Short HW 6: Z Bump

Course: Physics 165, *Introduction to Particle Physics* (2018)
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Due by: **Thursday**, February 15

Note that this short assignment is due in class on Thursday. You have only *two days* to do it. This should be quick, I recommend doing it right after class on Tuesday.

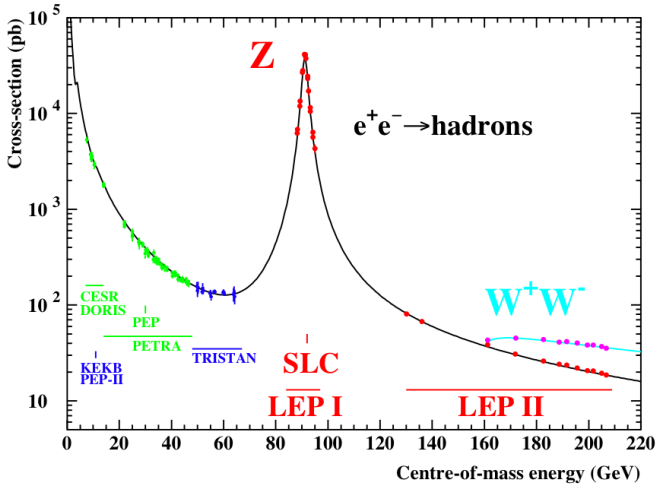
The **propagator** for a particle with four-momentum p^μ and mass M is proportional to

$$\frac{1}{p^2 - M^2 + iM\Gamma} \,. \tag{.1}$$

This means that any time you have a diagram with an internal line, the amplitude for that diagram is proportional to the above factor. The imaginary part is proportional to Γ, the **decay width** of the particle.

[**Flip**: 2/14: clarified part 2, added hint.]

Consider the following plot that combines data from the Stanford Linear Collider and the Large Electron–Positron Collider[1]:



1. What is the mass of the Z boson?
2. What is the order of magnitude of $\sqrt{M\Gamma}$? (Hint: the rate for a process goes like the amplitude times its complex conjugate.) [**Flip**: 2/14, added square root. Hint: $M^2\Gamma^2$ sets the width of the Z peak. What's a good characteristic size for this width?]
3. What is the value of the Z decay width in the PDG? (Full width.)
4. The decay width directly encodes the information of the Z boson's lifetime. Based on your above answers and dimensional analysis, estimate the lifetime of the Z boson. Answer in GeV to some power.

[1] https://arxiv.org/abs/hep-ex/0509008