Some anomalies in Baryon Time-like Form Factors

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Outline

- $e^+ e^- \to p\, p_{bar}$
- FF oscillations. Jump at threshold? Coulomb enhancement ?
- $e^+ e^- \to \Lambda_c\, \Lambda_{cbar}$
- Jump at threshold. Charmed “Baryonium” ?
- $e^+ e^- \to \Lambda\ \Lambda_{bar}$
- Jump at threshold. Narrow resonance close by ?
- $J/\psi \to \gamma\, NN_{bar}$
- Light Quarks “Baryonium” ?
- $e^+ e^- \to n\, n_{bar}$
- News from SND,CMD3 and BESIII
- G_E / G_M phase
- Relationship with spacelike zeros

$e^{+} e^{-} \rightarrow p p_{bar}$

$e^+ e^- \to pp_{bar}$

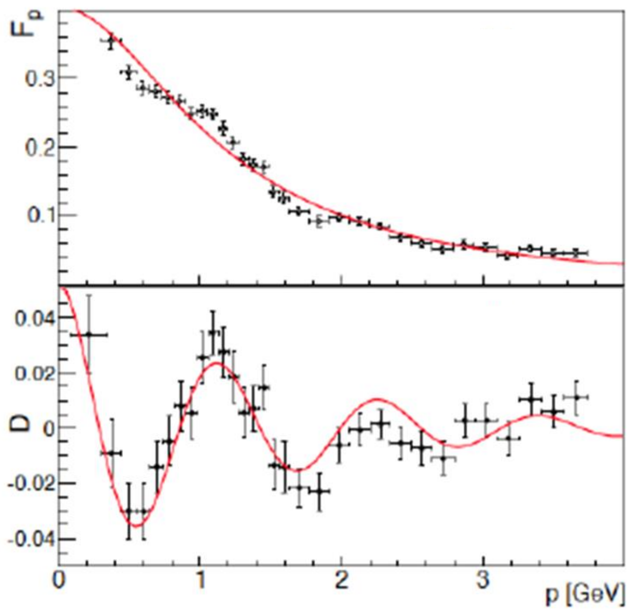
- There are many sets of data on $e^+ e^- \to pp_{bar}$ at low cm energies by PS170,BaBar,BESIII,CMD3, ADONE,DM1,DM2,FENICE,BES reported in details by Monica Bertani.
- In the following the energy region close to the threshold (thr) will be mostly considered, where essentially at the moment BaBar only, by means of ISR from Y(4S), have data.

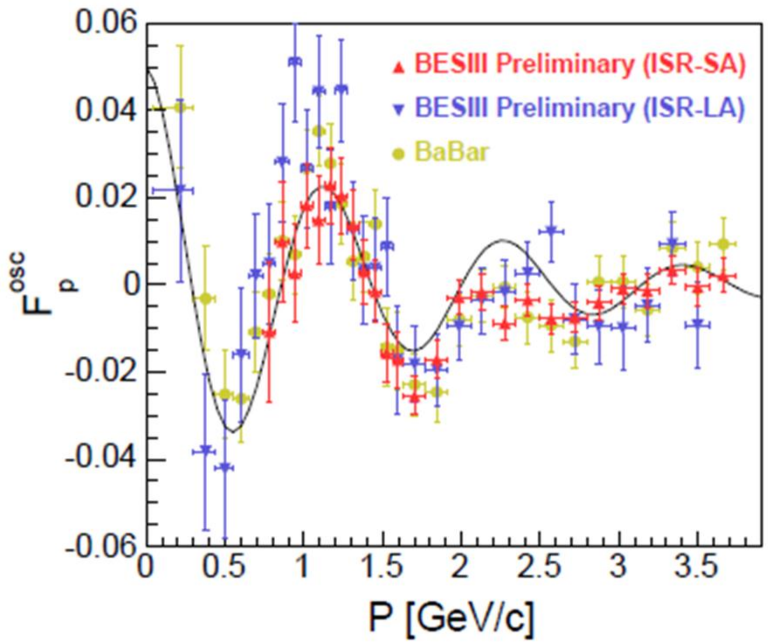
  (PS170 data on $pp_{bar} \to e^+ e^-$ at thr are affected by corrections due to incident p_{bar} spin flip because of the liquid H_2 target, difficult to handle).
- **$\sigma(e^+e^- \to BB_{bar}) = 4\pi\alpha^2/3W_B^2\, C\, \beta[|G_M(W_B^2)|^2+2M_B^2/W^2|G_E(W_B^2)|^2]$**

  $\beta = \sqrt{[1-(2M_B/W)^2]}$
- **$|G_{eff}| = \sqrt{[\ (|G_M|^2+2M_B^2/W^2|G_E(W_B^2)|)/(1+2M_B^2/W^2)\ ]}$**

Oscillations in G_{eff} (e^+e^- -> pp_{bar}) !

- Oscillations in F_p (e^+e^- -> pp_{bar}) seen by BaBar and confirmed by BESIII (as shown by Christof Rosner) , reported in details by Egle Tomasi-Gustafsson [A. Bianconi, E. Tomasi-Gustafsson PRL 114, 232301 (2015)]





- Fit by $F_{\rm osc}(p) \equiv A \exp(-Bp) \cos(Cp + D).$
- **Evidences of oscillations in other e^+e^- annihilation ?**

Long long time ago, in another galaxy…..

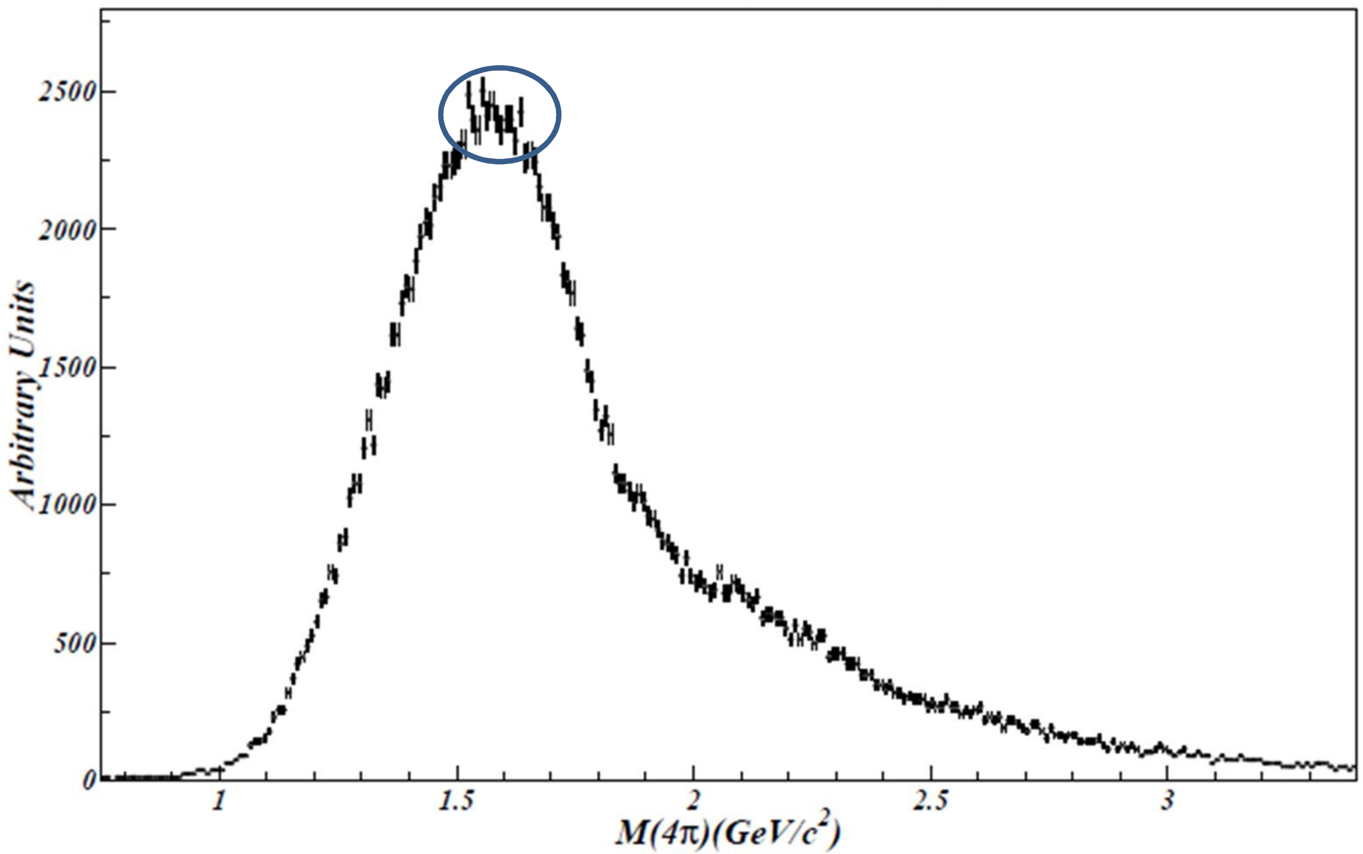
- E687 at FNAL in High Statistics Diffractive Photoproduction (like e^+e^- according to VMD) showed structures (for instance a dip in $3\pi^+3\pi^-$, later confirmed by BaBar and CMD3). Among them Simone Pacetti

showed at a DAΦNE Workshop (Alghero 2006) oscillations (?) in **Diffractive Photoproduction of $2\pi^+2\pi^-$**

Long long time ago, in another galaxy.....

$2\pi^+2\pi^-$ E687 data

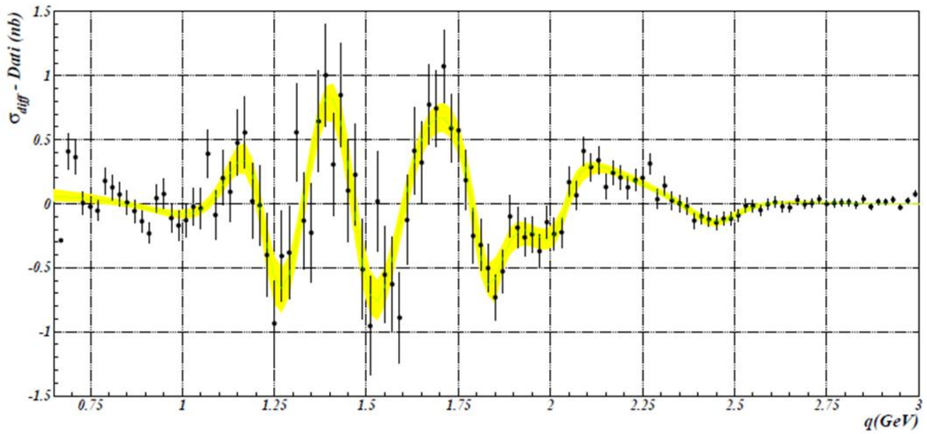
(P. Lebrun *Hadron '97*, Aug. 25-30, 1997)



E687 at FNAL
$2\pi^+2\pi^-$ Diffractive Photoproduction

Fit of the residual

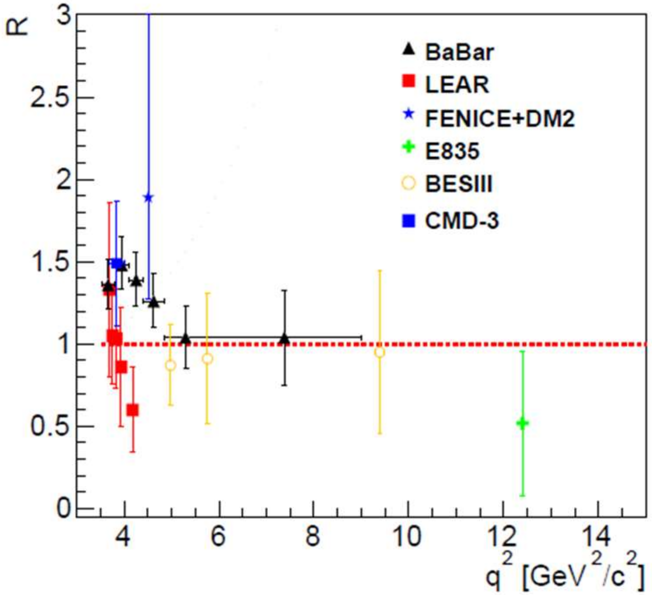
(P. Lebrun *Hadron '97*, Aug. 25-30, 1997)



Resonances	$\Gamma_{e^+e^- j} B_{j 2\pi^+ 2\pi^-} (KeV)$	$m(MeV)$	$\Gamma(MeV)$	$\phi(rad)$
V_1	$(4 \pm 2) \times 10^{-2}$	1209 ± 6	218 ± 16	2.56 ± 0.04
V_2	$(5 \pm 2) \times 10^{-2}$	1465 ± 8	265 ± 23	4.26 ± 0.08
V_3	$(1.1 \pm 0.6) \times 10^{-3}$	1820 ± 25	100 ± 30	0.7 ± 0.6
V_4	$(3 \pm 2) \times 10^{-3}$	2030 ± 20	170 ± 80	2.6 ± 0.4
V_5	$(1.3 \pm 0.7) \times 10^{-3}$	2460 ± 24	190 ± 60	2.5 ± 0.3

$G_E(q^2)/G_M(q^2)$: D wave at thr or early onset ?

- $R(q^2) = G_E(q^2)/G_M(q^2)$

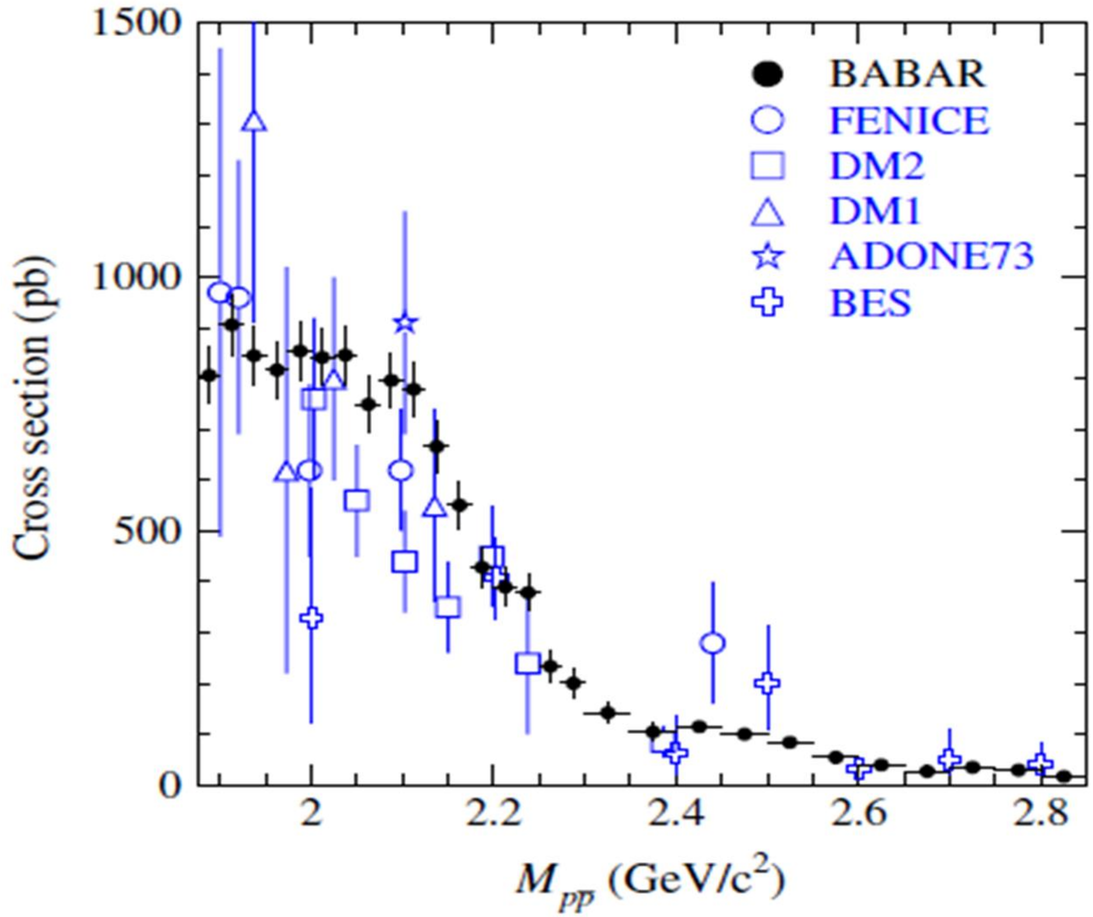


- **Analyticity: $G_E(4M_B^2)=G_M(4M_B^2)=G_S(4M_B^2)$ -> $G_D(4M_B^2)= 0$**
- Present data on $R(q^2)$ (in the case of BaBar unfortunately integrated on a too large Q^2 interval) indicate that **$G_D(q^2)$ seems not vanishing, close to thr :**

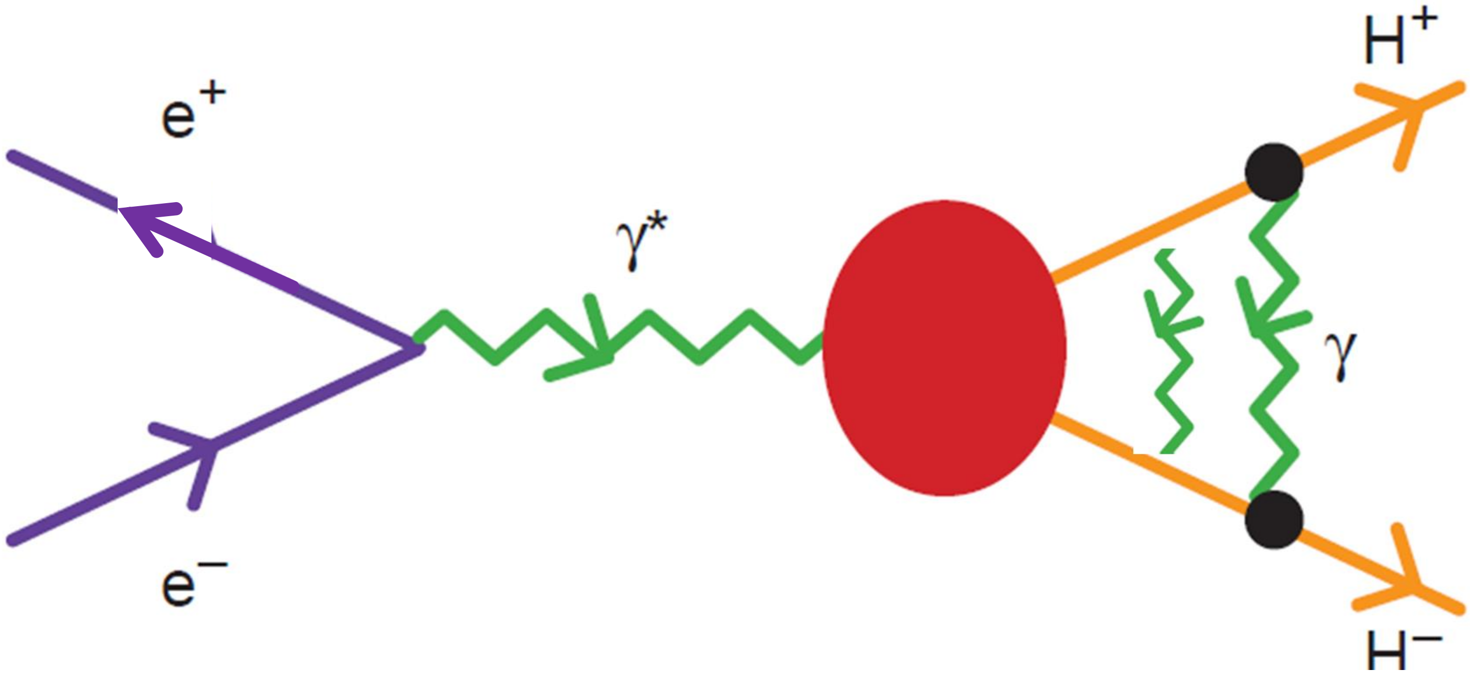
$G_D(q^2) \neq 0 \quad q^2 \approx 4M_B^2$?

Present data on $\sigma(e^+ e^- \to pp_{bar})$

- To be updated with BESIII data, presented by Christoff Rosner



Coulomb Enhancement Factor (CEF)



CEF Hypotheses

- In principle Coulomb interaction between the outgoing B^+B^- should plays an important role.
  However there is no full consensus on that.

- $\sigma(e^+e^- \to BB_{bar}) = 4\pi\alpha^2/(3W_B^2)\cdot \boxed{C} \cdot\beta[|G_M(W_B^2)|^2 + 2M_B^2/W^2|G_E(W_B^2)|^2]$

- C: Coulomb Enhancement Factors (CEF).
  Non Perturbative Correction to include Coulomb Interaction between the outgoing charged fermions

- Hypotheses to achieve CEF:

- In $\langle i|T_0+T_C|f\rangle$: the final state is not a plane wave $|f\rangle$, but $|\phi\rangle$ where ϕ is the wave function after Coulomb scattering

- T_0 (before Coulomb interaction) is a short range interaction, hence $\phi(r) \to \phi(0)$: **Coulomb affects S wave only**.

CEF Hypotheses

- Usually CEF is assumed to be the non relativistic pointlike fermions one (L.Landau,E.Lifschitz, 1950)

  $$|\phi(0)|^2 = \pi\alpha \, F/\beta \cdot 1/ [1- \exp(- \pi\alpha \, F/\beta)],$$

  F is a relativistic correction (not very important close to thr),
  according to Arbuzov $F = 2\,\beta/(1+\beta^2)$.
  Some also assume $F = \sqrt{(1-\beta^2)}$

- Photon exchanges among $B^+ B^-$ are taken into account by the Enhancement Factor $E = \pi\alpha \, F/\beta$
  E predicts a jump at thr: $1/\beta$ factor cancels the phase space β

- Many photons exchanges are taken into account by the Sommerfield Resummation Factor $R = 1/ [1- \exp(- \pi\alpha \, F/\beta)]$
  R is so that very soon the phase space β is restored

- An argument justifying pointlike CEF (never quoted explicitly):
  Coulomb has a long range, while Strong Force is a short one.
  Hence Coulomb acts when the hadron pair is already built.

BaBar $\sigma(e^+ e^- \to p p_{bar})$ close to thr

- BaBar $\sigma(e^+ e^- \to p p_{bar})$ close to thr

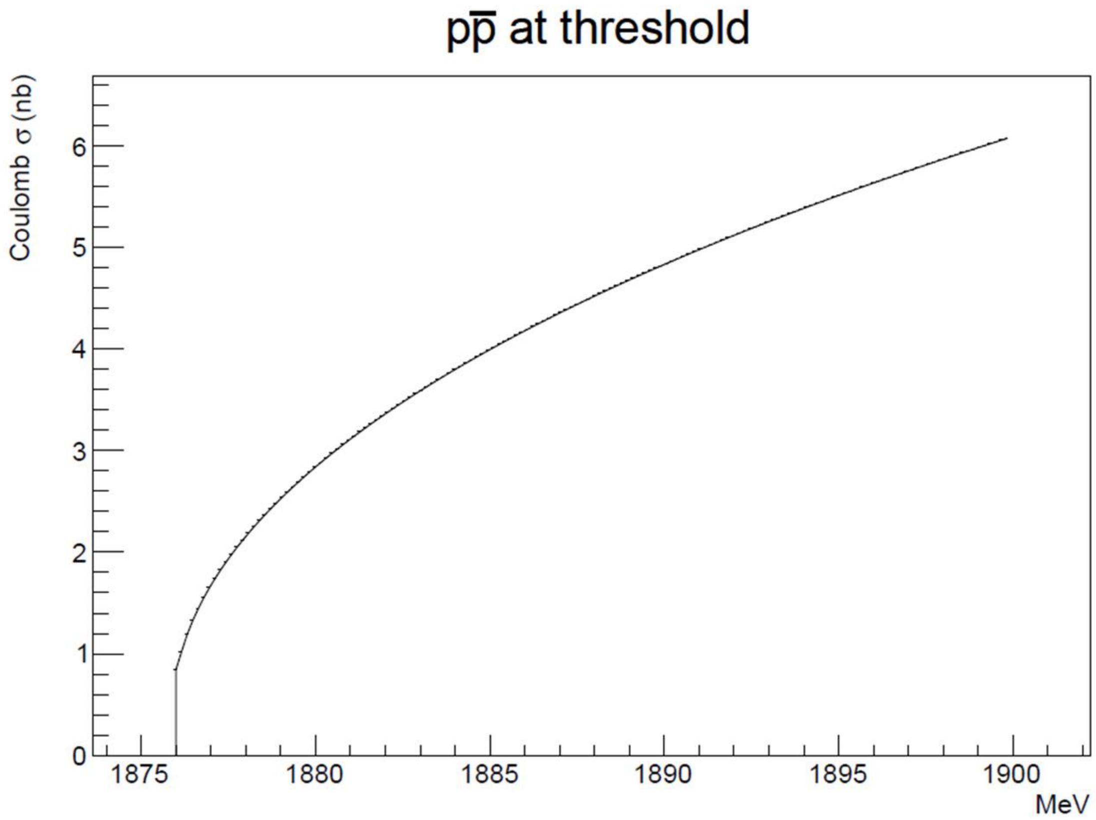
$M_{p\bar{p}}$ [GeV/c^2]	N	$\sigma_{p\bar{p}}$ [pb]
1.8765–1.8800	37 ± 7 ± 1	534 ± 94 ± 39
1.8800–1.8850	80 ± 10 ± 1	826 ± 106 ± 42
1.8850–1.8900	67 ± 10 ± 1	705 ± 105 ± 33
1.8900–1.8950	79 ± 11 ± 1	886 ± 121 ± 41
1.8950–1.9000	86 ± 12 ± 1	938 ± 128 ± 42
1.9000–1.9050	70 ± 11 ± 1	785 ± 123 ± 35
1.9050–1.9100	80 ± 11 ± 1	937 ± 135 ± 41
1.9100–1.9150	98 ± 13 ± 1	1096 ± 142 ± 46
1.9150–1.9250	156 ± 15 ± 2	862 ± 84 ± 32
1.9250–1.9375	188 ± 16 ± 3	811 ± 69 ± 31
1.9375–1.9500	208 ± 17 ± 3	887 ± 72 ± 33
1.9500–1.9625	181 ± 16 ± 3	780 ± 70 ± 30
1.9625–1.9750	209 ± 17 ± 3	850 ± 70 ± 32

- $\sigma(e^+ e^- \to p p_{bar})$ ≈ 0.85 nb flat (≤ 2 sd if extrapolated to first bin)
- CEF expects $\sigma_{thr} = 0.85 \cdot |G_S(4M_p^2)|^2$ nb

  Very tantalizing to infer that $G_S(4M_p^2)$ is close to 1 !

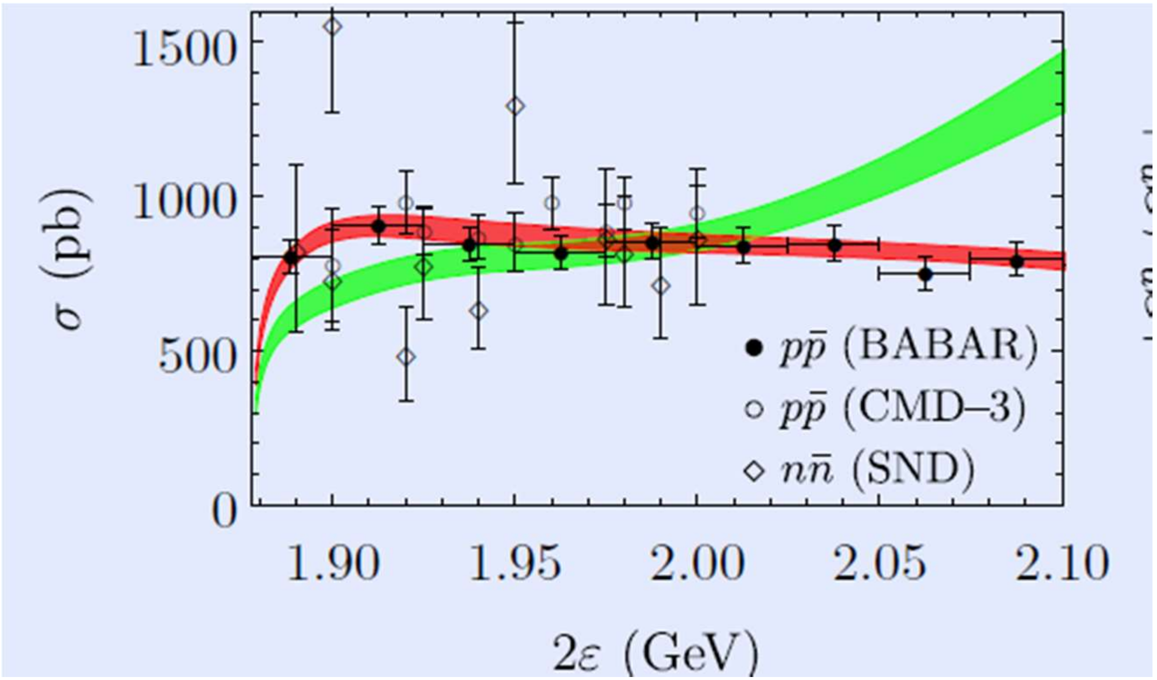
Coulomb interaction above trh

- Simple Coulomb interaction does explain a jump at thr but it is at odd with the flat $\sigma(e^+ e^- \to pp_{bar})$ above thr:



$\sigma(e^+ e^- \to pp_{bar})$ fit by means of FSI

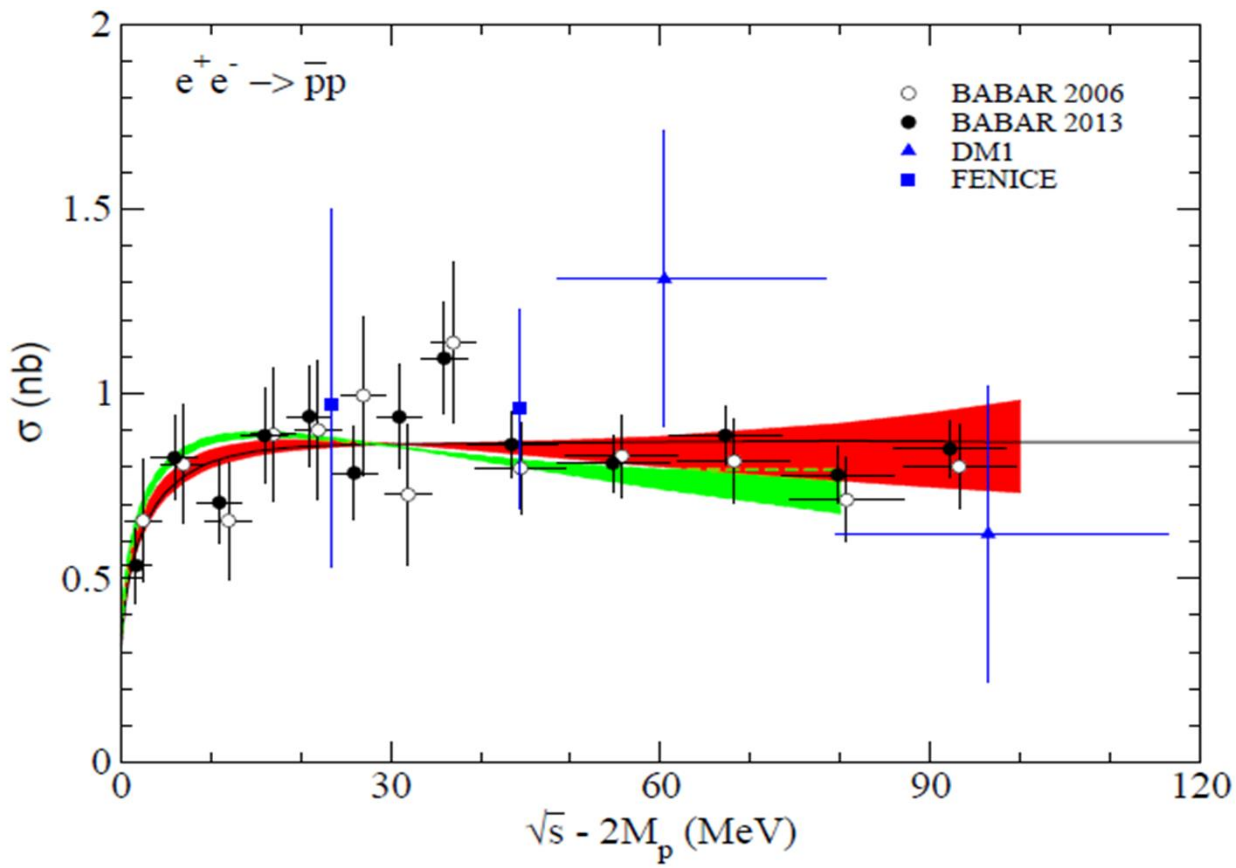
- FSI get a flat $\sigma(e^+ e^- \to pp_{bar})$ from the steep behaviour of elastic $\sigma(pp_{bar} \to pp_{bar})$ at low energies.
- FSI expect a sharp rise but not a jump on thr and no relationship with the pointlike FF
- A. Milstein in PhitoPsi17, Mainz :



$\sigma(e^+ e^- \to pp_{bar})$ fit by means of FSI

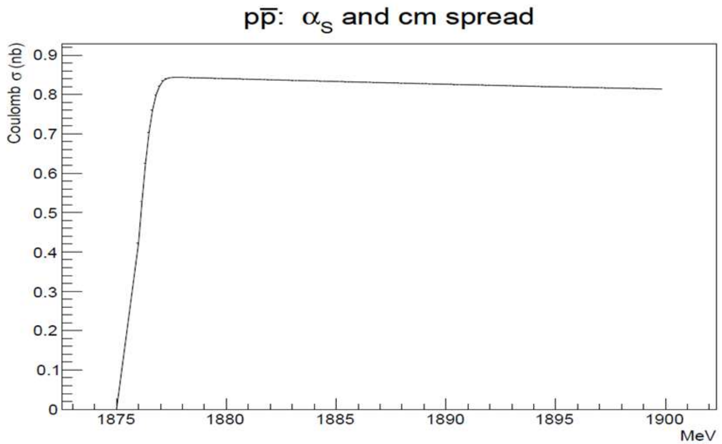
- J.Heidenbauer, X.W. Xang, U.G. Meissner

arXiv:1405.1628v1 [nucl-th] 7 May 2014



An Alternative Approach to CEF

- FSI approaches predict a vanishing $\sigma(e^+ e^- \to pp_{bar})$ at thr
- BaBar $\sigma(e^+ e^- \to pp_{bar})$ first bin not zero,
  but too wide (3.5 MeV) to check at the MeV level
  if the cross section vanishes or not at thr
- Persisting on a Coulomb enhancement at thr,
  consider another possible, empirical, approach:
  in R many gluons (pions) exchanged too.
  α_S instead of α should be considered:
  $R \approx 1/ [1- \exp(- \pi\alpha_S F/\beta)]$?



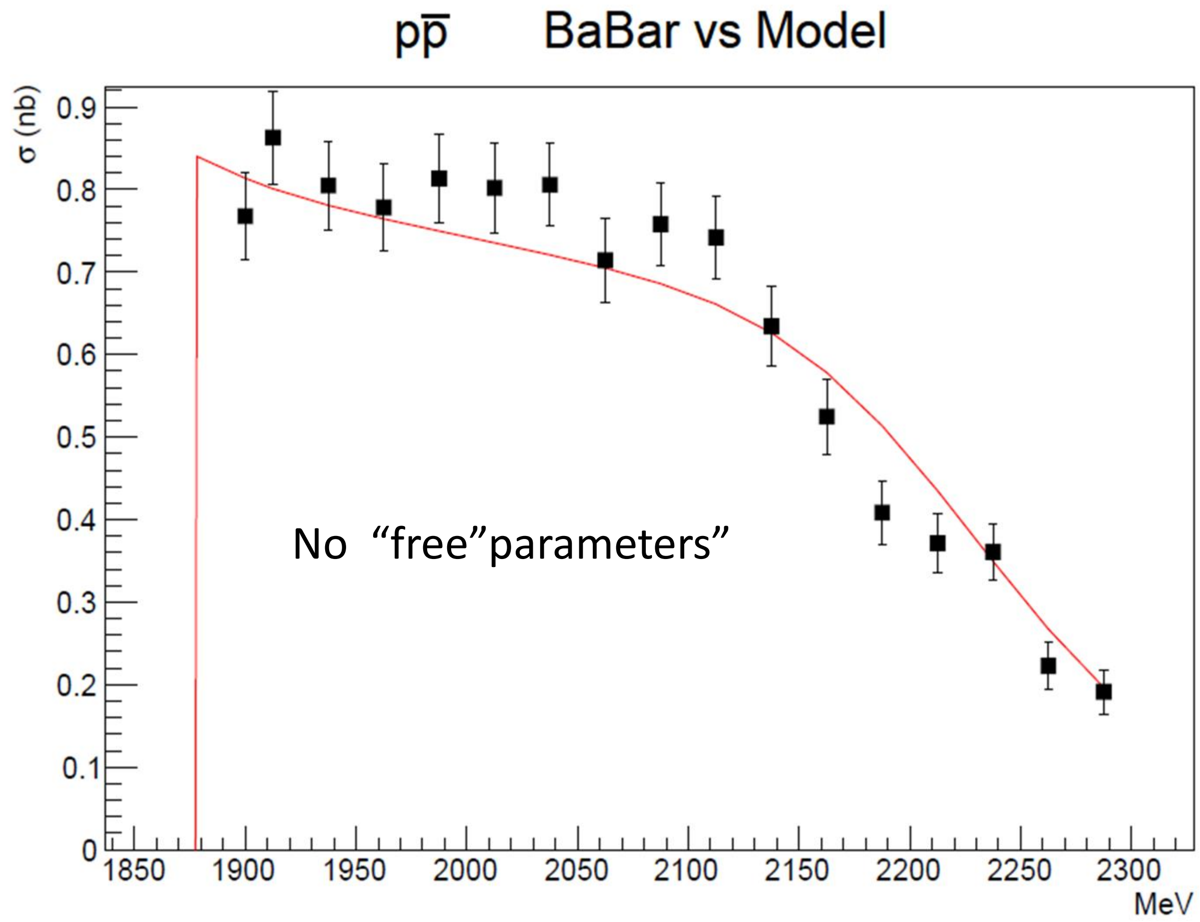
$\sigma(e^+ e^- \to pp_{bar})$ close to threshold

- Willing to include the asymptotic G_p expected behaviour, according to PQCD: $\sigma(e^+ e^- \to pp_{bar}) \sim 1/ [W^2 (W/\Lambda_{QCD})^8]$ a simple parametrization could be:

  $$\sigma(e^+ e^- \to pp_{bar}) \sim [\pi^2 \alpha^3 F/ /W^2] /[1- \exp(- \pi\alpha_S F/\beta)] \cdot$$
  $$\mathbf{1/[1 +((W-W_{thres})/\Lambda_{QCD})^N]}$$

- BaBar data (ΔW included) can be fit with such a formula, leaving as "free" param Λ_{QCD} and the exponent N in $(W/\Lambda_{QCD})^N$. The result is $\Lambda_{QCD} = 364 \pm 7$ MeV, $N = 7.0 \pm 0.3$, in good agreement with the expectation $\Lambda_{QCD} \sim 300$ MeV , N ~ 8
- **The persistence on Coulomb interpretation is driven by the results obtained by BESIII on** $e^+ e^- \to \Lambda_c \Lambda_{cbar}$ at thr

σ (e^+e^- -> pp_{bar}) (BaBar vs Model)



$e^+ e^- \rightarrow \Lambda_c \Lambda_{cbar}$

$e^+ e^- \to \Lambda_c \Lambda_{cbar}$

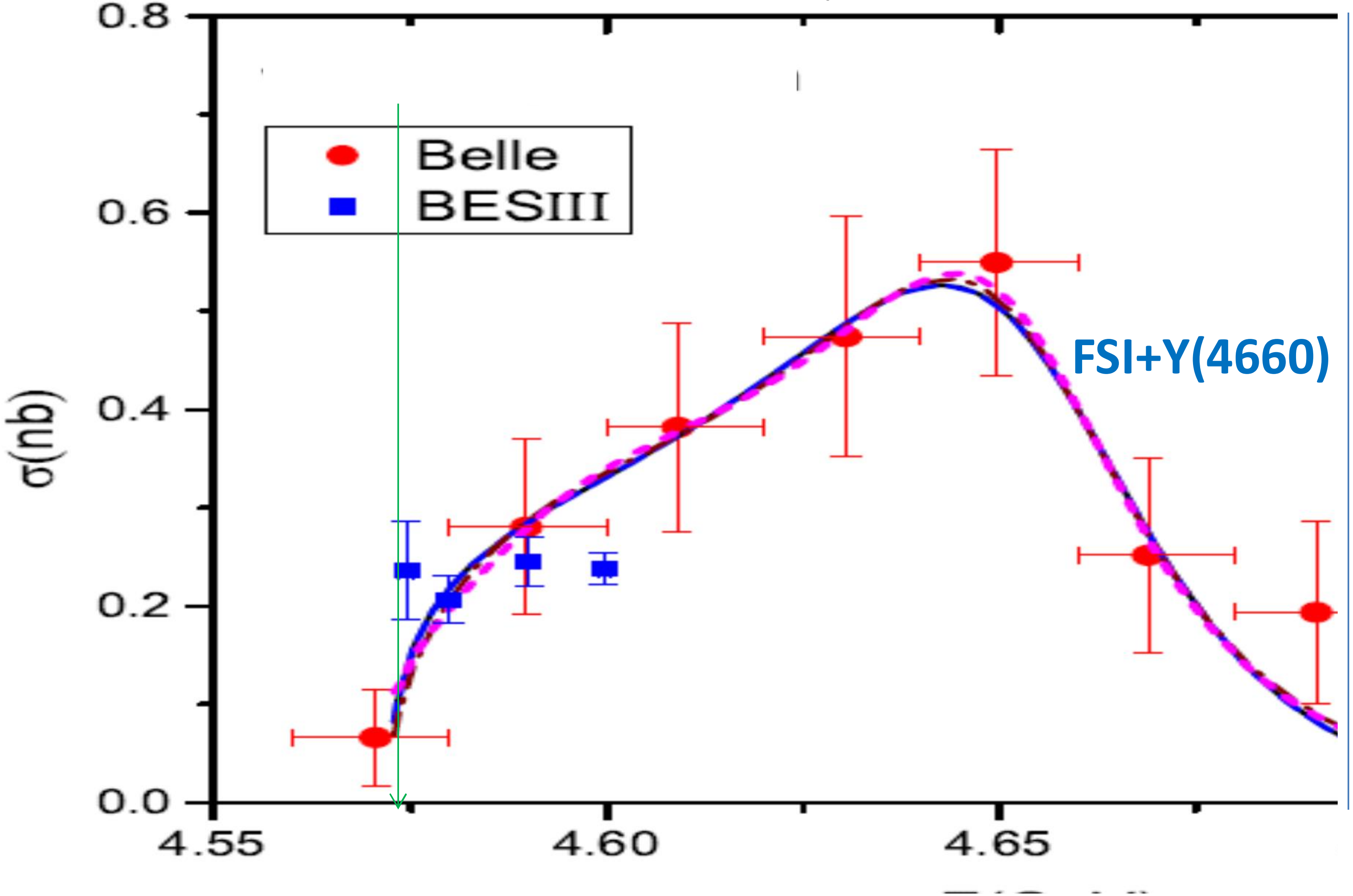
- $e^+ e^- \to \Lambda_c \Lambda_{cbar}$ **might be the ideal process to check the previous prejudices, achieved interpreting $e^+ e^- \to pp_{bar}$:**
- Because of the weak decay , $e^+ e^- \to \Lambda_c \Lambda_{cbar}$ can be detected with good efficiency even exactly at thr.
- The region sensitive to Coulomb interaction is enlarged, depending on the baryon velocity β_B only, since β_B scales like $1/\sqrt{M_B}$, close to a thr

- BESIII results (**Phys. Rev. Lett. 120, 132001)** reported in detail by Weiping Wang in his poster, are summarized and shown in the following .

Present data on $e^+ e^- \rightarrow \Lambda_c \Lambda_{cbar}$, close to thr

Belle G. Pakhlova *et al.* [Belle Collaboration], Phys. Rev. Lett. 101, 172001 (2008).

BESIII Ablikim *et al.*, arXiv:1710.00150 [hep-ex].

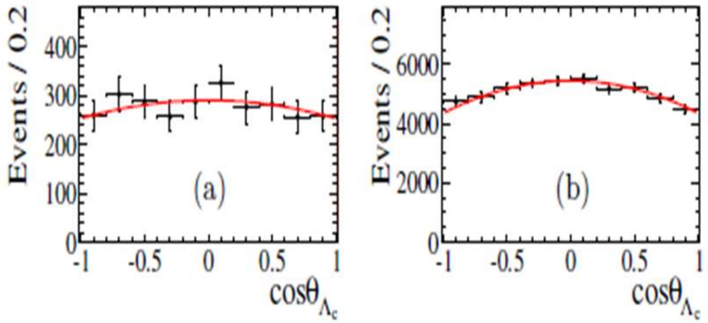


BESIII σ ($e^+ e^- \to \Lambda_c \Lambda_{cbar}$)

- The BESIII measurements indicate that:

- At thr there is indeed a jump in $\sigma(e^+ e^- \to \Lambda_c \Lambda_{cbar})$,
- Followed by a kind of a plateau
- At thr $\sigma(e^+ e^- \to \Lambda_c \Lambda_{cbar})$ is close to the pointlike value, once the Coulomb enhancement factor is taken into account:
  $\sigma(e^+ e^- \to \Lambda_c \Lambda_{cbar})_{pointl} \approx \pi^2\alpha^3/(2M_B) \approx 145$ pb
- Qualitatively, If $\sigma(e^+ e^- \to BB_{bar})$ would be driven by strong interaction, [asymptotically scaling as $(M_p / M_{\Lambda c})^{10}$] a quite smaller value (< 1 fb) would be expected [$\sigma(e^+ e \to pp_{bar}) \approx 0.85$ nb, at thr].

BESIII $e^+ e^- \to \Lambda_c \Lambda_{cbar}$ angular distributions



Angular distribution after efficiency correction and results of the fit to data at $\sqrt{s}$ = 4574.5 MeV (a) and 4599.5 MeV (b).

- The angular distr. is flat, as expected, at W= 4.57 GeV ($\beta_{\Lambda c}$= 0.026) within the errors.
  By the way very close to $\pi\alpha$=0.023, where Coulomb should matter
- The collected statistics is quite high at W=4.60 GeV ($\beta_{\Lambda c}$= 0.11) and as already seen in $e^+ e^- \to pp_{bar}$ at W=1.91 GeV (β_p = 0.20), there is a **very early onset of the D wave**.

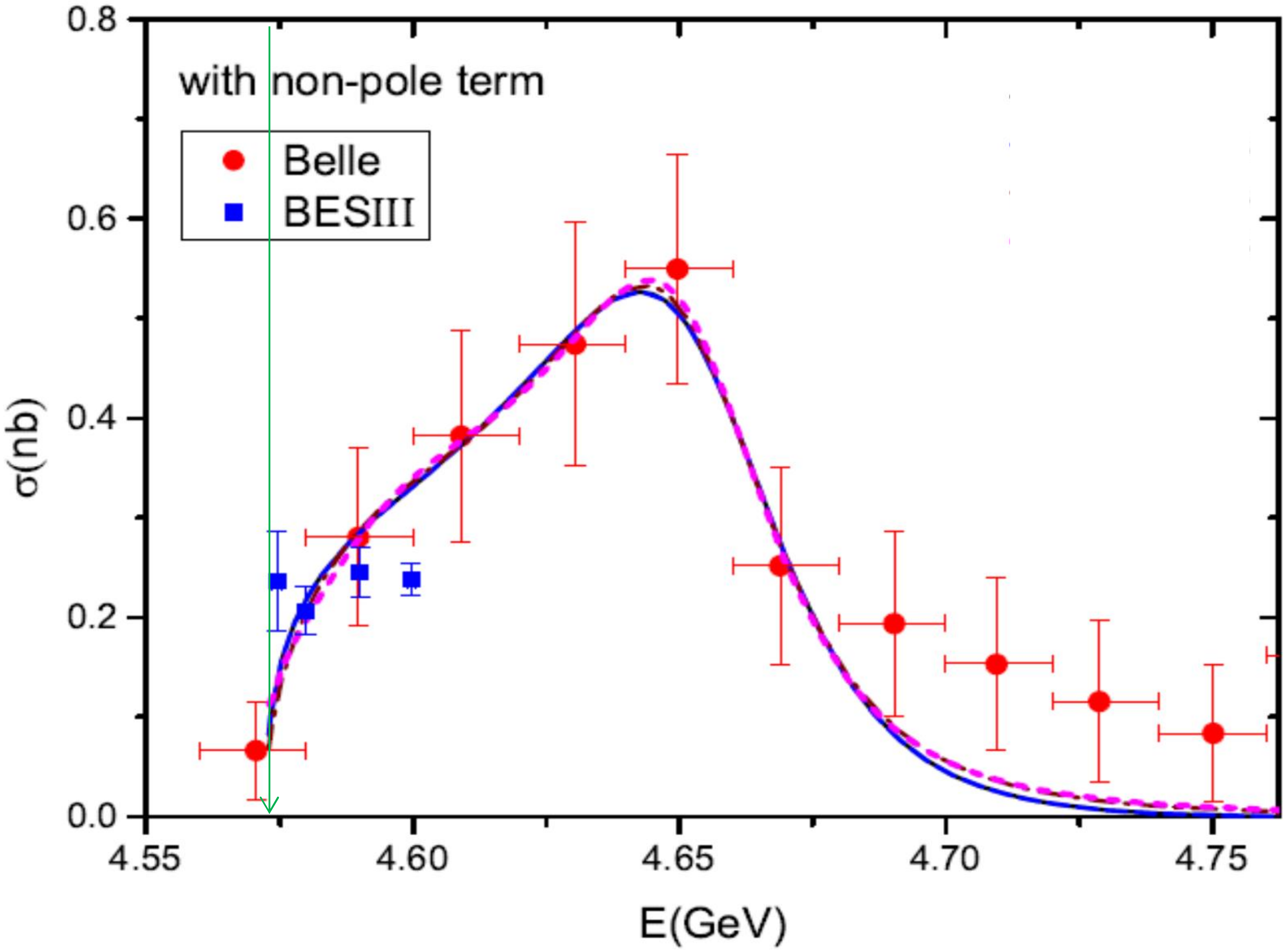
BESIII versus Belle in $e^+ e^- \to \Lambda_c \Lambda_{cbar}$

- Not settled yet, since there is some tension between BESIII and Belle in $\sigma(e^+ e^- \to \Lambda_c \Lambda_{cbar})$, as pointed out by Ulf Meissner and his collaborators and shown in the following , in particular:
- Belle data show a wide resonance, consistent with the Y(4660), seen by BaBar and Belle in $e^+ e^- \to \psi(3686) \pi^+ \pi^-$, hardly compatible with BESIII flat behaviour up to 4.6 GeV
- Belle data are fit by means of a resonance on top of $\Lambda_c\Lambda_{cbar}$ FSI, that predicts again a fast rise at thr, but not a jump.
- **More data at thr and above are needed and BESIII already got funds to increase maximum energy up to W = 4.9 GeV**

Data and fit FSI+Y(4660) on $e^+ e^- \to \Lambda_c \Lambda_{cbar}$

Belle G. Pakhlova *et al.* [Belle Collaboration], Phys. Rev. Lett. 101, 172001 (2008).

BESIII Ablikim *et al.*, arXiv:1710.00150 [hep-ex].

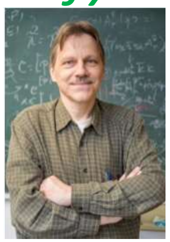


Fit to Belle Measurements

- Ling-Yun Dai, Johann Haidenbauer, Ulf-G. Meißner
  arXiv:1710.03142v1 [hep-ph] 9 Oct 2017

- Resonance Y(4660) [called X(4660) in this paper] + FSI @thr:
  M= (4652.5 ± 3.4) MeV
  Γ = (62.6 ± 5.6) MeV
  σ_{peak} ~ 0.55 nb [comparable to $\sigma(e^+ e^- \to pp_{bar})$ ~ 0.8 nb @ threshold]

- Concerning BESIII measurements they write:
  " *While they agree with the Belle data, as for as cross sections magnitude, they indicate a different trend in energy.*
  It is impossible to fit both data.
  Hopefully BESIII will extend their measurements at higher energies and thereby clarify the situation."



(our friend Ulf Meissner)

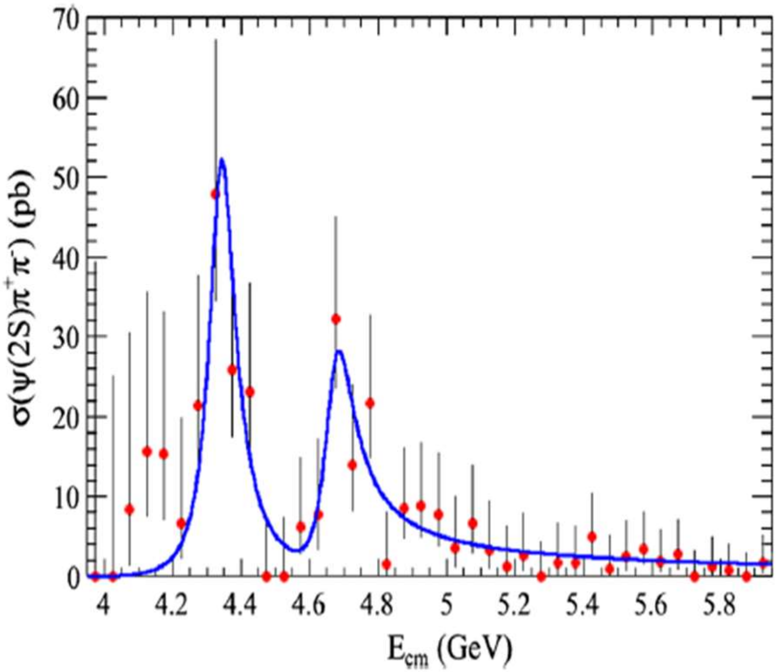
Other evidences of the Y(4660)

$e^+ e^-$ -> $\psi(3686)\ \pi^+ \pi^-$ by means of ISR

BaBar

M=4669 ± 22 , Γ=104 ± 49

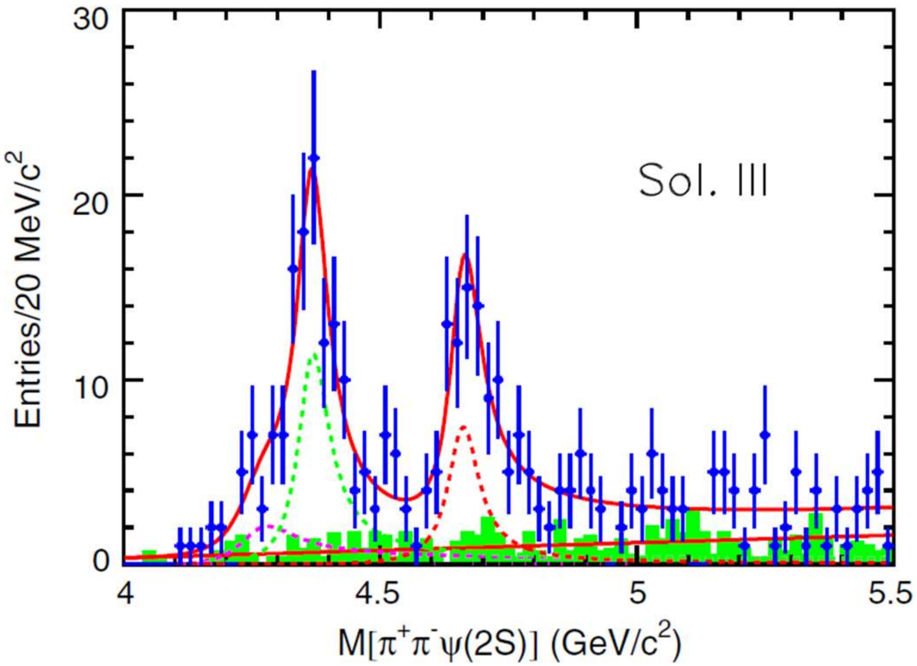
PHYSICAL REVIEW D **89**, 111103(R) (2014)



Belle

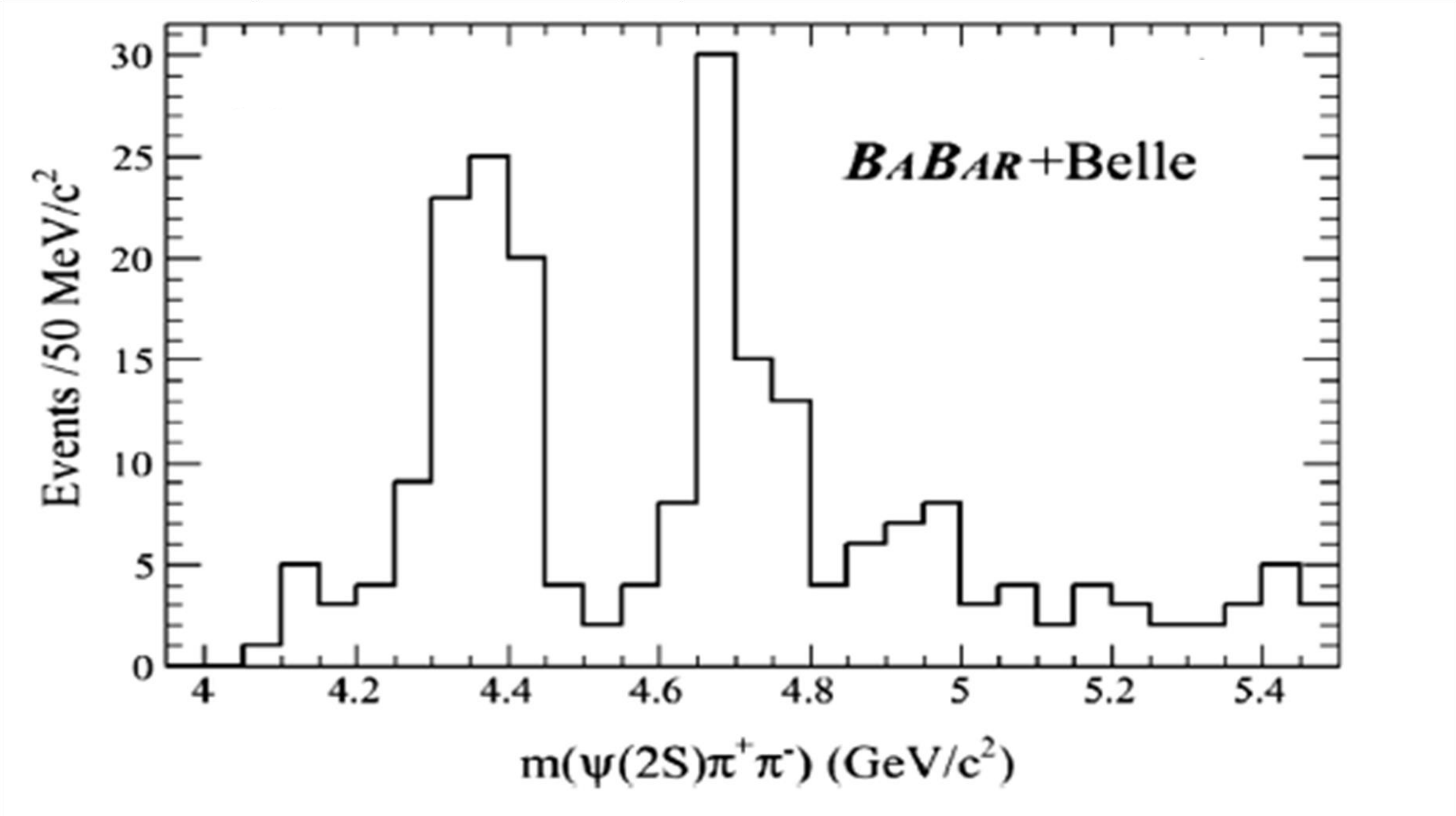
M=4652 ± 13 , Γ=68 ± 11

PHYSICAL REVIEW D **91**, 112007 (2015)



Other evidences of the Y(4660)

- Adding both measurements, to reduce the statistical error as done by BaBar in their paper:



Y(4660) in $e^+ e^- \to \psi(3686)\, \pi\, \pi$ cross section

- M = (4667 ± 7) MeV

  Γ = [36+32 (-14)] MeV (updated in PDG: 72 ± 11 MeV)

  $B\Gamma_{ee}$ = (1.4± 0.5) eV

- $\sigma_{peak} = 12\,\pi / M^2\, B\Gamma_{ee} / \Gamma \times 1.5$ (incl $\pi^0 \pi^0$) ~ **0.04** ± 0.025 nb

  to be compared to $e^+ e^- \to \Lambda_c \Lambda_{cbar}$ σ_{peak} ~ **0.55** nb

- **Y(4660) baryonic coupling ≥ 10 mesonic coupling**
  Unexpected !

  There is another mesonic decay
  with much larger BR than $\psi(3686)\, \pi\, \pi$?

  or

  Y(4660) is a charmed baryonium ?

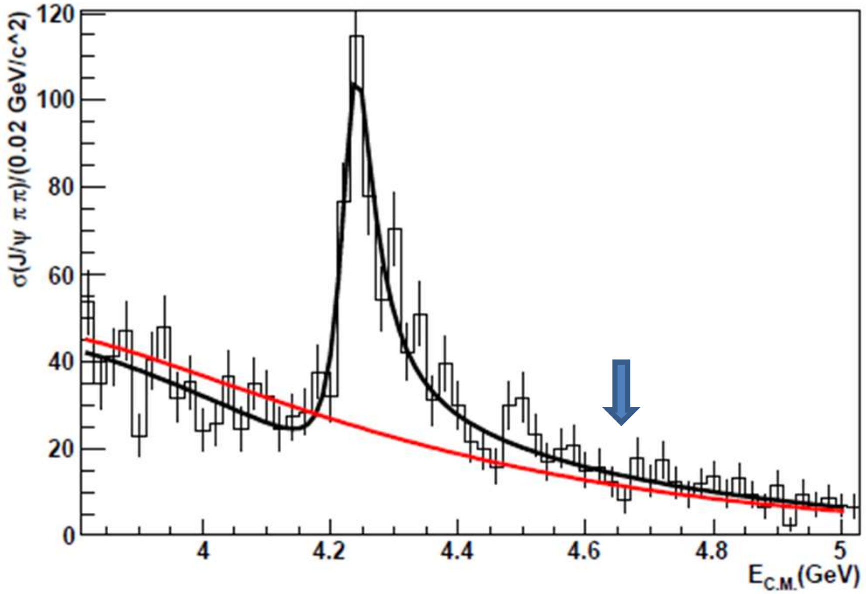
Y(4660) Charmed Baryonium ?

- The decay Y(4660)-> $J/\psi\ \pi\pi$ would be expected to be large if it is a cc_{bar} state, while at 90 % C.L.

  BR[Y(4660)-> $J/\psi\ \pi\pi$] /BR[Y(4660)-> $\psi(3686)\ \pi\pi$] < 0.46,

  according to BaBar data (arXiv:0808.1543 [hep-ex]) , as elaborated in arXiv:0911.2178v5 [hep-ph] (2017).

$e^+ e^- \to J/\psi\ \pi^+ \pi^-$



Y(4660) Charmed Baryonium ?

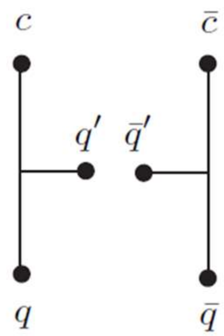
- According to R. Faccini et al. arXiv:0911.2178(2017),

  [see also L. Maiani, F. Piccinini, A. D. Polosa and V. Riquer, Phys. Rev. D 72, 031502]

  Y(4660) fulfills the old Rossi Veneziano, G.F. Chew paradigm

  [Nucl.Phys. B123,507(1977) , G.F.Chew Nucl.Phys. B79 (1974) 365]

  of a hidden charm tetraquark (charmed baryonium) decay: mostly poping up from the vacuum a light quark pair and falling apart as a charmed baryon pair



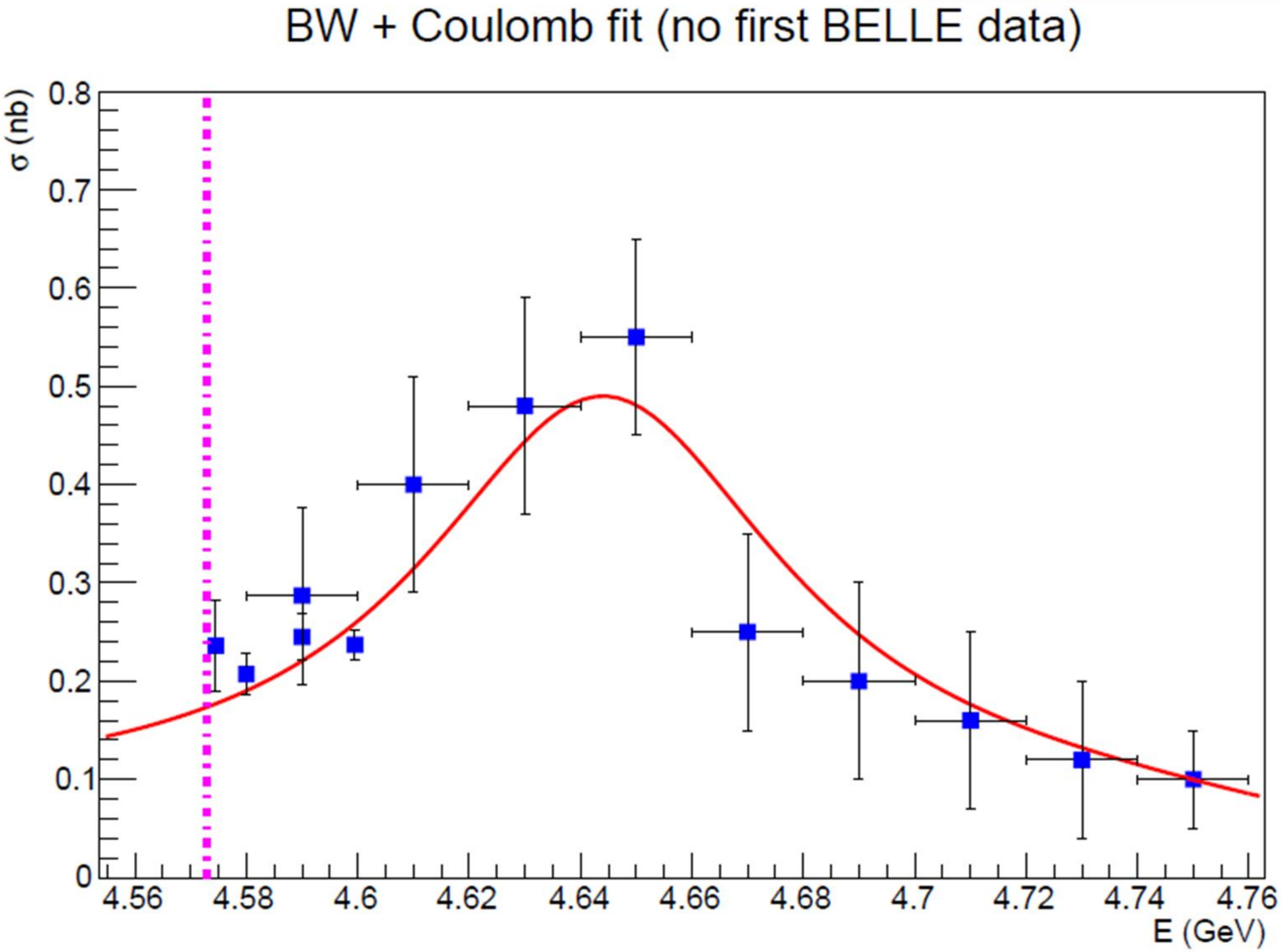
Y(4660) Charmed Baryonium ?

- Y(4660) mass, close to the $\Lambda_c\ \Lambda_{cbar}$ threshold, is in favour of its interpretation as a charmed baryonium.
- Y(4660)-> $\Lambda_c\ \Lambda_{cbar}$ shape and width, actually (expected large, according to the Rossi Veneziano model) is constrained by the threshold close by.
- If BESIII would not confirm the Y(4660) -> $\Lambda_c\ \Lambda_{cbar}$ decay a strong support of the interpretation of the XYZ states as tetraquark states would be somewhat in trouble.
- It might be that the Meissner et al conclusions are too drastic. In the following slide a fit with a Y(4660) on top of a Coulomb amplitude closer to a pointlike $\Lambda_c\ \Lambda_{cbar}$ at threshold is shown.

  More data by BESIII at threshold and above W=4.6 GeV will settle all these questions.

Try to fit by means of a simple model
Belle + BESIII data

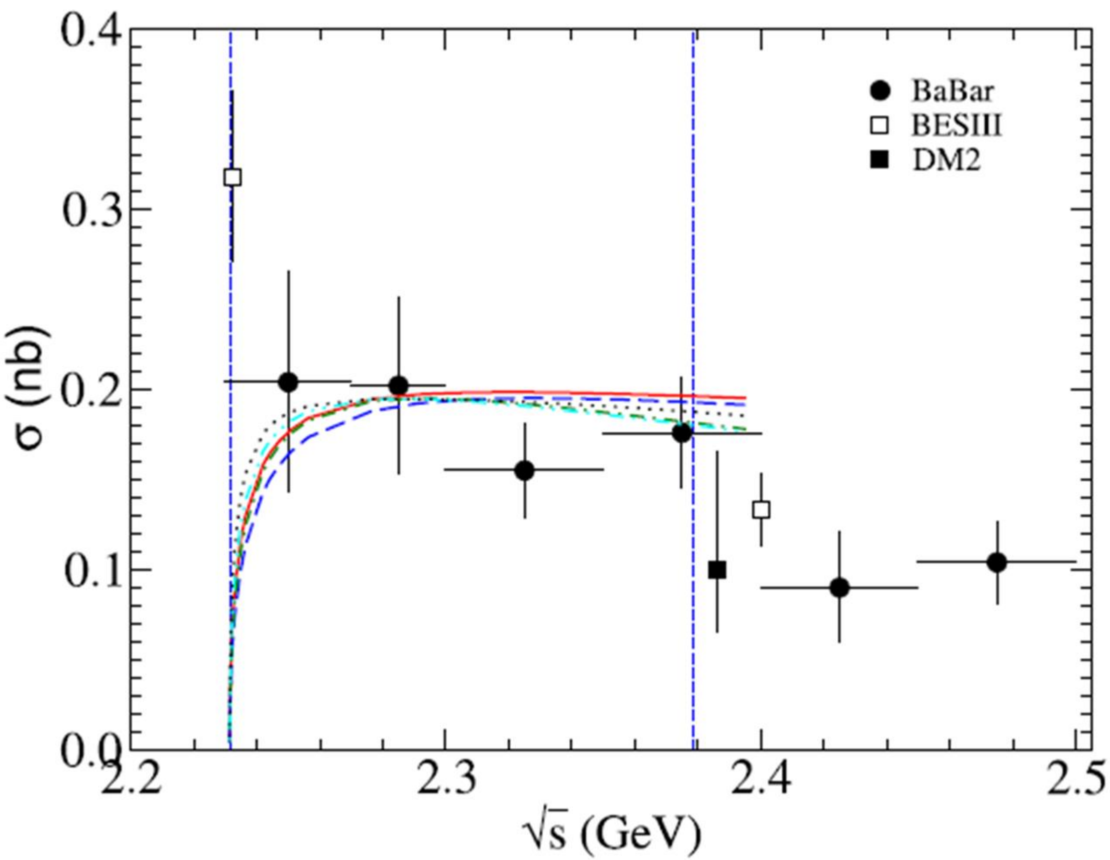
- Belle+ BESIII: M = 4644 ± 6 MeV , Γ= 80 ± 17 MeV P= 63 %



The mystery of
Neutral Baryon Pairs at thr

Present data on $e^+ e^- \to \Lambda \Lambda_{bar}$

- BESIII results (**Phys. Rev. D 97, 032013)** are reported in detail by Xiaorong Zhou
- Neutral Baryon: no Coulomb, but still jump at thr !

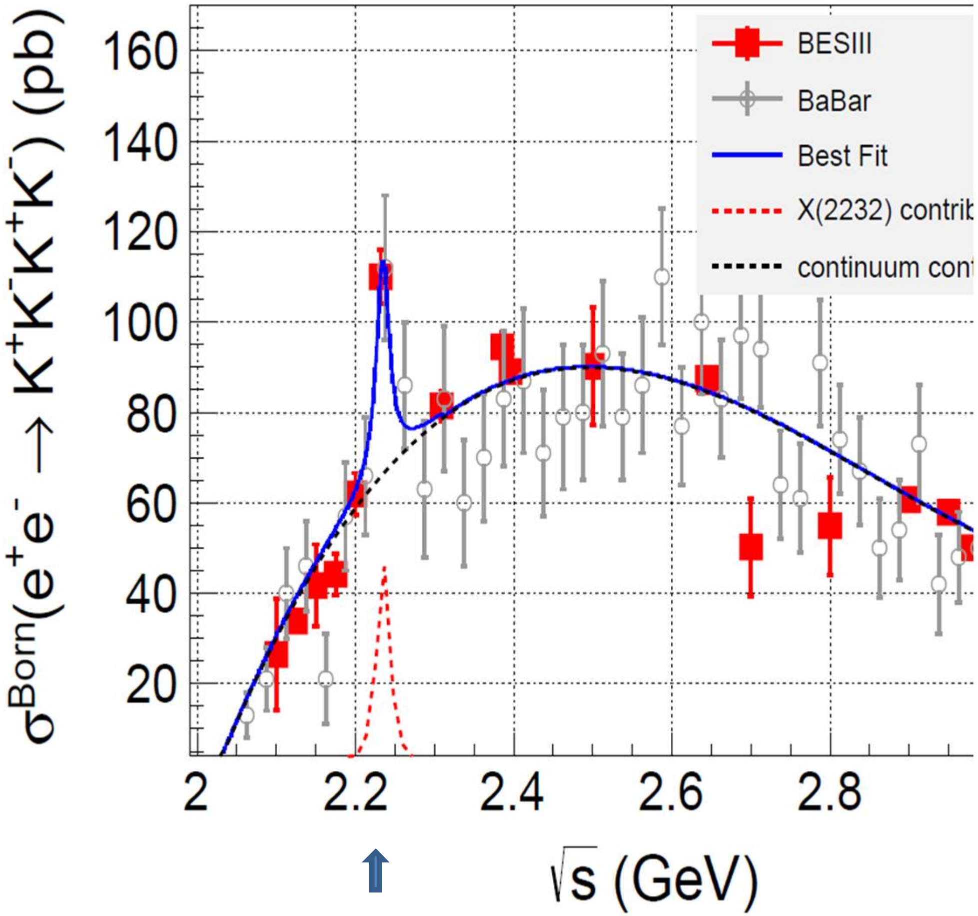


FSI fit to $e^+ e^- \to \Lambda \Lambda_{bar}$

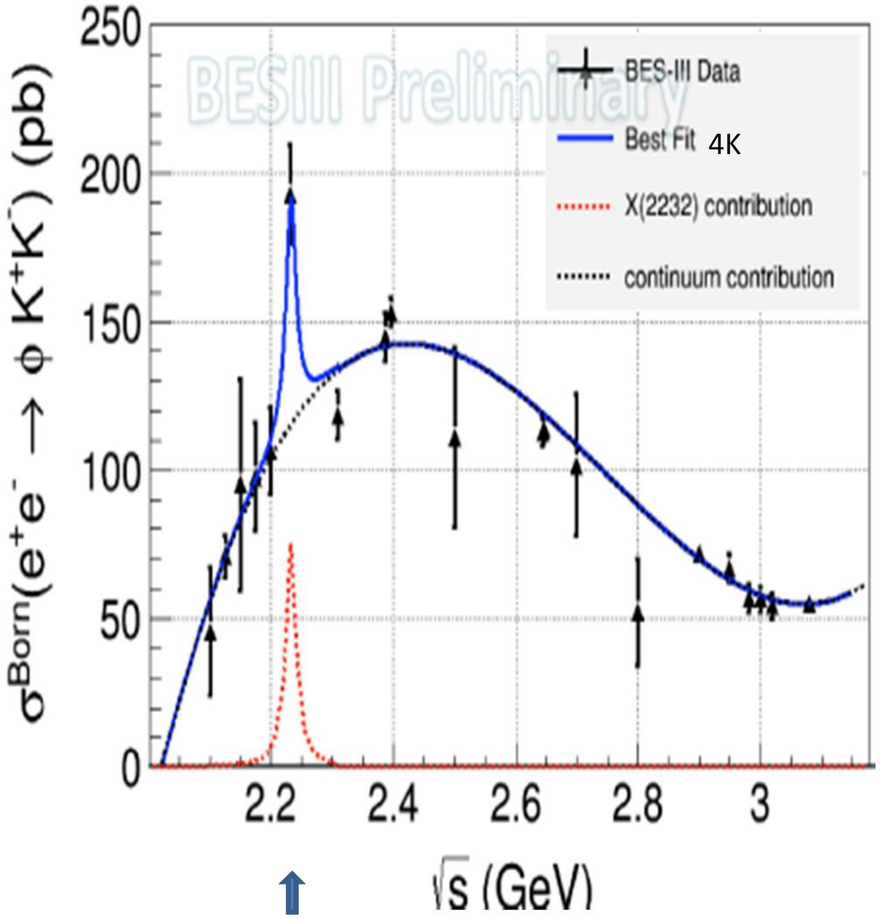
- J.Haidenbauer and U.G. Meissner [Phys.Lett B761 (2016)] FSI model fit BaBar, (even if the first point energy error is suspicious, it should already show a trend to zero), but not BESIII data.
- *"BESIII data suggest a very different trend for the energy dependence . Specifically, a large finite value for the cross section practically at the threshold is suggested. This cannot be reproduced by our model because of the phase-space β.*
- *There is no Coulomb interaction here that would change the threshold behavior*
- *The only possibility could be a very narrow resonance sitting more or less directly at the threshold, which would then allow to overrule the behavior from the phase space alone."*

An anomaly related to $e^+ e^- \to \Lambda \Lambda_{bar}$ thr ?

- $e^+e^- \to K^+K^- K^+K^-$, ϕK^+K^- M=2232 ± 3.5 MeV , Γ = 7.5(+13.5) MeV
  (A hint for such a resonance, more data needed)



$e^+ e^- \to \Lambda \Lambda_{bar}$ threshold



$e^+ e^- \to \Lambda \Lambda_{bar}$ threshold

Light Quarks “Baryonium” ?

BESIII $J/\psi \to \gamma\, pp_{bar}$
Sharp rise @ thr , light quarks **"baryonium"** ?

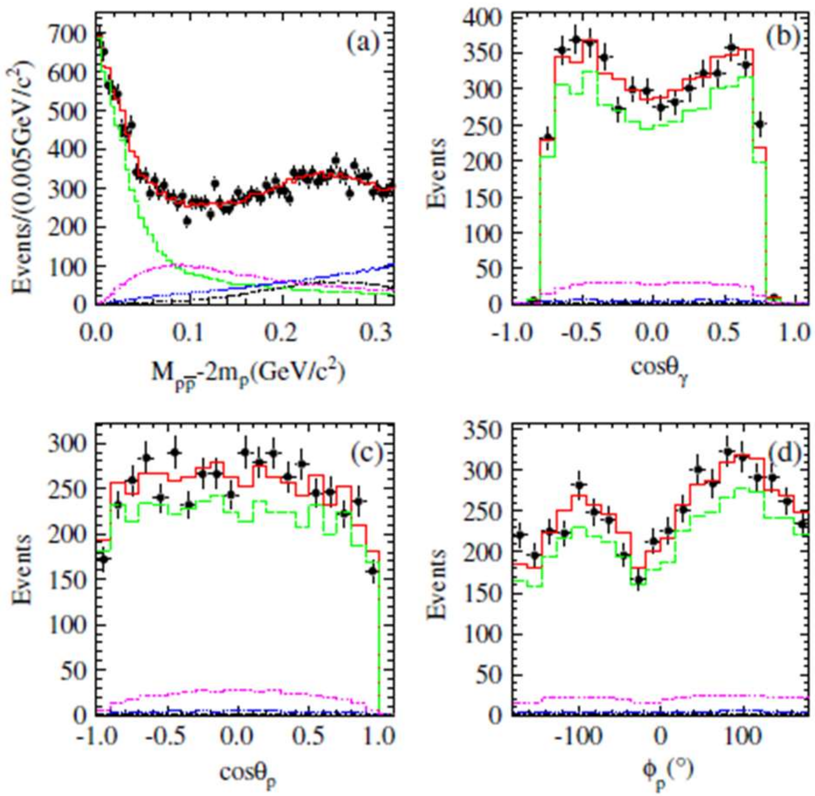


FIG. 2 (color online). Comparisons between data and PWA fit projection: (a) the $p\bar{p}$ invariant mass; (b)–(d) the polar angle θ_γ of the radiative photon in the J/ψ center of mass system, the polar angle θ_p and the azimuthal angle ϕ_p of the proton in the $p\bar{p}$ center of mass system with $M_{p\bar{p}} - 2m_p < 50\ \mathrm{MeV}/c^2$, respectively. Here, the black dots with error bars are data, the solid histograms show the PWA total projection, and the dashed, dotted, dash-dotted, and dash-dot-dotted lines show the contributions of the $X(p\bar{p})$, 0^{++} phase space, $f_0(2100)$ and $f_2(1910)$, respectively.

FSI or Light quarks **"baryonium"** in $J/\psi \to \gamma\, NN_{bar}$ @ thr ?

- Meissner et al FZJ–IKP(TH)–2004–20, HISKP-TH-04-24
  from $\sigma(pp_{bar} \to pp_{bar})$ scattering lengths:
  $a_0 = -0.18 - 1.18\, i$
  $a_1 = 1.13 - 0.61\, i$

- **If FSI :**
  $BR(J/\psi \to \gamma pp_{bar}) \approx \sigma(\gamma NN_{bar}) \times |a_0 + a_1|^2$
  $BR(J/\psi \to \gamma nn_{bar}) \approx \sigma(\gamma NN_{bar}) \times |a_0 - a_1|^2$
  $BR(\gamma nn_{bar}) / BR(\gamma pp_{bar}) \approx$ 0.5

- **If NN_{bar} resonance below thr (light quarks "baryonium"):**
  $BR(\gamma nn_{bar}) / BR(\gamma pp_{bar}) \approx$ 1

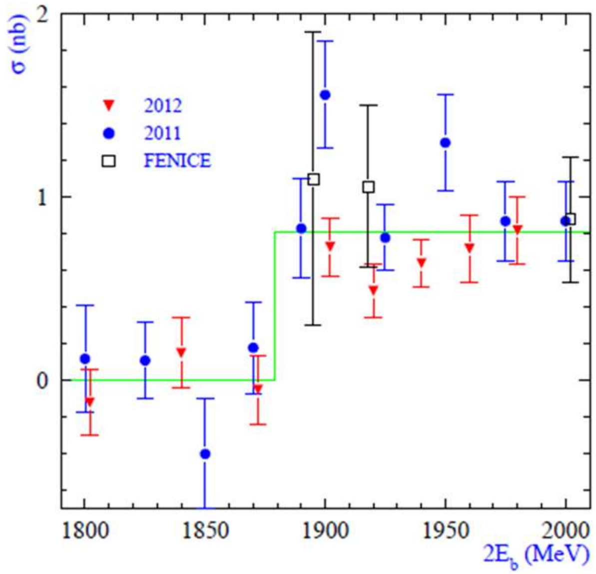
- **$BR(J/\psi \to \gamma nn_{bar})$ measured by BESIII (under review)**

$e^+ e^- \to n n_{bar}$

$e^+ e^- \to n\bar{n}$

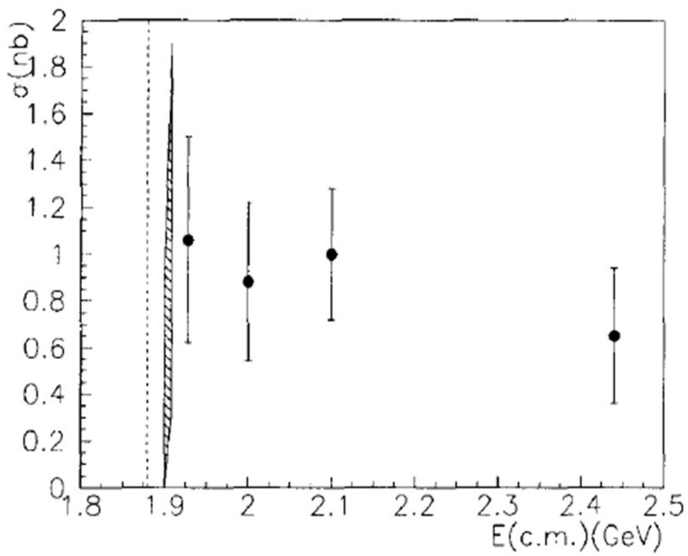
- Published data

SND



FENICE

A. Antonelli et al./Nuclear Physics B 517 (1998) 3–35



- Not vanishing cross section at thr (?)
- **New measurements by SND, CMD3**
- **New measurements by BESIII from 2 to 3 GeV ! (under review)**

G_E / G_M phase

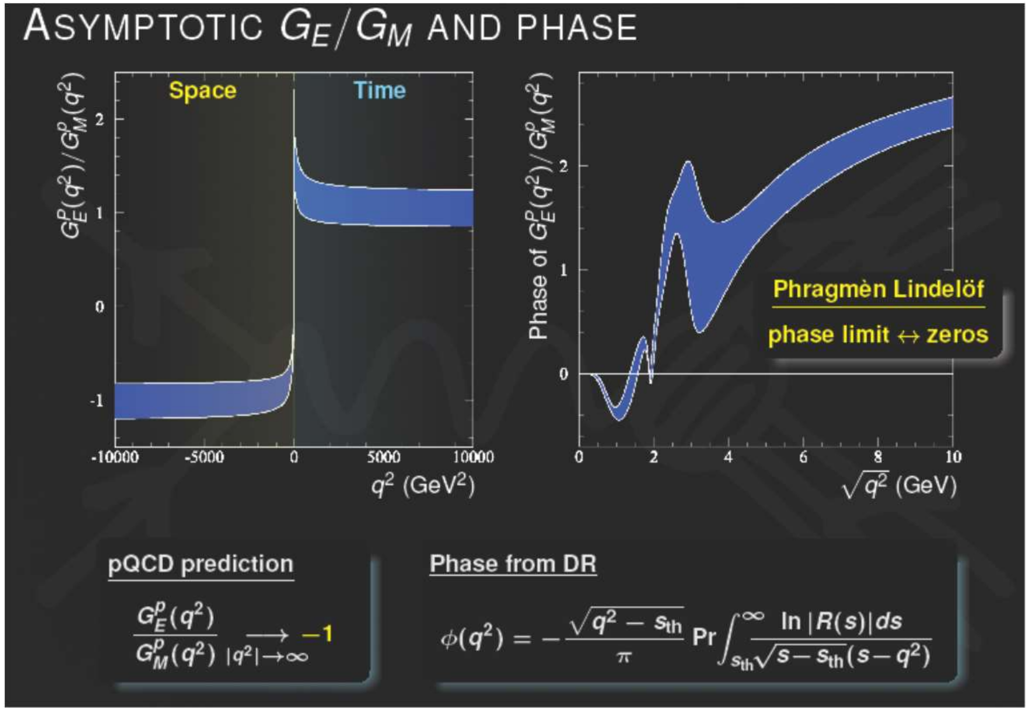
G_E / G_M phase @ BESIII

- Possible to get G_E/G_M phase ϕ_{EM}:
- $e^+e^- \to \Lambda\Lambda_{bar}$, $e^+e^- \to \Sigma\Sigma_{bar}$, shown in detail by Karin Schönning , from the decay angular distribution , due to Λ, Σ polarization. BESIII results in $e^+e^- \to \Lambda\Lambda_{bar}$ at 2.3 GeV, $J/\psi \to \Lambda\Lambda_{bar}$ under review
- $e^+e^- \to pp_{bar}$, in principle from p scattering on a slab of carbon fiber, for instance the DC inner wall (few permille) after CGEM installation?

- Expectations:
- Analiticity demands every amplitude real, asymptotically i.e. : in $e^+e \to pp_{bar}$ $\phi_{EM} \approx 0^0$ or 180^0
- But, applying Dispersion Relations, with a possible zero contribution to G_E/G_M spacelike, it has been found (Simone Pacetti):
  in $e^+e \to pp_{bar}$ $\phi_{EM} \approx 45^0$
  depending if there is indeed a zero in the G_E/G_M spacelike.
  Hence the G_E/G_M timelike phase tells about a spacelike zero !!

Dispersion Relation applied to $|G_E / G_M|$ to get the phase

- Dispersion Relations applied to $|G_E/G_M|$:
  input spacelike -> output timelike



Waiting for

Future

- Near Future
- Present theory is missing something
- $e^+ e^- \to p\bar{p}$: more data from CMD3 and BESIII
- $e^+ e^- \to \Lambda_c \Lambda_{cbar}$: more data at thr and above by BESIII
- $e^+ e^- \to \Lambda \Lambda_{bar}$ and $e^+e^- \to \phi K^+K^-$: more data around $\Lambda \Lambda_{bar}$ thr
- BR($J/\psi \to \gamma n n_{bar}$) : publication by BESIII
- $e^+ e^- \to n n_{bar}$: more data from SND, CMD3
  publication by BESIII
- G_E/G_M phase : more data from BESIII
- Far Future
- Super τ/charm : in Russia (Novosibirsk?)
  in China (Hefei, Beijing?)

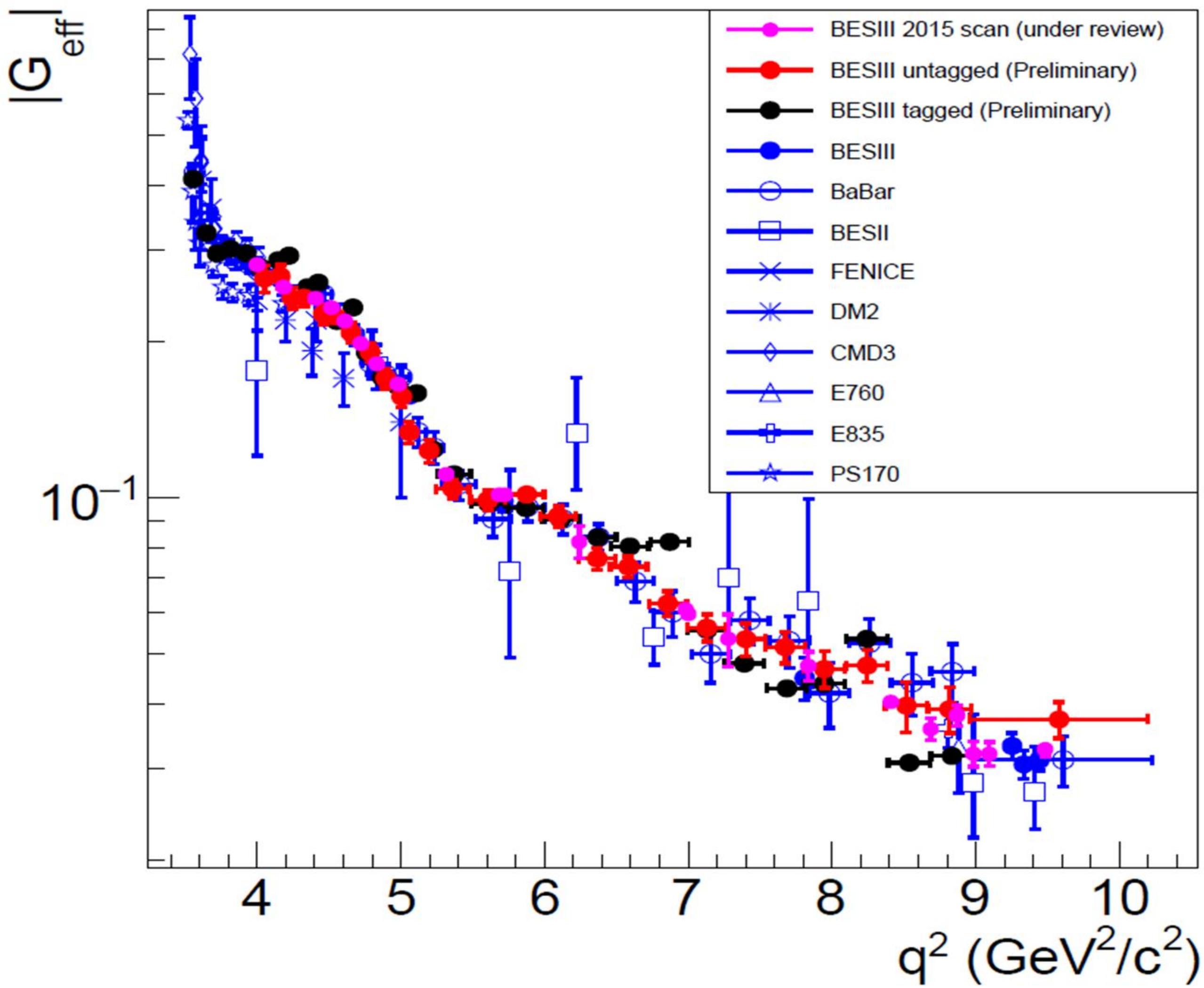
Thanks for

谢谢

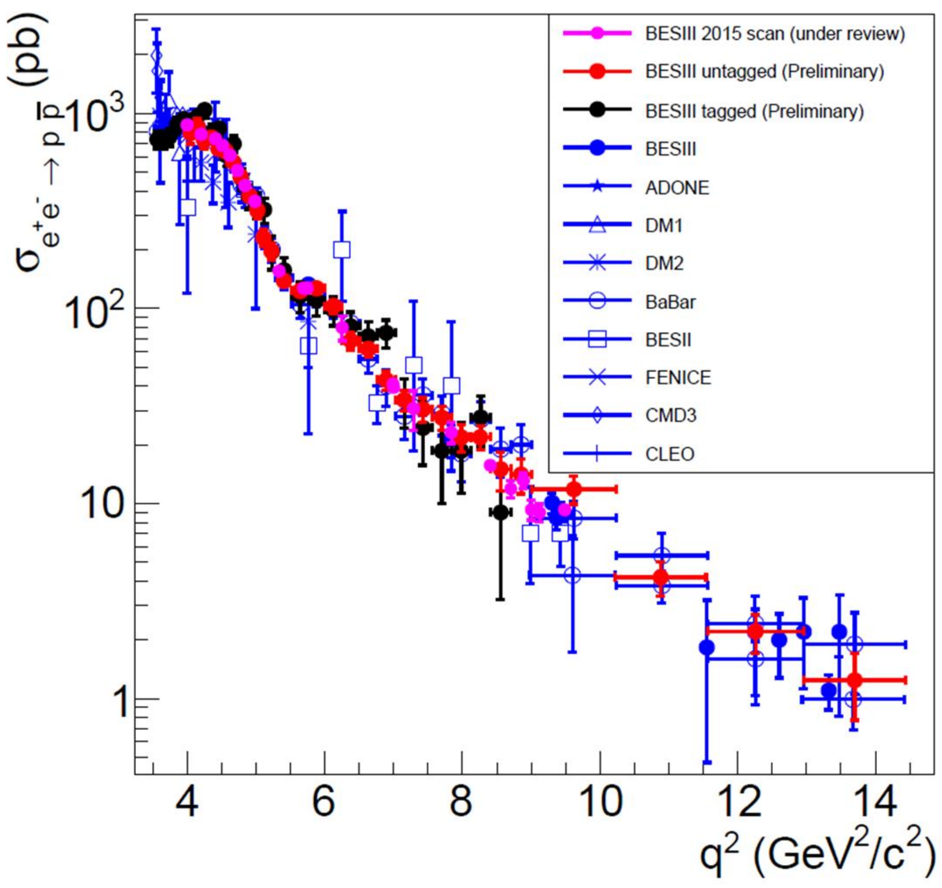
your attention

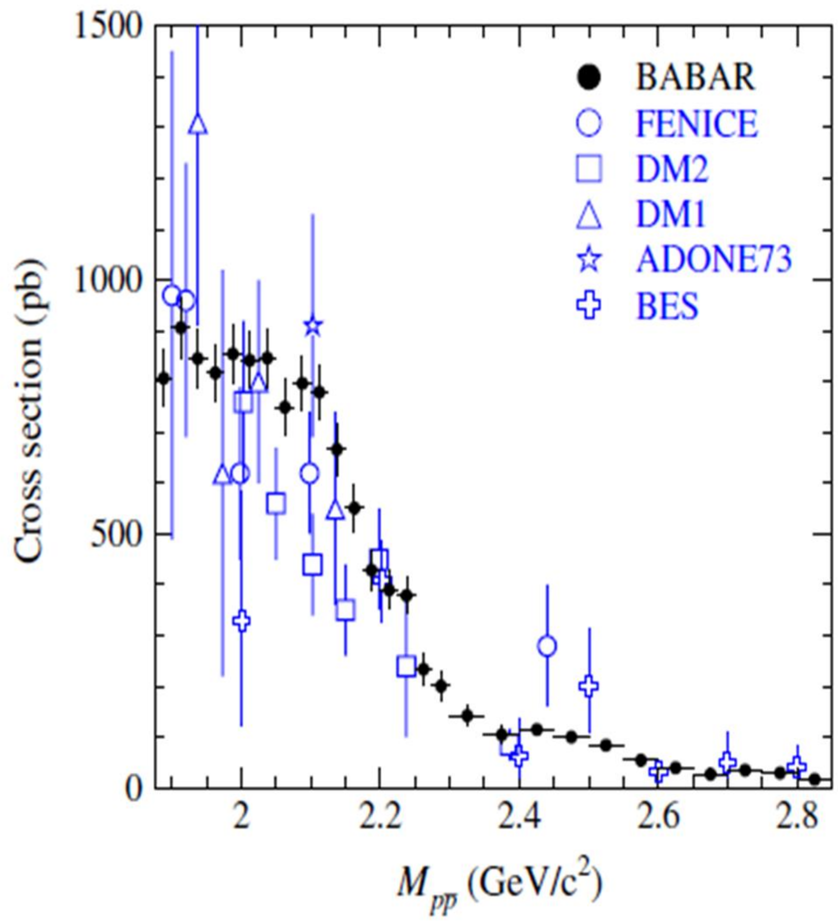
Backup slides

Present data on G_{eff} ($e^+ e^-$ -> pp_{bar})

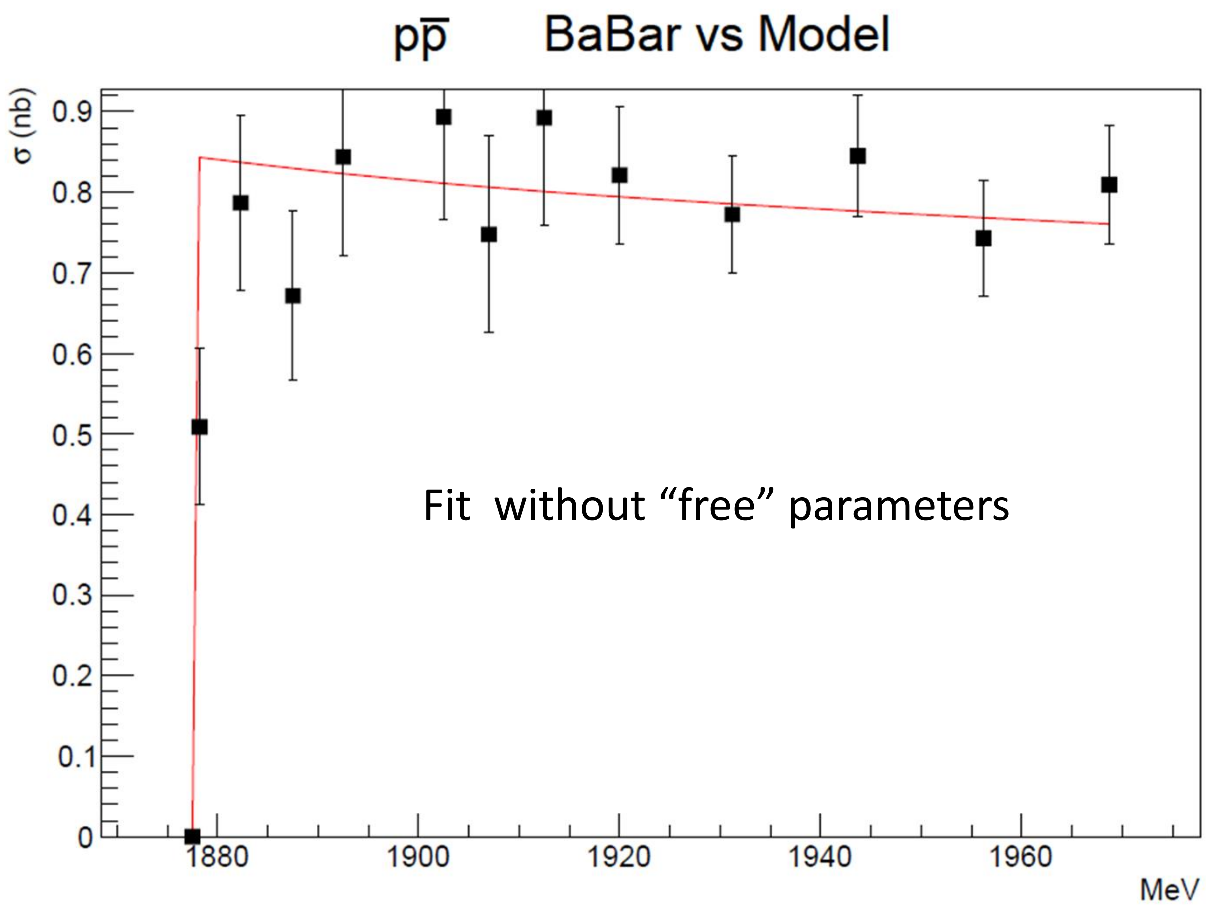


Present data on $\sigma(e^+ e^- \to pp_{bar})$

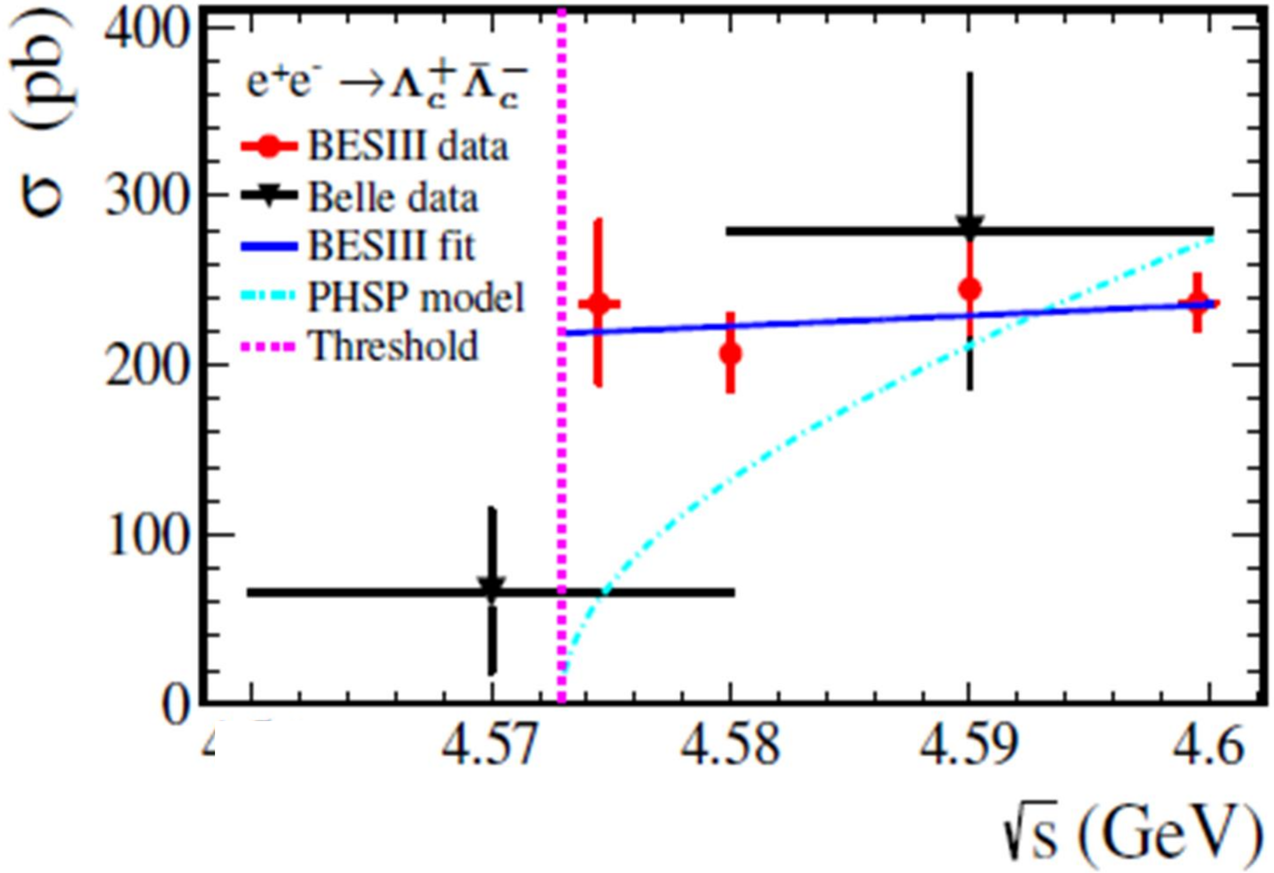




$\sigma(e^+ e^- \to p p_{bar})$ close to thr



BESIII σ ($e^+ e^-$ -> Λ_c Λ_{cbar})



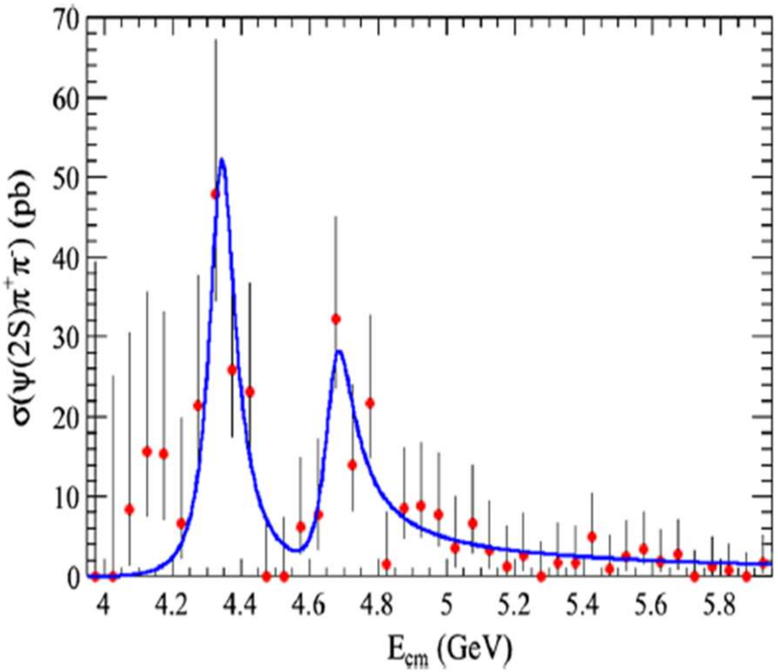
Other evidences of the Y(4660)

$e^+ e^-$ -> $\psi(3686)\ \pi^+\ \pi^-$ by means of ISR

BaBar

M=4669 ± 22 , Γ=104 ± 49

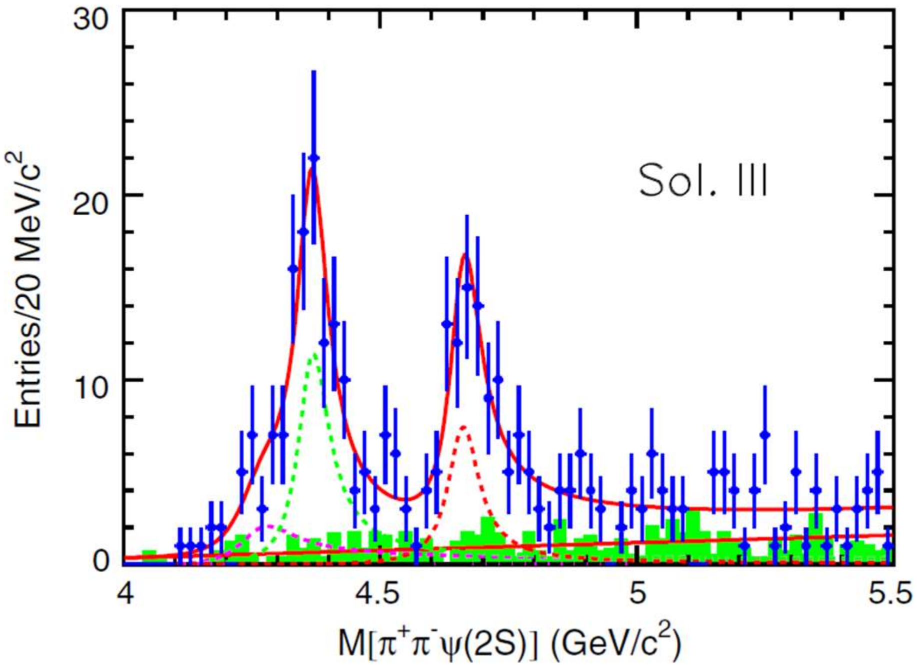
PHYSICAL REVIEW D **89,** 111103(R) (2014)



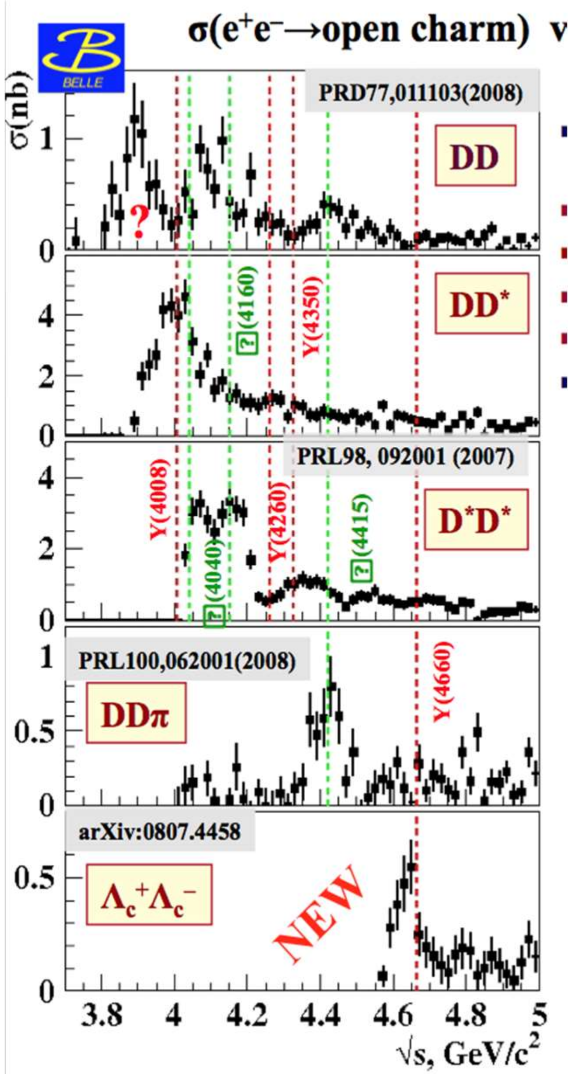
Belle

M=4652 ± 13 , Γ=68 ± 11

PHYSICAL REVIEW D **91,** 112007 (2015)

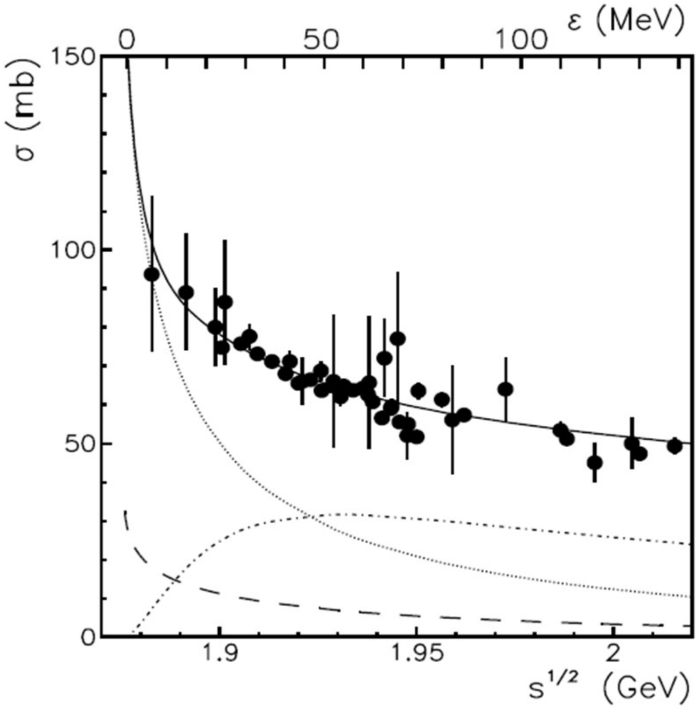


No Y(4660) in $e^+ e^-$ -> DD, DD*,D*D*
(from Steve Olsen)



FSI interpretation of J/ψ -> γ pp$_{bar}$ @ thr

FZJ–IKP(TH)–2004–20, HISKP-TH-04-24



σ(pp$_{bar}$ -> pp$_{bar}$)