Specification and Simulation of a High-Energy Physics Experiment

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Outline

- Motivations
- Modelling and Simulation Tool
- ALICE DAQ Specification
- Simulation Results
- Simulation Performances

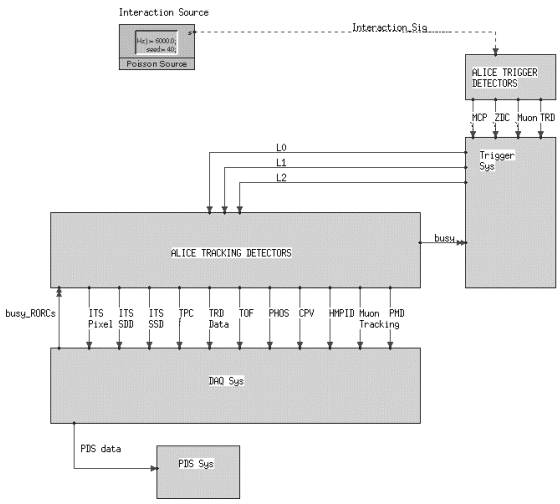
Motivations

- Significant Modifications of ALICE DAQ
  - New requirements, New architecture
- Verify Foreseen System
  - Help designers unambiguously define the system
  - Discover errors (input/output, performance, behavioural)
  - Confirm/Improve the design and the performances
  - Determine critical parameters
- Explore Other Options
  - Change sub-systems and observe new behaviours
  - Change parameters

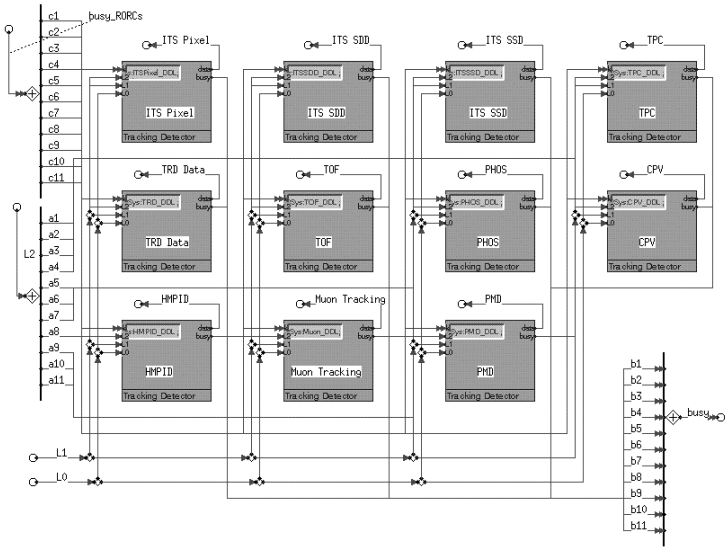
Modelling and Simulation Tool

- Foresight (Foresight Systems, Inc.)
  - System level modelling and simulation tool
  - Performances evaluation
- Specification
  - Data Flow Diagrams (event-driven processes, events, control flows)
  - State Transition Diagrams
  - Mini-Specs
  - Real-time Parameters

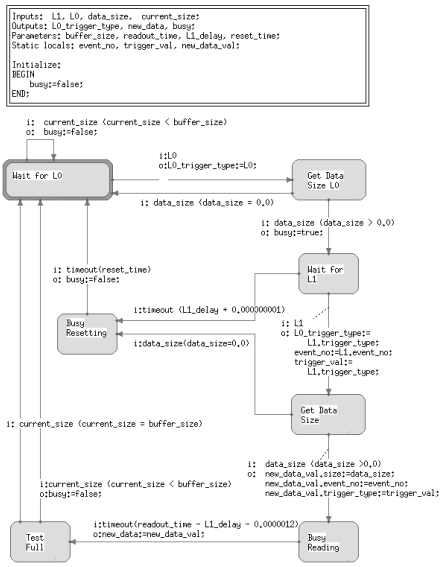
Specification: Overall Architecture



Specification: Tracking Detectors



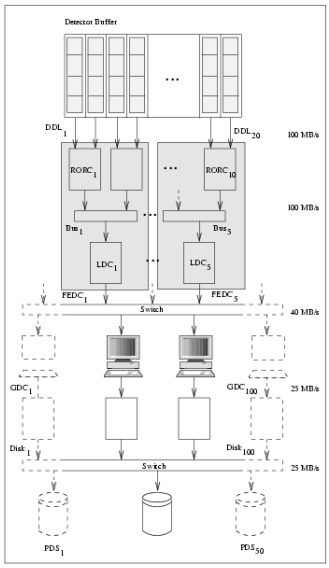
State Machine and Mini-Spec



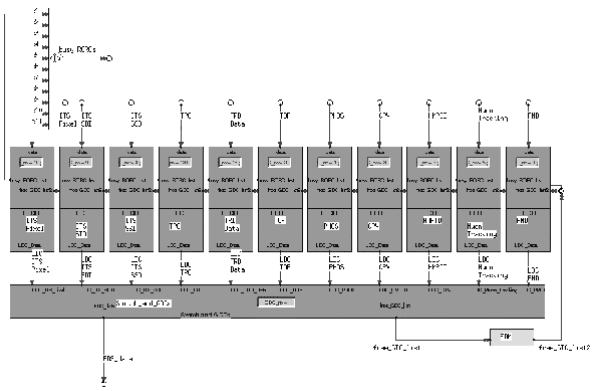

```
Inputs:  data;
Outputs:  bandwidth_rate;
Static locals: total_data_size;

Initialize:
BEGIN
    total_data_size:=0.0;
END;

Procedure:
BEGIN
    total_data_size:=total_data_size + data.data_type.size;
    bandwidth_rate:=total_data_size/gettime();
END;
```


DAQ Sub-System

- Detectors Buffer: 4 positions
- 397 DDLs: 100 Mbytes/s
- 299 RORCs: Size: 12 Mbytes
- 240 Bus: 100 Mbytes/s
- 240 LDCs: Size: 128 Mbytes
  - Sub-event building
- 100 GDCs: Size: 512Mbytes
  - Event Building
- 100 Disks: Files of 1 Gbytes
- 25 PDS: Infinite Buffer



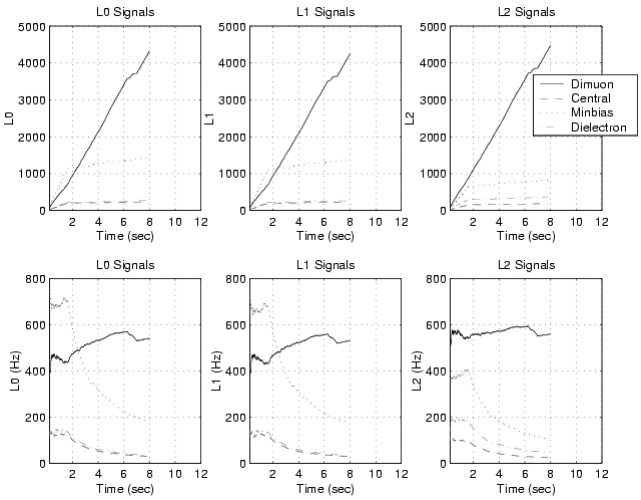
DAQ Sub-System



Results

- 12 Detectors
  - Trigger Signals
  - Buffer Occupancies
  - Bandwidth Rates
  - Event Building Rates
- New Trigger Algorithm

Trigger Signals



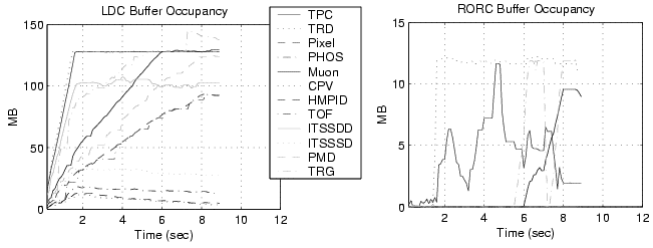
Dimuon: 0.57 MB / 4 Detectors

Central: 87MB / 8 Detectors

Minbias: 87 MB / All

Dielectron: 5MB / All

LDCs - RORCs

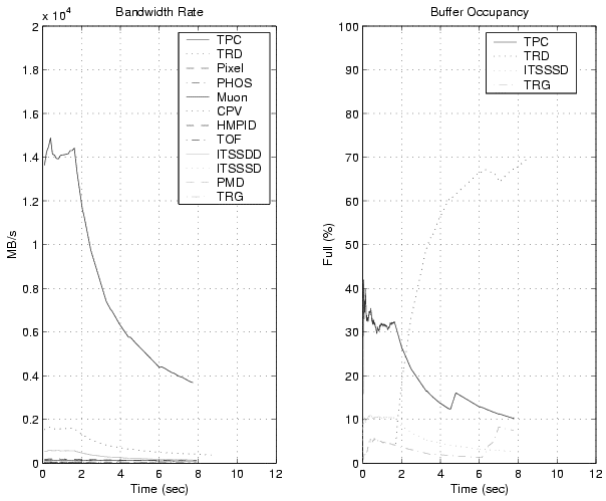


TRD limits Central, Minbias and Dielectron Events

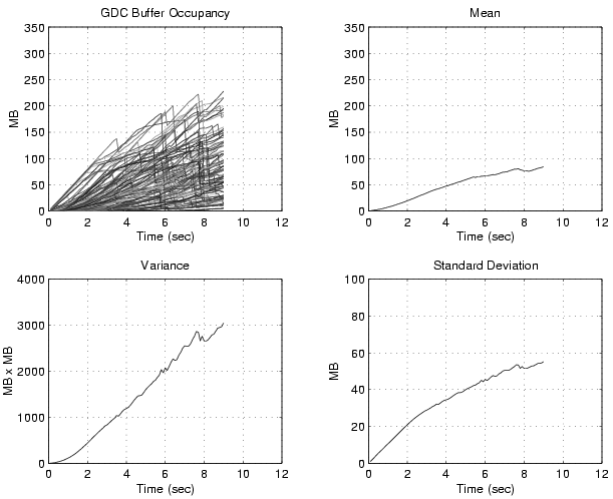
TRG limits Dimuon Events

(1 DDL, 0.12MB for Central events, 50 slots Multi-Event buffer)

Detectors Buffer occupancy



GDCs Buffer Occupancy

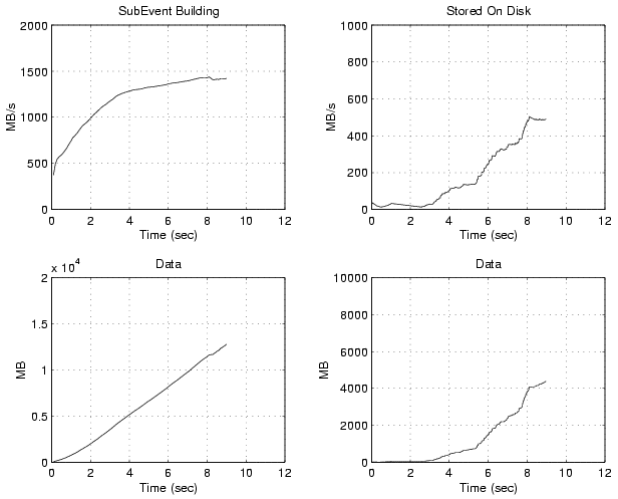


GDCs are unequally filled

Mean = 80MB

Deviation = 55MB

Event Building



Event Building = 1.5GB/s

Expected = 4GB/s

Disk Storage = 500MB/s

Expected: 1.25GB/s

Too Slow !

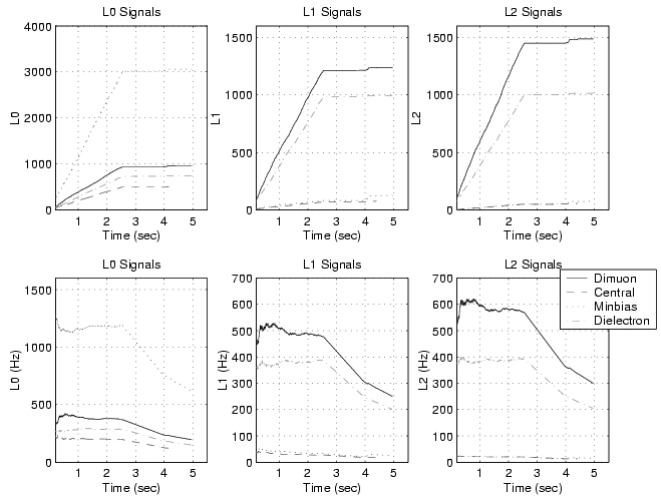
Reason:

Transfer Algorithm

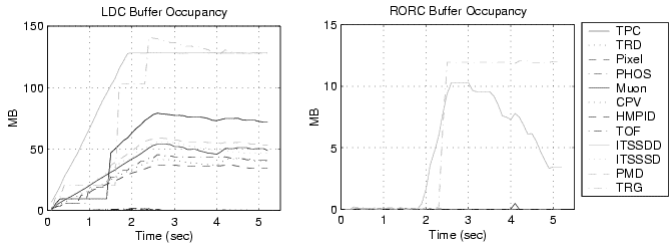
from LDCs to GDCs

New Trigger / Trigger Signals

L1 limits Central and Minbias Events, if L2 > 20 Hz



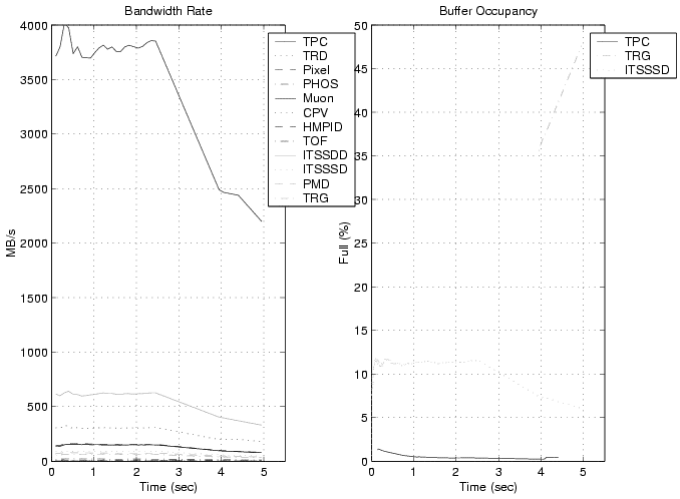
New Trigger / LDCs - RORCs



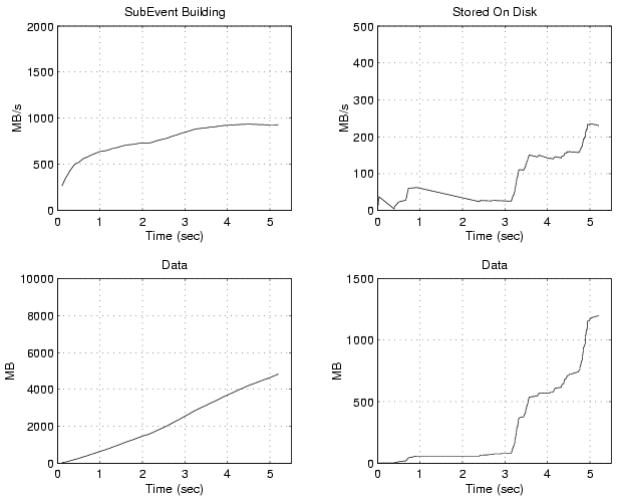
TRG limits Dimuon Events

Are TRG parameters correctly evaluated ?

New Trigger / Buffer occupancy



Event Building



Event Building = 1.0GB/s

Expected = 4GB/s

Disk Storage = 300MB/s

Expected: 1.25GB/s

Still Too Slow !

Summary of Trigger Signals

12 Detectors

L2 (Hz)	1.5s	6s	9s
Central	95	27	20
Dimuon	544	591	497
Dielectron	181	56	41
Minbias	400	127	93

New Trigger

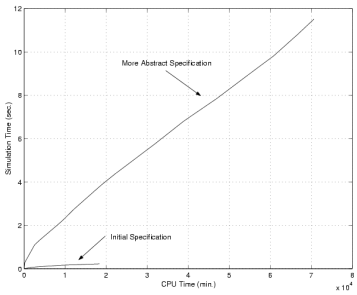
L2 (Hz)	2.5s	5s
Central	20	10
Dimuon	570	284
Dielectron	392	194
Minbias	20	15

Expected

L2 (Hz)	
Central	20
Dimuon	650
Dielectron	200
Minbias	20

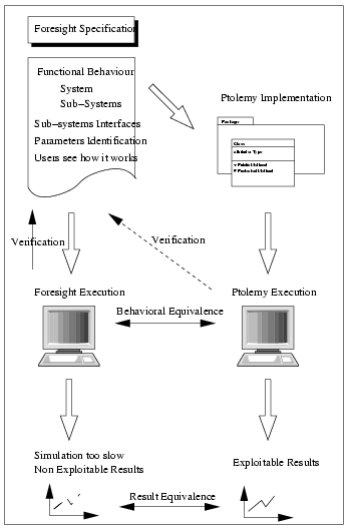
Simulation Performances

- Initial Specification
  - 12 days CPU time => 0.3sec
- Abstract Specification
  - More Abstract Internal Behaviour
  - Equivalent Observable Behaviour
  - Flows vehicle several data instead of one
  - New way of sending data to GDCs
  - Removal of Global Variables
  - (0.3s -> 18000mins) vs
    (0.3s -> 191mins) => ~95 times faster
  - Still Too Slow



Approach Adopted

- Foresight specification
  - functional behaviour of system
  - functional behaviour of sub-systems
  - interfaces definition
  - parameters identification/value
  - execution of specification
  - valuable document
- Ptolemy implementation
  - equivalent simulation
  - considered correct implementation of specification
  - exploitable results



Conclusion

- New Improvement
  - Impossible without changing observable behaviour
- Formal Specification / Tool
  - Good for Definition and Documentation
  - Simple Systems: Good for simulation
  - Complex system: Bad for long term simulation
  - Plot visualization during simulation
  - Resume Simulation