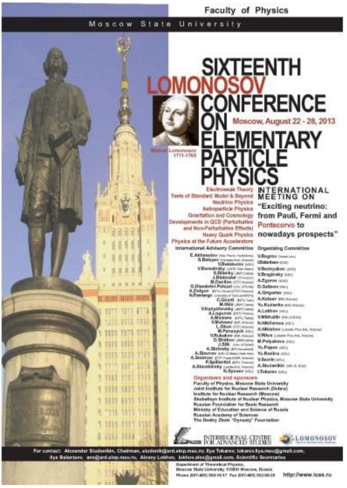


Recent results from CMD-3 detector

Peter A. Lukin
(on behalf of CMD-3 Collaboration)

Outline

- ✓ Introduction
- ✓ Collider & Detector
- ✓ Preliminary Results
- ✓ Conclusion

Introduction

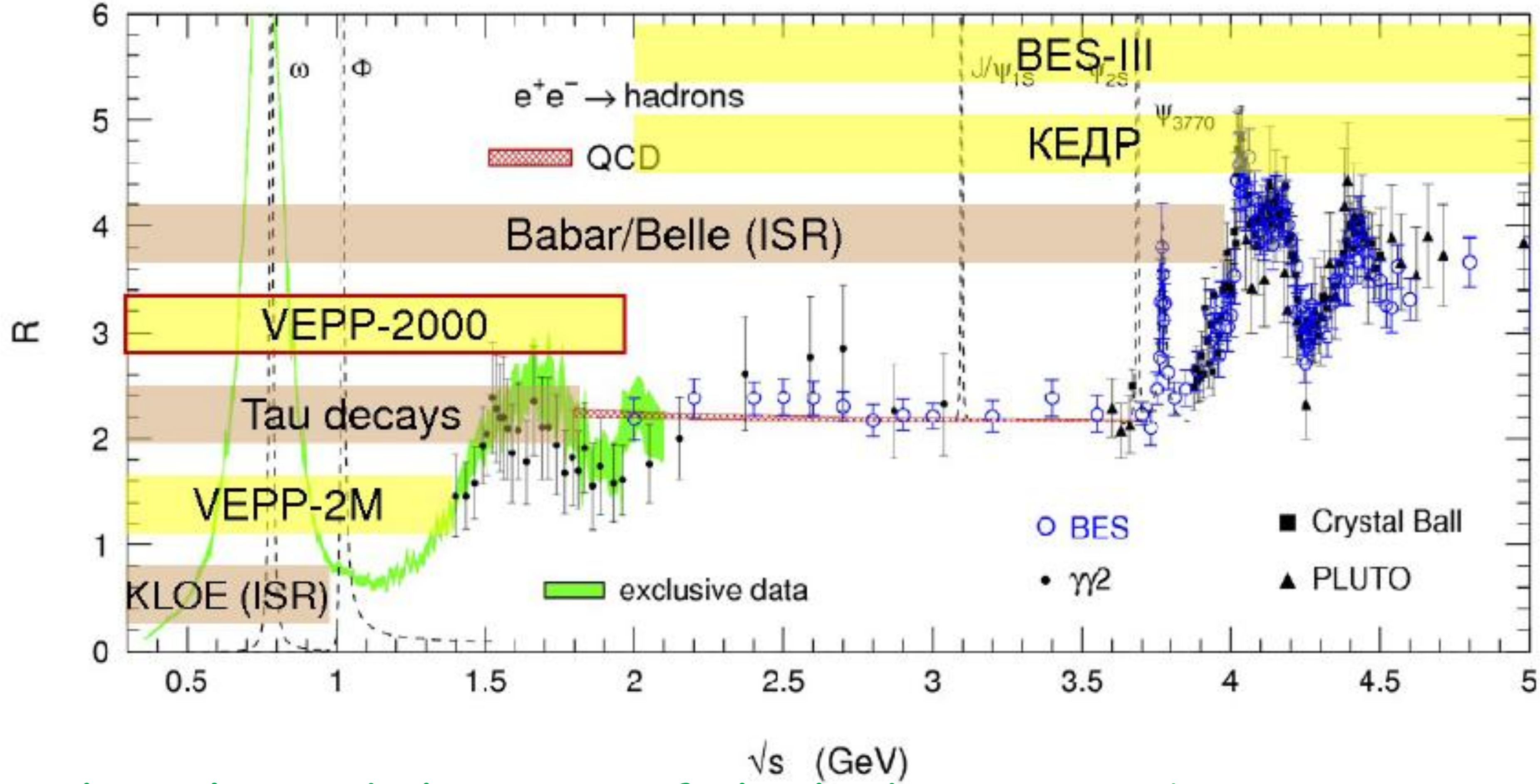
Measurement of the cross section e+e- →hadrons in the low energy range is interesting for:

- measurement of parameters of light vector mesons ρ, ω, φ, ρ', ρ'', ω', ω''
- test of QCD sum rules, ... etc, search of exotics (light hybrids and glueballs)
- CVC test in comparison with spectral functions of tau decays
- measurement of R(s) :

$$R(s) = \frac{\sigma(e^+e^- \to \gamma^* \to hadrons)}{\sigma(e^+e^- \to \gamma^* \to \mu^+\mu^-)}$$

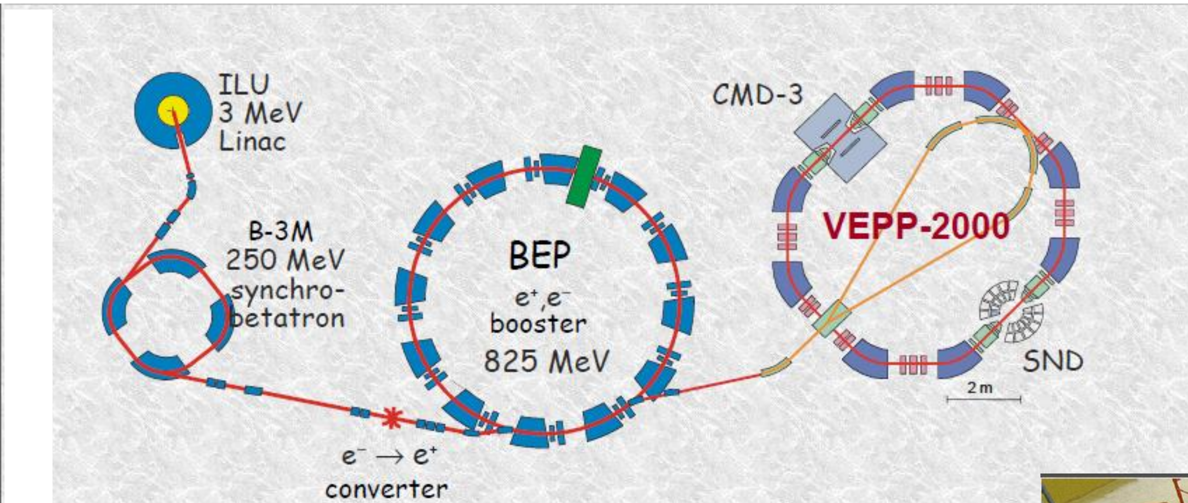
is essential for the interpretation of precision measurements of: muon (g-2) - good test of SM

R(s) measurements at low s

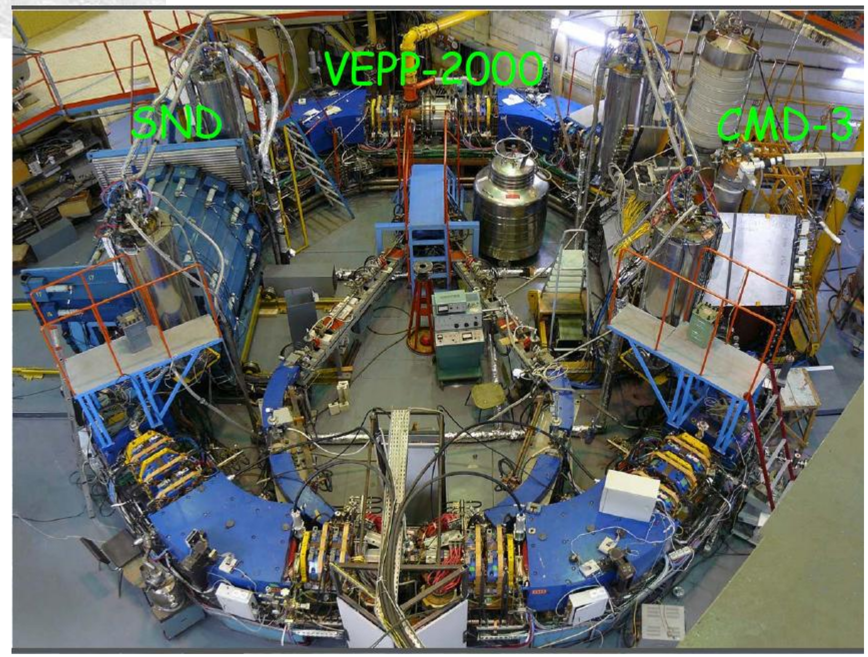


The value and the error of the hadronic contribution to muon (g-2) are dominated by low energy R(s) (<2GeV give 92%).

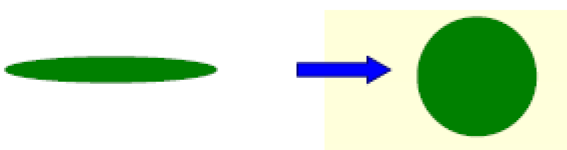
VEPP-2000 e^+e^- collider

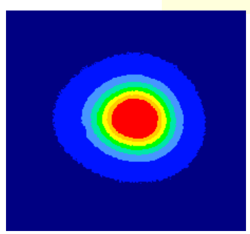


	VEPP-2M	VEPP-2000	
E (MeV)	510	510	900
Π (cm)	1788	2235	2235
$\mathcal{I}^+,\mathcal{I}^-$ (mA)	40	34	200
$\varepsilon \cdot 10^5$ (cm · rad)	3	0.5	1.6
β_x (cm)	40	6.3	6.3
β_z (cm)	5	6.3	6.3
ξ_x	0.016	0.075	0.075
ξ_z	0.050	0.075	0.075
$\mathcal{L}(\mathrm{cm}^{-2}\mathrm{s}^{-1})$	$3 \cdot 10^{30}$	$1 \cdot 10^{31}$	$1 \cdot 10^{32}$



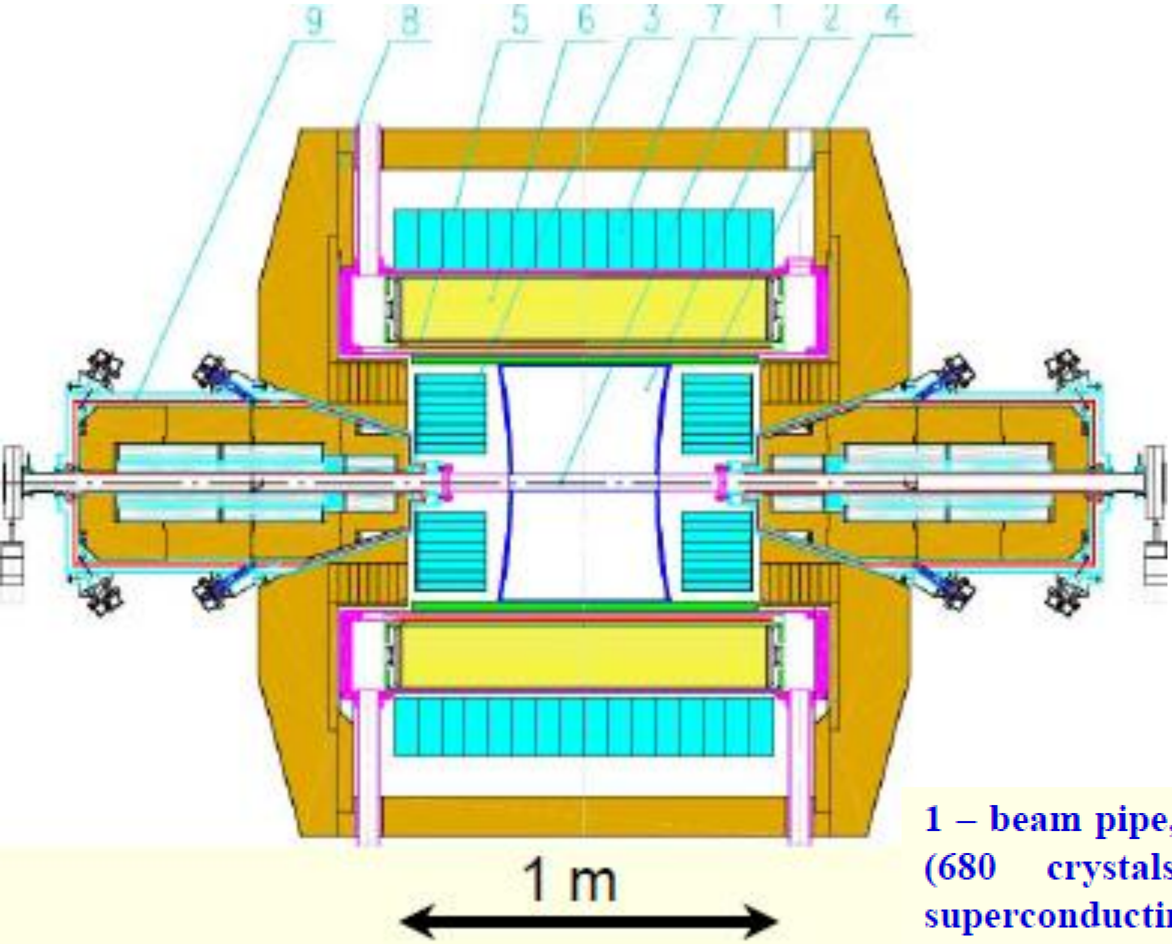
Main idea: Round Beams

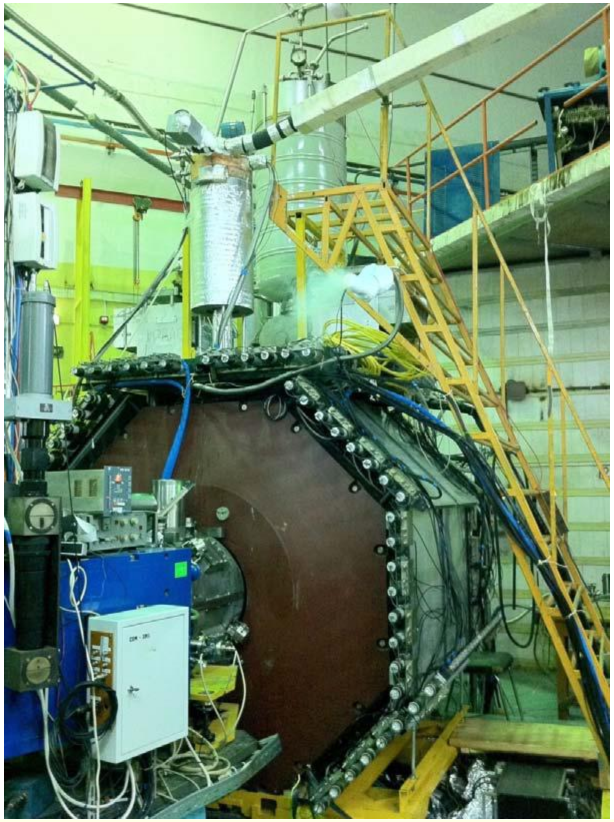




$$L = \frac{\pi\gamma^2 \xi_x \xi_y \varepsilon_x f}{r_e^2 \beta_y^*}\left(1+\frac{\sigma_y}{\sigma_x}\right)^2 \Rightarrow L = \frac{4\pi\gamma^2\xi^2\varepsilon f}{r_e^2\beta^*}$$

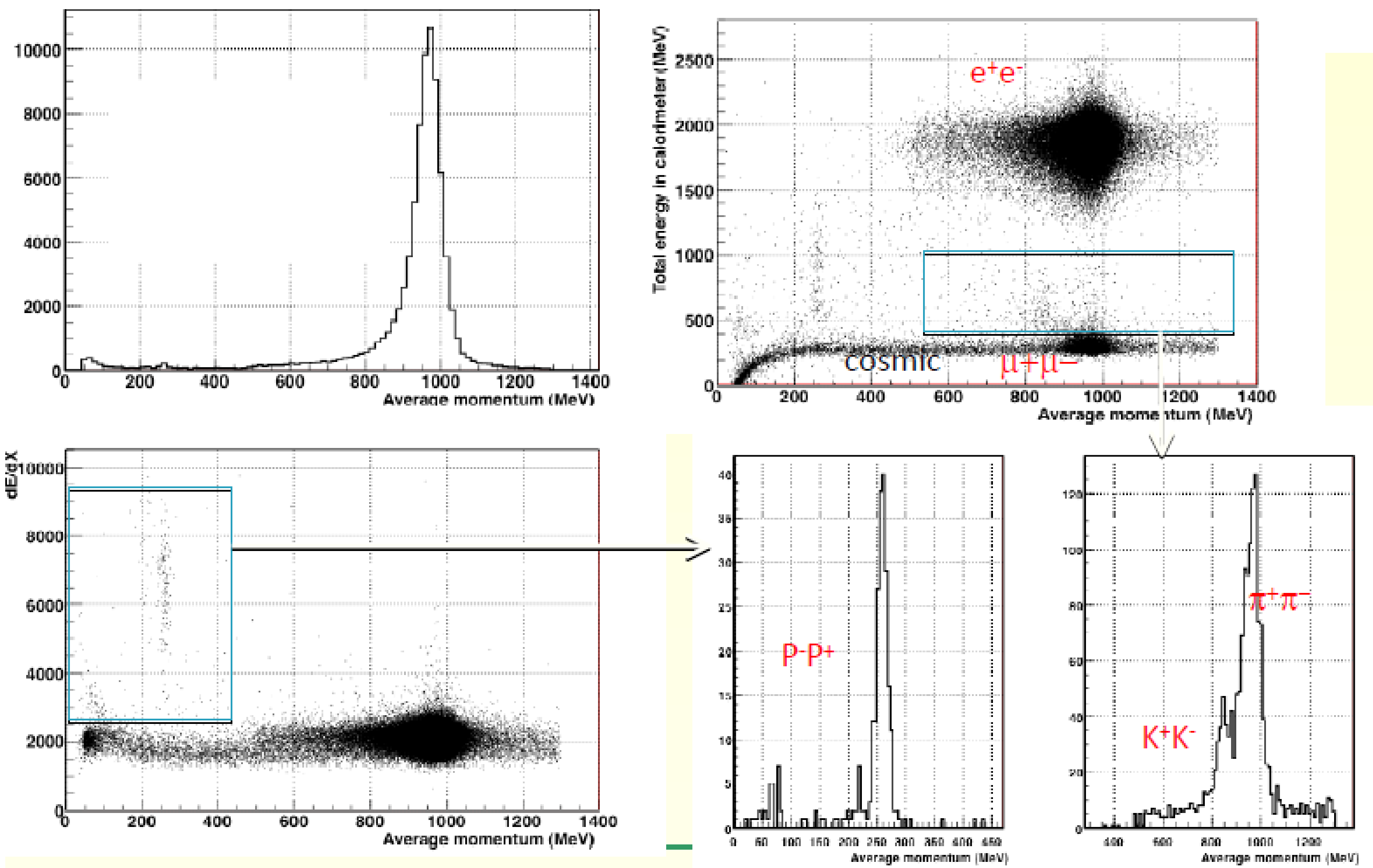
CMD-3 Detector



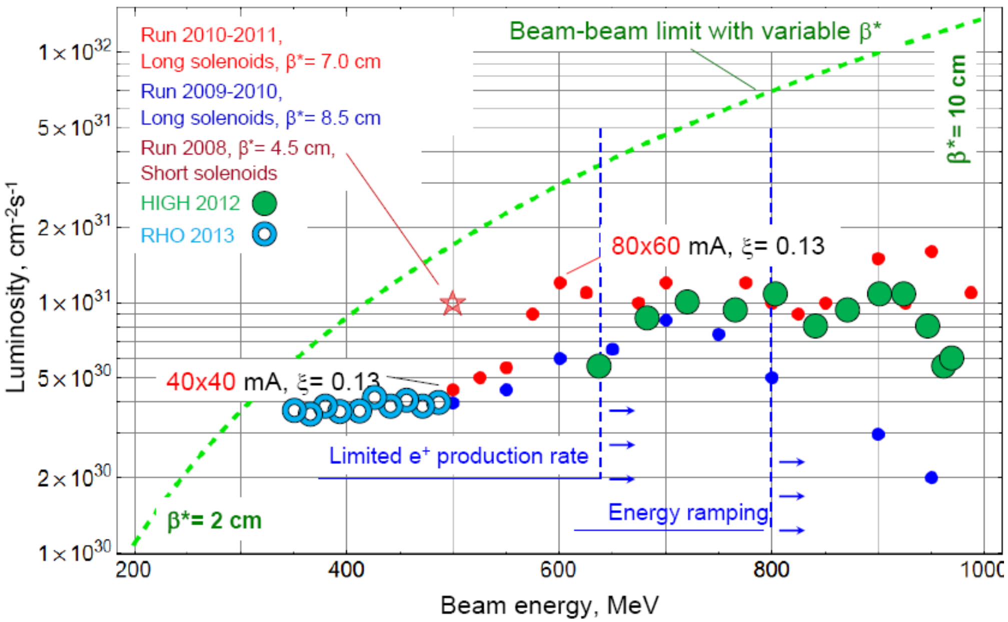


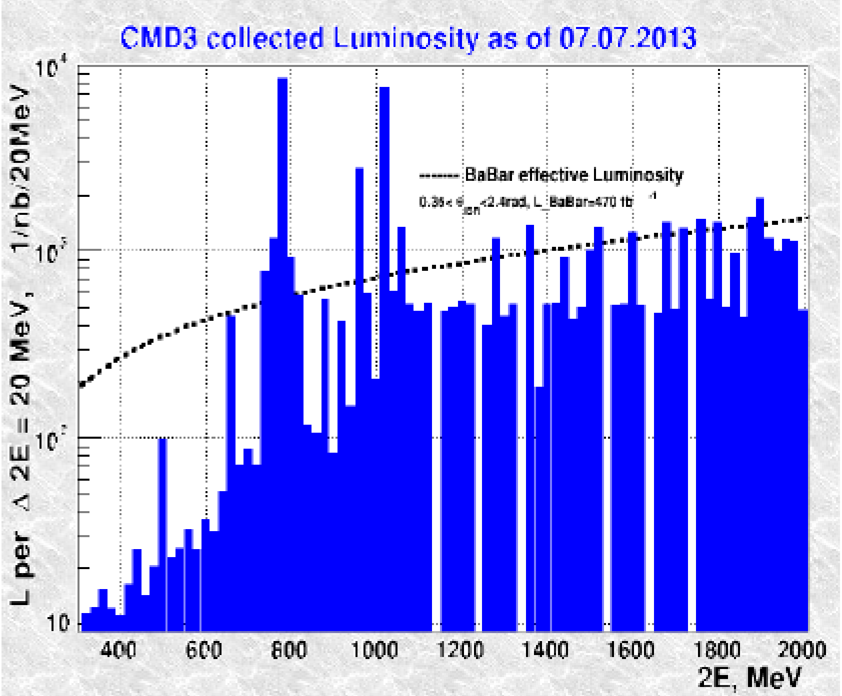
1 – beam pipe, 2 – drift chamber, 3 – BGO calorimeter (680 crystals), 4 – Z–chamber, 5 – CMD-3 superconducting solenoid, 6 – calorimeter LXe (400 liters), 7 – calorimeter CsI (1152 crystals), 8 –iron yoke, 9 – solenoids of VEPP-2000, (not shown) muon range system (scintillation counters) and TOF system.

Collinear Events @ CMD-3 ($E_{c.m.}$ = 1.95 GeV)



Collected Luminosity





Collected L ~ 60 pb^{-1} per detector

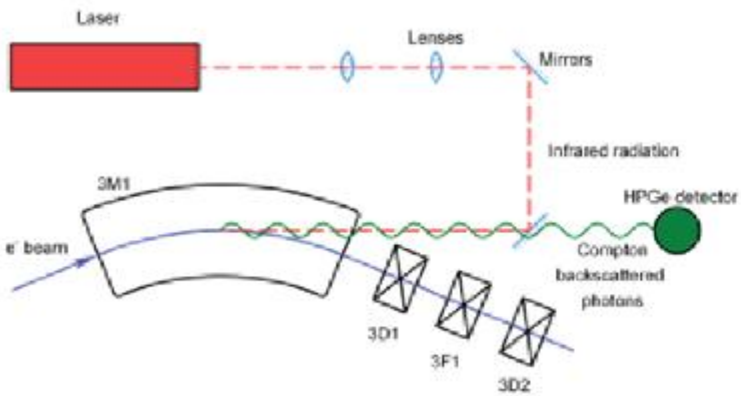
8.3 pb^{-1}	ω - region
9.4 pb^{-1}	< 1 GeV (except ω)
8.4 pb^{-1}	φ - region
34.5 pb^{-1}	> 1.04 GeV

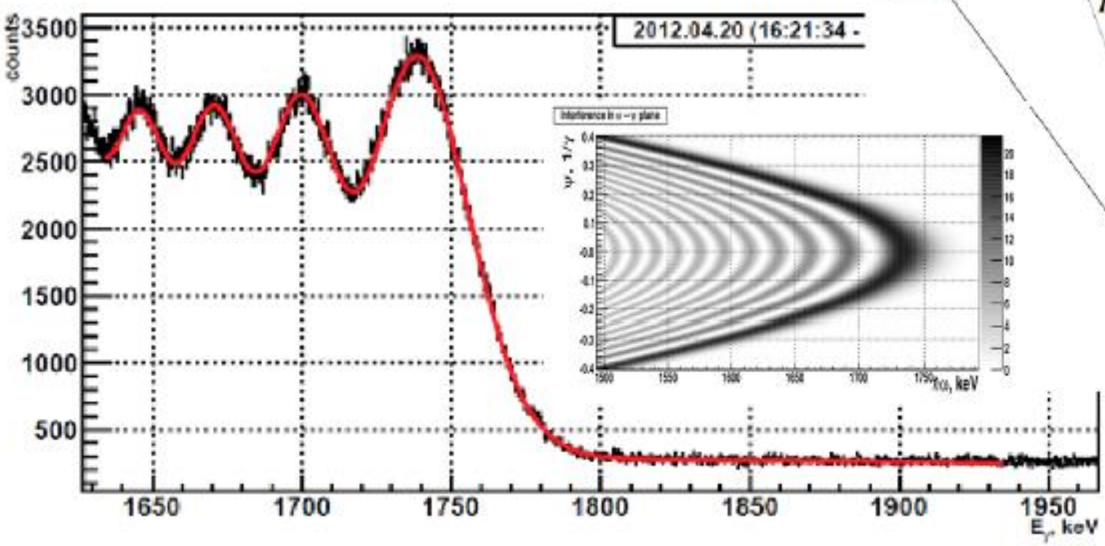
The maximum luminosity is $2\cdot10^{31}$ cm^{-2}s^{-1} at 1.7-1.8 GeV, falling much slower with decreasing energy than before the round beams

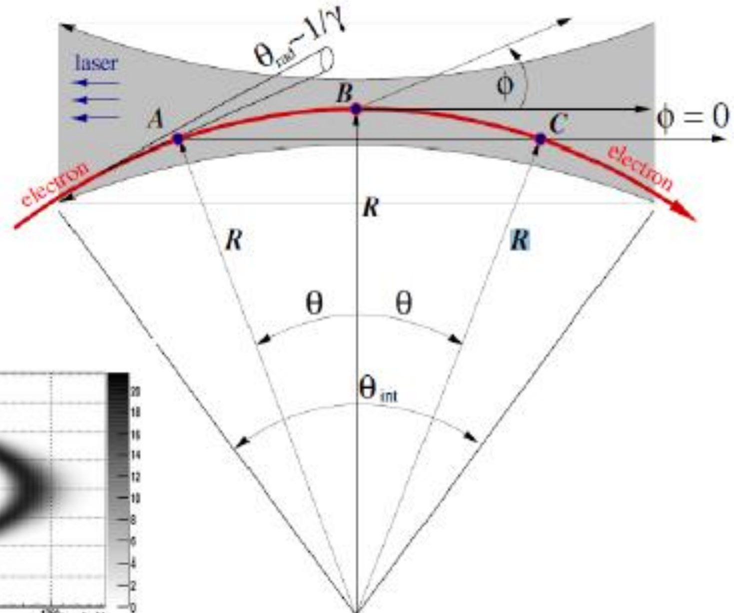
At high energies luminosity is limited by a deficit of positrons and maximum energy of the booster (900 MeV now)

In 2013 we reached 2 × 160 MeV, the smallest energy ever measured at ee colliders

Energy measurement by Compton back scattering





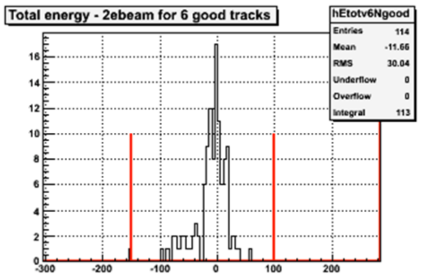


E = 993.662±0.016 MeV

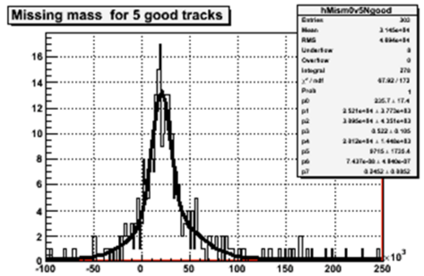
M.N. Achasov et al. arXiv:1211.0103v1 [physics.acc-ph] 1 Nov 2012

Process $e^+e^- \to 3(\pi^+\pi^-)$

We have very clean selection of 6 and 5 pions

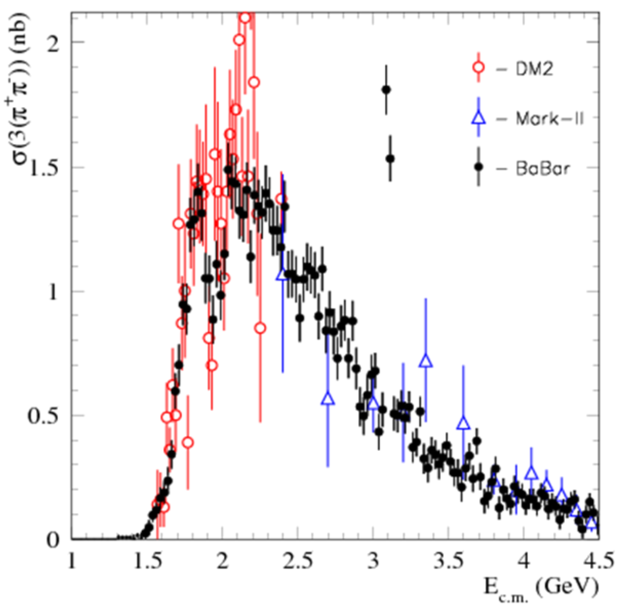


$E_{6\pi}$-$2E_{beam}$ (MeV)

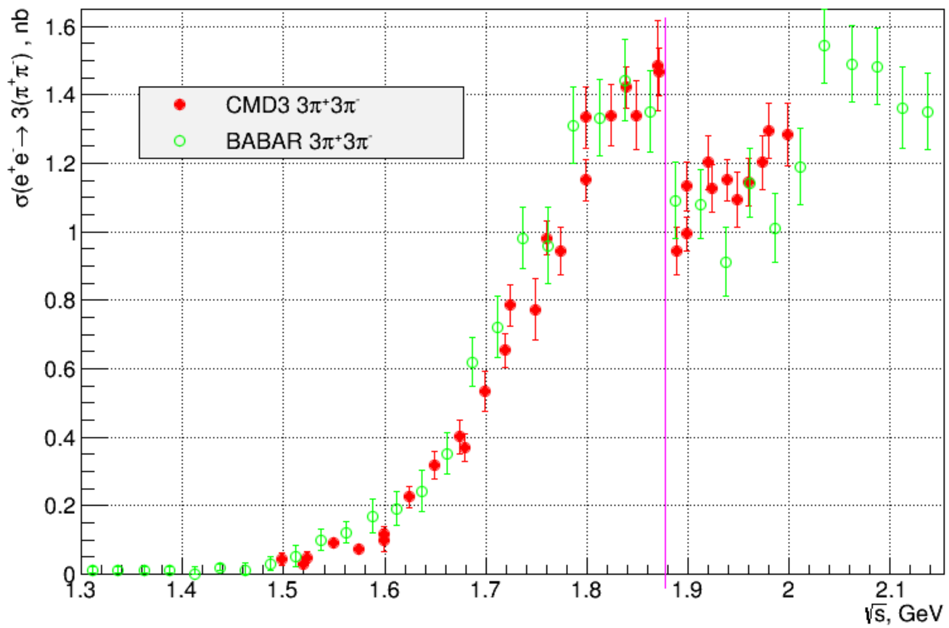


M_{miss}^2 (MeV^2)

Other data for e+e- -> 3(π+π-)



Phys.Lett. B723 (2013) 82-89



We study dynamics, pure phase space doesn't work, three models with JPC = 1^{--}, each with one ρ^0/event:

- $\rho(1450)(2\pi^+2\pi^-)_{S\text{-wave}} \to a_1(1260)^{\pm}\pi\pi\pi^+\pi^- \to \rho^0 2(\pi^+\pi^-) \to 3(\pi^+\pi^-)$
- $\rho(770)(2\pi^+2\pi^-)_{S\text{-wave}} \to 3(\pi^+\pi^-)$

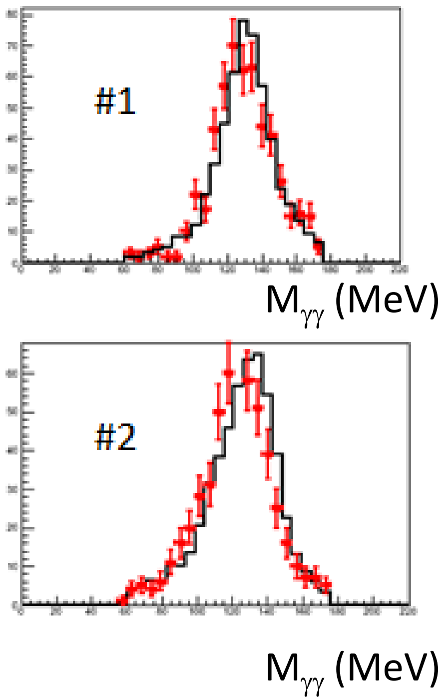
3 options for $2\pi^+2\pi^-$: phase space, $f^0(1370)$, $f^0(1500)$

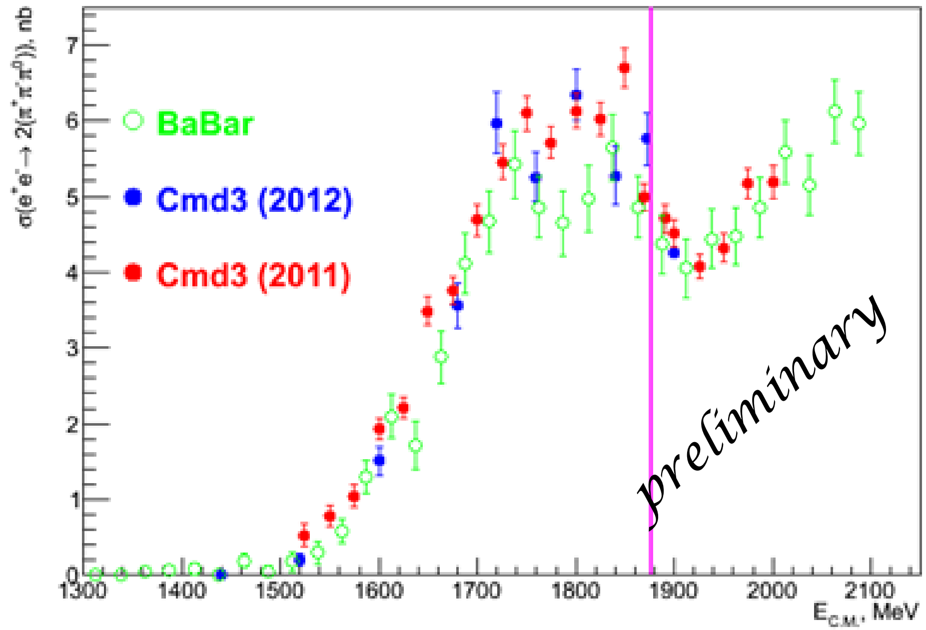
- $\rho(770)f_2(1270) \to 3(\pi^+\pi^-)$

The best description is with one ρ(770) and 4 pions in S-wave

Process $e^+e^- \to 2(\pi^+\pi^-\pi^0)$

We have relatively clean selection of 2 and 1 π^0 in addition to four charged tracks

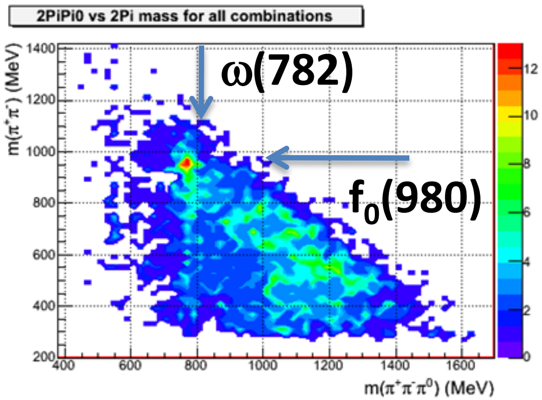


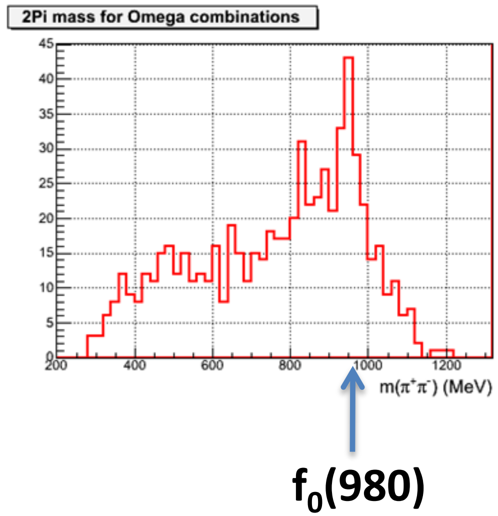


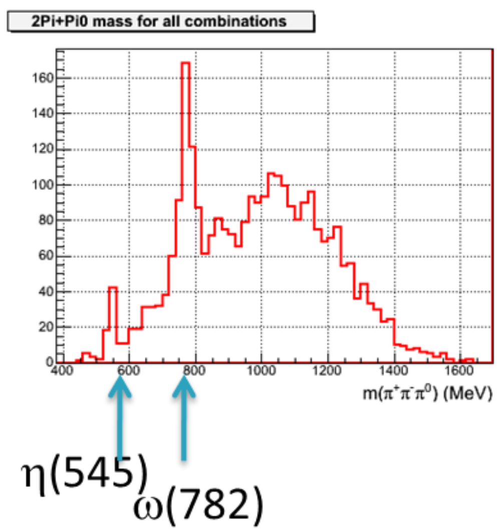
ωη, φη intermediate states are seen, systematic errors are under study.

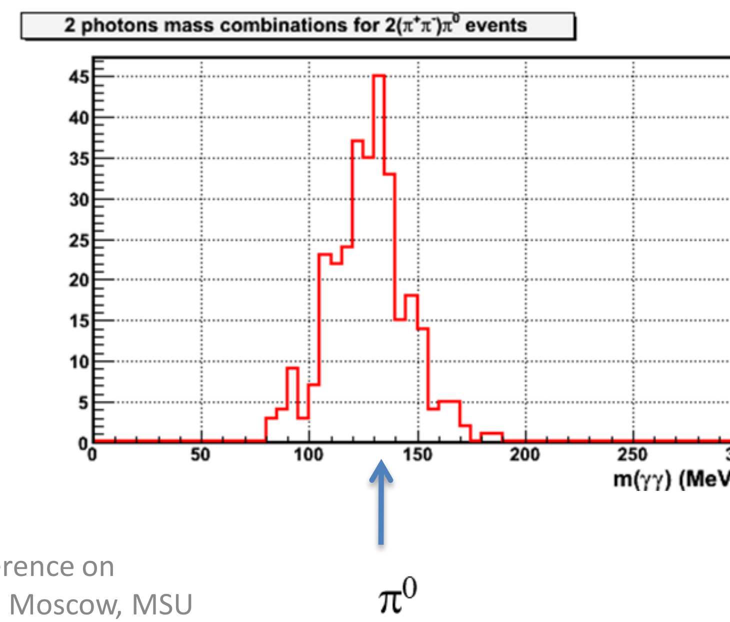
Look at the Process $e^+e^- \to 2(\pi^+\pi^-)\pi^0$

Example of ωf⁰(980) signal in $\omega\pi^+\pi^-$ final state.



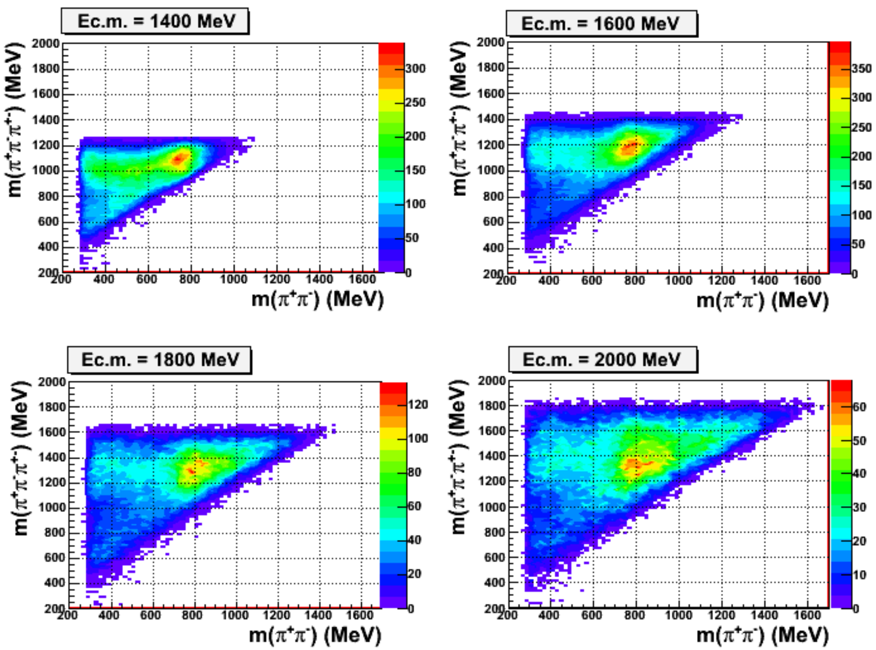


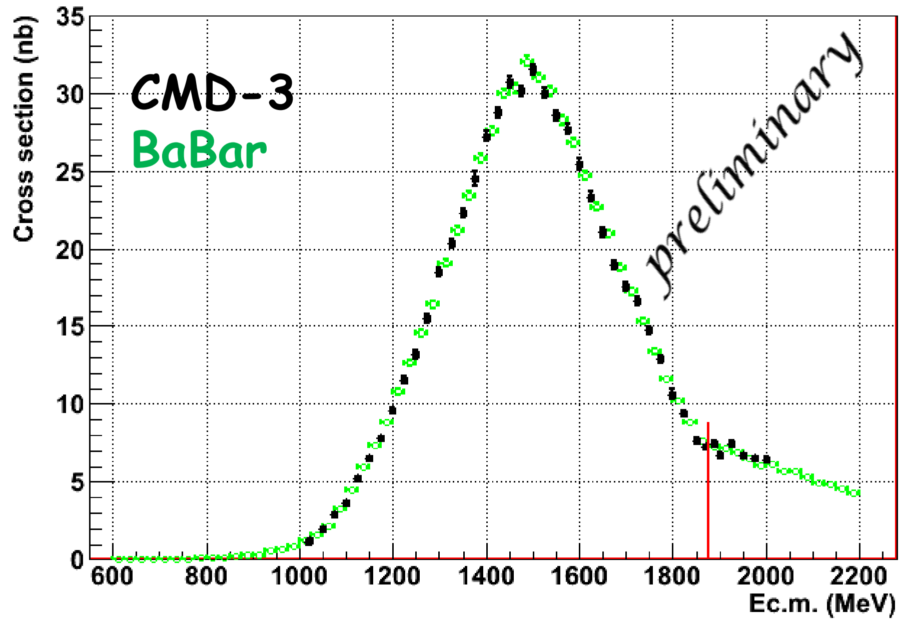




Detailed analysis is coming…

Process $e^+e^- \to 2(\pi^+\pi^-)$

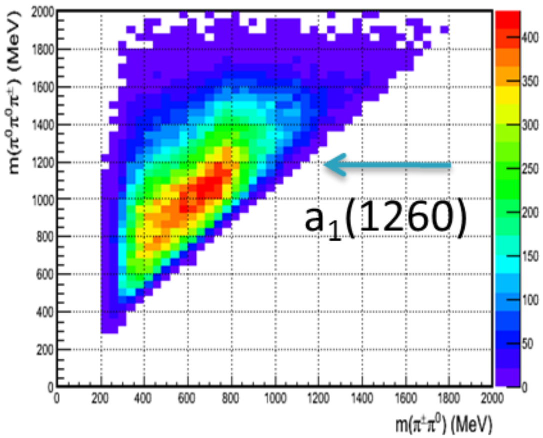


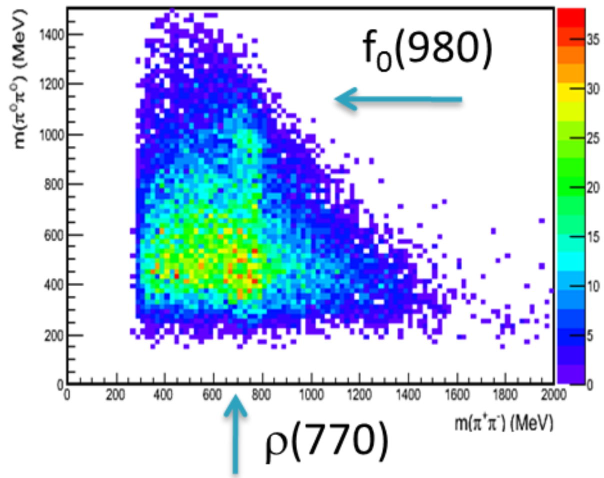


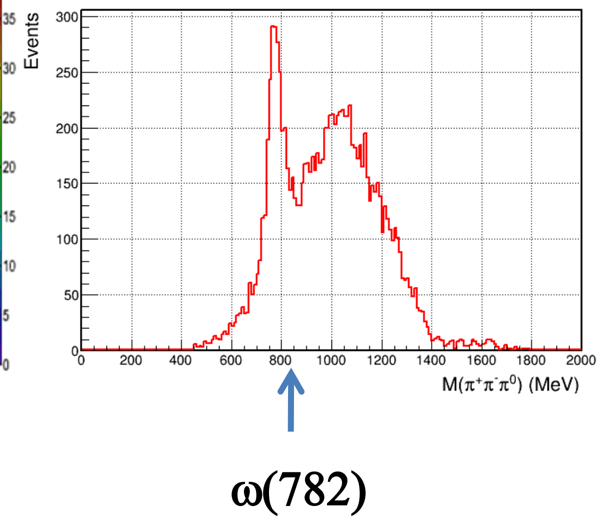
We confirm a1(1260)π dominance.
Some other states
(ρ(770)f0(600), ρ(770)f0(980))
are seen.

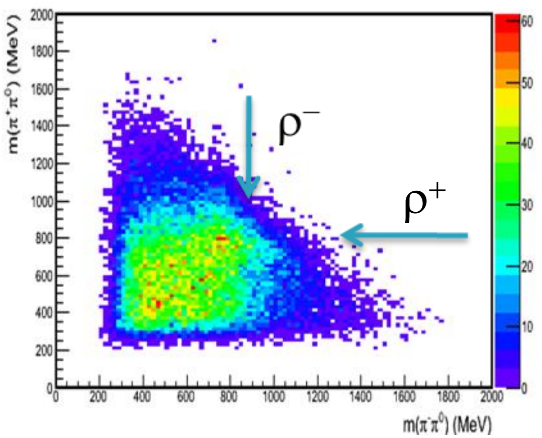
Statistical errors are at the level of 1-2% per point. Analysis of systematic errors is in progress.

Study of $e^+e^- \to \pi^+\pi^-\pi^0\pi^0$







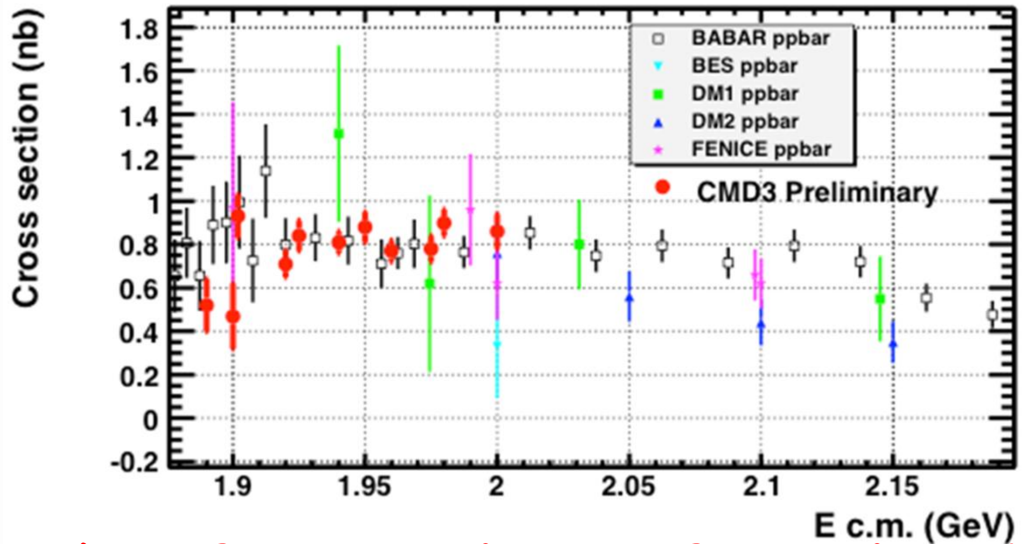


In addition to dominant $\omega\pi^0$ and $a_1\pi$ we see $\rho^+\rho^-$, $\rho(770)f^0(600)$?, $\rho(770)f^0(980)$

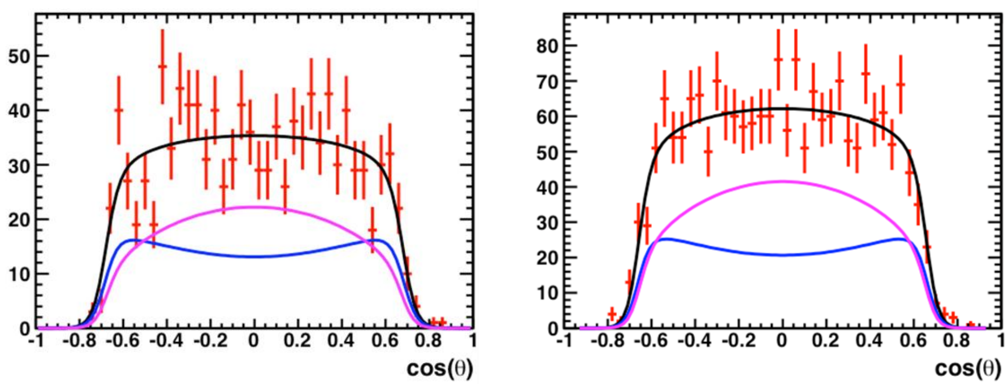
We have statistical errors at the level of 1-2% per point. Systematic errors are under study.

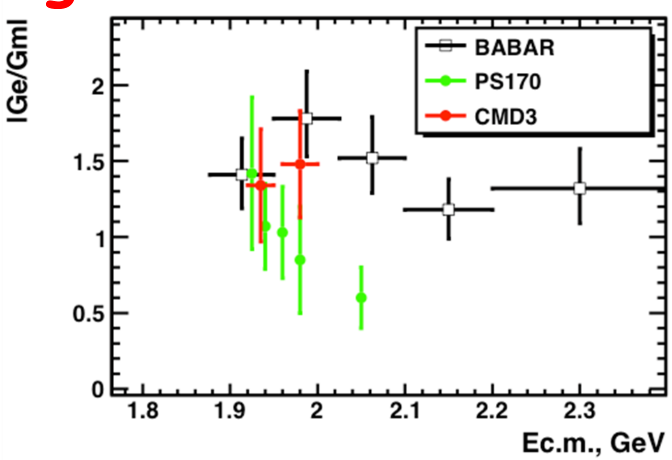
Preliminary results on $e^+e^- \to \bar{p}p$

Cross section

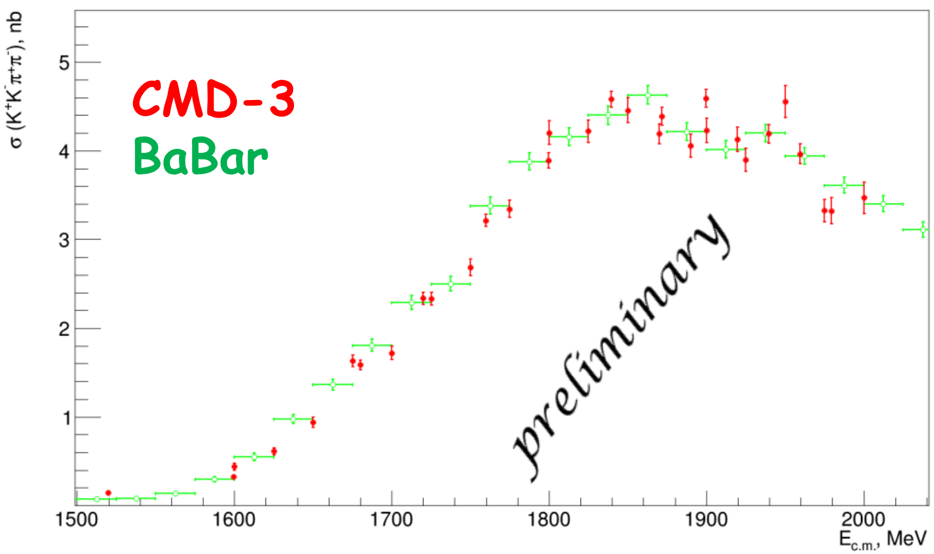


Ratio G_E/G_M from analysis of angular distributions

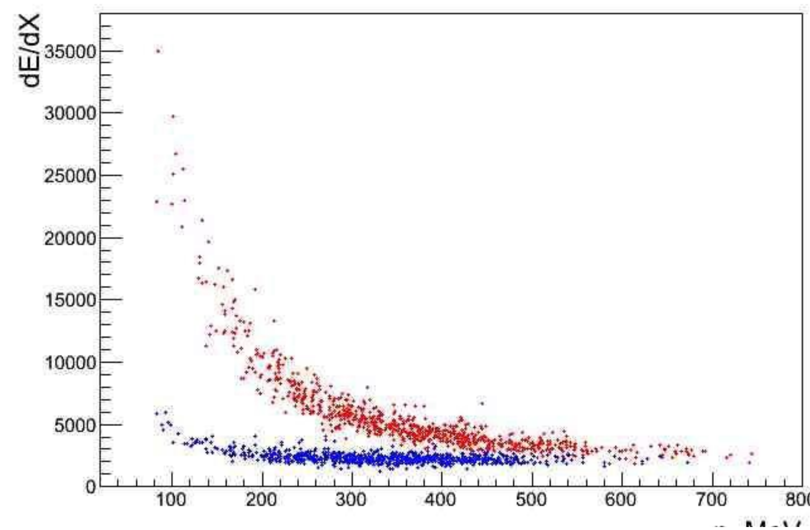


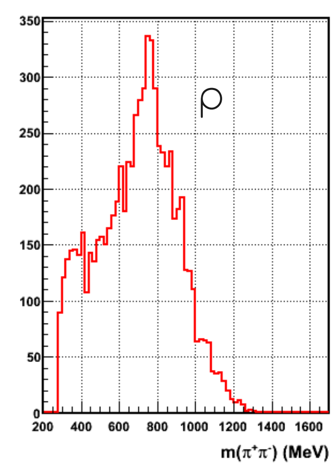


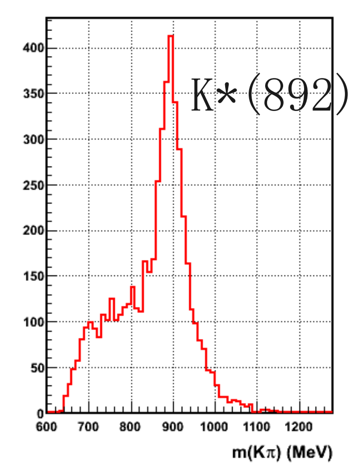
Process $e^+e^- \to K^+K^-\pi^+\pi^-$



πK particle identification by dEdX in DC







Rich dynamics seen, many intermediate states:

$K_1(1270)K \to K^*(892)K\pi$

$K_1(1400)K \to K^*(892)K\pi$

$K_1(1270)K \to \rho KK$

$K^*(892)K^*(892)$, $\varphi\pi\pi$

Conclusion

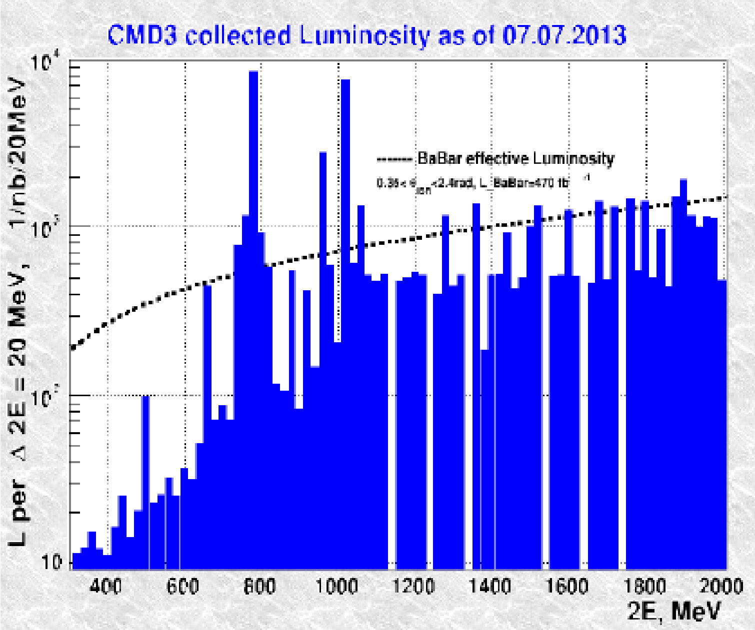
- ✓ New accelerator principles put on the base of the VEPP-2000 collider were successfully proved. First three experimental runs generated considerable amount of data which analysis is in progress now. The second detector, SND, with very good photon detection collected similar statistics and has a lot of various results on hadronic cross sections, particularly on channels with neutrals.
- ✓ The last experimental run ended in the middle of July 2013. Then a long shutdown for 1-1.5 years to increase the booster energy to 1 GeV and commission the new injection complex to reach 10^{32} $cm^{-2}s^{-1}$
- ✓ Hopefully, in the next 5-10 years the VEPP-2000 will produce the integrated luminosity ~ 1 fb^{-1} which should provide new precise interesting results on the hadron production in e^+e^- annihilation.

Stay tuned!

Thank You!

BACKUP SLIDES

Collected Luminosity



Data taking history

HIGH2011

Scan 1: E_{cm} = 1.05 – 2.0 GeV
Scan 2: E_{cm} = 1.89 – 1.075 GeV
ΔE_{cm} = 0.05 GeV, 500 nb^{-1}/point

HIGH2012

E_{cm} = 1.28 – 1.98 GeV
ΔE_{cm} = 0.04 GeV, 1000 nb^{-1}/point

RHO2013

E_{cm} = 0.32 – 0.98 GeV
ΔE_{cm} = 0.02 GeV, 100 nb^{-1}/point
around $\rho(770)$ peak:
ΔE_{cm} = 0.002 GeV, 700 nb^{-1}/point
around $\omega(782)$ peak:
ΔE_{cm} = 0.002 GeV, 2000 nb^{-1}/point

@ϕ(1020)/PHI2010-PHI2013/

E_{cm} = 0.984 – 1.04 GeV
ΔE_{cm} = 0.006 GeV,500-1000 nb^{-1}/point

The maximum luminosity is $2 \cdot 10^{31}\ cm^{-2}s^{-1}$ at 1.7-1.8 GeV, falling much slower with decreasing energy than before the round beams

At high energies luminosity is limited by a deficit of positrons and maximum energy of the booster (900 MeV now)

In 2013 we reached 2 × 160 MeV, the smallest energy ever measured at ee colliders

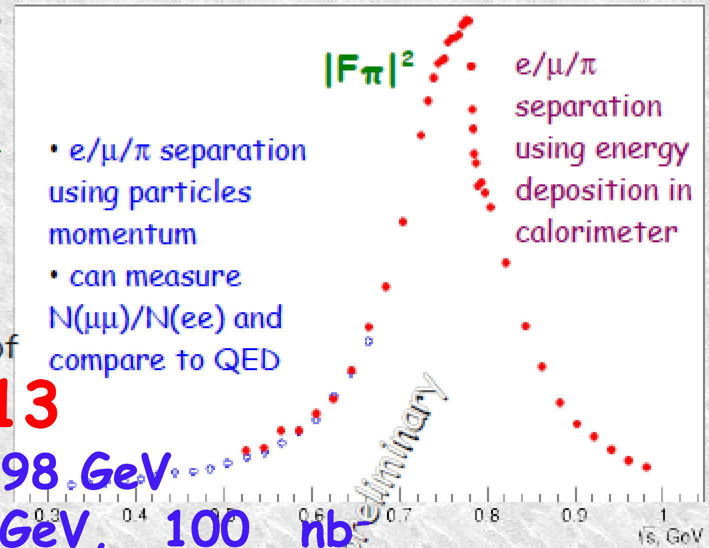
$e^+e^- \rightarrow \pi^+\pi^-$ @ CMD-3

Clean collinear events (mostly without background)

Overall corrections at the level of a few percent

Plans to reduce systematic error from 0.6-08% -> 0.35%:

- Event Separation will be checked by different methods (0.2%)
- More proof of Radiative corrections 0.3% -> 0.1%
- Determination of fiducial volume controlled independently by LXe and ZC subsystems (0.1%)
- Beam Energy measured by method of Compton back scattering of the laser photons(σ_E< 50 keV)(0.1%)



RHO2013

E_{cm} = 0.32 – 0.98 GeV

ΔE_{cm} = 0.02 GeV, 100 nb^{-1}/point

Statistical precision of cross section measurement