BHSE at ILC - revisited

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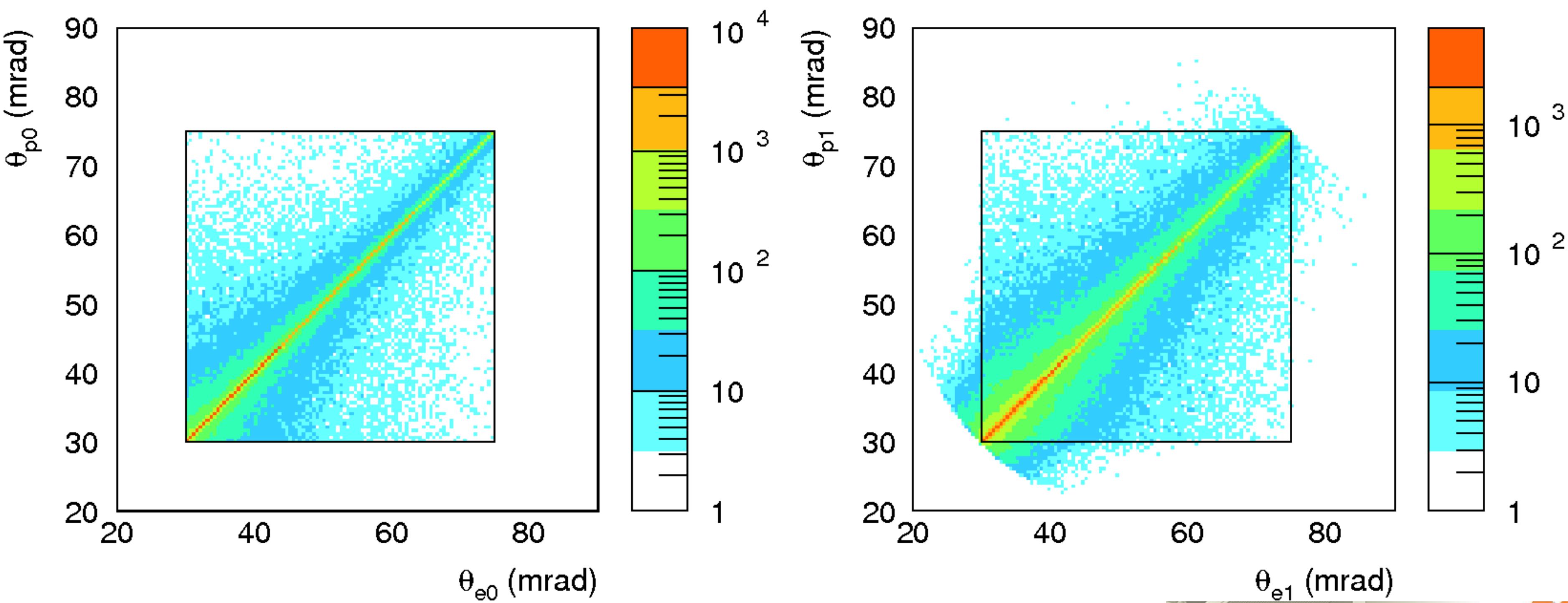
Summary

- BHSE at ILC analyzed using:
  - BHLUMI v4.04 Bhabha event generator
  - Guinea-PIG v1.2 (adapted by C. Rimbault) to simulate beam-beam effects on Bhabha pairs.
- Comparison with previous results
- Beam-beam effects on bhabha angular and energy distribution analyzed in order to propose selection cuts that effectively minimize BHSE

Cross-check with the 2007 results

- Reproduction of the results by C. Rimbault et al, JINST 2 (2007)
  - Lumical geometrical angular acceptance [26,82] mrad
  - Fiducial volume [30,75] mrad



Cross-check
- Basic cuts -

- Basic cuts: Both particles inside the fiducial volume, both E_e, $E_p > 0.8\ E_{beam}$
- Fine-tuning of the GP parameters (number of macroparticles, beam energy spread etc.) causes a variation of ± 0.2 % in the final BHSE

	C. Rimbault et al.	This work
Beamstrahlung	-3.78(4)	-3.91(4)
EM deflection	-0.65(2)	-0.62(2)
Total	-4.41(5)	-4.53(4)

Cross-check
- Improved cuts -

- Improved cuts:
  - One particle inside the fiducial volume, the other particle inside the geometrical acceptance (Angular range partly outside the FV → systematic uncertainty in the BHSE)
  - Random choice which cut is applied on which side
  - $E_e + E_p > 0.8\ E_{CM}$

	C. Rimbault et al.	This work
Beamstrahlung	-1.03(4)	-0.98(4)
EM deflection	-0.48(2)	-0.46(1)
Total	-1.51(5)	-1.45(4)

Selection cuts for background suppression [1]

- Legend:
  - AA is the angular part of the *improved cuts* by C. Rimbault
  - E_{rel} means: $E_e + E_p > 0.8\ E_{CM}$
  - E_{bal} means: $(E_e - E_p) < 0.1 \min(E_e, E_p)$
  - "$\Delta\varphi$" means: $\Delta\varphi < 5°$ (coplanarity)
  - "$\Delta\theta$" means: $\Delta\theta < 0.06°$

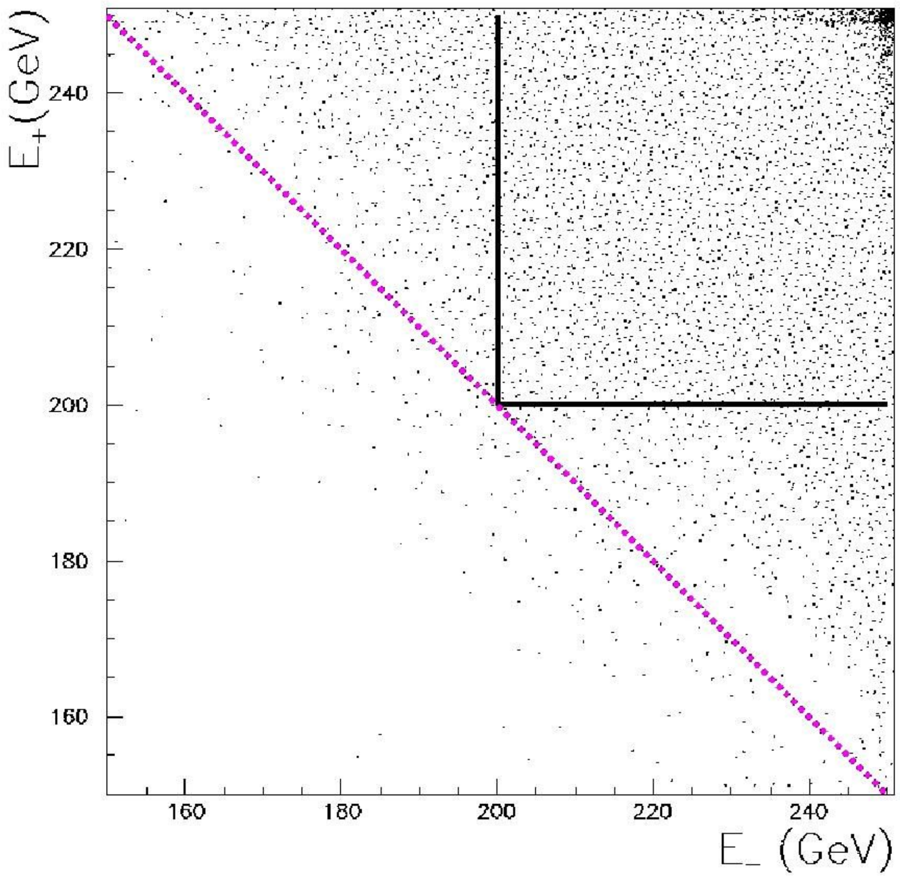
Algorithm	B/S [1]	BS BHSE (%)	EM defl. BHSE (%)	total BHSE (%)	Rel. sel. eff. (%)
AA + E_{rel}	3.7×10^{-3}	-0.98 ± 0.04	-0.46 ± 0.01	-1.45 ± 0.04	66.2
AA + E_{rel} + $\Delta\phi$	2.9×10^{-3}	-1.00 ± 0.04	-0.45 ± 0.01	-1.45 ± 0.04	65.4
AA + E_{bal} + $\Delta\phi$	2.2×10^{-3}	-5.80 ± 0.07	-1.25 ± 0.03	-7.04 ± 0.07	51.0
$\Delta\theta$ + E_{rel} + $\Delta\phi$	2.6×10^{-3}	-19.64 ± 0.08	-0.145 ± 0.011	-19.79 ± 0.08	67.3
$\Delta\theta$ + E_{bal} + $\Delta\phi$	1.6×10^{-3}	-19.62 ± 0.08	-1.12 ± 0.02	-20.75 ± 0.08	61.2

[1] M. Pandurović, *Fon u merenju luminoznosti i razvoj metode za identifikaciju b-kvarka u eksperimentima ILC i H1*, Ph.D. thesis, Univerzitet u Beogradu (2011)

Rel. selection efficiency is defined rel. to the LumiCal geometrical acceptance [26,82] mrad

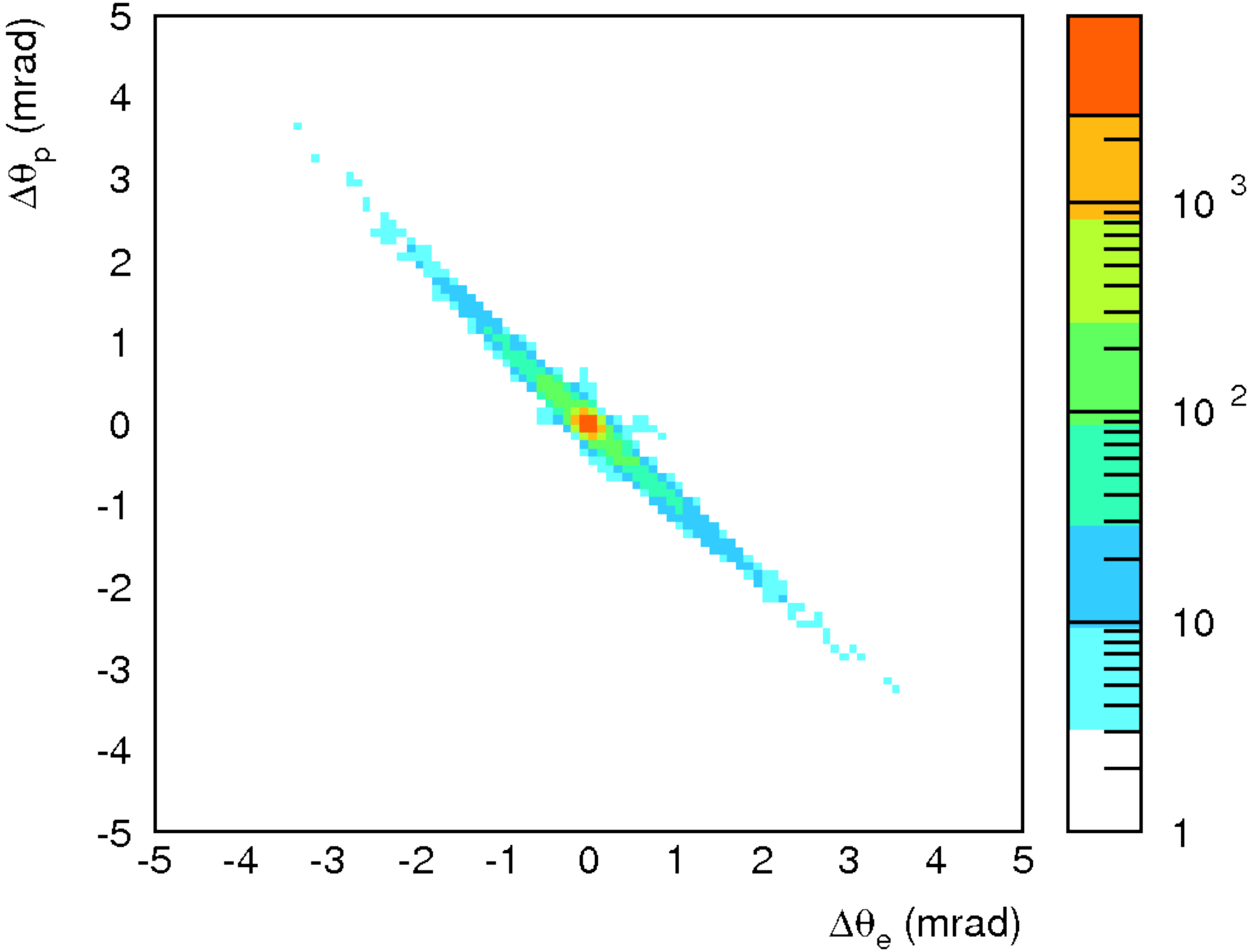
Cuts optimization

- Energy cuts – relative energy
  $(E_e + E_p) > 0.8\ E_{CM}$



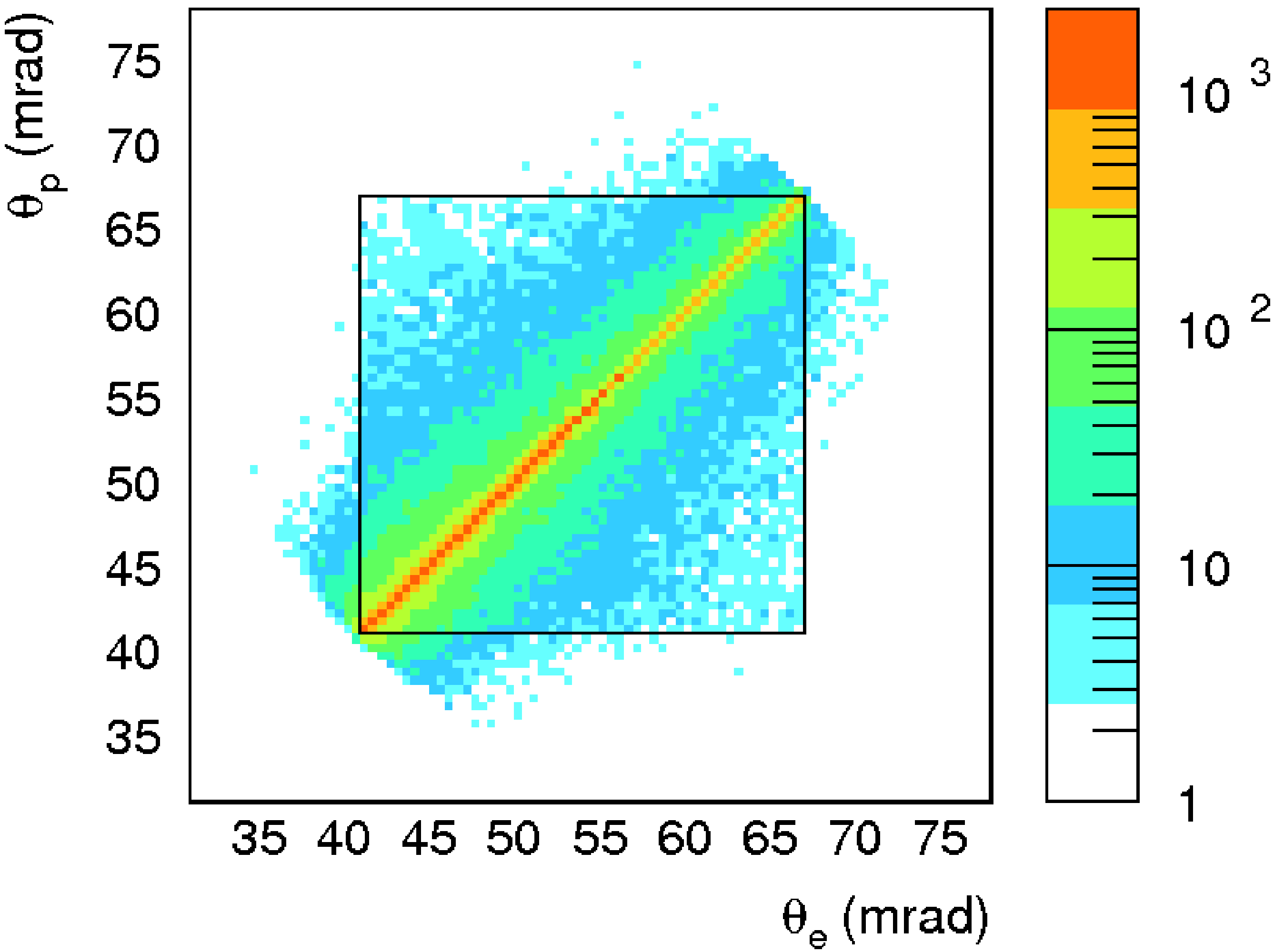
C. Rimbault et al, JINST 2 (2007)

Cuts optimization
Angular cuts



- Anticorrelated shift in θ_e, θ_p due to the asymmetric energy loss in Beamstrahlung (CM gains impulse in z-direction)

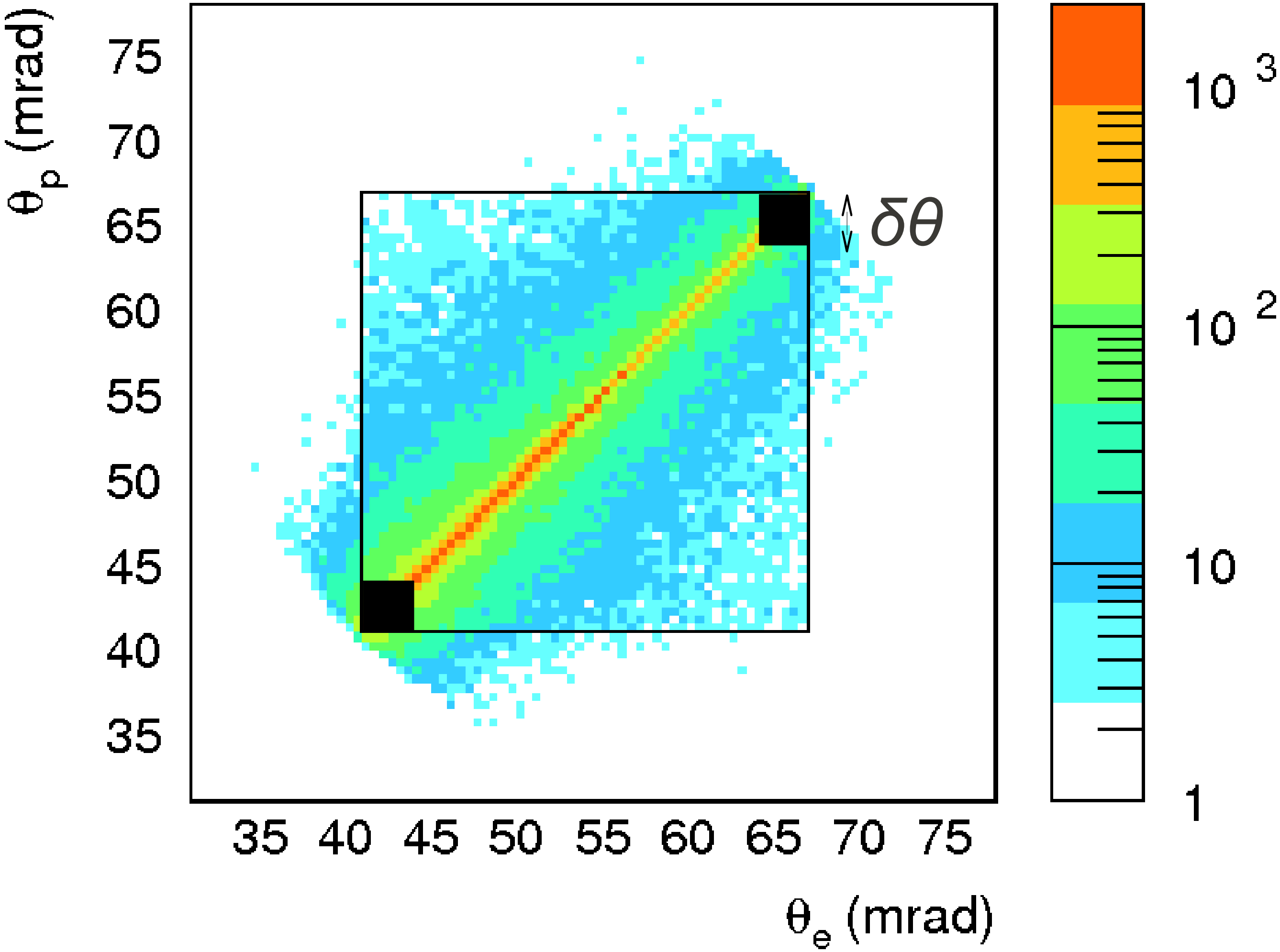
Cuts optimization



Most Bhabha events that migrate outside of the fiducial volume start out near the edges.

$\theta_e, \theta_p \approx \theta_{min}$
$\theta_e, \theta_p \approx \theta_{max}$

Cuts optimization

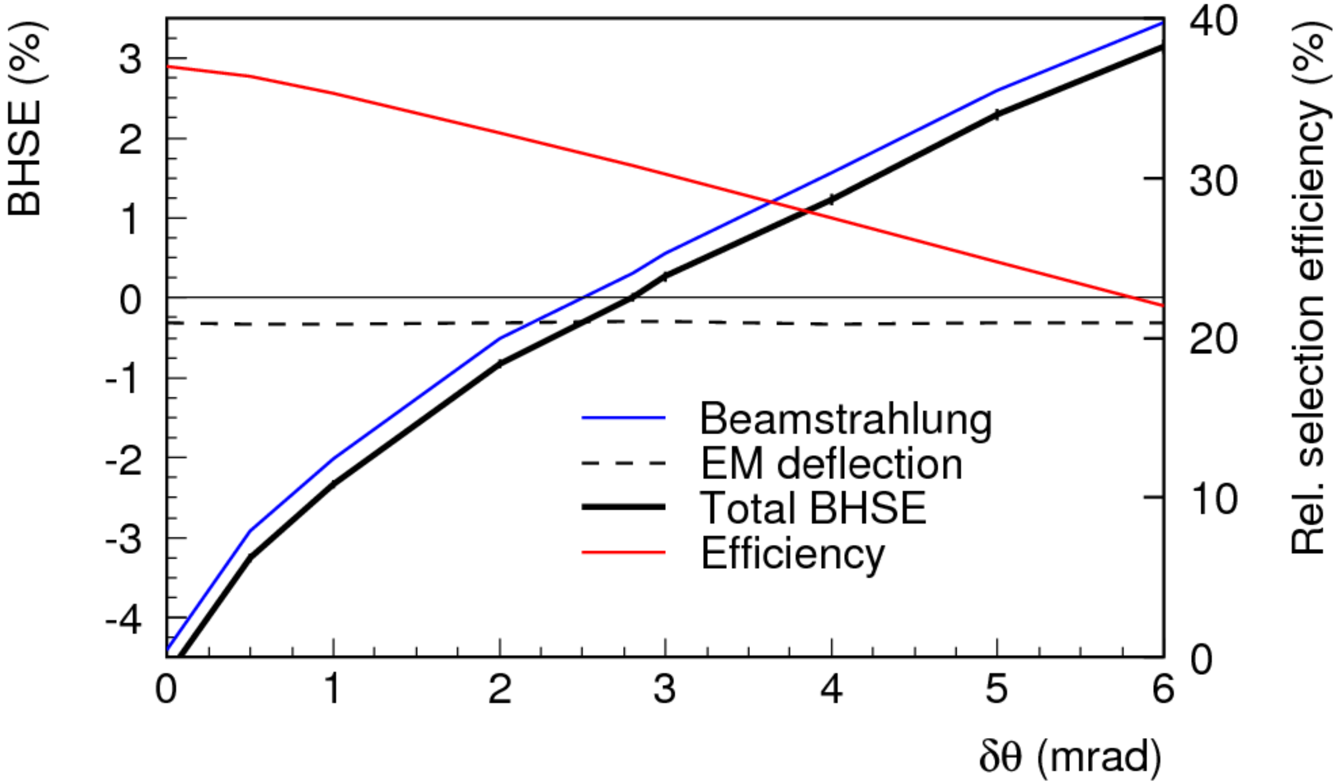


Recipe:

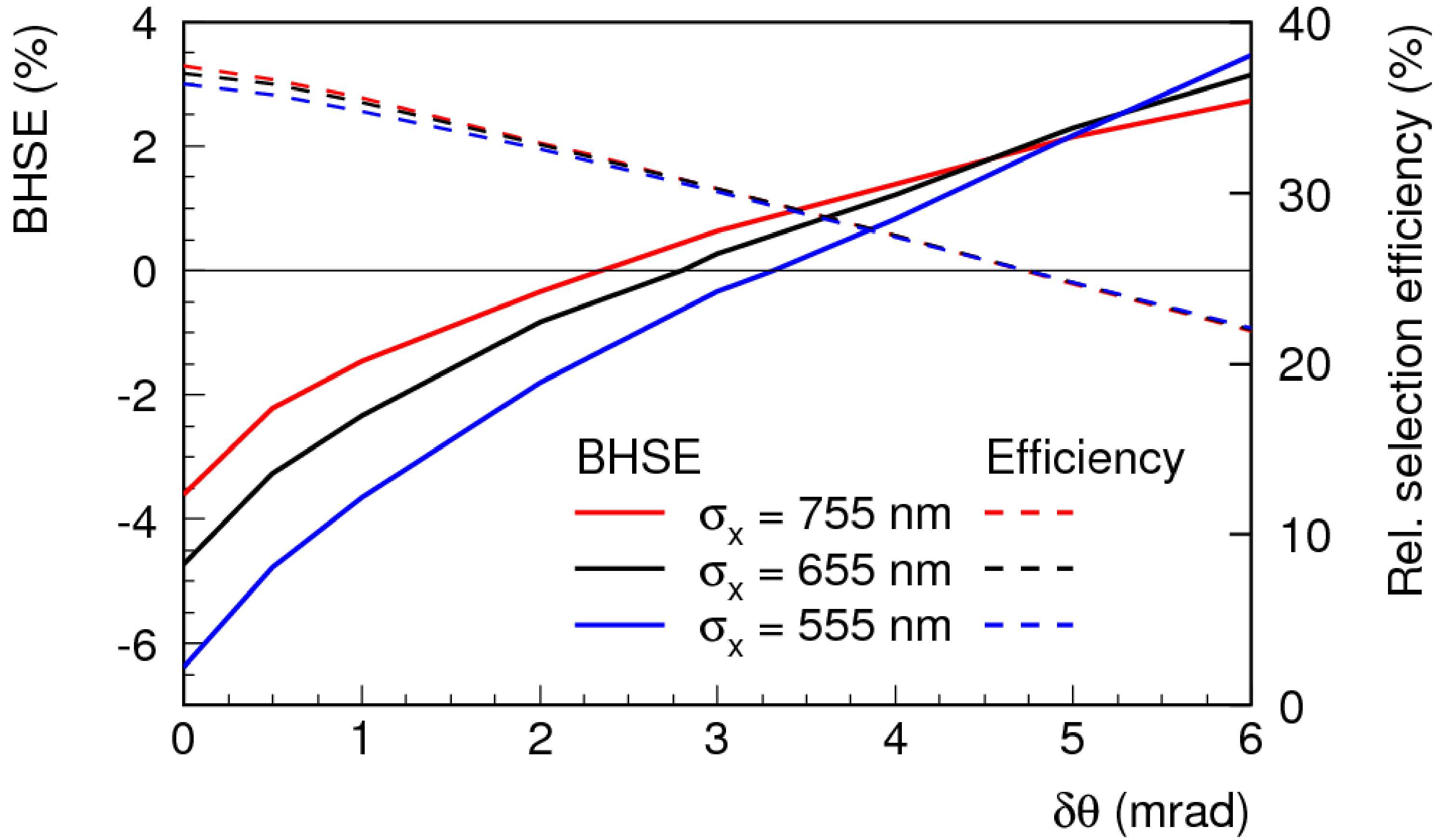
Remove the narrow regions "Both particles within $\delta\theta$ from θ_{min}, (θ_{max})" from the selection cuts.

E_{rel} + "dented" FV

- Present LumiCal geometry (FV = [41,67] mrad)
- BHSE can be reduced to zero.
  For $\delta\theta$ = 2.8 mrad, total BHSE = (0.005 ± 0.059) %
- Efficiency relative to the geom. acceptance [31,78] mrad



Sensitivity to σ_x

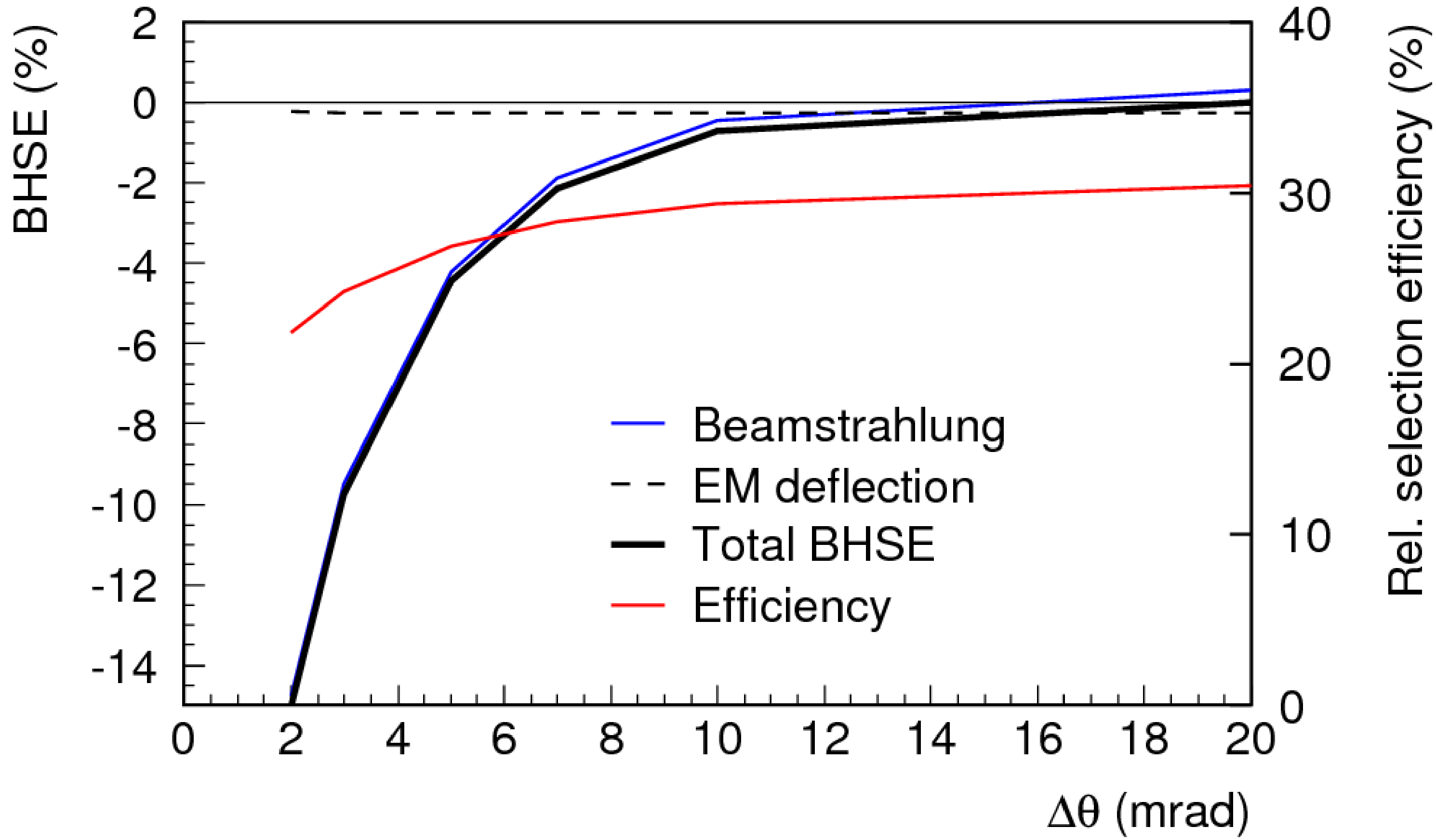


Collinearity and coplanarity

- *Δθ*: $\Delta\theta = \theta_{e^-} - \theta_{e^+} < (\Delta\theta)_{max}$
- *Coplanarity*: $\Delta\varphi = \varphi_{e^-} - \varphi_{e^+} < (\Delta\varphi)_{max}$
- *Collinearity*: $\Delta\varphi < (\Delta\varphi)_{max} \wedge \Delta\theta < (\Delta\theta)_{max}$

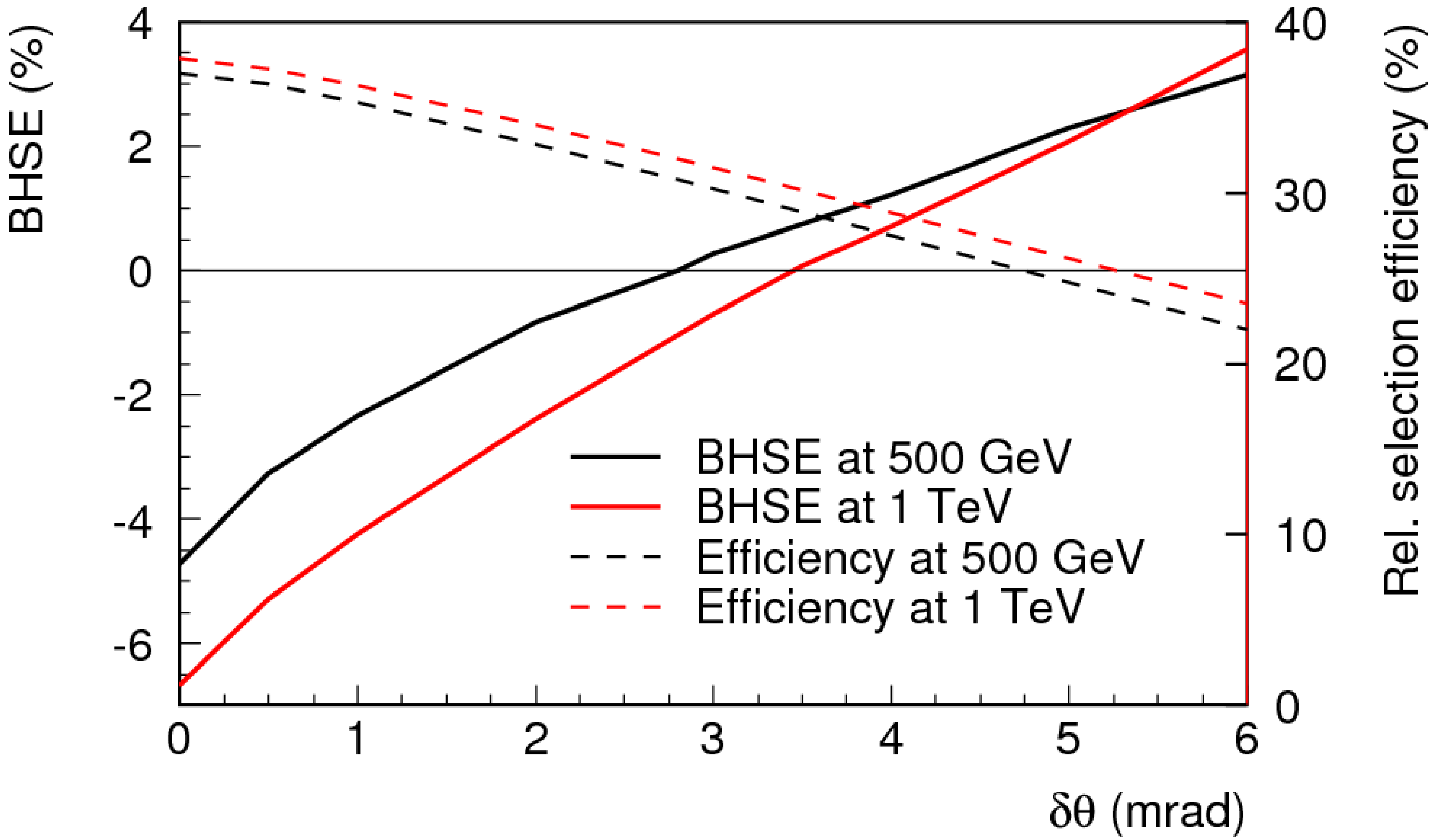
Collinearity

- E_{rel} + "dented" fiducial volume
- $\Delta\varphi < 5°$



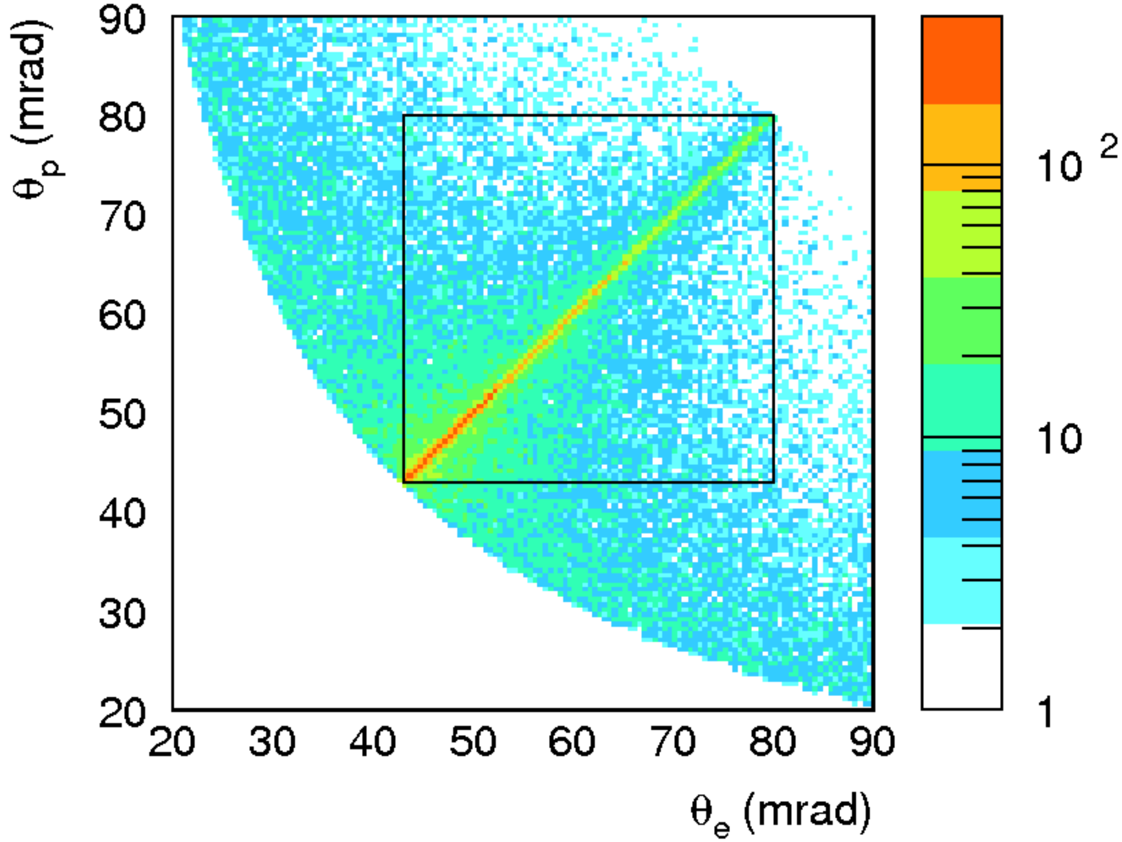
Comparison
500 GeV – 1 TeV

- E_{sum} + *"dented" selection cuts*



CLIC 3 TeV

- BHSE 71 % (E_{rel} + fiducial volume, simulated with Gaussian beams) – difficult to reduce to zero
- Needs to be more reliably estimated and corrected



Conclusions

- BHSE can be completely eliminated at ILC using suitable selection algorithms
- A range of parameters can be simultaneously manipulated to optimize BHSE ***and*** the background suppression
  - $\delta\theta$ (for the “dented” angular cuts)
  - $\Delta\theta$ (polar angle tolerance)
  - $\Delta\varphi$ (coplanarity tolerance, limited by the resolution in φ)
  - Energy cuts
- BHSE at CLIC is more dramatic – it has to be precisely estimated and corrected

Outlook

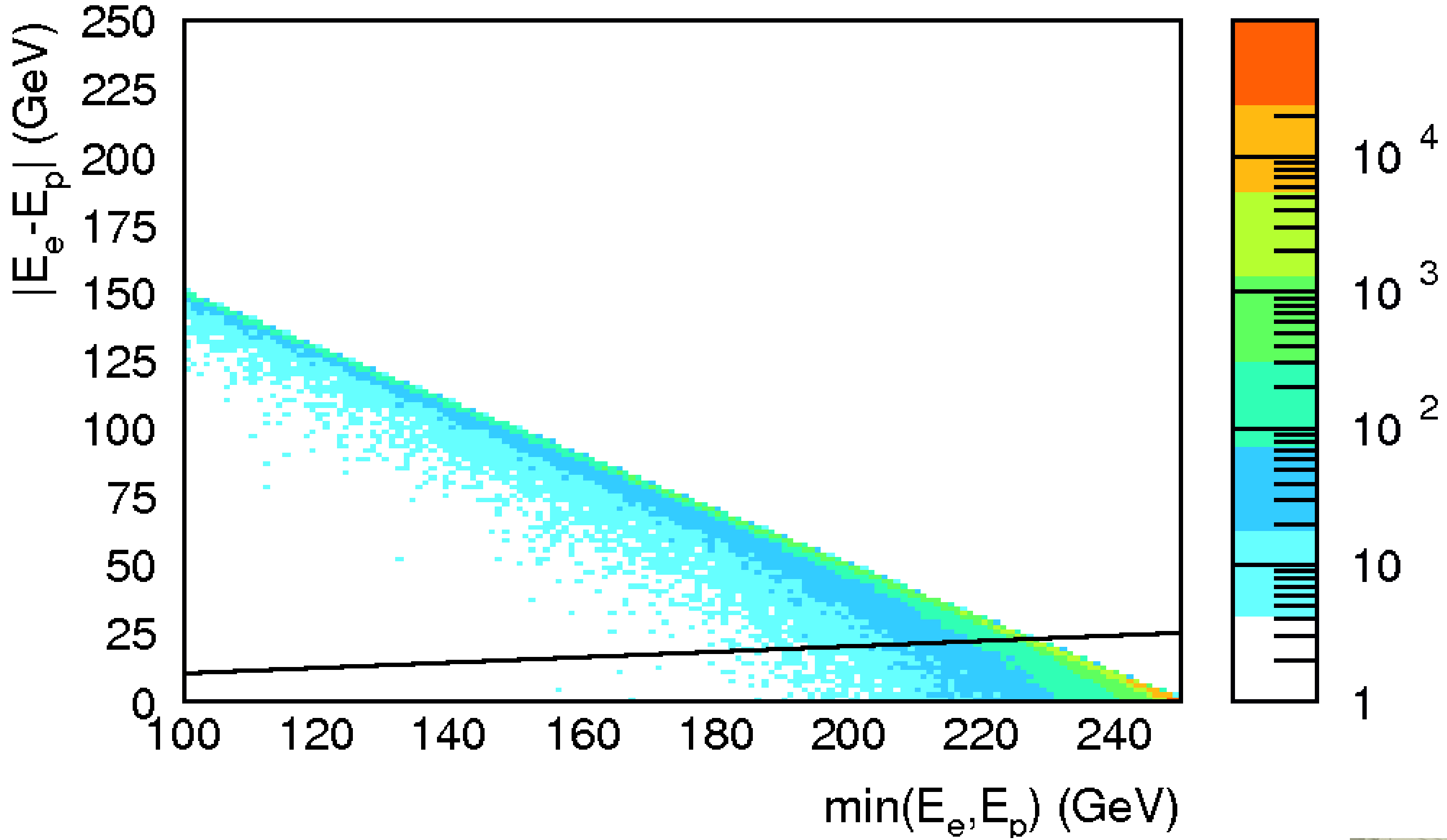
- Reevaluate the data-driven BHSE correction method (luminosity spectrum) for the present selection cuts.
- Include a simulation of the interaction with the detector (Barbie or similar)
    - Test the $\delta\theta$ extension of the angular criteria outside of the fiducial volume taking care of the influence of the partial deposition on the energy cuts
- Verify how these cuts affect the background suppression (M. Pandurović)

Thank you!

Additional slides

Cuts optimization

- Energy cuts – Energy balance
  $(E_e - E_p) < 0.1 \min(E_e, E_p)$



$E_{balance}$ + *"dented"* FV

- BHSE ≈ 0 for $\delta\theta$ = 2.15 mrad