Simulation of trigger in mass productions

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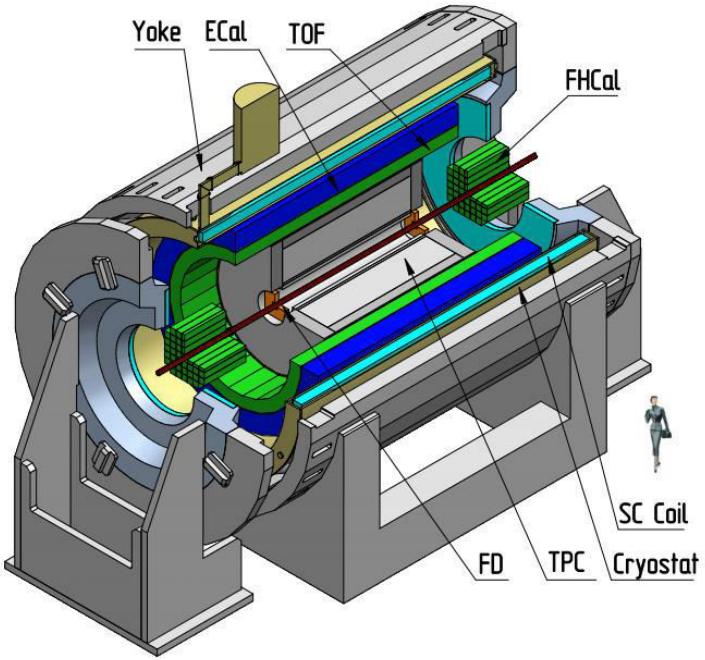
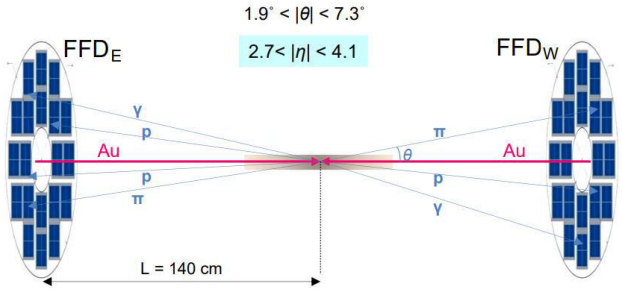
Trigger detectors at forward rapidity

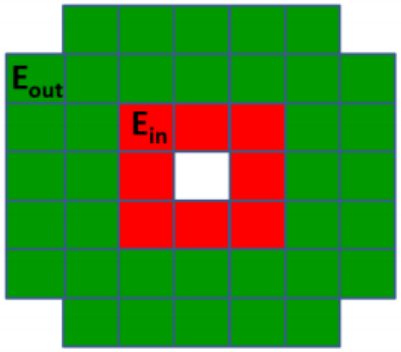


- FFD (Fast Forward Detector):
  - ✓ fast event triggering
  - ✓ T_0 for time measurements in the TOF and ECAL



- FHCAL (Forward Hadron Calorimeter):
  - ✓ potential for event triggering
  - ✓ poor T_0 and event vertex resolution

- MPD challenges at NICA energies:
  - ✓ low multiplicity of particles produced in heavy-ion collisions
  - ✓ particles are not ultra-relativistic (even the spectator protons)



$2 < |\eta| < 5$

~ 1x1 m^2

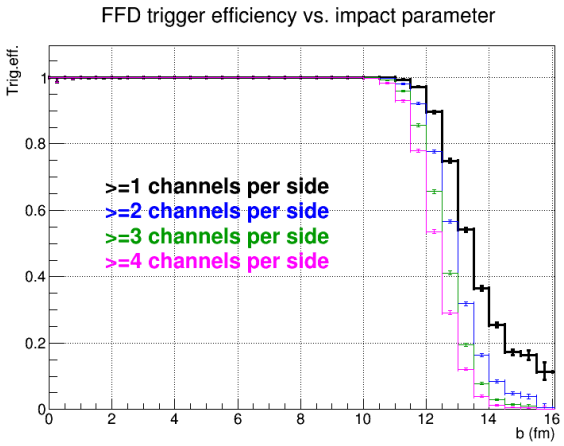
Simulation chain

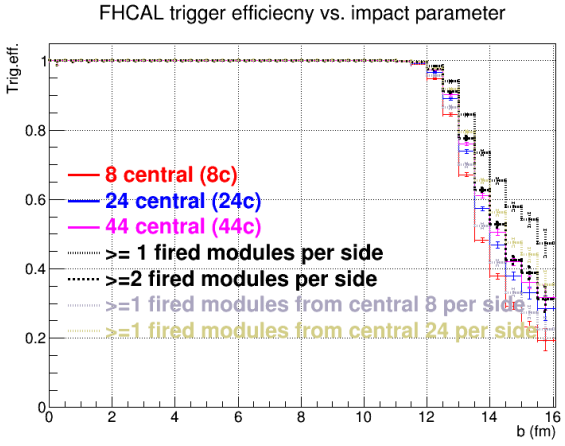
- Event generators: DCM-QGSM-SMM* (GSI version): Request 26 mass production
  - ✓ inelastic collisions (~0-16 fm), no empty events
  - ✓ realistic z-vertex with σ ~ 50 cm
- All detectors are simulated in the framework of the MpdRoot (Geant-4)
- FFD simulation :
  - ✓ default MpdRoot code
  - ✓ particle transport → showers in Pb converter → Cerenkov light generation in the quartz radiator
  - ✓ generation of photoelectrons in photocathode taking into account its quantum efficiency, loss of photons due to reflection and absorption (~ 50%), times of photoelectrons are simulated as arrival times of Cerenkov photons to the photocathode surface
  - ✓ channel is fired once number of collected photoelectrons exceeds a limit of ~1/3 mip
  - ✓ photoelectrons sorted by time are integrated to exceed the same threshold → time of the channel
  - ✓ times are additionally smeared by 40 ps to account for the effects of electronics, cabling etc.
- FHCAL simulation :
  - ✓ Default MpdRoot code
  - ✓ particle transport → showers in Pb tiles → simulation of light in scintillator tiles (dE/dx → photons) → simulation of total signal, times of photoelectrons are simulated taking into account the photon formation times and photon transport to the last scintillator tile in the module
  - ✓ channel is fired once total signal in the module exceeds a limit of ~1 mip
  - ✓ photoelectrons sorted by time are integrated to exceed the same threshold → time of the channel
  - ✓ times are additionally smeared by ~ 1 ns to match the measured resolution

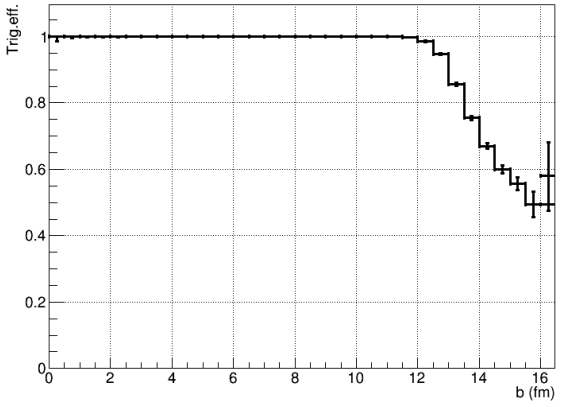
* Statistical Multifragmentation Model (**SMM**)

Trigger efficiency, BiBi@9.2

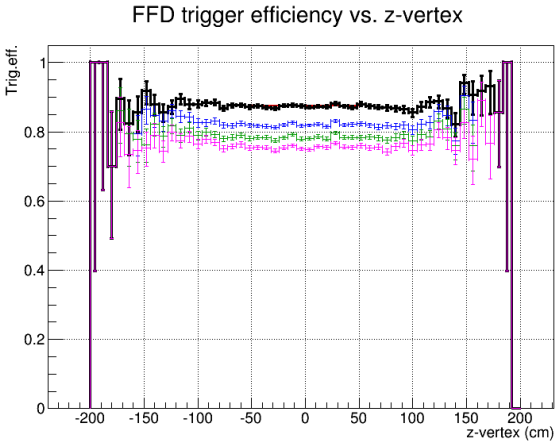
- Efficiency vs. impact parameter:

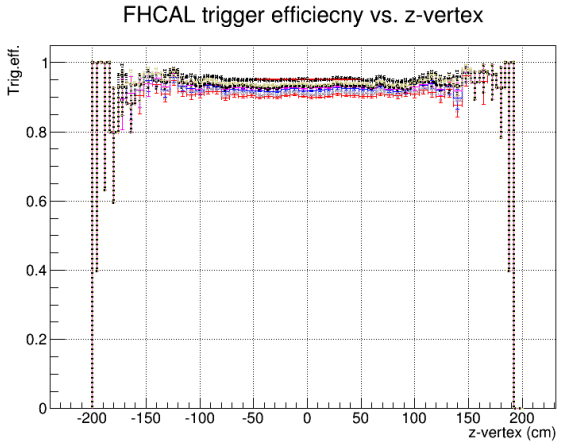


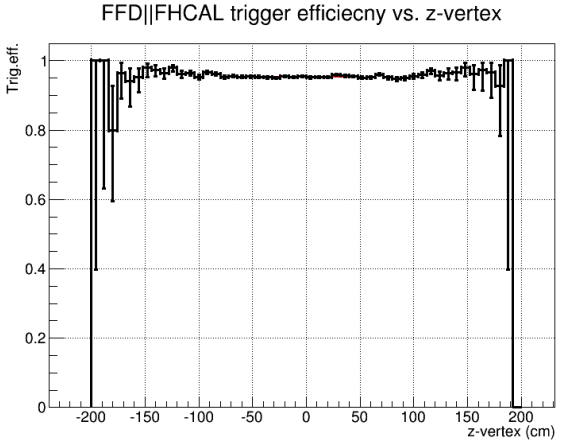




- Efficiency vs. event vertex (MC-generated) :



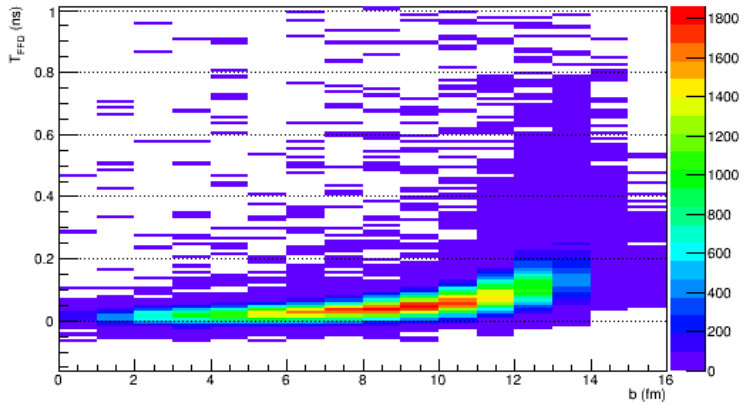


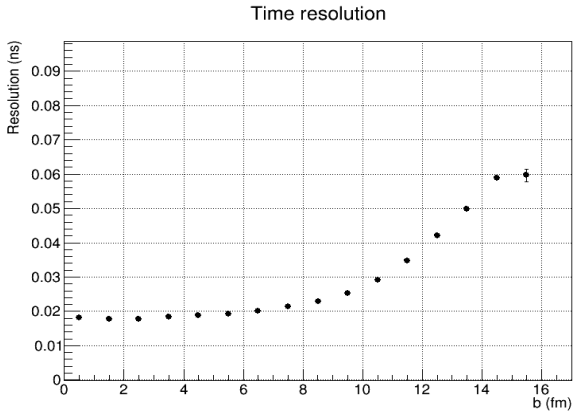


- FFD ~ 90%, FHCAL ~ 95%, FFD||FHCAL ~ 95%
- Flat efficiency vs. event z-vertex → potential to accept events with large values of z-vertex

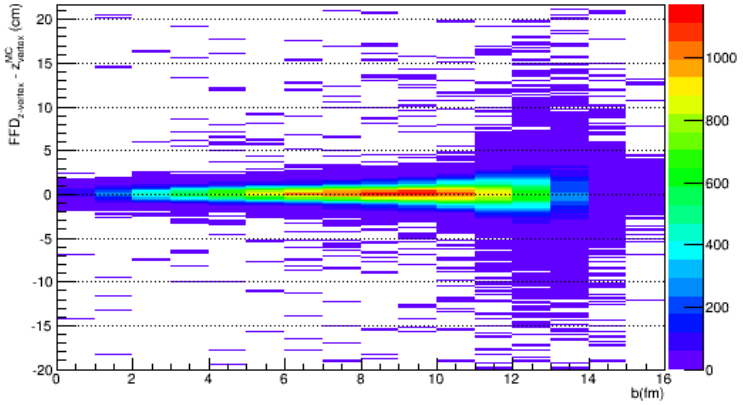
FFD resolution

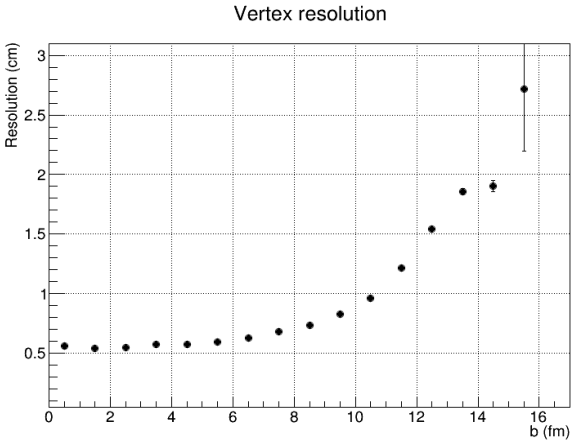
- T_0 resolution: $T_0 = (T_{FFDE} + T_{FFDW}) / 2 - L/c$
  - ✓ centrality bias
  - ✓ time resolution depends on centrality/multiplicity, <= 60 ps





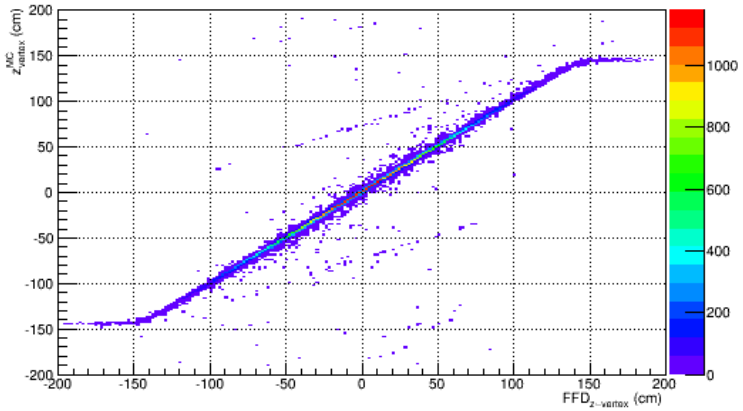
- Z-vertex resolution: $z\text{-vertex} = (T_{FFDW} - T_{FFDE}) / 2 * c$
  - ✓ no centrality bias
  - ✓ z-vertex resolution is worsens in peripheral collisions, 0.5-2 cm





FFD – Definition of trigger

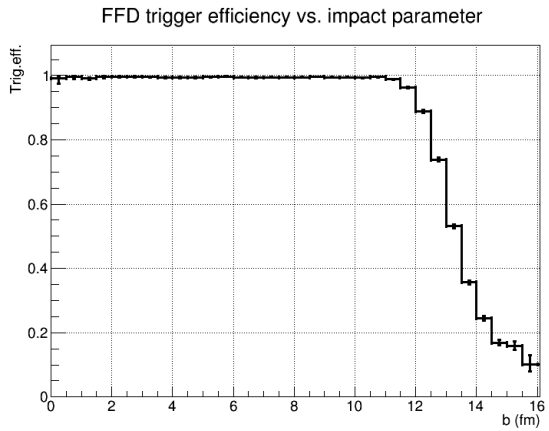
- FFD z-vertex vs. true z-vertex:

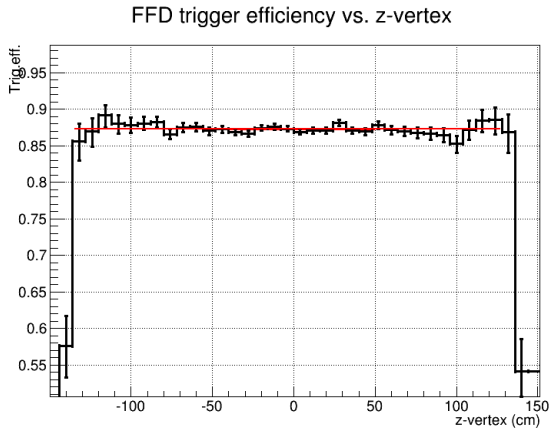


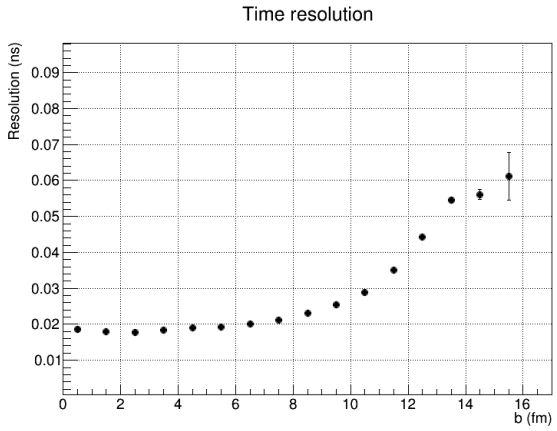
- FFD trigger definition:
  - ✓ at least one fired channel per side
  - ✓ meaningful times measured in the FFD-W and FFD-E , 0 < time $_{\text{FFD-E, FFD-W}}$ < 100 ns
  - ✓ reconstructed z-vertex, |z-vertex| < 140 cm

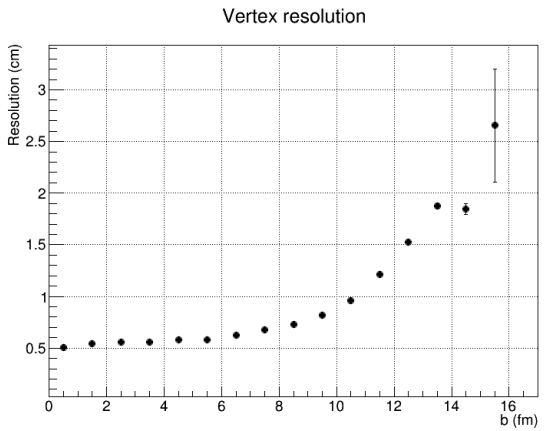
FFD trigger, summary

- FFD trigger definition:
  - ✓ at least one fired channel per side
  - ✓ meaningful times measured in the FFD-W and FFD-E , $0 < \text{time}_{E,W} < 100$ ns
  - ✓ reconstructed z-vertex, |z-vertex| < 140 cm





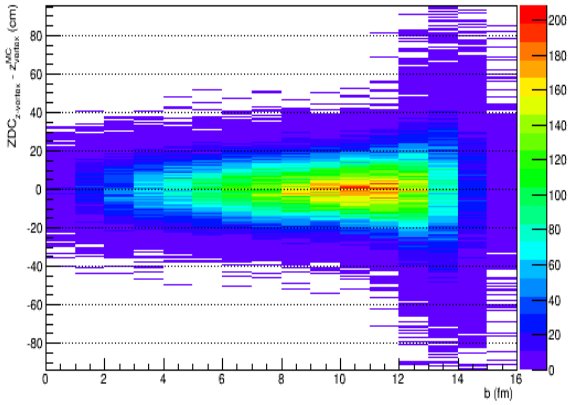


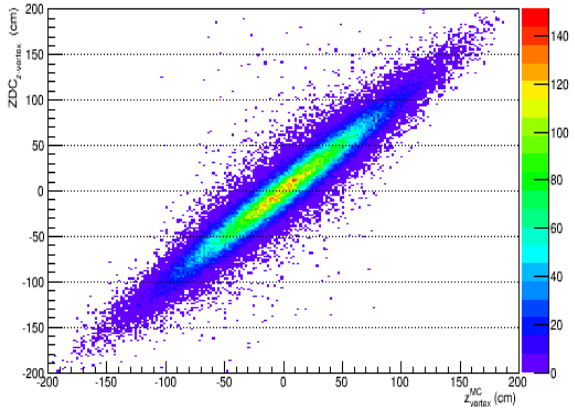


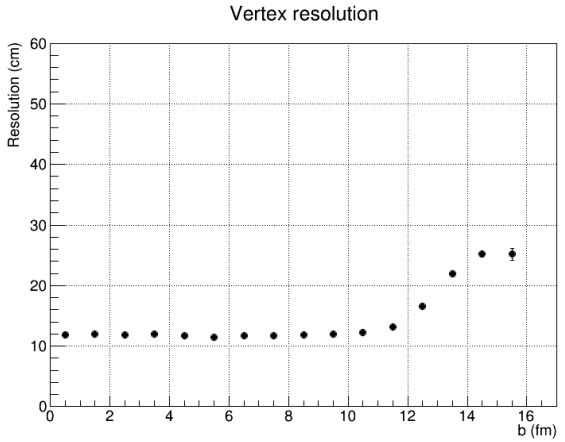
- FFD trigger efficiency – 87%

FHCAL resolution and trigger definition

- T_0 resolution:
  - ✓ meaningless with module resolution of ~ 1 ns → no PID possible (TOF T_0??? - unlikely)
- z-vertex resolution:
  - ✓ no bias, no limitations for z-vertex range
  - ✓ vertex resolution is very modest, worse in peripheral collisions, 10-30 cm cm



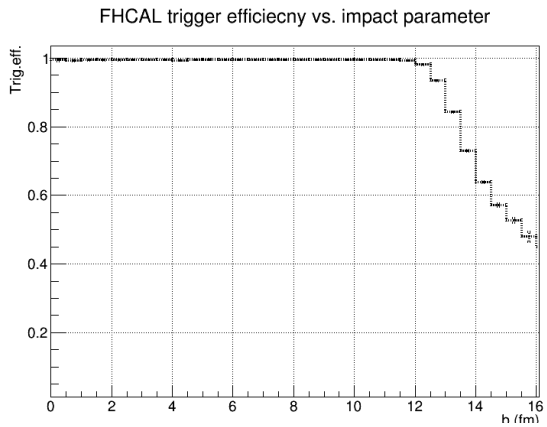


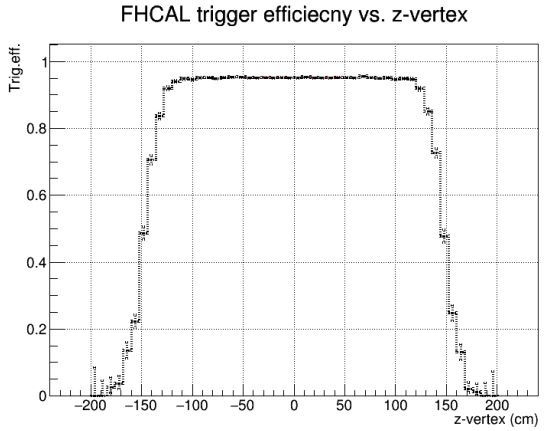


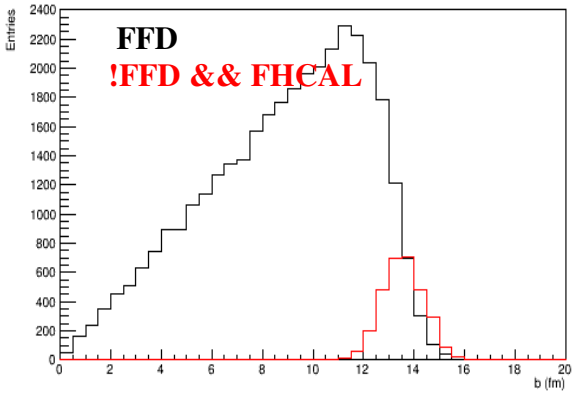
- FHCAL trigger definition:
  - ✓ at least one fired channel per side
  - ✓ meaningful times measured in the FHCAL-W and FHCAL-E , $0 < \text{time}_{E,W} < 100$ ns
  - ✓ reconstructed z-vertex, |z-vertex| < 150 cm

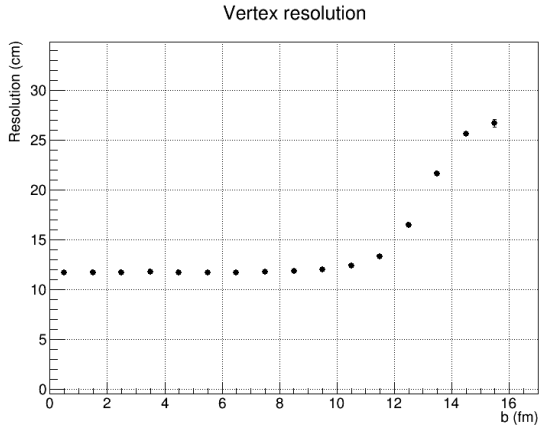
FHCAL trigger, summary

- FHCAL trigger definition:
  - ✓ at least one fired channel per side
  - ✓ meaningful times measured in the FHCAL-W and FHCAL-E , $0 < \text{time}_{E,W} < 100$ ns
  - ✓ reconstructed z-vertex, |z-vertex| < 150 cm









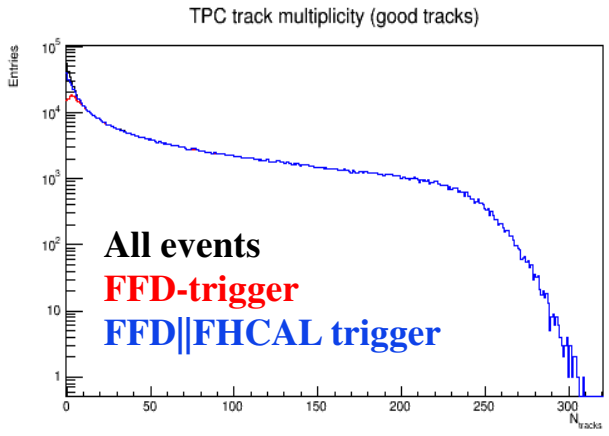
- FHCAL trigger efficiency – 95%

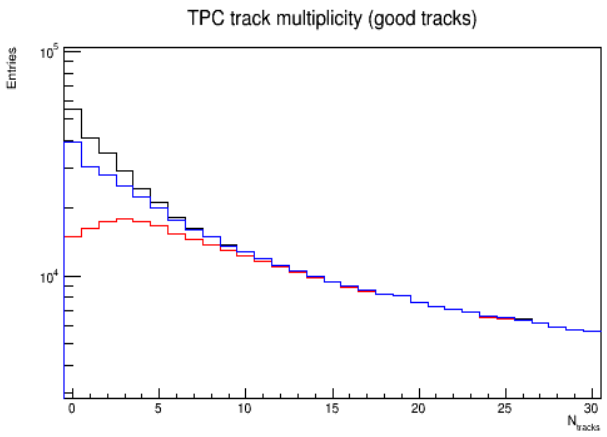
Summary for the trigger

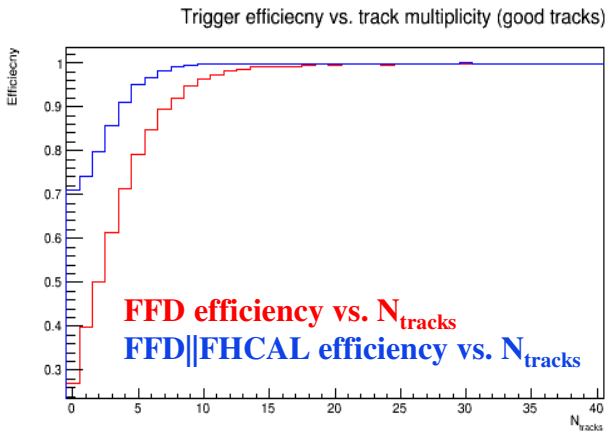
- Both, FFD and FHCAL triggers will be needed for data taking
- Extra efficiency for FHCAL trigger is for peripheral events (b > 12 fm)
- !FFD && FHCAL events won't have T_0 information for the TOF and ECAL
- Many uncertainties for the FFD trigger (exact configuration ???, details of realization ???)
- Possible outcomes for the mass productions:
  - ✓ ignore trigger in the simulations
  - ✓ simulate FFD trigger only
  - ✓ simulate FFD && FHCAL trigger

Implementation of FFD trigger

- Realistic simulation of FFD trigger is possible only with DCM-SMM, PHQMD, etc.
- Emulation of FFD trigger in UrQMD, PHQMD, etc. needs special event selections
- The easiest approach is to select/reject events by event track multiplicity
- Used the following definitions for a good track (subject to vary):
  - ✓ nHits > 10
  - ✓ DCA < 2 cm
  - ✓ |eta| < 0.5
  - ✓ p_T > 50 MeV/c

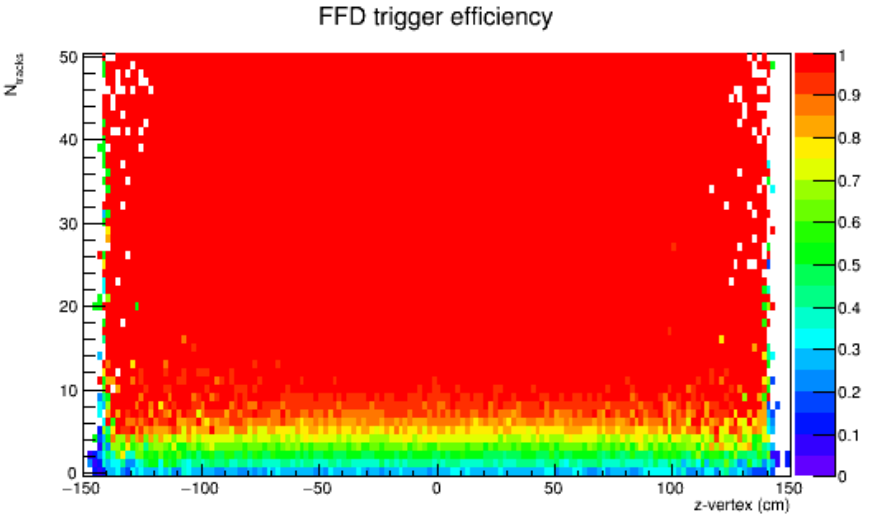


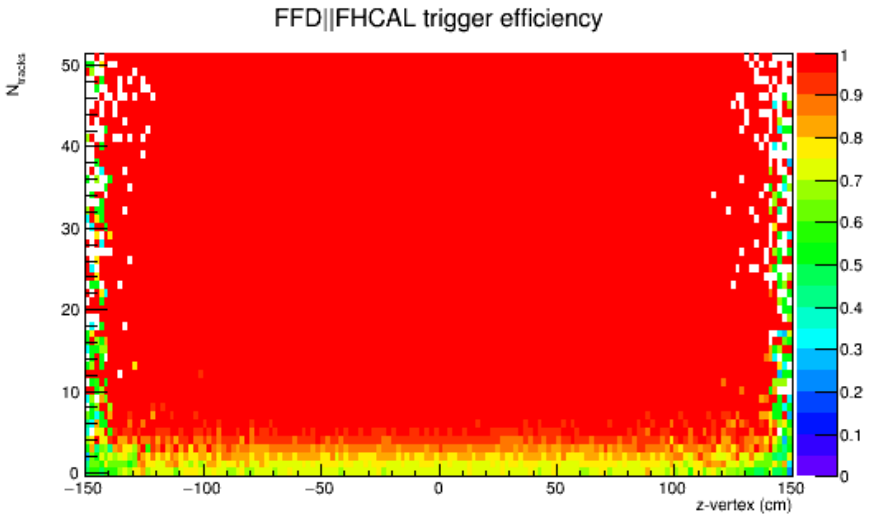




Z-vertex dependence of trigger efficiency

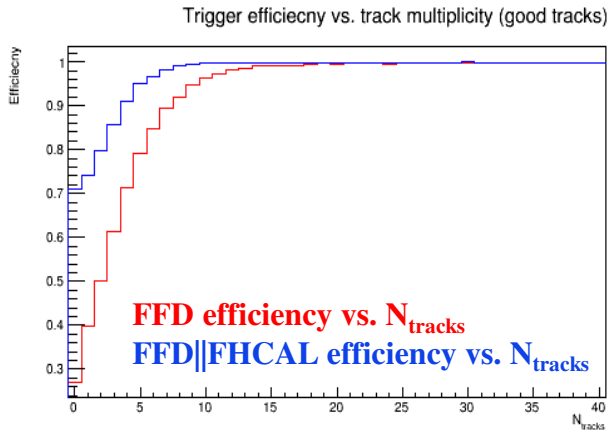
- Trigger track efficiency shows no z-vertex dependence: NONE





Emulation of trigger

- Proposed procedure:
  - ✓ Wagon #1 in the train: 1) counts number of good tracks (N_{tracks}) in the event; 2) reject event using N_{tracks}-dependent probabilities from slide 11



  - ✓ Wagon #2 for centrality categorization deals with the selected events only and provides centrality classes taking into account the limited trigger efficiency

- Such an approach will teach us how to deal with a triggered data sample → preparation for real data analysis
- In order not to overcomplicate things, the proposal is to work with FFD||FHCAL trigger with efficiency of ~ 95% only and to ignore the fact that !FFD&&FHCAL events do not have T_0 information
- Alternative would be to work with FFD events only with efficiency of ~ 87%