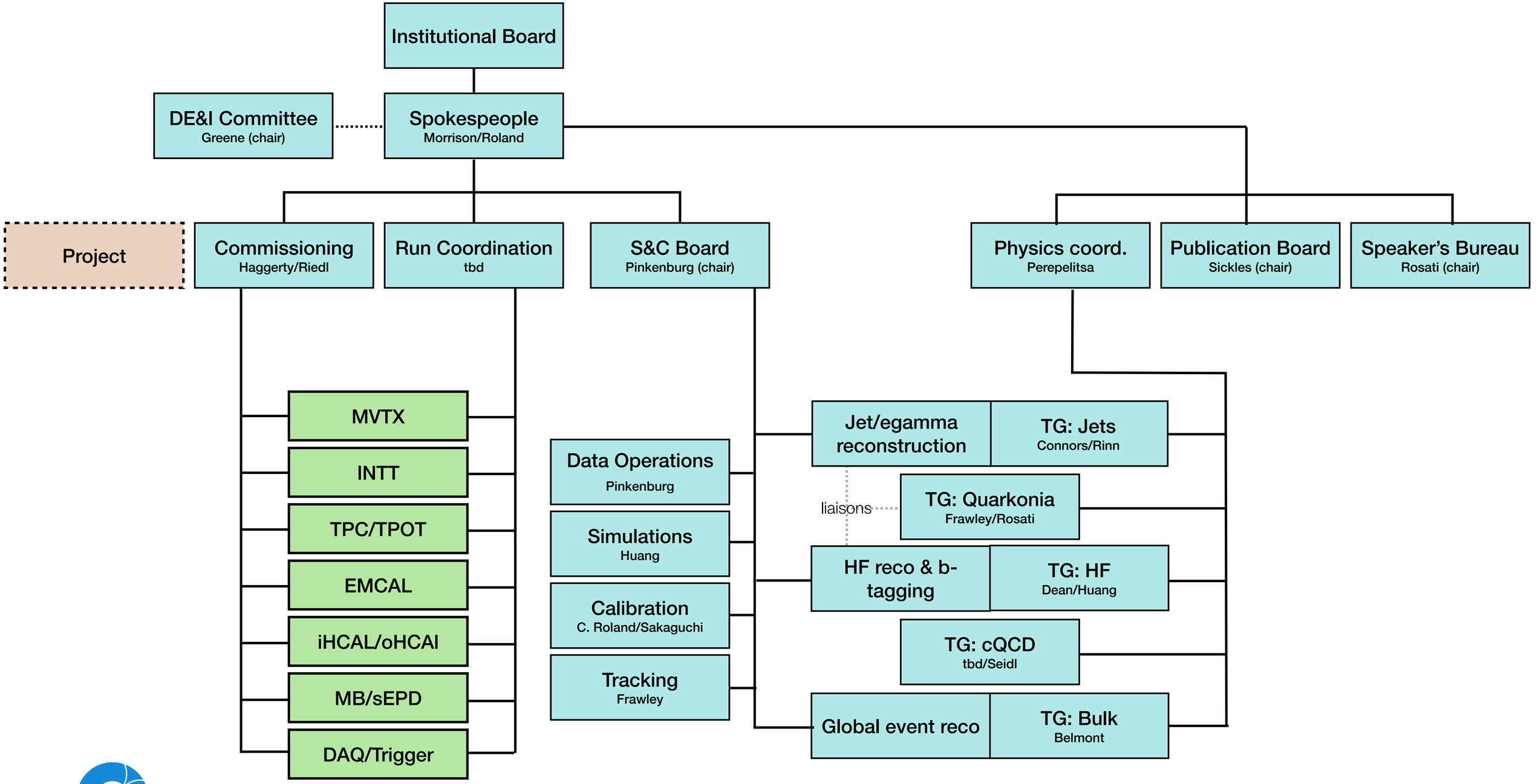
sPHENIX Readiness for Data Taking Including Computing and Commissioning Plan

David Morrison (BNL)
Gunther Roland (MIT)
co-spokespersons

Major elements of data taking readiness

- Technical – the availability of all necessary hardware (Ed O'Brien's talk)
- Organization – a structure of people with responsibilities and authorities to operate the experiment correctly and take data reliably
- Commissioning – a set of activities to verify that detectors are working as expected and that data is being properly and correctly acquired
- Computing – proper provisioning of resources to monitor and evaluate incoming data for many needs, such as developing and tracking calibrations



mergers just for graphics purposes

Tracking
T. Frawley

- **Cluster Finding** — C. Roland, Z. Ji
- **Track Seeding** — M. Peters
- **ACTS** — J. Osborn
- **TPC/IT matching** — T. Frawley
- **Truth matching** — D. Stewart
- **Vertexing** — T. Frawley
- **KF Particle** — C. Dean

Calo/jet reco
T. Rinn, S. Bazilevsky

- **Electron ID** — W. Ma
- **Topoclusters** — D. Perepelitsa
- **Jet reco, sEPD** — Y. Go, E. Umaka
- **B-tagging** — D. Lis, H.Okawa, S. Lim

Simulations
J. Huang

- **GEANT4** — C. Pinkenburg
- **MVTX** — Y. Corrales Morales
- **INTT** — G. Nukazuka
- **TPC** — T. Frawley/calib. TF
- **EMCAL** — J. Huang
- **HCAL** — X. He, M. Sarsour
- **TPOT** — H. Pereira Da Costa
- **Fast Sim (Tracking)** — X. Chen
- **sEPD** — R. Bi
- **MBD** — M. Chiu
- **Fast Sim (EMCAL)** — A. Lebedev

Calibration TF
C. Roland, T. Sakaguchi

- **TPC Calibration** — R. Corliss, H. Pereira Da Costa
  - **Distortion corr. scheme** — R. Corliss
  - **Readout/Space Charge Modeling** — E. Shulga
  - **Diffuse laser scheme** — R. Corliss
  - **Digital current scheme** — tbd
  - **Directed laser/ External det. scheme** — H. Pereira Da Costa
- **Calo Calibration** — J. Frantz
  - **Calo JES** — A. Angerami
  - **Tower rel. cal.** — J.Bryan
  - **HCAL E Scale** — R. Belmont, S. Bathe
  - **EM pi0/eta cal.** — B. Xia, S.Chauhan
  - **HCAL LED cal.** — D. Richford
  - **ECAL LED Cal.** — T. Rinn, S.Stoll
- **TPC/Global Alignment** — R. Boucher
- **MVTX Alignment** — Y. K. Kim

Data Operations
C. Pinkenburg

- **Workflow management** — NPPS
- **Conditions DB** — NPPS

sPHENIX

Visitor office

- Peter Steinberg and Mariette Faulkner
- No dedicated budget identified – unlike the case, historically, for PHENIX and STAR
- Collecting plans from Institutions for stationing student/postdocs/staff at BNL
- Support visitors to BNL in various ways:
  - Information, liaison to GUV center, hosting
  - Providing office space
  - Possible support with funds

Commissioning Task Force

- Established in May 2021
- Co-led by Caroline Riedl (UIUC) and John Haggerty (BNL)
- All sPHENIX subsystems are represented; regular meetings

Name	Institution
John Haggerty	BNL
Caroline Riedl	UIUC
Walter Sondheim	Los Alamos
Ming Liu	Los Alamos
Klaus Dehmelt	Stony Brook
Jin Huang	BNL
Takao Sakaguchi	BNL
Rachid Nouicer	BNL
Stefan Bathe	CUNY
Tim Rinn	UIUC
Martin Purschke	BNL
Chris Pinkenburg	BNL
Russ Feder	BNL
Steve Boose	BNL
Joel Vasquez	BNL
Hugo Pereira	CEA Saclay / LANL
Rosi Reed	Lehigh University

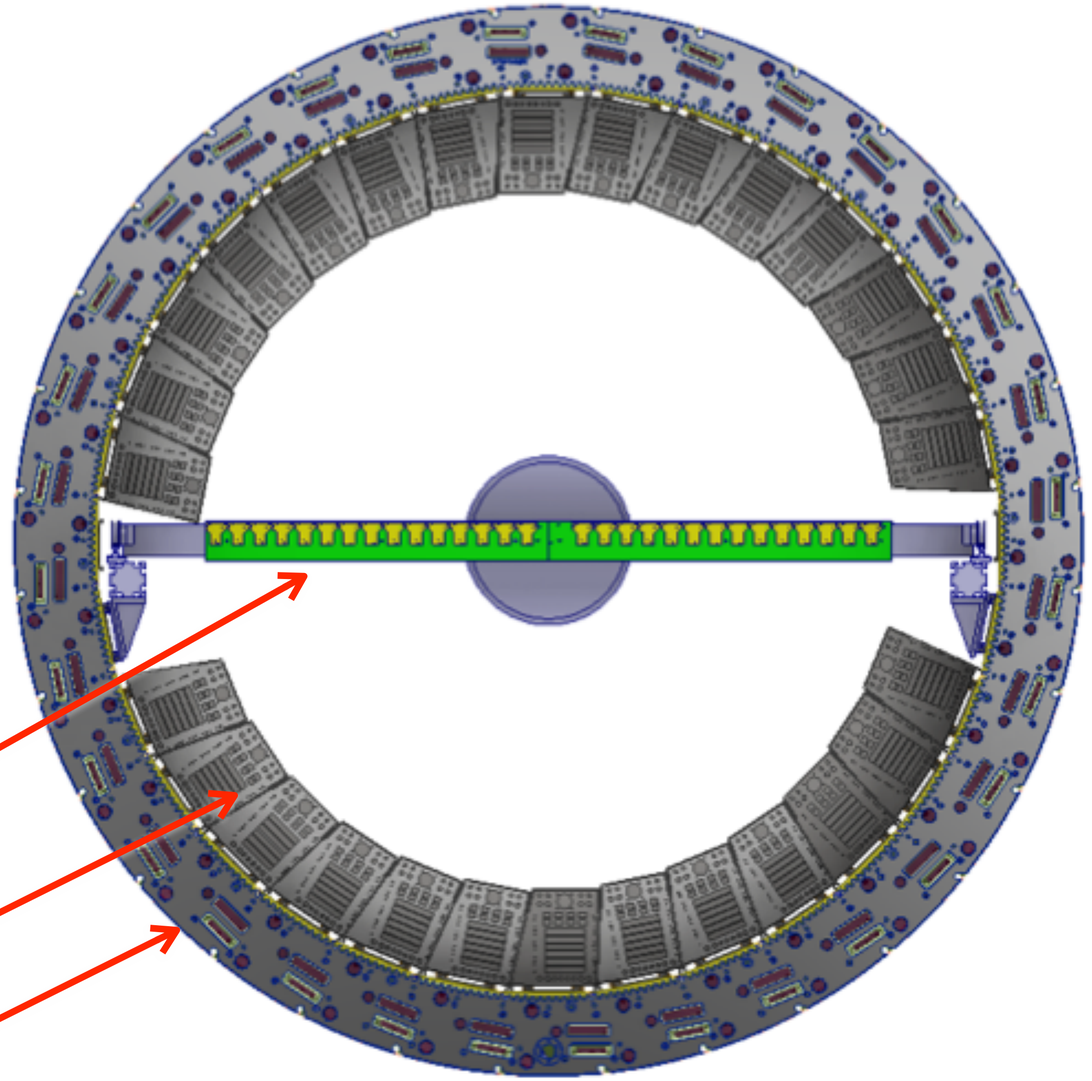
Commissioning stages

1. Pre-installation commissioning and testing
2. Installation commissioning
3. Post-installation commissioning
4. Magnet commissioning
5. DAQ and Electronics Installation and Commissioning
6. Full detector commissioning (essentially DAQ and computing commissioning)
7. Trigger commissioning
8. Cosmic ray running
9. Beam operation

Detector power ON

Magnet commissioning and mapping

- Preparing magnet for mapping is being done by the C-AD cryo and power supply groups under Kin Yip's leadership
- Looks to be on track for end of September mapping
- Aim to compare measured and calculated field maps in near real time



Many commissioning projects

- “Off carriage” tasks – commissioning detectors and electronics in the IR happens after magnet mapping – do as much as possible ahead of time
  - Calorimeter ADCs, TPC sectors, MBD, MVTX, INTT
- Full calorimeter commissioning
  - Trigger commissioning
  - Commissioning with cosmic rays
  - Commissioning with beam

TPC electronics commissioning

- Less operational experience with TPC electronics than with ADC system
- Production FEE should be complete in June
- FEE will be installed sector-by-sector at SBU
  - We need to provide LV power, DAQ, and support as electronics is installed
- Need to build experience with the electronics coupled to the TPC – will be a period of learning to acquire and work with the data
- TPC will be completed at SBU as much as possible, so that installation in sPHENIX only requires connections that can't be made outside the IR (cooling manifolds, fibers, LV cables)
- The calibration lasers are bulky and will be installed after the TPC is inserted in the bore of the solenoid

GANTT chart detail

Alignment system in-situ test	1 wk	Fri 1/20/23 8:00 AM	Thu 1/26/23 5:00 P
TPC gas available long term (?)	0.2 wks?	Thu 12/1/22 8:00 AM	Thu 12/1/22 5:00 P
Cosmics magnet OFF with at least TPC	5.6 wks	Fri 1/13/23 8:00 AM	Tue 2/21/23 5:00 P
Laser-align all tracking detectors	3 wks	Tue 2/28/23 8:00 AM	Mon 3/20/23 5:00

Computing effort for sPHENIX

- DAQ/Online computing is part of the project
- Offline computing is not part of the project
- Collaboration workforce – development and operations
- Nuclear and Particle Physics Software Group (T. Wenaus)
- Scientific Data and Computing Center (E. Lançon)
- NPPS and SDCC effort is on development and deployment – valuable contributions (PanDA, Rucio, Conditions DB, ACTS, etc)
- Also, SDCC operates the computing facility

sPHENIX Computing plan and resource needs, 2019-2022

- 1st sPHENIX Software and computing review: **June 18, 2018**
- Performance: **480s/event**: “At the current time the CPU needs exceed the available resources by about an order of magnitude “ (Pinkenburg, s18)
- Mitigations: 2 mr crossing angle to reduce incidental load on TPC; move from generic reconstruction and vertexing code to highly optimized packages
- “Goal is “prompt reconstruction” of data with fixed latency” (Roland, s17)
  - Approach informed by LHC experience. RHIC experience following a different approach (which led to the formation of the BNL Task Force on RHIC Detector Operations in 2016)

Report on the Task Force on RHIC Detector Operations

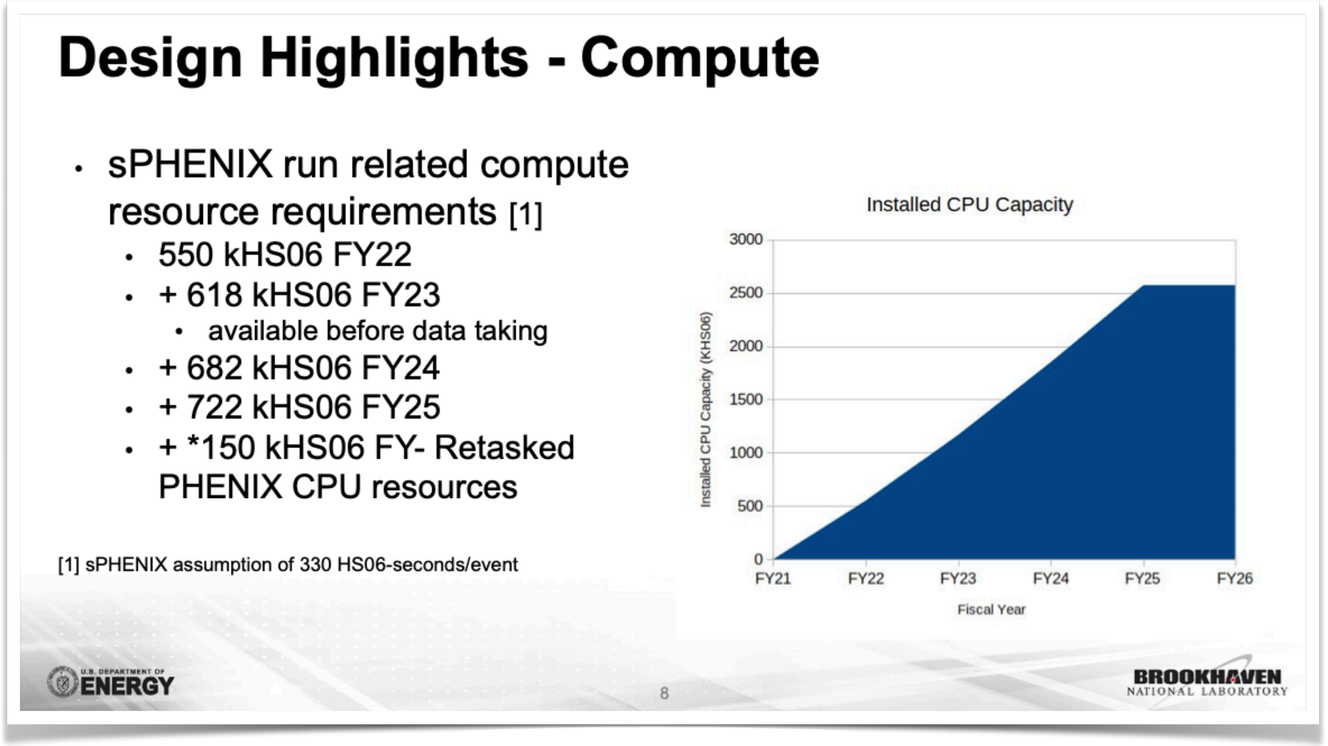
On April 16, 2016 Berndt Mueller formed a task force to investigate the operational processes that were in place during the 2015 RHIC Run to ensure that the RHIC detectors were making optimal use of the resources devoted to their operation. The formation of the task force was occasioned by the recent realization that two recently installed subsystems, the PHENIX MPC-EX and STAR HFT, had major issues in their operational configurations during the entirety of RHIC Run 15, extending into the first few weeks of RHIC Run 16 in the case of the STAR HFT. The task force was charged with identifying the root causes of the failures and recommending appropriate changes and improvements in the way the readiness and performance of detector systems at RHIC are monitored before and after RHIC runs in order to avoid similar failures in the future. The task force was composed of James Dunlop (chair), Michael Begel, Mickey Chiu, Bill Christie, Leo Greiner, John Lajoie, Laurence Littenberg, David Morrison, and Zhangbu Xu.

sPHENIX Computing plan and resource needs, 2019-2022

- 2nd S&C review took place **Sep 5-6, 2019**
  - Principle unchanged: “Resource planning foresees same-year reconstruction through 1 calibration pass and up to 2 reconstruction passes” and “Calibration/reconstruction with fixed latency” (Roland, s. 23)
  - Tracking time/event significantly reduced; goal defined as 5 sec/event for tracking and 4 GB/job (CRoland, s16)
  - Defined 24 sec/event reconstruction time (based on 5s/event for tracking) as key performance goal and basis for resource estimates (Soltz, s8)
  - Corresponding resource requests of 100k cores for Run 23 and 200k cores for Run 24 (Soltz, s10)

sPHENIX Computing plan and resource needs, 2019-2022

- 3rd S&C review took place **March 23-24, 2021**
  - Unchanged aims and reconstruction workflow
  - Reconstruction time 34 sec/event → continue to assume 24 sec/event for resource estimates and 4 GB/job
  - Re-cast estimates in kHS06; consistent with 2019 100k core estimate
    - within 1318 kHS06 envelope of SDCC planning document v2.4



sPHENIX Computing plan and resource needs, 2019-2022

- S&C Purchasing Readiness Review took place **July 19, 2021**
  - SDCC presented a new equipment purchasing plan based on FY'22 budget
  - Installed base in this plan at start of Run 23: 670 kHS06

sPHENIX budget request FY20-FY25

sPHENIX only	FY20	FY21	FY22	FY23	FY24	FY25	Total
Operations, Computer Space and Power	$80,000	$150,000	$1,310,000	$1,340,000	$1,470,000	$1,980,000	$6,330,000
Capital: early FY target purchases (1st round)	$0	$0	$1,820,000	$4,320,000	$2,780,000	$12,150,000	
Capital: mid-FY target purchases (2nd round)	$310,000	$440,000	$8,240,000	$0	$0	$0	
Capital: total for FY	$310,000	$440,000	$10,060,000	$4,320,000	$2,780,000	$12,150,000	$30,060,000
Total	$390,000	$590,000	$11,370,000	$5,660,000	$4,250,000	$14,130,000	$36,390,000

Additional details on slide #16

Current funding

NP Funding Guidance J Dunlop NP Budget Briefing Feb.'21

RHIC (all)	FY20	FY21	FY22	FY23	FY24	FY25	Total
J.Dunlop (S1, Feb 14, 2021)	$4,550,000	$6,400,000	$7,967,000	$9,495,000	$9,741,000	$9,589,000	$47,742,000
Cumulative total	$4,550,000	$10,950,000	$18,917,000	$28,412,000	$38,153,000	$47,742,000	

RHIC (all)	FY20	FY21	FY22	FY23	FY24	FY25	Total
Delta (Req. - J.Dunlop (S1, Feb 14, 2021))	$1,000,000	$2,120,000	-$7,843,000	$145,000	$2,581,000	-$6,591,000	-$8,588,000
Cumulative Delta (Req. - J.Dunlop (S1, Feb 14, 2021))	$1,000,000	$3,120,000	-$4,723,000	-$4,578,000	-$1,997,000	-$8,588,000	

Significant short fall in FY22 and FY25 – Labor flat (no increase in labor)

Brookhaven National Laboratory 7/19/21 D Benjamin (BNL-SDCC) 13

Benjamin, s13

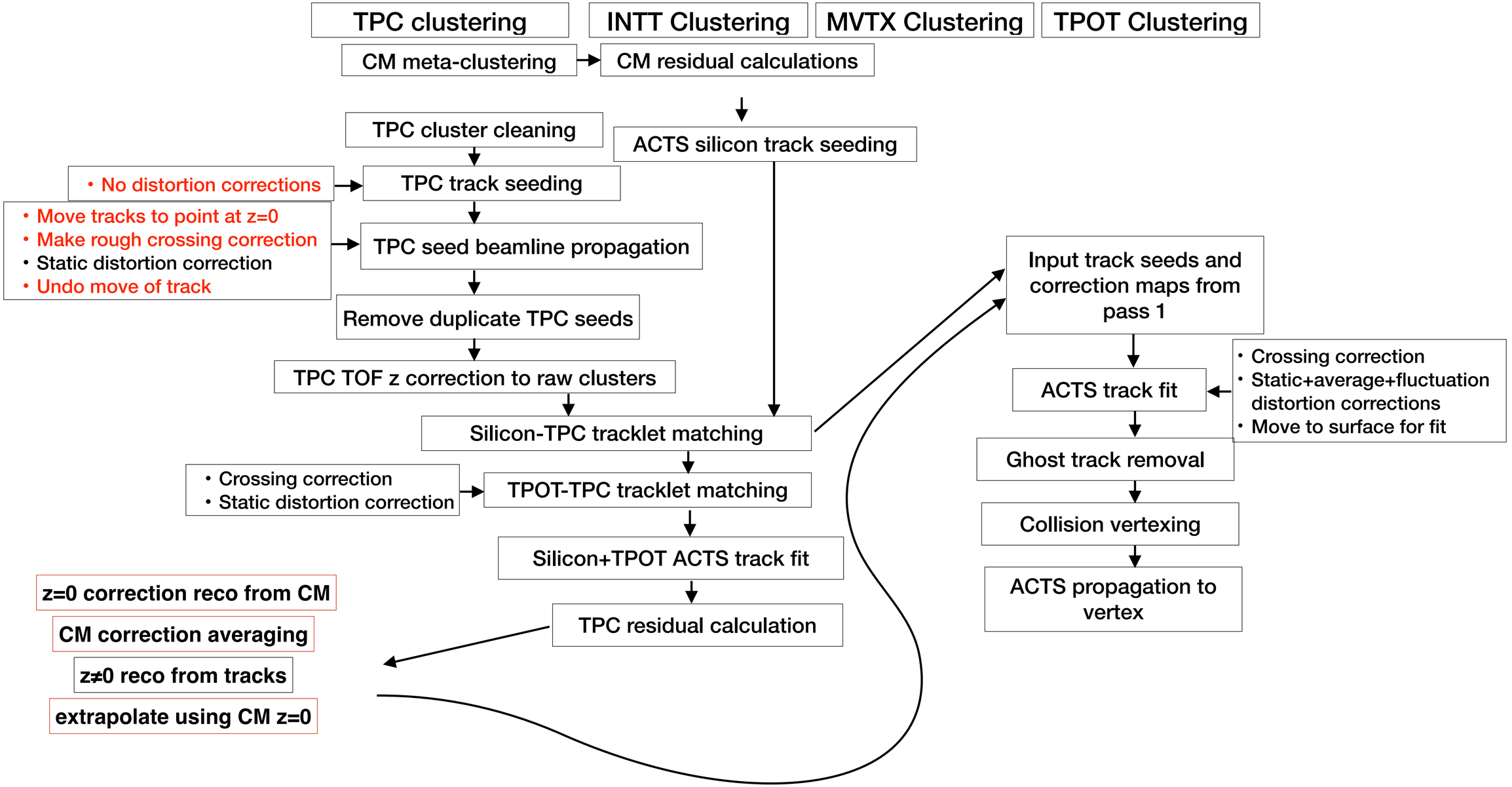
Current SDCC planning

- Dec 2021: +170 kHS06, 170 kHS06 (total, 23% of requested)
- Feb 2022: +30 kHS06: 200 kHS06 (total, 23% of requested)
- Dec 2022: +78 kHS06 (78 kHS06 of PHENIX included: 278 kHS06 (total, 25% of requested)
- Feb 2023: +392 kHS06 (65 kHS06 of PHENIX included): 670 kHS06 (total, 61% of requested)
- Feb 2024: +410 kHS06: 1080 kHS06 (total, 93% of requested)
- Feb 2025: +570 kHS06: 1650 kHS06 (total, 60% of requested)

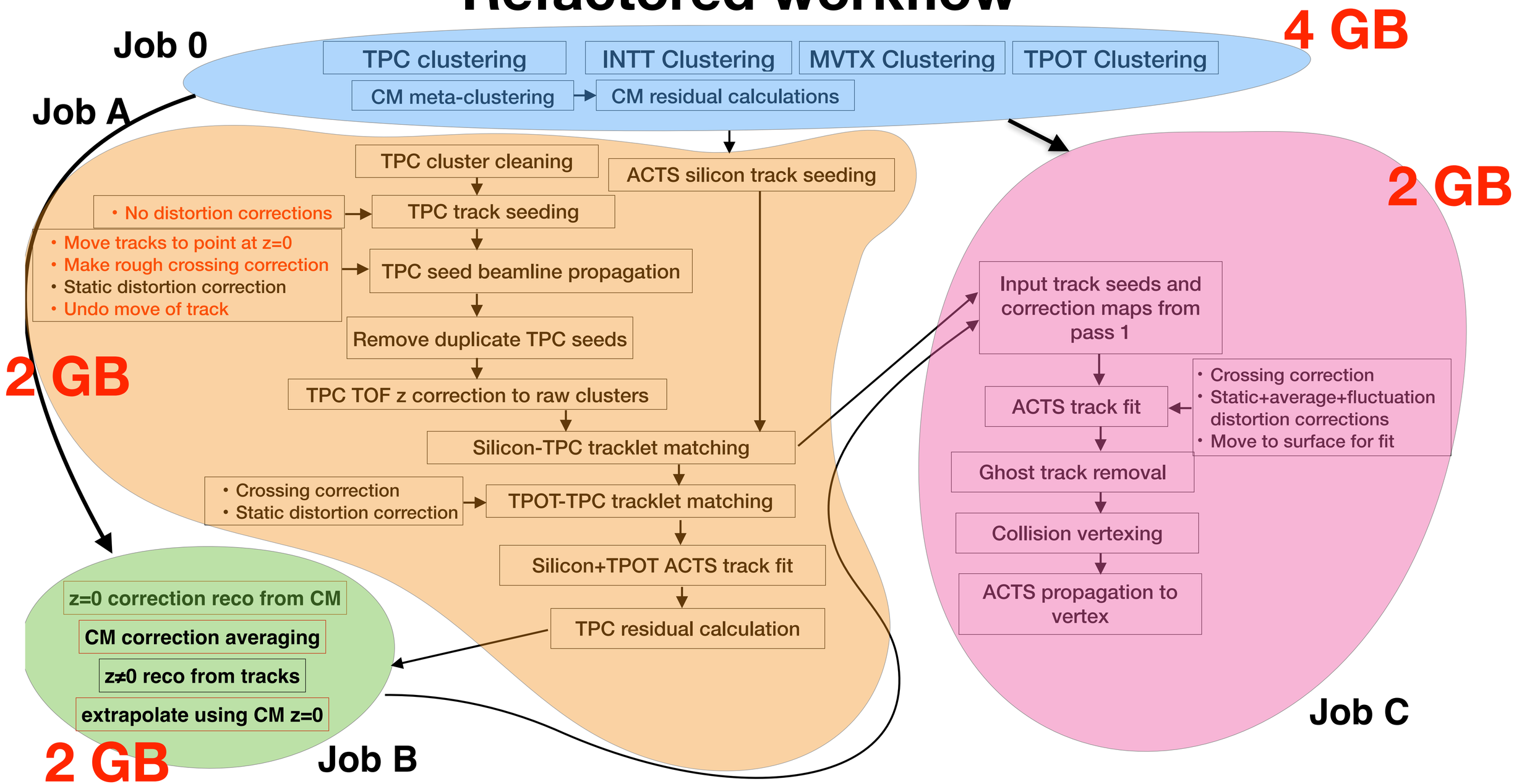
We continue to work with SDCC to understand budget impacts

July 19, 2021 4th sPHENIX Software & Computing Review 5

Soltz, s5


TPC clustering
INTT Clustering
MVTX Clustering
TPOT Clustering
CM meta-clustering
CM residual calculations
TPC cluster cleaning
ACTS silicon track seeding
• No distortion corrections
TPC track seeding
• Move tracks to point at z=0
• Make rough crossing correction
• Static distortion correction
• Undo move of track
TPC seed beamline propagation
Remove duplicate TPC seeds
TPC TOF z correction to raw clusters
Silicon-TPC tracklet matching
• Crossing correction
• Static distortion correction
TPOT-TPC tracklet matching
Silicon+TPOT ACTS track fit
TPC residual calculation
z=0 correction reco from CM
CM correction averaging
z≠0 reco from tracks
extrapolate using CM z=0
Input track seeds and correction maps from pass 1
ACTS track fit
• Crossing correction
• Static+average+fluctuation distortion corrections
• Move to surface for fit
Ghost track removal
Collision vertexing
ACTS propagation to vertex

Refactored workflow



sPHENIX Computing plan and resource needs, 2019-2022

- 4th S&C Review took place **May 16-17, 2022**
  - Guidance for a “worst-case” scenario of 600 kHS06 for Run 23
  - Day before review, SDCC planning document v3.26 released with projection of 500 kHS06 installed in “cautiously optimistic” scenario
  - Actual event reconstruction time improved to 21 sec/event (compared to 24 sec/event goal) and reduced memory usage of 2 GB/job for most of refactored reconstruction workflow
  - Estimate for CPU needs are 855 kHS06 (averaged over 40 weeks) and 1150 (fixed latency during high lumi 2nd half of Run 23)

(*) This is a new option enabled by reduced memory requirements

sPHENIX showed extensive progress in all areas of S&C

Thank you for the hard work and progress!

The panel would like to thank the sPHENIX project for putting together all of the presentations - they were dense in information and the presenters were very opened in answering our questions. The committee was impressed by the progress and the breadth of work in keeping the design and commission sPHENIX Software & Computing moving to completion.

The charges were extensive. Therefore, the committee decided to reserve its findings, comments and full set of recommendations for the final report and only focus here on a few essential key points (and a subset of immediate recommendations).

From closeout slides; full report expected imminently

sPHENIX Computing plan and resource needs, 2019-2022

- Considerations regarding minimal CPU needs:
  - TPC calibration and calorimeter calibration are data-driven. TPC calibration is sensitive to collision rate, i.e., the higher the data rate, the more data is needed for calibration
  - Calibration of detector to final UPP will require reconstruction of 50% of data set
  - CPU resources below 600 kHS06 will risk essential goal of Run 23, i.e., full commissioning of the detector before start of Run 24
- Minimal CPU needs can be met based on installed base (170kHS06), remaining FY22 purchase (180 kHS06) and a combination of FY23 purchase as in SDCC v3.26, temporary re-allocation of other SDCC resources**(*)** and possible delays in retirement of existing equipment.

(*) This is a new option enabled by reduced memory requirements

Is there precedent?

Subject: [Rhic-rcf-l] Farm batch slots reallocation
Date: Tue, 22 Jun 2021 17:39:29 -0400
From: RACF Computing Facility Staff <announce@rcf.rhic.bnl.gov>
To: rhic-rcf-l@lists.bnl.gov, bnl-shared-tier3-l@lists.bnl.gov

Summary: Farm batch slots repartitioning
Duration: Effective immediately for one month

Description:
We would like to inform you that upon request from NPP, a queue/slot re-partitioning will take effect shortly on the batch farm providing a **temporary major resource increase to the STAR experiment.** This followed a DOE request that STAR must complete its blinded analyses of the 2018 Isobar data by the end of the current fiscal year (this target was made as part of a notable Performance Evaluation and Measurement Plan from DOE ONP). In order to meet the deadline, the reallocation (a proportional reduction of slots from several groups by -40%) needs to remain in effect for the coming month and this **may cause some impact to the throughput of other jobs, including those of STAR non-Isobar related analysis and data production as well as those from ATLAS T3, EIC, PHENIX and sPHENIX.**
If during this period, you need additional resources, please contact us, we will try to find ways to accommodate your request.

We apologize in advance for the inconvenience and the short notice

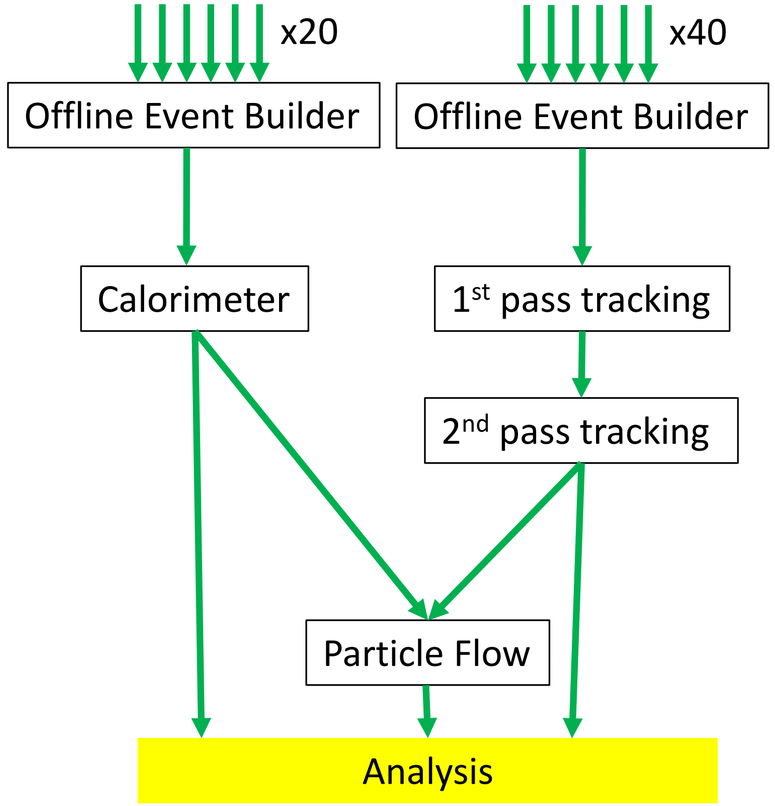
Readiness for Run-23 data taking

- Collaboration structure has been evolved to provide for commissioning, calibration, computing
  - Many key roles filled. Discussion of run coordinator role at recent collaboration meeting.
  - Active task forces on commissioning, calibration, and alignment
- Lean workforce for addressing visitor hosting responsibilities
- Computing needs far exceed SDCC provisioning plans for Run-23. Possible mitigation via purchases early in FY'23, dedication of SDCC resources, and postponed retirement of existing equipment.

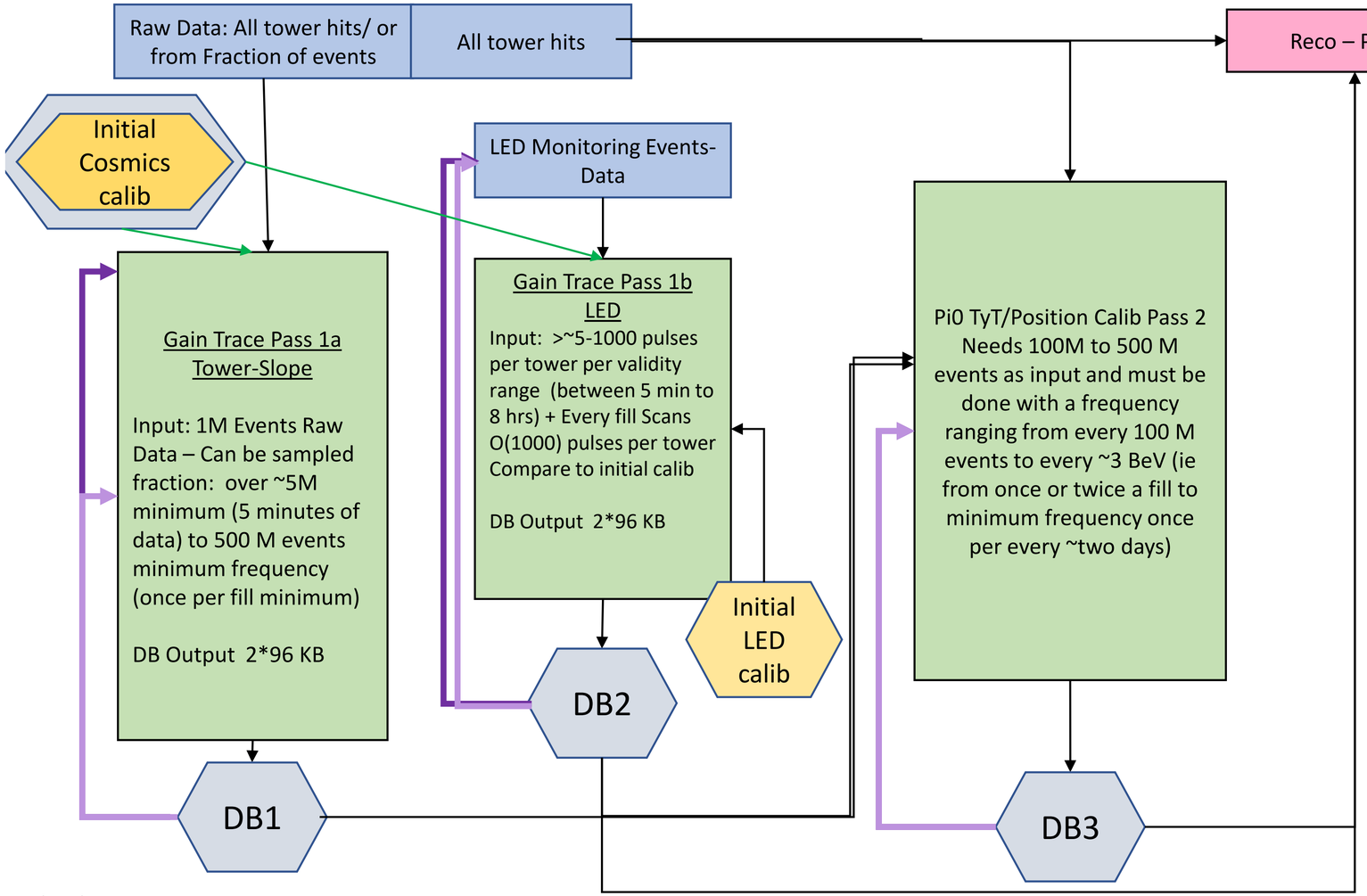
Extra slides

Current Production Workflow

1. **Event building (20/40 input streams, 1 output streams [each])**
   - Tracking Detectors
   - Calorimeters
2. **Calorimeter**
3. **1st pass tracking**
4. **2nd pass tracking**
5. **Particle Flow (combines tracks & calorimeter data)**



NEW: EMCal Workflow



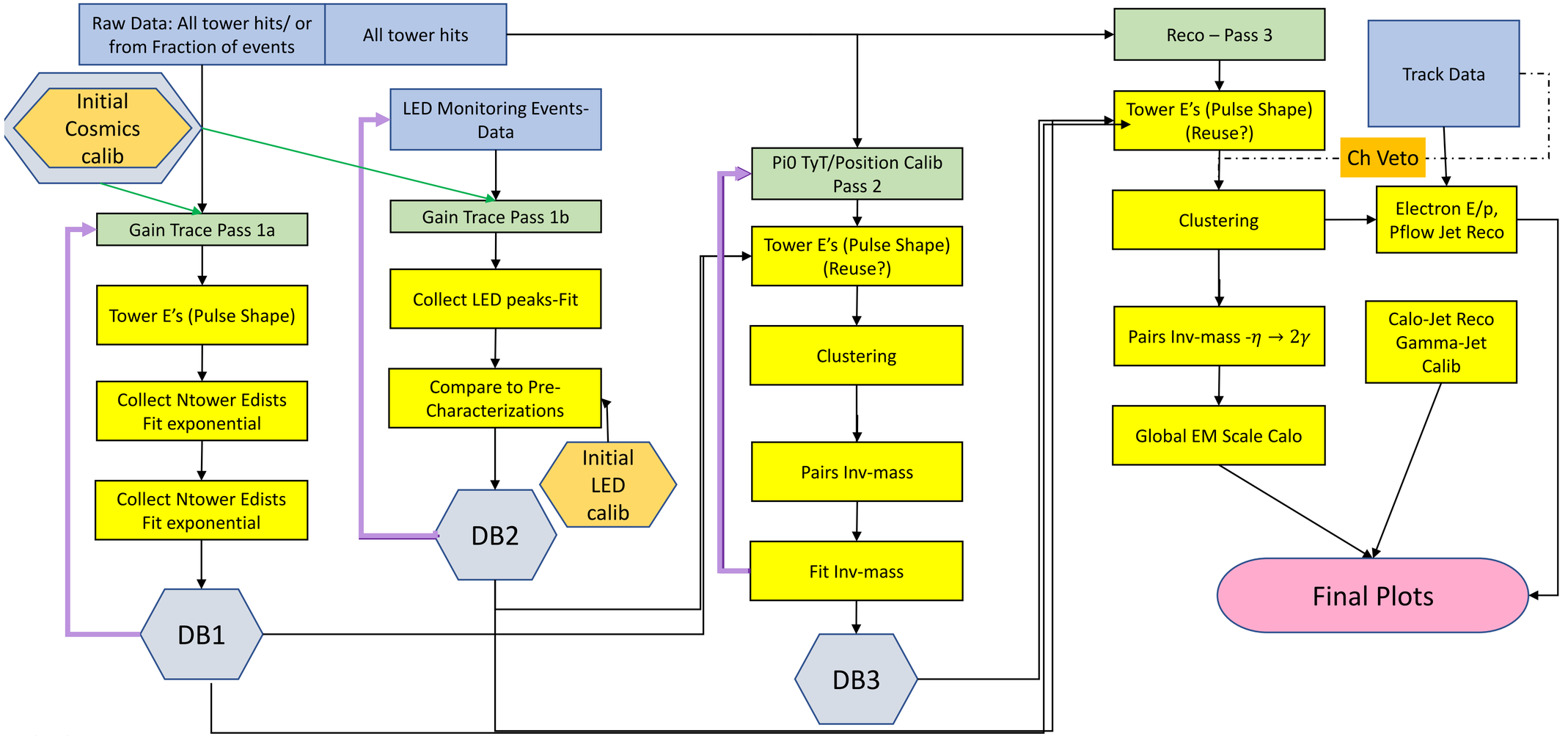
Note 1 : First two columns are common also to Hcal (same electronics)

Note 2: ALL DATA-DRIVEN CALIBRATIONS RUN ONLY ON PERIPHERAL EVENTS (ie, 40-100% centrality)

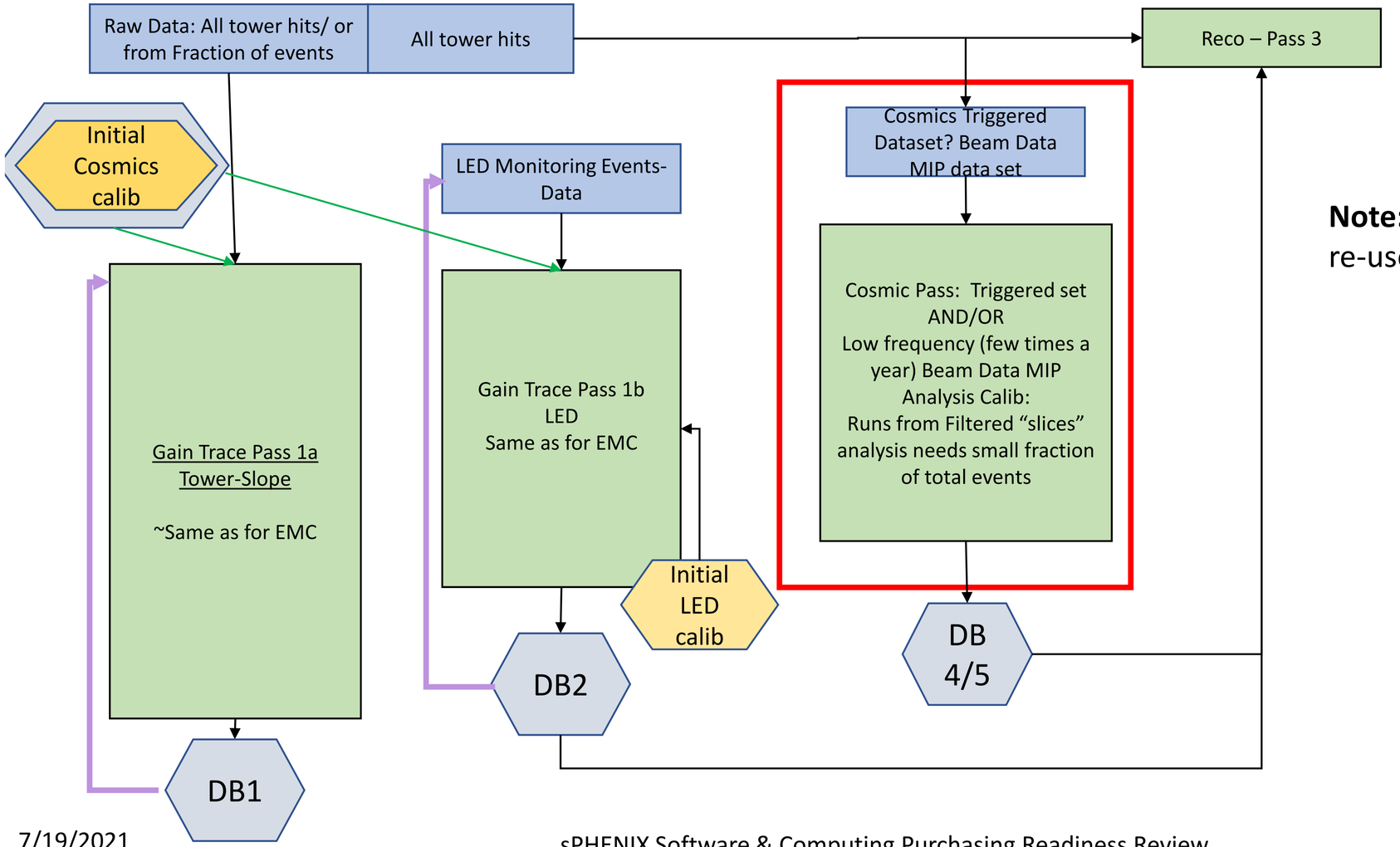
- ~5x smaller than MB → less time per event than MB event time estimates included in computing review

Note 3 : No Tracking needed

NEW: EMCal Calibrations (details)

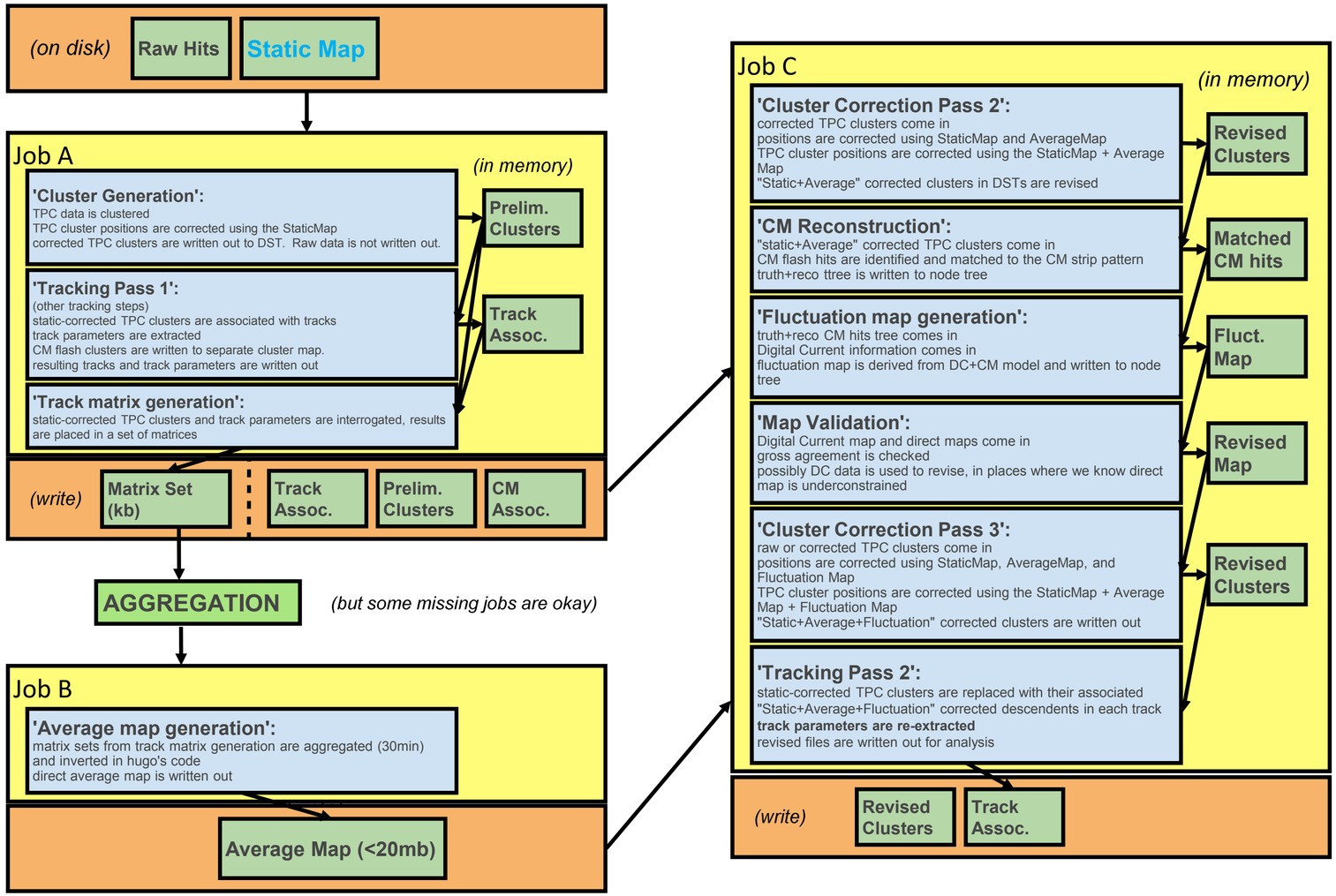


NEW: HCal Workflow Summarized



Note: EMCal code can be largely re-used for gain tracing

NEW: **TPC** distortions in Track Reco



Static Map: Space charge independent distortions (e.g. magnetic field), created from Laser flashes without beam

CM: Central Membrane, al strips illuminated by Laser, fired by interaction trigger

Average Map: space charge distortions averaged over 30 min aka “distortion correction”