Simulation Study of Trigger Decision Criterion for ALICE PHOton Spectrometer

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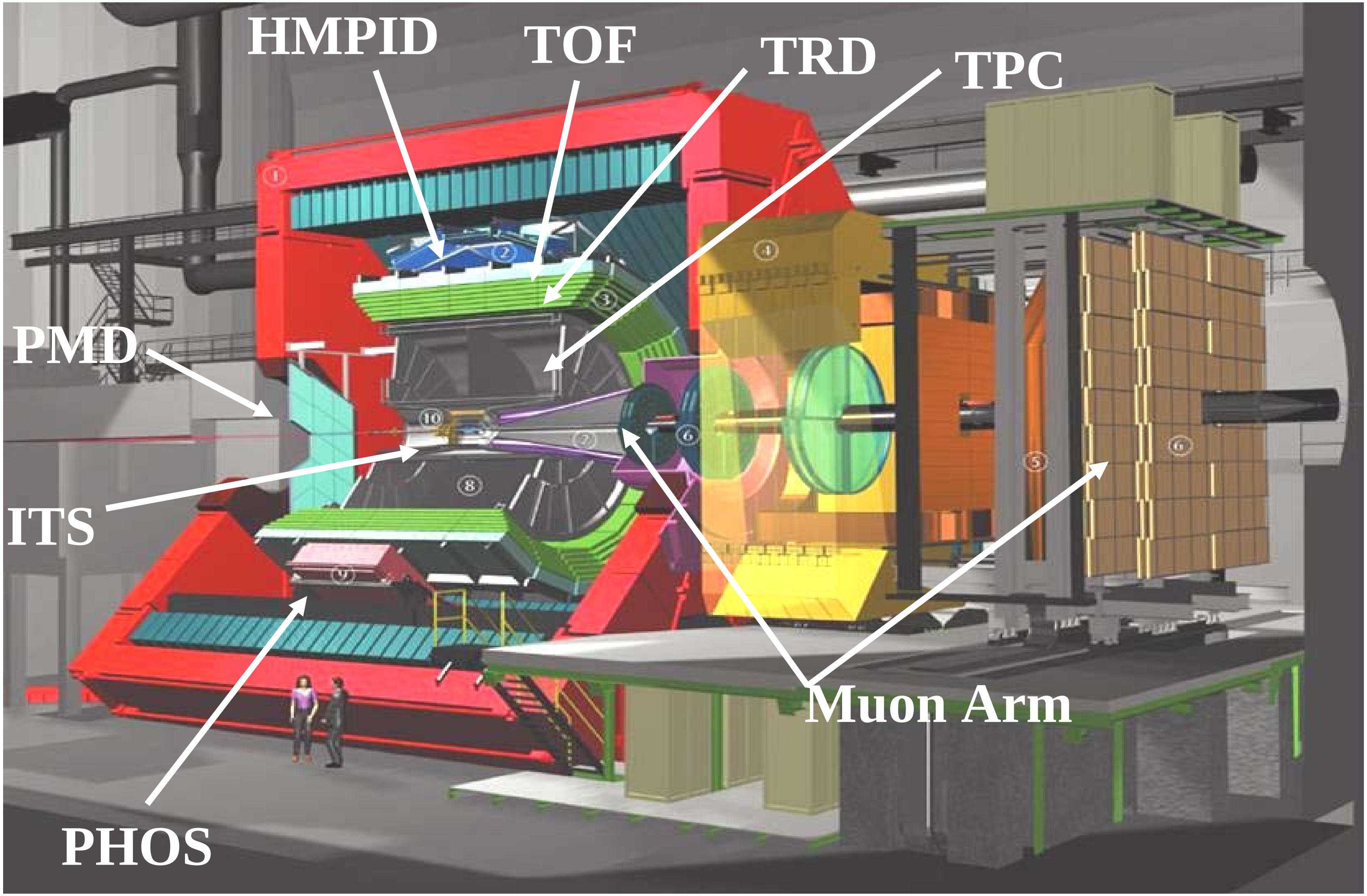
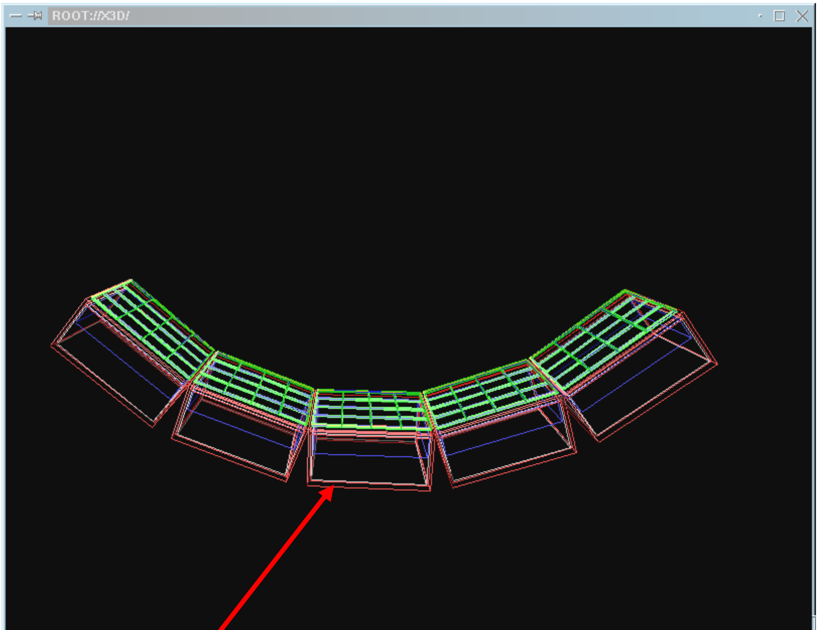
Outline

- **Introduction**
- **Trigger decision criterion of PHOS**
- **Energy reconstruction performance**
- **Trigger efficiency**
- **Trigger rate**
- **summary and outlook**

ALICE Set-up



Electromagnetic Calorimeter, PHOS



PHOS (PHOton Spectrometer) is a high resolution electromagnetic calorimeter consisting of 17920 detection channels based on lead-tungstate crystals(PWO_4).

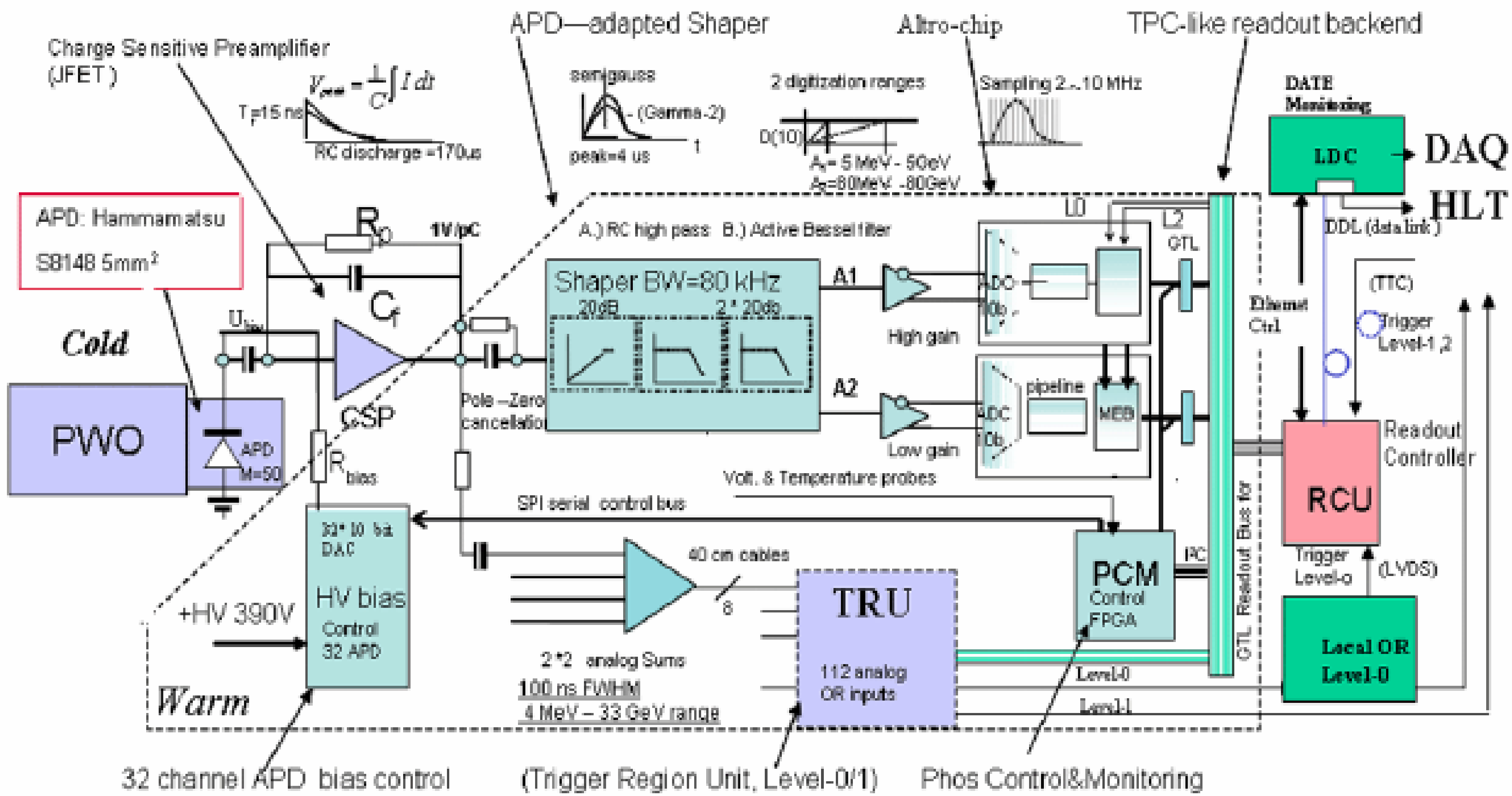
- **PHOS provides unique coverage of the following physics goals:**
  - -study of initial phase of the collision of heavy nuclei via direct single photons and diphotons;
  - -jet-quenching as a probe of deconfinement, studied via high p_T π^0;
  - -signals of chiral-symmetry restoration.

- **Technical data:**

17920 lead-tungstate crystals(PWO_4)

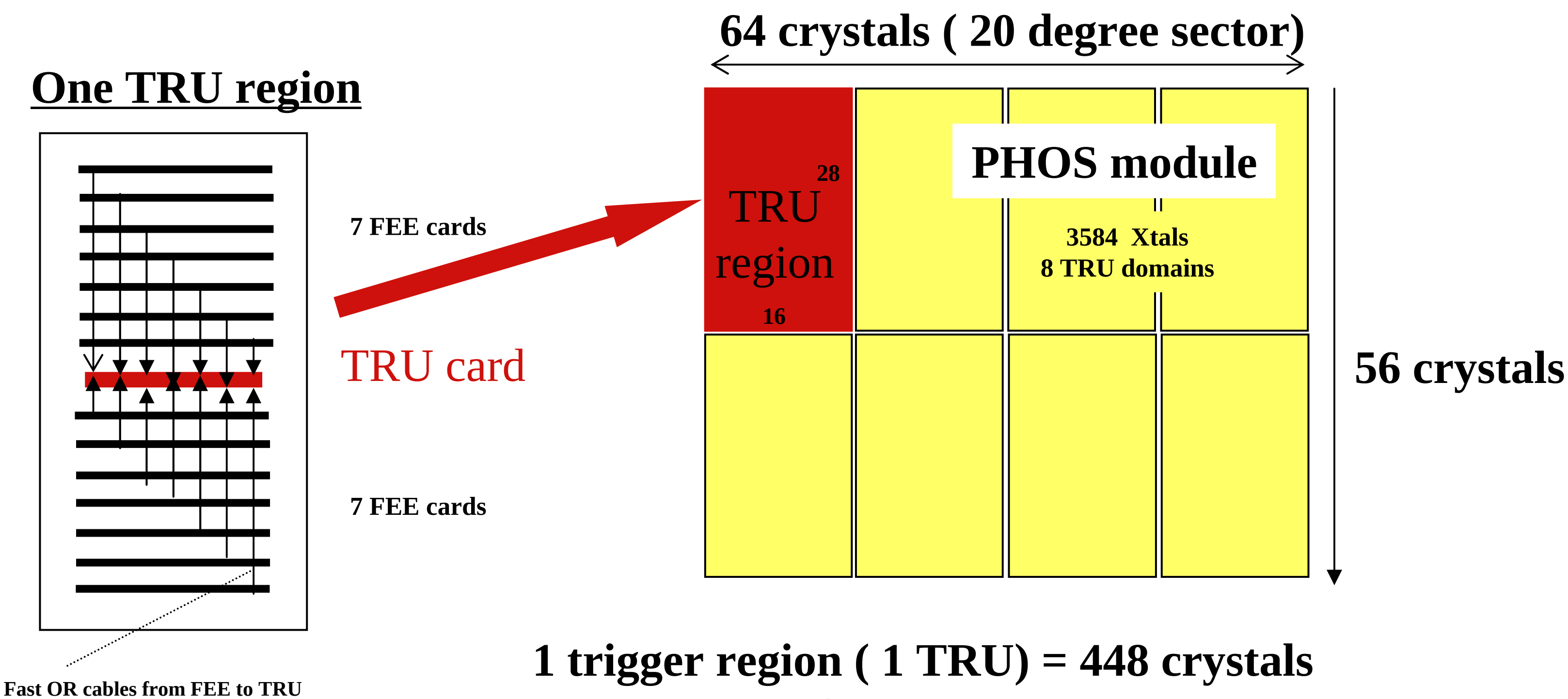
-distance to IP	4600mm
-coverage in pseudorapidity	-0.12;+0.12
-coverage in azimuthal angle	100º
-crystal size	22x22x180 mm^3
-depth in radiation length	20 X_0
-modularity	5 modules
-total area	8m^2
-total crystal weight	12.5 t
-operating temperature	-25 ºC
-photonreadout	APD

Trigger decision criterion of PHOS



Global overview over all PHOS electronics. FEE electronics is within the dotted area (warm).

Trigger Regions



1 trigger region (1 TRU) = 448 crystals

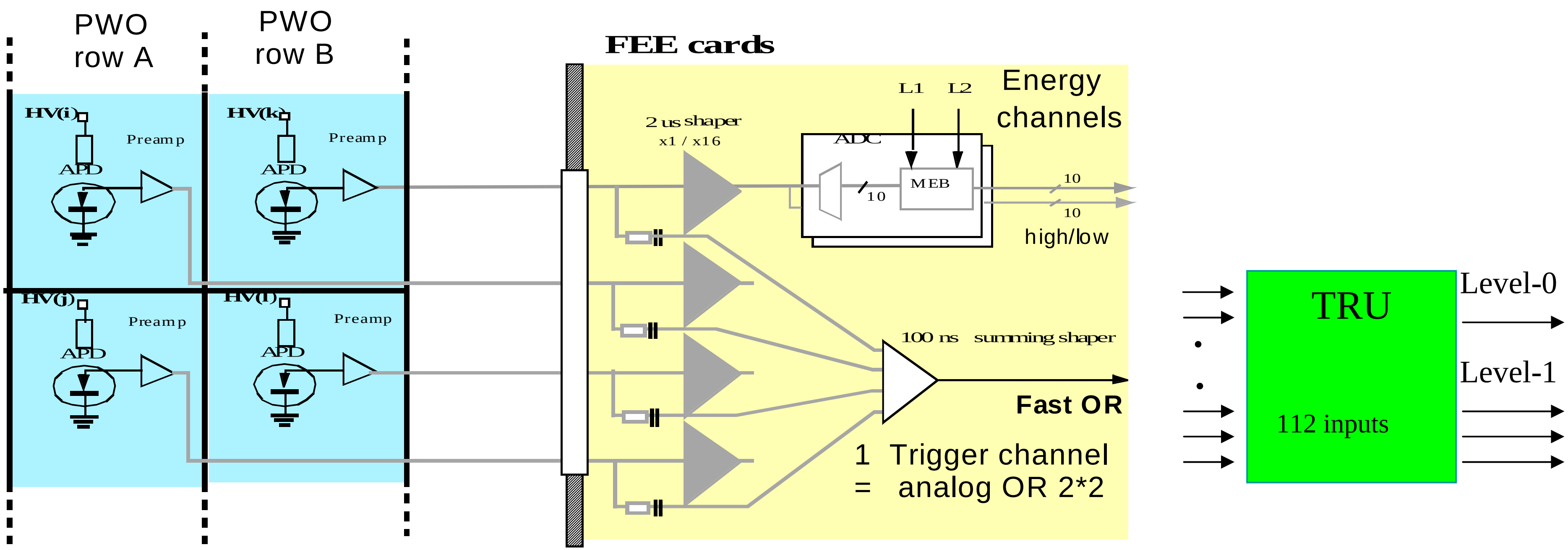
1 Fast OR for 2*2 crystal signals

8 Fast OR generated per FEE

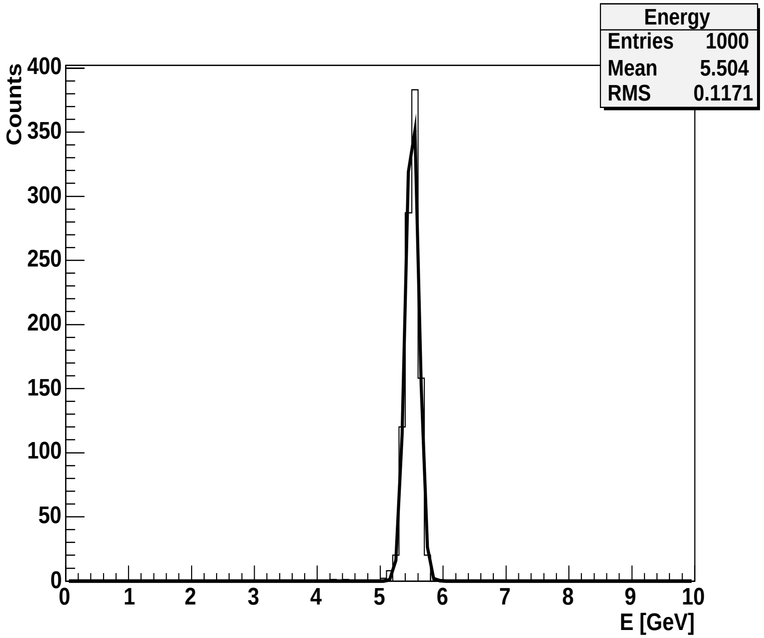
112 Fast OR inputs to each TRU

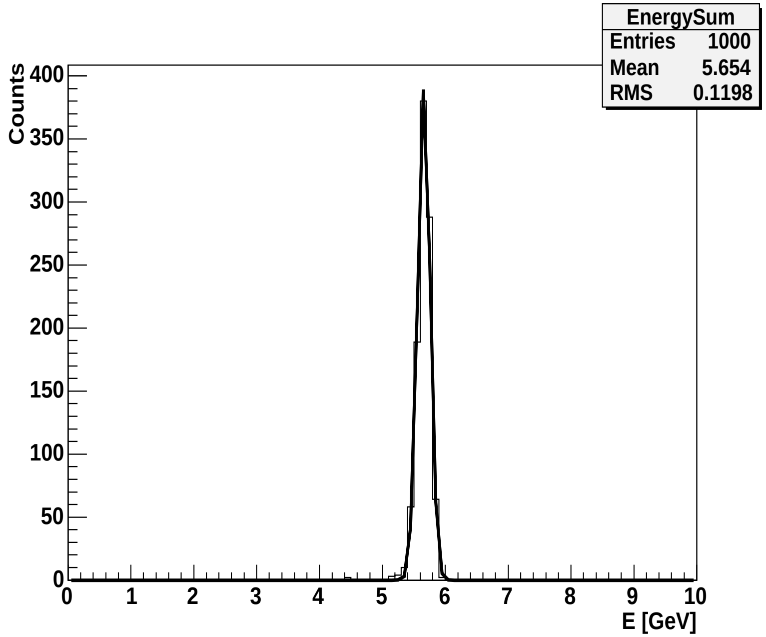
FEE->TRU signal routing

- 112 analog sums are fanned in, via 14 FEE to 1 TRU
- due to 2*2 sums one TRU covers 448 crystals
- 1 level-0 output
- 3 level-1 outputs



Reconstructed *E* distribution of incident electron with transverse momentum of 6 GeV/*c*





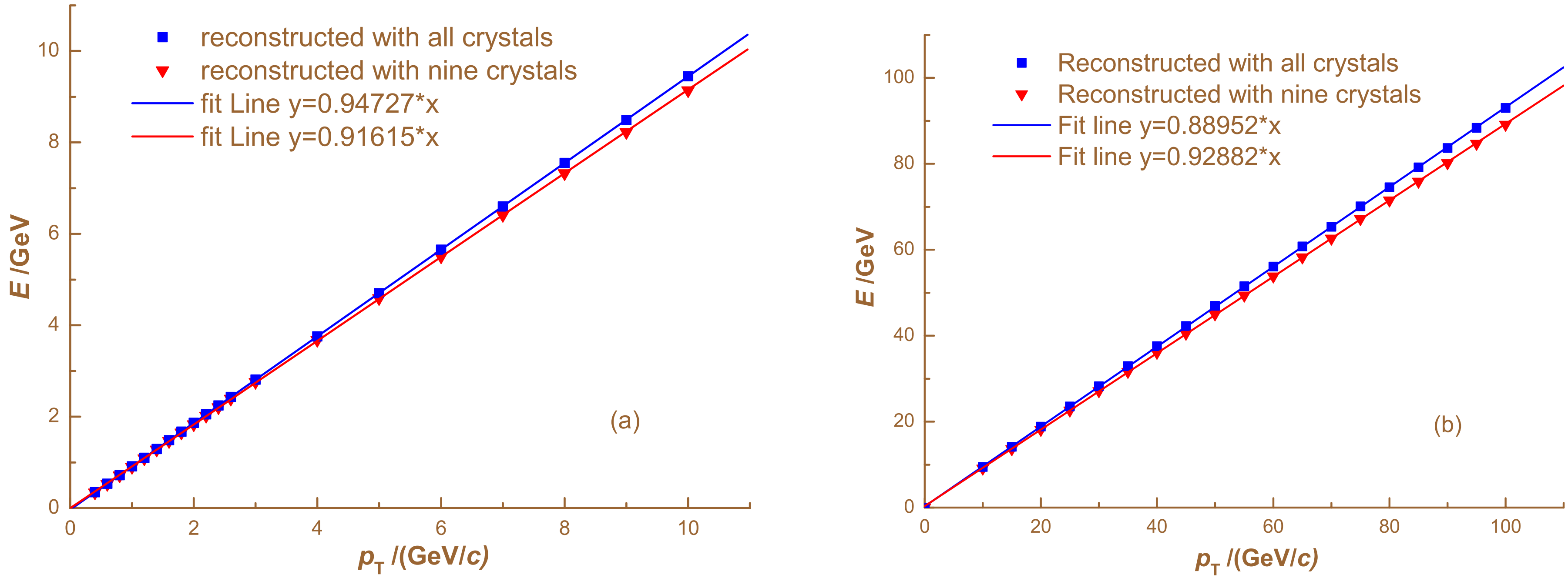
Left figure (sum of 3*3 crystals' deposited energy):

Mean value μ =5.51 GeV, covariance σ =0.104 GeV, σ_E/E=1.89%;

Right figure (sum of all activated crystals' deposited energy):

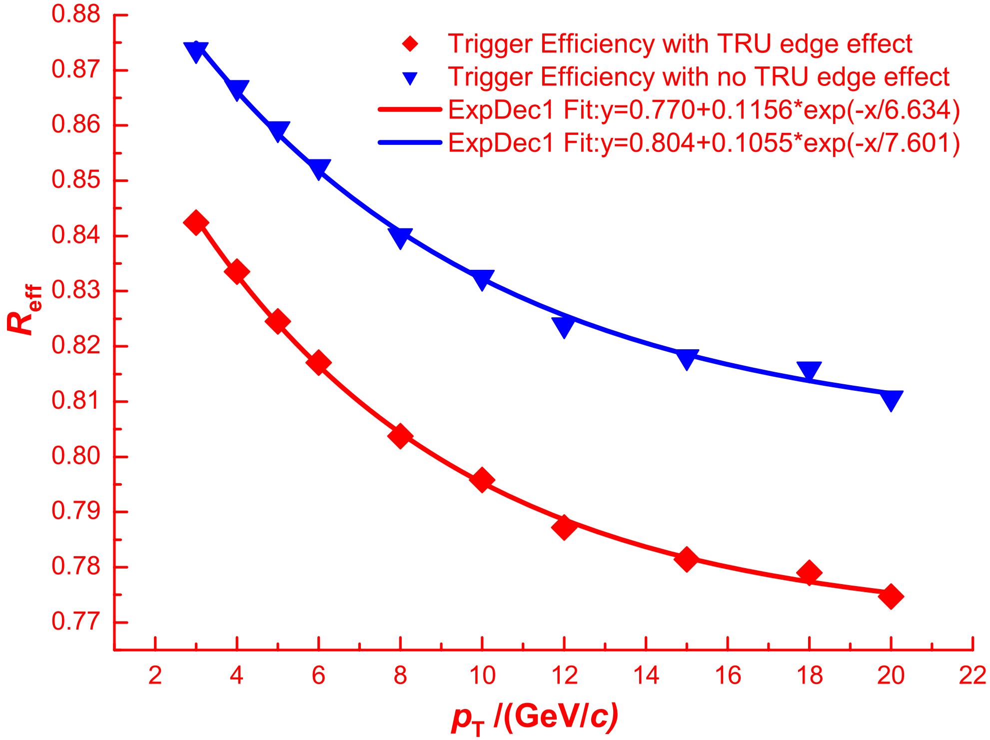
Mean value μ =5.66 GeV, covariance σ =0.099 GeV, σ_E/E=1.75%。

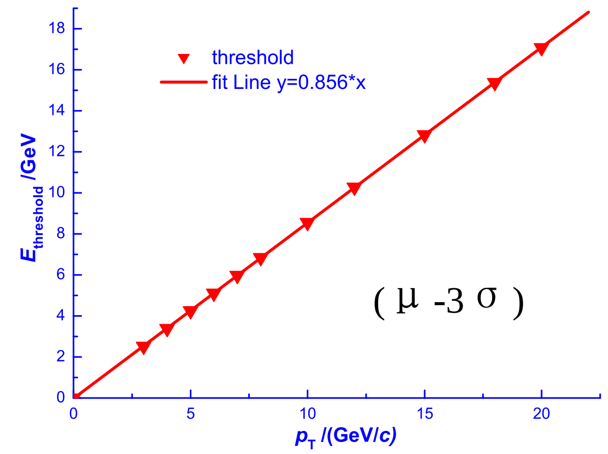
Reconstructed *E* distribution of incident electron in low p_T range (Fig. a) and high p_T range (Fig. b)



The energy reconstructed distribution is well fitted by the function $E = k \times p_T$ in a broad range.

Trigger efficiency of PHOS





Trigger threshold

Trigger efficiency is fitted well by:

$$R_{eff} = A_0 + A_1 e^{-\frac{p_T}{A_2}}.$$

Trigger efficiency loss about ~ 4% due to the TRU boundaries

Calculation method of trigger rate

p_T spectrum of direct photon, π^0 and η were obtained, fitted with power law distribution:

$$\frac{1}{2\pi p_T N_{ev}}\frac{dN}{dp_T} = A(1+\frac{p_T}{p_0})^{-n}.$$

(A, p_0 and n were determined by data fitting)

Particle number N_{par} per one collision measured by PHOS at the narrow p_T bin of $[p_T, p_T + \Delta p_T]$ is described approximately by the function:

$$N_{par} = A(1+\frac{p_T}{p_0})^{-n} \times 2\pi p_T \Delta p_T.$$

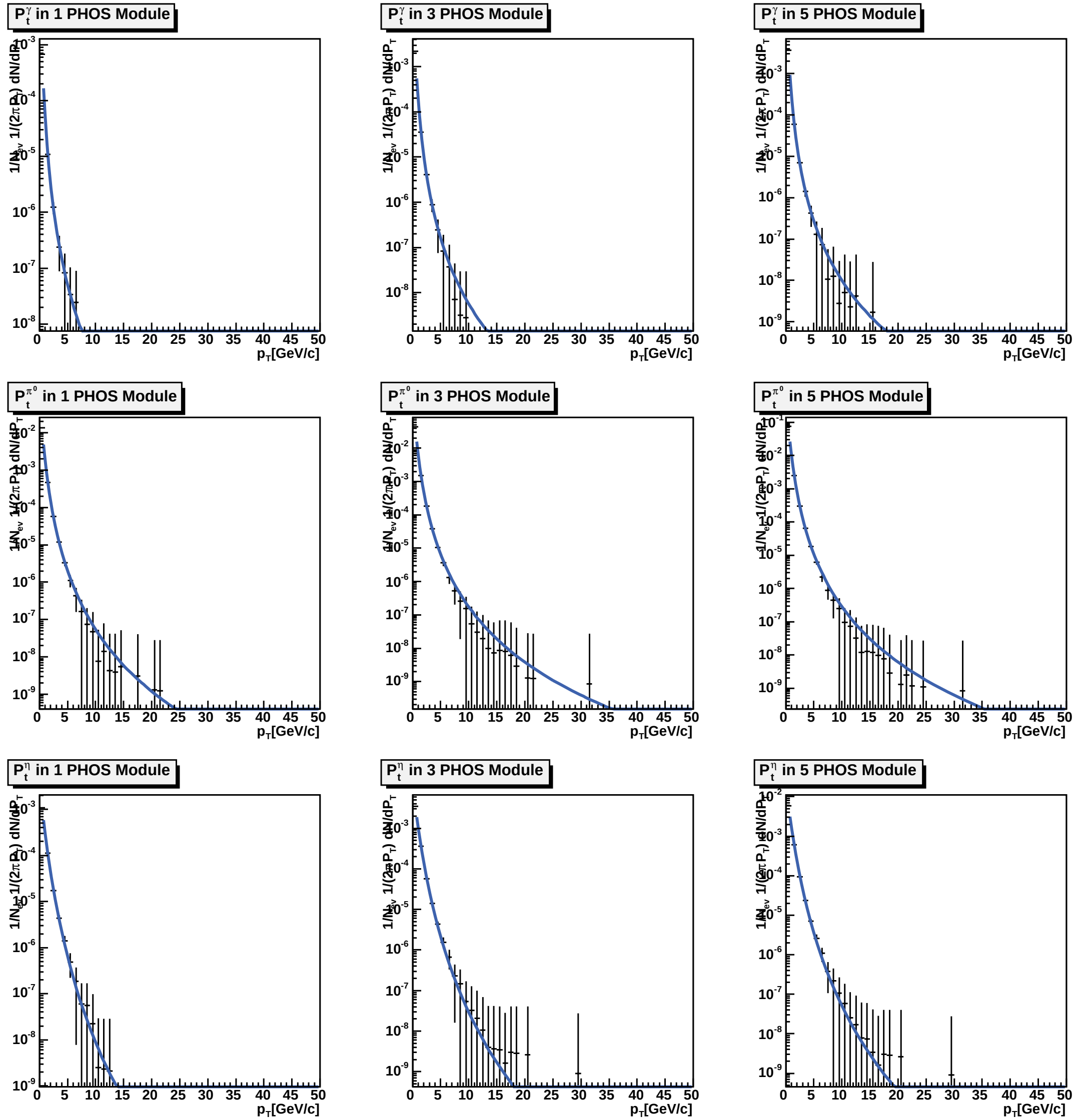
The talk allows 10% statistical error, then sample particles number N_{sample} is set to 100 which is sufficient to satisfy data analysis work. So the needed event number is calculated as follows:

$$N_{event} = \frac{N_{sample}}{N_{par} \times R_{eff}}.$$

Then, the trigger rate R_{trig} of PHOS was described by function:

$$R_{trig} = \frac{N_{event}}{t}$$

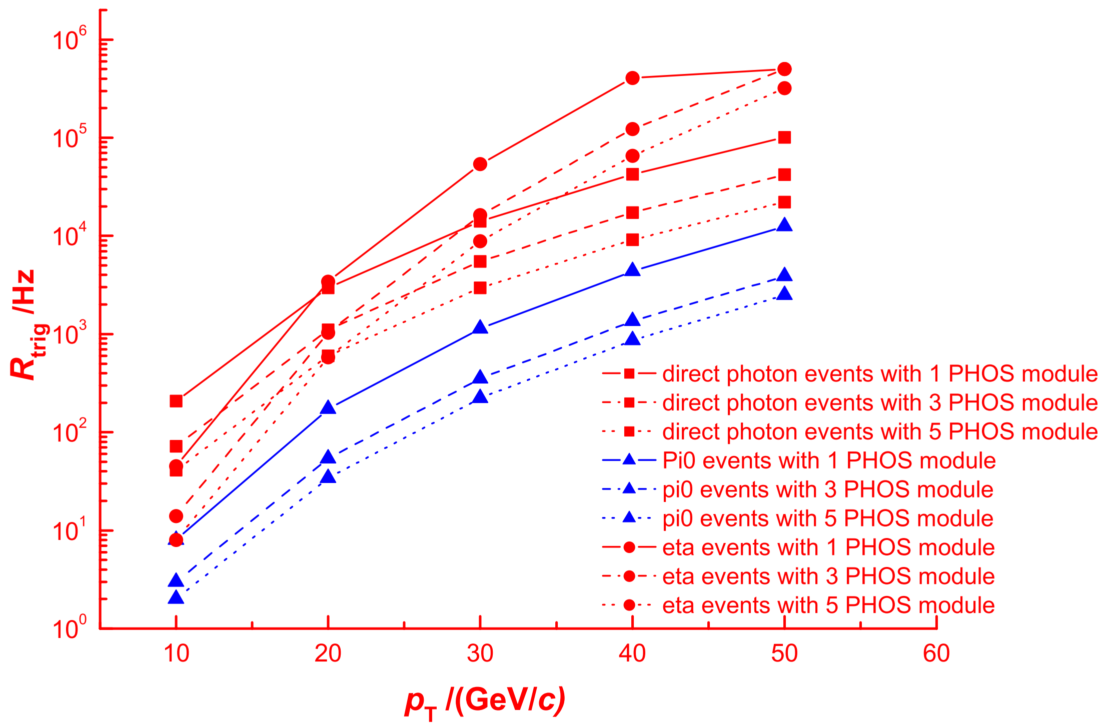
Where *t* means scheduled running time for each collision mode.

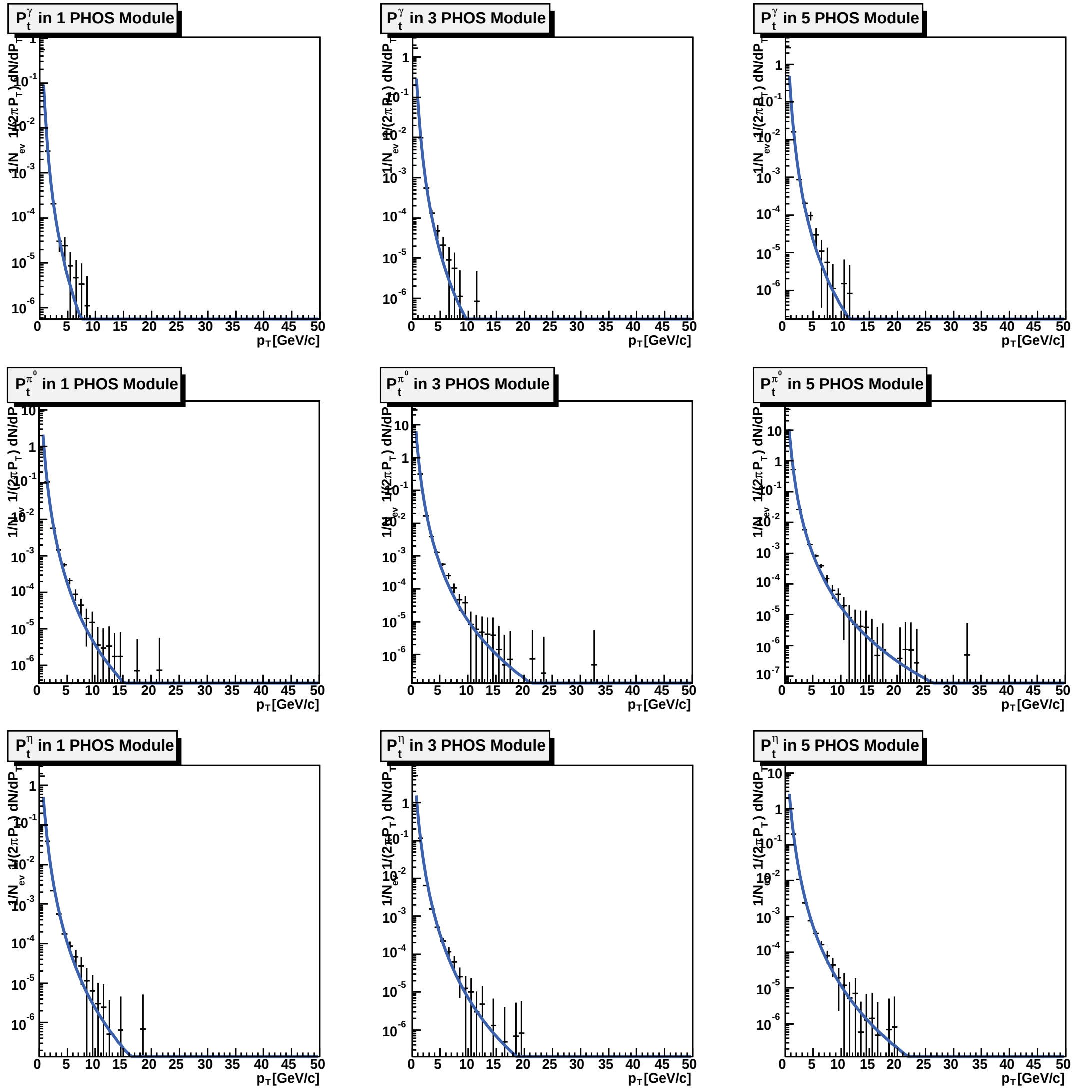


p_T spectrum at P-P collision mode with $\sqrt{s}$ = 14 TeV

Trigger rate of PHOS for P-P collision

- pp run: $\mathcal{L} = 5\times10^{30}\ cm^{-2}s^{-1}$, $\sqrt{s_{NN}}$=14 TeV, mini-bias events
  σ_{total}~0.1 b; Pythia6.2, 6×10^{6} pp collision events.

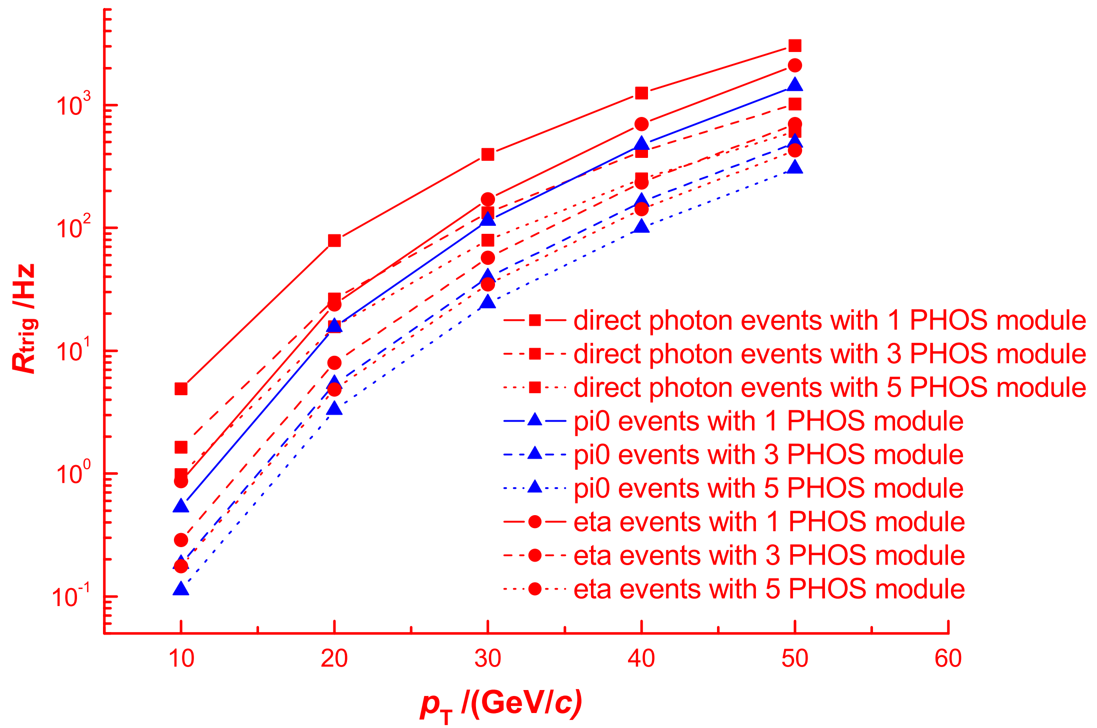




p_T spectrum at Pb-Pb collision mode with $\sqrt{s_{NN}}$ = 5.5 TeV

Trigger rate of PHOS for Pb-Pb collision

- **PbPb run: $\mathcal{L} = 5\times10^{26}$ cm^{-2}s^{-1}, $\sqrt{s_{NN}}$=5.5 TeV, σ_{total}~7.7 b; Hijing1.36, 1×10^5 PbPb collision events, impact parameters (0, 3 fm).**



Summary & Outlook

○ Summary of trigger decision criterion of PHOS

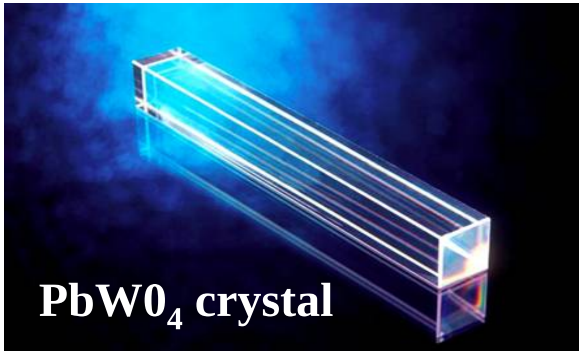
- with good performance of energy reconstruction in a broad transverse momentum range from 0.5 GeV/*c* to 100 GeV/*c*;
- trigger efficiency has a loss ~4% due to TRUs' boundaries, but adoption of TRU can ensure Level-0 trigger 300 ns decision latency and Level-1 trigger 5500 ns decision latency in FPGA after collision;
- trigger rate: 1) for direct photons was much higher than it for π^0 and η mesons, 2) PHOS could provide L0 trigger by itself to low p_T photon events and ALICE/CTP provide L0 trigger to high p_T photon events, 3) PHOS could provide L1 trigger by itself;

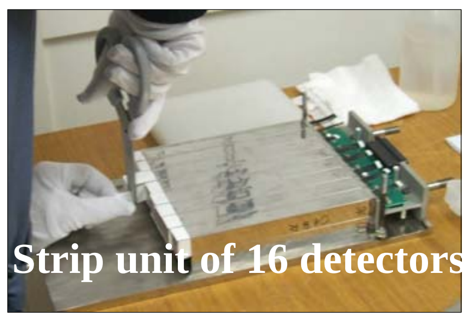
○ Outlook for the work

- lots of jobs on TRU need to do in FPGA programming (VHDL) for the ALICE/PHOS;
- lots of simulation jobs need to do for the physics in ALICE/PHOS.

Thanks!

Assembly of PHOS module





ALICE-PHOS FEE Cards
(Finished by Wuhan-Group)