



Geant4 Validation

Geant4 Validation Meeting

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30-09-2011



Physics lists

- "QGSP: quark gluon string model for high energy interactions of protons, neutrons, pions, and Kaons and nuclei.
- QGSP_BERT: Like QGSP, but using Geant4 Bertini cascade for primary protons, neutrons, pions and Kaons below $\sim 10\text{GeV}$.
- QGSP_BERT_EMV is like QGSP_BERT, but parameters of electromagnetic processes tuned to yield better cpu performance with only slightly less precision.
- Optical: optical physics
- CHIPS: Nuclear capture of negative particles and neutrons at rest is modeled using the modeling of the Chiral Invariant Phase Space (CHIPS) model.
- FTFP: The annihilation interactions of the anti-nucleons, elastic scattering are available
- Productions and physics lists:
 - QGSP_BERT_EMV+optical \rightarrow LHC11d6a, LHC11d6c
 - QGSP_CHIPS_EMV+optical \rightarrow LHC11d6b, LHC11d6d
 - QGSP_FTFP_BERT+optical \rightarrow LHC11d6e



Data - Productions

Real Data 126007 of LCH10d (anchor run for simulations) (4M events)

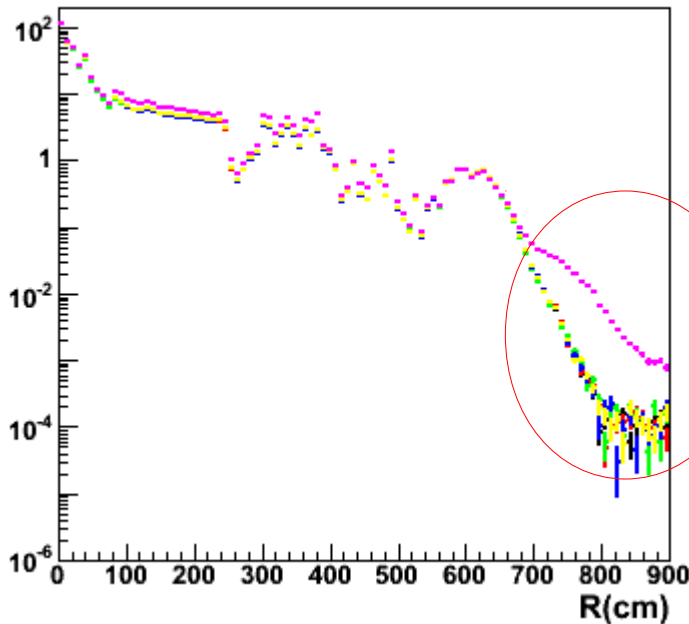
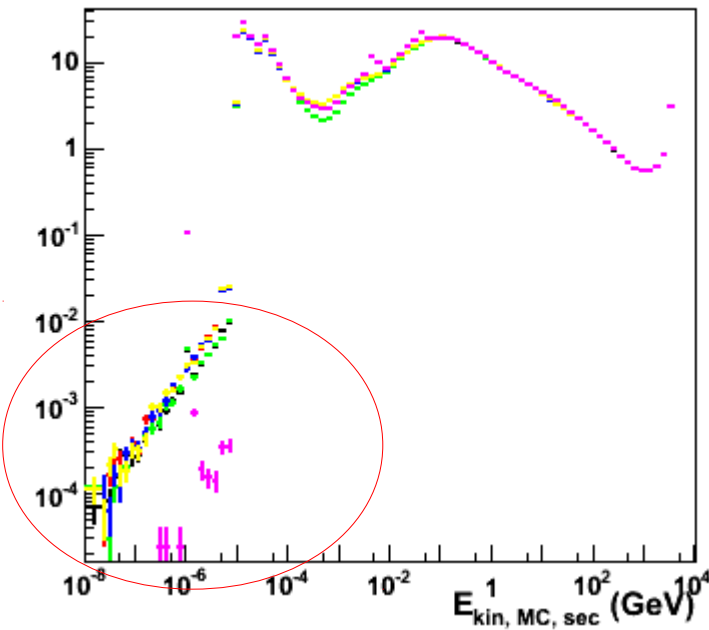
PYTHIA Production		physics list	statistics
LHC11d6a	Geant4 9.4.p02	QGSP_BERT_EMV +optical	117,900
LHC11d6b	9.4.p02	QGSP_BERT_CHIPS+optical	118,000
LHC11d6c	9.5.b01	QGSP_BERT_EMV +optical	98,100
LHC11d6d	9.5.b01	QGSP_BERT_CHIPS+optical	94,300
LHC11d6e	9.5.b01	QGSP_FTFP_BERT +optical	100,400
LHC11d6f	Geant3	-	119,600

(Anti-)nuclei		physics list	statistics
LHC11f6g	Geant4 9.5.b01	QGSP_FTFP_BERT+optical	105,500

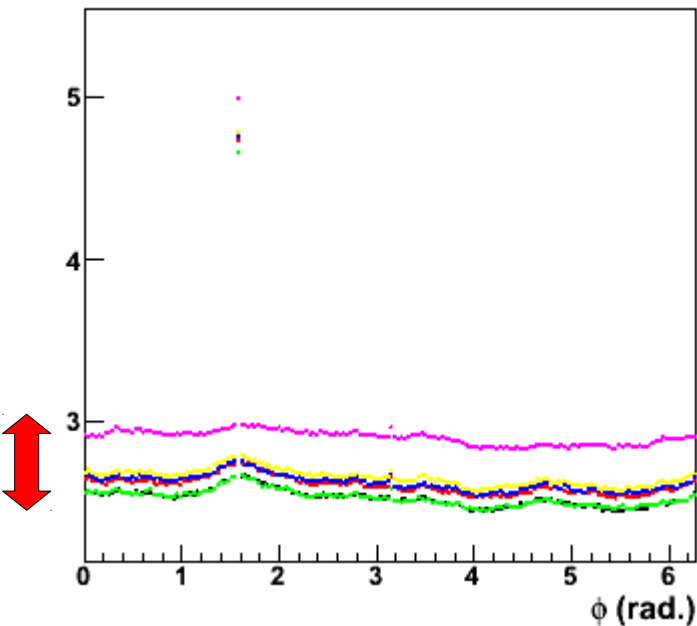


PYTHIA Simulations

Properties of Secondaries



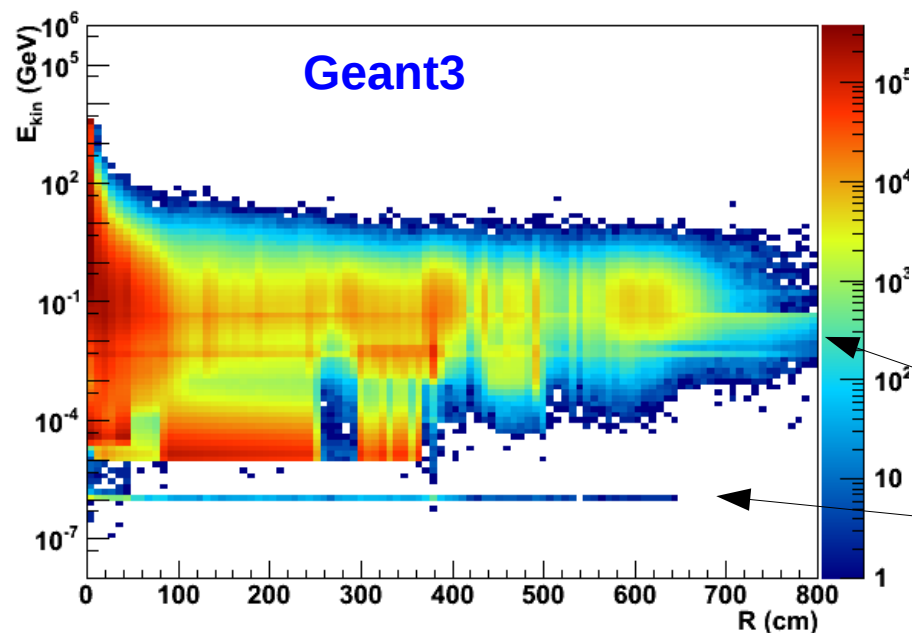
- All Geant4 simulations show similar properties of secondary particles
- Geant3 shows higher number of secondaries at all Φ and R , especially at $R > 700\text{cm}$
- Geant4 shows higher number of particles at very low E_{kin}



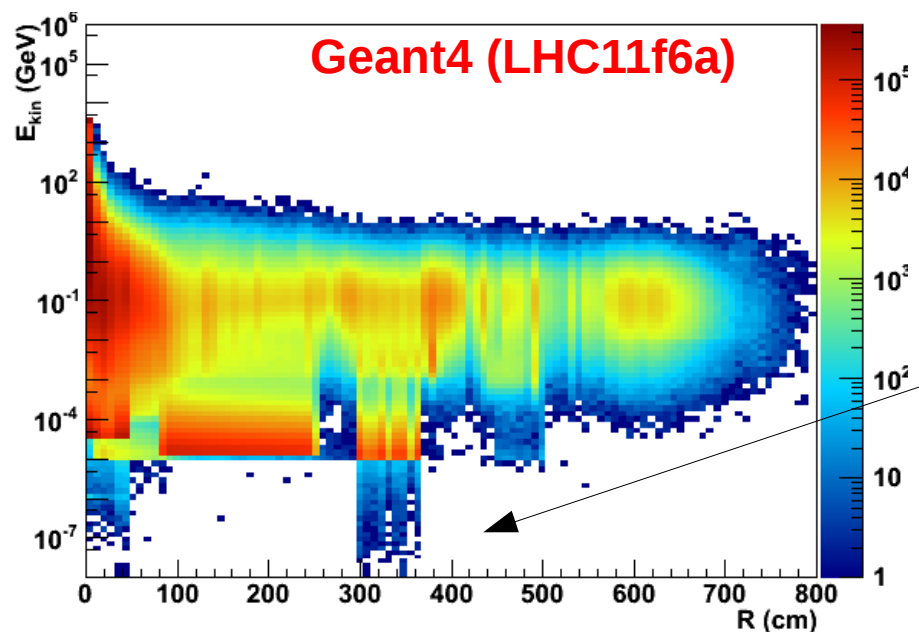
Run 126007

- Geant4A
- Geant4B
- Geant4C
- Geant4D
- Geant4E
- Geant3

Secondaries: E_{kin} - Generation Point

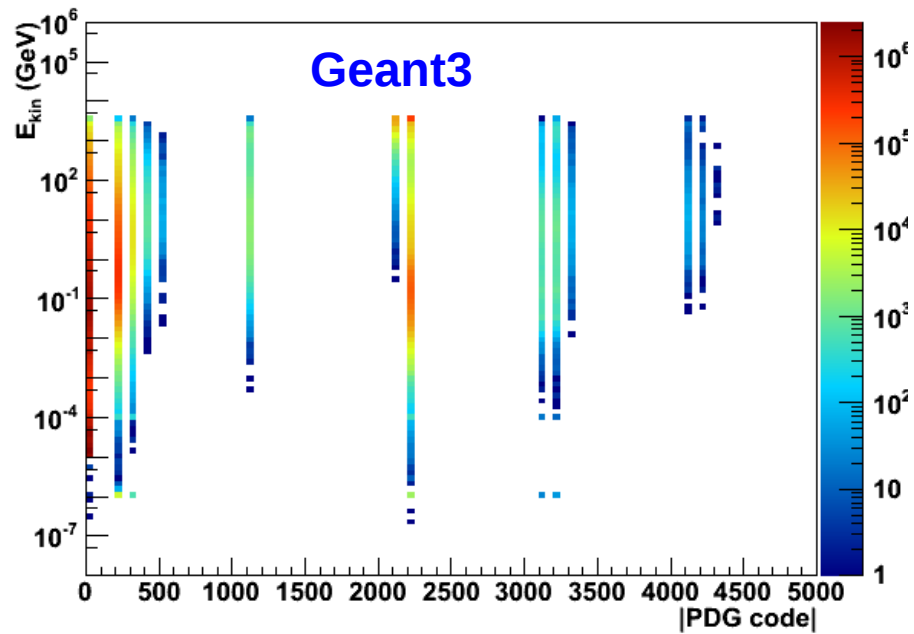


- Similar structures with small deviations:
- Geant3:
 - Band above $R > 700\text{cm}$
 - Band at $E_{kin} = 10^{-6}\text{ GeV}$ and all $R < 650\text{cm}$

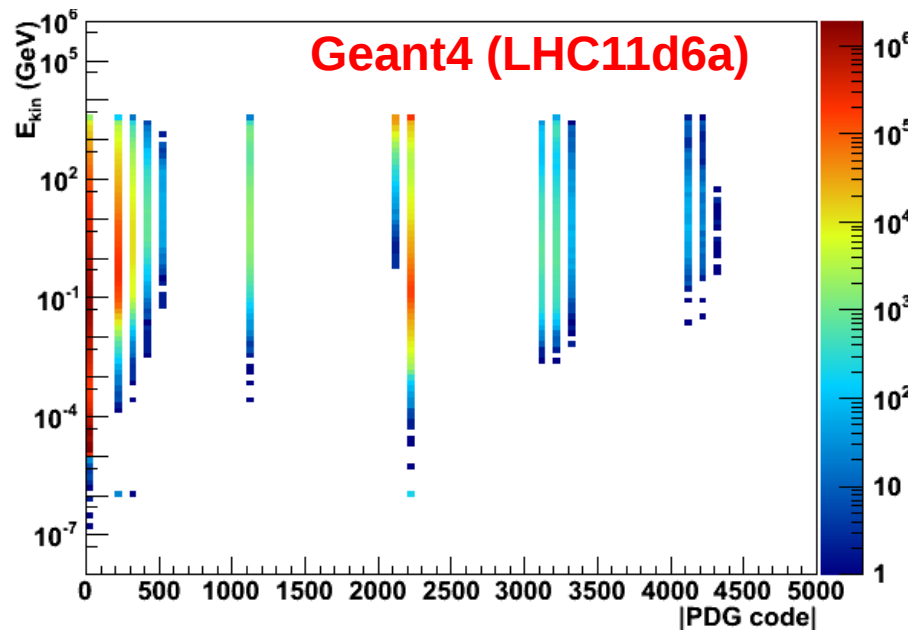


- Geant4:
 - Secondaries with low E_{kin} at ITS and TRD (maybe, these slow down the simulation)

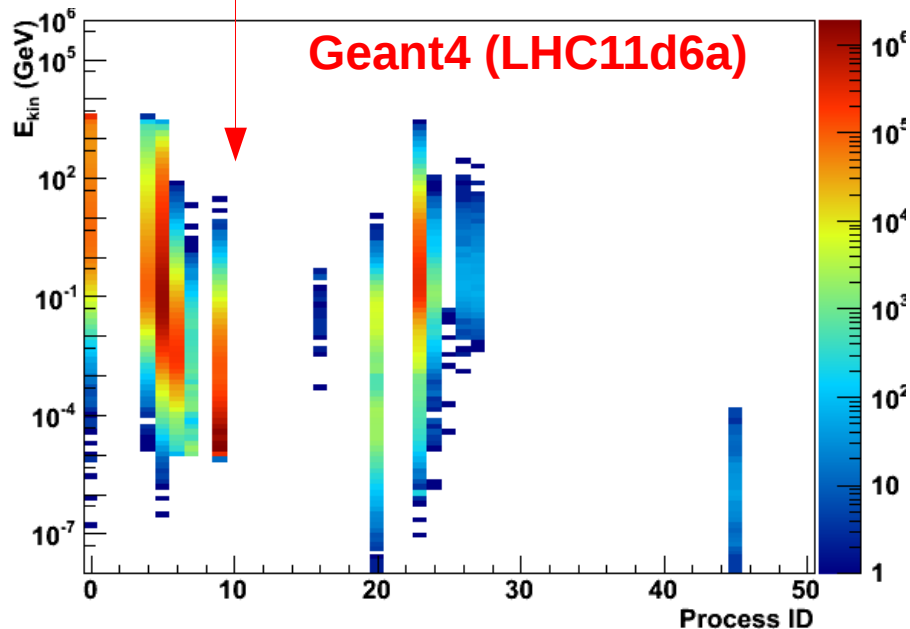
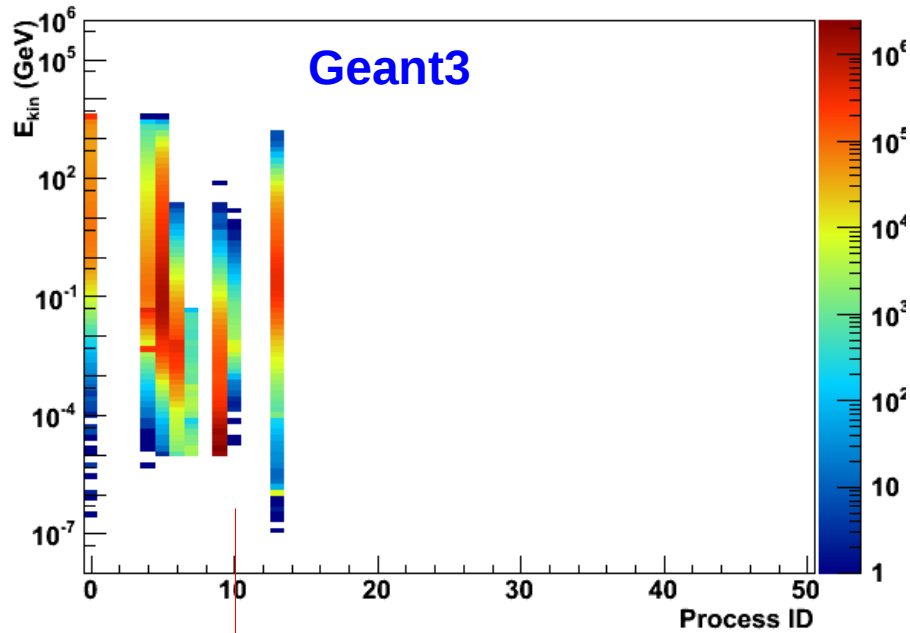
Secondaries: E_{kin} -PDG



- Test: rough separation in terms of |PDG value|
- Geant3 and Geant4 produce similar picture



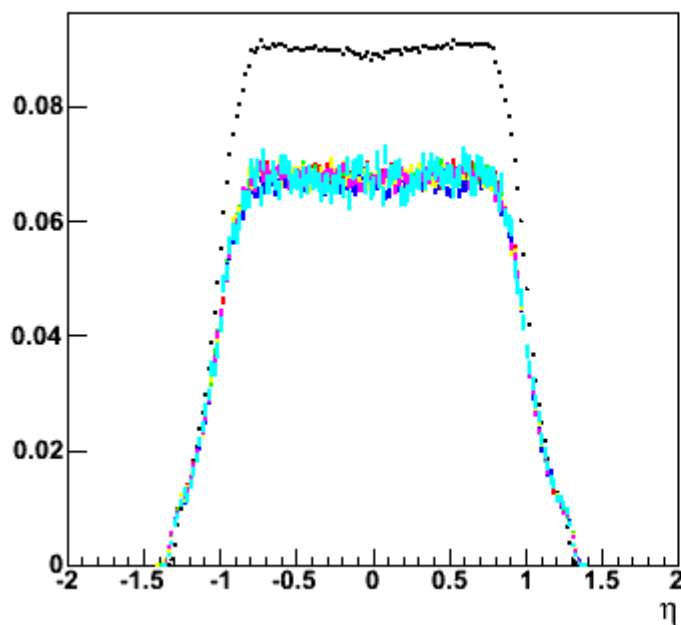
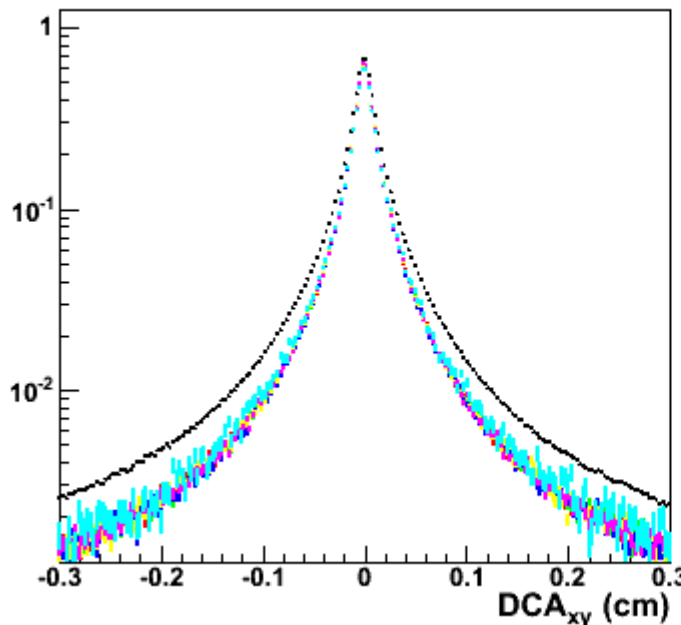
Secondaries: E_{kin} -ProcessID



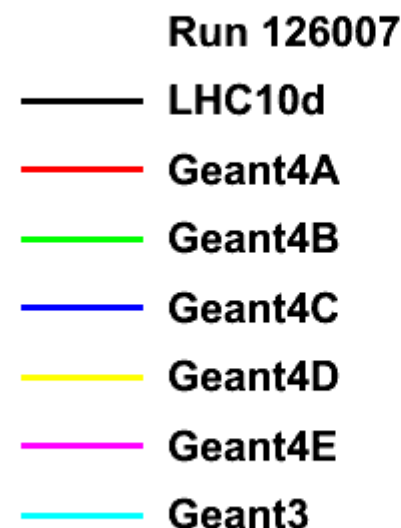
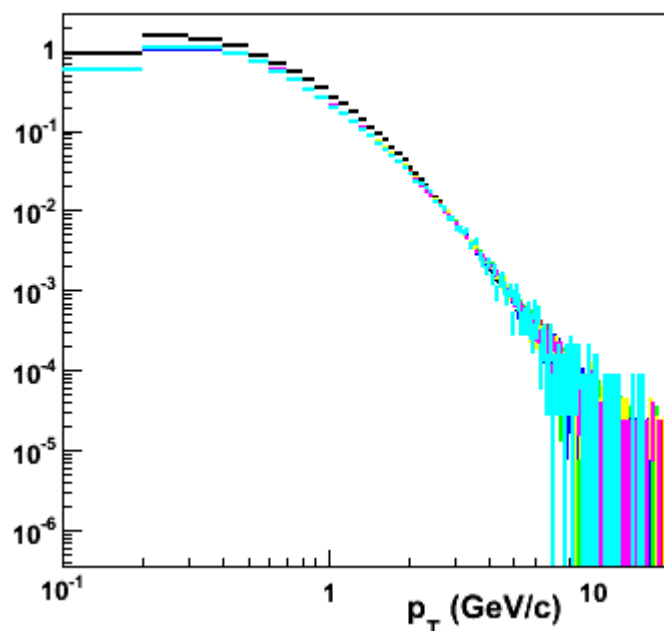
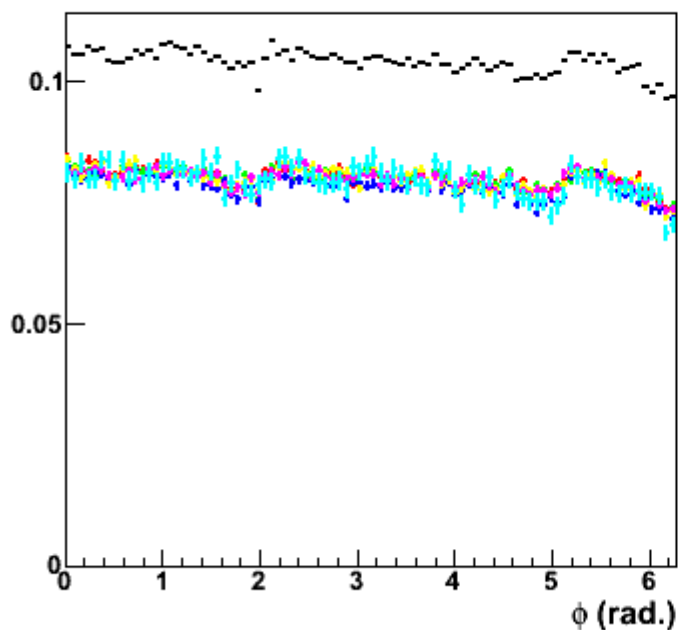
ID	G3	G4	Process
0	x	x	?
4	x	x	bending in B
5	x	x	particle decay
6	x	x	pair production
7	x	x	Compton scattering
9	x	x	bremsstrahlung
10	x		delta-ray
13	x		hadronic elastic scat.
16		x	nuclear absorption
20		x	hadronic inelastic scat.
23		x	nuclear photon fission
24		x	half step to avoid crossing
25		x	Rayleigh effect
26		x	parametrization activated
27		x	error matrix computed
45		x	?

Track Properties (Global)

Global tracks

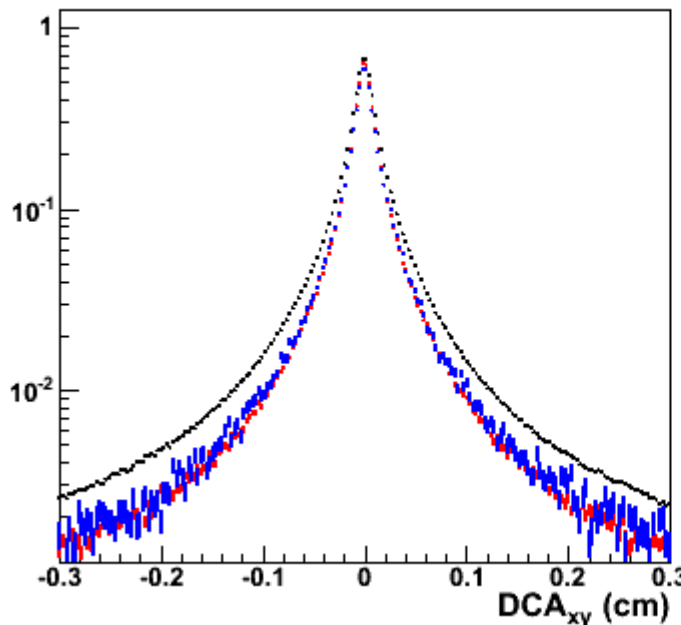


- Properties of reconstructed tracks are similar in Geant3 and Geant4
- Event generator underestimates particle yield but shape of distribution is similar

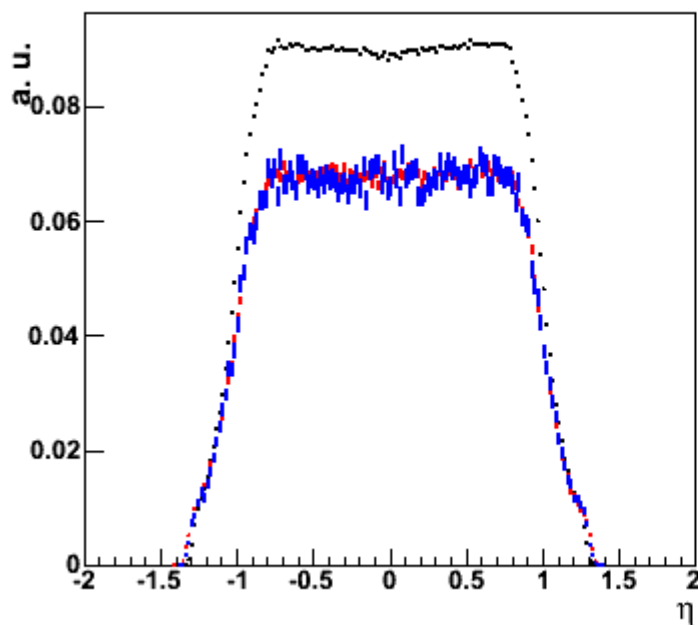


One Geant4 Production

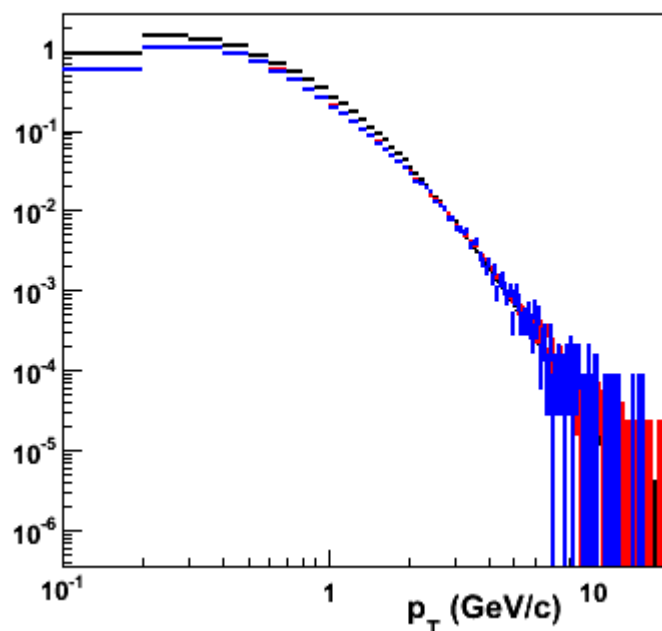
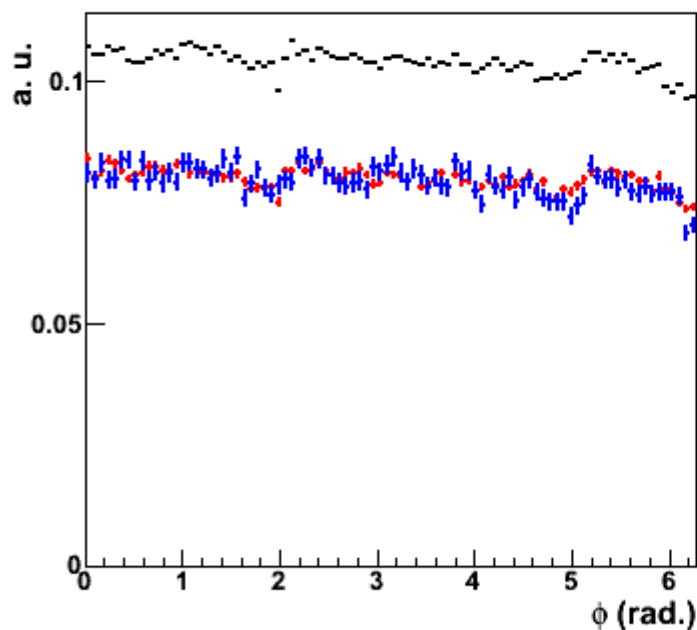
Global tracks



Global tracks

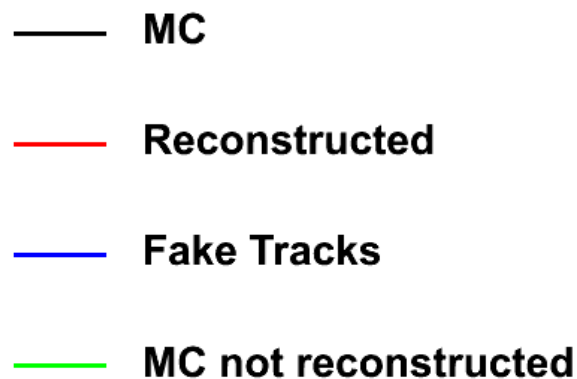
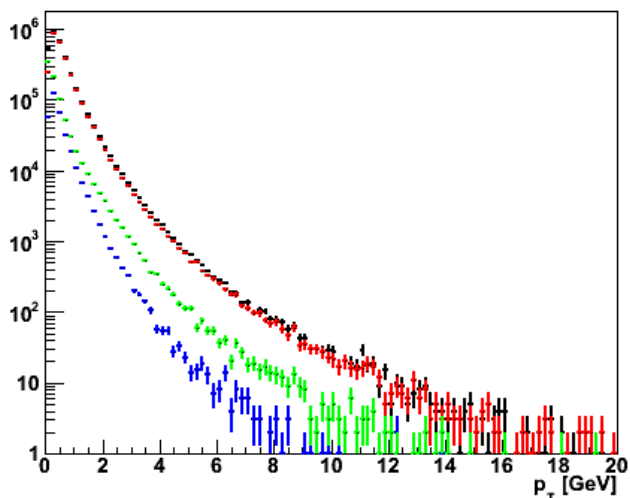


- Properties of reconstructed tracks are similar in Geant3 and Geant4
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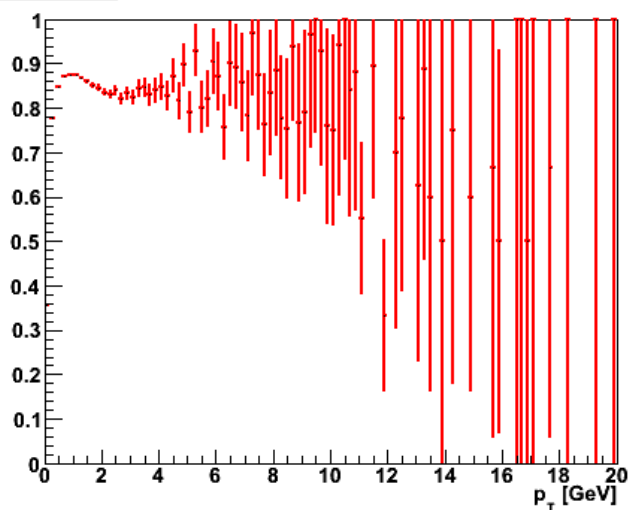
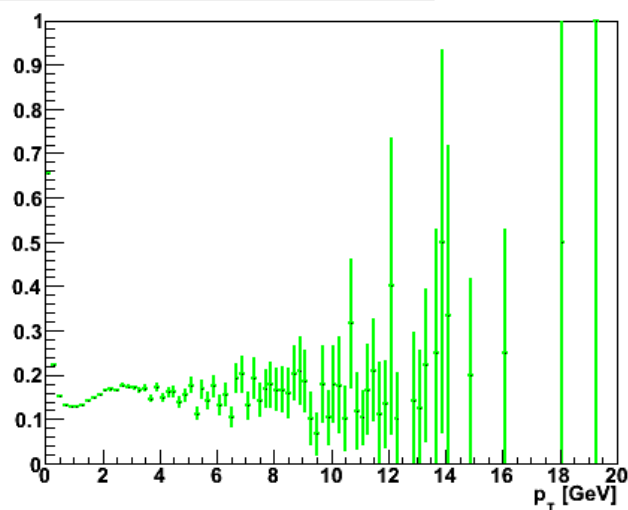


Run 126007
— ALICE
— GEANT4
— GEANT3

Reconstruction Efficiency (global tracks)



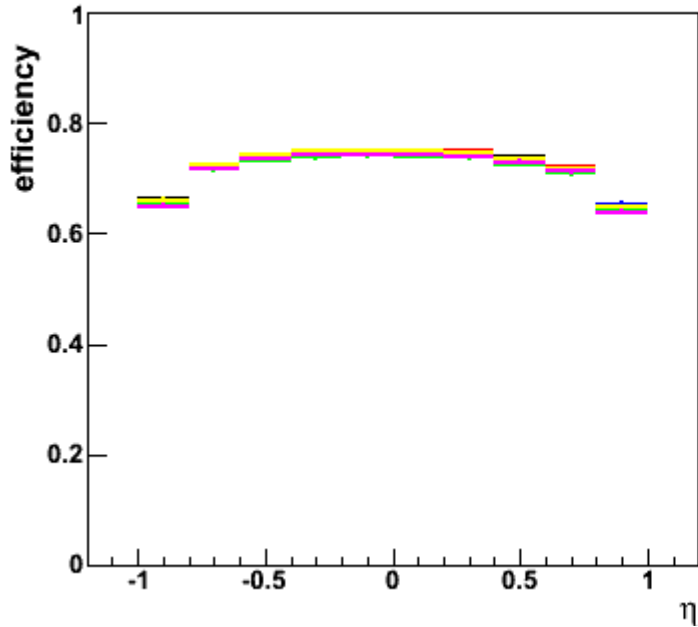
- Compare number of generated and reconstructed tracks and extract reconstruction efficiency and inefficiency
- Here, as example, the results as function of transverse momentum are presented

Efficiency

Inefficiency from non-rec. MC tracks


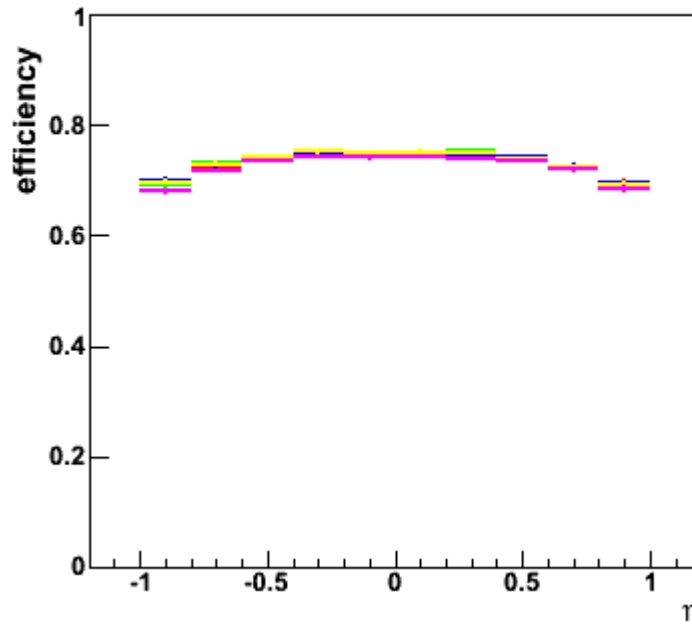
- Compare now efficiencies of different productions to each other
 - η , Φ , p_T
 - Global-, TPC-, and ITS- tracks

Efficiency $_{REC,\eta}$

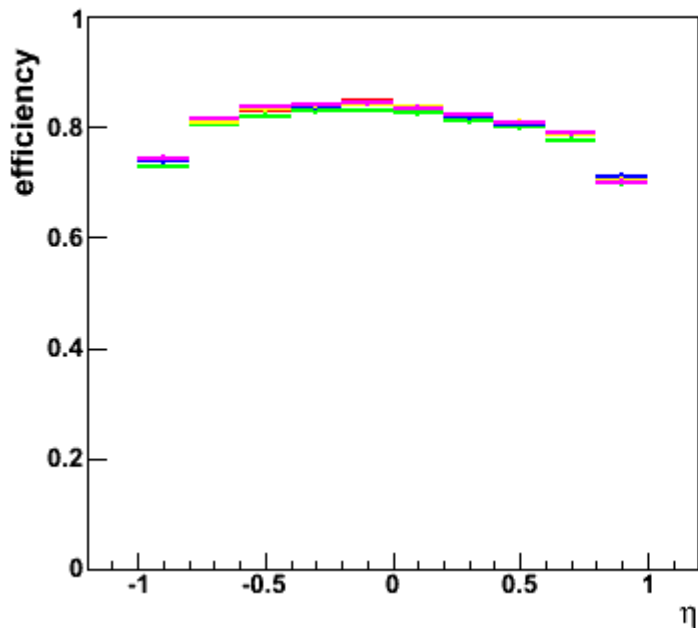
Global tracks



TPC tracks



ITS_SA tracks

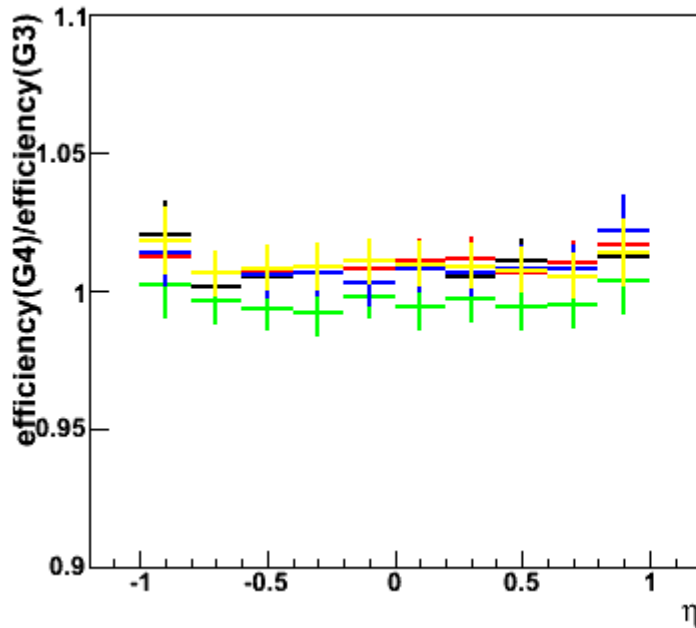


Run 126007

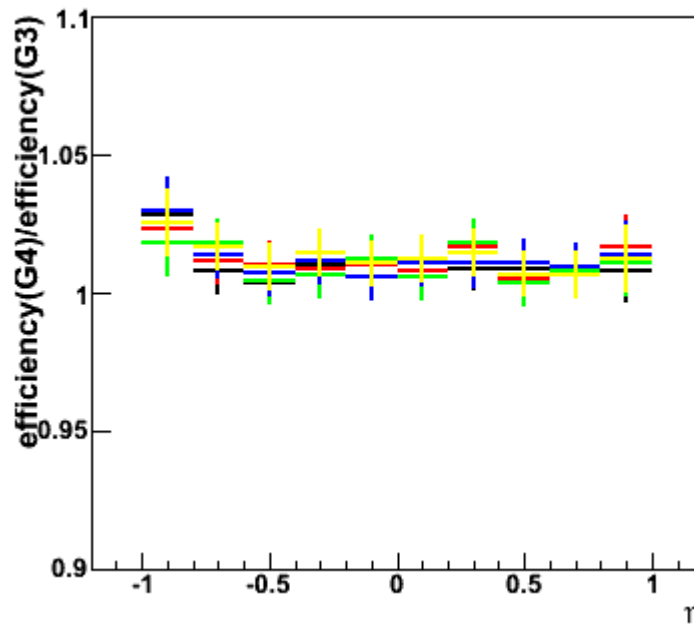
- Geant4A
- Geant4B
- Geant4C
- Geant4D
- Geant4E
- Geant3

- Averaged efficiencies(η) in Geant3 and Geant4 productions are on top of each others
- Check agreement of G3 and G4 with ratio

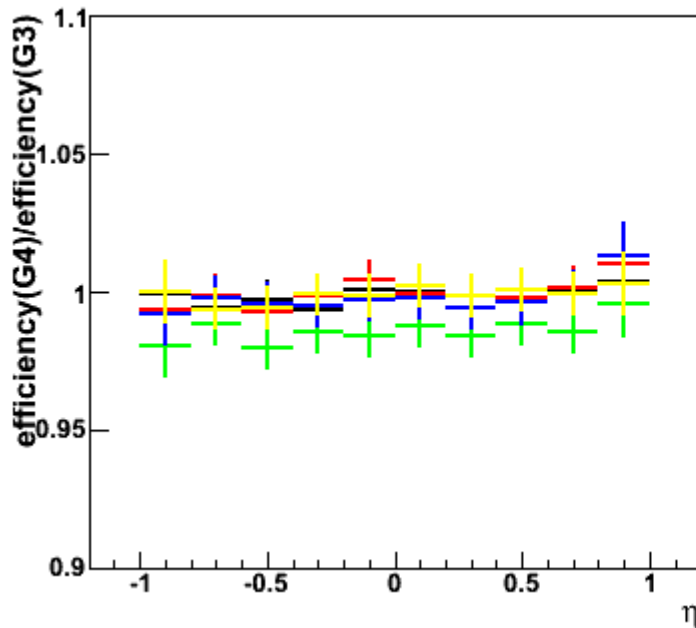
Global tracks



TPC tracks



ITS_SA tracks

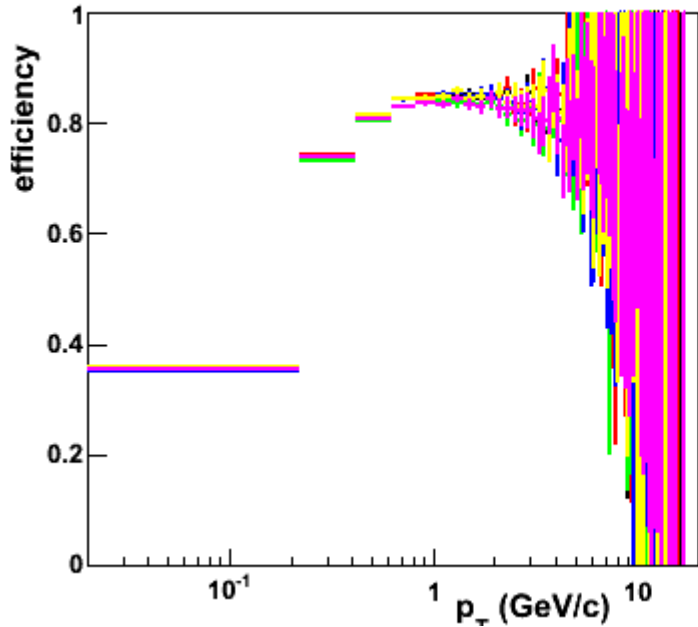
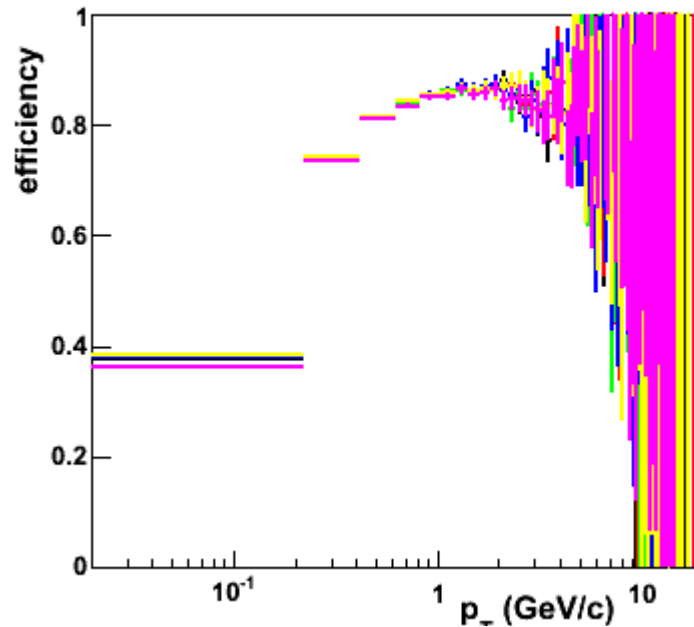
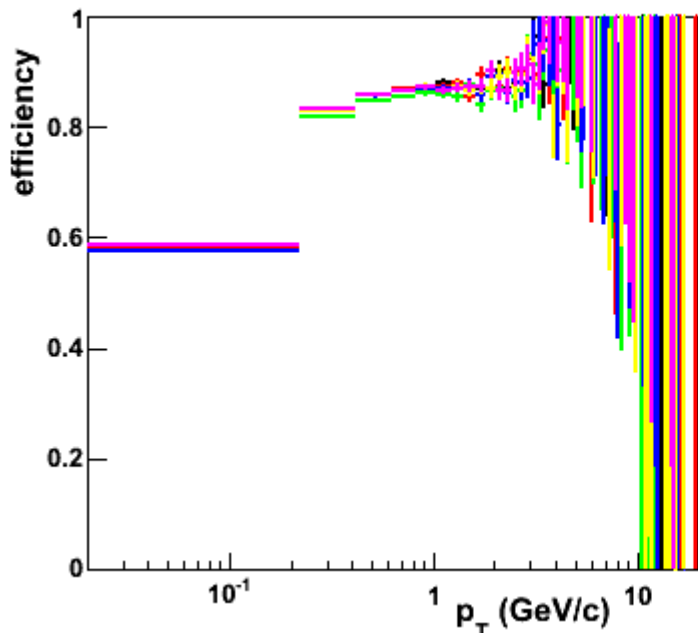

Run 126007

- Geant4A/Geant3
- Geant4B/Geant3
- Geant4C/Geant3
- Geant4D/Geant3
- Geant4E/Geant3

- Averaged efficiencies(η) in Geant3 and Geant4 productions agree within $<5\%$



Efficiency_{REC,pT}

Global tracks

TPC tracks

ITS_SA tracks

Run 126007

- Geant4A
- Geant4B
- Geant4C
- Geant4D
- Geant4E
- Geant3

- Averaged efficiencies(p_T) in Geant3 and Geant4 productions differ at low momenta
- Check agreement of G3 and G4 with ratio



Efficiency

/ Efficiency

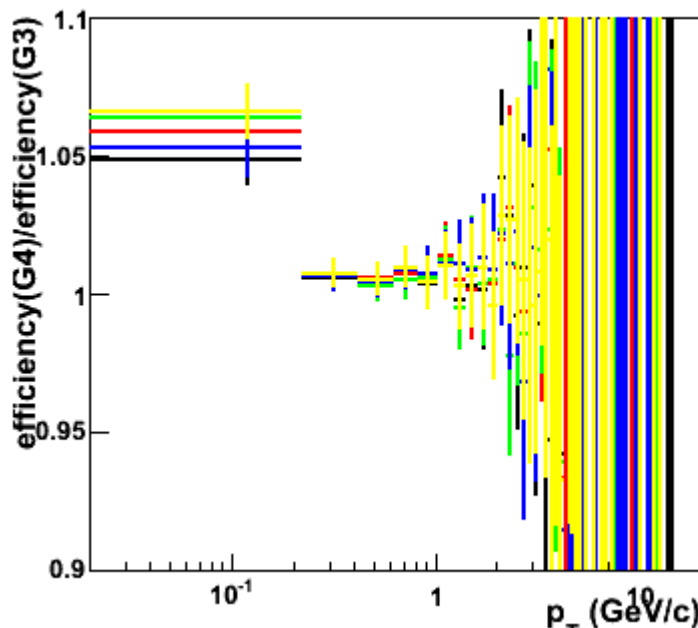
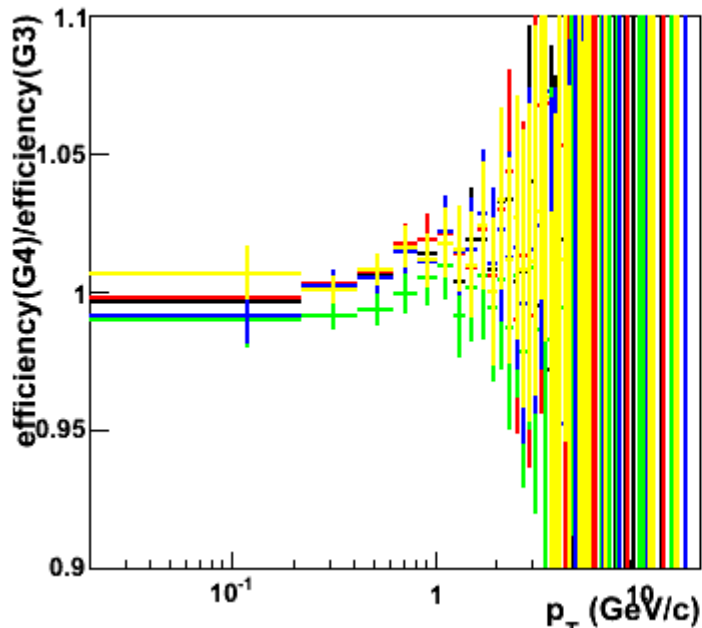


REC,pT,Geant4

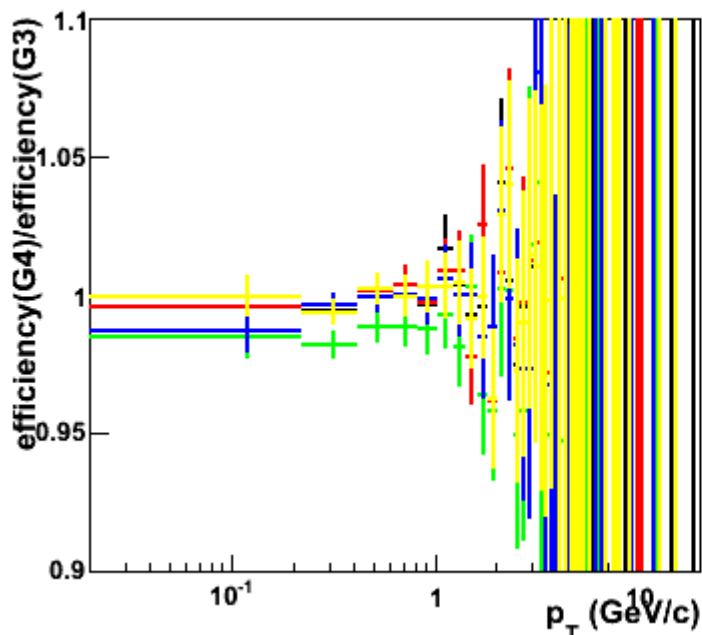
REC,pT,Geant3

Global tracks

TPC tracks



ITS_SA tracks



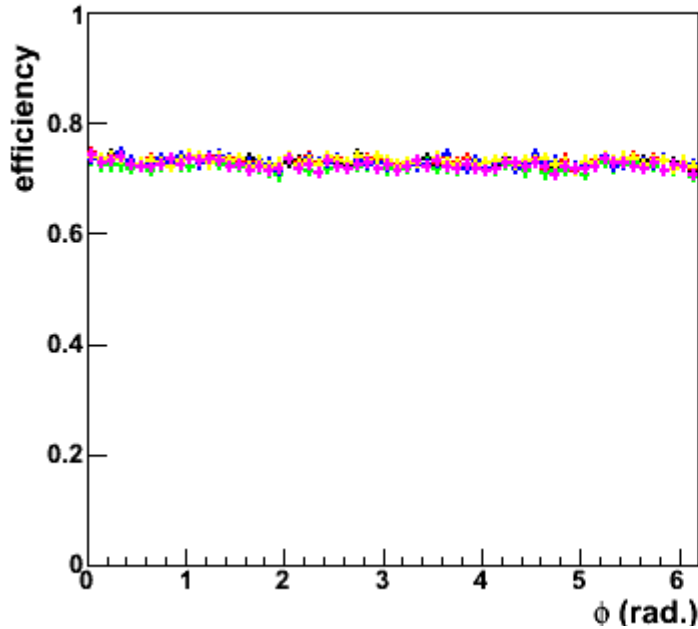
Run 126007

- Geant4A/Geant3
- Geant4B/Geant3
- Geant4C/Geant3
- Geant4D/Geant3
- Geant4E/Geant3

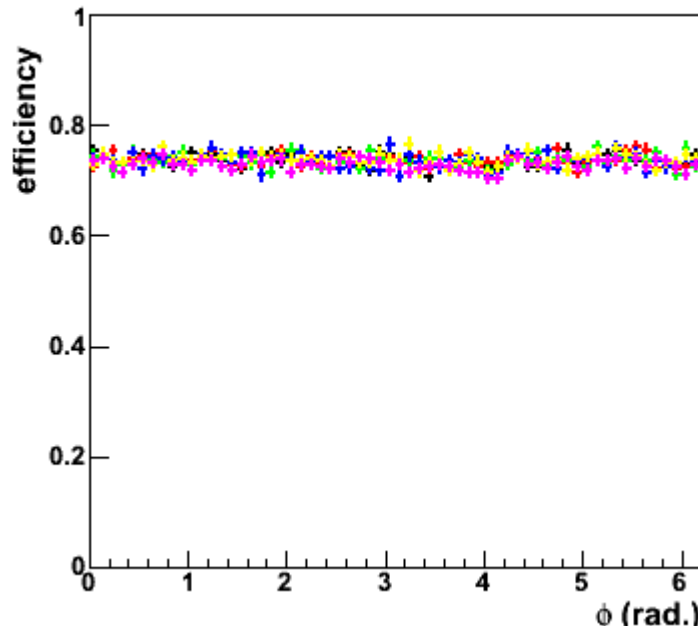
- Difference is within <7% in region with sufficient statistics
- Biggest deviation between G3 and G4 in TPC efficiency at low momenta
- Test again with higher statistics



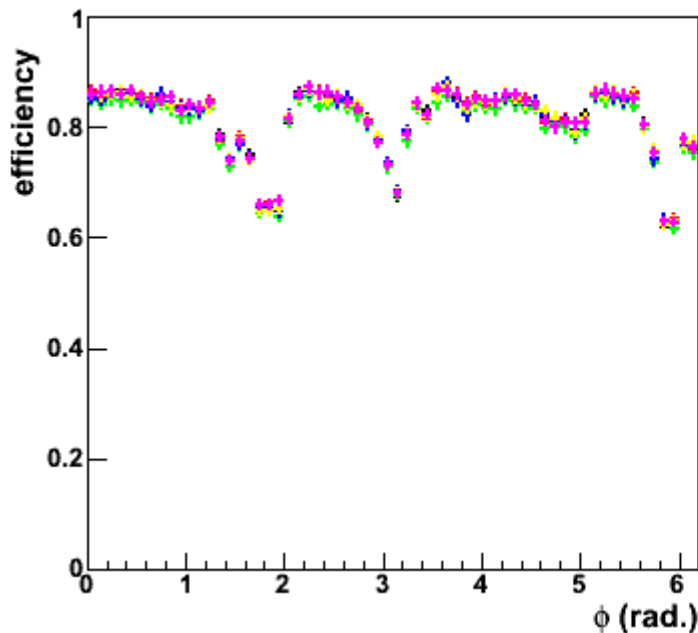
Global tracks



TPC tracks



ITS_SA tracks



Run 126007

- Geant4A
- Geant4B
- Geant4C
- Geant4D
- Geant4E
- Geant3

- Averaged efficiencies(Φ) of Geant3 and Geant4 productions are on top of each other
- Check agreement of G3 and G4 with ratio



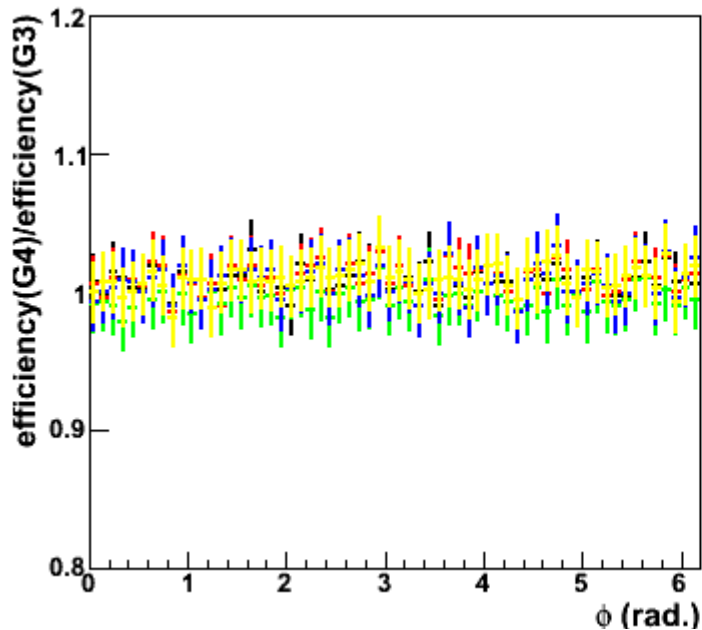
Efficiency / Efficiency



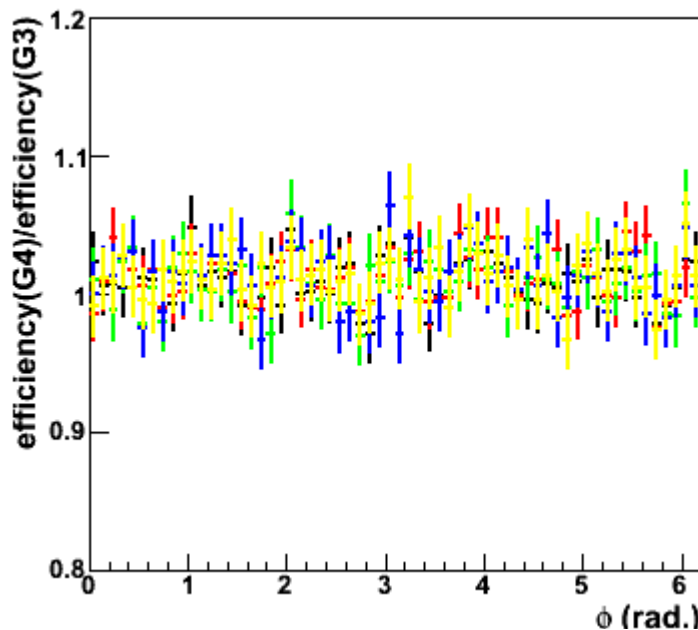
REC, Φ ,Geant4

REC, Φ ,Geant3

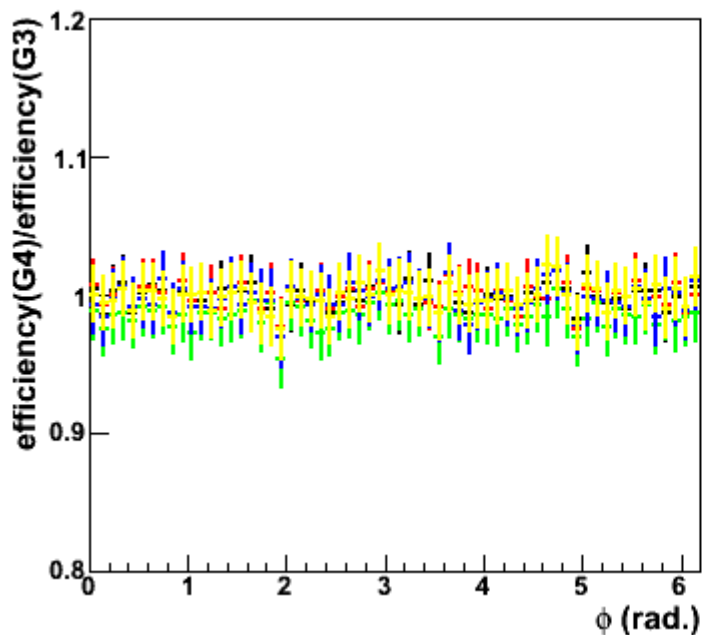
Global tracks



TPC tracks



ITS_SA tracks

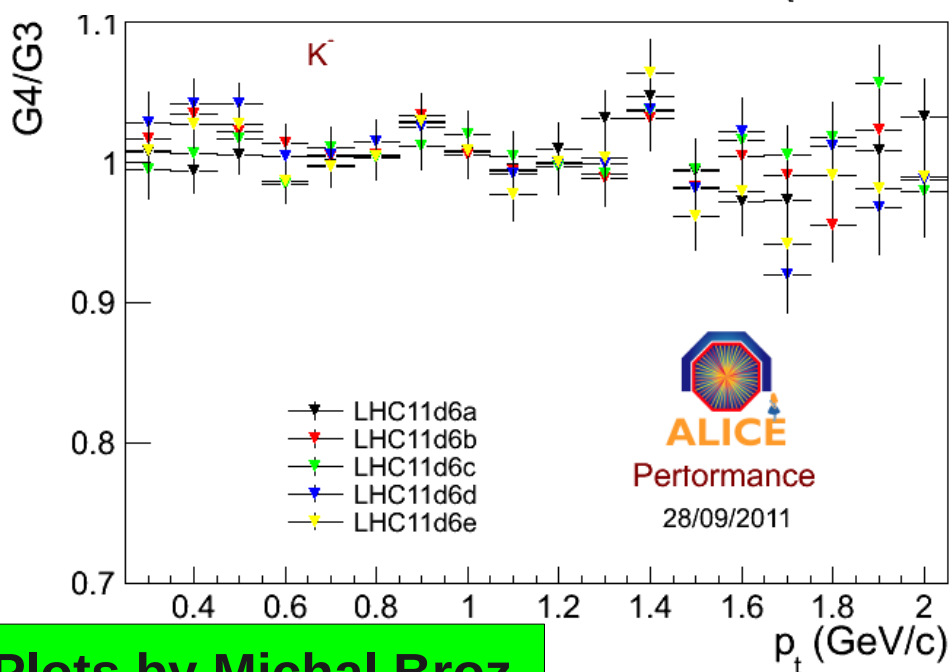
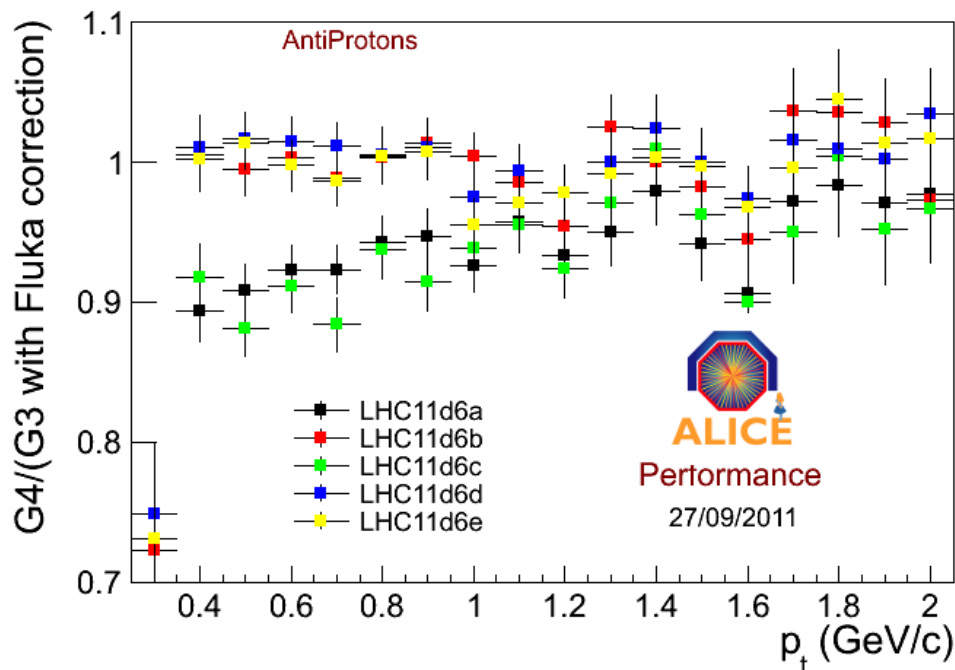
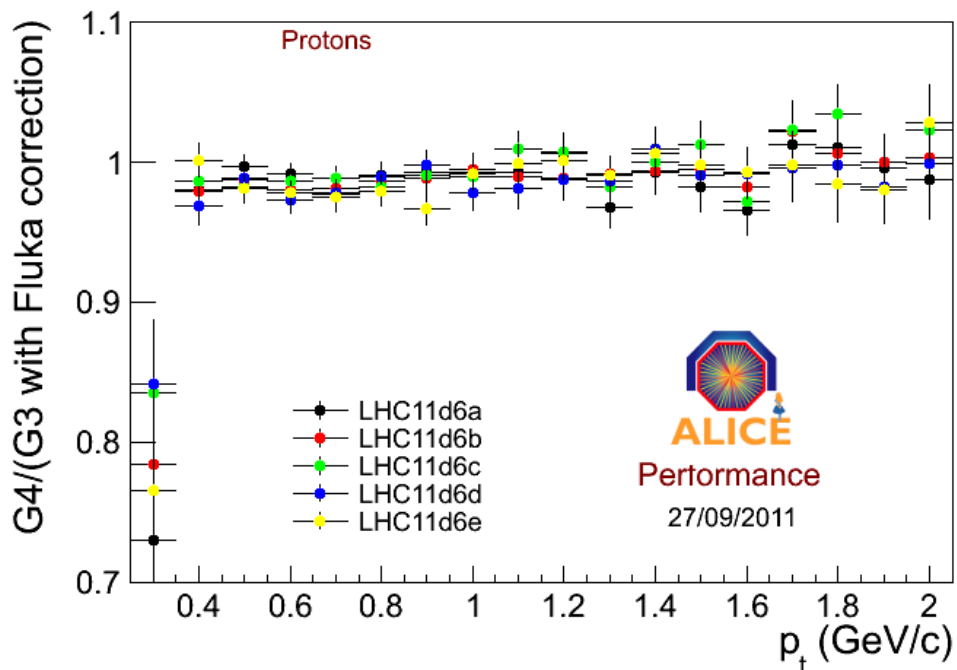


Run 126007

- Geant4A/Geant3
- Geant4B/Geant3
- Geant4C/Geant3
- Geant4D/Geant3
- Geant4E/Geant3

- Averaged efficiencies(Φ) of Geant3 and Geant4 productions agree within ~5%

Particle Absorption Efficiencies



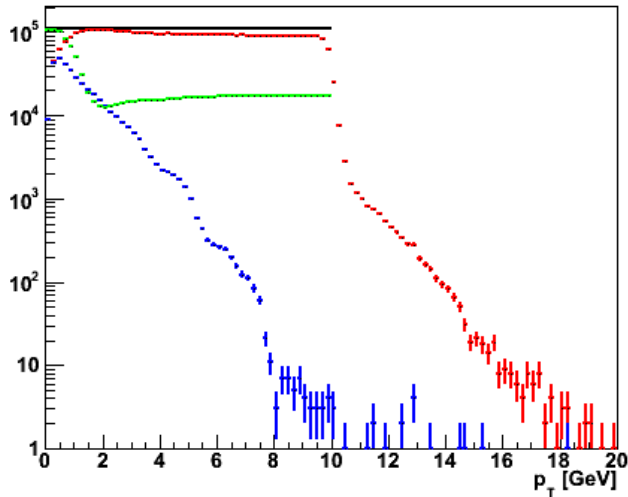
- Efficiency = ratio of generated and "Reconstructible" particles
- PL including CHIPS and FTFP give at least as good results as Fluka for p and \bar{p} , possibility to use one PL for studies of systematics
- Geant3 does not describe K^- correctly
 - G4 shows same results as G3 → None of the G4 physics lists seems any better than G3 for the K^-



Simulations of nuclei and anti-nuclei

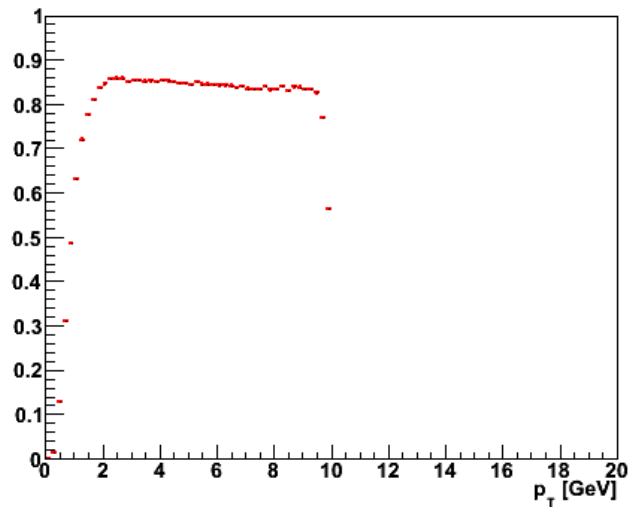
Nuclei (Global tracks)

- Production LHC11d6g has produced nuclei and anti-nuclei
- Compare number of generated particles and reconstructed tracks for nuclei and anti-nuclei separately
- Check difference in reconstruction efficiency

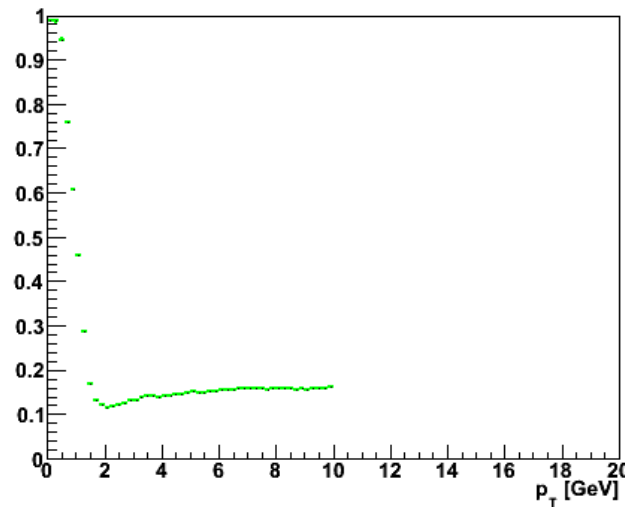


— MC
- - - Reconstructed
- - - Fake Tracks
— MC not reconstructed

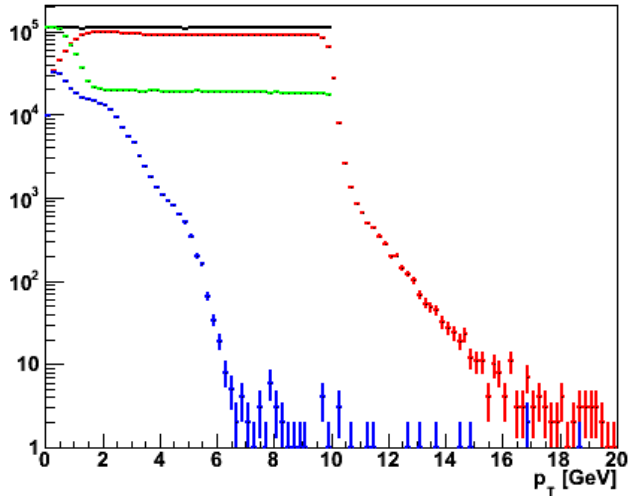
Efficiency



Inefficiency from non-rec. MC tracks



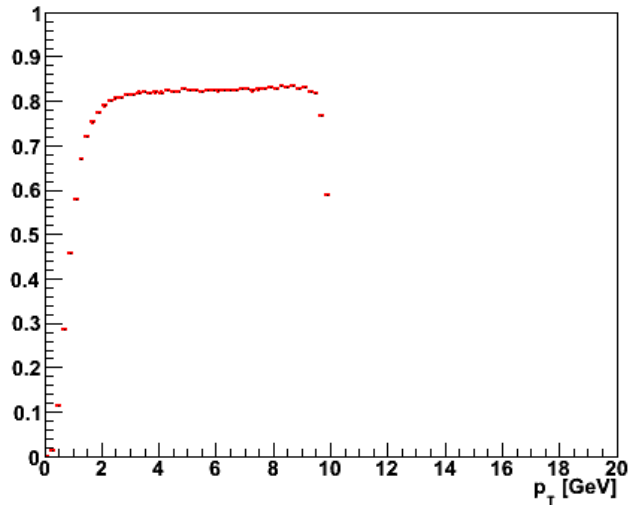
Anti-nuclei (global tracks)



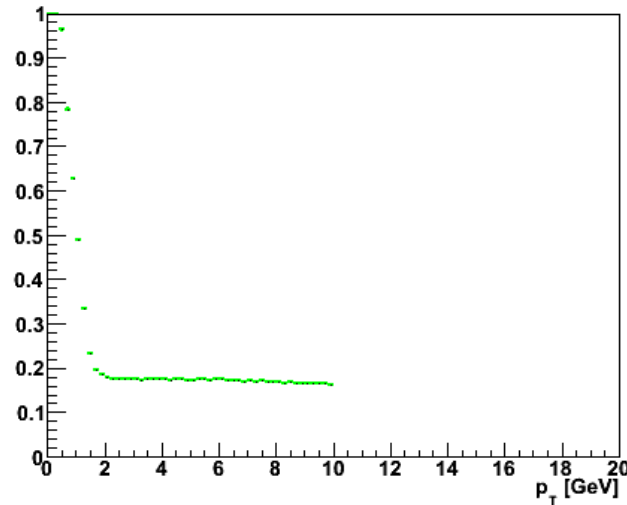
- MC
- Reconstructed
- Fake Tracks
- MC not reconstructed

- Production LHC11d6g has produced nuclei and anti-nuclei
- Compare number of generated particles and reconstructed tracks for nuclei and anti-nuclei separately
- Check difference in reconstruction efficiency

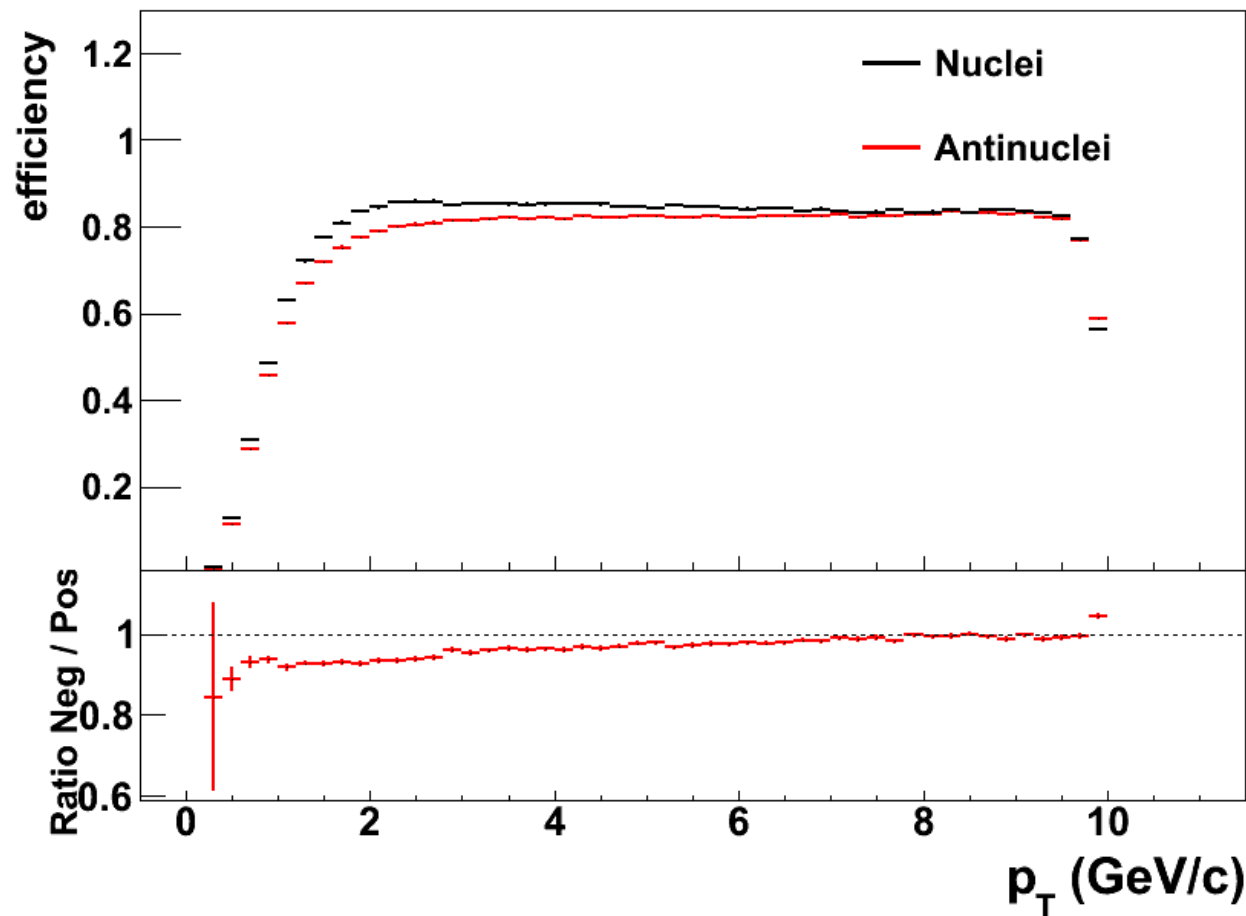
Efficiency



Inefficiency from non-rec. MC tracks



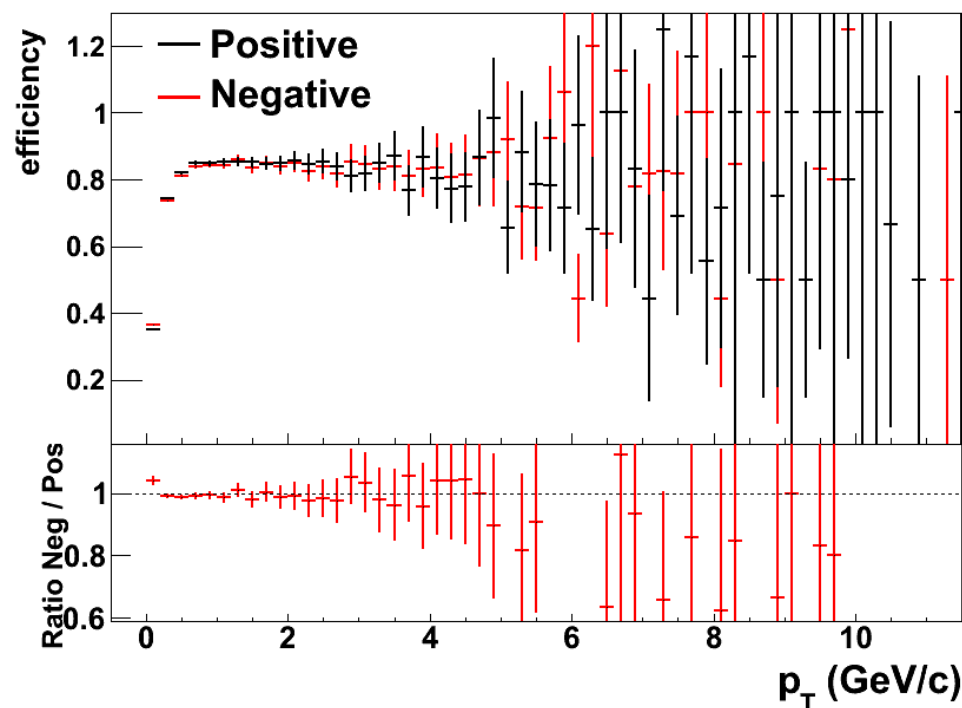
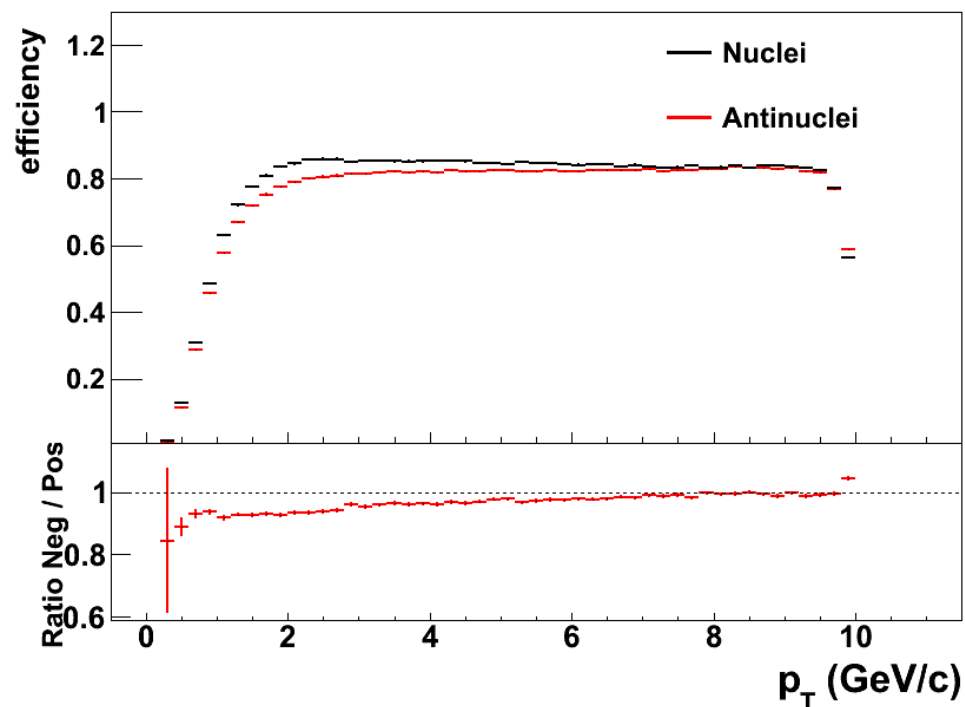
Comparison of Efficiencies (Global Tracks)



- Reconstruction efficiency for anti-nuclei is lower compared to nuclei
- Visible effect of absorption

- Lower value of reconstruction efficiency for anti-nuclei than for nuclei

Efficiency Ratios (Global tracks)



- Cross check:
 - Left: LHC11d6g (nuclei+anti-nuclei cocktail)
 - Right: LHC11d6e (Pythia Perugia0)
- For Perugia0, efficiencies of positive and negative particles are more close to each other

Summary

- 6 Geant4 productions
 - 5 using Pythia
 - 1 using nuclei cocktail
- Reconstruction efficiencies in Geant4 simulations in ITS and TPC are finally similar to those obtained in Geant3
- Reconstruction efficiency of anti-nuclei and nuclei look promising
- Small differences between distributions of secondary particles, e.g.:
 - Geant4 simulations produce extremely low energetic particles
 - No secondary particles coming from delta ray process in Geant4