Physics List Comparisons

Ermias ATOMSSA

Institut de Physique Nucleaire d'Orsay

November 13, 2013

Objective of study

- Understand the implication of using various available physics lists for Geant 4
  - Previous PiD algorithm work done using Geant 3
  - Feasibility of physics measurements $\bar{p}p \rightarrow \pi^0 e^+ e^-$ critically dependent on PiD
  - Tail of hadronic response plays dominant role in hadron rejection
- How does Geant 4 physics lists compare to the default option of Geant 3 (used so far)?
- Strategy: Select Geant 4 physics list with largest tail to be conservative?
- Geant 4 also offers other options with more or less cpu cost. What to use?
  - "Optical physics" simulation (very high cpu/storage cost)
  - "High precision neutron data" (very high cpu)
  - Most accurate parametrization of EM physics vs. tuned (for cpu) less accurate one
- PandaROOT setup
  - Full PANDA simulation vs. EMCal only simulation

PandaROOT setup

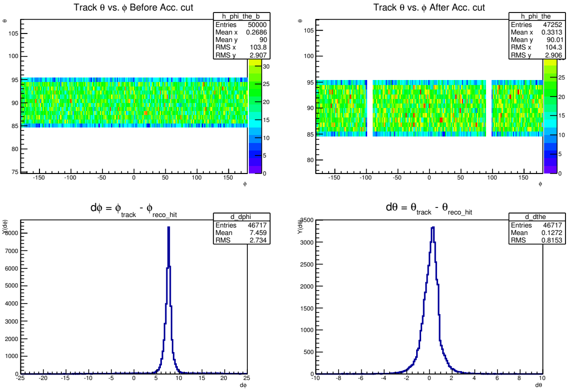
- Events
  - 50k π^+ and 50k π^- for each physics list
  - Uniform in $\phi \in (0, 360^\circ)$ and $\theta \in (85^\circ, 95^\circ)$
  - Acceptance cut to exclude $\phi \in$ (-100°,90°) and $\phi \in$ (90°,100°)
  - Each setup at 5 different momenta (in GeV/c: 0.5, 0.8, 1.0, 1.5, 3.0 and 5.0)
  - All tracks start from $(v_x, v_y, v_z) = 0.0$

- Detector setup for transport stage
  - More details on Geant physics lists next slide
  - EMCal only setup used for most comparisons
  - For sanity check, full panda setup compared to EMCal only in a few setups

- Reconstruction of the EMCal
  - Full EMCal reconstruction used with the following modules: PndEmcHitProducer, PndEmcHitsToWaveform, PndEmcWaveformToDigi, PndEmcMakeCluster, PndEmcHdrFiller, PndEmcMakeBump, PndEmcMakeRecoHit.
  - Bug/Feature? Cluster, Bump and RecoHit containers have exactly the same multiplicity and same energy for all objects.

- Plotted quantity: E_{reco}/E_{true}
  - E_{true}: Energy of simulated pion track
  - E_{reco}: Energy of EmcRecoHit object with closest θ_{reco} to θ_{origin} of simulated pion

- Events
  - 50k π^+ and 50k π^- for each physics list
  - Uniform in $\phi \in (0, 360°)$ and $\theta \in (85°, 95°)$
  - Acceptance cut to exclude $\phi \in$ (-100°,90°) and $\phi \in$ (90°,100°)
  - Each setup at 5 different momenta (in GeV/c: 0.5, 0.8, 1.0, 1.5, 3.0 and 5.0)
  - All tracks start from $(v_x, v_y, v_z) = 0.0$



Hadronic Physics Lists

Geant 3

- Limited number of choices for hadronic physics lists
- Default: HADR=3 (GEANH+NUCRIN)
- Other choices: HADR=4 (**FLUKA**), HADR=5 (**MICAP**), HADR=6 (**GCALOR**)

Geant 4

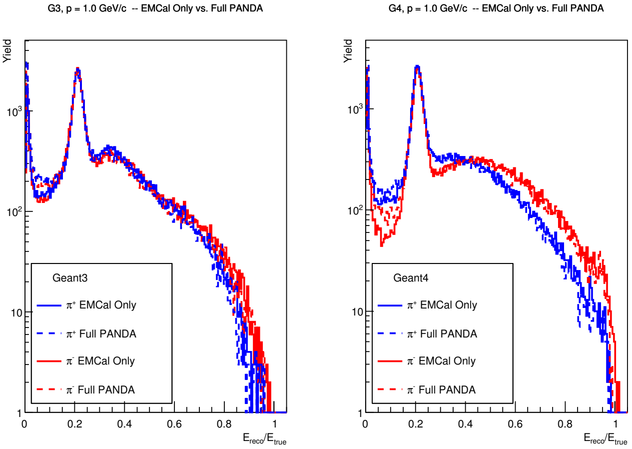
- Options depending on hadronic interaction and cascade (nuclear de-excitation) model
- Two "large" classes: Quark Gluon String (QGS) and Fritiof (FTF)
- Variations based on low energy hadronic interaction and nuclear de-excitation (cascade)
  - **QGSP_BERT** and **FTFP_BERT** (Bertini for LE interaction)
    → P="Precompound model": HE parametrisation for nuclear dexcitation
  - **QGSP_BIC** (Binary cascade for LE interaction)
    → P same as above, no FTFP_BIC list available
  - **QGS_BIC** and **FTF_BIC**
    → (Binary cascade used for nuclear de-excitation for the high energy model)
  - High precision neutron data versions:
    QGSP_BERT_HP, **QGSP_BIC_HP** **FTFP_BERT_HP**
- Soon to be deleted in Geant 4.10
  - **LHEP**: both high and low energy interactions use parametrized models
  - Chiral Invariant Phase Space (CHIPS) model for all nuclear de-excitations
    QGSC_BERT, **QGSC**

Hadronic Physics List Table

	Low Energy			High Energy			
Phys. List	h-N	de-ex.	$R(\pi^{\pm})$	h-N	de-ex.	$R(\pi^{\pm})$	C
QGSP_BERT	Bert.	Bert.	0 - 9.9	QGS	Prec.	12 - ∞	LEP: 9.5 - 25
QGSP_BIC	LEP	LEP	0 - 9.9	QGS	Prec.	12 - ∞	G4 Bug?
QGS_BIC	Bin.	Bin.	0 - 1.3	QGS	Bin.	12 - ∞	LEP: 1.2 - 25
FTFP_BERT	Bert.	Bert.	0 - 5	FTF	Prec.	4 - ∞	
FTF_BIC	Bin.	Bin.	0 - 5	FTF	Bic	4 - ∞	

h-N: Hadron-Nucleus interaction
de-ex: Nuclear de-excitation
R: Range
C: Comments (patching model when gap between LE & HE)
LEP: Low Energy Parametrization

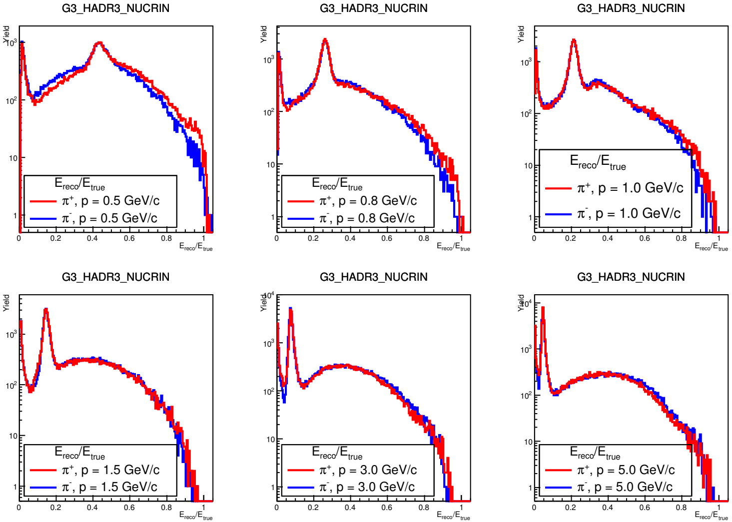
Full PANDA simulation vs. EMCal only



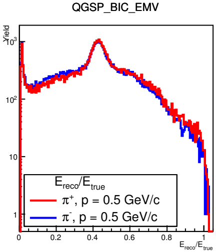
- Slight difference at low E_{reco}/E_{true} but the high end tail looks very similar
- Large gain in CPU usage with EMCal only simulation
- For purpose of comparison, will use EMCal only simulation consistently

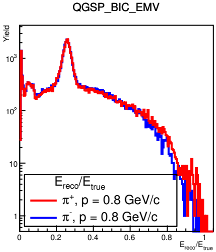
Momentum dependence

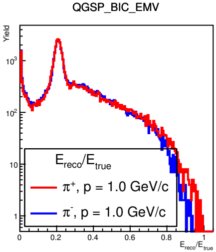
π^+ and π^- G3 HADR=3 (GEISHA,NUCRIN)

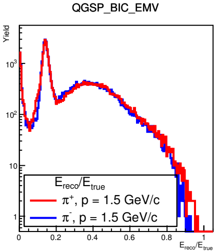


π^+ and π^- G4 QGSP, Binary cascade, param. EM processes (QGSP_BIC_EMV)

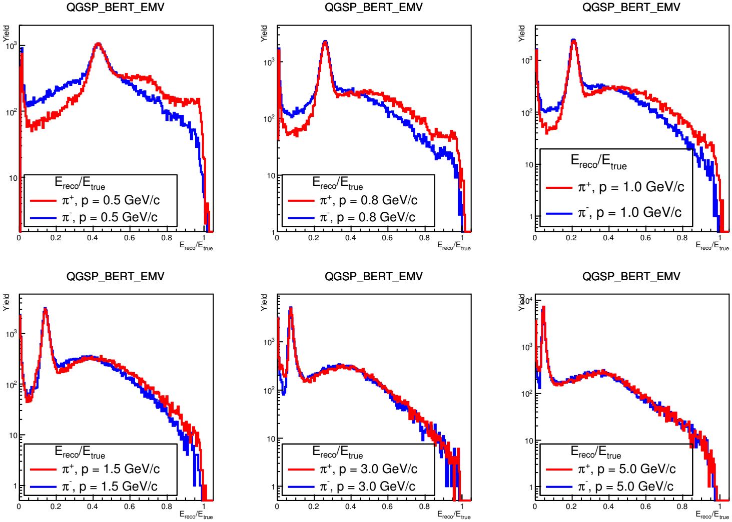






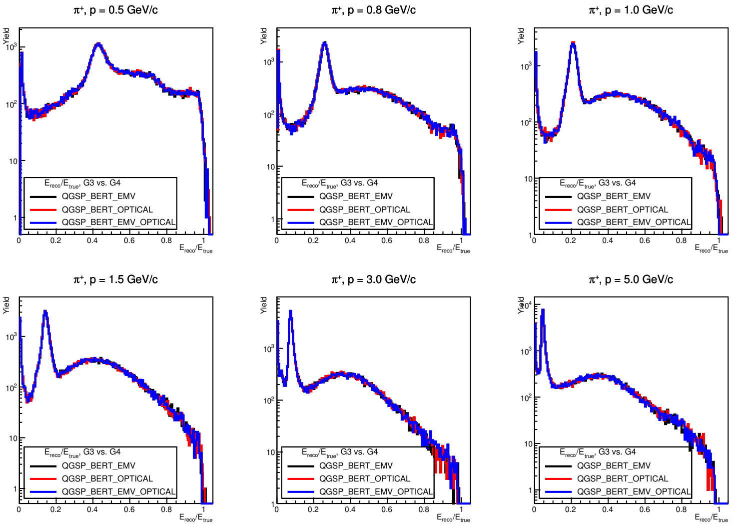


π^+ and π^- G4 QGSP, Bertini cascade, param. EM processes (QGSP_BERT_EMV)



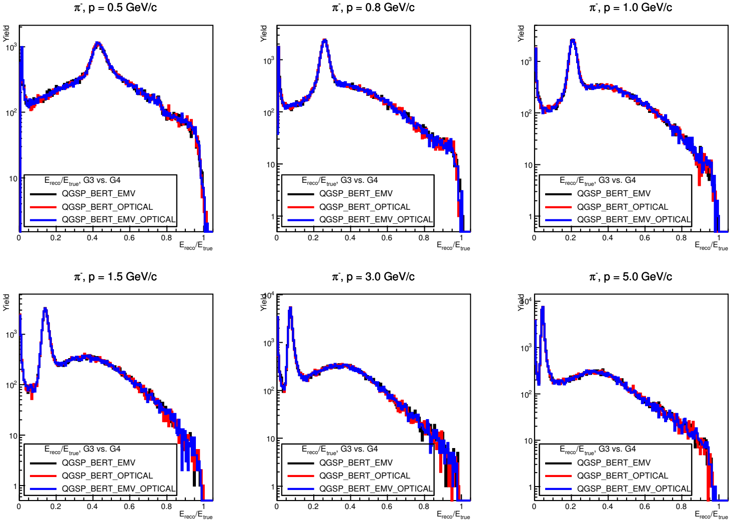
Performance tuned EM parameters and optical physics options

QGSP_BERT W and W/O EMV and optical physics



- No visible difference whether EMV parameters are tuned or not ($\Longrightarrow$ Use EMV)
- No visible difference whether optical physics is turned on or not ($\Longrightarrow$ Do not use optical)

QGSP_BERT W and W/O EMV and optical physics

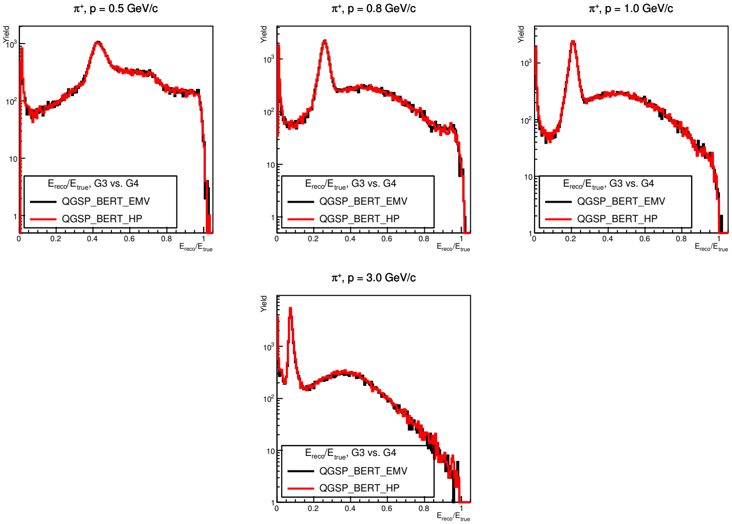


- No visible difference whether EMV parameters are tuned or not ($\Longrightarrow$ Use EMV)
- No visible difference whether optical physics is turned on or not ($\Longrightarrow$ Do not use optical)

High precision neutron data

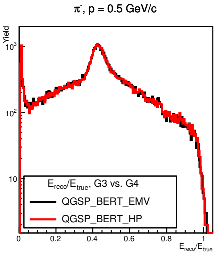
for neutron transport below 20 MeV

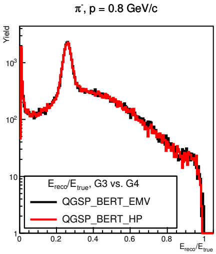
QGSP_BERT_EMV vs. QGSP_BERT_HP

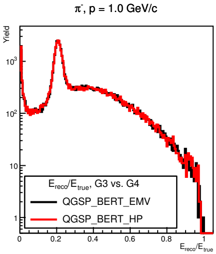


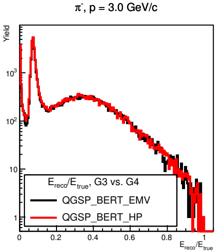
- No visible difference whether HP neutron data is used ($\Longrightarrow$ Do not Use HP)

QGSP_BERT_EMV vs. QGSP_BERT_HP





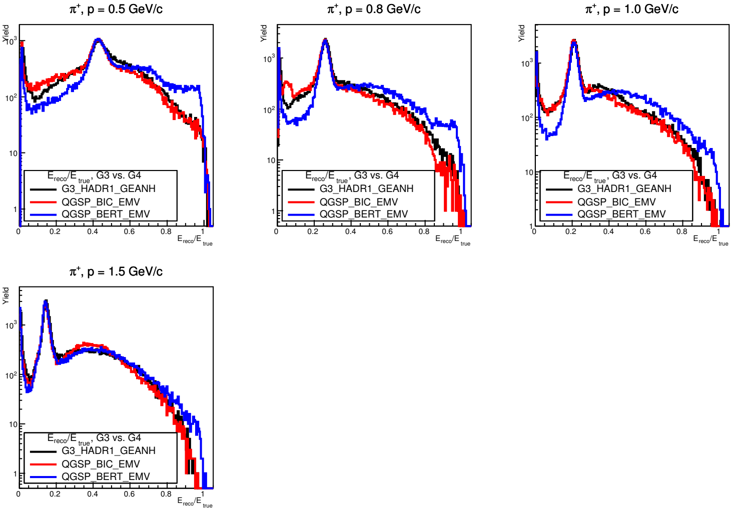




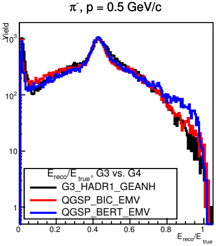
- No visible difference whether HP neutron data is used ($\Longrightarrow$ Do not Use HP)

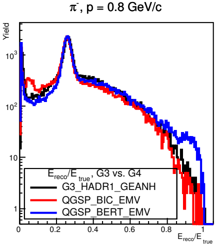
Geant3 vs. Geant4

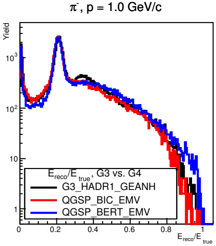
G4 π^+ G3 vs. QGSP_BERT_EMV vs. QGSP_BIC_EMV

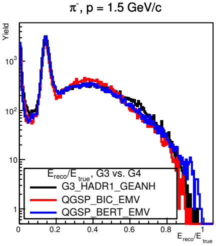


G4 π^- G3 vs. QGSP_BERT_EMV vs. QGSP_BIC_EMV









Backup

G3 options

HADR=1: GEANH

HADR=3: GEANH+NUCRIN (Default)

- GEANH: Transport
- NUCRIN: ?

HADR=4: FLUKA

- GEANH: Transport ?
- FLUKA: The FLUKA fragmentation model is utilized for interactions above the HETC limit

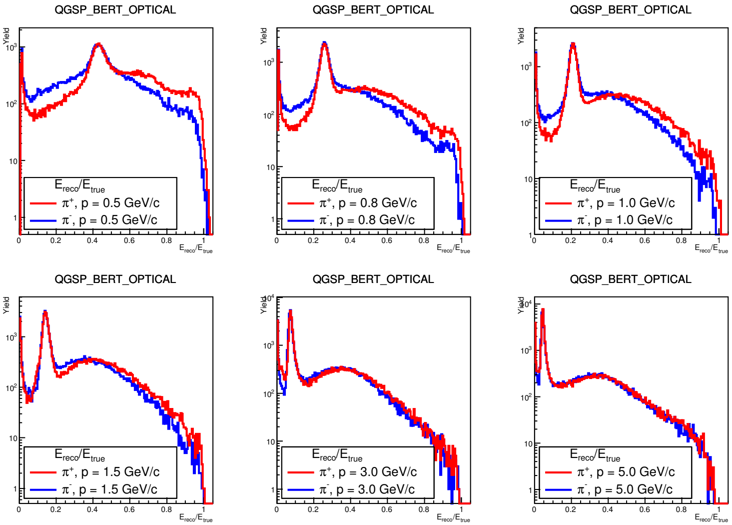
HADR=5: MICAP

- GEANH: Transport ?
- MICAP: Neutron code from the Monte-carlo-Ionization-Chamber-Analysis-Program for neutrons with a kinetic energy below 20 MeV.

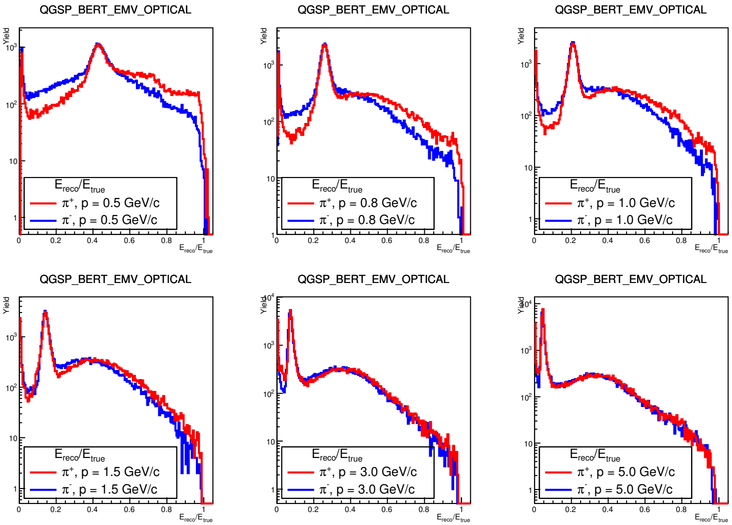
HADR=6: GCALOR

- HETC: The High-Energy-Transport-Code is transporting charged hadrons up to an energy of 10 GeV through the materials of the setup
- FLUKA and MICAP are also used in their validity domain

π^+ vs π^- G4 QGSP, Bertini cascade, Full EM Physics + Optical physics (QGSP_BERT_OPTICAL)



π^+ vs π^- G4 QGSP, Binary cascade, param. EM processes + Optical physics (QGSP_BIN_EMV_OPTICAL)



π^+ vs π^- G4 QGSP, Binary cascade, High Precision Neutron Package (QGSP_BERT_HP)