Breit-Wigner for Resonance

If there is only a single resonance present and all relevant thresholds are far away, then one may replace $\Gamma_R(s)_{\rm tot}$ with a constant, $\Gamma_{\rm BW}$. Under these conditions also the real part of Σ is a constant that can be absorbed into the mass parameter and Eq. (46.15) simplifies to

$$\mathscr{M}_{ba}^{\rm pole}\Big|_{N=1} = -\frac{g_b\, g_a}{s - M_{\rm BW}^2 + i\sqrt{s}\,\Gamma_{\rm BW}}\ , \tag{46.22}$$

which is the standard Breit–Wigner parametrization. For a narrow resonance it is common to replace $\sqrt{s}$ by $M_{\rm BW}$. If there are nearby relevant thresholds, $\Gamma_{\rm BW}$ needs to be replaced by $\Gamma(s)$. For two–body decays one writes

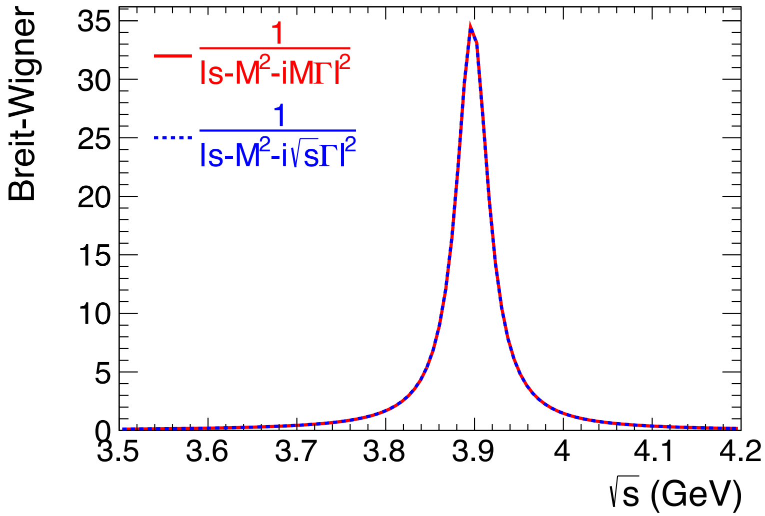
$$\Gamma(s) = \sum_c \Gamma_{R\to c}\left(\frac{q_c}{q_{R\,c}}\right)^{2L_c+1}\left(\frac{F_{L_c}(q_c, q_o)}{F_{L_c}(q_{R\,c}, q_o)}\right)^2\ , \tag{46.23}$$

where $q_{R\,c} = q(M_{\rm BW})_c$ denotes the decay momentum of resonance R into channel c. The Breit-Wigner parameters $M_{\rm BW}$ and $\Gamma_{\rm BW}$ agree with the pole parameters only if $M_R\Gamma(M_R) \ll M_{\rm thr.}^2 - M_R^2$, with $M_{\rm thr.}$ for the closest relevant threshold. Otherwise the Breit-Wigner parameters deviate from the pole parameters and are reaction dependent.

Ref: PDG

Breit-Wigner for Resonance

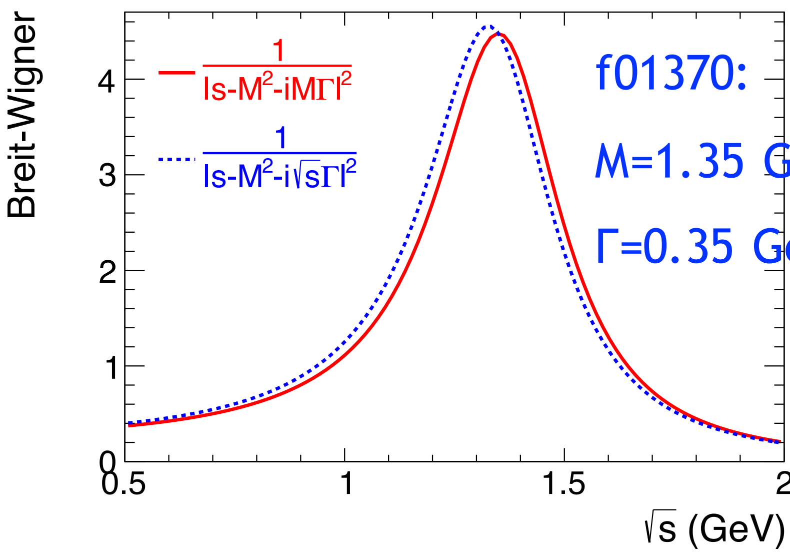
Constant width



Zc(3900)

M=3.8976 GeV

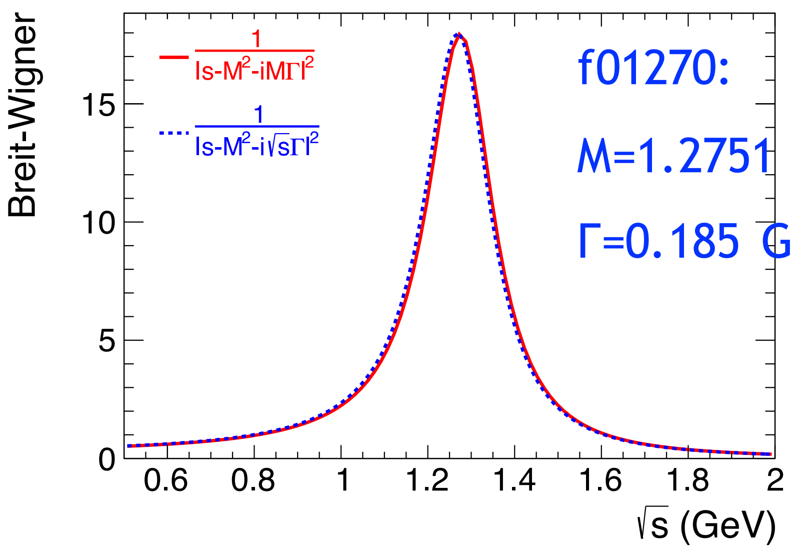
Γ=0.0435 GeV



f01370:

M=1.35 GeV

Γ=0.35 GeV



f01270:

M=1.2751 GeV

Γ=0.185 GeV

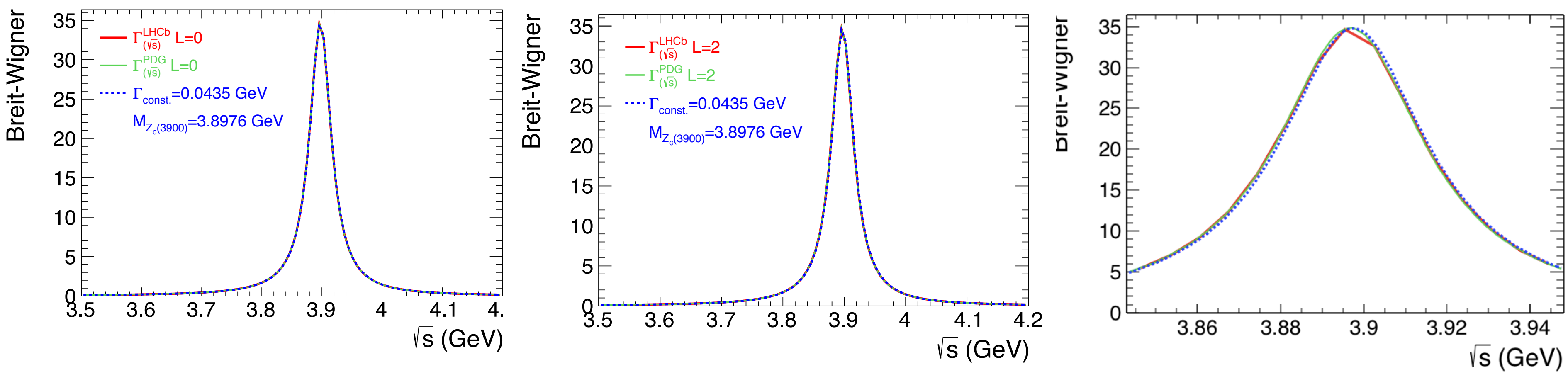
Breit-Wigner for Resonance

Ref: LHCb arXiv1606.07898

$$BW(m|M_0,\Gamma_0) = \frac{1}{M_0^2 - m^2 - iM_0\Gamma(m)},$$

is the Breit–Wigner amplitude including the mass-dependent width,

$$\Gamma(m) = \Gamma_0 \left(\frac{q}{q_0}\right)^{2L_A+1} \boxed{\frac{M_0}{m}} B'_{L_A}(q,q_0,d)^2 .$$



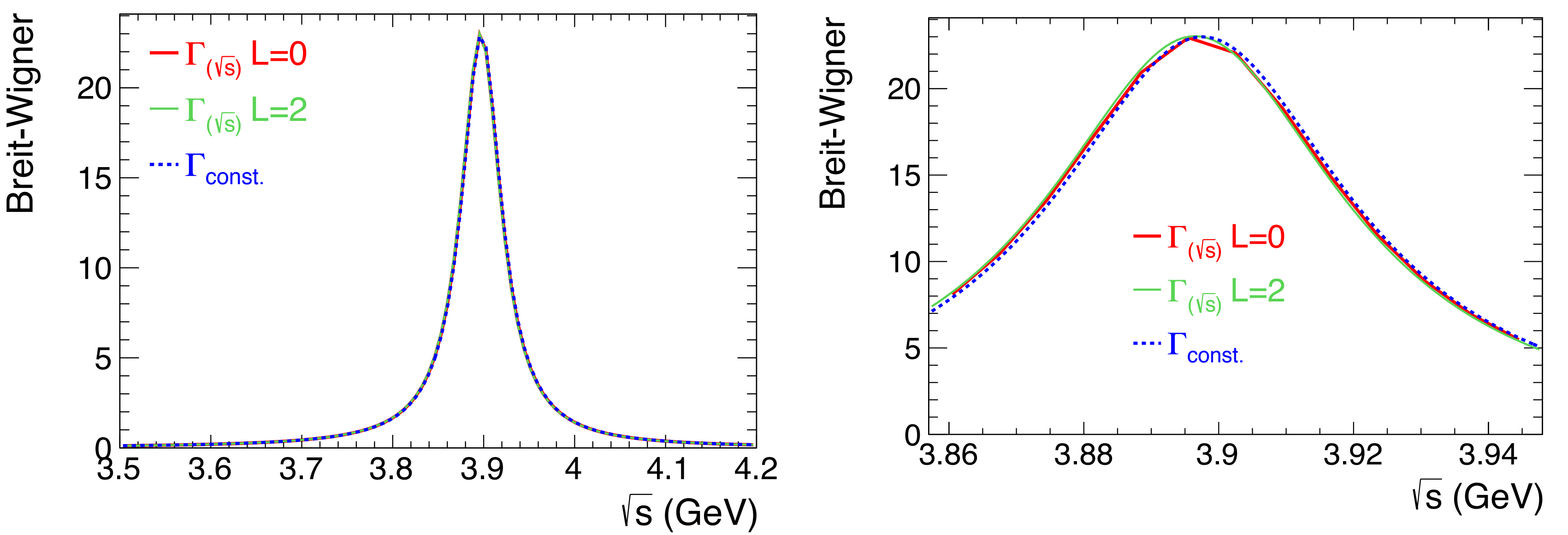
- Different definitions of BW have negligible effects on $Z_c(3900)$

Breit-Wigner for $Z_c(3900)$

Ref: LHCb

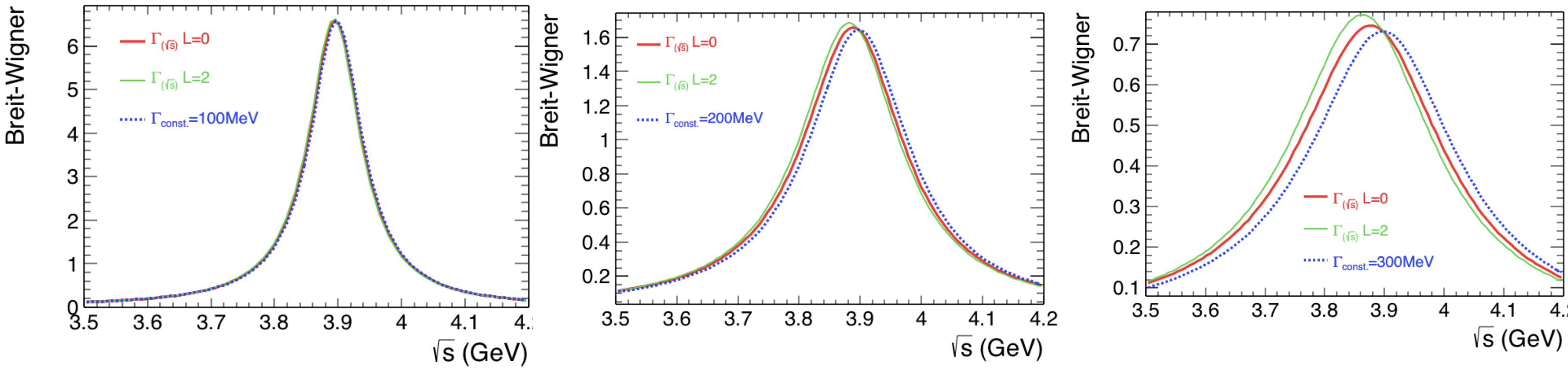
- L=0 or L=2 differences can be negligible for Z_c

M=3.8976 GeV, Γ=0.0435 GeV

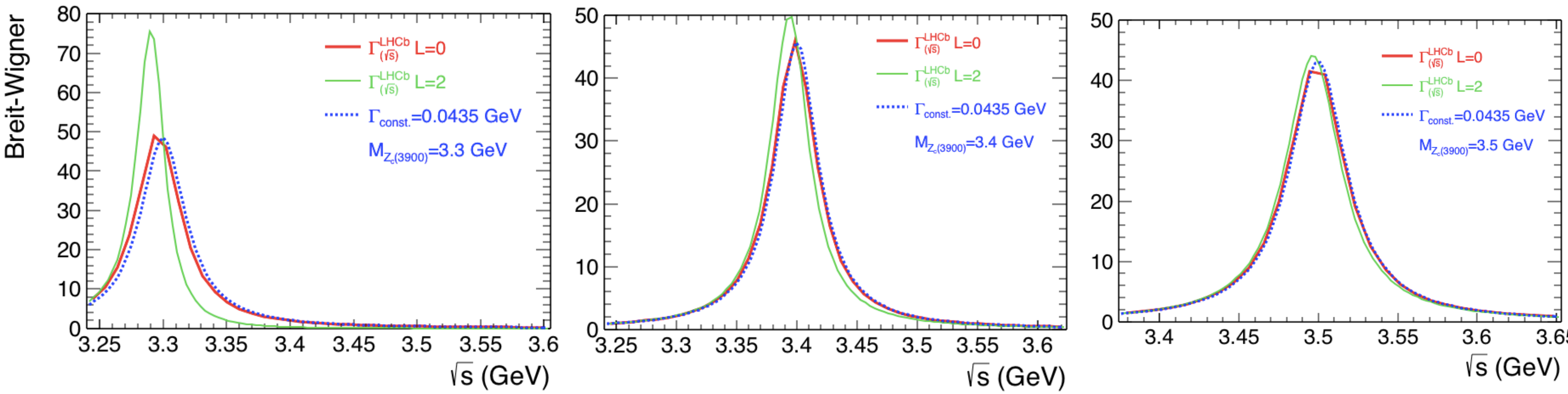


Breit-Wigner for $Z_c(3900)$

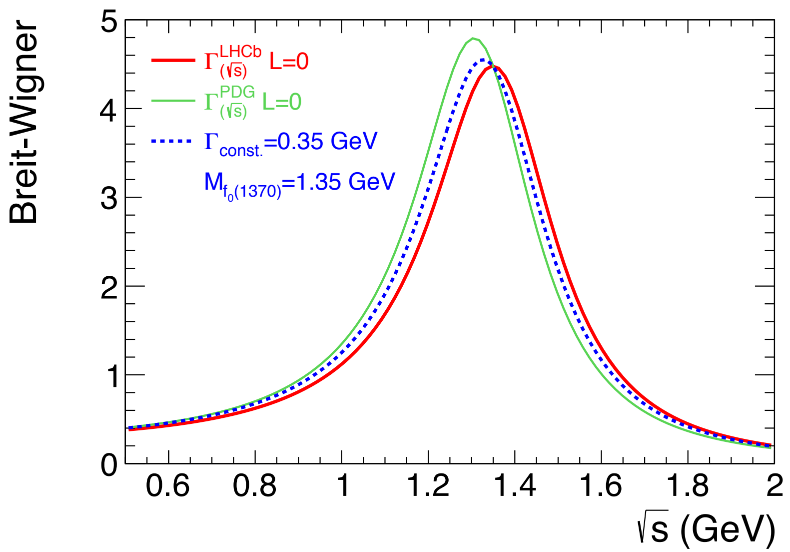
- M=3.8976 GeV, change width to 100, 200, 300 MeV



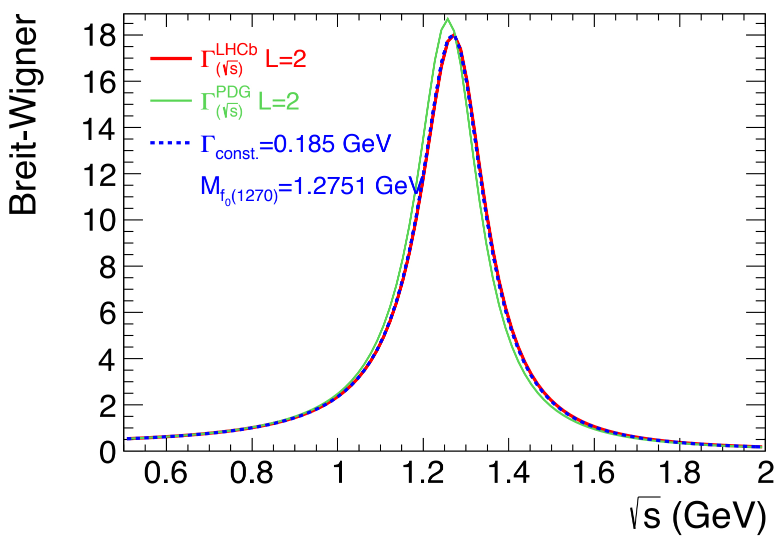
- Γ=0.0435 GeV, change Mass to 3.3, 3.4, 3.5 GeV

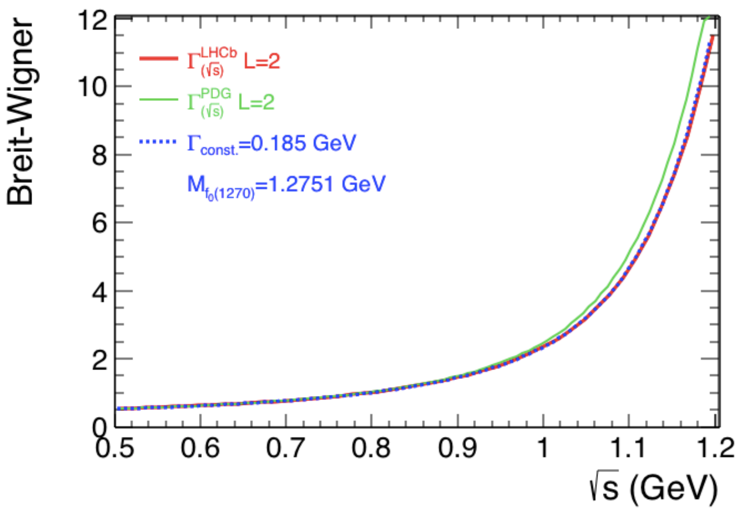


Breit-Wigner for $f_0(1370)$ & $f_2(1270)$



- Compare the different definitions of mass-dependent width with constant width





Parameterization of intermediates

Discuss with Ronggang:

He used BW of constant-width for Z_c, $f_0(1370)$, $f_2(1270)$

$$BW(s) = \frac{1}{s - M_0^2 + iM_0\Gamma}$$

$f_0(1370)$ J/ψ :

- Mass=1.350GeV, width=0.350GeV
- use mass-dependent BW as systematic uncertainty

- $f_2(1270)$ J/ψ
- Mass=1.271 GeV, width=0.1850GeV
- Use mass-dependent BW as systematic uncertainty

Systematic uncertainties sources

- Cross section measurement
  - Tracking… efficiency
  - kinematic fit
  - fit to $M(l^+l^-)$, $M(\pi^0 J/\psi)$
- PWA:
  - Data preparation, signal & sideband region…
  - For each amplitude, parameterizations