New approach to DM searches with mono-photon signature

J. Kalinowski[*], W. Kotlarski[+], **P. Sopicki**[*], K.Mękała, A. F. Żarnecki[*]
[*] *University of Warsaw*
[+] *Technische Universität Dresden*

EF10 DM@Colliders
Topical meeting on LOIs on WIMPs and other models
10.09.2020

Previously on Snowmass...

https://indico.fnal.gov/event/43959/contributions/190182/

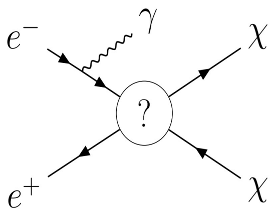
Details:
Eur. Phys. J. C (2020) 80: 634
arXiv:2004.14486

New approach to DM searches

Common approach:
- setting limits on the mediator mass for a given coupling structure/values

- This approach is suitable, if one can assume $M_{med} \gg \sqrt{s}$

Different approach needed for mediator masses of or below $\sim \sqrt{s}$



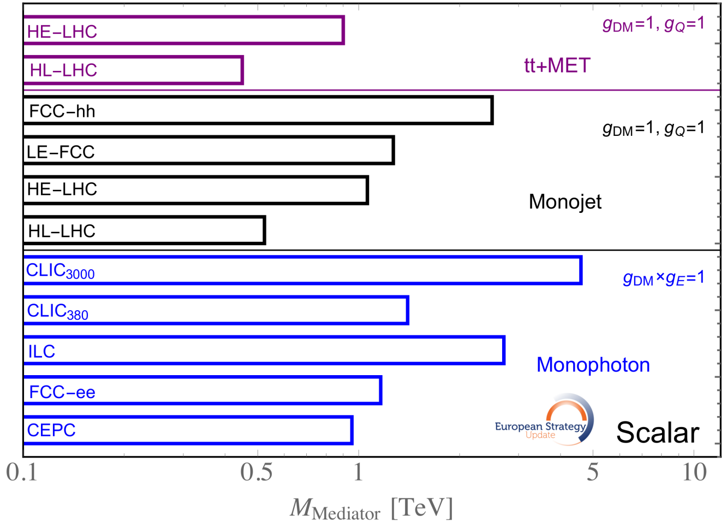
Experimental-like approach:

- set limits on the DM production cross section as a function of the assumed **mediator mass and mediator width**

- depends on the assumed **coupling structure**, but exact coupling values not relevant

- model independent upper limits on σ in this method can be then interpreted in different models

arXiv:1910.11775



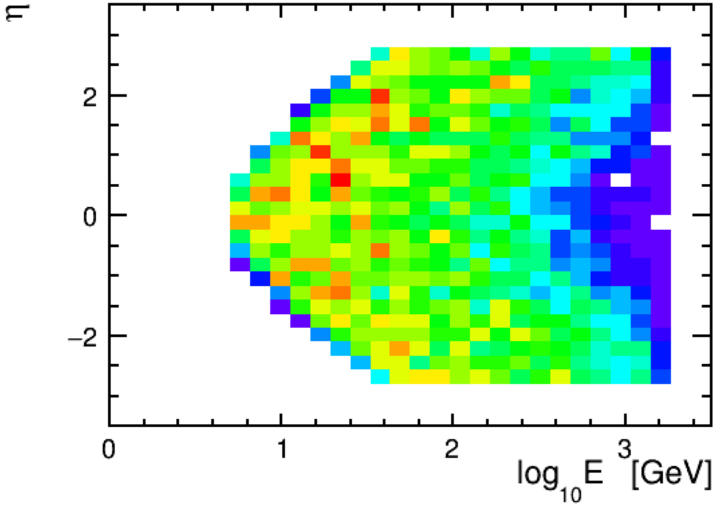
New approach to DM searches

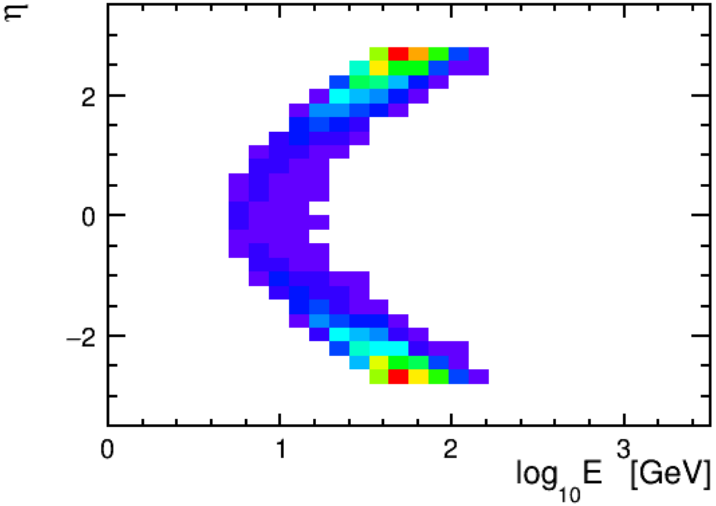
- Experimental approach:
  consider 2-D distribution of mono-photon event

Event selection: single γ with 7°< θ <173° and pT > 5 GeV, no other detector activity

- Main backgrounds @ 3TeV CLIC:

$e^+e^- \rightarrow \nu\bar{\nu}$





$e^+e^- \rightarrow e^+e^-$

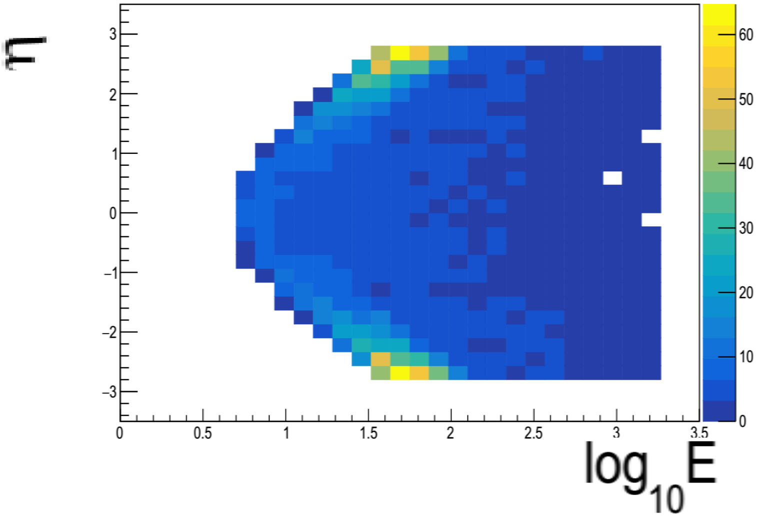
Samples to be merged

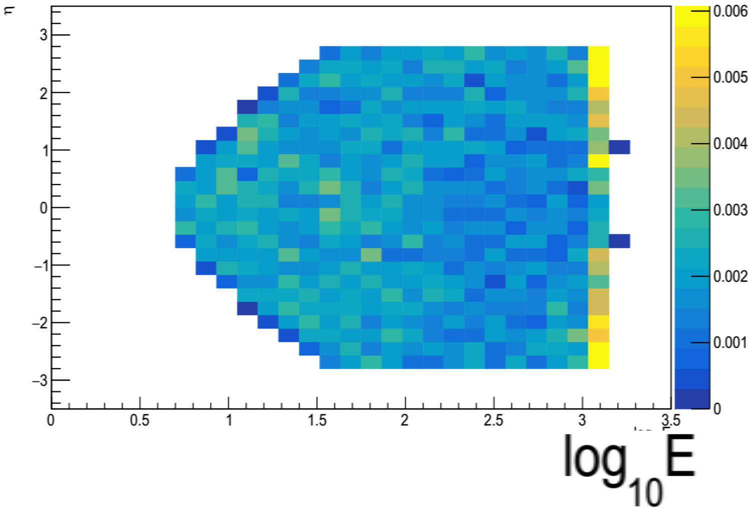
New approach to DM searches

- Experimental approach:
  consider 2-D distribution of mono-photon event

Event selection: signle γ
7°< θ <173° and pT > 5 GeV,
no other detector activity

- Main backgrounds vs signal @ 3TeV CLIC
  $e^+e^- \rightarrow \nu\bar{\nu}$ + $e^+e^- \rightarrow e^+e^-$ M_{DM}=50GeV M_{med}=1TeV Γ_{med}=50GeV





New approach to DM searches

- Experimental approach:
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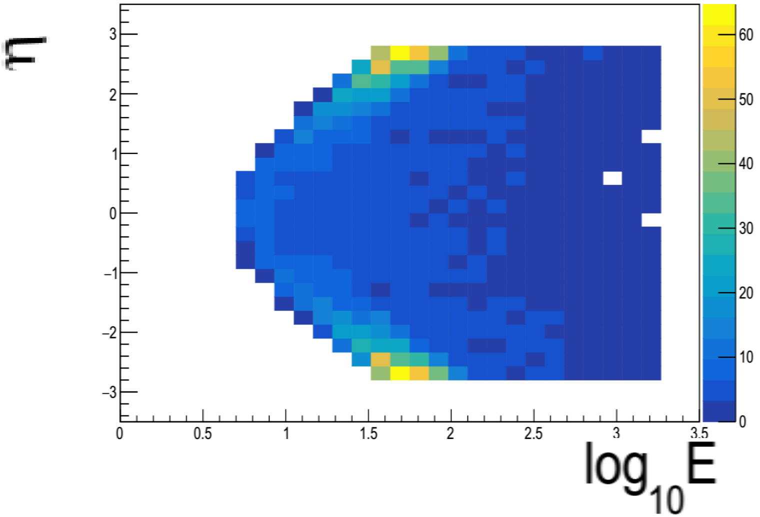
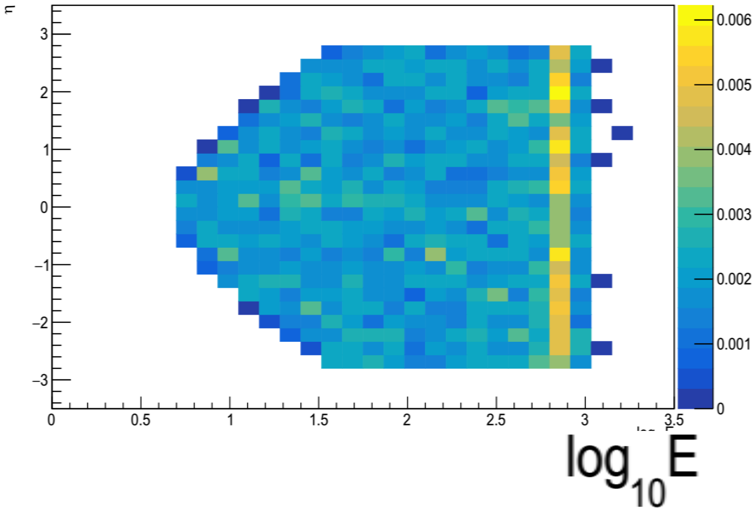
- Main backgrounds vs signal @ 3TeV CLIC
  $e^+e^- \rightarrow \nu\bar{\nu}$ + $e^+e^- \rightarrow e^+e^-$ M_{DM}=50GeV M_{med}=2TeV Γ_{med}=50GeV

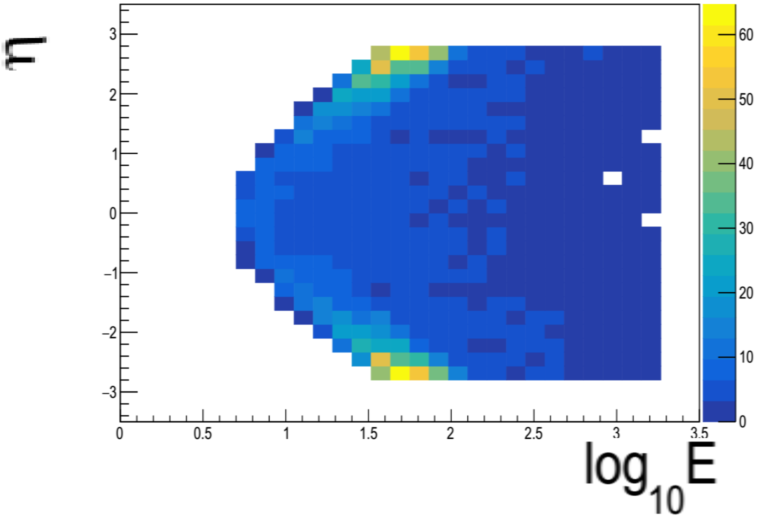


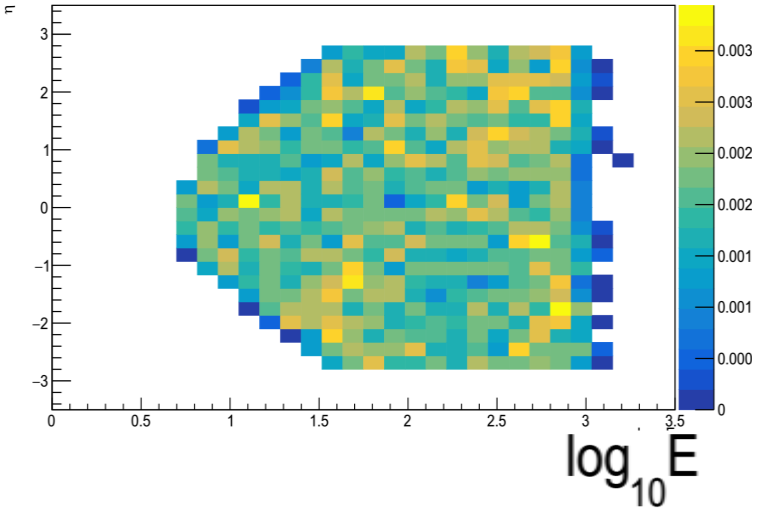


New approach to DM searches

- Experimental approach:
  consider 2-D distribution of mono-photon event

- Main backgrounds vs signal @ 3TeV CLIC
  $e^+e^- \to \nu\bar{\nu}$ + $e^+e^- \to e^+e^-$ M_{DM}=50GeV M_{med}=2TeV Γ_{med}=500GeV

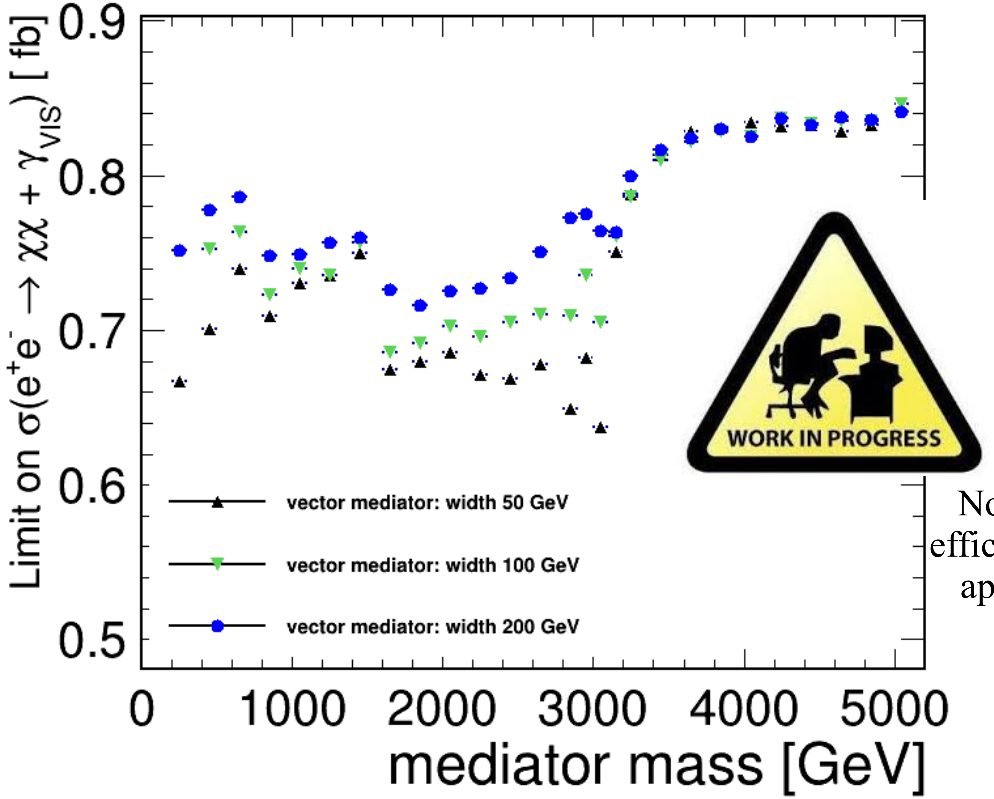




Upper Limit on $\sigma(e^+e^- \rightarrow \chi\chi + \gamma)$
as a function of a vector mediator mass
for 3 TeV collisions with +80%
polarisaton for electrons

- calculations with CLs method

- with smaller width of the mediator the limit gets stronger at the threshold



No cuts efficiencies applied

Conclusions

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Applied to Dark Matter analysis one can get model independent limits on cross sections of various scenarios

- **Wider range of mediator masses available**
- **Exact coupling values not needed**
- **Nice signal-background separation (i.e. RooStat test with hipothesis signal+bckg) and impact of the mediator width**

Upper limits on cross section $\sigma(e^+e^- \rightarrow \chi\chi + \gamma)$ are quite stable and flat even for ligther mediators

More to come:

- **different coupling structures**
- **different collider energies and polarisation**
- **include detector effects using Delphes**

Backup

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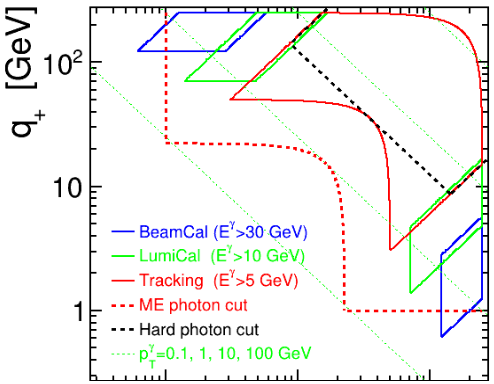
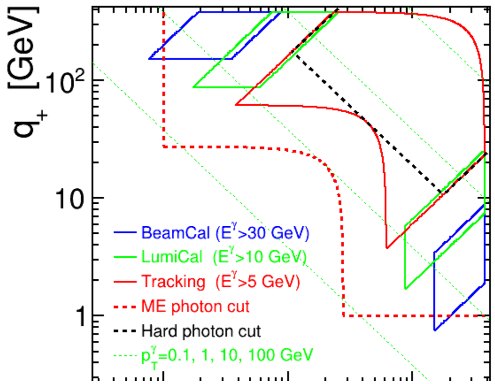
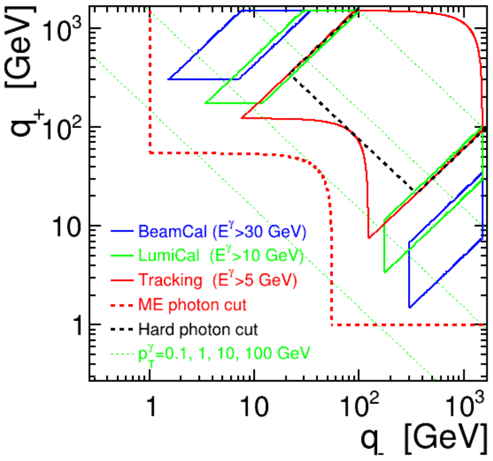
√s = 250 GeV



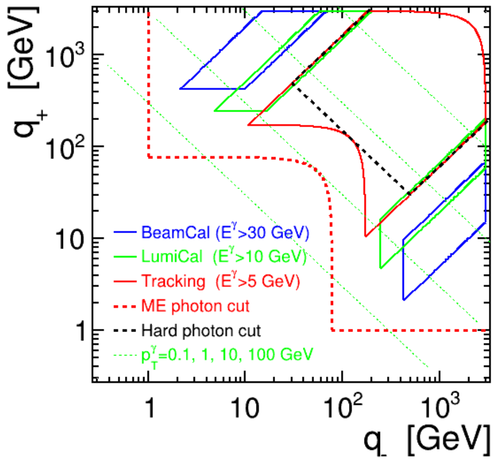
√s = 380 GeV



√s = 1.5 TeV



√s = 3 TeV



WIHZARD mono-photons: Bhabha

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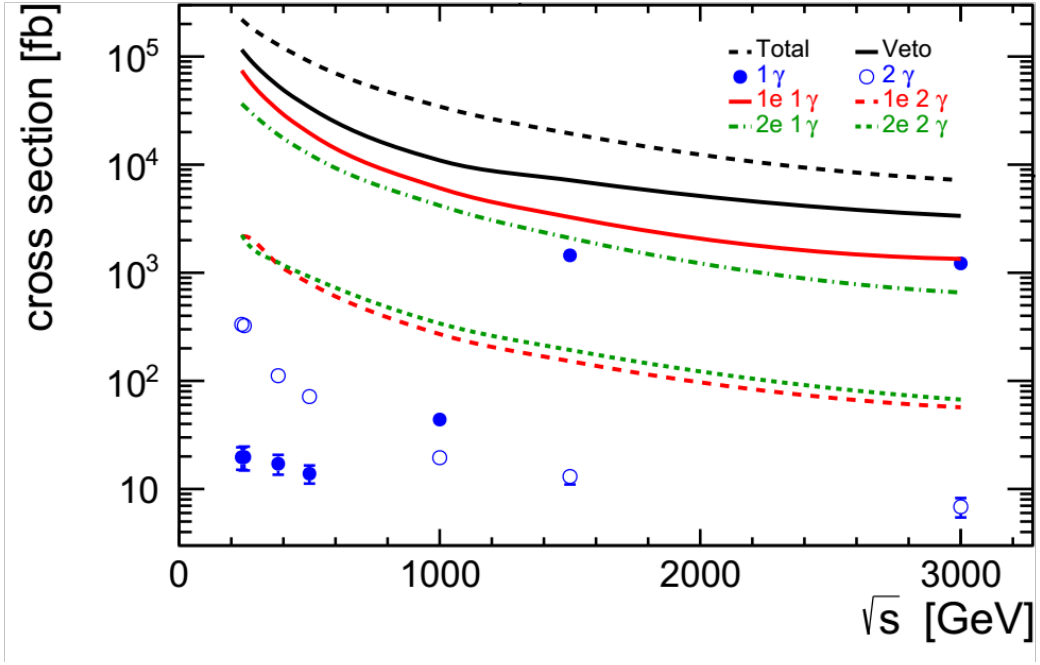
$\sqrt{s}[GeV]$	Whizard-2.8 $\sigma(e^+e^- \to e^+e^- + N\gamma)$ [fb] $e^+e^- + \gamma_{ME}$	$e^+e^- + 2\gamma_{ME}$	$e^+e^- + 3\gamma_{ME}$	$\sigma(e^+e^- \to e^+e^- + N\gamma)$ [fb] after ISR rejection
240	236000	26100	1500	220000
250	224000	24900	1400	209000
380	140000	18400	1200	128000
500	100000	14600	1100	89800
1000	39800	7700	700	34400
1500	23000	5300	500	19400
3000	8800	2700	300	7200

$\sqrt{s}[GeV]$	$q_{min}[GeV]$	Whizard-2.8 $\sigma(e^+e^- \to e^+e^- + N\gamma)$ [fb] $e^+e^- + \gamma_{ME}$	$e^+e^- + 2\gamma_{ME}$	$e^+e^- + 3\gamma_{ME}$	$\sigma(e^+e^- \to e^+e^- + N\gamma))$ [fb] after ISR rejection
380	q_{min}=0.1	141000	29500	3200	123000
	q_{min}=0.5	140000	21700	1500	126000
	q_{min}=1	140000	18400	1200	128000
	q_{min}=5	141000	10000	400	131000
	q_{min}=10	140000	5100	170	145000
	q_{min}=50	11200	160	2	11000
3000	q_{min}=0.1	8900	3700	420	6400
	q_{min}=0.5	9000	3000	230	7000
	q_{min}=1	8800	2700	300	7200
	q_{min}=5	8900	2000	140	7600
	q_{min}=10	8900	1300	90	7500
	q_{min}=50	7000	300	10	6100



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Which was a follow up:
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