Mono-photon DM and it’s Bhabha background studies*

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**brainstorming intent*

Some intro...

- Controling Bhabha σ singularities
  - e- or e+ too soft or too collinear to each other
  - ME-photon singularity and the collinear singularity with the beam
  - collinear singularity between final state leptons and photon
  - **singularity of the final state leptons to the beam axis**
    - Can be done with Mandelstam-t cut or pt/theta of the final state lepton
    - Presented approach inherited from whizard 1 analyses

```
cuts =
   all M > 4 GeV [e1,E1]
 and
 let subevt @meA = select if Index > 2 [A]
   in
     all Pt > 10 [@meA]
 and
   all M > 4 GeV [@meA,e1:E1]
 and
     all M < -4 [incoming e1, e1]
 and
   all M < -4 [incoming E1, E1]
```

Lets call this a ‘standard’ set of cuts

Dilemma

In case of mono-photon DM analysis:

essentially we should not cut on the electrons but not doing so makes the (whizard-2.7)
σ calculations diverge

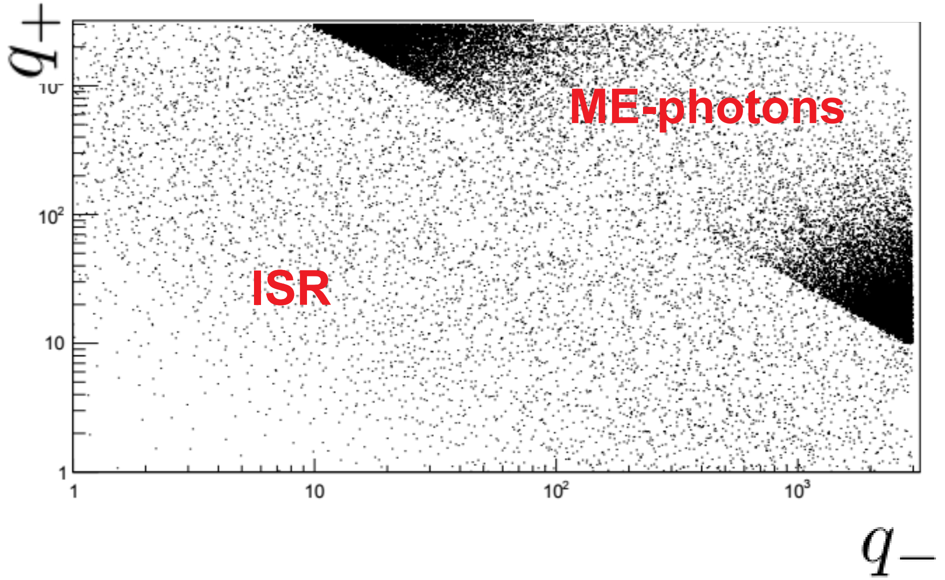
‘Standard’ approach

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

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

- **In case of mono-photon DM analysis:**
  - Not using a t-cut converged only
  - σ converges but

T-cut	cross section
M < -4	3.29775E+04
M < -0.1	6.24049E+04
M < -0.01	8.01619E+04



Cross checks...

- If we want leptons going into the pipe (theta < 0.01 mrad) => photons pt can't get larger than 30GeV (for 3TeV CLIC case)
  - Checked: σ zero if pt>30GeV required
- This weekend idea: Calculations show that it is possible to get hard photons with an electron that radiated it going into the beam pipe. That would require large Q transfer so maybe that would work:

  (all M < -4 [incoming e1, e1]

  or

  all M < -4 [incoming E1, E1])

  - More stable but still ~20% diffrencies between iterations
  - Added an arbitral-test cut on electron or positron Pt > 10 Gev – same ~20% diffrencies

Conclusions & Outlook

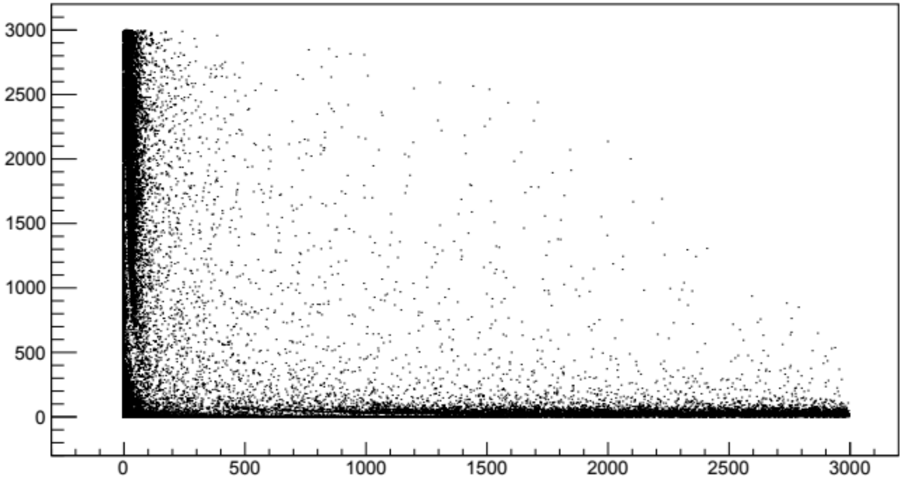
- Is there a way to properly treat the t-singularity in whizard-2.7?
  - Otherwise, some external MCs or tools would be needed to estimate the (missing) Bhabha background

Backups

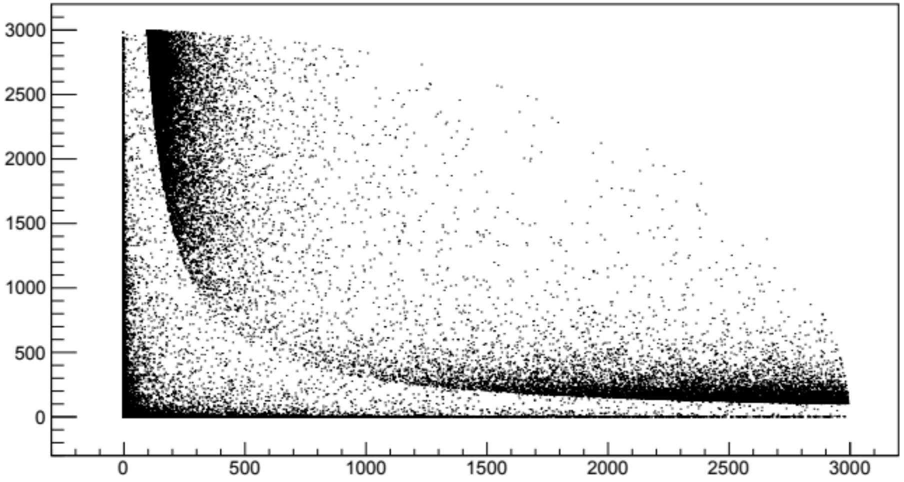
‘standard’ sets

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

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



Photon Pt > 10 GeV



Photon Pt > 100 GeV

```
( all  M < -4 [incoming e1, e1]
  or
    all M < -4 [incoming E1, E1] )
  and
    all M > 4 GeV [e1,E1]
  and
  let subevt @meA = select if Index > 2 [A]
in
    all Pt > 30 [@meA]
  and
    all M > 4 GeV [@meA,e1:E1]
```

10	199290	6.9788809E+03	2.21E+02	3.17	14.16	0.09	0.90	10
11	19836	9.4429812E+03	1.53E+03	16.25	22.88*	0.17		
12	19822	1.0122919E+04	1.03E+03	10.17	14.32*	0.17		
13	19806	9.9316900E+03	1.44E+03	14.54	20.46	0.38		
14	19794	1.0480502E+04	6.12E+02	5.84	8.22*	0.40		
15	19782	1.0819644E+04	7.85E+02	7.26	10.21	0.33		
16	19768	1.5623478E+04	3.08E+03	19.72	27.73	0.16		
17	19754	1.2075112E+04	4.01E+02	3.32	4.67*	0.63		
18	19744	1.2298021E+04	4.69E+02	3.81	5.35	0.59		
19	19728	1.3154269E+04	3.52E+02	2.68	3.76*	1.05		
20	19716	2.1806455E+04	8.36E+03	38.34	53.84	0.08		
20	197750	1.2073814E+04	2.00E+02	1.65	7.35	0.08	3.38	10
21	19704	1.6870530E+04	2.19E+03	12.98	18.21*	0.12		
22	19694	1.5844272E+04	1.73E+03	10.91	15.31*	0.20		
23	19682	1.4103637E+04	4.62E+02	3.28	4.60*	0.67		
24	19672	1.3641028E+04	3.73E+02	2.73	3.83*	0.87		
25	19654	1.5419545E+04	1.25E+03	8.11	11.37	0.31		
26	19638	1.4992710E+04	6.56E+02	4.37	6.13*	0.58		
27	19624	1.5272014E+04	1.13E+03	7.39	10.35	0.24		
28	19608	1.5288509E+04	6.54E+02	4.28	5.99*	0.45		
29	19594	1.4338083E+04	4.07E+02	2.84	3.97*	0.89		
30	19578	1.3263624E+04	5.25E+02	3.96	5.54	0.64		
30	196448	1.4202932E+04	1.88E+02	1.33	5.88	0.64	1.56	10
31	49984	1.6258512E+04	1.06E+03	6.50	14.54	0.14		
32	49972	1.4776456E+04	3.73E+02	2.52	5.64*	0.43		
33	49956	1.3351598E+04	3.41E+02	2.55	5.71	NaN		
34	49940	1.6422424E+04	5.73E+02	3.49	7.80	0.30		
35	49928	1.3942613E+04	3.34E+02	2.39	5.35*	NaN		
36	49910	1.1720083E+04	2.74E+02	2.34	5.23*	NaN		
37	49898	1.4978540E+04	5.42E+02	3.62	8.08	NaN		
38	49886	1.0992306E+04	1.19E+02	1.08	2.41*	NaN		
39	49872	1.3589188E+04	2.66E+02	1.96	4.38	NaN		
40	49858	1.1995254E+04	1.64E+02	1.37	3.05*	NaN		
40	499204	1.2140093E+04	7.72E+01	0.64	4.49	NaN	35.16	10

```
( all  M < -4 [incoming e1, e1]
or
  all M < -4 [incoming E1, E1] )
and
  all M > 4 GeV [e1,E1]
and
  ( all Pt > 10 [e1]
  or
   all Pt > 10 [E1] )
and
let subevt @meA = select if Index > 2 [A]
in
  all Pt > 30 [@meA]
and
  all M > 4 GeV [@meA,e1:E1]
```

10	199210	7.5026603E+03	3.12E+02	4.15	18.54	0.18	0.73	10
11	19828	1.4383983E+04	5.11E+03	35.55	50.06	0.14		
12	19808	9.5572791E+03	6.72E+02	7.03	9.90*	0.38		
13	19792	2.1647919E+04	1.03E+04	47.38	66.66	0.07		
14	19772	1.0760803E+04	5.09E+02	4.73	6.66*	0.53		
15	19756	1.1318977E+04	7.34E+02	6.48	9.11	0.33		
16	19740	1.2481906E+04	9.94E+02	7.96	11.19	0.27		
17	19724	1.5092442E+04	1.93E+03	12.81	17.99	0.20		
18	19708	1.4771577E+04	1.55E+03	10.48	14.71*	0.22		
19	19696	1.4728883E+04	7.86E+02	5.33	7.49*	0.39		
20	19676	1.4583429E+04	5.17E+02	3.55	4.97*	0.75		
20	197500	1.2352106E+04	2.58E+02	2.09	9.28	0.75	6.92	10
21	19664	1.4305778E+04	6.28E+02	4.39	6.15	0.58		
22	19648	1.3888284E+04	3.80E+02	2.73	3.83*	1.00		
23	19636	2.3481999E+04	9.11E+03	38.81	54.38	0.10		
24	19620	1.4384268E+04	5.44E+02	3.78	5.30*	0.68		
25	19600	1.8722015E+04	3.83E+03	20.48	28.67	0.22		
26	19580	1.4729333E+04	6.62E+02	4.50	6.29*	0.52		
27	19564	1.4684668E+04	8.41E+02	5.73	8.01	0.57		
28	19548	1.4923613E+04	8.21E+02	5.50	7.69*	0.43		
29	19536	1.3505147E+04	3.59E+02	2.66	3.71*	1.25		
30	19524	1.5229722E+04	9.98E+02	6.56	9.16	0.44		
30	195920	1.4116171E+04	1.93E+02	1.37	6.05	0.44	1.07	10
31	49992	1.6080946E+04	1.06E+03	6.59	14.73	0.13		
32	49976	1.3123858E+04	2.42E+02	1.84	4.12*	NaN		
33	49960	1.5870853E+04	3.05E+02	1.92	4.29	0.71		
34	49944	1.4252056E+04	2.61E+02	1.83	4.09*	NaN		
35	49932	1.2535305E+04	1.55E+02	1.23	2.76*	NaN		
36	49920	1.1482203E+04	4.07E+02	3.55	7.93	NaN		
37	49904	4.5909006E+04	3.16E+04	68.77	153.62	NaN		
38	49892	1.1699374E+04	2.31E+02	1.98	4.41*	NaN		
39	49880	1.8198402E+04	5.02E+03	27.58	61.59	NaN		
40	49866	1.2499172E+04	5.01E+02	4.00	8.94*	NaN		
40	499266	1.2995665E+04	9.37E+01	0.72	5.09	NaN	19.79	10