Performance of the ALICE PHOS trigger and improvements for RUN 2

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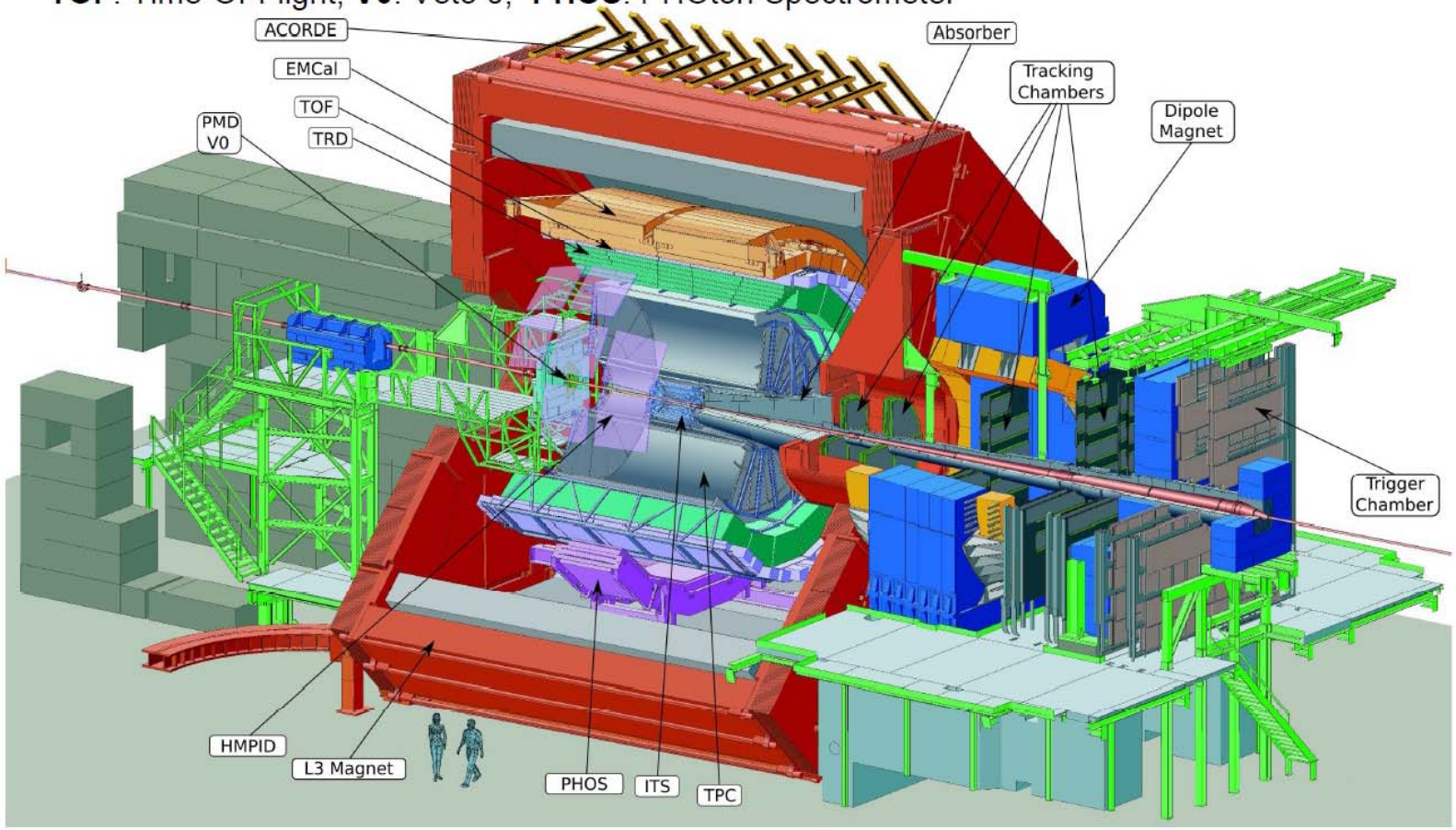
On behalf of the ALICE PHOS collaboration

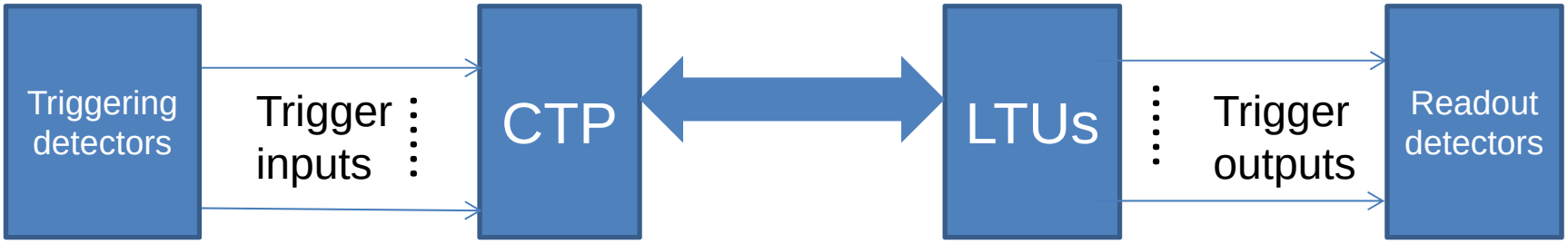
ALICE (A Large Ion Collider Experiment)

ITS: Inner Track System; **TPC**: Time Projection Chamber; **TRD**: Transition Radiation Detector
TOF: Time-Of-Flight; **V0**: Veto 0; **PHOS**: PHOton Spectrometer



ALICE trigger system

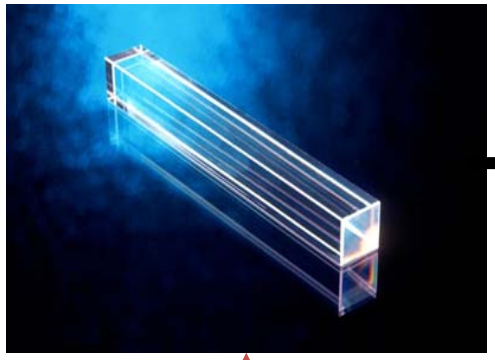
- Two kinds of detectors – triggering detectors and readout detectors
  - Triggering detectors provide trigger inputs to the trigger system.
  - Readout detector records data taken during physics runs
  - PHOS is both the triggering detector and the readout detector.
- Three levels of triggers – 24 L0-trigger inputs, 24 L1-trigger inputs and 12 L2-trigger inputs
  - L0 provides an early track on events of interests, L1 provides further information of these events, and L2 decides whether these events should be recorded.
  - PHOS is now contributing L0-triggers to the ALICE trigger system
  - PHOS L1-trigger is being developed and test in lab

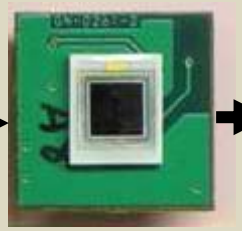


CTP: Central Trigger Processor
LTU: Local Trigger Unit

PHOton Spectrometer (PHOS)

Array of crystals	APD + preamplifer	trigger logic





L0/L1 triggers

Front-end electronics

readout

Signal to ALICE DAQ

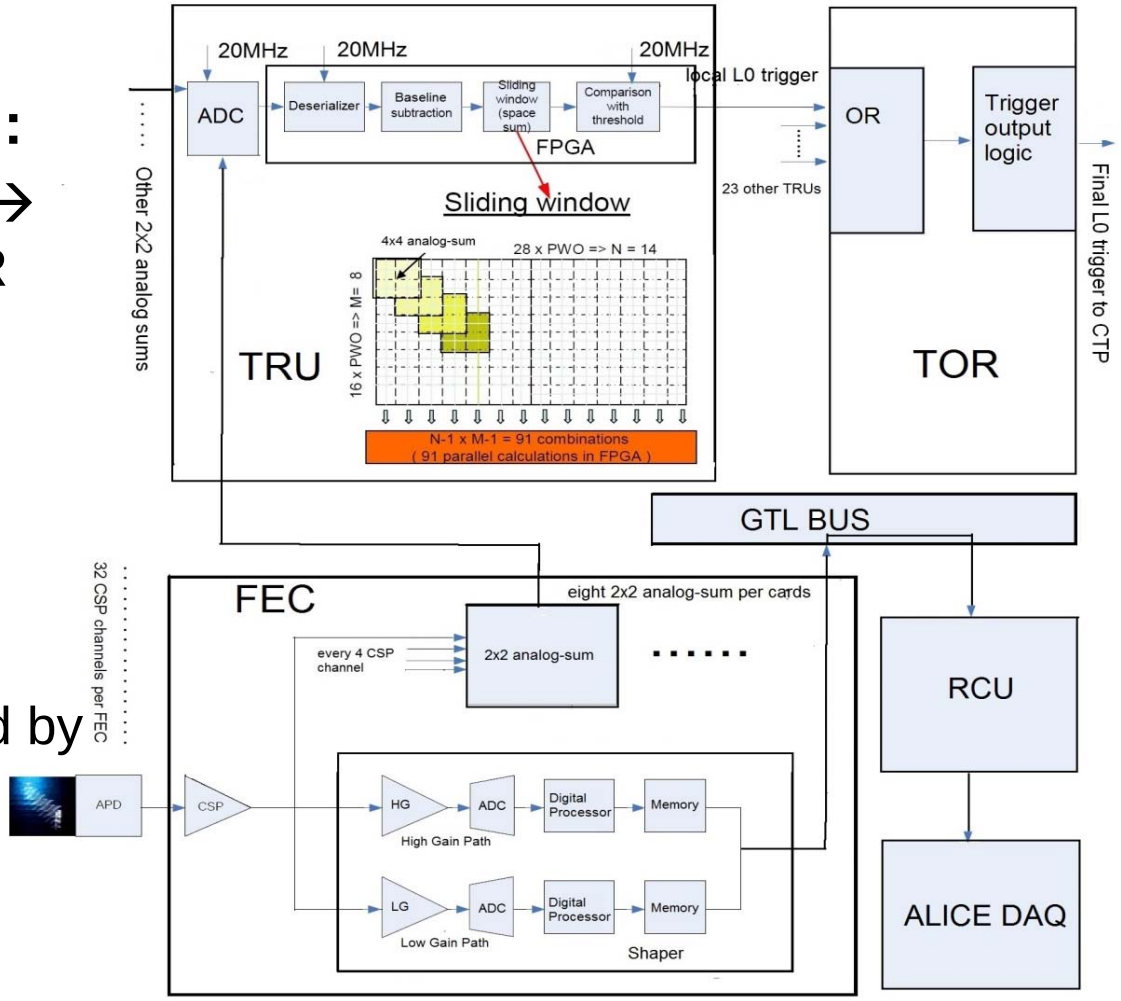
PHOS trigger working scheme

- **Trigger generation path:**

CSP signal→ 2x2 analog-sum→ TRU (local L0 decision) →TOR (final L0 decision)

- **Data recording path:**

CSP signal→ Shaper with two gains → ALICE DAQ controlled by RCU



Technical requirements

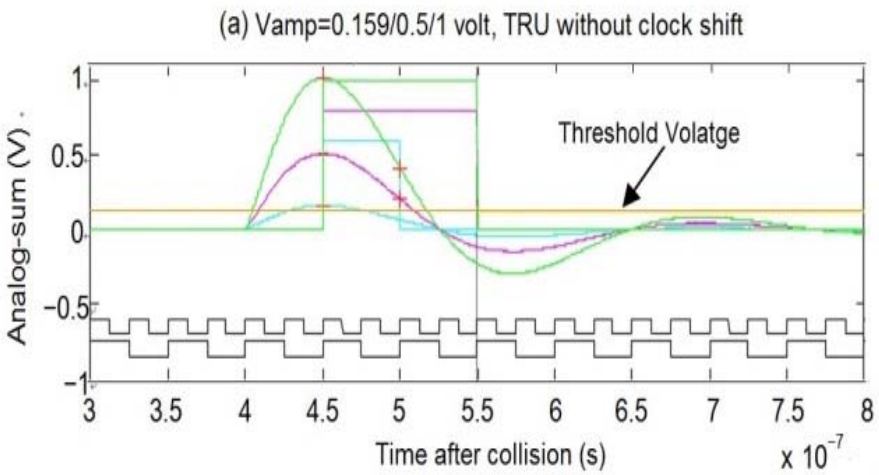
Ideally, L0-trigger outputs should fulfill three requirements:

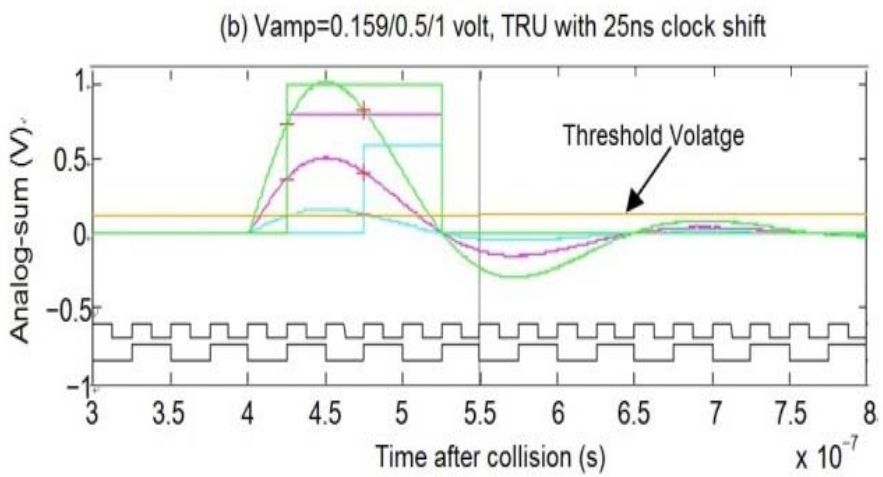
- Trigger decision should be made according to the peak value of the analog-sum signal
  - To ensure that the threshold comparison is based on the most accurate value
- Duration of 25 ns (bunch spacing)
  - Long trigger pulse would lead to missed photons
- Arrive at the CTP at a fixed time
  - CTP only accepts triggers arriving at a fixed time

Technical limitations

- TRU works at 20 MHz (requirement is 40 MHz)

- Can not assure that the trigger decision is made according to the peak of analog-sum signal
- Trigger pulse is at least 50 ns
- Trigger arriving time varies due to TRU clock shift





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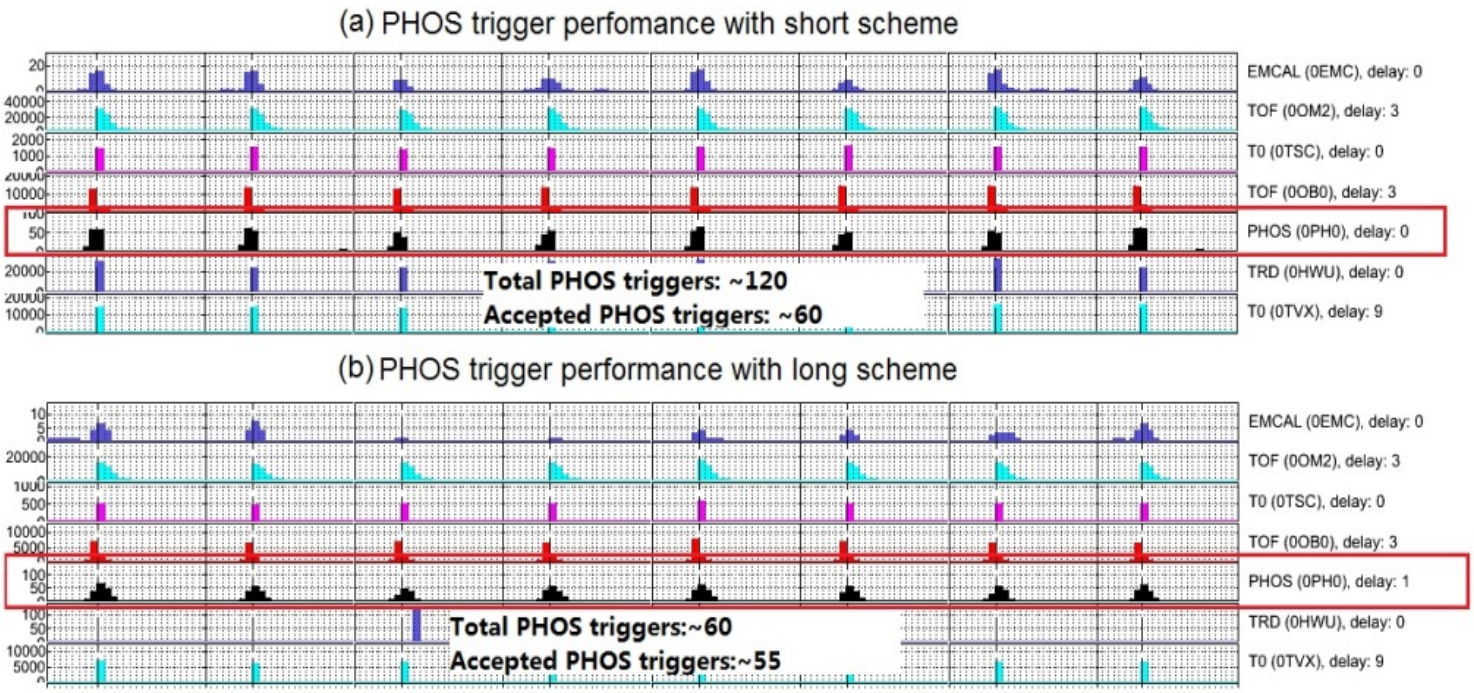
Trigger scheme selection

- **Performance of two trigger scheme were compared**

I. Short scheme: keep the first clock cycle when the signal is over threshold.

II. Long scheme: keep the trigger as long as the signal is over threshold.



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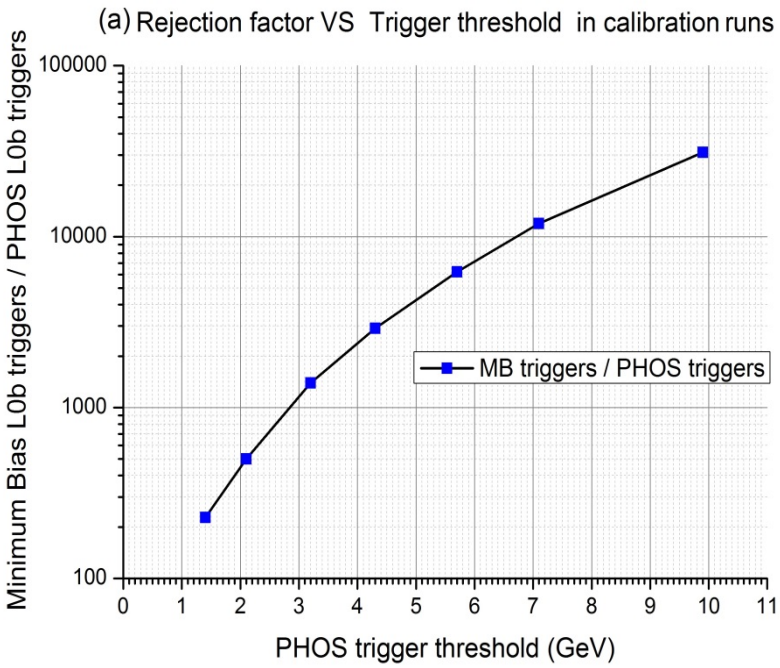
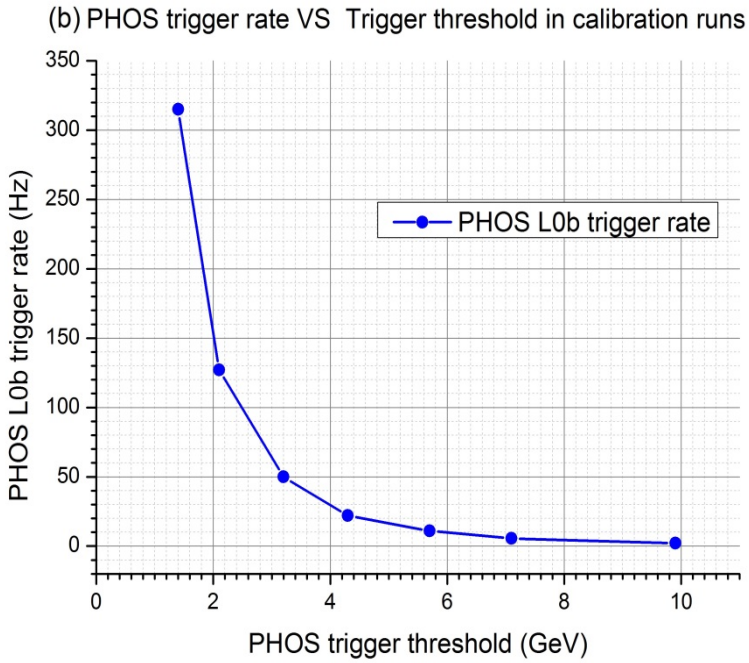
Performance analysis

- Is the trigger operating as expected?
  - *Rejection factor*
  - *PHOS trigger rate*
- How many triggers are fake ones?
  - *Trigger purity*
- How many photons does PHOS miss?
  - *Trigger efficiency*

Rejection factor

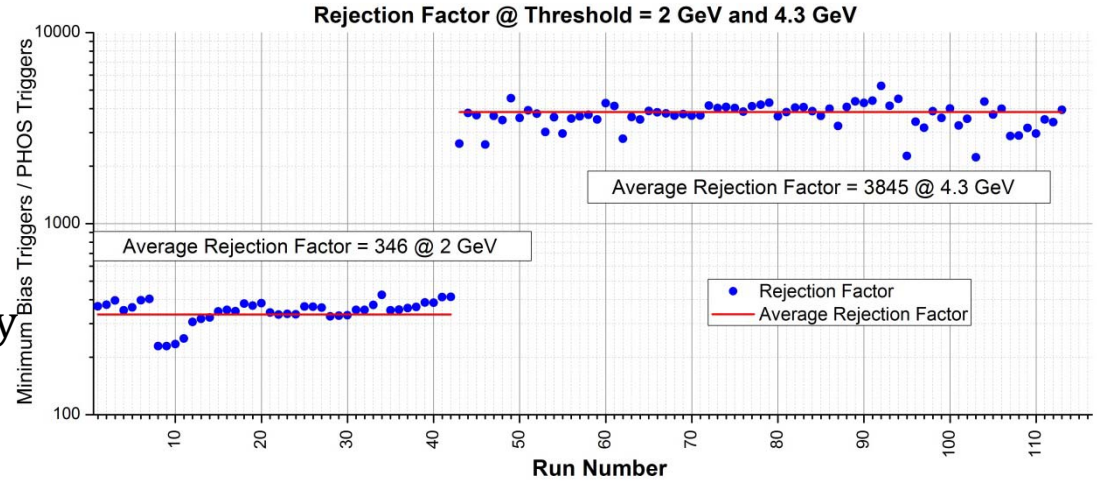
- $Rejection\ factor\ =\ N_{MB}\ /N_{PHOS}$
  - N_{MB} is the number of events triggered by minimum bias trigger
  - N_{PHOS} is the number of events triggered by PHOS

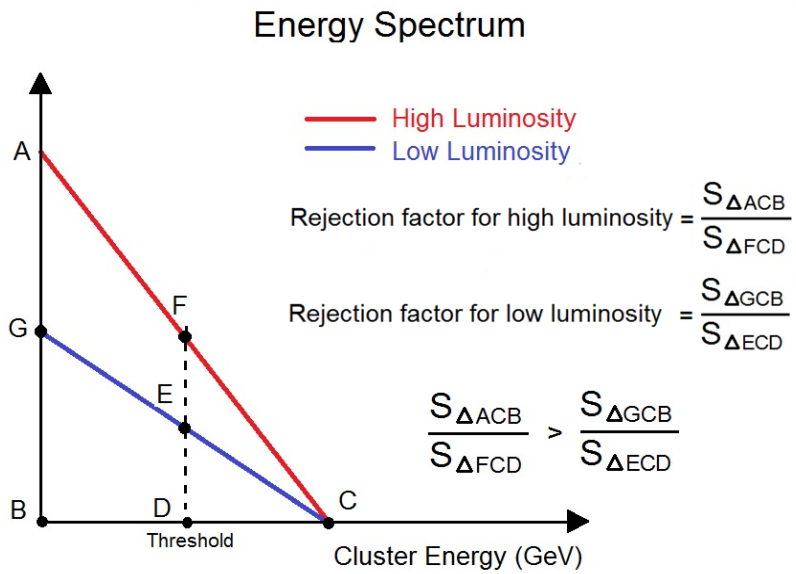


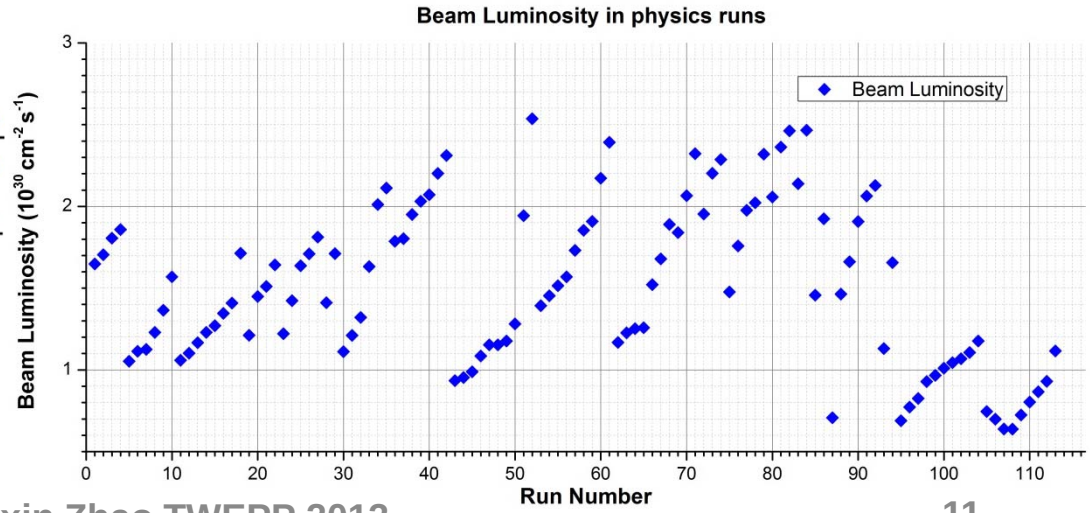


Rejection factor

- Remains reasonably stable during runs of the same threshold → PHOS trigger is working as expected
- 346@2GeV, 3845@4.3GeV
- $N_{PHOS} \frac{1}{\propto} Threshold$
- N_{MB} keeps on the same level
- Rejection factor $\propto$ Beam luminosity



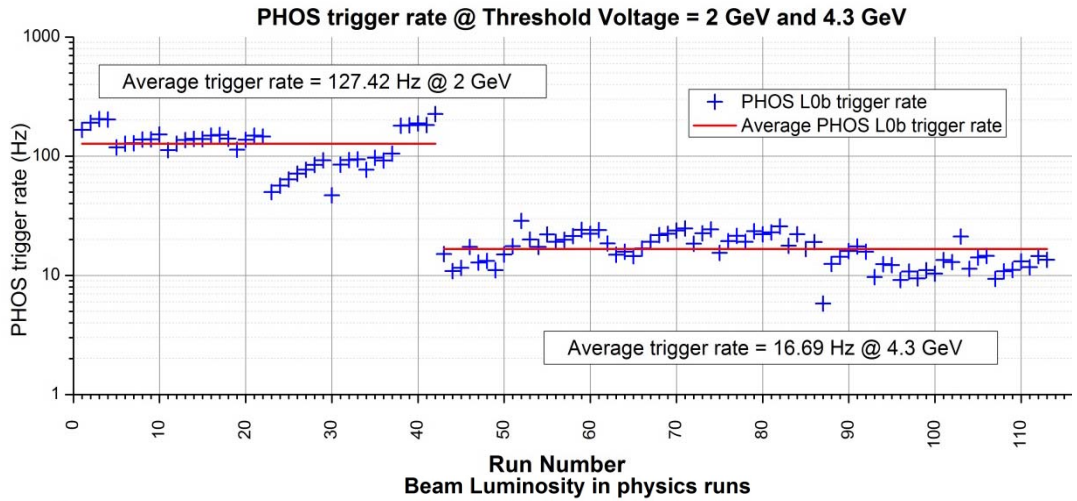




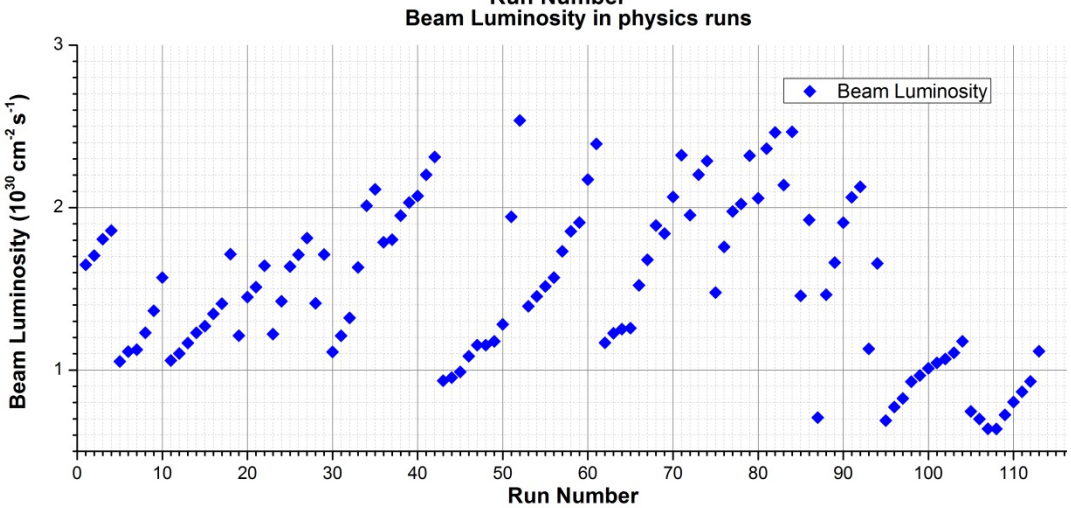
PHOS trigger rate

- Remains reasonably stable during runs of the same threshold → PHOS trigger is working as expected

- 127Hz@2GeV, 17Hz@4.3GeV
  - The number of events with photons whose energy is over threshold is in negative proportion to threshold

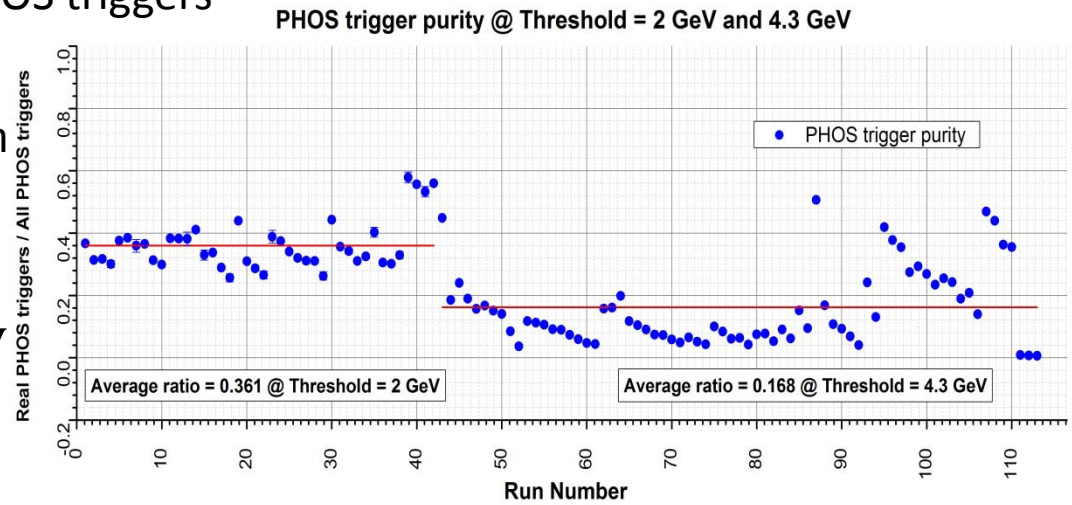


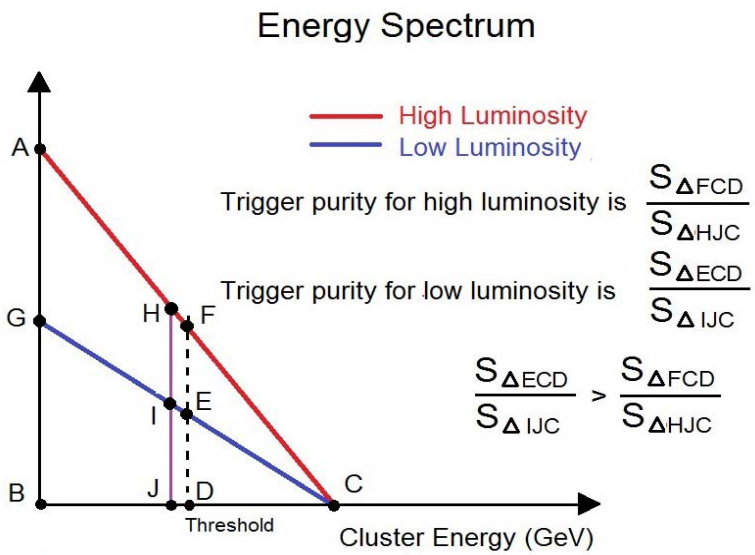
- Trigger rate ∝ Beam luminosity
  - There are more photons in the collisions of beams with high luminosity than that in the collision of beams with low luminosity



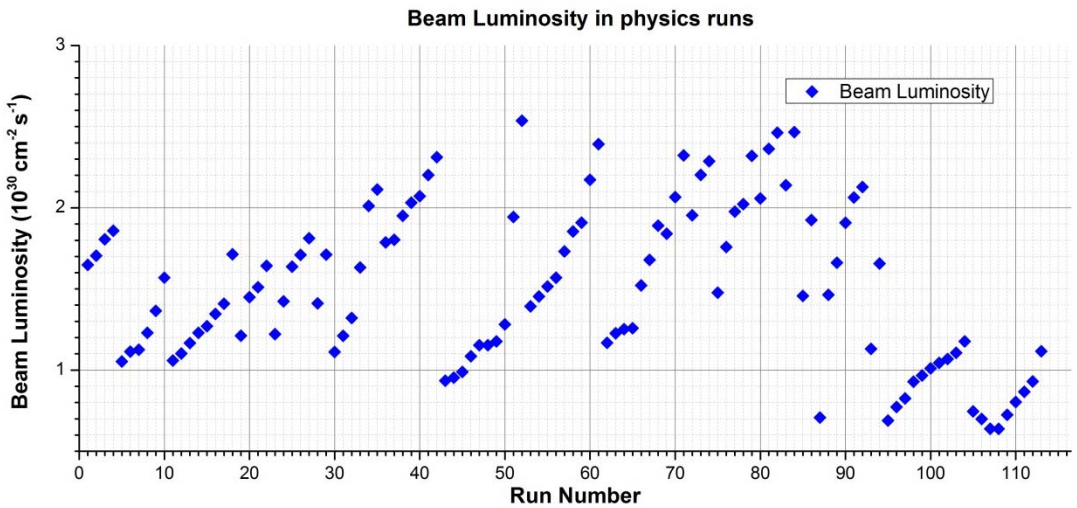
Trigger purity

- $Trigger\ Purity = N_{real\ PHOS} / N_{all\ PHOS}$
  - $N_{real\ PHOS}$ is number of real PHOS triggers
  - $N_{all\ PHOS}$ is the number of all PHOS triggers
- 0.36@2GeV,0.17@4.3GeV
- Triggered events@2GeV is more than triggered events@4.3GeV
- Noise could be regarded as constant
- Trigger purity $\frac{1}{\propto}$ Beam luminosity





Photons whose energy is in the region ranges from point J to point D may lead fake triggers by being added with noises



Trigger efficiency

- In principle, $Trigger\ efficiency = N_{PHOS}\ /\ N_{PHOS\_Over\_Thr}$

- N_{PHOS} is the number of events triggered by PHOS.
- $N_{PHOS\_Over\_Thr}$ is the number of events with clusters whose energy is over PHOS threshold.

- In calculation, $Trigger\ efficiency = E_{PHOS}\ /\ E_{PHOS\_Over\_Thr}$

- E_{PHOS} is the energy spectrum of PHOS triggered events
- $E_{PHOS\_Over\_Thr}$ is the energy spectrum of all the events that should be triggered by PHOS

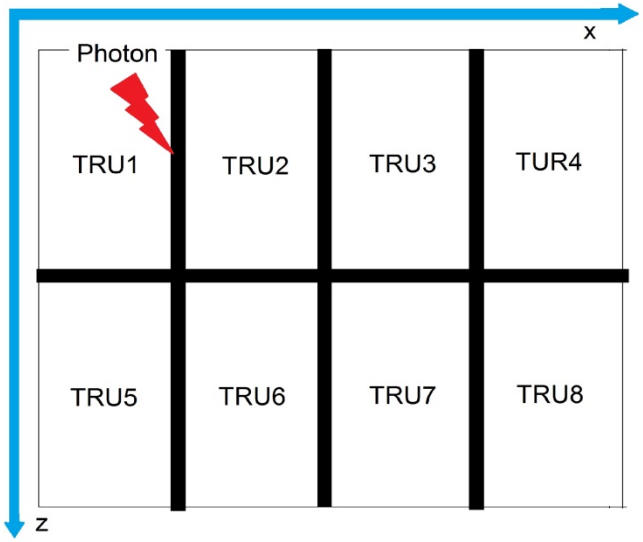
- Two factors that mainly affect trigger efficiency

- Boundary effect
- Noise during data recording

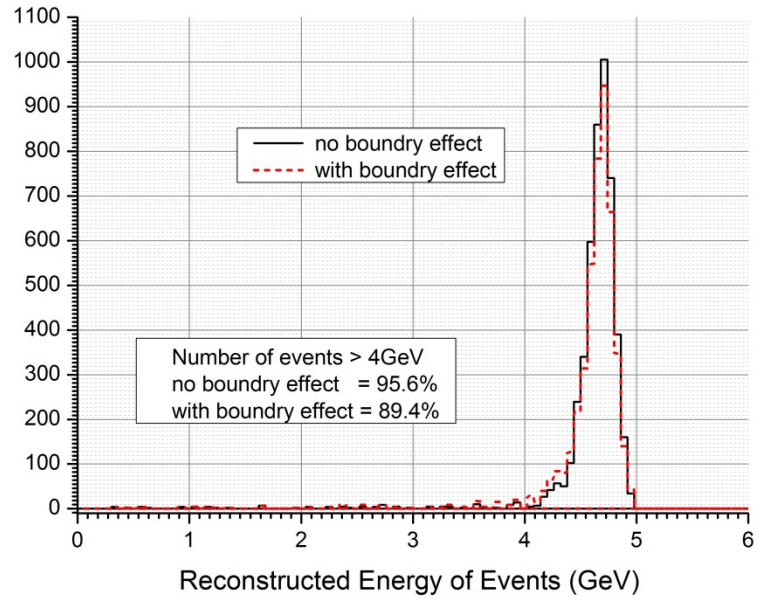
Boundary effect

- **Boundary effect** : energy deposited by photons at the boundary of TRUs could not be fully reconstructed, therefore, their corresponding events might be missed by PHOS.

(a) boundry effect



(b) Energy reconstruction of events in simulation



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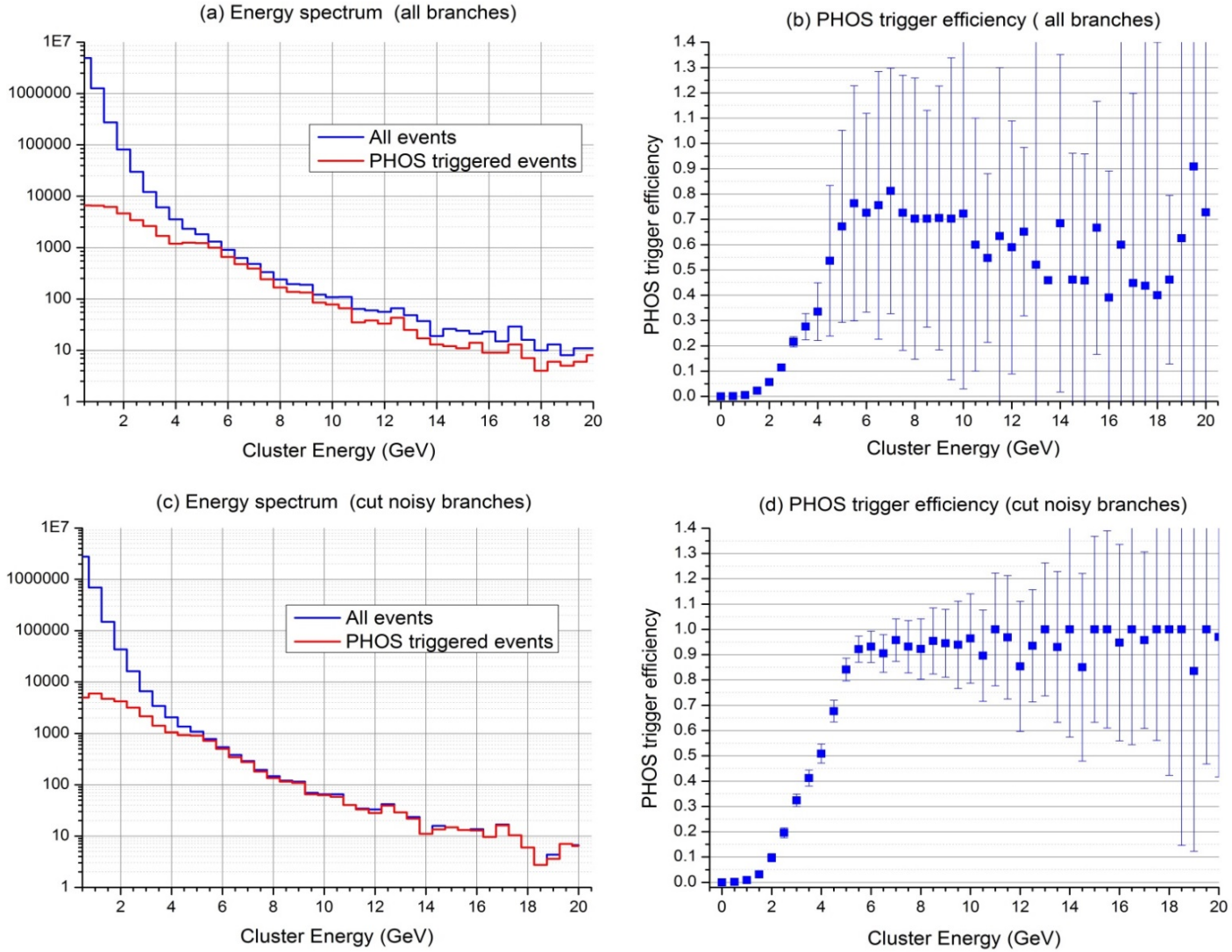
Trigger efficiency

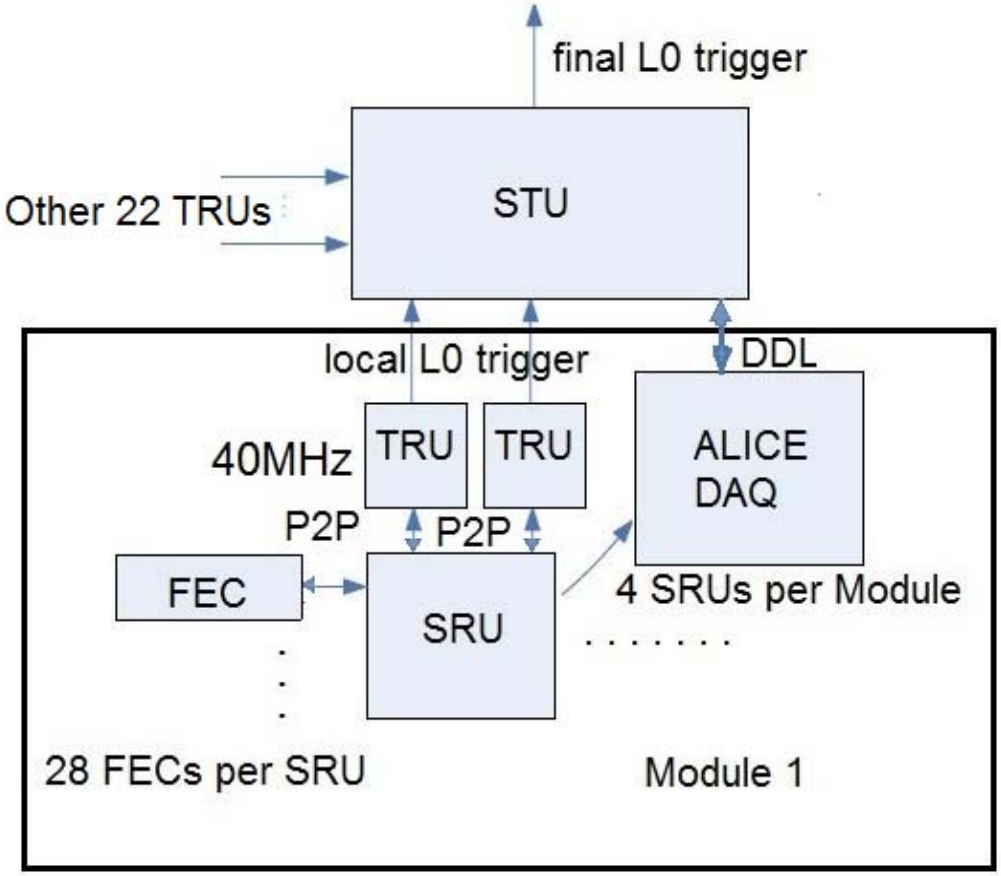


PHOS upgrade

- Deficiencies in PHOS:

- TRU working at 20 MHz but not the ideal 40MHz
- Noisy channels

- Replacing PHOS-TRU with EMCAL-TRU
  - Same prototype
  - FPGA -> 40 MHz sampling frequency
- Replacing PHOS-TOR with EMCAL-STU
  - Same prototype
  - DDL link included -> direct interface to DAQ)
- Replacing GTL bus with P2P bus + SRU



Conclusion

- PHOS trigger is working as expected
- Trigger efficiency is approximately 0.9 by removing noisy branches.
- Trigger purity varies with threshold voltage. Generally, 0.36 @ 2GeV and 0.17 @ 4.3GeV
- Upgrade is needed due to TRU working frequency and noisy channels. After the upgrade, PHOS is expected to reach an interaction rate of approximately 50 KHz for RUN2.

Thank you for listening !!!