Reconstruction and Calibration of MRPC Endcap TOF of BESIII

SUN Shengsen
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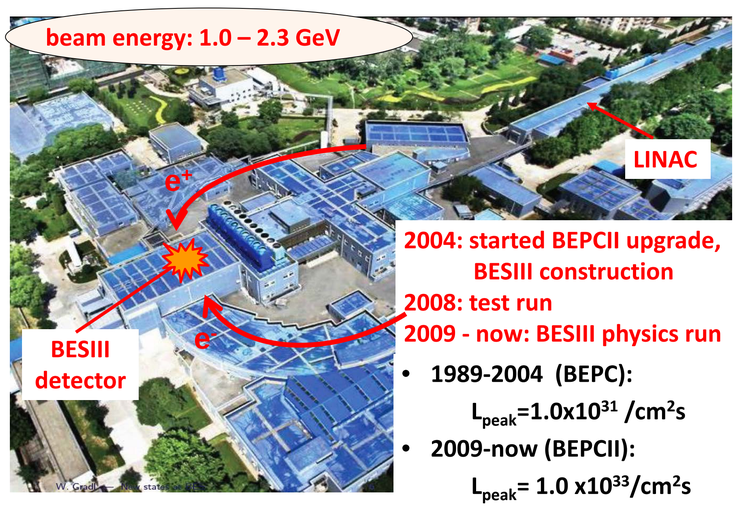
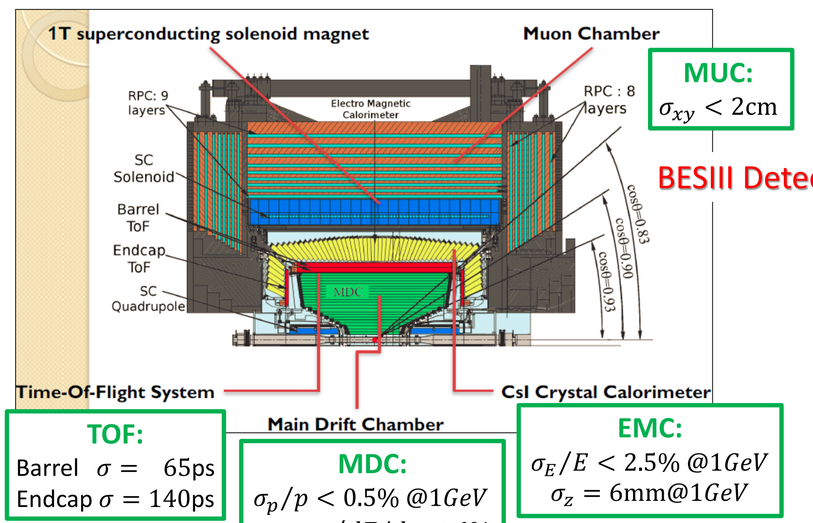


Beijing Electron Positron Collider(BEPC)



MUC: $\sigma_{xy} < 2\text{cm}$

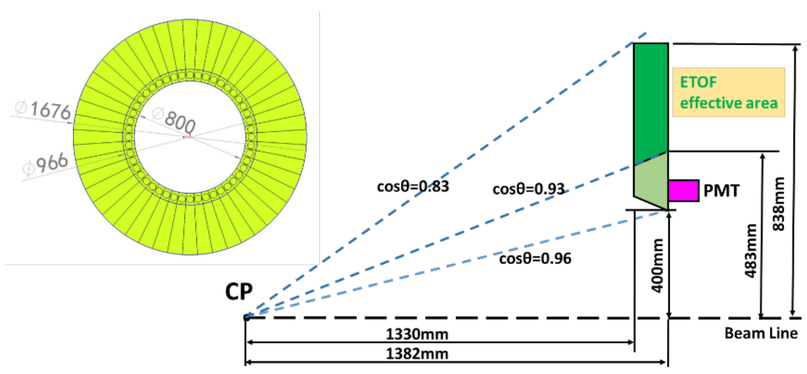
BESIII Detector

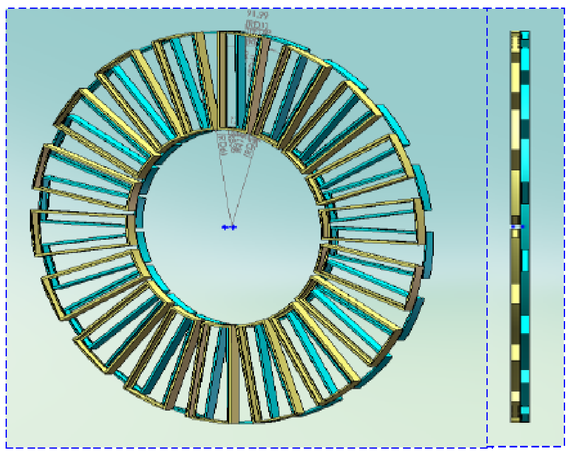
TOF: Barrel $\sigma =$ 65ps, Endcap $\sigma = 140$ps

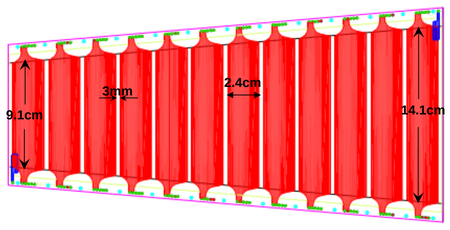
MDC: $\sigma_p/p < 0.5\%\ @1GeV$, $\sigma_{dE/dx}/dE/dx < 6\%$

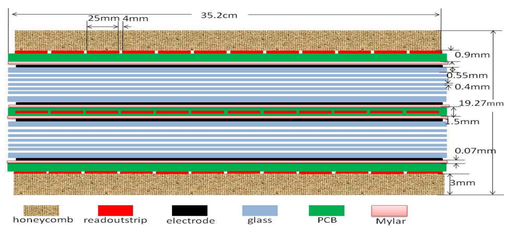
EMC: $\sigma_E/E < 2.5\%\ @1GeV$, $\sigma_z = 6\text{mm}@1GeV$

- Old BESIII endcap TOF:
  Two end caps of 48 scintillator BC404 + PMT R5924
  Time resolution: 138ps for pion@1GeV
- Target of MRPC endcap TOF upgrade:
  ✓ Higher granularity
  ✓ Better time resolution: <80ps

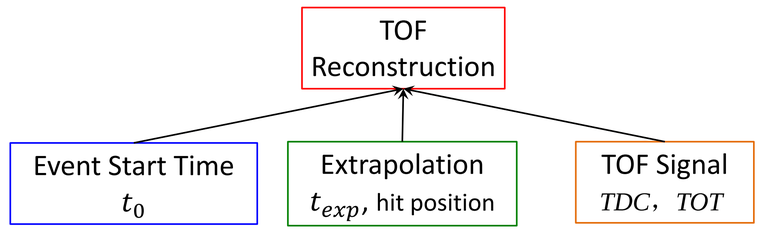


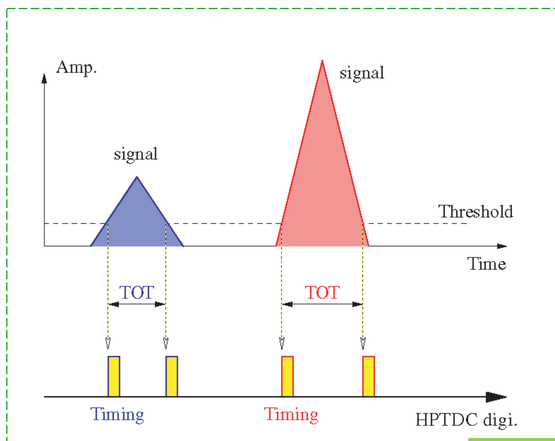


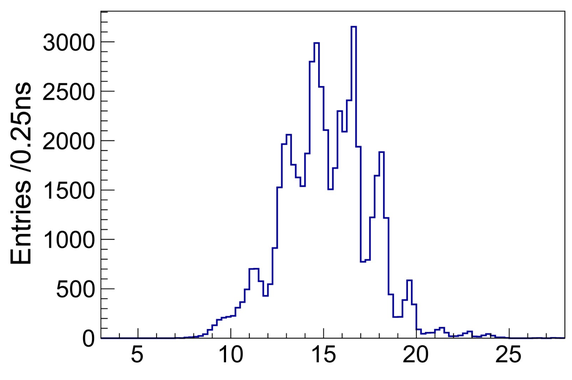




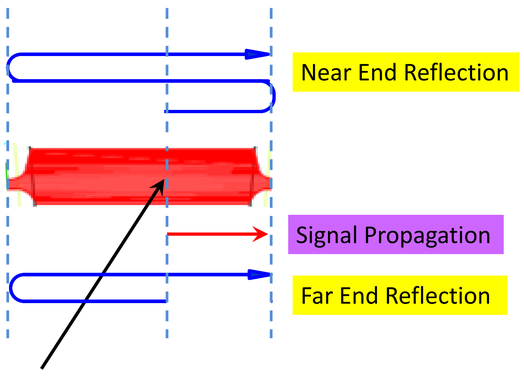
- Each TOF ring: 36 over-lapping MRPCs, no dead zone for particle identification
- 12 readout strips/module, double ends readout, 1728 channels
- Gas gap: 2×6 with thickness 0.22mm
- Resistive plate: floating glass
- Total thickness ~20mm

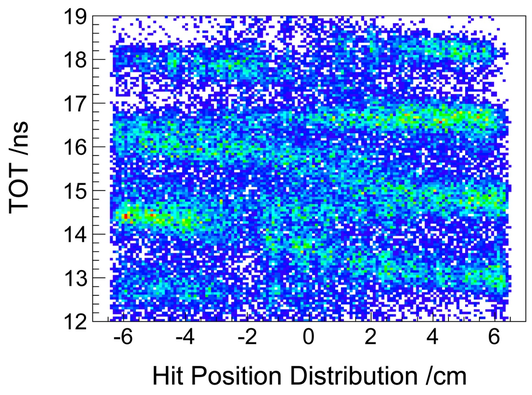




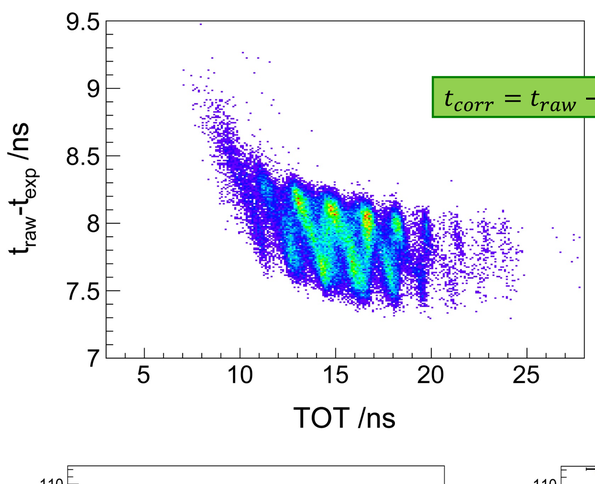


$$TOT = t_{trailing} - t_{leading}$$

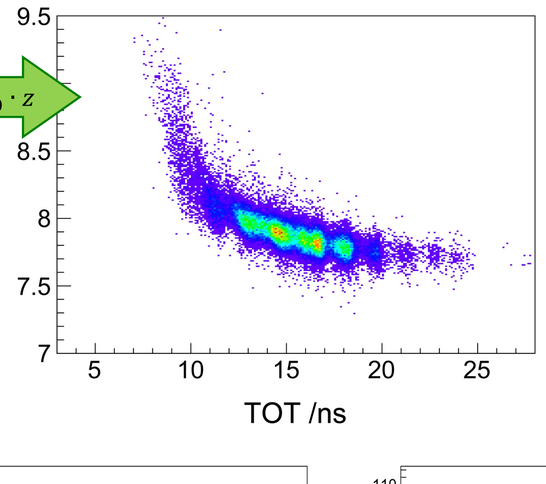




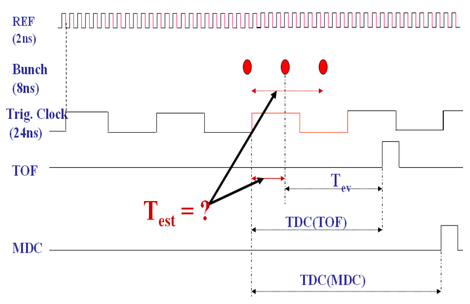
Signal reflection in strip causes the multi-peak in TOT distribution

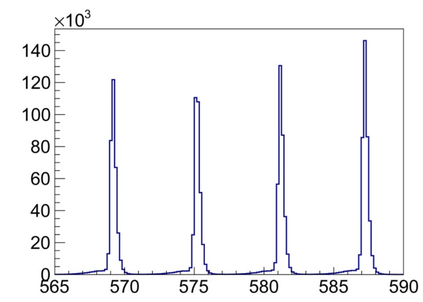


$$t_{corr} = t_{raw} - p_0 \cdot z$$



Event start time

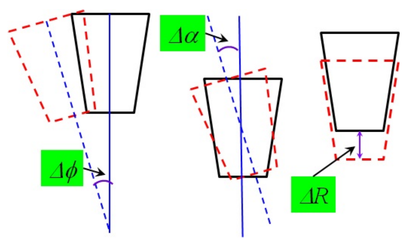




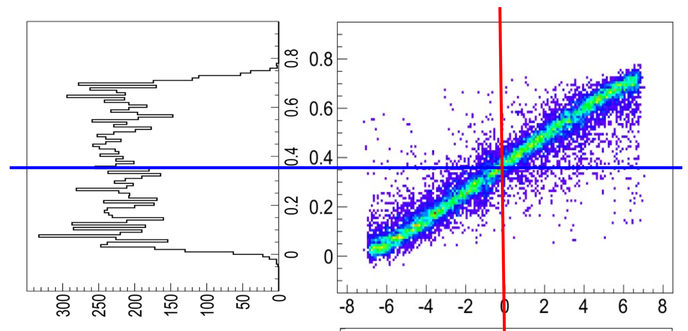
$$t_{EST} = TDC - (t_{tof} + t_{prog} + t_{elec-cable})$$

Alignment of Detector

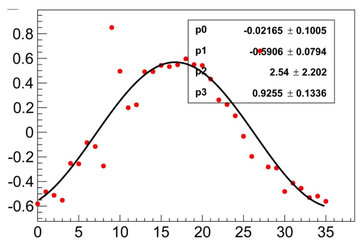
Installation location ≠ Ideal Position



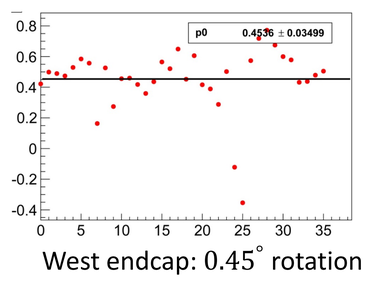
Definition of 3 variables



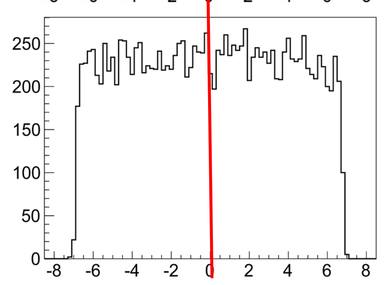
TOF: raw time difference between two ends of one strip



East endcap: 7mm lower



West endcap: 0.45° rotation



MDC: Extrapolated track hit position on the strip

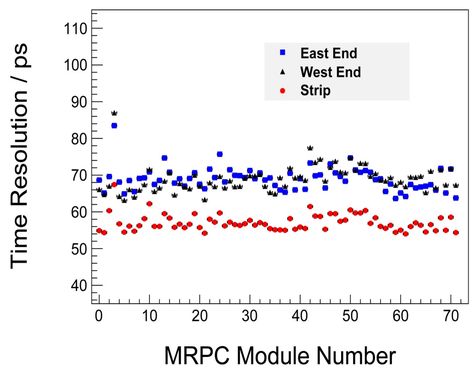
With the propagation time correction, the relationship of leading time and TOT become more smooth.
The empirical function could be used for MRPC-TOF calibration instead of spline fit.

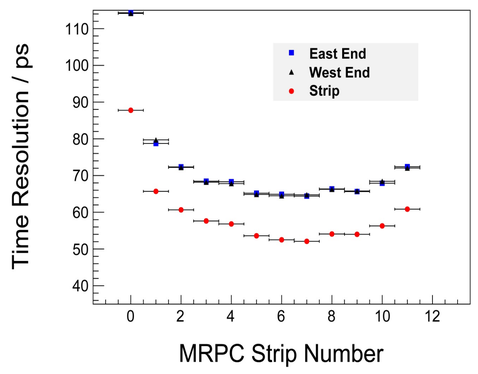
The empirical function for calibration of single end of one strip:

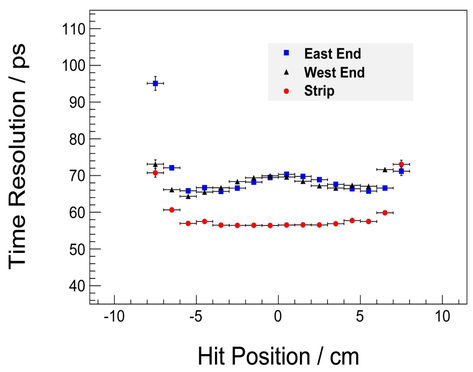
$$t_{Corr} = p_0 + \frac{p_1+p_2\cdot z}{\sqrt{Q}} + \frac{p_3+p_4\cdot z}{Q} + (p_5 + p_6\cdot z)\cdot Q + p_7\cdot Q^2 + p_8\cdot Q^3 + p_9\cdot Q^4 + p_{10}\cdot z + p_{11}\cdot z^2 + p_{12}\cdot z^3$$

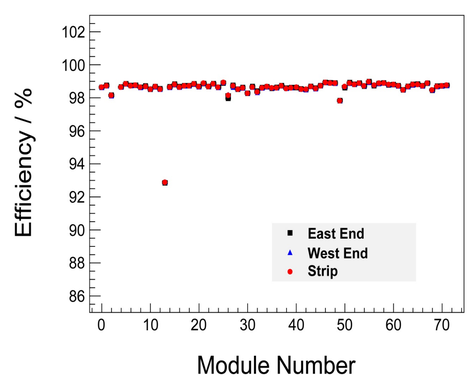
The empirical function for calibration of one strip with combination of two ends:

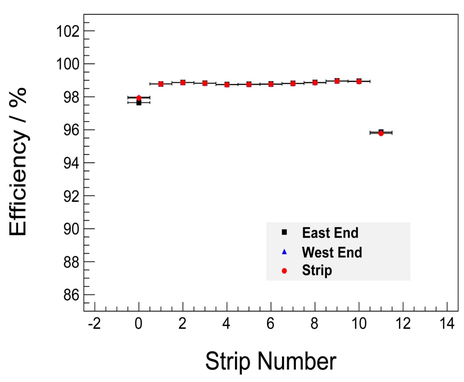
$$t_{corr} = p_0 + \frac{p_1}{\sqrt{Q}} + \frac{p_2}{Q} + p_3\cdot Q + p_4\cdot Q^2 + p_5\cdot Q^3 + p_6\cdot Q^4$$

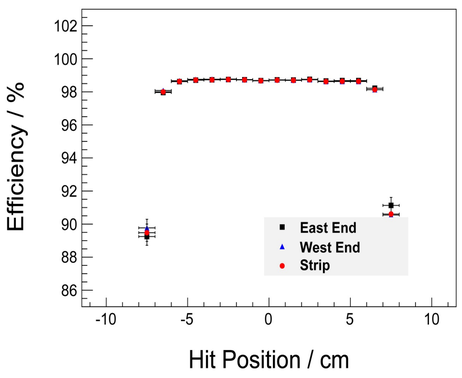


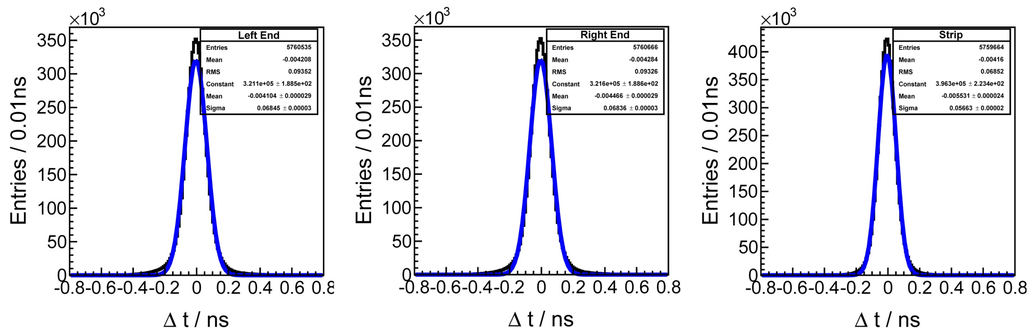












- The endcap TOF detector of BESIII has been upgraded with MRPC technology in the summer of 2015, began data taking in Dec. 2015.
- The multi-peaks in the TOT distribution is caused by the reflection of the signal in the strip.
- The algorithms of event start time and extrapolation of charged track were also updated and provide accurate results.
- The alignment of the new detector has been performed.
- With the empirical calibration function, the time resolution of MRPC end cap TOF of BESIII has been achieved 57ps, and the efficiency of reconstruction is over 98% for electrons in Bhabha events.