



Performance of High Resolution Time-of-Flight detector for Study of Identified Hadron Production at RHIC-PHENIX experiment

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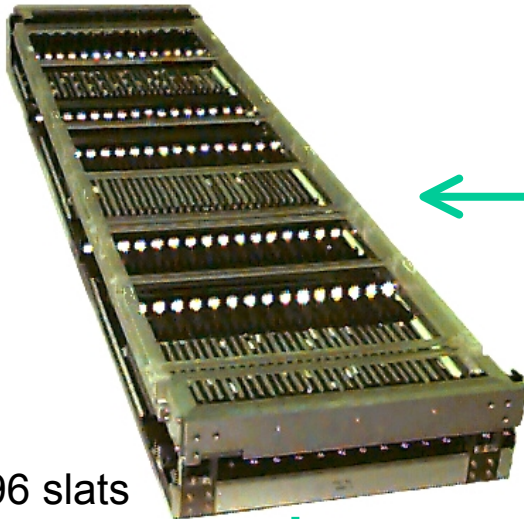
*JPS meeting at Niigata University
September 23, 2000*

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PHENIX-TOF

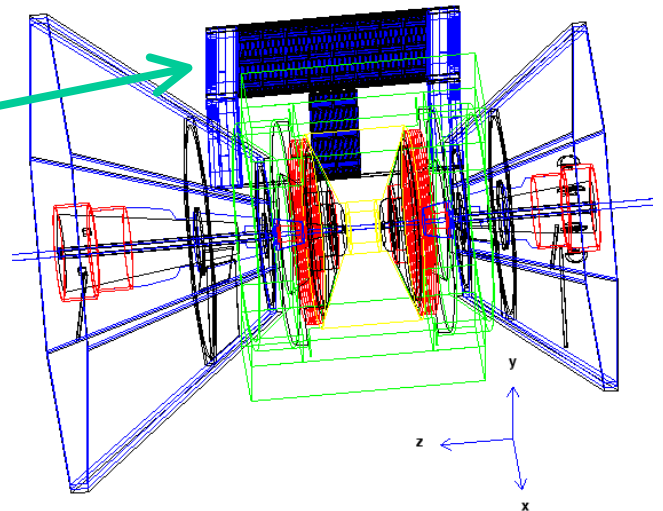
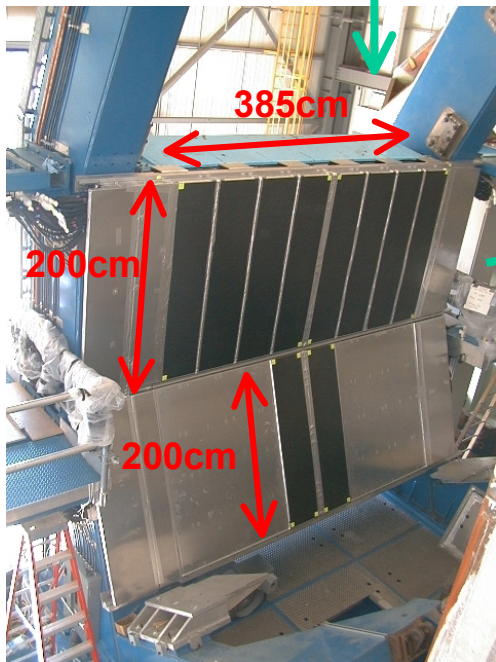
Device for Hadron PID



Panel: 96 slats



Slat: Plastic scintillator w. 2 PMT's

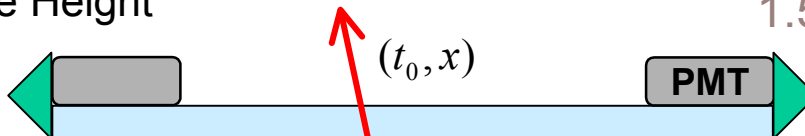


- 960 plastic scintillators with 1920 PMT's
- Locate at 5m from the vertex
- Acceptance : driven by HBT and ϕ meson
 $\Delta\theta = 40^\circ$, $\Delta\phi = 45^\circ$, $\Omega \sim 1/3$ Sr

Basic Design

Timing
Pulse Height

Scintillator:
1.5x1.5x64cm



$$\begin{cases} t_1 = t_0 + x / v_{light} \\ a_1 = a_0 \exp(-\frac{x}{\lambda}) \end{cases}$$

$$\begin{cases} t_2 = t_0 + (l-x) / v_{light} \\ a_2 = a_0 \exp(-\frac{l-x}{\lambda}) \end{cases}$$

$$\therefore \begin{cases} t_0 = \frac{t_1 + t_2}{2} - l / v_{light} \\ x = \frac{t_1 - t_2}{2} v_{light} \end{cases}$$

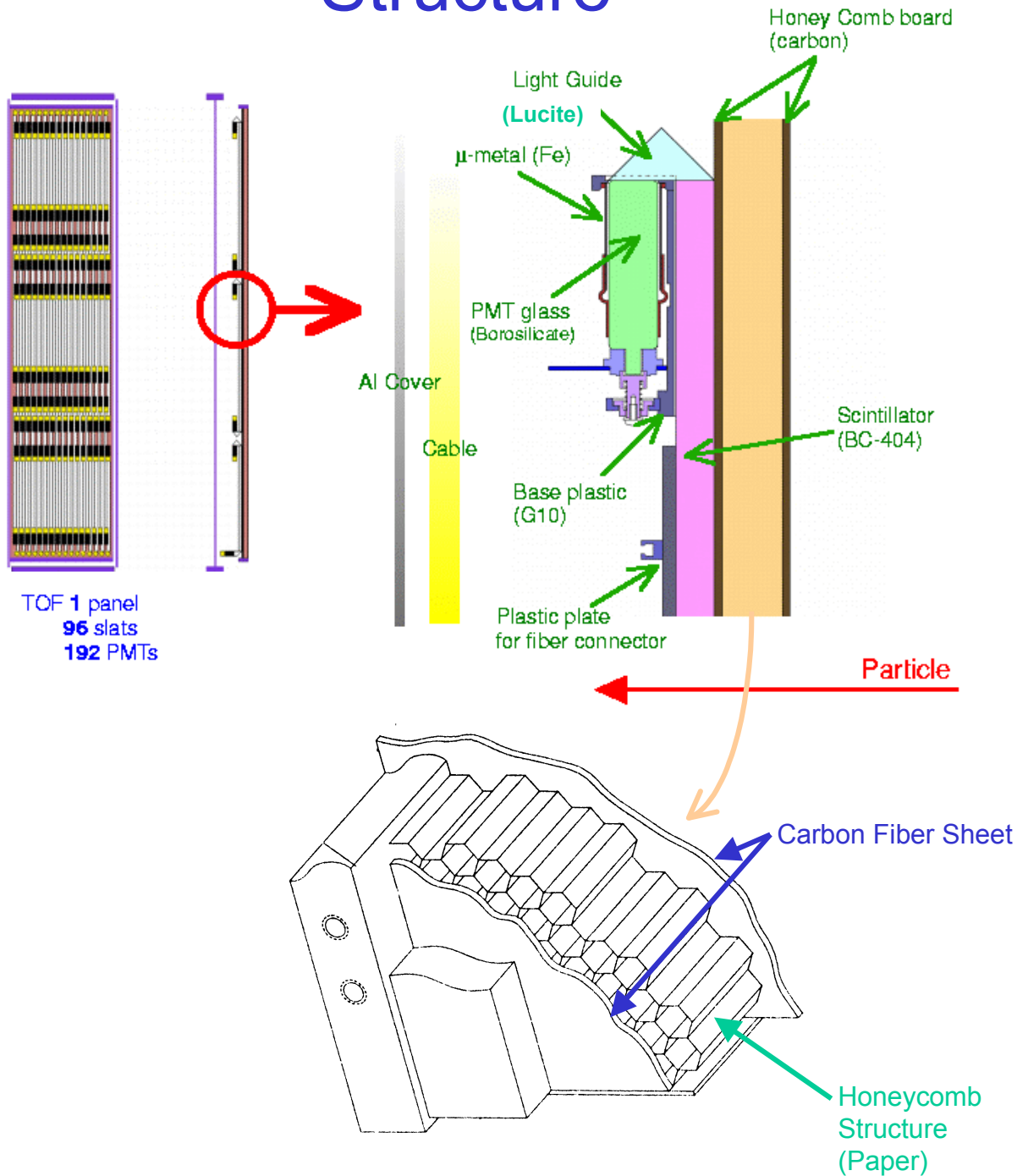
$$\delta t_0 = \sqrt{\left(\frac{\delta t_1}{2}\right)^2 + \left(\frac{\delta t_2}{2}\right)^2} \cong \frac{\delta t_1}{\sqrt{2}} \quad \longrightarrow \quad \mathbf{80 \text{ ps}}$$

$$\delta x = v_{light} \sqrt{\left(\frac{\delta t_1}{2}\right)^2 + \left(\frac{\delta t_2}{2}\right)^2} \cong \frac{v_{light} \delta t_1}{\sqrt{2}} \quad \longrightarrow \quad \mathbf{1.3 \text{ cm}}$$



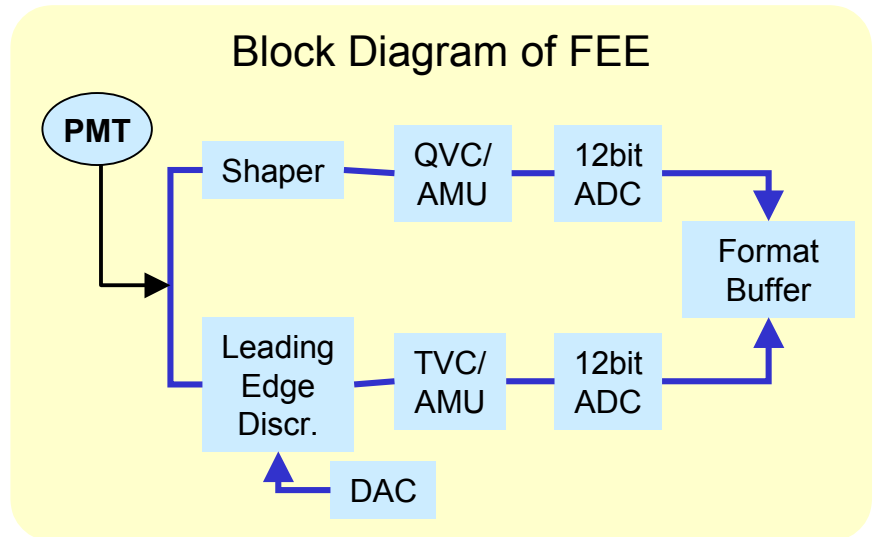
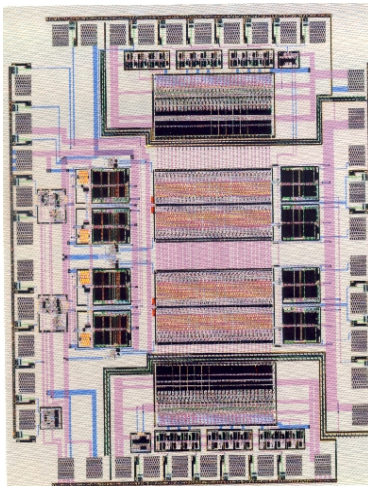
- Scintillator: Bicron BC404
 - decay constant : 1.8 ns
 - attenuation length : 160cm
- PMT : Hamamatsu R3478S
 - rise time : 1.3 ns
 - transit time : 14 + - 0.36 ns
- HV Bleeder with chip resistors

Structure



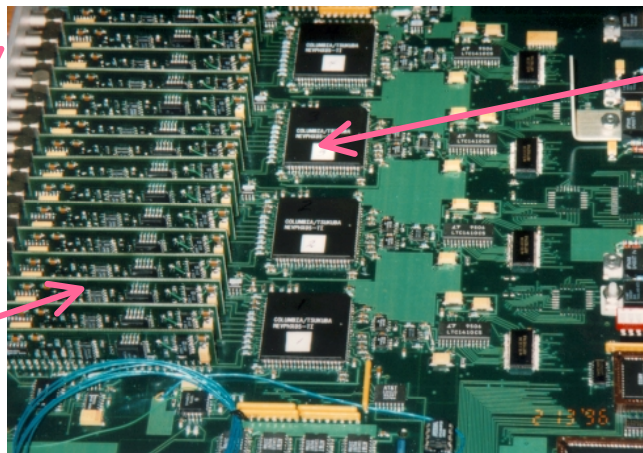
- Honeycomb Board
 - Rigid structure with “no mass”

TOF-FEE



PMT inputs
lemo

Discriminattor
Sub-board

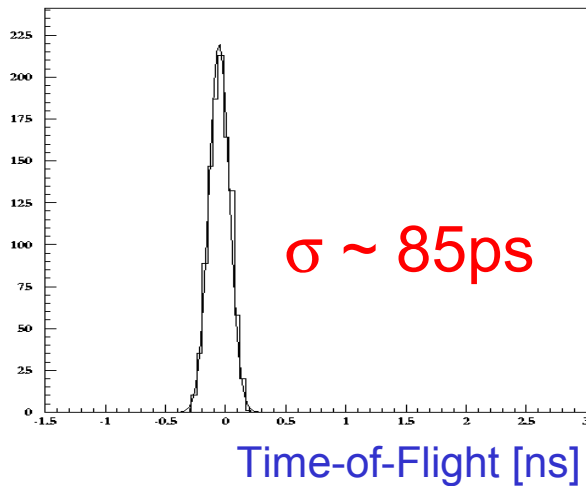


TVC+AMU chip
4ch/chip

FEE board
16ch/board
8layers PC

- Custom made chips of TVC+AMU and QVC+AMU
 - Overall timing resolution of <25 ps
 - First pipeline TDC with high resolution.
- Use of Analog memory Unit.

TOF Performance at CERN-WA98



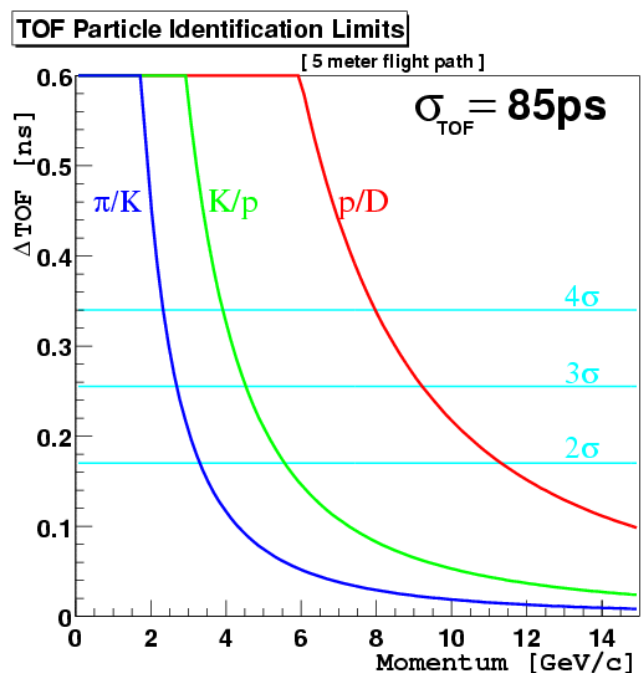
(1996)

Used high momentum π
TOF resolution for all 500 slats

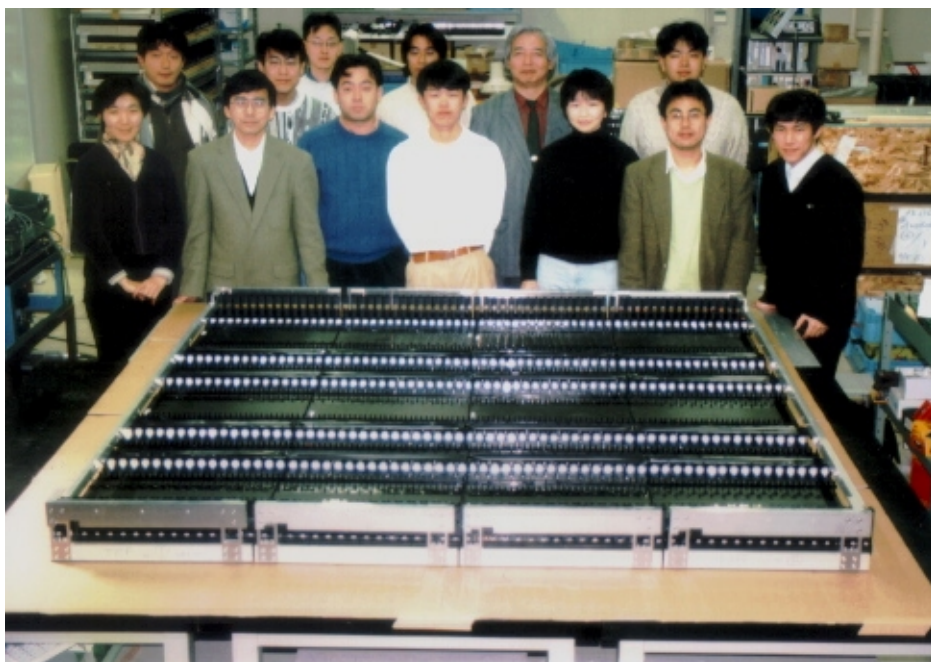
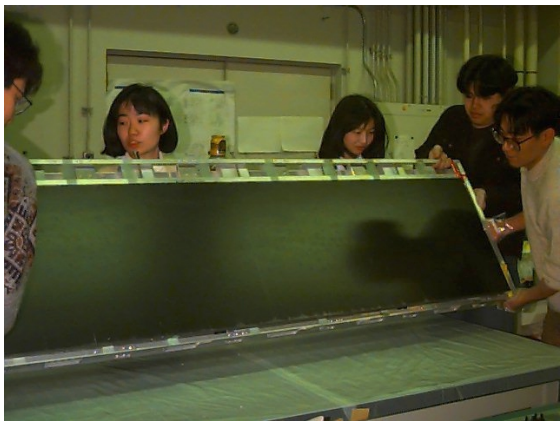
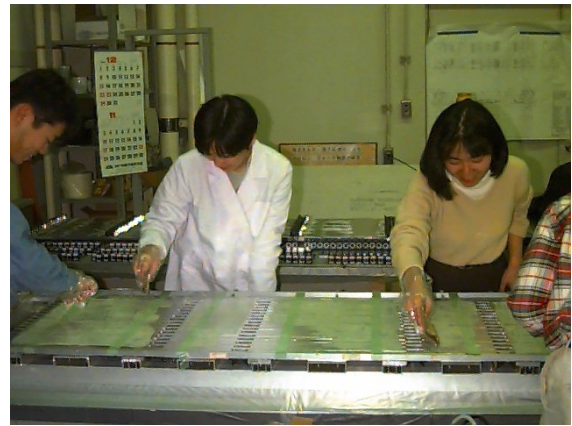
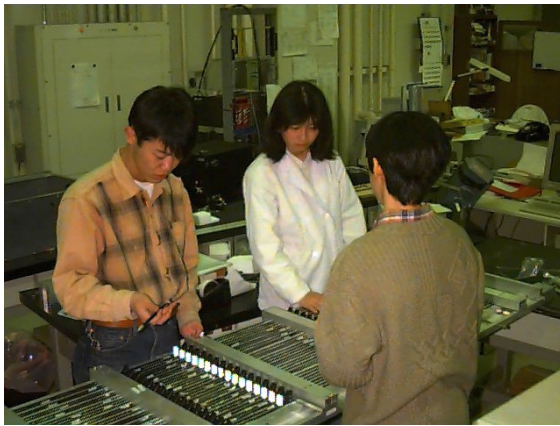
- 5 panels of TOF tested at CERN-WA98.
- Overall TOF resolution of $< 85\text{ps}$ obtained.

TOF PID Capability at RHIC-PHENIX

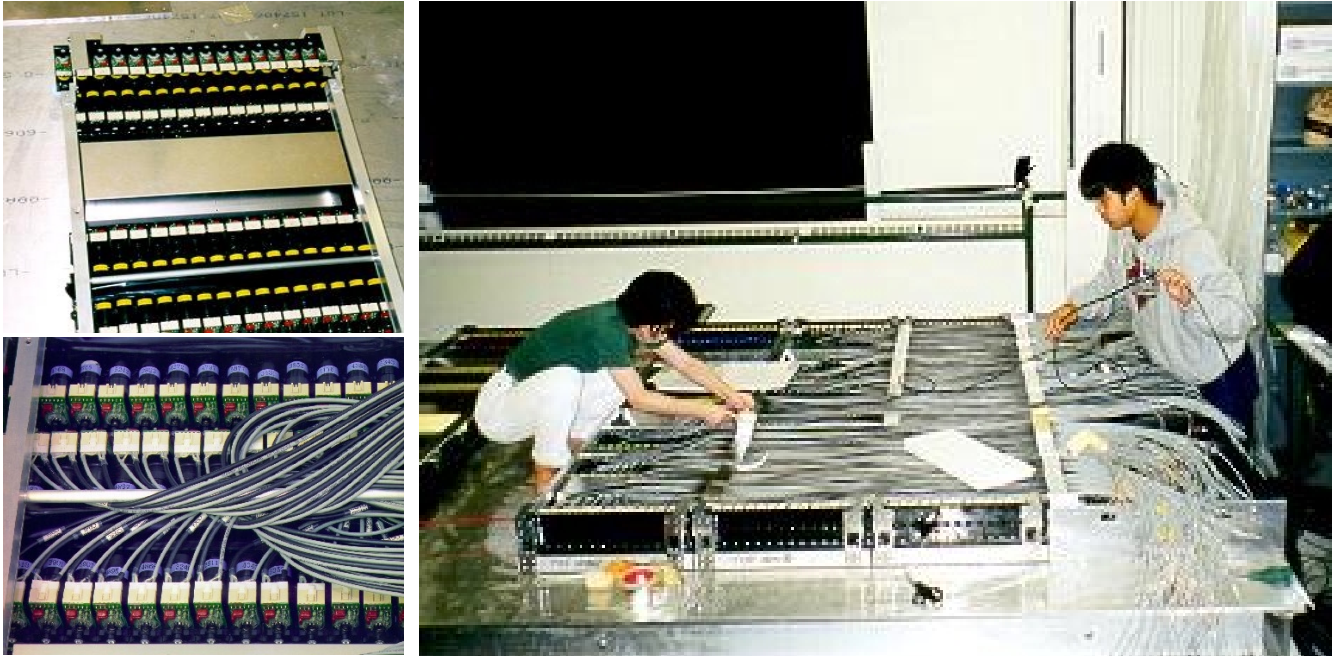
Time Resolution: $\sigma \sim 85\text{ps}$
 π / K separation to $2.4\text{ GeV}/c$
 $K / p, \bar{p}$ separation to $4.0\text{ GeV}/c$



Construction at Tsukuba (1996-1998)



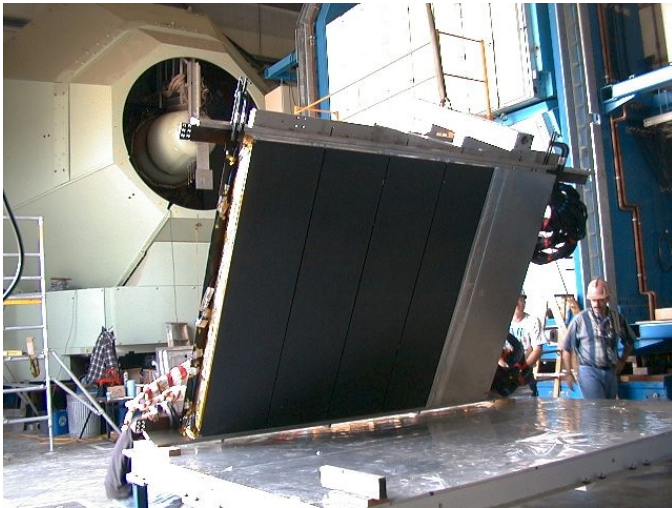
Construction at BNL (1998-1999)



- PMT installation
- Cable Assemble
- Signal Check

Installation in PHENIX

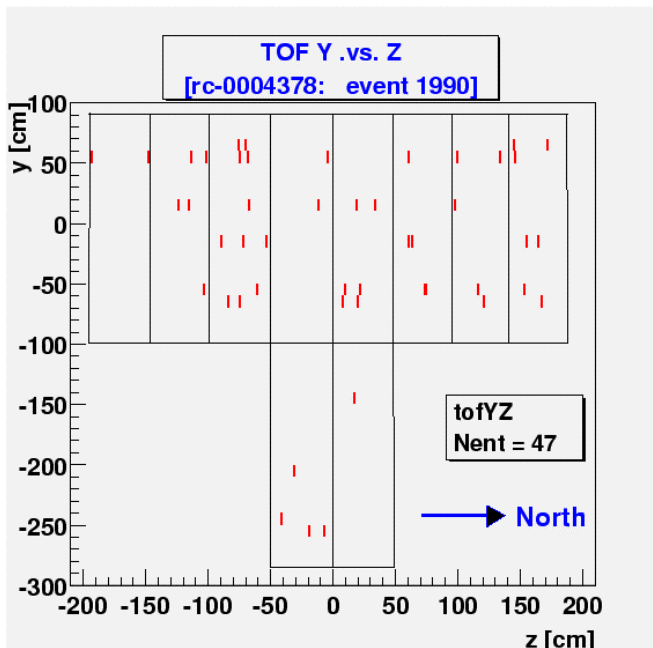
(August 1999)



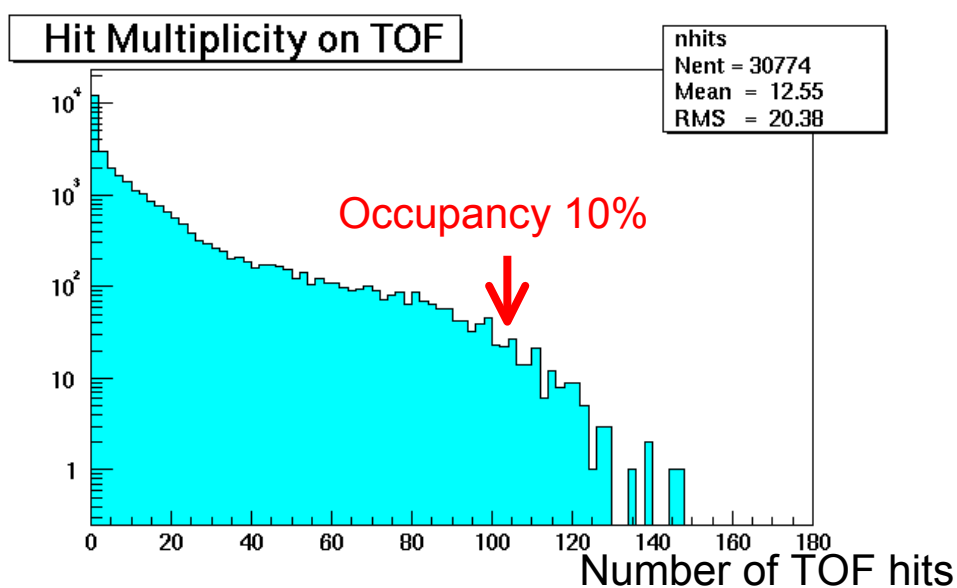
- All 10 panels were installed.

First Collisions at PHENIX

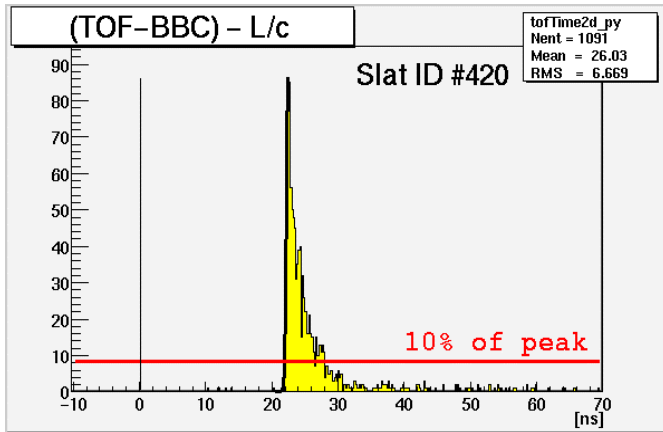
(6/15/2000)



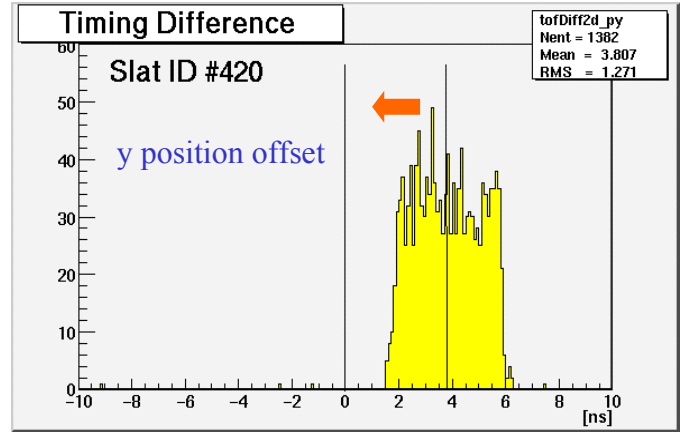
- The event display shows the fired slats of TOF
- TOF occupancy is less than 10%.



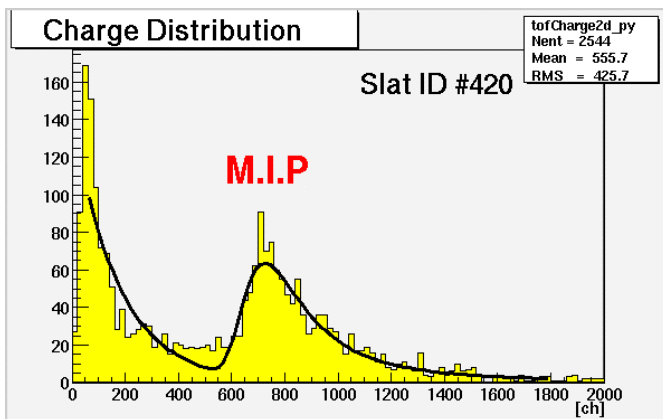
Year-1 Operation: Zero-field Run TOF Calibration



Time offset



$\Delta t = 5$ nsec
~ length of scinti. 64cm

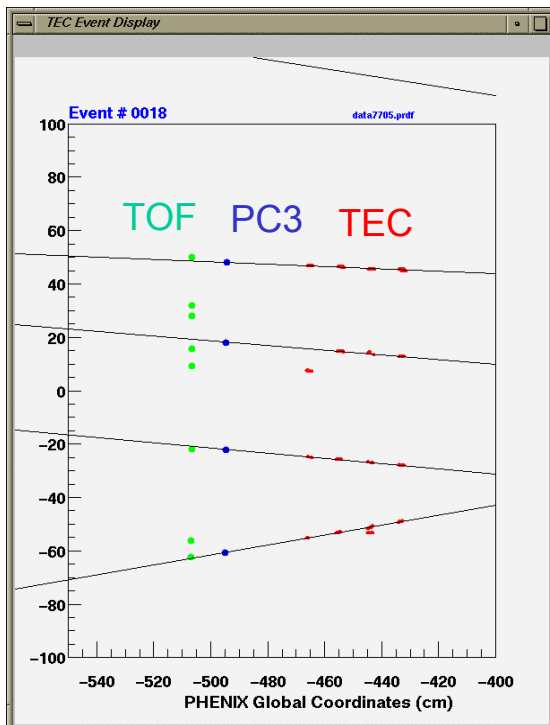
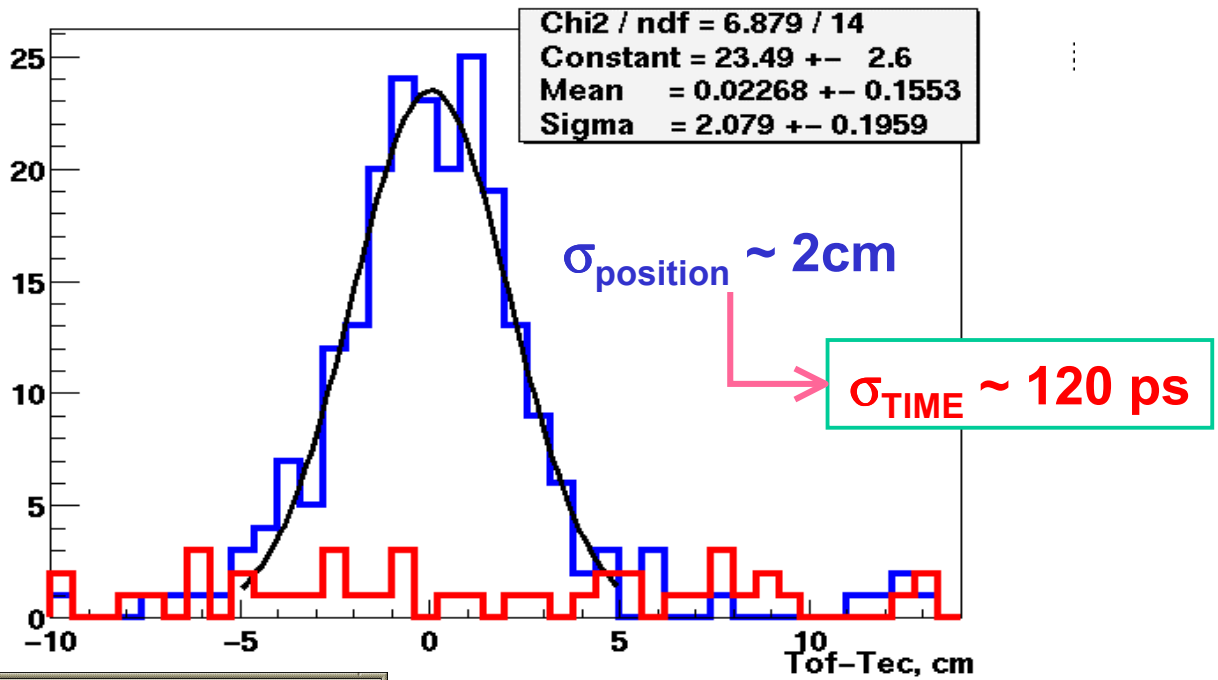


Calibration condition

- BBC Z vertex ($-40 < z < 40$ cm) are required
- L : straight path (from z-vertex TOF hit position with retracted geometry)
- Including BBC Coins, ZDC coins, BBC&ZDC trigger

- Rough calibration parameters obtained. [~ 100 ps level]
 - T0 value and Z-vertex information from BBC.
 - NO tracking information used yet. (To be done)
 - Timing offset, Position offset and Gain Correction

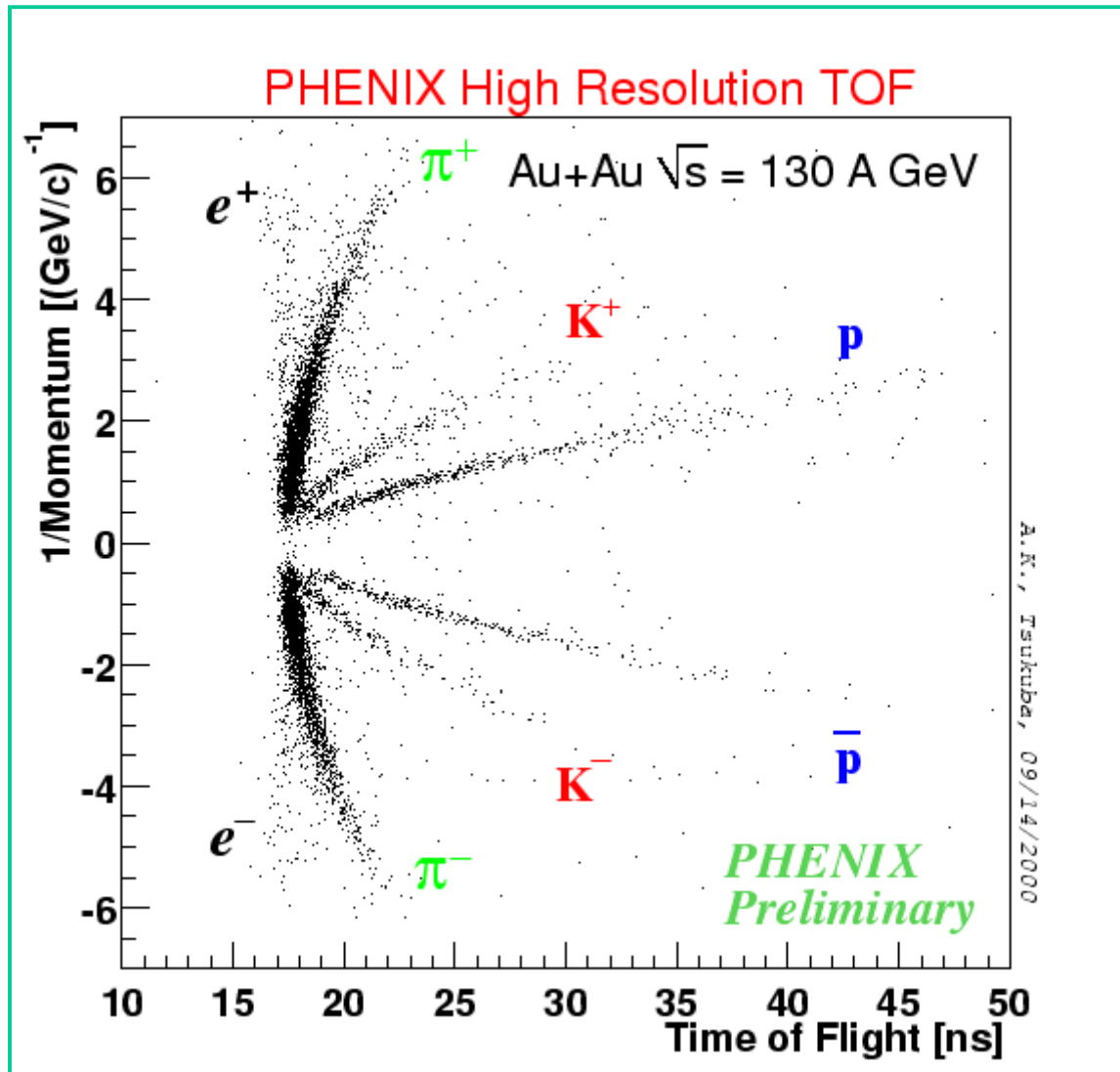
Track matching and TOF intrinsic timing resolution



$$\sigma_{\text{TOF-TEC}} = 2\text{cm}:$$

- Corresponding timing resolution is **120 ps**.
- Consistent with TOF intrinsic timing resolution of 120ps operated without slewing correction.

Particle Identification



- We can see clear π, K, p separation
- No slewing correction
- No final timing adjustment

Summary

- TOF is working in the first RHIC operating year.
- TOF intrinsic timing resolution is **120 ps** from TEC/TOF matching without slewing correction.
- TOF and Tracking chambers demonstrated clear separation of charged hadrons (π, K, p) at Au+Au $\sqrt{s} = 130$ AGeV collision.