# Update on GEANT3 and GEANT4 comparison

by

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**Acknowledgement**:

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# Objectives

- Comparison of background with UrQMD event generator and with two different transport engine (GEANT3 & GEANT4)
  Link: https://indico.gsi.de/event/10935/ (PWG meeting on 10.07.2020)
  https://indico.gsi.de/event/11015/ (PWG meeting on 31.07.2020)

- To understand the secondary pion production with GEANT3 and GEANT4 (Different physics lists) in MuCh absorber materials (Carbon, Concrete, Iron)

- Since the di-muon background is mostly contaminated by the decay of pions, that is why it is important to understand properly the secondary pion production using GEANT3 and GEANT4.

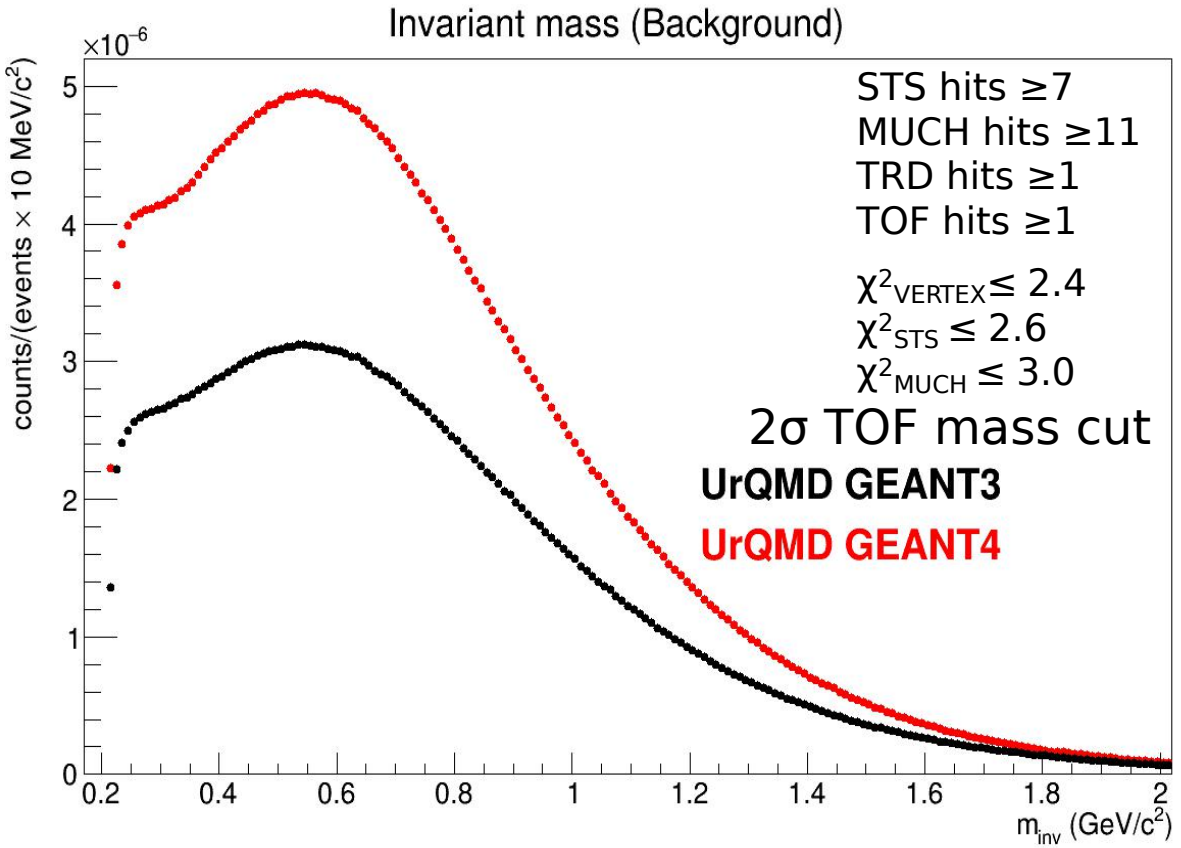
- The pions, which are born from pions are rejected. If particle scatters in material, it changes its momentum, and GEANT (MC) will produce a new particle with the same pdg, but with other momentum.

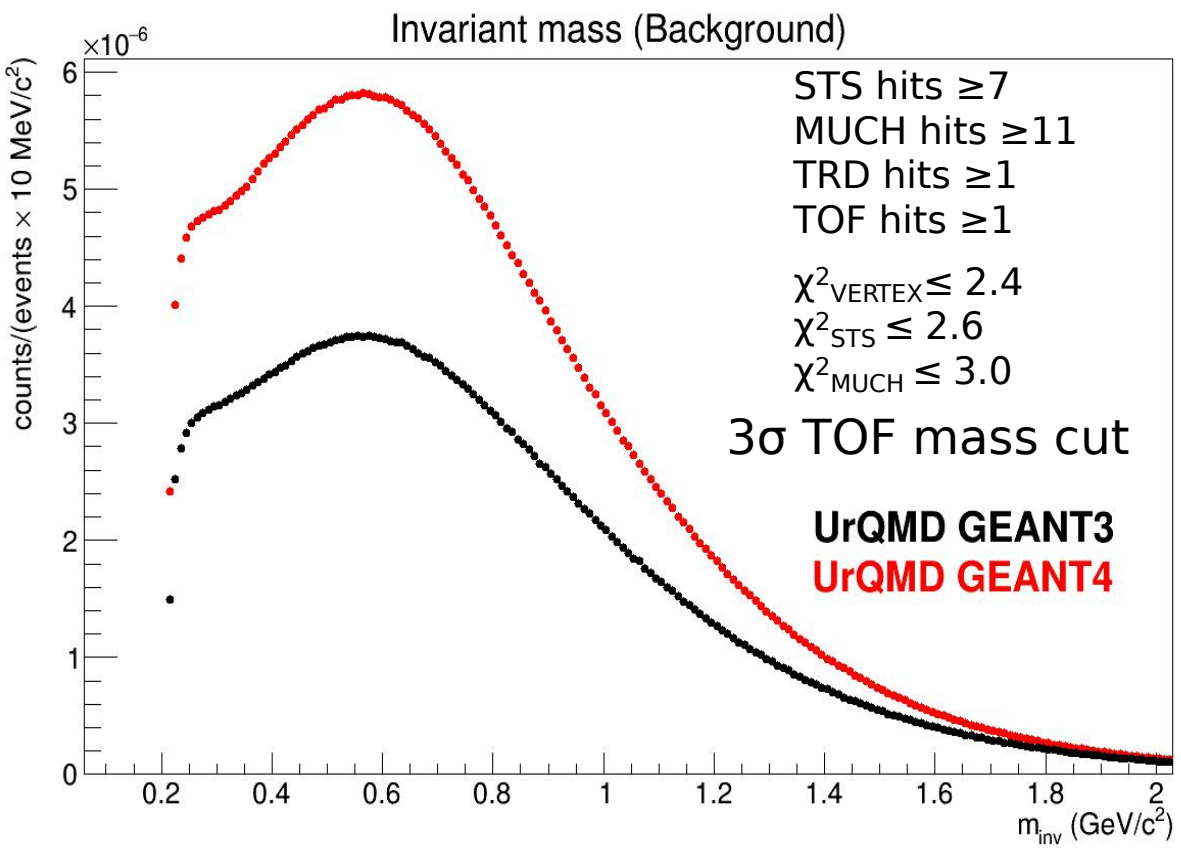
- Different materials of MuCh absorber is selected using the StartZ position of the secondary pions.

- All the results are based on MC information (Transport file).

# INVM background comparison

**Event generator : UrQMD**
**Transport engine : GEANT3/GEANT4**



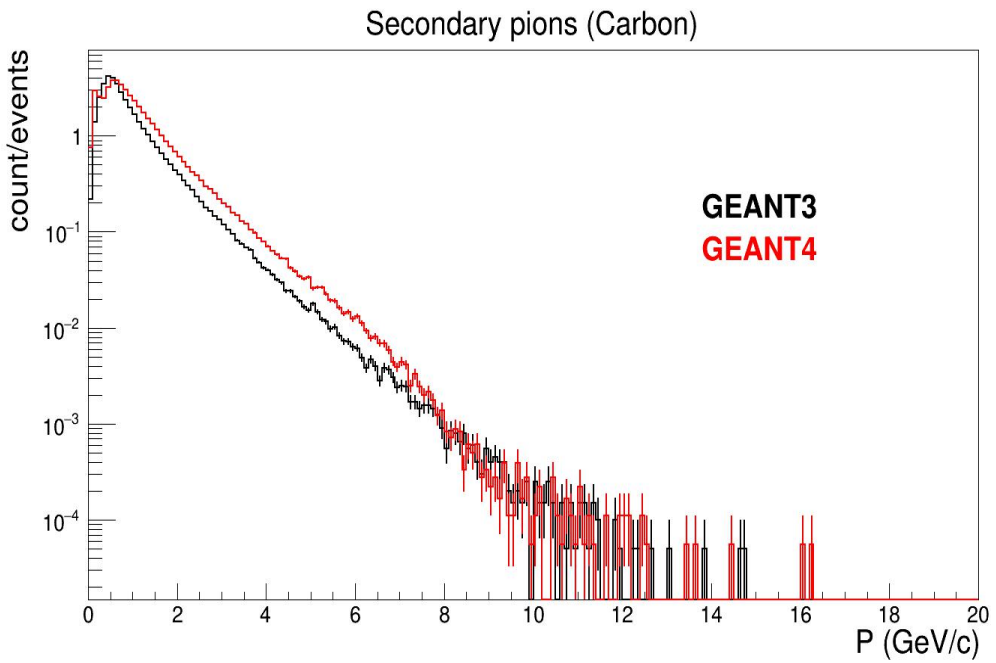



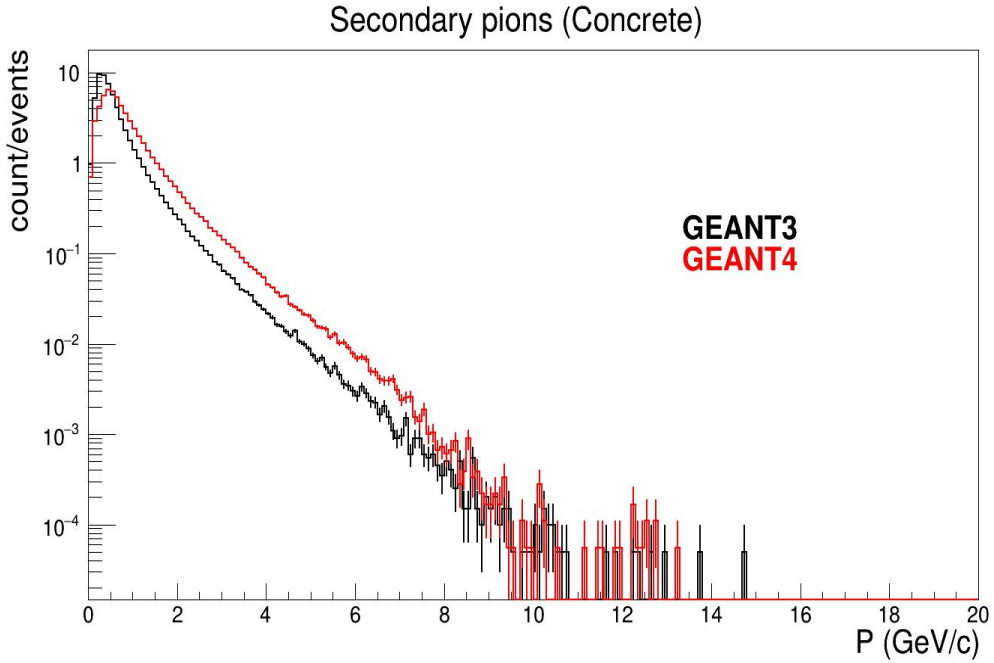

**Conclusion**: Background is more with GEANT4 transport engine as compared to GEANT3.

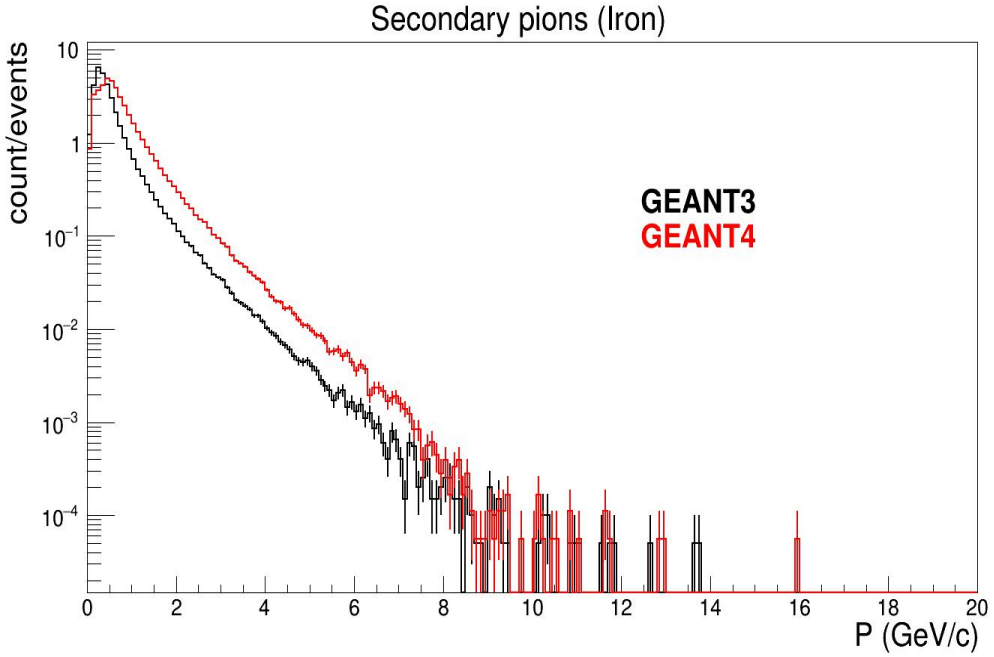
Files used: /lustre/cbm/users/anna/APR20/macro/much/data/sis100_muon_lmvm/12gev_urqmd/0_10/GEANT4/
/lustre/cbm/users/anna/APR20/macro/much/data/sis100_muon_lmvm/12gev_urqmd/0_10/GEANT3/

**Ref: https://indico.gsi.de/event/10935/**

# Momentum distribution of secondary pions




**NOTE** : Secondary pions are selected from the MCtracks using the condition |MCpdg| =211 and GetGeantProcessId != kPPrimary.

**Conclusion**: Momentum distribution of secondary pions are significantly different in GEANT4 as compared to GEANT3 .

## Different Physics List of GEANT4

- Hadronic Component:
  - QGSP_BERT (Default)
    - All standard Electro Magnetic (EM) processes
    - Uses Britini-style cascade up to 9.9 GeV
    - QGS model for high energies (>~18 GeV)
    - FTF in between energies
    - Used by ATLAS & CMS
  - QGSP_BIC
    - Same as QGSP_BERT, but Bertini cascade is replaced by Binary cascade and G4Precompound model
  - FTFP_BERT
    - Recommended by GEANT4 for HEP
    - Uses Bertini-style cascade for hadrons < 5 GeV
    - Uses FTF (Fritiof) model for high energies (> 4 GeV)
  - ……

**"QGS"** => Quark Gluon String model (> ~15 GeV)

**"FTF"** => FRITIOF String model (> ~5 GeV)

**"BIC"** => Binary Cascade model (< ~10 GeV)

**"BERT"**=>Bertini Cascade model (< ~10 GeV)

**"P"** => G4Precompound model used for de-excitation

*Default in the GEANT4 settings

## Different Physics List of GEANT4

- Electromagnetic Component:
    - EMV (Default)
        - less precise, but faster set of electromagnetic physics is used
    - EMY
        - It uses a set of EM processes with accurate simulation of gamma and charged particle transport. (Recommended for medical and space science applications)
    - EMZ
        - The best set of electromagnetic physics models selected from the low energy and standard packages
        - Slow compared to EMV and EMY
    - ……

**NOTE : The default Physics List in APR20 is QGSP_BERT_EMV, but the GEANT4 mannual is recommending FTFP_BERT for HEP!**



*Default in the GEANT4 settings

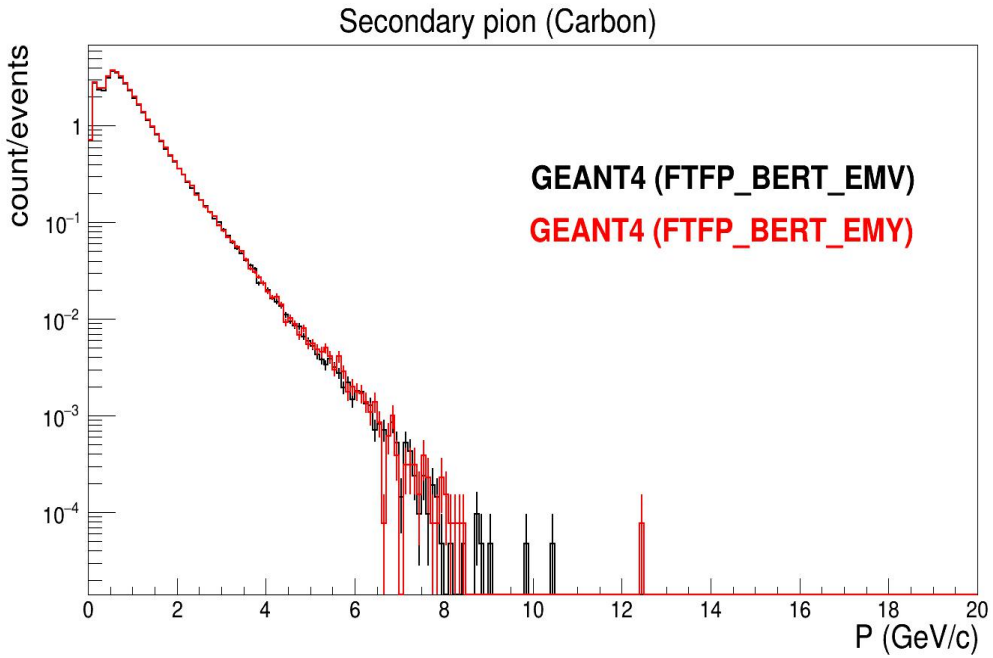
## Different Physics List of GEANT4

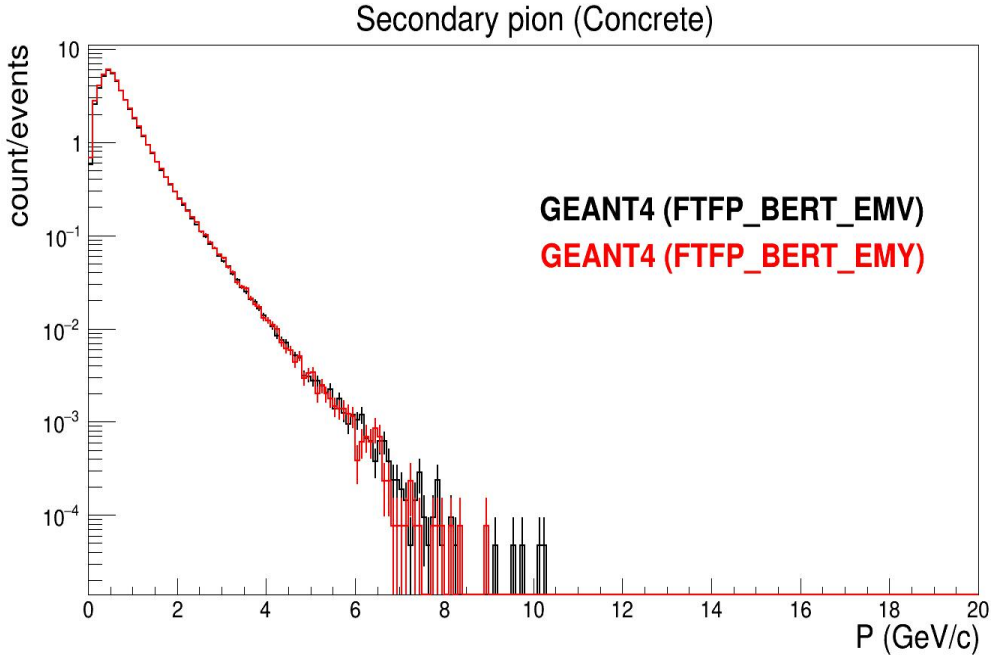
- Different physics lists are checked with GEANT4 for secondary pion production in MuCh absorber materials
  - QGSP_BERT_EMV (Default)
  - QGSP_BERT_EMY
  - QGSP_BIC_EMV
  - QGSP_BIC_EMY
  - FTFP_BERT_EMV
  - FTFP_BERT_EMY

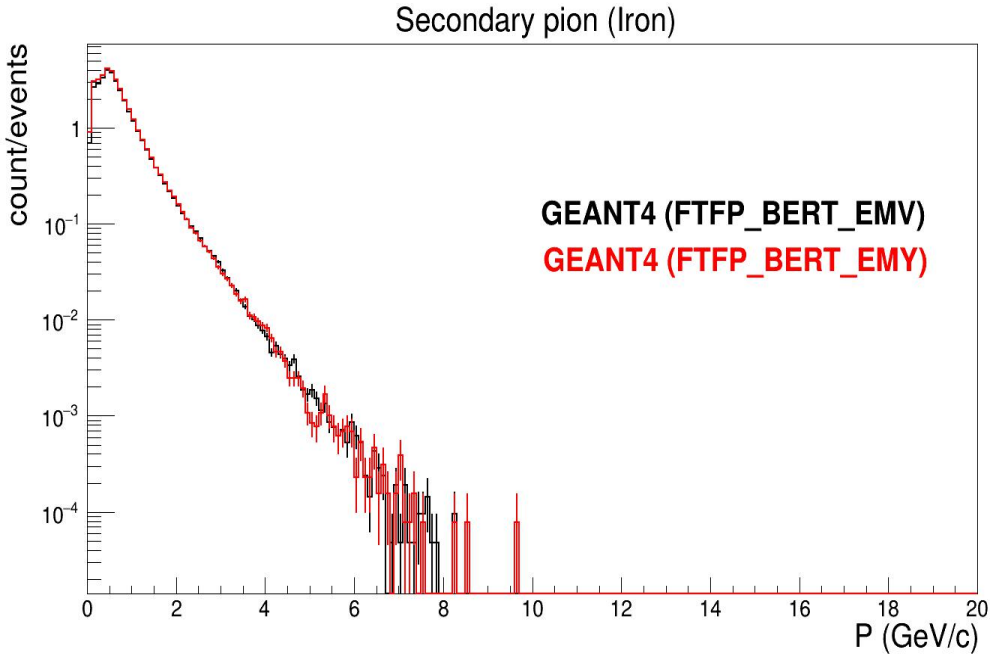
- System : Au+Au @8 AGeV/c (central)
- Events : Total number of events processed is 20k
- Setup : sis100_muon_lmvm
- CBMROOT : APR20 release

**NOTE : The use of EMY settings, increases the execution time by ~10%.**

System: Au+Au; Collision : Central; Beam Energy: 8 AGeV

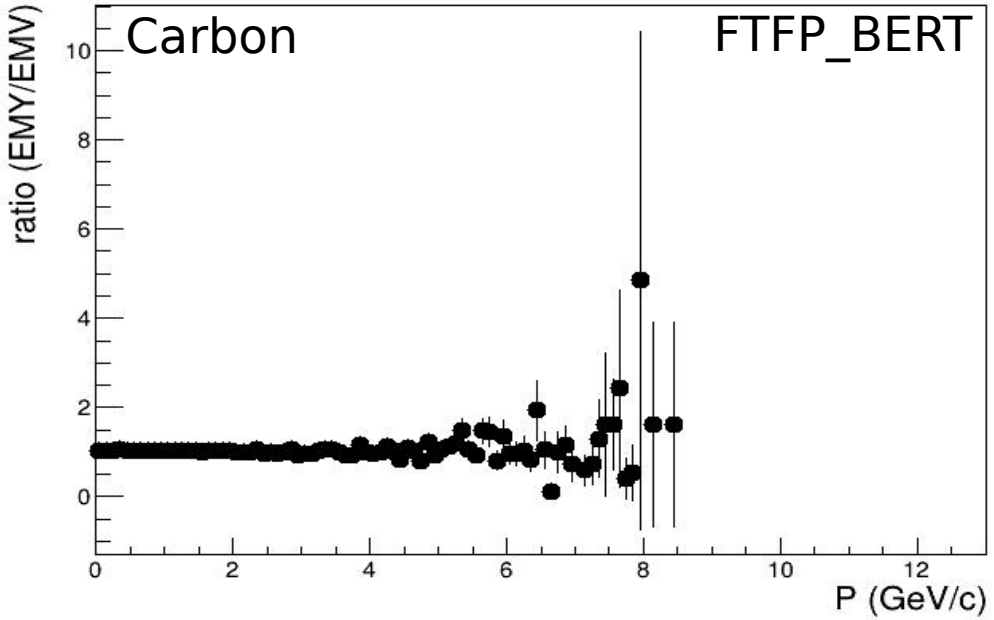


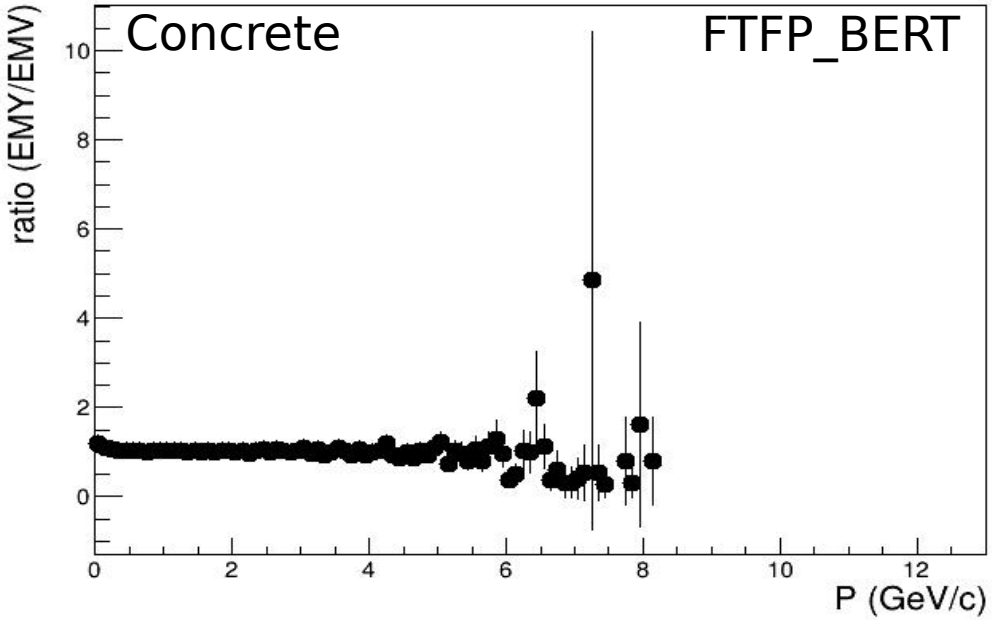



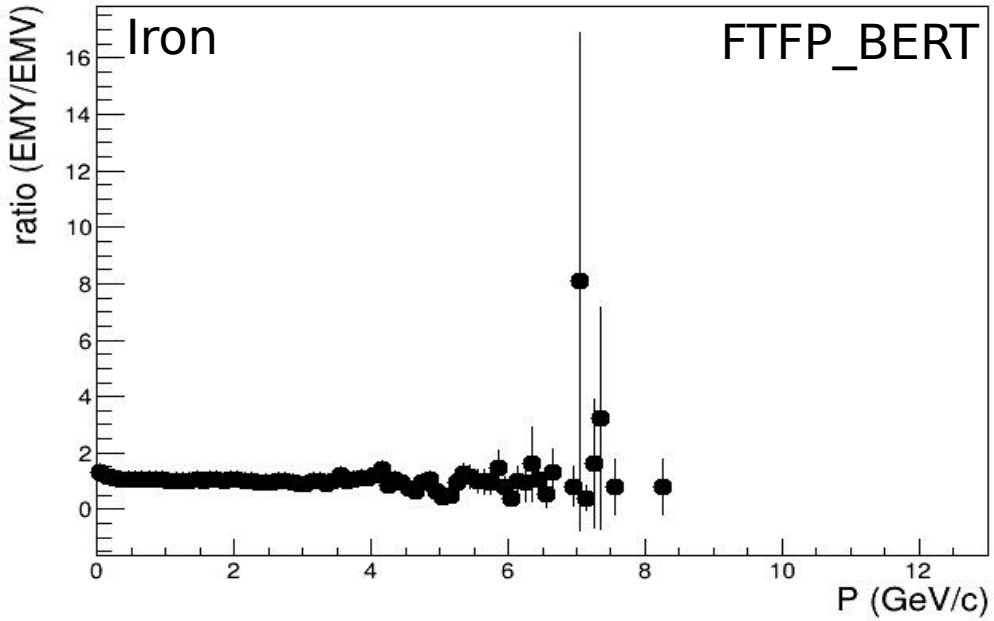




**NOTE** : No significant changes are observed with different electromagnetic components of GEANT4 settings

System: Au+Au; Collision : Central; Beam Energy: 8 AGeV

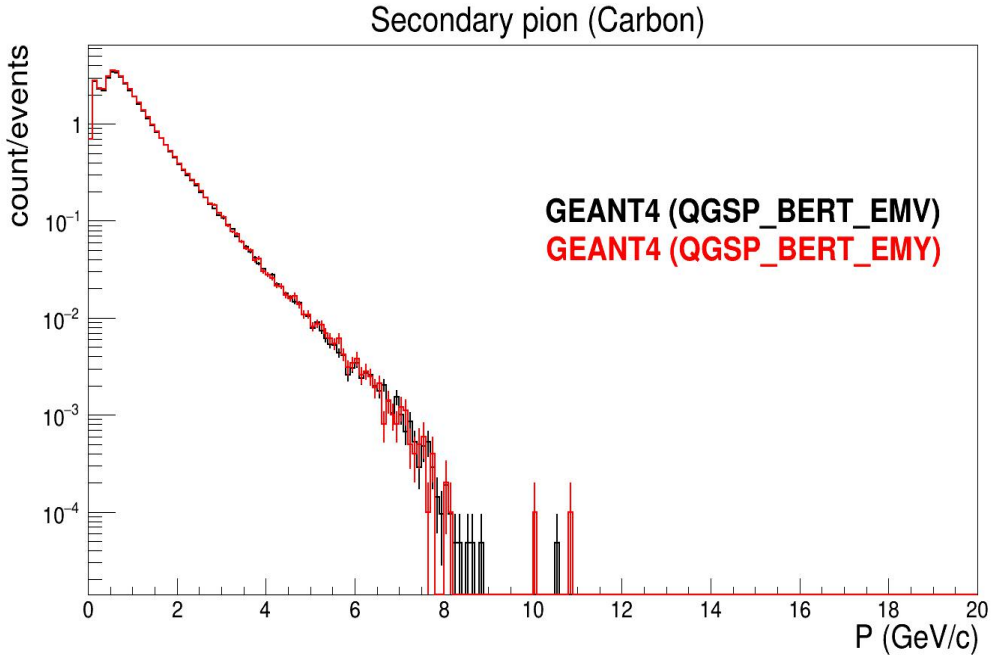


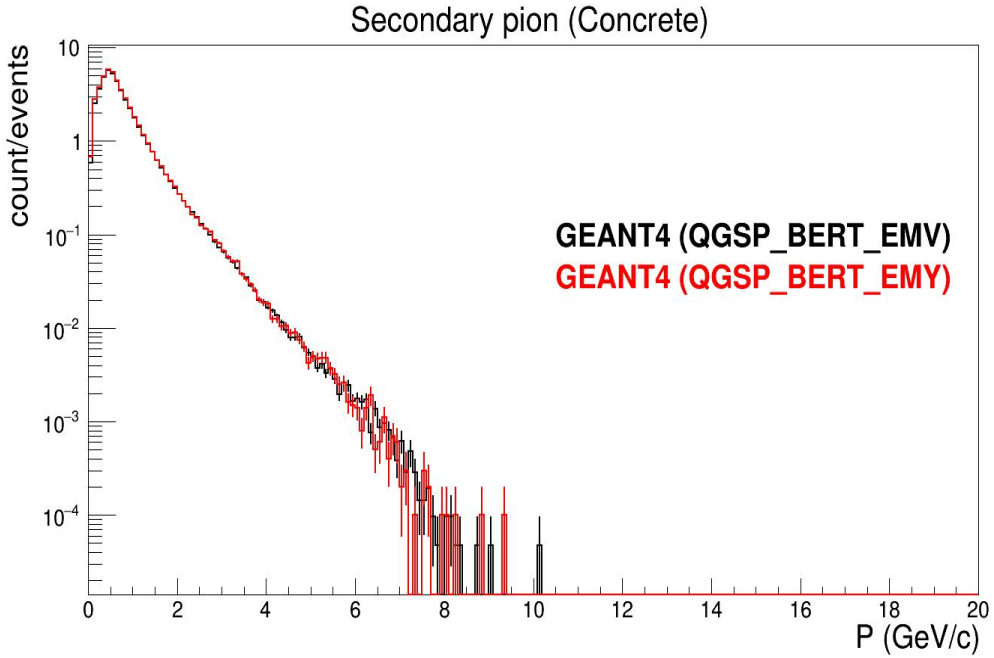



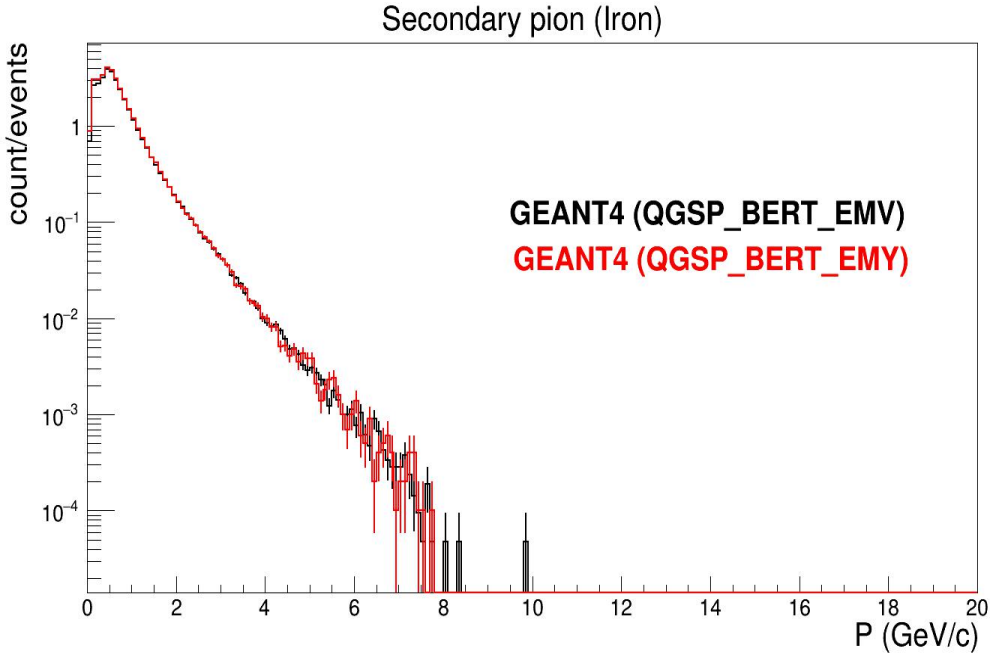




**NOTE** : Small increase of the ratio (EMY/EMV) in the low momentum region is observed.

# System: Au+Au; Collision : Central; Beam Energy: 8 AGeV

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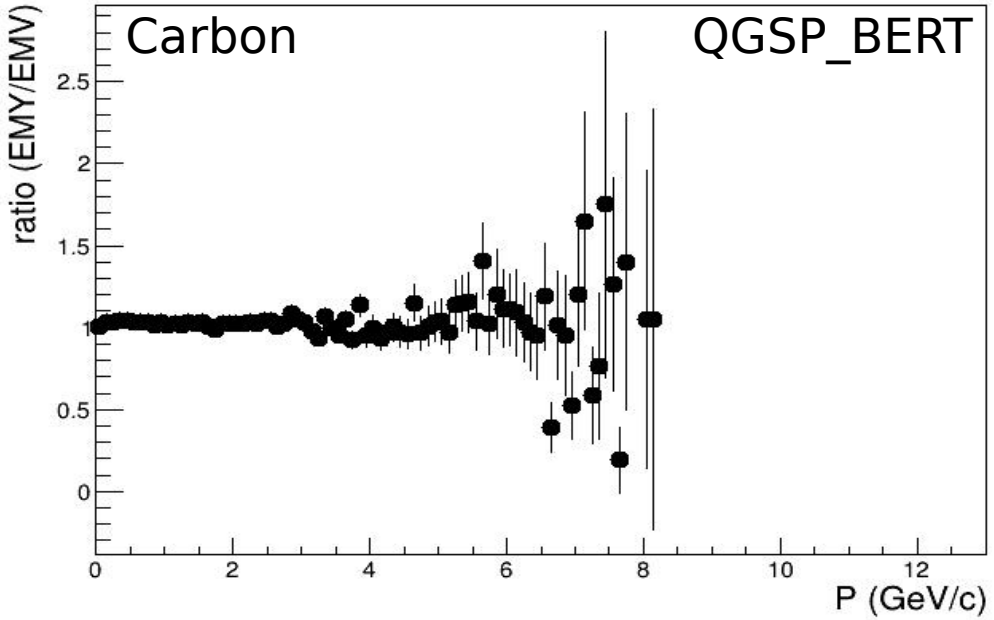


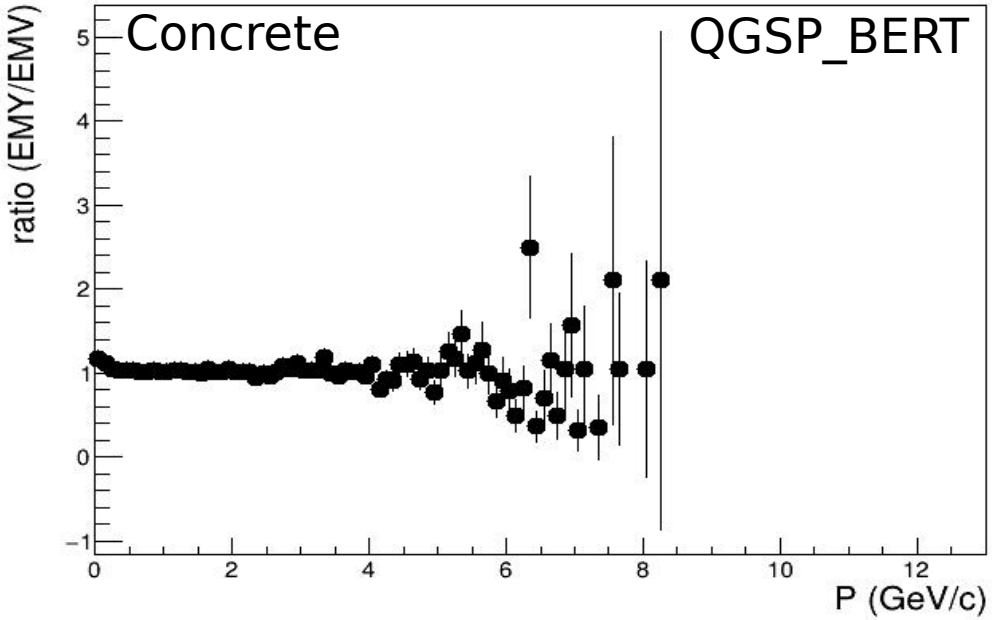


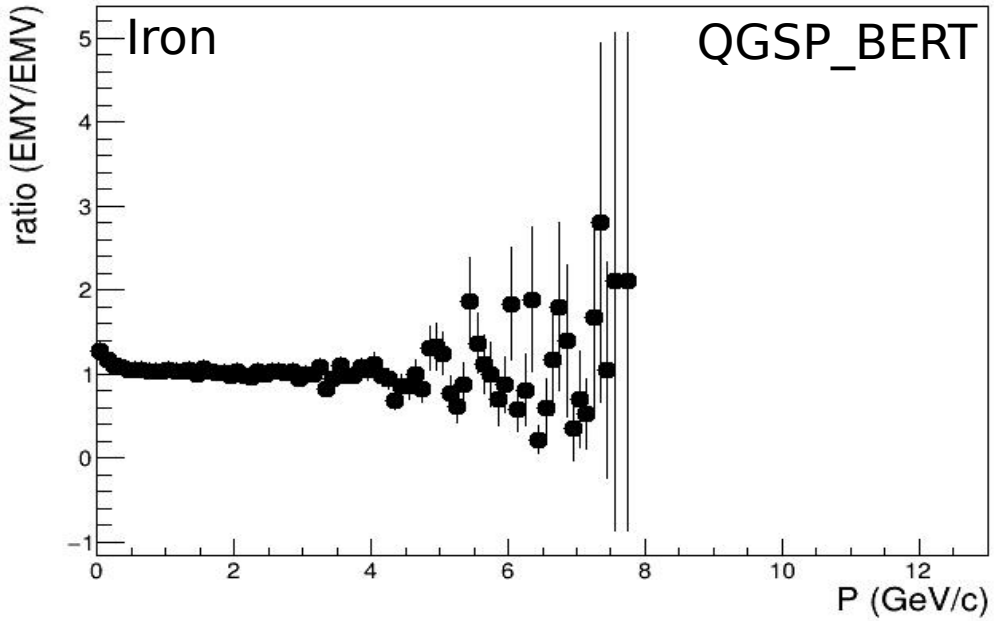


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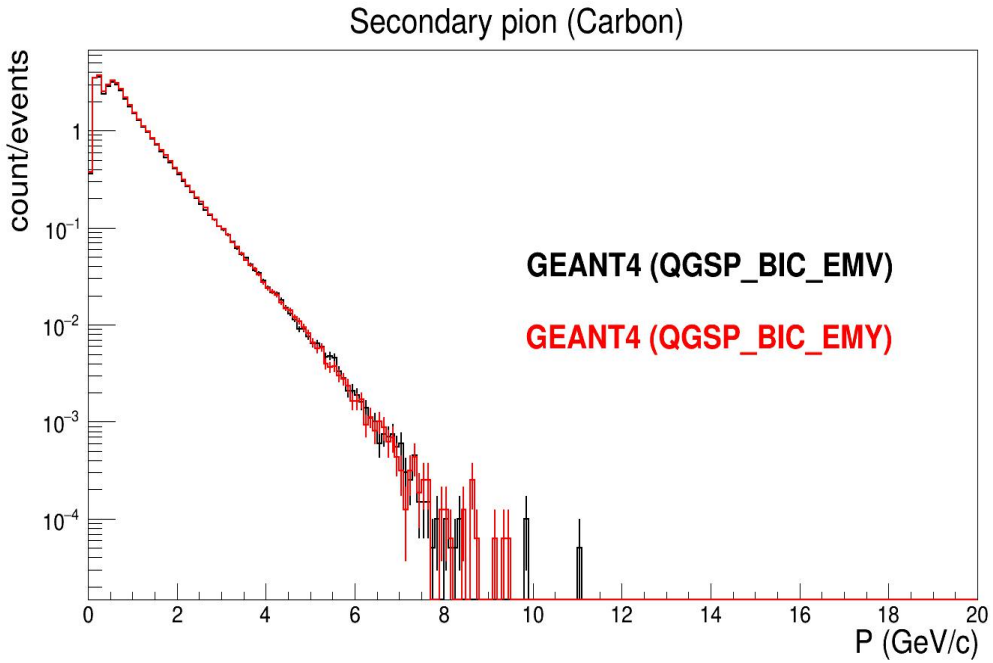


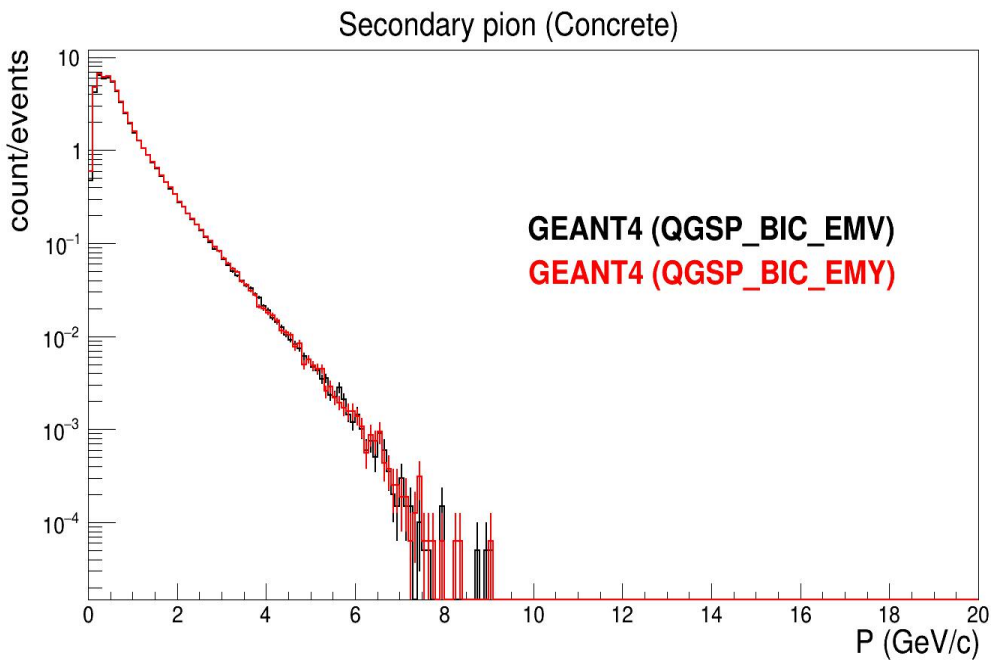


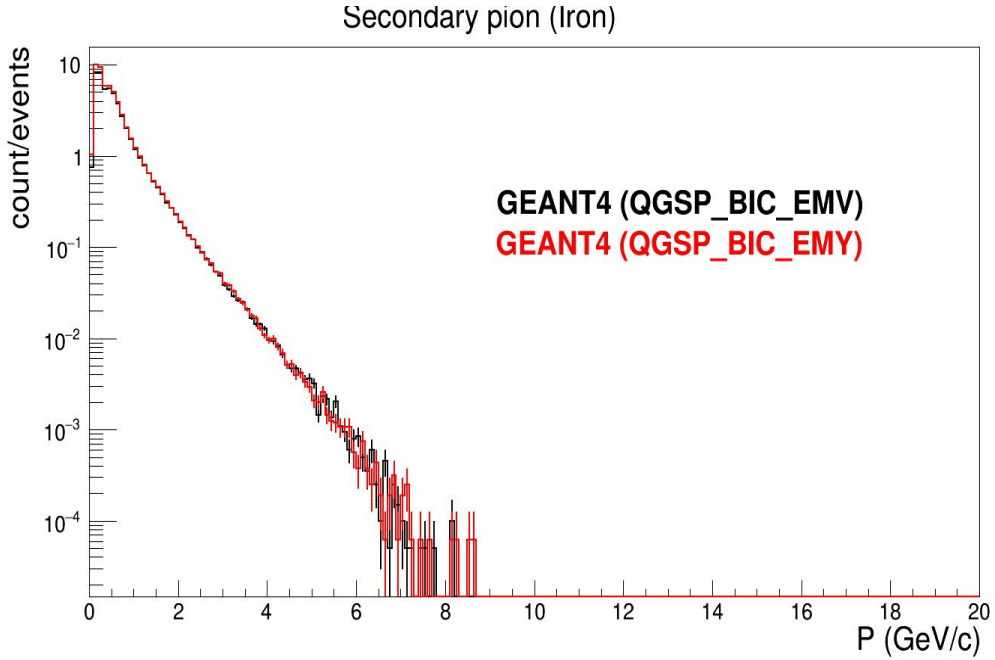


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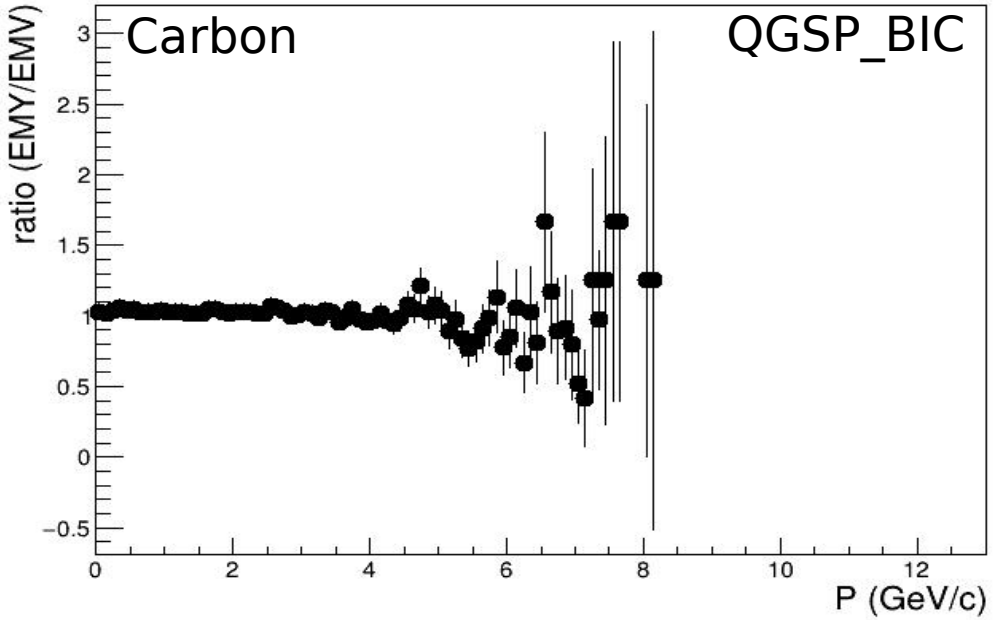
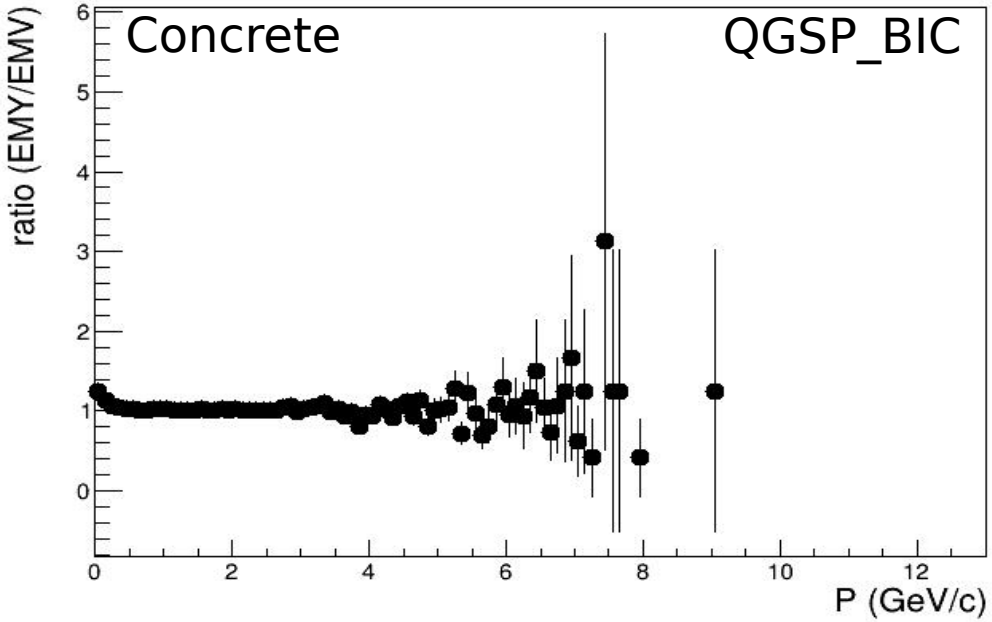
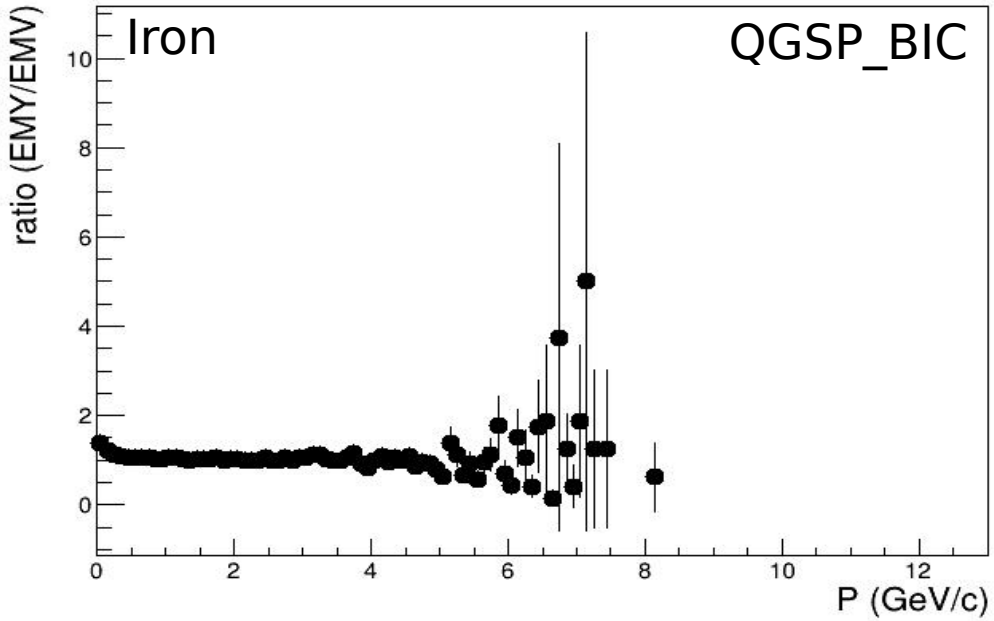
System: Au+Au; Collision : Central; Beam Energy: 8 AGeV

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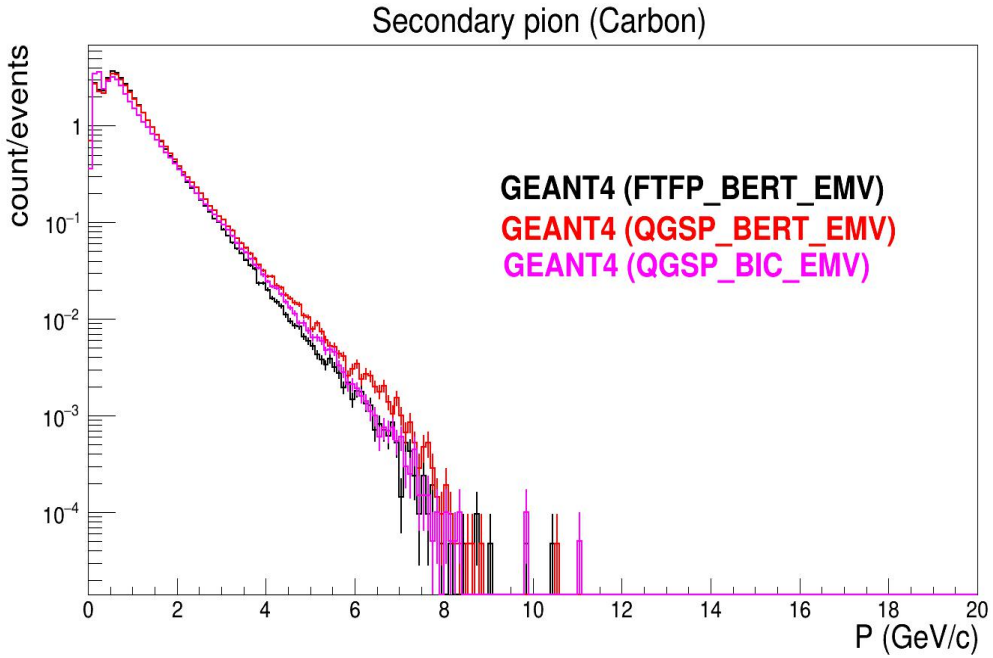
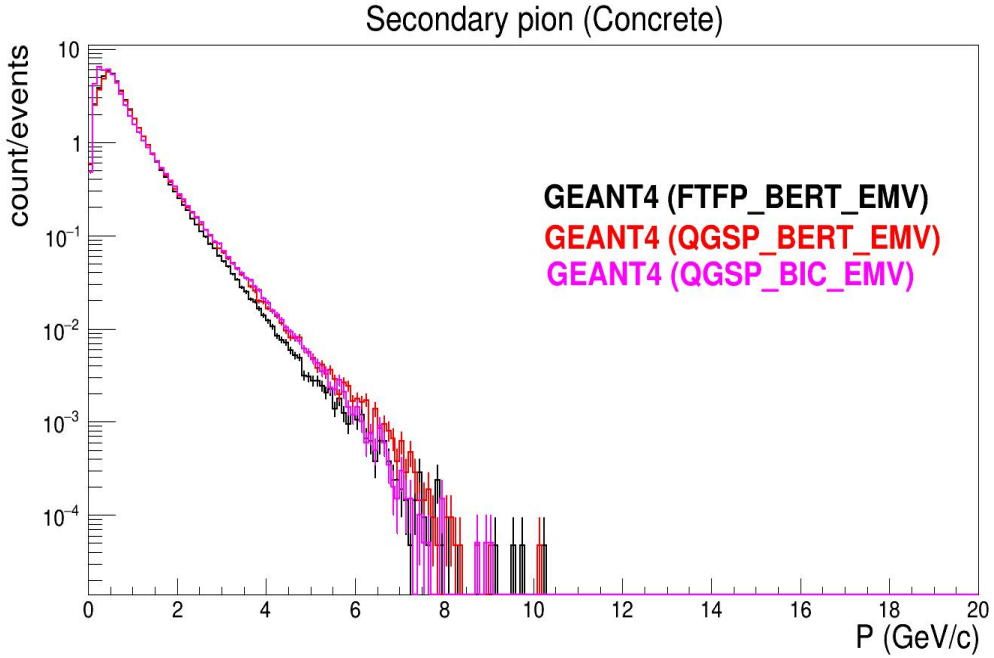
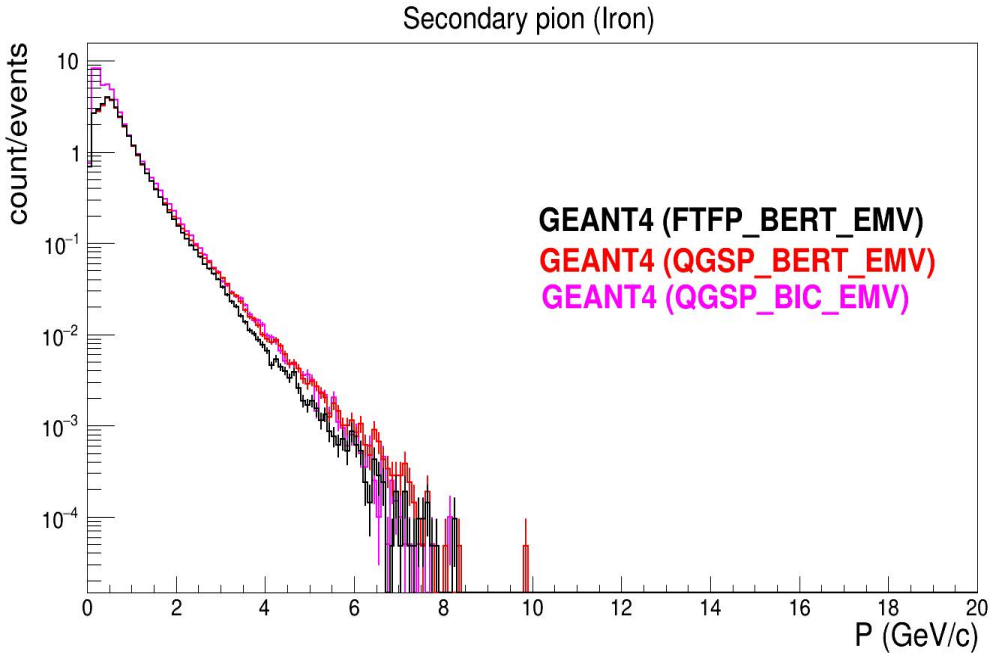
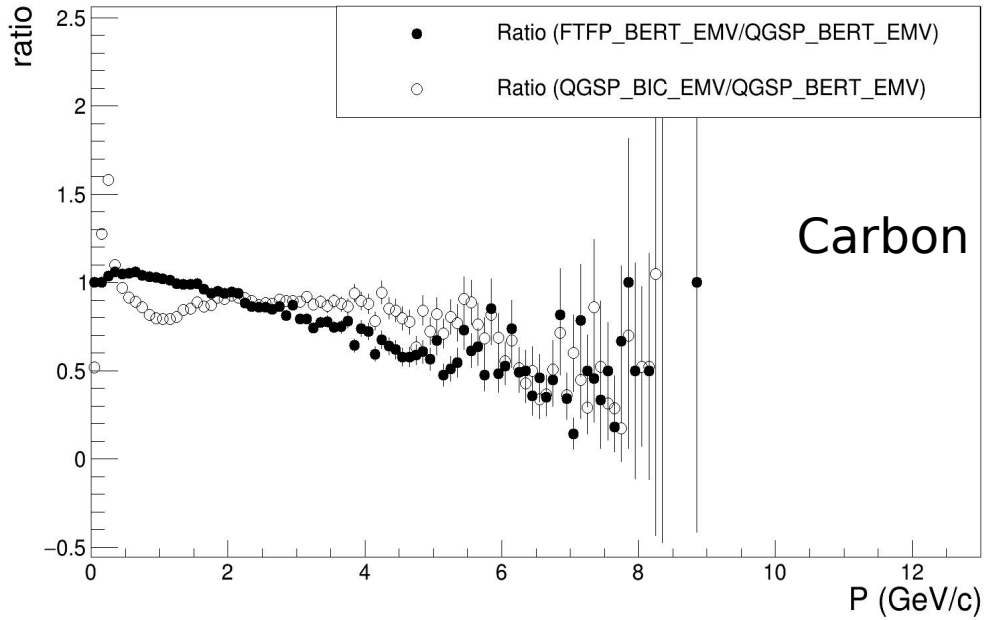


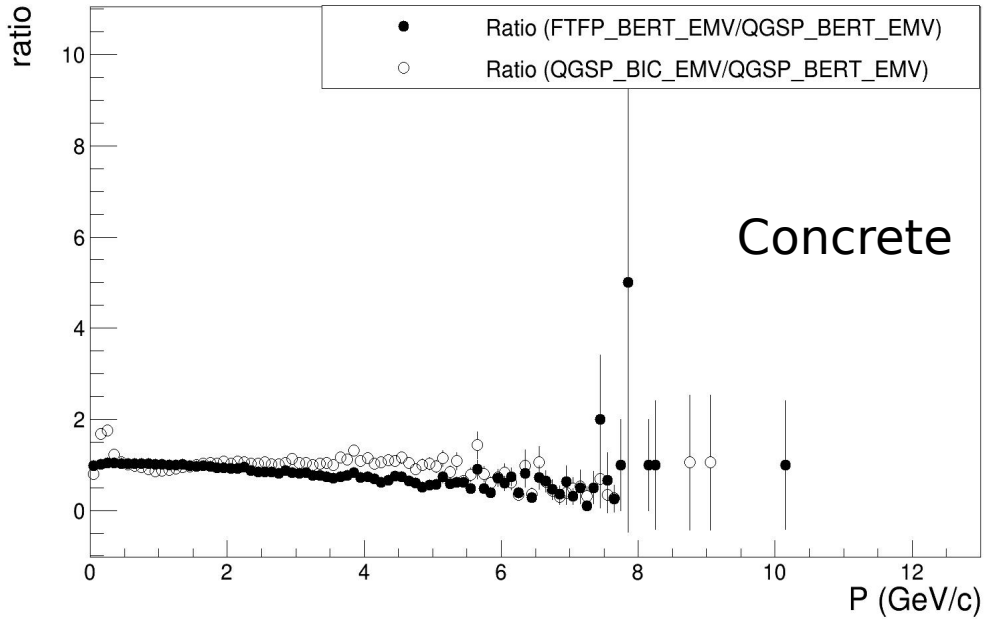



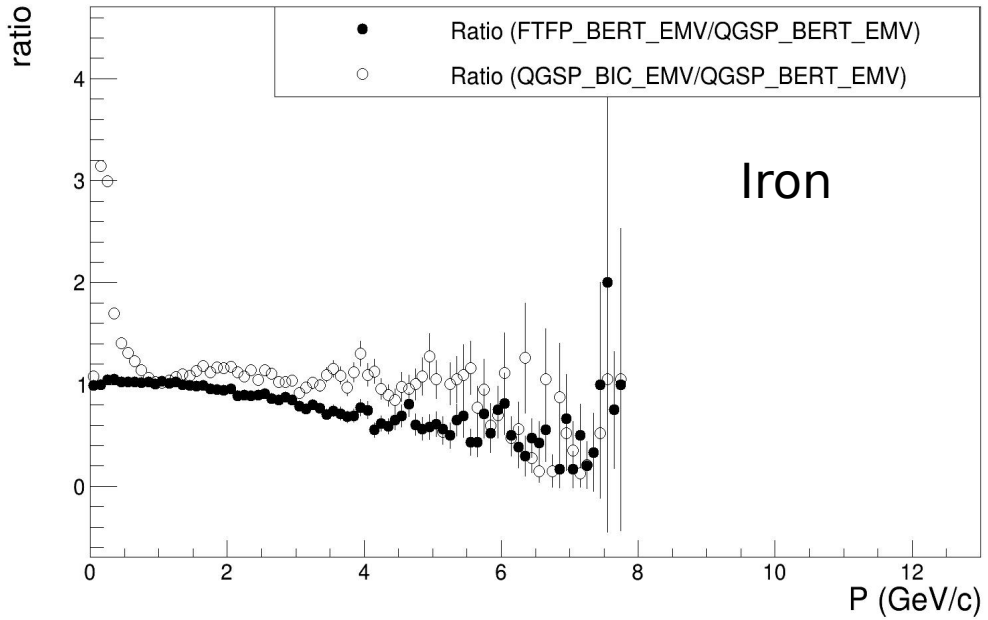




**NOTE** : Small differences are observed with different hadronic components of GEANT4 settings.

System: Au+Au; Collision : Central; Beam Energy: 8 AGeV



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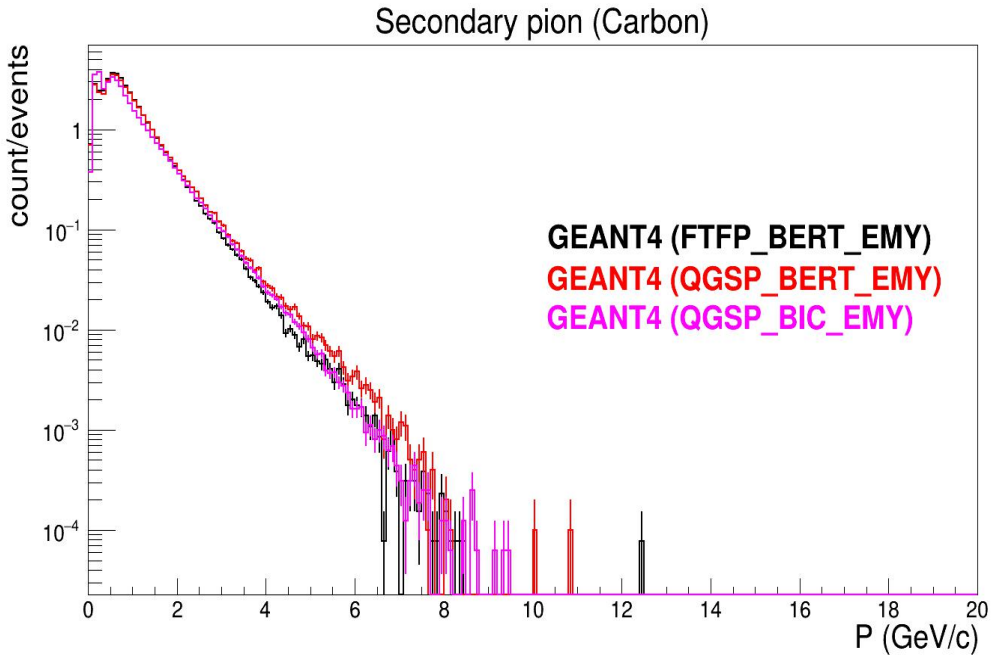


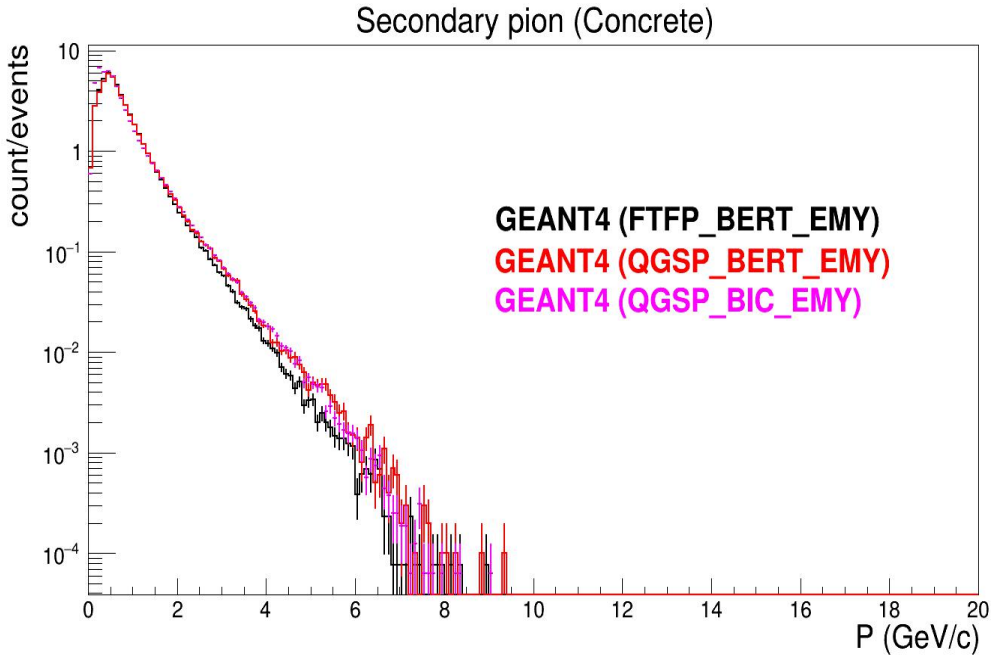


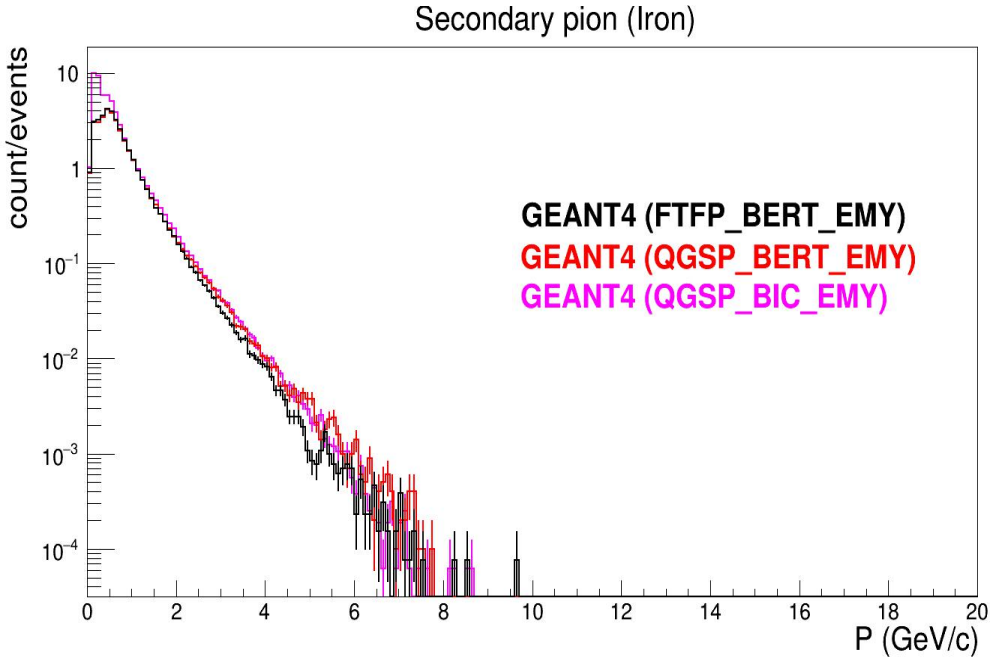


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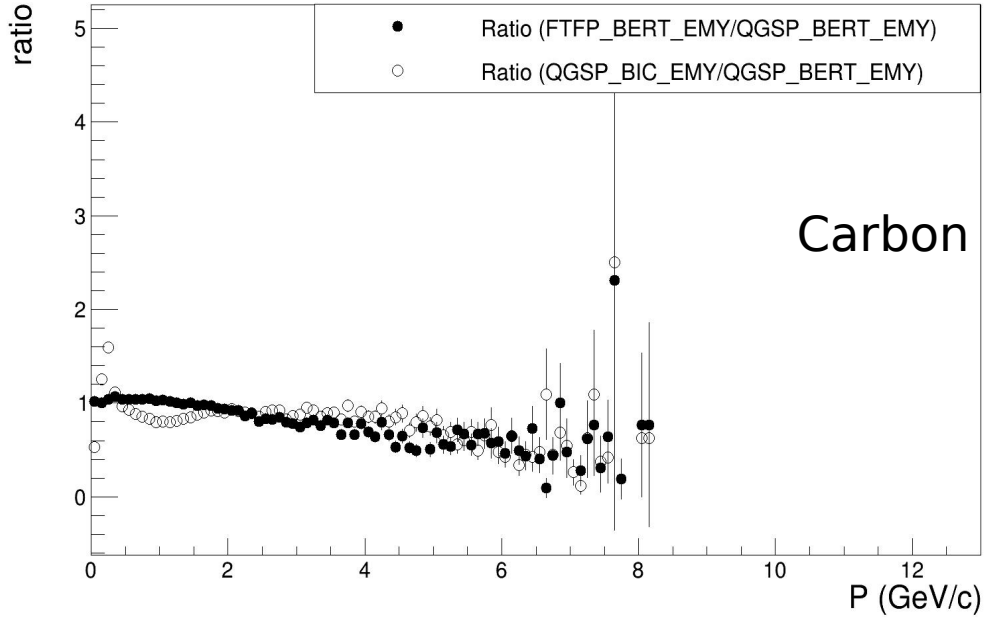
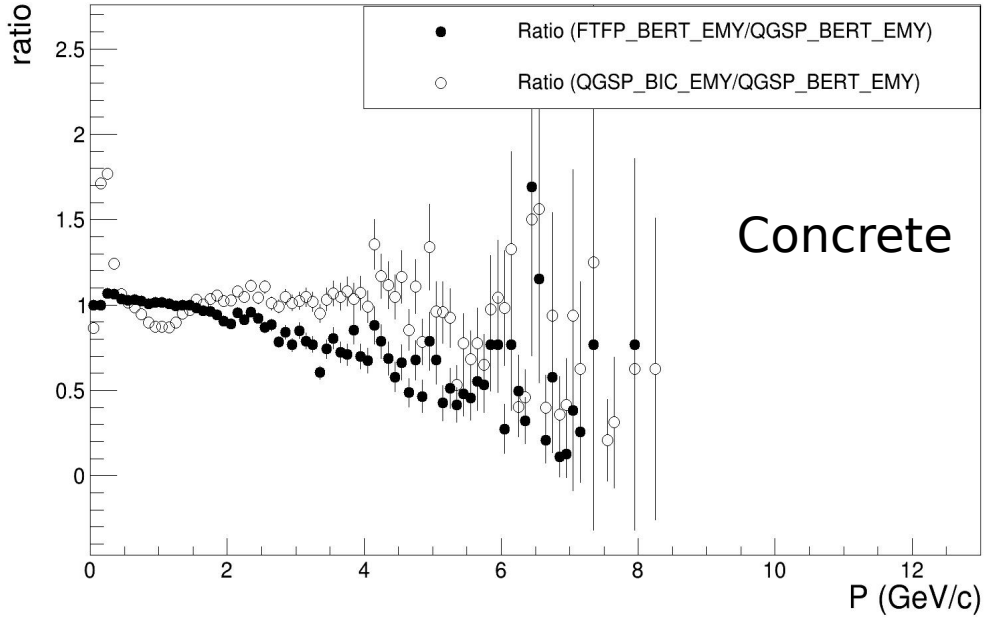
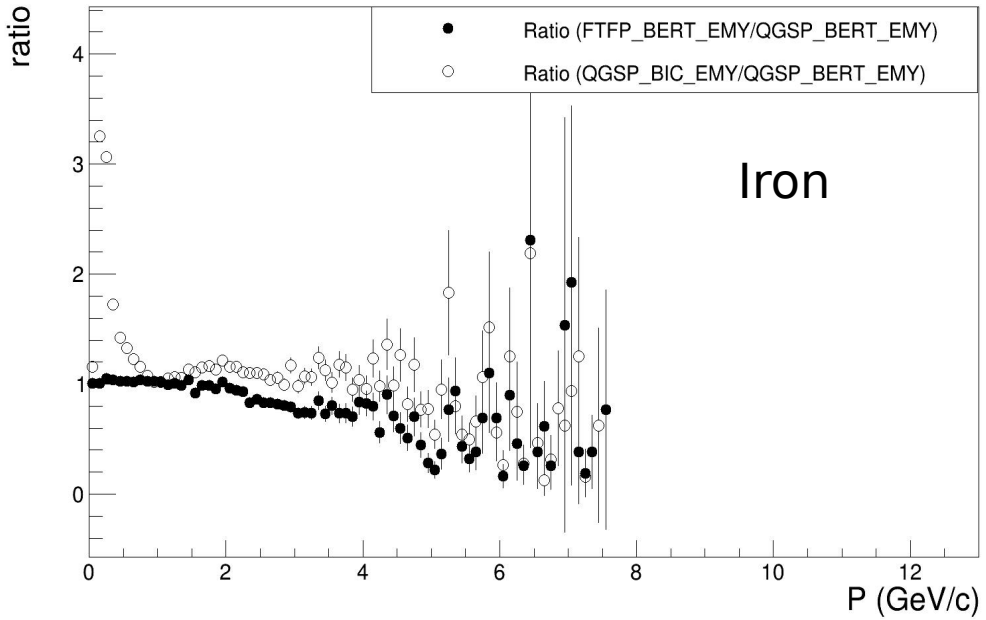


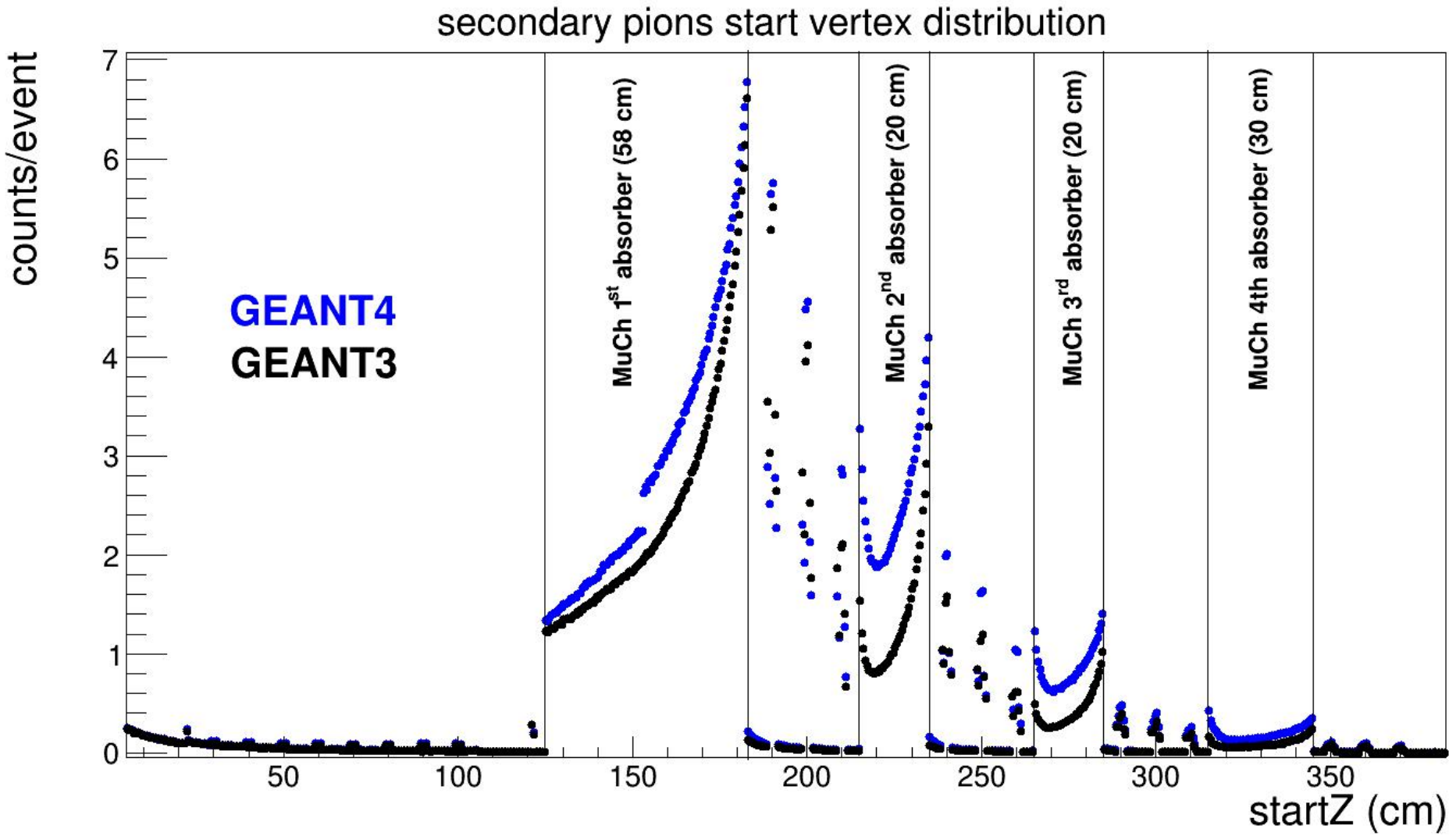
## Summary

- The increase in the combinatorial background with UrQMD (GEANT4) as compared to UrQMD (GEANT3) is mainly due to the generation of large number of pions with GEANT4.
- The hadronic interactions are more accurate in GEANT4 as compared to GEANT3. So should we move to GEANT4 for further simulations!
- Different physics lists in GEANT4 are used to compare the pion production (Needs more investigation to understand the differences observed)

**THANK YOU**

# Backup

## Z vertex distribution of the secondary pions

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