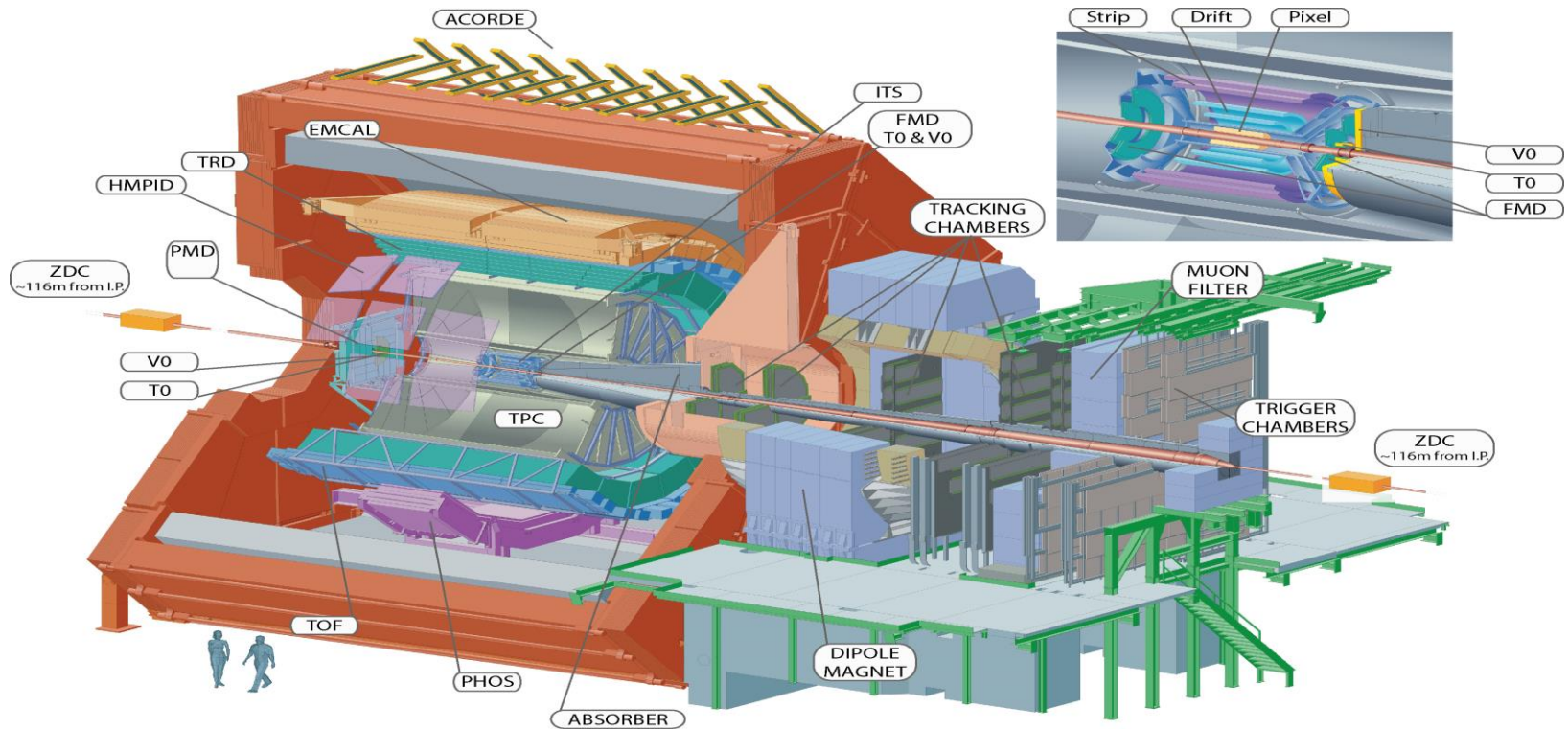
- **Central barrel ($\eta < 1$) in a solenoidal field with excellent tracking and PID capabilities. Study of hadronic signals, photons and dielectrons**

- **Forward muon spectrometer ($2.5 < \eta < 4$) study quarkonia and heavy flavour decays**

- **Forward detectors ($\eta > 3$) to characterize the collision: timing, vertex, centrality, event plane. FMD,T0,V0 and ZDC ($\eta > 8.7$), ZDCs at 112:5m from interaction point**
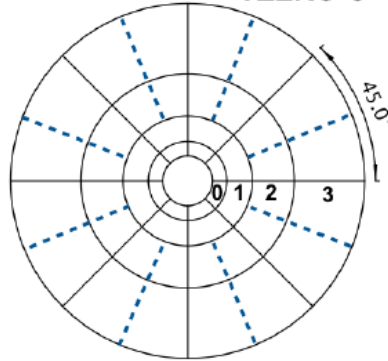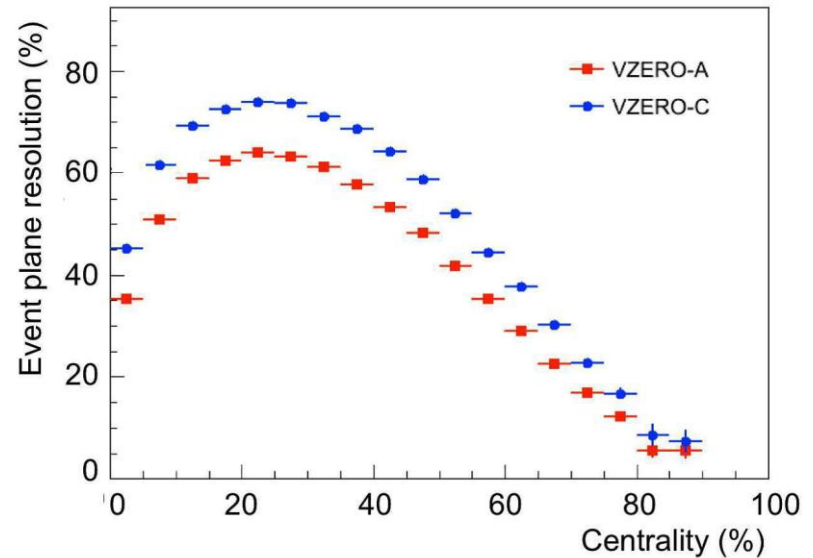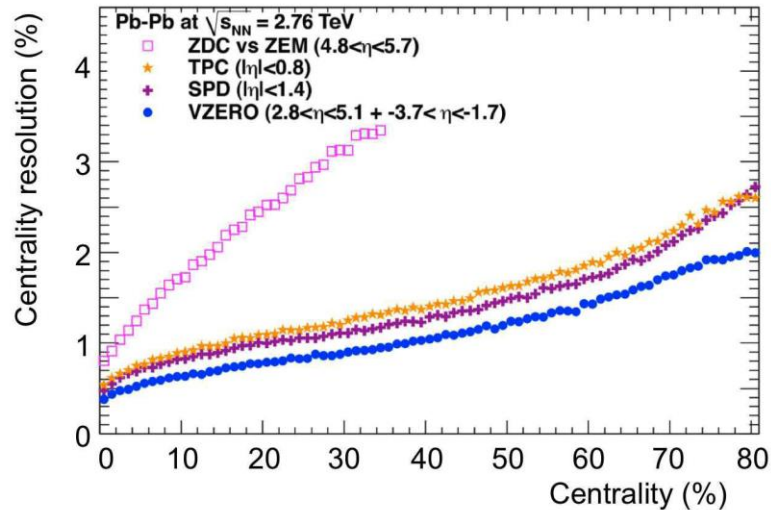
Forward trigger detector: V0 detector

VZERO-A
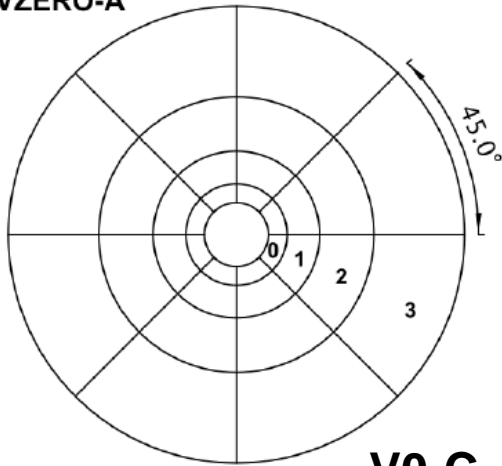
VZERO-C

Time resolutions of about 450 ps and 350 ps are achieved for V0-A and V0-C

V0-C -3.7 < η < -1.7
V0-A   2.8 < η < 5.1

- **The ALICE V0 detector, made of two scintillator arrays, at asymmetric positions, one on each side of the interaction point, plays a central role in ALICE. In addition to its core function as trigger, the V0 detector is used :**

- **to monitor LHC beam conditions, to measure the luminosity, to reject beam-induced backgrounds**

- **to measure basic physics quantities such as particle multiplicity, centrality and event plane direction of nucleus-nucleus collisions.**

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V0 performance during Run1
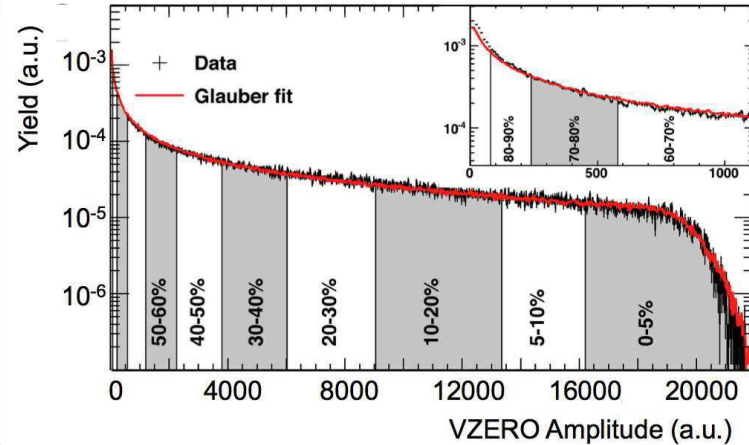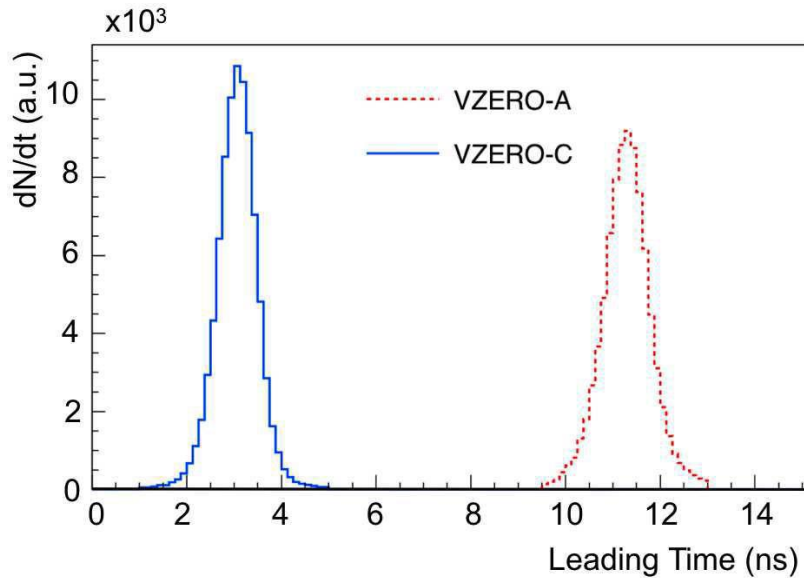
Forward trigger detector: T0 detector

T0-C   -3.28 < η < -2.97

T0-A   4.61 < η < 4.92

Time resolution of ~ 40ps for protons

and ~20ps for PbPb collisions

- **The ALICE T0 detector , made of two Cherenkov arrays, at asymmetric positions, one on each side of the interaction point (370 cm ,−70 cm) . T0 is primarily a trigger and timing detector for TOF system .**

- **It also played a crucial role during the high luminosity part of the Run 1. Being the first of the ALICE detectors to be turned on, T0 provided a direct feedback to the LHC team enabling them to tune and monitor the collision rate at Point 2**

- **T0 is used to monitor LHC beam conditions, to measure the luminosity, to reject on-line beam-induced backgrounds and to measure basic physics quantities such as event plane direction of nucleus-nucleus collisions.**
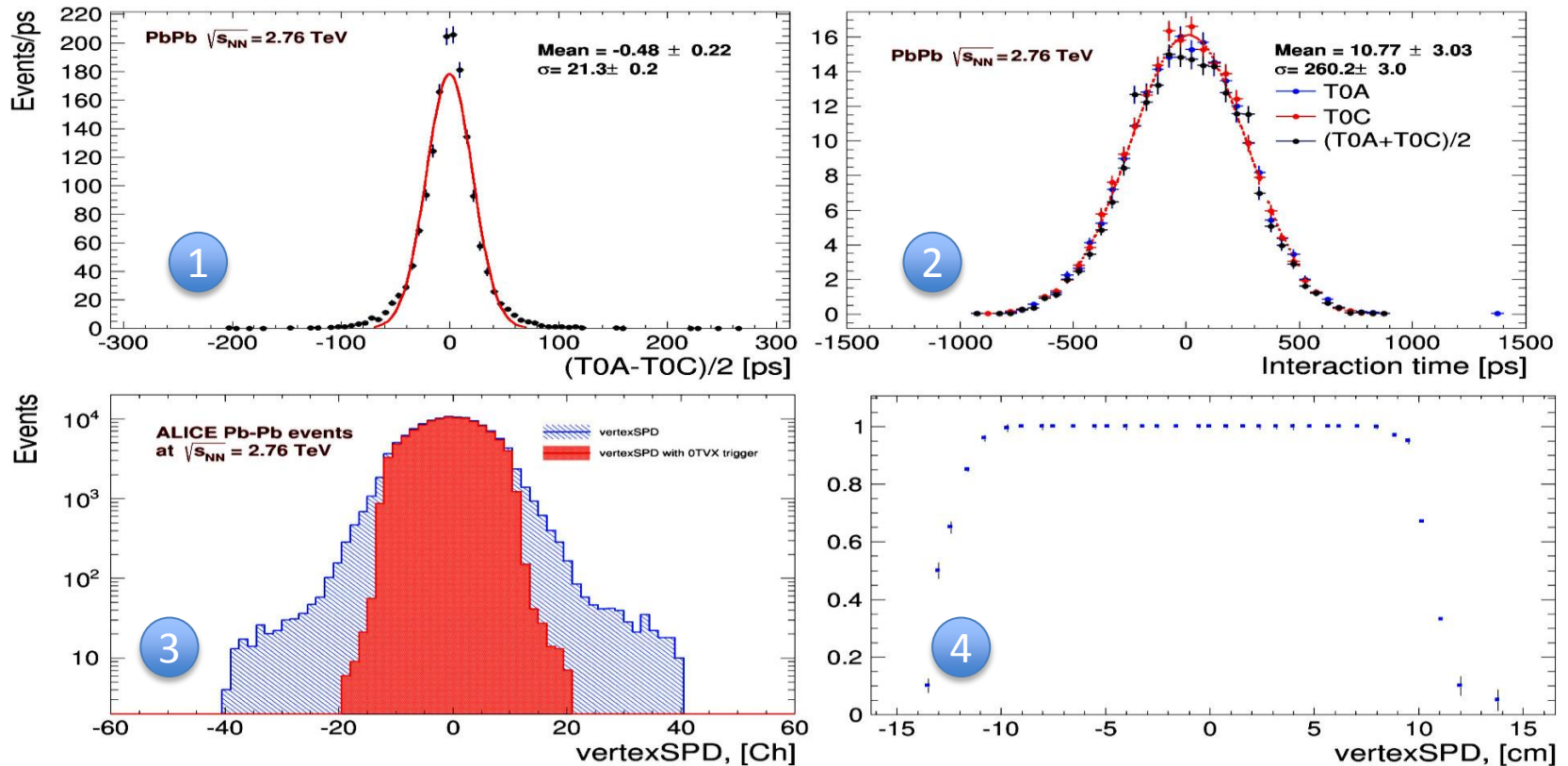
T0 performance during Run1

Figure 1 shows the time distribution of (T0A-T0C)/2 after slewing and vertex correction. The time resolution of the T0 detector is ~ 25 ps

**Figure 2 shows the time distribution of the summed arrival times** inT0A and T0C (interaction time) in Pb-Pb collisions

Figure 3: Background rejection by T0.

Figure 4: T0 vertex trigger efficiency during 2011 Pb-Pb runs for central and semi-central events (0-50%)

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van der Meer scan
The visible cross section for T0/V0 triggers are measured in a van der Meer scan
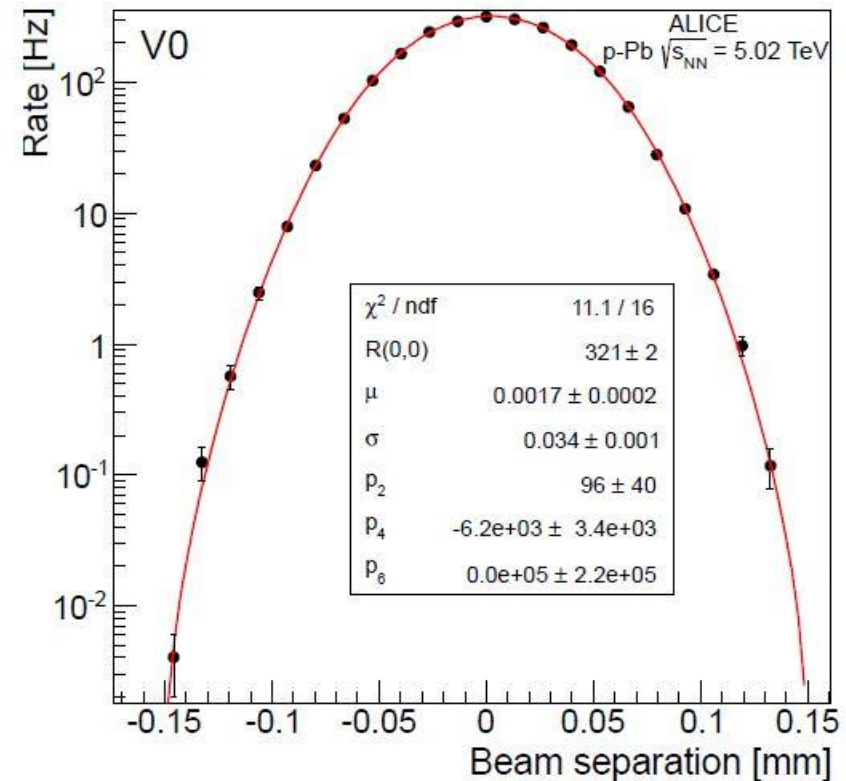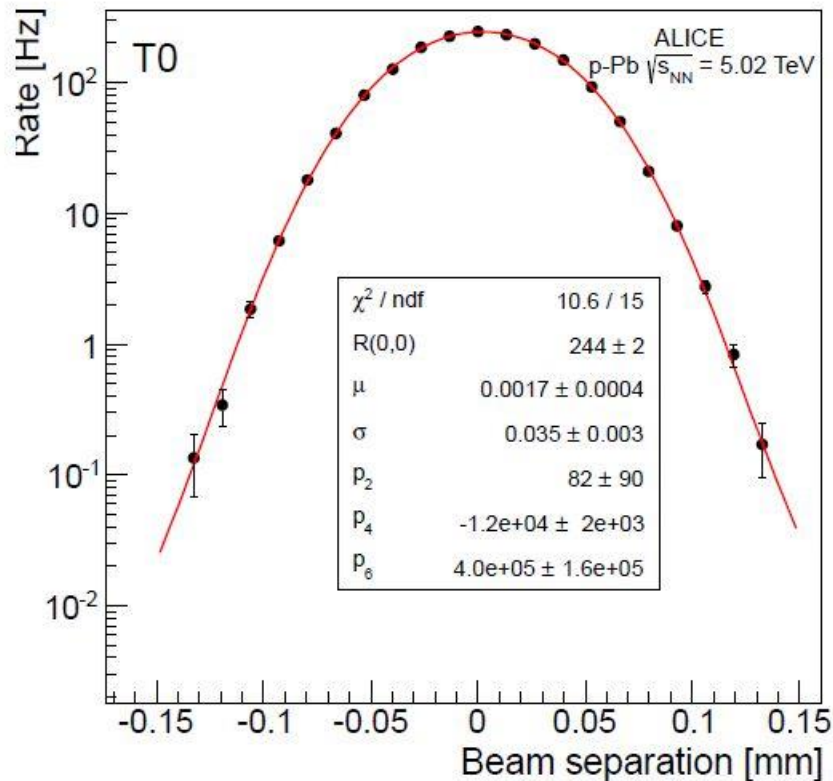
Rates of the T0 (left) and V0 (right) reference process as a function of beam separation for one typical pair of colliding bunches in the first vertical p–Pb scan. The solid red curve is a fit . The measured visible cross sections are used to calculate the integrated luminosity of the proton-lead and lead-proton data samples(CERN-PH_EP-2014-087)

NEED TO UPGRADE

- As a result of the LHC upgrade after the Long Shutdown 2, the expected luminosity and collision rate during the so called Run 3 will considerably exceed the design parameters for several of the key ALICE detectors systems including the forward trigger detectors.

- Forward trigger detectors will be replaced by the Fast Interaction Trigger (FIT). The concept of FIT has evolved from the experience gained by three ALICE groups: FMD, T0 and V0.

- FIT will incorporate modules with Cherenkov radiators (T0+) and modules with plastic scintillator plates (V0+) serviced by integrated electronics and readout. Both modules will use MCP-PMT light sensors. This presentation describes the Cherenkov option.

# Required functionality for FIT @ Run3 (better than T0 & V0 now)

- Minimum Bias trigger for pp collisions with efficiency comparable to the current V0, i.e. at least 83 % for vertex (A&C) and 93% for the OR signal (A|C).

- Event Multiplicity determination capable of selecting and triggering on central as well as on semi-central collisions. The centrality selection should match the performance of the present V0.

- Vertex location with a performance comparable to the present T0 system.

- Evaluation and rejection of beam-induced background and in particular beam gas event sensitivity on the level of the current V0 detector.

- Time resolution better than 50 ps for pp collisions, as in the present T0 system.

- Determination of collision time for TOF with resolution better than 50 ps.

- Event plane determination with a precision similar to the present V0 system.

- Minimal ageing over the ALICE operation period.

- No after pulses or other spurious signals.

- Direct feedback to LHC on luminosity and beam conditions.
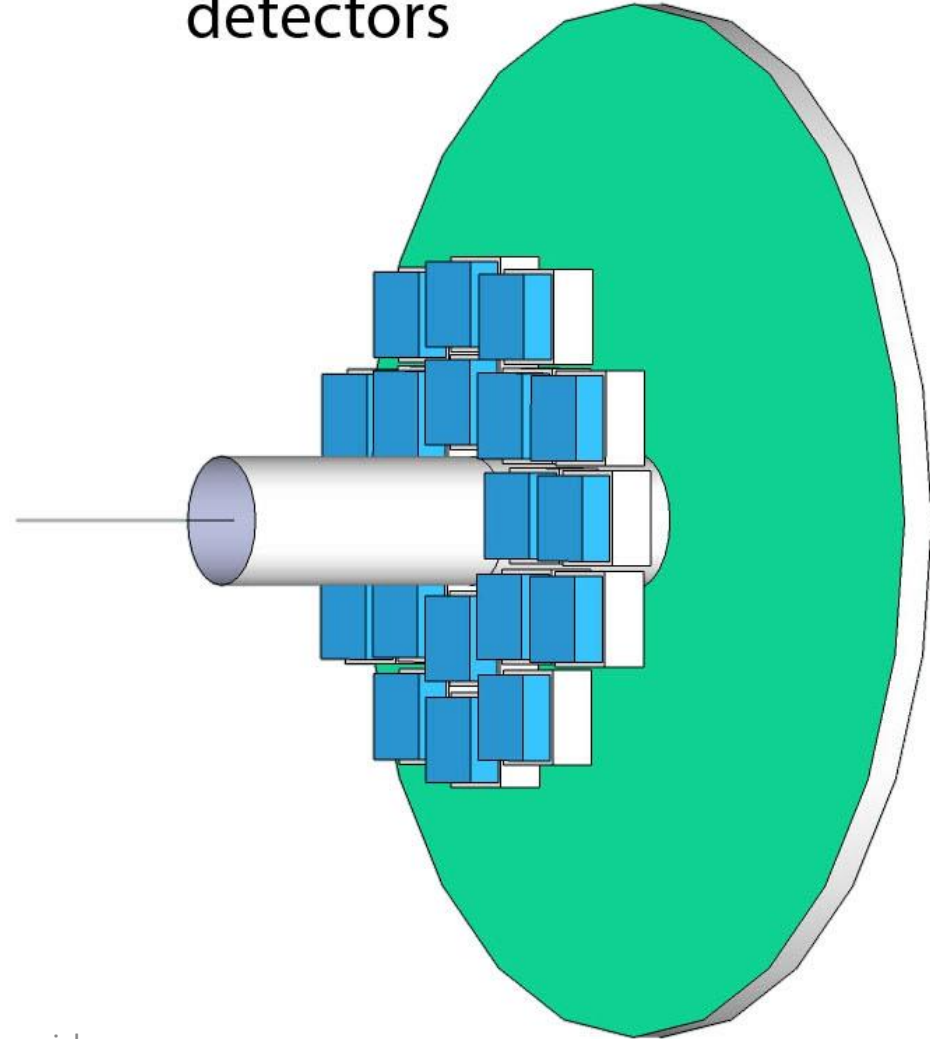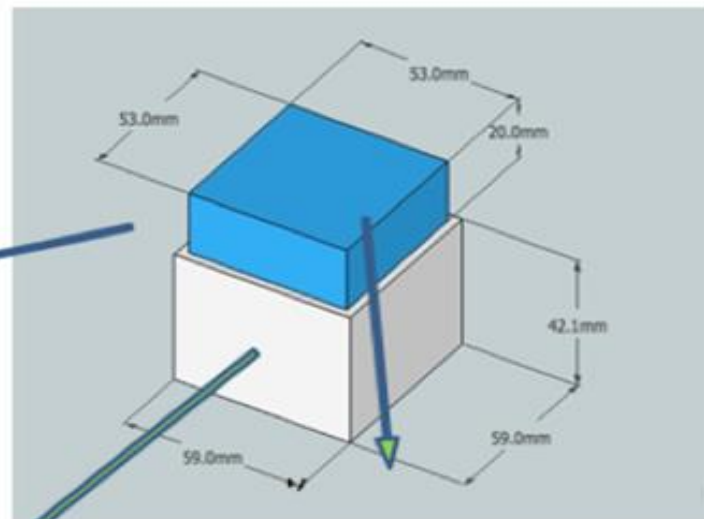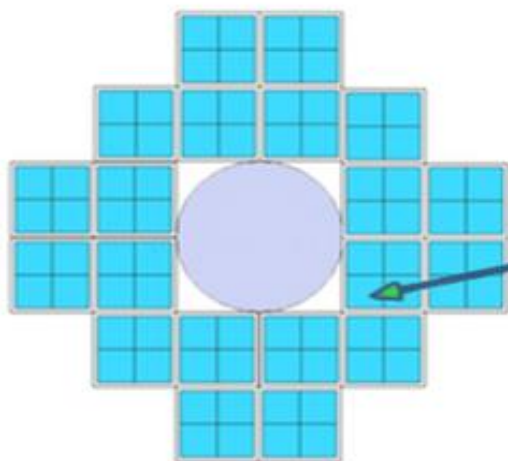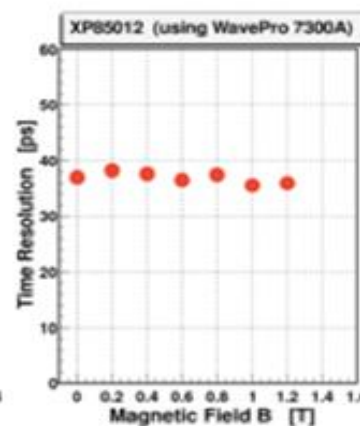
T0 & V0 → FIT
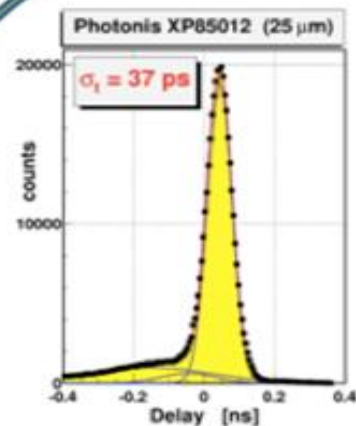
T0 and V0 now
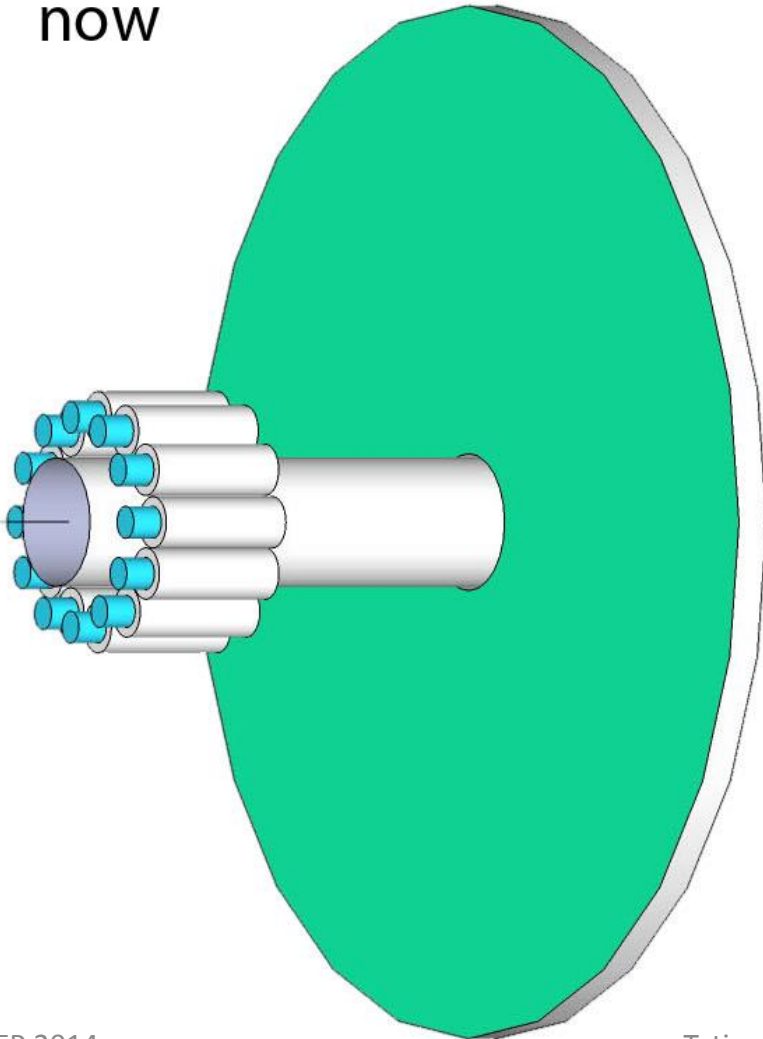
Upgraded detectors

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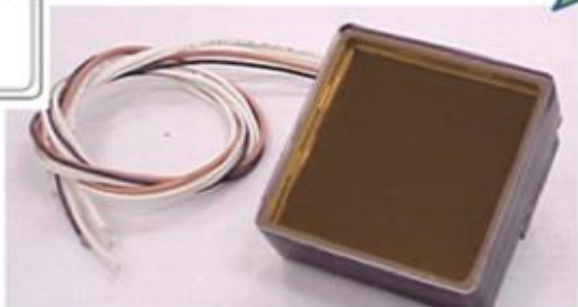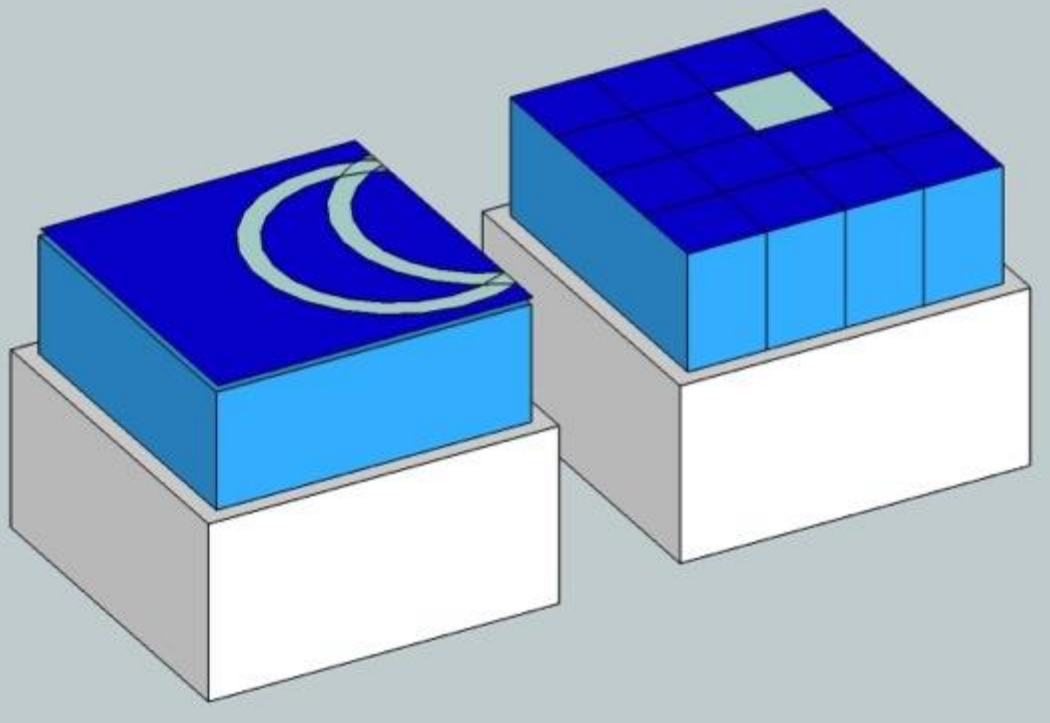
SYSTEM DESCRIPTION

MCP-PMT:
Photonis PLANACON®
XP85012 or XP85112

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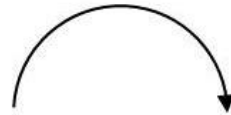
The inner walls of a **fragmented radiator** reflect the light and contain it within the sub-unit of the radiator. As a result the light intensity falling on the MCP surface is higher. Therefore **lower amplification (HV)** is needed.

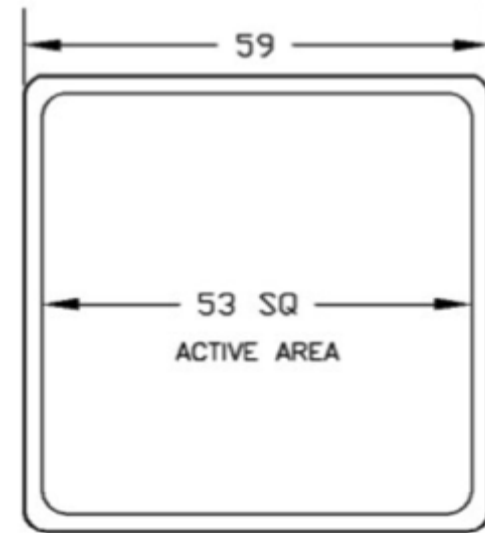Tatiana Karavicheva
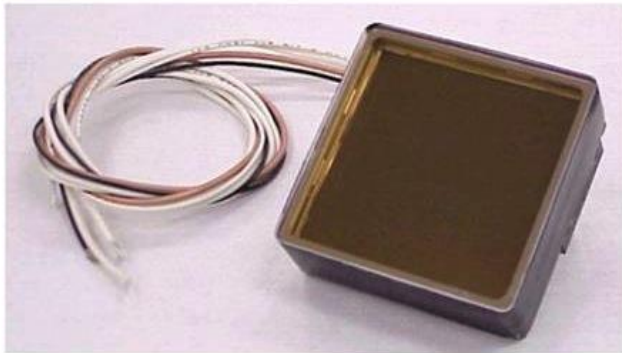
XP85012

PLANACON®

Window-side

Back-side

59
53 SQ
ACTIVE AREA

The XP85012 Planacon consists of a sealed, rectangular vacuum box of about 59 x 59 x 28 mm3 housing a pair of microchannel plates in a chevron configuration. The pore size is 25µm with the length to diameter ratio of 40:1. The spectral range is 200-650 nm with peak sensitivity around 380 nm and an average quantum efficiency of 22%. A gain of 10^5 is typically reached at 1800 V, with the maximum possible gain on the order of 10^7.

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 FIT
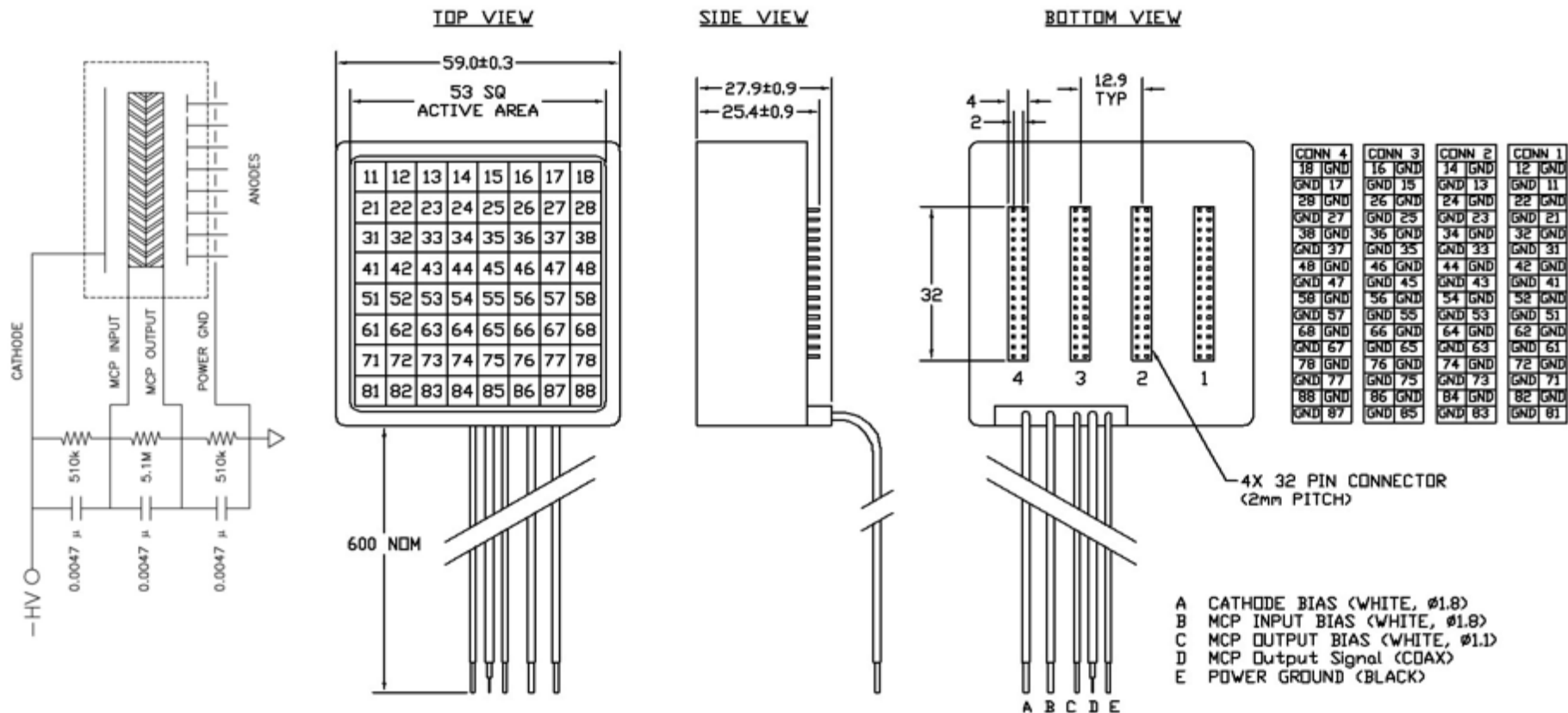
Big progress in MCP technology
## (since the initial R&D for ALICE)

- Appearance of commercially available MCP-PMTs (Hamamatsu, Photonis USA, BINP)

- Significant and ongoing improvement in lifetime:

  – Atomic Layer Deposition technology [NIM A639 (2011) 148]
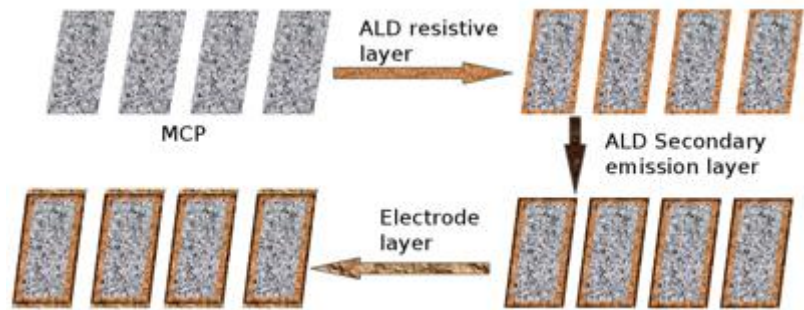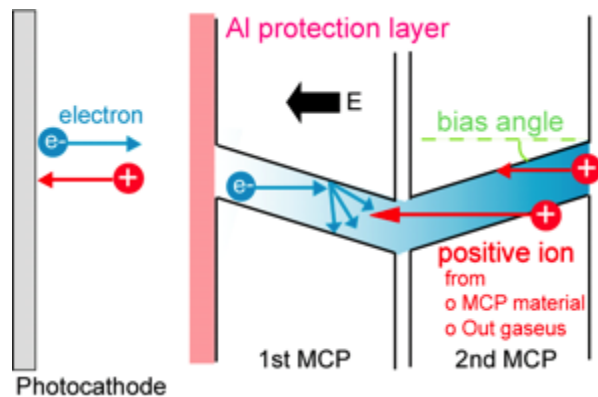
  – Modified photocathodes [JINST 6 C12026 (2011)]

  – Reduced outgassing (borosilicate glass)

For more information: Albert Lehmann, 12th Pisa Meeting on Advanced Detectors, May 2012
CERN Detector Seminar - 7 Feb. '14 T. Gys - MCP PMTs for fast photon detection

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# Reliability and lifetime
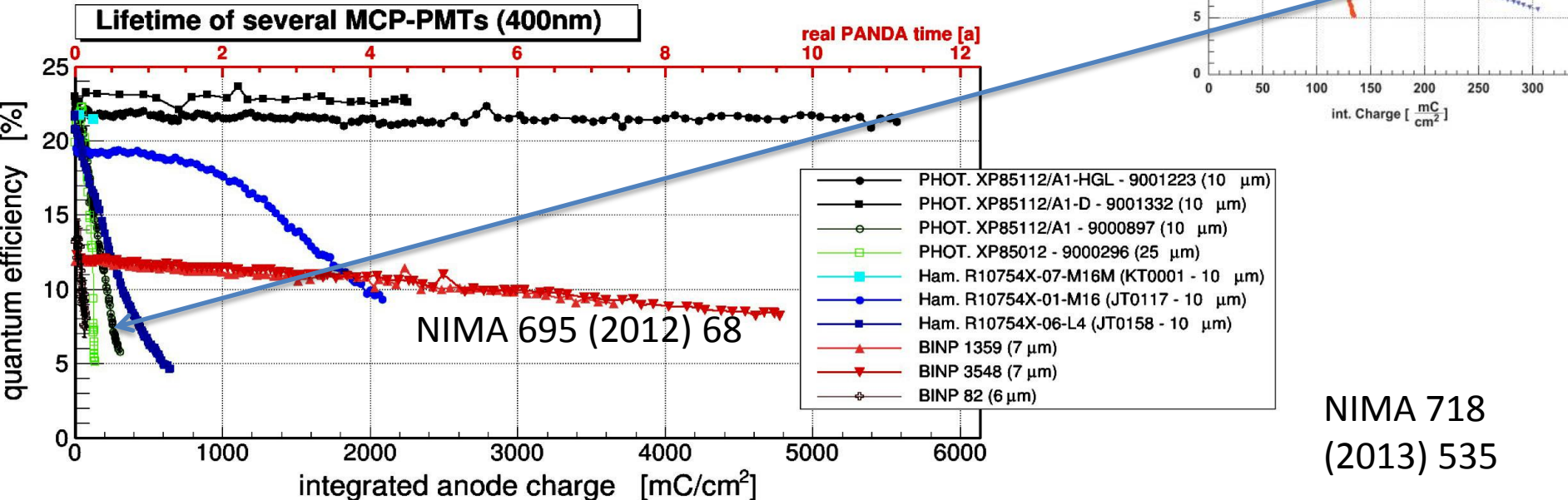
Dependence of the Quantum Efficiency on the Integrated Anode Charge for a variety of MCP-PMT sensors measured by PANDA collaboration. The performance of the ALD treated samples from Photonis USA is shown by the top curves.

A. Lehmann. Lifetime measurements of MCP-PMTs. DIRC2013: Workshop on fast Cherenkov detectors, Giessen Sept 4, 2013.
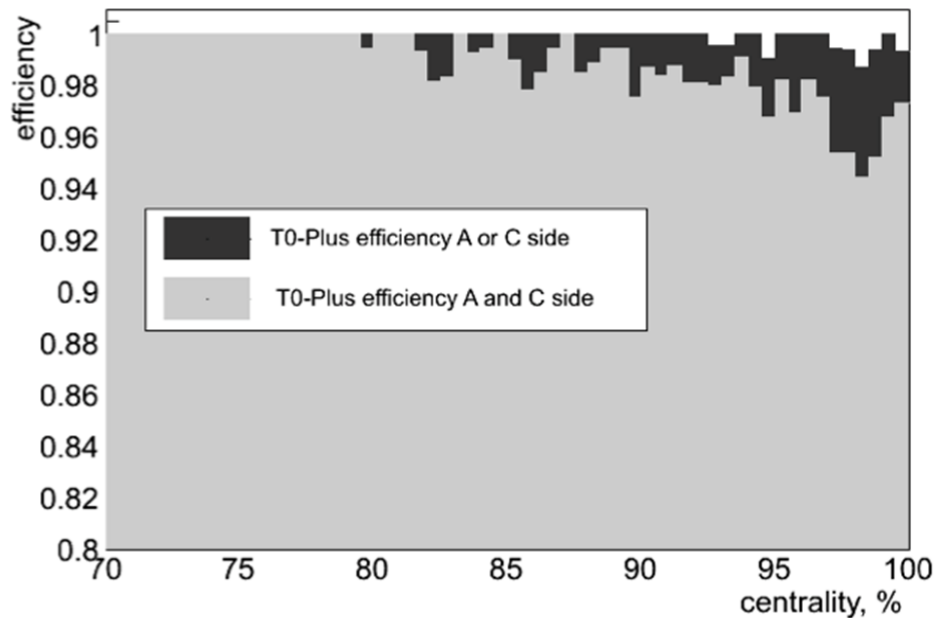
PMT (T0) vs. MCP-PMT (T0-Plus)
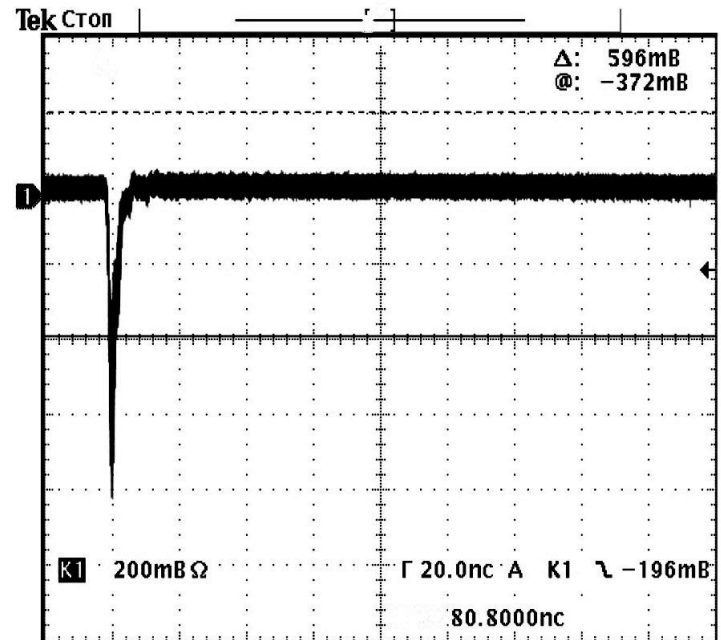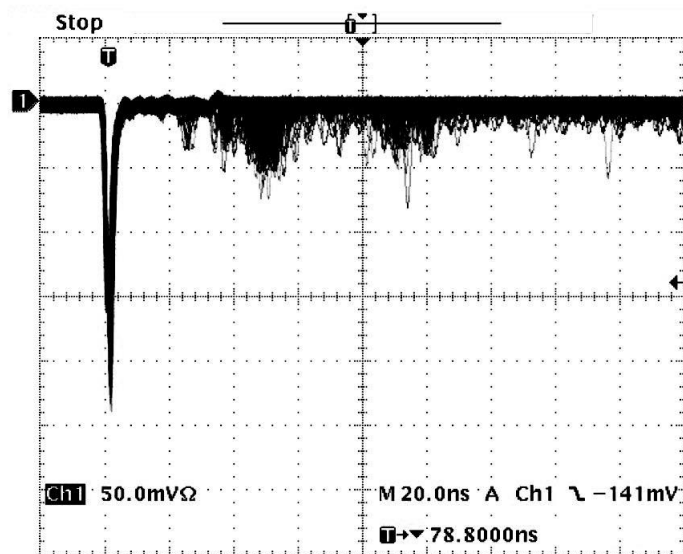
Integration on the muon spectrometer side (ITS, MFT, FIT)

12

7

11

3

Corrado Gargiulo

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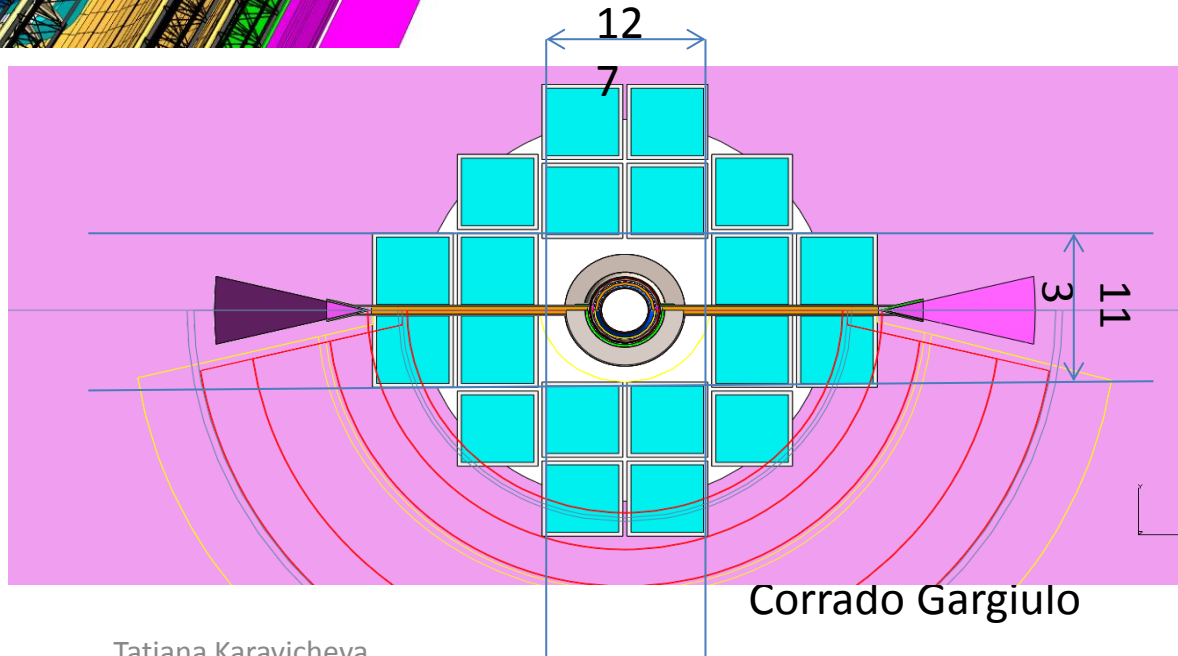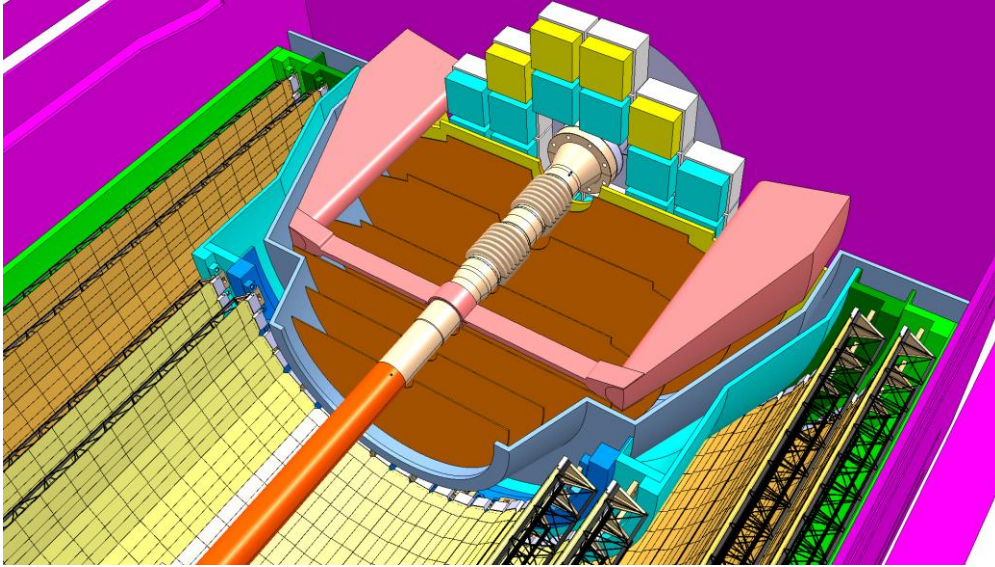
DETECTOR EFFICIENCY

Dependence of the efficiency on the event centrality for PbPb collisions at √s = 5.5 TeV

|	A	C	A&C	A|C
pp @ 14 TeV				
V0*	0.88	0.88	0.83	0.93
T0-Plus*	0.89	0.89	0.84	0.94
R_{min}=50 mm				
T0-Plus*	0.88	0.88	0.83	0.93
R_{min}=60 mm				
T0-Plus	0.88	0.86	0.80	0.93
Detailed geometry				
R_{min}=60 mm				
PbPb @ 5.5 TeV (b>13 fm; 70-100% centrality)				
T0-Plus	0.97	0.98	0.95	0.996
Detailed geometry				
R_{min}=60 mm				

Efficiency comparison between the current V0 and the proposed T0-Plus. Asterisks indicates that the simulations were done using a simplified geometry.

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Prototype of MCP-PMT based
fast forward detector (FFD) module (NICA)
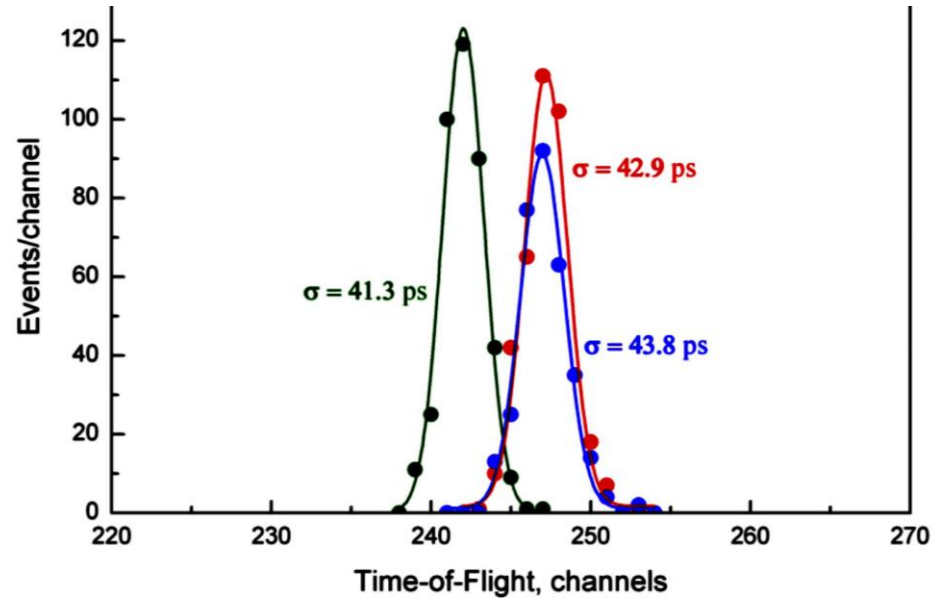
TOF peaks have   σ ≈ 41–44 ps, which corresponds to ≈ $σ_t$ 29–31 ps for
single channel of the detector
(PHYSICS OF PARTICLES AND NUCLEI LETTERS Vol. 10 No. 3 2013,pp 258-268)
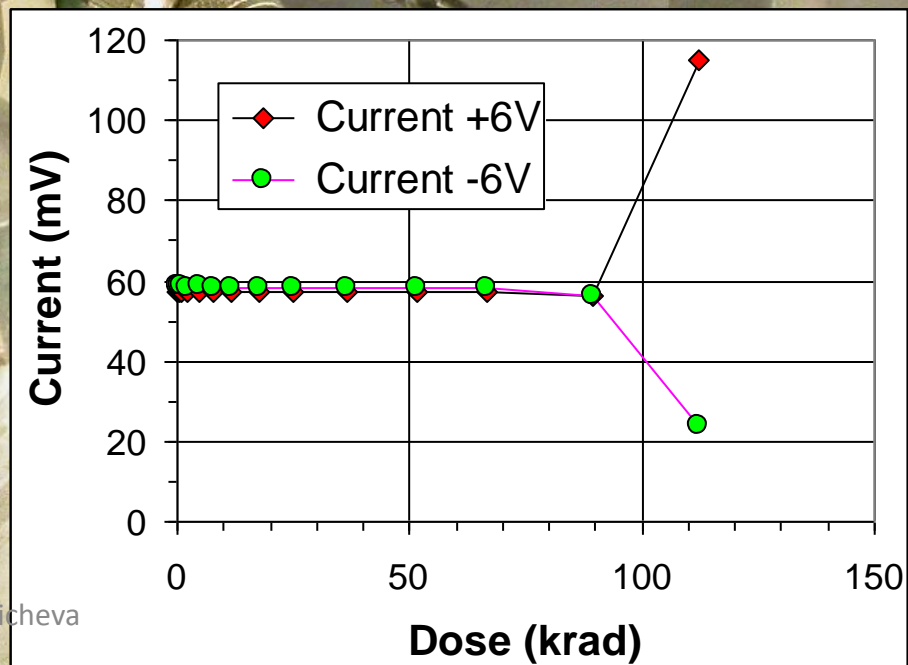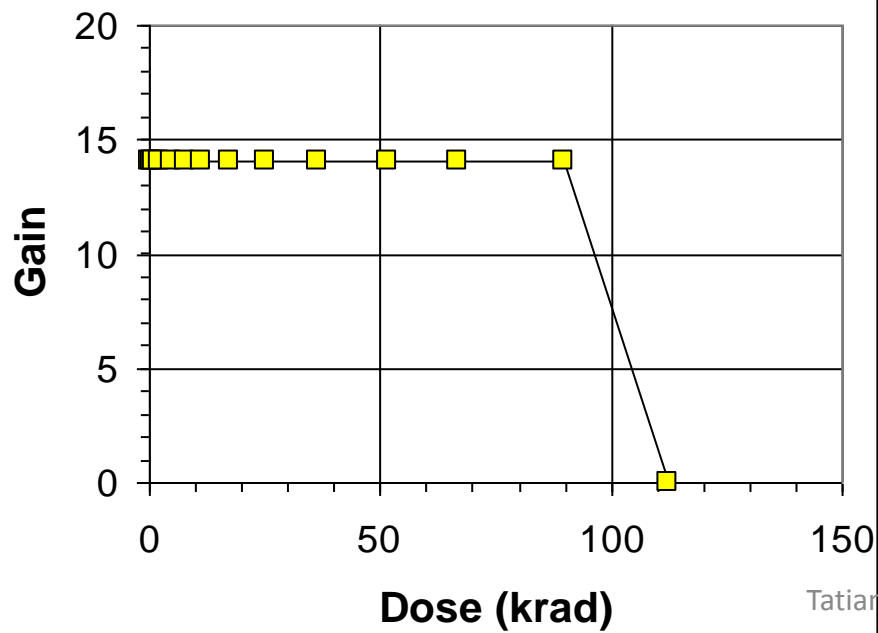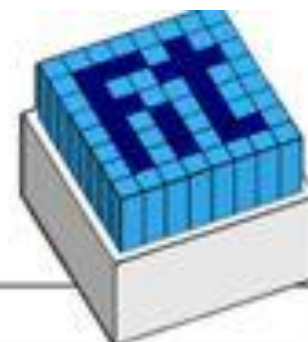
Expected dose during Run3

A. Alici and A. Tauro
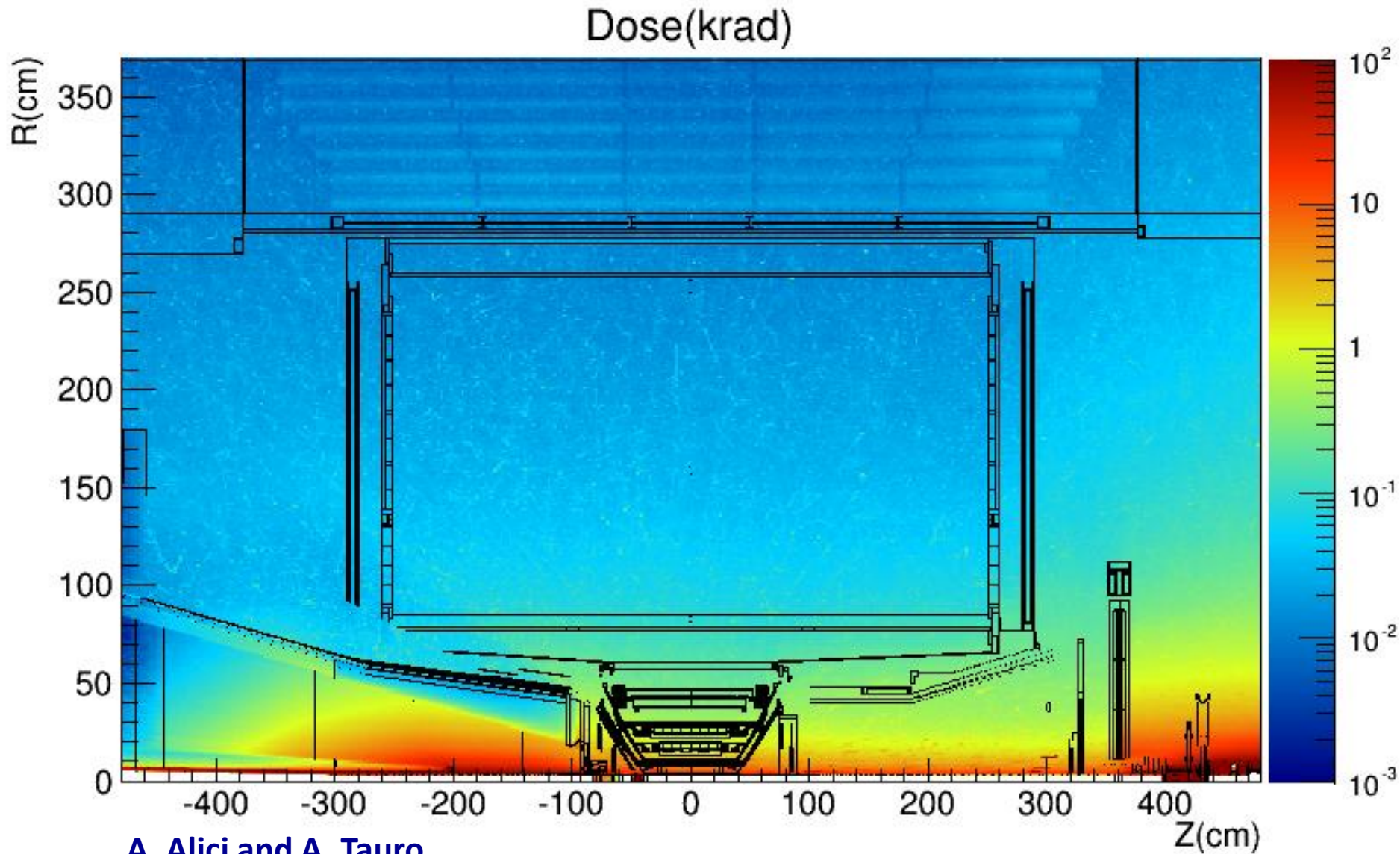
Expected Run3 dose
in the sensor region is < 10 krad

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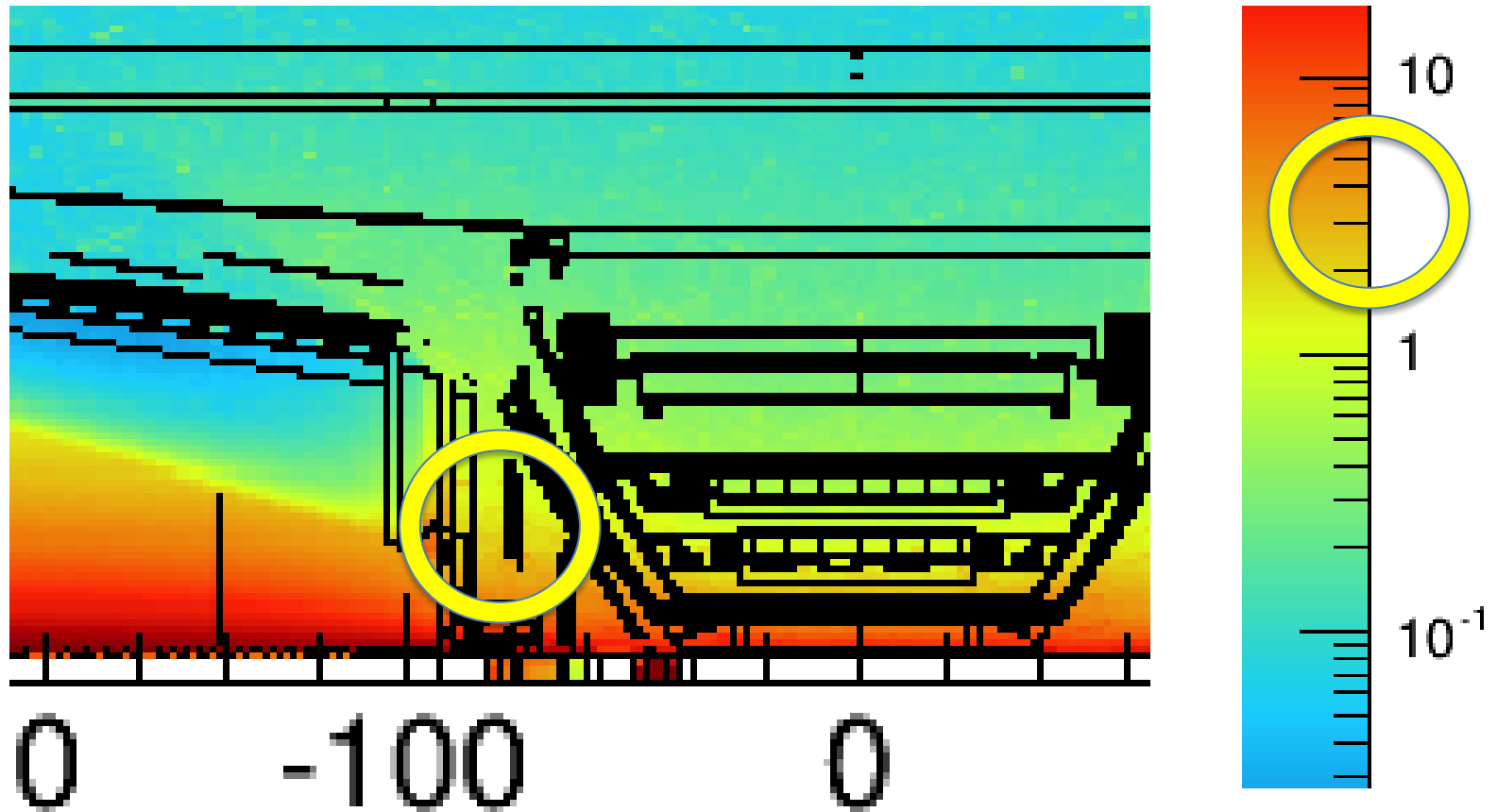
LDO Voltage Regulator
UCC284DP-5
(Texas Instrument)
Broken at ~100 krad exposure

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INSTITUTES PARTICIPATING IN R&D

Country	City	Institute
Denmark	Copenhagen	Niels Bohr Institute, University of Copenhagen
Finland	Jyväskylä	Helsinki Institute of Physics (HIP) and University of Jyväskylä
Mexico	Mexico City	Instituto de Física, UNAM
Russia	Moscow	Institute for Nuclear Research
Russia	Moscow	Moscow Engineering Physics Institute
Russia	Moscow	Russian Research Centre Kurchatov Institute
USA	Chicago	Chicago State University

TDR: CERN-LHCC-2013-019 / LHCC-TDR-015

FIT schedule

- **2013-2016** prototyping of detector modules and electronics; in-beam tests

- **2017** Purchase of MCP-PMT sensors and assembly of detector modules and electronics

- **2018** FIT installation

Thank you for your attention!

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