



Comment: scalar form factors beyond 1 GeV

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with S. Ropertz, C. Hanhart, EPJC **78** (2018) 1000

Beyond the Flavor Anomalies V

Siegen, 10/4/2024

Scalar form factors from $\bar{B}_{d/s}^0 \rightarrow J/\psi \{\pi\pi, \bar{K}K\}$

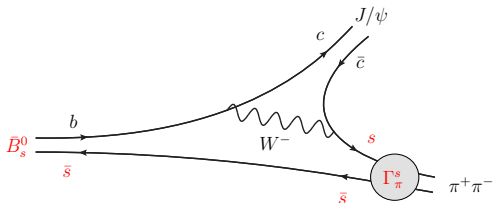
LHCb 2014, Daub et al. 2016, Ropertz et al. 2018

- universality of **final-state interactions** (J/ψ noninteracting spectator)
 - \rightsquigarrow rescattering in $\pi^+\pi^-$ related to **scalar** (S -waves) and **vector** (P -waves) **pion form factors**

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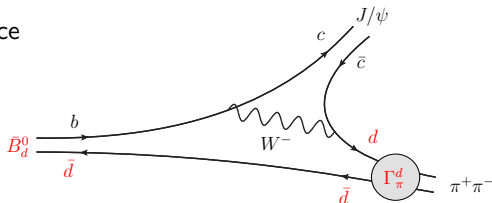
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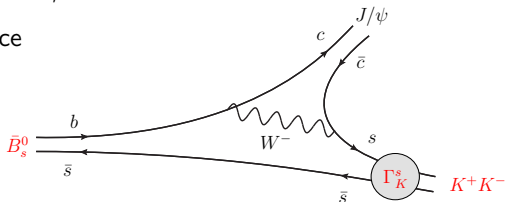
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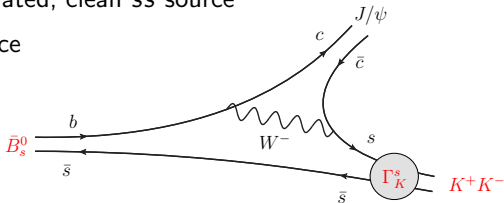
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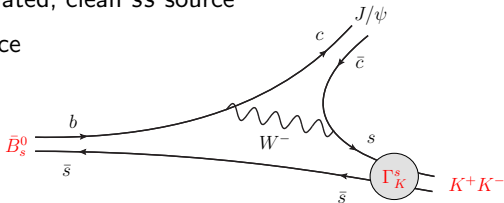
- $\pi\pi$ and $\bar{K}K$ coupled channels work up to 1.1 GeV
- beyond: strong coupling to $4\pi \rightarrow$ phase/inelasticity description??
- **resonances**, e.g. $\mathcal{B}(f_0(1500) \rightarrow 4\pi) = (48.9 \pm 3.3)\%$

PDG 2022

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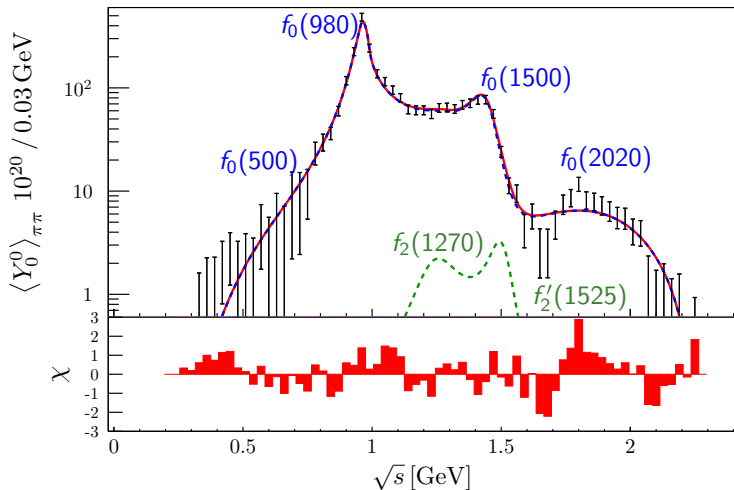
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- **resonances**, e.g. $\mathcal{B}(f_0(1500) \rightarrow 4\pi) = (48.9 \pm 3.3)\%$ PDG 2022
- **idea**: coupling to 4π via **resonances**, preserve unitarity Hanhart 2012
 in general very complicated; approximation: $\rho\rho$ or $\sigma\sigma$ Ropertz, Hanhart, BK 2018

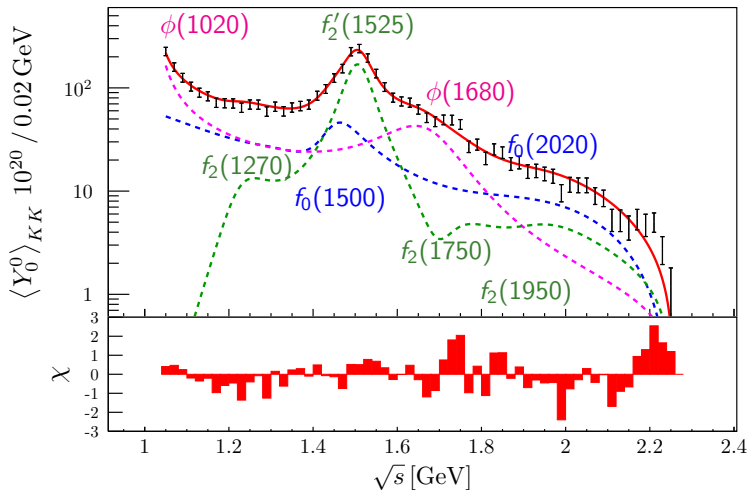
Fit $\langle Y_0^0 \rangle$ for $\bar{B}_s^0 \rightarrow J/\psi \pi^+ \pi^-$



Fit $(\rho\rho)$ with two additional resonances. *S*- and *D*-waves

$$\frac{\chi^2}{\text{ndf}} = \frac{376.2}{384 - 30} \approx 1.07$$

Fit $\langle Y_0^0 \rangle$ for $\bar{B}_s^0 \rightarrow J/\psi K^+ K^-$

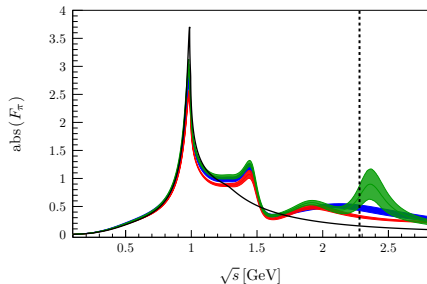


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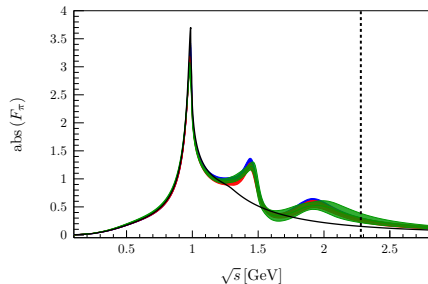
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Comparison F_π (modulus)

$\rho\rho$



$\sigma\sigma$



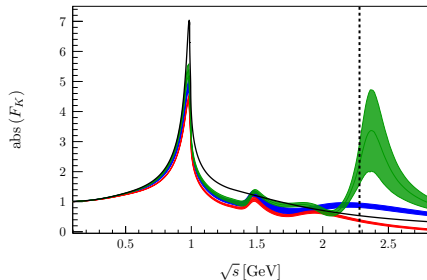
Omnès solution with $F_\pi(0) = 0$ and $F_K(0) = 1$ in black

$$F_\pi(s) = \Omega_{11}(s) F_\pi(0) + \frac{2}{\sqrt{3}} \Omega_{12}(s) F_K(0)$$

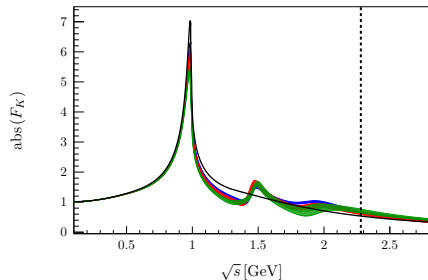
Phase input: Dai, Pennington 2014

Comparison F_K (modulus)

$\rho\rho$



$\sigma\sigma$



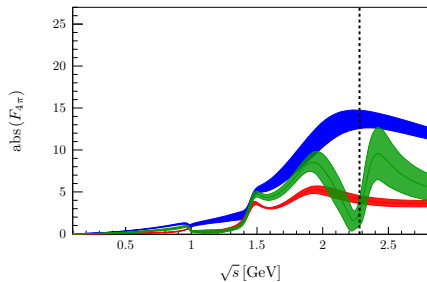
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$$\frac{2}{\sqrt{3}} F_K(s) = \Omega_{21}(s) F_\pi(0) + \frac{2}{\sqrt{3}} \Omega_{22}(s) F_K(0)$$

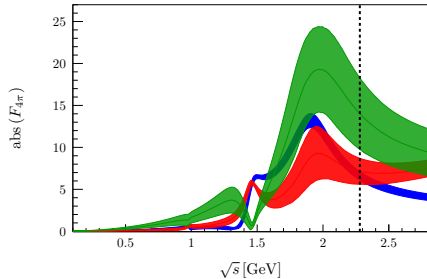
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Comparison $F_{4\pi}$ (modulus)

$\rho\rho$



$\sigma\sigma$



- suppressed at lower energies
- strong model dependence of the additional channel
- **need to include more exclusive data!**

Scalar form factors beyond 1 GeV

Conclusion

- **strange** scalar form factors from $\bar{B}_s^0 \rightarrow J/\psi\{\pi\pi, \bar{K}K\}$ up to 2 GeV
- coupled channels $\pi\pi \leftrightarrow \bar{K}K$ probably insufficient: 4π channel!

Ropertz, Hanhart, BK 2018

Outlook

- same for **nonstrange** scalar form factor from $\bar{B}_d^0 \rightarrow J/\psi\{\pi\pi, \bar{K}K\}$?
- $\bar{d}d$ source has **no isospin filter** $\rightarrow I = 0, 1$
- strong P -wave contribution for $\pi\pi$ expected Daub, Hanhart, BK 2016
 \rightarrow 10 partial waves for all helicity amplitudes (1 S -, 3 P - & D -waves)
- cf. also πK system in τ decays (more partial-wave selective!)

von Detten, Noël, Hanhart, Hoferichter, BK 2021