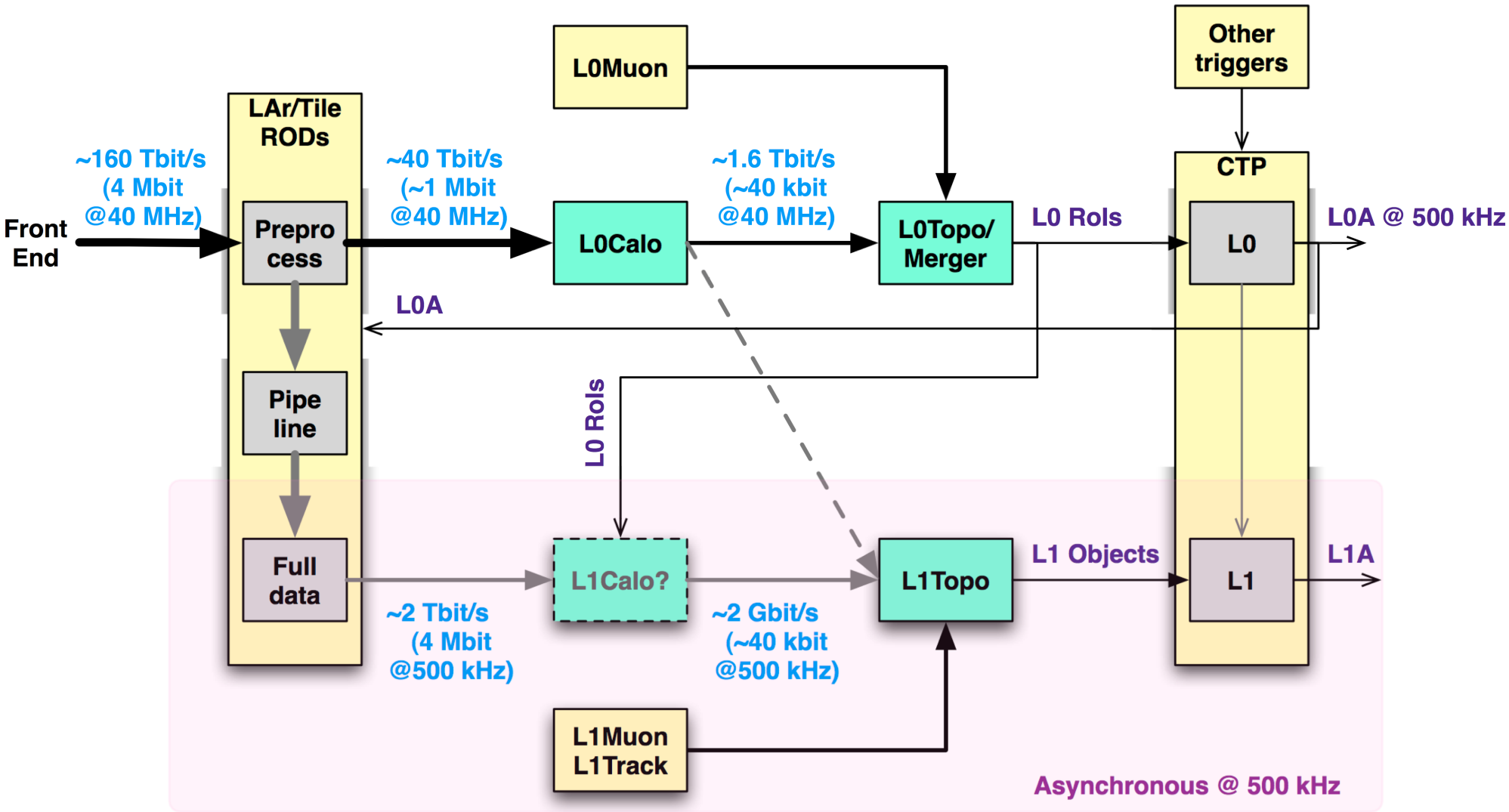
Phase2 Level-0 Calo Trigger

Murrough Landon
27 June 2011

- Phase 2 Overview: L0 and L1
- L0Calo Functionality
- Interfaces to calo RODs
- Interfaces to L0Topo

Baseline Phase 2 L1Calo Architecture



L0Calo Functionality

- Real time algorithms:
  - Find EM clusters, Tau/hadrons
    - Use fine granularity as much as possible to discriminate against QCD
  - Find jets
    - Ideally on the same module, but separate jet system is an option
    - Possibly larger size than at present, eg 1.2*1.2 in eta*phi?
  - Sum E, Et and missing Et components per L0Calo module
- Transmit results
  - EM/Tau/Jet RoIs and energy sums in real time to L0Topo
    - On L0A also send them to L1Track and L1Calo
- Readout
  - Buffer results for eventual L1A
    - Also send L0 readout to RODs for monitoring at L0?

L0Calo Algorithms

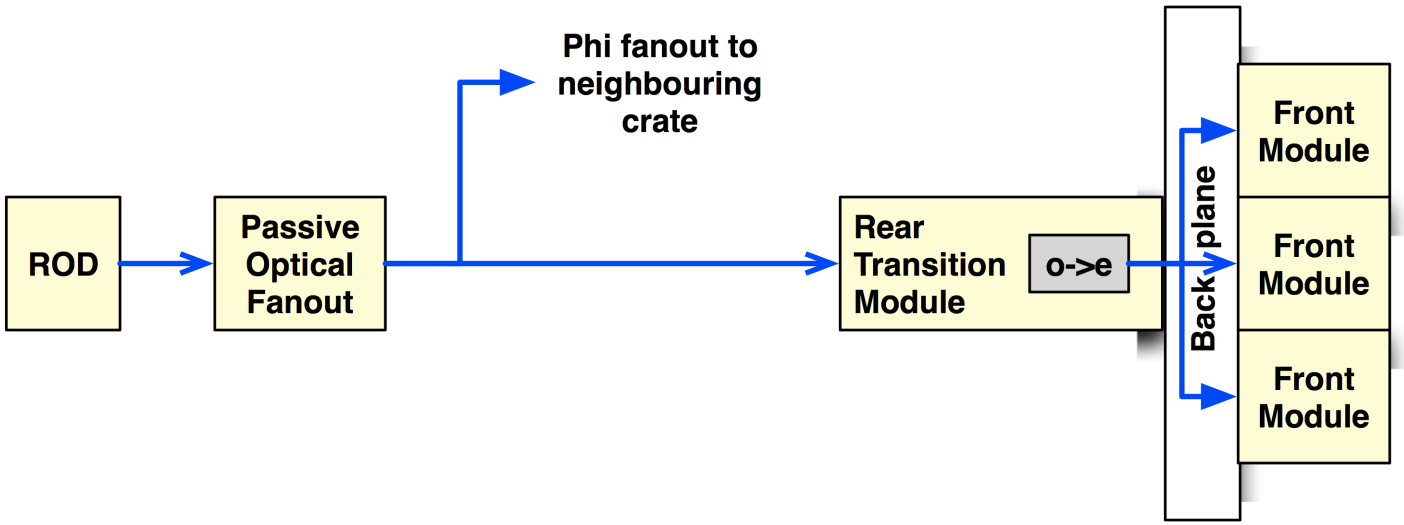
- Sliding windows, now with finer granularity
  - Limitations will be fanout and number of inputs per FPGA
    - Expect O(50) 10 Gb/s links into Virtex 7
- Adopt L2 EM/Tau ideas
  - L2 "R core": ratio of 3*7 to 7*7 LAr middle layer cells
    - L0Calo bandwidth might require middle layer cells summed in pairs
    - NB initial simulation results are disappointing for calo only trigger
- Investigating benefits of larger jet environment...
  - Present 0.8*0.8 eta*phi jets use 0.4*0.4 RoI maximum
    - Better to know if 0.8*0.8 area is a maximum within its environment
    - Problem: much larger fanout and more fibres per FPGA
    - Larger environment with 0.1 granularity may need separate jet system
    - Needs some simulation work...

L0Calo Components (1)

- Optical fanout and patch network
  - Fibres from calo RODs need to be duplicated/reorganised
    - Fanout across crate boundaries
    - Regroup fibres for optimum layout of L0Calo modules?
      - Merge EM and hadronic fibres in same eta*phi area to minimise crossing tracks
    - Separate L0 and L1 fibres from the same ROD
    - May need active components if passive fanout is not good enough
  - Significant component which needs some R&D work

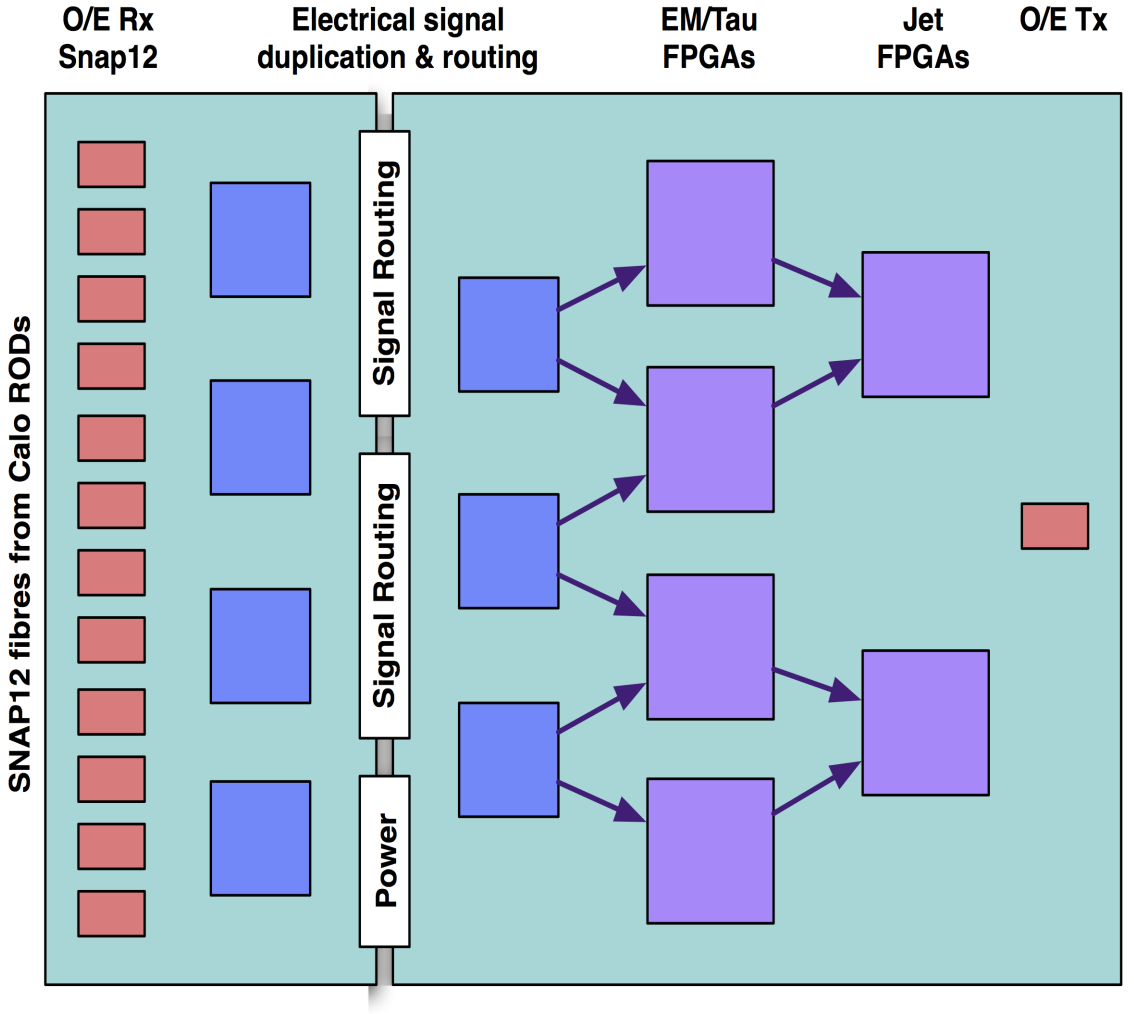
L0Calo Components (2)

- Rear transition modules
  - Optical receivers and fanout to adjacent L0Calo modules
    - Possible alternative: more optical and less electrical fanout
- Custom ATCA backplane
  - Transmission from RTMs to modules in same/next slots



L0Calo Components (3)

- L0Calo module (Sam)
  - Cover 0.4*1.6 eta*phi
    - Unless 0.8*0.8 shape better for fat jets?
  - Inputs via backplane
  - Find EM/Tau and Jet on same module
    - In separate FPGAs
    - Jet FPGAs resolve EM/Tau overlaps
    - Transmit combined RoIs to L0Topo
  - Four full ATCA crates
    - Or 8 for 0.8*0.8 option?



L0Calo Components (4)

- Auxiliary modules
  - Clock/trigger distribution ("TCM")
    - But may not be room for a dedicated module per crate
    - Distribute GBT signals directly to each module?
- Readout
  - L0 ROD to gather data for L0 accepted events
  - Local L0 event building to monitor trigger performance at L0?
  - Buffer data for readout to DAQ on L1A

LOCalo System

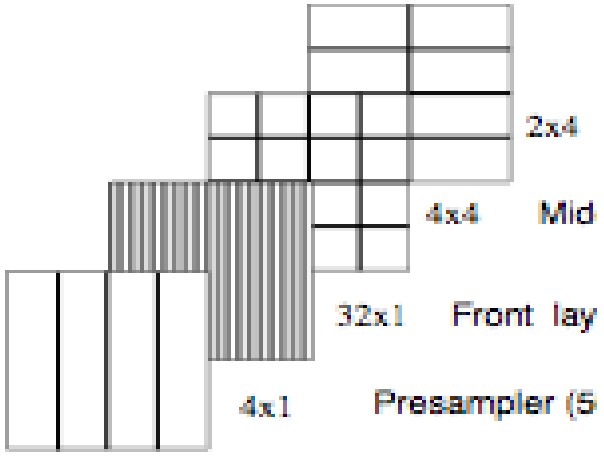
- Four full ATCA crates (14 or maybe 16 slots)
  - Each crate processes one quadrant in phi
  - Alternative with 0.8*0.8 modules uses 8 partly full crates
- Two (or four) racks
  - Plus same again for fibre empire?

Calo ROD – L0Calo Interface

- Calo Readout Driver (ROD) functions for L0Calo:
  - Derive calibrated Et from digitised pulses
    - No issues with analogue saturation
  - Assign Et to correct bunch crossing
  - Provide quality flags from optimal filter (pile up, etc)
  - Form sums of calorimeters cells into "mini towers"
    - Definition of mini towers (or "L0 primitives") to be defined
    - EM layer: both fine and coarse sums (for EM/Tau & Jet triggers)
  - Possibly run algorithms on cells within one ROD FPGA
    - Eg pi0 rejection using LAr EM strips
  - Transmit mini towers to L0Calo
  - Pipeline full data (for every cell) for use by L1 stage (& DAQ)

Calo ROD – L0Calo Links

- Baseline: 10 Gb/s links => 200 bits per bunch crossing
  - Assumes 25ns bunch crossings: half for 50ns LHC?
- Hadronic layer (and coarse EM sums for jet trigger):
  - One 10 Gb/s fibre link per 0.4*0.2 (or 0.2*0.4) in eta*phi
    - Can have finer eta*phi and depth granularity than now for jets
- EM layer fine granularity for EM/Tau algorithms:
  - One 10 Gb/s fibre link per 0.1*0.1 tower
    - 200 bits: more detail on eta, phi and depth
    - Concentrate bandwidth on middle layer?
      - Contains most of the energy
      - Heavily sum the strips layer



- Links to L1Calo
  - Originally said 1 fibre per 0.4*0.2 (LAr): but may need more!

LOCalo Inputs to LOTopo

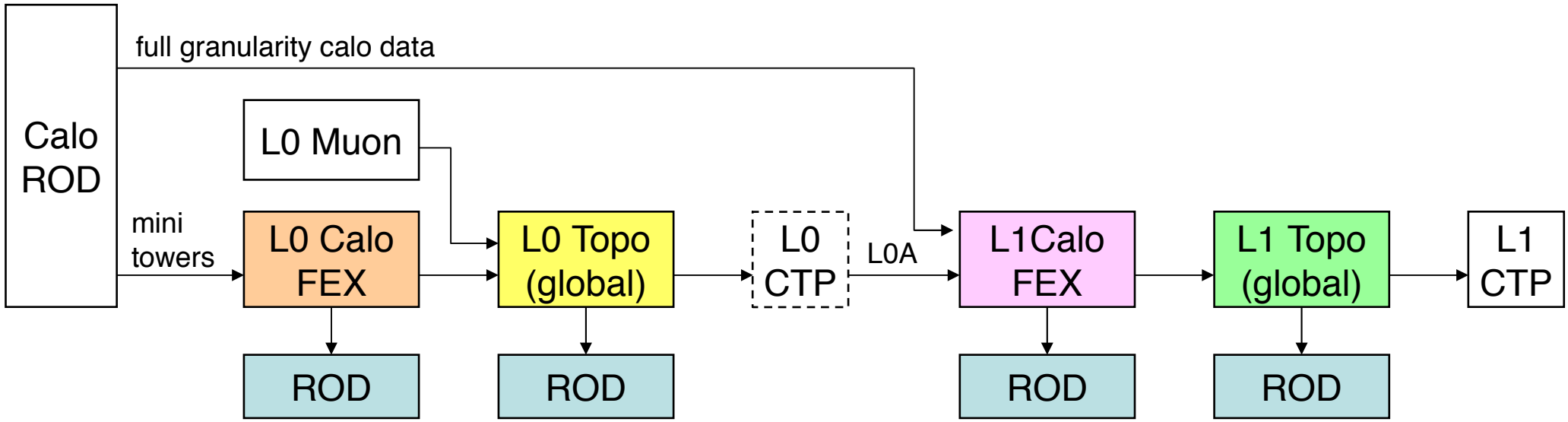
- One (or two) fibre(s) per LOCalo module
  - 200 (or 400) bits per 25ns bunch crossing
  - Perhaps 60-80 bits for Et, Ex, Ey, E
  - Leaves 120 (or 320) bits for RoI objects in 0.4*1.6 area
  - 25 bits per object => ~five (or twelve) RoIs per LOCalo module
    - Five RoIs may be a bit tight, twelve seems luxurious
    - 64 (or 128) inputs per LOTopo FPGA might be OK (or is too much)
- Suggestion: separate objects from sums
  - One (underused) fibre for Et, Ex, Ey, E
    - Processed in dedicated LOTopo FPGA
  - Second fibre for about eight EM/Tau/Jet RoIs

LOTopo Implementation & Algorithms

- Implementation much like phase 1 proposals?
  - Few modules in (part of) one ATCA crate
  - All (or most) fibres duplicated to each module
    - But different modules may run different sets of algorithms
    - All energy sum fibres to one module? Results via backplane
    - 64 LOCalo RoI fibres plus muon fibres may be too much for one FPGA
- Algorithms
  - Also similar to phase 1
    - Benefitting from greater precision in eta, phi and Et
    - Though EM/Tau overlaps with Jets hopefully removed at LOCalo
    - Scope for additional algorithms...
      - Possible benefit in having total E for use in missing Et algorithms?

R&D Work

- Already designing ATCA demonstrators for phase 1
- More demonstrators being planned
  - Study PCB simulation: really understand high speed links
  - Tests needed for optical fanout and patching
- Medium term: build up "slice" of full phase 2 system



Points of Attention

- Calo ROD – L0Calo links: bandwidth and organisation
  - Changes have major impact on ROD and L0Calo organisation
  - Status of LAr LOCs6?
  - Impact of increasing eta*phi space of "jet" fibres
  - What if (when?) LHC irrevocably decides for 50ns bunches
  - Need to recheck required bandwidth to L1Calo
- Usefulness (or not) of fine granularity
  - More simulation and/or new algorithm ideas
    - Keep high granularity L0Calo as preferred option in case of surprises
- Implications of larger jets
- R&D programme, timescale, division of labour...