1 For which kind of search scenarios at colliders are effective field theories (EFT) appropriate and why?

An EFT is an approximation to an underlying theory which is valid up to a certain energy cut off. An example for a EFT is the Fermi theory for beta decay, which treats the reaction as a contact interaction of four fermions without describing the W-Boson exchange. It is valid up about 100GeV. In BSM studies an EFTs are used to describe interactions with mediator masses higher than the accessible energy range. The explicit interaction mechanism is integrated out, thus an EFT is not limited to a specific mediator mechanism.

2 What is not described by an EFT?

The substructure of a particular interaction.

3 How can measurements of the width of SM bosons (e.g. Z boson) yield hints on invisible particle production?

The decay width of an unstable particle is the inverse of the mean lifetime and thus the decay rate of the particle. The total decay width Γ_{tot} is the sum of the decay rates into the different decay channels. Since the mean lifetime of an unstable particle is directly proportional to the density of final states and thus the number of allowed decay channels, the decay width also depends on the number of allowed decay channels.
The line shape of an unstable, short-lived particle resonance is described by the Breit-Wigner probability distribution. The width of this distribution is exactly the total decay width of the particle and can be measured at colliders by probing the event rate at different energies.
The invisible width of a particle is the fraction of the total decay width related to invisible decays which are not seen in our current detectors (e.g. final state neutrinos). The invisible with of a short-lived particle like the Z boson can be predicted within the standard model but also measured at colliders. If the measured and predicted widths are not compatible within the errors, there must be some other invisible decay channel of the Z boson not described by the standard model. A clear hint of physics beyond the standard model.

4 What is the advantage of searching invisible particles with initial state radiation jets at hadron colliders compared to the detection of other "recoiling" particles?

The initial state radiation (ISR) of gluons in hadron colliders (photons in lepton colliders) is well described by QCD, thus the production mechanism is understood and an additional source of uncertainties is eliminated. Reactions with invisible final states are often identified by searching for mono-jet events caused by ISR. An example of a process involving an ISR gluon is shown in figure 1. The ISR gluon recoils against the invisible final state, so the invariant mass of this invisible state can be calculated the following way (recoil mass measurement):

$$m_{inv} = \left(\sqrt{s} - E_{jet}\right)^2 - p_{jet}^2 \tag{1}$$

In this equation, E_{jet} and p_{jet} are energy and momentum of the reconstructed ISR jet and s is the center-of-mass energy. The well known mechanism of ISR reduces the error of theory calculations on the mass of the final state, allowing more precise predictions which are compared to experimental results.

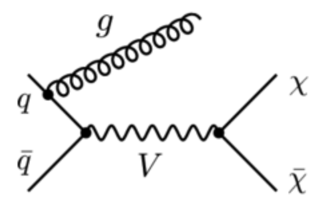

Figure 1: An example of ISR recoiling against an unknown final state. The unknown mediator particle decays into two unkown particles. If these particles are not visible, the signature in the detector is most likely a mono-jet event. The mass of the final state is calculated via the recoil mass technique.

5 How can BSM constraints from collider searches be connected to noncollider results? What do you have to keep in mind when comparing such results?

The models tested at colliders often feature the same parameters as models tested at other dark matter search experiments, e.g. the WIMP-nucleon scattering cross section at low background experiments like CRESST. The constraints obtained at colliders can be extrapolated to the energy region of complementary searches to compare constraints or even discoveries. This comparisons are heavily model dependent, so the conclusions drawn from this kind of extrapolations have to be interpreted with care and the model in mind.