The Fast Interaction Trigger Upgrade for ALICE

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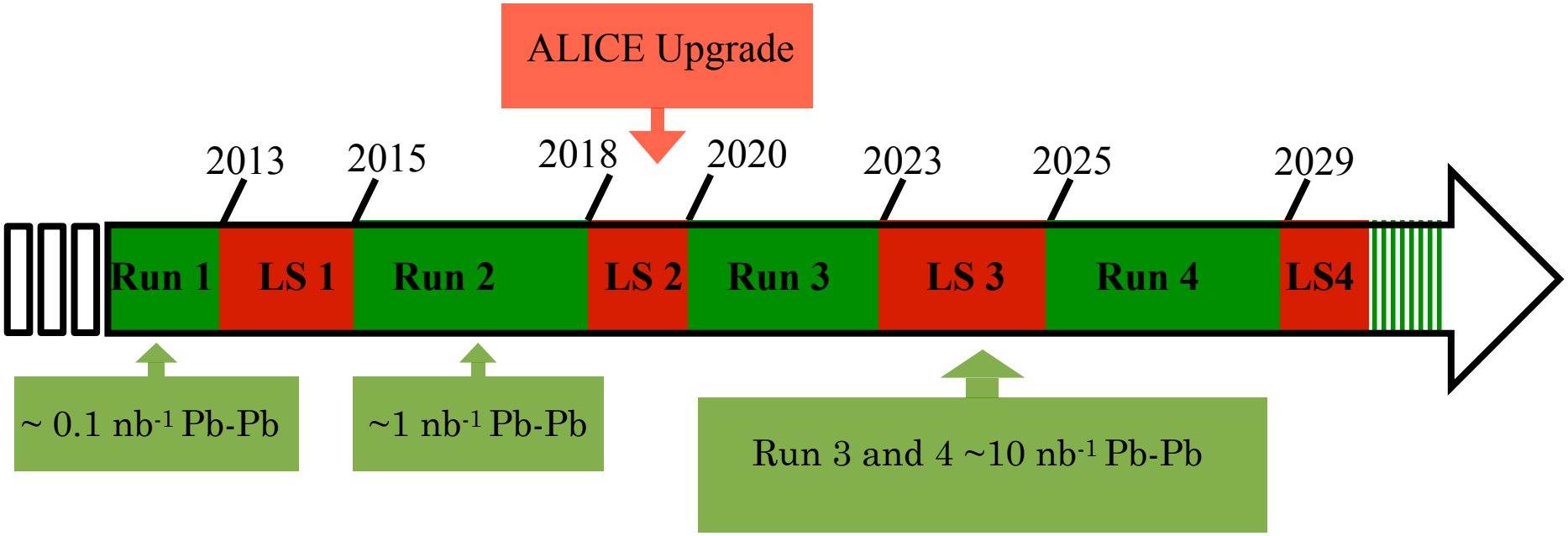
on behalf of the
ALICE Collaboration

LHC Upgrade

Heavy-ion program at LHC extended to Run 3 and Run 4

- Energy *Pb-Pb* 5.5 TeV, *p-Pb* 8.8 TeV, *pp* all energies
- LHC target luminosity *Pb-Pb* $\mathcal{L} = 6 \times 10^{27} \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Participation of ALICE, ATLAS, CMS, LHCb



* ALICE takes *pp* during all run periods

ALICE for Run 3 and 4

- Physics Observables driving the Upgrade
  - Low-p_T heavy-flavour mesons and baryons
  - Low-p_T charmonia (J/ψ and ψ (2S))
  - Low-mass dileptons

- Requirements
  - Minimum bias trigger selection (very low signal/background ratio for most of the physics signals)
  - High Rate: read the full 50 kHz delivered by LHC
  - Large data sample: $L_{int} > 10\ nb^{-1}$
  - Improve (add) heavy flavour vertexing at central (forward) rapidity
  - Tracking efficiency to measure particles down to very low p_T

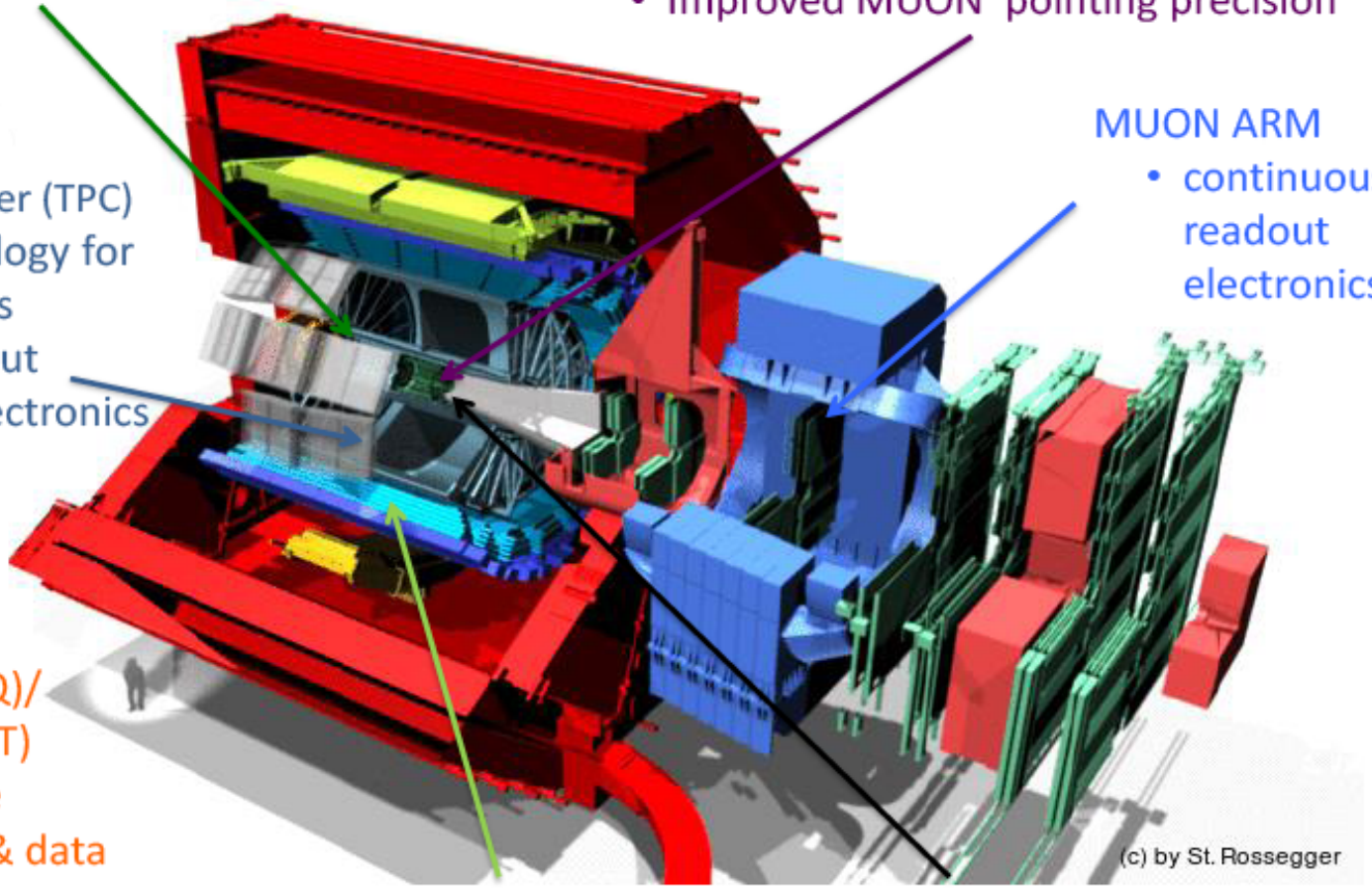
ALICE Upgrade

New Inner Tracking System (ITS)
- improved pointing precision
- less material

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

MUON ARM
- continuous readout electronics

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



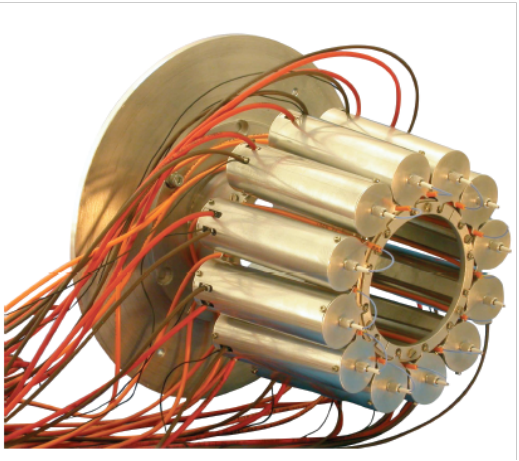
O^2 (Online and Offline)

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

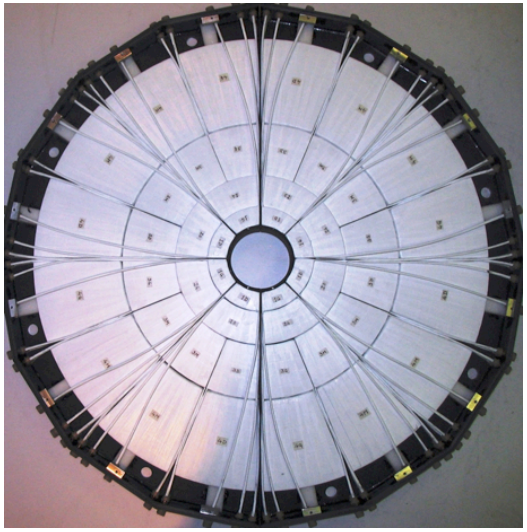
TOF, TRD
- Faster readout

New Trigger Detectors (FIT)

Current T0 and V0



- T0 consists of two arrays, placed on the opposite sides of the IP
- Cherenkov radiators, each coupled to PMTs (12 per module)
- $-5 < \eta < -4.5$, $2.9 < \eta < 3.3$

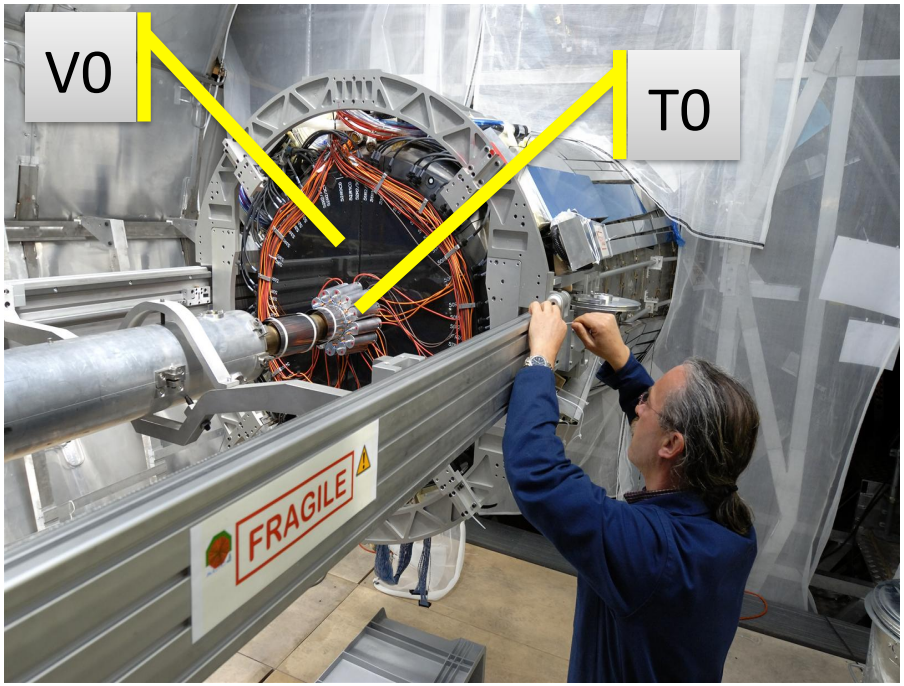


- The V0 consists of two arrays of 32 scintillating counters
- Installed on opposite sides of IP
- Scintillators coupled to PMTs by fibers
- $-3.7 < \eta < -1.7$, $2.8 < \eta < 5.1$

- Provide trigger, background reduction, time zero (for PID), centrality, and event plane determination

Current T0 and V0 and Upgrade Requirements

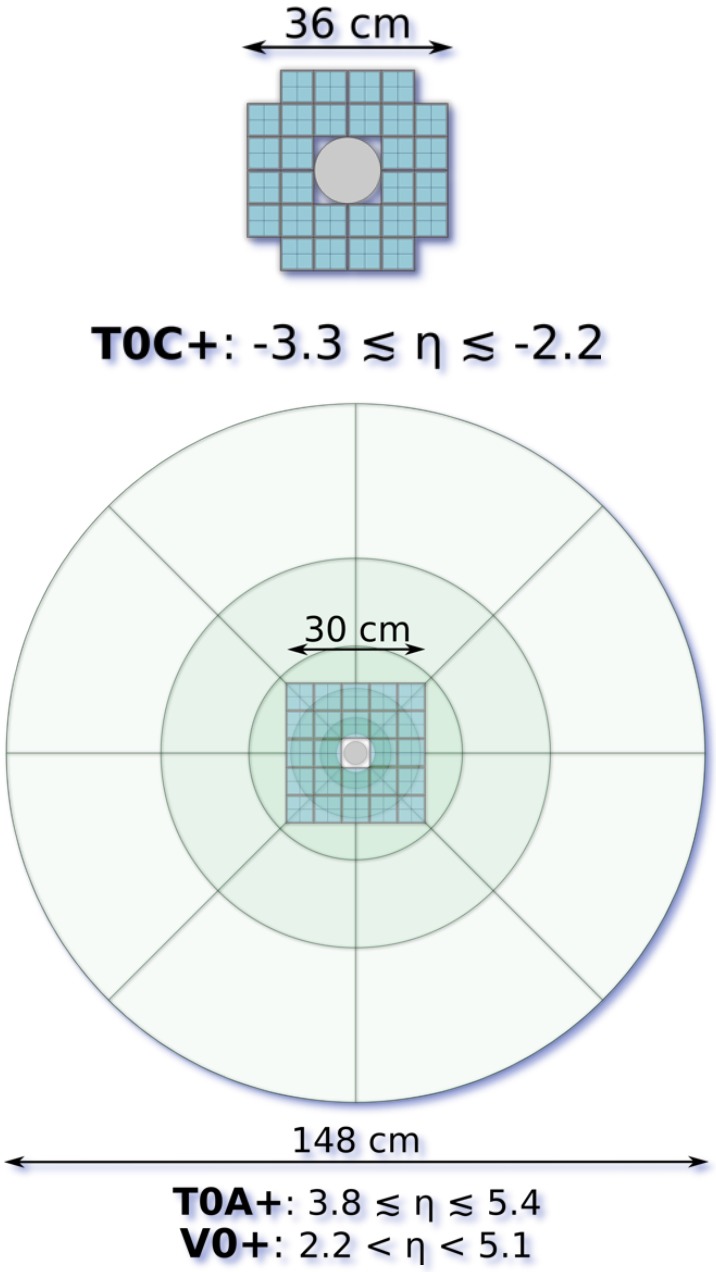
T0
Time resolution – yes
Amplitude resolution – yes
Durability – yes
Acceptance – NO
Hermeticity – NO
Modification Readout – NO



- Requirements
  - Preserve resolution
  - Increase acceptance
  - Integrate detectors

V0
Time resolution – NO
Amplitude resolution – yes
Durability – NO
Acceptance – yes
Hermeticity – yes
Modification Readout – NO

Fast Interaction Trigger (FIT)



- Good Time resolution < 30 ps

Time zero for PID

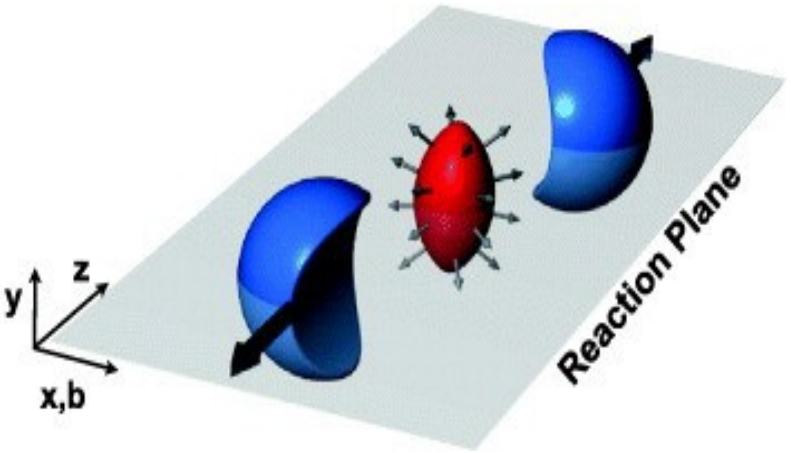
- Large acceptance

Trigger efficiency, centrality, beam gas background reduction, for *pp* and *Pb-Pb*, veto forward hadronic activity for the detection of ultra-peripheral *Pb-Pb* collision

- Finer segmentation

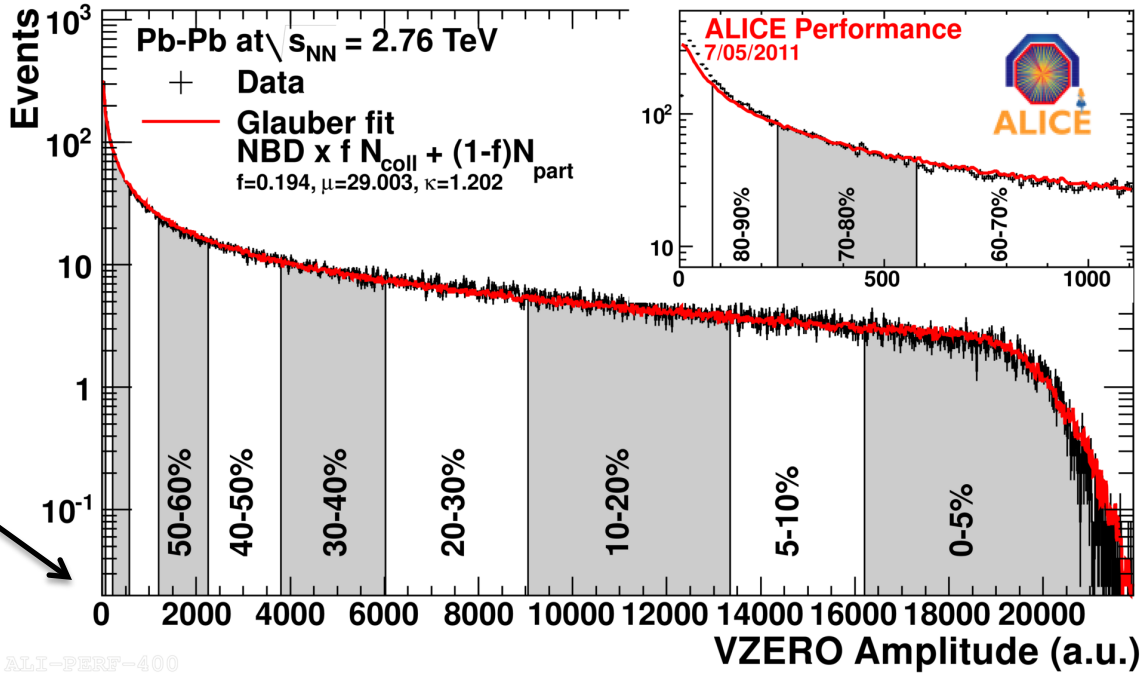
Reaction plane determination

Event Reaction Plane and Centrality

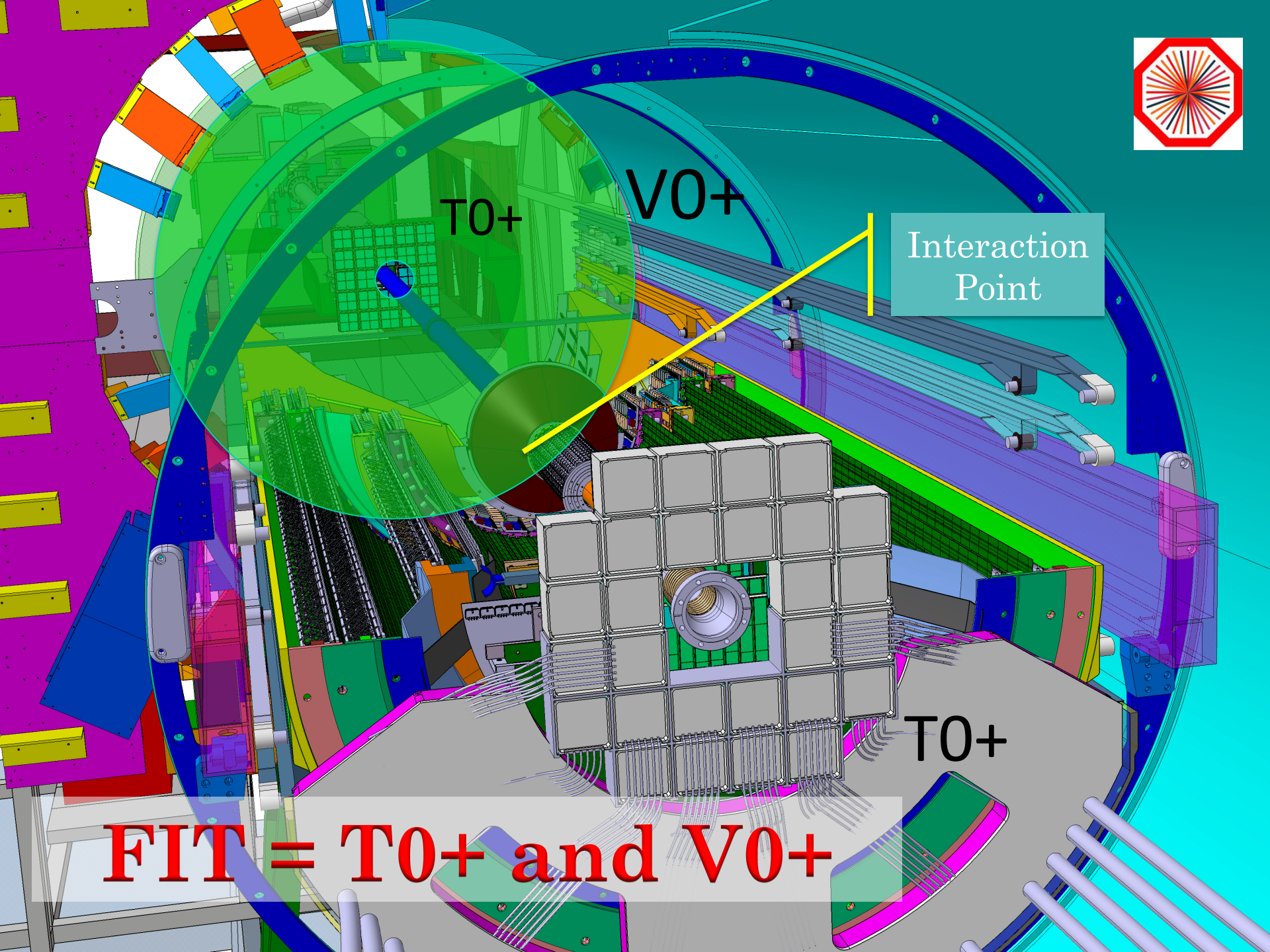


$$\frac{dN}{d\phi} = 1 + v_2 \cos(2(\phi - \Psi_{RP})) + \ldots$$

peripheral

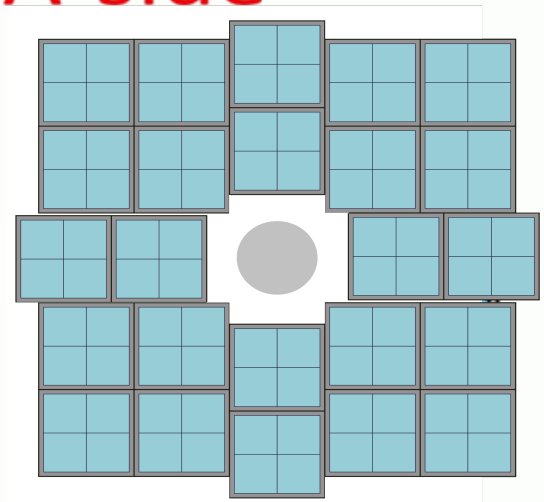


central


T0+
V0+
Interaction Point
T0+
FIT = T0+ and V0+

T0-Plus

A-side

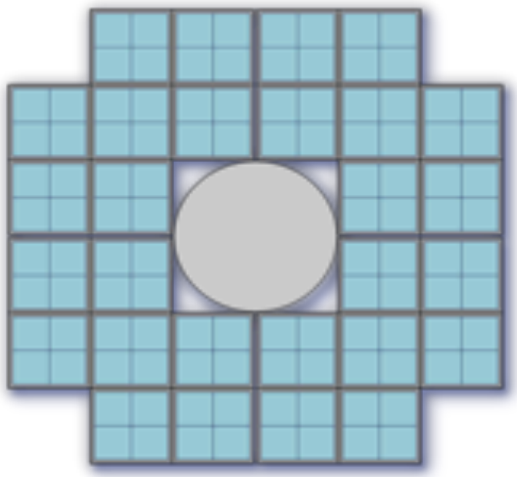


T0A+

Distance from IP: 3280 mm

Beam Pipe radius: 25 mm

C-side



T0C+

Distance from IP: 800 mm

Flange radius: 60 mm

PLANACON® **XP85012**

T0+ module

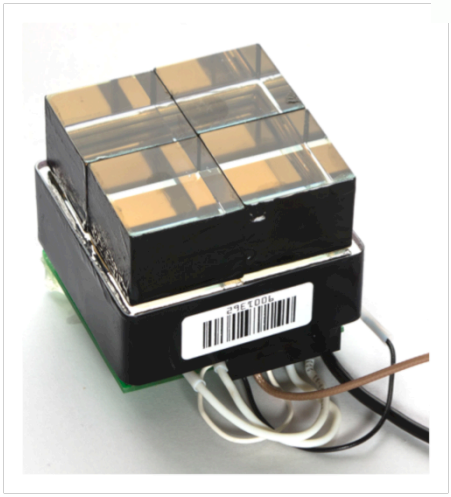
64 mm x 64 mm

76 mm long

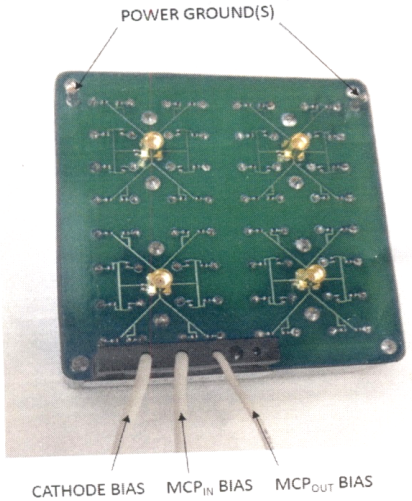
Quartz element

26.5 × 26.5 × 20 mm ^{3}

4 elements per module

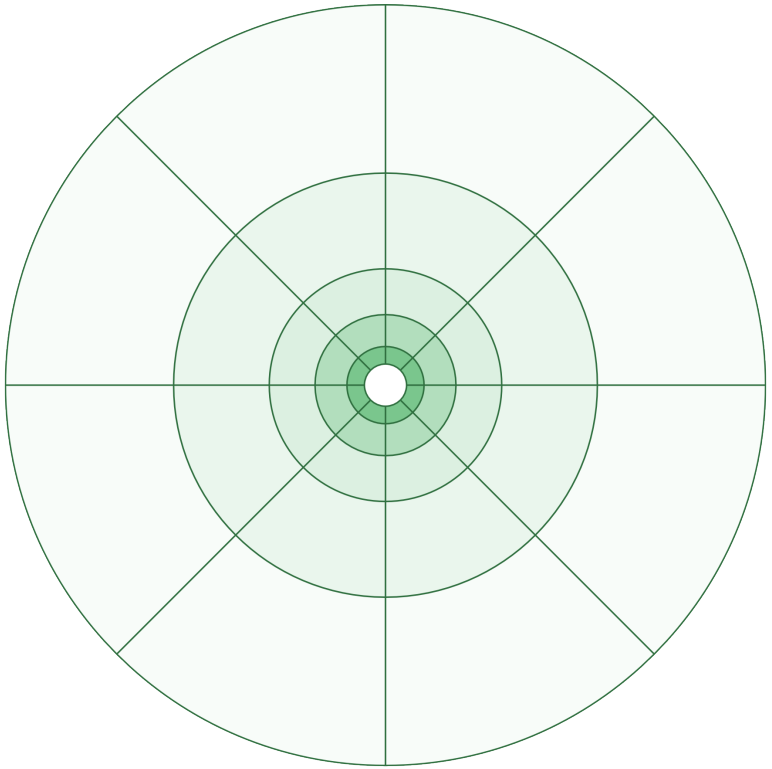


Quartz Radiators



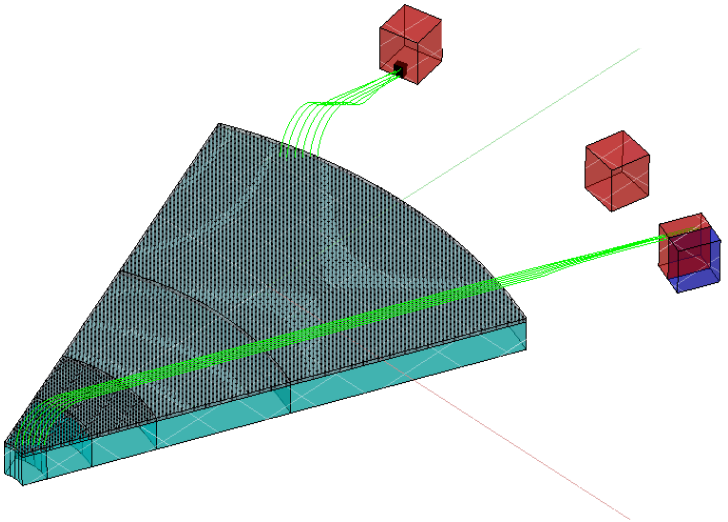
Modified base: RF grounded MCP out electrode, reduced anode-ground capacitance, and equalized propagation time from individual anodes to the output connectors.

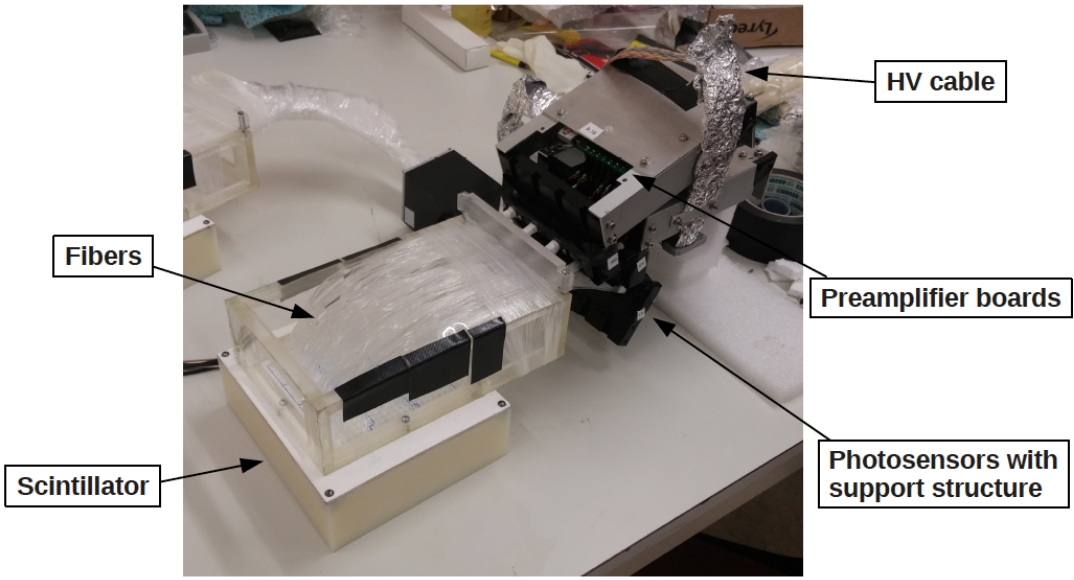
V0-Plus



148 cm

V0+: 2.2 < η < 5.1



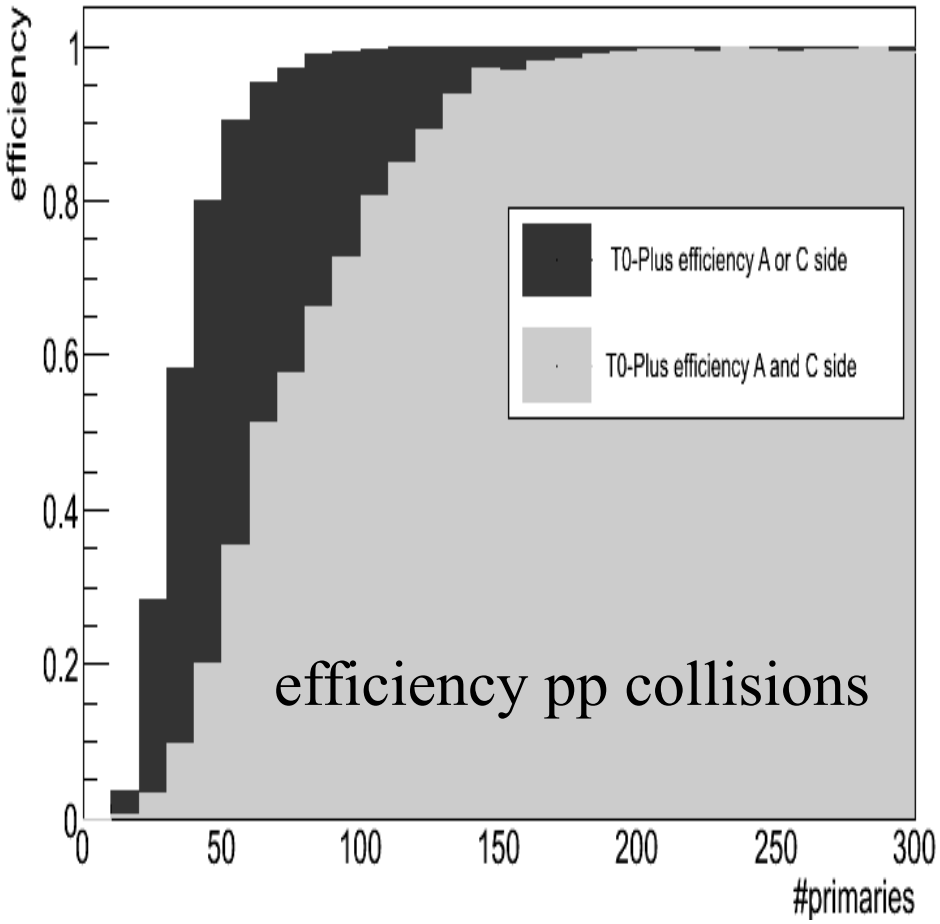


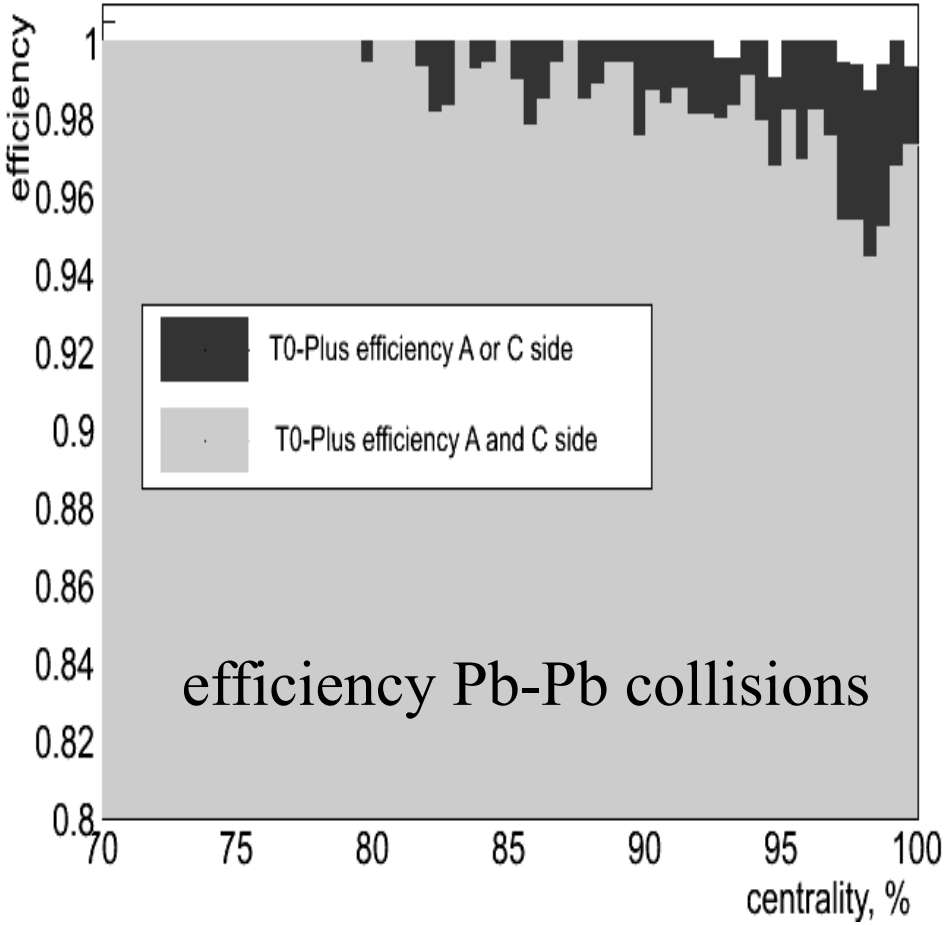
V0+ design still evolving

Prototype of V0+

Performance – Simulations 1

CERN-LHCC-2013-019 ; ALICE-TDR-015

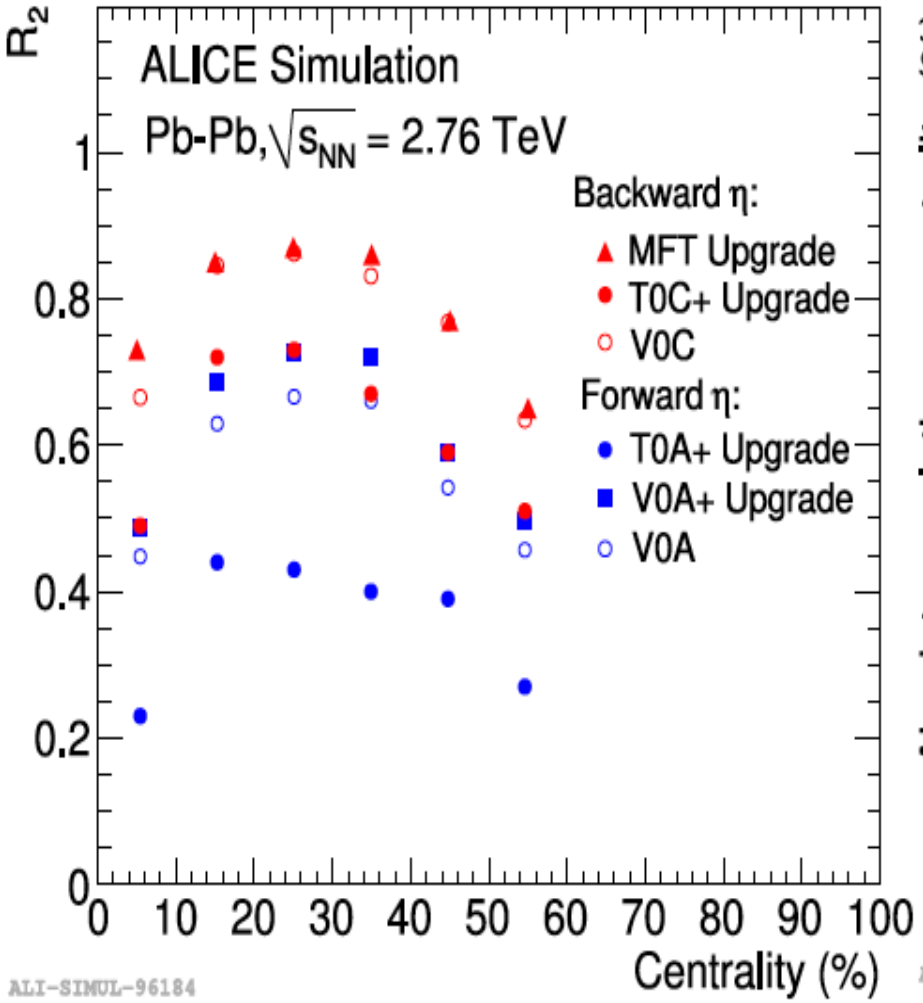




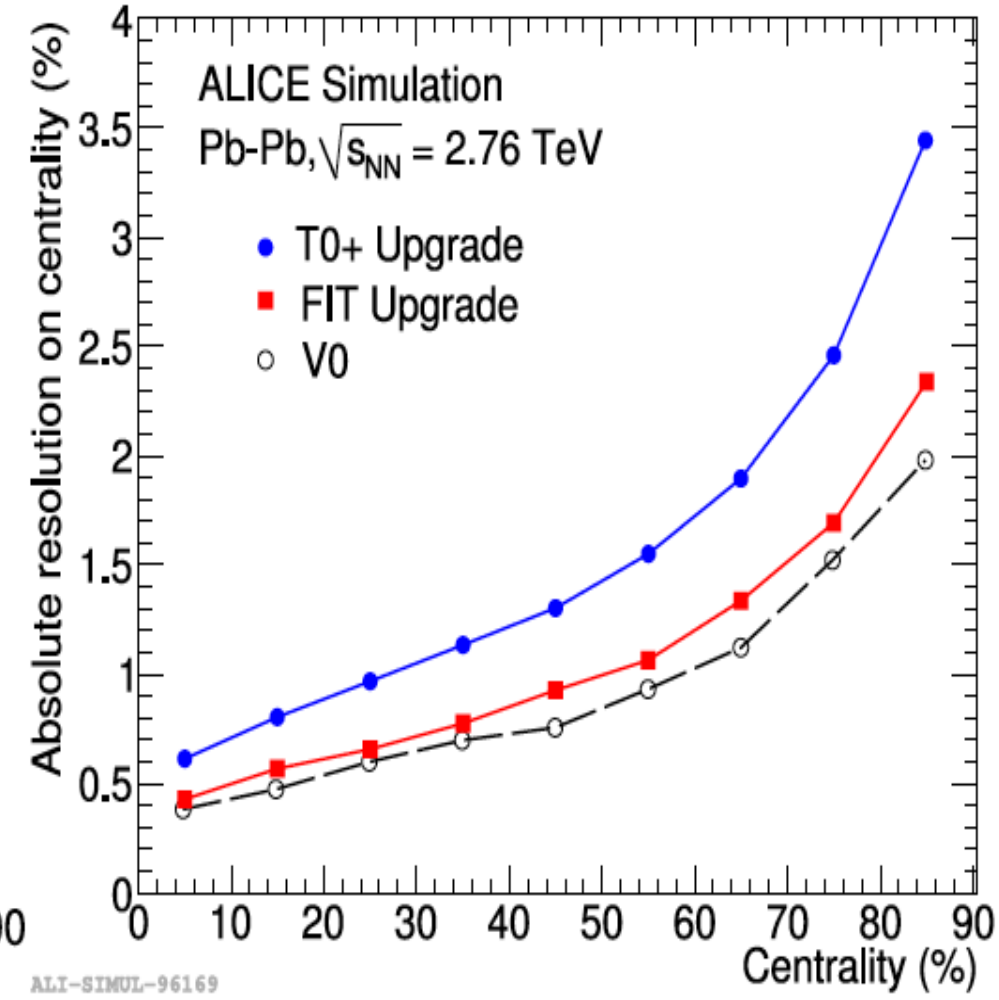
- HIJING events for Pb-Pb collisions at 5.5 TeV
- PYTHIA-6 events generated for p-p collision at 14 TeV

Performance – Simulations 2

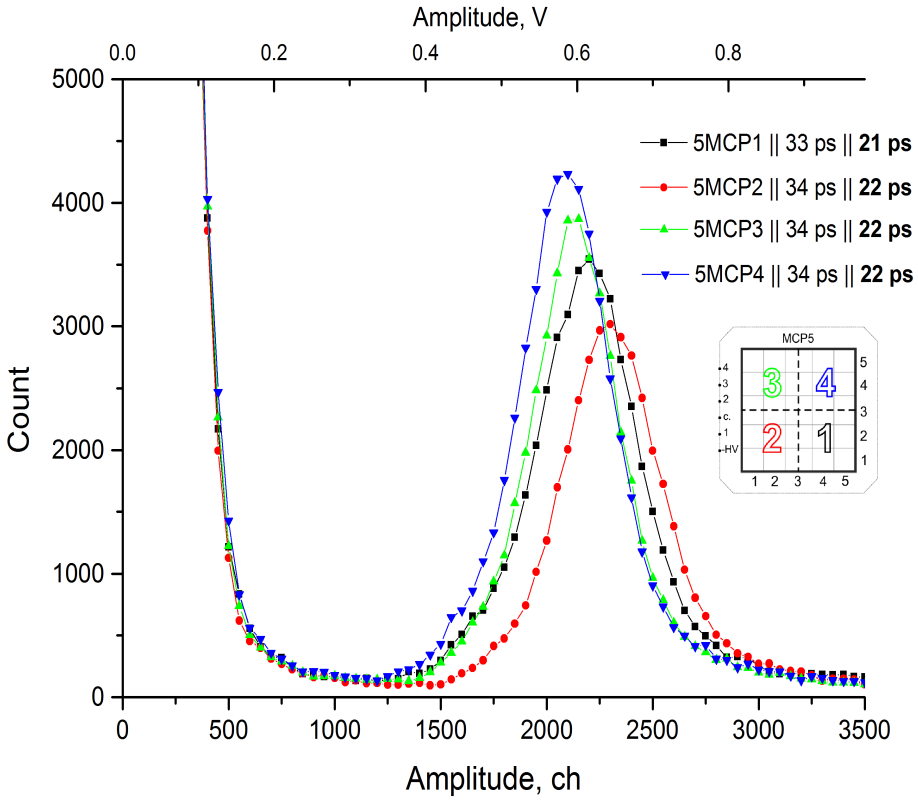
event plane resolution

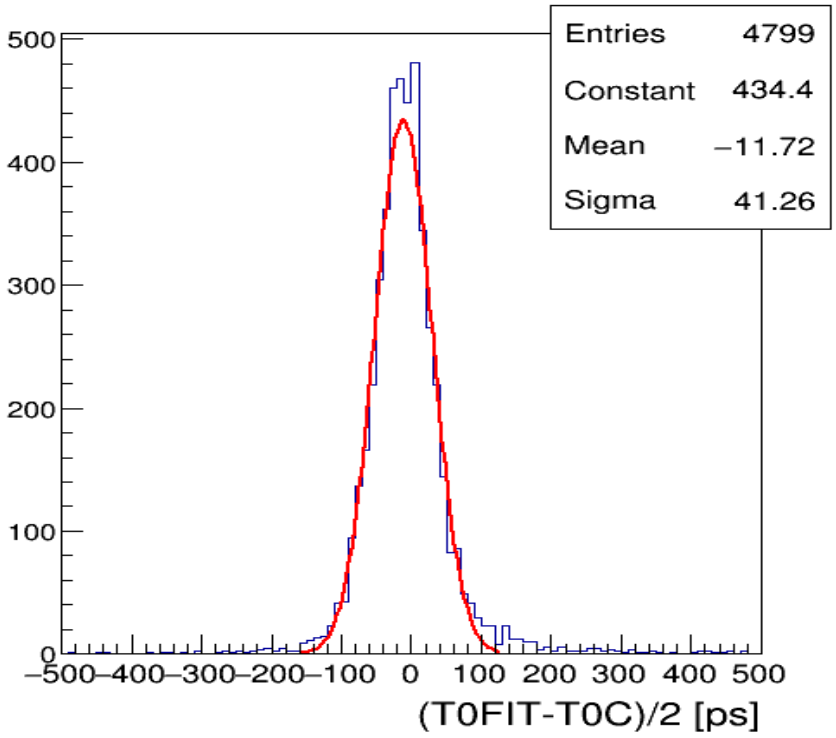


centrality resolution



Test Beam T0 - Plus





October 2015 test beam at T10

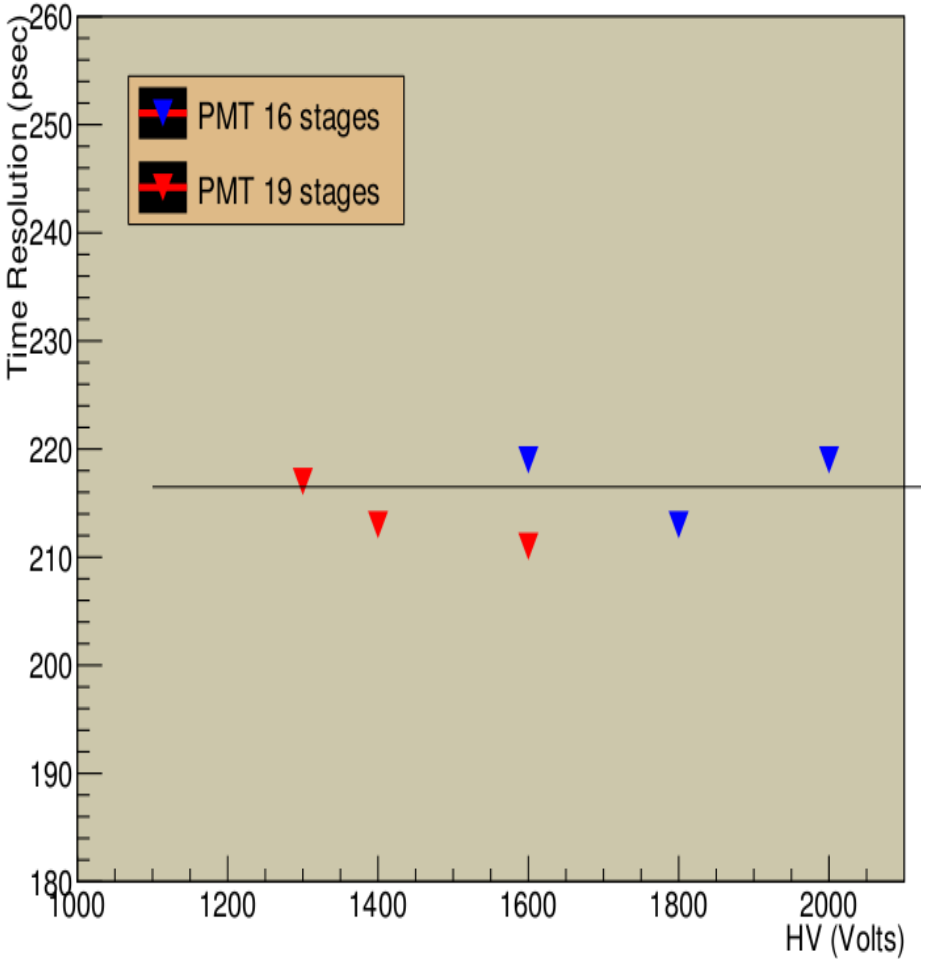
- 6 GeV pions
- MCP amplification 10^6
- Amplitude ~2100 channels
- Time resolution **~22 ps**

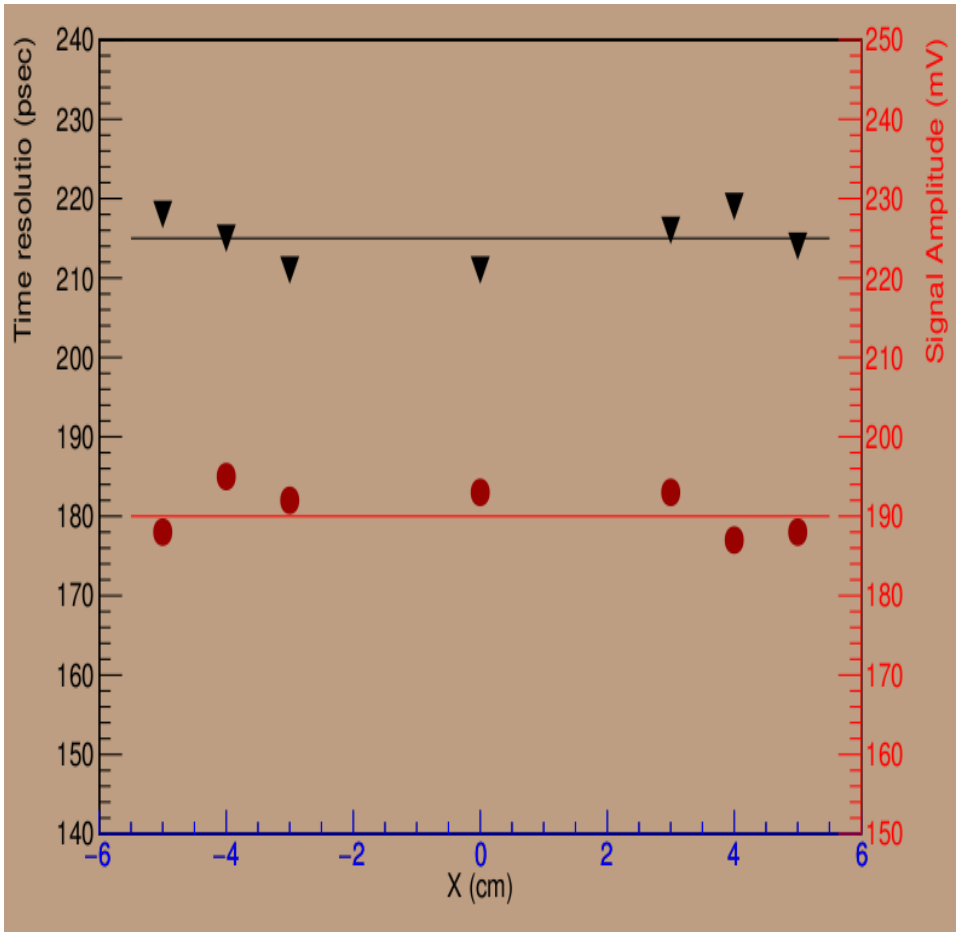
Module installed at P2 in ALICE

- 13 TeV pp collisions
- MCP amplification 10^6
- **Uncorrected** time resolution

Test Beam Results V0 -Plus

October 2015 PS test beam CERN T10





- Time and amplitude signal resolution along the detector. Fine Mesh PMT
- Time resolution not dependent on PMT HV or stages.

Final Notes

- The major upgrade of the ALICE detector allow us to exploit the high collision rate expected for the LHC Run 3
- The FIT upgrade is on track. The design is being finalized. Work on electronics and integration is underway.

FIT Collaborating Institutes

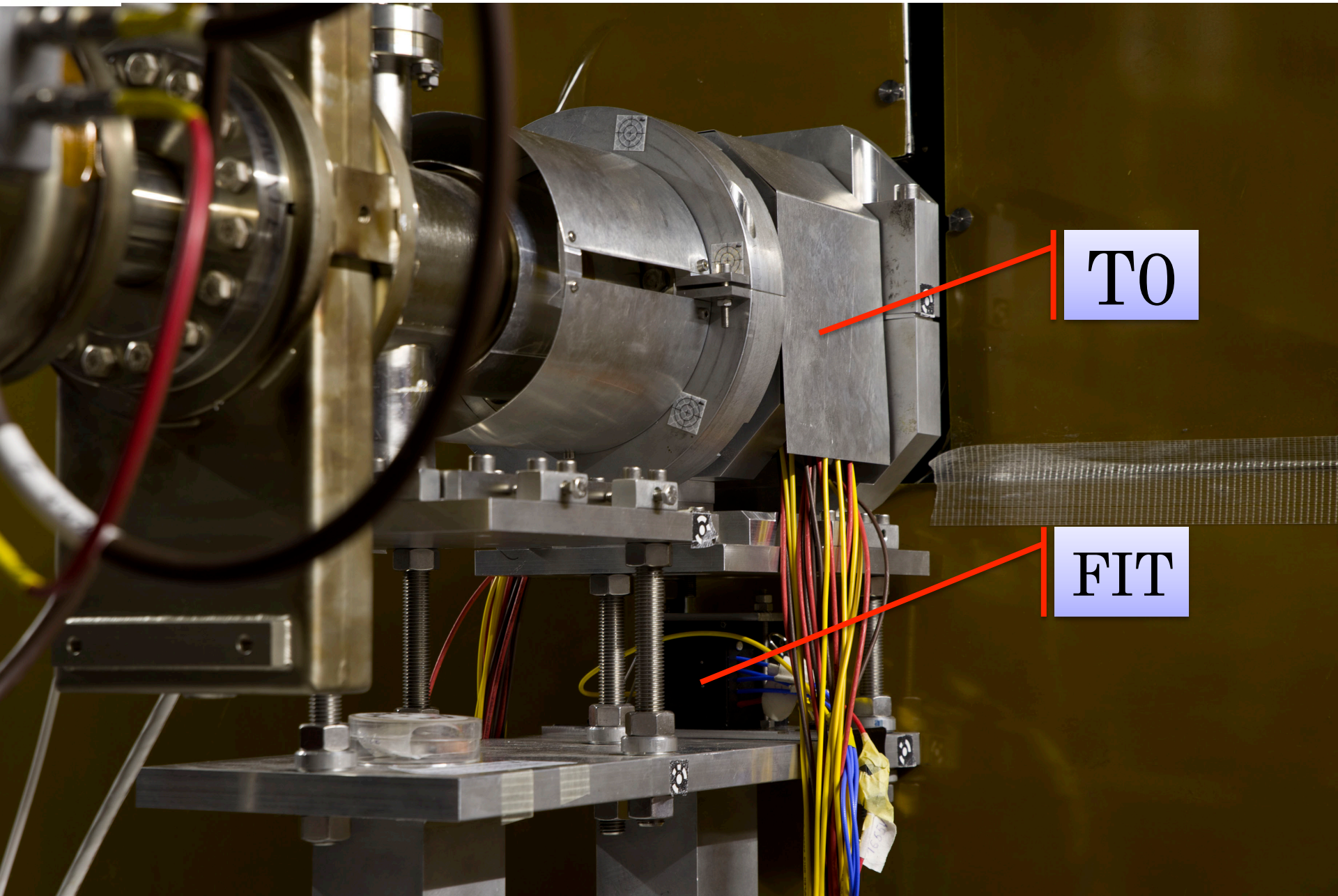
50 scientist, 14 institutions, 6 countries

Benemérita Universidad Autónoma de Puebla, California Polytechnic State University**, Chicago State University**, CINVESTAV, Helsinki Institute of Physics (HIP), Instituto de Física UNAM, Instituto de Ciencias Nucleares UNAM, Institute for Nuclear Research Moscow, Moscow Engineering Physics Institute, Niels Bohr Institute, Russian Research Centre Kurchatov Institute, Stefan Meyer Institute, Universidad Autónoma de Sinaloa, University of Copenhagen, Univ. of Helsinki, Univ. of Jyväskylä.

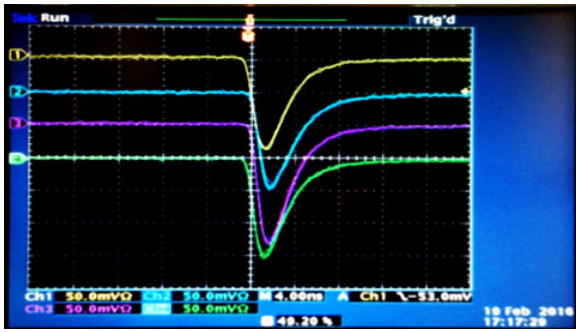
For **Chicago State University**, this material is based upon work supported by the National Science Foundation under grants NSF-PHY-1305280, NSF-PHY-1407051 and NSF-PHY-1624988

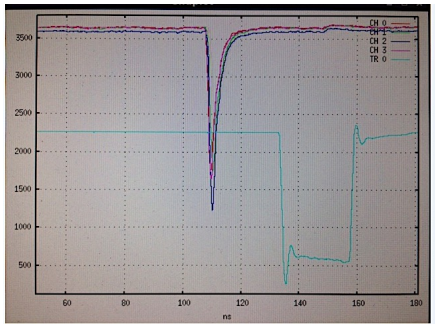
BACKUP

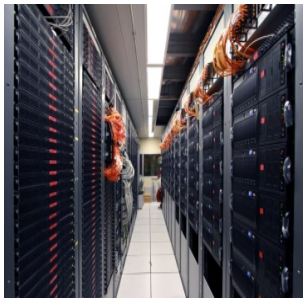
FIT module installed in ALICE



FIT configuration at P2



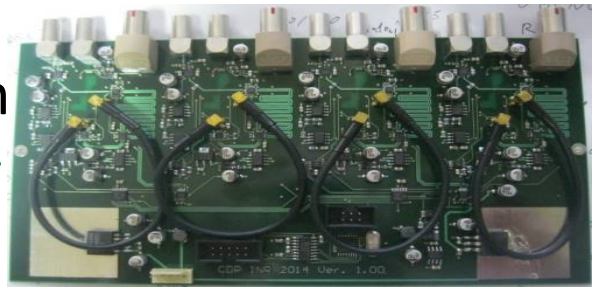




CR1/CR3

Cavern (rack C33)

40 m



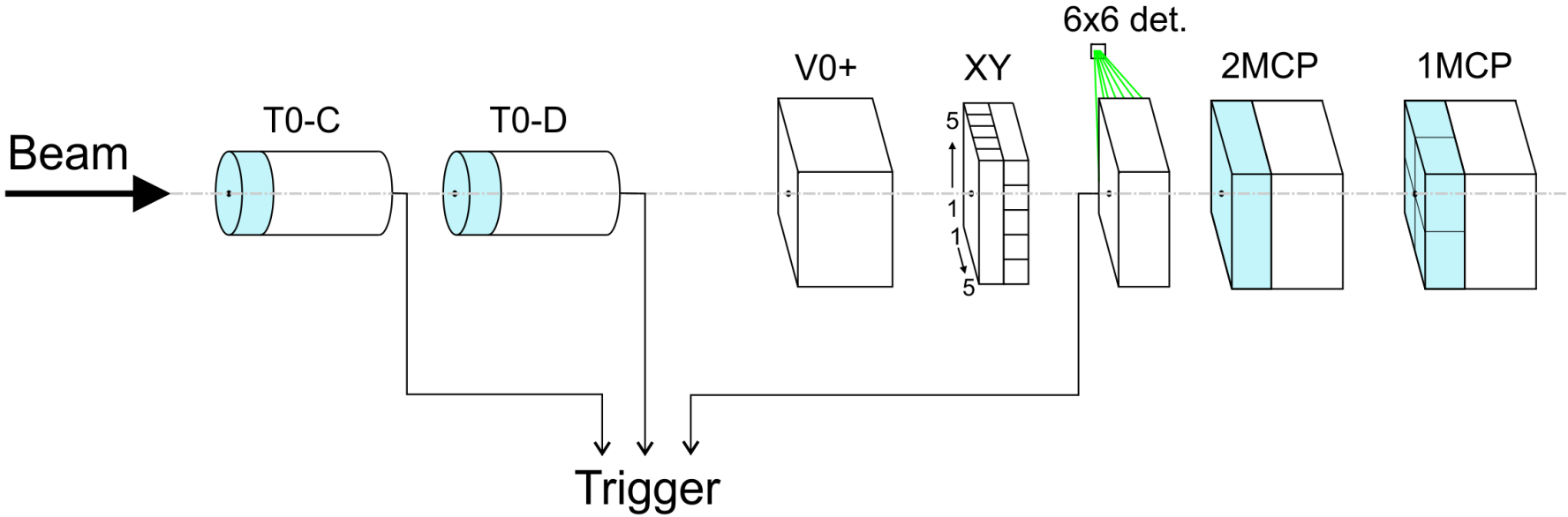
HV cable from CR4

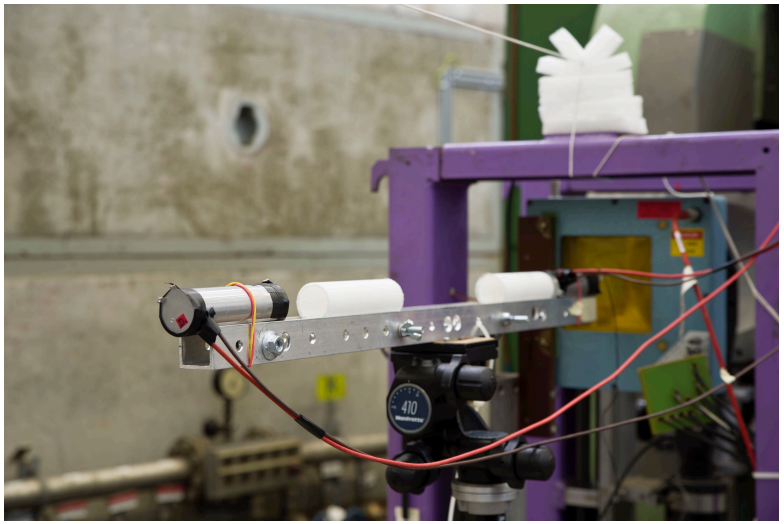
T0 TRM,QTC

OTVX signal as Trigger

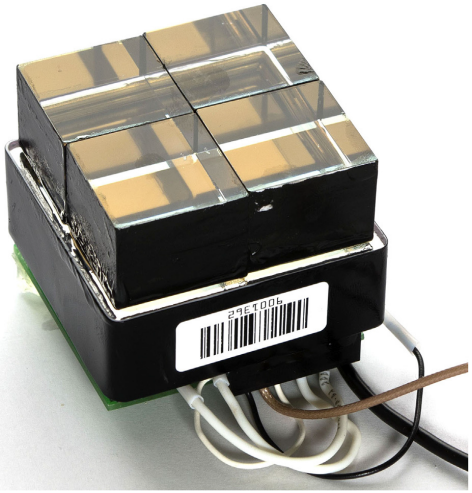
We use a spare link between Pit (rack C34) and CR1 (rack X09)
1T00U2YC34-51 fibers 17-18 (Pit) ---> 1DAQC1YX09-46-07
fibers 5-6 and than optical link from CR1 to CR3

Test Beam Setup at T10





Cross Talk and Modified Base



Oscilloscope pictures of the signals from a standard (upper part) and of the modified MCP