Excited quark production at 100 TeV

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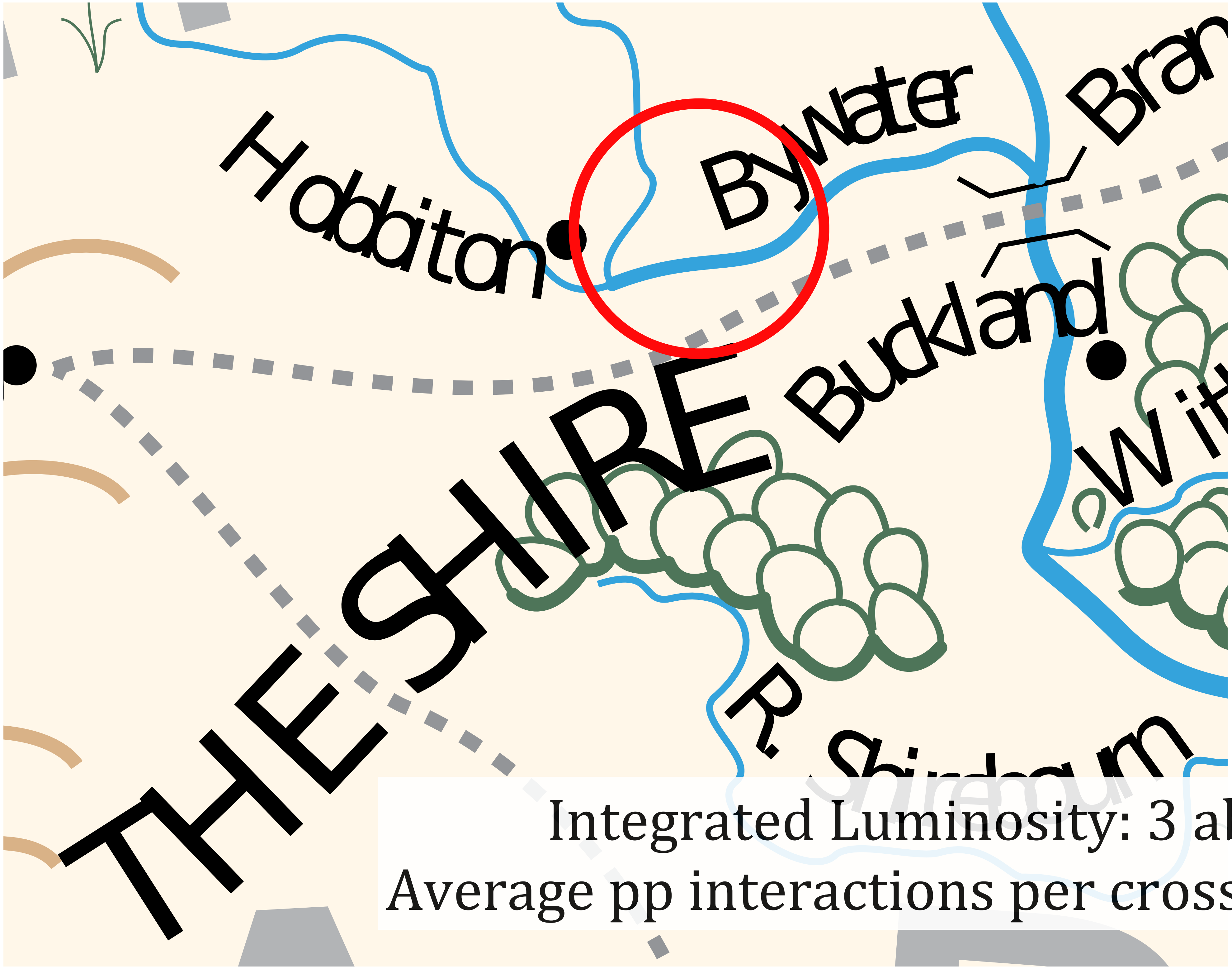
Motivation

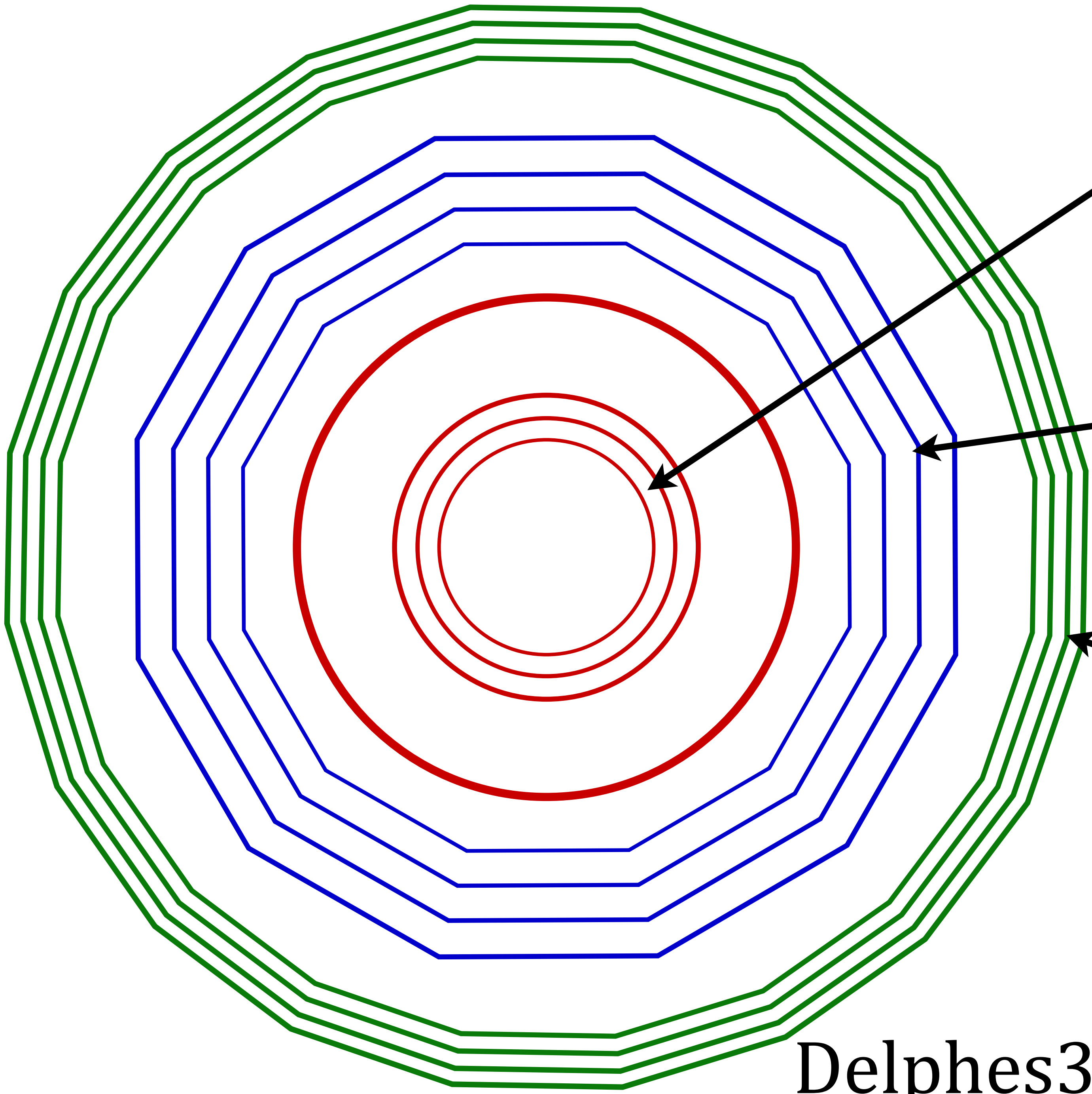
- At a hadron collider the strongly produced dijet resonance is among the first particle searches published.
- Probing quark compositeness is a natural model.
  - $1\ \text{eV}^{-1} \approx 0.2\ \mu\text{m}$ so $1\ \text{TeV}^{-1} \rightarrow 0.2 \times 10^{-18}\ \text{m}$
- Felix has already given you a better background that I can provide.

The collider



Integrated Luminosity: 3 ab^{-1}
Average pp interactions per crossing: 140

The Snowmass detector

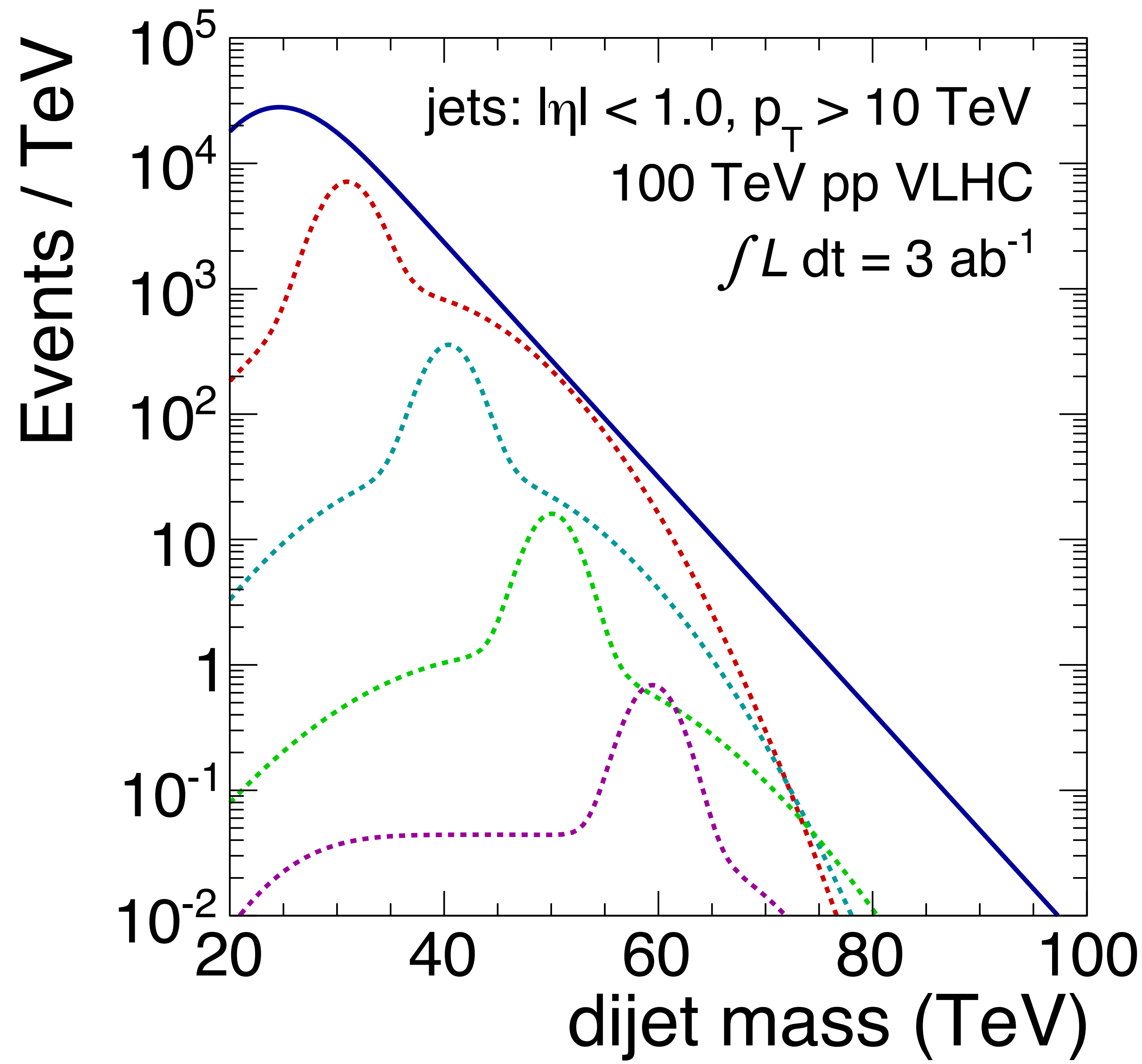


Delphes3 based detector simulation
http://arxiv.org/abs/1309.1057

Background sample

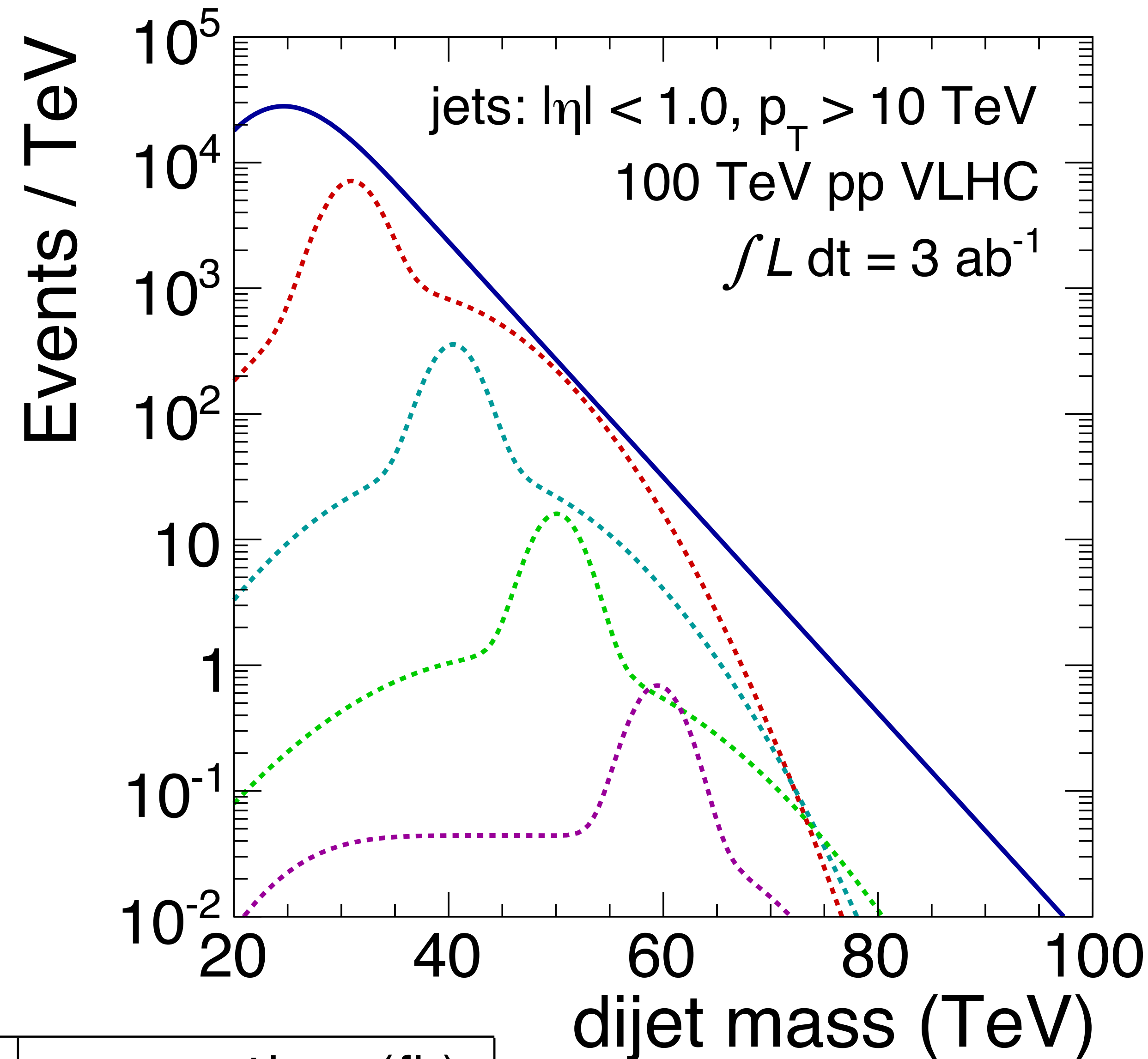
- The background is QCD dijets generated using Pythia.
- Nobody can generate 3000 fb^{-1} of QCD dijets.
  - Generated a large sample.
  - Parameterize the spectrum to scale up to the desired luminosity.
  - Selected parameterization is:

$$\mathcal{F}(m) \propto \frac{1}{2}\left(1 + \mathrm{erf}(\frac{m - m_0}{\sigma})\right) \cdot e^{-cm}$$



Signal sample

- The signal is also generated using Pythia.
- I use the convention $\Lambda = m_{q^*}$.
- These spectra are also parameterized using a Gaussian peak and a wide shape.

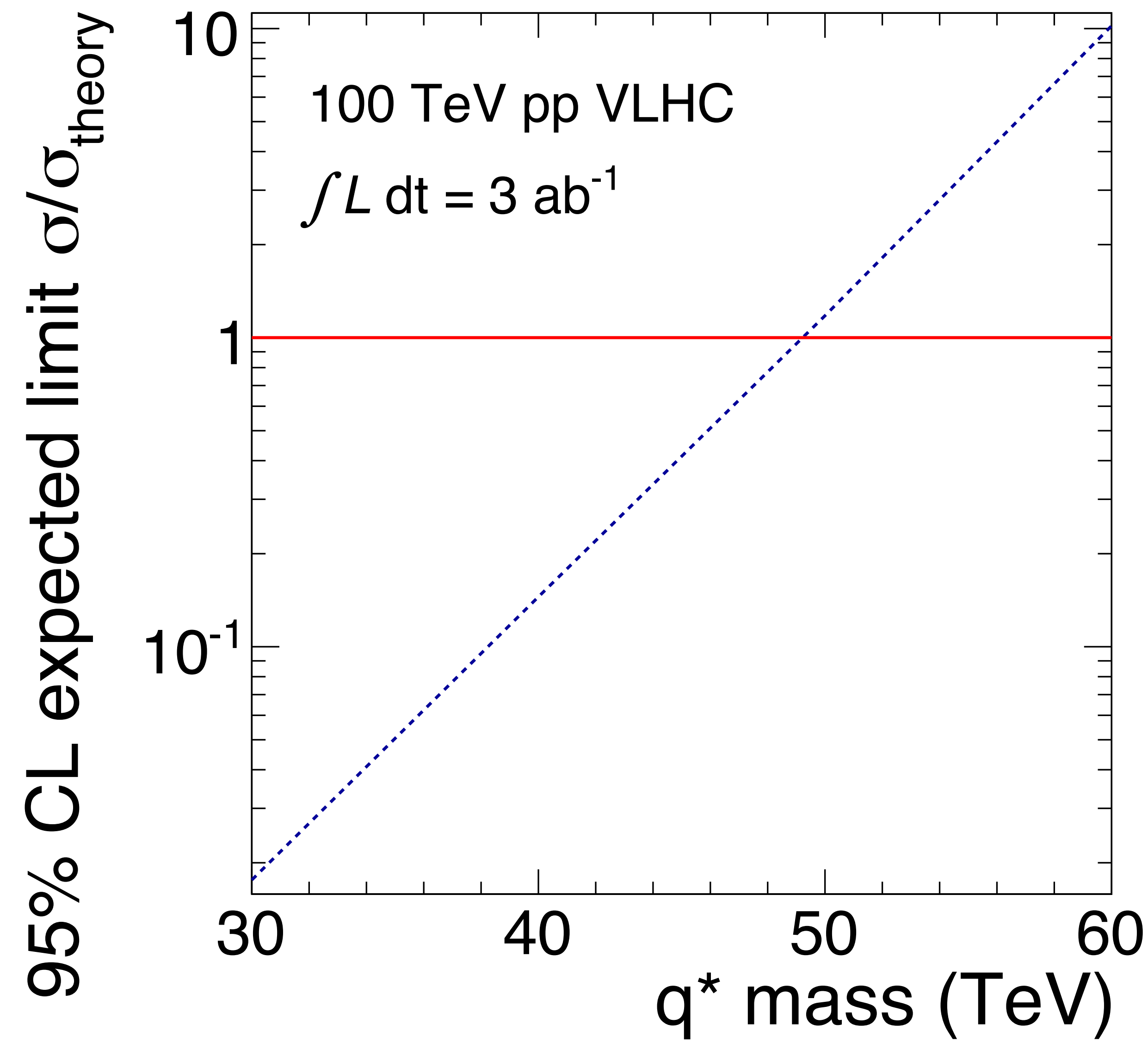



```
MSEL=0
MSUB(147)=1
MSUB(148)=1
MSUB(167)=1
MSUB(168)=1
PMAS(C4000001,1)=mq*
PMAS(C4000002,1)=mq*
RTCM(41)=mq*
RTCM(43)=1.0
RTCM(44)=1.0
RTCM(45)=1.0
```

q^* mass	cross-sections (fb)
30 TeV	22.8
40 TeV	0.986
50 TeV	4.38×10^{-2}
60 TeV	2.22×10^{-3}

Analysis

- Select the two highest p_t jets in the event and form the invariant mass.
  - $p_{t,jets} > 10$ TeV
  - $|\eta| < 1.0$
- In a 2σ window of the peaking portion of the signal count the number of expected signal and background events.
- Determine asymptotic limits using only the Poisson distributions.
- Systematic errors are not considered.



Results

- At 95% CL, one could exclude q* masses up to almost 50 TeV.
  - This is probing the structure of quarks down to 4×10^{-21} m.
- More advanced analysis methods would likely be able to offset the degradations in the limit due real systematic errors.