

The Particles

What is a Ξ (Cascade) Baryon?

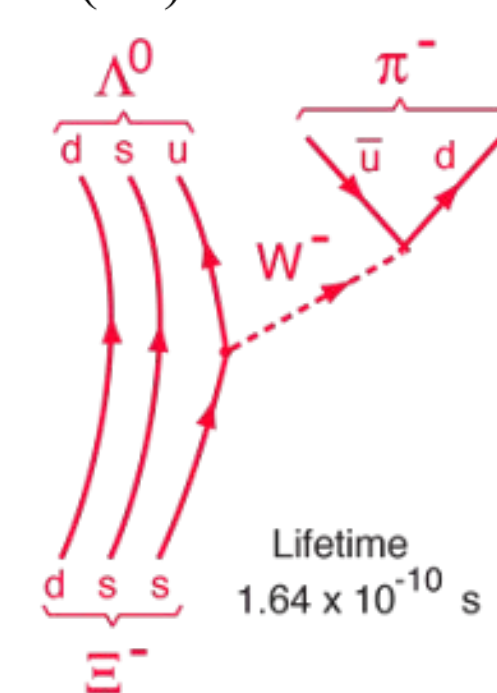
| | I | II | III |
|--------|--------------------------------|---------------------------------|----------------------------------|
| mass | $\approx 2.16 \text{ MeV}/c^2$ | $\approx 1.273 \text{ GeV}/c^2$ | $\approx 172.57 \text{ GeV}/c^2$ |
| charge | $\frac{2}{3}$ | $\frac{2}{3}$ | $\frac{2}{3}$ |
| spin | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ |
| | u up | c charm | t top |
| | d down | s strange | b bottom |

Baryon: Particle containing 3 quarks such as:

- proton (uud)
- neutron (ddu)
- Ξ^- (ssd)

Meson: Particle containing a quark anti-quark pair such as:

- π^0 ($\frac{1}{\sqrt{2}} [u\bar{u} - d\bar{d}]$)
- K^+ ($u\bar{s}$)



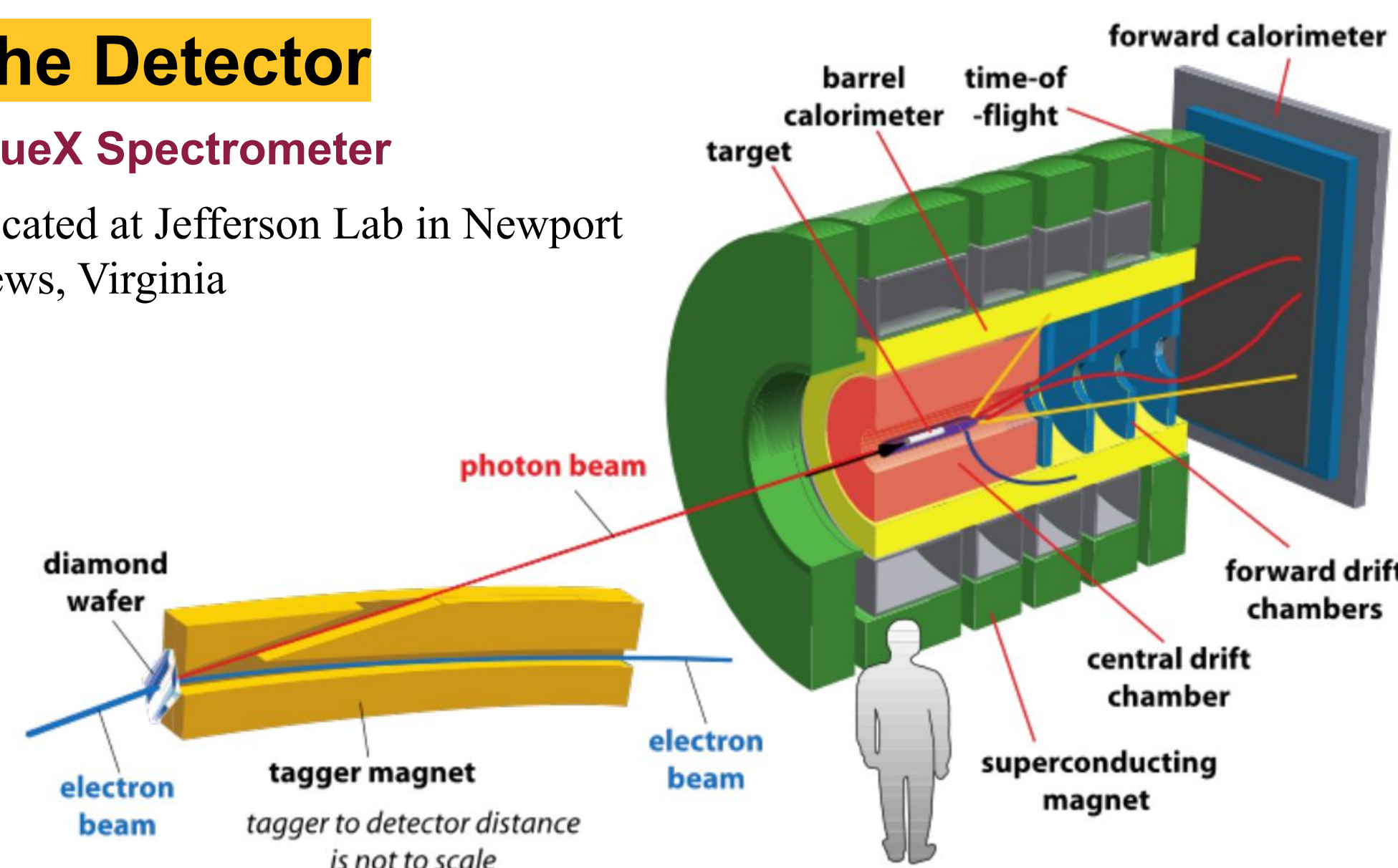
$\gamma p \rightarrow K^+ K^+ \Xi^{*+}$,
where $\Xi^{*+} \rightarrow \Xi^+ \pi^0$,
and $\Xi^+ \rightarrow \Lambda \pi^+$,
 $\Lambda \rightarrow p \pi^-$

Reaction producing a doubly-strange cascade baryon and its subsequent decays (with Feynman diagram for Ξ decay).

The Detector

GlueX Spectrometer

Located at Jefferson Lab in Newport News, Virginia



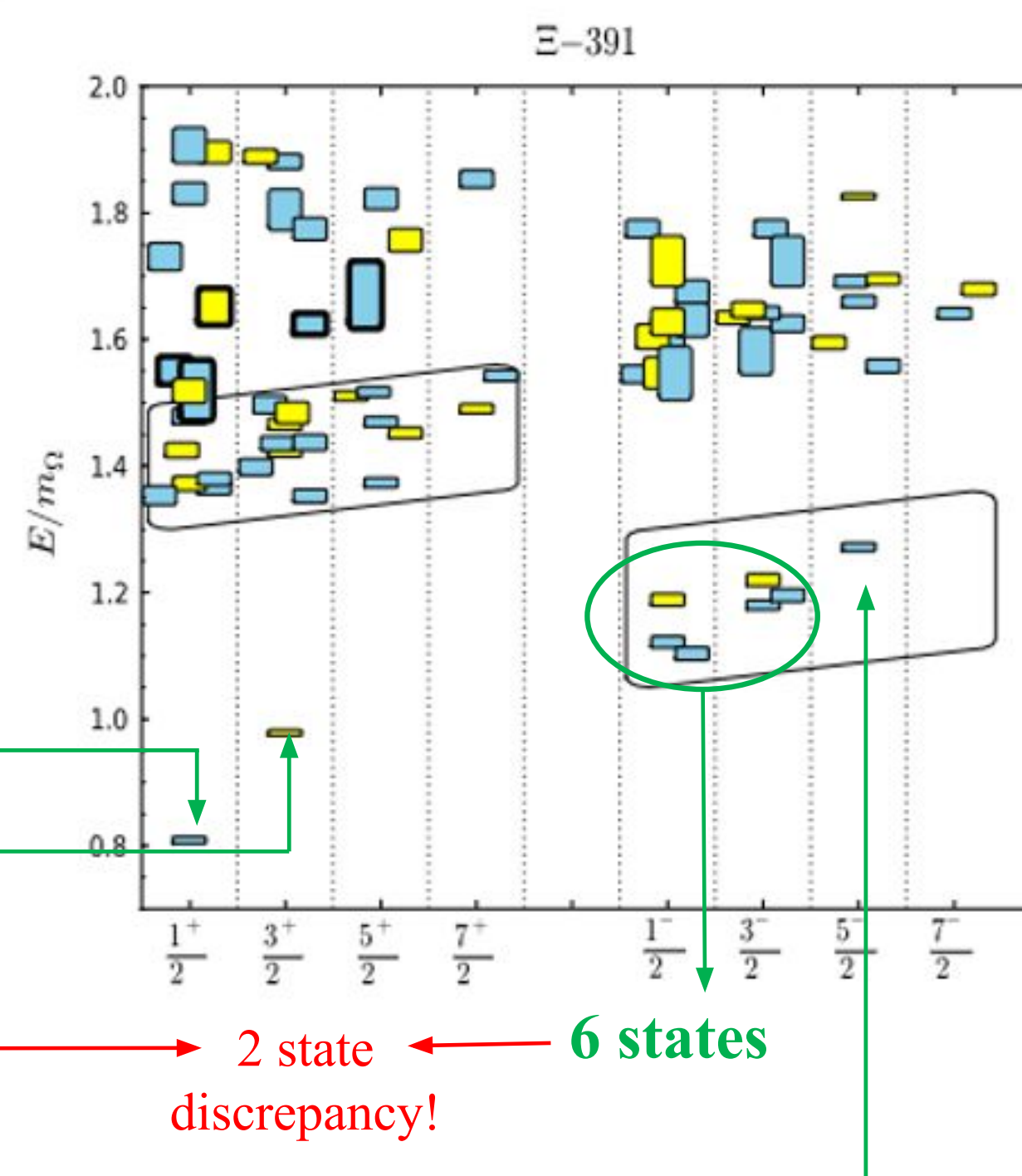
- Tagger uses bremsstrahlung (braking radiation) to produce photon
- Beam target consists of liquid hydrogen
- Start counter and time-of-flight give timing information
- Central (CDC) and forward (FDC) drift chambers provide charged particle tracking
- Barrel (BCAL) and forward (FCAL) calorimeters detect neutral particles

Theory

Lattice QCD Approach

- The PDG (Particle Data Group) measures 7 low-lying states
- Lattice QCD (Quantum Chromodynamics) predicts 9 low-lying states [1]

| PDG | J, P |
|-------------|---------------|
| Ξ | 1/2, + |
| $\Xi(1530)$ | 3/2, + |
| $\Xi(1620)$ | ?, ? |
| $\Xi(1690)$ | ?, ? |
| $\Xi(1820)$ | 3/2, - |
| $\Xi(1950)$ | ?, ? |
| $\Xi(2030)$ | $\geq 5/2, ?$ |

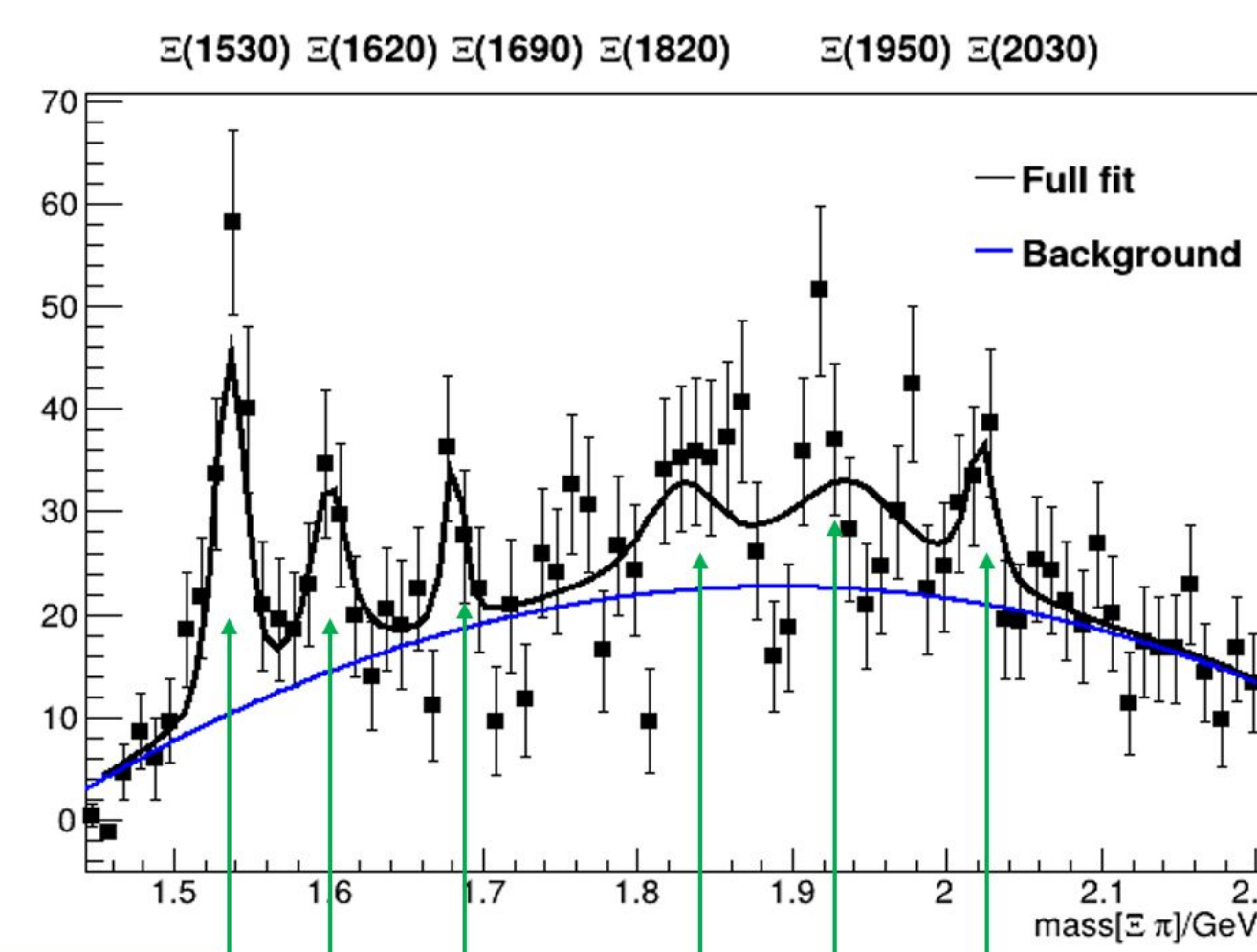


- Mass of pion at 391 MeV/c^2 (physical: 139 MeV/c^2)
- Slanted box regions contain states consistent with quark model calculations

Results

- Curve fitting using voigtians with 2nd degree polynomial background
- σ smear range = 5-15 MeV
- Centers and widths of each Ξ allowed to vary within PDG limits

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Literature Cited

[1] R. G. Edwards, N. Mathur, D. G. Richards and S. J. Wallace, Flavor structure of the excited baryon spectra from lattice QCD, Phys. Rev. D 87 (2013), p. 054506, URL: <https://link.aps.org/doi/10.1103/PhysRevD.87.054506>

Results (continued)

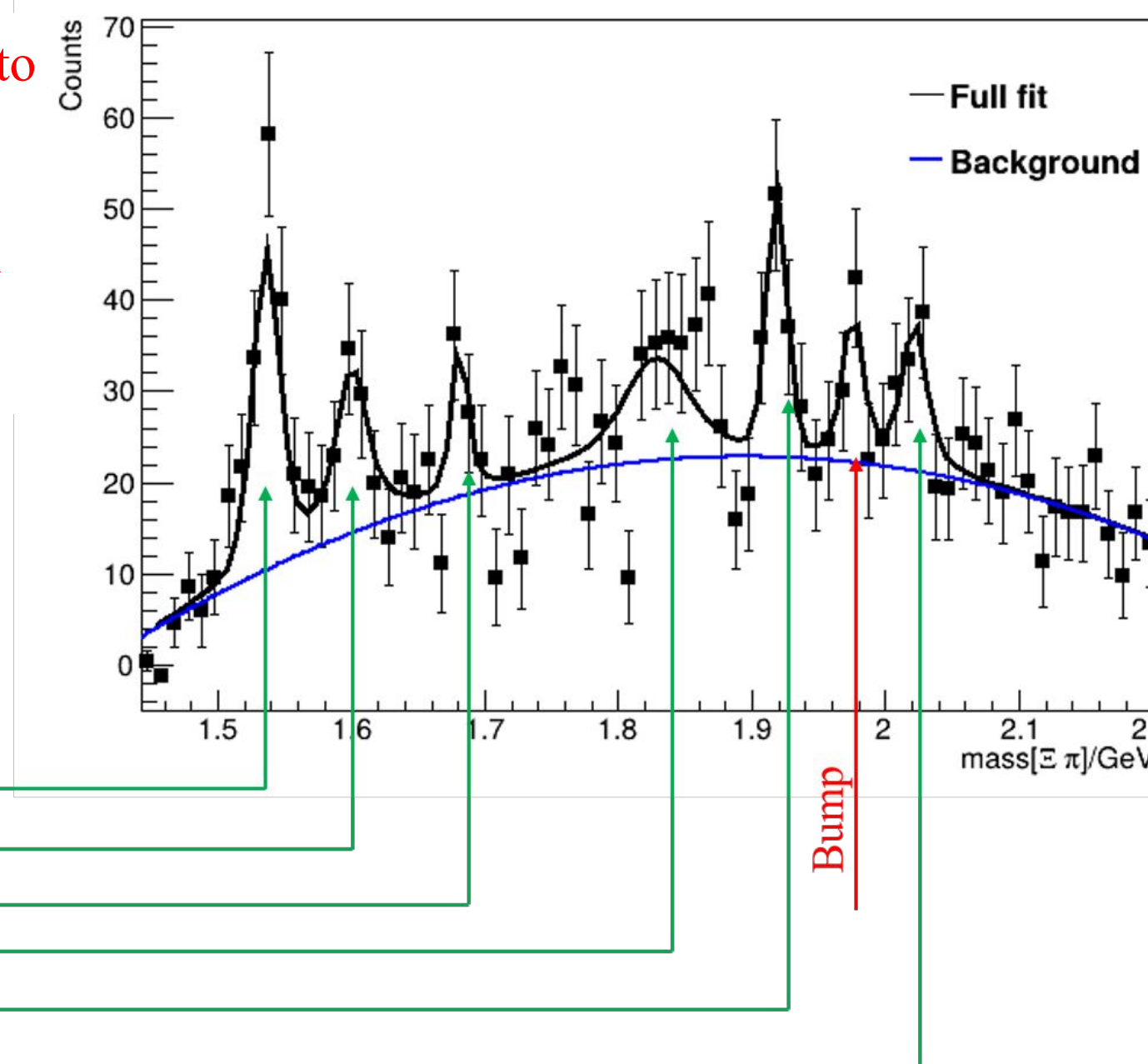
Citation: S. Navas et al. (Particle Data Group), Phys. Rev. D 110, 030001 (2024) and 2025 update

$\Xi(1950)$

$I(J^P) = \frac{1}{2}(??)$ Status: ***

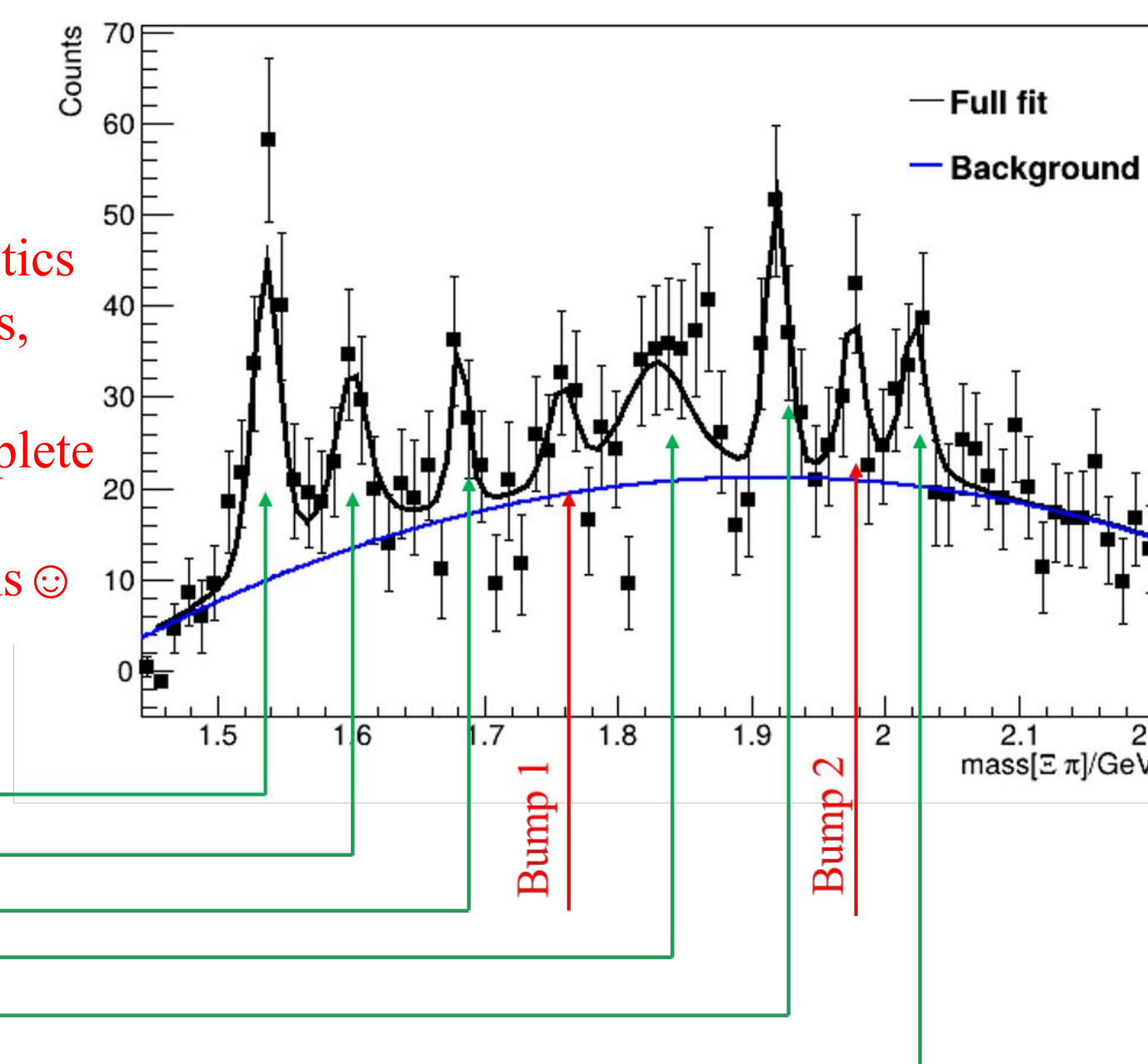
We list here everything reported between 1875 and 2000 MeV. The accumulated evidence for a Ξ near 1950 MeV seems strong enough to include a $\Xi(1950)$ in the main Baryon Table, but not much can be said about its properties. In fact, there may be more than one Ξ near this mass.

- $\Xi(1950)$ split into two separate peaks.
- Additional peak labelled as a "Bump".



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- Additional bump added at $\sim 1760 \text{ MeV}/c^2$
- Not enough statistics to promote bumps, but they could conceivably complete lowest box in the LQCD predictions ☺



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