Hadron Structure at BESIII

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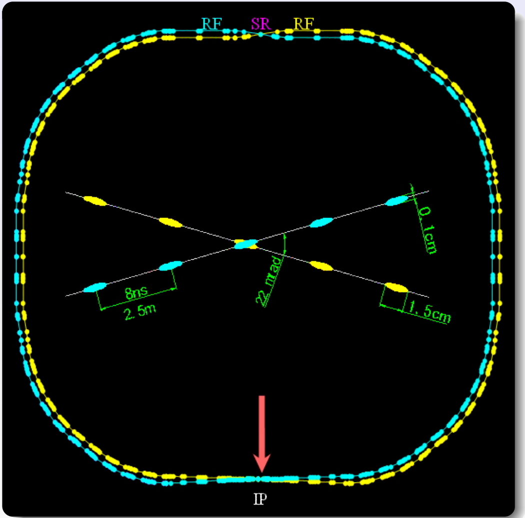
The Structure and Dynamics of Hadrons

International Workshop
XXXIX on Gross Properties of Nuclei and Nuclear Excitations

Hirschegg, January 16^{th} - 22^{nd}, 2011

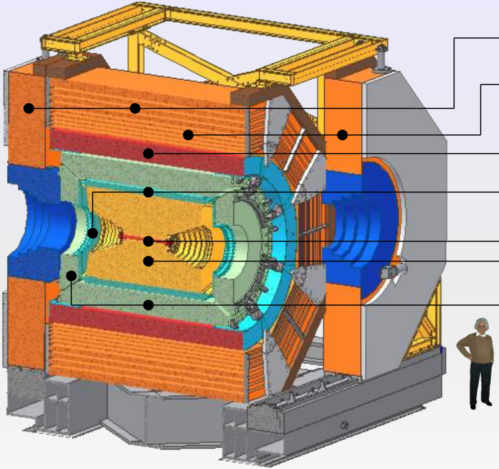
BEPCII: e^+e^- double ring collider



Design Features

- Beam energy: **1.0** - **2.3** GeV
- Crossing angle: **22** mrad (DAΦNE 50 mrad)
- **Luminosity: 10^{33} cm^{-2}s^{-1}**
- **Optimum energy: 1.89 GeV**
- Energy spread: **5.16×10^{-4}**
- Number of bunches: **93**
- Bunch length: **1.5** cm
- Total current: **0.91** A

The **BESIII** detector



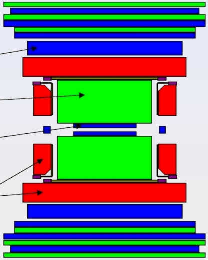
- **Magnet yoke**
- **RPC (9/8 layers Barrel/Endcaps)**
- **SC magnet, 1 Tesla**
- **TOF (scintillators), 90 ps**
- **Be beam pipe**
- **MDC, 120μm**
- **CsI(Tl) calorimeter, 2.5% at 1 GeV**

Performances à la *BaBar*

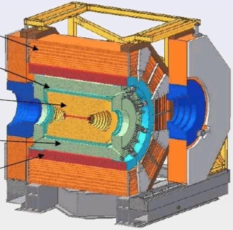
A significant improvement with respect to BESII

The **BESII** and **BESIII** detectors

BESII @ BEPC



BESIII @ BEPCII



Device	Performance
MDC	$\sigma_p/p = 1.7\%\sqrt{1+p^2}$, $dE/dx = 8\%$
TOF	180 ps (bhabha)
EMC	$\sigma_E/E < 22\%/\sqrt{E}$
MUC	3 layers
Magnet	0.4 T Solenoidal

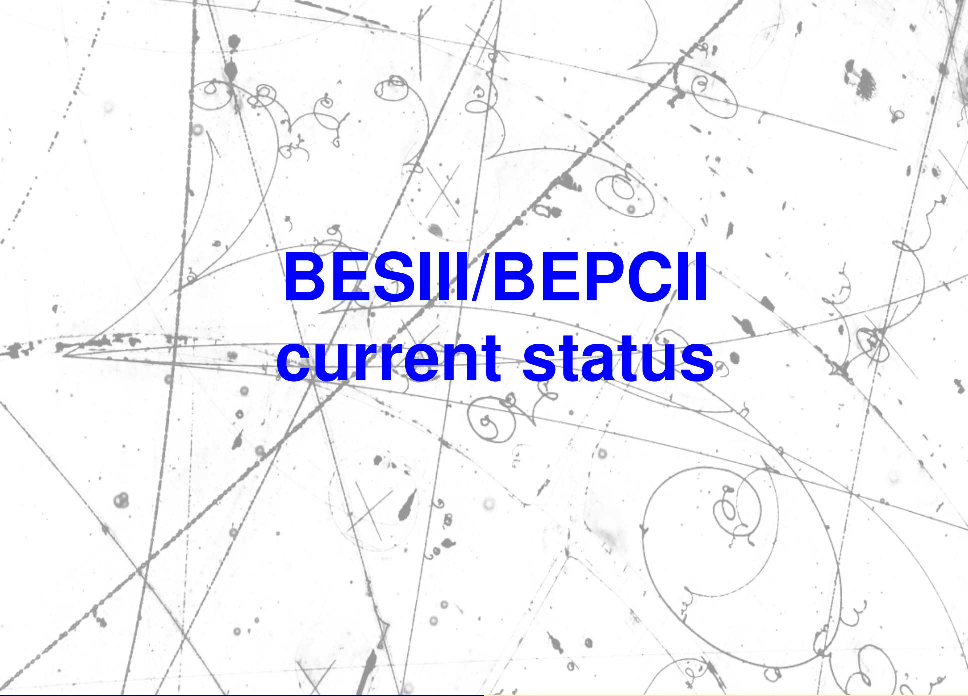
Device	Performance
MDC	$\sigma_p/p = 0.5\%$, $dE/dx < 6\%$
TOF	80 ps barrel (bhabha), 100 ps endcap
EMC	$\sigma_E/E < 2.5\%/\sqrt{E}$
MUC	9 barrel $+$ 8 endcap layers
Magnet	1 T Solenoidal

Physics at **BEPCII/BESIII**

arXiv:0809.1869 [hep-ex]
IJMP A V24, No1(2009)supp

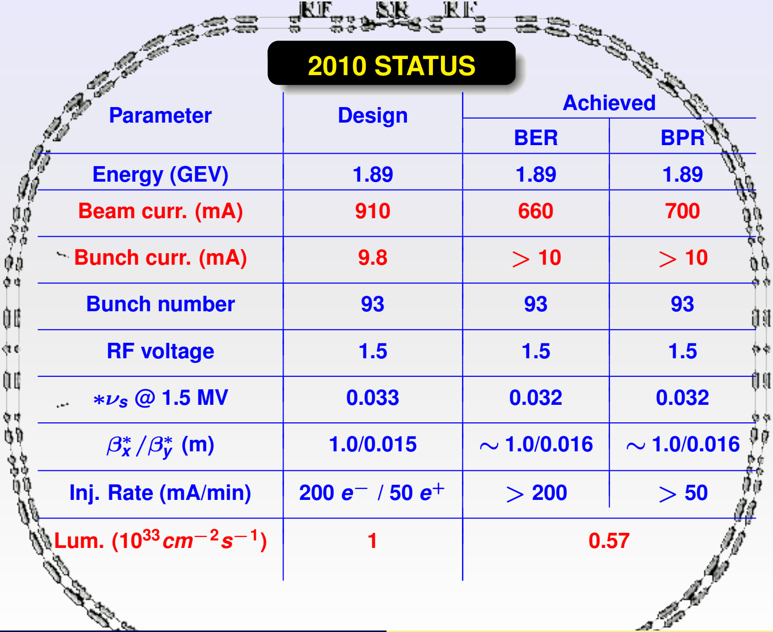
- $R_{\rm had}$ **and precision test of Standard Model**
- **Light hadron spectroscopy** ($\phi f_0(980)$, $\phi\pi^0$,...)
- **Charm and charmonium physics**
- τ **physics**
- **Precision measurements of CKM matrix elements**
- **Search for new physics / new particles**

Physics Channels	Energy (GeV)	Luminosity (10^{33} cm^{-2} s^{-1})	Events/year
J/Ψ	3.10	0.6	1.0×10^{10}
τ	3.67	1.0	1.2×10^{7}
$\Psi(2S)$	3.69	1.0	3.0×10^{9}
D^*	3.77	1.0	2.5×10^{7}
D_s	4.03	0.6	1.0×10^{6}
D_s	4.14	0.6	2.0×10^{6}



BESIII/BEPCII current status

BEPCII: e^+e^- double ring collider

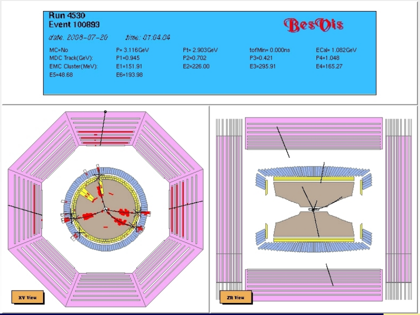


2010 STATUS

Parameter	Design	Achieved	
		BER	BPR
Energy (GEV)	1.89	1.89	1.89
Beam curr. (mA)	910	660	700
Bunch curr. (mA)	9.8	> 10	> 10
Bunch number	93	93	93
RF voltage	1.5	1.5	1.5
$*\nu_s$ @ 1.5 MV	0.033	0.032	0.032
β_x^* / β_y^* (m)	1.0/0.015	$\sim$ 1.0/0.016	$\sim$ 1.0/0.016
Inj. Rate (mA/min)	200 e^- / 50 e^+	> 200	> 50
Lum. ($10^{33} cm^{-2} s^{-1}$)	1	0.57	

BEPCII / BESIII milestones

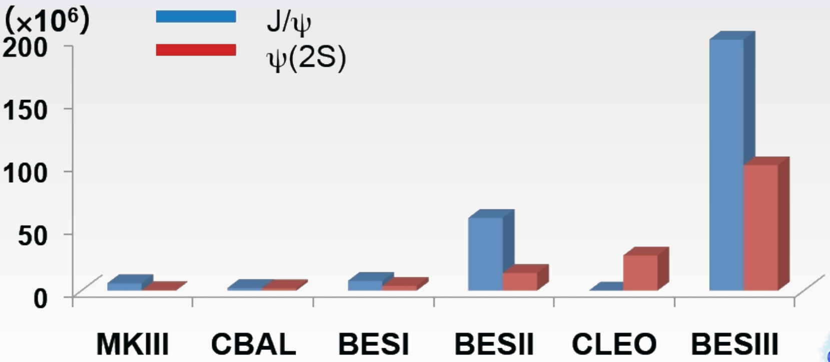
- **Mar. 2008:** Collisions at 500 mA $\times$ 500 mA, Luminosity: $1 \times 10^{32} cm^{-2} s^{-1}$
- **Apr. 30, 2008:** Move BESIII to IP
- **July 18, 2008:** First e^+e^- collision event in BESIII
- **Apr. 14, 2009:** $\sim$ 106 M $\Psi(2S)$ events ($150 pb^{-1}$) ($\sim 42 pb^{-1}$ at 3.65 GeV)
- **July 28, 2009:** $\sim$ 226 M J/Ψ events ($65 pb^{-1}$)
- **June 1, 2010:** $\sim 930 pb^{-1}$ at $\Psi(3770)$ ($\sim 70 pb^{-1}$ scanning in the $\Psi(3770)$ energy region)



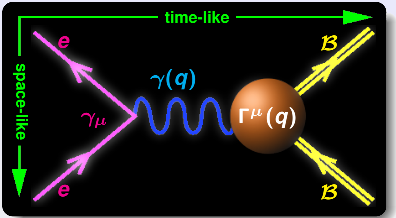
Record Luminosity on Jan 12, 2011
$5.7 \times 10^{32} cm^{-2} s^{-1}$
or
$8 \times$ CESRc
$45 \times$ BEPC

World J/Ψ and $\Psi(2S)$ Samples ($\times 10^6$)

- **BESIII:** $\sim$ 106 M $\Psi(2S)$ events (150pb^{-1})
  BESII: $\sim$ 14 M $\Psi(2S)$ events
- **BESIII:** $\sim$ 226 M J/Ψ events (65pb^{-1})
  BESII: $\sim$ 58 M J/Ψ events



Pointlike Baryons?



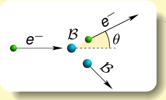
Nucleon current operator (Dirac & Pauli)

$$\Gamma^\mu(q) = \gamma^\mu F_1(q^2) + \frac{i}{2M_\mathcal{B}}\sigma^{\mu\nu} q_\nu F_2(q^2)$$

Electric and Magnetic Form Factors

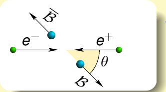
$$G_E(q^2) = F_1(q^2) + \tau F_2(q^2) \qquad \tau = \frac{q^2}{4M_\mathcal{B}^2}$$

$$G_M(q^2) = F_1(q^2) + F_2(q^2)$$



Elastic scattering (Rosenbluth)

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2 E_e' \cos^2\frac{\theta}{2}}{4E_e^3 \sin^4\frac{\theta}{2}} \left[G_E^2 - \tau\left(1+2(1-\tau)\tan^2\frac{\theta}{2}\right)G_M^2\right]\frac{1}{1-\tau}$$



Annihilation

Coulomb correction

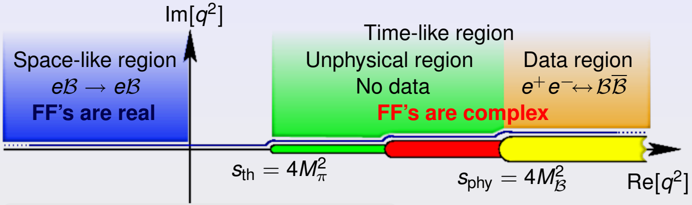
$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2\beta C}{4q^2}\left[(1+\cos^2\theta)|G_M|^2 + \frac{1}{\tau}\sin^2\theta|G_E|^2\right]$$

$$\beta = \sqrt{1-\frac{1}{\tau}}$$

Pointlike fermions e.g. $e^+e^- \longrightarrow \mu^+\mu^-$: $\frac{d\sigma}{d\Omega} = \frac{\alpha^2\beta_\mu C}{4q^2}\left(2-\beta_\mu^2\sin^2\theta\right) \Longrightarrow |G_E| = |G_M| \equiv 1$

Analyticity of baryon form factors

q^2-complex plane



Crossing: tot. helicity $= \begin{cases} 1 \Rightarrow G_E \\ 0 \Rightarrow G_M \end{cases}$

$$G_E(4M_\mathcal{B}^2) = G_M(4M_\mathcal{B}^2)$$

QCD counting rule constrains the asymptotic behaviour

Matveev, Muradyan, Tevkheldize, Brodsky, Farrar

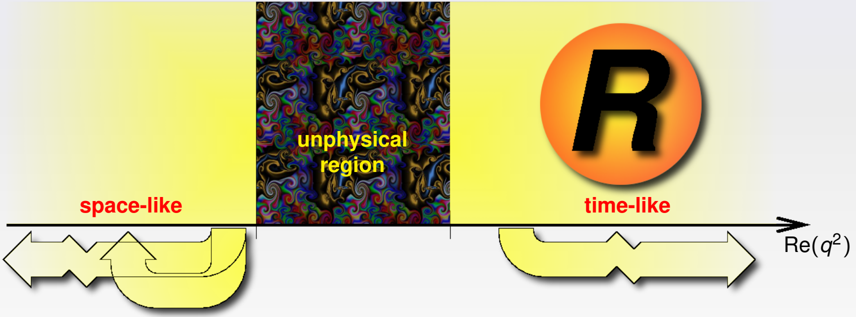
Counting rule: $q^2 \to -\infty$
$i = 1$ Dirac, $i = 2$ Pauli FF

$$F_i(q^2) \propto (-q^2)^{-(i+1)} \Rightarrow G_{E,M} \propto (-q^2)^{-2}$$

Analyticity: $q^2 \to \pm\infty$
(Phragmèn Lindelöf)

$$G_{E,M}(-\infty) = G_{E,M}(+\infty)$$

The ratio $R = \mu_p \frac{G_E^p}{G_M^p}$



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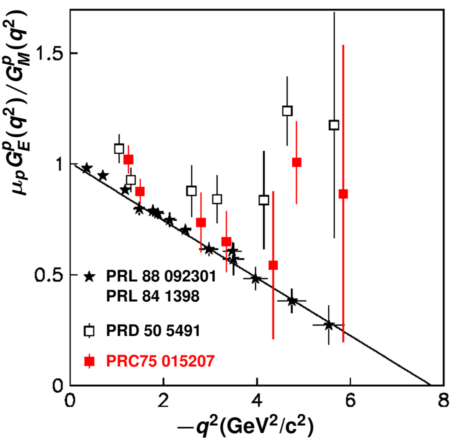
Space-like G_E^p / G_M^p measurements

Space-like data



$$G_E^p = F_1^p + \frac{q^2}{4M_p^2} F_2^p$$

$$G_M^p = F_1^p + F_2^p$$

Space-like

F_1 and $\frac{q^2}{4M_p^2} F_2$ cancellation

$$\frac{G_E^p(q^2)}{G_M^p(q^2)} < 1$$

Time-like

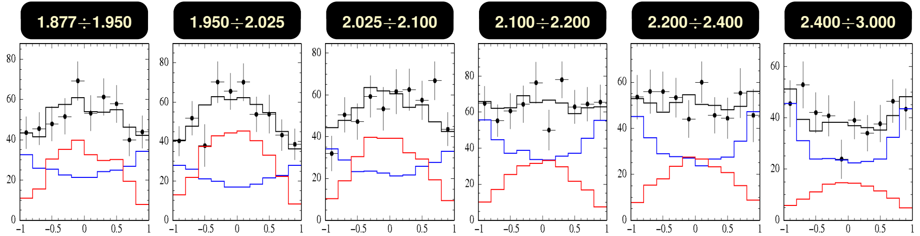
F_1 and $\frac{q^2}{4M_p^2} F_2$ enhancement

$$\left|\frac{G_E^p(q^2)}{G_M^p(q^2)}\right| > 1$$

$e^+e^- \longrightarrow p\bar{p}$ angular distribution (*BABAR*)

PRD73, 012005

$\cos\theta_p$ distributions form threshold up to 3 GeV [intervals in $E_{CM} \equiv q$ (GeV)]



Events/0.2 vs. $\cos\theta_p$

$$\frac{d\sigma}{d\cos\theta_p} = A\left[H_E(\cos\theta_p, q^2)\left|\frac{G_E^p(q^2)}{G_M^p(q^2)}\right|^2 + H_M(\cos\theta_p, q^2)\right]$$

H_E and H_M from MC

Histograms show contributions from

- G_E
- G_M

At low q

$\sin^2\theta_p > 1 + \cos^2\theta_p$

$\Rightarrow$

First observation!

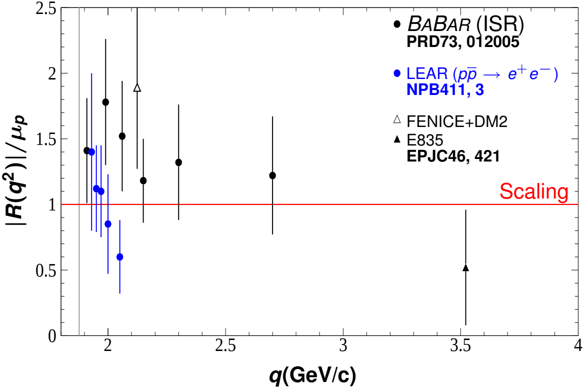
$|G_E^p| > |G_M^p|$

At higher q, $|G_E^p| \longrightarrow |G_M^p|$

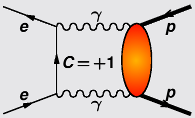
Time-like $|G_E^p/G_M^p|$ measurements

$$\frac{d\sigma}{d\cos\theta} = \frac{\pi\alpha^2\beta_p C}{2q^2}|G_M^p|^2\left[(1+\cos^2\theta) + \frac{4M_p^2}{q^2\mu_p^2}\sin^2\theta|R|^2\right]$$

$$R(q^2) = \mu_p\frac{G_E^p(q^2)}{G_M^p(q^2)}$$



$\gamma\gamma$ exchange

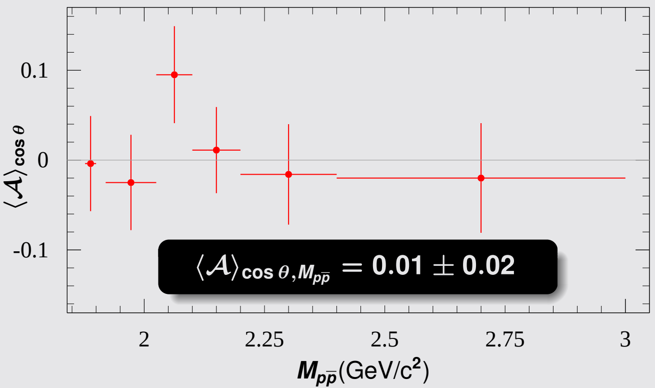


$\gamma\gamma$ exchange interferes with the Born term

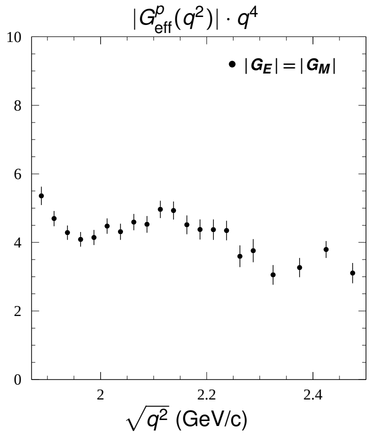
Asymmetry in angular distributions

[PLB659, 197]

$$\mathcal{A}(\cos\theta, M_{p\bar{p}}) = \frac{\frac{d\sigma}{d\Omega}(\cos\theta, M_{p\bar{p}}) - \frac{d\sigma}{d\Omega}(-\cos\theta, M_{p\bar{p}})}{\frac{d\sigma}{d\Omega}(\cos\theta, M_{p\bar{p}}) + \frac{d\sigma}{d\Omega}(-\cos\theta, M_{p\bar{p}})}$$



$|G_E^p(q^2)|$ and $|G_M^p(q^2)|$ from $\sigma_{p\bar{p}}$ and DR

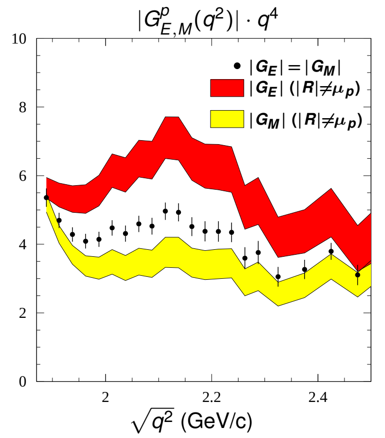


$$|G_{\rm eff}(q^2)|^2 = \frac{\sigma_{p\bar{p}}(q^2)}{\frac{4\pi\alpha^2\beta C}{3s}}\left(1+\frac{1}{2\tau}\right)^{-1}$$

- **Usually what is extracted from the cross section $\sigma(e^+e^- \longrightarrow p\bar{p})$ is the effective time-like form factor $|G^p_{\rm eff}|$ obtained assuming $|G_E^p| = |G_M^p|$ i.e. $|R| = \mu_p$**
- **Using DR's to parameterize R and the BABAR data on $\sigma(e^+e^- \longleftrightarrow p\bar{p})$, $|G_E^p|$ and $|G_M^p|$ may be disentangled**
- **BESIII can measure separately $|G_E^p|$ and $|G_M^p|$**

Cfr. talk by Simone Pacetti:
Dispersion Relations and Nucleon Form Factors

$|G_E^p(q^2)|$ and $|G_M^p(q^2)|$ from $\sigma_{p\bar{p}}$ and DR



$$|G_M(q^2)|^2 = \frac{\sigma_{p\bar{p}}(q^2)}{\frac{4\pi\alpha^2\beta C}{3s}} \left(1 + \frac{|R(q^2)|}{2\mu_p\tau}\right)^{-1}$$

- **Usually what is extracted from the cross section $\sigma(e^+e^- \to p\bar{p})$ is the effective time-like form factor $|G^p_{\text{eff}}|$ obtained assuming $|G_E^p| = |G_M^p|$ i.e. $|R| = \mu_p$**
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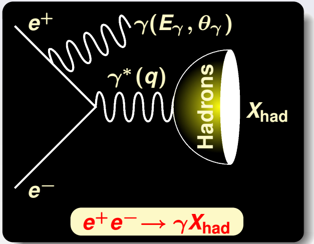
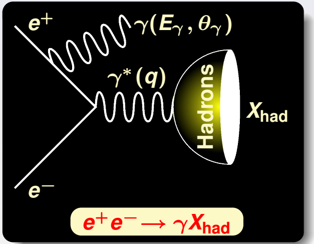
ISR



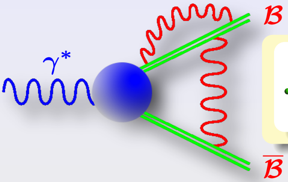
e^+
$\gamma(E_\gamma, \theta_\gamma)$
$\gamma^*(q)$
Hadrons
X_{had}
e^-
$e^+e^- \longrightarrow \gamma X_{had}$

ISR



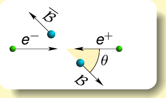
e^+
$\gamma(E_\gamma, \theta_\gamma)$
$\gamma^*(q)$
Hadrons
X_{had}
e^-
$e^+e^- \longrightarrow \gamma X_{had}$

The Coulomb Factor



$p\bar{p}$ Coulomb interaction as FSI

[Sommerfeld, Sakharov, Schwinger, Fadin, Khoze]



Annihilation — **Coulomb correction**

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2 \beta C}{4q^2}\left[(1+\cos^2\theta)|G_M|^2 + \frac{1}{\tau}\sin^2\theta |G_E|^2\right]$$

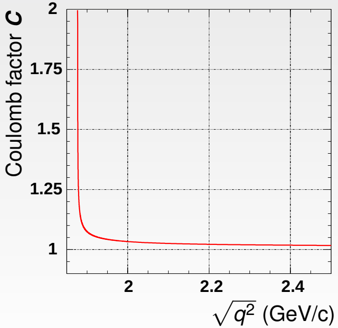
Distorted wave approximation

$$C = |\Psi_{\mathrm{Coul}}(0)|^2$$

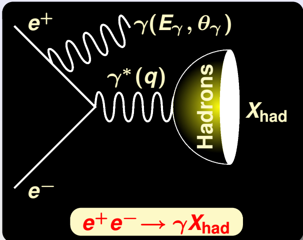
S-wave: $C = \dfrac{\frac{\pi\alpha}{\beta}}{1-\exp\left(-\frac{\pi\alpha}{\beta}\right)} \xrightarrow[\beta\to 0]{} \dfrac{\pi\alpha}{\beta}$

D-wave: $C = 1$

No Coulomb factor for boson pairs (P-wave)



Initial State Radiation



- $$\frac{d^2\sigma}{dE_\gamma \, d\theta_\gamma} = W(E_\gamma, \theta_\gamma) \cdot \sigma_{e^+e^- \to X_{had}}(s)$$
- $$W(E_\gamma, \theta_\gamma) = \frac{\alpha}{\pi x}\left(\frac{2 - 2x + x^2}{\sin^2 \theta_\gamma}\right)$$

- $s = q^2$, q .... X_{had} momentum
- E_γ, θ_γ ... CM γ energy, scatt. ang.
- E_{CM} .... CM e^+e^- energy
- $x = E_\gamma / 2E_{CM}$

Advantages

- All energies (q^2) at the same time
  $\Downarrow$
  Better control on systematics
  (e.g. greatly reduced point to point)
- Detected ISR $\Rightarrow$ full X_{had} angular coverage
- CM boost $\Rightarrow$ { at threshold $\epsilon \neq 0$; energy resolution $\sim$ **1 MeV** }

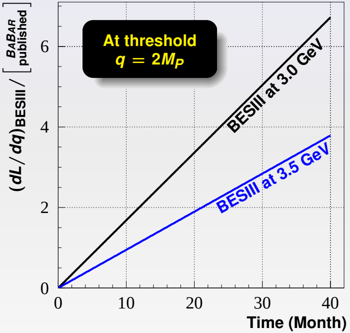
ISR: BESIII vs BABAR

ISR Luminosity

$$\frac{dL}{dq} = \frac{2q}{E_{cm}^2} L_{ee} \int_{\cos\theta_\gamma^{min}}^{\cos\theta_\gamma^{max}} W(E_\gamma, \theta_\gamma) d\cos\theta_\gamma$$

L_{ee} .... total luminosity

$\theta_\gamma^{min,\,max}$ ..... geom. accept.



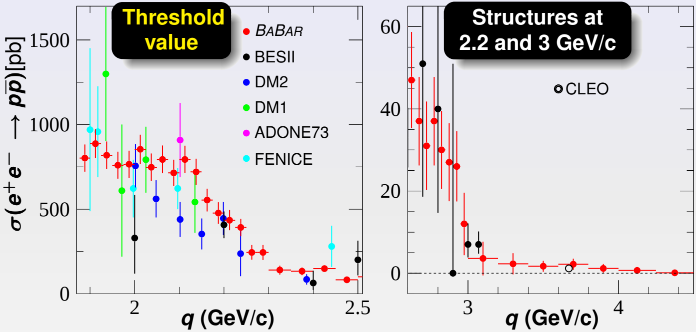
BESIII: lower CM energy ⇒ lower background ⇒ ISR γ detection + 0^o and No ISR γ detection ⇒ $\times$2.5 and $\times$5 in statistics

$e^+e^- \longrightarrow p\bar{p}$

EPJA39, 315

$$\sigma(e^+e^- \longrightarrow p\bar{p}) = \frac{4\pi\alpha^2\beta_p C}{3q^2}\left[|G_M|^2 + \frac{2M_p^2}{q^2}|G_E|^2\right]$$

$$C \underset{\beta\to 0}{\sim} \frac{\pi\alpha}{\beta}$$

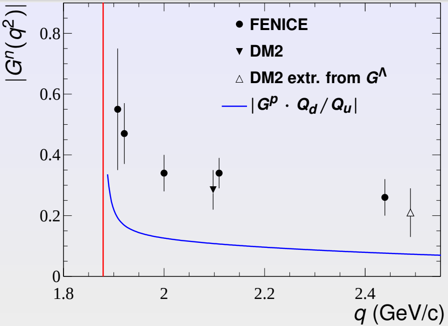


$$\sigma(e^+e^- \longrightarrow p\bar{p})(4M_p^2) = \frac{\pi^2\alpha^3}{2M_p^2}\frac{\cancel{\beta_p}}{\cancel{\beta_p}}|G^p(4M_p^2)|^2 = 0.85\,|G^p(4M_p^2)|^2 \text{ nb}$$

$|G^p(4M_p^2)| \equiv 1$ **as pointlike fermion pairs!**

Using the ISR technique with only few fb^{-1} of integrated luminosity BESIII can easily achieve the *BABAR* statistics

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



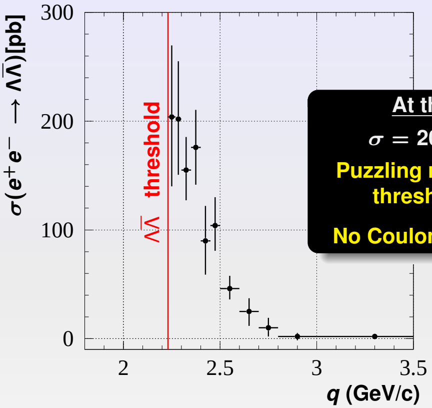
- Measured only once by FENICE at ADONE
- $\int\mathcal{L} = 500$ nb^{-1} (15' at BESIII)
- $\sim$ 100 candidates $n\bar{n}$ events!
- $\sigma(n\bar{n}) > \sigma(p\bar{p})$?
- Not zero at threshold?

BESIII has the unique possibility to measure this cross section

- $J/\Psi \to n\bar{n}$ (BR $\simeq 2 \cdot 10^{-3}$) $\geq 10^4$ events
- $\Psi(2S) \to n\bar{n}$ (BR $\simeq 3 \cdot 10^{-4}$) $\geq 10^3$ events
- At threshold by means of ISR (boost)
- n, $\bar{n}$ detection efficiency and pattern by means of: $J/\Psi \to n(\bar{p}\pi^+)$ and $J/\Psi \to \bar{n}(p\pi^-)$ ($\geq 10^5$ events)

$e^+e^- \longrightarrow \Lambda\bar{\Lambda}$

PRD76, 092006 (*BABAR*)



At threshold

$\sigma = 200 \pm 50$ pb

Puzzling non-vanishing threshold value!

No Coulomb correction!

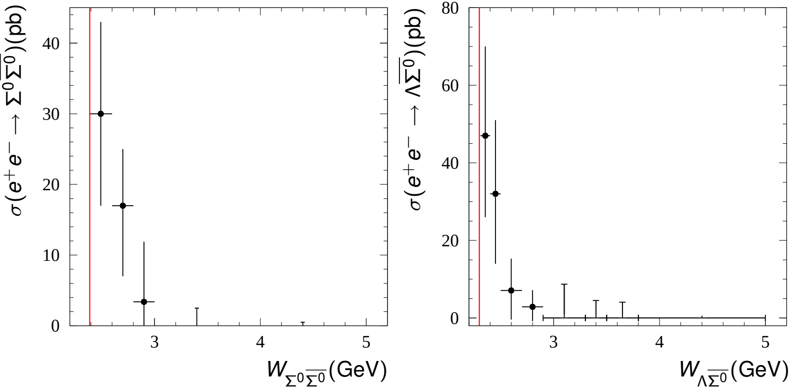
Only at the J/Ψ mass BESIII can increase the *BABAR* statistics at least by a factor of two because of a better Λ reconstruction resolution (only one Λ reconstructed)

Λ polarization for free $\Rightarrow$ G_E^Λ-G_M^Λ relative phase

$\Sigma^0\overline{\Sigma^0}$ and $\Lambda\overline{\Sigma^0}$ channels

PRD76, 092006

Cross sections of $e^+e^- \longrightarrow \Sigma^0\overline{\Sigma^0}$, $\Lambda\overline{\Sigma^0}$ via ISR (BABAR)

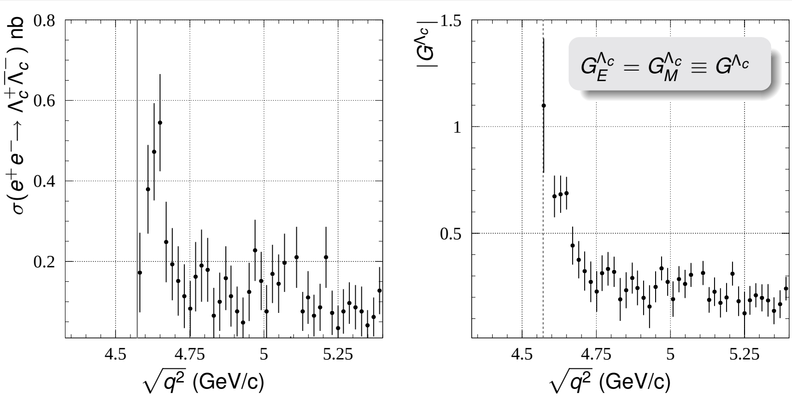


$\sigma(e^+e^- \longrightarrow \Sigma^0\overline{\Sigma^0})_{th} = 30 \pm 13$ pb

$\sigma(e^+e^- \longrightarrow \Lambda\overline{\Sigma^0})_{th} = 47 \pm 22$ pb

Λ_c^+ form factor

Belle $\sigma(e^+e^- \to \Lambda_c^+\overline{\Lambda}_c^-)$



$$|G^{\Lambda_c}(4M_{\Lambda_c}^2)| = 1.1 \pm 0.3(\text{stat}) \pm 0.4(\text{syst})$$

Accessible to BESIII

ISR: Physics Motivations

- Existing results, obtained by ***BaBar*** (ISR), show interesting and unexpected behaviors, mainly at thresholds, for

  $e^+e^- \longrightarrow p\bar{p}$ and $e^+e^- \longrightarrow \Lambda\bar{\Lambda}$

- Only one measurement (**FENICE** with energy scan) for

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

There are physical limits in reaching the threshold of many of these channels via energy scan (stable hadrons produced at rest can not be detected)

The Initial State Radiation technique provides a unique tool to access threshold regions working at higher resonances

BESIII Zero-Degree Detector

- J/Ψ, $\Psi(2S)$, $\psi(3770)$ resonances decay with high BR's to final states with π^0 and γ_{FS} (final state)
- At BESIII these decay channels represent severe backgrounds for typical ISR final states with γ_{IS} detected at wide angle

- π^0 and final γ angular distributions are isotropic
- ISR angular distribution is peaked at small angles

$\Longrightarrow$

A zero-degree radiative photon tagger will suppress most of these backgrounds

The BESIII Collaboration has accepted an upgrade (July 2011?) of the present luminosity monitor with a new zero-degree detector (ZDD), with a better energy resolution, to tag ISR photons as well as to measure the luminosity

Summary

An exciting scenario allow for the investigation of Form Factors at BESIII:

- $e^+e^- \longrightarrow p\bar{p}$
- $e^+e^- \longrightarrow n\bar{n}$
- $e^+e^- \longrightarrow \Lambda\bar{\Lambda}$
- Time-Like $|G_E^p/G_M^p|$, $|G_E^p|$ and $|G_M^p|$
- $e^+e^- \longrightarrow \Sigma^0\overline{\Sigma^0}$
- $e^+e^- \longrightarrow \Lambda\overline{\Sigma^0}$
- $e^+e^- \longrightarrow \Lambda_c^+\overline{\Lambda_c^-}$
- $|G_E^\Lambda|$-$|G_M^\Lambda|$ relative phase

Achieved luminosities:

- $\mathcal{L}_{\Psi(2S)}$: $5.7 \times 10^{32} cm^{-2} s^{-1}$
- $\mathcal{L}_{J/\Psi}$: $0.7 \times 10^{32} cm^{-2} s^{-1}$

Investigation at unprecedented luminosities!

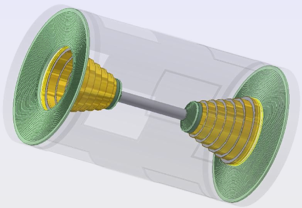
- wide energy range $\sqrt{s}$: $2 \div 4,6\ GeV$
- investigation at threshold and for different q^2 (ISR)

BACK-UP SLIDES

BESIII main features

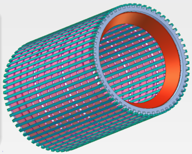
Drift Chamnber

- Low gas misture (60% He, 40% Propane)
- Carbon filter cylindres: $R_{\text{in}} = 6.3$ cm, $T_{\text{in}} = 1$ mm, $R_{\text{out}} = 81$ cm $T_{\text{out}} = 1$ cm
- 6 Al stepped flanges: T = 1.8 cm
- 43 layers: 7000 25 μm gold-plated sense wires, 22000 Al field-shaping wires
- $\sigma_{x,y} \sim 130$ μm, $\sigma(De/dx) \sim 6\%$



CsI Calorimeter

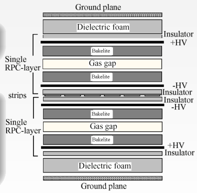
- 6240 CsI(Tl): 5280 Barrel, 960 Endcaps, 13000 photodiodes
- 28×5.2^2 cm^3
- $\Delta E/E \sim 2.5\%$ at 1 GeV, noise ~ 220 keV



Superconducting Magnet: 1 T

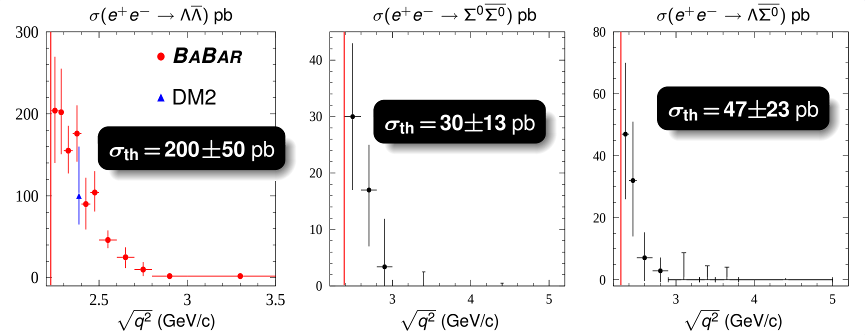
RPC μ Chambers

9/8 layers Barrel/Endcaps, Strip x, y 4cm
Plastic foil instead linseed oil: noise ~ 0.1 Hz/cm^2, $\epsilon \sim 95\%$



$$\sigma(e^+e^- \to \mathcal{B}^0\overline{\mathcal{B}}^0) = \frac{4\pi\alpha^2\beta C_0}{3q^2}\left[|G_M^{\mathcal{B}^0}|^2 + \frac{2M_{\mathcal{B}^0}^2}{q^2}|G_E^{\mathcal{B}^0}|^2\right] \xrightarrow[q\to 2M_{\mathcal{B}^0}]{} \frac{\pi\alpha^2\beta}{2M_{\mathcal{B}^0}^2}|G^{\mathcal{B}^0}|^2 \to 0$$

No Coulomb correction at hadron level: $C_0 = 1$



Remnant of Coulomb interactions at quark level? $\Rightarrow$ $C_0 \propto \beta^{-1}$ as $q \to 2M_{\mathcal{B}^0}$ $\Rightarrow$ For any neutral baryon $\sqrt{\sigma_{\mathcal{B}^0\overline{\mathcal{B}}^0}} \propto \frac{|G^{\mathcal{B}^0}|}{M_{\mathcal{B}^0}}$

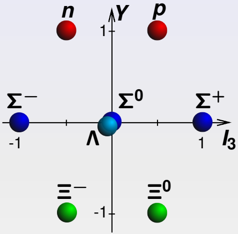
Baryon octet and U-spin

arXiv:0812.3283

Coulomb correction at quark level

$$\sqrt{\sigma_{\mathcal{B}^0\overline{\mathcal{B}^0}}(4M^2_{\mathcal{B}^0})} = K \cdot \frac{|G^{\mathcal{B}^0}|}{M_{\mathcal{B}^0}}$$

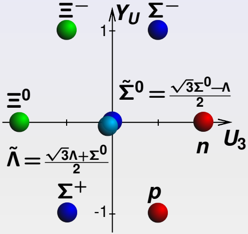
K is unknown but equal for all neutral baryons with equal quark content



$$\underline{(Y, I_3) \longrightarrow (Y_U, U_3)}$$

$$U_3 = -\tfrac{1}{2} I_3 + \tfrac{3}{4} Y$$

$$Y_U = -Q$$



Indirect relation: $G^{\Sigma^0} - G^{\Lambda} + \frac{2}{\sqrt{3}} G^{\Lambda\Sigma^0} = 0$

$$M_{\Sigma^0}\sqrt{\sigma_{\Sigma^0\overline{\Sigma^0}}} - M_{\Lambda}\sqrt{\sigma_{\Lambda\overline{\Lambda}}} + \frac{2}{\sqrt{3}}\overline{M_{\Lambda\Sigma^0}}\sqrt{\sigma_{\Lambda\overline{\Sigma^0}}} = (-0.06 \pm 6.0) \times 10^{-4}$$

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$$\sqrt{\sigma_{\mathcal{B}^0\overline{\mathcal{B}^0}}(4M^2_{\mathcal{B}^0})} = K \cdot \frac{|G^{\mathcal{B}^0}|}{M_{\mathcal{B}^0}}$$

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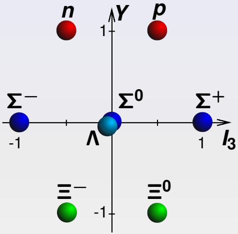

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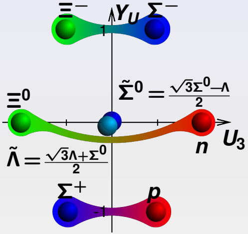

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Data and U-spin predictions at threshold

- $M_{\Sigma^0}\sqrt{\sigma_{\Sigma^0\overline{\Sigma^0}}} - M_\Lambda\sqrt{\sigma_{\Lambda\overline{\Lambda}}} + \frac{2}{\sqrt{3}}\overline{M_{\Lambda\Sigma^0}}\sqrt{\sigma_{\Lambda\Sigma^0}} = (-0.06 \pm 6.0) \times 10^{-4}$
- $\sigma(e^+e^- \to n\bar{n}) = \frac{1}{4}(3\sqrt{\sigma_{\Lambda\overline{\Lambda}}}M_\Lambda - \sqrt{\sigma_{\Sigma^0\overline{\Sigma^0}}}M_\Sigma)^2\frac{1}{M_n^2} = 0.5 \pm 0.2$ nb

$e^+e^- \to n\bar{n}$ (FENICE@ADONE)