Institute of High Energy Physics
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Offline filter of data with abnormal high voltage at BESIII drift chamber

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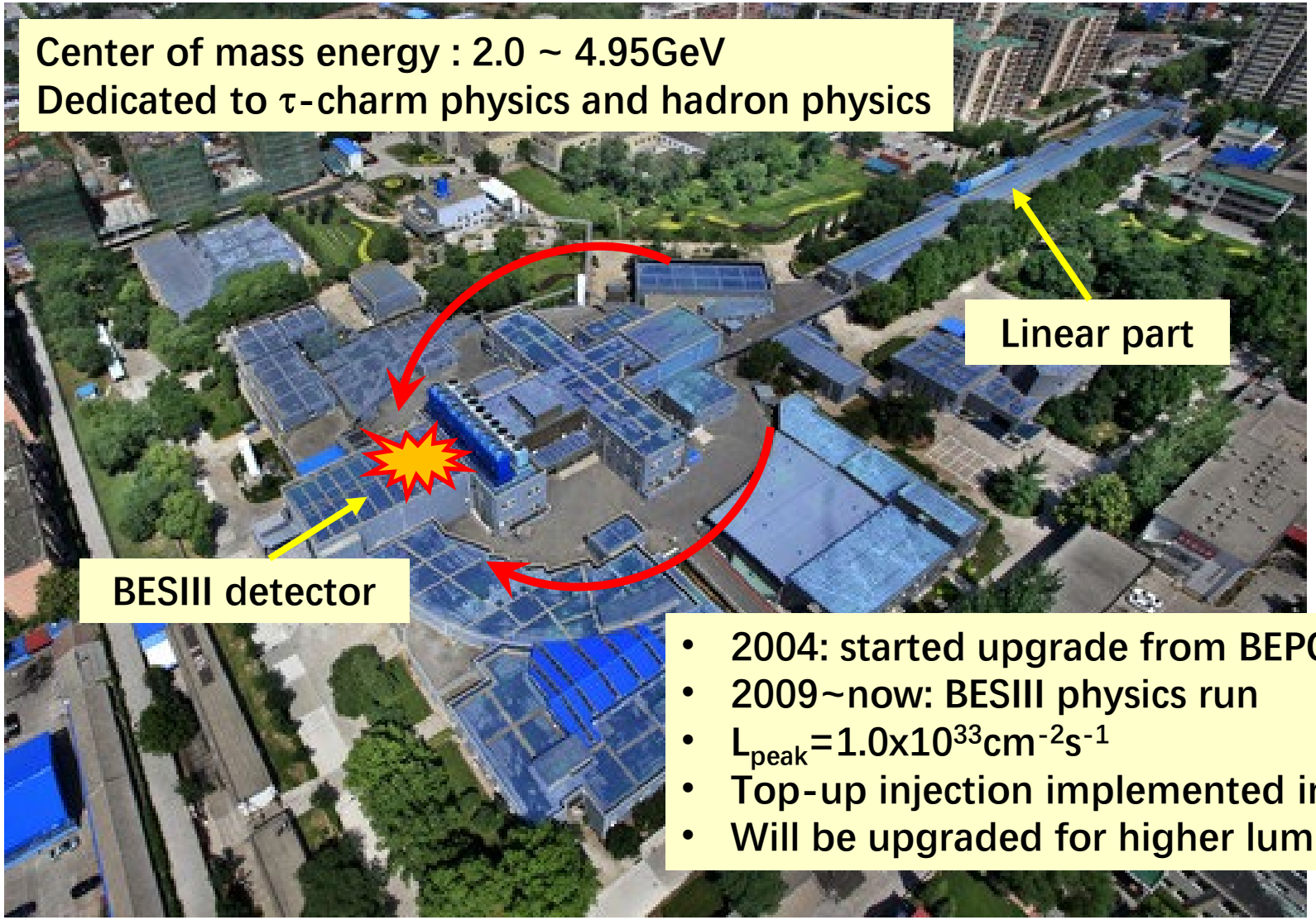
BESIII@ Beijing Electron Positron Collider II (BEPCII)

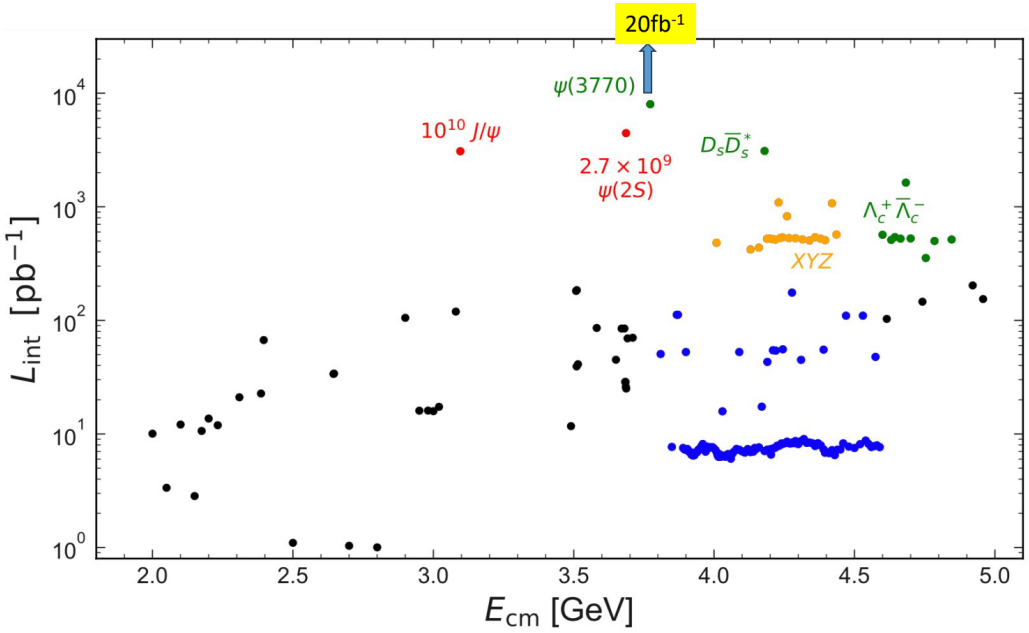


- 2004: started upgrade from BEPC/BESII
- 2009~now: BESIII physics run
- $L_{peak}=1.0x10^{33}cm^{-2}s^{-1}$
- Top-up injection implemented in 2019
- Will be upgraded for higher luminosity

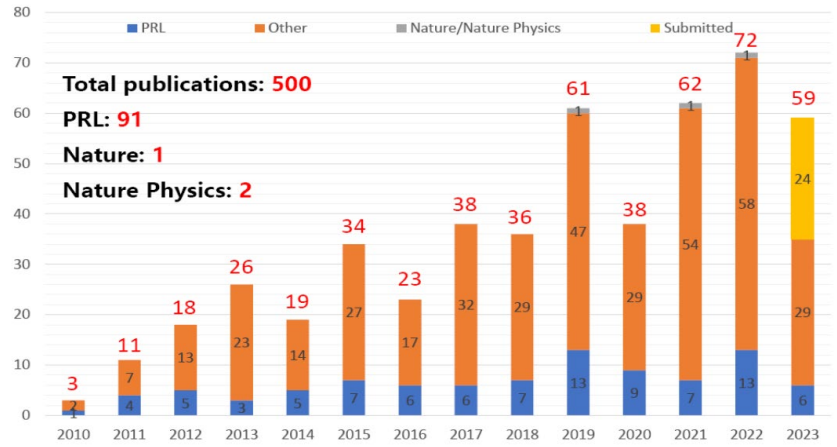
Rich BESIII Physics Program

- Light hadron physics
- Charmonium physics
- R values, QCD and τ physics
- Charm Physics
- Exotic Decays and New Physics

Total integrated luminosity: 2009-2023



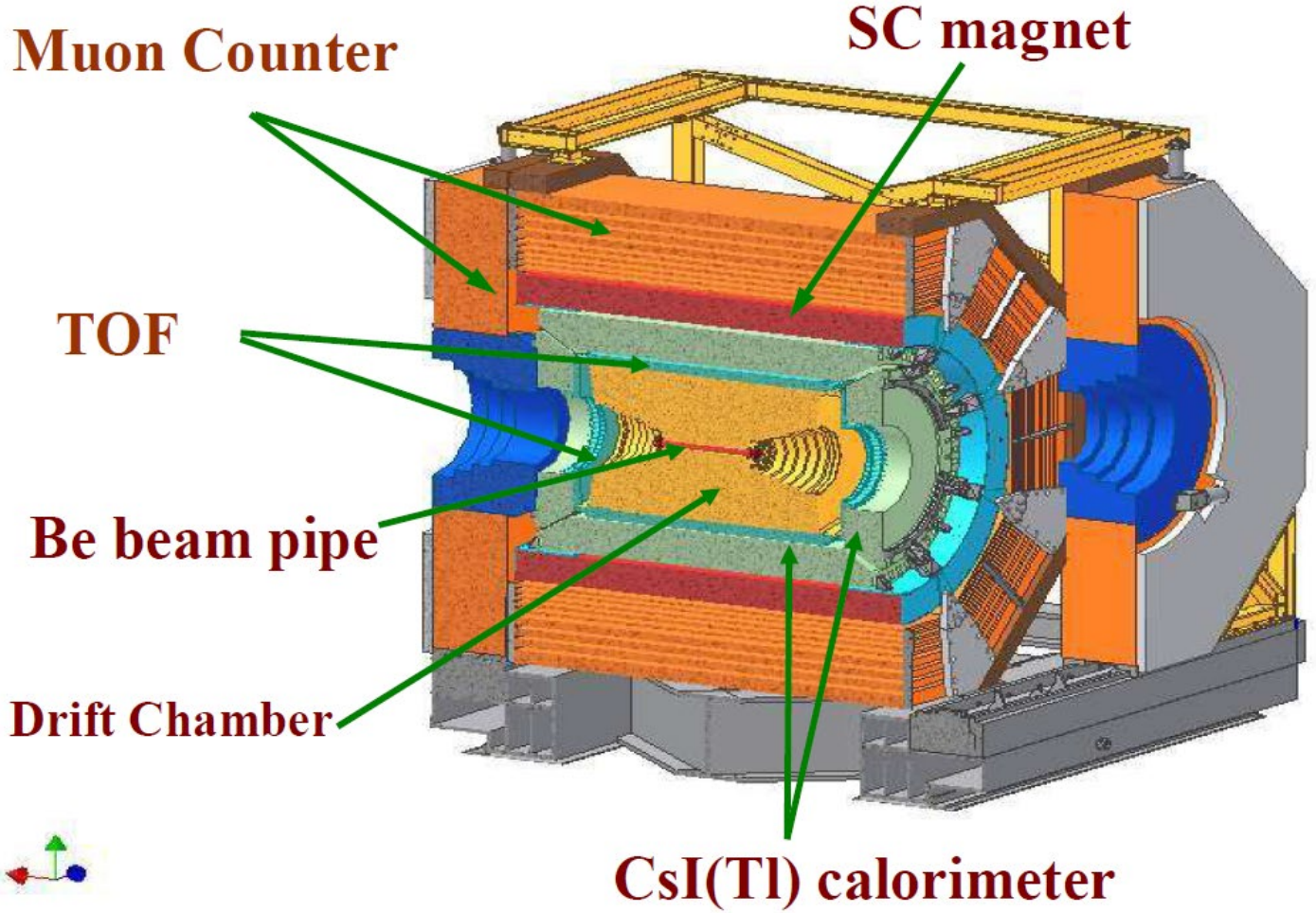
BESIII publications (May 9, 2023)



Unique dataset:
high statistics and clean environment

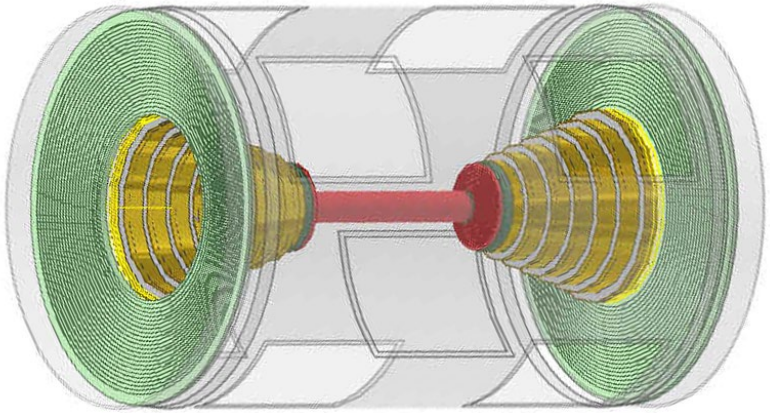
BESIII detector

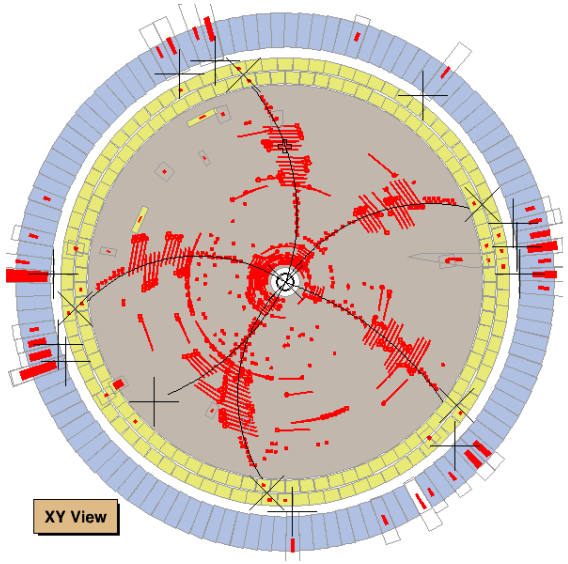
- Multilayer Drift Chamber (MDC)
  - spatial resolution: 115μm
  - σ_p/p=0.5%@1GeV
  - dE/dx resolution<6%
- TOF
  - σT = 68ps for barrel
  - σT = 98/60 ps (before/after upgrade) for endcaps
- EMC: CsI crystal
  - σE/E=2.5%@1GeV for barrel
  - σE/E=5.0%@1GeV for endcaps
- Magnet
  - 1T superconducting
- Muon ID
  - 9 layers of RPC for barrel
  - 8 layers of RPC for endcaps

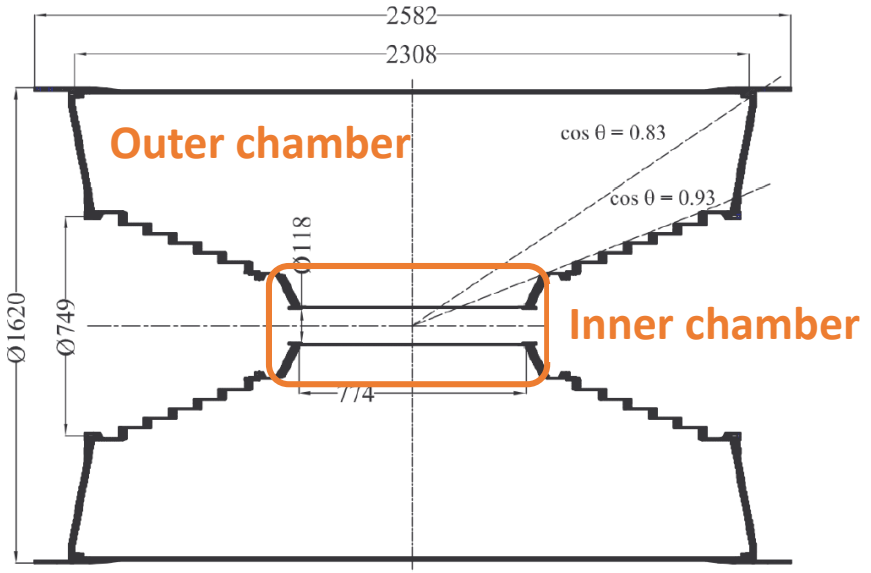


Multilayer drift chamber (MDC)

- An innermost sub-detector operating in 1T magnetic field
- Designed for tracking and dE/dx measurement
- Radius extension: 63mm ~ 810mm
- 6796 trapezoidal drift cells in 43 cylindrical layers
  - Inner chamber: 8 stereo layers
  - Outer chamber: 19 axial layers, 16 stereo layers
- Gas mixture: $He+C_3H_8$ (60/40)

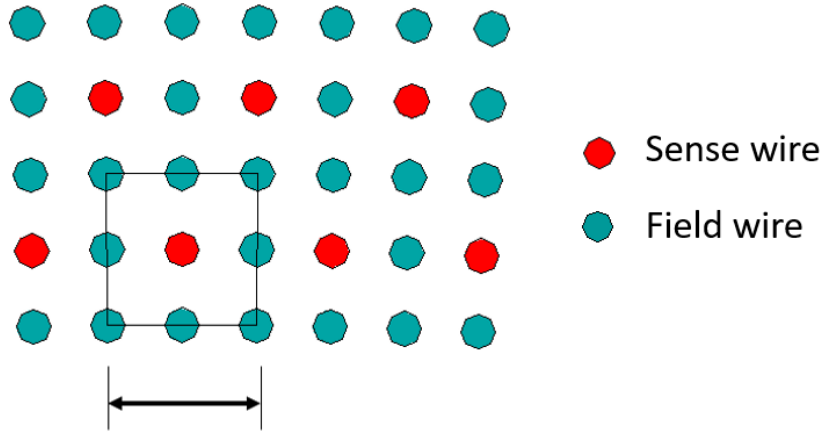






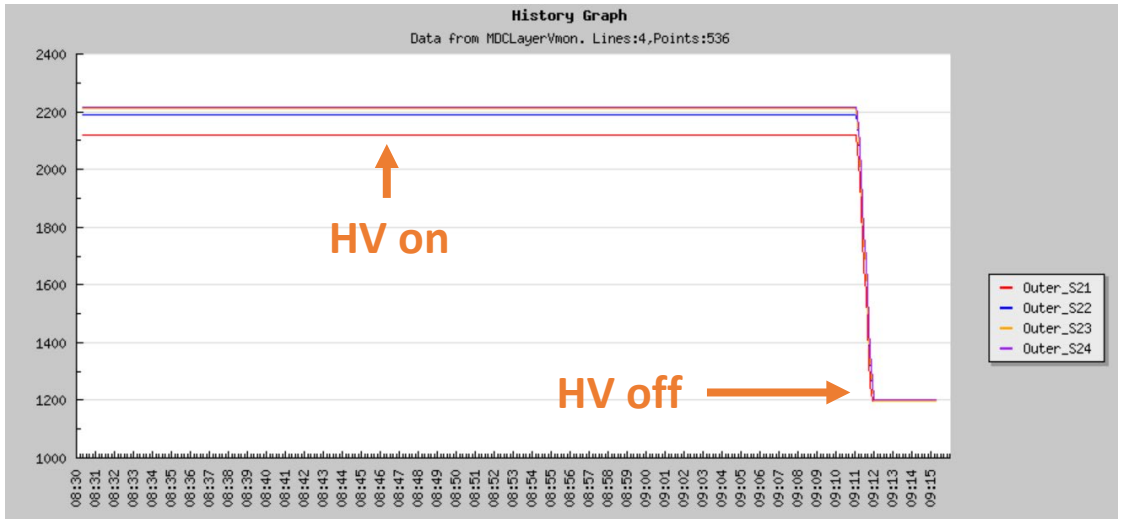
Drift cell and High Voltage (HV) configuration

- Sense wire
  - ϕ 25μm gold plated W
  - Connected to positive high voltage via feedthrough by CAEN HV power supplies
- Field wire
  - ϕ 110μm gold plated Al
  - kept at ground
- HV optimized to achieve the same gain in all layers



12 and 16.2mm for inner and outer chamber

Slow control monitor of MDC HV

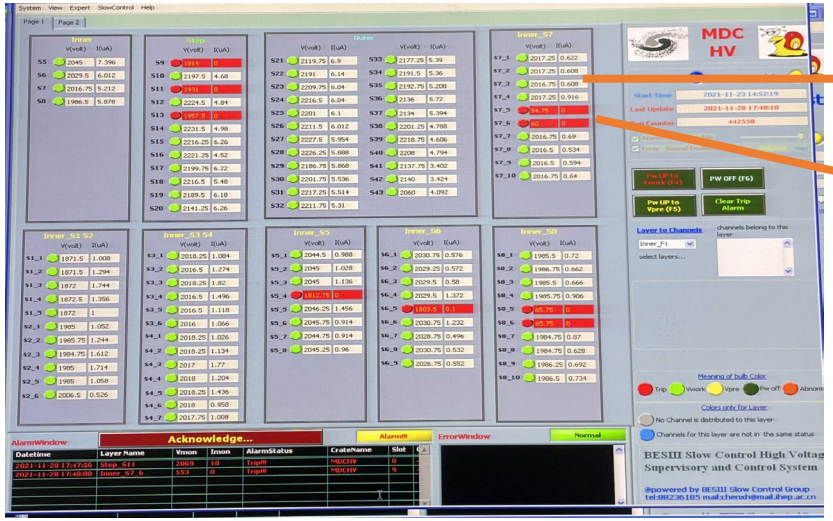


Feedthroughs of wires

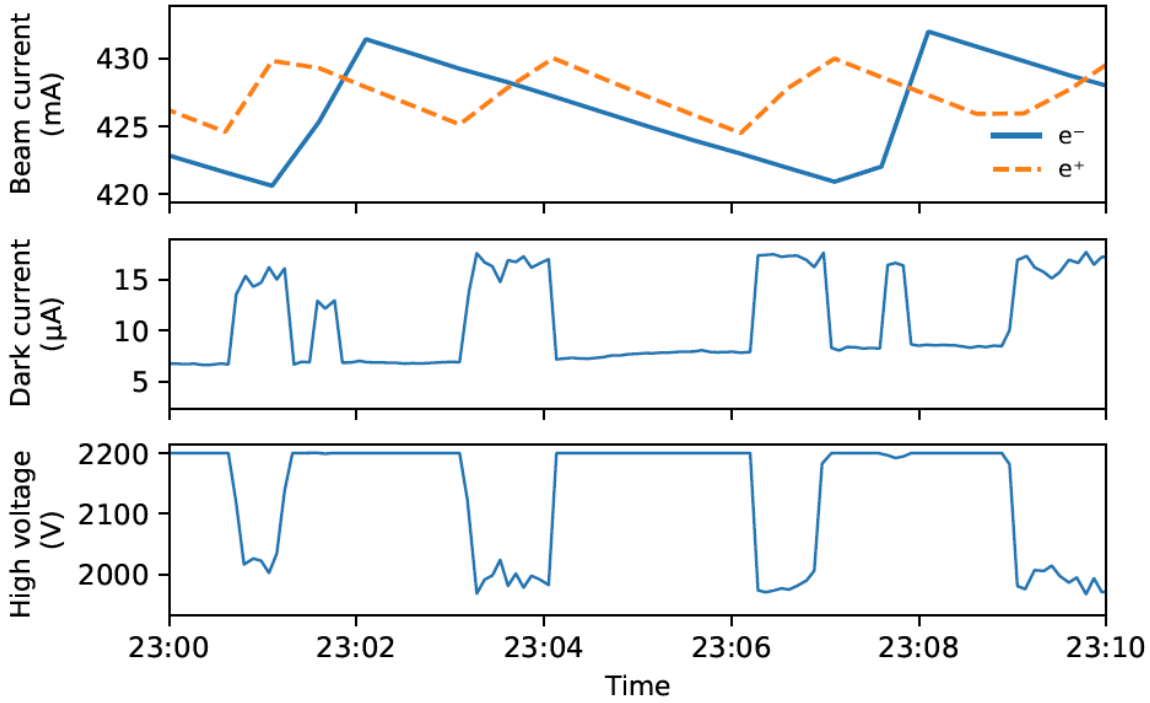
Stability of HV during operation

- Stable most of time during data taking
- Instability of HV due to serious beam-induced background may be caused by
  - Beam injection
  - Instability of beam

Slow control panel of MDC HV

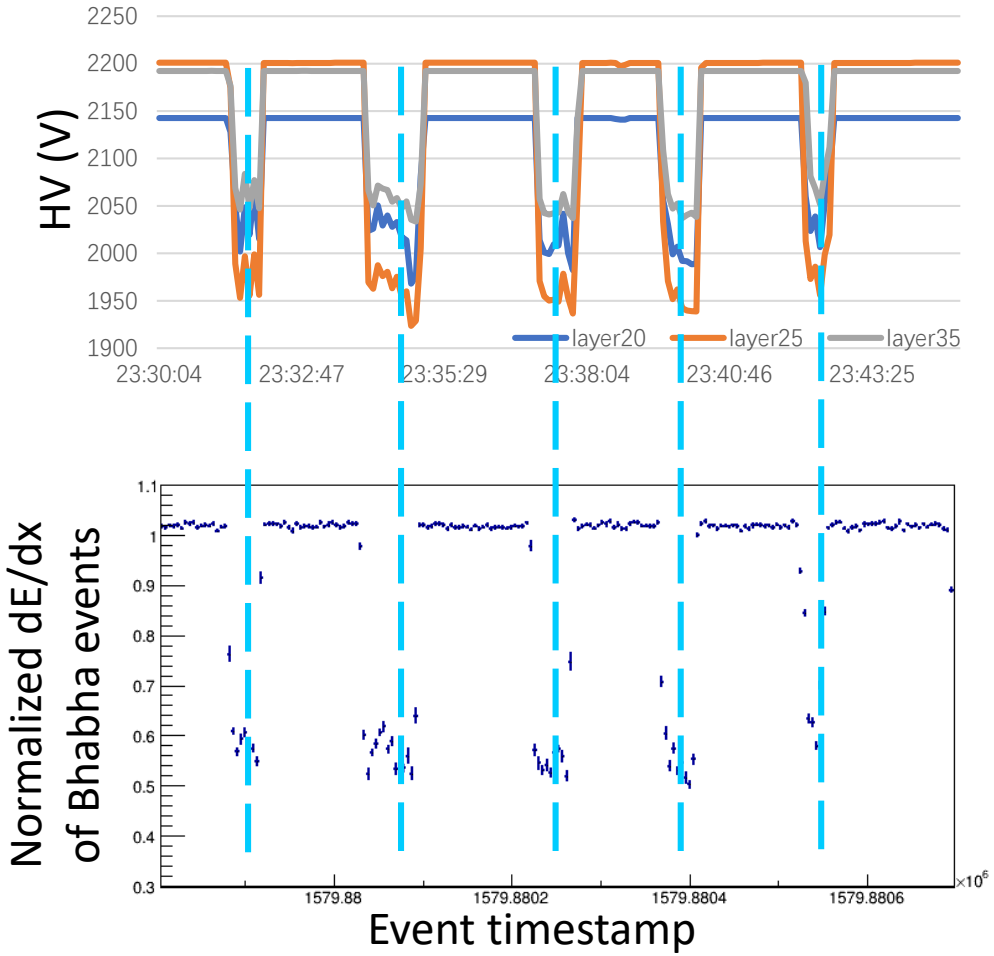


Instability of HV during top-up injection



Impact of abnormal HV on dE/dx measurement

- Drop of HV can cause significant decrease in gain
- May cause wrong dE/dx measurement
- Has negative impact on PID



dE/dx measurement of a cell

For a drift tube: $$\ln G = \frac{V \ln 2}{\ln(r_b/r_a)V_e}\left\{\ln\frac{V}{pr_a \ln(r_b/r_a)} - \ln K\right\}$$

M.E. Rose and S.A. Korff
Phys. Rev. **59** (1941) 850

Define M: $$M = \frac{\ln 2}{\ln(r_b/r_a)V_e}\left\{\ln\frac{V}{pr_a \ln(r_b/r_a)} - \ln K\right\}$$ → Approximately constant in proportional region with small fluctuation in V

So $$\frac{\Delta G}{G} = M\Delta V = MV_0\frac{\Delta V}{V_0} = k\frac{\Delta V}{V_0}$$ →

- Applicable to drift cell of the chamber
- V_0: HV at the sense wire
- k=MV_0: approximately constant with small fluctuation in HV

dE/dx measurement for a single cell: $$(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}} \propto G$$

Relative change of $(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}}$: $$\frac{\Delta(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}}}{(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}}} = k\frac{\Delta V}{V_0}$$

k =13.8 from previous prototype test

dE/dx measurement of the track

d*E*/dx measurement for a track:

$$(\mathrm{d}E/\mathrm{d}x)_{\mathrm{track}} = \frac{1}{N}\sum_{i=1}^{N}(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell},i}$$

Relative change:

$$\frac{\Delta(\mathrm{d}E/\mathrm{d}x)_{\mathrm{track}}}{(\mathrm{d}E/\mathrm{d}x)_{\mathrm{track}}} \approx \frac{1}{N}\sum_{i=1}^{N}\frac{\Delta(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}}}{(\mathrm{d}E/\mathrm{d}x)_{\mathrm{cell}}} \approx \frac{k}{N}\sum_{i=1}^{N}\frac{\Delta V_i}{V_i}$$

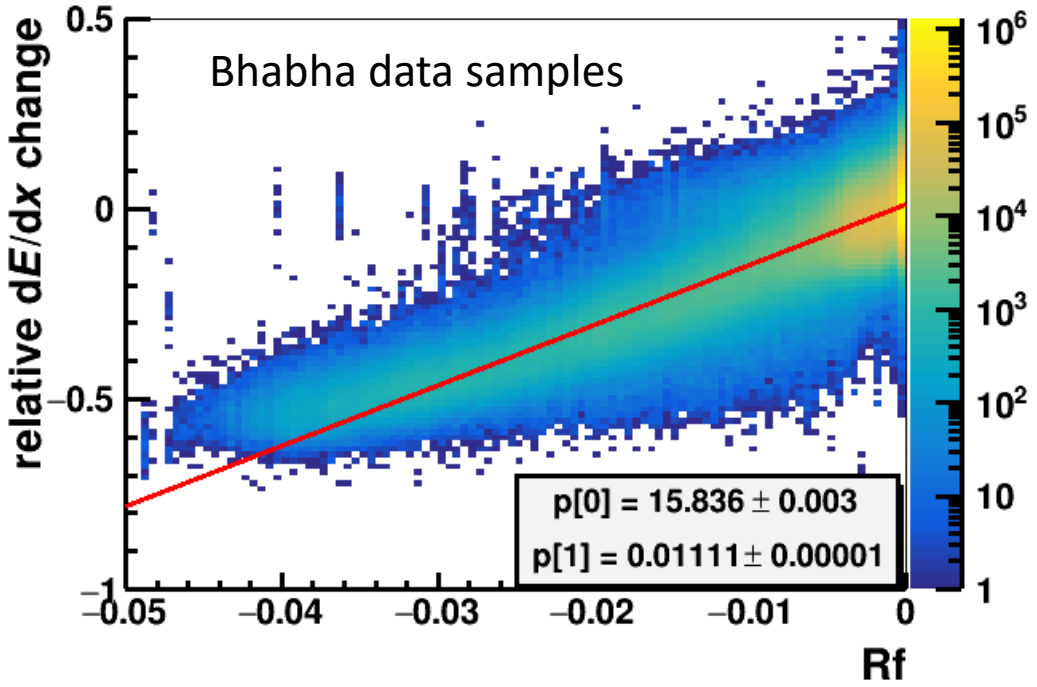
Define R_{f} to the average relative high voltage fluctuation over all layers

$$R_{\mathrm{f}} = \frac{1}{N}\sum_{i=1}^{N}\frac{\Delta V_i}{V_i}$$

Relation between dE/dx measurement and HV

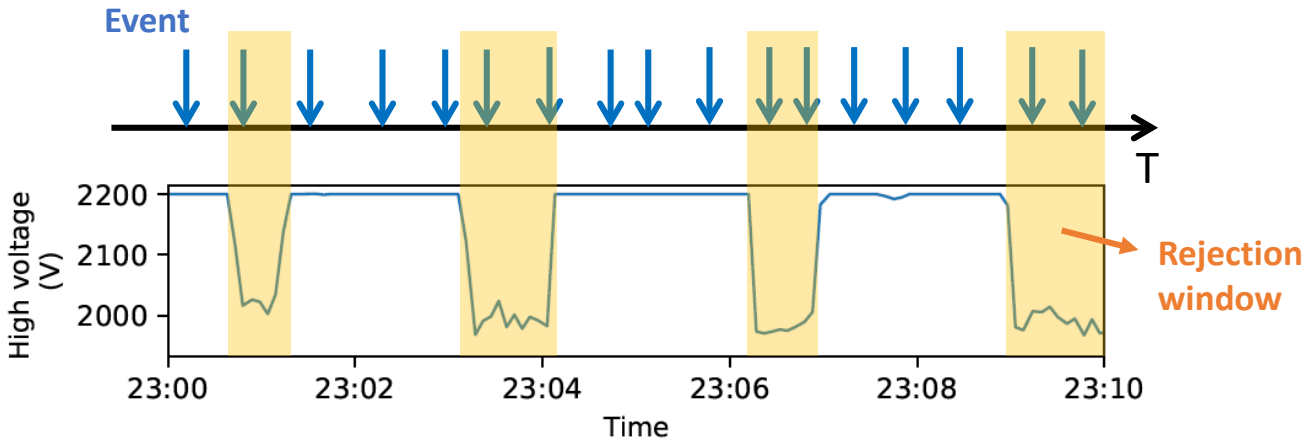
- Approximate linear relationship between dE/dx change and R_f from Bhabha data samples
  - k = 15.8: 1% average drop in HV causes a 15.8% decrease in dE/dx measurement

dE/dx measurement vs R_f

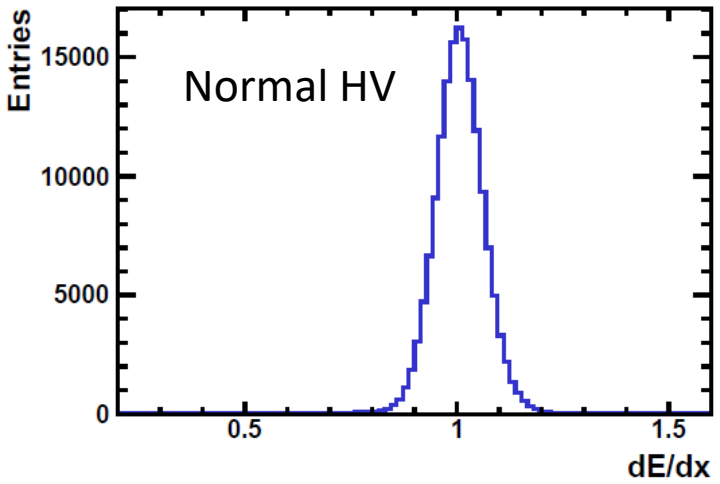


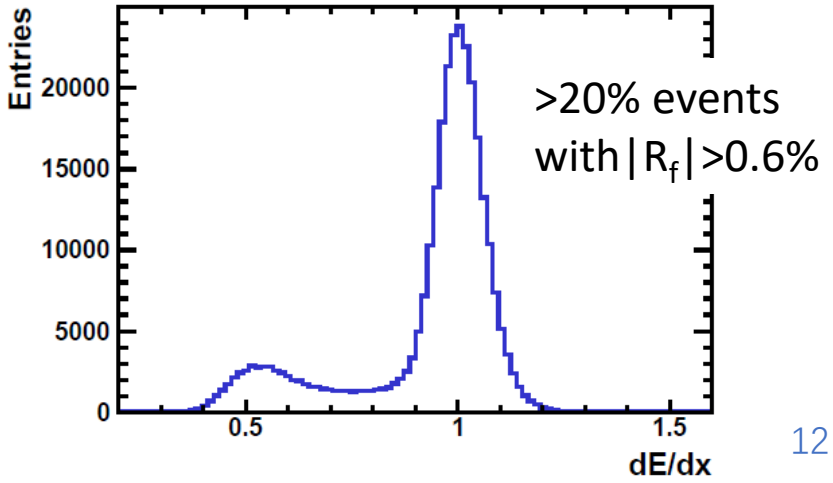
Offline event filter

- Change in dE/dx measurement due to HV instability less than 10% requires $|R_f|<0.6\%$
- In BESIII, the ratio of events with $|R_f|>0.6\%$
  - Around 1% for all data since 2009
  - Up to more than 20% in some small data sets
- An approach for guaranteeing data quality: offline event filter



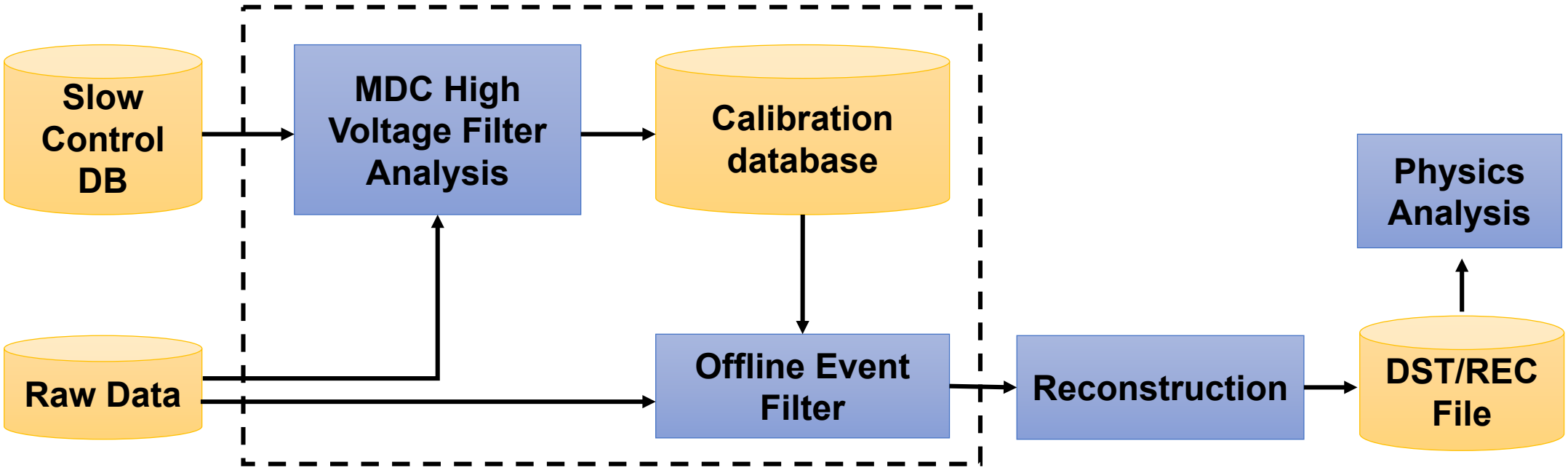
Normalized dE/dx distribution



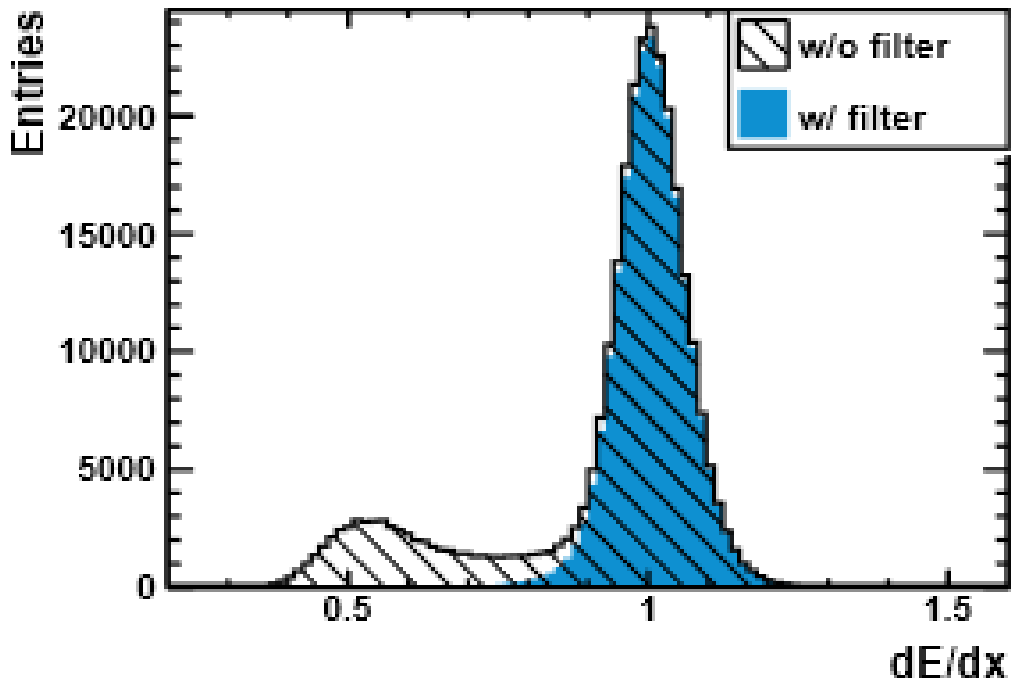


Workflow

- An algorithm to determine and validate the time window of HV drop developed
- Time windows saved to Calibration database
- Filter applied before reconstruction



dE/dx distribution w/o event filter



Events with abnormal HV removed effectively after offline event filter

Summary

- Instability of MDC HV due to serious beam-induced background has negative impact on dE/dx measurement
- Relationship between dE/dx measurement and HV fluctuation studied
- To guarantee data quality, an offline event filter software tool developed to remove events with abnormal HV

Thanks!