

Light Meson Spectroscopy at Phase-One

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Charmonium

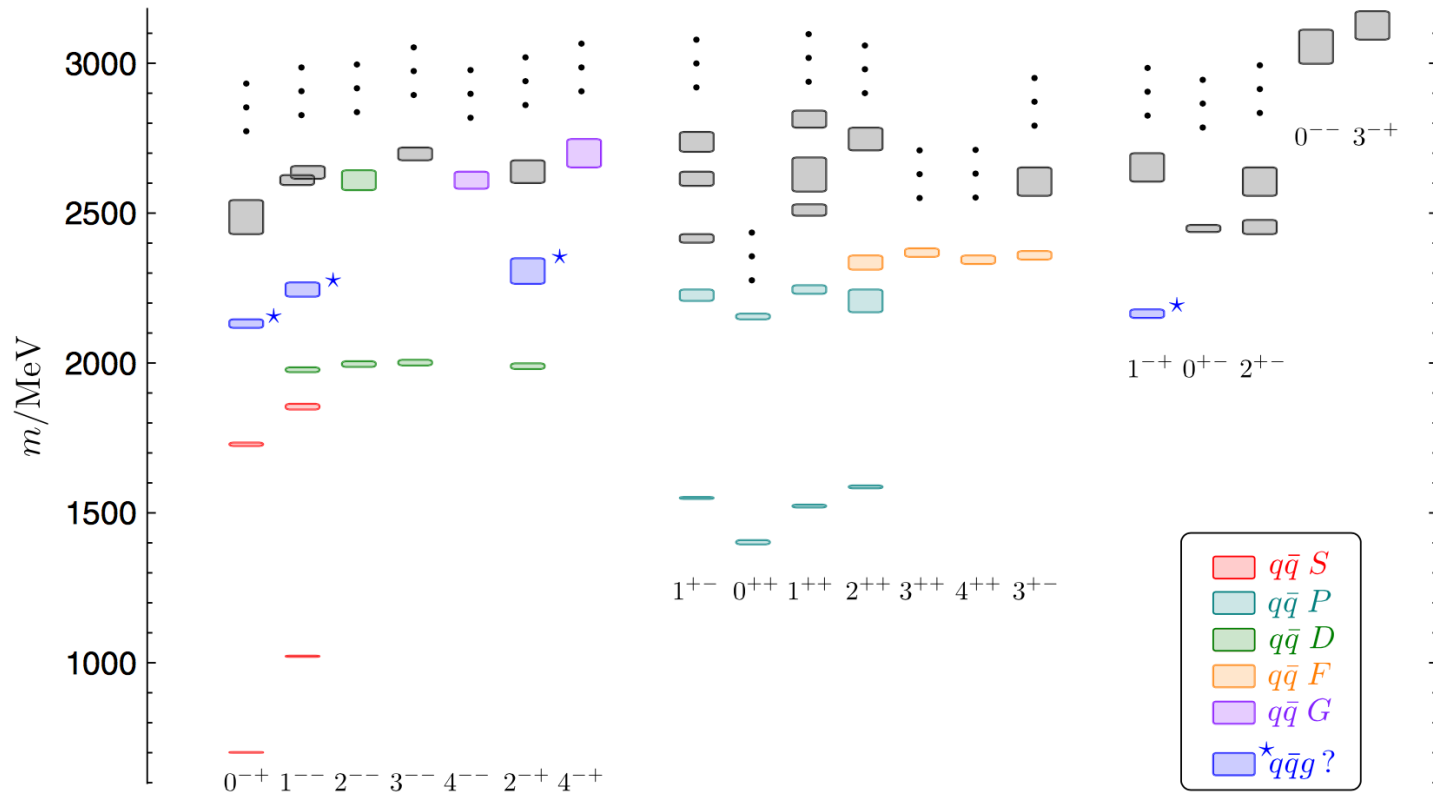
- Elisa Fioravanti stepped down as convenor of the Charmonium PWG
 - interim solution: Frank Nerling and Marc Pelizaeus
- Important topics for phase-one physics
- Update on studies covered in the Physics Performance Report
 - h_c width measurement (someone need to take over work started by Dima Melnychuk)
 - χ_{cJ} angular distributions
- New topic utilizing full simulation
 - h_c in hadrons, i.e. 3, 5, and 7 pions
 - high spin states, e.g. narrow 3D_2 state

Light Meson Spectrum

Color-less $q\bar{q}$ states ($q = u, d, s$)
 Multiplets of $q\bar{q}$ mesons with same J^{PC}

Additional color-less states:

- Glueballs: gg, ggg 
- Hybrids: $q\bar{q}g$ 
- Tetraquarks: $(q\bar{q})(q\bar{q})$ 



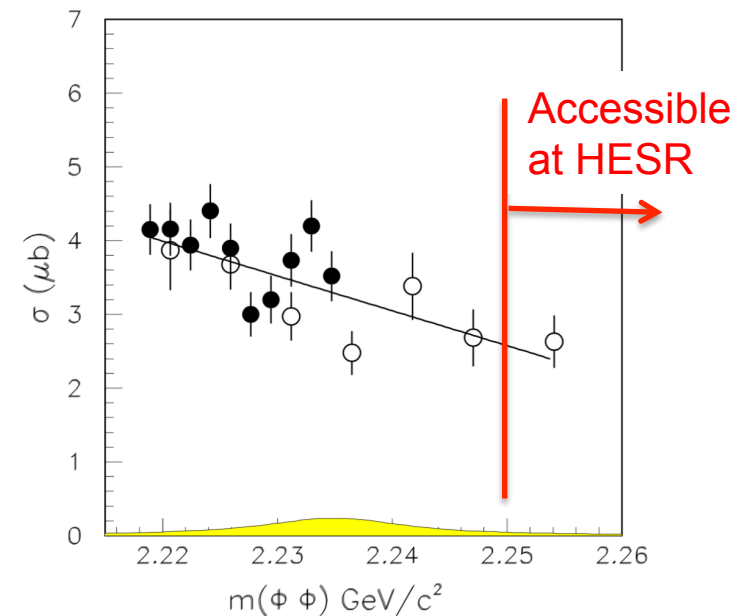
Light Mesons in $\bar{p}p$ Annihilation at PANDA

- Antiproton-proton annihilation
 - huge cross sections for light meson production: 100 nb ... 10 μ b
 - gluon rich processes \rightarrow production of glueballs and hybrids
- Access in formation to
 - neutral resonances with $m > 2.25 \text{ GeV}/c^2$ and
 - non-exotic quantum numbers
- Access in production to all resonances with
 - at least one recoil meson and
 - variable center-of-mass energy (\rightarrow tunable phasespace)
- Many broad and overlapping states
 - requires (often) partial wave analysis techniques to identify resonances

Search for glueballs in $\Phi\Phi$

- $\bar{p}p \rightarrow \Phi\Phi$ studied in Physics Performance Report [K. Goetzen]
- Study of narrow $f_J(2230)$ previously reported by MARK III and BES II
 - outdated, since this state is excluded by Babar and BES III with superior statistics
 - not accessible in formation at HESR
- Potential: Scan above 2.25 GeV
 - Jetset (1998): cross section >100x larger than expected from OZI rule \rightarrow gluonic component?
 - broad $f_2(2300)$ and $f_2(2330)$ glueball candidates observed in πN
- Need an update on this topic

$\bar{p}p \rightarrow \Phi\Phi$ Cross Section



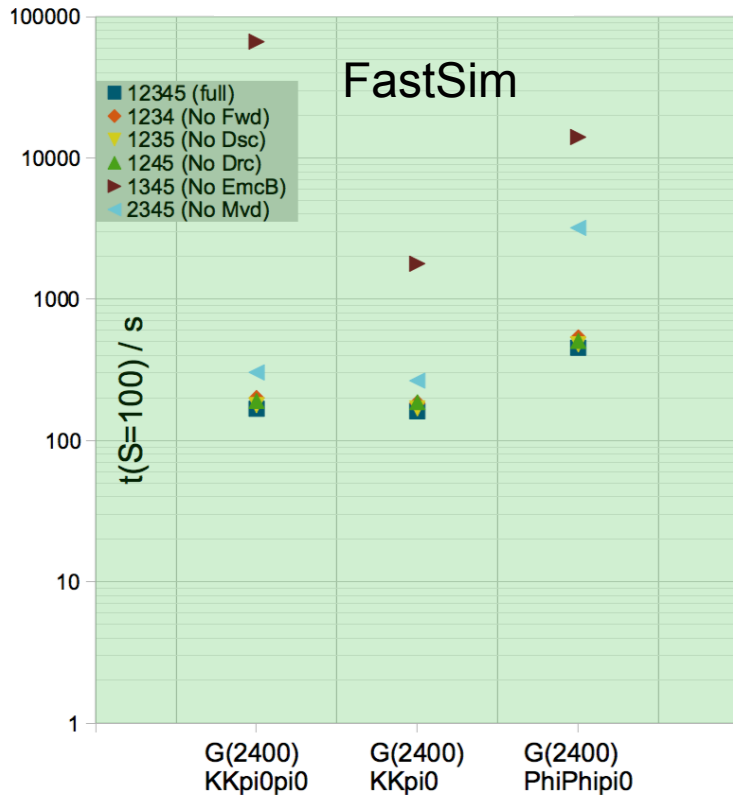
Jetset, Phys. Rev. D 57, 5370 (1998)

Glueball Studies

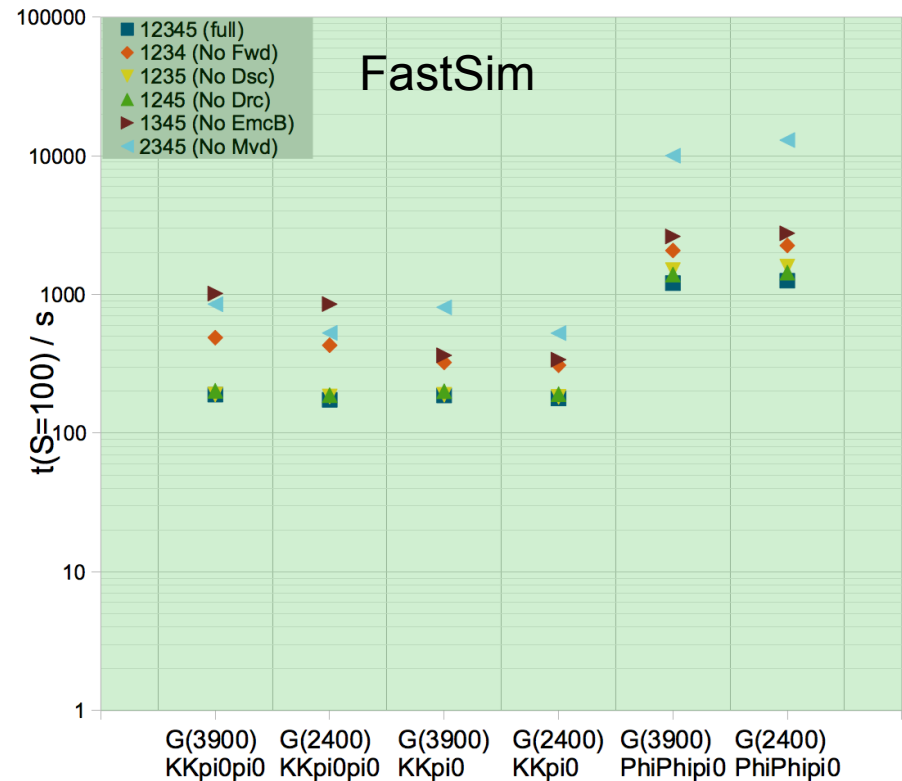
- Studies performed for the scrutiny report
 - focus on feasibility and performance for 6 different detector options
 - carried out in fast simulation
- Study of glueball production in $\bar{p}p \rightarrow K^+K^-\pi^0$, $K^+K^-\pi^0\pi^0$ and $\Phi\Phi\pi^0$
 - assuming cross section of 10 nb (including decays to final state)
 - background cross sections 50 to 80 mb
- “Light” glueball $m = 2400 \text{ MeV}/c^2$ (could be 2^{++} or 0^{-+})
 - $E_{\text{CMS}} = 2.57 \text{ GeV}$ and 5.47 GeV
 - could be broad, study final states w/o intermediate resonances
- “Heavy” glueball $m = 3900 \text{ MeV}/c^2$
 - $E_{\text{CMS}} = 5.47 \text{ GeV}$
 - could be narrow, assume $\Gamma = 10 \text{ MeV}$
 - search for narrow signal in production

Glueball Studies

Light glueball
at $E_{\text{CMS}} = 2.57 \text{ GeV}$



Light / heavy glueball
 $E_{\text{CMS}} = 5.47 \text{ GeV}$



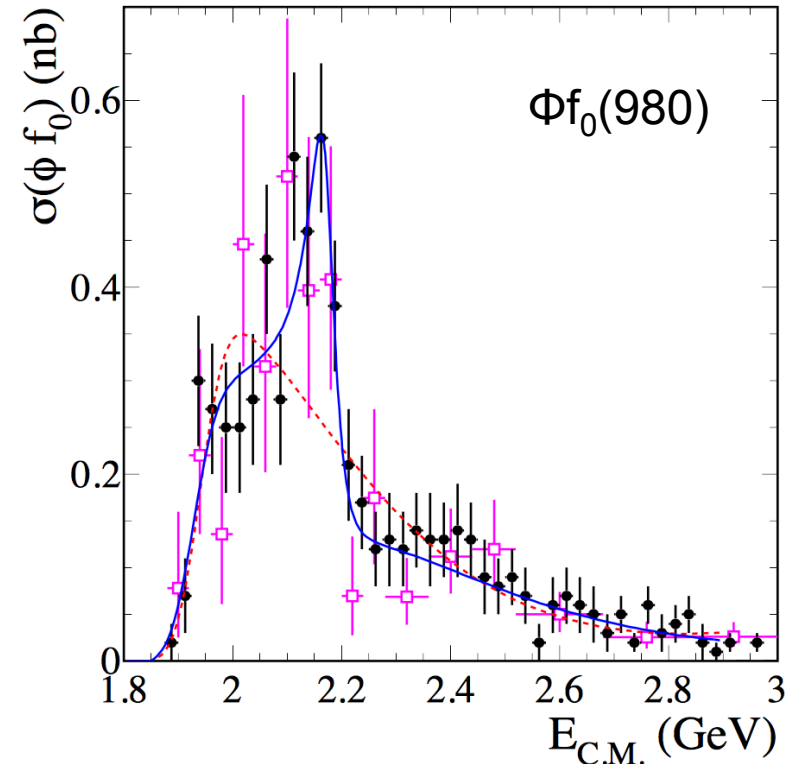
[Malte Albrecht]

Phase-one luminosity: 800 ... 8000 / d reconstructed
signal events depending on channel

Y(2175)

- $Y(2175) \rightarrow \Phi f_0(980)$ observed in ISR events $e^+e^- \rightarrow Y_{\text{ISR}} K^+ K^- \pi^+ \pi^-$
 - $m \sim 2175 \text{ MeV}/c^2$; $\Gamma \sim 60 \text{ MeV}$
- Confirmed in $J/\psi \rightarrow Y(2175)\eta$ [BES II and BES III]
- Similar: $Y(4260) \rightarrow J/\psi f_0(980)$ also observed in ISR events
- Is $Y(2175)$ a light analogue to the $Y(4260)$?

BaBar, Phys.Rev.D74, 091103 (2006)



Are there analogies of the X, Y, Z states in the light (strange) meson sector?

Y(2175) Studies

- $\bar{p}p \rightarrow Y(2175)\pi\pi, Y(2175)\pi^0$ at $E_{\text{CMS}} = 3 \text{ GeV}$
 - Y(2175) reconstructed in $\Phi\pi^+\pi^-$ and $\Phi\pi^0\pi^0$
 - assumed signal cross section: 100 nb
 - background cross section: 70 mb

Beam-time to record 1000 reconstructed events in the $\Phi\pi^+\pi^-\pi^0$ final state

	$f_{BR} = 5 \%$	$f_{BR} = 10 \%$	$f_{BR} = 30 \%$
$L = 2 \cdot 10^{30}$	99.5 d	24.9 d	2.8 d
$L = 2 \cdot 10^{31}$	9.95 d	2.49 d	0.28 h
$L = 2 \cdot 10^{32}$	0.995 d	0.249 d	0.028 h

[Ch. Motzko]

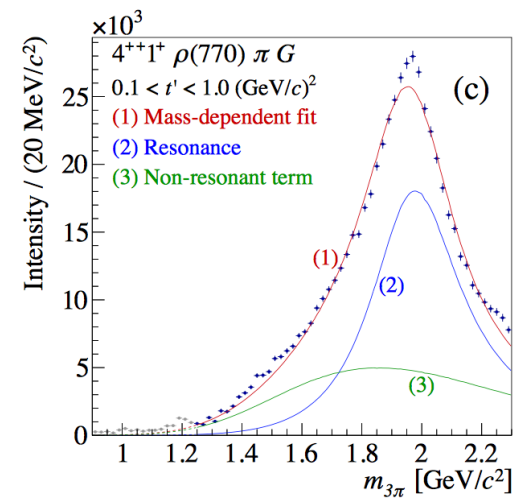
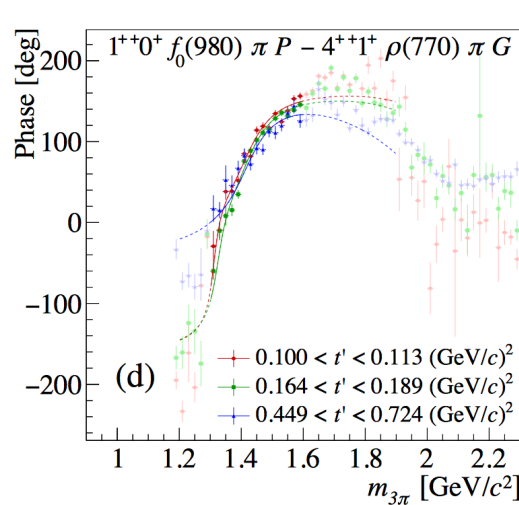
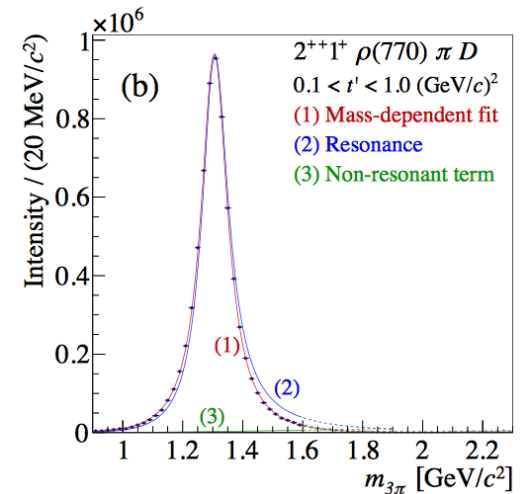
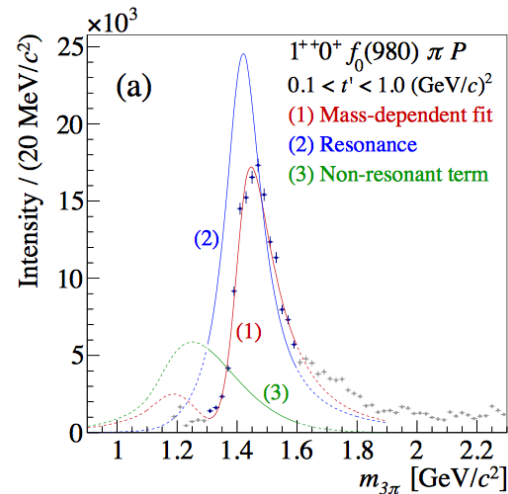
FastSim,
full detector setup

Phase-one luminosity: 200 / d reconstructed signal events

Recent Observation of $a_1(1420)$ at Compass

- Compass: Observation of a new axial-vector meson in diffractive 3π dissociation ($m \sim 1414$ MeV and $\Gamma \sim 153$ MeV)
 - 46×10^6 events analyzed
 - 88 waves fitted
- Iso-spin partner of $f_1(1420)$?
- $a_1(1420)$ and $f_1(1420)$ could be $K\bar{K}\pi$ molecules
- $f_1(1420)$ observed in $\bar{p}p \rightarrow K^0 K^- \pi^+ \pi^+ \pi^-$

Phase-one: 800 M / d
produced 4π events



Compass, Phys. Rev. Lett. 115, 082001 (2015)

Plans

- Full simulation studies

- $Y(2175) \rightarrow \Phi\pi\pi$ in $\bar{p}p \rightarrow Y(2175)\pi\pi, Y(2175)\pi^0$
- energy scan $\bar{p}p \rightarrow \Phi\Phi$
- light glueball $G \rightarrow \Phi\Phi, K\bar{K}, K\bar{K}\pi$ in $\bar{p}p \rightarrow G\pi^0, G\eta, G\pi\pi$
- $a_1(1420) \rightarrow 3\pi$ in $\bar{p}p \rightarrow 4\pi, 5\pi$



<https://panda-wiki.gsi.de/foswiki/bin/view/PhysicsCmt/PhysicsAnalysisActivities>

- Include realistic backgrounds
- Address feasibility of partial wave analyses

Summary

- Light meson spectroscopy at PANDA
 - large production cross sections
 - gluon-rich processes (glueballs, hybrids)
- Feasibility studies
 - full simulation with realistic background estimations
 - addressing partial wave analyses
 - prioritized list of channels
- Analysts are highly welcome to contribute !