Monte Carlo simulation of the DIRC prototype

03/21/06

Outline

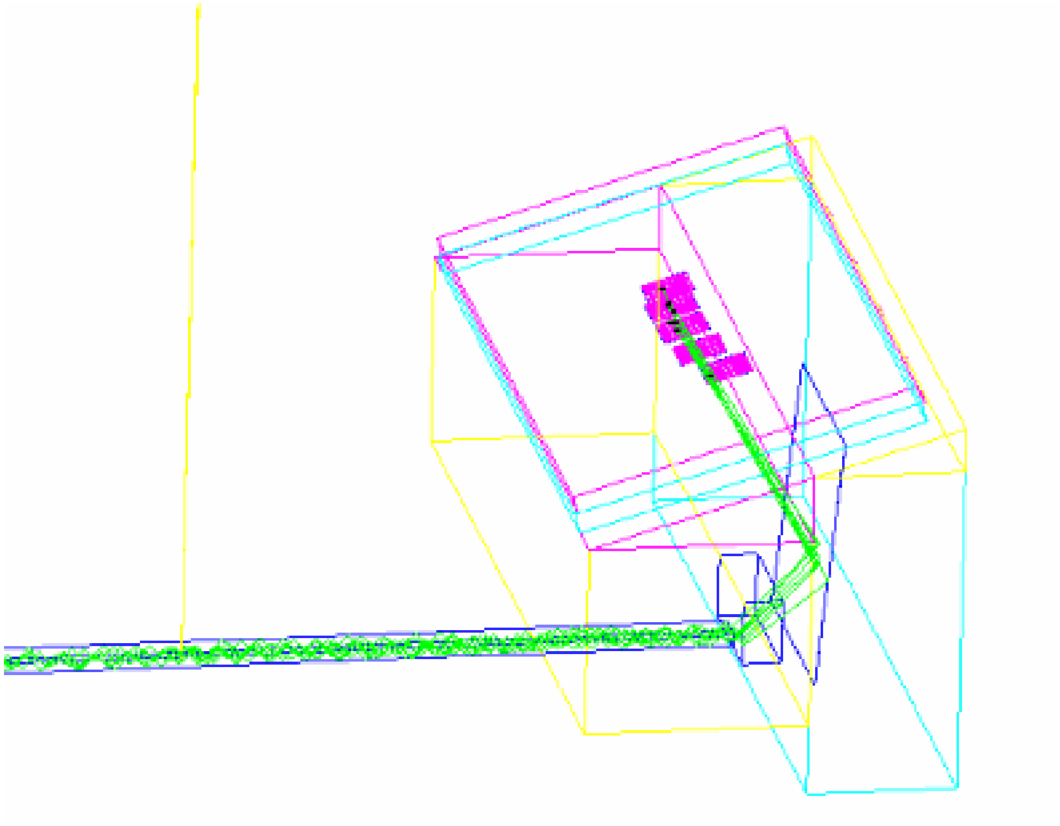
- Main features of the program
- Charge sharing implementation
- Comparison of simulated data with test beam data

Program overview

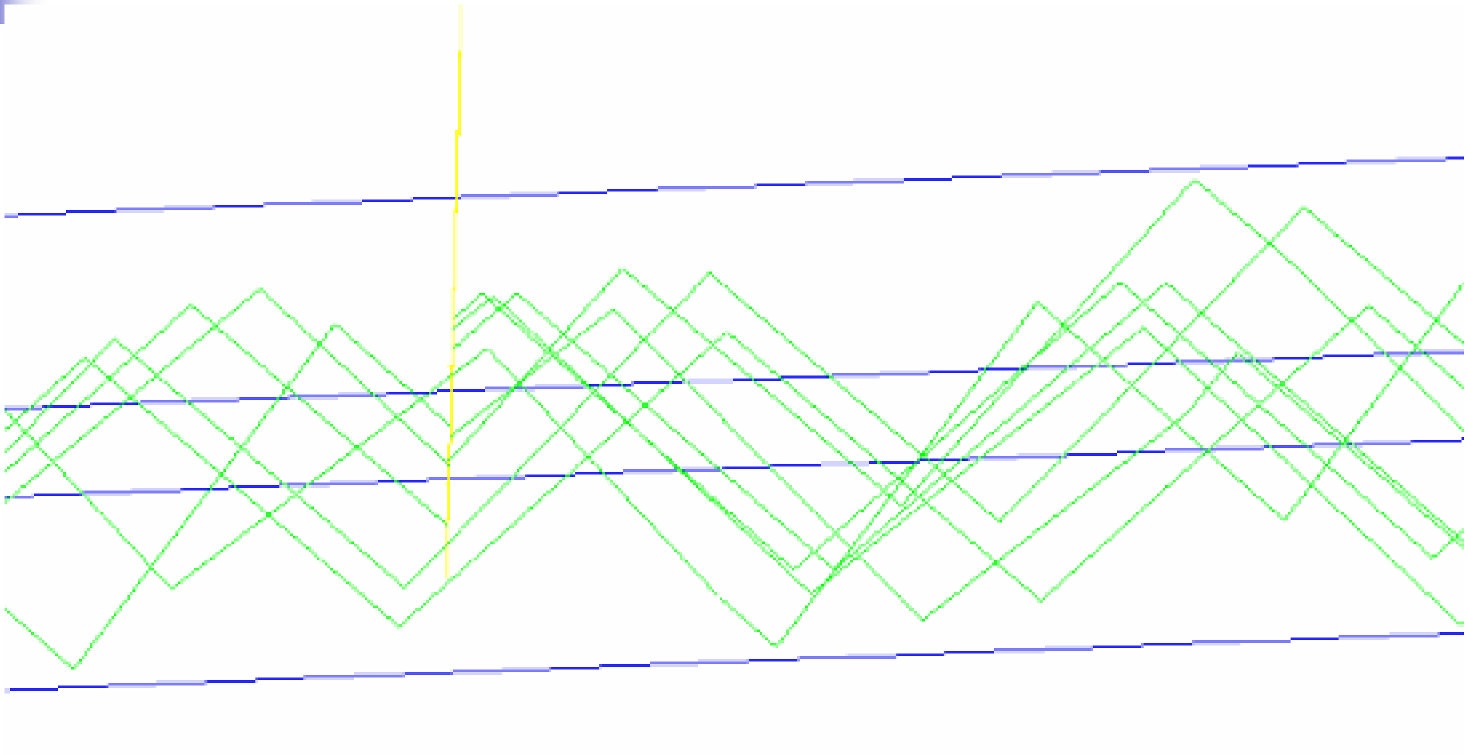
- All important features have been added

  (main parts of the DIRC prototype, refractive indices of materials, probabilities of reflection on the mirrors, physics, etc.)
- Three different types of PMTs (Hamamatsu 8500 and 9500, Burle)
- Two different configurations of PMTs

The DIRC prototype

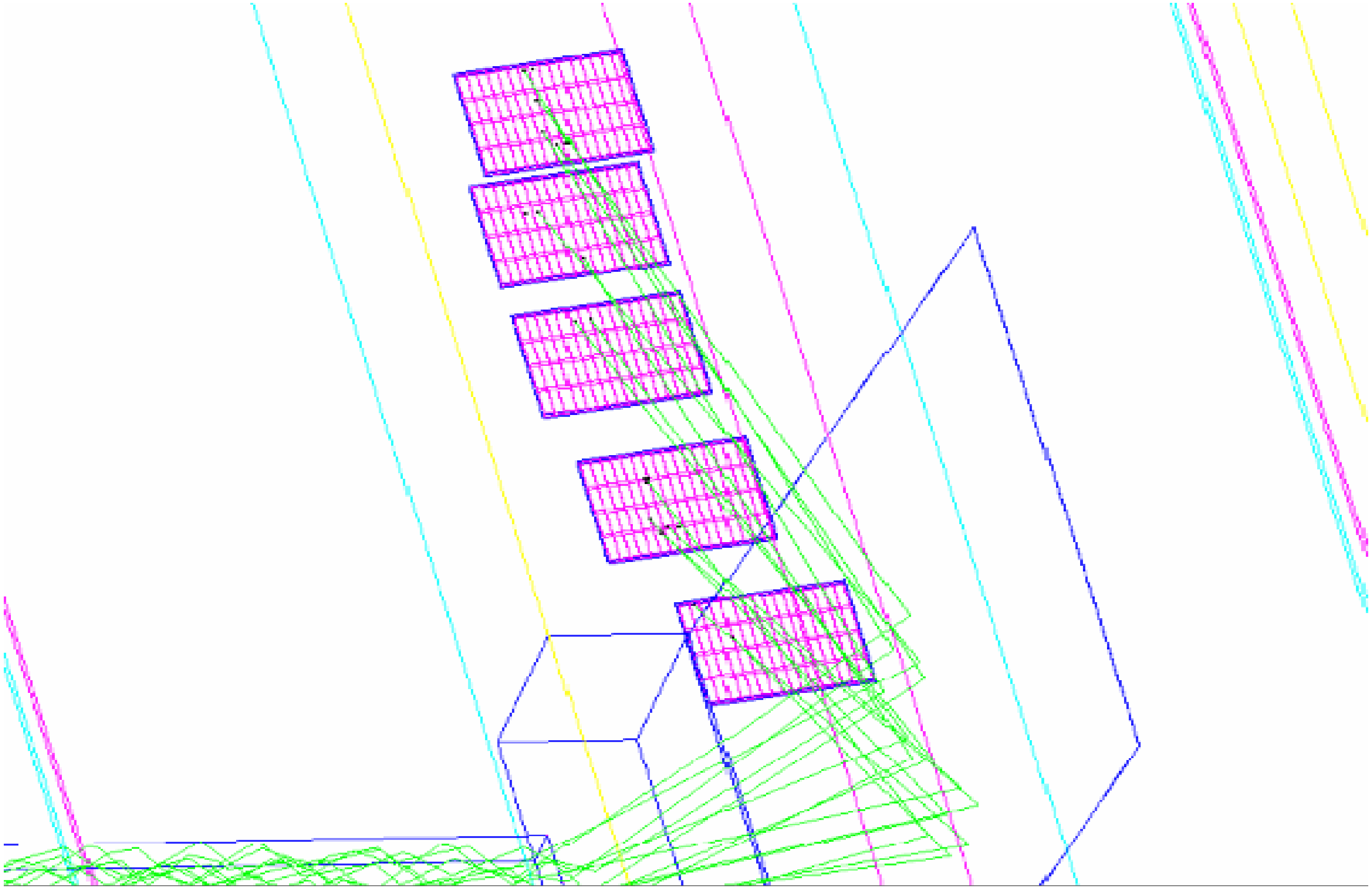


Generation of photons



- Up to ~1000 cherenkov photons (about 300 transported)

Detection of photons



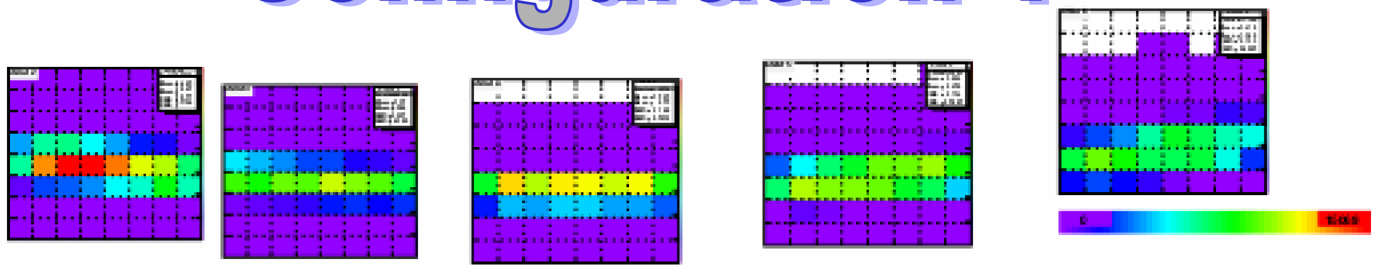
Two configurations

1. Configuration
   - Two Hamamatsu 8500 in slot 2 and 3
   - Three Burle PMT in slot 4, 5, and 6

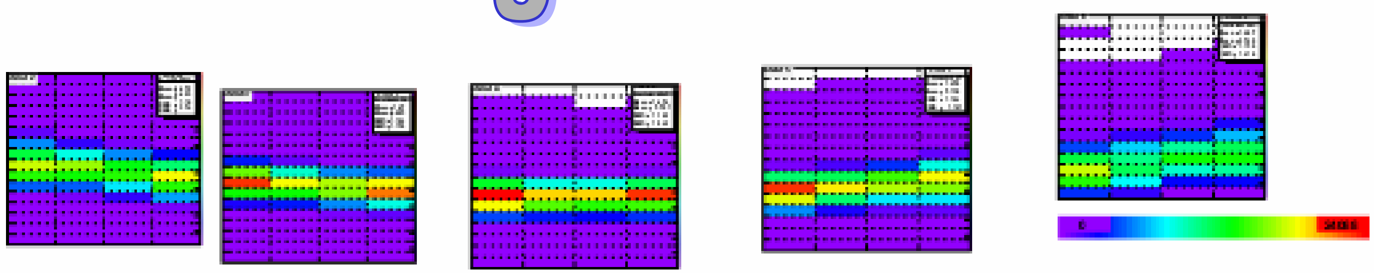
2. Configuration
   - Five Hamamatsu 9500 (estimation for best position)

Cherenkov Ring visualization

Configuration 1



Configuration 2

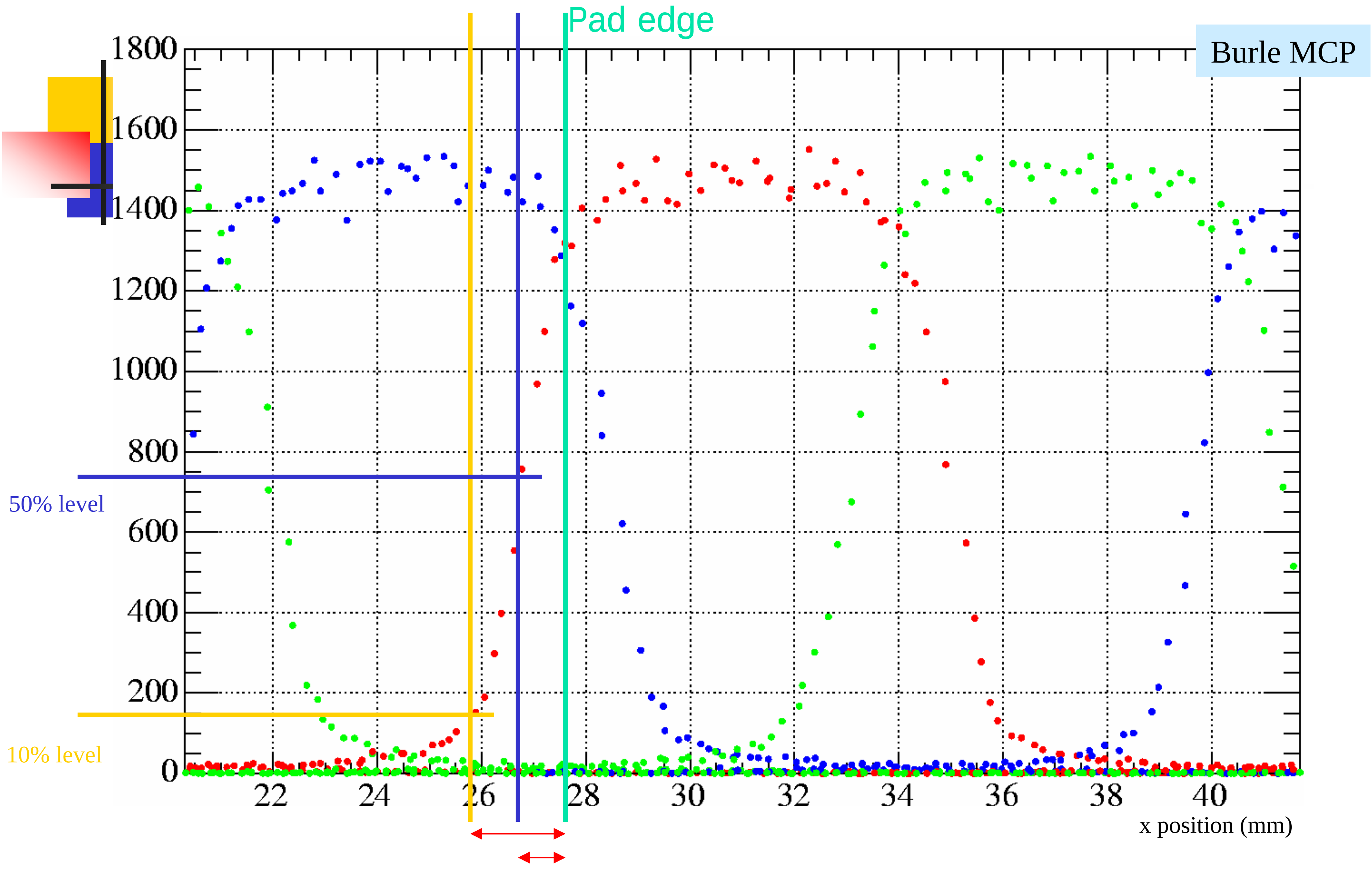


Charge sharing implementation

Main features of charge sharing

- It depends on the position of the hit inside the pad and its distance from the neighbor pads.
- Up to 4 (6) pads can be involved in charge sharing.

Charge Sharing Range



~1mm range for drop to 50% relative hit probability

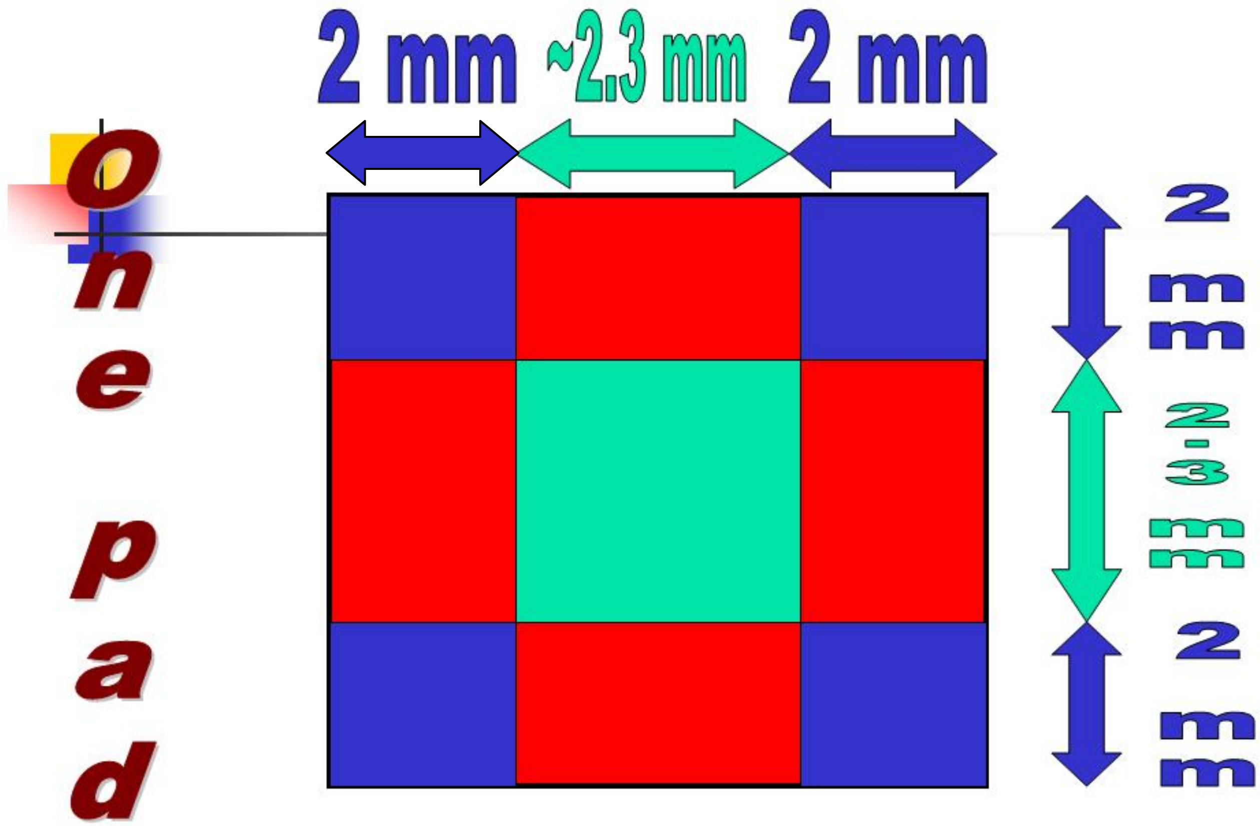
~2mm range for drop to 10% relative hit probability

Distance dependence

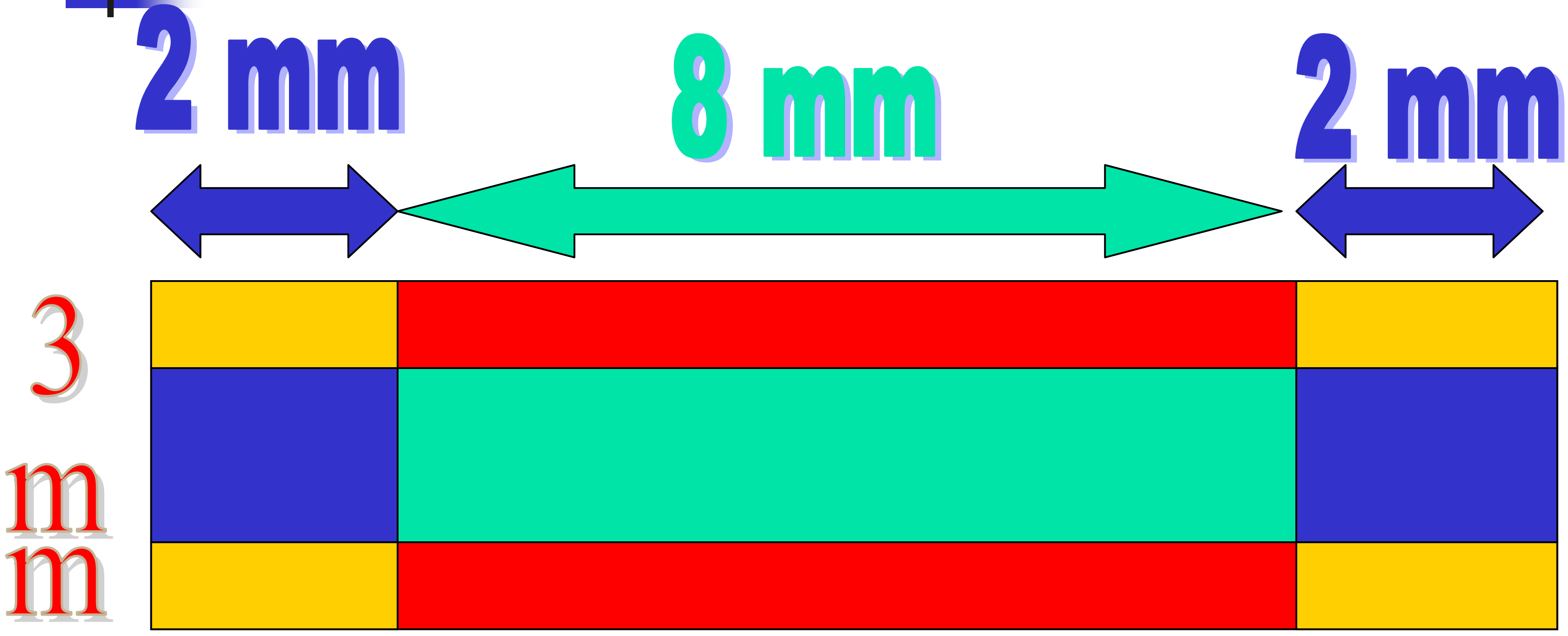
Requirements:

- On the edge of pad– 90% probability of the hit in neighbor pad
- 1 mm far from the edge – 50% probability of the hit in the neighbor pad
- 2 mm far from the edge – 10% probability of the hit => requirements for error function
- Same implementation for all PMTs

Charge sharing division of Hamamatsu 8500 & Burle



Charge sharing of Hamamatsu 9500



Charge sharing summary for configuration 1

	Total hit	Percentage
2 pads	147542	33.3% (16.7)%
3 pads	46157	10.4% (6.9)%
4 pads	15132	3.4% (2.6)%
Total	208831	47.1% (26.2)%

Charge sharing summary for configuration 2

	Total hits	Percentage
2 pads	523322	51.5 (25.7)
3 pads	115826	11.4 (7.6)
4 pads	34179	3.4 (2.5)
5 pads	1065	0.1 (0.1)
6 pads	48	$5x10^{-5}$
Total	674444	66.4 (35.9)

Conclusion

- Charge sharing does not change the shape and occupancy of the Cerenkov ring
- It creates about 26% (36) of “fake” hits in configuration 1 (2) and about each second (two of three) cherenkov photon detected causes charge sharing

ThetaC resolution from pixels

- Full Monte Carlo simulation
- Assignment of average cherenkov angle for each pad (each hit within one pad has the same cherenkov angle)
- Single gauss fit

ThetaC from pixels (cont.)

σ	PEAK 1				PEAK2				PEAK 1 & 2	
Slot	***MC ch. sh***	***MC without ch. sh***	***Run 12b***	***Run 14***	***MC ch. sh***	***MC without ch. Sh.***	***Run 12b***	***Run 14***	***MC ch. sh***	***MC without ch. Sh.***
2	**10.8**	**9.7**	**10.9**	**11.6**	**11.4**	**10.1**	**12.1**	**11.7**	**10.9**	**9.9**
3	**10.7**	**9.9**	**9.2**	**9.4**	**10.4**	**9.6**	**9.9**	**9.8**	**10.6**	**9.9**
4	**9.2**	**8.1**	**10.9**	**10.2**	**8.8**	**7.8**	**11.3**	**11.5**	**9.1**	**8.0**
5	**11.4**	**10.4**	**13.5**	**13.8**	**11.3**	**10.4**	**15.4**	**16.7**	**11.4**	**10.4**
6	**11.8**	**11.2**	**13.4**	**13.5**	**11.6**	**11.1**	**13.1**	**13.0**	**11.8**	**11.3**

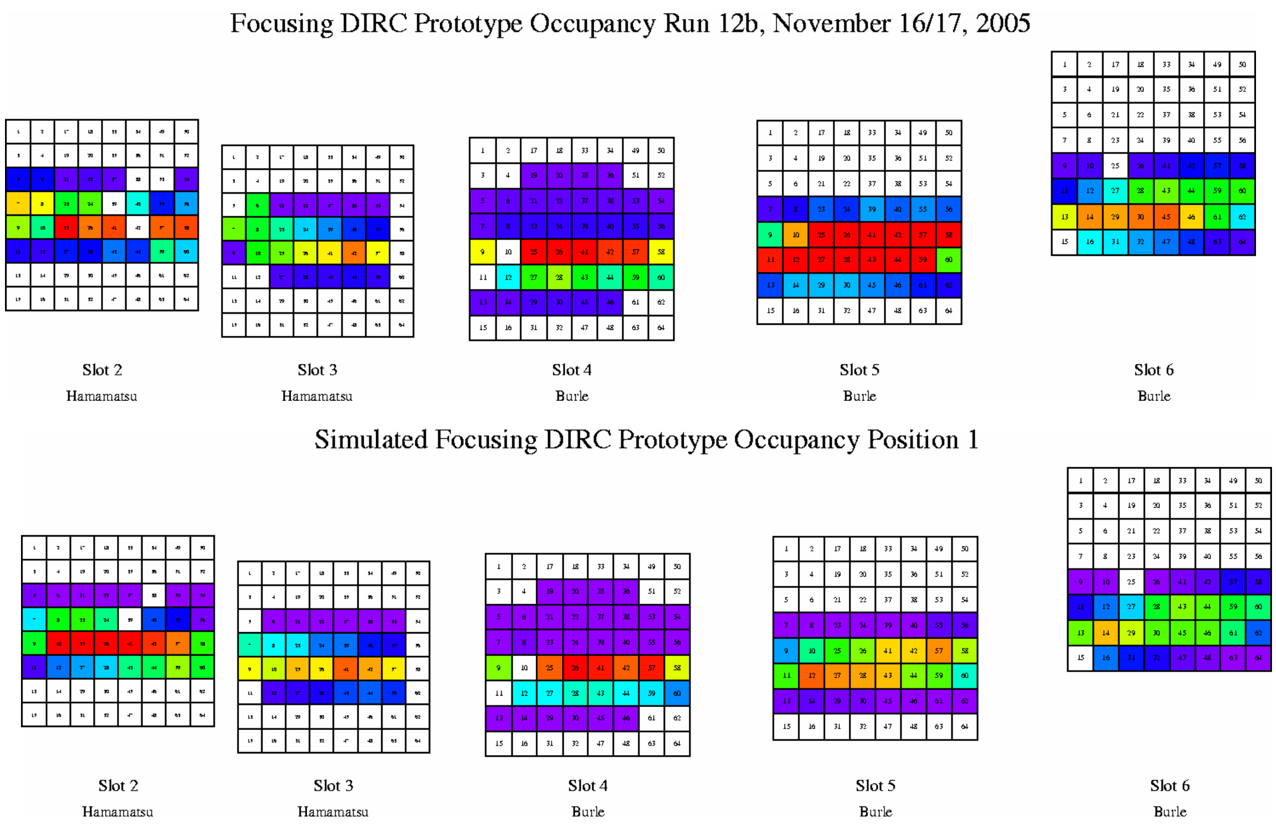
Configuration 1 (two hamamatsu 8500 + three burle)

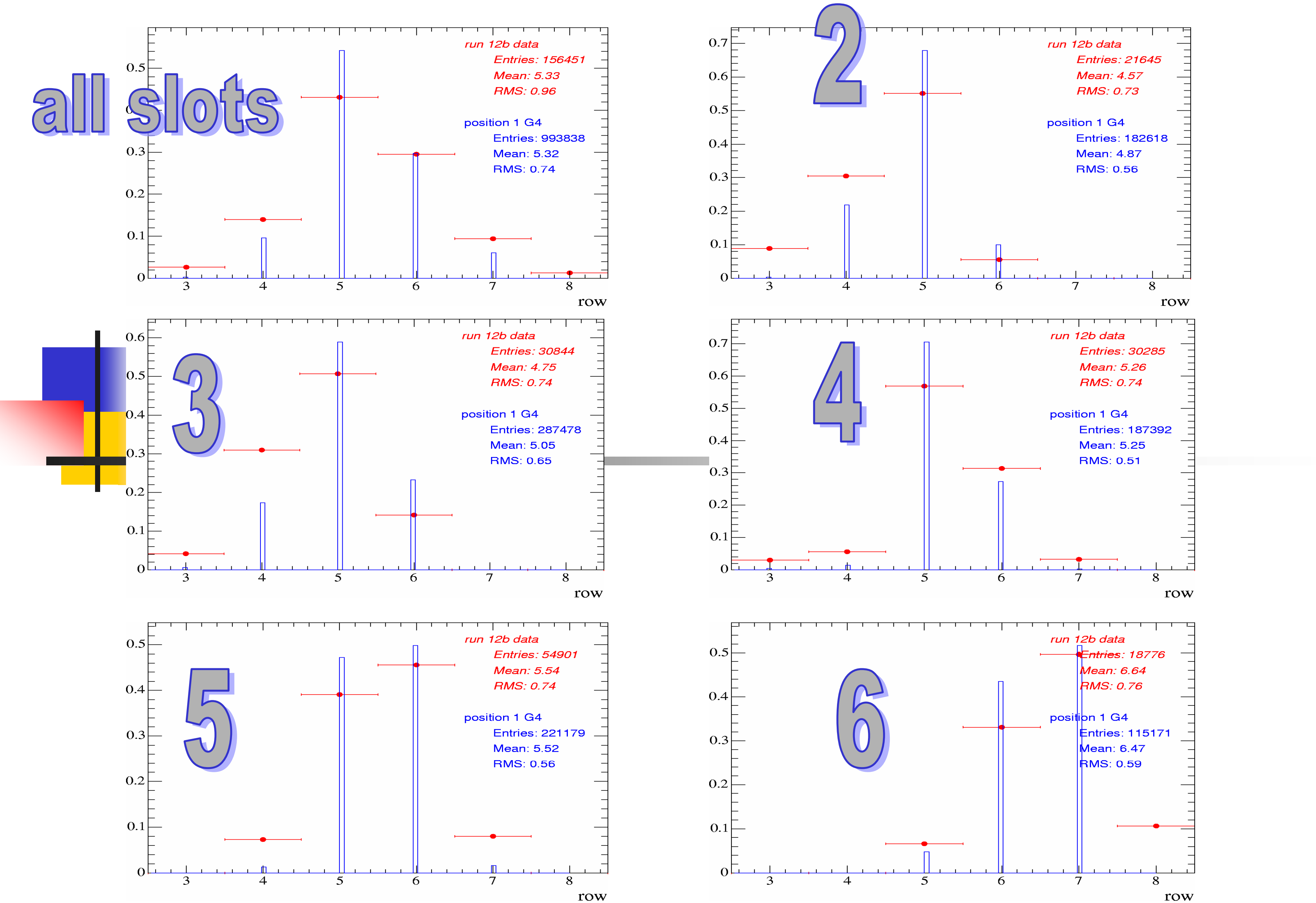
ThetaC from pixels

Sigma (mrad)	PEAK 1		PEAK2		PEAK 1 & 2	
Slot	*MC ch.sh*	*MC without ch. sh*	*MC ch. sh*	*MC without ch. sh.*	*MC ch. sh*	*MC without ch. sh.*
2	11.1	10.1	10.8	10.0	11.1	10.1
3	8.4	7.3	8.1	7.2	8.4	7.4
4	8.7	7.8	8.4	7.8	8.6	7.9
5	7.7	5.8	7.4	5.9	7.9	6.0
6	13.4	12.3	12.4	11.6	13.2	12.2

Comparison of simulated data with test beam data

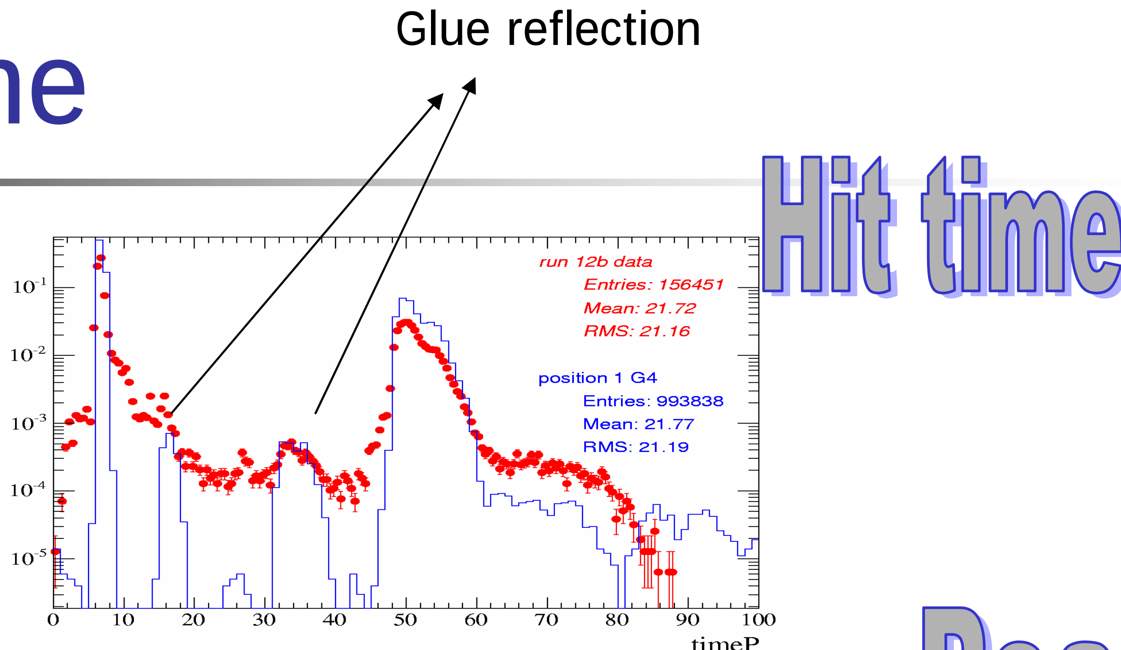
Location of the Cherenkov ring and multiplicity of hits

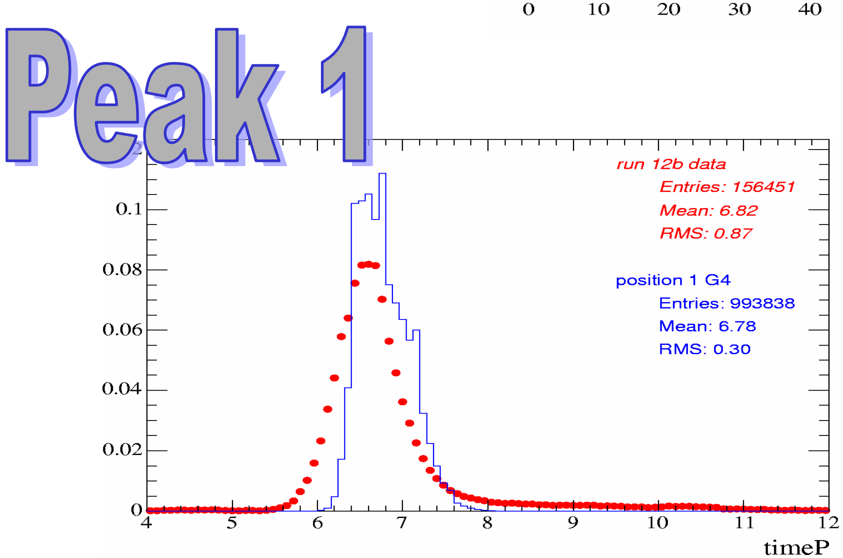


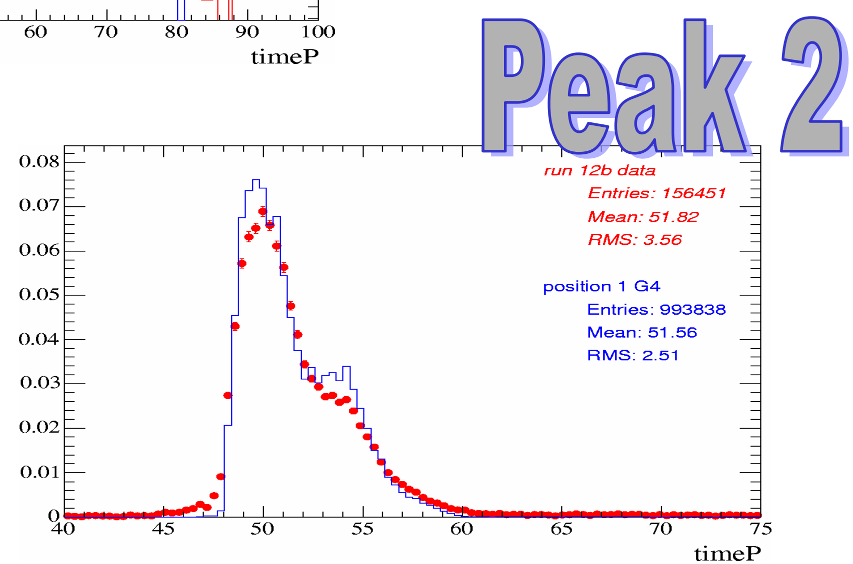


all slots
run 12b data
Entries: 156451
Mean: 5.33
RMS: 0.96
position 1 G4
Entries: 993838
Mean: 5.32
RMS: 0.74
row
2
run 12b data
Entries: 21645
Mean: 4.57
RMS: 0.73
position 1 G4
Entries: 182618
Mean: 4.87
RMS: 0.56
row
3
run 12b data
Entries: 30844
Mean: 4.75
RMS: 0.74
position 1 G4
Entries: 287478
Mean: 5.05
RMS: 0.65
row
4
run 12b data
Entries: 30285
Mean: 5.26
RMS: 0.74
position 1 G4
Entries: 187392
Mean: 5.25
RMS: 0.51
row
5
run 12b data
Entries: 54901
Mean: 5.54
RMS: 0.74
position 1 G4
Entries: 221179
Mean: 5.52
RMS: 0.56
row
6
run 12b data
Entries: 18776
Mean: 6.64
RMS: 0.76
position 1 G4
Entries: 115171
Mean: 6.47
RMS: 0.59
row

Hit time

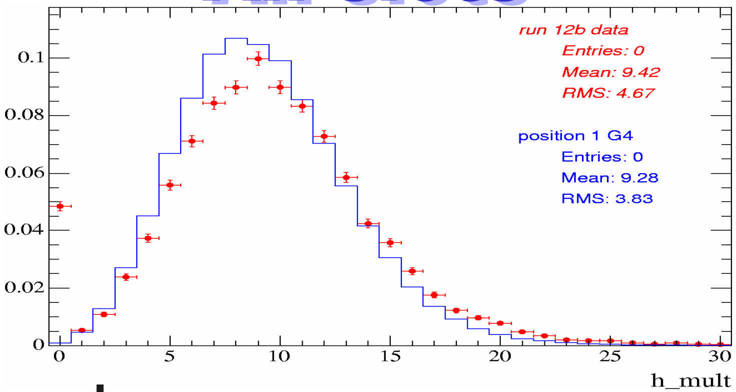

Glue reflection
Hit time
run 12b data
Entries: 156451
Mean: 21.72
RMS: 21.16
position 1 G4
Entries: 993838
Mean: 21.77
RMS: 21.19
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0 10 20 30 40 50 60 70 80 90 100
timeP

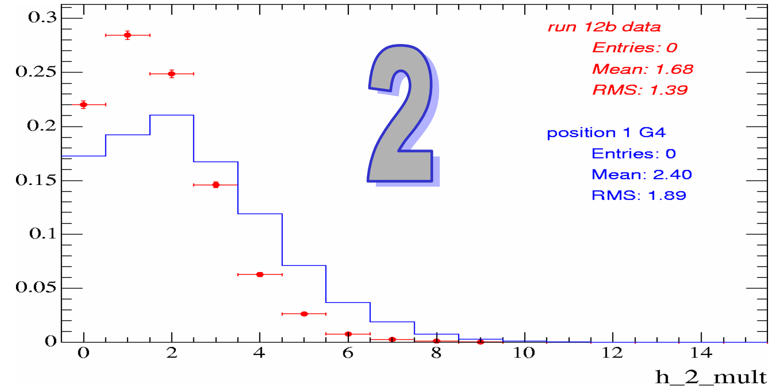

Peak 1
run 12b data
Entries: 156451
Mean: 6.82
RMS: 0.87
position 1 G4
Entries: 993838
Mean: 6.78
RMS: 0.30
0 0.02 0.04 0.06 0.08 0.1
4 5 6 7 8 9 10 11 12
timeP

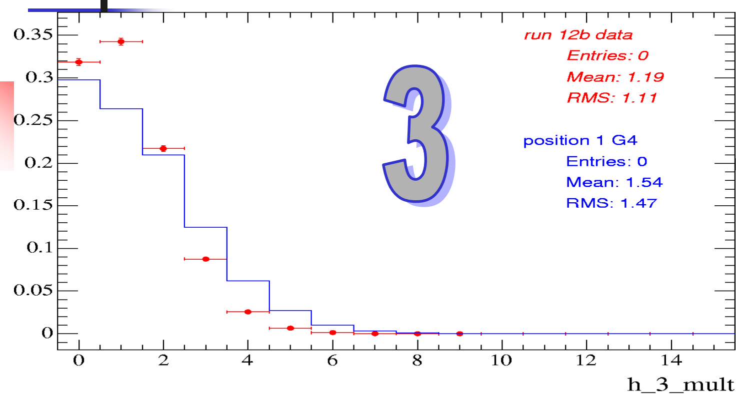

Peak 2
run 12b data
Entries: 156451
Mean: 51.82
RMS: 3.56
position 1 G4
Entries: 993838
Mean: 51.56
RMS: 2.51
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
40 45 50 55 60 65 70 75
timeP

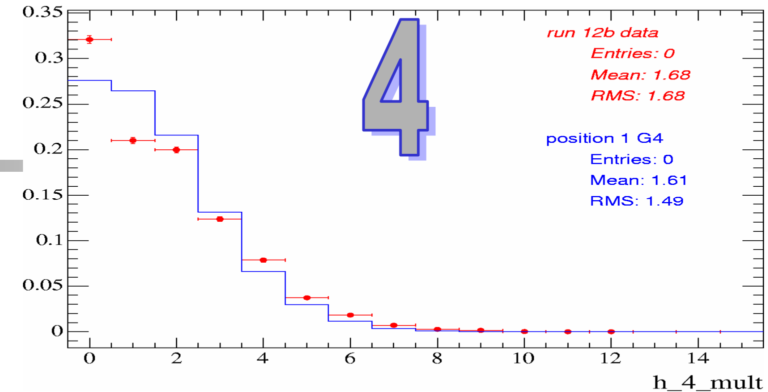
Overall multiplicity of hits per event

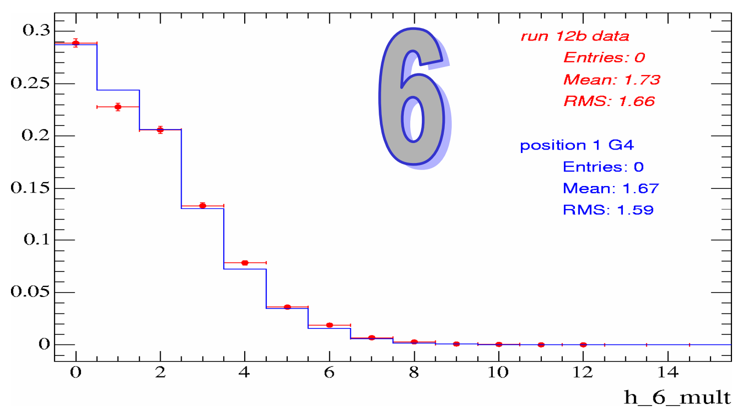
All slots

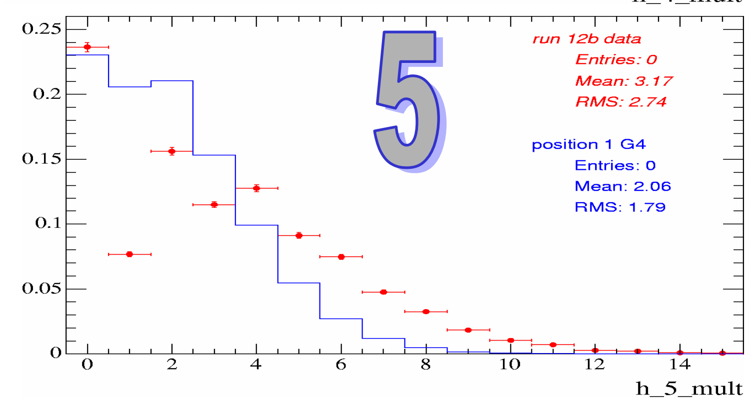

run 12b data
Entries: 0
Mean: 9.42
RMS: 4.67
position 1 G4
Entries: 0
Mean: 9.28
RMS: 3.83
h_mult


2
run 12b data
Entries: 0
Mean: 1.68
RMS: 1.39
position 1 G4
Entries: 0
Mean: 2.40
RMS: 1.89
h_2_mult


3
run 12b data
Entries: 0
Mean: 1.19
RMS: 1.11
position 1 G4
Entries: 0
Mean: 1.54
RMS: 1.47
h_3_mult


4
run 12b data
Entries: 0
Mean: 1.68
RMS: 1.68
position 1 G4
Entries: 0
Mean: 1.61
RMS: 1.49
h_4_mult


6
run 12b data
Entries: 0
Mean: 1.73
RMS: 1.66
position 1 G4
Entries: 0
Mean: 1.67
RMS: 1.59
h_6_mult


5
run 12b data
Entries: 0
Mean: 3.17
RMS: 2.74
position 1 G4
Entries: 0
Mean: 2.06
RMS: 1.79
h_5_mult

Conclusion

- The flexible model of the DIRC prototype with most important features was created (different configurations of PMTs, different positions, different particles, etc.)
- It makes possible to generate direction cosine and cherenkov angle assignments.

Conclusion (cont.)

- The output file can be converted into the format of DIRC prototype output file, so it is possible to analyze simulated data with the analysis software
- It was written manual which explains MC implementation.