A Forward Tracker for STAR

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Outline

I Motivation

II STAR-Introduction

III STAR-FTPC

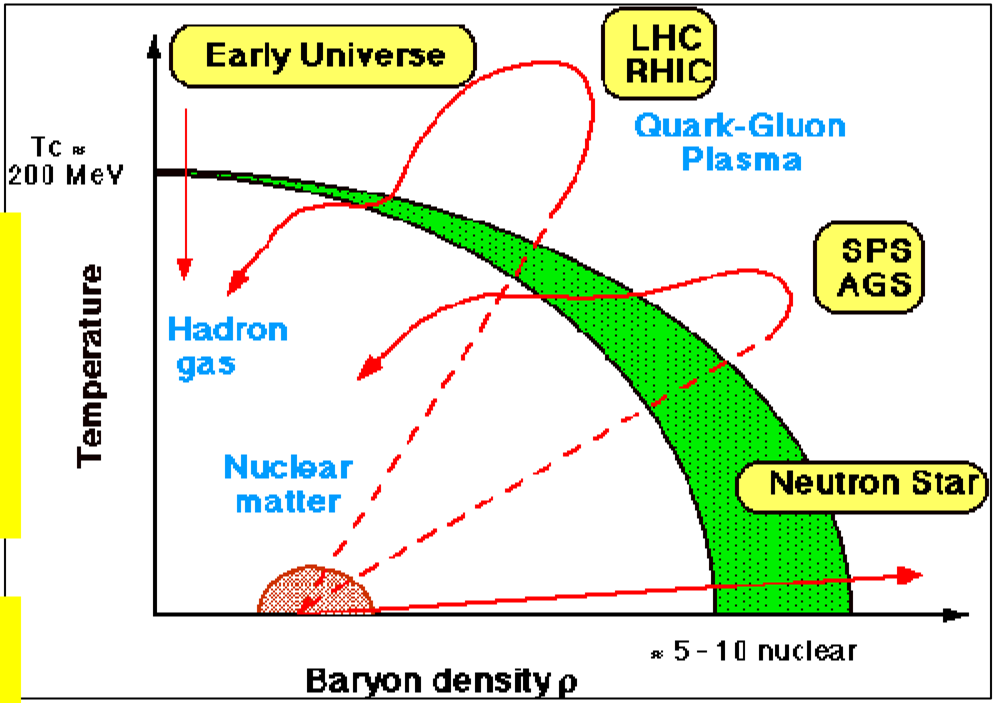
- Physics
- Design
- Simulations

Motivation

The goal is to search for QGP-signatures at high densities and temperatures.

STAR is optimized to measure the hadrons produced in each reaction on an Event-by-Event basis.

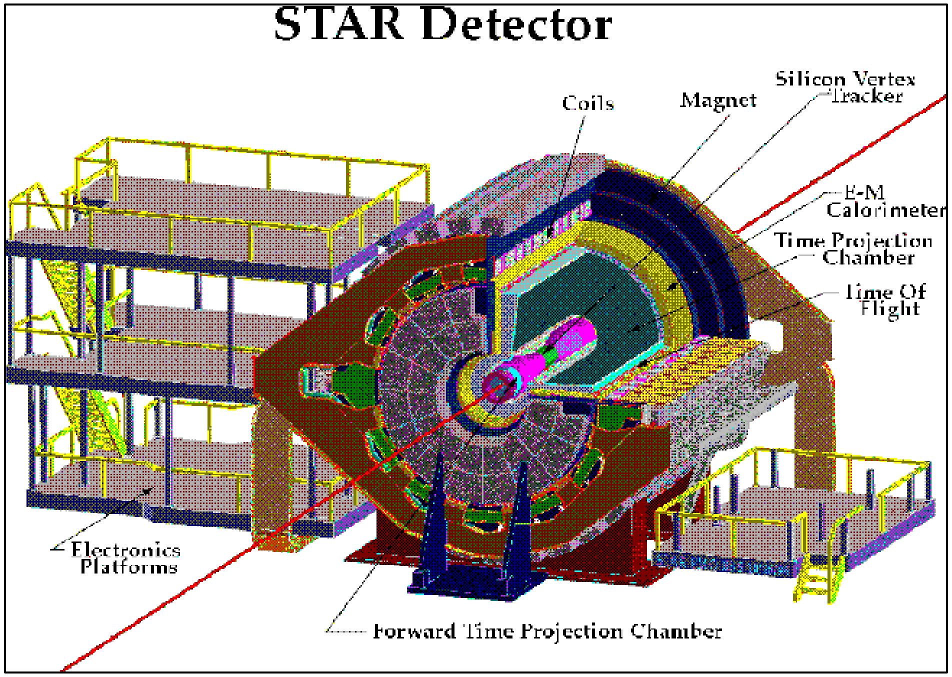
Large acceptance around mid-rapidity, with particle identification via dE/dx.



STAR+RHIC

RHIC:

- Au +Au $\sqrt{s_{nn}} = 200$ GeV
- p+Au $\sqrt{s_{nn}} = 350$ GeV
- p+p $\sqrt{s_{nn}} = 500$ GeV



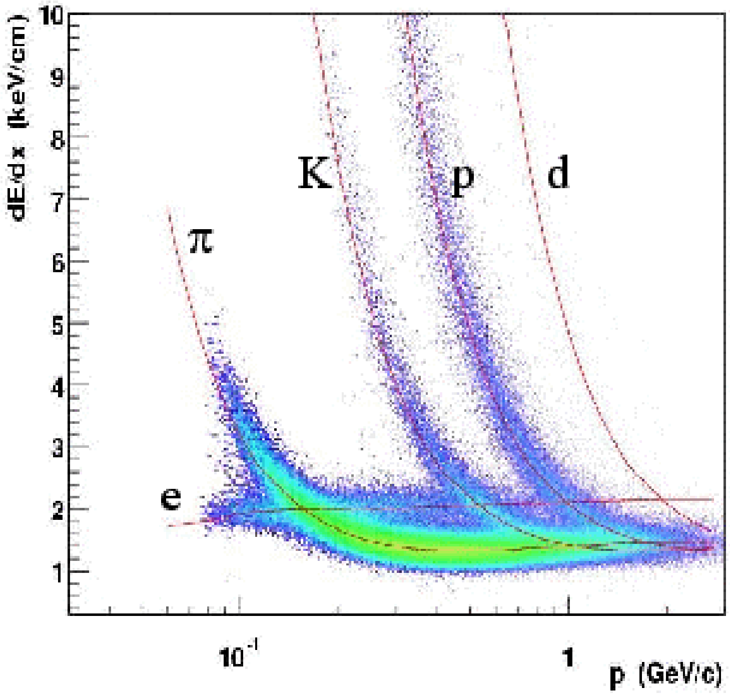
STAR:

- Y1:TPC, CTB, ZDC, L3, RICH
- Y2: TPC, SVT, FTPC, CTB, ZDC EMC, L3, Tofp, RICH

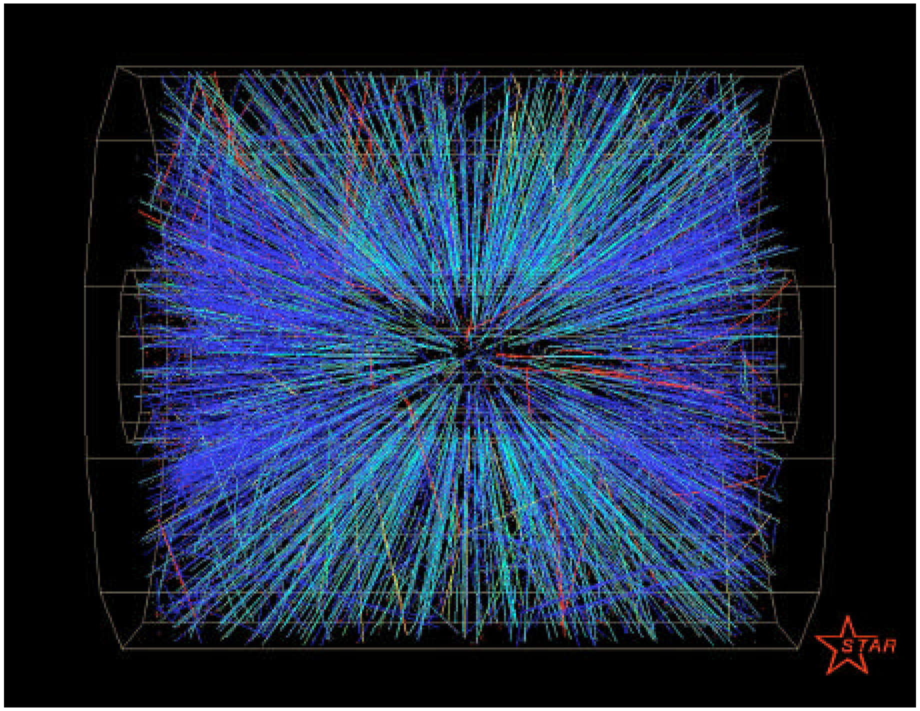
First run 2000

TPC:

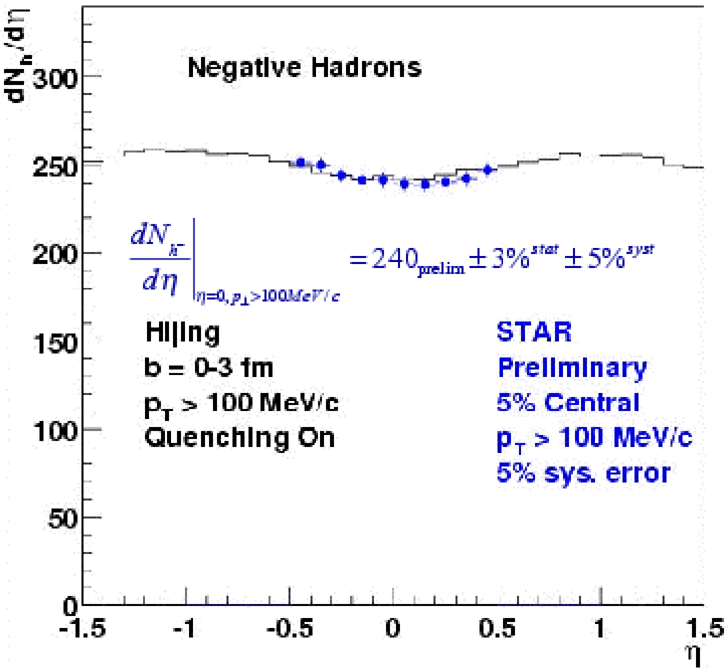
dE/dx = 8%
dp/p = 2%
(π^{+-} at 500 MeV/c)

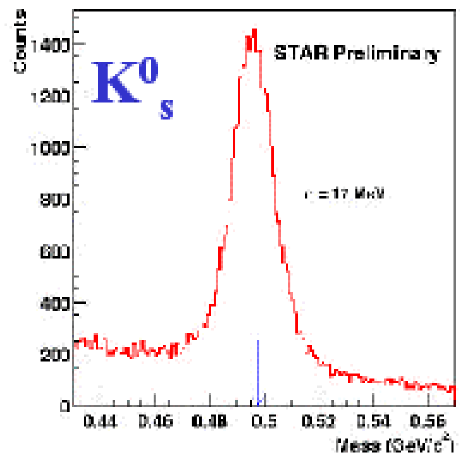


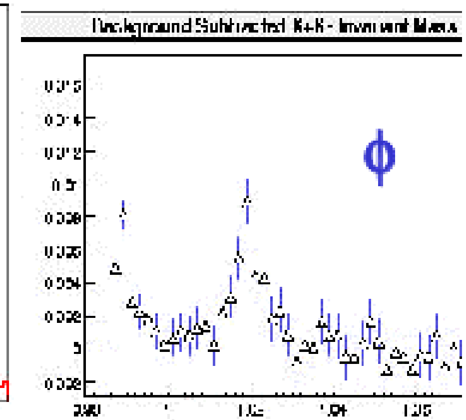
L3 Mid-central event



First run 2000

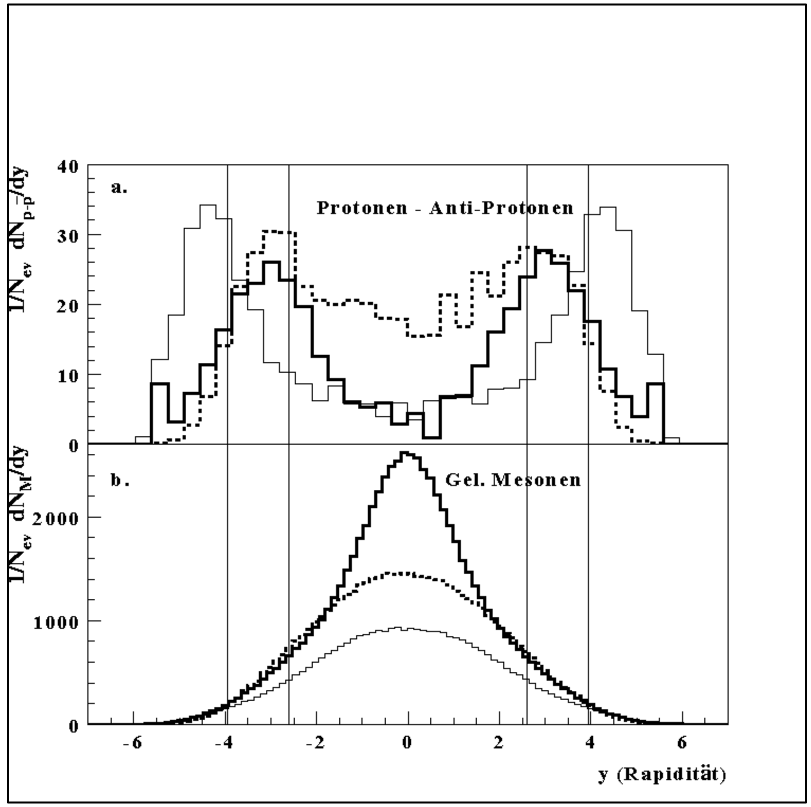






Physics with FTPC

- Extend the acceptance of STAR tracking into a region 2.5 < $|\eta|$ <4.0, p_t>40 MeV/c.
- Charged particles dp/p ~ 12%.
- Neutral strange particles K_s, Λ.
- Inclusive measurements $dN/dydp_t$.
- N+-N-net proton distribuion.
- Event-by Event fluctuation in dN/dy , $<p_t>$.
- Study of directed ,elliptical flow.
- DCC
- Asymmetric systems.



FTPC design

Idea ➔ Tracking in forward region $\eta>2$

Problems ➔ Track density, occupancy ~30%

Solution

Radial drift

$E \perp B$ ➔ $v_D \neq$ const.

s

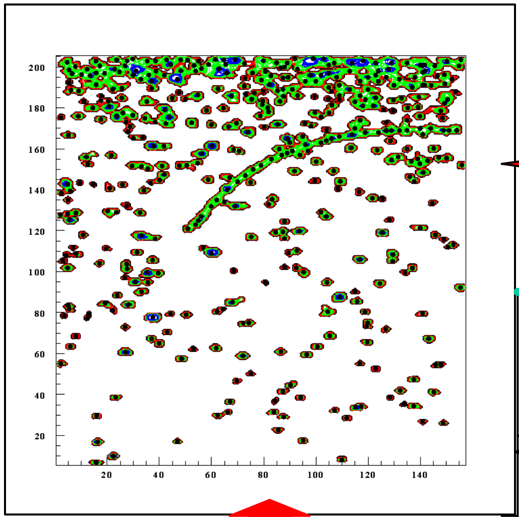
d

m

m

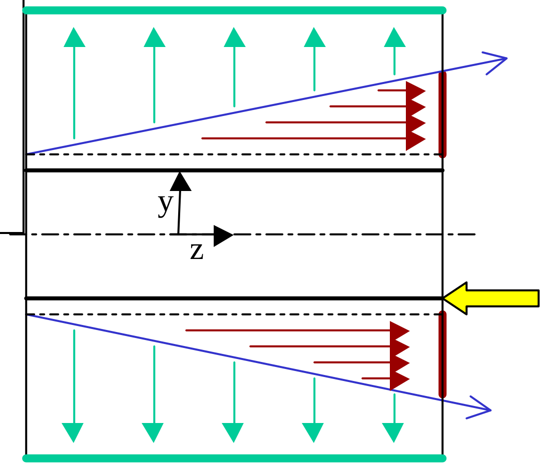
y

Why radial drift ?

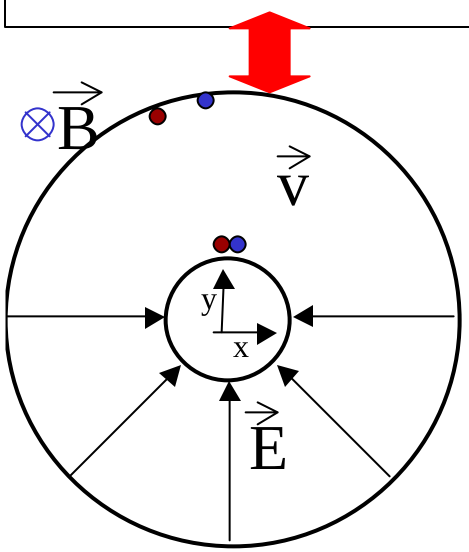


High track density for 2.5< |η|<4.

Occupancy of ~30-35% at inner radius.



Large dip angle for drift to end caps .

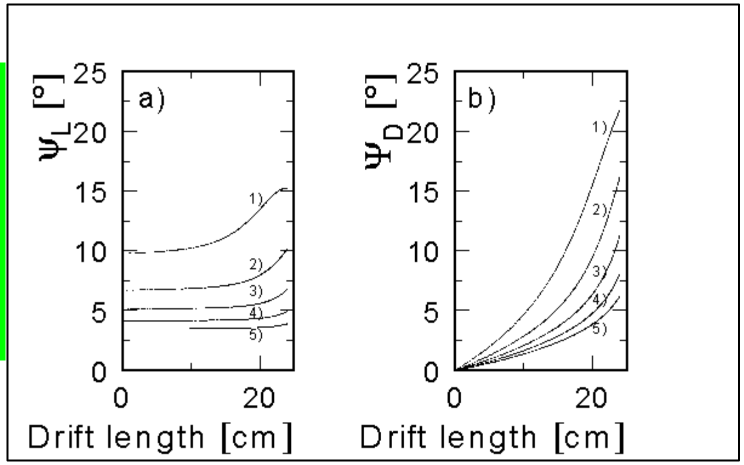


Small track to track distance at small angles or high η.

Lorentz angle

Gas Ar/CO_2

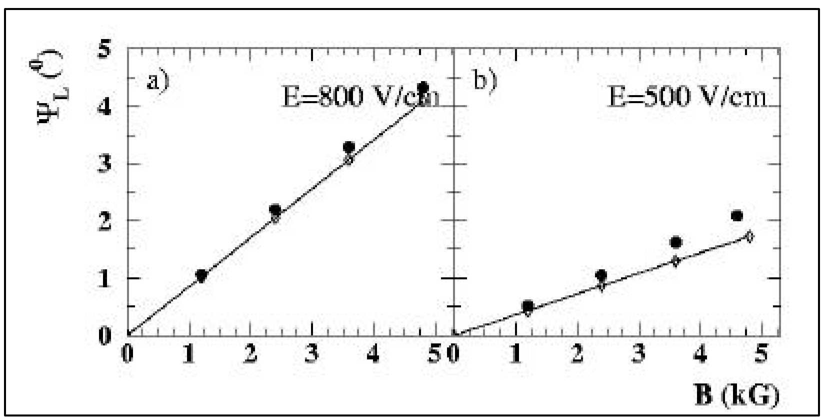
1) 80/20
2) 70/30
3) 60/40
4) 50/50
5) 40/60



Deflection in $\vec{E} \perp \vec{B}$ field.

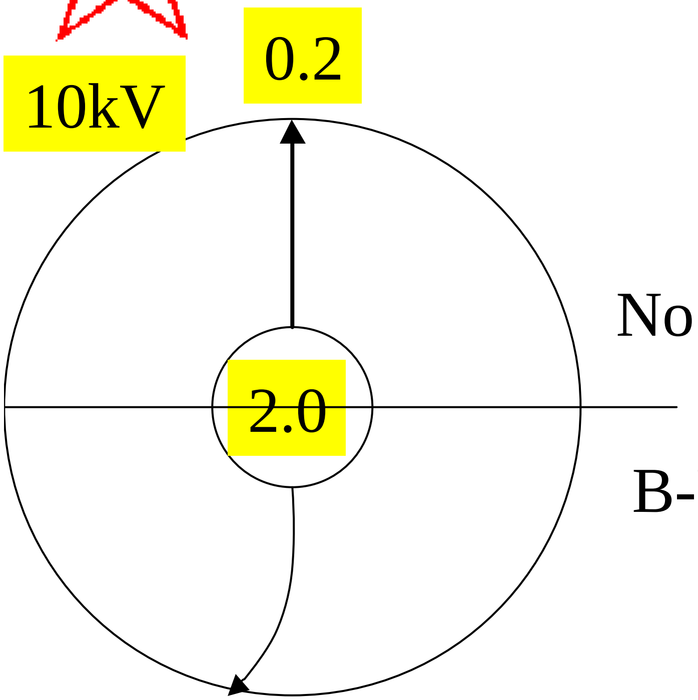
$$\Psi_D = Deflection\ \ angle$$
$$\Psi_L = Lorentz\ \ angle$$
$$B = 0.5T$$

$$\Psi_D = \int_{r0}^{r} \frac{\Psi_L(r)}{r} dr$$



Ar/CO_2 Ar/DME

Radial drift



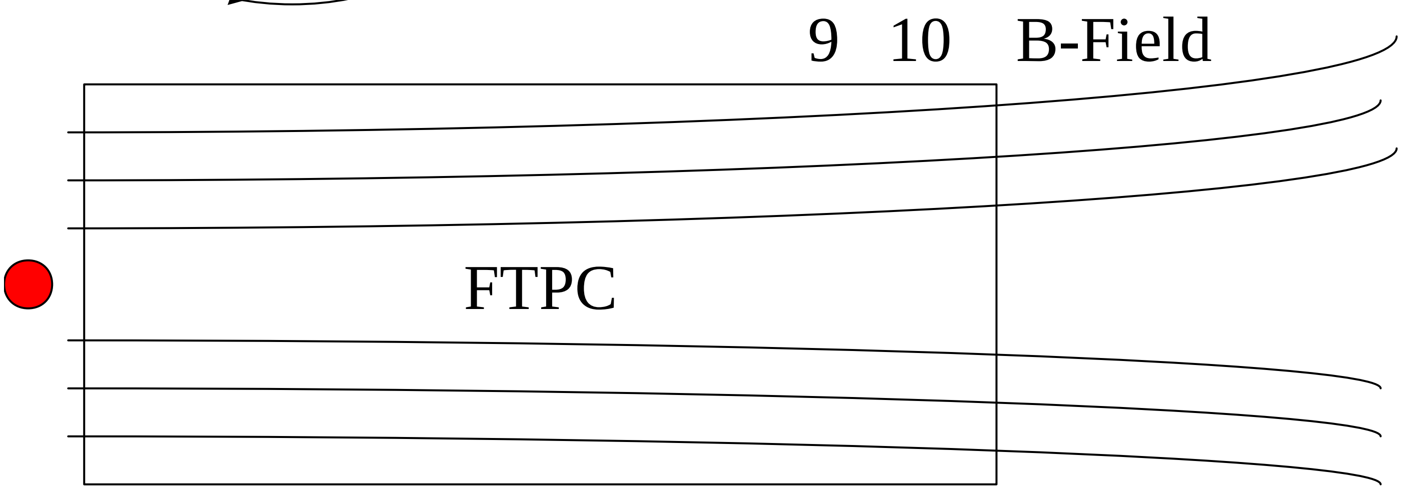
No B-Field

$E \sim 1/r \Rightarrow \mathbf{v_D} \neq \text{const.}$

+

B-Field

$E \perp B \Rightarrow F = q\,(\mathbf{v_D} \times \mathbf{B})$



FTPC design

Final design

2 Chambers 1200 mm x 730 mm.

Each FTPC has 5 rings with 6 sectors.

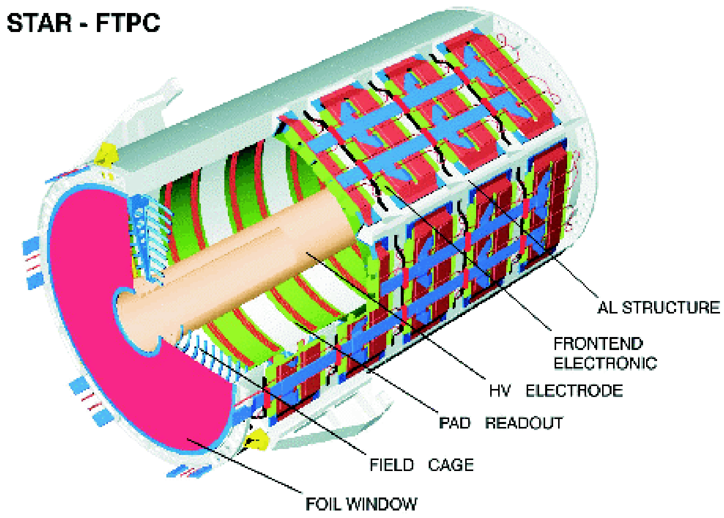
Each chamber has 10 padrows.

One padrow has 960 pads.

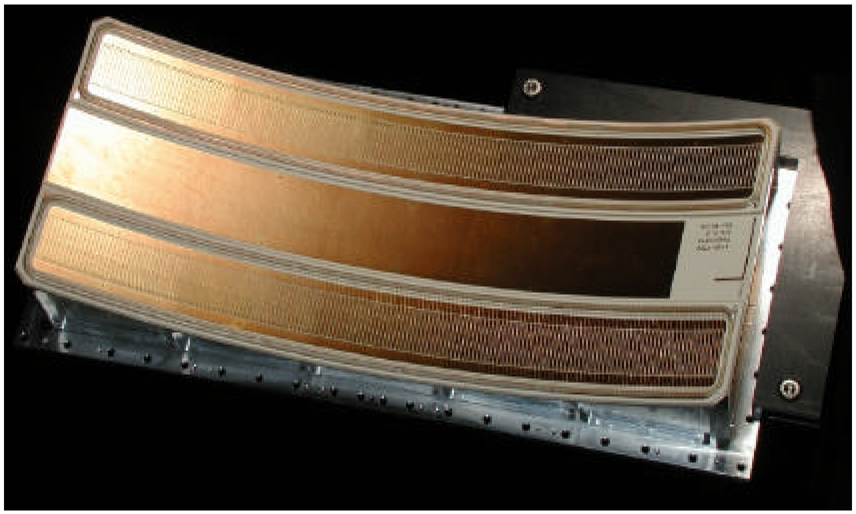
In total 9600 pads/FTPC.

Gas = Ar/CO_2 (50/50).

Each electronic channel samples with 256 timebins (220 ns) and a 10 bit ADC.

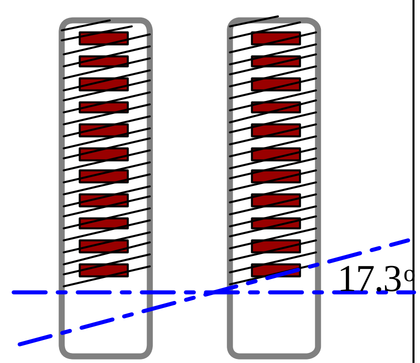


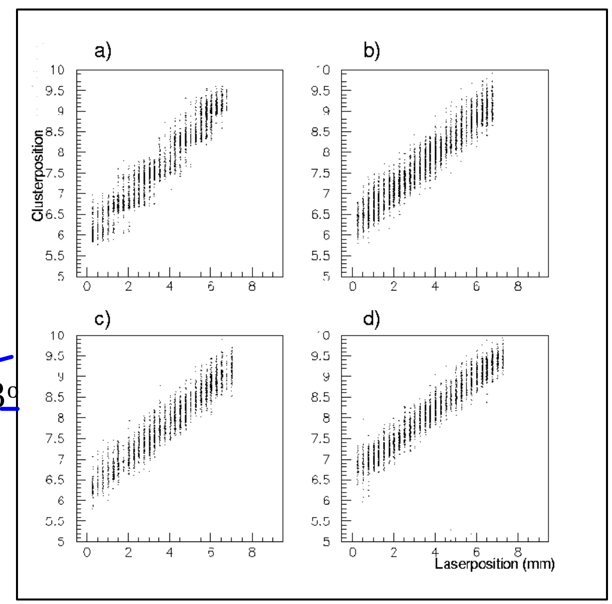
Readout Chamber



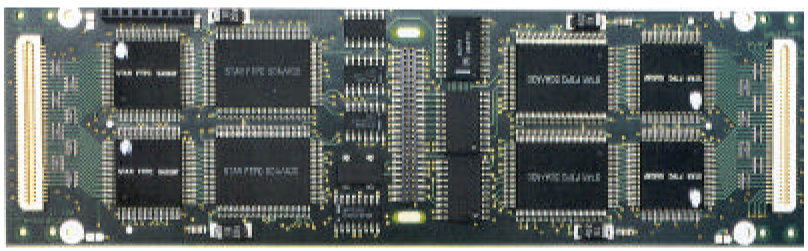
- One pad plane has 320 pads arranged in 2 parallel rows.
- One Pad 1.6 x 20 mm^2.
- Pad pitch 1.9 mm.
- Bending radius 310 mm.

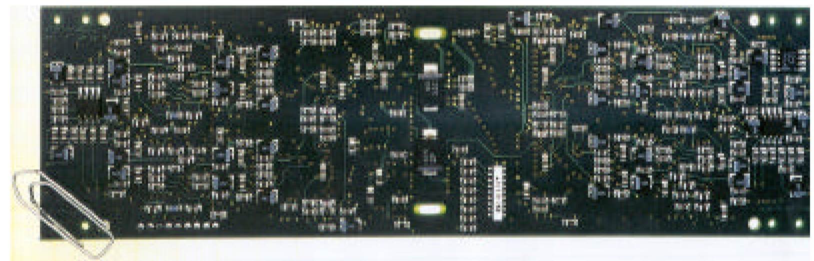
- Sense wire tension 30 g.
- Sense wire / pad angle 17.3^o.
- Sense wire / pad gap 1.5 mm. Sense wires are fixed by conductive glue.



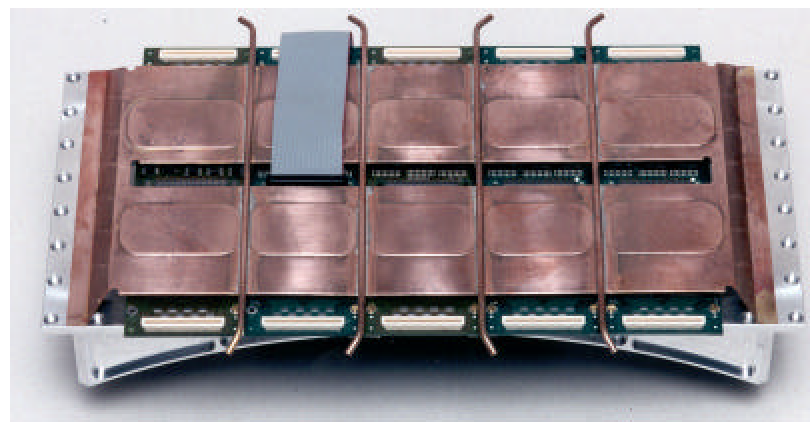


FTPC-Electronics

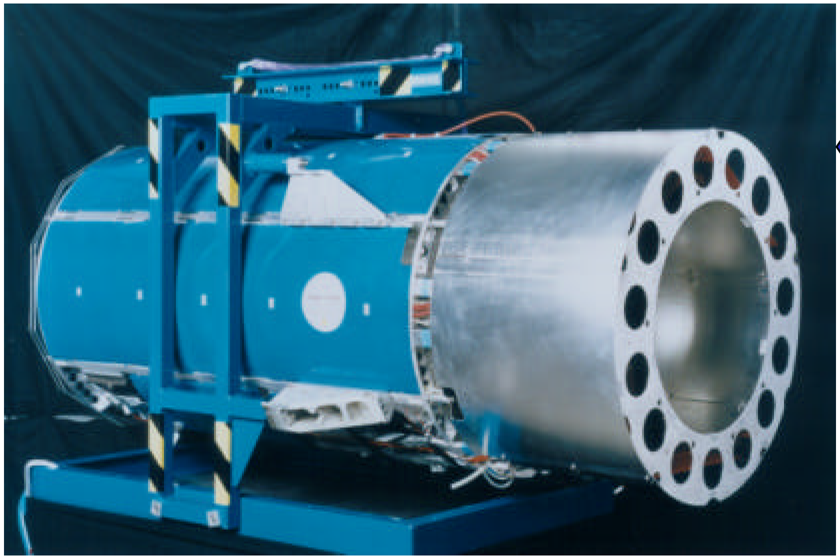




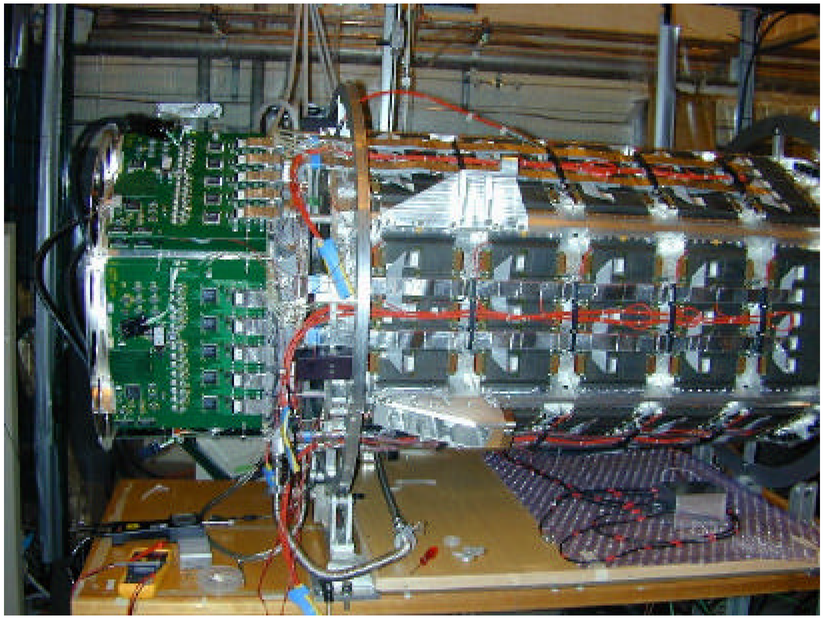
- 150 FEE-cards/FTPC
- 64 channels / FEE-card
- 256 time bins / channel
- 220 ns / bin
- 10 bit ADC



Finally

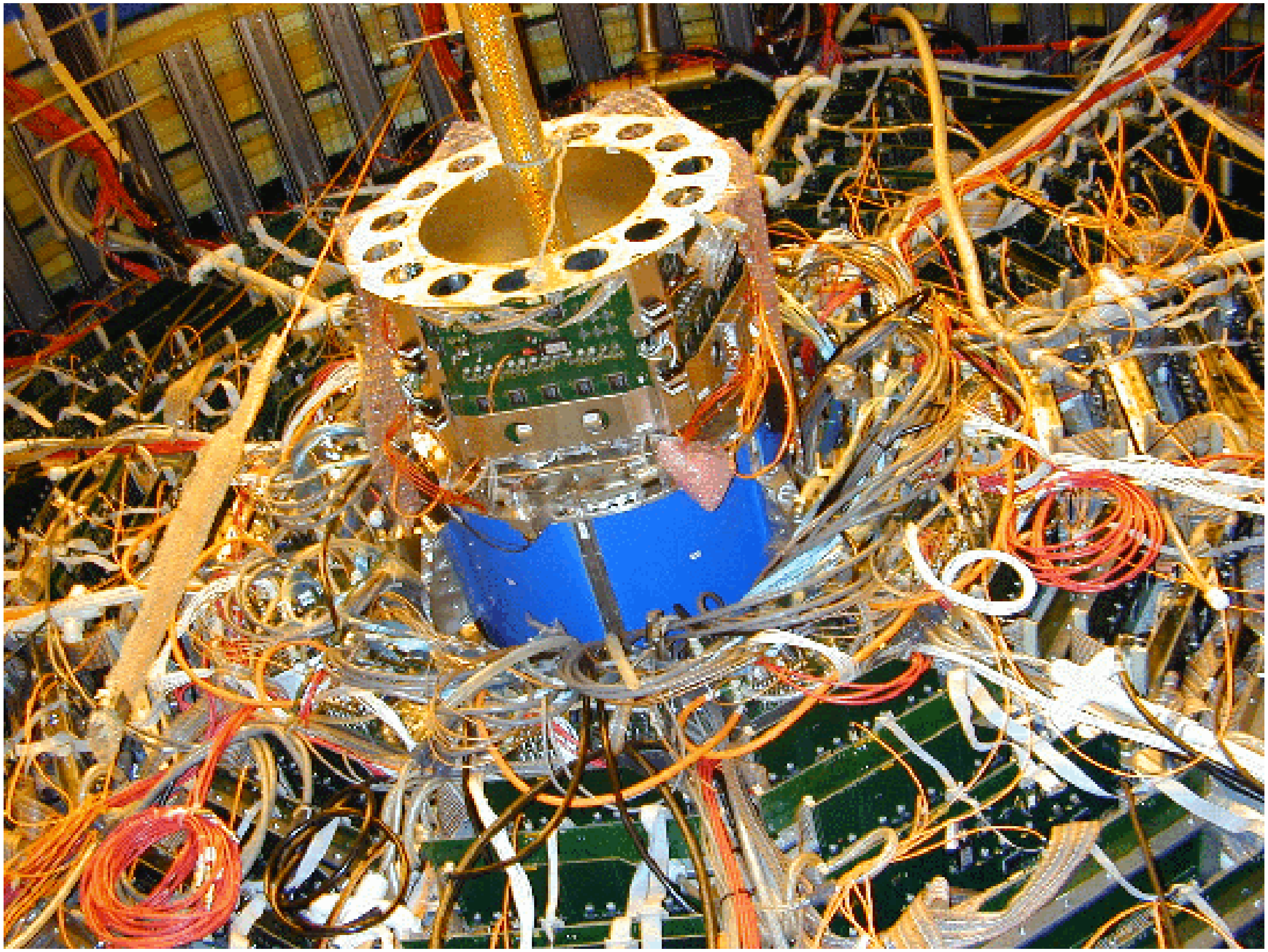


Installation view

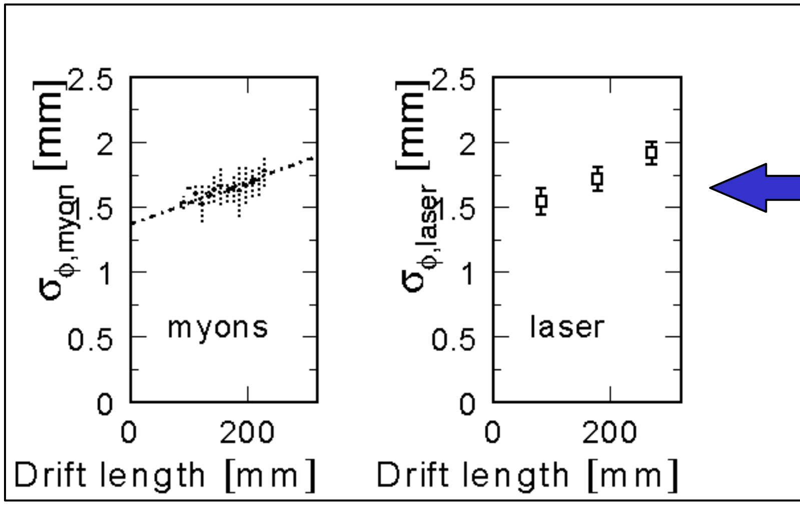


Test bench

Installed FTPC

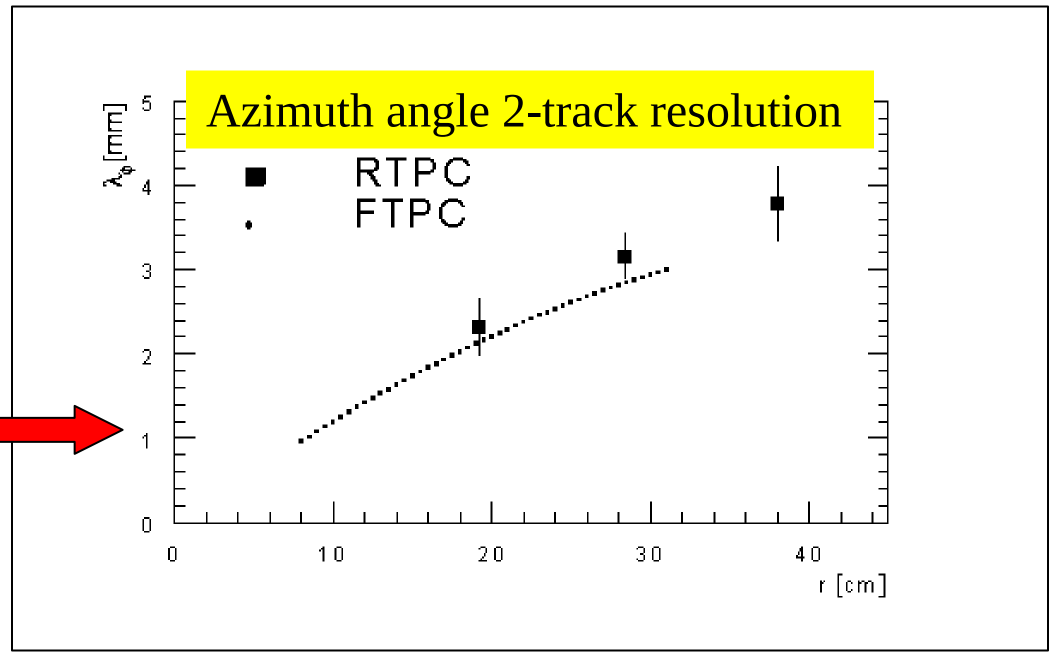


FTPC Parameters

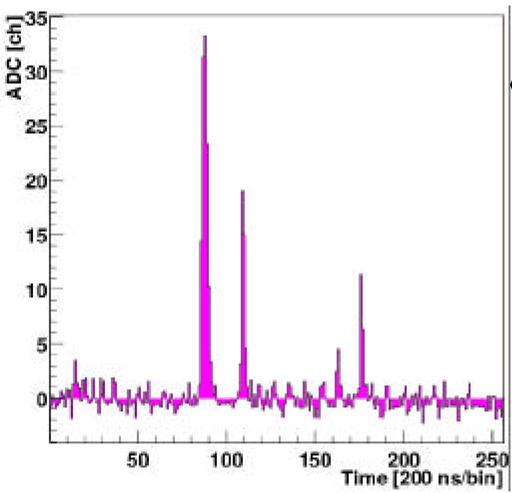


Pad response function
$s_{prf} \cong 1.4\,mm$

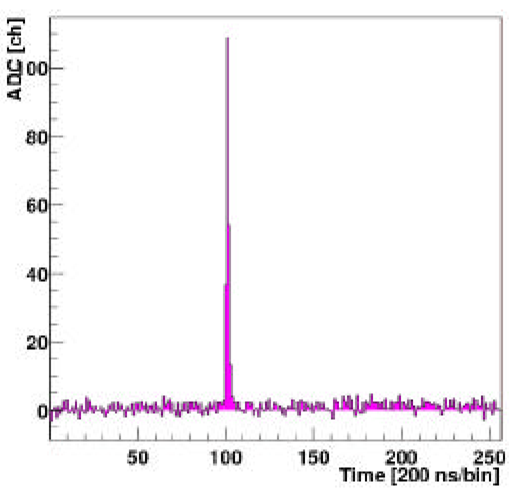
Two-track resolution
~1 mm



First Signals

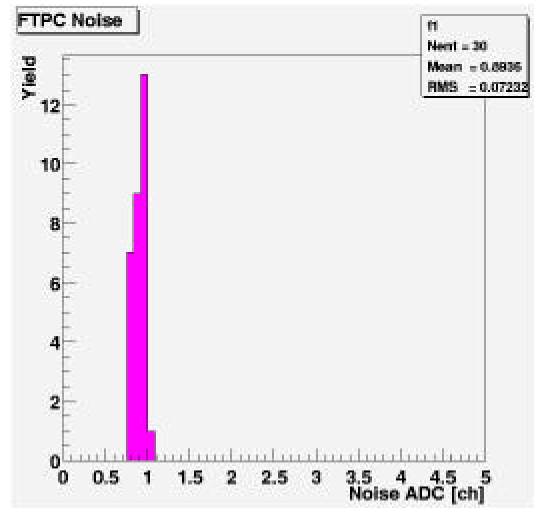


Laser

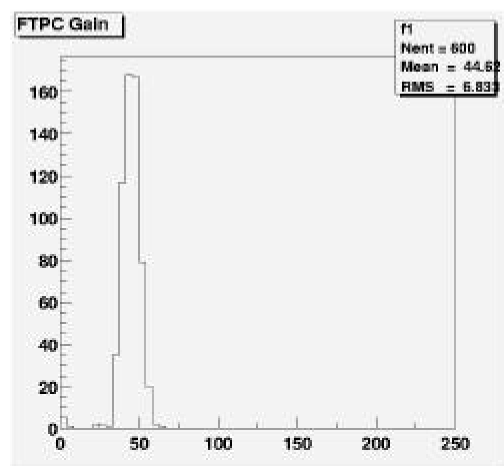


Cosmic

FEE-Noise



FEE-Gain

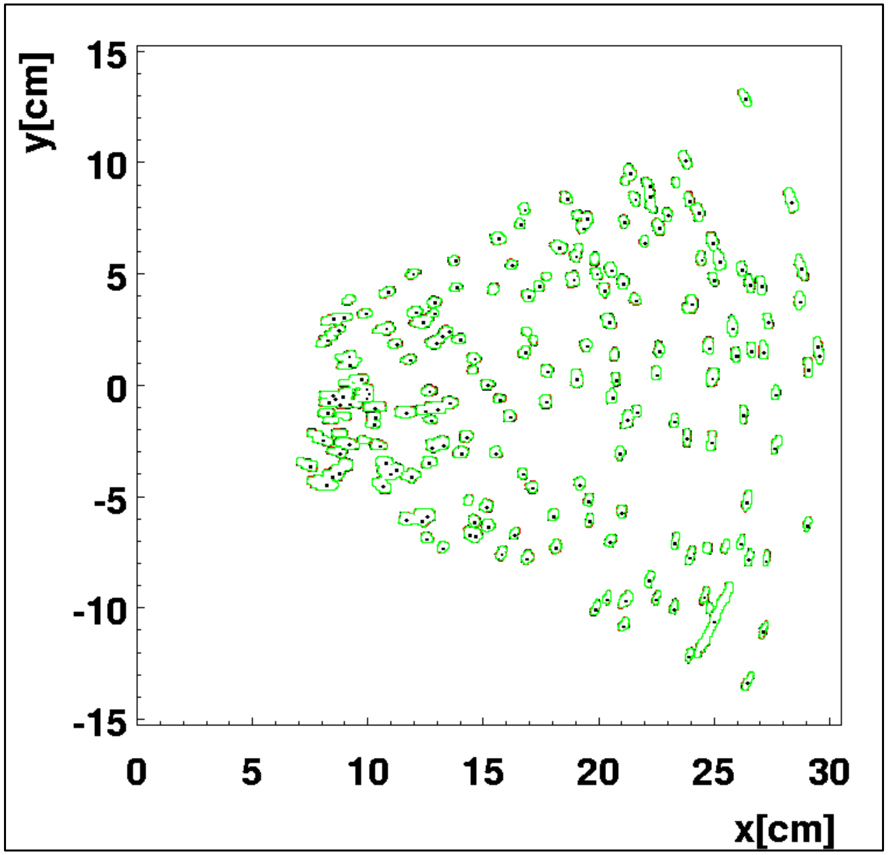


Cluster finding

Peep hole algorithm needs 1-3 s per Event depending on the occupancy.

Needs deconvolution at inner radii, for up to 30% of the clusters.

Correct for t0, E ⊥ B and v_D.

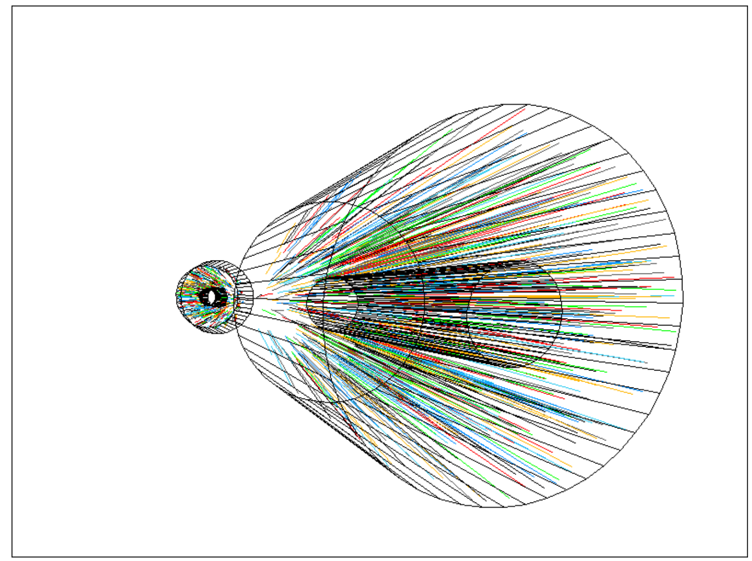


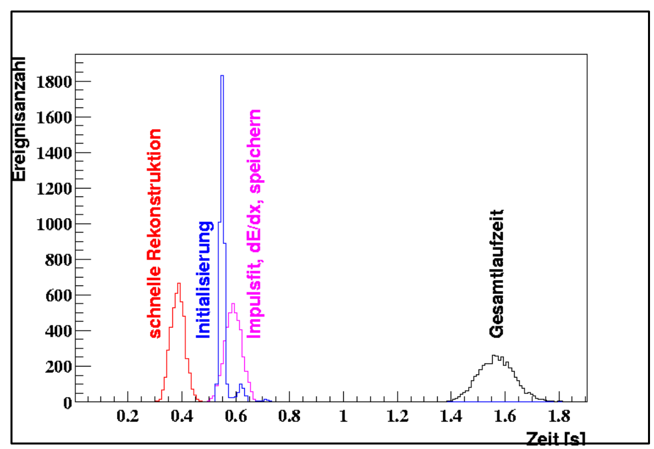
Track finding

Conformal mapping algorithm with follow-your-nose method. Needs 1.6 s for ~15000 clusters which correspond to ~1000 tracks.

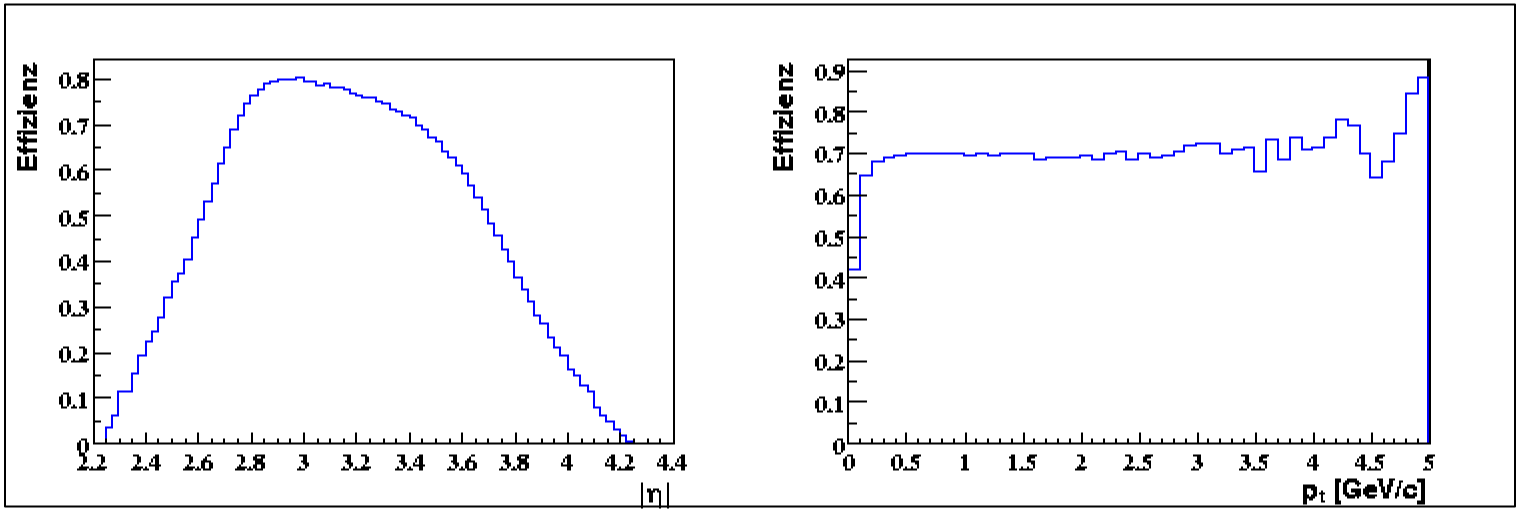
Possibility to track with and without vertex constraint.

Split tracks below 1%.

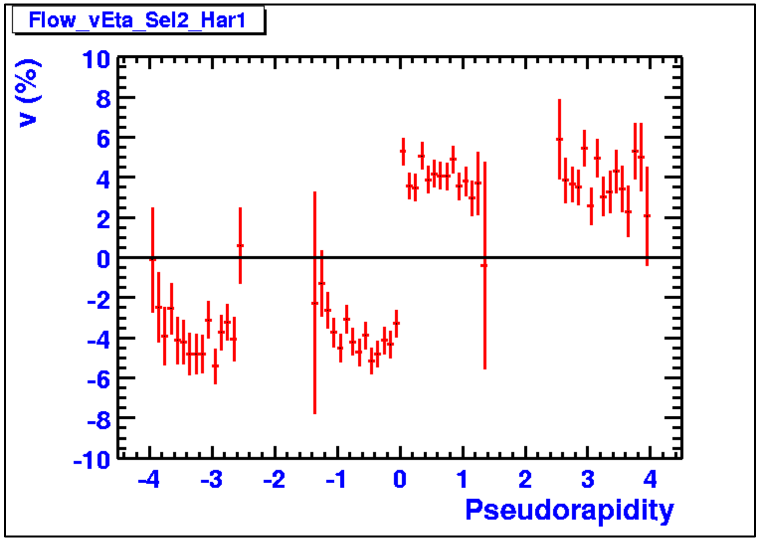




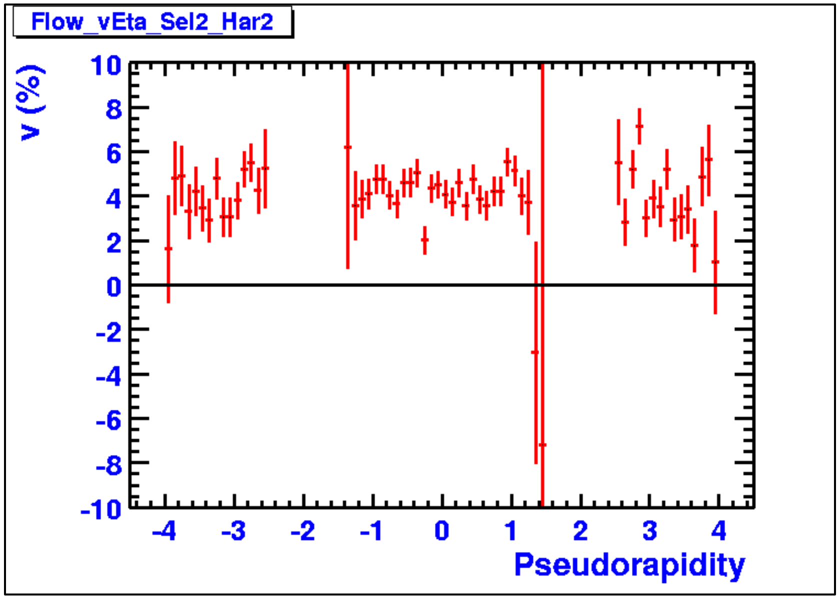
Efficiency & Resolution



Flow-Studies



Mevsim simulation
Directed flow = 4.5%
Elliptic flow = 4.5 %
No pt dependece.

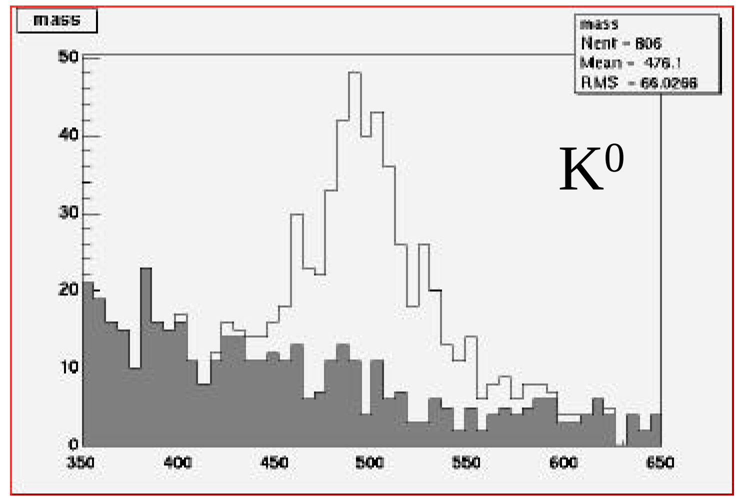


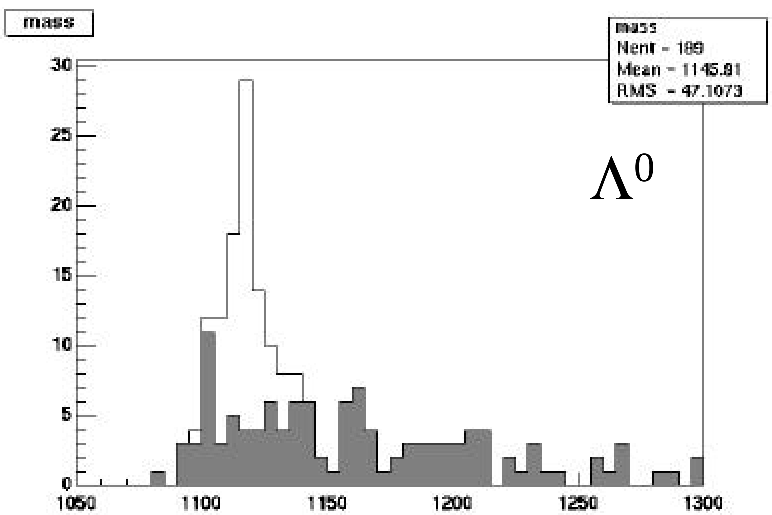
Eventplane determination by TPC.

V0-Studies

Invariant mass method
without dE/dx.
Using DCA and position cuts.

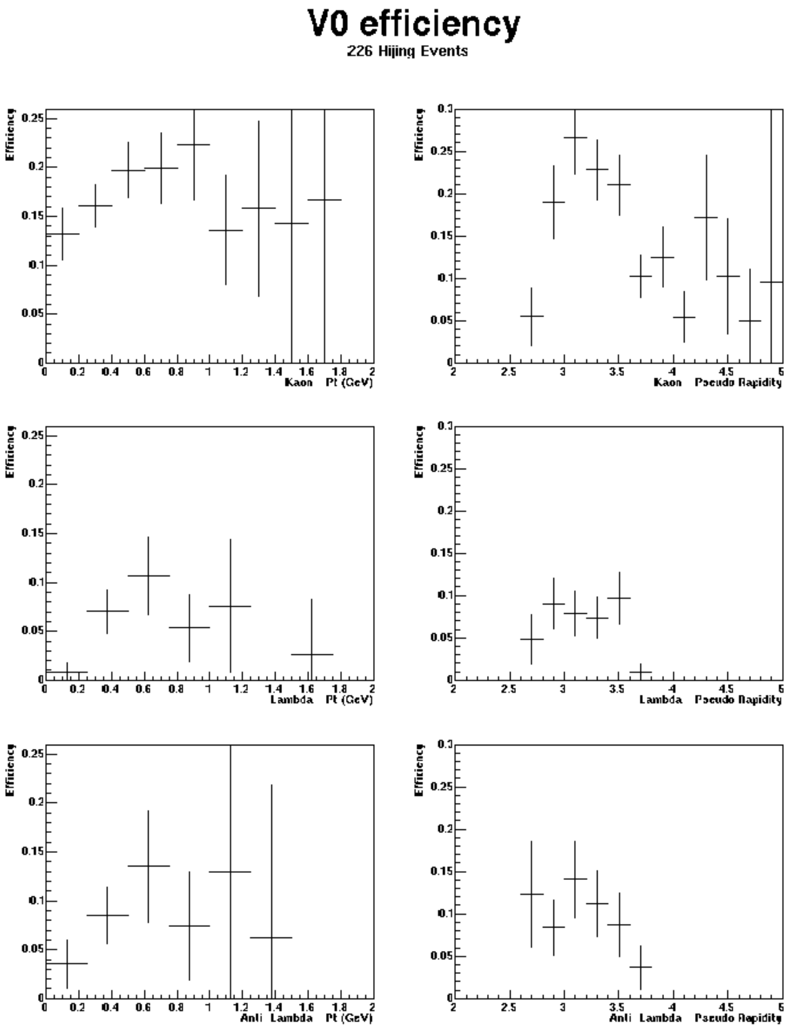
Result: It's possible !

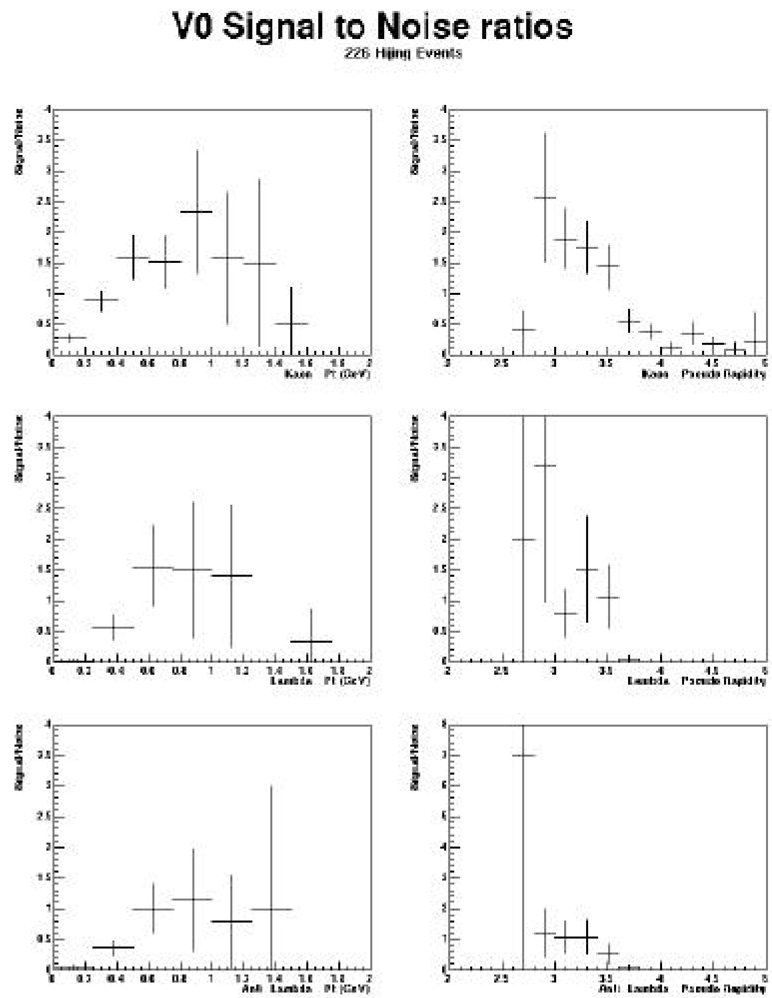




HIJING = 226 Events
Acceptance FTPC:
Kaons = 9.6/evt
Lambda = 4.8/evt
Efficiency:
Kaons = 1.7/evt
Lambda = 0.3/evt

V0-parameter

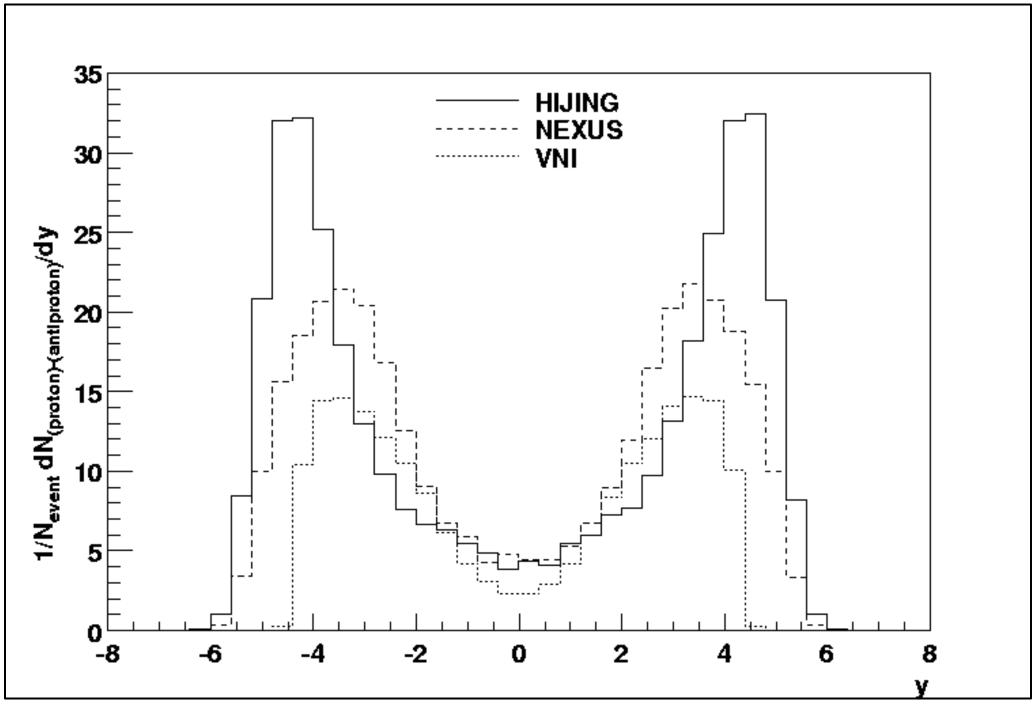




Charge net-baryons

Net-charge measured by difference h+ - h-.

High sensitivity in FTPC acceptance.



Summary

- Two Forward TPC were designed, built and installed with a two-track resolution ~1 mm using a radial drift field.
- A complete analysis chain was designed, realized. It's tested, and written in C++ embedded in ROOT.
- Simulations were performed to verify the Event by Event as well as the inclusive capabilities of the FTPC.
- Feasibility studies showed that it is possible to measure V0, within the FTPCs.
- Flow studies showed that the FTPC is capable of measuring directed and elliptic flow with and without the TPC.
- FTPCs are ready, waiting for beam.