FastSim Studies for Glueball Searches

Summary of the activities in Bochum

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XLIX. PANDA Collaboration Meeting, GSI
11.06.2014

RUHR UNIVERSITÄT BOCHUM

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Outline

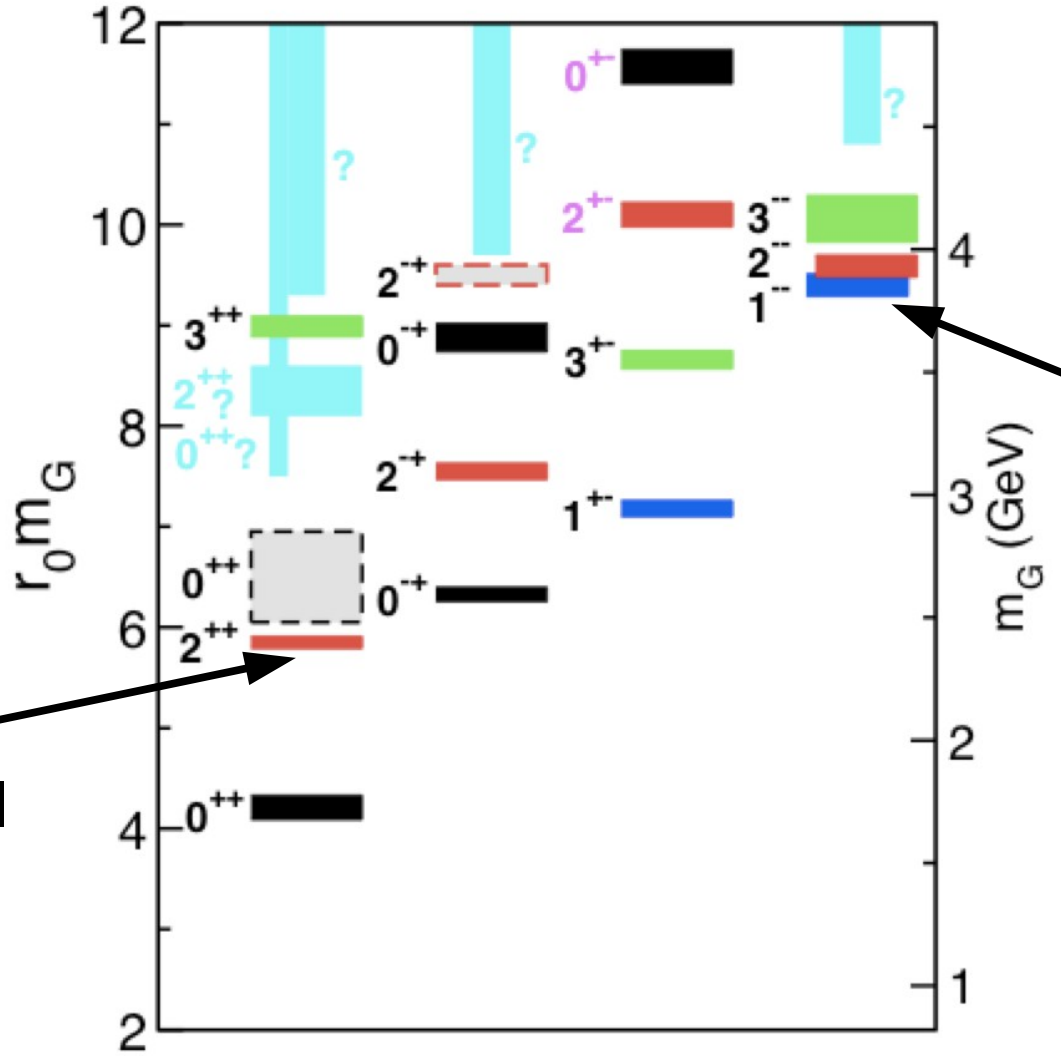
- Analysis overview:
  - Selection criteria
  - Data samples and cross sections
  - Background studies
- Mass spectra and angular distributions
- Results:
  - Selection efficiency
  - Measurement time
  - Signal to background ratio

General Considerations

- Feasibility study for the search for Glueballs with FastSim framework (study of a light, broad and a heavy narrow GB)
- Using PandaRoot *scrut14* release (Rev. #24893)
- Idea for the measurement: Explore mass range in production, followed by detailed investigation in formation
- Assumptions: Nominal *average* Luminosity is $1 \cdot 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

  -> $\approx 8\mathrm{pb}^{-1}$/ day
- Figure of Merit:
  - 100 reconstructed signal events (discovery)
  - 1000 reconstructed signal events (spin-parity analysis)
  - S/B > 1 (= significance of >7σ for S=100)
  - Homogeneity of Dalitzplot and angular distributions

Glueball masses: The LQCD glueball spectrum



Light glueball

Heavy Glueball

Analysis Overview

G(2400)

$$J^{PC} = 2^{++}$$

- Light glueball, large width

  -> glueball resonance not simulated, studied PHSP distributed events

- Studied at p=15 GeV/c and p=2.4 GeV/c (prod. threshold)

G(3900)

$$J^{PC} = 1^{--}$$

- Heavy glueball, small width

  -> $\Gamma = 10\,\mathrm{MeV}$

- Studied at p=15 GeV/c

Decay modes

$$\overline{p}p \to G\pi^0 \to KK\pi^0$$
$$\overline{p}p \to G\pi^0\pi^0 \to KK\pi^0\pi^0$$
$$\overline{p}p \to G\pi^0 \to \phi\phi\pi^0$$

Selection Criteria

- All analyses:
  - π^0 mass window
  - 4C-Fit
    - Selection of best candidate per event based on χ^2
    - Cut on Probability: $\mathrm{Prob}(\chi^2, 4) > 5\%$
  - PID: KaonLoosePlus/Minus

- $\phi\phi\pi^0$ channel:
  - Additional $\phi\phi$ mass window:

$$r = \sqrt{(m(\phi_1) - m(\phi_{\mathrm{PDG}}))^2 + (m(\phi_2) - m(\phi_{\mathrm{PDG}}))^2} < 0.25\,\mathrm{GeV}$$

Data Samples and Cross Sections

P=2.4 GeV/c

- Signal: 200k events for 6 different detector setups
- Background:
  - 200M DPM for all setups

P=15 GeV/c

- Signal: 200k events for 6 different detector setups
- Background:
  - 1500M DPM for full detector
  - 500M DPM for all other setups

Cross sections:

- Glueball production cross section: $\sigma_{\mathrm{S}} \approx 10\,\mathrm{nb} \rightarrow 86400/\mathrm{day}$ at design luminosity
- Total $\overline{p}p$ cross section:
  - 50mb at p = 15GeV/c (5M events per second at design Luminosity)
  - 80mb at p = 2.4GeV/c (8M events per second at design Luminosity)

Background

- No chance to simulate enough DPM for needed measurement time
- If no event from DPM passed selection:

  -> Assumed 1 surviving event (and scaled number up to needed time)

  -> background is probably overestimated!
- Some dedicated background channels have been studied:
  - For $K^+K^-\pi^0$ channel

    -> $\bar{p}p\pi^0, \quad \pi^+\pi^-\pi^0$
  - For $\phi\phi\pi^0$ channel:

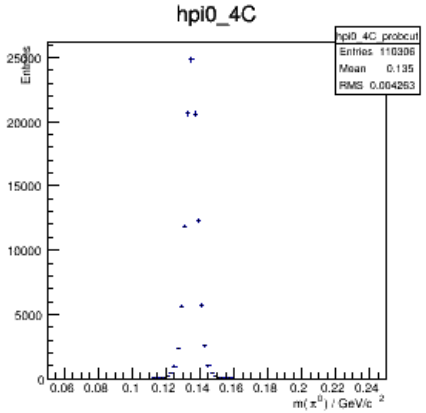
    -> $\pi^+\pi^-\pi^+\pi^-\pi^0 \quad (\sigma \approx 1\,\mathrm{mb})$: Simulated 400M events:

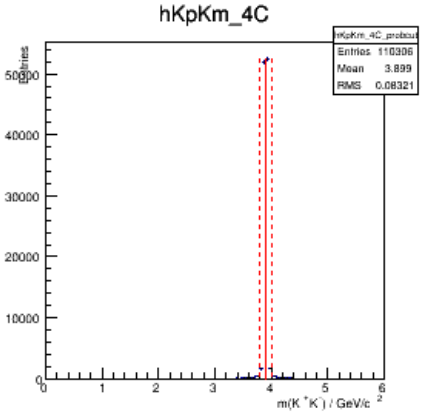
    None surviving 4C-fit

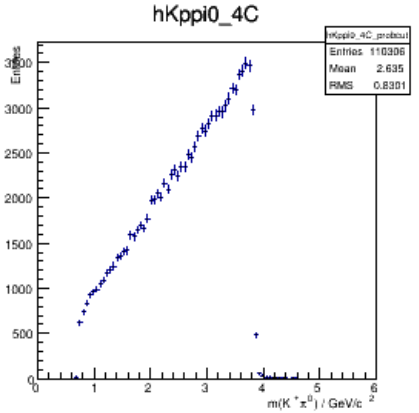
    -> $\bar{p}p\pi^+\pi^-\pi^0$: These events survive in FastSim (!), if PID is insufficient

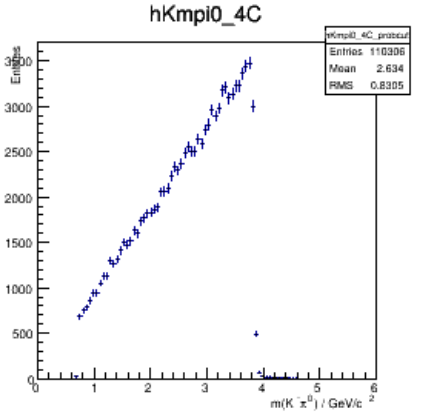
    (observed in large DPM sample)

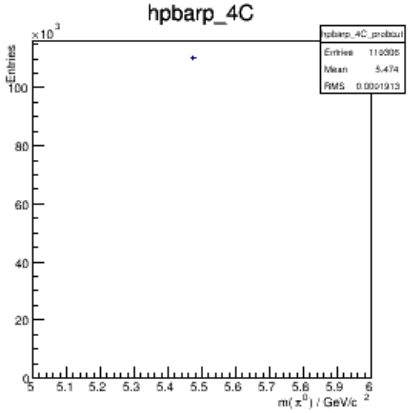
$\overline{p}p \to G(3900)\pi^0 \to K^+K^-\pi^0$

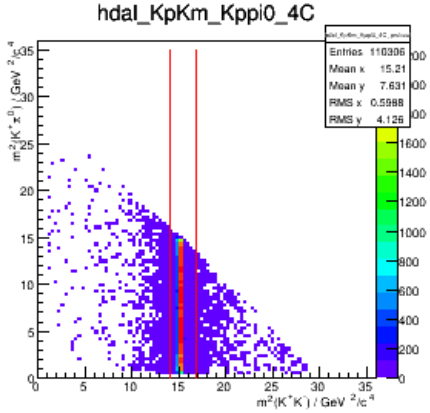


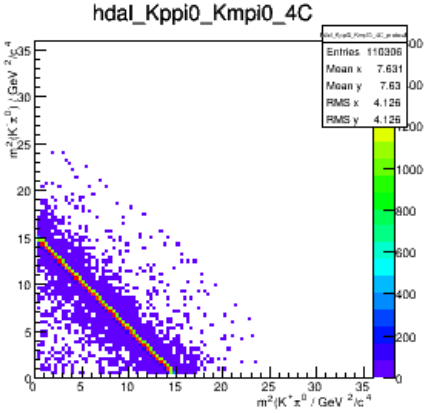




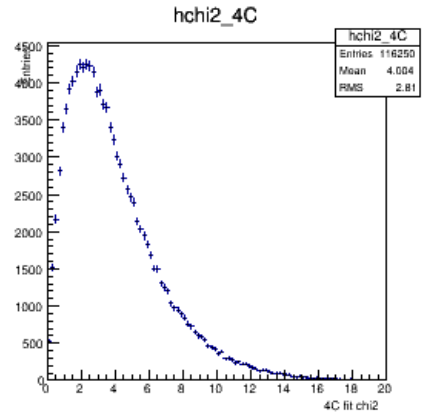


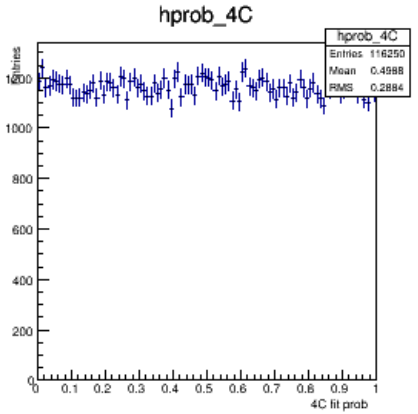


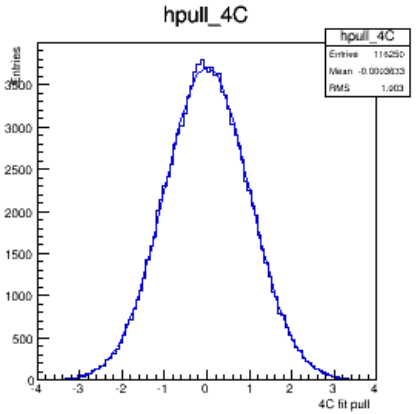




$p_{\overline{p}}$=15 GeV/c

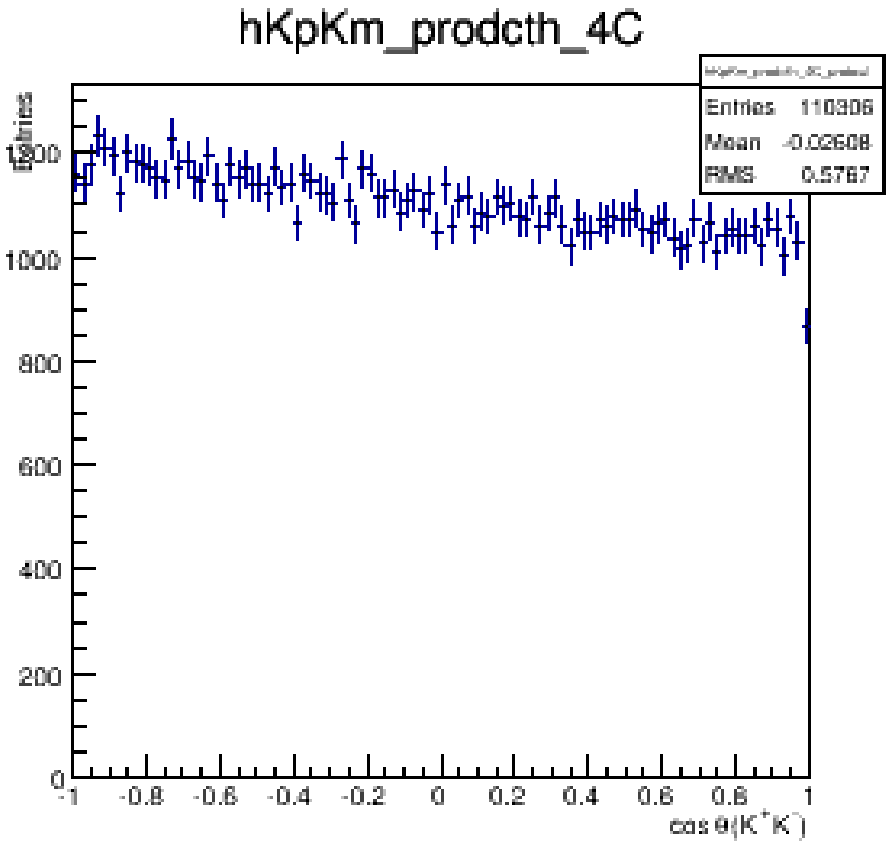


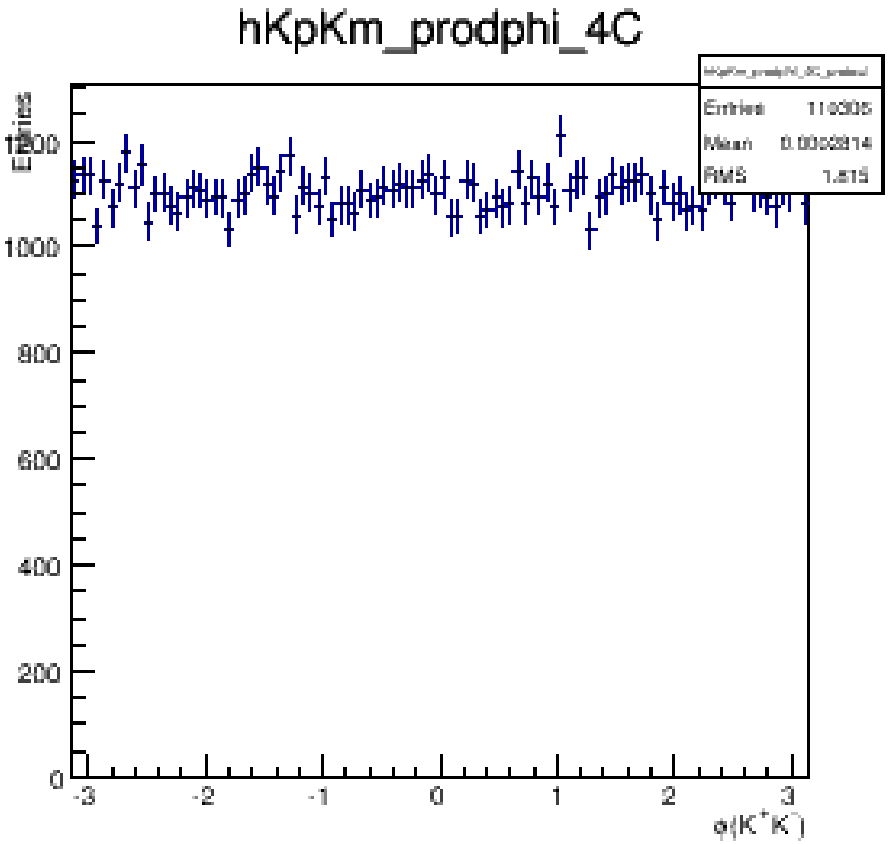




$\overline{p}p \to G(3900)\pi^0 \to K^+K^-\pi^0$

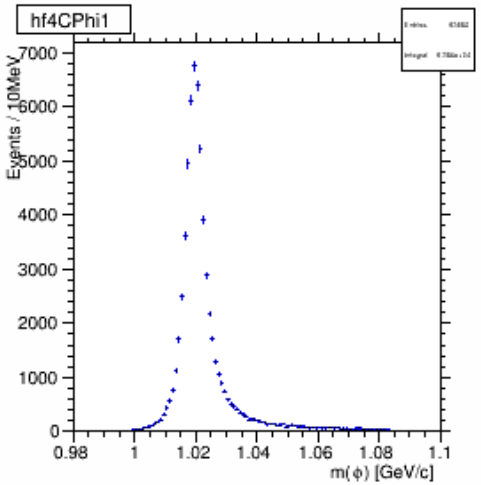
Production angles

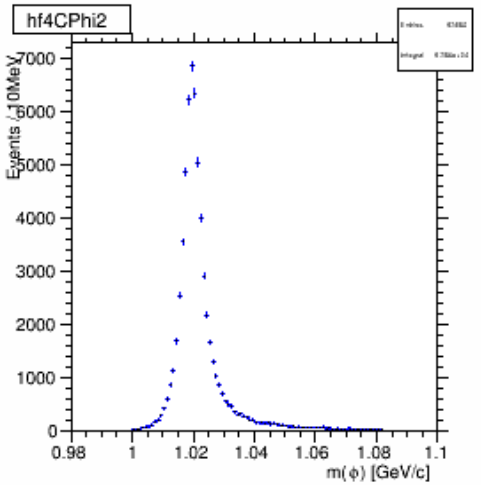


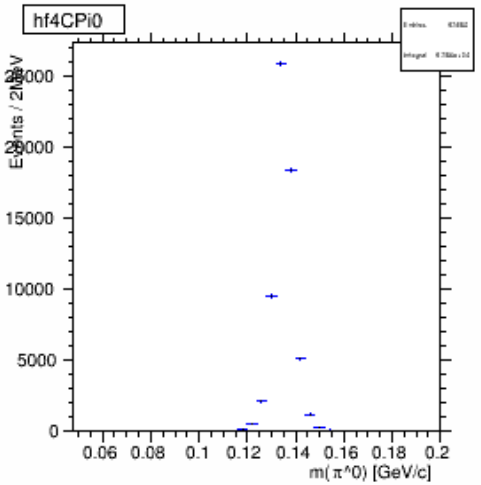


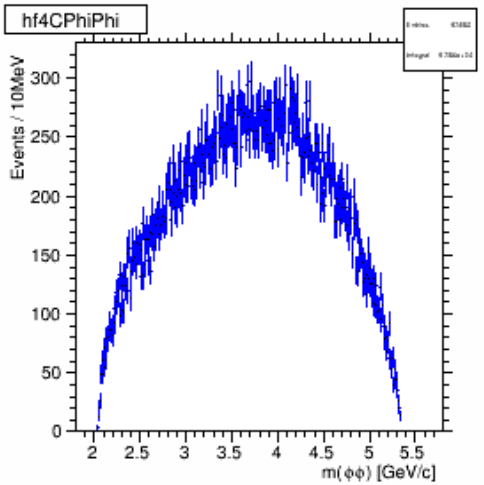
$p_{\overline{p}}$=15 GeV/c

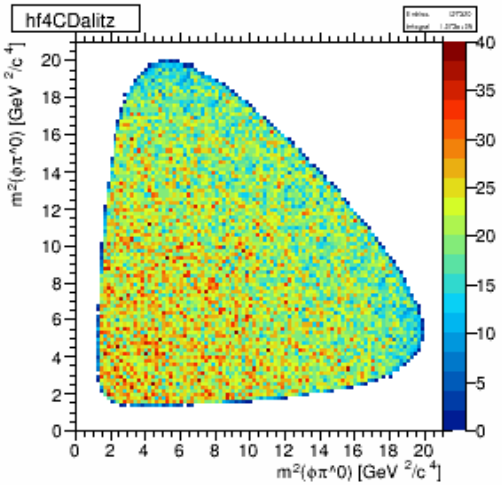
$$\overline{p}p \to G(2400)\pi^0 \to \phi\phi\pi^0$$

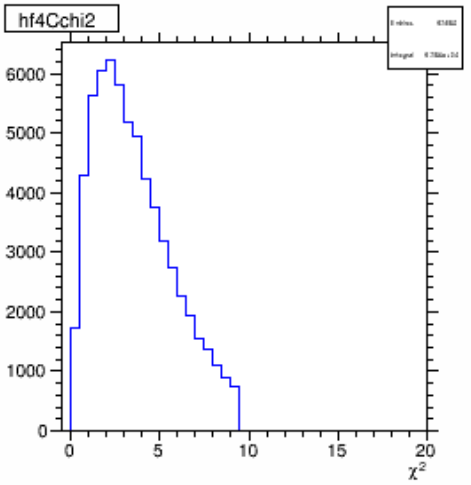


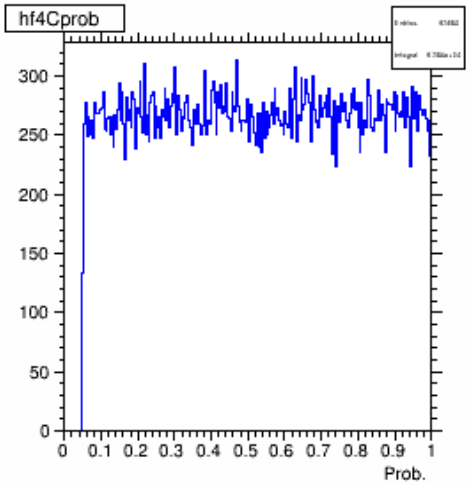


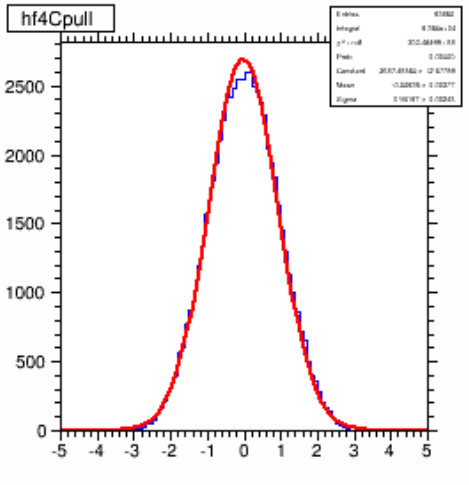








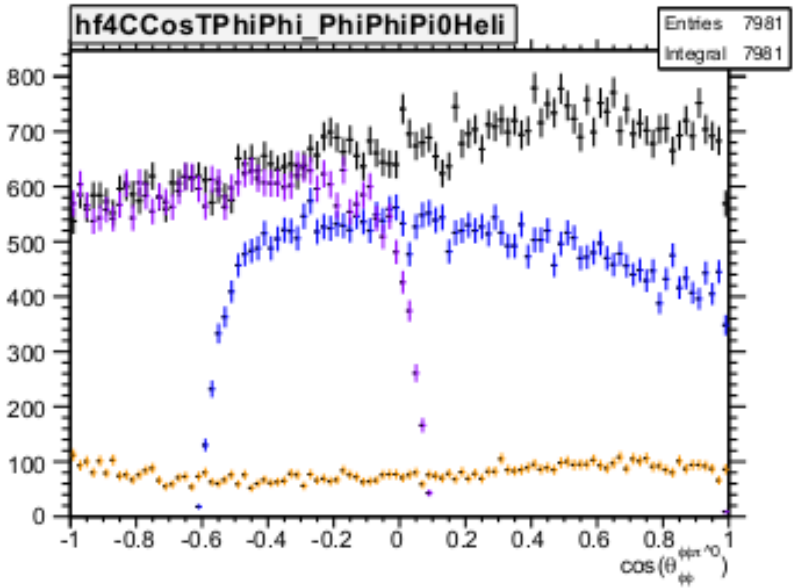


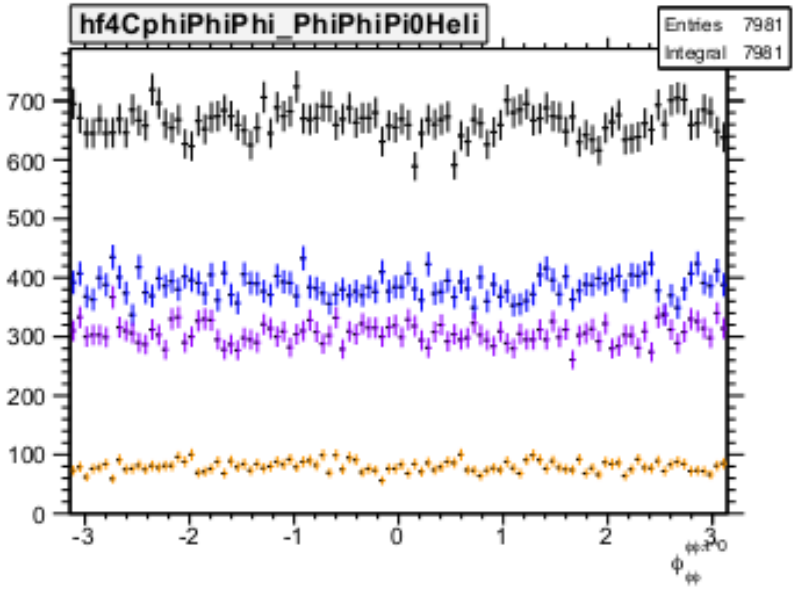


$p_{\overline{p}}$=15 GeV/c

$\overline{p}p \to G(2400)\pi^0 \to \phi\phi\pi^0$

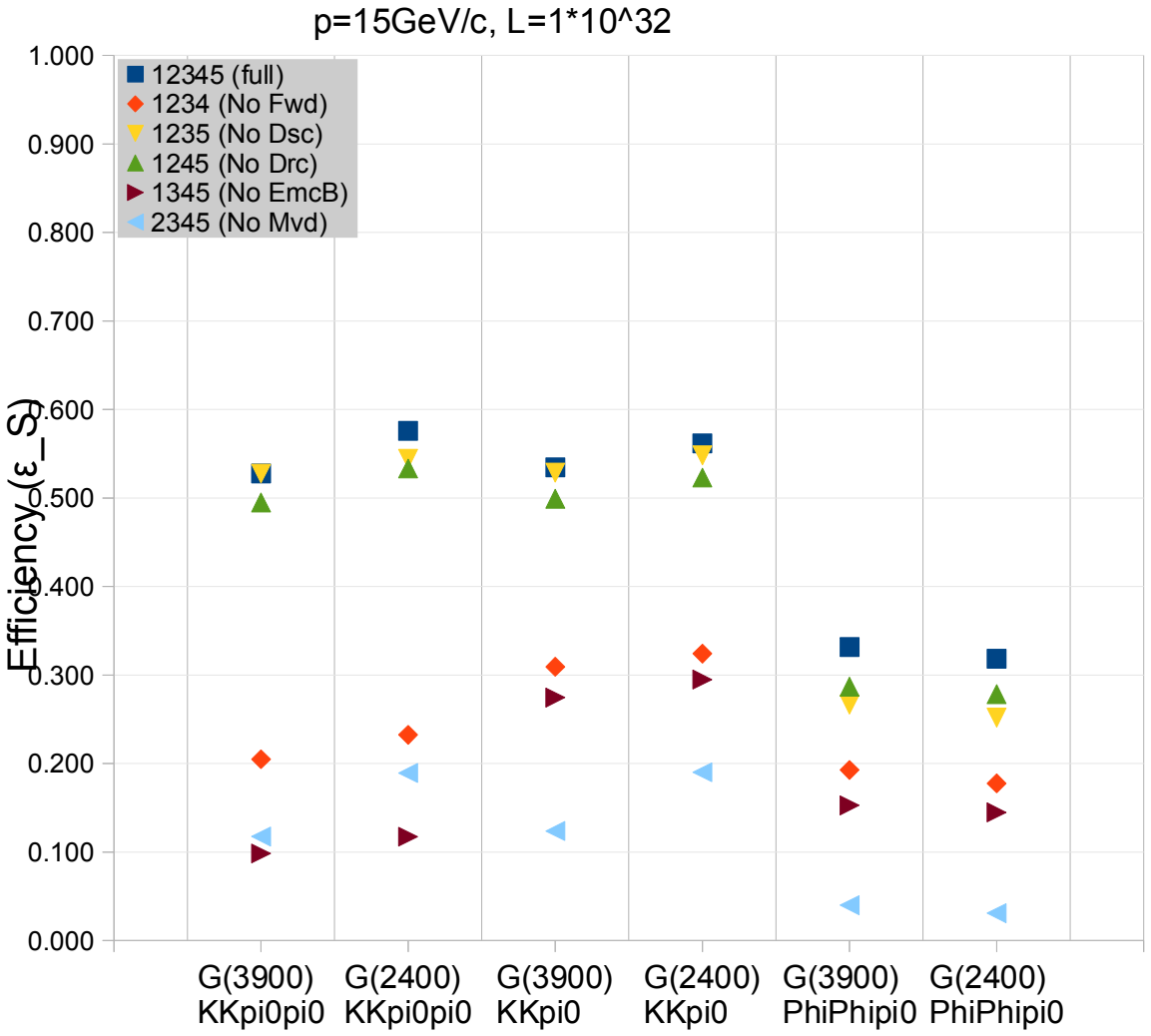
Angular distributions for different detector setups

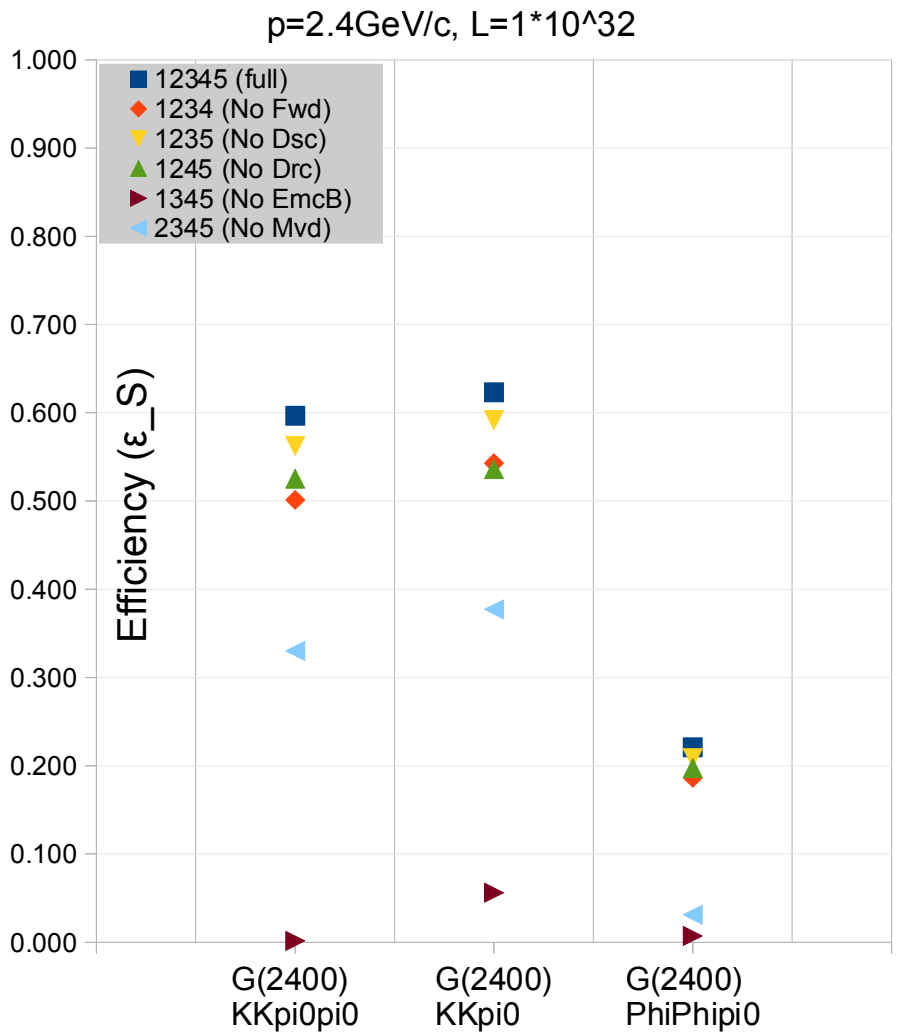




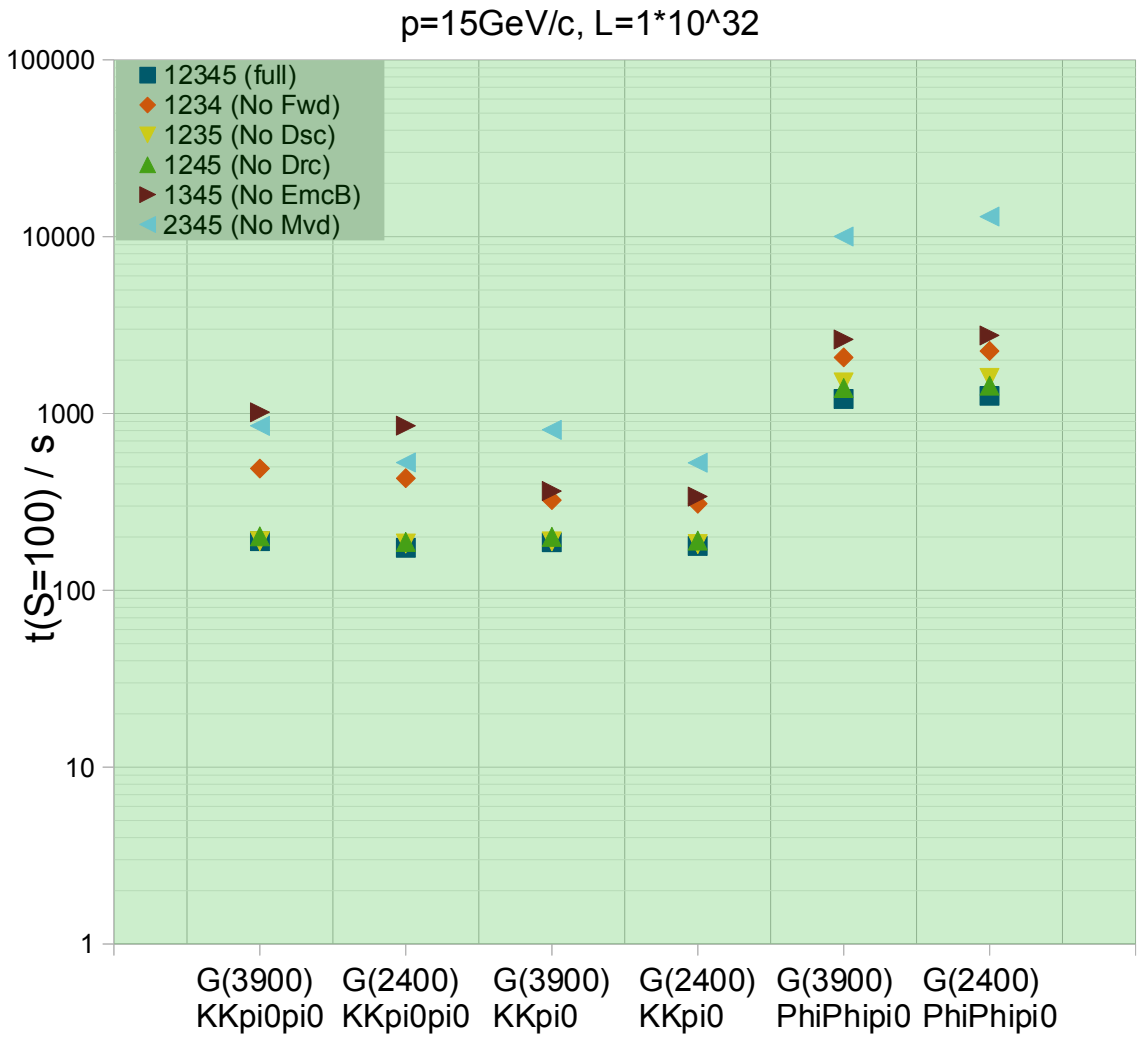
Full Detector
No MVD/GEM
No EMC B
No FS

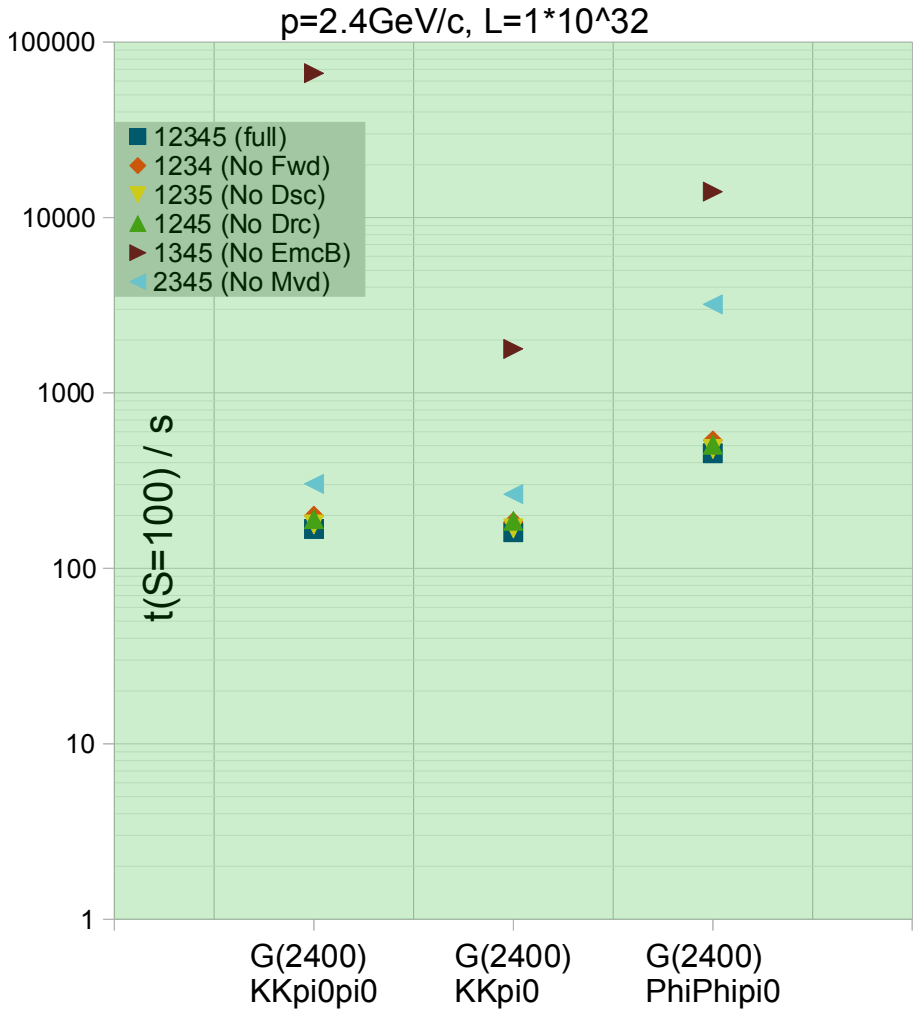
Selection Efficiency
(p=15 and 2.4GeV/c)



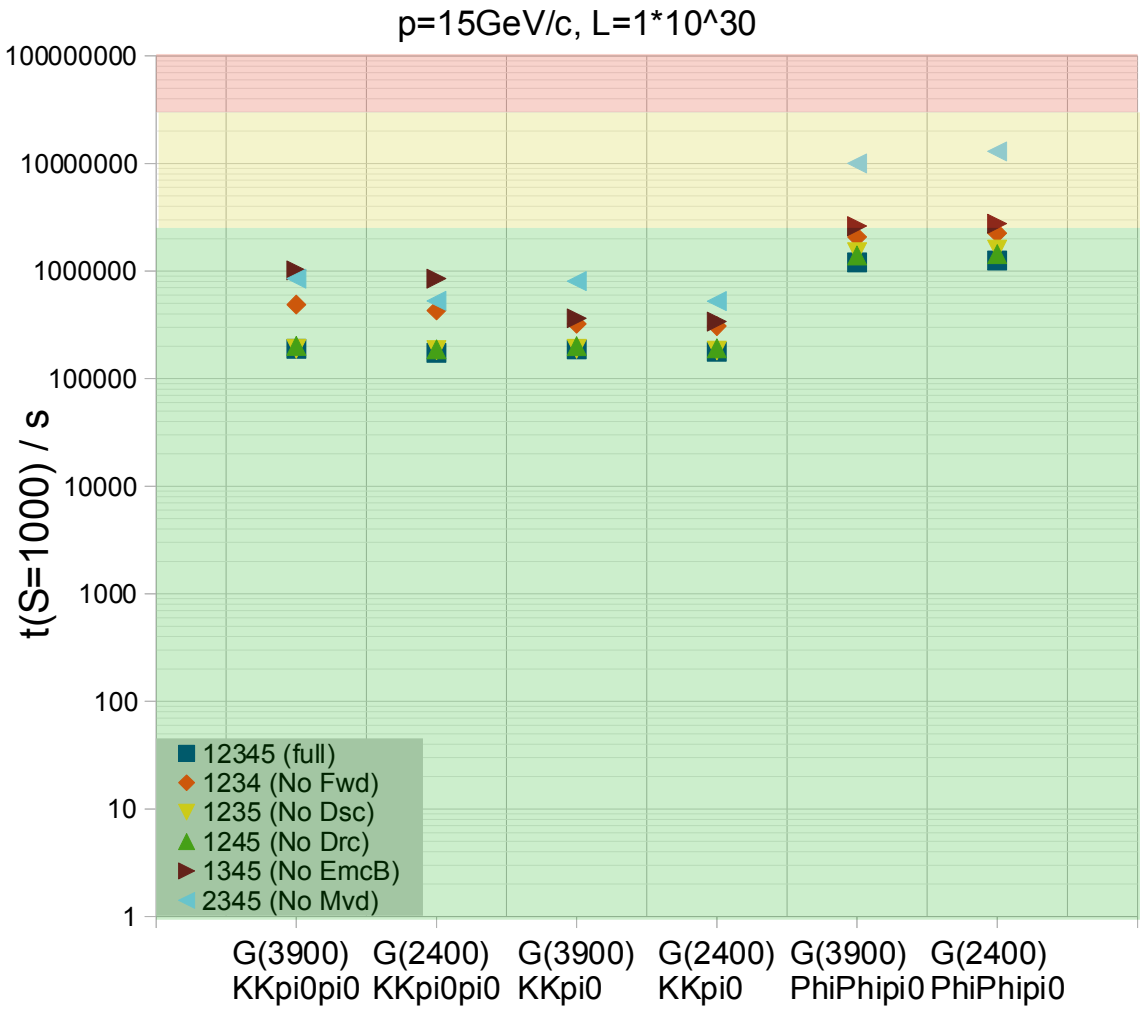


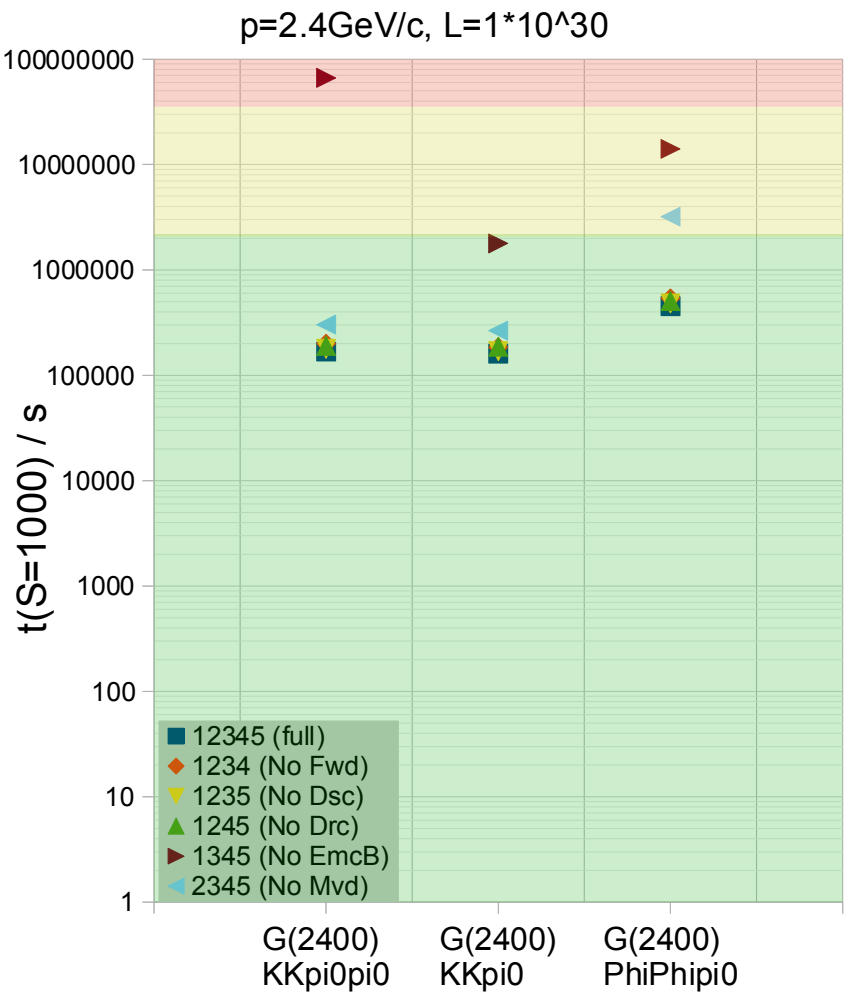
Time needed for 100 events
(p=15 and 2.4GeV/c)



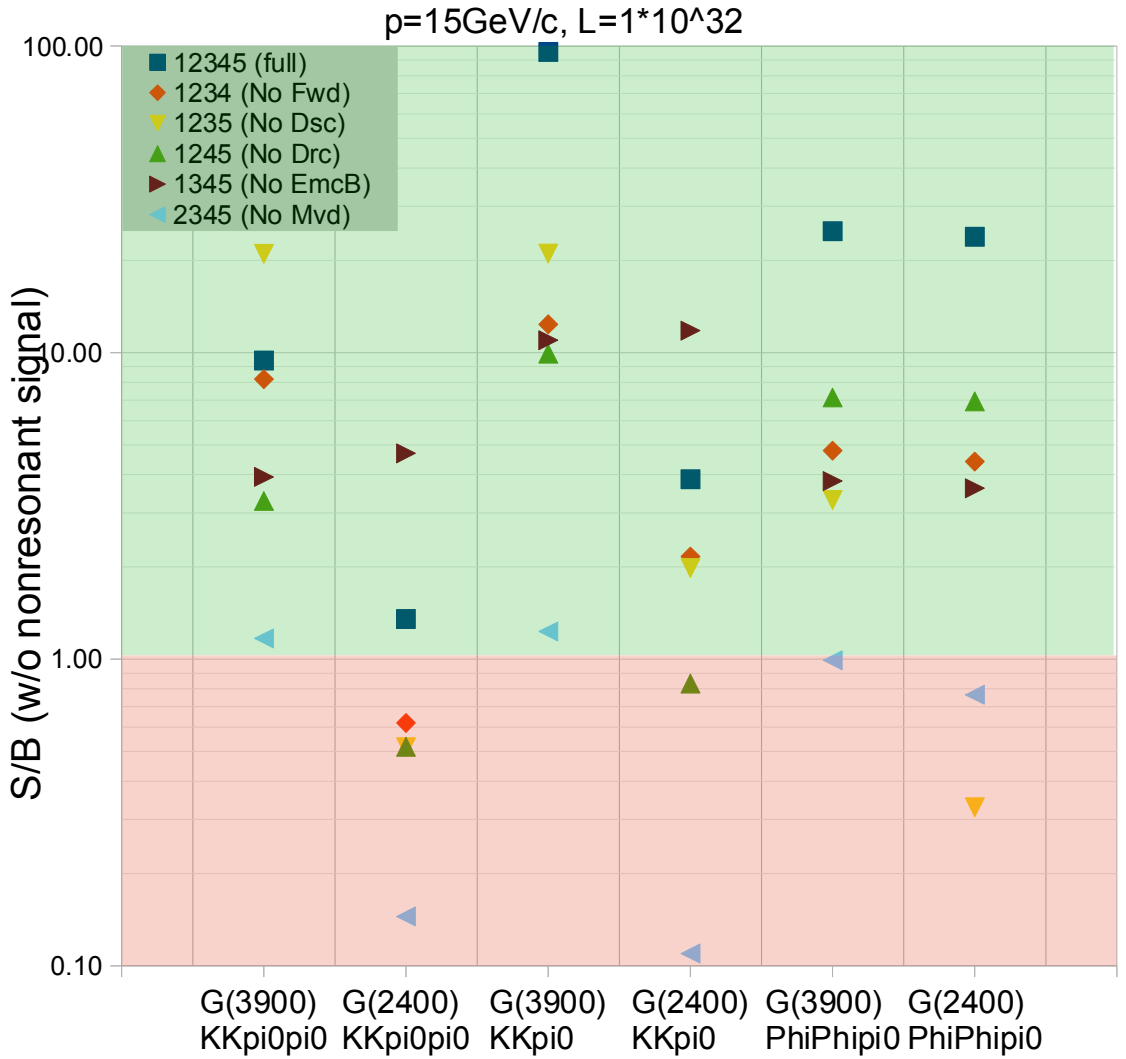


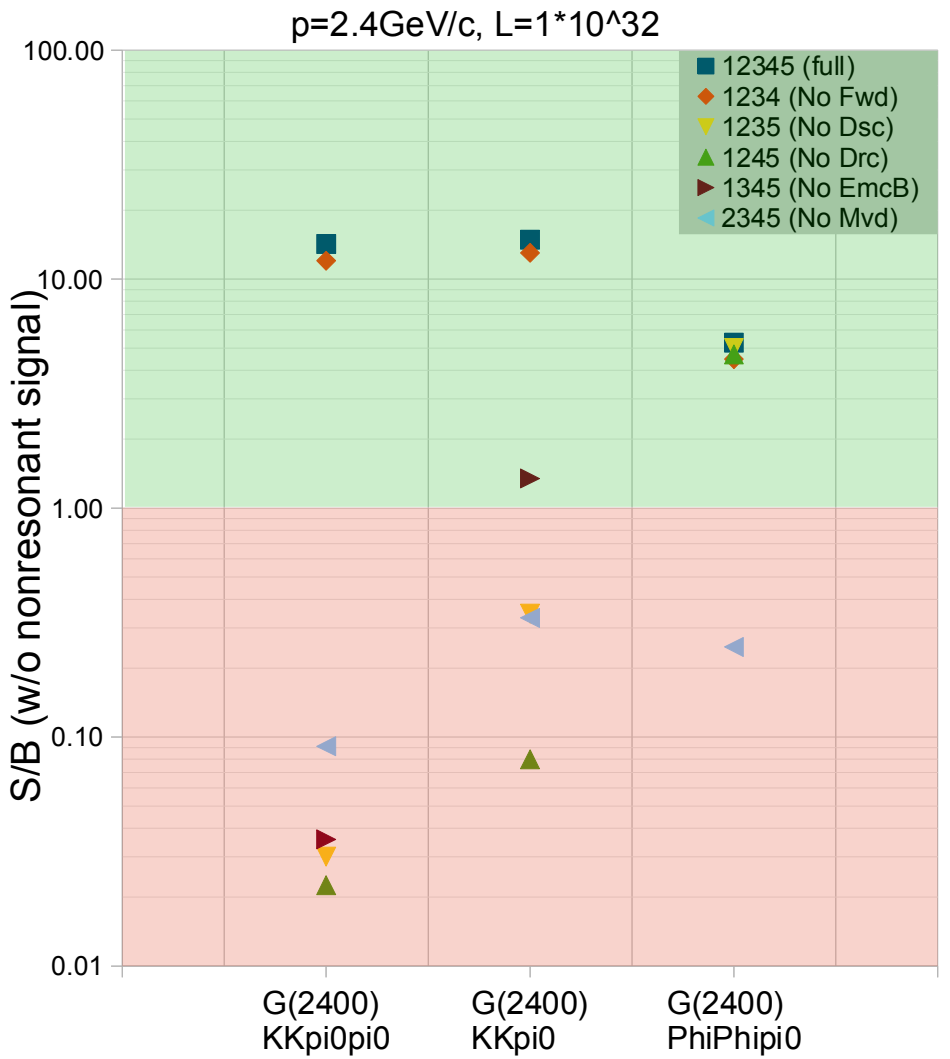
Worst Case: 1000 Signal Events at 100 times lower Luminosity





S/B (w/o non-resonant signal)
(p=15 and 2.4GeV/c)





Summary

- Severe drop in efficiency when leaving out

  MVD/GEMs or EMC Barrel
- Disc DIRC important to suppress $\bar{p}p\pi^+\pi^-\pi^0$ background in FastSim -> Full simulation needed to account for higher order effects and possible antiproton annihilation in the inner detector layers?
- S/B values to be taken with caution due to "upscaling"
- Production cross section could be (at least) an order of magnitude larger/smaller