

Status of $\bar{p}p \rightarrow$ Glueball + Recoil Analysis with FSIM

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General Considerations

- Search for (heavy) glueballs in mass range 3 – 5 GeV/c²
- Explore mass range in production, followed by detailed investigation in formation
- Assume glueball production cross section of 10 nb (guided by $f_0(1500)$ results from CB@LEAR)
- Glueball width could be small (assume 10 MeV)
- Main background channels:
 - $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-\eta$
 - $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-\pi^0$
 - $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-\pi^0\pi^0$
 - $\bar{p}p \rightarrow K^+K^-K^+K^-\pi^0$ (non-resonant)
 - $\bar{p}p \rightarrow \pi^+\bar{p}\pi^-\rho\pi^0$ (seen in DPM events)

Assumptions and Scenario for FSIM Studies

- Concentrating on decay channel:
 $\bar{p}p \rightarrow G\pi^0 \rightarrow \phi\phi\pi^0 \rightarrow K^+K^-K^+K^-\pi^0$
- $M_G = 3900 \text{ MeV}/c^2$, $\Gamma = 10 \text{ MeV}$
- Studies at $p_{\bar{p}} = 15 \text{ GeV}/c$ and $p_{\bar{p}} = 7.7 \text{ GeV}/c$ (threshold)
- Using scrut14 release, revision **#24893**

- Nominal **average** Luminosity: $\mathcal{L} = 1 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$

$\Rightarrow \approx 8 \text{ pb}^{-1}/\text{day}$

- At $p_{\bar{p}} = 15 \text{ GeV}/c$ the total $p\bar{p}$ cross-section is about **50 mb**

$\Rightarrow \mathcal{L} \cdot \sigma_{p\bar{p},\text{tot}} = 5 \cdot 10^6$ interactions per second

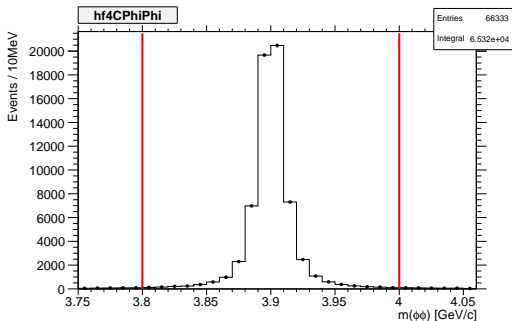
- Figure of Merit: Time to measure
 - 100 signal events (discovery)
 - 1000 signal events (spin-parity analysis / PWA)

with $S/N > 1$ ($\Rightarrow 7\sigma$ significance for $S = 100$)

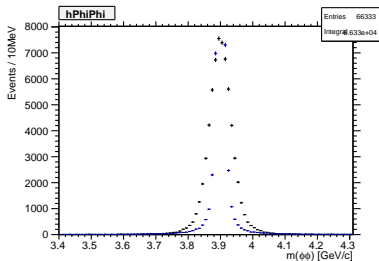
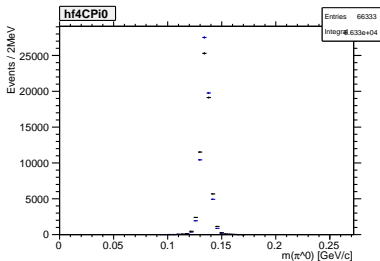
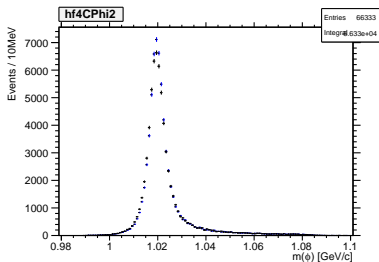
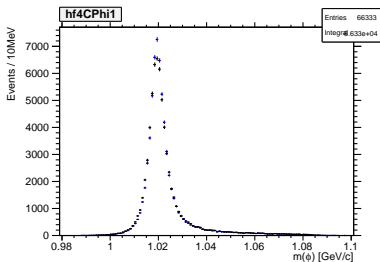
Cuts

- Generated signal events w/ Glueball resonance for 5 different detector setups and both beam momenta
- 200.000 PHSP events each
- π^0 mass window: $0.1 \text{ GeV}/c^2 < m(\pi^0) < 0.17 \text{ GeV}/c^2$
 - $\phi\phi$ -window:
$$r = \sqrt{(m(\phi_1) - m(\phi_{\text{PDG}}))^2 + (m(\phi_2) - m(\phi_{\text{PDG}}))^2} < 0.25$$
 - Cut on 4C-Fit probability: $\text{Prob}(\chi^2, 4) > 0.05$
 - PID: `PidChargedProbability:KaonLoosePlus/Minus`

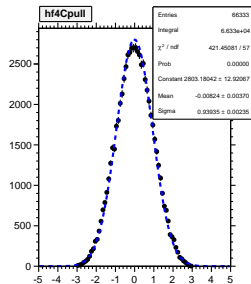
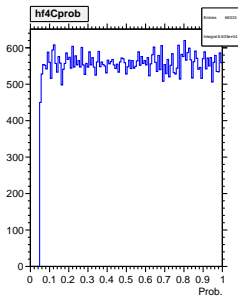
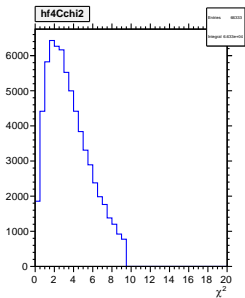
- Only considering background events within $3.8 \text{ GeV}/c^2 < m(\phi\phi) < 4.0 \text{ GeV}/c^2$ (see plot below)
- Background channel: $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-\eta$ ($\sigma_S \approx 1 \text{ mb}$)
- Generated $4 \cdot 10^8$ events: **NO** event survives kinematic fit
- Studied DPM events to identify other background channels
- Generated $1.5 \cdot 10^9$ DPM events for full detector setup: Using Loose PID, only **9** $K^+K^-K^+K^-\pi^0$ events survive
- Huge amounts of DPM background needed



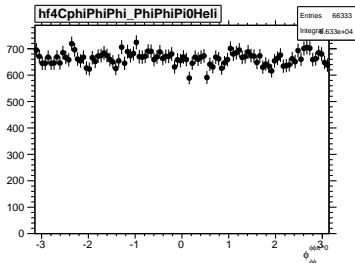
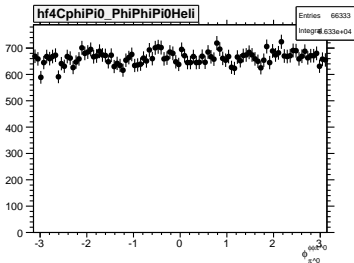
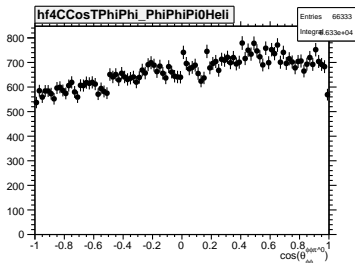
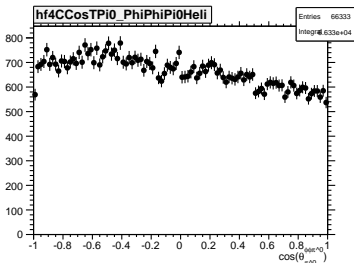
Mass spectra ($p_{\bar{p}} = 15 \text{ GeV}/c$, blue: 4C-Fit, black: unfitted)



4C-Fit Quality



Production angles of G and π^0



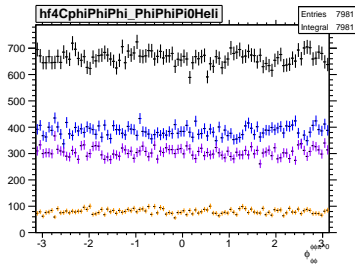
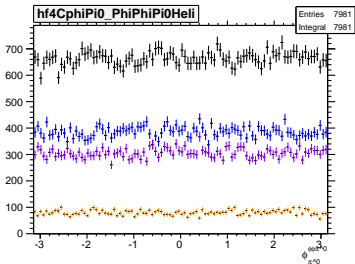
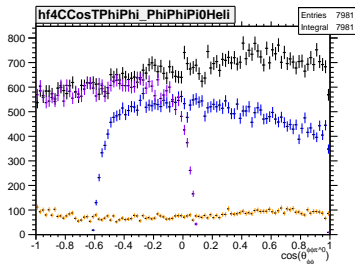
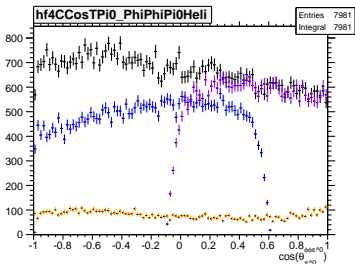
$M = 3900 \text{ MeV}/c^2$, $\Gamma = 10 \text{ MeV}$ Glueball at $p_{\bar{p}} = 15 \text{ GeV}/c$

Detector Setup	ϵ_S [%]	ϵ_B	$\frac{S}{N}$	t(S=100) nominal \mathcal{L}	t(S = 100) $\mathcal{L}/10$	t(S = 100) $\mathcal{L}/100$
12345	33.2	$6 \cdot 10^{-9}$	2.78	20 min	3.3 hr	1.4 d
2345	4.0			170 min	28 hr	12 d
1 345	15.3	$(1 \cdot 10^{-8})$	(0.76)	44 min	7.3 hr	3 d
12 45	28.7			23 min	3.9 hr	1.6 d
123 5	26.7	$(1 \cdot 10^{-8})$	(1.33)	25 min	4.2 hr	1.7 d
1234	19.3			35 min	5.8 hr	2.4 d

Detector setups: 1=MvdGem, 2=EmcBarrel, 3=Drc, 4=Dsc, 5=FwdSpec

Numbers in brackets statistically not significant (scaled up from only 2 surviving events...)

Production angles of G and π^0 - Different Detector Setups



Full detector; No ForwardSpectr.; No EMC Barrel; No MVD/GEM

Todo and conclusion

- Studies at lower beam momentum in progress
- Background studies for different detector setup needed
- Identification of minimal setup (?)
- PID needed
- For final report: study of at least one more decay channel ($G \rightarrow \eta'\eta'$) feasible?