A New Time of Flight System for the FOPI Detector

Budapest *(Hungary)*, Bucharest *(Romania)*

Clermont-Ferrand *(France)*, Darmstadt *(Germany)*, Dresden *(Germany)*

Heidelberg *(Germany)*, Moscow *(Russia)*, Seoul *(South Korea)*

Strasbourg *(France)*, Warszawa *(Poland)*, Zagreb *(Croatia)*

and

Coimbra *(Portugal)*

Physics Motivation

Pestov Spark Counter (PesToF)

Glass Resistive Plate Chamber ($\varnothing$ 5 cm)

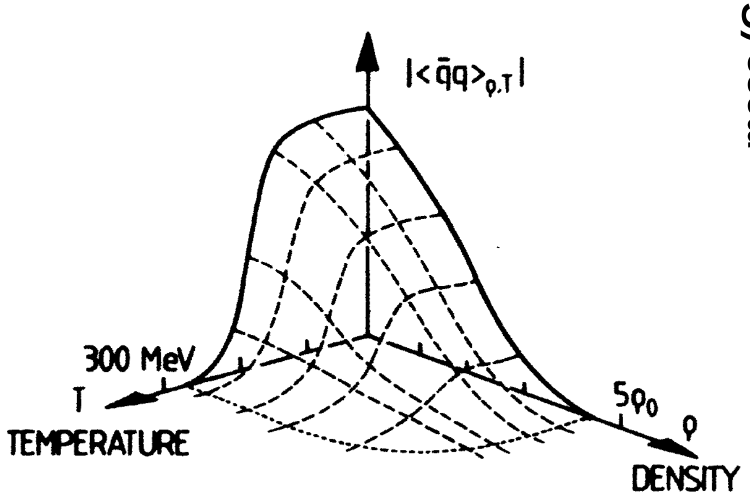
Stripe Glass Resistive Plate Chamber (160×10 cm)

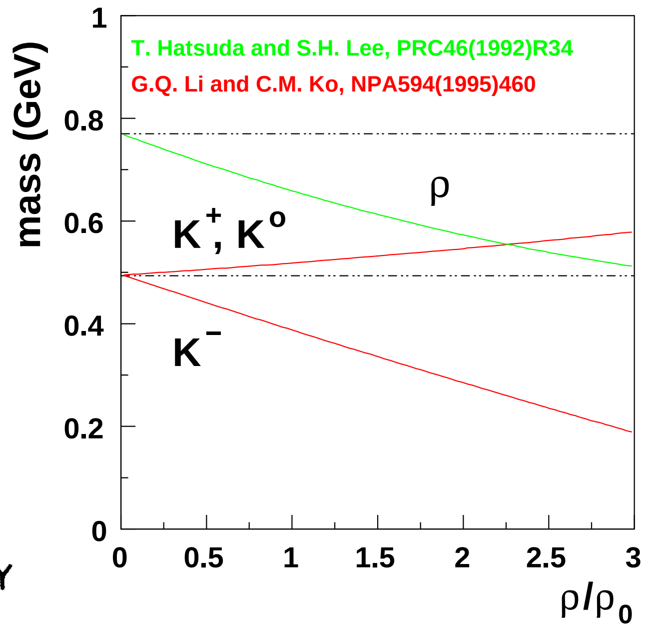
Conclusion

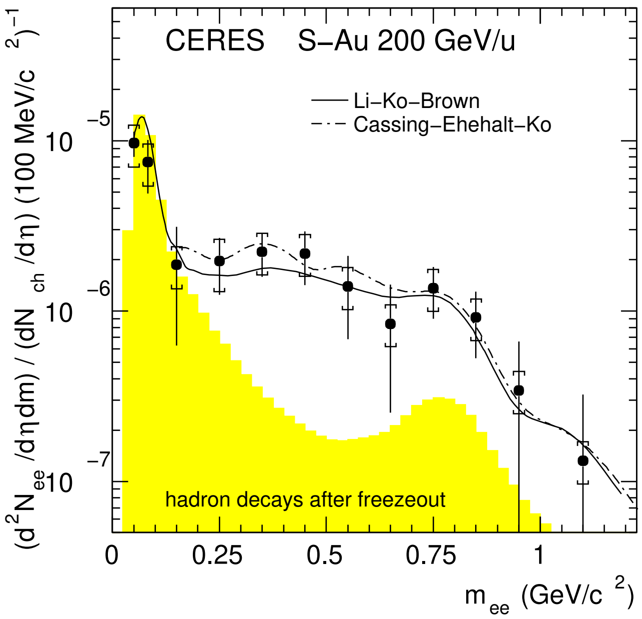
Physics Motivation

▷ In-Medium Effects:

- Mass Modification with Medium







- Some Evidences

e^+e^- Inv. Mass Spectrum:

$\rightarrow$ Broadening & Shift of the ρ Meson Peak

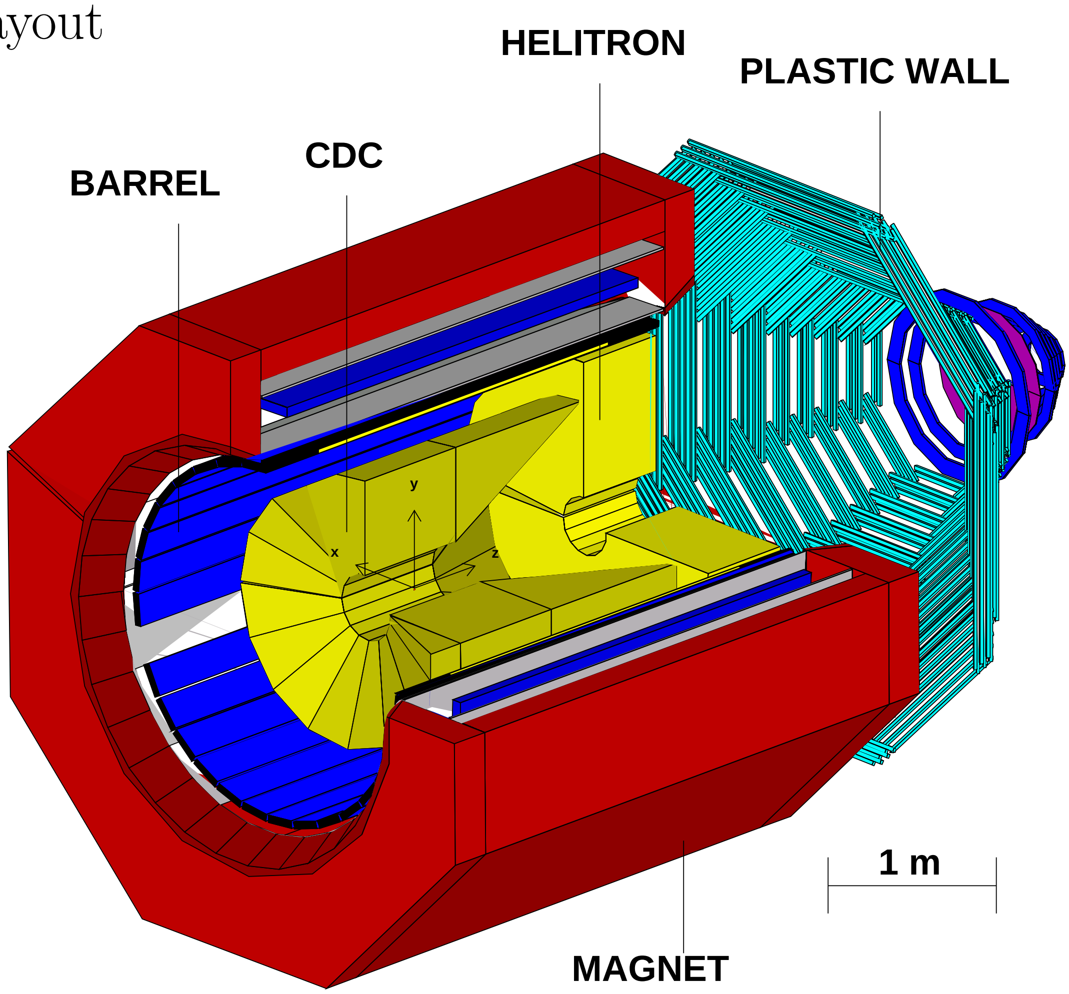
- Others Observables:

$\Downarrow$

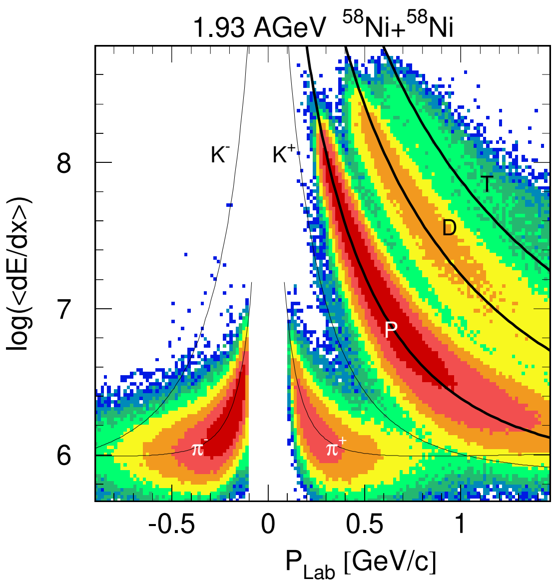
		with in–medium effects	
	$E_{threshold}$ (GeV)	yield	momentum
K^-	2.5	↗	↘
K^+	1.6	↘	↗
K^o	1.6	↘	↗

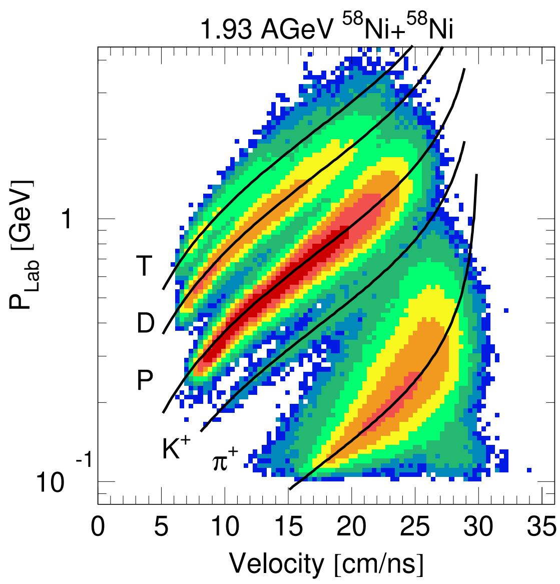
▷ FOPI Detector:

◦ Layout



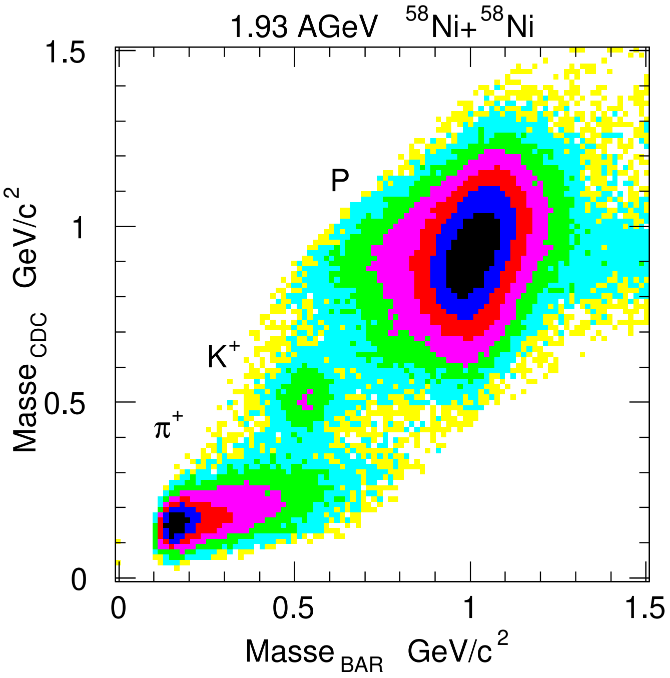
◦ Particle Identification

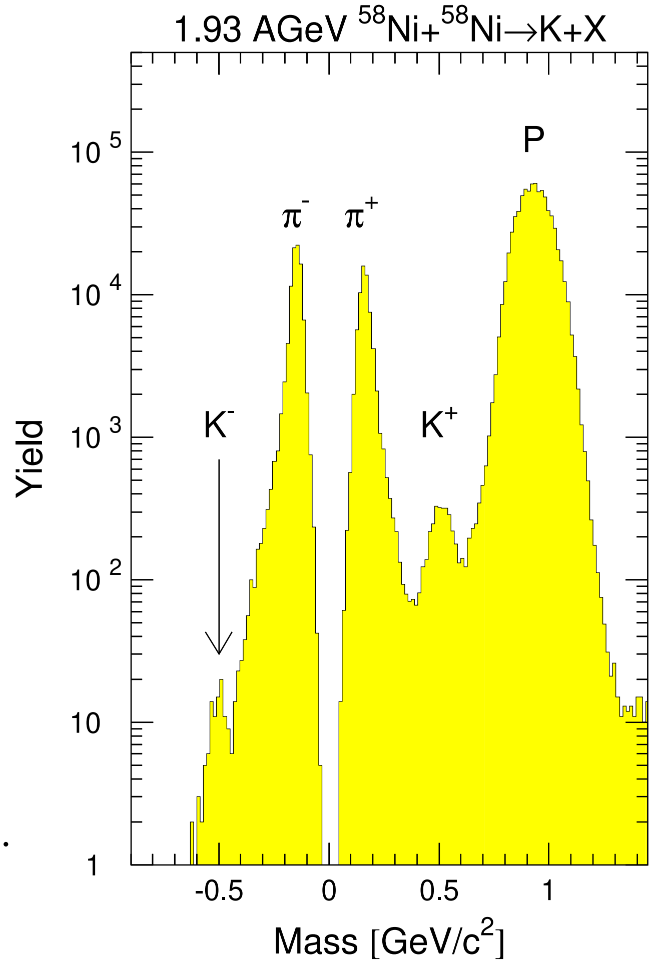




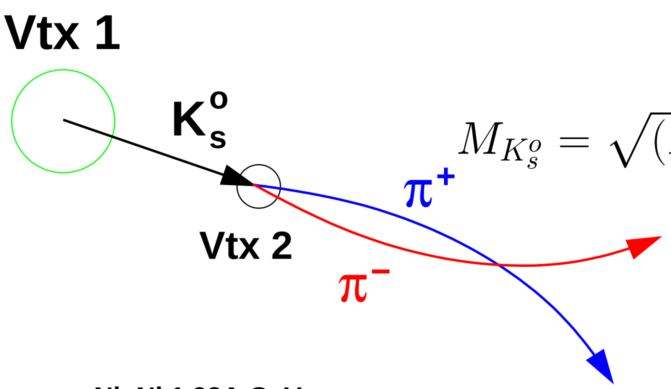
CDC: Bethe-Bloch   CDC/ToF: $P = \gamma m \beta$

○ Charged Strange Particle Id.

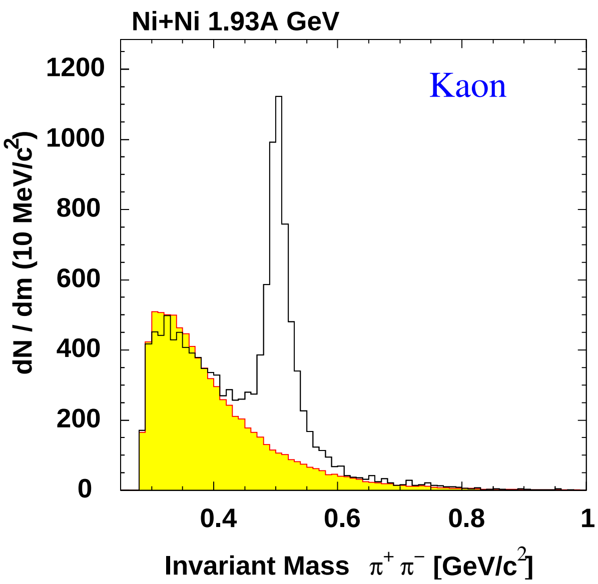


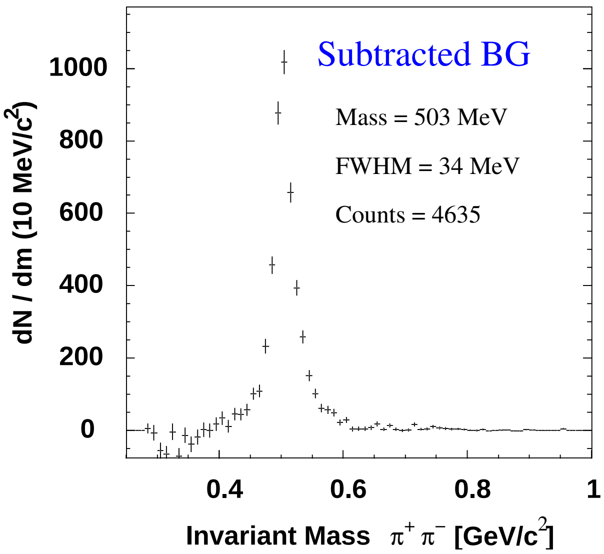


○ Neutral Strange Particle Id.

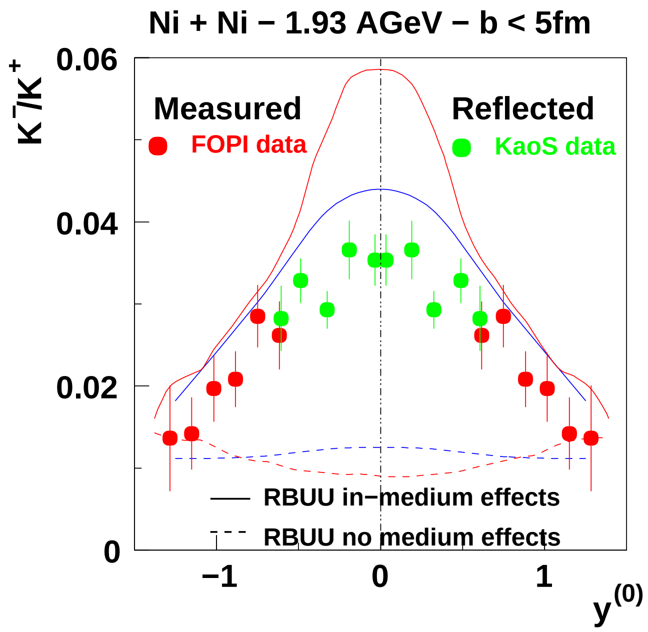


$$M_{K_s^o} = \sqrt{(E_{\pi^+} + E_{\pi^-})^2 - (P_{\pi^+} + P_{\pi^-})^2}$$





- Results (highlights)
  - Ratio K^-/K^+



M. Menzel et al., GSI-Report 2000-01, p47

K. Wisniewski et al., accepted for publication in EPJ.A

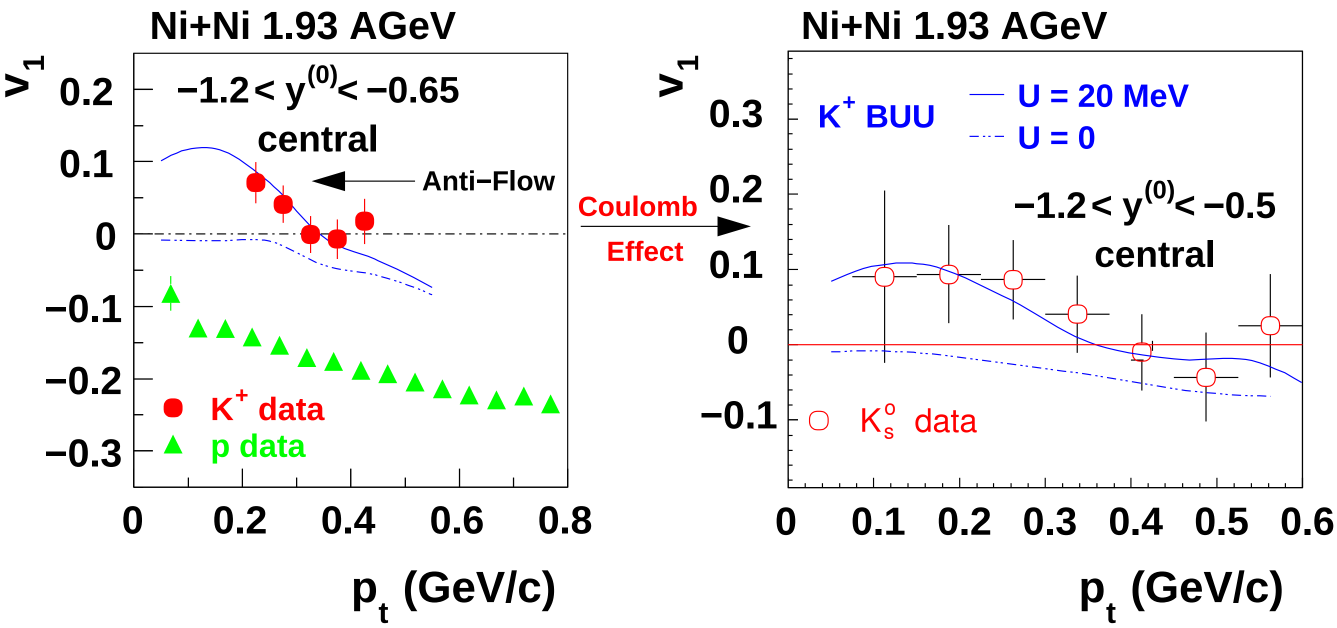
G.Q. Li and G.E. Brown, Phys. Rev. C58 (1998) 1698

W. Cassing and E.L. Bratkovskaya, Phys. Rep. 308 (1999) 65

K^- Yield $\nearrow$, Attractive Pot. at Mid-Rapidity (fireball)

K^+ Yield $\searrow$, Repulsive Pot.

  - Directed Differential Flow ($v_1 = < \frac{P_x}{P_t} >$)

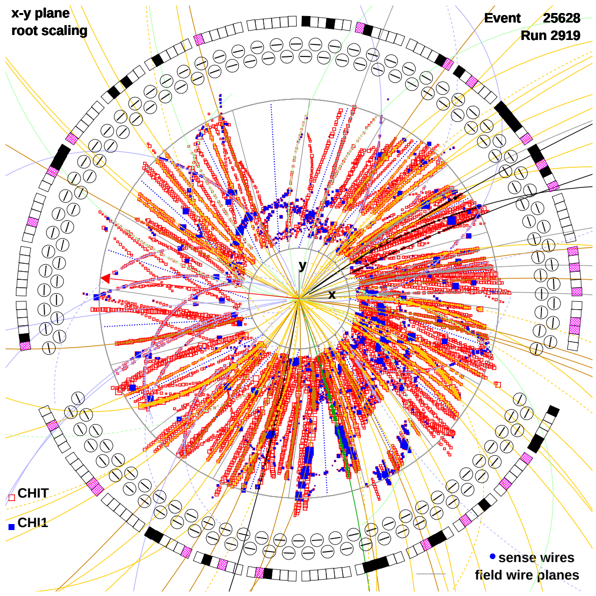


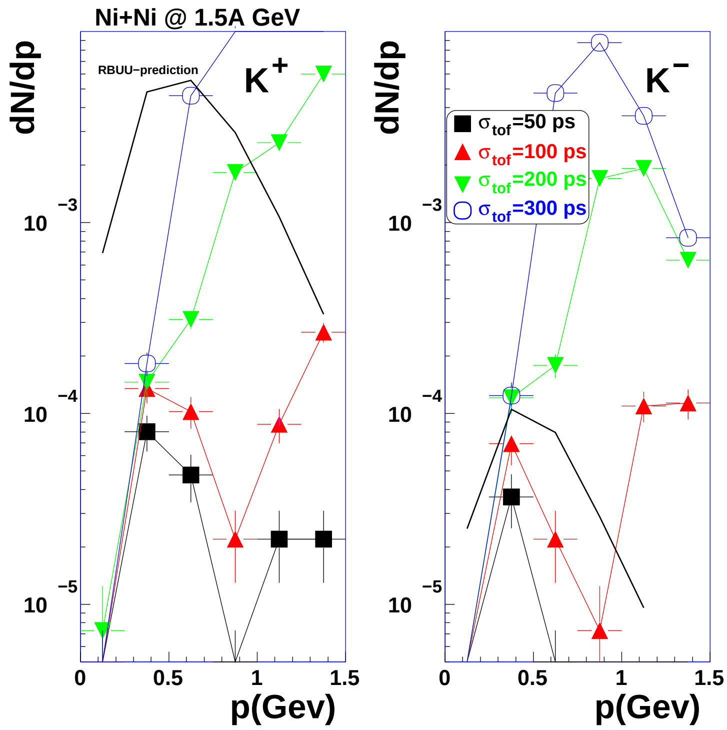
Ph. Crochet et al., PLB486 (2000)/R. Kutsche, thesis DISS.2000-05 (2000)

$\Longrightarrow$ Data Favor the In-Medium Scenario

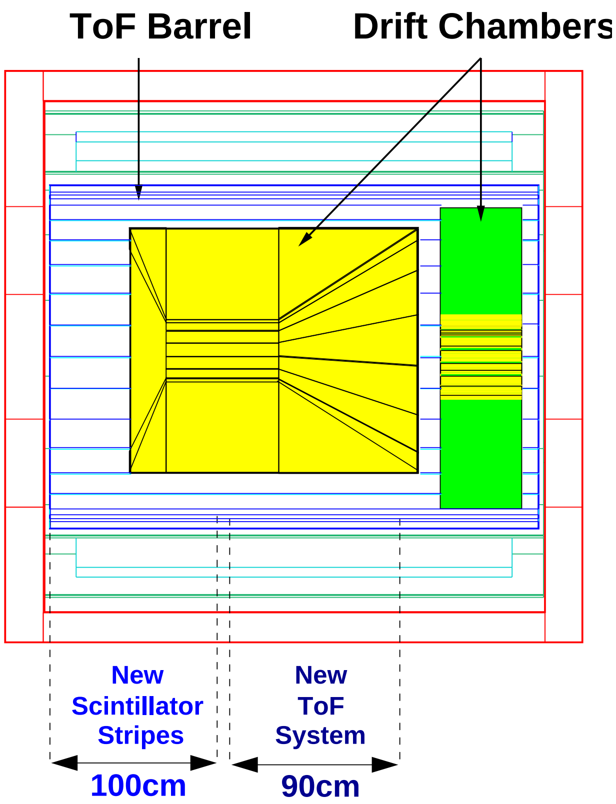
$\Longrightarrow$ DDF for K^-, Higher $\rho \rightarrow$ Au + Au

- Goal





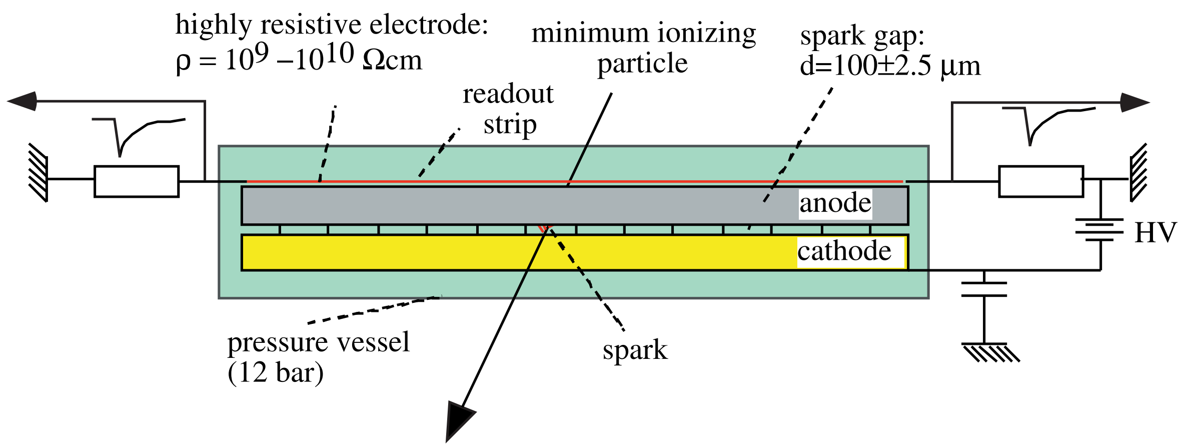
  - ◇ Au + Au @ 1.5A GeV
    - → Granularity : ∼ 700
    - → Resolution : < 100 ps
- FOPI Upgrade



- CDC/Hellitron:
  Wires Changing
  Faster Readout electronics
- DAQ
  Speed Up Factor ∼ 50
- ToF Barrel
  New Scintillators Stripes
  New ToF with Gas Detectors

PesToF Spark Counter

▷ Layout: (30 cm and 90 cm)



◇ Cathode: (bulk Al)

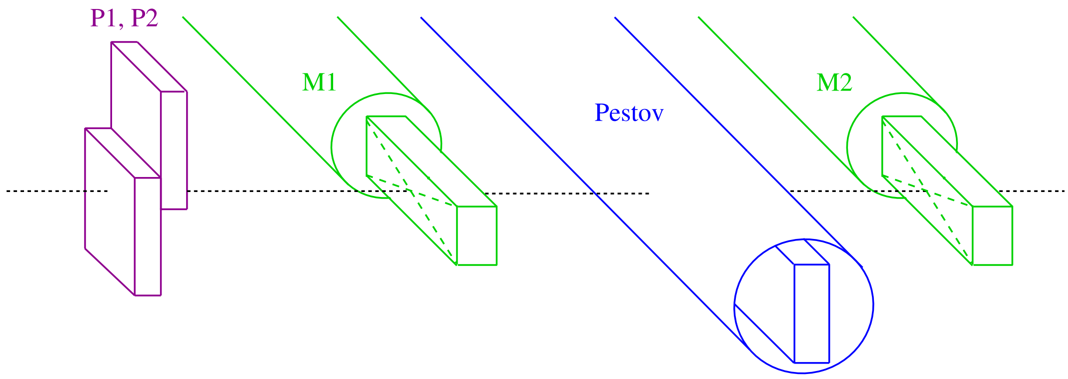
◇ Anode: (glass: $\rho \sim 5\ 10^9\ \Omega{\cdot}\mathrm{cm}$)

◇ Gas Mixture: (12 atm)
(77% Ne + 20% Iso-C_4H_{10} + 2.5% C_2H_4 + 0.5% C_4H_6)

◇ 16 Stripes Readout Board

▷ Beam test: (@ GSI)

○ Setup (rate: $\leq$ 50 Hz/cm^2)



◇ Fragmented ^{12}C @ 1.5A GeV $\rightarrow$ proton (MIP)

◇ Scintillator P1, P2 $\rightarrow$ Beam Focusing

◇ Scintillator M1, M2 $\rightarrow$ Start Counters

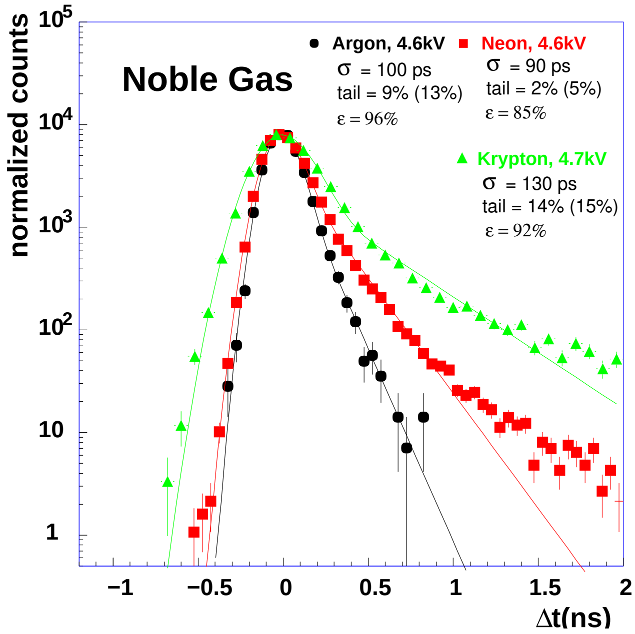
○ Results (30 cm)

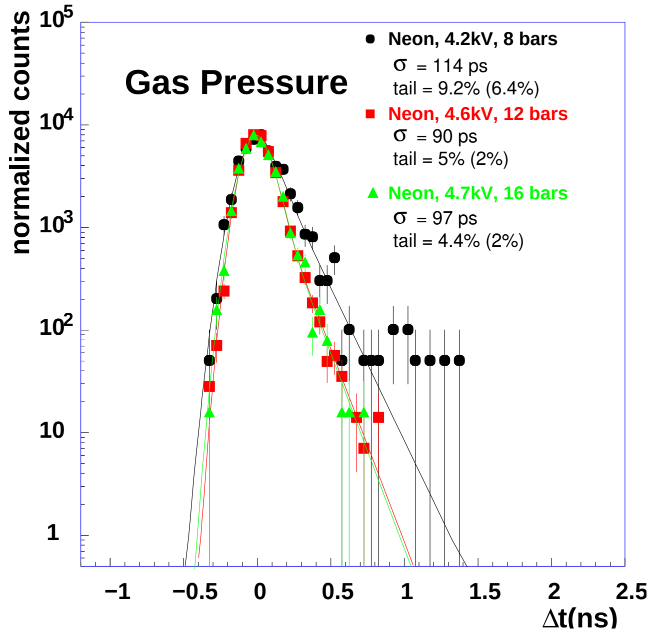
◇ Definitions

Efficiency: $\epsilon = N_{pes}/N_{trig}$

Absolute Tail: Events Outside $\pm$ 300 ps/Total Events

(Relative Tail): Events Outside Gaussian/Total Events





◇ Noble Gas

Best Time Response For Ne:

→ Highest Townsend Coeff. (α) Drift Velocity (v_{drift})

Higher Efficiency for Ar and Kr:

→ Higher Atomic Number: (Z_{Ne}=10, Z_{Ar}=18, Z_{Kr}=36)

◇ Gas Pressure: (for Ne gas mixture)

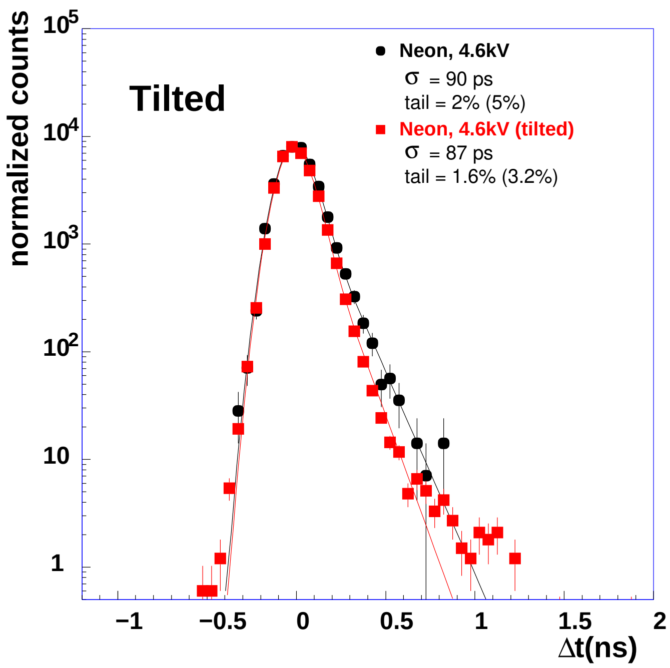
Smaller Mean Free Path: ($1/\alpha$)

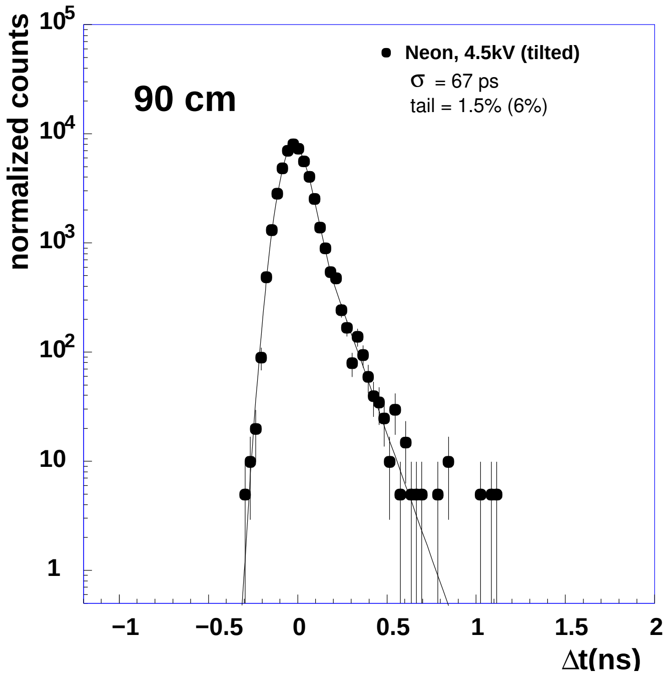
→ Degradation with Decreasing Pressure

→ No Improvement with Increasing Pressure

Rem: No Optimization of the Electronics (grounding)

◦ Results (30 cm & 90 cm)





◇ Tilted Position: (45^o)

Higher Energy Loss:
$\rightarrow$ Reduction of the Tail

◇ 90 cm Counter: (better grounding and electronics.)

Standard Ne Gas Mixture at 12 Atm.:
$\rightarrow$ $\sigma_{int} \sim$ 60 ps
$\rightarrow$ Absolute Tail ($\pm$ 300 ps) of 1.5 %

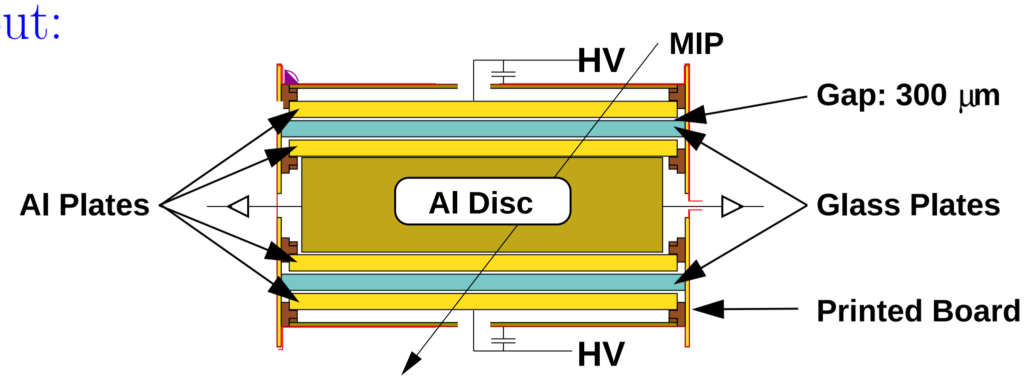
▷ Conclusion:

◦ Fulfilled the Requirements of FOPI

◦ High Requirements for the Glass Anodes
(Flatness: $\pm$ 3 μm, $\rho \sim 5\ 10^9\ \Omega{\cdot}$cm)

Glass Resistive Plate Chambers (∅ 5 cm)

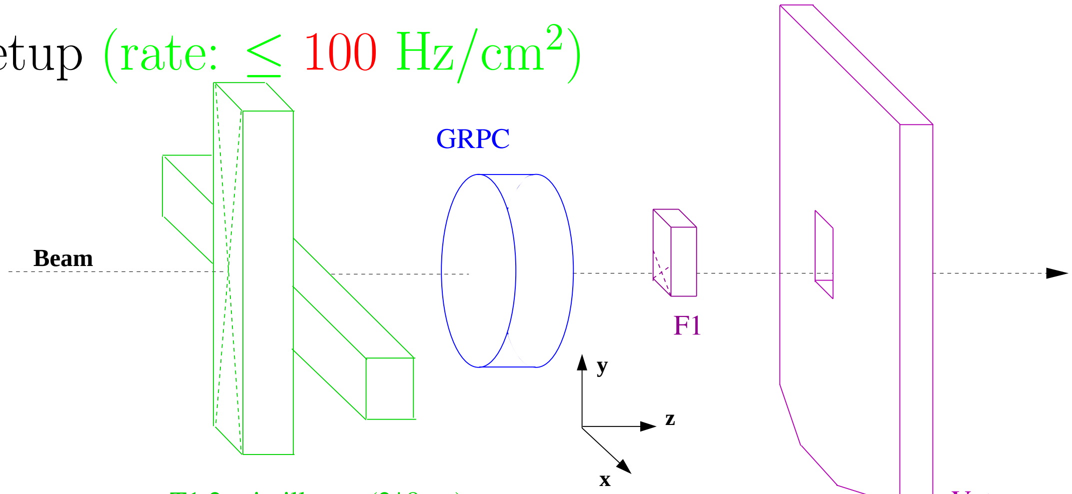
▷ Layout:



- ◇ 2 Glass Plates of ∅ 50 mm ($\rho \sim 10^{12}$ Ω·cm)
- ◇ 4 Aluminum Plates of ∅ 47 mm (HV ∼ 6 kV)
  → No Spacers: Glass and Al Plates Glued on PB.
- ◇ Two Pre-amplifiers via an Aluminum Disc
- ◇ No Floating Anode: Tension Divider
- ◇ Gas Mixture: (1 atm)
  85% freon +10% SF_6 + 5% iso-C_4H_{10}

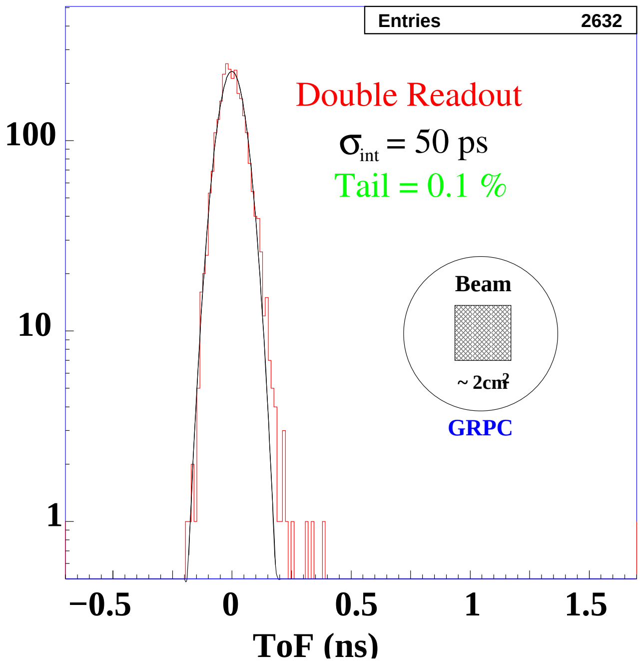
▷ Beam test: (@ CERN)

- ∘ Setup (rate: ≤ 100 Hz/cm^2)



- ◇ π's @ 3.5 & 7 GeV/c,
- ◇ Scintillator F1 and Veto Paddle → Beam Positioning
- ◇ Scintillator T1, T2 → Start Counters

▷ Resolution in the Center:



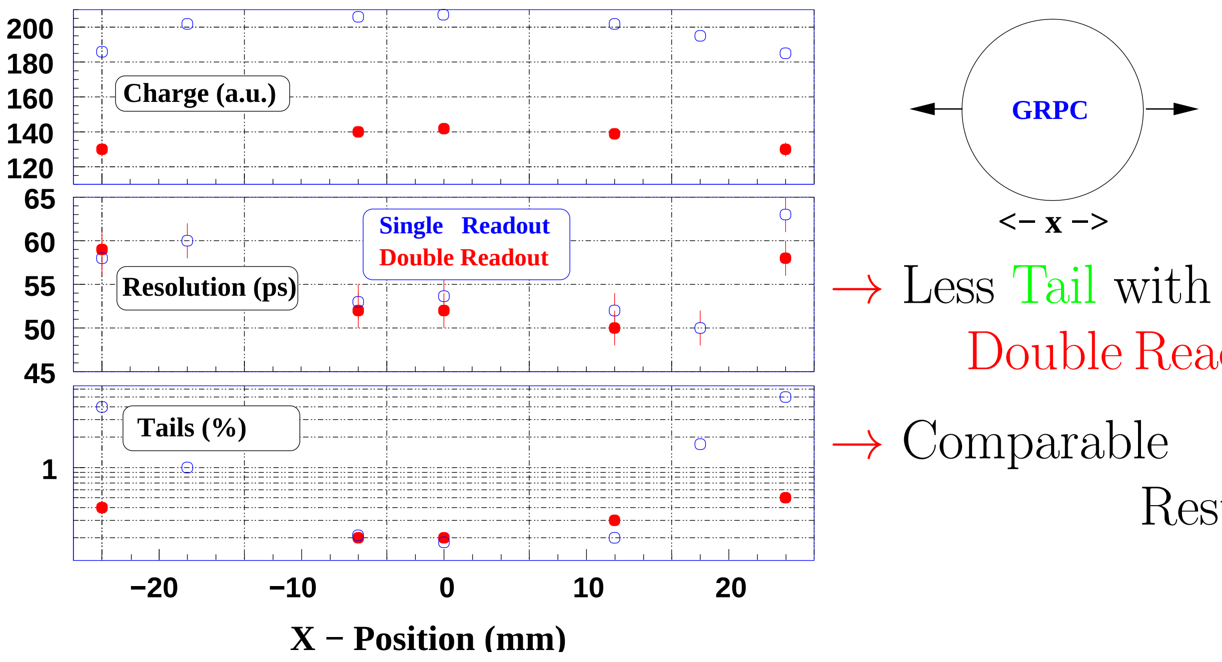
◇ Efficiency: > 99 %

◇ Intrinsic Resolution: ∼ 50 ps

◇ Absolute Tails: ∼ 0.1 %
(events outside ± 300 ps)

→ Good Time Response Function

▷ Position Dependence:



→ Less Tail with Double Readout

→ Comparable Results

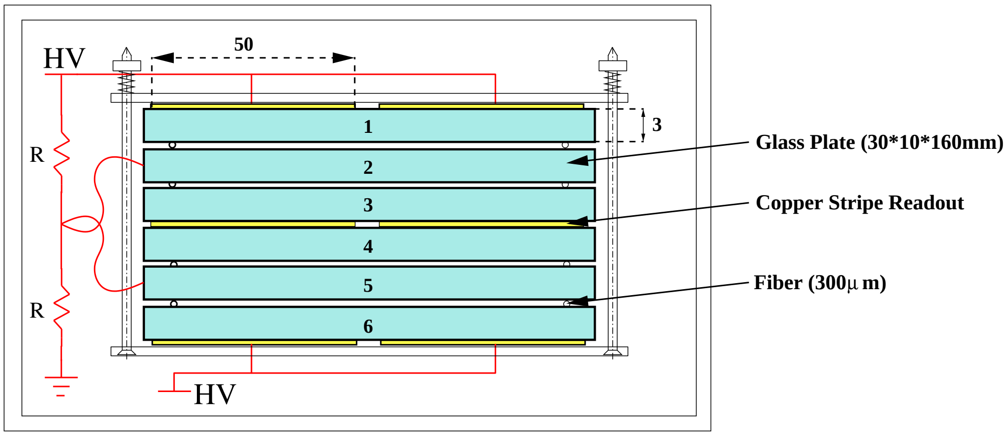
◇ Intrinsic Resolution at the Edge: ∼ 60 ps

◇ Absolute Tails: < 1 % (double readout mode)

→ Small Edge Effects

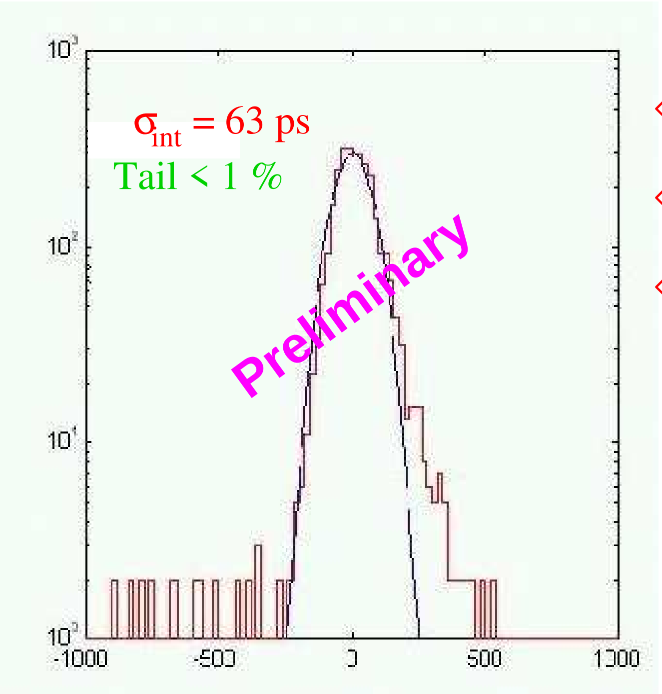
Stripe GRPC (160 × 10 cm)

▷ Layout:



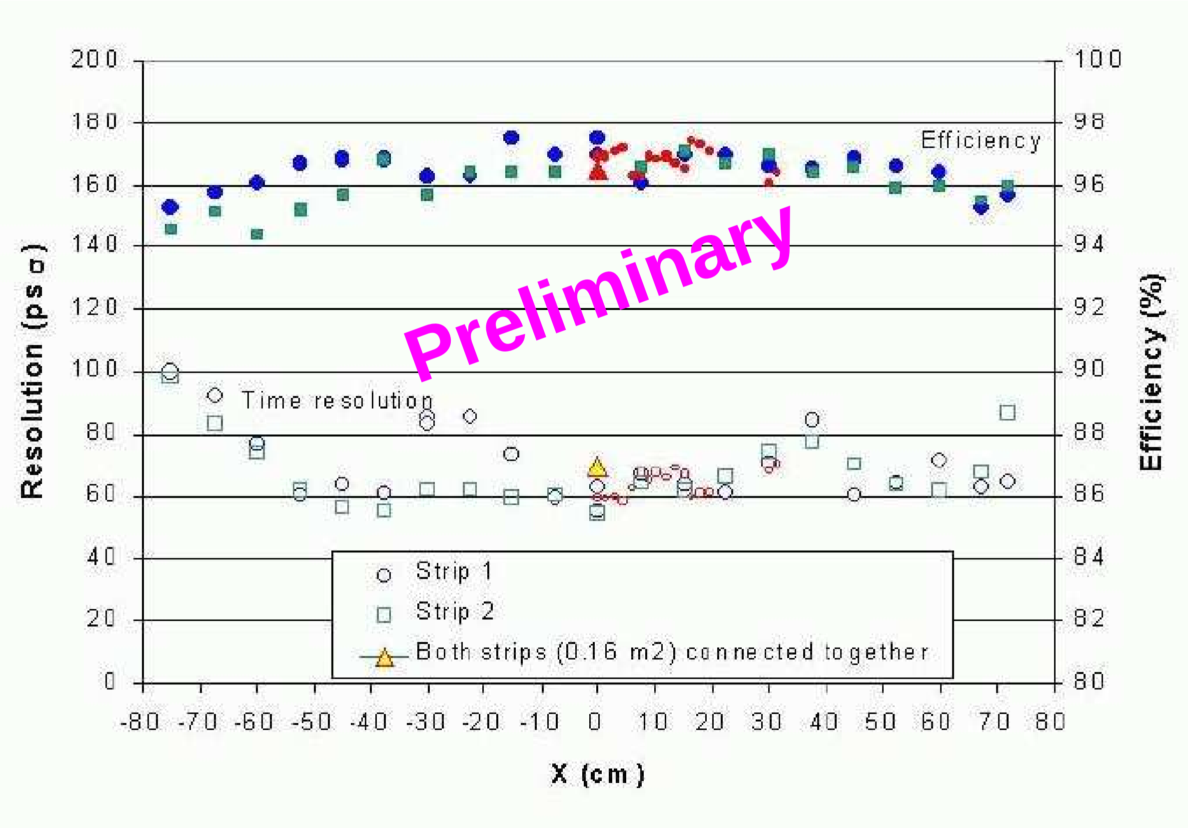
- ◇ 6 "Normal" Glass Plates: ($\rho \sim 2\times10^{12}\ \Omega \cdot \mathrm{cm}$)
- ◇ 4 Gaps Maintained with Spacers: (fibers of 300 μm)
- ◇ 6 Copper Stripes: (4 for HV, 2 for readout)
- ◇ Tension Divider: (no floating anode)
- ◇ Standard Gas Mixture: (same as for the ∅ 5 cm counter)

▷ Resolution in the Center:



- ◇ Intrinsic Resolution: $\sim$ 60 ps
- ◇ Absolute Tails: $<$ 1 %
- ◇ Efficiency: $>$ 97 %

▷ Position Dependence:



◇ High Efficiency: > 96 %

◇ Good Resolution along the X-Axis: ∼ 70 ps

→ Except on the Left Side

(one plate cracked during transportation)

◇ Small Fraction of Tail

⇒ Very Promising Results

⇒ Still Open Questions (edge effects, cross-talks etc...)

Conclusion

▷ PesToF Counters:

- ∘ Good Time Response Function (in σ and tail)
- ∘ Good Knowledge of Detector Perf. (3 years of R & D)
- ∘ High Pressure Gas (12 atm)
- ∘ Pb with Glass Production (cristalization spots $\leftrightarrow$ ρ)

$\rightarrow$ 2/3 of the ordered plates are not usable

▷ GRPC Counters:

- ∘ Good Time Response Function (in σ and tail)
- ∘ New Technique (needs of R & D)
- ∘ Atm Pressure
- ∘ Commercial Plates (no need for high accuracy)

$\Longrightarrow$ Next FOPI-ToF with Stripe GRPC

$\Longrightarrow$ New Design in Progress

$\Longrightarrow$ New Prototype under Beam soon