New geometry with shielding in the beam generator

The MOLLER Project
Measurement **O**f a **L**epton **L**epton **E**lectroweak **R**eaction

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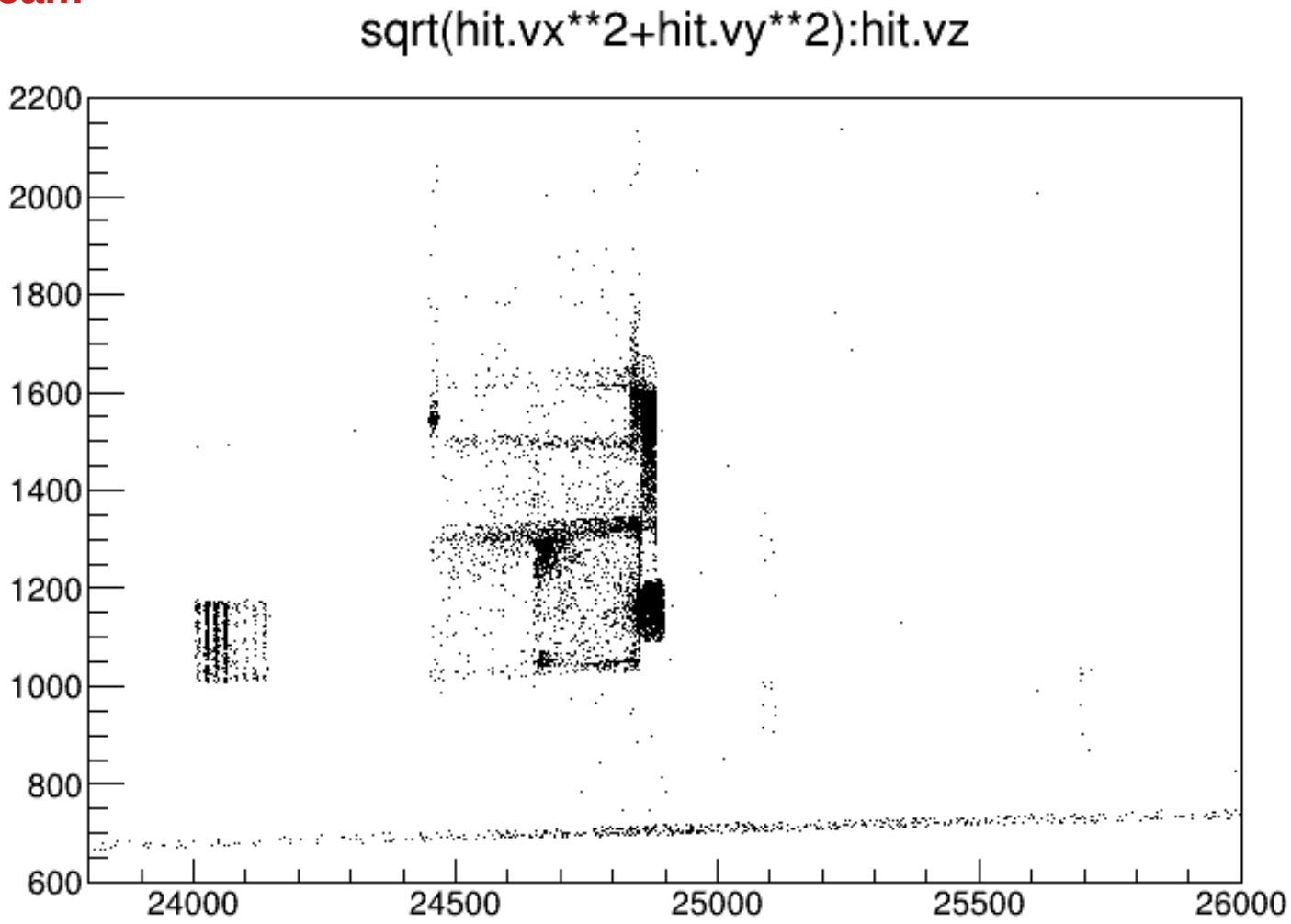
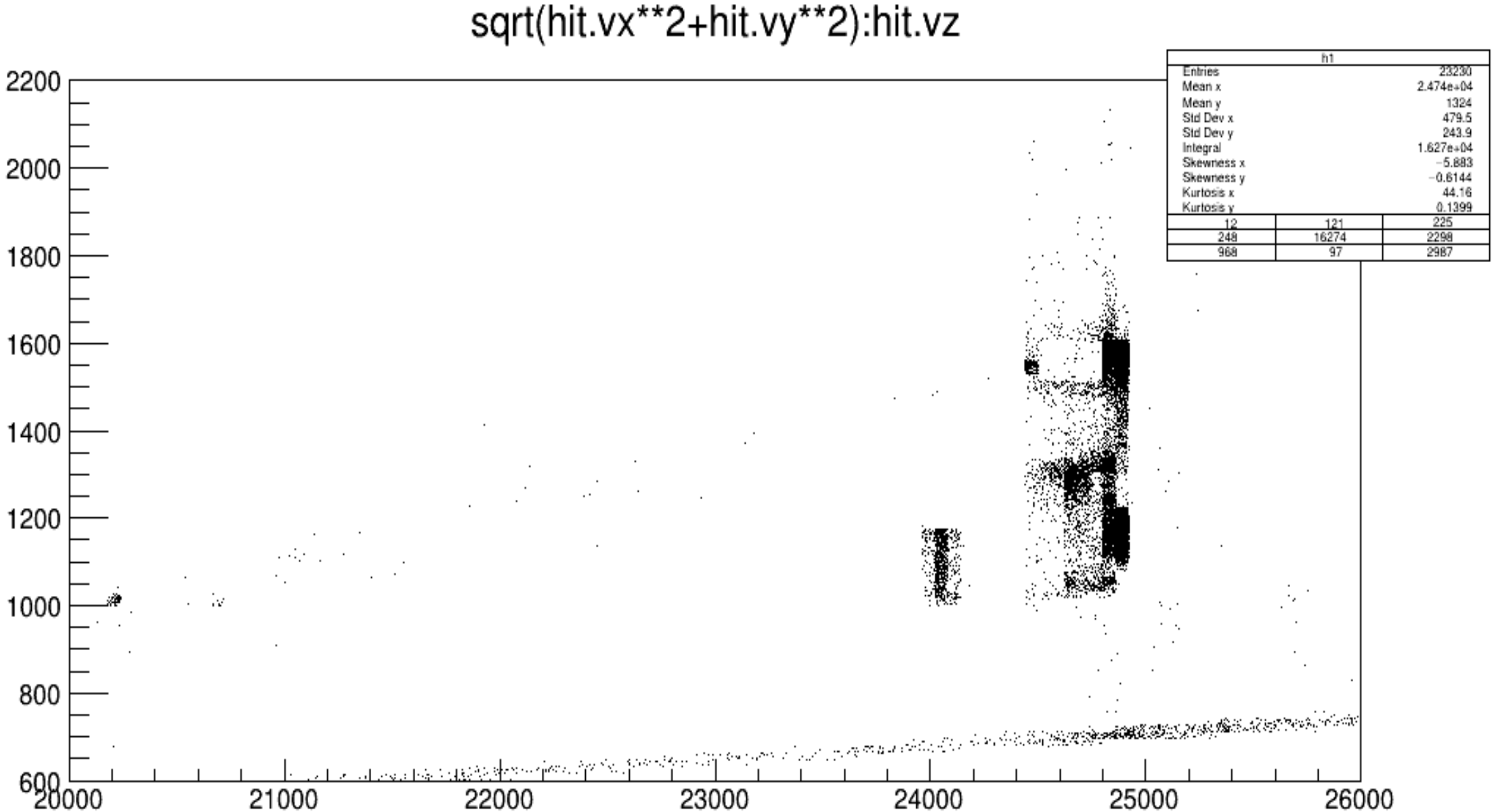
The origin location of all the secondaries anywhere for 55,000,000 events

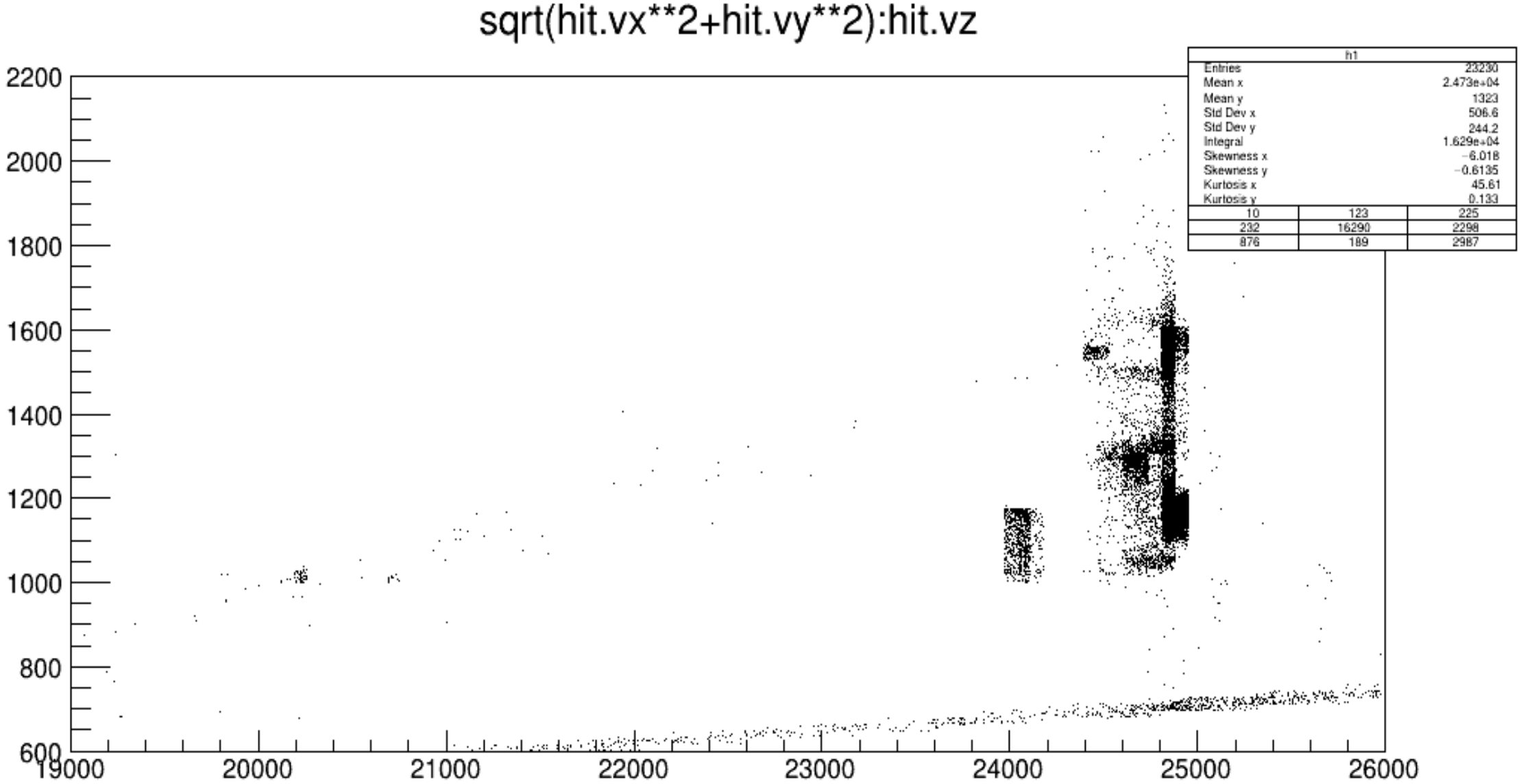
(26 cm concrete and upstream Lead)

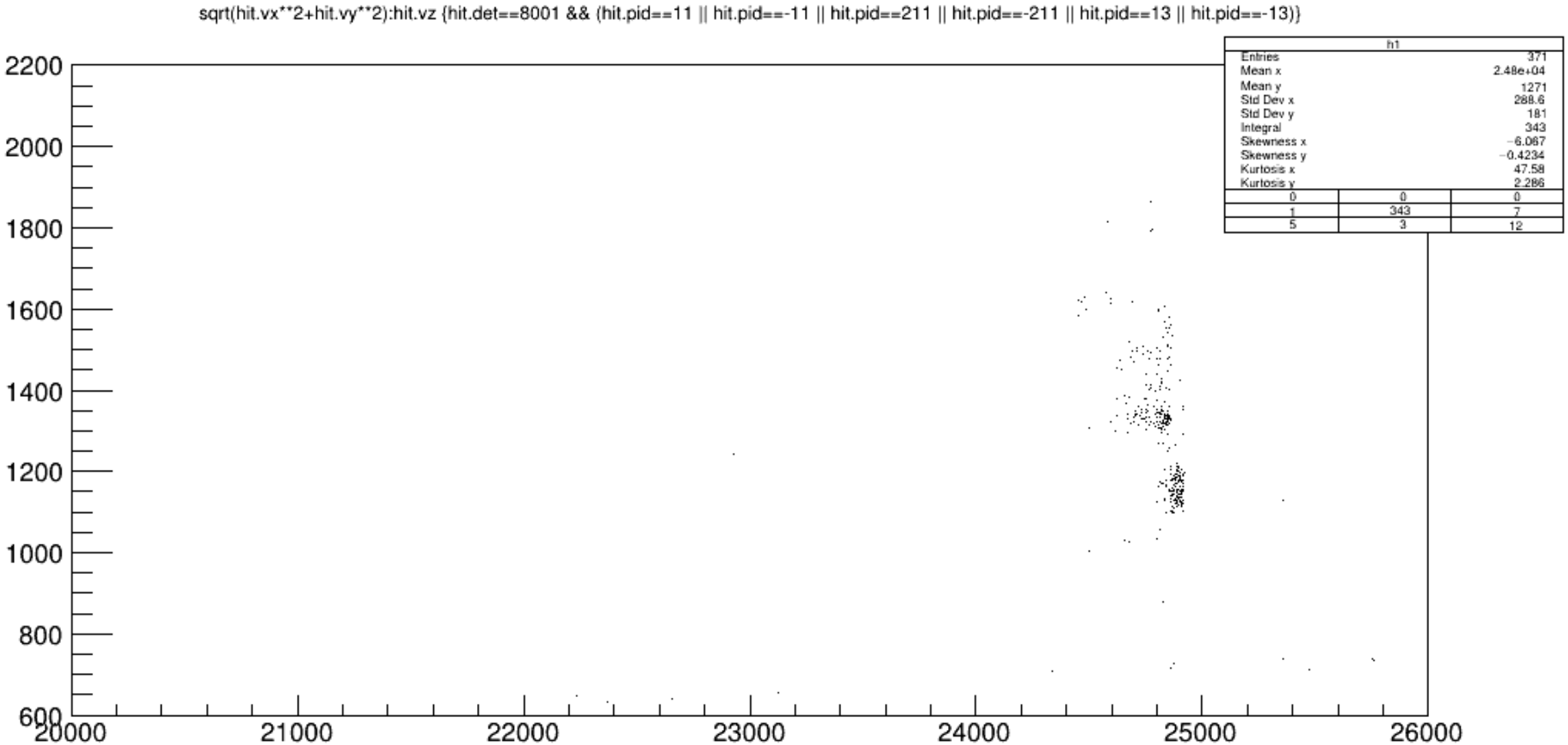
Beam

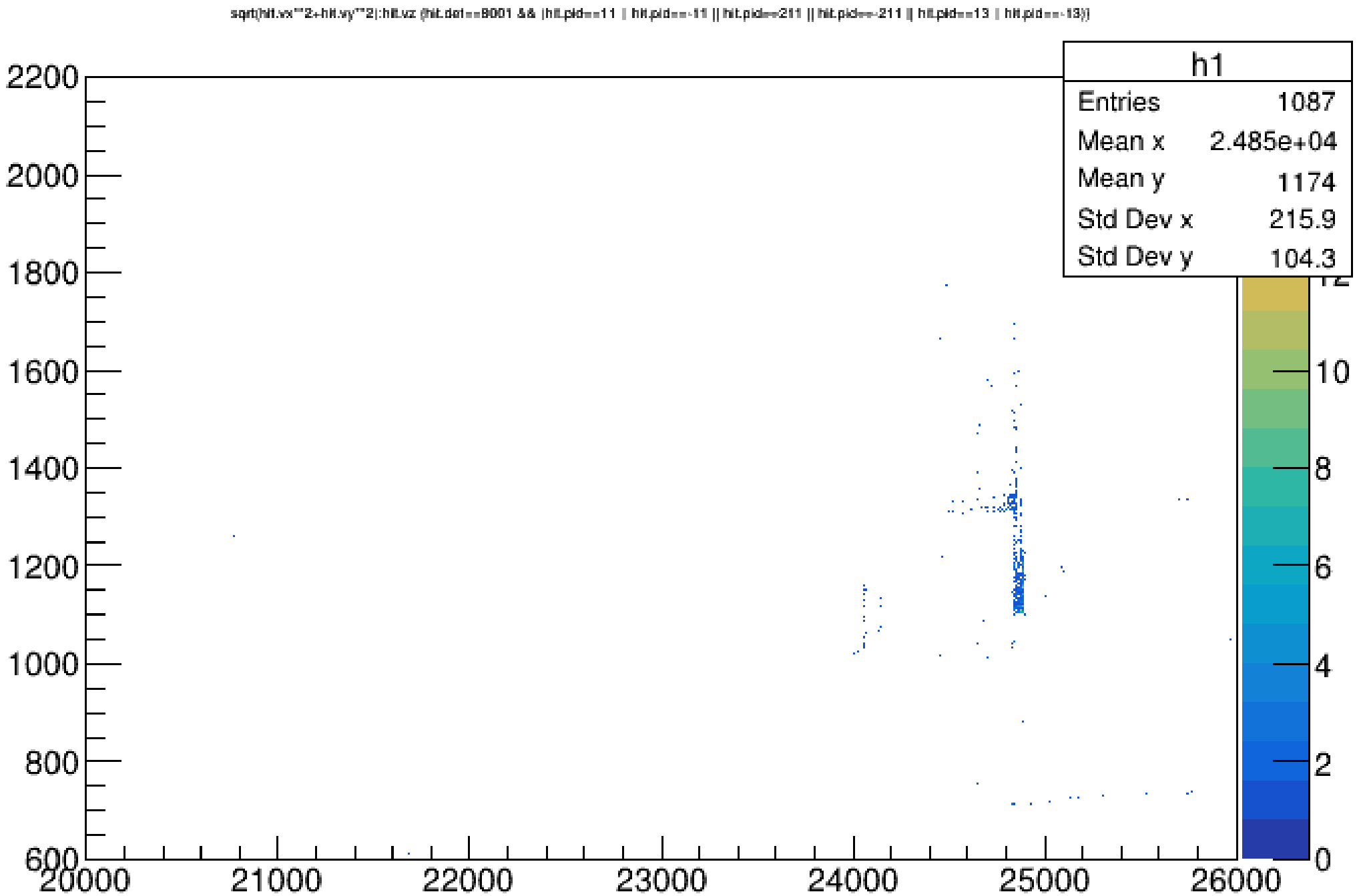


T->Draw("sqrt(hit.vx**2+hit.vy**2):hit.vz>>h1(100,23800,26000,100,600,2200)")


sqrt(hit.vx**2+hit.vy**2):hit.vz
h1
Entries 23230
Mean x 2.474e+04
Mean y 1324
Std Dev x 479.5
Std Dev y 243.9
Integral 1.627e+04
Skewness x −5.883
Skewness y −0.6144
Kurtosis x 44.16
Kurtosis y 0.1399
12 121 225
248 16274 2298
968 97 2987
2200
2000
1800
1600
1400
1200
1000
800
600
20000
21000
22000
23000
24000
25000
26000


sqrt(hit.vx**2+hit.vy**2):hit.vz
h1
Entries 23230
Mean x 2.473e+04
Mean y 1323
Std Dev x 506.6
Std Dev y 244.2
Integral 1.629e+04
Skewness x −6.018
Skewness y −0.6135
Kurtosis x 45.61
Kurtosis y 0.133
10 123 225
232 16290 2298
876 189 2987
2200
2000
1800
1600
1400
1200
1000
800
600
19000
20000
21000
22000
23000
24000
25000
26000


sqrt(hit.vx**2+hit.vy**2):hit.vz {hit.det==8001 && (hit.pid==11 || hit.pid==-11 || hit.pid==211 || hit.pid==-211 || hit.pid==13 || hit.pid==-13)}
h1
Entries 371
Mean x 2.48e+04
Mean y 1271
Std Dev x 288.6
Std Dev y 181
Integral 343
Skewness x −6.067
Skewness y −0.4234
Kurtosis x 47.58
Kurtosis y 2.286
0 0 0
1 343 7
5 3 12
2200
2000
1800
1600
1400
1200
1000
800
600
20000
21000
22000
23000
24000
25000
26000


sqrt(hit.vx**2+hit.vy**2):hit.vz (hit.det==8001 && (hit.pid==11 || hit.pid==-11 || hit.pid==211 || hit.pid==-211 || hit.pid==13 || hit.pid==-13))
h1
Entries 1087
Mean x 2.485e+04
Mean y 1174
Std Dev x 215.9
Std Dev y 104.3
2200
2000
1800
1600
1400
1200
1000
800
600
20000
21000
22000
23000
24000
25000
26000
10
8
6
4
2
0

Comparison of rates at the Lucite for 5,000,000 events (Low energy particles, hit.p<2*MeV)

Rates $GHz/\mu A/Detector$	Rate of electrons	Rate of pions	Pi/e	Rate of photons from electrons	Rate of photons from pions	Pi/e
Concrete and Lead at 16cm	$(1.12 \pm 0.04) \times 10^{-4}$	$(7.93 \pm 0.30) \times 10^{-7}$	0.71%	$(1.96 \pm 0.03) \times 10^{-3}$	$(7.54 \pm 0.03) \times 10^{-5}$	3.85%
Concrete and Lead at 21cm	$(7.88 \pm 0.32) \times 10^{-5}$	$(6.95 \pm 0.28) \times 10^{-7}$	0.88%	$(1.55 \pm 0.02) \times 10^{-3}$	$(7.46 \pm 0.03) \times 10^{-5}$	4.81%
Concrete and Lead at 26cm	$(6.10 \pm 0.38) \times 10^{-5}$	$(7.30 \pm 0.29) \times 10^{-7}$	1.20%	$(1.43 \pm 0.03) \times 10^{-3}$	$(7.43 \pm 0.03) \times 10^{-5}$	5.20%
Concrete and Lead at 30cm	$(6.03 \pm 0.90) \times 10^{-5}$	$(7.72 \pm 0.30) \times 10^{-7}$	1.28%	$(1.36 \pm 0.02) \times 10^{-3}$	$(7.34 \pm 0.03) \times 10^{-5}$	5.40%
Concrete and Lead at 35cm	$(4.56 \pm 0.21) \times 10^{-5}$	$(7.89 \pm 0.31) \times 10^{-7}$	1.73%	$(1.24 \pm 0.02) \times 10^{-3}$	$(7.89 \pm 0.03) \times 10^{-5}$	6.36%

Beam generator

55M events

Concrete and Lead at 26cm	$(2.05 \pm 0.13) \times 10^{-3}$			$(1.023 \pm 0.001) \times 10^{-1}$		

500M events (Raj's results)

Concrete and Lead at 26cm	$(5.48 \pm 0.22) \times 10^{-3}$			$(1.99 \pm 0.01) \times 10^{-1}$		

Comparison of rates at the Lucite for 5,000,000 events (High energy particles, hit.p>2*MeV)

Rates $GHz/\mu A$ $/Detector$	Rate of electrons	Rate of pions	Pi/e	Rate of photons from electrons	Rate of photons from pions	Pi/e
Concrete and Lead at 16cm	$(4.89 \pm 0.28) \times 10^{-5}$	$(4.63 \pm 0.08) \times 10^{-6}$	9.47%	$(1.96 \pm 0.03) \times 10^{-3}$	$(7.54 \pm 0.03) \times 10^{-5}$	3.85%
Concrete and Lead at 21cm	$(2.37 \pm 0.19) \times 10^{-5}$	$(4.69 \pm 0.08) \times 10^{-6}$	19.79%	$(1.55 \pm 0.02) \times 10^{-3}$	$(7.46 \pm 0.03) \times 10^{-5}$	4.81%
Concrete and Lead at 26cm	$(1.69 \pm 0.12) \times 10^{-5}$	$(4.70 \pm 0.08) \times 10^{-6}$	27.81%	$(1.43 \pm 0.03) \times 10^{-3}$	$(7.43 \pm 0.03) \times 10^{-5}$	5.20%
Concrete and Lead at 30cm	$(1.76 \pm 0.16) \times 10^{-5}$	$(4.66 \pm 0.08) \times 10^{-6}$	26.48%	$(1.36 \pm 0.02) \times 10^{-3}$	$(7.34 \pm 0.03) \times 10^{-5}$	5.40%
Concrete and Lead at 35cm	$(1.09 \pm 0.09) \times 10^{-5}$	$(4.81 \pm 0.08) \times 10^{-6}$	44.13%	$(1.24 \pm 0.02) \times 10^{-3}$	$(7.89 \pm 0.03) \times 10^{-5}$	6.36%

Beam generator

55M events

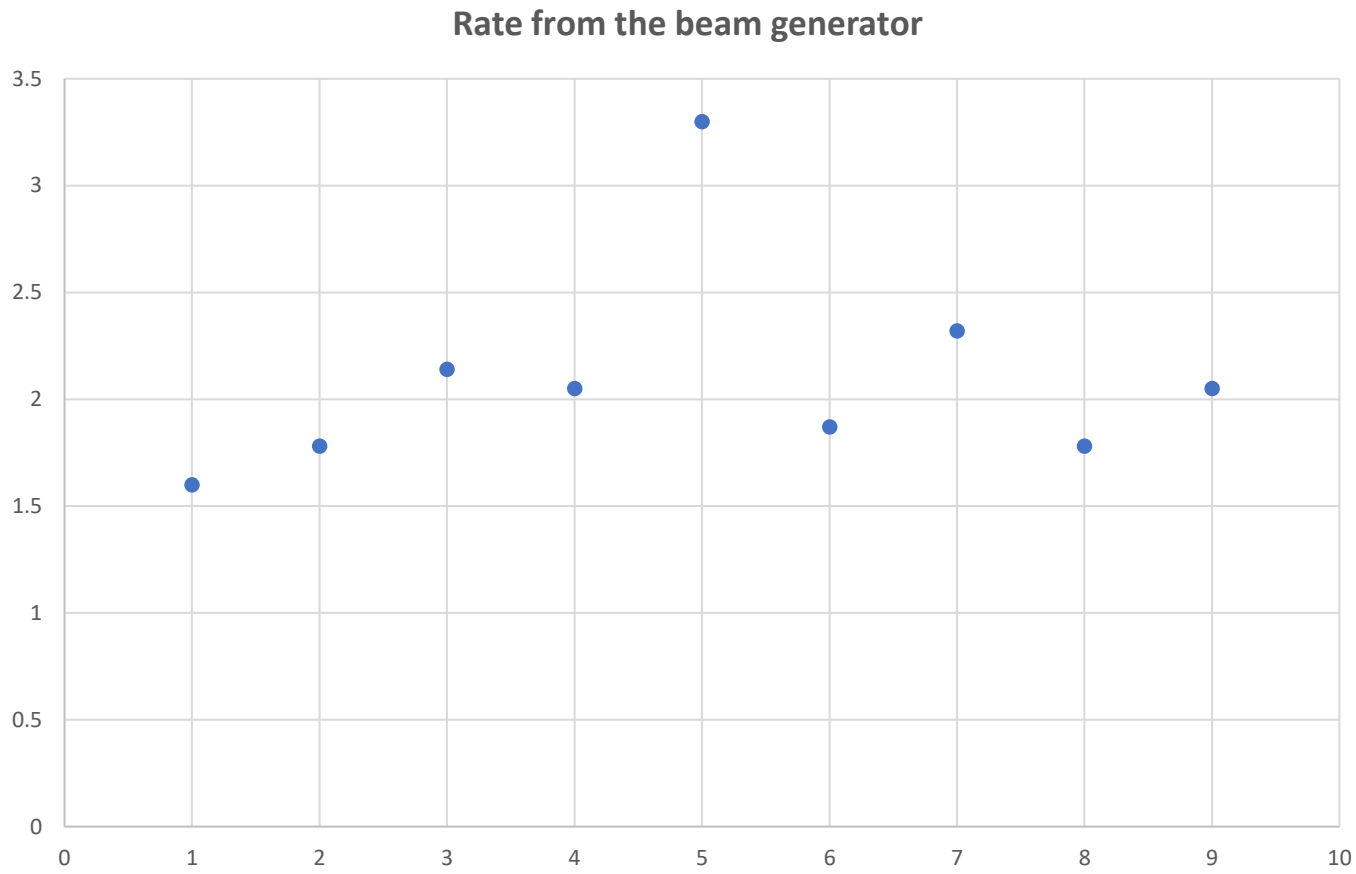
Concrete and Lead at 26cm	$(1.30 \pm 0.14) \times 10^{-3}$			$(1.023 \pm 0.001) \times 10^{-1}$		

500M events (Raj's results)

Concrete and Lead at 26cm	$(4.19 \pm 0.19) \times 10^{-3}$			$(1.99 \pm 0.01) \times 10^{-1}$		

Calculating uncertainties

Rate from the beam generator (9 groups of 5M events)
$(1.60 \pm 0.38) \times 10^{-3}$
$(1.78 \pm 0.40) \times 10^{-3}$
$(2.14 \pm 0.44) \times 10^{-3}$
$(2.05 \pm 0.43) \times 10^{-3}$
$(3.30 \pm 0.54) \times 10^{-3}$
$(1.87 \pm 0.41) \times 10^{-3}$
$(2.32 \pm 0.45) \times 10^{-3}$
$(1.78 \pm 0.40) \times 10^{-3}$
$(2.05 \pm 0.43) \times 10^{-3}$
RMS= 2.151245117
RMS/sqrt(9) = 0.717081706



Total rate from 45M events: $(1.89 \pm 0.13) \times 10^{-3}$

Calculating “rate” variable

In electrons and pions generation,

Rate/ 85*e9*14*(number of simulations=50) = Rate/5.95e13

```
T->Draw("1","(rate/5.95e13)*(hit.det==8001 && hit.p<2*MeV && (hit.pid==11 || hit.pid==-11 || hit.pid==211 || hit.pid==-211 || hit.pid==13 || hit.pid==-13))")
```

```
T->Draw("1","(rate/5.95e13)*(hit.det==8000)")
```

In the beam generation, the "weight" for each event (stored in the “rate” variable) is

85e-6μ A /1.6e-19 / 100,000 (the number of events in one simulation) =5.31e9

And then normalize it:

5.31e9 /85*14*e9*(number of the simulations=500) = 8.9e-6

```
T->Draw("1","8.9e-6*(hit.det==8001 && hit.p<2*MeV && (hit.pid==11 || hit.pid==-11 || hit.pid==211 || hit.pid==-211 || hit.pid==13 || hit.pid==-13))")
```

```
T->Draw("1","8.9e-6*(hit.det==8000)")
```

Calculating “rate” variable

In electrons and pions generation,

Rate/ 85*e9*14*(number of simulations=50) = Rate/5.95e13

In the beam generation, the "weight" for each event (stored in the “rate” variable) is

85e-6μ A /1.6e-19 / 100,000 (the number of events in one simulation) =5.31e9

And then normalize it:

5.31e9 /85*14*e9*(number of the simulations=500) = 8.9e-6

Thank you

University of Manitoba