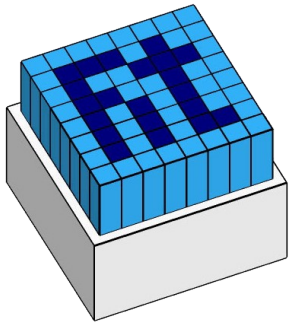


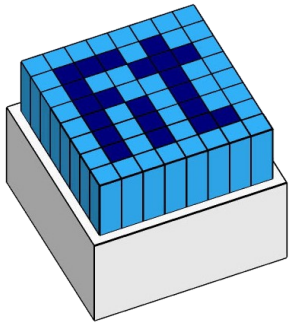
Tutorial (1)

Held before FIT beam test @ PS (06.2016)

23.05.2016, CERN

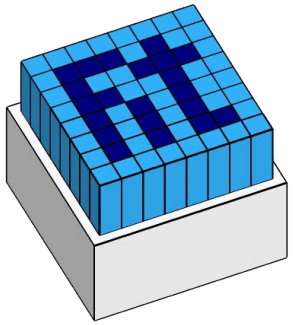
Maciej Slupecki
University of Jyvaskyla, Finland

UNIVERSITY OF JYVÄSKYLÄ



Outline

- Practical information
  - Maps, local transport
  - East area – **access** (dosimeter, helmet, shoes, edh)
  - East area – facility layout
  - Test setup (layout, electronics)
- ALICE @ CERN LHC
- FIT after LHC Upgrade
  - A few words on **history** of T0 and V0
    - Function, performance, limitations
  - **Requirements** after the LHC upgrade in 2020
  - Current FIT default (+ options)
- Preparation for part 2: **root** installation and environment setup



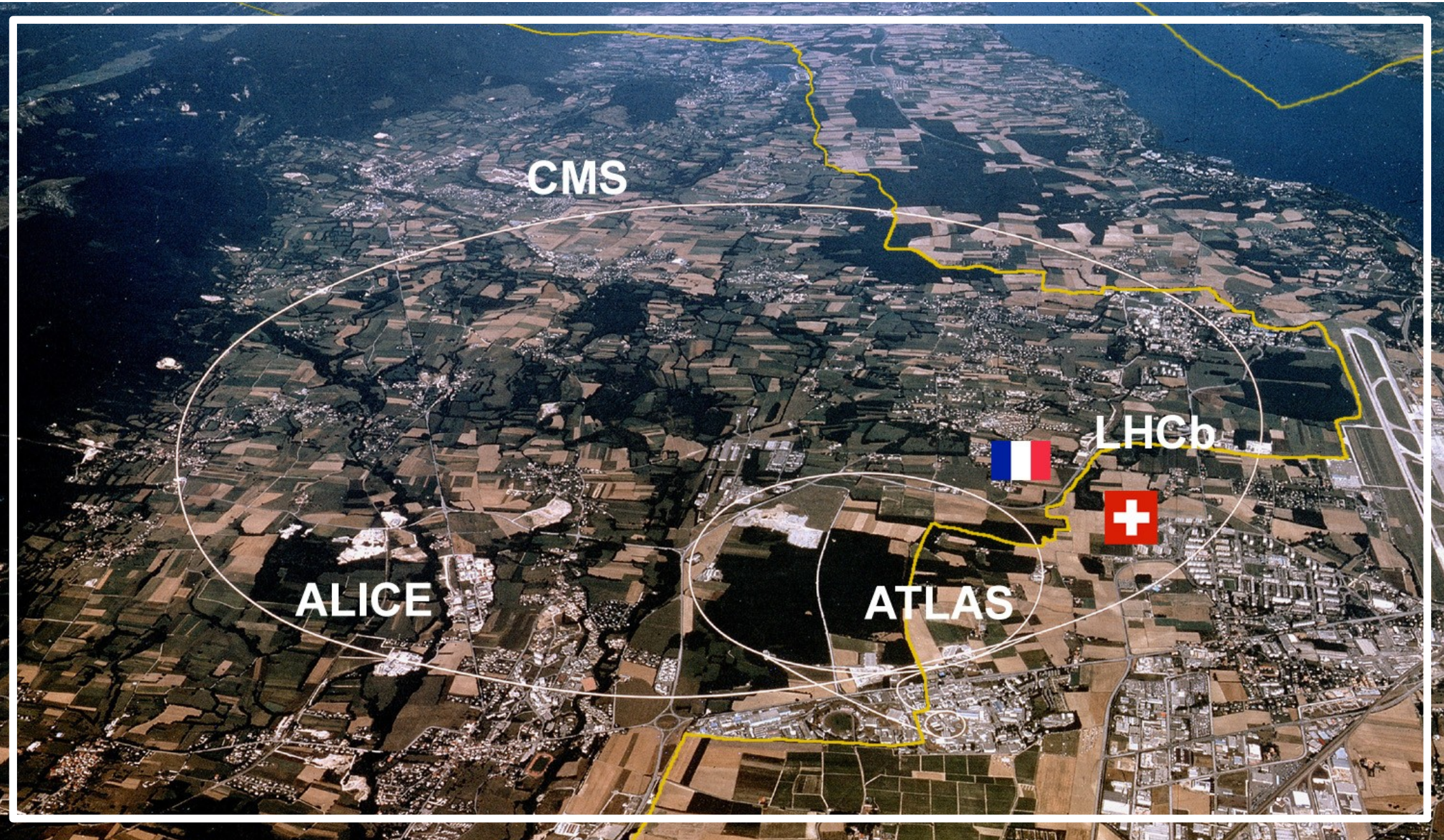
Practical information

- Maps, local transport
- East area – **access** (dosimeter, helmet, shoes, edh)
- East area – facility layout

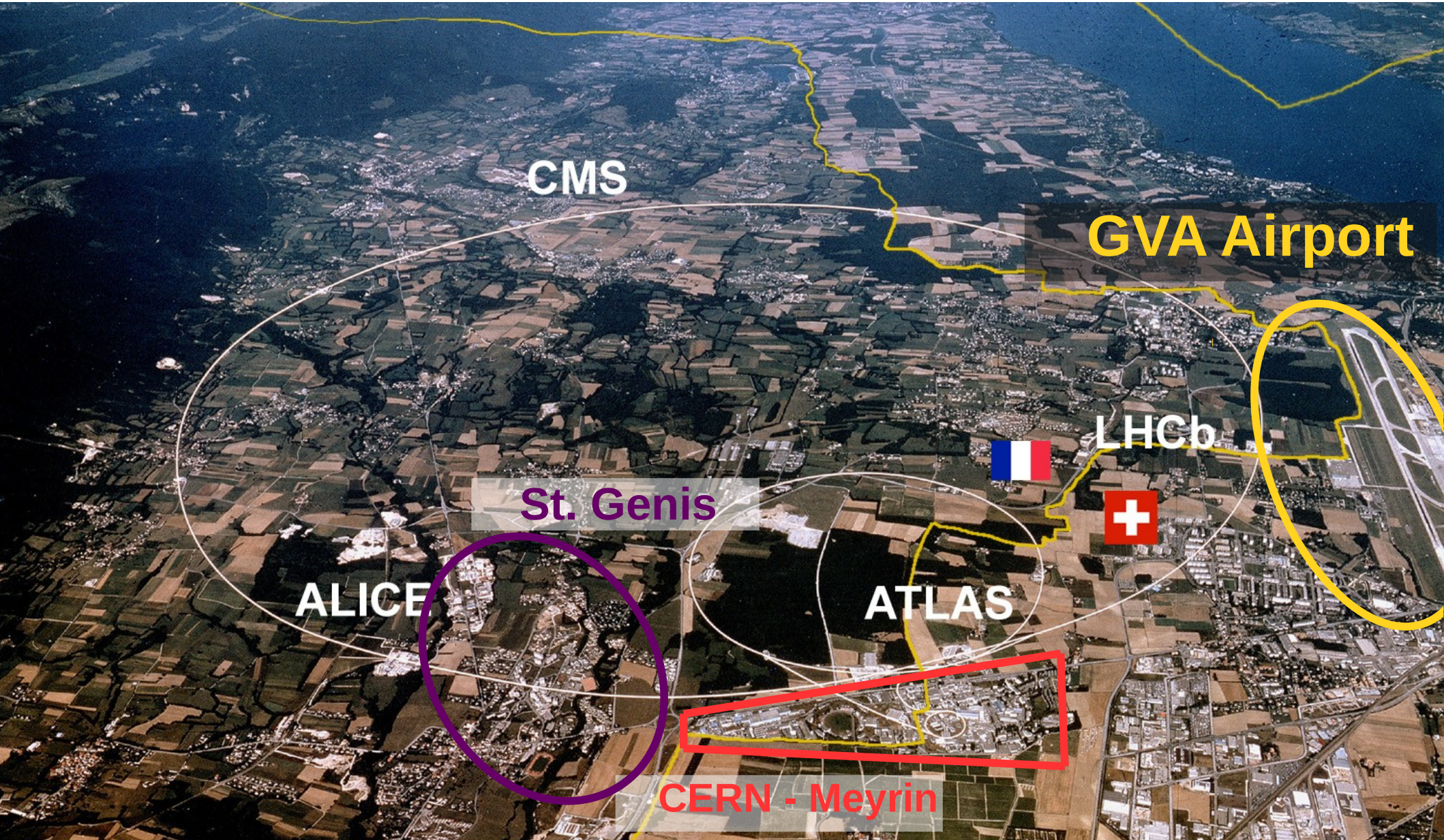
ALICE @ CERN LHC

ALICE @ CERN LHC

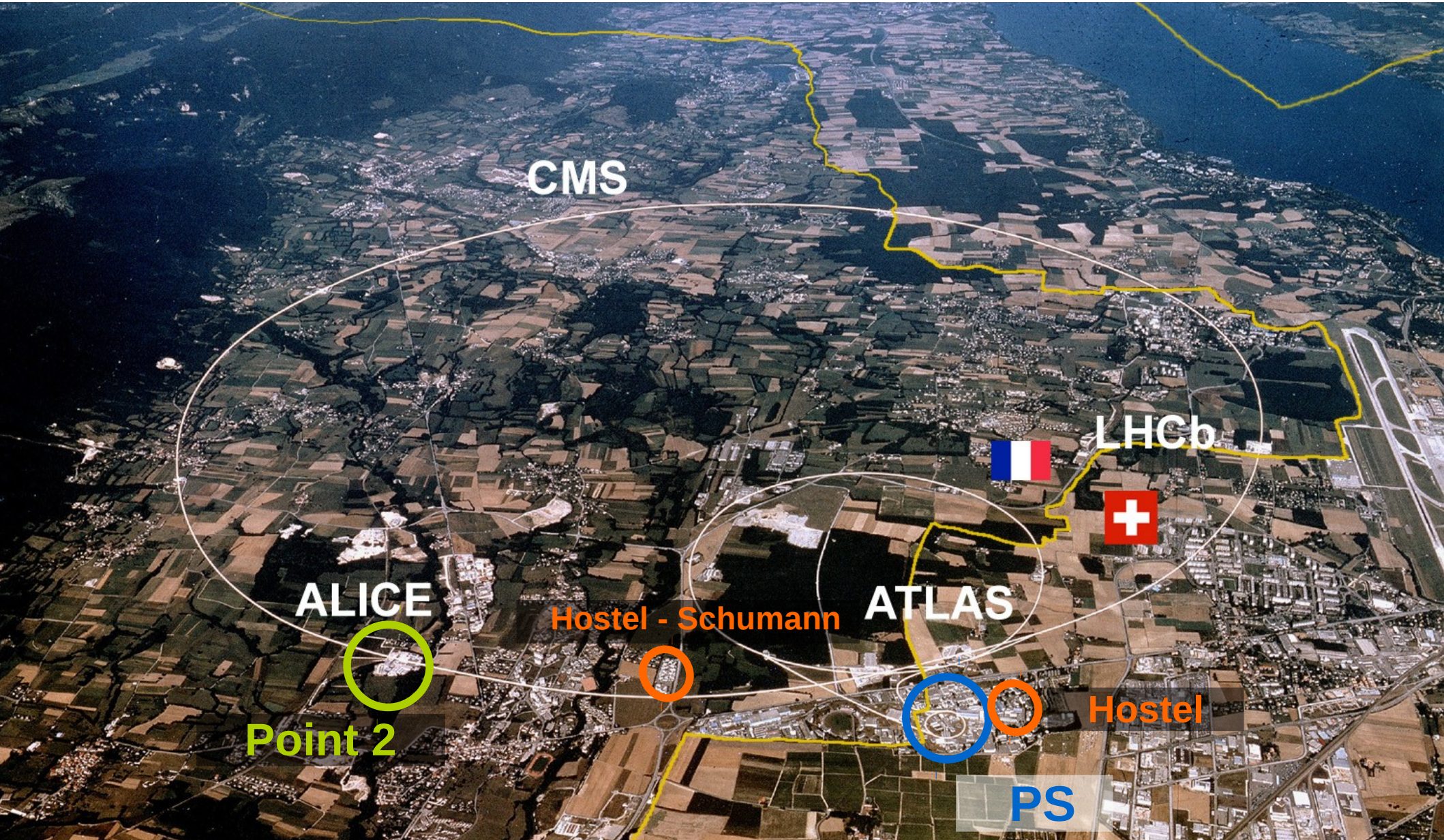
ALICE @ CERN LHC



ALICE @ CERN LHC

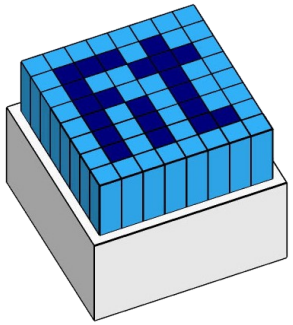


ALICE @ CERN LHC



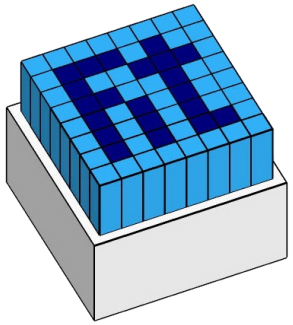
Practicalities – Basic

- Finding a location at CERN: https://maps.cern.ch/mobile/
- Naming conventions:
  - Treat building numbers as random numbers
    (bld 521 will most likely be far away from bld 520)
  - Room 157-R-028 = bld 157, ground floor, room 028
- Registration at CERN: Users Office, bld 61 (same complex as restaurant 1)
- Dosimetry service: bld 55, next to the guard's booth at the main entrance
- Restaurant 1: bld 501
- Restaurant 2: bld 504 (usually less crowded)
- Pre-register your wifi devices before coming to CERN to be able to use them straight away:
  http://information-technology.web.cern.ch/help/connect-your-device
  - Otherwise you can use eduroam network if your home institution provides this service



Practicalities – Access

- Requirements to enter the T10 beam test site at proton synchrotron:
  - Valid CERN User status and CERN ID card
    - http://usersoffice.web.cern.ch/new-registration
    - Your team leader will have to start the pre-registration process
  - Dosimeter
    - How to obtain:
      - https://sir.cern.ch → Radiation protection training for work in Supervised Radiation Areas
      - First-time-dosimeter users are eligible to get it for 3-months period
      - The next time you will need additional medical certificate or certificate signed by your home institution
    - http://dosimetry.web.cern.ch/en/content/personal-dosimeter-employed-or-associated-members-personnel
  - Safety shoes & helmet



Practicalities – EDH

- Requirements to enter the T10 beam test site at proton synchrotron:
  - EDH request
    - http://edh.cern.ch
      - Access request → Bottom-right corner: Add
        - Access site: Meyrin
        - Select proper entries from Access Building and Zone fields
        - You can leave the dates empty or set them according to the time of your visit
        - Justification is mandatory, for example: Participation in FIT beam test for ALICE in June 2016
    - **Buildings / rooms**:
      - Control Room T10 (**0157-R-028**) – our main control room
      - Control Room T9.2 (**0157-R-016**) – just an additional office space
    - Remember to save and send your EDH request (round buttons on the top of the webpage)
      - EDH signature password is different than your CERN user password
    - Be patient – there is a whole chain of (2-4) people who need to approve your request
  - You can check all your access permissions (and what is possibly missing) here:
    - http://cern.ch/adams

Practicalities

Entrance to the building 157

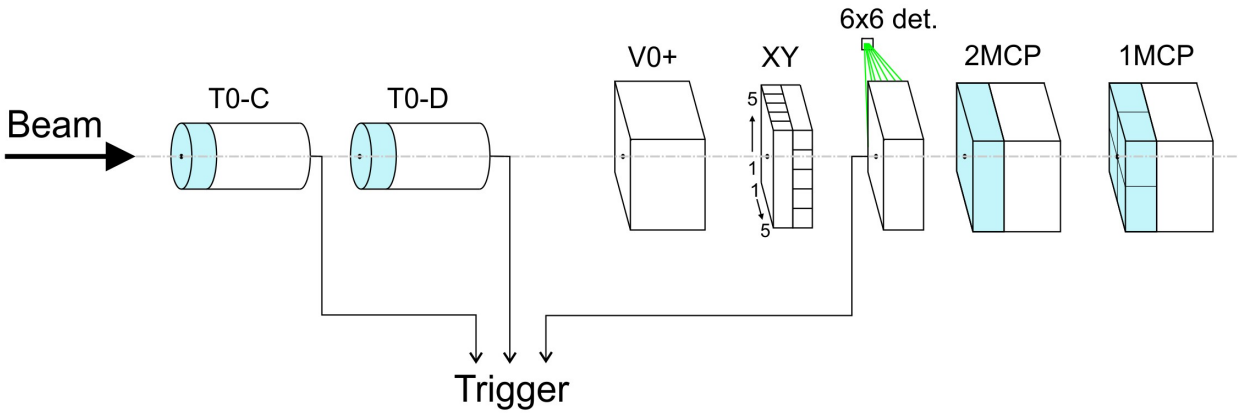
(dosimeter is required)

Terminal to encode your ID card to gain acess to T10 and T9.2 **after EDH request has been approved**

Entrance to the experimental hall

- Dosimeter, helmet and safety shoes are required

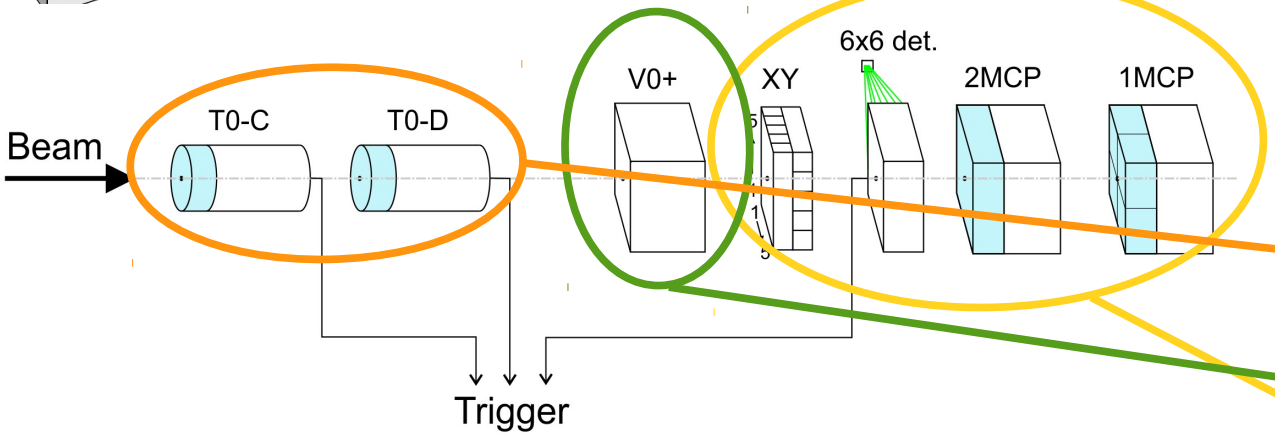
Experimental Cavern T10

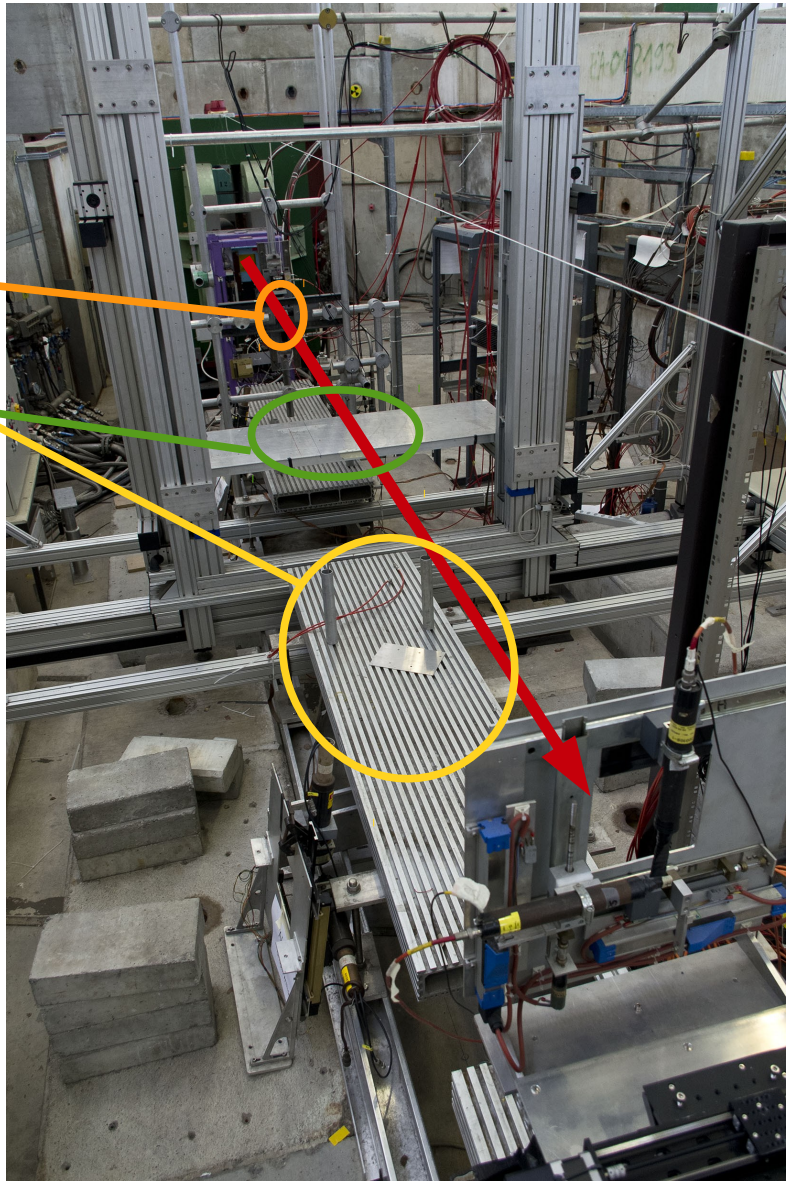


CAEN DT57** Digitizer

- http://www.caen.it/csite/CaenProd.jsp?parent=14&idmod=651

Experimental Cavern T10





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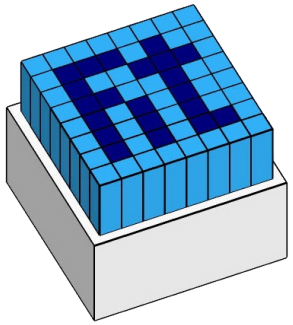
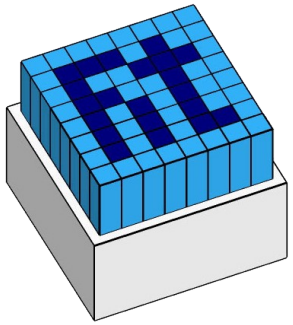


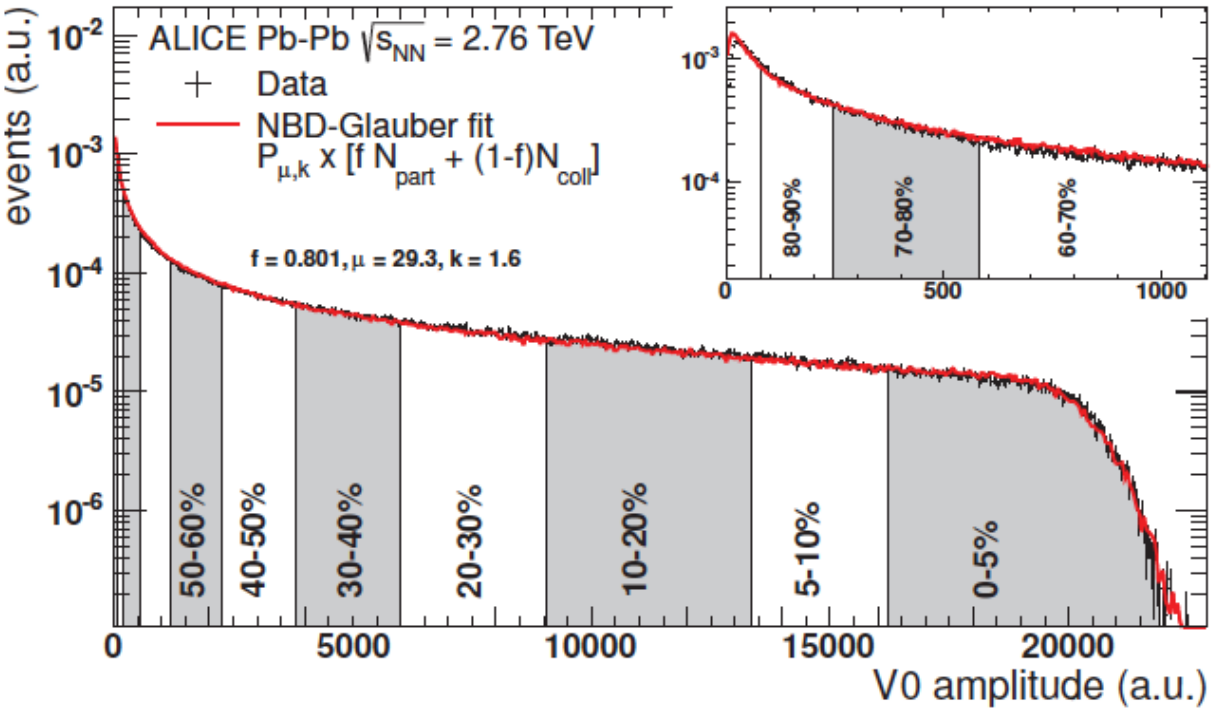
ALICE @ CERN LHC

- The big(ger) picture
  - Quark Gluon Plasma
  - Centrality, Event plane, Elliptic flow
- T0 & V0 – history lesson
- LHC schedule

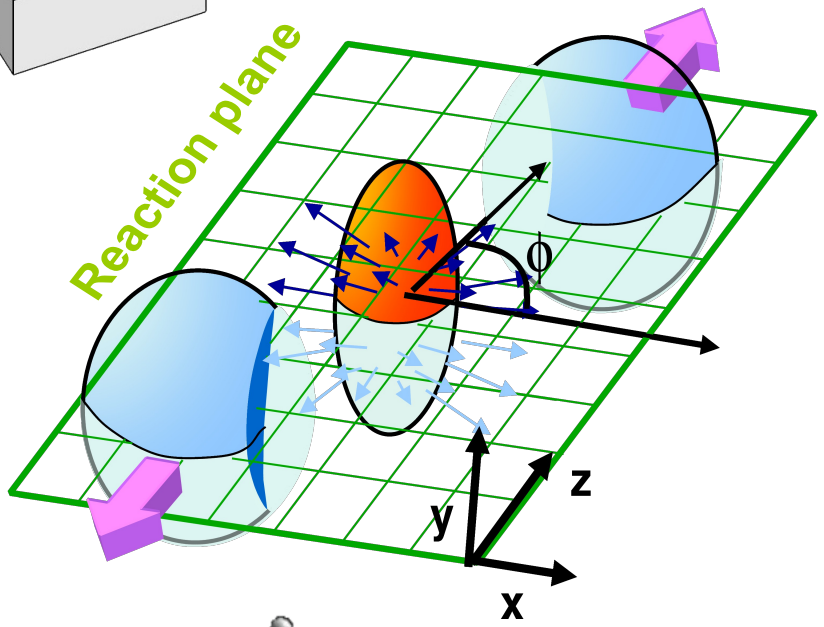


ALICE @ CERN - Goal

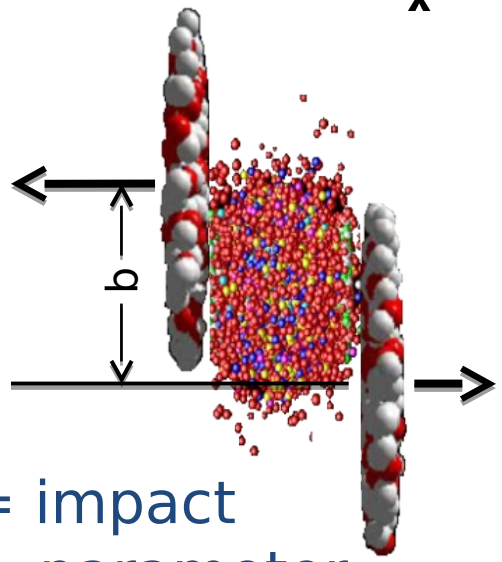
- ALICE is mainly interested in **heavy ion collisions.**
  - But also pp data is collected.
- Study the formation stages and properties of quark-gluon plasma (QGP). Short general recipe:
  - Select events on the basis of the **centrality** class, they belong to;
  - Extract the **event plane (EP)** - an angle at which two nuclei collided;
  - Study the **elliptic flow** of the QGP (ie. the distribution of outgoing particles after the collision with respect to the event plane) → compare with theoretical models;



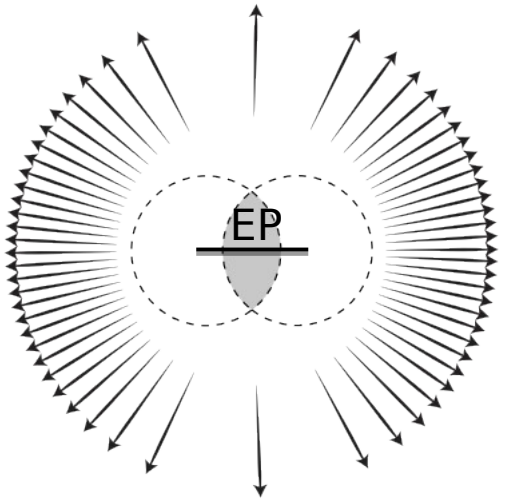
ALICE – Centrality and EP



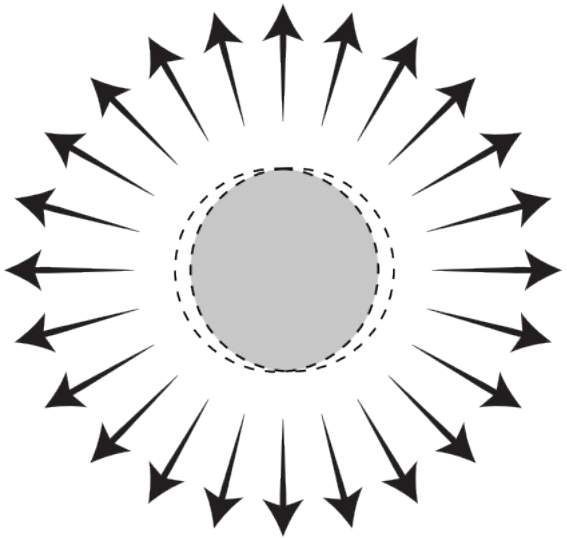
- The flow (density) of particles along the event plane is higher
  - distribution of particles → centrality and event plane
  - Centrality is bound to impact parameter with the theoretical model (see Glauber model)



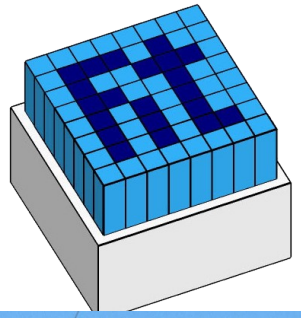
b = impact parameter

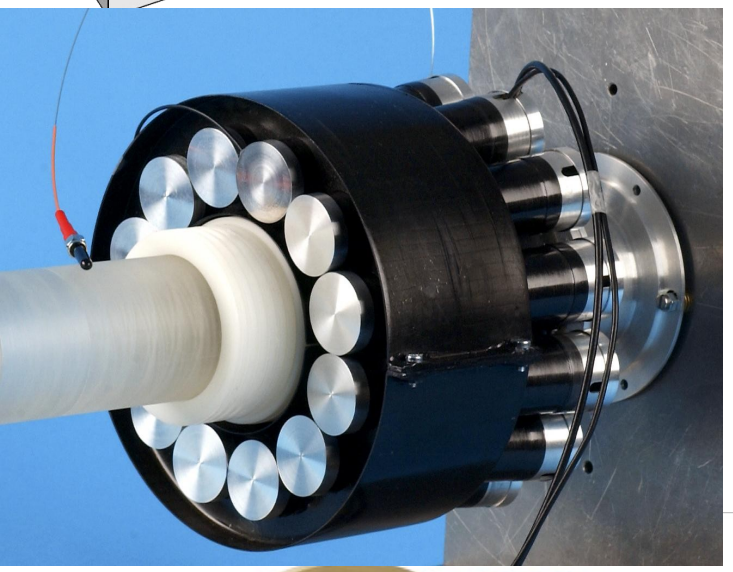


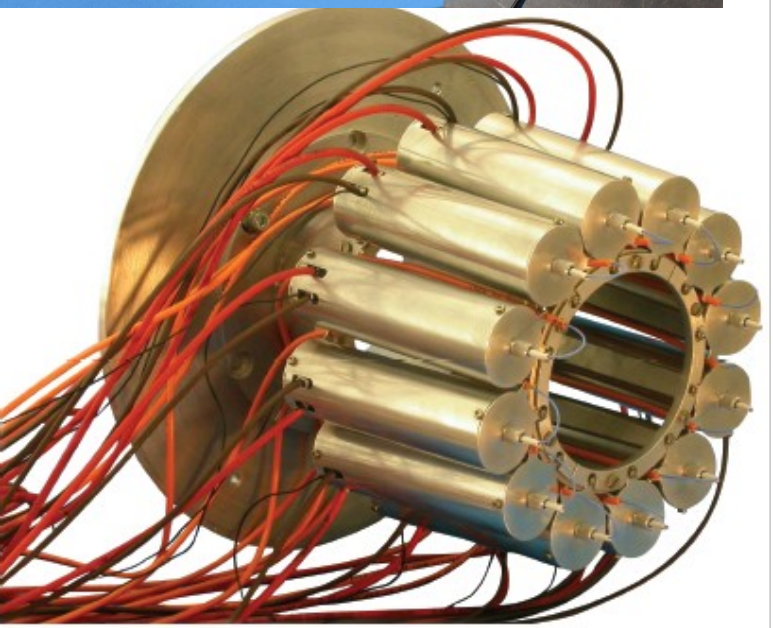
Peripheral



Central







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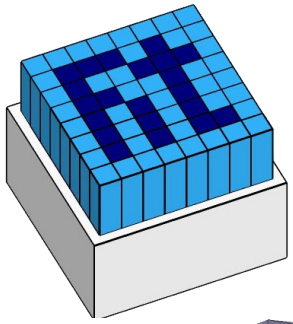
Current T0

Cherenkov counters:

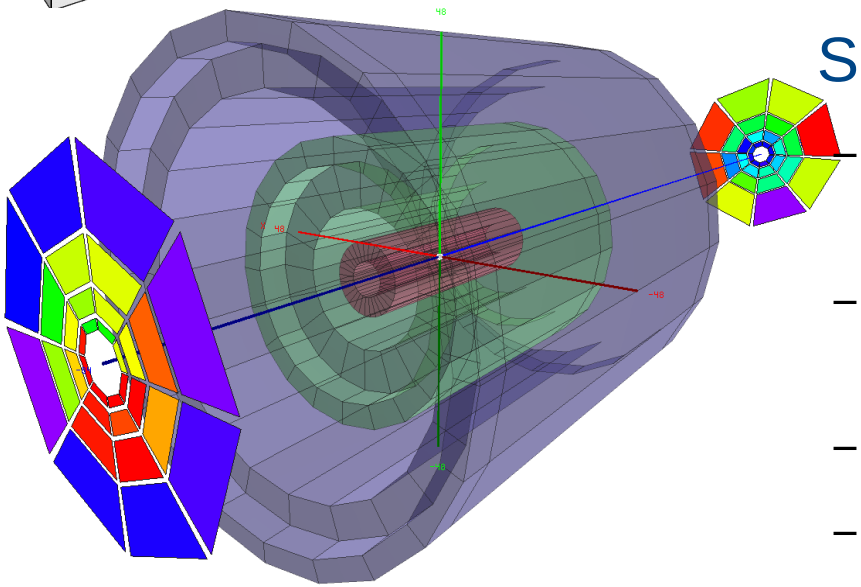
- Quartz radiator → PMT
- 12+12 detectors on both sides of the IP
- Placed around beamline as close to it as possible
- Requires **HV**
- Online **laser** calibration
- Time resolution better than 50 ps
- Online minimum bias (MB) trigger
- Online vertex determination
- Start time for Time-Of-Flight (TOF) detector

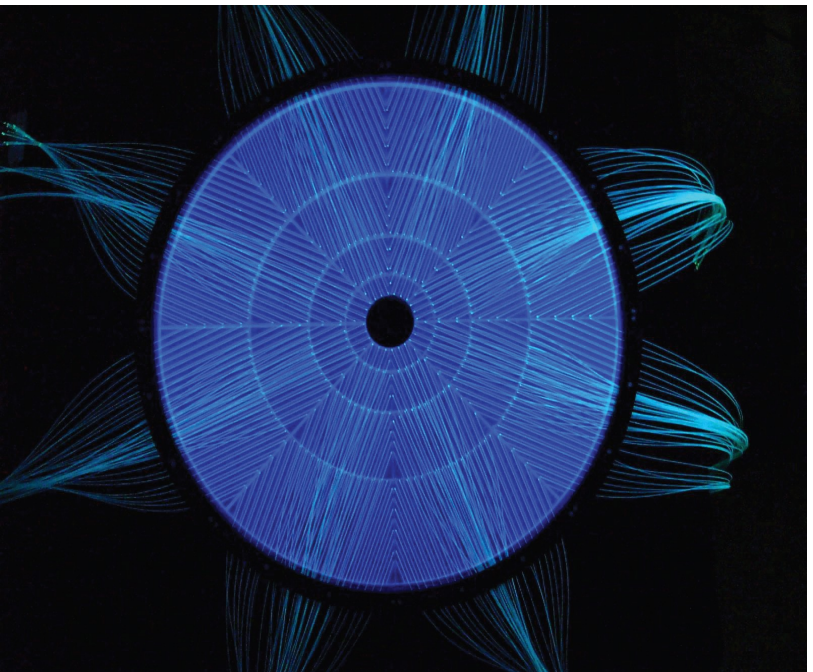
Limitations:

- Small acceptance
- Lack of hermeticity



Current V0





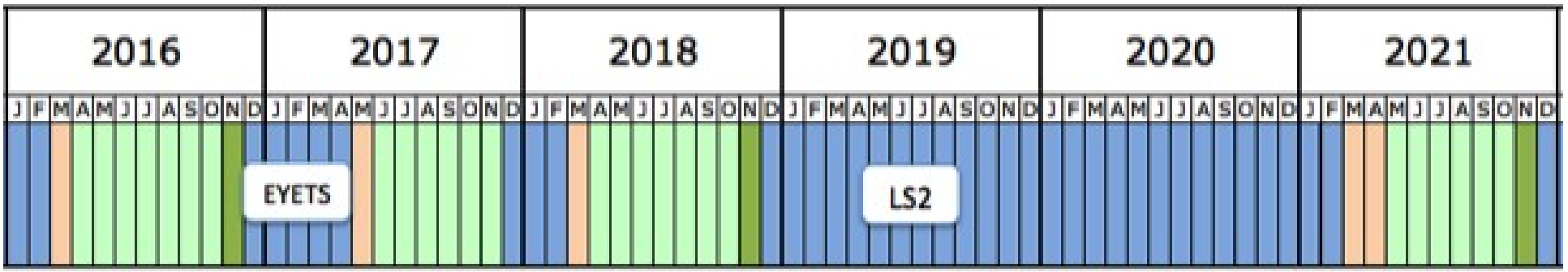
Scintillator sectored rings:

- A and C side (340 cm and 90 cm from IP respectively)
- Wavelength shifting (WLS) fibers → clear optical fibers → PMT
- 4 rings placed around beamline
- 8 sectors
- Requires **HV**
- Time resolution better than 1 ns
- Online MB trigger

Limitations:

- Low time resolution
- Durability issues

CERN LHC schedule

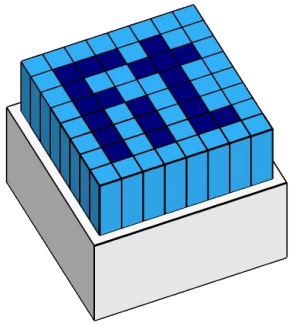


LHC **upgrade** during the Long Shutdown2 (LS2)

- Increase in **luminosity** (number of collisions per s per cm^2)
- Sustained p-p operation at 25 ns **bunch crossing time**
- **Minimum-bias** Pb-Pb at the target interaction rate of 50 kHz (20 us)
  - (now <1 kHz; downgraded from available 8 kHz)

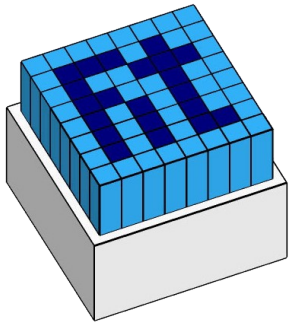
→ ALICE needs a new fast interaction trigger → **FIT**

- Installation and commissioning during 2019 – 2020



FIT after LHC Upgrade

- Description
- Previous beam test results
- Simulation results
- Recent problems & fixes



The LS2 ALICE upgrades

ALICE
A JOURNEY OF DISCOVERY

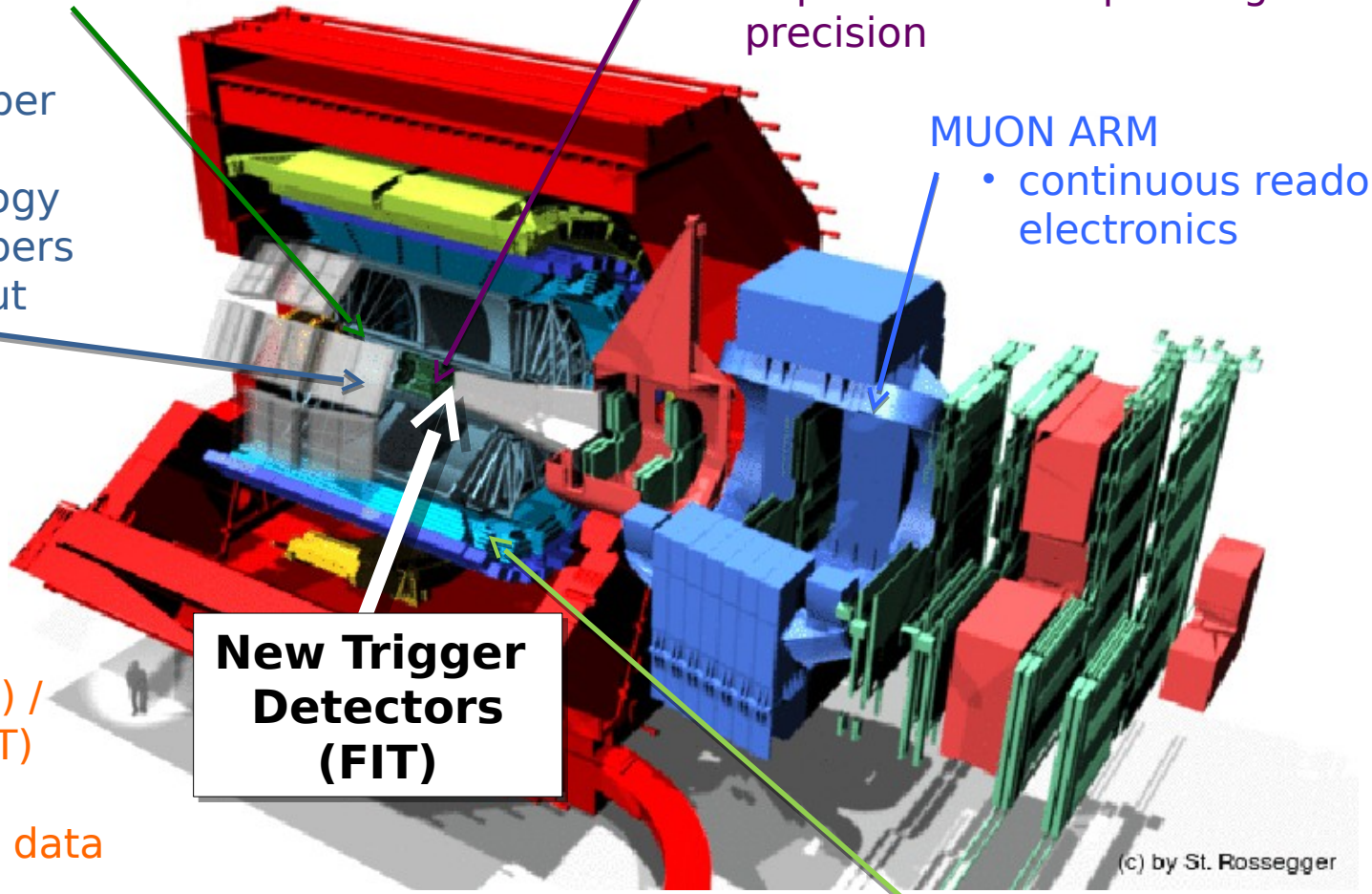
New Inner Tracking System (ITS)
- improved pointing precision
- less material -> thinnest tracker at the LHC

Muon Forward Tracker (MFT)
- new Si tracker
- Improved MUON pointing precision

Time Projection Chamber (TPC)
- new GEM technology for readout chambers
- continuous readout
- faster readout electronics

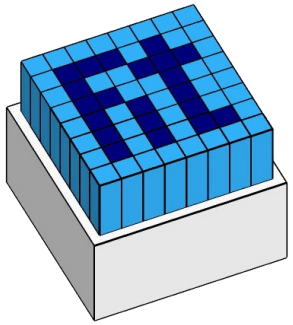
MUON ARM
- continuous readout electronics

New Central Trigger Processor



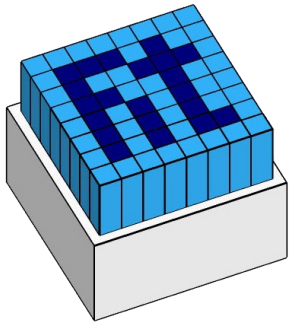
Data Acquisition (DAQ) / High Level Trigger (HLT)
- new architecture
- on line tracking & data compression
- 50kHz Pb-Pb event rate

TOF, TRD
- Faster readout



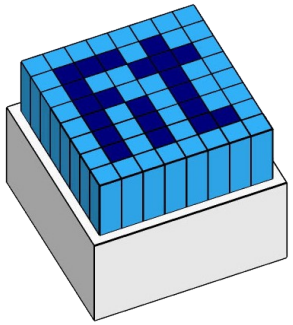
Why ALICE needs FIT

- Luminosity monitoring & feedback to LHC
  - **Essential** for the operation of ALICE
- Fast Interaction Trigger
  - Online **Vertex** determination
  - Minimum Bias and **centrality** selection
  - Rejection of **beam/gas** events
  - **Veto** for Ultra Peripheral Collisions
- Collision time for Time-Of-Flight particle ID
- **Multiplicity** → **Centrality** and **Event Plane**



Historical view vs. requirements for FIT

Requirements for FIT after LS2	T0	V0
Time resolution	**yes**	**no**
Amplitude resolution	**yes**	**yes**
Durability	**yes**	**no**
Acceptance	**no**	**yes**
Hermeticity	**no**	**yes**
Module / detector size	**no**	**no**
Electronics	**Needs modification**	**no**
Readout	**no**	**no**

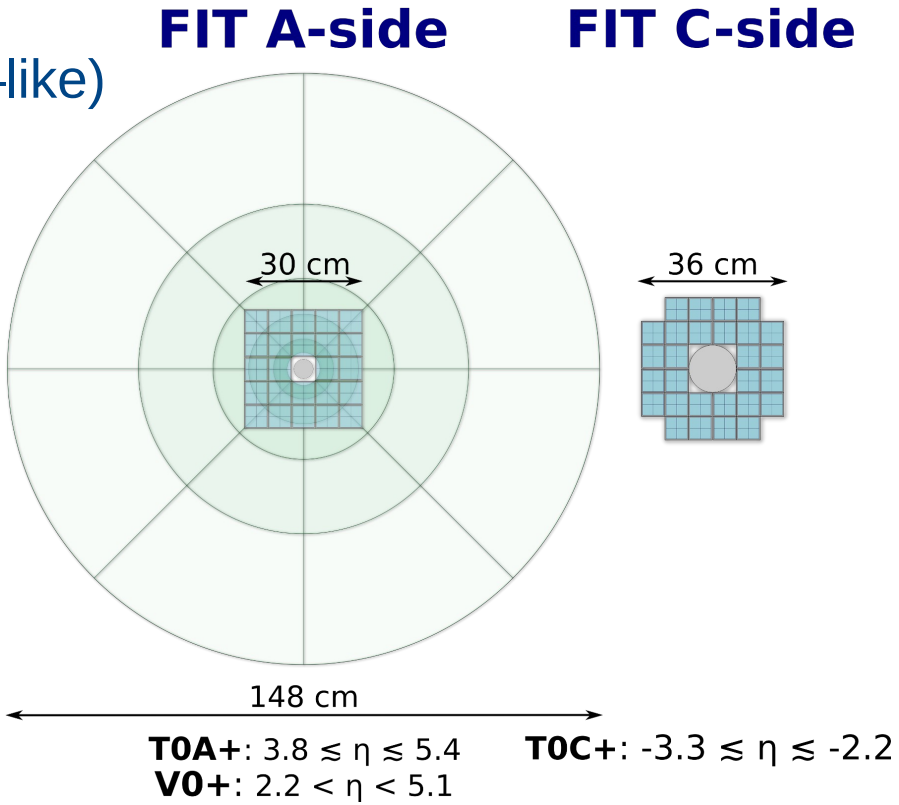


Designing FIT

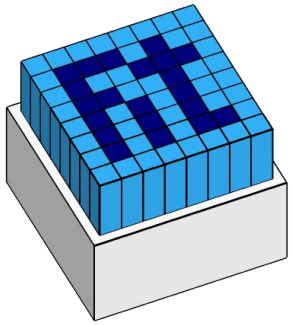
- How to make FIT **fast** (ΔT < 50 ps)
  → Cherenkov radiators (quartz) + MCP (T0–like)
- How to make FIT **big** (large acceptance)
  → Large area scintillators (V0–like)

FIT = **T0+** and **V0+**

To fulfill all of ALICE requirements FIT must incorporate the elements of both T0 and V0



- For reliable operation both elements must be well integrated with each other

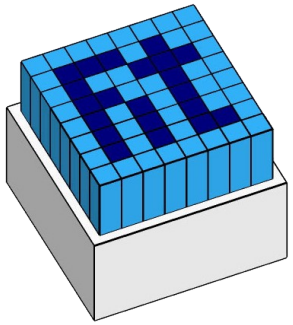


FIT geometry

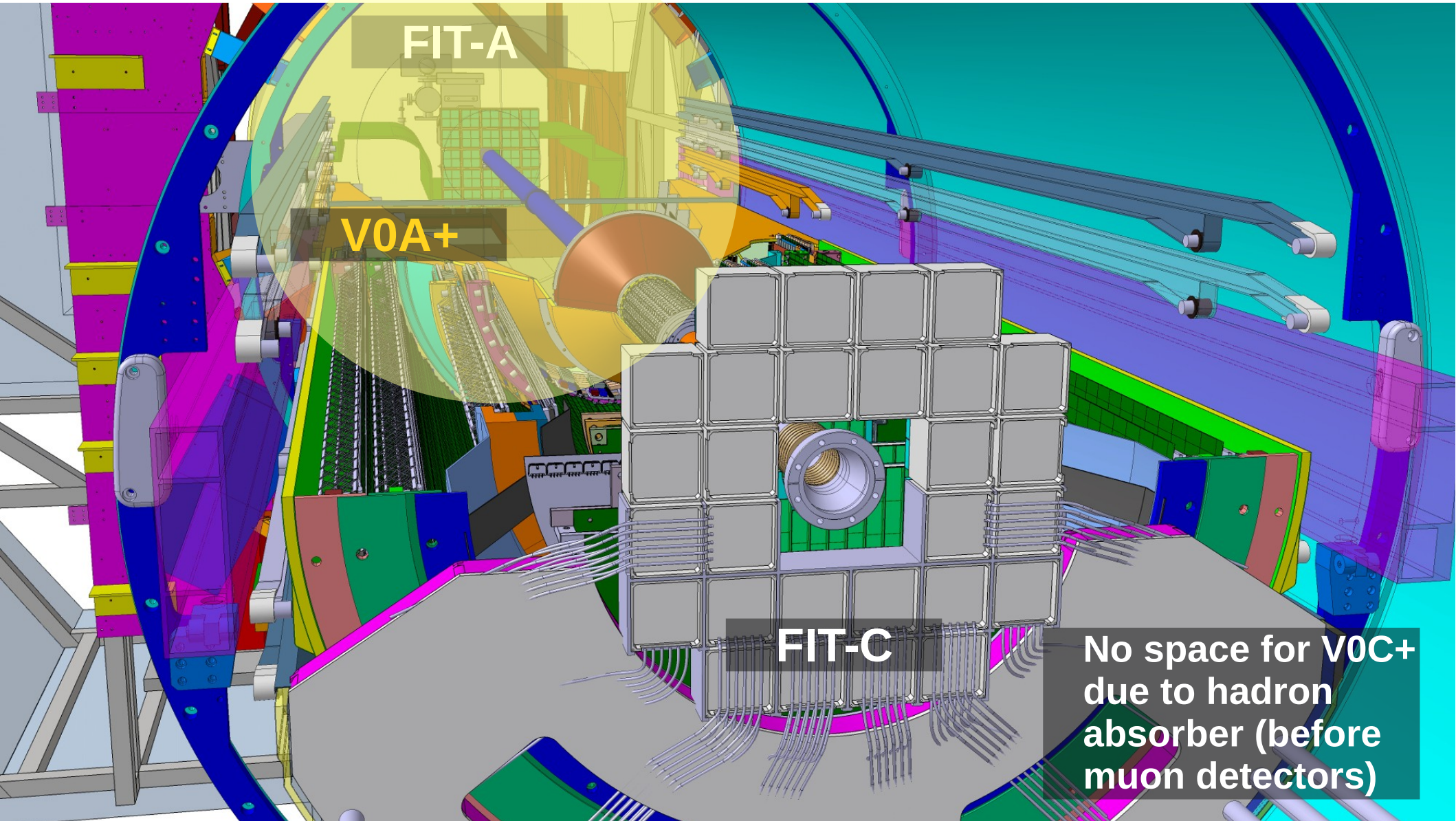
ALICE
A JOURNEY OF DISCOVERY

FIT-A

FIT-C

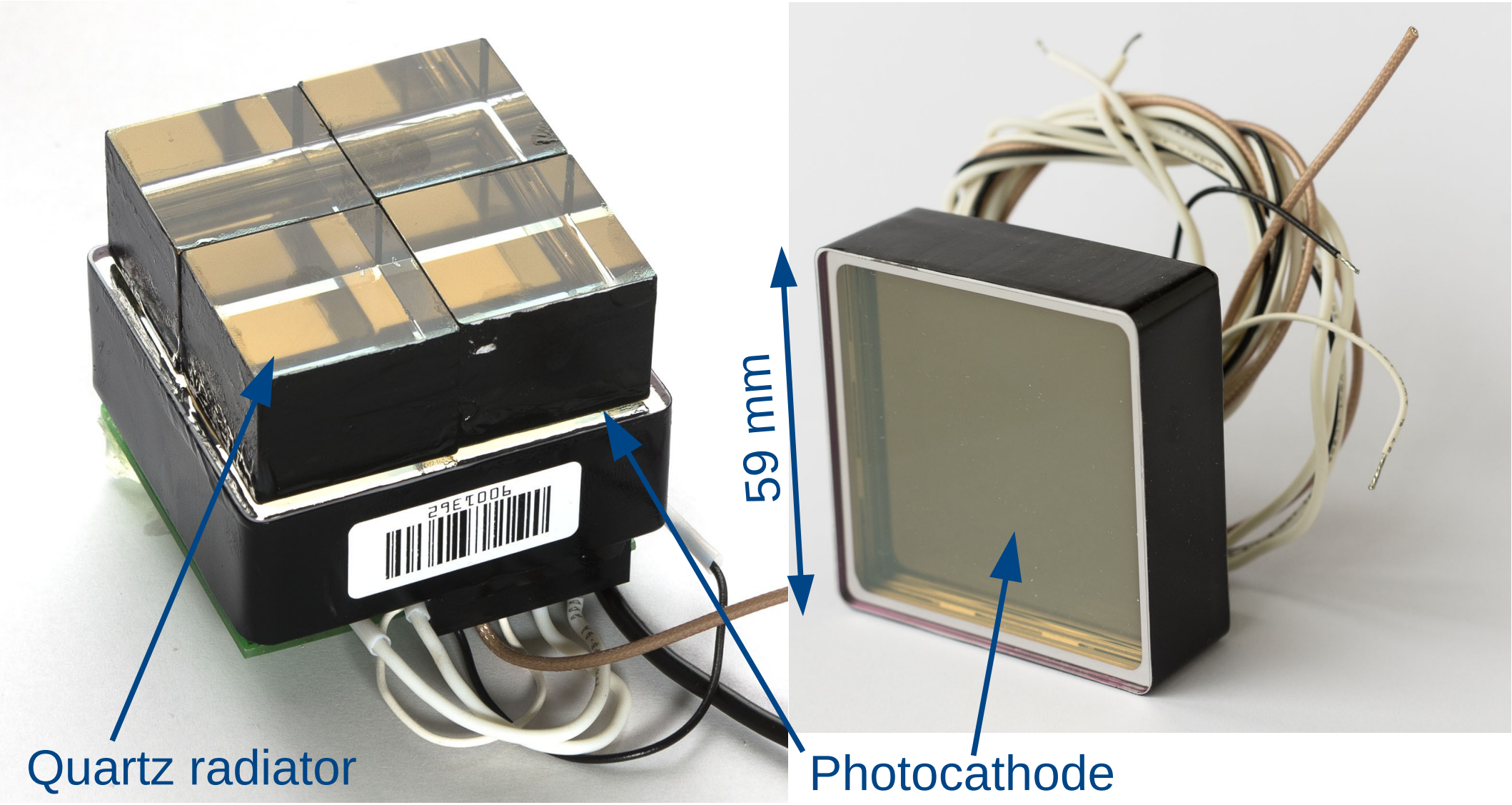


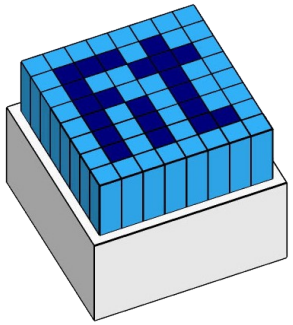
FIT geometry



The prototype of FIT T0+ module

PLANACON XP85012 MCP-PMT





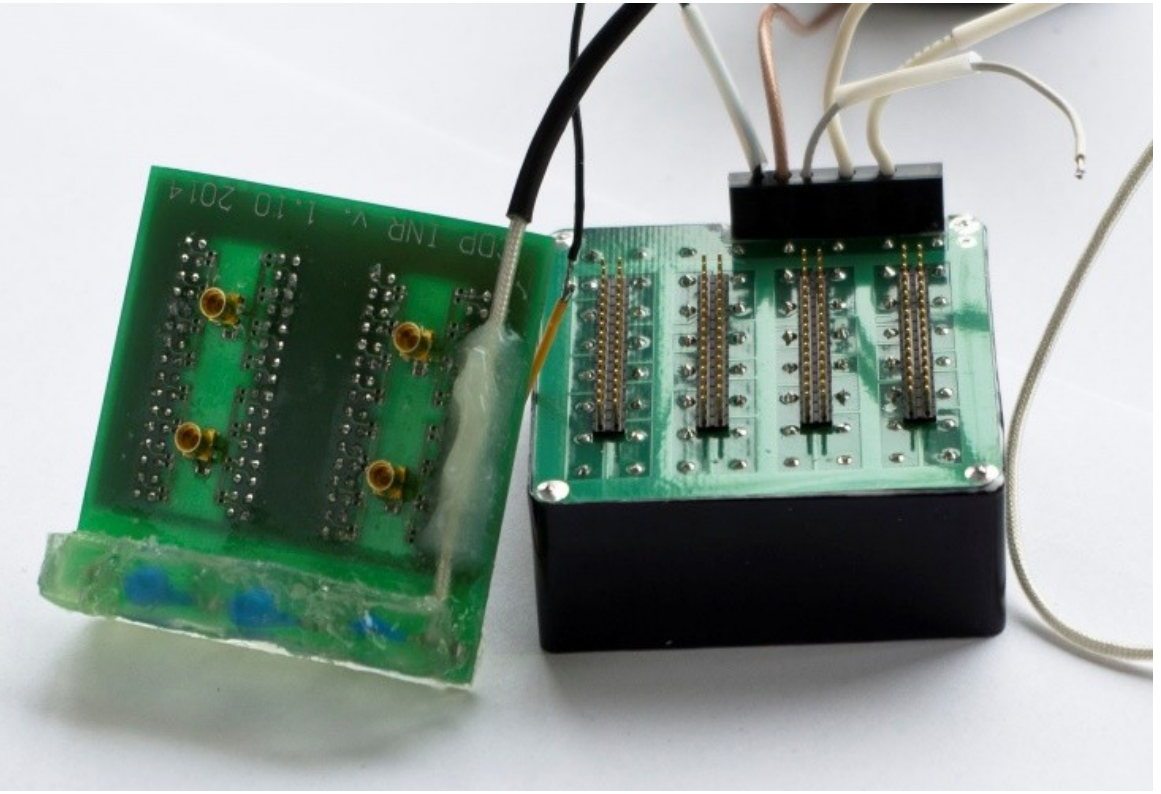
The main problems
with a standard PLANACON® XP85012

- **Common output** (64 anodes connected together) → capacitance
  → positive crosstalk → distorted **time** measurements
- Need for **additional PCB** → increased inductance and capacitance
  → signal shape distortion (also dependent on coordinates)
- Different **trace lengths** for individual anodes
  → decreased the MCP **time resolution**.

Our solution

- **New PCB** for XP85012 was designed and manufactured at INR and assembled to a new PLANACON MCP by Photonis
- The **modified** PLANACON
  - Eliminated the '**positive crosstalk**'.
  - Increased **signal amplitude** for a given MCP gain
  - Eliminated additional PCB
  - Improved **time resolution** and signal shape stability
  - Reduced the **size** of the unit

PLANACON XP85012 Standard vs. modified



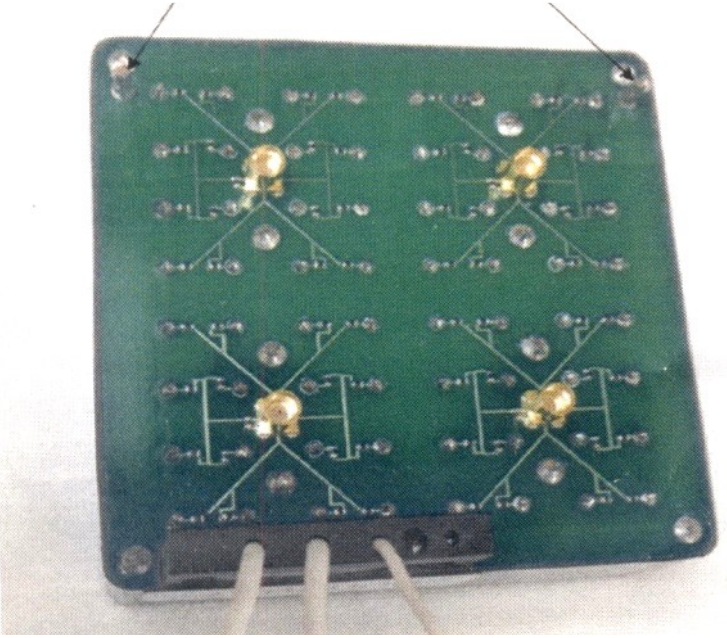
Top: **Standard** off-the-shelf PLANACON®.

It has a **common output** and uses **non-RF** connectors for anode outputs.

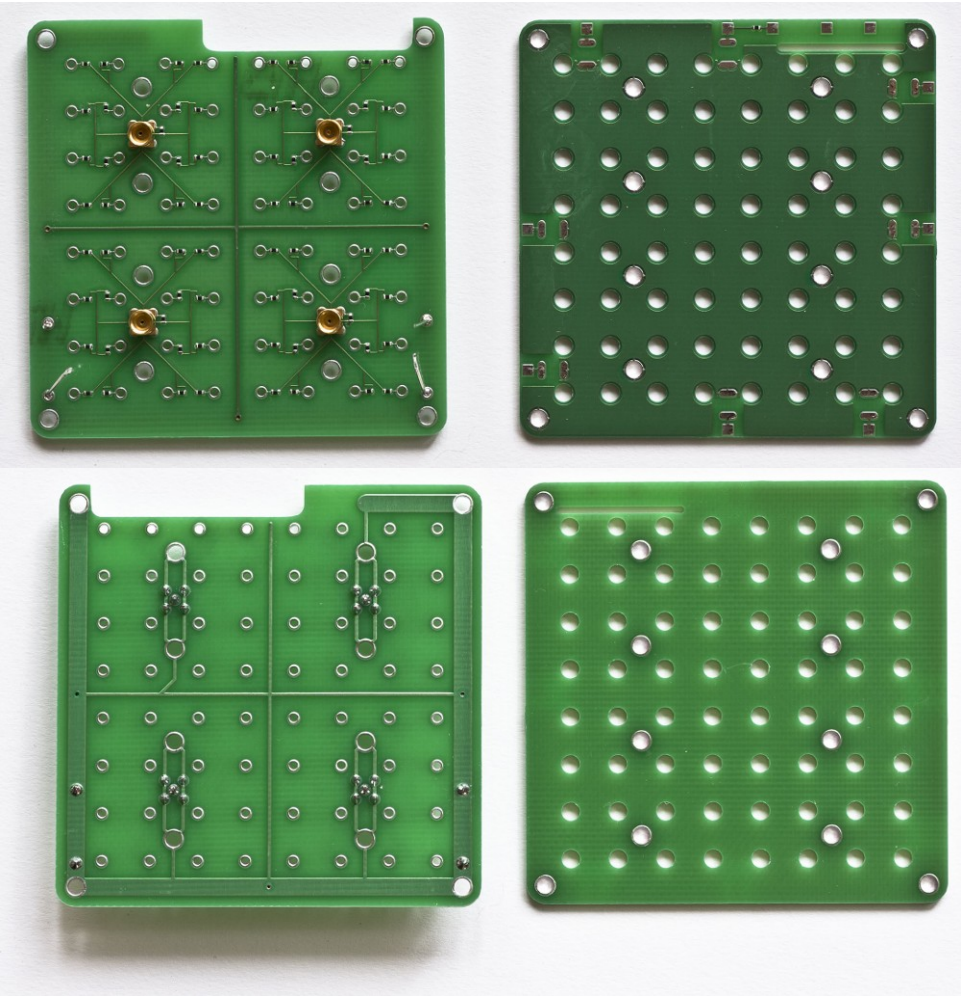
Top left: An additional backplane PCB combining 4 x 16 anodes.

Modified variant has:

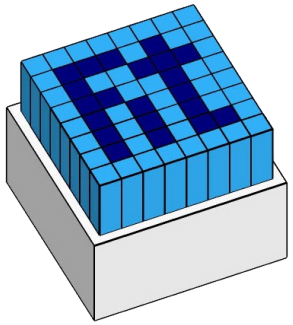
- **RF** grounded MCP out electrode
- **Reduced** anode-ground **capacitance**
- **Equalized propagation time** from individual anodes to the output connectors.



PLANACON XP85012
News on modification

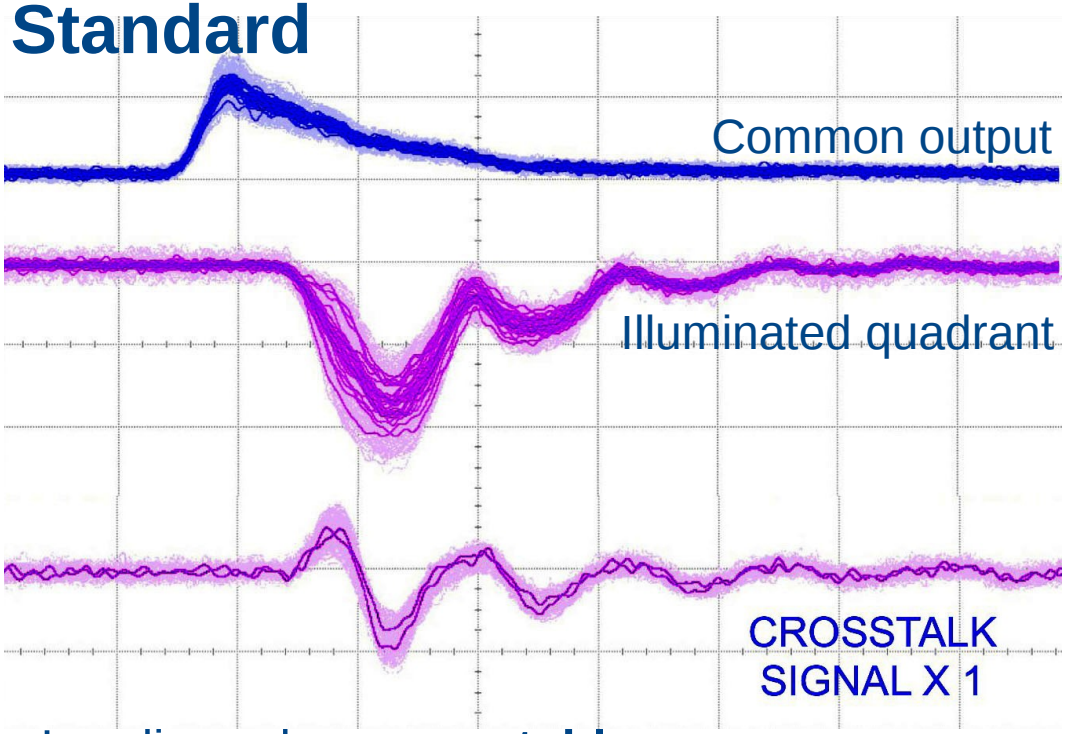


- One MCP was modified last year and tested in November 2015
- The PCBs are now installed in two more MCPs and stored at CERN
  - ready to be **tested** at PS @ 6 GeV/c in **June 2016**



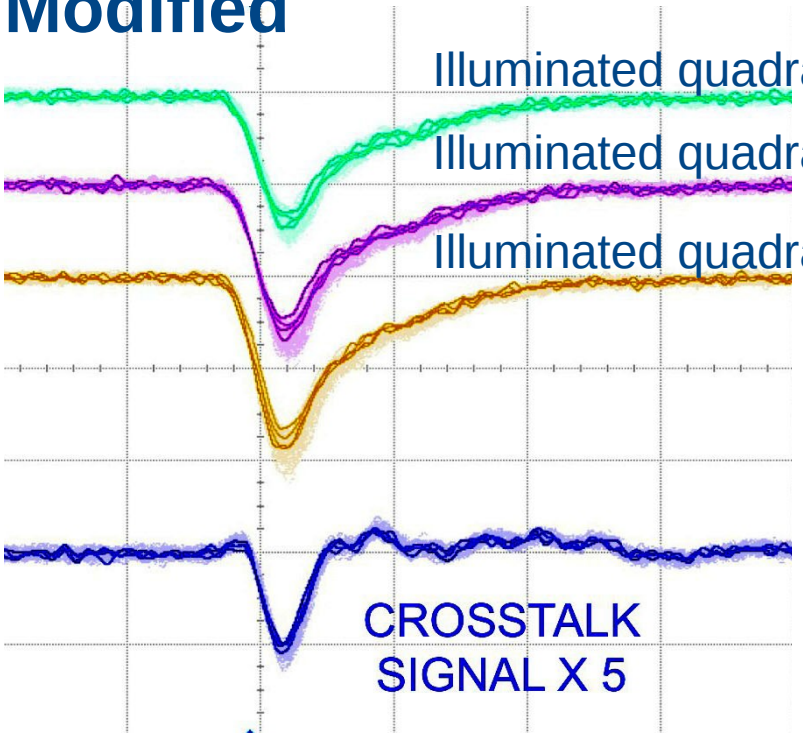
Laser tests of the modified PLANACON

Standard

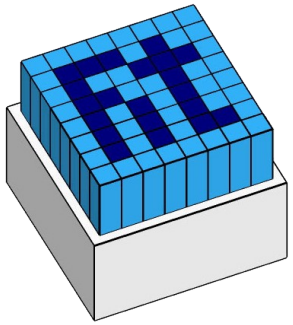


- Leading edge → **unstable**
  - depends on charge distribution between individual anodes of the three illuminated quadrants.
- Trailing edge → o**scillation**
- The **crosstalk** signal is **large**.

Modified



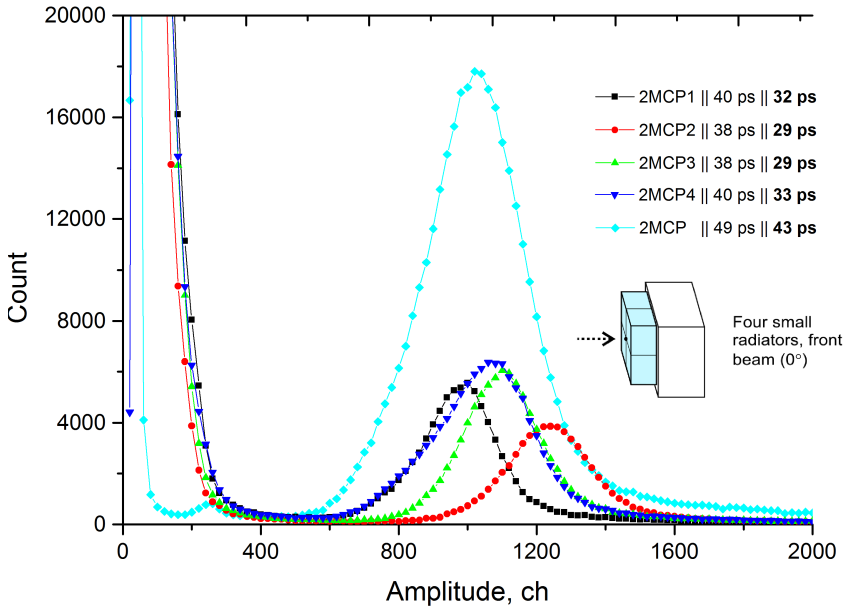
- Signals from the 3 illuminated quadrants → **stable** and without oscillations.
- The **crosstalk** signal:
  - is **~5x smaller**
  - has only a negative component
  - no time shift
  - the trailing edge is 1.5x shorter.



Beam tests (@PS, 6 GEV/c) of the modified PLANACON

ALICE
A JOURNEY OF DISCOVERY

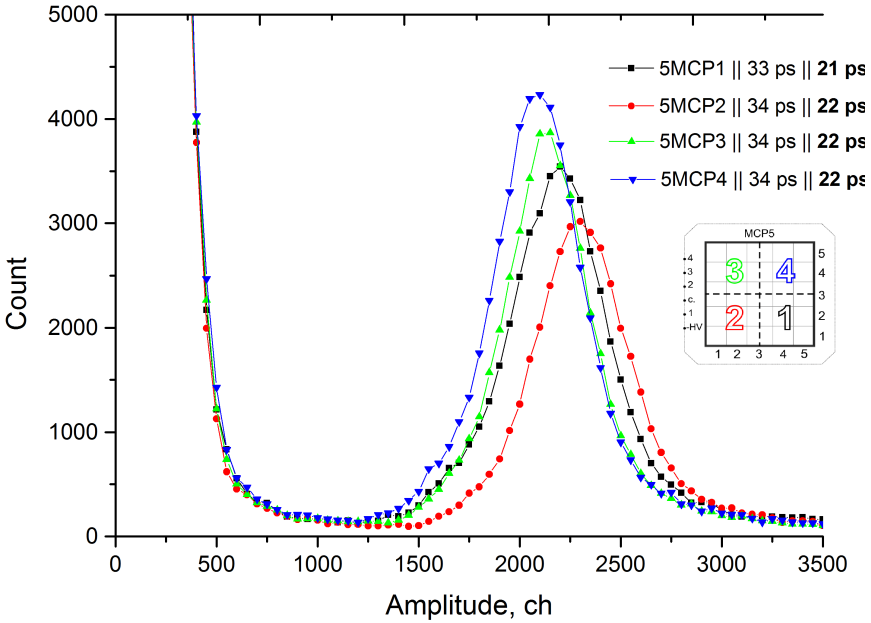
Standard



As measured in June 2015

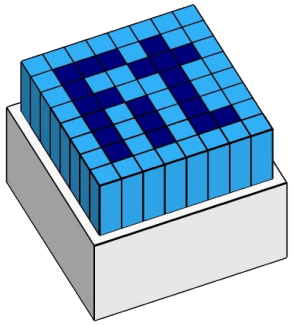
- **Standard** XP85012
  - MCP amplification 10^6
  - Amplitude ~**1100** channels
  - Time resolution **~30 ps**

Modified



As measured in October 2015

- **Modified** XP85012
  - MCP amplification 10^6
  - Amplitude ~**2100** channels
  - Time resolution **~22 ps**



ALICE
A JOURNEY OF DISCOVERY

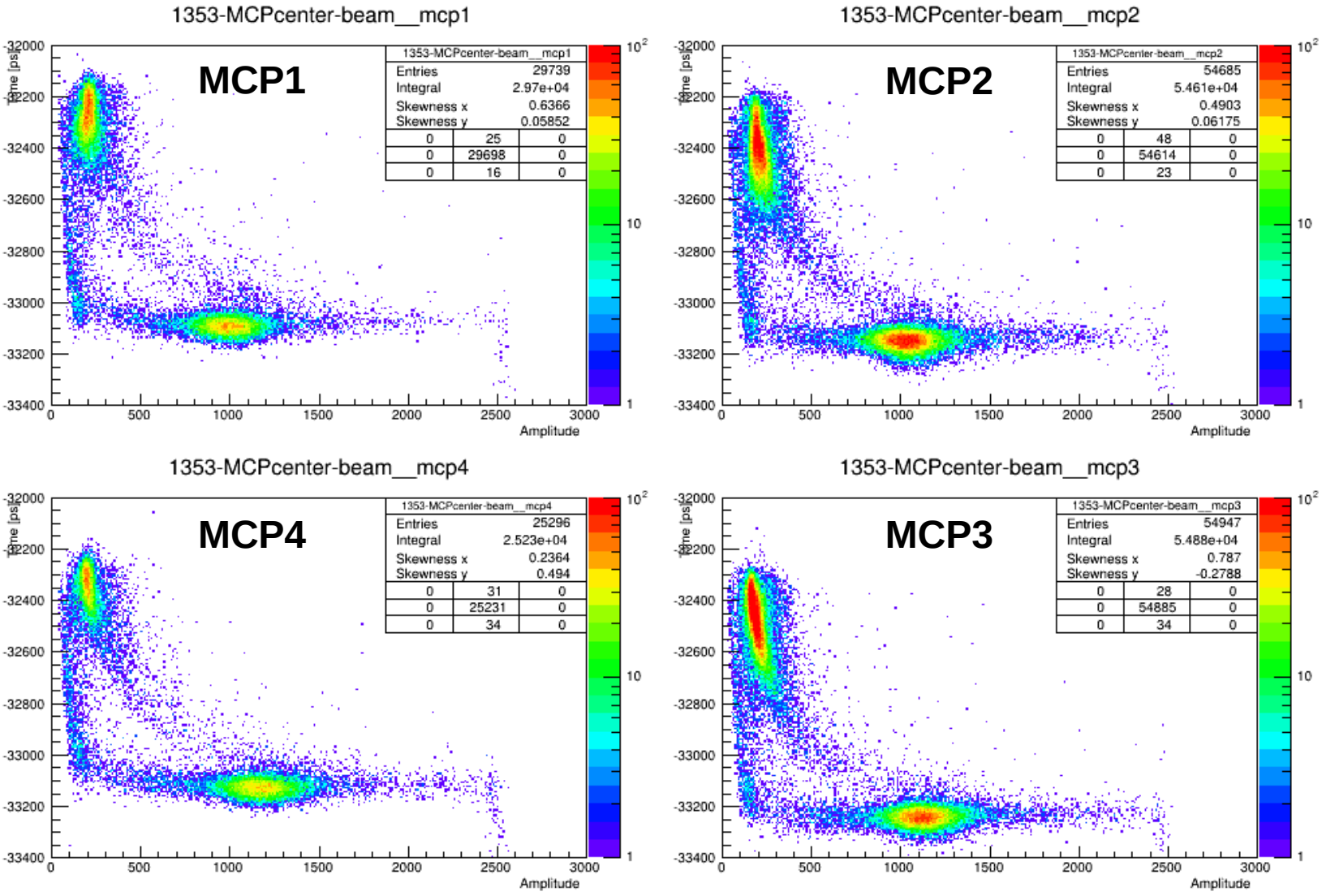
A short history detour.

- (Almost) raw data collected in June 2015 with an unmodified MCP
- Interpretation

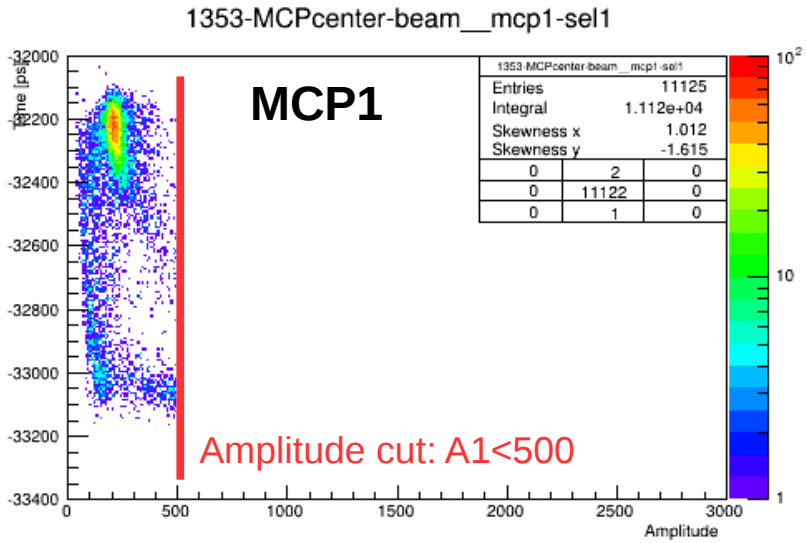
No cuts applied to raw data from unmodified MCP

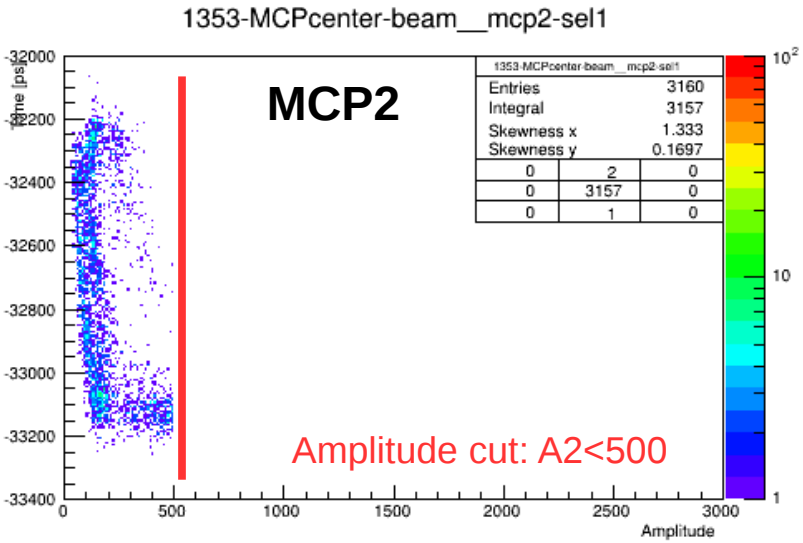
ALICE
A JOURNEY OF DISCOVERY

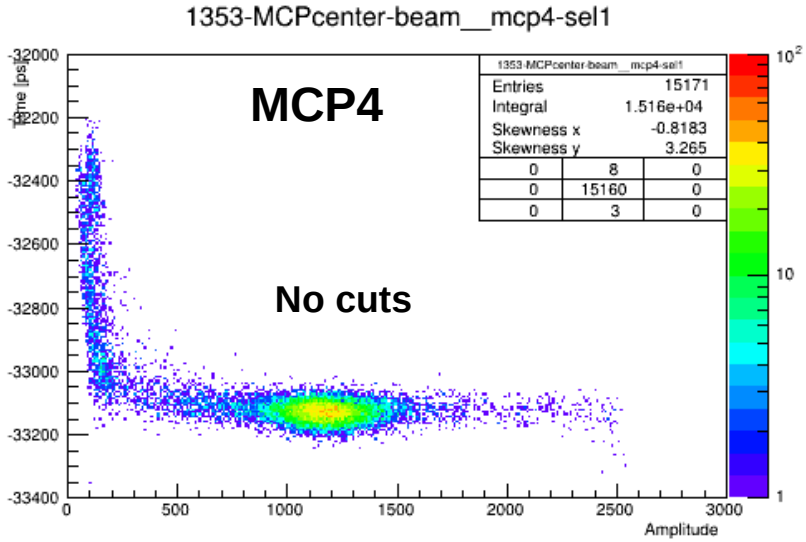
No cuts

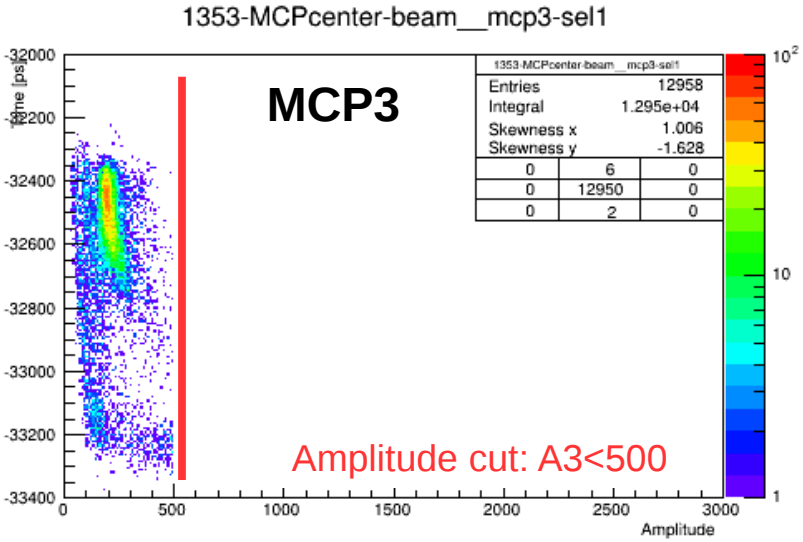


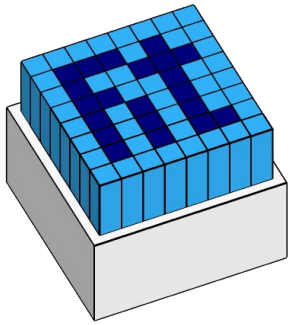
Aplitude cuts at 3 pixels









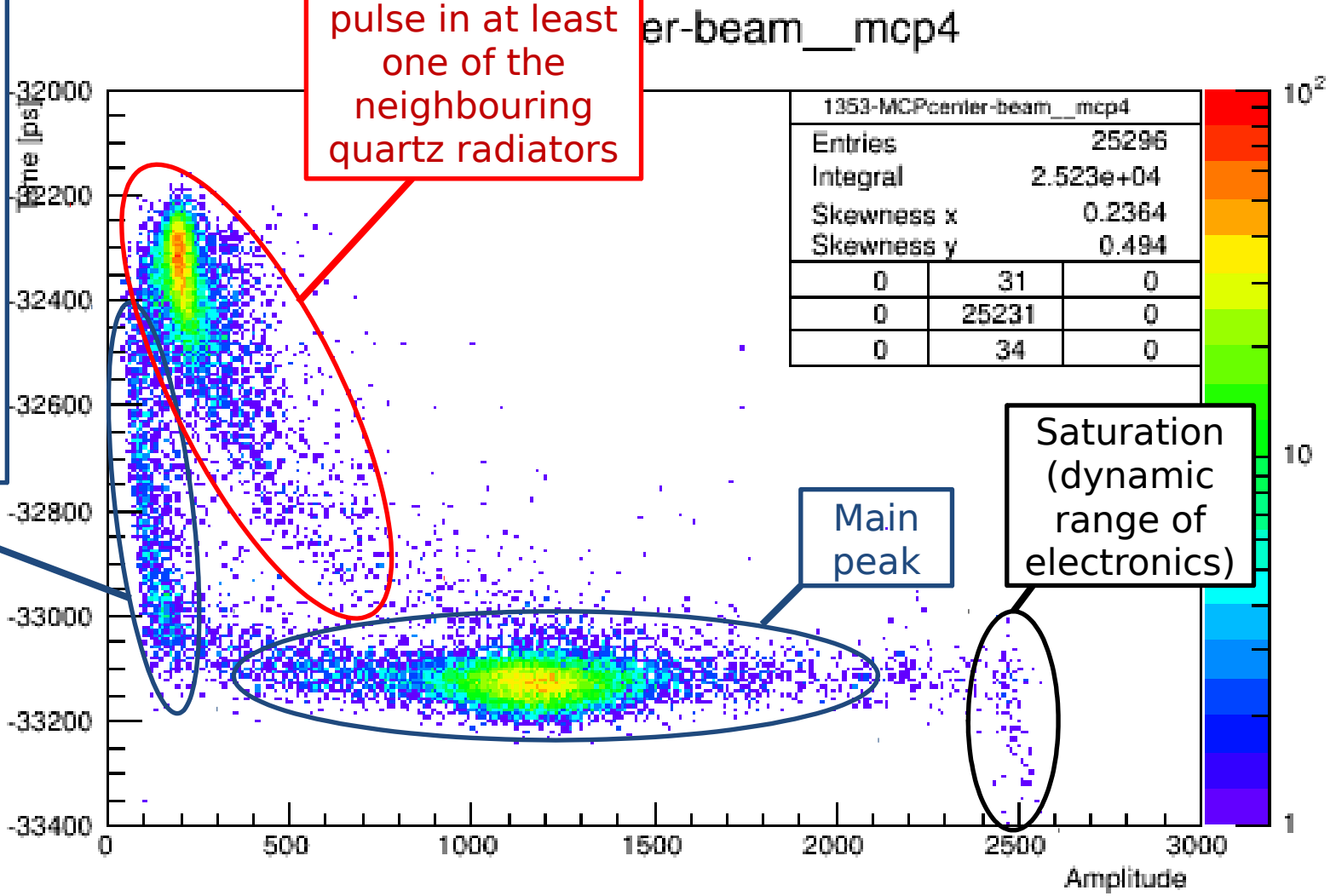


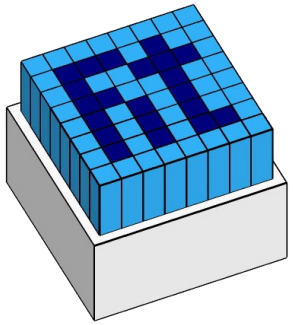
Interpretation

Events exactly at the center between 4 quartz crystals.

This section appears only when **no** high-amplitude pulses are present in the neighbouring quartz radiators.

The effect of high-amplitude pulse in at least one of the neighbouring quartz radiators

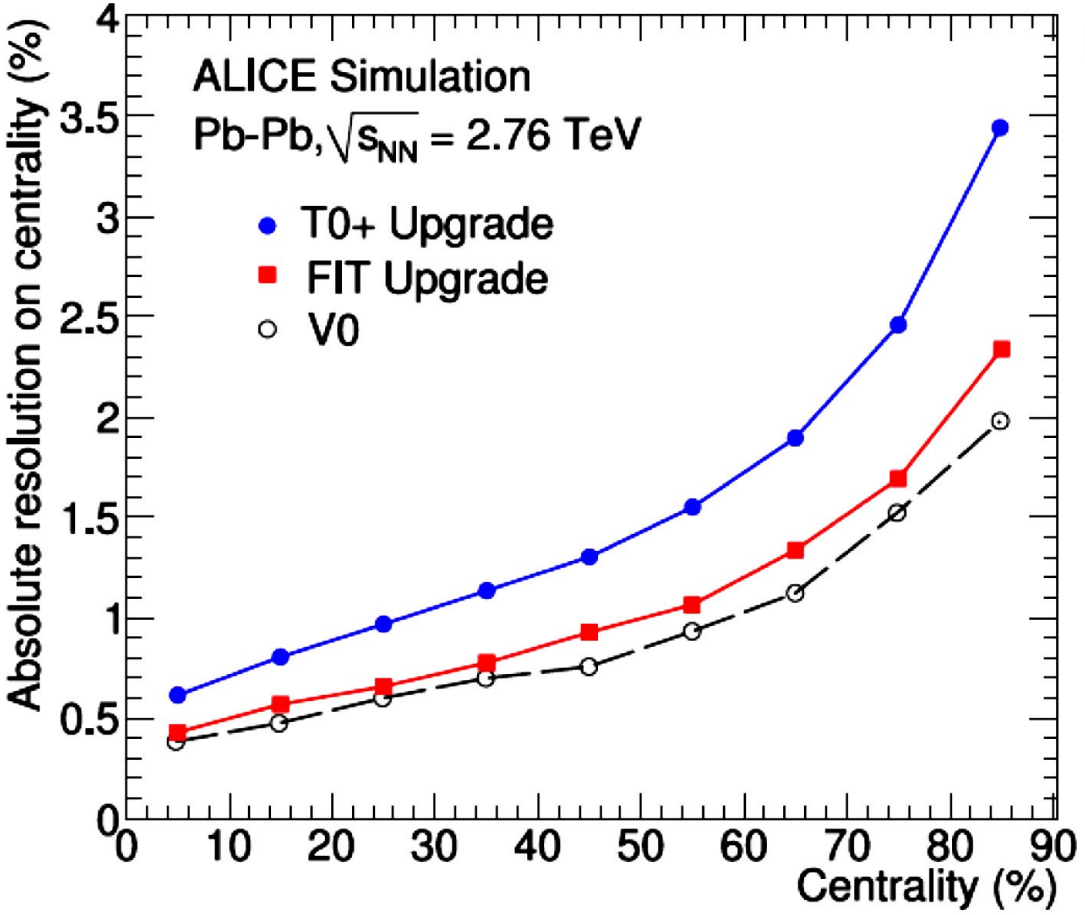


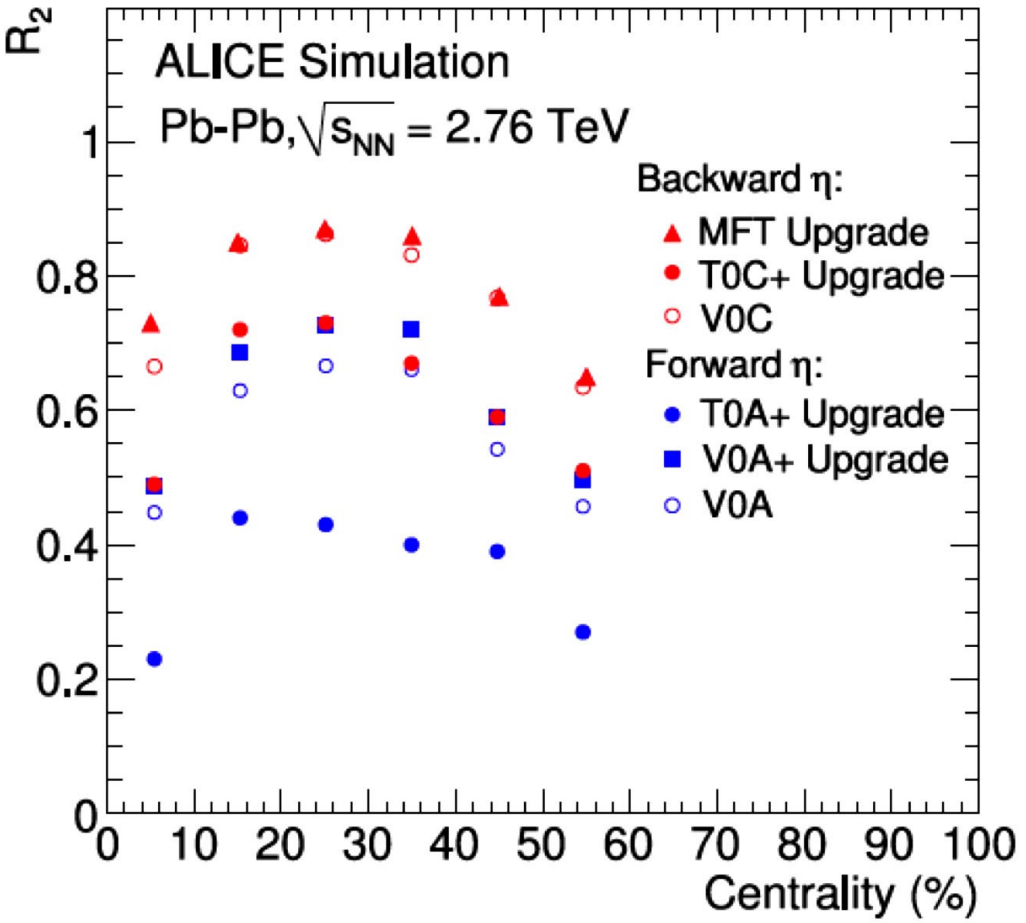


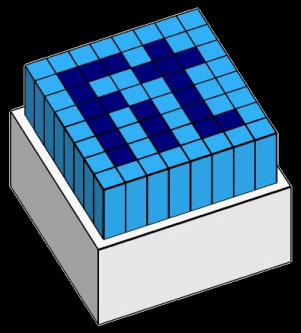
ALICE
A JOURNEY OF DISCOVERY

End of detour and back to V0

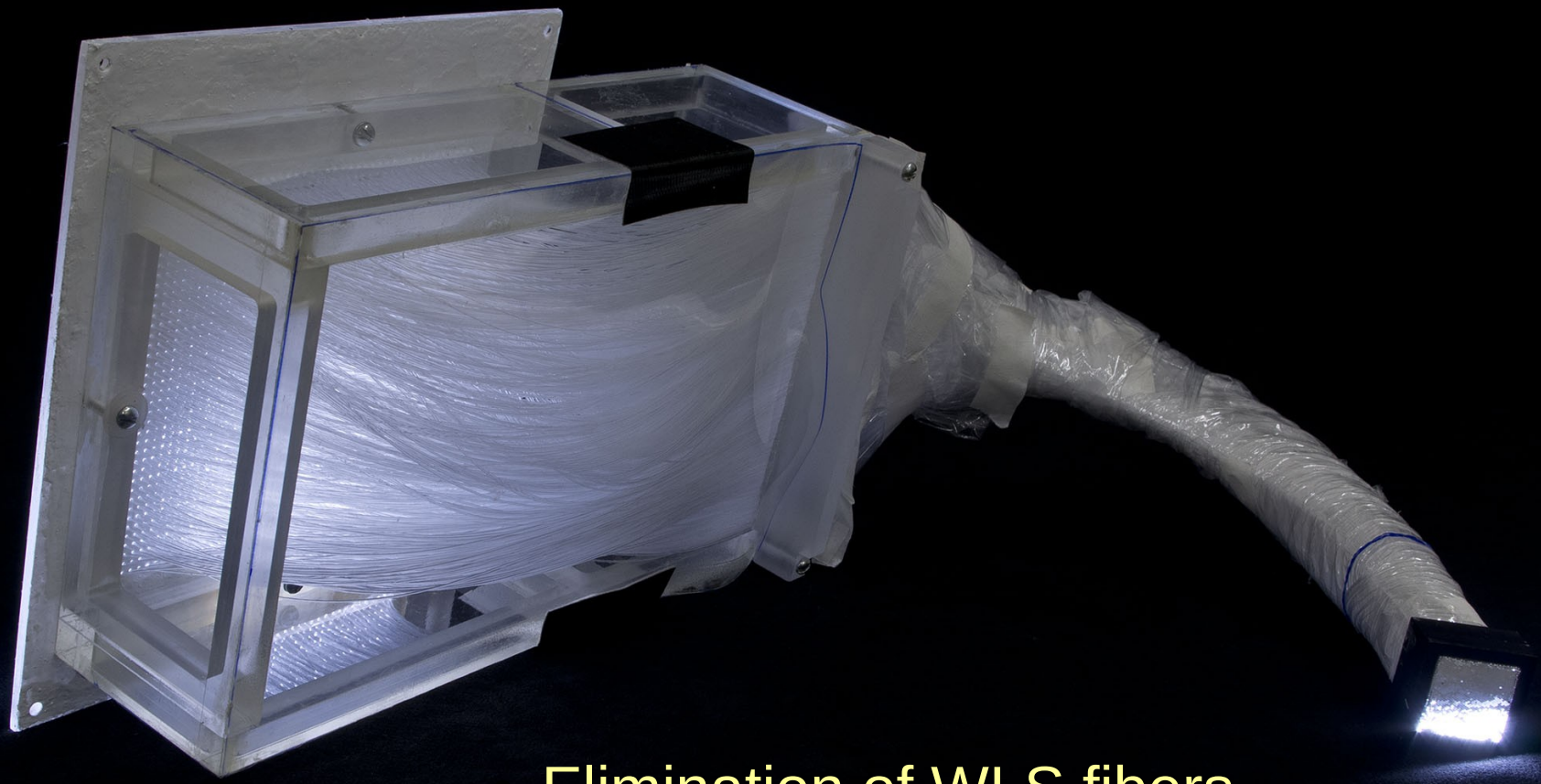
Importance of V0+





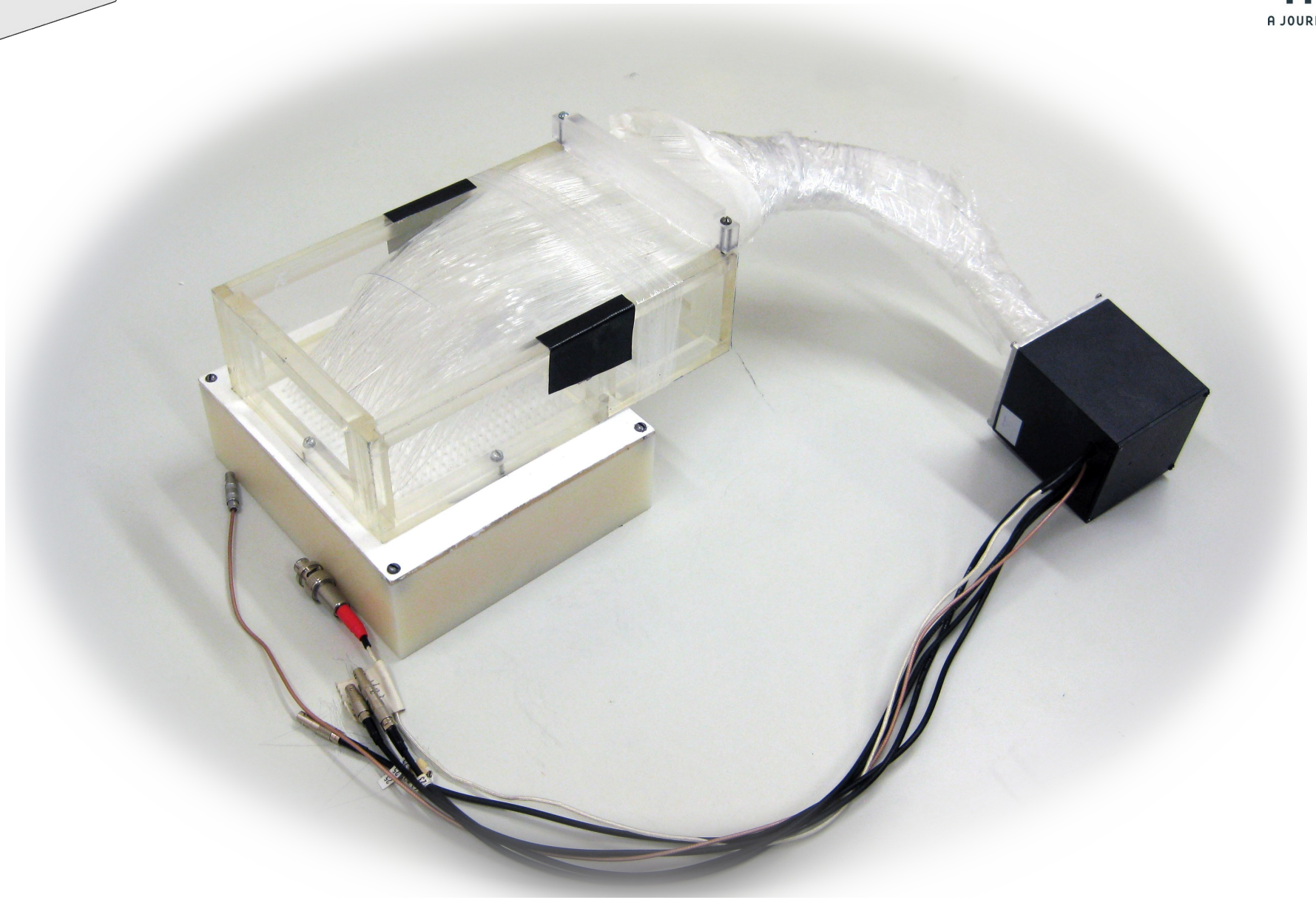


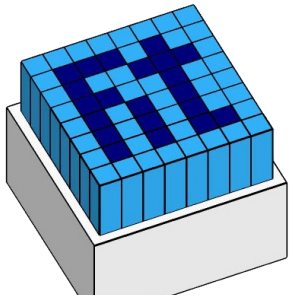
V0+ light collection



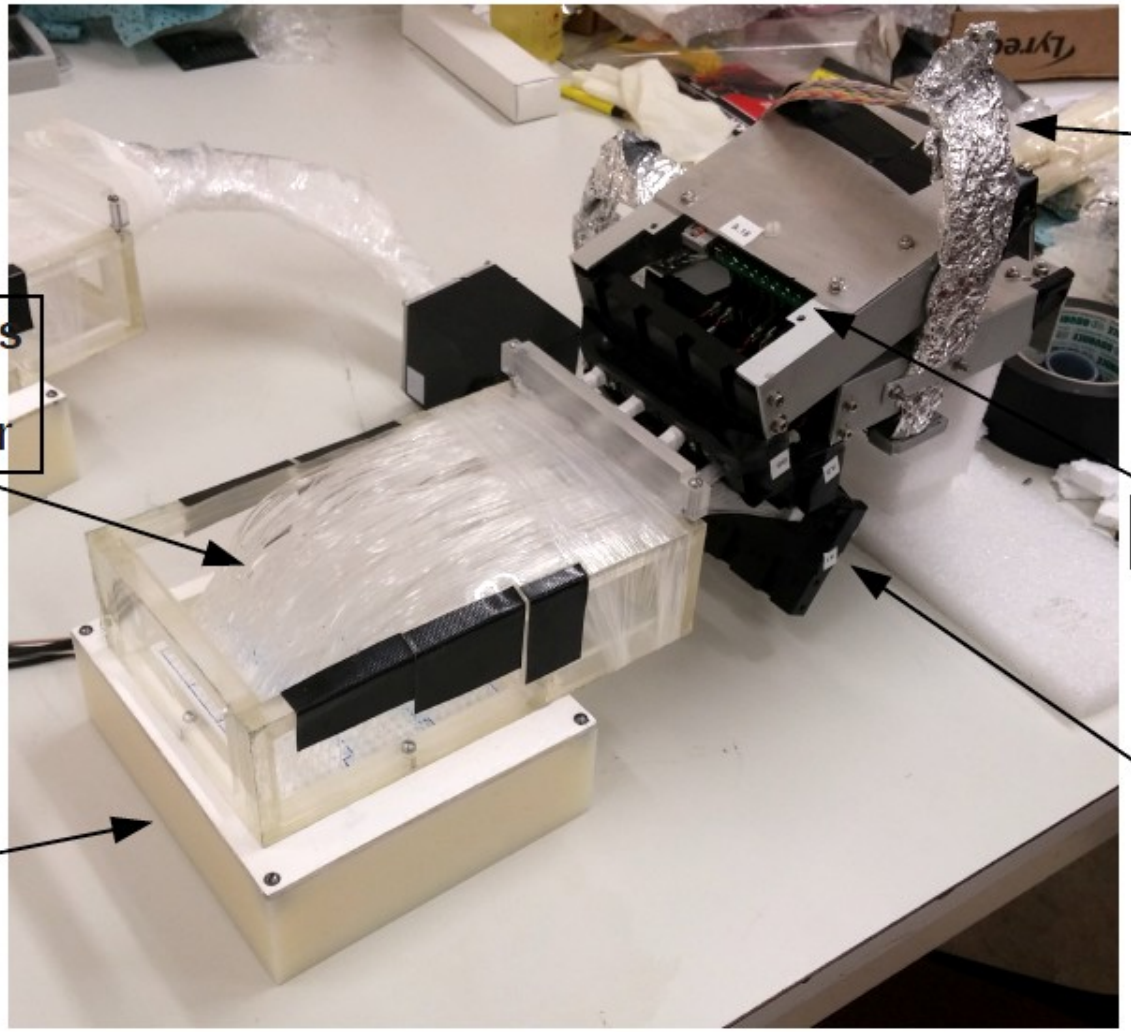
Elimination of WLS fibers
→ better timing

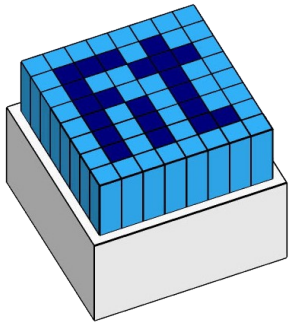
V0+ prototype with MCP-PMT



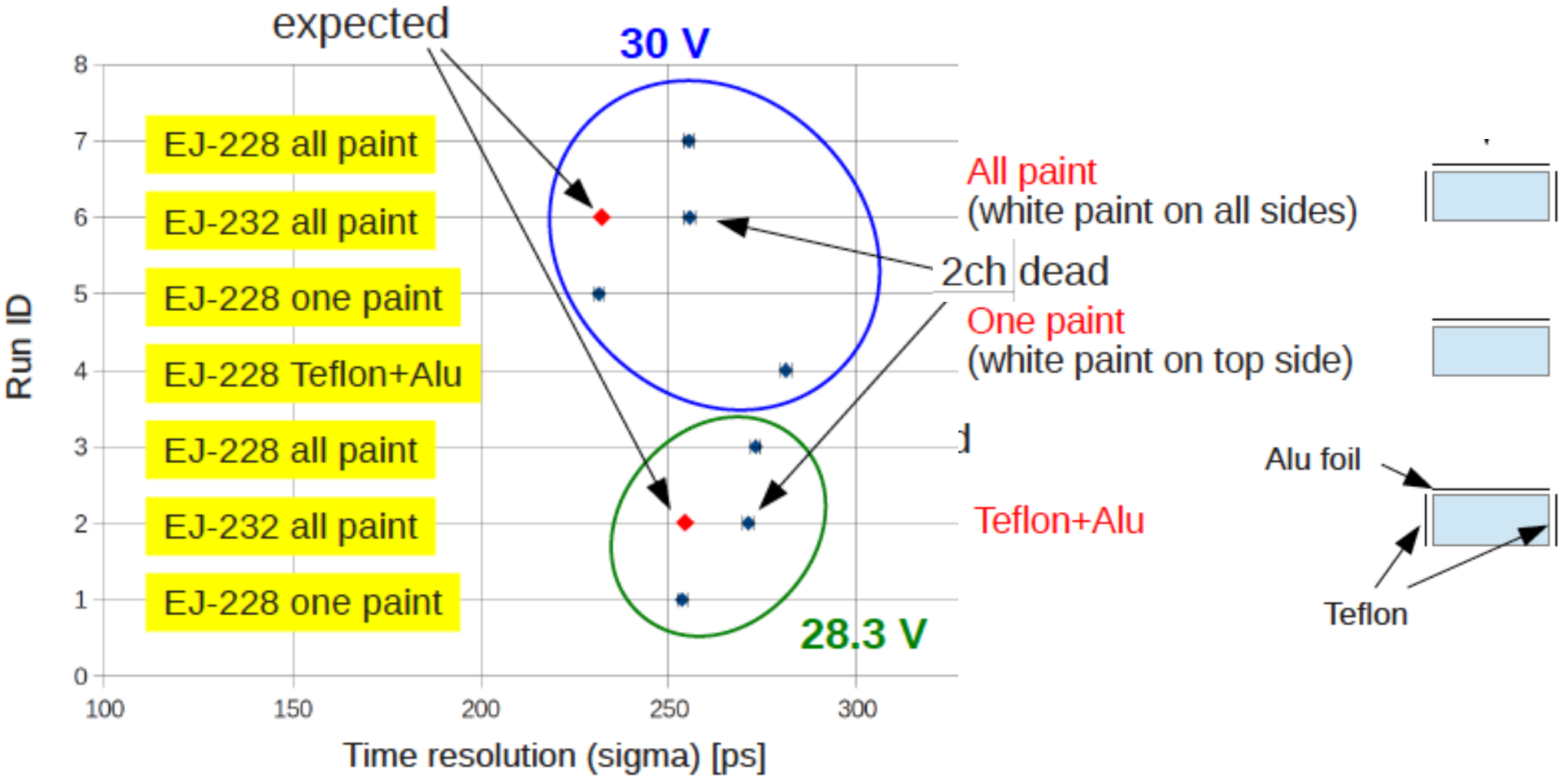


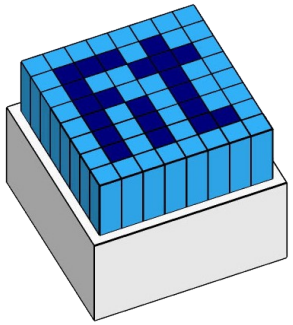
V0+ prototype with SiPM





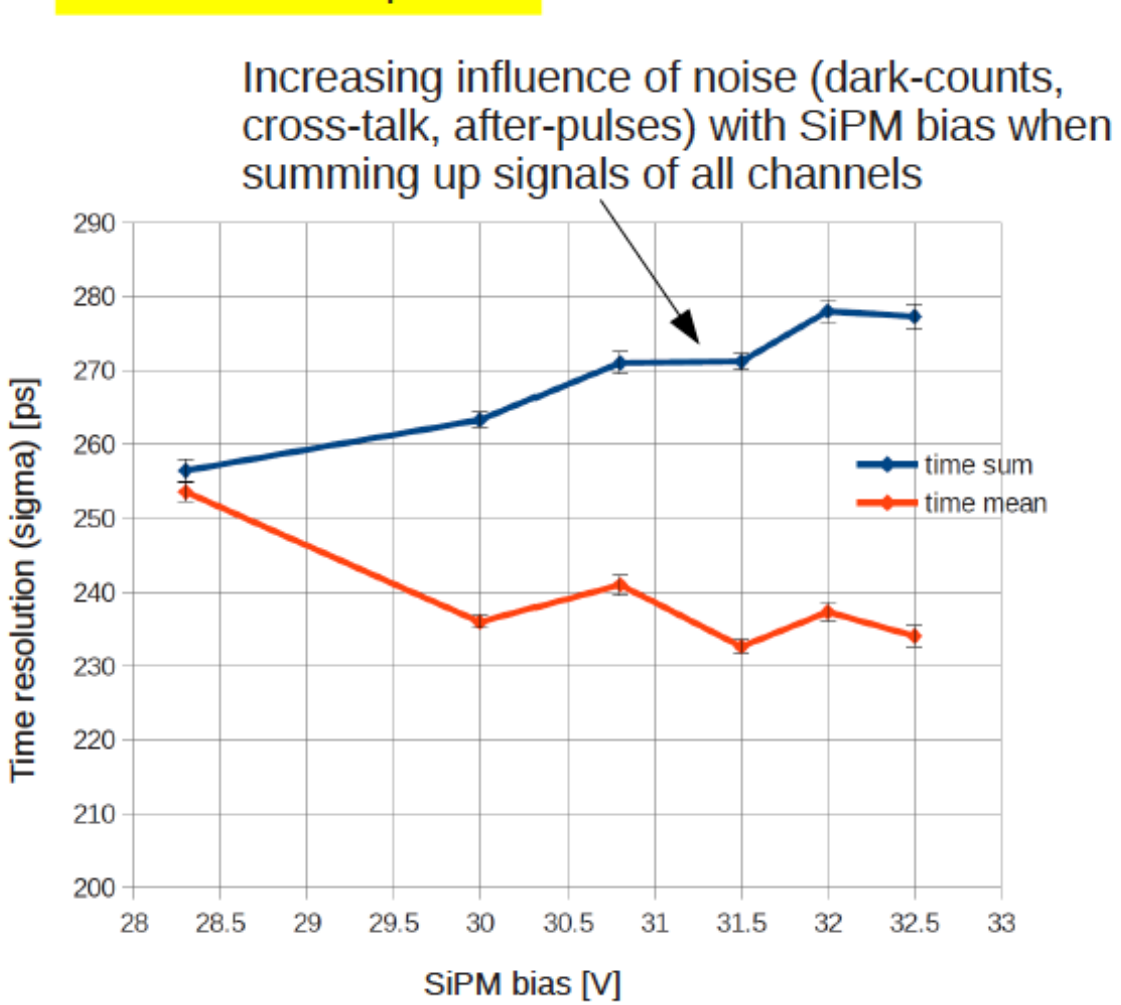
Scintillator material

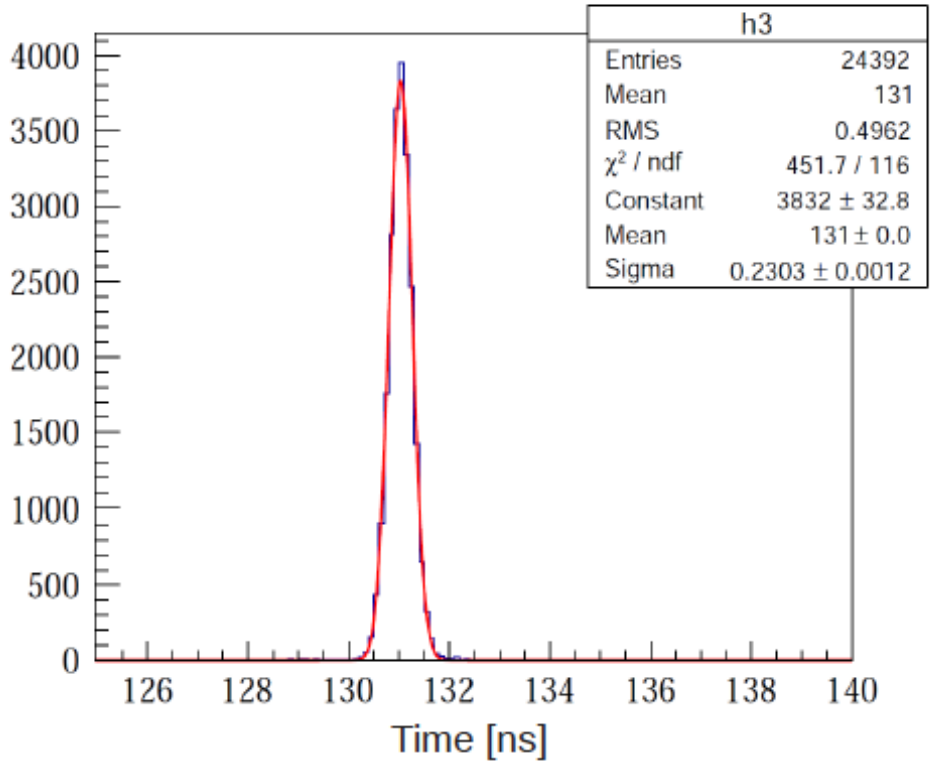




SiPM bias voltage

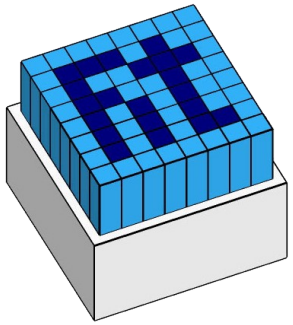
EJ-228 one side painted





Best result with EJ-228 one side painted and 31.5V SiPM bias.

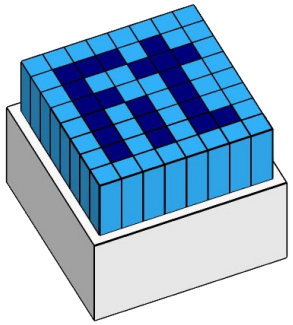
σ ~ 230 ps



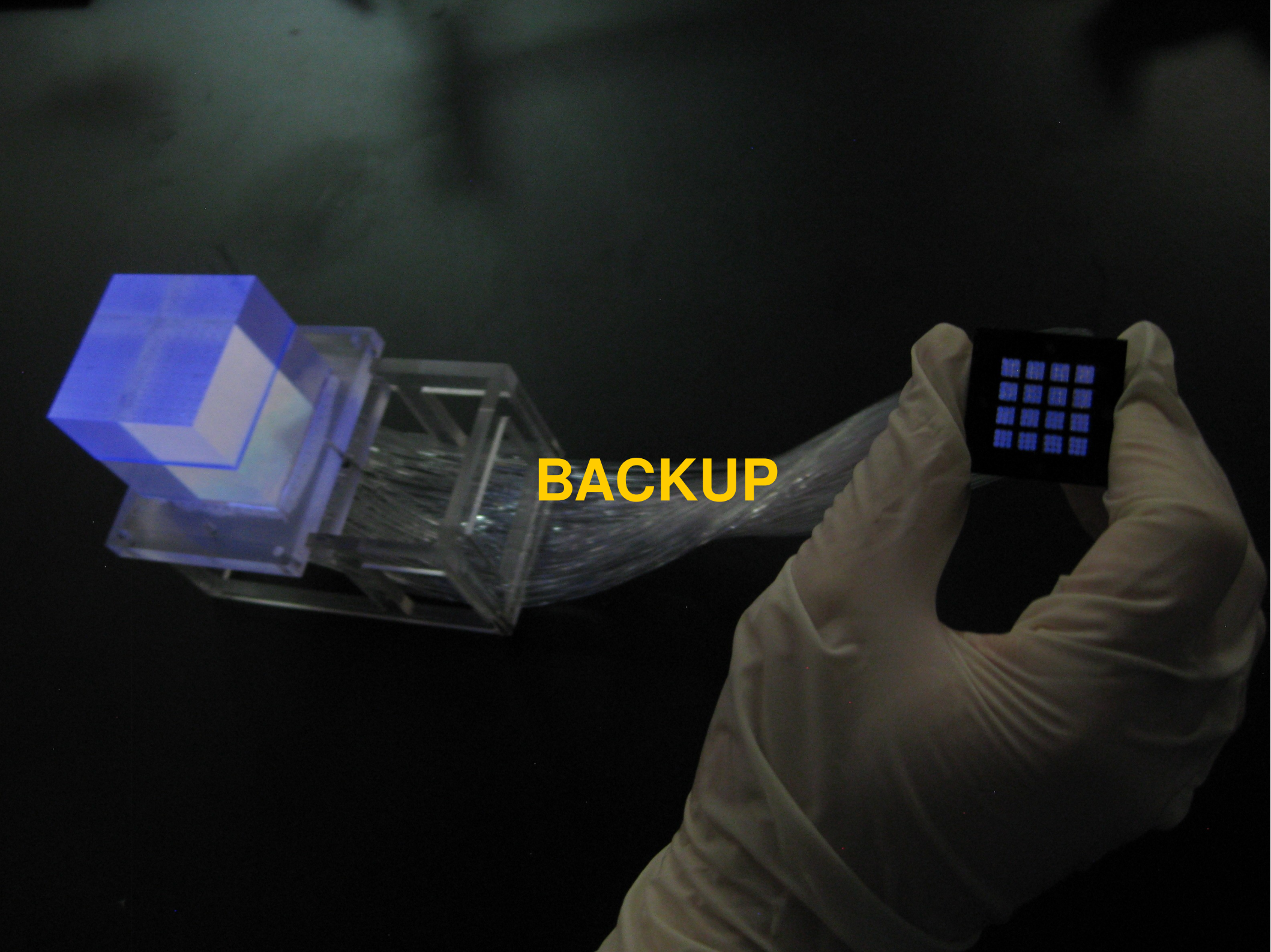
ALICE
A JOURNEY OF DISCOVERY

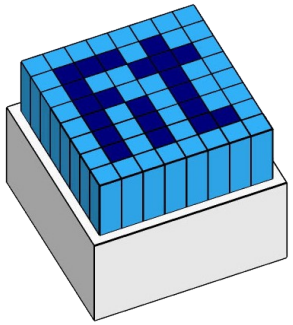
Root installation progress

- How does it go? Are there any questions?
- Will you be ready by next Monday?



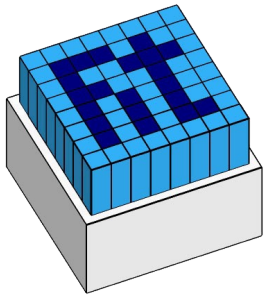
Thank you for your attention
Questions?


BACKUP



V0+ challenges
with respect to V0

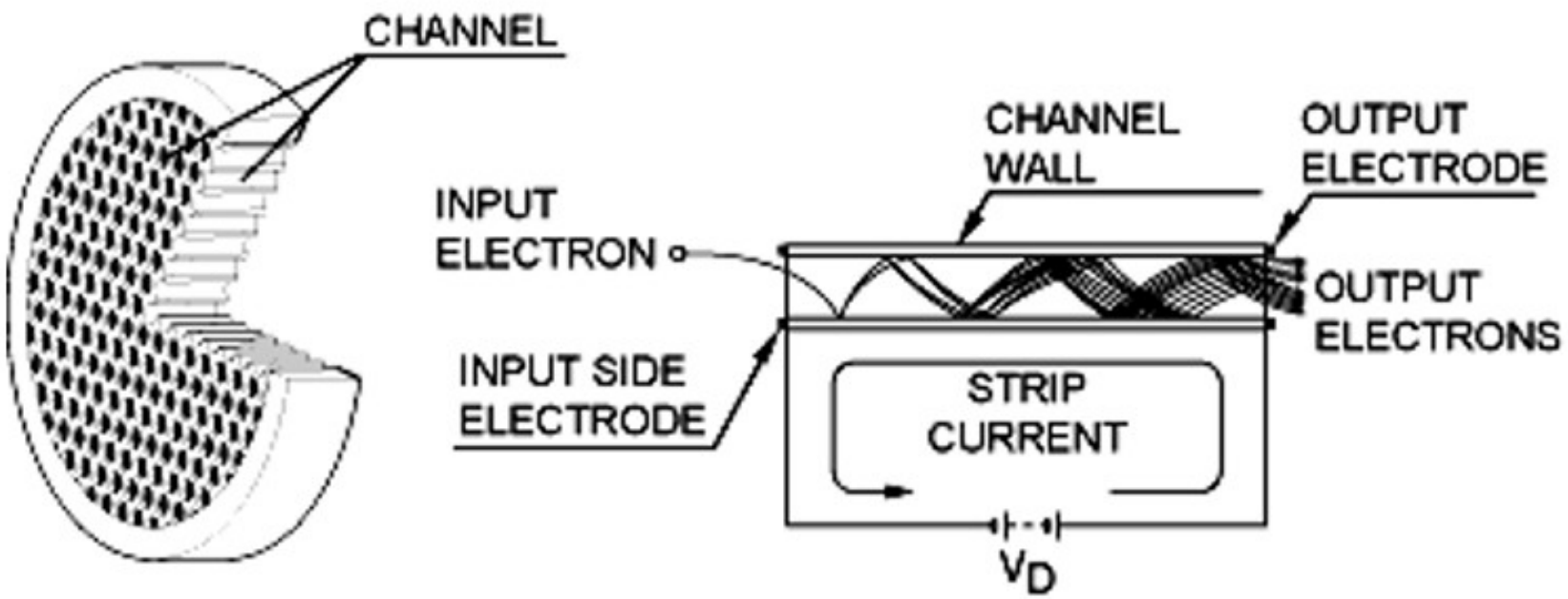
- Improve the **time** resolution (by an order of magnitude)
- Retain good **amplitude** resolution
- Eliminate the **ageing** problem of V0
- Get rid of after-pulses
- Increase the active **area** x 3.2
- Increase the number of **channels** by ≥25%
- Design new electronics
- Provide continuous readout
- Reduce the total **cost**



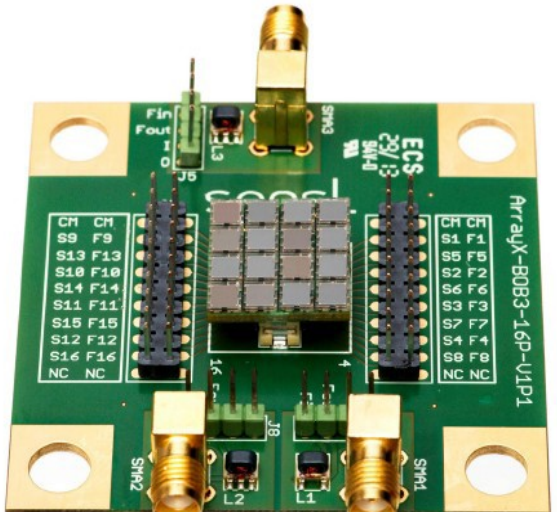
FIT Collaboration (July 2015)

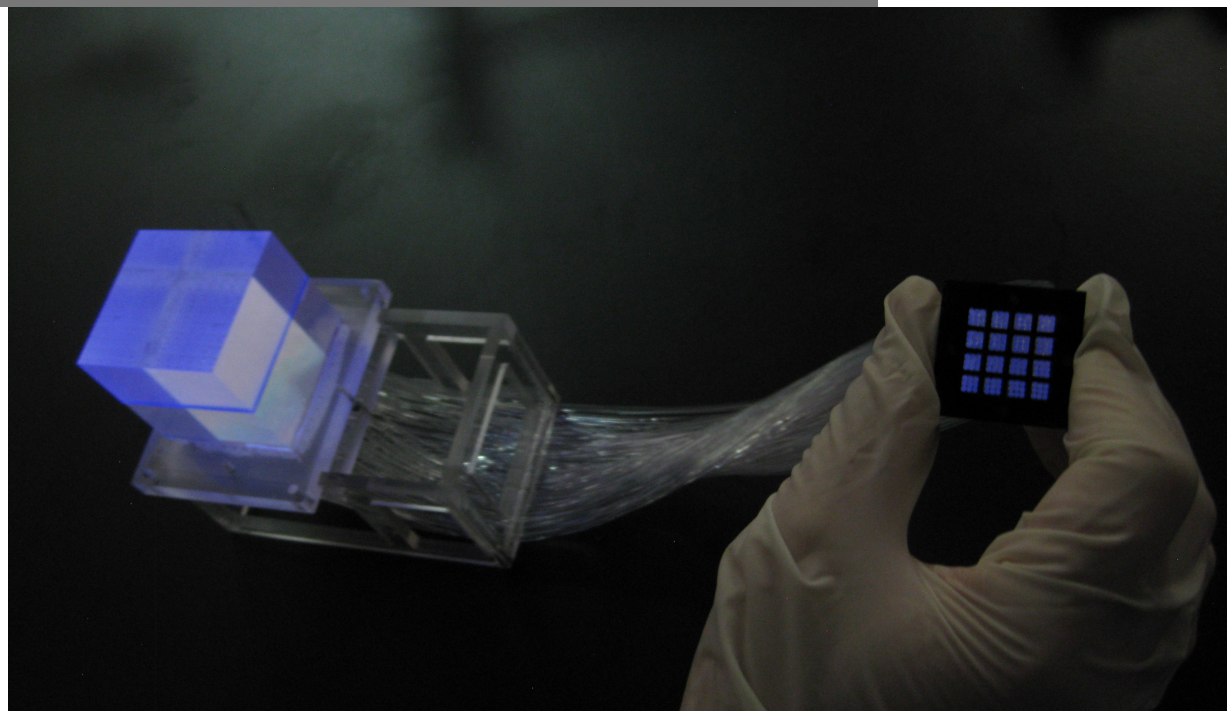
Country	City	Institute
Austria	Vienna	Stefan Meyer Institute
Denmark	Copenhagen	Niels Bohr Institute, University of Copenhagen
Finland	Jyväskylä	Helsinki Institute of Physics (HIP) and Univ. of Jyväskylä
Finland	Helsinki	Helsinki Institute of Physics (HIP) and Univ. of Helsinki
Mexico	Mexico City	Instituto de Física, UNAM
Mexico	Mexico City and Merida	CINVESTAV
Mexico	Mexico City	Instituto de Ciencias Nucleares, UNAM
Mexico	Puebla	Benemérita Universidad Autónoma de Puebla
Mexico	Culiacan, Sinaloa	Universidad Autónoma de Sinaloa
Russia	Moscow	Institute for Nuclear Research, RAS
Russia	Moscow	Moscow Engineering Physics Institute
Russia	Moscow	Russian Research Centre Kurchatov Institute
USA	Chicago	Chicago State University
USA	San Luis Obispo	California Polytechnic State University

MCP – based detectors



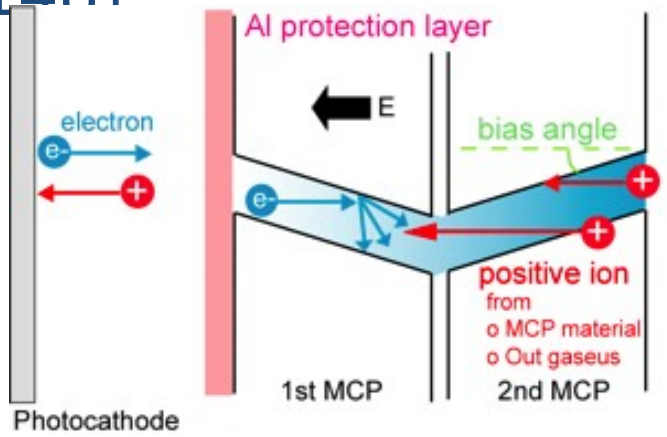
SiPM Sensl

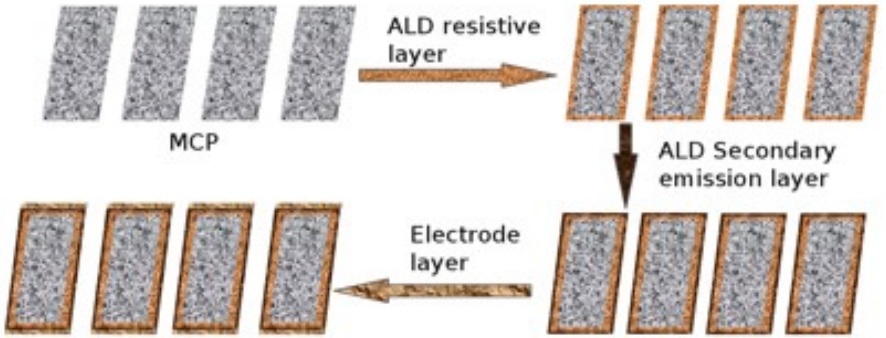




Big progress in MCP technology
(since the initial R&D for ALICE)

- Appearance of commercially available MCP-PMTs (Hamamatsu, Photonis USA, BINP)
- Significant and ongoing improvement in lifetime:
  - **A**tomic **L**ayer **D**eposition technology [NIM A639 (2011) 148]





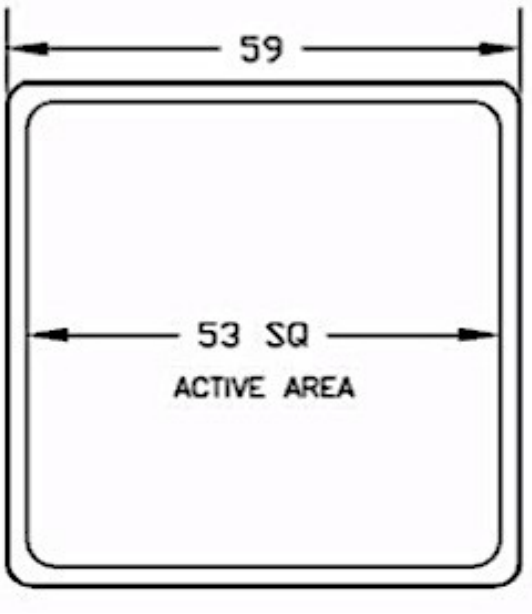
  - Modified photocathodes [JINST 6 C12026 (2011)]
  - Reduced outgassing (borosilicate glass)

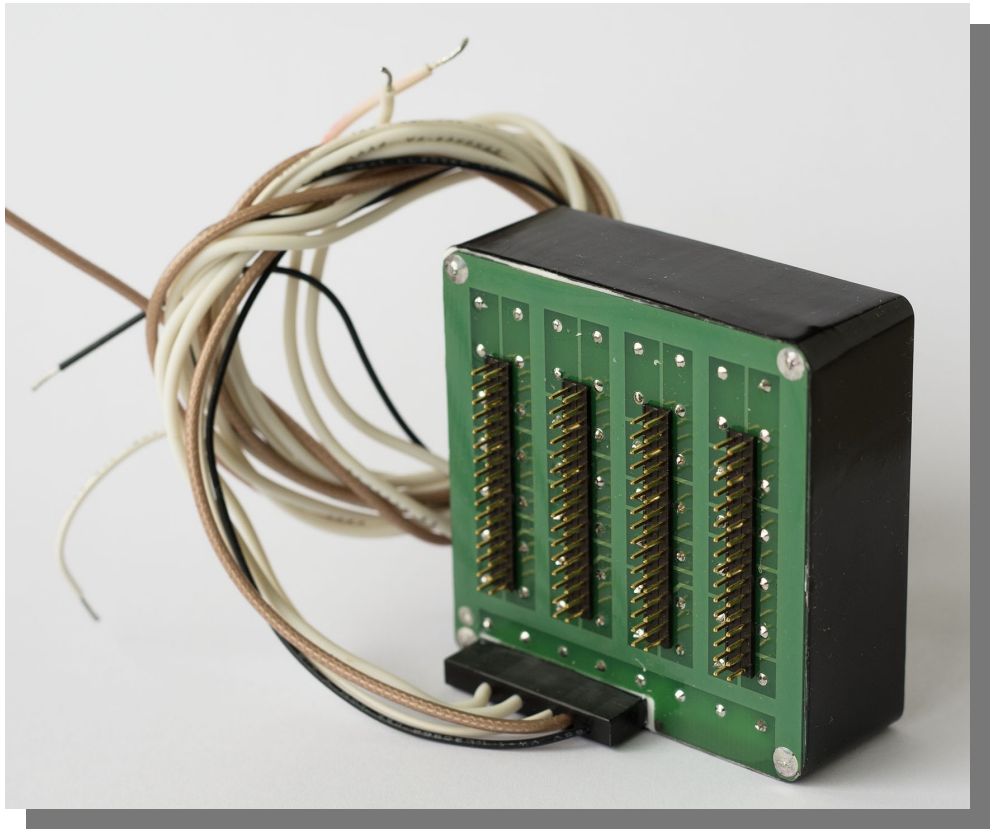
For more information: Albert Lehmann, 12th Pisa Meeting on Advanced Detectors, May 2012

Available Now

XP85012

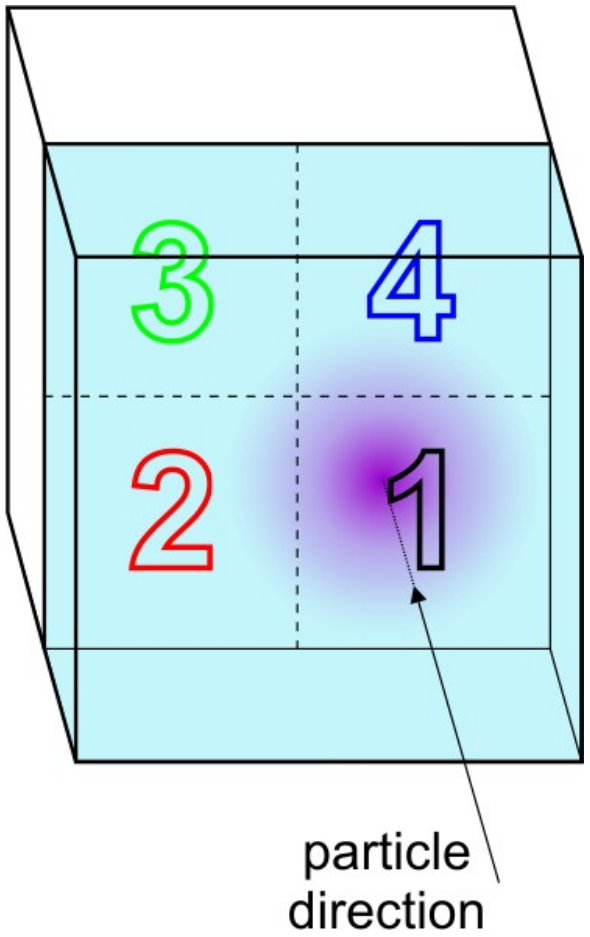
'LANACON®






MCP
setup
ALICE FIT
Wladyslaw Trzaska
Tatiana Karavicheva
165821

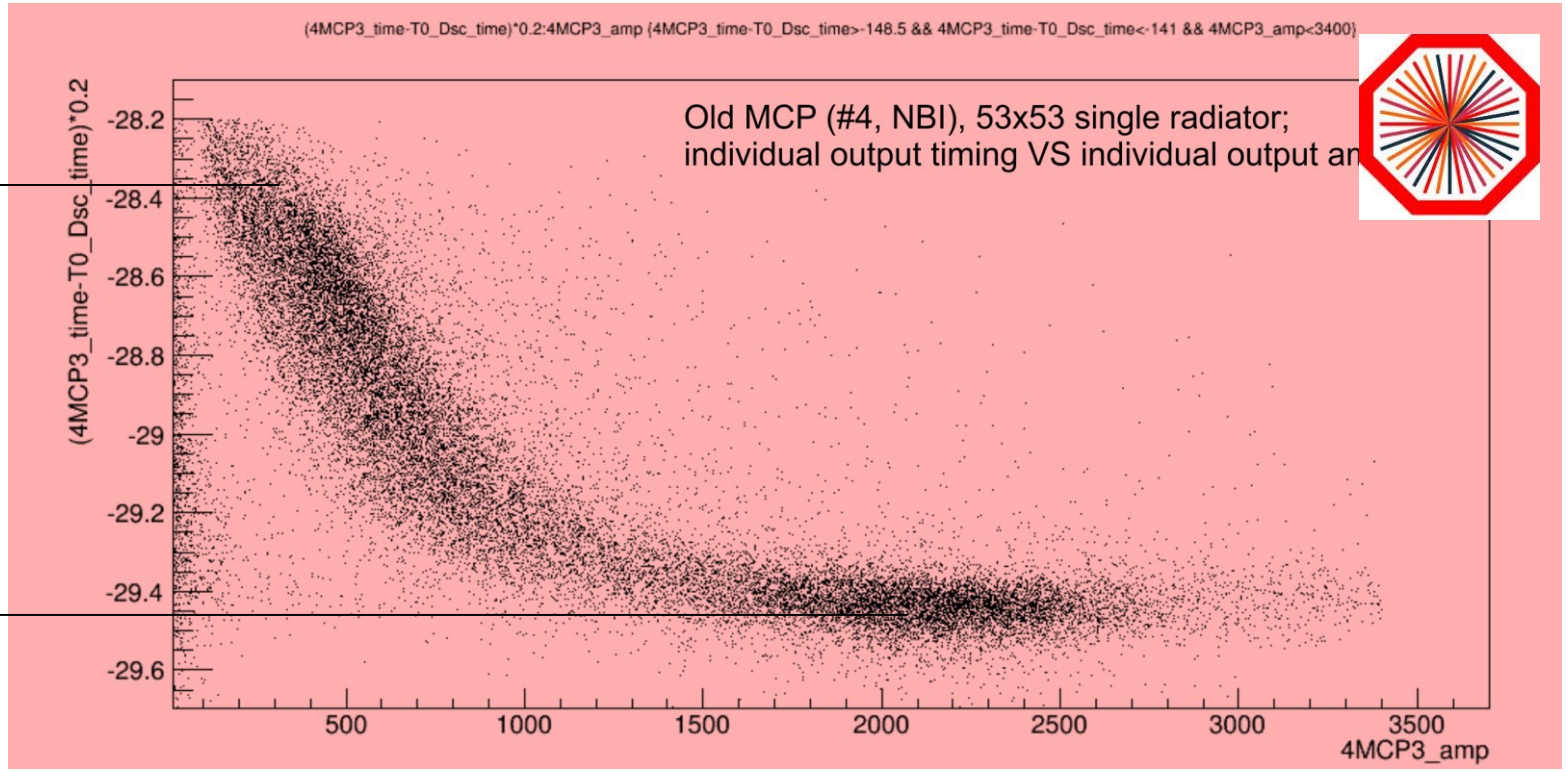
Checking the influence of positive cross-ta on the detector's timing:



- A **single 53 x 53 mm² radiator** was used to distribute Cherenkov light from **one MIP** over **all four quadrants** of the MCP.
- This configuration simulated an event with multiple MIPs hitting simultaneously several sectors of the MCP
- Registered MIPs were going through the sector #1 generating the main signal.
- The optical cross-talk in neighboring sectors (#2 and #4) was the largest.
- The optical cross-talk in the diagonal sector (#3) was the smallest.
- Electrical pulses from the neighboring sectors (#2 and #4) induced electrical cross-talk on the pulse from the main sector (#1) influencing its time resolution

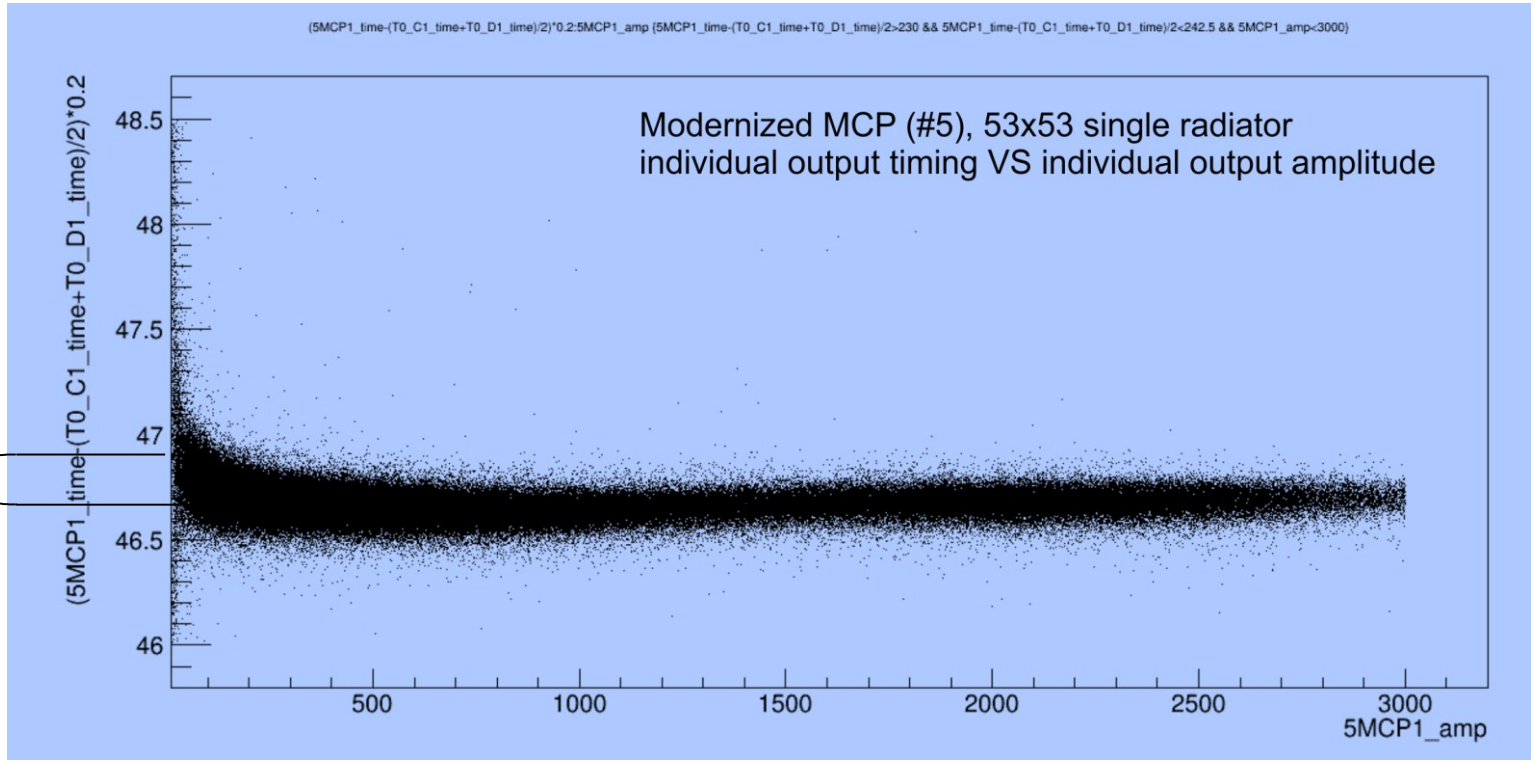
STANDARD PLANACON

>1.0 ns

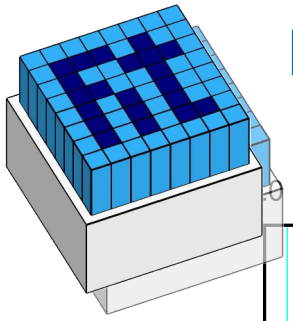


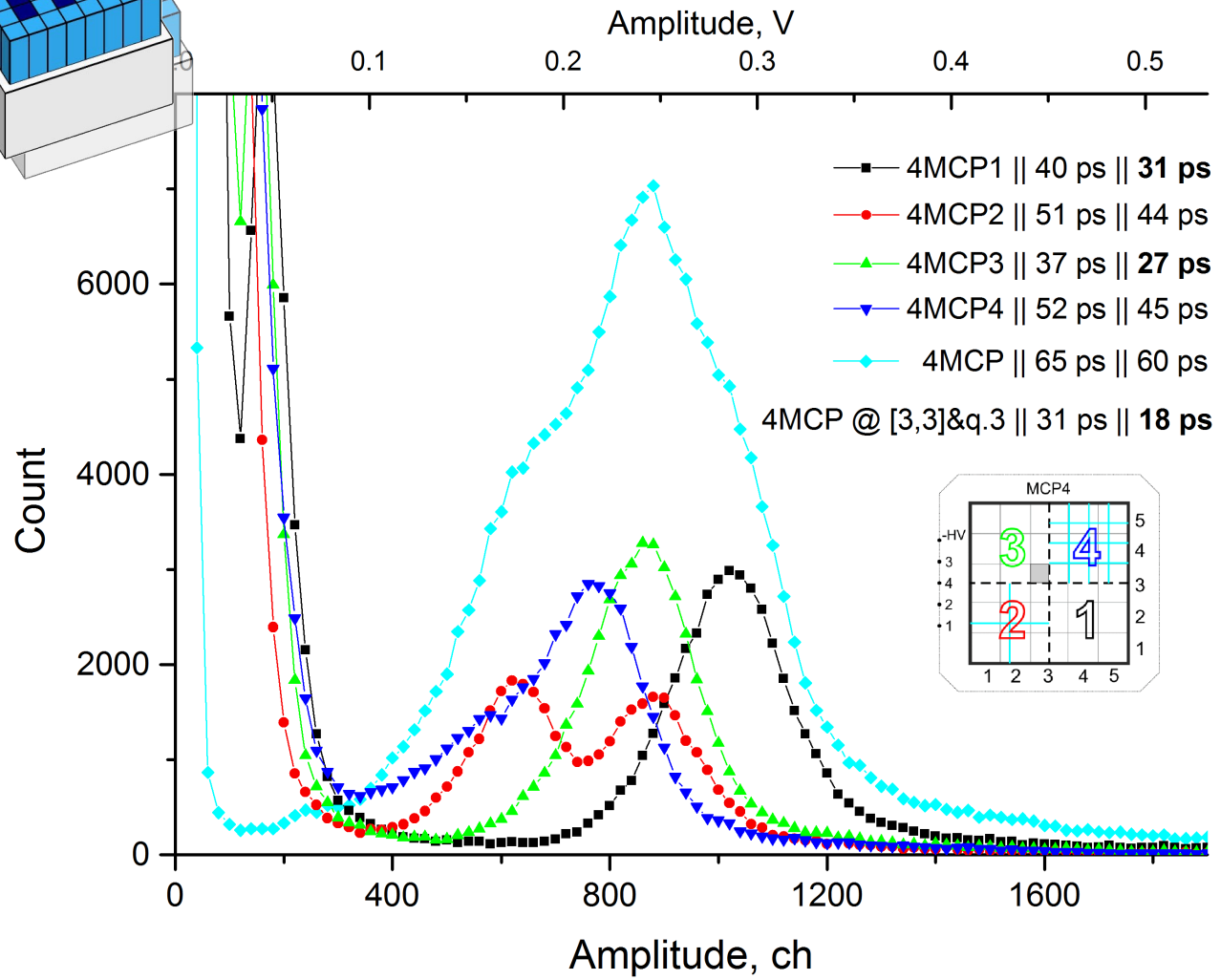
MODIFIED PLANACON

~0.2 ns



Radiator granularity results (October 2015 data)

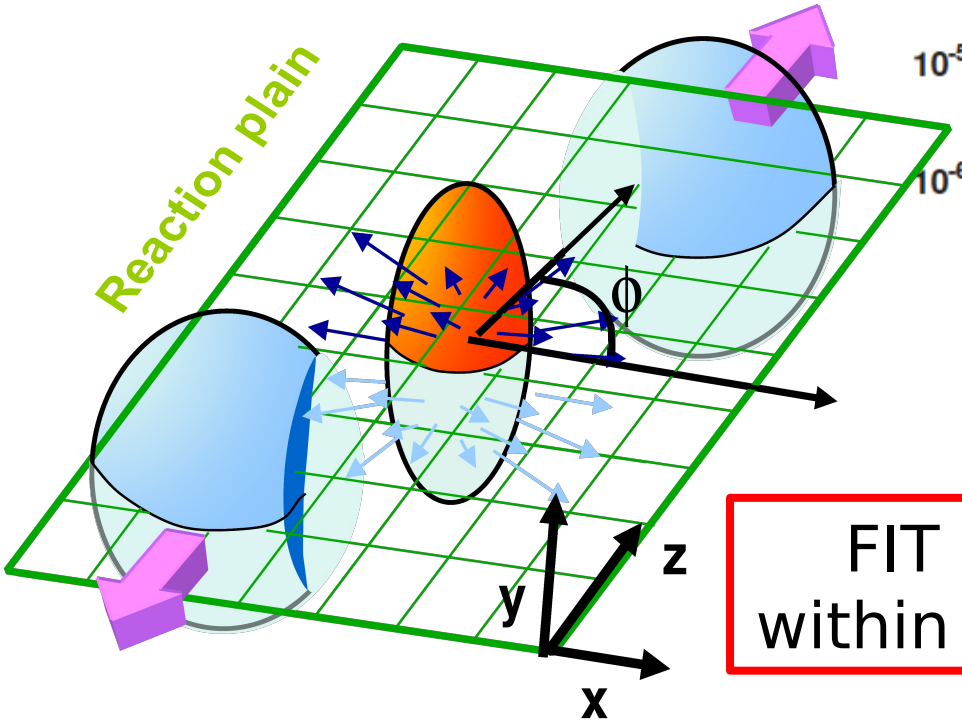


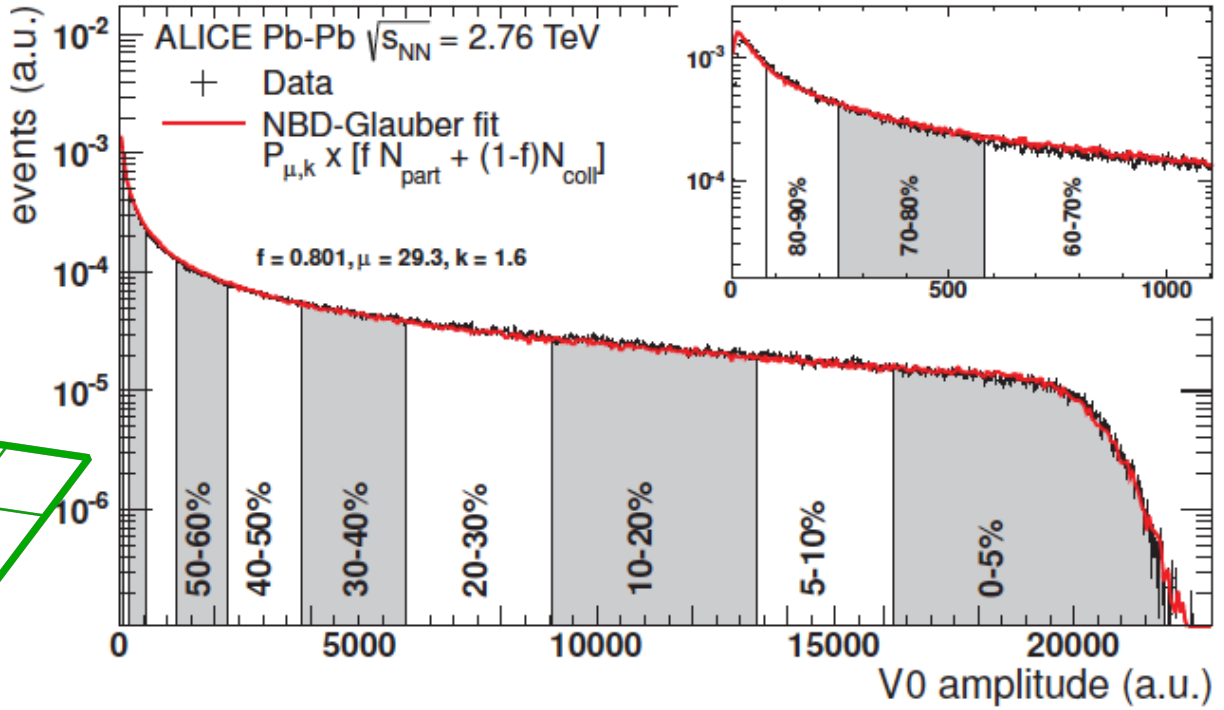


Results for the **repaired NBI MCP** with different combinations of fragmented radiators.
4MCP1-radiator- 1/4
4MCP2-radiators 4/16 new
4MCP4-radiators 16/64
4MCP3-radiator 1/4

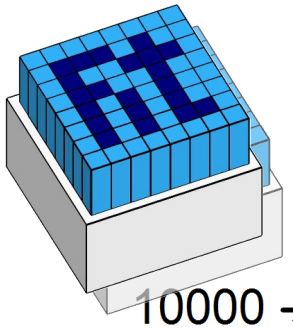
Conclusion - Reproducible results for quadrants with default radiators (#1, #3) comparing to June 2015 data.
- No benefit in further segmentation of radiators;
- Best timing for 4 default radiators;
-Perfect pulse shape and largest amplitude for 4 default radiators;

Why FIT should maximize acceptance:



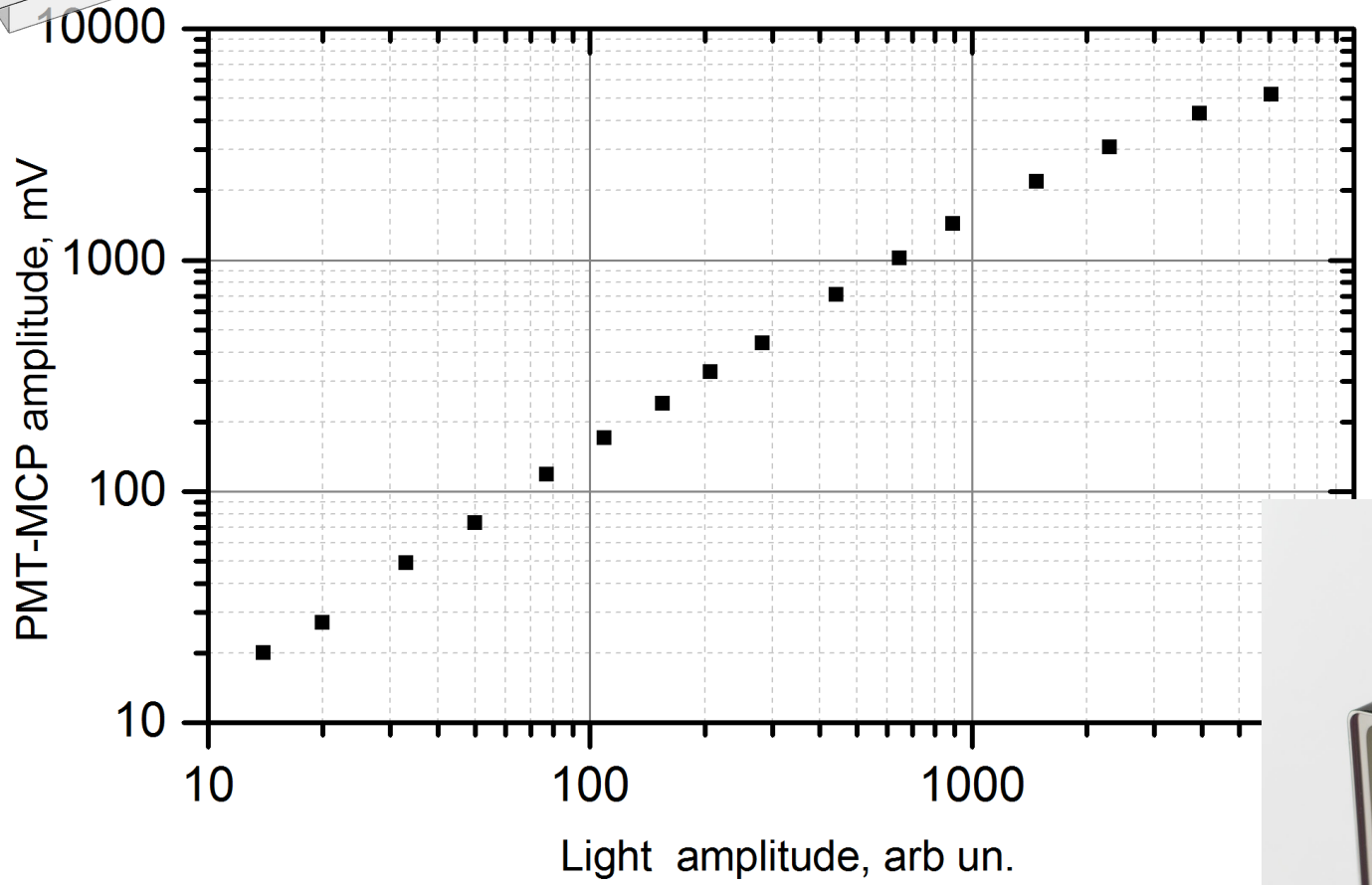


FIT should be as large as possible within the available space inside ALICE!



PLANACON® linearity

Log-log scale



Fulfills the requirements; no after-pulses; radiation hard

Expensive: ~300 $ / cm² of photocathode