Streaming readout for EIC

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RBRC
RIKEN BNL Research Center

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University

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- Logically: Hits labeled by time stamps, not event numbers. Definition of an event not part of the electronics!

Why triggered?

- Triggered DAQ was a necessity because electronics was too slow
- Trade-off: Rather have dead-time than no experiments
- Modern triggered system reduce dead-time with large efforts
  - Often by building a streaming front end and then adding a trigger module.
- *If you never heard of triggers, you wouldn't build one.*

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- Third generation: Long term storage.
  - This drives adoption by HEP.

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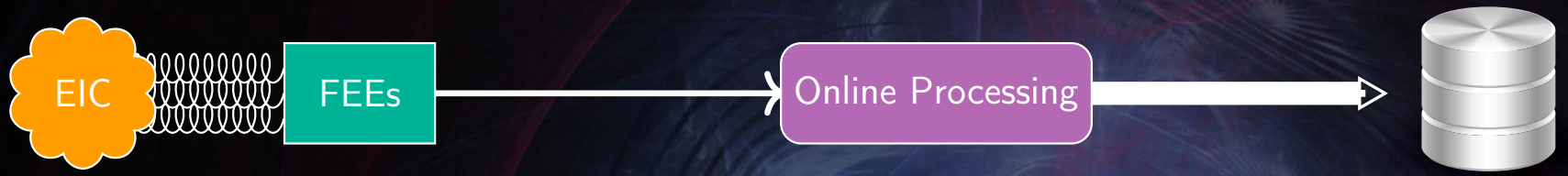

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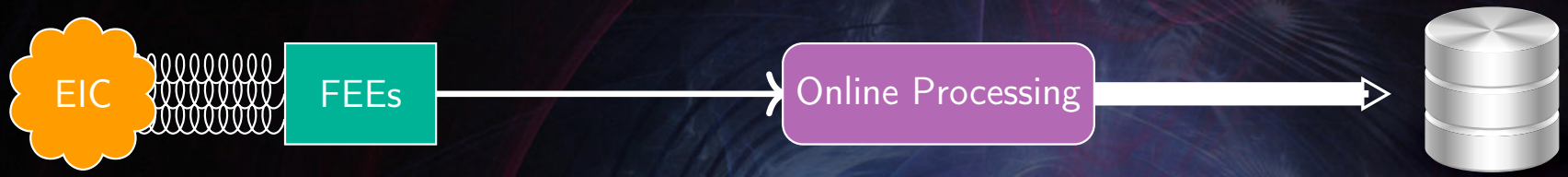

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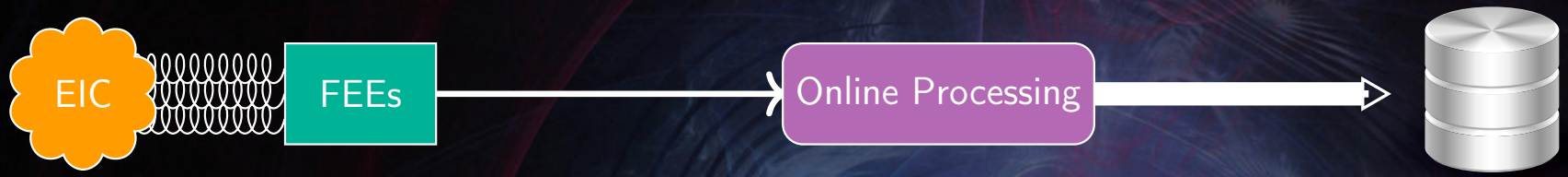

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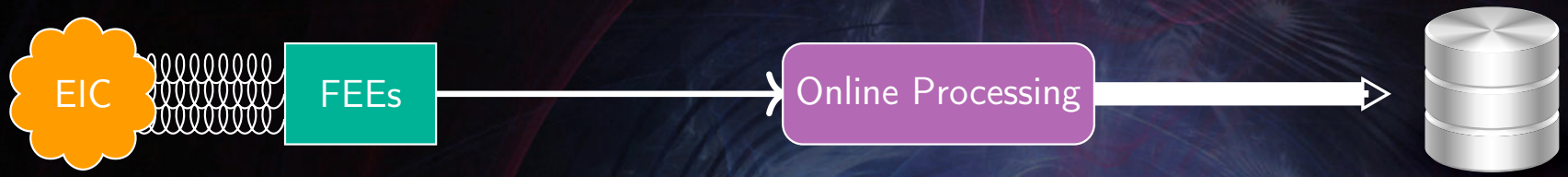

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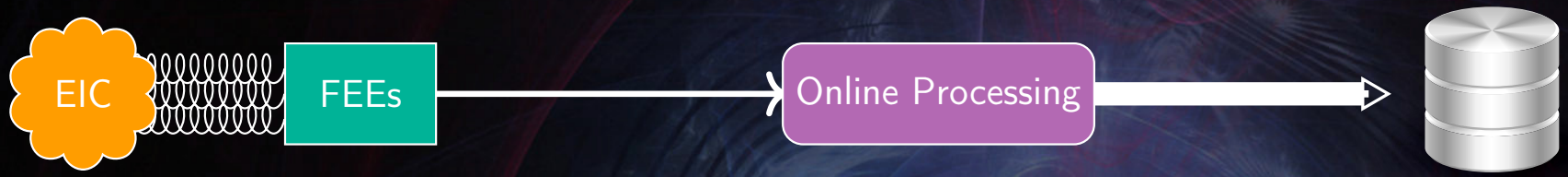

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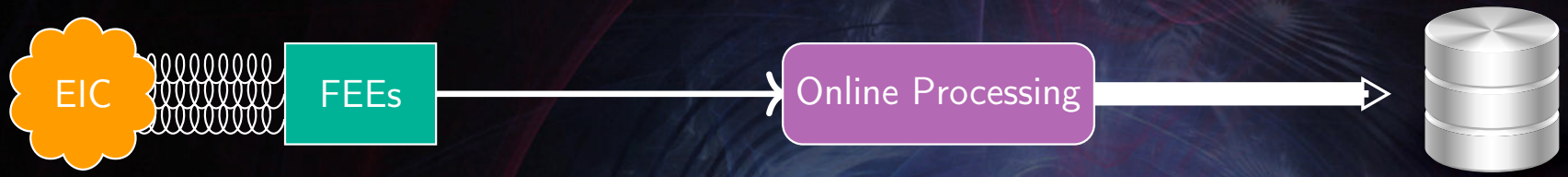

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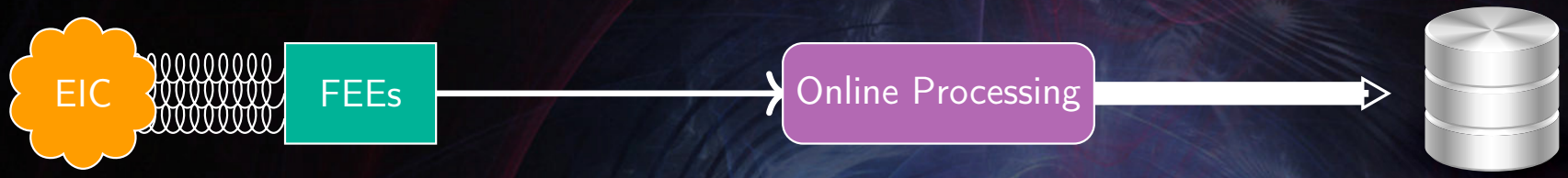

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- Save data to long term storage

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- Move complexity from hardware to software (and from online to offline)
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- Remove bottleneck of event building.
  - Can easily scale to large channel counts.
  - Event building always "brittle". What happens if FEE dies?

Spectrum of SRO

- Save all data
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- Maximum physics
- Highest rate

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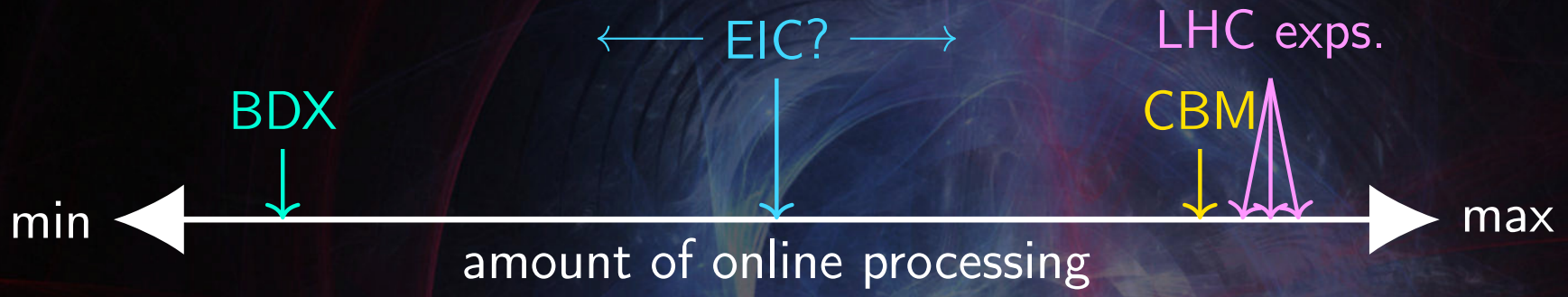

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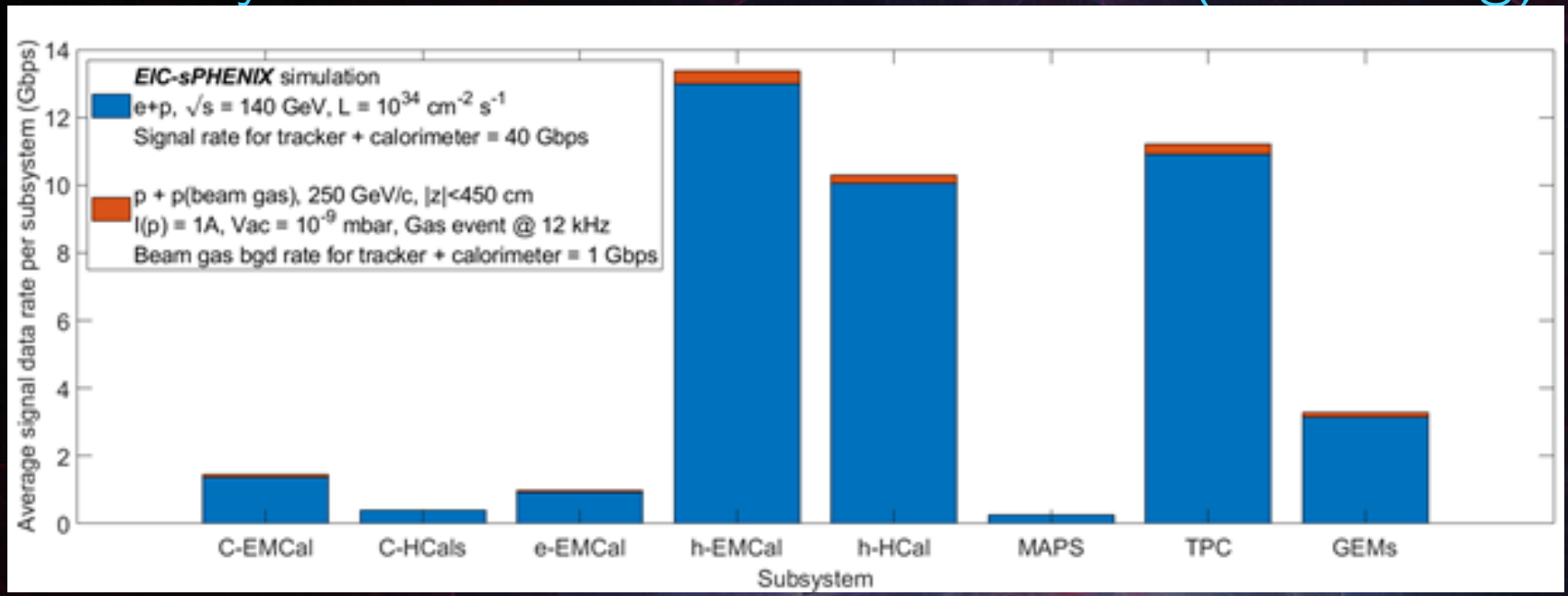
A rate study: sPHENIX based EIC detector (Jin Huang)



Total rate around 100 GBit/s. This is 1/2 the rate of sPHENIX!

- » Rates are very well doable for sPHENIX, will be trivial for EIC time frame.
- » EIC SRO is on the safe side of the spectrum!
- » BeAST: similar rate
- » JLEIC: First estimate: 250 GByte/s for vertex detector. Need streaming, ROI/noise suppression.

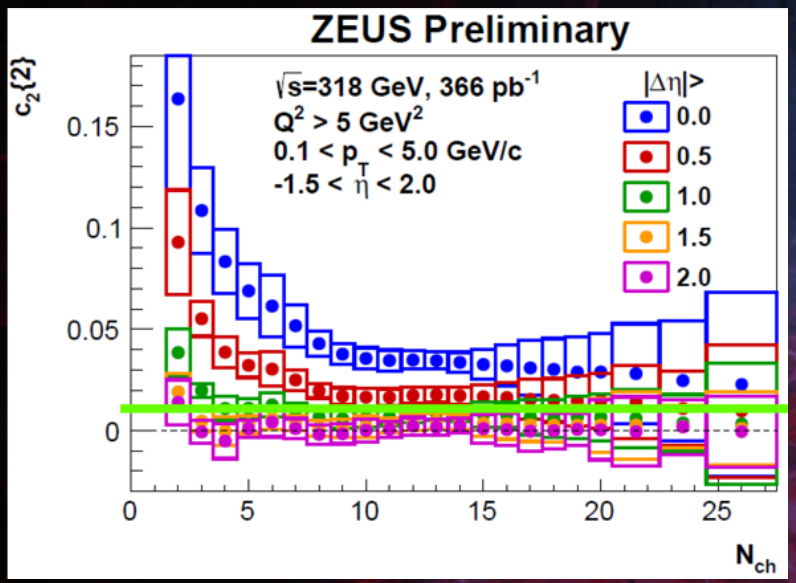
(Different detectors might give different rates, especially if channel count is drastically larger.)

For EIC, streaming readout is *insurance*

- If rates are higher than estimated, can easily compensate (by adding back "maybe steps") without losing physics!
- SRO is simpler, easier to reason about and debug.
- No complex trigger electronics/timing.
- Avoid critical bottle neck of event builder (can do event building over and over again offline).
- Does your trigger capture all interesting events? Also the channels you think of in the future?

Unexpected physics

- In 2016, surprising evidence of collectivity in p+p collisions [CMS, Phys. Lett. B 765 (2017) 193]
- Inspired search for QGP signatures in even smaller systems: e+p [ZEUS, QM18], e+e [MOD, arxiv:1906.00489]
- HERA data (currently) limited by statistics and trigger.



- $c_2\{2\} < 0.01$ at $N_{ch} = 15$
- implies $v_2 < 0.1$
- Room for small v_2, need more statistics!

(Figure / discussion courtesy Austin Batsy, IS2019, ZEUS QM18)

- Need to record large amounts of high multiplicity events with minimal trigger bias, including low Q^2 and diffractive events.
- At LHC: streaming/locally triggered front ends, HLT on N_{ch}
- At EIC: Natural fit for streaming readout

Implications of SRO

- Can record everything / have full information for data decision
  - Is there physics neglected because we couldn't trigger on it?
  - Can we get better exp. by not having trigger detectors?
- Multiplexer chips to reduce ADC count (APV, DREAM, etc) don't work
  - At EIC minimally biased: Too much deadtime anyway
- Need to maximize the impact of online analysis!
  - "Analysabiilty" is another metric, often neglected

Detector design needs to consider physics needs, readout and analysis!

What is happening?

- Consortium of many institutes to build a streaming readout standard (not only for EIC)
  - solves many pain points
  - small labs can contribute too!
- We meet twice a year. Everybody is welcome!
- Many developments in the pipeline at many institutes!
  - JLAB: INDRA facility (Innovation in Nuclear Data Readout and Analysis)
  - BNL: sPHENIX partial streaming readout
  - INFN: ASICS, BDX / KM3Net streaming readout
- eRD23: Streaming Readout (PIs: Marco Battaglieri, JCB)

Next workshop / working group

RBRC
RIKEN BNL Research Center

- Next workshop will be at BNL – hosted by RBRC
- Three days: November 13 to 15
- Website: https://www.bnl.gov/srv2019/

Can we establish a EIC Streaming Readout Working Group?

Who are we: SRC members

- Catholic University of America: S. Ali, V. Berdnikov, T. Horn, M. Muhoza, I. Pegg, R. Trotta
- INFN Genova: **M. Battaglieri,** A. Celentano
- Stony Brook University / RBRC: **J. C. Bernauer**
- Massachusetts Institute of Technology: D. Hasell, R. Milner
- Thomas Jefferson National Accelerator Facility: C. Cuevas, M. Diefenthaler, R. Ent, G. Heyes, B. Raydo, R. Yoshida
- New: Brookhaven National Laboratory: M. Purschke, J. Huang

Additionally many regulars

$\longrightarrow$We welcome new members!$\longleftarrow$