HCAL Upgrade Workshop Summary

- Very successful workshop
- ~ 30 people attended the sessions
- Covered
  - near term problems in detector
  - Strawmen proposals for HB/HE/HF/HO
  - SIPM status
  - Back end readout (synergy with ECAL/RCT/GCT?)
  - Discussion with muon team on MTT joint proposal
  - Brief discussions of Phase II upgrades
- Developed plan of action of next months

Talks Day 1

Wednesday 19 November 2008

top

14:00	Intro/Goals for Front End (10') (Slides)	Jim Freeman
14:10	HB/HE Strawman Design (30') (Slides)	Chris Tully
14:40	HO Strawman Immediate, Phase I, Phase II (20') (Slides)	Jim Freeman
15:00	HF Problem, near term solutions (10') (Slides ; more information)	Yasar Onel
15:10	SIPMs: Specifications for HB/HE, HO (10') (Slides)	Jim Rohlf
15:20	SIPMs: CERN Team Report (20')	Arjan Heering
15:40	SIPMs: Italy Team Report (10') (Slides)	Aldo Penzo
15:50	BREAK (20')	
16:10	Overview of Back End Issues (15') (Slides)	Drew Baden
16:25	Joint ECAL/HCAL Back-end Architecture Possibilities (25') (Slides)	Jeremy Mans
16:50	DCC/DAQ Issues (25') (Slides)	Eric Hazen
17:15	Implications on XDaq, ethernet vx CAEN (25') (Slides)	John Jones
17:40	Directed Discussion: Back End (30')	Drew Baden

Talks Day 2

Thursday 20 November 2008

top

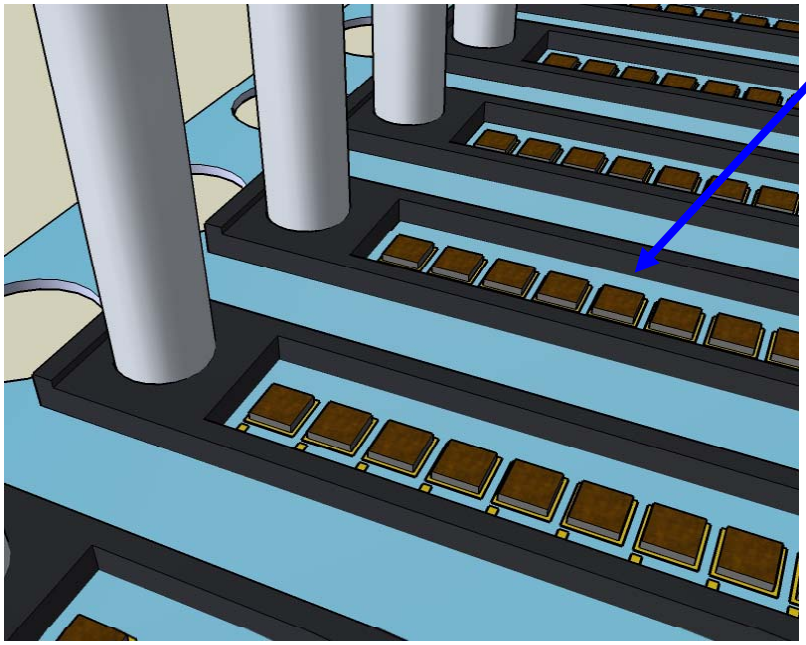
08:45	Rad Hard FPGA (15') (Slides)	Tulio Grassi
09:00	FE Electronics: New QIE (15') (Slides)	Julie Whitmore
09:15	FE Electronics: GOL Replacement (15') (Slides)	Julie Whitmore
09:30	Front End: RBX Cooling (10') (Slides)	Ianos Schmidt
09:40	FE Electronics: TDC and Clocking (15') (Slides)	John Jones
09:55	Simulation Progress (15') (Slides)	Shuichi Kunori
10:10	Phase II : HE Upgrade (15') (Slides) Rad damage, Quartz plate, GEMs, ...	Yasar Onel
10:25	Phase II : HF Replacement? (20') (Slides)	Aldo Penzo
10:45	Phase II: MTT (15') (Slides)	Alessandro Montanari
11:00	BREAK (20')	
11:20	Directed Discussion: HO short and long term upgrades (30') Design, schedule, resources, DCS	Jim Freeman (moderator)
11:50	Directed Discussion: HF short term upgrade (30')	Aldo Penzo, moderator
12:20	LUNCH (40')	
13:00	Directed Discussion: HB/HE Phase I Strawman Planning (2h00')	

Phase I Upgrade (SIPMs)

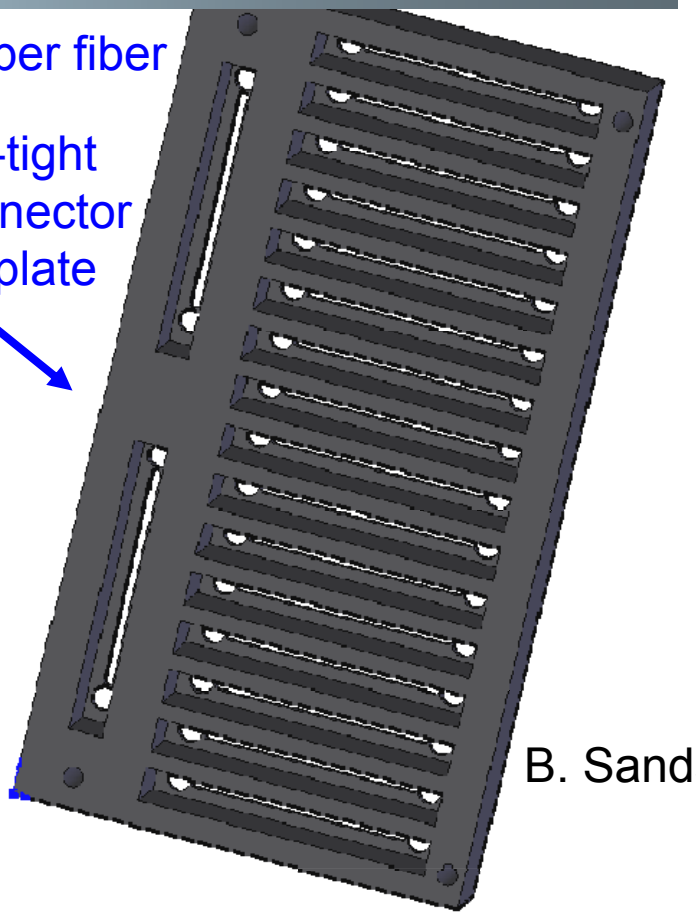
- Major concept is replacement of HPDs with SIPMs
  - Work well in B field
  - Much higher gain and QE → less noise, can split signal for TDC
  - Operates at ~50V (not 8KV)
  - Geometry allows new segmentation possibilities

Replace HPDs with SIPMs. Allows arbitrary segmentation

Proposed by Arjan Heering and Sergey Los



P. Rubinov



B. Sands

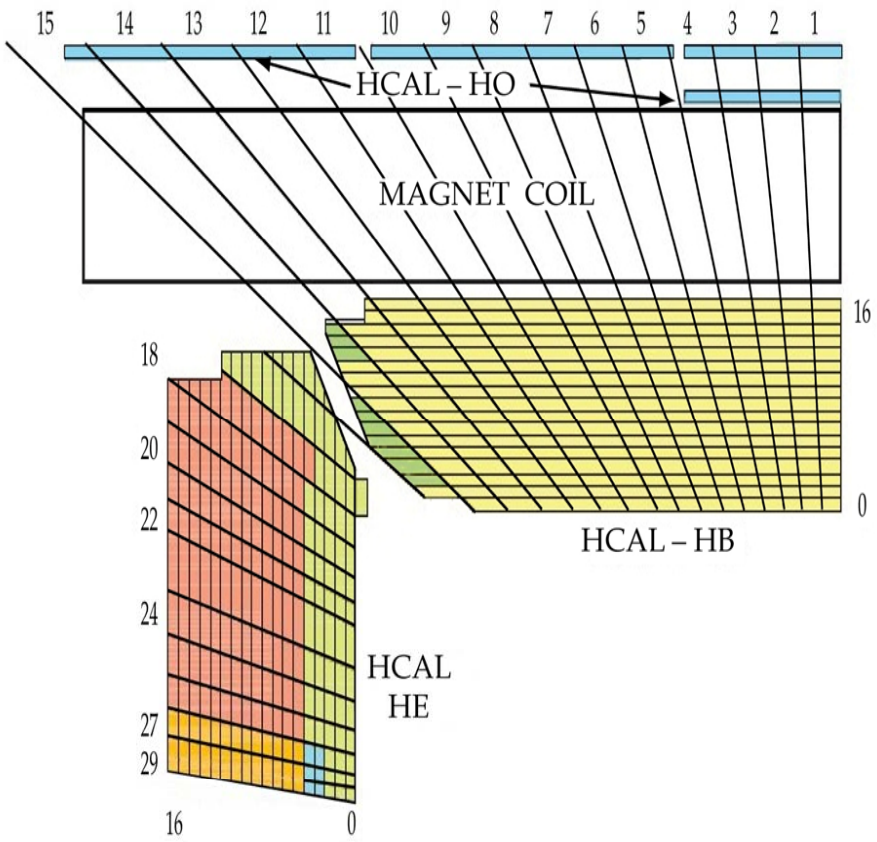
Basic Concept

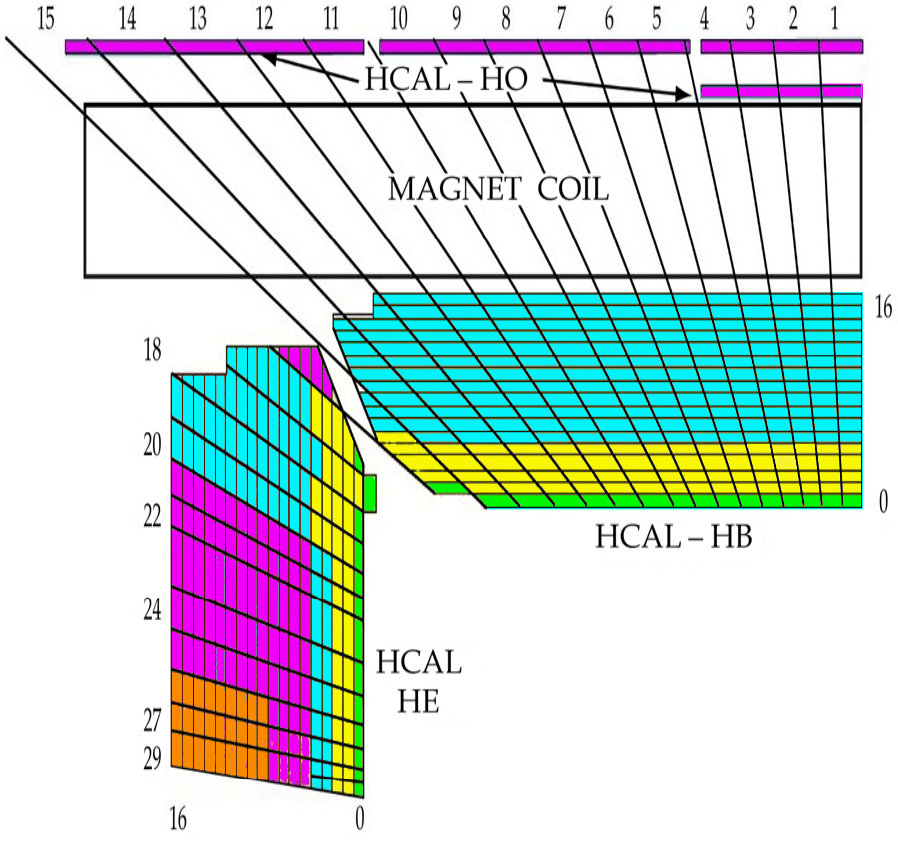
- **Do Optical/Electrical Conversion at the Megatile Connector**
- **1 SiPMs (1mm^2) per fiber**
- **Perform Analog Addition to form (segmented) towers**

HB Long. Segmentation

18 Channel RMs

48 Channel HB RMs
32 Channel HE RMs

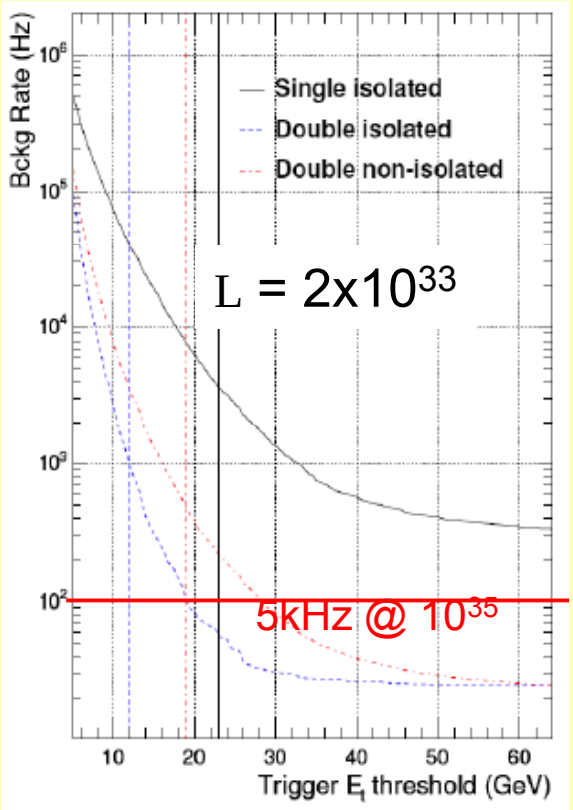


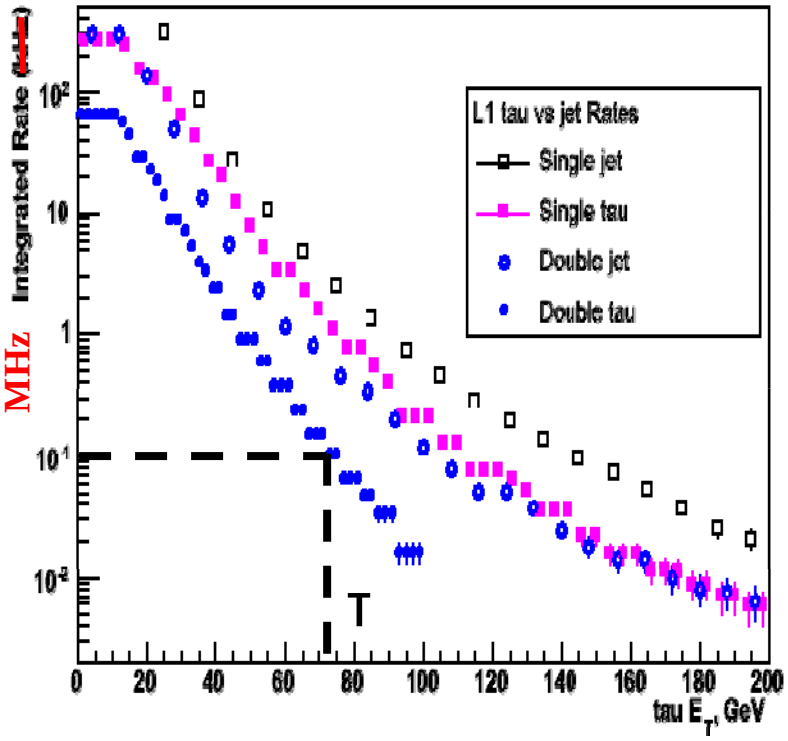


Need for Improved Lepton Isolation at L1 trigger @ 10^{35}

Single electron trigger rate

Isolation criteria are insufficient to reduce rate at L = 10^{35} $cm^{-2}.s^{-1}$





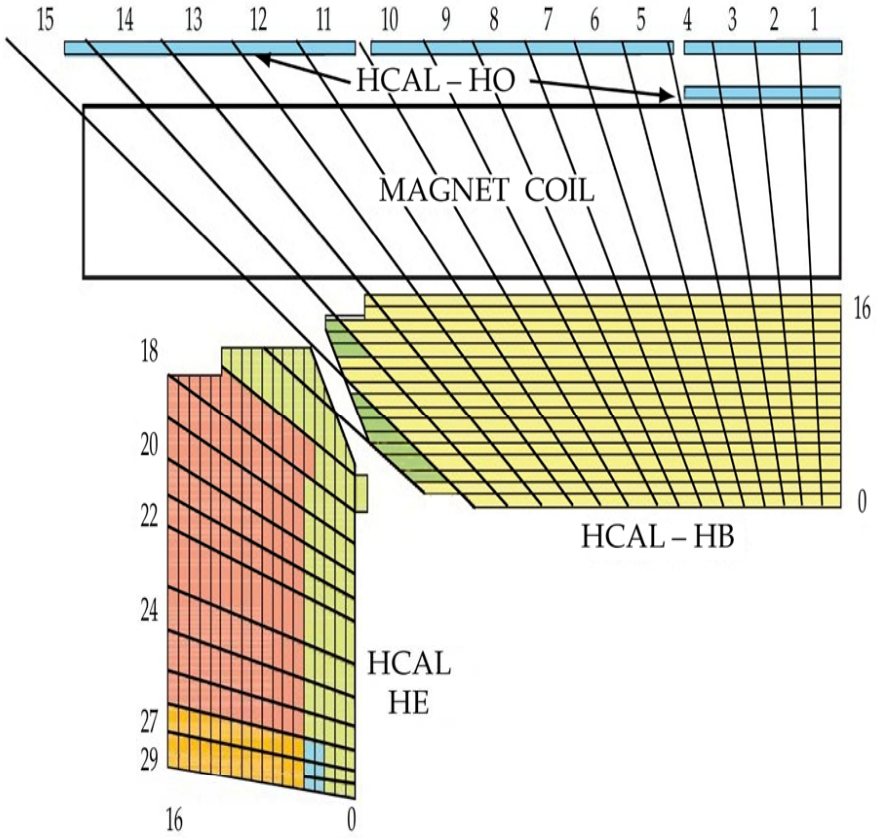
Removing Layer 0 from HCAL

Isolation cone improves rejection

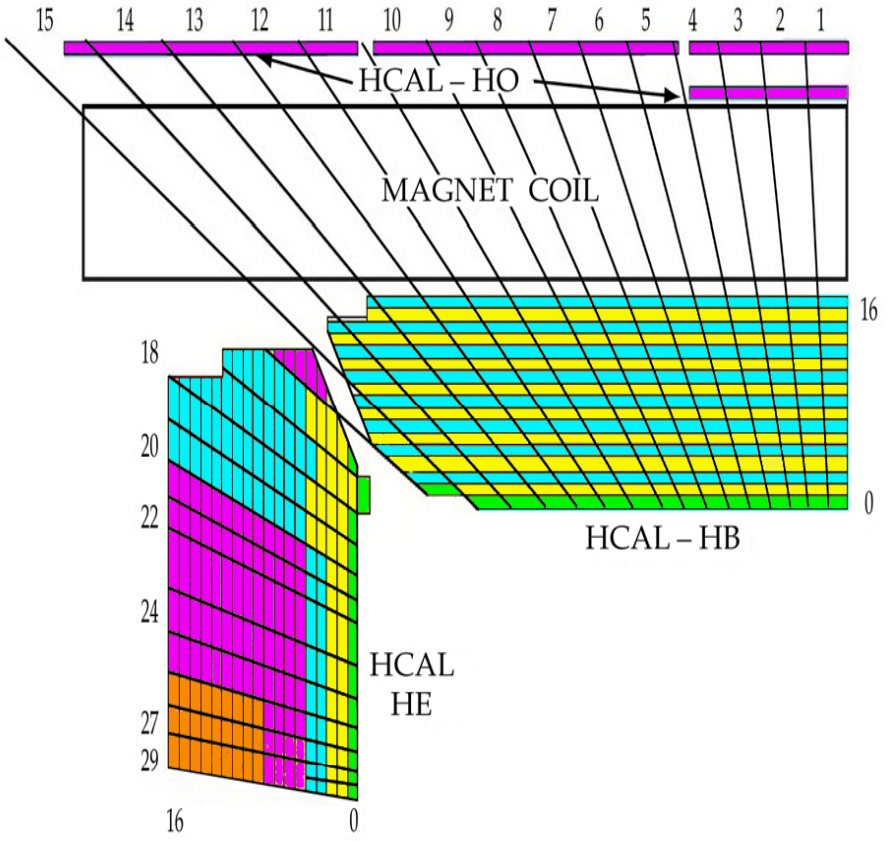
We need to get another x200 (x20) reduction for single (double) tau rate!

Allows other possible Longitudinal Segmentation

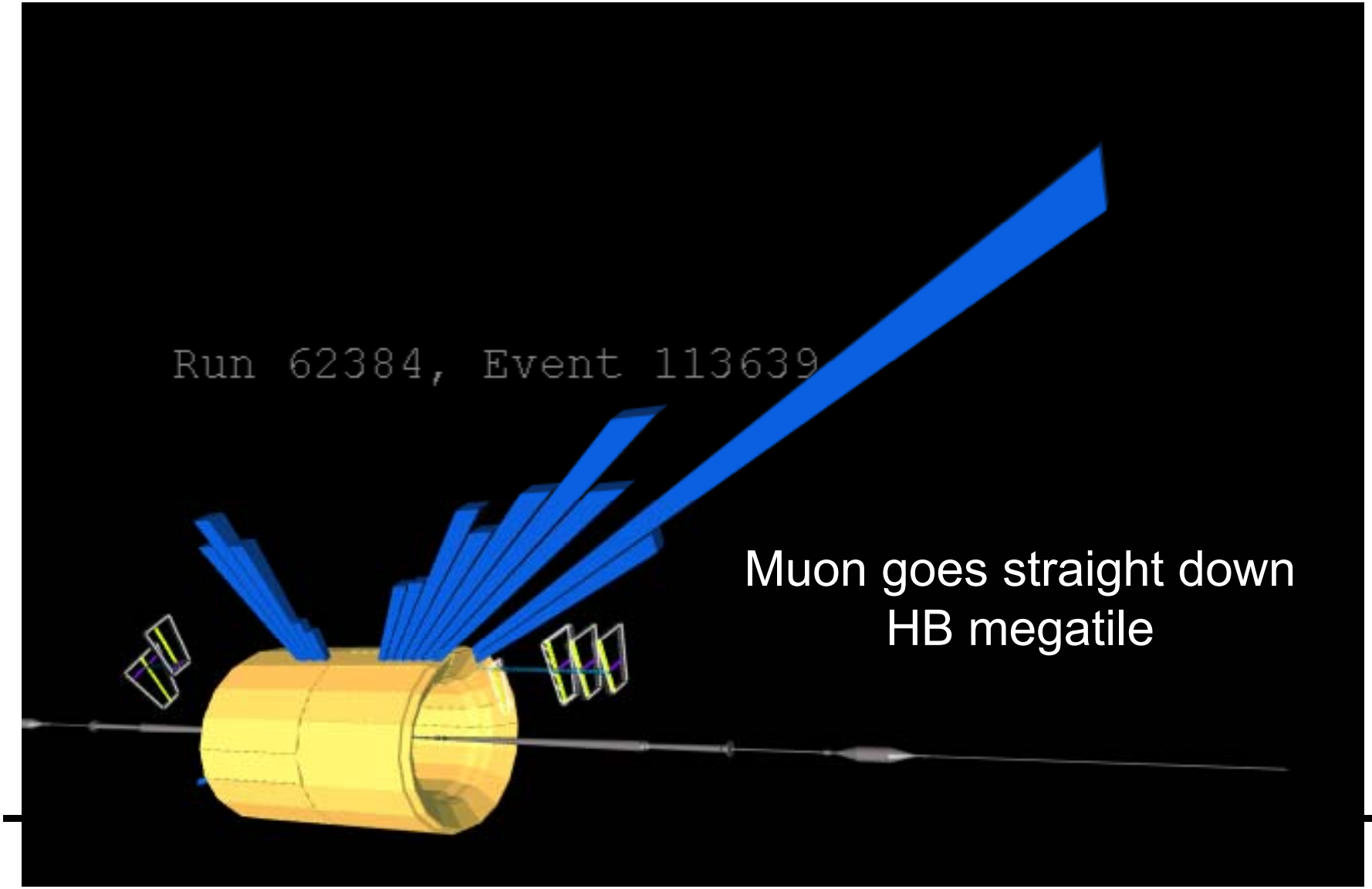
18 Channel RMs



48 Channel HB RMs
32 Channel HE RMs



Mohawk Events



HB Digital Readout Bandwidth

Current Readout (1.6 GHz) Format

	D(31:30)	D(29:25)	D(24)	D(23:22)	D(21:17)	D(16)	D(15:14)	D(13:9)	D(8:7)	D(6:5)	D(4:3)	D(2)	D(1)	D(0)
Optical Cable 1	QIE 0 Exp (1:0)	QIE 0 Mant (4:0)	QIE_Reset (abort gap marker?)	QIE 1 Exp (1:0)	QIE 1 Mant (4:0)	"0"	QIE 2 Exp (1:0)	QIE 2 Mant (4:0)	QIE 0 CapID(1:0)	QIE 1 CapID(1:0)	QIE 2 CapID(1:0)	Control Flag=0	Data Flag=1	"1"
Optical Cable 2	QIE 4 Exp (1:0)	QIE 4 Mant (4:0)	QIE_Reset (abort gap marker?)	QIE 5 Exp (1:0)	QIE 5 Mant (4:0)	"0"	QIE 3 Exp (1:0)	QIE 3 Mant (4:0)	QIE 4 CapID(1:0)	QIE 5 CapID(1:0)	QIE 3 CapID(1:0)	Control Flag=0	Data Flag=1	"1"

FE DATA FORMAT

Possible HB Readout (3.2 GHz) Format with GOL

QIE0 8-bit	QIE1 8-bit	QIE2 8-bit	QIE3 8-bit	QIE4 8-bit	QIE5 8-bit
TDC0 5-bit	CapID(0-3) 2-bit	ErrBit 1-bit	TDC3 5-bit	CapID(4-5) 2-bit	ErrBit 1-bit

Optical Cable 1

QIE6 8-bit	QIE7 8-bit	QIE8 8-bit	QIE9 8-bit	QIE10 8-bit	QIE11 8-bit
TDC6 5-bit	CapID(6-7) 2-bit	ErrBit 1-bit	TDC9 5-bit	CapID(8-11) 2-bit	ErrBit 1-bit

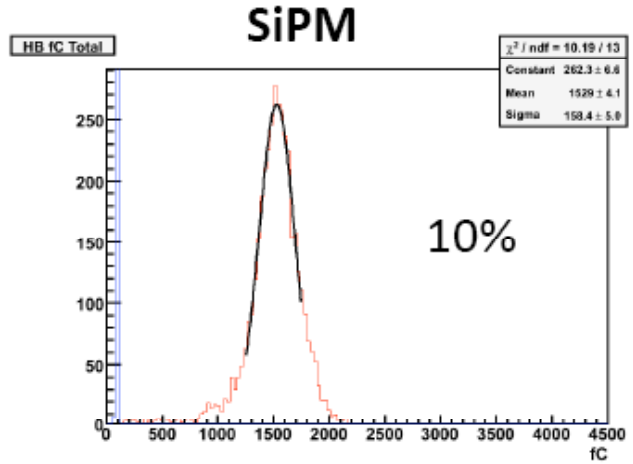
Optical Cable 2

Phase I HCAL upgrade critical components

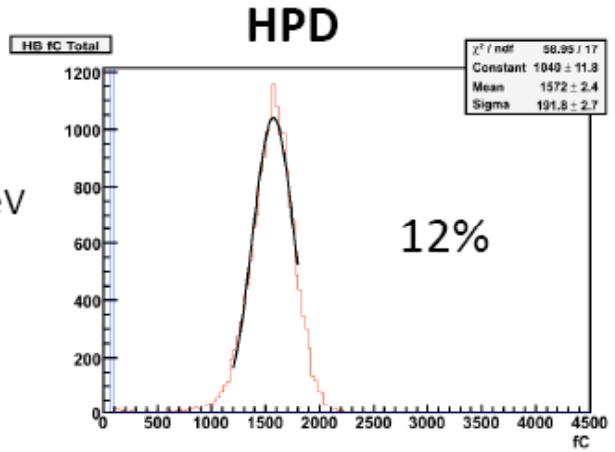
- SIPM looks good
- New QIE (QIE10)
- GOL studies on track to handle data flow
- Cooling looks feasible
- Discrete parts (regulators, FPGAs) look OK

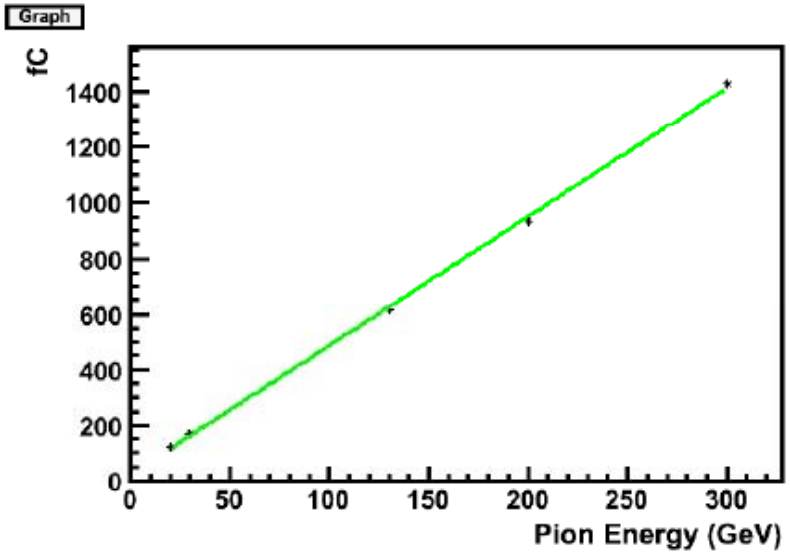
SIPM that satisfies HB dynamic range needs

MAPD by Zecotek, 40k pixels per mm^2, 9 mm^2 (360k pixels)

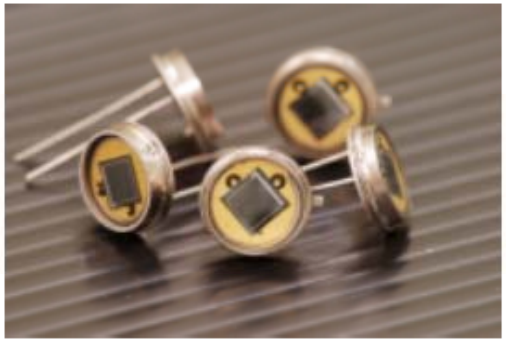


300 GeV pions

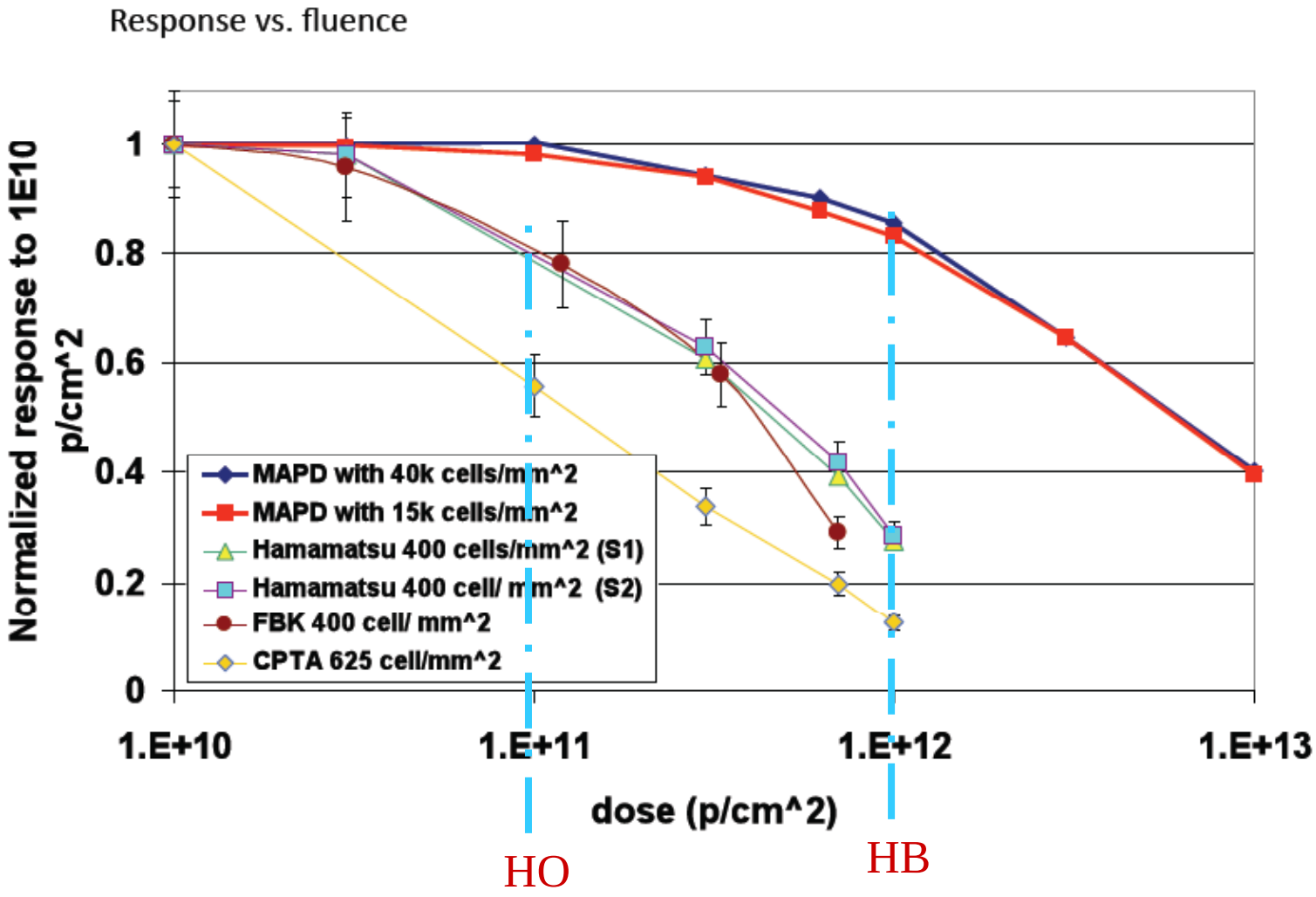




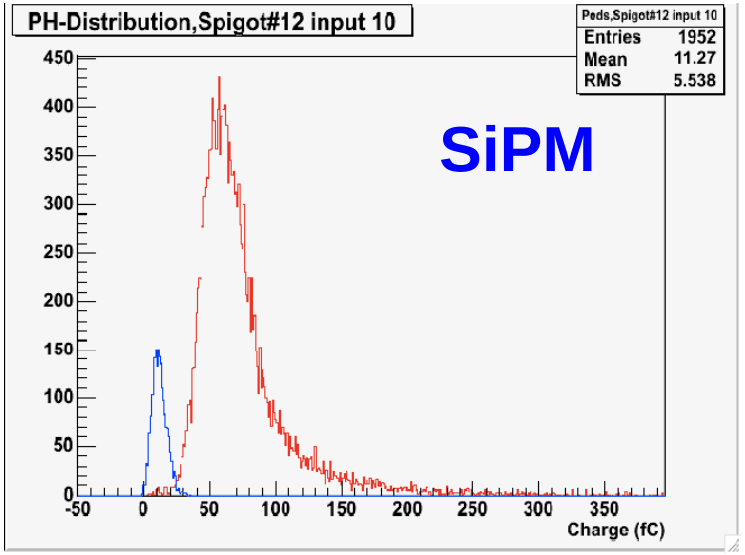
SiPM Linearity

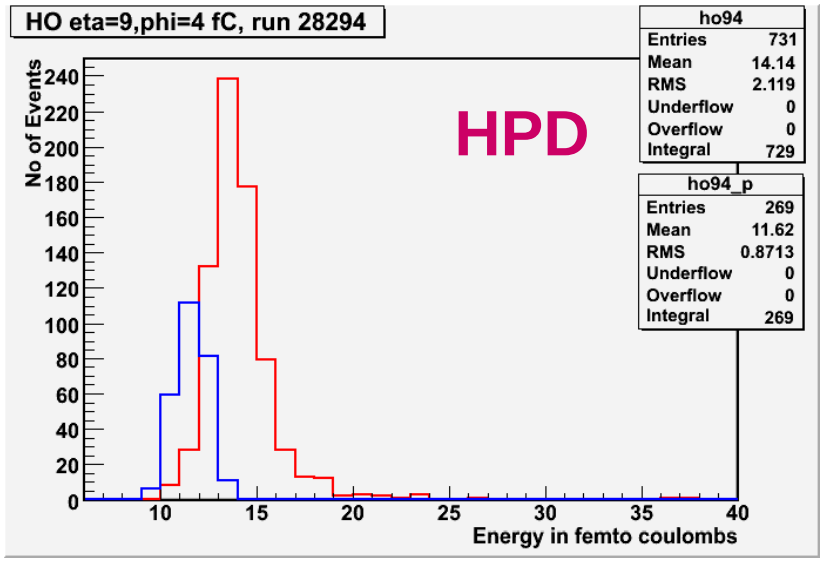


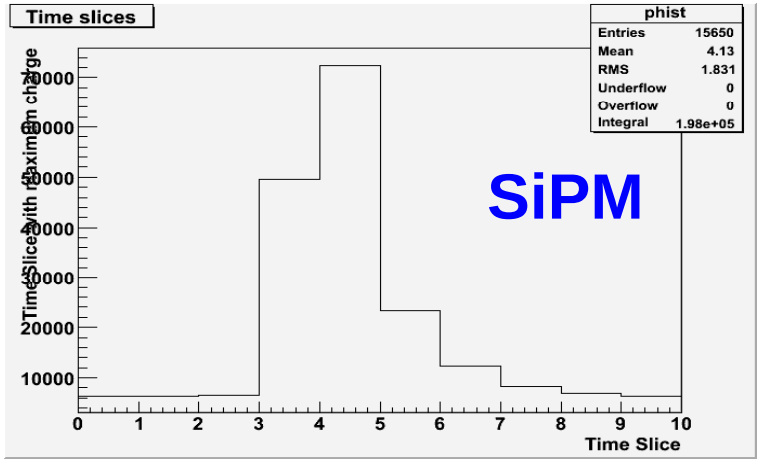
New SIPMs satisfy predicted SLHC Rad Needs

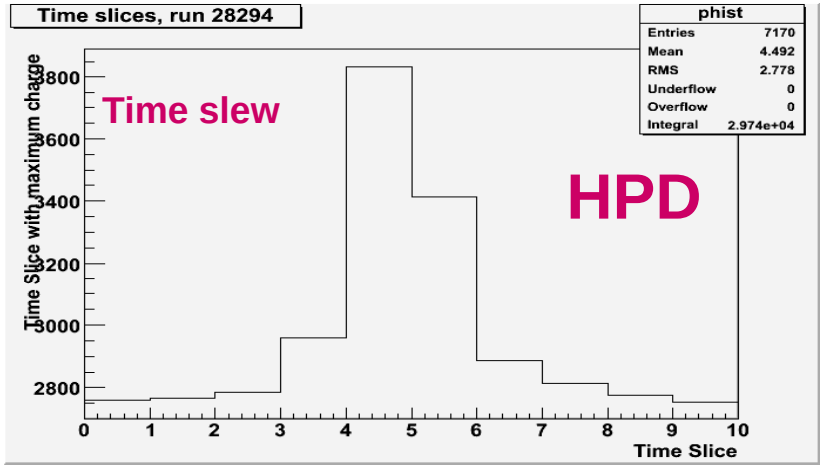


Muon response for YB1



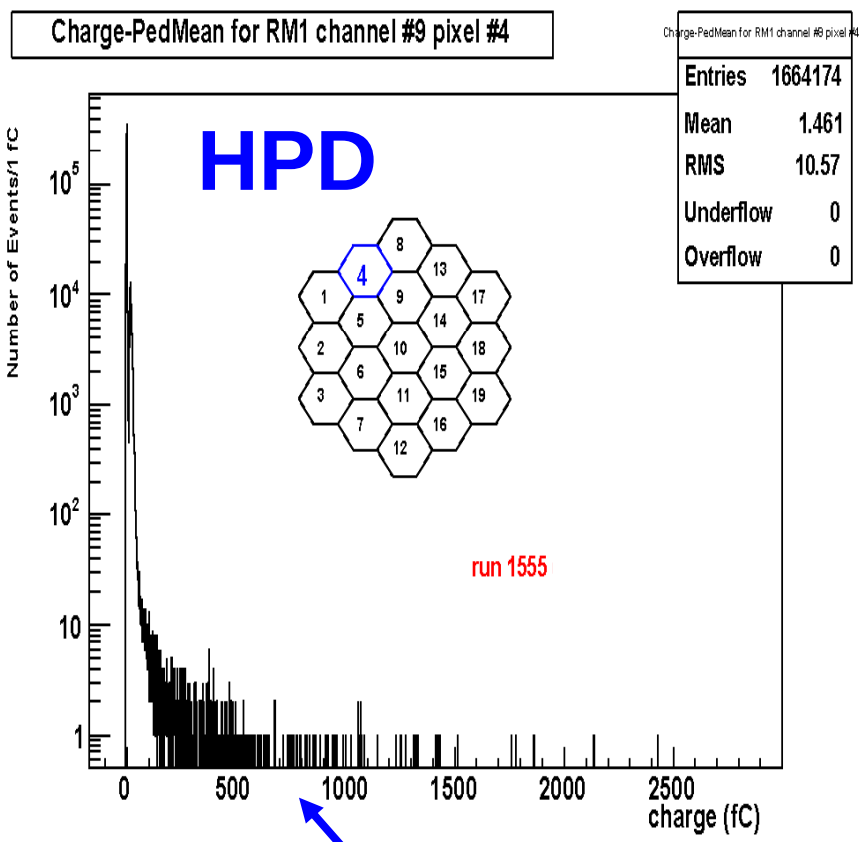


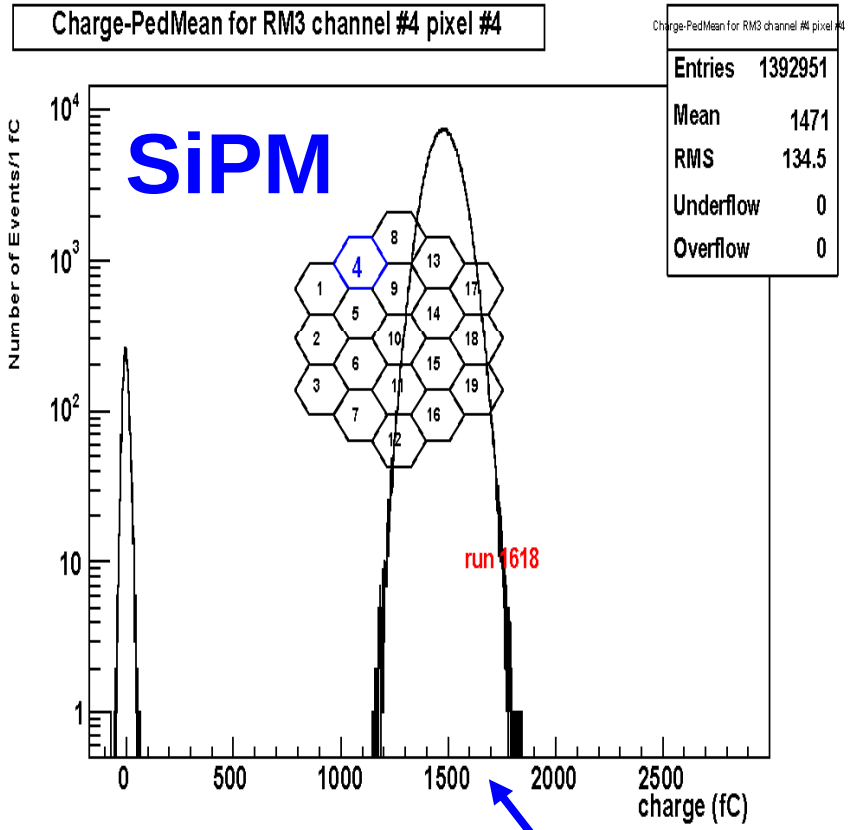




HPD vs. SiPM in 4T B Field

SiPMs are very quiet and operate at higher gain.





HPD Discharge Noise

LED calibration pulse

Quad QIE10 Specs

- QIE10
  - Clock > 40 MHz
  - Match to SiPM response
    - HB - ZETEC 40,000 pixel device
    - 4X Dynamic range of QIE8
  - 1 Extra bit resolution (5--> 6)
  - Keep non-linear response as in QIE8
  - Charge sensitivity of lowest range
    - QIE8: Norm - 1fC/LSB, Calib - 1/3 fC/LSB
    - QIE10: 10x less sensitive
      - Set by lowest SiPM gain (Singapore Zecotek - HB?)
  - Need to control rate effects (DC coupling)
  - 2 or 4 QIE10 per package, either multi-channel QIE die or separate dice in single package
  - Form a “discriminated signal” to send to the FPGA for TDCing
    - 1 TDC signal per channel

Back End Plan

- FE changes require redesign of HCAL backend
  - Denser channel count, built-in resources for newer FPGAs, etc
  - Working with the evolution in RCT/GCT (uTCA?)
- Ideas are in play to consider how to collaborate with evolution of ECAL
  - Selective Readout being considered
    - Increase in HCAL channel count by a factor of 4
    - More DAQ links, harder zero suppression, more pileup
  - ECAL has faced this issue already
- Incremental cost of current HCAL backend towards a more unified HCAL/ECAL approach
  - Work underway to understand physics gains especially at high luminosity
    - E.g. provides readout of necessary depths for isolation cuts on the E/Gamma path as well as fine-grain ECAL information for jets

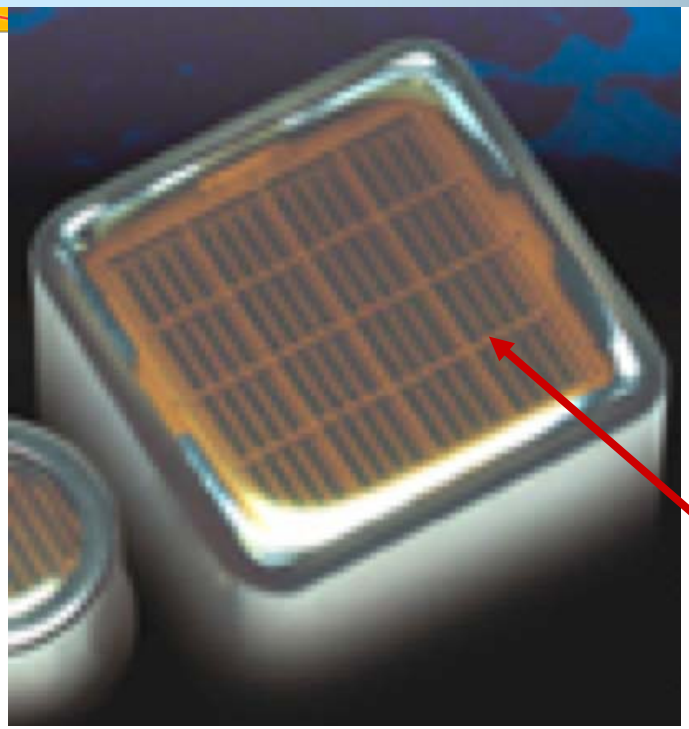
Advantages of this plan

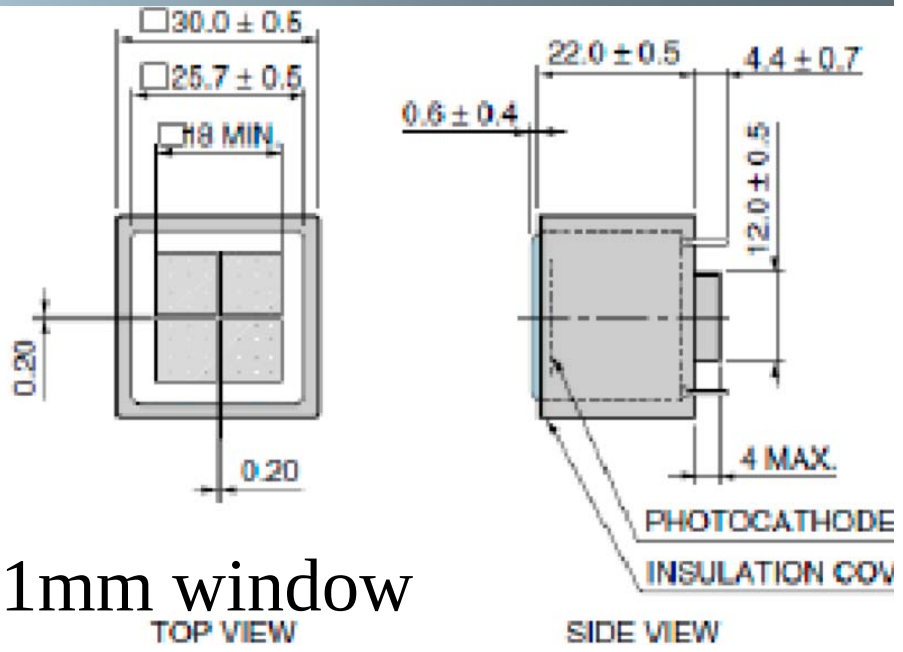
- Depth segmentation can be decided late in process → allows experience with real CMS collision physics
- Can accommodate new GBT if present on right timescale
- Can have phased installation (ie HB one shutdown, HE next, or other combinations.) Graceful installation in regular shutdowns

HO SIPM RBXs

- We will install 2 SIPM RBXs into HO in Feb.
  - Gain operational experience, lifetime
  - Develop control and monitoring system

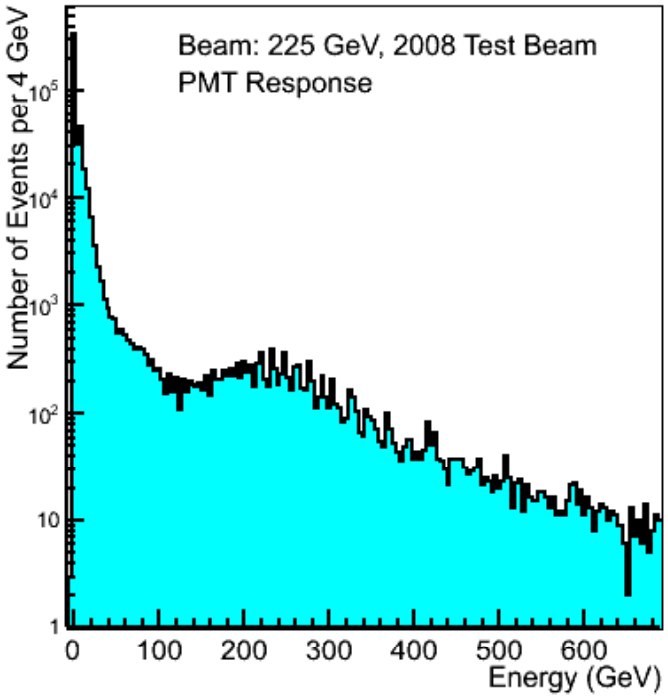
HF: proposed replacement PMT for HF

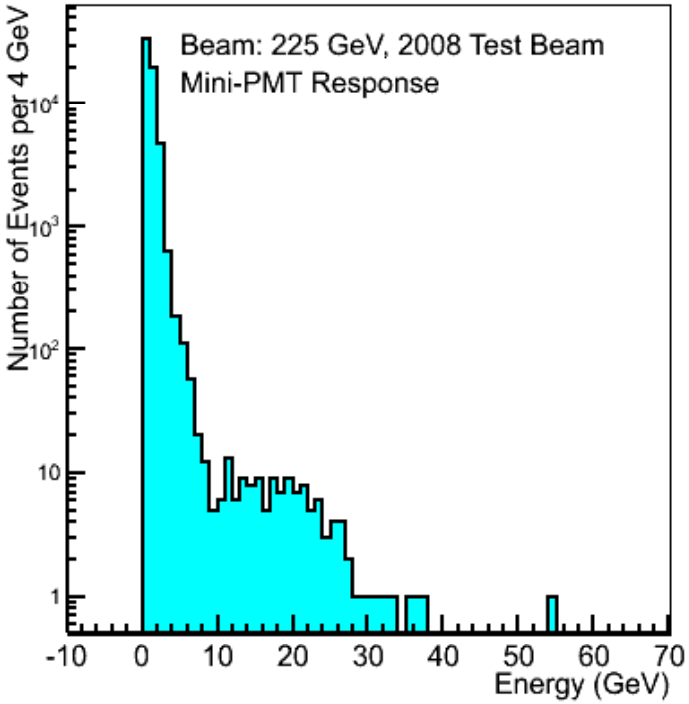


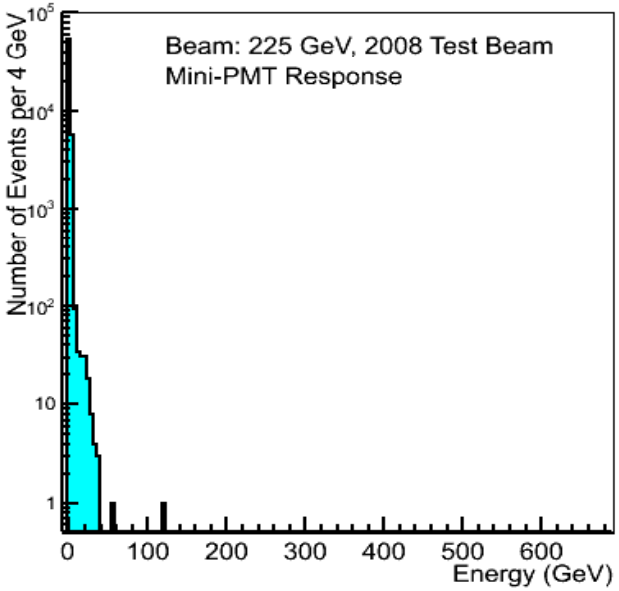


1mm window

New multi-anode pmt has 2X better QE. Improves HF low end performance







Muon-Induced Backgrounds

MiniPMT vs

Standard HF PMT

~ like glass thickness…

HF PMT Upgrade

- Will further investigate metal wall pmts (with high QE)
- Multi-pixel pmt will allow upgrade path to have 2 separate readouts → eliminate pmt Cerenkov events.
- Using Phase I electronics would also provide TDC information.