PHENO 2012

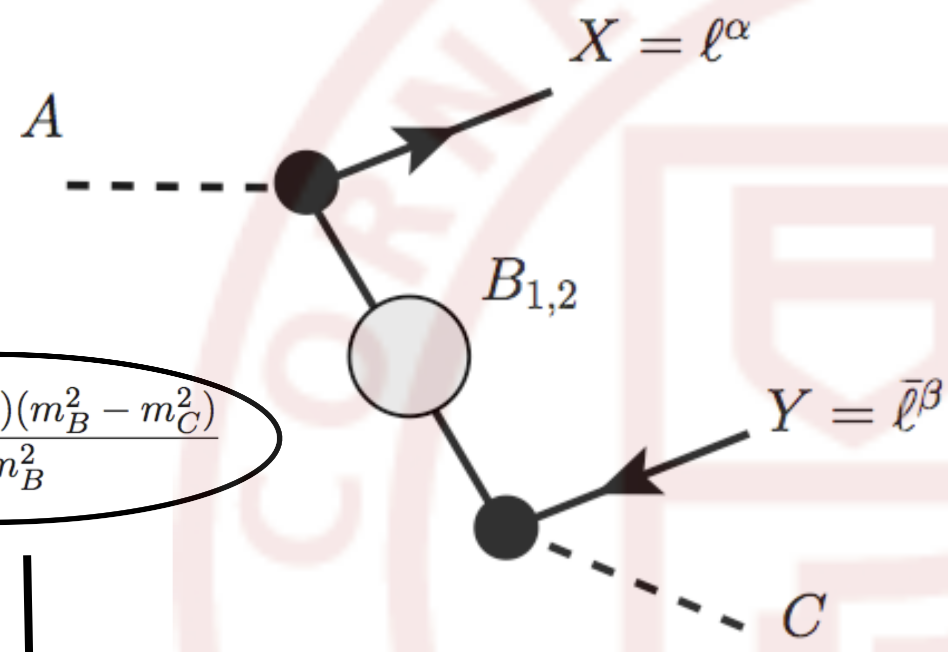
Kinematic edges with flavor oscillation and non-zero widths.

work done in collaboration with Yuval Grossman *and* Dean J. Robinson.

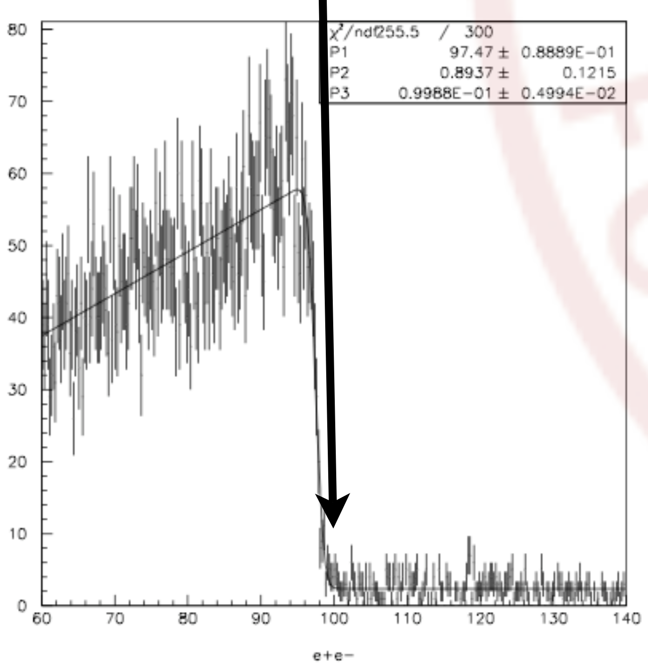
talk based on Yuval Grossman, MM and Dean J. Robinson, *JHEP 1110 (2011)* ***127***, [hep-ph/1108.5381].

Mario Martone, PHENO 2012, Pittsburgh University 05/07/12

Kinematic Edges: *Generalities*



$$s_0 = \frac{(m_A^2 - m_B^2)(m_B^2 - m_C^2)}{m_B^2}$$



Log likelihood fit to di-electron edge as function of m_{ee}. The ordinate shows event per bin per 16 fb^{-1}

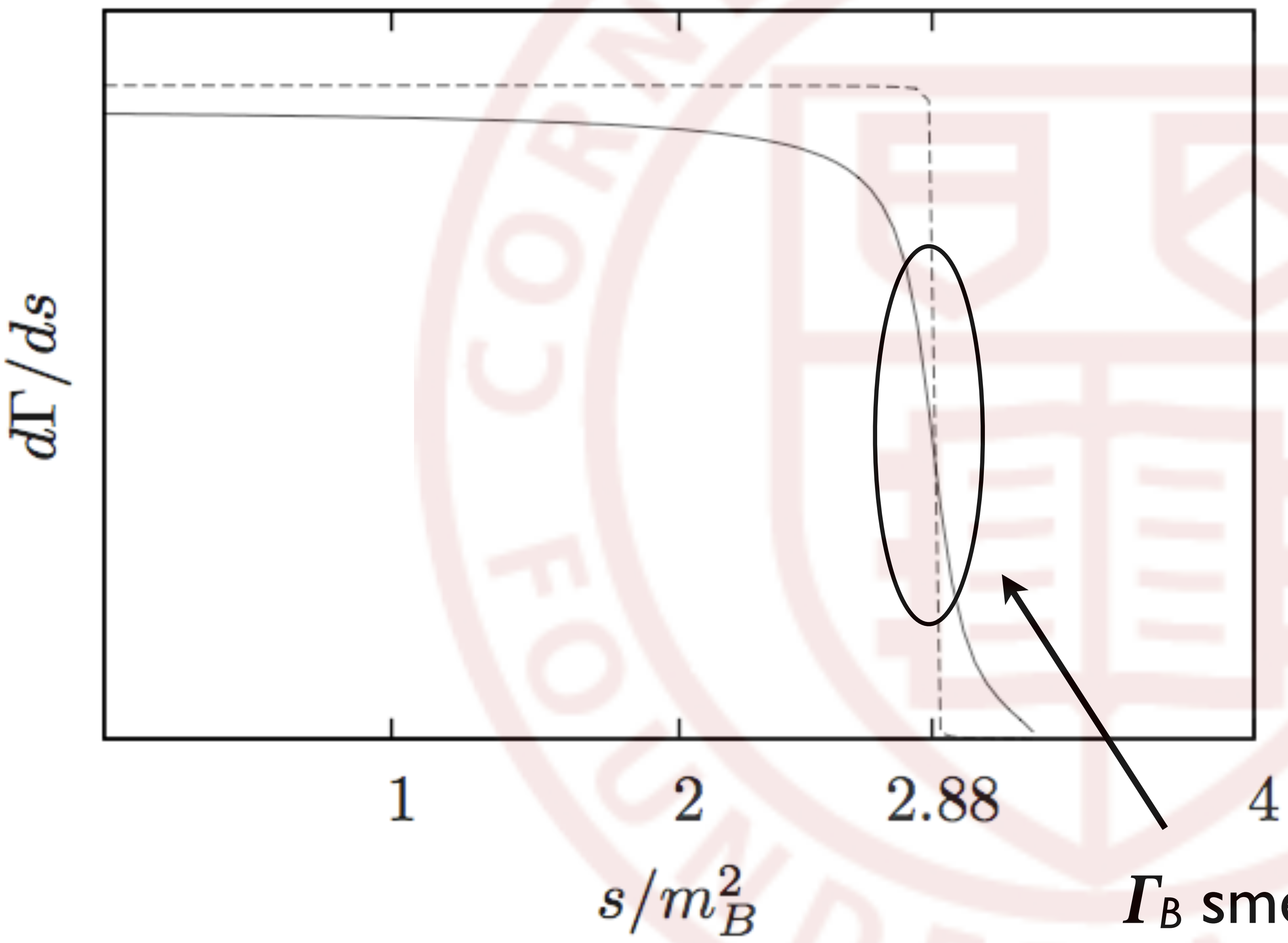
KE or Endpoint method

The location of the kinematic edge provides an indirect means to constrain the masses of *A*, *B* and *C*

- *X* and *Y* should be massless.
- The intermediate *B* should an on-shell mass eigenstate.
- It neglects that *B* must have non-zero width Γ_B.
- We expect Γ_B to smear out the kinematic edge.

Cornell Particle Theory

Non-zero widths



Γ_B smears out the kinematic edge!

- To study flavor oscillations we need to include non-zero width effects.
- We neglect Γ_A and compute the decay amplitude using a *Breit-Wigner:*

$$i\mathcal{M} = \frac{i g_X g_Y}{p_B^2 - m_B^2 + i m_B \Gamma_B}$$

Most studies of kinematic edges assume universal slepton masses but we expect that RG-running down to the TeV scale produces a mass splitting. For the *smuon* and the *selectron* we expect $\Delta m_{\tilde{\ell}} \sim$few GeVs

- kinematic edges could then be used to probe a non-trivial flavor structure.

No-mixing

B.C. Allanach, J. P. Conlon and C. G. Lester, Phys. Rev. D**77** *(2008) 076006*, [hep-ph/0801.3666].

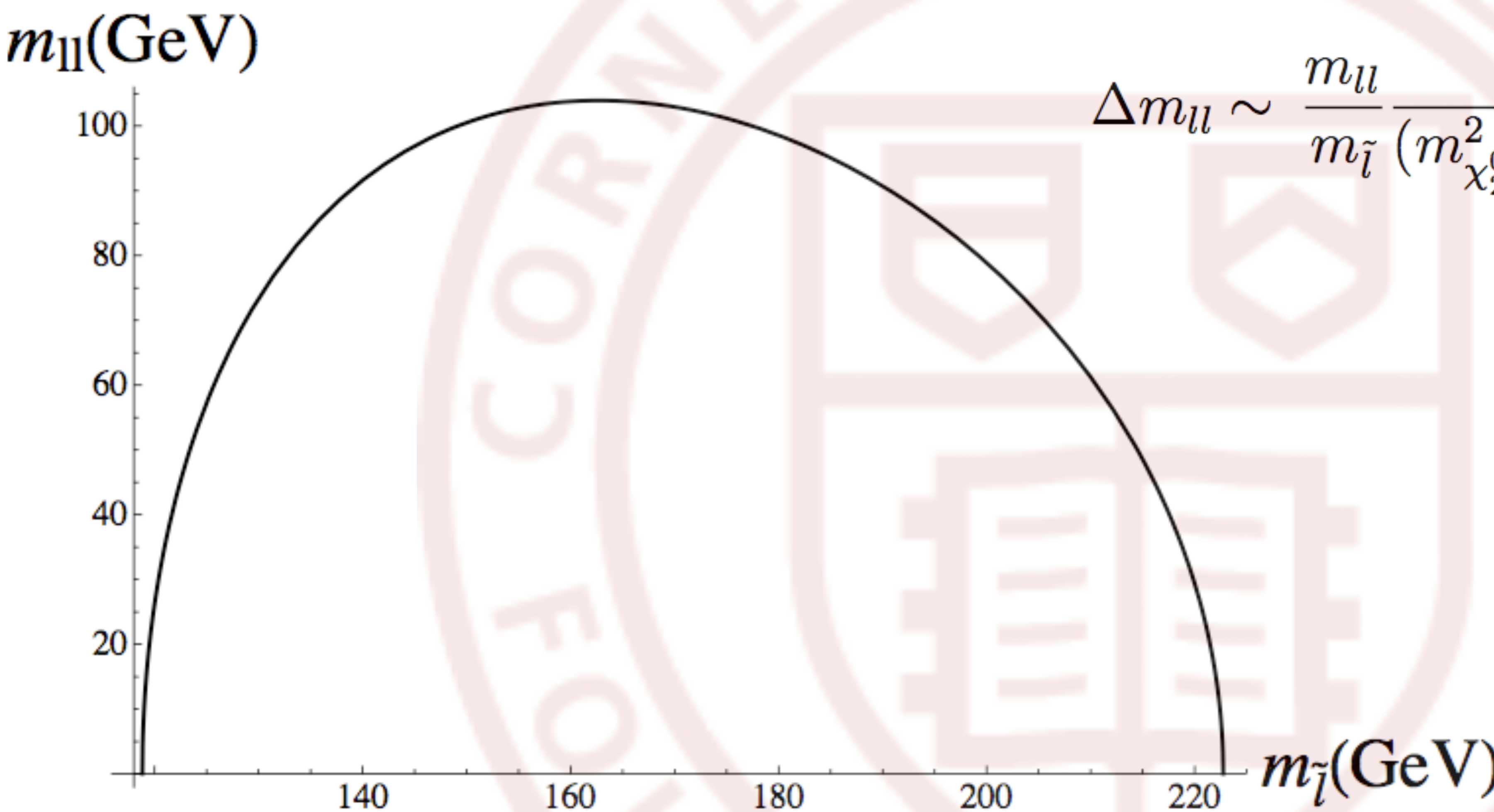
No-oscillation

Iftah Galon and Yael Shadmi, Phys. Rev. D***85*** *(2012) 015010* [hep-ph/1108.2220].

General case

Yuval Grossman, MM and Dean J. Robinson, *JHEP 1110 (2011)* ***127***, [hep-ph/1108.5381].

kinematic edge splitting



$$\Delta m_{ll} \sim \frac{m_{ll}}{m_{\tilde{l}}} \frac{m^2_{\chi^0_2} m^2_{\chi^0_1} - m^4_{\tilde{l}}}{(m^2_{\chi^0_2} - m^2_{\tilde{l}})(m^2_{\tilde{l}} - m^2_{\chi^0_1})} \Delta m_{\tilde{l}}$$

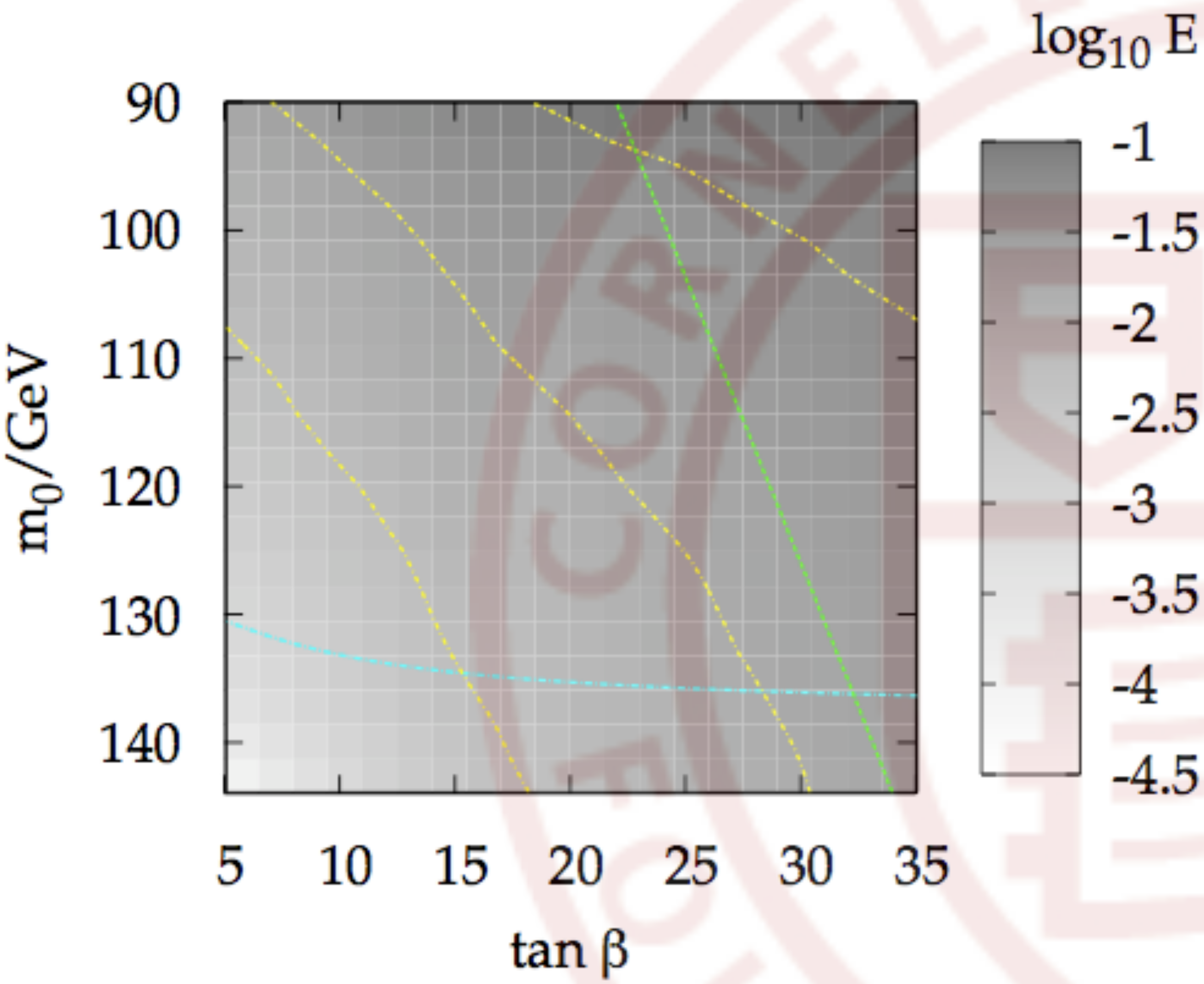
Endpoint location as a function of the slepton mass, with the neutralino masses at values $m_{\chi^0_2}=222$ GeV and $m_{\chi^0_1}=118$ GeV (SU3 values).

soft leptons

If one of the two slepton is too close to either neutralinos one of the emitted lepton is too soft and therefore hard to detect.

No mixing

$$E \equiv \frac{\Delta m_{\tilde{l}}}{m_{\tilde{l}}}$$



B.C. Allanach, J. P. Conlon and C. G. Lester, Phys. Rev. D**77** *(2008) 076006*, [hep-ph/0801.3666].

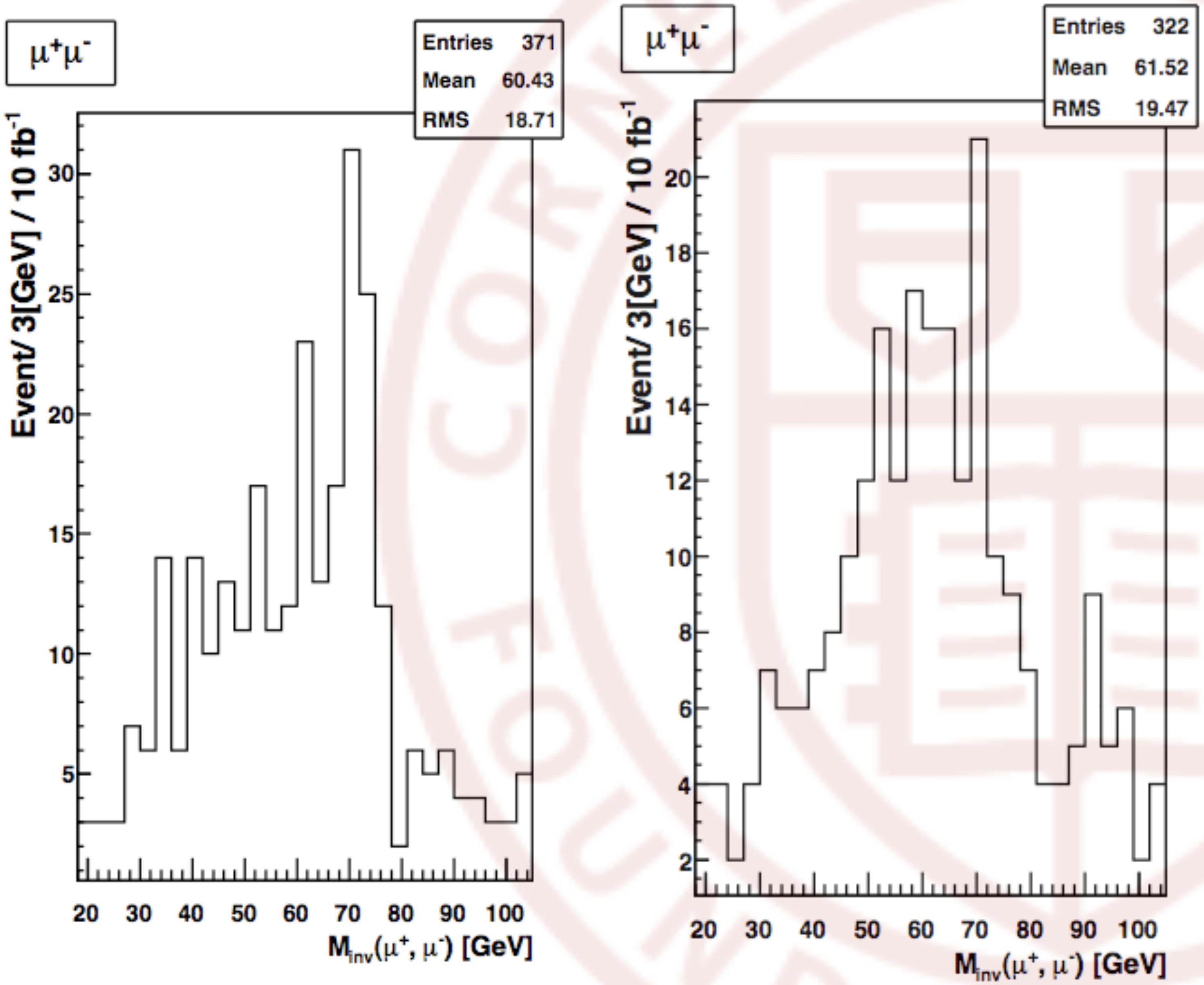
In absence of mixing, using kinematic edge splitting in same-flavor-di-lepton distributions, we therefore could have sensitivity up to

$$\frac{\Delta m_{\tilde{\ell}}}{m_{\tilde{\ell}}} \sim 10^{-4}$$

Expected 30 fb^{-1} 1-sigma sensitivity, *E*, to selectron-smuon mass splitting in perturbed mSUGRA around SPS1a. The region to the right of the almost vertical side has $m_{\tilde{\tau}_1} < m_{\chi_1^0}$. The region underneath the mostly horizontal line has $m_{\tilde{\chi}_2^0} - m_{\tilde{\ell}} < 10$ GeV. The lighter lines show contours of $\log_{10}E$=-2,-2.5,-3 (top to bottom).

Mixing without oscillation

Iftah Galon and Yael Shadmi, Phys. Rev. D**85** *(2012) 015010* [hep-ph/1108.2220].



Opposite-sign-di-muon invariant mass distributions with slepton masses $m_{\tilde{l}_1}=131$ GeV and $m_{\tilde{l}_2}=133.8$ GeV. Left the small mixing case ($\sin^2\theta$=0.4) right the large mixing one ($\sin^2\theta$=0.9).

For large mixing the edges in the same-flavor distributions is harder to measure but the $e\mu$ distribution should exhibit some edge structure which would indicate flavor mixing.

Regimes

$$x \equiv \frac{\Delta m}{\bar{\Gamma}}$$

$x \ll 1$ Oscillations length scale is too long, *oscillation effects unimportant.*

$x \sim 1$ Oscillation effects are significant.

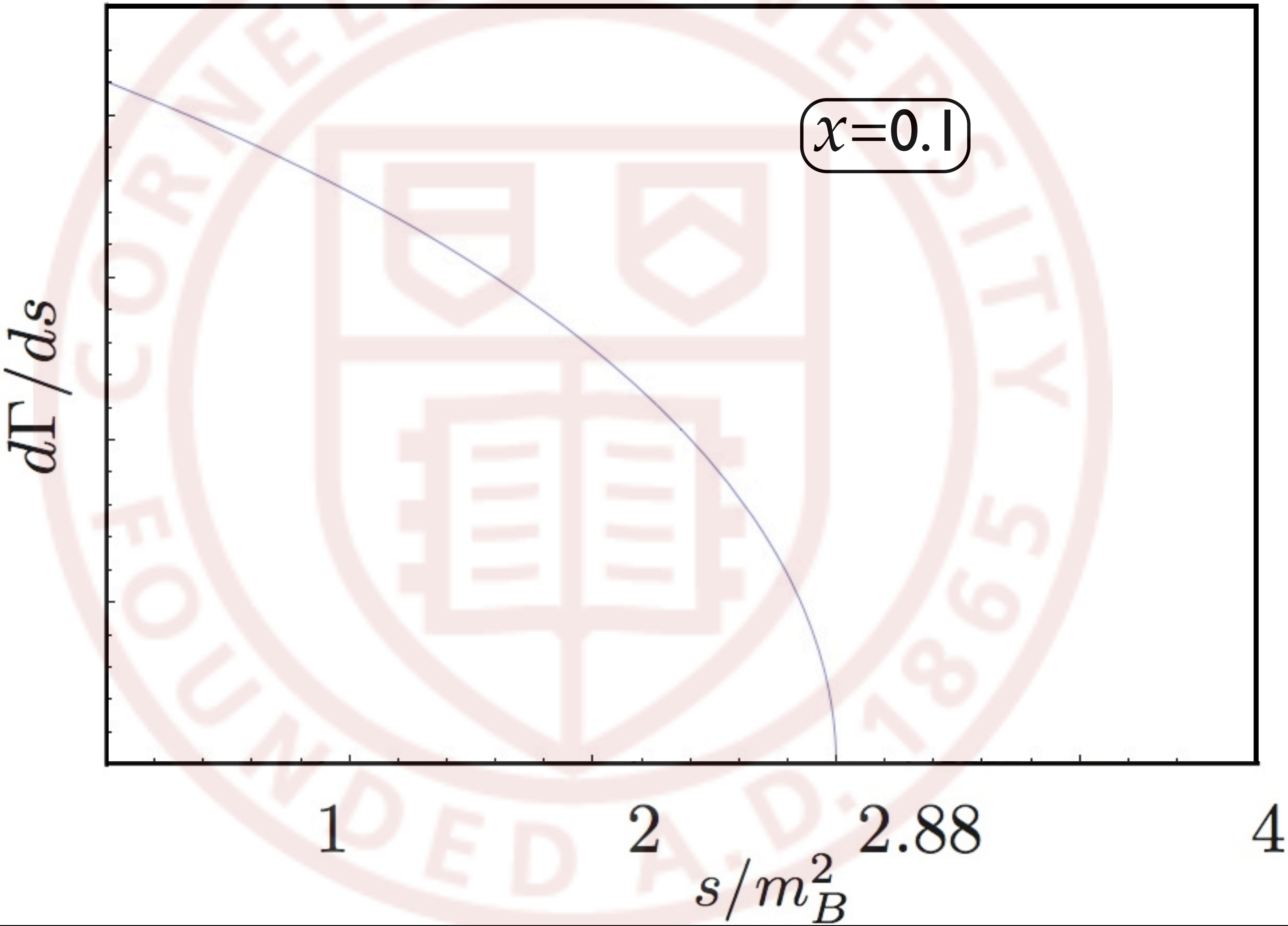
$x \gg 1$ Oscillations are too fast and average out, *oscillation effects unimportant.*

Sleptons are almost degenerate.

No-oscillation

Iftah Galon and Yael Shadmi, Phys. Rev. D***85*** *(2012) 015010* [hep-ph/1108.2220].

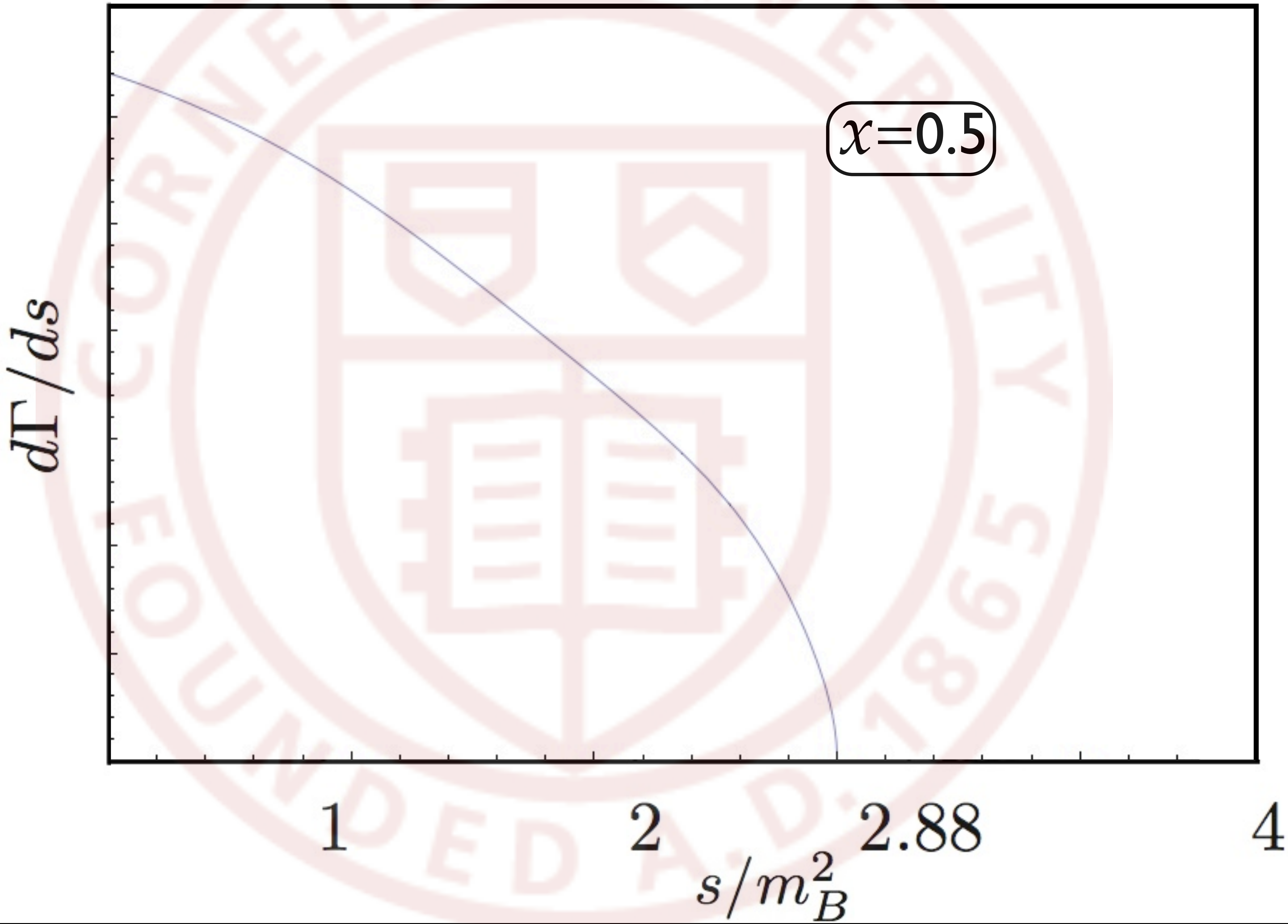
KE with Flavor oscillations



Differential decay rate with parameter choice m_A/m_B=2, m_C/m_B=0.2 and $\Gamma_B/m_B=10^{-1}$ (solid) or $\Gamma_B/m_B=10^{-3}$ (dashed).

KE with Flavor oscillations

Differential decay rate with parameter choice $m_A/m_B=2$, $m_C/m_B=0.2$ and $\Gamma_B/m_B=10^{-1}$ (solid) or $\Gamma_B/m_B=10^{-3}$ (dashed).



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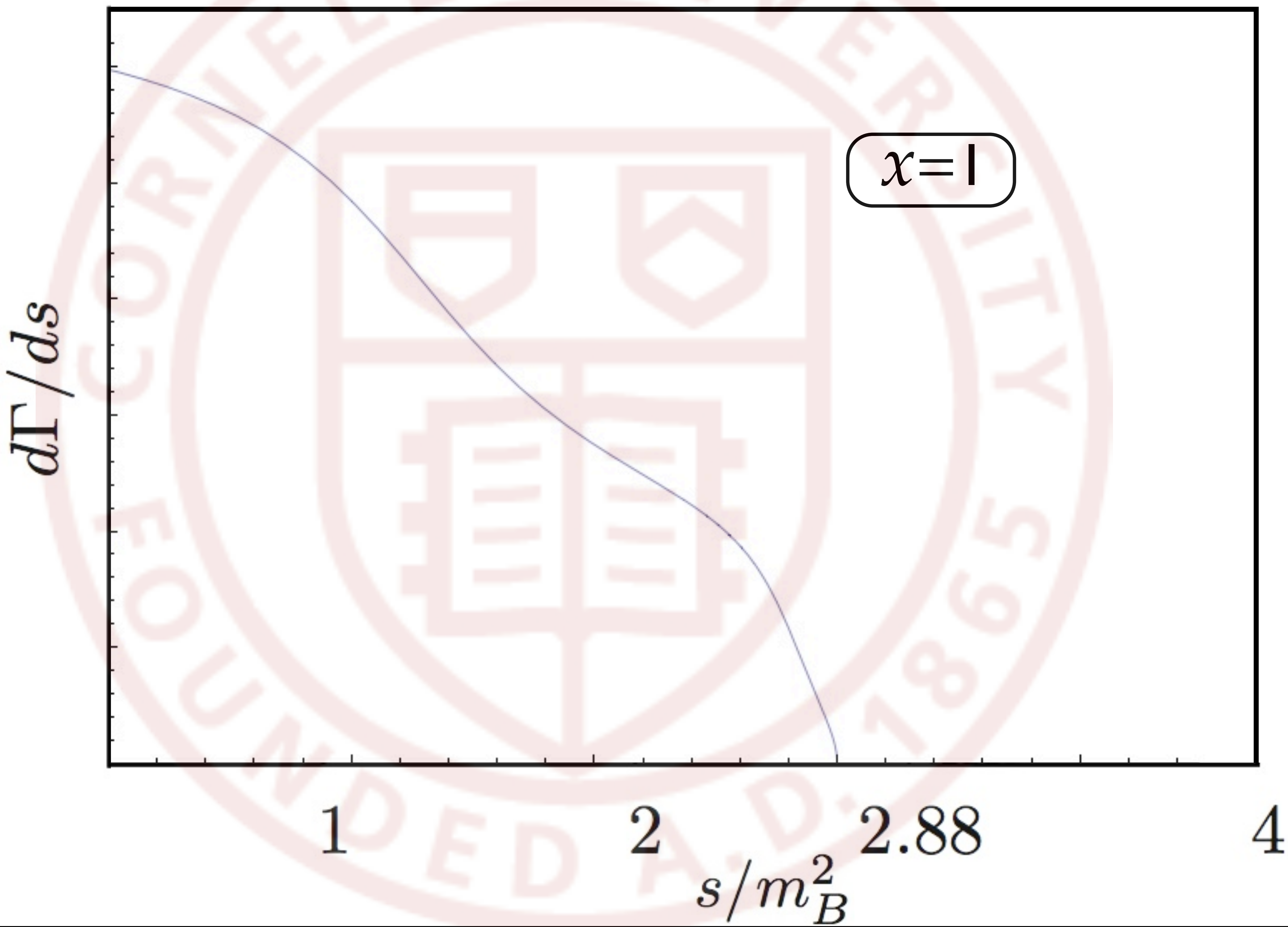
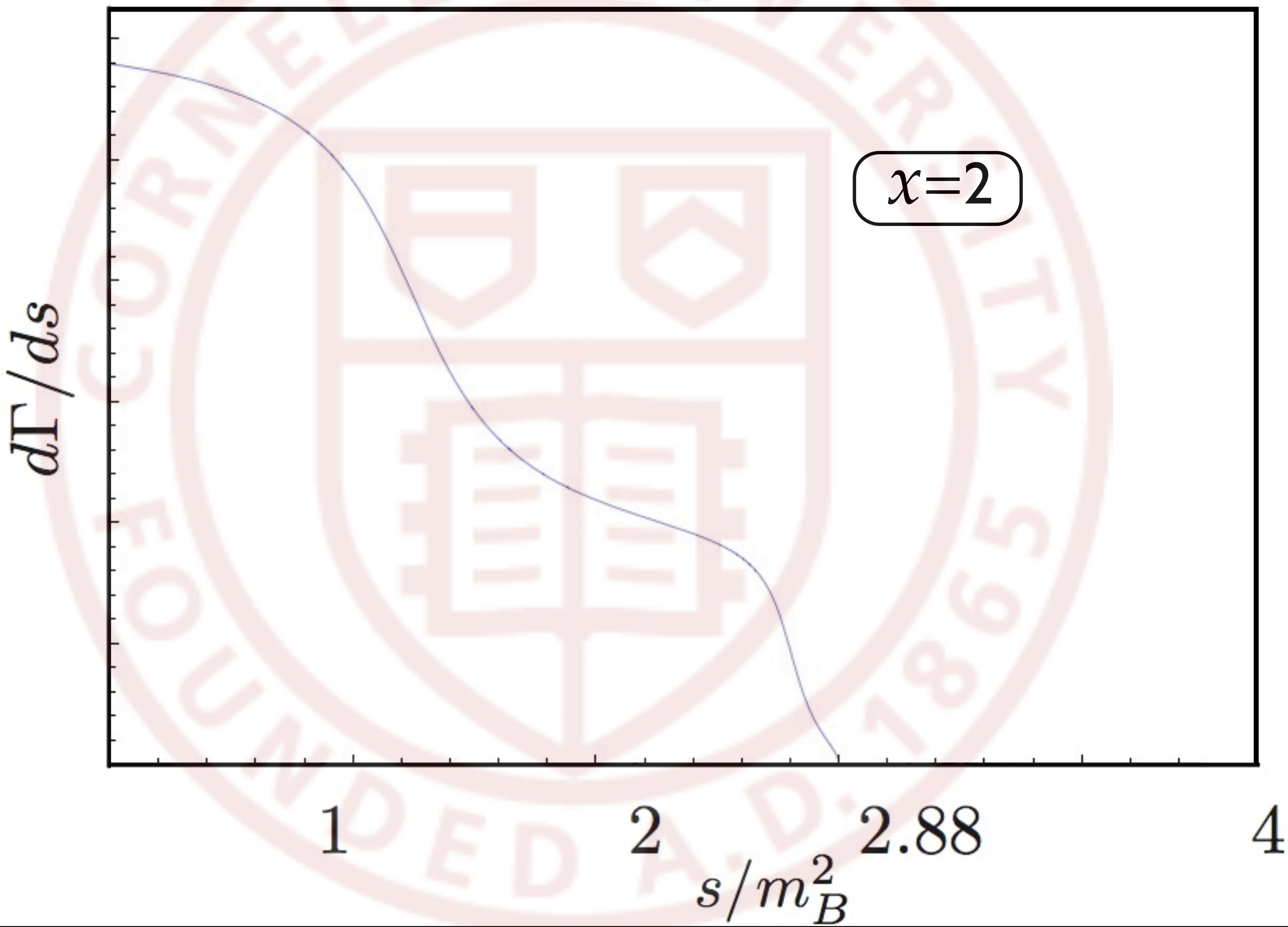


KE with Flavor oscillations



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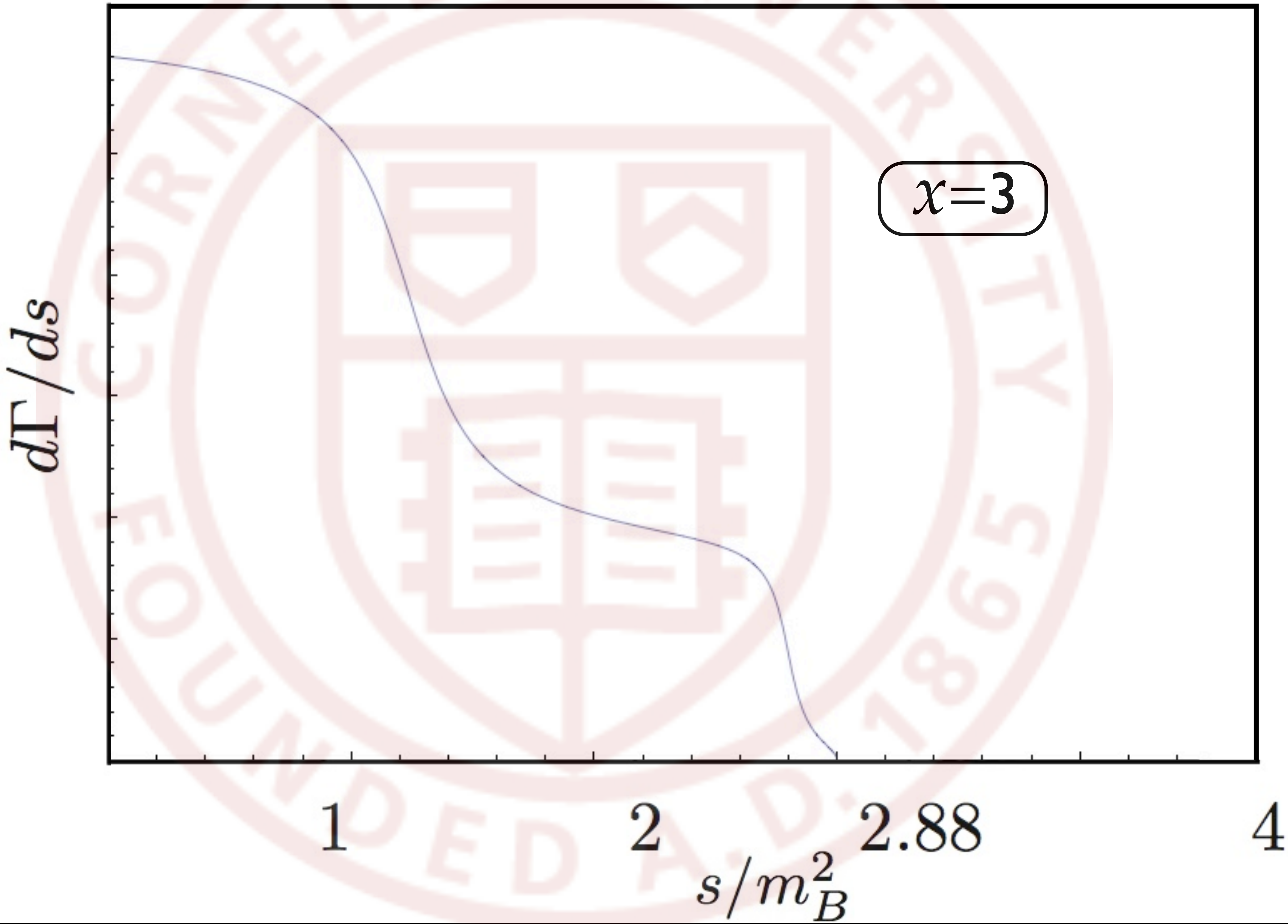
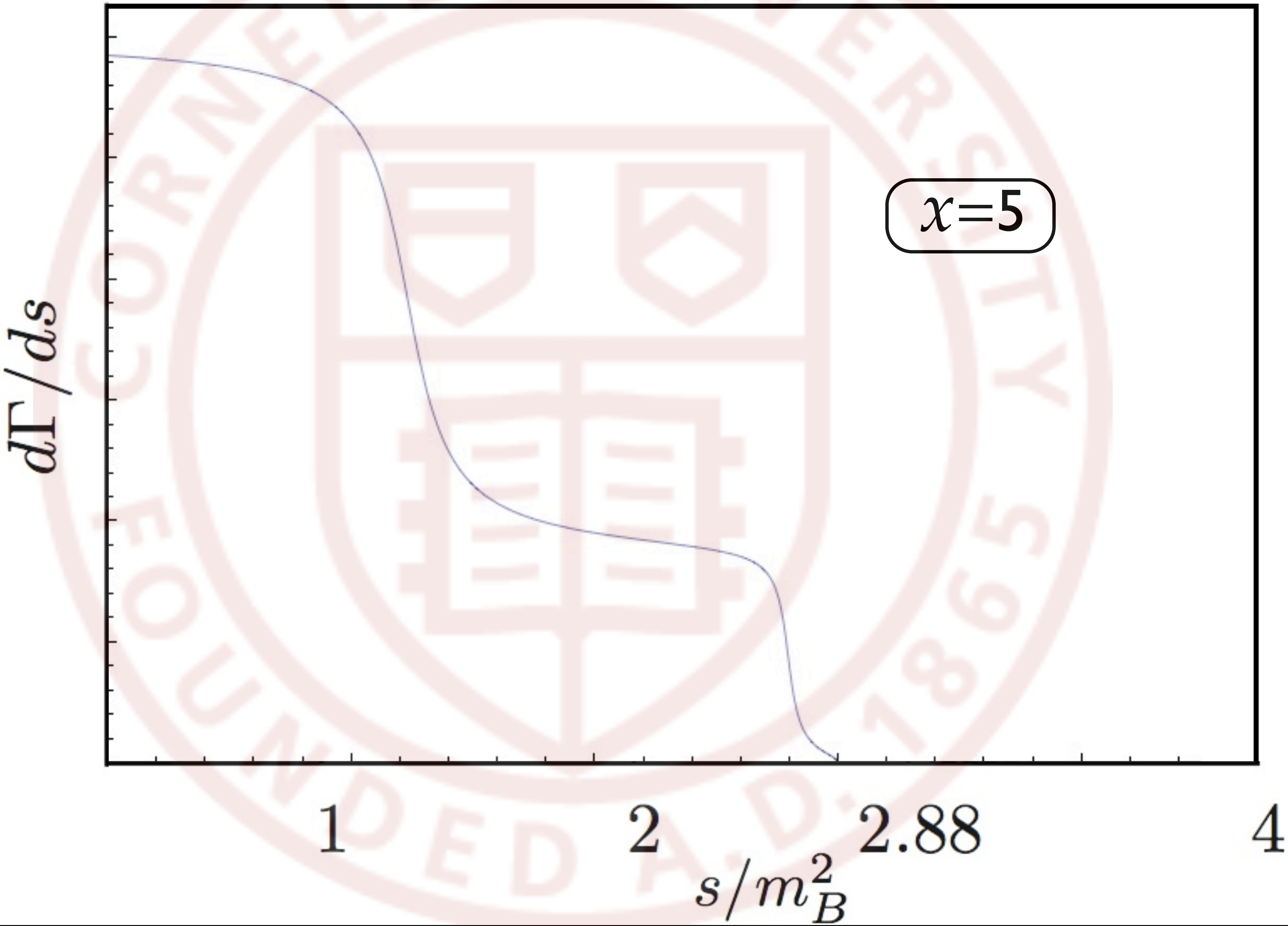


KE with Flavor oscillations



Differential decay rate with parameter choice m_A/m_B=2, m_C/m_B=0.2 and $\Gamma_B/m_B=10^{-1}$ (solid) or $\Gamma_B/m_B=10^{-3}$ (dashed).

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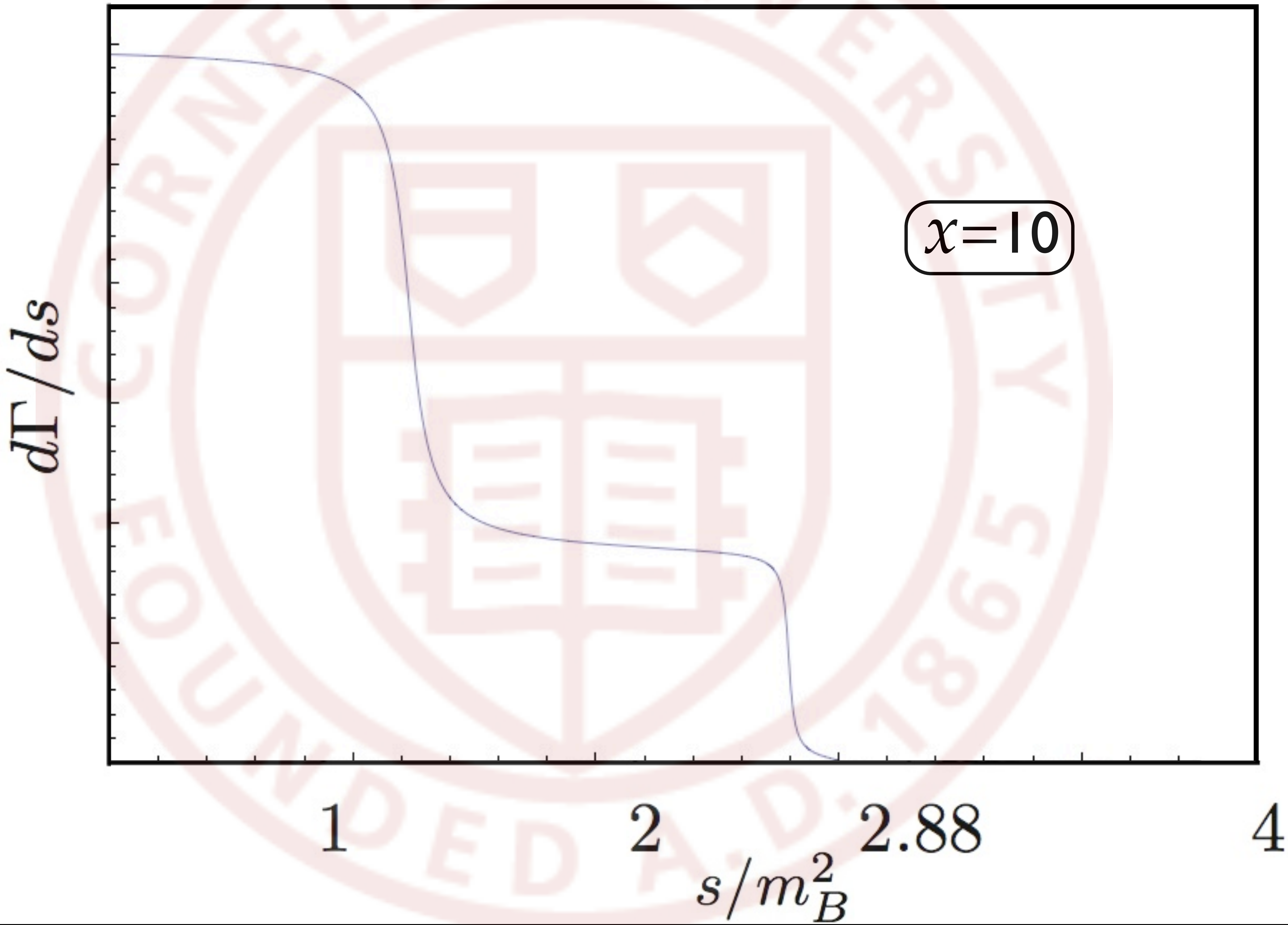

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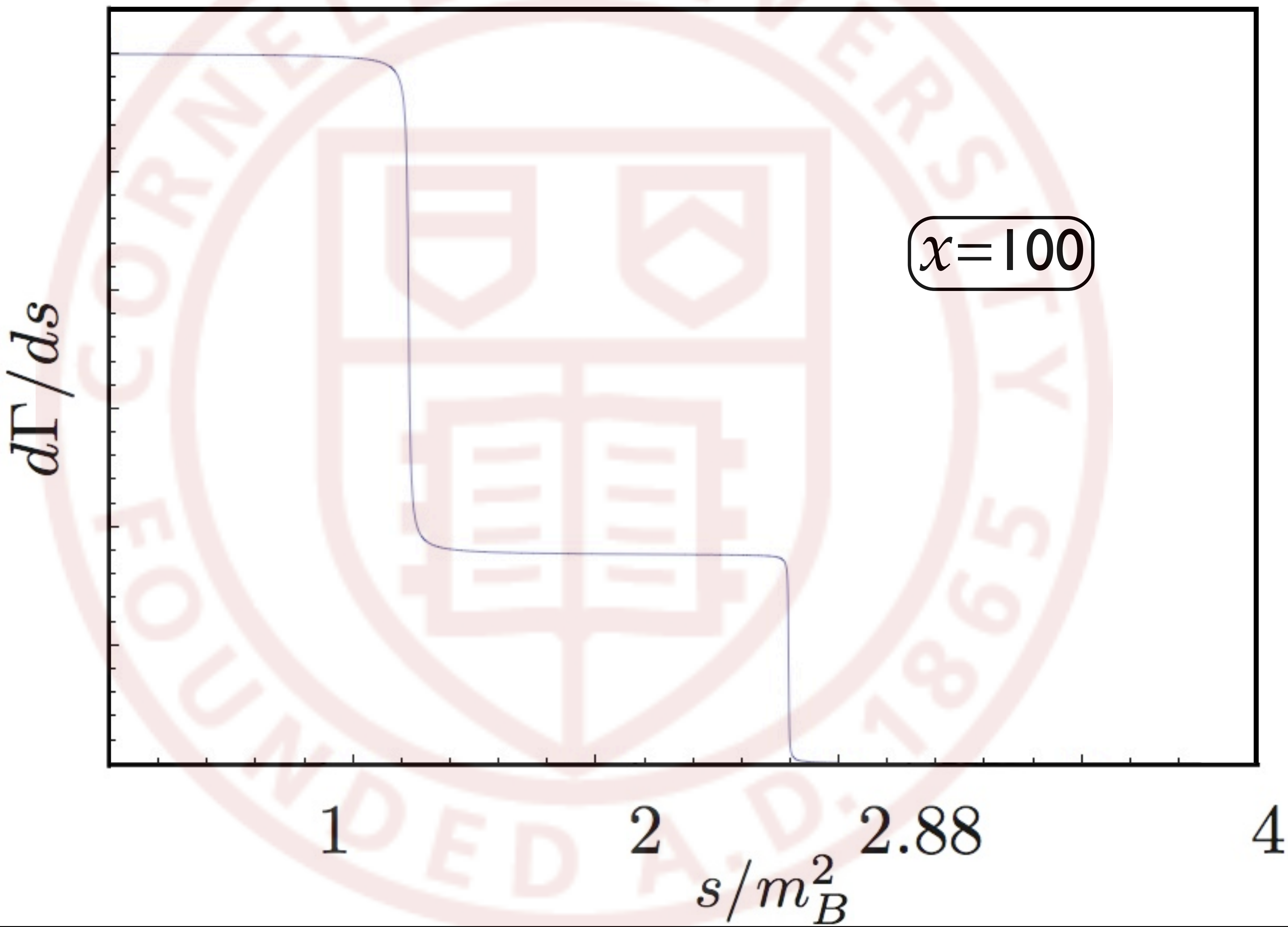

edge width

Gradient of the differential decay rate near the kinematic edge

$$d^2\Gamma/ds^2 = \frac{f(s_0)}{(s-s_0)^2+\sigma^2}$$

We can therefore identify σ as the edge width:

$$\sigma \simeq \frac{4m^2 z}{x}\left(1 - \frac{m_{\chi_1}^2 m_{\chi_2}^2}{m^4}\right)$$

EDGE RESOLUTION CRITERION

The two edges can be resolved if

$$|s_0^1 - s_0^2| > \frac{\sigma_1+\sigma_2}{2}$$

In the case in exam this criterion reduces to a simple restriction on *x*

$$x > 1$$

Future Directions

- This is a first step towards studying the most general non-universal flavor scenario, including slepton oscillation. For $x \sim 1$ it is hard to clearly resolve the two edges.

- We plan in carrying out a more detailed analysis in specific and concrete SUSY scenarios, like the ones presented in the case oscillations are absent.

Conclusions

• kinematic edges provide one of the many tools to extract superpartner masses which are particularly useful if the final state cannot be fully reconstructed.

• KE could turn useful to identify a non-universal flavor structure since for certain value of slepton masses, the edge splitting is bigger than the mass splitting itself (not always true + soft leptons).

THE END