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U.S. DEPARTMENT OF ENERGY
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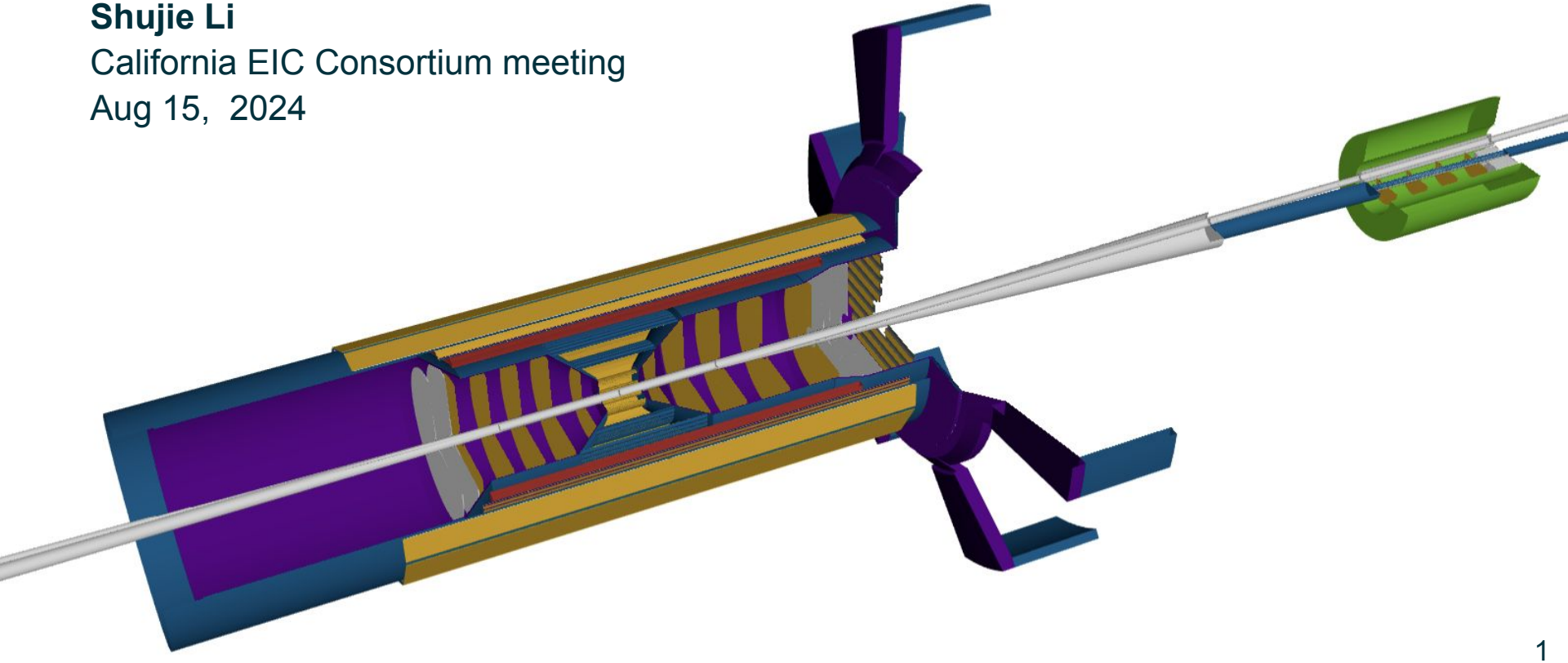
# Tracking Software Status

**Shujie Li**

California EIC Consortium meeting

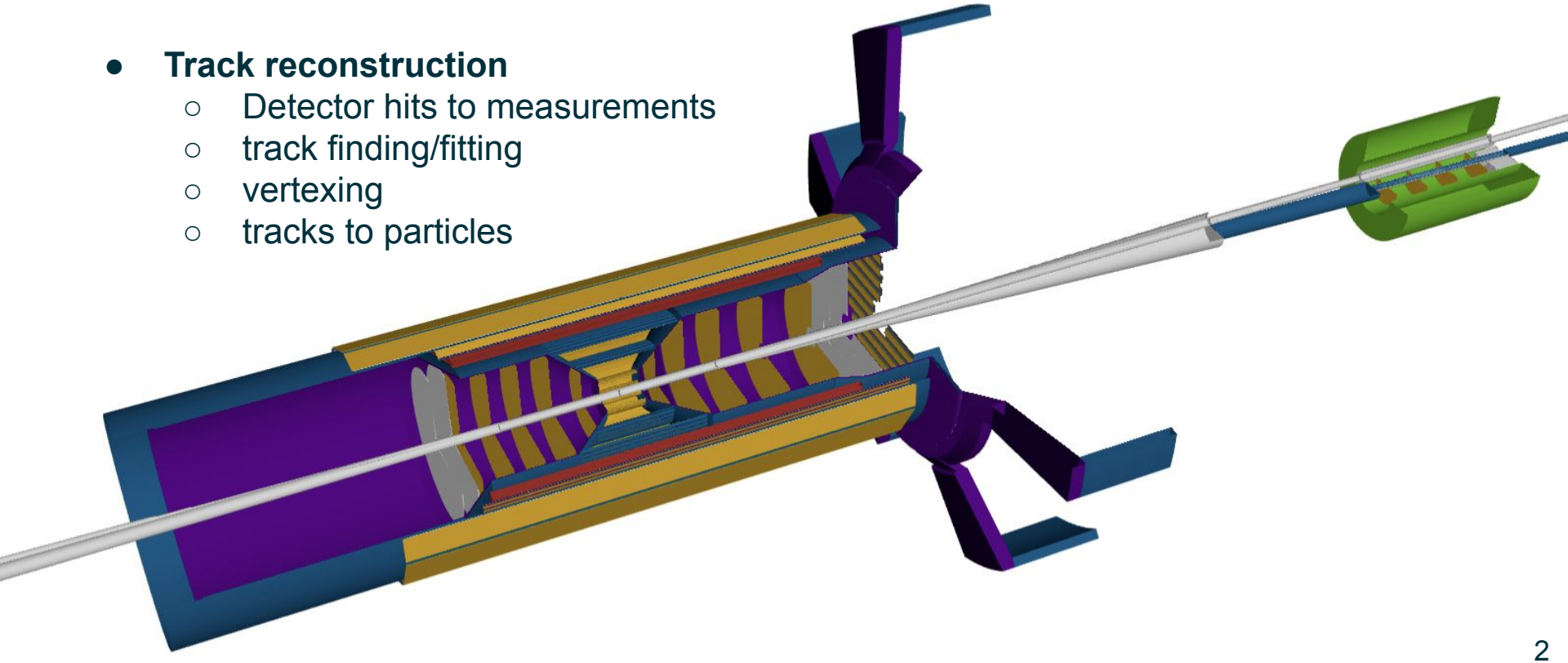
Aug 15, 2024



This is a **software-oriented** talk (for some ongoing tracker R&D, see Barbara's talk from yesterday).

- **ePIC tracker configuration, and its implementation in software**
  - performance benchmark
  - realistic Si sensor in simulation

- **Track reconstruction**
  - Detector hits to measurements
  - track finding/fitting
  - vertexing
  - tracks to particles



# ePIC Tracker Configuration

**Central Barrel region (45 - 135 degrees)**:

- 3 ITS3 vertex layers
- 2 EIC-LAS Silicon barrel
- 2 MPGD
- 1 AC-LGAD

**Forward/backward region:**

- 2x(5 Silicon disks + 2 MPGD disks)
- 1 forward AC-LGAD disk

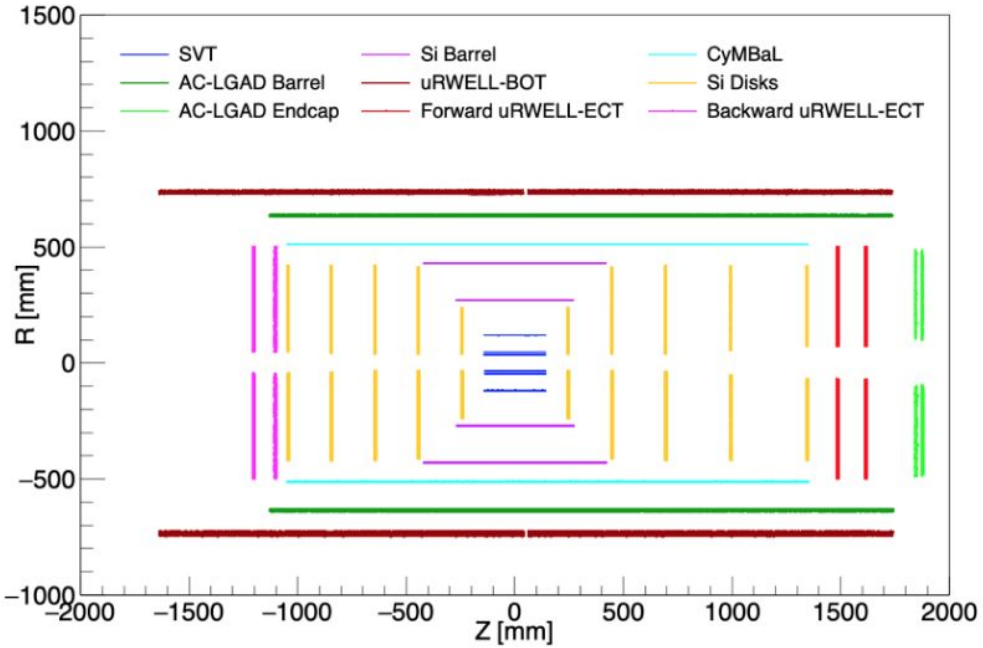
**Far-forward:**

- 4 AC-LGAD in B0

**Far-backward:**

- low-$Q^2$ tagger

For tracking performance study, see Minjung's talk this morning



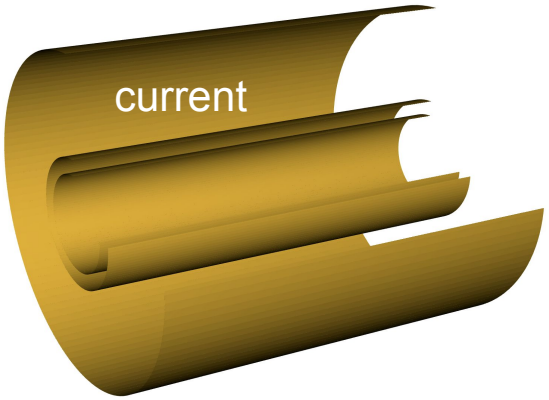

- 5 to 8 hits per charged particle
- eta coverage up to -4 to 4 (central), 4.4-5.9 (FF)
- meet the physics requirements as defined in the yellow report

| | Momentum Resolution | Spatial Resolution |
|---|---|---|
| Backward (-3.5 to -2.5) | ~0.10%×p⊕2.0% | ~ 30/pT μm ⊕ 40 μm |
| Backward (-2.5 to -1.0) | ~ 0.05%×p⊕1.0% | ~ 30/pT μm ⊕ 20 μm |
| Barrel (-1.0 to 1.0) | ~0.05%×p⊕0.5% | ~ 20/pT μm ⊕ 5 μm |
| Forward (1.0 to 2.5) | ~0.05%×p⊕1.0% | ~ 30/pT μm ⊕ 20 μm |
| Forward (2.5 to 3.5) | ~0.10%×p⊕2.0% | ~ 30/pT μm ⊕ 40 μm |

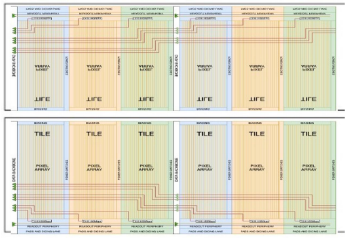
# Towards a Realistic Si Tracker Description

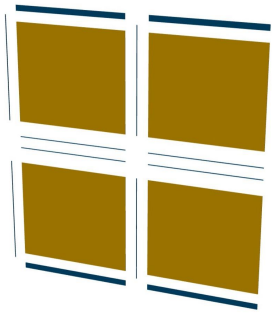
## Vertex layers

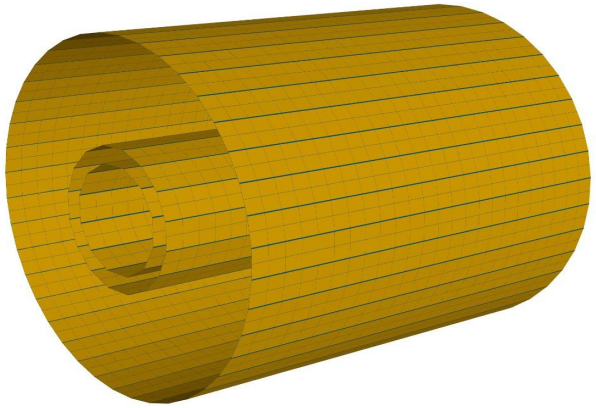
- **Current(official) simulation v24.08:**
  - smooth barrel assembled by 128 staves per layer




- **New design**
  - ITS3 sensor unit with inactive areas
  - implemented for vertex tracker (see Joseph Xu's talk)



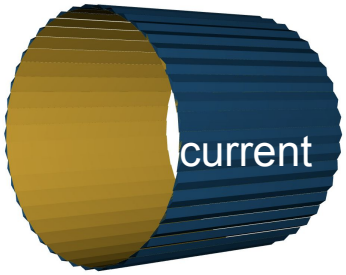


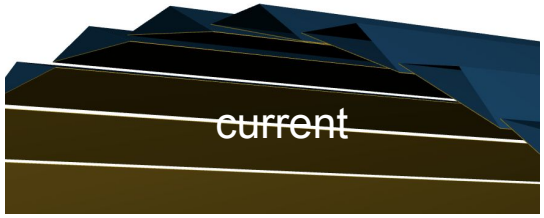


- **To do:**
  - make the sensor surface curved
  - apply the same RSU design on outer Si barrels and disks

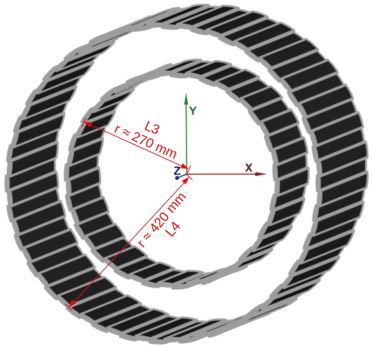
# Si Outer Barrels

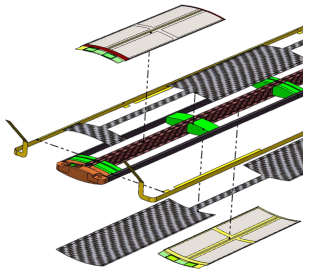
- **Current(official) simulation:**
  - 44 tilt staves (Si+Al+carbon fiber plates) with triangular support frame




- **New Design**
  - EIC-LAS, staggered RSU
  - implementation in progress (Long Li from U. of Birmingham)

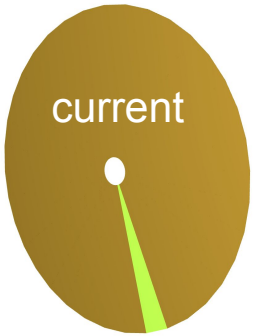


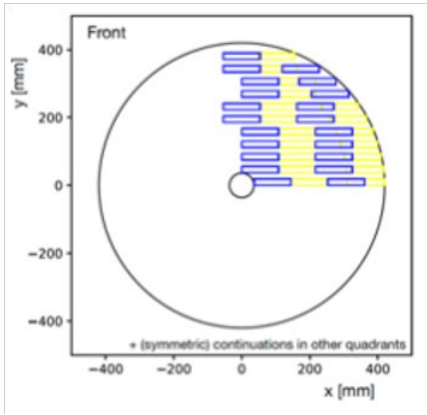



https://indico.bnl.gov/event/23659/

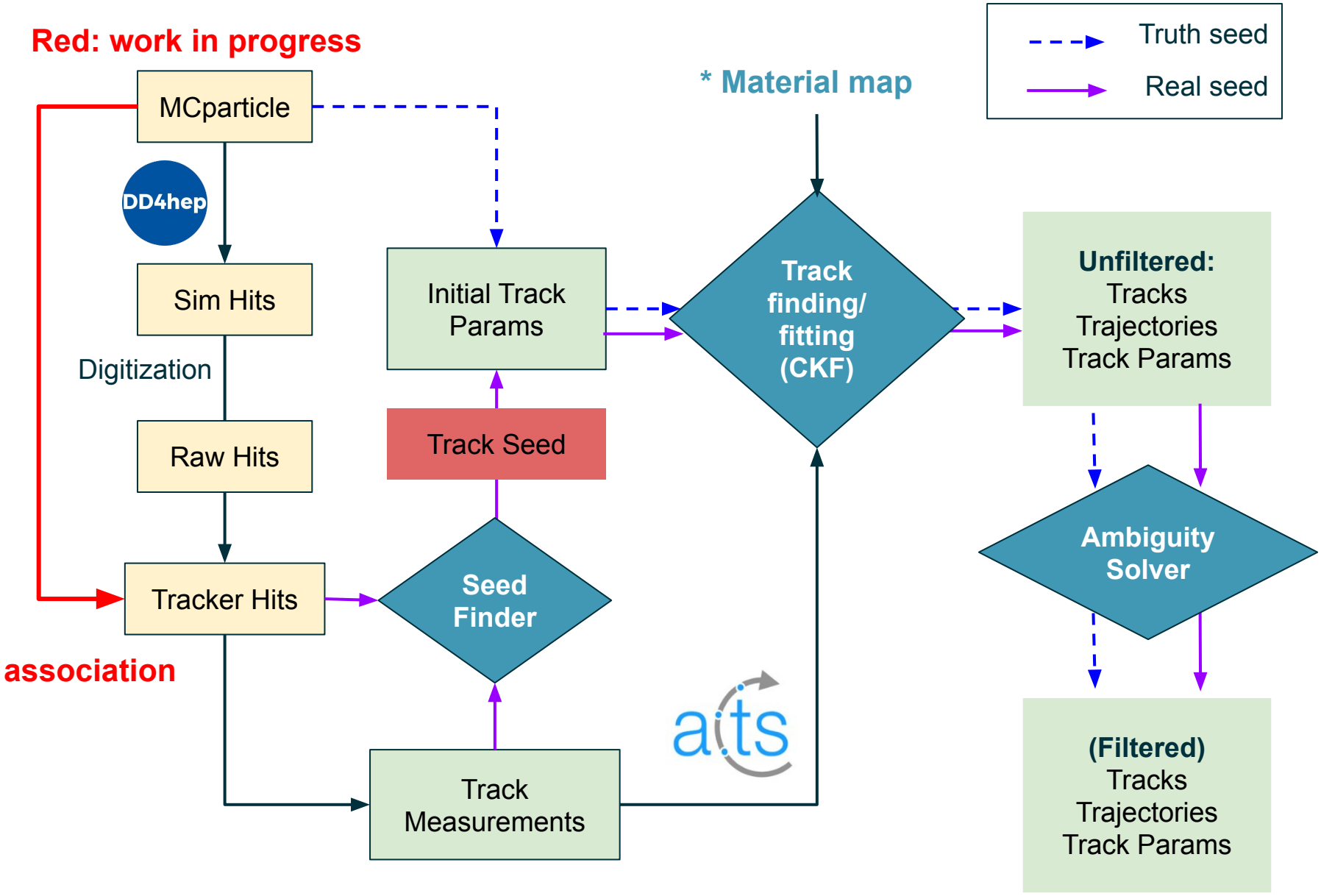

# Si Disks

- **Current(official) simulation:**
  - disks from 36 trapezoid slices.
  - a centered hole in the center to accommodate for the beampipe fanout
- **New Design**
  - EIC-LAS, tiled RSU (see Skye Heiles's talk)
- To do:
  - implementation of tiles
  - study acceptance effect near the beamline



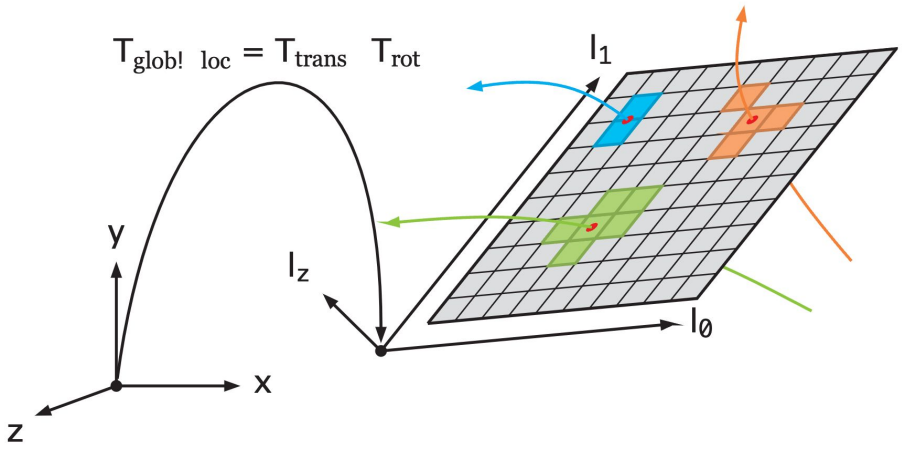



# Track Reconstruction



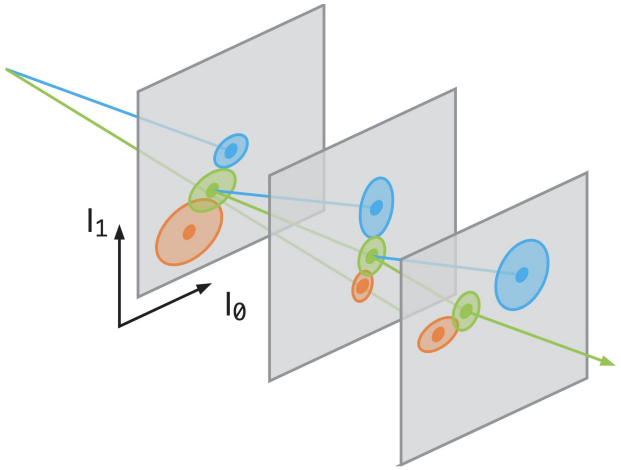
# Track Reconstruction

- **Space point formation**
  Raw hits from DD4hep
  → digitization
  → TBD: charge sharing/clustering
  → global/local coordinates transformation
  → measurement: ($l_0$, $l_1$,edep,time)




- **Track finding/fitting**

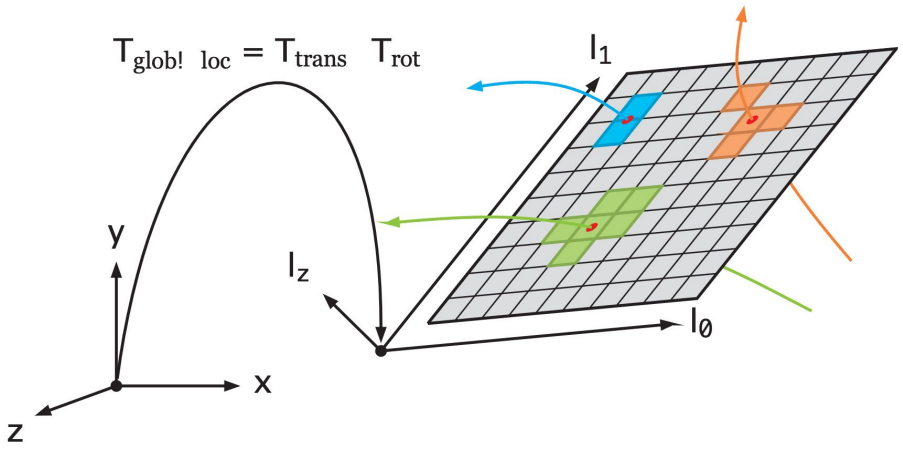
  **Combinatorial Kalman Filter (CKF)**
  - seed (triplet) finder to provide realistic initial guess
  - combine track finding and fitting
    → user-defined measurement selector (number, chi2)




- up to 8 tracking central tracking layers/hits for fitting. What if…
  - receive additional hits due to sensor noise (see Mito Funatsu's talk)
  - miss layer/hits due to dead area in sensor (see Joe Xu's talk)

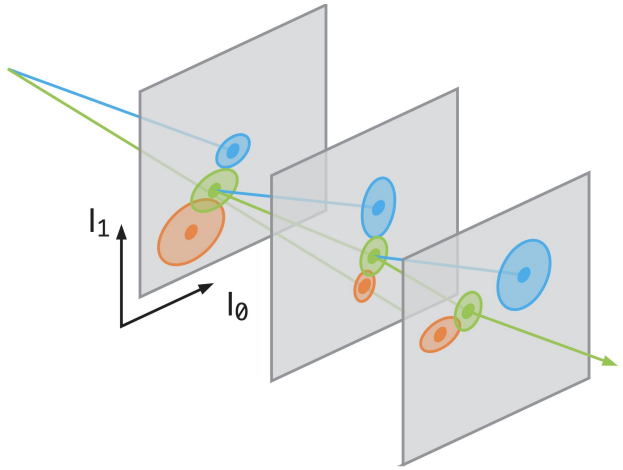
# Track Reconstruction

- **Space point formation**
  Raw hits from DD4hep
  → digitization
  → TBD: charge sharing/clustering
  → global/local coordinates transformation
  → measurement: ($l_0$, $l_1$,edep,time)




- **Track finding/fitting**

  **Combinatorial Kalman Filter (CKF)**
  - seed (triplet) finder to provide realistic initial guess
  - combine track finding and fitting
    → user-defined measurement selector (number, chi2)
  - allows track branching ⇒ overlapped/duplicated tracks
    → see Minjung Kim's talk on ambiguity solver

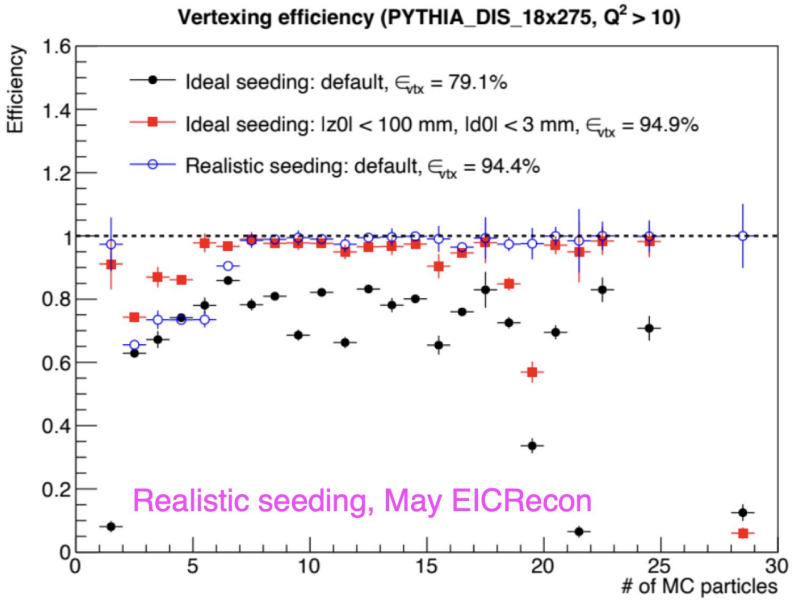


# Vertexing

- **Primary vertexing**
  - Iterative vertex finder with ACTS
  - Effort led by Xin Dong (LBNL)
  - Available in EICrecon, optimization ongoing

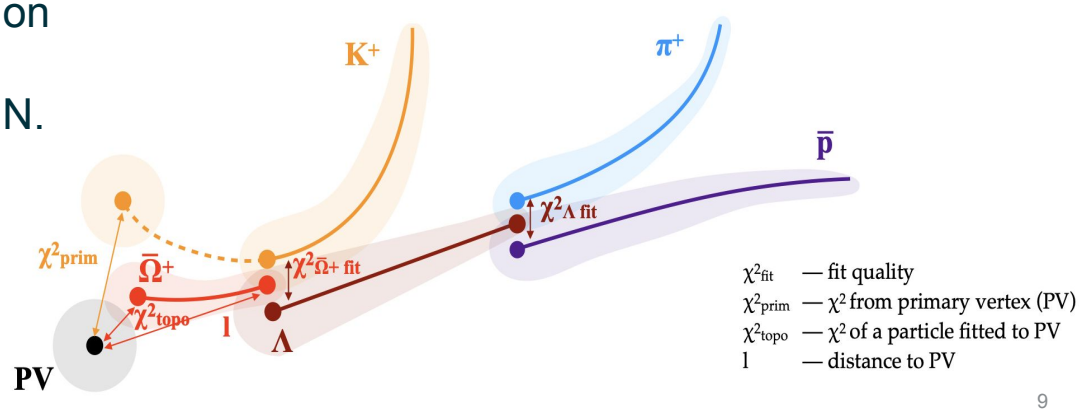
to do:

- vertex to track/particle association
- track to vertex distance




*Plots from Rongrong Ma*

- **Secondary vertexing**
  - approach 1:
    - vertexing algorithm based on ACTS examples
    - implementation started by N. Schmidt (ORNL)
  - approach 2:
    - TBD: adopt the KFParticle package

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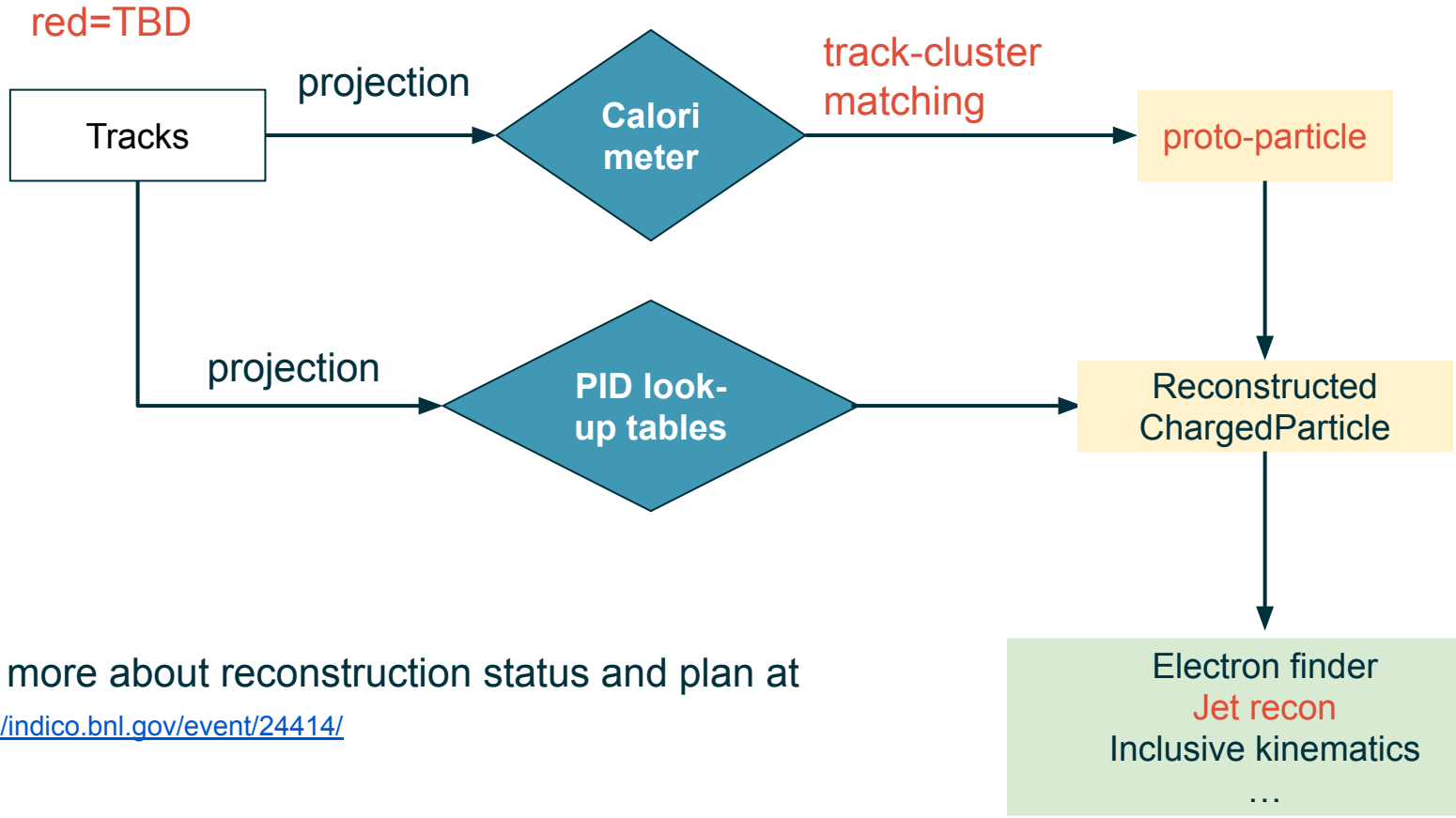
# Track to Particle




See more about reconstruction status and plan at
https://indico.bnl.gov/event/24414/

Join ongoing effort/discussions at

- reconstruction WG meeting (Tue 12:30 pm PT)
  https://indico.bnl.gov/event/24526/
- Joint tracking and track recon, vertexing meeting (Thu 8:00 am PT)
  https://indico.bnl.gov/event/24487/

Thanks!