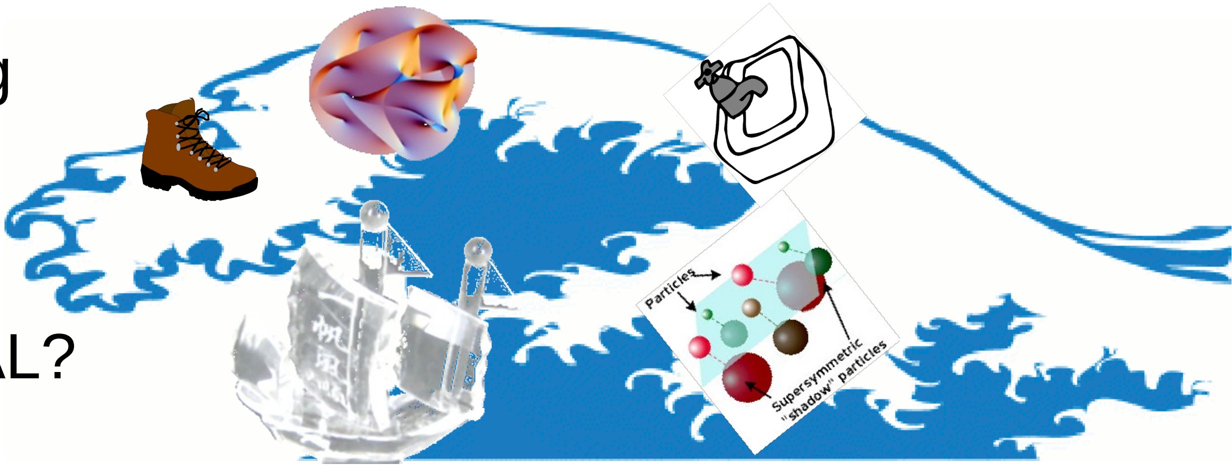
ECAL Phase II R&D Status

Context: Something is coming



What does this mean for ECAL?

Crystal ship

Early warnings: Ongoing detector performance and aging studies

Planning ahead: Device R&D

What do we want to upgrade?

- The scope of the Phase 2 upgrades is still not fully defined
- We will almost certainly replace the entire tracker system
- We will have to replace much of the trigger system
- We may have to replace elements of the forward calorimetry
- We may have to replace or shield some elements of the forward muon system
- We will need some information from the initial running to fully define the scope

Important questions:

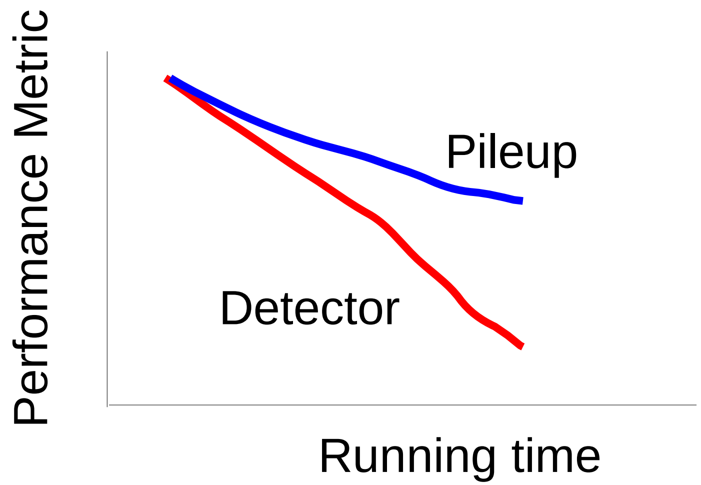
How do we decide?

How much lead time is needed to prepare if large projects are req'd?

Phase 2

Detector performance will degrade with integrated luminosity

Instantaneous luminosity will degrade measurement capabilities



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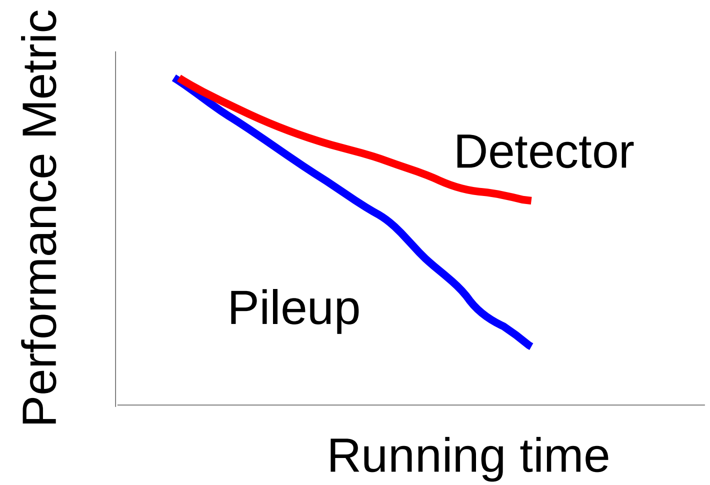


Many possible metrics: ID effs, resolutions, global quantities (MET)...
Most important metrics are *known unknowns* until data arrive.

(also, we are talking about long time scales here, other components (backend) could become increasingly difficult to support, independent of $\mathcal{L}$)

Understanding we have now

It's absolutely imperative to accurately characterize the aging of our existing detector.

If we do this only using in situ measures, the answers will likely come too late to act.

Need combination of test beam/bench top measures and observations of in situ performance to accurately extrapolate to future performance.

ECAL talks today on crystal studies:

- *Recent Crystal Calorimetry Test Results from CERN*
  by Sasha SINGOVSKI (University of Minnesota)
- *Recent studies of hadron damage to Xtals*
  by Guenter DISSERTORI (ETHZ)

Understanding we have now

New studies proposed (UMN)

- focus on changes in the transparency of the $PbWO_4$ crystals with hadron flux, repeating at first the measurements done at CERN and investigating the recently observed bleaching with infra-red radiation

- measure transmission of visible light in the test crystals in situ during irradiation studies using modified spectrometer w/ rad hard quartz fibers

- allows immediate measurements right after radiation (no ~100 day wait for induced radiation to decay). Closer approximation to LHC conditions at high luminosities

ECAL Phase II R&D

On going work by Caltech group on crystal R&D, CMS and DOE detector development program.

Right: Modern high performance, large size crystals are available.

See Marat's talk this session.

Product Name

LYSO crystal bar of 25 X 25 X 280 mm^3 with six faces polished; Ce 0.15%; Dimension tolerance: < 0.2 mm; FWHM pulse height resolution < 12.5% at 662 keV .

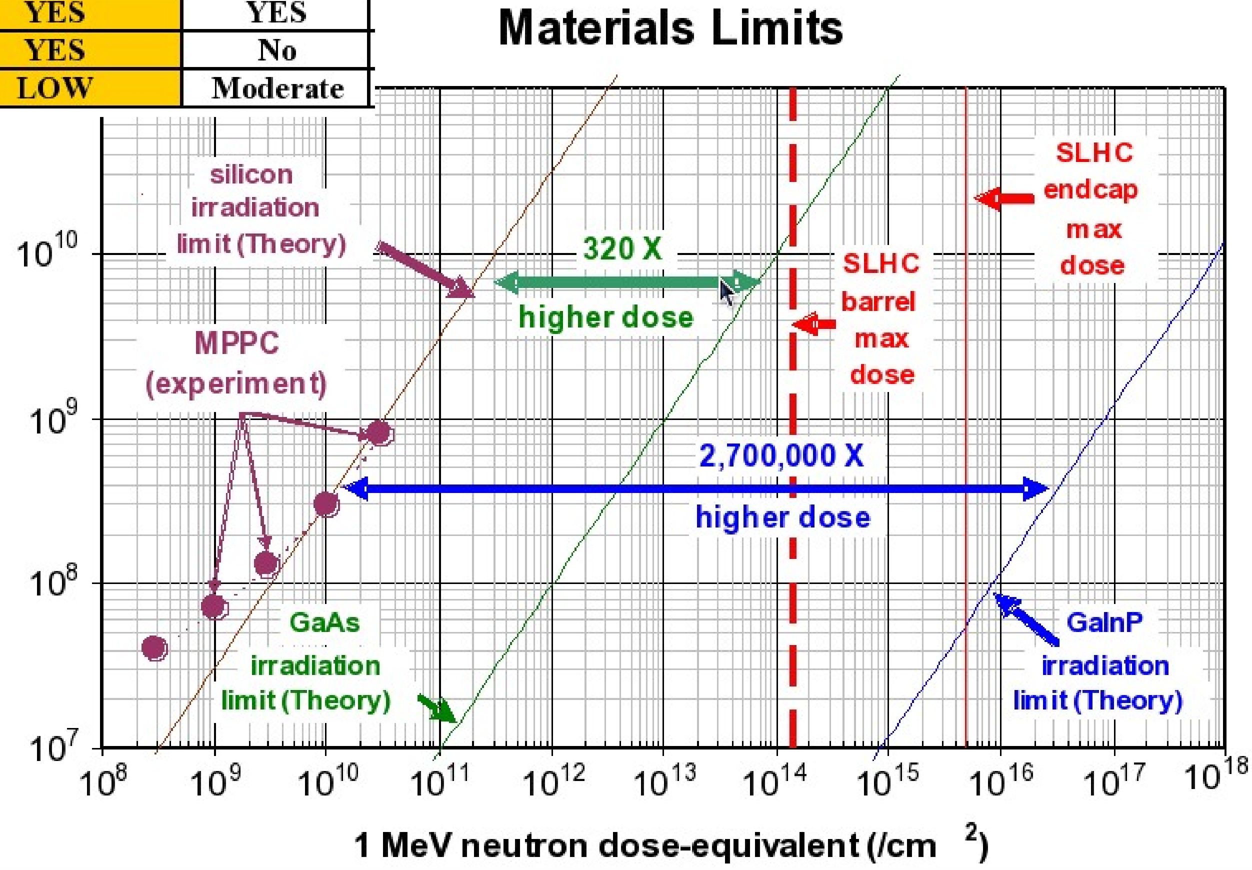
ECAL Phase II R&D

Proposal for R&D for GaAs or GaInP Photodetectorsfor SLHC ECAL Endcap Calorimeters (UVA)

	Unit	GaInP Photomultiplier Chip™	GaAs Photomultiplier Chip™	SiPMT MPPC[6]
Absorber		GaInP	GaAs	Si
Wavelength range	nm	280-650	280-900	300-900
Detection Efficiency	%	25-50	25-50	10-50
Dark Counts @25°C	Mcps/cm²	0.1	50	50
Bias Voltage	volts	<100	<100	<100
Tolerate B fields		YES	YES	YES
Radiation Hard		VERY	YES	No
Cost		LOW	LOW	Moderate

Radiation Hard/Stable Semiconductor Photodetectors for the SLHC.

See Chris Neu's talk



Trigger

For Phase 1, only optical SLB is on the table. Upgrade from copper to fiber to connect TCC to RCT.

What happens later?

SLHC high luminosity implies a huge number of p-p collisions (~400)*

Higher ECAL occupancy results in increased ECAL data volume and data readout bandwidth

Integration of ECAL TPGs in new trigger system is required

Improved integration of ECAL trigger and readout paths could be attempted

Not only trigger issue: Improved pileup modeling needed all around!

ECAL data volume

At LHC:

Total event size per DCC (FED): 40 kBytes
After data reduction in DCC: 2 kBytes (factor 20)

→ average output bandwidth ~ 200 MB/s, for L1A=100 kHz

- Data filtering:
  Selective readout + zero suppression
  SR: read trigger tower with E_T>2-3 GeV + 8 surrounding towers (225 crystals)

At SLHC:

Increase the SR and ZS thresholds or/and
Energy/time pulse analysis on board → transmit energy and time (factor 5 reduction)
Increase the data bandwidth
Lossless data compression

Assuming full event readout and L1A max=100 kHz
→ bandwidth 4 GBytes/s / DCC (10 time samples)
→ bandwidth 800 MBytes/s / DCC (energy/time)

J Varela Oct 2, 2009

Possible upgrade directions

- Phase 1:
  Optical interface to new trigger system: oSLB
- Phase 1.5/2:
  Re-design DCC → higher output data rate (e.g. 2 slink, or new DAQ link)
  larger FPGAs (energy/time filters)

  DCC and TCC: same board, different firmware ?

  SRP integrating HCAL and possibly tracker information ?

  Large project requiring strong collaboration

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Need close ties between simulation, detector peformance, and trigger groups

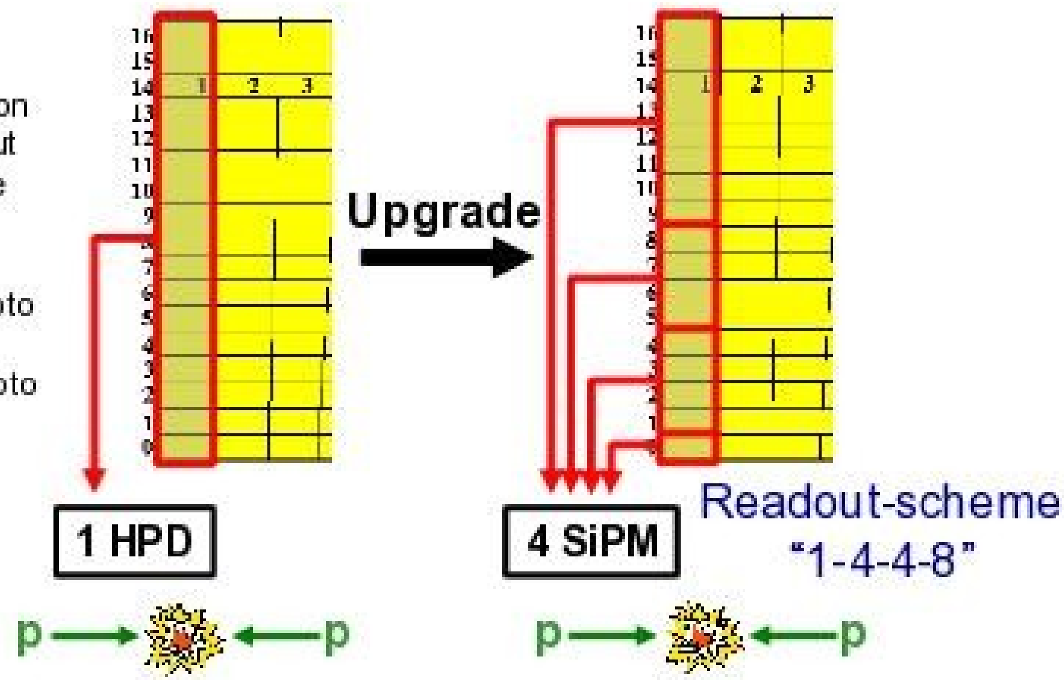
HCal Upgrade

➔ **Upgrade: 4 x more readout channels**

- Plan: additional segmentation in longitudinal direction

Schematic illustration of the HCAL readout before and after the upgrade.

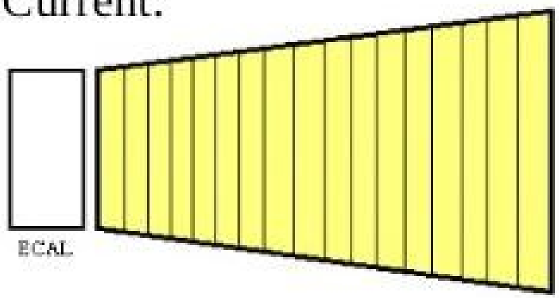
HPD = "**H**ybrid **P**hoto **D**etector";
SiPM = "**Si**licon **P**hoto **M**ultiplier".

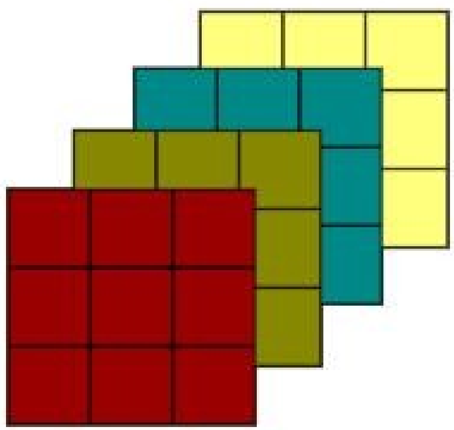


- Resolve parts of showers in **longitudinal direction** after the upgrade

HCAL Segmentation

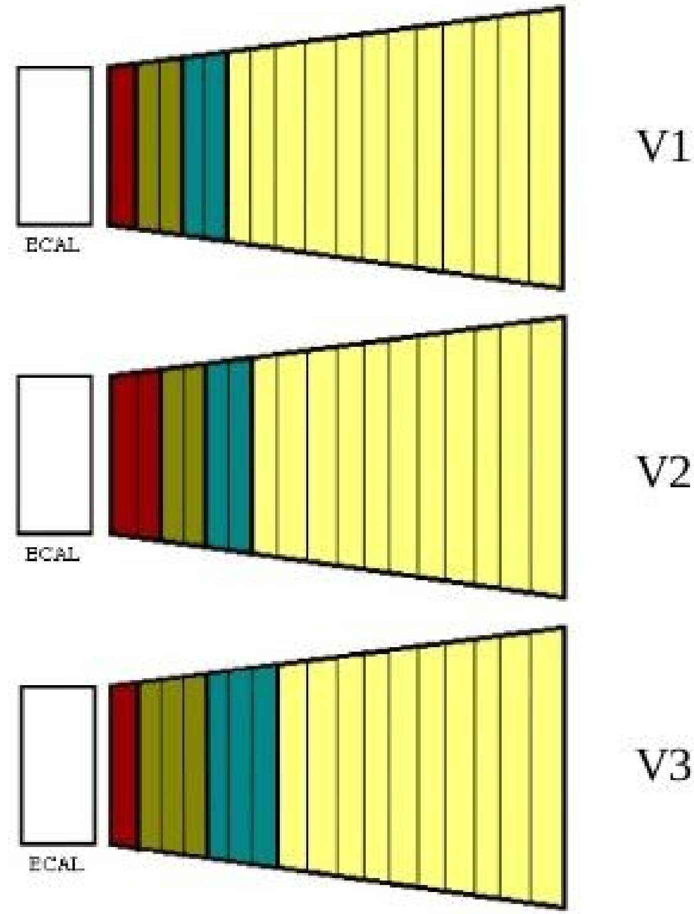
Current:





4 depths of HCAL

With SLHC upgrade, we can split HCAL into 4 depths:

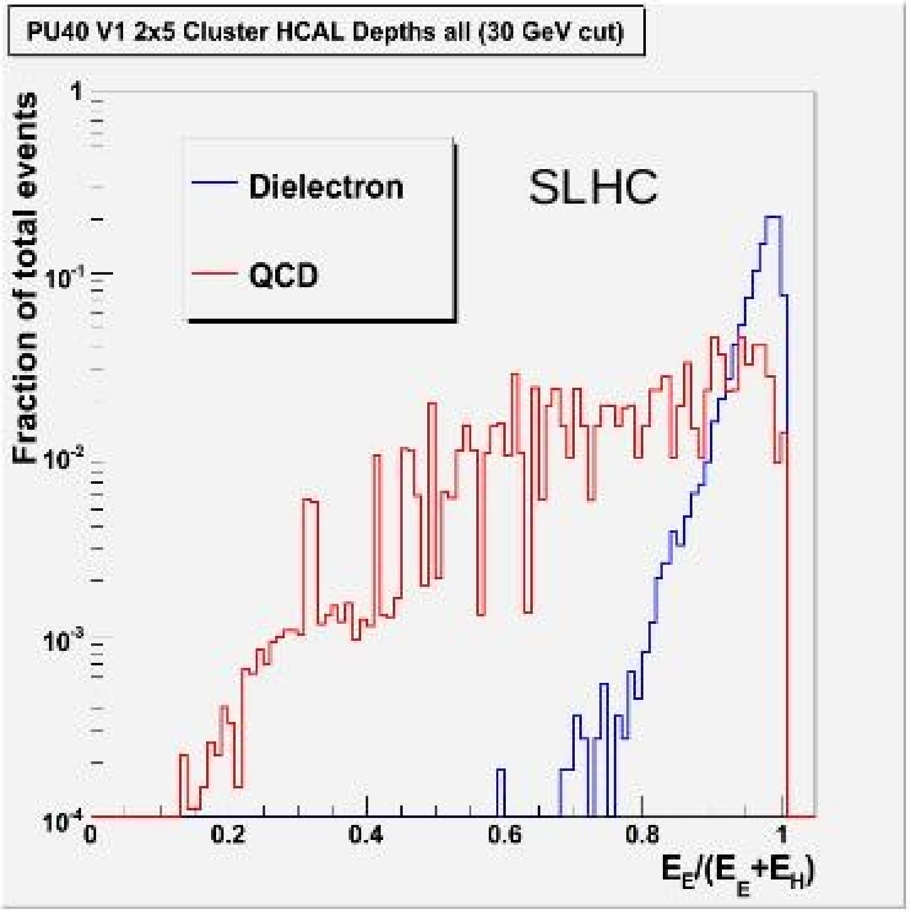


4 UMN SLHC Ongoing Work October 28, 2009

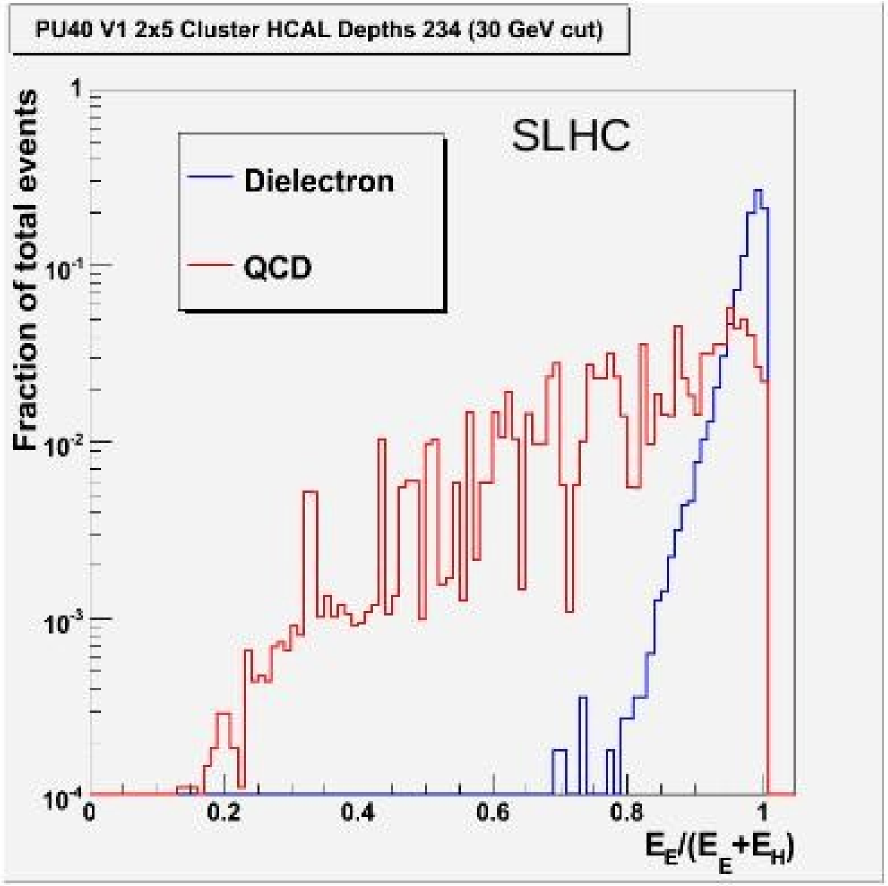
J. Mans

Need for coherent calorimetry projects

No-Segmentation Case



Segmentation V1, H=Depths 2-4



J. Mans

Terra (Notus) Incognita?

Schedules
Requirements In flux
Scope

But many basic questions can be addressed to prepare for the future

Forming a task force is just the beginning

Need to inclusive and broad efforts.

Develop solid strategies
(test, prototype, simulate)to
catch the wave
(or the particle)?