Resonance production with a quark coalescence type model

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Outlook

- Experimental data on resonances
- Quark coalescence models
- How to include resonances?
- Invariant mass spectrum
- Parity questions
- Results
- Expected yields
- Summary

Resonance measurements

- NA49
  - data on K*(892), Λ(1520), ϕ(1020)
  - resonance yields differ from thermal model predictions (difference increases with increasing widths)
    P.Seyboth QM08, Monday
- RHIC
  - data on ρ(770), K*(892), ϕ(1020), Σ*(1385),
    Ξ*(1530), Λ(1520), . . .

Hadronization – Quark coalescence

- Fast hadronization process
- v_2 scaling ~ valence quark scaling ~ quark coalescence
- ALCOR (Bíró, Lévai, Zimányi 1995)
  - describes hadron yields at SPS and RHIC
- MICOR (Csizmadia, Lévai 1999)
  - describes p_T spectra for hadrons
- Recombination models
  - Hwa, Yang; Greco, Ko, Lévai; Fries, Müller, Bass ...

MICOR

- Microscopic rehadronization
- Quantum mechanics based:
  - $$g_{gh} = V_g \frac{-M_{h,Q'}}{2\pi} \int d^3\vec{x}_1 d^3\vec{x}_2 \cdot \tilde{\Psi}^*(\vec{x}_1, \vec{x}_2) V(\vec{x}_1 - \vec{x}_2) \phi_1(\vec{x}_1) \phi_2(\vec{x}_2)$$
- Prehadron production rate:
  - $$\langle \sigma^h v \rangle = \frac{\int d^3\vec{p}_1 d^3\vec{p}_2 \cdot f_q(m_1, \vec{p}_1) f_q(m_2, \vec{p}_2)(\sigma(k) v_{12})}{\int d^3\vec{p}_1 d^3\vec{p}_2 \cdot f_q(m_1, \vec{p}_1) f_q(m_2, \vec{p}_2)}$$
- Need quasi-particle momentum distribution!
- Prehadron --> Hadron
- Makes only the meson octet and the baryon decuplet
- Protons, pions, ... came from the decays

Could we add resonances to MICOR?

- Resonance <--> higher mass
- MICOR hadron mass:
  - $M_h = m_{q1} + m_{q2}$
- Production rate will increase with the mass
  - $M_h \sim g_{gh} \quad => \quad <\sigma v> \sim |g_{gh}|^2 \sim M_h^{\,2}$
- Production rate will increase with the mass

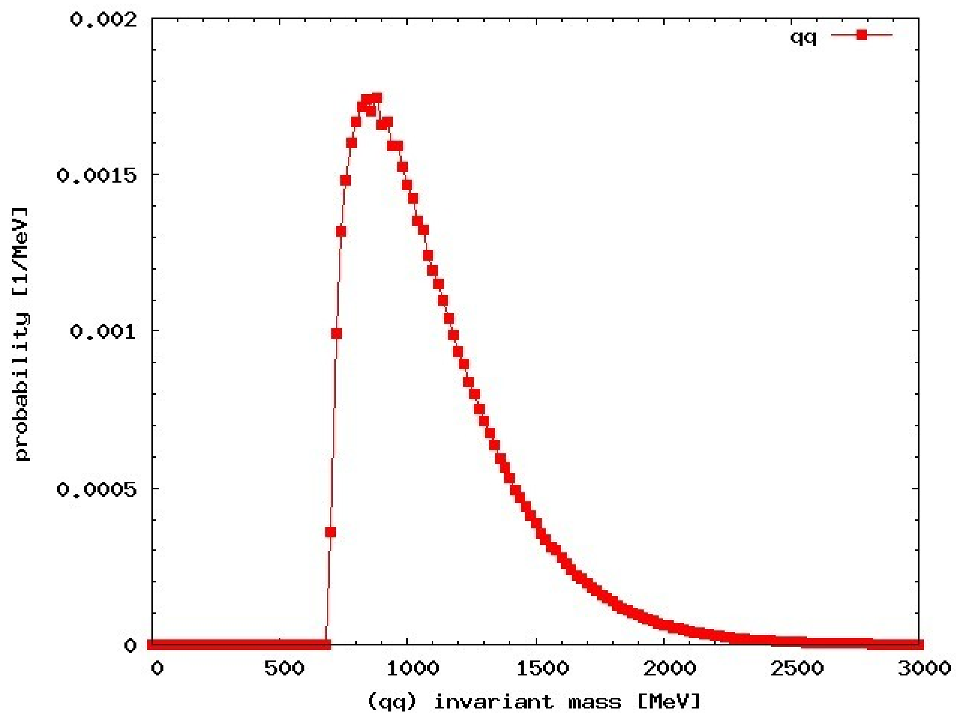
  => too sensitive to high energy resonances

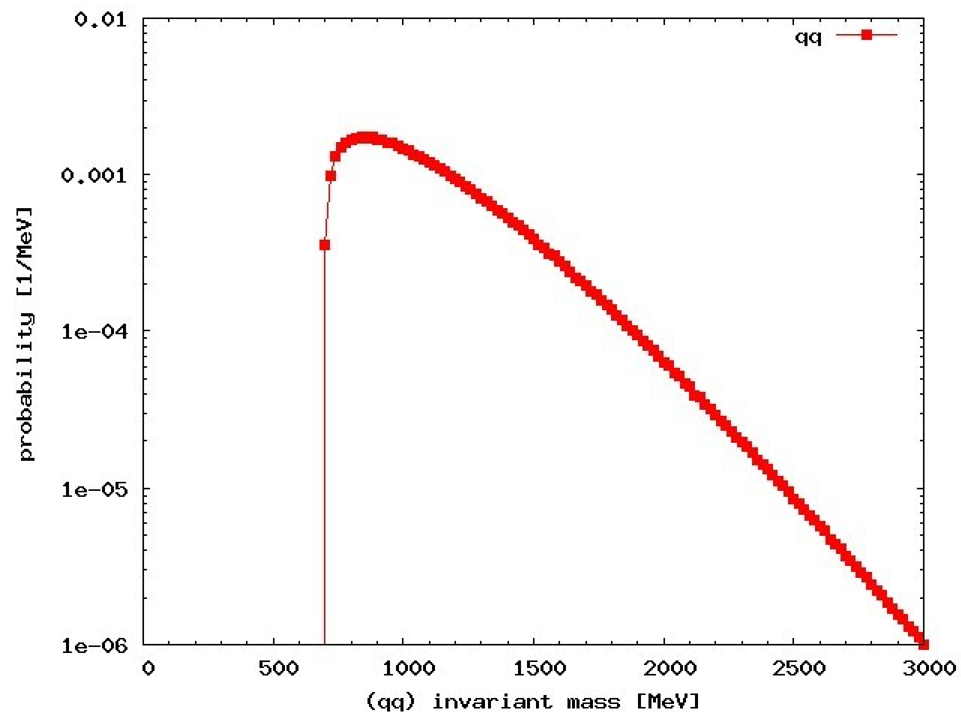
  (proper decays, mass, width; still unknown reson.)
- Solution : use the real relativistic kinematics!

  Thus we can obtain higher invariant masses

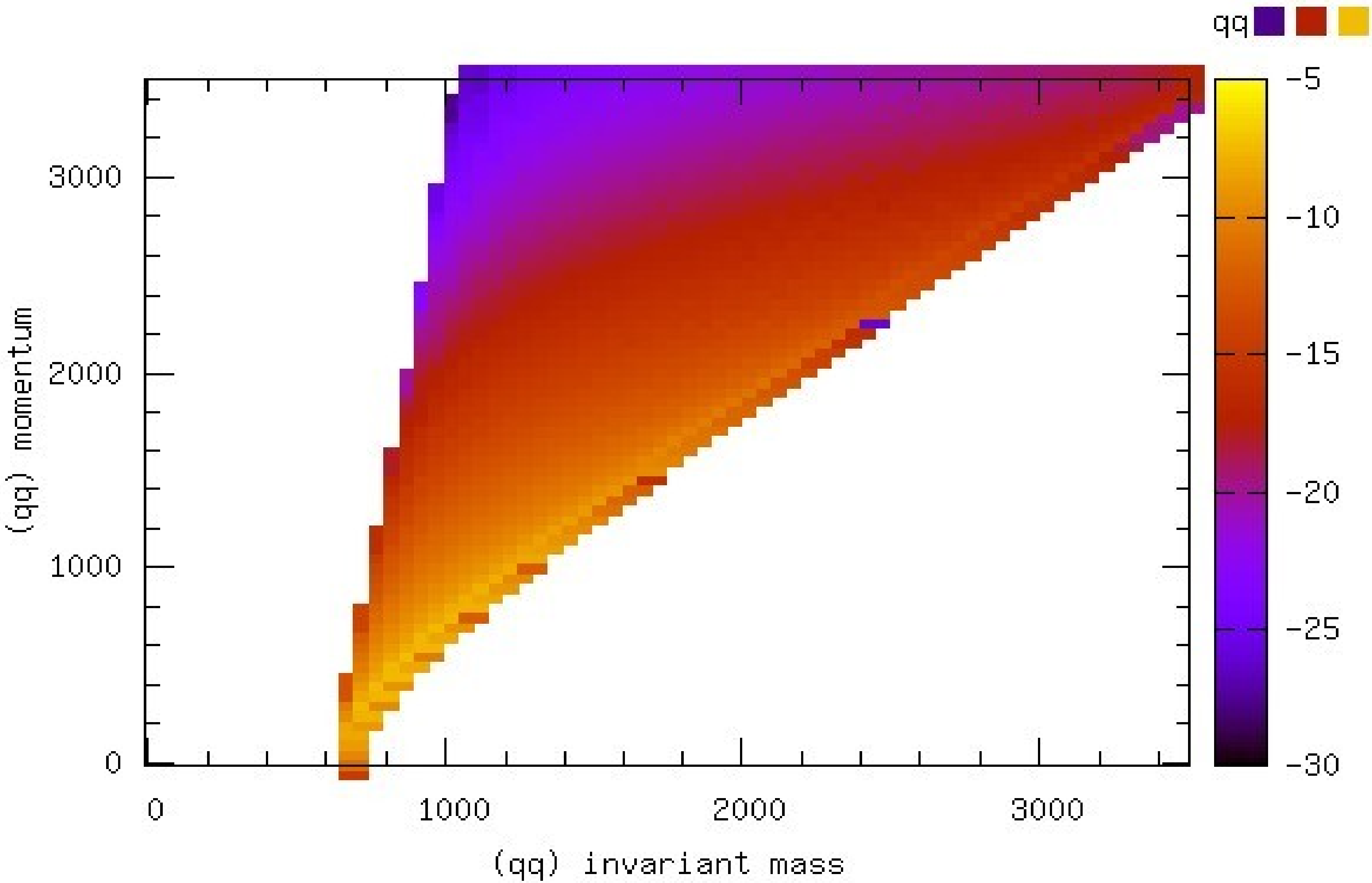
Invariant mass

- Massive quasi-particle collision: $M_{qq}=||p_1^{\mu}+p_2^{\mu}||$
- Need initial quark momentum distribution (Jüttner d.)

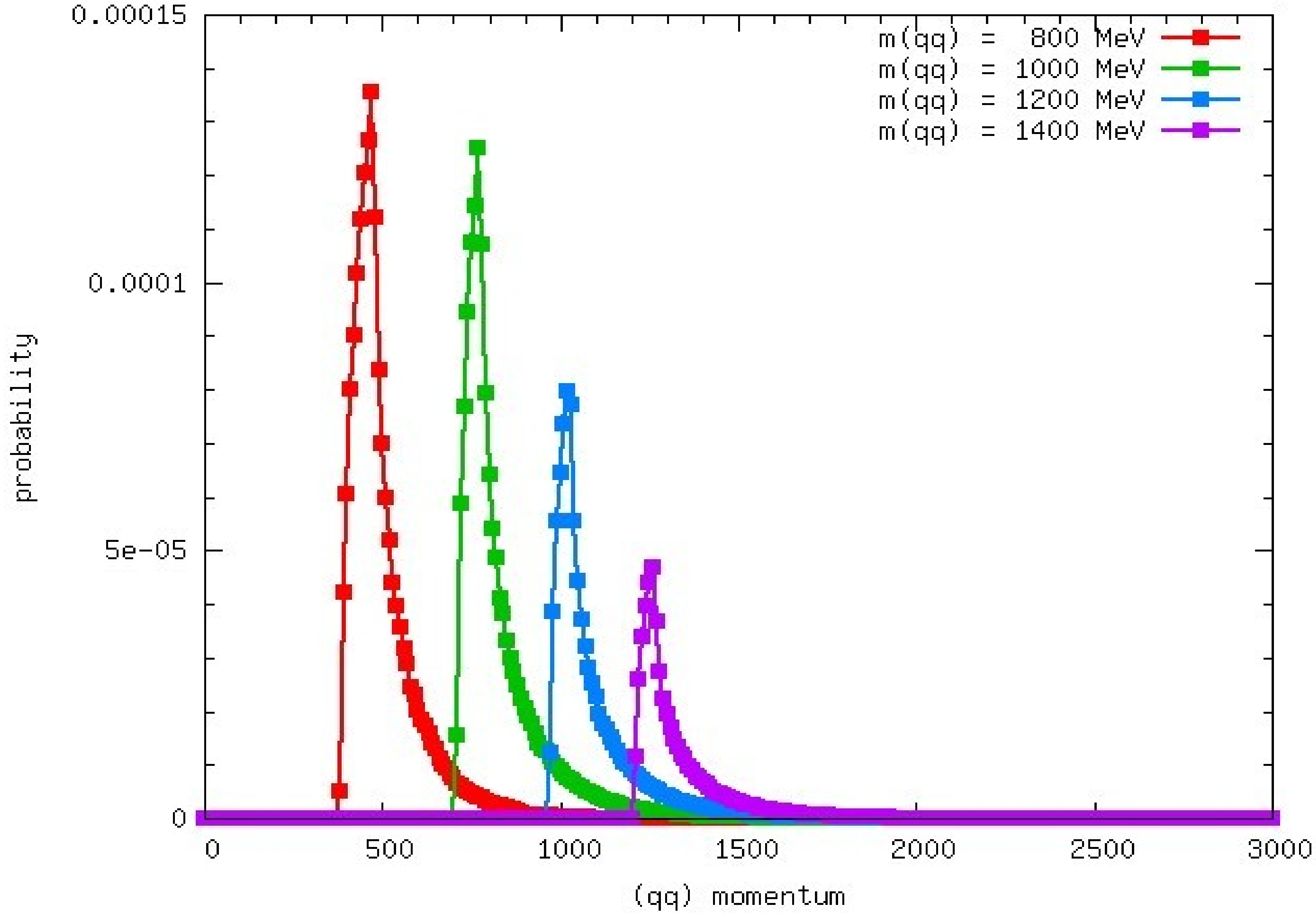




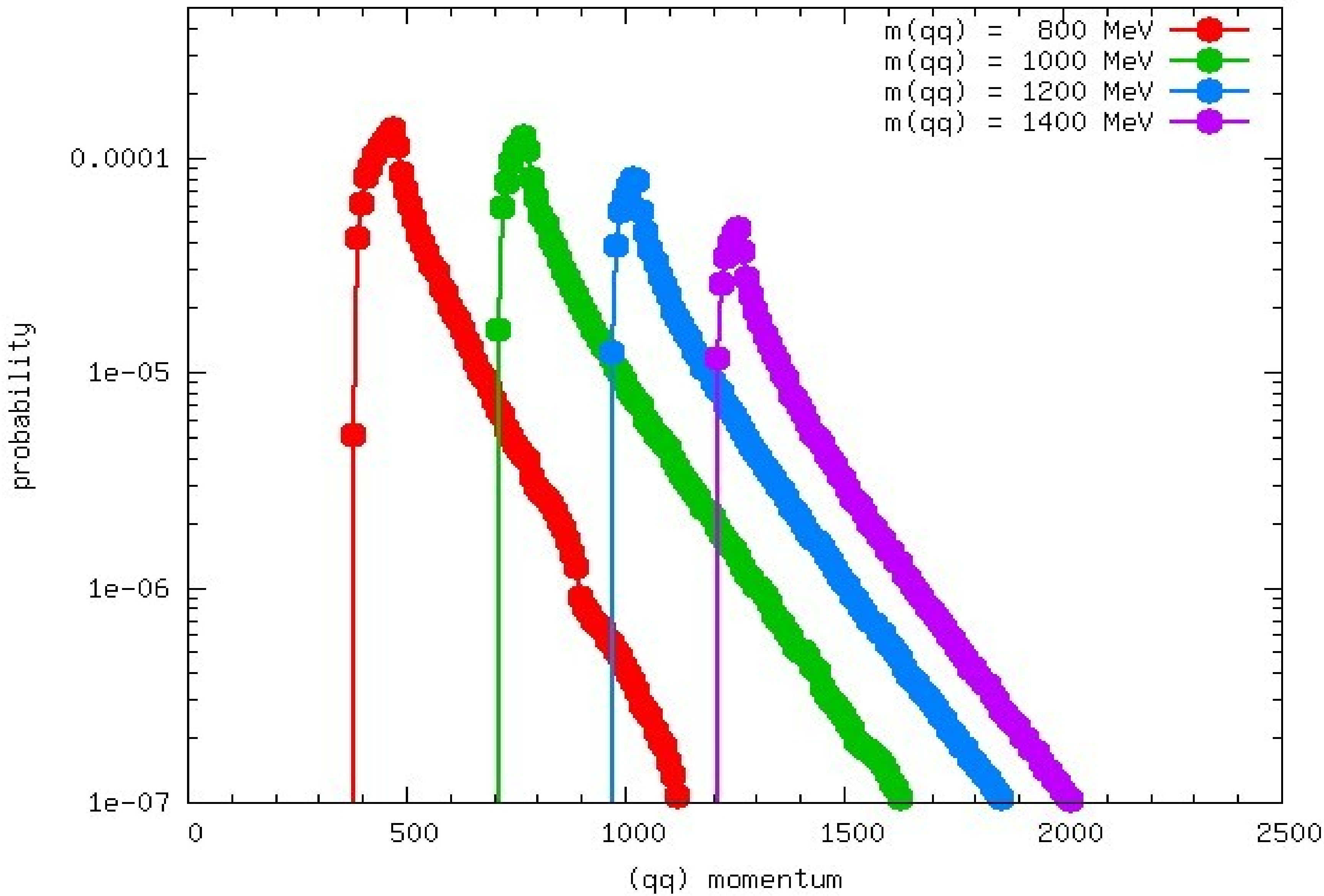
Binded (qq) momentum distributions



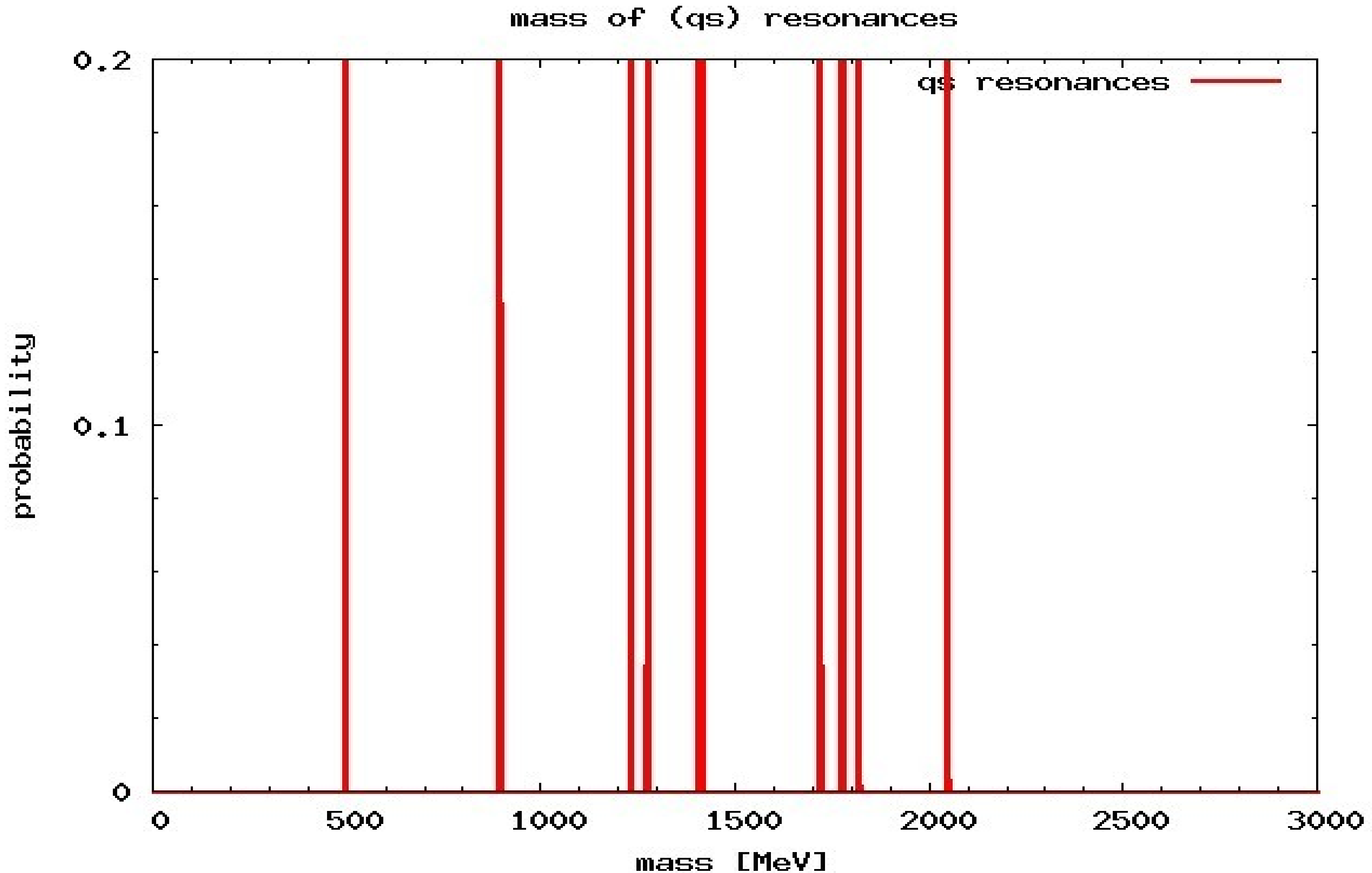
Binded (qq) momentum distributions



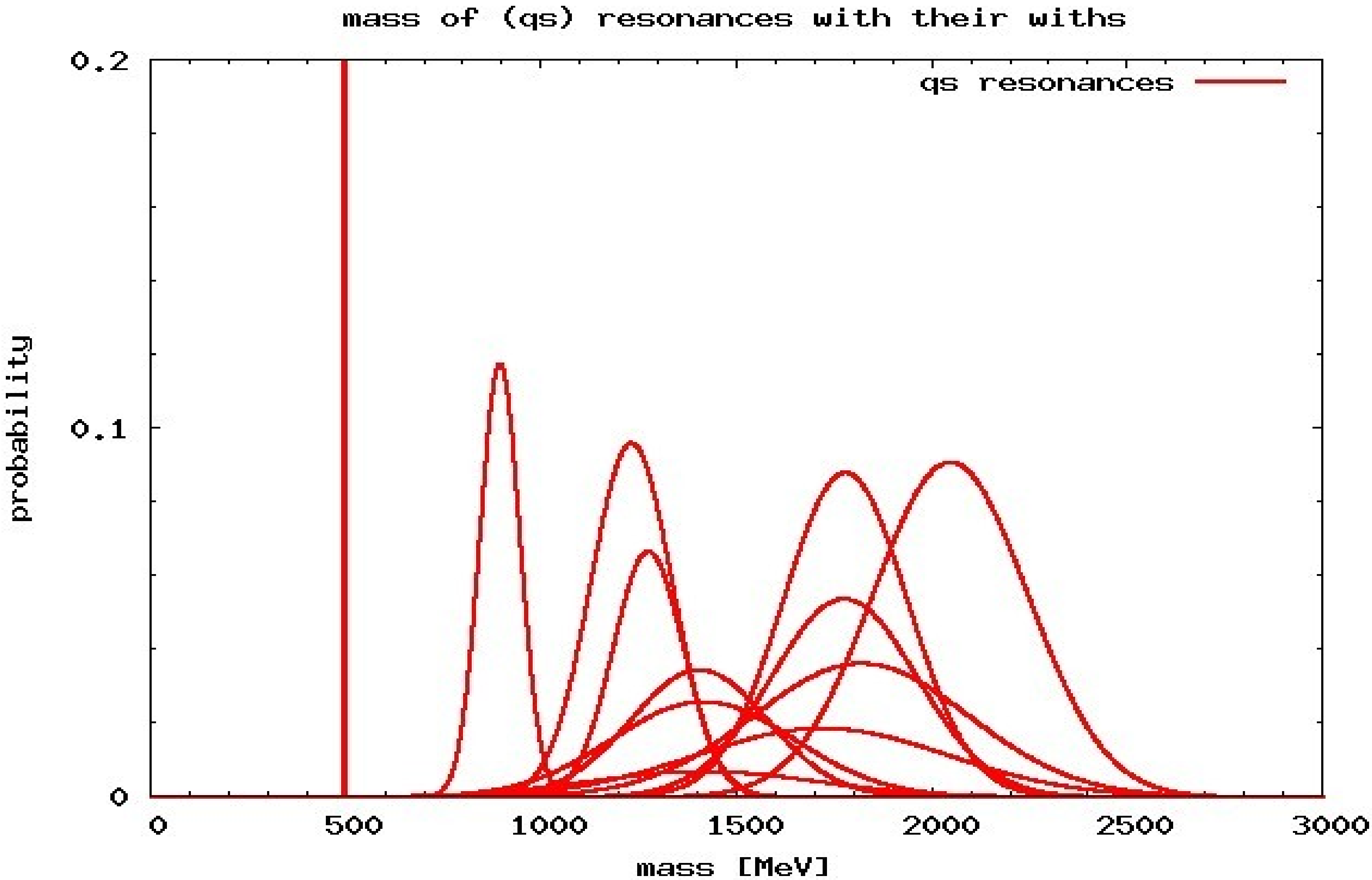
Binded (qq) momentum distributions



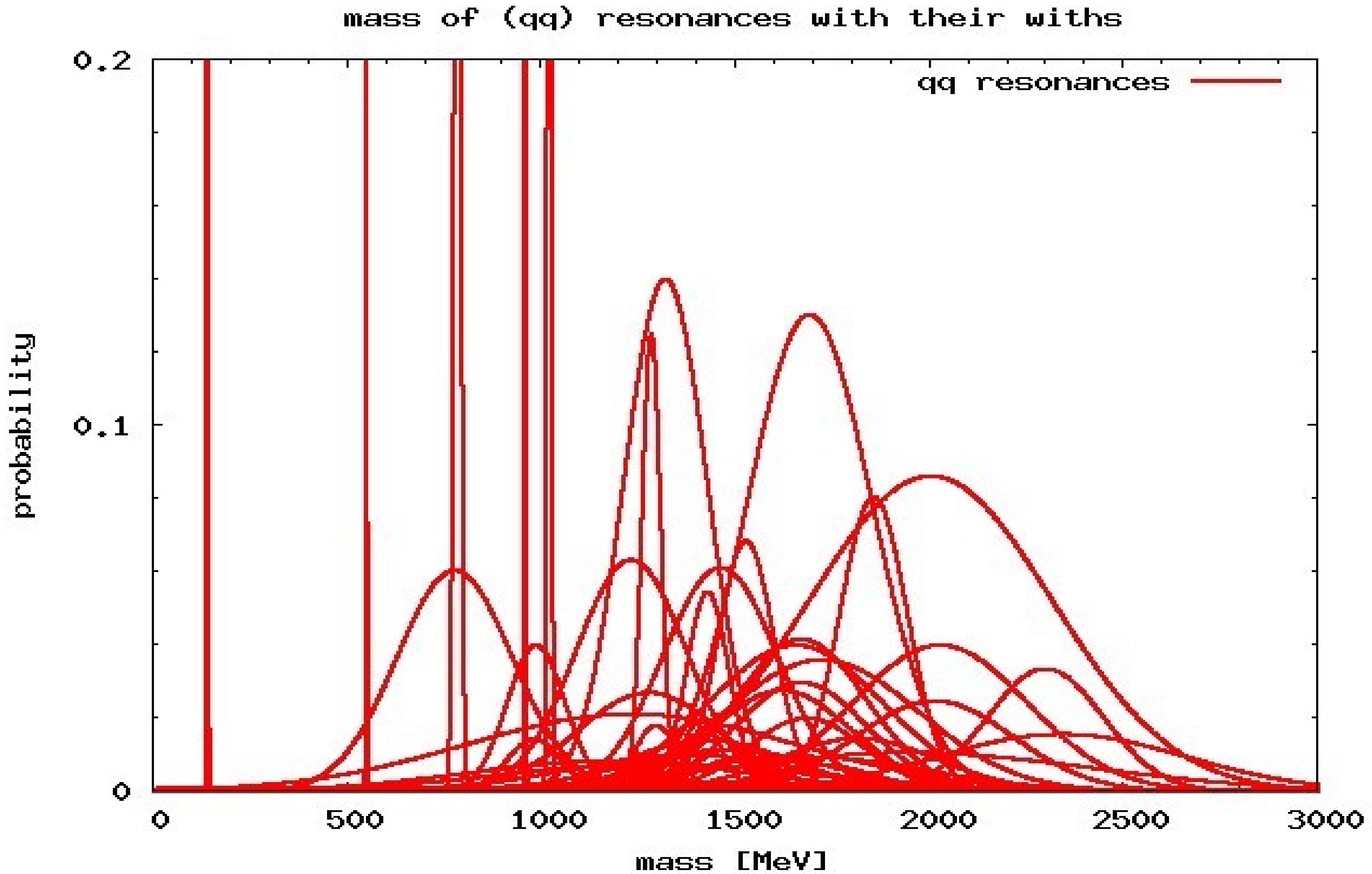
qs resonance masses



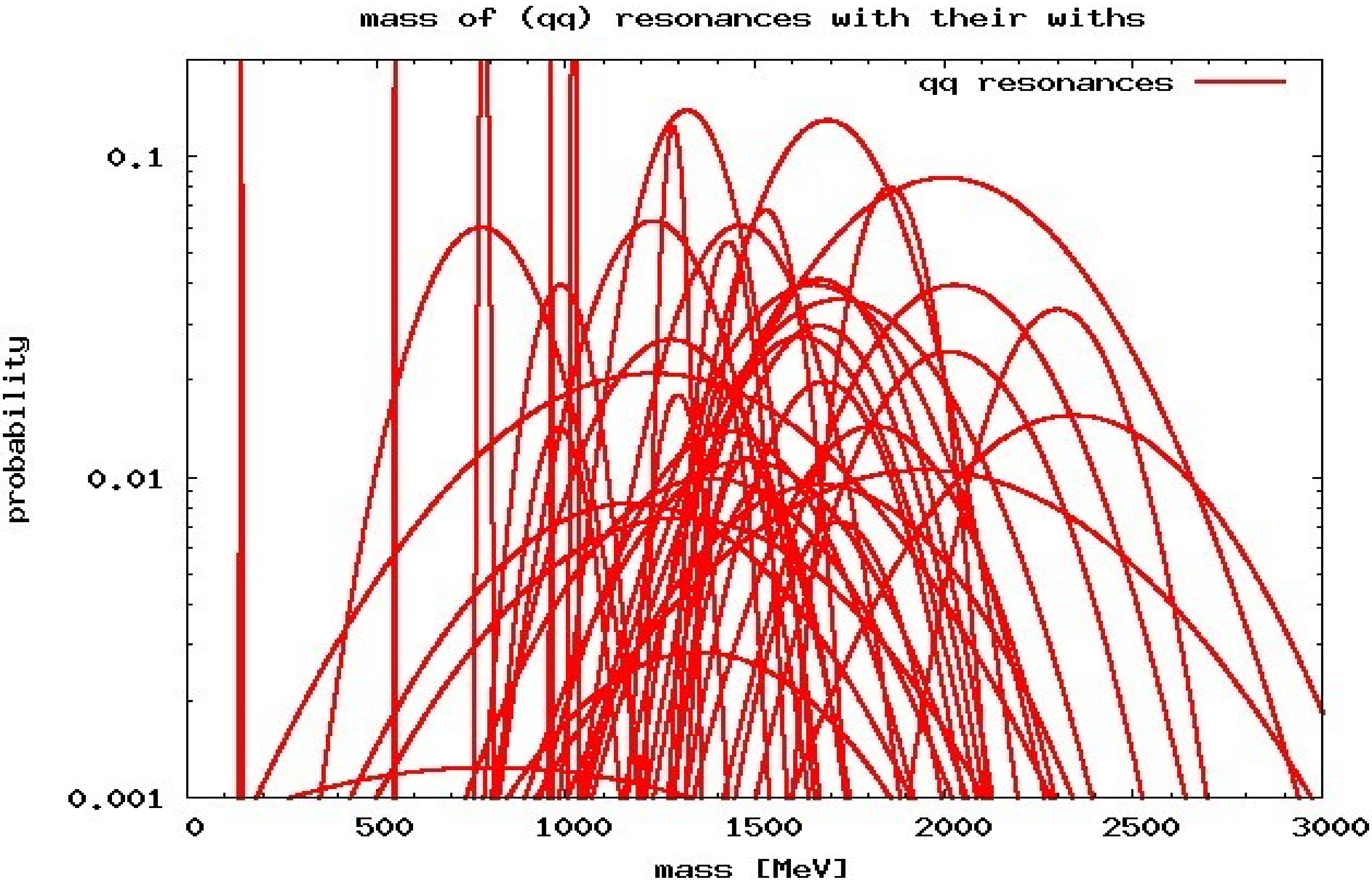
qs resonance mass spectrum (lin scale)



qq resonance mass spectrum (lin scale)



qq resonance mass spectrum (log scale)

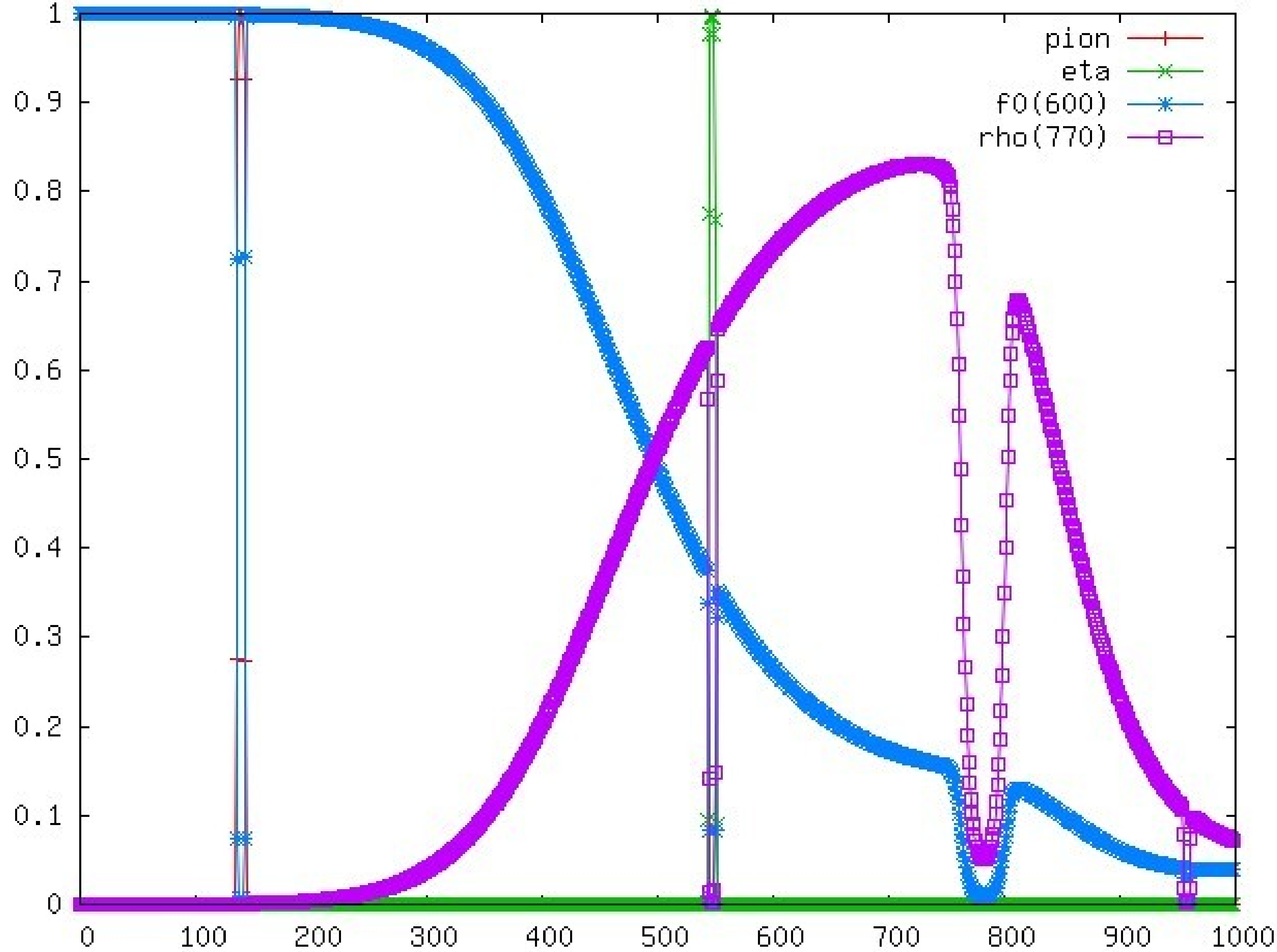


Selecting the proper resonances

- q+q --> (qq) with: mass = invariant mass
- Which resonance could appear from a (qq) state?
  - Resonance width characterizes the decay
  - Use the same width for production channels
- Define the appearance of a resonance at mass = m
- Probability to produce hadron resonance "H" from (qq) invariant mass m_{qq} :

$$\boldsymbol{P}(H|m_{qq}) = \frac{\exp((m_H - m_{qq})^2/2s_H^2)}{\sum_h \exp((m_h - m_{qq})^2/2s_h^2)}$$

Resonance appearance



Parity

- Experimental data: f_0/ρ suppression

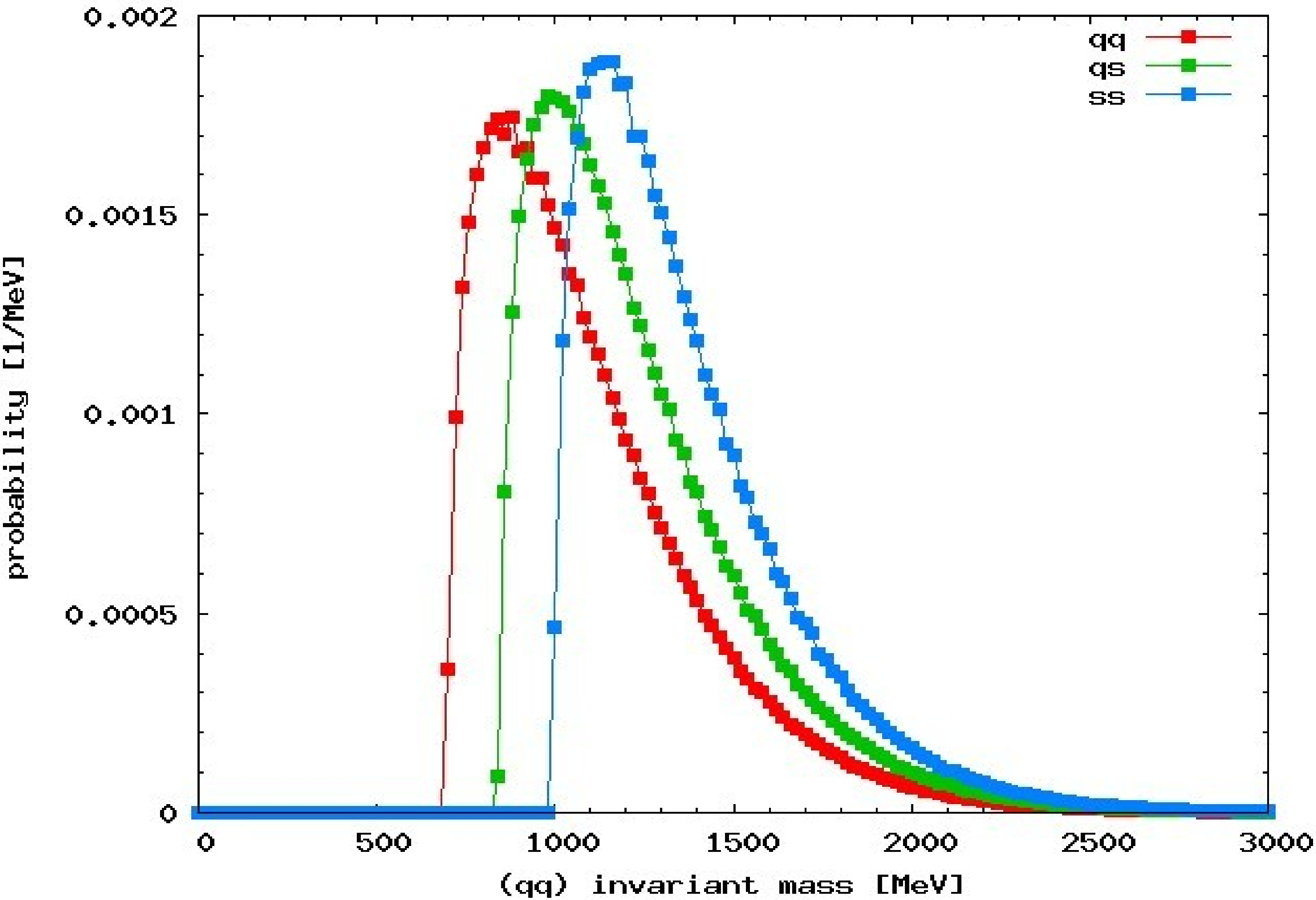
  how to handle this? :

  - Quantum mechanics : Zimányi '04, Müller '06
  - Should we consider +1 and -1 parity resonance cocktails with a parity suppression factor?
  - Imbalance in the decay chains
  - Quasi-quark mass has big influence on primer f_0 yield

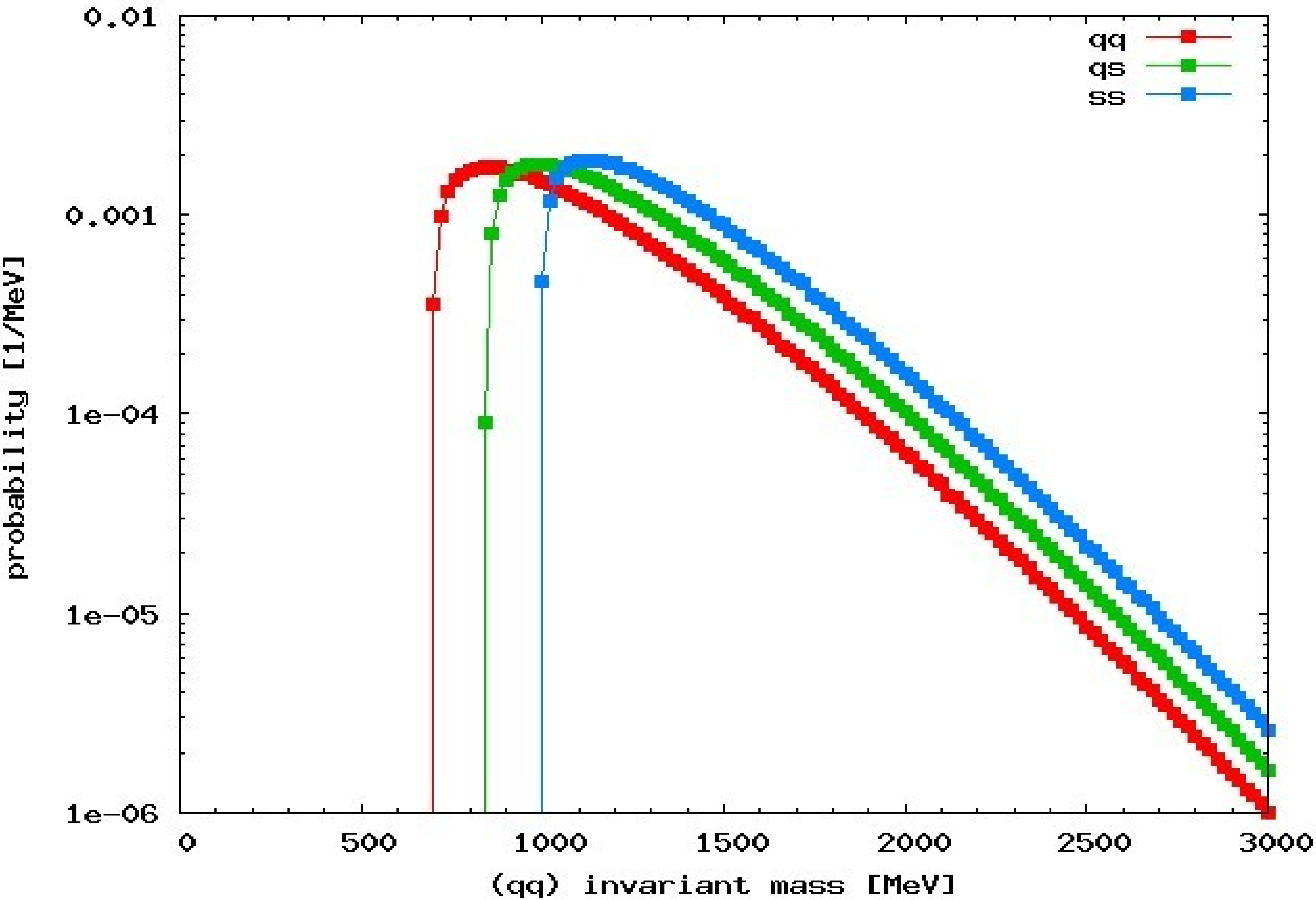
Baryons and Strangeness production

- Baryons are made of a diquark and a quark
  - qqq invariant mass spectrum is similar to qq
  - Baryon resonances, width, appearance, ...
- Insert strange quark into the system: mass: m_s
  - New mesons: qs, ss
  - New baryons: qqs, qss, sss

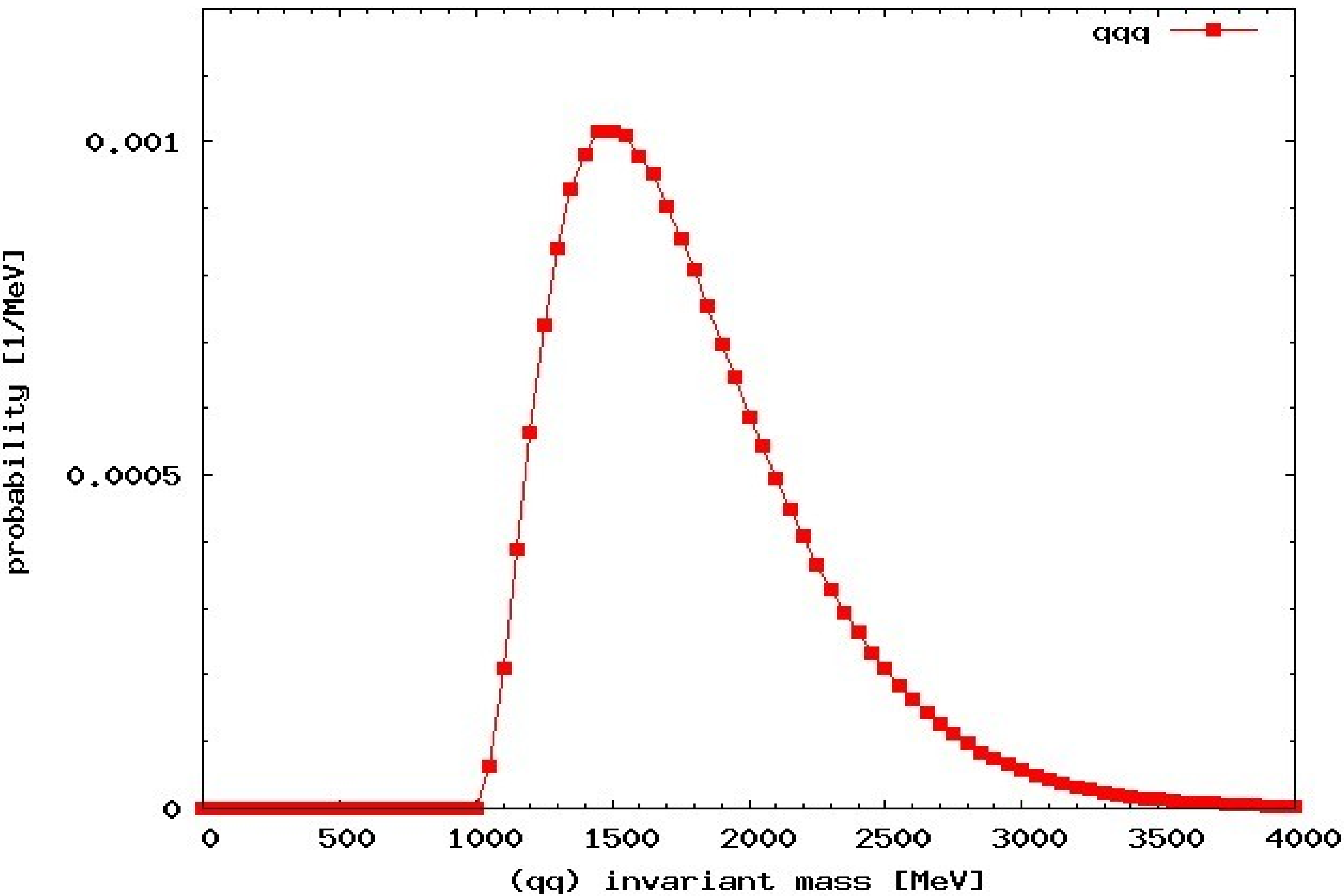
Mesonic invariant mass probabilities



Mesonic invariant mass probabilities



Baryonic invariant mass probability



Predictions at RHIC

- Parity check
  - $\phi(1020)$ <-> $\phi(1680)$,
    without parity suppression $\phi(1680) / \phi(1020) = 0.22$
  - $\Sigma(1385)$ <-> $\Lambda(1520)$
    without parity suppression $\Lambda(1520) / \Sigma(1385) = 0.91$
- Expected yields for resonances with small width
  - $\rho_3(1690) / \phi(1020) = 0.10$
  - $\Sigma(1660) / \Sigma(1385) = 0.55$

Conclusion

- Coalescence models can be extended for resonance productions
- Relativistic kinematics <=> prehadron mass spectrum
- Successful application for mesonic and baryonic resonances
- Predictions for measurable hadron resonance ratios