BabaYaga@NLO for radiative processes

Workshop on radiative corrections and Monte Carlo simulations for electron-positron collisions

Marco Ghilardi

May 8, 2025

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BabaYaga@NLO

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- It simulates multiple QED processes
  - $\rightarrow\ e^+e^- \rightarrow \mu^+\mu^-\ (+n\gamma)$
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  with multiple-photon emission in a QED Parton Shower framework, matched with exact NLO matrix element

C.M. Carloni Calame et al., Nucl. Phys. B 584 (2000) 459

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- Extension to $\pi\pi$ final state wit NLOPS in *sQED* with:
  - $F \times$ *sQED*
  - GVMD
  - *FsQED*

  E. Budassi et al., arXiv:2409.03469

Radiative processes

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  - ↪ Pure perturbative approach

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- Radiative Bhabha
  - ↪ Virtual amplitude evaluated with RECOLA

NLO calculation for $\mu\mu\gamma$ and $\pi\pi\gamma$

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- Divergences
  - Dimensional regularization for UV divergences - ε
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  ↪ Semi-automatic computation through FEYNCALC and FEYNARTS.

  ↪ Evaluation of scalar and tensor integrals through COLLIER

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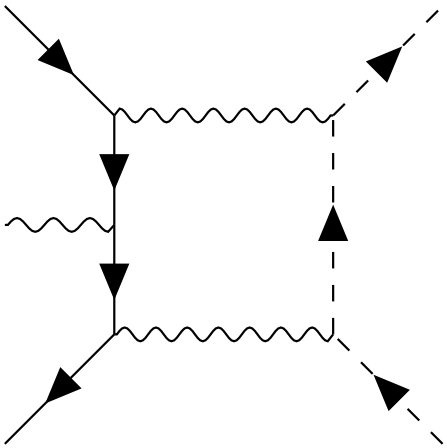

5-point instabilities

Considering the $\mu\mu\gamma$ channel in a KLOE-like scenario [arxiv:1201.0968]

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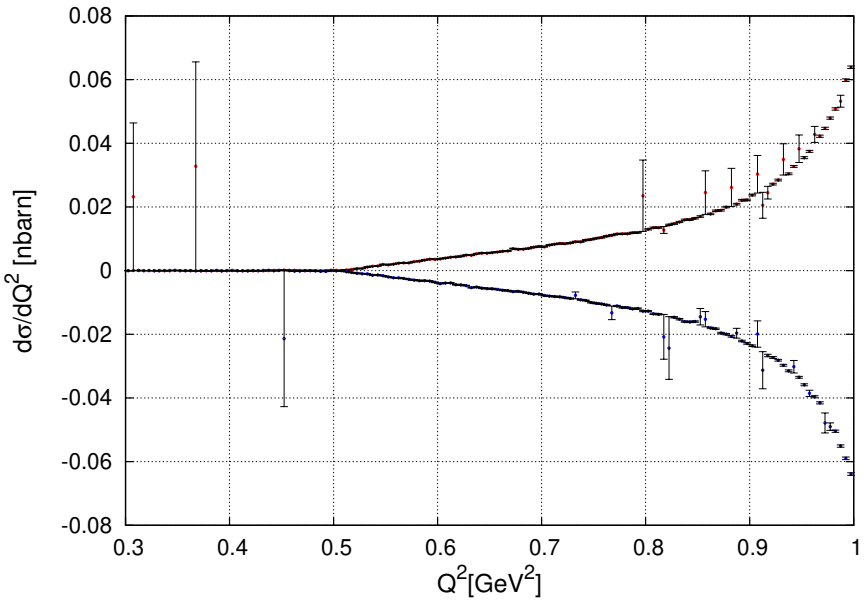

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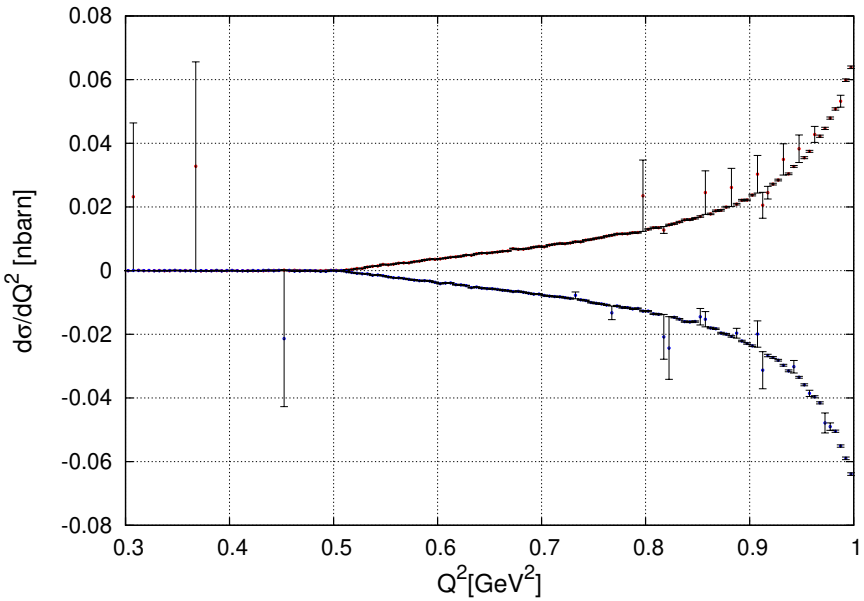

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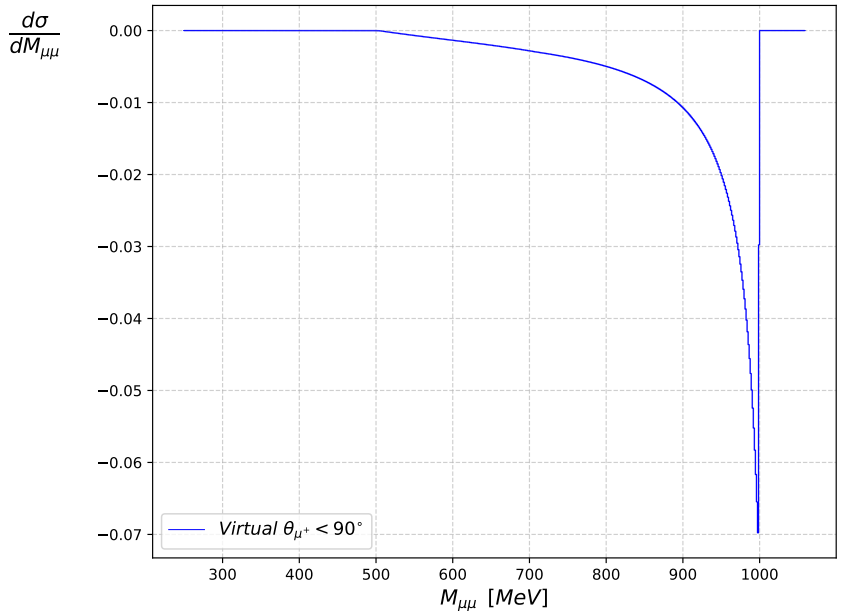

- $2 \cdot 10^9$ accepted events

5-point instabilities

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- Only the 5-point contribution to the virtual amplitude.

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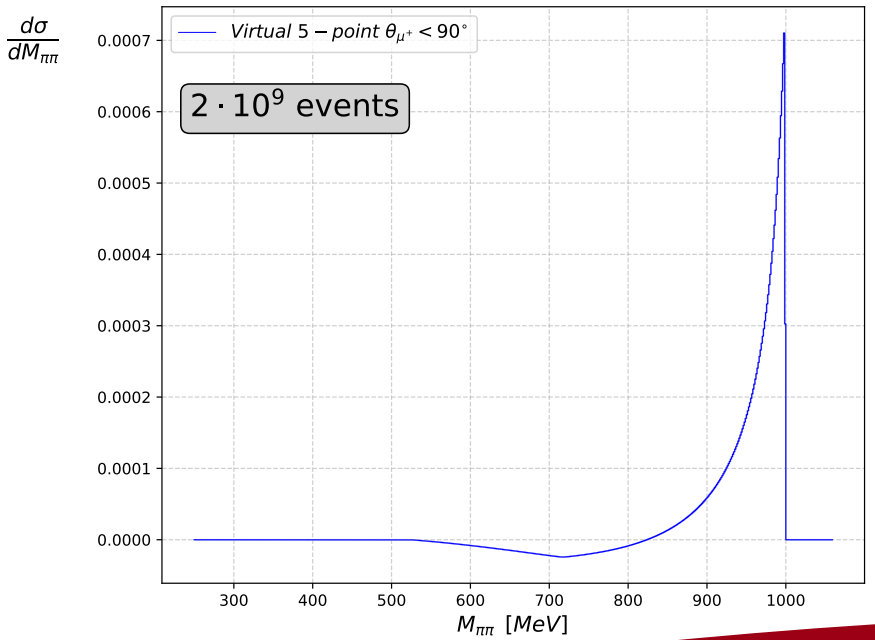

$F \times sQED$ for $\pi\pi\gamma$

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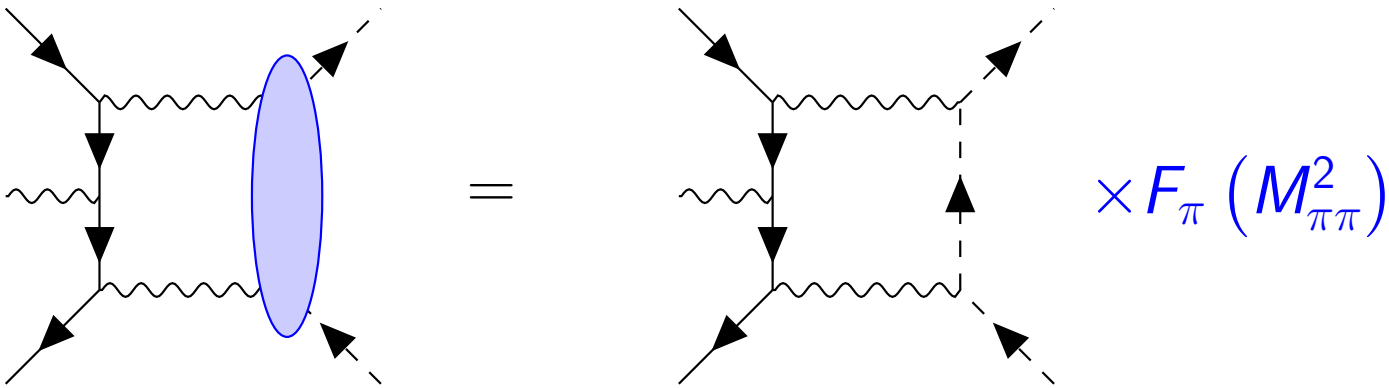
- ISR real photon



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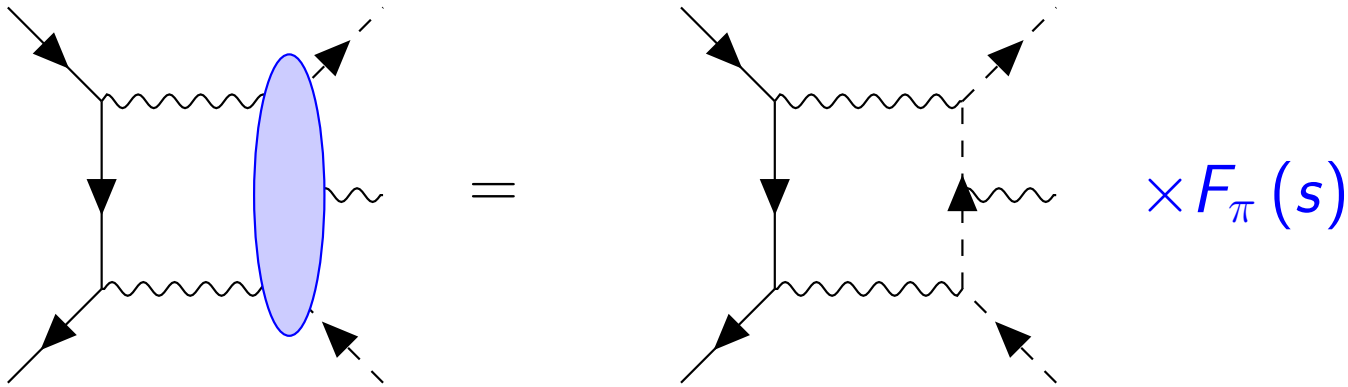

KLOE-I event selection - $\pi\pi\gamma$

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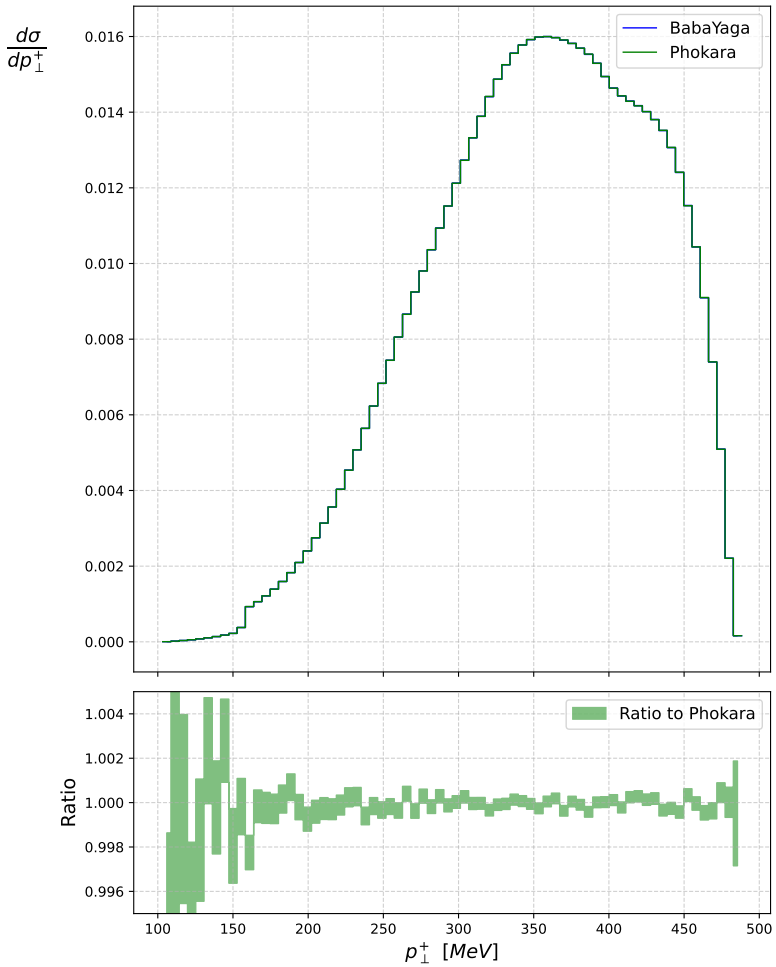
- $\star$ $\sqrt{s} = 1.02\,\text{GeV}$

- $50^\circ \leq \theta_\pm \leq 130^\circ$
- $\left|p_\pm^z\right| \geq 90\,\text{MeV} \ \vee \ \left|p_\pm^\perp\right| \geq 160\,\text{MeV}$
- $50^\circ \ \leq \theta_\gamma \leq 130^\circ \ \wedge \ E_\gamma \geq 20\,\text{MeV}$
- $0.1\,\text{GeV}^2 \leq M_{XX}^2 \leq 0.85\,\text{GeV}^2$



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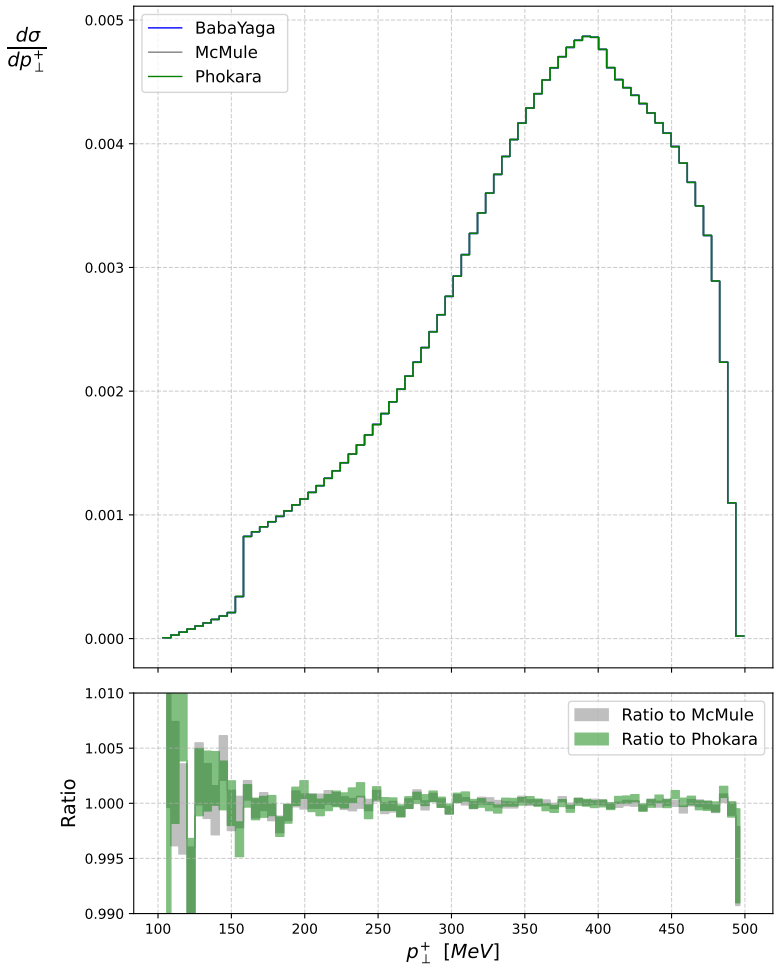

KLOE-I event selection - $ee\gamma$

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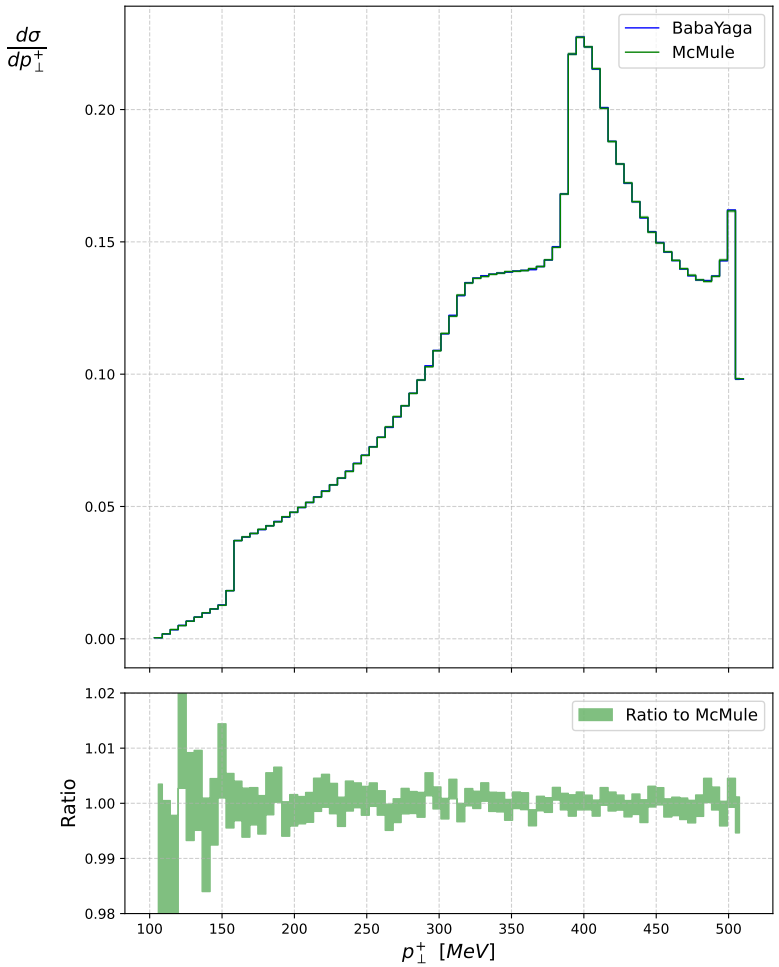

KLOE-II event selection - $\pi\pi\gamma$

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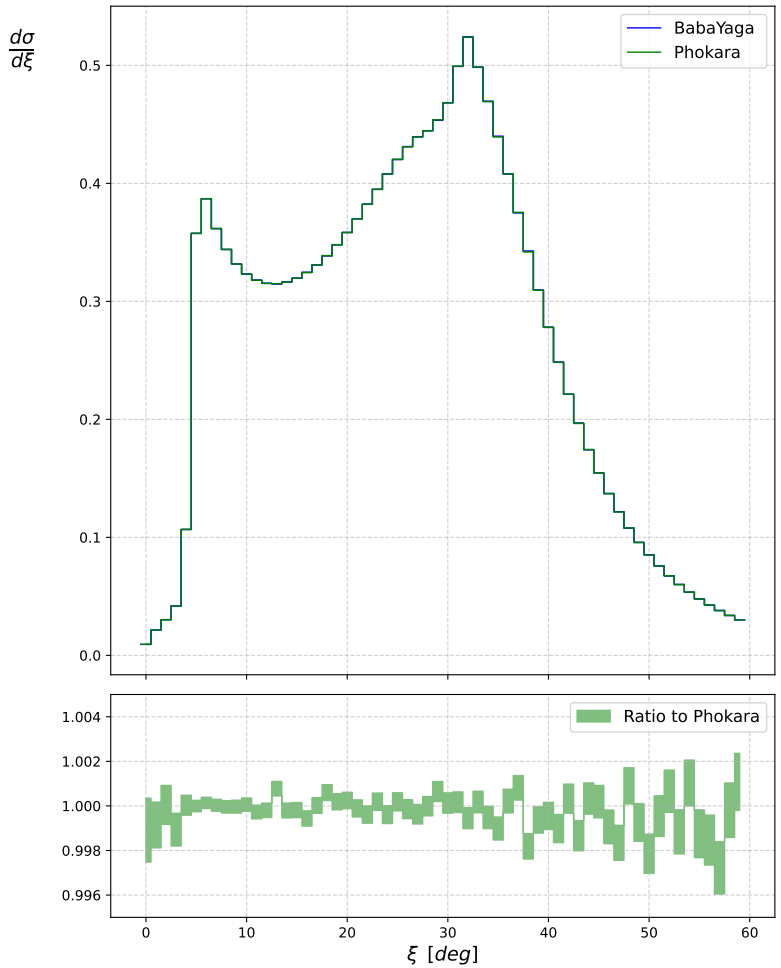
- $50^\circ \leq \theta_\pm \leq 130^\circ$
- $\left|p_\pm^z\right| \geq 90\,\text{MeV} \ \vee \ \left|p_\pm^\perp\right| \geq 160\,\text{MeV}$
- $\theta_{\tilde{\gamma}} \leq 15^\circ \ \vee \ \theta_{\tilde{\gamma}} \geq 165^\circ$
- $0.35\,\text{GeV}^2 \leq M_{XX}^2 \leq 0.95\,\text{GeV}^2$

where

$$\begin{cases} p_{\tilde{\gamma}} = -\left(p_+ + p_-\right) \\ \xi = \left|\theta^+ + \theta^- - \pi\right| \end{cases}$$



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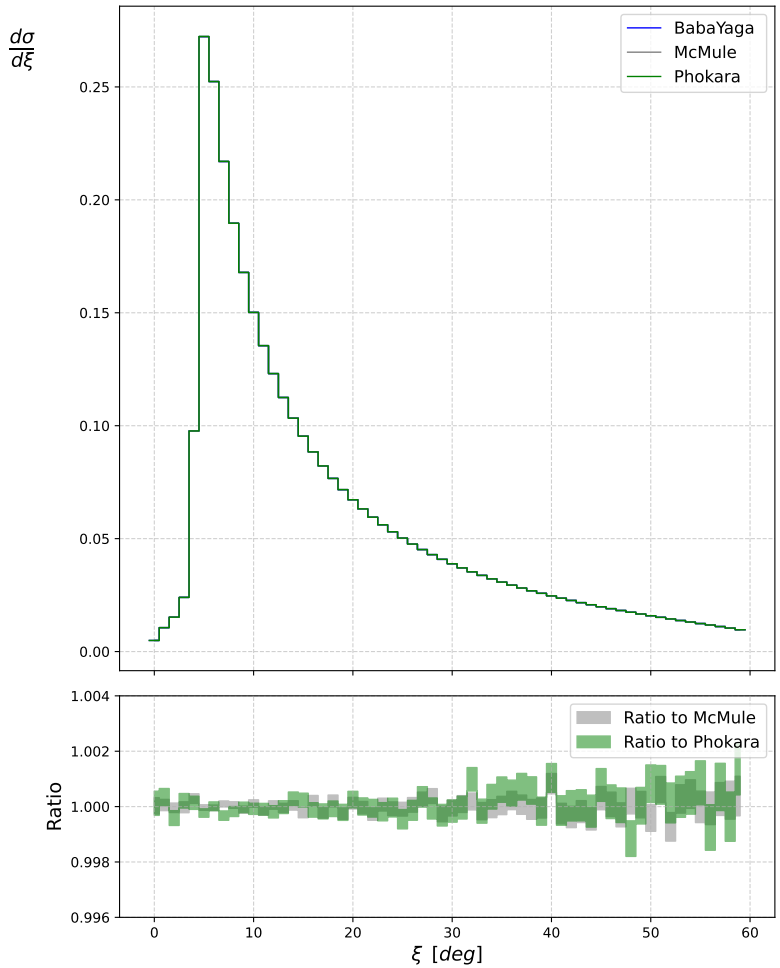

BES3 event selection - $\pi\pi\gamma$

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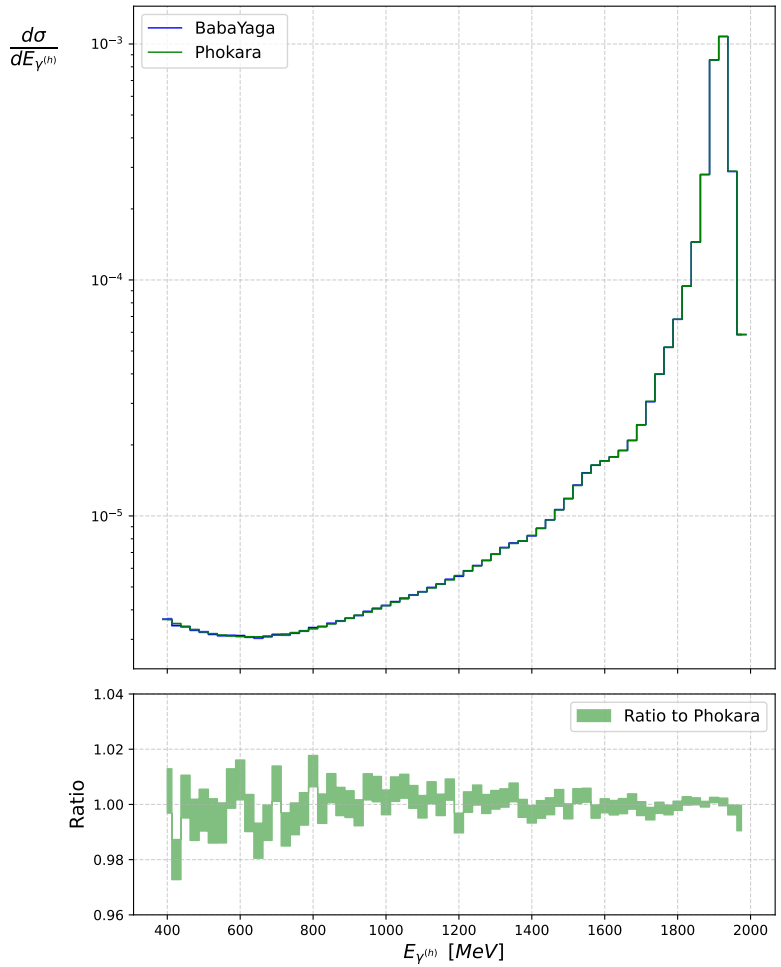
- $\star$ $\sqrt{s} = 4\,\text{GeV}$

- $|\cos\theta_{\pm}| \leq 0.93 \wedge |p_{\pm}^{\perp}| \geq 300\,\text{MeV}$
- $|\cos\theta_{\gamma}| \leq 0.8 \wedge E_{\gamma} \geq 25\,\text{MeV}$ or
  $0.86 \leq |\cos\theta_{\gamma}| \leq 0.92 \wedge E_{\gamma} \geq 50\,\text{MeV}$
- $\exists!$ photon with $E_{\gamma} \geq 400\,\text{MeV}$



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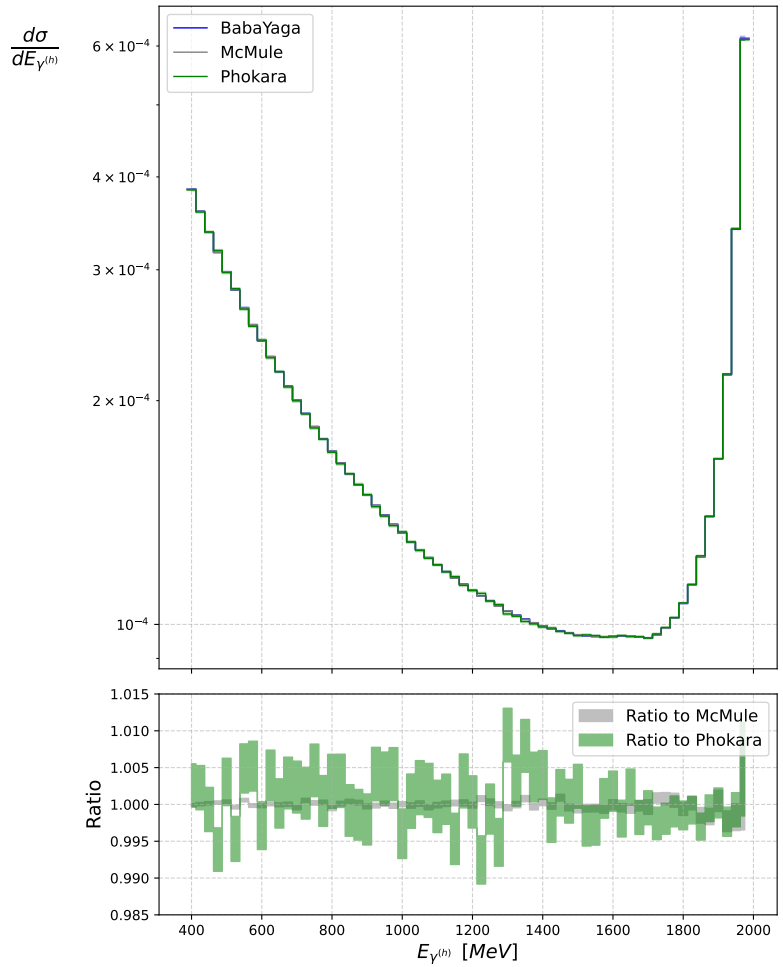

B event selection - $\pi\pi\gamma$

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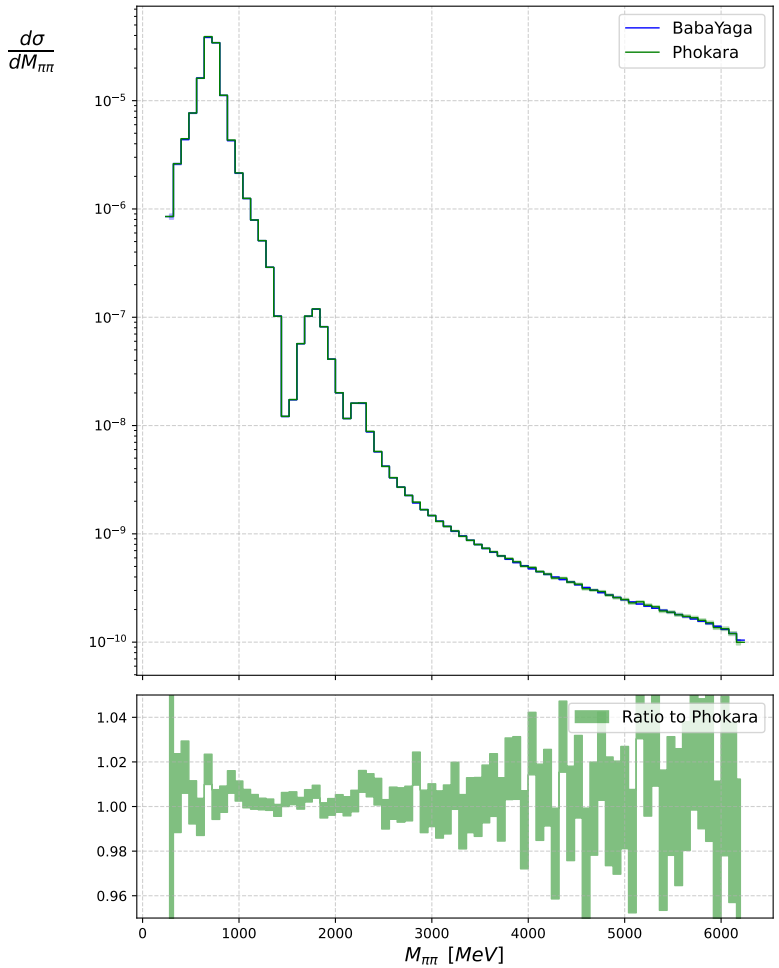
- $\star$ $\sqrt{s} = 10\,\text{GeV}$

- $0.65\,rad \leq \theta_{\pm} \leq 2.75\,rad \wedge |p_{\pm}| \geq 1\,\text{GeV}$
- $0.6 \leq \theta_{\gamma} \leq 2.7\,rad \wedge E_{\gamma} \geq 3\,\text{GeV}$
- $\theta_{\tilde{\gamma},\gamma(h)} \leq 0.3 rad$
- $M_{\pi\pi\gamma} \geq 8\text{GeV}$



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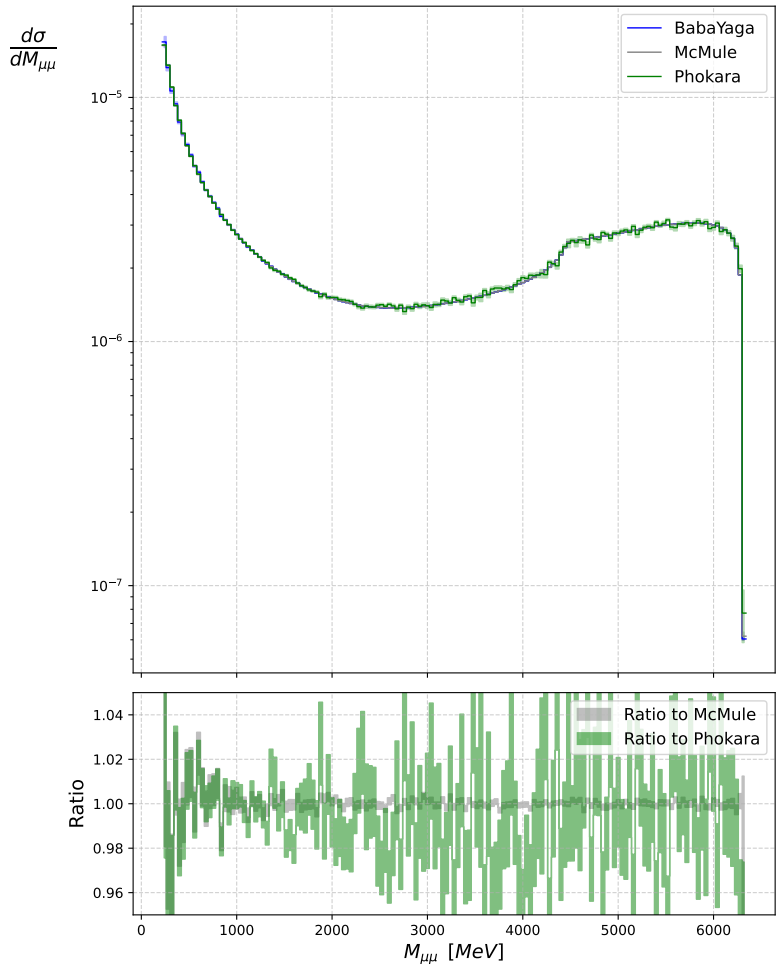

Work in Progress

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Completed

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Ongoing

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NLOPS for radiative channels

Q&A