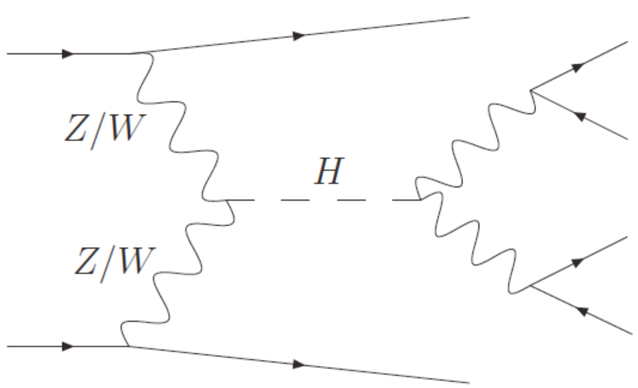
Role of timing in Pileup Mitigation at Hi-Lumi LHC

Emphasis on ie VBF Higgs production or WW scattering in future program of LHC is complicated by high event pileup.

In these examples (often forward) jets must be associated with observed Higgs or W candidates.

In the forward region associating jets with the right candidate is difficult using track vertexing. The complimentary time domain(event time) would be useful if $t_{resolution} << t_{bunch\ crossing}$ (~200 picosec).

Developments in high rate picosec photosensors and trackers would be useful.



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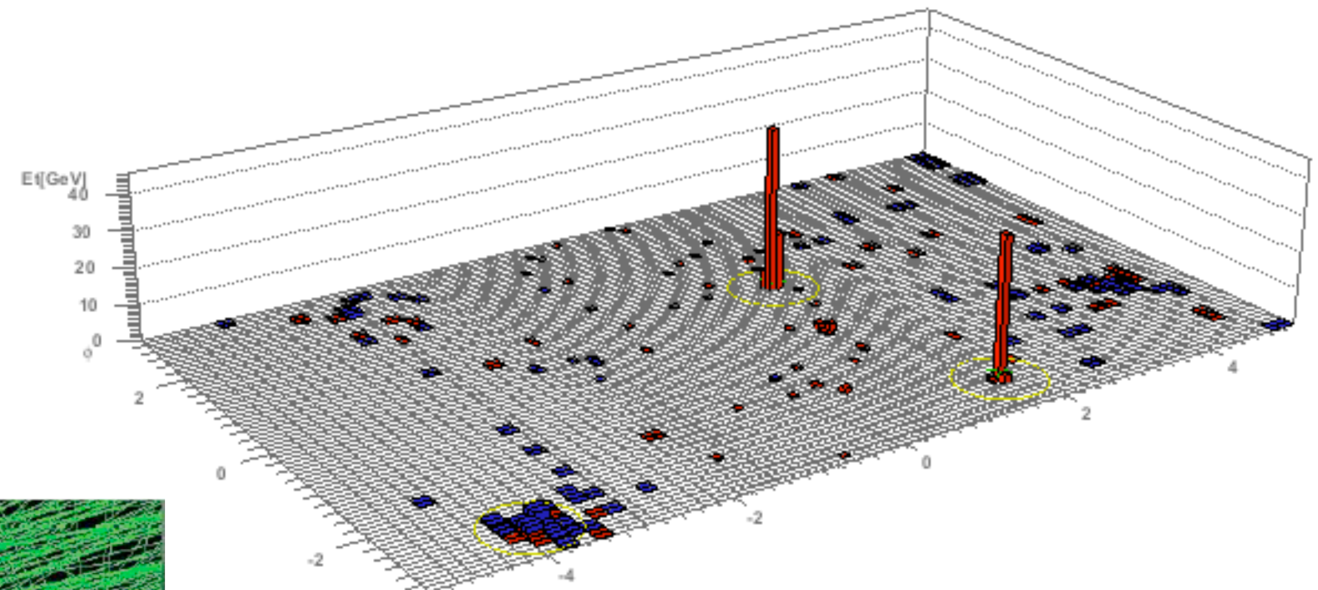
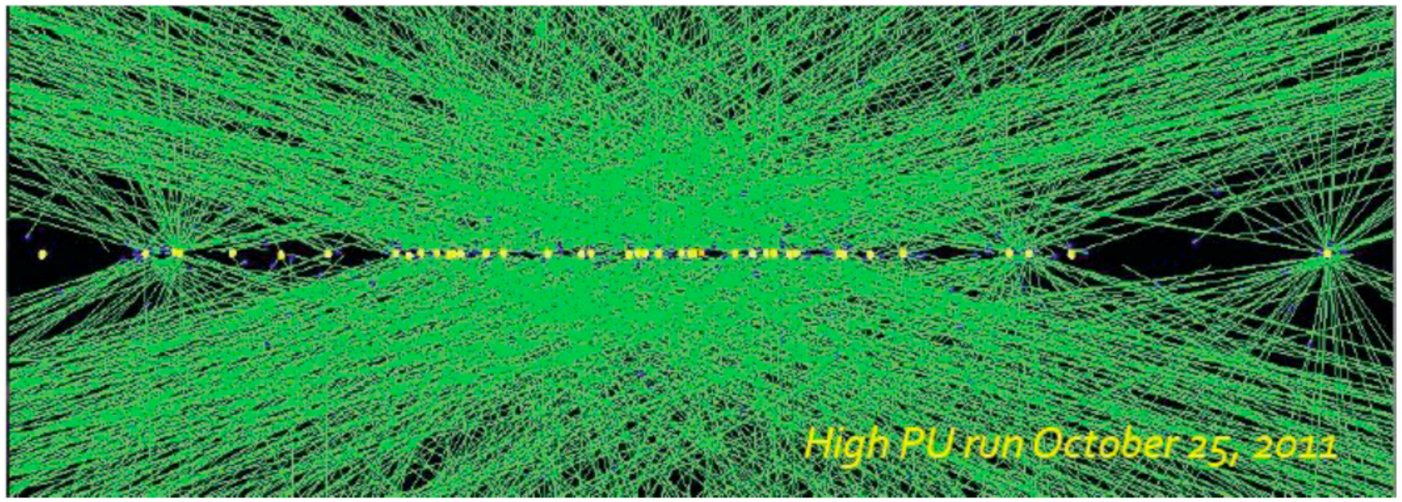




in above Higgs->2 gamma and proton jet fragments observed very forward region

How to associate them with proper vertex when pileup prese
Timing may provide a key tool.

many vertices in hi-PU event even today

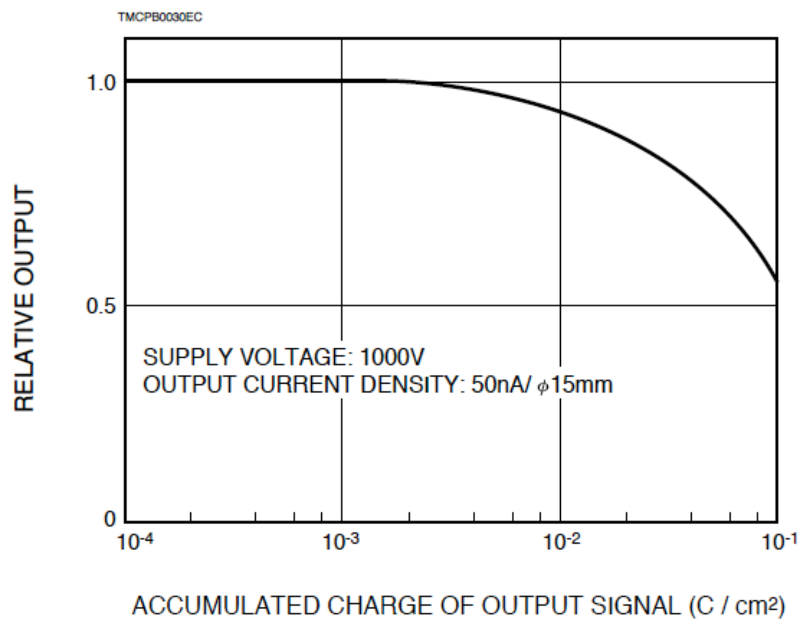
Work in CMS forward calorimeter task force and DOE AD R&D: K. McDonald & S. White- co-PI's

Photosensors

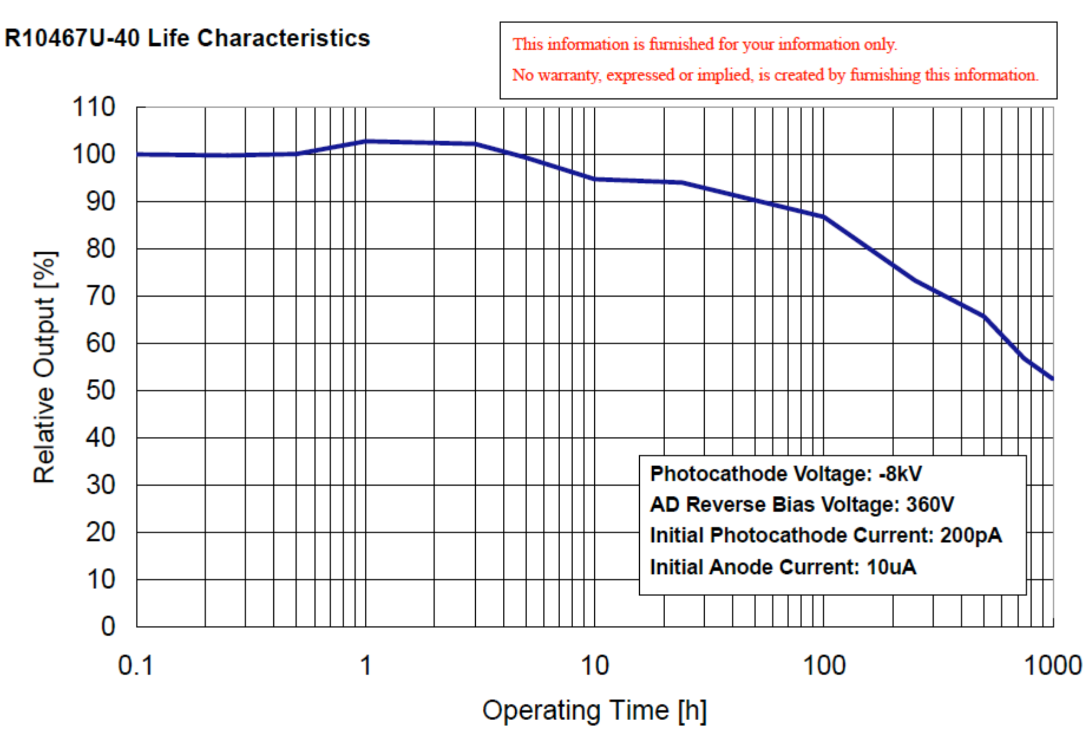
lifetime is an issue in MCP-PMT

compare Hamamatsu data on:

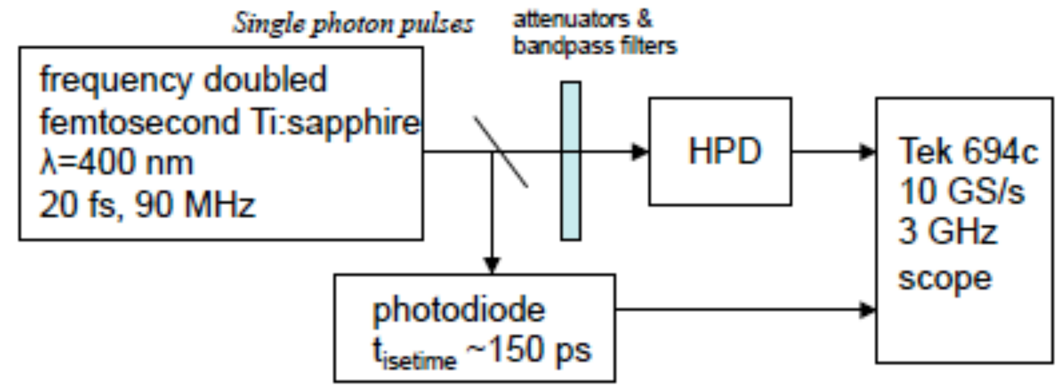
MCP · Life



compared to new technology evaluated by our collaboration:

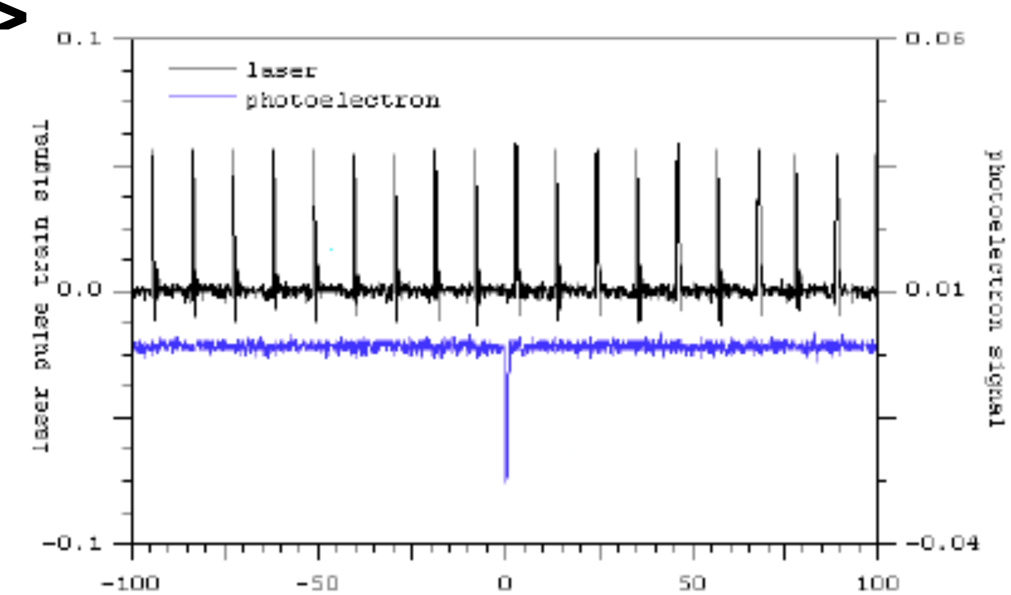


our measured single photon time response:

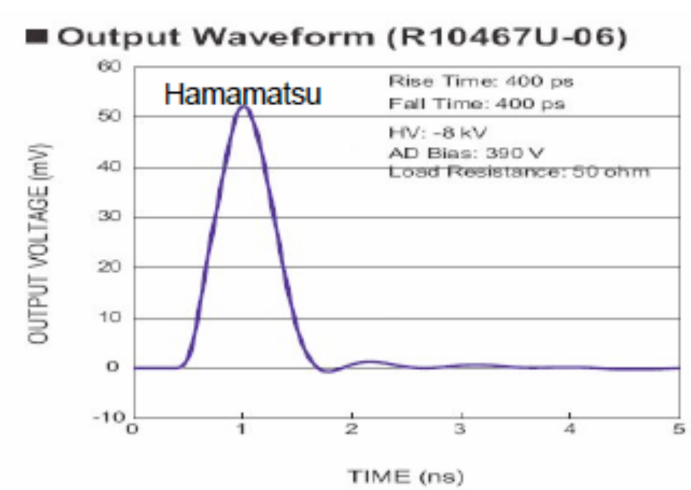


Ti:sapphire oscillator:
attenuate to
95 femtoWatt
~200 kHz count rate
~2x10^5 photons/sec
(<0.002 photon/pulse)

=>

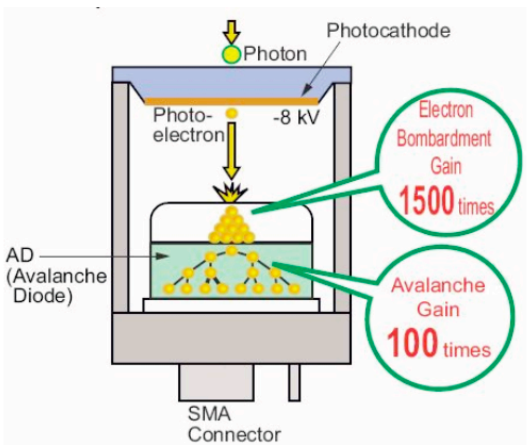


Measured jitter relative to photodiode=11 picosec!!



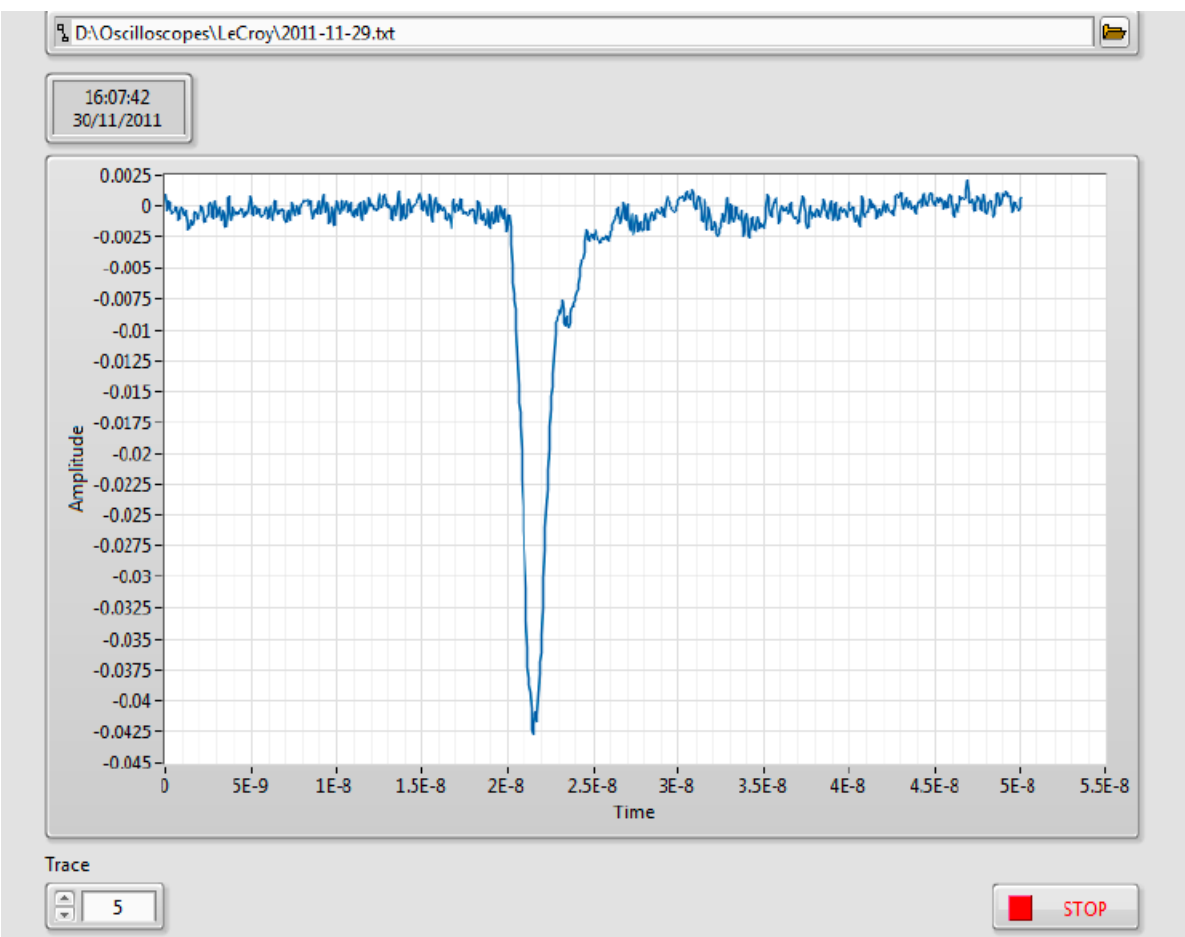
Conservatively factor of 360 improvement (MCP->HAPD) !!!

Picosecond Charged particle tracking:

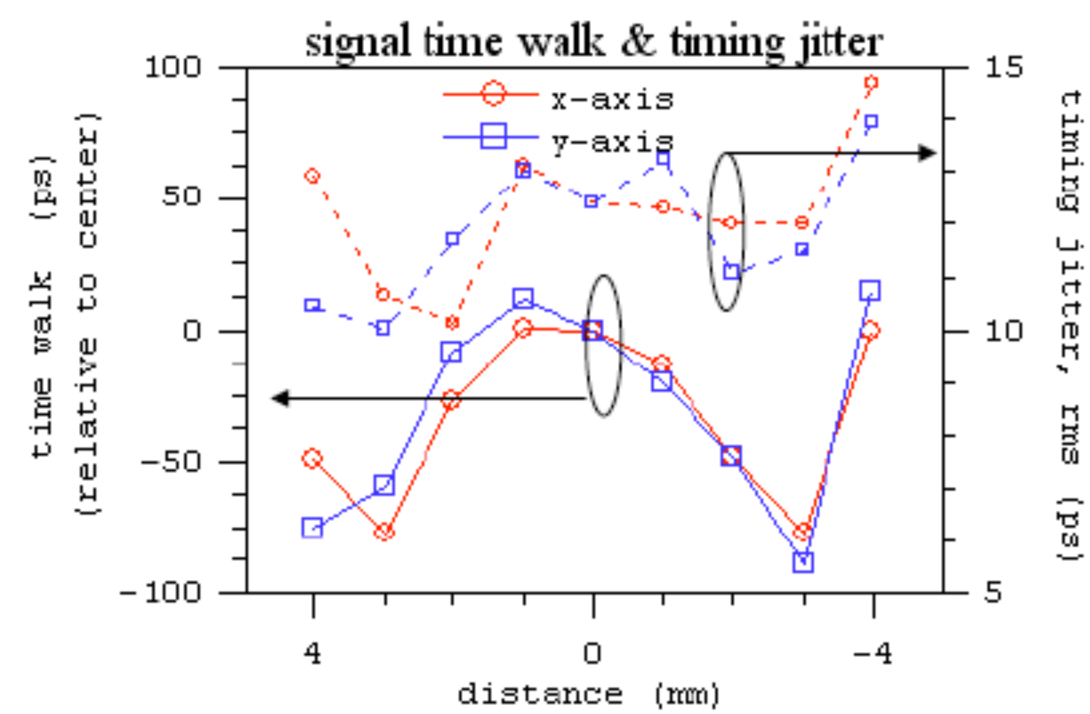


Hybrid APD (results on previous slide) is an accelerator followed by APD used as charged particle detector. Since it yields 11 picosec jitter why not use APDs as direct charged particle detector?

Initial beamtests with deep-depleted APD's @ ATF, LNF, PSI yield high SNR & 600 picosec t_{rise} but poor uniformity. Improved with better metalization of APD.



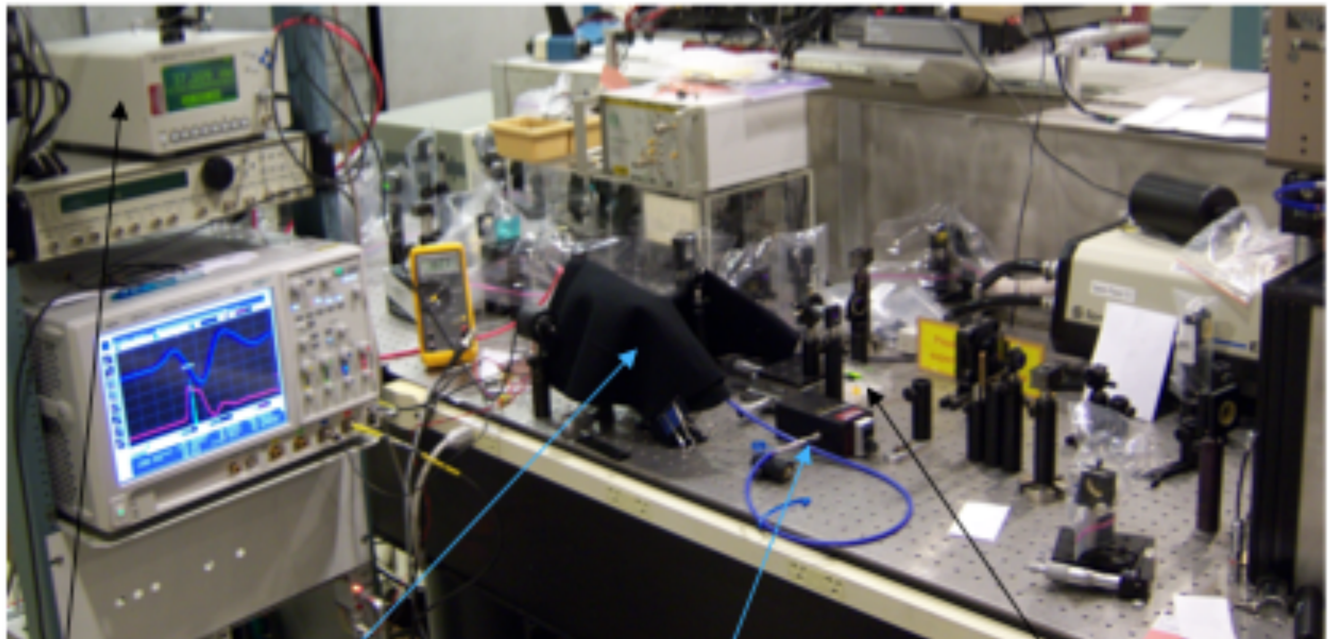
in this figure noise level dominated by scope noise floor

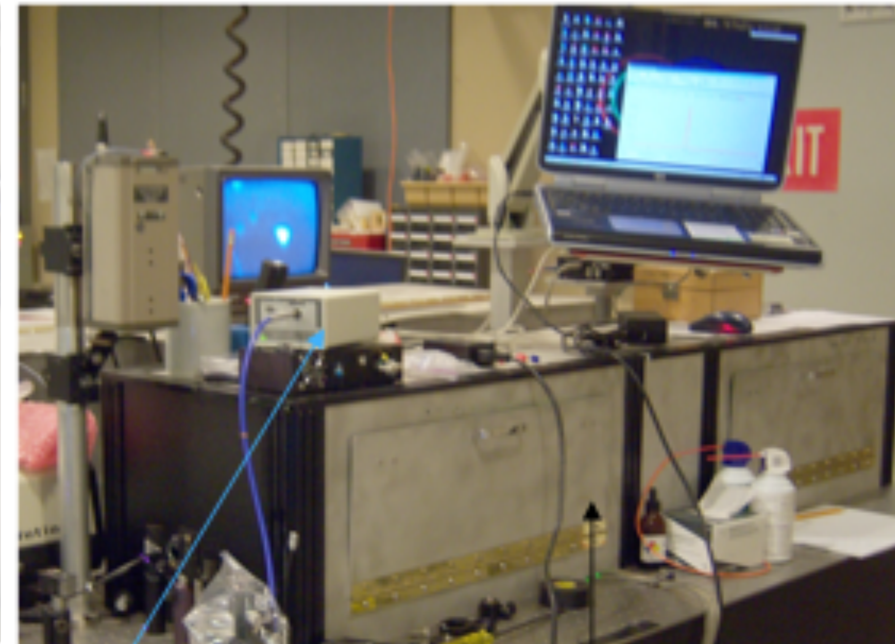


intermediate results with early metalization improvement

Experimental set-up for femtosecond laser tests

use 1000 nm laser to mimic MIP





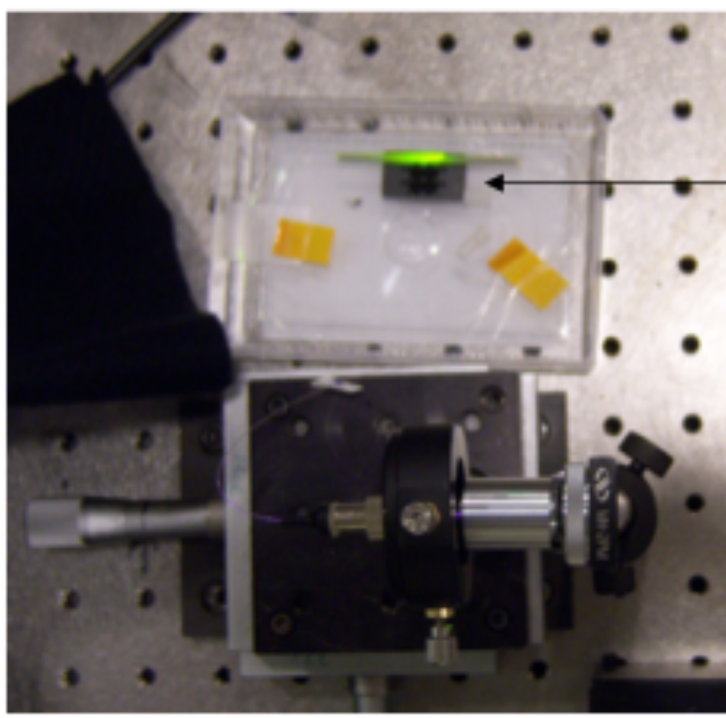
optical power meter

RMD APD

monochromator for IR wavelength selection

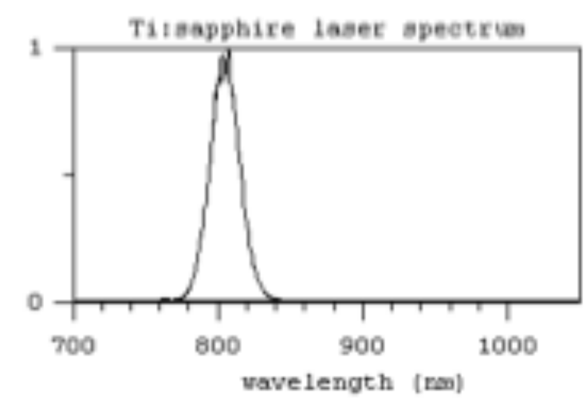
IR spectrometer

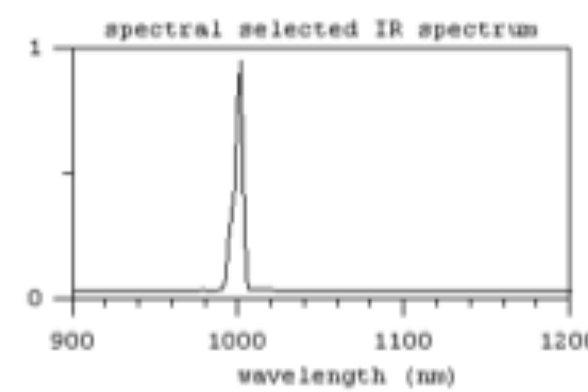
Femtosecond Ti:sapphire laser oscillator



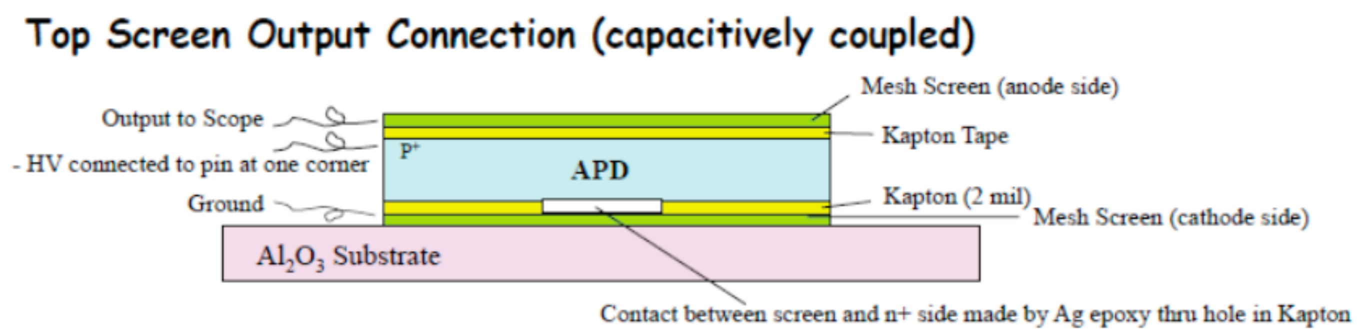
white light supercontinuum generation from photonic crystal fiber

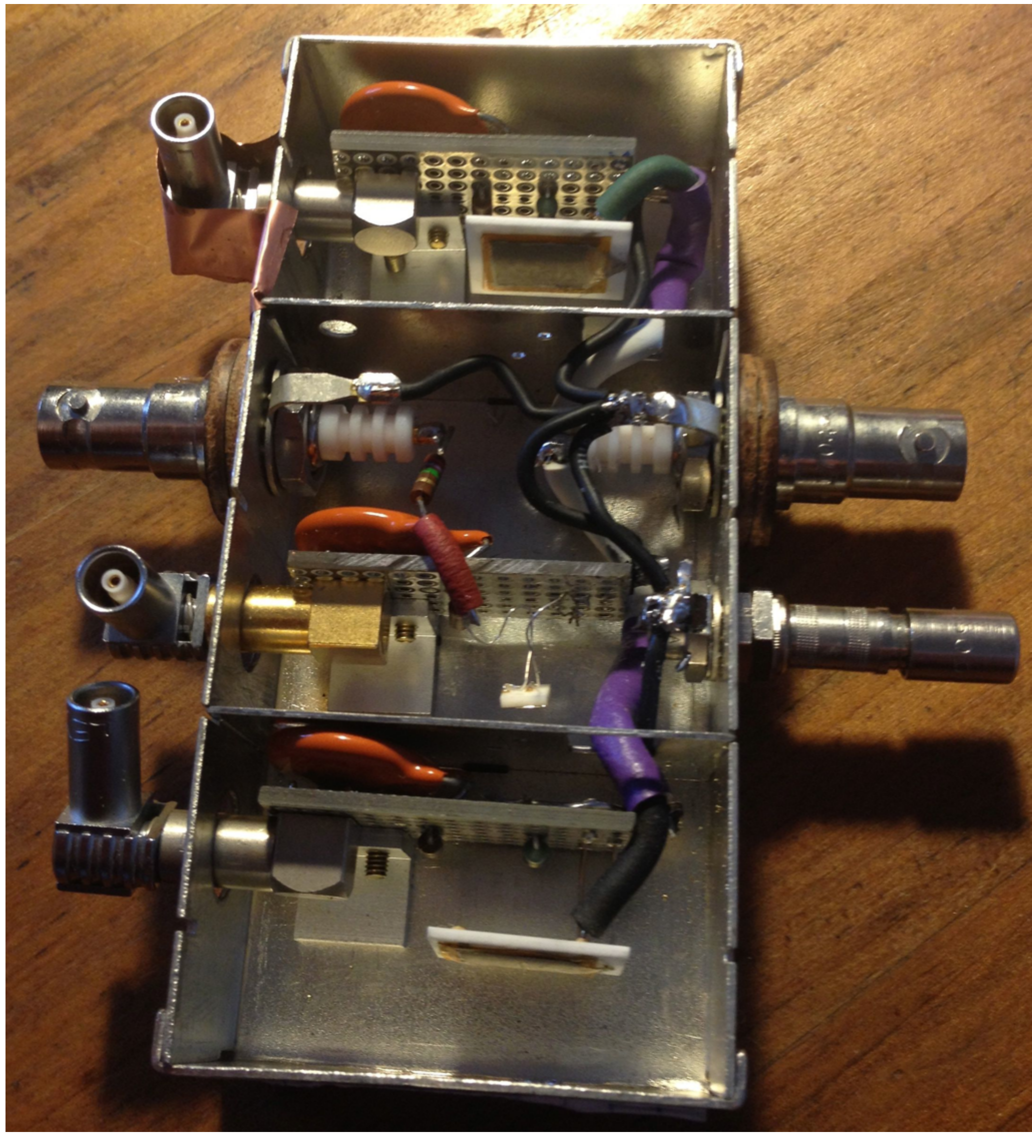
send IR beam directly from φ=0.6 mm optical fiber directly onto the APD both separated by <5 mm.





Deep Depleted APD with MicroMegas mesh for field shaping





"telescope" for Jan-Feb 2013 beam test at SPS.=>
Since characterization with laser (intensity and wavelength to match MIP charge deposition) now shows good uniformity, initial run planned without need of external tracking device.

Rad hardness and lifetime:

Initial studies based on CMS APD scaling laws showed several years at 10^7 Hz/cm^2. (http://arxiv.org/abs/0901.2530)
In December 2012 completed initial rad damage tests at PS. Results soon.