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Particle Identification in the Reaction $p\bar{p} \to \Xi^-\bar{\Xi}^+$

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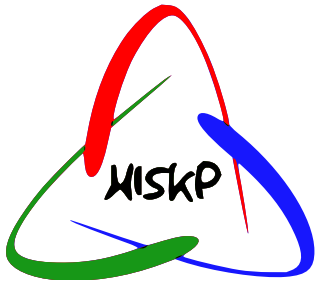
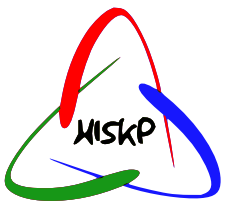


25.11.2016



Investigation of Ξ-Baryons

- only few exited Ξ^*-baryons are confirmed
- quantum numbers of these states are mostly unknown

at first: groundstate Ξ

$$p\bar{p} \rightarrow \Xi^-\bar{\Xi}^+ \rightarrow (\Lambda\pi^-)\left(\overline{\Lambda}\pi^+\right) \rightarrow (p\pi^-)\,\pi^-\,(\bar{p}\pi^+)\,\pi^+$$

Simulations

Signal

- $\mathrm{p\bar{p}} \to \Xi^-\bar{\Xi}^+ \to (\Lambda\pi^-)\,(\bar{\Lambda}\pi^+) \to (\mathrm{p}\pi^-)\,\pi^-\,(\bar{\mathrm{p}}\pi^+)\,\pi^+$
- 500000 Events
- $E_{CMS} = 3.0\,\mathrm{GeV}$ $\quad p_{\bar{\mathrm{p}}} \approx 3.75\,\mathrm{GeV}$

Backgrund

- DPM generator
- 500000 Events
- $E_{CMS} = 3.0\,\mathrm{GeV}$ $\quad p_{\bar{\mathrm{p}}} \approx 3.75\,\mathrm{GeV}$

Single Tracks

- 500000 single tracks e, μ, π, K, p
- uniform distribution, $p < 3.75\,\mathrm{GeV}$

Softwareversions

- PandaROOT Jan16
- FairROOT 15.11
- Fairsoft mar15
- marcos from $VMCWORKDIR/marco/run

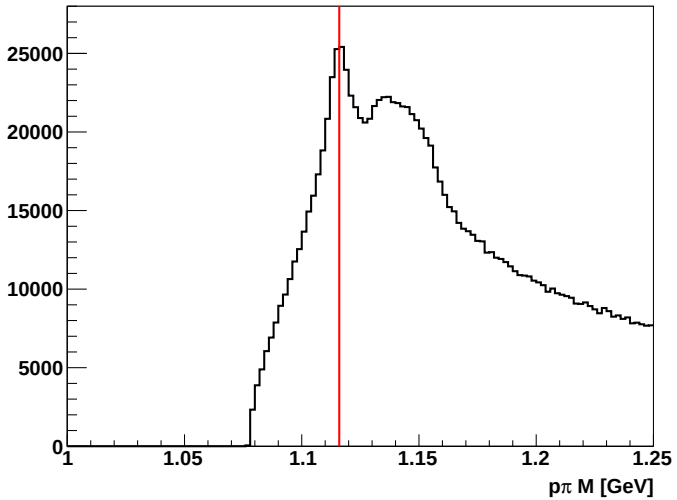
PID algorithms

- PidAlgoMvd
- PidAlgoStt
- PidAlgoEmcBayes
- PidAlgoDrc
- PidAlgoDisc
- PidAlgoMdtHardCuts

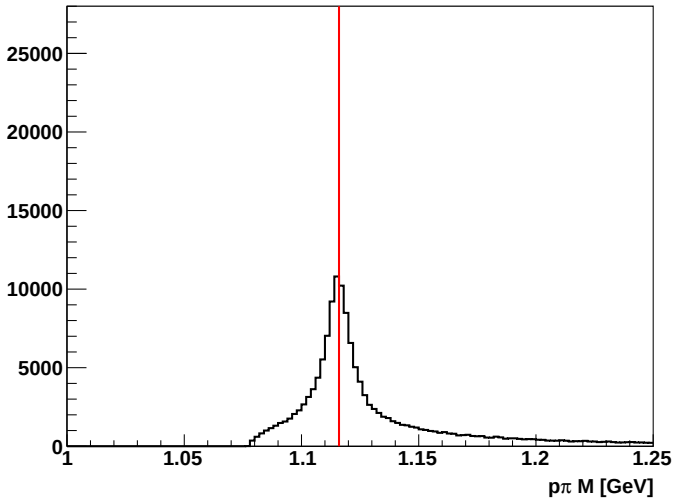
Reactionselection - Combining Tracks

- combine $\pi^- p \rightarrow \Lambda$, $\pi^+ \overline{p} \rightarrow \overline{\Lambda}$

all combinations



correct combination



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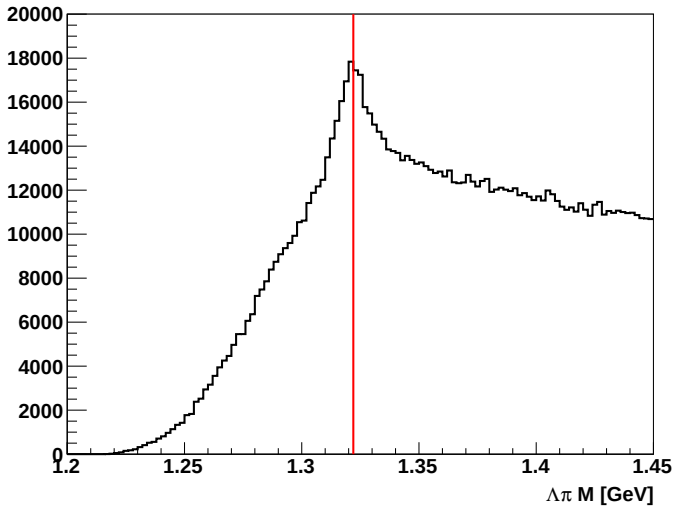

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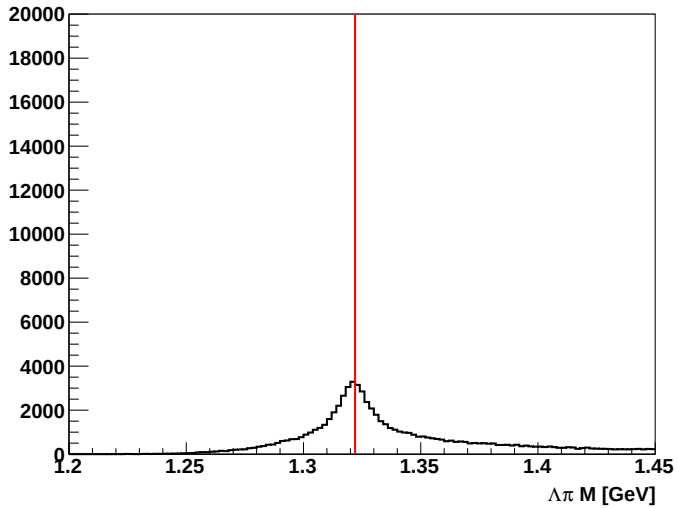
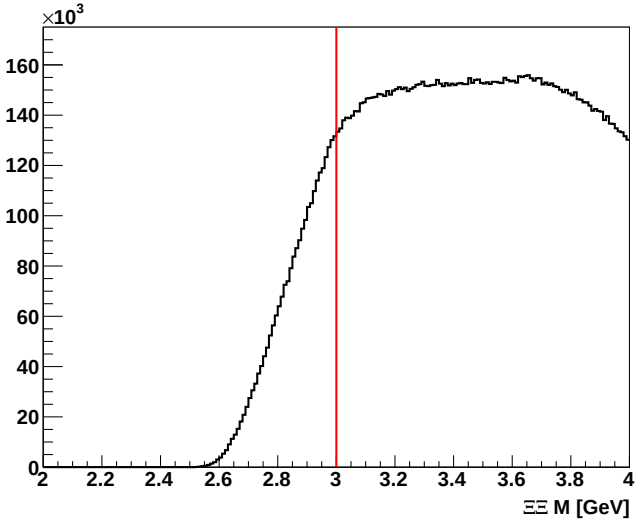


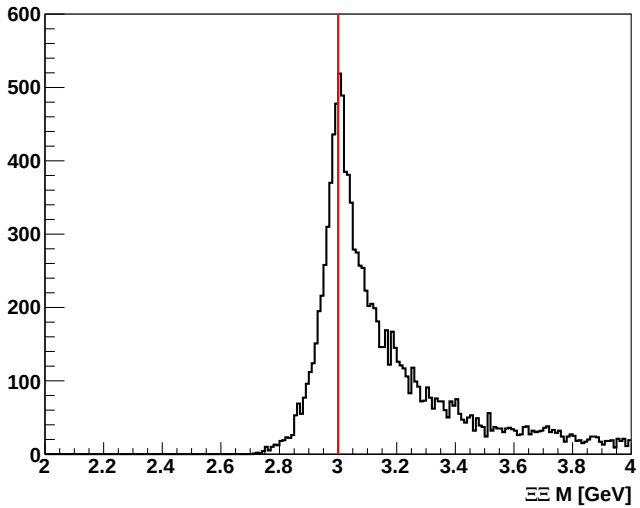
Reactionselection - Combining Tracks

- combine $\pi^- p \rightarrow \Lambda$, $\pi^+ \overline{p} \rightarrow \overline{\Lambda}$
- combine $\pi^- \Lambda \rightarrow \Xi^-$, $\pi^+ \overline{\Lambda} \rightarrow \overline{\Xi}^+$
- combine $\Xi^- \overline{\Xi}^+ \rightarrow \mathrm{CMS}$

all combinations



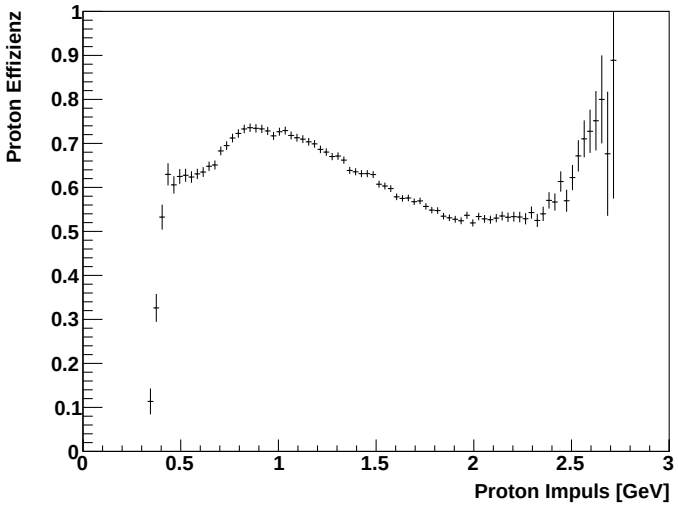
correct combination

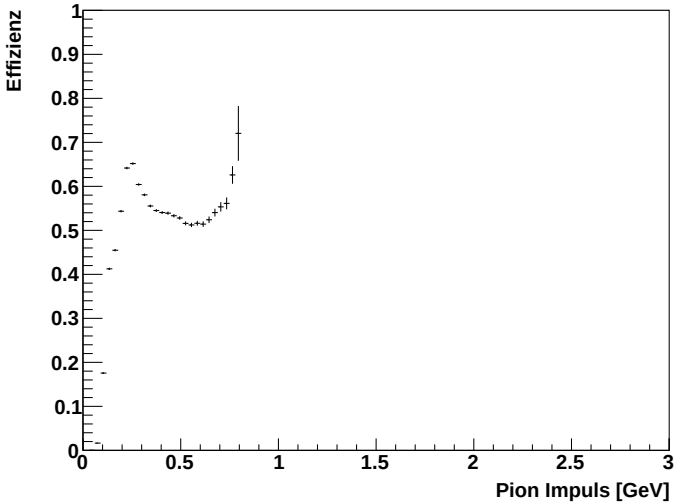


Reconstructionefficiency

track reconstruction (Signal)

	Efficiency
π^-	54.3 %
π^+	50.2 %
p	62.5 %
$\overline{\text{p}}$	61.0 %
Λ	32.3 %
$\overline{\Lambda}$	28.8 %
Ξ^-	18.0 %
$\overline{\Xi}^+$	15.0 %
CMS	2.7 %

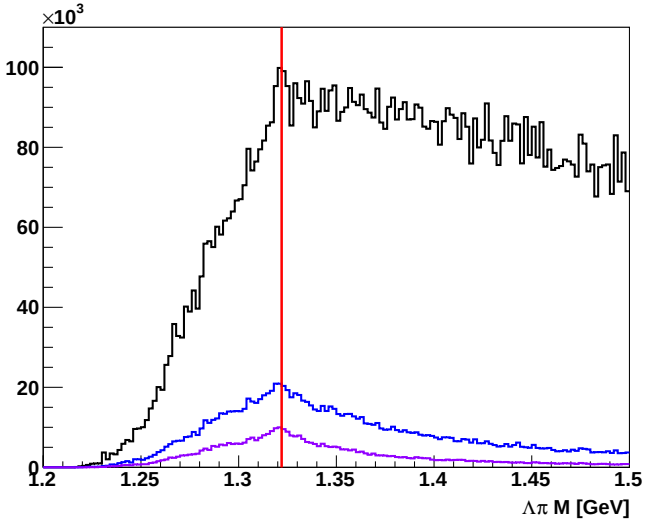




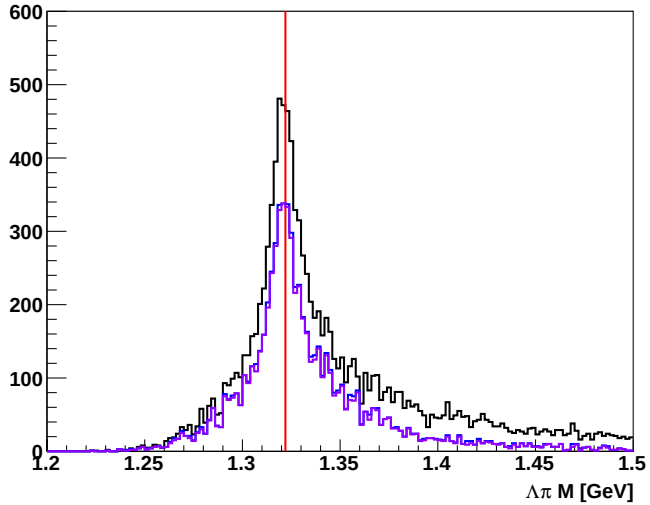
Reactionselection - Cuts

- Λ mass: $1.115\,\text{GeV} \pm 0.1\,\text{GeV}$
- center of mass energy: $3.0\,\text{GeV} \pm 0.6\,\text{GeV}$
- total momentum: $p_t < 0.6\,\text{GeV}$; $2.5\,\text{GeV} < p_z < 4.9\,\text{GeV}$

all combinations



correct combination



blue: M_Λ, E_{CMS} purple: P_{CMS}

Information from a PID Detector

- conditional probability $P_X(S)$ for track S being of a particle of type X.

$$\vec{P}(S) = \begin{pmatrix} P_\mathsf{e} \\ P_\mu \\ P_\pi \\ P_\mathsf{K} \\ P_\mathsf{p} \end{pmatrix} \qquad \sum P_X(S) := 1$$

Examples

no information

$$\vec{P}(S) = \begin{pmatrix} 0,2 \\ 0,2 \\ 0,2 \\ 0,2 \\ 0,2 \end{pmatrix}$$

some information

$$\vec{P}(S) = \begin{pmatrix} 0,1 \\ 0,15 \\ 0,15 \\ 0,5 \\ 0,1 \end{pmatrix}$$

perfect information

$$\vec{P}(S) = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}$$

Combined Probabilities

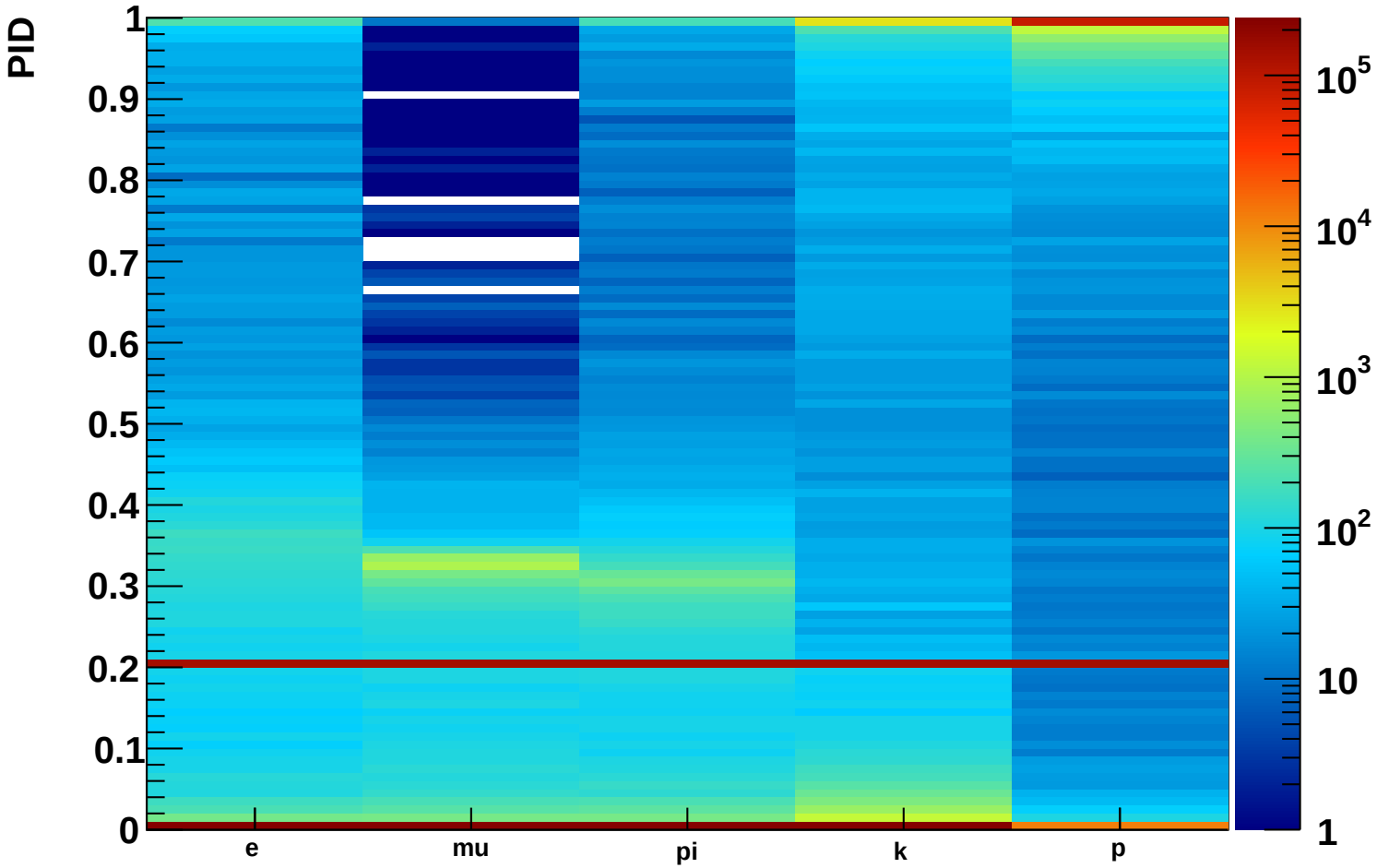
Combination of Detectors

$$\vec{P}_{ges}(S) = \begin{pmatrix} P_{\mathsf{e},ges} \\ P_{\mu,ges} \\ P_{\pi,ges} \\ P_{\mathsf{K},ges} \\ P_{\mathsf{p},ges} \end{pmatrix} = \begin{pmatrix} P_{\mathsf{e},MVD} \cdot P_{\mathsf{e},STT} \cdot \dots \\ P_{\mu,MVD} \cdot P_{\mu,STT} \cdot \dots \\ P_{\pi,MVD} \cdot P_{\pi,STT} \cdot \dots \\ P_{\mathsf{K},MVD} \cdot P_{\mathsf{K},STT} \cdot \dots \\ P_{\mathsf{p},MVD} \cdot P_{\mathsf{p},STT} \cdot \dots \end{pmatrix} /N$$

Examples

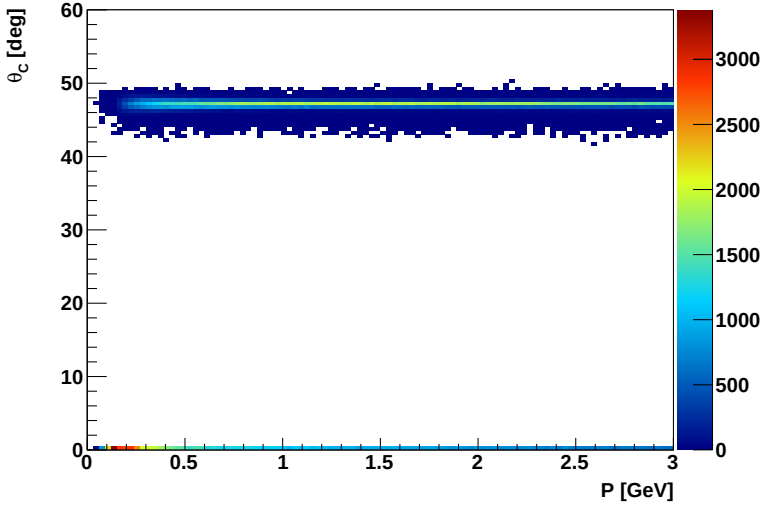
$$\vec{P} \otimes \begin{pmatrix} 0,2 \\ 0,2 \\ 0,2 \\ 0,2 \\ 0,2 \end{pmatrix} = \vec{P} \qquad \vec{P} \otimes \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}$$

PID Probabilities DRC - Protons

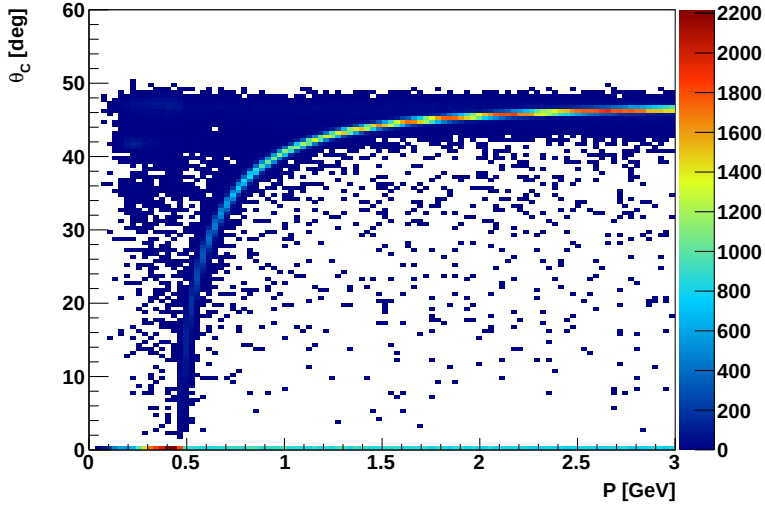


Barrel Cherenkov

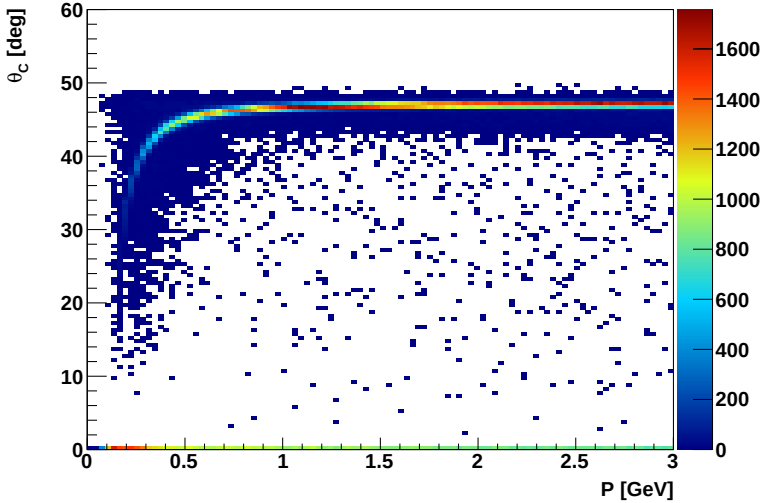
Elektronen



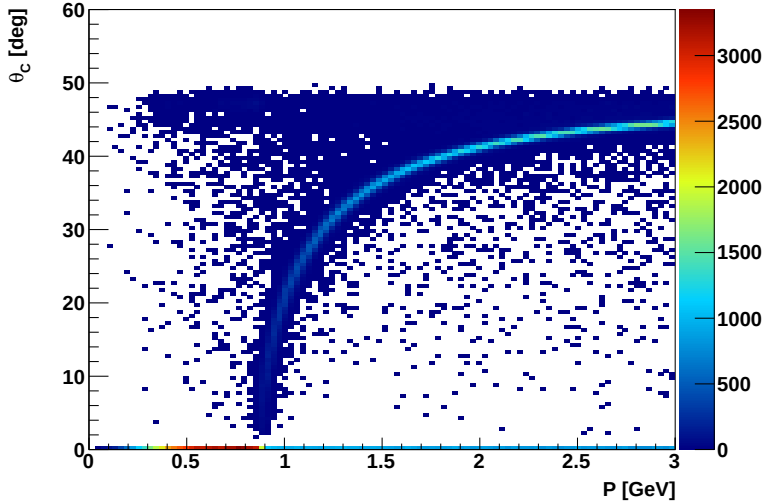
Kaonen



Pionen

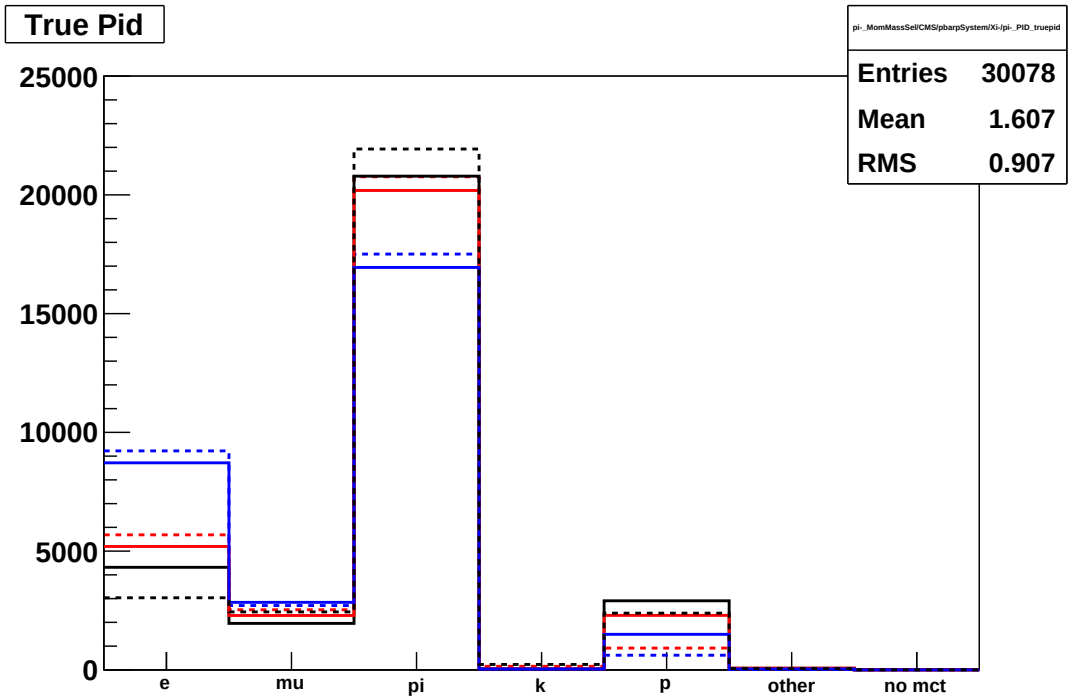


Protonen



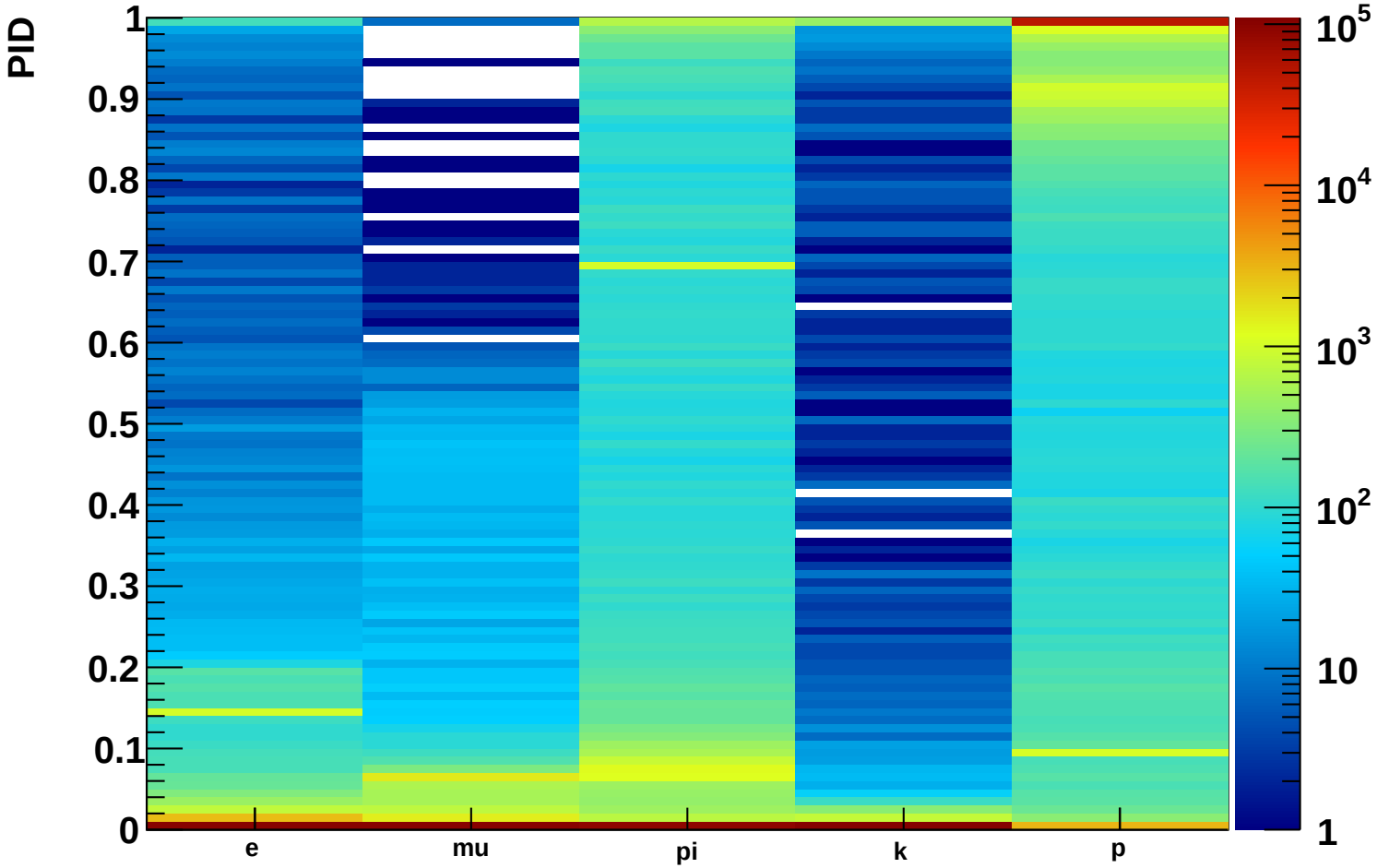
Flux

- particle species are produced in different numbers
- can be used like information from an additional detector
- depends on reconstruction and applied cuts
- assumtion: dominated by background



p	black
π_Λ	red
π_Ξ	blue
pos.	cont.
neg.	dashed

PID Probabilities Alle - Protons



Efficiency and Specificity

Efficiency for Particlespecies X

$$E_X = P\left(\text{identified as } X \middle| \text{ was } X\right)$$

$$E_X = \frac{\text{number of correct tracks after cut}}{\text{number of correct tracks before cut}}$$

Efficiency and Specificity

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$$E_X = P\left(\text{identified as } X \middle| \text{ was } X\right)$$

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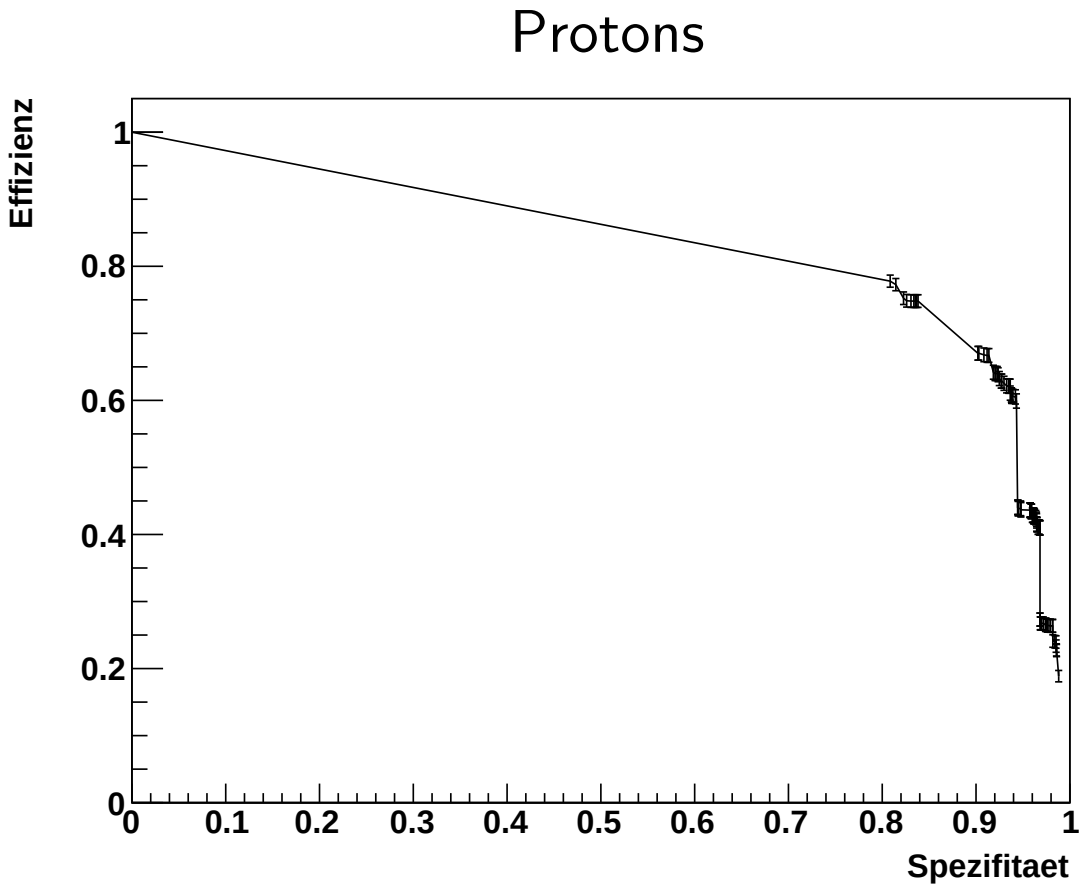
Specificity for Particlespecies X

$$S_X = P\left(\text{identified as not } X \middle| \text{ was not } X\right)$$

$$S_X = 1 - \frac{\text{number of wrong tracks after cut}}{\text{number of wrong tracks before cut}}$$

Efficiency and Specificity



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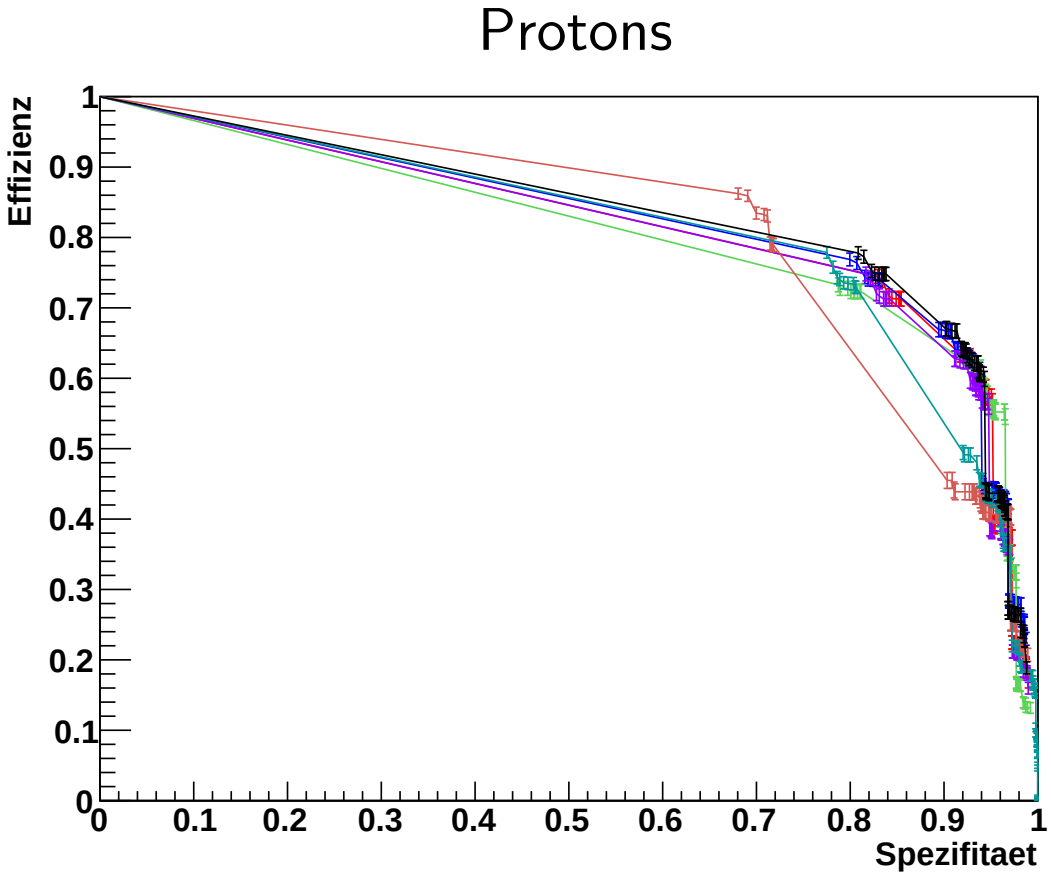
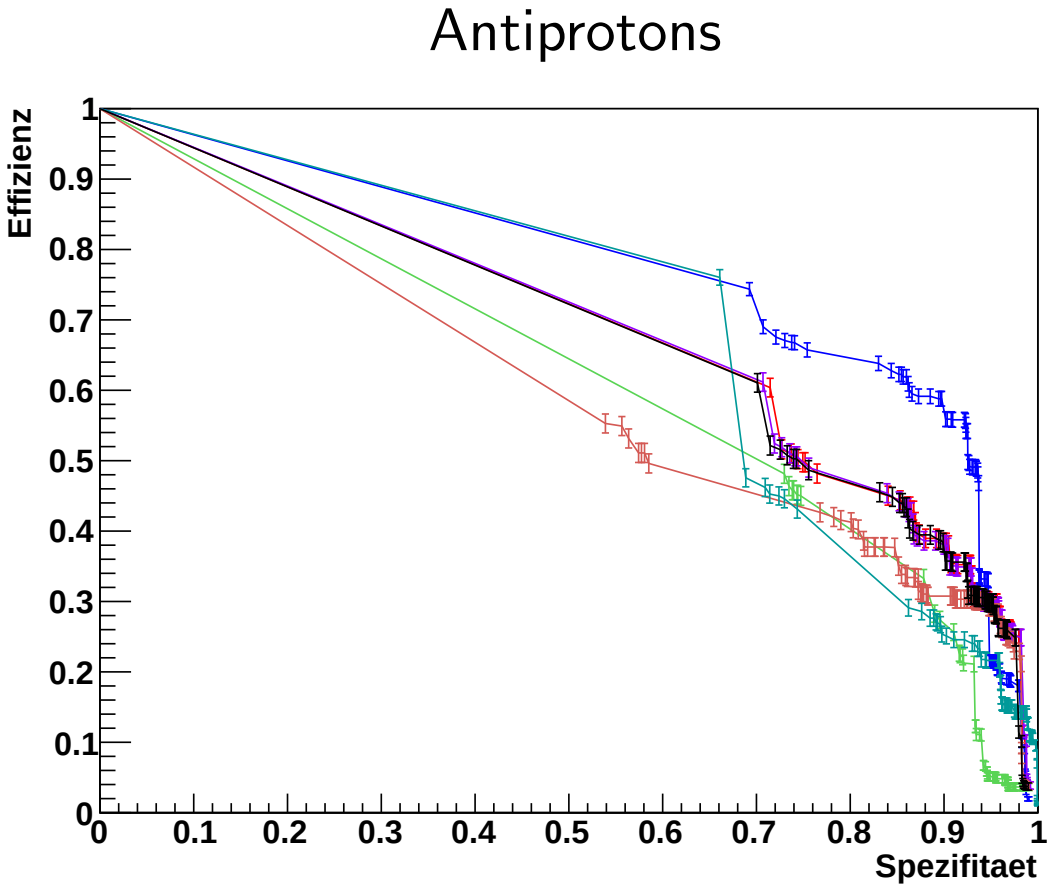


without

DRC	red	DSC	blue	EMC	green
MDT	purple	MVD	brown	STT	cyan

Efficiency and Specificity



without

DRC	red	DSC	blue	EMC	green
MDT	purple	MVD	brown	STT	cyan

PID Efficiencies

	no PID	> 0.25	> 0.50
π^-	54.3 %	49.1 %	47.1 %
π^+	50.2 %	45.5 %	43.5 %
p	62.5 %	34.8 %	27.4 %
$\overline{\text{p}}$	61.0 %	34.4 %	27.6 %
Λ	32.3 %	12.7 %	9.2 %
$\overline{\Lambda}$	28.8 %	11.9 %	8.8 %
Ξ^-	18.0 %	6.4 %	4.4 %
$\overline{\Xi}^+$	15.0 %	5.7 %	4.0 %
CMS	2.7 %	0.3 %	0.12 %

Outlook

- solve problems with Cherenkovdetectors
- vertexreconstruction
- kinematic fit
- exited Ξ^*
- ...