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Event generation for mono-photon analysis

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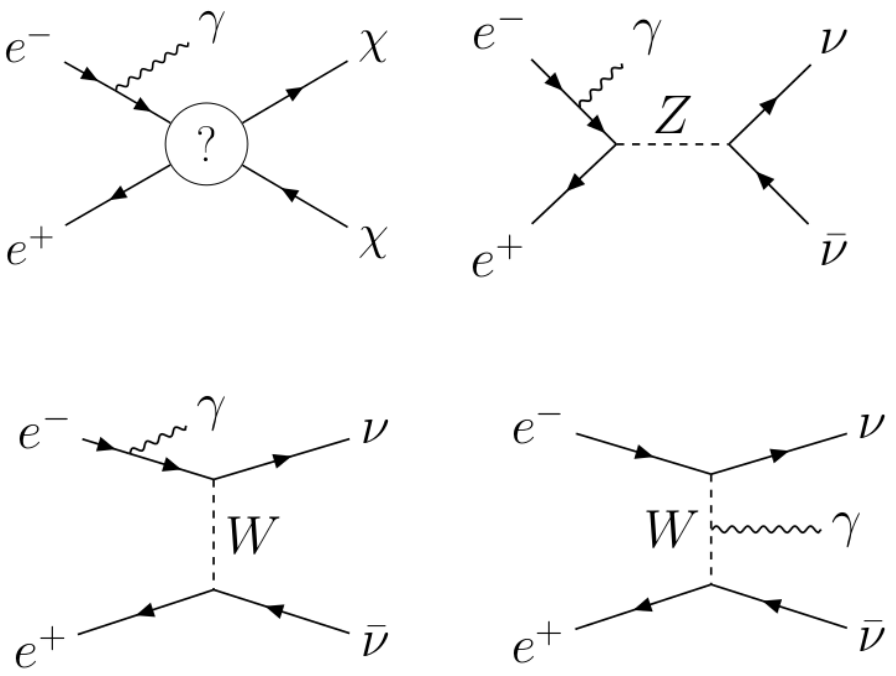
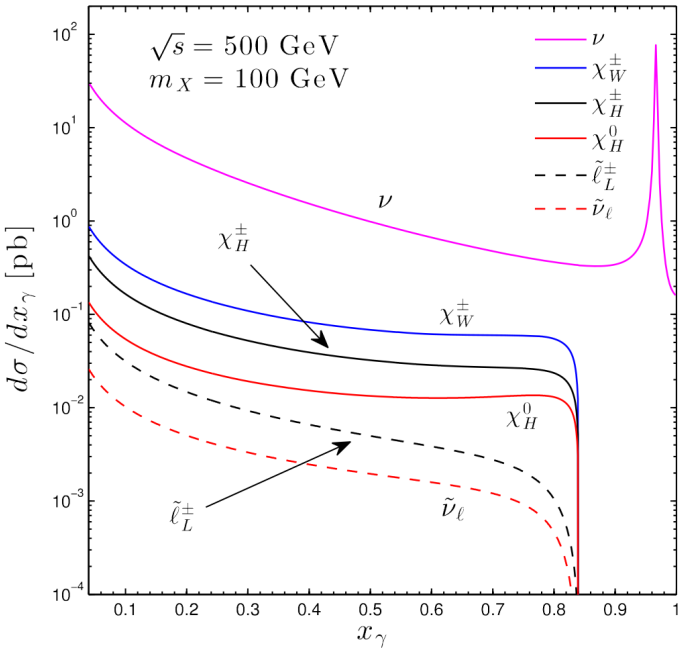
CLIC Workshop 28.08.2019

Some intro...



Neutrinos processes used as background and for the tests shown in this talk

Basic distributions may differ depending on the DM Model



Choi et al.
PH REV D 92, 095006 (2015)

Some intro...

- Aim is to avoid double-counting of ISR and matrix element photons (ME-pht)
- Tests presented here aim to separate ISR from ME-pht and to cross check whizard generation performance
  - Whizard generator offers flags and tools
  - For cross check: a semi-analytical generator KKMC was used. MC tuned for LEP

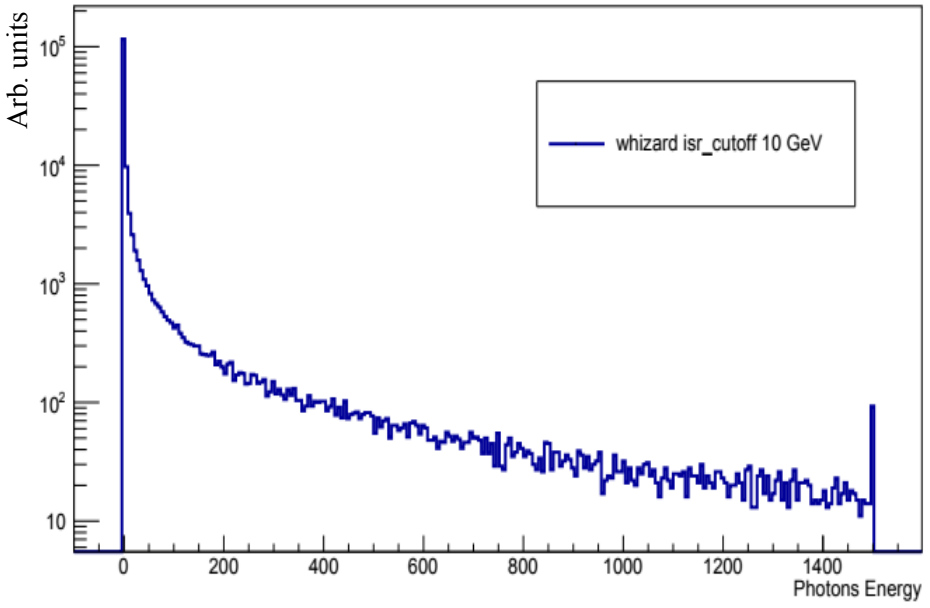
S. Jadach, B.F.L. Ward, Z. Wąs
Computer Physics Communications 130 (2000) 260–325

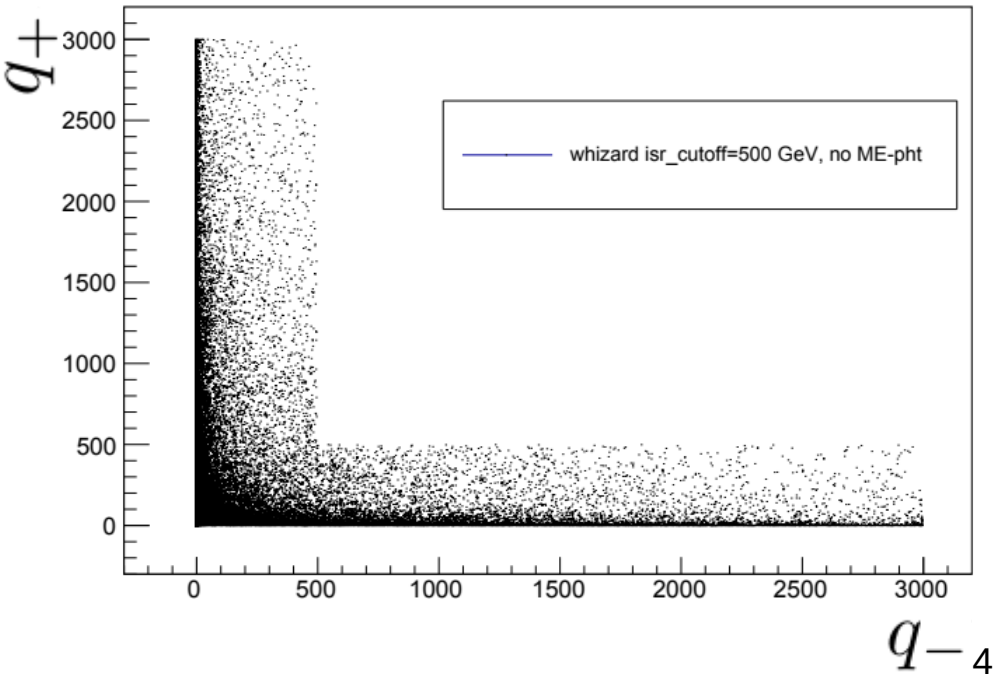
ISR cut off?

Whizard flag *isr_q_max* tested – failed to compute correct cross section
- *manual* selection

$$q_- = 2\sqrt{(E_{e_-} E_\gamma)}\sin(\frac{\theta_\gamma}{2})$$

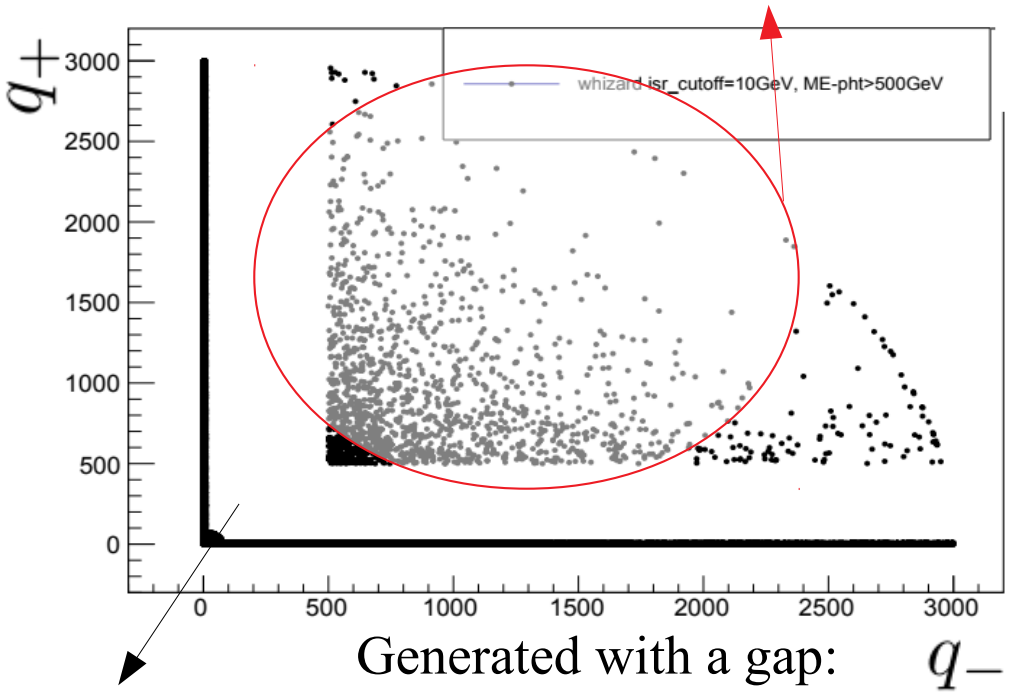
$$q_+ = 2\sqrt{(E_{e_+} E_\gamma)}\cos(\frac{\theta_\gamma}{2})$$





ISR cutoff using momentum transfer

Matrix Element Photons



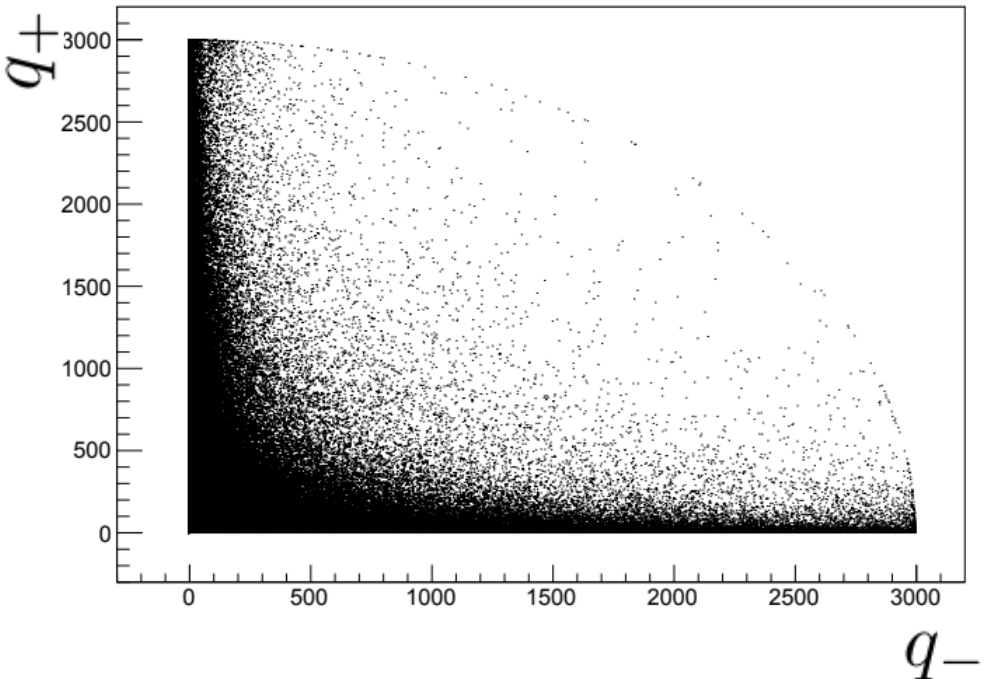
ISR Photons

Generated with a gap:

ISR: q < 10 GeV

ME photons: q > 500GeV

q^+q^- for Whizard $\nu\bar{\nu}$



For futher analysis: merging ISR and ME-pht at q = 10 GeV

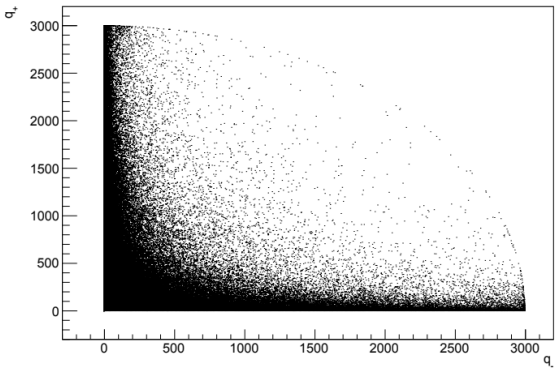
MCs comparison after selection

- Cuts performed to obtain basic selection
  - Cut on theta of photons: 7° on both sides
  - Minimum Energy requirement for photons: E > 5 GeV

- Efficiencies
  - Whizard: theta: 0,652 En: 0,504 all: 0,0959
  - KKMC: theta: 0,329 En: 0,499 all: 0,0976

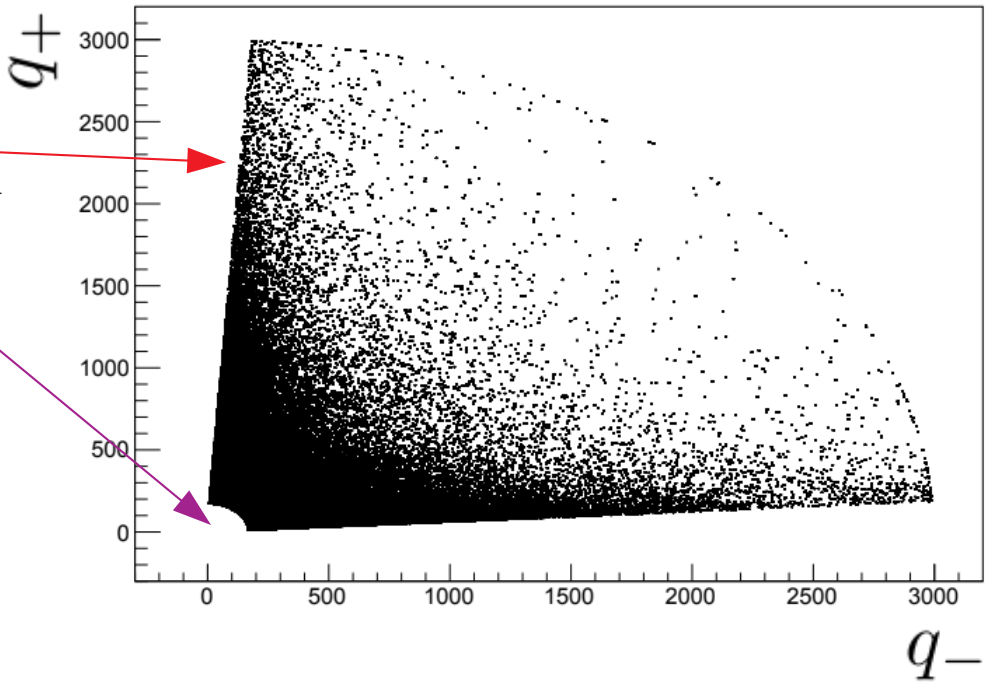
MCs comparison after selection

q^+q^- for Whizard $\nu\bar{\nu}$



Theta cut 7°
Pht Energy > 5 GeV

q^+q^- for Whizard $\nu\bar{\nu}$ after selection

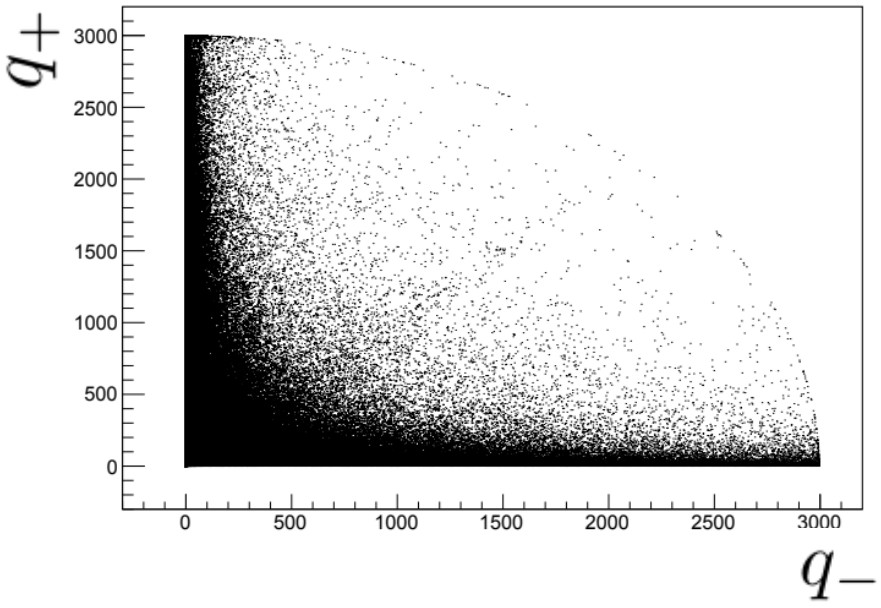


Cuts represent central detector region

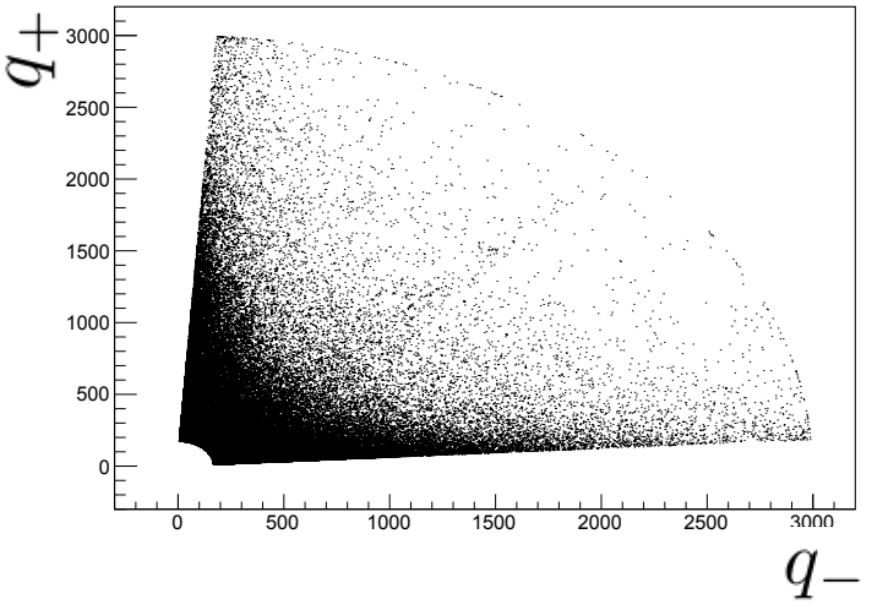
- BeamCal to be used later on

MCs comparison after selection

q^+q^- for KKMC $\nu\bar{\nu}$

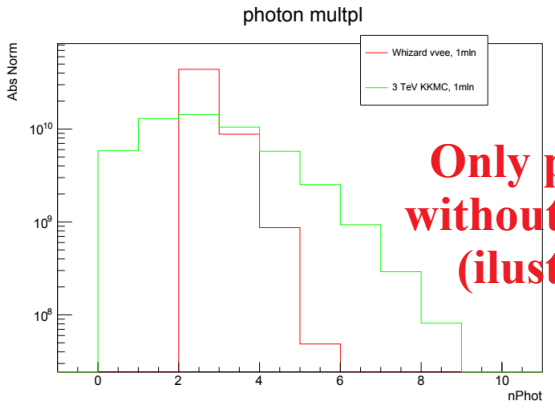


q^+q^- for KKMC $\nu\bar{\nu}$ after selection

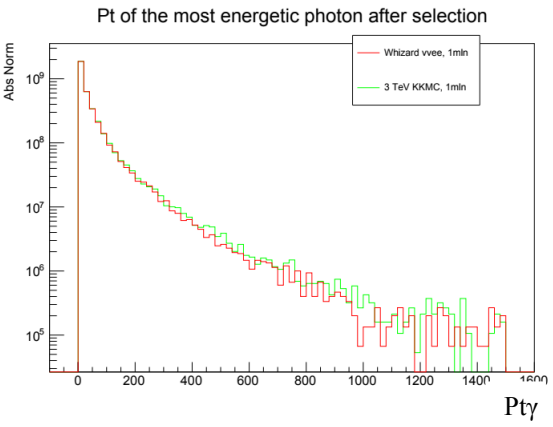


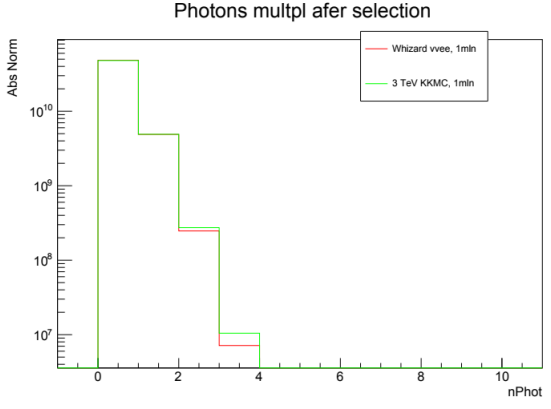
Distributions of events in the same phase space for KKMC

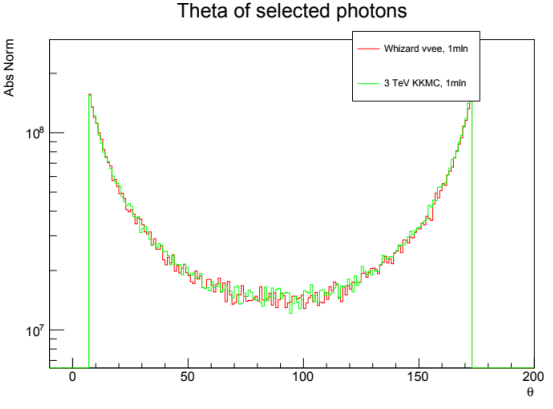
MCs comparison after selection



Only plot here without selection (ilustrative)

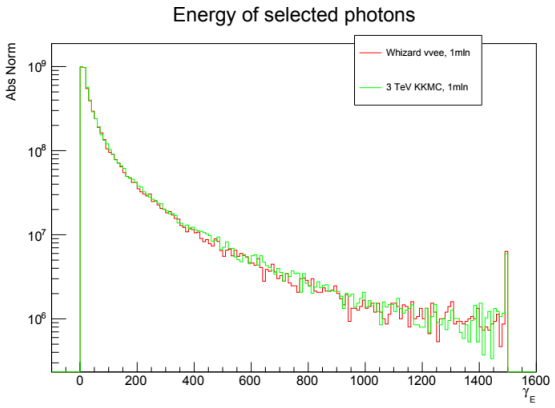


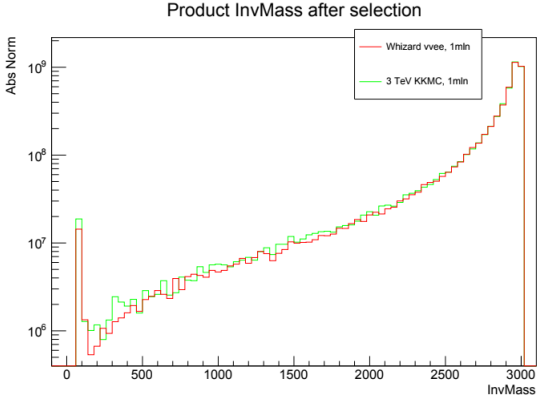


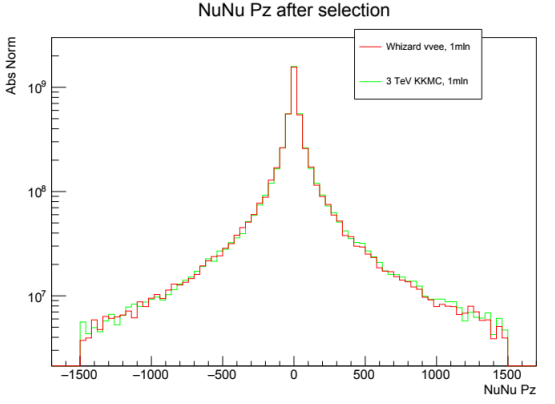


MCs comparison after selection

- Photon distributions agree between MCs
- Merging procedure works nicely

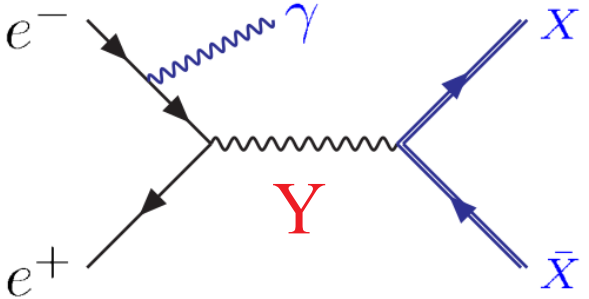






Simple Dark Matter Model

Simple Dark Matter Model (by W. Kotlarski)



X – Dirac, real or complex Dark Matter particle

Y – real (scalar) or vector mediator

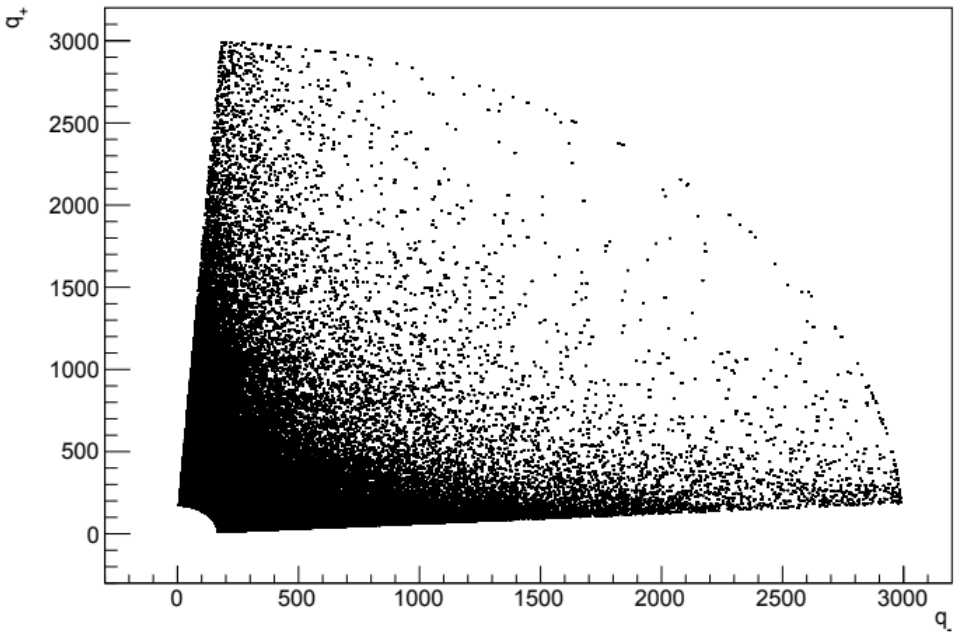
One can steer the masses, mediator widths and couplings between DM particles/electrons

Set-up used to check whether one can distnguish between different DM models using mono-photon analysis:

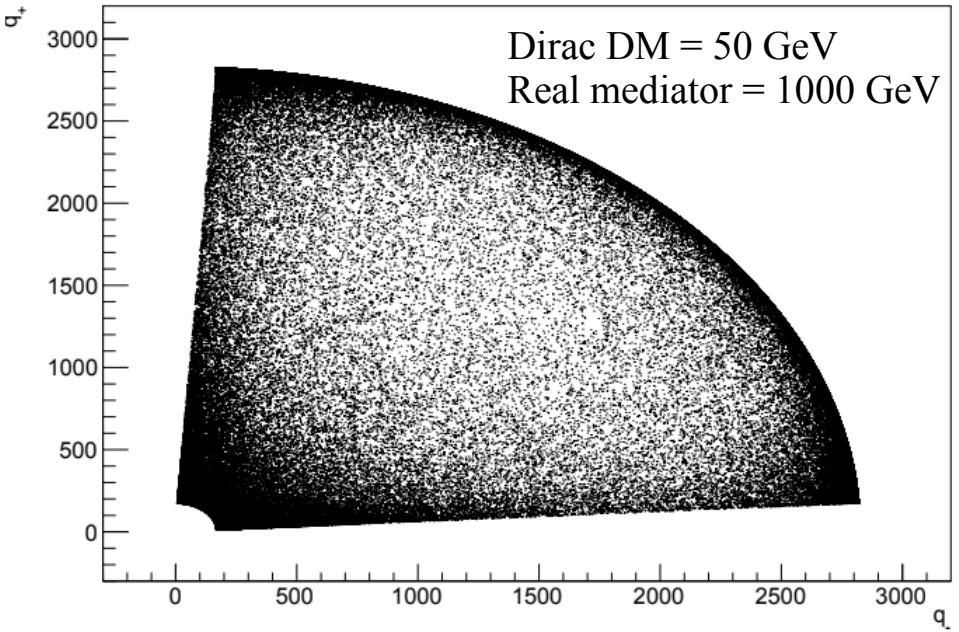
X masses set to 50 GeV
Y masses set to 1000 GeV, initial width = 50 GeV (adaptive)

Simple Dark Matter Model

SM background



SimpDM Model

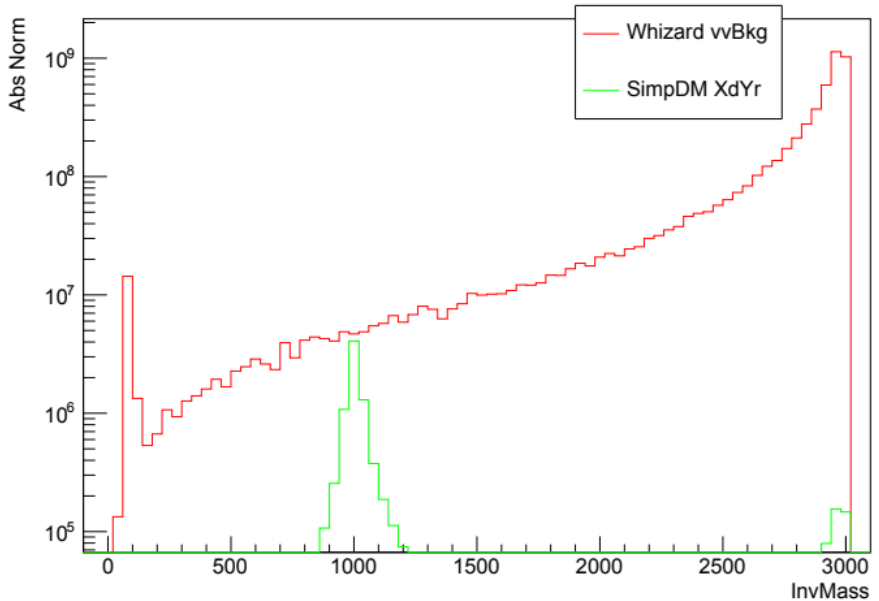


Comparison of SM *vv* background (left) and SimpDM (right) with Dirac DM particle and real mediator (using absolute normalisation)

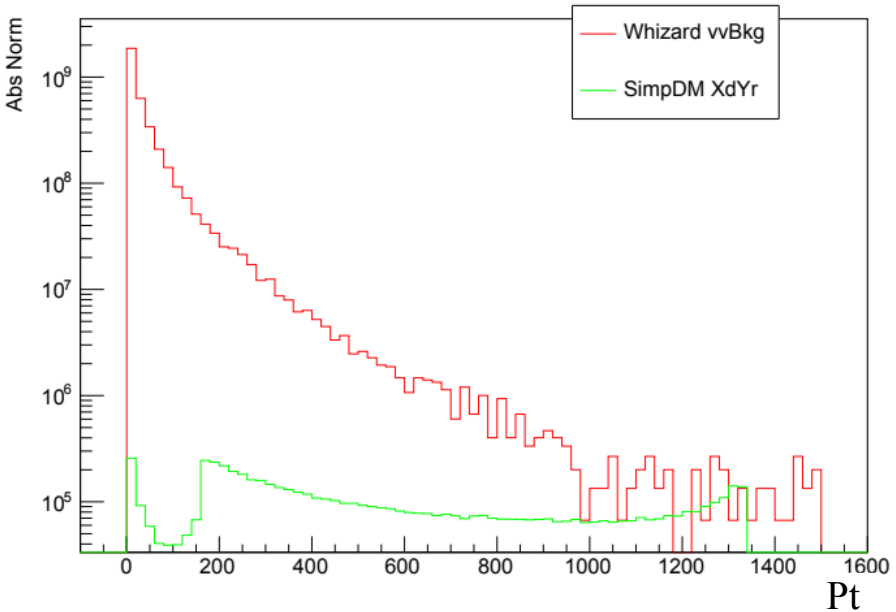
X Dirac masses set to 50 GeV; Y masses set to 1000 GeV, width = ~40 GeV

Simple Dark Matter Model

DM/fermions gen lev invariant mass after selection



Pt of the most energetic photon after selection

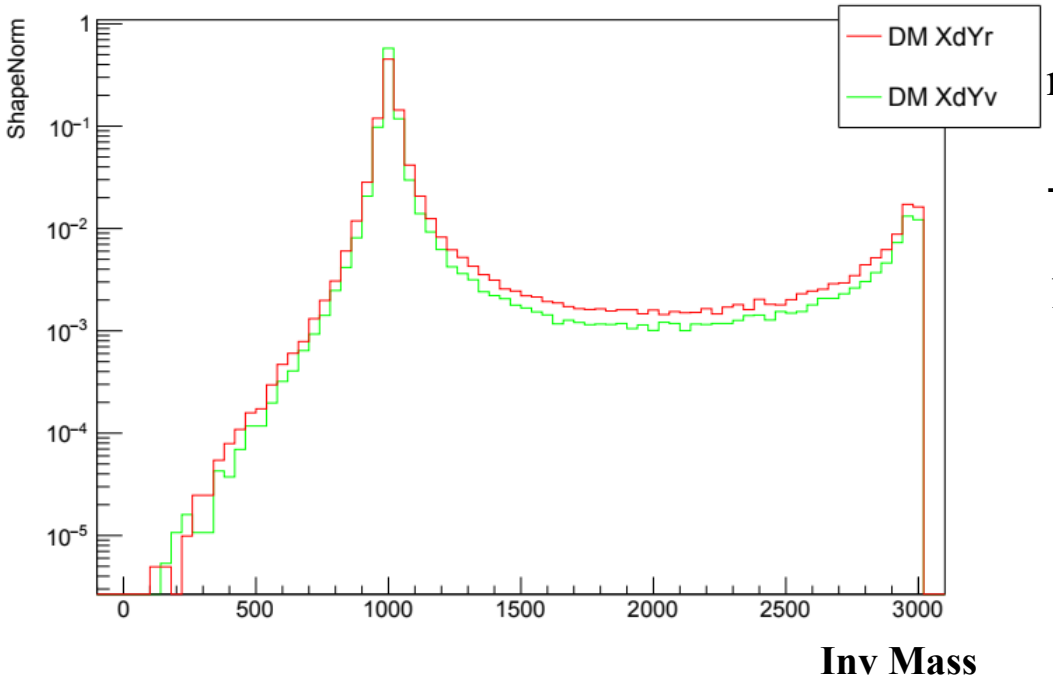


Comparison of *vv* background and SimpDM with Dirac DM particle and real mediator (using absolute normalisation)

X Dirac masses set to 50 GeV; Y masses set to 1000 GeV, width = ~40 GeV

Simple Dark Matter Model

DM gen level invariant mass after selection



Two models comparison:

- red:

50GeV Dirac DM and 1 TeV real (scalar) mediator with width ~40 GeV

XY coupling set to 1

- green:

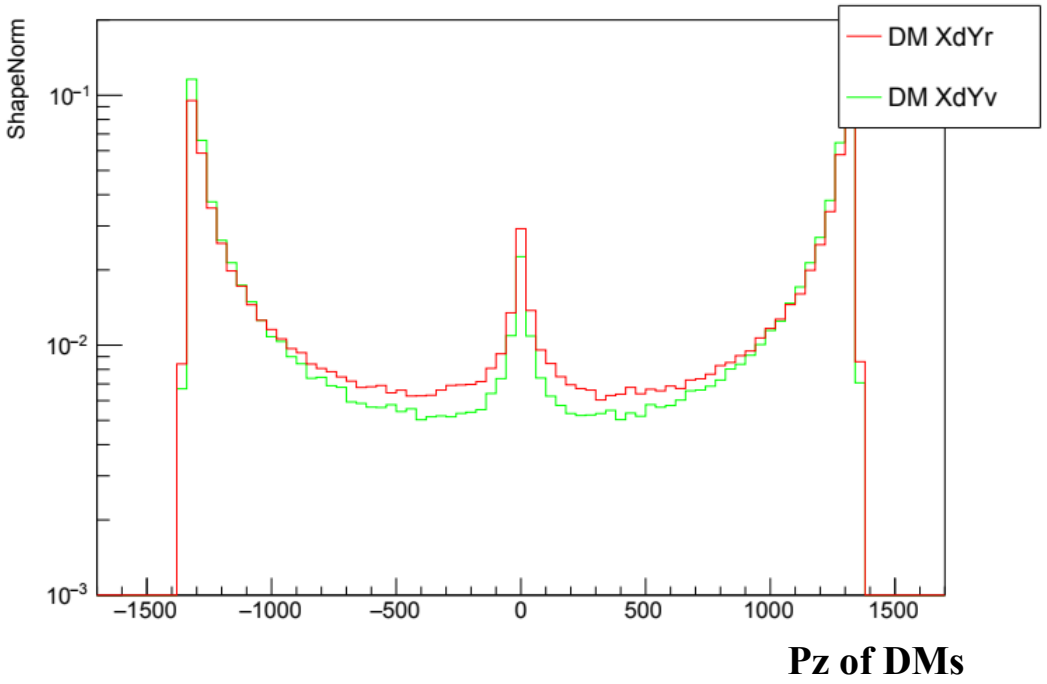
50 GeV Dirac DM and vector mediator of 1TeV with width ~30 GeV

XY coupling set to 1

Distributions depends on **mediator masses, widths and couplings**

Simple Dark Matter Model

DM gen level Pz after selection



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XY coupling set to 1

- green:

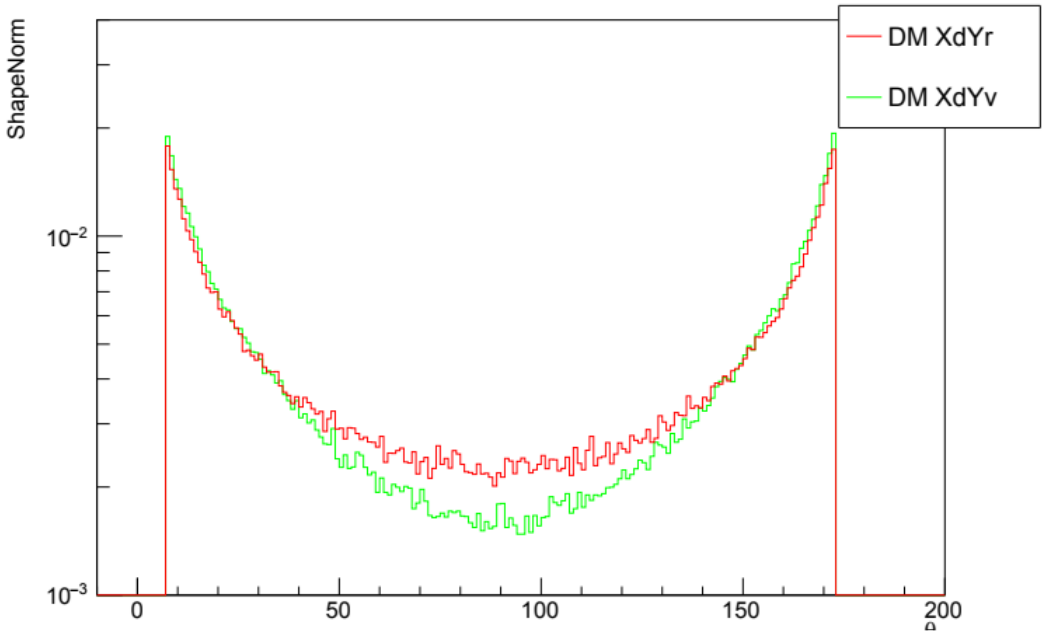
50 GeV Dirac DM and vector mediator of 1TeV with width ~30 GeV

XY coupling set to 1

Distributions depends on **mediator masses, widths and couplings**

Simple Dark Matter Model

Theta of the most energetic photon after selection



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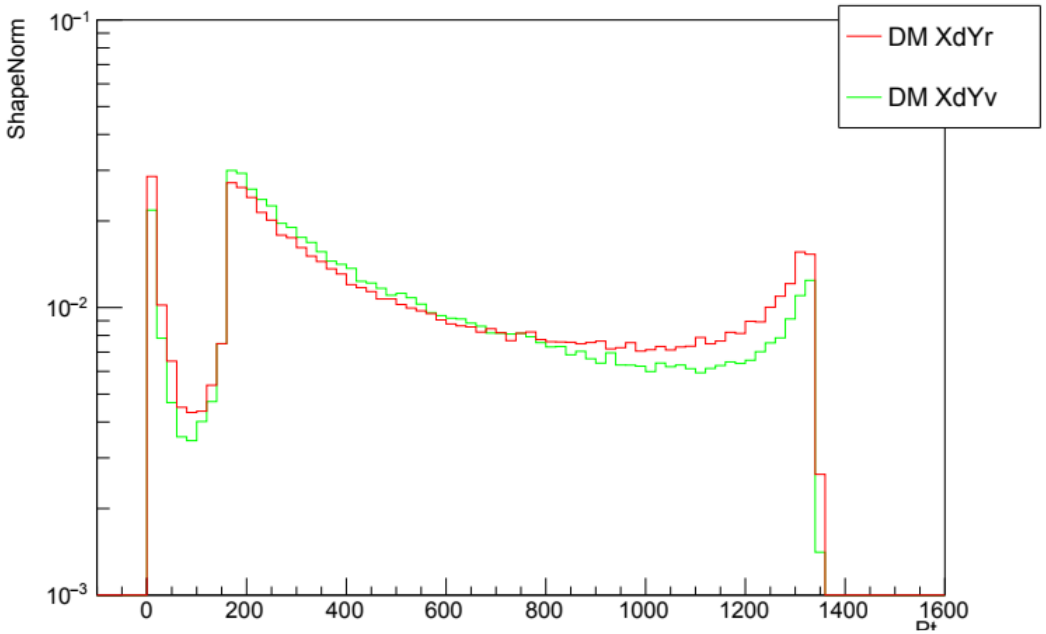
Distributions depends on **mediator masses, widths and couplings**

Simple Dark Matter Model

Pt of the most energetic photon after selection



Pt of #1 photon

Two models comparison:

- red:

50GeV Dirac DM and 1 TeV real (scalar) mediator with width ~40 GeV

XY coupling set to 1

- green:

50 GeV Dirac DM and vector mediator of 1TeV with width ~30 GeV

XY coupling set to 1

Distributions depends on **mediator masses, widths and couplings**

Conclusions & Outlook

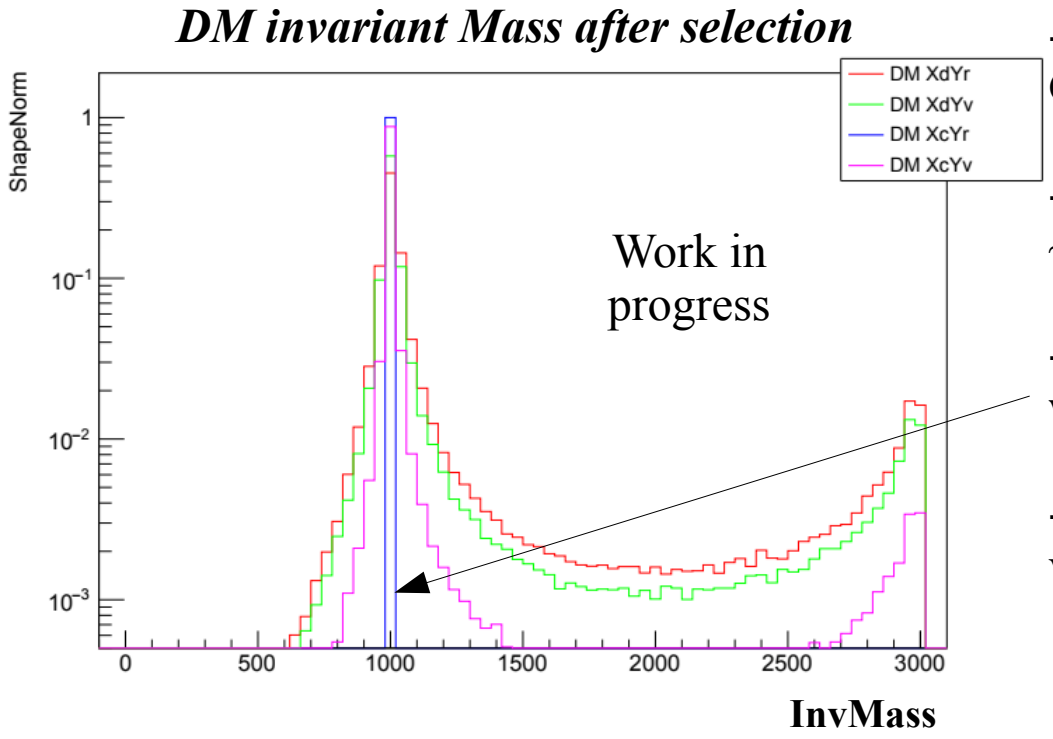
- Merging ISR photons with ME-pht and avoiding double counting at the same time works fine
- Very good agreement between Whizard and semi-analitical e+e- LEP-tuned KKMC in the central detector region
- Simple Dark Matter machinery passed first tests and is ready to be used in further analysis

  - Lets see how this works with beam spectra, BeamCal to reduce Bhabha...

Thank you for your attention!

Backups

Simple Dark Matter Model



More models comparison:

- red: X=50 GeV Dirac, Y=1 TeV real, width ~40 GeV; X-to-Y coupling set to 1

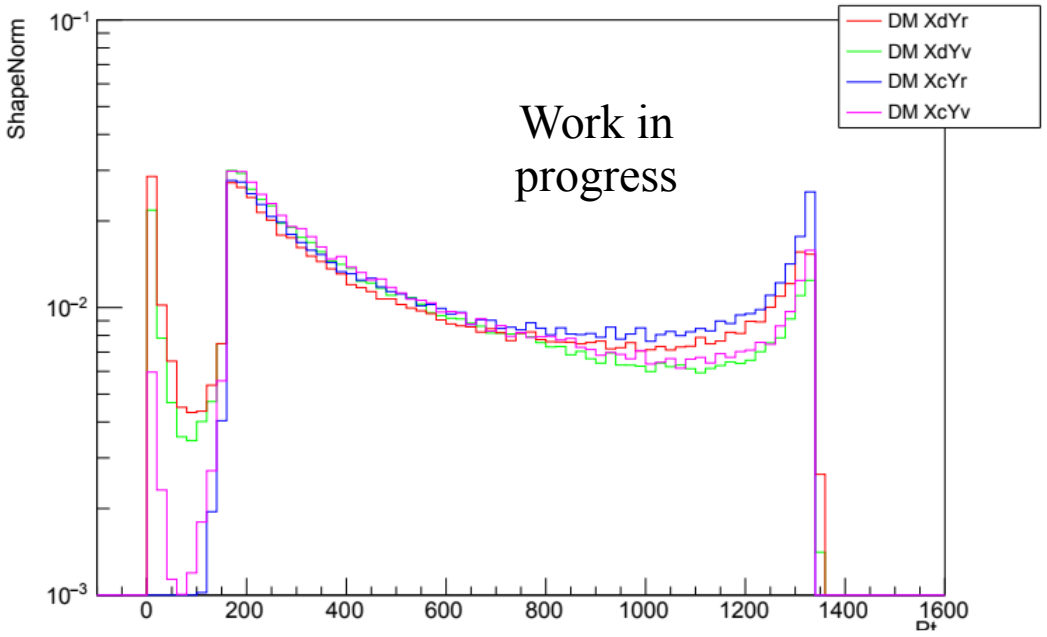
- green: X=50 GeV Dirac, Y=1TeV vector, width ~30 GeV; X-to-Y coupling set to 1

- blue: X=50 GeV complex DM, Y=1TeV real, **width ~MeV**; X-to-Y coupling 1 GeV

- magenta: X=50GeV complex DM, Y=1TeV vector, width 6.5 GeV, XY-coupl =1

Simple Dark Matter Model

Pt of the most energetic photon after selection



Pt of #1 photon

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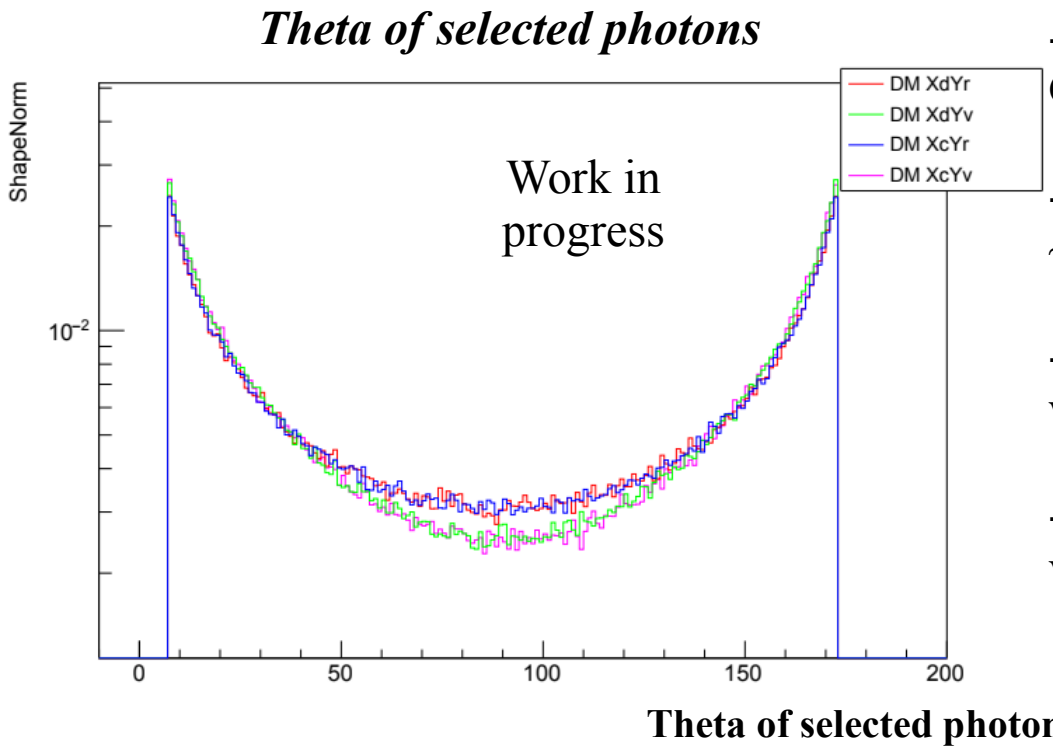
Simple Dark Matter Model



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- green: X=50 GeV Dirac, Y=1TeV vector, width ~30 GeV; X-to-Y coupling set to 1

- blue: X=50 GeV complex DM, Y=1TeV real, width ~MeV; X-to-Y coupling 1 GeV

- magenta: X=50GeV complex DM, Y=1TeV vector, width 6.5 GeV, XY-coupl =1