Latest results of the G4 simulation

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Outline

- New features in G4 DIRC simulation
- Physical processes and their influence on background
- Peak 1 - Peak 2 ratio

Part 1

New features in G4 simulation

New features

- Choice of main parameters from batch file => called “messengers” in G4
- Choices have been added for:

1. Plotting of cherenkov photons and electrons
2. Beam position
3. Primary particle and its energy
4. Charge sharing – on/off

How these commands look in G4 batch file

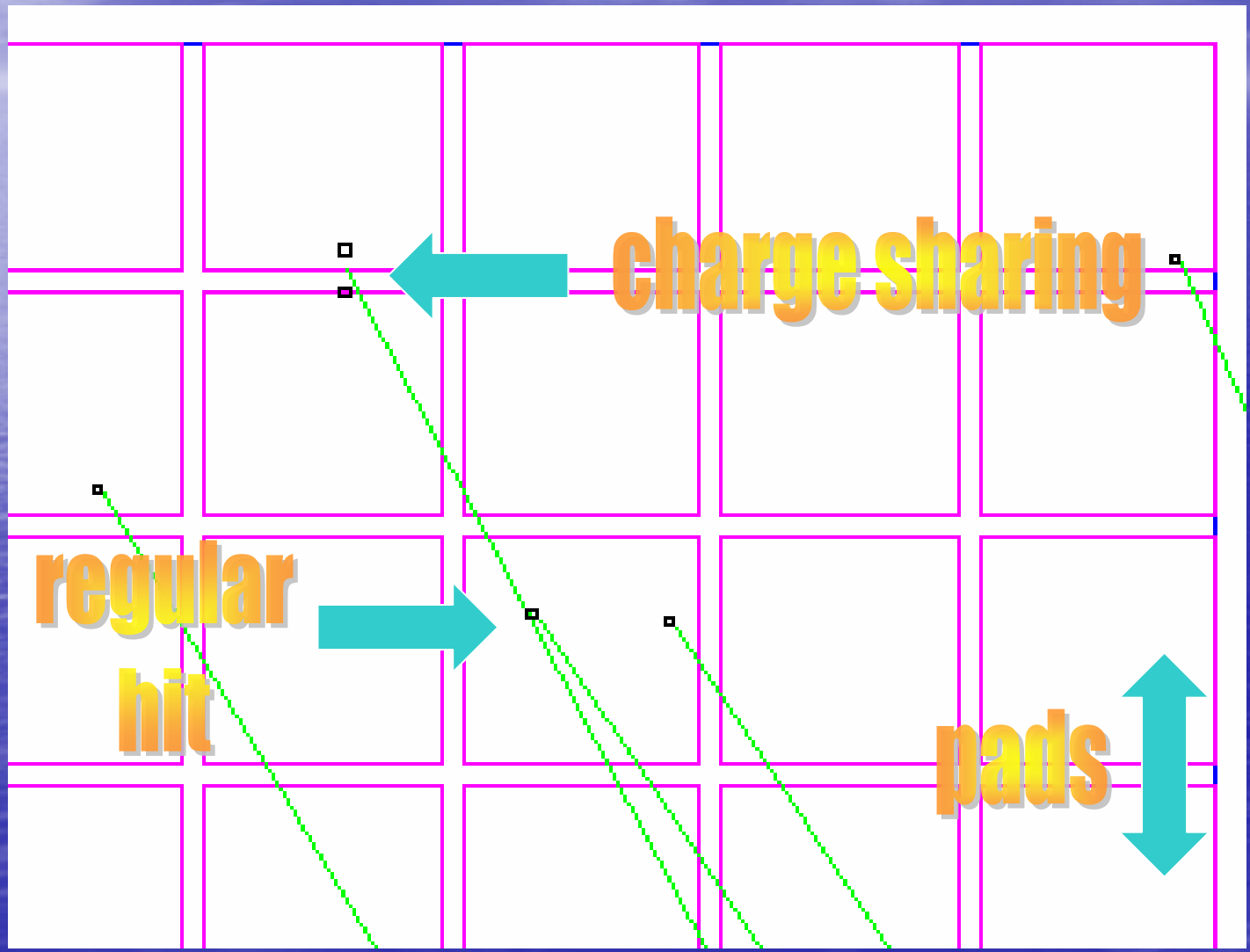
- beam position
  /Dirc/beam/position 1
- primary particle
  /particle/gun e-
- energy of entering particle
  /particle/energy 10 GeV

- all options will be described in a manual

Charge sharing

- When particle hits PMT between pads => charge sharing is created.
- Two hits are created in the nearest two pads.
- Time of second particle is generated within 200 ps window, pmt delay generated separately
- Cherenkov angle is the same
- Position efficiency is set to one

Charge sharing



Charge sharing (cont.)

	Peak 1	Peak 2	Ratio per event
Hits with charge sharing	291633	202414	5.8:4.0
Hits without charge sh.	255 739	179 075	5.1:3.6

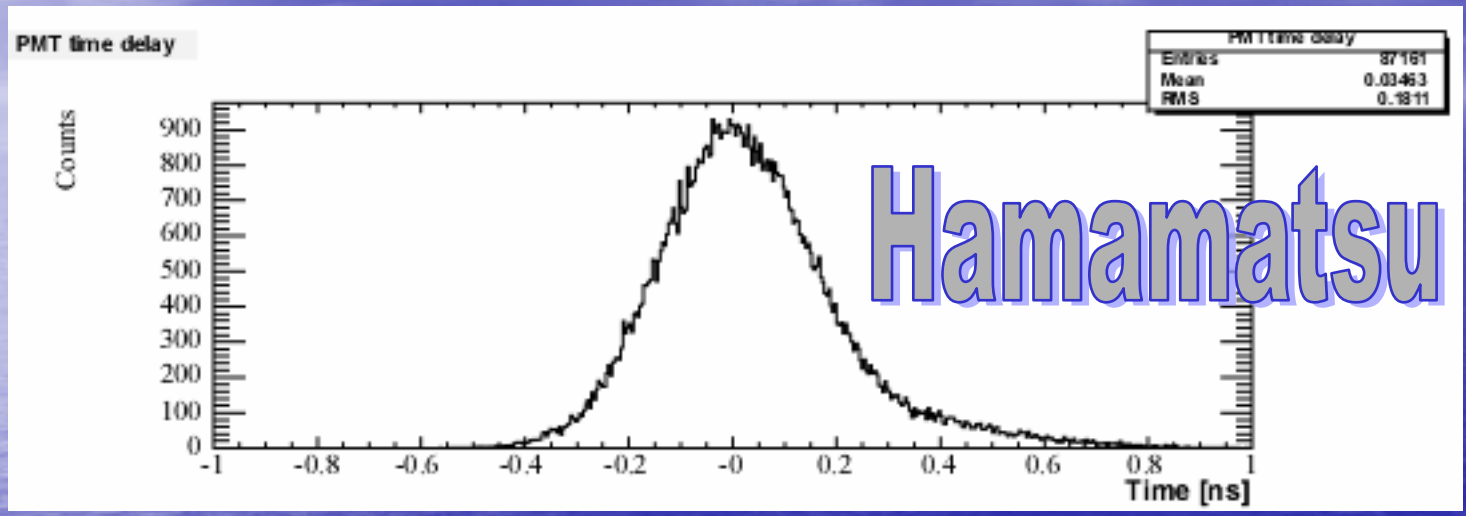
50000 events

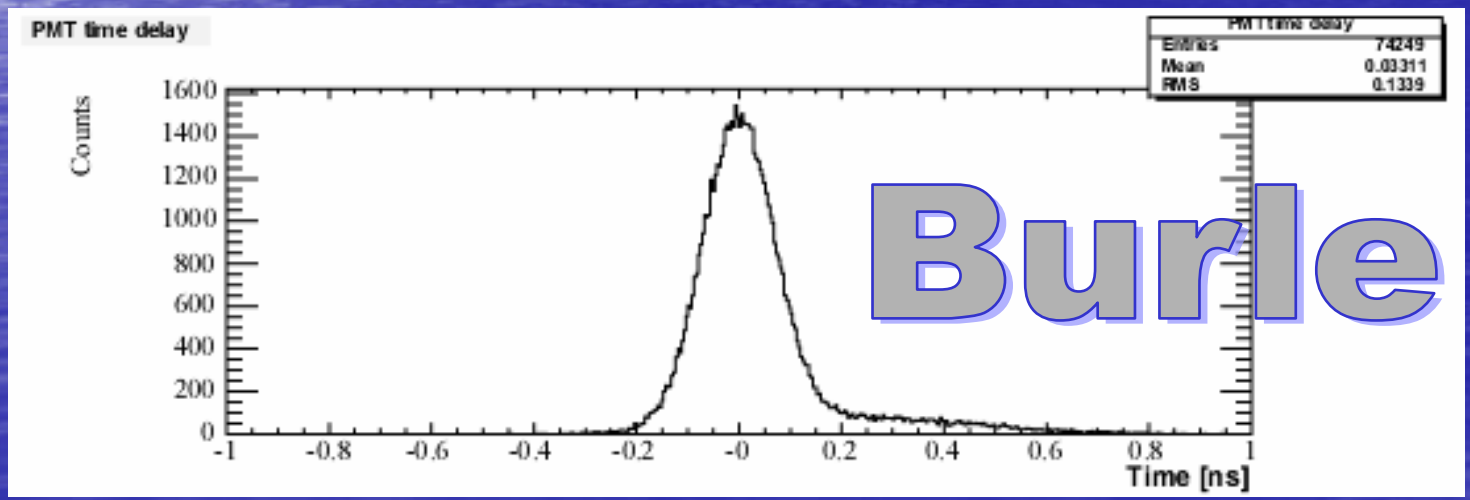
PMT smearing

- PMT smearing has been added according pictures

- Different smearing for Hamamatsu and Burle PMTs

PMT smearing





Part 2

Physical processes in G4 simulation

Physics in G4 simulation

- Background in data is much higher than in G4 simulation => attempt to explain this discrepancy

- Two main processes have been studied:

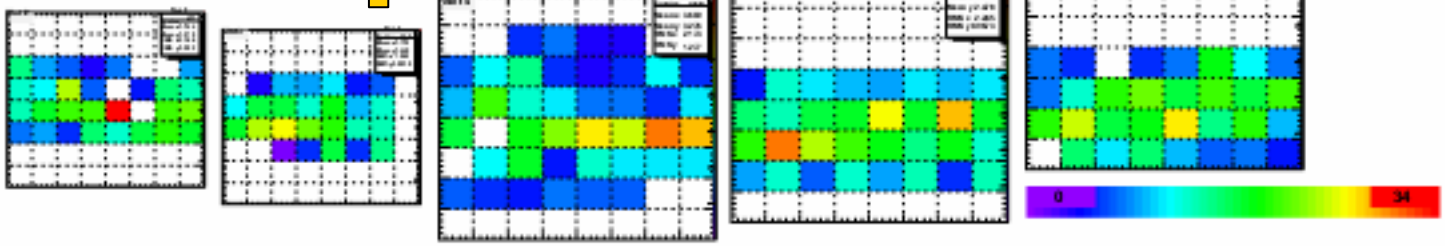
1. Bremstrahlung
2. Multiple scattering

Physics in G4 (continue)

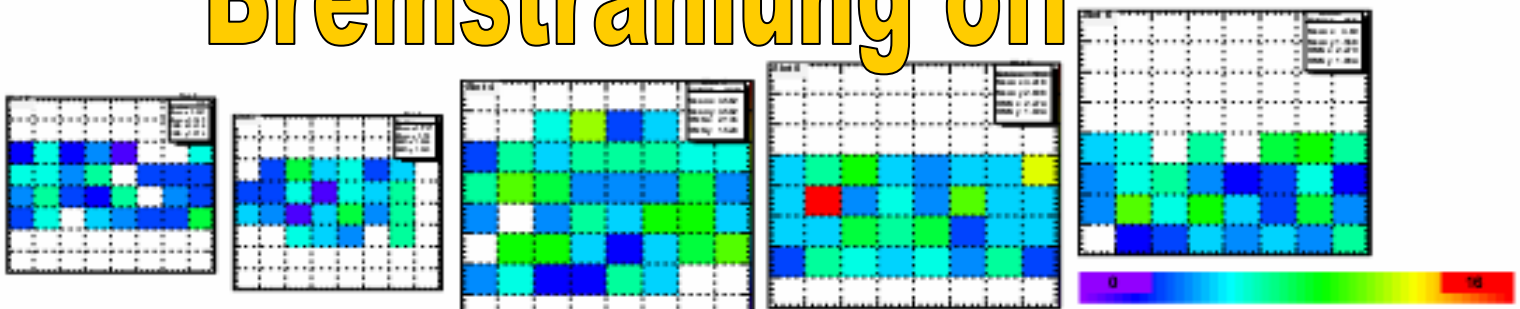
- First, I was interested only in photons which are generated by secondary electrons (I killed all photons generated by primary electrons)

Physics in G4 (cont.)

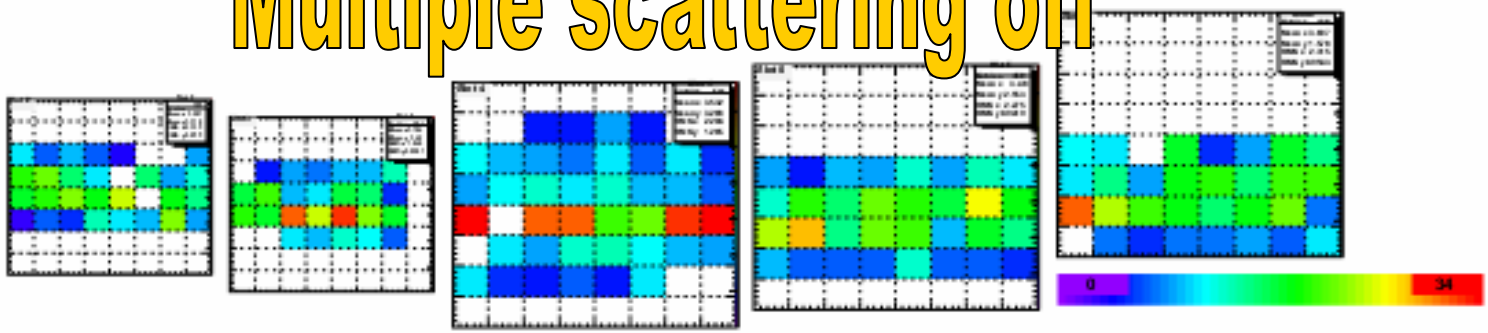
All processes on



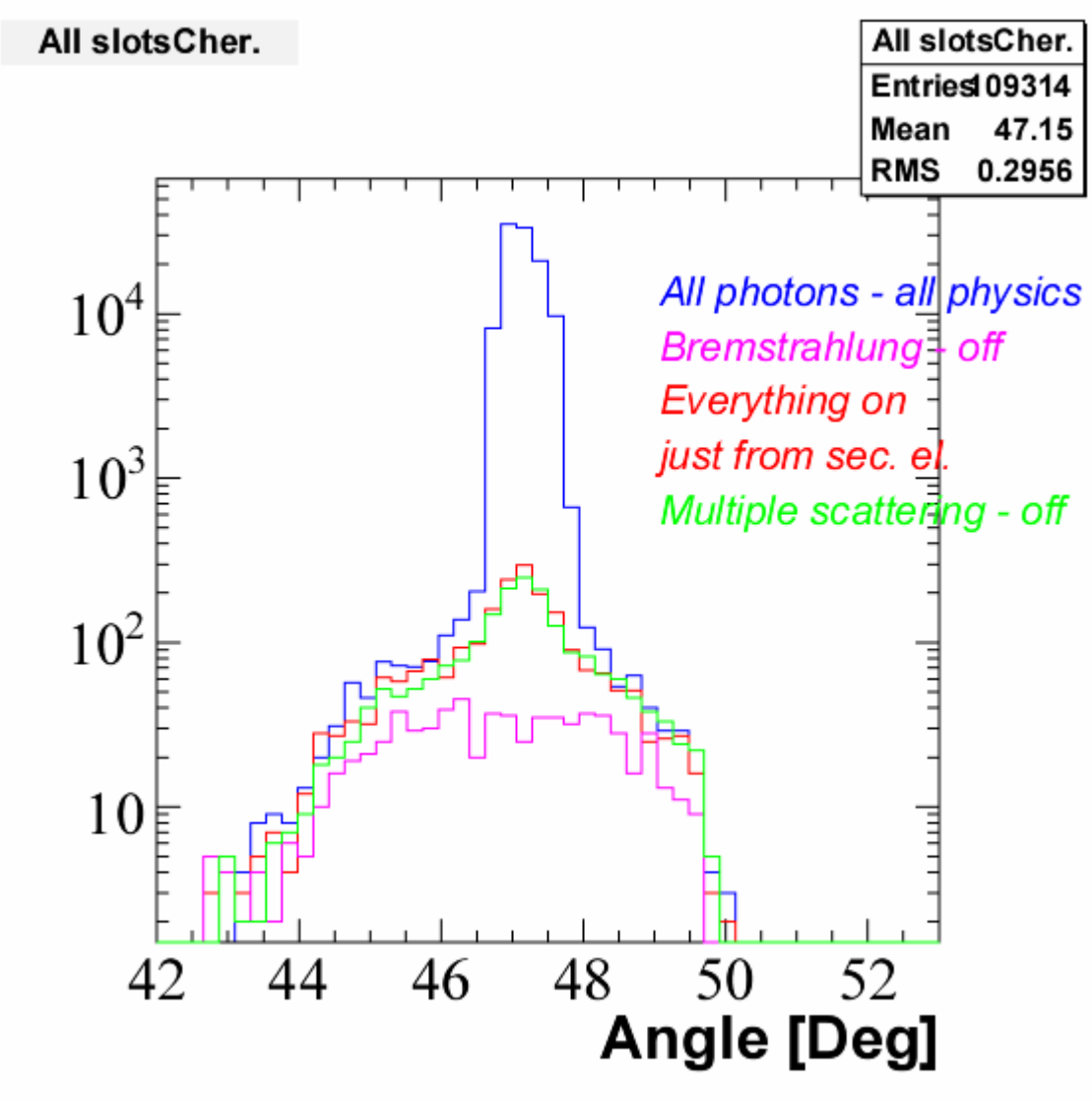
Bremstrahlung off



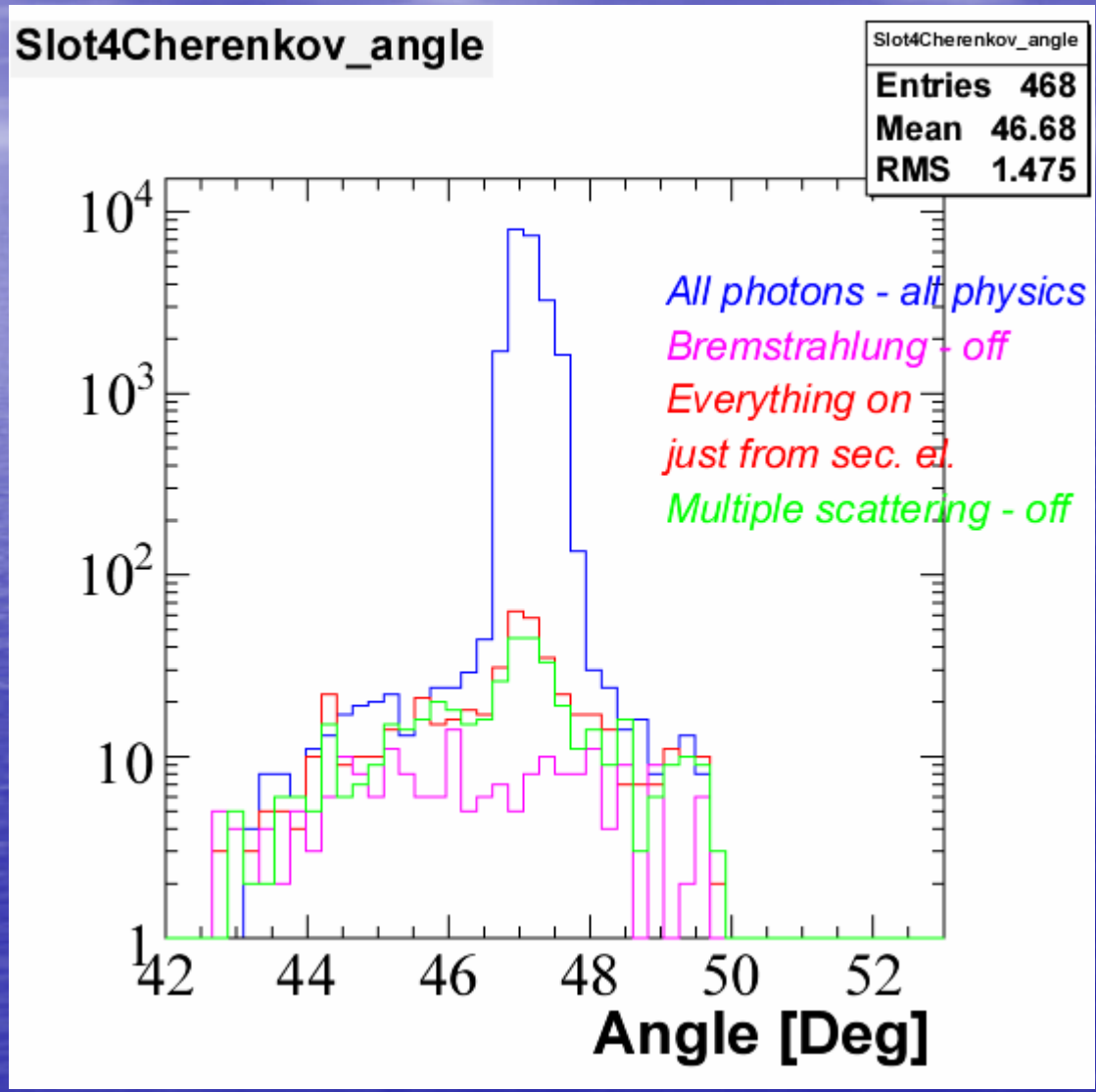
Multiple scattering off



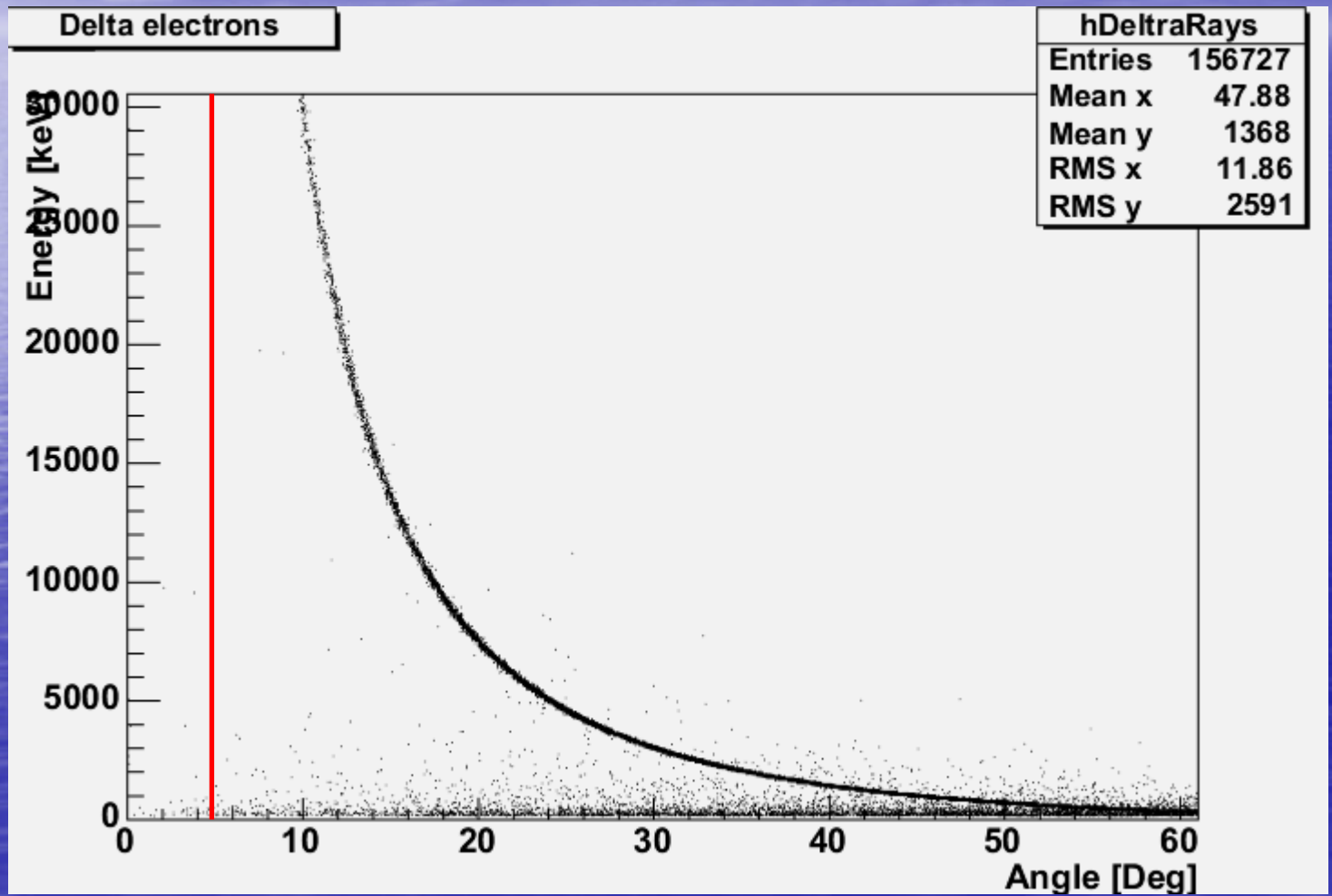
All photons – all slots



Slot 4


Slot4Cherenkov_angle
Slot4Cherenkov_angle
Entries 468
Mean 46.68
RMS 1.475
All photons - all physics
Bremstrahlung - off
Everything on
just from sec. el.
Multiple scattering - off
10^4
10^3
10^2
10
1
42
44
46
48
50
52
Angle [Deg]

Angle vs. energy of delta-elec.



Conclusion

- bremstrahlung – electrons produce photons mainly in the same direction as primary electron
- multiple scattering – electrons produce photons uniformly
- due to small acceptance of DIRC prototype (42-50 deg), most of photons produced by sec. electrons are not registered

Part 3

Peak 1 – Peak 2 ratio

Peak 1 – Peak 2 ratio

- huge discrepancy between real data (2.1:1) and G4 simulation (1.3:1) presented last time by Joe

- Let me try to explain this discrepancy

Peak 1 – Peak 2 ratio

- Differences between Peak 1 and Peak 2 for 410 nm photon:

1. 4 layers of epotek – transmission
   - for 410 nm photon – no attenuation
2. 400 (600) bounces
   - for 410 nm – p = 0.999700708 =>
   loss of 11.3% (16.4%)

Peak 1 – Peak 2 ratio (cont.)

3. Transmission through quartz (10 m difference) – 410 nm photon –

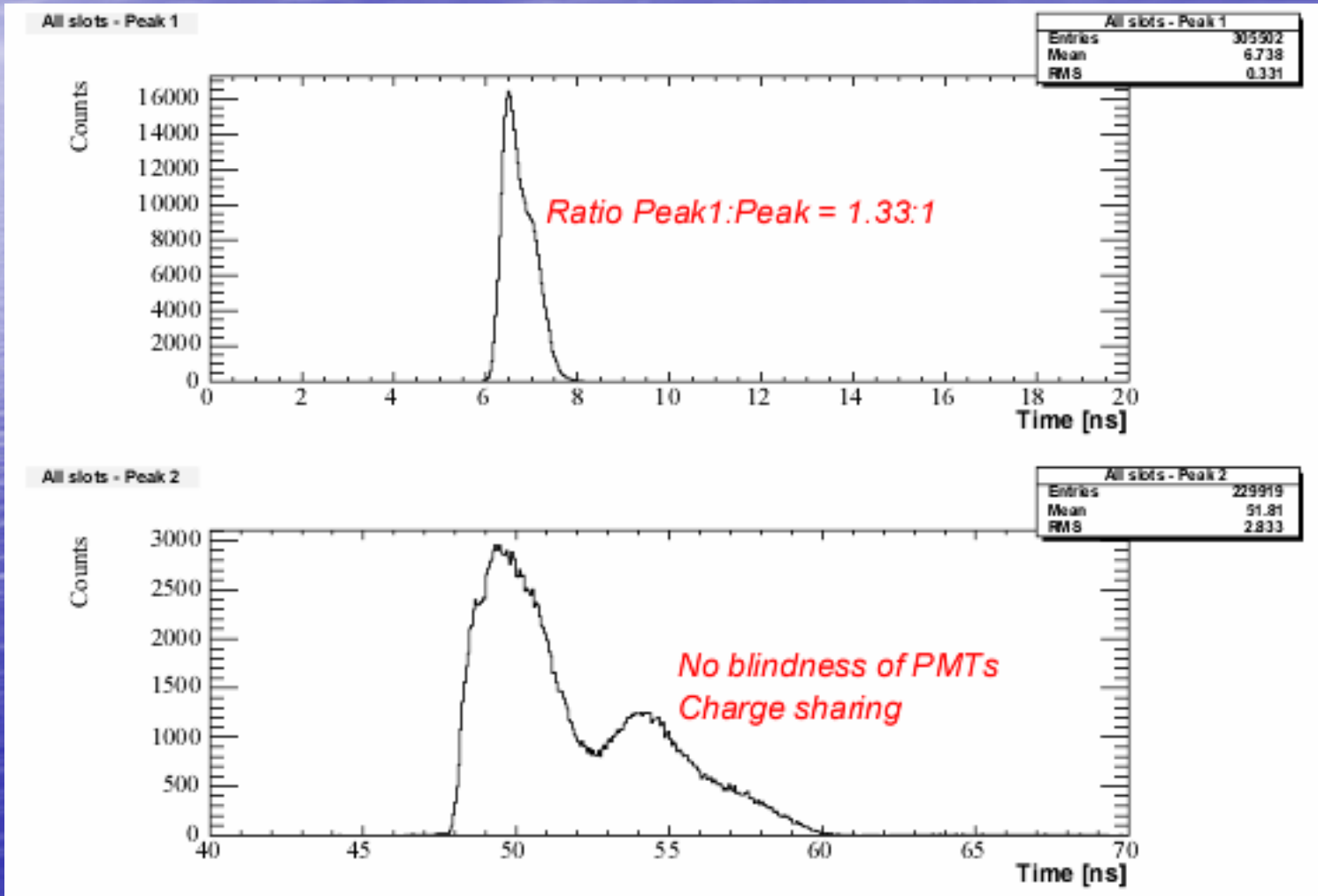
   p = .99729958 per 1 m => loss of 2.7%

4. Reflection coefficient of the mirror at the end of the bar – 410 nm photon –

   p = 0.94 => loss of 6%

=> Total loss of about 20% (25%) photons

Ratio from G4 simulation



Comparison

- 1.33 : 1 from the simulation
- 1.25 (1.33) : 1 from values which have been put into simulation

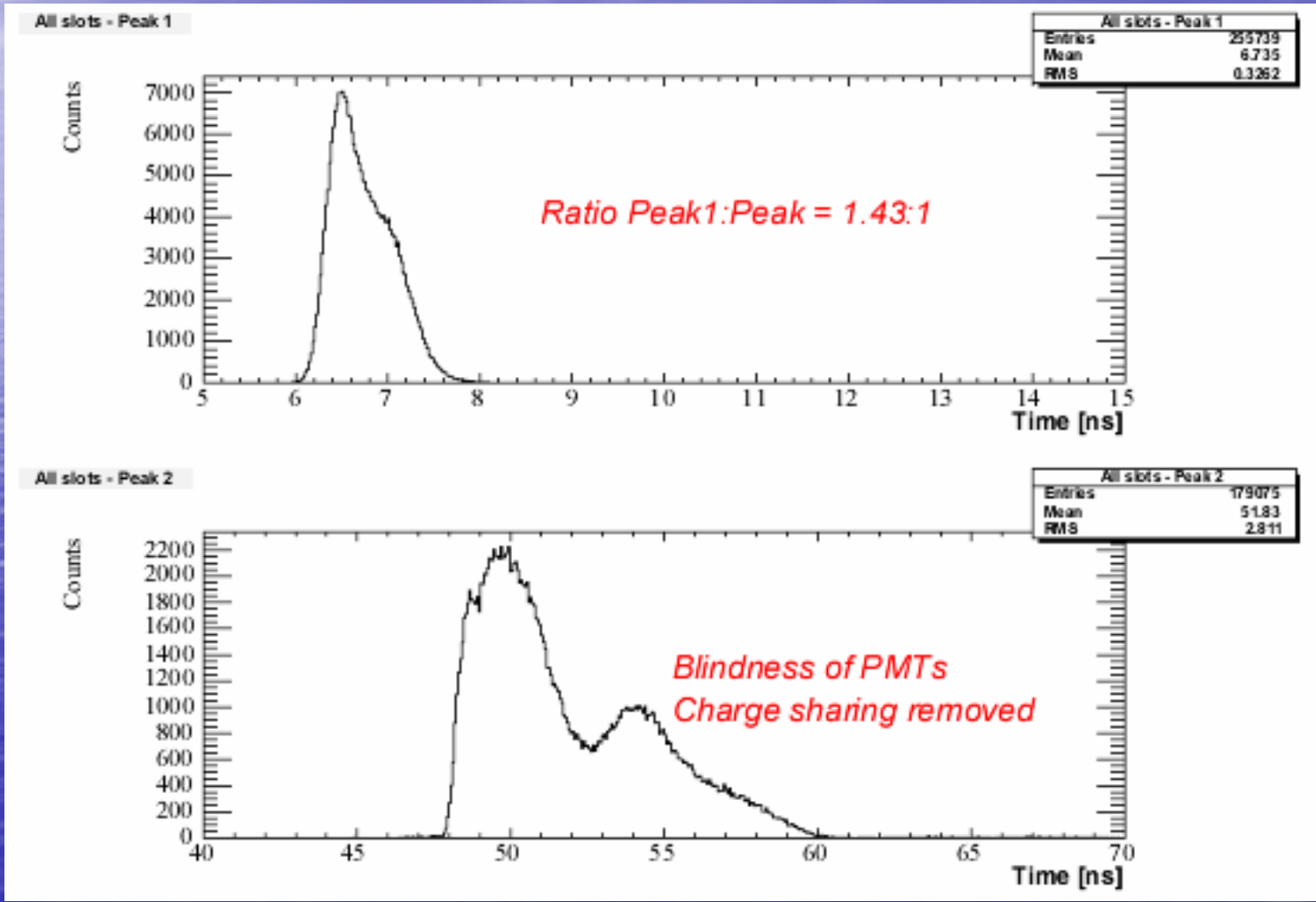
=> good agreement

Blindness of PMT's

- I accept only first hit in a given pad => if two hits occur in one pad => hit from peak 1 is accepted

Note: charge sharing does not change Peak1 – Peak 2 ratio

Blindness of PMT's (cont.)



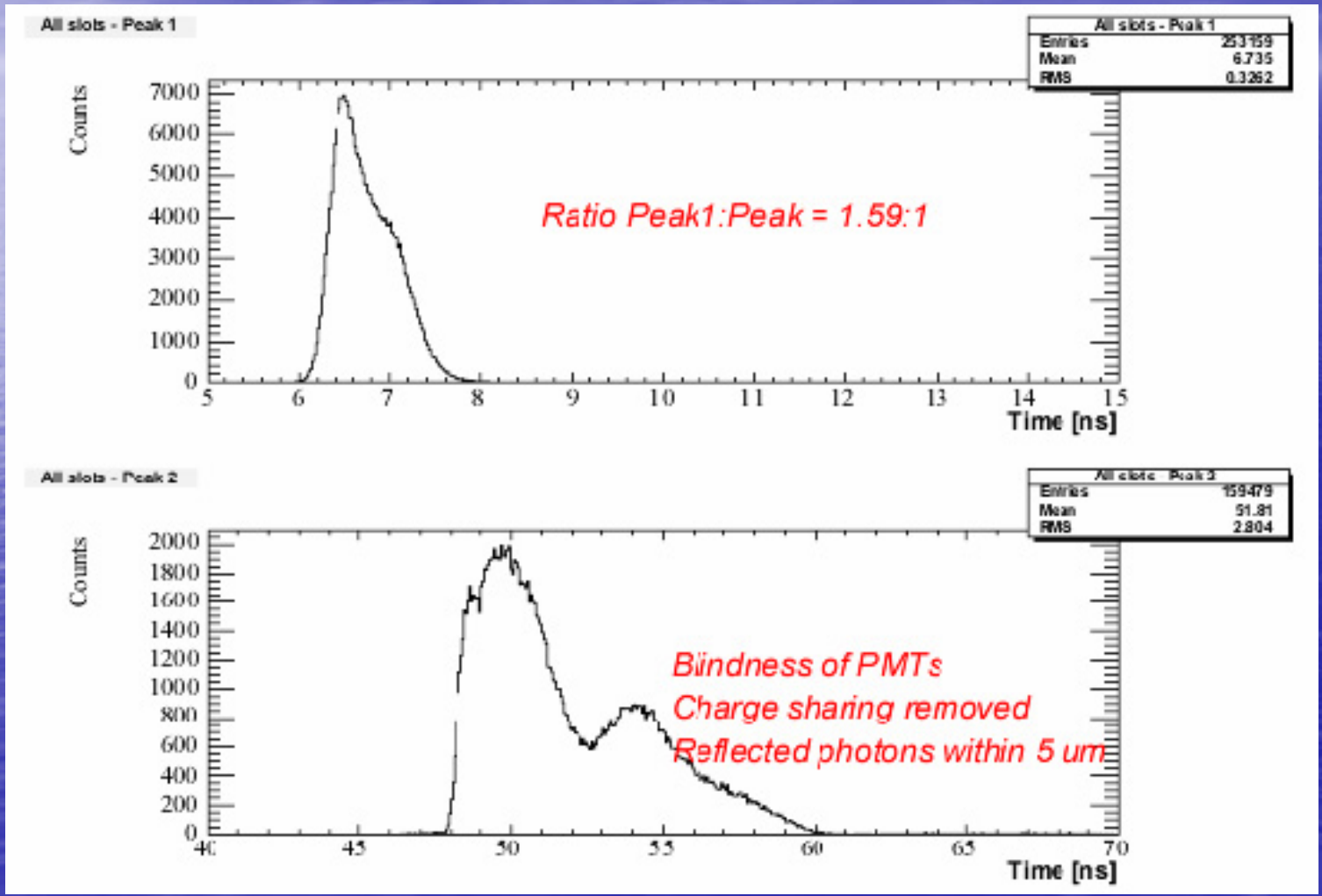
Peak 1 – Peak 2 ratio (cont.)

- The ratio from G4 simulation is still very low comparing to real data

- Nevertheless, bar is not perfect, and the edges are round with radius of 5 μm

  => let me kill all photons which bounced not far than 5 μm from the edge

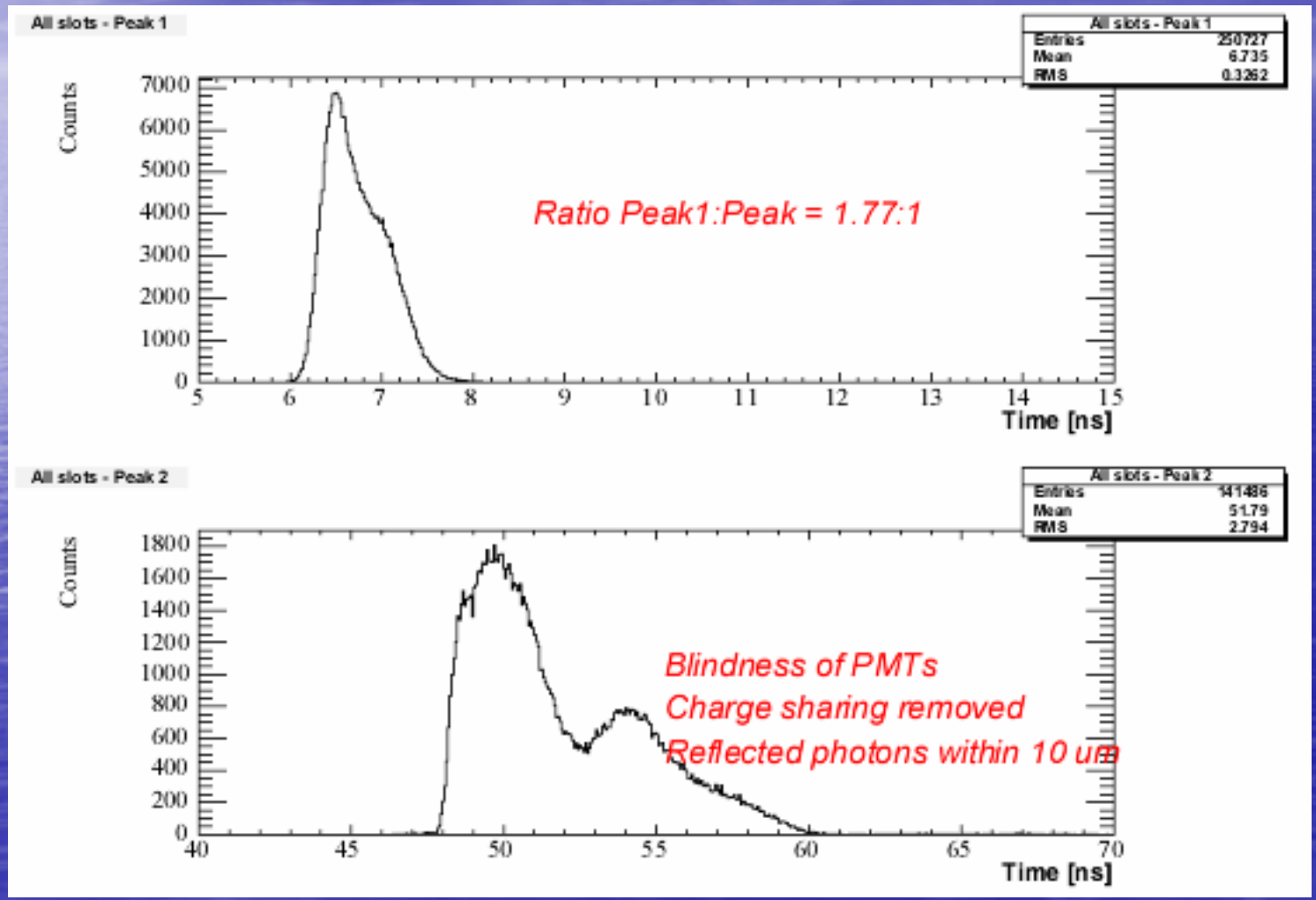
Peak 1 – Peak 2 ratio (cont.)



Peak 1 – Peak 2 ratio (cont.)

- still not satisfying ratio
- so let me try to do last attempt – let me kill all photons which bounced less than 10 μm far from the edge

Peak 1 – Peak 2 ratio (cont.)



First conclusion

- Even with killing of photons which bounced not far than 10µm from the edge, the ratio is 1.77:1 => still very far from data ratio 2.1:1.
- Not able to explain with current knowledge ☹ => necessity to explore the different positions

Ratio 1 – Ratio 2 (cont.)

- Position 1 – z = 59.6 cm – first bar
- Position 3 – z = 161.21 cm – second bar
- Position 5 – z = 262.89 cm – third bar

Peak 1 – Peak 2 ratio (cont.)

Position 1	Data			Simulation			ratio
slot	peak 1	peak 2	ratio 1:2	peak 1	peak 2	ratio 1:2	data/MC
2	30,873	14,530	2.12	57,495	38,357	1.50	1.42
3	21,169	10,742	1.97	44,399	30,486	1.46	1.35
4	29,673	14,625	2.03	46,748	34,946	1.34	1.52
5	54,233	25,740	2.11	56,755	40,222	1.41	1.49
6	19,153	8,371	2.29	50,342	35,064	1.44	1.59

Peak 1 – Peak 2 ratio (cont.)

Position 3	Data			Simulation			ratio
slot	peak 1	peak 2	ratio 1:2	peak 1	peak 2	ratio 1:2	data/MC
2	36,969	22,490	1.64	1,256	867	1.45	1.13
3	25,451	16,156	1.58	852	611	1.39	1.13
4	35,902	22,064	1.63	922	682	1.35	1.20
5	66,707	41,222	1.62	1,144	866	1.32	1.22
6	21,877	12,608	1.74	1,011	741	1.36	1.27

Peak 1 – Peak 2 ratio (cont.)

Position 5		Data			Simulation		ratio
slot	peak 1	peak 2	ratio 1:2	peak 1	peak 2	ratio 1:2	data/MC
2	15,912	12,548	1.27	1,132	925	1.22	1.04
3	11,208	8,706	1.29	895	693	1.29	1.00
4	16,354	11,766	1.39	949	712	1.33	1.04
5	29,705	23,049	1.29	1,030	858	1.20	1.07
6	9,273	7,237	1.28	994	766	1.30	0.99

Conclusion

- Position 1 (first bar) – the ratio doesn't correspond at all (2.1:1 vs. 1.4:1 => data/MC = 1.50)
- Position 3 (second bar) – the ratio is better, however it still doesn't correspond (1.63:1 vs. 1.38:1 => data/MC = 1.18)
- Position 5 (third bar) – the ratio corresponds quite well (1.30:1 vs. 1.26:1 => data/MC = 1.03)