Diamond Beam Monitor Simulation

Luka Kanjir

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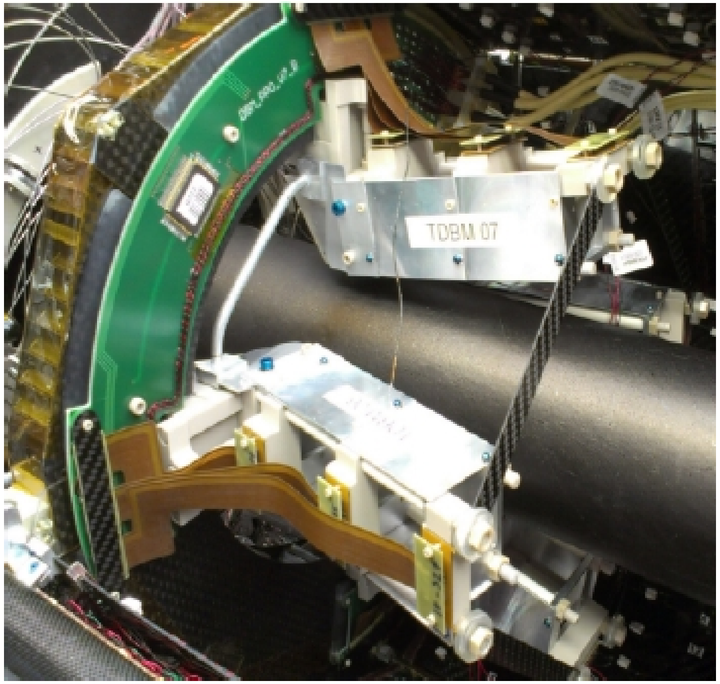
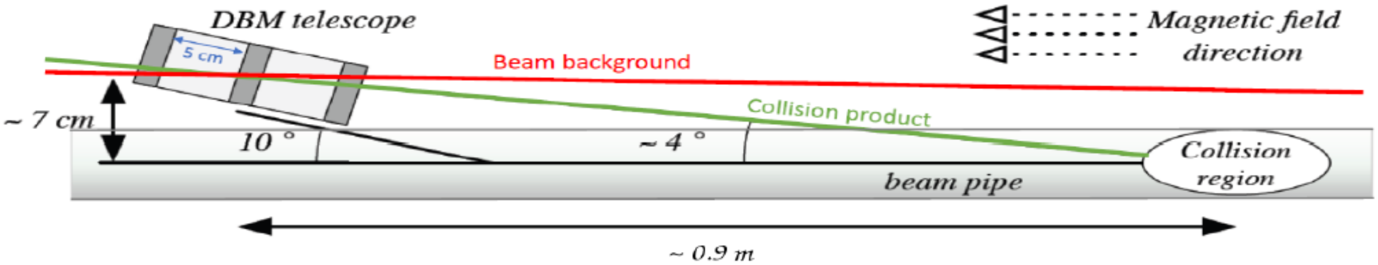
Overview

- Diamond Beam Monitor
- Two streams for luminosity monitoring, H-stream and T-stream
- H-stream simulation
- Simulation results
- Possible ways to continue

Diamond Beam Monitor (DBM)

- Diamond and silicon sensors for beam spot, background monitoring and bunch-by-bunch luminosity monitor
- 8 telescopes, 6 diamond, 2 silicon, 3+1 at each side of ATLAS with 3 modules per telescope, each module with FEI4B readout chip
- $3.2<|\eta|<3.5$, first diamond based tracking detector
- ~90 cm from IP on both sides, ~70 mrad angle
- Detector should be able to recognize if the particle is from background or from IP
- Part of pixel detector
- The active area of module is ~89% (20x16.8 mm^2)
- 26880 pixels (80x336) , $50 \cdot 250\ \mu m^2$ pixel size
- **Position sensitive detector with time resolution of 25 ns**



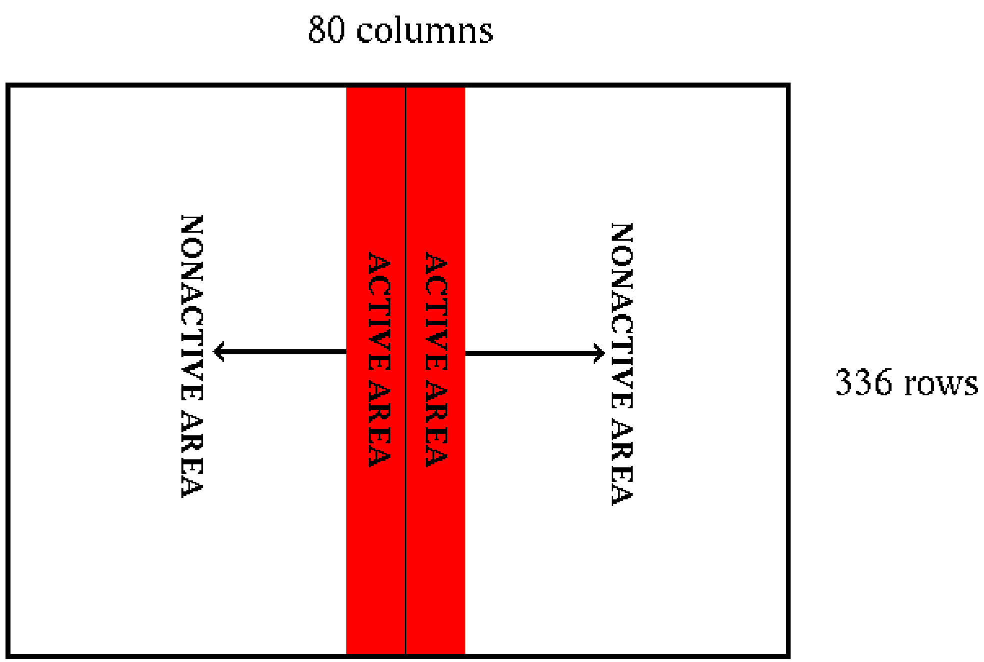


DBM as luminosity detector

- There are two streams envisage for luminosity measurements
- Data that comes from FE-I4B chip are analyzed in two separated streams **T-stream** and **H-stream**
- **T-stream** (trigger-based stream) will be used for particle counting approach
  – detailed information: coordinates and ToT
  – developed in second stage
- **H-stream** (HitOr – based stream) – event counting approach
  – have single bit information 1 or 0 (hit or no hit)
  – possible to include or exclude individual pixels
  – **this is what is studied in this work**

Definition of active surface

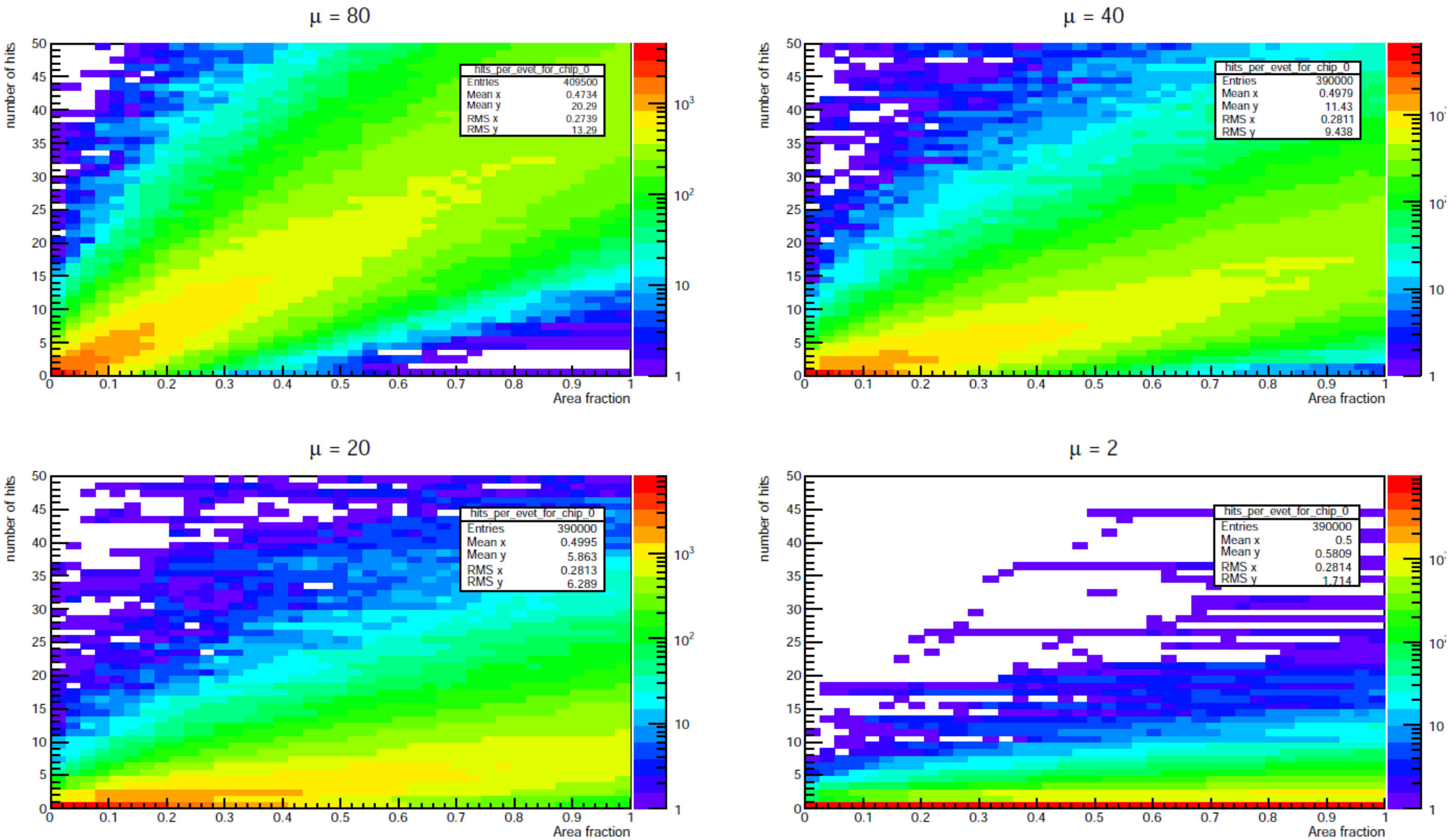
- Active surface size defines acceptance → this means that the calibration has to be done for each size of active area
- The active area changed in way: starting from the center of chip, extending a given number of columns



Monte Carlo data

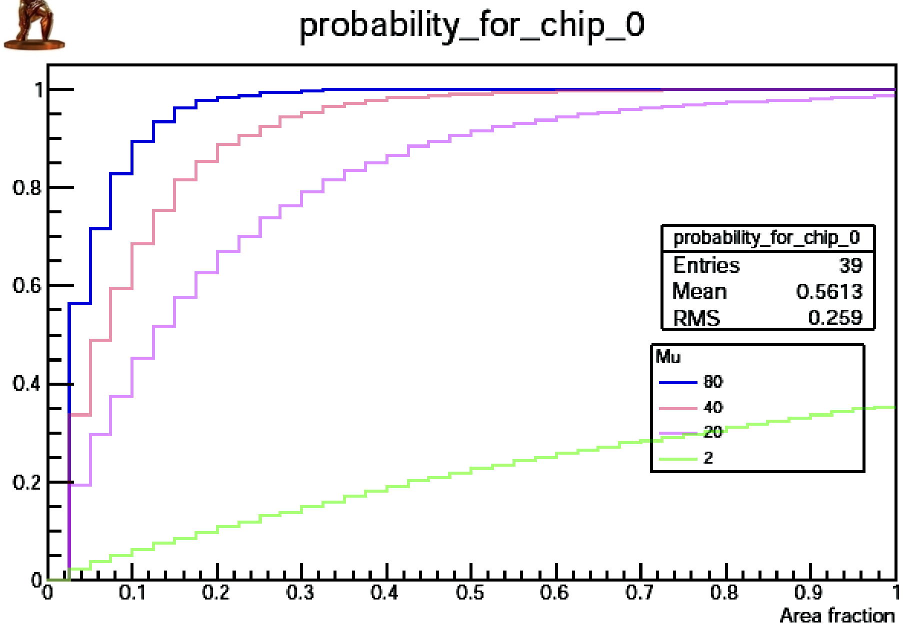
- For this study the Monte Carlo samples were used
- The samples were:
  - mc15_13TeV.159000.ParticleGenerator_nu_E50.recon.RDO.e3711_s2576_s2132_r6565
  - mc15_13TeV.159000.ParticleGenerator_nu_E50.recon.RDO.e3711_s2576_s2132_r6566
  - mc15_13TeV.159000.ParticleGenerator_nu_E50.recon.RDO.e3711_s2576_s2132_r6567
  - mc15_13TeV.159000.ParticleGenerator_nu_E50.recon.RDO.e3711_s2576_s2132_r6568
- For different samples have $\langle\mu\rangle = 2$, 20 , 40 and 80
- Number of events studied here was 10 000

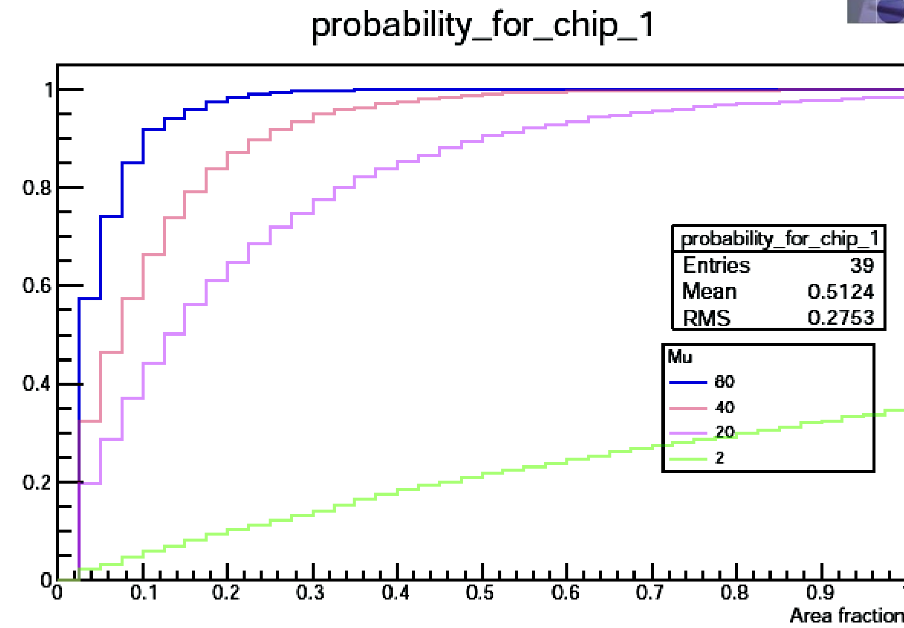
Number of hits in chip 0 for different <μ>

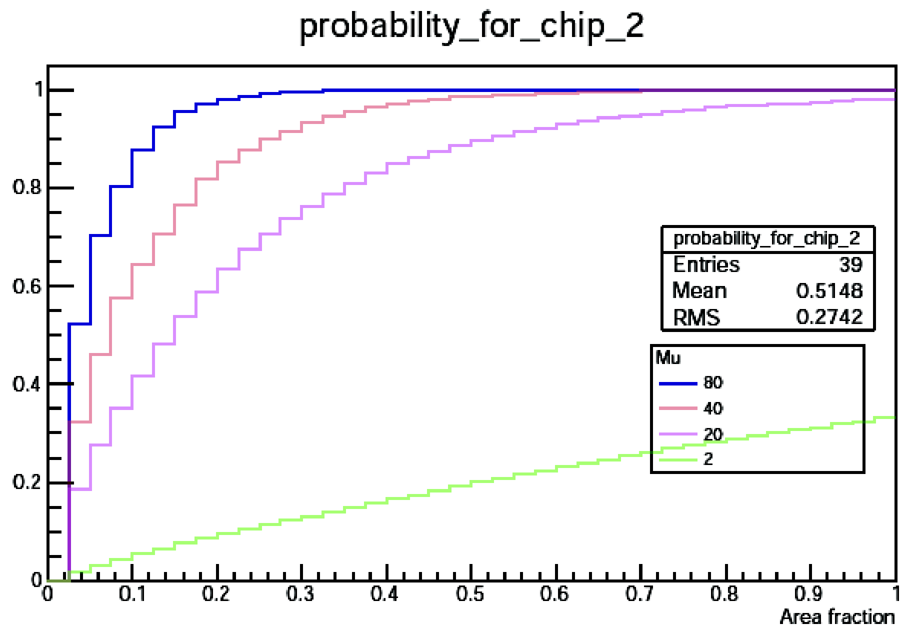


- Plots shows event distribution versus number of hits and versus active area of detector
- As <μ> increases, there are more and more events in which the number of hits in chip is higher

Event probabilities for three chips





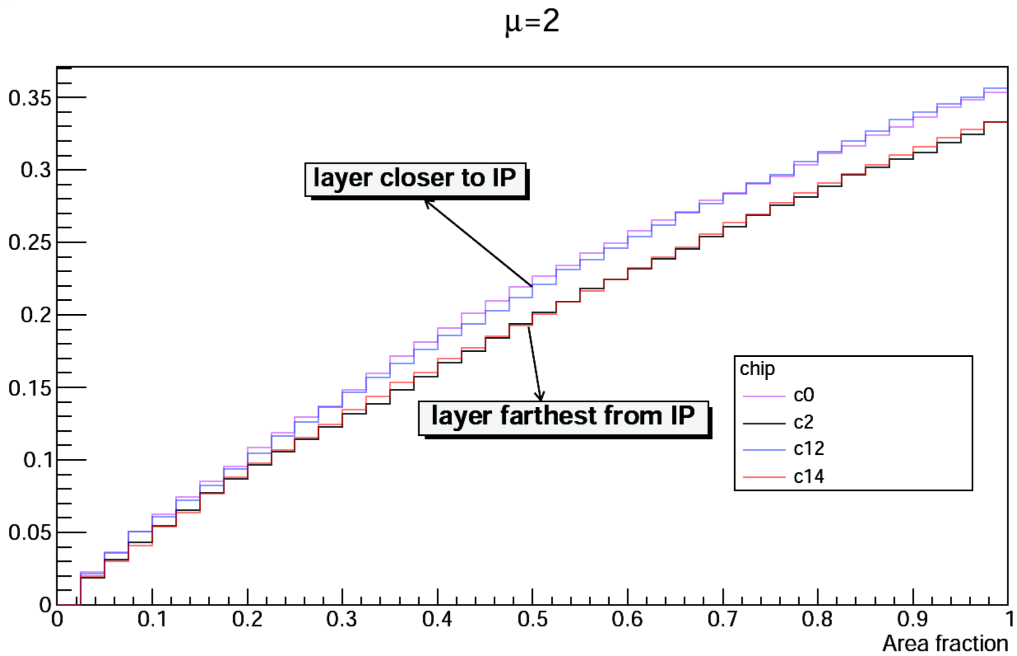


- This histograms shows how event probabilities for chips depends upon the active area of chip
- The probability that the chip is hit was calculated as ratio between non empty events and number of recorded events

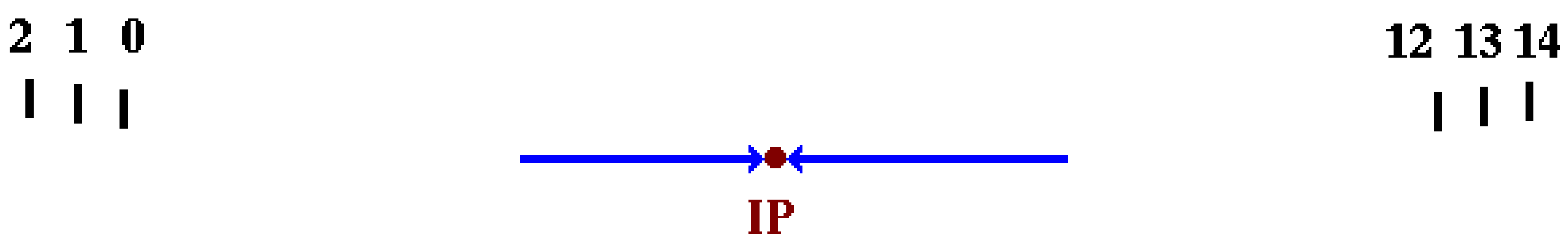
$$r_{\mathrm{OR}} = \frac{N_A}{N_E}$$

- For higher <μ>, event probability is rising much faster with increasing active area of detector

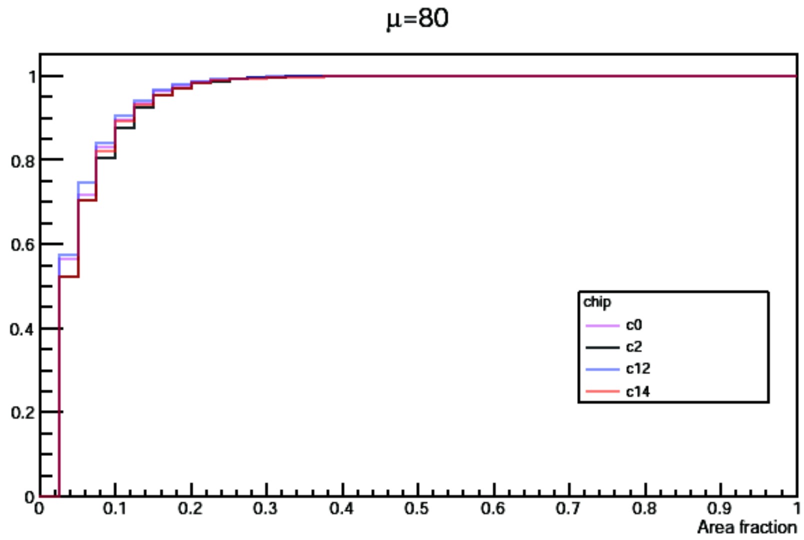
Event probabilities for different chips with $\langle\mu\rangle=2$

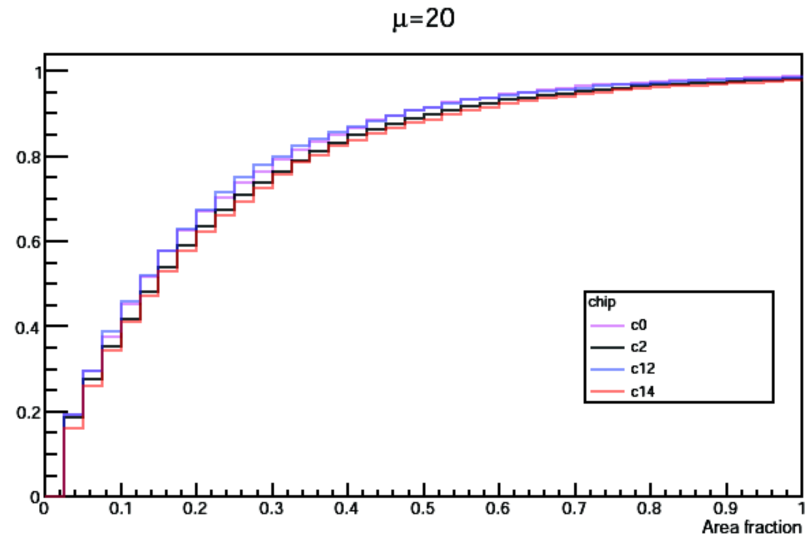


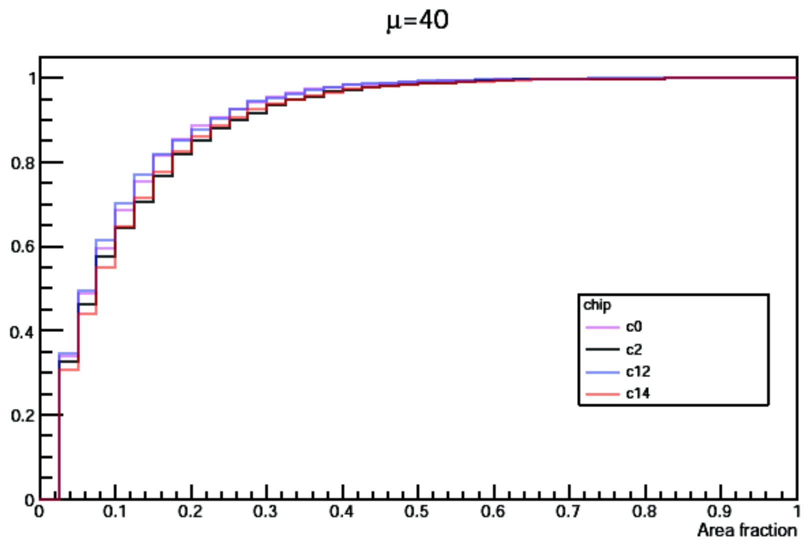
- c0 and c12 are the chips closest to the IP, c2 and c14 are chips which are the farthest from IP
- Event probabilities for chips closer to IP are higher

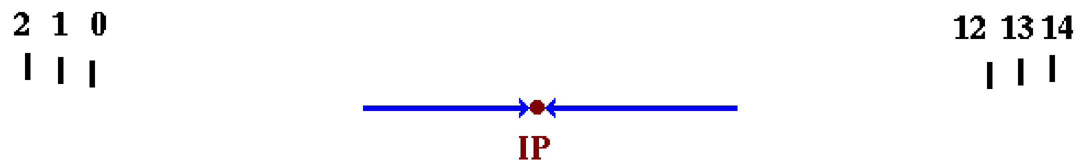


Event probabilities for different chips with <μ> = 20, 40 and 80









Calibration constant, c

- To calculate the μ_vis the following equation was used

$$\mu^{vis} = -\ln(1 - r_{\mathrm{OR}})$$

- <μ> were known from Monte Carlo sample, so with it and μ^{vis} the calibration constant was calculated from

$$c = \frac{\mu^{vis}}{<\mu>}$$

- The error estimate for μ^{vis} is given by

$$\sigma_{\mu^{vis}_{\mathrm{OR}}} = \sqrt{\frac{1}{N_E}} \cdot \sqrt{\frac{r_{\mathrm{OR}}}{1 - r_{\mathrm{OR}}}}$$

- The error for c is then just

$$\sigma_{c_{\mathrm{OR}}} = \frac{\sigma_{\mu^{vis}_{\mathrm{OR}}}}{<\mu>}$$

Chip 2

- Next table shows the calibration constants and visible μ with errors for chip 2
- The active area for this data is 32.5 % of the chip

<μ>	μ_vis	Δ μ_vis	c	Δc
2	0.1489	0.0040	0.0745	0.0020
20	1.5498	0.0192	0.0775	0.0009
40	2.9431	0.0424	0.0735	0.0011
80	6.2146	0.2180	0.0777	0.0027

- Calibration constant for chip 2 is ~7.5 %

Calibration constants for all chips placed in telescopes (T0 to T7) for <μ>=20 and active area 32.5 %

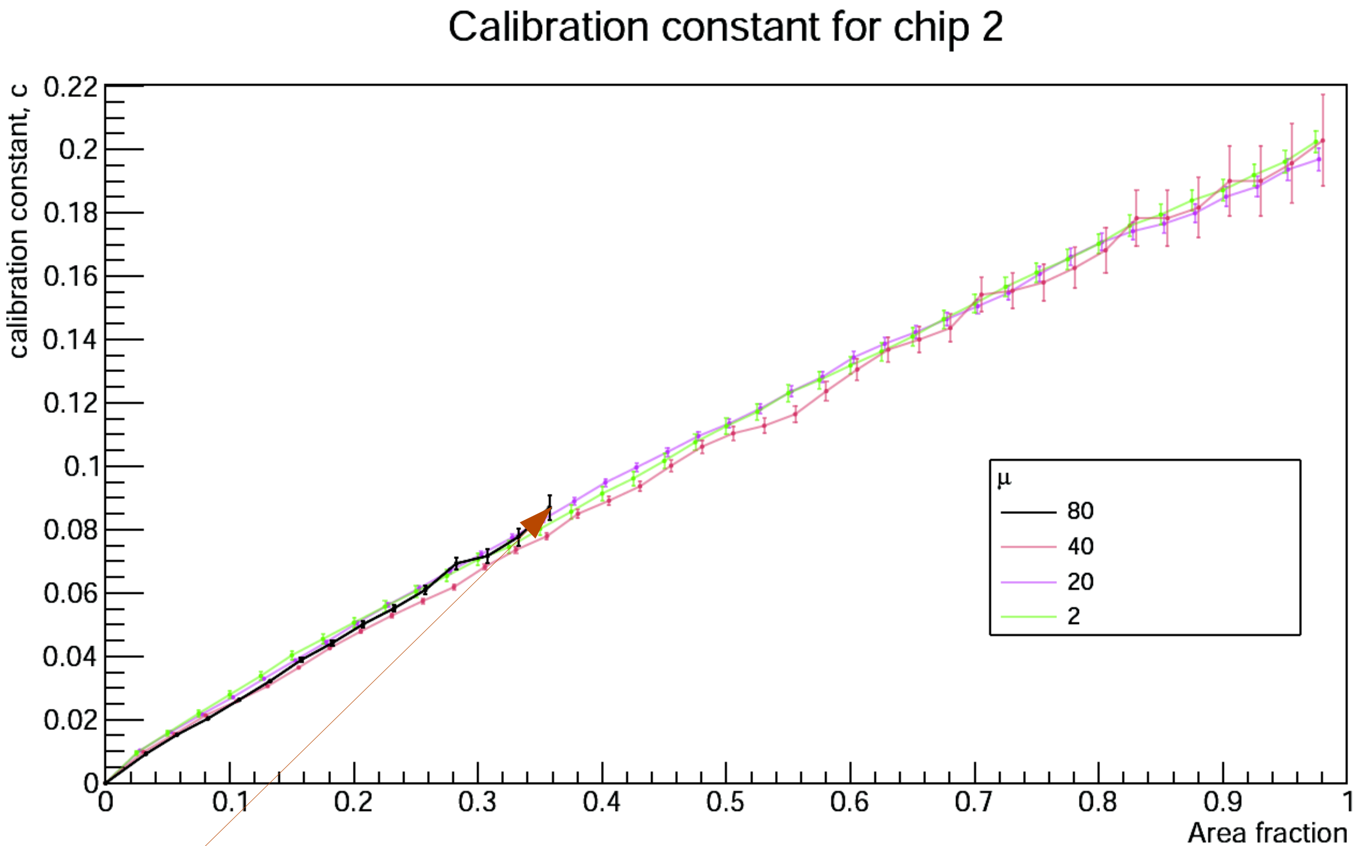
Closest to the IP

plane	c of T0	c of T1	c of T2	c of T3	c of T4	c of T5	c of T6	c of T7
0	0.0844	0.0810	0.0831	0.0852	0.0867	0.0831	0.0854	0.0861
1	0.0806	0.0779	0.0789	0.0782	0.0815	0.0785	0.0779	0.0829
2	0.0775	0.0727	0.0744	0.0746	0.0767	0.0747	0.0757	0.0779

Farthest from the IP

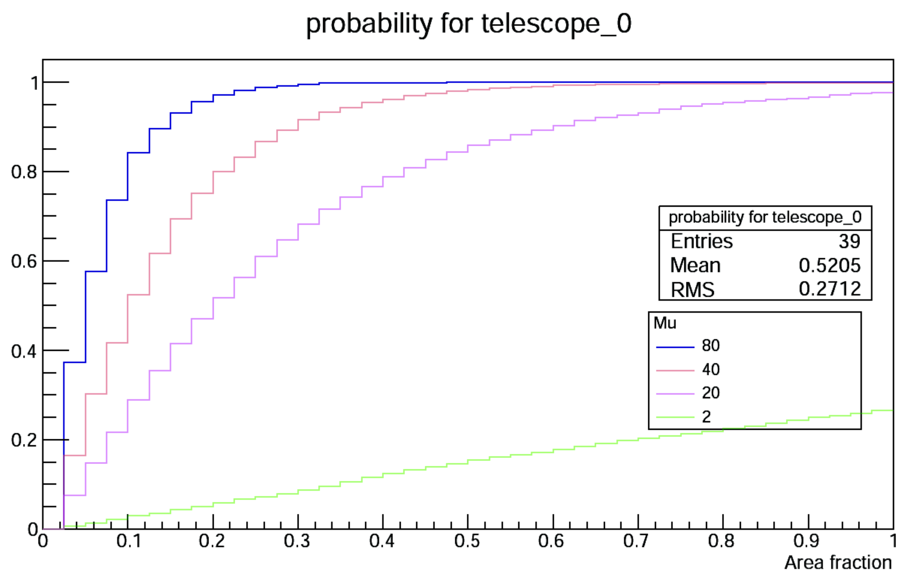
- From above table it can be seen that chips which are closest to IP have have similar calibration constants
- Chips which are farthest from IP have in average smallest calibration constants

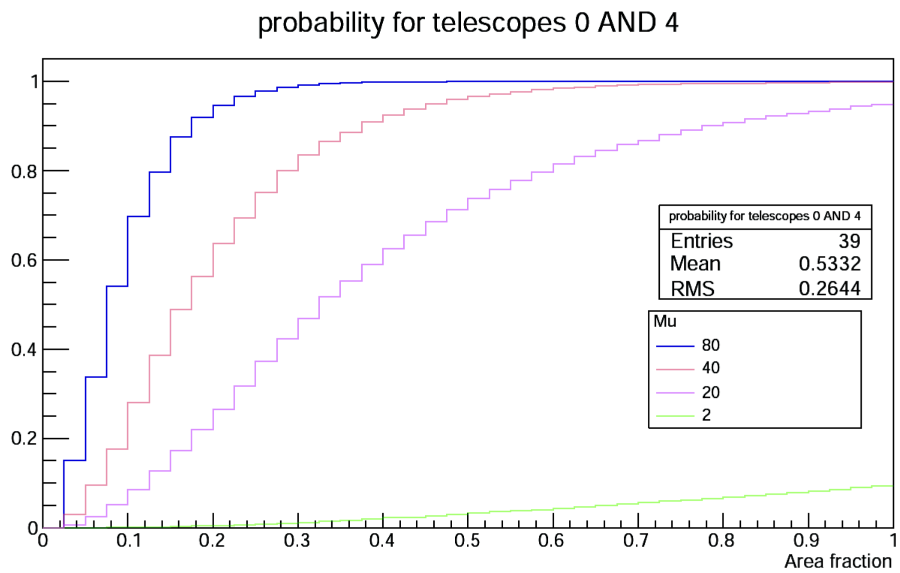
Chip 2 calibration constant, c



- The plot shows calibration constants for chip 2 for different <μ>
- This is done so that the simulation could be tested
- For <μ> = 80 the calibration constant is just calculated up to active area ~35 % because the statistics was to low, and with my script it was not possible to get the results which would make sense
- Calibration constants for different <μ> agree within an error

Telescope event probabilities





- This plots shows probability that telescopes detects tracks
- Telescope 0 and 4 are on different sides of ATLAS
- Number of tracks trough one telescope is equal to smallest number of hits among the three chips of telescope
- When the calibration constants for single chip is determined, it is possible to investigate telescopes or even the different relations between telescopes
- If this two plots are compared, the main difference is that there are less events which have tracks in both telescopes 0 and 4

Summary

- The calculation were made on Monte Carlo simulations for different <μ> with 10 000 events
- Calibration constants are very similar for the chips in the same layer, it is ~ 8%
- The calibration constant is consistent for all <μ> samples
- After good understanding the chips, it is possible to investigate telescopes and even the different combinations of them