

Update of the muon simulations

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Outline

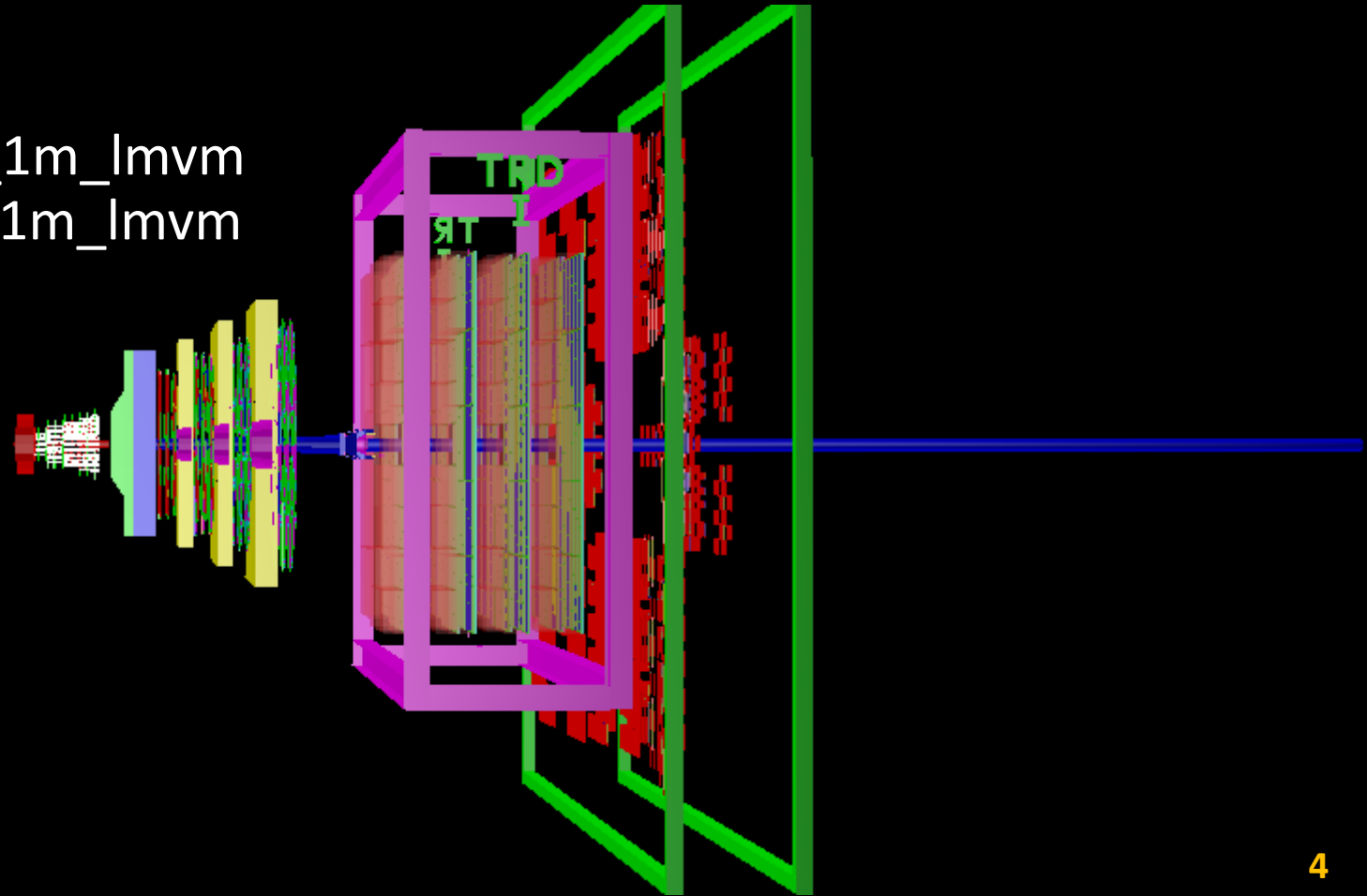
- Validation of the new MUCH geometry
- GEANT3 vs. GEANT4 issue
- Conclusions

Input

- cbmroot master git version
- Software apr21p2
 - GEANT4-10-7-1 (2020-2021)
- UrQMD
/lustre/cbm/prod/gen/urqmd/auau/8gev/centr/urqmd.auau.8gev.centr.*.root
- PLUTO
/lustre/cbm/prod/gen/pluto/auau/cktA/8gev/omega/mpmm/pluto.auau.8gev.omega.mpmm.*.root

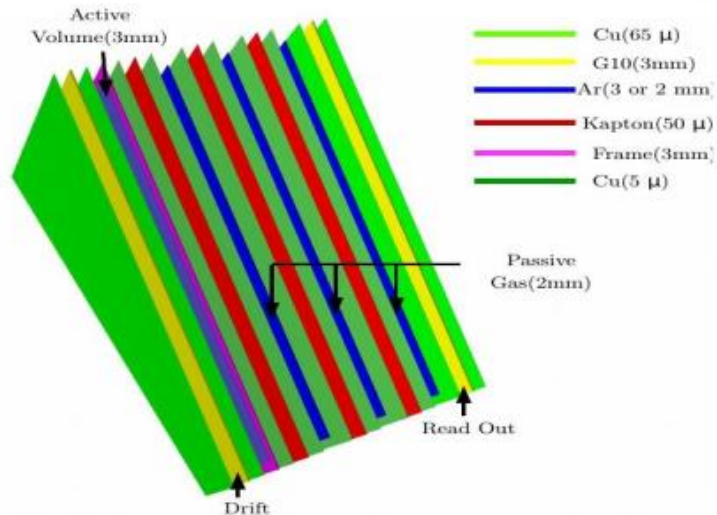
Geometry

- magnetGeoTag = v22b
- pipeGeoTag = v21d:v21i
- stsGeoTag = v22c
- muchGeoTag = v21c_sis100_1m_1mvm
v20c_sis100_1m_1mvm
- trdGeoTag = v20c_1m
- tofGeoTag = v21a_1m
- platGeoTag = v22b
- fieldTag = v22b

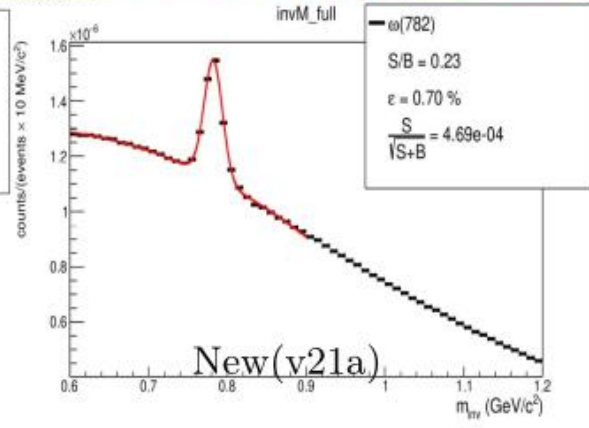
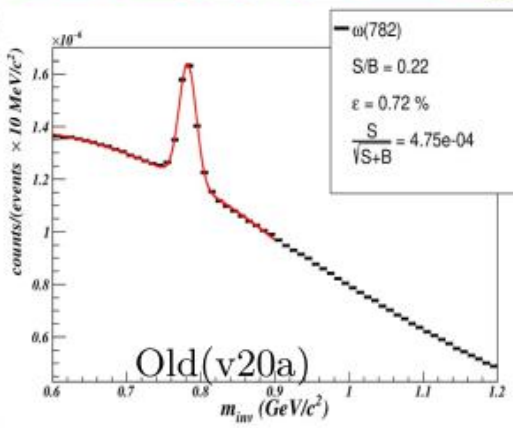
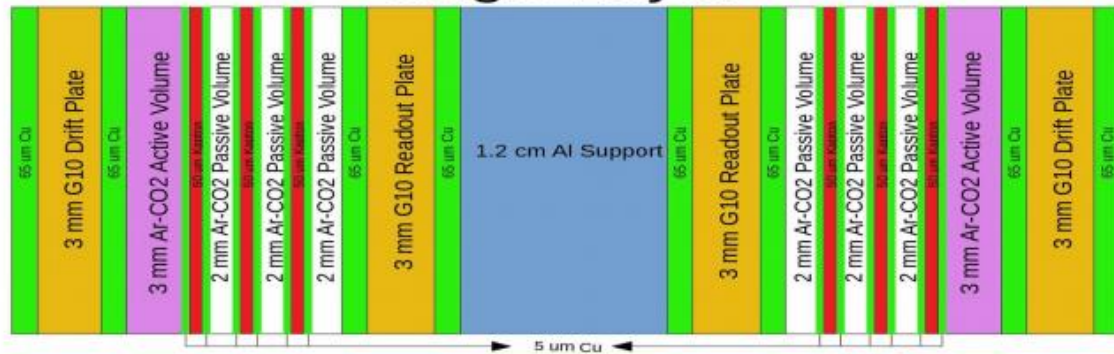


Implementation of realistic geometry, gas mixture and material budget for GEM chambers

- Implementation of 6 mm passive volume
- Implementation of GEM foils
- Implementation of realistic gas mixture Ar/CO₂ in 70/30 volume ratio
- Implementation of the optimized Al cooling plate
- Total thickness : 15.44 mm



Updated Configuration of MuCh for single Layer

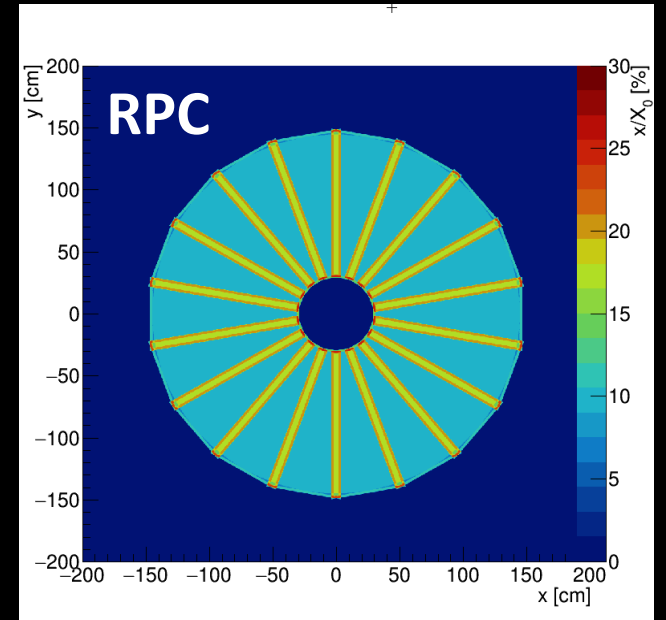
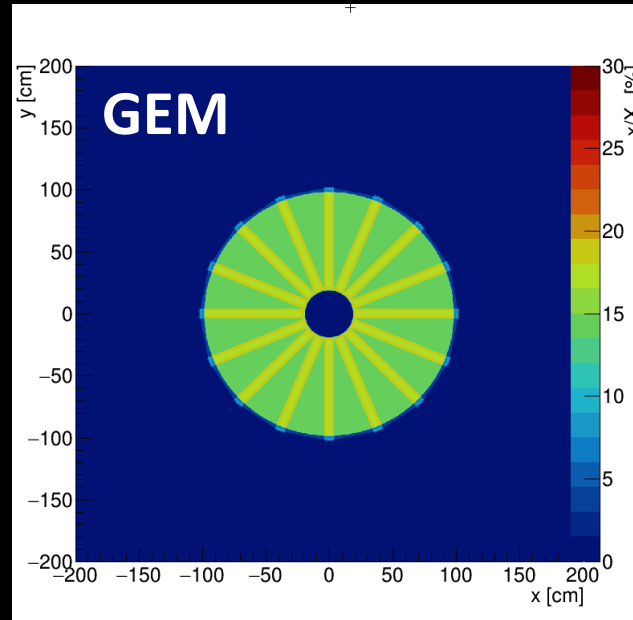


Ref: Internal note is under preparation

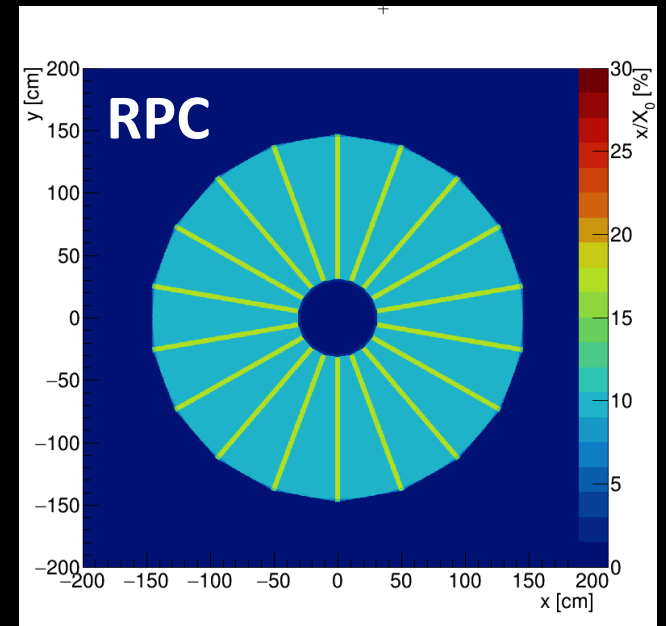
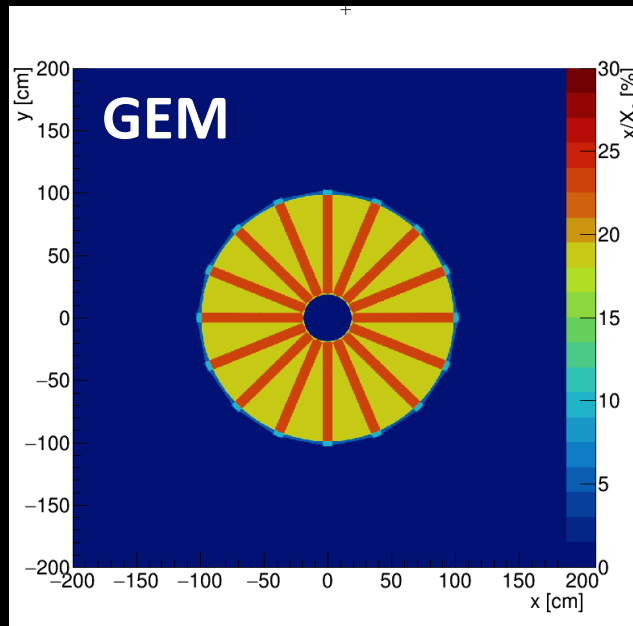
NOTE: v21a, Not committed yet to repository. Will be include in upcoming release.

Material budget

v20c

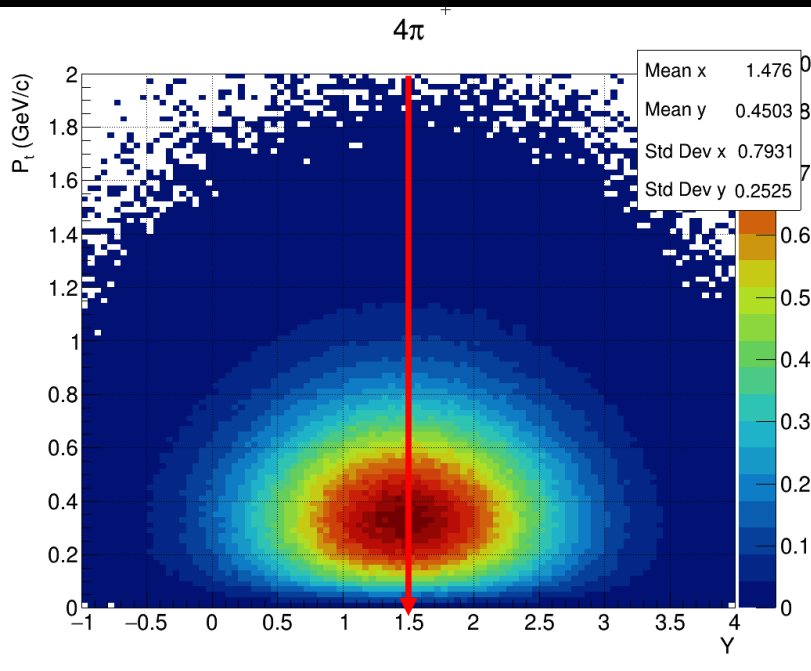


v21c

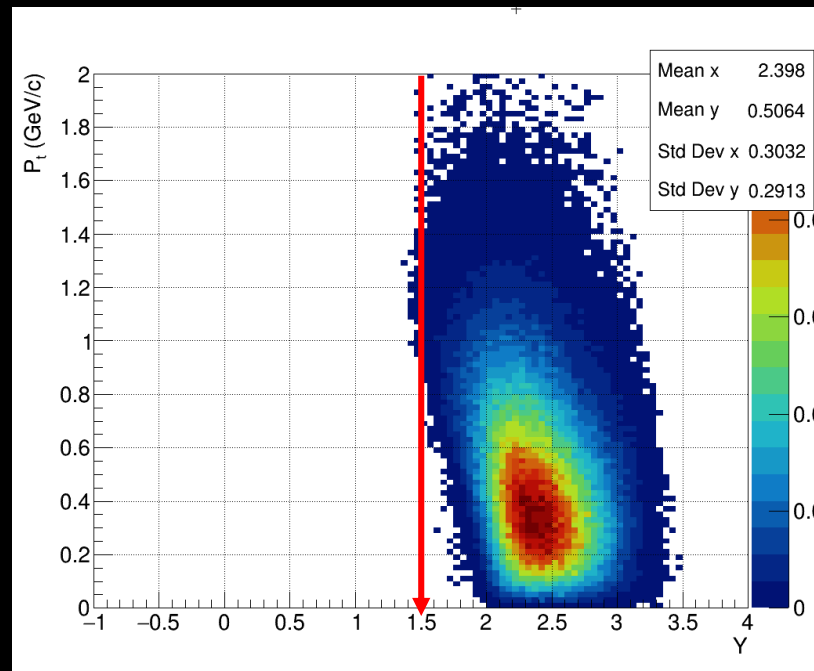


ω MC acceptance

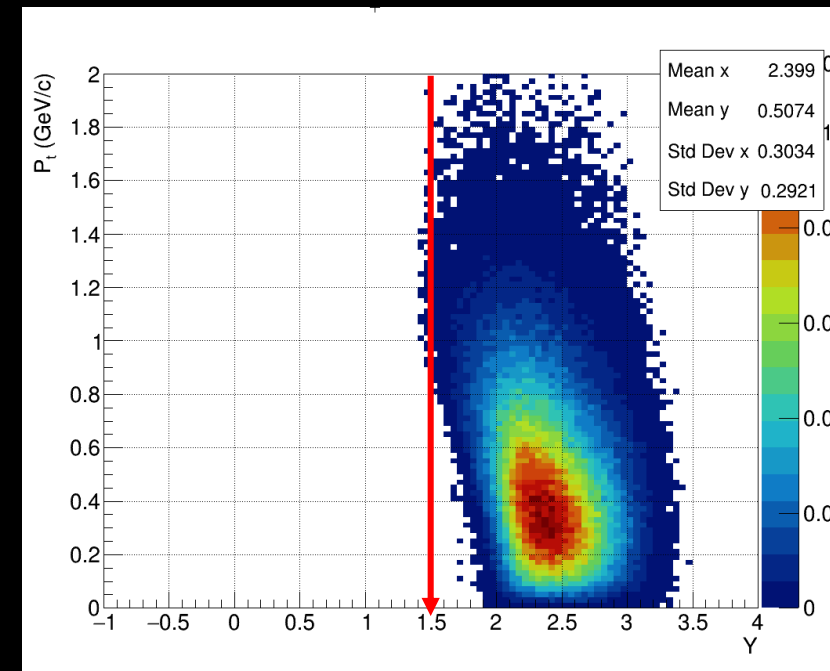
4π



v20c

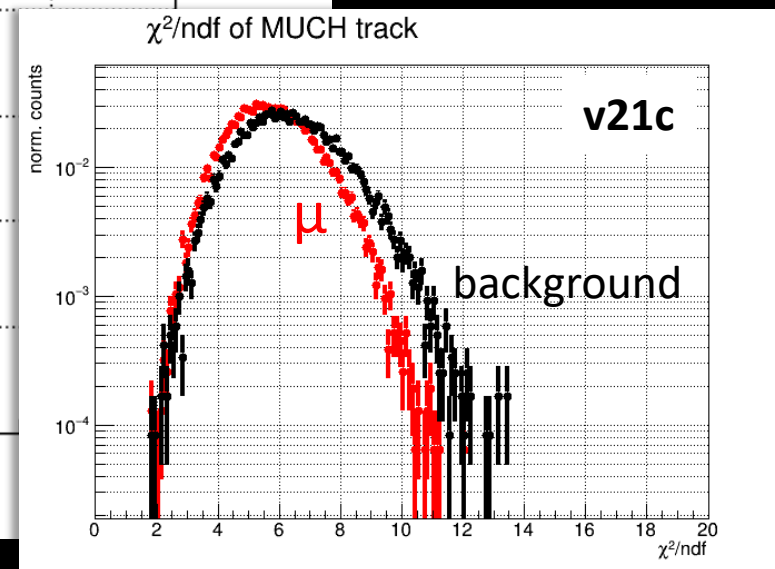
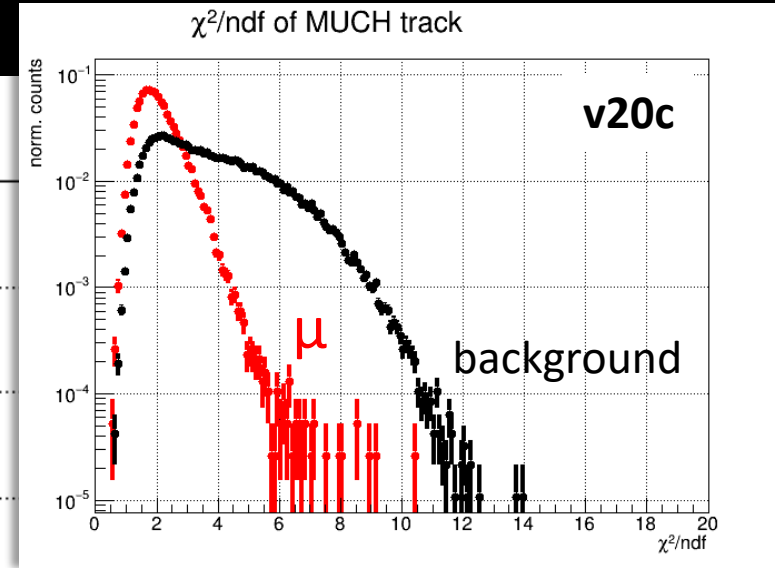
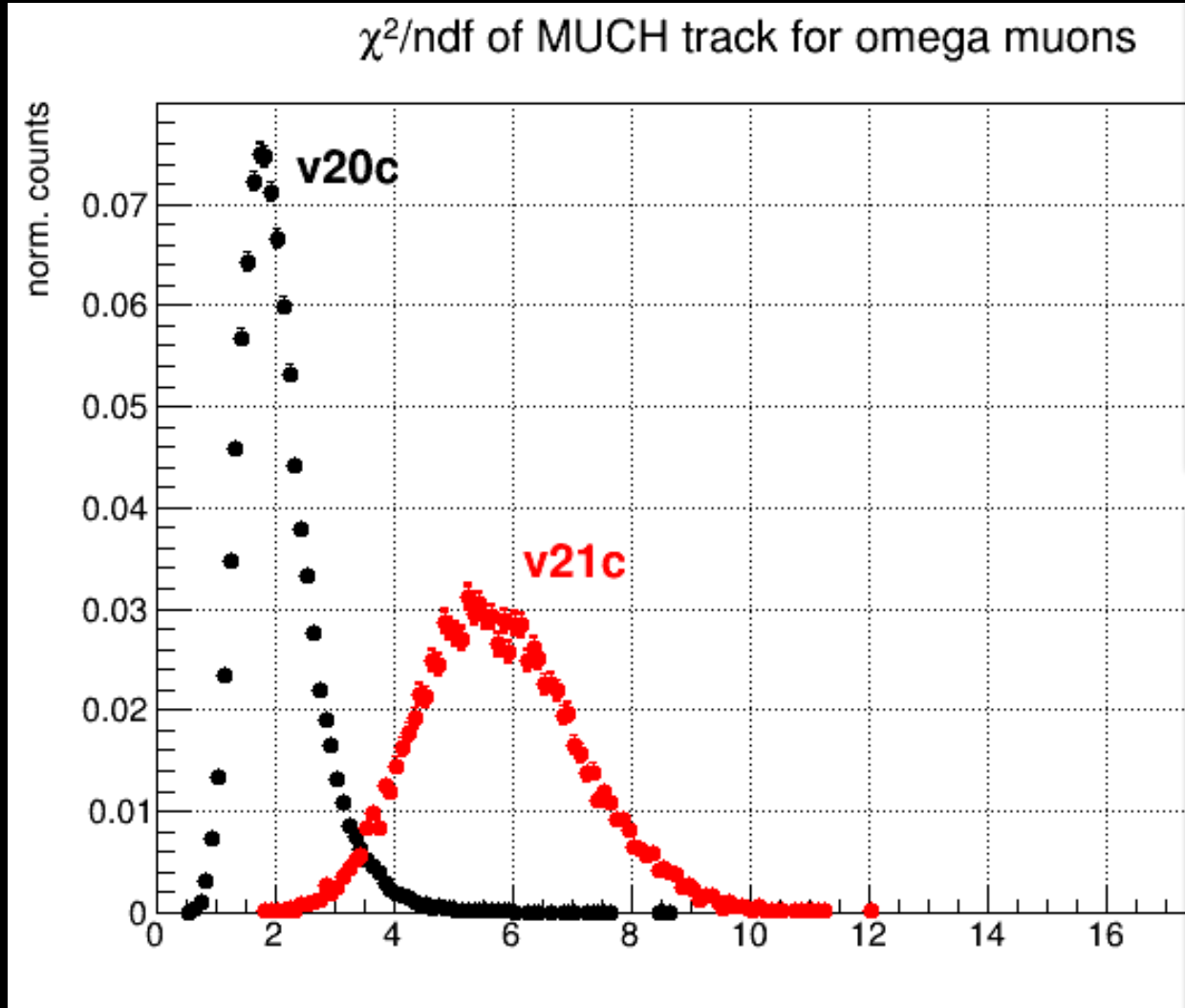


v21c



χ^2/ndf of tracks in MUCH

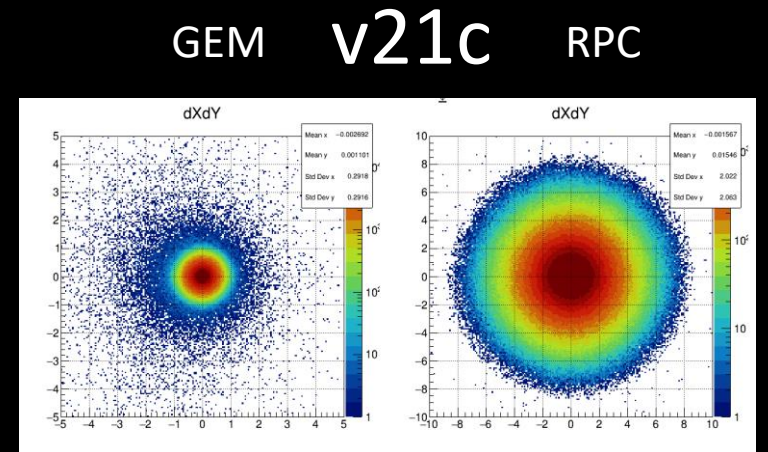
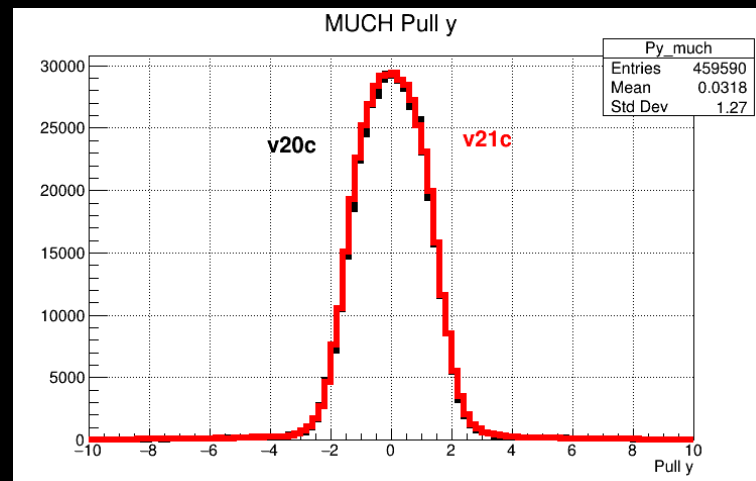
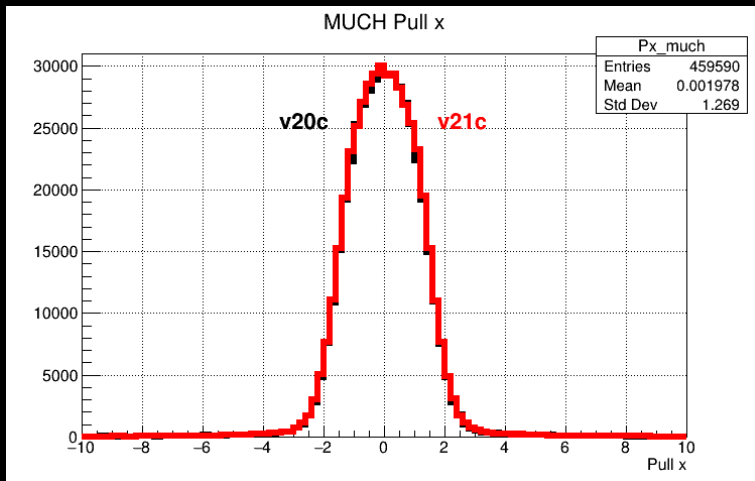
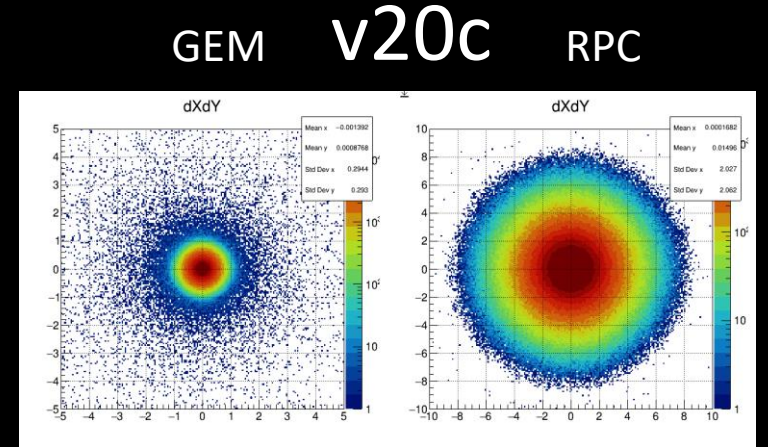
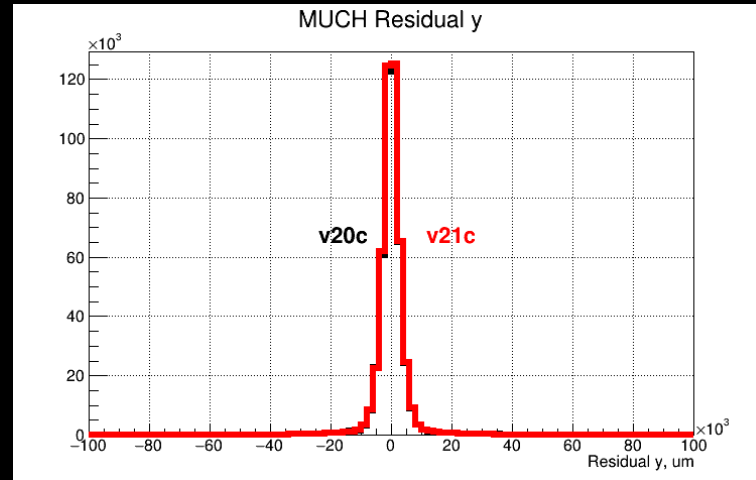
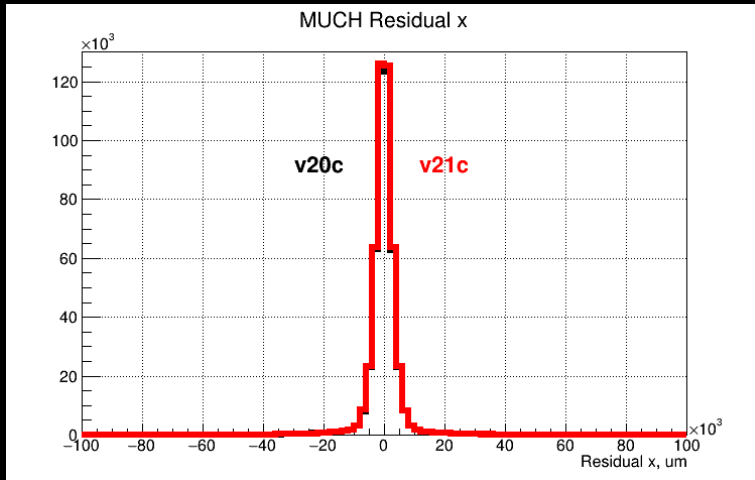
SetChi2MuchCut(20.)
SetChi2StsCut(3.)
SetChi2VertexCut(3.)
SetNofMuchCut(10)
SetNofStsCut(4)
SetNofTrdCut(1)
SetSigmaTofCut(3)



littreck takes into account all materials

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***** CbmLitMaterialEffectsImp::Update - MUCH material muchstation01layer3supportAl_0
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Hit coordinates



L1 performance

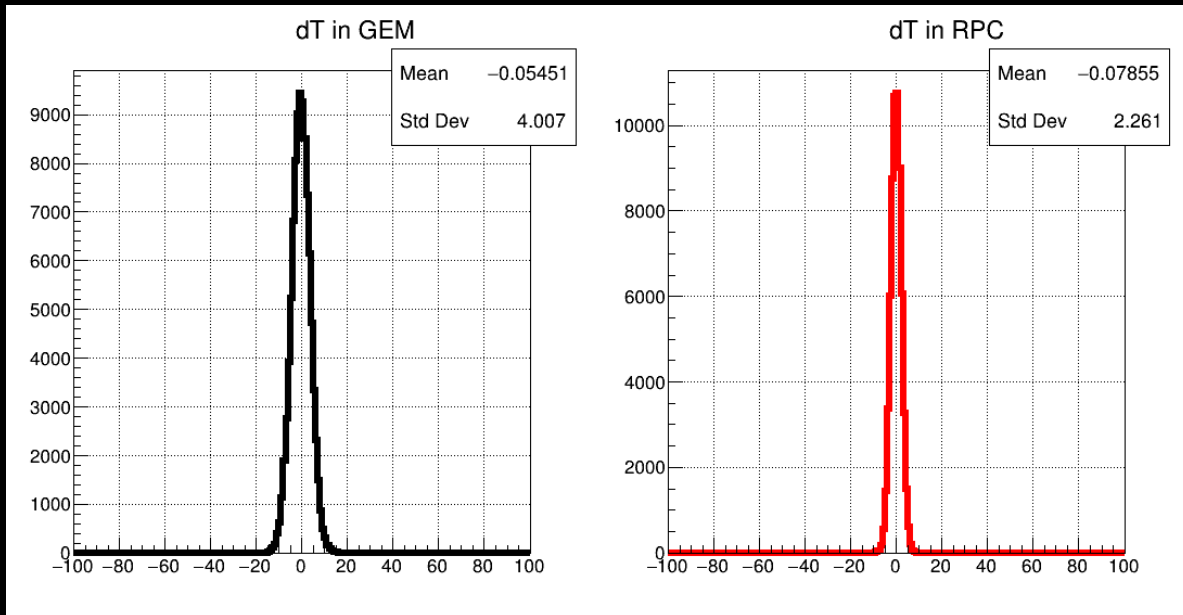
Time from MUCH hits

$$\chi^2_{\text{MUCH}}(x, y, t)$$

v20c

GEM

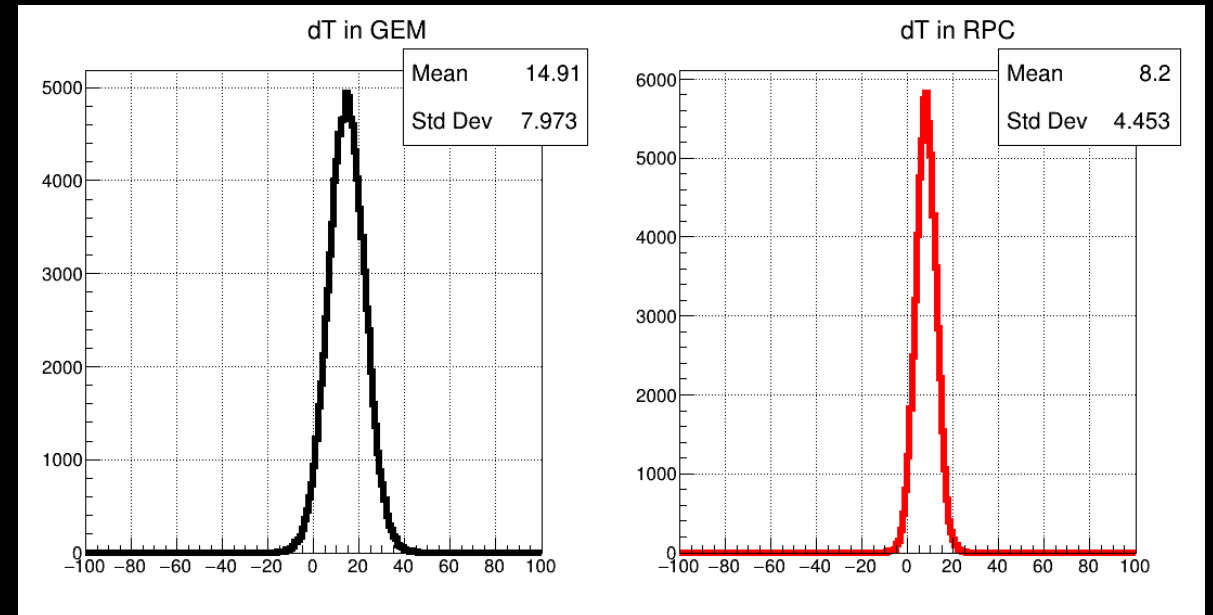
RPC



v21c

GEM

RPC



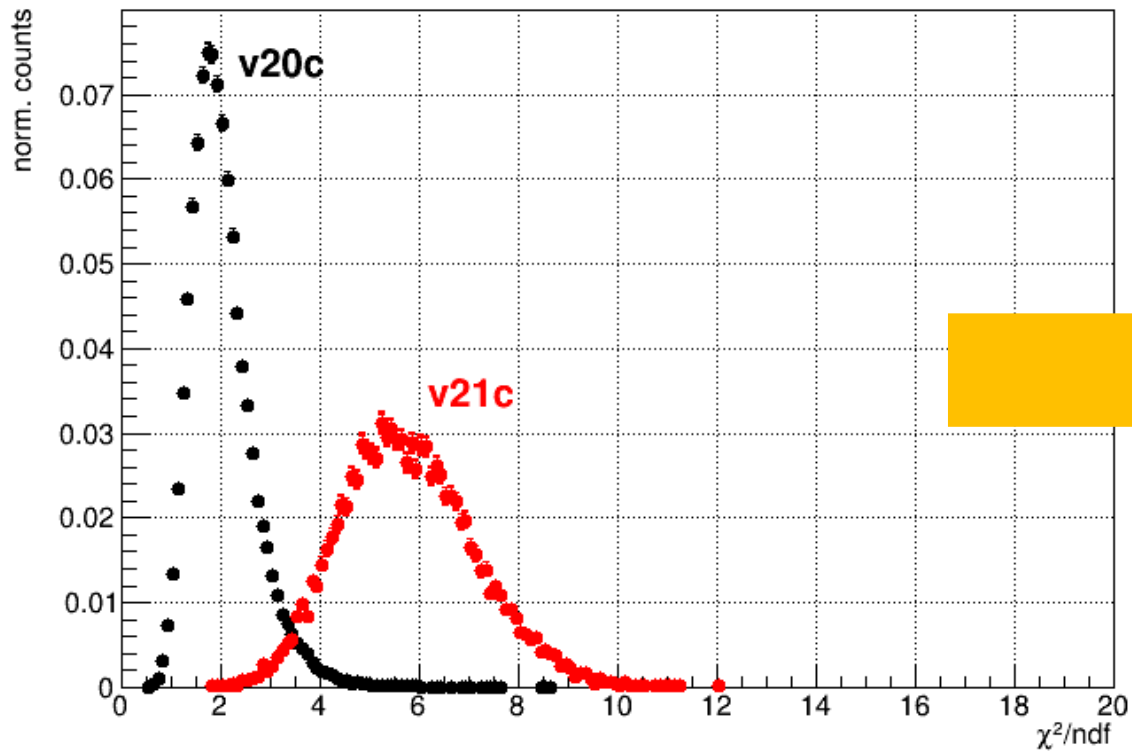
The drift time correction for GEM and RPC hits was not adopted to new geometry

χ^2/ndf of tracks in MUCH

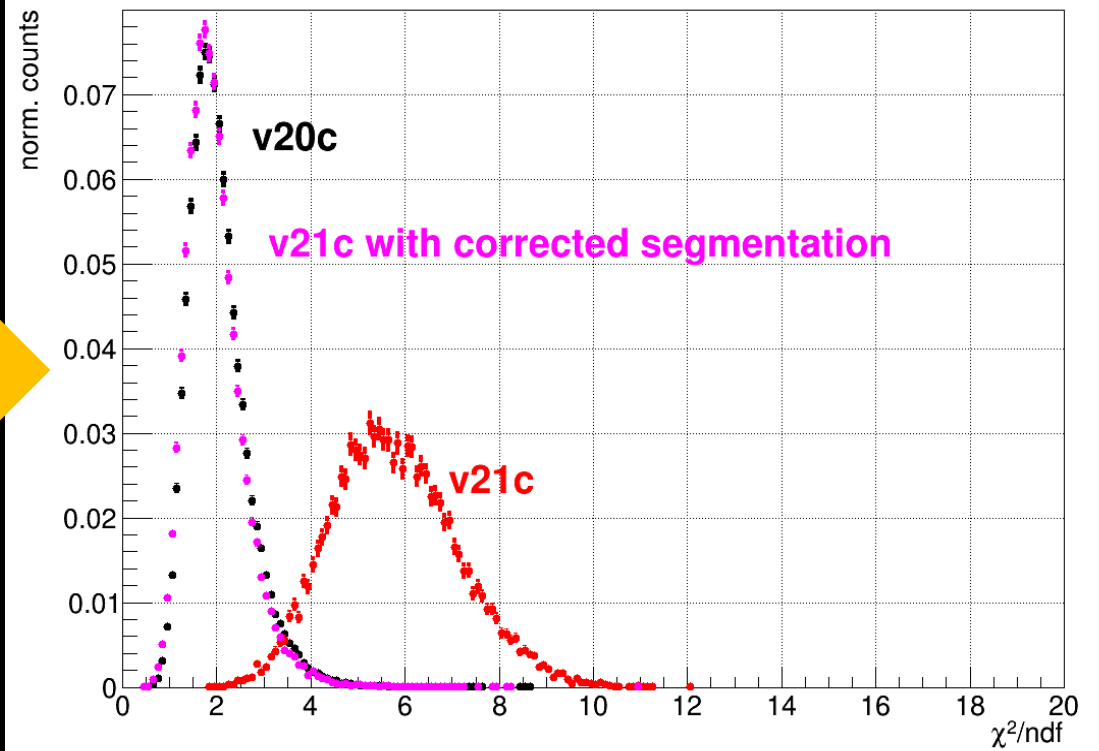
<https://redmine.cbm.gsi.de/issues/2452> is closed

SetChi2MuchCut(20.)
SetChi2StsCut(3.)
SetChi2VertexCut(3.)
SetNofMuchCut(10)
SetNofStsCut(4)
SetNofTrdCut(1)
SetSigmaTofCut(3)

χ^2/ndf of MUCH track for omega muons



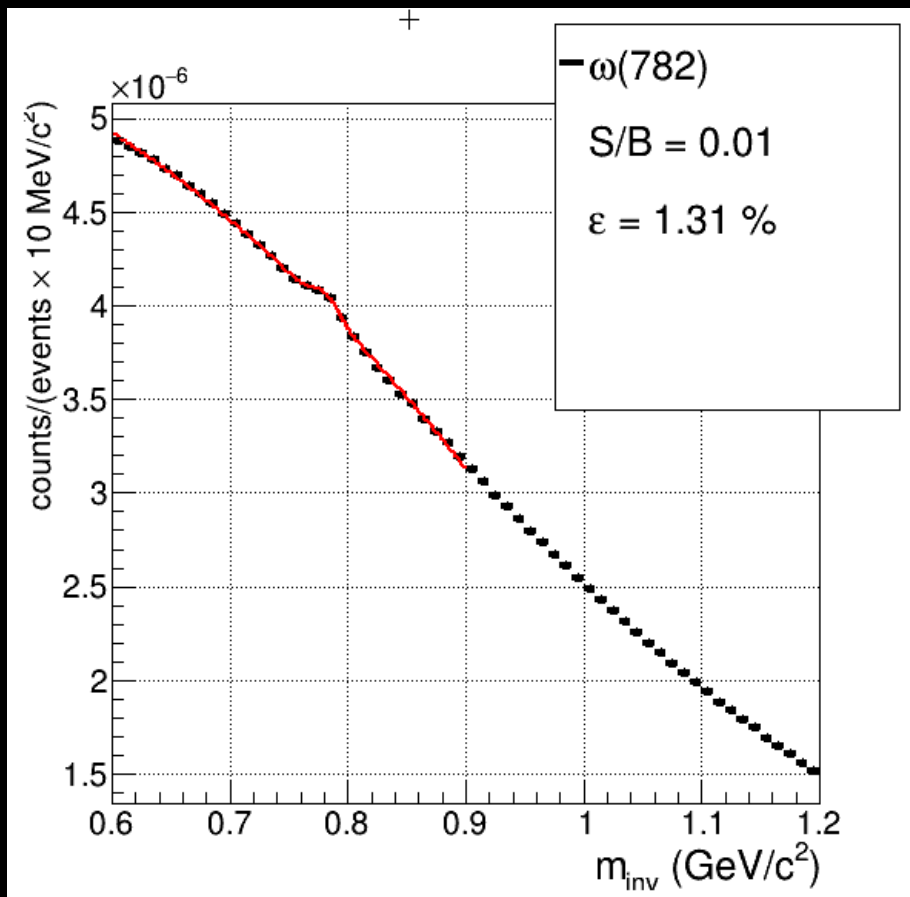
χ^2/ndf of MUCH track for omega muons



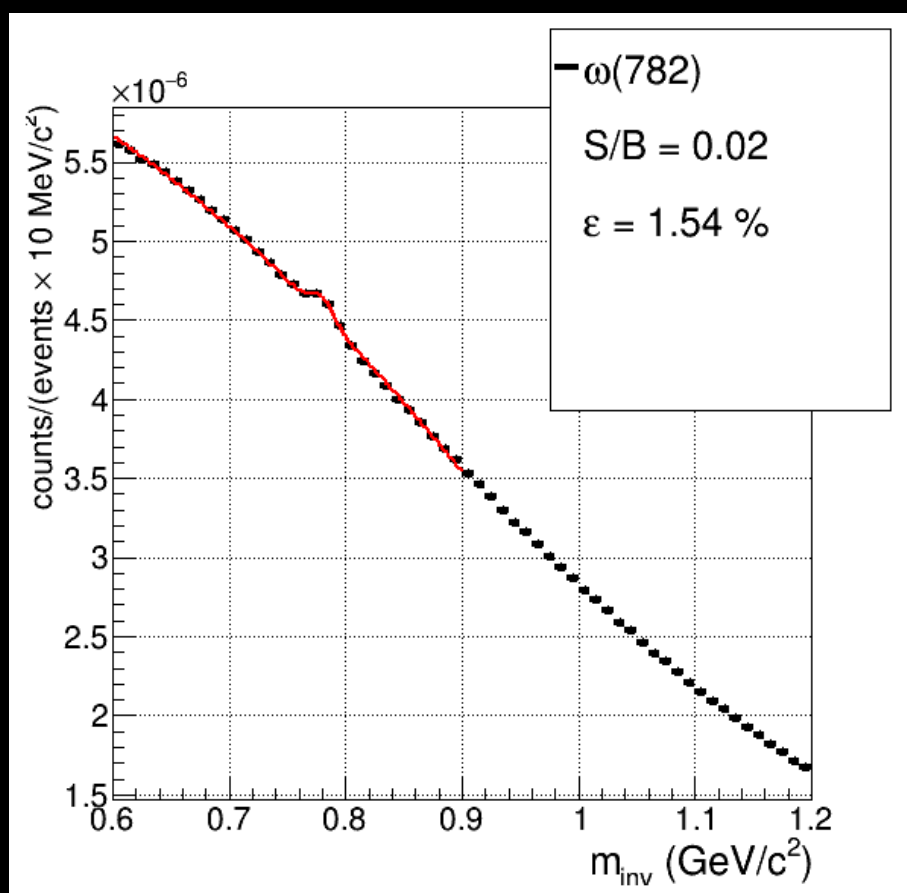
Invariant mass spectra

ω multiplicity 2.28721
 $\mu\mu$ branching ratio $7.4e-5$

v20c



v21c



Cuts:

N of STS hits ≥ 4

N of MUCH hits ≥ 10

N of TRD hits ≥ 1

$\chi^2_{\text{vertex}} \leq 3.0$

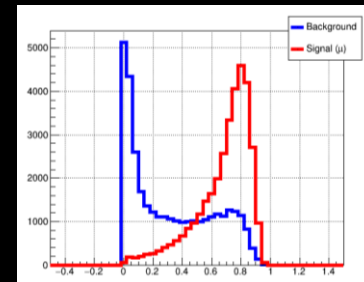
$\chi^2_{\text{STS}} \leq 3.0$

$\chi^2_{\text{MUCH}} \leq 3.0$

3σ cut in TOF

ANN for cuts optimization for v21c

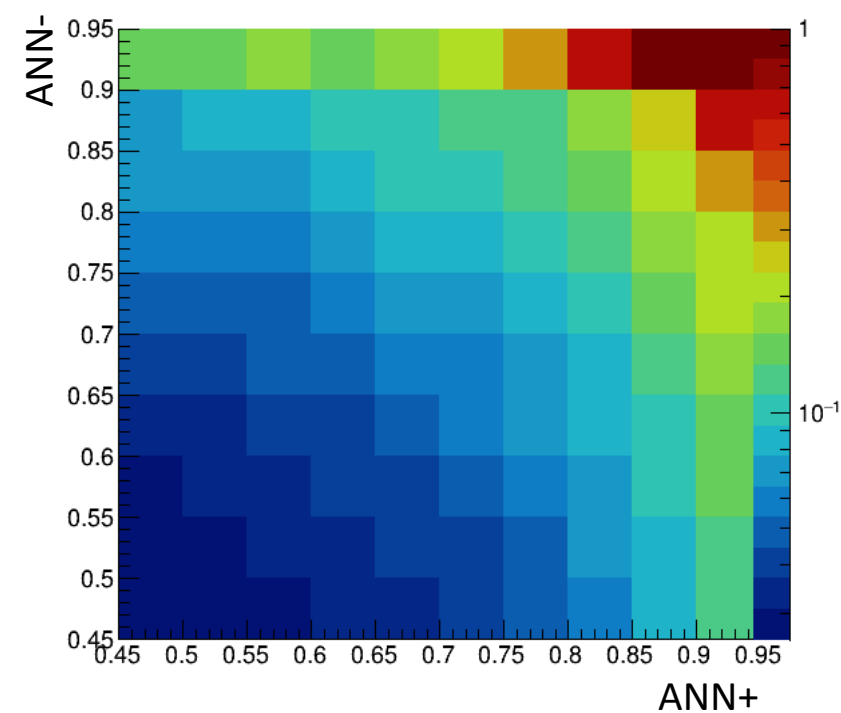
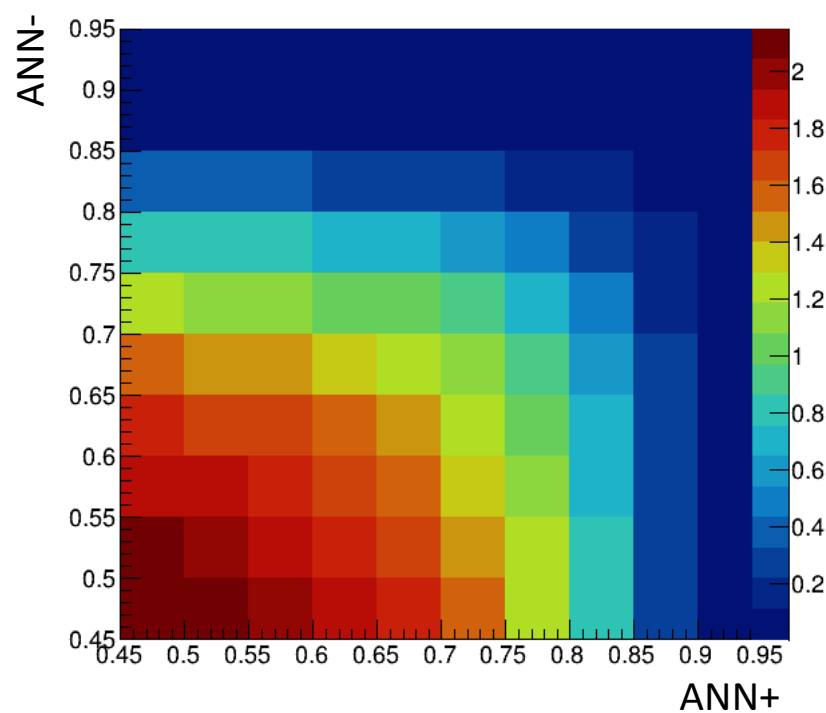
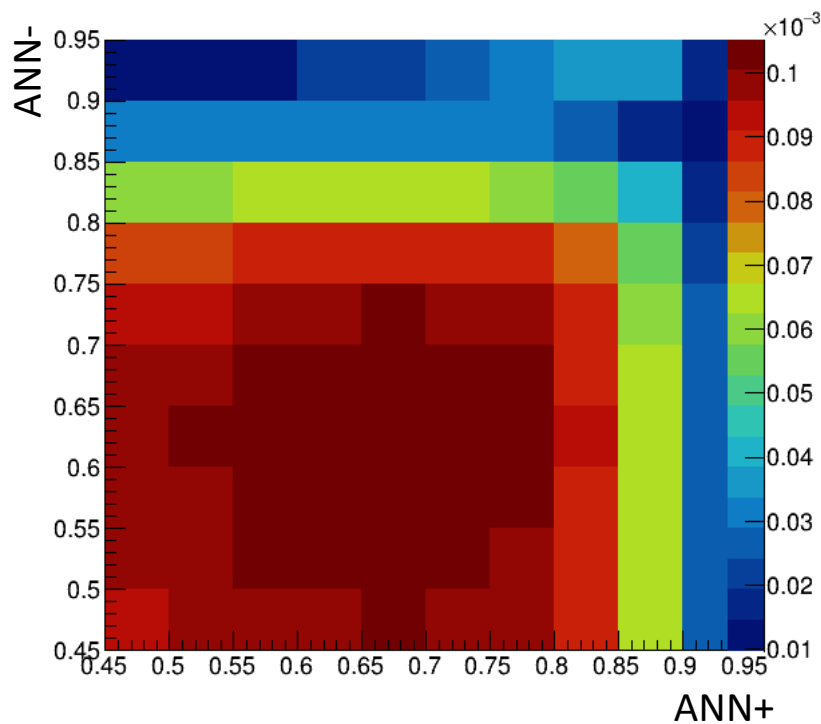
χ^2_{Vertex}
 χ^2_{STS}
 χ^2_{MUCH}
momentum
 m^2_{TOF}



Significance

Efficiency

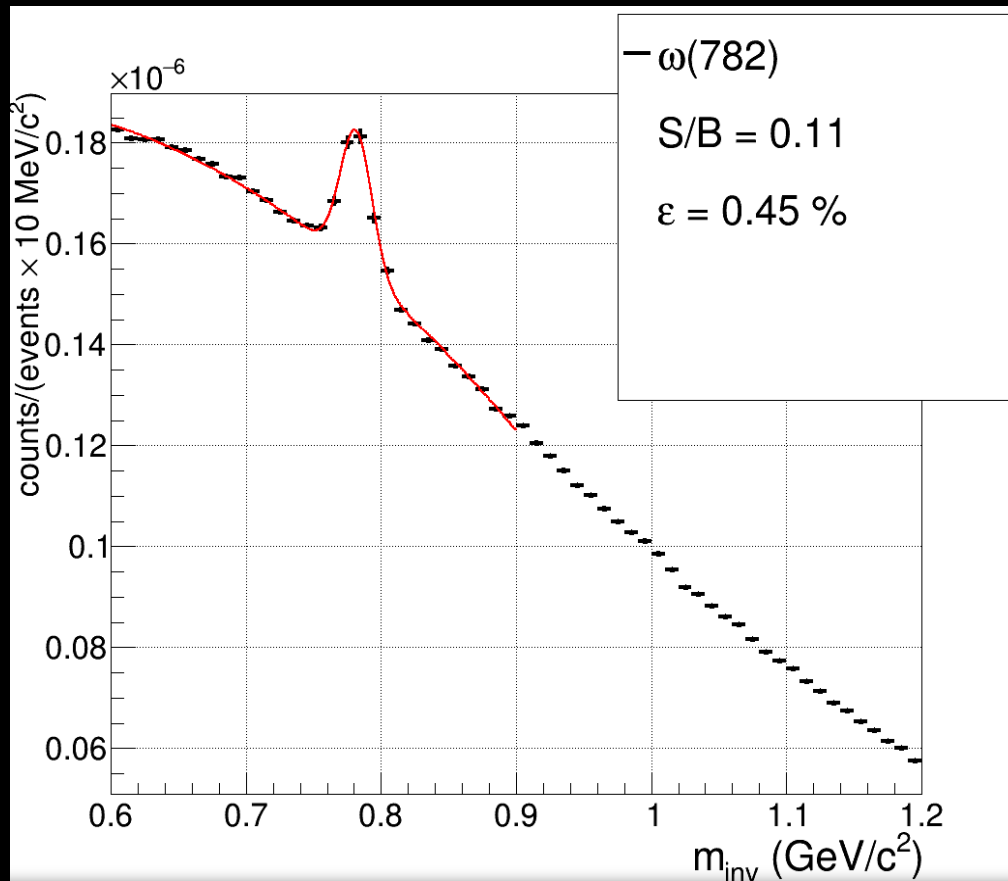
ω /background ratio



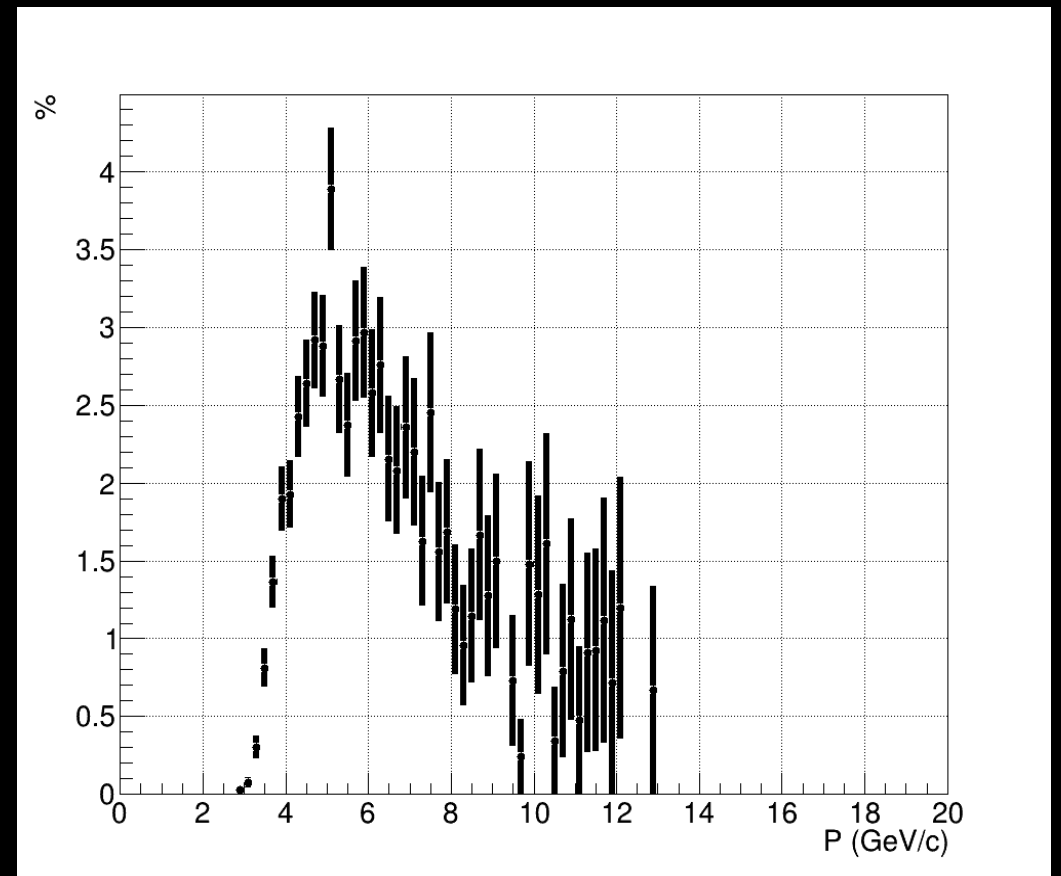
$\omega \rightarrow \mu\mu$

$ANN_- > 0.8, ANN_+ > 0.8$

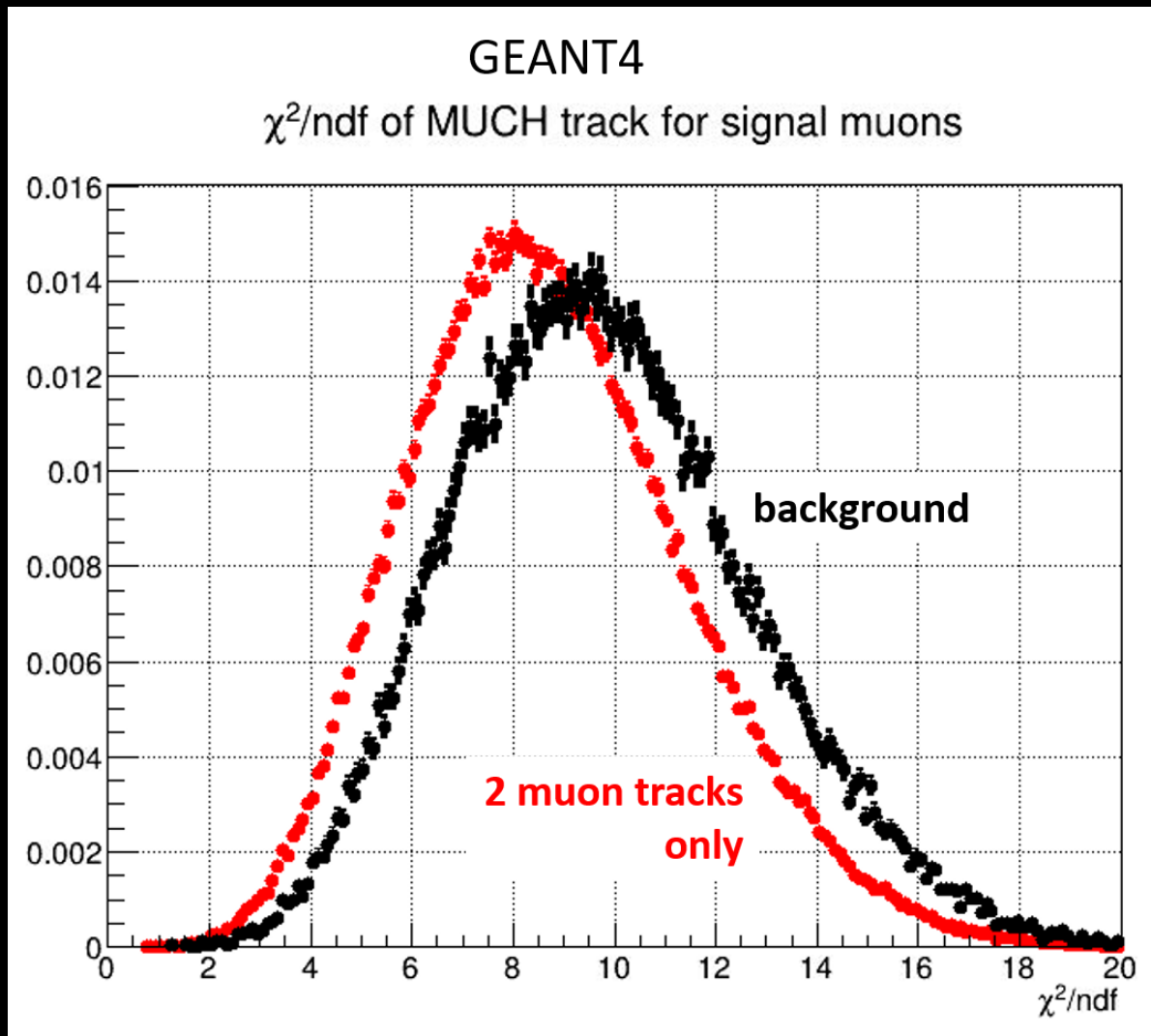
Invariant mass spectrum



ω efficiency

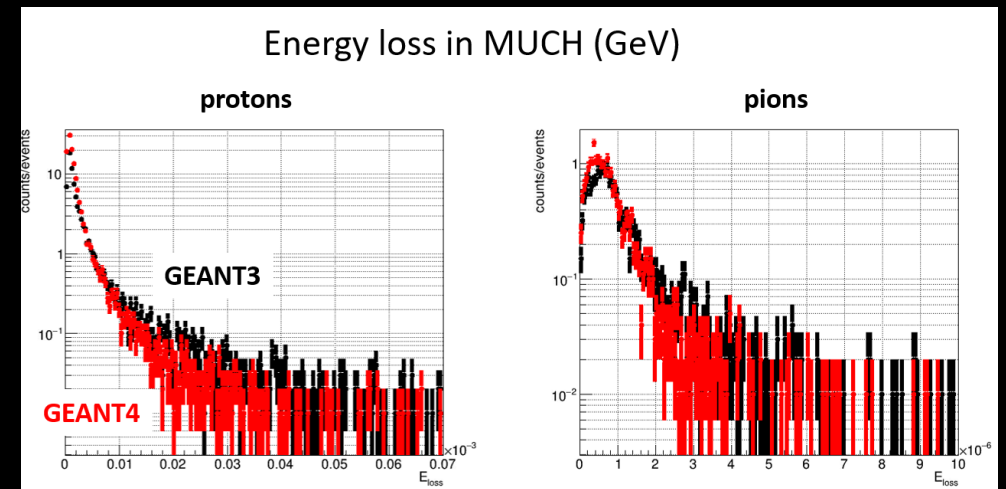
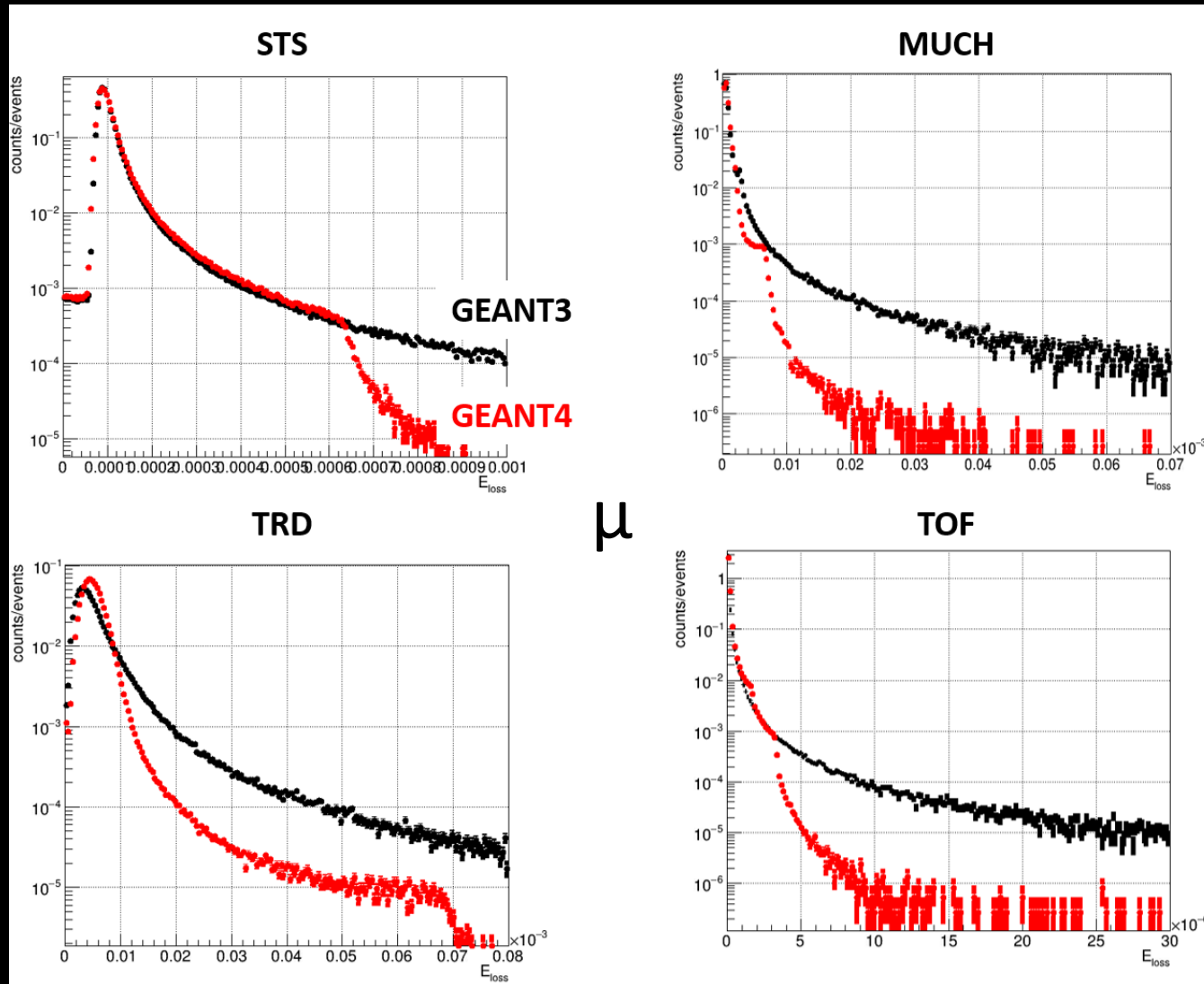


Source of the GEANT3/4 discussion



1. Test of new geometry didn't show any difference in physics performance in comparison with old geometry (CBM Progress Report 2020)
2. It was decided to switch to GEANT4 simulations
3. The strange χ^2 in MUCH system was found using GEANT4 for new geometry

GEANT3 vs. GEANT4: energy loss for μ



Thresholds in GEANT3 and GEANT3

- GEANT3 (VMC)

- 1 MeV cut-off
- 100 keV cut-off

- GEANT4

- „stepLimiter“

Material : MUCHiron

Range cuts : gamma 1 mm e- 1 mm e+ 1 mm proton 1 mm

Energy thresholds : gamma 20.6438 keV e- 1.29592 MeV e+ 1.21169 MeV proton 100 keV

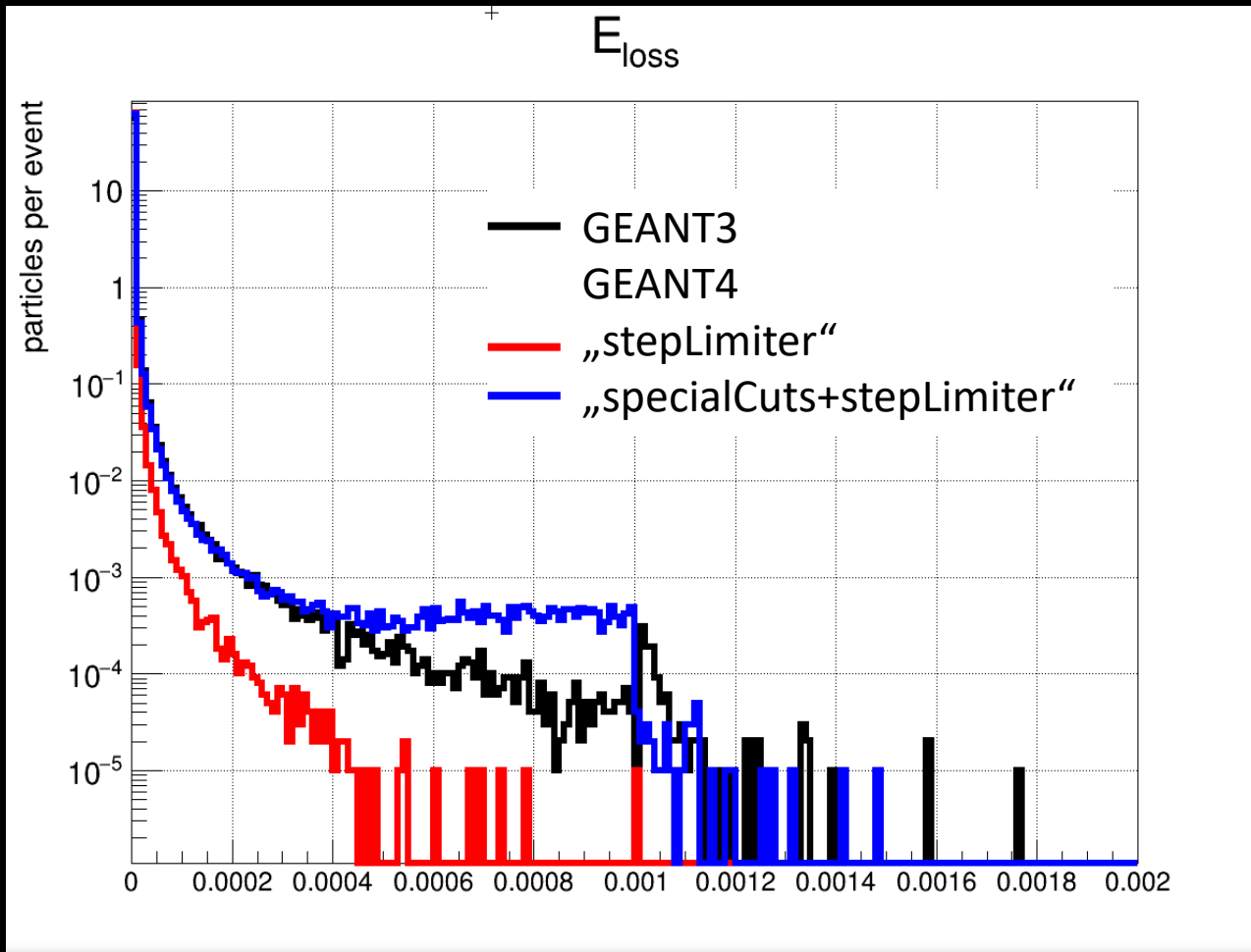
- „specialCuts+stepLimiter“ (ALICE muon settings)

Material : MUCHiron

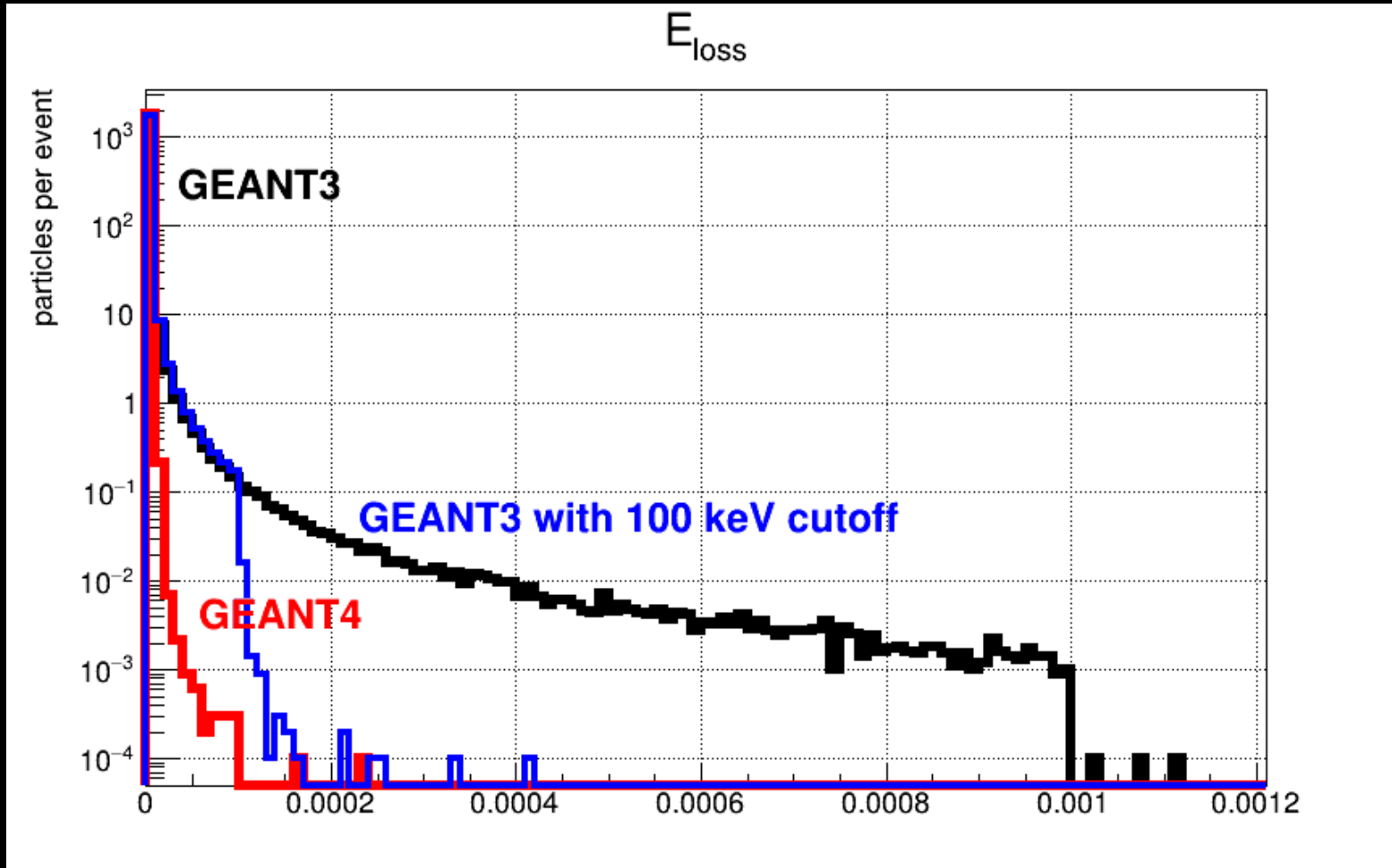
Range cuts : gamma 900 m e- 3.9 m e+ 3.9 m proton 3.9 m

Energy thresholds : gamma 10 GeV e- 10 GeV e+ 10 GeV proton 390 MeV

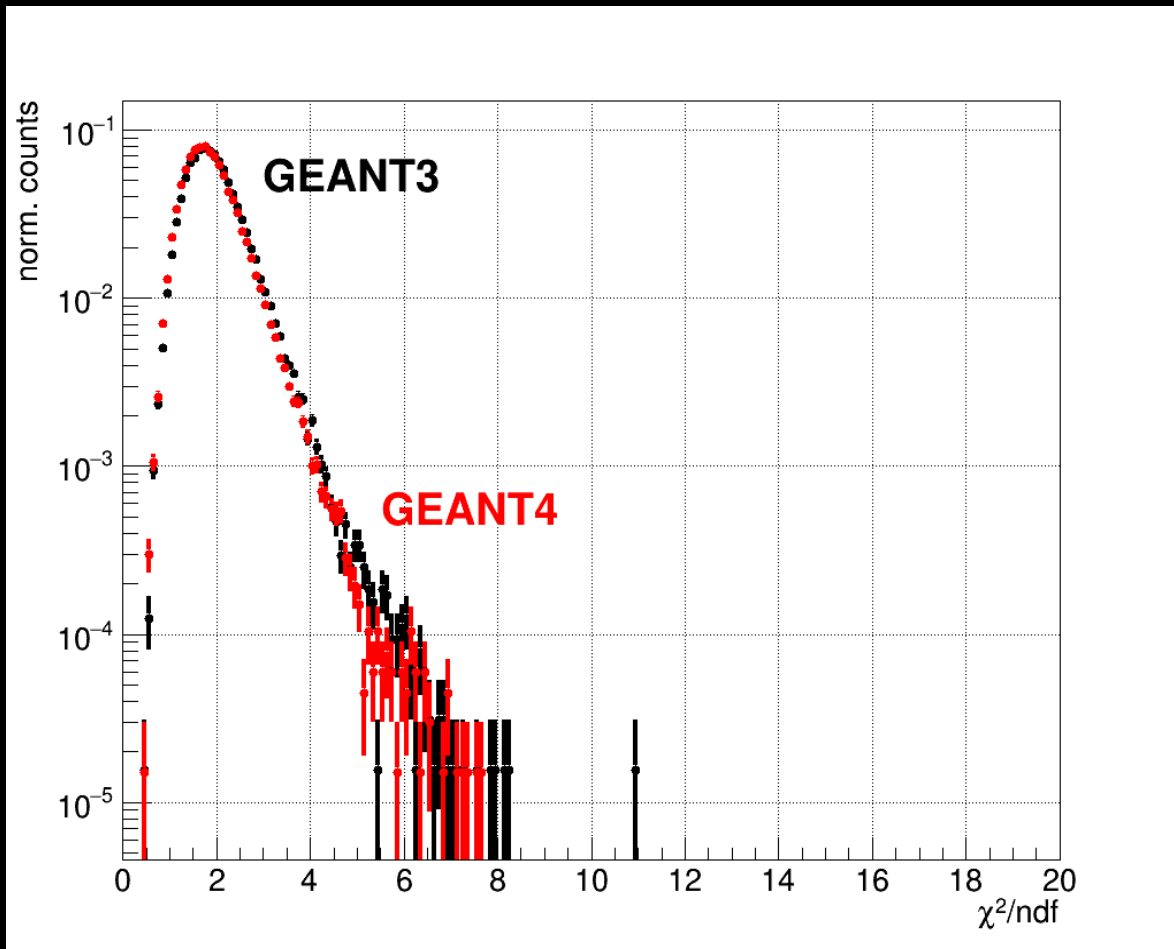
GEANT3 vs. GEANT4: energy loss for μ



GEANT3 vs. GEANT4: energy loss for μ



Issue with time shift in MUCH was found



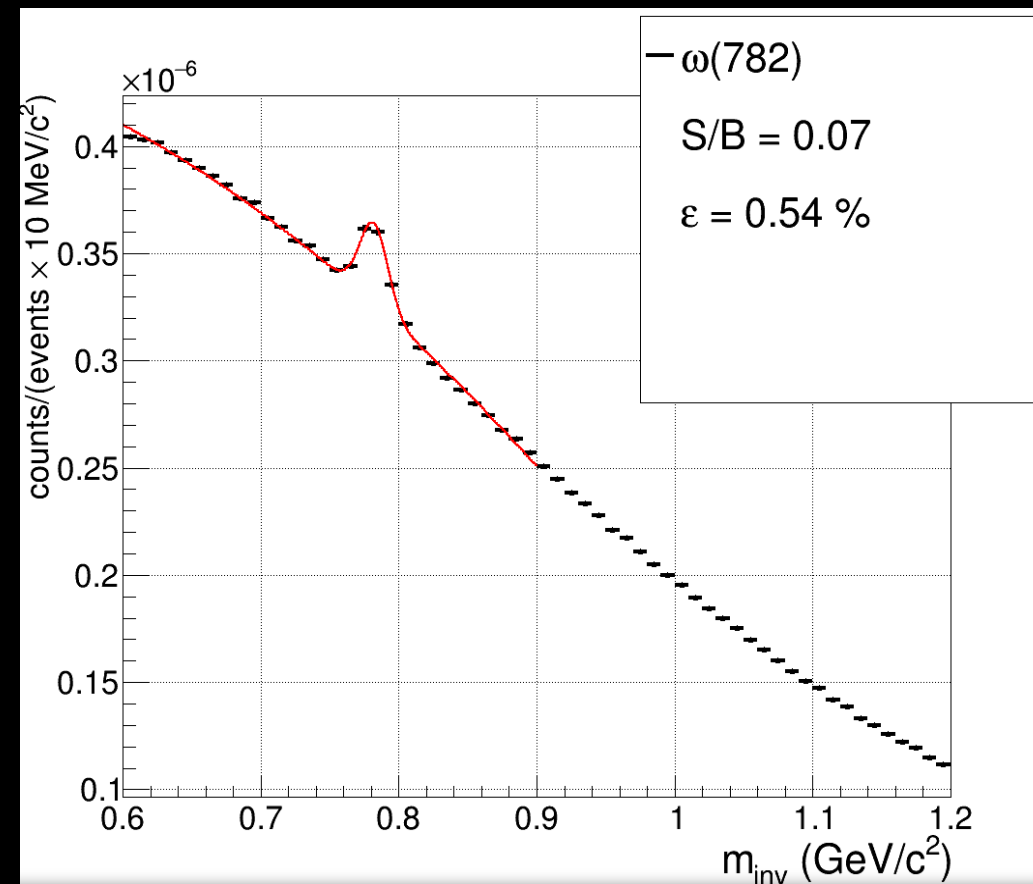
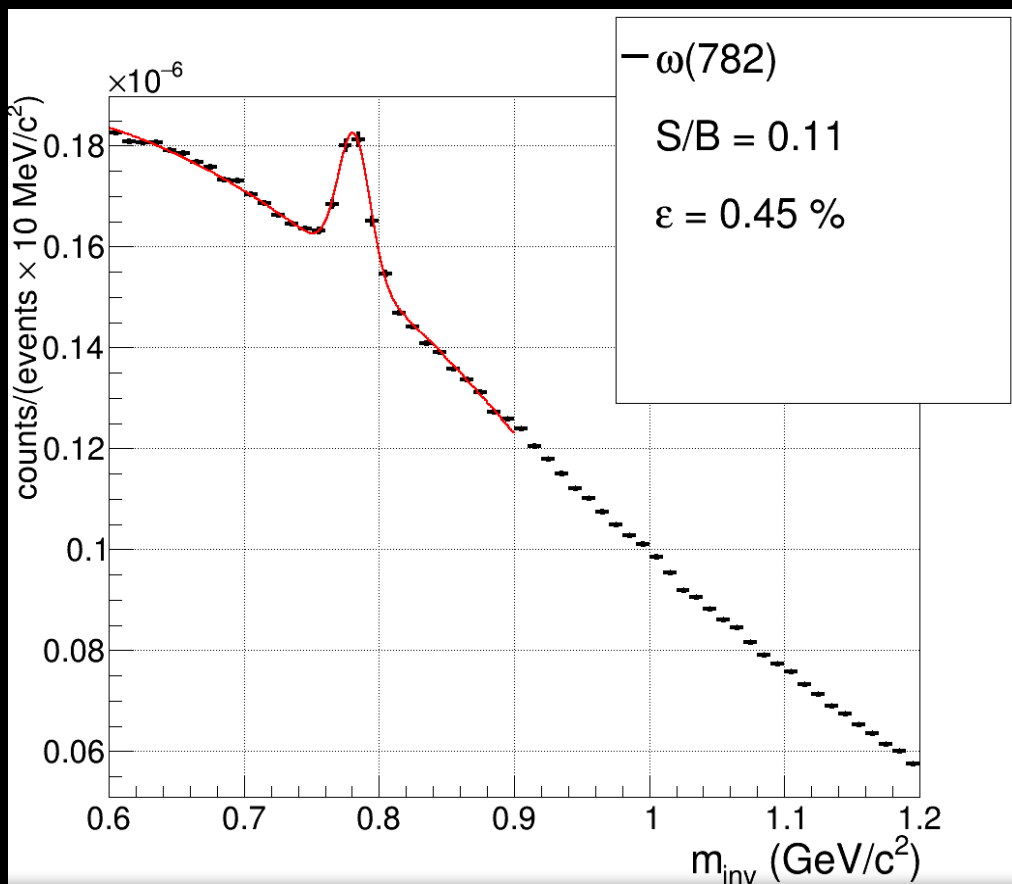
Conclusion:

difference in χ^2 was due to time shift (uncorrect segmentation scheme), but not due to GEANT4

GEANT3 vs. GEANT4

Invariant mass spectrum

$ANN_- > 0.8, ANN_+ > 0.8$



Conclusions

- The segmentation scheme for MUCH new geometry is corrected.
- Difference in χ^2_{MUCH} was due to uncorrect segmentation scheme, but not due to GEANT4. Now we can switch to the GEANT4 with standard cbmroot settings.
- **Next step:** common production with v21c.