Master-2 internship: Analysis of data from the Time Projection Chambers of the T2K Near Detector

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Definition of the pull

As a very simple yet powerful quantity to check the quality of the fit results, we construct for each data's entry the so-called pull, the difference of the estimated and the true value of a parameter, normalised to the estimated error on the parameter,

$$pull = \frac{p_{estim} - p_{true}}{\sigma_p}.$$

If everything is OK, the distribution of the pull values is a standard normal distribution, i.e. a Gaussian distribution centred around zero with a standard deviation of one.

Definition of the pull

Once the dE/dx energy deposit value for a reconstructed particle track has been determined, it is compared to the expected value for various particle types (electron, muon, proton, and pion) through a quantity called the pull, defined in the below equation, where $(dE/dx)_{meas}$ is the measured dE/dx for the reconstructed track, $(dE/dx)_{exp,i}$ is the dE/dx expected for particle of type i at the measured momentum, and $\sigma_{(dE/dx)_{exp,i}}$ is the uncertainty, i.e. the width or sigma or resolution, of the expected dE/dx distribution for a particle of type i at the measured momentum. The pull is then defined as

$$\delta_E(i) = \frac{(dE/dx)_{meas} - (dE/dx)_{exp,i}}{\sigma_{(dE/dx)_{exp,i}}}.$$

That is to say, the pull gives the number of standard deviations the measured dE/dx is from the expected value for a particle of type i.

Current plan

- Fit the dE/dx distribution by a gaussian.
- Compare the mean and sigma of the fitted gaussian for MC (Monte-Carlo simulation result) and data for production 6 on one side and production 7 on the other.
- Make the same distributions of dE/dx per for different bin of momentum (10 bins of 200 MeV for example). Then, once again, compare the data and MC for production 6 and production 7.

Current plan

• Next, I will make the same comparison but for different types of particle. If production-6 MC and data agree quite well, I can use the prod6 MC as if it was the data to compare MC production 6 and production 7 for all type of particle (e, mu, pions, protons...) using the true particle type in the MC.

Results for positively charged particles

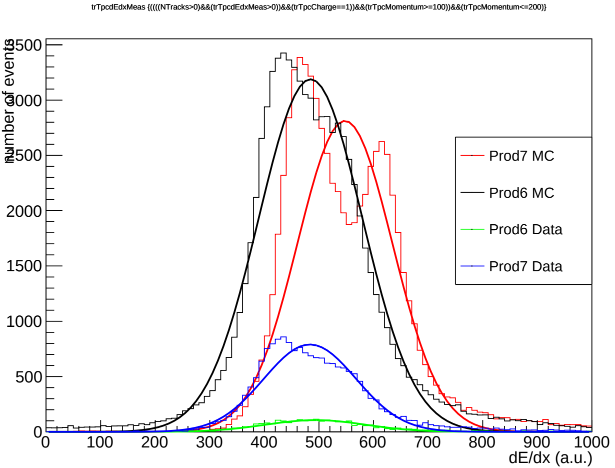

Figure: Distribution of the energy loss for positively charged particles with momenta between 100 and 200 MeV/c.

Results for positively charged particles

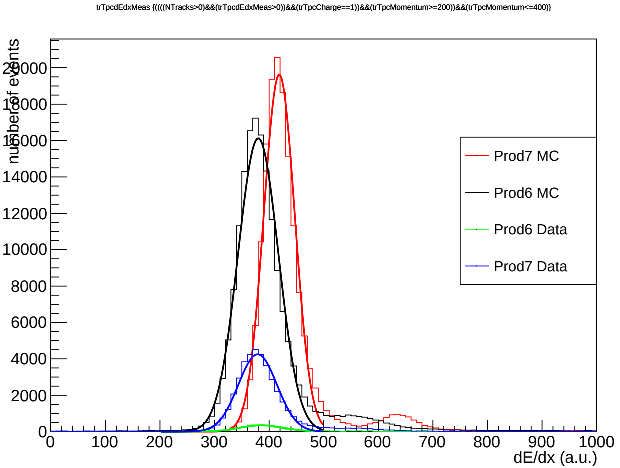

Figure: Distribution of the energy loss for positively charged particles with momenta between 200 and 400 MeV/c.

Results for positively charged particles

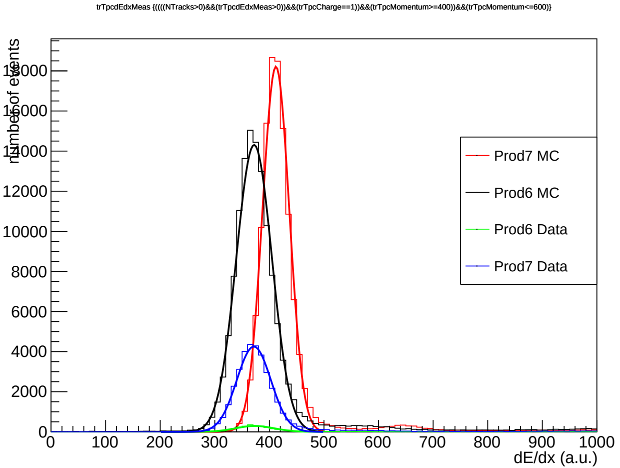

Figure: Distribution of the energy loss for positively charged particles with momenta between 400 and 600 MeV/c.

Results for positively charged particles

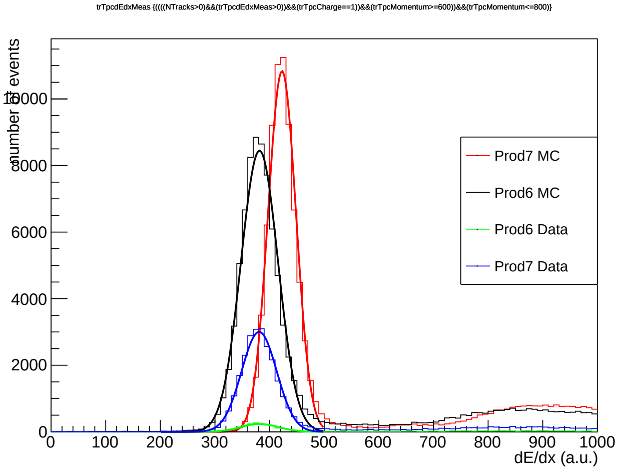

Figure: Distribution of the energy loss for positively charged particles with momenta between 600 and 800 MeV/c.

Results for positively charged particles

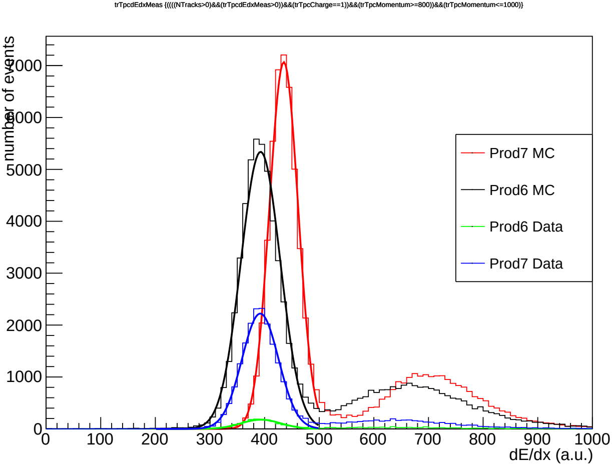

Figure: Distribution of the energy loss for positively charged particles with momenta between 800 and 1000 MeV/c.

Results for positively charged particles

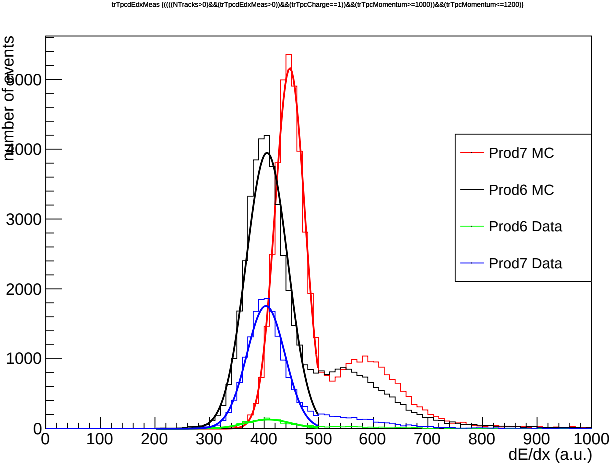

Figure: Distribution of the energy loss for positively charged particles with momenta between 1000 and 1200 MeV/c.

Results for positively charged particles

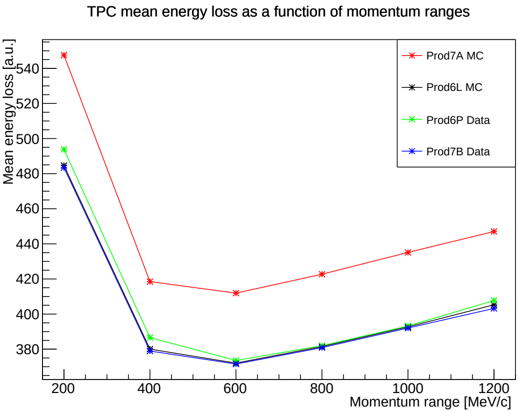

Figure: Mean energy loss of positively charged particles in the TPCs as a function of the momentum ranges. For example, the first red star on the left means that the mean energy loss is 547.6 a.u. for positively charged particles whose momenta are in the range 100 MeV/c $\leq$ p $\leq$ 200 MeV/c.

Results for positively charged particles

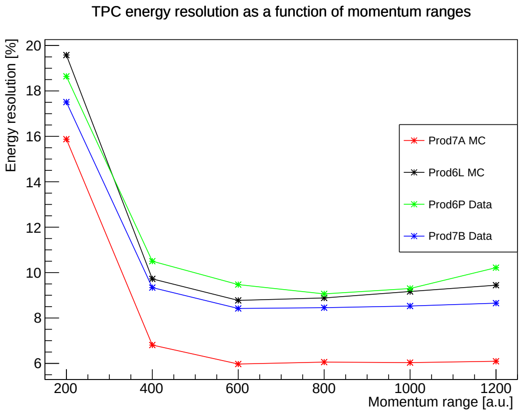

Figure: Energy resolution of the TPCs for the positively charged particles as a function of the momentum ranges. For example, the first red star on the left means that the Prod7A MC energy resolution of the TPCs is 15.9 % for positively charged particles whose momenta are in the range 100 MeV/c $\leq$ p $\leq$ 200 MeV/c.

Results for positively charged particles

Table: The mean energy loss $[a.u.]$ of positively charged particles in the TPCs as a function of particles' momentum ranges $[MeV/c]$.

Momentum ranges $[MeV/c]$	7B.Data	7A.MC	6P.Data	6L.MC
$[100, 200]$	483.423	547.561	493.834	484.612
$[200, 400]$	378.949	418.506	386.578	380.035
$[400, 600]$	371.54	411.929	373.577	372.046
$[600, 800]$	380.882	422.71	381.973	381.502
$[800, 1000]$	392.046	435.117	393.24	392.709
$[1000, 1200]$	403.223	447.046	407.73	405.274

Results for positively charged particles

Table: The TPCs' energy resolution [%] for positively charged particles as a function of particles' momentum ranges [MeV/c]

Momentum ranges $[MeV/c]$	7B.Data	7A.MC	6P.Data	6L.MC
[100, 200]	17.5104	15.876	18.6448	19.5802
[200, 400]	9.33841	6.80835	10.5013	9.72171
[400, 600]	8.41889	5.97209	9.47114	8.77438
[600, 800]	8.45345	6.05675	9.06075	8.88268
[800, 1000]	8.52678	6.03364	9.29754	9.16646
[1000, 1200]	8.65252	6.09328	10.2159	9.44417

Results for negatively charged particles

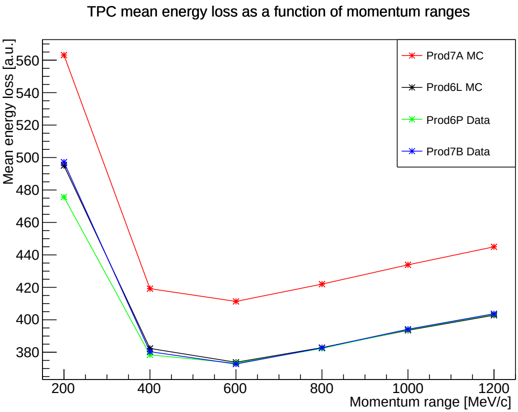

Figure: Mean energy loss of negatively charged particles in the TPCs as a function of the momentum ranges. For example, the first red star on the left means that the mean energy loss is 547.6 a.u. for negatively charged particles whose momenta are in the range 100 MeV/c $\leq$ p $\leq$ 200 MeV/c.

Results for negatively charged particles

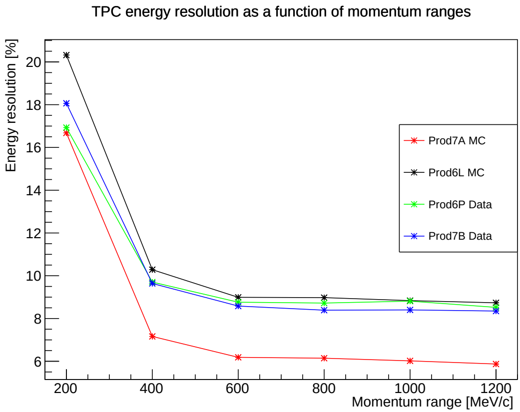

Figure: Energy resolution of the TPCs for the negatively charged particles as a function of the momentum ranges. For example, the first red star on the left means that the Prod7A MC energy resolution of the TPCs is 15.9 % for negatively charged particles whose momenta are in the range 100 MeV/c $\leq$ p $\leq$ 200 MeV/c.

Results for negatively charged particles

Table: The mean energy loss $[a.u.]$ of negatively charged particles in the TPCs as a function of particles' momentum ranges $[MeV/c]$.

Momentum ranges $[MeV/c]$	7B.Data	7A.MC	6P.Data	6L.MC
$[100, 200]$	497.164	563.142	475.682	495.058
$[200, 400]$	380.358	419.189	378.407	382.354
$[400, 600]$	372.76	411.343	373.276	373.832
$[600, 800]$	382.748	421.998	382.371	382.852
$[800, 1000]$	394.185	433.878	393.893	393.522
$[1000, 1200]$	403.727	444.988	403.451	402.837

Results for negatively charged particles

Table: The TPCs' energy resolution [%] for negatively charged particles as a function of particles' momentum ranges [MeV/c]

Momentum ranges $[MeV/c]$	7B.Data	7A.MC	6P.Data	6L.MC
[100, 200]	18.0645	16.6779	16.9297	20.3194
[200, 400]	9.63869	7.16254	9.70321	10.2835
[400, 600]	8.58237	6.18497	8.76252	8.99123
[600, 800]	8.38946	6.14392	8.72267	8.97669
[800, 1000]	8.40198	6.01915	8.81223	8.83611
[1000, 1200]	8.34964	5.87226	8.52075	8.73445

The End