INFN Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali di Frascati

RADIO MONTECARLOW

Primary Monte-Carlo simulation generator of the process $e^+e^- \to a_0(980)\rho(770)$ for the CMD-3 experiment

PETER A. LUKIN

BUDKER INSTITUTE OF NUCLEAR PHYSICS

AND

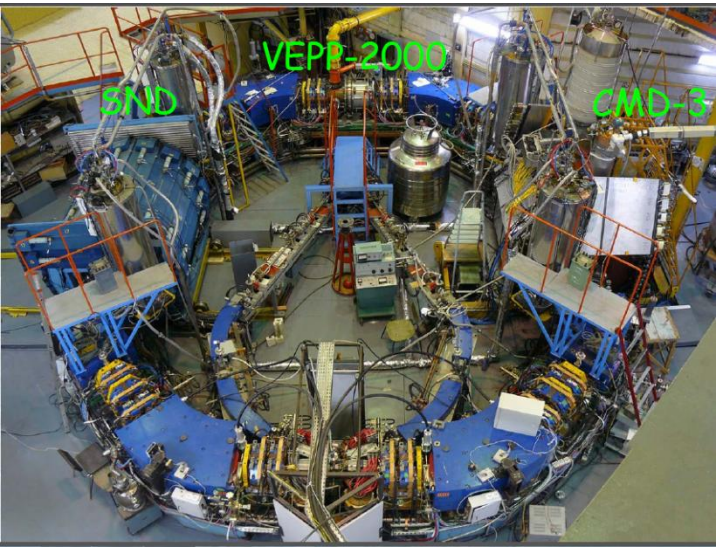
NOVOSIBIRSK STATE UNIVERSITY

XVI Radio MonteCarLow WG: LNF, 18-19 November 2014

OUTLINE

- INTRODUCTION
- MOTIVATION
- GENERATOR
- MASS AND ANGULAR DISTRIBUTIONS
- CONCLUSION

INTRODUCTION



VEPP-2000

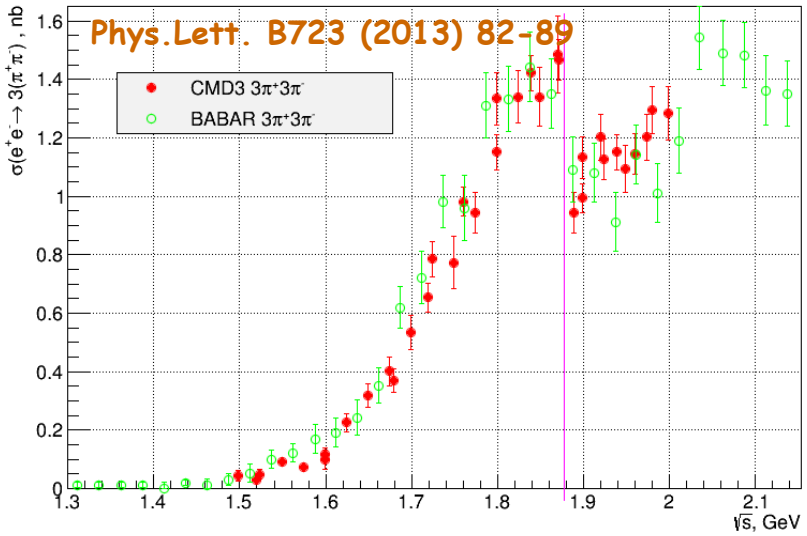
2E = 0.32 – 2.0 GeV

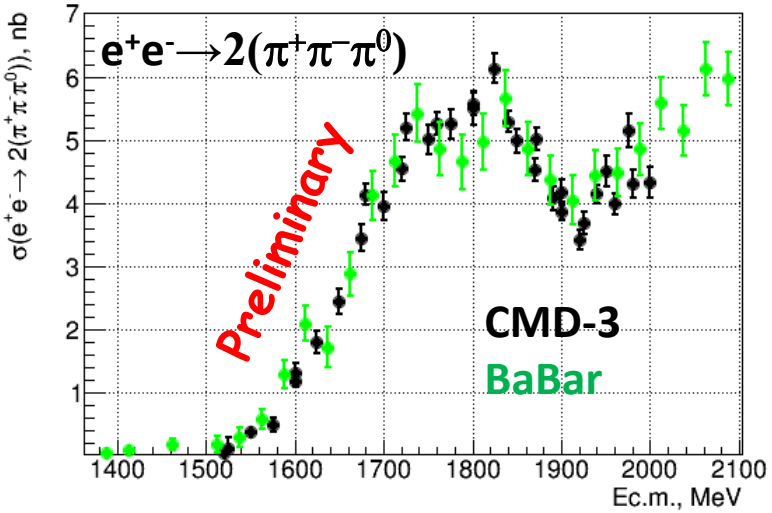
Round beams

$L = 2 \cdot 10^{31}\ cm^{-2} \cdot c^{-1}$ at 1.8 GeV

CMD-3

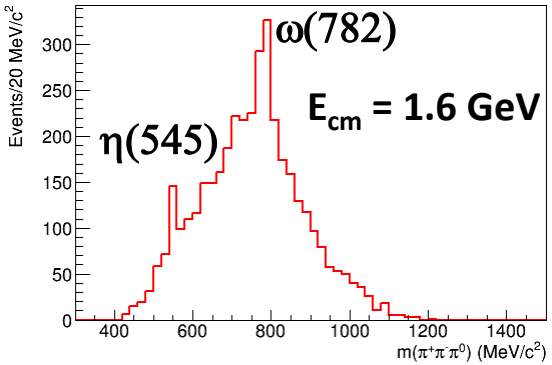
DC – drift chamber,
ZC – Z-chamber
SC solenoid, B = 1.3 T
LXe – LXe calorimeter (400 l)
TOF – Time of Flight system
CsI – CsI calorimeter (1152 cr)
BGO – BGO calorimeter (680 cr)
MU – muon range system

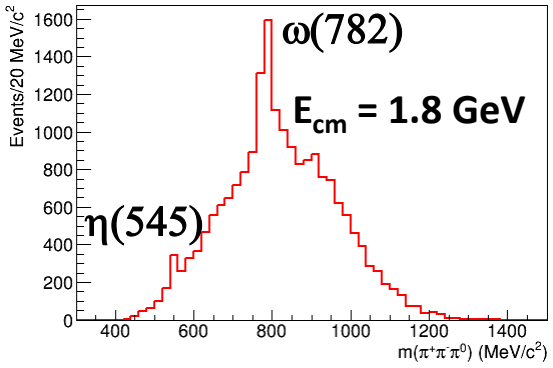


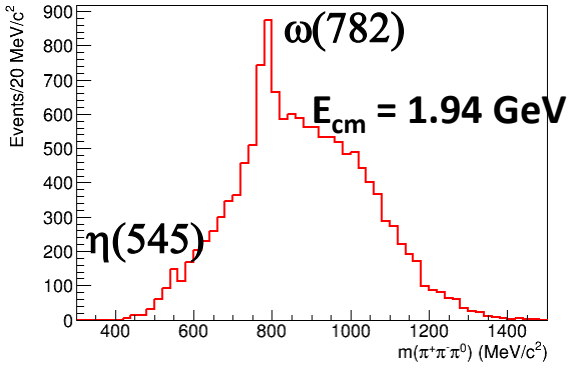


MOTIVATION

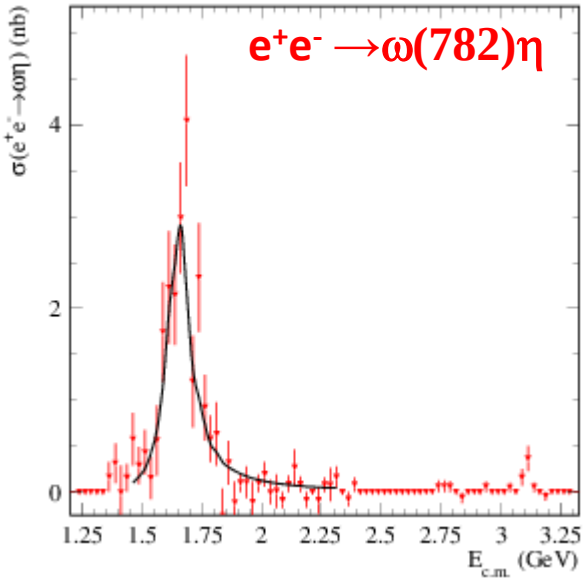
To calculate detection efficiency for $e^+e^- \to 2(\pi^+\pi^-\pi^0)$ we have to correctly describe angular correlations between particles



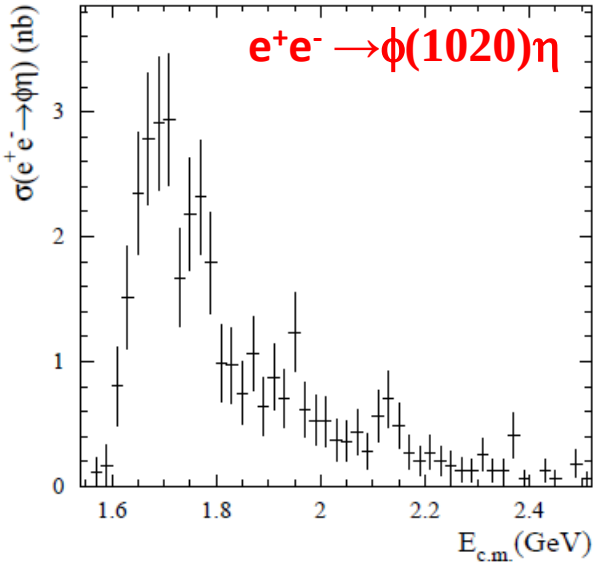




$\sigma(4\pi 2\pi^0) = 0.61$ nb @ 1.7 GeV



$\sigma(4\pi 2\pi^0) = 0.11$ nb @ 1.7 GeV

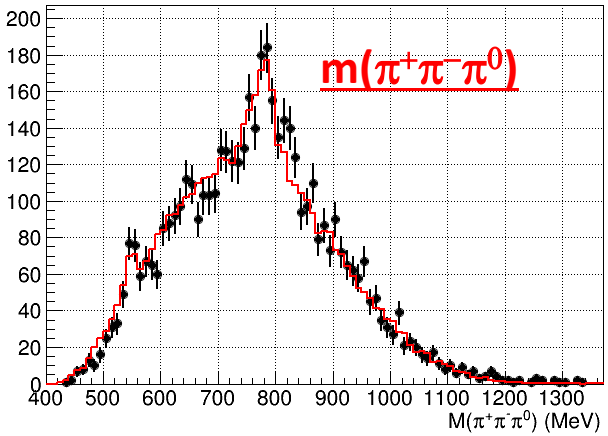


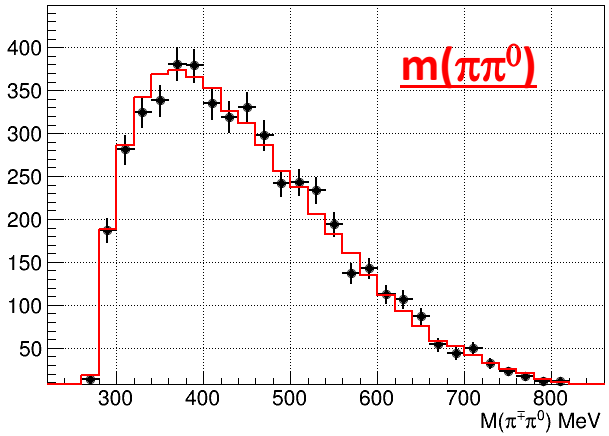
At least we need:

- $\omega(782)3\pi$
- $\omega(782)\eta$
- $\eta 3\pi$
- $a_0(980)\rho(770)$
- $\rho(770)4\pi$

DYNAMICS AT E_{cm} = 1720 MeV

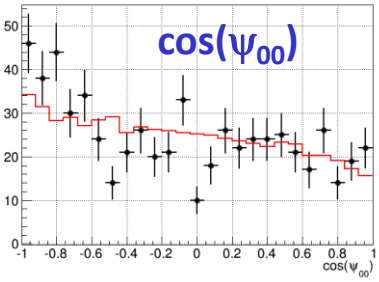
Talk @ XV RadioMonteCarlo (Mainz,Germany, 11/04/2014):

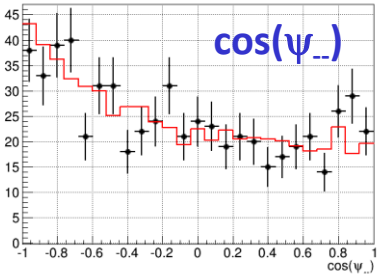


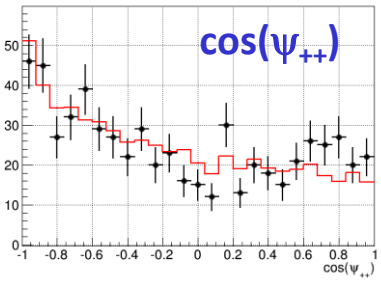


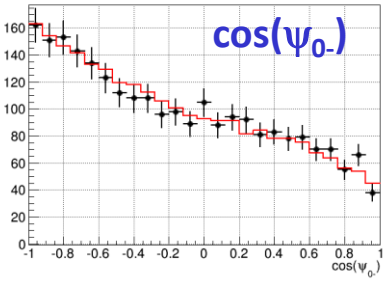
$(\omega 3\pi) \rightarrow (61\pm6)\%$
$(\omega\eta) \rightarrow (27\pm7)\%$
$(\rho 4\pi) \rightarrow (12\pm4)\%$

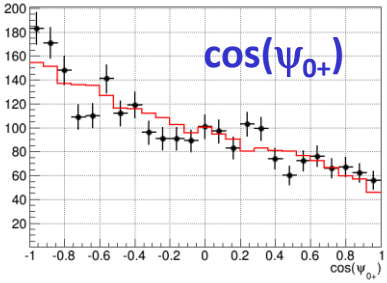
Determined the fractions of $\omega 3\pi$, $\omega\eta$, $\rho 4\pi$ from the fit of $m(3\pi)$ we could describe $m(2\pi)$ and angular correlations well enough.

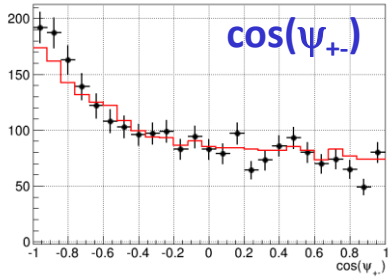




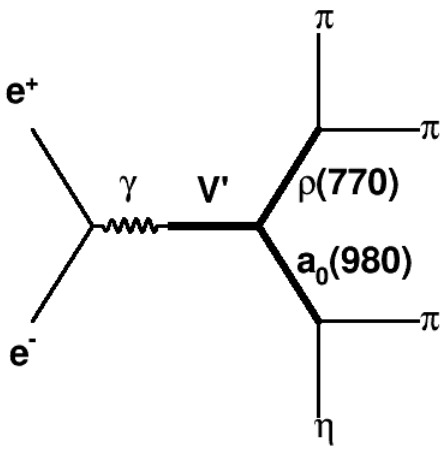








GENERATOR



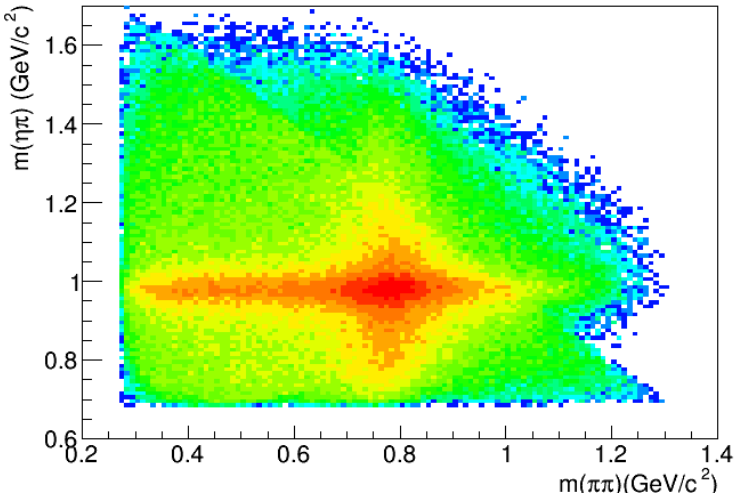
$$J_\mu = \sum \frac{(p_{\pi_1} - p_{\pi_2})_\mu}{((p_{\pi_1} + p_{\pi_2})^2 - M_\rho^2 + iM_\rho\Gamma_\rho)\cdot((p_{\pi_3} + p_\eta)^2 - M_{a_0}^2 + iM_{a_0}\Gamma_{a_0})}$$

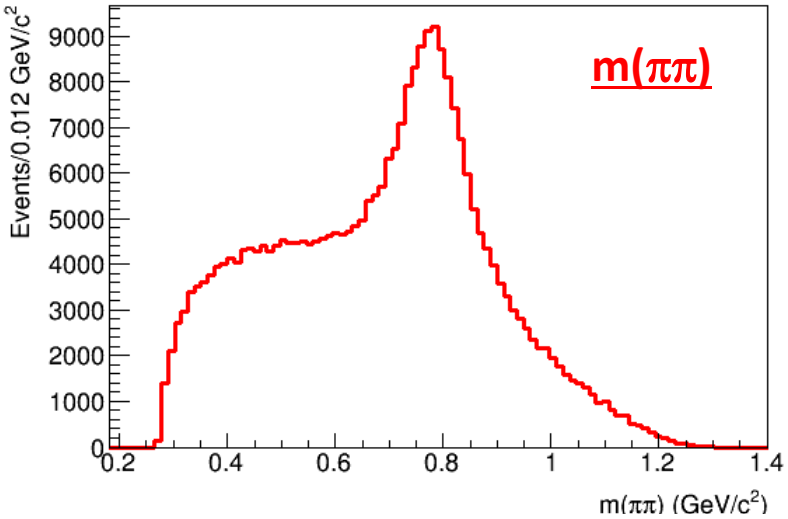
ρ(770) [h] $I^G(J^{PC}) = 1^+(1^{--})$

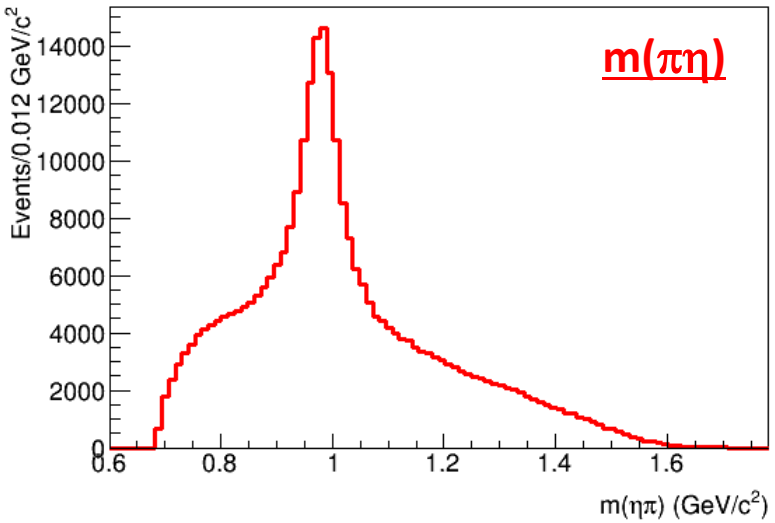
Mass $m = 775.26 \pm 0.25$ MeV
Full width $\Gamma = 149.1 \pm 0.8$ MeV
$\Gamma_{ee} = 7.04 \pm 0.06$ keV

a₀(980) [j] $I^G(J^{PC}) = 1^-(0^{++})$

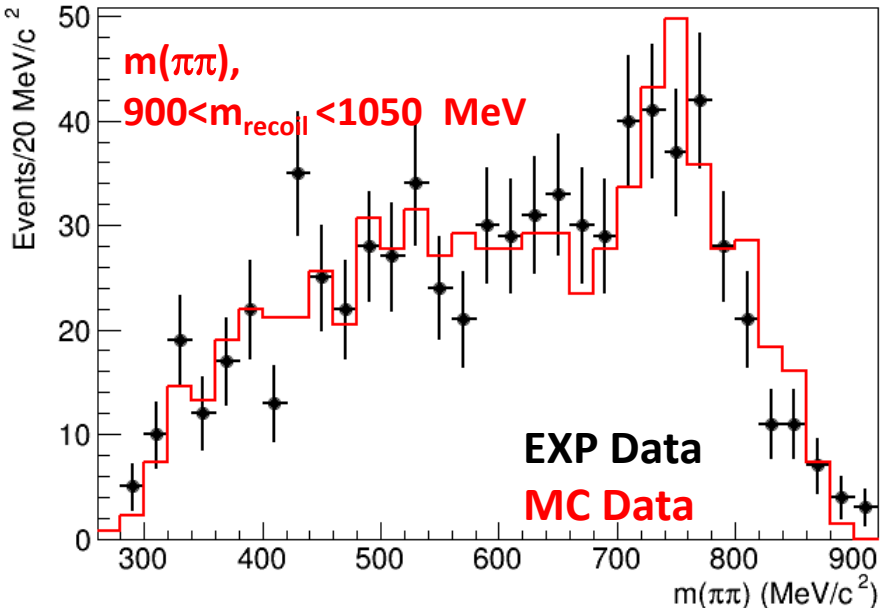
Mass $m = 980 \pm 20$ MeV
Full width $\Gamma = 50$ to 100 MeV

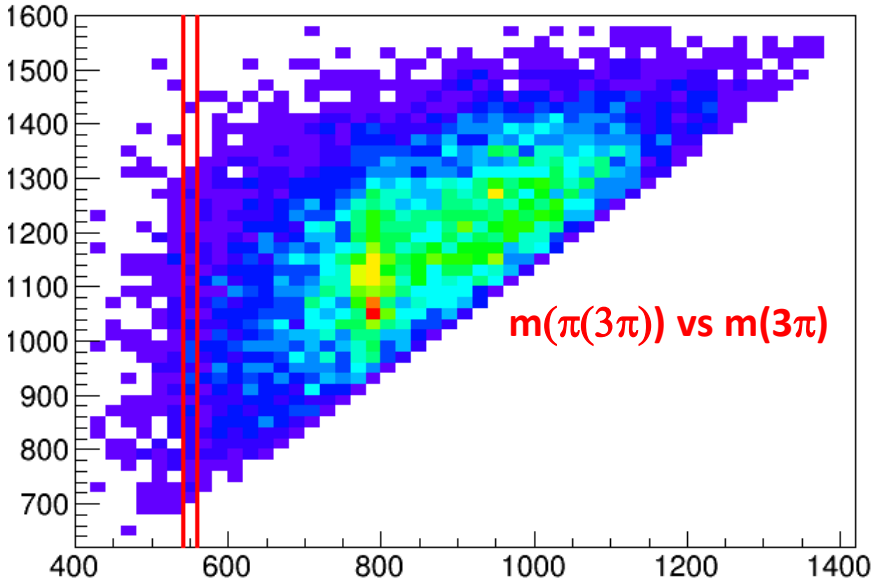


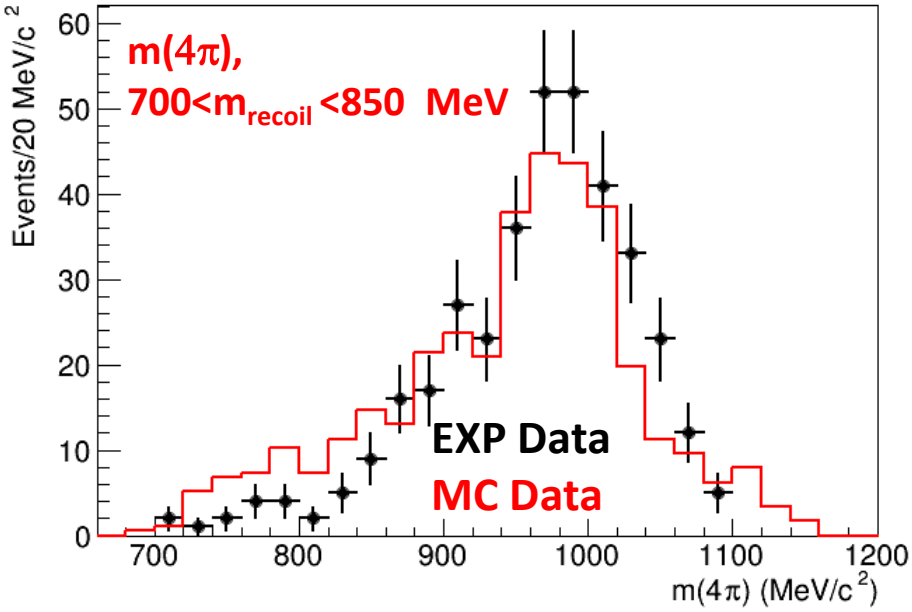


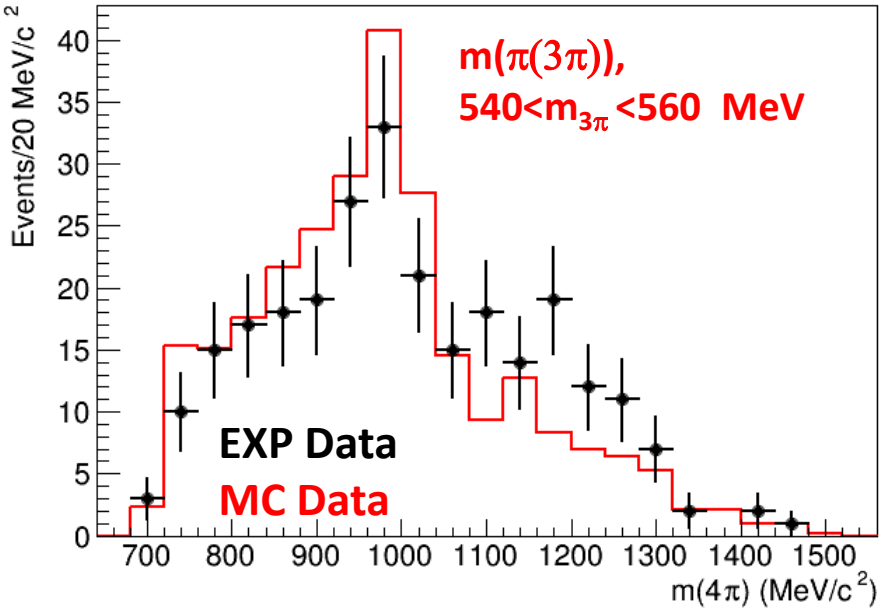


EXPERIMENTAL MASS DISTRIBUTIONS @ E_{cm} = 1872 MeV

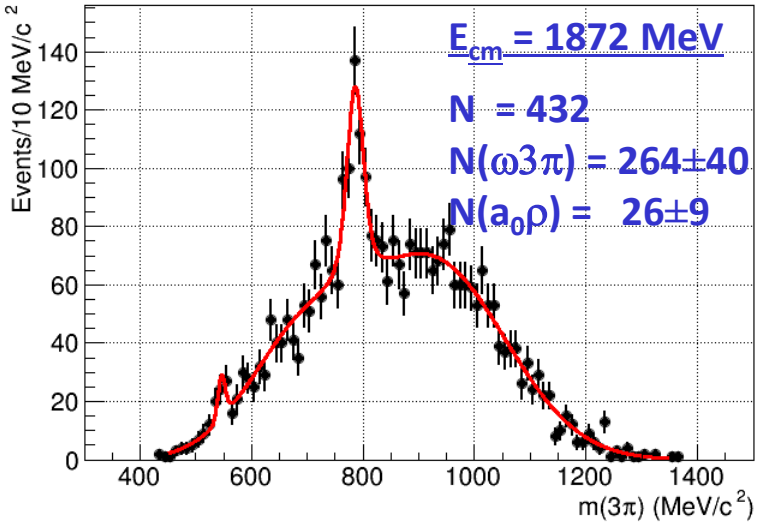








ANGULAR CORRELATIONS FOR $2(\pi^+\pi^-\pi^0)$ AT E_{cm} = 1872 MeV

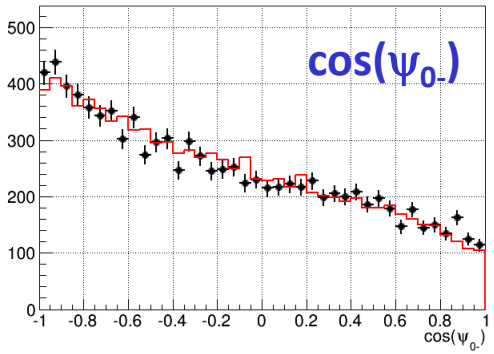


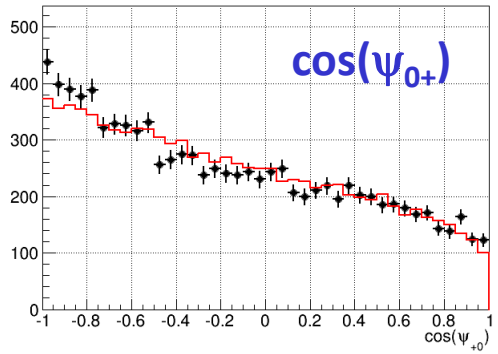
Model:

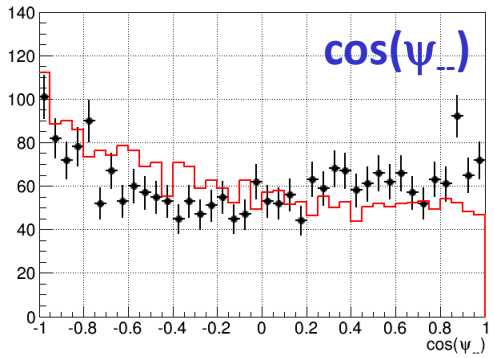
(ω3π) = (61±9)%
(a_0ρ) = (6±2)%
(ρ4π) = (33±9)%

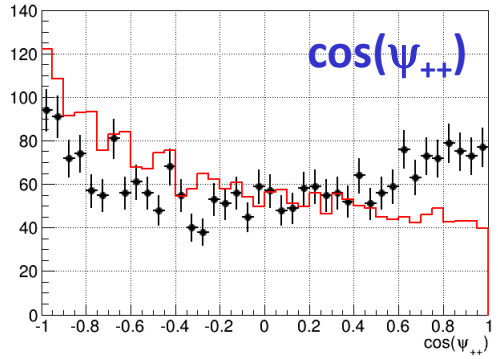
From fit

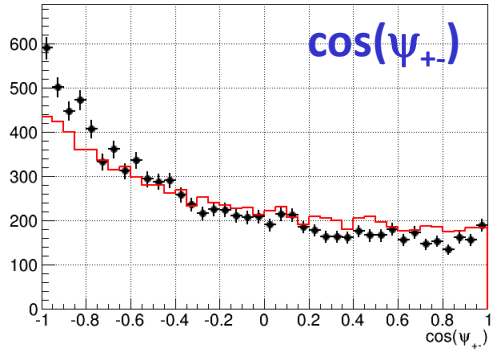
All the rest

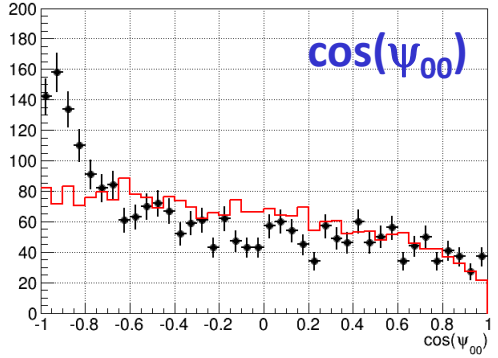




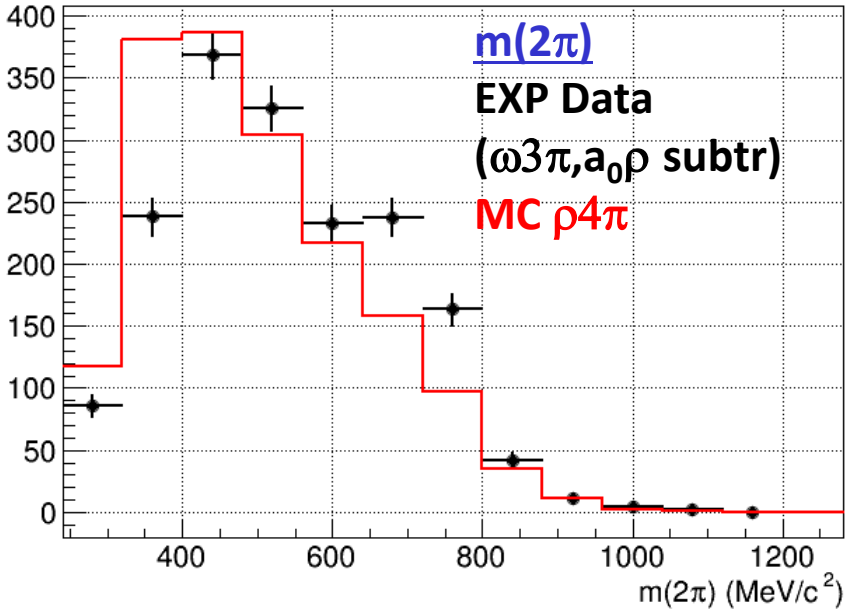


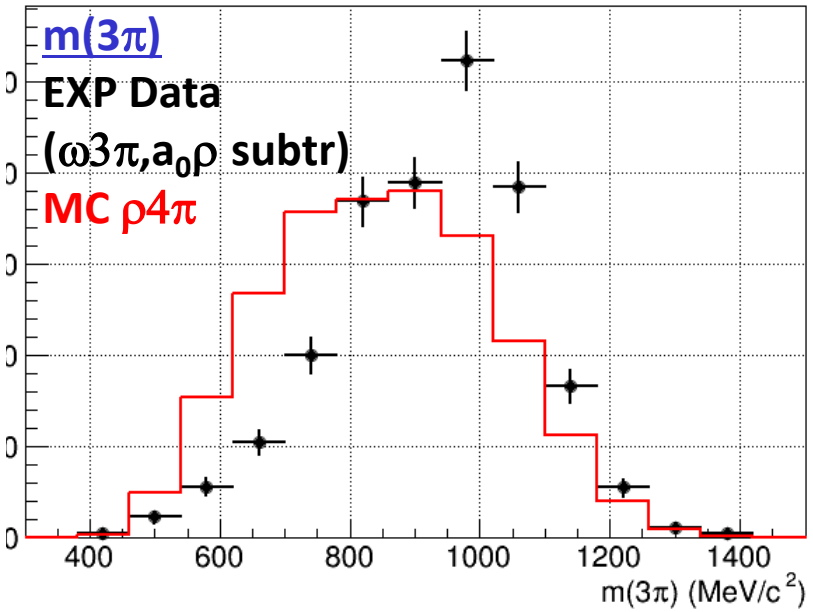


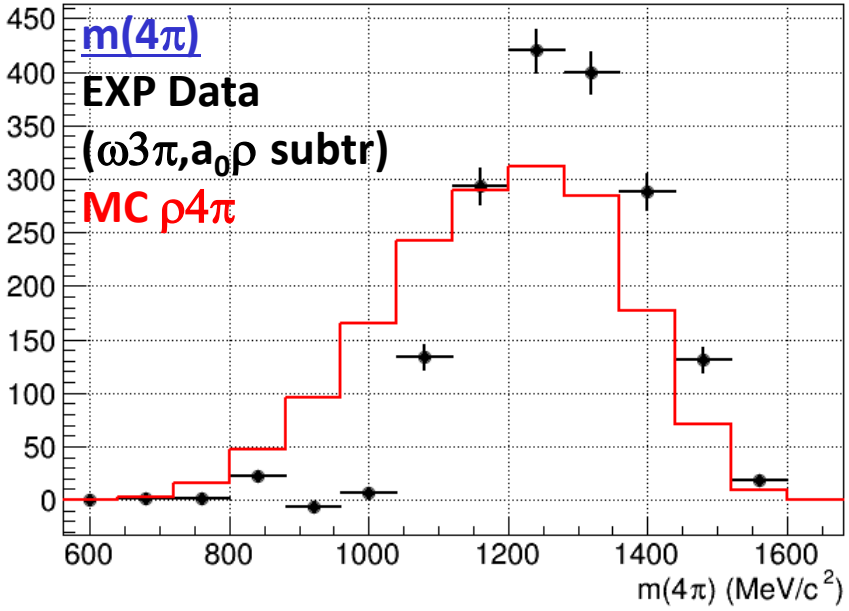




MASS DISTRIBUTIONS FOR $2(\pi^+\pi^-\pi^0)$ AT E_{cm} = 1872 MeV







- More clear ρ signal in EXP data than provided by ρ4π is observed
- Narrow resonance state in m(4π) is seen
- $f_0(1370)$ intermediate prroduction with consequent $f_0(1370)\rightarrow\rho\rho$ decay is a good candidate
- Primary MC generator of the process $e^+e^-\rightarrow f_0(1370)(2\pi)_{\text{P-wave}}$ is needed

CONCLUSION

- Primary Monte-Carlo Generator of the process $e^+e^- \to a_0(980)\rho(770)$ has been created and installed into the CMD-3 Experiment Monte-Carlo simulation package.
- The signal from $e^+e^- \to a_0(980)\rho(770)$ has been observed in the CMD-3 experimental data at E_{cm}= 1872 MeV by studying $2(\pi^+\pi^-\pi^0)$ final state.
- Angular correlations and mass distributions for $2(\pi^+\pi^-\pi^0)$ final state at E_{cm}= 1872 MeV could not be described by contributions of $\omega 3\pi$, $a_0(980)\rho(770)$ and $\rho(770)4\pi$ contributions
- Narrow resonance state decaying into $\pi^+\pi^-\pi^+\pi^-$, $\pi^+\pi^-\pi^0\pi^0$ is needed to describe mass distributions (at least)
- Primary Monte-Carlo Generator of the process $e^+e^- \to f_0(1370)(2\pi)_{P\text{-wave}}$ is the next step of the analysis

Thank You! Stay tuned!

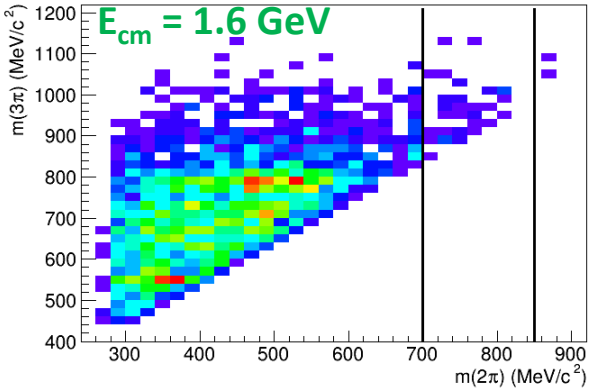
Questions ? Comments ? Discussion …

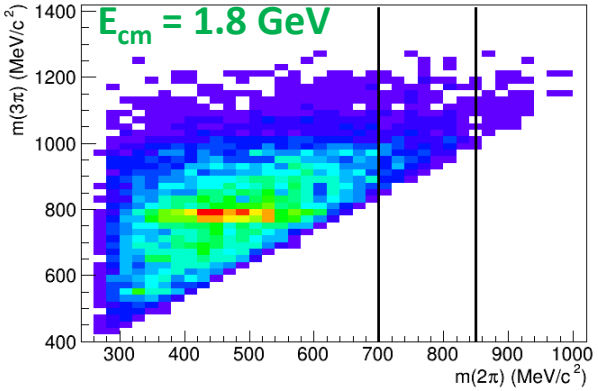
Novosibirsk,
Bugrinsky Bridge – 3rd bridge over Ob river in t

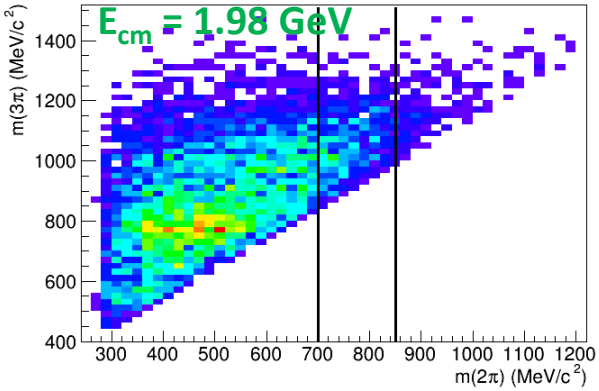
BACKUP SLIDES

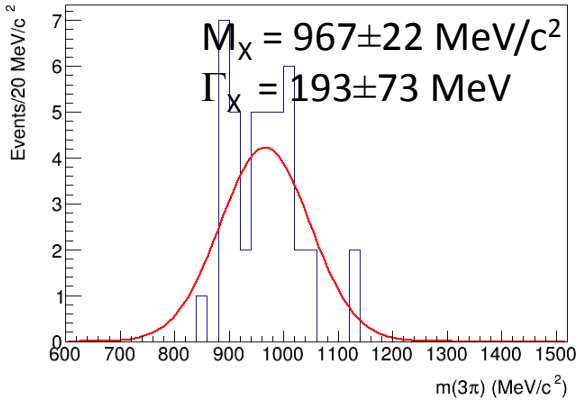
Evidence of $e^+e^- \to h_1(1170)3\pi \to (\rho\pi)\,3\pi$ *?*

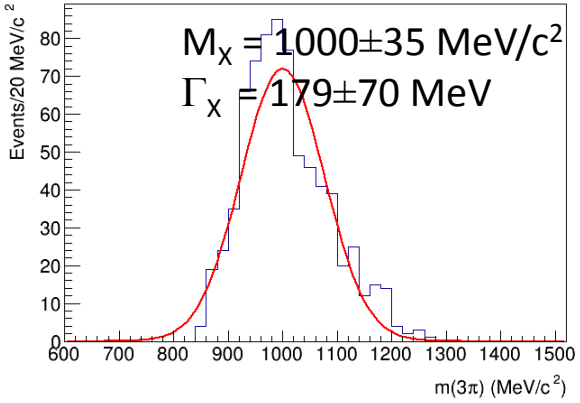
We study m(3π) versus m(2π) to search for possible X → ρ(770)π decay

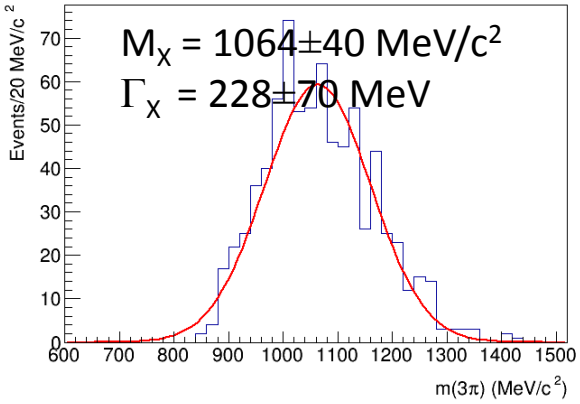












$h_1(1170)$

$I^G(J^{PC}) = 0^-(1^{+-})$

Mass m = 1170 ± 20 MeV
Full width Γ = 360 ± 40 MeV

$h_1(1170)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	308

$h_1(1170)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	CHG	COMMENT
1170±20 OUR ESTIMATE				

$h_1(1170)$ WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	CHG	COMMENT
360±40 OUR ESTIMATE				

$h_1(1170)$ is only candidate for the X-state, listed in PDG. $M_x(E_{cm})$, $\Gamma_X(E_{cm})$ should be studied

DO WE SEE $e^+e^- \to b_1(1235)\rho(770)$?

PDG(2014)

$b_1(1235)$ $I^G(J^{PC}) = 1^+(1^{+-})$

Mass $m = 1229.5 \pm 3.2$ MeV (S = 1.6)
Full width $\Gamma = 142 \pm 9$ MeV (S = 1.2)

$b_1(1235)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\omega\pi$	dominant		348
[D/S amplitude ratio = 0.277 ± 0.027]			

$b_1(1235)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
1229.5± 3.2 OUR AVERAGE		Error includes scale factor of 1.6. See the ideogram below.				
1225 ± 5		WEIDENAUER	93	ASTE		$\overline{p}p \to 2\pi^+2\pi^-\pi^0$
1235 ±15		ALDE	92C	GAM2		38,100 $\pi^- p \to \omega\pi^0 n$
1236 ±16		FUKUI	91	SPEC		8.95 $\pi^- p \to \omega\pi^0 n$
1222 ± 6		ATKINSON	84E	OMEG	±	25–55 $\gamma p \to \omega\pi X$
1237 ± 7		ATKINSON	84E	OMEG	0	25–55 $\gamma p \to \omega\pi X$
1239 ± 5		EVANGELIS...	81	OMEG	–	12 $\pi^- p \to \omega\pi p$
1251 ± 8	450	GESSAROLI	77	HBC	–	11 $\pi^- p \to \pi^-\omega p$
1245 ±11	890	FLATTE	76C	HBC	–	4.2 $K^- p \to \pi^-\omega\Sigma^+$
1222 ± 4	1400	CHALOUPKA	74	HBC	–	3.9 $\pi^- p$
1220 ± 7	600	KARSHON	74B	HBC	+	4.9 $\pi^+ p$

$b_1(1235)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
142± 9 OUR AVERAGE		Error includes scale factor of 1.2.				
113±12		WEIDENAUER	93	ASTE		$\overline{p}p \to 2\pi^+2\pi^-\pi^0$
160±30		ALDE	92C	GAM2		38,100 $\pi^- p \to \omega\pi^0 n$
151±31		FUKUI	91	SPEC		8.95 $\pi^- p \to \omega\pi^0 n$
170±15		EVANGELIS...	81	OMEG	–	12 $\pi^- p \to \omega\pi p$
170±50	225	BALTAY	78B	HBC	+	15 $\pi^+ p \to p4\pi$
155±32	450	GESSAROLI	77	HBC	–	11 $\pi^- p \to \pi^-\omega p$
182±45	890	FLATTE	76C	HBC	–	4.2 $K^- p \to \pi^-\omega\Sigma^+$
135±20	1400	CHALOUPKA	74	HBC	–	3.9 $\pi^- p$
156±22	600	KARSHON	74B	HBC	+	4.9 $\pi^+ p$