Preliminary Iron Flux

Firenze – TIM 04 Feb 2020

Caterina Checchia – University of Firenze
Francesco Stolzi – University of Siena

Outline

(1) Data set and pre-selections

(2) Calibration of Iron charge in CHD

(3) Introduction of quenching in MC TASC

(4) Fe selection and MC-FD comparison

(5) Interacting events

(6) Efficiency

(7) Preliminary Iron Flux

(8) Preliminary Systematic studies

(1) Data set and Pre-selection

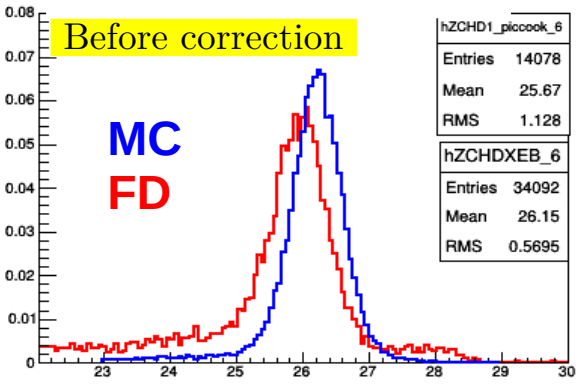
- **Data set**
  - **Montecarlo data (MC):**
    - **Epics** data from 100 GeV to 100 Tev reweighted according to Ballon89 Sanriku (emulsion) $\gamma_{\text{from Sanriku}}$ = -2.59.
  - **Flight Data (FD):**
    - Pass 3.1 Data from 01/2016 to 06/2018 30 months for calibrations;
    - Pass 4.0 Data from 01/2016 to 10/2019 46 months for flux.
- **Pre-selection**
  - Trigger HET;
  - CHD paddles matched by reconstructed track;
  - Reconstructed track using Kalman Filter for Heavy Nuclei (FF=3);
  - Acceptance A.

(2) Calibration of Iron charge in CHD

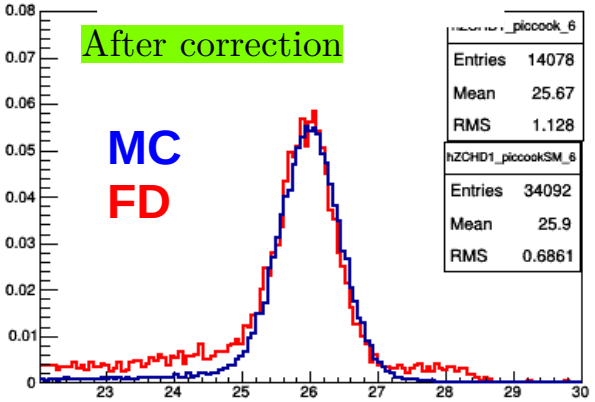
- **Flight data:**
  - Gaussian fit to dE/dX distribution in CHDX-Y;
  - Fit σ_{FD} **vs Z** with pol2 function;
  - Tarlé Correction (dE/dX→Z);
  - Energy shift correction using $f(E)=a+b*\log E+c*(\log E)^2$.
- **MC Data:**
  - Gaussian fit to dE/dX reweighted distribution in CHDX-Y;
  - Fit σ_{MC} **vs Z** with pol2 function;
  - Definition of smearing function according to $\sigma^2_{SME}= \sigma^2_{FD} - \sigma^2_{MC}$;
  - Gaussian smearing correction event by event to MC data;
  - Tarlé Correction (dE/dX→Z);
  - Energy shift correction using $f(E)=a+b*\log E+c*(\log E)^2$.

Charge correction for smearing, quenching and energy shift

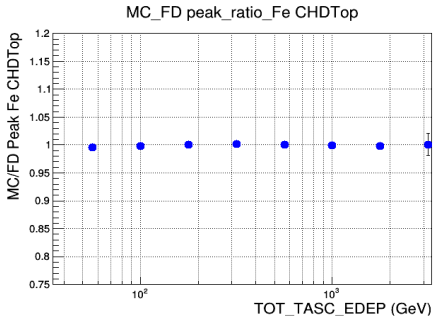
CHDX 316 – 562 GeV

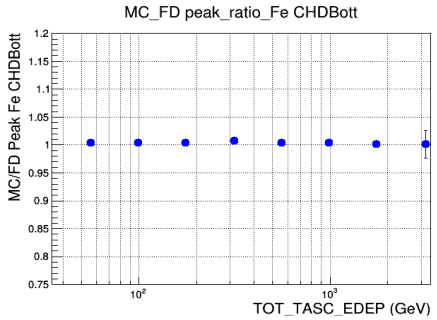


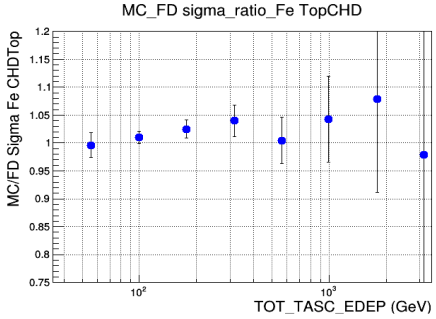
CHDX 316 – 562 GeV

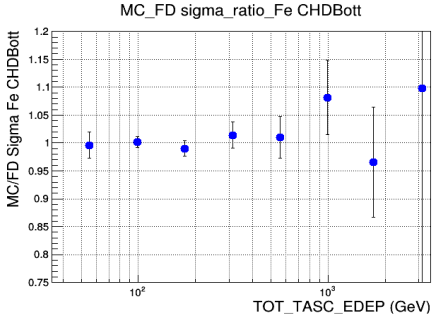


MC/FD ratio for Peak and Sigma after correction



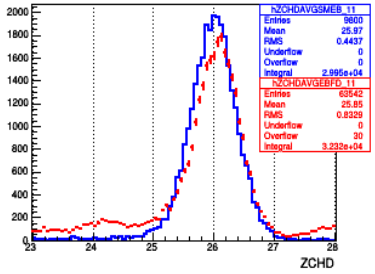




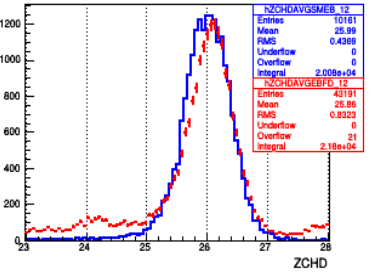


Average CHD charge: MC vs FD

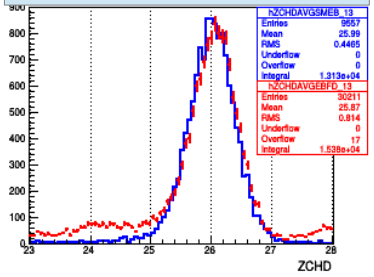
125.9 – 158.5 GeV



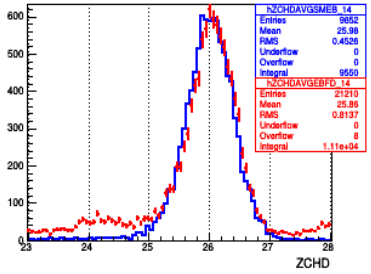
158.5 – 199.5 GeV



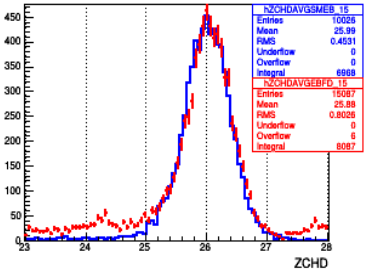
199.5 – 251.2 GeV



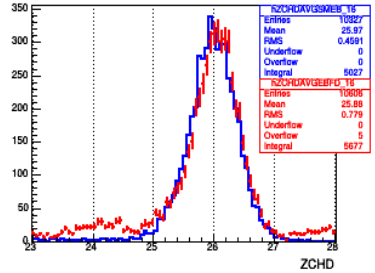
251.2 – 316.2 GeV



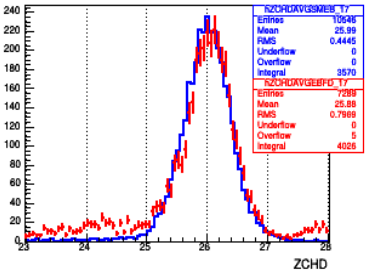
316.2 – 389.1 GeV



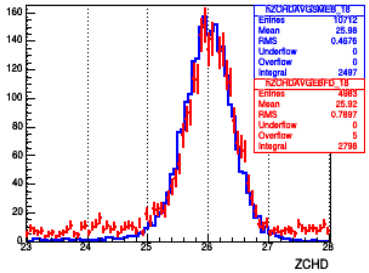
389.1 – 501.2 GeV



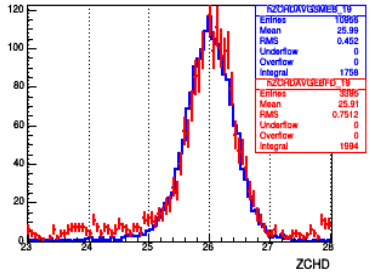
501.2 – 631.0 GeV



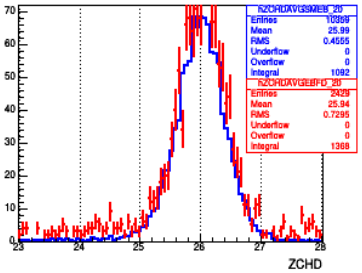
631.0 – 794.3 GeV



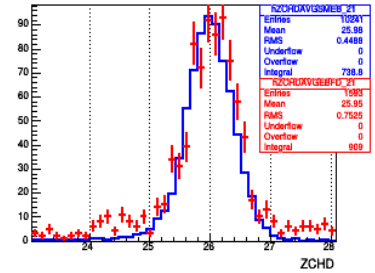
794.3 – 1000.0 GeV



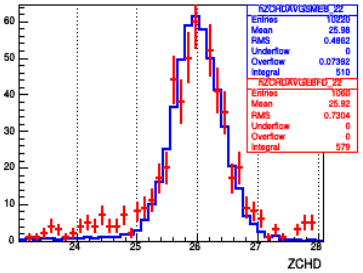
1.00 – 1.25 TeV



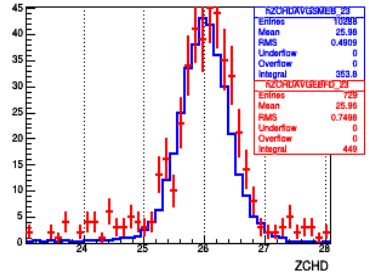
1.25 – 1.59 TeV



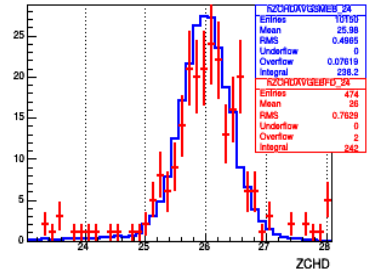
1.59 – 2.00 TeV



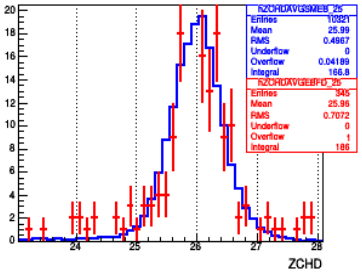
2.00 – 2.51 TeV



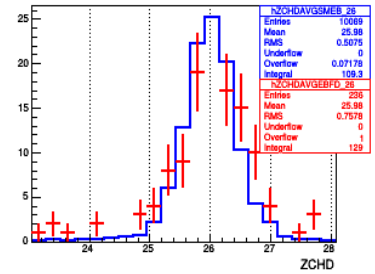
2.51 – 3.16 TeV



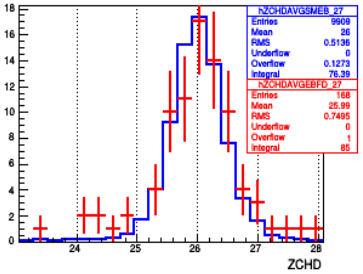
3.16 – 3.89 TeV



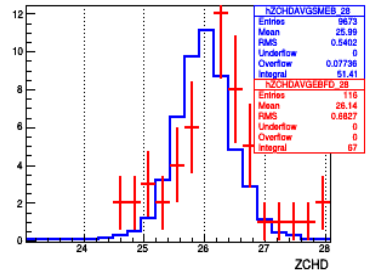
3.89 – 5.01 TeV



5.01 – 6.31 TeV



6.31 – 7.94 TeV



P-Sel,
Pass4.0

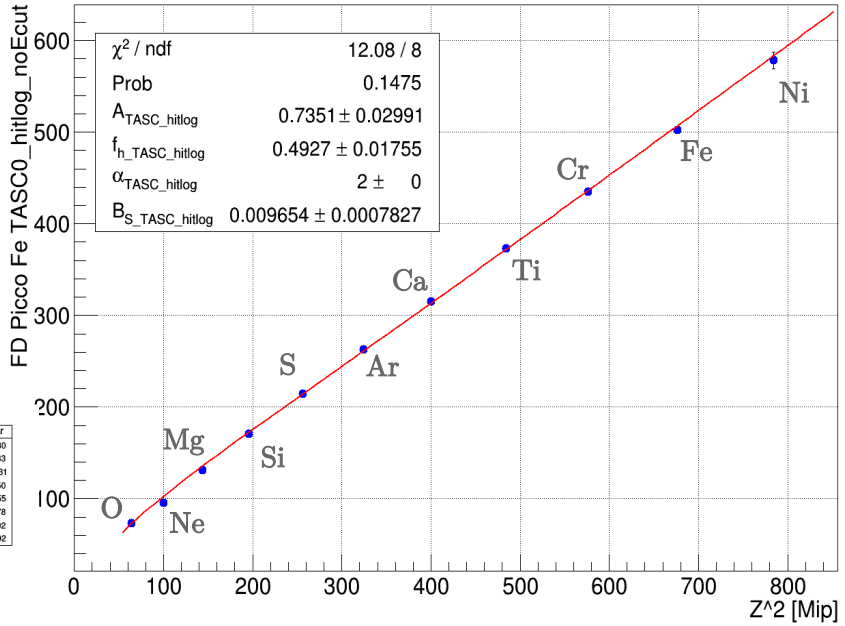
MC = Blue
FD = Red

(3) Introduction of quenching in MC TASC

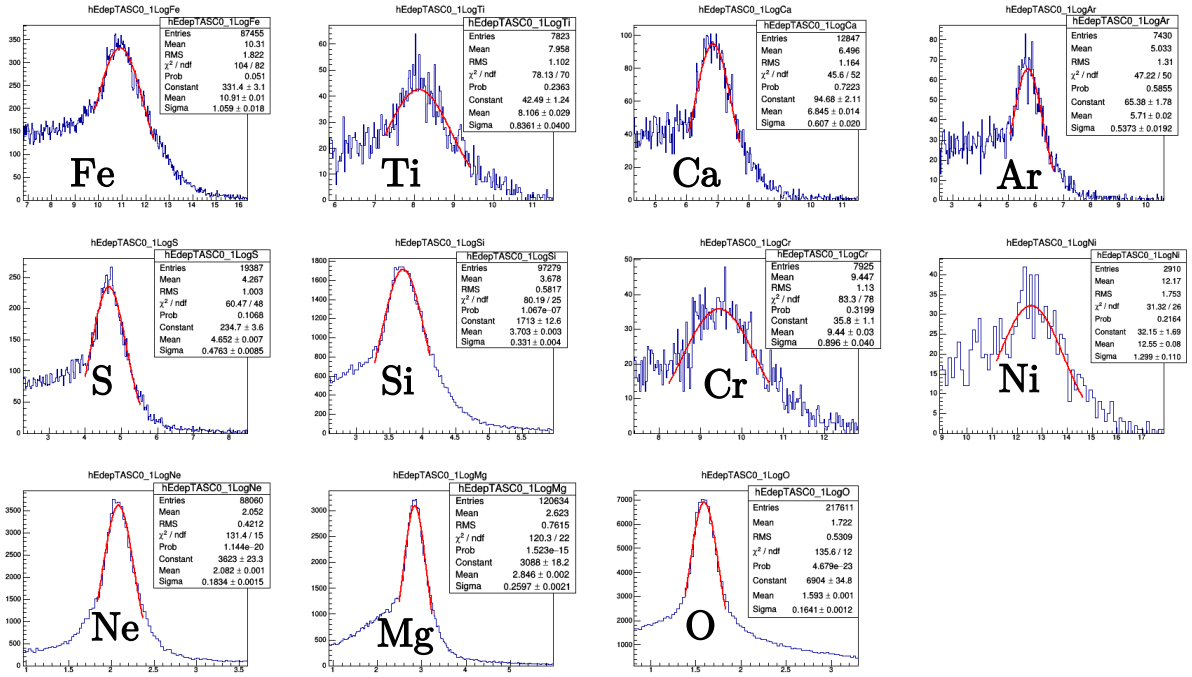
Flight Data: realization of Tarlé funcion

- Gaussian fit to Mip peak in TASCX1 Hit Log for Nuclei from O to Ni;
- Fit ***peak vs Z²*** with Tarlé function;

Hit Log Peak vs Z²



TASCX1 Hit Log Peak



EPICS: applying quenching according to Tarle FD function

In MC EPICS, TASCEdep is stored in the two different contributions:

- **EdepH** = edep for charged nuclei with Z>=2
- **EdepS** = edep for single charged particles (|Z| = 1)

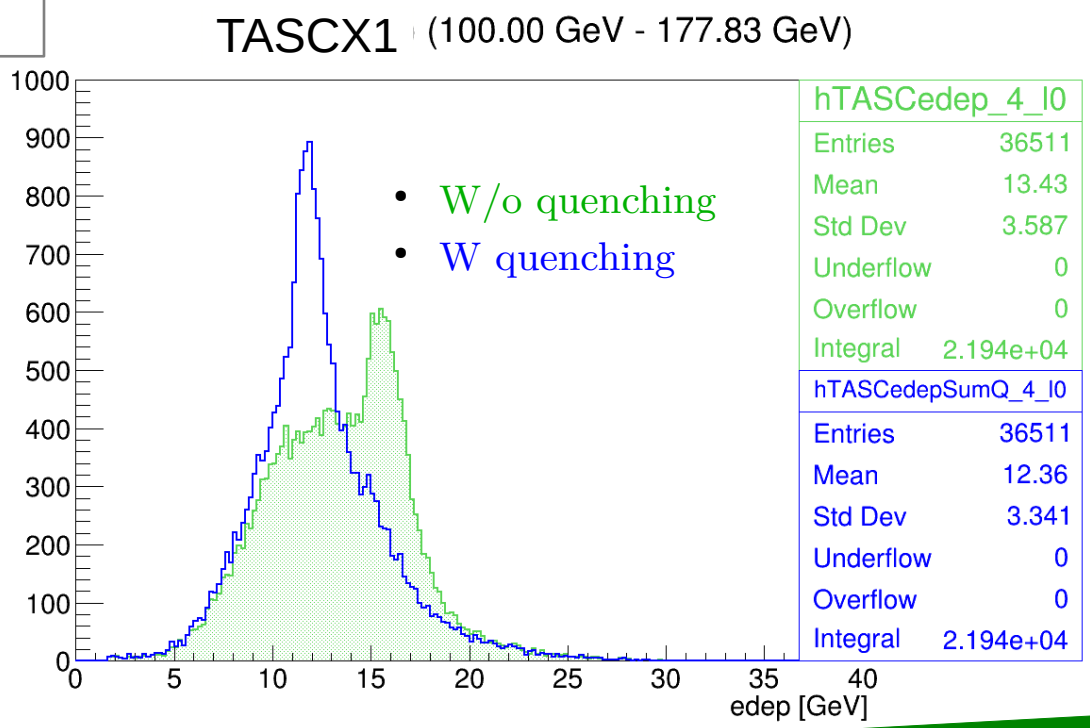
thus TASCedep = EdepH + EdepS

The quenching in TASC is then applied as follows:

$$\text{TASCedepSumQ} = \begin{cases} Q(edepH + edepS) & \text{if edepH}\neq 0 \\ edepS & \text{if edepH=0} \end{cases}$$

STD method

This because the Tarlé parametrization (Q function in the formula) has been obtained from FD where the two compontents (H and S) are not separated



(4) Fe selection and MC-FD comparison

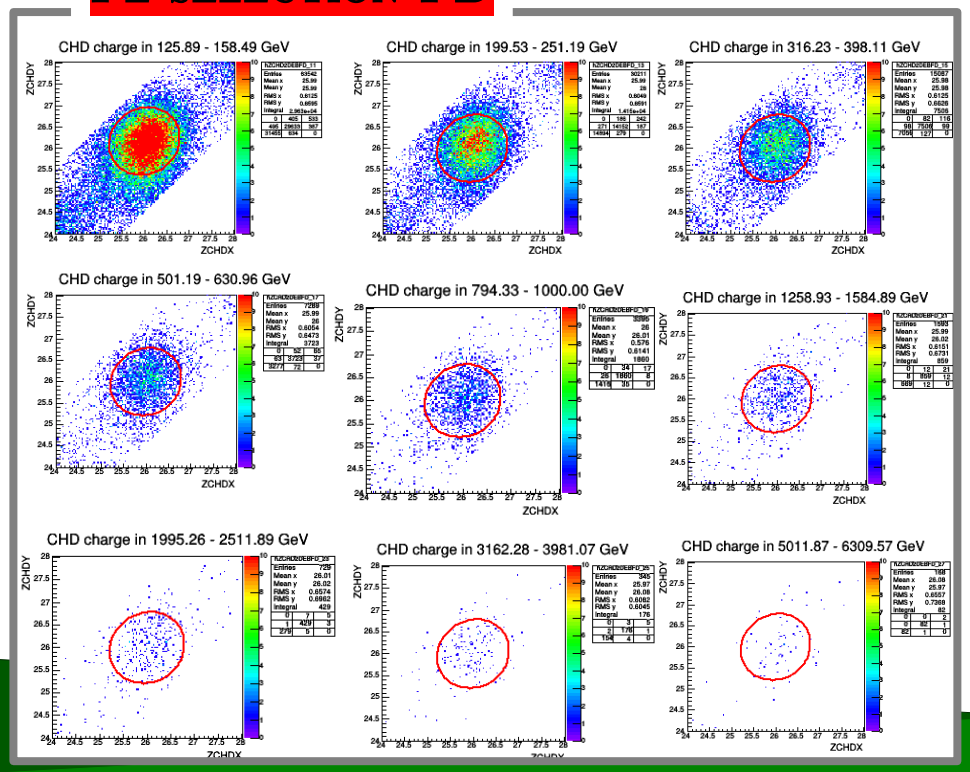
Flight and Montecarlo data Standard (STD) selection

- Trigger HET;
- CHD paddles matched by reconstructed track;
- Reconstructed track using Kalman Filter for Heavy Nuclei
- Acceptance A

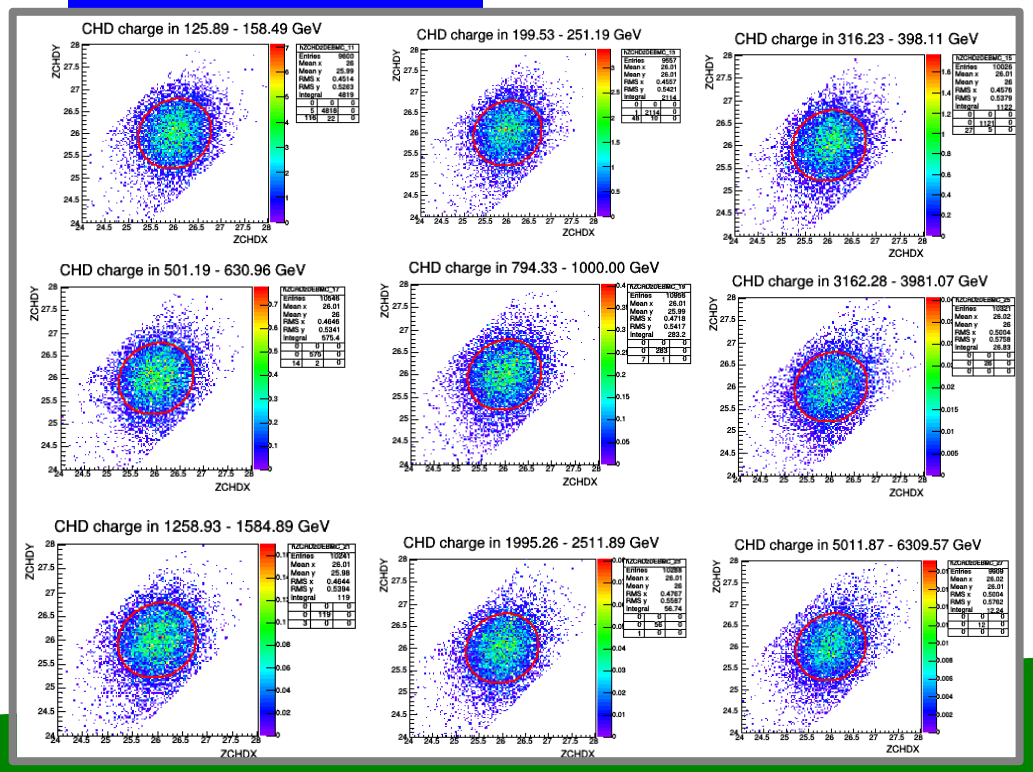
Pre-Selections

- Consistency cut CHDX-Y within 30% ;
- Ellipse cut (X: 26.0,Y: 26.0, Rx: 0.748, Ry: 0.825)

Fe selection FD

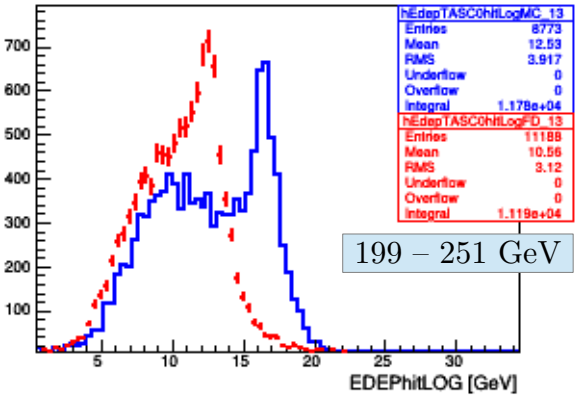


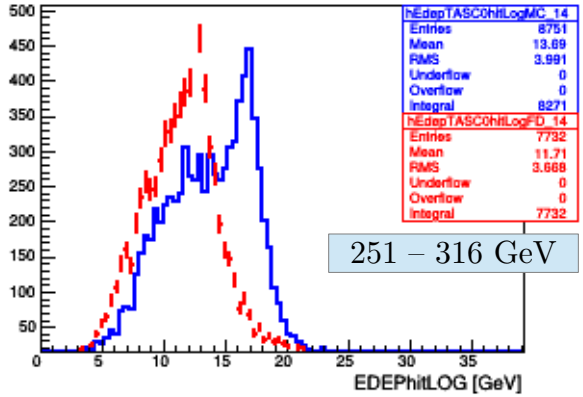
Fe selection MC

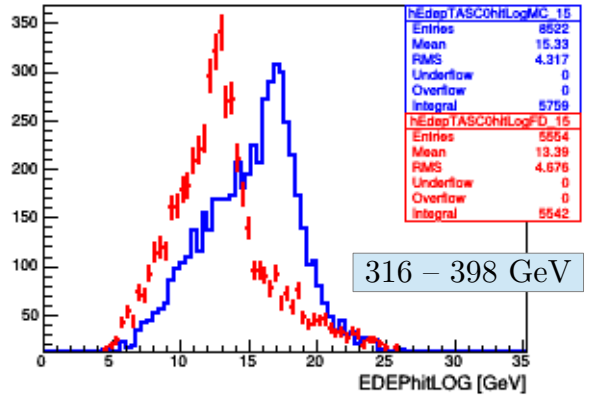


EdepTASC Hit Log Layer TASCX1 for MC and FD

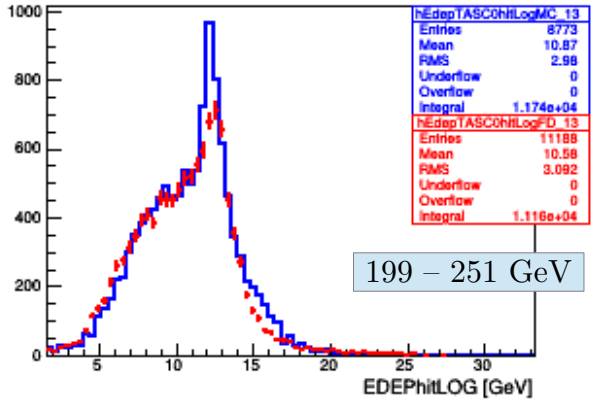
Before Quenching introduction

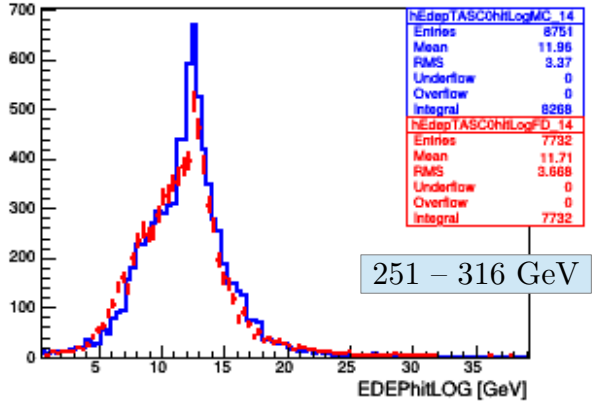


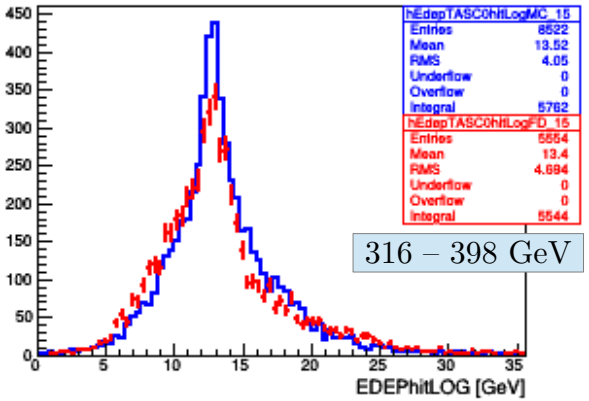




After Quenching introduction



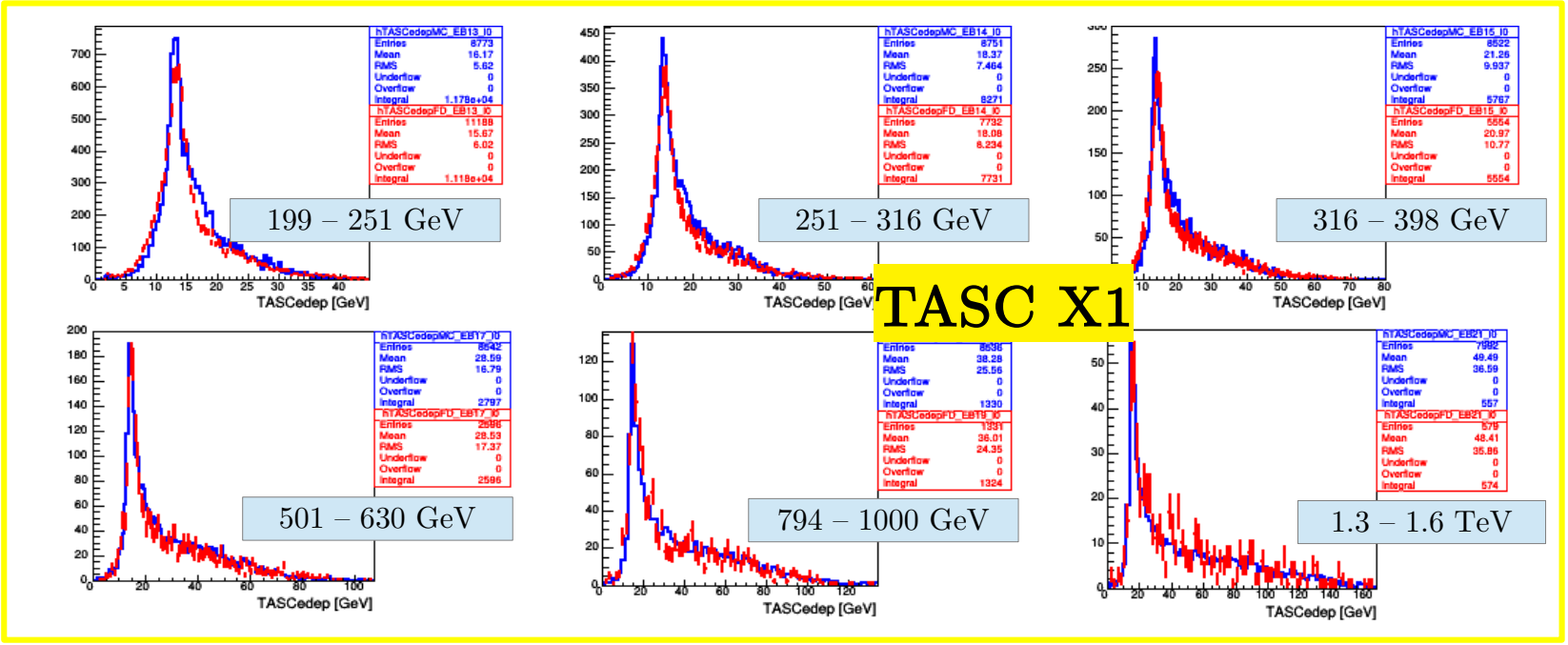


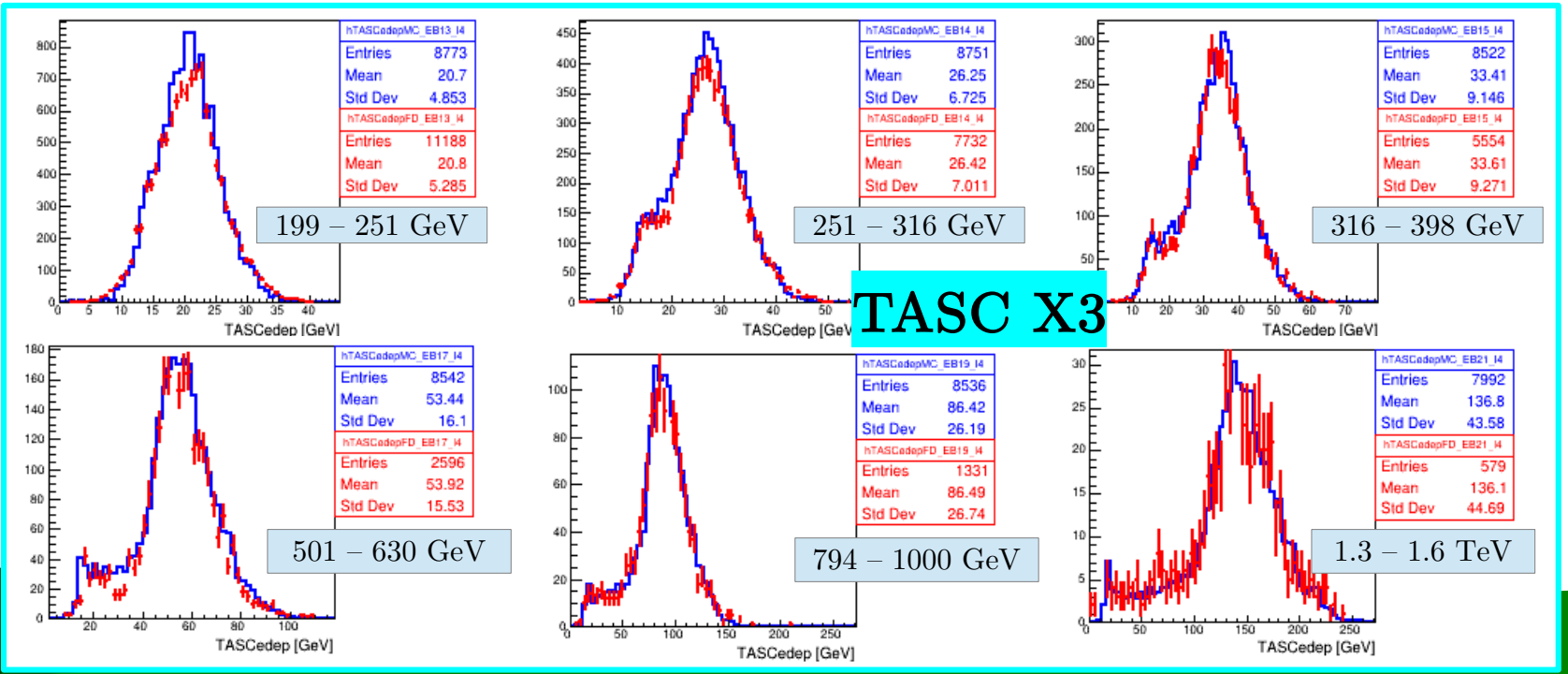


MC = Blue

FD = Red

TASC edep MC-FD comparison





MC = Blue

FD = Red

(5) Cut on Not-Interacting events

MC EPICS

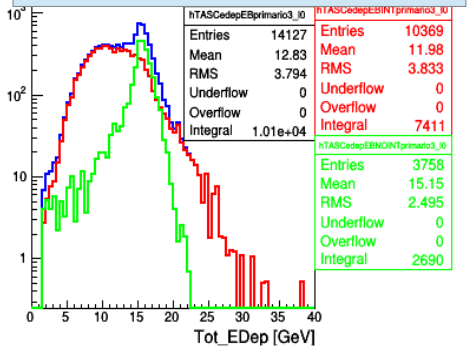
Green = non interacting

Red = interacting

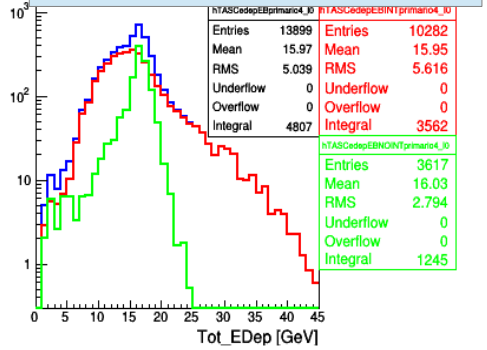
Blue = all

TASCX1 edep

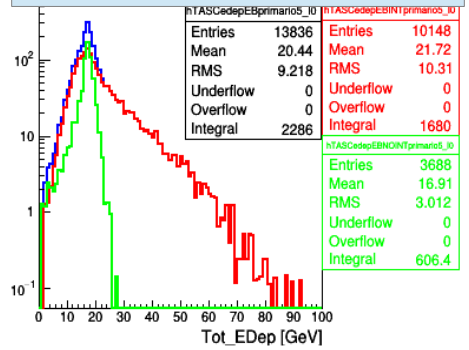
398 – 631 GeV



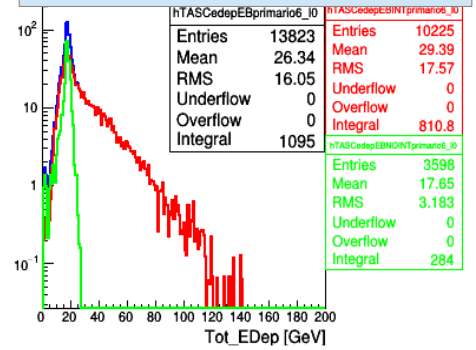
631 – 1000 GeV



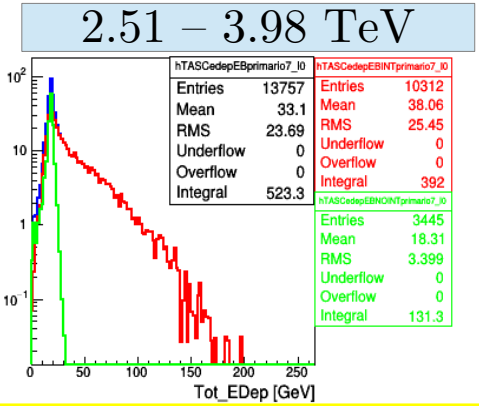
1.00 – 1.59 TeV



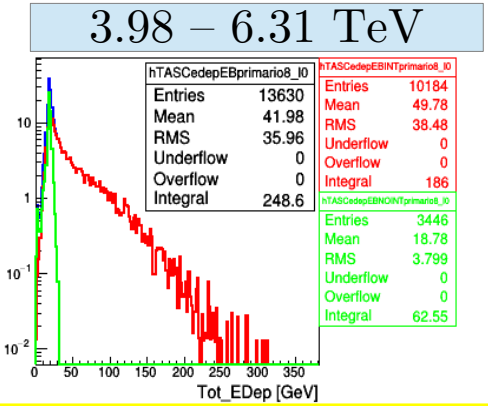
1.58 – 2.51 TeV



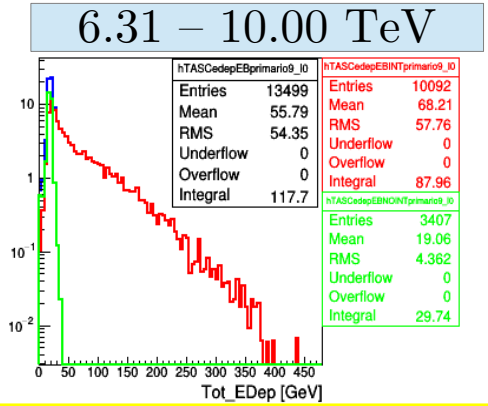
2.51 – 3.98 TeV



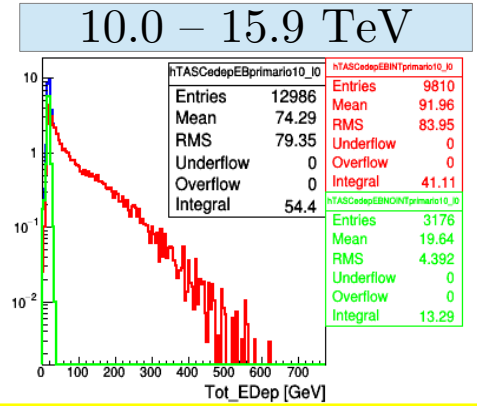
3.98 – 6.31 TeV



6.31 – 10.00 TeV



10.0 – 15.9 TeV

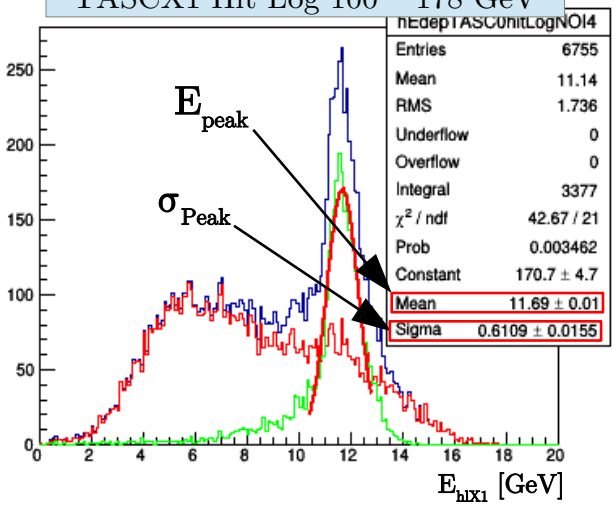


Energy Bins in primary energy

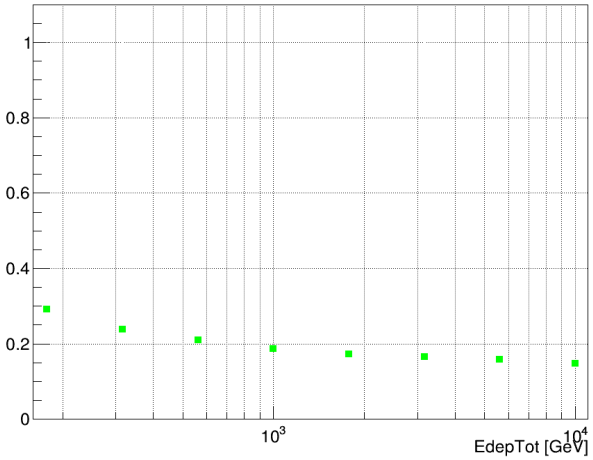
Shower Event Selection (SES_{STD})

$$|E_{hlX1}-E_{peak}|>3\sigma_{peak} \;||\; |E_{hlY1}-E_{peak}|>3\sigma_{peak} \;||\; |E_{hlX2}-E_{peak}|>3\sigma_{peak}$$

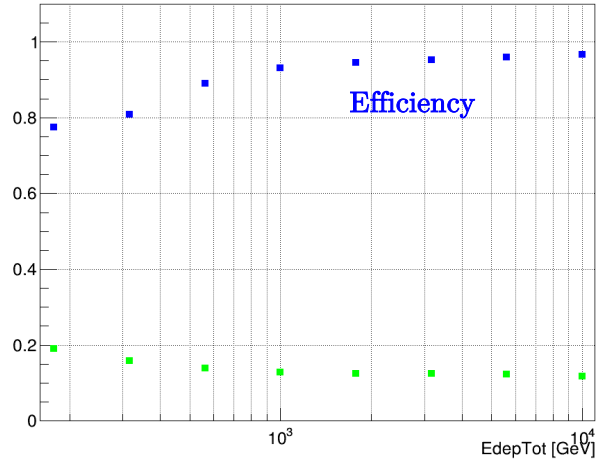
TASCX1 Hit Log 100 – 178 GeV



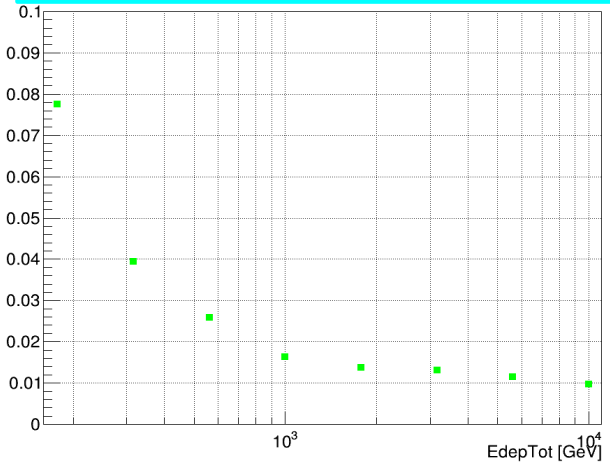
Contamination before cut on TASCX1



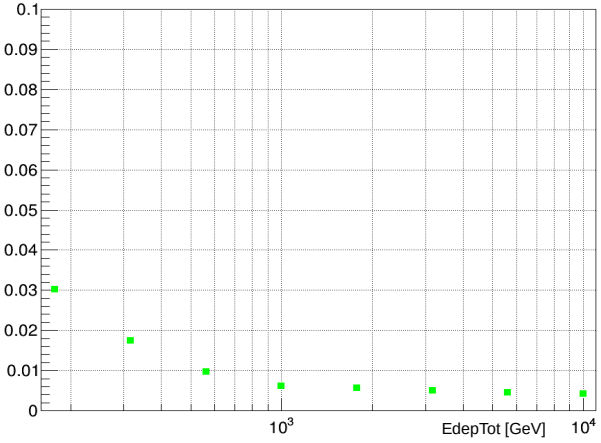
Contamination after cut on TASCX1



Contamination before cut on TASCX3

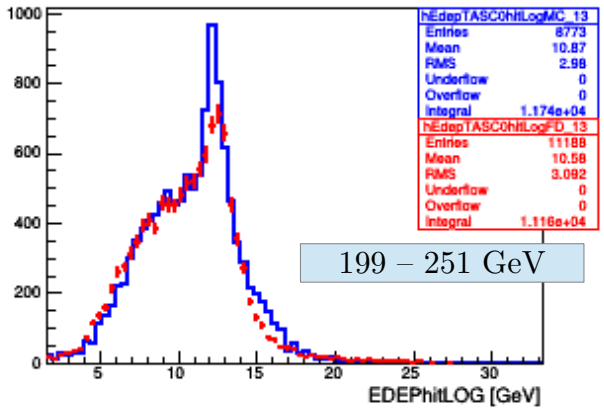


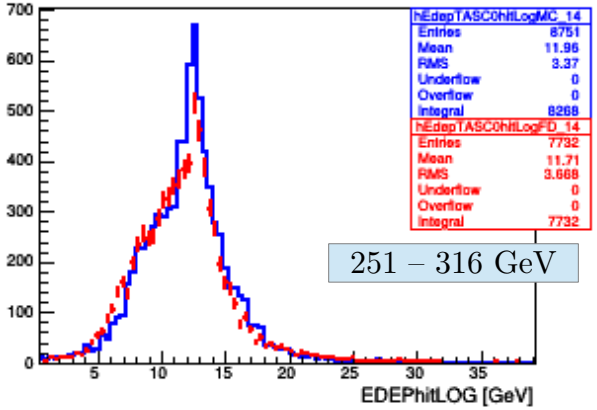
Contamination after cut on TASCX3

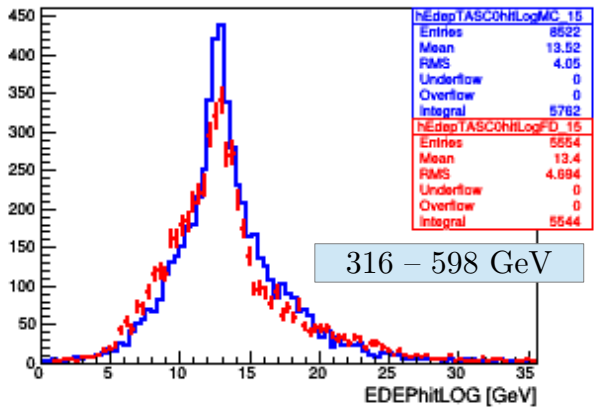


EdepTASC Hit Log Layer TASCX1

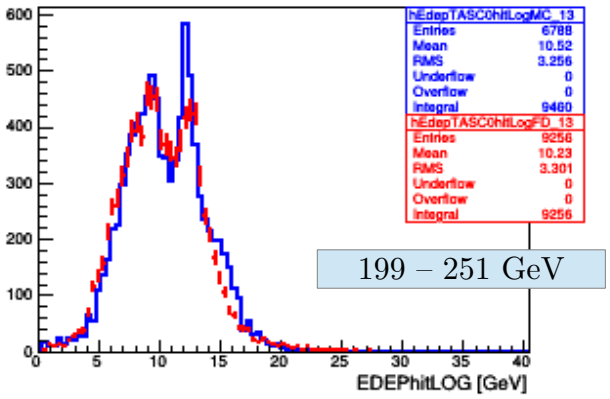
Before SES_{STD}

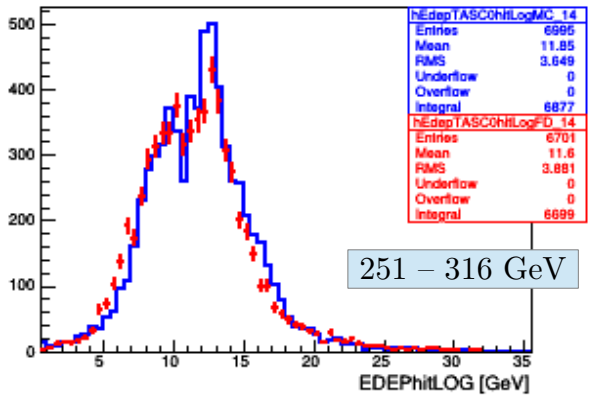


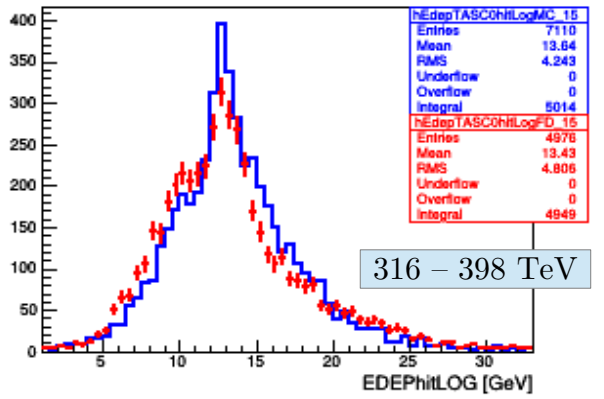




After SES_{STD}



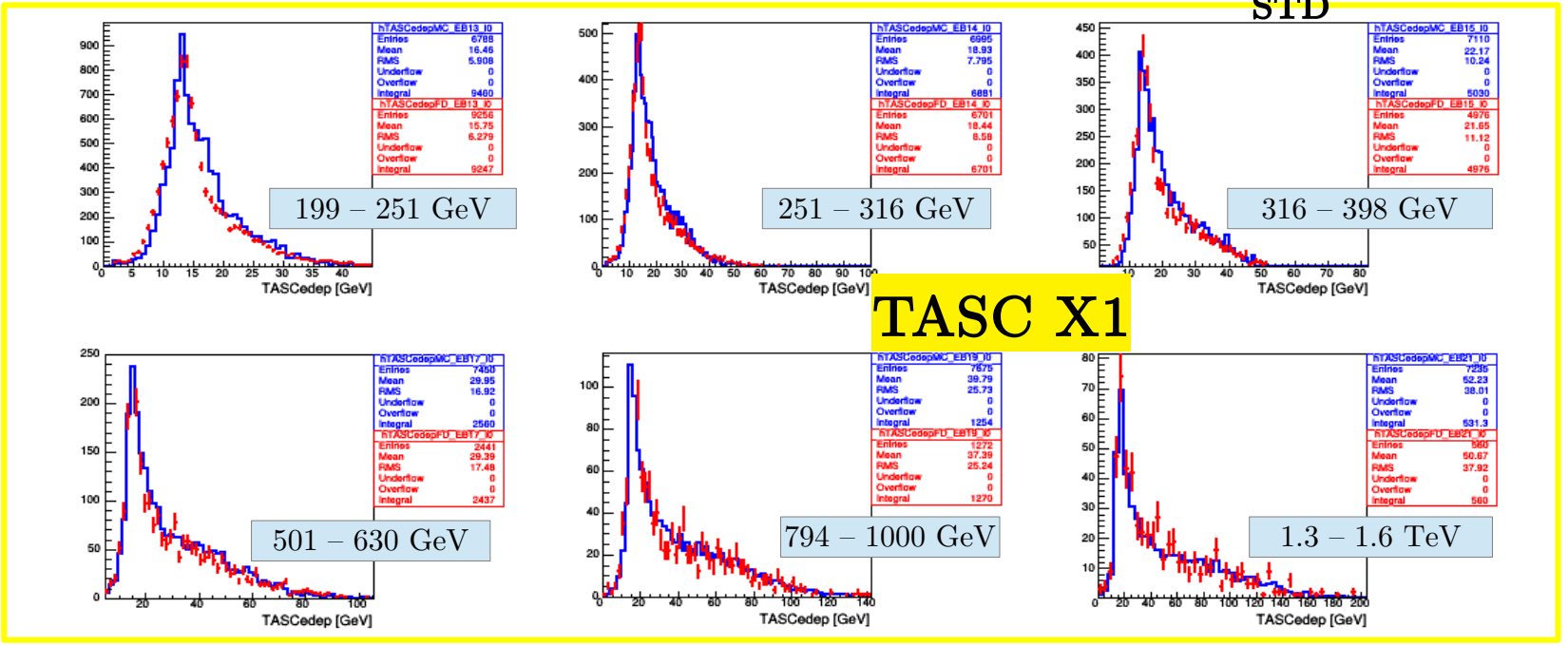


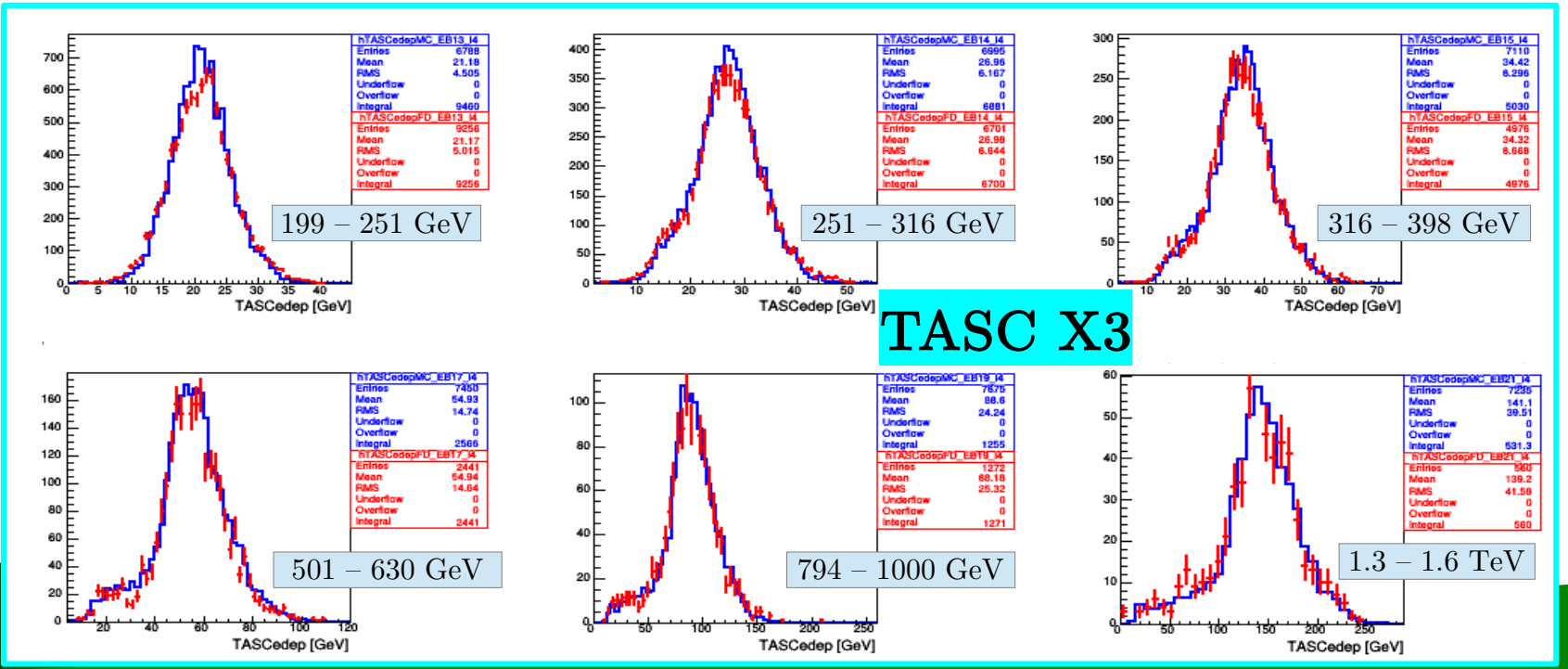


MC = Blue

FD = Red

TASC edep MC-FD after cut SES_{STD}

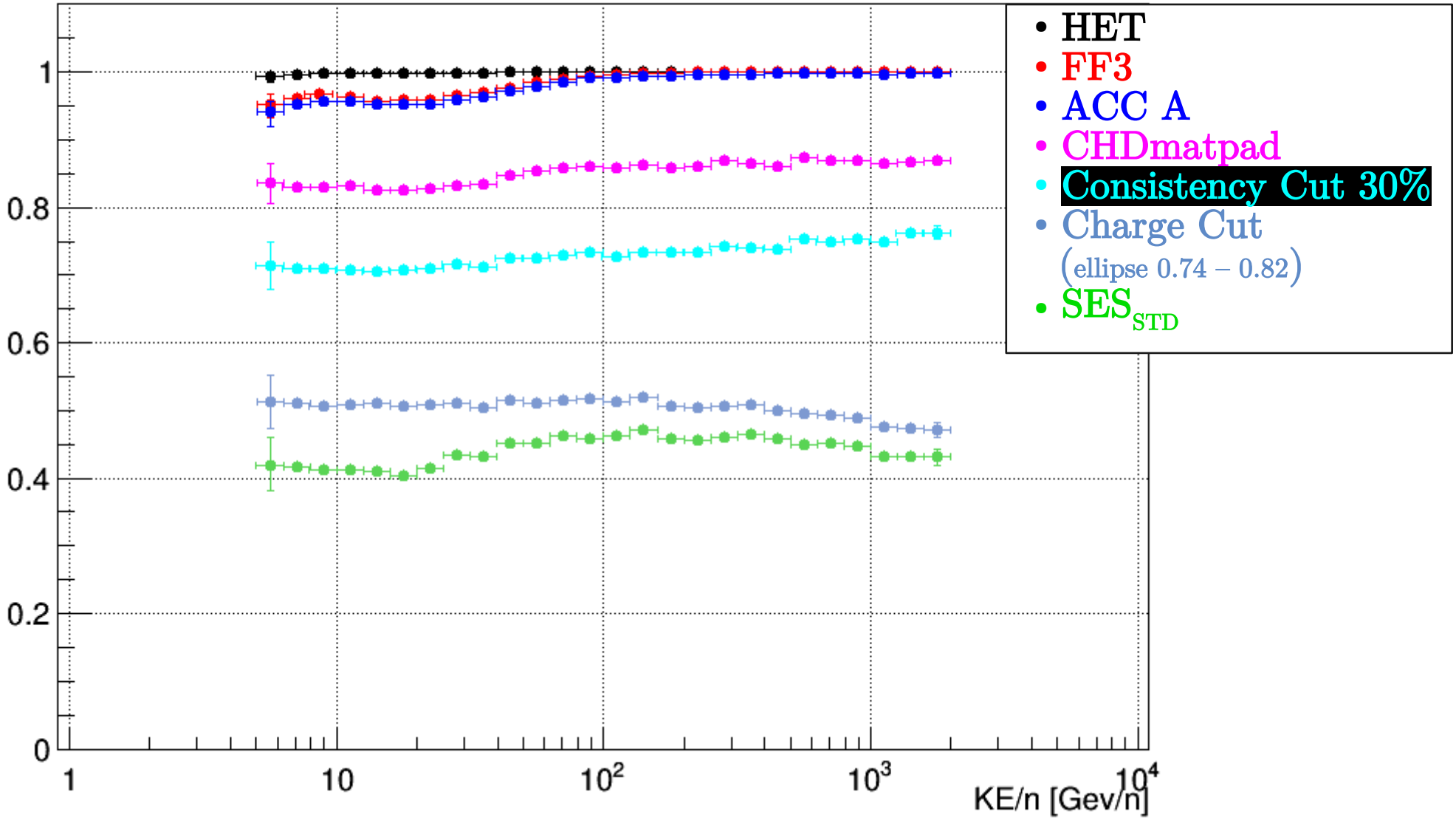




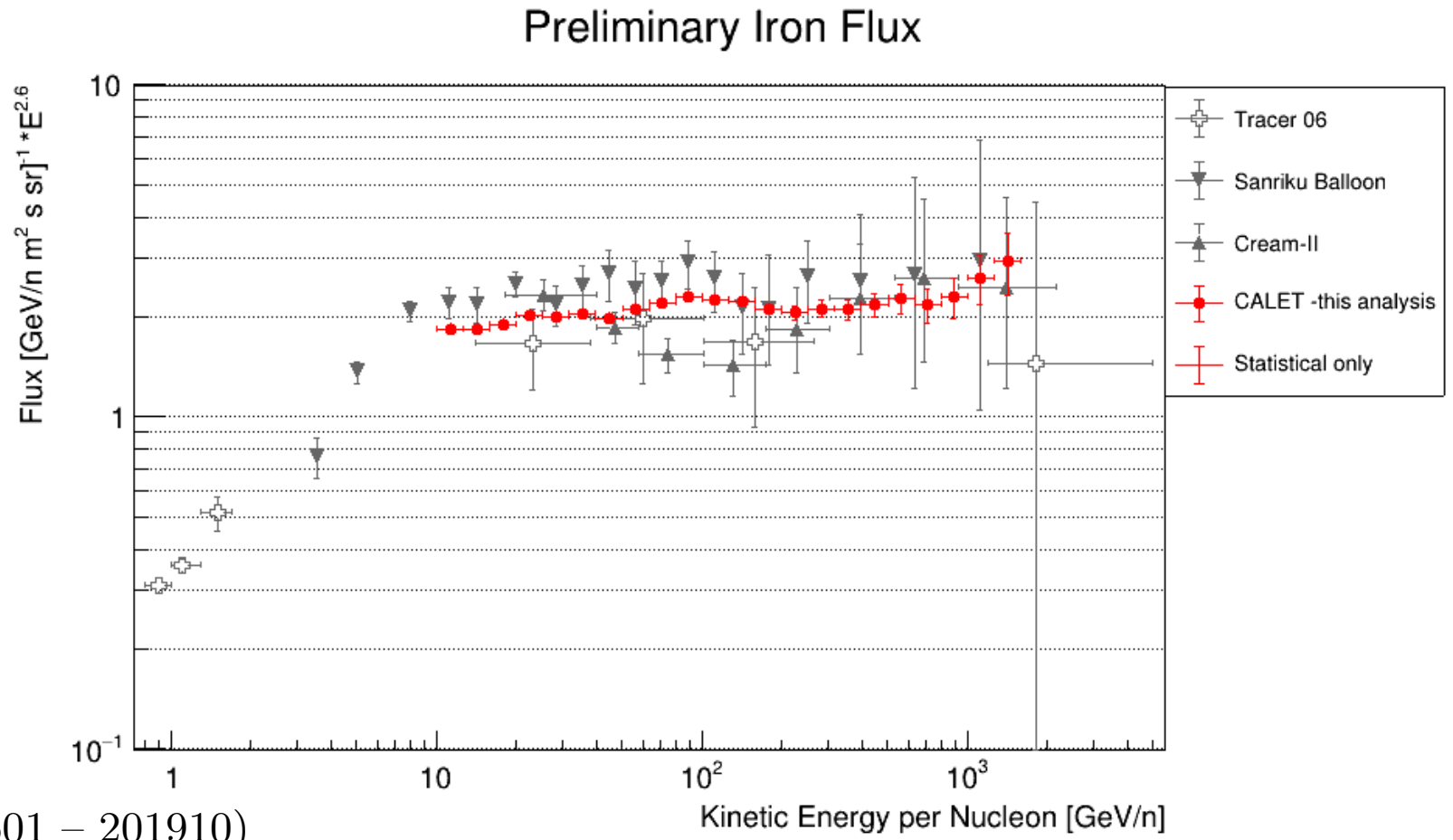
MC = Blue

FD = Red

(6) Efficency with STD + SES_{STD} cuts



(7) Preliminary Iron Flux



- Pass 4.0
- 46 months (201601 – 201910)
- STD selections + SES_{STD}
- Unfolding using Bayes method (2 iterations)
- MC Reweighted to Sanriku with $\gamma = 2.59$

(8) Preliminary Systematic Studies

(a) Charge selection;

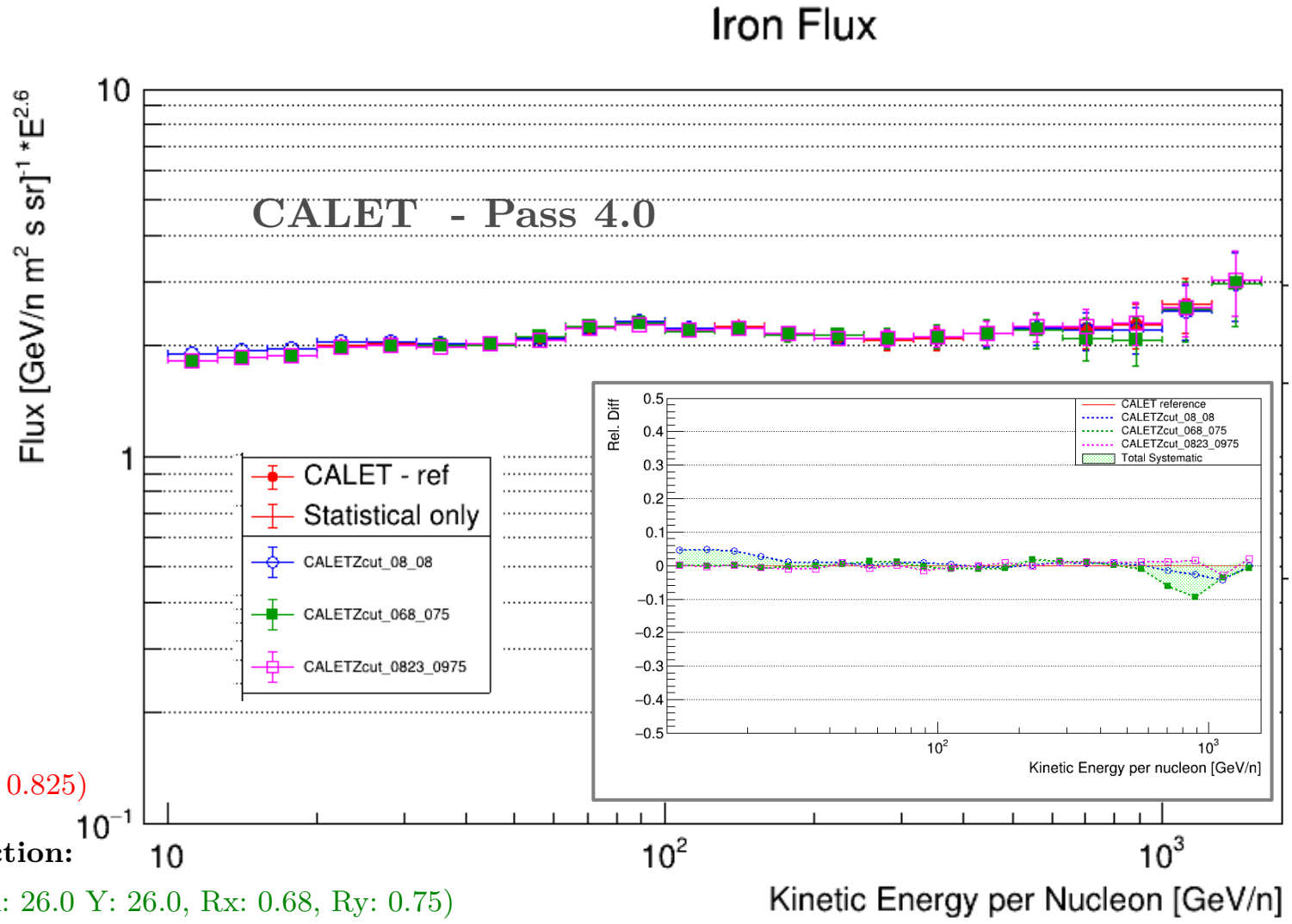
(b) Shower Event Selection;

(c) Unfolding with different Bayes iteration;

(d) Unfolding with different method (SVD);

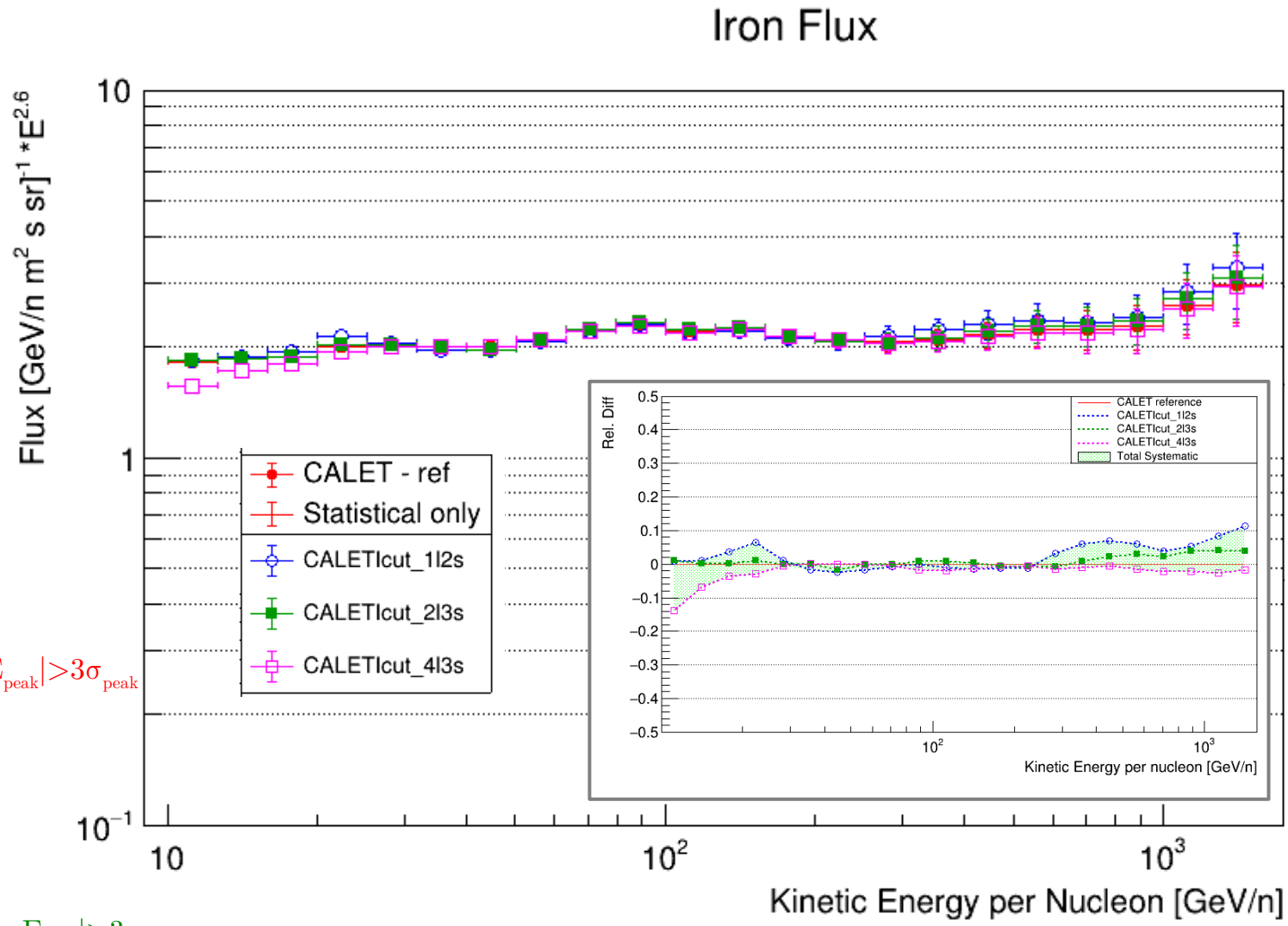
(e) Reweighting.

(8)(a) Charge Selection



- **STD Cut:**
  - Ellipse cut
    (X: 26.0,Y: 26.0, Rx: 0.748, Ry: 0.825)
- **3 different cuts for charge selection:**
  - Ellipse cut: **-10% wrt STD** (X: 26.0 Y: 26.0, Rx: 0.68, Ry: 0.75)
  - Ellipse cut: **+10% wrt STD** (X: 26.0, Y:26.0, Rx: 0.823, Ry:0.975)
  - Circle cut: X: 26.0, Y: 26.0, **R: 0.8**.

(8)(b) SES Selection

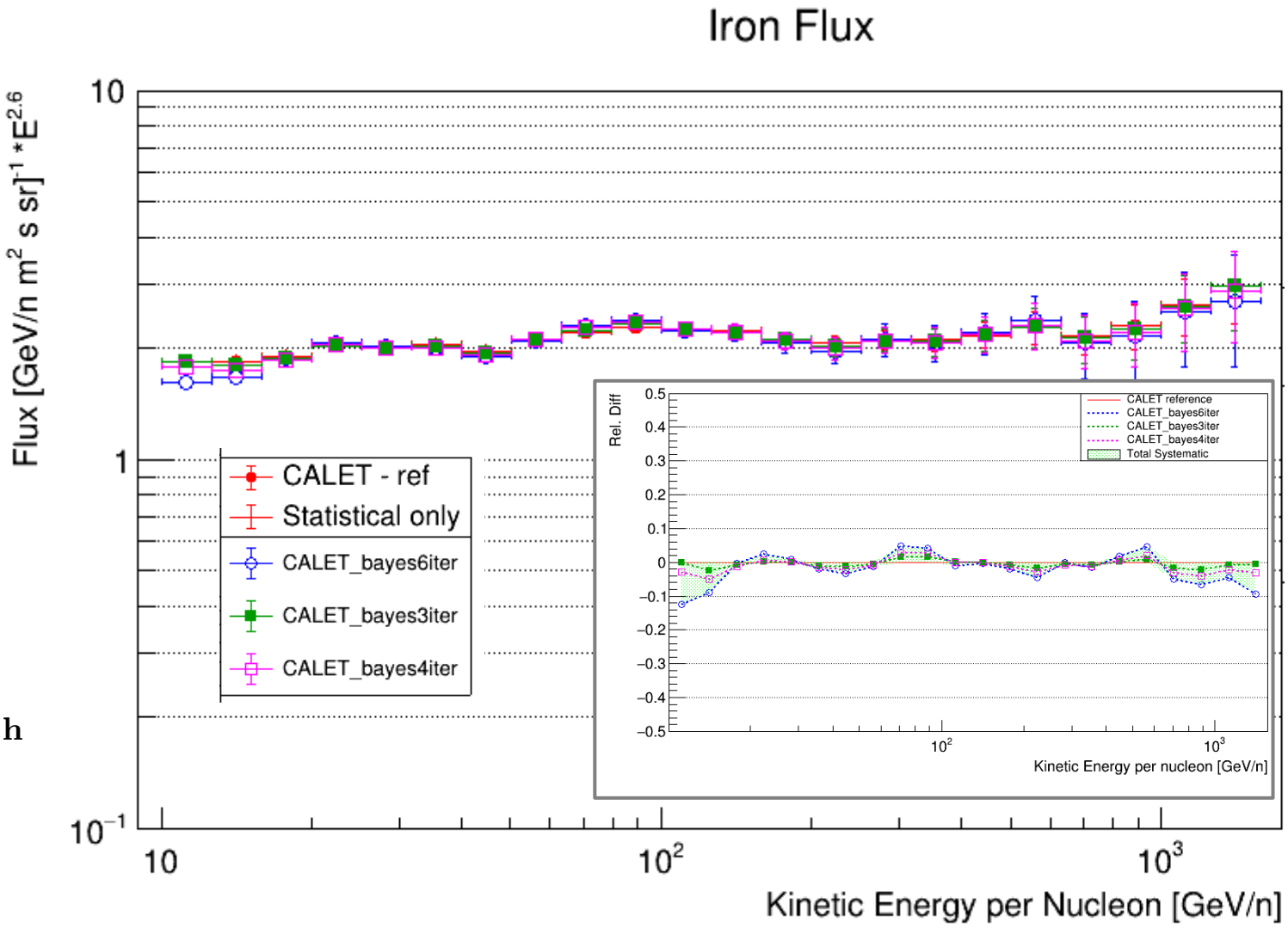


- **STD cut:**
  - **3l3σ:** $|E_{hlX1}-E_{peak}|>3\sigma_{peak}$ || $|E_{hlY1}-E_{peak}|>3\sigma_{peak}$ || $|E_{hlX2}-E_{peak}|>3\sigma_{peak}$

- **3 different cuts for shower event selection:**
  - **2l3σ:** $|E_{hlX1}-E_{peak}|>3\sigma_{peak}$ || $|E_{hlY1}-E_{peak}|>3\sigma_{peak}$
  - **4l3σ:** $(E_{TASCX1}-E_{peakTASC})>3\sigma_{peakTASC}$ || $|E_{TASCY1}-E_{peakTASC}|>3\sigma_{peakTASC}$ || $|E_{TASCX2}-E_{peakTASC}|>3\sigma_{peakTASC}$ || $|E_{TASCY2}-E_{peakTASC}|>3\sigma_{peakTASC}$
  - **1l2σ:** $|E_{hlX1}-E_{peak}|>2\sigma_{peak}$

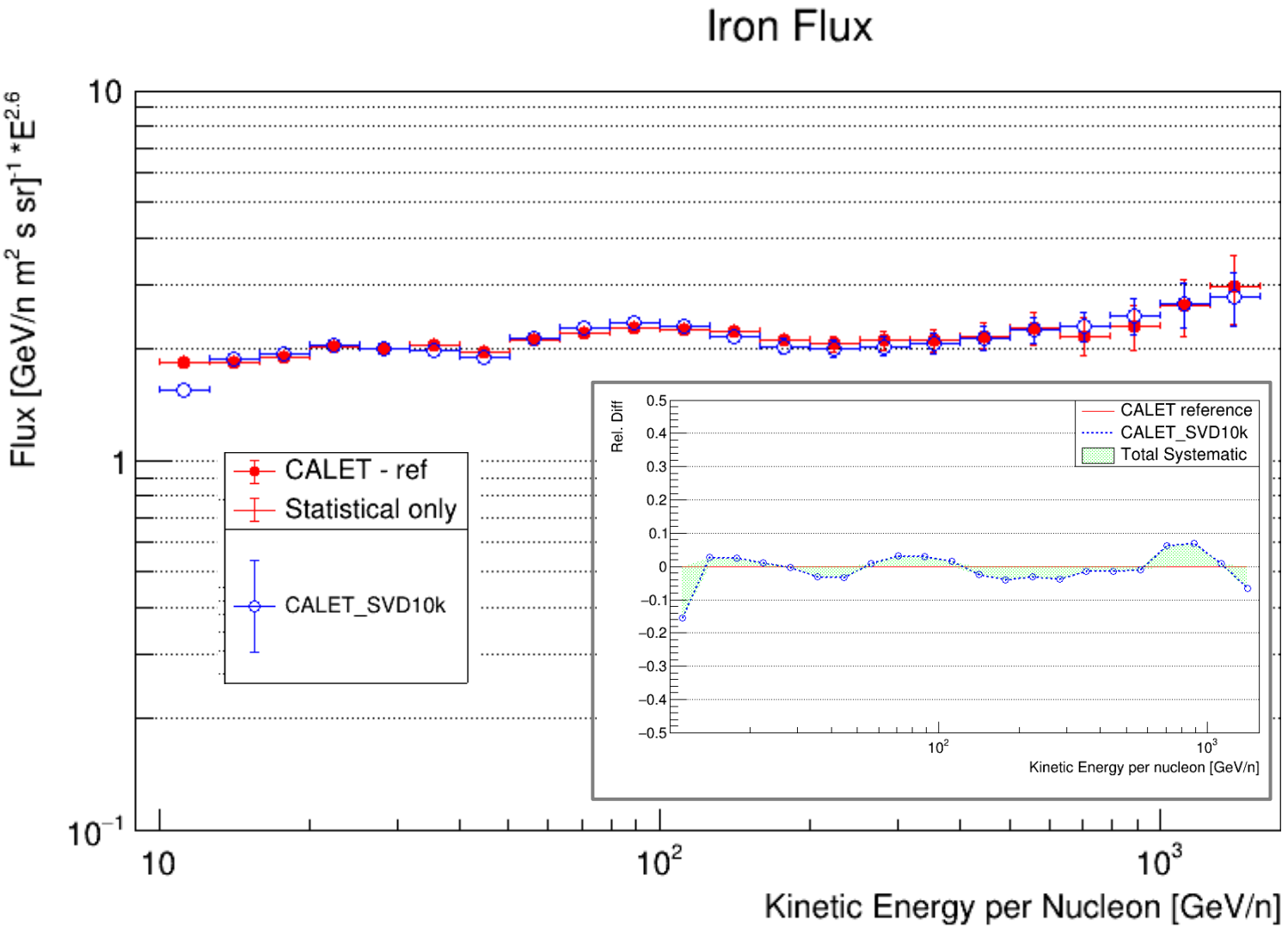
(8)(c) Unfolding

- **STD cut:**
  - Bayes with 2 iterations
- **3 different unfolding with Bayes method:**
  - Bayes with 3 iterations
  - Bayes with 4 iterations
  - Bayes with 6 iterations

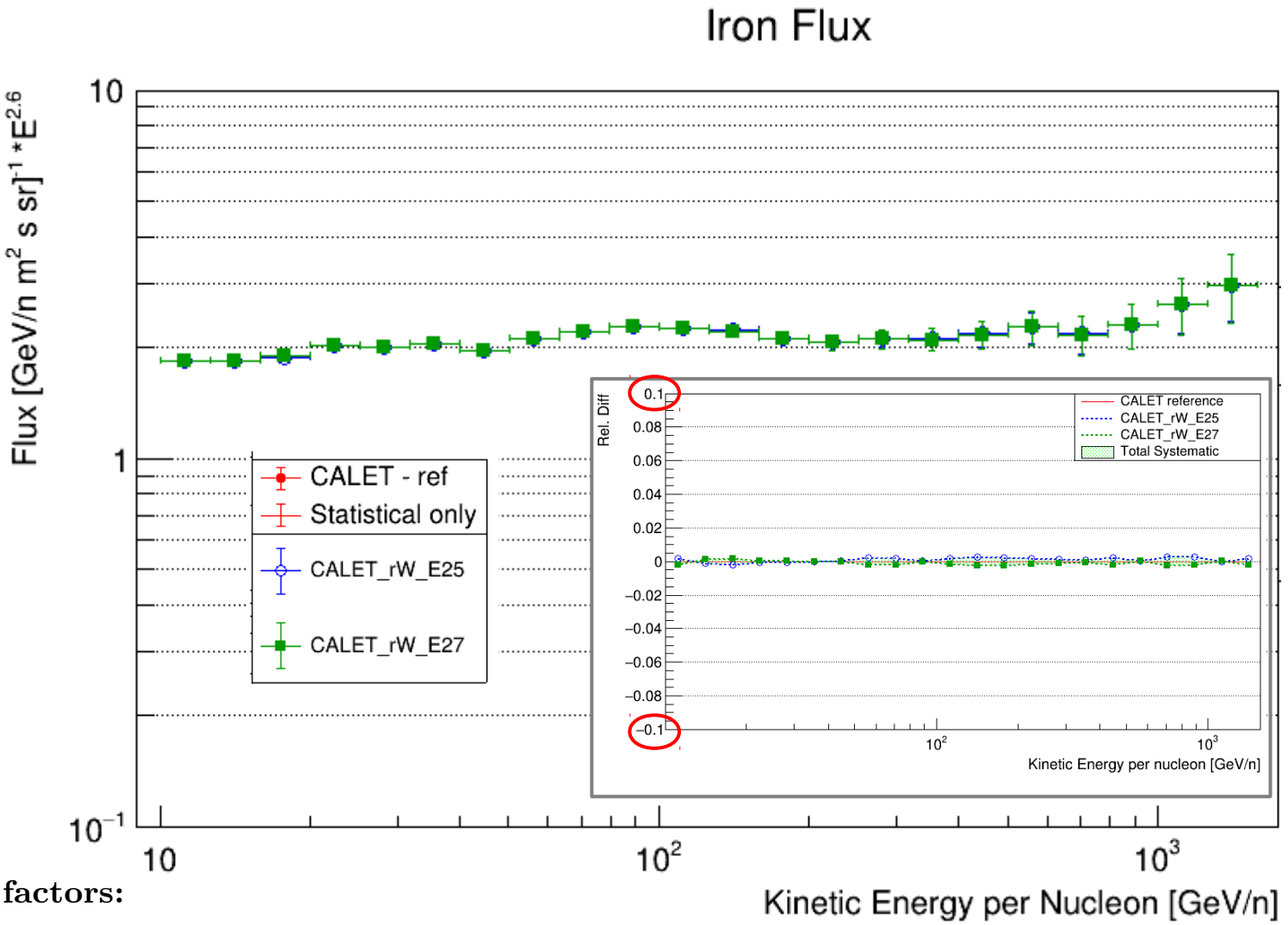


(8)(d) Unfolding

- **STD cut:**
  - Bayes with 2 iterations
- **1 different method:**
  - SVD with kterm = 10

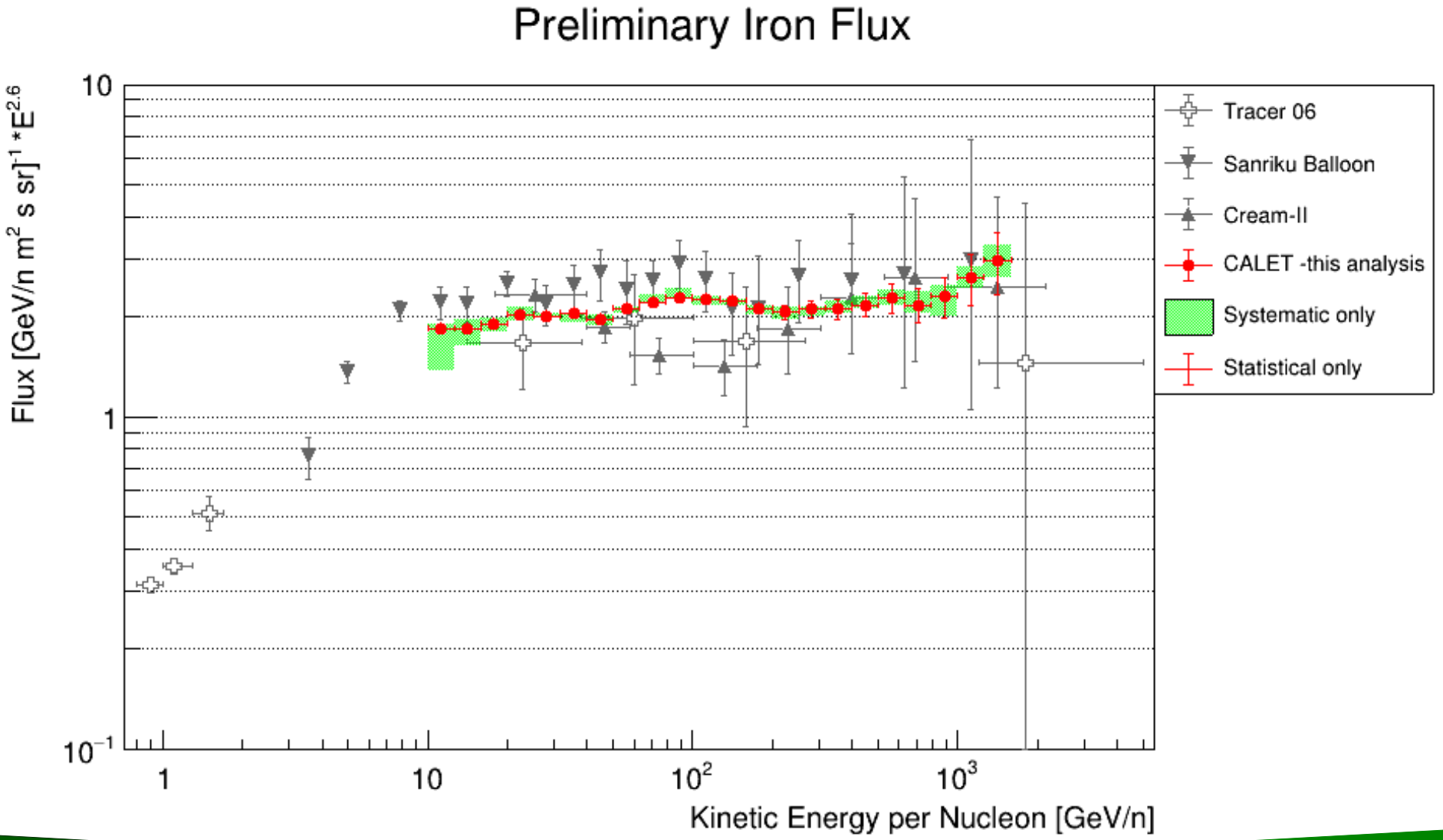


(8)(e) Reweighting



- **STD reweighting:**
  - $\gamma = 2.597$
- **2 different reweighting factors:**
  - $\gamma = 2.7$
  - $\gamma = 2.5$

(8) Preliminary Iron Flux with Systematics

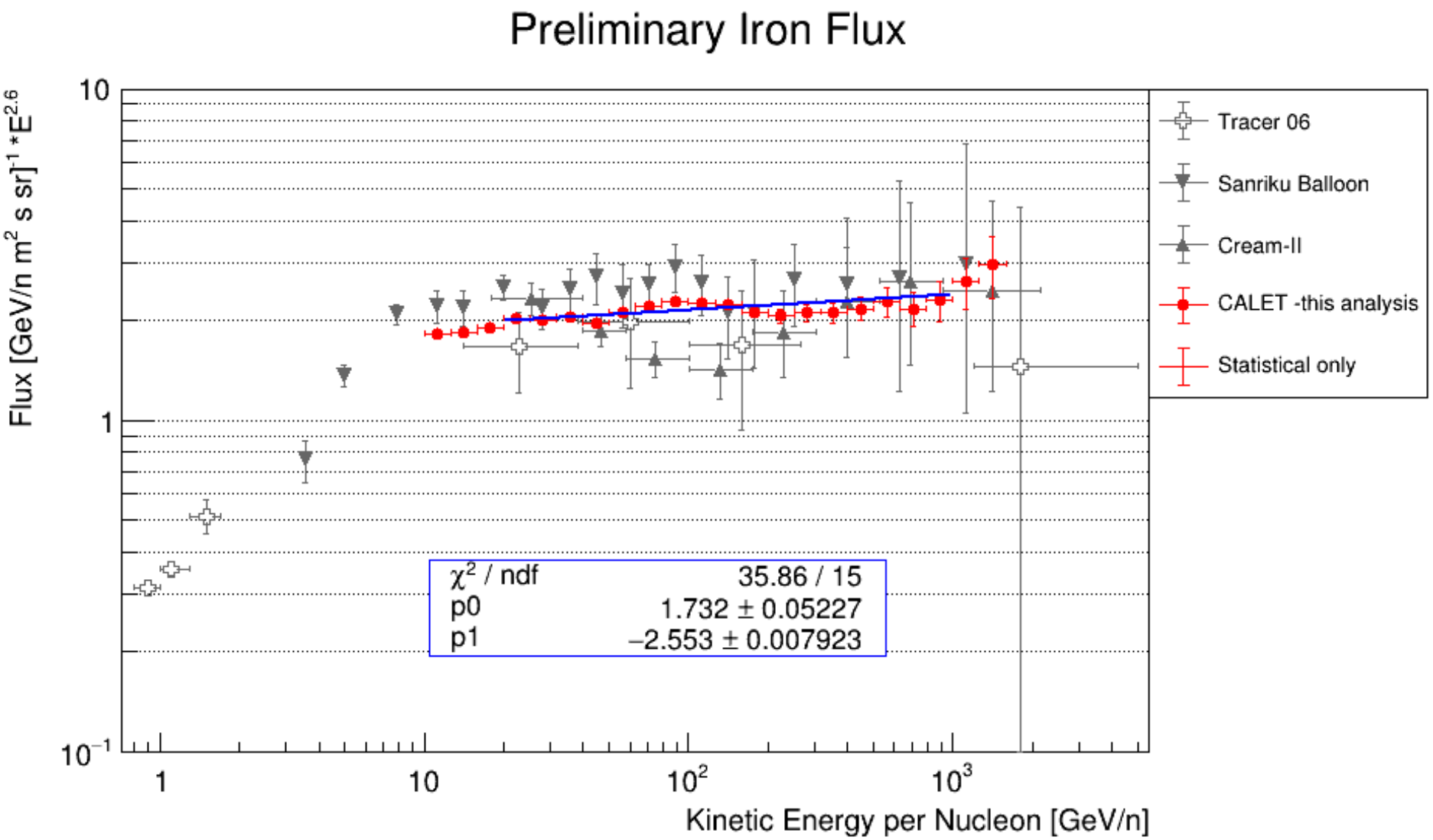


To Do List

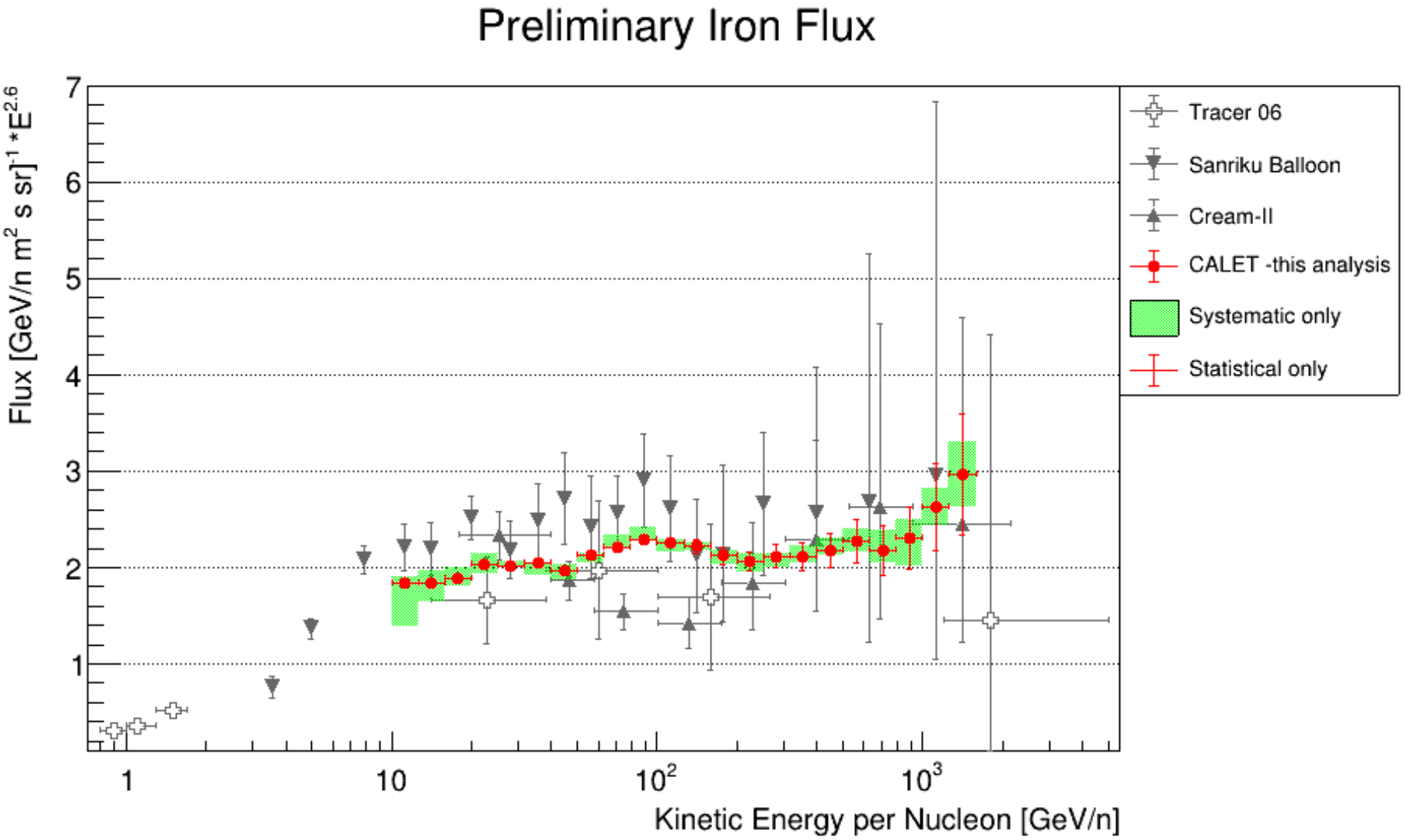
- Add others systematics (LT, trigger, acceptance)
- Improve charge calibrations with Pass 4.0
- Improve pass 4.0 quenching simulations in EPICS
- Estimate of background from neighbouring nuclei with MC
- Re-do this analysis with FLUKA simulations
- ...

BACKUP

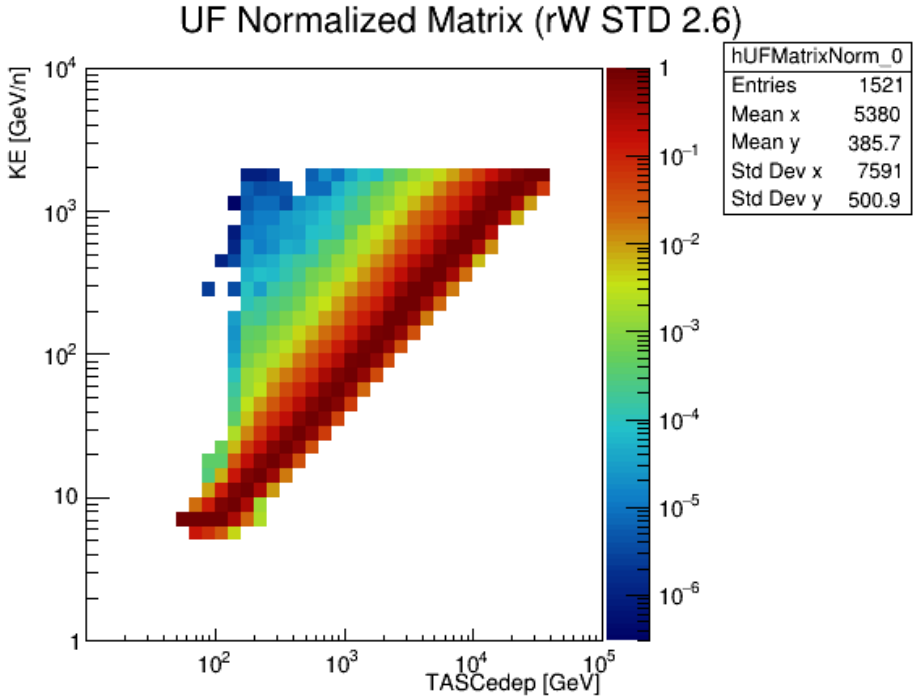
PRELIMINARY SPECTRAL INDEX RESULT



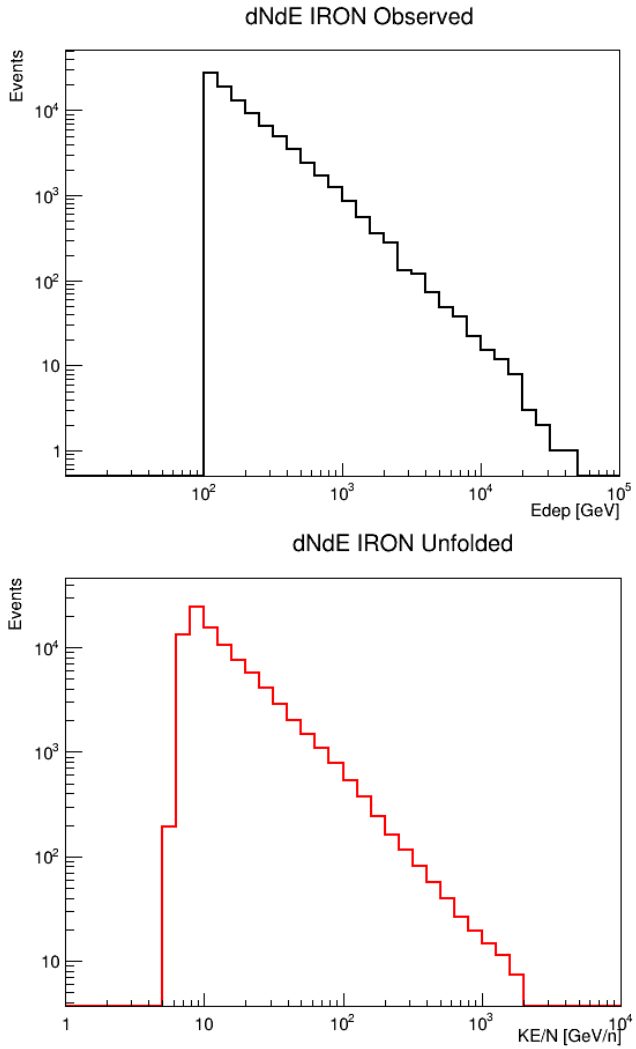
Preliminary Iron Flux (No-log scale)



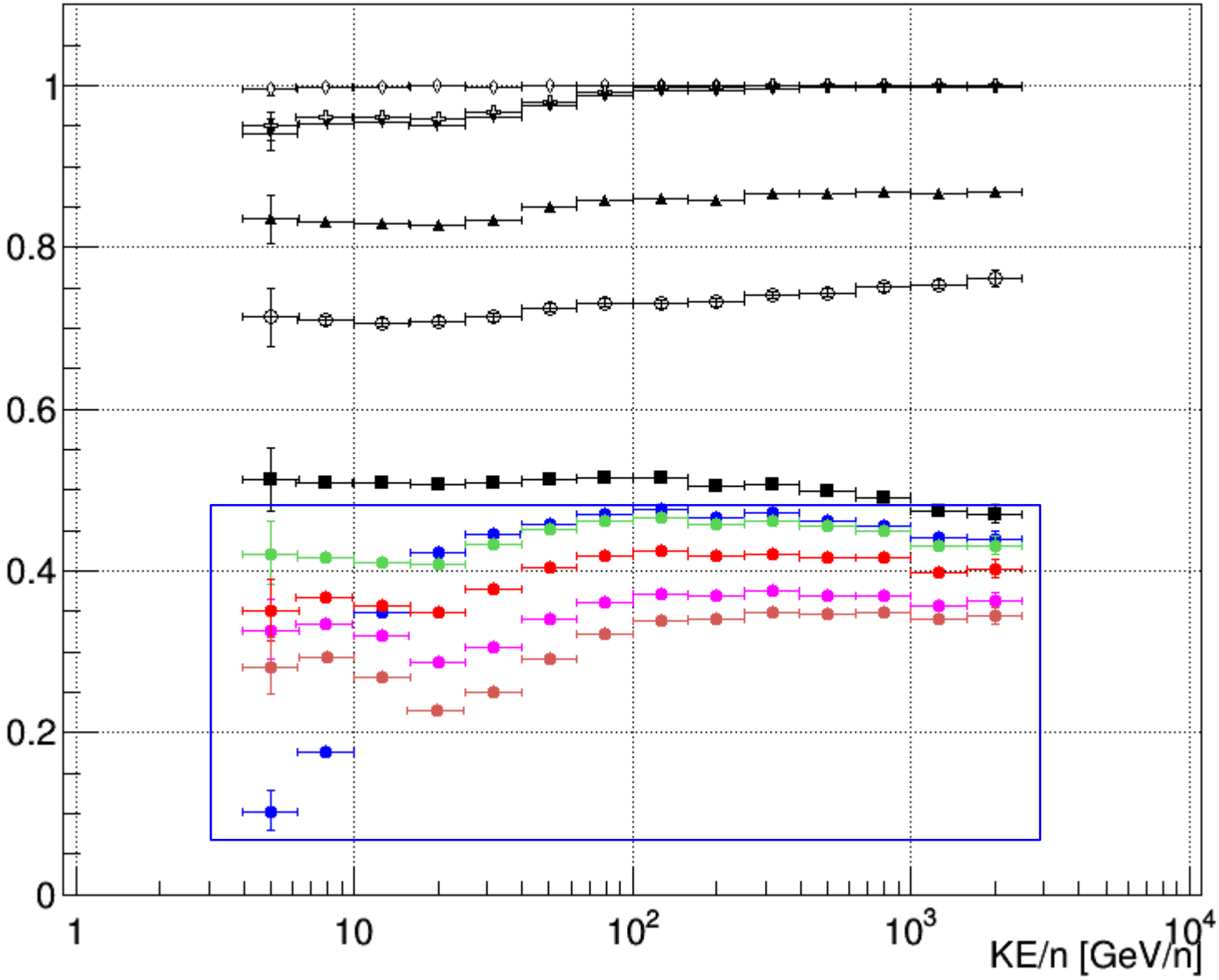
Unfolding Matrix and dNdE



The matrix is normalized to the maximum for each column

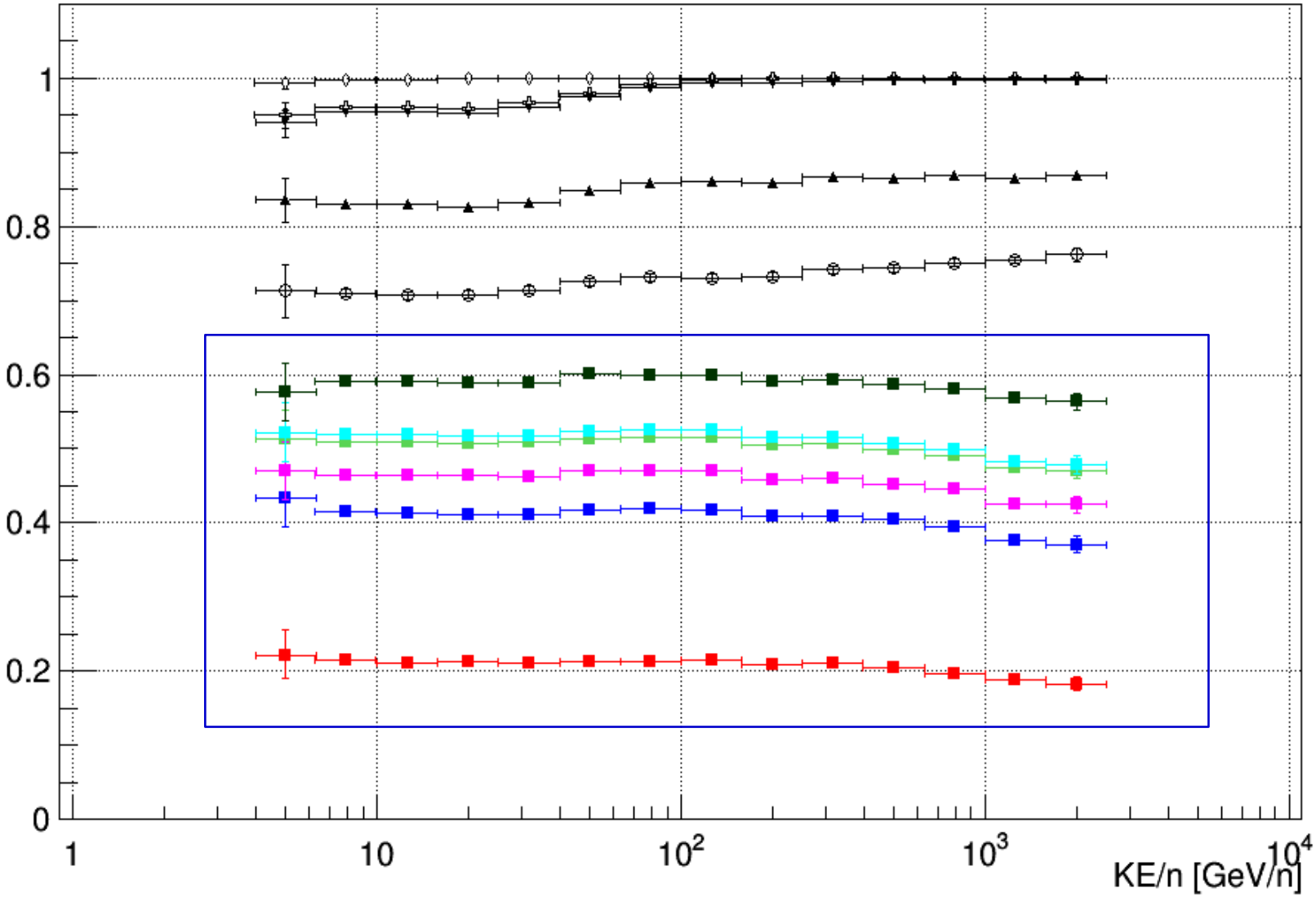


Global Efficiency for different SES



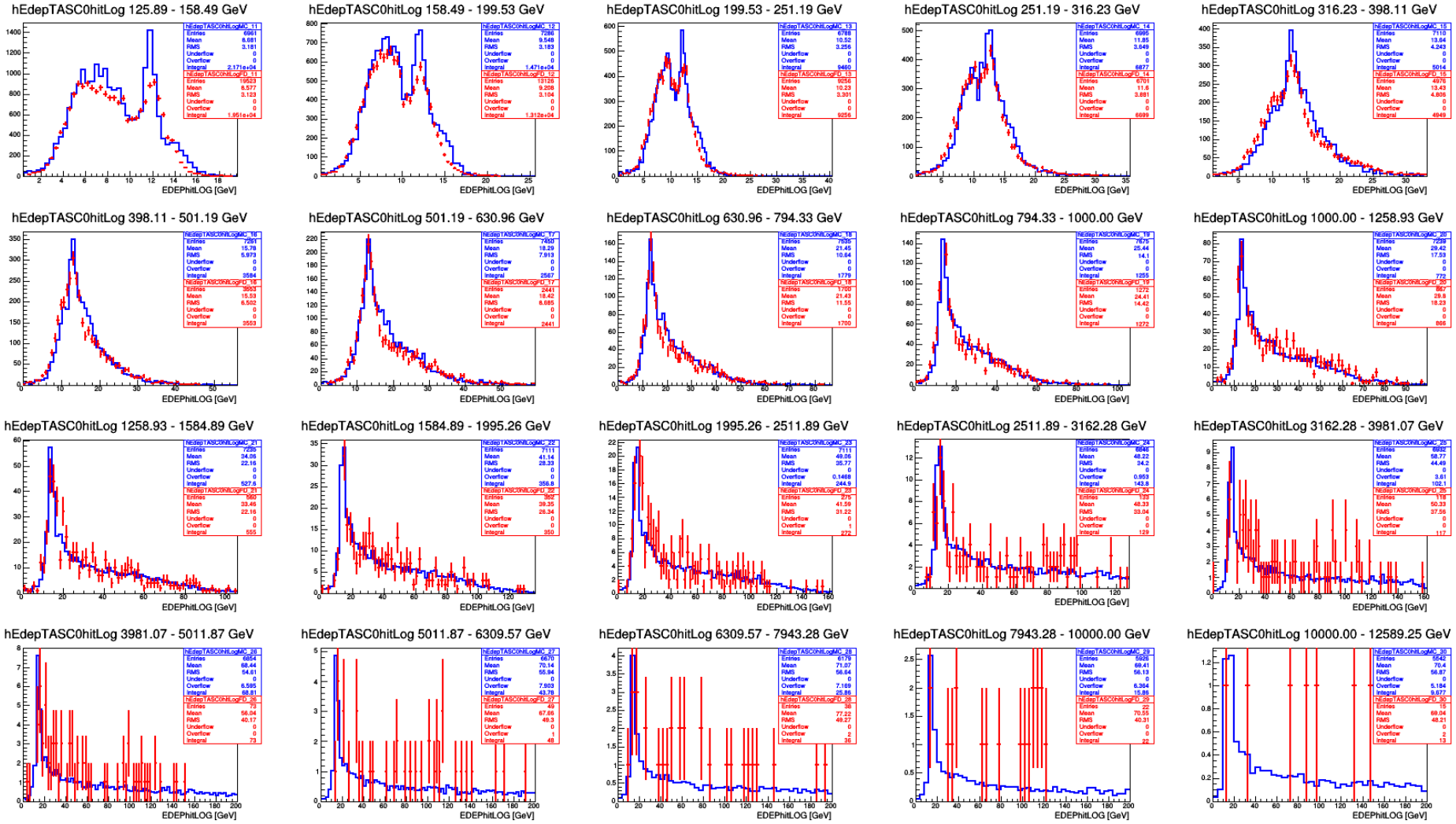
nLayer	sigma
1	3
1	2
4	3
2	3
3	3

Global Efficiency for different charge selections

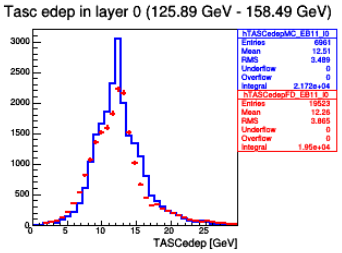


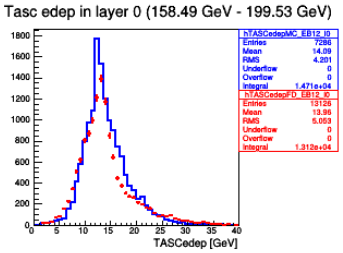
rX	rY
0.95	0.95
0.73	0.90
0.68	0.75
0.61	0.675
0.4	0.4
0.748	0.825

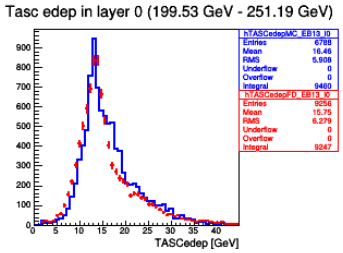
EdepTASC Hit Log Layer TASCX1

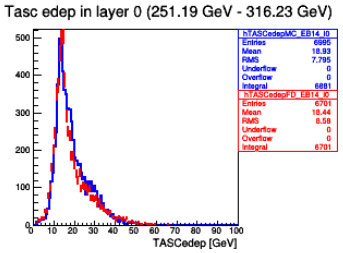


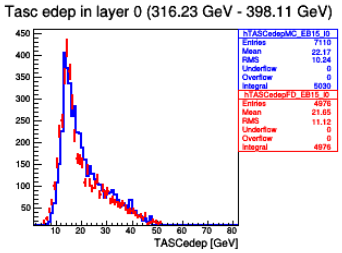
TASCedep on Layer TASCX1

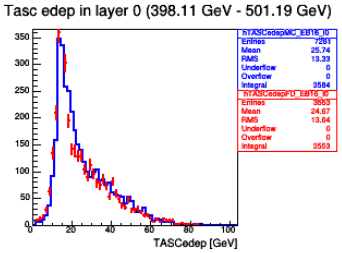


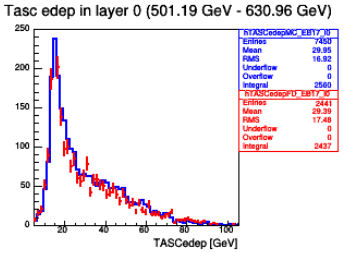


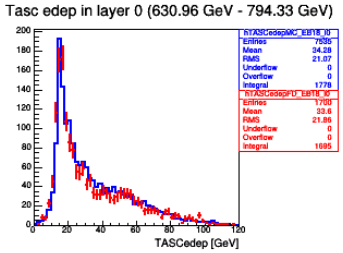


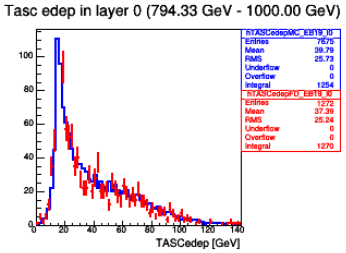


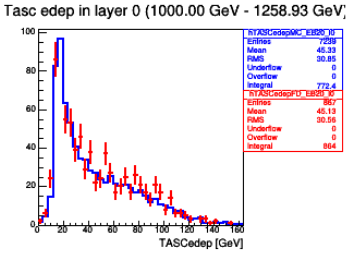


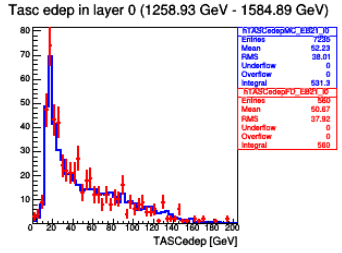


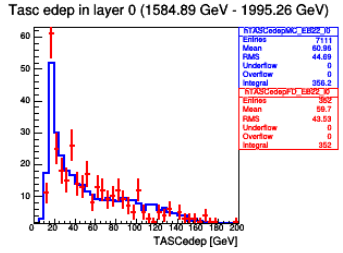


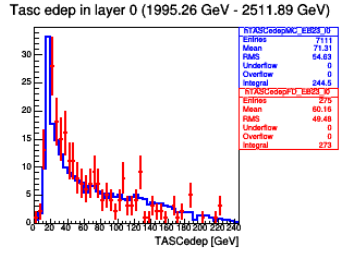


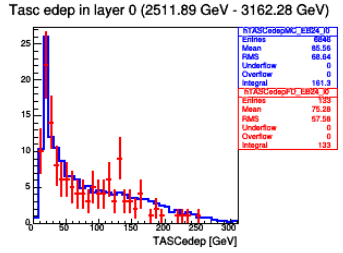


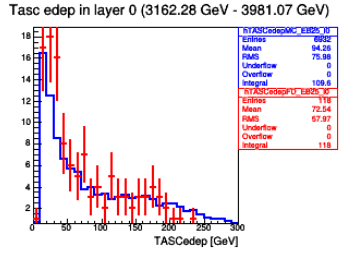


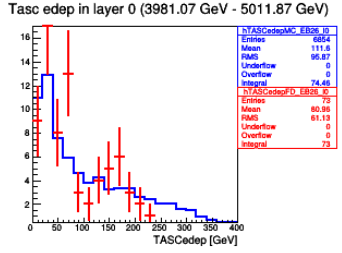


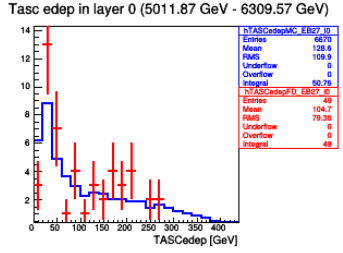


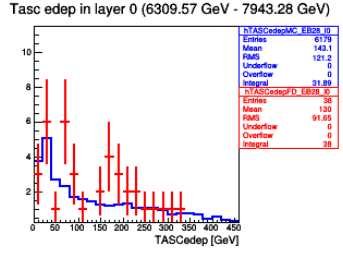


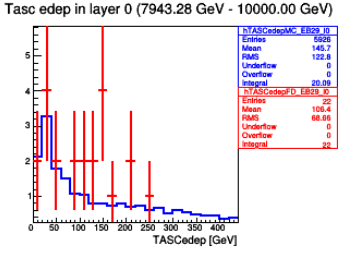


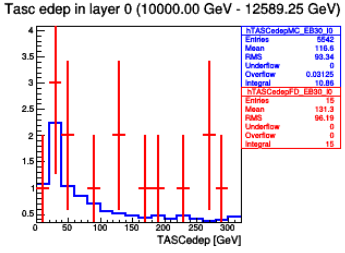




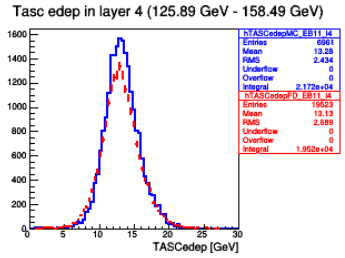


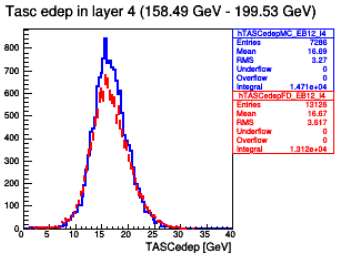


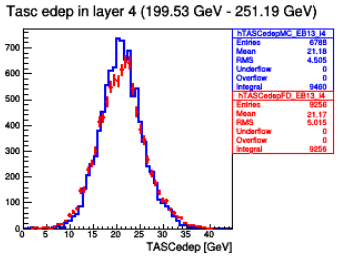


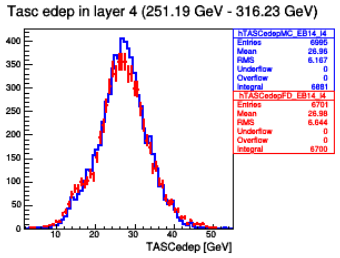


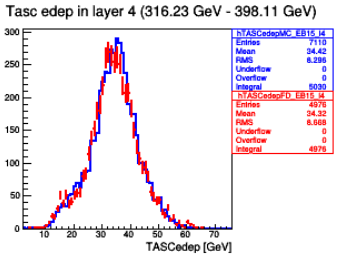
TASCedep on Layer TASCX3

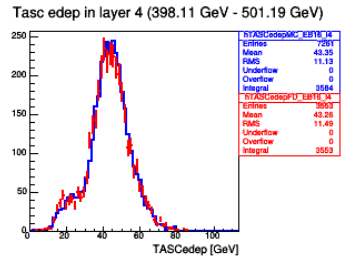


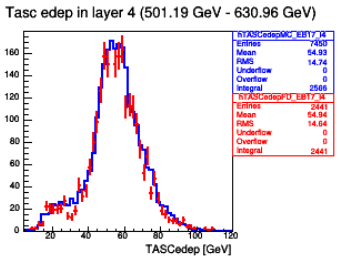


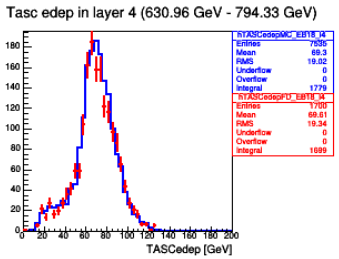


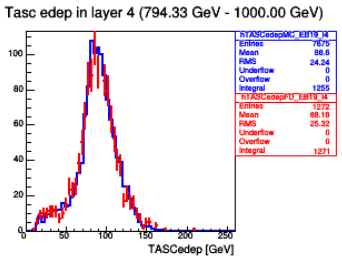


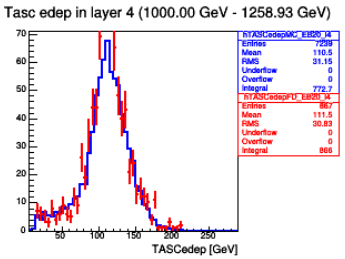


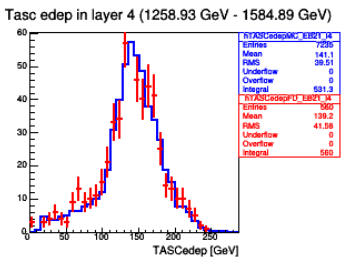


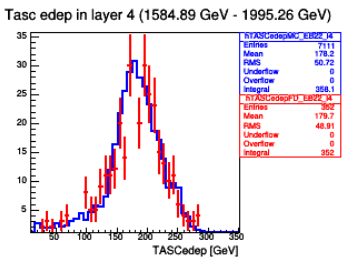


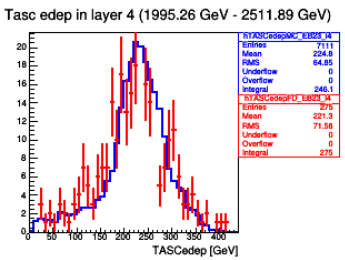


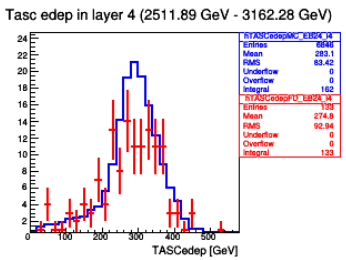


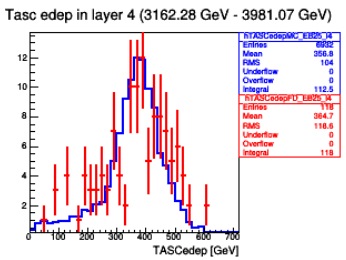


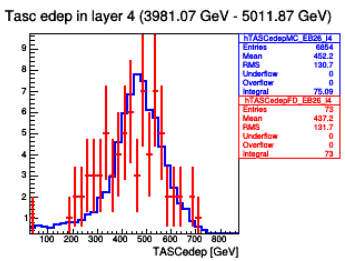


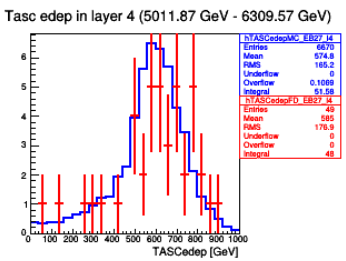


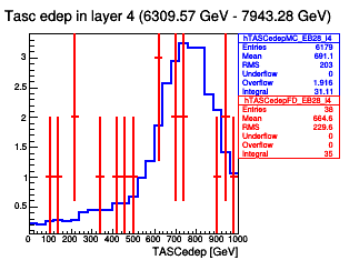


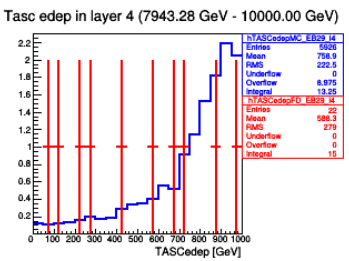


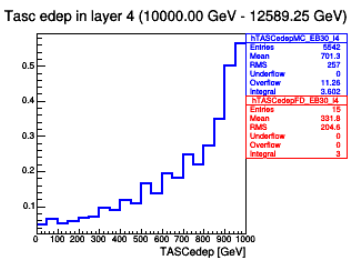




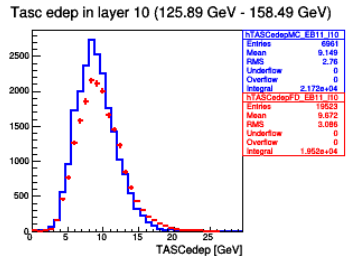


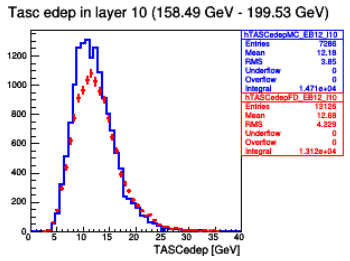


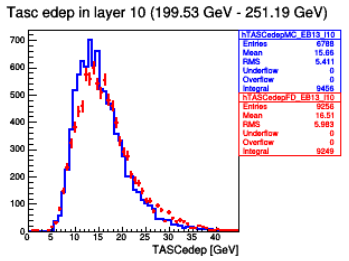


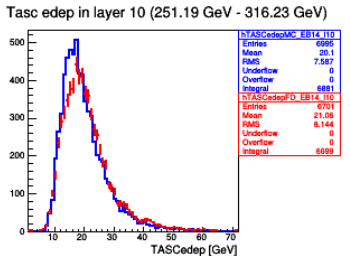


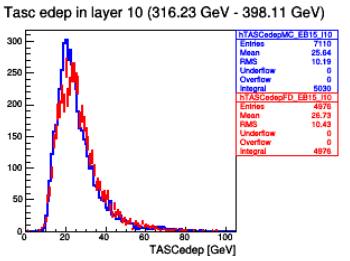
TASCedep on Layer TASCX6

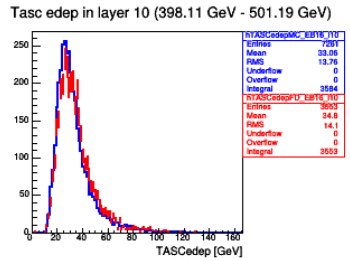


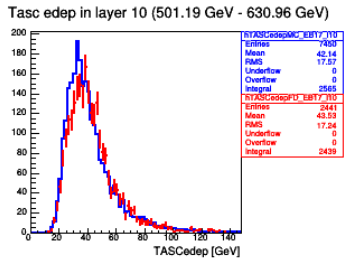


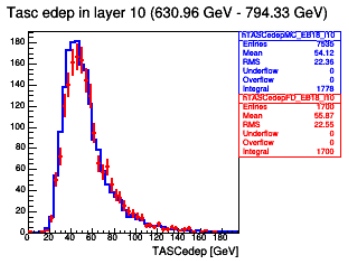


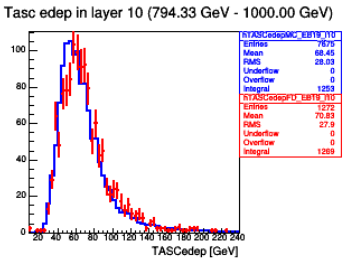


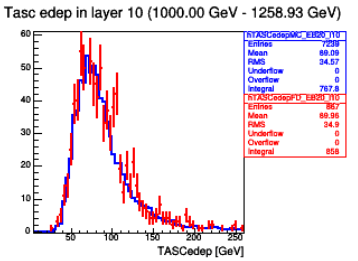


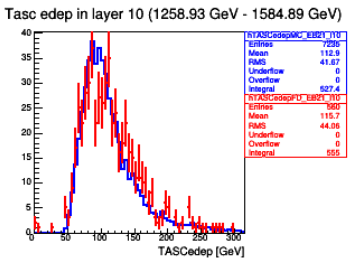


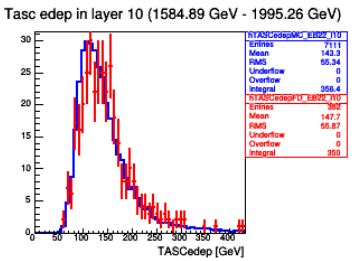


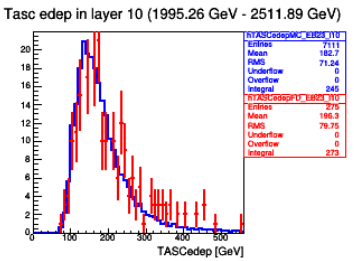


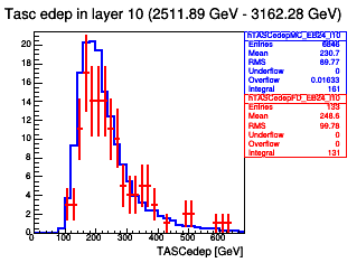


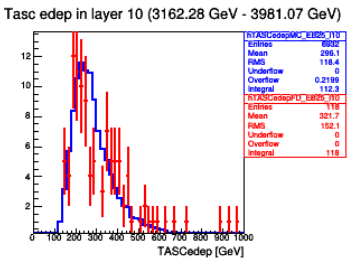


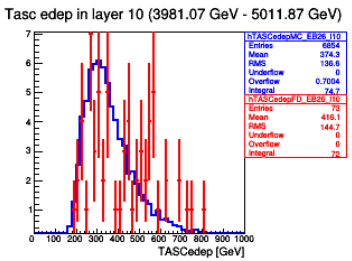


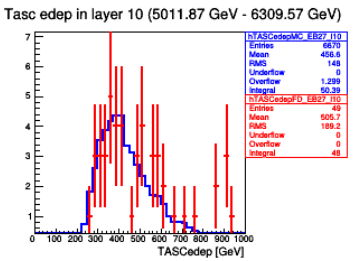


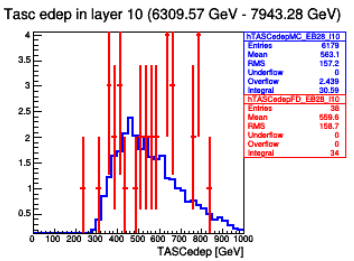


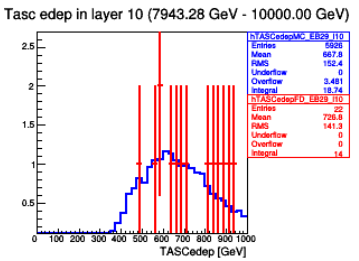


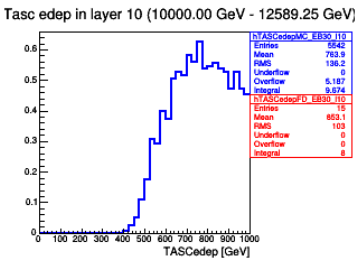




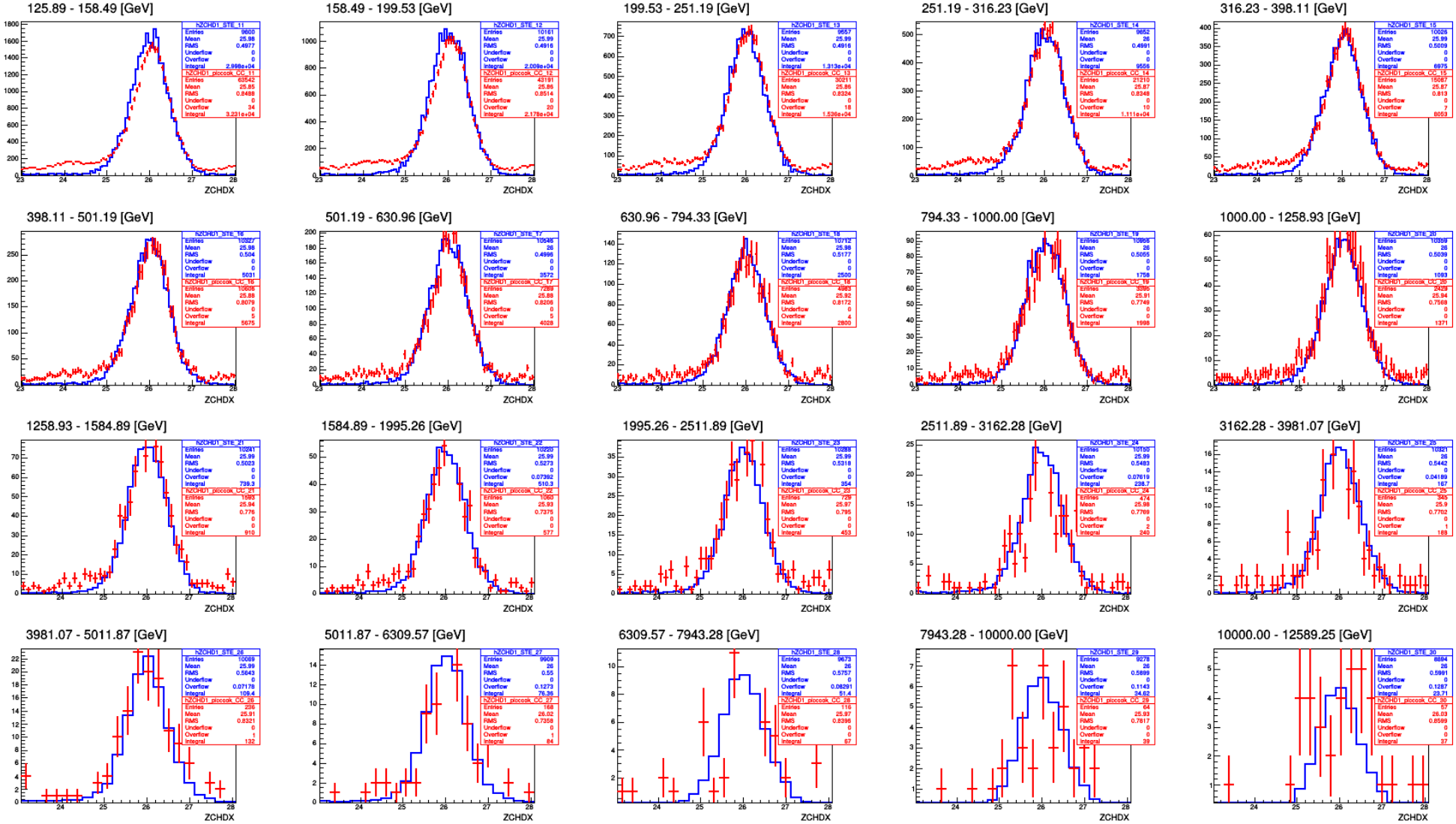




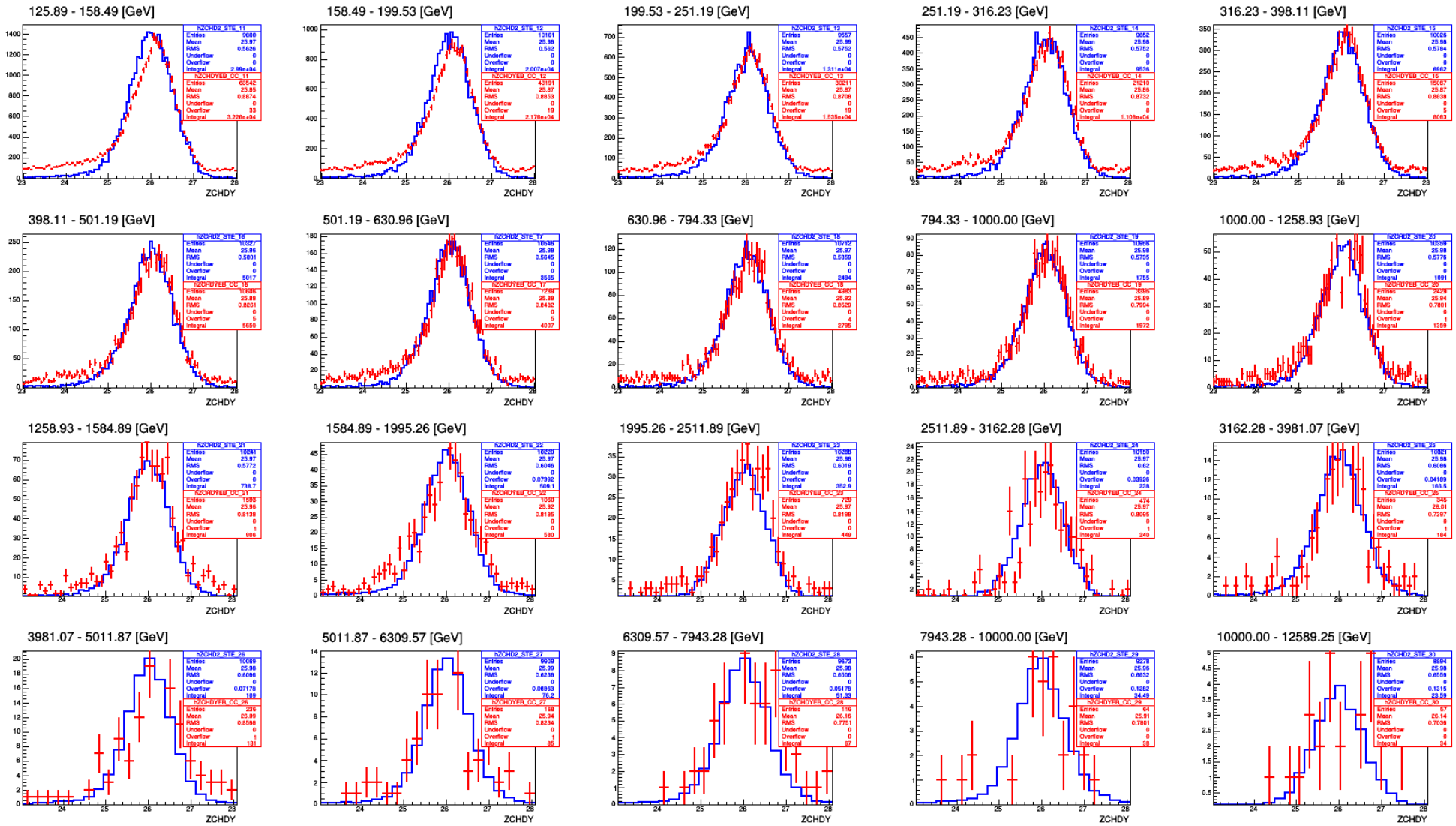




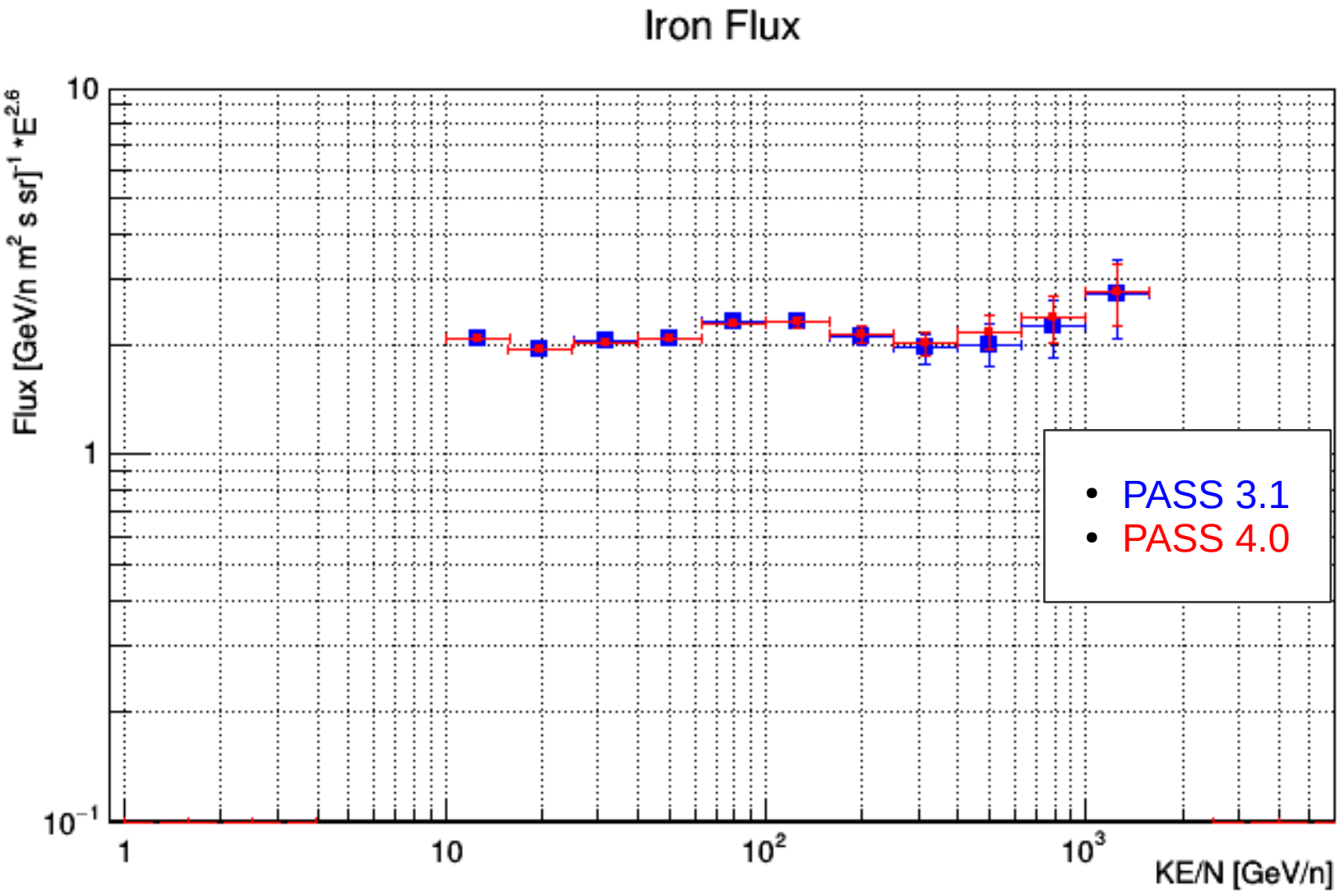
CHD charge on layer X



CHD CHARGE ON LAYER Y



Comparison Pass 3.1 – Pass4.0

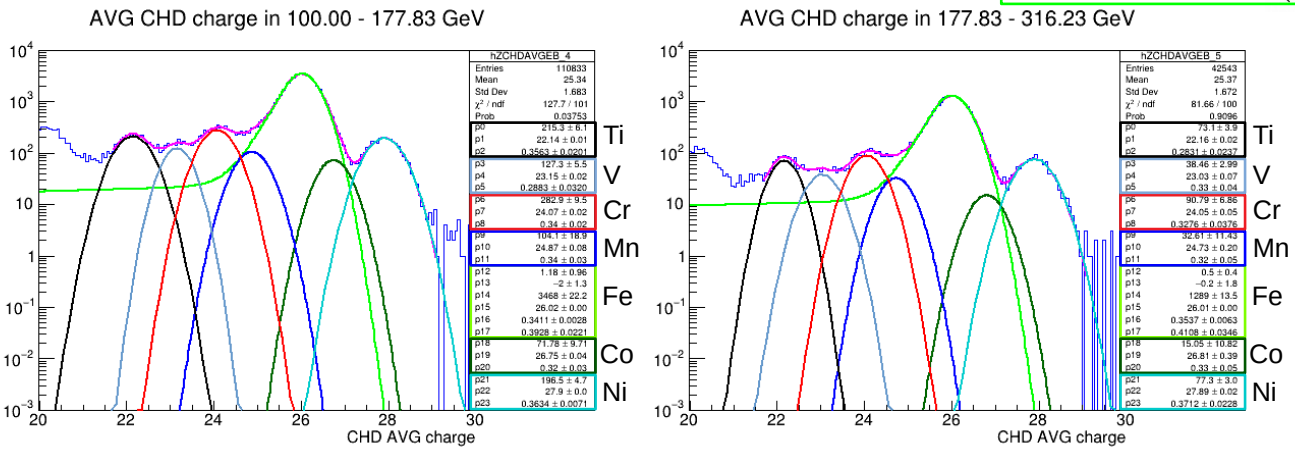


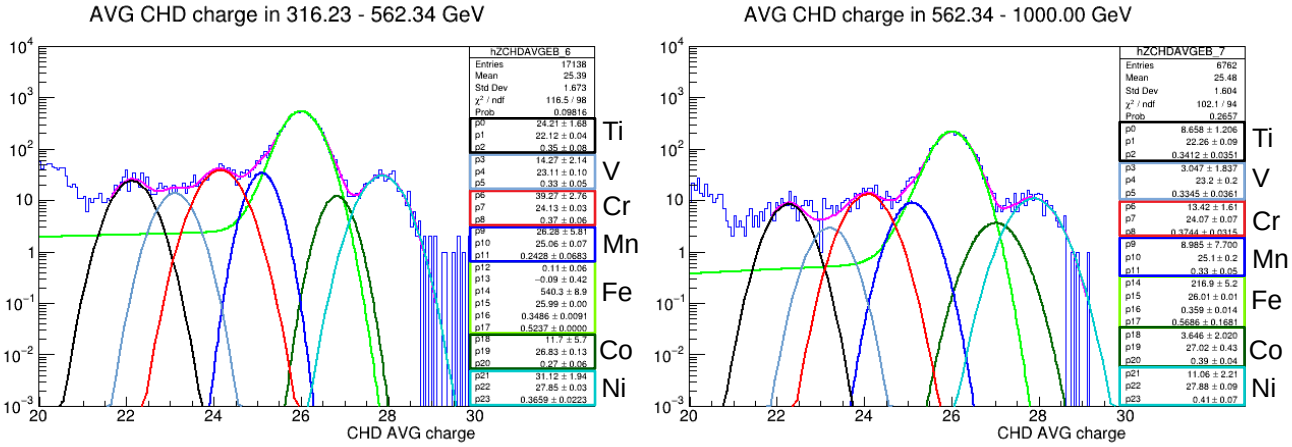
Background extimation on FD

Procedure:

- Fit of the charge distribution in CHD elements between Z = 22 and Z =28 (from Ti to Ni)
- Fit function for **Ti, V, Cr, Mn, Co and Ni** is a **gaussian**
- Fit function for **Iron** is an **asymmetrical gaussian** (from Koselo et al, 1996)

$$f(x) = \begin{cases} A \cdot \exp\left(\dfrac{F \cdot (2x - 2\mu + F)}{2\sigma^2}\right) + (a + bx + cx^2) & \text{if } x < (\mu - F) \\ A \cdot \exp\left(\dfrac{-(x+\mu)^2}{2\sigma^2}\right) + 0 & \text{if } x \geq (\mu - F) \end{cases}$$

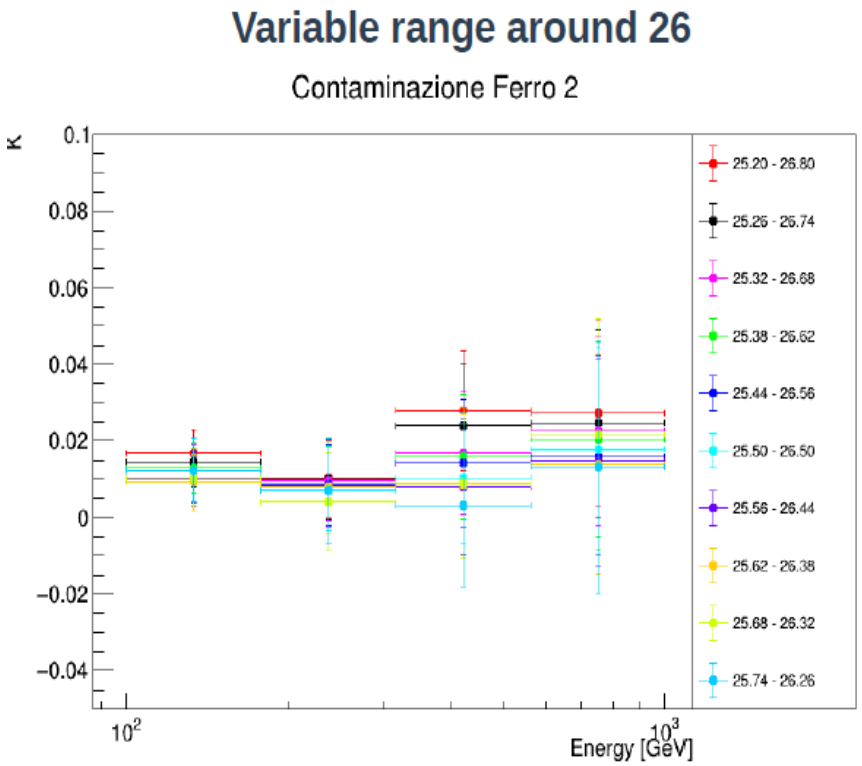


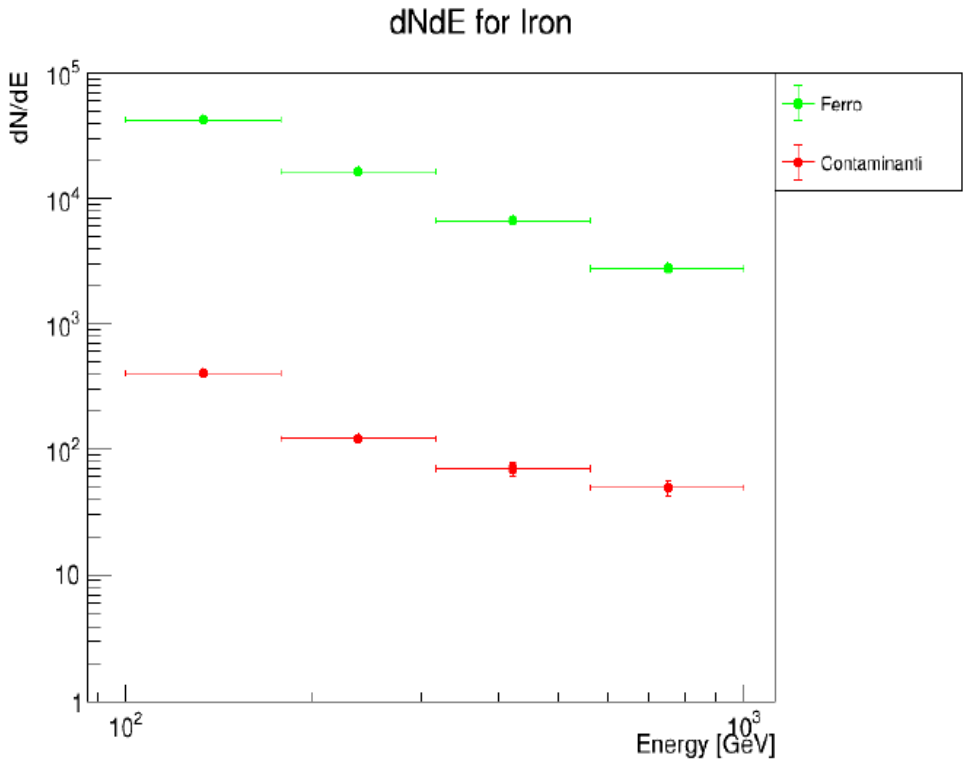


Where:

- μ is the peak centroid,
- F is the distance from the centroid to the point where the Gaussian behavior begins and
- the tailing ends;
- σ is the Gaussian sigma;
- A is the amplitude of the peak.

Contaminants extimations





Contamination around 2%