RD51 COLLABORATION

April 2013 mini week

SRS FOR THE NEXT-100 DETECTOR: SCALING UP FROM NEXT-DEMO

J. Toledo

The NEXT Collaboration

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NEXT's experimental area in Canfranc

AGENDA

SUMMARY OF NEXT-DEMO FE & DAQ

FROM NEXT-DEMO TO NEXT-100

- PMT plane upgrade for NEXT-100
- Tracking plane upgrade for NEXT-100
- The trigger system remains the same…

THE ONLINE SYSTEM

- Online system in NEXT-DEMO
- DAQ PC farm for NEXT-100

SUMMARY

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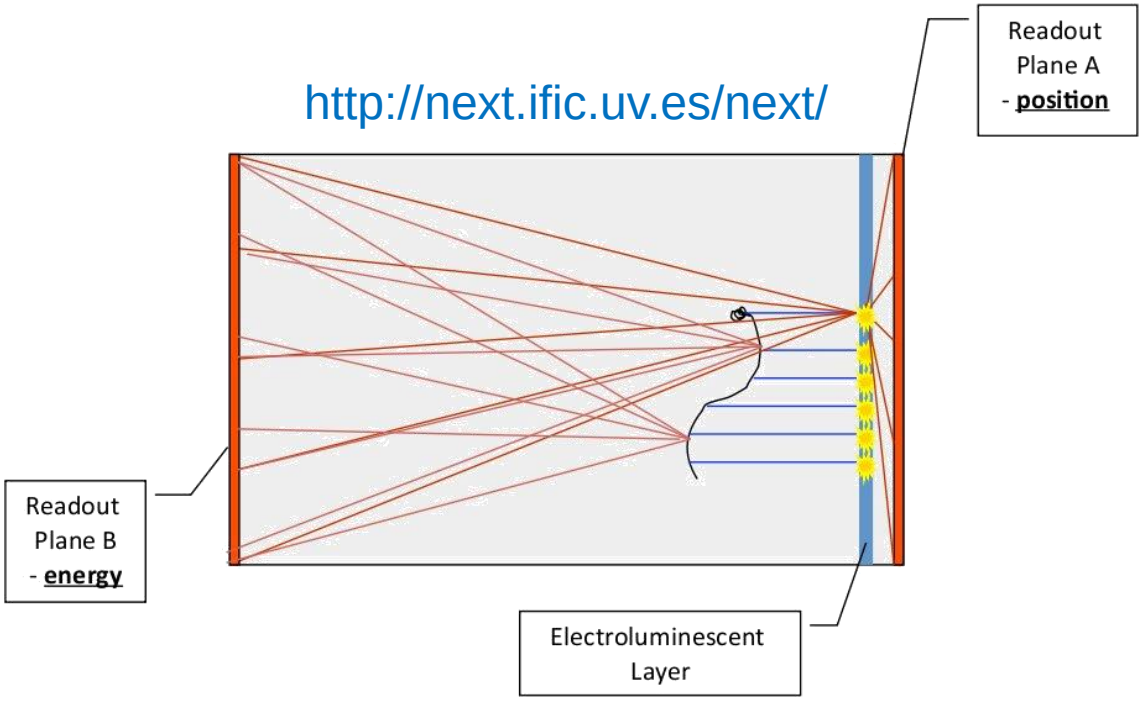
Summary of NEXT-DEMO FE&DAQ

In order for NEXT to be competitive with the new generation of 0nuBB experiments, we need energy resolution < 1%, very low background (~ 10^-4 counts/(keV kg y)) and large target mass.

NEXT optimizes energy resolution by using electroluminescent amplification (EL), which provides a large yield of photons as a signal; it is compact, as the Xe gas is under high pressure; and it allows the measurement of the topological signature of the event to further reduce the background contamination.

On the tracking side, we'll make use of SiPMs coated with a suitable wavelength shifter, while radiopure photomultipliers will be installed for the measurement of the energy and the primary scintillation needed to estimate the t0.

http://next.ific.uv.es/next/



Summary of NEXT-DEMO FE&DAQ

NEXT-DEMO TPC at IFIC, Valencia, with SRS readout

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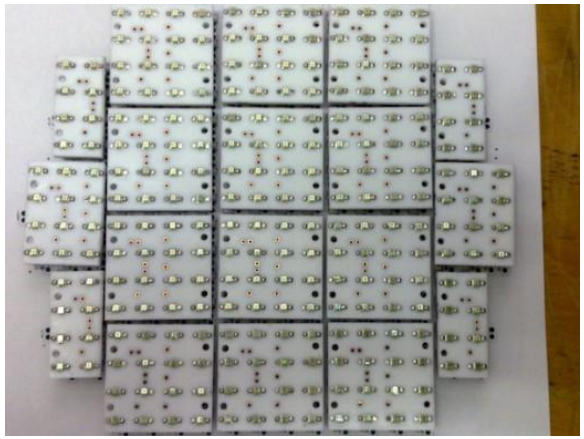
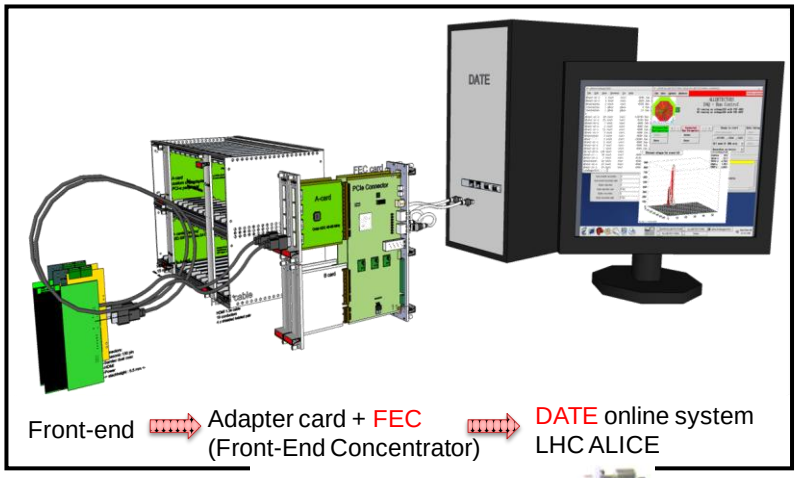
Summary of NEXT-DEMO FE&DAQ

Readout chain for a 248-ch SiPM plane



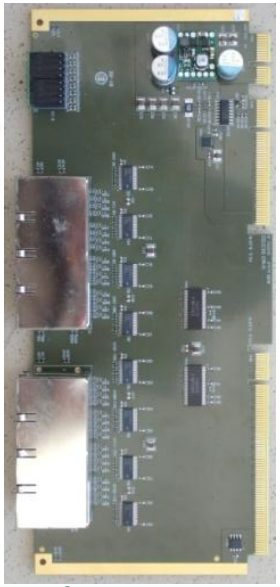


16x SiPM-FE boards

CAT6 cable

Data

Clock, trigger, cmd



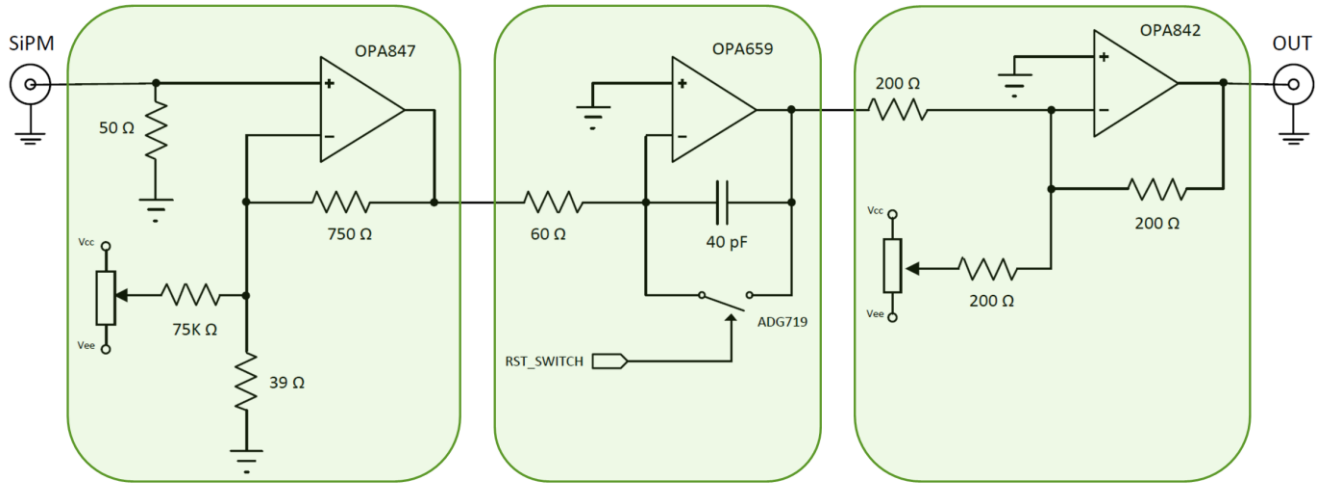
2x DTC adapter cards

2x FECs

2x GbE

Summary of NEXT-DEMO FE&DAQ

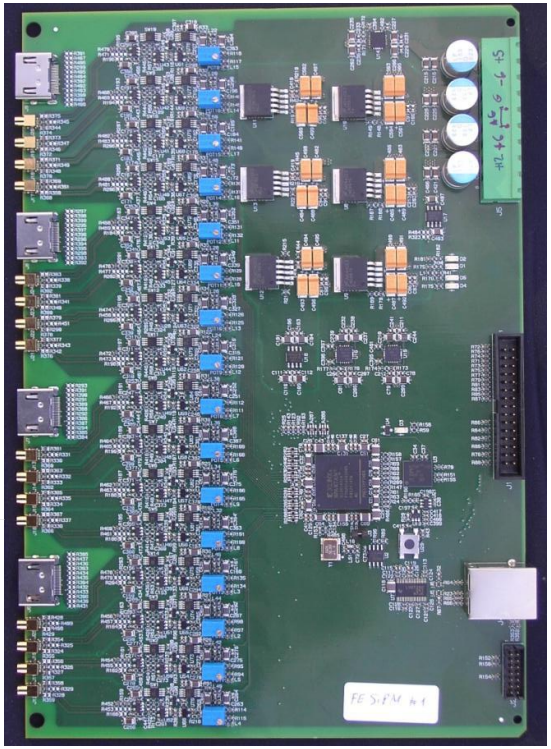
16-ch SiPM front-end board with amplifiers, gated integrators, ADCs and DTC interface to the FEC module

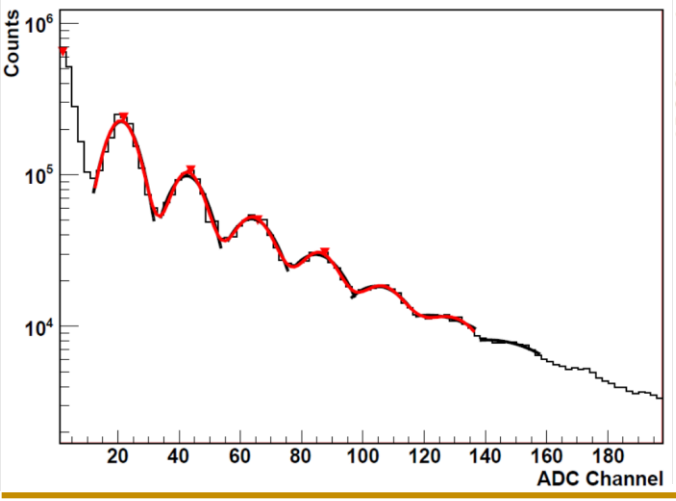


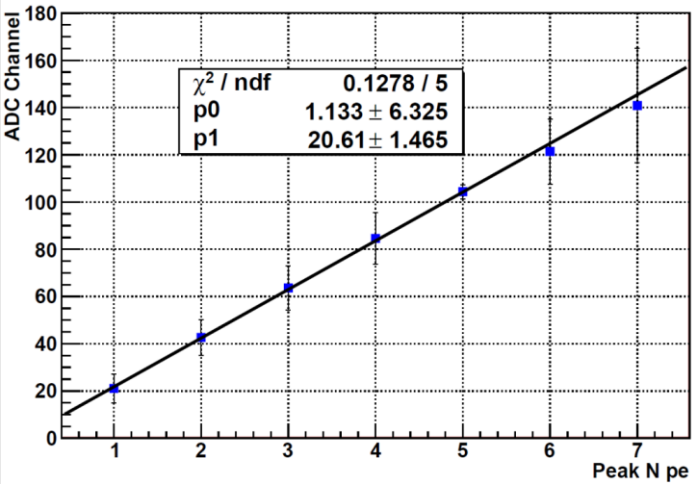
Stage 1: transimpedance amplifier + offset correction

Stage 2: gated integrator

Stage 3: inverter + offsset correction







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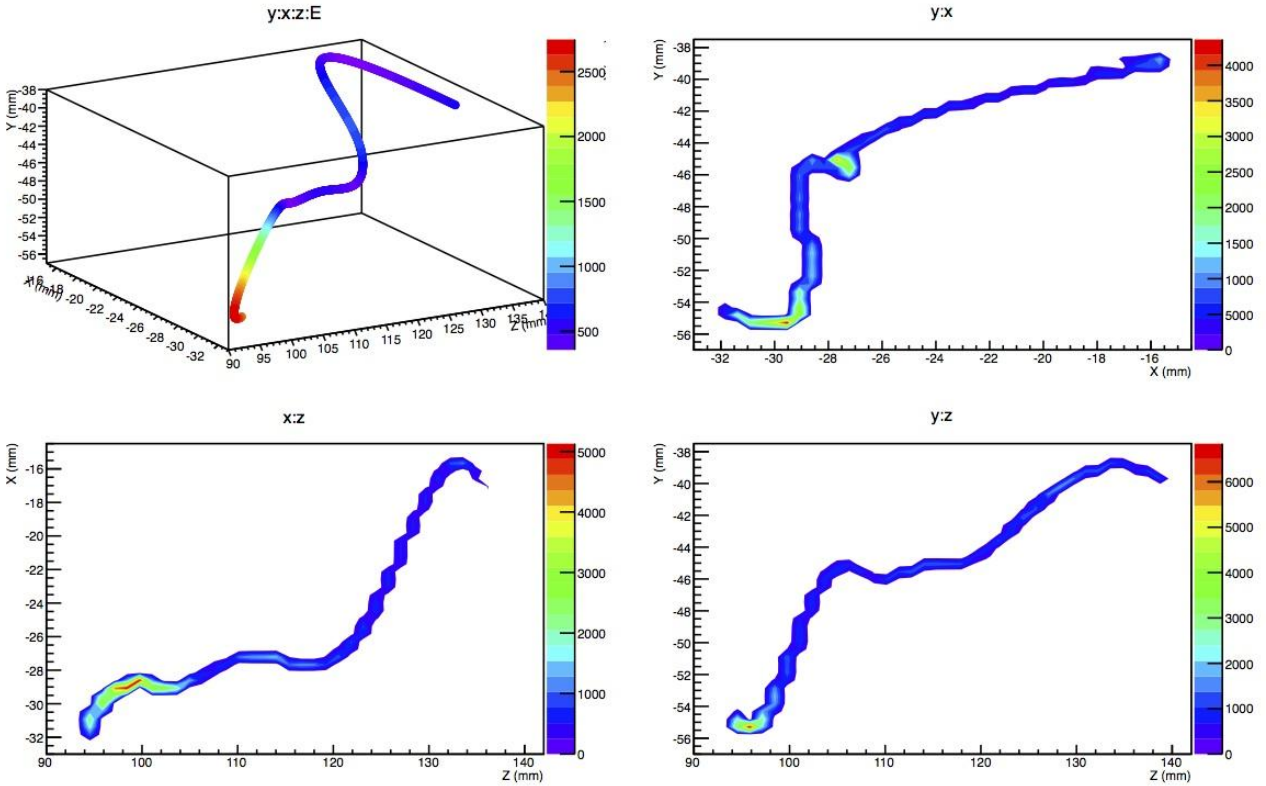
Summary of NEXT-DEMO FE&DAQ

Real data: electron produced by the interaction of a 660 keV gamma from a Cs-137 radioactive source

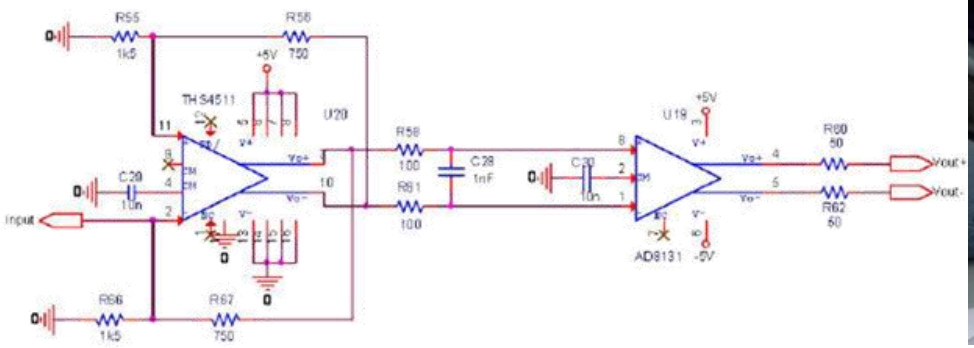
Random walk of the electron (due to multiple scattering) while depositing a constant amount of the energy (electron behaves like a mip for most of the trajectory). When the electron ranges out, a blob of energy, coded in red in the 3D projection is formed, giving the signature of the electron (wire+blob)

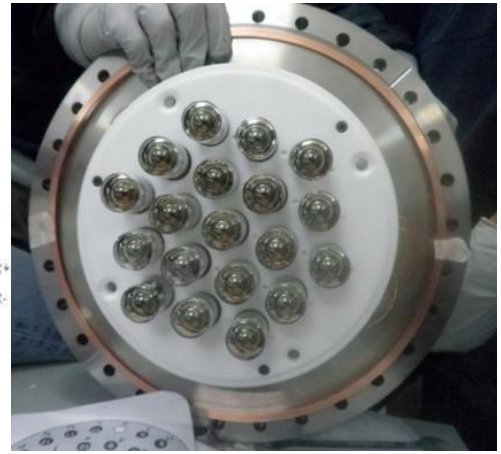


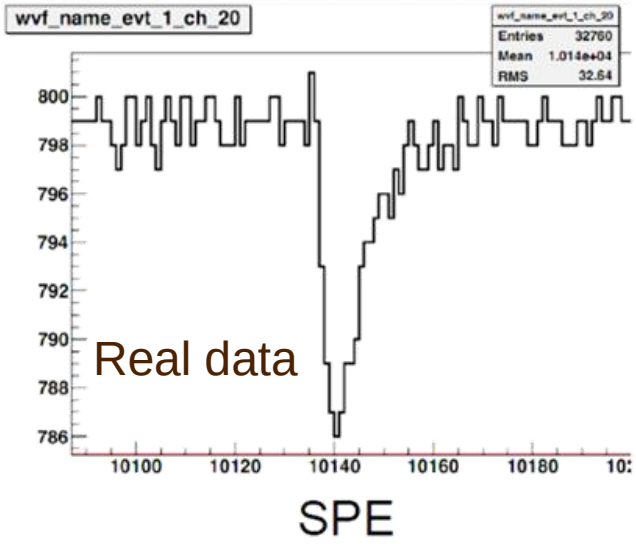
The signature for a bb0nu event would have two blobs (due to the two electrons ranging in the gas) providing a distinctive signature of the decay

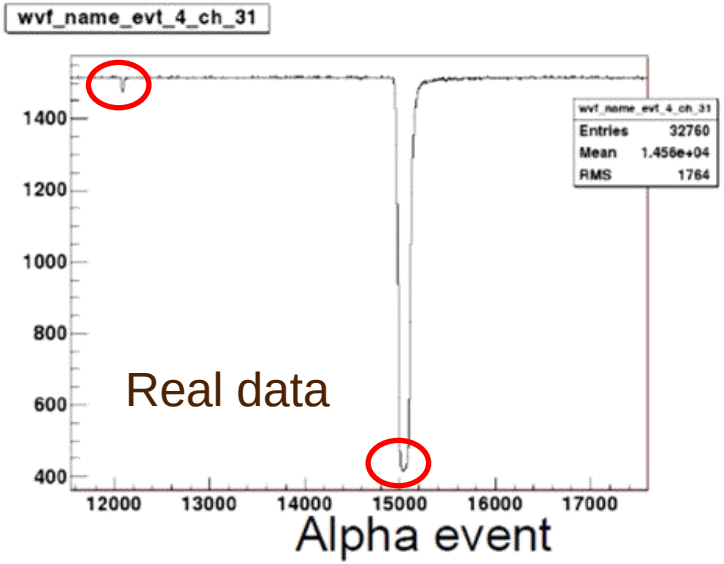
Summary of NEXT-DEMO FE&DAQ

7-ch PMT front-end board with amplifiers (currently, with HDMI output connectors to interface FEC+ADC card) – 3 FE boards read out the PMT plane









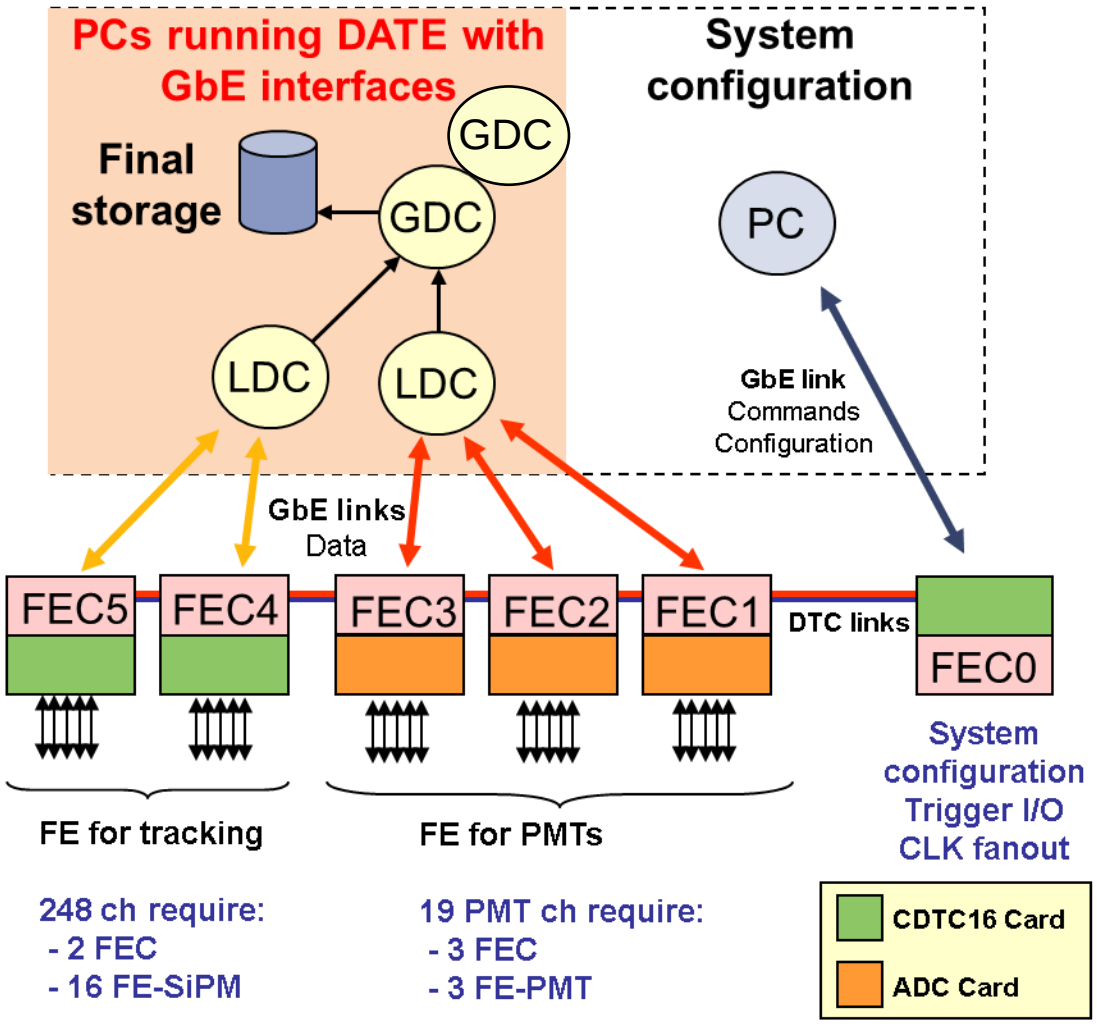
Summary of NEXT-DEMO FE&DAQ

DAQ:

- PMT plane: 3 FECs (19 ch)
- SiPM Plane: 2 FECs (248 ch)
- 2 LDCs and 1 GDCs

Sub-event sizes:

- 800 μs
- 2 bytes/SiPM ch @ 1 MHz + timestamping + overhead
- 2 bytes/PMT ch @ 40 MHz + + timestamping + overhead
- No zero suppression !!



Summary of NEXT-DEMO FE&DAQ

- **DAQ performance:**
  - Raw data throughput (target: 10 Hz trigger rate, 800 µs waveform length)
    - PMT plane (40 MHz sapling rate): ~ 17,5 MByte/s
    - SiPM Plane(1 MHz samplig rate): ~ 4,5 MByte/s
    - Total: ~ 22 MByte/s

- **PC farm limitations:**
  - Max. 80 MByte/s (sustained) per LDC without storing data on disk
    - Beyond this value, frames are lost
    - No flow control between FEC and DATE
  - Max. 26 MByte/s (sustained) per GDC storing data on a PC hard disk

- **Hardware limitations:**
  - 80% FEC FPGA resources used: need larger FPGAs for NEXT-100
  - DDR2 buffer throughput limits number of front-end channels per FEC: need faster buffer for NEXT-100
  - Single GbE link per FEC is not enough for NEXT-100

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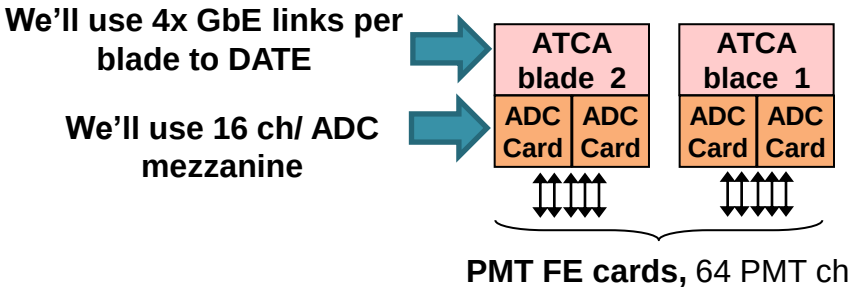
PMT plane upgrade for NEXT-100

- Moving from 19 to 64 PMT channels is straightforward: just add more front-end boards and FECs!
  - Event lenght increases x4 (from 800 μs to 3,2 ms)
  - So, event size increases by 4 x 64/19 ≈ 14 compared with NEXT-DEMO
  - **On-FEC zero suppression may leave the overall increment in a factor of 2 !!**

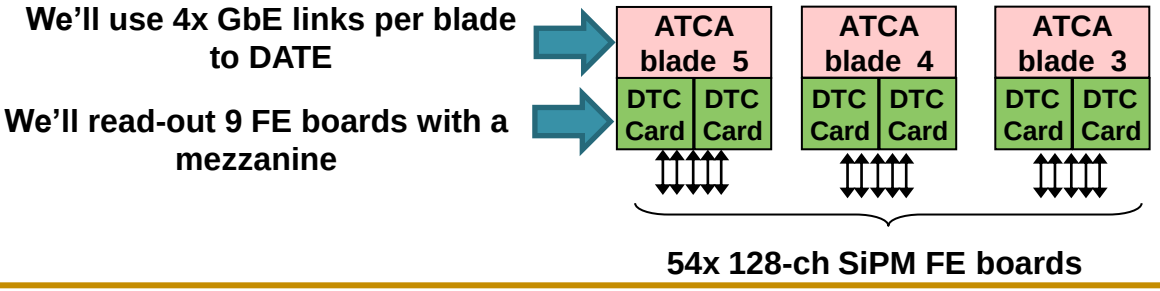
- We'll move to the ATCA FEC form factor
  - 2x mezzanines and 2x FPGAs per ATCA FEC blade (lager, faster buffer and higher throughput to LDCs)

- According to our simulations, with 16ch/mezzanine, 4x GbE links/FEC, we'll lose < 0,01% of interesting events for a 10 Hz nominal trigger rate



Tracking plane upgrade for NEXT-100

- Moving from 248 to 6,800 SiPM channels and longer events (3,2 ms) is not so straightforward.
  - **Throughput increase: 4(event length) x 27,4(more ch) / 20 (zero-suppression) ≈ 5,5**
- We'll do this with:
  - New 128-ch FE cards with reduced power, simplified circuit, more powerful FPGA (Virtex-6) and automatic offset voltage compensation
  - New mode of operation: triggered mode with internal buffer and zero suppression at the FE level (this justifies the use a Virtex-6)
  - Use of ATCA FEC blades
  - New DTC interface card in ATCA mezzanine form factor
  - According to our simulations, with 4x GbE links/FEC, we'll lose a negligible amount of interesting events for a 10 Hz nominal trigger rate



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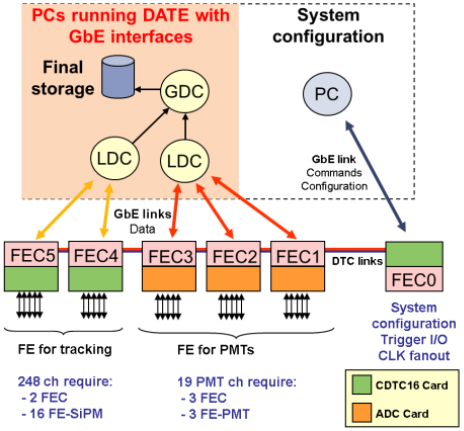
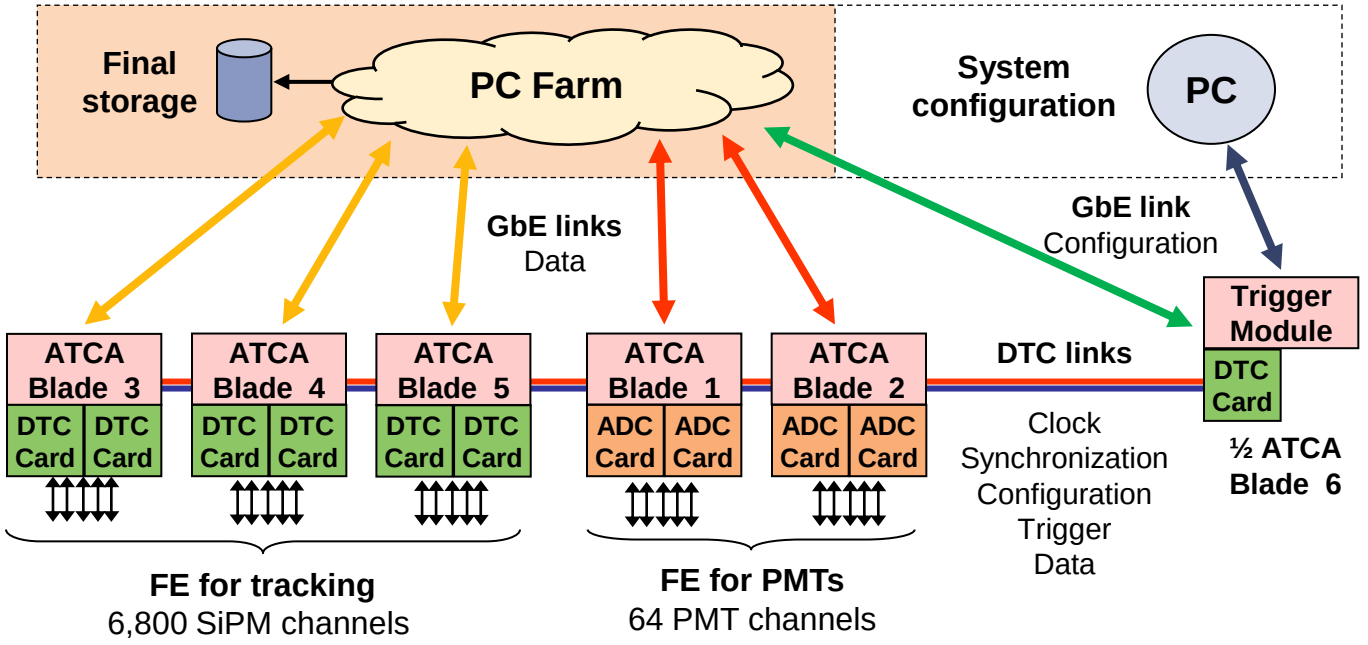
The trigger systems remains the same...

- Trigger module can be either a FEC blade with a 8xDTC mezzanine or an SRU module
- Receives trigger candidates from the PMT FECs, runs the trigger algorithm and distributes a trigger signal
- There's something new for NEXT-100: info from each trigger will be stored as if it was a 3rd DAQ partition

NEXT-DEMO DAQ



NEXT-100 DAQ – ATCA architecture



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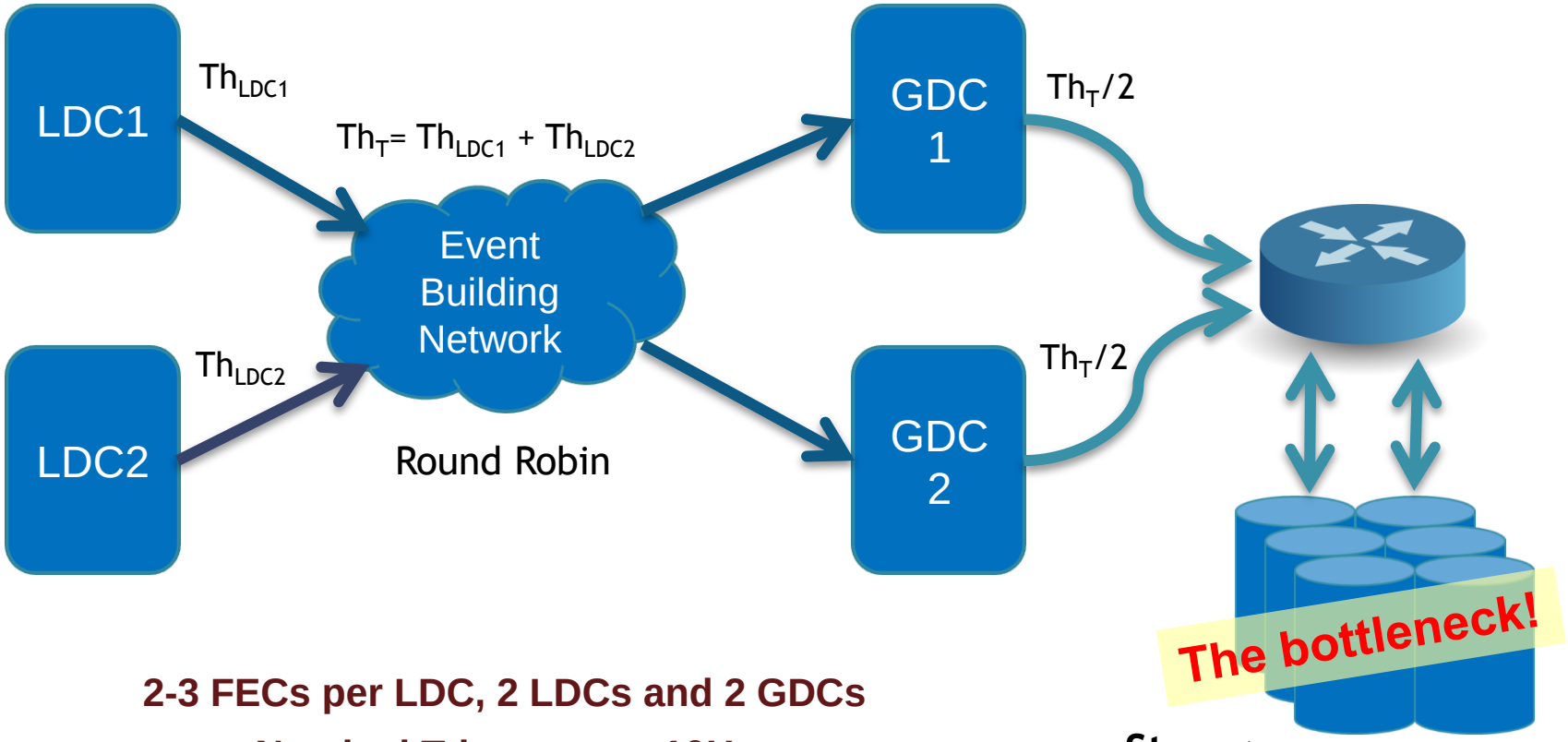
Online system in NEXT-DEMO: DAQ



2-3 FECs per LDC, 2 LDCs and 2 GDCs

Nominal Trigger rate: 10Hz

6.5 TB, RAID-5 + 1 Spare

3 Servers + GlusterFS

Tested filesystems: ext3, ext4, xfs

Tested: Linux I/O system scheduler

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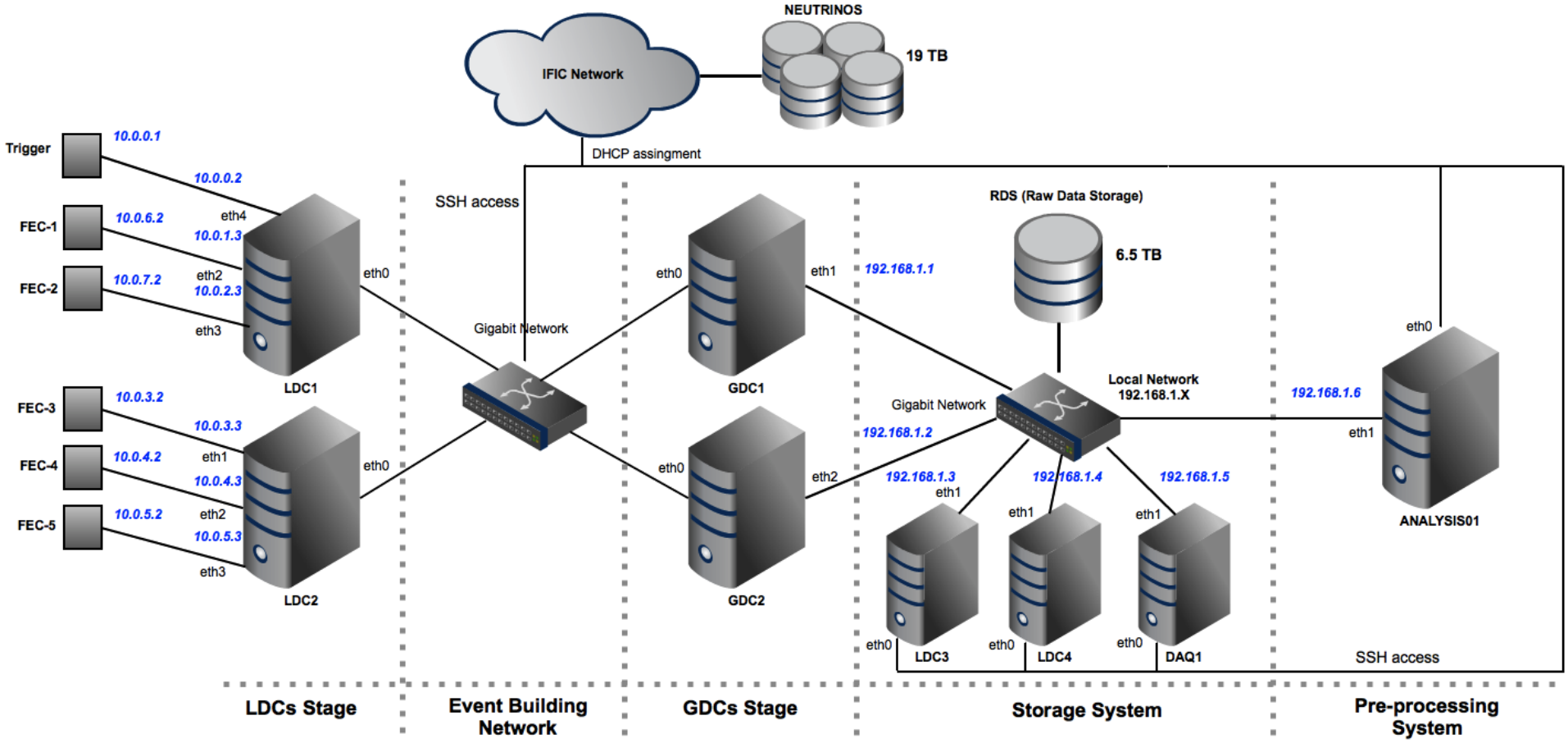
DAQ and Online in NEXT-DEMO: the full picture



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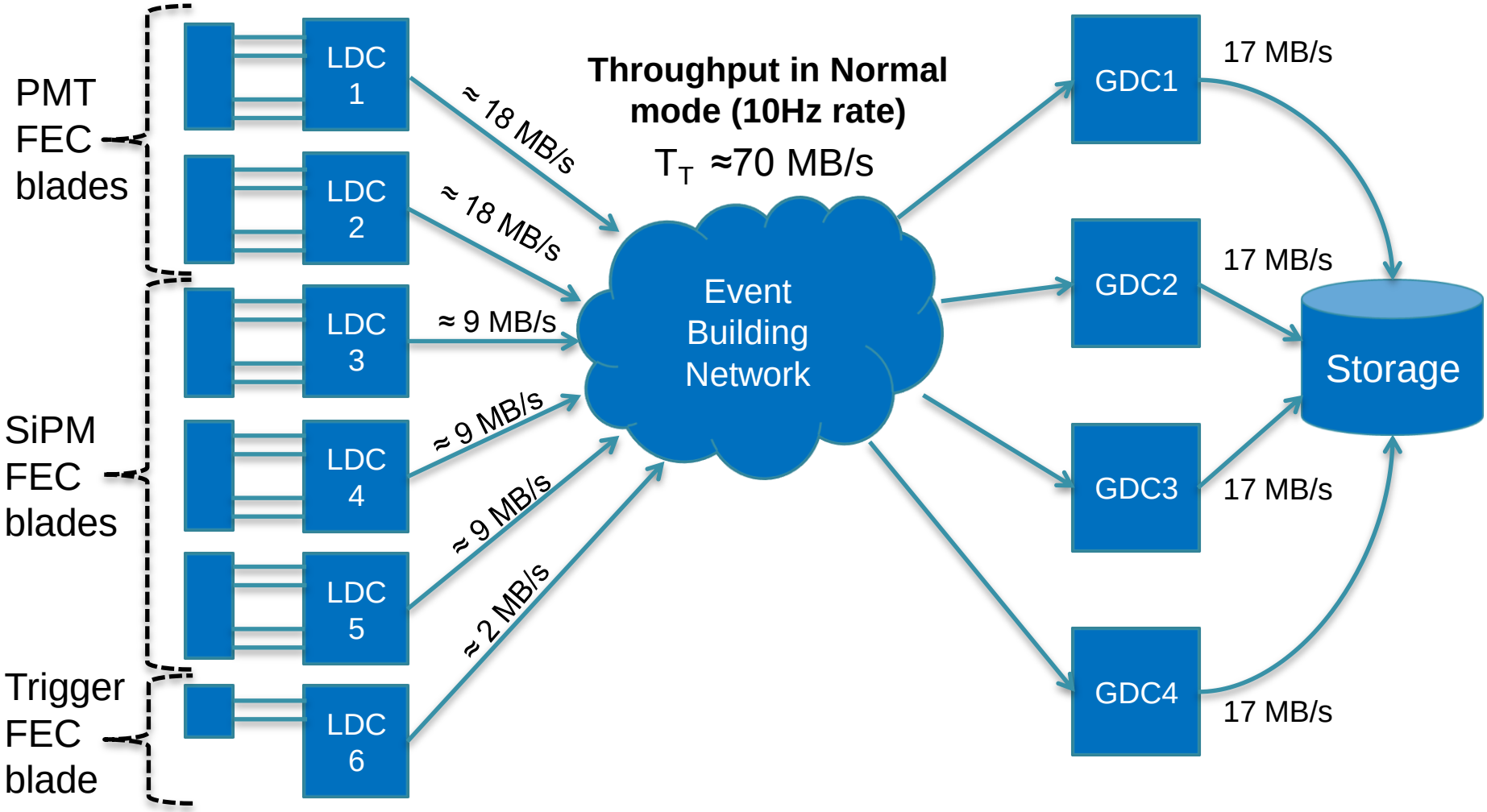
DAQ system for NEXT-100



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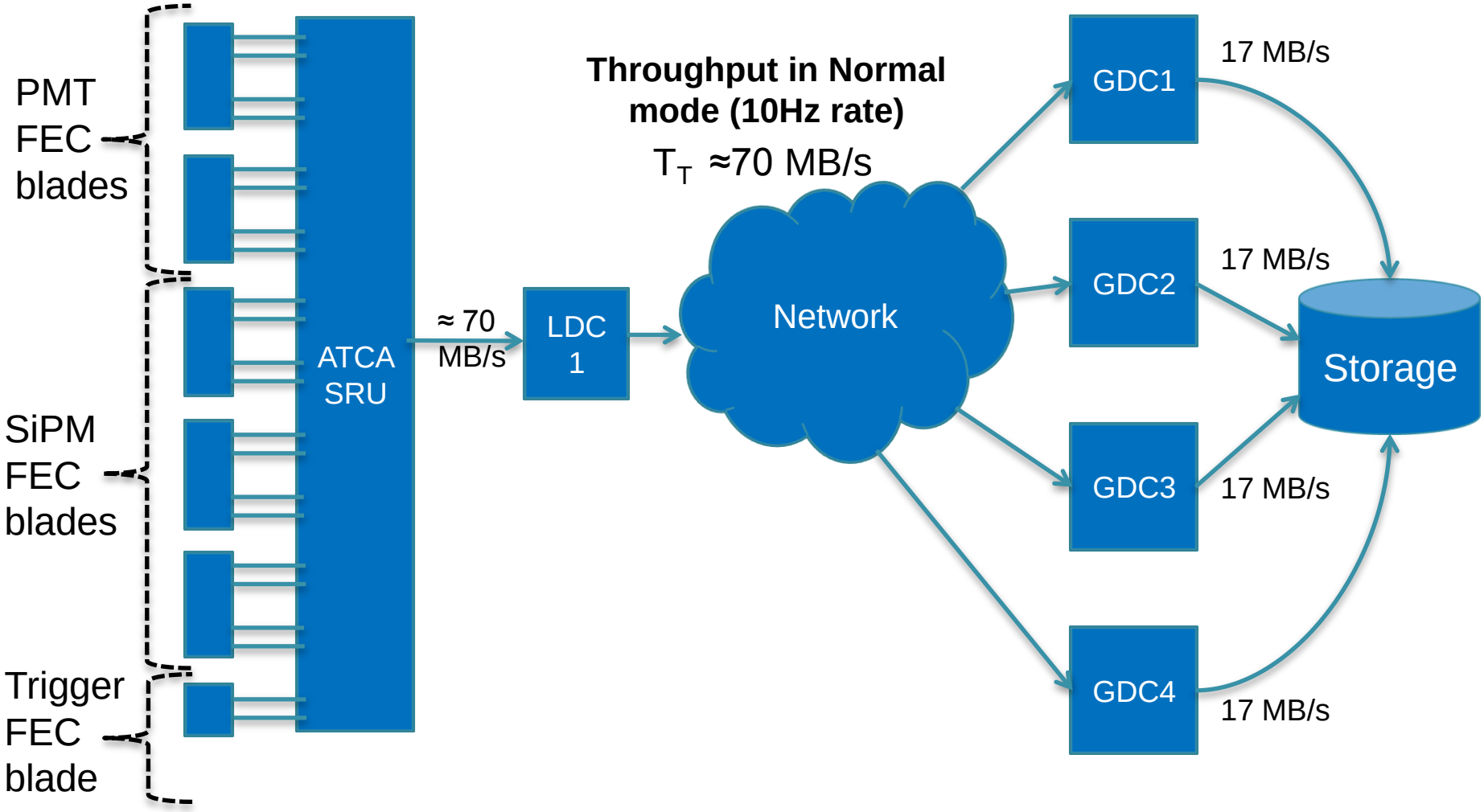
DAQ system for NEXT-100 with ATCA SRU



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Summary

- NEXT-DEMO is successfully taking data with SRS
  - Energy and tracking data look really good!! ☺
  - Still, struggling with the disk bottleneck
- Upgrading to NEXT-100 will rely on:
  - More complex SiPM FE with zero-suppression and buffering
  - Use of the coming SRS ATCA blades
  - Lots of work (needless to say)

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