Comments on charge sharing with H-8500

J. Va'vra

SuperB collaboration meeting in London, 2011

Content

- What is our aim when thinking about the charge division ?
- Cross-talk vs. Charge sharing
- Charge sharing with MCP detectors. Tests with a computer and scope.
- Is H-8500 charge sharing the same as in MCP detectors, or is it much smaller ? We did not know the answer up to this point.
- Do we have any evidence from the test beam that the ADC pad treatment improves the Cherenkov angle resolution ?
- Test in the SLAC scanning setup with a scope.

Present FDIRC predicted performance

Doug Roberts, SuperB workshop, Annecy, 2010

Table 1: FDIRC performance simulation by Geant 4 MC.

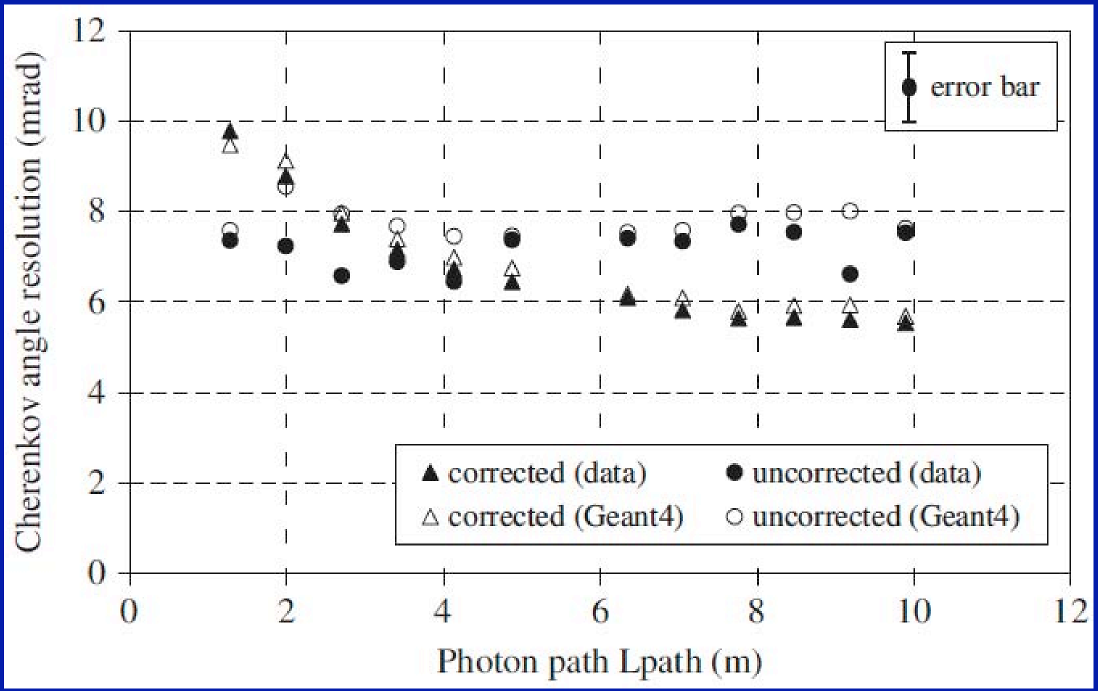
Design	Option	θ_c resolution [mrad]
1	FDIRC with 3 mm x 12 mm pixels with a micro-wedge	8.1
2	FDIRC with 3 mm x 12 mm pixels & no micro-wedge	8.8
3	FDIRC with 6 mm x 12 mm pixels with a micro-wedge	9.0
4	FDIRC with 6 mm x 12 mm pixels & no micro-wedge	9.6

- **The most conservative decision, which is a design #4, would give the same performance as the BaBar DIRC (~9.6 mrads for di-muons).**
- **However, one should point out that FDIRC will correct out the chromatic error by timing, which would reduce the error by 0.5-1 mrads.**
- **If we reduce the pixel size in y-direction by the charge sharing we gain. The question is how much, and is the improvement worth the effort ?**

1-st FDIRC prototype in the ESA test beam

J. Benitez, D.W.G.S. Leith, G. Mazaheri, B.N. Ratcliff, J. Schwiening,
J. Va'vra, L.L. Ruckman, G.S. Varner, NIM A 595 (2008) 104

H-9500 with 3 mm x 12 mm pixels:



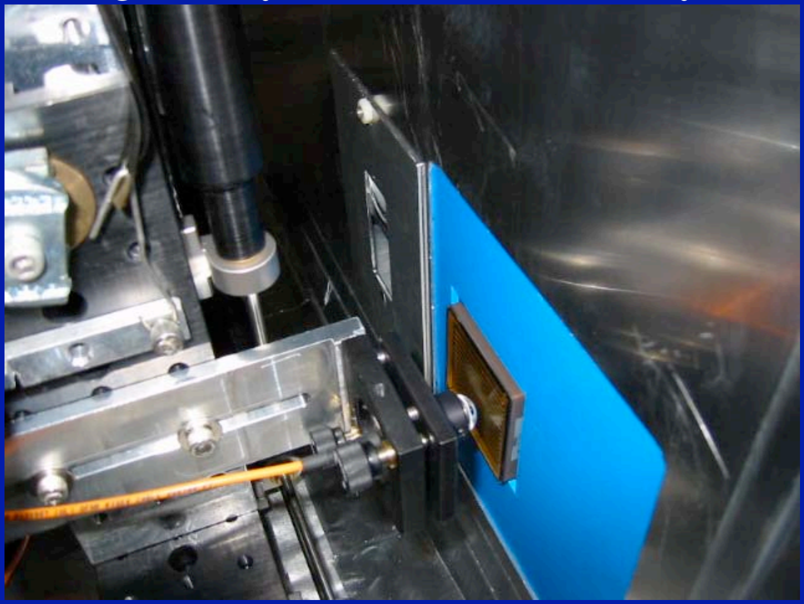
Corrected for chromatic errors

- **One can see that with the chromatic correction the performance with 3mm x 12mm pixels is superB.**
- **If we adopt H-9500 with 3mm x 12mm pixels, we would have 64 pixels/tube.**

Optics in the SLAC scanning setup

J. Va'vra

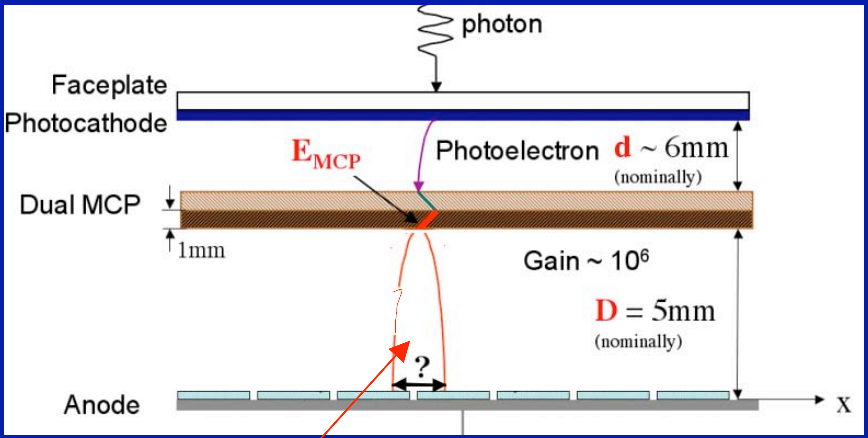
The light entry into tube under study:



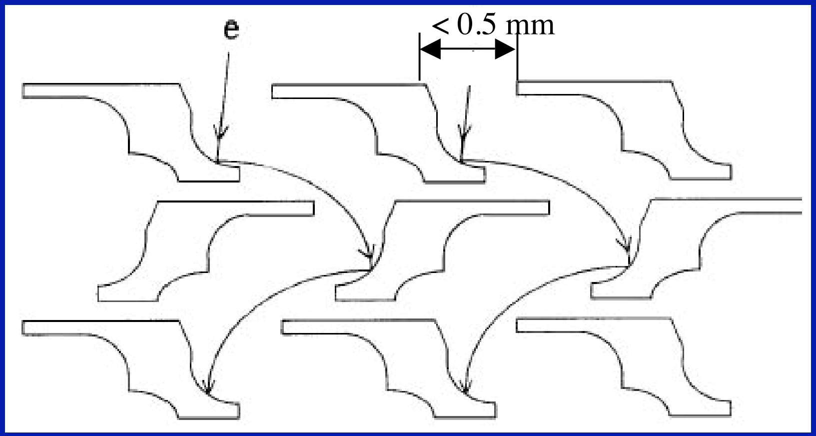
- Fiber ends with a lens, which produces a parallel beam. After a few mm of air gap, I placed another lens with very a short focal length (f = 15mm).
- The picture shows the H-8500.
- I am getting ahead of myself, but we have indications that a combination of two lenses produces a light scatter affecting tails.

Two devices to consider in this talk

Burle MCP tube used in this study:



H-8500 tube electrode structure:



Avalanche is large (a few mm).
We can observe two pulses on neighboring pads, if laser points exactly to their boundary.

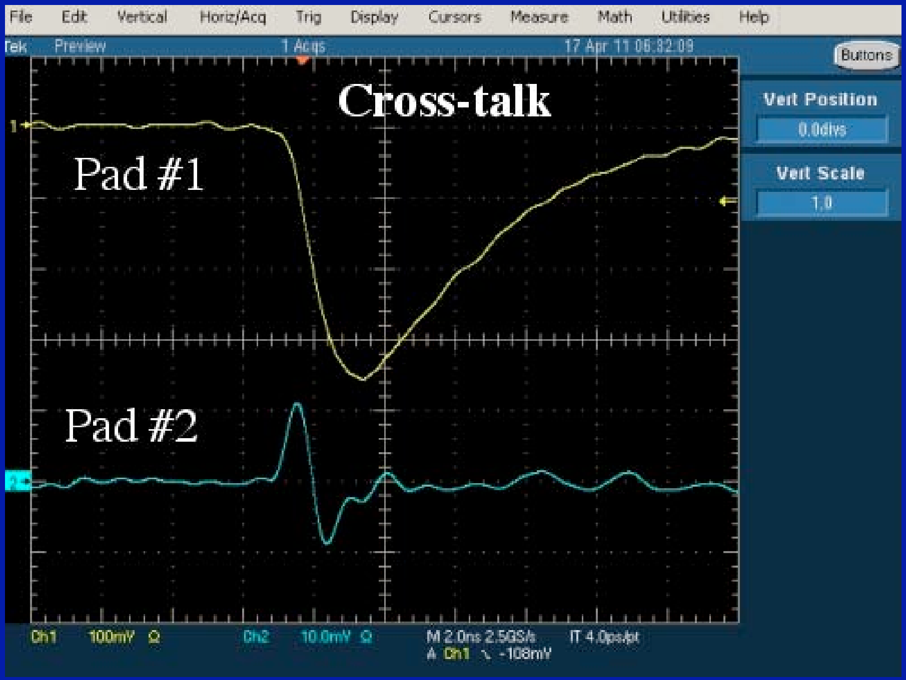
My guess: avalanche size near anodes is < 1mm

- **I do not posses the detailed electrostatic design of these tubes, but all empirical studies point to the fact that the Burle MCP charge spread is significantly larger than that of the H-8500 tube.**

Cross-talk in H-8500

J.Va'vra

Single photoelectron signal and its cross-talk to neighboring pad:

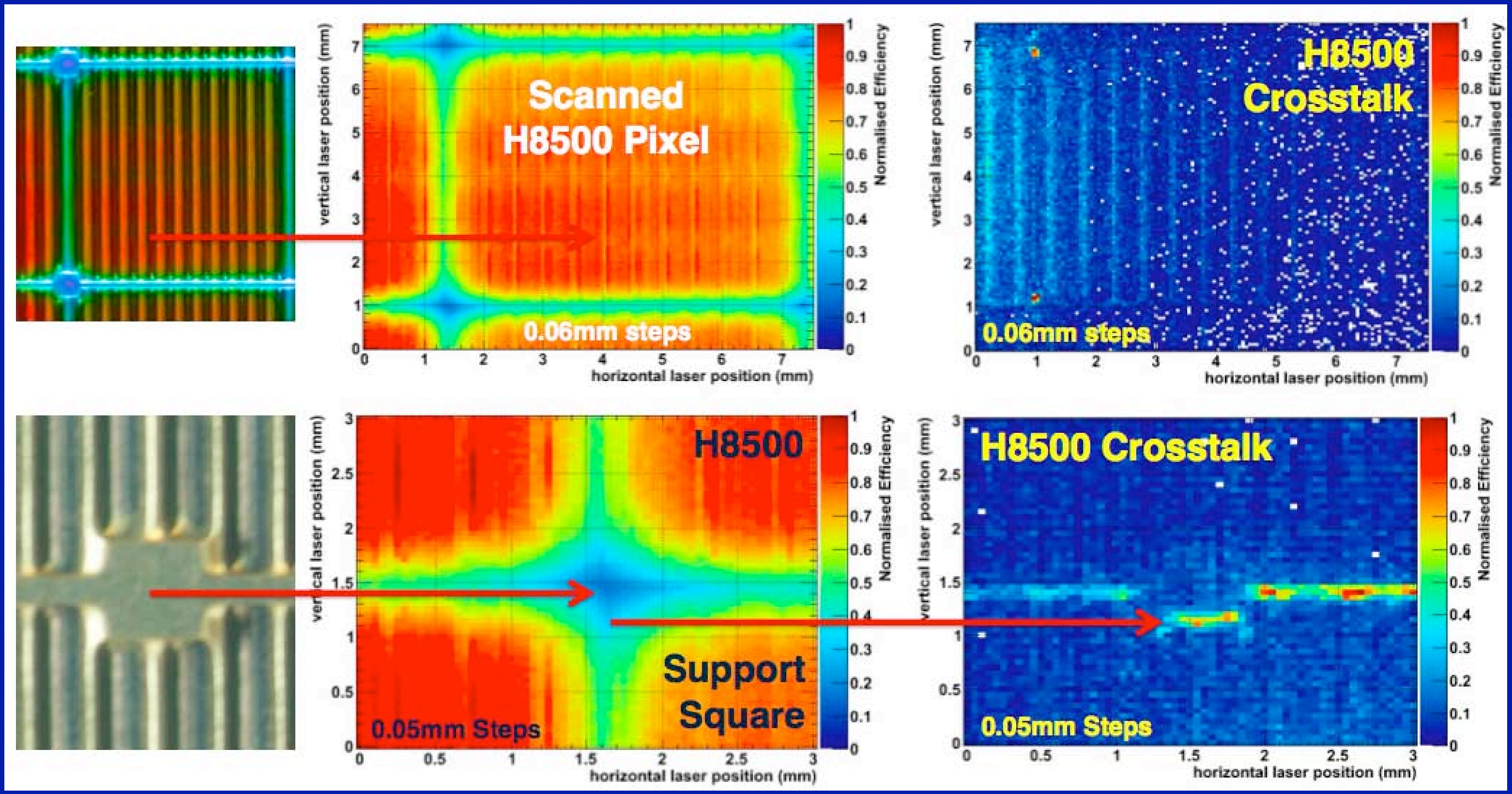


- The single photoelectron is located in the center of a pixel.
- HV: -1.0kV

- **This is what I call a classical pixel-to-pixel electrical cross-talk.**
- **Its magnitude is about ~3% and it is a derivative of the primary signal.**
- **Its magnitude does not depends where in pixel you are, to my best knowledge. But, see the next slide….**

Extremely detailed scans of H-8500

R. Montgomery, E.N. Cowie, M. Hoek, T. Keri, B. Seitz, Glasgow, U.K. - This is part of Panda R&D effort

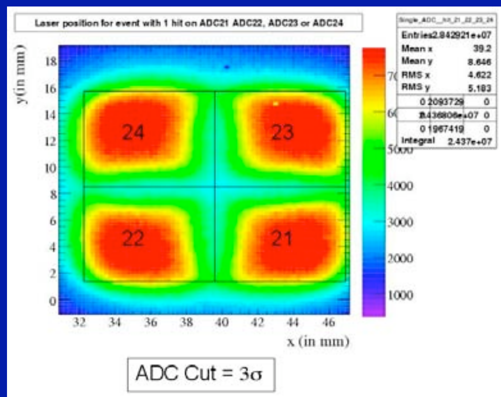


- Is this an electrical cross-talk or an optical cross-talk caused by laser bouncing between photocathode and dynodes several times ? That is what I think this is. Debate is going between me and M. Hoek. They are looking into it.
- If this is the electrical cross-talk, its value has a very precise geometrical origin related to the dynode structure design. I do not believe it.

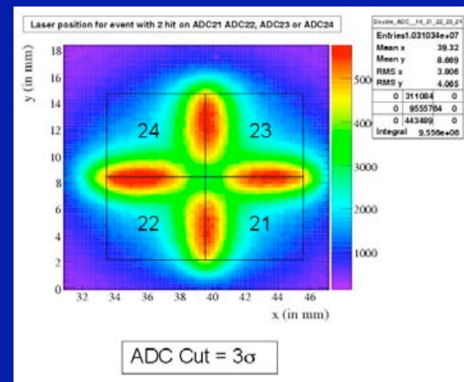
Charge sharing study with Burle MCP-PMT

Mathiew, a student working for us for 3 months, SLAC scanning setup, FDIRC effort

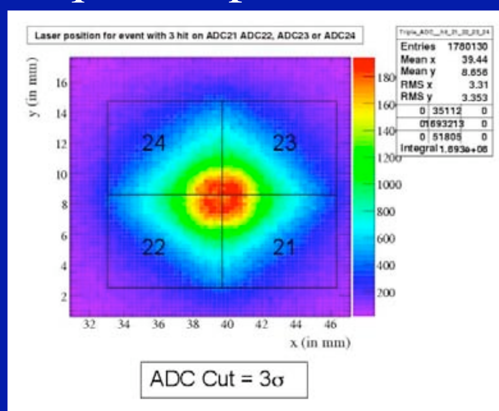
Require single ADC hit:



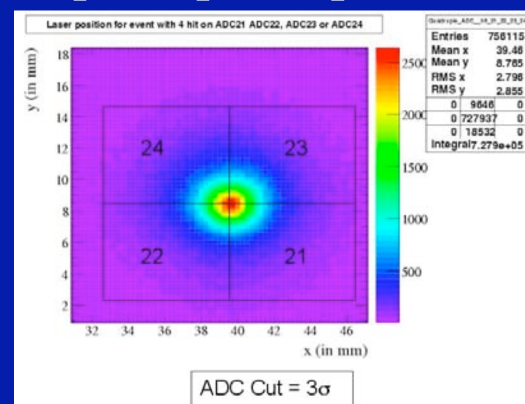
Require double ADC hit:



Require triple ADC hit:



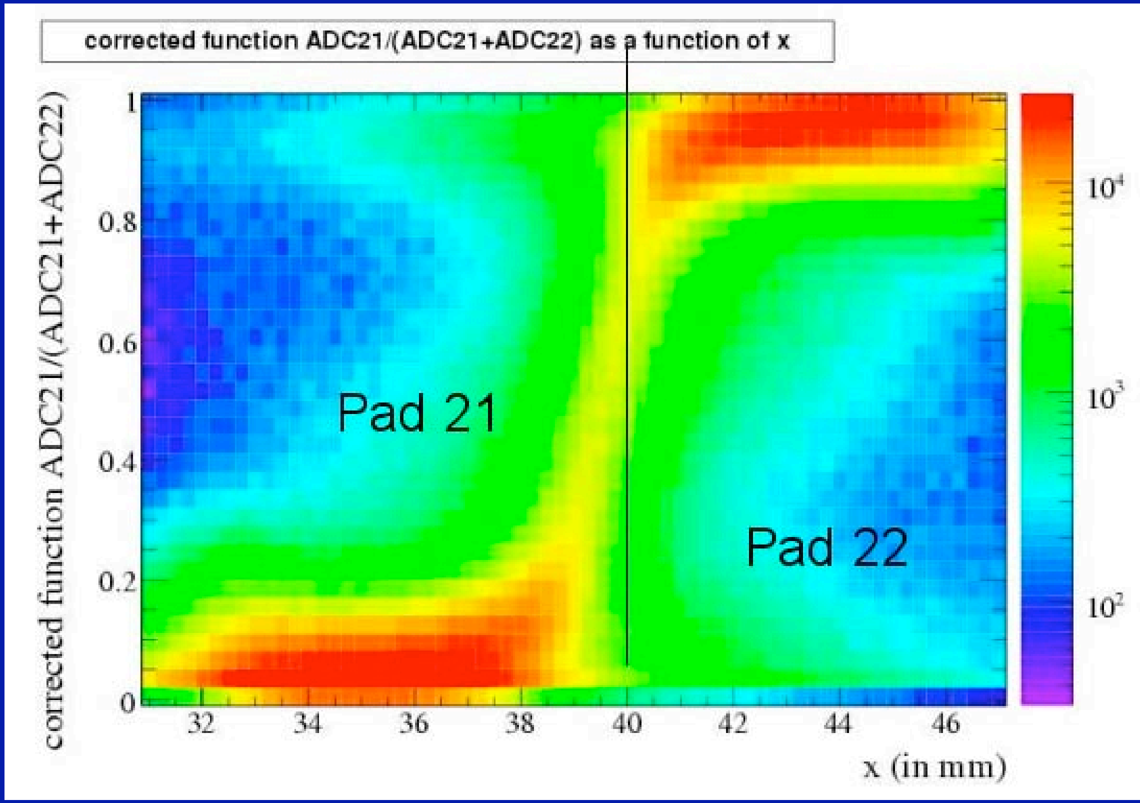
Require quadruple ADC hit:



- **The charge sharing clearly works for the MCP-PMT detector.**

Charge sharing study with Burle MCP-PMT

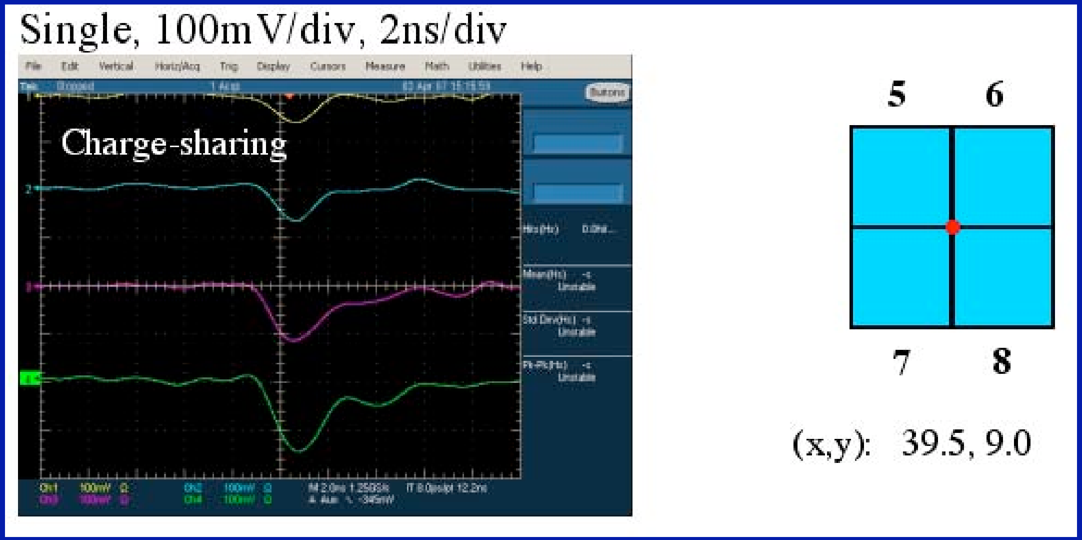
Mathiew, a student working for us for 3 months, SLAC scanning setup, FDIRC effort



- **The charge sharing can be used to interpolate over ±1.5mm from the pixel boundary in each direction.**

Can one see it by the scope ?

J.Va'vra

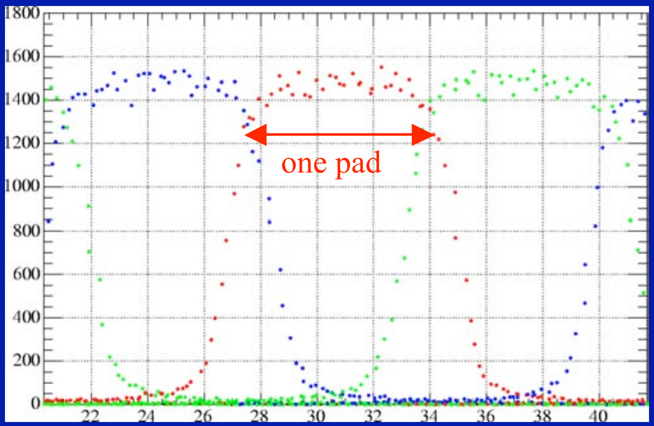


- **Place a scope on a boundary of 4 pads and see clearly four single pe pulses at the same time. By moving the laser position in small steps, one can make appropriate pulses to disappear.**
- **One can get clearly convinced by the scope that the charge division must work <u>with the MCP detector</u>.**

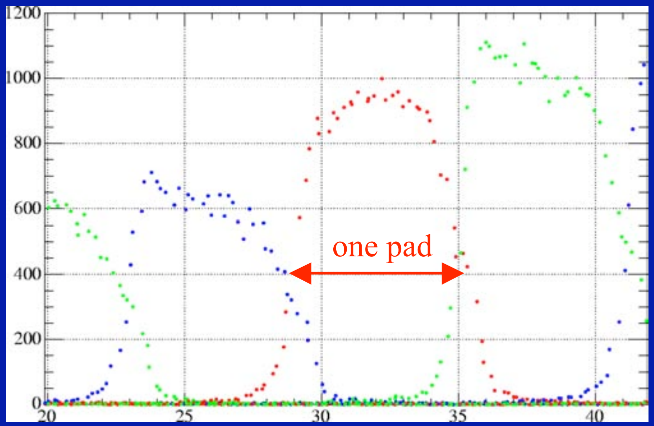
Early scans at SLAC

SLAC scanning setup, FDIRC effort

Burle MCP:



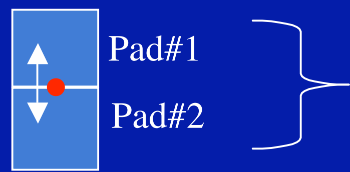
H-8500:



- **Burle MCP has clearly larger tails.**
- **H-8500 tube has, however, tails also.**
- **<u>This tail motivated me to believe that we should try to do charge sharing with H-8500. On the basis of this plot I asked French engineers to add an ADC into the electronics readout.</u>**
- **However, in retrospect I believe the H-8500 tail on this plot is due to large extent the light scatter in the lens optics.**

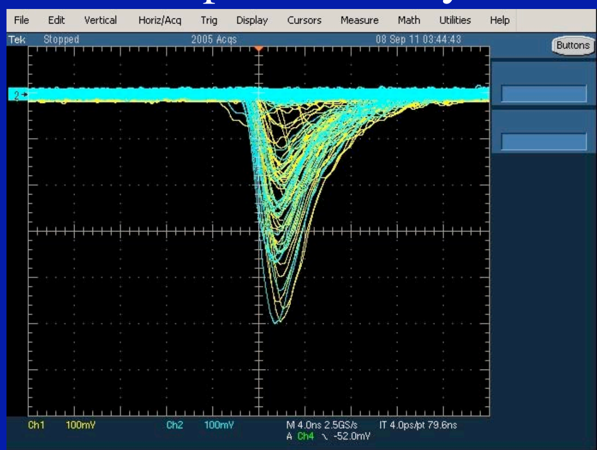
H-8500: Do I see the charge sharing with a scope ?

J.Va'vra, new SLAC scanning setup, new H-8500 tube

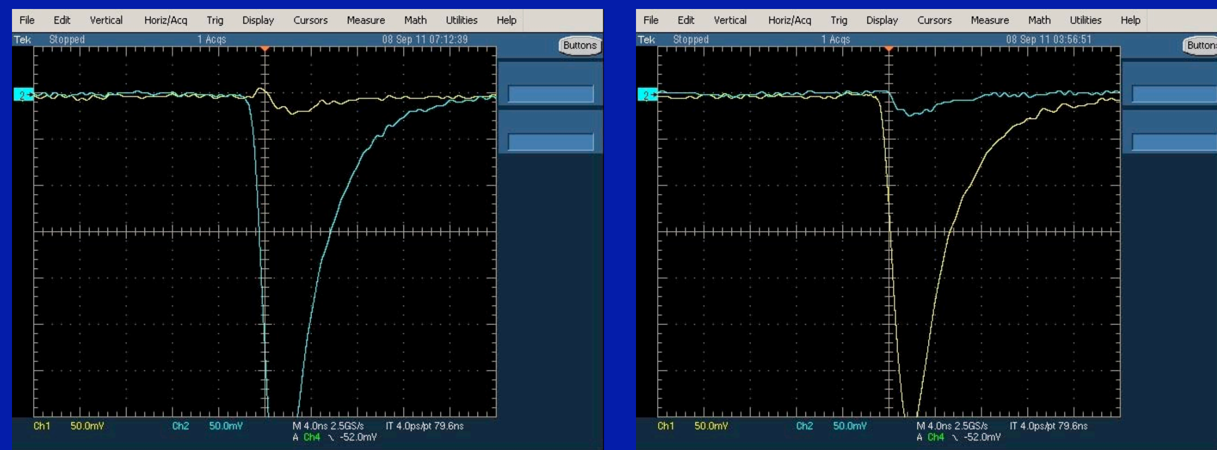


Maximum charge sharing position

Laser on pad boundary:



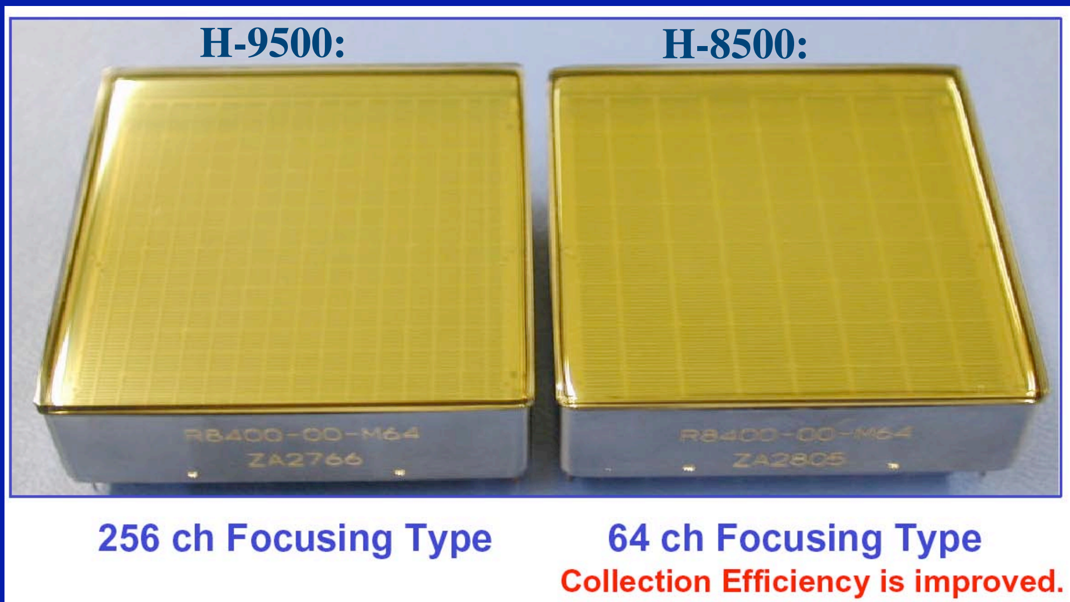
Single photoelectron pulses and corresponding cross-talk:



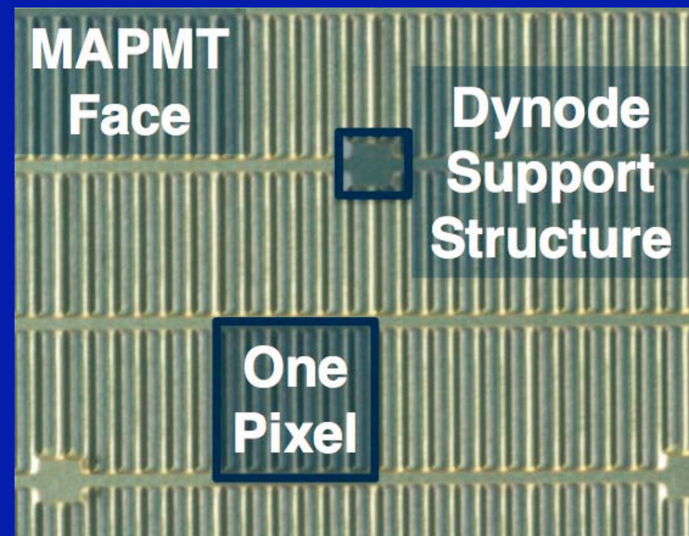
- **Set the probability of a hit to <<1%.**
- **Move the laser position in 200 micron steps, and search for a clear sign of charge sharing, which is to observe pulses on both pixels with two equal amplitudes. And then slowly explore the the charge sharing range.**
- **Instead, I always see a signal either on one pad or the other one.**
- **I conclude that if there is a charge sharing region, it is very small.**

What is the explanation ?: Electrode structure of MaPMTs

Hamamatsu Multi-anode PMTs:



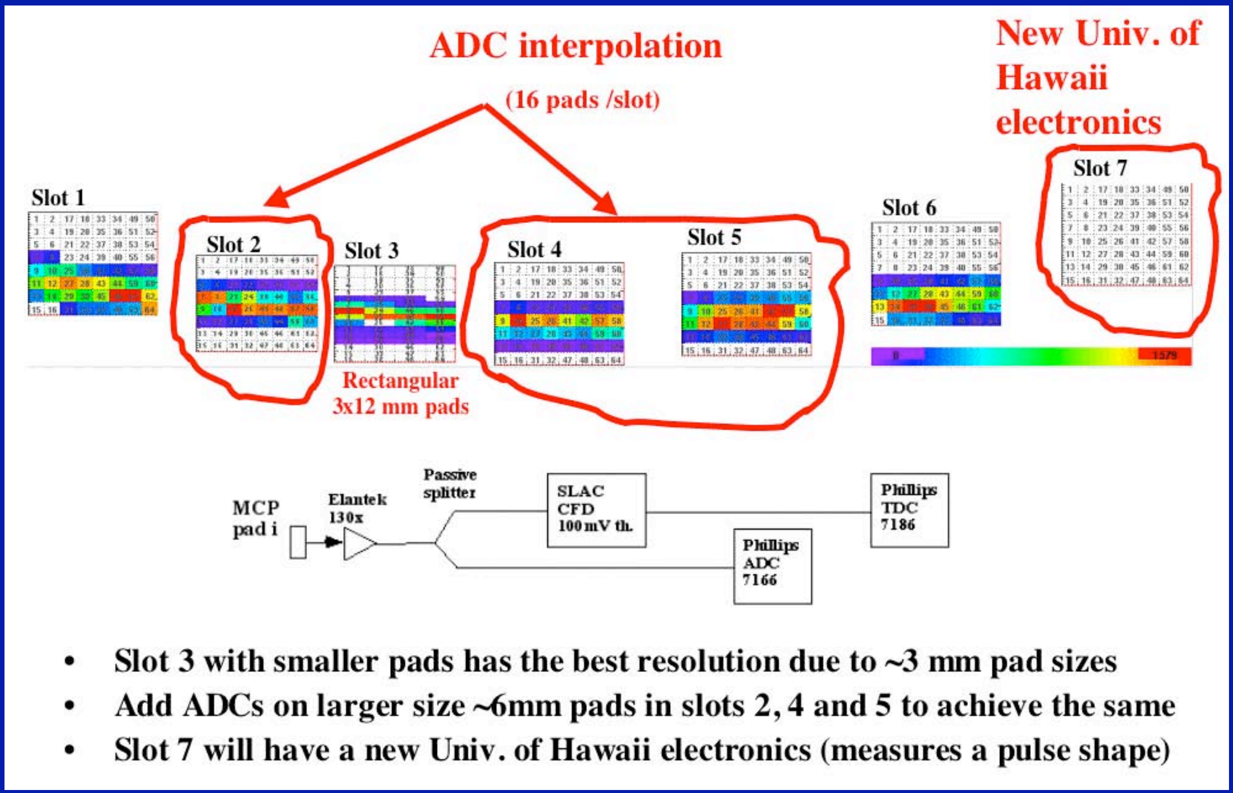
R. Montgomery’s IEEE poster:



- **Notice a little entrance electrode around each pad boundary. In my opinion, this deflects photoelectrons away from the pad boundary, which reduces the charge sharing.**

The 1-st FDIRC prototype in the ESA test beam

J. Va'vra



A simple ADC analysis:

If pads i&k are neighbors:
if ($ADC_i > 5$ && $ADC_k > 5$):
=> $\theta_c = [\theta_c(i) + \theta_c(k)]/2$

A simple cross-talk cut:

If pads i&k are neighbors:
if ($TDC_i > TDC_k$ &&
diff_TDC < 1ns):
=> kill a pad with TDC_k

- **The resolution with 3mm x 12mm pixels using H-9500 was clearly the best.**
- **The aim of this analysis was to see if a simple charge sharing would improve the Cherenkov angle resolution even for 6mm pixels.**

The 1-st FDIRC prototype in the ESA test beam

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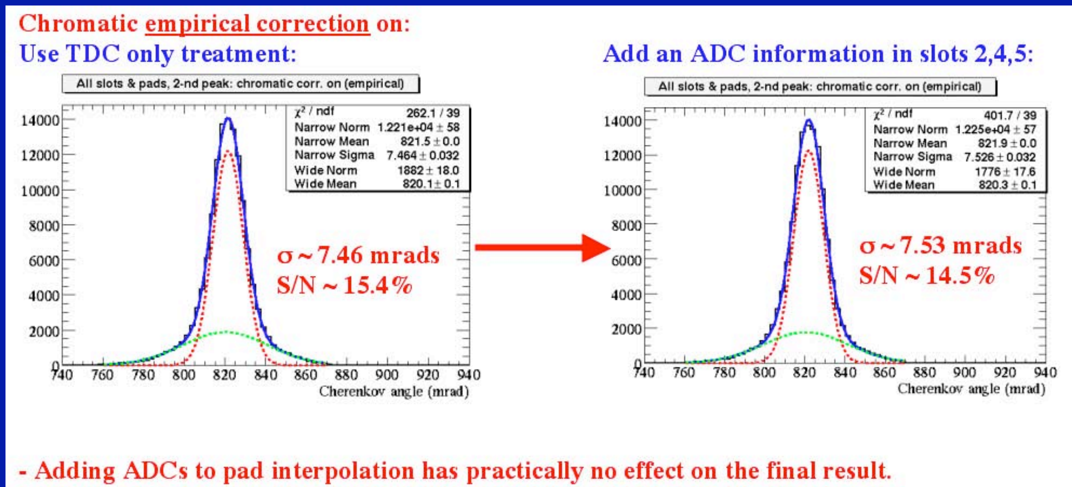

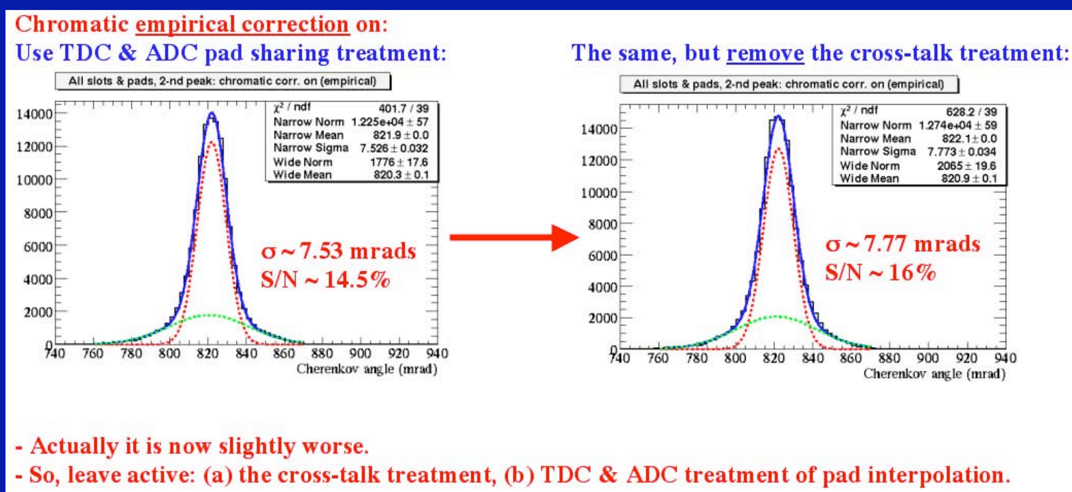

- **The overall effect of the ADC treatment of the pad charge sharing is small.**
- **If anything, then the cross-talk treatment helps a bit.**
- **Unfortunately, this is for all tubes involved, i.e., I did not do this analysis for a specific device (we had one H-8500 and two Burle MCPs).**
- **I have also contacted Joe Schwiening and Jose Benitez. Unfortunately, they did not do this particular analysis at that time.**

Conclusion

- After a lot of confusion on my part, I concluded that the H-8500 pixel interpolation using the charge sharing will not work. This is because of (a) small avalanche size in H-8500 and (b) the electrode design of H-8500.
- If we insist on better Cherenkov resolution, we sould switch to H-9500 tube, and use 3mm x 12 mm pixels. This was tried on the 1-st FDIRC prototype in the test beam and it worked very well.
- Doug was hinting this result in his 1-st scanning analysis.
- I contacted Hamamatsu about all this: no answer so far.