Performance of HypTPC for E104

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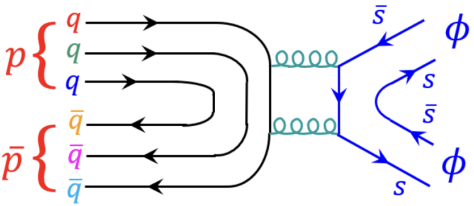
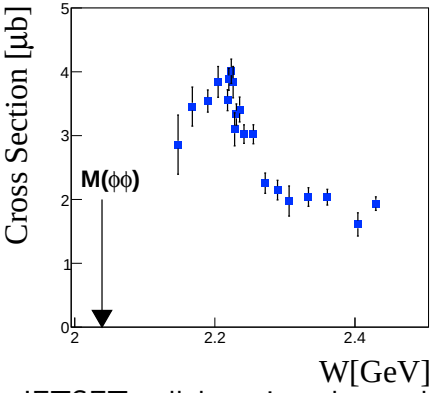
Korea-China Joint Workshop, Jeju ,

$\bar{p}p \rightarrow \phi\phi$ Reaction



- $\bar{p}p \rightarrow \phi\phi$ may occure through two gluon emission.
- According to OZI rule, purely gluonic process should be strongly suppressed.



- JETSET collaboration observed unexpectedly large cross-section for the reaction.[1]

[1] JETSET, Phys. Rev. D 57, 5370 (1998).

Possible Reaction Mechanisms for $\bar{p}p \to \phi\phi$

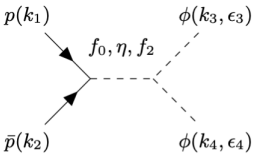
- Resonant gluonic state, i.e. glueball
- Four quark state involving $\bar{s}s$
- Two-step process involving meson pairs, i.e. $\bar{p}p \to \omega\omega$ [1]

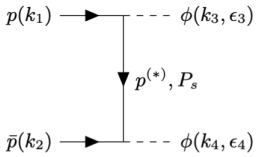
$$\sigma(\bar{p}p \to \phi\phi) = \tan^4 \delta\sigma(\bar{p}p \to \omega\omega) \simeq 10\,\mathrm{nb}$$

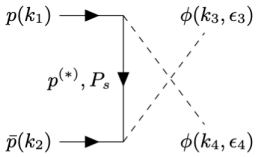
- $\bar{s}s$ content in $\bar{p}p$ wave-function ($\simeq 250\,\mathrm{nb}$)
- Hadron production and rescattering in OZI-allowed transition
- Baryon exchange in t and u channel diagrams.

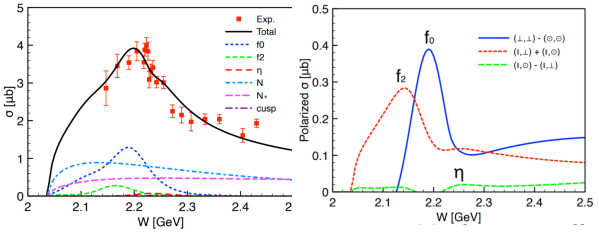
[1] J. Ellis et al., Phys. Lett. B 353, 319 (1995).

Hadronic Channels for $\bar{p}p \to \phi\phi$





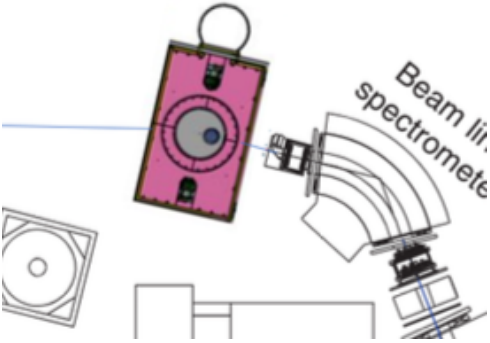


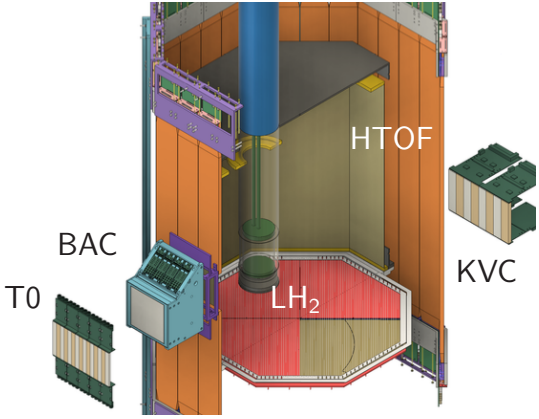


- A new theoretical calculations suggests that polarization observable could reveal the contributions of the individual processes.[1]

[1] D.Y. Lee et al., Phys. Lett. B 866, 139528 (2025).

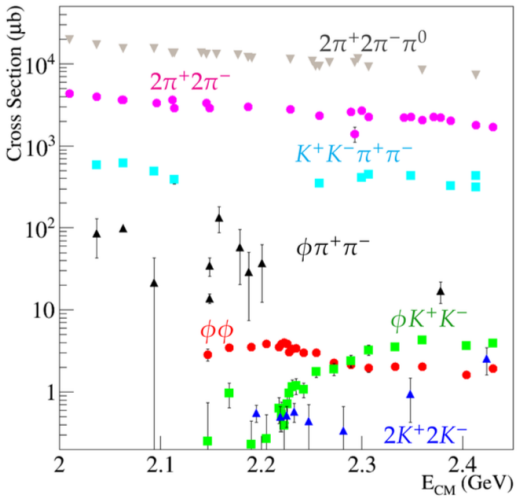
J-PARC E104





- 2×10^5/*spill* $\bar{p}$ beams are available up to 1.2 GeV/c at K1.8 BR

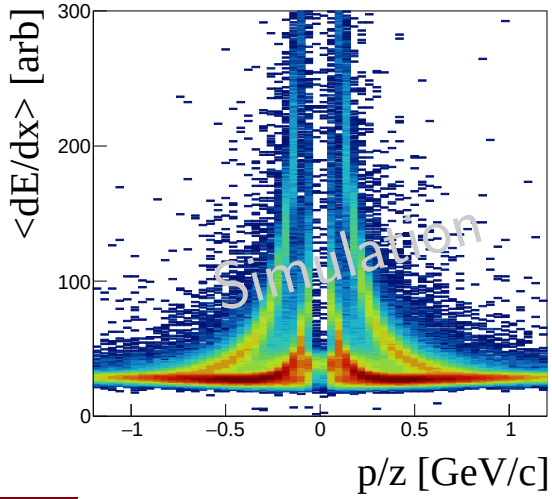
Background Reactions

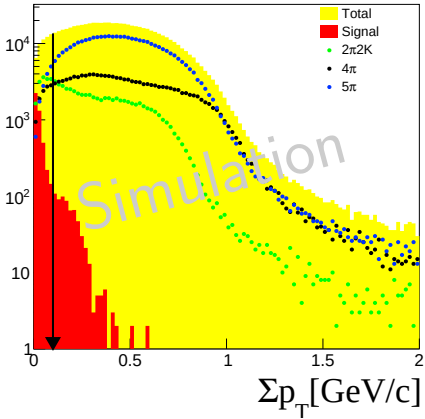


Reactions	$p^{lab}_{thre}[\mathrm{GeV}/c]$
$2\pi^+2\pi^-\pi^0$	0
$2\pi^+2\pi^-$	0
$K^+K^-\pi^+\pi^-$	0
$\phi\pi^+\pi^-$	0
$2K^+2K^-$	0.662
ϕK^+K^-	0.767
$\phi\phi$	0.866
$\bar{p}p\pi^+\pi^0$	1.219

- HIgh background exist in four charged-track emission

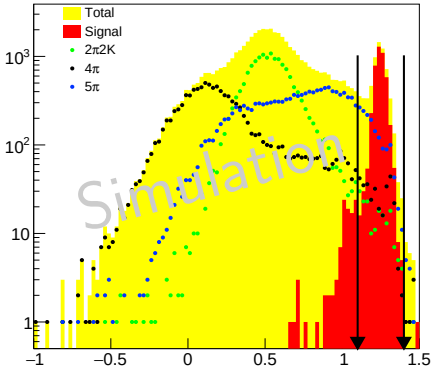
Particle ID and Momentum Balance



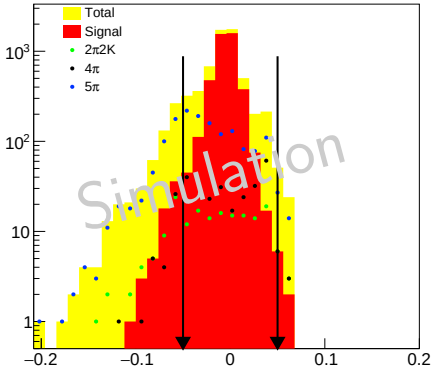


- Transverse momentum cut rejects π^0 events and events with large tracking error.

Energy Balance for $\phi\phi$ Separation

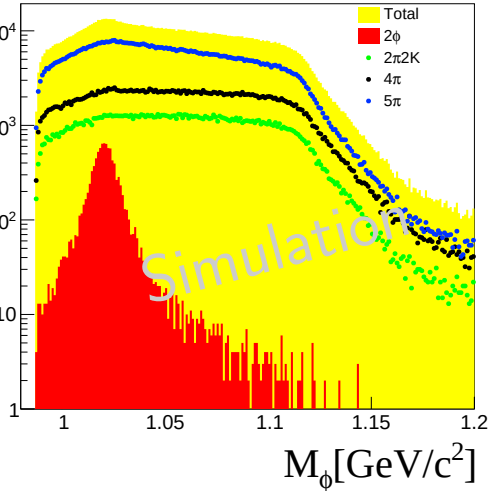


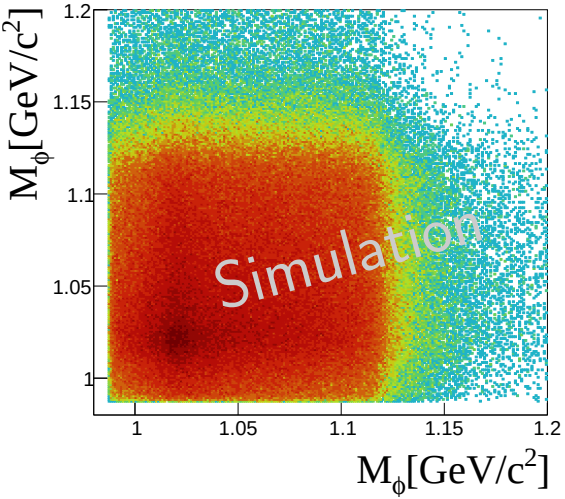
- Energy balance cut with π mass assumption.



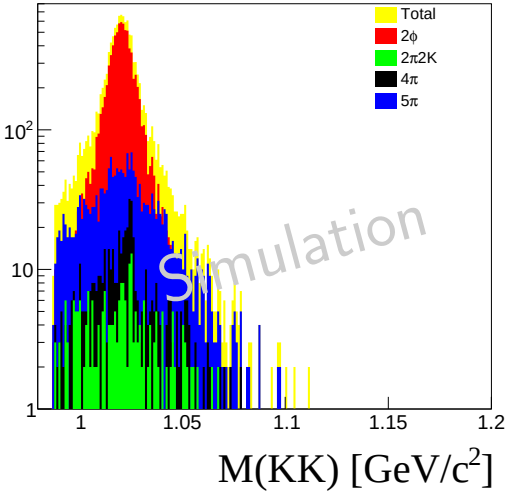
- Energy balance cut with K mass assumption.

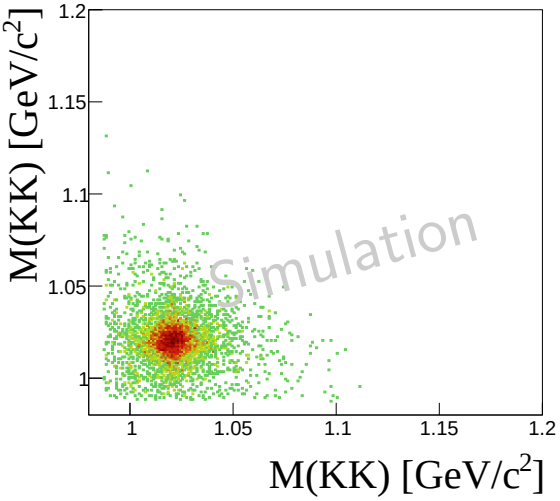
Raw $\phi\phi$ Spectrum



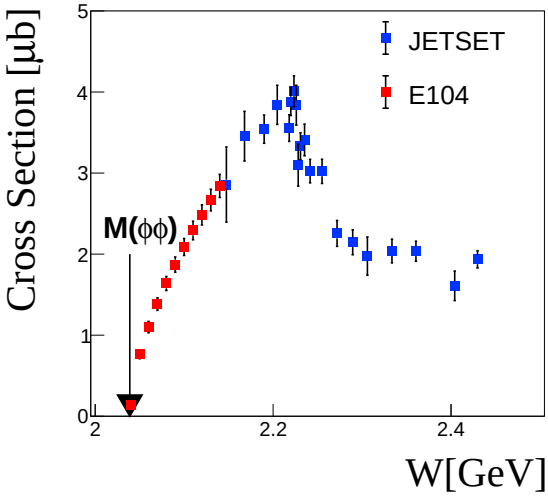


Selected $\phi\phi$ Spectrum





Expected Yield



W (BeamMom)	Expected Yield
2.04 GeV(0.87 GeV/c)	100 events
2.05 GeV(0.90 GeV/c)	200 events
2.06 GeV(0.93 GeV/c)	250 events
2.07 GeV(0.97 GeV/c)	300 events
2.08 GeV(1.00 GeV/c)	350 events
2.09 GeV(1.02 GeV/c)	400 events
2.10 GeV(1.06 GeV/c)	400 events
2.11 GeV(1.08 GeV/c)	400 events
2.12 GeV(1.11 GeV/c)	400 events
2.13 GeV(1.14 GeV/c)	400 events
2.14 GeV(1.17 GeV/c)	400 events

- For polarization measurement, some energy bins could be merged if statistics are necessary.

Summary

- The cross section near threshold for the $\bar{p}p \rightarrow \phi\phi$ reaction was observed to exhibit an unusually large violation of the OZI rule.
- The J-PARC E104 experiment will be conducted this year, aiming to measure both the total and polarized cross sections from threshold to 1.17 GeV/c—a kinematic range that has never before been explored.