ILC Detector Requirements for Smuon Analysis

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Outline

- The Colorado SUSY group
- SUSY parameter points and masses
- Simulation tools
- Smuon studies
- Detector requirements

SUSY FastMC Studies at CU Boulder

Many undergraduates contribute to SUSY and calorimetry studies at CU with funding fron NSF, UROP, and other sources. These students include:

Chris Geraci	Paul Steinbrecher	Elliot Smith
Maria Gulda	Kyle Miller	Jack Gill
Keith Drake	Jesse Smock	Matthew Phillips
	Sarah Moll	

`http://hep-www.colorado.edu/SUSY`

`http://hep-www.colorado.edu/~nlc`

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- Attempt reconstruction of SUSY masses using fast MC detector simulation

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- Determine whether measurements are attainable
- Determine whether changes in detector or accelerator design might help with measurements

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Nine separate parameter points chosen for studies: SPS1-9

- 6 mSUGRA parameter points
- 2 GMSB points
- 1 AMSB point

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We have focused on SPS1 and several other mSUGRA points

The SUSY Parameter points

	mSUGRA					
	SPS1	SPS2	SPS3	SPS4	SPS5	SPS6
M_0	100	1450	90	400	150	150
$M_{1/2}$	250	300	400	300	300	300
A_0	-100	0	0	0	-1000	0
$tan(\beta)$	10	10	10	50	5	10
μ	352.39	124.77	508.59	377.03	639.80	393.09

	GMSB			AMSB
	SPS7	SPS8		SPS9
Λ	$40,000$	$100,000$	M_0	400
M_{mes}	$80,000$	$200,000$	$M_{3/2}$	60000
N_5	3	1		
$tan(\beta)$	15	15	$tan(\beta)$	10
μ	300.03	398.31	μ	869.90

The SUSY Masses

	minimal SUGRA						GMSB		AMSB
	SPS1	SPS2	SPS3	SPS4	SPS5	SPS6	SPS7	SPS8	SPS9
$\widetilde{\chi}_1^0$	96.05	79.54	160.55	118.66	119.51	117.50	161.65	137.19	175.51
$\widetilde{\chi}_2^0$	176.82	135.34	296.95	218.14	226.33	215.54	260.06	252.33	549.03
$\widetilde{\chi}_3^0$	358.81	140.84	512.87	383.91	642.83	398.70	306.26	404.00	874.37
$\widetilde{\chi}_4^0$	377.81	269.45	529.57	401.08	652.95	418.06	379.94	426.28	875.97
$\widetilde{\chi}_1^+$	176.38	104.03	296.85	218.06	226.33	215.20	256.33	252.03	175.67
$\widetilde{\chi}_2^+$	378.23	269.03	529.51	402.28	652.68	418.19	379.45	426.47	877.22
h^0	113.97	115.71	116.95	115.39	119.79	114.71	113.57	114.83	114.83
H^0	394.15	1444.10	573.03	404.63	694.03	457.84	378.37	515.01	912.56
A^0	393.63	1442.95	572.42	404.43	693.86	457.26	377.89	514.49	911.74
H^+	401.77	1446.18	578.30	416.28	698.49	464.40	386.70	521.17	915.83
$\widetilde{\nu}_e$	186.00	1454.17	275.99	441.22	244.52	243.25	249.06	347.61	309.71
$\widetilde{e}_R^-$	142.97	1451.69	178.33	416.54	191.45	191.30	127.43	175.87	303.01
$\widetilde{e}_L^-$	202.14	1456.33	287.11	448.40	256.30	255.81	261.47	356.61	319.66
$\widetilde{\tau}_1^-$	133.22	1439.46	170.59	267.61	180.67	184.34	120.45	169.42	271.28
$\widetilde{\tau}_2^-$	206.13	1450.38	289.22	414.91	257.86	258.31	263.40	357.59	322.54
$\widetilde{t}_1$	379.11	1003.88	623.83	530.58	220.74	474.12	779.09	957.65	1005.17
$\widetilde{t}_2$	574.71	1307.41	819.54	695.88	644.65	659.73	863.00	1058.68	1128.80
$\widetilde{b}_1$	491.91	1296.56	757.50	606.86	535.86	589.80	822.17	1021.90	1112.07
$\widetilde{b}_2$	524.59	1520.09	791.35	706.45	622.99	623.42	843.35	1048.26	1232.88
$\widetilde{u_R}$	520.45	1530.08	791.78	715.10	624.49	621.87	830.54	1033.16	1227.35
$\widetilde{u_L}$	537.25	1532.70	816.57	730.24	641.82	638.97	859.66	1080.25	1218.09
$\widetilde{g}$	595.19	784.37	914.26	721.03	710.31	708.58	926.04	820.50	1275.18

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Analysis

- ROOT

Endpoint Method Overview

$$e^+e^- \longrightarrow X\bar{X}$$

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$$E(X) = 250GeV$$

$$E(Z) = \gamma(E_{Z,cm} + \beta P_{Z,cm} cos(\theta))$$

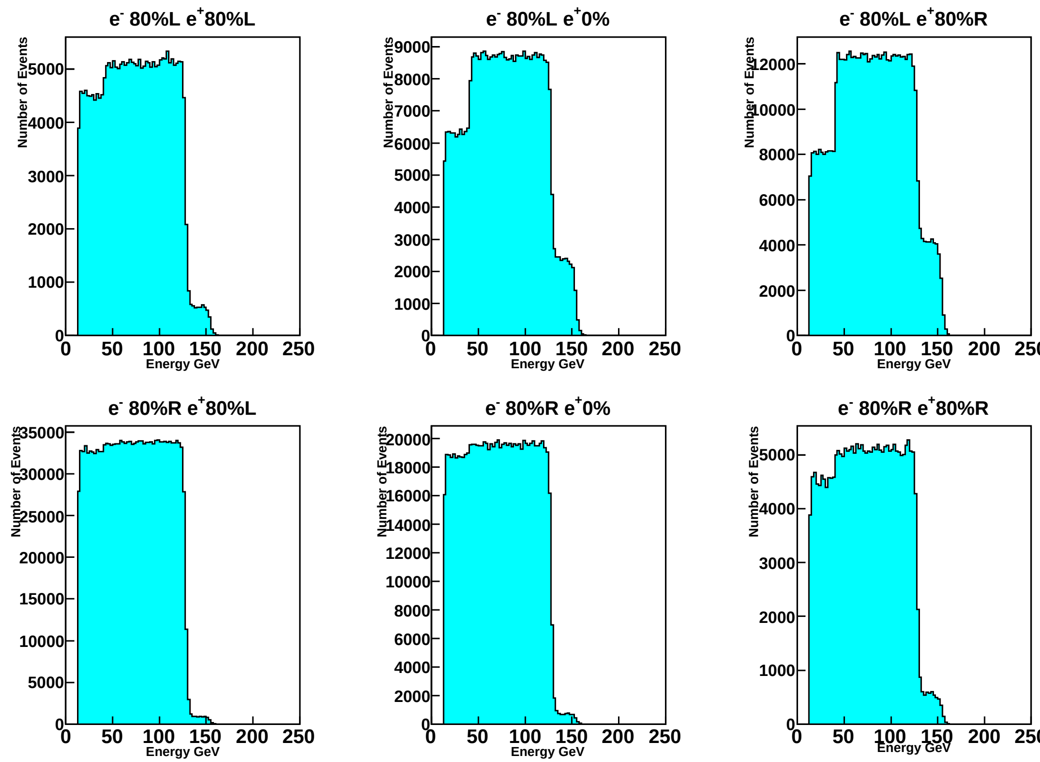
Energy of visible (particle Z) follows a uniform distribution between an E_{max} and E_{min}.

Smuon Energy Distribution at SPS1

$$e^+e^- \to \widetilde{\mu}_R^+\widetilde{\mu}_R^-$$

$$e^+e^- \to \widetilde{\mu}_L^+\widetilde{\mu}_L^-$$

$$\widetilde{\mu}^\pm \to \widetilde{\chi}_1^0\mu^\pm$$

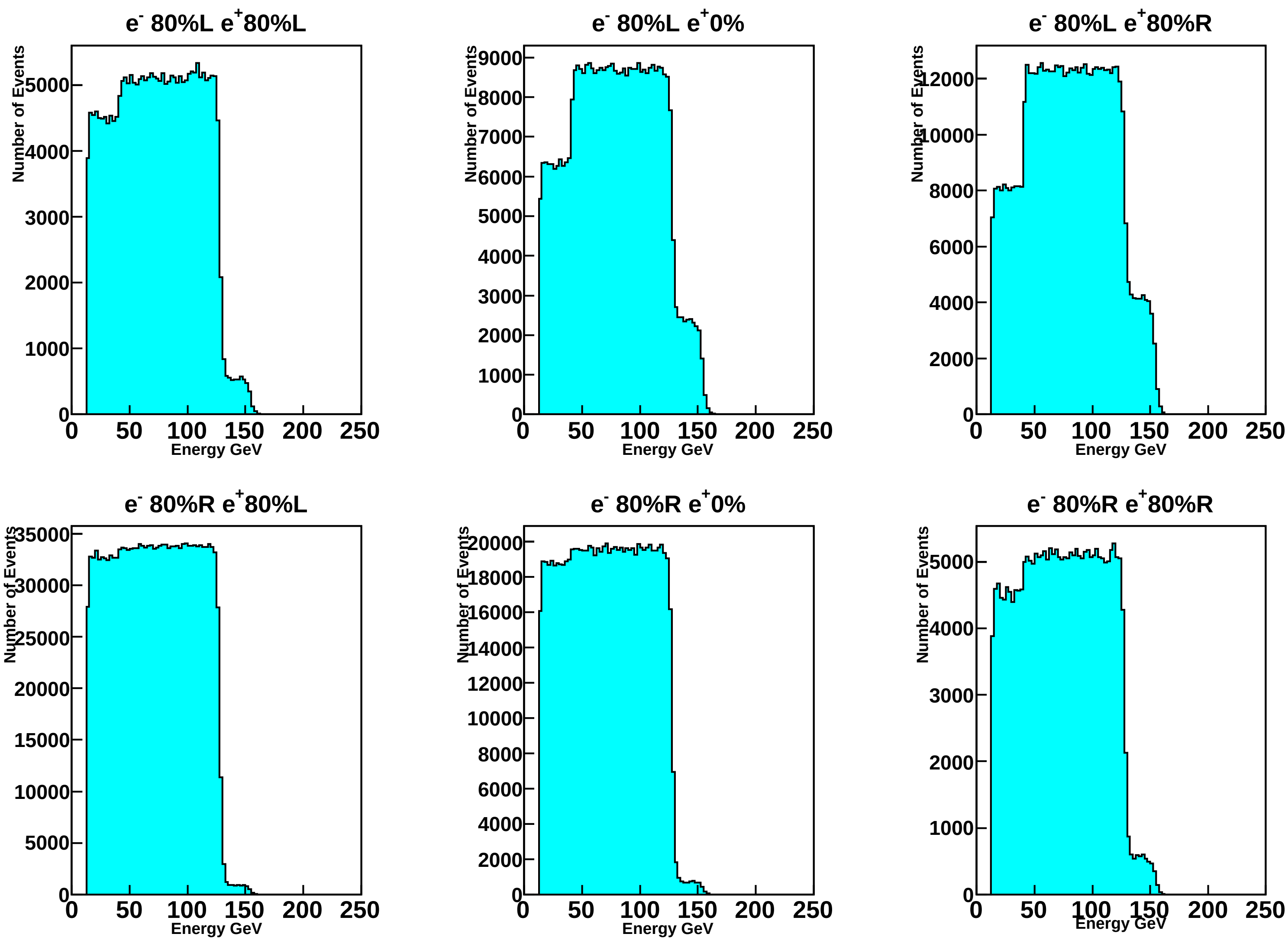


Two distributions corresponding to two different smuons add to form energy distribution with four endpoints.

Number of events is proportional to cross section and thus polarization.

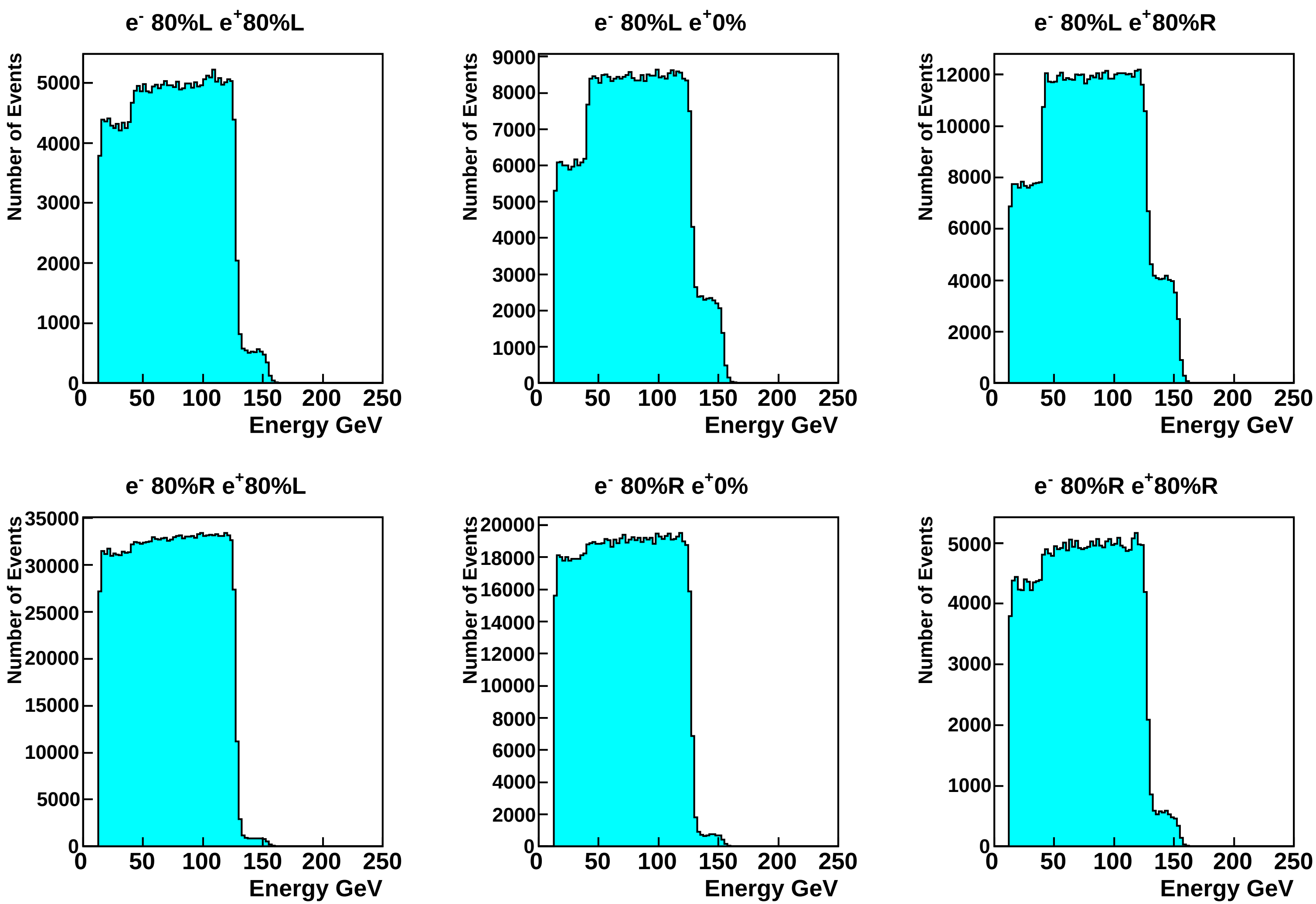
Smuon energy angular dependence

No cut on angle



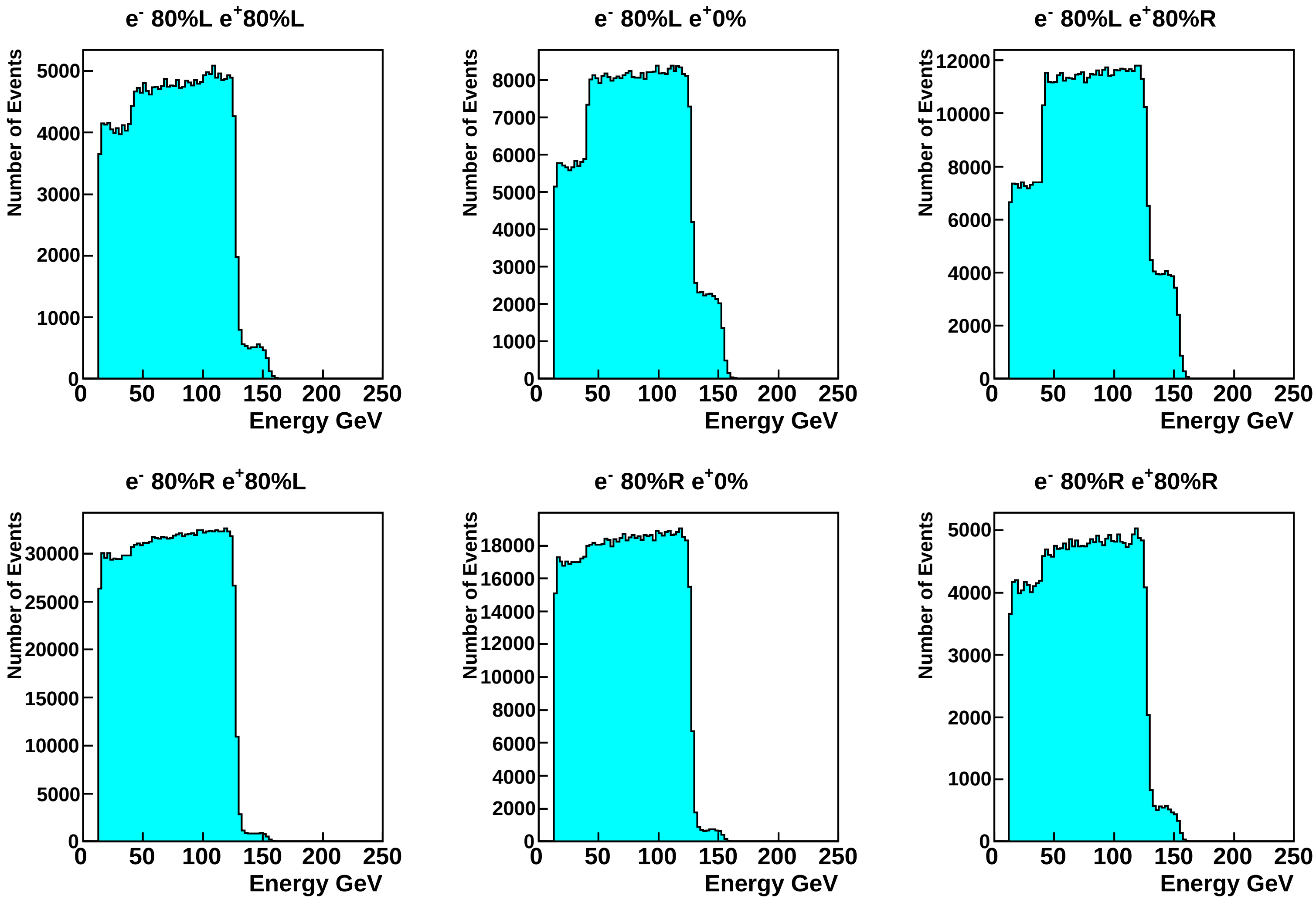
Smuon energy angular dependence

Angle cut: $cos(\theta) < 0.95$



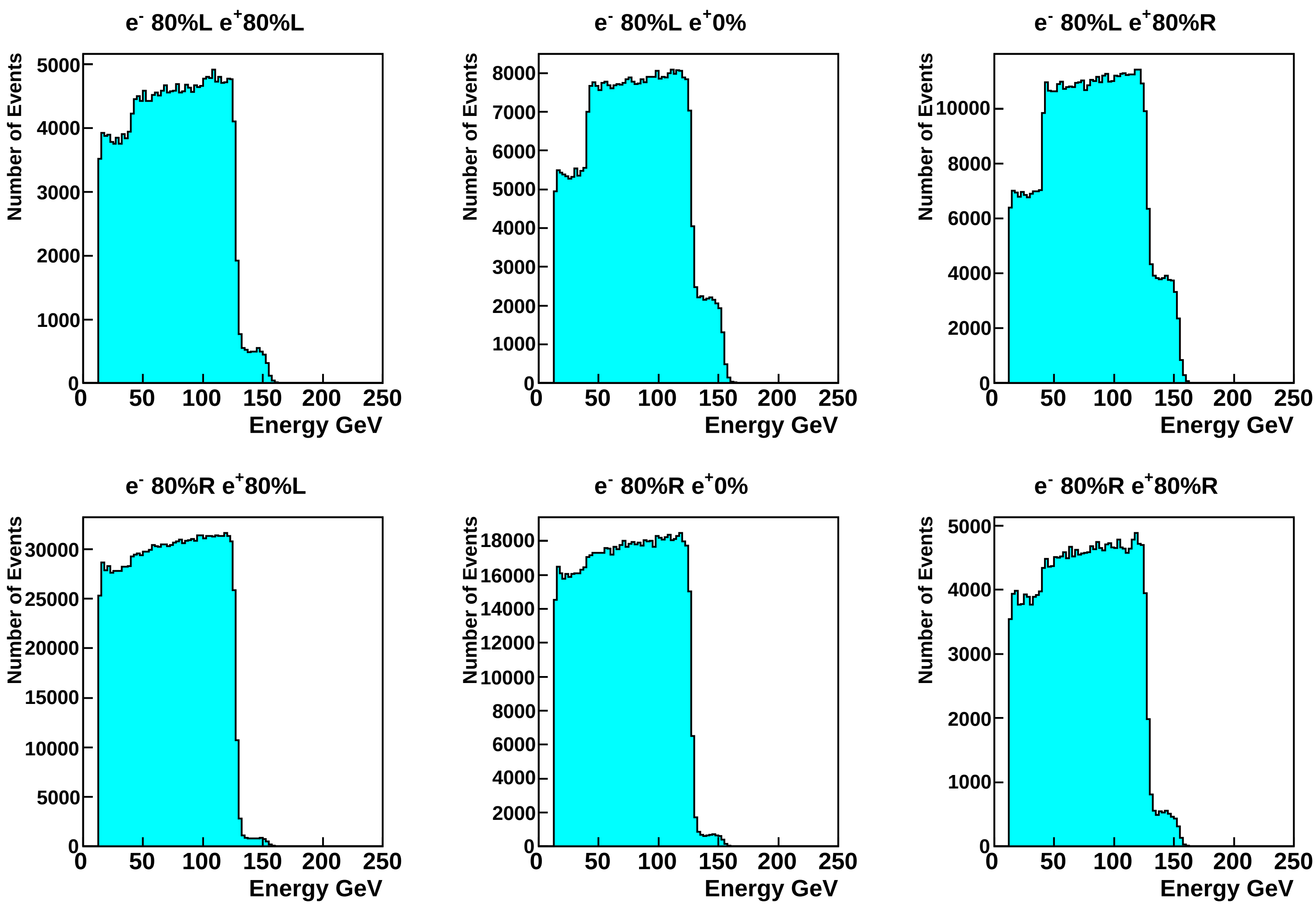
Smuon energy angular dependence

Angle cut: $cos(\theta) < 0.9$



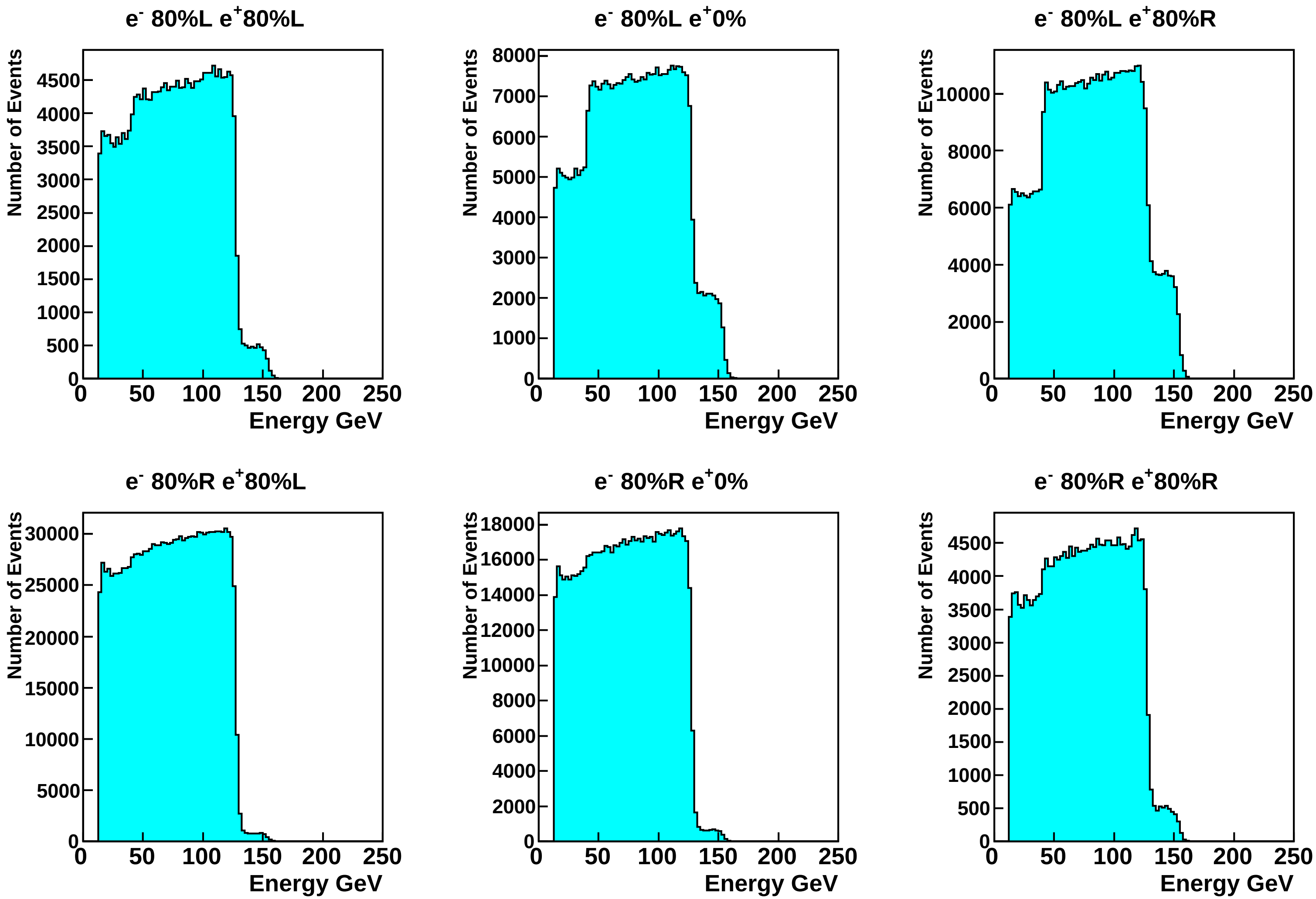
Smuon energy angular dependence

Angle cut: $cos(\theta) < 0.85$



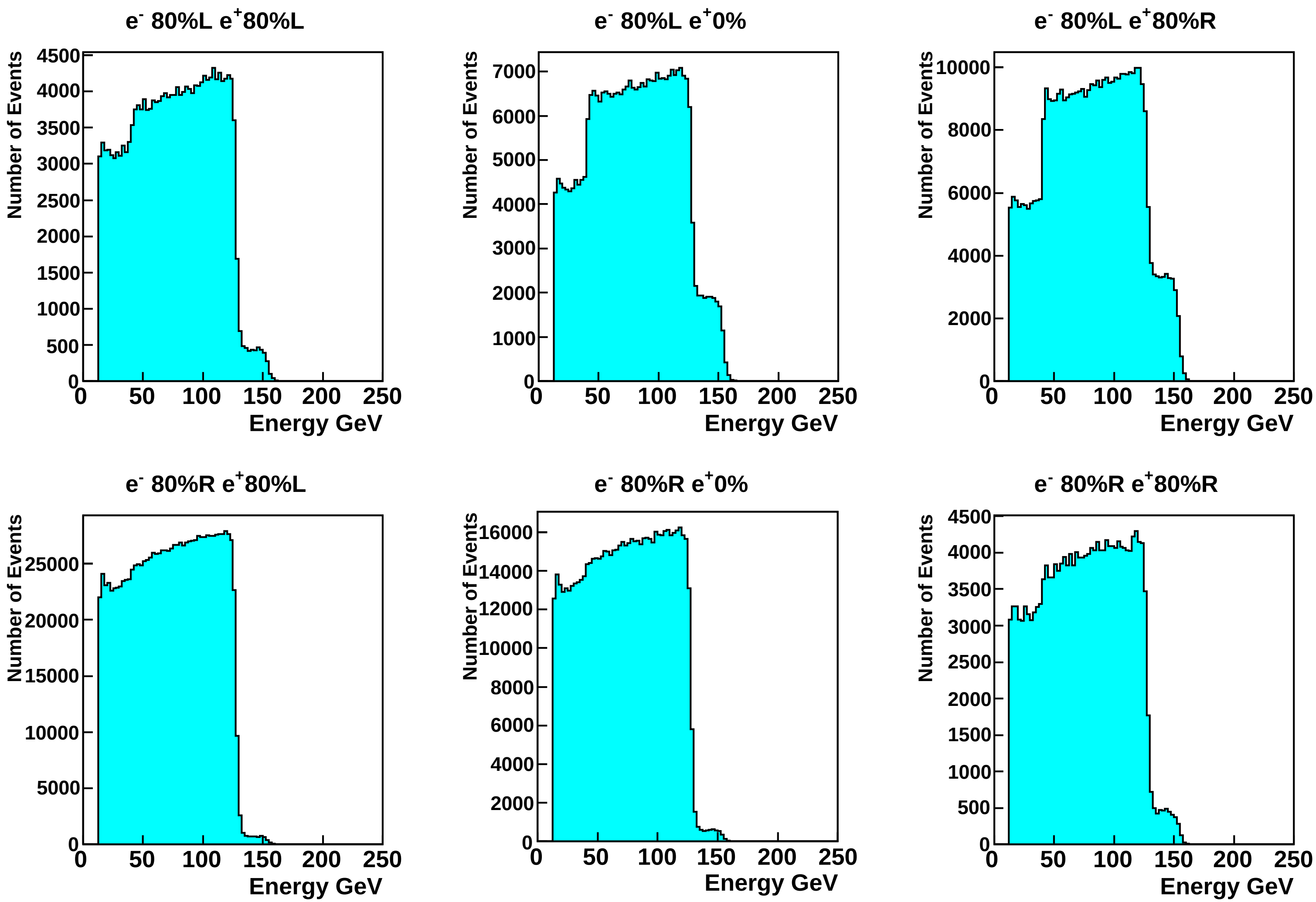
Smuon energy angular dependence

Angle cut: $cos(\theta) < 0.8$



Smuon energy angular dependence

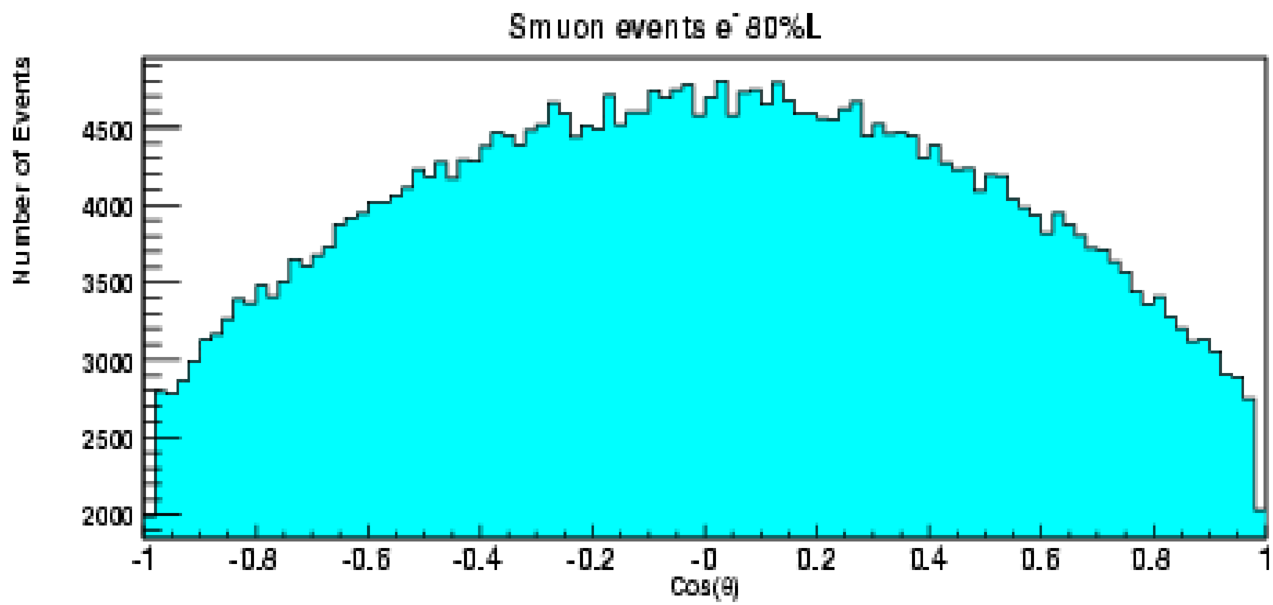
Angle cut: $cos(\theta) < 0.7$



Smuon energy angular dependence

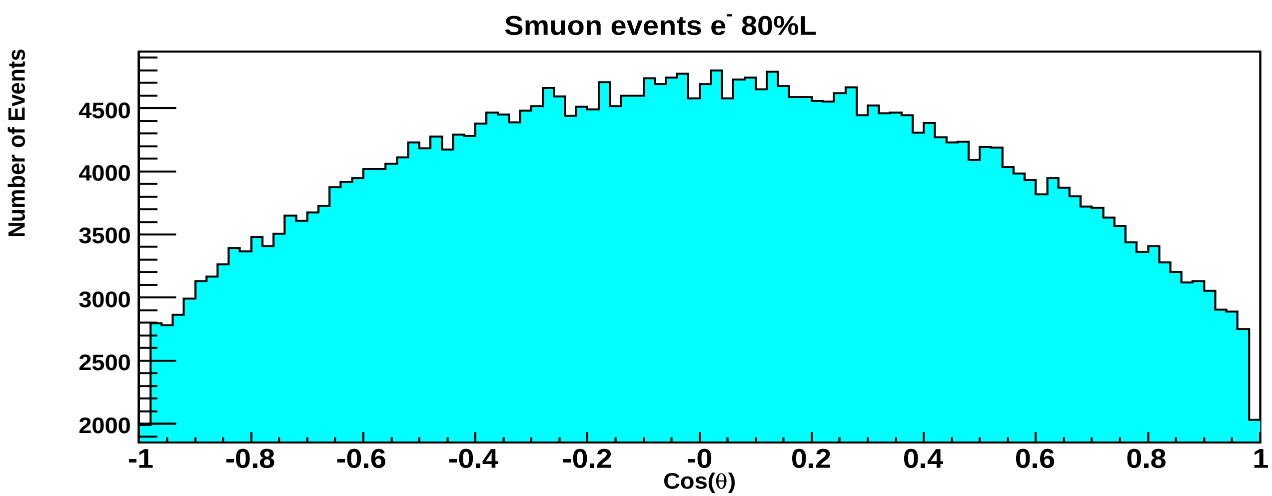
Angular distribution of smuon production is peaked at $cos(\theta) = 0$.

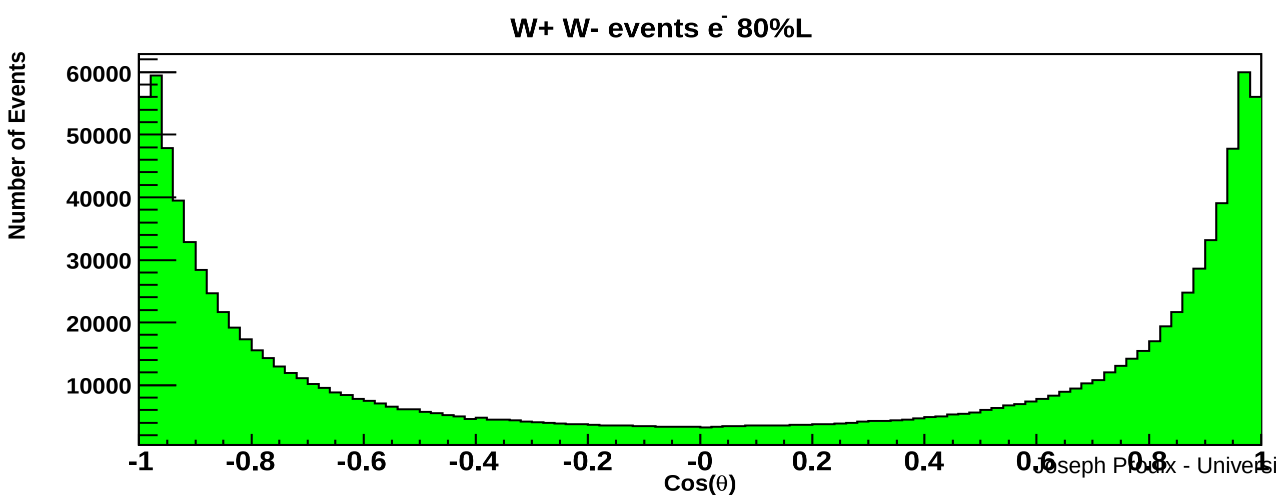
Therefore angular cuts have only a minor effect, mostly at the low end of energy spectrum.



W pair production

For t-channel events, (gauginos, e.g.) angular cuts affect the high end of the energy spectrum, and are much more pronounced.





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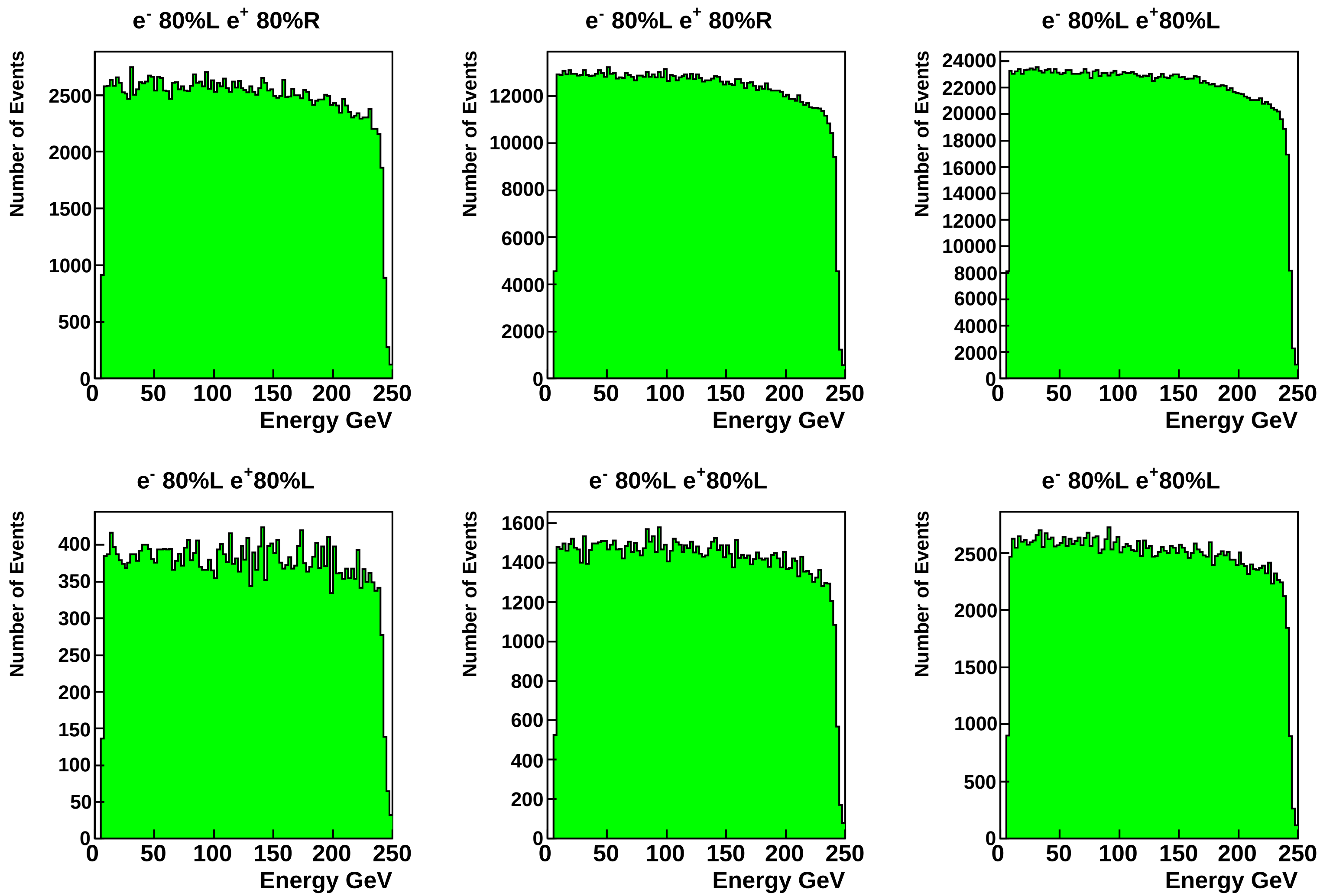

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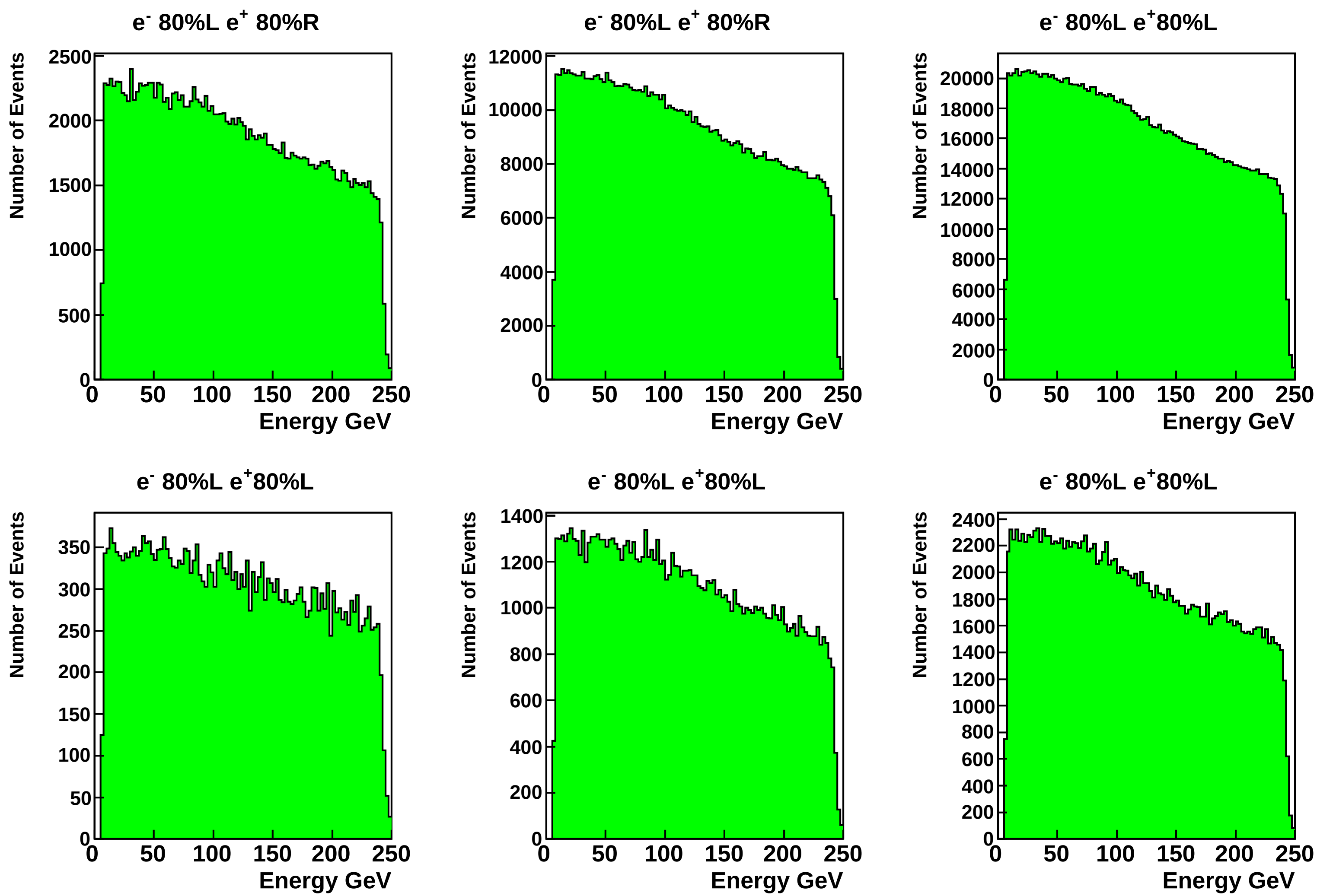

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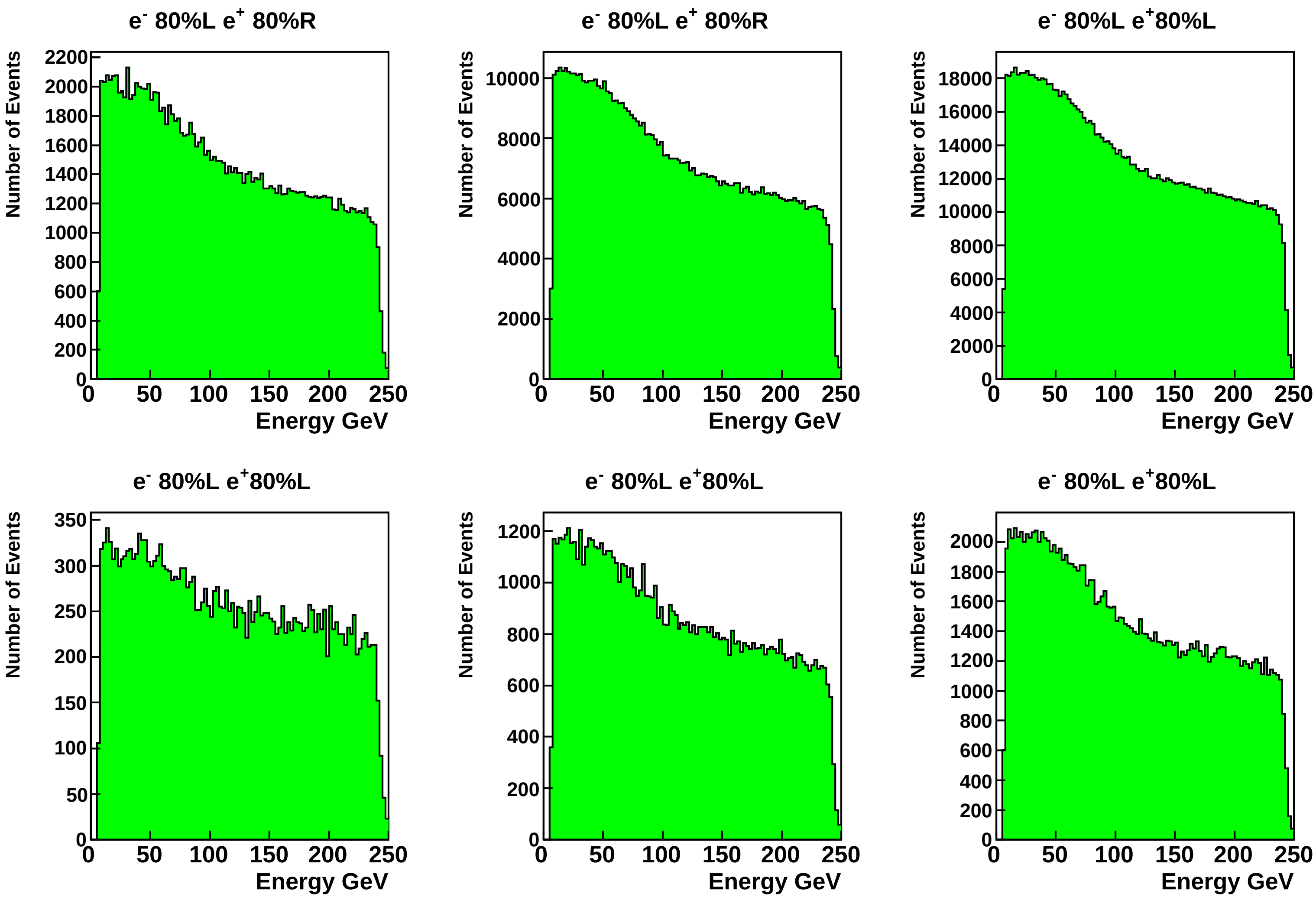

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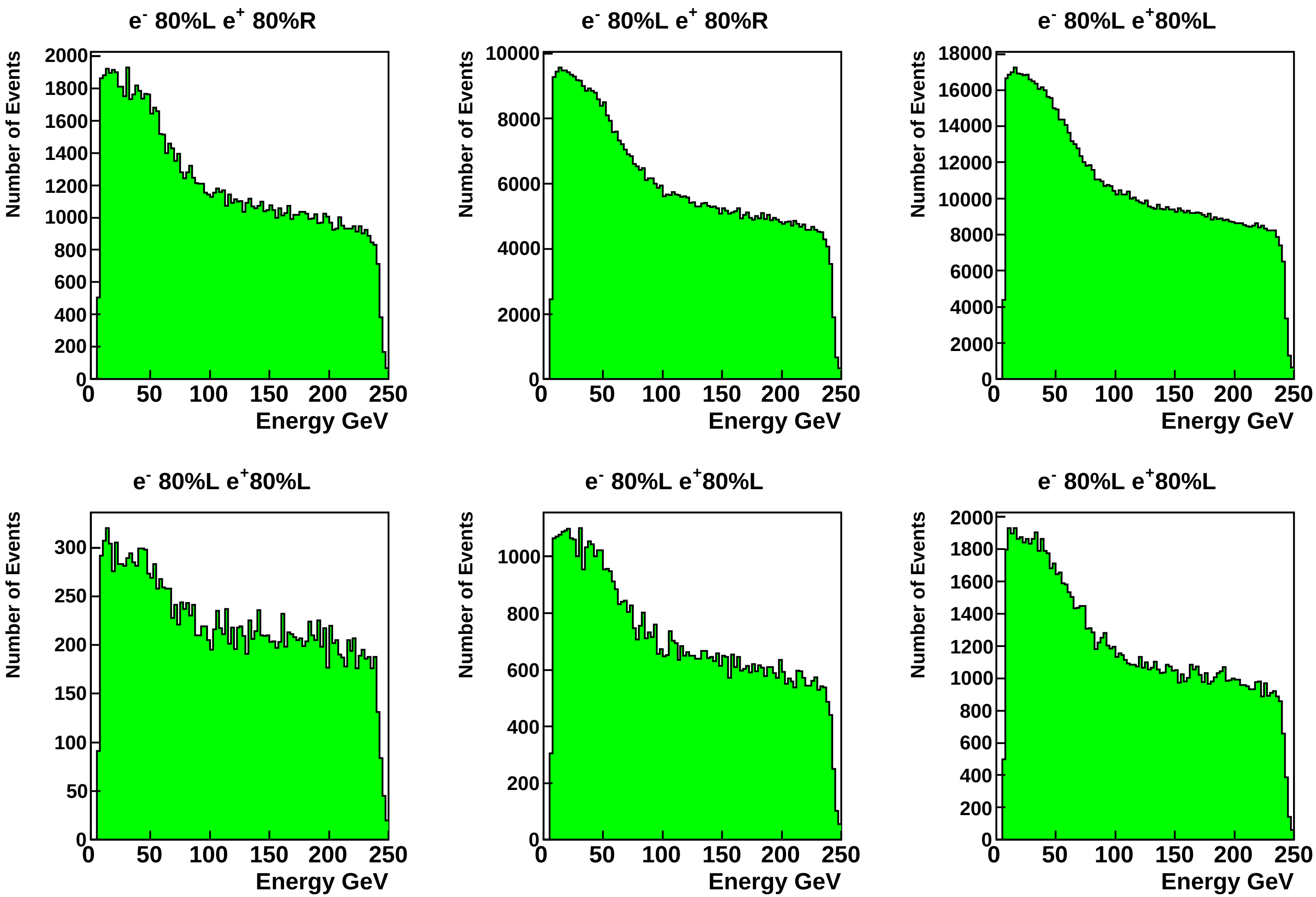

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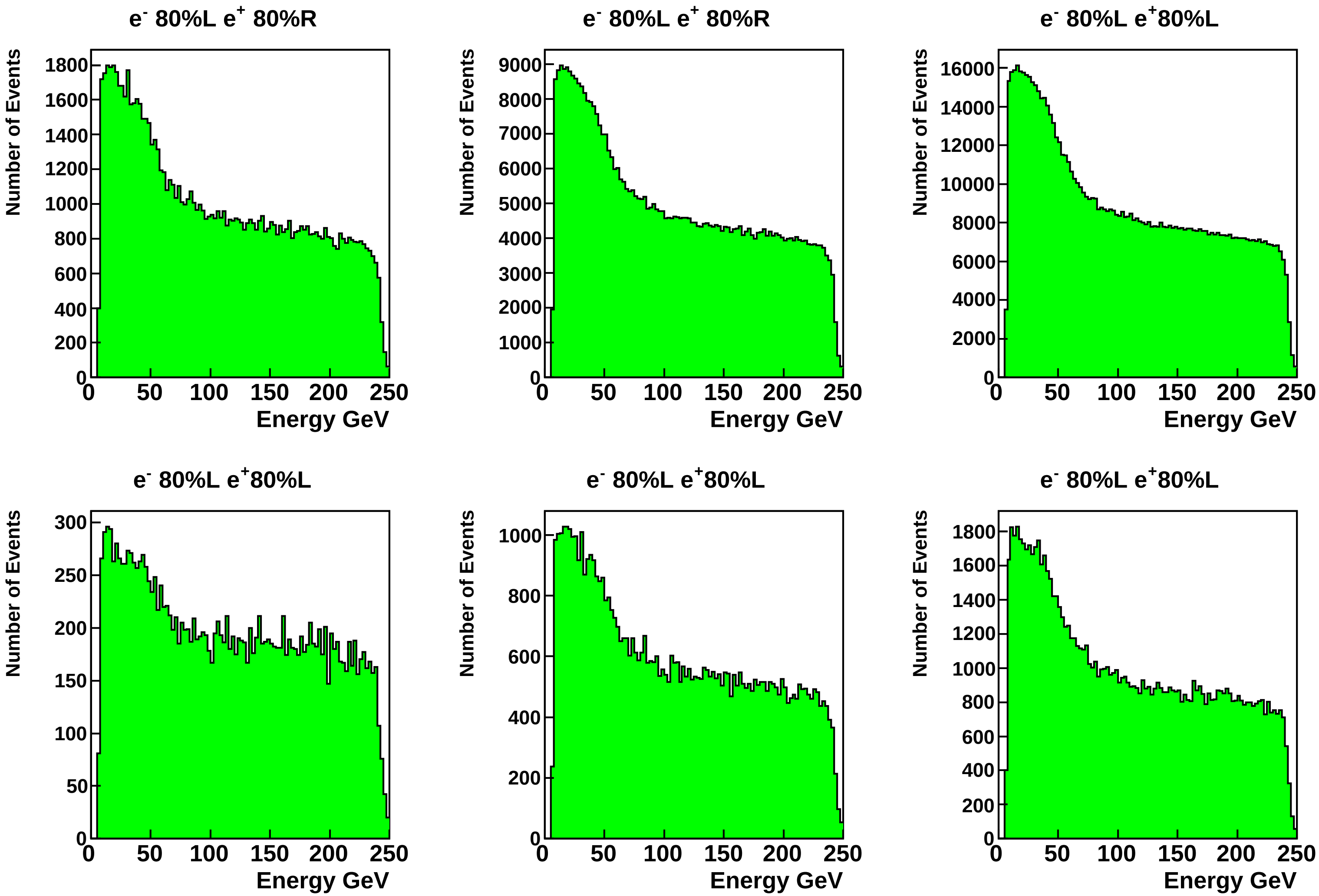

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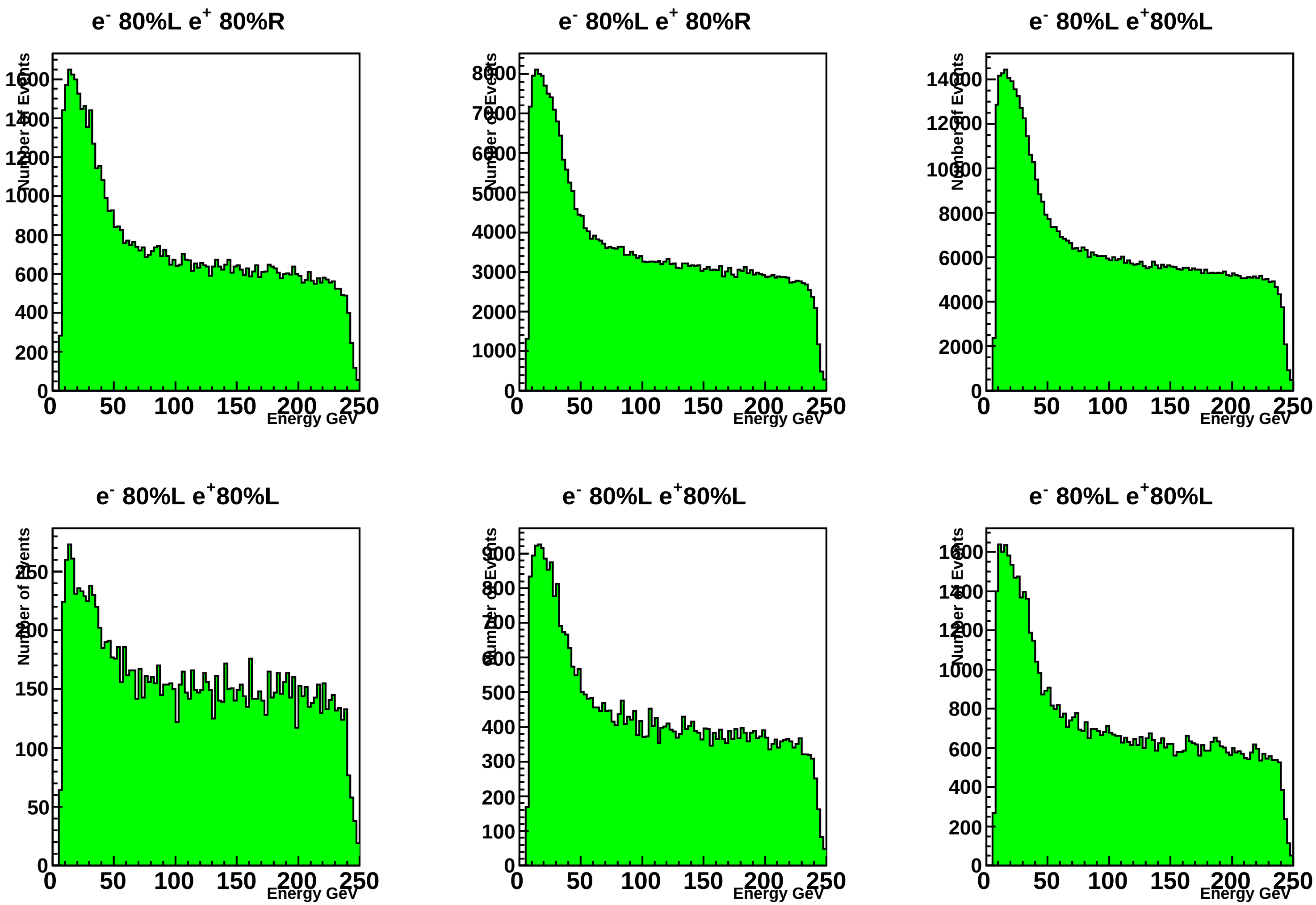
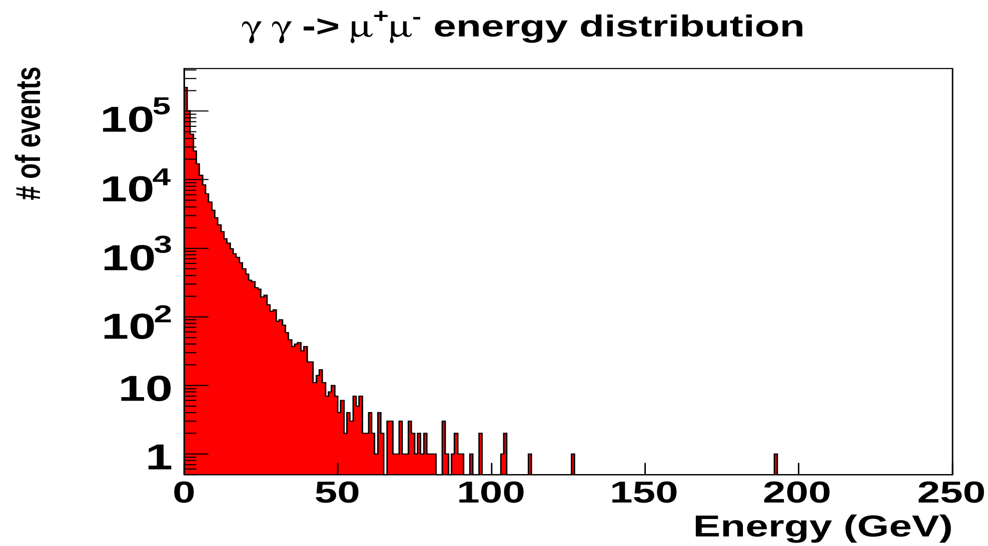


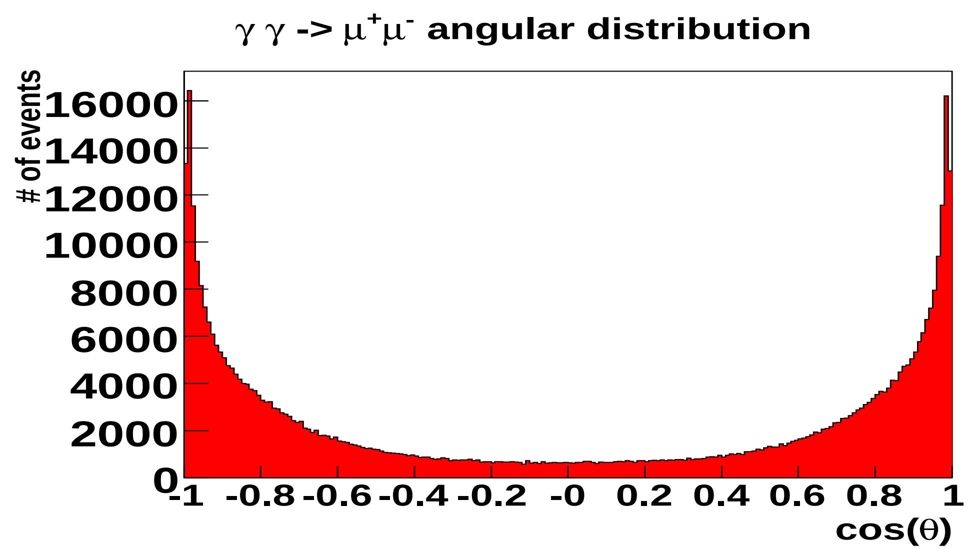
Two-photon background

$$e^+e^- \to e^+e^-\gamma\gamma$$

$$\gamma\gamma \to \ell^+\ell^-$$

- Extremely high cross section
- Peaked at low energy
- Peaked at low angle





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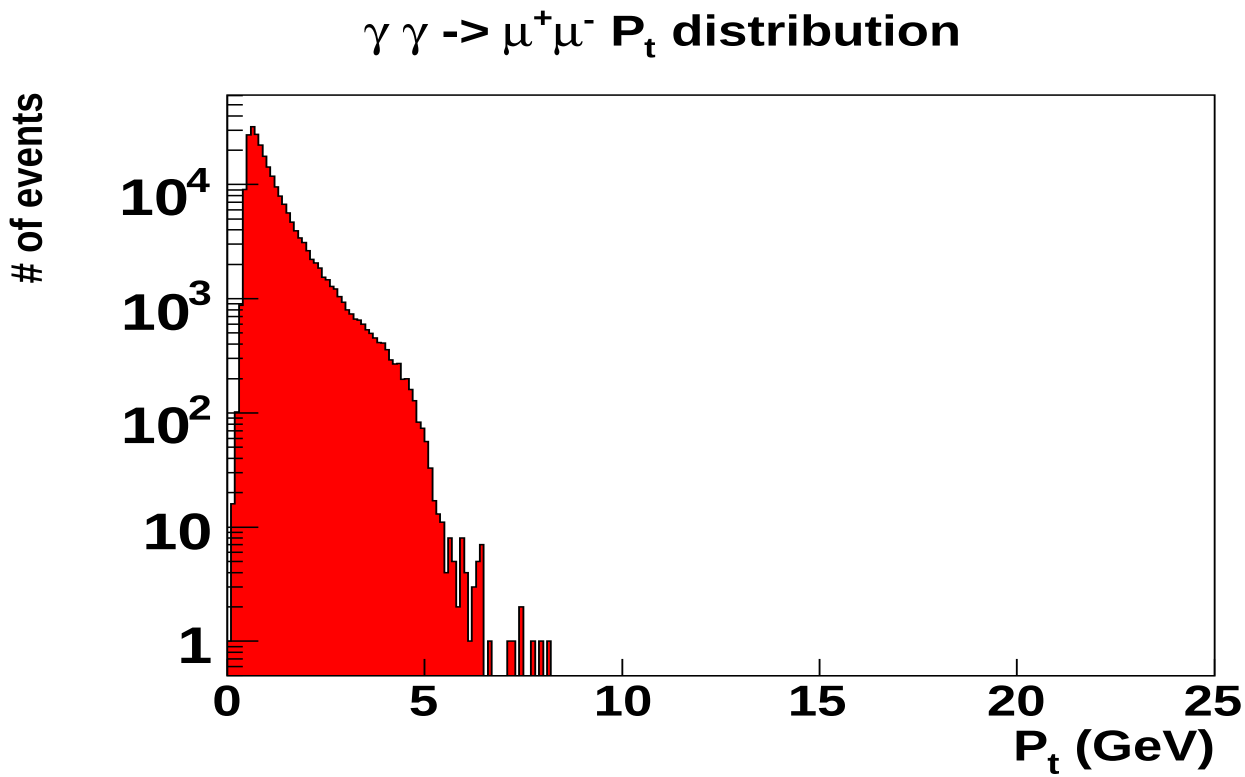

- Detector needed in highly forward region to detect scattered electrons
- Background is mostly eliminated with missing Pt cut
- Remaining background (from taus) is polarization-independent

Conclusions

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- Good energy (momentum) resolution

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Smuon studies do not drive muon detector requirements.