Recent results from the SND experiment at VEPP-2000 collider

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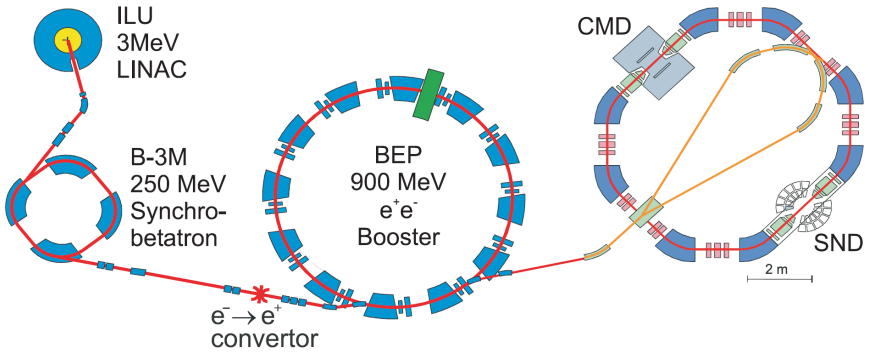
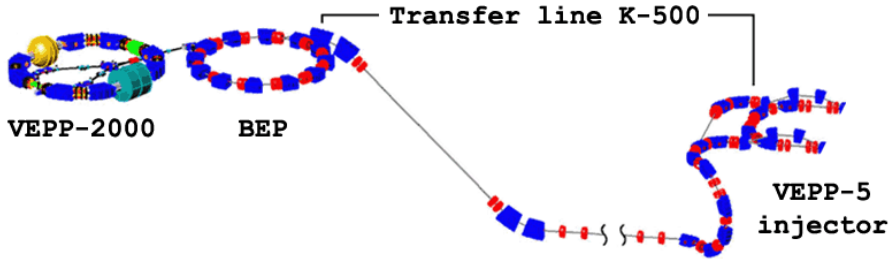
VEPP-2000 e^+e^- collider



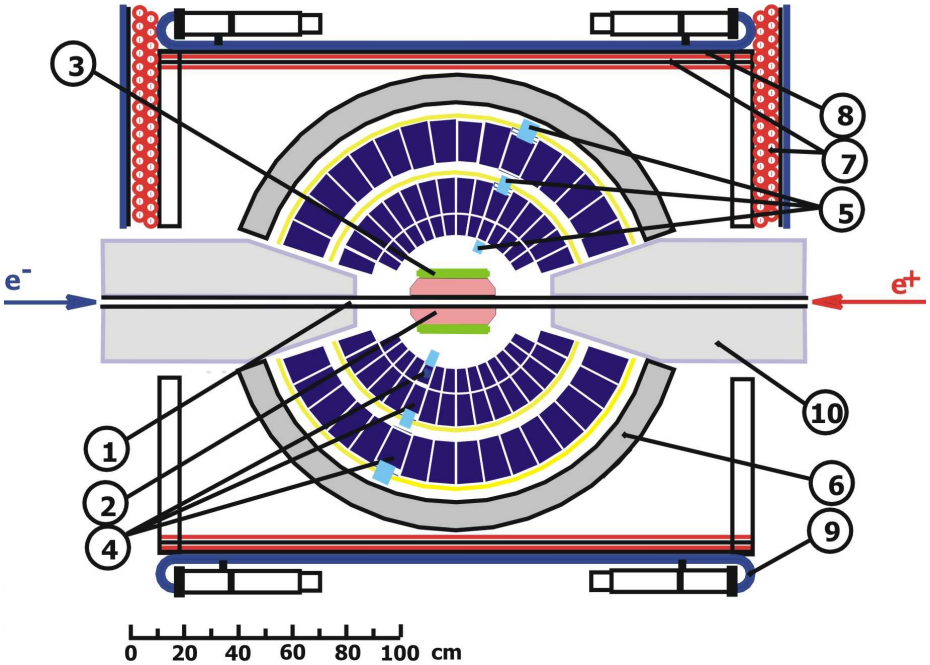


VEPP-2000 parameters

- c.m. energy E=0.3-2.0 GeV
- Luminosity at E=1.8 GeV
  $10^{32} cm^{-2} sec^{-1}$ (project)
  $4x10^{31} cm^{-2} sec^{-1}$ (achieved)
- Beam energy spread - 0.6 MeV at E=1.8 GeV

- 10 times more intense positron source
- Experiments at upgraded VEPP-2000 was restarted by the end of 2016
- About 50 pb^{-1} of integrated luminosity has been already collected during the 2017 run

SND detector



1-beam pipe, 2-tracking system, 3-aerogel Cherenkov counter , 4 - NaI(Tl) crystals, 5 - phototriodes, 6 - iron muon absorber, 7-9 - muon detector, 10 - focusing solenoids.

SND collected data at the VEPP-2M (1996-2000) and VEPP-2000 (2010-2013,2016-?)

Main physics task of SND is study of all possible processes of e^+e^- annihilation into hadrons below 2 GeV.

- The total hadronic cross section, which is calculated as a sum of exclusive cross sections.
- Study of hadronization (dynamics of exclusive processes).

SND data

$\sqrt{s}$, GeV	0.36-0.97	0.98-1.06	1.06-1.38
IL, pb^{-1}	9.1	13.2	8.8

Table: VEPP-2M

$\sqrt{s}$, GeV	0.30-0.97	0.98-1.05	1.05-2.00
IL, pb^{-1}	15.4	6.9	100

Table: VEPP-2000

$\approx$ 15 hadronic processes are currently under analysis

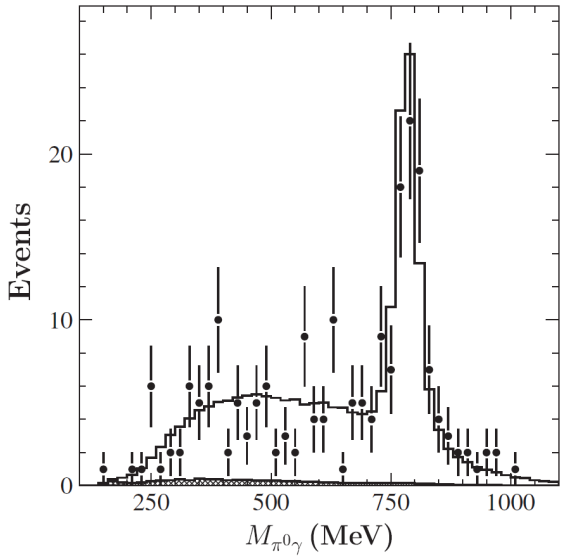
Precise measurements:

- $e^+e^- \to \pi^0\gamma$ (VEPP-2M)
- $e^+e^- \to K^+K^-$
- $e^+e^- \to \pi^+\pi^-$

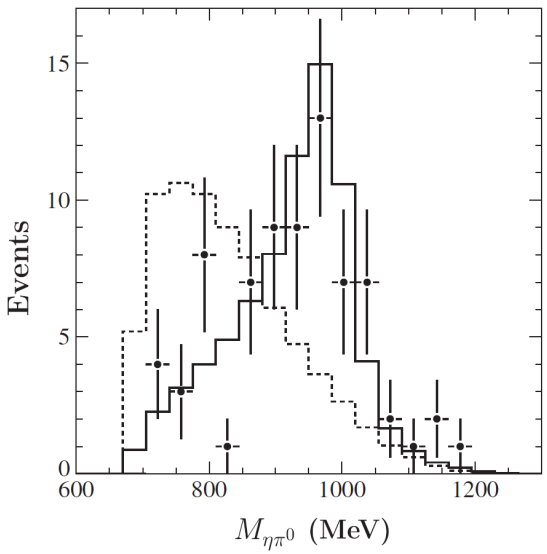
First measurements

- $e^+e^- \to \pi^+\pi^-\pi^0\eta$
- $e^+e^- \to \omega\eta\pi^0$

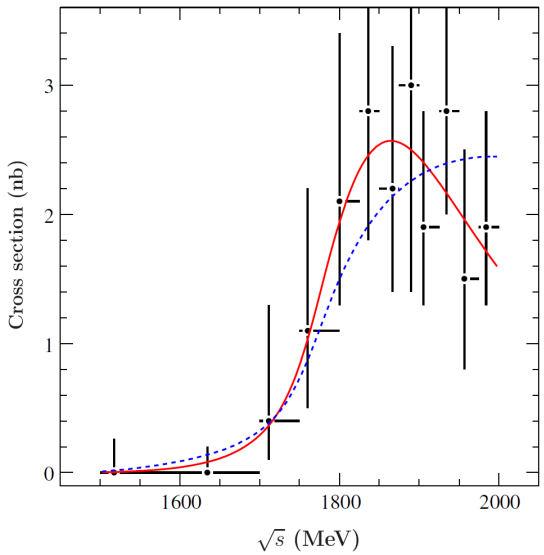
$e^+e^- \to \omega\eta\pi^0 \to \pi^0\pi^0\eta\gamma \to 7\gamma$



The histogram is the sum of simulated $e^+e^- \to \omega\eta\pi^0$ and background events



The dominant mechanism is $\omega a_0(980)$



Fit of the cross section with and without a resonance contribution

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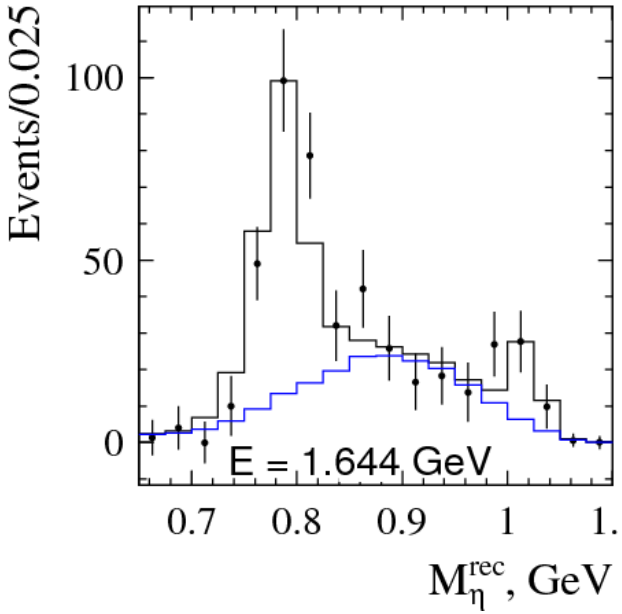
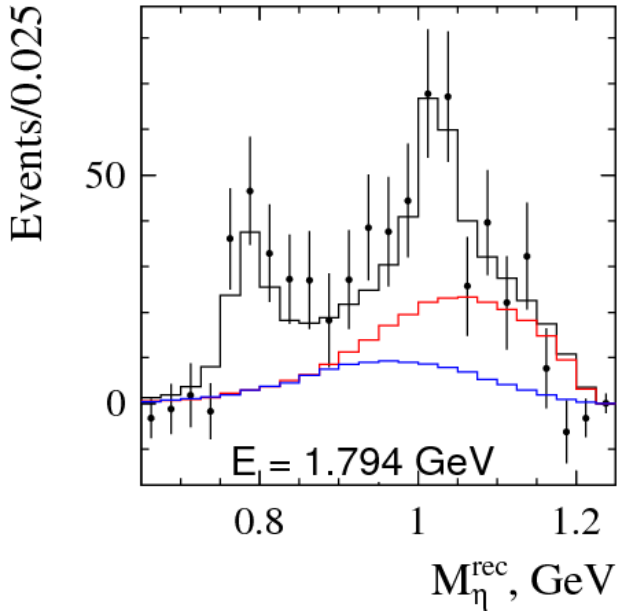
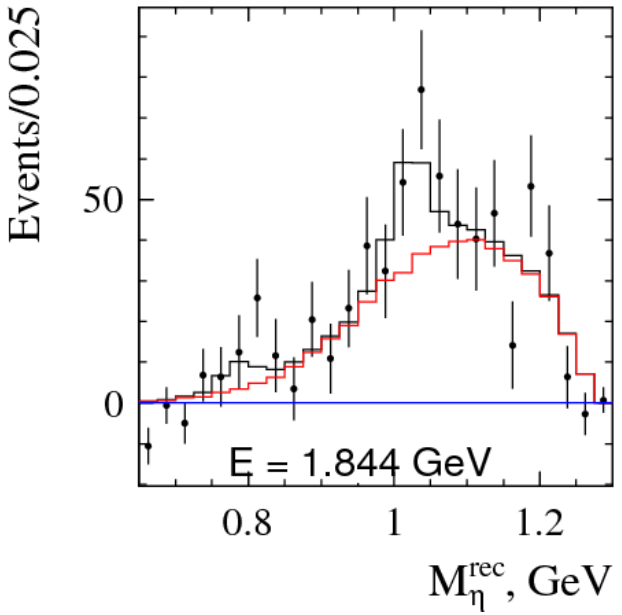
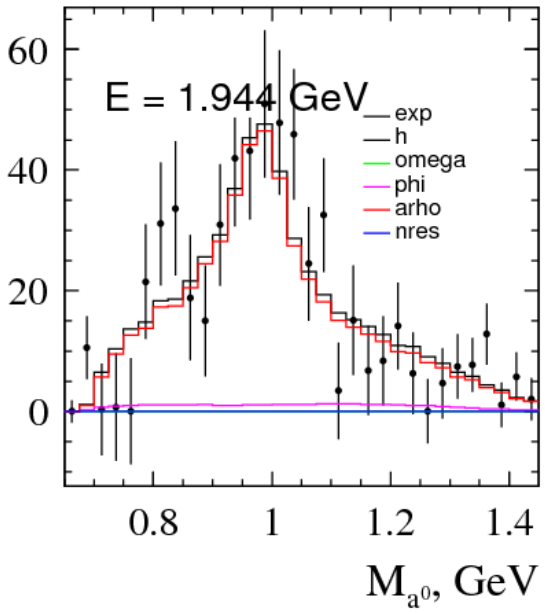
$e^+e^- \to \pi^+\pi^-\pi^0\eta$







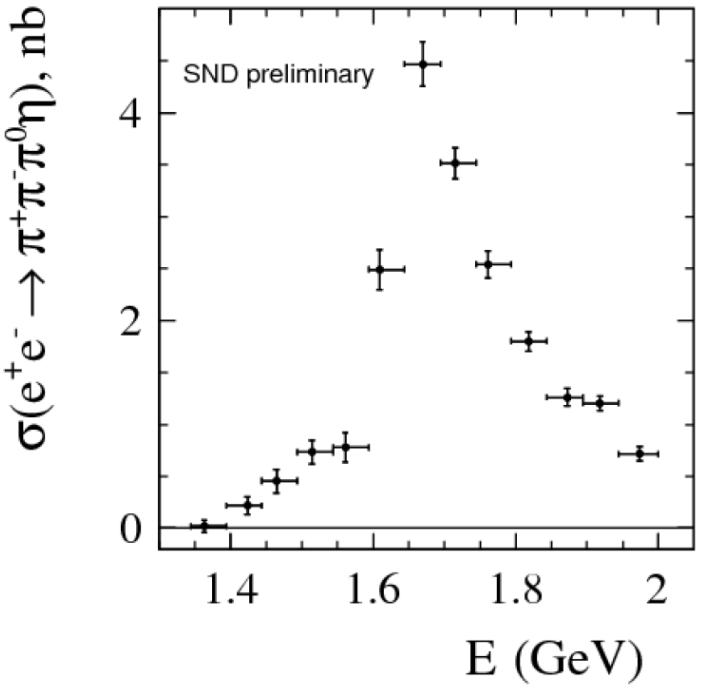


$\omega\eta$ and $\phi\eta$ intermediate states are clearly seen in the spectrum of the mass recoiling against η

$a_0(980)\rho$ intermediate state is seen in the $\eta\pi$

Also there is a non-resonant cotribution

$e^+e^- \to \pi^+\pi^-\pi^0\eta$

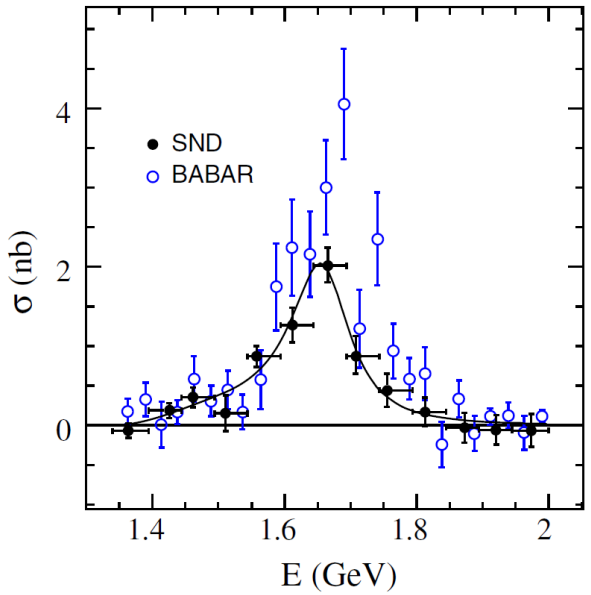


First measurement of this process

- $\phi\eta$ and $\omega\eta$ contribution is 50-60% below 1.8 GeV
- Above 1.8 GeV the dominant reaction mechanism is $a_0(980)\rho$

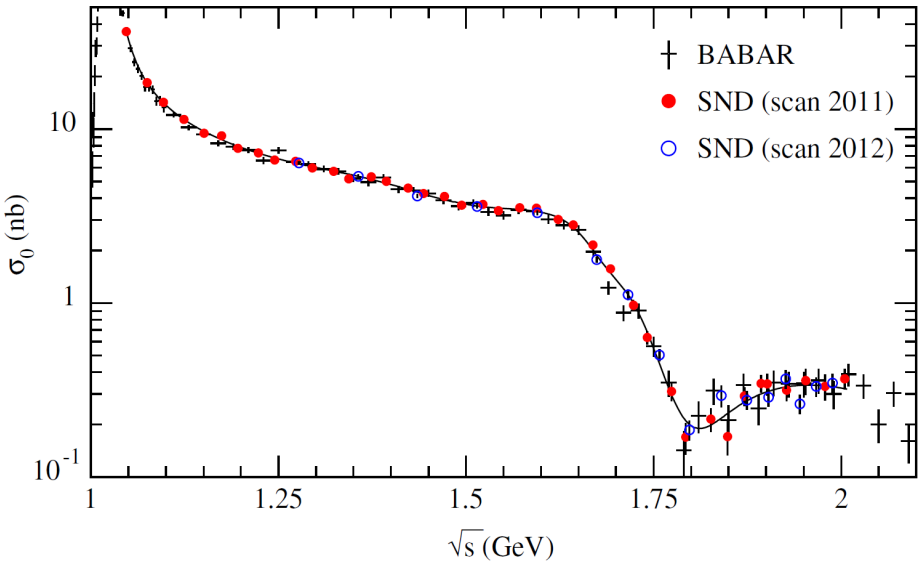
– The process $e^+e^- \to \omega\eta$ has been measured separately

– There is a significant difference between SND result and the previous BABAR measurement



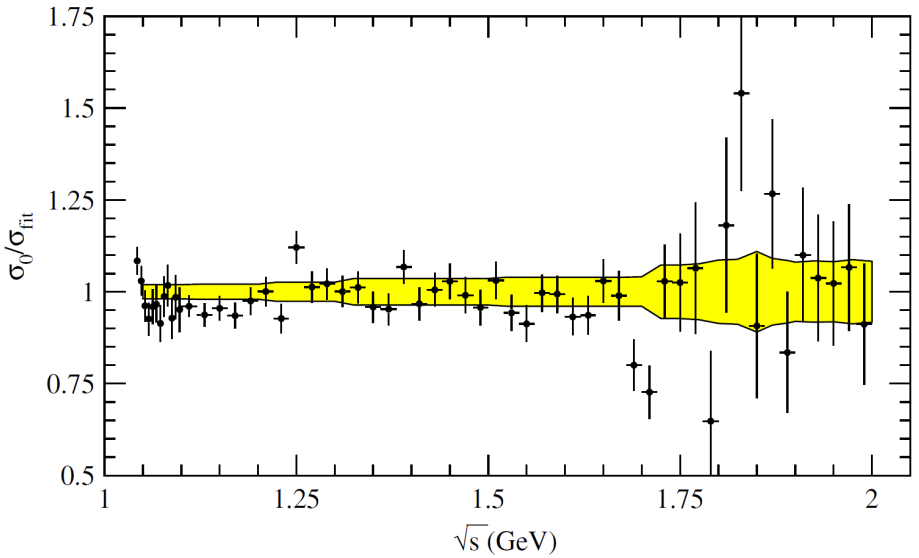
Phys. Rev. D 94, 092002 (2016)

$e^+e^- \to K^+K^-$



- Our results are in agreement with BABAR measurement and have similar accuracy
- Both isoscalar and isovector resonances contribute into the cross section

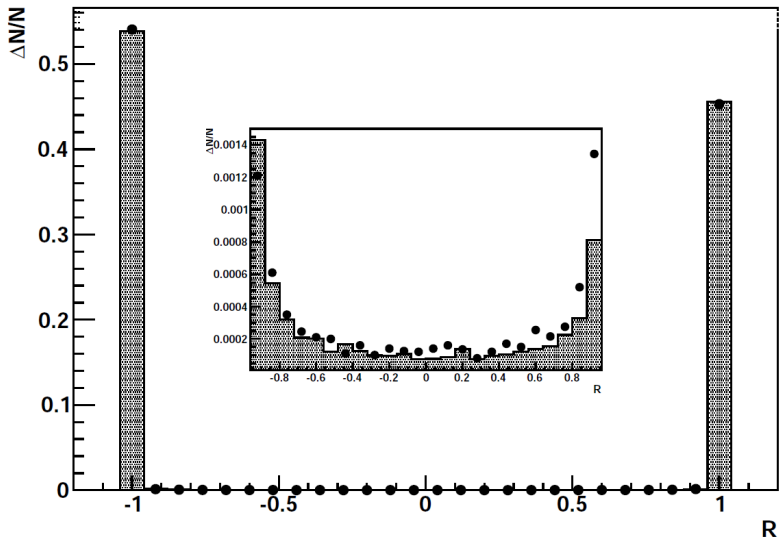
BABAR data and the SND fit ratio, the shaded band represents the SND and BABAR systematic uncertainties combined

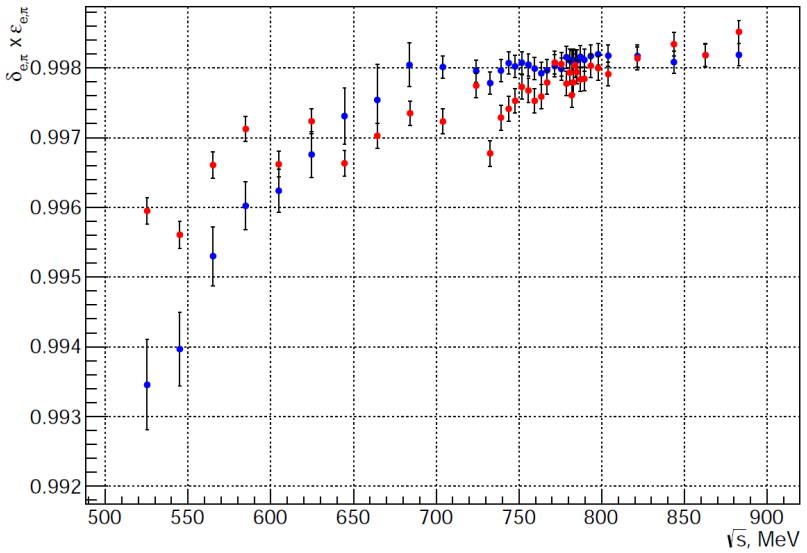


Phys. Rev. D 94, 112006 (2016)

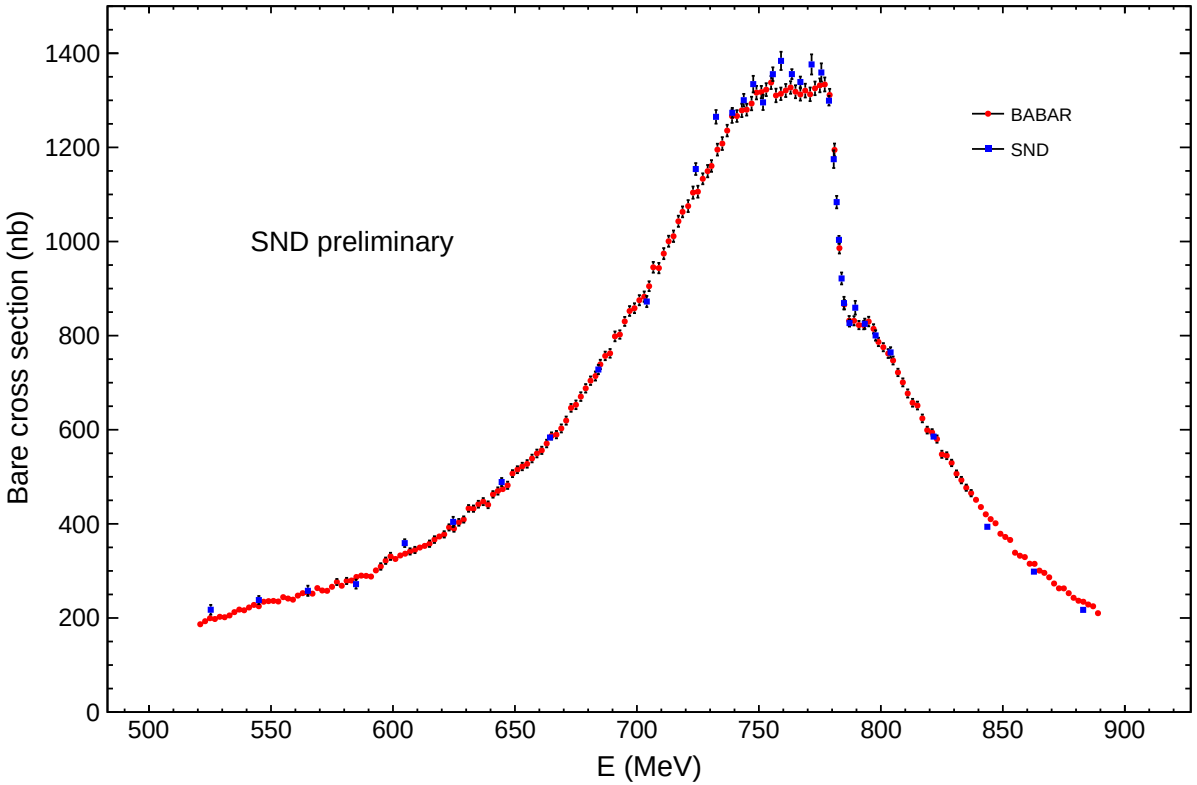
$e^+e^- \to \pi^+\pi^-$

- Selection criteria are common (collinear tracks, cuts on energy deposition and everage θ, muon system veto). The $e^+e^- \to e^+e^-$ process is used for normalization.
- The selected events are divided into two classes (e^+e^- and $\pi^+\pi^-$,$\mu^+\mu^-$) by the enrgy deposition using machine learning techniques.
- The $\mu^+\mu^-$-events are subtracted according to the theoretical cross section, integrated luminosity and detection efficiency.





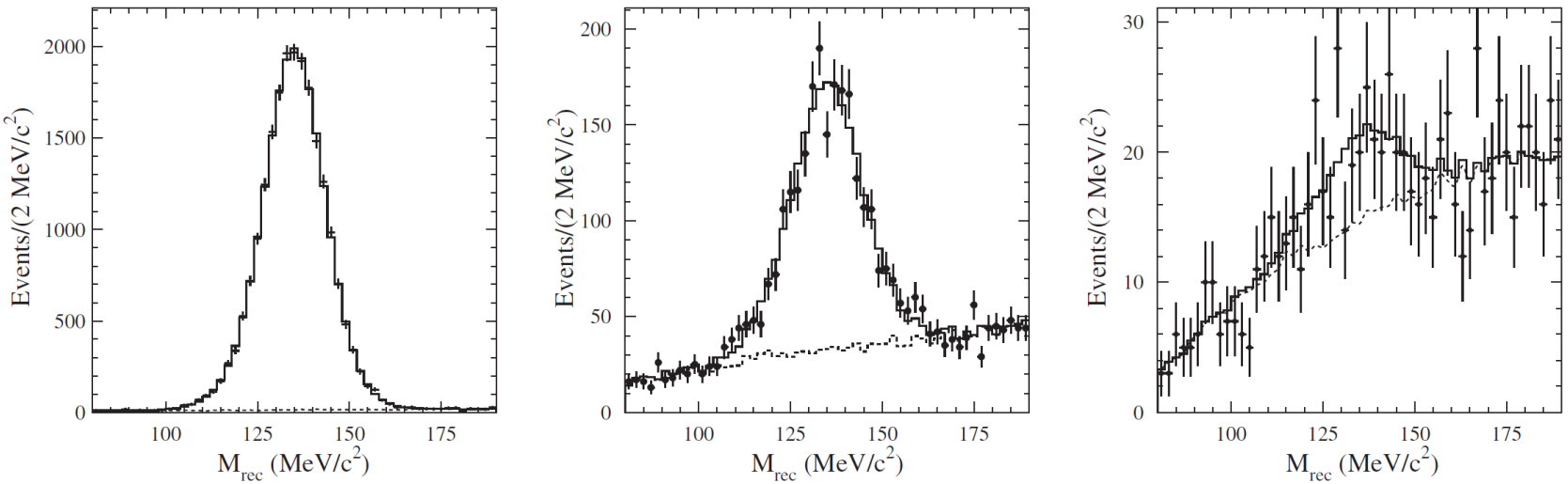
JINST T01002 (2017)



- Identification efficiencie contribution to the systematics is less than 0.2% for the most energy points
- Total systematic uncertainty is estimated to be < 1 %

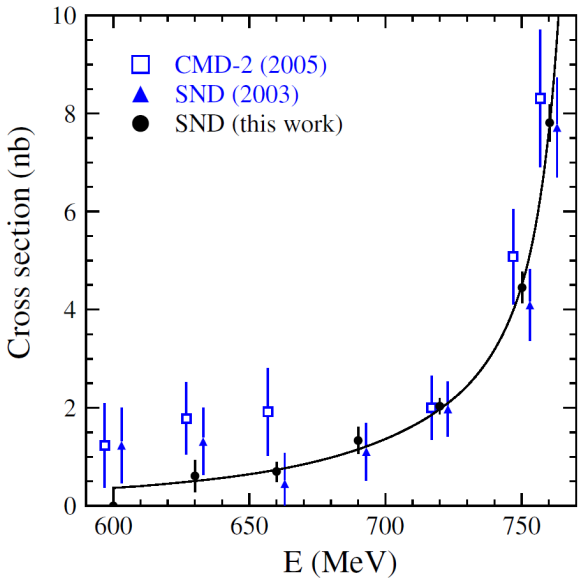
There is difference between SND result and the previous BABAR measurement

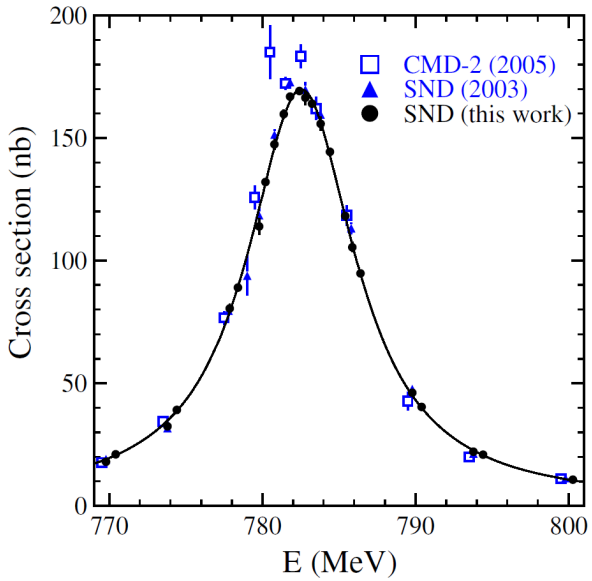
$e^+e^- \to \pi^0\gamma$

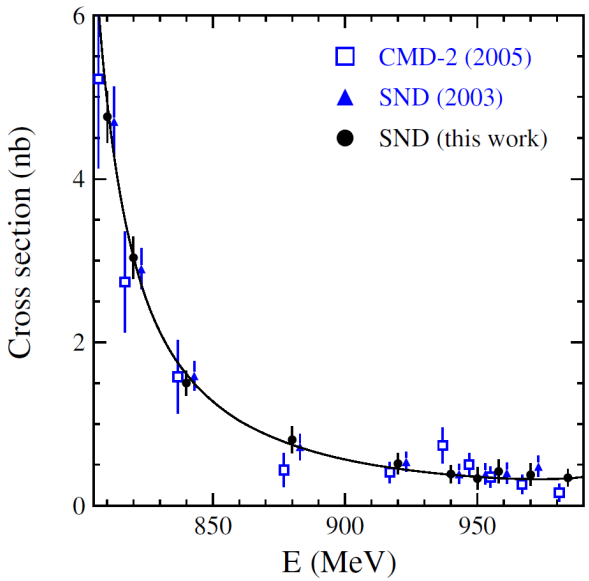


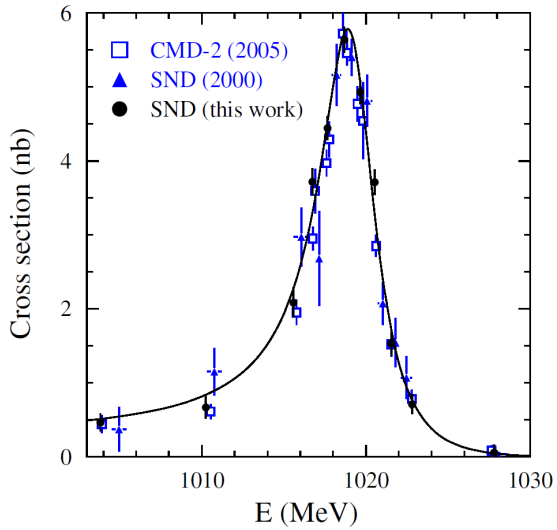
- The $e^+e^- \to \gamma\gamma$ process is used for normalization. Many selection criteria are common for 2γ and 3γ (trigger, absence of charged tracks, cuts on the total energy deposition and event momentum, muon system veto)
- Final selection is based on 4C kinematic fit ($\chi^2_{3\gamma} < 30$)
- The number of $e^+e^- \to \pi^0\gamma$ events is determined from the fit to the M_{rec} spectrum

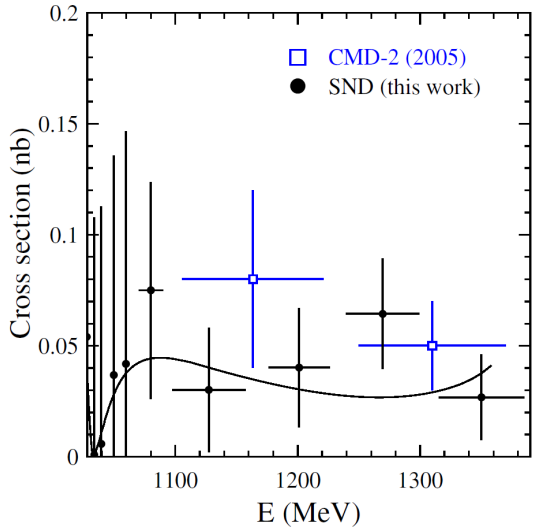
$e^+e^- \to \pi^0\gamma$











The most precise measurement of the cross section (Systematic uncertainty at the ω peak is 1.4%)

Phys. Rev.D 93, 092001 (2016)

Results

- The SND detector accumulated $\approx 120\ pb^{-1}$ of integrated luminosity at the VEPP-2000 collider in the c.m. energy range 0.3 - 2 GeV.
- Data analysis on hadron production is in progress.
- Measurements of the $\pi^0\gamma$ and K^+K^- cross sections have comparable or better accuracy than previous ones.
- $\pi^+\pi^-\pi^0\eta$ and $\omega\eta\pi^0$ cross sections have been measured for the first time.
- After VEPP-2000 upgrade, data taking was resumed, with a goal of $\approx 1\ fb^{-1}$ of integrated luminosity.