TOP QUARK FCNC IN γP COLLISIONS AT LHEC AND FCC-EP

TopFCNC Study Group

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PROCESSES AND DIAGRAMS

Signal diagrams related to the process “a p > w+ j” within MG5

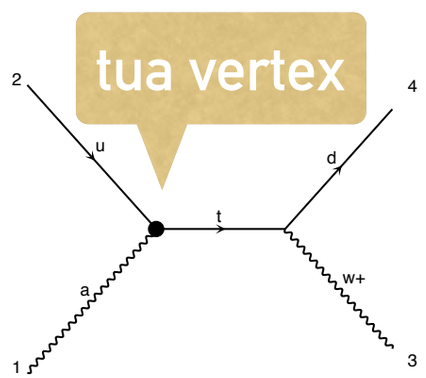
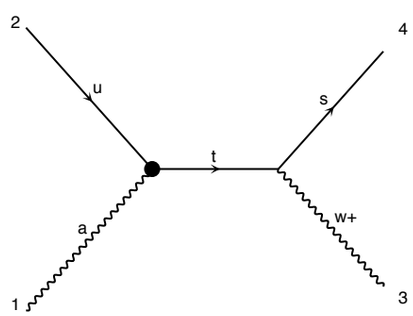


diagram 2 NP=1, QCD=0, QED=2



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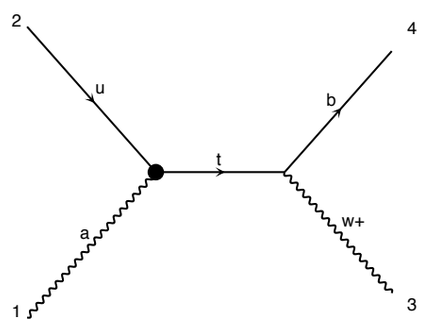

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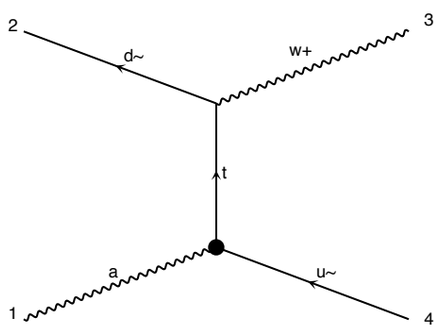

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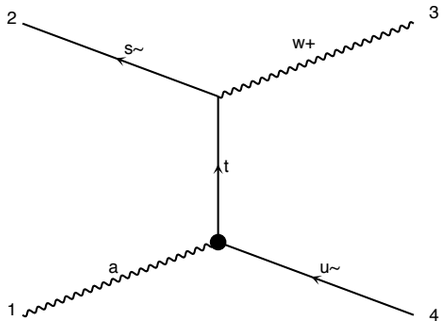

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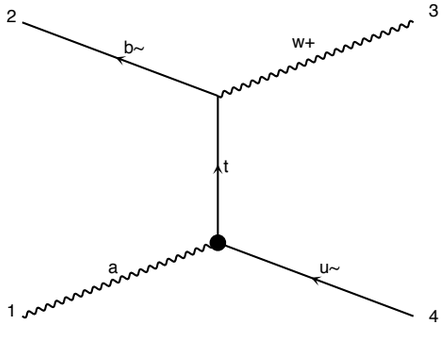

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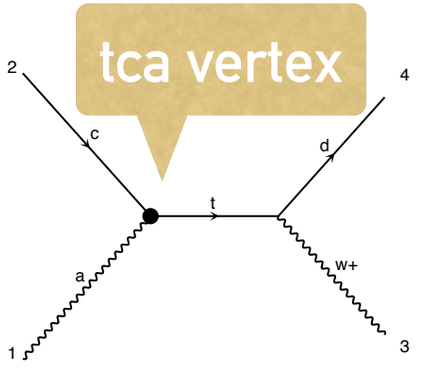

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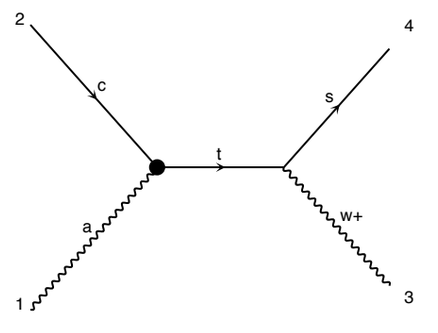

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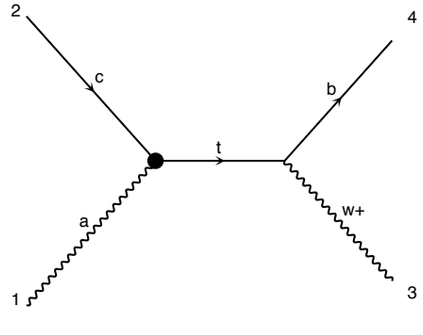

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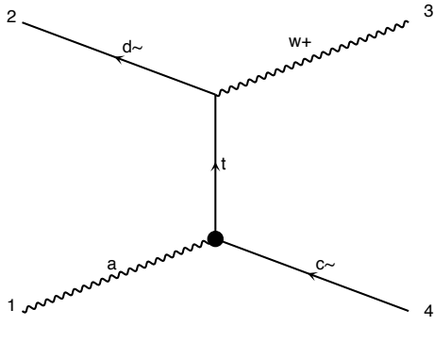

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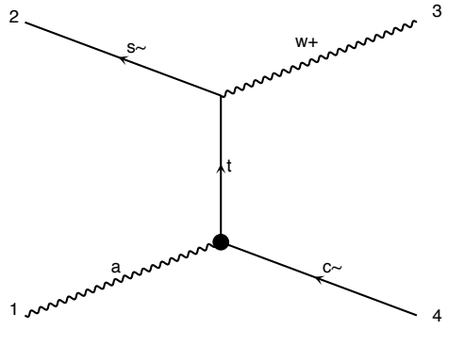

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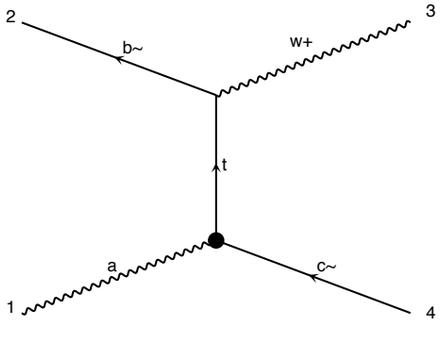


diagram 2 NP=1, QCD=0, QED=2

CROSS SECTIONS

LASER	Cross section (pb) for $\gamma p \to W^+ j$		
Collision	SM	SM+FCNC($\lambda = 0.1$)	SM+FCNC($\lambda = 0.01$)
LHeC$-\gamma p$	7.247×10^1	9.906×10^1	7.279×10^1
FCC-ep$-\gamma p$	1.919×10^2	2.453×10^2	1.924×10^2

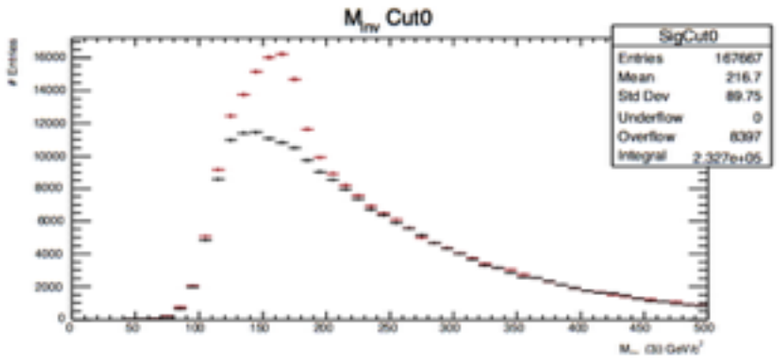
Cross sections for process $\gamma p \longrightarrow W^+ j$ in the LHeC and FCC-ep based γp collisions.

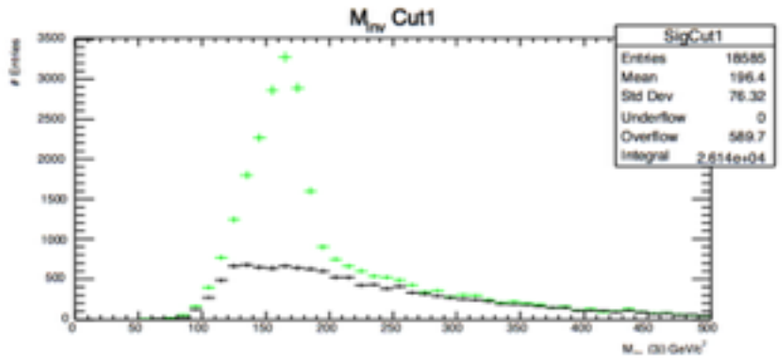
EPA	Cross section (pb) for $\gamma p \to W^+ j + X$		
Collision	SM	SM+FCNC($\lambda = 0.1$)	SM+FCNC($\lambda = 0.01$)
LHeC$-\gamma p$	6.337×10^0	9.982×10^0	6.379×10^0
FCC-ep$-\gamma p$	1.962×10^1	2.797×10^1	1.976×10^1

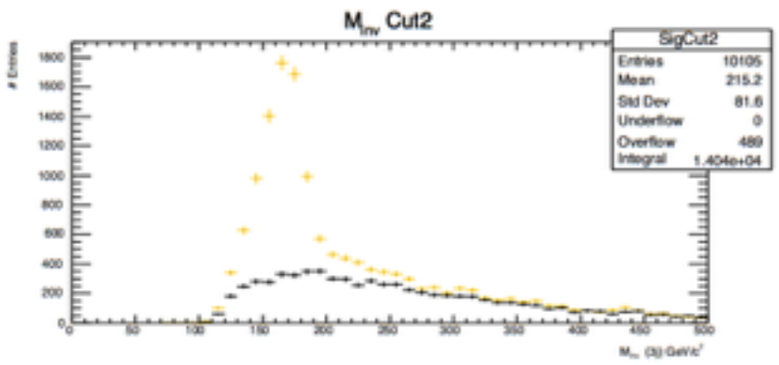
We find that cross section for laser option is about an order of magnitude larger than epa option.

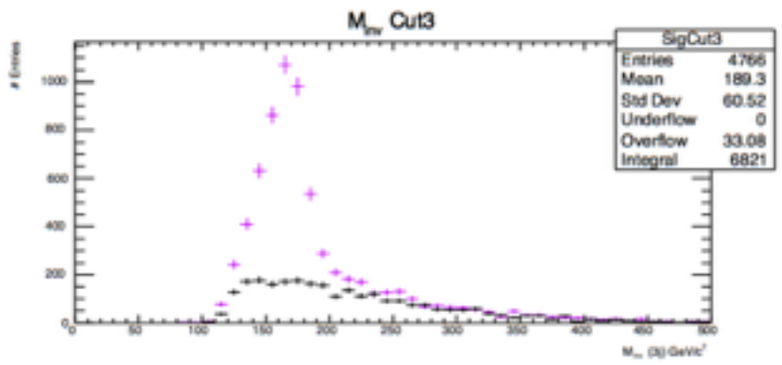
ANALYSIS

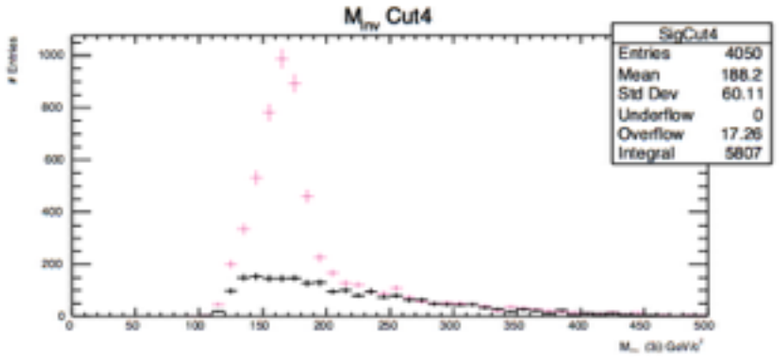
➤ Top quark invariant mass plots after cuts for LHeC(epa)

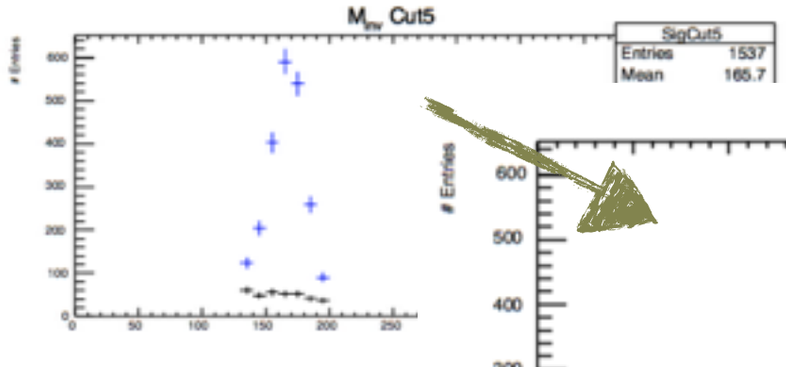




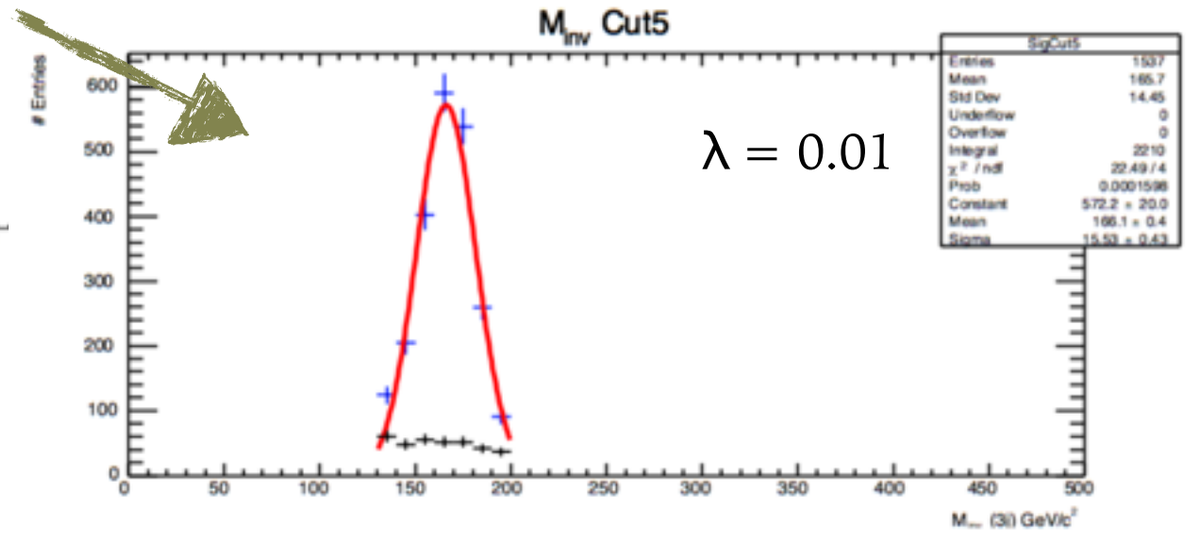






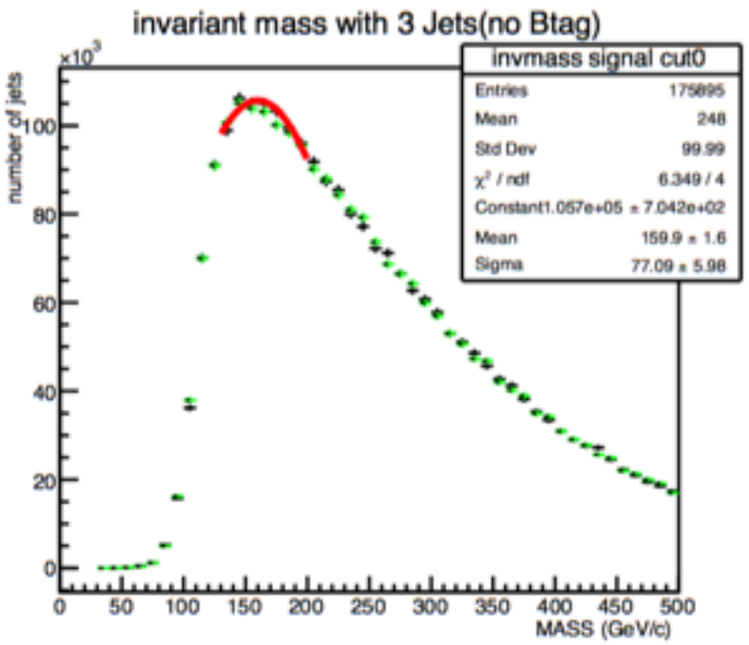


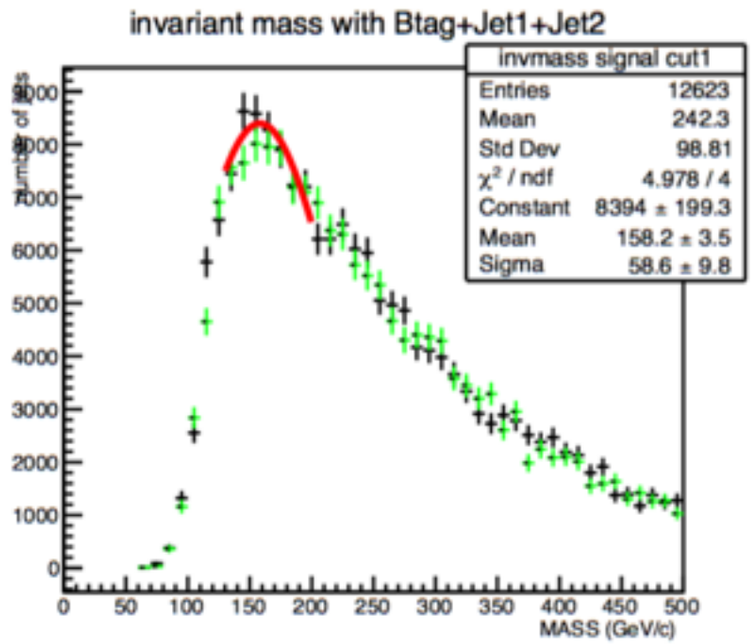
Cuts		
Cut-0	(Preselection cuts)	$Jets \geqslant 3$
Cut-1	$Jets \geqslant 3$	Jet with b-tag
Cut-2	$p_T(j_2, j_3) > 30$	$p_T(j_b) > 40$
Cut-3	$-2.5 < \eta(j_1, j_2, j_3) < 0$	Region
Cut-4	$50 < M_{inv}(j_2, j_3) < 100GeV$	W mass rec.
Cut-5	$130 < M(j_b + j_2 + j_3) < 200GeV$	Top mass rec.

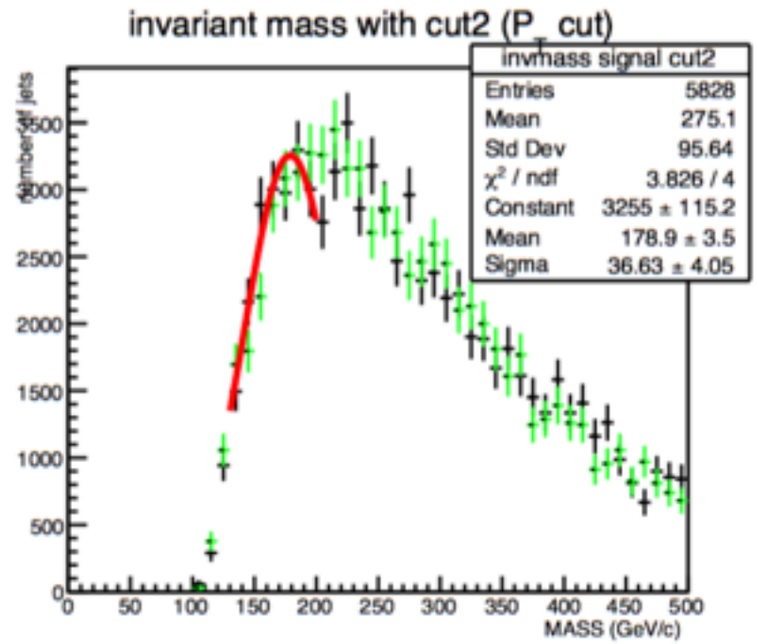


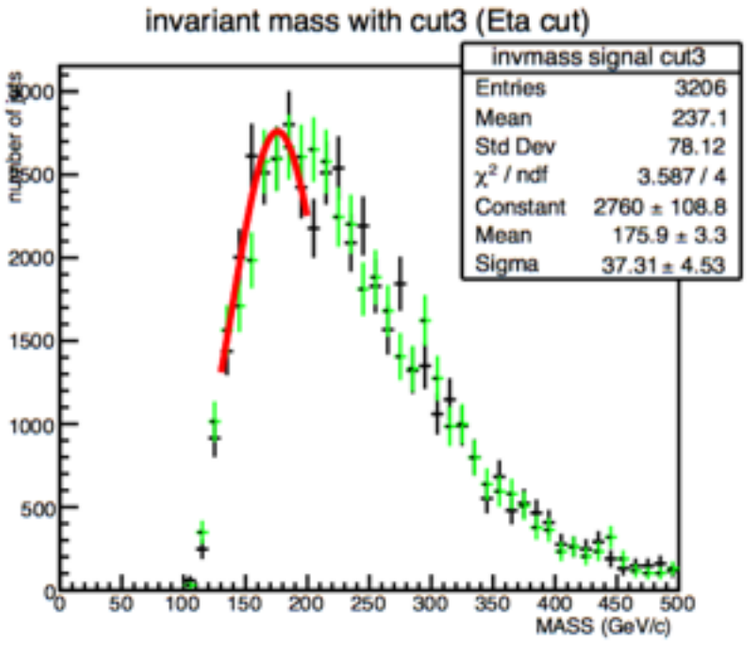
ANALYSIS

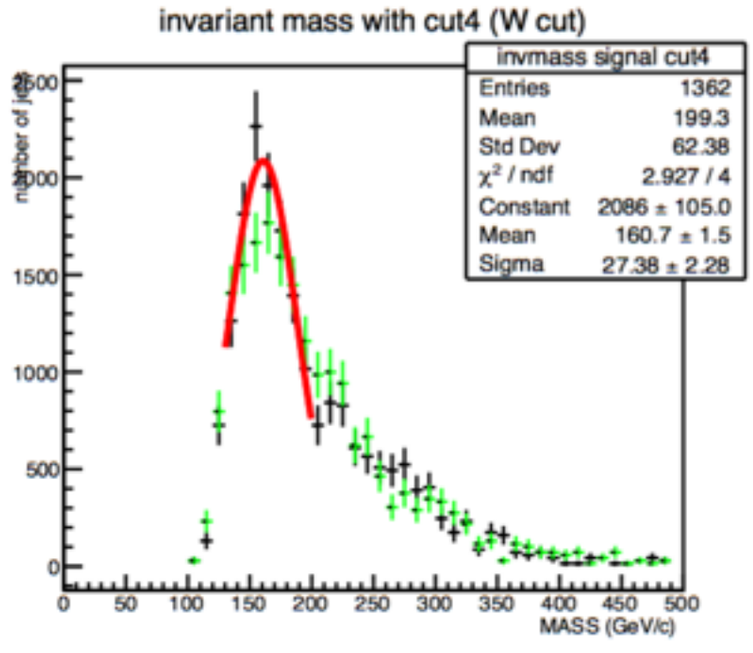
- Top quark invariant mass plots after cuts for LHeC(laser)

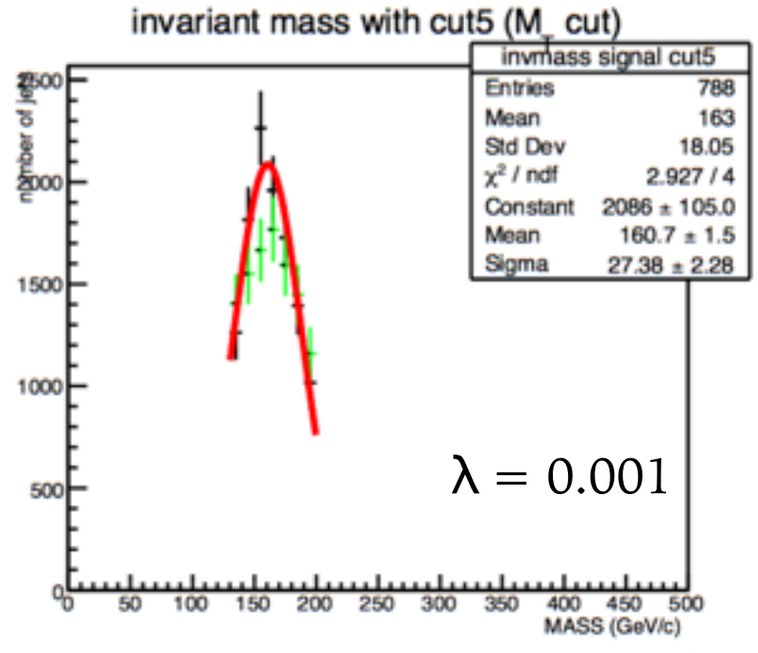






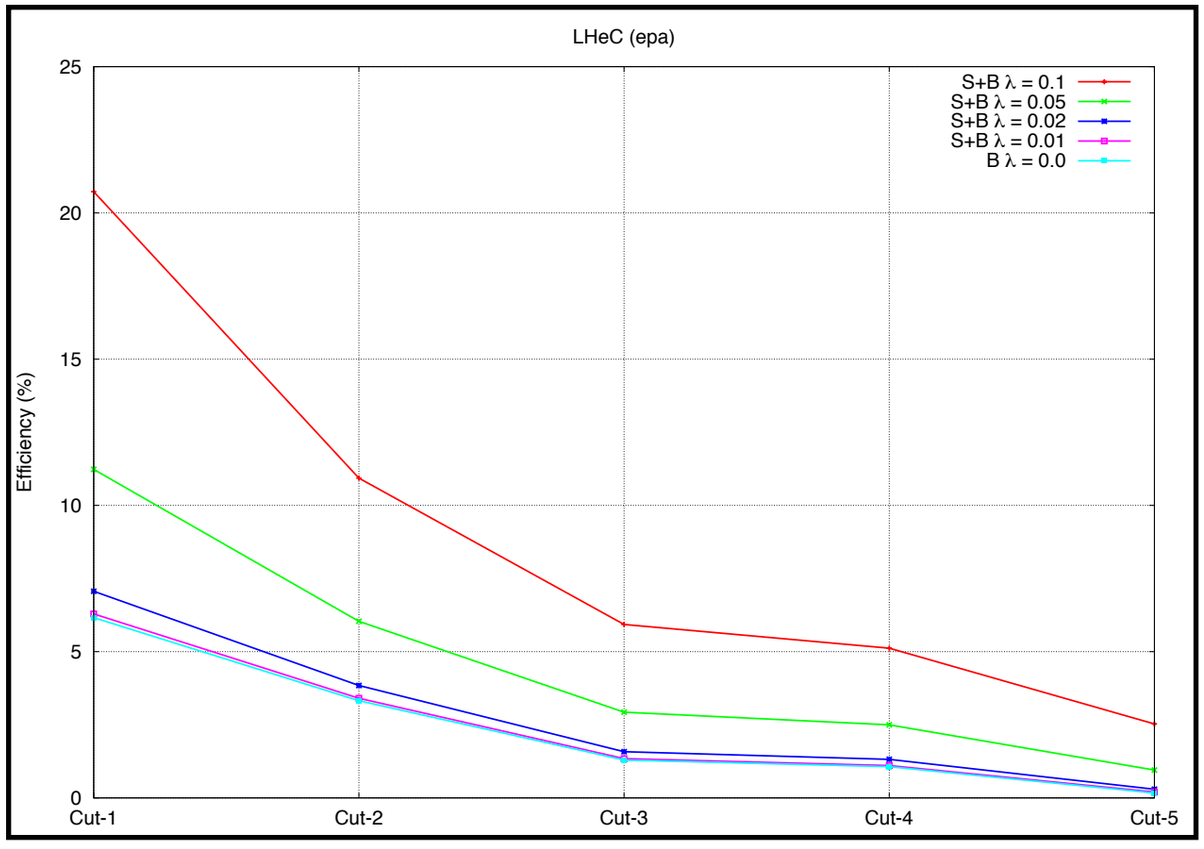


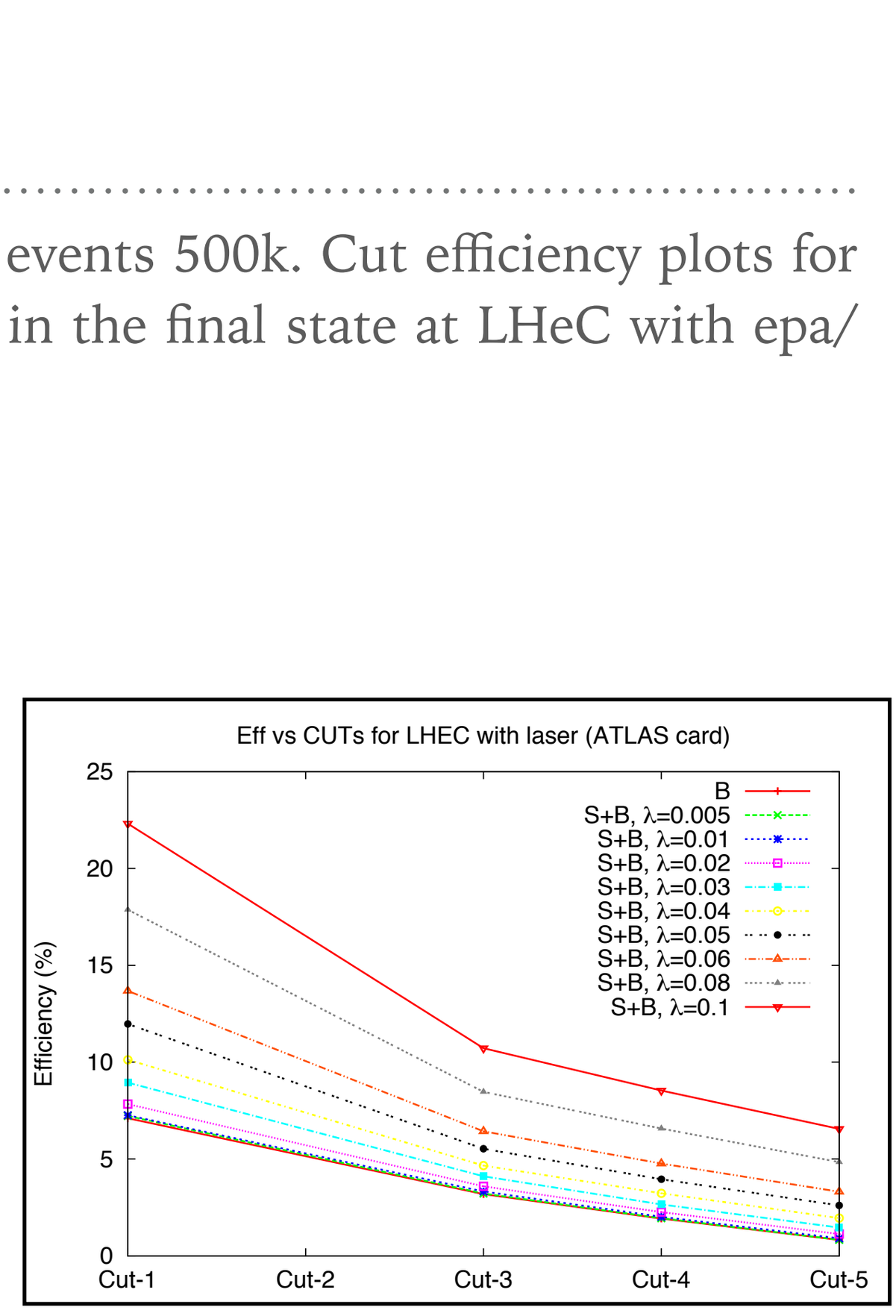




ANALYSIS

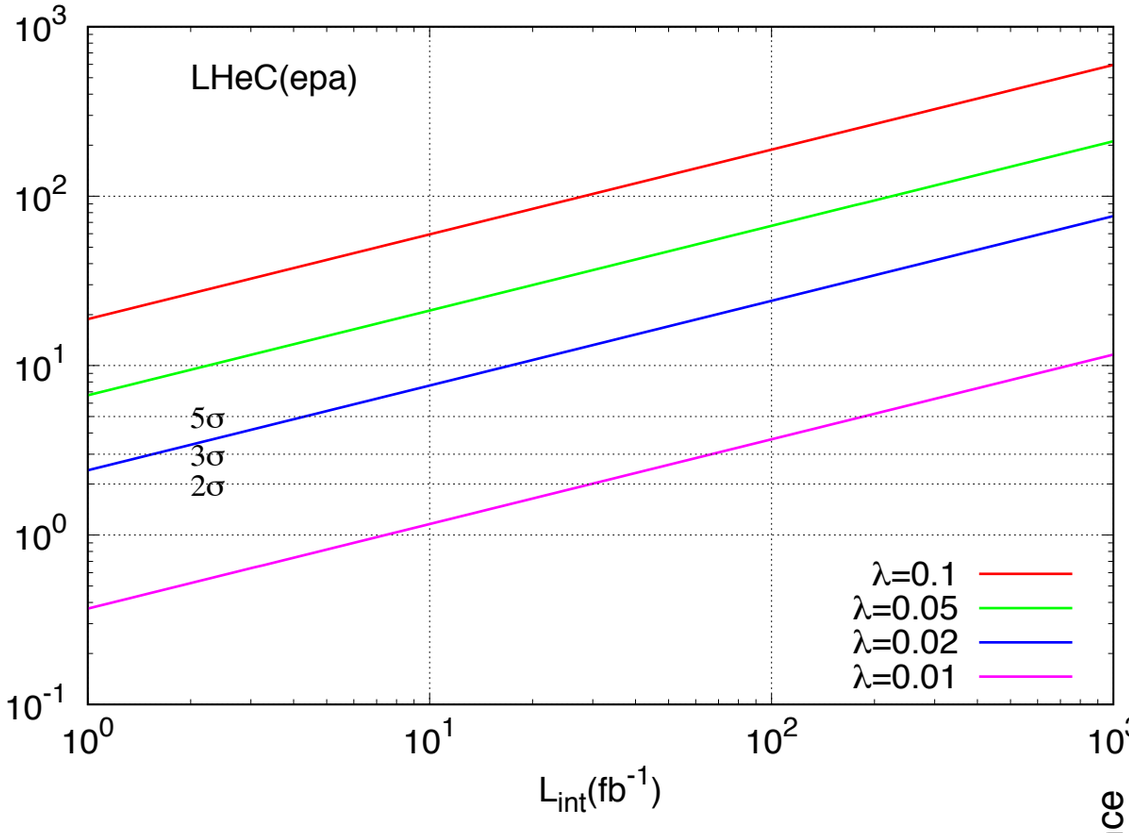
- Signal and background number of events 500k. Cut efficiency plots for three jets originating from W+jet in the final state at LHeC with epa/ laser options





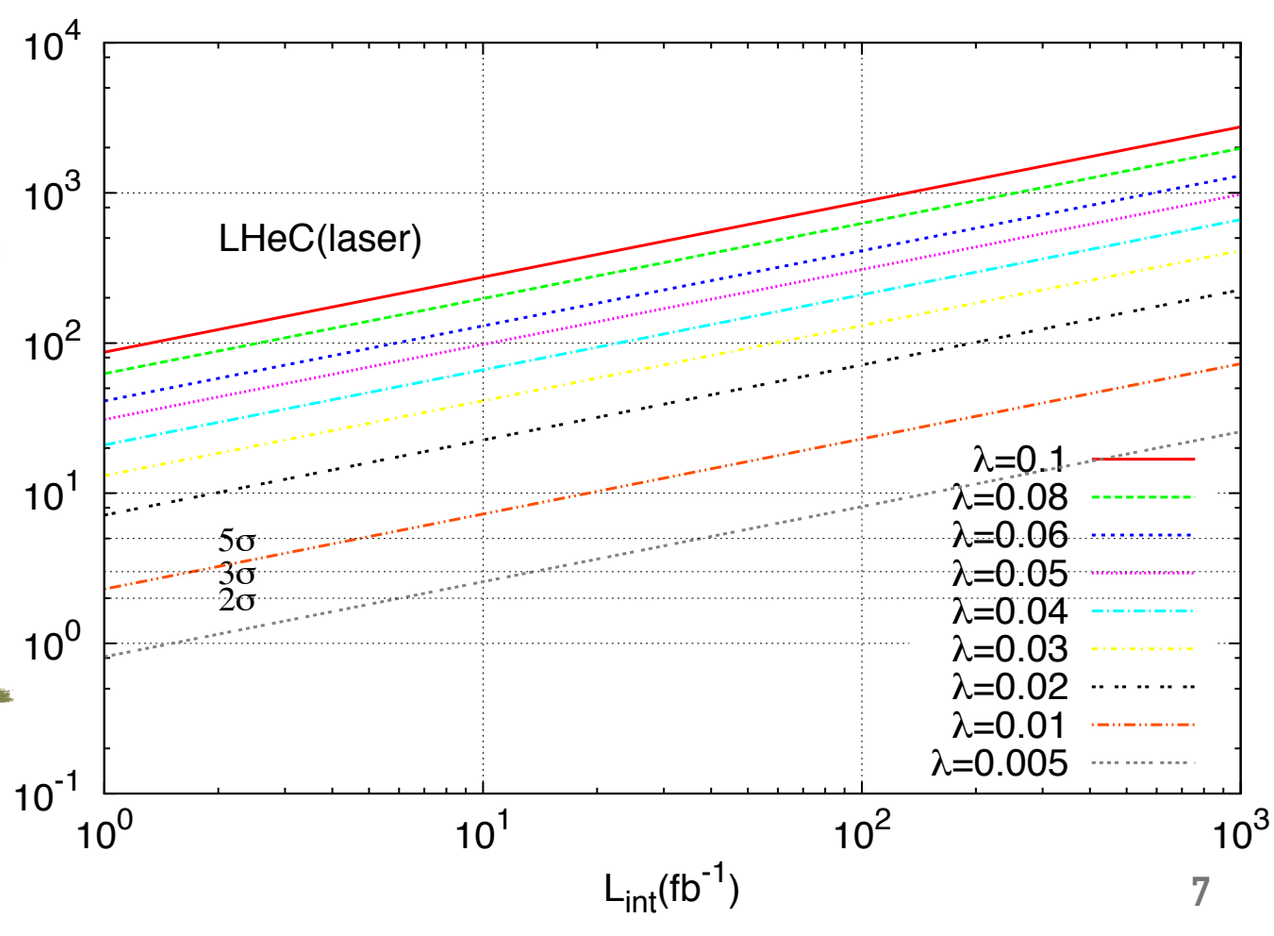
ANALYSIS

- Statistical significance

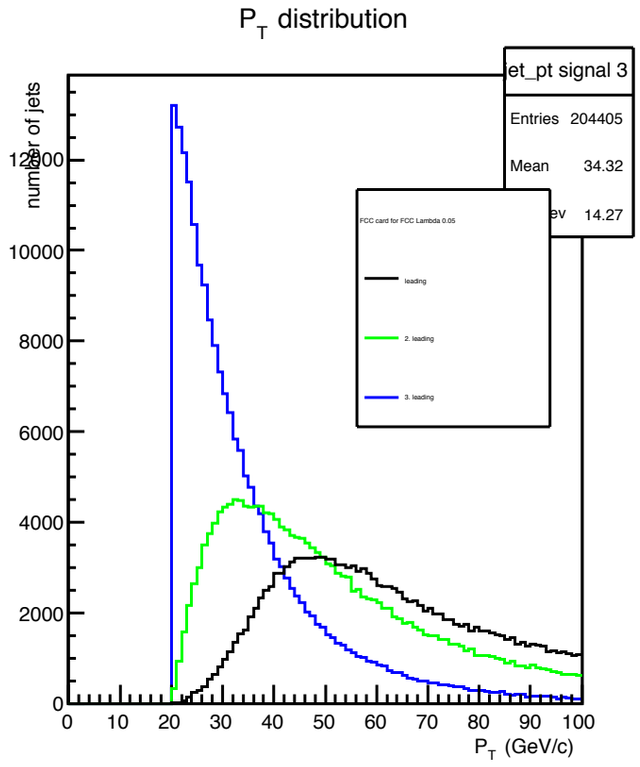


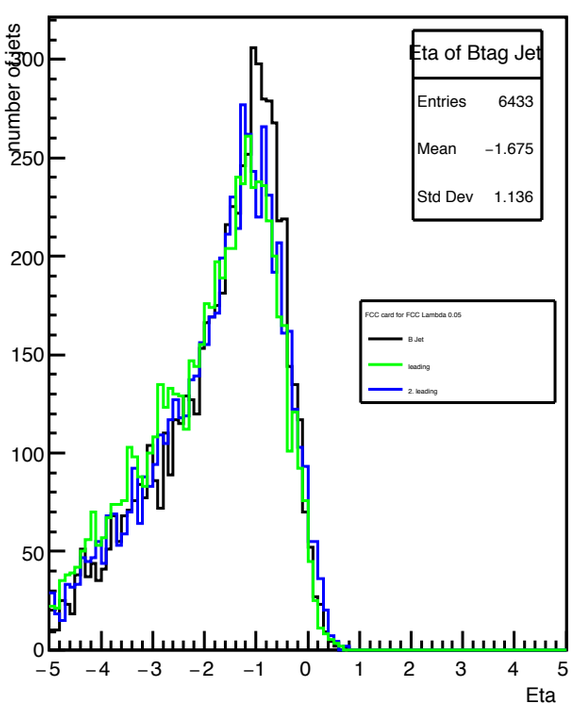
- Significance 3σ for λ=0.01 at LHeC(epa) with L_{int}=70/fb.

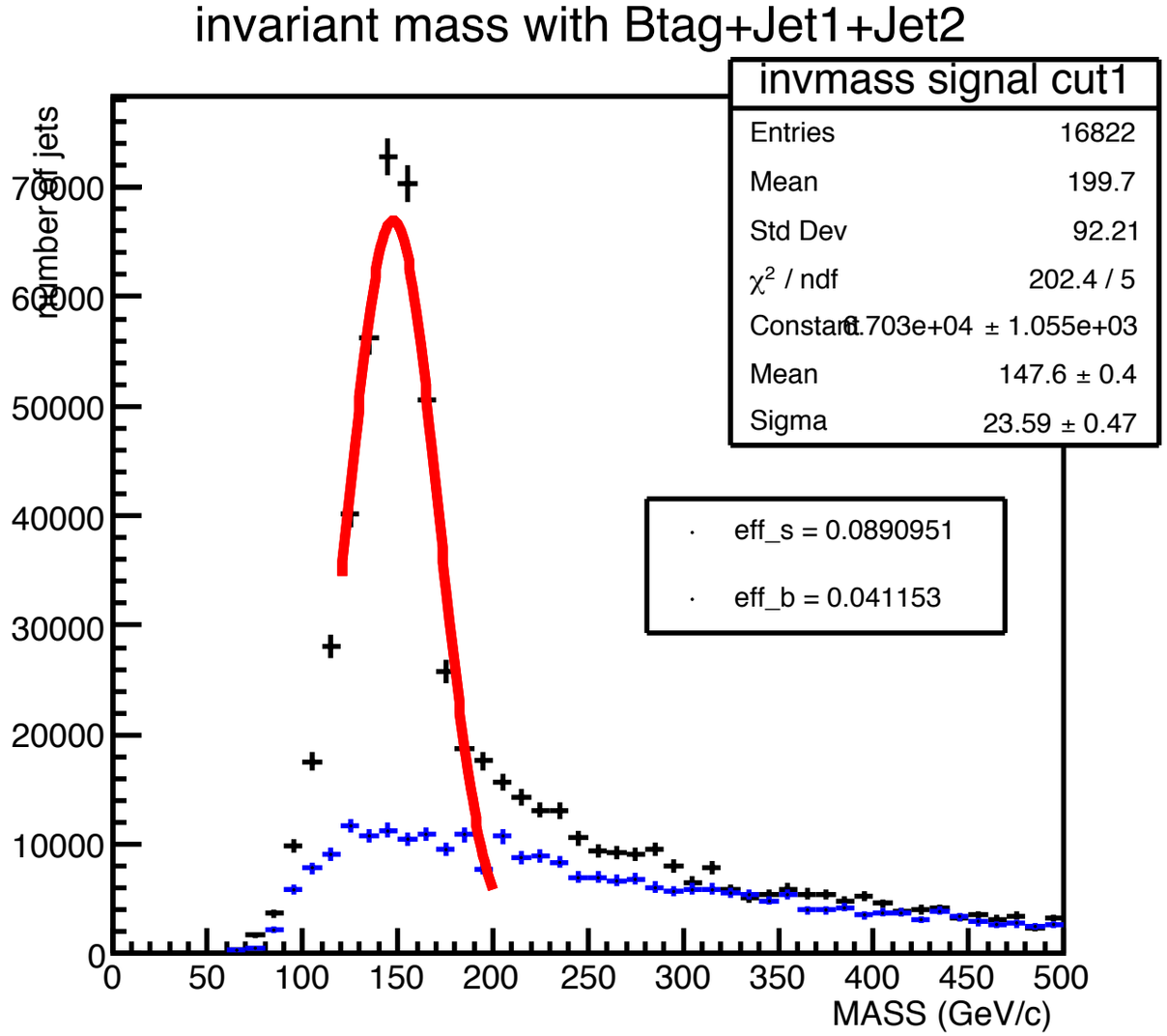
- Significance 3σ for λ=0.005 at LHeC (laser) with L_{int}=15/fb.



DISTRIBUTIONS FCC-EP (LASER)



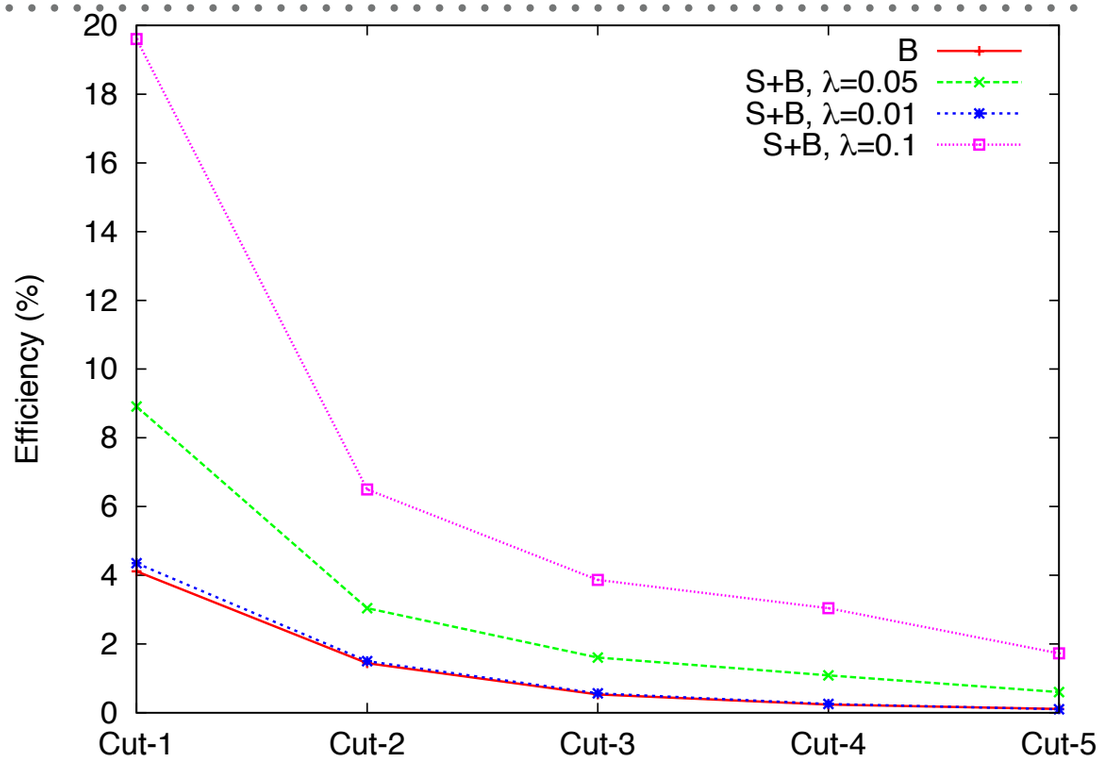


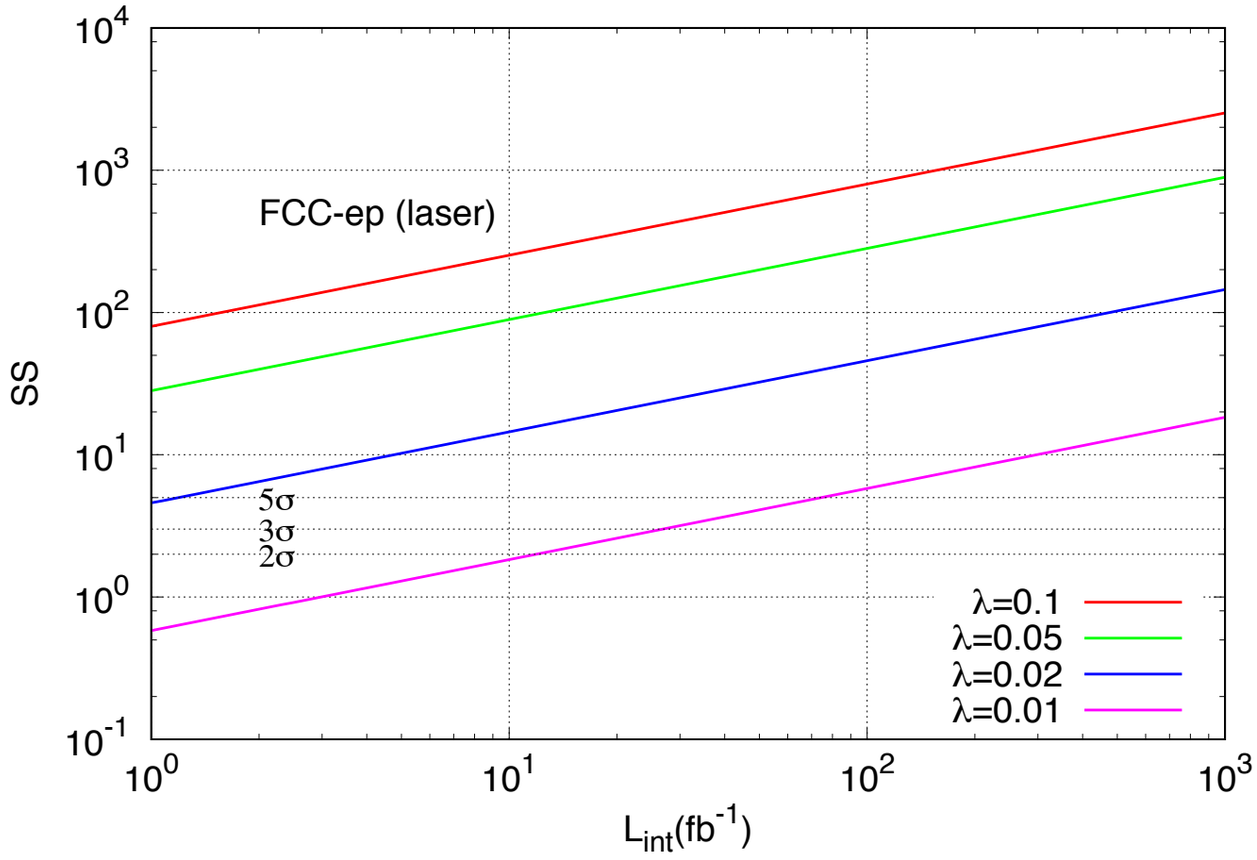


- *FCC-ep based gamma-p collision, signal+background, $\lambda = 0.05$, top mass reconstruction after b-tagging.*

ANALYSIS FOR FCC-EP(LASER)

- Top mass reconstruction, Cut efficiency and Statistical significance, simulation with Delphes FCC detector card.





- FCC-ep based gamma-p collision

SUMMARY

We use topFCNC_UFO model within MG5

- signal+background for W +j (where j=u,d,s,c,b)
- for detector simulation we use Delphes detector card
  - ATLAS card for LHeC
  - FCC card for FCC-ep

Top mass reconstruction

- preselection cuts + cuts-1 / 2 / 3 / 4 / 5

- cut efficiencies plot, significance plot
- started gamma-p luminosity discussion

For next meeting

- **luminosity discussions for different options of photon-proton collisions**

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PHOTON–PROTON LUMINOSITY (RR)

The luminosity of photon-proton collisions* (ring-ring type)

- $L_{\gamma p} = n_\gamma n_p k_e / s_{eff} T_e$

where $n_\gamma (\approx n_e)$, n_p are the numbers of particles in the bunches, k_e is the number of electron bunches in the ring, s_{eff} is the transverse area of bunches ($\sigma_p \gg \sigma_\gamma$), $T_e = T_e^c + T_e^f$ is the sum of accelerating time per cycle and filling time. Using the circumference of electron ring ($2\pi R$) and speed of light (c), the luminosity of photon-proton collisions can be compared with the electron-proton collisions through

- $L_{\gamma p} = L_{ep} (2\pi R / T_e c)$

Taking design parameters, $L_{\gamma^* p} < L_{ep}$ for LHeC (RR).

*NIMA365/317

PHOTON–PROTON LUMINOSITY (LR)

The luminosity of photon-proton collisions* (linac-ring type)

- $L_{\gamma p}=n_\gamma n_p f_\gamma/(2\pi\sigma_p^{\,2})$

where $n_\gamma(=n_e)$, n_p are the numbers of particles in the bunches, $f_\gamma=n_b f_{rep}$ being the number of bunches per pulses n_b, and repetition rate f_{rep}. Note that above equation neglects the effects of distance between the conversion region and collision point.

Taking into account the distance effects, the expression for differential luminosity can be written as

- $dL_{\gamma p}/d\omega=f(\omega)n_\gamma n_p f_\gamma/[2\pi(\sigma_e^{\,2}+\sigma_p^{\,2})]\ \exp(-z^2\theta^2{}_\gamma(\omega)/2(\sigma_e^{\,2}+\sigma_p^{\,2}))$

where ω is the energy of high energy photon (high energy photon), z is the distance between the conversion region and collision point, θ_γ is the angle between high energy photon and electron beam direction, $f(\omega)$ is the normalised differential cross section

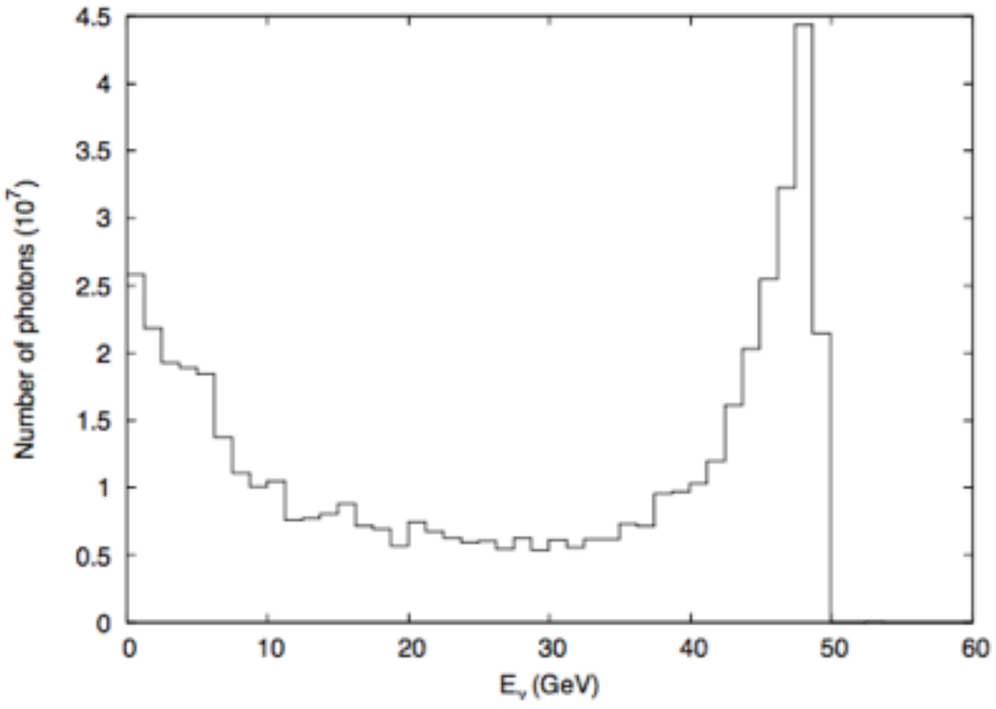
- $f(\omega)=2\pi\alpha^2/(E_b\,\sigma_c\,x\,m_e^{\,2})\ [1/(1-y)+1-y-4r(1-r)+\lambda_e\lambda_0 rx(1-2r)(2-y)]$

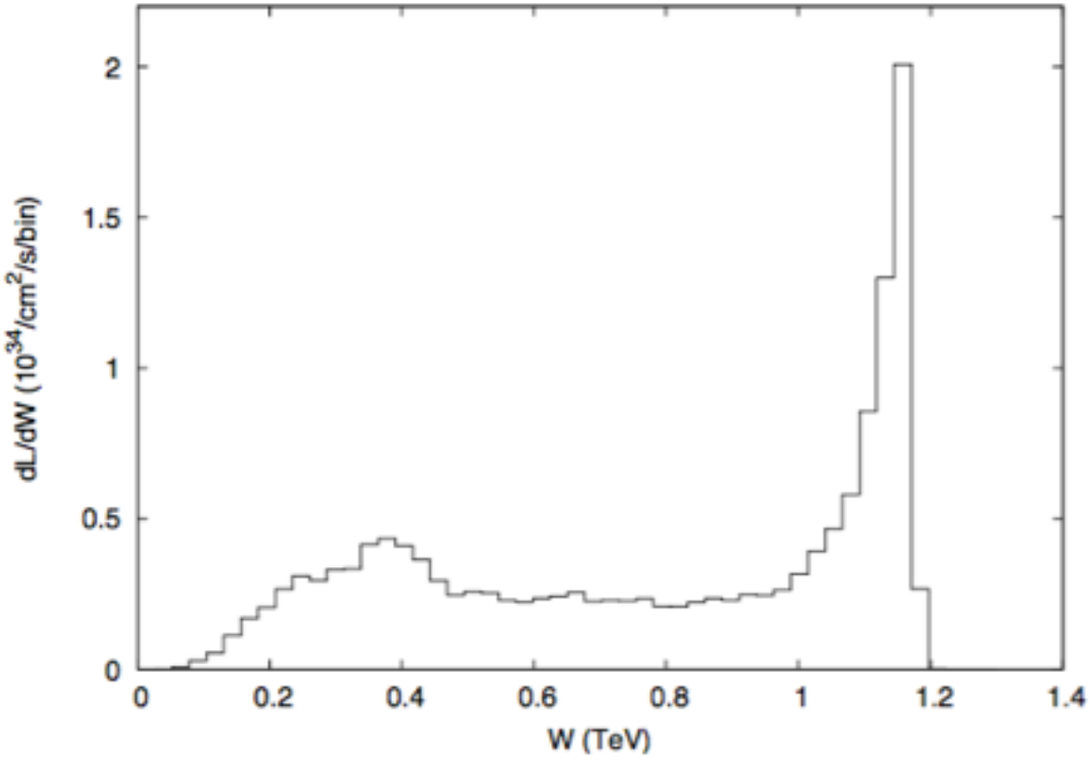
where $y=\omega/E_e$ and $r=y/[x(1-y)]$, with $x=4E_e\omega_0/m_e^{\,2}$ and ω_0 being laser photon energy, λ_e and λ_0 are the helicities of electron and laser photon. High energy photon has maximal energy with the condition $\omega_{max}=E_e x/(x+1)=0.83E_e$. Photon-proton invariant mass is defined as $W_{\gamma p}=2\sqrt{\omega E_p}$.

*NIMA365/317

PHOTON–PROTON LUMINOSITY (LASER)

- In case of a pulsed linac without energy recovery the laser photon can be backscattered from electron beam to produce high energy photon beam, the rms spot size $\sigma \sim 10 \mu m$, and a distance $z=600$ cm, reduces luminosity by a factor of 40%, a simulated example of photon spectrum after the conversion point and gamma-p differential luminosity spectrum





LHeC CDR, p330