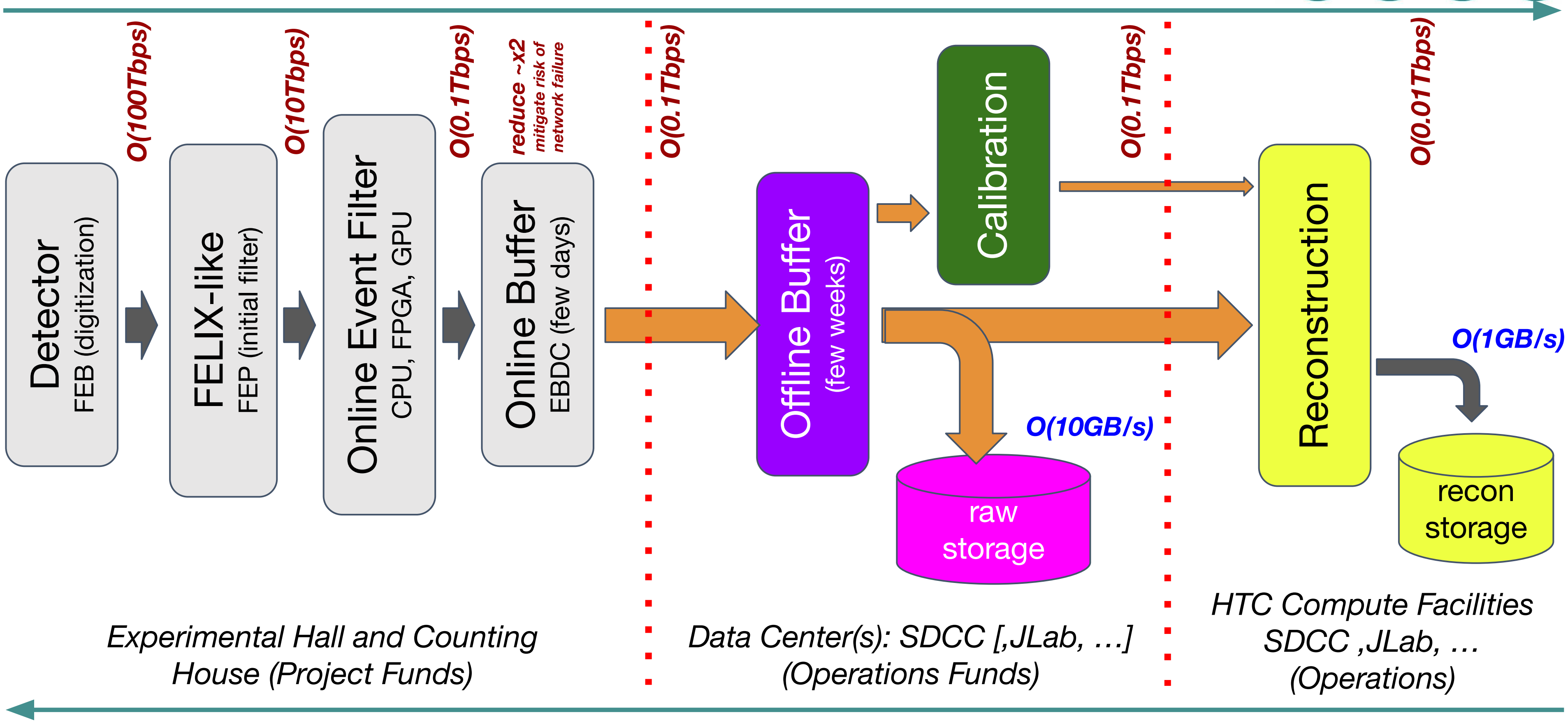
Computing Plan Status

D. Lawrence

EIC Computing Meeting
Oct. 18 2021

Data Storage and Compute



Detector
FEB (digitization)

O(100Tbps)

FELIX-like
FEP (initial filter)

O(10Tbps)

Online Event Filter
CPU, FPGA, GPU

O(0.1Tbps)

reduce ~x2
mitigate risk of network failure

Online Buffer
EBDC (few days)

O(0.1Tbps)

Offline Buffer
(few weeks)

Calibration

O(0.1Tbps)

raw storage

O(10GB/s)

Reconstruction

O(0.01Tbps)

O(1GB/s)

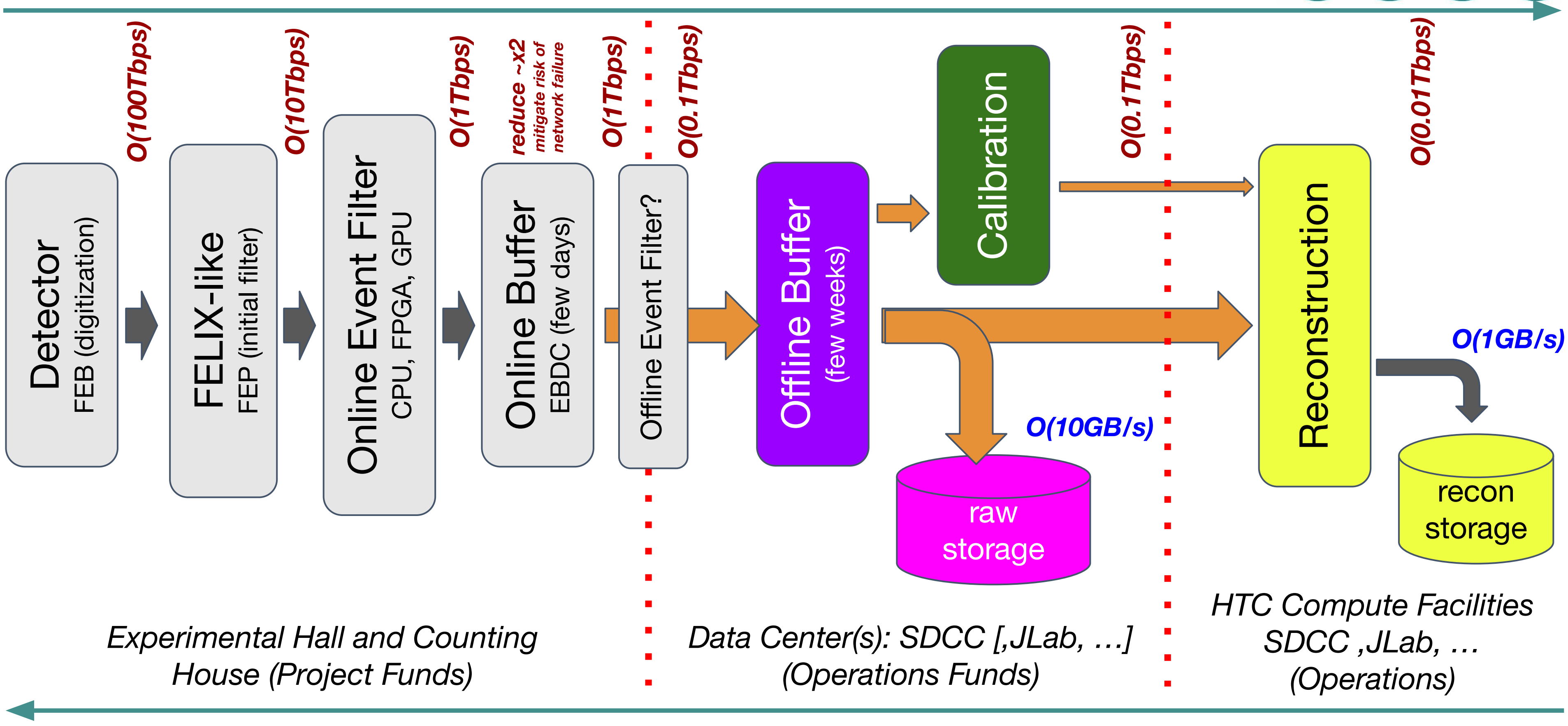
recon storage

Experimental Hall and Counting House (Project Funds)

Data Center(s): SDCC [,JLab, …] (Operations Funds)

HTC Compute Facilities
SDCC ,JLab, …
(Operations)

Data Storage and Compute



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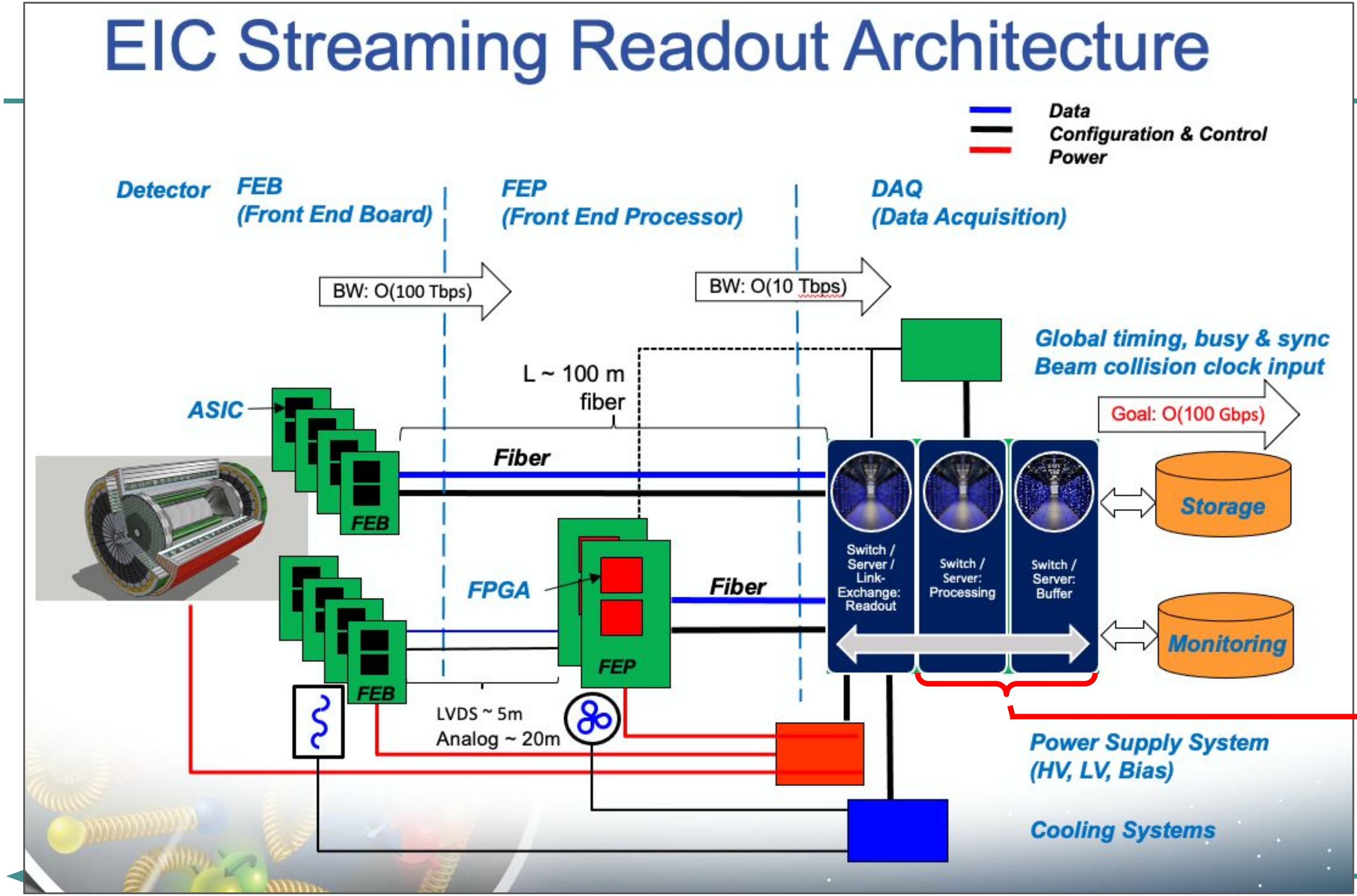
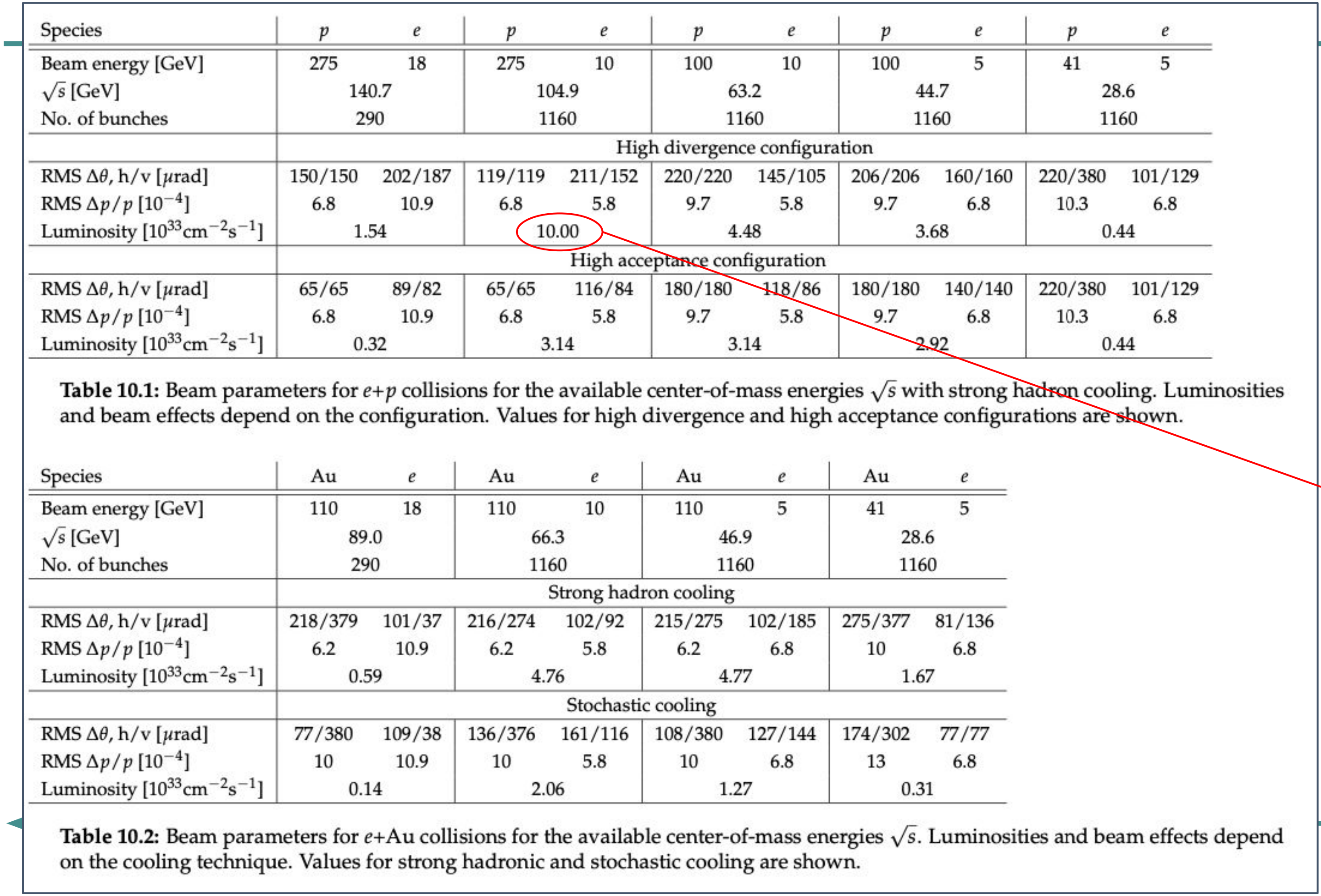
EIC Streaming Readout Architecture



EIC Streaming Readout (From Fernando Barbosa's talk at AI4EIC Sep. 9, 2021)

factor of 100 in data reduction

from EIC Yellow Report



Species	p	e	p	e	p	e	p	e	p	e
Beam energy [GeV]	275	18	275	10	100	10	100	5	41	5
$\sqrt{s}$ [GeV]	140.7		104.9		63.2		44.7		28.6	
No. of bunches	290		1160		1160		1160		1160	
	High divergence configuration									
RMS $\Delta\theta$, h/v [μrad]	150/150	202/187	119/119	211/152	220/220	145/105	206/206	160/160	220/380	101/129
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9	6.8	5.8	9.7	5.8	9.7	6.8	10.3	6.8
Luminosity [10^{33}cm^{-2}s^{-1}]	1.54		10.00		4.48		3.68		0.44	
	High acceptance configuration									
RMS $\Delta\theta$, h/v [μrad]	65/65	89/82	65/65	116/84	180/180	118/86	180/180	140/140	220/380	101/129
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9	6.8	5.8	9.7	5.8	9.7	6.8	10.3	6.8
Luminosity [10^{33}cm^{-2}s^{-1}]	0.32		3.14		3.14		2.92		0.44	

Table 10.1: Beam parameters for $e+p$ collisions for the available center-of-mass energies $\sqrt{s}$ with strong hadron cooling. Luminosities and beam effects depend on the configuration. Values for high divergence and high acceptance configurations are shown.

Species	Au	e	Au	e	Au	e	Au	e
Beam energy [GeV]	110	18	110	10	110	5	41	5
$\sqrt{s}$ [GeV]	89.0		66.3		46.9		28.6	
No. of bunches	290		1160		1160		1160	
	Strong hadron cooling							
RMS $\Delta\theta$, h/v [μrad]	218/379	101/37	216/274	102/92	215/275	102/185	275/377	81/136
RMS $\Delta p/p$ [10^{-4}]	6.2	10.9	6.2	5.8	6.2	6.8	10	6.8
Luminosity [10^{33}cm^{-2}s^{-1}]	0.59		4.76		4.77		1.67	
	Stochastic cooling							
RMS $\Delta\theta$, h/v [μrad]	77/380	109/38	136/376	161/116	108/380	127/144	174/302	77/77
RMS $\Delta p/p$ [10^{-4}]	10	10.9	10	5.8	10	6.8	13	6.8
Luminosity [10^{33}cm^{-2}s^{-1}]	0.14		2.06		1.27		0.31	

Table 10.2: Beam parameters for e+Au collisions for the available center-of-mass energies $\sqrt{s}$. Luminosities and beam effects depend on the cooling technique. Values for strong hadronic and stochastic cooling are shown.

From YR 2.10

"Most of the key physics topics discussed in the EIC White Paper [2] are achievable with an integrated luminosity of 10 fb^{-1} corresponding to 30 weeks of operations."

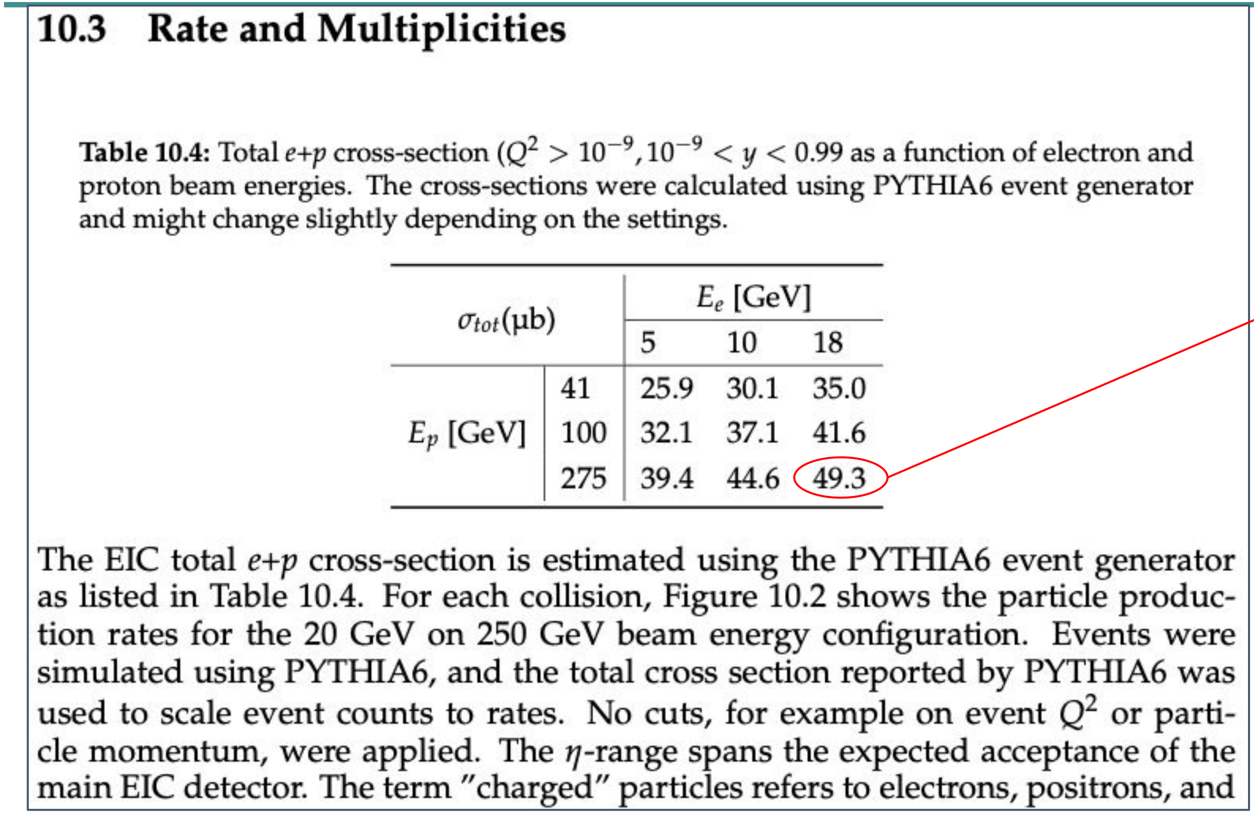
10×10^{33} cm^{-2}s^{-1} x 30 weeks

=

18.1 fb^{-1}

(assumes 100% beam up time. YR also says 60% operational efficiency which would bring this to 10.3 fb^{-1})

bottom line: 10fb^{-1} represents roughly first year of running with about half of that for *ep* scattering *from EIC Yellow Report*



10.3 Rate and Multiplicities

Table 10.4: Total e+p cross-section ($Q^2 > 10^{-9}, 10^{-9} < y < 0.99$ as a function of electron and proton beam energies. The cross-sections were calculated using PYTHIA6 event generator and might change slightly depending on the settings.

σ_{tot}(µb)		E_e [GeV]		
		5	10	18
E_p [GeV]	41	25.9	30.1	35.0
	100	32.1	37.1	41.6
	275	39.4	44.6	49.3

The EIC total e+p cross-section is estimated using the PYTHIA6 event generator as listed in Table 10.4. For each collision, Figure 10.2 shows the particle production rates for the 20 GeV on 250 GeV beam energy configuration. Events were simulated using PYTHIA6, and the total cross section reported by PYTHIA6 was used to scale event counts to rates. No cuts, for example on event Q^2 or particle momentum, were applied. The η-range spans the expected acceptance of the main EIC detector. The term "charged" particles refers to electrons, positrons, and

For *ep* scattering representing ***half*** of a 30 week year of running we expect:

50µb x 5fb^{-1} = 250B collisions

Inclusive *ep* scattering MC DST:
~600MB/2k events = 300kB/event

250B/(15weeks*7days/wk*24hr/d*3600s/hr)/(60% accel. efficiency) =46kHz

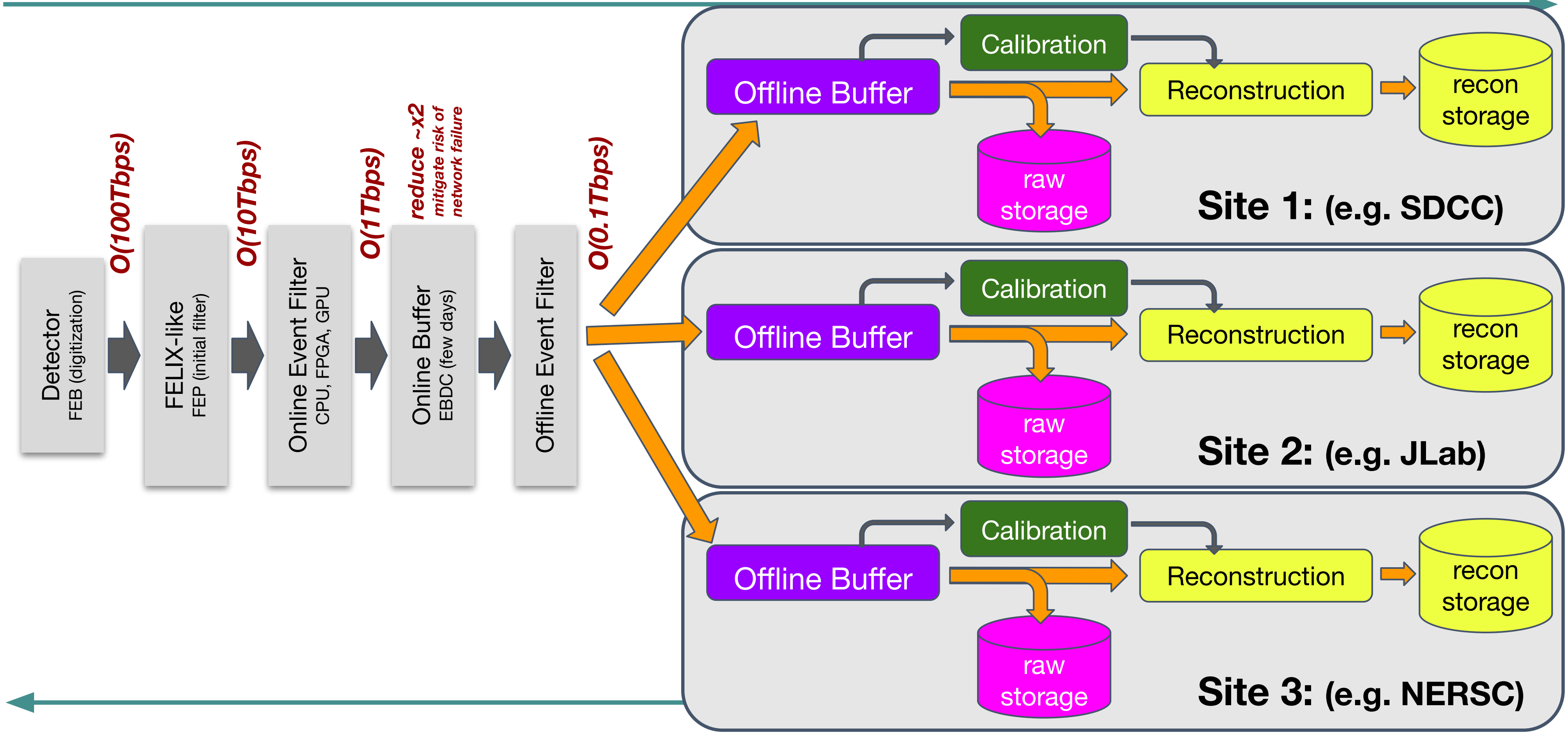
46kHz * 300kB = 14GB/s (**140Gbps**)

close to Jin's simulation calculation of O(100Gbps)

Multiple levels of event filter

	Input/Output	Reduction Factor	Technology
FELIX-like Compute Interface	100Tbps/10Tbps	10	FPGA
Online Event Filter	10Tbps/1Tbps	10	FPGA, (GPU), CPU
Offline Event Filter	<1Tbps/01.Tbps	~10	FPGA, GPU, CPU
Reconstruction	1Tbps/0.1Tbps	10	(FPGA), GPU,CPU

Federated Computing Model



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Offline Buffer → Calibration → Reconstruction → recon storage; raw storage

Site 1: (e.g. SDCC)

Offline Buffer → Calibration → Reconstruction → recon storage; raw storage

Site 2: (e.g. JLab)

Offline Buffer → Calibration → Reconstruction → recon storage; raw storage

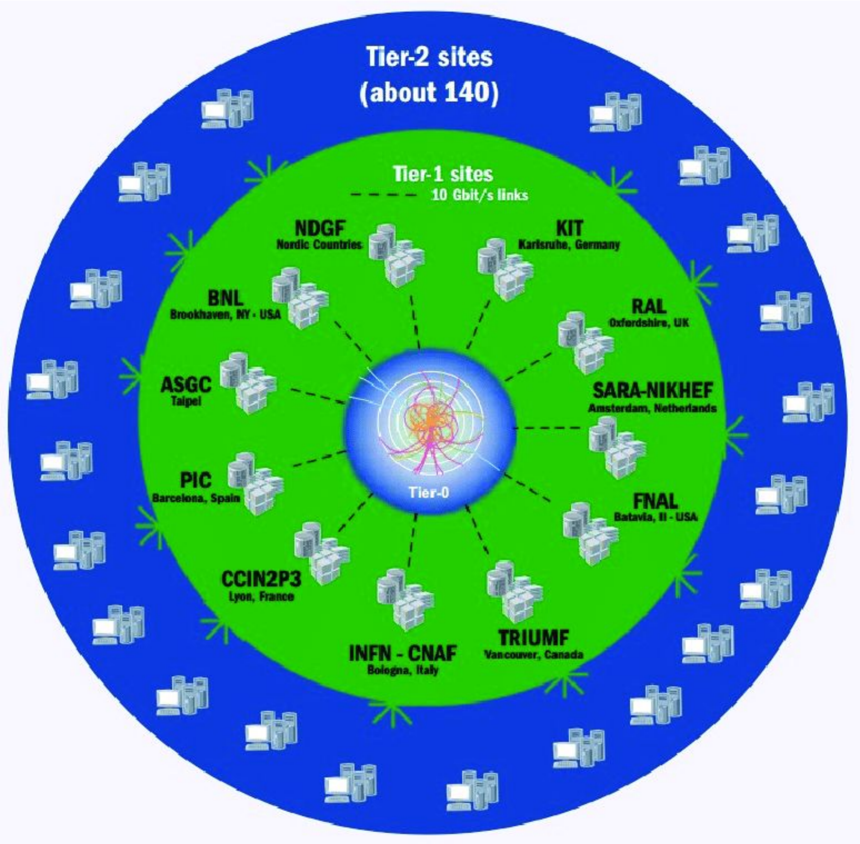
Site 3: (e.g. NERSC)

Federated Computing Model

Benefits of using a federated model in the near-time pipeline

- Each site only needs to handle a fraction of data
- EIC computing becomes a smaller fraction of each compute farm
- One site having diminished capacity temporarily can easily be absorbed by others without reconfiguration

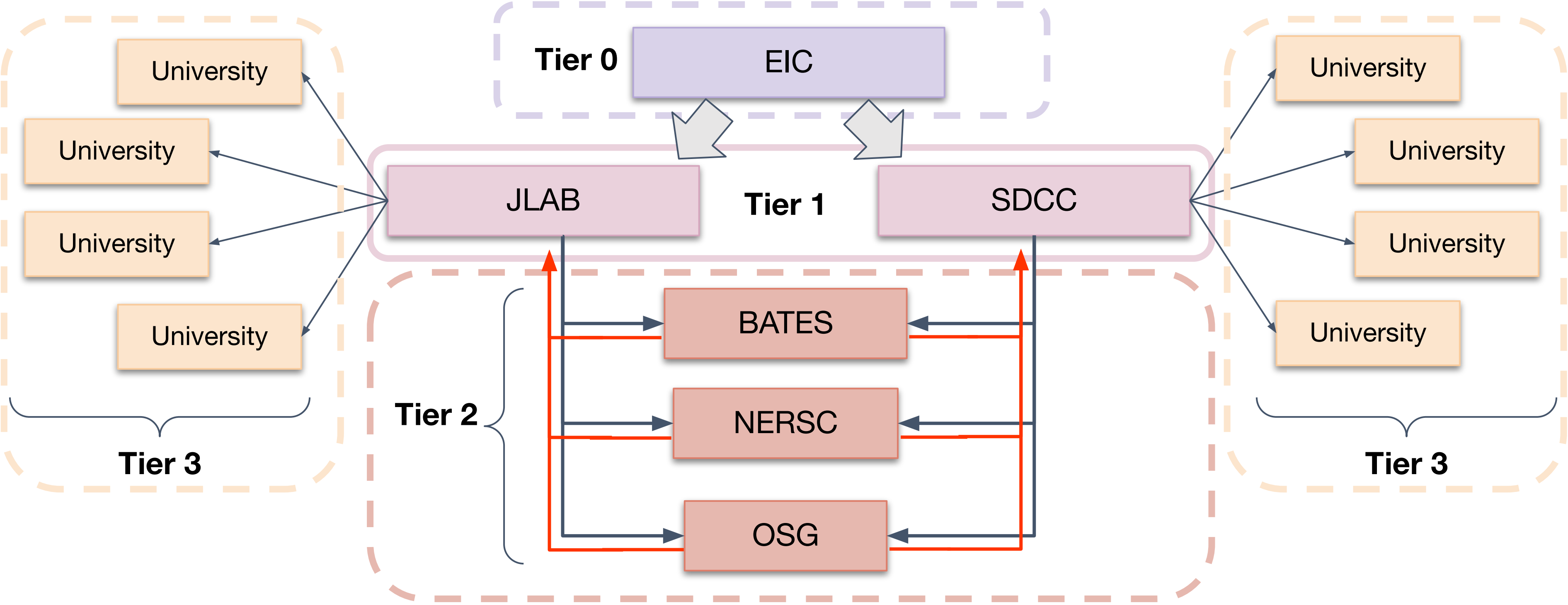
Worldwide LHC Computing Grid (WLCG)



- **Tier 0 - LHC**
  - ○ Store all raw data
  - ○ 20% of LHC computing
  - ○ Initial reconstruction
  - ○ Distribute raw data and initial recon to all Tier 1 sites
- **Tier 1 - multiple sites(13)**
  - ○ Combined capacity to store all data from Tier 0
  - ○ Compute for large scale reprocessing
  - ○ Distribute data to Tier 2 sites
  - ○ Store simulated data from Tier 2 sites
- **Tier 2 - Universities and Scientific sites (155)**
  - ○ Compute for specific analysis tasks
  - ○ Some reconstruction
  - ○ Simulation
- **Tier 3 - End users**
  - ○ small clusters or personal computers

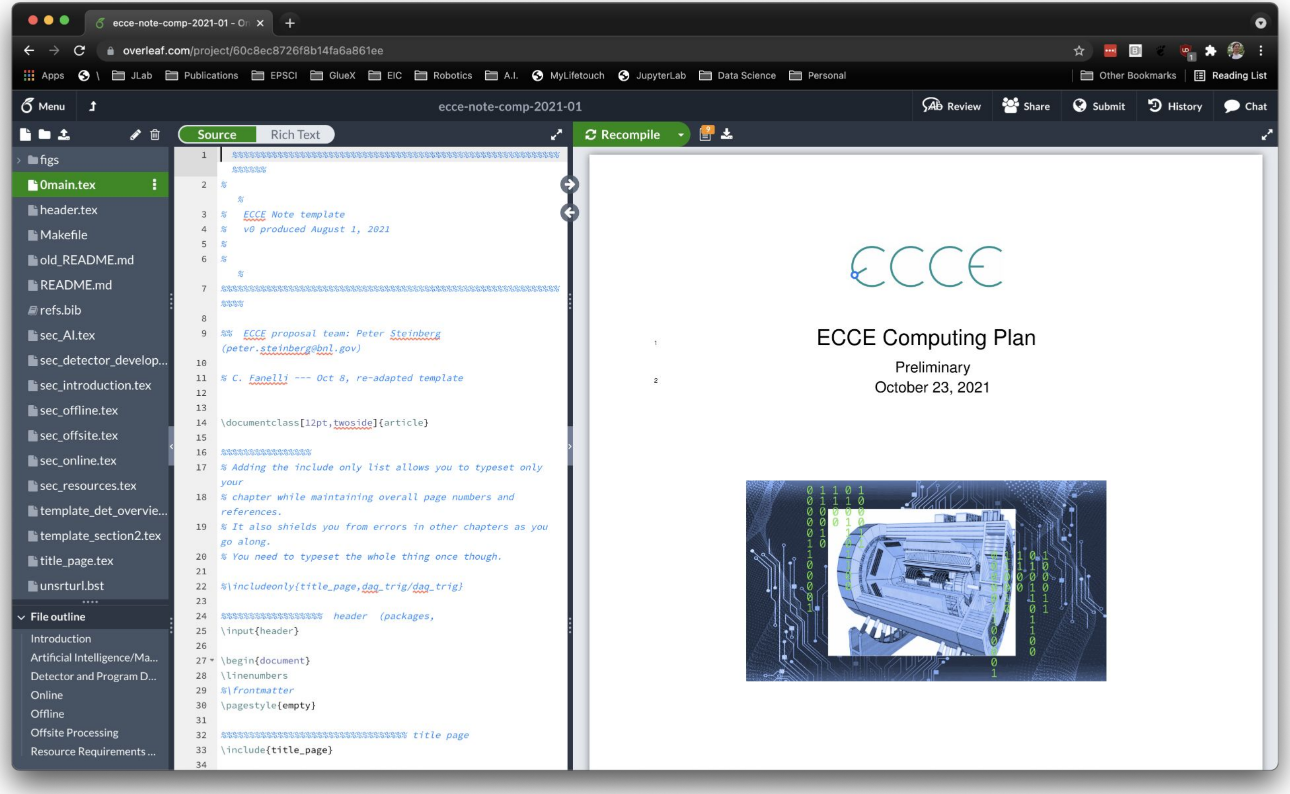
https://home.cern/science/computing/grid-system-tiers

An EIC Butterfly Model



*Nearly all storage (raw data, reconstructed data, simulated data) is stored across **Tier 1** sites*

ECCE Computing Plan



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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%                                                                   %
%   ECCE Note template
%   v0 produced August 1, 2021
%
%                                                                   %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%  ECCE proposal team: Peter Steinberg (peter.steinberg@bnl.gov)

% C. Fanelli --- Oct 8, re-adapted template


\documentclass[12pt,twoside]{article}

%%%%%%%%%%%%%%%%%
% Adding the include only list allows you to typeset only your
% chapter while maintaining overall page numbers and references.
% It also shields you from errors in other chapters as you go along.
% You need to typeset the whole thing once though.

%\includeonly{title_page,daq_trig/daq_trig}

%%%%%%%%%%%%%%%%%%  header  (packages,
\input{header}

\begin{document}
\linenumbers
%\frontmatter
\pagestyle{empty}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% title page
\include{title_page}

```

1
2

ECCE Computing Plan

Preliminary
October 23, 2021

Key features:

1. Streaming Readout
2. Reconstruction in near-real time (~2weeks)
3. Federated Computing

- Internal deadline of Oct. 23
  - rough draft, all sections
- Internal review Oct. 24-30
- Designated Reader review Nov. 1-15
- Final draft Nov. 30

Open Questions

- Computing/Storage
  - What are DOE rules, where are they written, can they be updated?
  - LHC-style pyramid model vs. butterfly model?
  - Common system for all EIC experiments?
- Data Processing/Software
  - Limitations on calibration latency? *(e.g. detector design)*
  - Nature and number of filters. Types of technology that can be used (e.g. FPGA, GPU, …)

Backups