# Looking at the dEdx angular dependence for mc2020 v02-02 DST samples

**A. Irles***, **IFIC (UV/CSIC),*
*(but with borrowed material from Y. Okuwaga and, specially, U. Einhaus)*

# dE/dx angular dependece (a bit of history)

- S. Bilokin PhD

The $dE/dx$ as a function of particle momentum and $|\cos\theta|$ for different hadrons is shown in Fig. 9.18. One can immediately spot the dependence of the $dE/dx$ value on the polar angle of the particles. This happens because of the knocked-out electron emittance or $\delta$-ray probability is increased with increasing length of the TPC track. Therefore, one needs to apply an angular correction to remove the angular dependence of the $dE/dx$ value, which is

$$\frac{dE}{dx} \rightarrow \frac{dE}{dx}\theta^{0.15}, \tag{9.4}$$

where $\theta$ is the polar angle of the particle. This angular is known to be applied at other experiments, which have the TPC devices [46] [47].

- The 0.15 was found empirically
  - Bilokin only applied this to his REC/DST files (during analysis)
- Similar correction was introduced in MarlinReco and in previous experiments (ALEPH, HARP)

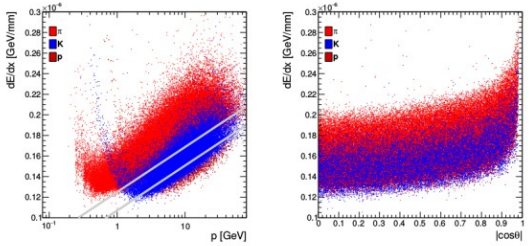
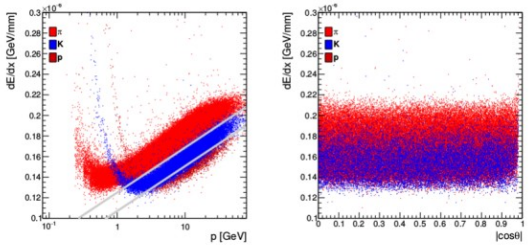



Figure 9.18: *The energy deposition per track length $dE/dx$ as function of the particle momentum, the particle polar angle $|\cos\theta|$ for different particles. Two gray lines separate out the region with a maximal kaon concentration.*




Plots made using tracks associated to secondary vertices (LCFIPlus) … DBD REC dedicated samples

# dE/dx angular dependence: ILCsoft v02-02

- MarlinReco/Analysis/PIDTools → Compute_dEdxProcessor
  - Applied **BEFORE smearing**
- Two correction factors:
  - F1 as function of the nhits (contributing to the truncated mean) → let's ignore this one for the moment
  - f2 as function of the lambda angle of the track.

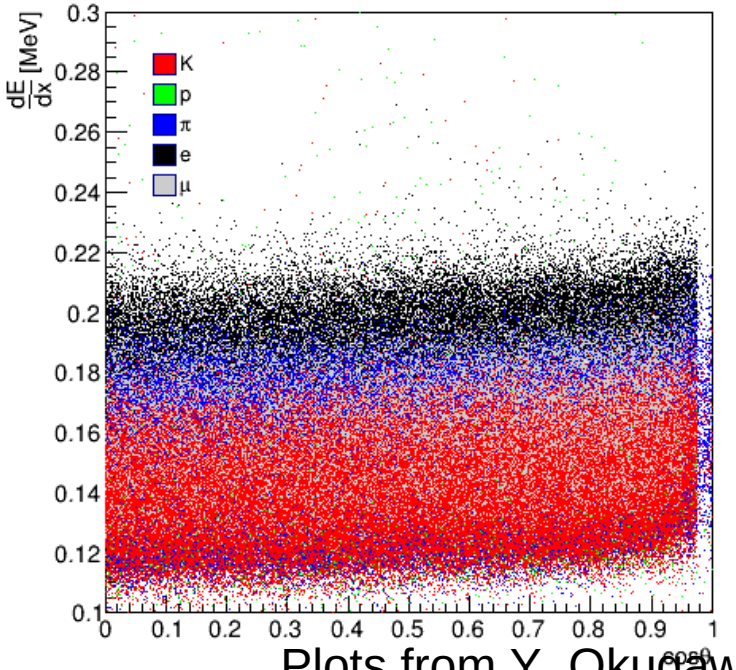
```
//correct polar angle dependence and number of hits dependence
double Compute_dEdxProcessor::getNormalization(double dedx, float nHit, double trkcos){
  //cal. hit dep.
  double f1 = 1 + std::exp(-nHit/_ncorrpar);
  //cal. polar angle dep.
  // double c=1.0/sqrt(1.0-trkcos*trkcos);
  // double f2=1.0/(1.0-0.08887*std::log(c));

  //cal. polar angle dep.   20160702
  //double c = std::acos(trkcos);
  //if(c>3.141592/2.0) c= 3.141592-c;
  //double f2 = 1.0/std::pow(c, 0.0703);

  //change polar angle dep. 20170901
  double f2 = _acorrpar[0] / (_acorrpar[0] + _acorrpar[1] * trkcos * trkcos);

  return dedx/(f1*f2);
}
```

# dE/dx angular dependece : new samples (2f→ had)



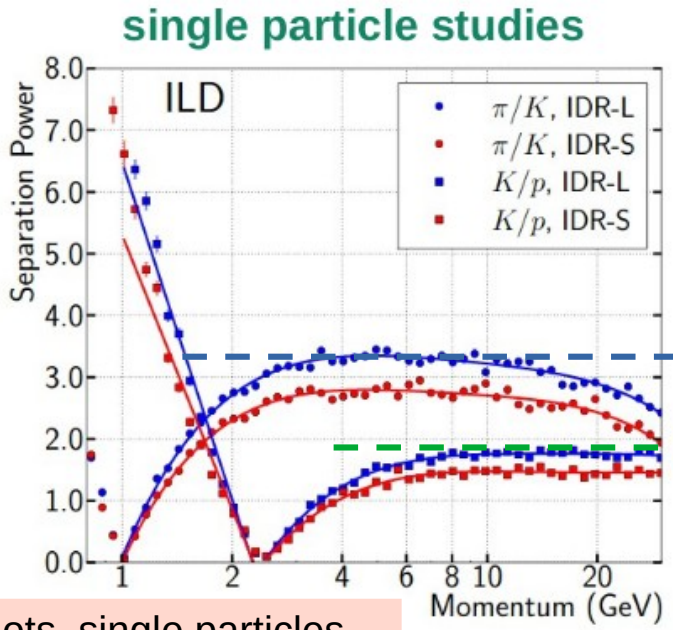

Plots from Y. Okugawa

Plots made using only tracks associated to a secondary vertices (LCFIPlus).

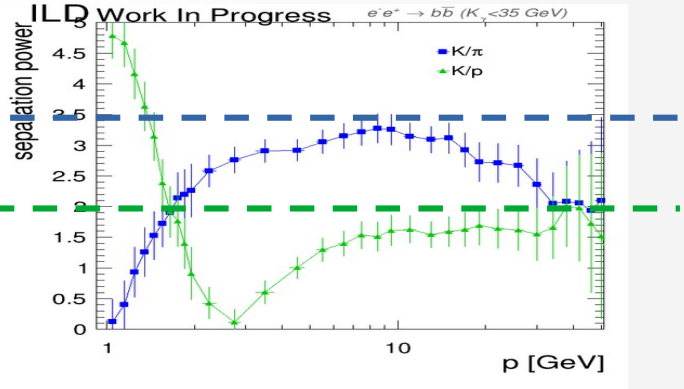
v02-02 soft and DST samples

- However, we observed an unexpected angular dependence.
- With a cost in the separation power performance

# dE/dx angular dependece : new samples (2f → had)




IDR plots, single particles




Plots from Y. Okugawa

- However, we observed an unexpected angular dependence.
- With a cost in the separation power performance

Plots made using only tracks associated to a secondary vertices (LCFIPlus).

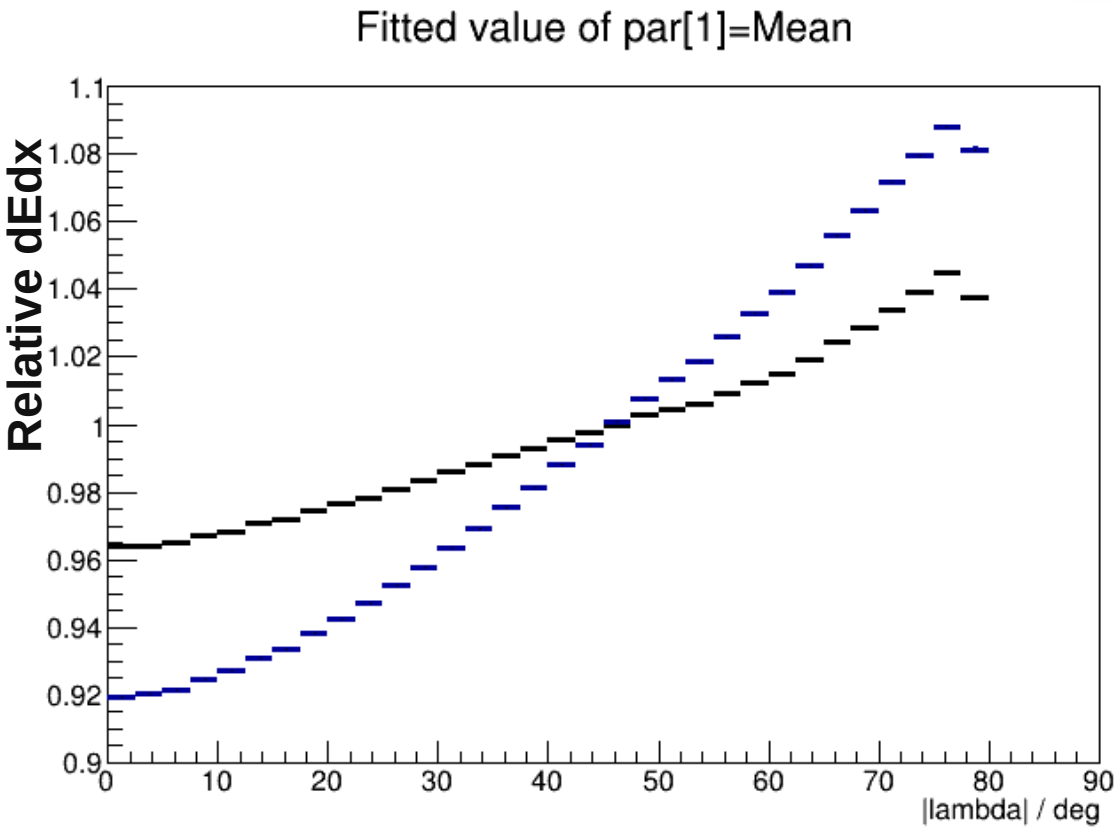
v02-02 soft and DST samples

# dEdx angular dependence using the “official tools”

- Let’s use the official tools, and single particle samples
- Single particle samples recently re-generated (thanks to A. Miyamoto et al)
  - REC files are stored at /ilc/prod/ilc/mc-2020/ild/rec/1-calib/single/ILD_l5_o1_v02_nobg/v02-02-01/00015417
  - DST-merged at /ilc/prod/ilc/mc-2020/ild/dst-merged/1-calib/single/ILD_l5_o1_v02_nobg/v02-02-01/00015417/00

- dEdxAnalyser provided by U. Einhaus
  - Lots of improvements/additions in the last days/weeks.
  - Ready to use (non experts included)
- Can be run over REC and DST files and using PFOs as main objects or only MarlinTrks
- Among others, it includes the plots for angular dependence of the dE/dx value.
  - The histogram/plot **'NormLambdaFullAll_1'** is the fitted mean of this dependence,
  - Same **'NormCosThFullAll_1'**

# dEdx angular dependence using the “official tools”




**BLACK**

**dEdx angular dependence after the nominal correction in v02-02-01 (and before)**

**BLUE**

**dEdx angular dependence after removing the v02-02-01 correction**

Plots made using first track in PFOs in the mc2020 DST 2f→had samples

**This plot shows clearly that current correction is not enough**

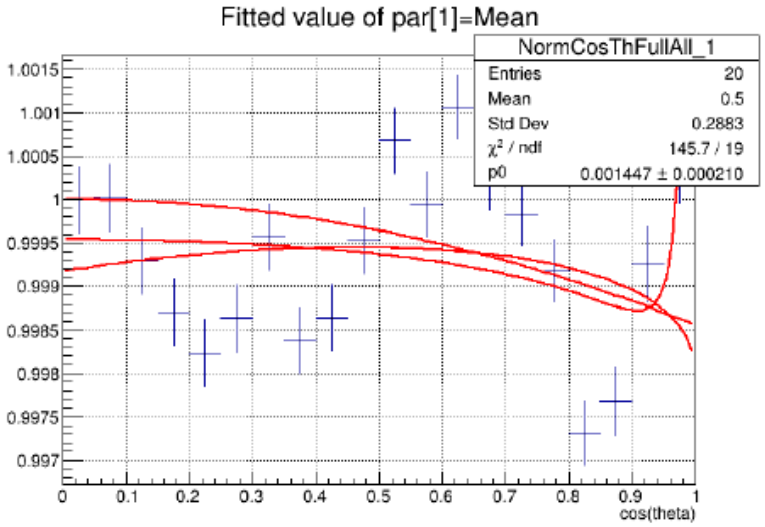
**While it was ~ok for the mc2018 (see bkup)**

# dEdx angular dependence using the “official tools”

- One step back:
- U. Einhaus has looked at the regenerated single particle REC sample (before any dEdx truncation/computation)
  - and has checked the correction parameters.
  - Exploring several functional dependences
- **Polinomyal dependence**
  - **Reduces the fluctuations to the per mil level**

## pol3

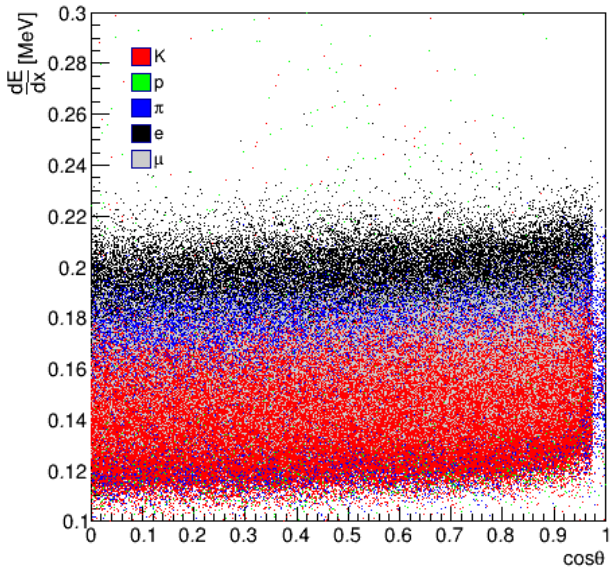
- $f = 1 / ( p_0 + p_1 \lambda + p_2 \lambda^2 + p_3 \lambda^3 )$
- p = [0.948185, 0.000520502, 3.33231e-5, -1.51052e-7]
- $\chi^2$/ndf = 105/28
- Residuals: 0.2 %

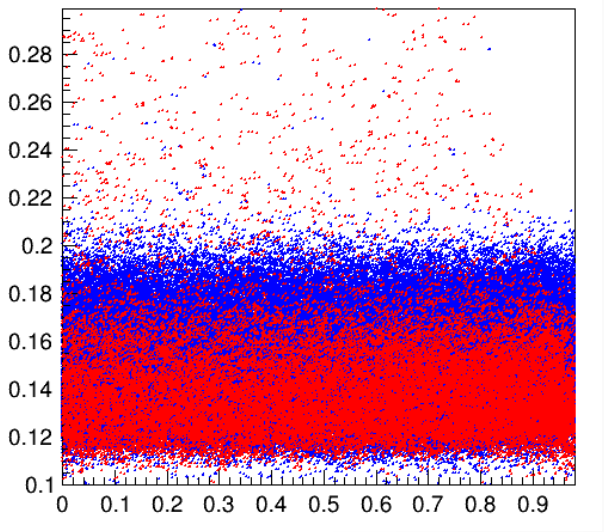



Uli Einhaus | Meeting | 01.01.2000 | Page 4

Plots made using all tracks in REC single particle files

# Impact of the new parametrisation in “realistic events”



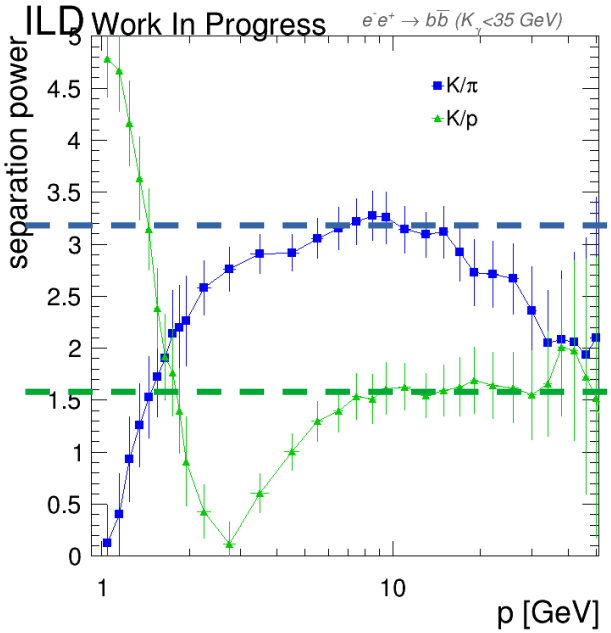



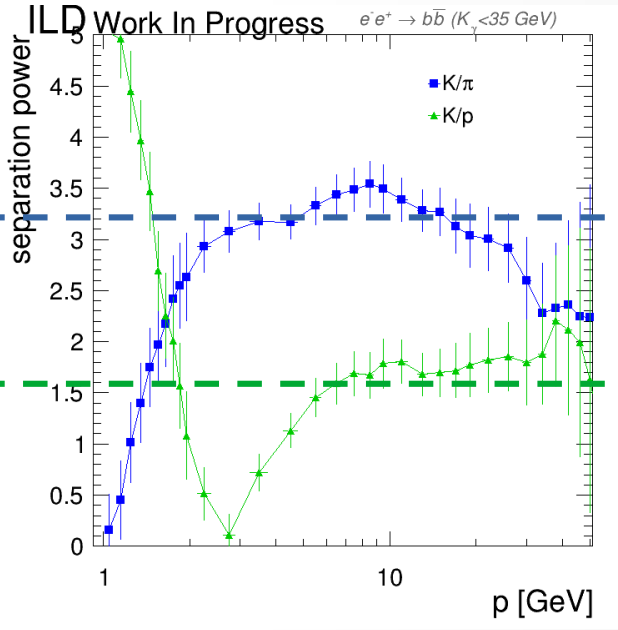
Plots made using only tracks associated to a secondary vertices (LCFIPlus).

Std correction (from v02-02)

Undoing of the Std correction (from v02-02) & application of new one

# Impact of the new parametrisation in “realistic events”




Plots made using only tracks associated to a secondary vertices (LCFIPlus).

Std correction (from v02-02)

Undoing of the Std correction (from v02-02) & application of new one

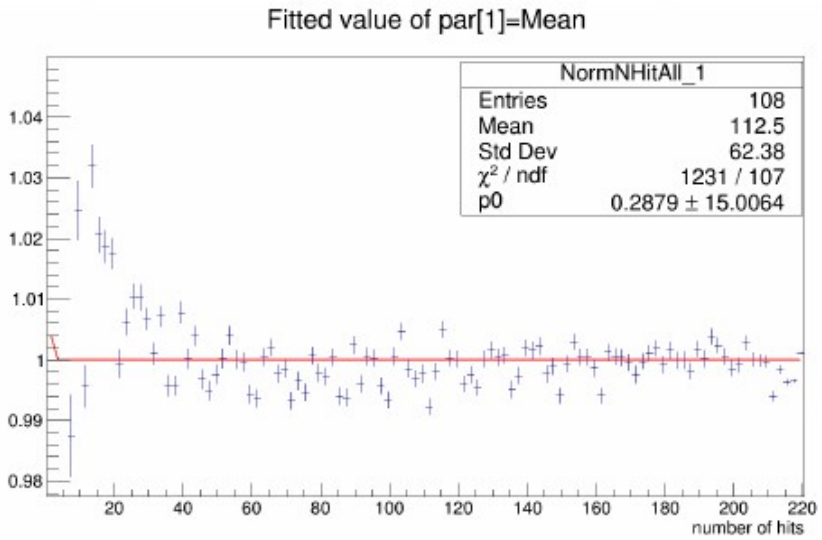
**We recover the expected performance**

# Nhit correction?

- ▶ Actual correction is at the per-mile level.
- ▶ U. Einhaus has studied what would be the new nHit correction factors:
  - Using the REC single particle files
  - After doing only the angular correction → what nHits correction remains?
  - Very small one, for the case with very few nhits (not statistically important?)
- ▶ **Proposal: ignore it for the moment this correction.**

## nHits correction?

- f = 1 + exp( - nHits / p ) with p = 1.468 in default reco
- exp(-10/1.468) = 0.0011 (1 permille) vs. data fluctuations O(1%)
- fit to data with un-done correction gives p = 0.2879




Uli Einhaus | Meeting | 01.01.2000 | Page 5

# Strategy for mc2020 DST samples

mc2020 DST sample

Proc1 (new)

Correct_Compute_dEdxProcessor In ILDPerformance v02-02-xx

Undo the v02-02 correction & apply the new one

Reminder… the correction was originally done before the smearing while the DST have post-smearing dEdx info.
The factors are also calculated before smearing,

Proc2 (same processor with updated BB parameters)

Re-run the PID likelihood?

Under study.. (not trivial / clean solution so far)

Use new Beta Bloch parameters for PID Processor

Your processor

**The input parameters are to be obtained from single particle samples**

# Strategy for mc2021 new samples

mc2021 REC

New Compute_dEdxProcessor
In MarlinReco/Analysis/PIDTools
v02-02-xx

mc2021 DST

Your Analysis

Apply Marlin Reco with new dEdx computation and new parametrizations (automatically good dEdx and dEdxPID)

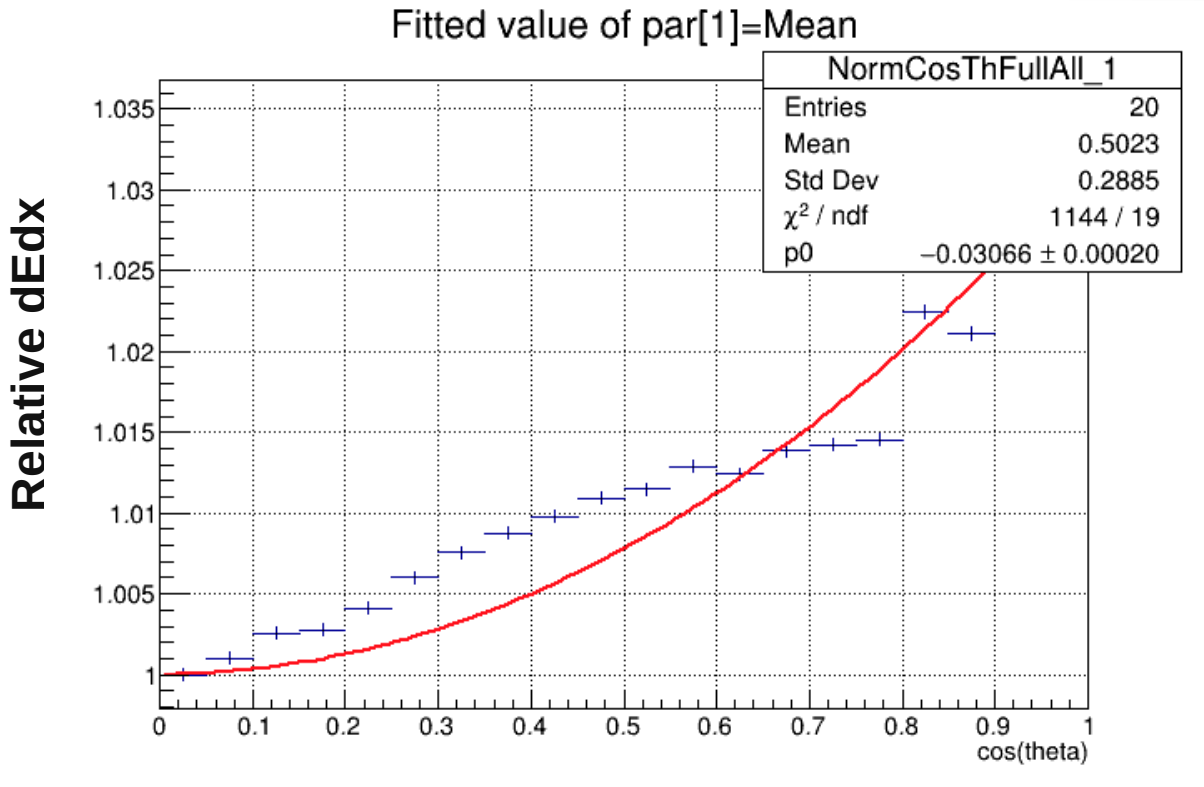
# What to do next?

- Check the new fit parameters of dEdx (Beta Bloch parametrers, to be the input of the LokelihoodPID processor)
- Study how to best re-implement the LikelihoodPID
- **Pack everything in a new patch release v02-02-xx**
  - **The exact "how" is to be decided**

- **We would need some feedback from analyzers in order to be sure that the correction proposal of existing mc2020 DST samples is acceptable**
  - **Maybe a partial reprocessing of some 2020 REC files 2f→hadrons could help?**

# back-up

# dEdx angular dependence using the “official tools”




**BLUE**

**dEdx angular dependence for mc2018 (corrrected)**
**Residuals are at the % level**

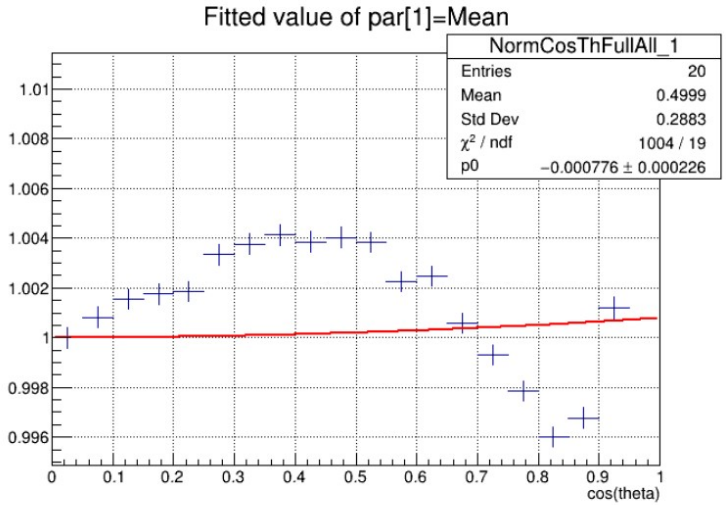
# dEdx angular dependence using the “official tools”

- One step back:
  - U. Einhaus looks at the regenerated single particle REC sample (before any dEdx computation) and have checked the correction parameters.

- **CASE A: same type of correction**
  - **The corrected distribution still shows a % level dependence on the angle**

## Masakazu’s formula, updated

- $f = 1 / ( 1 + p \cos^2\theta )$
- $p = -0.1489$
- $\chi^2/ndf = 883/19$
- Residuals: 0.8 %



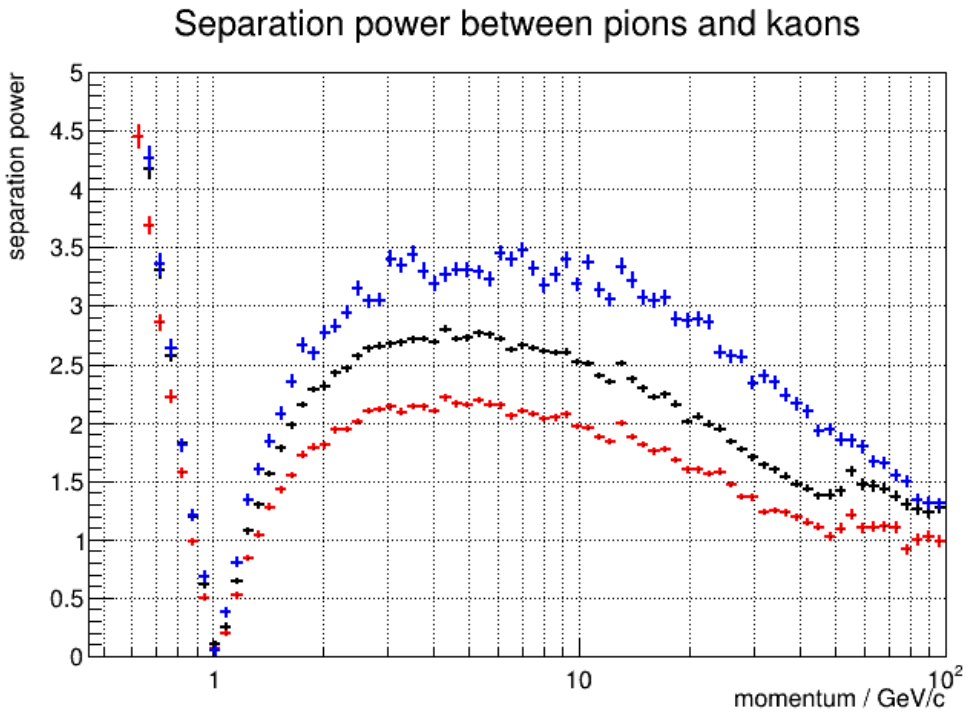

Uli Einhaus | Meeting | 01.01.2000 | Page 2

Plots made using all tracks in REC single particle files

# dEdx angular dependence using the “official tools”

**RED**

**dEdx angular w/o correction**




**BLACK**

**dEdx angular dependence after the nominal correction in v02-02-01 (and before)**

**BLUE**

**dEdx angular dependence after removing the v02-02 correction and applying a new parametrization from the black curve**

New_factor = 1 + [0]*lambda+[1]*lambda*lambda
(pol3 also explored but we got same Chi2/Ndf)

Plots made using MarlinTrks in single Particle events. DST files