Vacuum Tracker Technical Status and Cost Estimate

Director's Review

Feb 24 th, 2003

Fermilab Particle Physics Division

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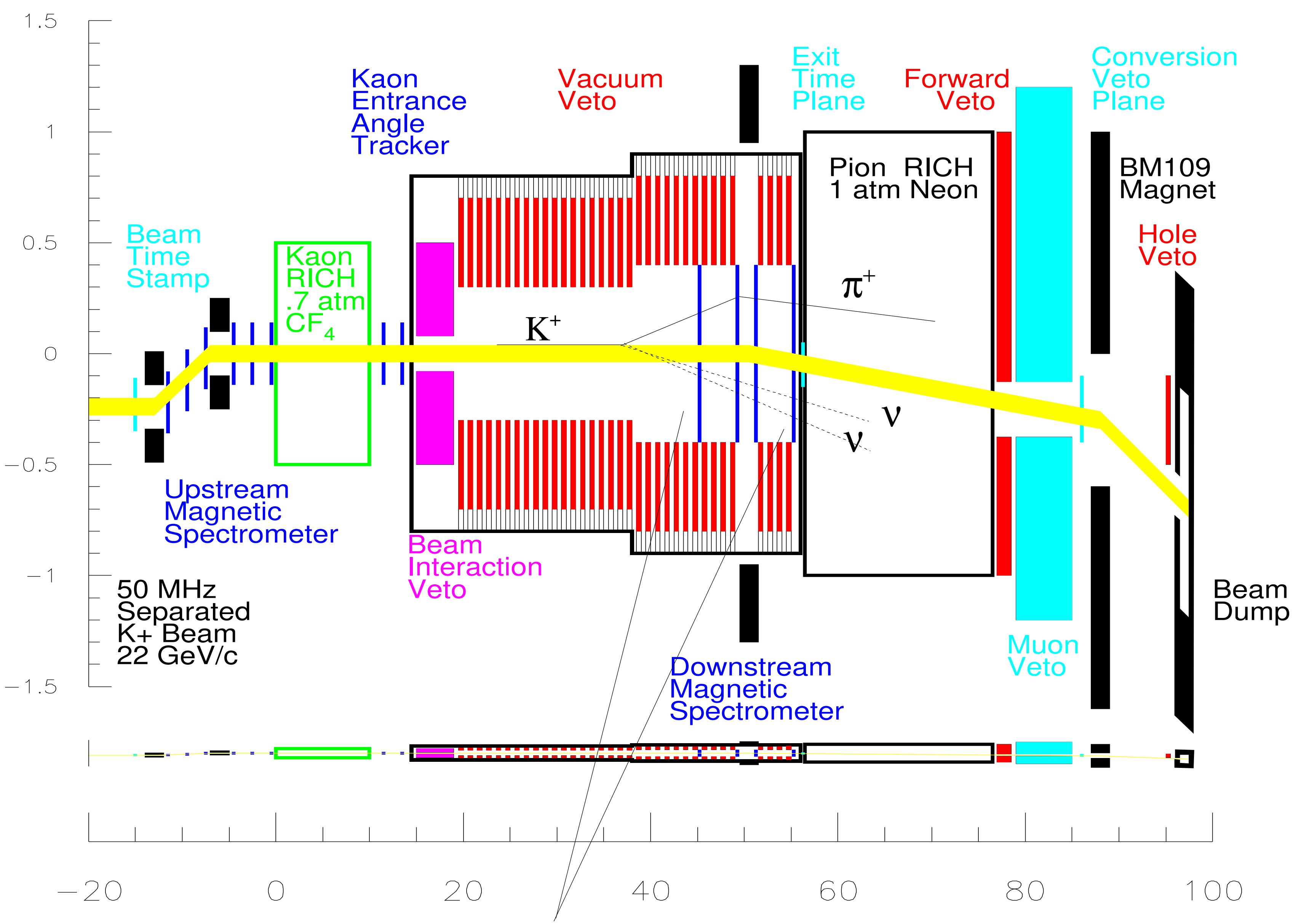
Down Stream Magnetic Spectrometer (Vacuum Tracker)



4 Stations of straw drift tubes to measure charged particle kinematics in vacuum volume

Overview

29–layer tracking system based on 4640 straw drift tubes arranged into **doublets**

5 mm diameter, 1 meter long straws with 30 µm wall kapton straws

150 µm hit resolution, 30 nsec drift time

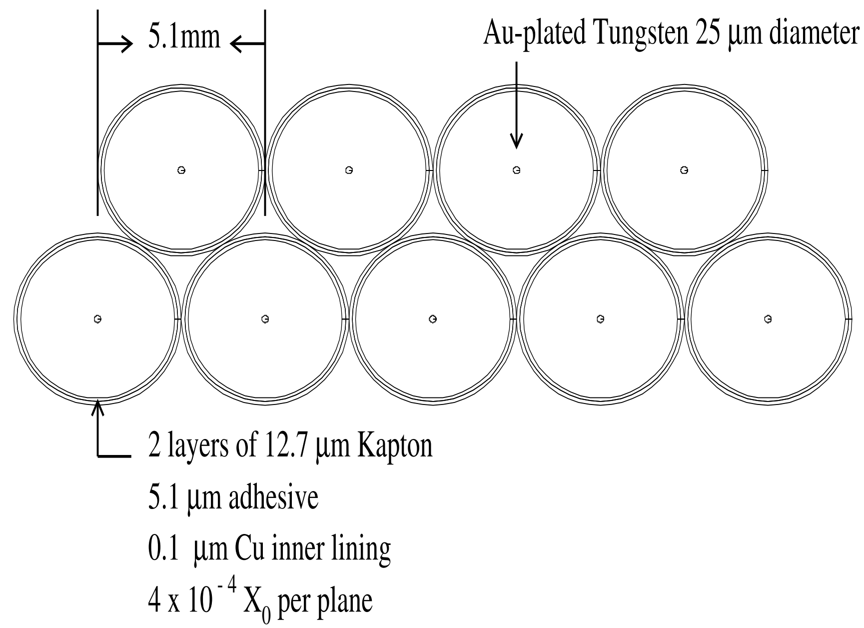
Maximum hit rate of 120 KHz/wire

Operation in vacuum decay volume:

– Straw must survive 15 psi differential pressure

– Straw must not spoil vacuum quality

Straw Doublet



Comparison of Material

Layout	Radiation Length (10^{-3} X_0)
5 straw layers (1st Chamber)	**2.1**
8 straw layers (2nd–4th Chamber)	**3.4**
KTeV Drift Chamber (X,X’,Y,Y’)	1.1
KTeV Drift Chamber and Vac.Window	3.2
4–layer 500 mm scintillating fibers	5.7
4–layer 835 mm scintillating fibers	9.5
300 µm double–sided silicon	3.2
BTeV silicon pixel	8.9

Mechanical Parameters of CKM Straws

Parameters	Value
Stress induced on Kapton under vacuum	1/6 of yield point
Diffusion rate through Kapton	0.2–0.4 μTorr liters/sec/straw
Linear expansion under vacuum	~ 380 μm/meter
Linear thermal expansion coefficient	9.9 μm/meter/°F
Linear humidity expansion coefficient	12 μm/meter/%RH

May 2001 PAC–Subpanel Technical Review of Vacuum Tracker

Committee Concerns and Recommendations :

- This system represents an engineering challenge and a technical risk, particularly since no previous straw system has been operated in vacuum.

- There are complications in the assembly process: e.g. the straw characteristics change under vacuum, and the electroplating of small section of beam–region sense wires to reduce gain.

- The committee recognized that a 20–channel prototype is a very important milestone for the experiment.

We set out to build two 20–channel prototypes:

(1) To understand the significant assembly issues.

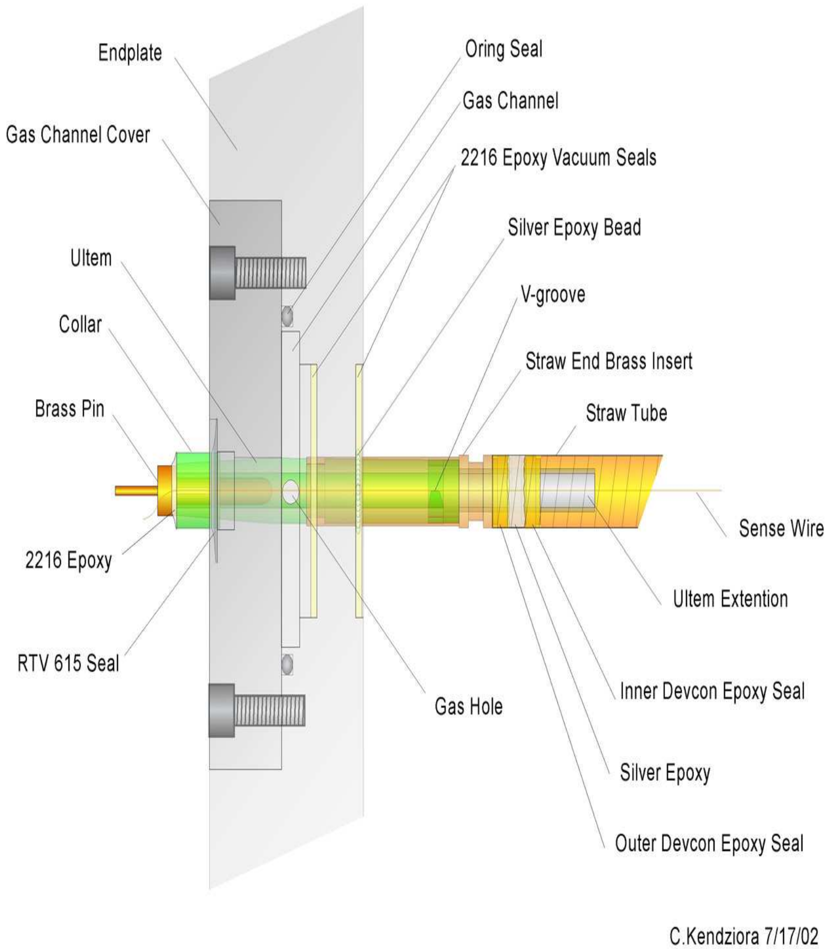
(2) To prove that straws drift chambers can work in a vacuum.

(3) To develop engineered–costs and electronics.

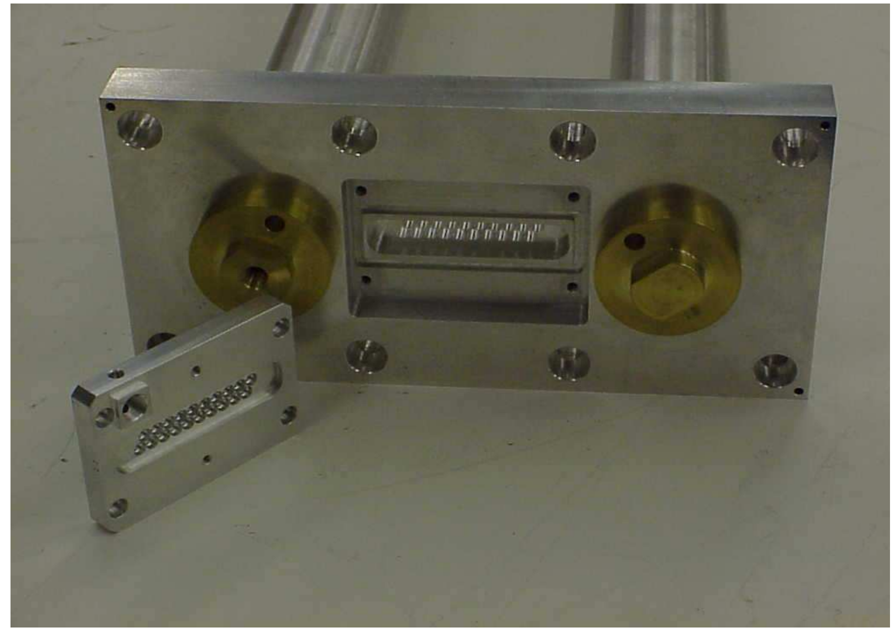
(4) The prototypes are useful for understanding the simulation and offline–reconstruction

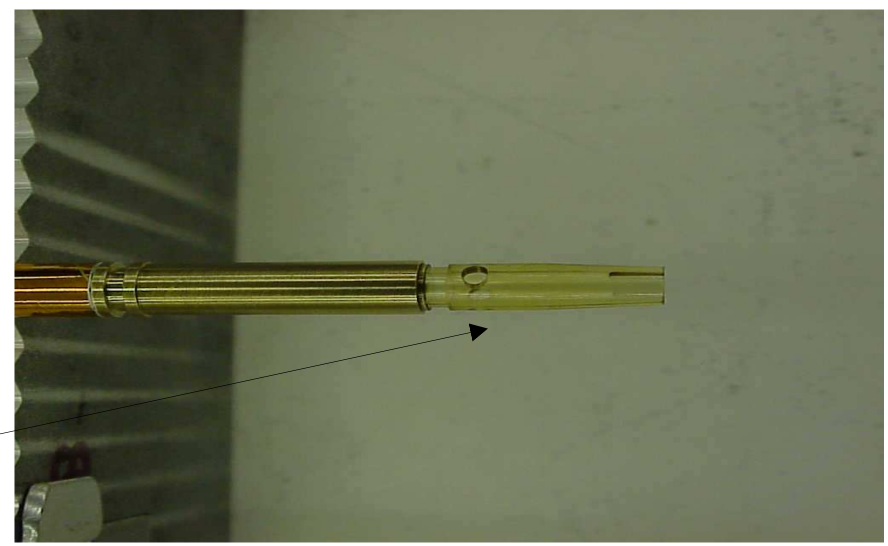
We have submitted our results for publication in NIM–A late last year (FERMILAB–PUB–02–241–E).

Assembly Highlights



Vacuum–tight Frame Components

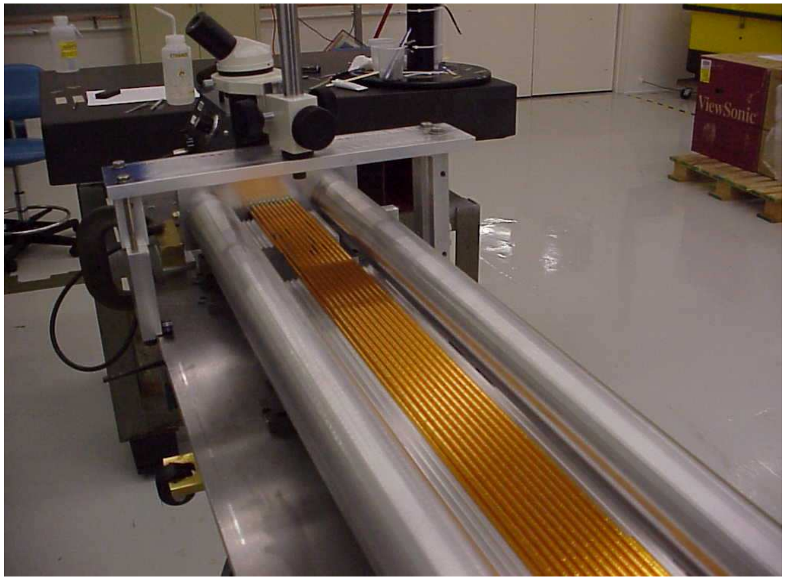


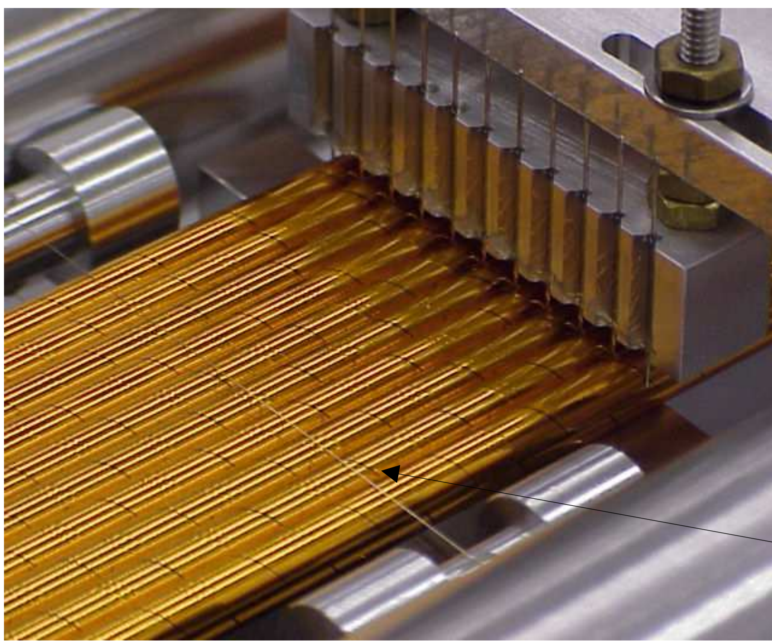


Wire–centering BNL871 "ultem"

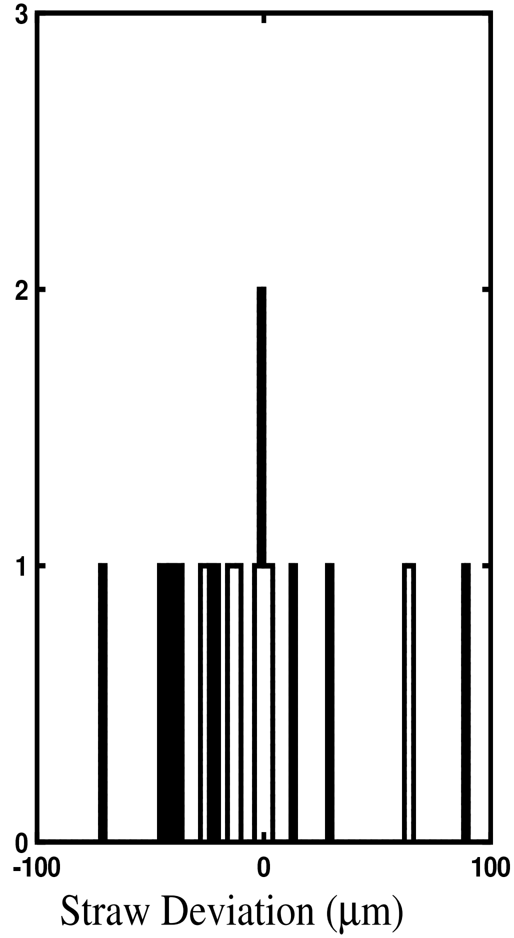
Assembly Highlights

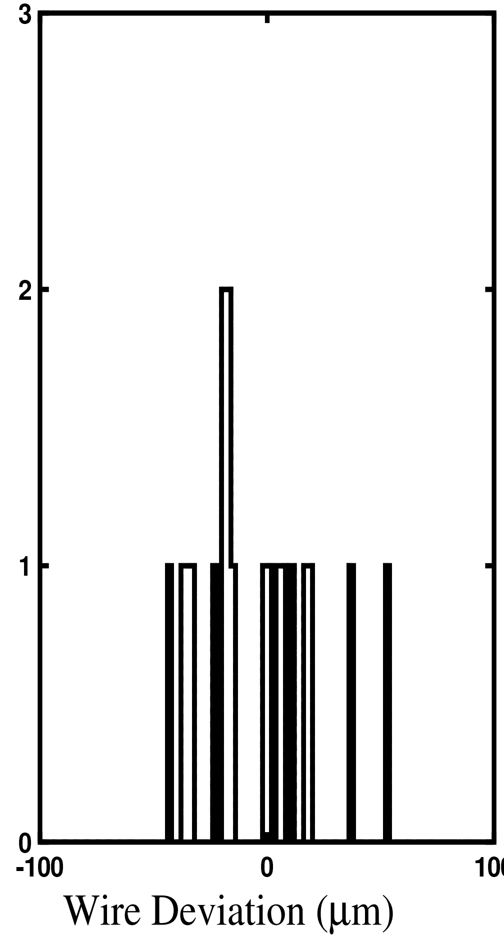
Straw Alignment



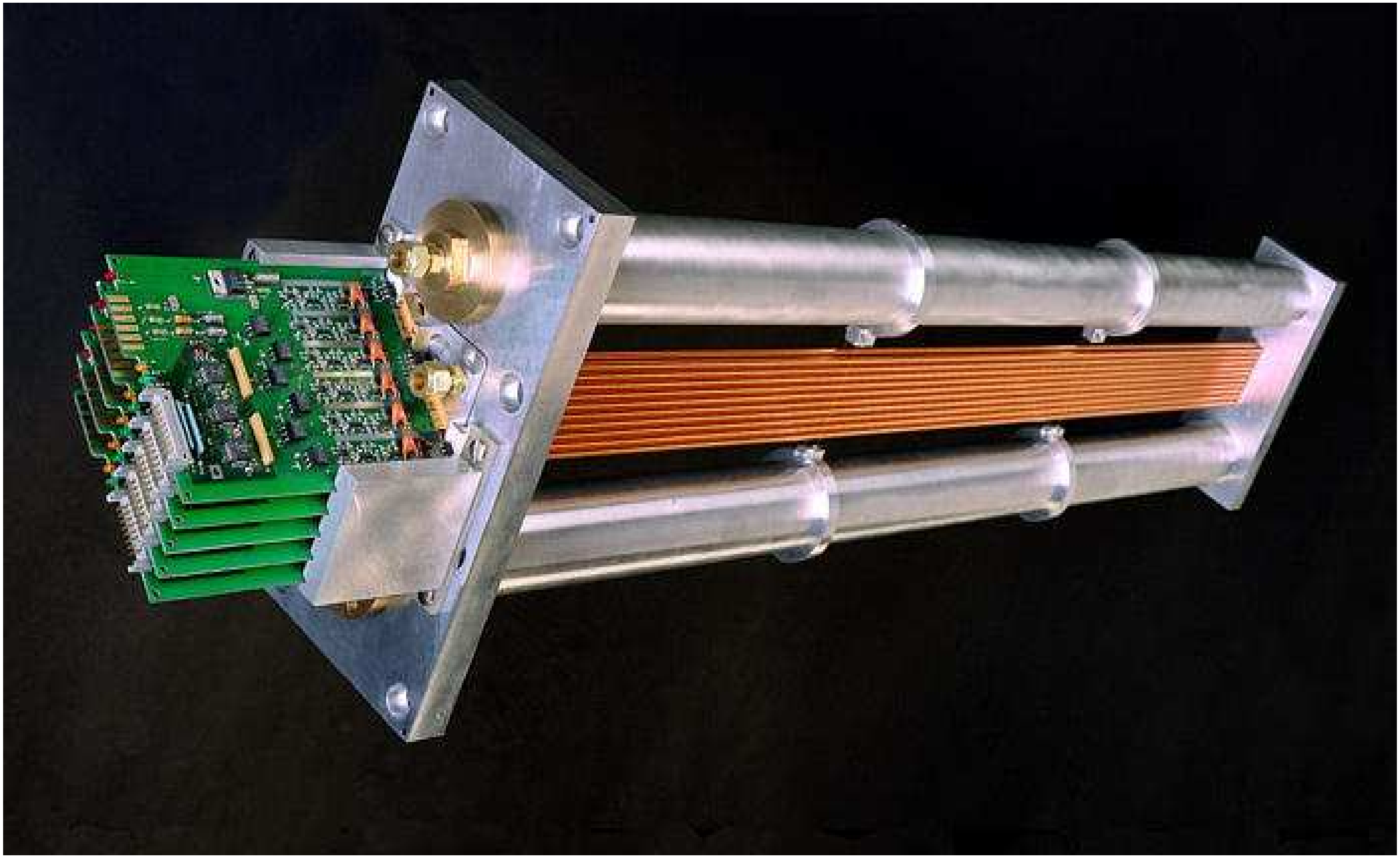


Straws glued to a support wire

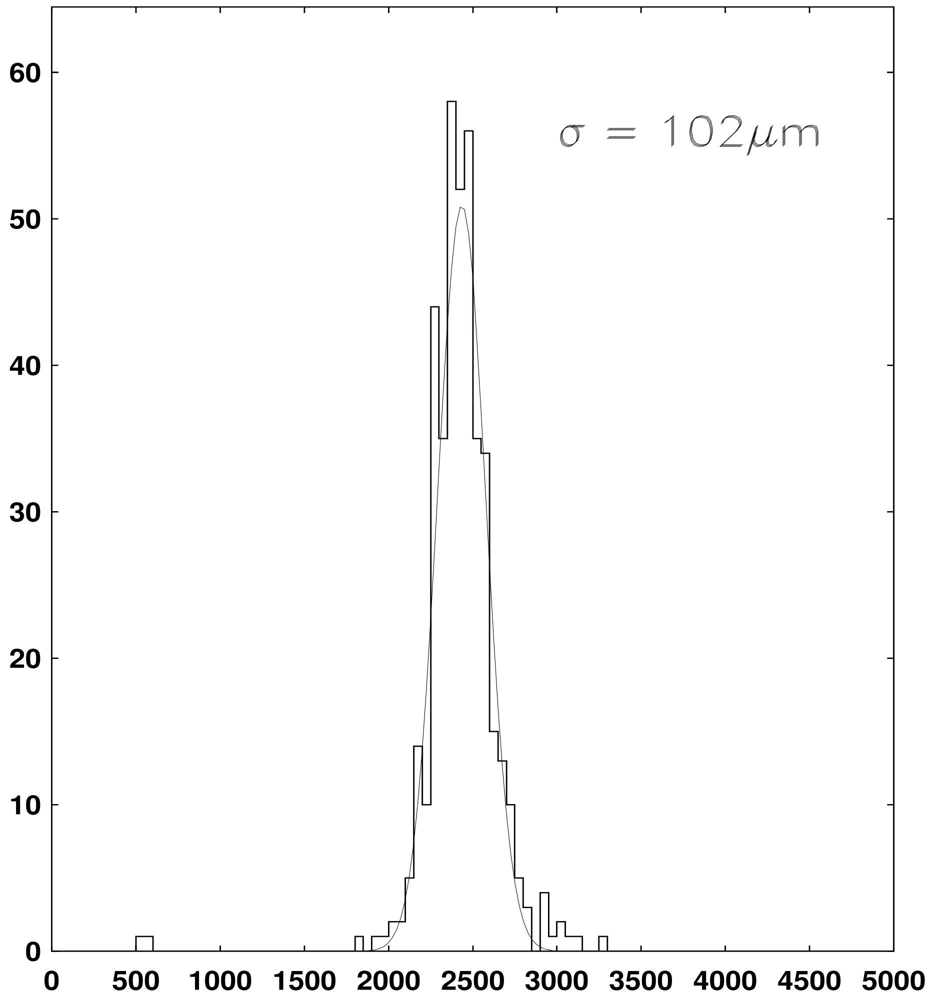




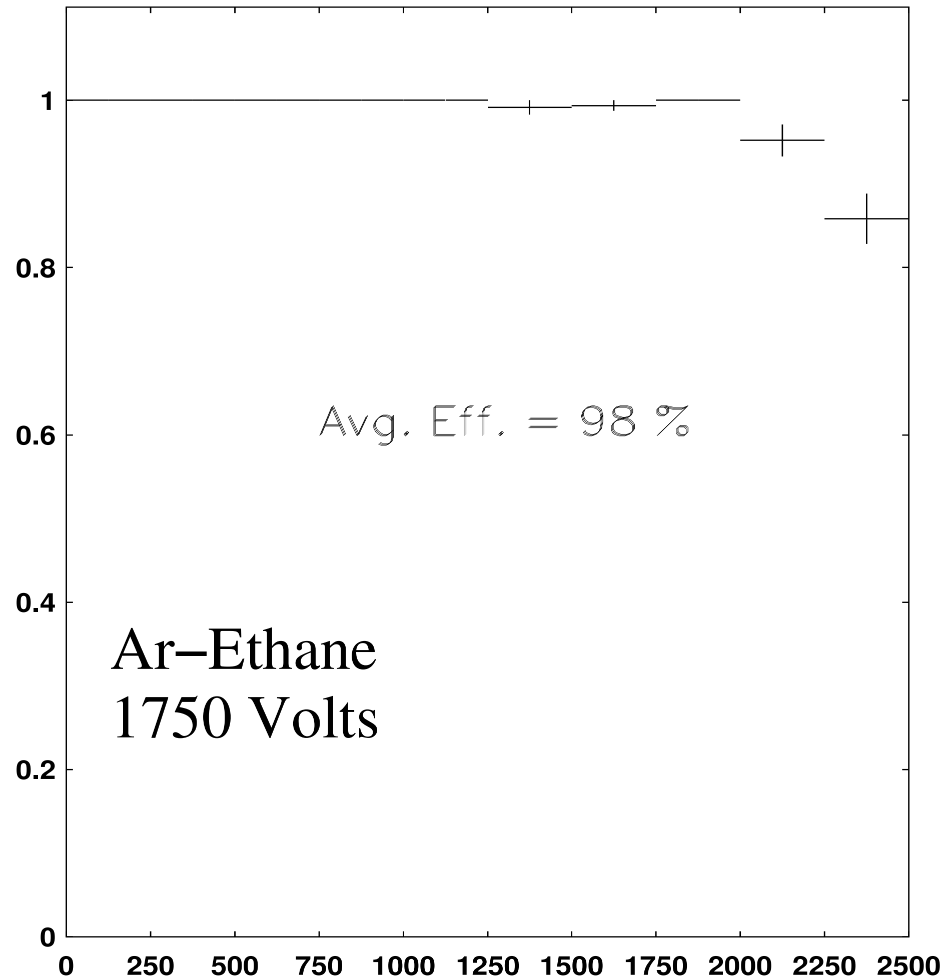
20−Channel Prototype



Cosmic Study of Chamber Performance in 1 atm

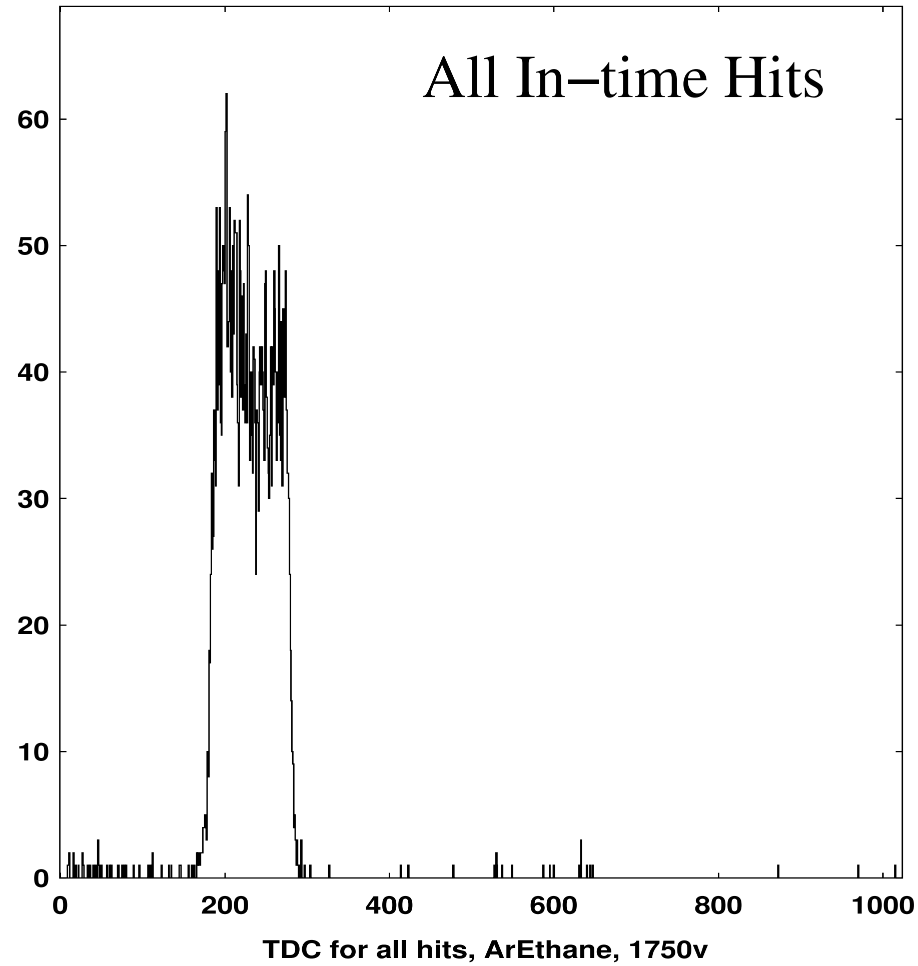


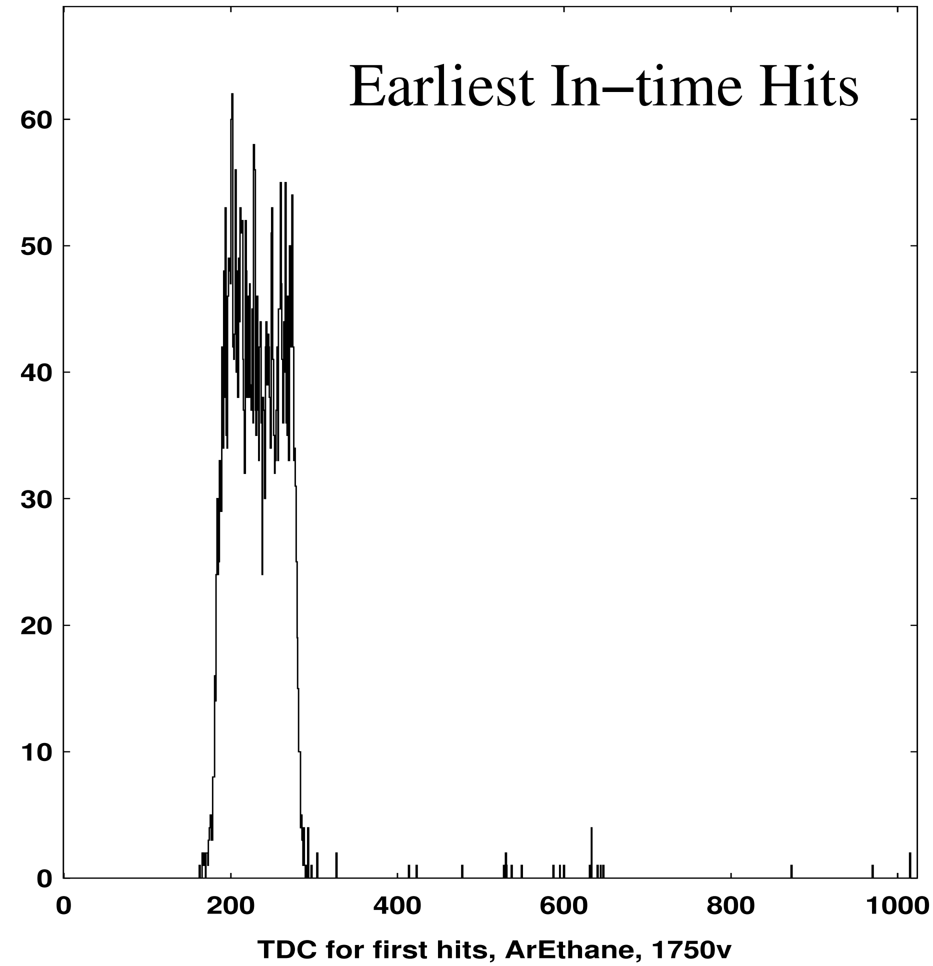
Sum of Distance (μm)



Track DOCA to Wire (μm)

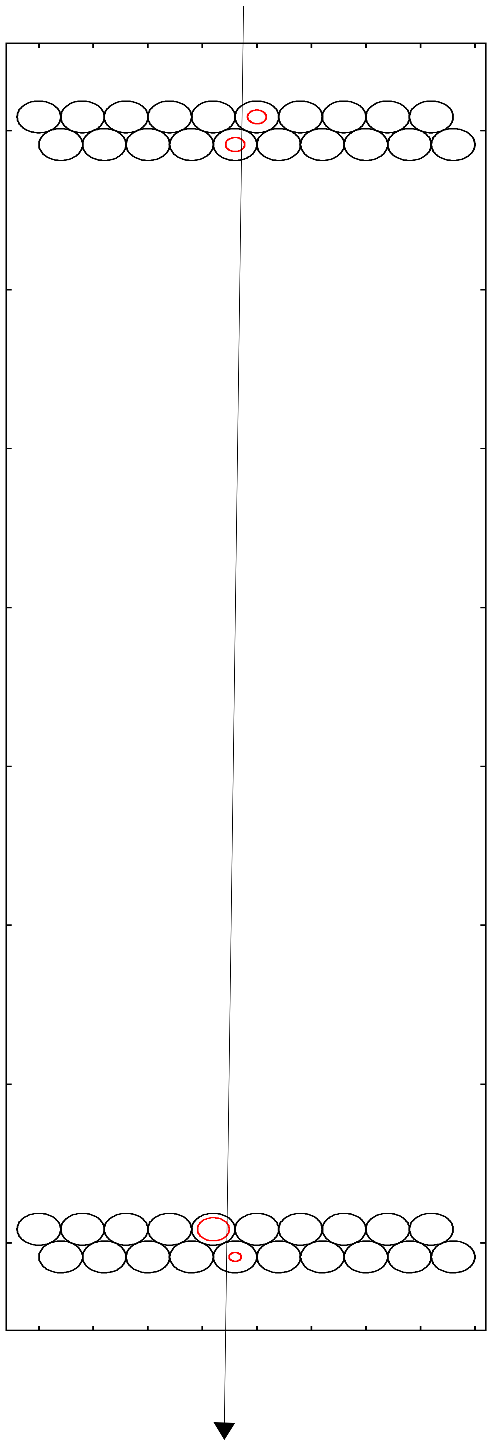
Drift Time Characteristics of Straws



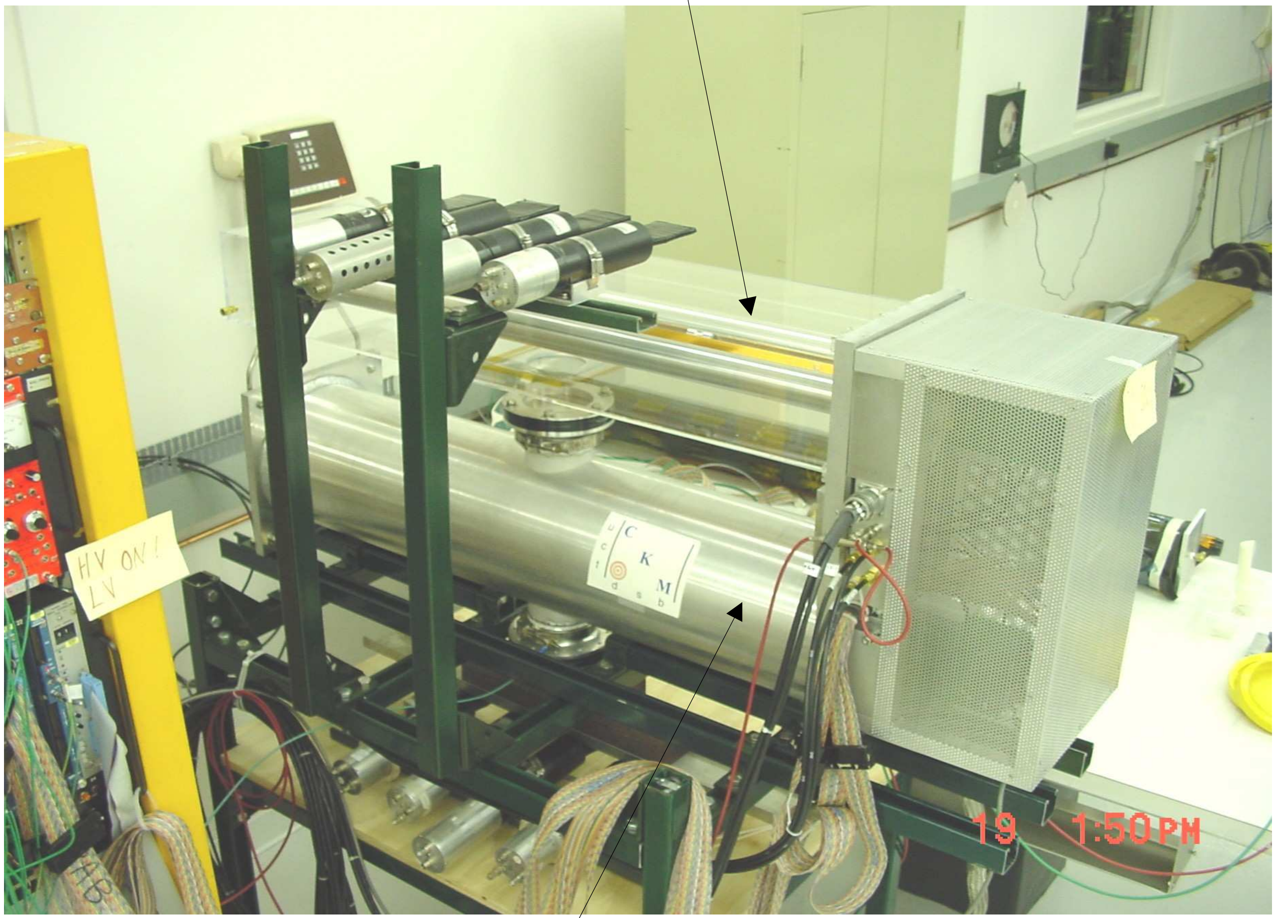


*0.5 nsec/count TDC

Chamber Operation in Vacuum



Chamber in Air

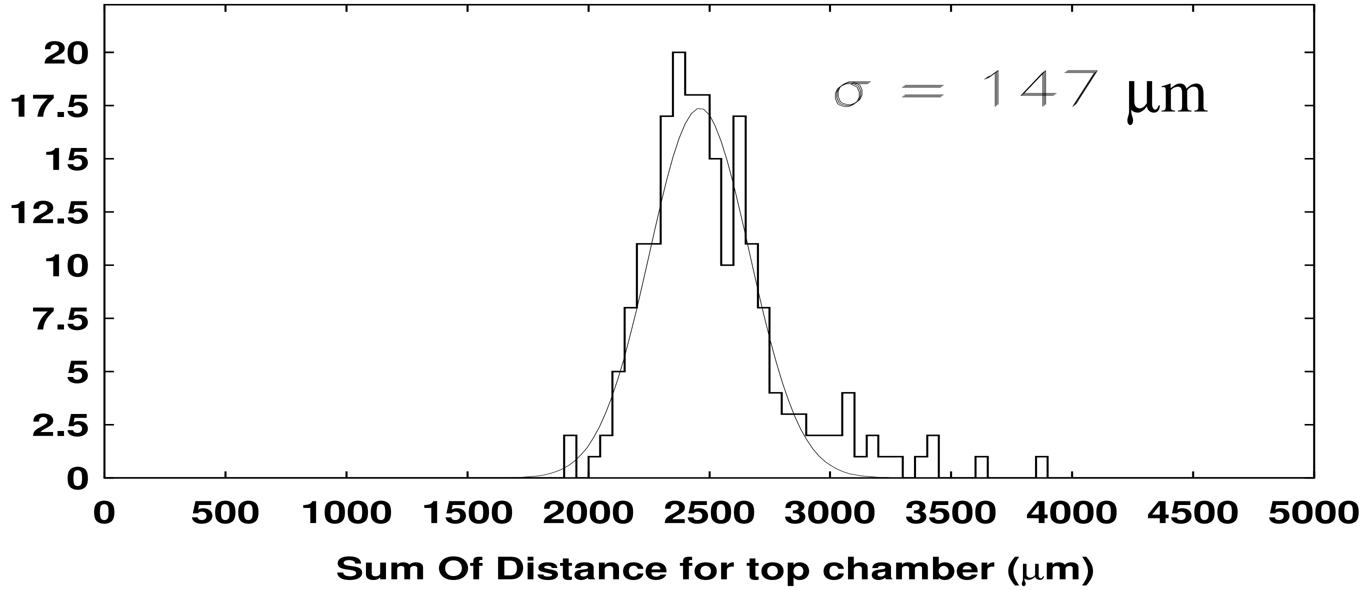


Chamber in 0.5 Torr Vacuum

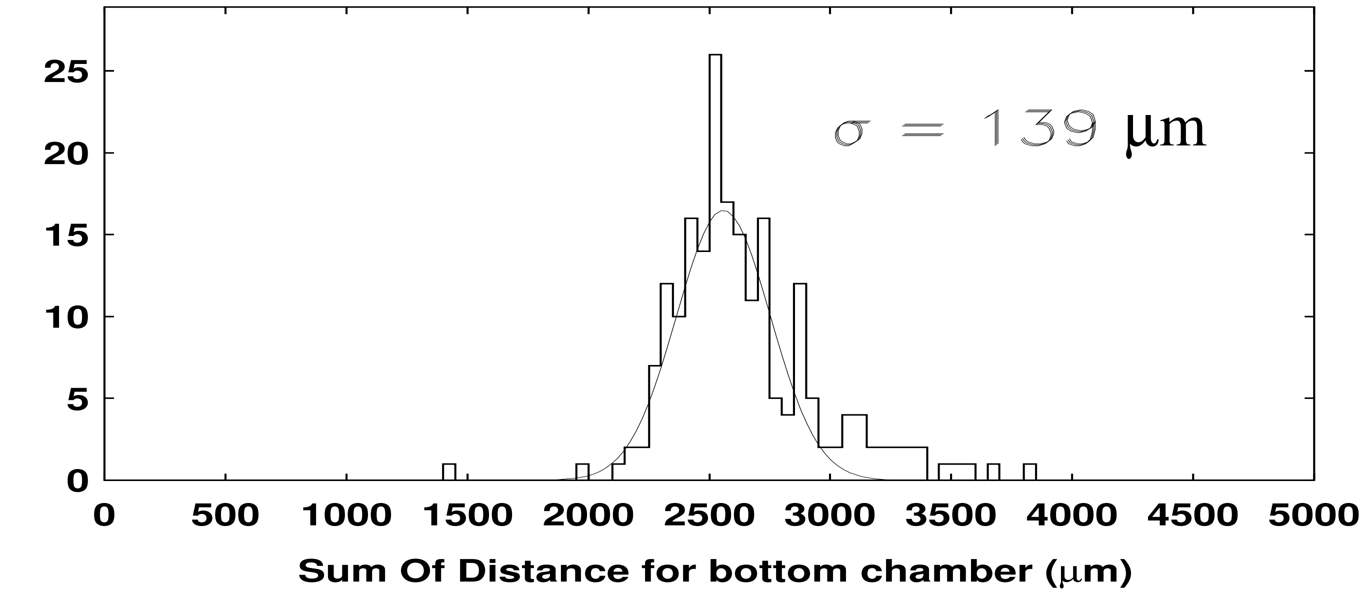
Cosmic Test Stand

Cosmic Study of Chamber Performance in Vacuum

Chamber at 1 atm



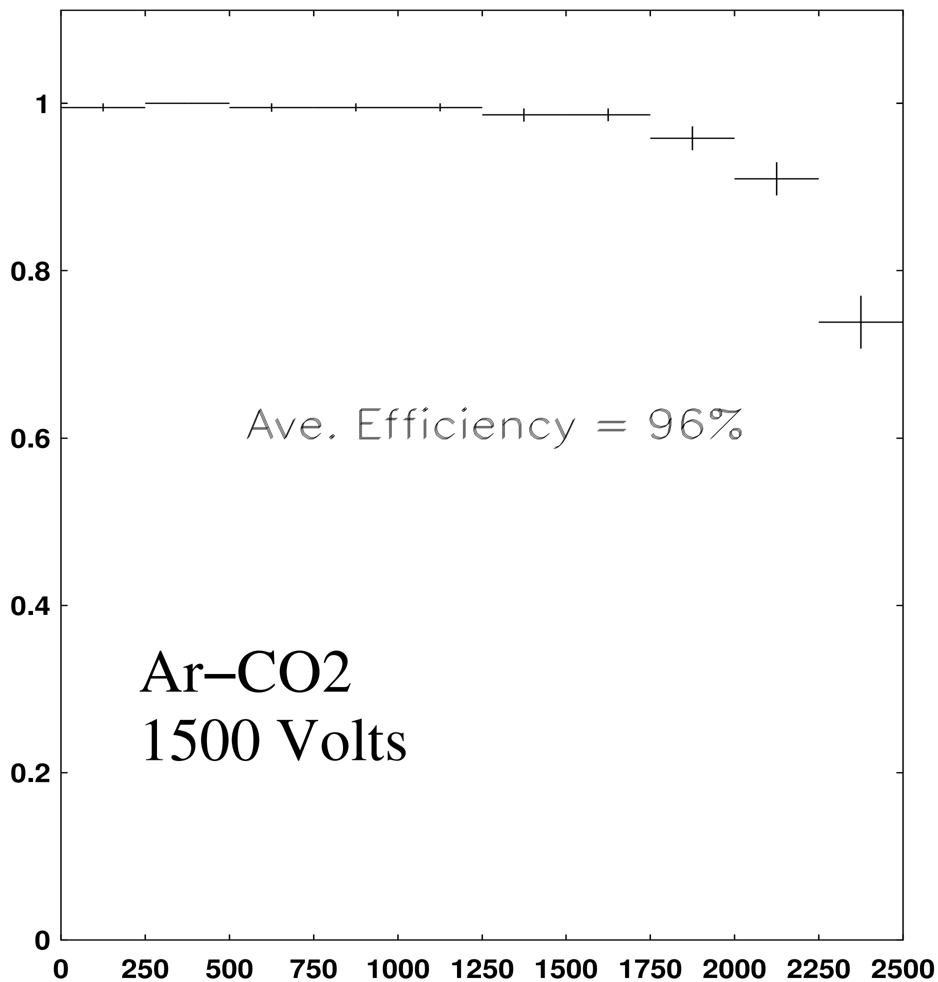
Chamber in 0.5 Torr Vacuum



* ArCO2
1500 Volts

Cosmic Study of Chamber Performance in Vacuum

Chamber in
0.5 Torr
Vacuum



Track DOCA to Wire (μm)

Summary of Technical Status

We have understood the significant construction and assembly issues.

Straw drift tubes in vacuum behave as well as conventional drift tubes.

We are continuing to study large (O(100)) samples of straws in vacuum for long term.

We are rapidly developing a full scale conceptual design, keeping in mind the straw reliability issues.

Conceptual Design

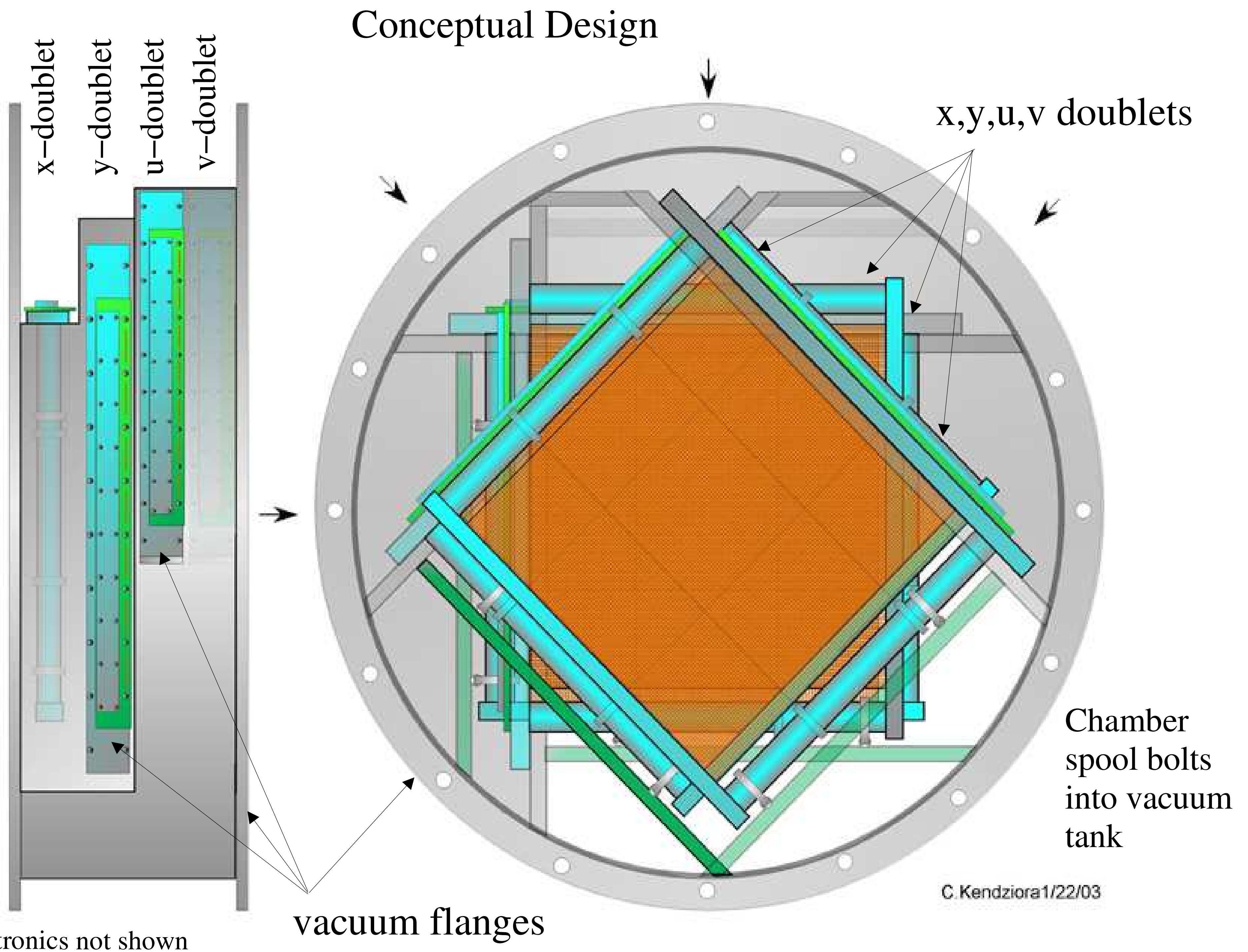
Based on the design of 20–channel prototype.

Construction of ~ 15 identical planar doublets, each with 320 straw channels.

Doublets are inserted into "spool", which bolts to the rest of the vacuum tank.

If a straw is found to leak, gas flow to that doublet can be disabled. This is a loss of 2 measurements out of 8 (5 for DMS1).

We are continuing to study large (O(100)) samples of straws in vacuum for long term. This is ~ 1/3 of a doublet.



* electronics not shown

Vacuum Tracker Cost Estimate

Submitted to PAC/Technical Review Subpanel in June 4–2001

WBS Item (2.7)	Costing Source	Quantity	Total
2.7.1 Prototyping cost	Nguyen		$50K
2.7.2 Production tooling	Krider		$85K
2.7.3 Chamber Stations	Krider	4	$350K
2.7.4 Vacuum Components	Kendziora		$100K
2.7.5 Gas System	Nguyen		$50K
2.7.6 Spectrometer Coils	KTeV/Jensen		$750K
2.7.7 Spectrometer Iron	guess		$250K
2.7.8 Exit Time Plane (ETP)	Scaled to BTSM		$93K
Subtotal M&S Cost			$1728K

* Labor and contingency not included

- The costing source was based on experience with similar systems: KTeV Transition Radiation Detector (Krider), KTeV Drift Chamber (Nguyen), and extensive experience with vacuum systems (Kendziora).

- The estimate was done **prior** to our construction of the two 20–channel prototypes.

- A reexamination of the costs did not reveal significant differences **except** that we will now use the existing KTeV analysis magnet (~$1M).

- We look forward to sharing these findings with the reviewers.

Back up Slides

Cost Reexamination

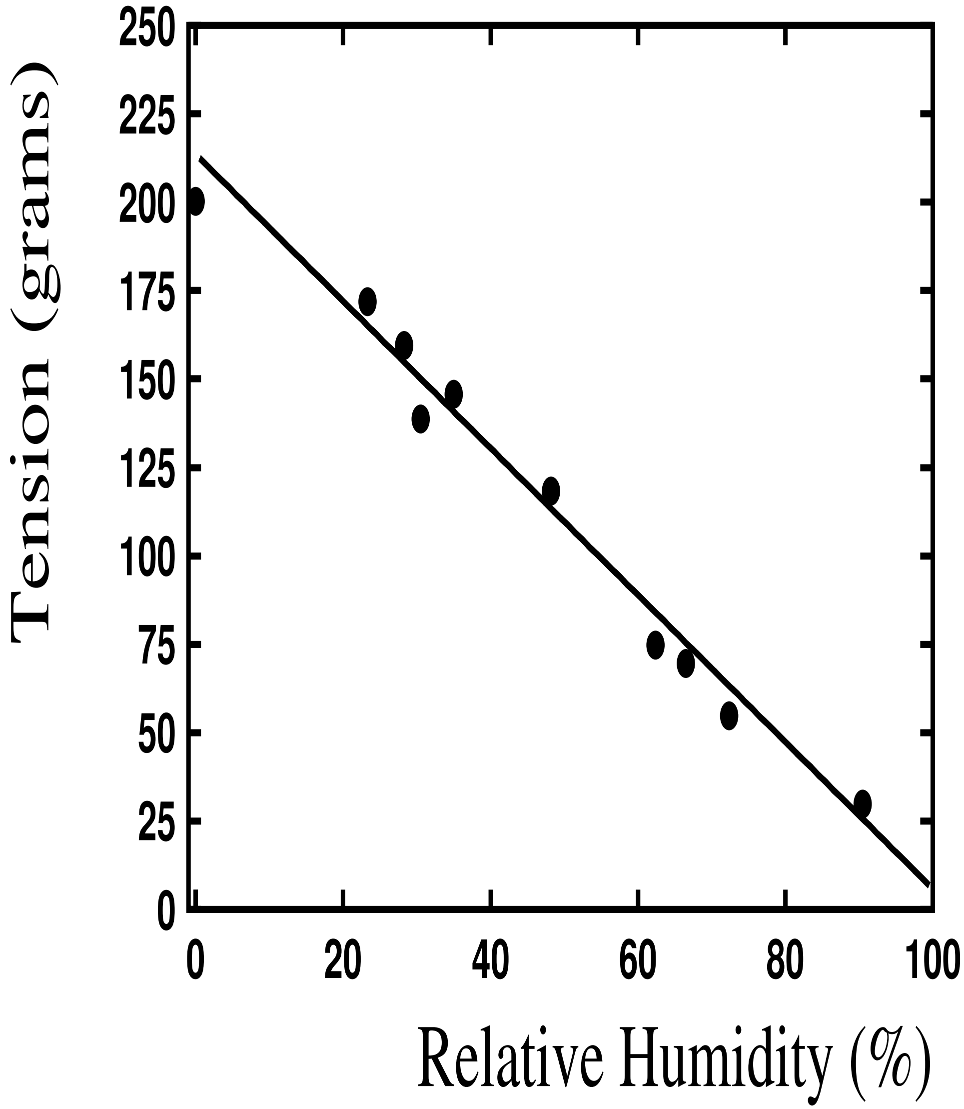
Feb–18–2003

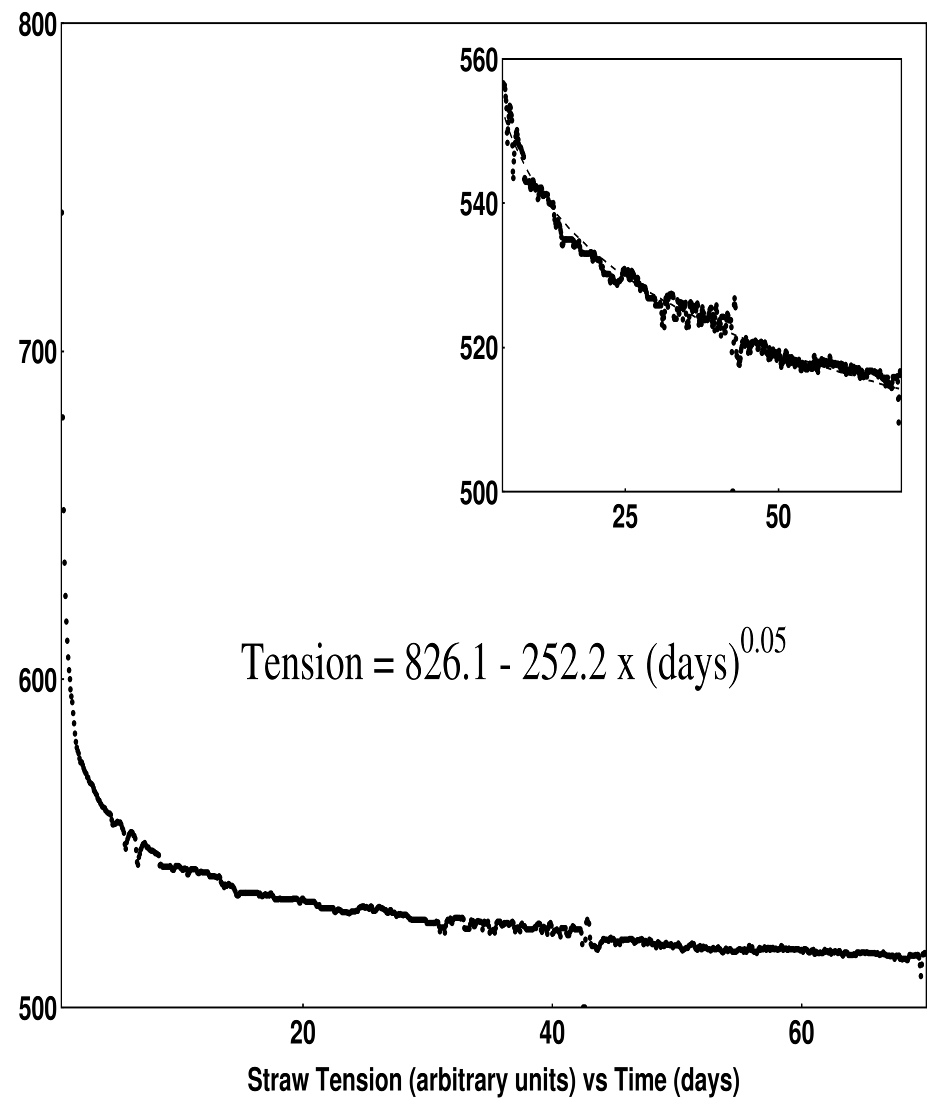
Item	Cost per	Quantity	Extended Cost
Ultem and Collar	$1	10000	10K
Brass center pin	$5	10000	50K
Brass straw ends	$5	10000	50K
Straws	$7	5000	35K
Frame Material	$1,000	15	15K
Frame Machining	$9,800	15	147K
Spool Piece *	$50,000	4	200K
Gas system	$50,000	1	50K
Monitoring	$10,000	1	10K
Assembly tooling	$50,000	1	50K
QC equipment	$25,000	1	25K
Total			642K

Labor: 1 physicist for 1 year, 1 engineer for 1 year, 1 senior tech for 1 year, 4 mechanical techs for 1 year.

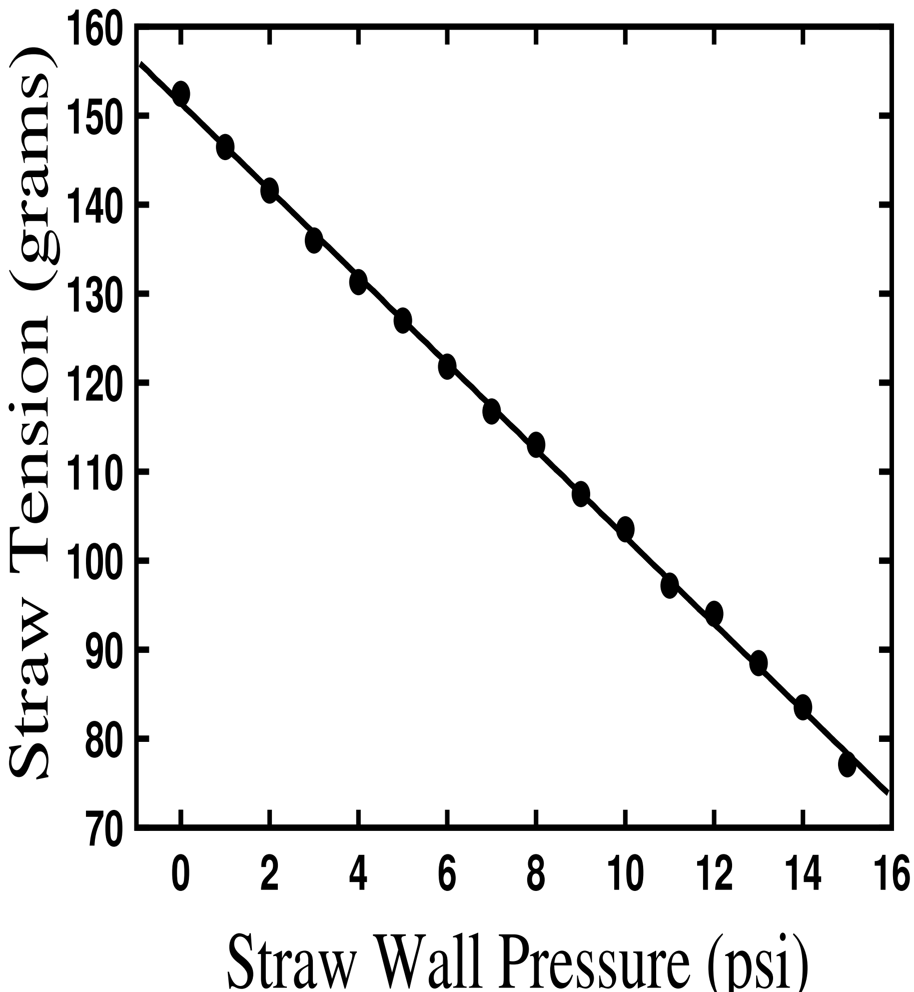
* Typical spool piece for VVS costs ~ $17K per spool

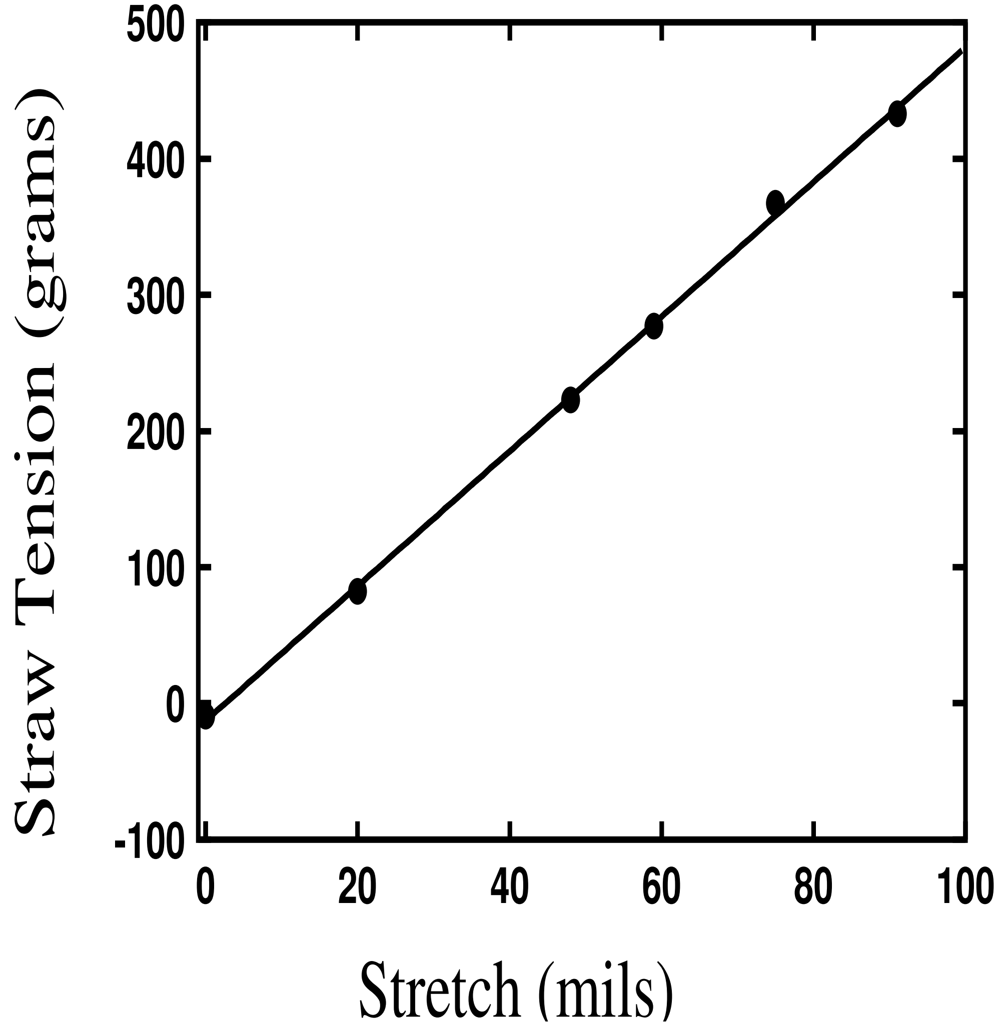
Straw Mechanical Properties





Straw Mechanical Properties





Measurement of Straw Diffusion

Gas	μT/liters/sec
Helium	9.8
N_2	0.2
Neon	0.4–0.9