Update of beamstrahlung function

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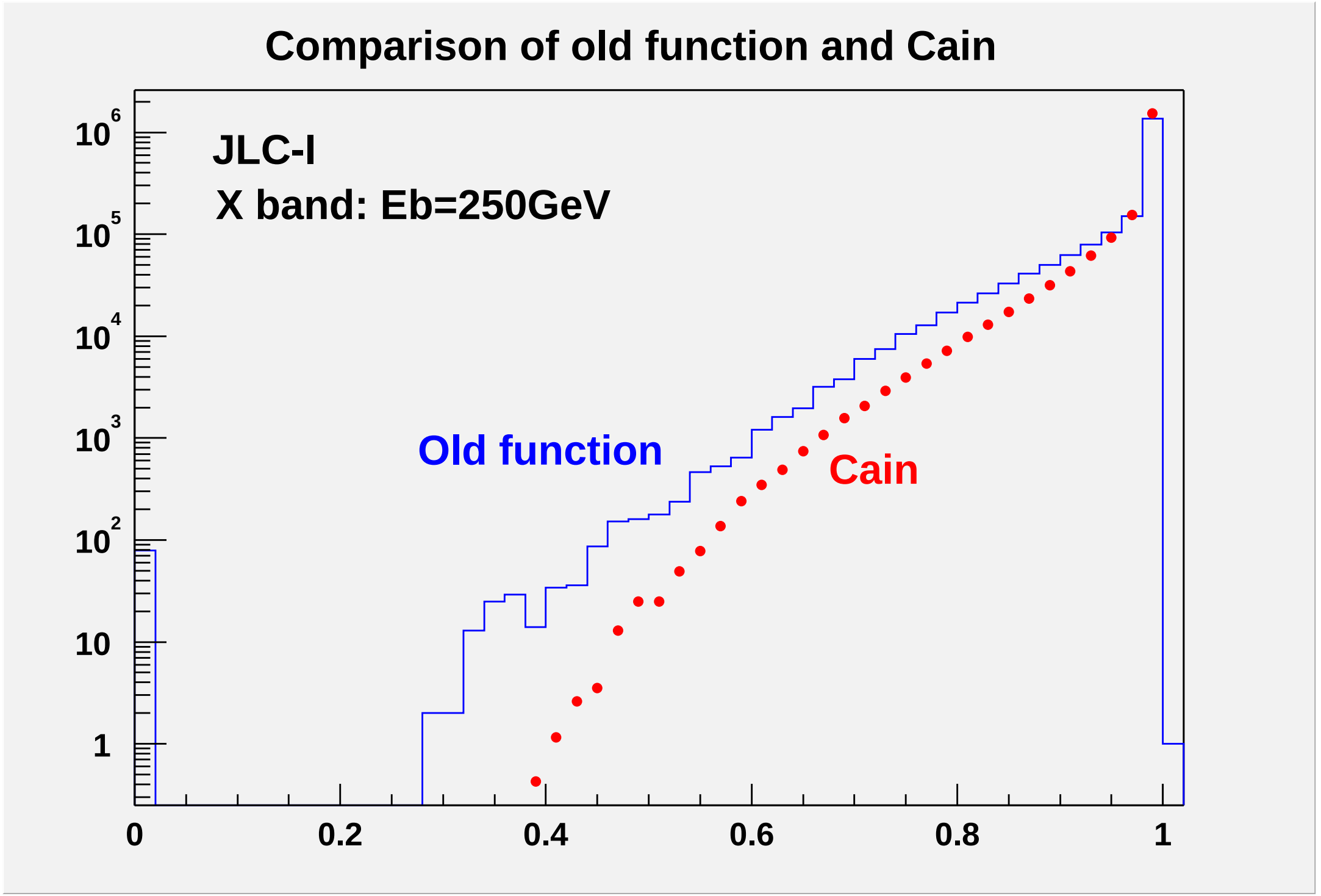
@ JLC weekly meeting
19-April-2002

1. New argorithm

2. Parameter files for the latest JLC parameters


Comparison of old function and Cain
JLC-I
X band: Eb=250GeV
Old function
Cain
10^6
10^5
10^4
10^3
10^2
10
1
0
0.2
0.4
0.6
0.8
1

Beam energy distribution

- Needs to know $\sqrt{s}$ and p_z from energies of e^+ and e^-.
- Energies of e^+/e^- changes during a collision;
  $\rightarrow$ *function of time*

$$f(z,\tau) = e^{-n_\gamma \tau}\frac{e^{-\eta}H(n_1\eta^{1/3}\tau)}{1-z}$$

$z = E/E_0$: fractional beam energy
τ : collision time

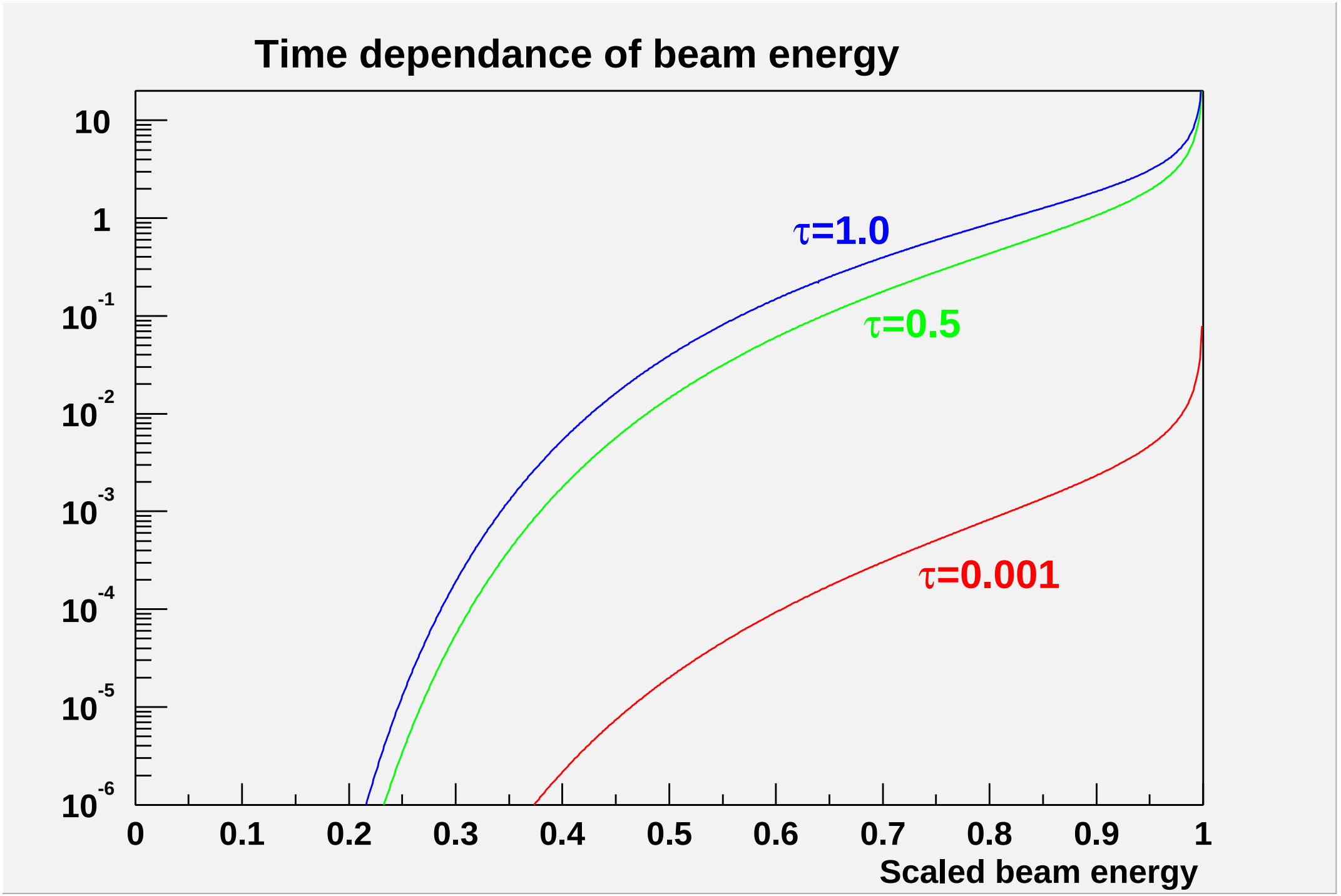
$$\xi = \frac{r_e^2 E_0 N}{\frac{1}{2}m_e\alpha\sigma_z(\sigma_x+\sigma_y)},\quad n_{cl} = \frac{\alpha r_e N}{\frac{1}{2}(\sigma_x+\sigma_y)},\quad n_\gamma = n_{cl}\left(\frac{1-0.598\xi+1.061\xi^{5/3}}{1+0.922\xi^2}\right),$$

$$\eta = \frac{1-z}{\xi z},\quad n_1 = \frac{n_{cl}+\xi\eta n_\gamma}{1+\xi\eta}.$$

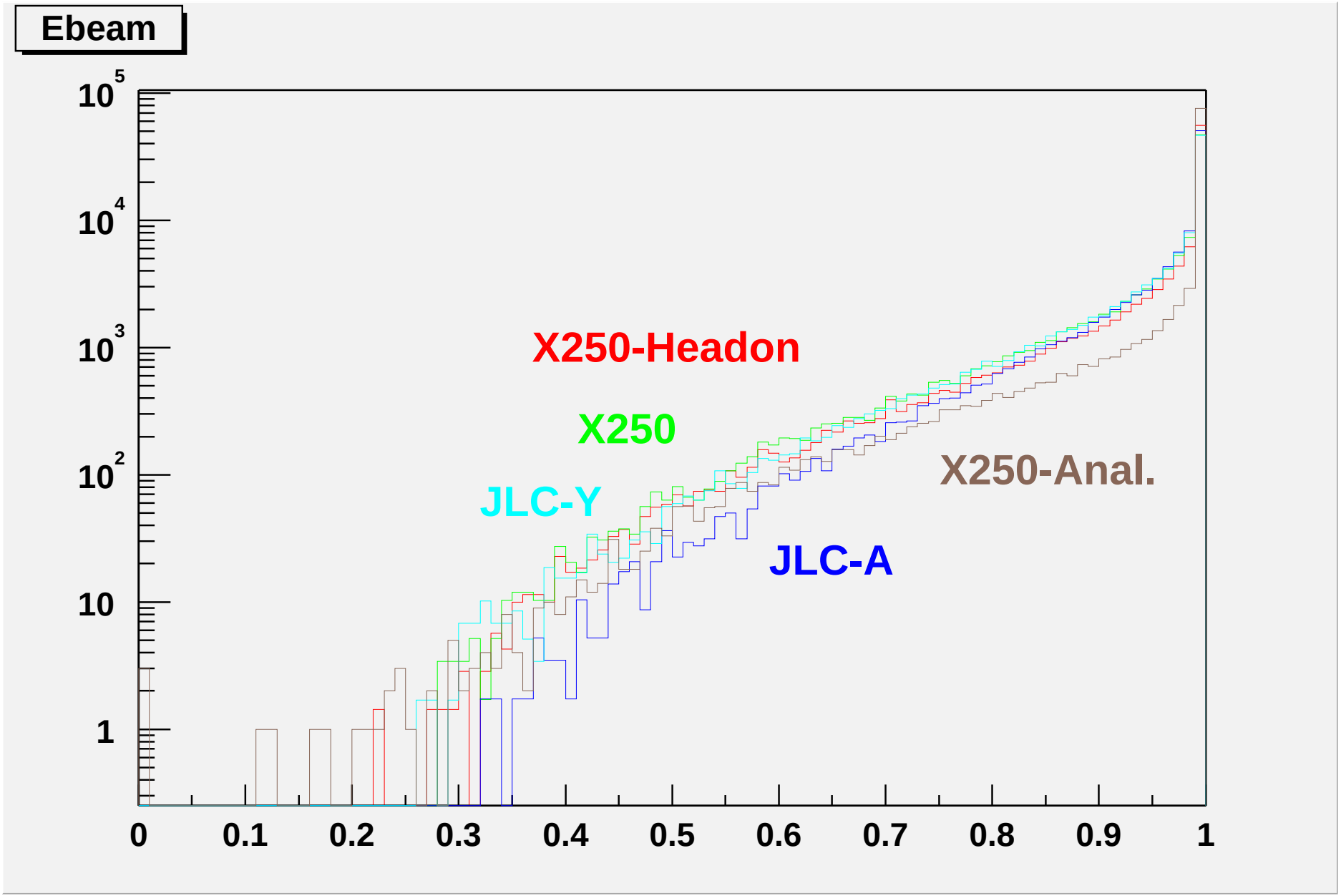
$$H(x) = \sqrt{\frac{3}{8\pi}}\left(\frac{\sqrt{x/3}}{1+0.53x^{-5/6}}\right)^{3/4} e^{4(x/3)^{3/4}}$$

r_e : classical electron radius
m_e : electron mass
α : fine structure constant

Event generation: E_{e^+/e^-} is generated by $F(z) = \int_0^1 f(z,\tau)d\tau \equiv < f(z,\tau) >$


Time dependance of beam energy
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
τ=1.0
τ=0.5
τ=0.001
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Scaled beam energy

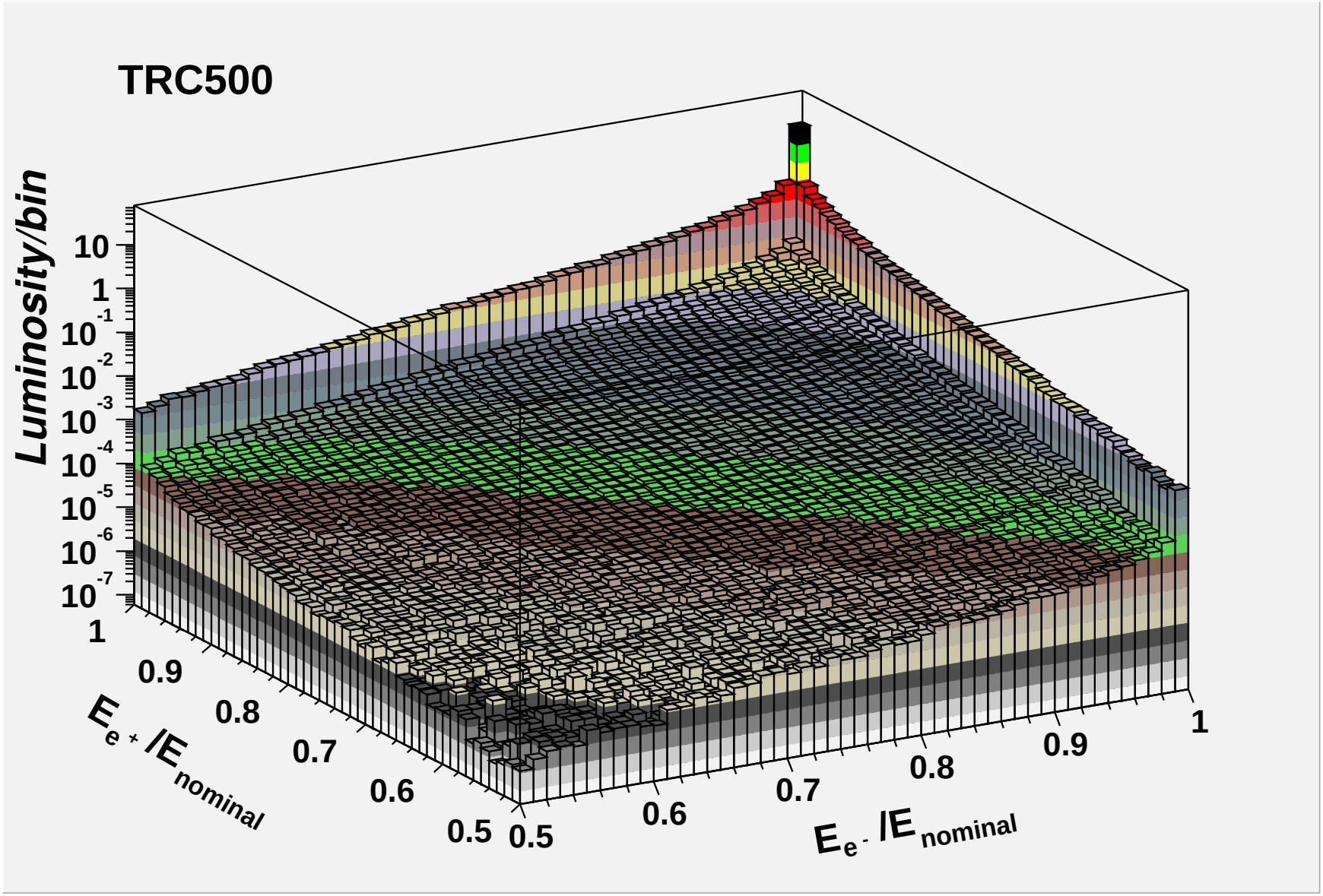
Comparison of electron energies: cain vs old function



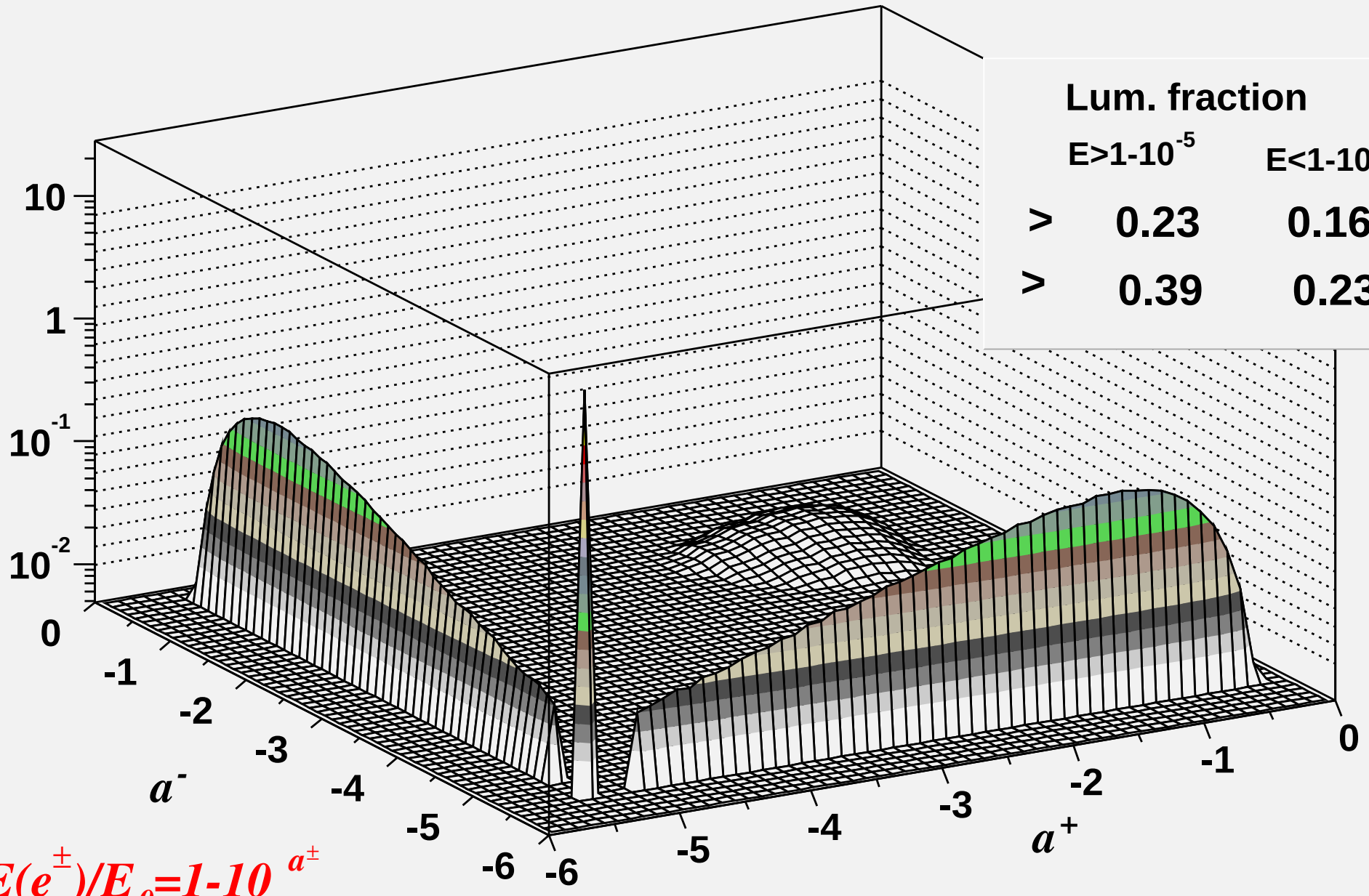
New method

- 2D histogram of $\frac{d\mathcal{L}}{dE_{e^-}dE_{e^+}}$ is obtained from Cain.
- 2D histogram is approximated by an empirical formula.
  Since $\frac{d\mathcal{L}}{dE_{e^-}dE_{e^+}}$ is singular, histogram binning is divided to three regions.
  - Without energy loss
  - Either e^+ or e^- looses energy.
  - Both e^+ and e^- loose energy
- E_{e^-} and E_{e^+} are generated based on the formula.

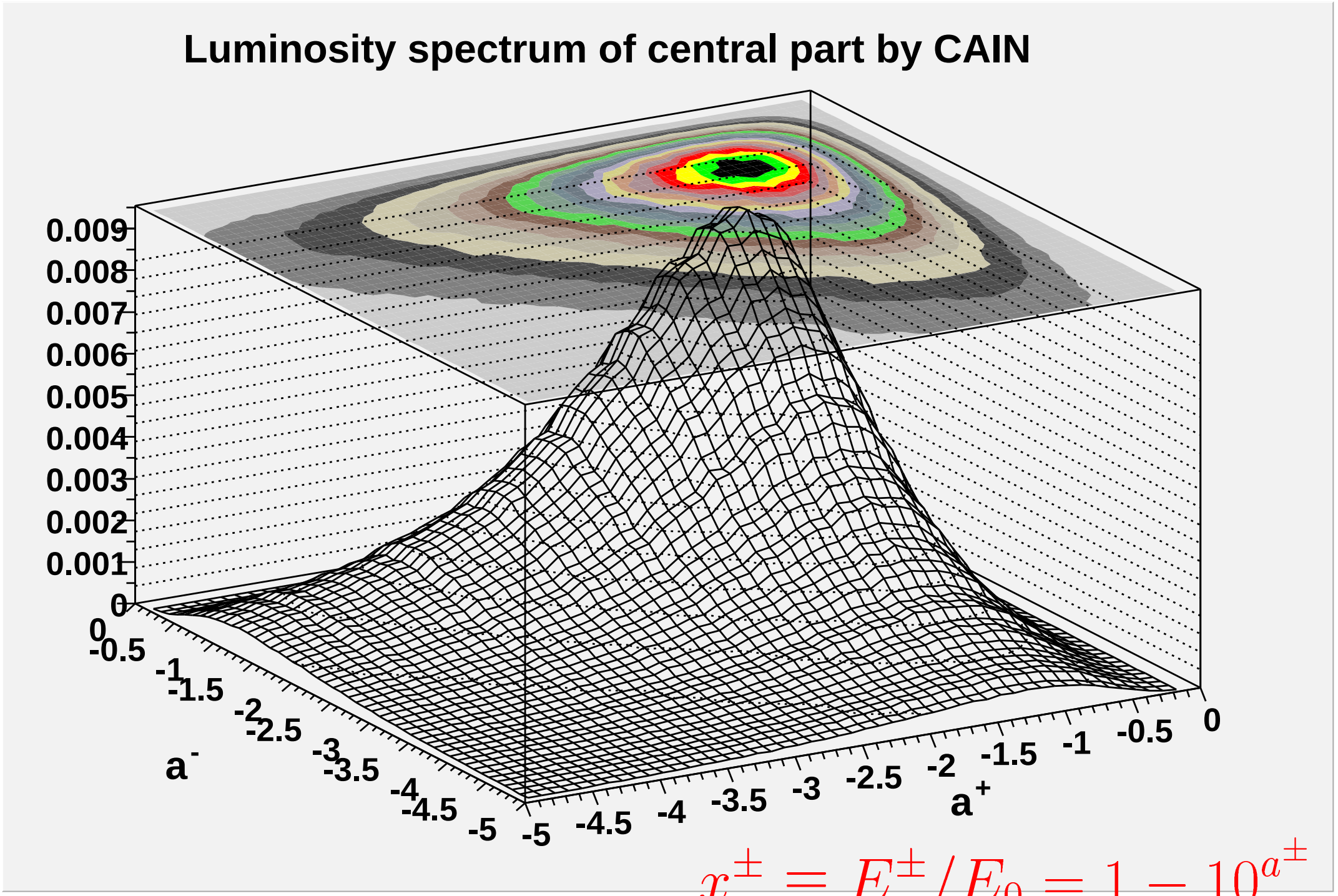
Typical 2D luminosity distribution



2D distribution of luminosity (TRC500)



Lum. fraction	$E>1-10^{-5}$	$E<1-10^{-5}$
>	0.23	0.16
>	0.39	0.23

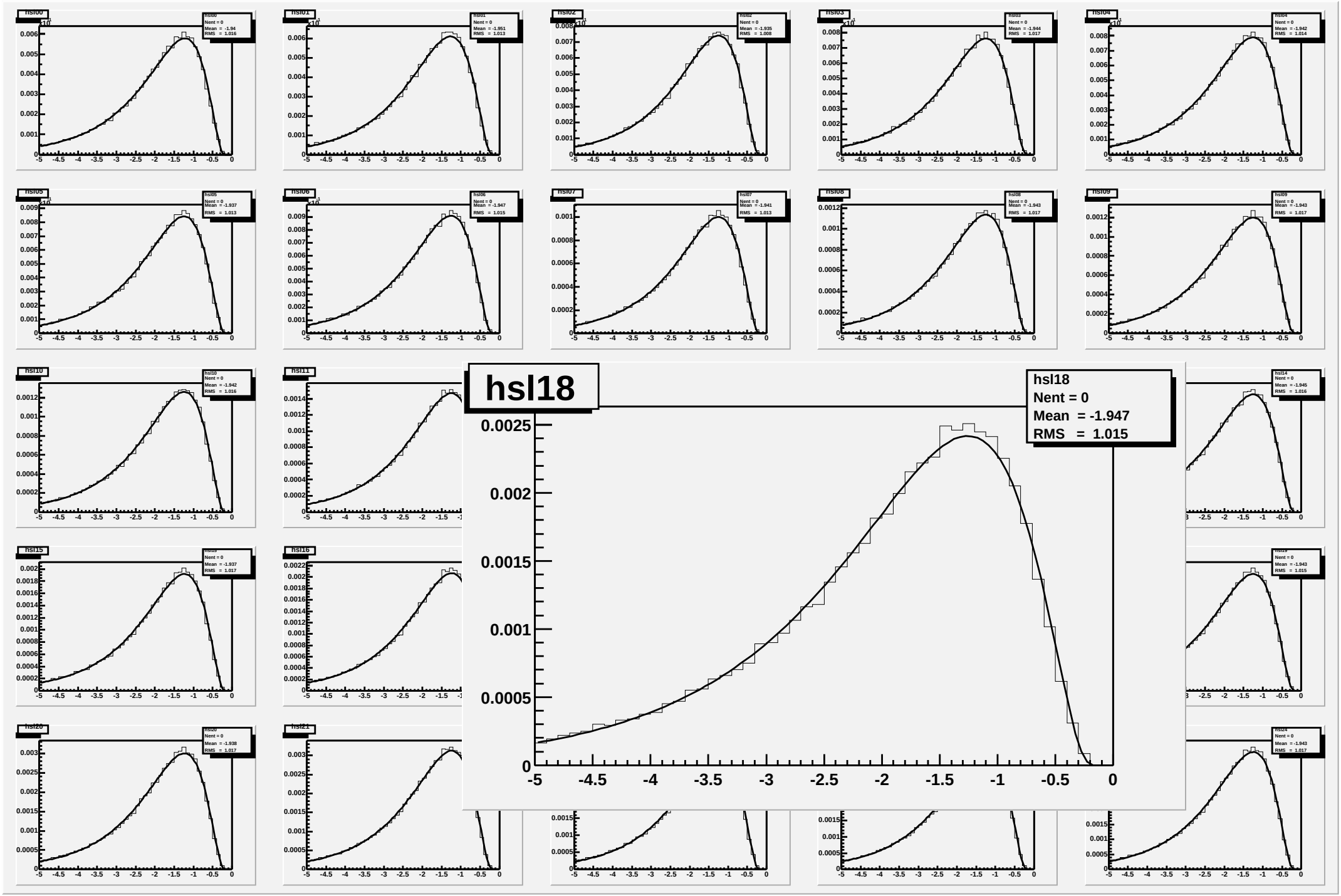

Luminosity spectrum of central part by CAIN
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
a-
-5
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
a+
$x^{\pm} \equiv E^{\pm}/E_0 = 1 - 10^{a^{\pm}}$

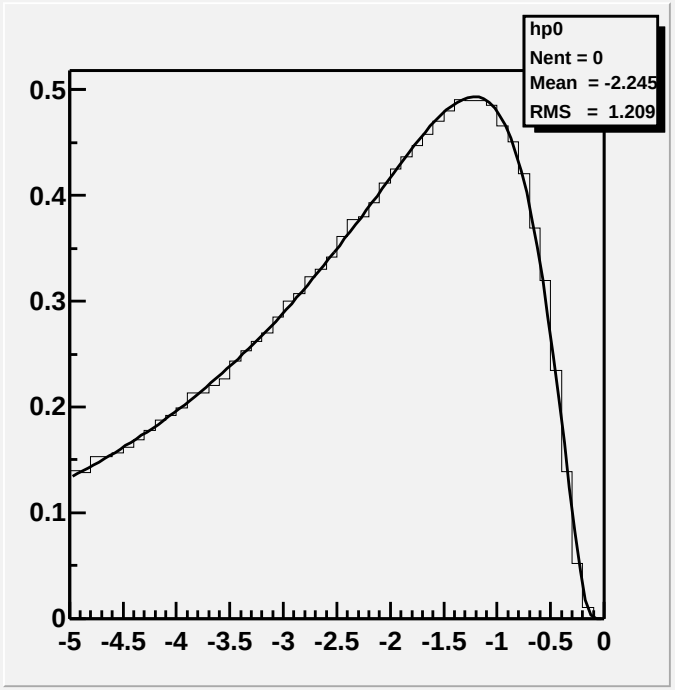
Functions used to fit spectrum

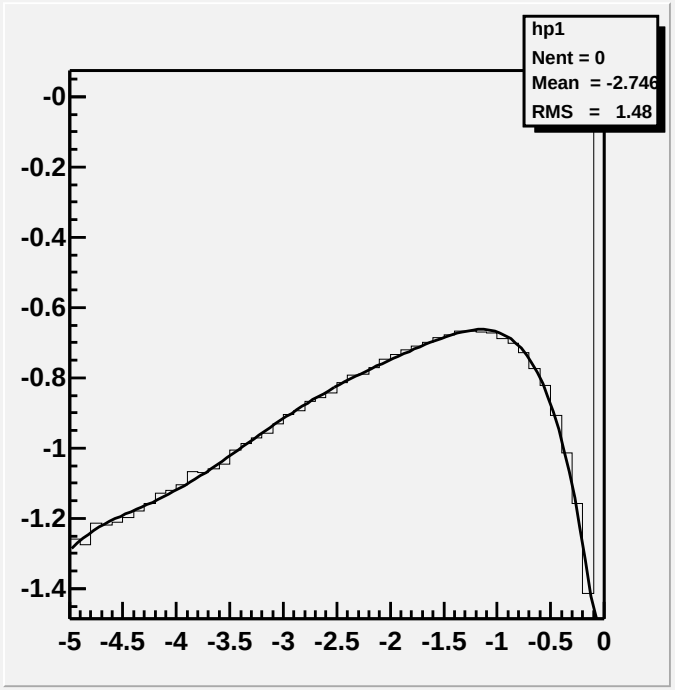
- x-slice of central part

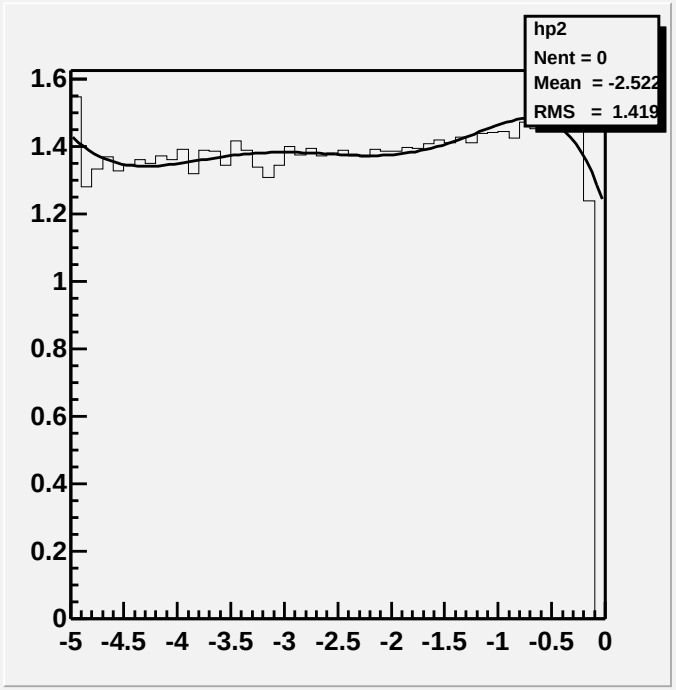
$$f(x) = p_0 e^{p_3(x+p_1)} \left(\cosh\left[p_2(x+p_4)\right] - 1\right)$$

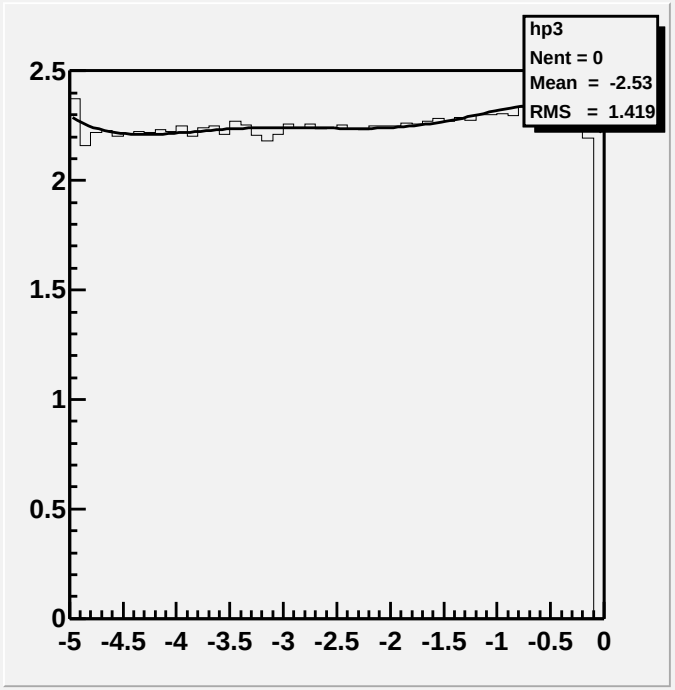
- y dependance of parameters
  - p_0 : $f(x)$
  - $p_1 \sim p_4$: 6th order polynomial
- Edge part:
  10-th order polynomial

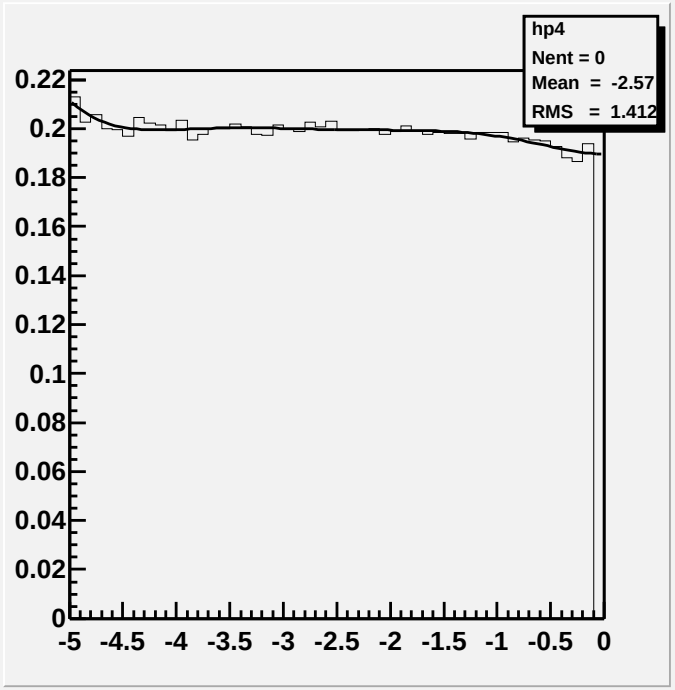

hsl18
hsl18
Nent = 0
Mean = -1.947
RMS = 1.015


hp0
Nent = 0
Mean = -2.245
RMS = 1.209

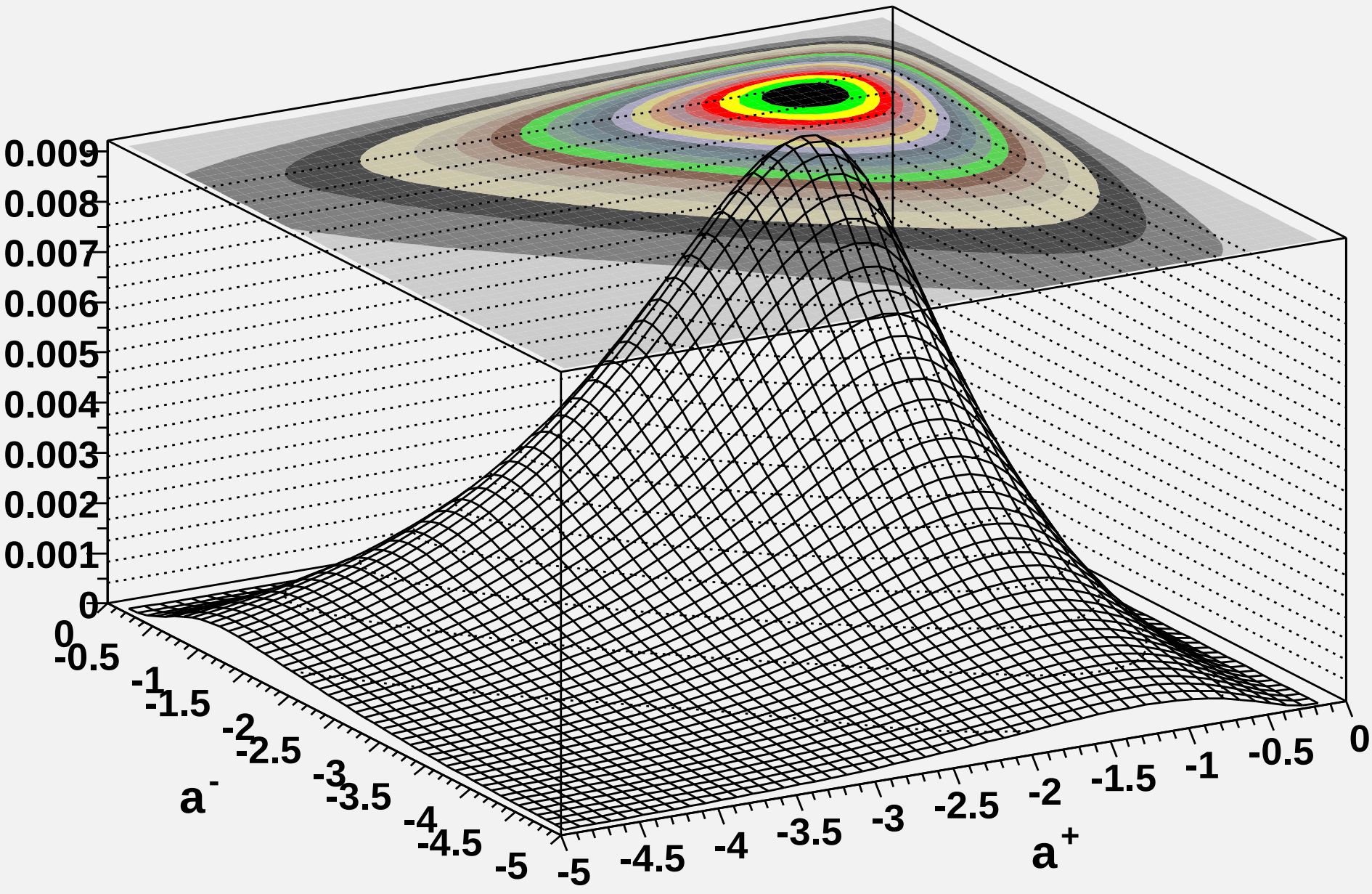

hp1
Nent = 0
Mean = -2.746
RMS = 1.48

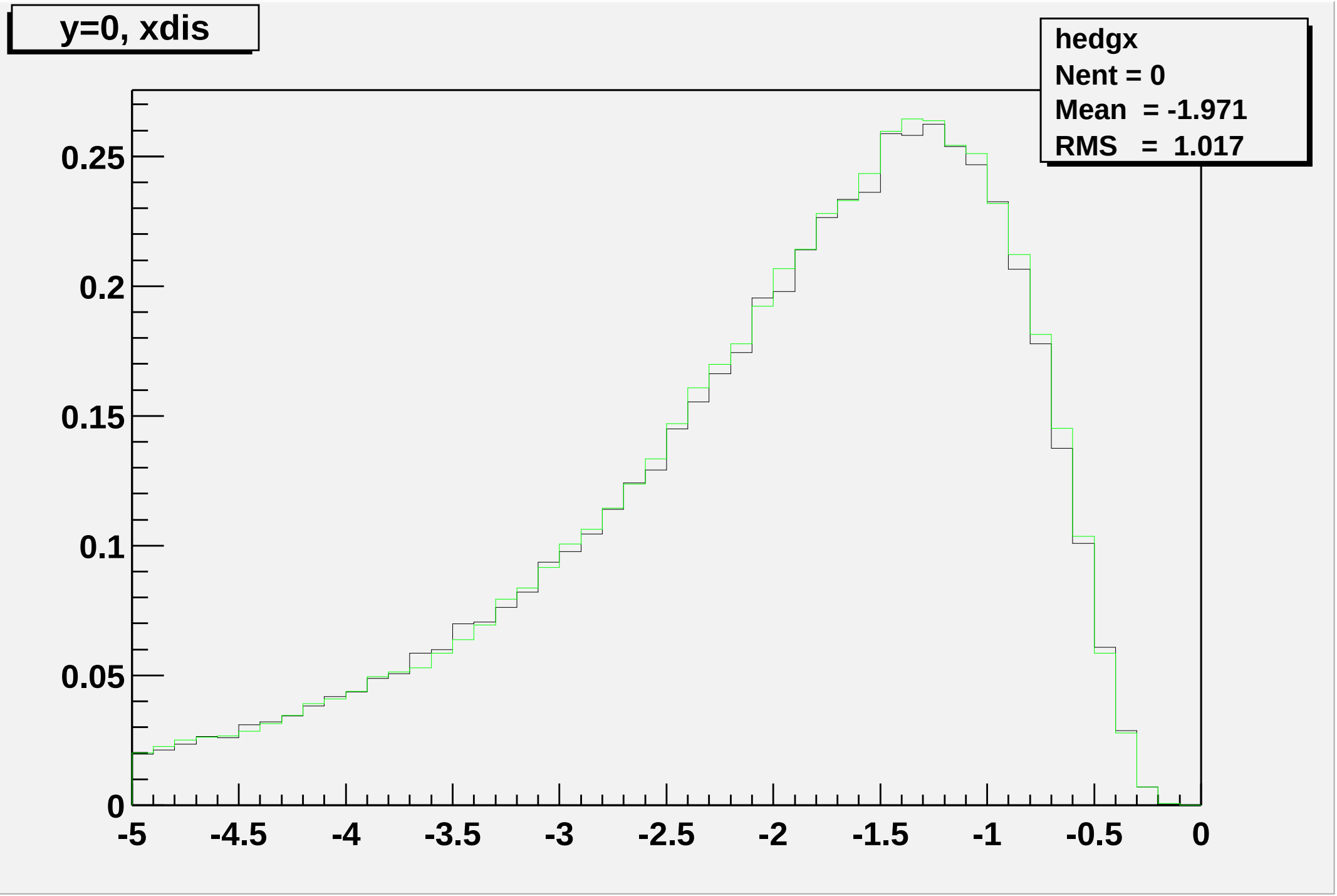

hp2
Nent = 0
Mean = -2.522
RMS = 1.419

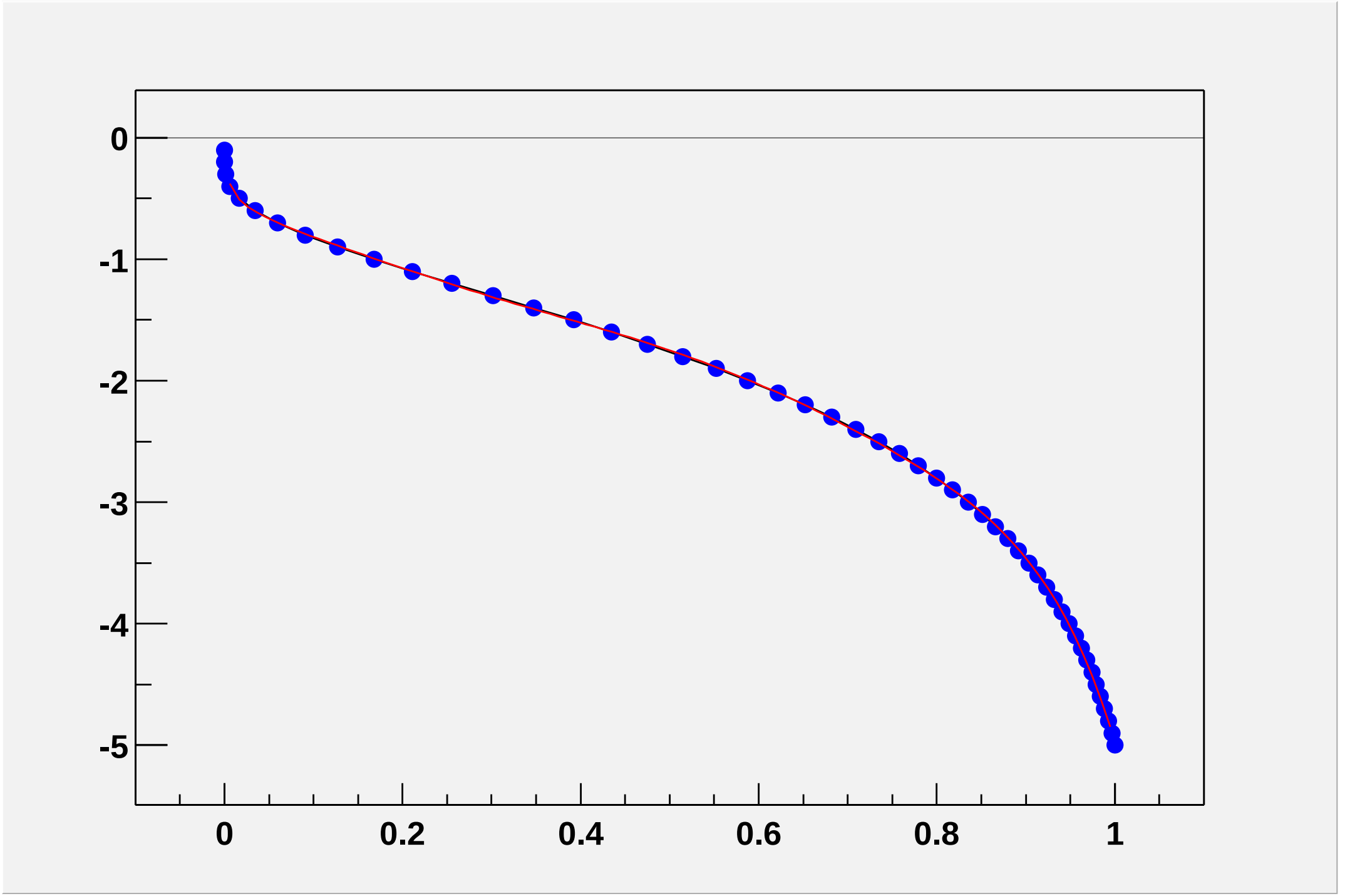

hp3
Nent = 0
Mean = -2.53
RMS = 1.419

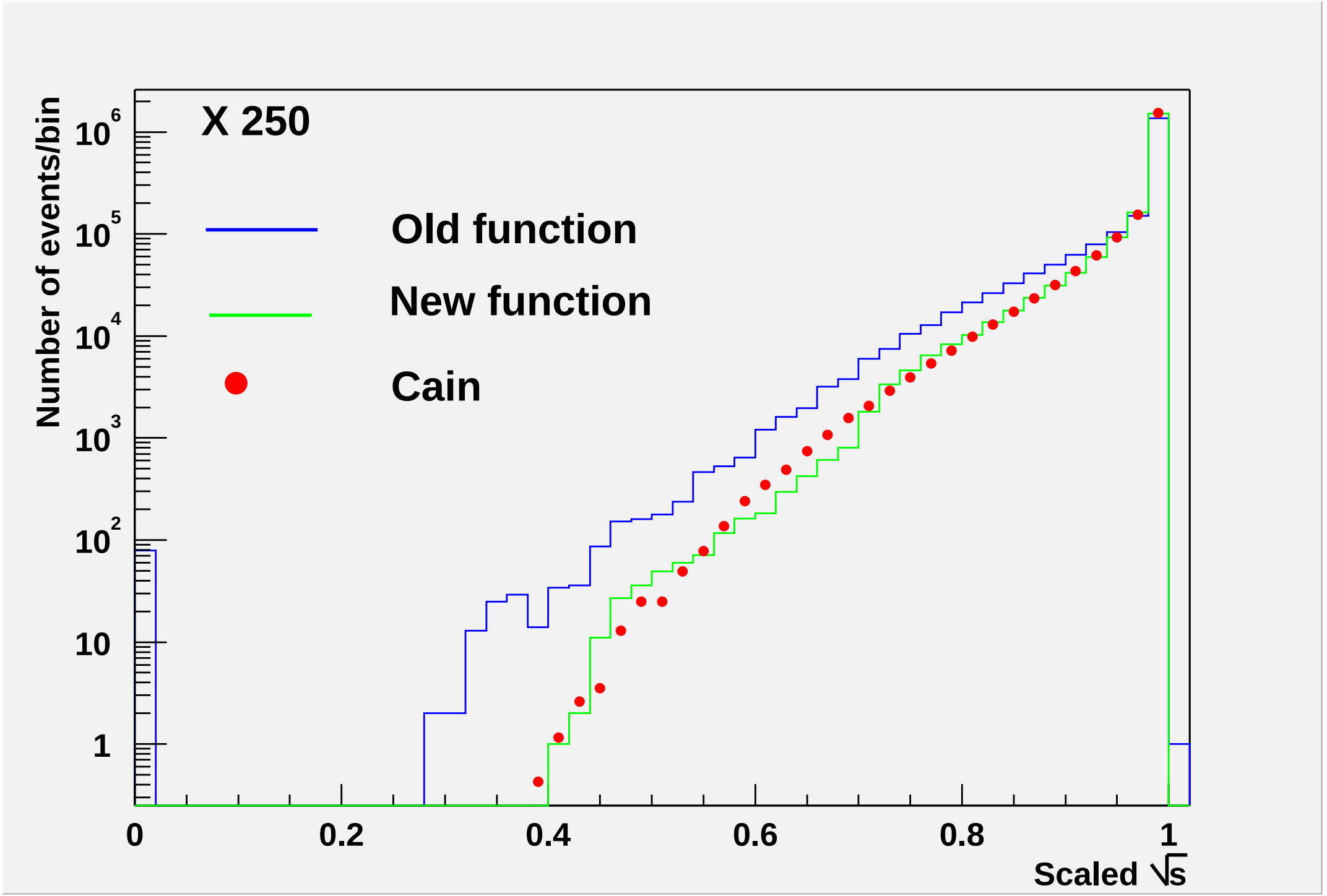

hp4
Nent = 0
Mean = -2.57
RMS = 1.412

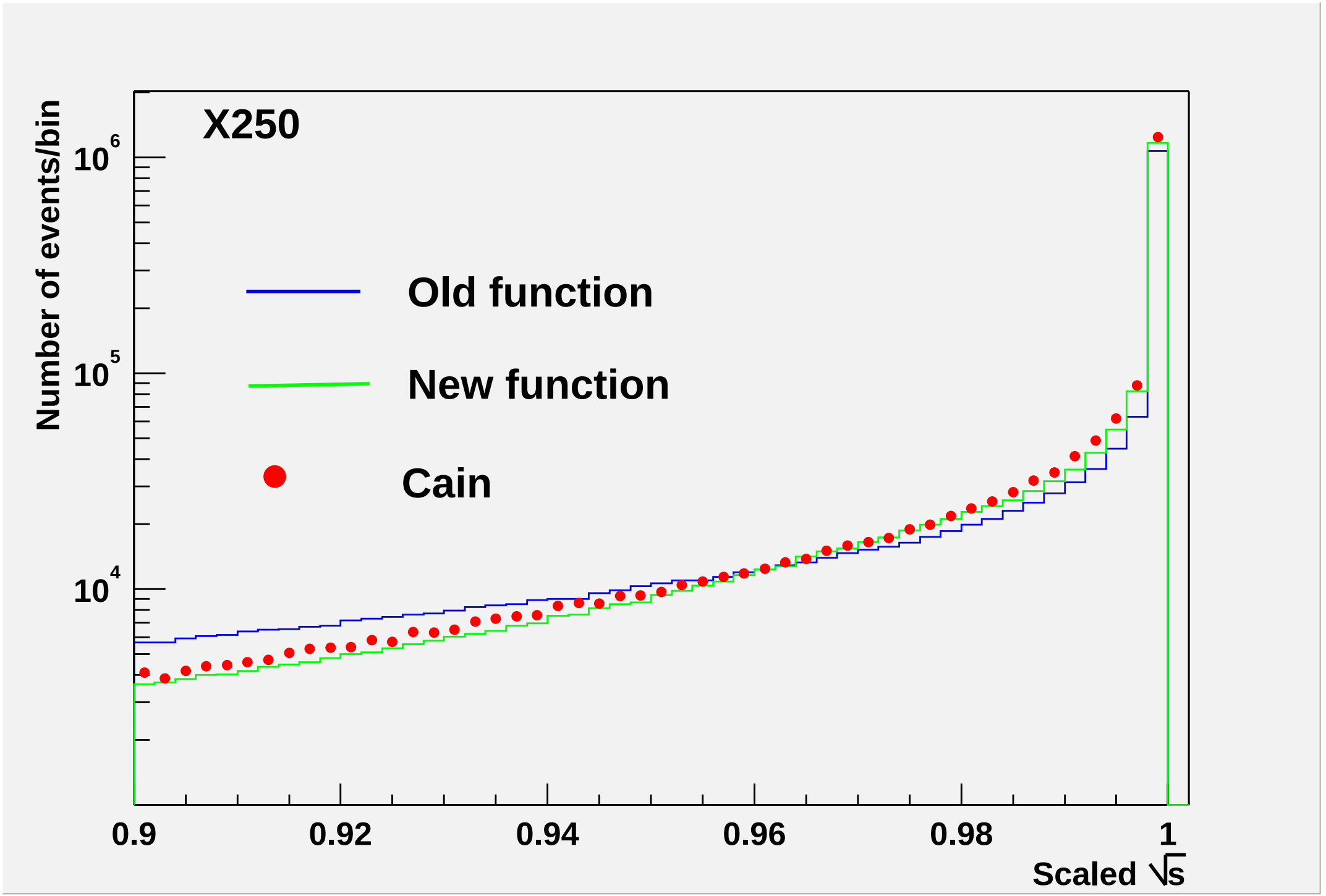
Luminosity spectrum of central part by fitted formula

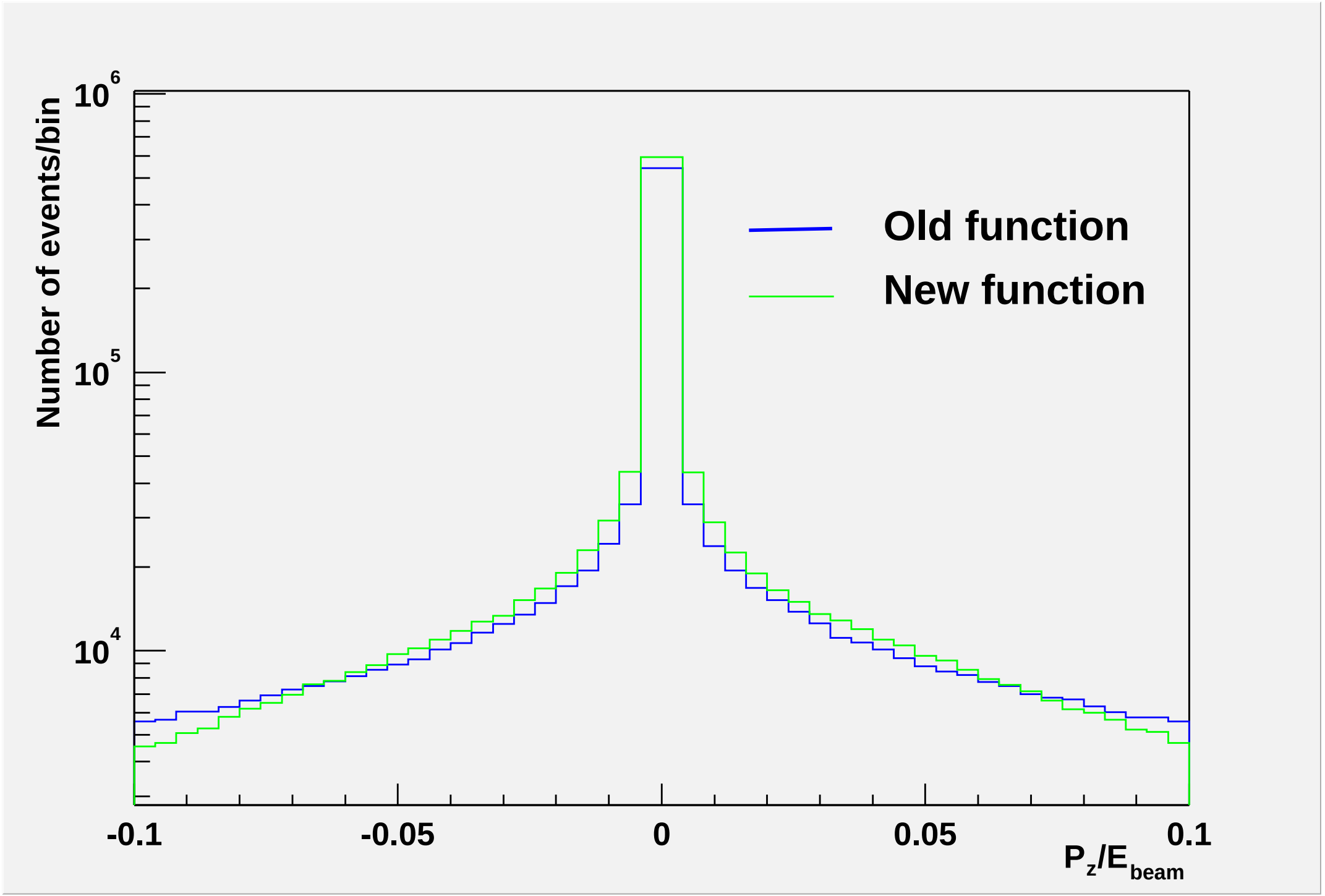



y=0, xdis
hedgx
Nent = 0
Mean = -1.971
RMS = 1.017
0.25
0.2
0.15
0.1
0.05
0
-5
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0


0
-1
-2
-3
-4
-5
0
0.2
0.4
0.6
0.8
1


X 250
Old function
New function
Cain
Number of events/bin
10^6
10^5
10^4
10^3
10^2
10
1
0
0.2
0.4
0.6
0.8
1
Scaled √s


X250
Number of events/bin
10^6
10^5
10^4
Old function
New function
Cain
0.9
0.92
0.94
0.96
0.98
1
Scaled √s

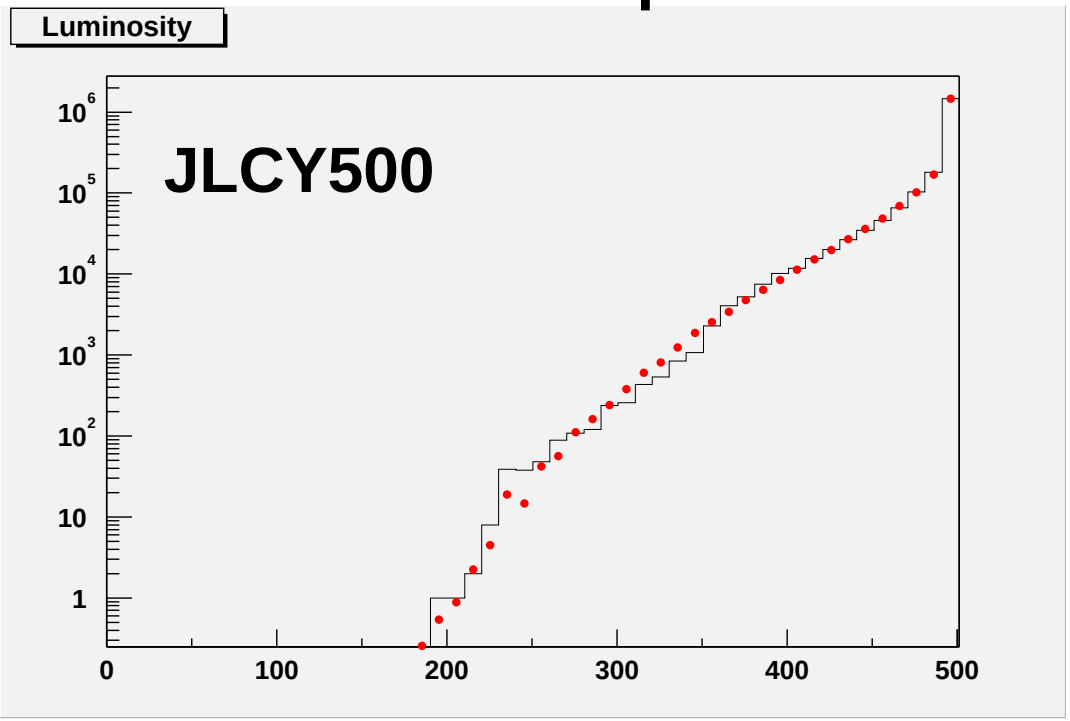

Number of events/bin
10^6
10^5
10^4
-0.1
-0.05
0
0.05
0.1
P_z/E_beam
Old function
New function

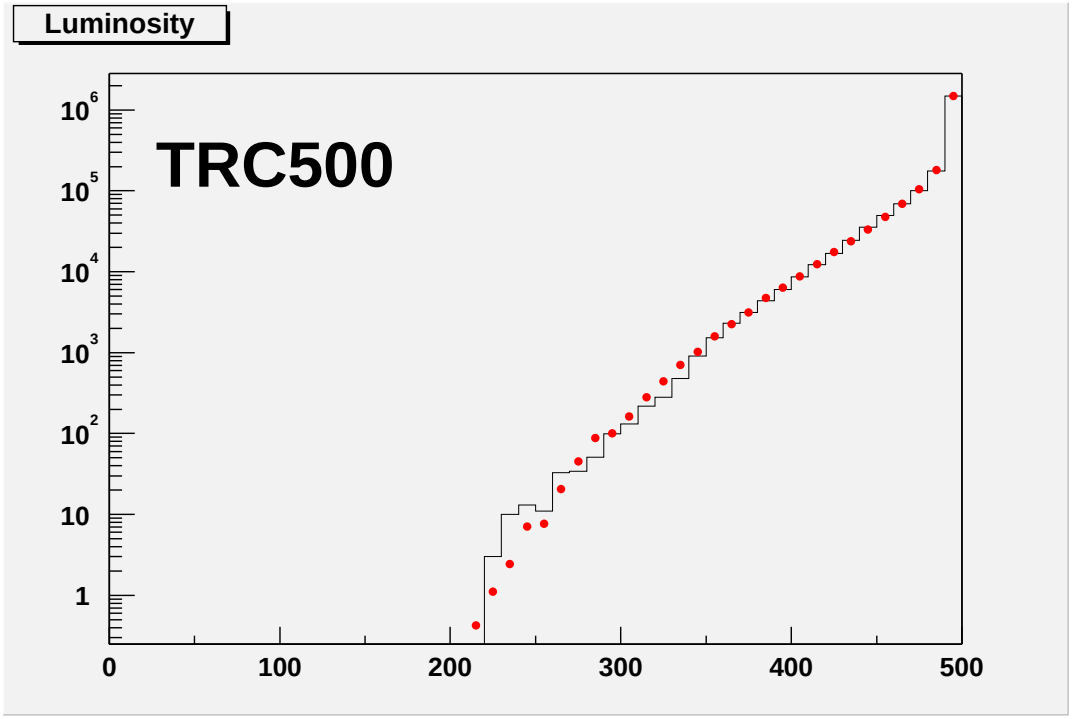
Accelerator parameters

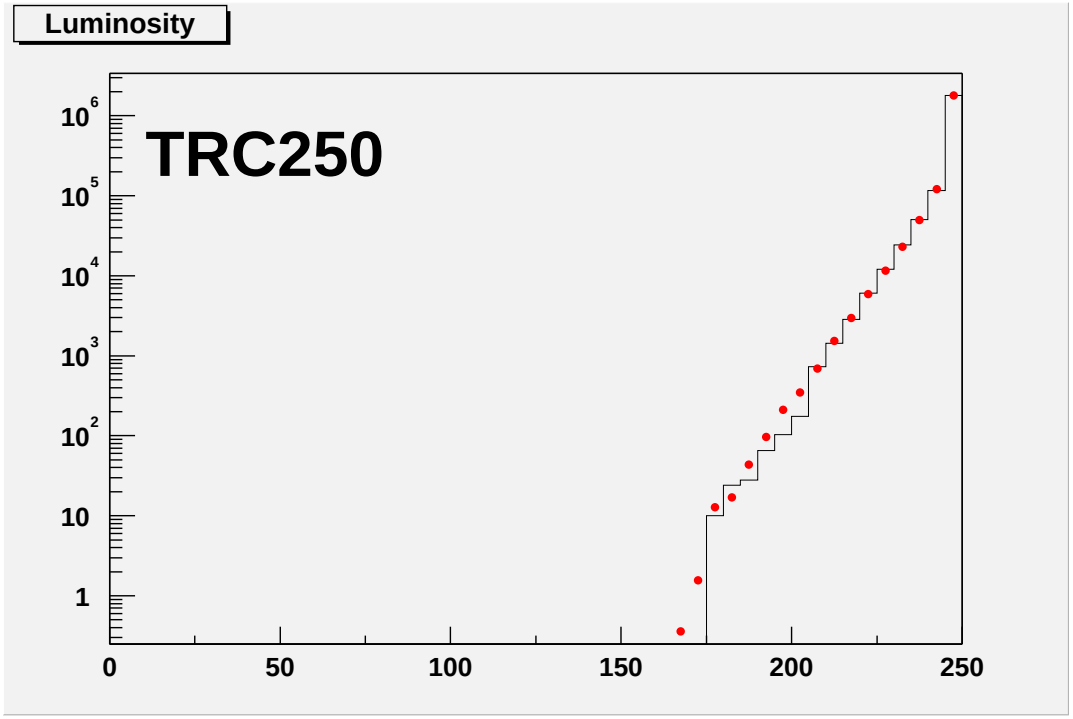
name	jlcy500	jlcy300	jlca500	jlca300	trc500	trc1000	x250_n63
$E_{beam}(GeV)$	250.5	150.0	267.5	150	250.0	500.0	250.0
$N_{particles}(\times 10^{10})$	0.70		0.75		0.75	0.75	0.63
N_{bunch}	190		95		192	192	90
$freq.$	150		150		150	100	150
$\beta_x(mm)$	7		10		8	13	10
$\beta_y(\mu m)$	80		100		110	110	100
$\gamma\epsilon_x(\times 10^{-6})$	4.0		4.0		3.6	3.6	3.0
$\gamma\epsilon_y(\times 10^{-8})$	4.0		6.0		4.0	4.0	3.0
$\sigma_Z(\mu m)$	80		90		110	110	67
$\theta_{cross}(mrad)$	7.0		7.0		7.0	7.0	0.0
Luminosity($10^{33}cm^{-2}s^{-1}$)	24.75	14.82	9.30	5.21	25.17	25.08	10.85

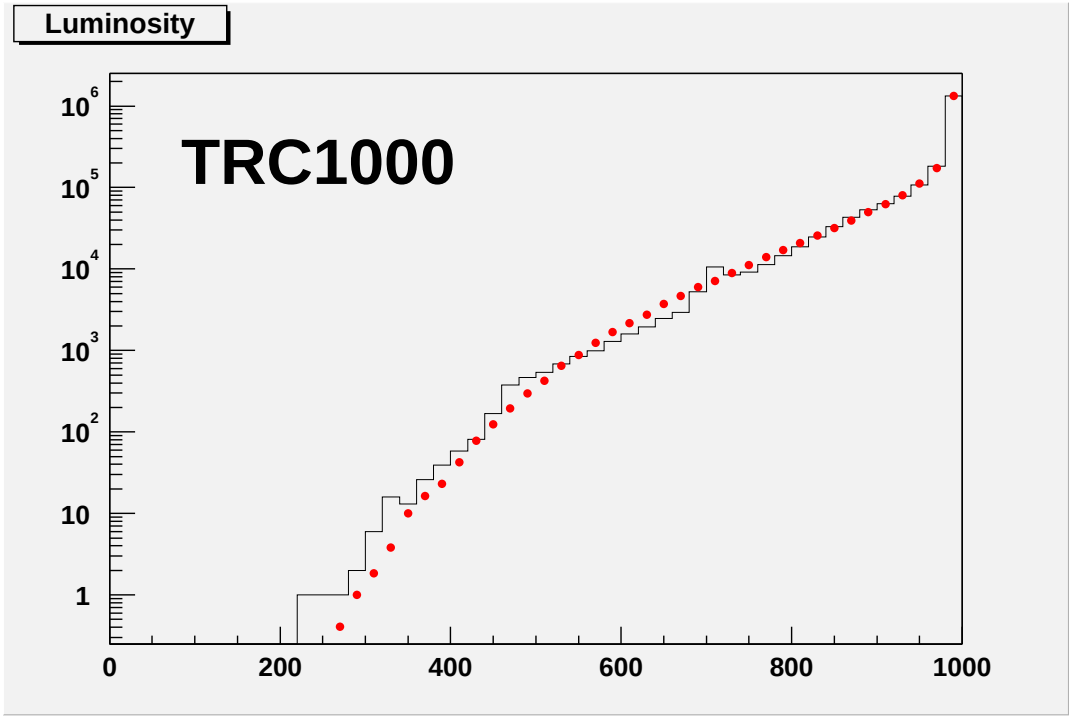
name	trc250	trc300	trc350	trc400	trc450	trc500	trc100
Luminosity($10^{33}cm^{-2}s^{-1}$)	12.59	15.13	17.67	20.21	22.74	25.17	25.08

Comparison of new function and CAIN









Influence to total cross sections

process: $e^+e^- \to ZZ$ at $\sqrt{s} = 300$ GeV

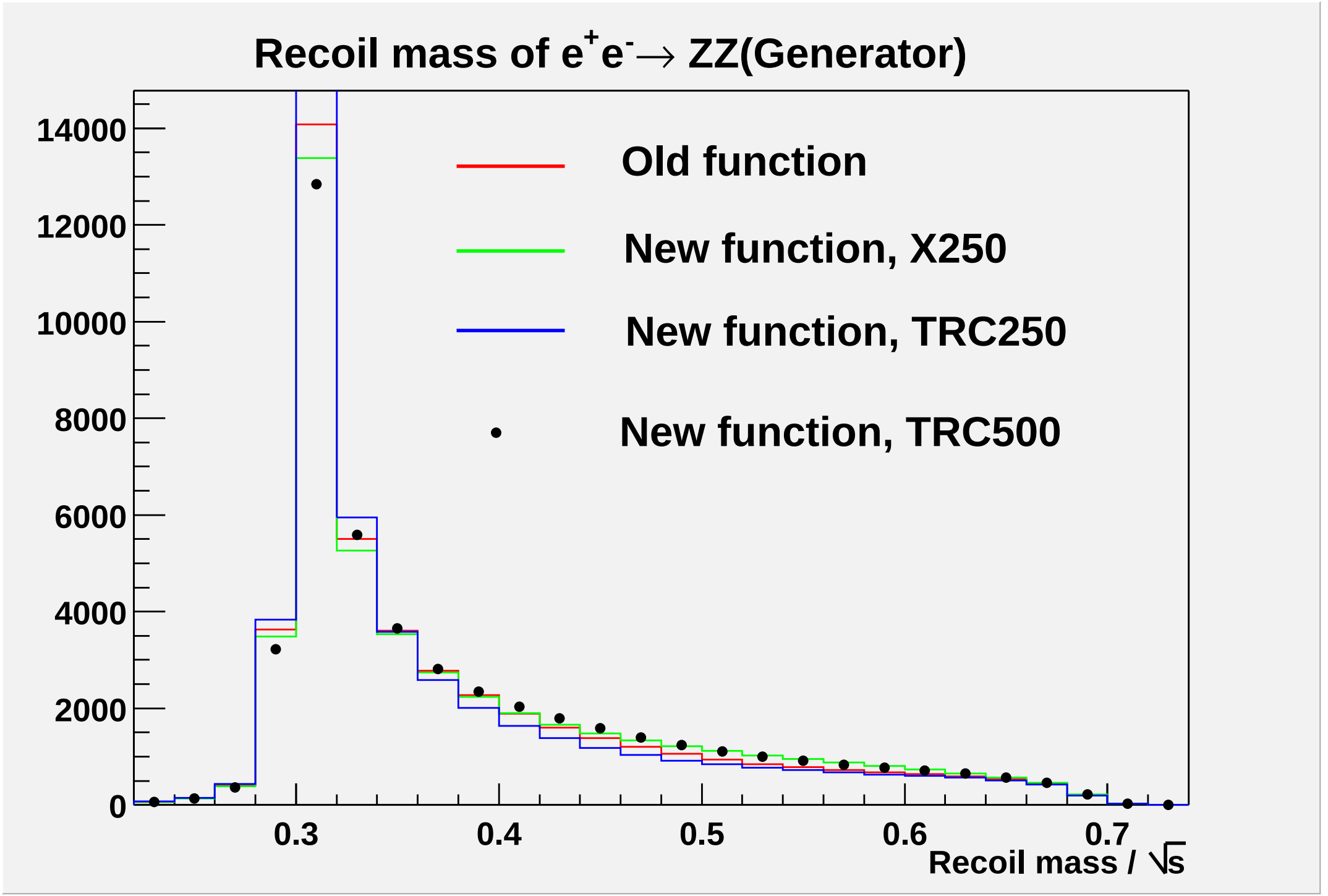
σ decreases with energy.

$\therefore < E >$ up $\to \sigma$ down

program: Physsim (Bases)

Spectrum	total cross section(fb)
X250(old)	922.15 ± 0.41
X250(new)	927.44 ± 0.42
TRC300	917.36 ± 0.42
TRC500	928.56 ± 0.42

(including $\pm 0.5\%$ of uniform initial energy spread)


Recoil mass of $e^+e^- \rightarrow ZZ$(Generator)
Old function
New function, X250
New function, TRC250
New function, TRC500
14000
12000
10000
8000
6000
4000
2000
0
0.3
0.4
0.5
0.6
0.7
Recoil mass / $\sqrt{s}$

Summary

1. **The generator for beamstrahlung spectrum is improved.**

   new method
   latest parameter sets

   Possible further improvements:

   Non-uniform initial energy spread
   Z dependance(?)

2. **Next step**

   Update Pythia interface and Physsim package.
   Update figures for roadmap

$$\text{Ex. } M_x \text{ distribution of } e^+e^- \to ZH \to \ell\bar{\ell}X$$