Motivation
- From 2021: software-only high level trigger (HLT)
- Significant computing challenge
- Potential option: use GPUs

R&D standalone project: Allen
- Run full first stage of HLT (HLT1) on GPUs
- Process thousands of events in parallel
- Exploit data-parallelism within events
- One GPU has to process 30/60 k events/s

Data flow
- Event builder
- Raw data
- Selection decisions
- Raw data is decoded on the GPU

Summary
- First project running a full HLT on GPUs for a HEP experiment
- All decoding, clustering and tracking algorithms are implemented in CUDA
- The current status of full Velo, primary vertices, full UT and SciFi decoding runs on a V100 at 112 kHz

Infrastructure of Allen:
- Custom memory manager for GPU memory
- Static scheduler
- Physics performance checks

Tasks of Allen:
- Run full HLT1 chain
- Reduce data rate by factor 30 based on single and two-track selections

Motor
LHCb Upgrade Trigger Diagram
30 MeV miss elastic rate (full rate event building)
Software High Level Trigger
Full event reconstruction, inclusive and exclusive kinematical geometric selections
Buffer events to disk, perform online detector calibration and alignment
Add offline precision particle identification and track quality information to selections. Output full event information for inclusive triggers, trigger candidates and related primary vertices for exclusive triggers
10.0 GB/s to storage

1. Velo: Pixel detector, 26 planes
- Masked clustering
- Find cluster seeds
- Load only neighbouring pixels of a seed, use 8 bit mask to find cluster

SciFi: 12 planes of 2 \times 2.5 \text{ m} long scintillating fibre arrays
- Pattern recognition
- Extrapolate Velo tracks to SciFi planes with a parametrisation for the magnetic field deflection
- Challenge: single fibre efficiency \(-96\%

4. Ut: Strip detector, 4 planes
- Pattern recognition
- Extrapolate Velo tracks to the UT planes, define search windows
- Form 3-/4-hit tracks
- Obtain momentum estimate from ch2-fit

3. Ut: Strip detector, 4 planes
- Pattern recognition
- Extrapolate Velo tracks to the UT planes, define search windows
- obtains momentum estimate from ch2-fit

2. Primary vertex finding
- Extrapolate Velo tracks to beamline, find 2 position of track
- Fill histogram with z positions
- Find peaks in histogram → seeds
- Vertex fit using weight

Kalman filter
- Use single precision
- Parameterise transport in magnetic field
- Run w/o smoother

Muon ID
- Extrapolate SciFi tracks to muon stations, find closest hits
- Decide if track originates from a muon
- Work in progress