



# CMX → L1 Topo Data Formats

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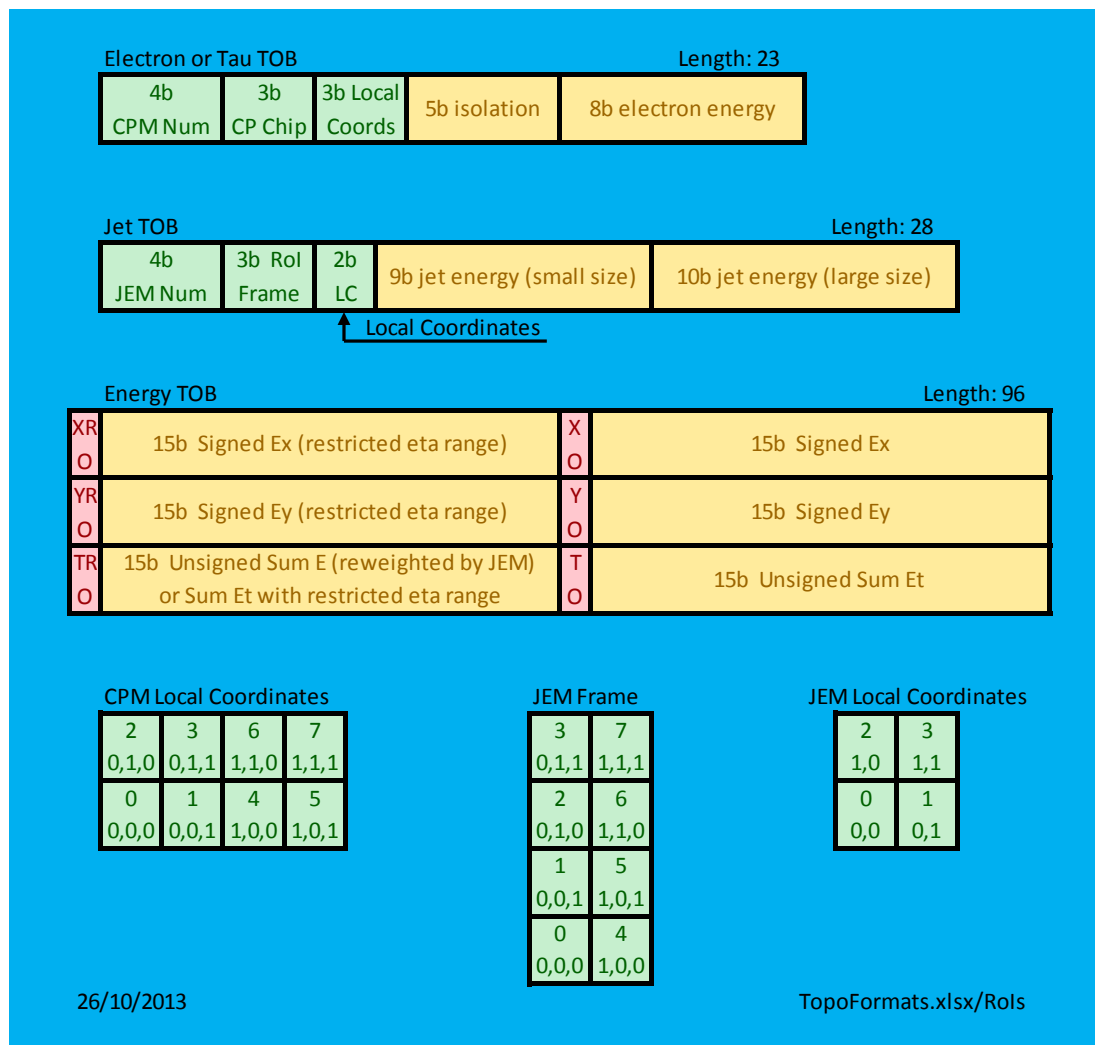
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# Introduction

- Past Developments
  - TOB formats specified by Stephen Hillier
  - Discussions prior and during Birmingham 2013 meeting
  - Specific requests:
    - include CRC
    - Subtick
    - Portion of BCID
  - Agreement to prepare a document describing the CMX-> Topo protocol
    - [https://twiki.cern.ch/twiki/bin/viewauth/Atlas/L1CaloUpgrade#New\\_data\\_transfer\\_and\\_readout\\_fo](https://twiki.cern.ch/twiki/bin/viewauth/Atlas/L1CaloUpgrade#New_data_transfer_and_readout_fo)
    - Would like to finalize the format/protocol

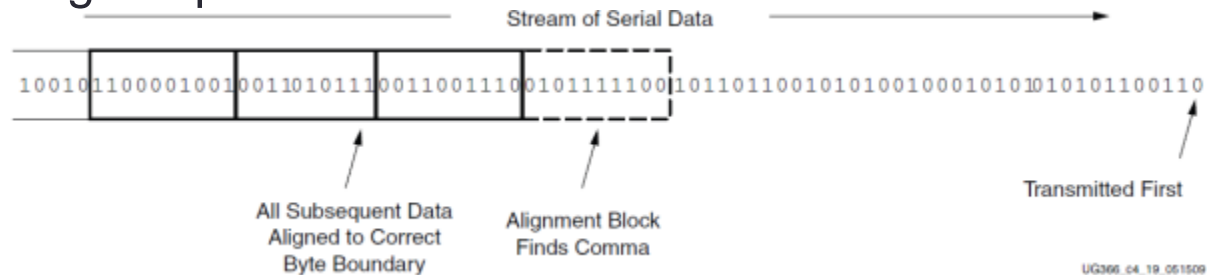
# TOB formats

- Removed the Overflow bit from Jet and EM TOBs



# 8b/10b crash course

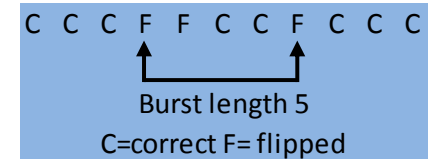
- Each of 256 data 8bit 'characters' encoded into 10 bit word
  - Two 10 bit words for each 8b character:
    - 'Running Disparity' + or –
      - Five of each, or 4 and 6, or 6 and 4 of 0s and 1s
      - DC balancing, gain control
    - Maximum 'run length' of same bit value is 5
      - Clock Data Recovery
- Additional 'K' characters for control provided
  - Should send a specific agreed K character for byte alignment at beginning of operation



- In our case: send in specific 'subtick' – fixing the event frame
- Also send BCID or send only on specific BCID to sync channels
- Good idea to keep sending periodically to detect and recover from errors

# 8b/10b 'built in' error checking

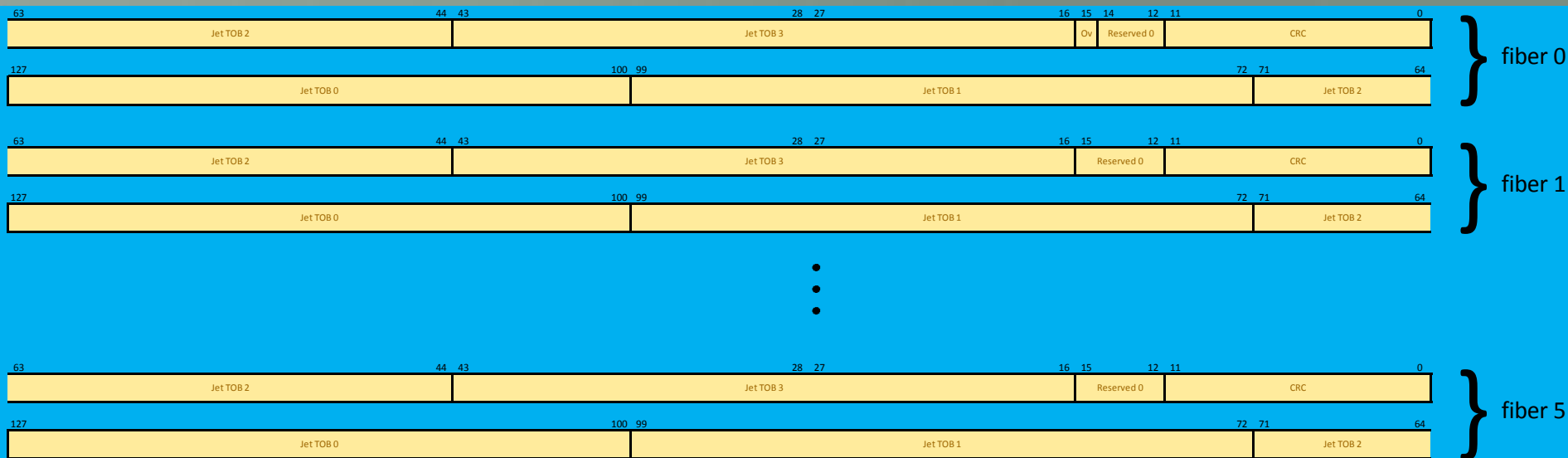
- 10b character must be in the table – error flagged otherwise by RX
- RX tracks RD and flags errors
- But: 36% of single bit flips result in a valid 10b character with correct RD
- But But: in serial communication burst errors common
  - 55% of length 2 bursts, 26% length 10 bursts result in valid, correct RD characters
- Because of decoding, errors may be manifested as longer bursts in decoded data
  - e.g. 10b corruption: 111010011 -> 111001011 8b corruption: 01100001 -> 00001110



# CRC crash course

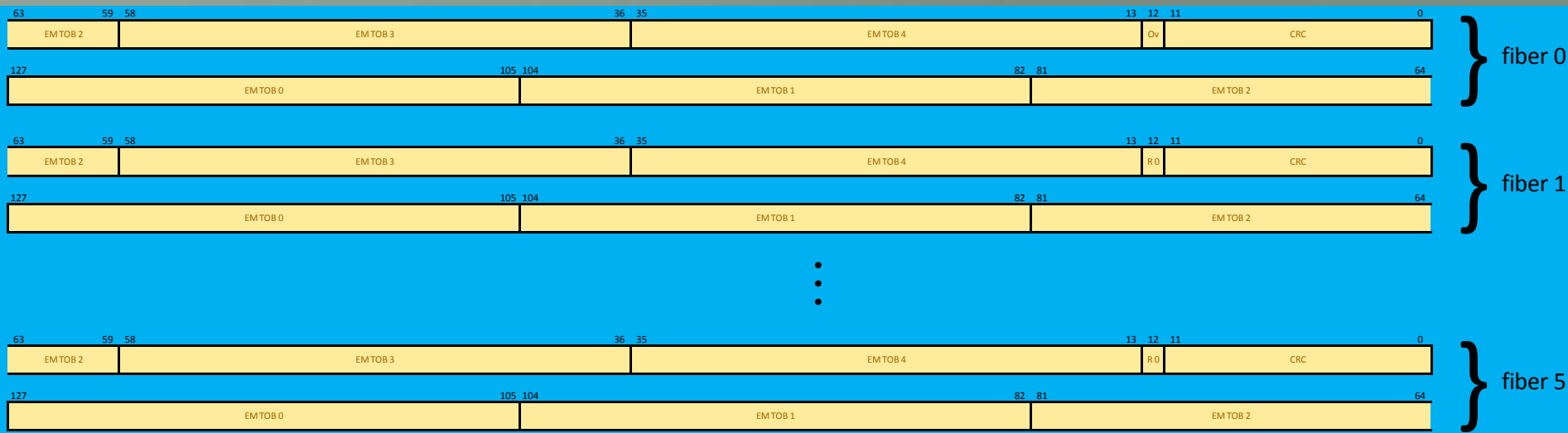
- Cyclic Redundancy Check:
  - a remainder from polynomial division of the 'message' by the 'generator polynomial'
- Properties:
  - Choice of generator poly important!
  - If you choose well:
    - All errors with odd number of bit flips caught
    - All error bursts up to the length of the check value caught
  - More complicated errors will be caught with high probability depending on the choice of the generator poly
    - Longer the CRC the higher the probabilities
  - To catch all single bit errors in serial data we need length 5
  - To catch all bursts confined to single word we need length 8
  - Papers written on generator poly choice
- Calculation
  - In 'old' systems performed serially on bit level
  - Can be parallelized to operate on chunks of input data at cost of memory
  - To minimize latency on TX side attach check value after 'message'
  - One 'subtick' latency cost; small DRAM use
- CMX: in all types at least 12 bits left over on fiber – use them for CRC
  - All errors with two bits flipped (in 8b data) caught
  - >99.9% of four and six arbitrary bit flips caught
  - >99.9% of burst errors of length up to 32 caught

# Proposed Jet TOB packing



- Front load Jet TOBs onto fibers
  - E.g. if 3 TOBs are present TOB 0 on fiber 0,1 and 2 will be present rest->0
- Most significant words sent first 127-112 then 111-96...

# Proposed EM/Tau TOB packing

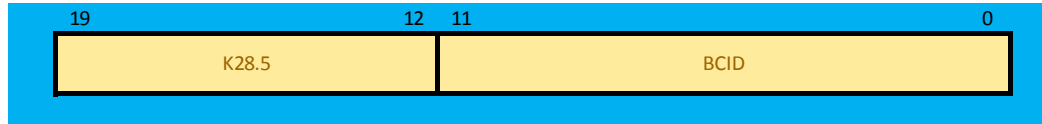


- Same front-loading and transmission order



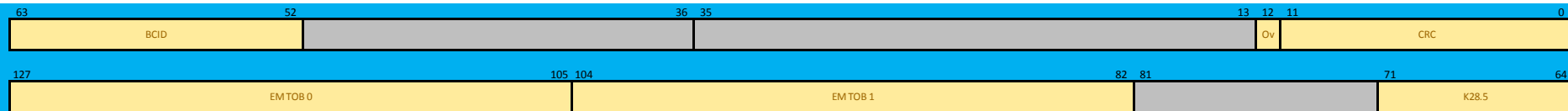
# Alignment information splicing

Alignment word:



- If only Jet/EM TOBs 0 and 1 present replace bits 71 to 52 by the alignment word

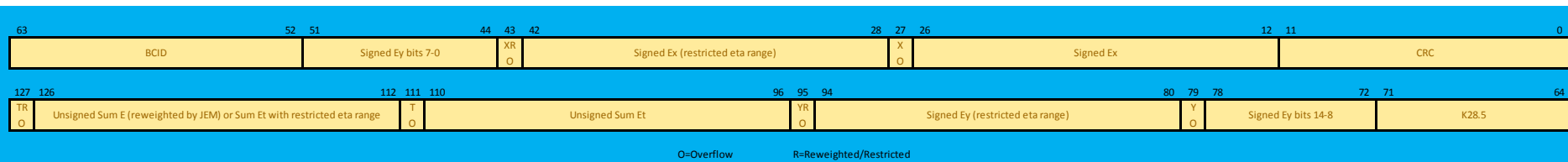
Example for EM fiber:



- K28.5 provides byte alignment and flagging re-framing problem
- K28.5 placement always on byte 8 provides event-frame lock and verification
  - No subtick counter necessary
- BCID inclusion provides intra-fiber alignment and verification

# Energy TOB

- 1 fiber sufficient
- Alignment word always present



# Conclusions

- Format and protocol transmitting all required physics payload
- Byte alignment, event alignment and inter-fiber alignment data provided
- Robust error detection provided
- Small resource and latency cost