Trigger Efficiency study for the SUSY trilepton analyses

UK SUSY exotics meeting

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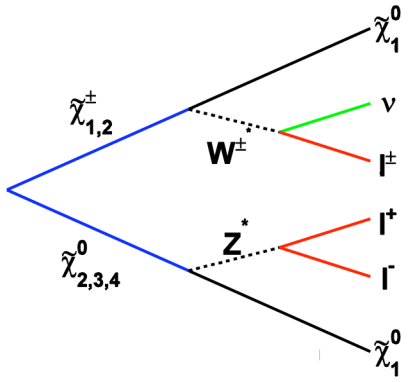
- Motivation
  - Understand the trigger for the trilepton channels
- Strategy
  - Identify effective & reliable trigger items for the SUSY trilepton channels
  - Try to keep in line with the work of the trigger group
  - Explore signal trig. efficiencies at various selection stages of the analysis
  - Identify points for improvement
  - Explore the effects in background samples
  - For future data-driven background analyses, will need to explore additional trigger lines
- Thanks to:
  - Tina and Matt for providing useful codes/samples!

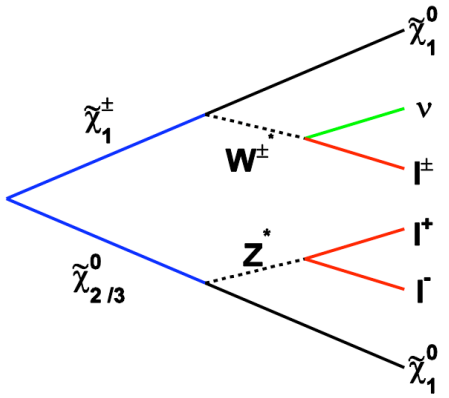
SUSY Trilepton channels looked at

For more detail, refer to Tina's slides

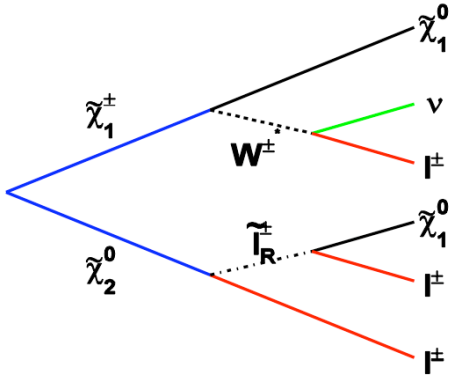
SU2 trilep



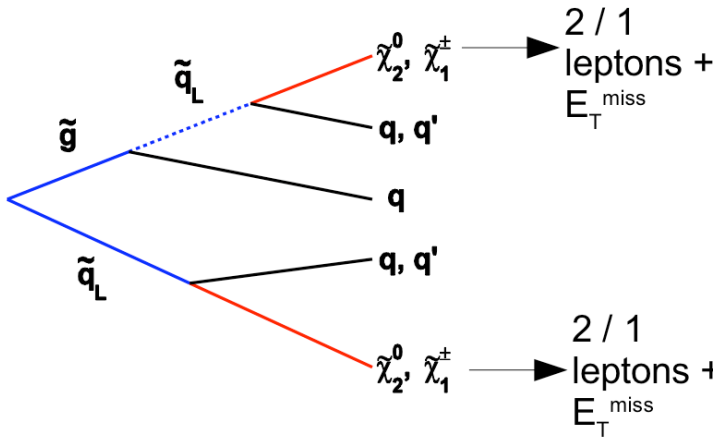
SU2 DG



SU3 trilep



SU3 NDG



Some of the shared characteristics:

- ~3 leptons,
- Missing ET,
- softer leptons c.f. other SUSY channels

Trigger menu for L=10^{33} $cm^{-2}s^{-1}$

Typical trigger efficiency output for the standard CSC productions based on reconstruction in 12.0.6 (using SU2 DG sample)

Focus on "stable" leptonic triggers
for the trilepton channels

- 2e15i (double object pass restrictive)
- e25i (threshold higher than sel leps)
- e60 (no isolation, high threshold)

- mu20 (still looking for the definition)

In particular look at:

- e25i U mu20

dummy →

dummy →
iffy →

n/a →

iffy →
→

iffy →

========== Trigger Efficiencies (%) ==========

Trigger	L1	L2	EF
Photonic Triggers			
g10	100.0000	100.0000	100.0000
2g20i	37.8378	21.6216	14.8649
g60	33.7838	24.3243	21.6216
Electron Triggers			
e10	100.0000	100.0000	0.0000
e10TRTxK	100.0000	100.0000	100.0000
2e15i	37.8378	27.0270	24.3243
e25i	79.7297	74.3243	71.6216
e60	33.7838	24.3243	18.9189
Zee	0.0000	0.0000	0.0000
Muon triggers			
mu6	1.3514	91.8919	91.8919
mu6l	1.3514	91.8919	91.8919
mu20	17.5676	72.9730	68.9189
Tau Triggers			
tau10	100.0000	89.1892	89.1892
tau10i	100.0000	87.8378	85.1351
tau15	93.2432	83.7838	82.4324
tau15i	93.2432	82.4324	78.3784
tau20i	87.8378	75.6757	71.6216
tau25i	78.3784	63.5135	60.8108
tau35i	67.5676	51.3514	50.0000
tauNoCut	100.0000	100.0000	100.0000
Jet Triggers			
jet20kt	94.5946	94.5946	94.5946
jet20a	94.5946	94.5946	94.5946
jet20b	94.5946	64.8649	62.1622
jet20c	94.5946	39.1892	36.4865
jet20d	94.5946	29.7297	24.3243
jet160	86.4865	16.2162	12.1622
2jet120	55.4054	16.2162	14.8649
3jet65	29.7297	16.2162	14.8649
4jet50	24.3243	14.8649	14.8649
frjet10	4.0541	0.0000	0.0000
fljet10	4.0541	17.5676	0.0000
bjet35	94.5946	86.4865	86.4865
Missing Et triggers			
met10	100.0000	100.0000	100.0000

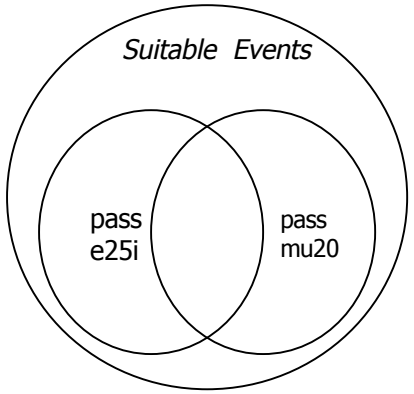
Defining Trigger Efficiency

Event-based trigger efficiencies calculated at each stage of analysis using Tina's samples and selection

Apply suitable normalisation to remove offline reconstruction/acceptance/detector inefficiencies and isolate trigger effects

Hence define,

$$\text{Eff} = \frac{\text{Events passed given trigger}}{\text{Suitable Events}},$$



Where,

Suitable Events => have leptons, where

- electrons satisfy:
  - $|\eta| < 2.5$ for ,
  - exclude cracks,
  - loose isEM.

normalisation criteria as defined by e/γ group

- muons satisfy:
  - ? nothing in particular

Summary of SUSY trilepton analysis cuts

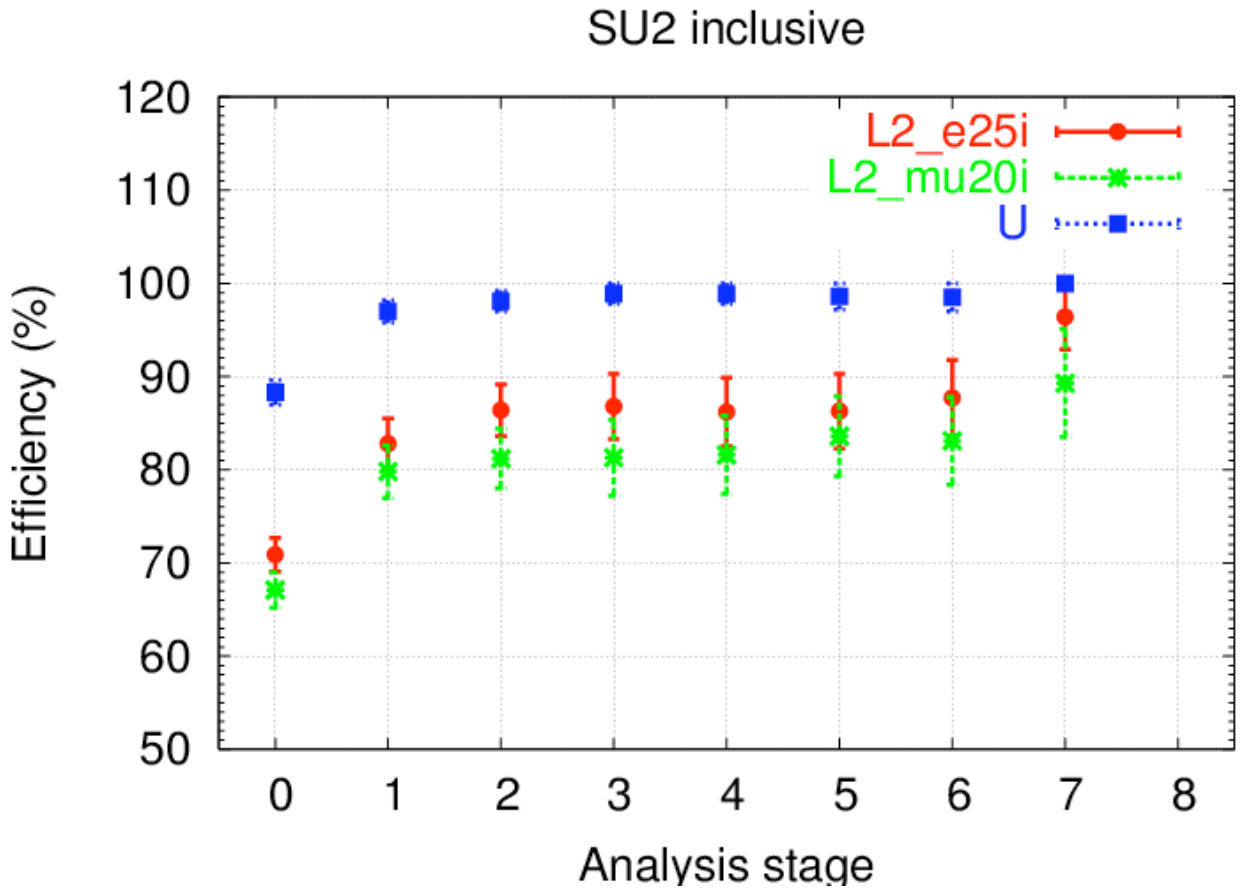
	SU2 Inc	SU2 DG	SU3 Inc	SU3 NDG	Analysis stage
No Cuts*	✓	✓	✓	✓	* Overlap removal and object definition done with EventView $\|\eta\| < 2.5$ and Pt > 10 GeV for reconstructed leptons
Nº Lep ≥ 3	✓	✓	✓	✓	At least three leptons (l = e, μ)
SFOS Lep	✓	✓	✓	✓	2 leptons with SFOS (e+e-, μ+μ-) that satisfy $M_{SFOS} > 20$ GeV
Track Iso	✓	✓	✓	✓	Track Isolation in ΔR (0.2), $Pt^{max} < 1$ GeV
Imp Para	✓	✓	✓	✓	Impact Parameter, IP/σ IP < 6
Z Window	✓	✓			Remove events with any SFOS pair that fall in: 80 GeV < M_{SFOS} < 100 GeV
ET Miss	✓	✓	✓	✓	Et Miss > 30 GeV
Pt Jets	✓		✓	✓	At least one jet with Pt > 200 GeV
No b jets		✓			No b-tagged jets

Efficiencies for the SU2 inclusive sample

File (M)	Analysis stage		L2_e25i	L2_mu20i	L2_e25i ∪ L2_mu20i	Suit. Ev.	Tot. Ev.
9.7/11 2x1700	0	No Cuts*	(70.9 ± 1.8)%	(67.1 ± 1.9)%	(88.3 ± 1.3)%	633	49200
5.3 32	1	N° Lep ≥ 3	(82.8 ± 2.7)%	(79.8 ± 2.8)%	(97.0 ± 1.2)%	203	391
4.7 24	2	SFOS Lep	(86.4 ± 2.8)%	(81.2 ± 3.2)%	(98.1 ± 1.1)%	154	307
3.5 11	3	Track Iso	(86.8 ± 3.5)%	(81.3 ± 4.1)%	(98.9 ± 1.1)%	91	189
3.2 10	4	Imp Para	(86.2 ± 3.7)%	(81.6 ± 4.2)%	(98.9 ± 1.1)%	87	177
2.7 7.6	5	Z Window	(86.3 ± 4.0)%	(83.6 ± 4.3)%	(98.6 ± 1.4)%	73	140
2.2 7.4	6	ET Miss	(87.7 ± 4.1)%	(83.1 ± 4.7)%	(98.5 ± 1.5)%	65	128
5.2	7	Pt Jets	(96.4 ± 3.5)%	(89.3 ± 5.8)%	(100.0 ± 0.)%	28	50

*

Efficiencies for the SU2 inclusive sample

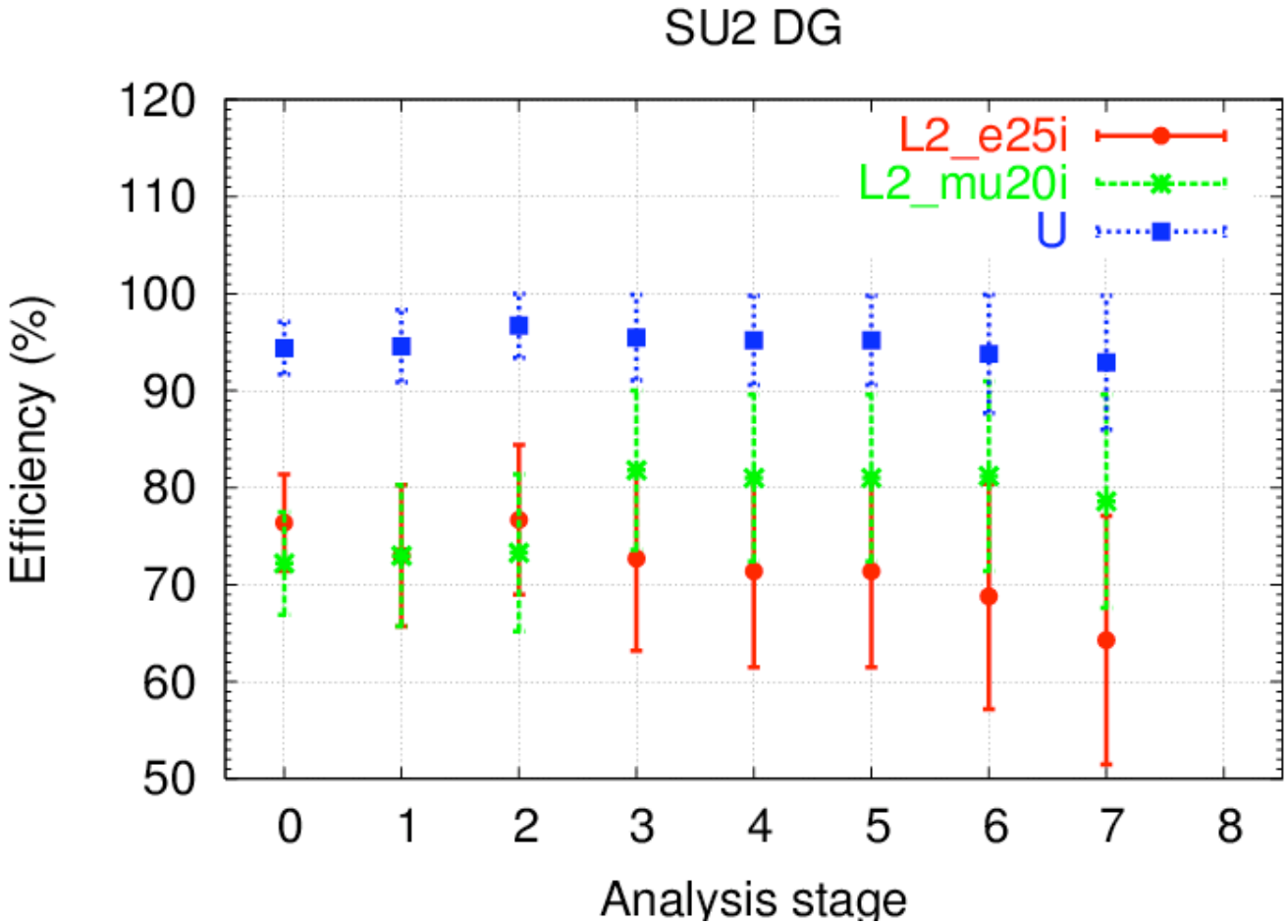


Efficiencies for the SU2 direct $\chi^{+/-}\chi^{0}$ production sample

File (M)	Analysis stage		L2_e25i	L2_mu20i	L2_e25i ∪ L2_mu20i	Suit. Ev.	Tot. Ev.
9.7/11	0	No Cuts*	(76.4 ± 5.0)%	(72.2 ± 5.3)%	(94.4 ± 2.7)%	72	314
5.3	1	N° Lep ≥ 3	(73.0 ± 7.3)%	(73.0 ± 7.3)%	(94.6 ± 3.7)%	37	80
4.7	2	SFOS Lep	(76.7 ± 7.7)%	(73.3 ± 8.1)%	(96.7 ± 3.3)%	30	68
3.5	3	Track Iso	(72.7 ± 9.5)%	(81.8 ± 8.2)%	(95.5 ± 4.4)%	22	56
3.2	4	Imp Para	(71.4 ± 9.9)%	(81.0 ± 8.6)%	(95.2 ± 4.6)%	21	52
2.7	5	Z Window	(71.4 ± 9.9)%	(81.0 ± 8.6)%	(95.2 ± 4.6)%	21	46
2.2	6	ET Miss	(68.8 ± 11.6)%	(81.2 ± 9.8)%	(93.8 ± 6.1)%	16	38
1.9	7	No b-jets	(64.3 ± 12.8)%	(78.6 ± 11.0)%	(92.9 ± 6.9)%	14	34

*

Efficiencies for SU2 (direct $\chi^{+/-}\chi^{0}$ prod.) sample

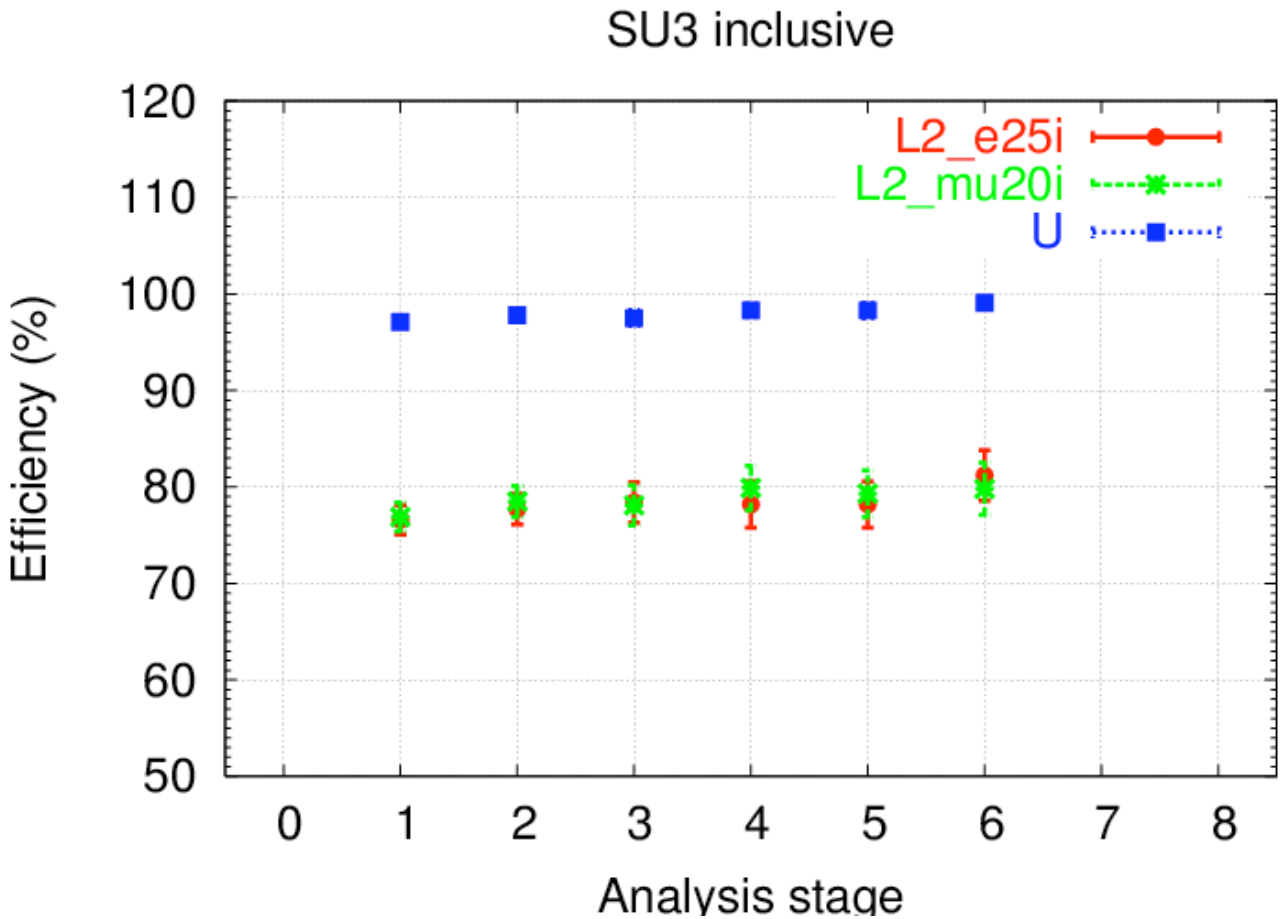


Efficiencies for the SU3 inclusive sample

File (M)	Analysis stage		L2_e25i	L2_mu20i	L2_e25i ∪ L2_mu20i	Suit. Ev.	Tot. Ev.
~2x20 880x20	0	No Cuts*	-	-	-	-	199250
13 142	1	Nº Lep ≥ 3	(76.6 ± 1.5)%	(76.9 ± 1.5)%	(97.1 ± 0.6)%	819	1713
12 118	2	SFOS Lep	(77.7 ± 1.6)%	(78.5 ± 1.6)%	(97.8 ± 0.6)%	646	1436
8.4 66	3	Track Iso	(78.4 ± 2.1)%	(78.1 ± 2.1)%	(97.5 ± 0.8)%	393	865
8.1 52	4	Imp Para	(78.2 ± 2.4)%	(79.9 ± 2.3)%	(98.3 ± 0.7)%	303	679
7.8 51	5	ET Miss	(78.2 ± 2.4)%	(79.3 ± 2.4)%	(98.3 ± 0.8)%	294	663
6.8 38	6	Pt Jets	(81.2 ± 2.6)%	(79.8 ± 2.7)%	(99.1 ± 0.6)%	223	518

*

Efficiencies for the SU3 inclusive sample

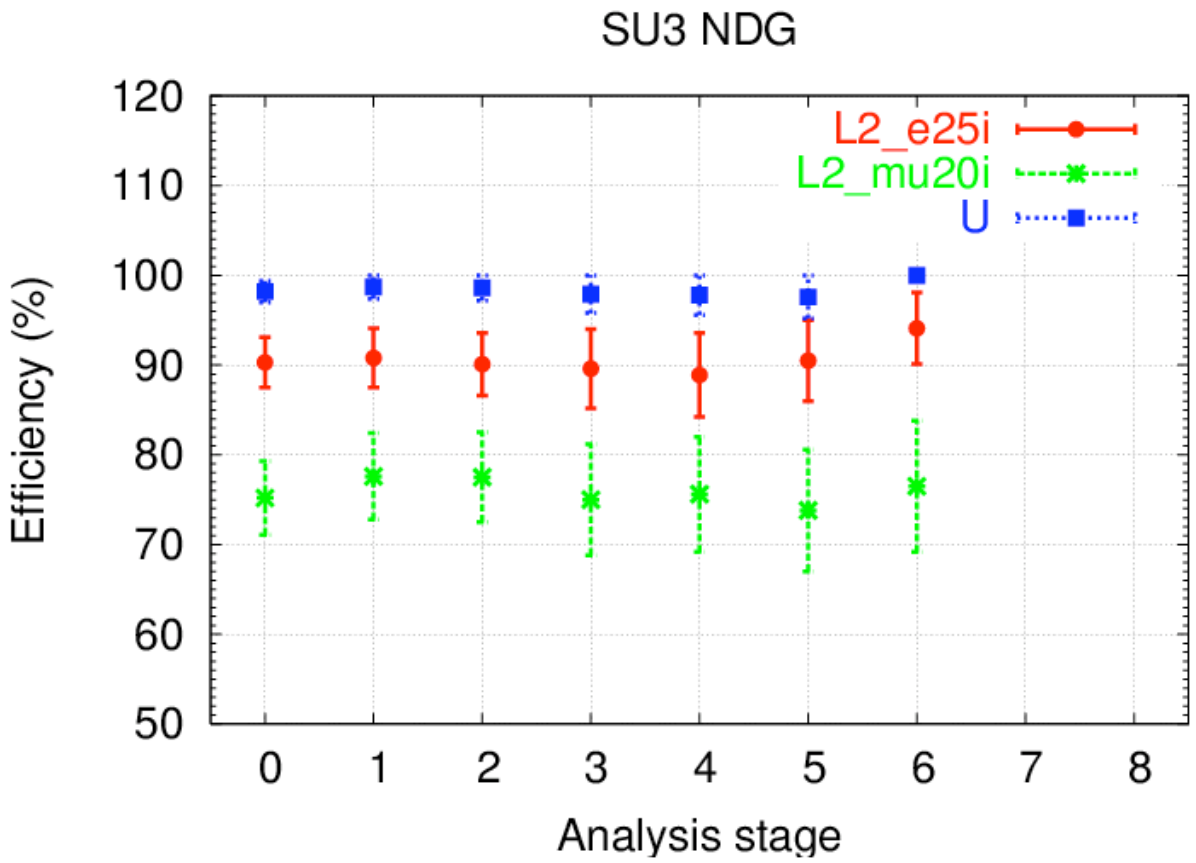


Efficiencies for the SU3 non-direct $\chi^{+/-}\chi^{0}$ prod. sample

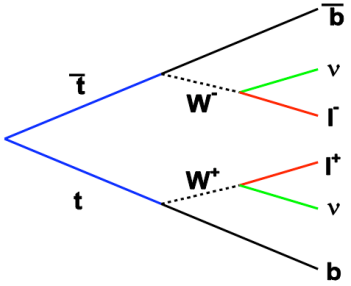
File (M)	Analysis stage		L2_e25i	L2_mu20i	L2_e25i ∪ L2_mu20i	Suit. Ev.	Tot. Ev.
~2x20	0	No Cuts*	(90.3 ± 2.8)%	(75.2 ± 4.1)%	(98.2 ± 1.2)%	113	432
13	1	Nº Lep ≥ 3	(90.8 ± 3.3)%	(77.6 ± 4.8)%	(98.7 ± 1.3)%	76	152
12	2	SFOS Lep	(90.1 ± 3.5)%	(77.5 ± 5.0)%	(98.6 ± 1.4)%	71	145
8.4	3	Track Iso	(89.6 ± 4.4)%	(75.0 ± 6.2)%	(97.9 ± 2.1)%	48	102
8.1	4	Imp Para	(88.9 ± 4.7)%	(75.6 ± 6.4)%	(97.8 ± 2.2)%	45	95
7.8	5	ET Miss	(90.5 ± 4.5)%	(73.8 ± 6.8)%	(97.6 ± 2.4)%	42	91
6.8	6	Pt Jets	(94.1 ± 4.0)%	(76.5 ± 7.3)%	(100.0 ± 0.)%	34	76

*

Efficiencies for the SU3 non-direct $\chi^{+/-}\chi^{0}$ prod. sample



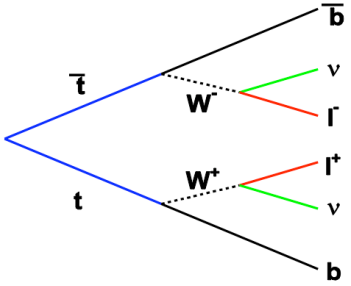
tt background sample

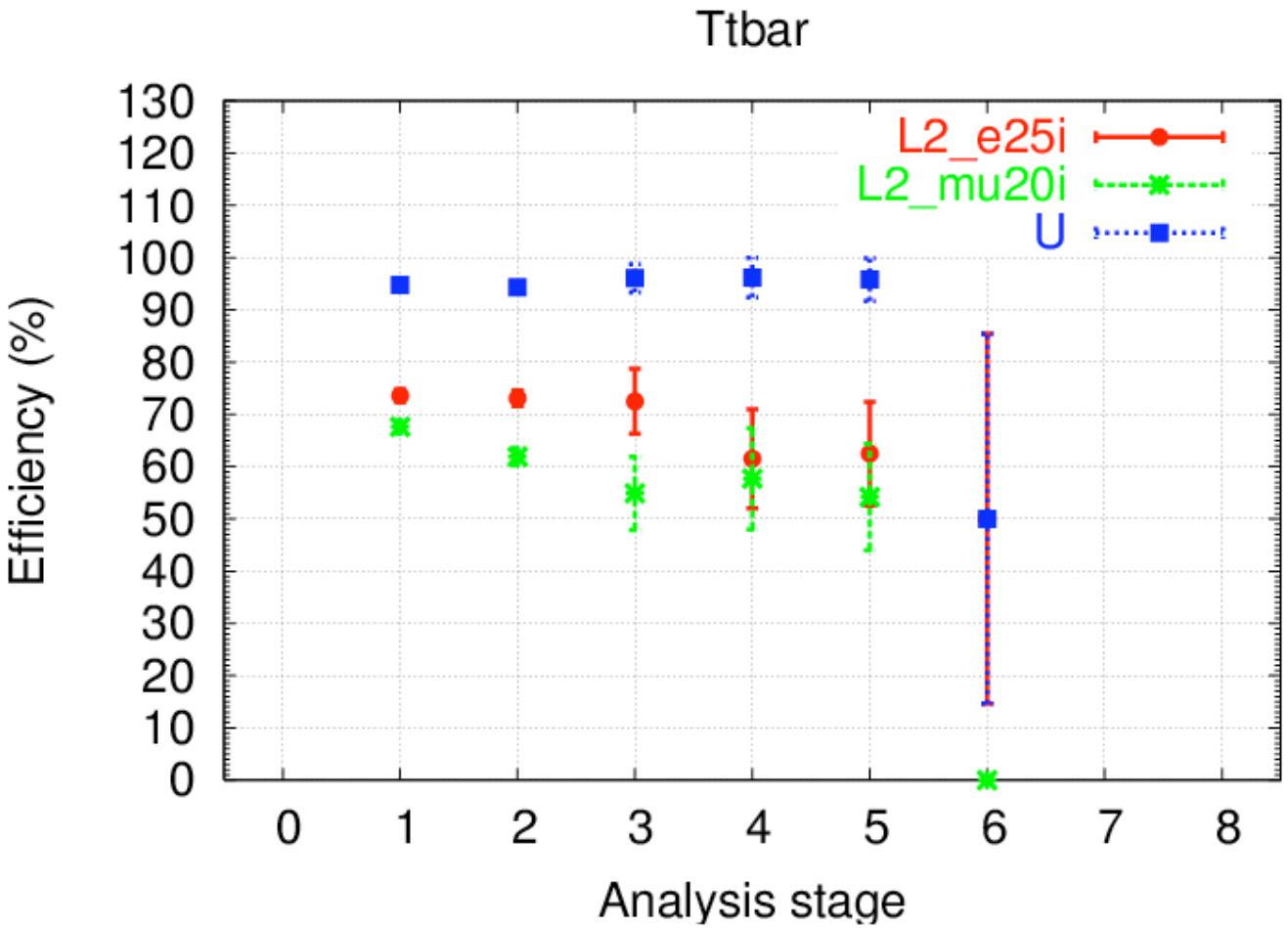


File (M)	Analysis stage		L2_e25i	L2_mu20i	L2_e25i ∪ L2_mu20i	Suit. Ev.	Tot. Ev.
206	1	N° Lep ≥ 3	(73.6 ± 1.2)%	(67.6 ± 1.2)%	(94.8 ± 0.6)%	1454	2474
137	2	SFOS Lep	(73.1 ± 1.5)%	(61.9 ± 1.7)%	(94.3 ± 0.8)%	854	1634
8.7	3	Track Iso	(72.5 ± 6.2)%	(54.9 ± 7.0)%	(96.1 ± 2.7)%	51	106
5.3	4	Imp Para	(61.5 ± 9.5)%	(57.7 ± 9.7)%	(96.2 ± 3.8)%	26	62
4.9	5	ET Miss	(62.5 ± 9.9)%	(54.2 ± 10.2)%	(95.8 ± 4.1)%	24	57
0.9	6	Pt Jets	(50.0 ± 35.4)%	(0. ± 0.)%	(50.0 ± 35.4)%	2	6

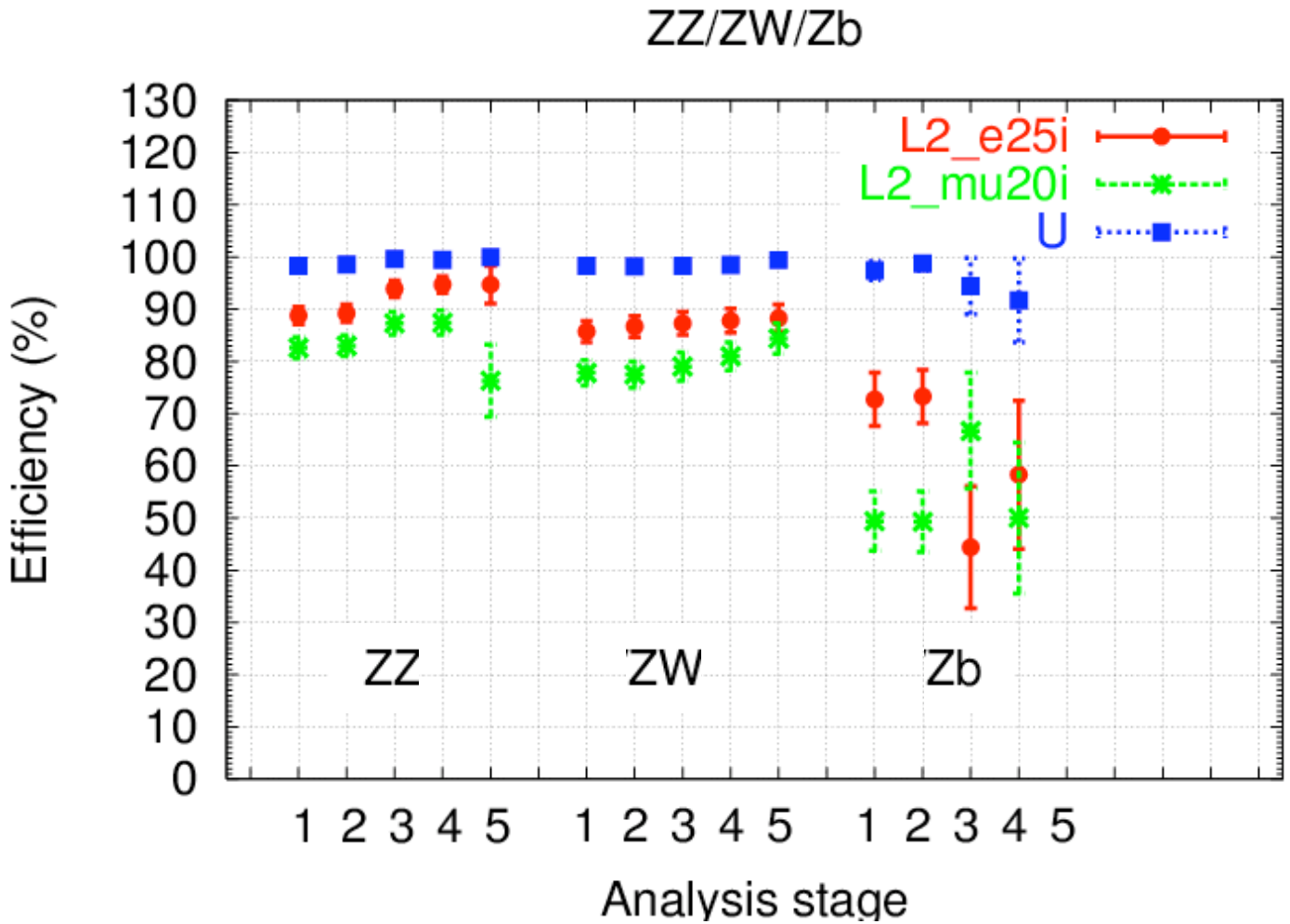
$|\eta|$ < 2.5 and pT > 10 GeV for recon ele and muo
Overlap removal and object definition done with Event View

tt background sample





Other contributing SM backgrounds



Summary

- Event level trigger efficiencies studied for the trilepton channels with focus on leptonic trigger items with 12.0.6
- mu20 trigger definitions / normalisations not yet understood, but generally have a lower efficiency tendency...
- e25i trigger threshold may be too high for trilepton selection
- There is some sample dependencies for individual e/μ triggers, but efficiencies are generally flat wrt analysis cuts
- Total trigger efficiencies after all selection *look* good:

SU2 Inc	SU2 DG	SU3 Inc	SU3 NDG
100%	(93 ± 7)%	(99 ± 1)%	100%

- But of course still plenty to be understood in preparation for real data!

Backup

Default cut values for e25i

e25i

The e25i starts with an EM25i Level-1 trigger candidate. The TrigL2CaloHypo jobOptions show the cuts are optimised in the following eta bins: |eta| < 0.75, 0.75 < |eta| < 1.5, 1.5 < |eta| < 1.8, 1.8 < |eta| < 2.0, 2.0 < |eta| < 2.5. The default cut values are

- ET(cluster) threshold = 20 GeV
- ET of leakage into hadronic calo < [3.8 GeV, 3.8 GeV, 3.8 GeV, 3.8 GeV, 3.8 GeV], no leakage cut applied if ET(cluster)>90GeV
- Rcore threshold > [0.895,0.895,0.895,0.895,0.895]
- Eratio > [0.730,0.730,0.730,0.730,0.730]

The TrigL2IDCaloHypo jobOptions show the cuts are optimised in 4 eta bins: |eta| < 0.75, 0.75 < |eta| < 1.5, 1.5 < |eta| < 2.0, 2.0 < |eta| < 2.5 (Note: compared to the calorimeter cuts the 2 bin in 1.5<|eta|<2.0 are merged. For the calorimeter part there are 2 bins as the granularity fo the first electro-magnetic sampling changes.). As track algorithms IDScan is used.

- track pT > 5 GeV
- E/p > [0.5, 0.5, 0.5, 0.5]
- E/p < [5.5, 5.5, 5.5, 5.5]
- Delta Eta(cluster-track) < [0.018, 0.018, 0.018, 0.018]
- Delta Phi(cluster-track) < [0.06, 0.06, 0.06, 0.06]

The TrigEFEgammaHypo jobOptions contain the selection cuts which are as follows

- cluster ET > 22.5 GeV
- 0.5 < E/p < 2.08 in |eta| < 1.37, 0.5 < E/p < 3.86 in |eta| > 1.37
- Delta Eta(cluster-track) < 0.0036
- Delta Phi(cluster-track) < 0.037
- fraction of TR hits: disabled

L1_2EM15i

- EM ET > 11 GeV
- EM ring isol ≤ 3 GeV
- HAD isol ≤ 2 GeV
- Had ring isol ≤ 2 GeV