软件分会总结

李腾

2024年超级陶粲装置研讨会, 兰州大学

2024-7-10

Talks in Software Session

周一 08/07

打印 | PDF | 全屏 | 详细视图 | 过滤

14:00
- EicC径迹探测器设计和优化 — Aiqiang Guo — 14:00 - 14:25
- Alignment of BESIII — Linghui Wu — 14:25 - 14:50
- LHCb tracking/trigger — Peilian Li — 14:50 - 15:15

15:00
- High Level Trigger at Belle II — Chunhua Li — 15:15 - 15:40

周二 09/07

打印 | PDF | 全屏 | 详细视图 | 过滤

09:00
- STCF DTOF simulation and reconstruction — 玥潼 冯 — 09:00 - 09:20
- STCF RICH simulation and reconstruction — 清源 黄 — 09:20 - 09:40
- STCF MUD simulation and reconstruction — Yulin Liu — 09:40 - 10:00

10:00

周二 09/07

打印 | PDF | 全屏 | 详细视图 | 过滤

14:00
- STCF core software — Teng Li — 14:00 - 14:20
- 探测器与事例可视化应用研究 — Kaixuan Huang — 14:20 - 14:40
- STCF event display — Qiongbing Zhang — 14:40 - 15:00

周一 08/07

打印 | PDF | 全屏 | 详细视图 | 过滤

16:00
- STCF digitization — Binbin Qi — 16:10 - 16:30
- STCF tracking with Hough — 杭 周 — 16:30 - 16:50

17:00
- Low momentum track fitting at STCF — 珍娜 陆 — 16:50 - 17:10

周二 09/07

打印 | PDF | 全屏 | 详细视图 | 过滤

10:00
- PANDA EMC reconstruction — Shengsen Sun — 10:30 - 10:55

11:00
- STCF EMC simulation and reconstruction — 博 王 — 10:55 - 11:15

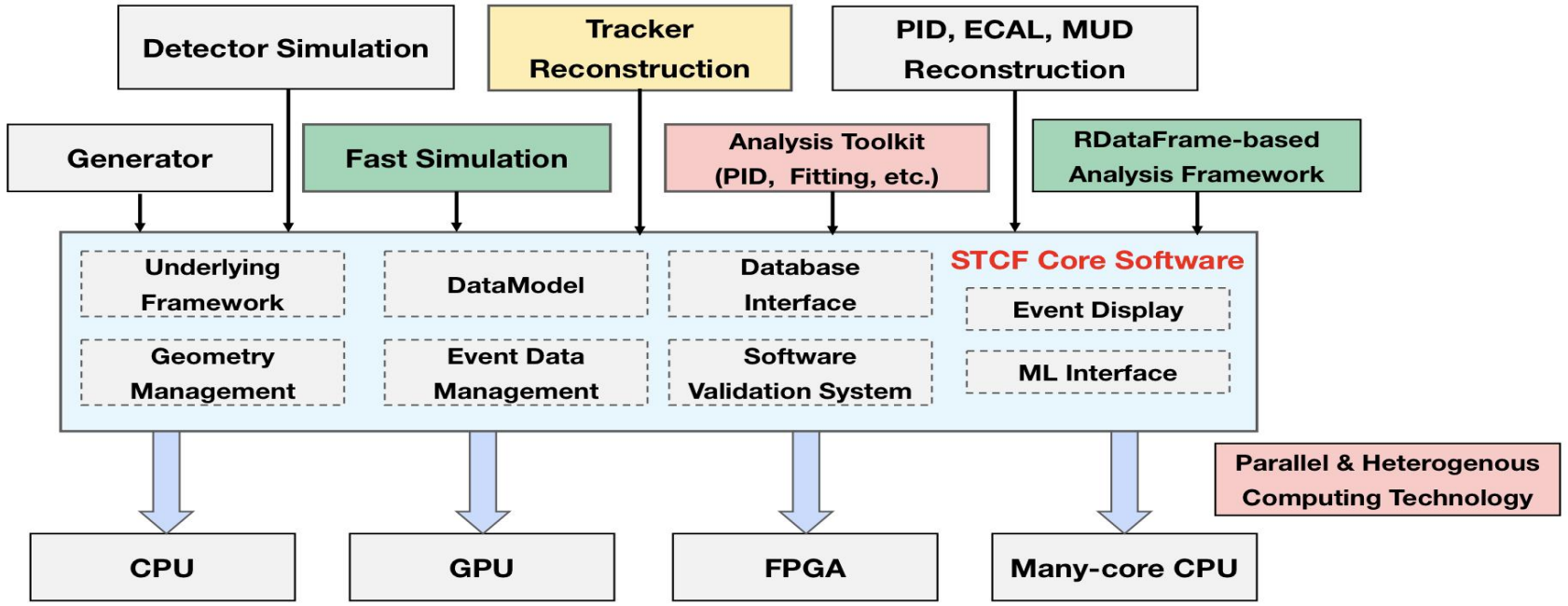
- AI Assistant for HEP data analysis - Dr. Sai — Ke Li — 15:30 - 15:55

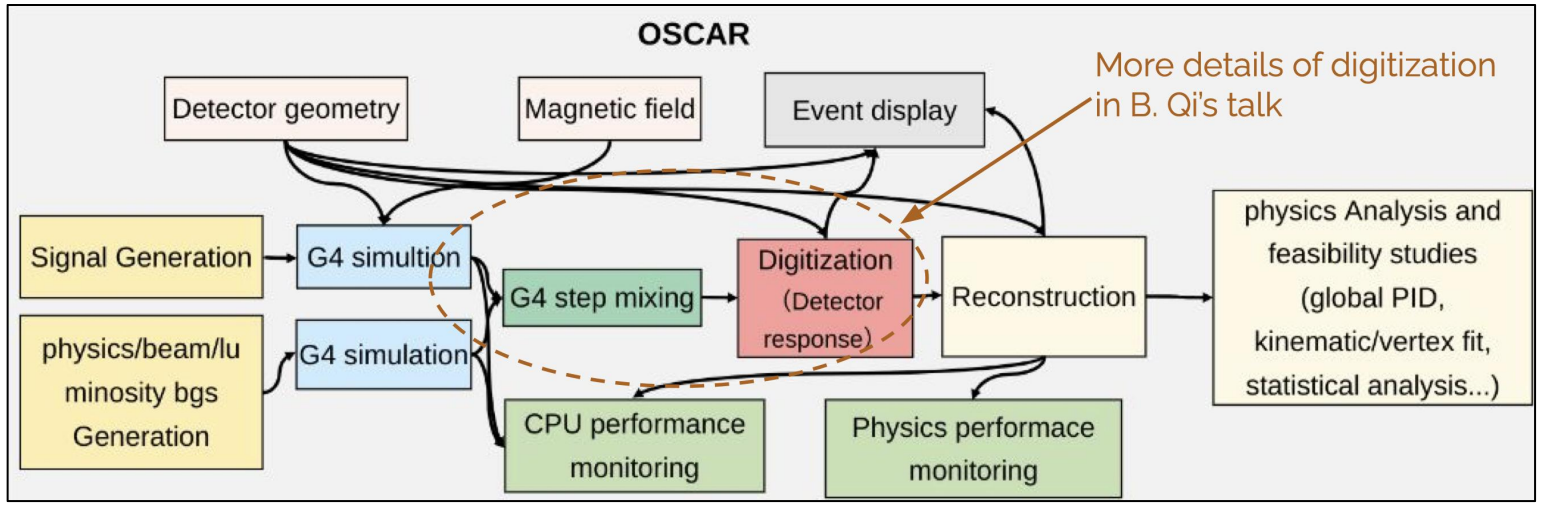
16:00
- GNN for STCF tracking — Xiaoqian Jia — 15:55 - 16:15
- Application of CNN for DTOF — 志鹏 姚 — 16:15 - 16:35
- STCF global PID with ML — Yuncong Zhai — 16:35 - 16:55

19 talks in 6 sessions

STCF Software Progress

Status of STCF software: Overview





Status of OSCAR:

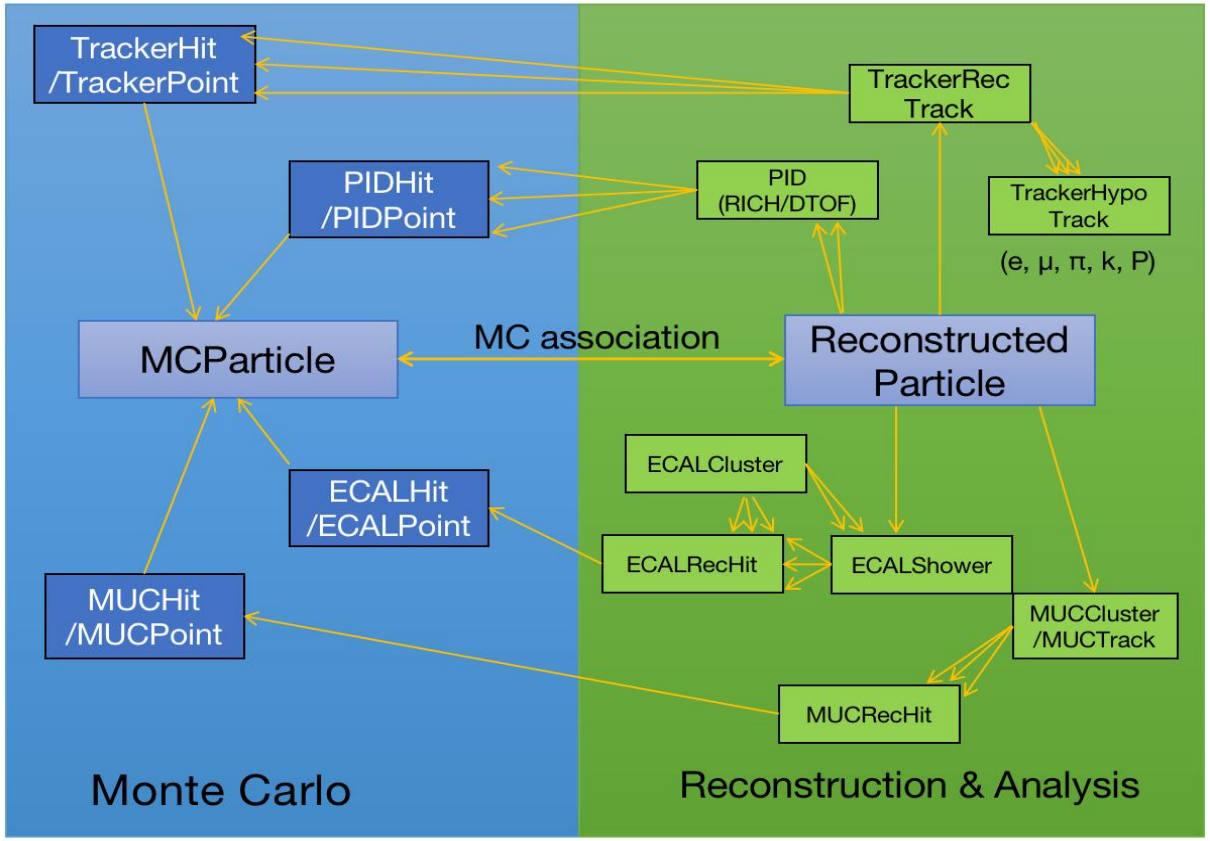
- More than 10 releases have been released
- Latest version includes **full data processing chain** (generator, simulation, mixing and digitization, reconstruction, analysis toolkits)
- Complete physics analyis work is onging within OSCAR

Status of STCF software: Core Software

T. Li

- Core software is developed as the skeleton of OSCAR, to support the entire offline data processing

- Underlying event loop control using SNiPER (adopted also by JUNO, LHAASO, nEXO, HERD)
- Event Data Model (EDM) based on podio (key4hep adopted by CEPC, ILC, FCC...)
- Detector description using DD4hep
- Supports multithreading, Machine Learning and heterogeneous computing
- Supports event display, database, tests...

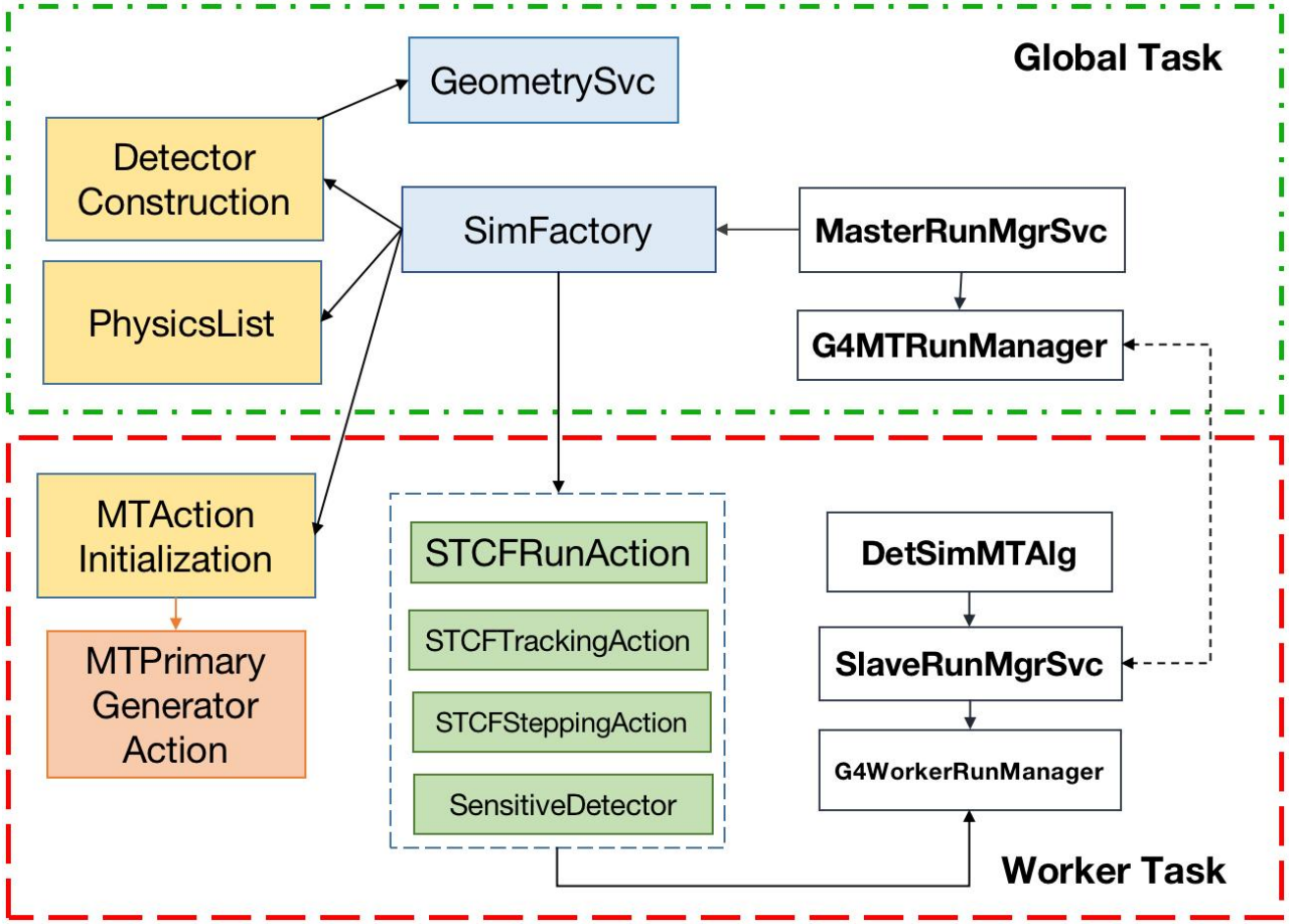


OSCAR Event Data Model

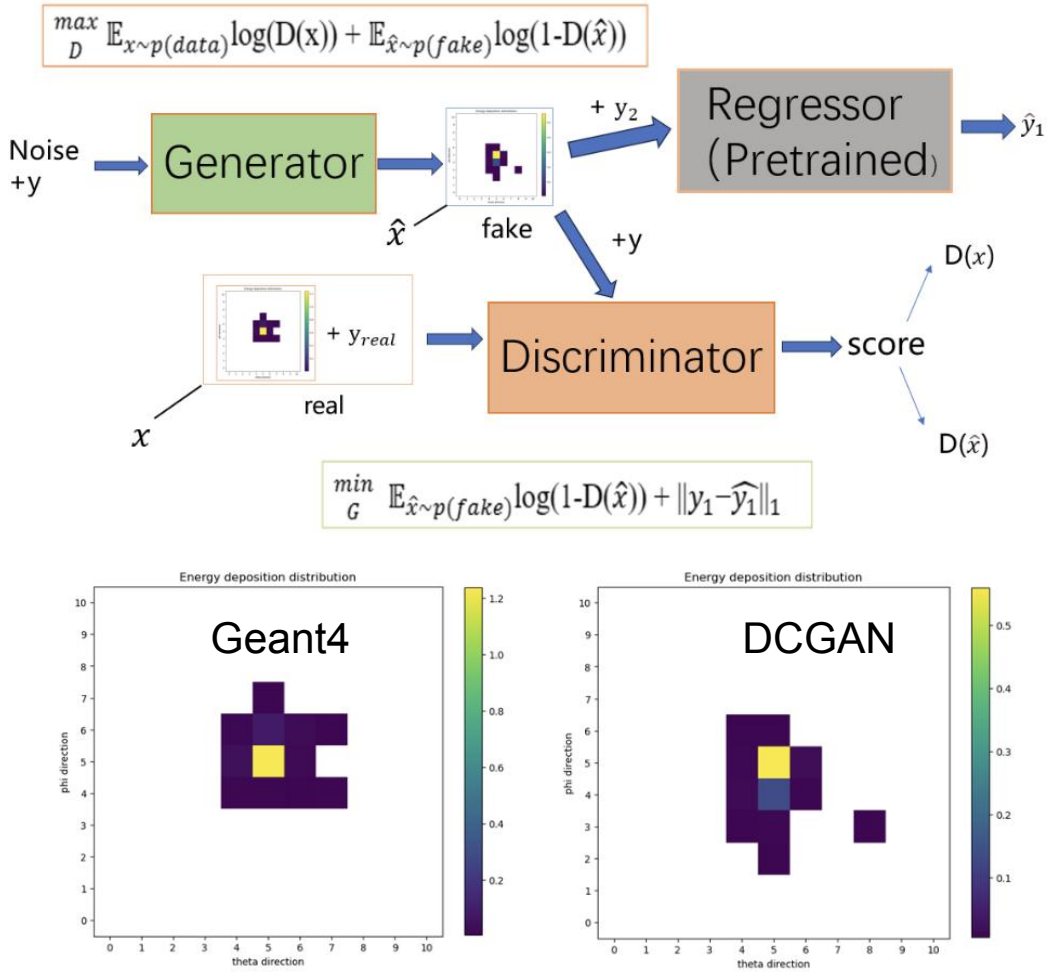
Status of STCF software: Core Software

T. Li

- Recent development focuses on boosting the software performance



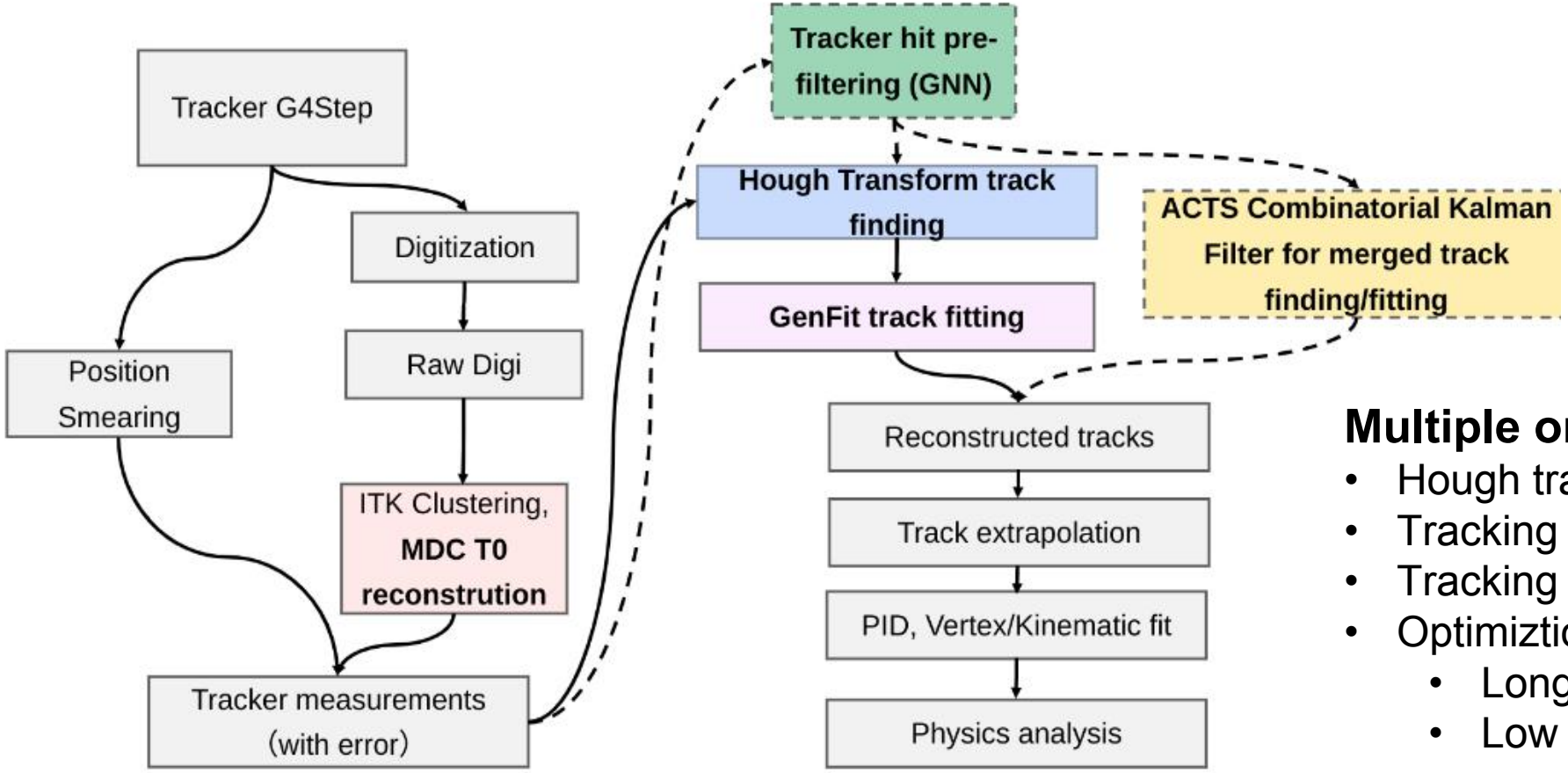
Concurrent Detector Simulation

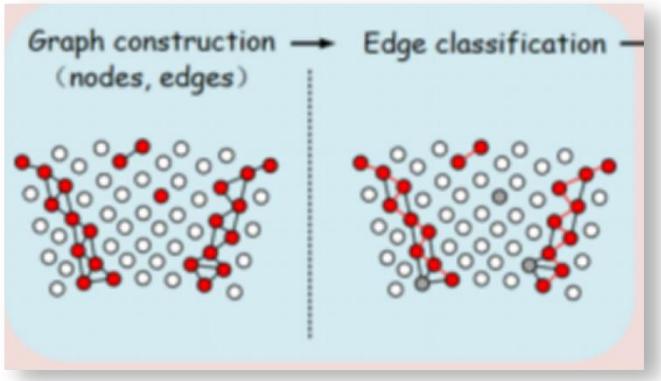


Fast Simulation Based onDCGAN

Tracking Software

X.C. Ai



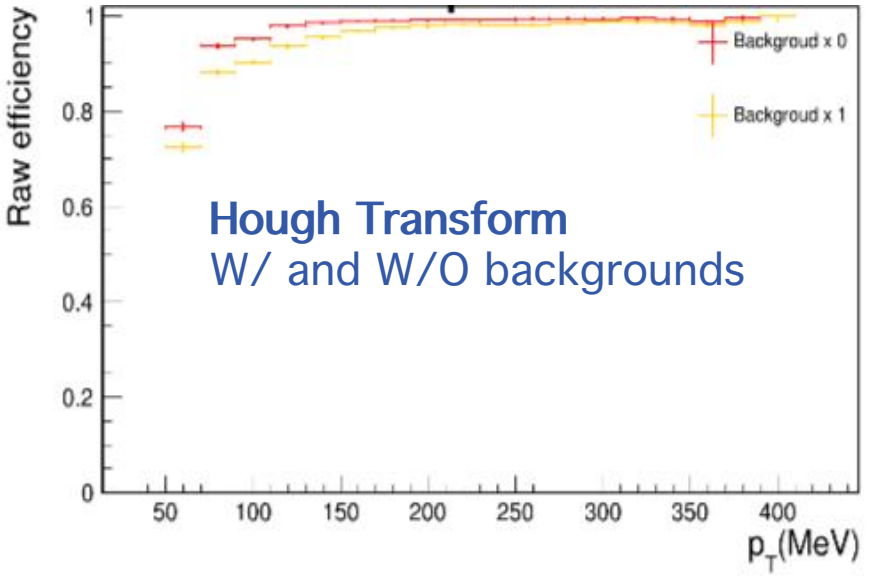


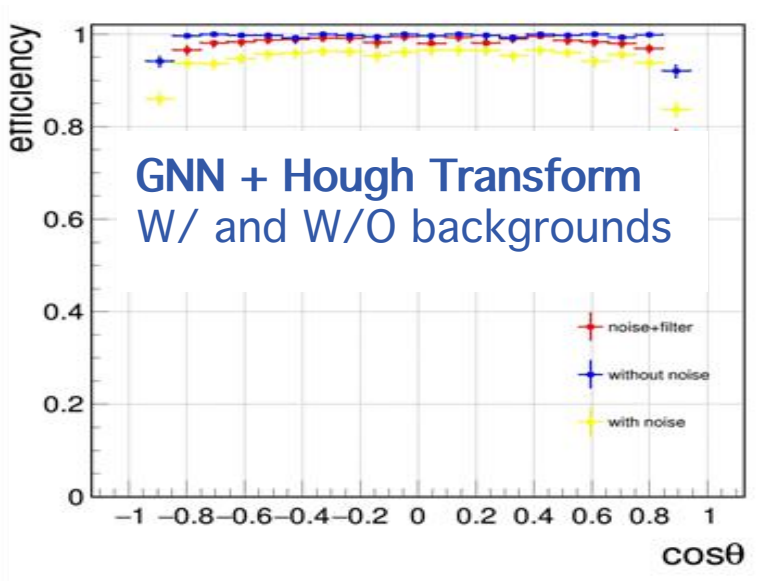
Multiple ongoing studies

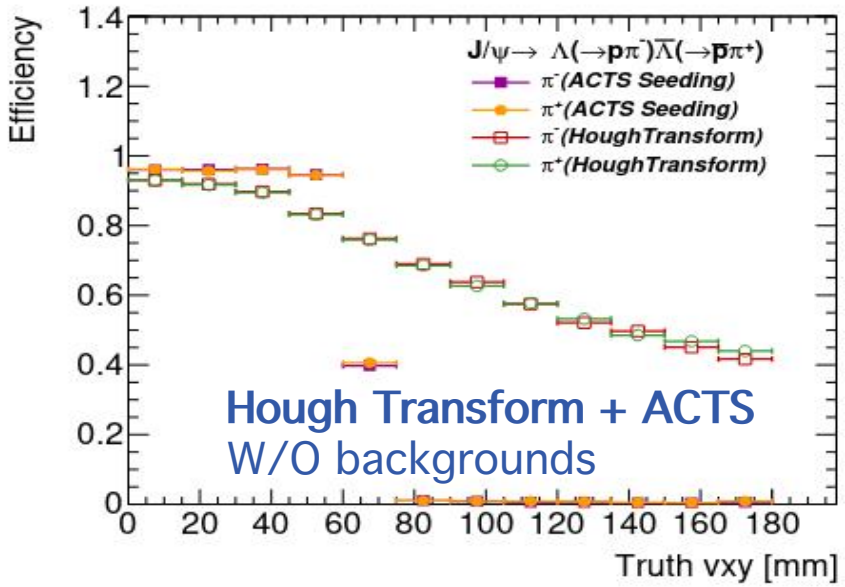
- Hough transform as baseline
- Tracking with ACTS
- Tracking with GNN
- Optimiztions
  - Long-lived particles
  - Low momentum particles
  - ...

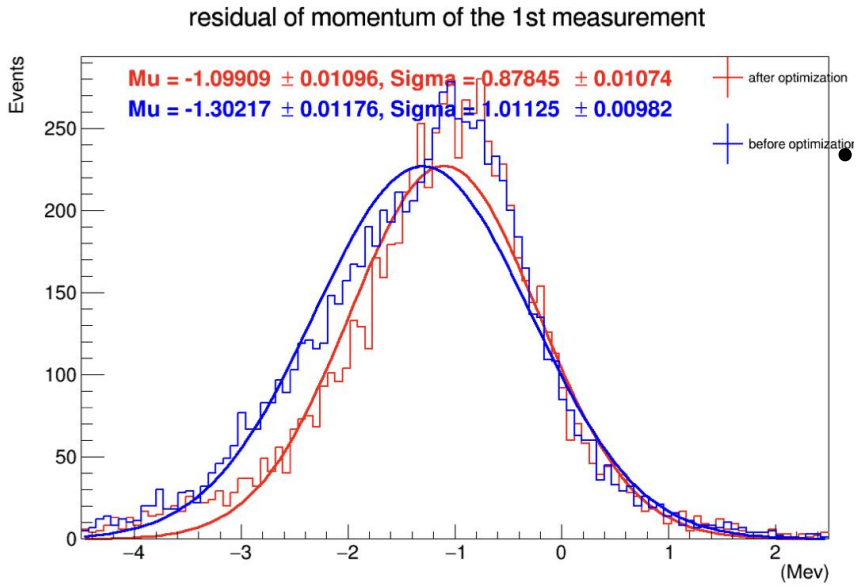
Tracking Software

H. Zou, Z.N Lu, X.Q. Jia





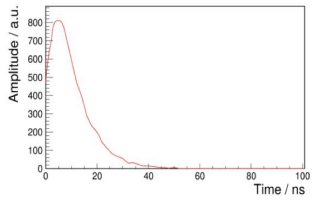




- Tracking efficiency is **above 95%** in central region for p_T > 100 MeV/c, even with backgrounds
- 99% noise hits can be removed by GNN (except first/secondary long tracks backgrounds)
- Tracking resolution for low p_T looping tracks has been improved

ECAL Software

B. Wang



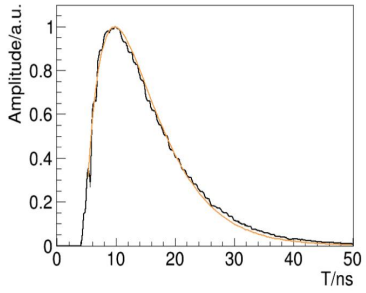
Geant4 optical simulation for each layer unit (standalone)

Sampling

Points (E-T) in each layer unit

Fluorescence transfer parameterized simulation

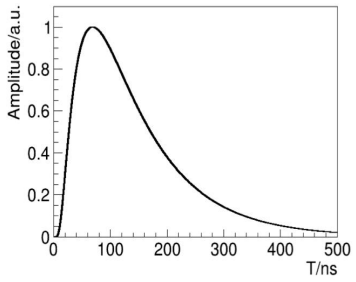
Light output nonuniformity



convolution

Scintillation process

Electronics response function



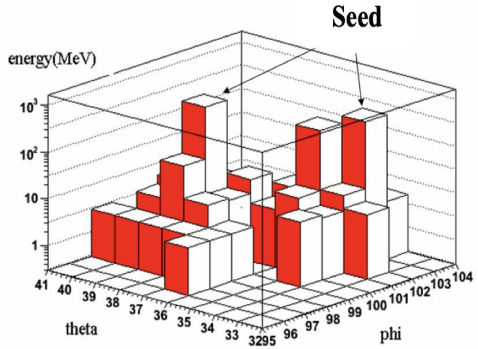
Electronic noise

ADC (12.5ns)

Output waveform

ECAL Digitization

ECALRecAlg



π^0 Cluster (two photons)

Cluster search

Seed search

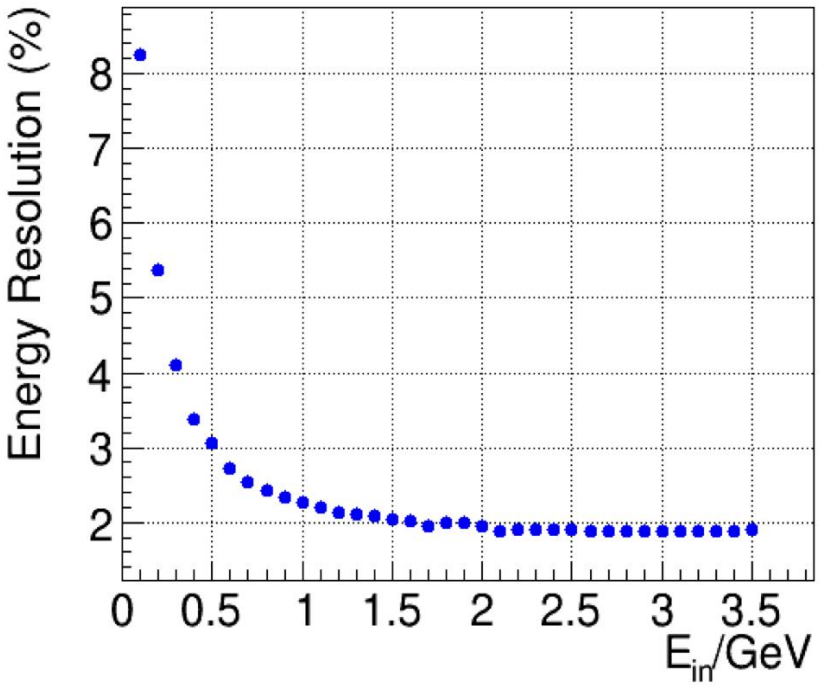
Clusters split into Showers

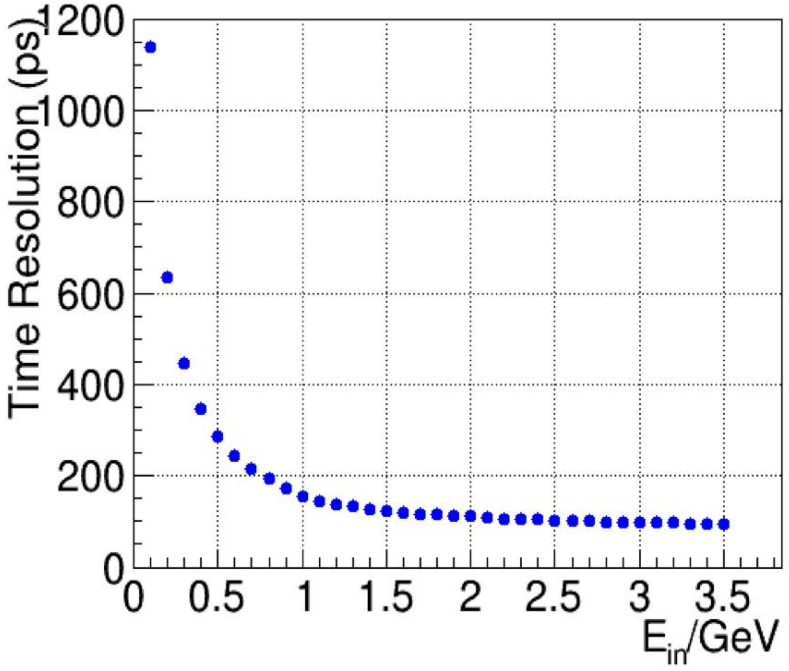
Calculation and correction of shower energy and position

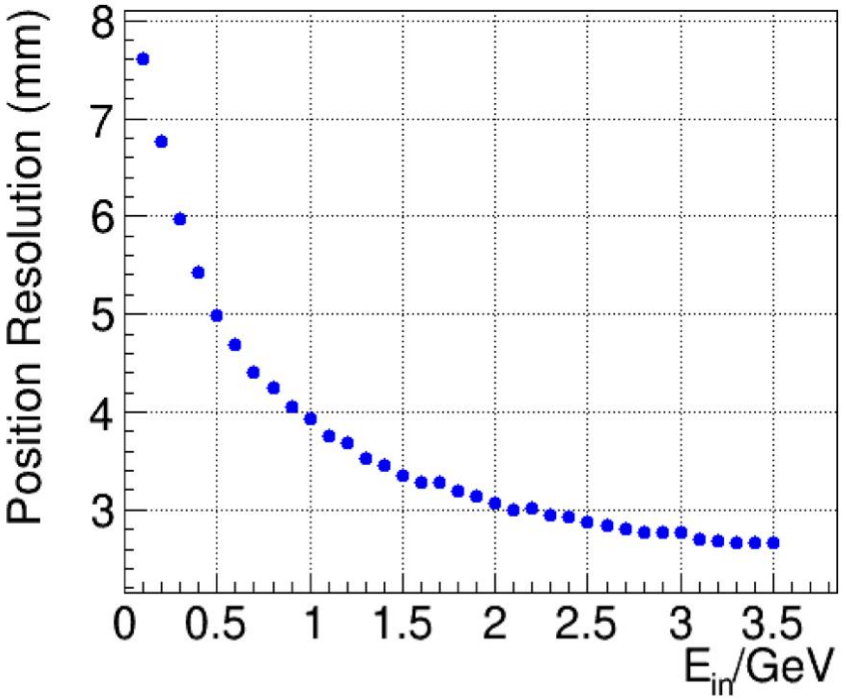
ECAL Reconstruction

ECAL Software

B. Wang







- ✓ σ_E = 2.27% @ 1 GeV
- ✓ σ_E = 8.26% @ 0.1 GeV
- ✓ With background
- ✓ Meet the requirement

- ✓ σ_T = 153 ps @ 1 GeV
- ✓ Fitted with Gaussian function
- ✓ With background
- ✓ Meet the requirement

- ✓ σ_{pos} = 4.0 mm @ 1 GeV
- ✓ With background
- ✓ Meet the requirement

DTOF Reconstruction

Y.T. Feng

❖ Timing method

TOF reconstruction

$$cos\theta_c = \frac{1}{n\beta} = \frac{\vec{v}_t \cdot \vec{v}_p}{|\vec{v}_t| \cdot |\vec{v}_p|} \qquad \begin{cases} \vec{v}_t = (a, b, c) \\ \vec{v}_p = (\Delta X, \Delta Y, \Delta Z) \end{cases}$$

$$LOP = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2} \implies TOF_{rec} = T - \frac{LOP \cdot \overline{n_g}}{c} - T_0$$

Likelihood construction

$$\mathcal{L}_h = \prod_{i=0}^{N_{p.e.}} f_h(TOF_i)$$

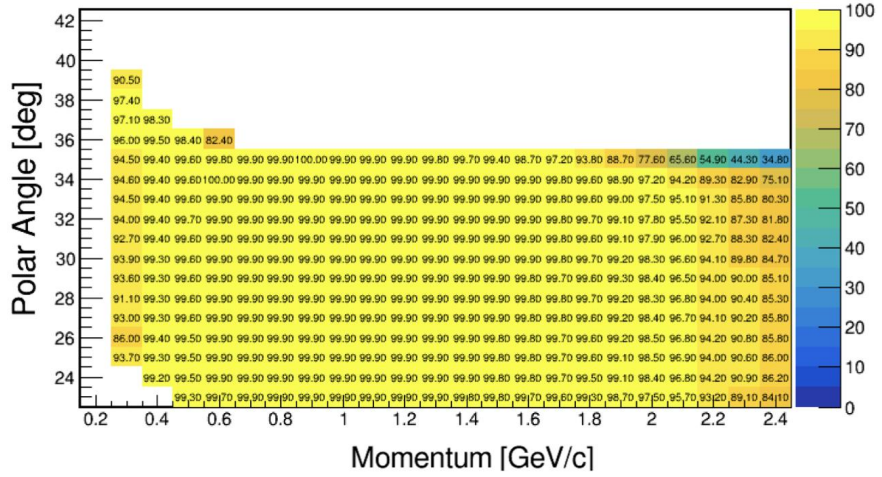
signal bkg

$$f_h(t) = Gaus(TOF_{rec} | TOF_{hypo}, \sigma) + 0.05$$

where $TOF_{hypo} = \frac{LOF}{c\beta_{hypo}}$

π efficiency after mixing BKG in different $(|\vec{p}|, \theta)$:

$(K \text{ mis} - \text{ID} = 2\%)$



❖ Imaging method

π efficiency $\sim 99\%$, at $p = 2.0$ GeV/c $(K \text{ mis} - \text{ID} = 2\%)$

Photon TOA v.s. (x_s, y_s) Reconstruction

$$cos\theta_c = \frac{1}{n\beta} = \frac{\vec{v}_t \cdot \vec{v}_p}{|\vec{v}_t| \cdot |\vec{v}_p|} \qquad \begin{cases} \vec{v}_t = (a, b, c) \\ \vec{v}_p = (x_s - x_0, y_s - y_0, z_s - z_0) \end{cases}$$

$$z_s = z_2 + 2mT$$

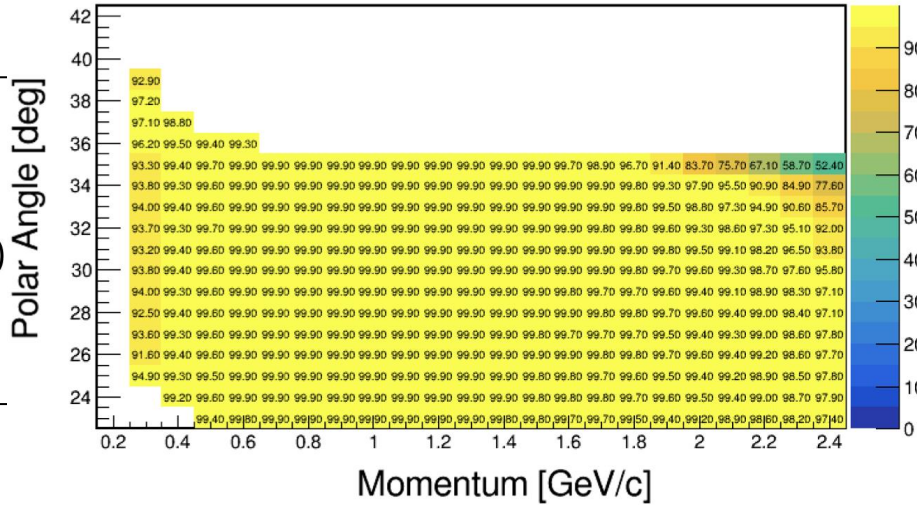
$$(x_s, y_s) \Rightarrow z_e, \phi_c \Rightarrow TOA = \boldsymbol{TOF} + \frac{\Delta LOF_e}{\beta c} + TOP$$

Likelihood construction

$$\mathcal{L}_h = p_h(N_{p.e.}) \prod_{i=0}^{N_{p.e.}} f_h(x_i, t_i)$$

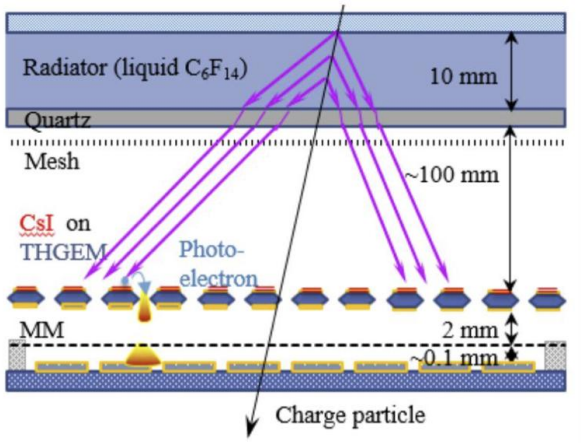
$$p_h(N_{p.e.}) = \sum_{n=0}^{N} Poisson_h(n, N_e) \times F_{bkg}(N - n)$$

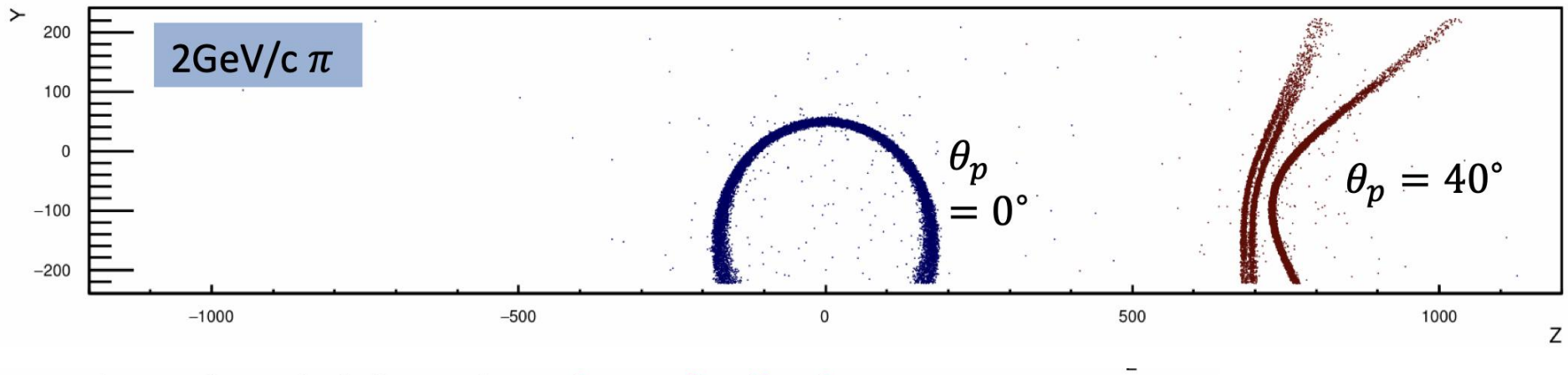
$$f_h(x, t) = S_h(x, t) + const_{bkg}$$



RICH Reconstruction

Q.Y. Huang





- The photon collected in each anode pads follows the **Poisson distribution**

$$pdf_{i,h} = Poisson\left(N_i + 10^{-3}, mean_{i,h} + 10^{-3}\right),$$

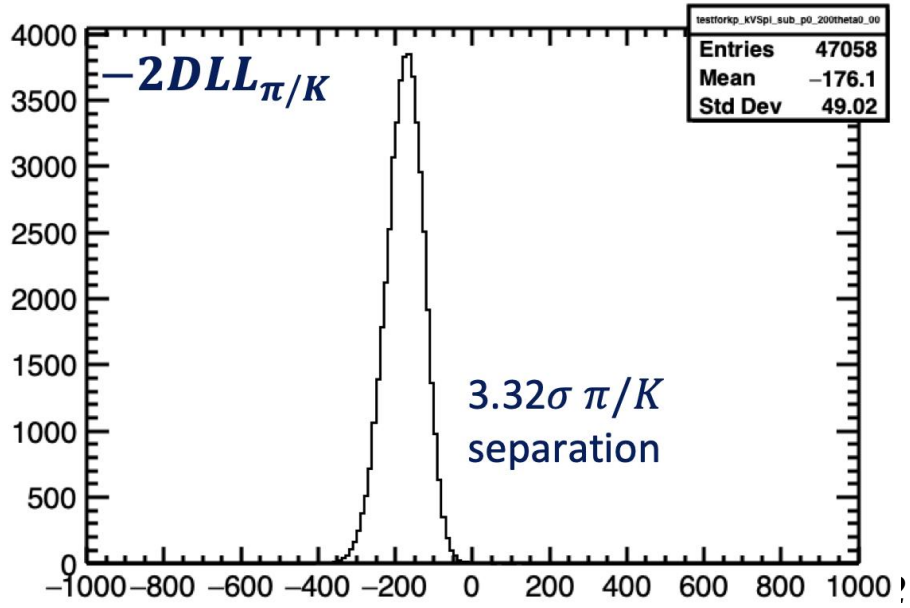
- Likelihood of h hypothesis:

$$\ln \mathcal{L}_h = \sum_i^{npads} \ln pdf_{i,h}$$

- π, K separation:

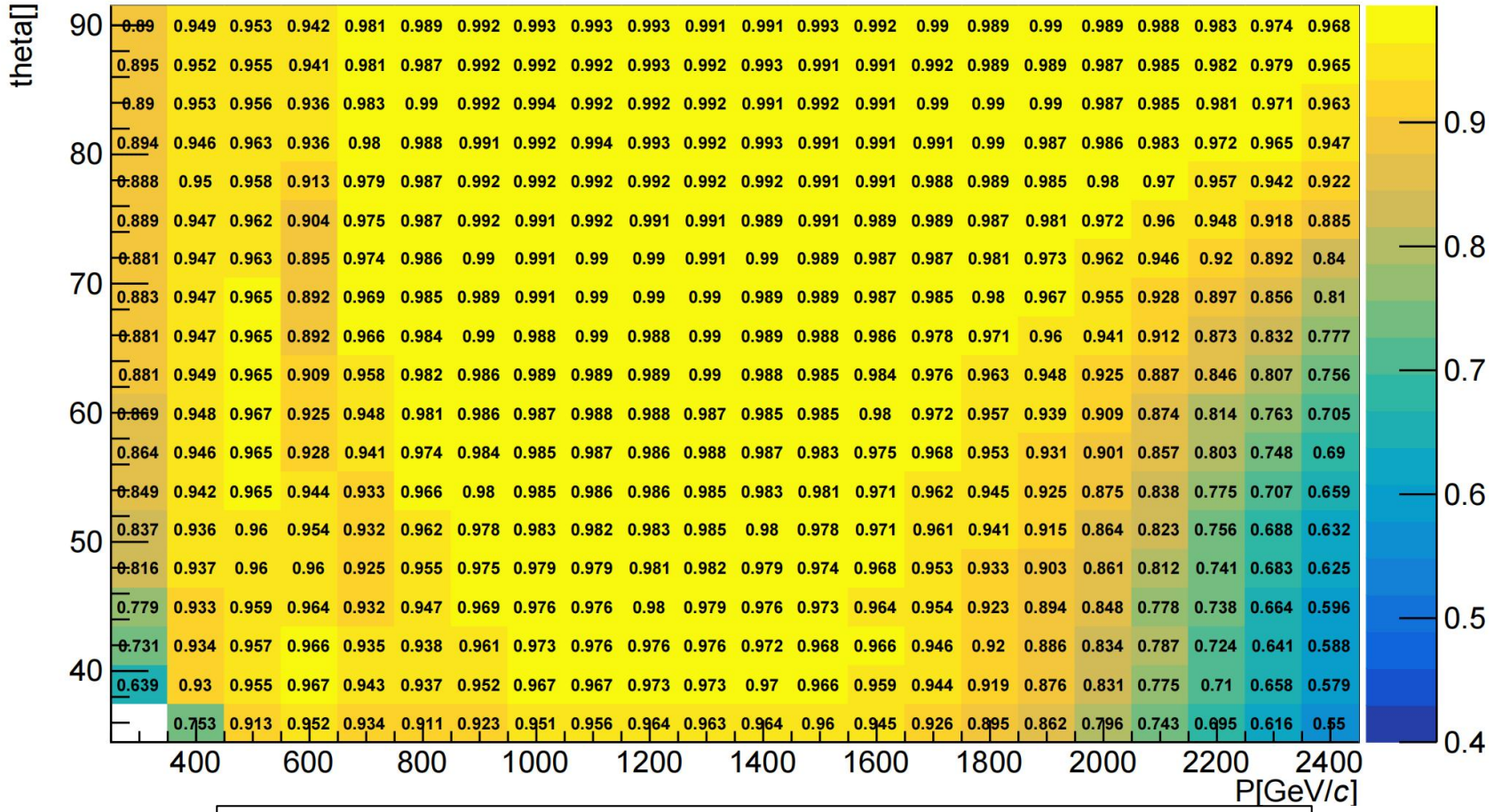
$$DLL = \sum_i^{npads} \ln \frac{pdf_{i,\pi}}{pdf_{i,K}}$$

Now PDF generated on the fly



RICH Reconstruction

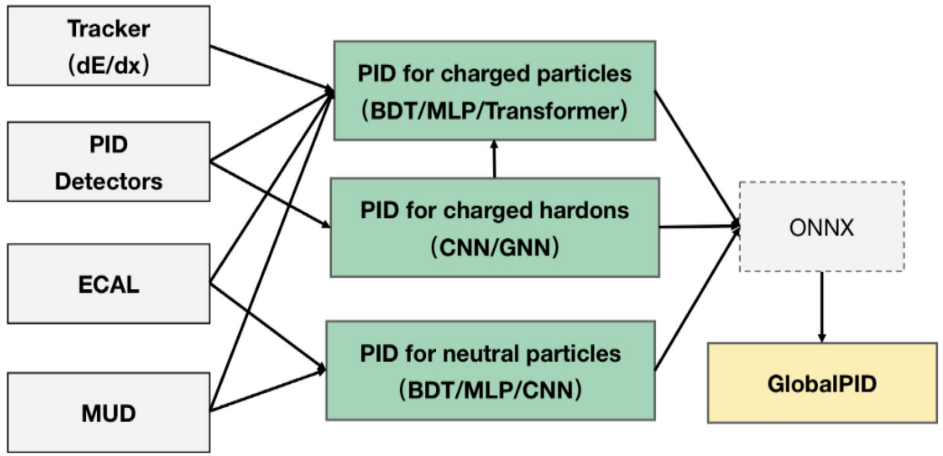
Q.Y. Huang

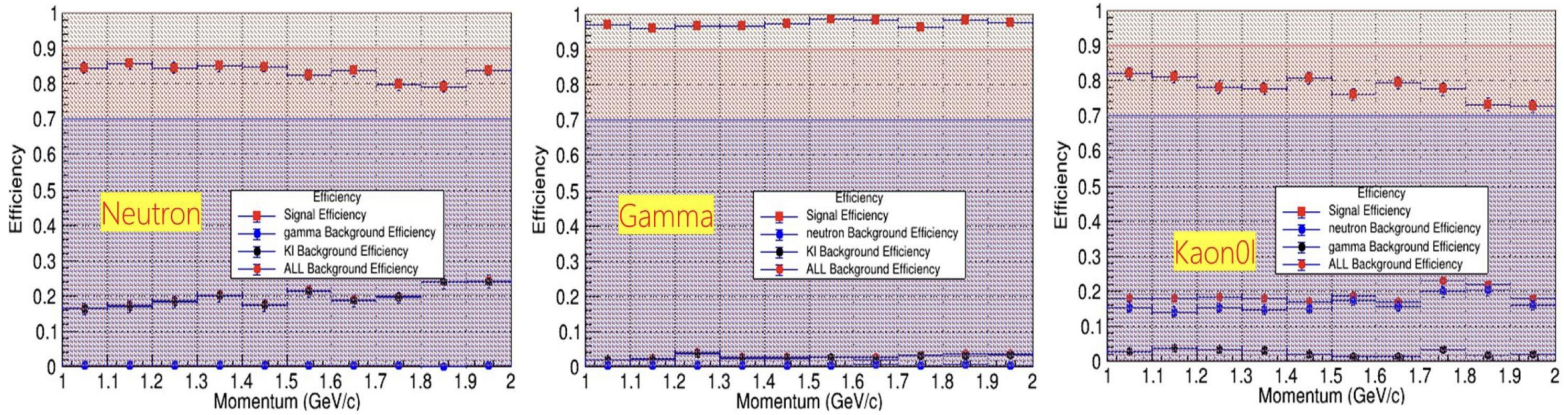


π PID Efficiency with K miss-id. at 2%
Meet CDR requirements in most bins

PID Based on Machine Learning

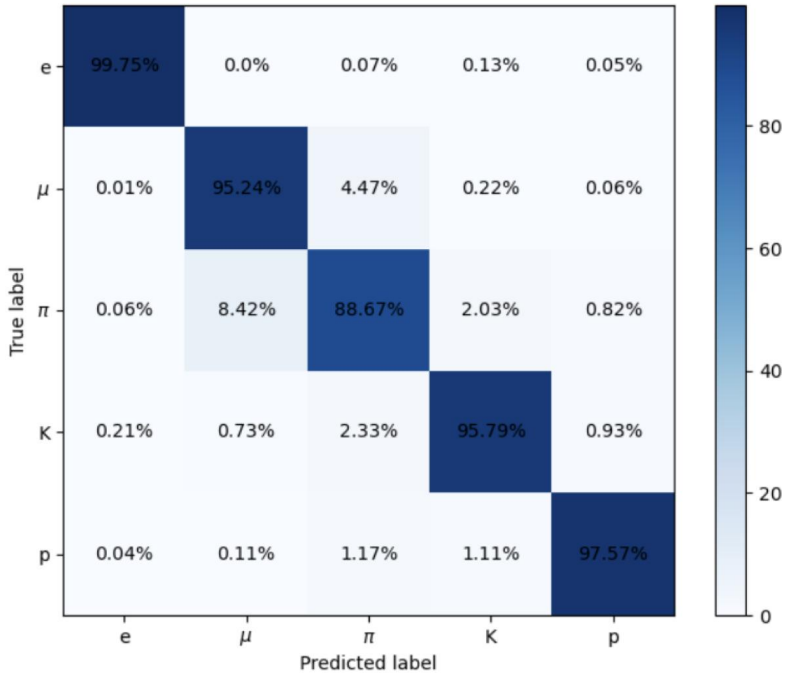
Y.C. Zhai

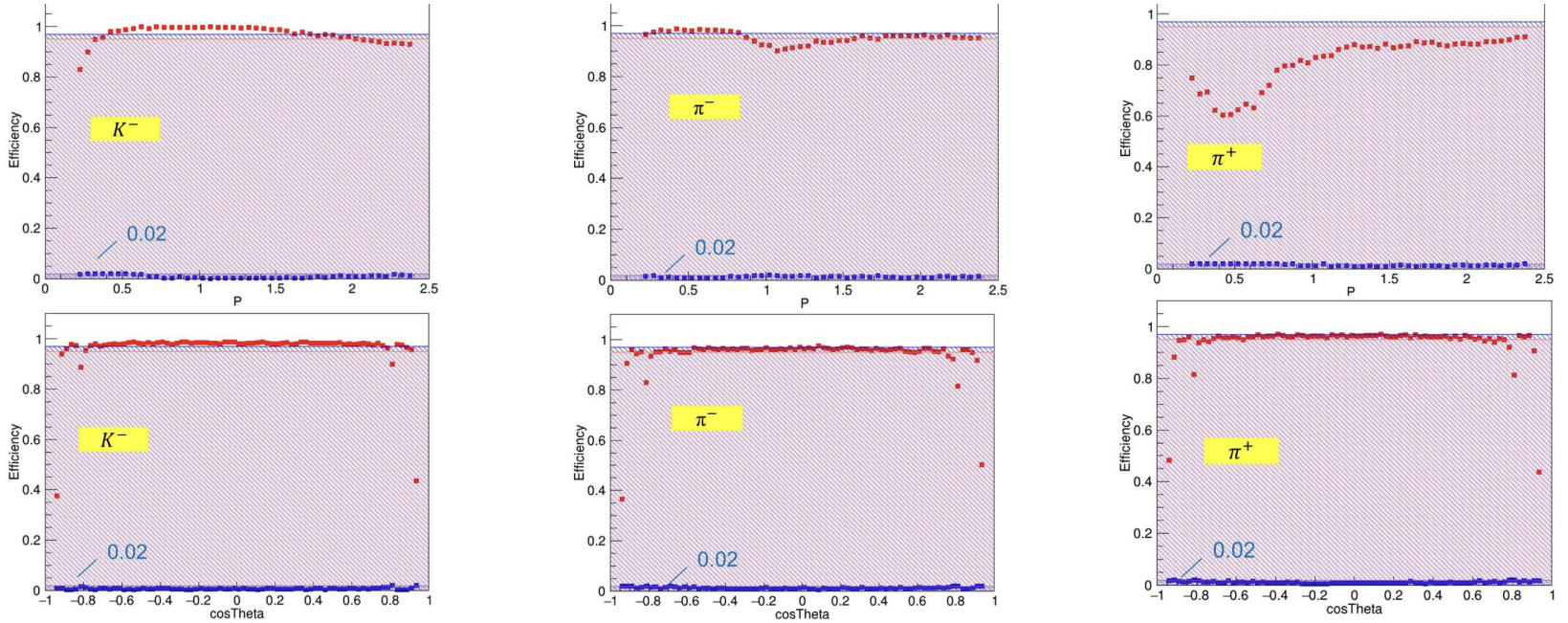




PID for neutral particles

基于机器学习的STCF粒子识别算法

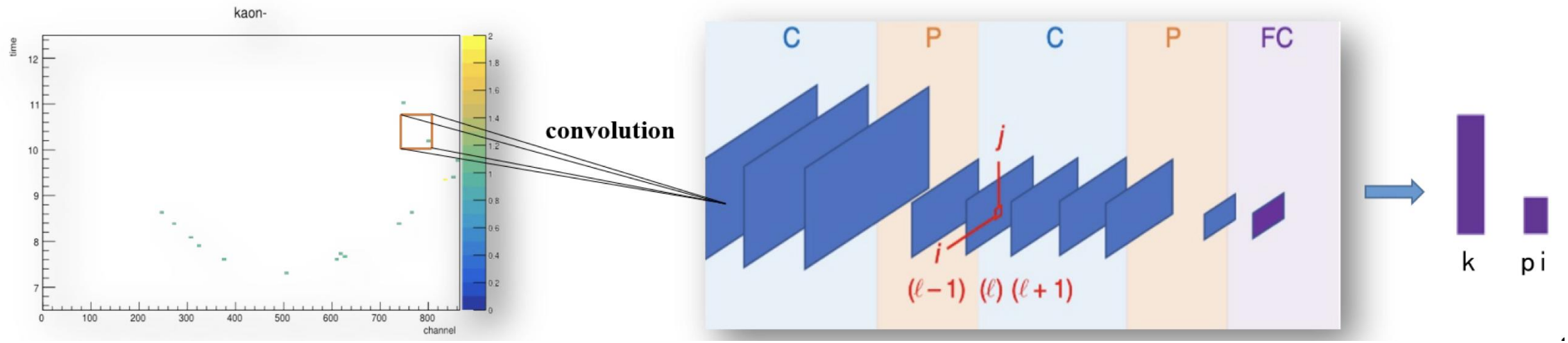




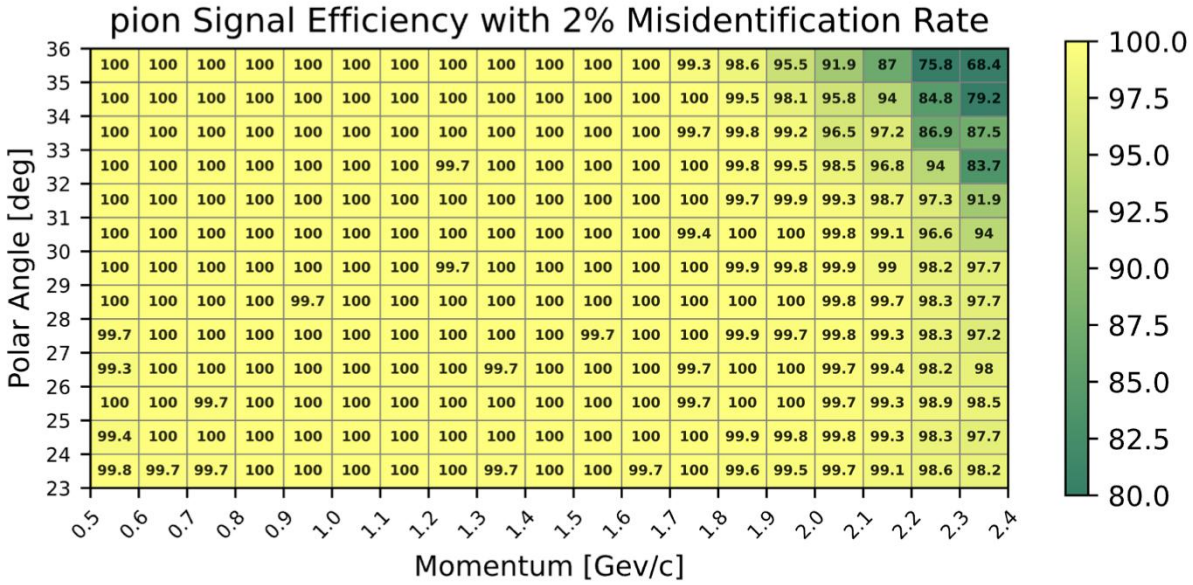
PID for charged particles

PID Based on Machine Learning

Z.P. Yao



DTOF PID powered by CNN

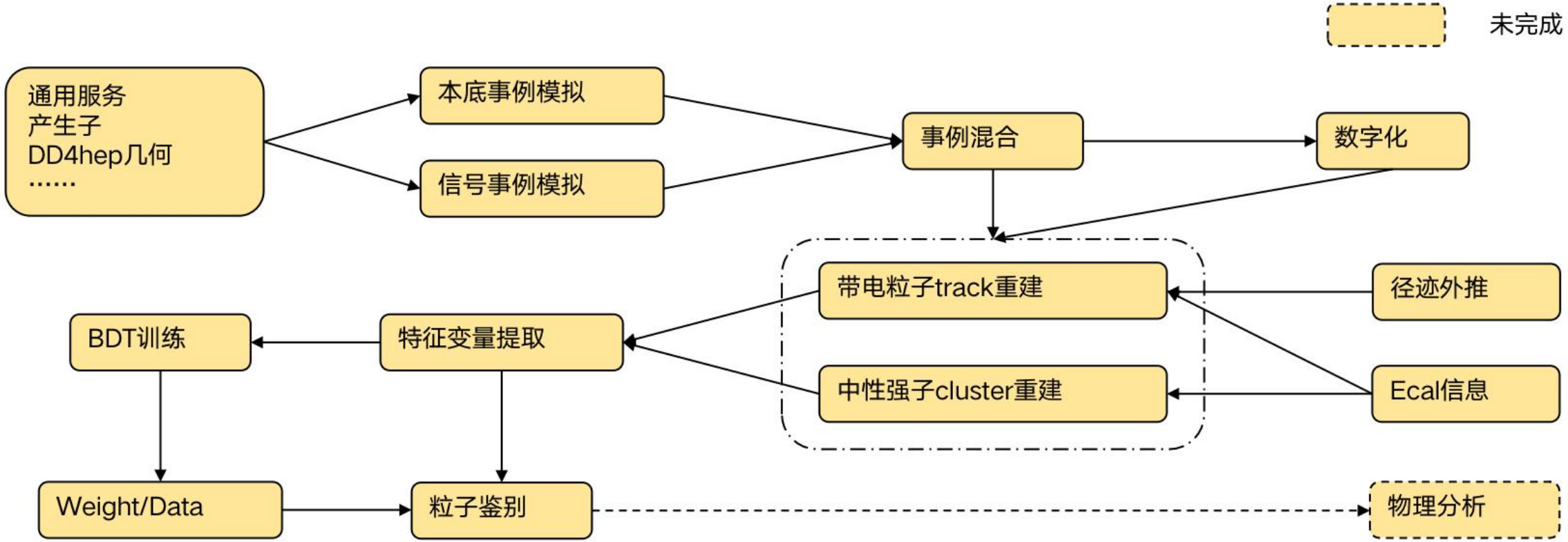


Pion efficiency ~99% at 2 GeV/c,
with kaon miss identification < 2%

Meet CDR requirements

MUD Software

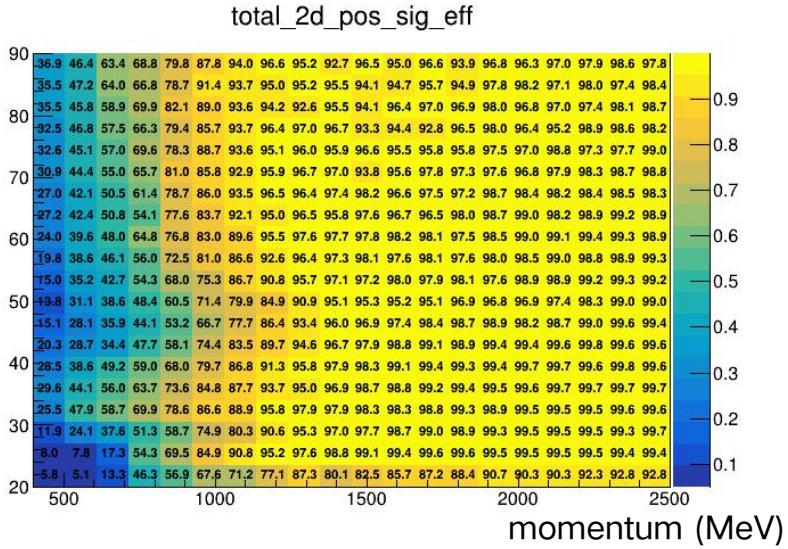
Y. L. Liu



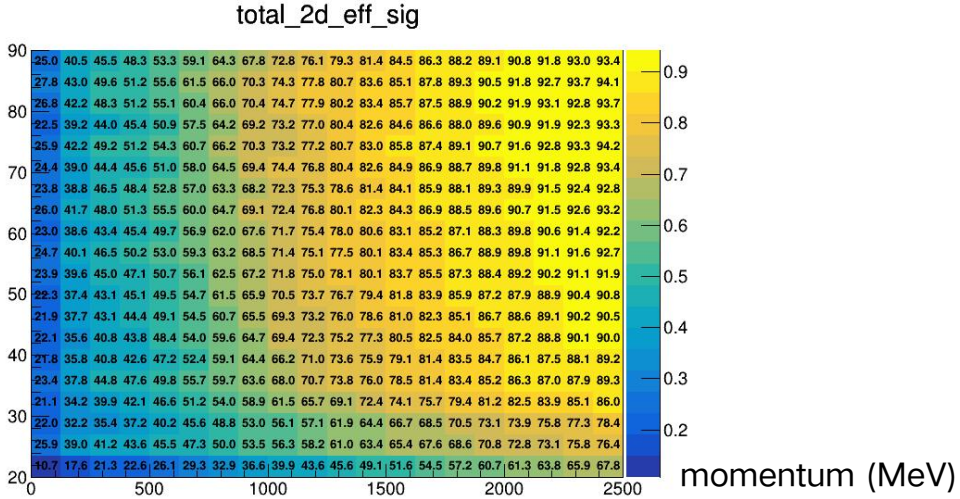
MUD Software

Y. L. Liu

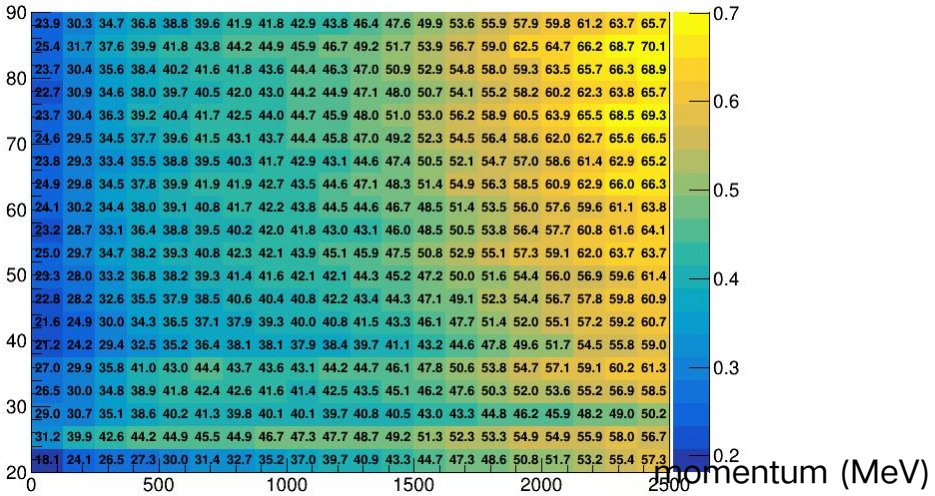
无本底，μ+/π+鉴别效率@supp=30



有本底，μ+/π+鉴别效率@supp=30



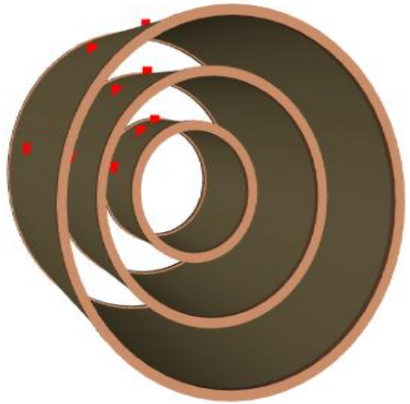
无本底，中性强子/γ鉴别效率@supp=30

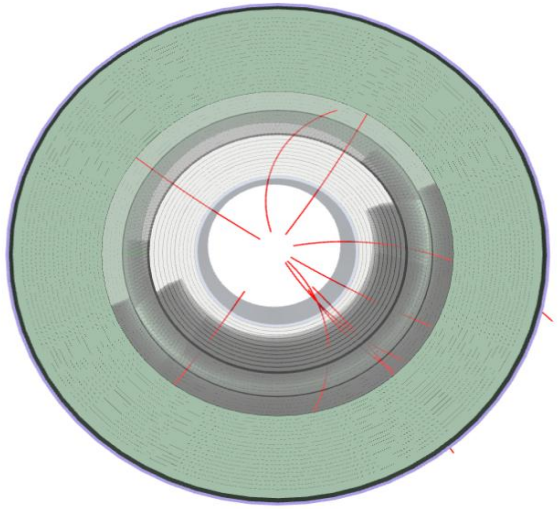


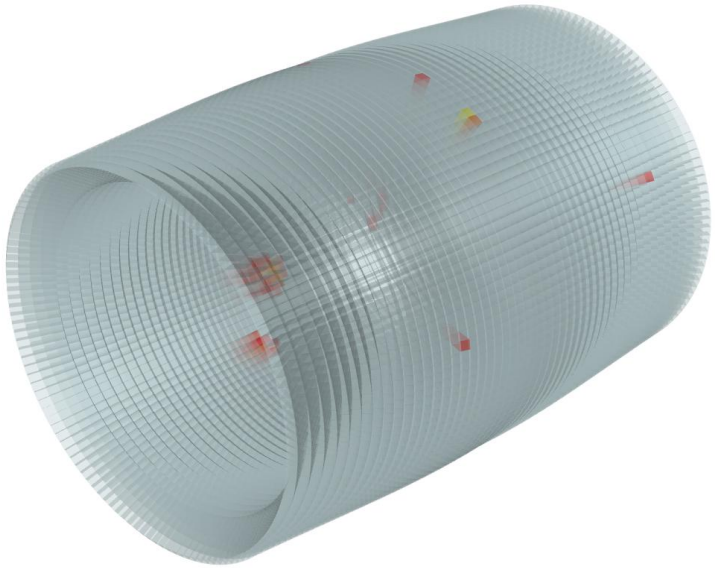
有本底，中性强子/γ鉴别效率@supp=30

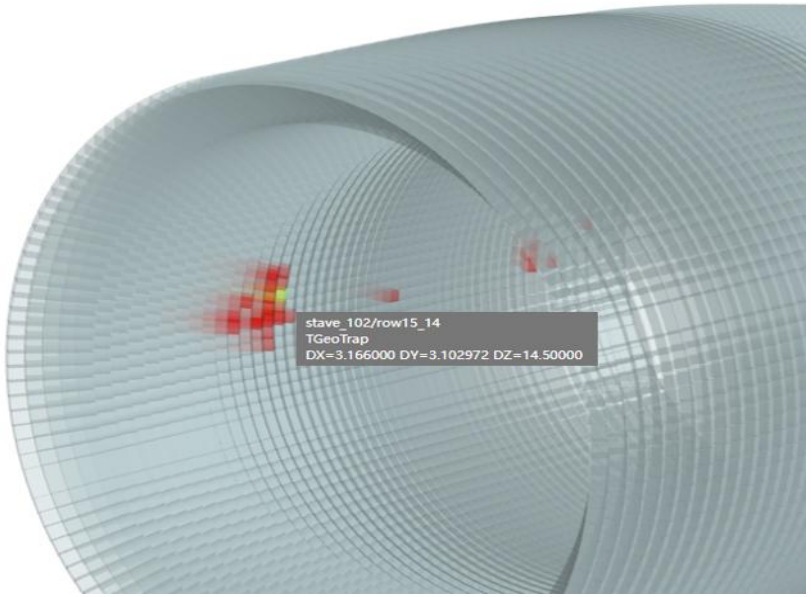
Event Display

Q.B. Zhang









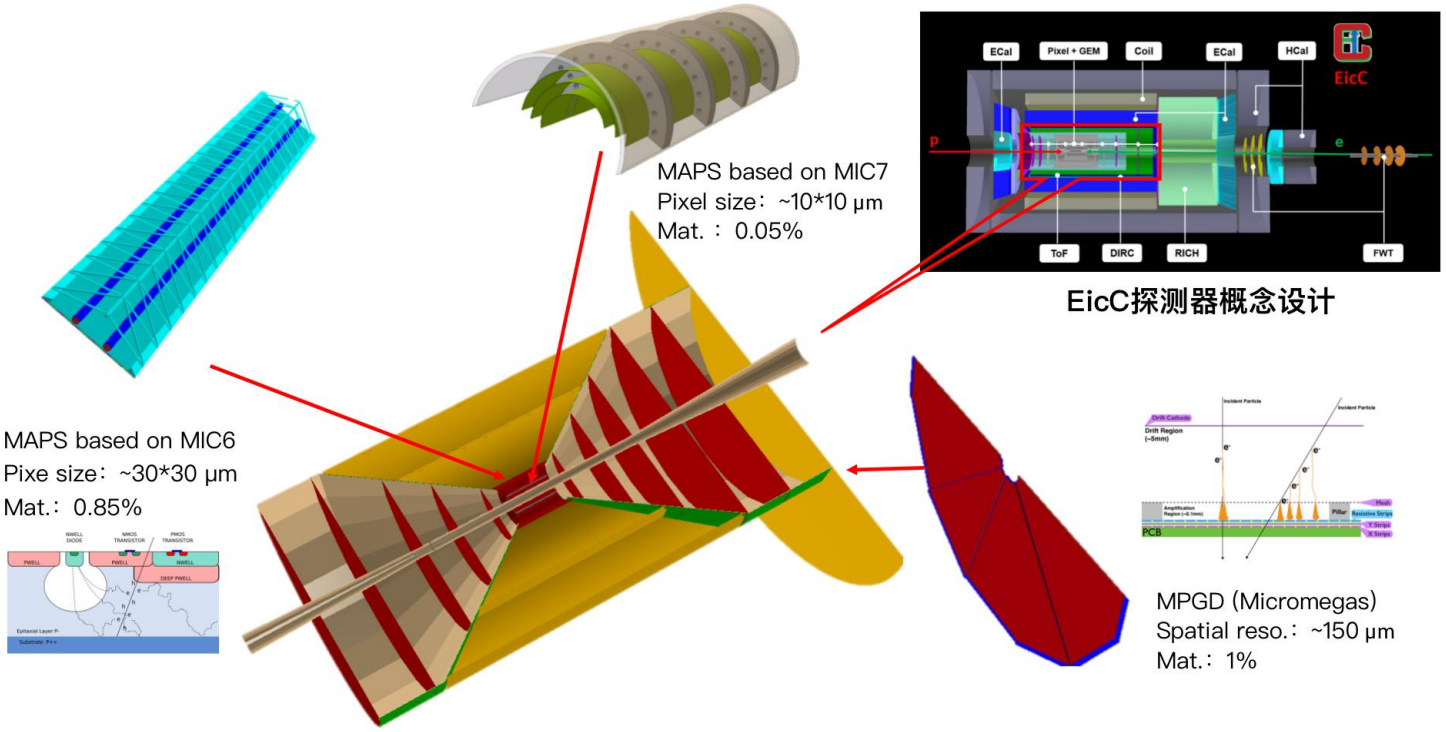
Detector and Event Display software is being developed

- Based on Web3D tech.
- Visulize detector geometry, simulated hits and reconstructed particles
- Beta version to be released in Aug.

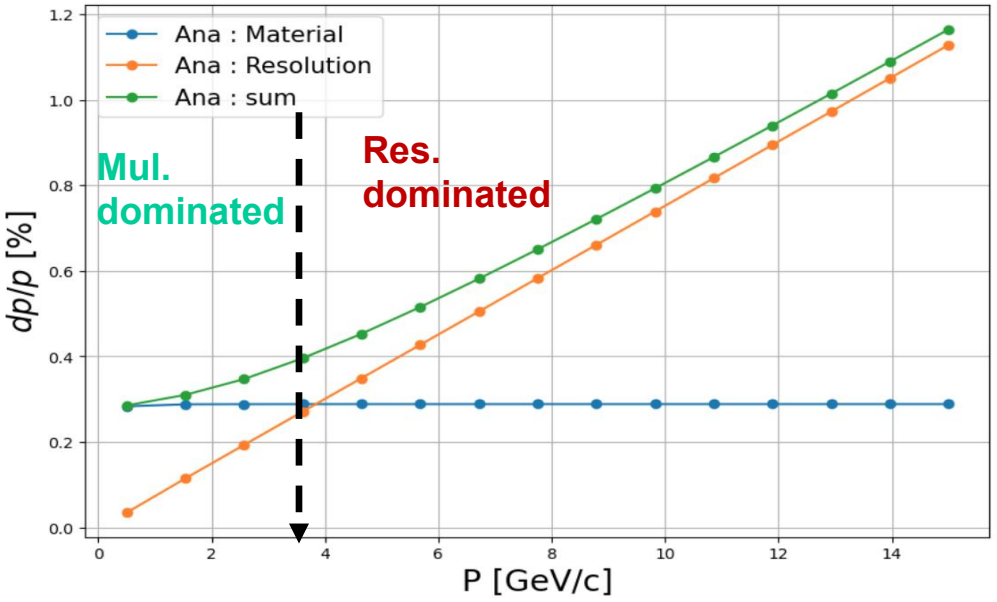
Invited Talks

EicC tracking detector

Aiqiang Guo



EicC探测器概念设计



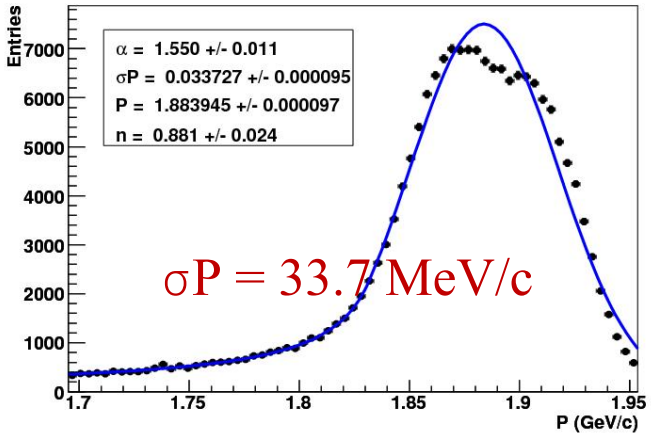
- A conceptual design for EicC traker, which consistes of MAPS and MPGD, is proposed
- Optimize the geometry further for both barrel and endcap region

For detector design, need to consider multiple factors besides the momentum resolution: Pt coverage, budget, support structure, etc.

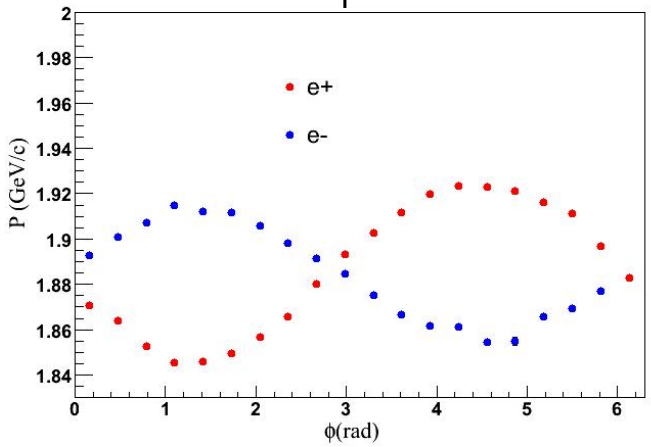
BESIII Alignment

Linghui Wu

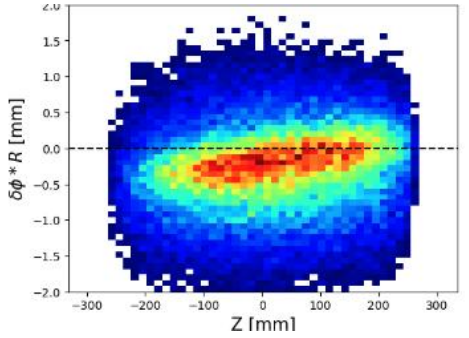
Momentum distribution



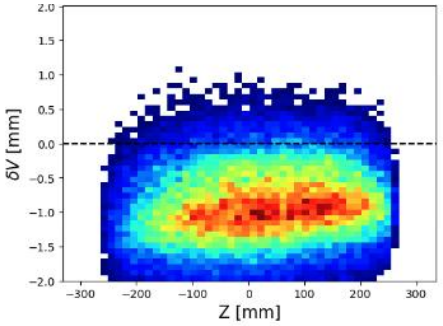
P vs ϕ

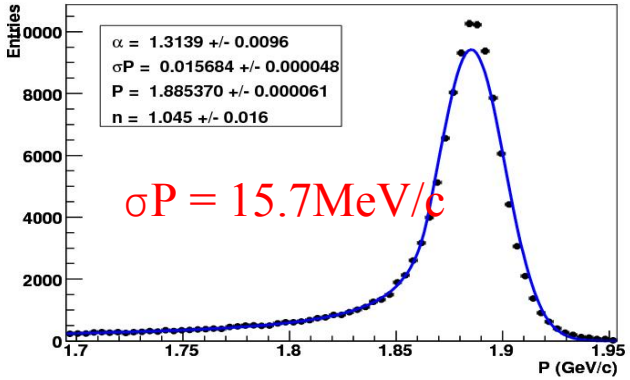


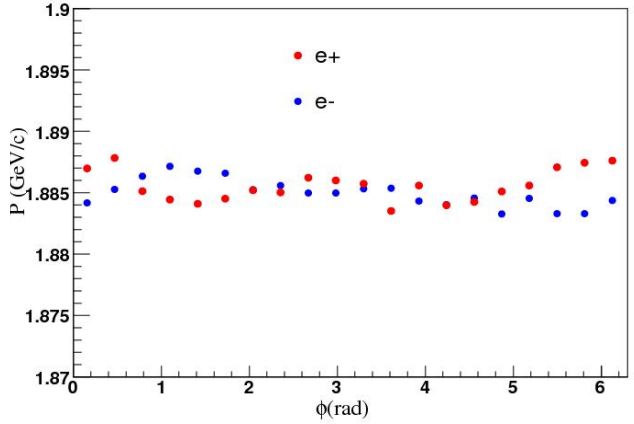
Rϕ residual vs z

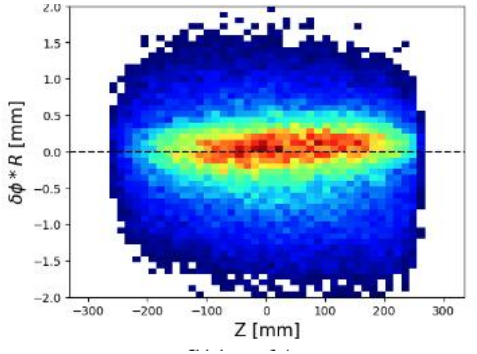


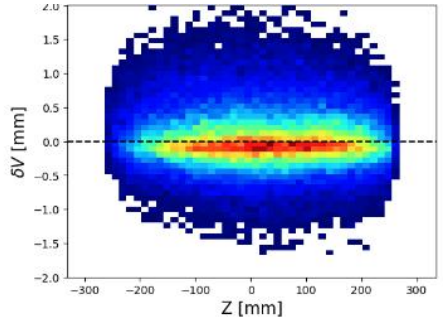
V residual vs z









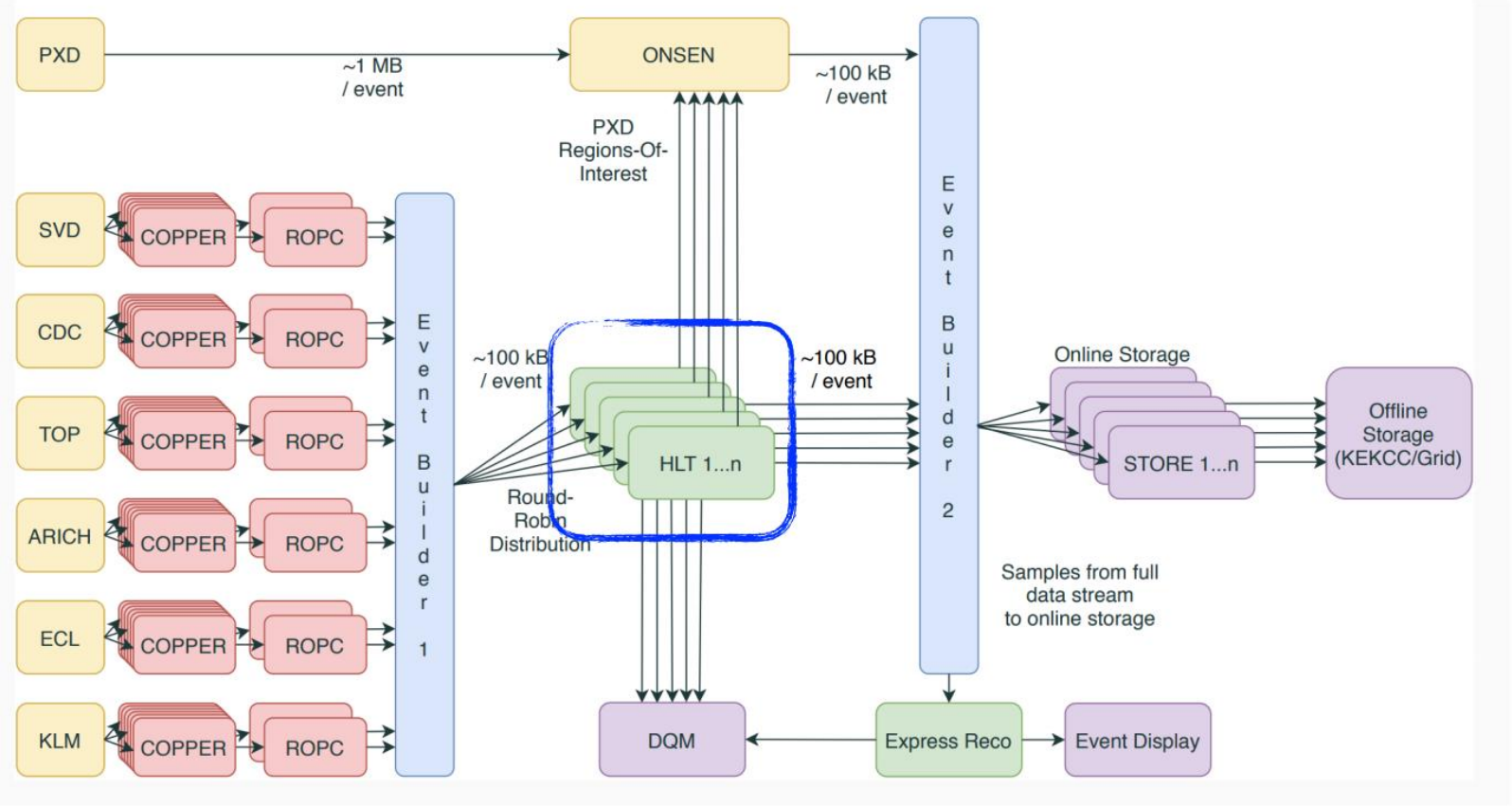


Serious misalignment effect in psi(3770) data in 2009 is fixed

- BESIII drift chamber is well aligned using residual parameterization and Millepede methods
- Preliminary alignment of CGEM detector performed with cosmic ray data

High Level Trigger at Belle II

Chunhua LI

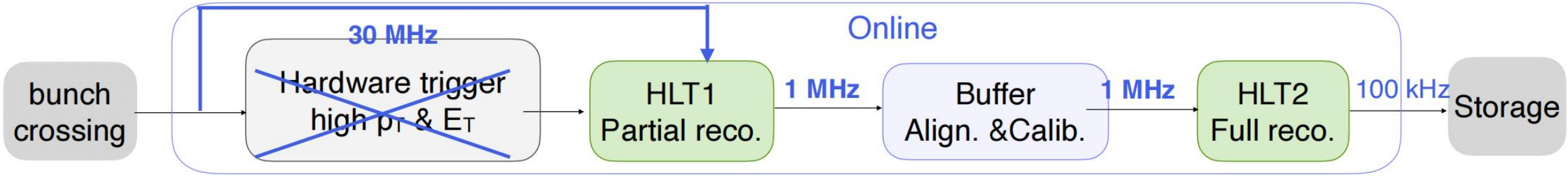


HLT in Belle II DAQ

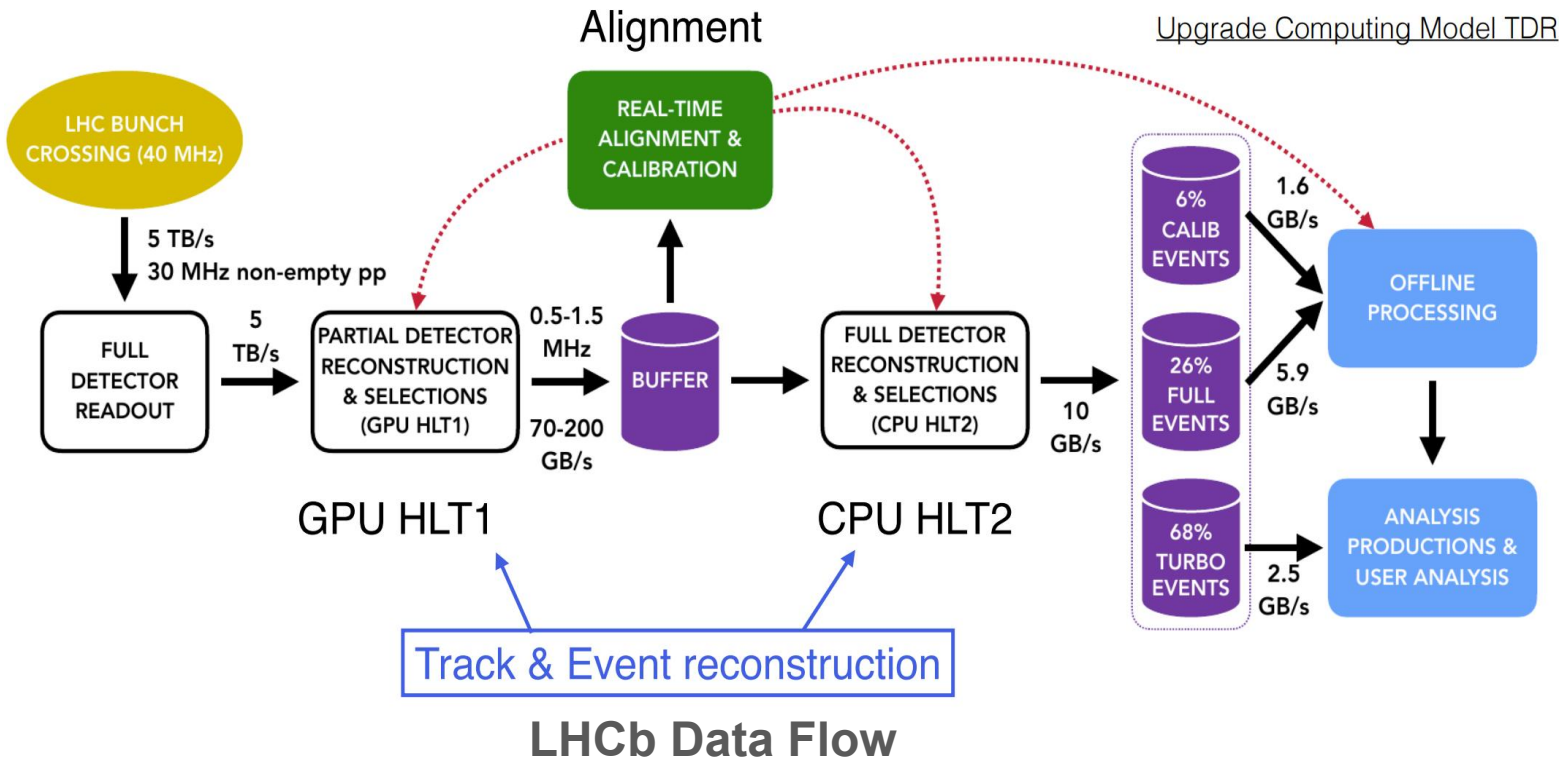
- **Physics Trigger:** suppress event rates from 30 kHz to 10 kHz
- **PXD RoI:** provide HLT trigger result and tracking information of SVD and CDC to calculate Region of Interest of PXD.
- **Calibration:** Flag samples for the calibration of detectors
- **DQM:** Information from Reconstruction for data quality monitoring

LHCb Trigger for Upgrade: Real-time analysis

Peilian LI



Hardware trigger in RUN3 is removed



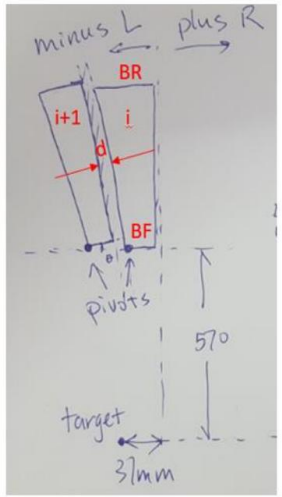
LHCb Data Flow

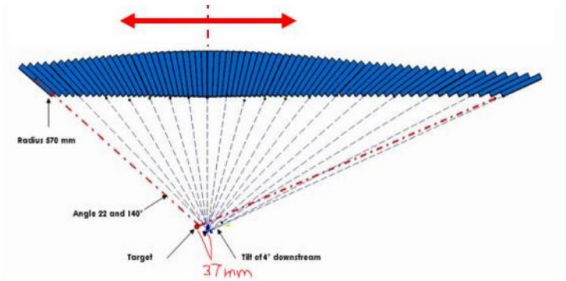
LHCb Run 3 changes the trigger paradigm with software only, pioneering in the real time processing

- Partial tracking reconstruction at 30 MHz input rate using GPUs
- Full offline-quality reconstruction at 1 MHz input rate using CPUs
- FPGA clustering applied in VELO and downstream tracking in good progress
- Turbo-mode with reduced event size for selective persistency

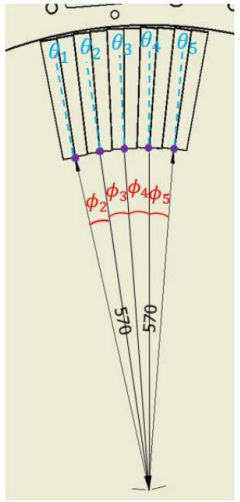
PANDA EMC Software

Shengsen Sun



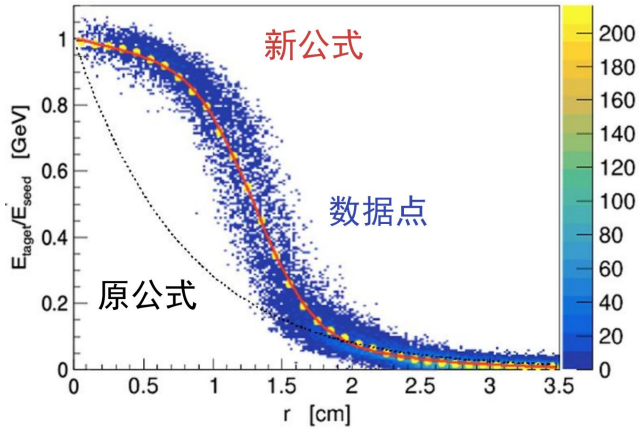


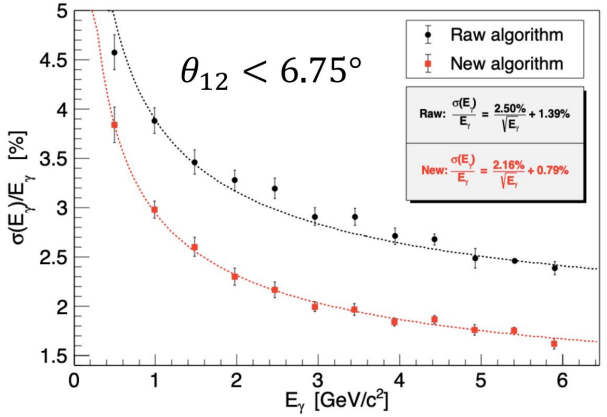
- ✓ z positions of the crystals are defined by the gap d and the crystal dimension
- ✓ For the (i+1)th crystal (minus)
  - ✓ $z_{i+1} = z_i - (BF + d)/cos\theta_i$
  - ✓ where $\theta_{i+1} = \theta_i + \text{atan}(\frac{BR_i - BF_i}{L})$
- ✓ Place the crystals from center to side one by one



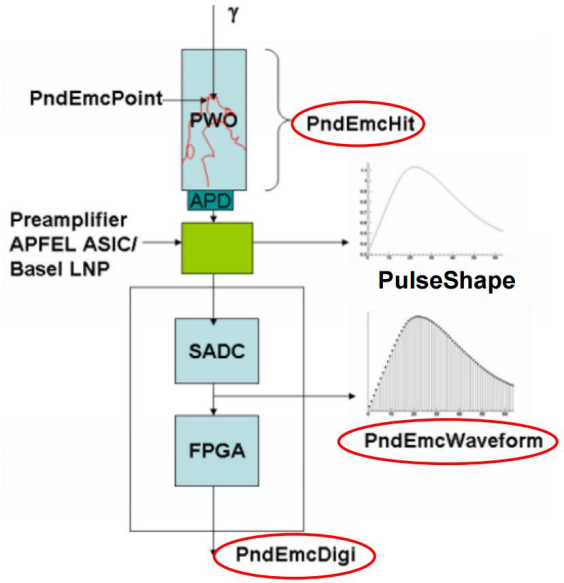
geometry construction

小夹角两个光子事例的能量分辨





energy split



digitization

Signal Generator (SG)
- Analog waveforms creation
- Noises generation
- Digitization
- Pile-up waveforms creation

Feature Extraction (FE)
- Hit detection
- Amplitude/time extraction
- Pile-up recovery

Time-based simulation

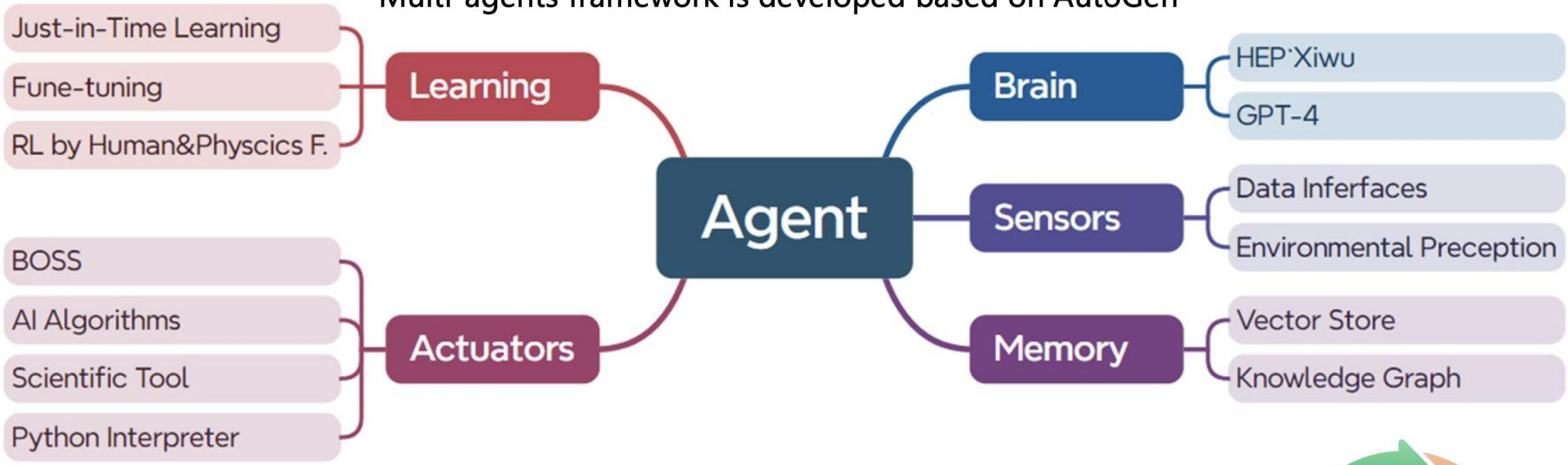
From 2018 to 2023, full Panda EMC software was developed by IHEP, NKU and USTC

- Include geometry, digitization, reconstruction and calibration
- Digitization was developed with eletronics team
- Noval energy split algorithm was developed to improve energy resolution

AI assistant for BESIII - Dr. Sai

Ke LI

Multi-agents framework is developed based on AutoGen



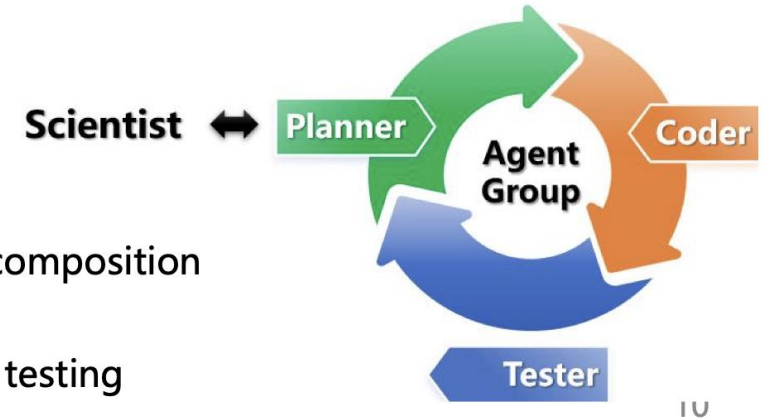
Key of this project:

make the results from AI more reliable

- New architecture
- Good quality data
- In-the-fly validation and test

Main Agents:

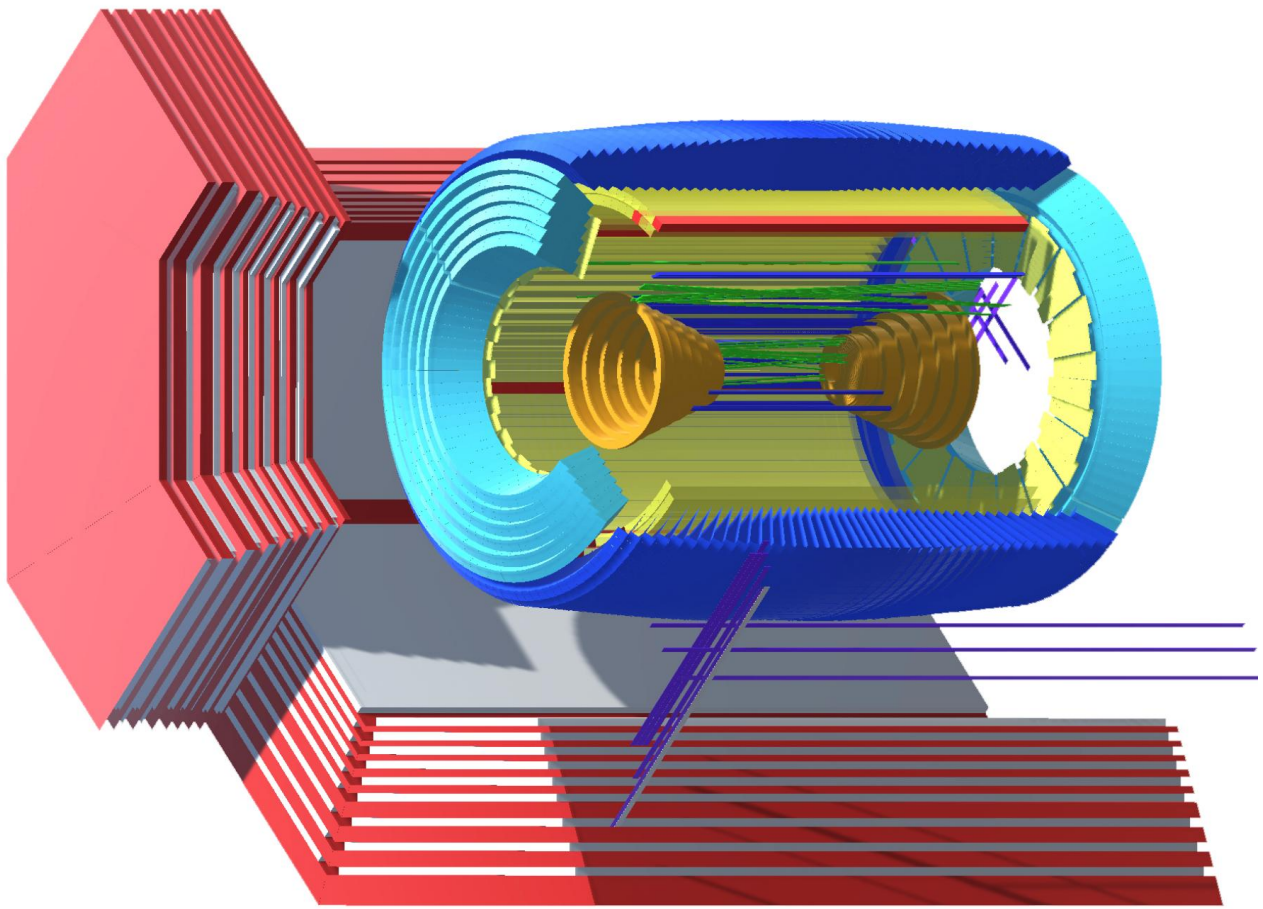
- Planner: Planning and tasks decomposition
- Coder: Write BOSS code
- Tester: Using scientific tools for testing



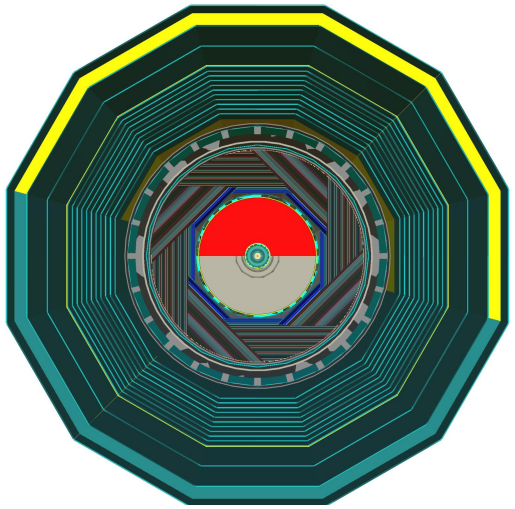
Potential to be used in STCF as well

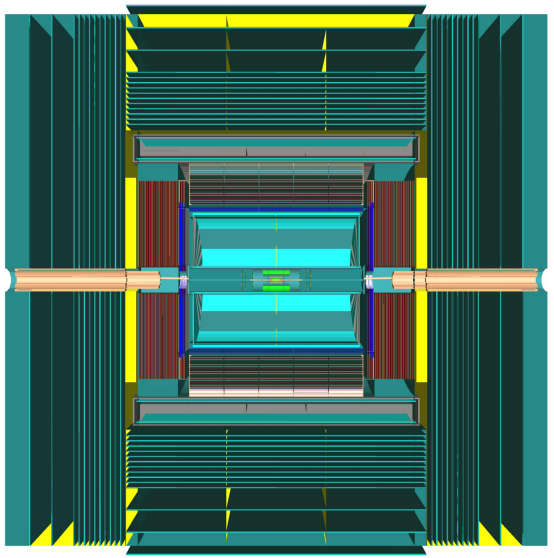
Detector and Event Display

Kaixuan Huang

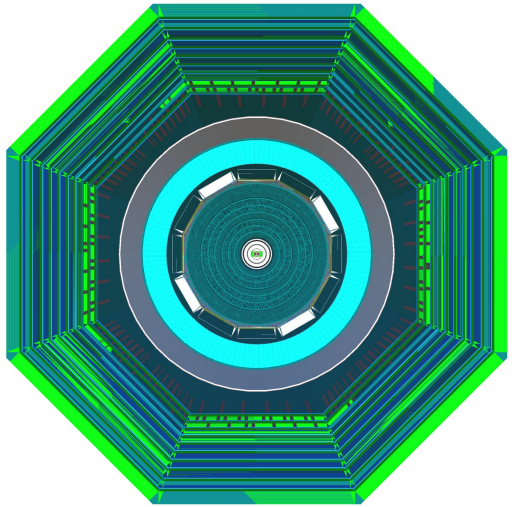


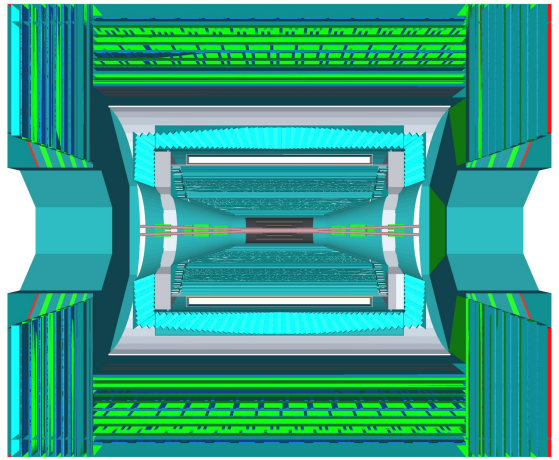
BESIII Event Display in Unity





CEPC in Unity





STCF in Unity

总结

- STCF offline software is in good shape
  - Full offline data processing chain is in place
  - Recent work focuses on performance optimization
  - Data analysis is on-going within OSCAR system
- Several invitated talks offer good references for STCF
  - Track optimization
  - Software trigger
  - EMC software
  - LLM
  - Event Display

Thanks for your attention