Basic reference for this lecture: chapter 1 of Srednicki.

QFT arises from the marriage of special relativity and quantum mechanics.

I presented various arguments for the impossibility of single-particle relativistic quantum mechanics:

- Heuristic reasoning from $\Delta p \Delta q \sim \hbar$ and $E = mc^2$ leading to creation of particle/anti-particle pairs.

- Inconsistency of single-particle interpretation of the Dirac equation. I just mentioned this without any detail as we have not even introduced the Dirac equation yet.

  How inconsistencies arise in the single-particle interpretation of the Dirac equation is explained in detail in chapter 2 of Itzykson and Zuber.

  The history of the Dirac equation and of Dirac’s wildly creative resolution of the impasse are discussed for example in chapter 1 of Weinberg’s book. (If you like history of physics, you could also read Schweber’s great book “QED and the men who made it”). Dirac quickly realized that the single-particle interpretation of his equation was untenable and developed a multi-particle interpretation based on the “Dirac sea” and hole theory.

  While hole theory (when treated with care care) gives correct results, it is not the modern approach and is best regarded historical curiosity.

  Since after all this the single-particle interpretation of the Dirac equation is simply wrong, and Dirac’s hole theory is morally (if not technically) wrong, I do not recommend that you spend time on these topics now. After you are comfortable with the main ideas QFT, it will be instructive to go back to them.

- Argument from causality. Again, just a sketch since we have not developed the formalism yet. The causality argument is nicely discussed in chapter 1 of Banks’ book. See also section 2.1 of Peskin.

There seem to be a priori two routes towards a consistent relativistic QM:

1. Promote time $T$ to an operator $\hat{T}$, on equal footing with the familiar position operator $\hat{X}^i$ (usually called $\hat{q}^i$). In covariant language, we have $\hat{X}^\mu(\tau) = (\hat{T}(\tau), \hat{X}^i(\tau))$, where $\tau$ is proper time.

2. Demote the position operator to an ordinary label, just like time is treated in ordinary non-relativistic QM. Both time and position are labels on operators, the quantum fields $\hat{\varphi}_a(x^\mu)$, which are operator-valued functions of spacetime.
Although this is at this stage far from obvious, when properly developed the two routes are completely equivalent – using one or the other viewpoint is often a matter of taste or technical convenience. By a horrible terminology, approach 1 is sometimes called the first-quantized viewpoint, and approach 2 the second-quantized viewpoint. In both cases we are just quantizing exactly once. Approach 1 emphasizes the role of particles, approach 2 emphasizes the role of fields. Particles are quanta of fields, and fields are coherent states of quanta. Both ideas are equally fundamental, in fact they are dual to each other. (Don’t worry if you don’t follow these vague philosophical pronouncements now, hopefully you will one day). Approach 2 is the conventional one, and the most convenient in most applications, and is the one that we will follow.

I am taking for granted a working knowledge of special relativity and of the covariant formalism (manipulations with Lorentz indices, Minkowski metric etc.). Chapter 2 of Srednicki has a very quick review. If you need to brush up on this, there are many standard textbooks. For example, most general relativity books start with a review of special relativity, see e.g. the first three chapters of Schutz’ book “A first course in general relativity”.