Sampa chip for sPhenix

Trigger/Streaming Readout

https://eic.jlab.org/wiki/index.php/Trigger/Streaming_Readout

PHENIX -> sPHENIX

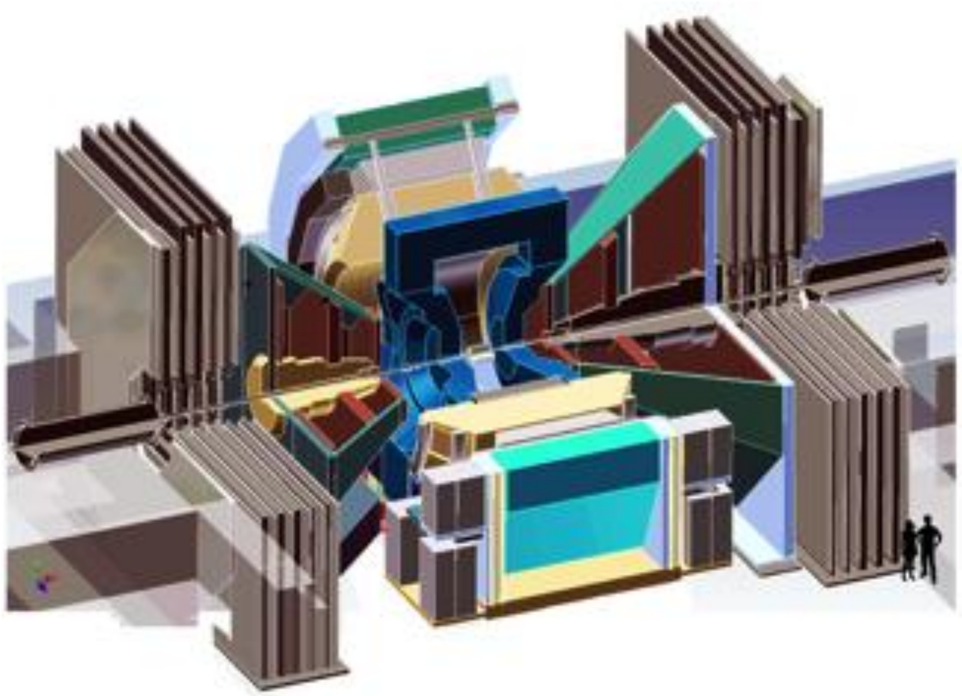
PHENIX has been around since the early 90's

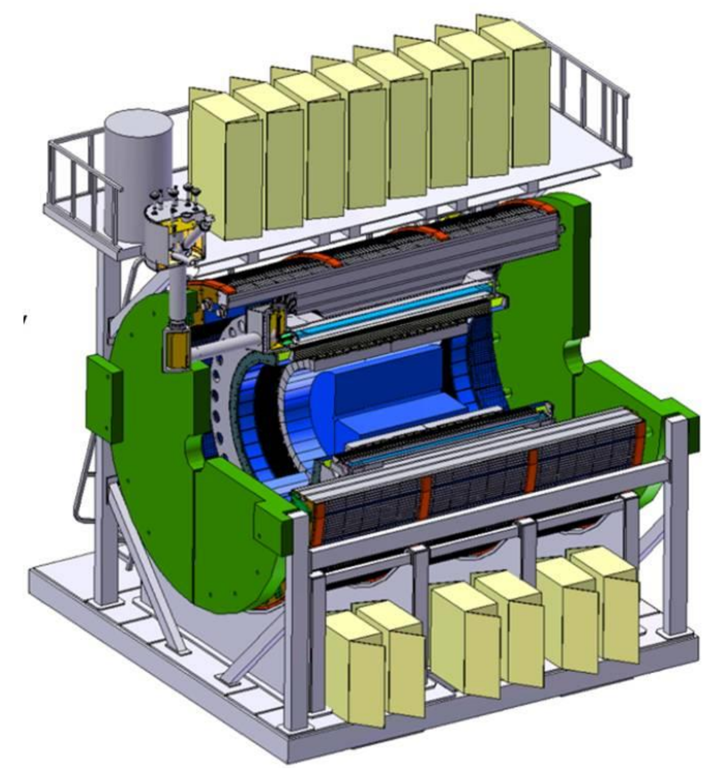
Still, the experiment is showing its age – much older than the cars most of us drive

sPHENIX is a replacement for the ageing PHENIX experiment

It's not an upgrade! Not a single detector component survives

New collaboration formed 12/2015





The BaBar Magnet

We had looked at magnets, but none of the available ones were quite right, then --

The BaBar magnet secured from SLAC after SuperB canceled, arrived at BNL in February 2015

Considerable additional equipment also acquired (power supplies, dump resistor, quench protection, cryogenic equipment)

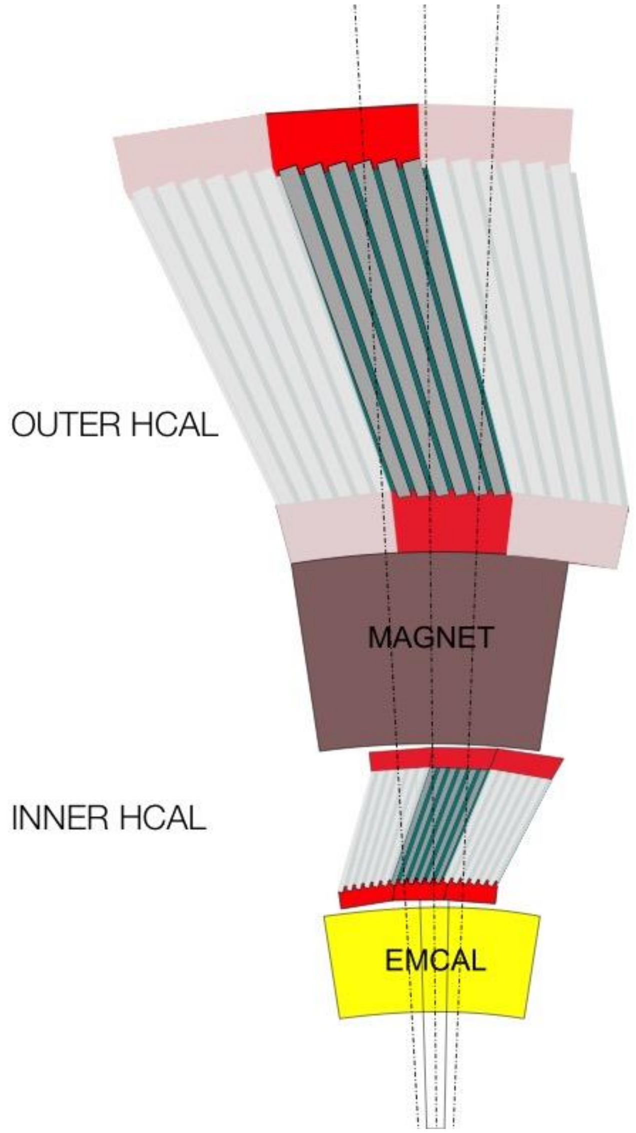
SMD and CAD preparing it for low power cold test

Well suited to our needs without compromises

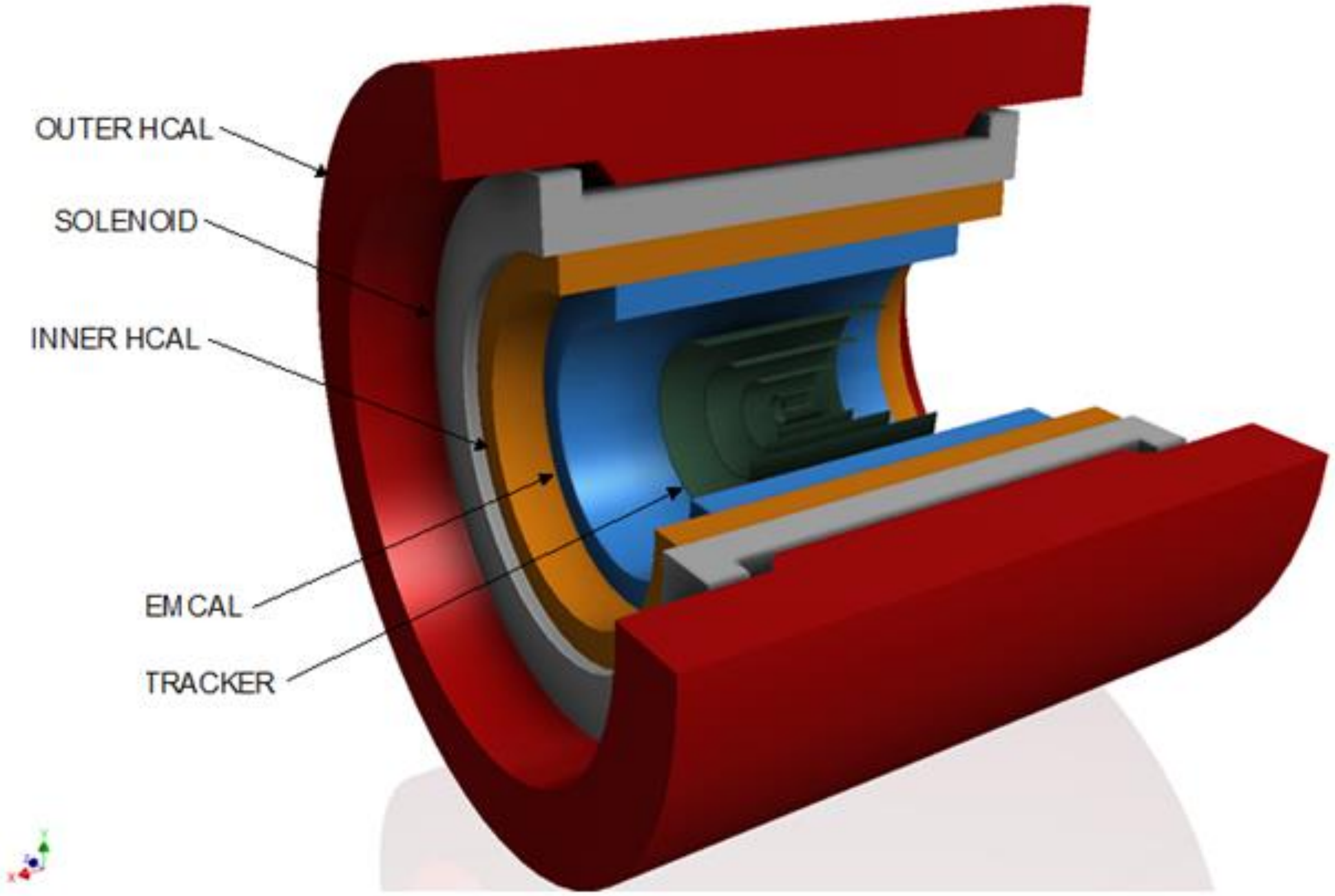
- 1.5 T central field
- 2.8 m diameter bore
- 3.8 m long
- $1.4X_0$ coil+cryostat

This really gave a tremendous boost to this project!

sPHENIX – the Concept



- Outer HCAL ≈$3.5\lambda_I$
- Magnet ≈$1.4X_0$
- Inner HCAL ≈$1\lambda_I$
- EMCAL ≈$18X_0$≈$1\lambda_I$



HCAL steel and scintillating tiles with wavelength shifting fiber

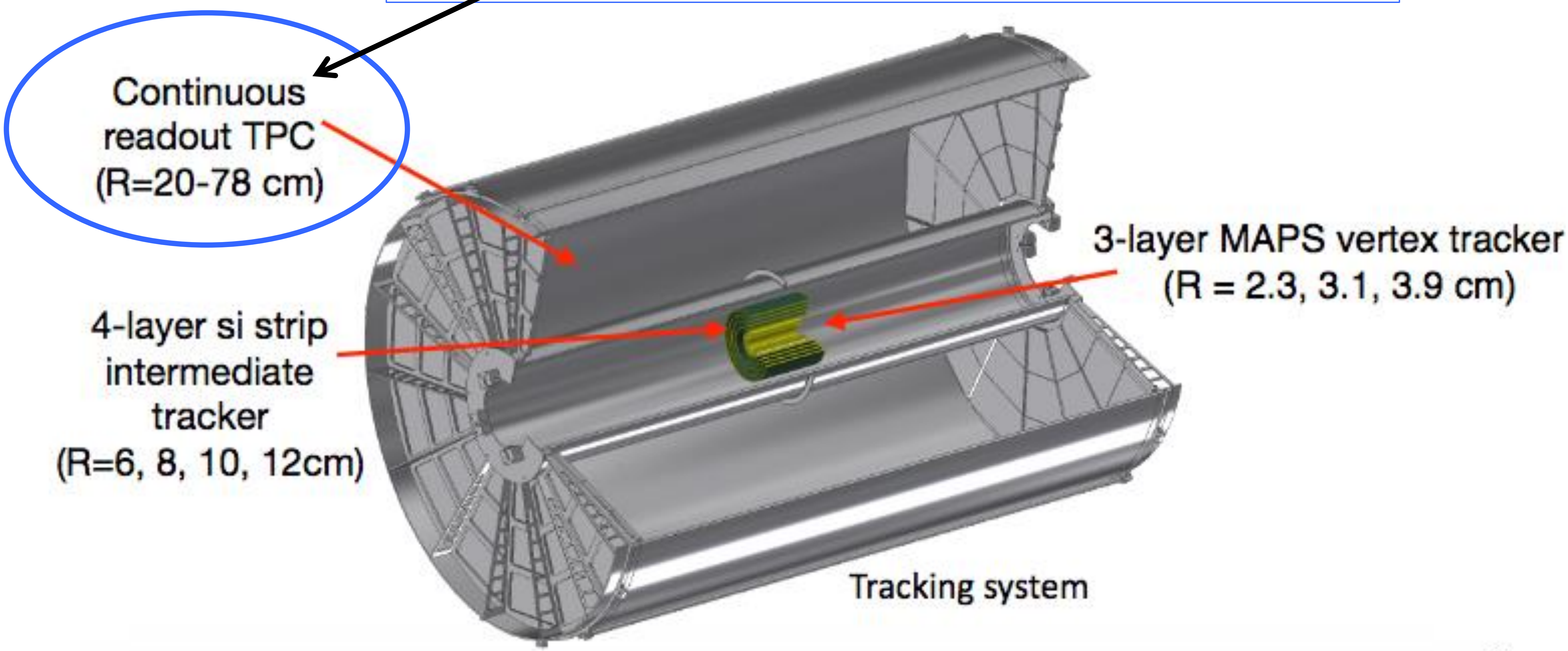
- 2 longitudinal segments.
- An Inner HCal inside the solenoid.
- An Outer HCal outside the solenoid.
- $\Delta\eta \times \Delta\varphi \approx 0.1 \times 0.1$
- 2 x 24 x 64 readout channels
- $\sigma_E/E < 100\%/\sqrt{E}$ (single particle)

SiPM Readout

Tracking

There it is – the "C" word.

Continuous Readout == Streaming Readout



Why a “continuous” – streaming – readout?

TPCs are usually considered slow devices – 1-2 KHz event rate

Long drift time for primary electrons to gain stage

Longer time to “drain” positive ions

“Classic” TPCs operate with a gating grid to stop Ion Back Flow (IBF)

But we want to take data at ~15KHz!

Need IBF control -> high mobility gas (Ne), tuning of gain stages

Can’t have a gating grid! ➔ Streaming readout

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The rest of the detectors follow a classic event-triggered scheme

Need to “marry” the CR with triggered events!

How I explain Streaming Readout to the Public Affairs guys

Think of the recordings of a shopping mall's security cameras

You store, say, a month worth of video

Most of the time, absolutely nothing of interest happens

But when there's something going on, a burglary or so, you go back and cut out the 15 minutes of video in question for the cops

Think of those 15 minutes as the long-term stored data

Translate to sPHENIX…

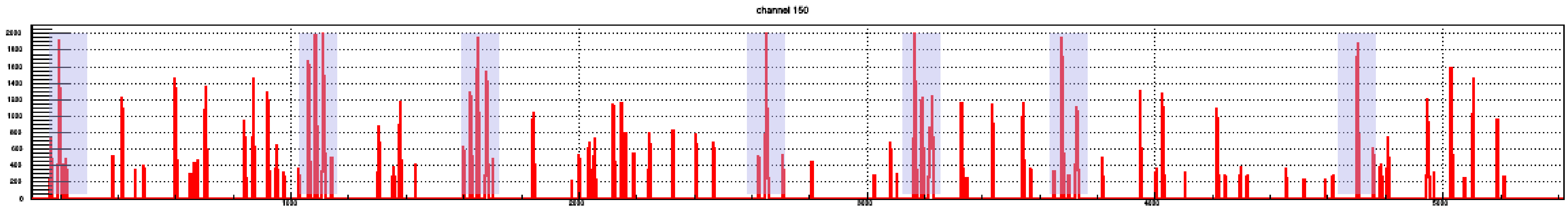
We record the arrival of charge continuously

But at the end, we are really only interested of the piece of "recording" at the time we triggered an actual event

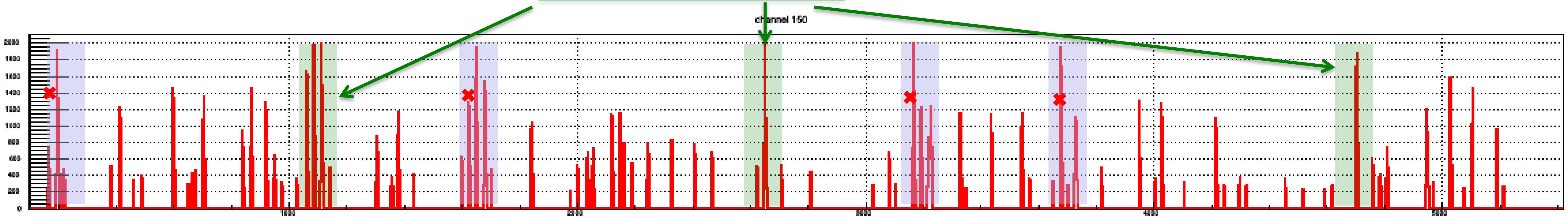
So stored "events" for the TPC will be a series of short "charge recording segments" covering the times when we triggered the rest of the experiment.

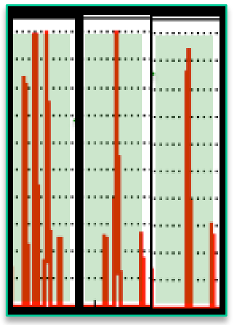
Streaming Readout concept

The streaming data are recorded all the time, and broken up in chunks above threshold



Only chunks correlated with triggered events are then kept





This results in a greatly reduced data stream
The real-time processing demands are very high

Dealing with high data rates

PHENIX has never been afraid of high data rates and volumes

I personally claim a portion of that fame…

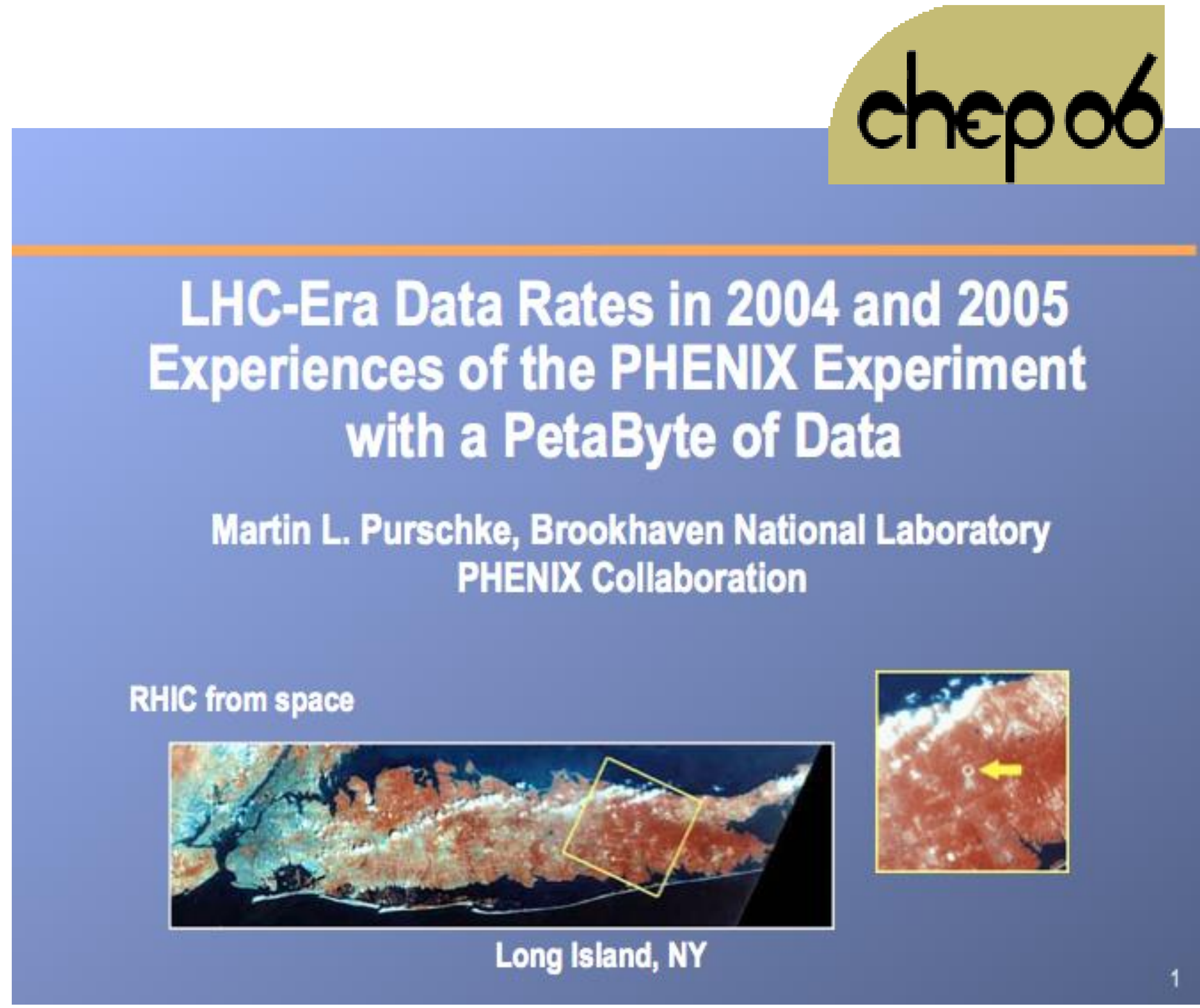
We fully intend not to sacrifice data and "take all we can"

Current design goal is 15KHz of event rate

This is possible right now, but will be less of an issue in 2020+

PHENIX was capable of taking a 1.5GByte/s fully compressed data stream

Not a hard limit, was what the detector had to "give"

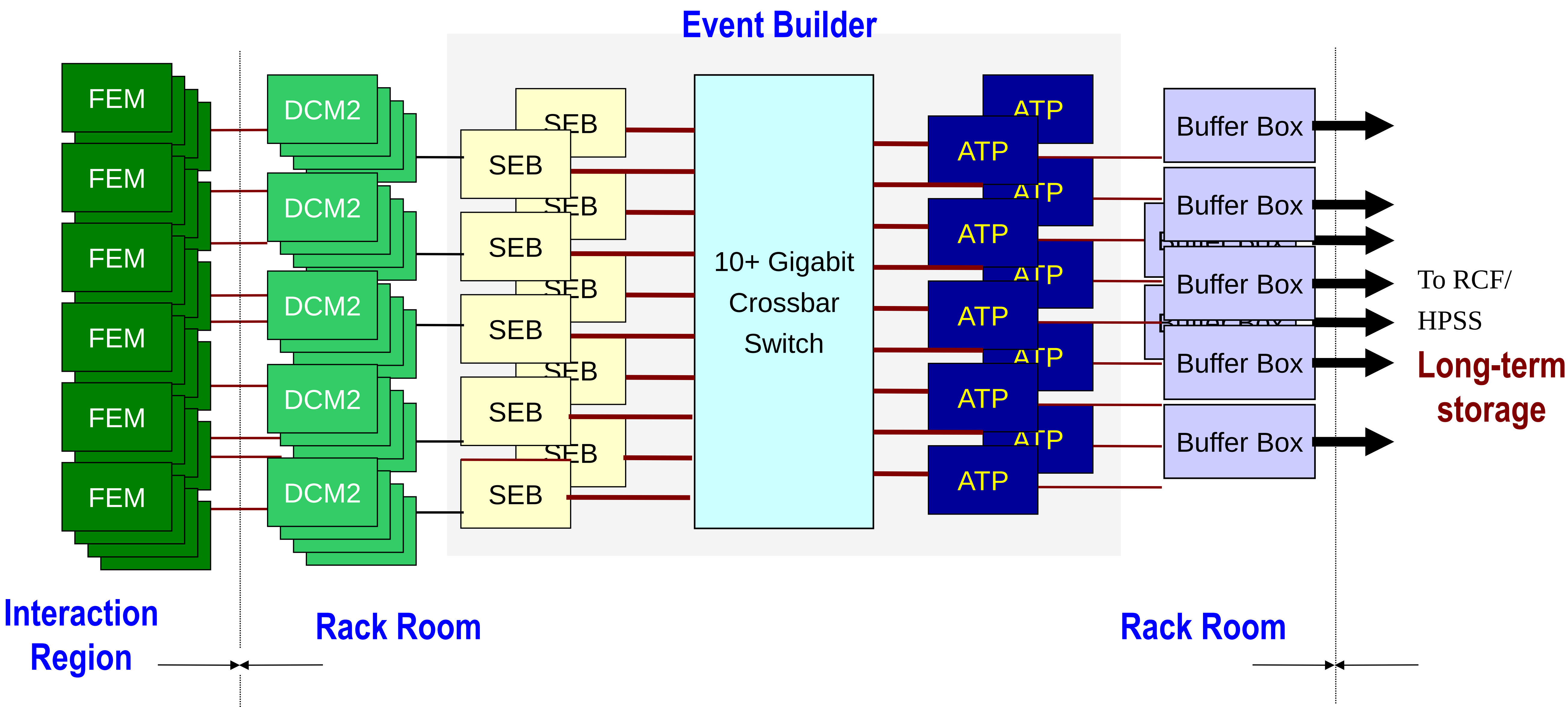


My opening slide from the CHEP in 2006

The sPHENIX DAQ

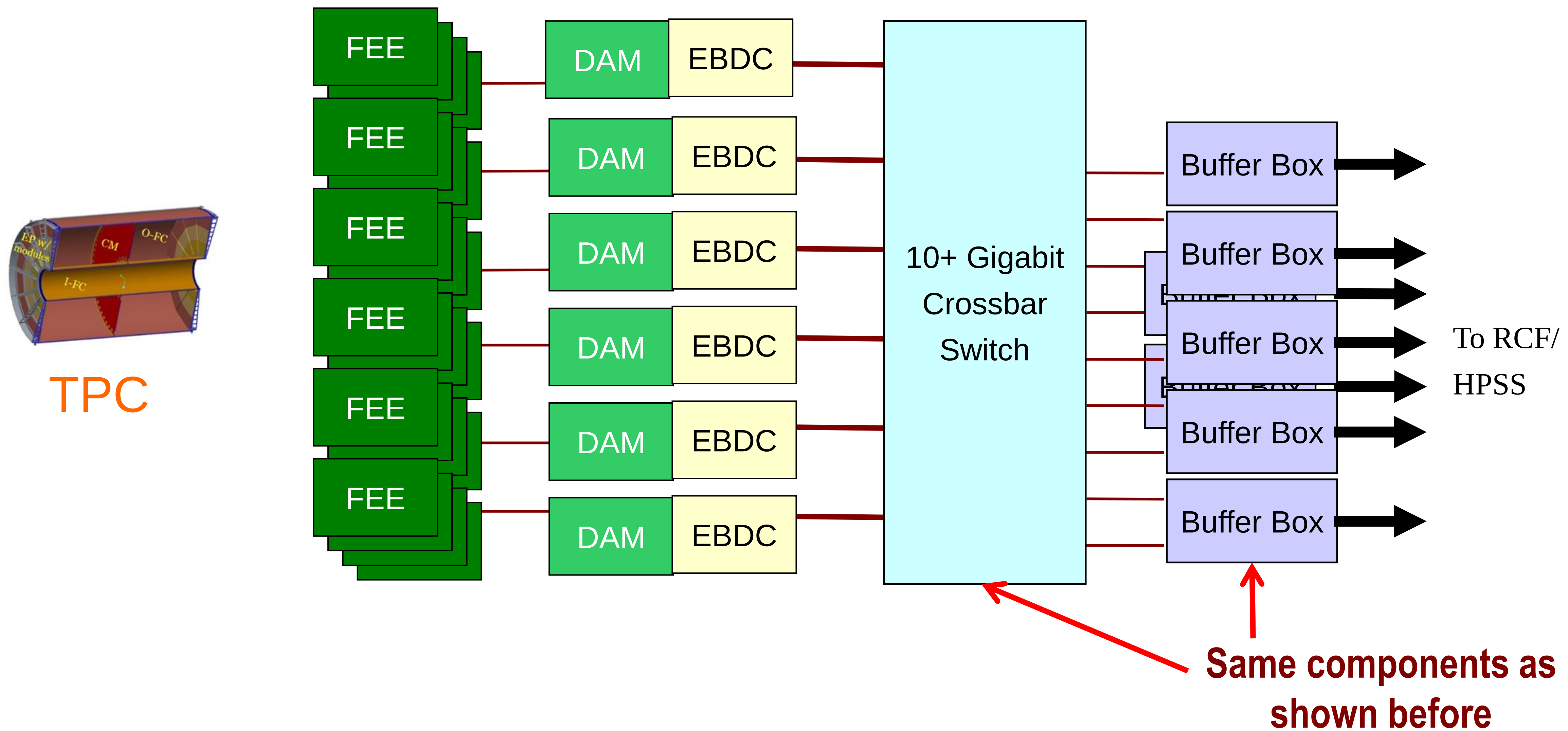
- As much as possible, we will re-use the existing PHENIX DAQ
- We have been asked by review committee members why we wouldn’t want to upgrade a 15yr old DAQ
- Answer: We already did that, we have just the system that we would build today
- We “only” need to add the streaming readout for the TPC
- First off, the TPC dwarf the calorimeter/INTT/MAPS data volume
- ~70% of data volume from the TPC – estimate!
- The “rest” : 10Gbit/s to mass storage, give or take
- TPC: 30+Gbit/s ?? Remains to be seen
- Aiming for 40Gbit/s sustained to long-term storage (working number)

The "classic" triggered readout part of the DAQ



- DCM-2 receives data from digitizer, zero-suppresses and packages
- SEB collects data from a DCM group
- ATP Assembles events and compresses data
- Buffer Box data interim storage before sending to the computing center

The streaming TPC readout



- DAM Data Aggregation Module
- EBDC Event Buffering and Data Compressor

Front-End – ALICE SAMPA Chip

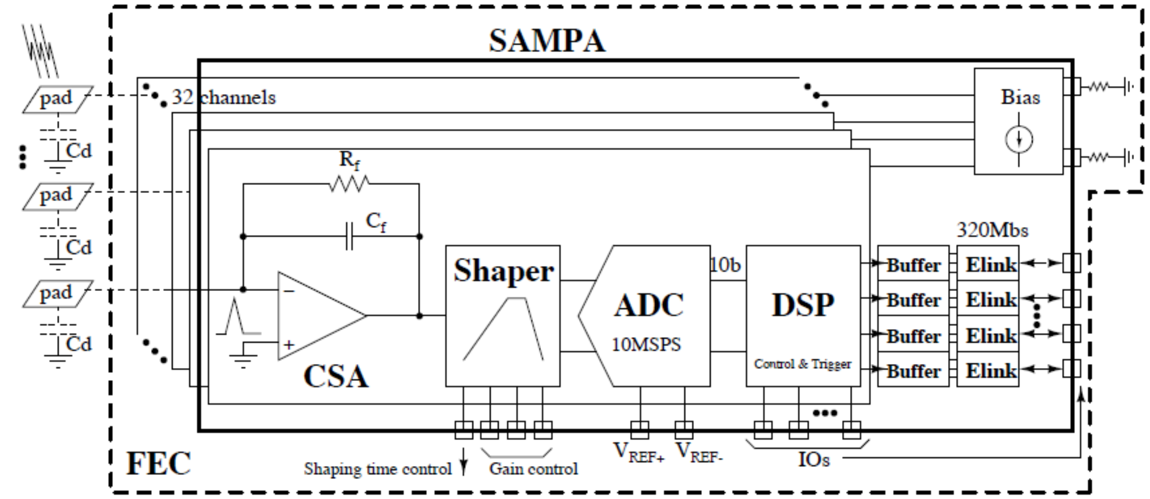


Figure 6.4: Schematic of the SAMPA ASIC for the GEM TPC readout, showing the main building blocks.

ASIC developed for ALICE for the TPC

More functionality than we would need while streaming

10Ms/s @ 10Bit -> 100Mbit/s internally, 32channels

This oversubscribes its external links

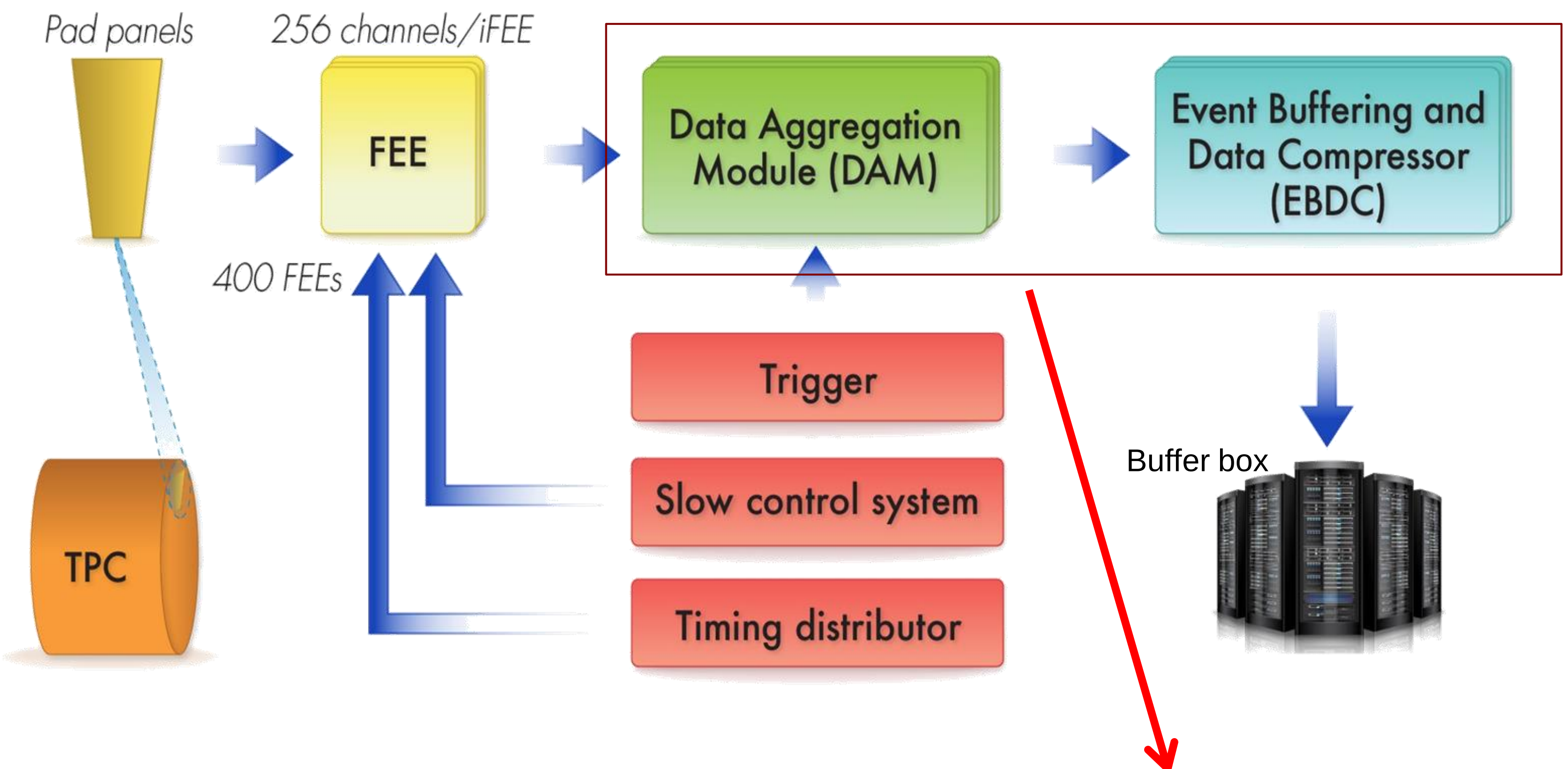
Above-threshold waveform delivery – send chunks of the waveform around samples “sticking out” above a threshold + bookkeeping

Estimate 5 samples/channel/hit and 3 channels -> 15 samples/”hit”

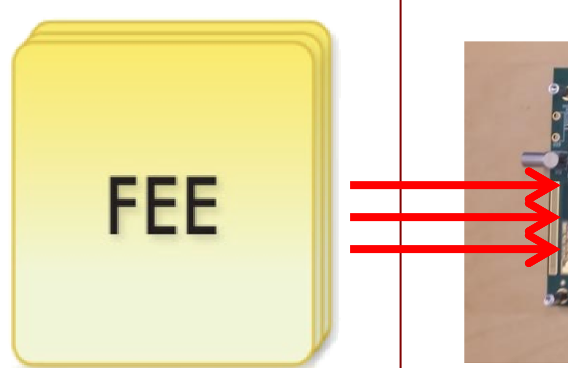
8 Sampa chips on one Front-end card – 256 channels

~400 FEE cards

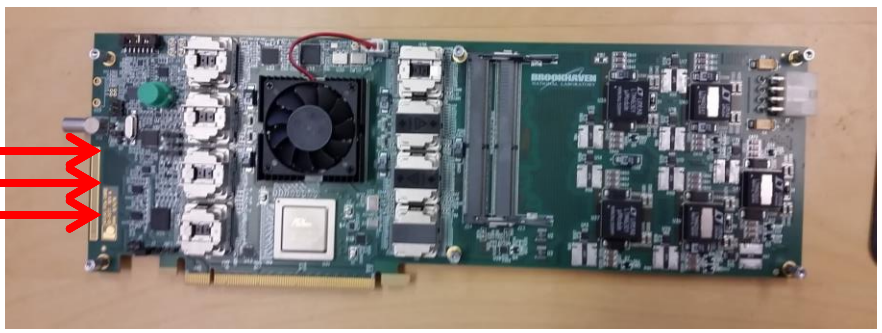
Data path overview



About 10 PCs (EBDC) with one FELIX card each



Up to 48 FEE->Card (48 fibers)



ATLAS Felix PCIe card

+

Data Rates

- We use 40Gbit/s to storage as working/planning number
- We always used the buffer boxes to buy ourselves a solid factor of 2 between DAQ rate and storage rate (that’s just the ~50% duty factor of RHIC x Experiment, based on past experience).
- The longer you can buffer, the better the ratio (averaging over machine development, access downtime, etc.)
- Phenix had ~70 hrs buffer time for 200 GeV Au+Au running
- Compression – since PHENIX run 2 (2002) we have used a late-stage compression of the data that gains another ~40%
- (that is a cool number in another respect as it tells you your “information content /bit”)

Summary

Marriage of streaming-readout TPC with triggered readout for calorimeters + “rest”

In a very early stage – hardware pre-selection only ~10 weeks ago

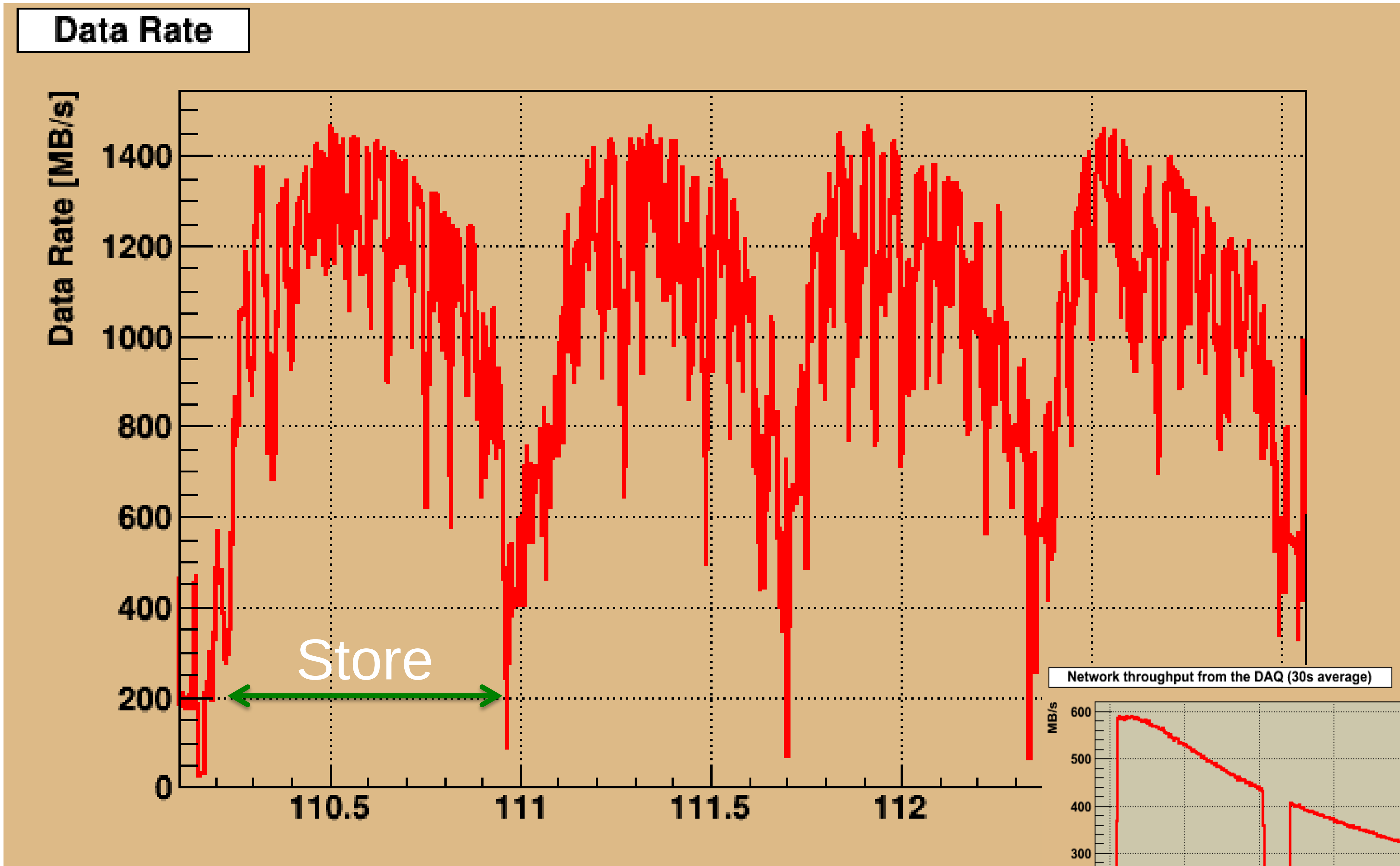
ALICE Sampa chip + FEE + DAM + EBDC data path

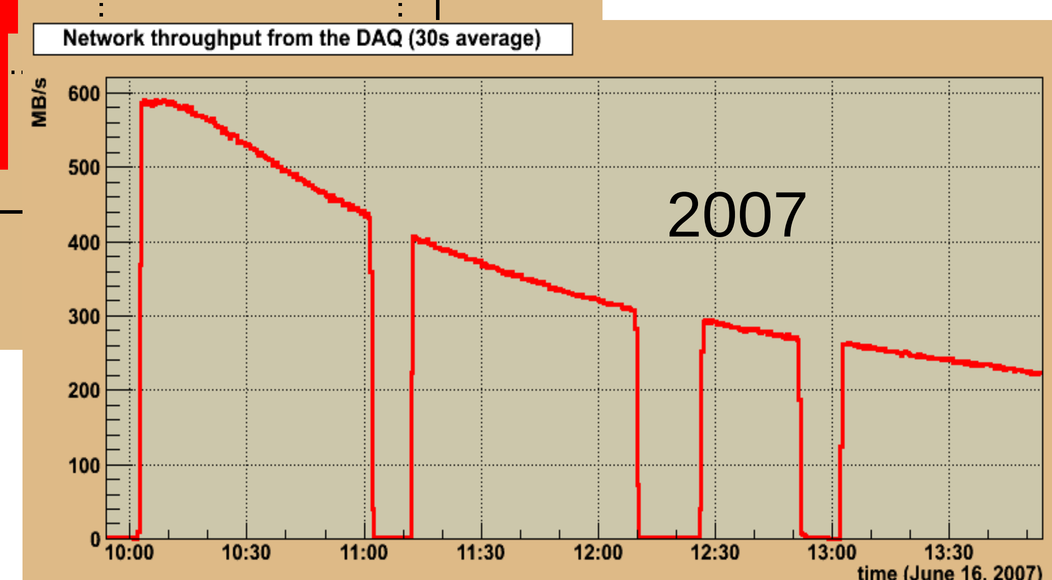
ATLAS Felix PCIe card strongest candidate (developed at BNL, easy collaboration)

Lots of experience with individual parts, software, technology

Integration of it all will be the major part of the work

Data Rates (Run14)





SAMPA for SoLID

Main advantage :

- no deadtime from demultiplexing
- treatment in real time
- zero suppression

Might need to be adapted to SoLID

- singles rate too high : large buffer
- smarter singles trigger (coincidence between planes)

Conclusion

SAMPA chip might work

Need to test :

- integration time
- suppression
- data transfer rates
- pile-up