Request for Continuation of USCMS Support through 2015 Sebastian White- Aug. 5, 2015

The 2 primary CMS challenges of the HL-LHC are clearly 1) integrated dose to the detector and 2) significant (mu=140 or 200) pileup due to higher luminosity @40 MHz.

My primary activity for the past few years (and particularly on CMS starting with a mandate from Joel Butler since 2013) has been to develop tools for pileup mitigation using fast timing.

People who attended the June LHCC meeting are aware that Kevin Einsweiler presented his ATLAS Timing Task Force's conclusion that the approach usually discussed by CMS – ie tagging a few physics objects in an endcap- is not interesting. I agree fully with Kevin's conclusion- particularly since the usual discussion without knowledge of t0 is essentially useless.

If allowed to continue, I can deliver to US-CMS a realistic, demonstrated detector technology (actually likely 2) by the end of the year. With this technology I will also work with CMS collaborators at Princeton and FNAL to introduce a GEANT model (we already did this once for the endcap with Sunanda) and try to make a comprehensive evaluation of the benefit of timing to CMS in HL-LHC.

<u>What I am requesting:</u>

I was supported by US-CMS to put this effort together until end of 2014. Sergio Bertolucci, CERN Research Director, partially picked up the slack by supporting me (at the standard CERN subsistence level) through the end of July 2015 (to work in the RD50 &RD51 CERN groups). In the meantime I joined the Princeton CMS group at CERN but we are still in the process of putting together my financial support through a mix

of neuroscience and HEP funding. The Princeton CMS R&D budget is, at the moment, severely strained, as you must be aware.

I request that USCMS resume my support at the level of 2014 until the end of this calendar year (I could forward you the appointment letter of then acting FNAL Director, Jack Anderson). I am certain to bring both the sensor development and physics simulation to a critical milestone by then.

High level view of Physics Benefit

I was active, working with Chris Tully, Sunanda and Umesh in getting a MIP sensitive timing layer into the endcap model. Chris has shown some results at CMS meetings.

We now see urgency in putting together a hermetic model of timing in order to finally make significant progress on the evaluation of the physics benefit. This has been presented in the Fast Timing Simulation meetings (chaired by Chris and de Fatis). De Fatis presented part of this and one of my plots (below) at a CMS plenary this month.

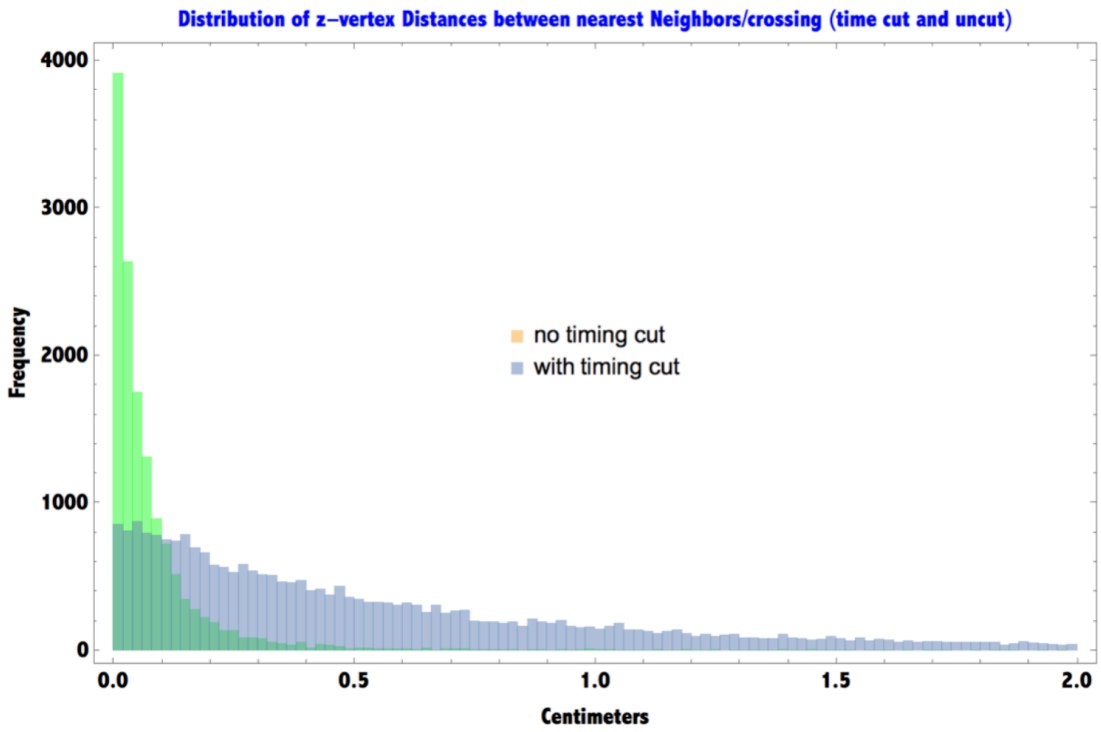
With this comprehensive view of CMS timing we will be able to understand what is the minimum coverage required vs. physics benefit. We are mindful of the cost impact and could provide details. Our current, successful, Si sensor is already down to an interesting $\$8/cm^2$ cost level and we are comfortable with projecting cost impact to CMS.

My work (as in the example below) has always been in LHC modeling- rather than full CMS detector. But, with the support of enthusiasts like Joel, Lindsey Gray, Umesh, Chris and others , we will certainly be able to get a high level conclusion out within 2015.

I think the role of a t0 measurement needs no explanation (see http://arxiv.org/abs/1409.1165).

But it is critical to understand that, once you have reasonable (eta extent is something our modeling will answer) MIP sensitive timing coverage, the payoffs are enormous.

Here is a simple example from a calculation of mine presented at the CMS plenary:



A MIP layer performance consistent with either our RD51 detector or our Hyperfast Silicon will obviously greatly reduce the vertex merging issues in CMS.

But perhaps a more pressing question is how much "physics object tagging" done by this (MIP-sensitive) layer alone fulfills the pileup mitigation needs. It is good that CMS continues to look into potential timing of the calorimeters. But before CMS considers investing in very expensive 6 Million channels of timing for HGCAL, for example, it would be good to have an overview of the relative benefit. There may be no significant additional benefit. It would be good if US-CMS can reach this conclusion before ATLAS points it out to us publicly.

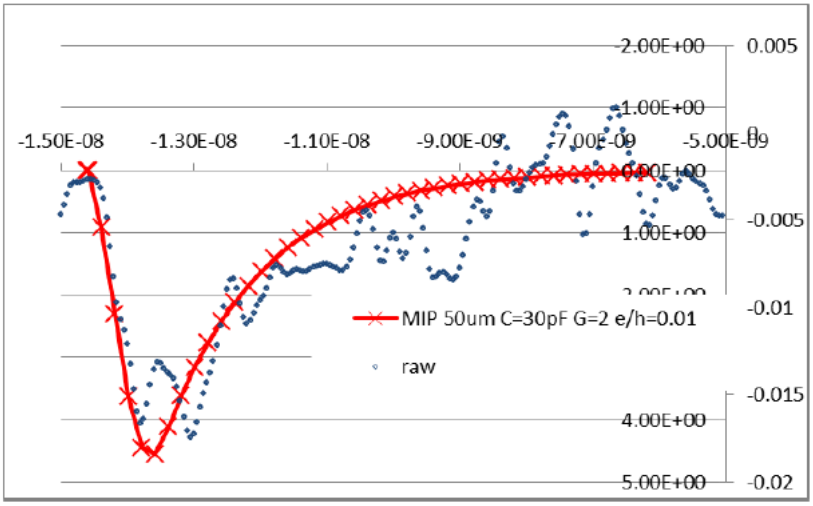
There is nothing else out there

I originally received support under the DOE Advanced Detector R&D Program, then from FNAL/Joel, then from Sergio because there is nothing else out there.

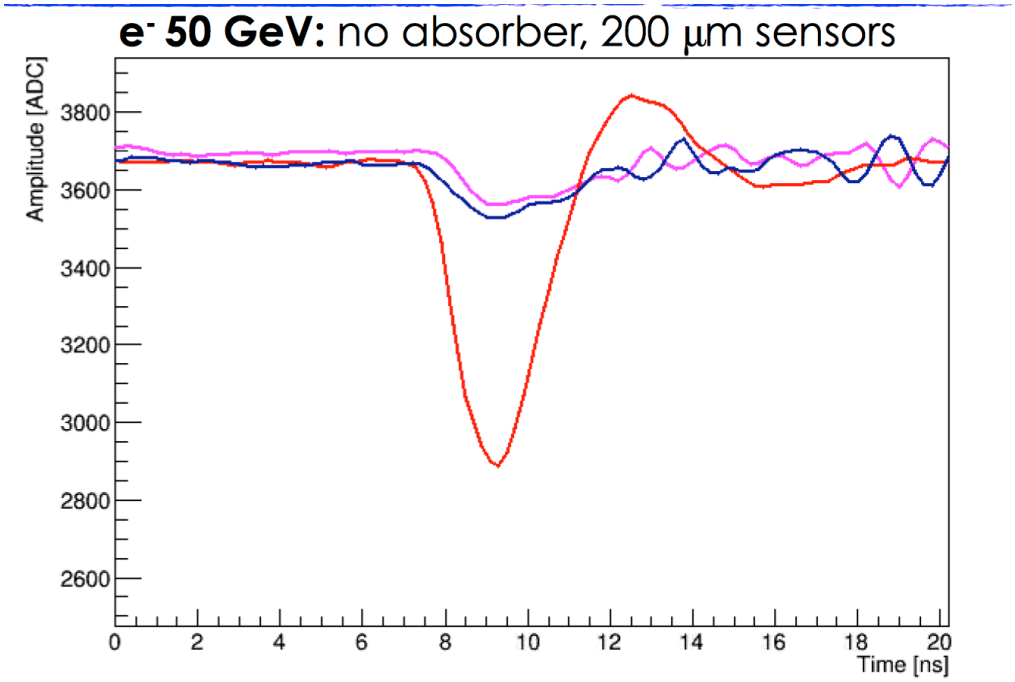
To illustrate this I show below typical scope traces from our Silicon telescope in this week's PS run at T10 and compare with those from the 2 other silicon technologies sometimes discussed in CMS (LGAD (aka UFSD) and HGCAL sensors). It doesn't take a rocket scientist to anticipate that our performance is vastly superior (as we, in fact, find).

I have been very close to the LGAD project, (which is getting a lot of attention from Abe Seiden for ATLAS) since I work with the RD50 group. I could go into the many technical hurdles they face, but won't. Instead it is worth pointing out that theirs is fundamentally a pixel sensor project (50 micron/pixel).

If CMS cares at all about budget constraints it would be easy to argue against investing in > 10^4 times as many channels as are needed for the job. Bad idea!



Above is an LGAD waveform presented by Hartmut Sadrozinski at the RD50 meeting in Santander this summer.

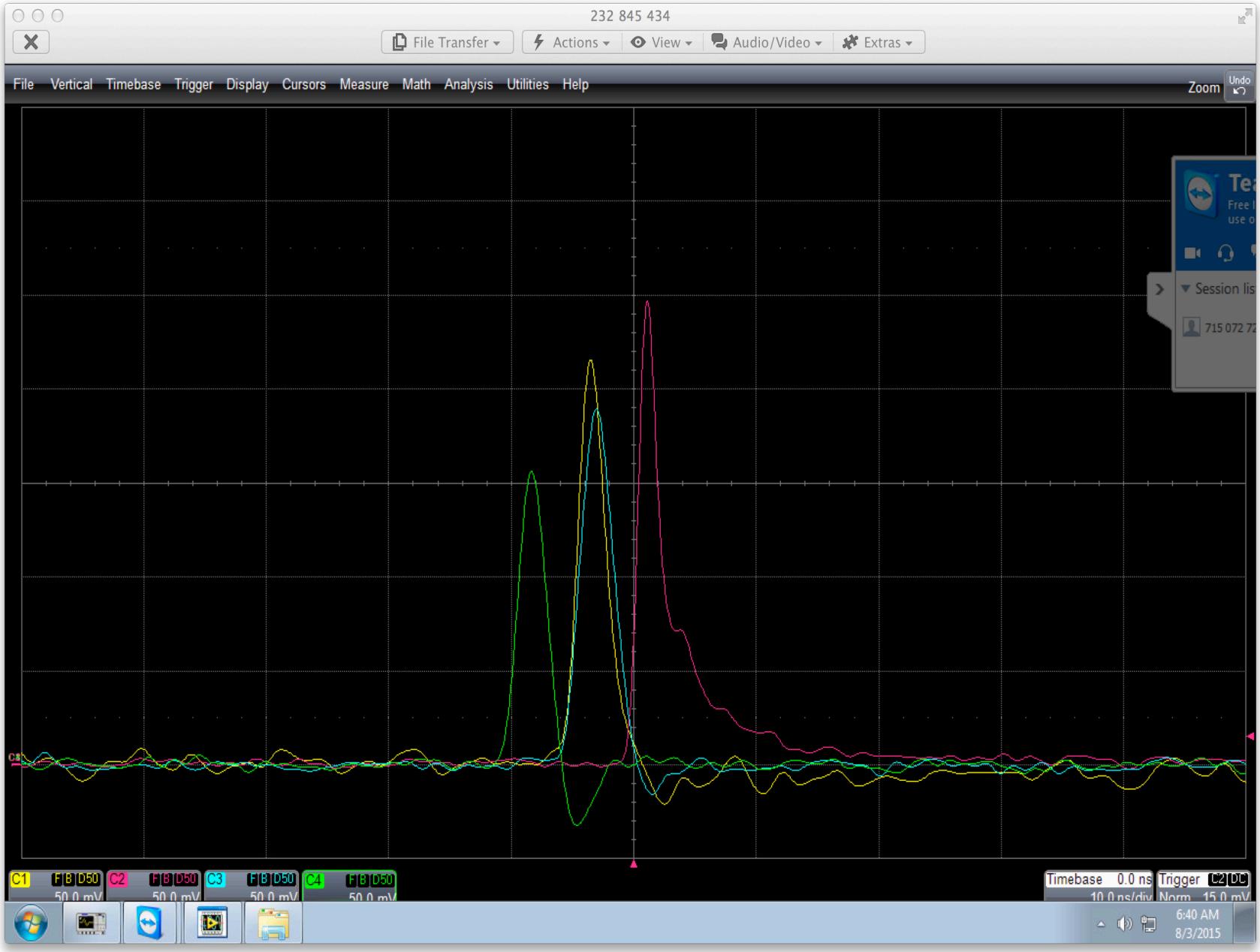


Above is a scope trace of HGC sensors for 1 MIP (not the nice trigger pulse but the 2 little pulses) from H2 this past month.

Below is a scope trace from our most recent run this week in the PS T10 testbeam from our 4 Si sensor telescope. Note the 10ns/div scale. Ch.2-4 use state-of the-art FEE we have been using with Erich Griesmayer(CIVIDEC) for the past few years. Ch.1 is the "new kid on the block" -a high bandwidth Si-Ge transimpedence amplifier we developed with our collaborator Mitch Newcomer and ~15k$ out of our extremely limited US-CMS R&D support.

See also a recent DESY talk I gave, which includes also our RD51 work:

http://instrumentationseminar.desy.de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