The upgrade of endcap TOF in BESIII

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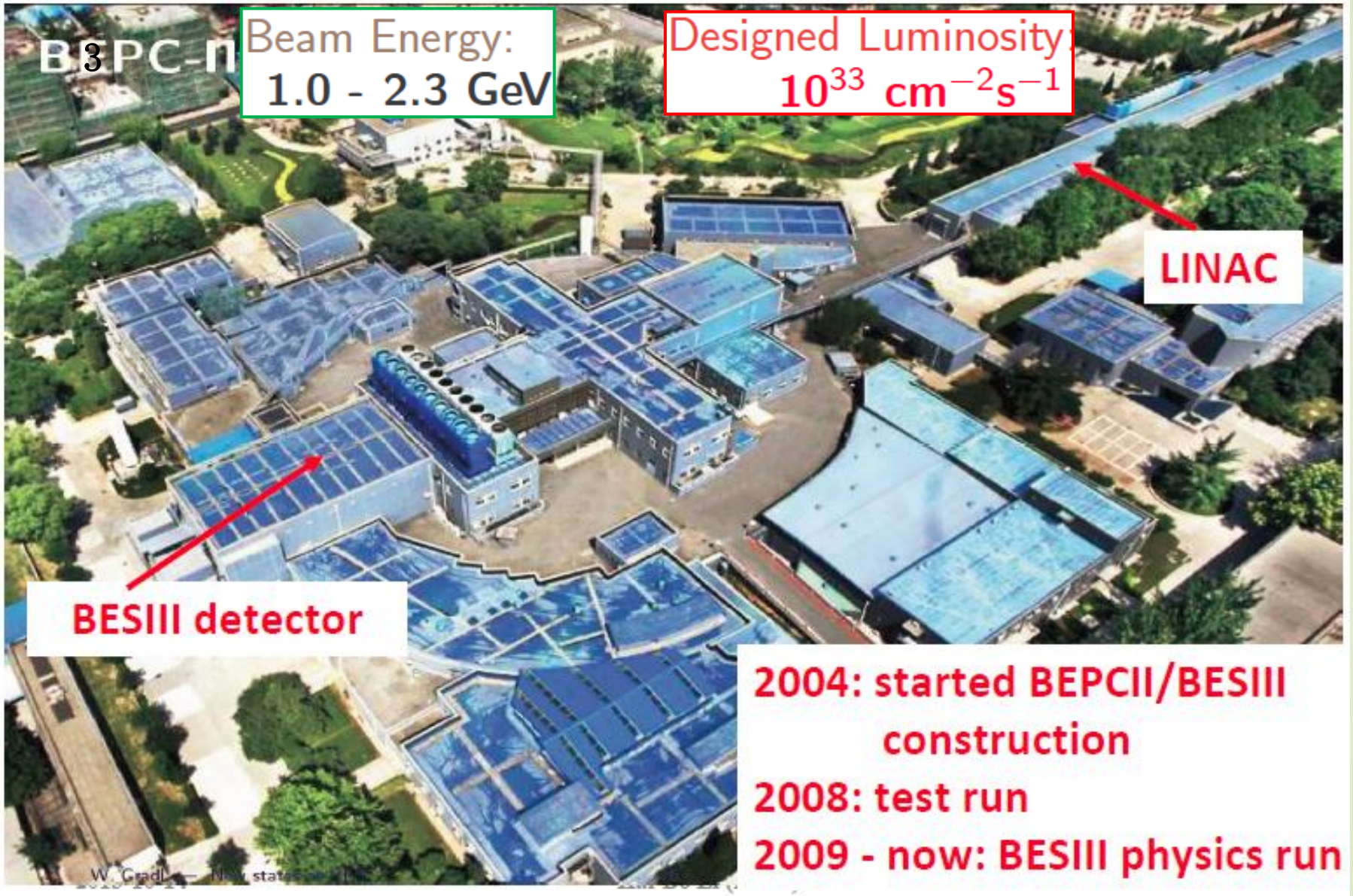
Outline

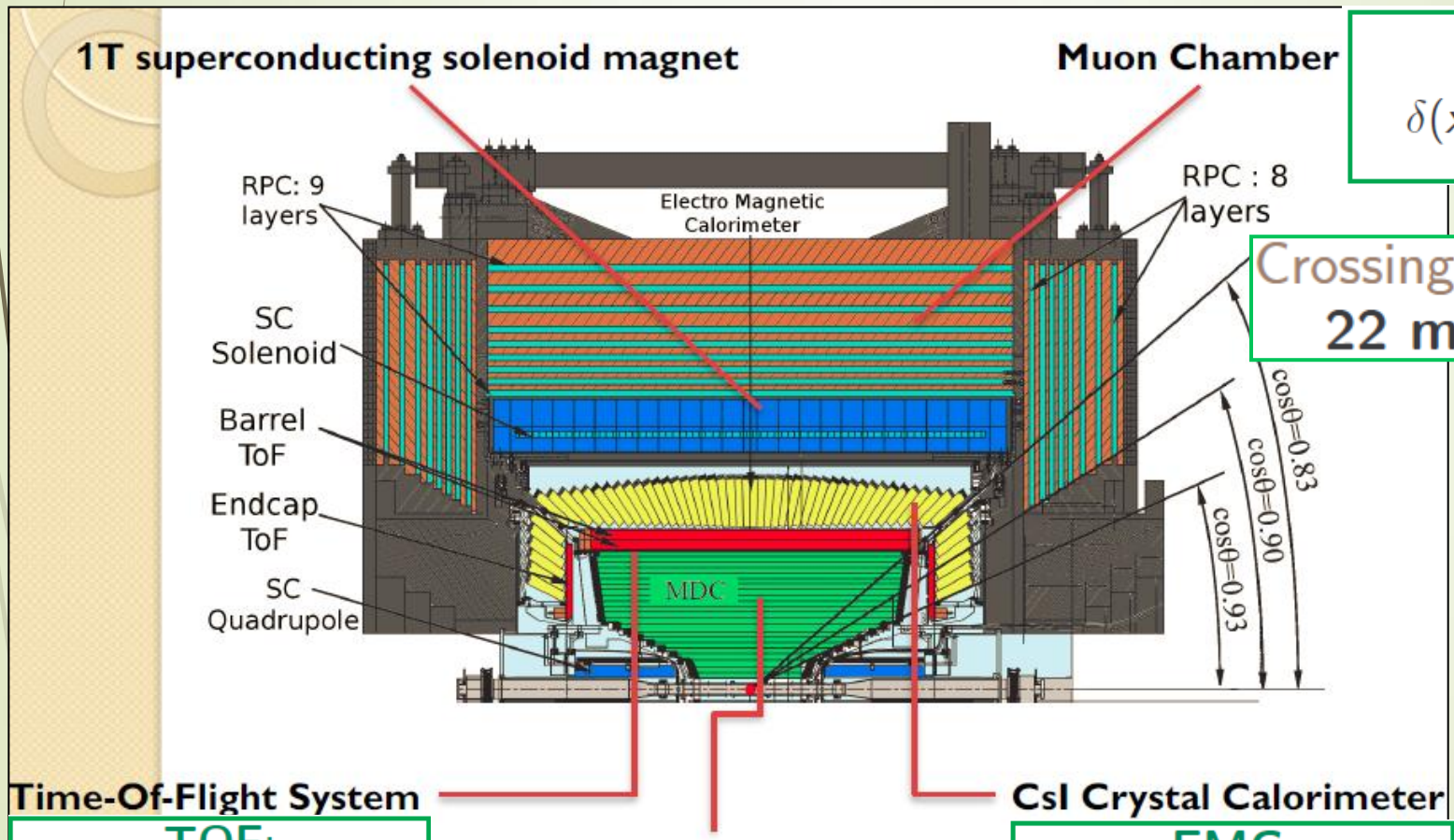
- Introduction of BEPCII/BESIII
- The status of BTOF
- The upgrade of ETOF
- Summary

Beijing Electron-Positron Collider II (BEPCII)



tau-charm factory!

Beijing Spectrometer III (BESIII)



MUC:

$\delta(xy) < 2$ cm

Crossing angle

22 mrad

TOF:

$\delta t = 70$ ps Barrel

$\delta t = 140$ ps Endcap

MDC:

$\frac{\delta p}{p} < 0.5\%$ @1 GeV

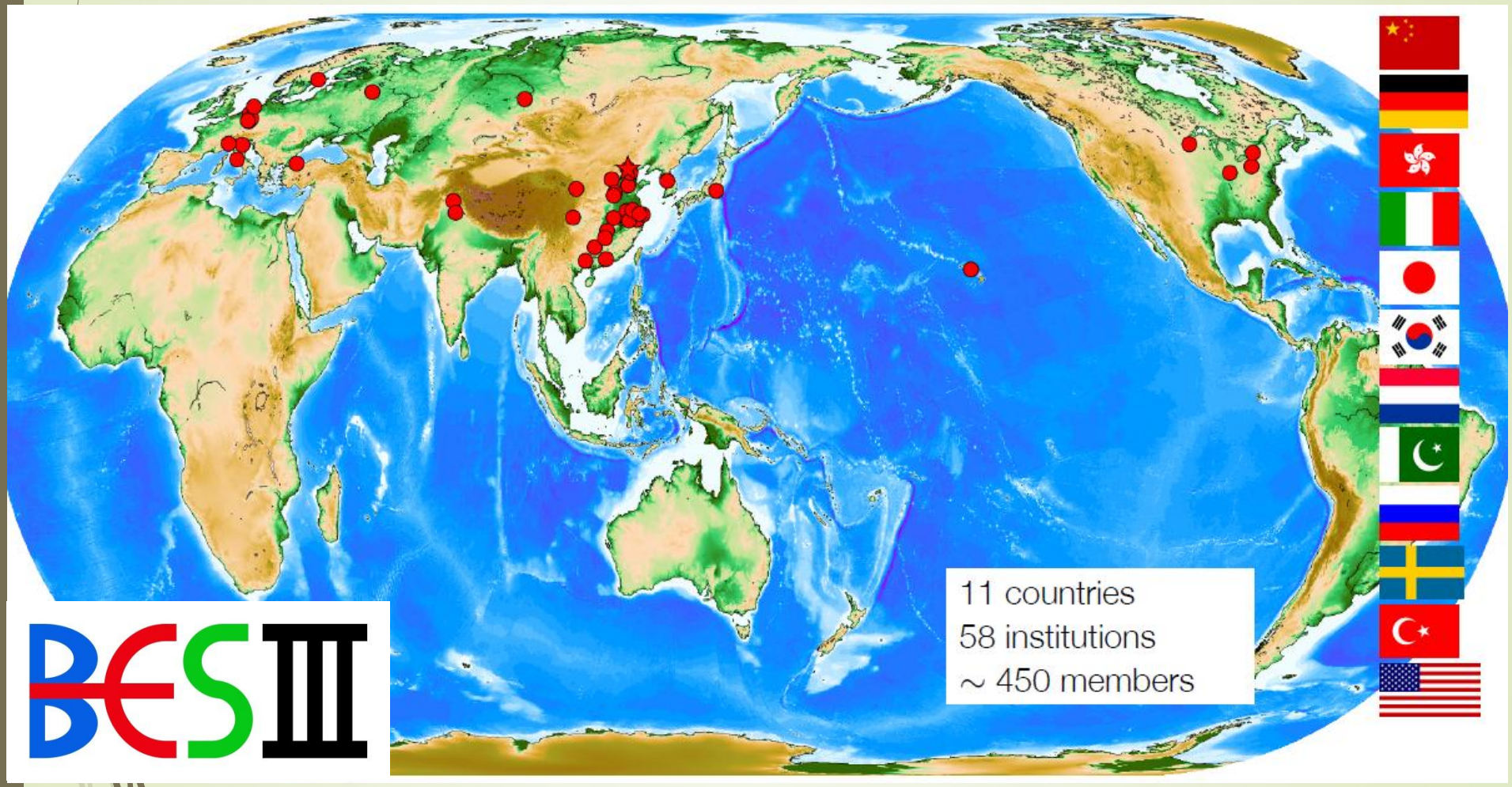
$\frac{\delta(dE/dx)}{dE/dx} < 6\%$

EMC:

$\frac{\delta E}{E} < 2.5\%$ @1 GeV

$\delta z = 0.6/\sqrt{E}$

BESIII collaboration



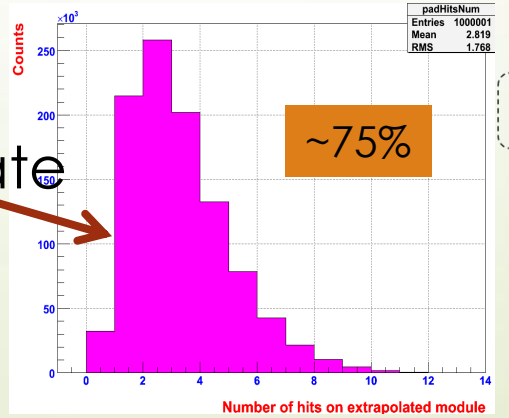
The status of BTOF

Experiment	Year	Resolution(ps)
DIRAC	2002	123
BELLE	**2002**	**90**
CDFII	2003	100
HARP	2004	160
BESIII	**2008**	**65**

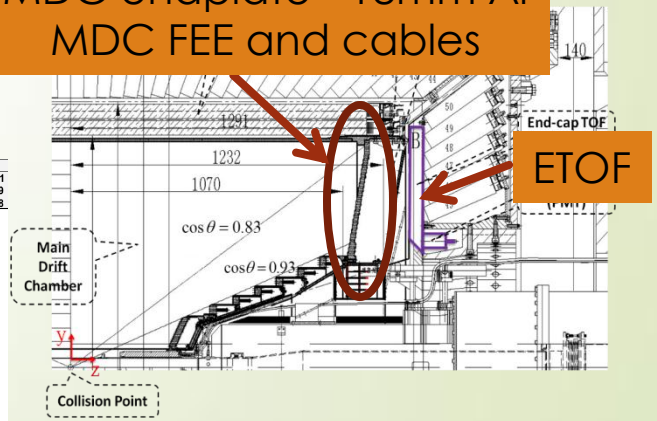
- BTOF:
  - Results of two layers
  - With plastic scintillator + PMT mode, the world level performance

The upgrade of ETOF

- The old BESIII E-TOF: EJ204 scintillator + R5924 PMT
  - Intrinsic resolution ~80ps
  - Meet the design goal
- Time resolution ~138ps for pion, possible reasons:
  - Scattering effect
  - Valid speed: 96ps/cm
  - Tracking
  - Higher multi-hit rate

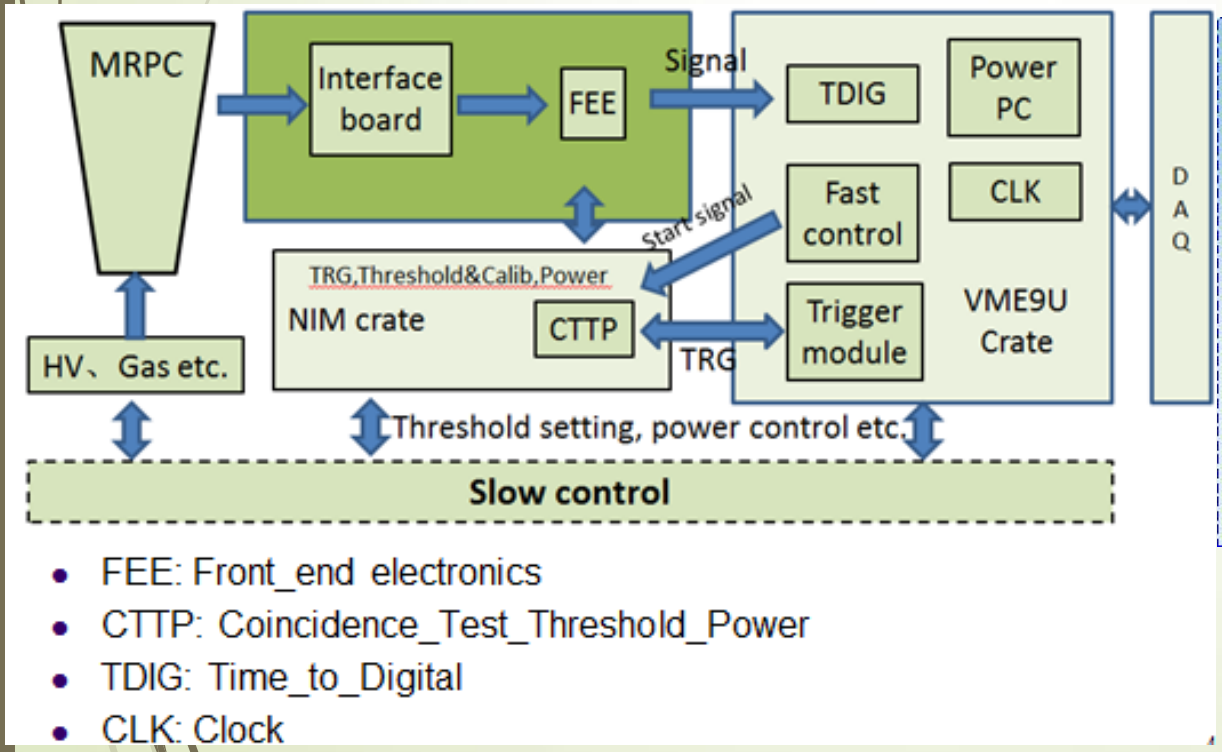


- The target of upgrade
  - Higher granularity
  - Better time resolution:
    - MRPC intrinsic: <55ps
    - Non-intrinsic: ~50ps
  - Total resolution <80ps

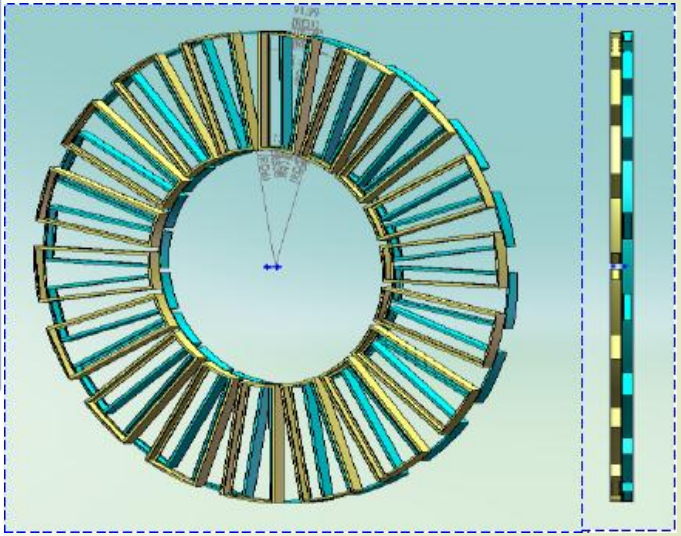


The design for ETOF

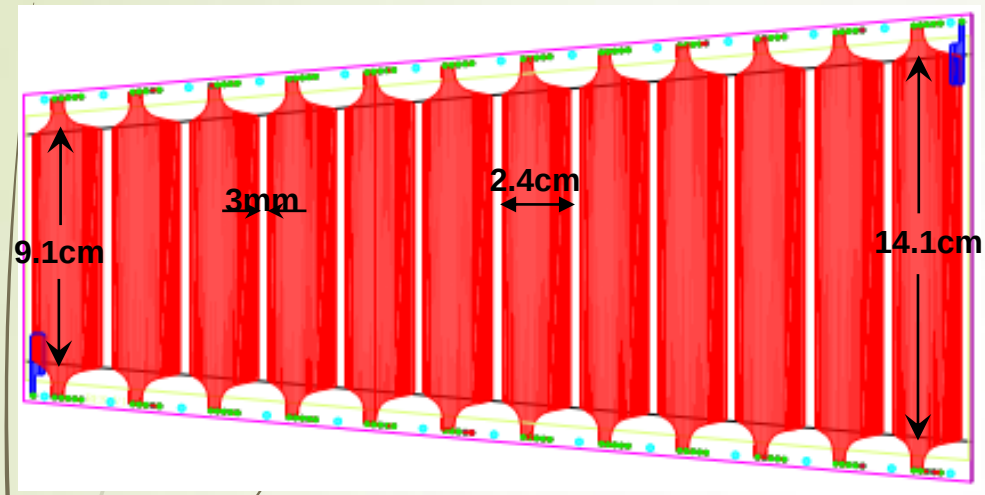
- The block diagram of new ETOF(Left figure)
- Each ETOF ring: 36 over- lapping MRPCs, no dead zone for particle detection



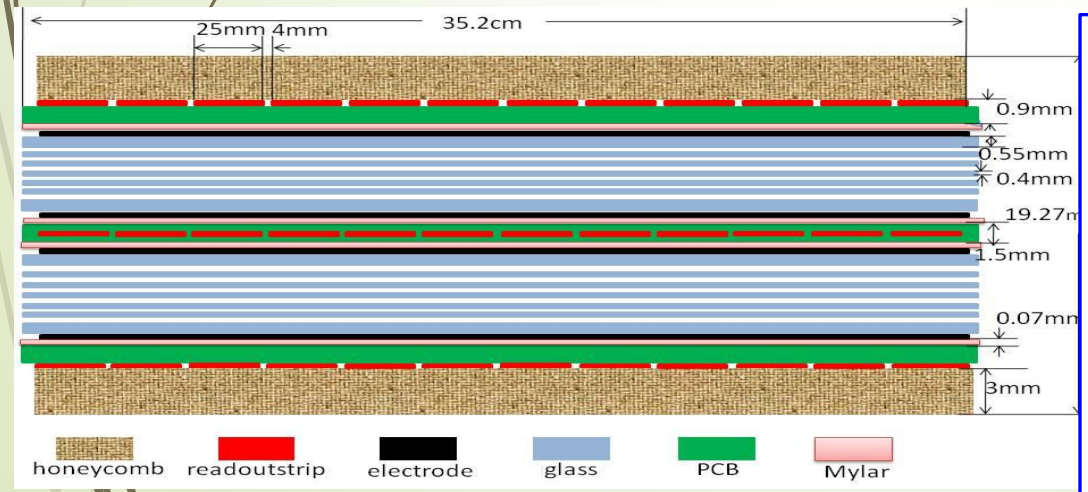
- FEE: Front_end electronics
- CTTP: Coincidence_Test_Threshold_Power
- TDIG: Time_to_Digital
- CLK: Clock



Structure of the MRPC



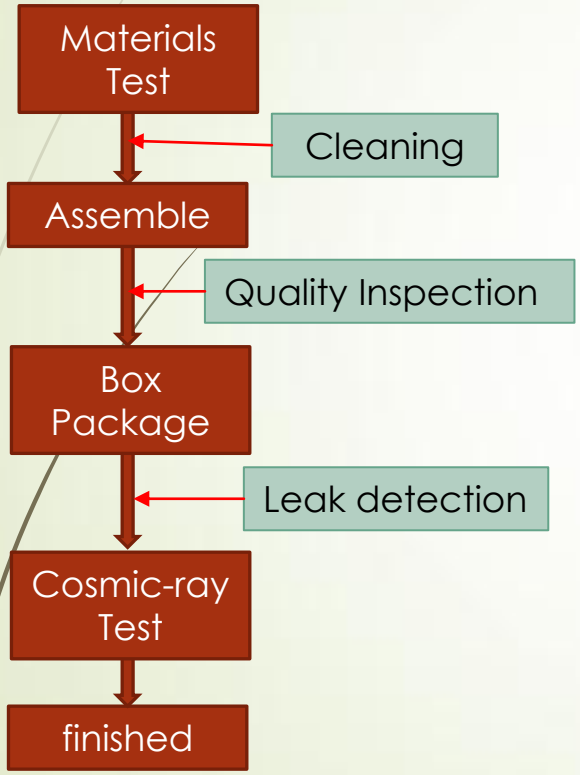
- Readout strip:
  - Width: 2.4 cm
  - Length: 9.1-14.1 cm
- 24 channels / module 1728CH



- Gas gap: 2 x 6
- Gap size: 0.22 mm
- Resistive plate: floating glass
- Total thickness: ~20 mm

MRPC module mass production

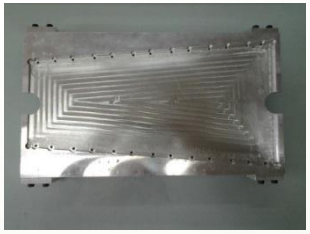
Production processes and quality control



Materials Testing



Assembling





80 MRPC modules is produced

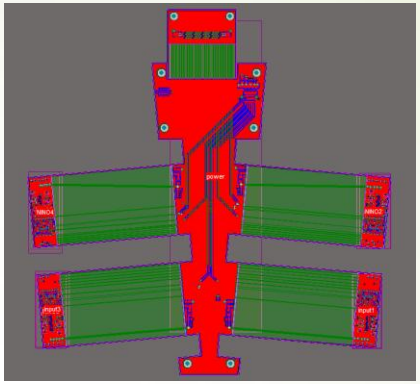
Finish production

Production record

Front-end electronics

FEE board

- Based on the NINO ASIC
- Differential input
- LVDS output
- Charge-TOT conversion
- Time jitter: ~10 ps
- Each board deals with *one* MRPC
- The soft cable is used

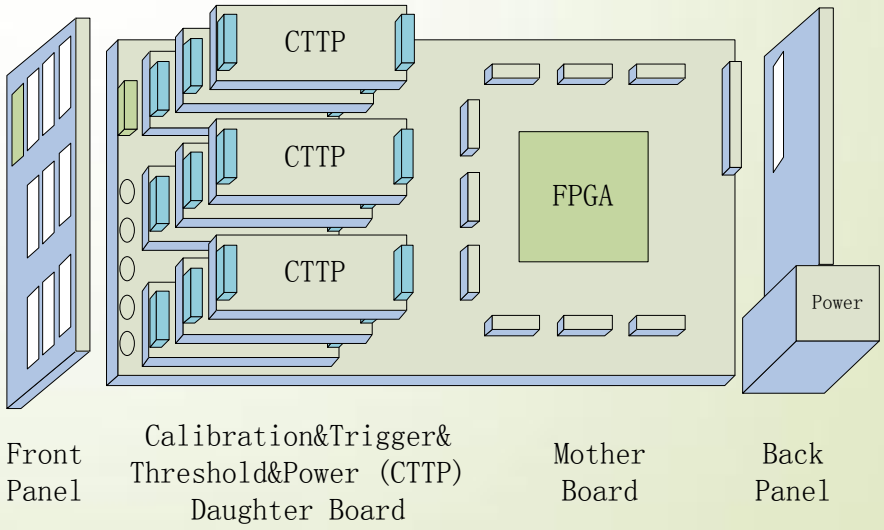


cables

CTTP board

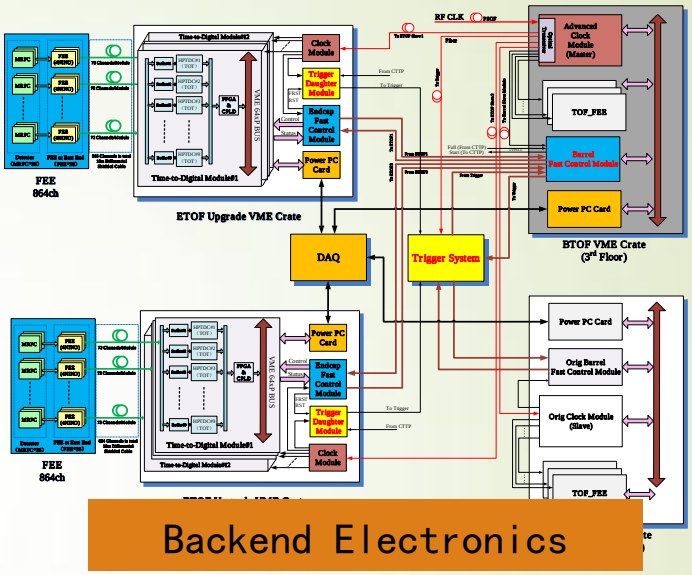
- Coincidence
- Test signal
- Threshold
- Power supply for FEE
- The conceptual design is ongoing

Front-end Elec.

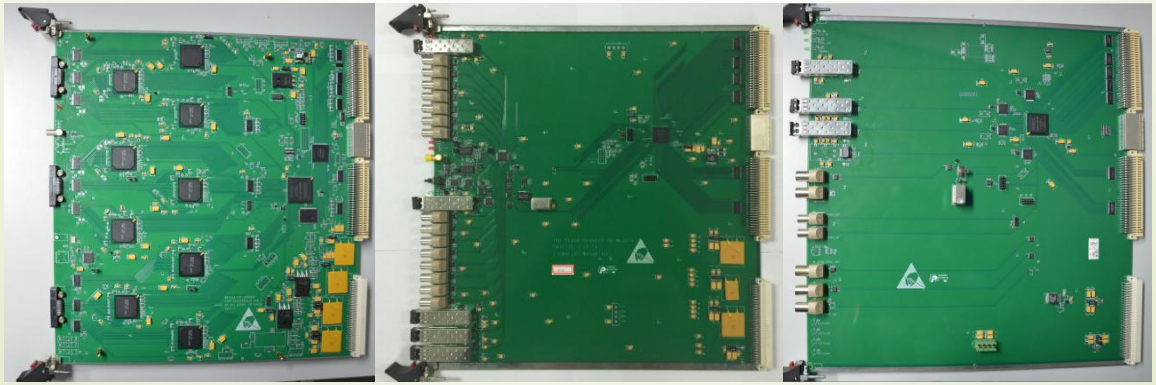


Backend Electronics

- TDIG board
  - Based on the HPTDC chips
  - Leading-&.Trailing-edge recording
  - 72 channels / VME 9U module
- Clock board
  - LVPECL output
  - Light output
- Fast control board
  - LVDS input
  - Connect with CTTP by RS485 signal
- **Time precision contributed by electronics (RMS): <25ps**



Backend Electronics

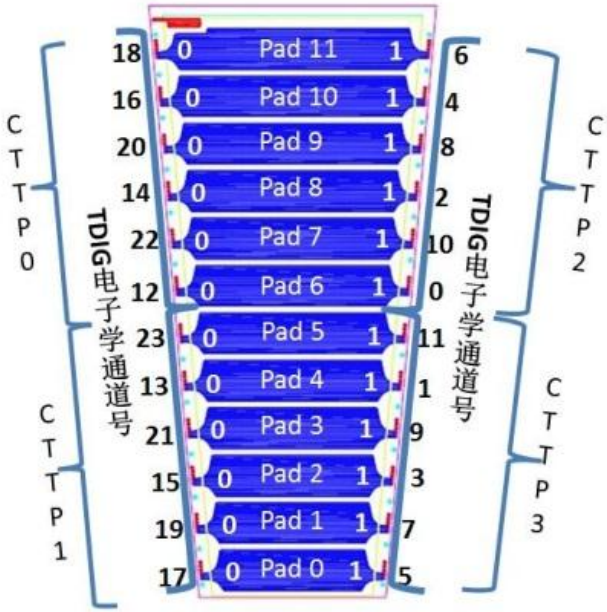


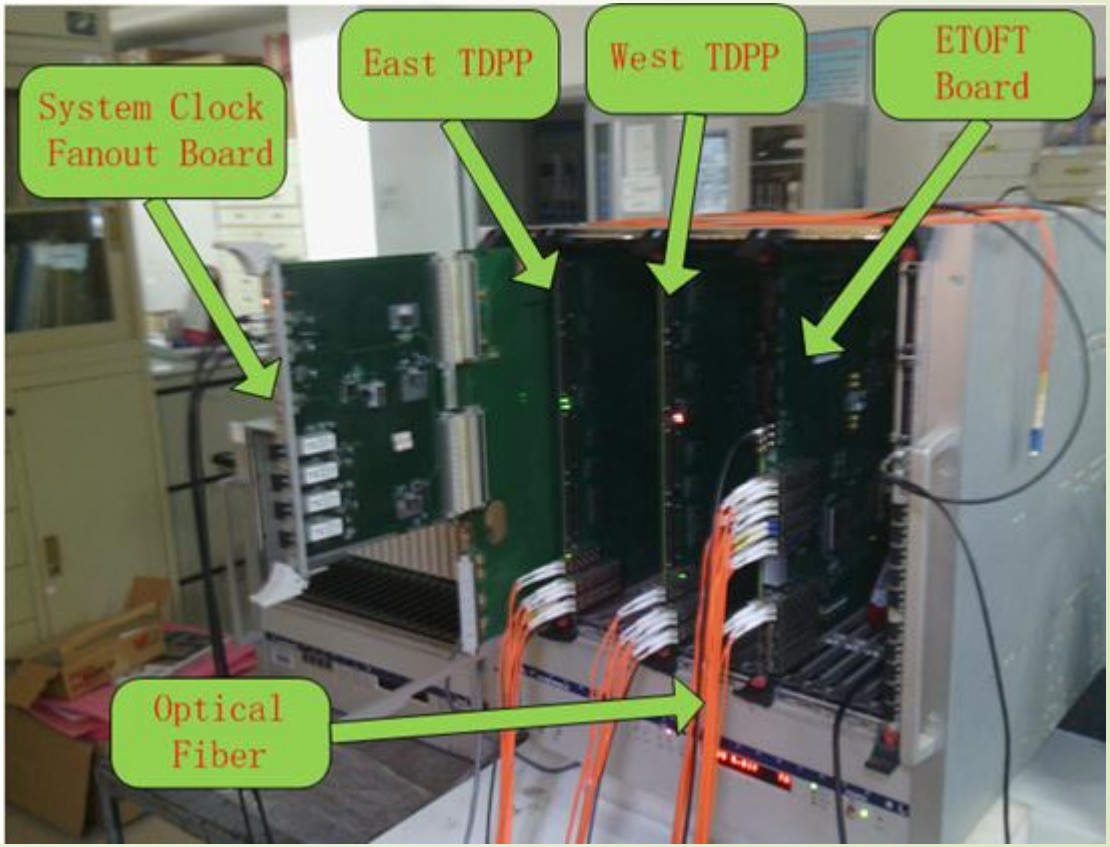
Time Digitizer | Clock Module | Fast Control

Trigger system

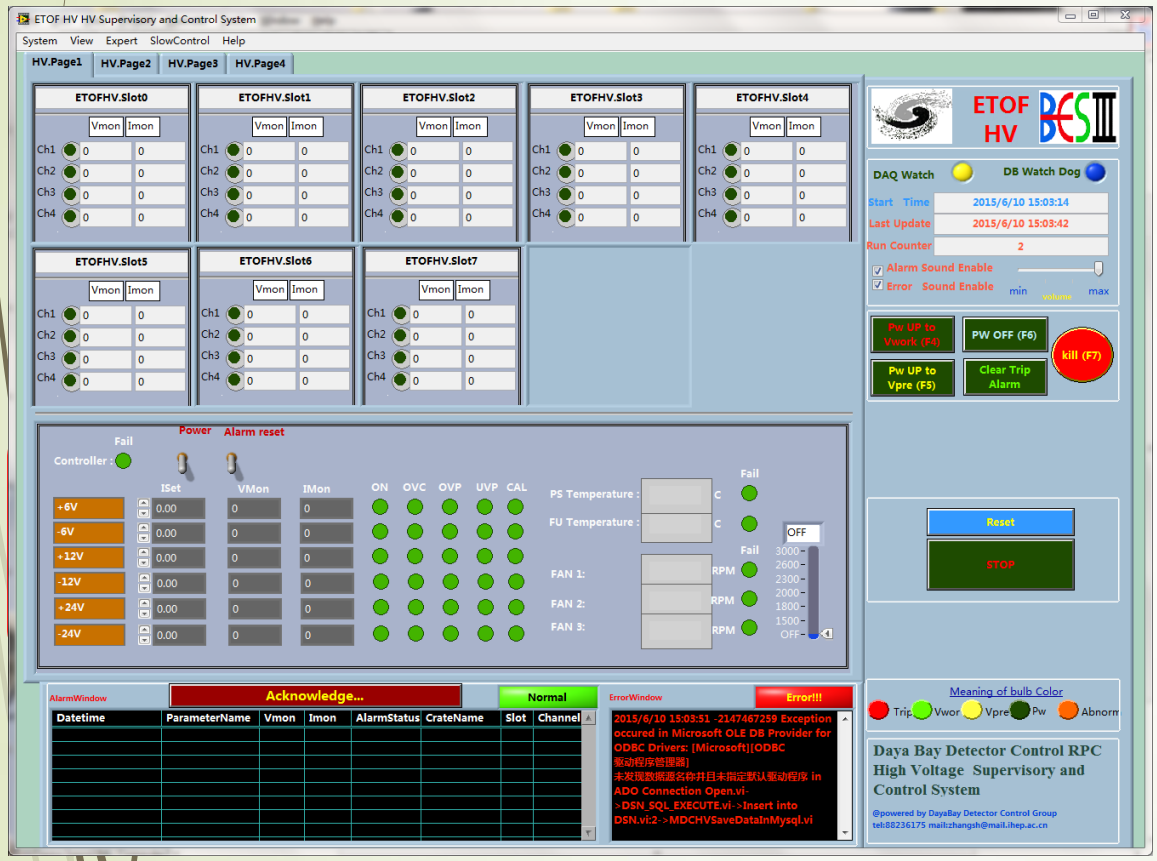
- ETOF Trigger system consist of TDPP(Trigger Data Pre-Processor), ETOFT(ETOF Trigger Board),SIF2(Signal Integration and Fanout) and FPGA firmware.
- Trigger conditions: NETOF>=1, NETOF>=2, Back to Back

Or signal from four NINO chips as one output





Slow control system - HV system



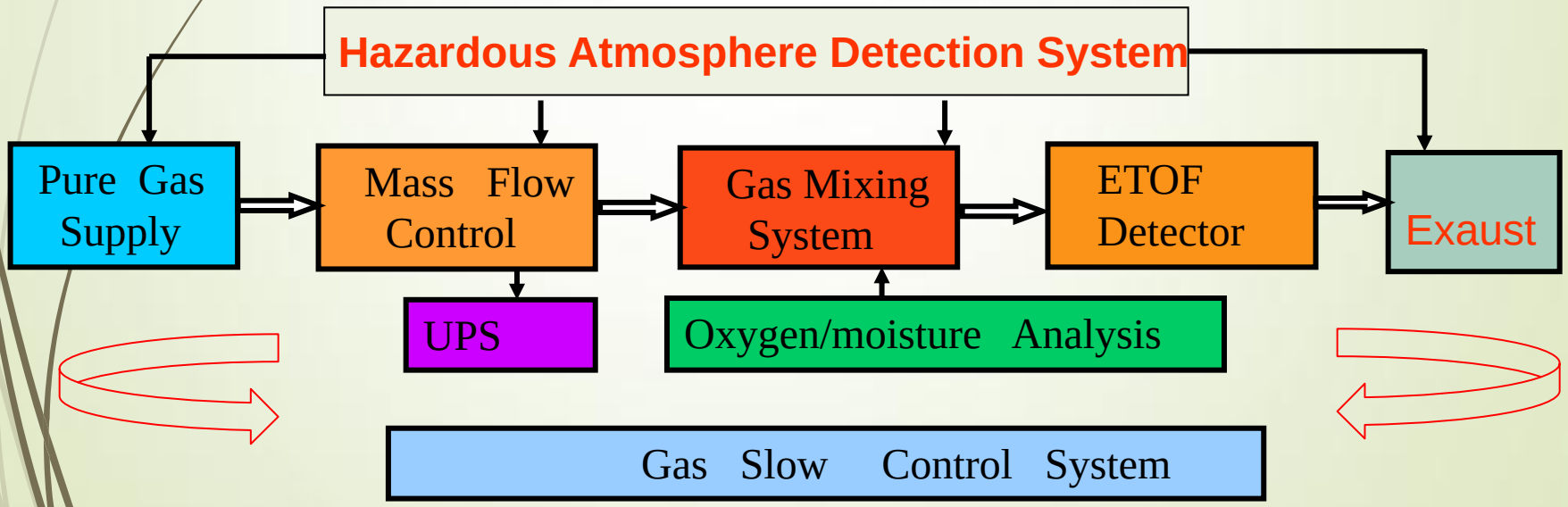
Features:

- Control and configration
- Monitoring Vmon and Imon
- Historical and real time plot
- Crate status monitoring
- … …

CrateN8304 with N1470

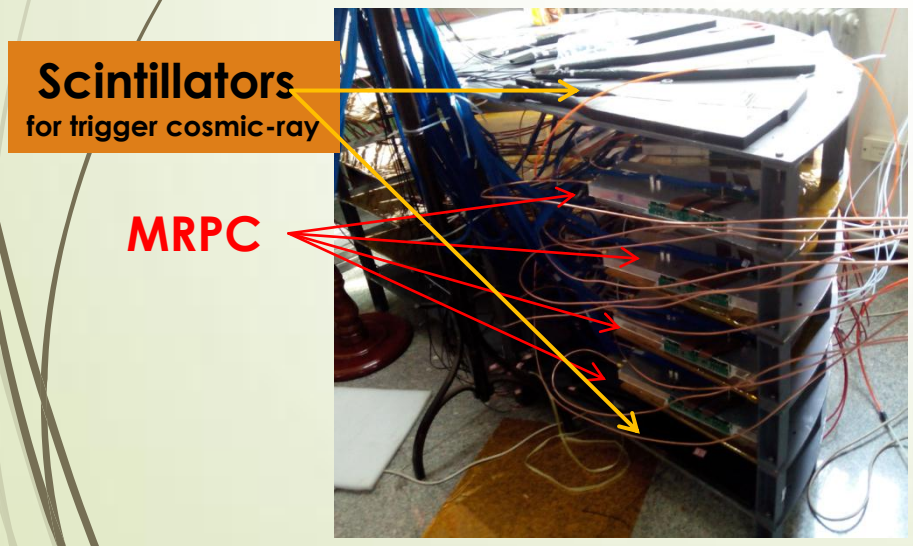
Gas System

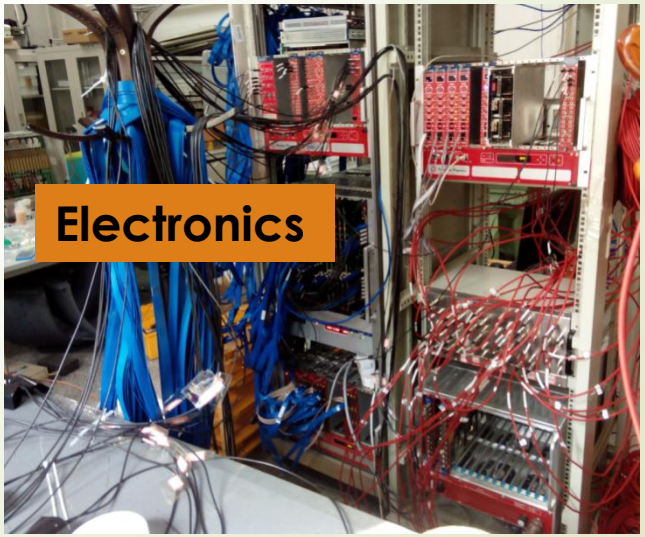
- Gas ratio: 90%R134a+5%C4H10+5%SF6.
- Operated by gas slow control system
  - the status of gas mixture
  - automatic responses
  - Status monitors and interlocks



Cosmic ray test

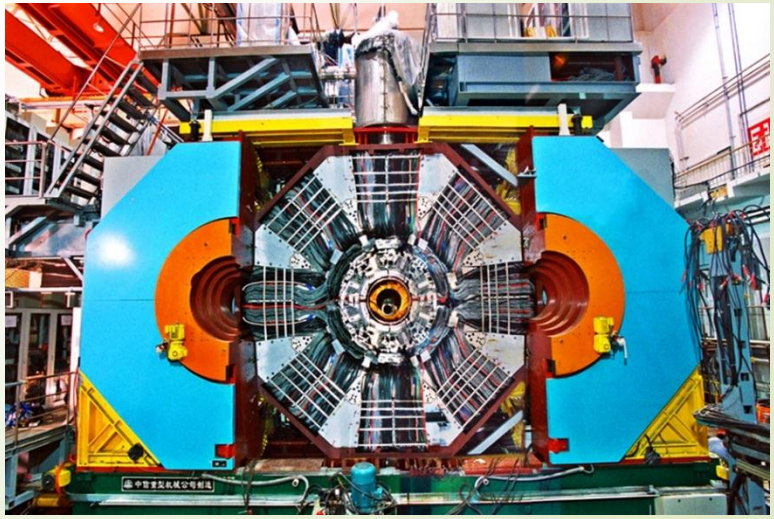
- The production of the whole system
  - Sep. 2014 ~ Mar. 2015
- Combined all the systems together
- 3 months cosmic-ray test
- Intrinsic resolution better than 60ps, efficiency ~97%





The summer installation process

- Take one endcap as example:
  - 1) Move cement board and open the door of BESIII: 2 days
  - 2) Swing and install supports: 4 days
  - 4) Move the endcap of EMC out: 1day
  - 5) Remove old ETOF. Install the MRPCs: 16days
  - … recover the endcap: 8days.
- The total last about 60 days(concurrently some days)



The procedure of MRPC installation

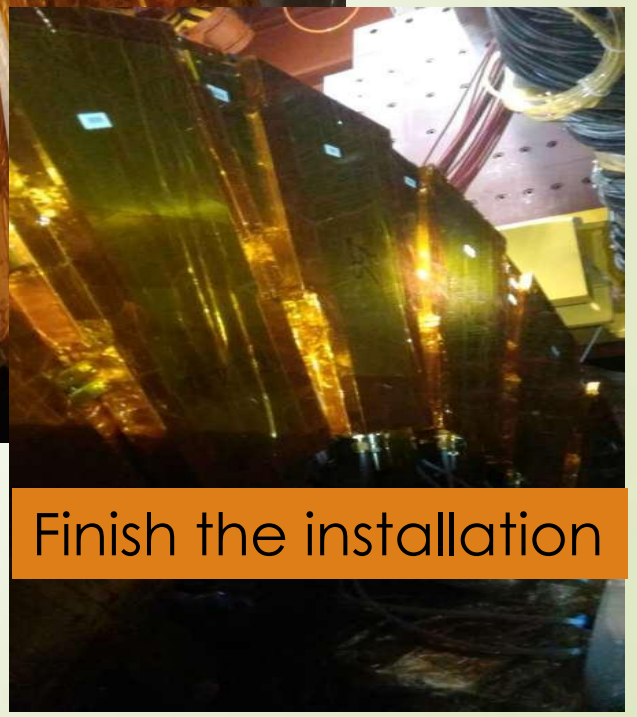
leakage Ratio check → electronics check → location guarantee

installation → gas pipes & HV wires → test with HV → next

The test of the detectors

- Everyday four or six MRPC modules installed
- gas pipe and HV cables connected next
- In the evening test the detectors installed
  - The noise ratio of each channel <0.1% @150mV
- The installation duration: 2015 Aug. ~Oct. 7th,
  - Install （daytime）
  - Test （evening）
  - Overtime （holidays）

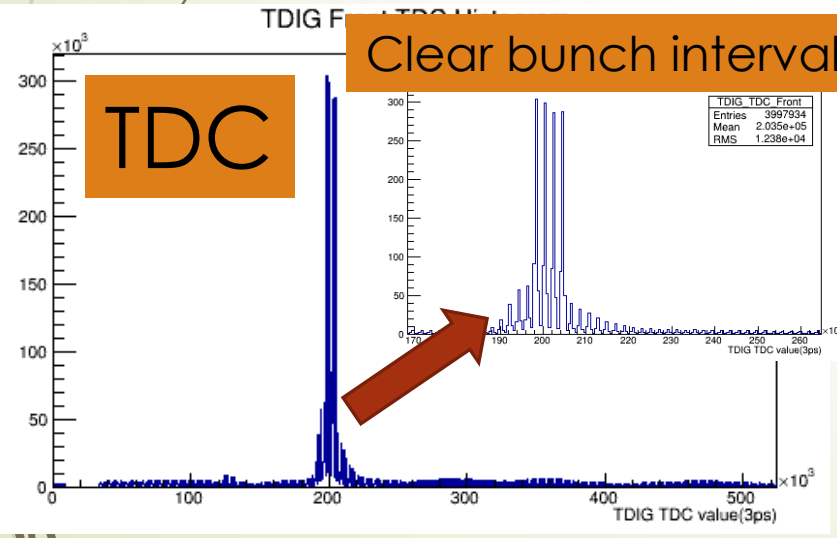
MRPC installation

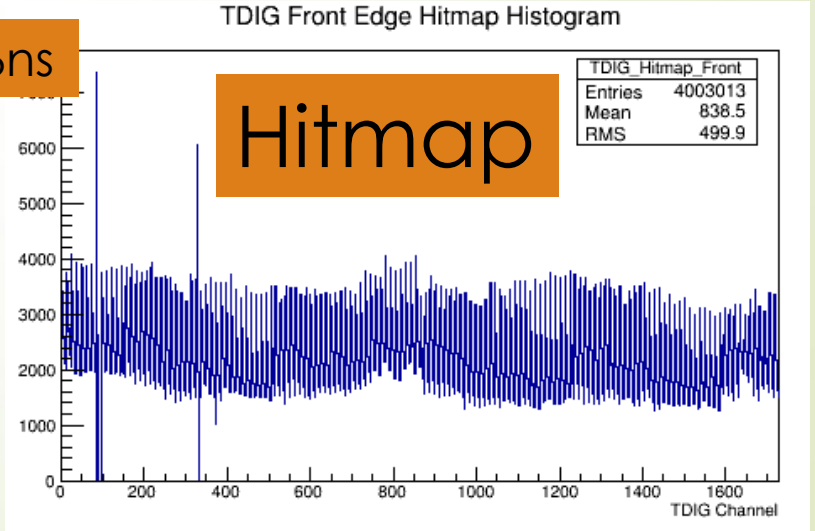


Finish the installation

First results with the collision data

- The system tuning is finished in Nov. 2015 using cosmic ray
- The collision data taking is started on Jan. 4th, 2016
- Some online plots from collision data show below

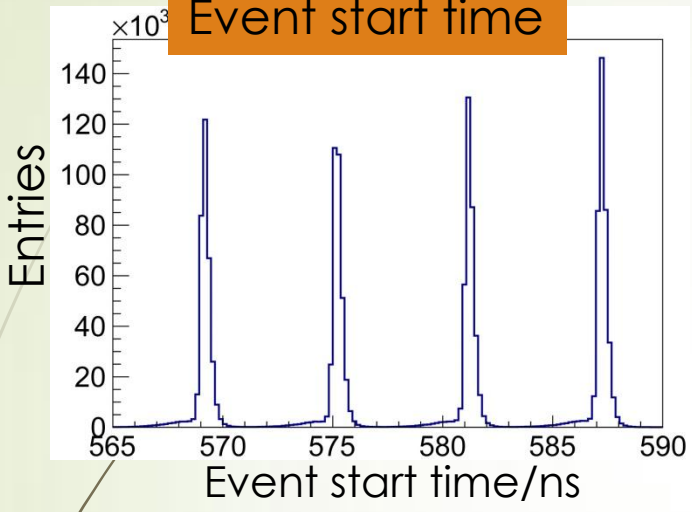




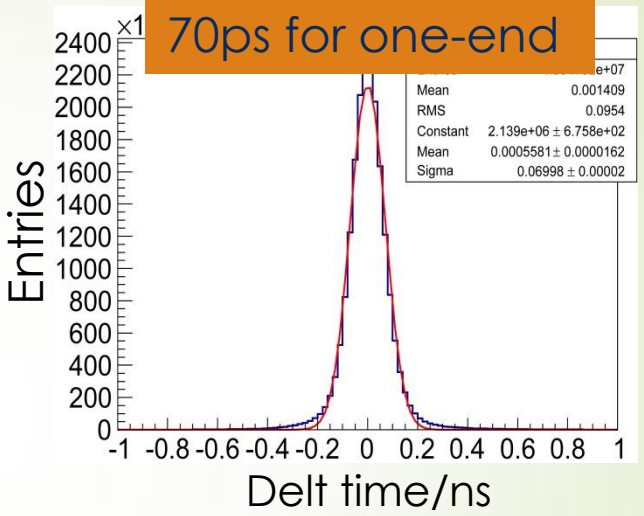
Clock interval 24ns, event start time determined by offline

The performance with the collision data

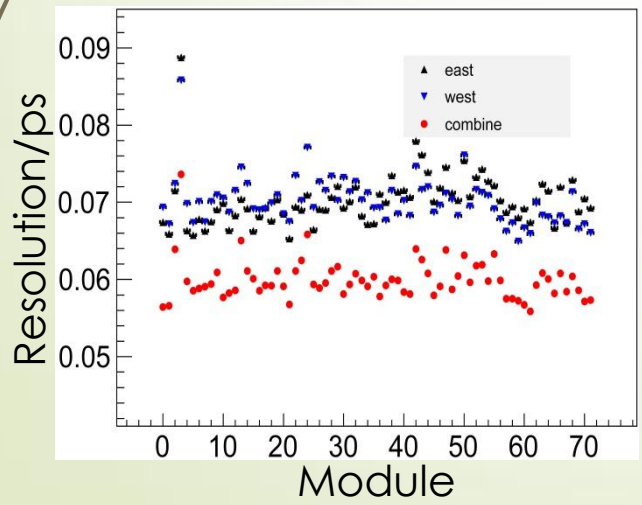
Event start time



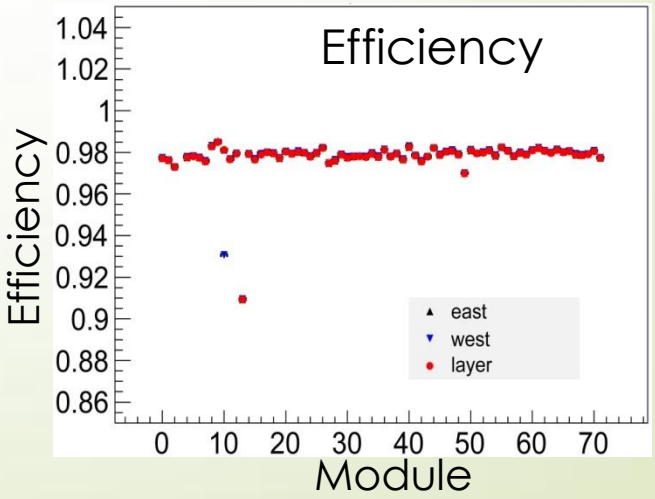
Time resolution
70ps for one-end



Time resolution: 60ps for combined



Efficiency ~98%



Summary

- The BEPCII/BESIII is introduced briefly
- The status of TOF and the upgrade of ETOF are presented
- The new ETOF has worked together with BESIII successfully
- The results show very good performance.
  - Time resolution for one-end: 70ps
    - Intrinsic resolution better than 50ps
  - Combined time resolution: ~60ps
  - Efficiency: ~98%

Thank you!