1. Check what process gives the largest contribution to VV, Vgamma background at high MET in the electron channel in the control sample without the b-jet requirement. Consider a veto on events with e-gamma mass around the Z - does it improve the sensitivity?

In this channel $W\gamma$ strongly dominates at high MET; see Figure 1 and Table 1. Recall from the documenation a $\pm 50\%$ systematic uncertainty on the rates of $W\gamma$ and $Z\gamma$; this uncertainty results in only a 2.5–3.0% variation in the measured electron mid-ID rate scale factor, which is propogated to the final upper limits.

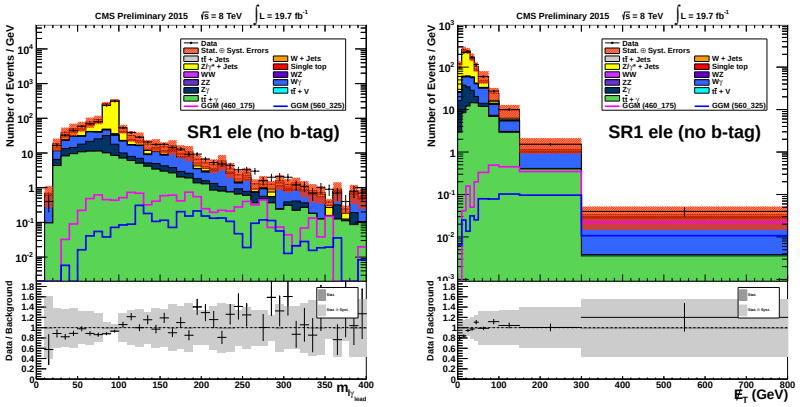

Figure 1: Plots of $m_{e\gamma}$ (left) and $\not\!\!E_T$ (right) for the electron channel in SR1 with no b-tag requirement, however the 'VV, Vγ' entry typically shown is separated into WW, WZ, ZZ, Wγ, and Zγ components. All other analysis methods are applied as usual.

Process	MET (GeV)				
	0–25	25–50	50–100	100–300	$\geq$ 300
WW	2.7	9.1	10.3	4.0	0.1
WZ	14.7	20.2	5.1	1.6	0.2
ZZ	9.5	10.1	1.4	0.3	0.0
Wγ	302.1 $\pm$ 5.0	728.5 $\pm$ 9.3	591.6 $\pm$ 10.3	202.2 $\pm$ 3.2	12.0 $\pm$ 0.3
Zγ	422.2 $\pm$ 7.0	416.2 $\pm$ 5.8	63.0 $\pm$ 1.2	6.1 $\pm$ 0.1	0.0

Table 1: Expected yields for the 'VV, Vγ' background processes in the sample of events used to derive the electron mis-identification rate, the electron channel in SR1 with the b-tag requirement removed. Only statistical errors are presented here, which is negligable for those not shown.

For a veto on $m_{e\gamma}$, in short it increases sensitivity to absolute event yields

but does not end up changing the sensitivity of the analysis.

Such a cut removes mostly $Z\gamma$ which has a lower MET, and changes the shape of the total background to be more signal-like. This should in principle reduce sensitivity slightly, but the end result of the limits show this change isn't enough to notice. For a cut rejecting $m_{e\gamma}$ within 10 GeV of the nominal Z mass (81–101 GeV), Figure 2 compares the MET shapes and the expected exclusion for only this channel.

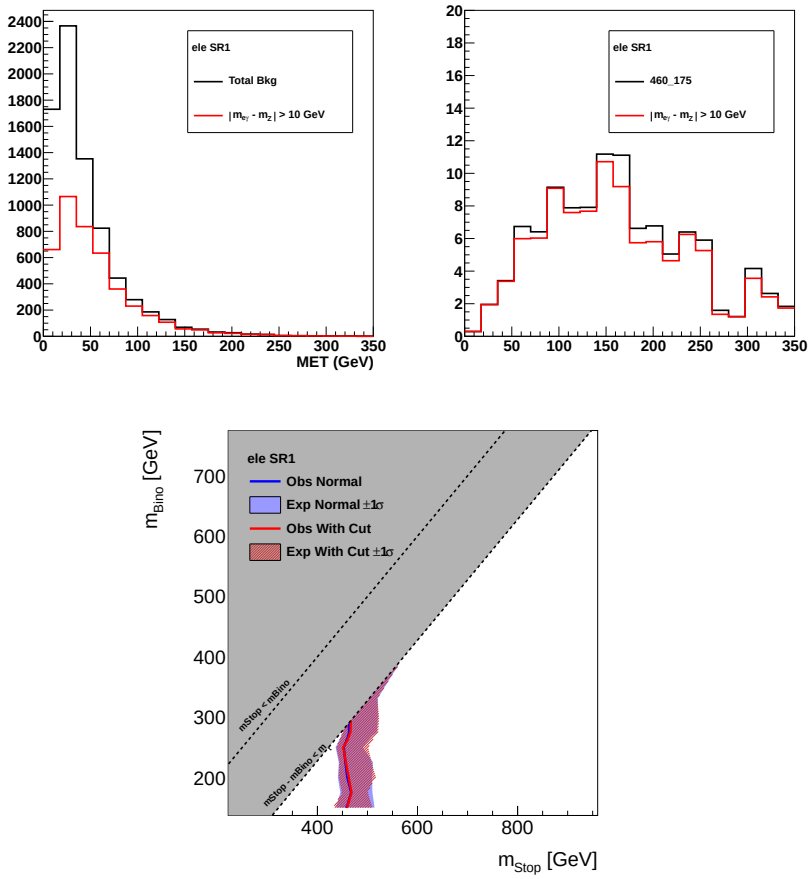

Figure 2: Comparison of MET with and without a cut on $m_{e\gamma}$ within 10 GeV of the nominal Z mass for the total background (top left) and signal with M(stop) = 460 GeV and M(bino) = 175 GeV (top right). Within the electron channel in SR1, no significant difference is seen in the upper limits (bottom).

2. Add a MET cut or give a few columns in bins of MET for the 1L signal regions for the table on page 25

Not completely sure what is meant by 1L, so I did this for several regions. See Tables 2–7.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	20606 ± 300	28216 ± 344	4128 ± 105	178 ± 25	2.0 ± 2.2
$t\bar{t}$ + jets	21633 ± 122	81402 ± 339	85840 ± 292	28072 ± 77	242 ± 1
W + jets	12528 ± 166	41116 ± 401	28984 ± 246	7776 ± 47	247 ± 3
Z + jets	5560 ± 67	6458 ± 65	1113 ± 11	221 ± 2	4.5 ± 0.1
Single t	2466 ± 10	8753 ± 18	8310 ± 19	2699 ± 11	52 ± 1
Diboson	275 ± 1	719 ± 1	550 ± 1	187 ± 1	6.0 ± 0.2
Vγ	525 ± 7	1287 ± 14	657 ± 7	191 ± 3	17.4 ± 0.3
$t\bar{t} + W$	27 ± 0	98 ± 0	126 ± 0	83 ± 0	3.4 ± 0.1
$t\bar{t} + Z$	23 ± 0	74 ± 0	92 ± 0	73 ± 0	3.0 ± 0.1
$t\bar{t} + \gamma$	323 ± 1	1168 ± 3	1272 ± 3	524 ± 2	5.2 ± 0.2
Total Background	63965 ± 371	169291 ± 632	131071 ± 396	40004 ± 95	583 ± 4
GMSB (460_175)	10.5 ± 0.5	64 ± 2	83 ± 3	–	–
GMSB (560_325)	1.50 ± 0.11	11.9 ± 0.6	28 ± 1	–	–
Data	62840	166158	133805	41034	500

Table 2: **ele pre-selection:** Observed data and expected event yields for the electron pre-selection channel. Errors here are statistical only.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	4600 ± 177	7695 ± 233	1901 ± 56	96 ± 4	0.35 ± 0.17
$t\bar{t}$ + jets	23988 ± 127	88206 ± 344	91929 ± 293	31100 ± 79	259 ± 1
W + jets	13084 ± 178	41082 ± 414	27812 ± 243	8047 ± 50	232 ± 2
Z + jets	3597 ± 40	4997 ± 44	1454 ± 12	325 ± 2	2.9 ± 0.1
Single t	2597 ± 10	9220 ± 18	8672 ± 19	2844 ± 12	65 ± 2
Diboson	246 ± 1	730 ± 1	549 ± 1	201 ± 1	5.7 ± 0.2
Vγ	572 ± 7	1419 ± 13	804 ± 8	293 ± 3	3.5 ± 1.2
$t\bar{t} + W$	26 ± 0	104 ± 0	133 ± 0	89 ± 0	3.7 ± 0.1
$t\bar{t} + Z$	21 ± 0	74 ± 0	93 ± 0	71 ± 0	3.1 ± 0.1
$t\bar{t} + \gamma$	305 ± 1	1126 ± 2	1213 ± 3	531 ± 2	5.8 ± 0.3
Total Background	49035 ± 285	154653 ± 589	134560 ± 386	43597 ± 95	581 ± 3
GMSB (460_175)	12.2 ± 0.4	65 ± 2	78 ± 2	–	–
GMSB (560_325)	1.25 ± 0.07	12.3 ± 0.6	31 ± 1	–	–
Data	47947	151191	137196	44928	510

Table 3: **muon pre-selection:** Observed data and expected event yields for the muon pre-selection channel. Errors here are statistical only.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	–	–	–	–	–
$t\bar{t}$ + jets	72 ± 1	280 ± 2	384 ± 3	164 ± 1	0.87 ± 0.06
W + jets	13.6 ± 0.2	42 ± 1	34 ± 1	11.0 ± 0.5	–
Z + jets	352 ± 7	406 ± 7	54 ± 1	4.0 ± 0.2	–
Single t	5.6 ± 0.3	23 ± 1	26 ± 1	8.1 ± 0.6	0.79 ± 0.02
Diboson	4.7 ± 0.1	6.4 ± 0.1	3.0 ± 0.1	0.80 ± 0.03	–
Vγ	62 ± 2	103 ± 2	35 ± 1	33 ± 2	6.0 ± 0.2
$t\bar{t} + W$	0.32 ± 0.02	0.83 ± 0.04	1.51 ± 0.05	1.03 ± 0.05	0.08 ± 0.02
$t\bar{t} + Z$	0.70 ± 0.03	1.33 ± 0.05	1.39 ± 0.05	0.85 ± 0.05	0.02 ± 0.01
$t\bar{t} + \gamma$	91 ± 1	328 ± 1	373 ± 2	159 ± 1	1.63 ± 0.11
Total Background	603 ± 7	1190 ± 8	911 ± 4	382 ± 3	9.4 ± 0.2
GMSB (460_175)	0.36 ± 0.02	2.5 ± 0.1	16.4 ± 0.7	56 ± 2	7.6 ± 1.5
GMSB (560_325)	0.28 ± 0.02	0.54 ± 0.08	2.7 ± 0.1	14.0 ± 0.6	3.9 ± 0.3
Data	585	1257	1002	413	9

Table 4: **ele_sr1:** Observed data and expected event yields for the electron channel in SR1. Errors here are statistical only.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	–	–	–	–	–
$t\bar{t}$ + jets	76 ± 1	307 ± 2	388 ± 3	171 ± 1	1.38 ± 0.09
W + jets	10.1 ± 0.8	39 ± 1	30 ± 1	4.9 ± 0.6	–
Z + jets	42 ± 1	49 ± 1	7.0 ± 0.3	1.56 ± 0.13	–
Single t	4.7 ± 0.4	27 ± 1	23 ± 1	12.4 ± 0.7	–
Diboson	1.21 ± 0.05	3.2 ± 0.1	2.4 ± 0.1	0.89 ± 0.04	0.07 ± 0.00
Vγ	35 ± 1	59 ± 1	57 ± 2	41 ± 2	–
$t\bar{t} + W$	0.29 ± 0.03	1.07 ± 0.05	1.32 ± 0.05	1.07 ± 0.06	0.09 ± 0.00
$t\bar{t} + Z$	0.17 ± 0.02	0.76 ± 0.04	1.14 ± 0.06	0.70 ± 0.03	0.02 ± 0.00
$t\bar{t} + \gamma$	89 ± 1	342 ± 1	373 ± 1	166 ± 1	2.4 ± 0.2
Total Background	259 ± 2	828 ± 3	883 ± 4	400 ± 3	4.0 ± 0.2
GMSB (460_175)	1.39 ± 0.17	4.5 ± 0.2	14.4 ± 0.5	51 ± 2	8.8 ± 1.5
GMSB (560_325)	0.07 ± 0.00	0.37 ± 0.05	2.6 ± 0.2	12.5 ± 0.4	6.2 ± 0.4
Data	241	866	930	434	4

Table 5: **muon_sr1:** Observed data and expected event yields for the muon channel in SR1. Errors here are statistical only.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	–	–	–	–	–
$t\bar{t}$ + jets	–	0.06 ± 0.00	0.29 ± 0.04	0.12 ± 0.01	–
W + jets	–	–	–	–	–
Z + jets	0.68 ± 0.13	1.10 ± 0.03	0.02 ± 0.00	–	–
Single t	–	–	–	–	–
Diboson	0.09 ± 0.00	0.02 ± 0.00	0.01 ± 0.00	–	–
Vγ	–	5.2 ± 0.1	1.02 ± 0.03	–	–
$t\bar{t} + W$	–	0.03 ± 0.02	–	–	–
$t\bar{t} + Z$	–	0.04 ± 0.01	0.05 ± 0.00	–	–
$t\bar{t} + \gamma$	0.46 ± 0.04	3.1 ± 0.1	2.5 ± 0.1	1.18 ± 0.10	0.05 ± 0.02
Total Background	1.22 ± 0.13	9.6 ± 0.2	3.9 ± 0.1	1.30 ± 0.10	0.05 ± 0.02
GMSB (460_175)	4.9 ± 0.3	39 ± 2	–	–	–
GMSB (560_325)	0.19 ± 0.03	7.2 ± 0.3	–	–	–
Data	4	4	4	2	0

Table 6: **ele_sr2:** Observed data and expected event yields for the electron channel in SR2. Errors here are statistical only.

Channel	MET (GeV)				
	0–25	25–50	50–100	100–300	≥ 300
QCD	1.20 ± 2.31	1.07 ± 2.15	1.19 ± 2.29	1.29 ± 2.44	–
$t\bar{t}$ + jets	0.06 ± 0.04	0.34 ± 0.07	0.35 ± 0.09	0.21 ± 0.02	–
W + jets	–	0.11 ± 0.01	–	–	–
Z + jets	0.22 ± 0.00	–	–	–	–
Single t	–	–	–	–	–
Diboson	–	–	0.08 ± 0.00	–	–
Vγ	–	–	–	–	–
$t\bar{t} + W$	–	–	0.04 ± 0.00	–	–
$t\bar{t} + Z$	–	–	–	–	–
$t\bar{t} + \gamma$	0.52 ± 0.05	2.4 ± 0.2	2.4 ± 0.1	1.30 ± 0.08	0.05 ± 0.02
Total Background	0.80 ± 0.06	2.9 ± 0.2	2.9 ± 0.2	1.51 ± 0.09	0.05 ± 0.02
GMSB (460_175)	3.2 ± 0.2	40 ± 2	–	–	–
GMSB (560_325)	0.57 ± 0.05	10.1 ± 0.6	–	–	–
Data	2	4	6	4	0

Table 7: **muon_sr2:** Observed data and expected event yields for the muon channel in SR2. Errors here are statistical only.

3. Check the numbers for systematic uncertainties, especially check the PAS and the numbers given during your presentation.

The table in the pre approval presentation was mistakenly taken from an older presentation. The numbers in the PAS in Table 2 is correct, although now that I check more closely there is some truncation/rounding that could be cleaned up in a first round of editing. For example the line "Photon ID" has a range of 0.638 – 1.547%, which is reported as 1.5% in the PAS and 0.6 - 1.5% in the AN. This likely isn't controversial having said the more presice values, but should be more uniform in the documentation.

4. Consider rebinning the SR2 results plots to reduce the statistical noise.

Originally SR2 was binned coarser, however the decision to use CR1 for a systematic uncertainty in SR2 created the need for uniform binning in every channel. In the pre-approval slides, notice that CR2 is using this coarser binning despite not being used.

That being said if you rebin SR2 then you should rebin $\Delta \equiv \text{SR1} - \text{CR1}$ as well when used for the systematic in SR2. The results are shown in Figure 3.

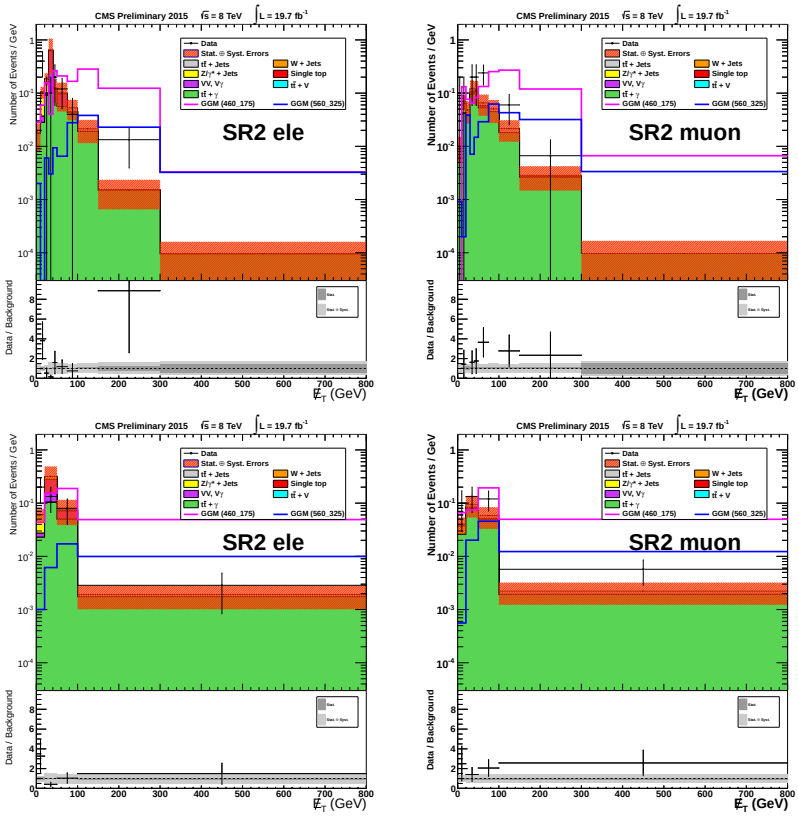

Figure 3: MET in SR2 with previously shown binning (top) and rebinned (bottom) for electron (left) and muon (right) channels.

The effect of rebinning SR2 in this way on the exclusion curve is shown in Figure 4.

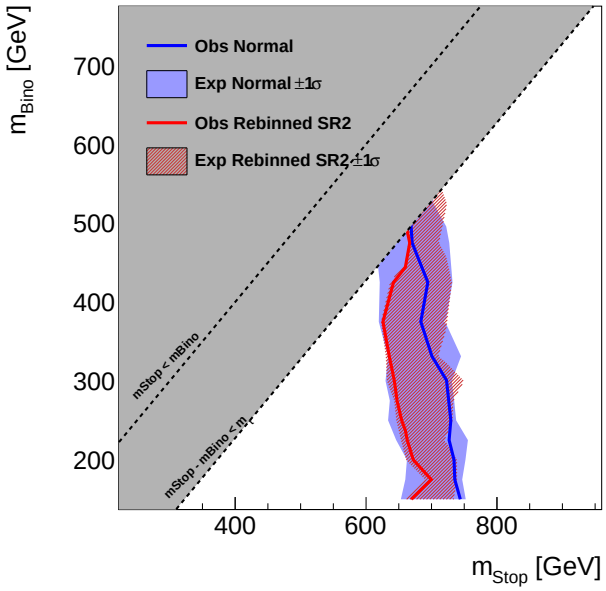

Figure 4: Comparison of the exclusion curves for the previously shown binning and with SR2 rebinned.

5. Add a cut flow table for a couple representative points.

Cut	Number of events (% of previous)	
	ele	muon
All events	15000	15000
== 1 tight lepton	1694 (11)	1520 (10)
== 0 loose leptons	1694 (100)	1520 (100)
HLT	1354 (80)	1436 (94)
N(jets) ≥ 3	1153 (85)	1247 (87)
N(b-tags) ≥ 1	937 (81)	1004 (81)
N(γ, fake) ≥ 1	741 (79)	805 (80)
Exclusive categories:		
SR1	477	504
CR1	30	30
SR2	264	301
CR2	1	5

Table 8: Cut flow table for the M(stop) = 460 GeV, M(bino) = 175 GeV signal model.

Cut	Number of events (% of previous)	
	ele	muon
All events	15000	15000
== 1 tight lepton	1492 (10)	1407 (9)
== 0 loose leptons	1492 (100)	1407 (100)
HLT	1157 (78)	1351 (96)
N(jets) ≥ 3	1004 (87)	1144 (85)
N(b-tags) ≥ 1	815 (81)	910 (80)
N(γ, fake) ≥ 1	557 (68)	656 (72)
Exclusive categories:		
SR1	392	484
CR1	34	33
SR2	165	172
CR2	2	1

Table 9: Cut flow table for the M(stop) = 560 GeV, M(bino) = 375 GeV signal model.

I was curious why there were fewer selected photons for the heavier bino model where the photons should have higher P_T, so I also made a cutflow table for photon selection requirements; see Table 10. The difference is purely that the heavier bino has a higher branching ratio of $\tilde{\chi}_1^0 \to Z\tilde{G}$.

Cut	Number of photons (% of previous)	
	460_175	560_375
All candidates	11712	10030
$\|\eta\| < 1.4442$	9904 (85)	8636 (86)
$E_T > 20$ GeV	8005 (81)	6741 (78)
$H/E < 0.05$	7010 (88)	5940 (88)
Electron veto	5361 (76)	4426 (75)
Neutral had. iso	5005 (93)	4152 (94)
Photon iso	3941 (79)	3140 (76)
Charged had. iso	3525 (89)	2767 (88)
$\sigma_{i\eta i\eta} < 0.012$	3517 (99)	2761 (99)
$\Delta R(\gamma, \mu) \geq 0.7$	3391 (96)	2628 (95)
$\Delta R(\gamma, e) \geq 0.7$	3254 (96)	2480 (94)

Table 10: Cut flow table for photon candidates in events passing the preselection in either the electron or muon channel. Two signal models are compared, 460_175 referring to M(stop) = 460 GeV and M(bino) = 175 GeV and similarly for 560_375.

6. Provide expected signal and background numbers for a point near the exclusion to allow for a check on the expected limit.

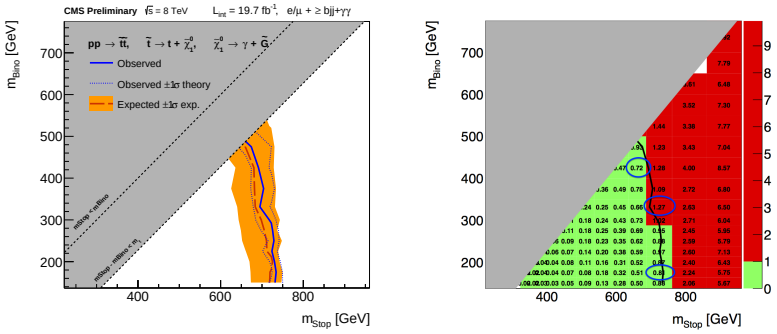

Figure 5: Exclusion plot in PAS (left). On the right is a plot of numerical R-values for the observed upper limits (R $\equiv$ U.L. / σ_{theory}) with the observed exclusion curve overlayed. The blue circles signify the points chosen for Table 11 below.

Signal Point (mStop_mBino)	Cross section (fb)	Observed Limit (fb)	Expected Limit (fb)
710_175	6.93	5.61 $\pm$ 1.05	$7.08\ ^{+3.88}_{-1.88}$
710_325	6.93	8.77 $\pm$ 1.64	$9.30\ ^{+3.58}_{-3.28}$
660_425	11.78	8.48 $\pm$ 1.51	$10.06\ ^{+4.27}_{-2.81}$

Table 11: Observed and expected cross section upper limits for a sample of points near the exclusion. These points are highlighted as blue circles in Figure 5.