JÜLICH
FORSCHUNGSZENTRUM

FairMQ with FPGAs and GPUs

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Message Queues

- The FairRoot analysis framework uses message queues for data exchange between different computing tasks and processes
- Asynchronous communication protocol
  (i.e. receiver not necessarily active while sending of data)
- Not received data is saved in a FIFO (first in, first out) like structure
- Message queue benefits:
  - Processes are independent from each other
  - Datapaths between processes can be easily changed and adjusted
  - Work can be spread over several processes on different hosts

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FairMQ

- FairMQ: Abstract transport layer in FairRoot to use message queues, at the moment ZeroMQ and NanoMSG supported
- Base class: FairDevice
- Supported patterns: push-pull and pub-sub
- Documentation + examples: *https://github.com/FairRootGroup/FairRoot/tree/dev/example/Tutorial3/macro*
- Further information about FairMQ:
  M. Al-Turany et al.
  Extending the FairRoot framework to allow for simulation and reconstruction of free streaming data
  DOI: 10.1088/1742-6596/513/2/022001

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Integration of FairMQ

Integration of FairMQ into external projects:

1. Integration into Jülich Digital Readout System for ASICs (JDRS)
   - Analyze data from ASIC prototypes with FairRoot
   - Create datapaths with FairMQ for saving and monitoring of data stream
2. Use GPU as high performance processor for FairRoot
   - As work towards GPU-based online reconstruction
     - Understanding & evaluation algorithms
     - Possible data transport layer for actual experiment
   - Possible application in offline analysis

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ZeroMQ

- *ZeroMQ is a high-performance asynchronous messaging library aimed at use in scalable distributed or concurrent applications.*
- Open source lightweight messaging system, designed for high throughput and low latency scenarios
- Usable in inter-thread, inter-process and inter-node communication
- Bindings (interfaces) to use ZeroMQ available in more than 30 languages
- For further Information: *http://zguide.zeromq.org/*

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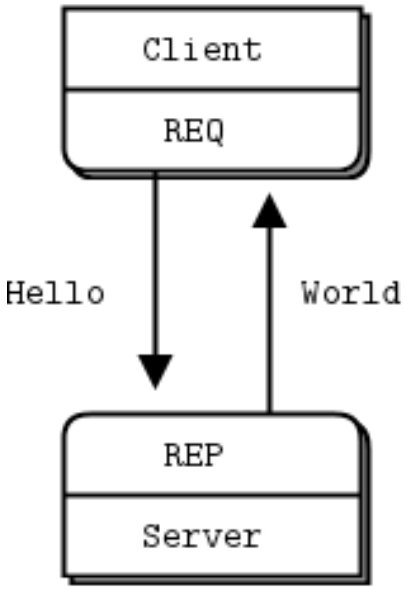
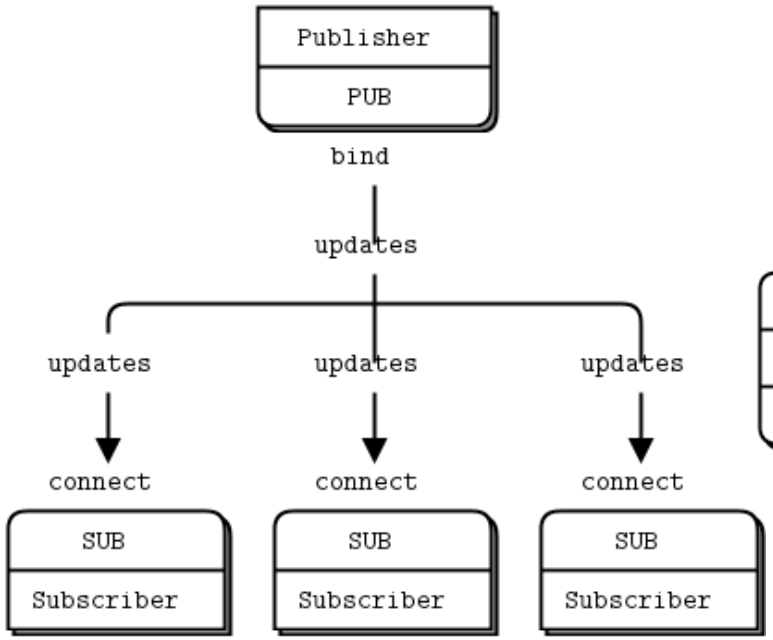
ZeroMQ Patterns

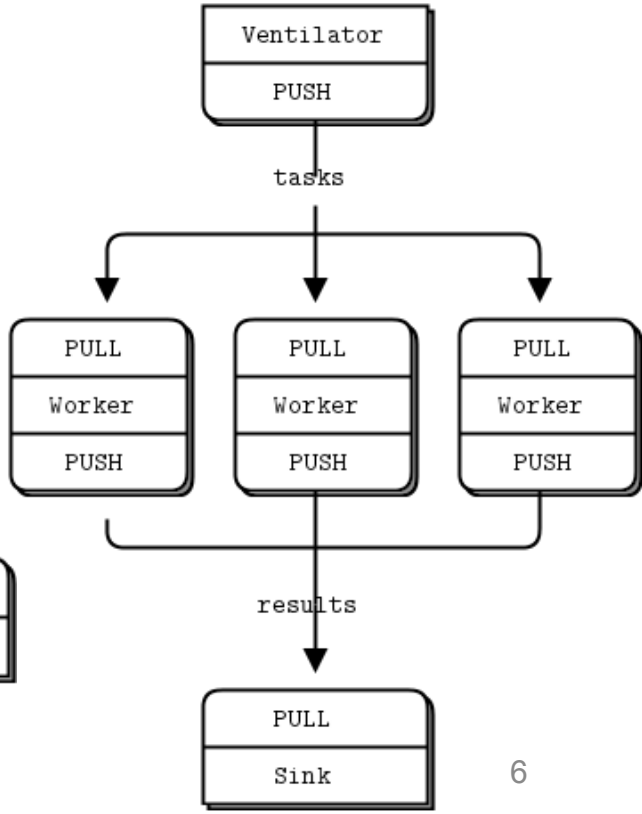
Request-Reply



Publisher-Subscriber
(distribution of data)



Push-Pull
(distribution of load)



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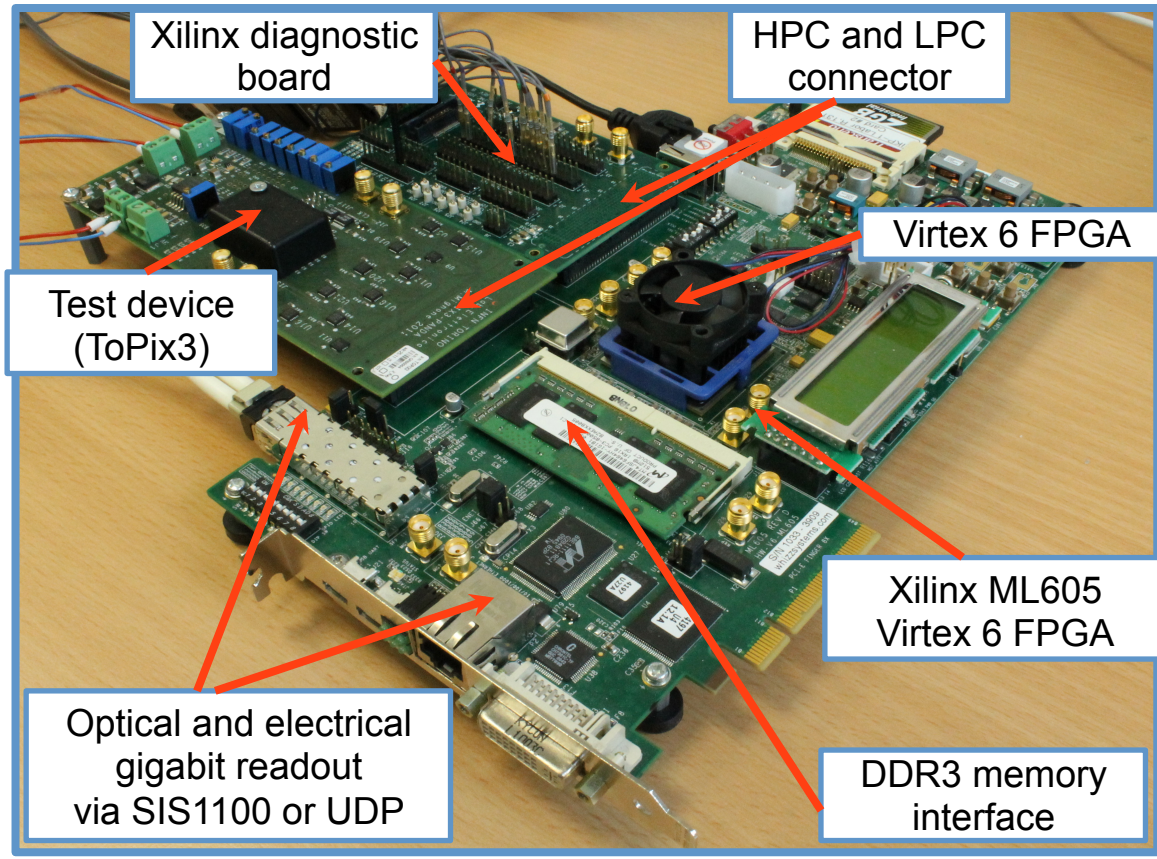
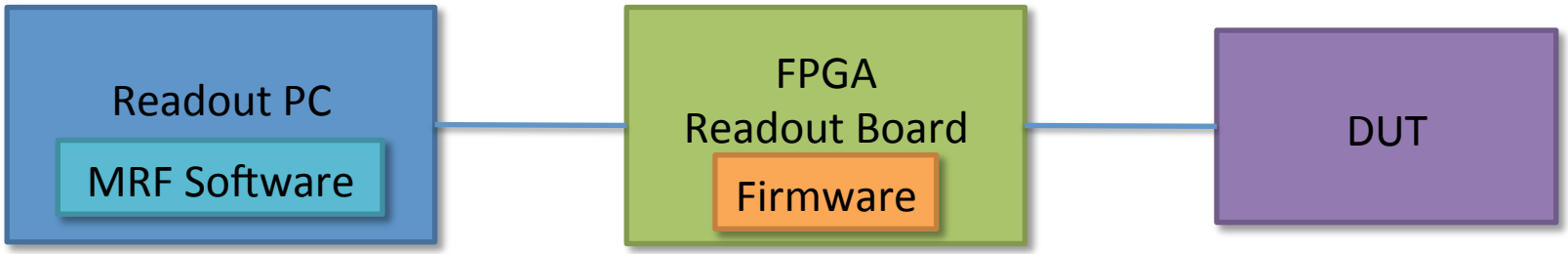
Jülich Digital Readout System

- Readout system for front end ASIC development
- One system to characterize different ASICs
- Requirements:
  - Fast for high data rates,
  - flexible for different kinds of ASICs
  - easy adoptable





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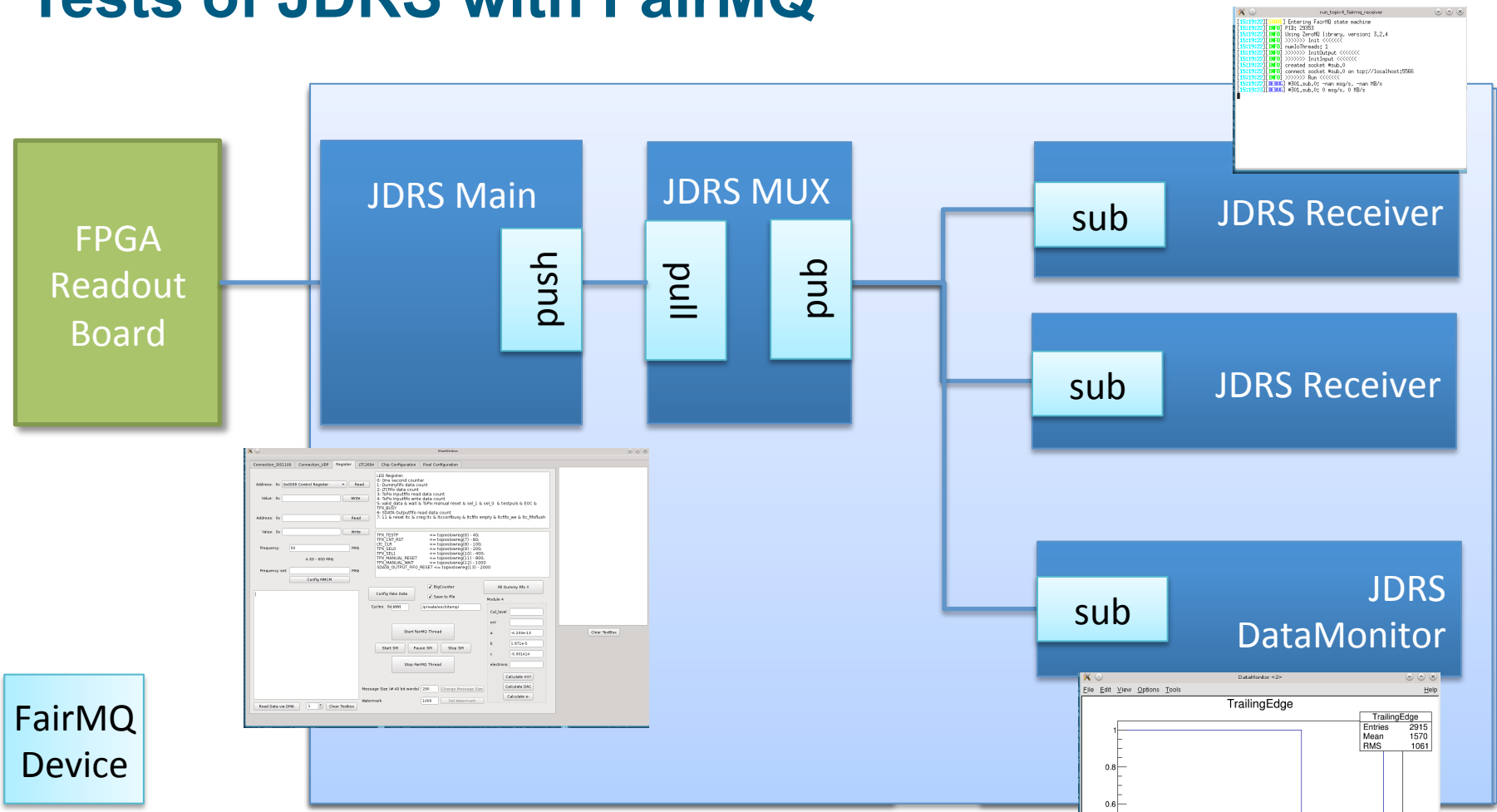
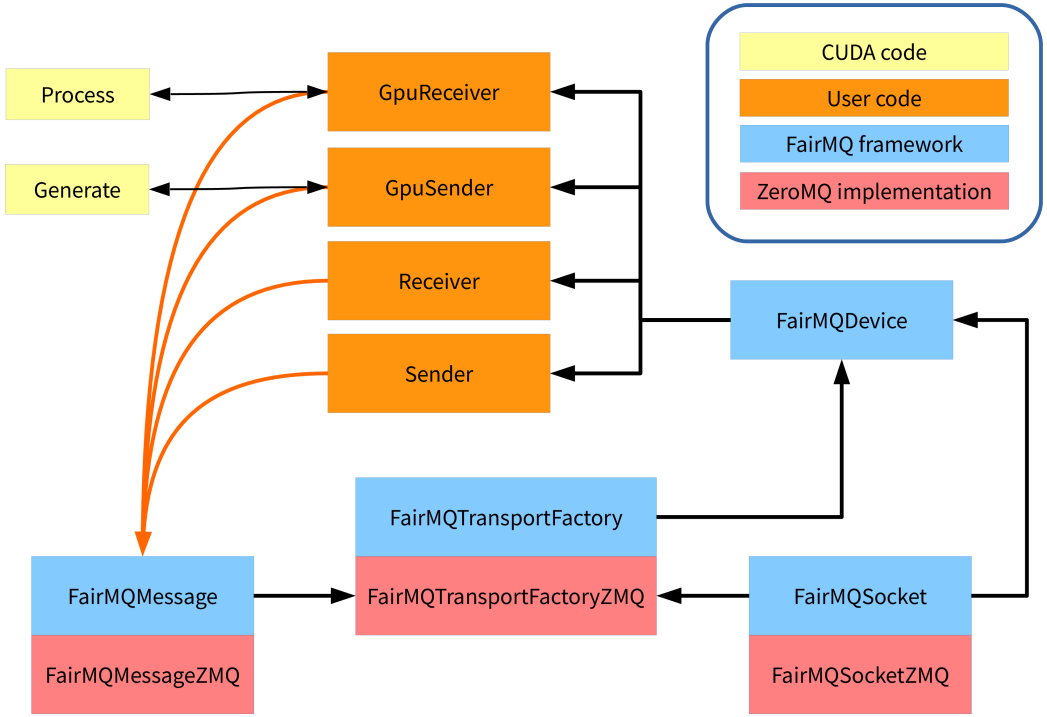
Tests of JDRS with FairMQ



GPU Online Analysis

- Sender/Receiver: create/read message over transport factory
- GpuSender: creates message, calls Generate on GPU to create test data payload
- GpuReceiver: reads message, calls Process on GPU to perform operations on test data payload
- Generate: cuRAND RNG
- Process: x^2, sqrt(x), check difference



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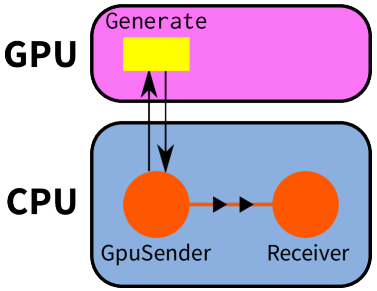
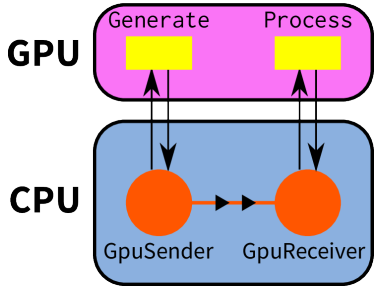
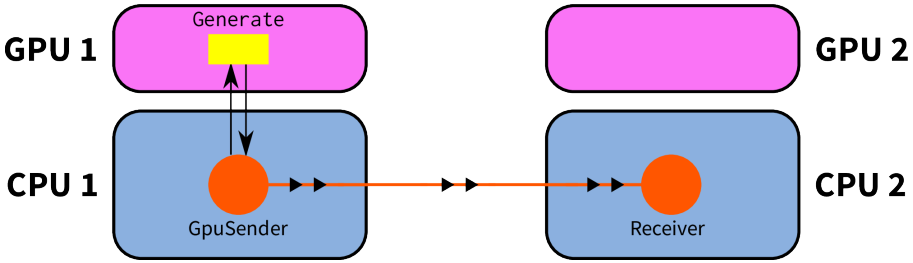
Test Configuration



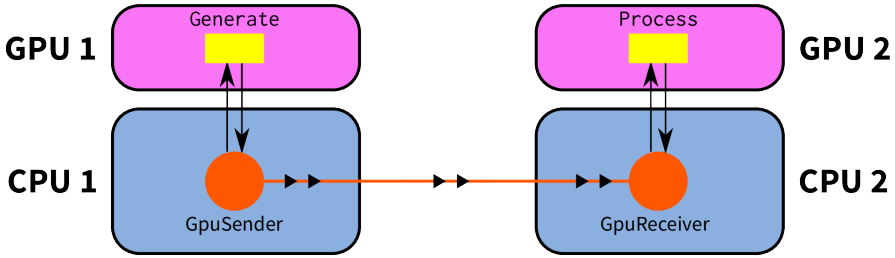
GpuSender to Receiver



GpuSender to GpuReceiver



GpuSender to Receiver



GpuSender to GpuReceiver

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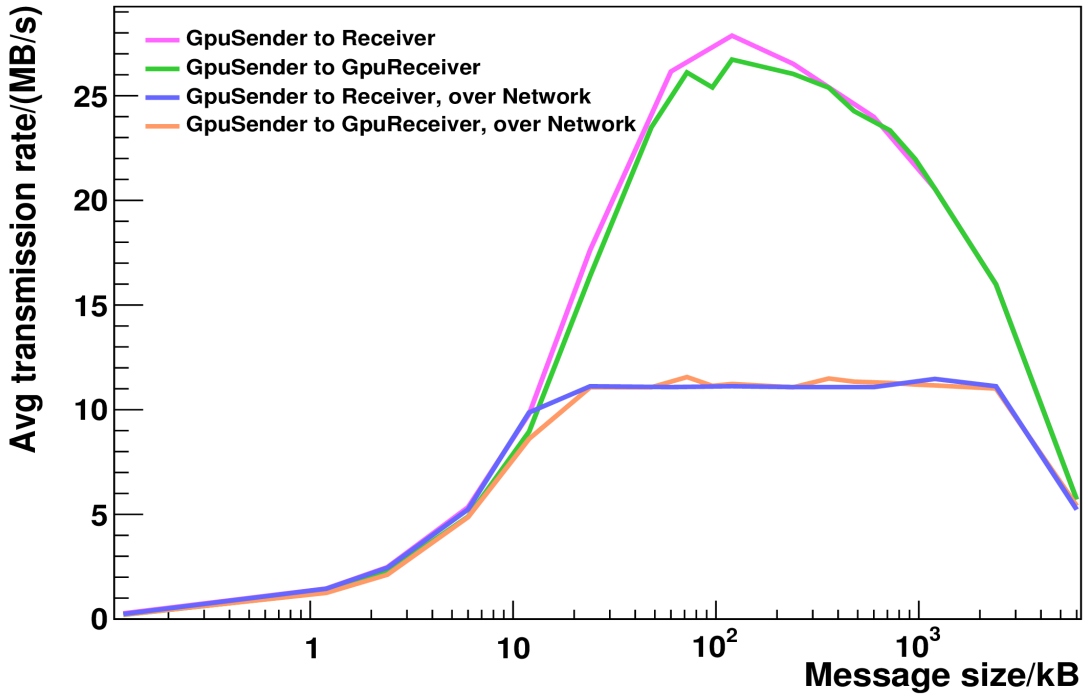
Test Results



- Study response of data generation and transmission chain:
- analyze transmission rate as a function of the number of events
- for different configurations
- Performance of transmission over network limited by available bandwidth

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Summary

- FairRoot uses message queues for inter-process and/or inter-host communication, FairMQ
- JDRS and GPU have been interfaced with FairMQ transport layer
- Planned to use for ToPix4 testbeam in October 2014
- Performance tests an optimization for GPU online analysis are ongoing

Thank you for your attention

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Dankeschön

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