

CC-MULTIPI SELECTION IN FGD1 FOR 4π ACCEPTANCE

LIVERPOOL-GENEVA MEETING

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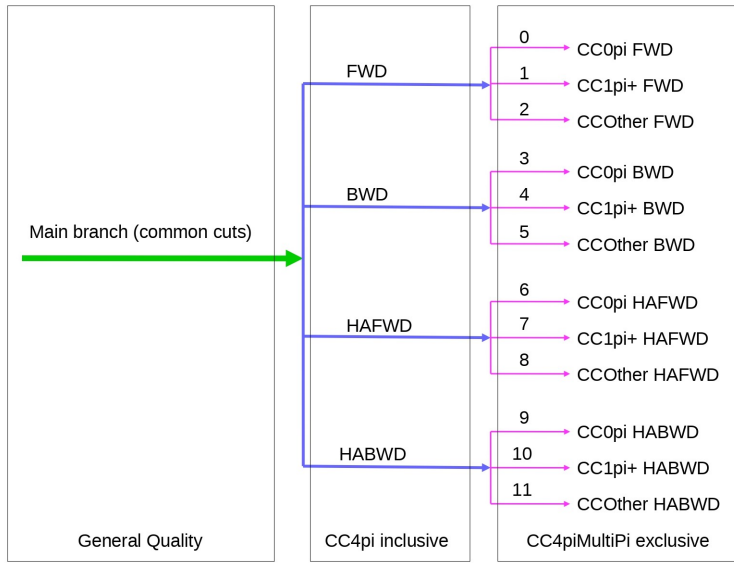


■ NumuCC4piMultiPi selection

- ▶ Cuts
- ▶ Variables
- ▶ First tests

■ Muon and Pion kinematics

NUMUCC4piMULTIpi SELECTION CUTS



NUMUCC4piMULTIpi SELECTION CUTS

General Quality

1. Event Quality Data,
2. Total Multiplicity,
3. Quality and Fiducial,

CC4pi inclusive

(for FWD, BWD, HAFWD and HABWD)

4. Quality,
5. Veto,
6. PID,
7. 4pi,

CC4piMultiPi exclusive

CC0 π (for FWD, BWD, HAFWD and HABWD)

8. CC-0 π ,
9. ECal π^0 Veto.

CC4piMultiPi exclusive

CC-1 π^+ (for FWD, BWD, HAFWD and HABWD)

8. CC-1 π^+ ,
9. ECal π^0 Veto.

CC4piMultiPi exclusive

CC-Other (for FWD, BWD, HAFWD and HABWD)

8. CC-Other.

NUMUCC4PIMULTIPI SELECTION CUTS: GENERAL QUALITY

1. **Quality cut (Beam and DAQ quality cut):**

- ▶ If Monte Carlo, this cut is ignored,
- ▶ Checks ND280 Good DAQ flag and cuts if negative,
- ▶ Cuts all events which come from a bad spill.

2. **Total multiplicity cut:**

- ▶ Cuts events with strictly less than 1 track.

3. **Track good quality and fiducial volume cut:**

- ▶ Cuts all events which do not have at least one "good quality" track.

NUMUCC4PIMULTIPI SELECTION CUTS: GENERAL QUALITY

Particle identification

■ Low angle track:

- ▶ track started in FGD1 fiducial volume (first layer excluded),
- ▶ track with > 18 clusters in the TPC,
- ▶ track with charge = -1 ,
- ▶ sort by momentum (based on curvature).

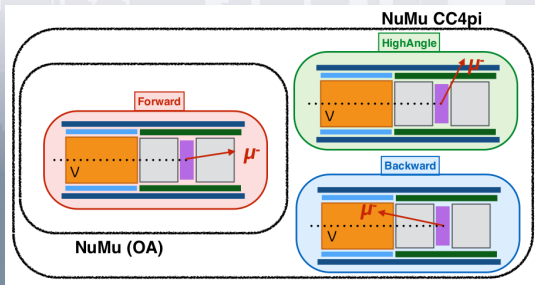
■ High angle track:

- ▶ track started in FGD1 fiducial volume (first and last layers excluded),
- ▶ track with < 18 clusters in TPC,
- ▶ Activity in the ECal,
- ▶ track which stops in the Side Muon Range Detector or in the BarrelECal FV (needed to compute the momentum of tracks)
- ▶ sort by momentum range (based on track length and energy loss within a certain volume)

NUMUCC4PIMULTIPI SELECTION CUTS: CC4PI INCLUSIVE

Comment:

The tracks are tested in order (highest momentum first) until one track passes all cuts. This is to avoid more than one muon candidate.



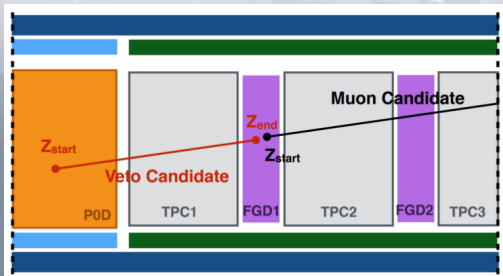
NUMUCC4PIMULTIPI SELECTION CUTS: CC4PI INCLUSIVE

4. (FWD, BWD and HA) Quality:

- ▶ ≥ 1 forward track,

5. (FWD, BWD and HA) Veto:

- ▶ reject events in which the μ^- candidate comes from out FV,
- ▶ reject events in which track is broken in two,



NUMUCC4PIMULTIPI SELECTION CUTS: CC4PI INCLUSIVE

6. FWD μ^- PID:

- ▶ $(L_{mU} + L_{pi}) / (1 - L_p) > 0.8$ for $p < 500\text{MeV}$,
- ▶ $L_{mU} > 0.05$,
- ▶ If $p > 280\text{MeV}$: should not stop in FGD2,
- ▶ If $PIDMipEm > 15$, then the muon candidate should not stop in the barrel ECal and only in certain regions of the Downstream ECal.

6. BWD μ^- PID:

- ▶ $L_{mU} > 0.05$,

NUMUCC4PIMULTIPI SELECTION CUTS: CC4PI INCLUSIVE

6. HA μ^- PID:

- ▶ Enter the SRMD,

Or:

- ▶ In ECal: $PIDMipEm > -100$ and $Length > 0$ and $EMEnergy > 0$,
- ▶ In ECal: $PIDMipEm < 0$ and $Length/EMEnergy > 0.8$,

7. (FWD, BWD and HA) 4pi:

- ▶ verify that we don't have more than 1 μ^- candidate.

Sample/cut	Fwd	Bwd	HAFwd	HABwd
Position	Start in FGD1(2)	Stop in FGD1(2)	Start in FGD1(2) - Stop in ECAL/SMRD	Stop in FGD1(2) - Start in ECAL/SMRD
Track Quality	> 18 TPC Hits	> 18 TPC Hits	< 18 TPC Hits	< 18 TPC Hits

Fig from Ciro Riccio's Slides

NUMUCC4PIMULTIPI SELECTION CUTS: CC4PIMULTIPI EXCLUSIVE

CC0 π (for FWD, BWD, HAFWD and HABWD):

8. CC0 π :

Reject events with:

- ▶ π^\pm in TPCs,
- ▶ e^\pm in TPCs,
- ▶ ME FGD,
- ▶ π FGD,

9. ECal π^0 Veto.

CC-1 π^+ (for FWD, BWD, HAFWD and HABWD):

8. CC-1 π^+ :

Reject events with:

- ▶ π^- in TPCs,
- ▶ e^\pm in TPCs,

Select events with either:

- ▶ $(\pi^+ + ME)$ in TPCs = 1,
- ▶ ME = 0 and π^+ (inTPC + inFGD) = 1,

9. ECal π^0 Veto.

CC-Other (for FWD, BWD, HAFWD and HABWD):

8. CC-Other:

Select events with either:

- ▶ $\geq 1e^\pm$ in TPCs,
- ▶ $\geq \pi^-$ in TPCs,
- ▶ $> 1(\pi^+ + ME)$ in TPCs.

NUMUCC4PIMULTIPI SELECTION VARIABLES

Pion

- NegPionMom
- NegPionCosTheta
- NegPionTheta
- PosPionMom
- PosPionCosTheta
- PosPionTheta
- NegPionTrueMom
- NegPionTrueCosTheta
- NegPionTrueTheta
- PosPionTrueMom
- PosPionTrueCosTheta
- PosPionTrueTheta

Pion

- TrueNegPionMom
- TrueNegPionCosTheta
- TrueNegPionTheta
- TruePosPionMom
- TruePosPionCosTheta
- TruePosPionTheta
- TruePrim_pi_truemom
- TruePrim_pi_costheta
- TruePrim_pi_theta
- TrueSec_pi_truemom
- TrueSec_pi_costheta
- TrueSec_pi_theta

Lepton

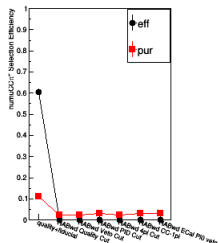
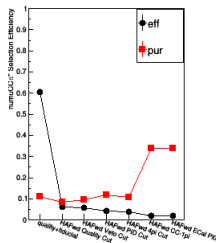
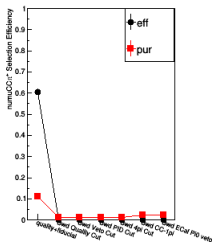
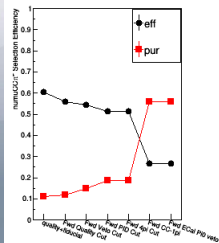
- truelepton_mom
- truelepton_costheta
- truelepton_theta

Muon

- selmu_mom
- selmu_costheta
- selmu_theta
- Truemu_mom
- Truemu_costheta
- Truemu_theta

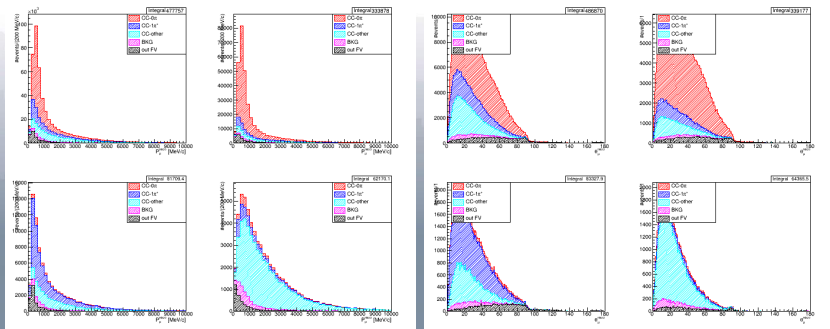
NUMUCC4PIMULTIPI SELECTION FIRST TESTS: EFFICIENCY AND PURITY

- Efficiency and purity of the selection vs cuts (for FWD, BWD, HAFWD and HABWD).



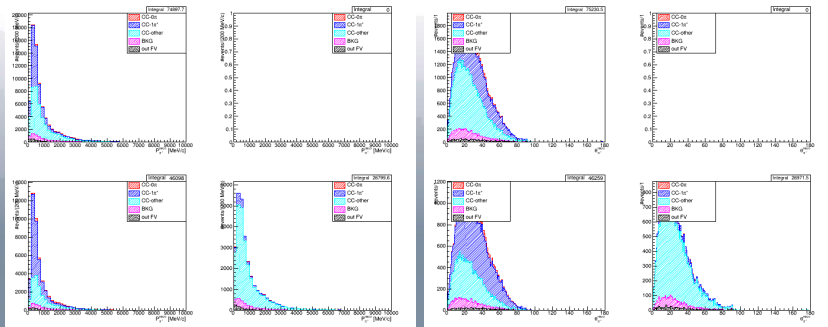
NUMUCC4PIMULTIPI SELECTION FIRST TESTS: MUON VARIABLES

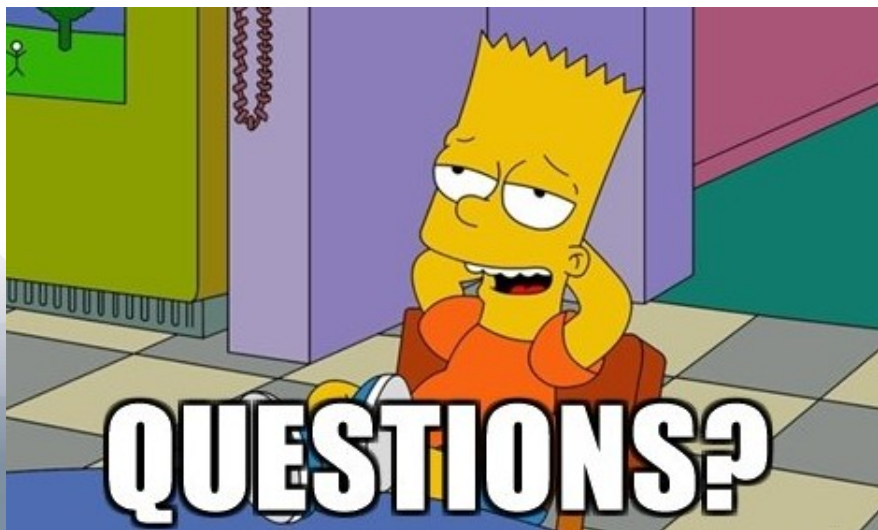
- Momentum and angular distribution (for Total, CC0 π , CC1 π + and CCOthers).



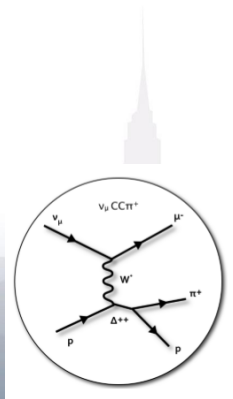
NUMUCC4PIMULTIPI SELECTION FIRST TESTS: PION VARIABLES

- Momentum and angular distribution (for Total, CC0 π , CC1 π + and CCOthers).

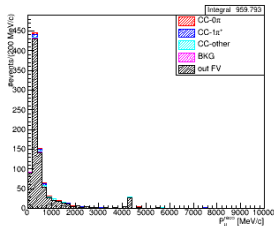
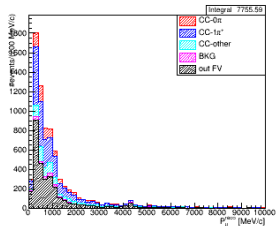
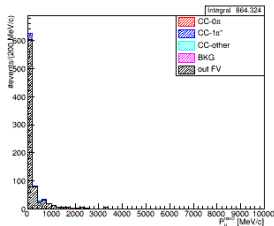
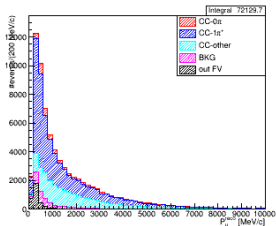




- nd280Highland2 v2r29
- Production 6B for MC
- Production 6M for Data
(problems running the data).

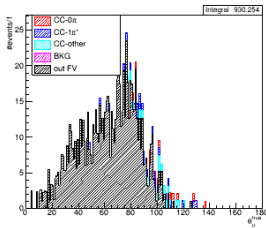
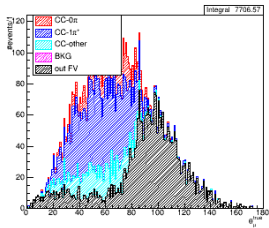
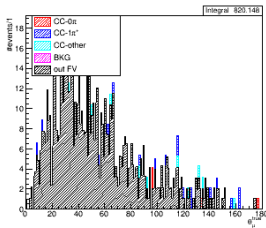
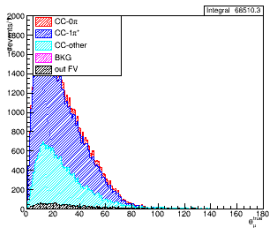


MUON KINEMATICS



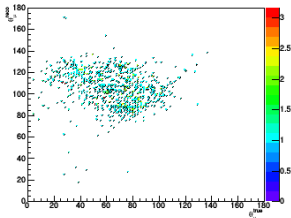
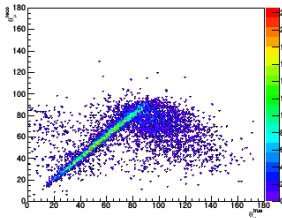
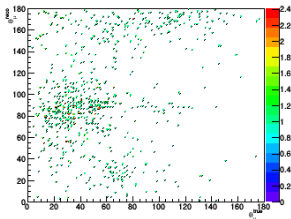
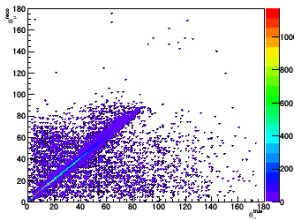
- Momentum distribution (for FWD, BWD, HAFWD and HABWD).

MUON KINEMATICS



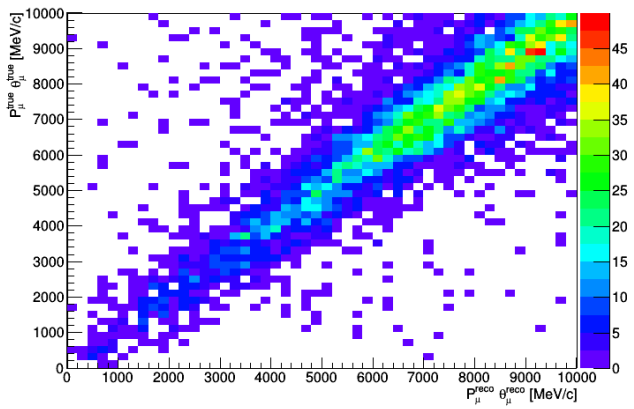
- Angular distribution (for FWD, BWD, HAFWD and HABWD).

MUON KINEMATICS



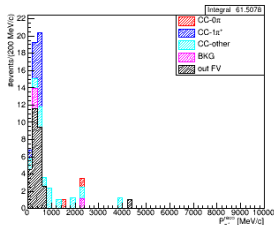
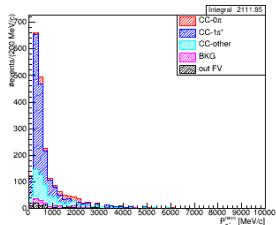
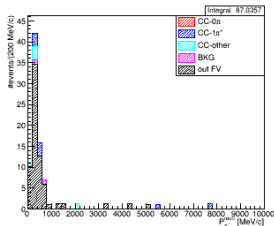
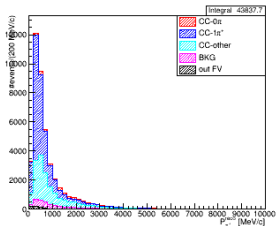
- Relationship between reco and true muon angle (for FWD, BWD, HAFWD and HABWD).

MUON KINEMATICS



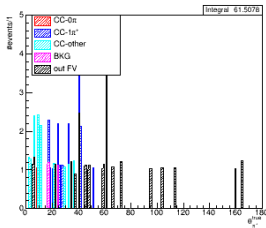
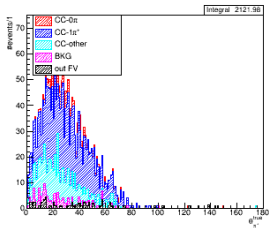
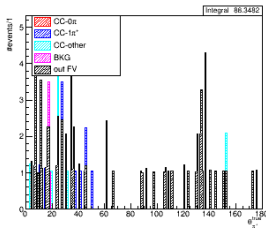
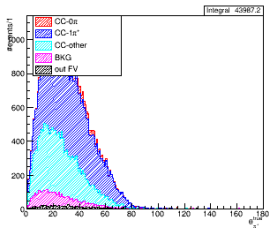
- Relationship between true and reco muon momentum per muon angle.

PION KINEMATICS



- Momentum distribution (for FWD, BWD, HAFWD and HABWD).

PION KINEMATICS



- Angular distribution (for FWD, BWD, HAFWD and HABWD).

Until now:

1. The ν_μ CC-MultiPi selection in FGD1 for 4π acceptance has been implemented and is now working.
2. Inclusion of proton variables for the study of $CC-1\pi^+p$ (Stephanie is going to do it).
3. Found and included TOF code of Alfonso.
4. Created a data base at CERN so we can start testing the selection.
5. Created a document with all the changes done in Highland2 packages for the 4π selection to work (important for the validation later).

What to do now:

1. Start testing the selection.
2. Improve the π PID (join task with FGD2 and ECal teams).
3. Start working in the systematics of the selection.

GRACIAS
ARIGATO
SHUKURIA
JUSPAXAR
DANKSCHEEN
TASHAKKUR ATU
YAQHANYELAY
SUKSAMA
EKHMET
THANK
YOU
BOLZIN
MERCİ
BIYAN
SHUKRIA
TINGKI
MAAKE
GRAZIE
MEHRBANI
PALDIES
KOMAPSUMNIDA
MAKITA
MIMMONCHAR
SPASSIBO
SHACHALRIYA
NURUN
CHALTU
UNILJIESEM
UNILYIBAD
WABEEJA
MAITEKA
YOSPAGIBATAM
HUI
SPASIBO
DEKADUJA
RENACHALIYA
UNILJIESEM
HATUR SE
PROJU
SIKOMO
HERASTAHNY
GAEJTHO
GOZAIMASHITA
EFCHARISTO
AGUYJE
FAKAAGE
TAYTAPUCH
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MAKITA
MIMMONCHAR

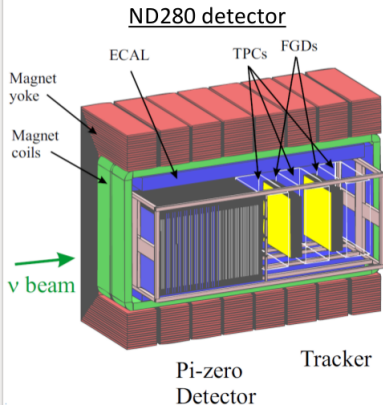
A faded, light blue silhouette of a city skyline, including a prominent skyscraper with a pointed top, serves as the background for the slide.

Support slides

NUMUCC4PIMULTIPI SELECTION CUTS: GENERAL QUALITY

Detector

21



ND280 detector

Fiducial volume [mm]

Low angle:

$$[X_{\min} + 57.66, X_{\max} + 57.66]$$

$$[Y_{\min} + 57.66, Y_{\max} + 57.66]$$

$$[Z_{\min} + 10.125, Z_{\max}]$$

High angle:

$$[X_{\min} + 57.66, X_{\max} + 57.66]$$

$$[Y_{\min} + 57.66, Y_{\max} + 57.66]$$

$$[Z_{\min} + 10.125, Z_{\max} + 10.125]$$