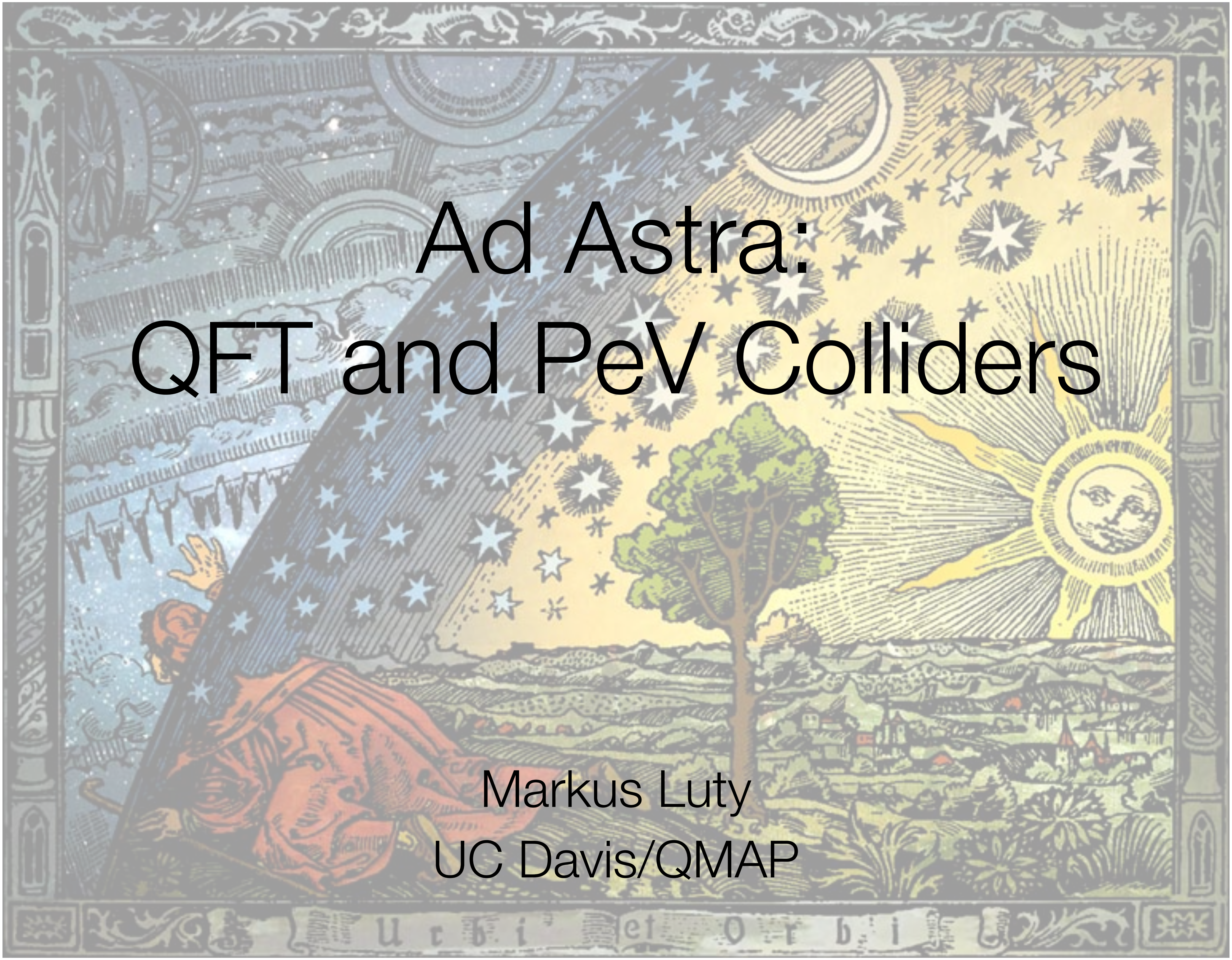
Ad Astra: QFT and PeV Colliders

Markus Luty
UC Davis/QMAP



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The Cosmology “Nightmare Scenario”

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Outline of this talk

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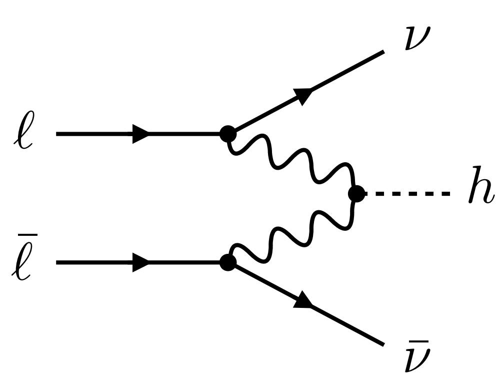

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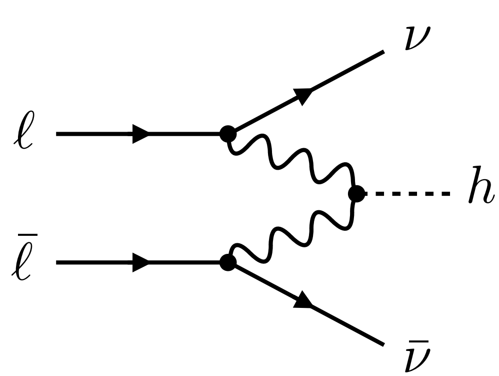

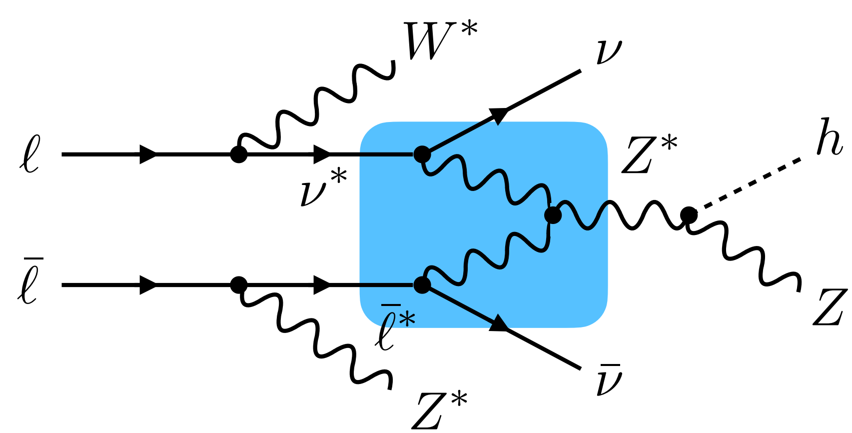

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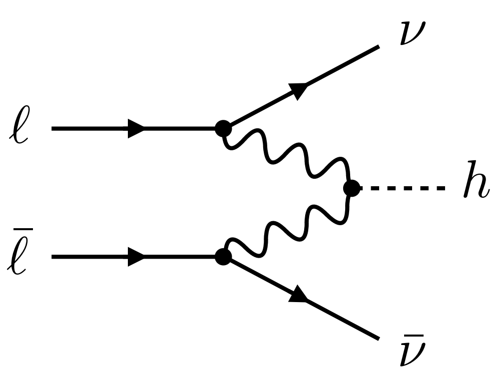

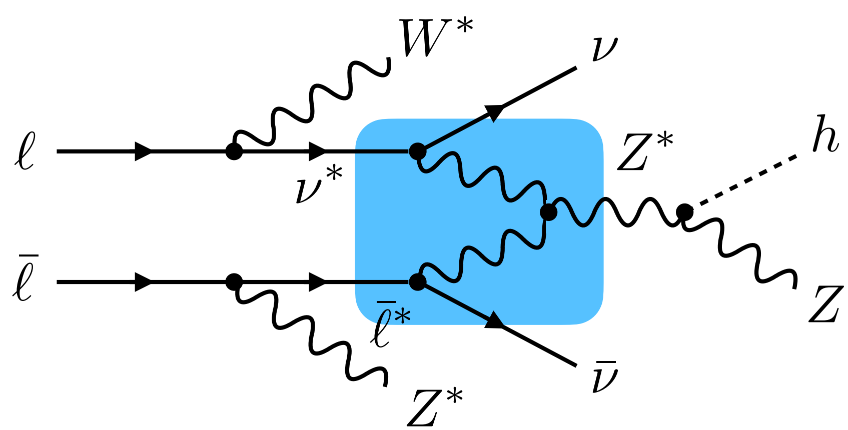

At PeV collider, expect $\sim 10^4$ $W/Z/h$ in typical EW event

QCD: Factorization

Standard approach: focus on partially inclusive quantities

$$\ell\bar{\ell} \to X$$

$$pp \to W + X$$

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$$\vdots$$

$X =$ hadrons

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Factorization theorems:

$$\sigma(p_1 p_2 \to \ell\bar{\ell} + X) \sim \sum_{a,b} \int_0^1 dx_1 \int_0^1 dx_2 \underbrace{f_{1/a}(x_1) f_{2/b}(x_2)}_{\text{soft}}$$
$$\times \underbrace{\sigma(ab \to \ell\bar{\ell} + X)}_{\text{hard}}$$

Other Approaches

- Energy correlators

  Basham, Brown, Ellis, Love (1978) ...

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- Intuitive
- Wilsonian (compute 'one scale at a time')
- # of possible observables scales with energy

  $$\mu^+\mu^- \to W_1 W_2 \cdots W_n + X$$

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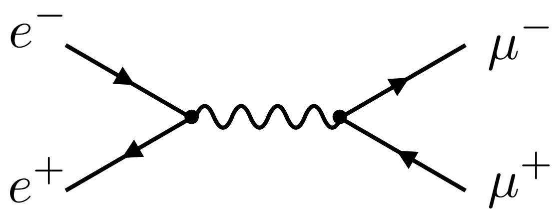
- EW gauge invariance broken in IR
- Unbroken EW gauge governs underlying hard process

Back to Basics

QED:



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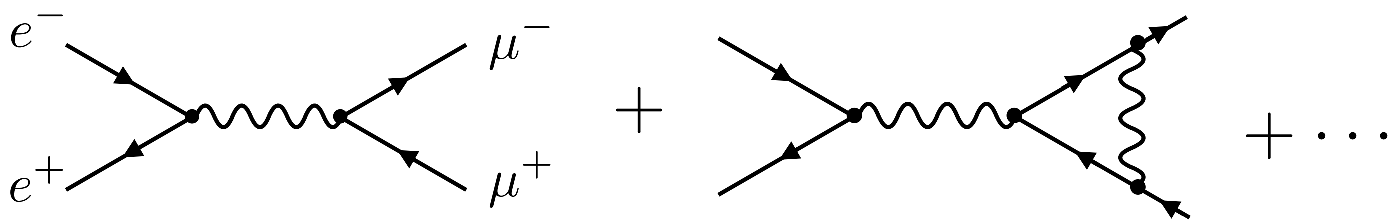

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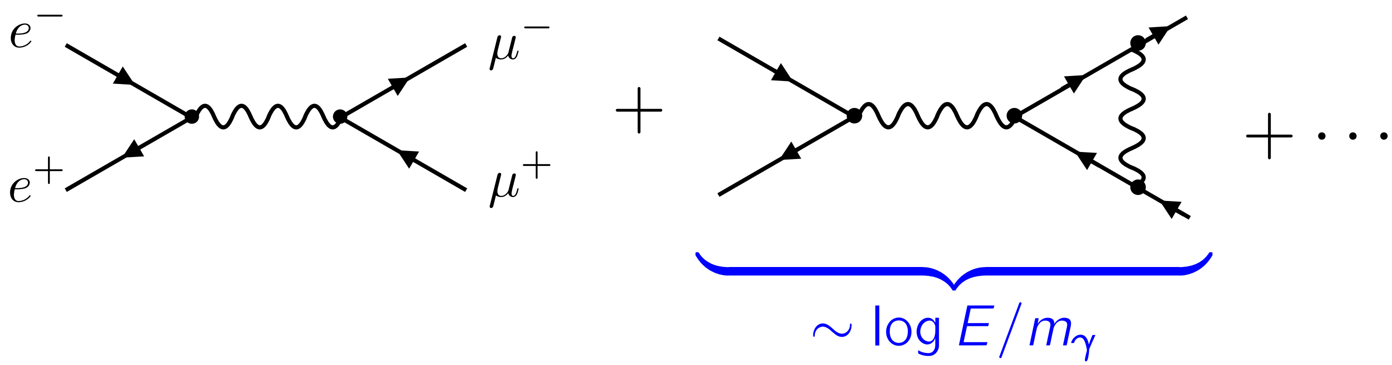

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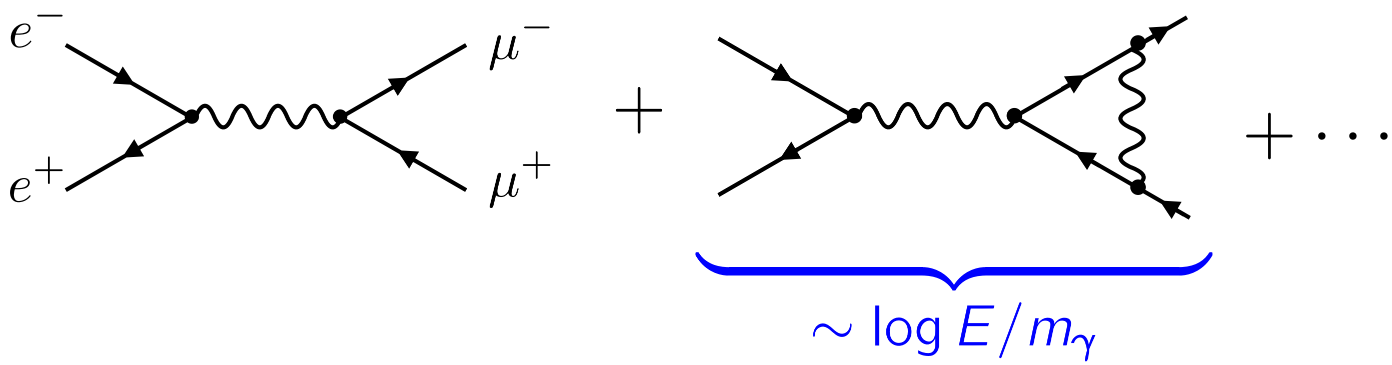

Bloch, Nordsiek (1937!): QED amplitudes are finite if we sum over soft photons in final state

$$\sum_{n=0}^{\infty} \int d\Phi(\gamma_1)\cdots d\Phi(\gamma_n)\,\Theta(E_\gamma < \delta)$$
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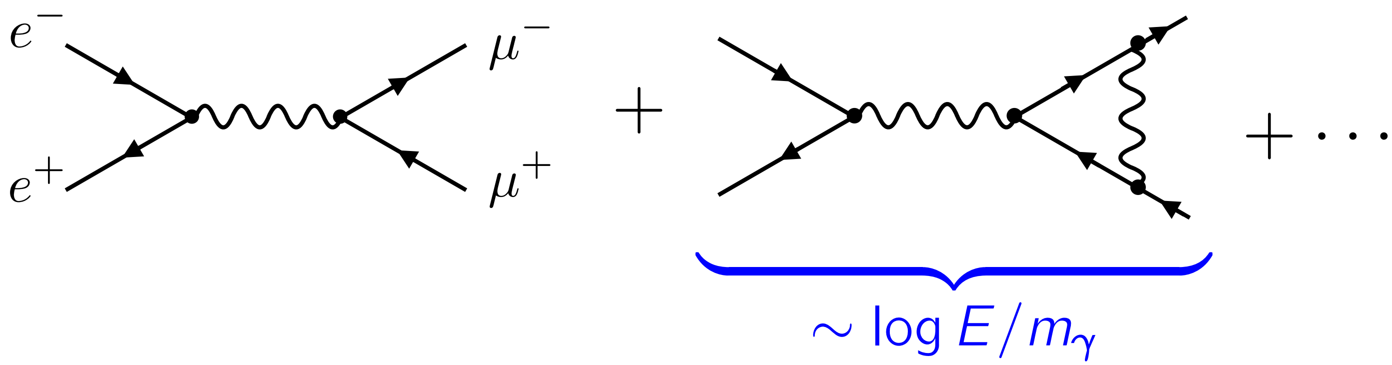

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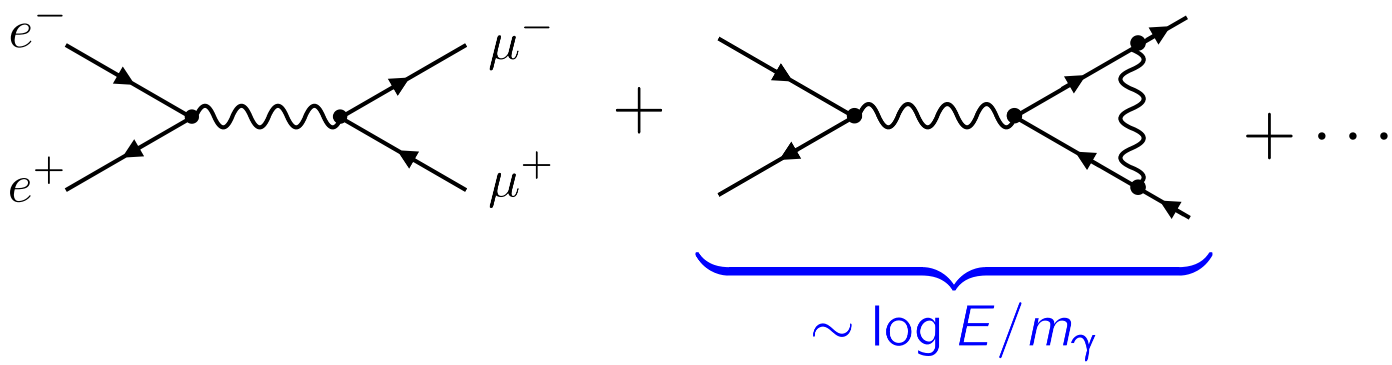

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But what about the initial state?

KLN Theorem

QFT amplitudes are finite if we sum over initial or final states within an energy range

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Can we obtain a pricipled understanding of the relation between ‘parton’ states and initial/final states in experiments?


AND NOW FOR
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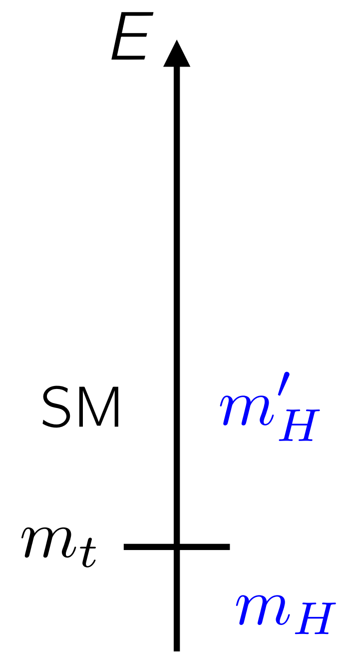

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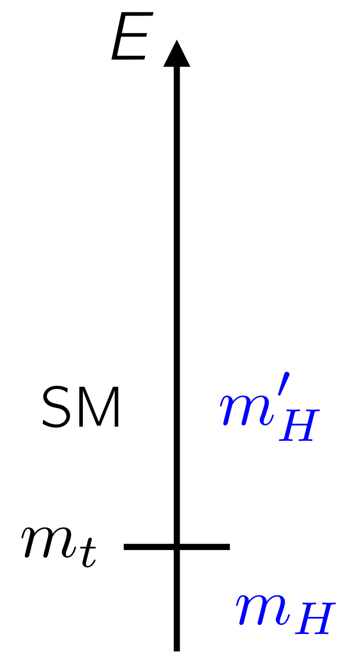

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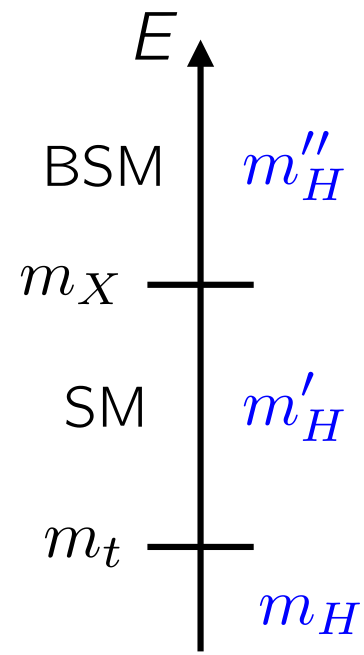

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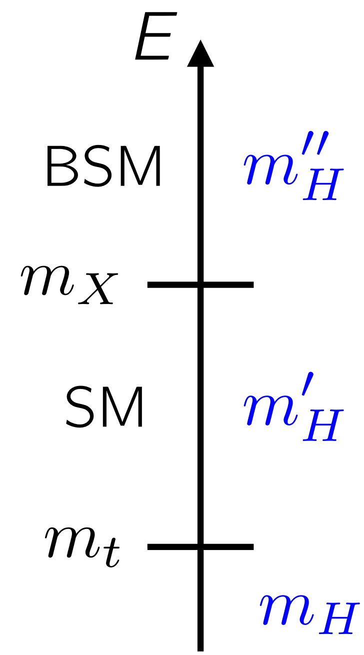

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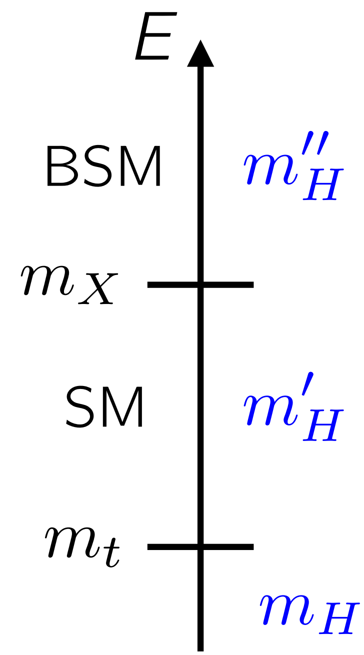

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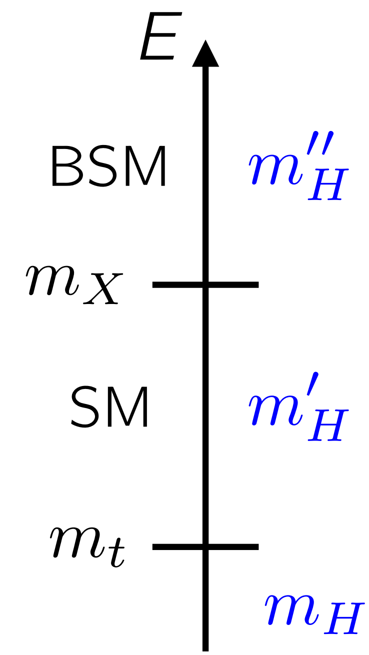

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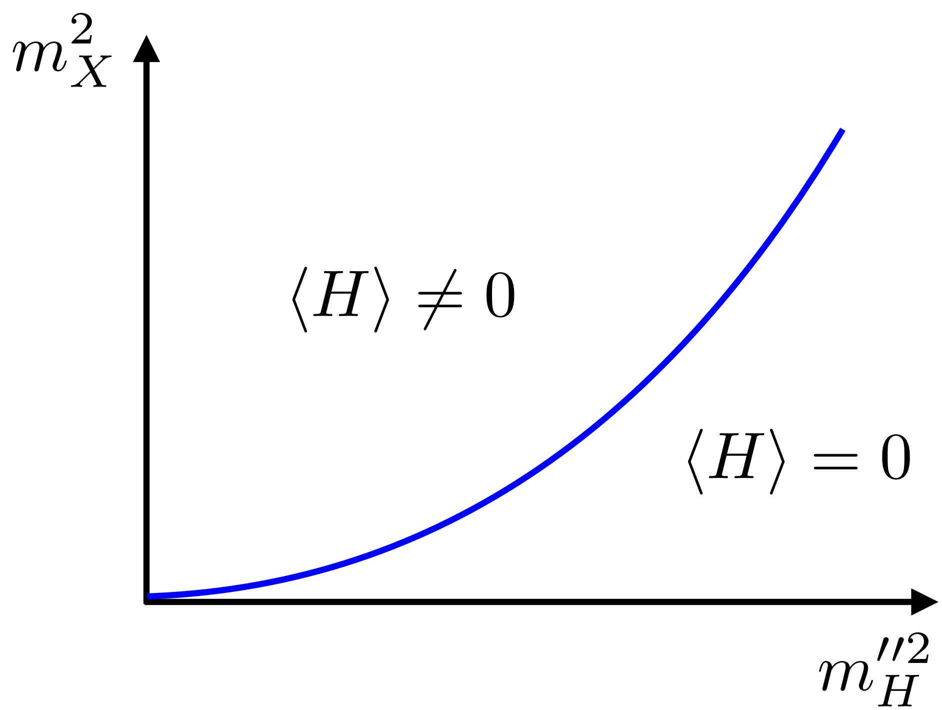

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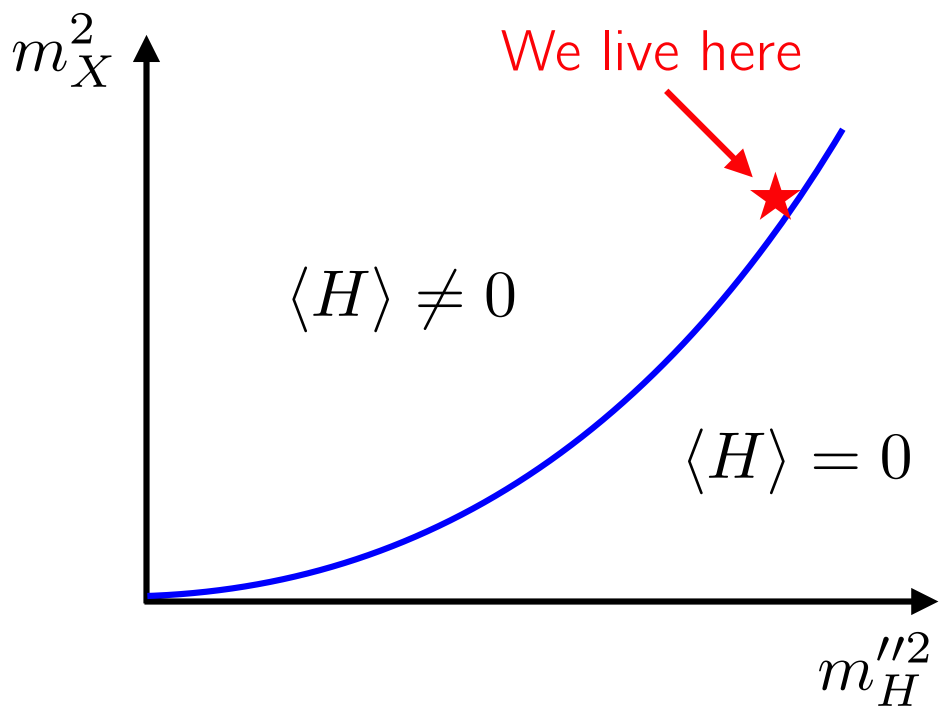

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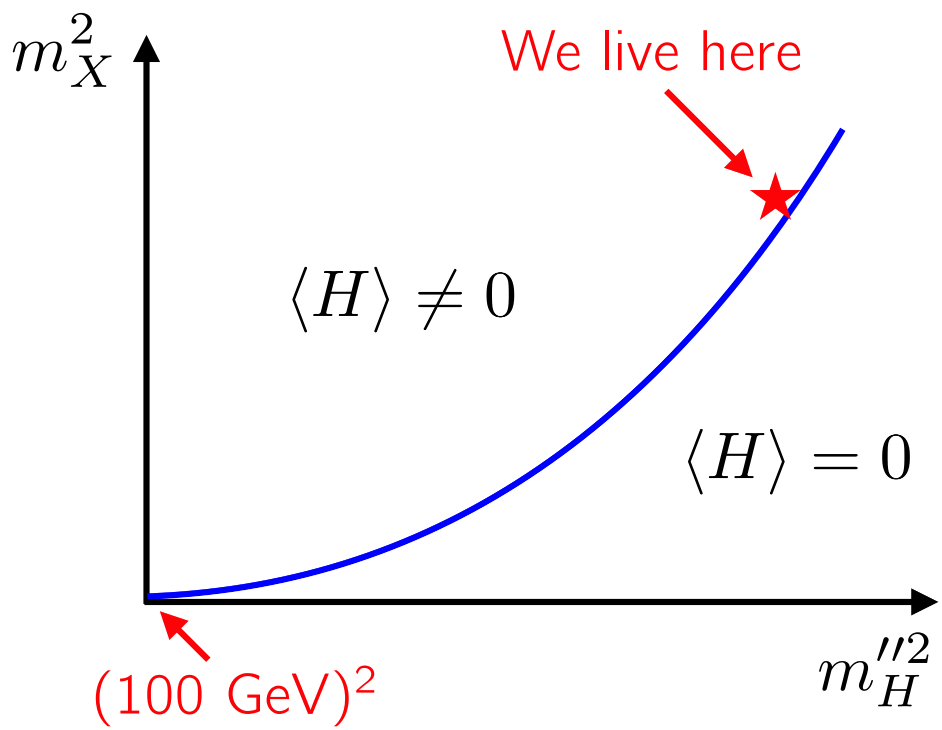

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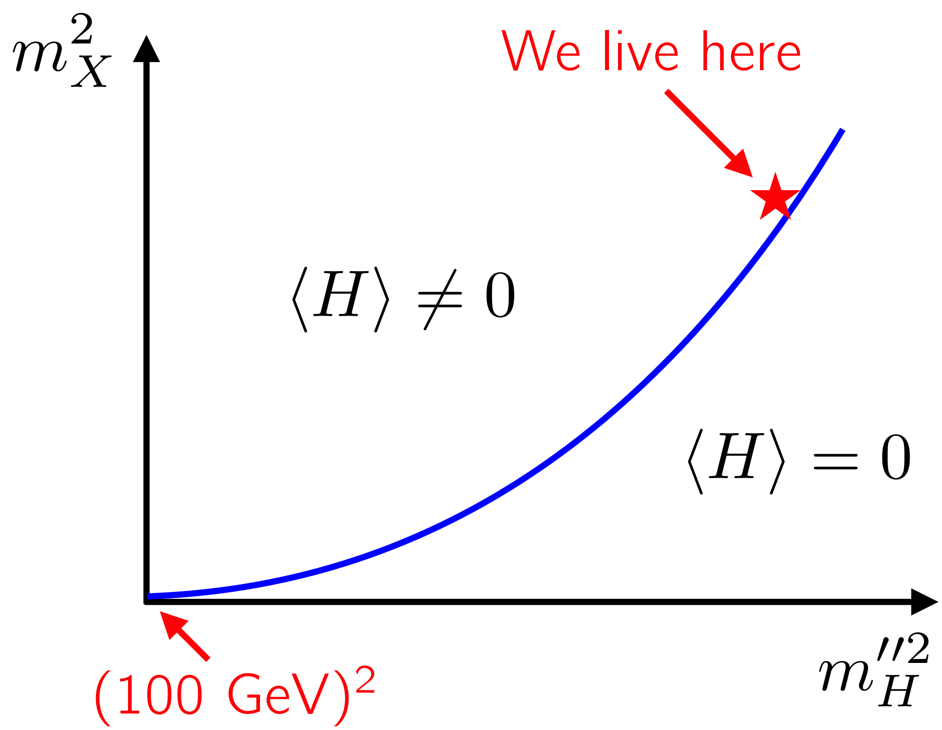
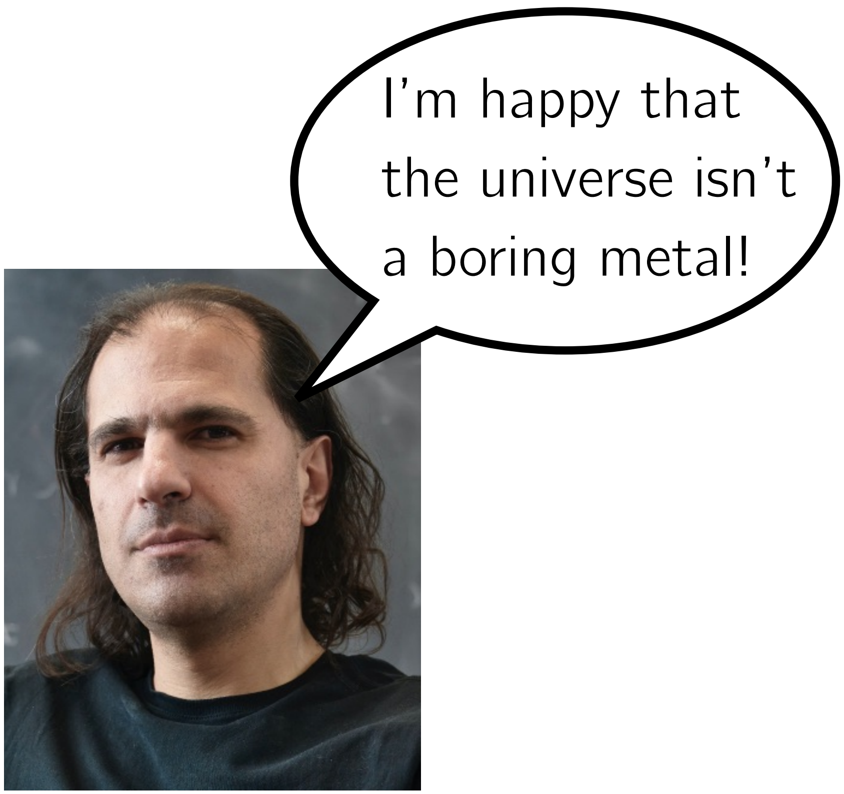
- No problem if there are no physical scales above ∼ TeV ...including quantum gravity!

- Otherwise, large hierarchy 'explained' by the fact that the universe is close to a second order phase transition





No Conclusions

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I hope we keep exploring…