# SoLID Tracking Update

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VMM3 digitization

- Previously, assuming VMM3 chip with 25ns shaping time, 43ns deadtime, and 6-bit readout mode
  - Tracking efficiency and accuracy reasonable for all 3 SoLID configurations
  - efficiency > 80%, accuracy > 90%

- Current tests indicate that VMM3 needs to operate with 50ns shaping time, and much longer deadtime
  - ~130ns deadtime with 6-bit mode
  - ~300ns deadtime with 10-bit mode

- These parameters have critical impact on tracking performace
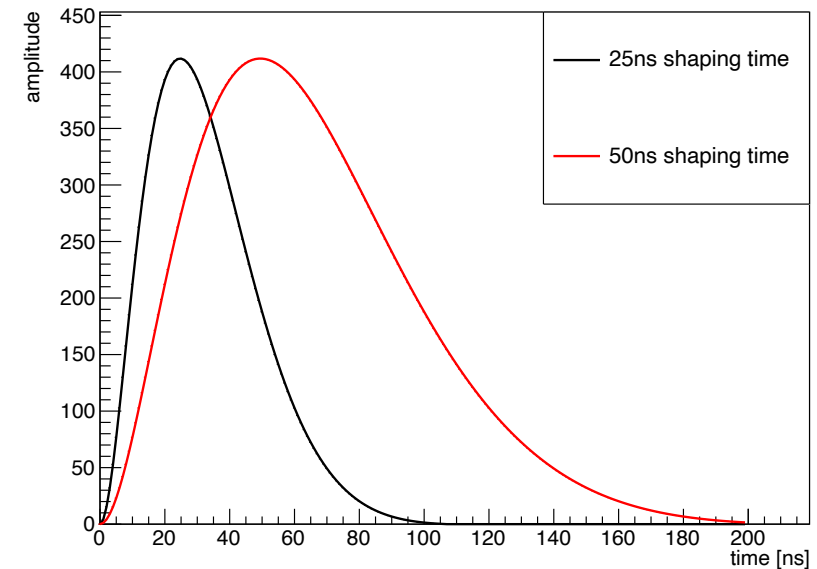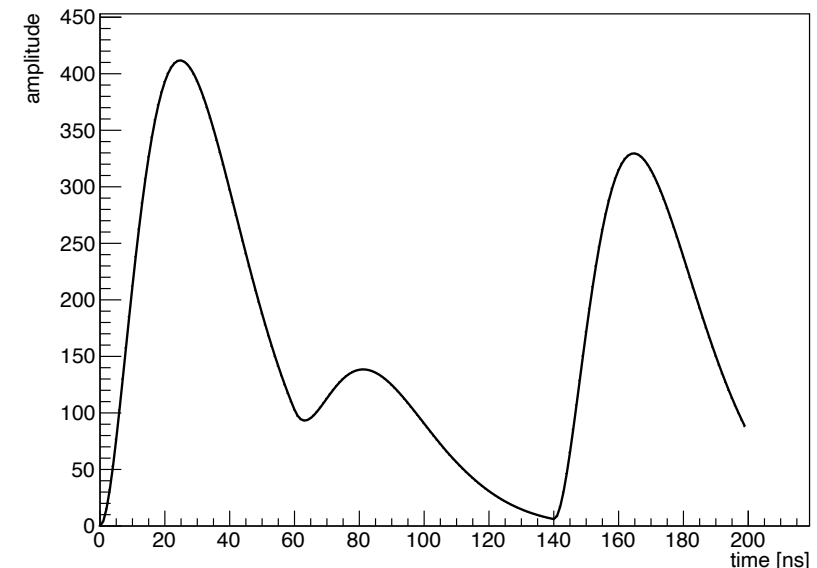
Issue with the VMM3 Chip

- Changing from 25ns shaping time to 50ns shaping time, at 100% SIDIS background:
  - Tracking efficiency 91.6% -> 86.2%

- Increasing deadtime from 43ns to 300ns has a prominent impact on tracking

- Likely requires some hardware changes to make tracking works again

Tracking efficiency vs. VMM dead time

SIDIS single track

efficiency [%]

VMM dead time [ns]
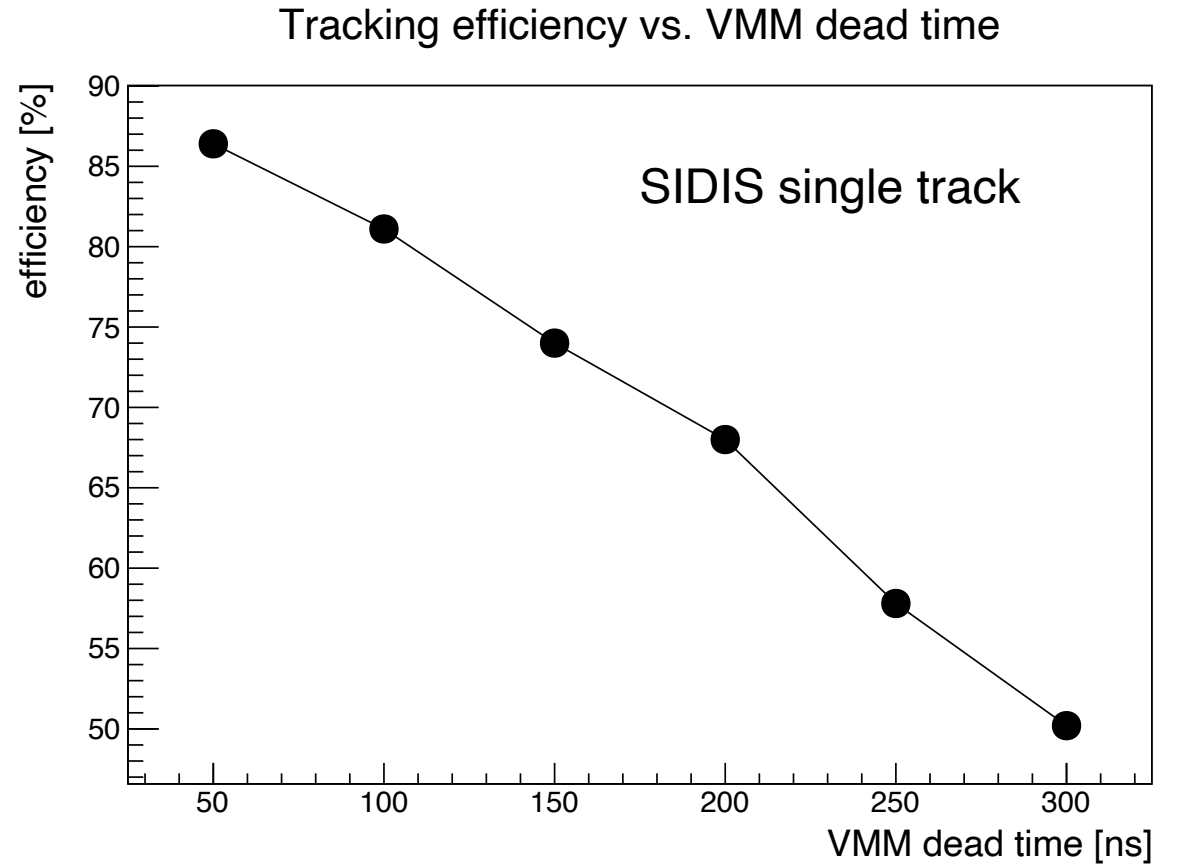
Some Ideas for Improvement (for SIDIS and JPsi)

1. Adding more GEM planes
2. Segmenting strips or separating the chambers for shared GEMs
3. Allow more than one missing hit for a track
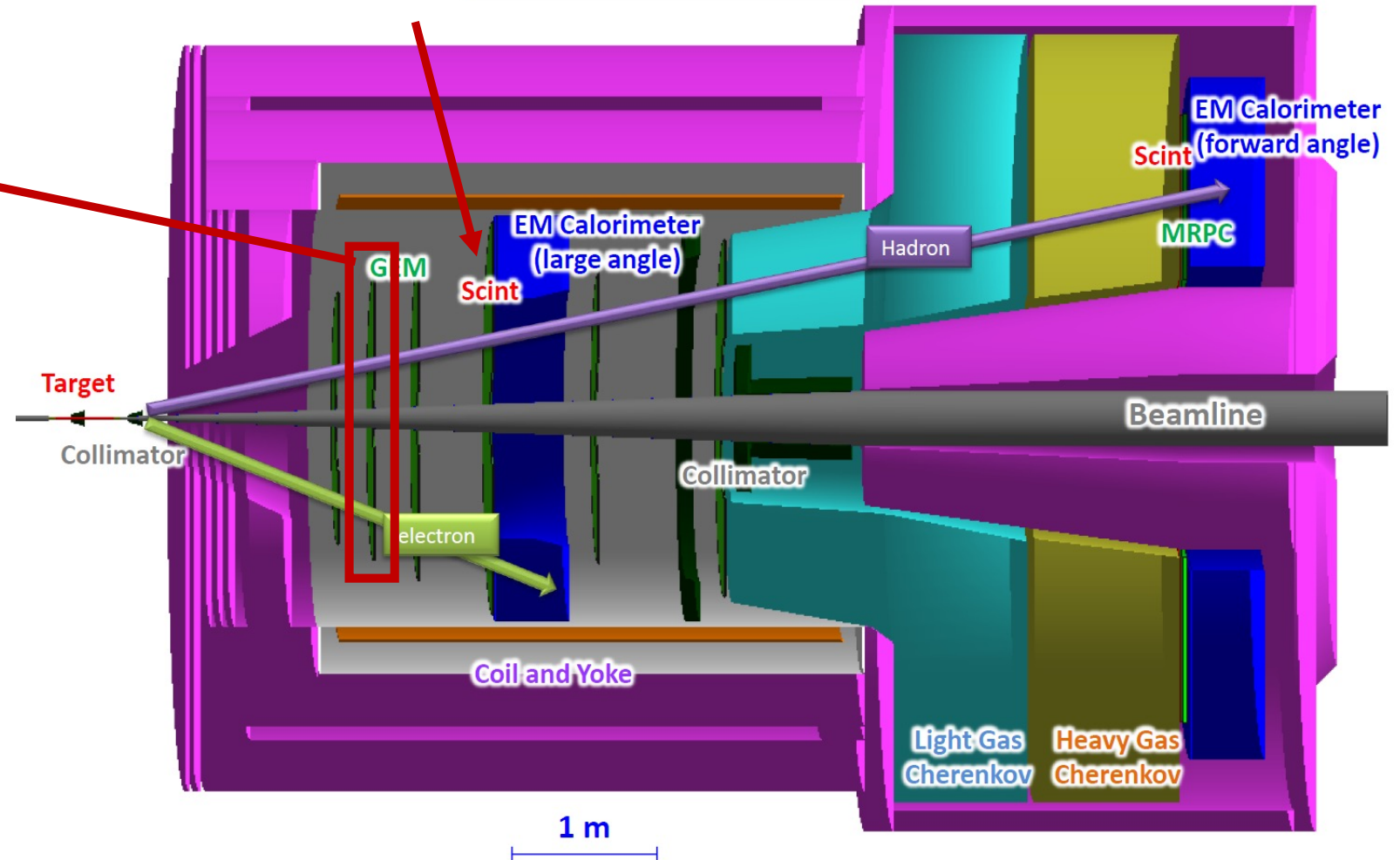4. Play with the 10-bit vs. 6-bit modes
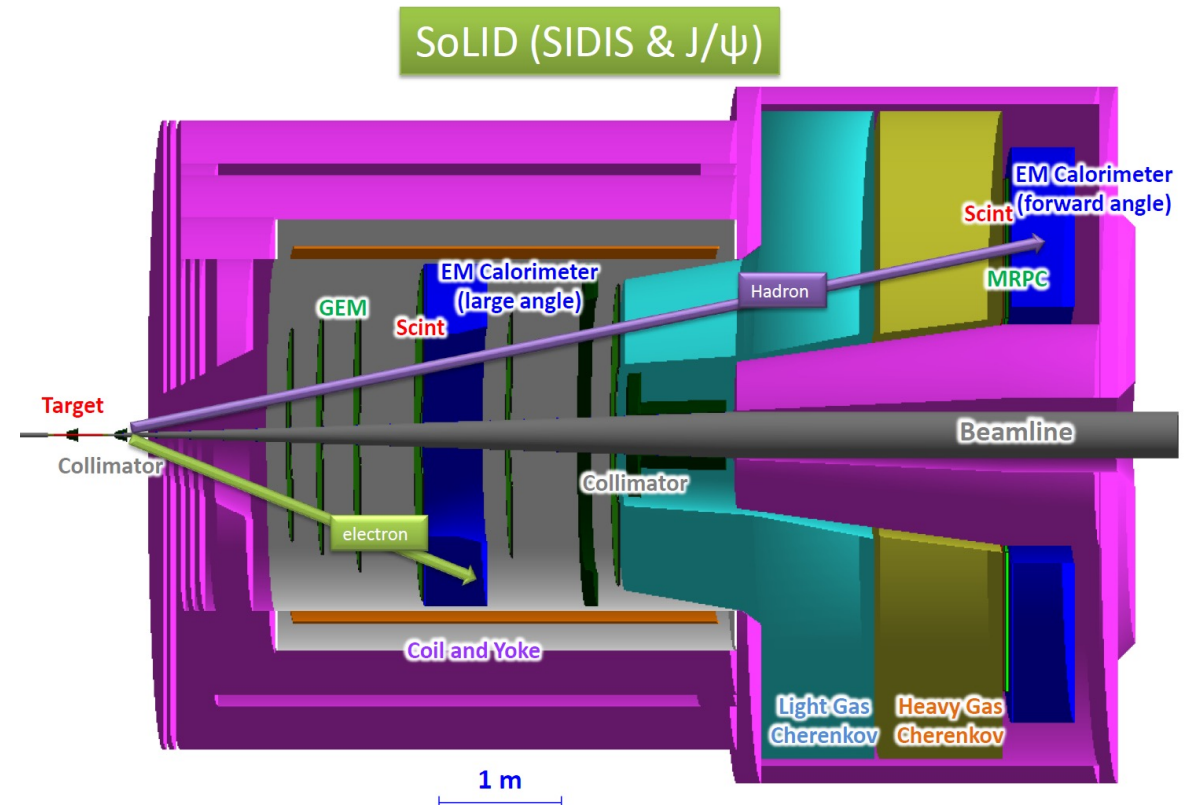
SoLID (SIDIS & J/ψ)

Some Ideas for Improvement (for SIDIS and JPsi)

Add one more shared GEM here

SoLID (SIDIS & J/ψ)

Separated the 2nd GEM into two GEMs, large angle part stay at the same location, small angle part moved downstream after LAEC

In addition, using 6-bit mode for GEMs with high occupancies, use 10-bit mode for low occupancy ones

GEM

Scint

EM Calorimeter (large angle)

EM Calorimeter (forward angle)

Scint

MRPC

Hadron

Target

Beamline

Collimator

Collimator

electron

Coil and Yoke

Light Gas Cherenkov

Heavy Gas Cherenkov

1 m

Current Estimation for Tracking Performance
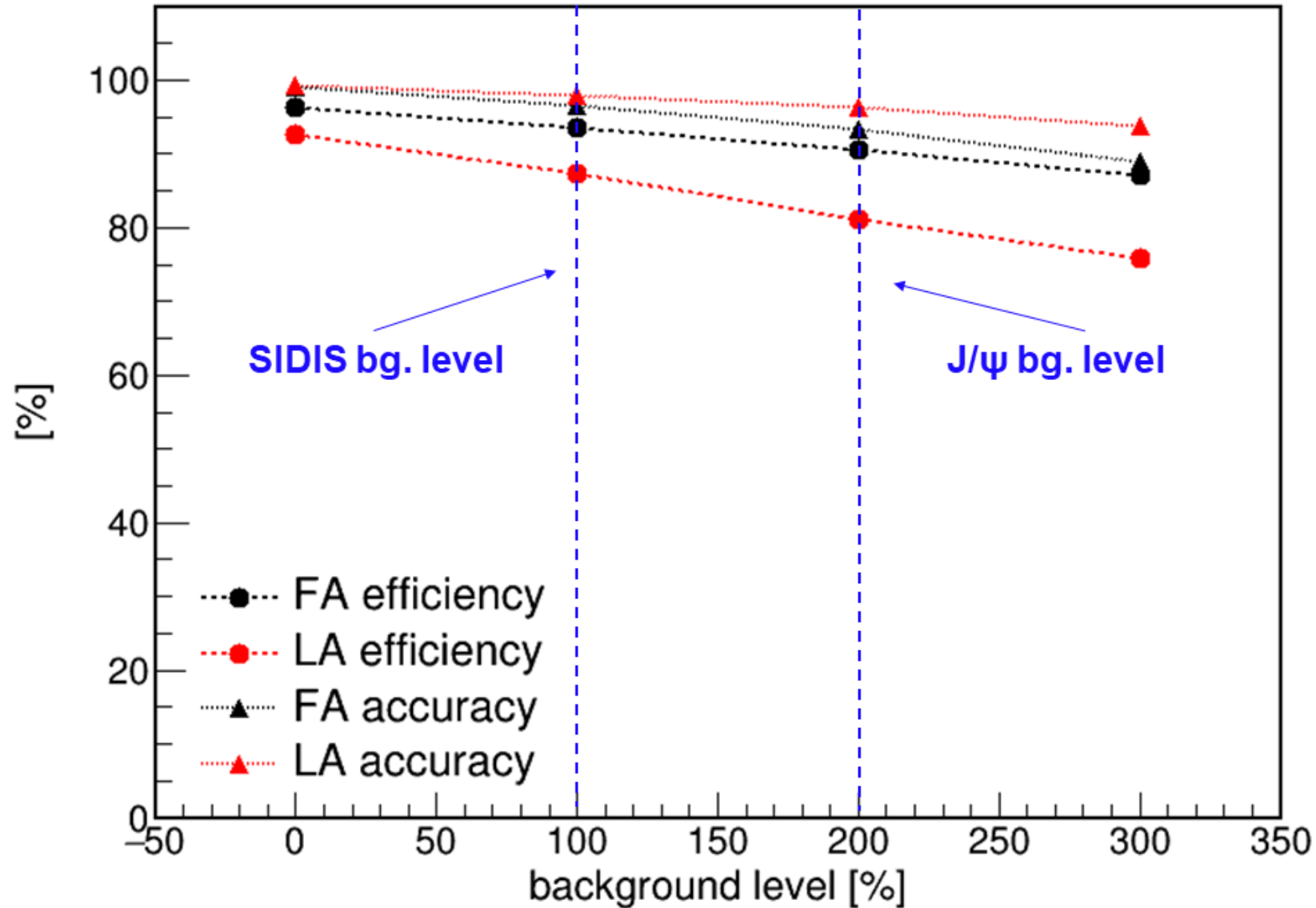
Current Tracking Algorithm (Kalman Filter)

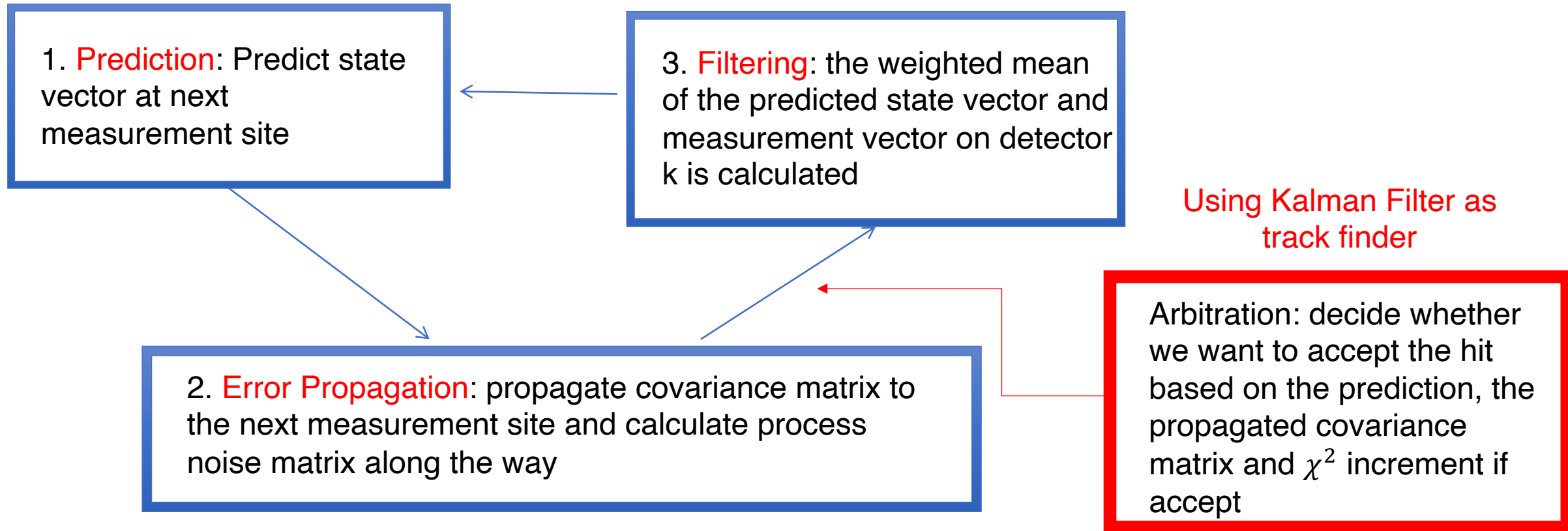Kalman Filter: a recursive fitting algorithm based on χ^2 minimization

1. Prediction: Predict state vector at next measurement site

3. Filtering: the weighted mean of the predicted state vector and measurement vector on detector k is calculated

Using Kalman Filter as track finder

2. Error Propagation: propagate covariance matrix to the next measurement site and calculate process noise matrix along the way

Arbitration: decide whether we want to accept the hit based on the prediction, the propagated covariance matrix and χ^2 increment if accept

Plan for ACTS Upgrade

- ACTS: exp.-independent toolkit for track reconstruction, implemented in modern C++
- Plugins exist for converting geometry from DD4HEP
- Common algorithms implemented including combinatorial KF, seeding finding, vertex finding…

- Assuming 1 person full time, starting september 2024
- Step 1 for the ACTS upgrade:
  - converting geometry, making material map, and have a first working version that can reconstruct a single track (no background)
    - ➢ Checking previous vertex resolution results
    - ➢ Expect 6 months of work

Plan for ACTS Upgrade

- **Step 2 for the ACTS upgrade:**
  - Adding background and testing CKF
    - ➢ Check with the current tracking reconstruction results
    - ➢ Expect 3 months of work

- **Step 3 for the ACTS upgrade:**
  - Making the implementation for all SoLID detector configurations: SIDIS-He3, SIDIS-NH3, JPsi, PVDIS…
    - ➢ Check with the current tracking reconstruction results
    - ➢ Expect 3 months of work

- Lots of experience and knowledge have been collected based on previous studies using the current CKF-like reconstruction program, 1year of work for 1 person full time should be reasonable

Conclusion

- With 300ns dead time for the VMM3 chip, tracking reconstruction becomes very difficult
  - Require certain "fundamental" hardware changes: adding more GEM planes, segmenting more strips…
  - After making minimum changes, tracking works for SIDIS and JPsi, but result is only moderate

- Good to consider some other alternative readout chips

- Plan to upgrade tracking software to ACTS, starting in September, expect 1 year of work for 1 person full time (including myself)