Being curious about the Universe

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2017. 6. 17 @ BRL Workshop

Higgs and Gravitational Wave

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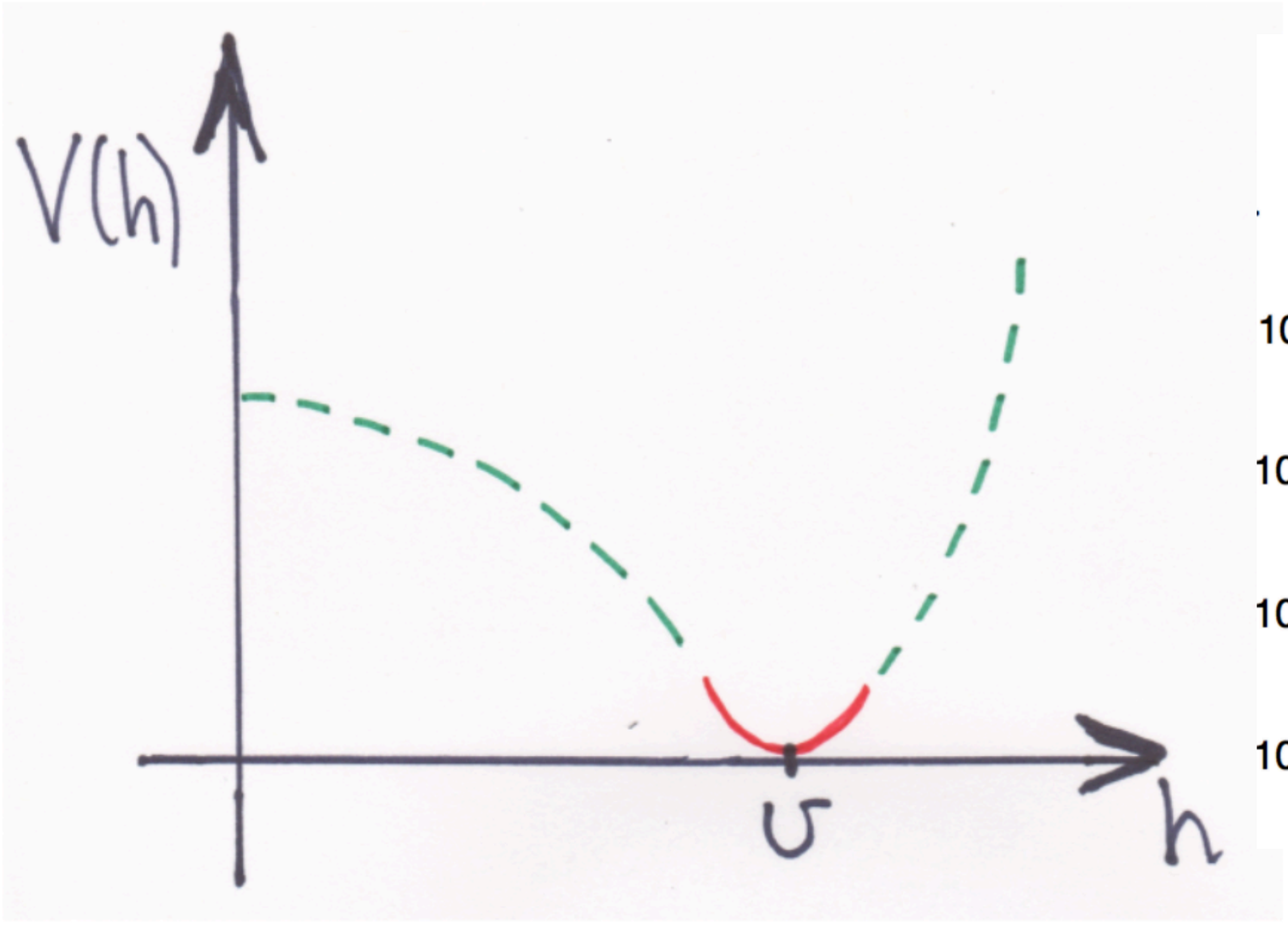
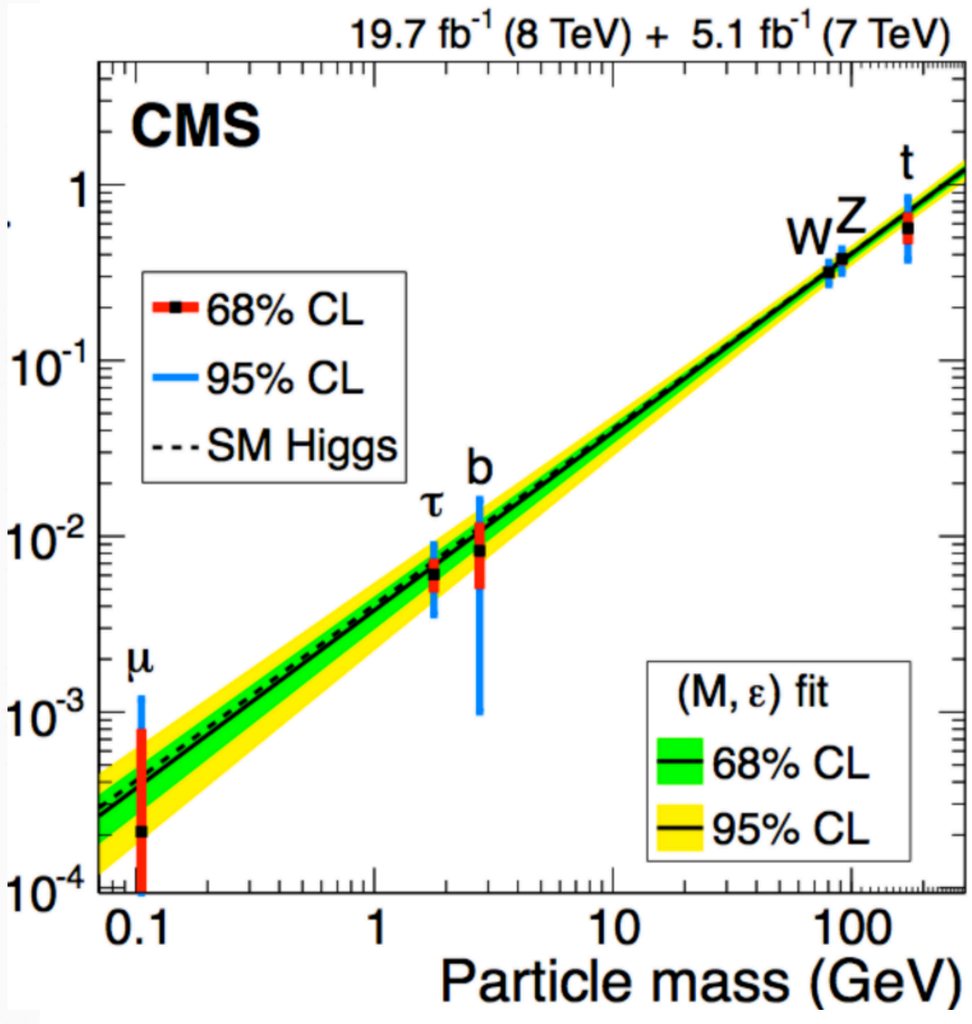
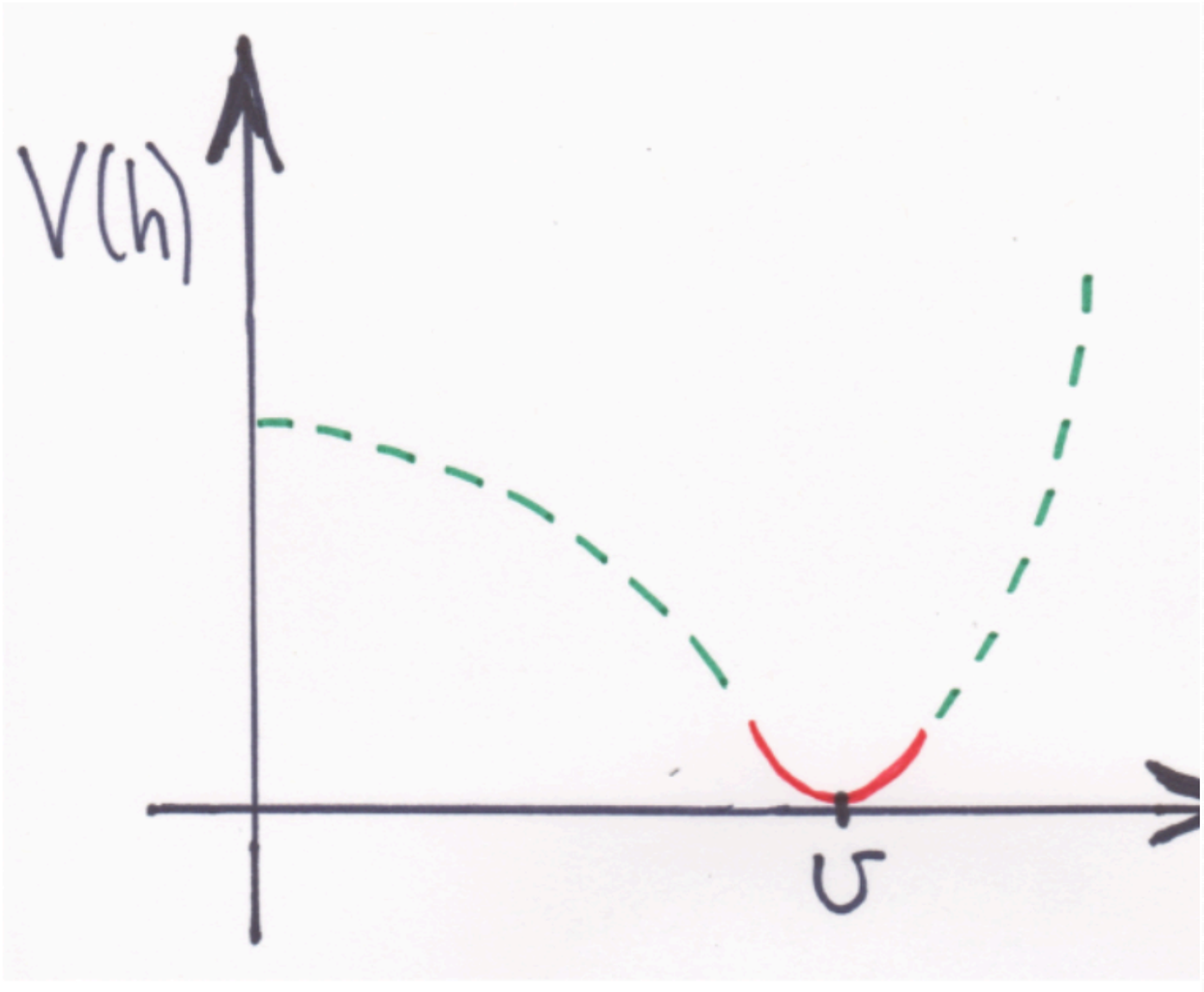
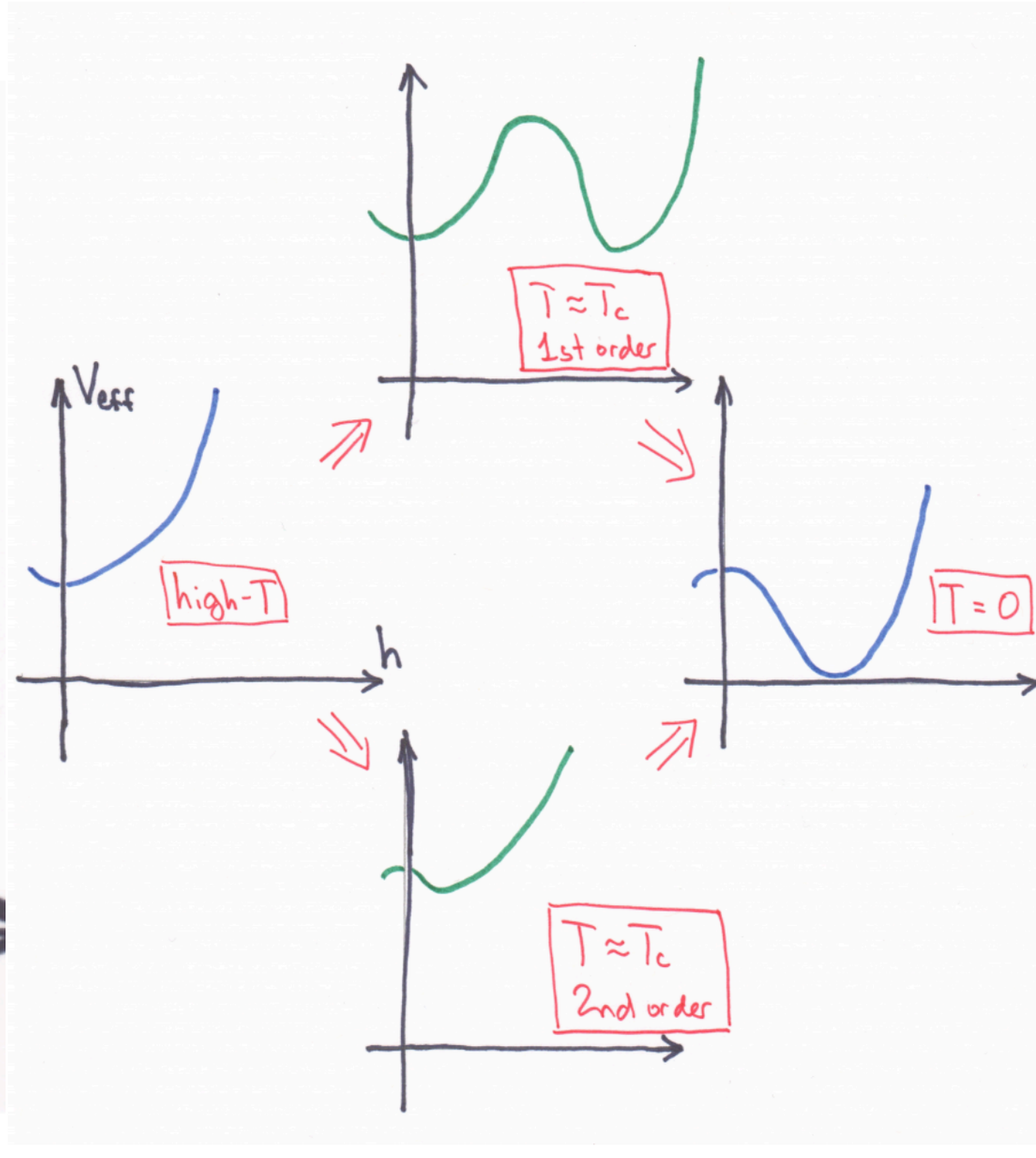
What we know about the Higgs



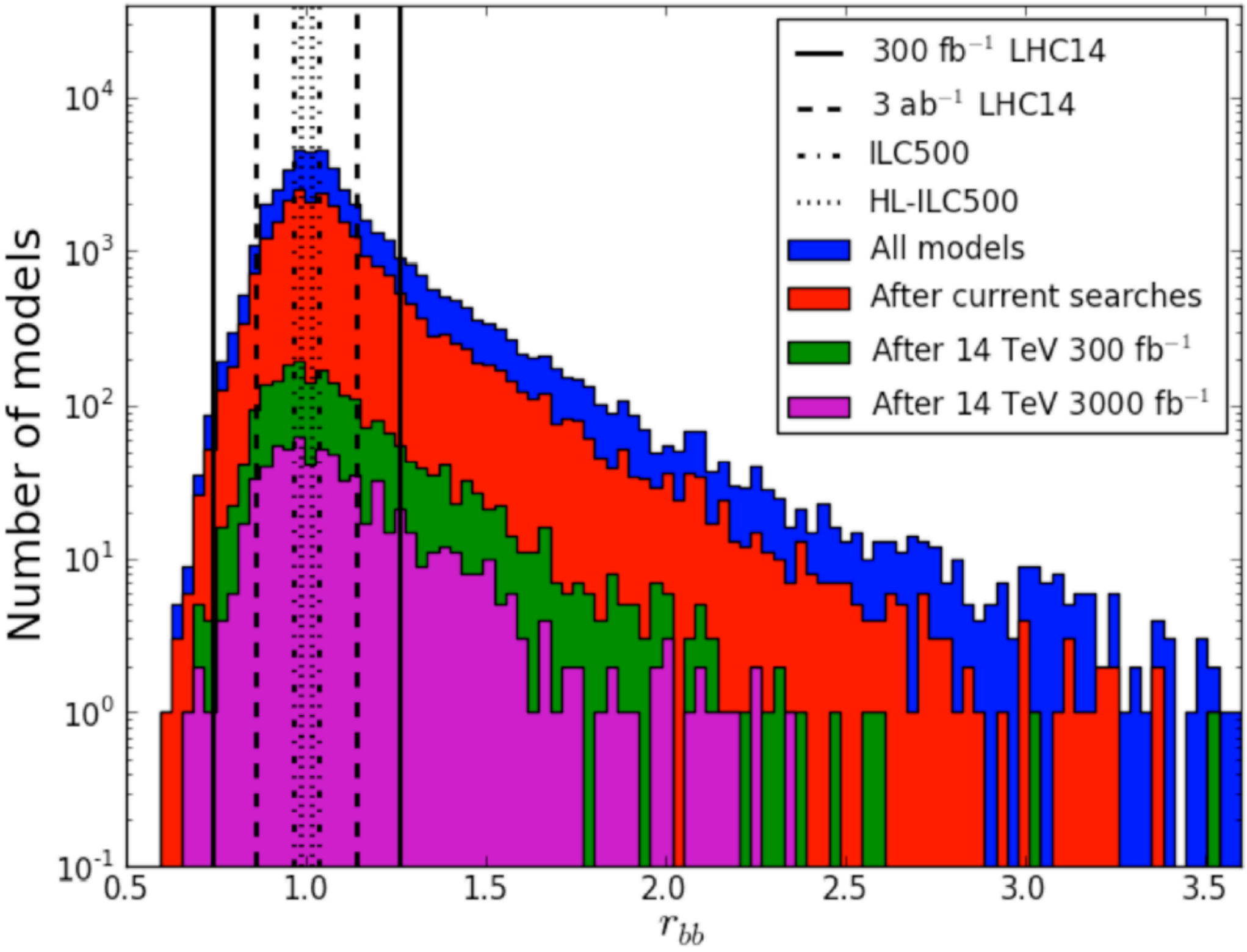


What we don't know about the Higgs !

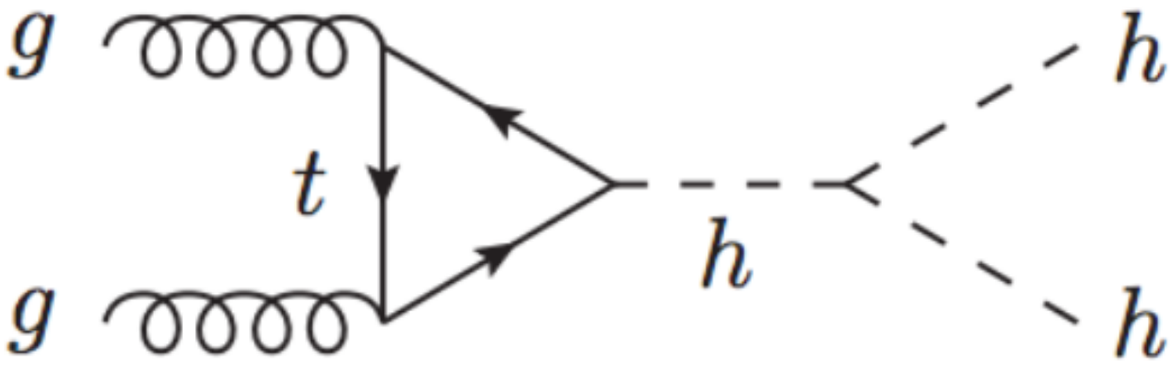


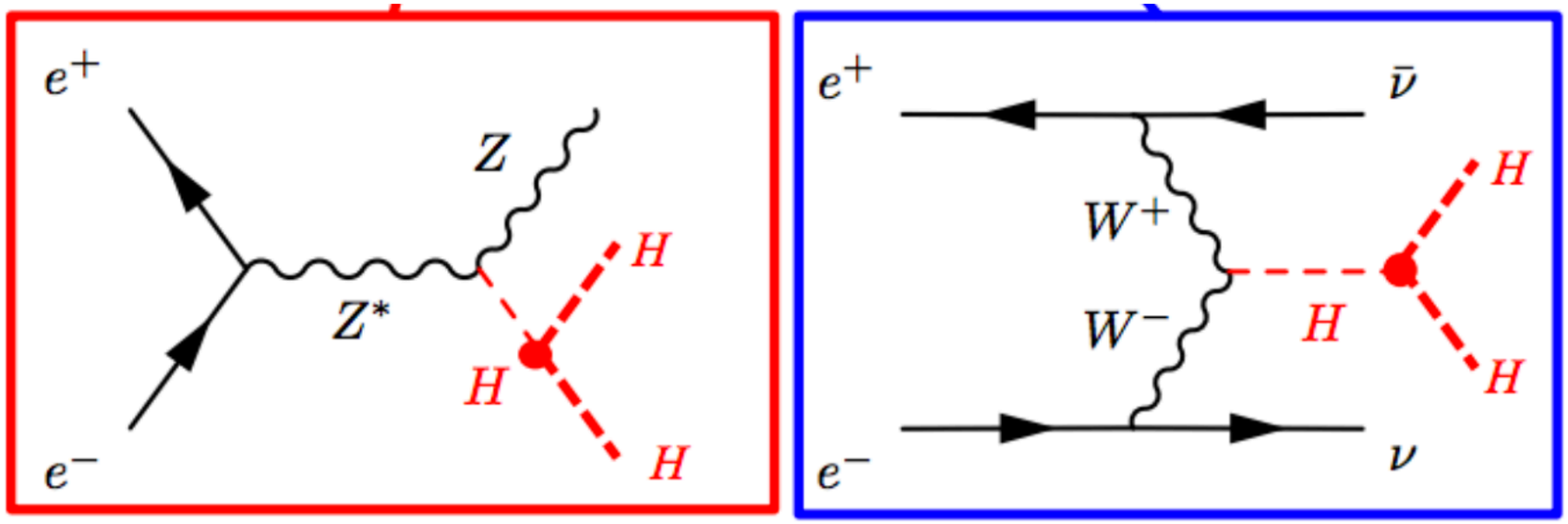


$\Gamma(h \to b\bar{b})/(SM)$



Higgscision





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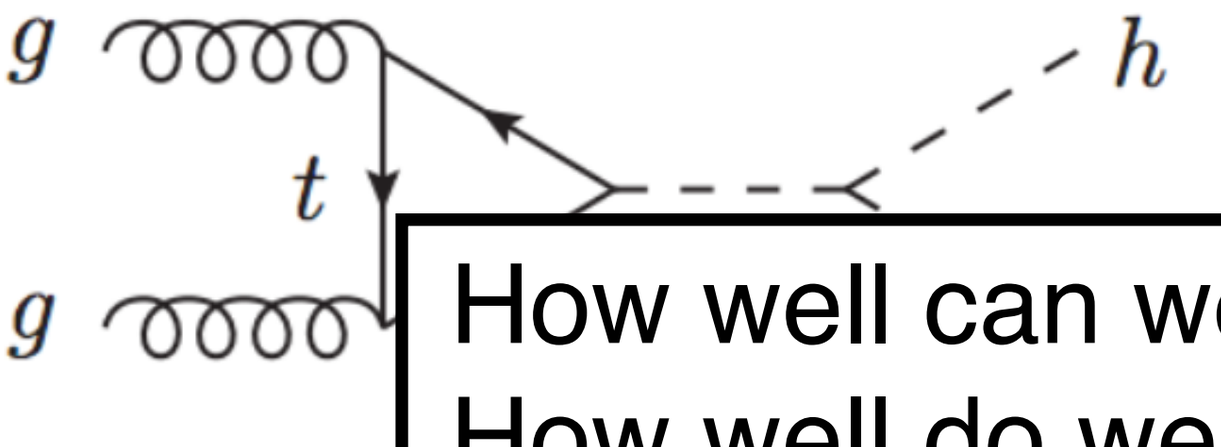
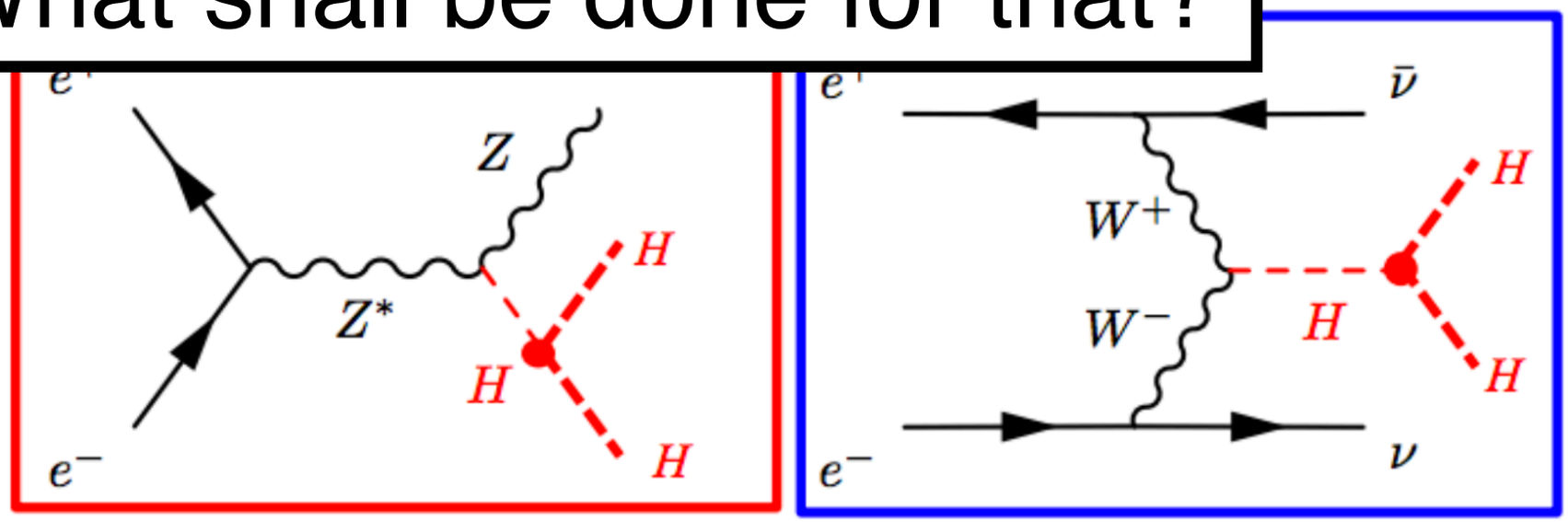
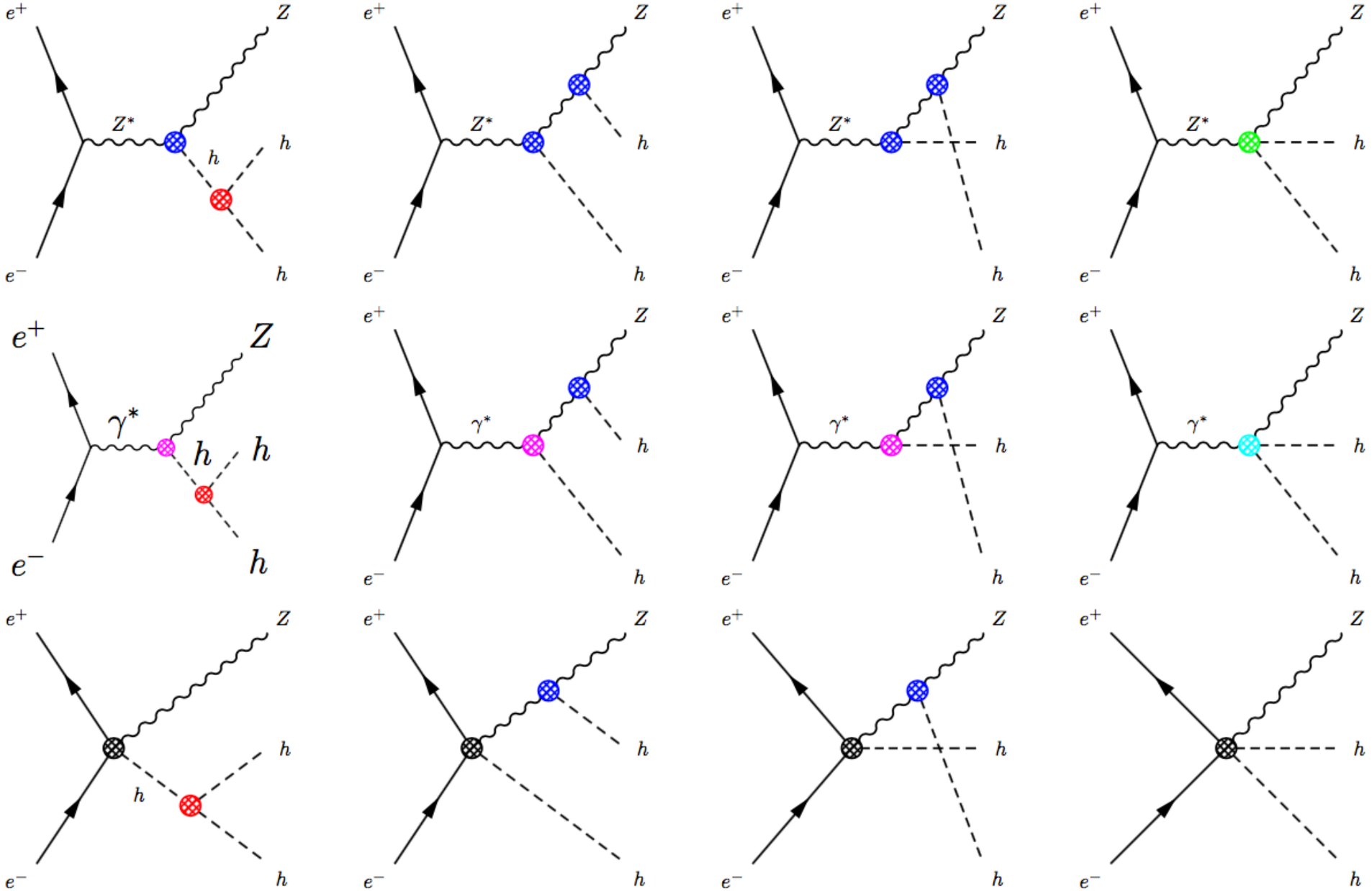


How well can we measure?
How well do we need to?
What shall be done for that?



Higgscision obstacles



Higgscision - Model independent Higgs EFT

$$\Delta\mathcal{L} = \frac{c_H}{2v^2}\partial^\mu(\Phi^\dagger\Phi)\partial_\mu(\Phi^\dagger\Phi) + \frac{c_T}{2v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu \Phi)(\Phi^\dagger \overleftrightarrow{D}_\mu \Phi) - \frac{c_6\lambda}{v^2}(\Phi^\dagger\Phi)^3$$
$$+\frac{g^2 c_{WW}}{m_W^2}\Phi^\dagger\Phi W^a_{\mu\nu}W^{a\mu\nu} + \frac{4gg' c_{WB}}{m_W^2}\Phi^\dagger t^a \Phi W^a_{\mu\nu}B^{\mu\nu}$$
$$+\frac{g'^2 c_{BB}}{m_W^2}\Phi^\dagger\Phi B_{\mu\nu}B^{\mu\nu} + \frac{g^3 c_{3W}}{m_W^2}\epsilon_{abc}W^a_{\mu\nu}W^{b\nu}{}_\rho W^{c\rho\mu}$$
$$+i\frac{c_{HL}}{v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu \Phi)(\overline{L}\gamma_\mu L) + +4i\frac{c'_{HL}}{v^2}(\Phi^\dagger t^a \overleftrightarrow{D}^\mu \Phi)(\overline{L}\gamma_\mu t^a L)$$
$$+i\frac{c_{HE}}{v^2}(\Phi^\dagger \overleftrightarrow{D}^\mu \Phi)(\bar{e}\gamma_\mu e) \ .$$

Higgscision -

Mode EFT

$$\Delta\mathcal{L} = \frac{c_H}{2v^2}\partial^\mu \qquad \frac{c_6\lambda}{v^2}(\Phi^\dagger\Phi)^3$$
$$+\frac{g^2 c_W}{m_W^2}$$
$$+\frac{g'^2 c_B}{m_W^2}$$
$$+i\frac{c_{HL}}{v^2} \qquad t^a L)$$
$$+i\frac{c_{HE}}{v^2}$$

Electroweak precision test,
e+e- > VV
Higgs couplings
e+e- > Zh
e+e- > nu nu h (VBF)
…
can altogether constrain

single Higgs couplings at ~1%,
Higgs width at ~1%!!!
triple Higgs couplings at >5%

- 2+1 papers coming soon.

- Plan to develop further with a prospect graduate student.

Model-Independent Determination of the Triple Higgs Coupling at e^+e^- Colliders

Tim Barklow[a1], Keisuke Fujii[b], Sunghoon Jung[a1], Michael E. Peskin[a1], and Junping Tian[c]

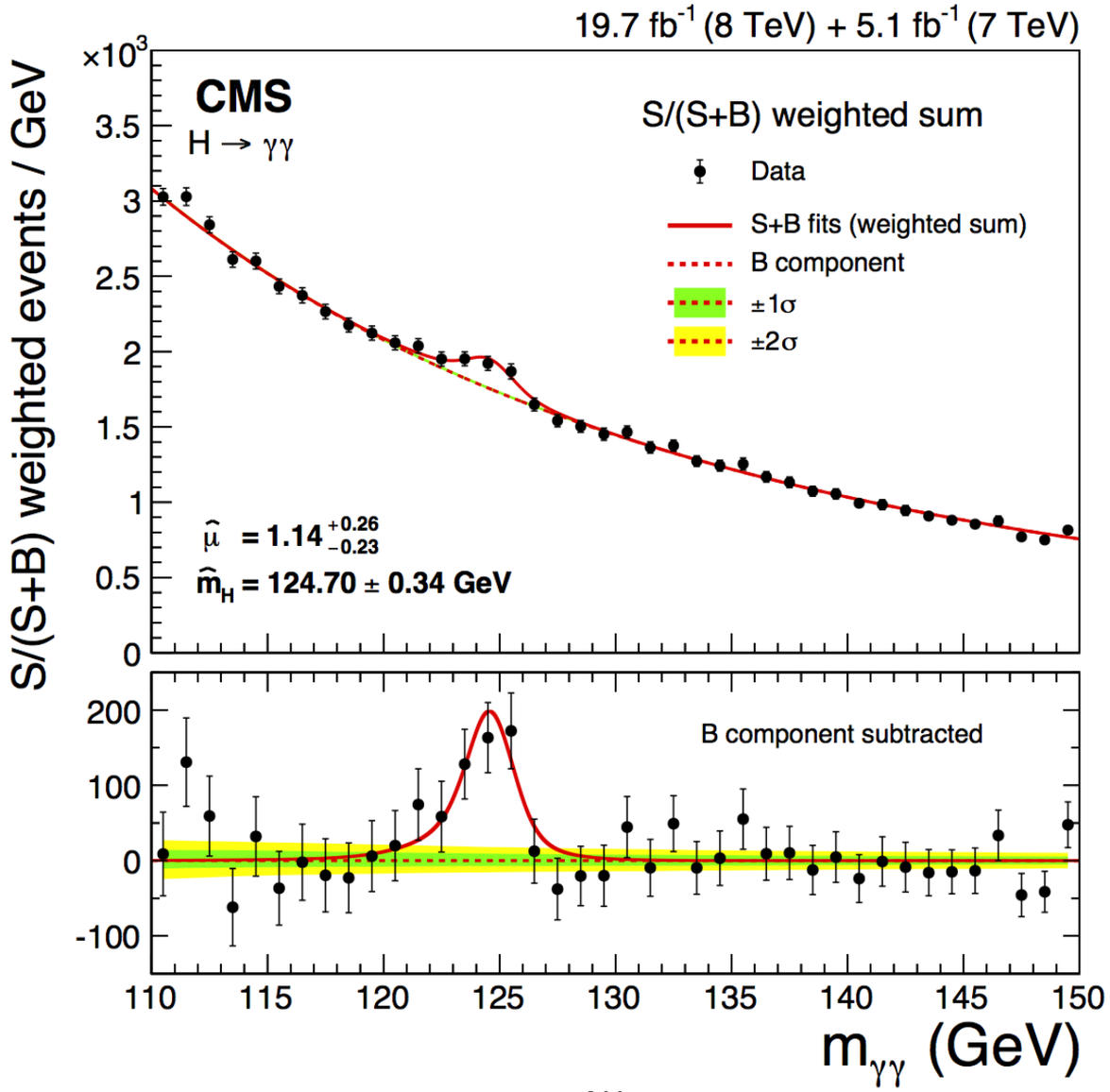
Improved Formalism for Precision Higgs Coupling Fits

Tim Barklow[a], Gauthier Durieux[b], Keisuke Fujii[c], Christophe Grojean[b,d], Jiayin Gu[b,e], Sunghoon Jung[f], Robert Karl[b], Jenny List[b], Tomohisa Ogawa[c], Michael E. Peskin[a], Junping Tian[g], and Kechen Wang[b,e]

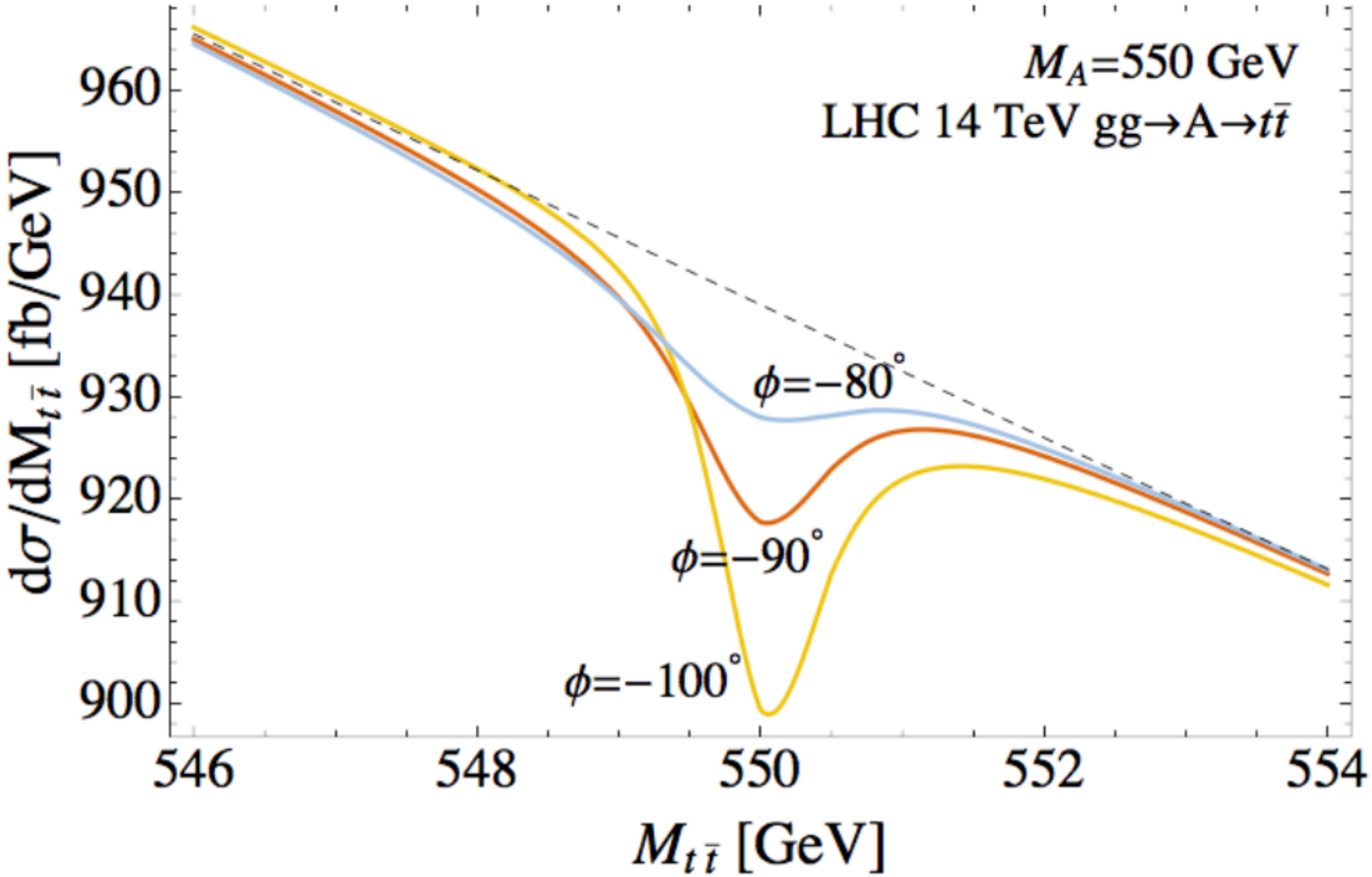
125 GeV SM-like Higgs

- First time in my academic life, this Higgs makes me suspect the SUSY (SUZY?).
- Not because SUSY is not discovered.
- But because the Higgs is SM-like and 125 GeV!

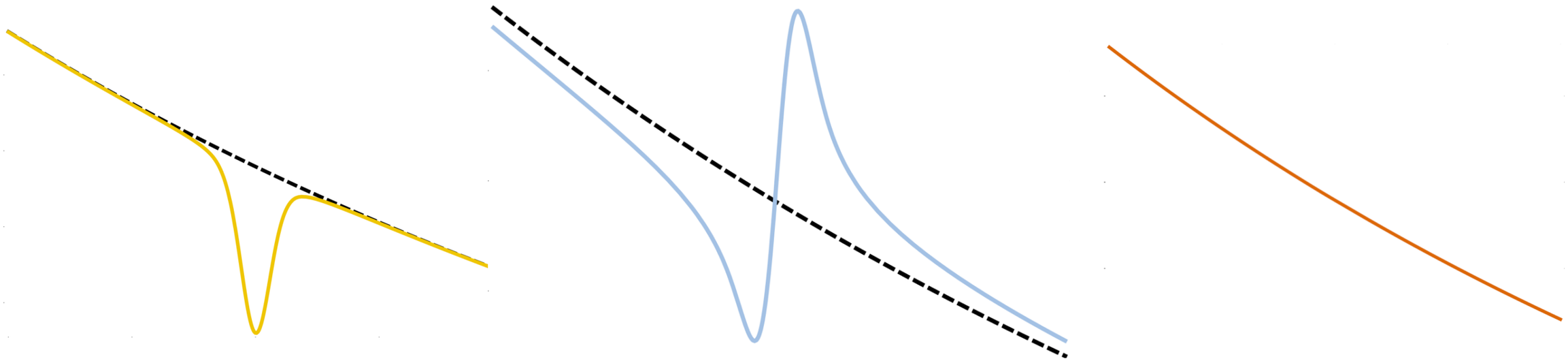
Higgs also led me to think about what particles and resonances are.



We found that this is a heavy Higgs in the MSSM or 2HDM



We found that a heavy Higgs (and many BSM particles) appears as many guises.



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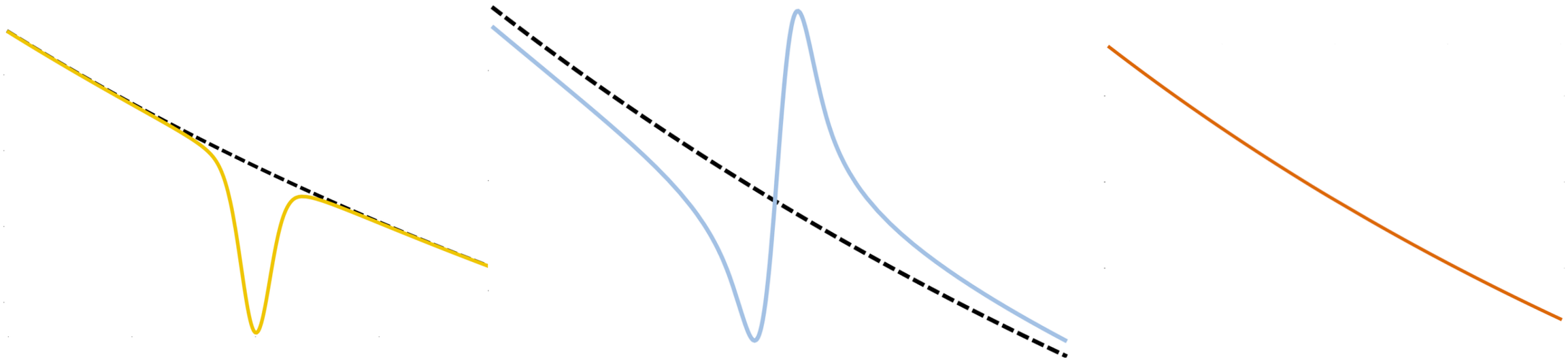
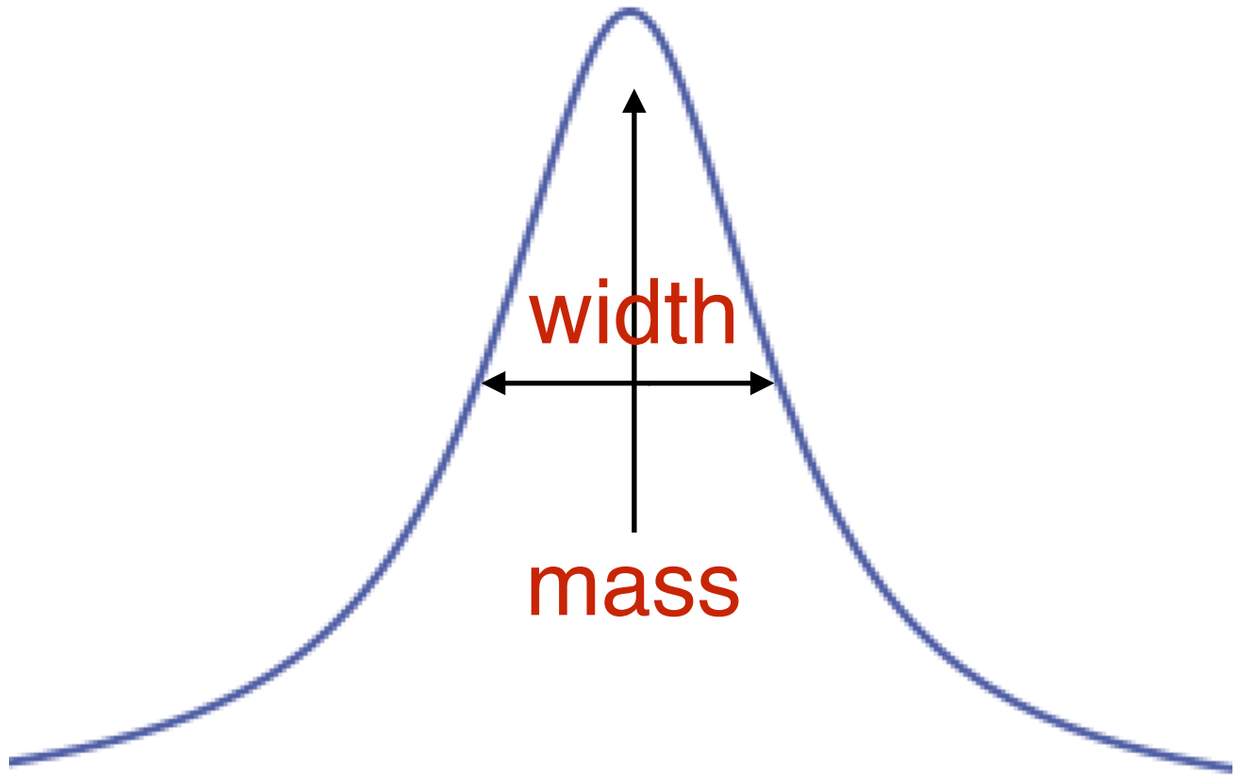
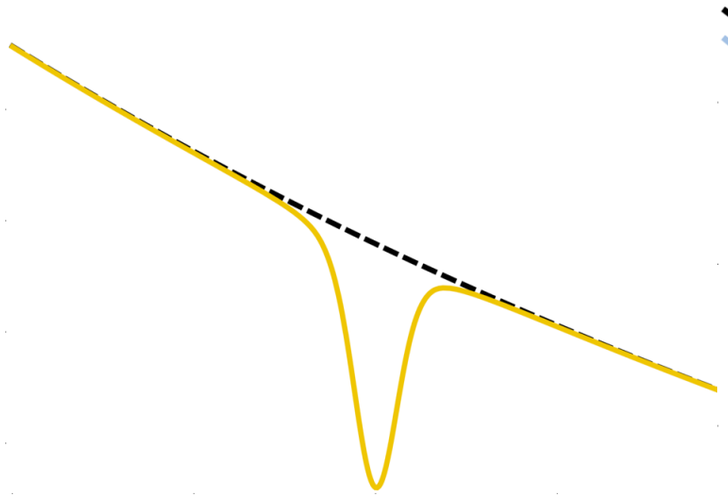
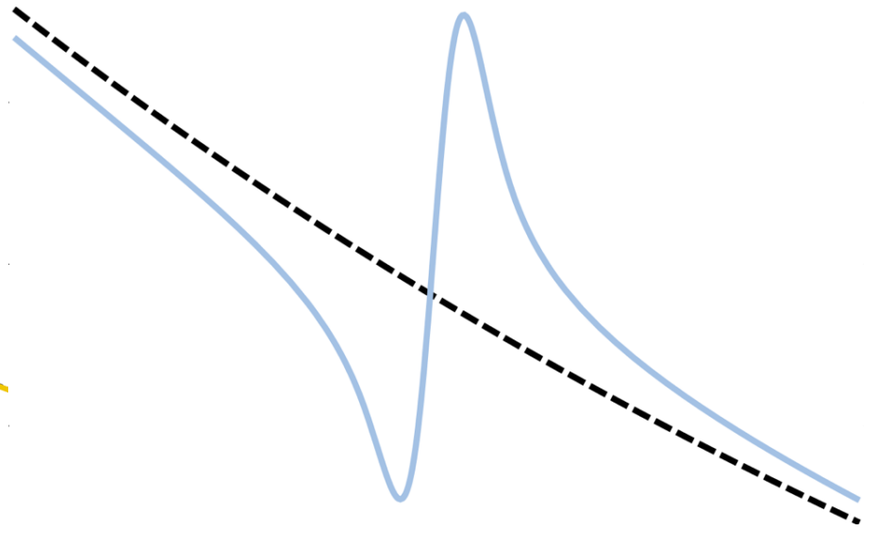


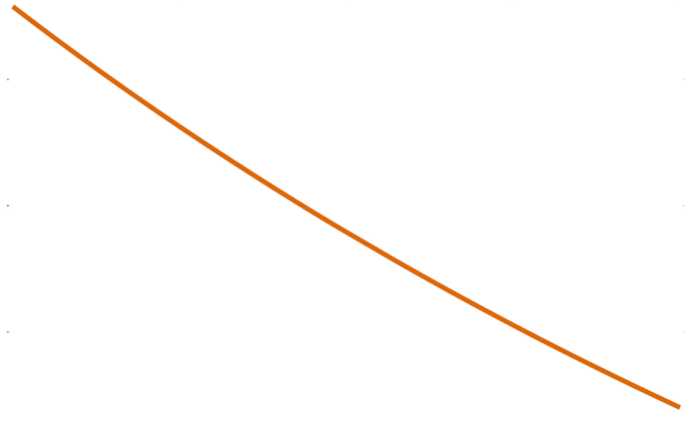
In addition to underlying physics and how to discover them as we have studied,
I am further curious about…

What can we learn/measure from resonance shapes?





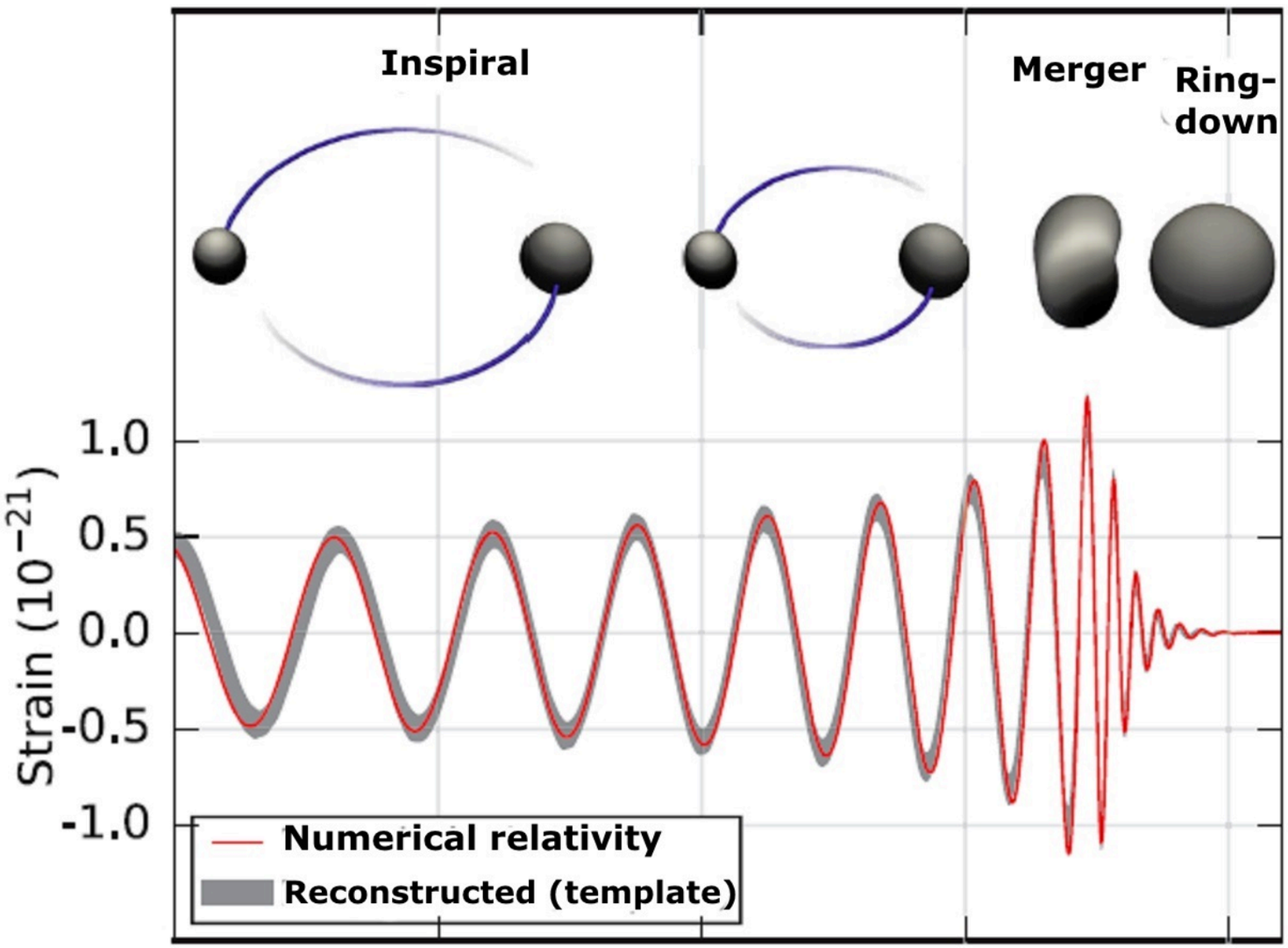




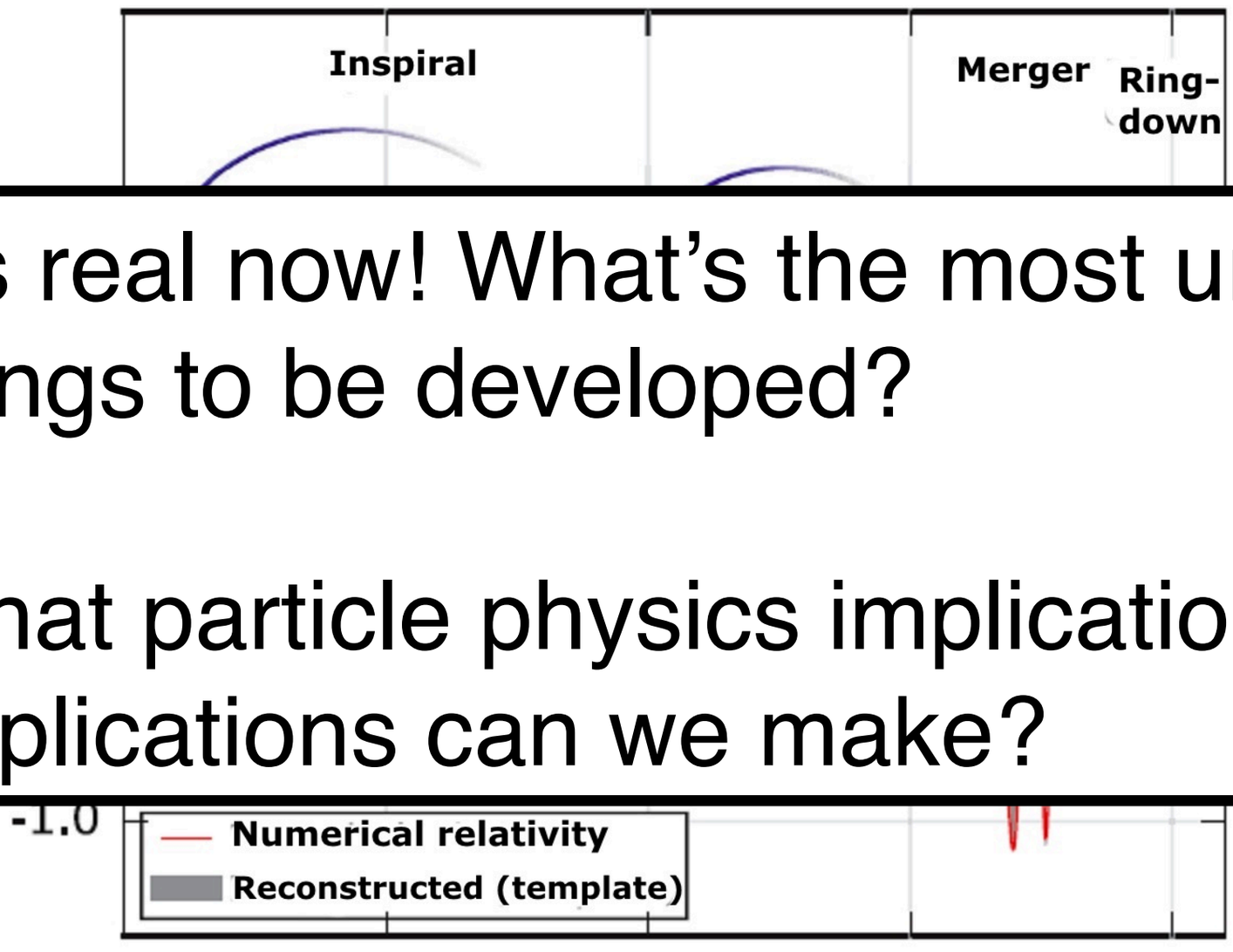
Then, suddenly

literally, suddenly…

GW was discovered



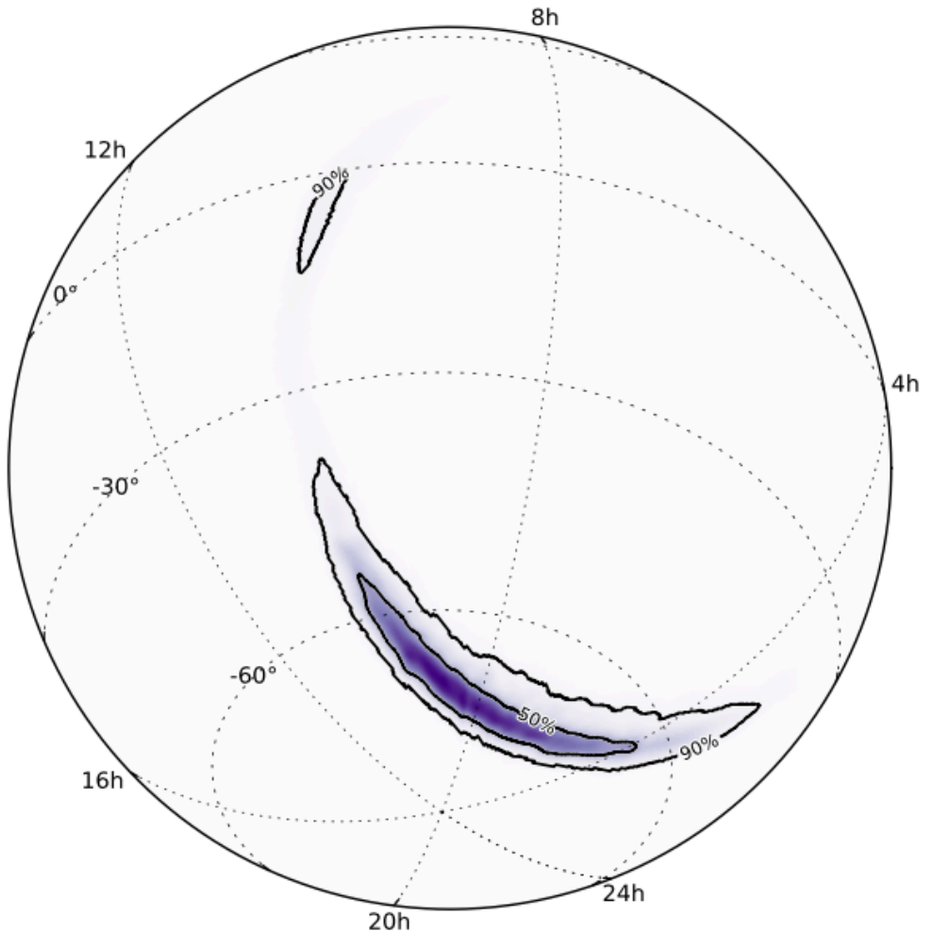
GW was discovered

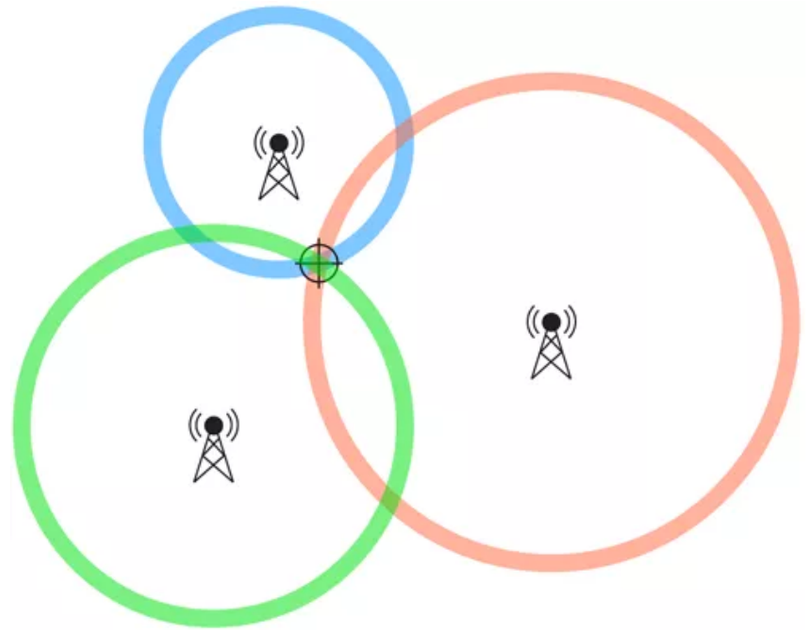


It’s real now! What’s the most urgent things to be developed?

What particle physics implications and applications can we make?

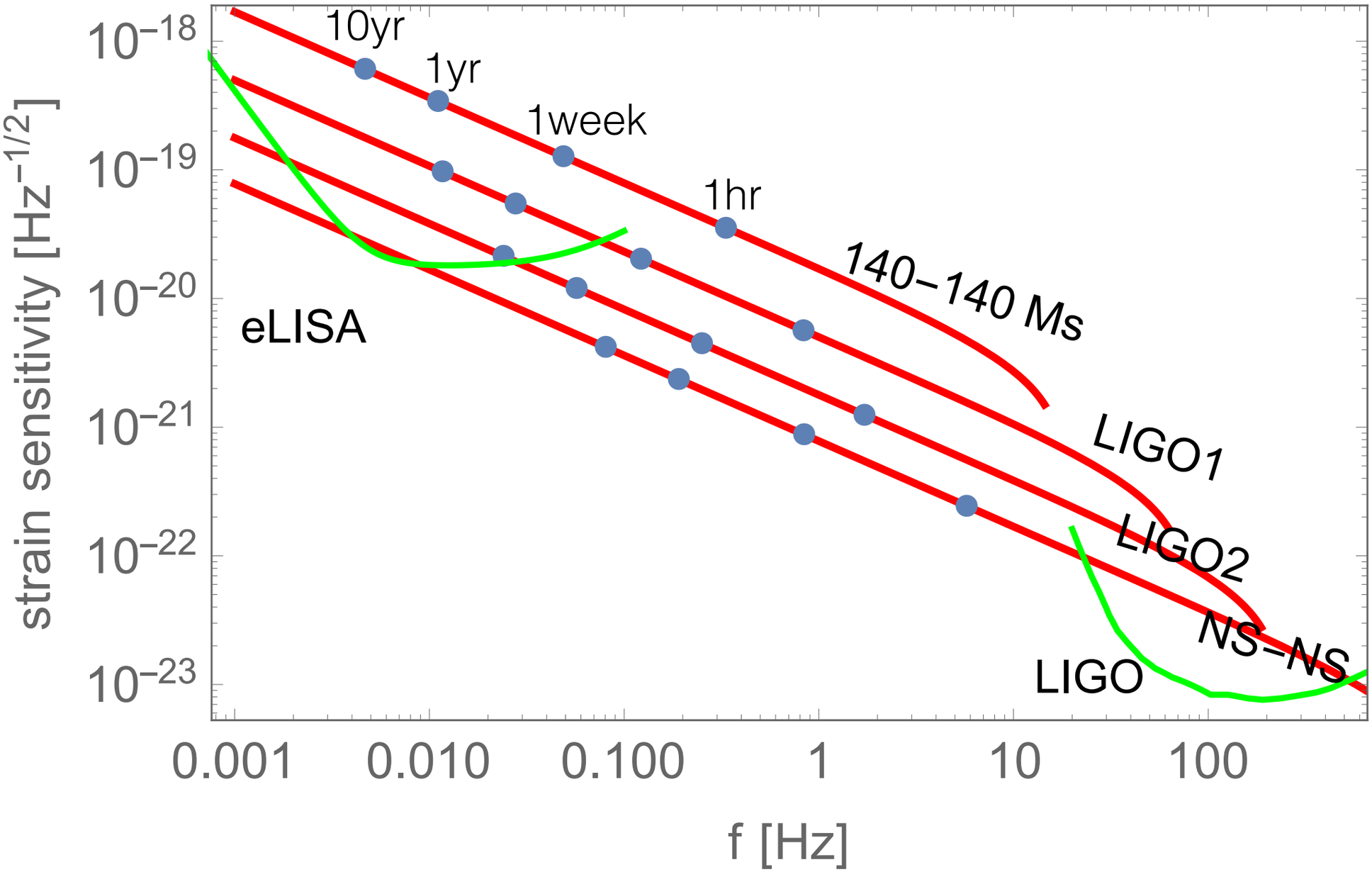
LIGO doesn't know where GW comes from! (What?!)



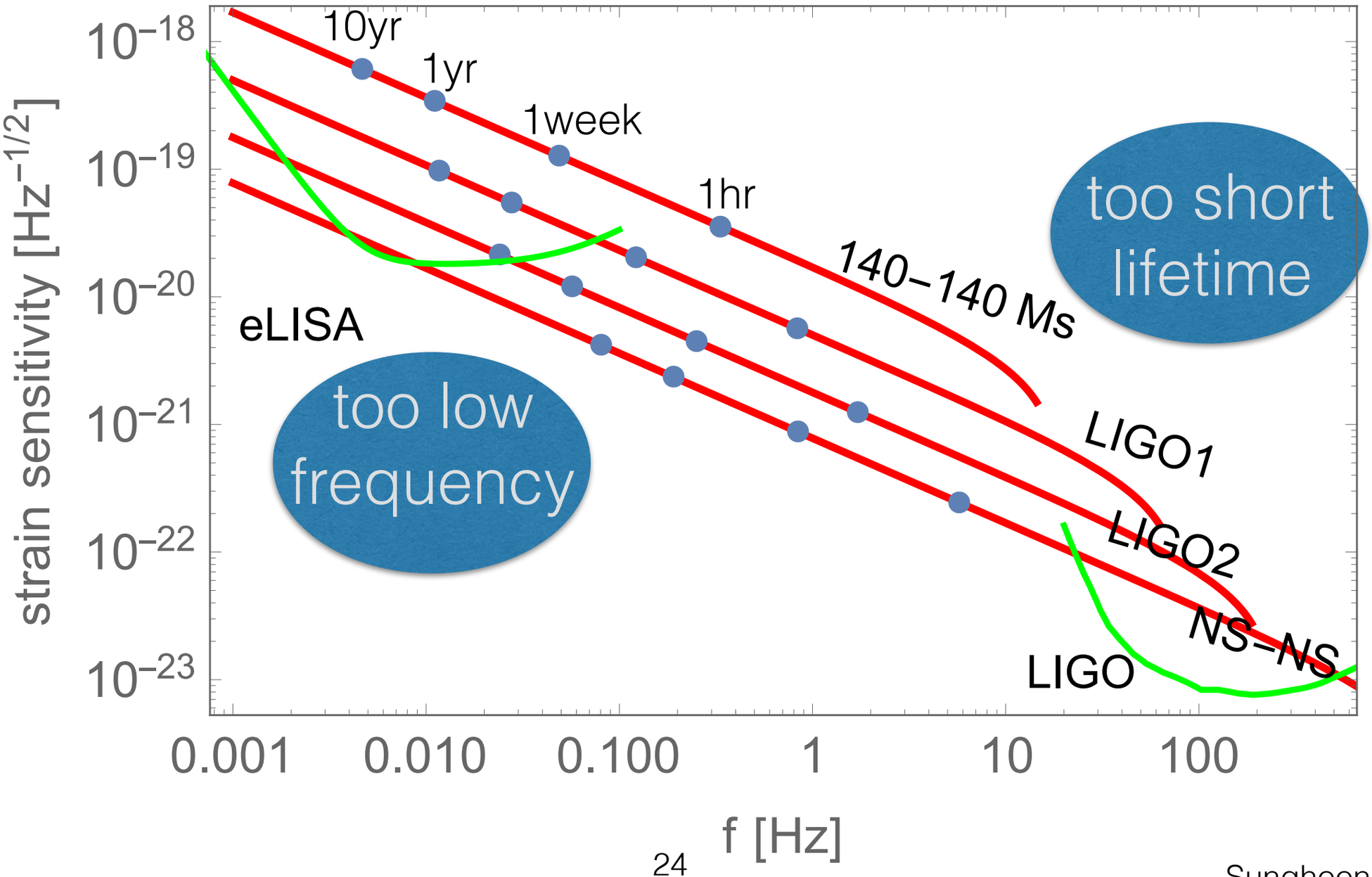


Triangulation requires one more detector, while still limited by short signal time/stat.

GW life curves



We learned that mid-frequency band
that is not being planned/developed
has an ideal balance btwn lifetime and frequency
for good localization!



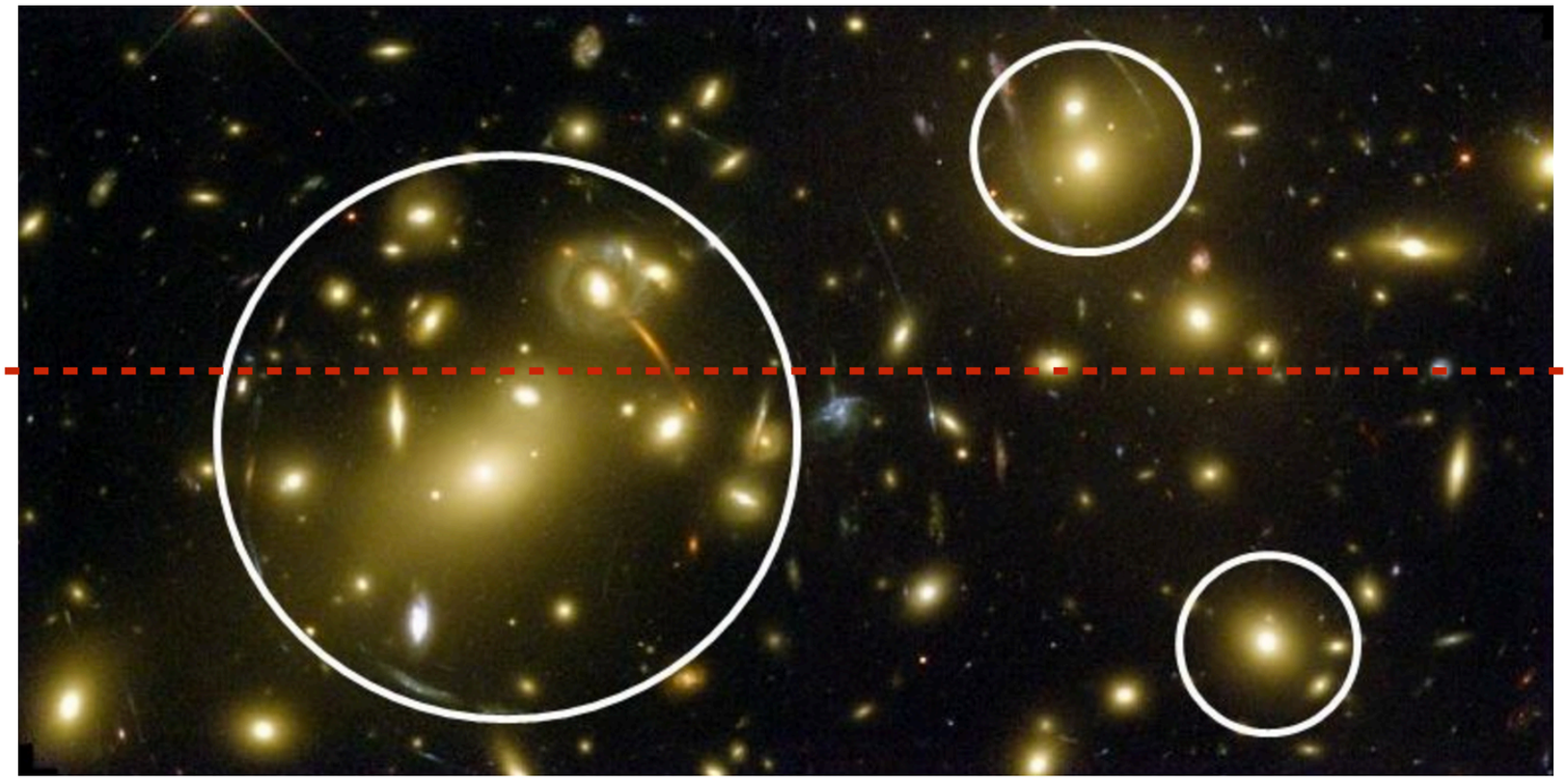
- 1+1 papers coming soon.

- Plan to follow up and apply to dark matter/cosmology (with another graduate student).

Angular Resolution of Single-Baseline Atom Interferometers for Deci-Hz Gravitational Waves

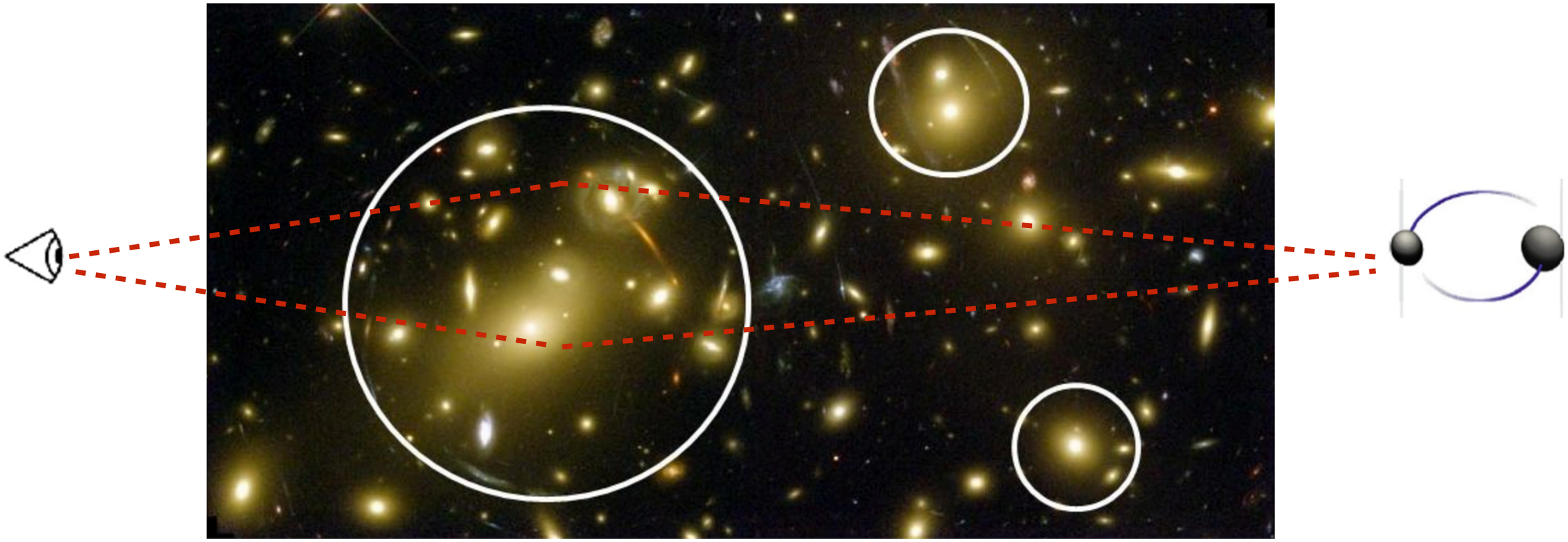
Peter W. Graham[1,*] and Sunghoon Jung[2,3,†]

One powerful example is to utilize DM's gravity



As DM sub halos move, shapiro time delay of GW would change.

Also, GW can be lensed.



We found that the lensing effect can be measured even at LIGO !

(Work with Dr. Chang Sub Shin)

Thank you