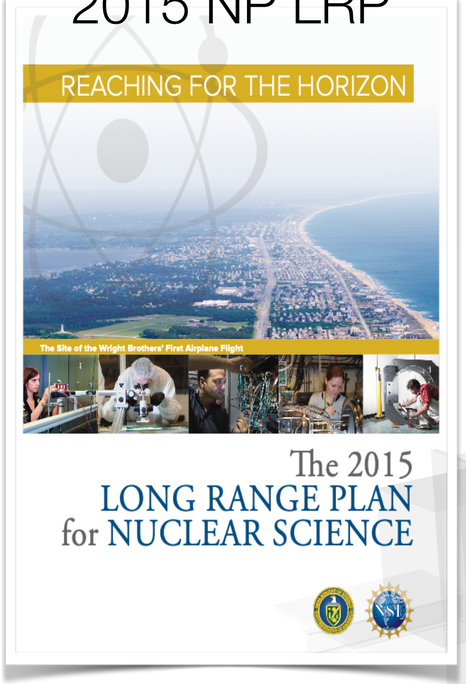
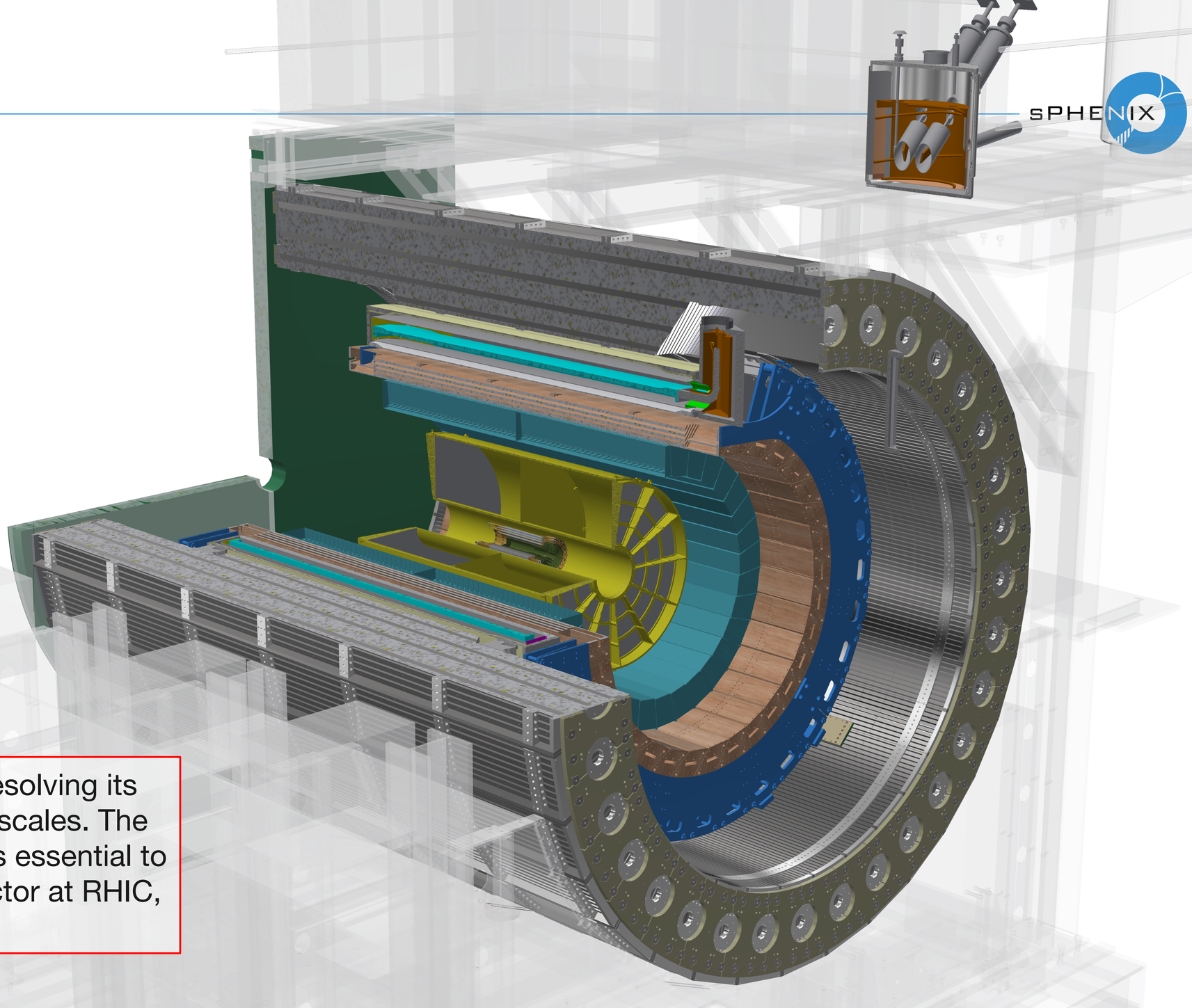
sPHENIX Progress

David Morrison (BNL)
Gunther Roland (MIT)

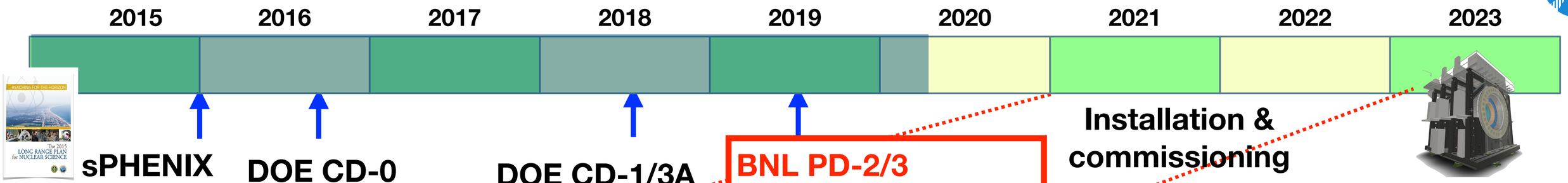
2015 NP LRP





"Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of [RHIC and the LHC] is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX."

Most important news: Official start of construction (9 months ago)



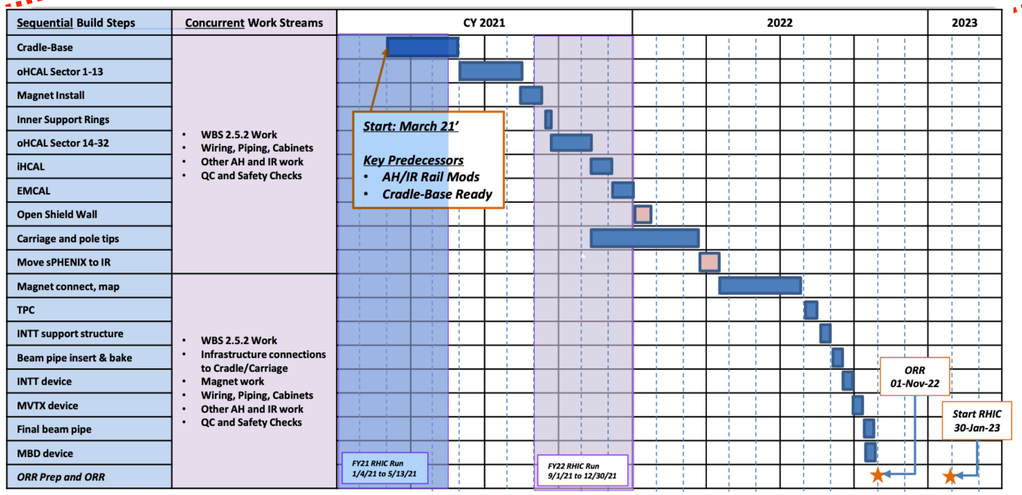
sPHENIX science collaboration

DOE CD-0
"Mission need" approval

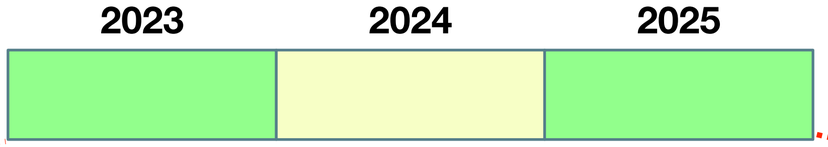
DOE CD-1/3A
Cost, schedule, advance purchase approval

BNL PD-2/3
: Final project design approval, authorization to execute

Installation & commissioning



n.b.: re-plan schedule as re-opening schedule becomes clear



Year	Species	Energy [GeV]	Phys. Wks	Rec. Lum.	Samp. Lum.	Samp. Lum. All-Z
Year-1	Au+Au	200	16.0	7 nb^{-1}	8.7 nb^{-1}	34 nb^{-1}
Year-2	p+p	200	11.5	—	48 pb^{-1}	267 pb^{-1}
Year-2	p+Au	200	11.5	—	0.33 pb^{-1}	1.46 pb^{-1}
Year-3	Au+Au	200	23.5	14 nb^{-1}	26 nb^{-1}	88 nb^{-1}

Collaboration and project are committed to sPHENIX being ready for data taking in early 2023

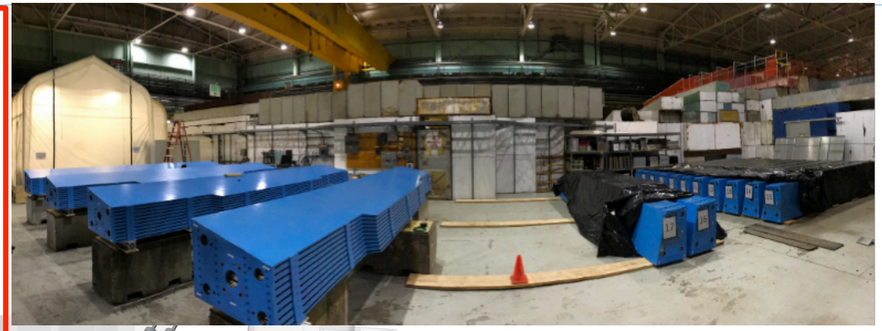
https://indico.bnl.gov/event/4788/attachments/19066/24594/sph-trg-000_06142018.pdf

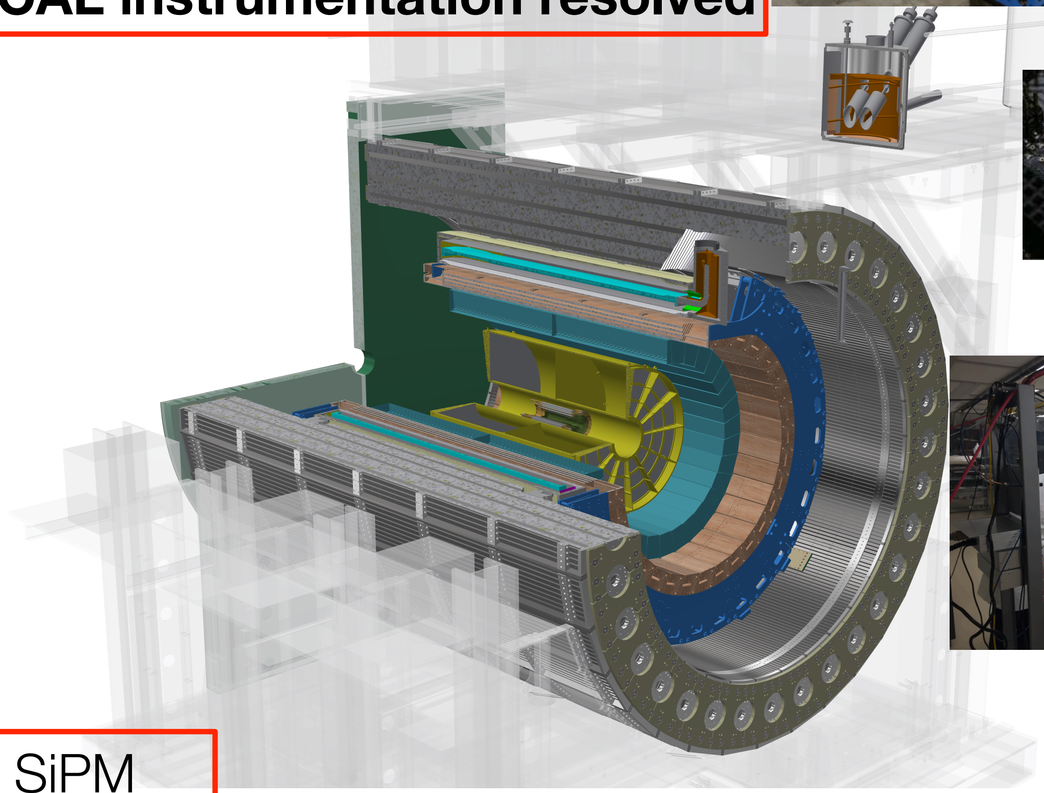
Construction proceeding on all subsystems

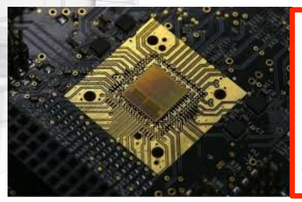
All oHCAL sectors at BNL

Scintillating tile production proceeding at Uniplast

iHCAL instrumentation resolved





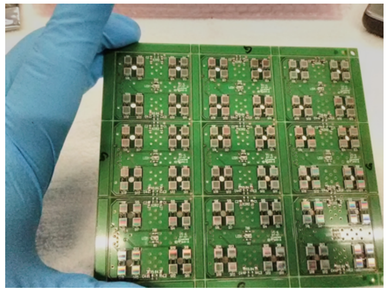


SAMPA v5 TPC FE chip successfully produced and qualified (USP/Lund)

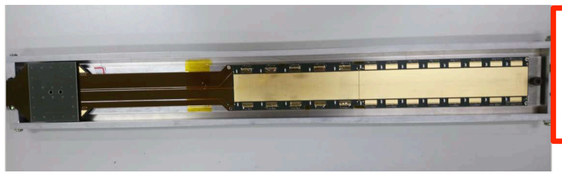
EMCAL “sector 0” prototype produced

Block production has **resumed** at UIUC

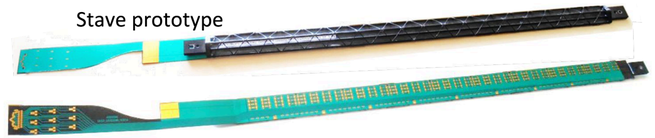
GEM factories starting up (Temple, VU, WSU)



50% of SiPM daughterboards received



First INTT module assembled (NCU)



First sPHENIX MVTX staves produced at CERN

sPHENIX collaboration

2016 2017 2018 2019

U. Sao Paolo

NCU, Taiwan

Florida AMU

- Steady growth after CD-0
  - 20 new institutions (79 total)
    - world-class expertise in relevant physics, silicon, TPCs, calorimetry, electronics, computing
  - about 25% non-US institutions
  - ≈ 300 participants (➔ 400-500 by 2023)
- Steady evolution of collaboration organization
  - Added speaker's bureau (M. Rosati), Diversity committee (V. Greene)
    - regular reports in fortnightly meting, consultation of D,E&I on appointments

Software/Computing

- Annual review of sPHENIX software/computing (May ’18, Sep ’19)
- Among key recommendations:
  - **Use of non-BNL computing resources:**
    - Running on HPC (CORI@NERSC)
    - Container based running for CERN local accounts
    - Running on the OSG
  - **Collaboration on common software:**
    - Workfest w/ ALICE/STAR (July ’19)
    - Workfest w/ ALICE/STAR/CBM/ATLAS (Jan ’20)
    - Kickstarted:
      - ACTS for sPHENIX (ATLAS)
      - TPC distortion correction (ALICE)

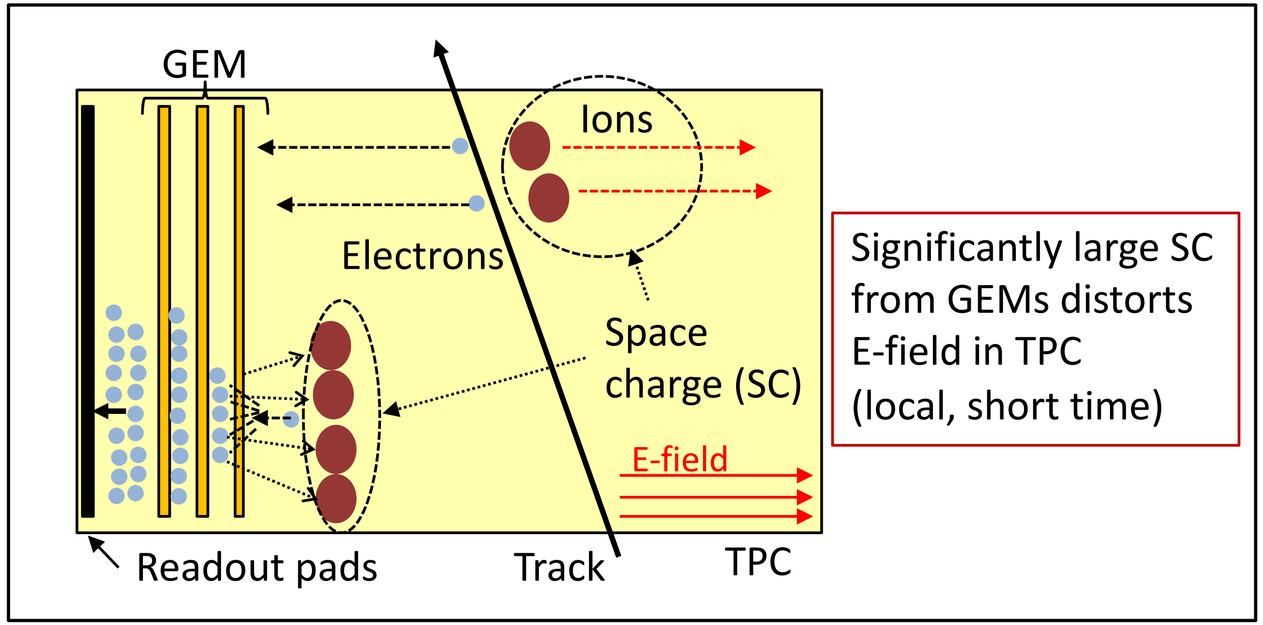
Learning from ALICE/ATLAS/CMS/STAR: Charged particle tracking

Key tracking challenges:

1. **Upsilon mass resolution requires 150μm hit resolution → TPC distortion corrections**
2. Reconstruction time budget of 5s/event → speed-up of 2018 tracking by 100x

Distortion corrections:

- **Established calibration taskforce**
- Workfests with ALICE/STAR experts (@CERN, @BNL)
- Work is proceeding on distortion map, simulations, correction algorithms and verification
- Diffuse laser system will play key role



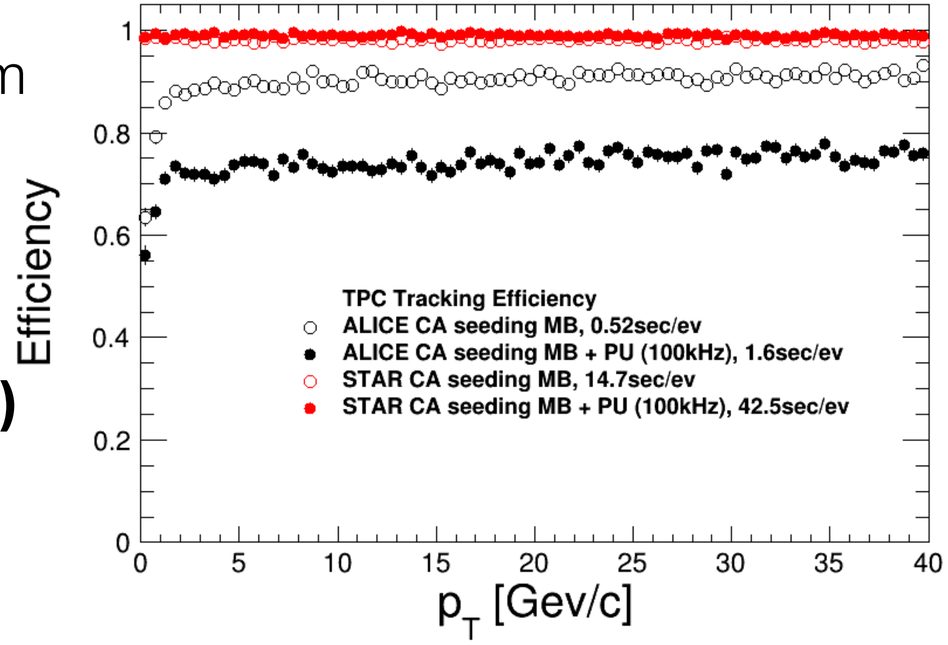
Learning from ALICE/ATLAS/CMS/STAR: Charged particle tracking

Key tracking challenges:

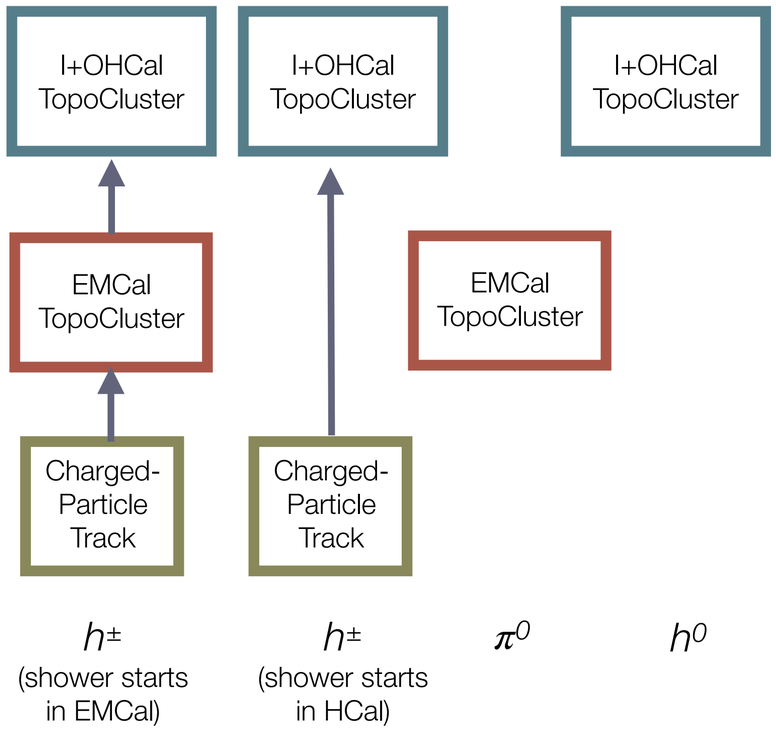
1. Upsilon mass resolution requires 150μm hit resolution → TPC distortion corrections
2. **Reconstruction time budget of 5s/event → speed-up of 2018 tracking by 100x**

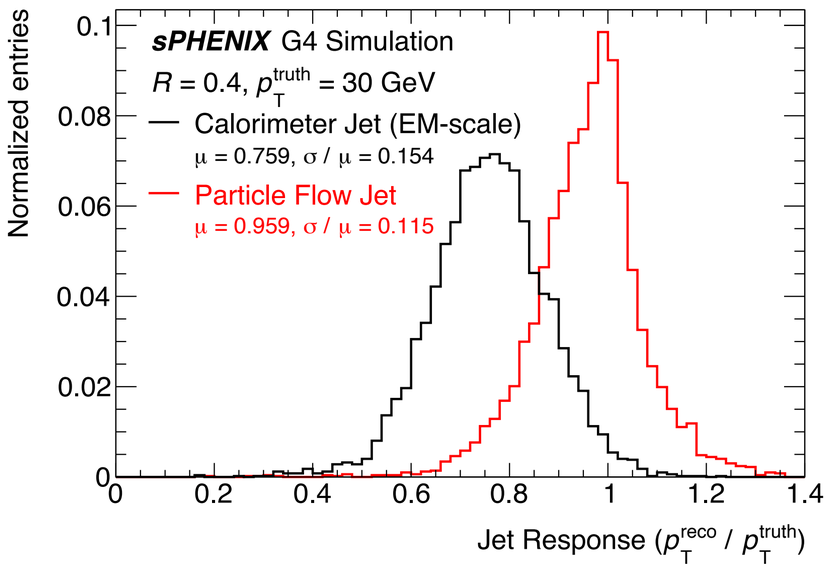
Track reconstruction speed-up:

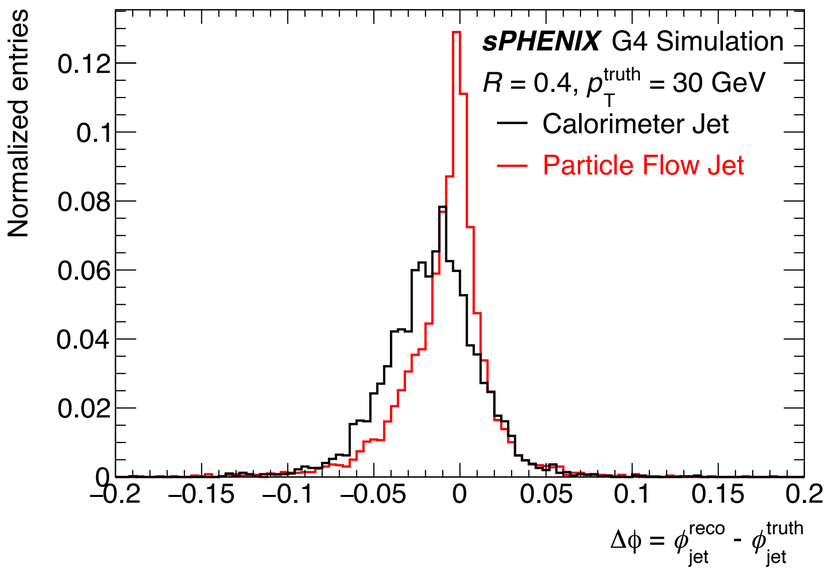
- Implemented new Cellular Automaton track seeding algorithm (ALICE/STAR)
  - time/event reduced from **460s (Hough) to 1.6s (CA)**
- Implemented ACTS package track propagator/fitter
  - time/track reduced from **40ms (Genfit) to 0.5 ms (ACTS)**
- Work continuing on integration and tuning (by summer)
- **5s/event goal is in sight**
- Also: KFParticle generalized HF finder/fitter (CBM) integrated in sPHENIX HF framework



Learning from CMS/ATLAS: Particle flow(*) jet reconstruction

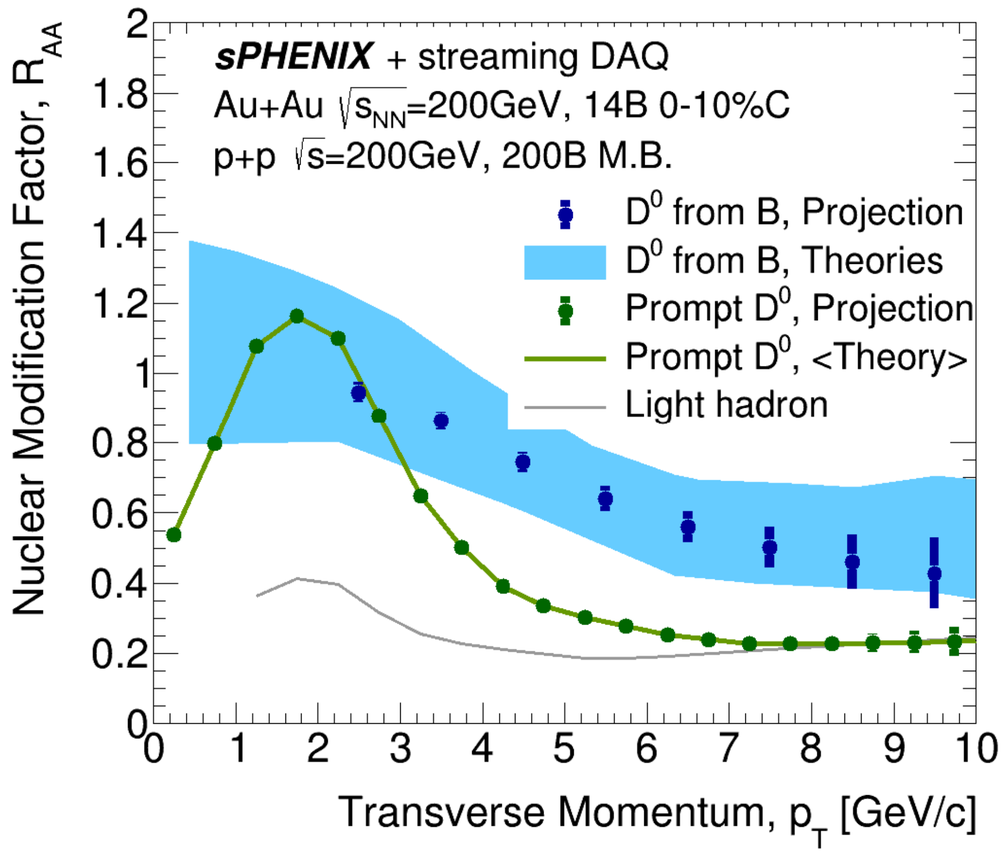


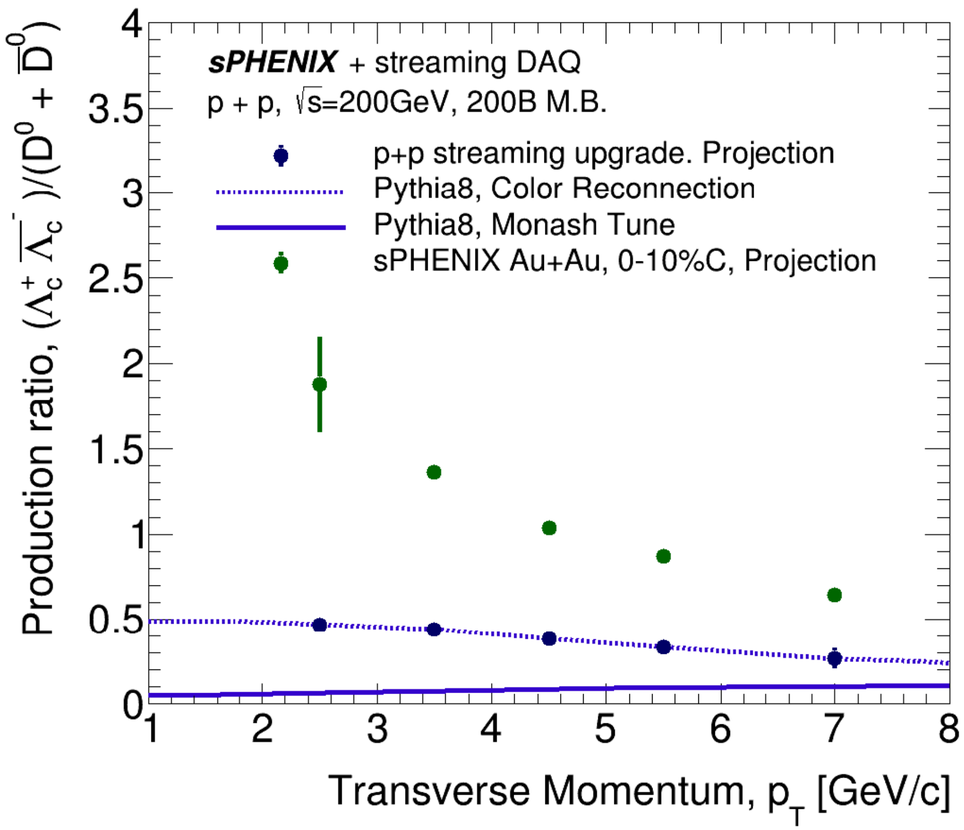




- Implementation of particle-flow jet reconstruction using “best of” techniques from ATLAS/CMS
  - highlights importance of charged particle tracking for jet physics
- **Significant improvement in angular resolution and p_T response possible**
- Particle-flow jets enable measurement of jet sub-structure observables

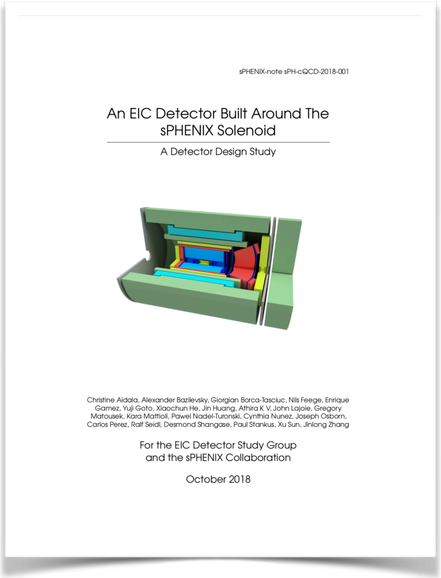
Exploring high statistics p+p min bias data taking





- Calorimeter readout limits readout rate to 15kHz
- Challenge to match A+A statistics in p+p for *untriggered* probes
- Exploring use **streaming readout of tracking detectors-only (MVTX, INTT, TPC)** for high statistics low-pT (untriggered) HF program in p+p

Continued progress in cold QCD program


sPHENIX-note sPH-cQCD-2018-001

An EIC Detector Built Around The sPHENIX Solenoid

A Detector Design Study

Christine Aidala, Alexander Bazilevsky, Giorgian Borca-Tasciuc, Nils Feege, Enrique Gamez, Yuji Goto, Xiaochun He, Jin Huang, Athira K V, John Lajoie, Gregory Matousek, Kara Mattioli, Pawel Nadel-Turonski, Cynthia Nunez, Joseph Osborn, Carlos Perez, Ralf Seidl, Desmond Shangase, Paul Stankus, Xu Sun, Jinlong Zhang

For the EIC Detector Study Group and the sPHENIX Collaboration

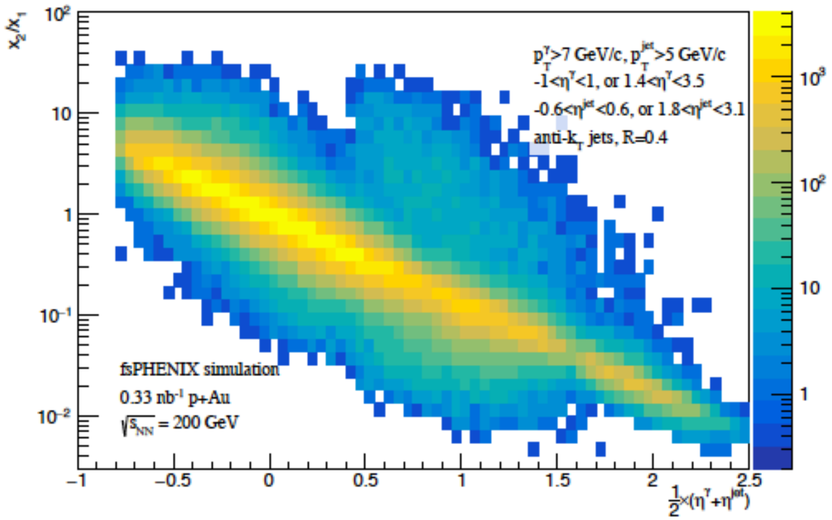
October 2018

Significant presence of sPHENIX collaborators in EICUG, EIC YR and related activities

Continued discussion in collaboration as EIC planning process unfolds (e.g., upcoming call for EoIs)

New case studies of cold QCD measurements with sPHENIX detector (barrel and barrel + modest forward instrumentation)

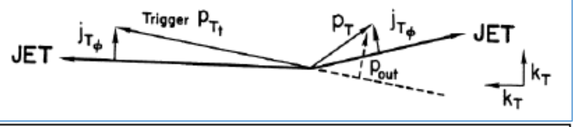
γ + jet

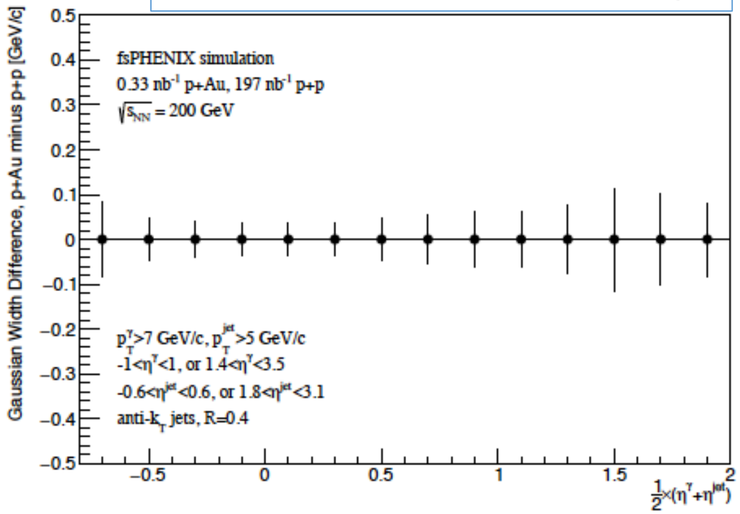


Transverse momentum broadening in pA probes transport coefficient $\hat{q}$

$$\langle \hat{q}L \rangle / 2 \simeq \langle p_{out}^2 \rangle_{pA} - \langle p_{out}^2 \rangle_{pp}$$

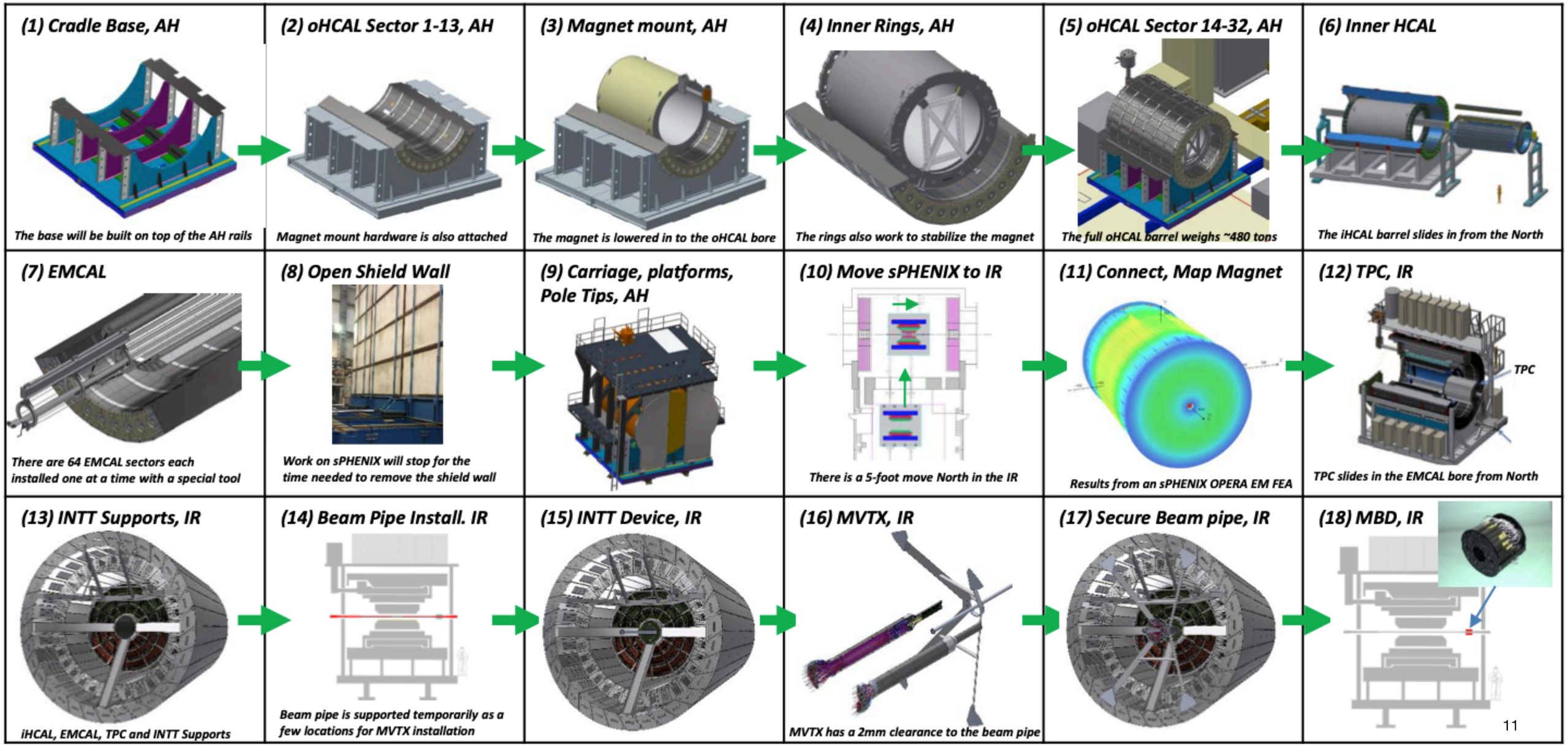
M. J. Tannenbaum, Phys. Lett. B **771** (2017) 553.





Sensitivity at x~10^{-2}–10^{-3}

Challenges: 1008 infrastructure and sPHENIX installation schedule



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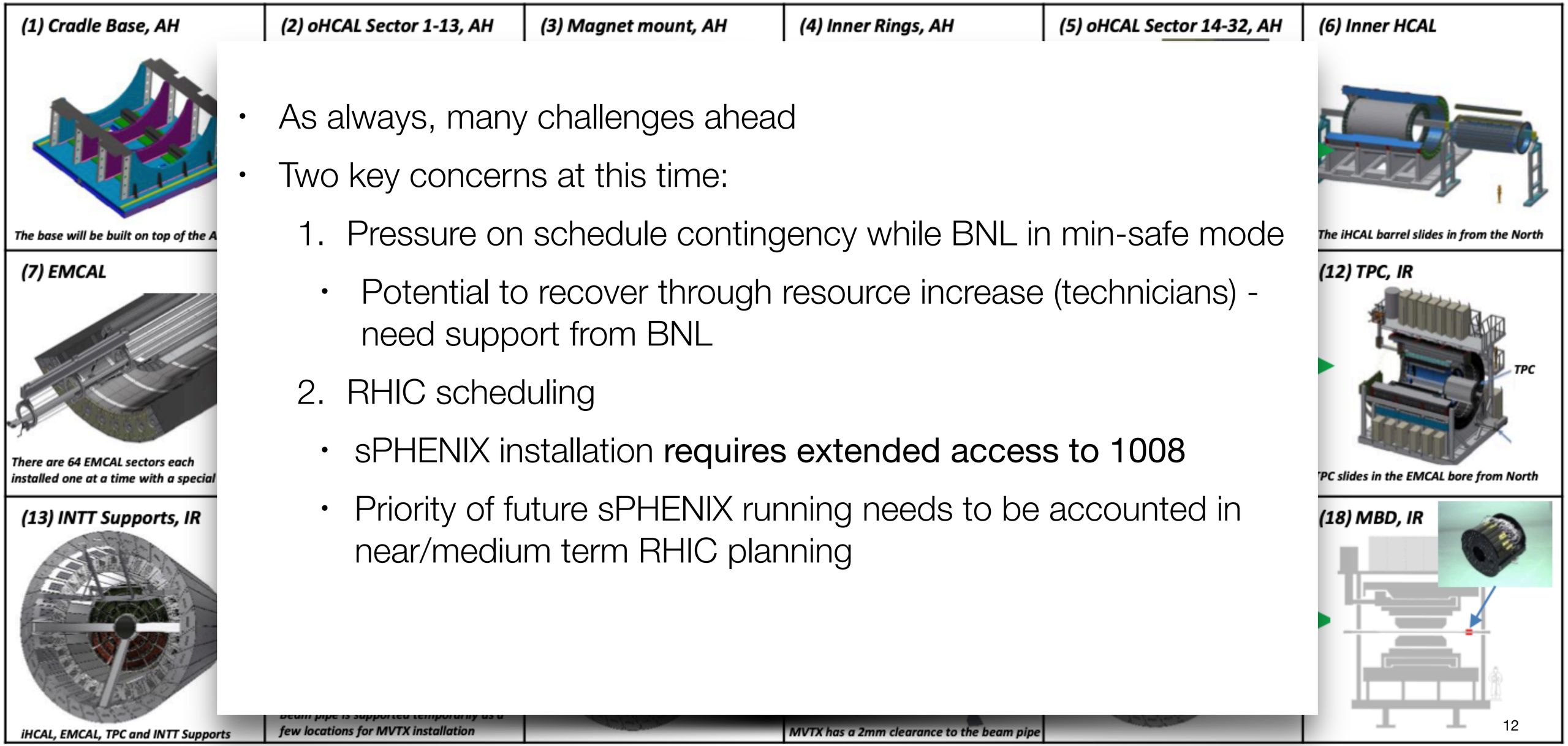

- As always, many challenges ahead
- Two key concerns at this time:
  1. Pressure on schedule contingency while BNL in min-safe mode
     - Potential to recover through resource increase (technicians) - need support from BNL
  2. RHIC scheduling
     - sPHENIX installation **requires extended access to 1008**
     - Priority of future sPHENIX running needs to be accounted in near/medium term RHIC planning

Summary

- Construction is proceeding with the goal of having full sPHENIX baseline detector **ready for physics in early 2023**

- Collaboration continues to grow, adding strong institutions with relevant science and technical expertise

- Led by topical physics groups, implementing state-of-the-art reconstruction algorithms to maximize physics performance

- Continued enthusiasm for cold QCD studies with sPHENIX barrel and use of sPHENIX as foundation for highly capable EIC detector

- Key challenge is 1008 infrastructure/installation schedule - sPHENIX needs to be considered early in RHIC run planning process