Time-like Baryon Form Factors near Threshold Status and Perspectives

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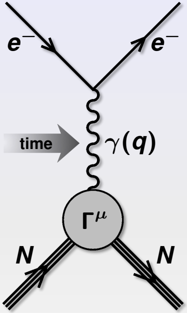
Tatranská Štrba, (Slovak Republic)

Outline

- **Baryon FF: definitions and properties**
- **Last News on Baryon FF near threshold**
- **Energy Scan and ISR techniques**
- **The $n\bar{n}$ case at BESIII**

Nucleon Form Factors definition Space-like region ($q^2 < 0$)



- **Electromagnetic current** ($q = p' - p$)

$$j^\mu = \langle N(p')|J^\mu(0)|N(p)\rangle = e\bar{u}(p')\left[\gamma^\mu F_1(q^2) + \frac{i\sigma^{\mu\nu}q_\nu}{2M}F_2(q^2)\right]u(p)$$

- **Dirac and Pauli form factors F_1 and F_2 are real**
- **In the Breit frame**

$$\begin{cases} p = (E, -\vec{q}/2) \\ p' = (E, \vec{q}/2) \\ q = (0, \vec{q}) \end{cases} \qquad \begin{cases} \rho_q = j^0 = e\left[F_1 + \frac{q^2}{4M^2}F_2\right] \\ \vec{j}_q = e\,\bar{u}(p')\vec{\gamma}u(p)\,[F_1 + F_2] \end{cases}$$

- $2M\bar{u}(p')\gamma^\mu u(p) = \bar{u}(p')[(p + p')^\mu + i\sigma^{\mu\nu}q_\nu]u(p)$
- $\bar{u}(-\vec{p})u(\vec{p}) = E/M$
- $u^\dagger(-\vec{p})u(\vec{p}) = 1$

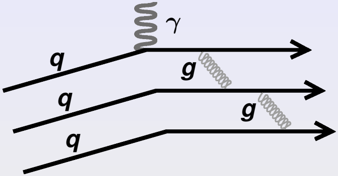
Sachs form factors

$$G_E = F_1 + \frac{q^2}{4M^2}F_2$$
$$G_M = F_1 + F_2$$

Normalizations

$$F_1(0) = Q_{\mathcal{B}} \qquad G_M(0) = \mu_{\mathcal{B}}$$
$$F_2(0) = \kappa_{\mathcal{B}} \qquad G_E(0) = Q_{\mathcal{B}}$$

pQCD asymptotic behavior
Space-like region



- **pQCD**: as $q^2 \to -\infty$, $F_1(q^2)$ and $F_2(q^2)$ must follow counting rules
- Quarks exchange gluons to distribute momentum

Dirac form factor F_1

- Non-spin flip
- Two gluon propagators
- $F_1(q^2) \underset{q^2\to-\infty}{\sim} (-q^2)^{-2}$

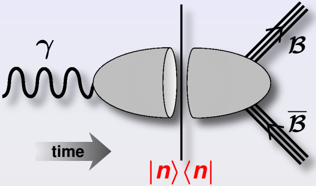
Pauli form factor F_2

- Spin flip
- Two gluon propagators
- $F_2(q^2) \underset{q^2\to-\infty}{\sim} (-q^2)^{-3}$

Sachs form factors G_E and G_M

- $G_{E,M}(q^2) \underset{q^2\to-\infty}{\sim} (-q^2)^{-2}$
- Ratio: $\frac{G_E}{G_M} \underset{q^2\to-\infty}{\sim}$ constant

Nucleon form factors
Time-like region ($q^2 > 0$)



- **Crossing symmetry**:

$$\langle \mathcal{B}(p')|J^\mu|\mathcal{B}(p)\rangle \longrightarrow \langle \overline{\mathcal{B}}(p')\mathcal{B}(p)|J^\mu|0\rangle$$

- **Form factors are complex functions of** q^2

Optical theorem

$$\mathrm{Im}\langle \overline{\mathcal{B}}(p')\mathcal{B}(p)|J^\mu(0)|0\rangle \sim \sum_n \langle \overline{\mathcal{B}}(p')\mathcal{B}(p)|J^\mu(0)|n\rangle\langle n|J^\mu(0)|0\rangle \Rightarrow \begin{cases} \mathrm{Im}F_{1,2} \neq 0 \\ \text{for } q^2 > 4m_\pi^2 \end{cases}$$

$|n\rangle$ are on-shell intermediate states: 2π, 3π, 4π, ...

Time-like asymptotic behavior

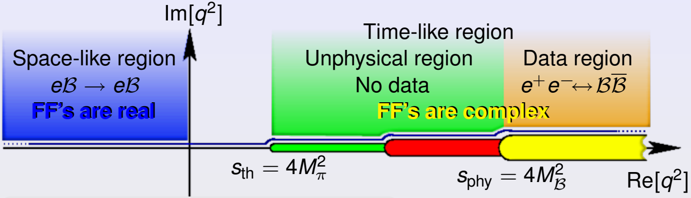
Phragmèn Lindelöf theorem:

If a function $f(z) \longrightarrow a$ as $z \longrightarrow \infty$ along a straight line, and $f(z) \longrightarrow b$ as $z \longrightarrow \infty$ along another straight line, and $f(z)$ is regular and bounded in the angle between, then $a = b$ and $f(z) \longrightarrow a$ uniformly in this angle.

- $$\underbrace{\lim_{q^2 \to -\infty} G_{E,M}(q^2)}_{\text{space-like}} = \underbrace{\lim_{q^2 \to +\infty} G_{E,M}(q^2)}_{\text{time-like}}$$

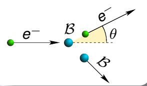
- $$G_{E,M} \underset{q^2 \to +\infty}{\sim} (q^2)^{-2}$$ **real**

Cross sections and analyticity



Time-like: had. helicity $= \begin{cases} 1 \Rightarrow |G_E| \\ 0 \Rightarrow |G_M| \end{cases}$

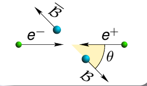
$$G_E(4M_\mathcal{B}^2) = G_M(4M_\mathcal{B}^2)$$



Elastic scattering

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

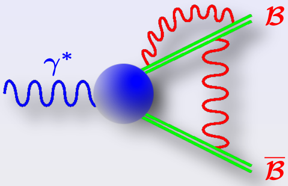
$$\tau = \frac{q^2}{4M_\mathcal{B}^2}$$



Annihilation Coulomb correction

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

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



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

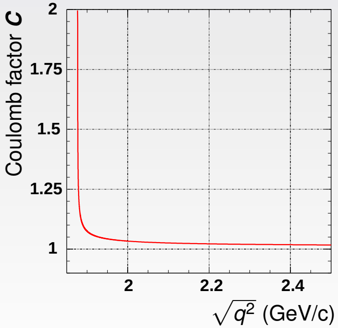
[Sommerfeld, Sakharov, Schwinger, Fadin, Khoze]

Distorted wave approximation

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

- **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)



Sommerfeld Enhancement and Resummation Factors

Coulomb Factor $\mathcal{C}$ for S-wave only:

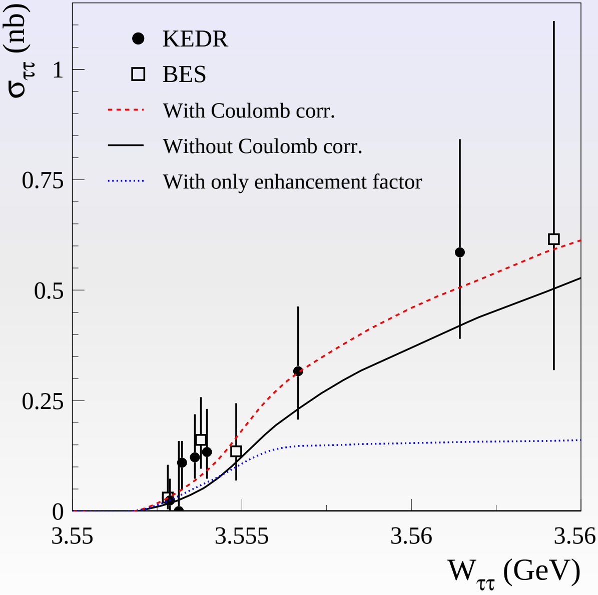
- **Partial wave FF:** $G_S = \dfrac{2G_M\sqrt{q^2/4M^2} + G_E}{3}$ $\qquad G_D = \dfrac{G_M\sqrt{q^2/4M^2} - G_E}{3}$
- **Cross section:** $\sigma(q^2) = 2\pi\alpha^2\beta\,\dfrac{4M^2}{(q^2)^2}\left[\mathcal{C}\,|G_S(q^2)|^2 + 2|G_D(q^2)|^2\right]$

$$\mathcal{C} = \mathcal{E} \times \mathcal{R}$$

- **Enhancement factor:** $\mathcal{E} = \pi\alpha/\beta$
- **Step at threshold:** $\sigma(4M^2) = \dfrac{\pi^2\alpha^3}{2M^2}\,\dfrac{\not\beta}{\not\beta}\,|G_S(4M^2)|^2 = 0.85\,|G_S(4M^2)|^2$ nb

- **Resummation factor:** $\mathcal{R} = 1/[1 - \exp(-\pi\alpha/\beta)]$
- **Few MeV above threshold:** $\mathcal{C} \simeq 1 \;\Rightarrow\; \sigma(q^2) \propto \beta\,|G_S(q^2)|^2$

The $e^+e^- \to \tau^+\tau^-$ case



Pointlike Baryons?

R. Baldini Ferroli, S. Pacetti, A. Zallo and A. Zichichi

[arXiv:0812.3283]

No Sommerfeld resummation factor in $e^+e^- \longrightarrow p\bar{p}$?

R. Baldini Ferroli, S. Pacetti and A. Zallo

[arXiv:1008.0542]

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

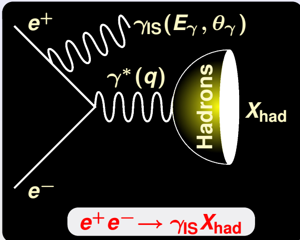
- Only one measurement (**FENICE** with energy scan) for

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

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

Initial State Radiation



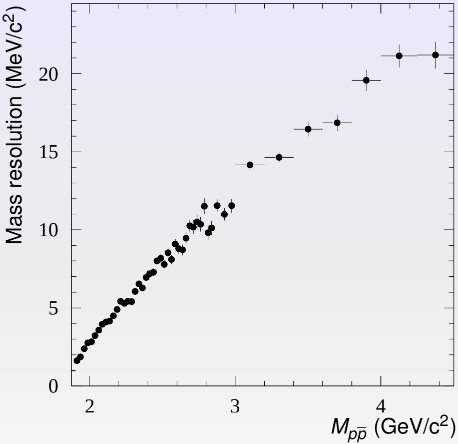
- $$\frac{d^2\sigma}{dE_\gamma \, d\theta_\gamma} = W(E_\gamma, \theta_\gamma) \cdot \sigma_{e^+e^- \to X_{had}}(s)$$
- $$W(E_\gamma, \theta_\gamma) = \frac{\alpha}{\pi x} \left(\frac{2 - 2x + x^2}{\sin^2 \theta_\gamma} \right)$$

- $s = q^2$, q .... X_{had} momentum
- E_γ, θ_γ ..CM γ_{IS} 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 $\Rightarrow$ $\begin{cases} \text{at threshold } \epsilon \neq 0 \\ \text{energy resolution } \sim 1 \text{ MeV} \end{cases}$

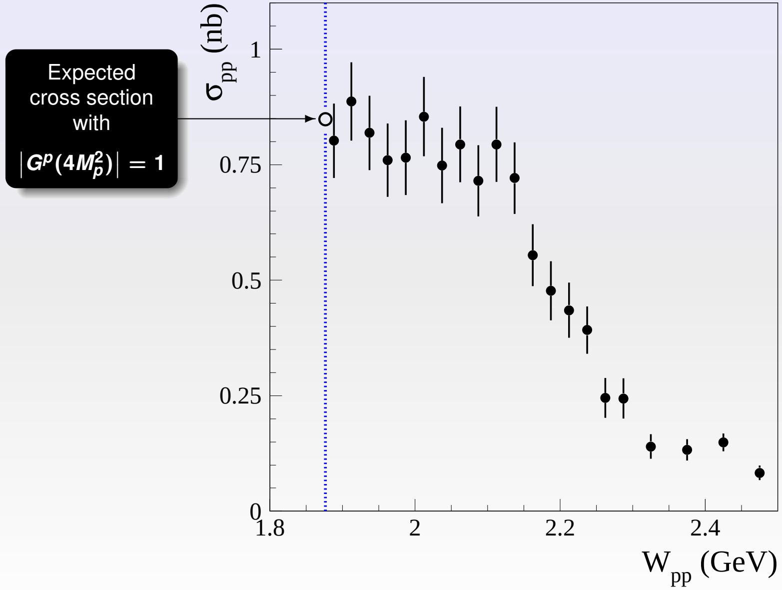
Mass resolution in $e^+e^- \to p\bar{p}$ (BABAR with ISR)



Incredibly good at threshold ($\sim$ 1 MeV/c^2), as e^+e^- c.m.
$\Delta p_T / p_T \sim 0.5\%$ at 1 GeV

BaBar via ISR: $e^+e^- \longrightarrow p\bar{p}$

[PRD73, 012005]



Proton form factor at $q^2 = 4M_p^2$

$$\sigma(e^+e^- \to p\bar{p})(4M_p^2) = 0.83 \pm 0.05 \text{ nb}$$

BABAR

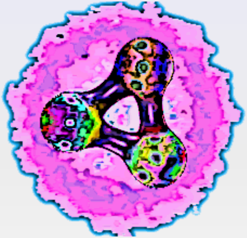
$$\sigma(e^+e^- \to p\bar{p})(4M_p^2) = \frac{\pi^2\alpha^3}{2M_p^2}\frac{\not\beta}{\not\beta}|G^p(4M_p^2)|^2 = 0.85\,|G^p(4M_p^2)|^2 \text{ nb}$$

$$|G^p(4M_p^2)| \equiv 1$$

$$|G^p(4M_p^2)| = 0.99 \pm 0.04(\text{stat}) \pm 0.03(\text{syst})$$

Proton form factor at $q^2 = 4M_p^2$

$$|G^p(4M_p^2)| \equiv 1$$



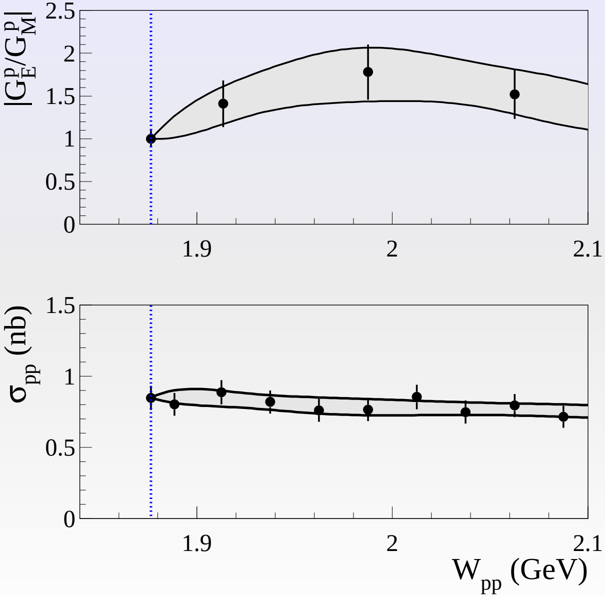
At $q^2 = 4M_p^2$ protons behave as pointlike fermions!

Sommerfeld Resummation Factor Needed?

Resummation Factor Needed?

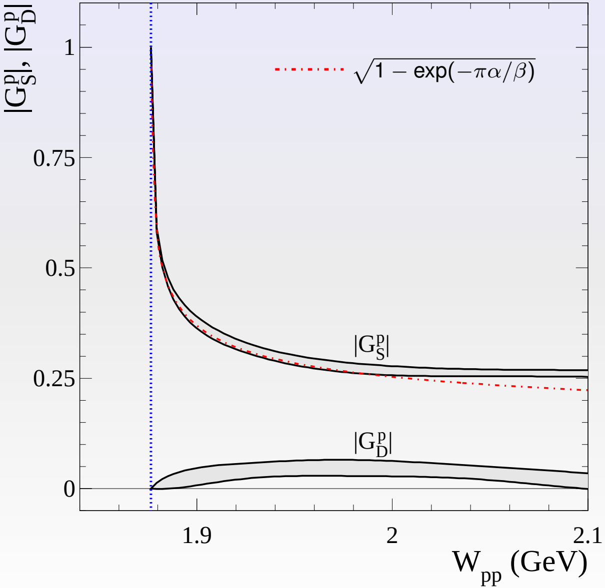
- **At threshold:** $G_E/G_M = 1$
- $\sigma(q^2)$, $|G_E/G_M| \rightarrow G_S, G_D$
- $G_S = \sqrt{1 - \exp(-\pi\alpha/\beta)}$
- **No need of Resummation Factor**

BABAR: $|G_E^p/G_M^p|$ and $\sigma(e^+e^- \longrightarrow p\overline{p})$ [PRD73, 012005]



BABAR: $|G_E^p/G_M^p|$ and $\sigma(e^+e^- \to p\bar{p})$

[PRD73, 012005]



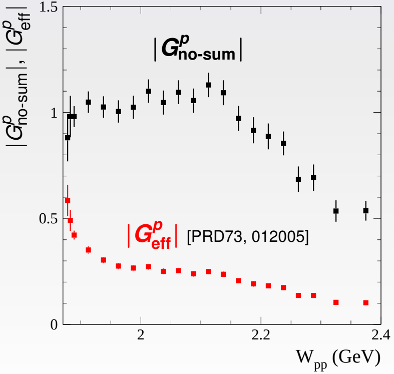
Integrated Sommerfeld factor and G_{eff} (BABAR)

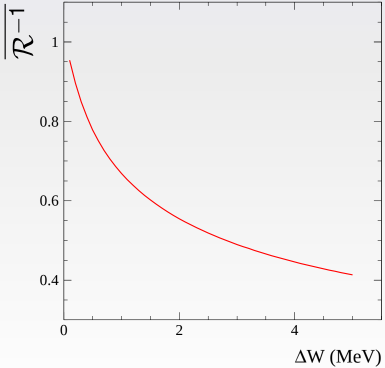
$$|G^p_{\mathrm{eff}}|^2 = \frac{\sigma(q^2)}{\mathcal{C}\,\frac{16\pi\alpha^2}{3}\,\frac{\sqrt{1-1/\tau}}{4q^2}\left(1+\frac{1}{2\tau}\right)}$$

$$|G^p_{\text{no-sum}}|^2 = \frac{\sigma(q^2)}{\mathcal{E}\,\frac{16\pi\alpha^2}{3}\,\frac{\sqrt{1-1/\tau}}{4q^2}\left(1+\frac{1}{2\tau}\right)}$$

$$\overline{\mathcal{R}^{-1}} = \frac{1}{\Delta W}\int_0^{\Delta W}\left[1-e^{-\frac{\pi\alpha}{\beta}}\right]dw$$

$$\Delta W = W_{pp} - 2M_p$$





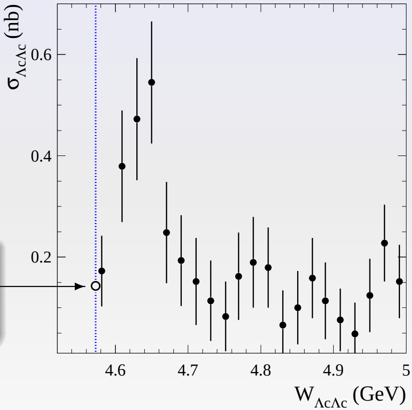
Resummation Factor Needed?

For a wide energy range ($\sim$ 200 MeV):

- **Proton behaves as a pointlike particle**
- **e.m. dominance, no strong interaction?**
- **Mild sensitivity to $\mathcal{B}\overline{\mathcal{B}}$ invariant mass resolution**

$e^+e^- \longrightarrow \Lambda_c^+\overline{\Lambda}_c^-$

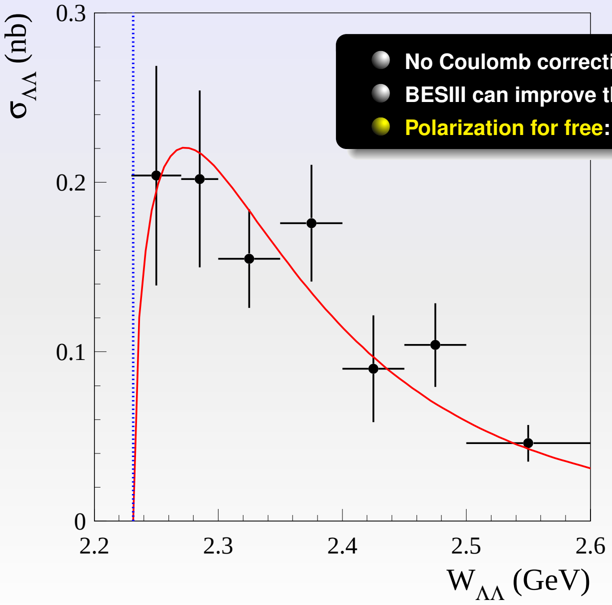
[Belle PRL101, 172001]



Expected cross section with $\left|G^{\Lambda_c}(4M_{\Lambda_c}^2)\right| = 1$

BABAR: $e^+e^- \to \Lambda\bar{\Lambda}$

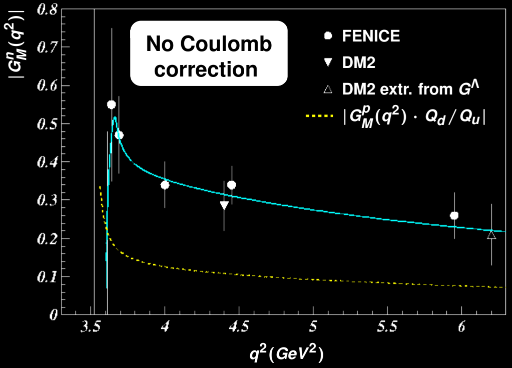
[PRD76, 092006]



- No Coulomb correction (?)
- BESIII can improve this result
- Polarization for free: $\Lambda \to p\pi^-$

Time-like $|G_M^n|$ measurements

Only two measurements by FENICE and DM2



	$\vert G_M^n/G_M^p\vert$
Data	~ 1.5
Naively	$\sim \vert Q_d/Q_u\vert$
pQCD	< 1
Soliton models	~ 1
VMD (Dubnicka)	$\gg 1$

BABAR does agree with FENICE

Large $G_M^\Lambda \overset{\text{U-spin}}{\Longrightarrow}$ large G_M^n

Cross sections can be measured directly in energy scan measurements or using ISR technique

First results from VEPP2000 collider

E.Solodov

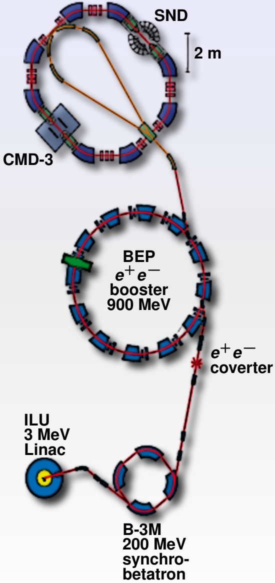
(for CMD-3 collaboration)

Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia

HADRON2011, Munich, Germany

June 2011

VEPP-2000 at Novosibirsk

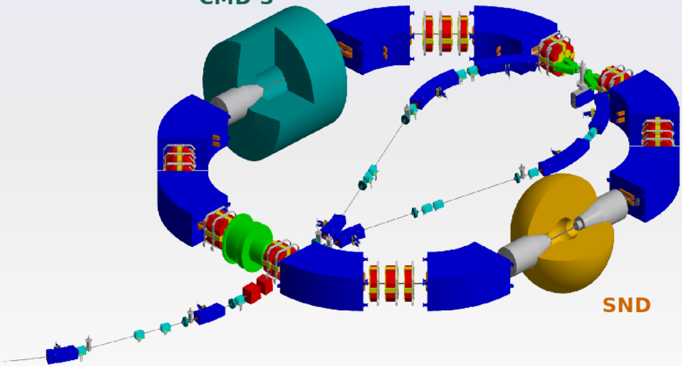


VEPP-2000 at 900 MeV

Circumference	24.388 mm
RF frequency	172.0 MHz
RF voltage	100 V
RFharmonic number	14
Momentum compaction	0.036
Syncrothrotron tune	0.003
x-emittance	2.2×10^{-5}
z-emittance	2.2×10^{-5}
Energy loss/turn	41.5 keV
z-damping decrements	2.3×10^{-5}
x-damping decrements	2.3×10^{-5}
s-damping decrements	4.6×10^{-5}
Energy spread	6.4×10^{-4}
β_x at IP	6.3 cm
β_z at IP	6.3 cm
Betatron tunes (x, z)	4.1, 2.1
Particles/bunch	1.0×10^{11}
Bunches/beam	1
Tune schifts (x, z)	0.075, 0.075
Luminosity/IP	1×10^{32} cm^{-2} s^{-1}

VEPP-2000

Integrated luminosity ~ 100 pb^{-1} per detector/year



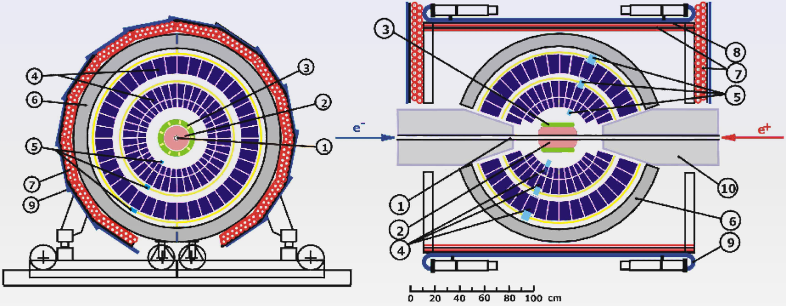
Total integrated luminosity with all detectors on VEPP-2M ~ 70 pb^{-1}

Physics program at VEPP-2000

1. Precise measurement of the quantity
   $R=\sigma(e^+e^- > had.)/\sigma(e^+e^- > \mu^+\mu^-)$ – GOAL <1% syst. for major channels
2. Study of hadronic channels:
   $e^+e^- > 2h, 3h, 4h \ldots, h= \pi, K, \eta$
3. Study of 'excited' vector mesons: ρ', ρ'', ω', φ',..
4. CVC tests: comparison of $e^+e^- >$ hadr. (T=1) cross section with τ-decay spectra
5. Study of nucleon-antinucleon pair production – nucleon electromagnetic form factors, search for NNbar resonances, ..
6. Hadron production in 'radiative return' (ISR) processes
7. Two photon physics
8. Test of the QED high order processes 2->4,5

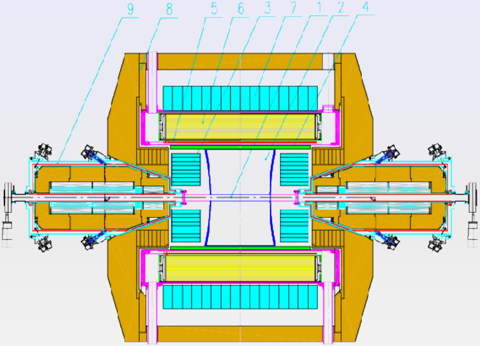
Two detectors have been build for the study

Spherical Neutral Detector



1 – VEPP-2000 vacuum chamber, 2 – tracking system,
3 – aerogel counters, 4 – electromagnetic calorimeter NaI(Tl),
5 – vacuum phototriodes, 6 – absorber, 7-9 – muon system,
10 – VEPP-2000 phocusing solenoid

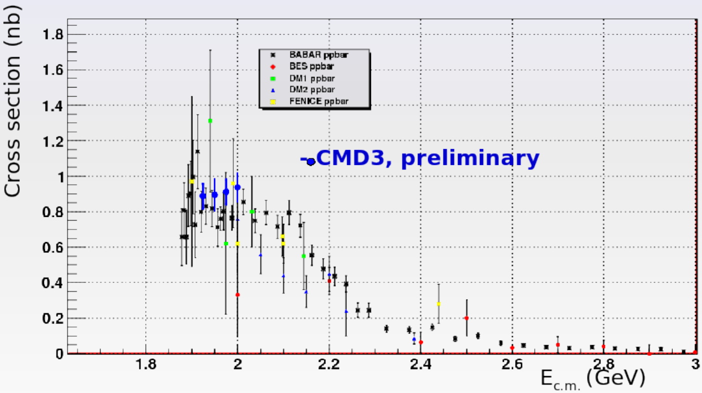
Cryogenic Magnetic Detector-3



1 – vacuum chamber
2 – drift chamber
3 – electromagnetic calorimeter BGO
4 – Z – chamber
5 – CMD SC solenoid
6 – electromagnetic calorimeter LXe
7 – electromagnetic calorimeter CsI
8 – yoke
9 – VEPP-2000 solenoid

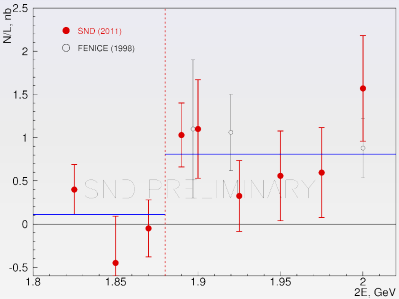
Preliminary results for the e^+e^- -> PbarP study

Clear signature of the PbarP events



First preliminary result from SND

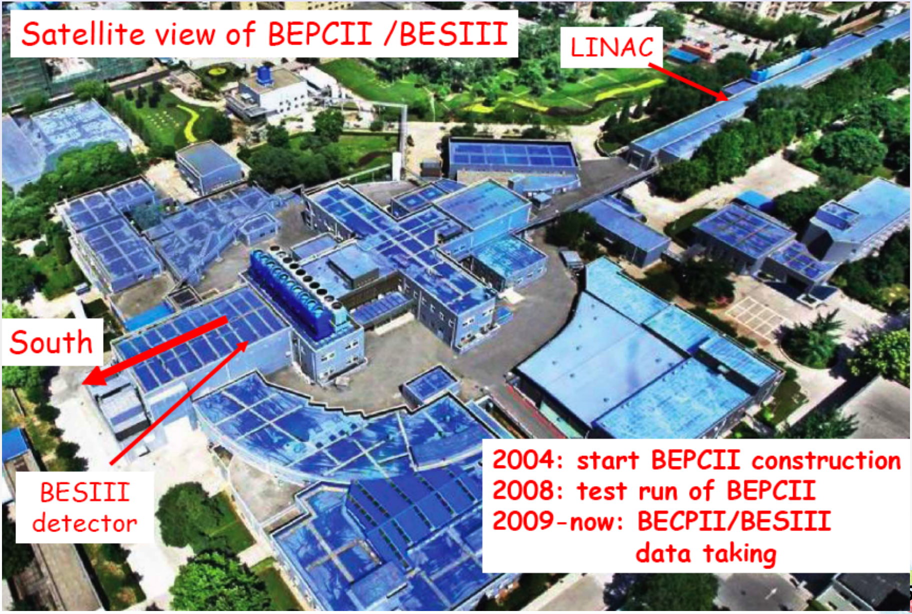
$e^+e^- \to n\bar{n}$



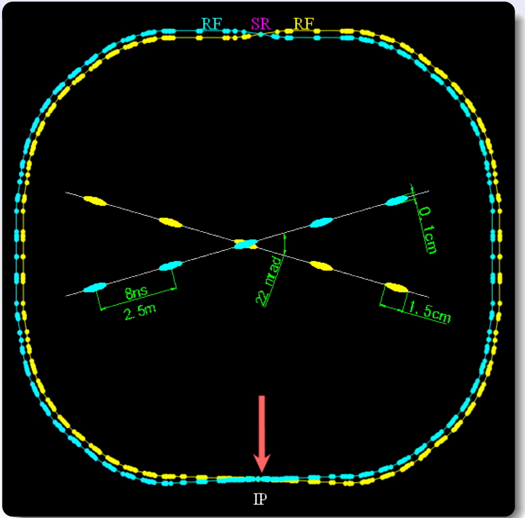
- Scan 2011
- $n\bar{n}$ cross section is presented, efficiency ~ 30%
- $e^+e^- \to p\bar{p}$, $\gamma\gamma$ backgrounds are subtracted
- Below the $n\bar{n}$ threshold $\sigma = 0.1 \pm 0.2$ nb
- Above the $n\bar{n}$ threshold $\sigma = 0.8 \pm 0.2$ nb

BESIII Status, Results and Perspectives

BEPCII/BESIII



BEPCII: e^+e^- double ring collider

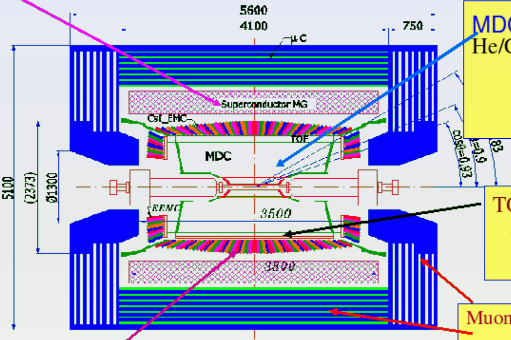


Design Features

- 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** $\times$ **10^{-4}**
- Number of bunches: **93**
- Bunch length: **1.5** cm
- Total current: **0.91** A

BESIII Detector

Magnet: 1 T Super conducting



MDC: small cell & Gas:
He/C_3H_8 (60/40), 43 layers
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 100 ps Barrel
110 ps Endcap

Muon ID: 9 layers RPC
8 layers for endcap

EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

Data Acquisition:
Event rate = 4 kHz
Total data volume ~ 50 MB/s

The detector is hermetic for neutral and charged particles with excellent resolution, PID, and large coverage

BESIII at BEPCII: Status

So far BESIII has collected:

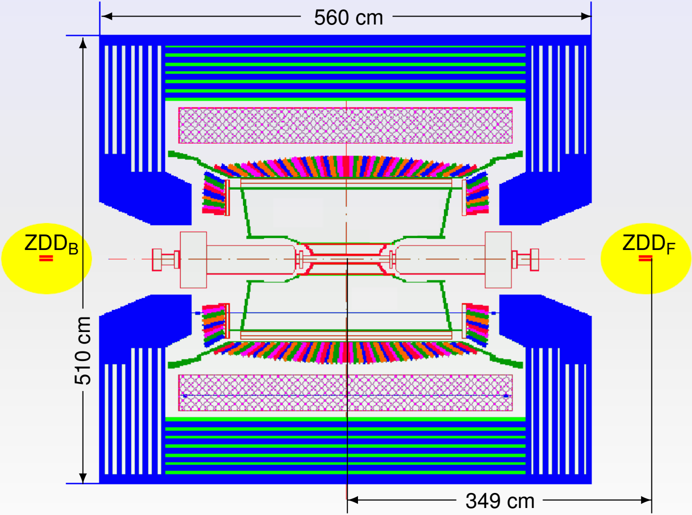
- 2009: 225 Million J/ψ
- 2010-11: 2.9 fb^{-1} $\psi(3770)$ (3.5×CLEO-c 0.818 fb^{-1})
- May 2011: 0.5 fb^{-1} at 4010 MeV (one month) for D_s and XYZ spectroscopy

BESIII will also collect:

- more J/ψ, ψ', $\psi(3770)$
- data at higher energies (for XYZ searches, R scan and D_s physics)

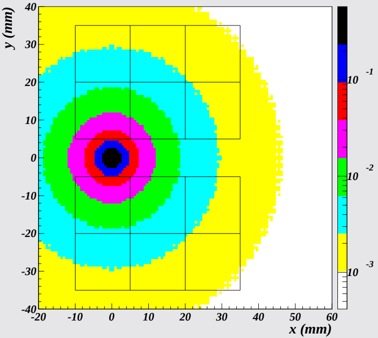
ISR at zero degrees

BESIII and ZDD

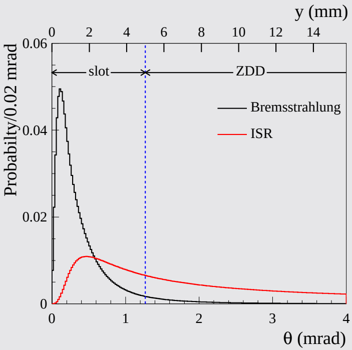


ISR on ZDD and Bremsstrahlung contamination

ISR angular distribution on ZDD



Bremsstrahlung and ISR



Proposal for a 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**

$\Longrightarrow$

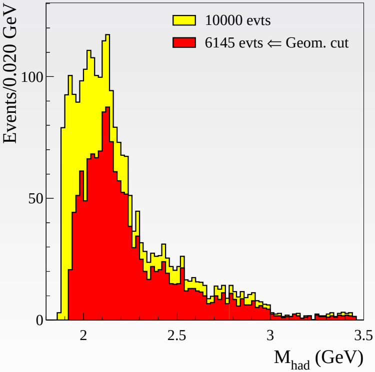
A zero-degree radiative photon tagger will suppress most of these backgrounds

A new zero-degree detector (ZDD) will be installed this summer at BESIII to tag ISR photons as well as to measure the luminosity

$n\bar{n}$ physics case

The $n\bar{n}\gamma_{\rm IS}$ physics case

- $e^+e^- \longrightarrow n\bar{n}\gamma_{\rm IS}$ at a center of mass energy: $E_{c.m.} = 3.77$ GeV
- $\gamma_{\rm IS}$ energy range: $50\ \text{MeV} \leq E_{\gamma_{\rm IS}} \leq (E_{c.m.}/2)\left(1 - 4M_n^2/E_{c.m.}^2\right)$
- Beam pipe suppresses sinc. rad. bkg. and $\gamma_{\rm IS}$ with $E_{\gamma_{\rm IS}} < 50$ MeV
- $\gamma_{\rm IS}$ in ZDD and only antineutron detected in BESIII
- $\bar{n}$ annihilation star detected in TOF ($\Delta t_{\rm TOF} = 150$ ps) and EMC



- 10000 events with $\gamma_{\rm IS} \longrightarrow$ ZDD
- $M_{\rm had} = E_{c.m.}\sqrt{1 - 2E_{\gamma_{\rm IS}}/E_{c.m.}}$
- Geometrical cut:
  - $\bar{n} \longrightarrow$ BESIII
  - No constraint in n

$n\bar{n}\pi^0$ and $n\bar{n}\gamma_{\rm FS}$ backgrounds

- $e^+e^- \to n\bar{n}\pi^0$ and $e^+e^- \to n\bar{n}\gamma_{\rm FS}$ (with a final state photon) are important backgrounds for $e^+e^- \to n\bar{n}\gamma_{\rm IS}$
- Assuming $\sigma(e^+e^- \to n\bar{n}\pi^0) \simeq \sigma(e^+e^- \to p\bar{p}\pi^0)$:

$$\frac{\text{Ev}(n\bar{n}\pi^0)}{\text{Ev}(n\bar{n}\gamma_{\rm IS})}\left[M_{\Upsilon(4S)}\right] \simeq R_{BABAR} = \frac{\text{Ev}(p\bar{p}\pi^0)}{\text{Ev}(p\bar{p}\gamma_{\rm IS})}\left[M_{\Upsilon(4S)}\right] = 0.06$$

- In **BESIII**, directly at the $\psi(3770)$ mass:

$$R_{\rm BESIII} = 0.06 \times \underbrace{\left(\frac{0.012}{3\times 10^{-6}}\right)}_{p\bar{p}\pi^0 \text{ cross section ratio}} \times \underbrace{\left(\frac{1}{10.7}\right)}_{\text{Lum. ratio}} = 22.4$$

$\gamma_{\rm IS} \to$ **ZDD**

$$\frac{\text{ZDD solid angle}}{\text{BESIII solid angle}}$$

$$\frac{2\cdot(2\cdot 4.5\cdot 3/349^2)}{4\pi\cos\theta_{\rm min}} = 3.8\cdot 10^{-5}$$

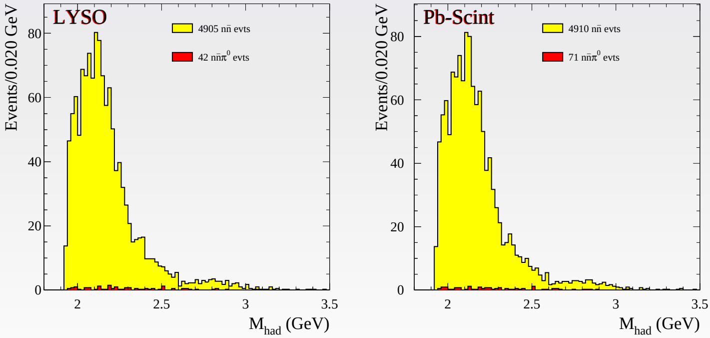
$\Rightarrow$

$$\frac{\text{Ev}(n\bar{n}\pi^0,\ \pi^0 \to 0^o)}{\text{Ev}(n\bar{n}\gamma_{\rm IS},\ \gamma_{\rm IS} \to 0^o)} = 0.0008$$

$$\frac{\text{Ev}(n\bar{n}\gamma_{\rm FS},\gamma_{\rm FS} \to 0^o)}{\text{Ev}(n\bar{n}\gamma_{\rm IS},\gamma_{\rm IS} \to 0^o)} \sim 0.0001$$

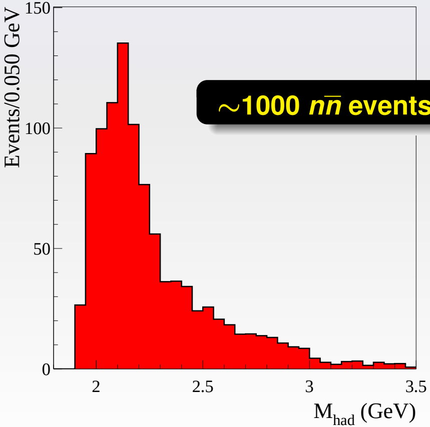
The $n\bar{n}\pi^0\gamma_{IS}$ background reduction

- **Geometrical cut on $\bar{n}$**
- **π^0 detection in BESIII**: at least one of the π^0 photons with $E_\gamma>50$ MeV in BESIII not in a 200 mrad cone around $\bar{n}$ direction
- **Kinematic fit**: $\chi^2 \leq 10$



Expected $n\bar{n}$ events

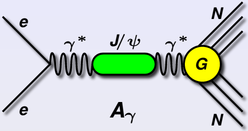
- Integrated luminosity: $\int \mathcal{L}dt = 2.5\ \text{fb}^{-1}$
- Detection efficiency: $\epsilon \sim 0.5$
- Center of mass energy: $E_{c.m.} = 3.77$ GeV



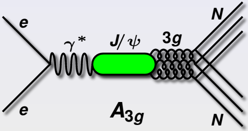
$\sim$1000 $n\bar{n}$ events

Measurement of $J/\psi \longrightarrow p\bar{p}, n\bar{n}$

- $p\bar{p}$ amplitude A^p_γ from BaBar data
- $n\bar{n}$ amplitude A^n_γ from FENICE data
- $A^p_\gamma - A^n_\gamma$ relative phase from pQCD



$$B(J/\psi \to n\bar{n}) = \left| \frac{A_{3g} + A^n_\gamma}{A_{3g} + A^p_\gamma} \right|^2 B(J/\psi \to p\bar{p}) = (1.4 \pm 0.2) \times 10^{-3}$$

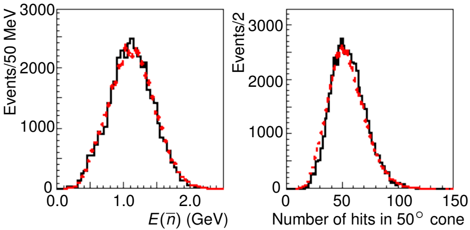


- BESII at BEPC [PLB591,42]: $B(J/\psi \longrightarrow p\bar{p}) = (2.26 \pm 0.01 \pm 0.14) \times 10^{-3}$
- FENICE at ADONE [PLB444,111]: $B(J/\psi \longrightarrow n\bar{n}) = (2.2 \pm 0.4) \times 10^{-3}$

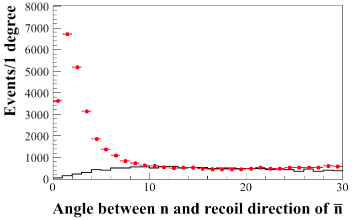
$$B(J/\psi \longrightarrow p\bar{p}) \simeq B(J/\psi \longrightarrow n\bar{n})$$
$$\Downarrow$$
large $A^N_{3g} - A^N_{3g}$ relative phase

Preliminary results: $J/\psi \to p\bar{p}$, $n\bar{n}$

***n* identification: 0.6 GeV$\leq$ *E* $\leq$2.0 GeV**



***n* identification: 0.06 GeV$\leq$ *E* $\leq$0.06 GeV**



Comparison for $\bar{n}$ in $J/\psi \to n\bar{n}$ and $J/\psi \to p\bar{n}\pi^0$

- **deposit energy in EMC**
- **number of hits in a 50° cone around the *n* shower**

$B(J/\psi \to n\bar{n}) = (2.07 \pm 0.01 \pm 0.14) \times 10^{-3}$
PDG: $B(J/\psi \to n\bar{n}) = (2.2 \pm 0.4) \times 10^{-3}$

$B(J/\psi \to p\bar{p}) = (2.112 \pm 0.004 \pm 0.027) \times 10^{-3}$
PDG: $B(J/\psi \to p\bar{p}) = (2.17 \pm 0.07) \times 10^{-3}$

$B(J/\psi \to p\bar{p}) \simeq B(J/\psi \to n\bar{n})$
suggests a phase $\sim 90°$ between strong and em amplitudes!

Conclusions

- Pointlike Behavior at and well above threshold
- No Sommerfeld Resummation Factor
- Neutral Baryons Puzzle

Perspectives

- More results from *BaBar* ($\times 2$) and Belle (?)
- BESIII: ISR now, scan 2012-2013
- VEPP-2000 $N\overline{N}$ near threshold soon