Electromagnetic Calorimeter WG Introduction

ECAL @ SLHC

Goals: Review expectations for ECAL at SLHC
Joint sessions w/ HCAL on off detector hardware (Phase1/2)
Detector/front-end specific issues (Phase 2)
Discussions!
- Define needs to flesh out ideas (eg. simulation tools)
- Layout highest priority short term projects.

Bob Hirosky
Francesca Nessi-Tedaldi

Electromagnetic Calorimeter WG Introduction

Discussions will cover two general areas:

Phase 1: off-detector*
(Joint session with HCAL at 16:10 Today)

Phase 2: on-detector
(Thursday Morning-Afternoon)

*slight weight towards off-detector in this talk, but many on-detector issues at this workshop

ECAL Occupancy

J. Varela

p-p minimum bias collisions at sqrt(s)=14 TeV:
~ 5 π^0 per rapidity unit
<P_T> ~500 MeV

SLHC
up to 400 p-p collisions per crossing
crossing rate 20 MHz

Per Trigger Tower ($\Delta\eta.\Delta\varphi$ ~0.1 x 0.1), per crossing :
~ 12 γ (γ rate in ECAL ~2.4 MHz/cm^2)
<P_T> ~3 GeV

No empty ECAL towers!

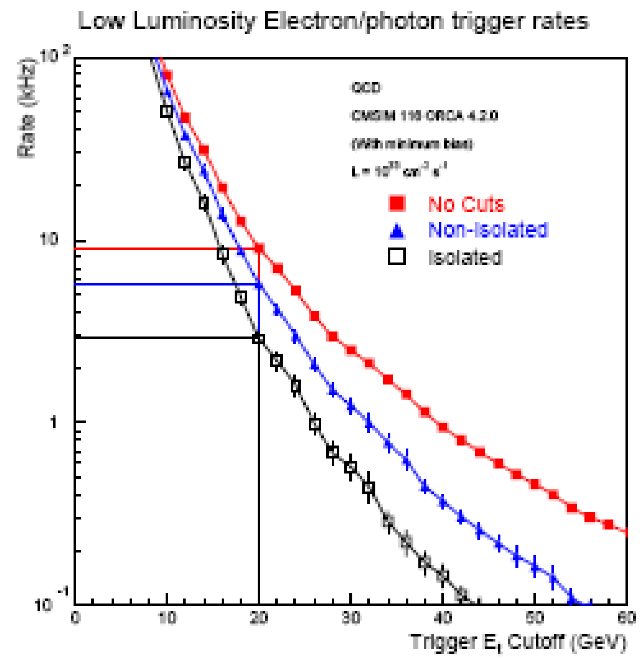
Trigger Rates

L1 e/γ trigger: QCD background rates

J. Varela

At LHC low luminosity ($L=10^{33}cm^{-2}s^{-1}$)
~ 1 p-p collision per crossing

	Rates		Prob/collision	
GeV	No cuts (kHz)	H/E+isol (kHz)	No cuts (kHz)	H/E+isol (kHz)
ET>20	10	3	2.5 10-4	7.5 10-5
ET>30	3	0.5	7.5 10-5	1.3 10-5
ET>50	0.5	0.06	1.3 10-5	1.5 10-6



At SLHC ($L=10^{35}cm^{-2}s^{-1}$), assuming prob/collision x 400 (cuts are probably less efficient)

→

	Rates	
GeV	No cuts (kHz)	H/E+isol (kHz)
ET>20	2000	600
ET>30	600	100
ET>50	100	12

Electron & Photon Measurement

J. Varela

Moliere radius ~ crystal size
~ 100% of shower energy is contained in 3x3 crystal window
(when no electron radiation or photon conversion)

Average pile-up energy in 3x3 window:
$\sim 2\ \pi^0 \rightarrow \langle E_T \rangle \sim 1$ GeV ; $\sigma(E_T) \sim \langle E_T \rangle \sim 1$ GeV

worse at trigger tower granularity

For non-converted photons of E_T=50 GeV:
σ (pile-up) ~ 2%
σ (ECAL) < 1%

Energy resolution is dominated by pile-up.

Preshower could allow to identify individual pile-up photons

can ultimately gain at trigger by increasing granularity, but difficult to implement...

Is the tracker material at SLHC an issue?

ECAL Data Volume

J. Varela

At LHC:

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

→ 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 thresholds at the expense of physics or
Increase the data bandwidth

We assume full event readout and L1A max=100 kHz
→ bandwidth 4 GBytes/s / DCC

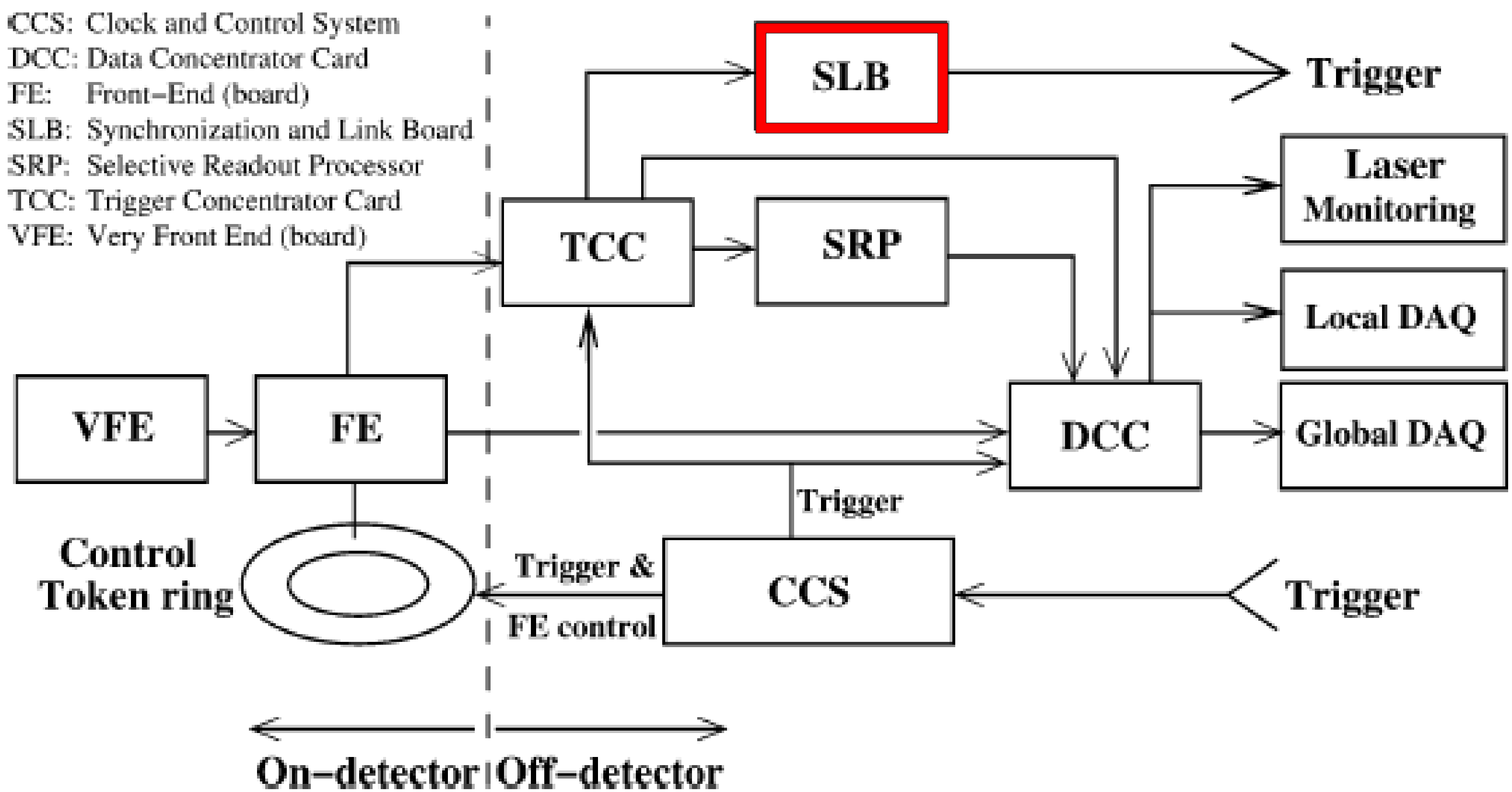
If trigger granularity is increased also helps to optimize SR.

Not tenable for Phase 1, but can maybe Phase 2?

ECAL Readout and trigger paths

Minimal Phase 1 upgrade for compatibility w/ expected trigger hardware changes

But no added functionality, no advance prep. for Phase 2. Can take advantage of HCAL/trigger R&D on (u)TCA to prepare for future...

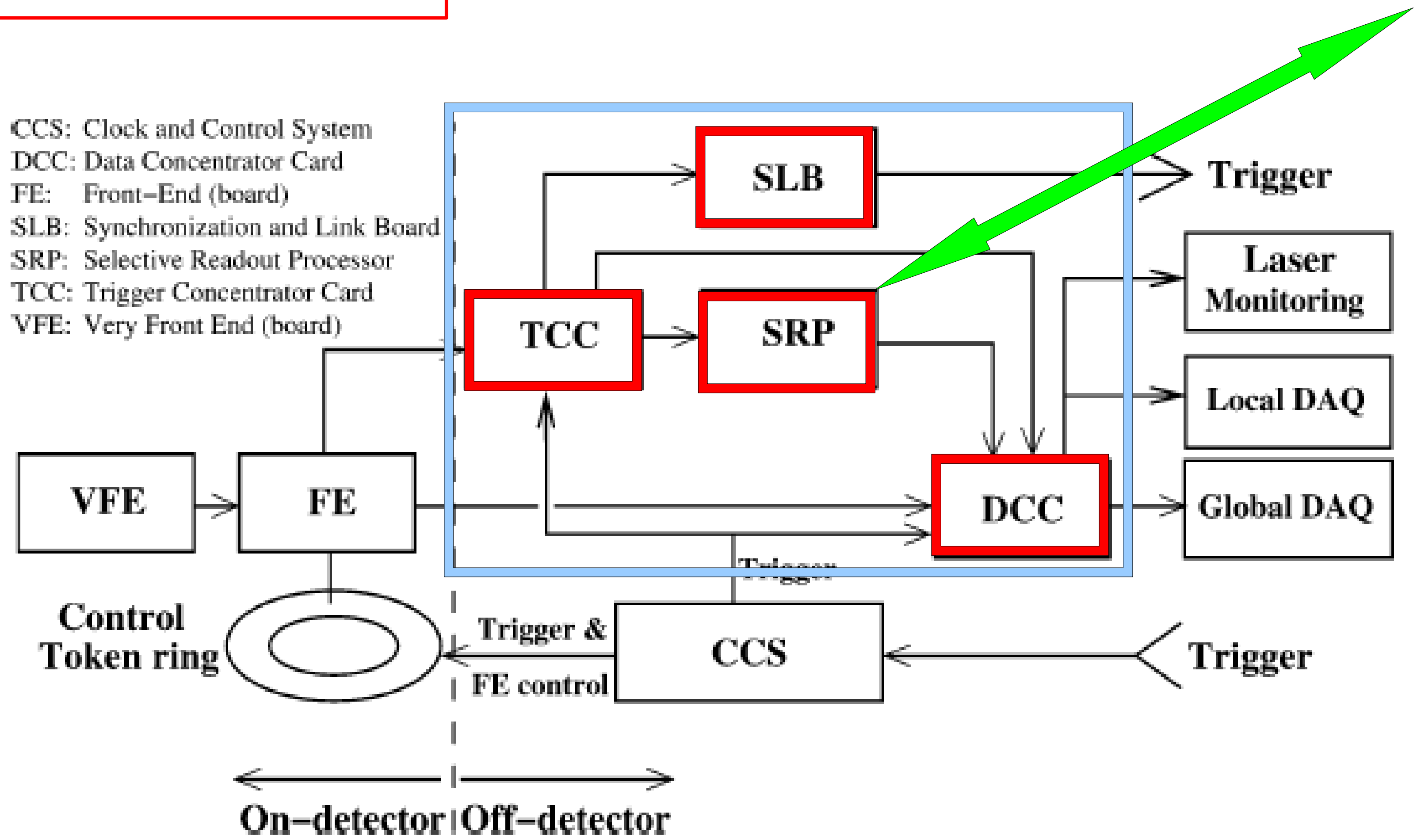


ECAL Readout and trigger paths

Can, in principle, move to common technology platform w/ HCAL

Simplify, more tightly combine trigger/readout paths in ECAL

More tightly couple selective readout w/ HCAL



But need strategy and baseline functional descriptions...

ECAL Readout and trigger paths

Phase 1 improvement to TPGs?

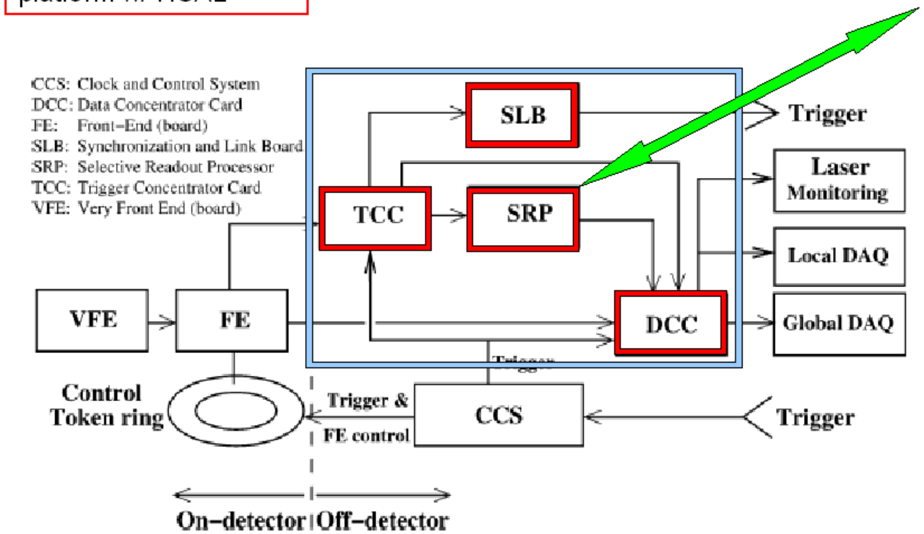
Should handle any scenario w/ finer granularity in Phase 2?
Prospects for future data links?

Ideas for tighter coupling w/ HCAL? and Compatibility w/ cal/track matching scenarios? (latencies, interconnects, etc)

Can, in principle, move to common technology platform w/ HCAL

Simplify, more tightly combine trigger/readout paths in ECAL

More tightly couple selective readout w/ HCAL



Installation/commissioning, backwards compatible initially in Phase 1?

...

Physics justifications, Physics justifications, Physics justifications

Radiation Levels

F. Nessi-Tedaldi

Approximate radiation levels and fluences, rescaled from the ECAL TDR for 3500 fb^{-1} at 10^{35}cm^{-2}s^{-1}:

in front of crystals:

η=2.0: 5×10^{13} fast hadrons/cm^2

η=2.9: 4×10^{14} fast hadrons/cm^2

at shower max →crystals :

η=2.6: 570 kGy, 50 Gy/h

η=2.9: 1400 kGy, 140 Gy/h

behind crystals →VPT, HV/LV cables, fibers, HV pcbs:

η=2.6: 150 kGy, 20 Gy/h

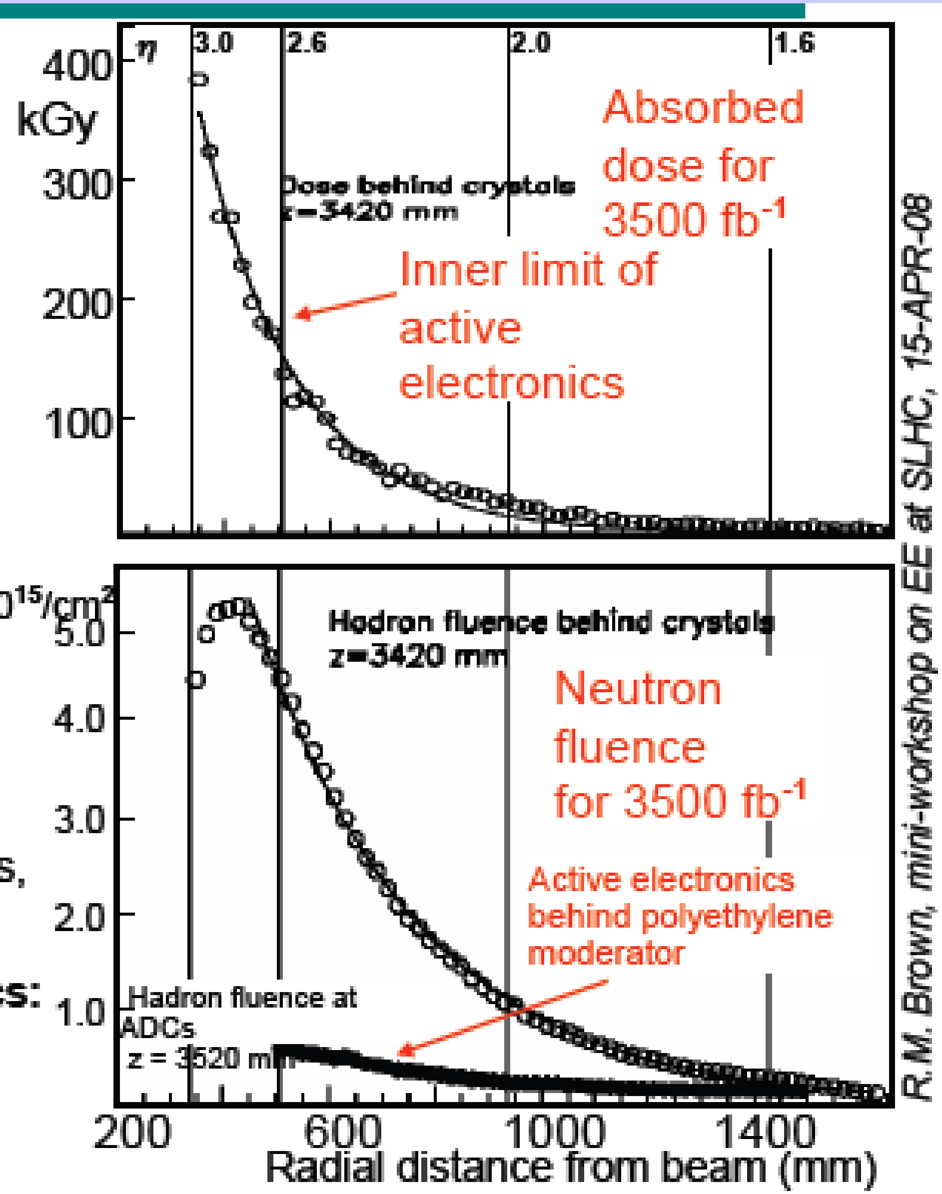
η=3.0: 370 kGy, 50 Gy/h

max 5×10^{15} hadrons/cm^2 (mostly 1 MeV neutrons, with max 3×10^{14} charged hadrons/cm^2)

behind moderator →active readout electronics:

η=2.6: 150 kGy, 20 Gy/h

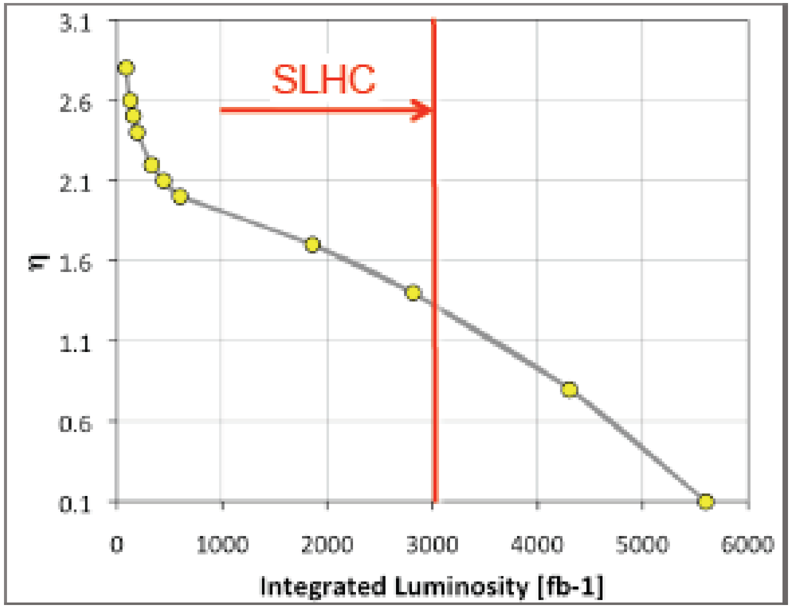
η=2.6: 5×10^{14} fast hadrons/cm^2, mostly neutrons



Evolution of light output loss w/ radiation

F. Nessi-Tedaldi

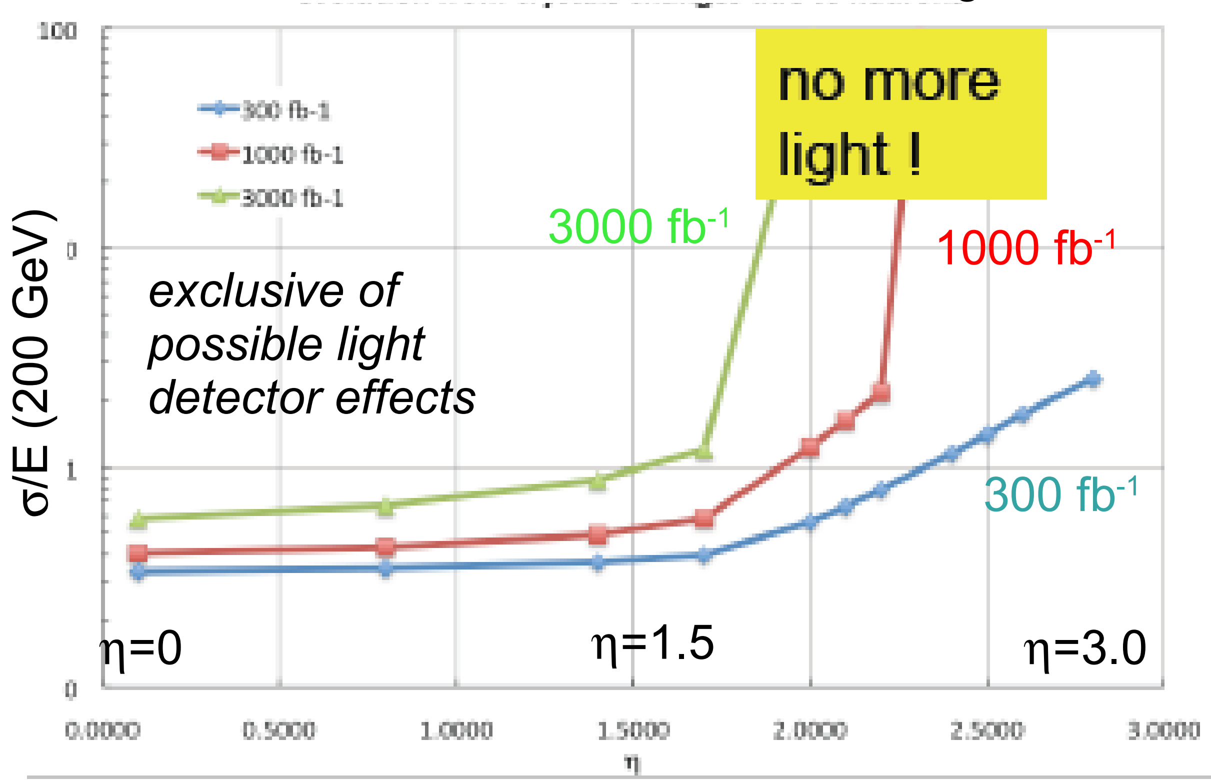
η value vs. $\int \mathcal{L}dt$, at which μ_{IND}(420 nm) = 2 m^{-1} (~60% of Light Output loss) is expected to be reached in the ECAL



(using EB star densities from draft Radiation Hardness ECAL detector paper, Eds. I. Dafinei, P. Lecomte)

Need to explore new, future detector material options...

Possible scenario for resolution degradation



Talks on detector technologies/studies tomorrow

Constraints

Manpower and $$$ (always!)

Time to build and install (~6 months install for Phase 1)

Detector access

- logistical issue for EB (removal of detector)
- health issue for EE (detector activation!)

Planning Thoughts

How should we reinterpret data from a precision ECAL in pile-up dominated environment?

Off-detector:

- keep close collaboration w/ HCAL, economy of scale in R&D and manufacturing
- minimize redundant work, rebuilding hardware for each phase

On-detector:

- how many technologies to explore (particle/light detection)
- if there is a future EE, what materials? geometry?

Many interesting issues ahead...