Phase 2 L1Calo/Calo Interface

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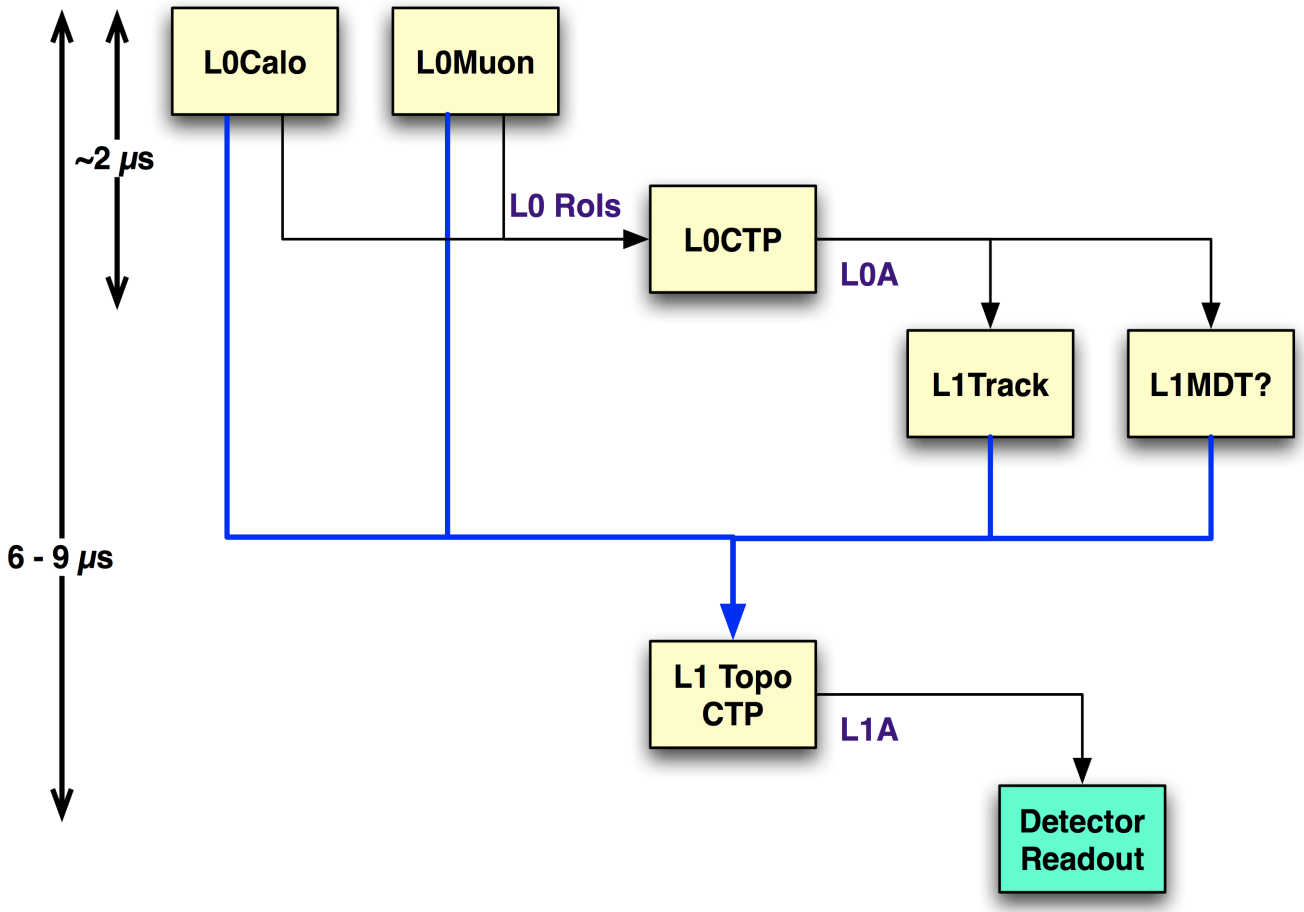
- Introduction
- Calo RODs
- Granularity and algorithms
- Calo-L1Calo links
- L1Calo design?
- Summary

Introduction

- L1Calo/Calo interface "task force"
  - Proposed at the recent ATLAS upgrade week
  - 1 person per LAr/Tile/L1Calo system
    - Myself, Arno Straessner, Christian Bohm
  - Discuss issues of L1Calo/Calo interface
    - Make some proposals for wider discussion?
  - First phone meeting on Friday morning
- Required from L1Calo
  - Idea of what we want the Calo RODs to provide us
  - Granularity, bandwidths, preprocessing algorithms
  - Constraints and requests on channel and ROD organisation
- Aim of this talk
  - (Re)start us thinking about the above

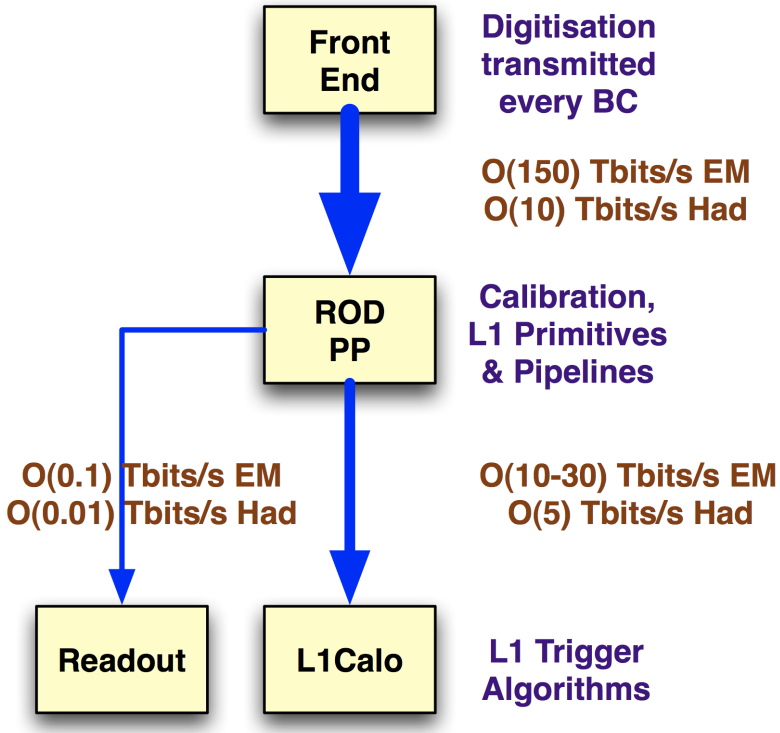
Reminder: Likely Phase2 Trigger

- Fast Level0 Calo and Muon RoIs needed for L1 track trigger(s)
- Slower Level1 topological trigger from combination of calo, muon, inner tracker (and MDTs?)



Reminder: Calo FE, ROD and L1

- Digitise all cells every BC and transmit to RODs in USA15
- Preprocess for L1Calo
  - Et (or energy?) per BC
  - Maybe also precise timing?
  - Fine granularity sums
  - Location within mini towers?
    - Coordinate of EM strip max?
  - Quality flags
    - Pile up detected
    - Fine structure in EM strips?
      - Eg for π0 rejection



*NB bandwidths are **very** approximate!*

LAr ROD (EM)

- Latest aim is for one ROD to cover one half FE crate
  - Or a similar number of cells with different eta*phi shape
    - Barrel half FEC is 0.2*1.5 (1 PS, 8 Front, 4 Middle, 2 Back FEBs)
    - Endcap half std FEC is 0.8*0.4 (1 PS, 6 Front, 4 Middle, 2 Back FEBs)
  - ROD contains four TCA mezzanines, each with one(?) FPGA
- L1Calo (my!) preference
  - One ROD mezzanine covers a "domino" of 0.4*0.2 (eta*phi)
  - "Barrel": ROD covers 1.6*0.2 (eta*phi)
    - In the range 1.4-1.6 this includes some endcap special crate FEBs
    - Would need duplication of a few B/E transition region fibres
  - Endcap Standard: ROD covers 0.8*0.4
  - Endcap Special: ROD covers 0.8*0.8?
    - Might have larger "domino" eg 0.8*0.2
    - More compact info to L1Calo from eta>2.5

Hadronic Layer RODs

- TileCal
  - Current Tile proposal: ROD covers 3.0*0.1 in eta*phi
    - Much less dense than LAr ROD: be more ambitious!?
  - L1Calo (my!) preference:
    - ROD covers 0.2 in phi (either split at eta=0 or more dense)
    - One EM 0.4*0.2 domino
- HEC/FCAL
  - Not yet thought about it

L1Calo Ambition Level?

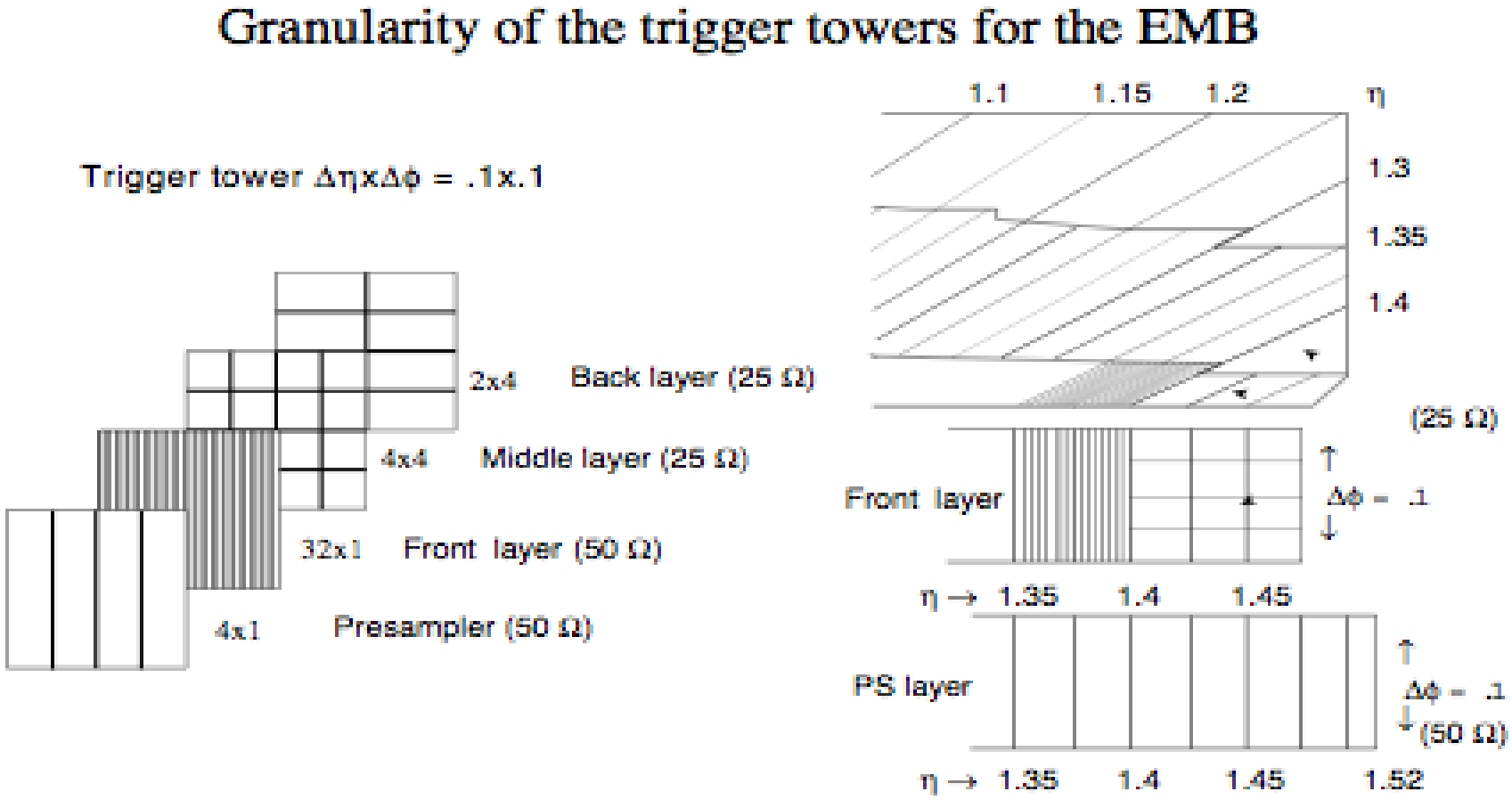
- Phase 2 timescale
  - Not expected before 2020?
  - Few years needed for prototyping, production, installation and commissioning
- What should we aim for?
  - System that (just) comfortably and reliably uses the limits of FPGA and link technology in about 2015?

Granularity

- Present L1Calo
  - Mainly based on 0.1*0.1 towers in both EM and hadronic
  - This is the hadronic layer granularity
  - But EM layer has much finer granularity – unused so far
- L1Calo Phase 2
  - Not much change in hadronic layer?
    - Would more depth samplings be useful?
    - Might anyway be worth separating Tile D cells (0.2*0.1 geometry)
  - Expect big (tenfold?) increase in EM data to phase 2 L1Calo
  - Roughly same calo:l1calo bandwidth for both layers
    - Perhaps between 3:1 and 5:1??
    - Same fraction of input/output fibres for all RODs EM and hadronic

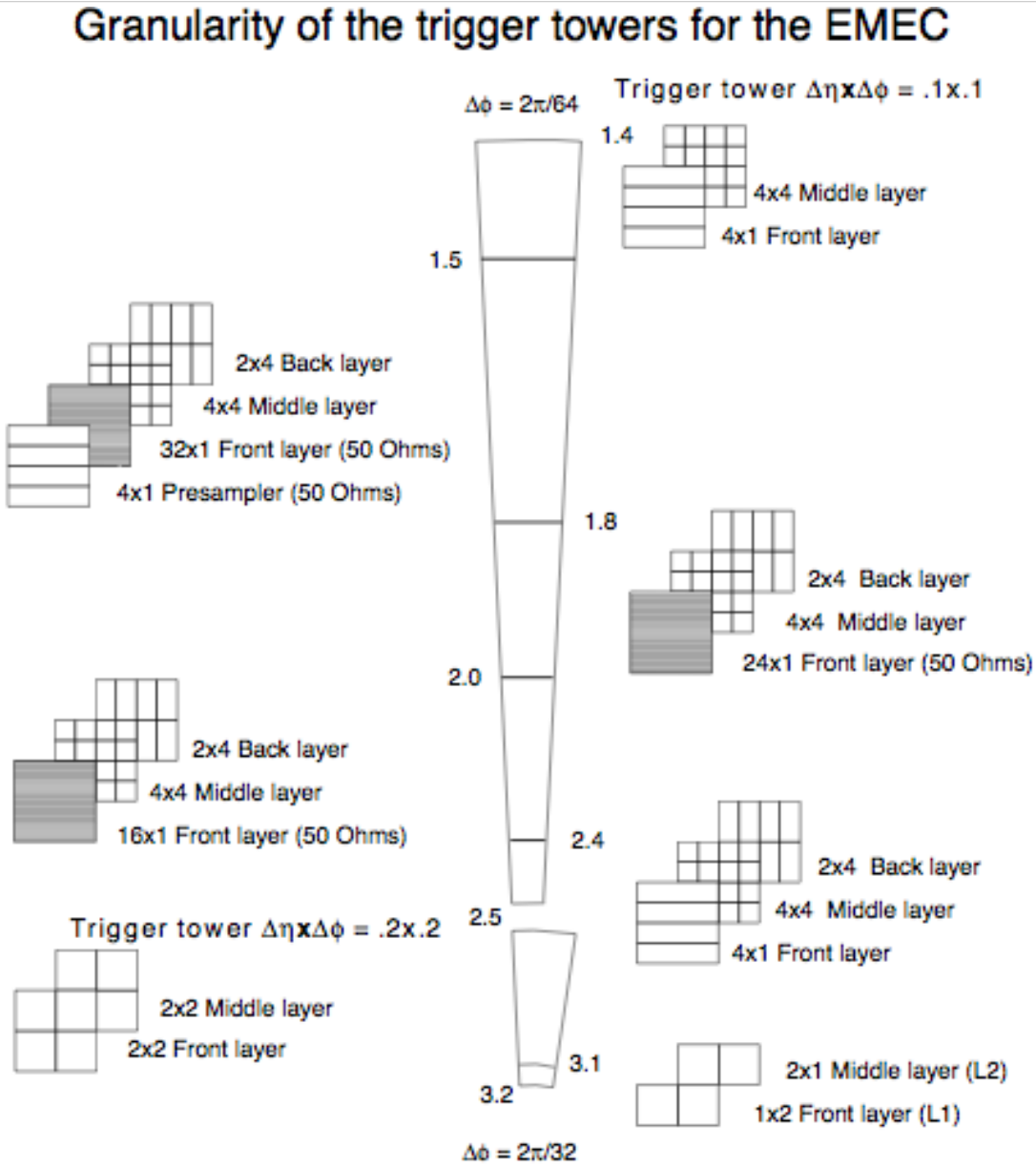
EM Barrel Geometry

- Each layer has a different geometry
  - Uniform in eta, except for barrel/endcap transition region



EM Endcap Geometries

- Seven different layouts between eta=1.4 and eta=3.2
- Many different ways cells are grouped into FEBs
  - Always(?) by layer
- NB two granularities in the EM barrel
- One in the FCAL
- (Plus similar in the hadronic layer)



Algorithms

- Basic sliding window with finer granularity
- Try to import good algorithms from present L2
- Best EM selection:
  - Look at ratio of 3*7 vs 7*7 middle layer cells
  - Simulation question: how does this degrade with granularity
    - Suppose we had sums of 2 middle cells + 1 matching back layer cell
    - Would have to look at 4*7 vs 8*7 cells
- Next best (for π0 rejection):
  - Look for fine structure (double peaks) in strip layer
  - This really needs the full granularity to be useful
    - Probably too much data to ship to L1Calo
    - Good candidate for more sophisticated ROD preprocessing?
  - Simulation/algorithm/firmware question: what would be the best way to process and transmit this information?

Link Bandwidths and FPGAs

- Links
  - CERN GBT link
    - 84 bits of payload data @ 40 MHz
  - Standard 6.4Gbit/s (linespeed) link
    - 128 bits of data @ 40 MHz
  - Future(?) 10Gbit/s link
    - Presumably around 200 bits @ 40 MHz?
- FPGAs
  - Latest FPGAs can handle 40 6.4Gbit/s links
    - Increased from 36 links in last years model
  - Might we have ~70 10Gbit/s links per FPGA in 2015?

Links to L0/L1Calo (1)

- EM layer:
  - Suggest one fibre per one (or two?) 0.1*0.1 towers
    - Economy model: around 60-100 bits per tower
    - Deluxe model: up to 200 bits per tower?
  - Contents to be decided later (and adjusted whenever)
    - Essential that all depth samplings arrive at the same ROD FPGA
    - Example:
      - Eight 8bit sums of 2 middle + 1 back layer (0.05*0.0125)
      - Two 8bit sums of PS + front layer (0.05*0.1)
      - For each sum, 1 bit pileup flag, 1 (or few) bits coordinate of max cells within the sum, n bits precise timing within 1 BC
      - Total around 100 bits
  - Maybe additional 1 fibre with low granularity (0.1*0.1) sums
  - Additional fibres per 0.4*0.2 with extra info for L1Topo??
    - Eg bitmap of strip layer hits for track matching?
    - Precise timing for z vertex and/or slow heavy exotic particles?

Links to L0/L1Calo (2)

- Hadronic layer:
  - Suggest one fibre per eight 0.1*0.1 towers
  - Allows 10-20 bits per tower depending on link speed
  - Good to (slightly) underuse the bandwidth
    - Need to cope with extra cells in overlap regions
    - Eg crack and gap scintillators
    - Tile and HEC cells in 1.4 to 1.6 region
    - Might have up to ten towers per link in places
- More compact in low granularity endcaps/FCAL?

ROD Outputs to L0/L1Calo?

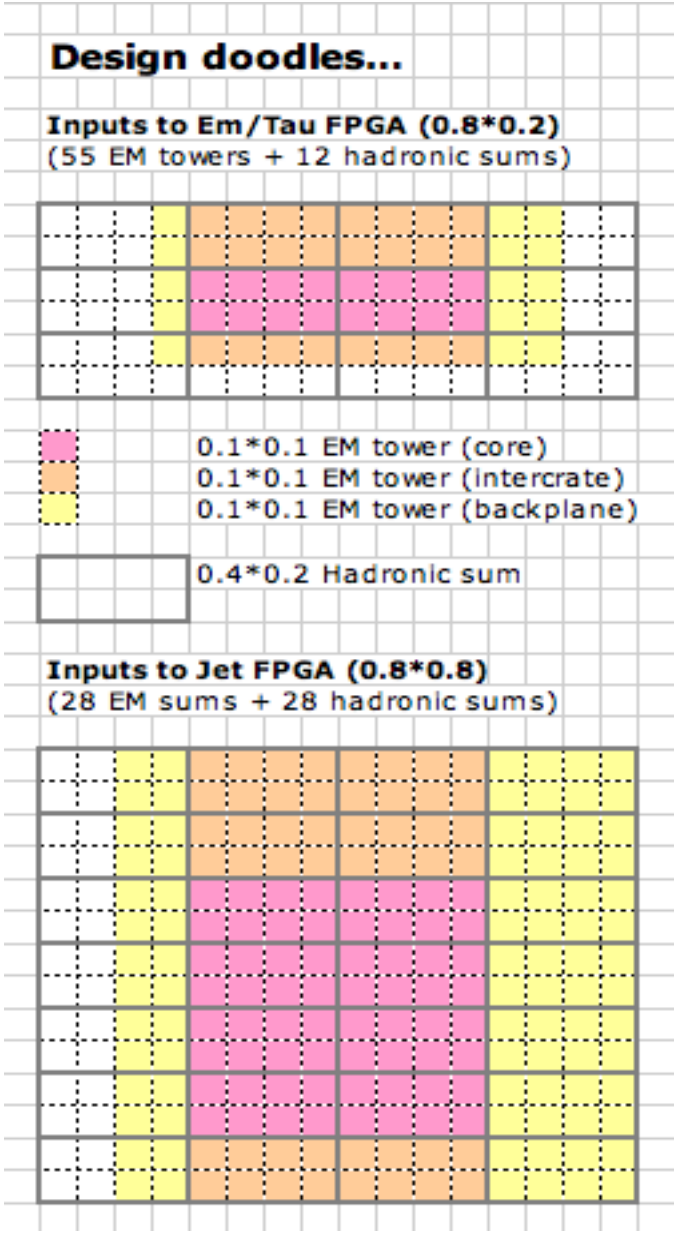
- EM layer
  - Probably four (or maybe two) SNAP12 bundles per ROD
    - One per mezzanine (or per two mezzanines)
    - Same for all eta, but RODs & links somewhat underused at high eta?
- Hadronic layer (HEC and Tile)
  - Depends on density of channels per ROD
  - For present Tile ROD, probably one SNAP12 bundle per ROD
    - Could have two or four as for EM RODs with higher density RODs

Inputs to L0/L1Calo

- One 0.4*0.2 area in eta*phi might have:
  - 8 (or 4) EM fibres covering one (or two) 0.1*0.1 tower each
  - 1 Hadronic fibre covering eight 0.1*0.1 towers
  - Perhaps additional 1 EM fibre with low granularity sums
    - Useful if Jet/Energy algorithms are in a separate FPGA
  - And maybe additional fibres per 0.4*0.2 area with extra information used only by L1 topological trigger (not for L0)
- Regroup to one SNAP12 with EM+Had fibres
- Optically duplicate each bundle at the same time
  - Intercrate fanout

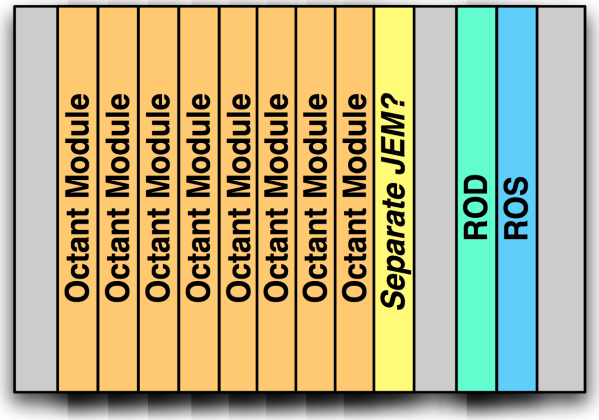
L1Calo Phase 2 Architecture? (1)

- Single processor module (0.8*0.8)
  - For all objects: EM, tau, jet
  - Maybe 4 TCA mezzanines like LAr ROD?
  - If so, could have one FPGA per 0.8*0.2
    - If we have one fibre per 0.1*0.1 tower:
    - 11*5 EM fibres plus 4*3 hadronic fibres
    - Separate FPGA (one per module) for jets?
      - Unless one 2015 FPGA handles lots more inputs?
    - Total of 88 0.1*0.1 fibres plus 2*28 0.4*0.2 sum fibres per module
    - Around 12 SNAP12 fibre bundles
    - About 1.5 Tbit/s total bandwidth per module
- Or could imagine separate JEM
  - One per octant crate covering all eta
    - Same module, different firmware?



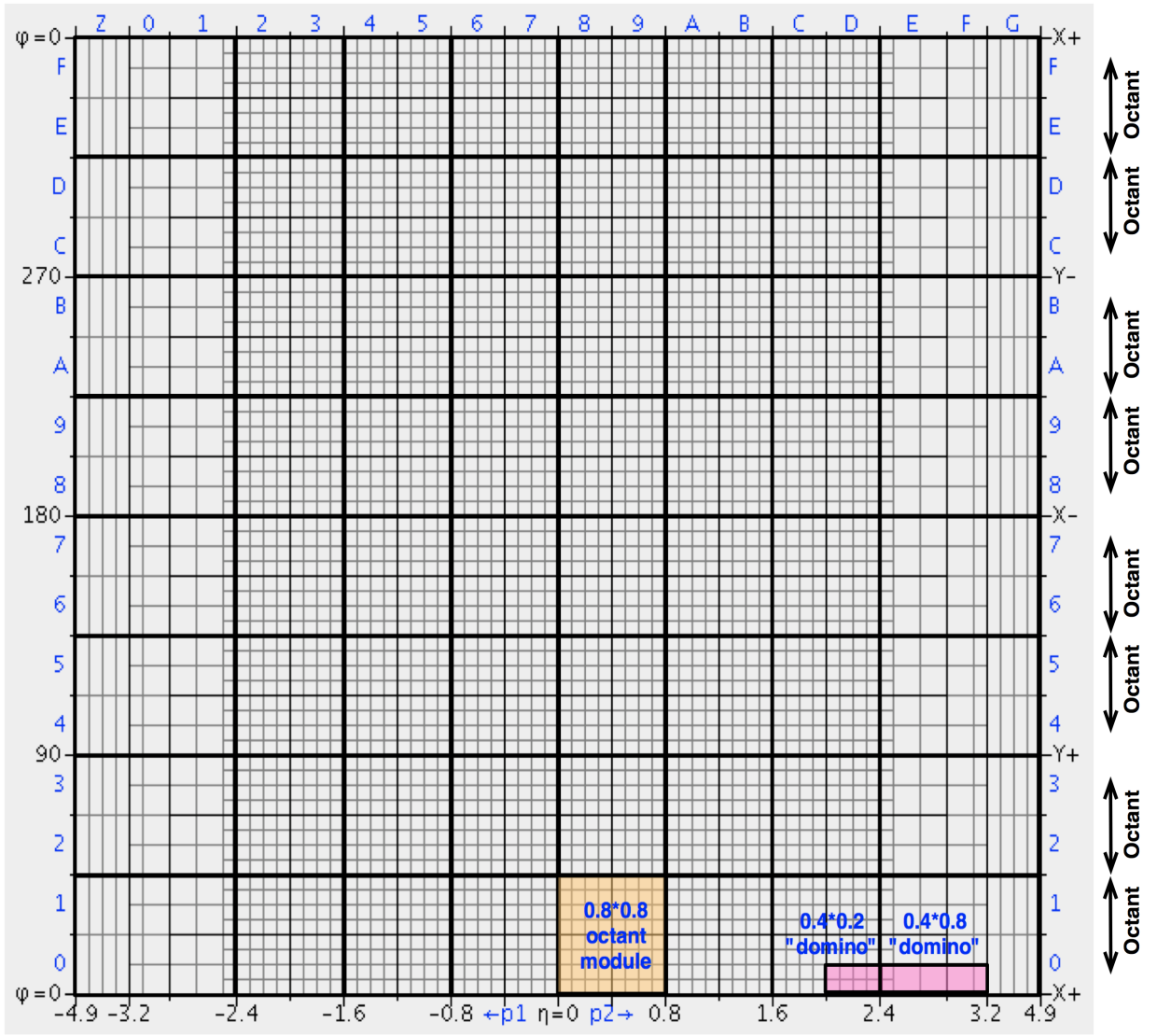
L1Calo Phase 2 Architecture? (2)

- Phi octant layout
  - Intercrate fanout from RODs, eta fanout via backplane
  - Output to global topological merger
  - ROD/ROS in same crates?



L1Calo ATCA crate? (One octant, all eta)

Phi octant architecture (one crate per octant)



0.1*0.1 tower grid

Summary

- Trying to get a rough L0/L1Calo design
  - Are our current thoughts reasonable?
- Suggesting rough bandwidth from RODs
  - Number of links per ROD
  - Organisation of RODs
    - Eg barrel/endcap overlap in LAr
    - Two phi bins in Tile ROD
- Need to propose granularity of L0/L1 sums
  - And any other preprocessing we would like