Electromagnetic processes and trigger system (Fixed-target mode)

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Electromagnetic dissociation

EMD

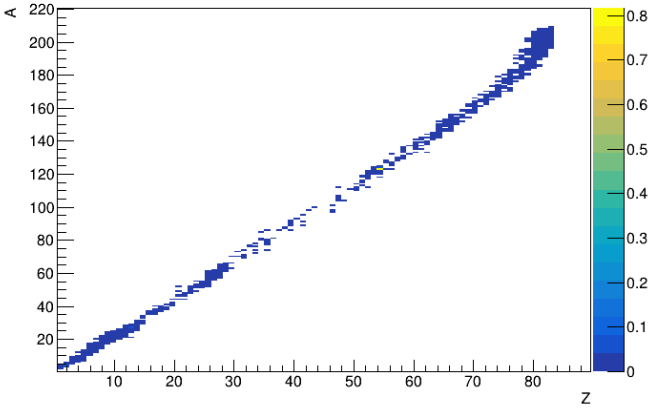
- EMD: Electromagnetic dissociation of nuclei in the beam:
  - ✓ absorption of photons with emission of several neutrons, protons (mostly one) and other particles
  - ✓ new nucleus is produced after emission which gets lost from the beam (wrong A/Z ratio)

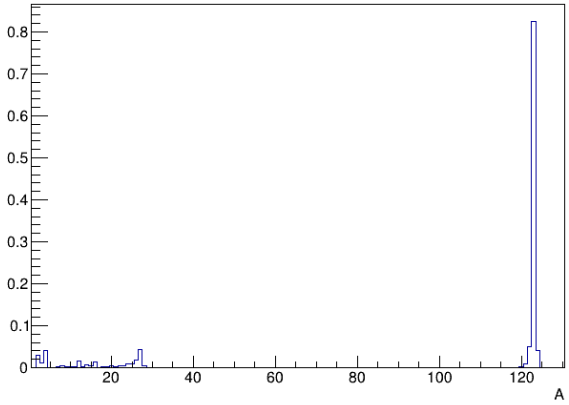
- Main consequences of EMD:
  - ✓ MPD: emitted particles may fire the MPD trigger system and contaminate hadronic events
  - ✓ NICA: reduced beam lifetime
  - ✓ General: contamination/heating of construction materials and magnets

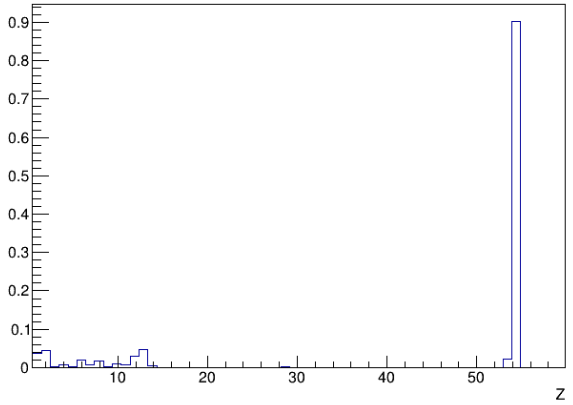
- How relevant/often? :
  - ✓ Collider mode, BiBi@7 GeV:
    σ_{had} ~ 7 b, $\boldsymbol{\sigma_{EMD}^{single}}$ ~ 24 b (<n> ~ 1.382, <p> ~ 0.046), $\boldsymbol{\sigma_{EMD}^{mutual}}$ ~ 2 b
  - ✓ Fix-target mode, Xe+W (T = 2.5 A·GeV):
    σ_{had} ~ 5.7 b, $\boldsymbol{\sigma_{EMD}^{single}}$ ~ 2.58 b (<n> ~ 1.038, <p> ~ 0.0269)

- Cross sections are large:
  - ✓ EMD is a way more important for beam losses than hadronic interactions
  - ✓ EMD events may fire the trigger:
    <u>collider mode</u>: two simultaneous single EMD events or mutual EMD event for forward detectors or any EMD event for the TOF
    <u>fixed-target</u>: any EMD event

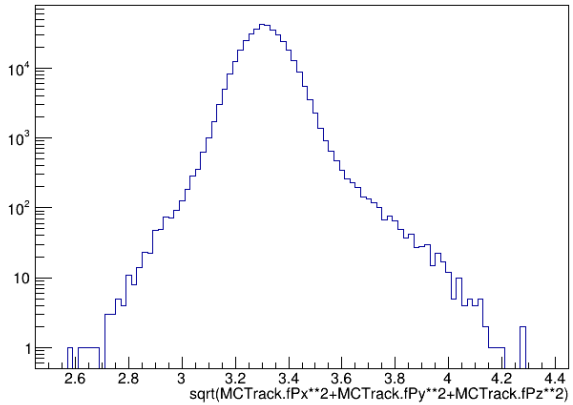
EMD events by RELDIS (Xe + W)



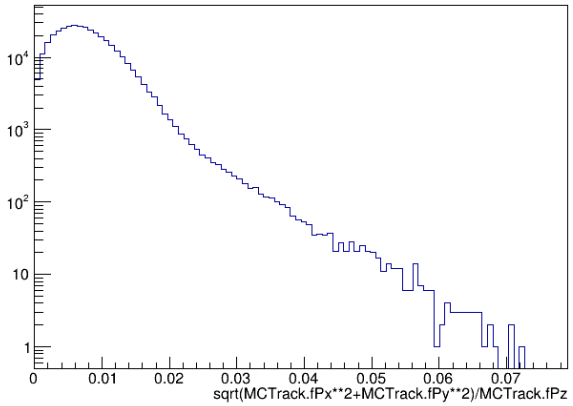




energy of produced neutrons



p_T/p_Z for neutrons



- Quite monochromatic neutron beam is produced with E ~ 3.3 MeV
- At a distance L neutron beam shifts from the central line by ~ L * p_T/p_z → scrapes inner part of FHCAL at (85+300-500) cm from the FXT interaction point
- FFD and TOF can be fired by secondary particles mostly

Single EMD events: FXT configuration

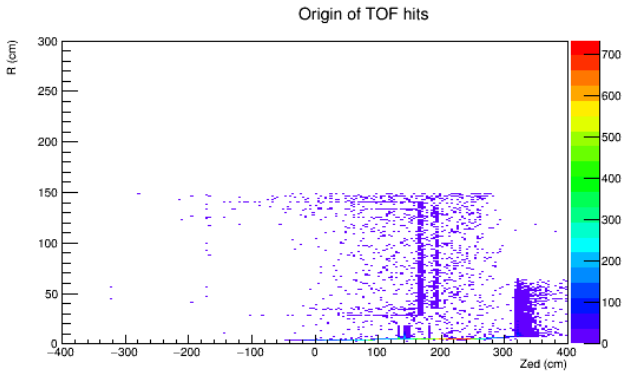
- 1 M events processed with standard MpdRoot selections (σ_{vertex} = -85 cm) and trigger tunes
- Standard collider mode trigger configuration: East detectors must fire (West is ignored)

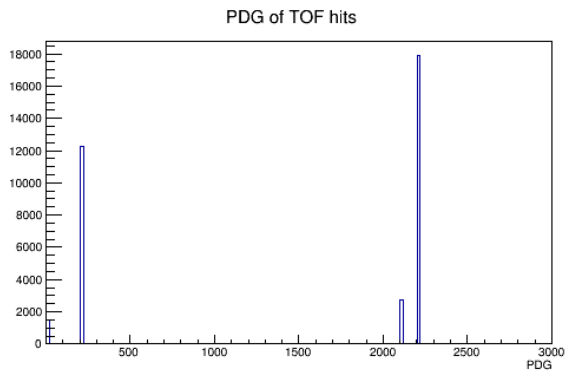
FFD: 0.0147594 0.00230625 0.000816667 0.000297917
FHCAL: 0.0957146
TOF: 0.0211604 0.00528125 0.0012125 0.000215625

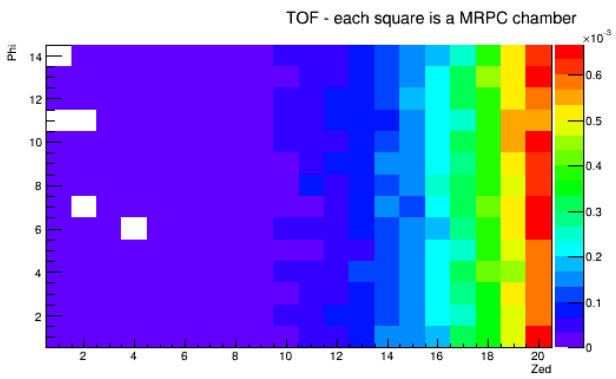
- Rather large background from single EMD events with effective cross section of up to:
  - ✓ 0.04 b (FFD) – 1% of hadronic events
  - ✓ 0.25 b (FHCAL) – 5.4% of hadronic events
  - ✓ 0.05 b (TOF) – 1.2% of hadronic events
- Efficiency of TOF and FFD to EMD events can be significantly reduced by requiring a larger number of fired channels (in expense of lower trigger efficiency for hadronic interactions)
- Efficiency of FHCAL fired by forward neutrons spraying the detector is stable vs. acceptance selections
- EMD events are characterized by rather low track multiplicity at central rapidity → will not pass centrality characterization by track multiplicity → safe for most of foreseen analyses
- However a significant part of FHCAL-triggered peripheral hadronic collision will have irreducible admixture of EMD events

Single EMD events: TOF

- Closer look at TOF:







- What if we mask MRPC chambers at large |zed| for trigger decision:
  - ✓ 1-20 MRPC: 0.0211604 0.00528125 0.0012125 0.000215625
  - ✓ 3-18 MRPC: 0.013074 0.00215937 0.000371875 5.625e-005
  - ✓ 4-17 MRPC: 0.0097625 0.00139479 0.000223958 3.95833e-005

- TOF trigger efficiency for EMD events is reduced by a factor of ~ 2, but still remains quite noticeable

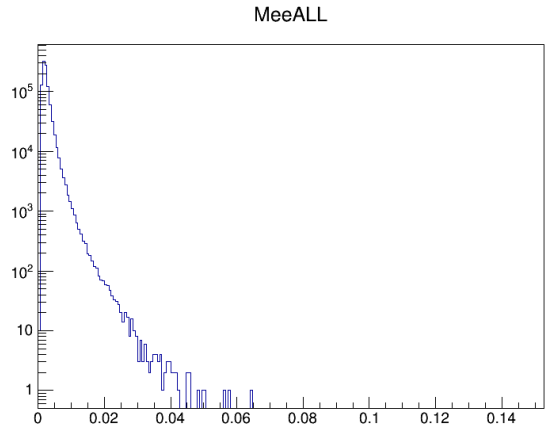
Conclusions for EMD

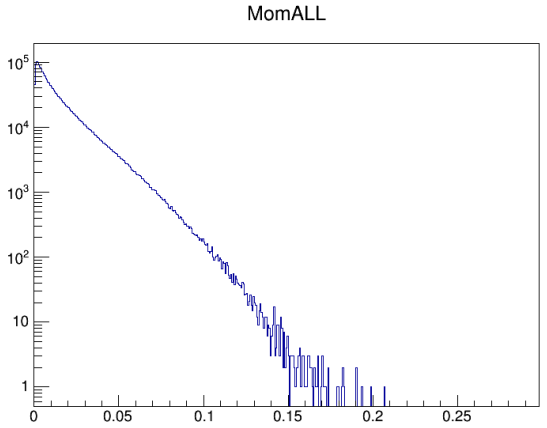
- EMD processes play a noticeable role for the NICA and MPD
- EMD processes play comparable role for beam losses as hadronic interactions
- EMD processes will contaminate peripheral events, FHCAL trigger is most affected
- EMD processes will not drive logic of online trigger, EMC events will constitute ~ 5 percent of recorded events → not a big loss for DAQ bandwidth
- However, analysis of peripheral hadronic events will require extra efforts to make sure that selected events are not contaminated by EMD processes → very peripheral collisions beyond 90% will not be accessible for physics.

$\gamma\gamma \rightarrow e^+e^-$

Photoproduction

- Photoproduction of dielectron pairs
- Widely studied in Ultra-Peripheral Collisions (UPC) at RHIC and LHC:
  - ✓ cross section – hundreds of kilobarns
  - ✓ requires dedicated trigger (low multiplicity at central rapidity, zero forward activity)
- Photoproduction will happen in A+A at NICA energies as well → produced leptons may fire the trigger system
- Order-of-magnitude estimations for photoproduction of e^+e^- pairs were obtained using Starlight event generator, results kindly provided by E. Kryshen and N. Burmasov – THANKS!!!
- Xe + W, T = 2.5 GeV, 1M events, σ ~ 4900 b, M_{ee} ans p_T of produced pairs and electrons:





- Pushed 1M events of γγ→ee through MpdRoot with standard settings for the trigger system

Single EMD events: East only

- 1 M events processed with standard MpdRoot selections (σ_{vertex} = -85 cm) and trigger tunes
- Standard FXT trigger configuration: East detectors must fire (West is ignored)

FFD: 0.190043 0.083921 0.031097 0.009338
FHCAL: 0.136123
TOF: 0.000121 1e-006 0 0

- All trigger detectors are sensitive to photoproduction with effective cross section of up to:
  - ✓ 882 b (FFD) – x 155 of hadronic events
  - ✓ 640 b (FHCAL) – x110 of hadronic events
  - ✓ 0.6 b (TOF) – x 0.1 of hadronic events

- How reliable are the estimations ???

- Can we do something to reduce efficiency to photoproduced electrons?
  - ✓ TOF: increase number of fired MRPCs: 0.6 b (1 MRPC) → < 0.005 b (2 MRPCs)
  - ✓ Larger number of FFD channels → not a solution
  - ✓ Different FHCAL acceptance → not a solution
  - ✓ FFD && FHCAL → efficiency of 7% → not a solution

Conclusions

- Photoproduction processes have huge cross sections but characterized by very low multiplicity (~ 2 tracks)
- Forward detectors are heavily affected and pickup photoproduction events
- TOF trigger with number of fired MRPCs >=2 is mostly blind to photoproduction

BACKUP