# Estimation of Background Corrections in Multiplicity Array

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BRAHMS Analysis Note #20

December 20, 2000

## 1 Introduction

This document describes the procedure and results of estimating the ratio of secondaries in multiplicity in the tiles. The estimates has been made using GBRAHMS simulations using as input central Fritiof events.

### 1.1 Defining primaries

A primary particle is basically a particle that is measured in the detector and which originates from the collision. All other particles are secondaries. When doing simulations there are different ways of defining primaries. One definition is to say that a primary particle is a particle that would have hit the detector if there were no material in the path from the collision to the tile. This is the definition that is chosen in this analysis. But one could also define primaries as particles which originates within a certain volume around vertex as has been previously done by Hironori Ito at BNL.

## 2 Simulations

For all simulations the same Fritiof file was used. The file contained central events, with impact parameter, $b$, ranging from 0 to 2 fm. The energy was $\sqrt{s} = 130\ GeV$.[1] All simulations were done for 1000 events. The idea behind the different simulations is, that by switching off different elements of the detector, estimates can be made of the contribution of the individual components.[2]. Furthermore switching off hadronic interactions is assumed to deactivate the production of secondaries. The five simulations are:

**A** Every component of the detector is switched on and hadronic interactions included.

**B** All hadronic interactions are made inactive.

**C** No beam pipe but hadronic interactions included.

**D** No beam pipe or support for the tiles included. Hadronic interactions included.

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[1]The Fritiof file can be found at NBI, at: `nfs/hehi/hehi22/hehi/jakobsen/simu/frit702/130_auau_0_2.zdat`
[2]This is described in Appendix B

**E** No beam pipe, no support and no silicon detectors included. Hadronic interactions included.

**F** No beam pipe, no support for tiles, no silicon detectors and no hadronic interactions.

# 3 Results

The tiles are arranged in a hexagon with approximately 8 tiles on each side. The hexagon may be considered as 8 rings of tiles with the same pseudo rapidity. All following graphs shows the energy deposit in tiles for four such rings, namely ring 1 which corresponds to tile numbers:[3] 1, 9, 17, 25, 33 and 41 with $\eta \in [1.73; 1.99]$, ring 2 which corresponds to 2, 10, 18, 26, 34, 42 with $\eta \in [1.36; 1.72]$, ring 3 corresponds to 3, 11, 19, 27, 35, 43 with $\eta \in [0.83; 1.35]$, and ring 4 which corresponds to tiles 4, 12, 20, 28, 36 and 44 with $\eta \in [0.03; 0.80]$. A cut on 100 MeV energy deposit has also been applied.

The two following graphs (figure 1 and 2) show situation A, where every component of the detector is active. These simulations will be the ones compared to in the following graphs (figures 3, 4, 5, 6, 7, 8, 11 and 12).

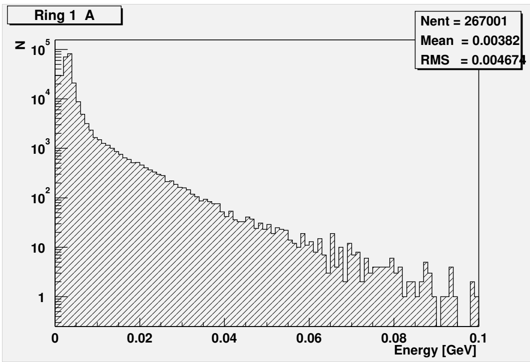


Figure 1: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

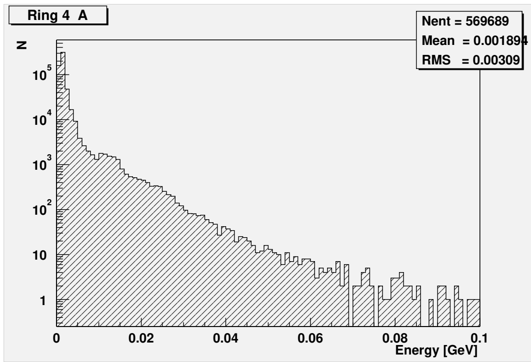


Figure 2: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

Now in order to compare this with the simulation without the hadronic interactions, the following formula[4] is used to estimate number of primaries:

$$N_{pri} = \frac{E_{pri}}{\langle dE_{pri} \rangle} = \frac{E_{tot} - E_{sec}}{\langle dE_{pri} \rangle} = \frac{E_{tot} - N_{sec} \cdot \langle dE_{sec} \rangle}{\langle dE_{pri} \rangle} \tag{1}$$

where $E_{pri}$ is the energy deposited by primaries in tiles per event, $E_{sec}$ is the energy deposited by secondaries per event, $E_{tot}$ is the total energy deposited in a tile per event and $N_{sec}$ is the number of secondary particles from the simulation, which is defined as the number of particles interacting in tile with all background sources minus number of particles interacting in tile when background is switched off. Also $\langle dE_{sec} \rangle$ is the average of energy loss spektrum of the secondaries, which is formulated in equation 2. $\langle dE_{pri} \rangle$ is the average energy of energy loss spektrum of primaries, which is calculated from simulations without background sources.

[3]GBRAHMS numbering.
[4]Taken from [1].

$$\langle dE_{sec} \rangle = \frac{\langle dE_{tot} \rangle \cdot N_{tot} - \langle dE_{pri} \rangle \cdot N_{pri}}{N_{sec}} \quad (2)$$

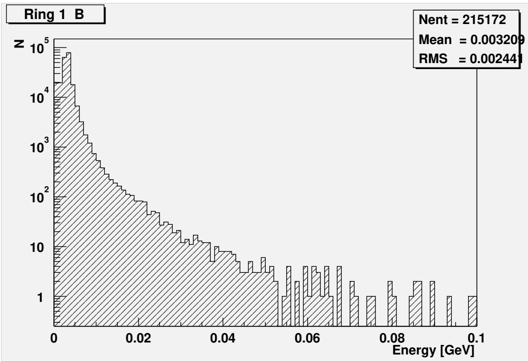


Figure 3: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41. No hadronic interactions.

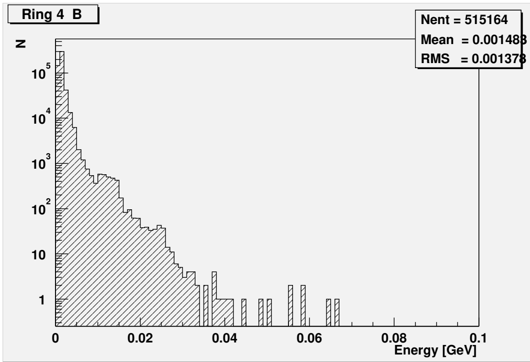


Figure 4: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44. No hadronic interactions.

For the comparison of situation A and B for ring 4, details are included here. The values used are for equations 1 and 2:

$$E_{tot} = \frac{569689 \cdot 0.001894}{1000\, events} = 1.079\ GeV/event$$

$$N_{sec} = \frac{569689 - 515164}{1000\, events} = 54.5\, secondaries/event$$

$$\langle dE_{sec} \rangle = \frac{0.001894 \cdot 569689 - 0.001488 \cdot 515164}{569689 - 515164} = 0.005710\ GeV/\text{particle}$$

where the above values has been read off graphs 2 and 4. By inserting these values in 1, we get $N_{pri} = 516\ particles$. This should be compared to:

$$\frac{E_{tot}}{\langle E_{pri} \rangle} = \frac{1.079\ GeV/event}{0.001488\ GeV/\text{particle}} = 725 \text{ particles} \quad (3)$$

So when comparing A and B for ring 4, the ratio $\frac{N_{sec}}{N_{tot}}$ is: $\frac{725-516}{725} \cdot 100\% = 29\%$. For ring 1 similar calculations gives a difference of 32%. Before comparing to previously suggested correction factor, let's take a look at the other simulations.

The difference difference in multiplicity in situation A and C, can now be calculated using formula 1 and data from figures 5 and 6. Doing this, the deviation between 1A and 1C is 6.3% and between 4A and 4C is 3.3%. This shows that the beam pipe does not contribute significantly to the background.

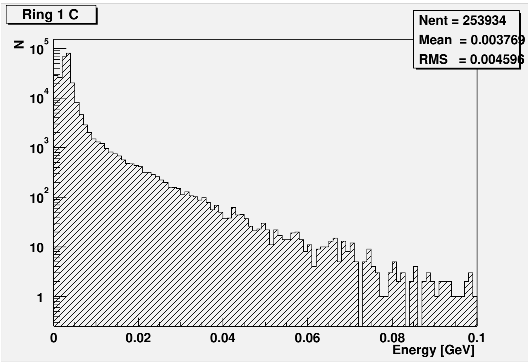


Figure 5: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41. No Beam pipe.

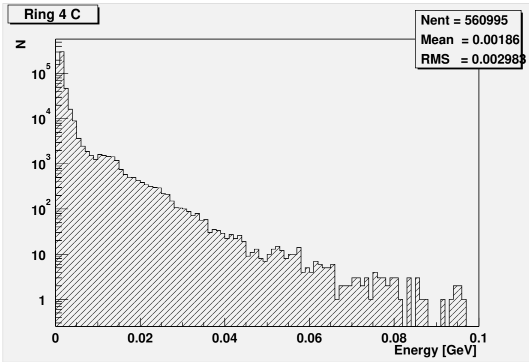


Figure 6: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.No Beam pipe.

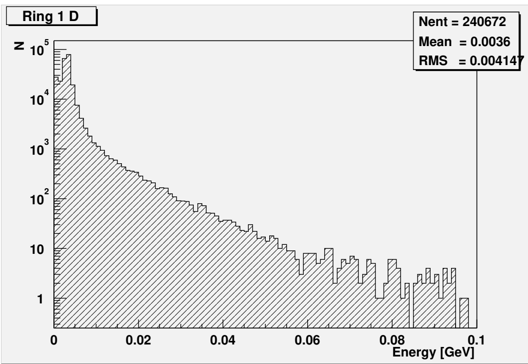


Figure 7: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41. No Beam pipe or support.

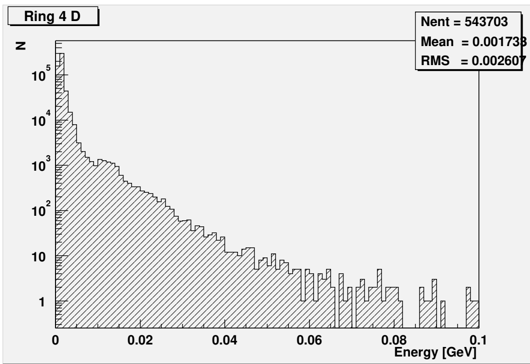


Figure 8: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.No Beam pipe or support.

Now taking a look at the situation where both beam pipe and tile support is inactive on graph 7 and 8. The percentage deviation is for 1D 15% and for 4D 13%. The simulations shows that the support for the tiles roughly contributes of about 10% more secondaries than the beampipe.

To get a rough estimate of the contribution from the silicon detectors, consider situation E on graphs 9 and 10.

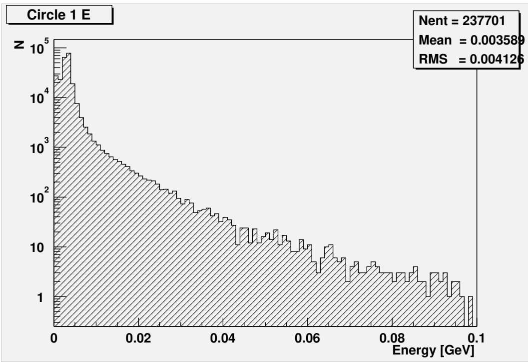


Figure 9: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41. No Beam pipe, support or silicon.

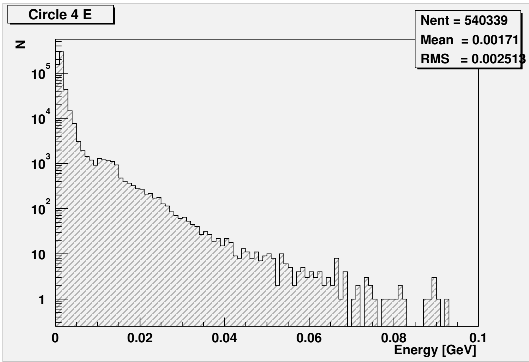


Figure 10: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44. No Beam pipe, support or silicon.

The ratio $\frac{N_{sec}}{N_{tot}}$ is for situation E ring 1 16% and for ring 2 12%. This is hardly any different than situation D.

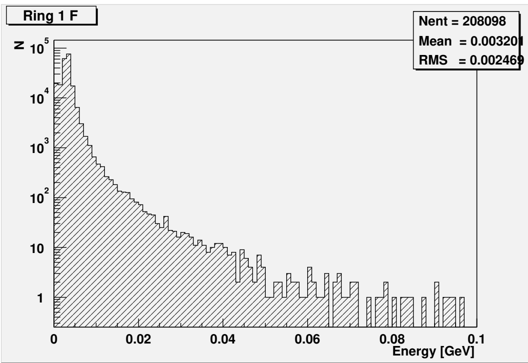


Figure 11: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41. No Beam pipe, support, silicon or hadronic interactions.

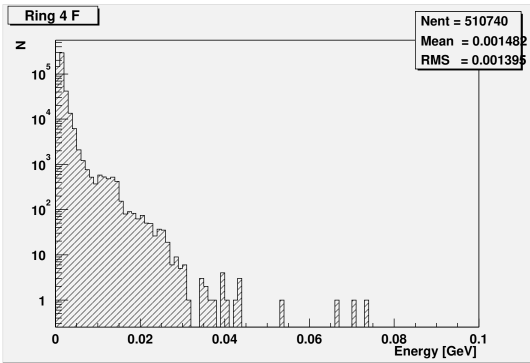


Figure 12: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44. No Beam pipe, support, silicon or hadronic interactions.

On graph 11 and 12 all material between collision zone and the tiles has been removed (situation F). Again the deviation is calculated and the result is for 1F 35% and for 4F 30%. The deviation is similar to situation B and shows that the largest contributor to the background caused by the hadronic interactions.

## 4 Comparison with other models

The correction calculated until now has been the ratio $\frac{N_{sec}}{N_{tot}}$. Table 4 summarises the results:

| | $B$ | $C$ | $D$ | $E$ | $F$ |
|---|---|---|---|---|---|
| Ring 1 | 32% | 6% | 15% | 16% | 35% |
| Ring 2 | 33% | 7% | 14% | 16% | 33% |
| Ring 3 | 32% | 5% | 14% | 16% | 32% |
| Ring 4 | 29% | 3% | 13% | 12% | 30% |

Table 1: Summary of simulation deviations, when calculating it as $\frac{N_{sec}}{N_{tot}}$. The rest of the values was calculated using data which is in appendix A.

From earlier estimations of the ratio of secondaries, mentioned by J.H. Lee [2], it has been found out that the ratio $\frac{N_{sec}}{N_{pri}}$ can be described as shown on figure 13:

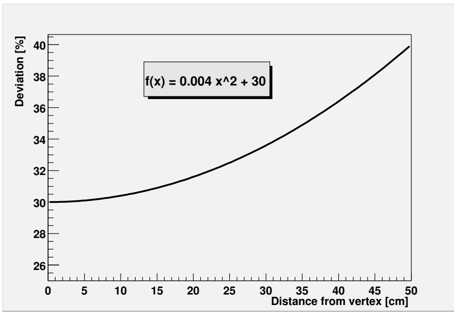


Figure 13: Ratio of secondaries as a function of distance from vertex.

This should be compared with the following table for $\frac{N_{sec}}{N_{pri}}$:

| | $B$ | $C$ | $D$ | $E$ | $F$ |
|---|---|---|---|---|---|
| Ring 1 | 48% | 7% | 17% | 19% | 53% |
| Ring 2 | 50% | 7% | 16% | 19% | 49% |
| Ring 3 | 47% | 5% | 17% | 19% | 47% |
| Ring 4 | 41% | 3% | 14% | 13% | 42% |

Table 2: Summary of simulation deviations, when calculating it as $\frac{N_{sec}}{N_{pri}}$ . The rest of the values was calculated using data which is in appendix A.

The background ratio for simulations B and F are about 10% higher than earlier estimations.

# A Additional graphs

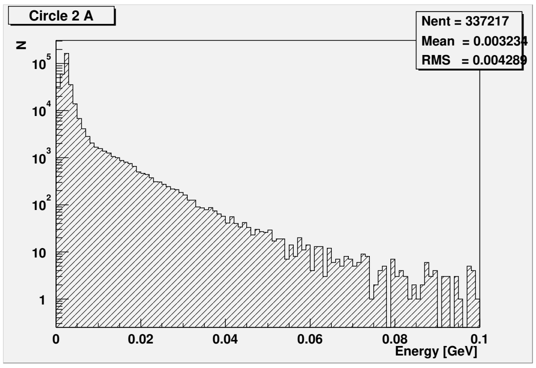


Figure 14: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

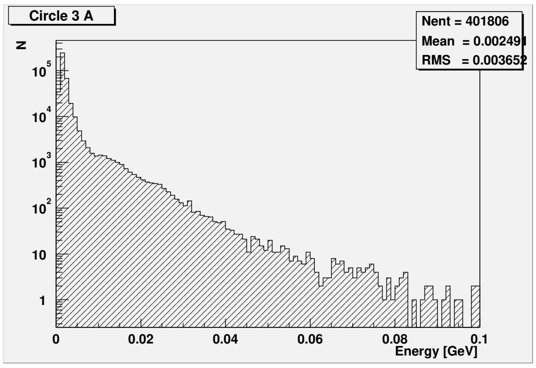


Figure 15: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

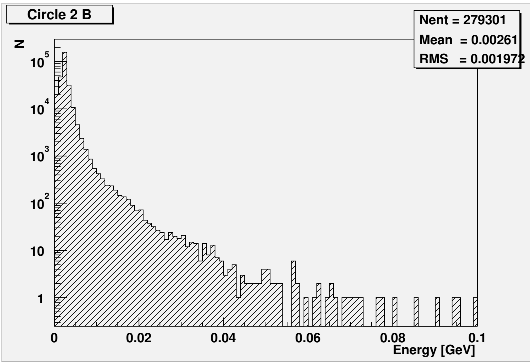


Figure 16: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

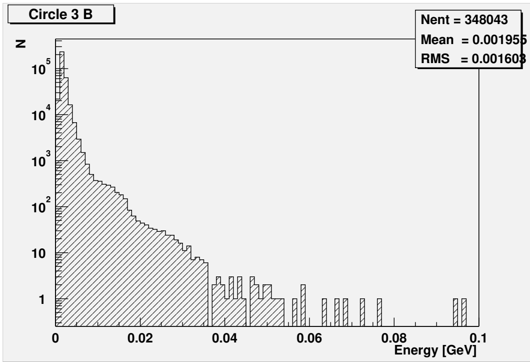


Figure 17: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

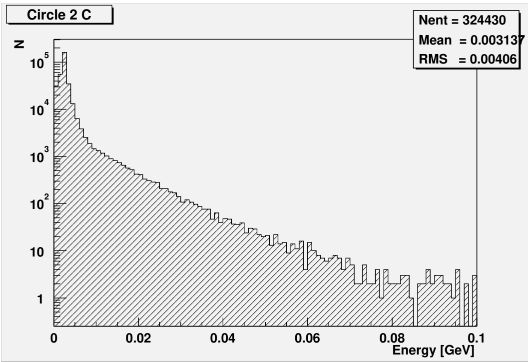


Figure 18: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

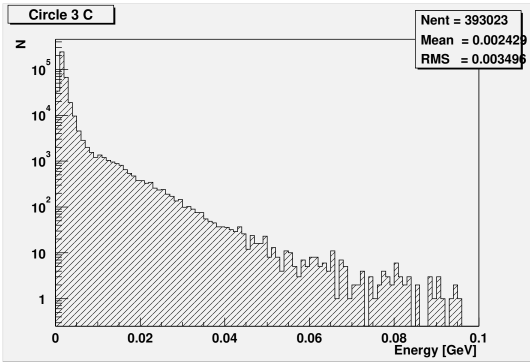


Figure 19: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

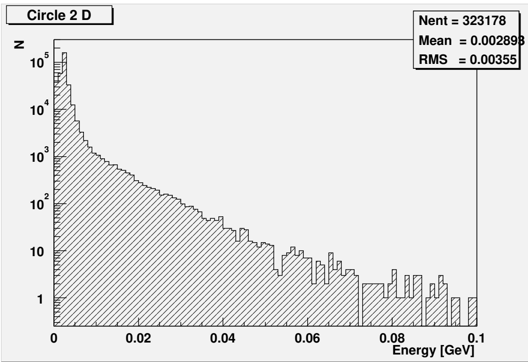


Figure 20: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

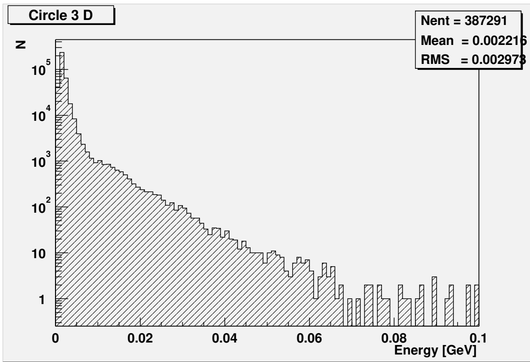


Figure 21: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

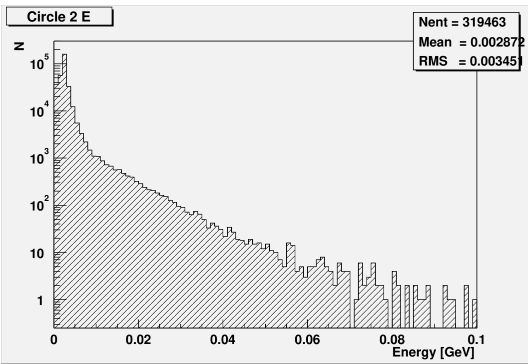


Figure 22: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

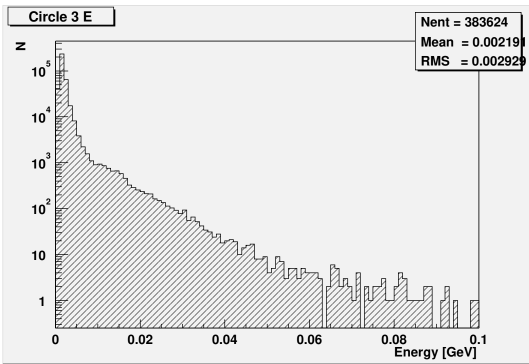


Figure 23: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

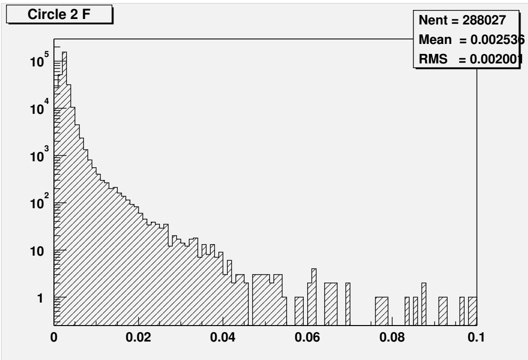


Figure 24: Energy deposit in tiles: 1, 9, 17, 25, 33 and 41.

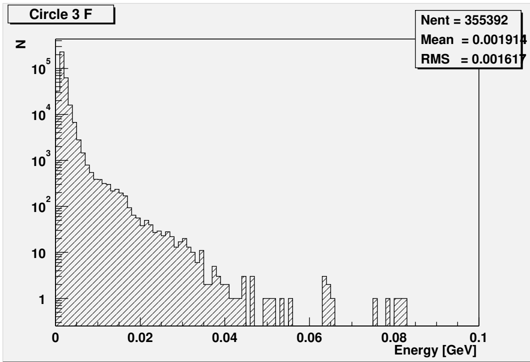


Figure 25: Energy deposit in tiles: 4, 12, 20, 28, 36 and 44.

# B Procedure used to make volumes inactive

In order to make specific parts of the detector inactive one should implement commands like: `set_tree beam z` in the `.kumac` file.[5] Nevertheless this has shown to be inaccurate, so in stead GBRAHMS were recompiled without the detector volumes.

Before compiling GBRAHMS some lines in the file `gbrahms/src/user/zigeom.F` were commented out, in order to make beam pipe, silicon detectors, and the support for the tiles inactive during the simulation. The lines were:

```
call bd_prea
call bd_supp
call bd_endc
call bd_spaa
call bd_phot
call bd_beampipe
call bd_silicon
```

# C Macro used to run GBRAHMS

```
* Defining the geometry
geoini

* The following syntax is used to control hadronic interactions.  (default is 1):
* =0 no hadronic interactions.
* =1 Hadronic interactions.  secondaries processed.
* =2 Hadronic interactions.  No secondaries stored.
HADR 2
* recalculates parameteres
physi
```

[5]See example of kumac file in appendix C

```
* Defining what part of the spectrometer to examine (turned on) set_tree cave z
set_tree fms1 z
set_tree fms2 z
set_tree mids z
set_tree tofw z
set_tree tpm1 z
set_tree tpm2 z
set_tree d5 z
set_tree mult o
set_tree dx z
set_tree fms2 z
set_tree t1 z
set_tree t2 z
set_tree bb z
set_tree zdc z
set_tree beam o
set_tree shld z

geodef
geofin
* recalculates parameteres
physi

call gbr2c.f
call init_detector

* kinematics
evsplit 1
cards spac 1
* Fritiof simulation
cards ukin 5 /nfs/hehi/hehi22/hehi/jakobsen/simu/frit702/130_auau_0_2.zdat
kine 1 0.  130.  0.  180.  0.  360.  0 50
swit 3 1

* Save the geometry, field and magnet settings
setup/save geom NoHadron_1000ev.geo
setup/save field NoHadron_1000ev.fld
setup/save magnet NoHadron_1000ev.mag

* Binary data output file.
call GBRFILE('NoHadron_1000ev.cdat')

* Number of events that should be simulated
analyze GBRANA 1000 1

call GBREND
quit
```

# References

[1] Jens Jørgen Gaardhøje. *Analysis of charged particle multiplicity data.* BRAHMS analysis note #11, Copenhagen, 2000.

[2] J.H. Lee. *From ADC to dN/deta.* BRAHMS analysis note #14, New York, 2000.