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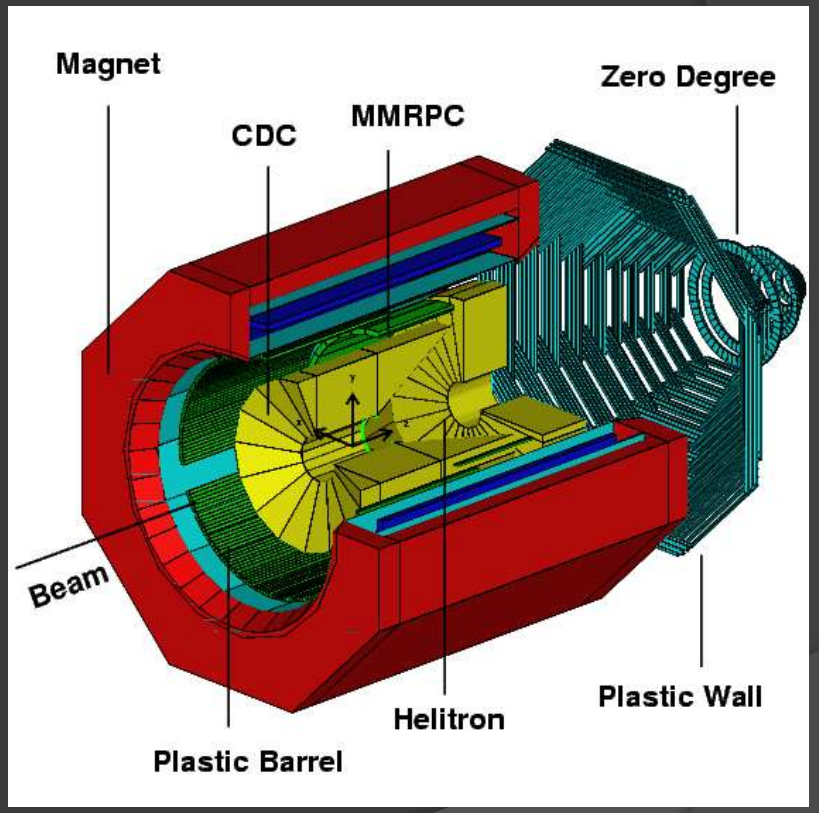
PERFORMANCE OF FOPI MMRPC BARREL IN RECENT HEAVY-ION EXPERIMENTS

Outline

- motivation - FOPI ToF upgrade
- requirements for detector design
- Multi-strip Multi-gap RPC
- detector performace
- summary & outlook

FOPI Detector @ SIS-18

- FOPI (4π) detector at GSI:
  - large acceptance & good charged particle identification
  - beam energy up to 2 AGeV
- physics program: study of strangeness in heavy-ion collisions
- upgrading the charged Kaon ID capability from 0.5 to 1 GeV/c



Requirements for ToF detector

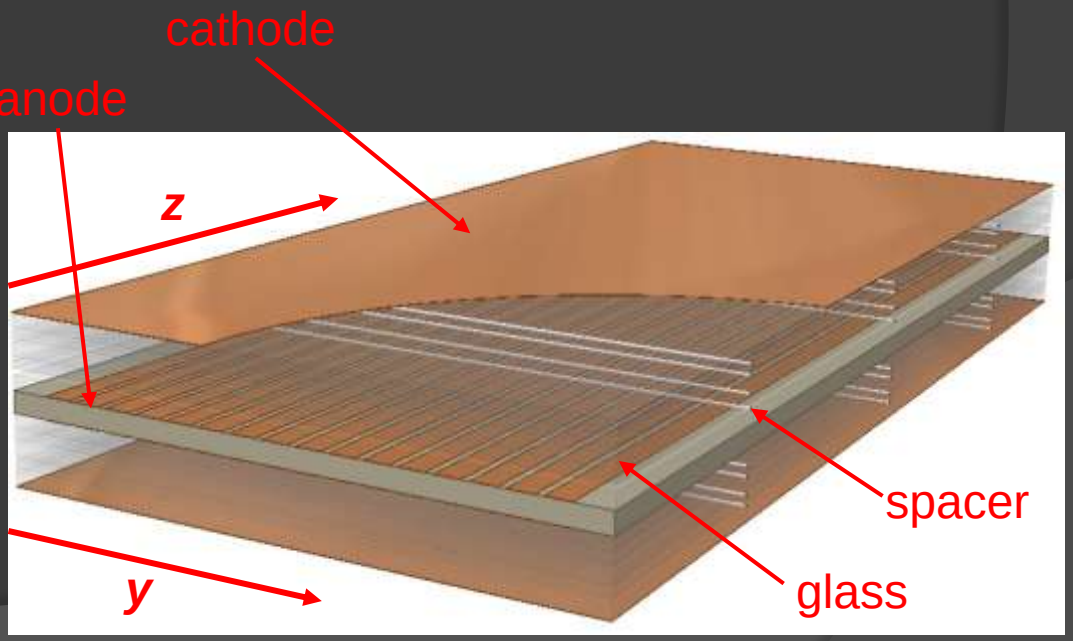
- excellent time resolution: discrimination between charged kaons and pions on 1m flight distance => $\sigma_{ToF} < 100$ ps
- rare probe => high efficiency
- detector in magnetic field 0.6 T
- in Au->Au @ 1.5 AGeV 60 particles expected in Barrel acceptance => high granularity
- space (upgrade)

Solution: Multi-strip Multi-Gap RPC

- design consideration: CDC matching
- long and narrow strips:
- multi-strip: good resolution in y, double-hit capability
- two-sided

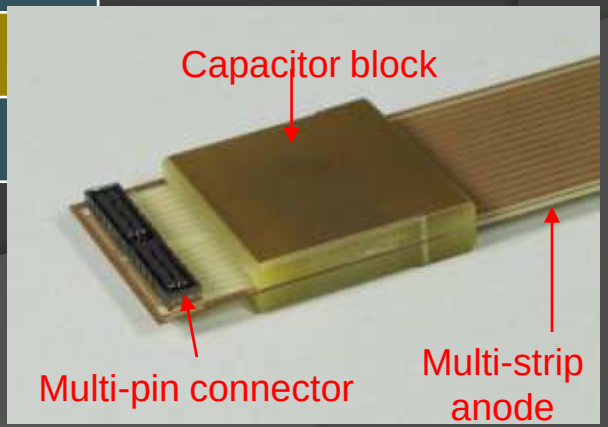
readout: position

resolution in z

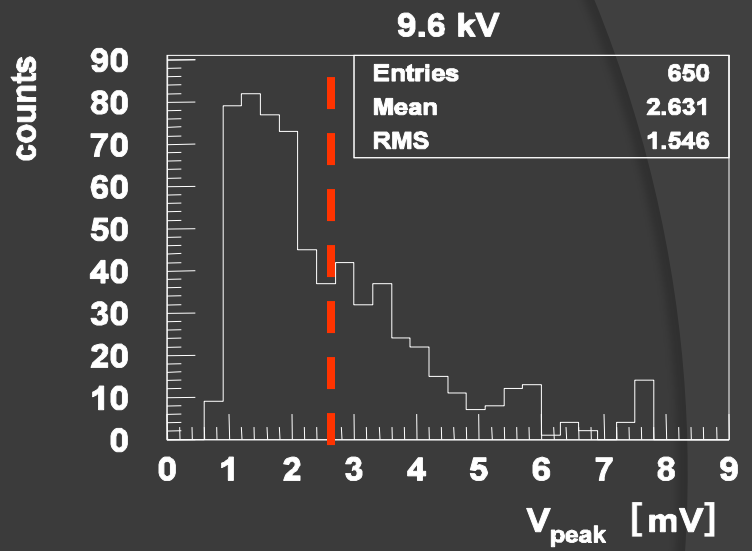


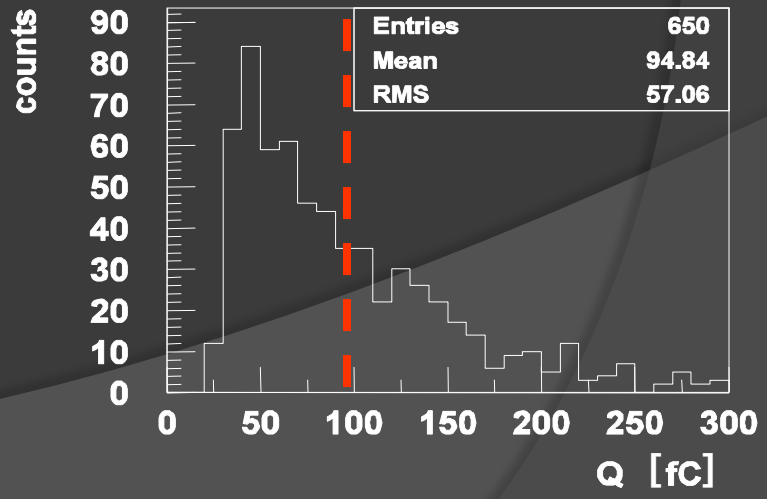
Characteristics of FOPI MMRPC

Operational characteristics:	
active area	90 × 4.6 cm^2
gaps	8 × 220 μm (sandwich)
resistive plate	0.5 and 1 mm float glass
strips	16 (pitch 1.94 mm/0.6mm)
applied voltage (@ full ε)	9.6 kV (E~110 kV/cm)
gas mixture	$C_2F_4H_2$/isobutane/SF_6 80/5/15
avalanche mode	small signals (~40 fC, avr. 95 fC)
signal connection	50 Ω impedance
cross-talk	< 5%



Primary signal of MMRPC

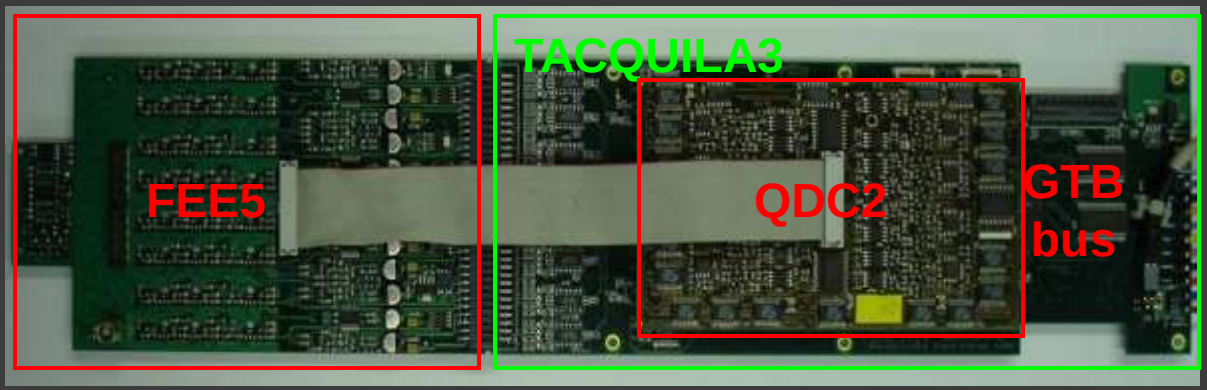




- single-strip cosmics signal measured directly with DSO: average charge ~ 95 fC

Readout electronics: (FEE5 + Tacquila3 + QDC2)

- **custom electronics** developed for MMRPC
- free-running common stop system at 40 MHz



- front-end electronics (FEE5) characteristics:
  - 9.5 x 14.5 cm^2 6 layer PCB
  - 16 channels time + charge
  - 1.5 GHz bandwidth
  - high gain (fixed to 160)
  - power consumption 0.55 W/ch
  - intrinsic time resolution σ_t<18 ps

M. Ciobanu et al., **IEEE Trans. Nucl. Sci 54 (2007) 1201**

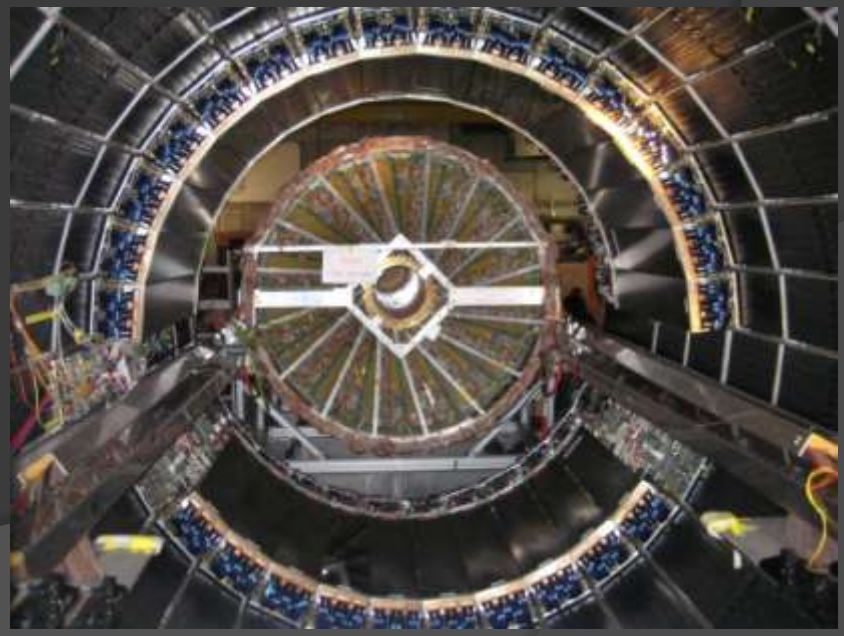
TACQUILA3:
- dimension 9.5 x 25 cm^2
- time ch.: 16 TACs
- intrinsic res. σ_t <10 ps
- charge ch.: 16 ADCs
- power consum. 0.5 W/ch
- up to 30 cards daisy-chained via GTB bus

K. Koch et al., IEEE Trans. Nucl. Sci. 52 (2005) 745

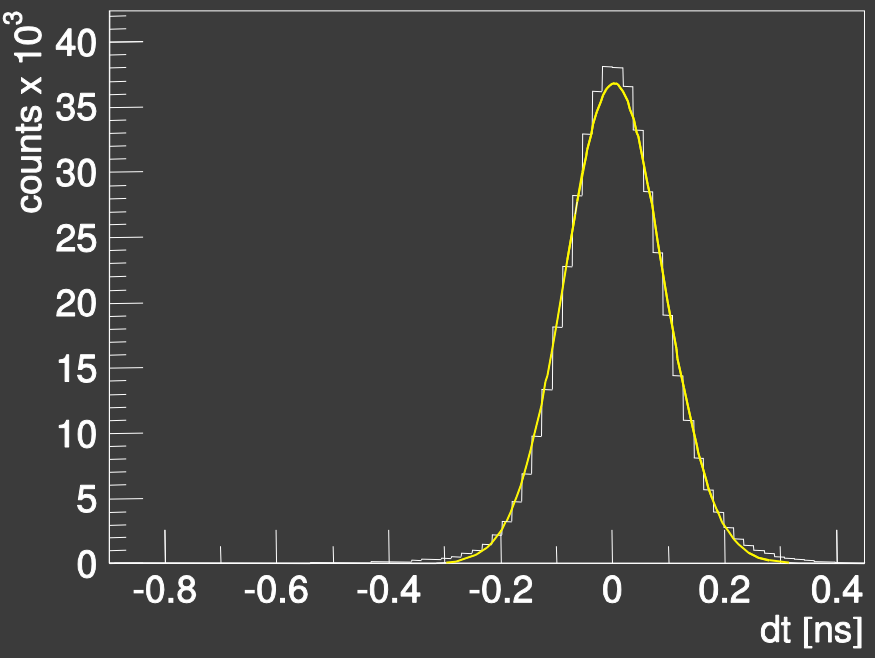
Electronic resolution:
- components:
  FEE5 ~ 18 ps
  TAC ~ 10 ps
  δt ~ 15 ps
- combined system:
  σ_E < 25 ps

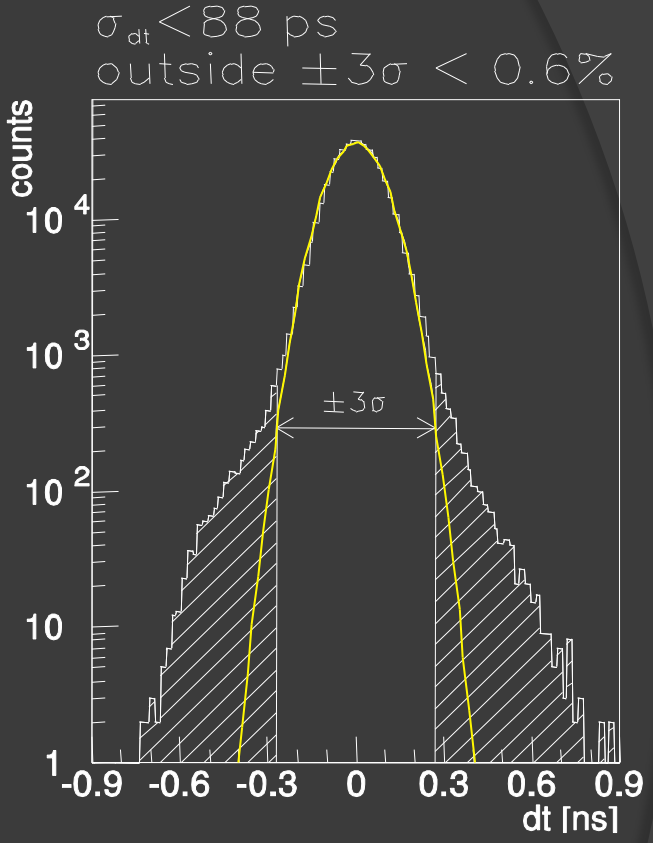
MMRPC ToF Barrel

- MMRPC Barrel consists of 30 Super-Modules
- each SM has 5 counters (16 strips each) = 4800 readout channels
- min. distance to target 0.96 m
- polar angle coverage (relative to nominal target position) 36°-67°
- active area 5.12 m2
- geometrical coverage 88.7%
- in operation from 2007
- stable performance
- experiments: **Ni->Ni**, Ru->Ru, Ru->Pb, p->p, π^-->A



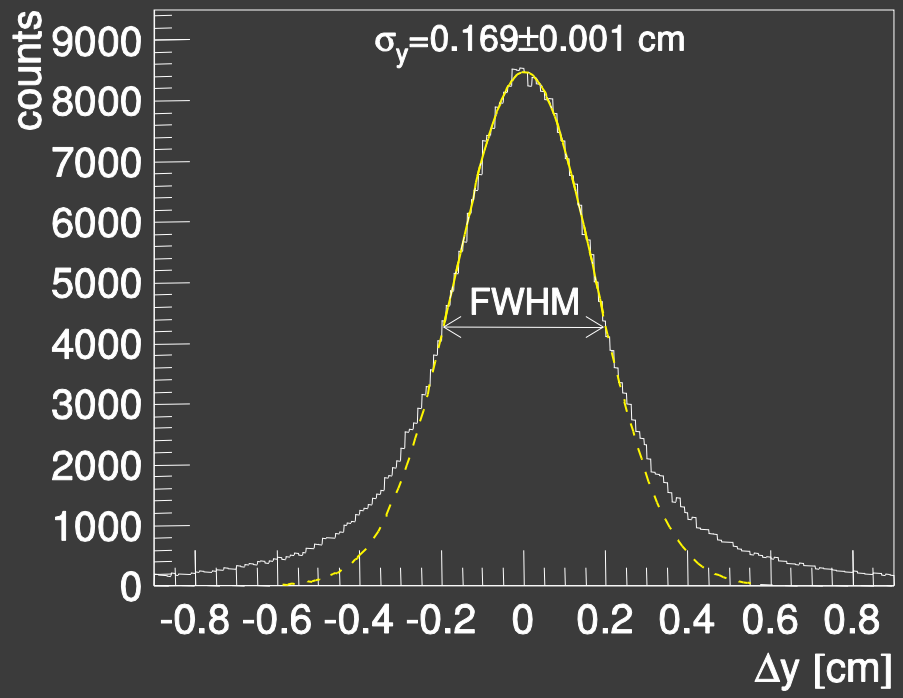
Time resolution

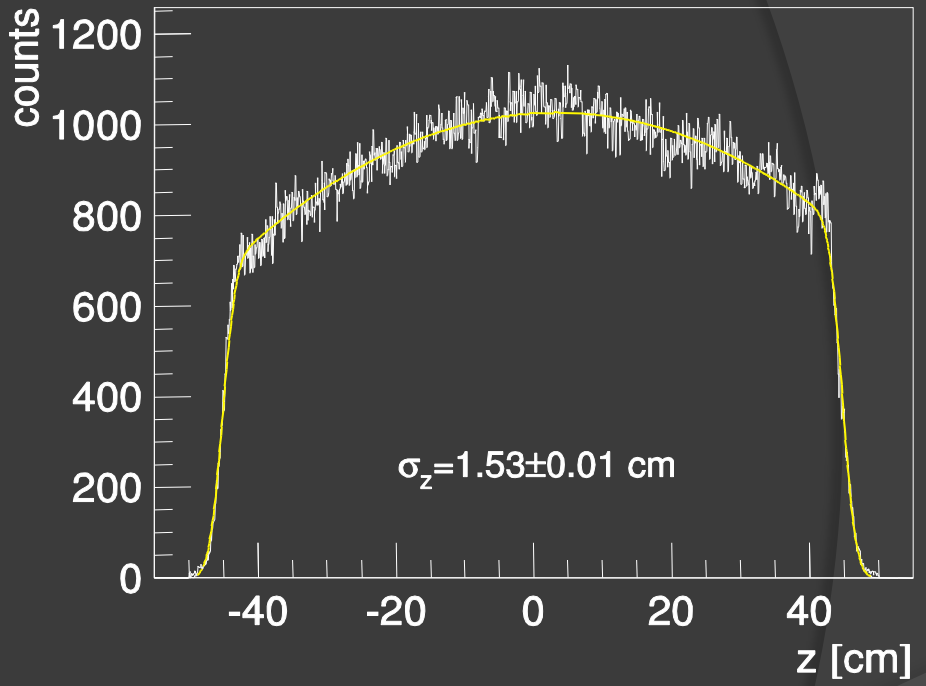




- $\sigma_{ToF} < 90$ ps
- estimated resolution Start detector (PC Diamond): $\sigma_{Start} < 55$ ps
- time resolution of MMRPC: $\sigma_{MMRPC} < 70$ ps

Position resolution

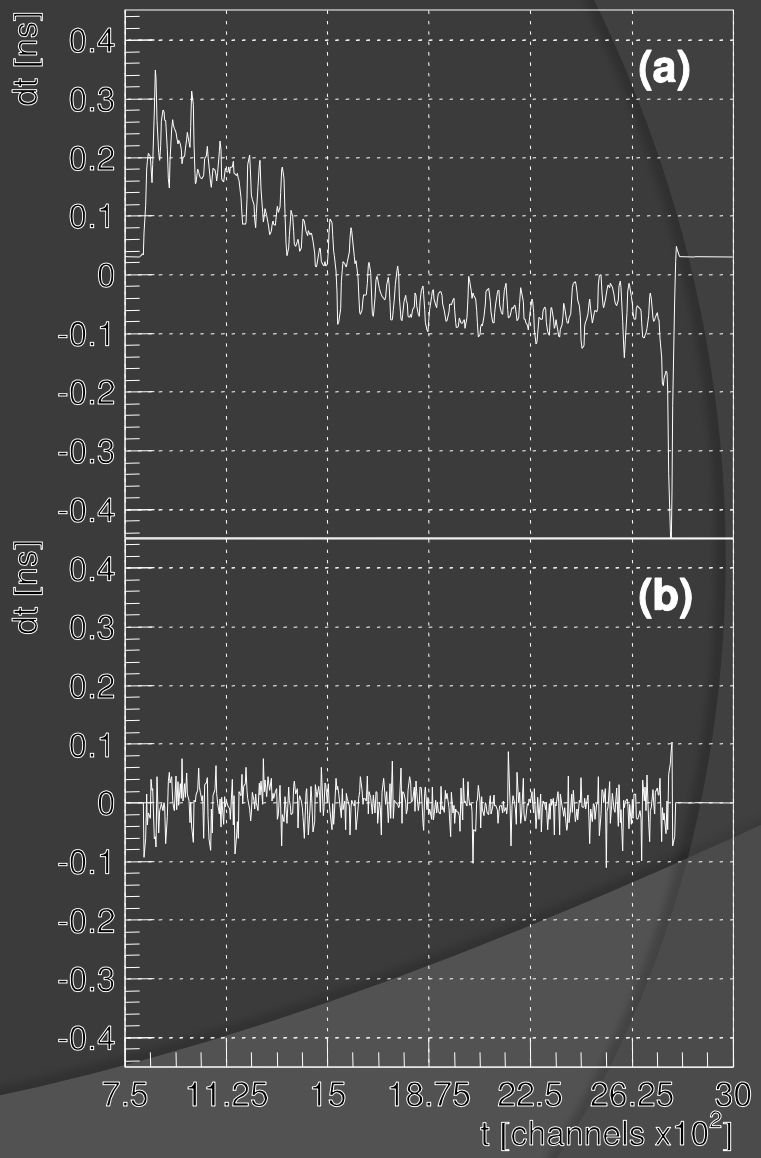




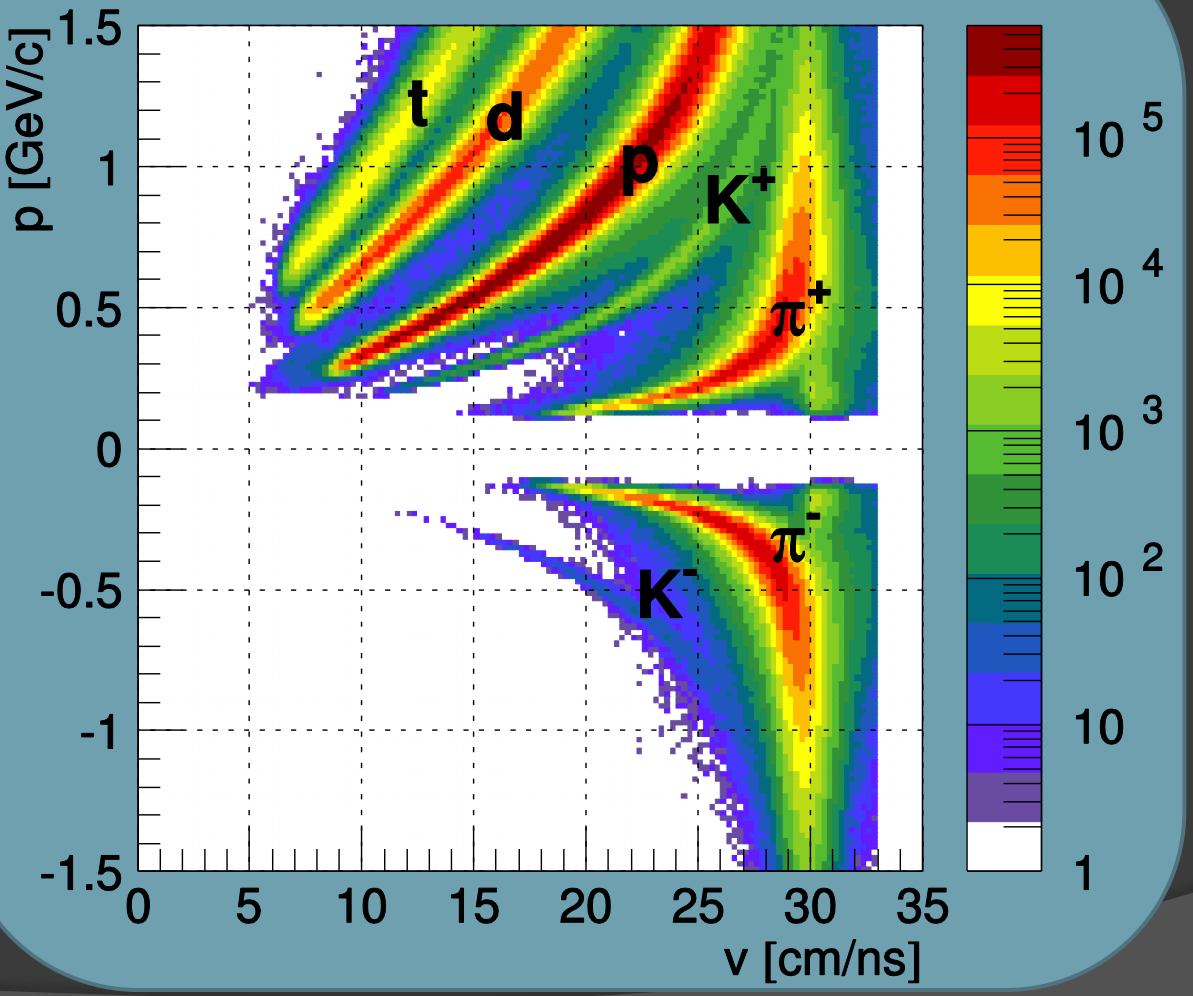
- position resolution relative to CDC: extrapolated tracks
- estimate using fit across the counter: $\sigma_y < 0.17$ cm (pitch 1/10 in)
- along the strips: $\sigma_z < 1.55$ cm (ERF)

Calibration issues

- due to new electronics it took some time before all effects were recognized and corrected
- one particular example is correction of differential non-linearity (DNL) that are intrinsic to tacquila cards
- temperature dependence, has to be done periodically
- one needs a large statistics to correct each channel, in our case we do it per tacquila card



Particle identification



- discrimination between kaons and other charged particles is improved:

K^+/π^+ up to 1.2 GeV/c

K^-/π^- up to 0.8 GeV/c

- result depends not only on performance of MMRPC, good performance of Start detector is paramount

Summary & outlook

- FOPI MMRPC ToF Barrel is in operation since 2007 (5 experiments)
- HI program as proposed by collaboration before upgrade is finished
- performance of the detector is in agreement with design parameters:

  $\sigma_{ToF} < 90$ ps, $\sigma_{MMRPC} < 70$ ps
- time resolution of ToF strongly depends on performance of Start detector
- efficiency relative to CDC is 95%

Summary & outlook

- position resolution in transversal and longitudinal direction:

  $\sigma_y < 0.17$ cm and $\sigma_z < 1.55$ cm
- this allows charged kaon ID up to 1GeV/c as required for upgrade

- no signs of ageing inside of detector so far (visual inspection)
- “robust detectors”: glass, gas, HV…
- if rate is not a problem:

  highly recommendable

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