Search for a Self Interacting Dark Mater at the CMS Experiment

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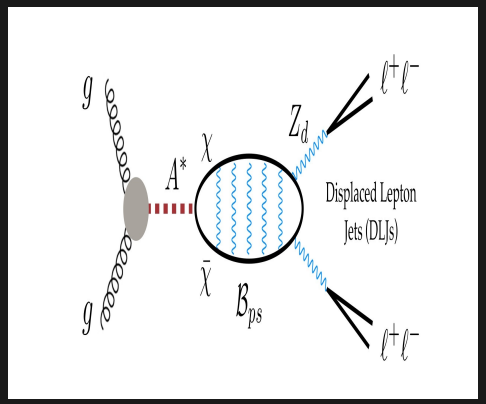
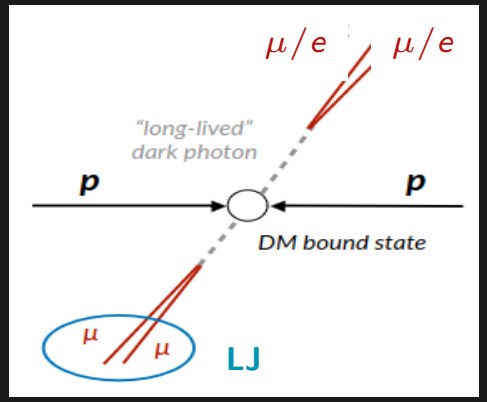
Self Interacting Dark Matter Model

1. Light $Z_d \rightarrow$ Boosted Z_d
2. Small Z_d - SM Coupling $\rightarrow$ Long-Lived Z_d



Displaced decays of boosted $Z_d \rightarrow$ Displaced, collimated leptons (Displaced Lepton Jets (LJs))



Free Parameters:

- Bound state mass (m_B)
- Dark photon mass (m_{Z_d})
- Kinetic mixing between Z_d and SM, ϵ

Reconstruction Objects:

- PF electrons
- PF Photons
- PF Muons
- DSA Muons

Signal:

- m_B: from 100 to 1000 GeV.
- m_{Z_d}: from 0.25 to 5 GeV.
- Z_d L_{xy}: from 0.3 to 300 cm.

Lepton Jets (LJs)

- Group of collimated leptons in a tight cone.
- We apply anti- k_T clustering ($\Delta R = 0.4$) to **PF** e**, PF** γ**, PF** μ and **DSA** μ.

Conditions to reconstruct an LJ:

- $|\eta| < 2.4$
- $p_T > 30$ GeV
- $\sum Q_\mu = 0$ (to prevent b-quark cascade decays)

Object Cuts	$\eta <$	$p_T >$	ID	Isolation
PF e	2.4	10 GeV	Loose	Loose
PF γ		20 GeV	Loose	Loose
PF μ		5 GeV	Loose	None
DSA μ		10 GeV	DSA	None

Categories of LJs:

- $e\gamma$ ($N_\mu = 0$)
- μ ($N_\mu >= 1$)

Events Categories:

- 4μ: 2 μ-type LJs
- $2\mu 2e$: 1 $e\gamma$ -type LJ and 1 $\mu-$ type LJ

Distribution Without Any Cuts

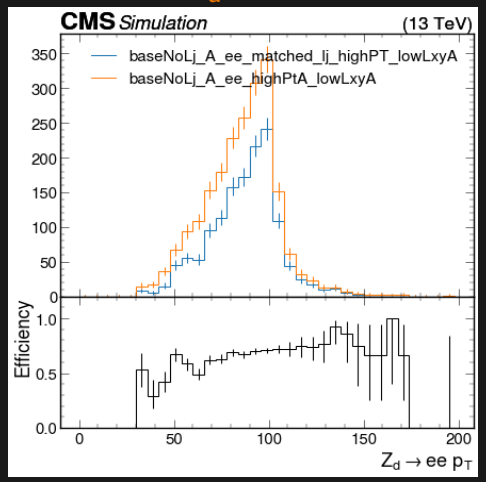
$e\gamma$ Lepton Jet Reconstruction Efficiency

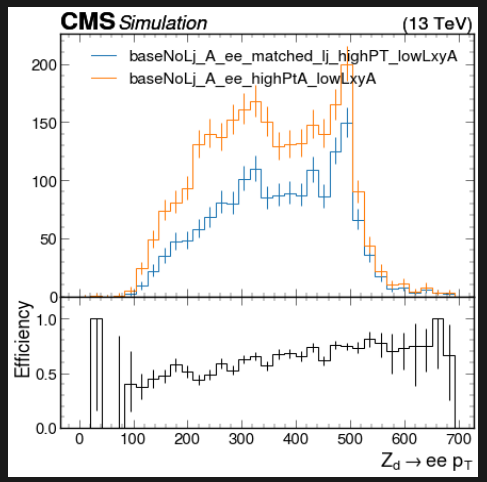
Dark Photon p_T

$L_{xy} < 150$ cm

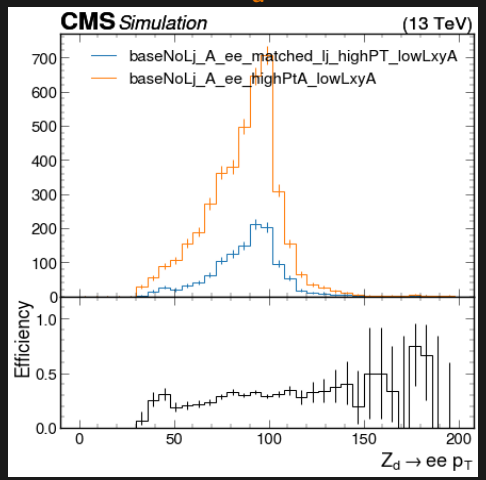
$Z_d \to ee$, $Z_d < L_{xy} > = 300$ cm

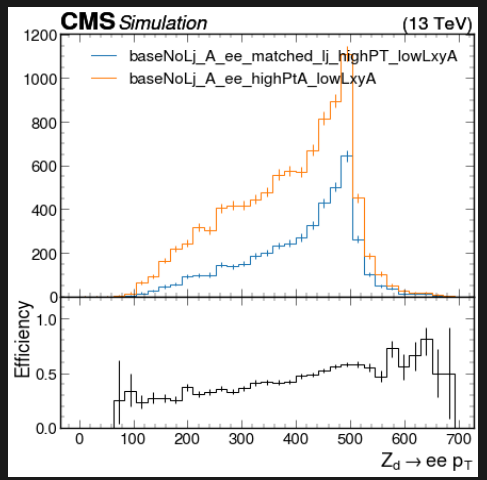
$m_{Z_d} = 0.25$ GeV (more collimated)





$m_{Z_d} = 5$ GeV (less collimated)





$m_B = 200$ GeV

$m_B = 1000$ GeV

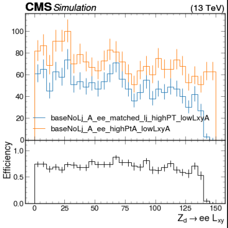
Note: The x ranges are different in these plots

- We see a sharp turn-on at 30 GeV, the cut on p_T we applied on the LJs.
- For more collimated leptons, efficiency is more or less constant after $p_T > 30$ GeV.
- For less collimated leptons, as the p_T increases, the efficiency increases.
- Overall lower efficiency for the less collimated leptons.

Z_d L_{xy}

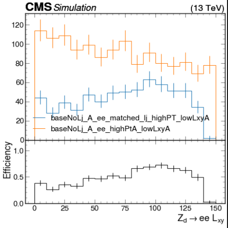
Z_d $p_T > 30$ GeV

$Z_d \to \mu\mu$, $m_B = 200$ GeV, $Z_d < L_{xy} > = 300$ cm

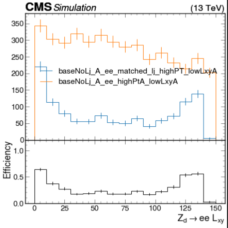


m_{Z_d} = 0.25 GeV

(more collimated)



m_{Z_d} = 1.2 GeV



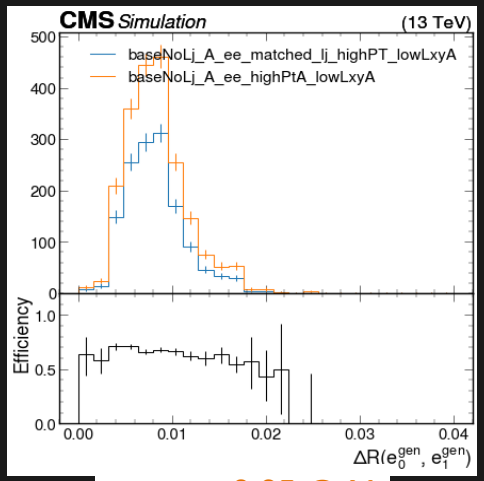
m_{Z_d} = 5 GeV

(less collimated)

$\Delta R(e_0^{gen}, e_1^{gen})$

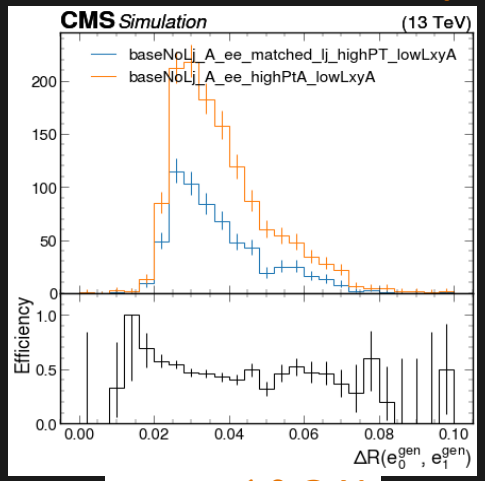
Z_d $p_T > 30$ GeV, Z_d $L_{xy} < 150$ cm

$Z_d \rightarrow ee$, $m_B = 200$ GeV, $Z_d < L_{xy} > = 300$ cm

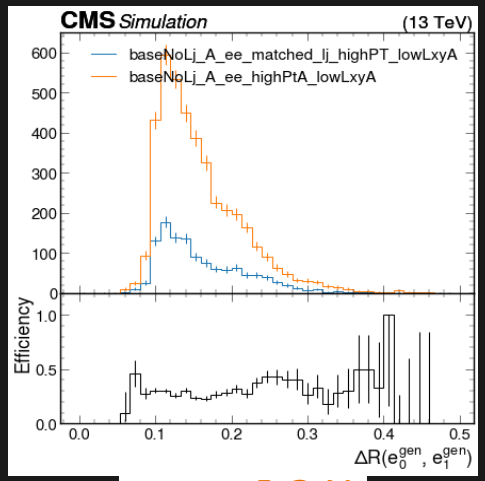


$m_{Z_d} = 0.25$ GeV

(more collimated)



$m_{Z_d} = 1.2$ GeV



$m_{Z_d} = 5$ GeV

(less collimated)

- We see non-zero efficiency in the whole range of ΔR.
- Efficiency is not changing much as a function of ΔR.
- Overall lower efficiency for less collimated electrons as we saw earlier in the L_{xy} plot.

Note: The x ranges are different in these plots

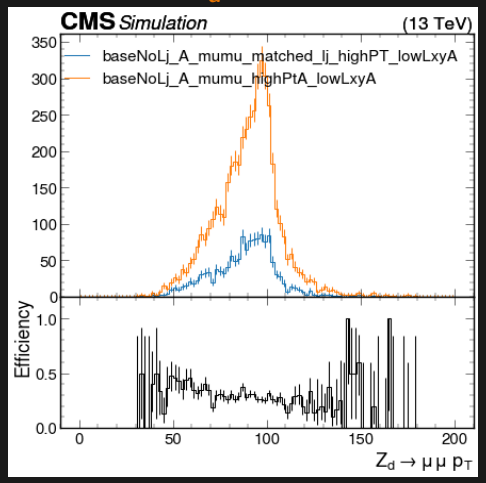
μ Lepton Jet Reconstruction Efficiency

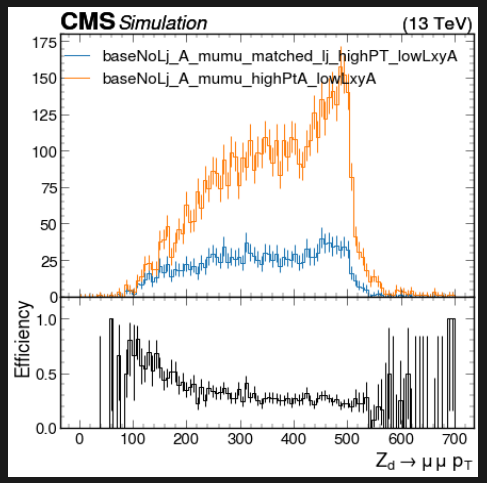
Z_d p_T

$L_{xy} < 400$ cm

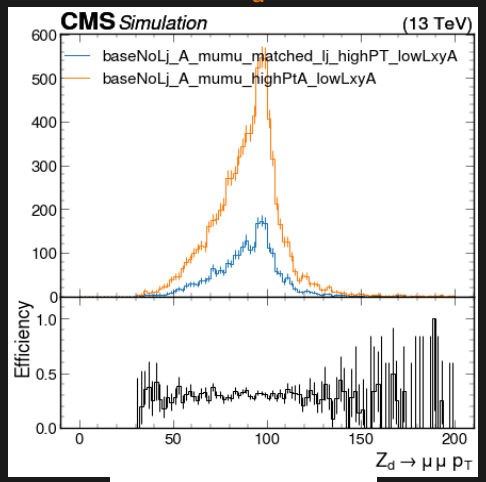
$Z_d \to \mu\mu$, $Z_d < L_{xy} > = 300$ cm

$m_{Z_d} = 0.25$ GeV (more collimated)

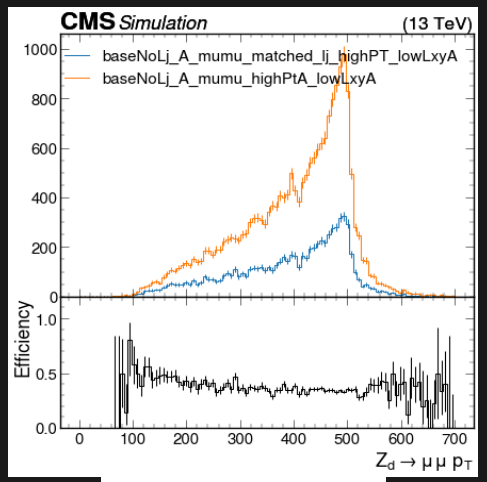




$m_{Z_d} = 5$ GeV (less collimated)



$m_B = 200$ GeV



$m_B = 1000$ GeV

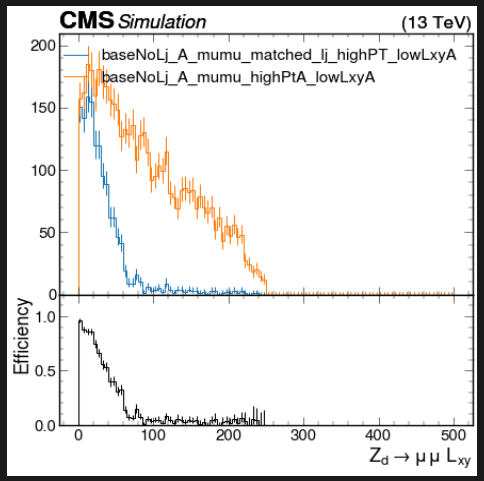
- We see a sharp turn-on at 30 GeV, the cut on p_T we applied on the LJs.
- After the turn-on, efficiency slightly decreases as the p_T increases for both cases.

Note: The x ranges are different in these plots

Z_d L_{xy}

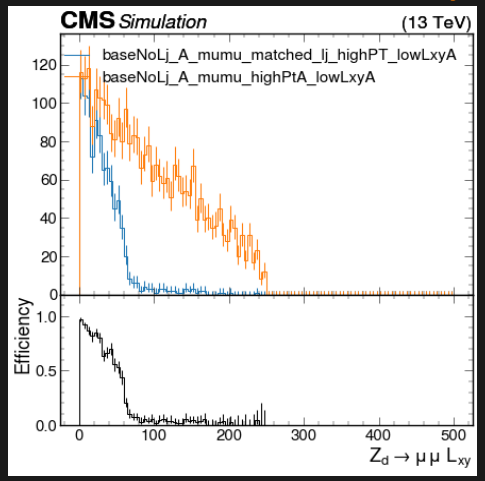
Z_d $p_T > 30$ GeV

$Z_d \to \mu\mu$, $m_B = 200$ GeV, $Z_d < L_{xy} > = 300$ cm

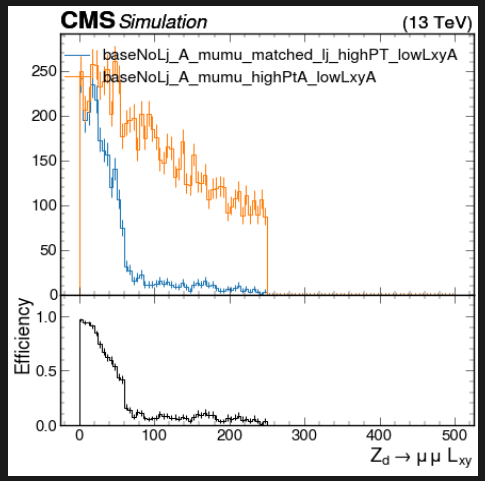


$m_{Z_d} = 0.25$ GeV

(more collimated)



$m_{Z_d} = 1.2$ GeV



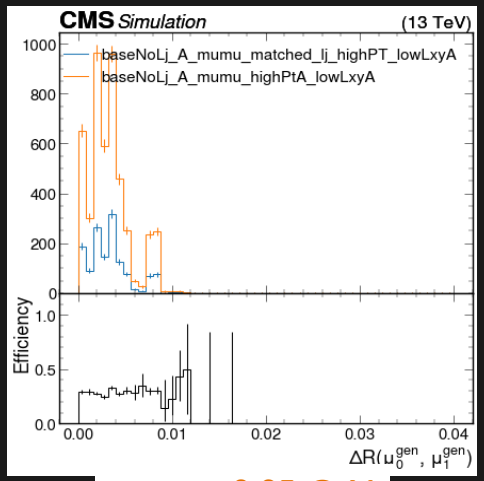
$m_{Z_d} = 5$ GeV

(less collimated)

$\Delta R(e_0^{gen}, e_1^{gen})$

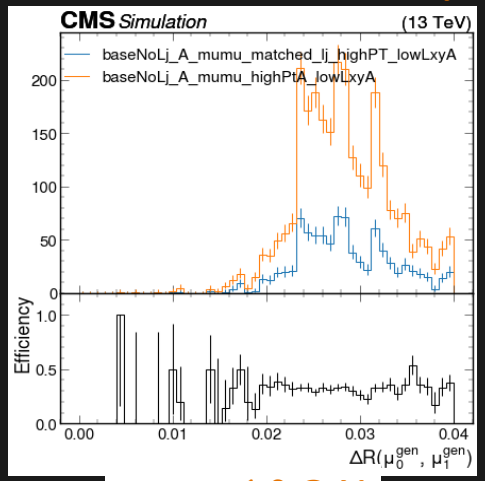
$Z_d\ p_T > 30$ GeV, $Z_d\ L_{xy} < 150$ cm

$Z_d \to ee$, $m_B = 200$ GeV, $Z_d < L_{xy} > = 300$ cm

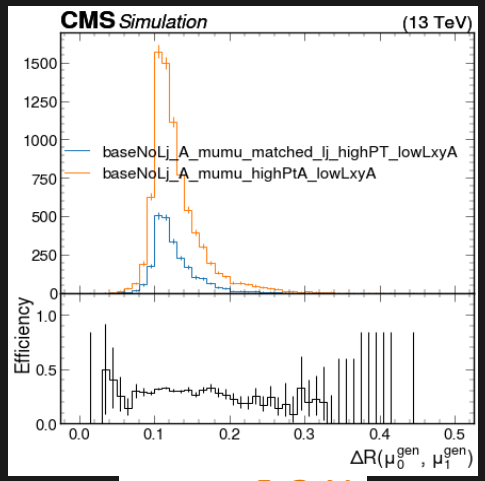


$m_{Z_d} = 0.25$ GeV

(more collimated)



$m_{Z_d} = 1.2$ GeV



$m_{Z_d} = 5$ GeV

(less collimated)

- We see non-zero efficiency in the whole range of ΔR.
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