Aging in Large CDF Tracking Chambers

International Workshop on Aging Phenomena in Gaseous Detectors

DESY
Hamburg, Germany
October 2001

Presented by:
Morris Binkley, Fermilab

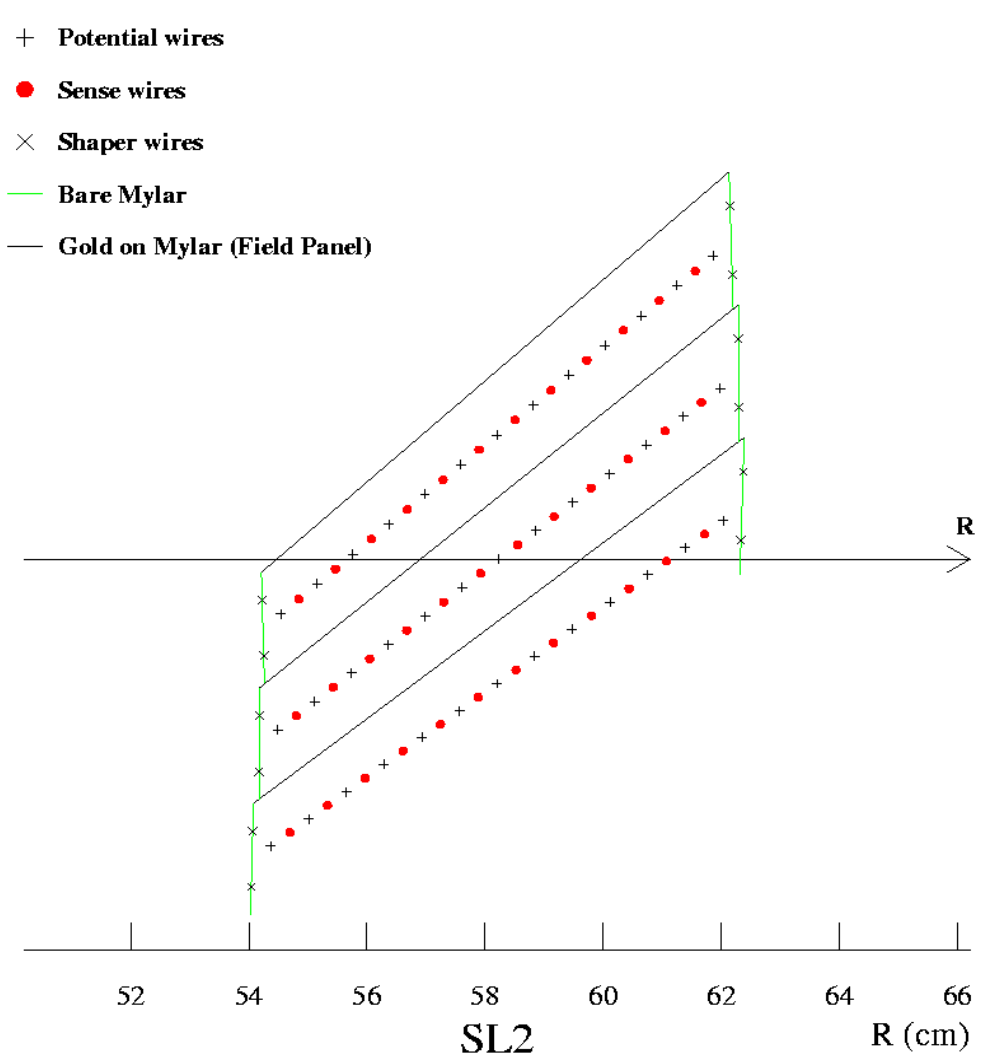
Other contributors:
R.L. Wagner, A. Mukherjee,
G. Bauer, D. Ambrose,
D.M. Khazins

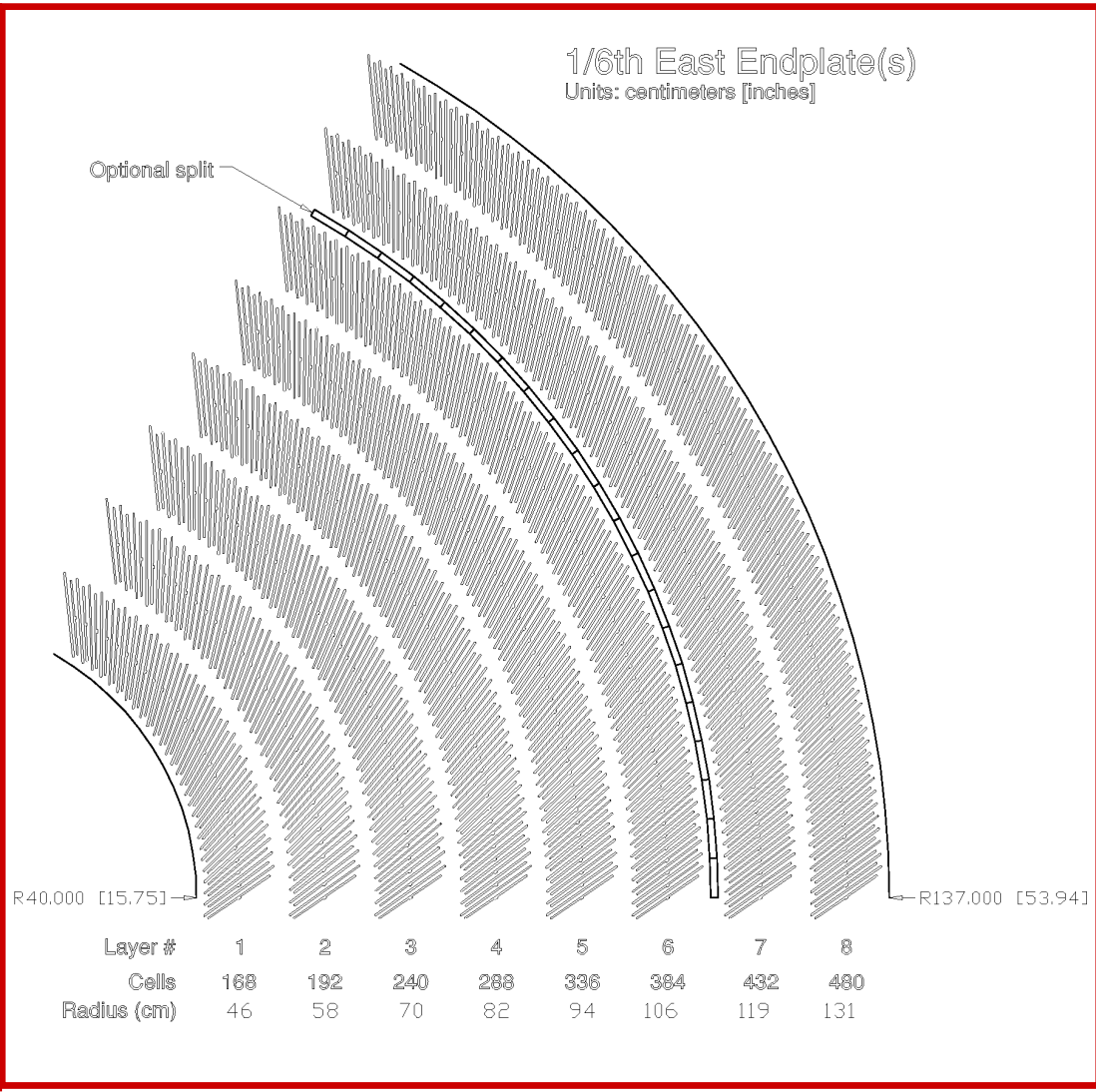
Specifications of Large CDF Chambers

- General Large Chamber Parameters:
  - Sense Wires: 40 micron Au plated tungsten.
  - Gas: 50/50 Argon/Ethane plus about 1% alcohol.
  - Size: approx. 3 meters long by 3 meters diameter.
- Chamber for Run 1 (CTC):
  - Cathode planes: 140 micron 304 stainless steel wires.
  - About 6000 wires; approx. 5 cm drift distance
  - Ethyl Alcohol used to reduce aging.
- Chamber for Run 2 (COT):
  - Cathode planes: 350 angstrom vapor-deposited Au on mylar sheets.
  - About 30000 wires; approx. 1 cm drift distance
  - Isopropyl Alcohol used to reduce aging.

COT Chamber Under Construction

Cell Geometries for COT – Run2.

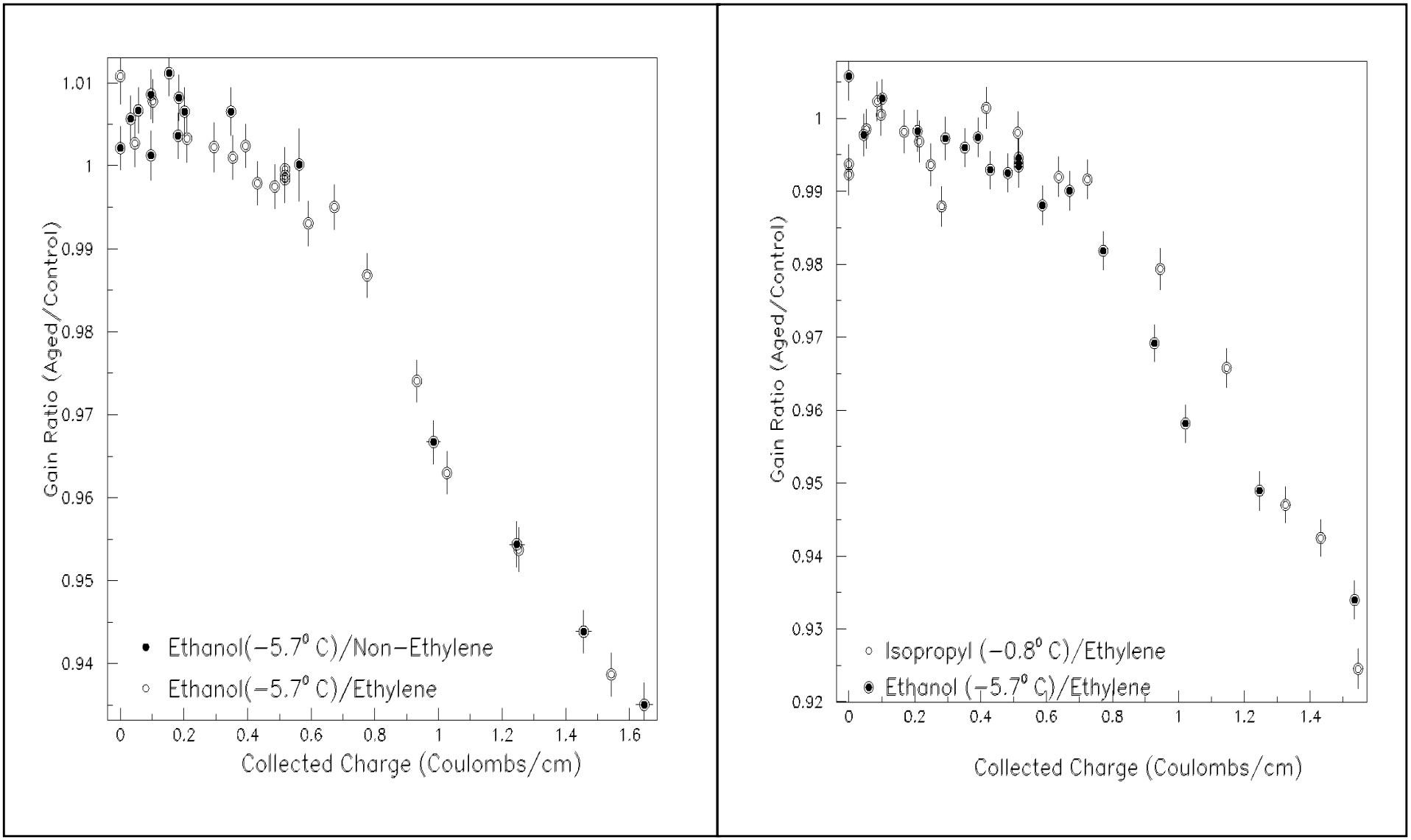




Run 1 Experience with Aging (CTC)

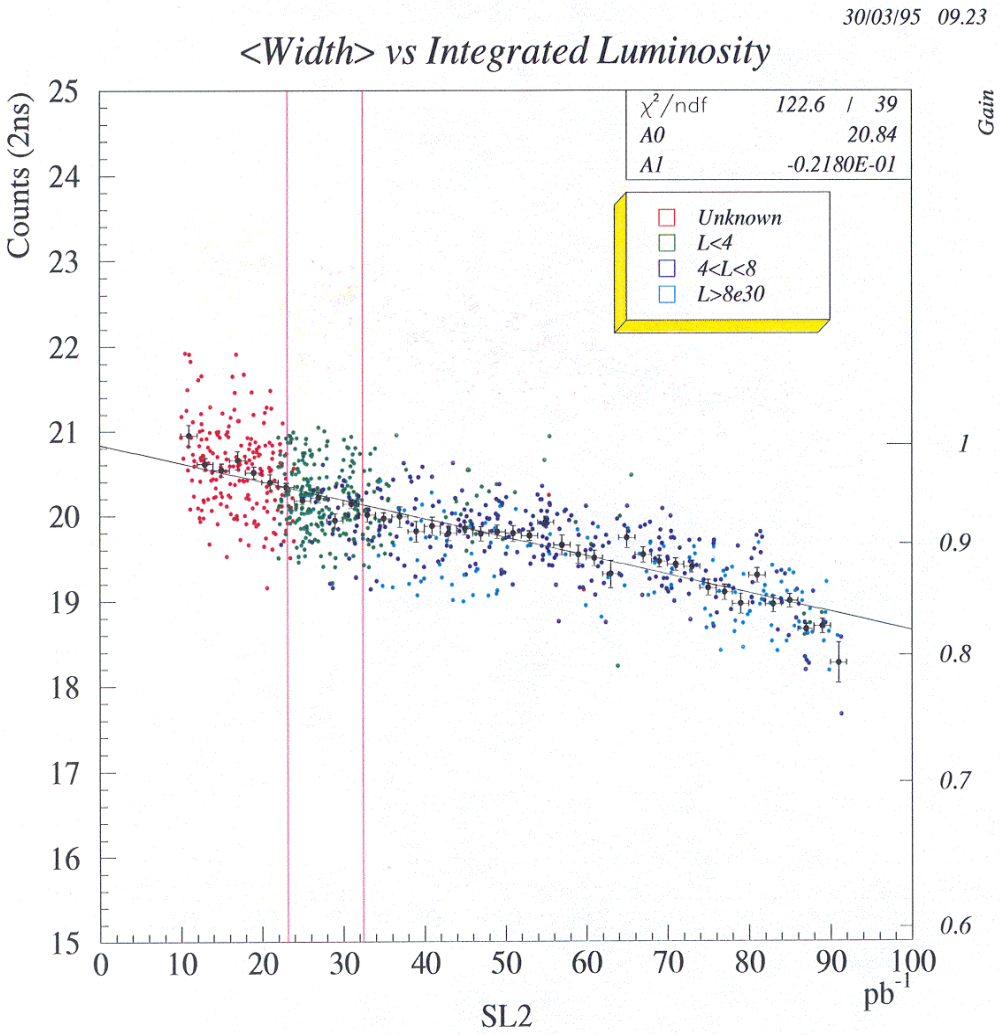
- Prior to Run 1, tests on prototype chambers indicated aging rates < 10%/Coulomb/cm.
  - Using regular Argon/Ethane gas from CDF supply tanks.
- Near the end of Run 1 (early 1995), much larger aging effects (1000%/C/cm) were noticed in the CTC.
  - This large aging rate was consistent with starting in early 1994 coincident with two unrelated occurrences:
    - There was a change in ethane supply (much more ethylene).
    - There was a significant increase in instantaneous luminosity.
- Aging effect of ethylene was measured before the change.
  - Without alcohol, aging rate with ethylene about 80%/C/cm.
  - With ethyl or isopropyl alcohol, aging rate about 5%/C/cm.

Aging results with ethylene and alcohol

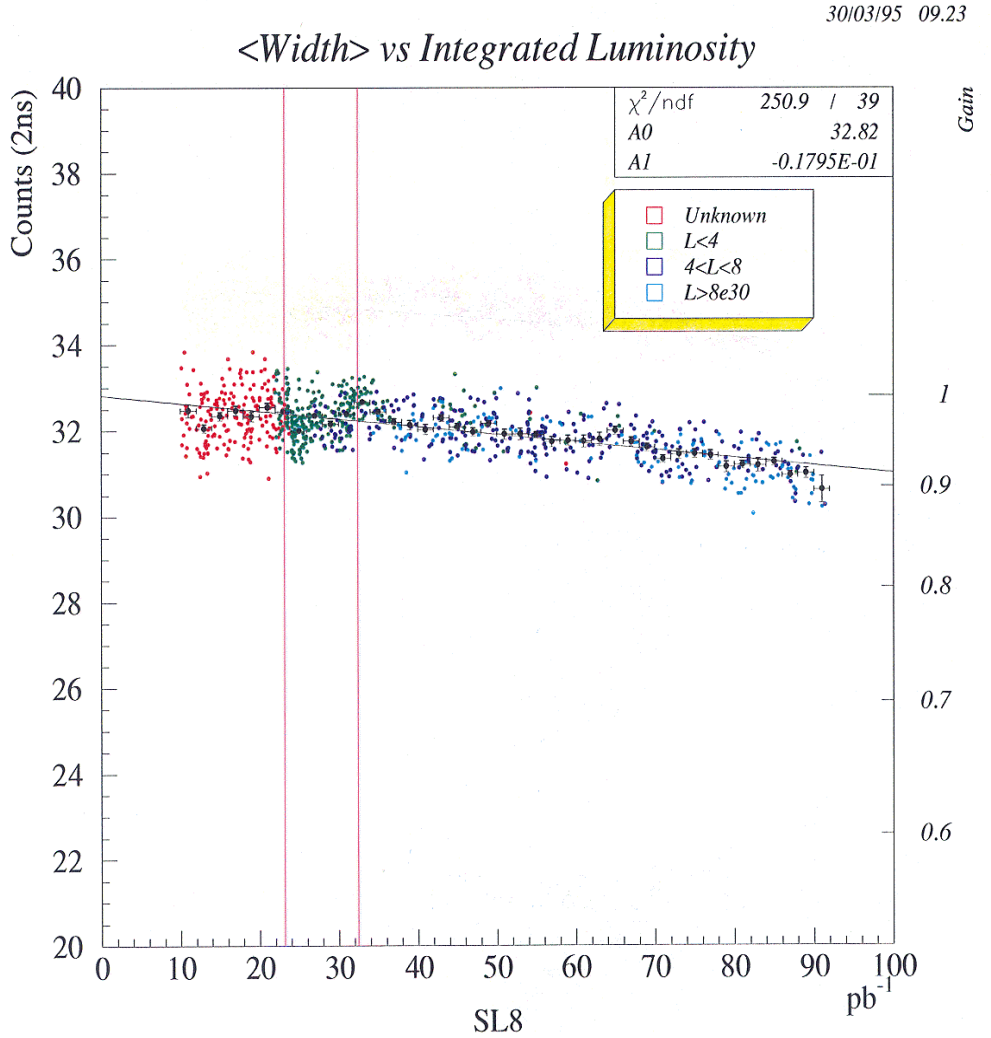


Measuring CTC Aging from CDF Data.

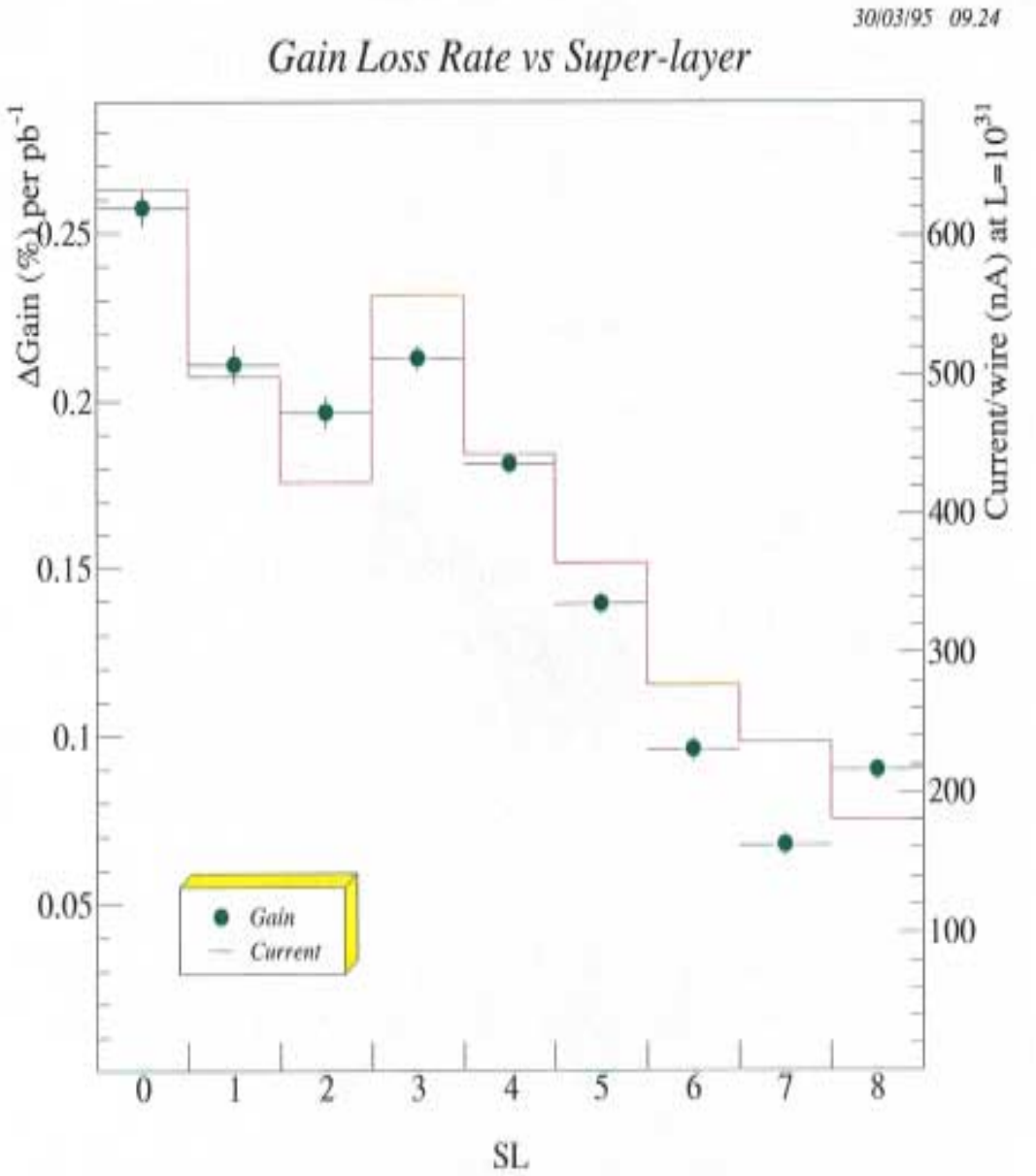
Innermost Superlayer SL0



Outermost Superlayer SL8



CTC Summary Plots: ΔGain = 1000%/coulomb/cm



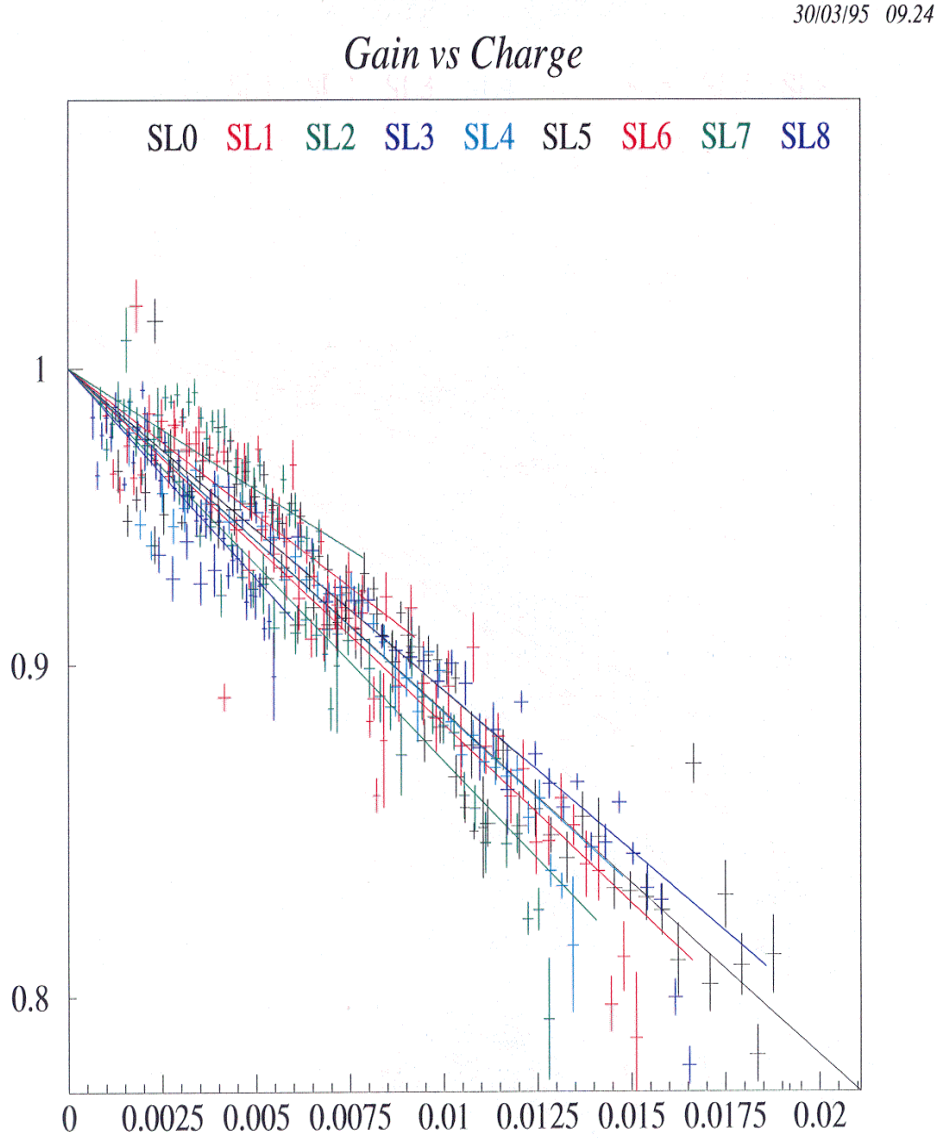
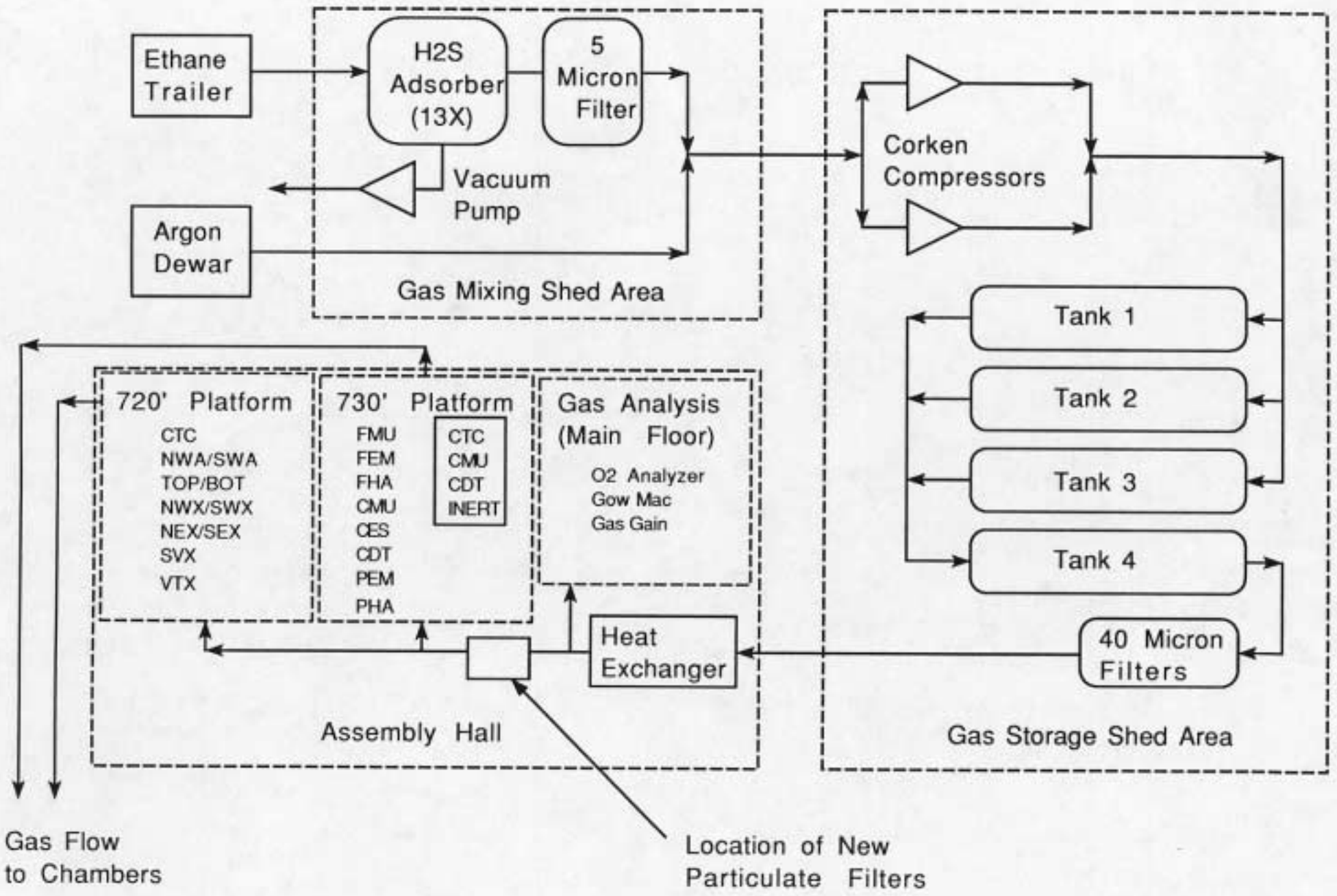


Figure 1. CDF Gas System Simplified Diagram

May 1995



Response to measured CTC aging rate.

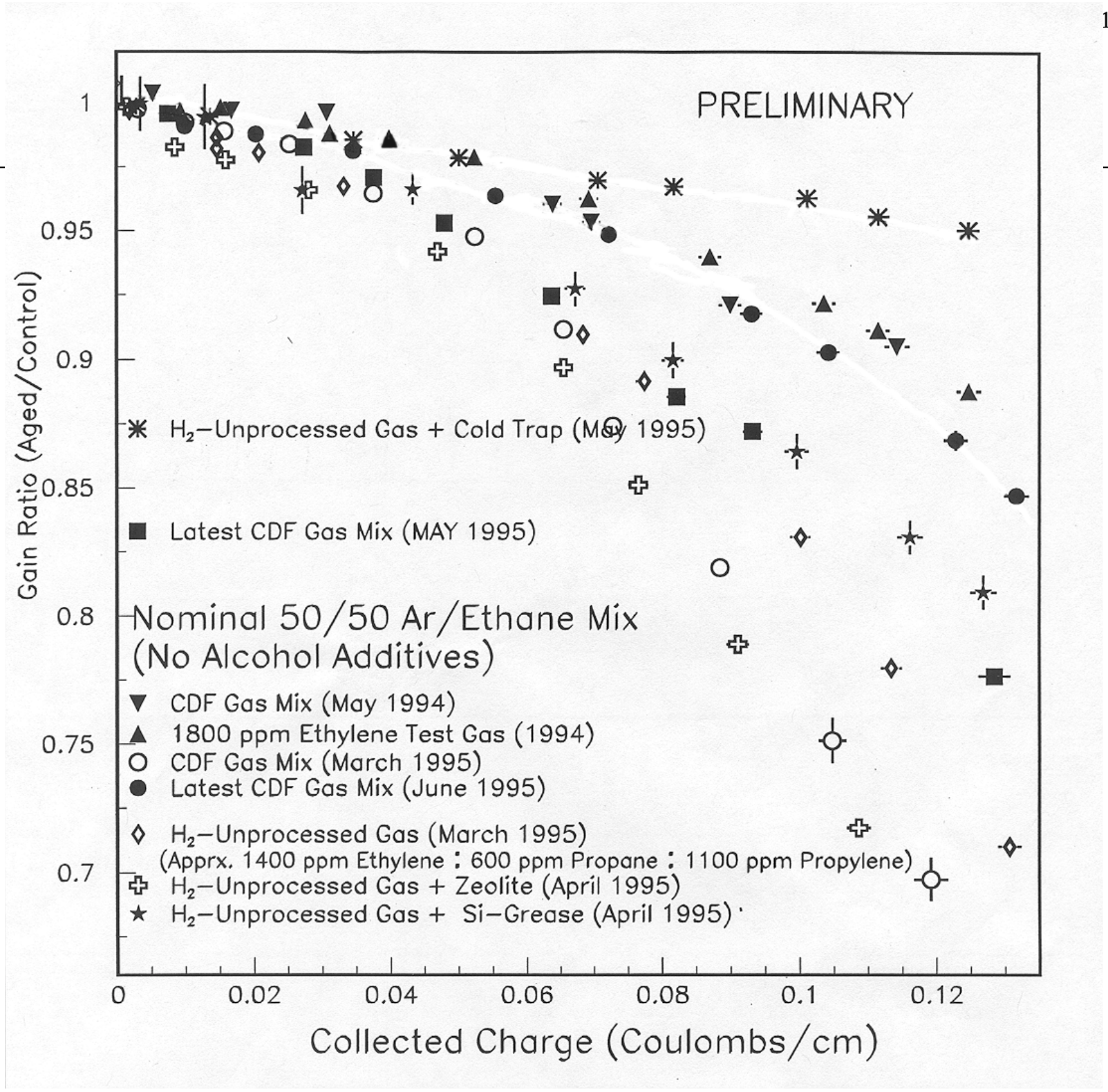
- March-April 1995 CTC parts of gas system cleaned.
  - Mineral oil inlet pressure relief replace by mech. valve.
  - Alcohol bubbler backflushed and refilled (silicone and gylcol found); many valves on the gas platform cleaned.
  - Molecular sieve cleaned of HYVAC oil; plumbing fixed.
- After above cleaning, monitor chambers were inserted into the CTC gas flow.
  - Sr^{90} sources were used as the source of aging.
  - Fe^{55} sources were used to measure gains.
  - MC's are 3 tubes in parallel and SS's a single tube.
  - Each chamber took the take full CTC gas flow.
  - Source exposure over 2 to 3 inches; current ~ 1μa.

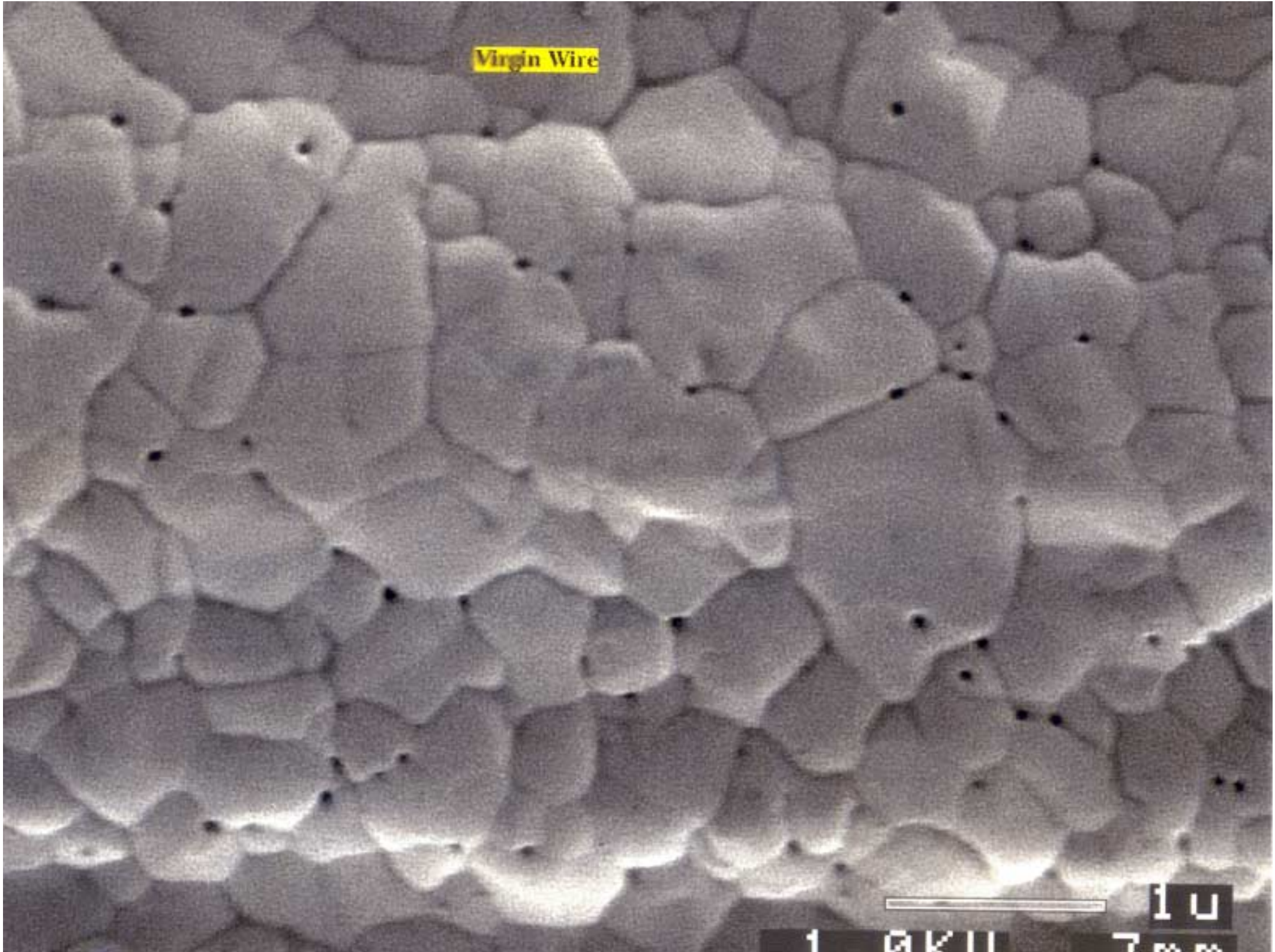
Chronology of Monitor Chamber Results

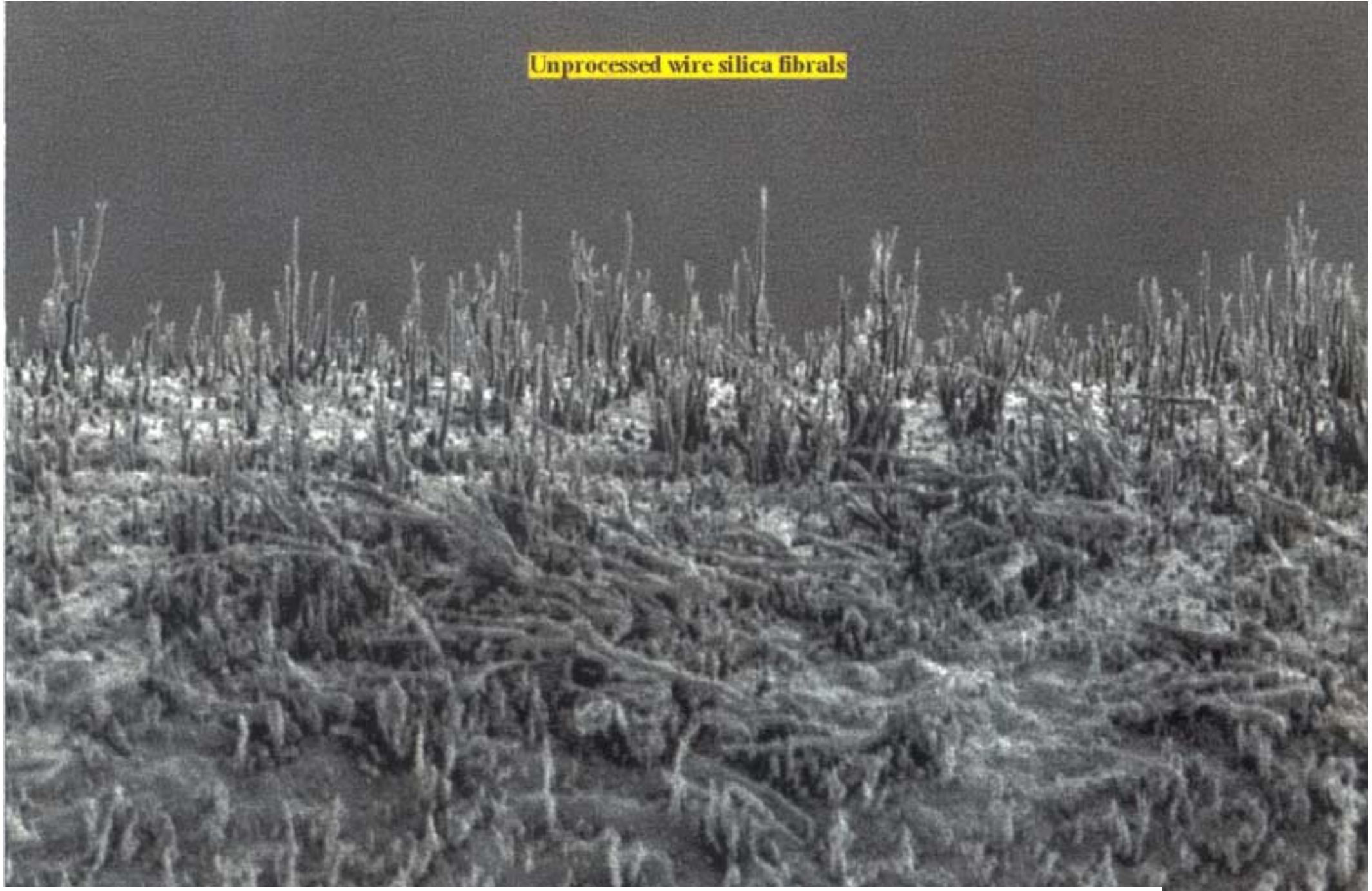
- Apr: Aging rate measured after alcohol bubbler ~100k%/C/cm .
- Apr-May: Many more gas valves cleaned, aging still ~100k%/C/cm .
- May-Jun: Aging at CTC input (50 m. from bubbler) ~15k%/C/cm .
- Suspect aerosols from alcohol may contribute to aging. Put a filter canister after the alcohol bubbler with a single Cu wool filter pad.
- Jun-Jul: Aging at CTC input ~10k%/C/cm; at CTC exhaust < 0.5k%/C/cm.
- Jul: Aging just before Cu wool filter, but after bubbler (100 ±7)k%/C/cm.
- Jul: Aging directly after Cu wool filter canister (50 ±11)k%/C/cm.
- Pack second Cu wool pad in canister and heat with heating tape (~50 °C).
- Aug: Aging directly after Cu wool filter (16 ±4)k%/C/cm.
- Aug: Aging at CTC input: (3±2)k%/C/cm; at exhaust (0.4±0.2)k%/C/cm
- Put a 2nd Cu wool canister after bubbler; raise alcohol bubbler temperature to ~20 °C so that only 1/6th of the gas must flow through the bubbler.
- Nov-Feb: Aging directly after two Cu wool canisters (.05 ±.03)k%/C/cm.
- Nov-Feb: Aging CTC input (.01±.03)k%/C/cm; exhaust (0.8±.02)k%/C/cm

Analyzing Wires with Aging.

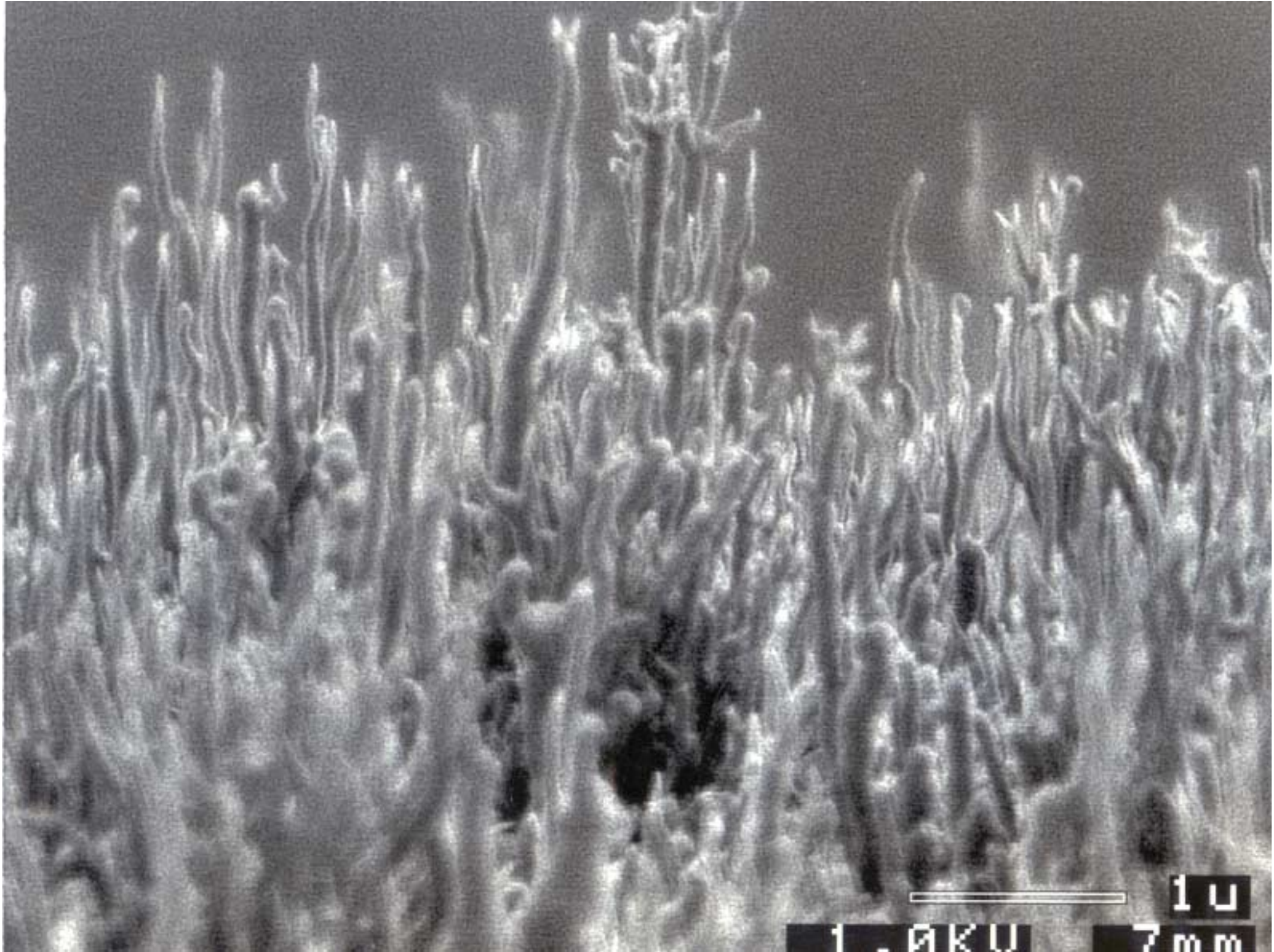
- Aged wires were scanned using an electron microscope to help interpret the findings. Energy and Wave Dispersive Spectroscopy (EDS and WDS) gave good spatial resolution and elemental spectroscopy. Additional Fourier Transform Infrared Spectroscopy (FTIR) gave information on molecular bonds.
- Wires for test chambers without alcohol had deposits dominated by silicon and oxygen in the form of silica. Pictures showed a landscape of thin fibers that resemble a dense, burnt out forest.
- Wire growths in test chambers after the bubbler showed carbon dominated deposits (~45%) with long aliphatic hydrocarbon chains. Pictures showed a smooth coating with “nodules.” There were a number of clumps with high Al content, one with W.
- CTC sense wire growths showed carbon (23-20%), oxygen (8-15%), and silicon (1.2-3%). Some similarity to test chambers after the bubbler, but coating thinner and the “nodules” more sparse.

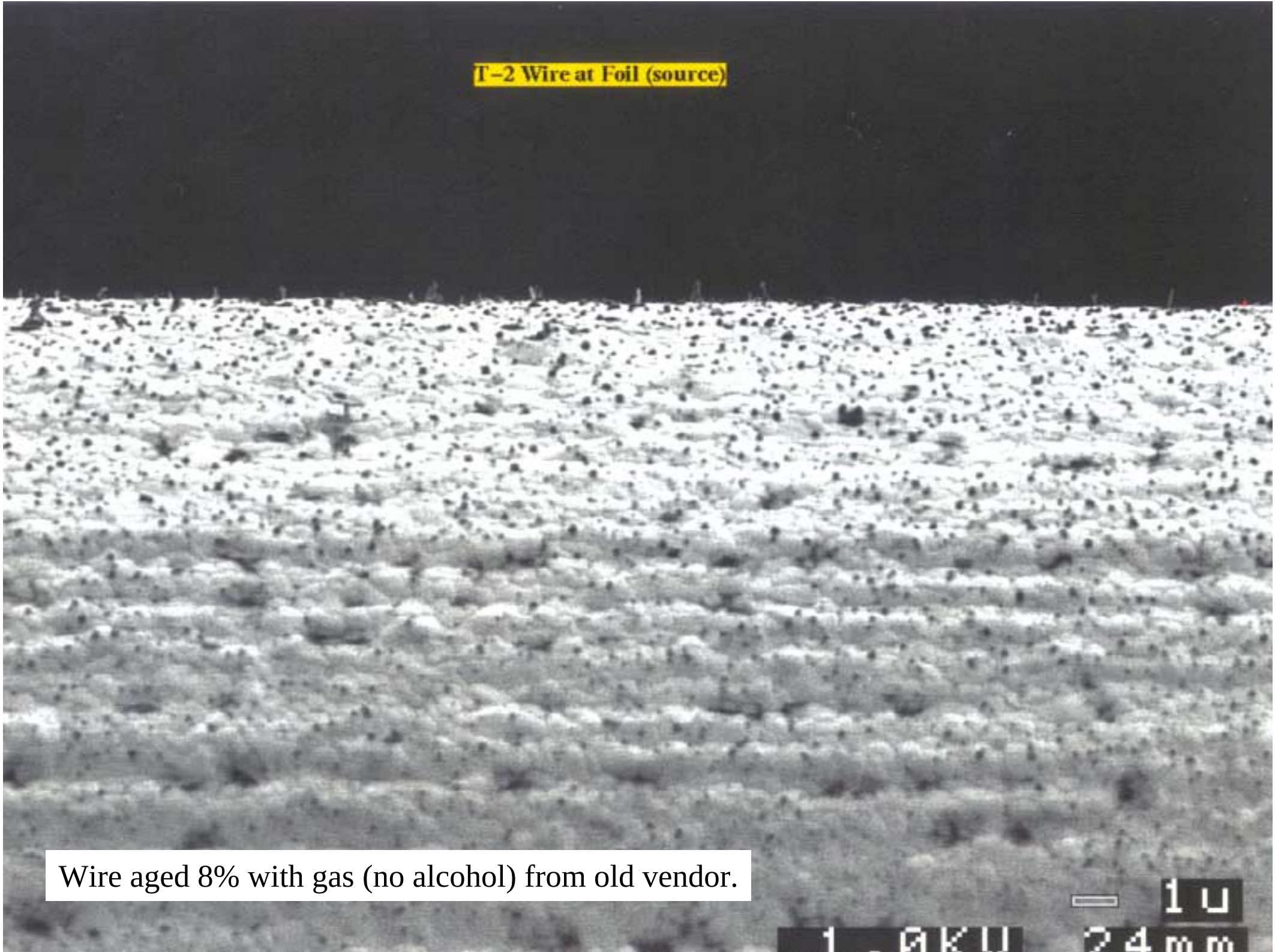

PRELIMINARY
Gain Ratio (Aged/Control)
1
0.95
0.9
0.85
0.8
0.75
0.7
0
0.02
0.04
0.06
0.08
0.1
0.12
Collected Charge (Coulombs/cm)
H2–Unprocessed Gas + Cold Trap (May 1995)
Latest CDF Gas Mix (MAY 1995)
Nominal 50/50 Ar/Ethane Mix
(No Alcohol Additives)
CDF Gas Mix (May 1994)
1800 ppm Ethylene Test Gas (1994)
CDF Gas Mix (March 1995)
Latest CDF Gas Mix (June 1995)
H2–Unprocessed Gas (March 1995)
(Apprx. 1400 ppm Ethylene : 600 ppm Propane : 1100 ppm Propylene)
H2–Unprocessed Gas + Zeolite (April 1995)
H2–Unprocessed Gas + Si–Grease (April 1995)

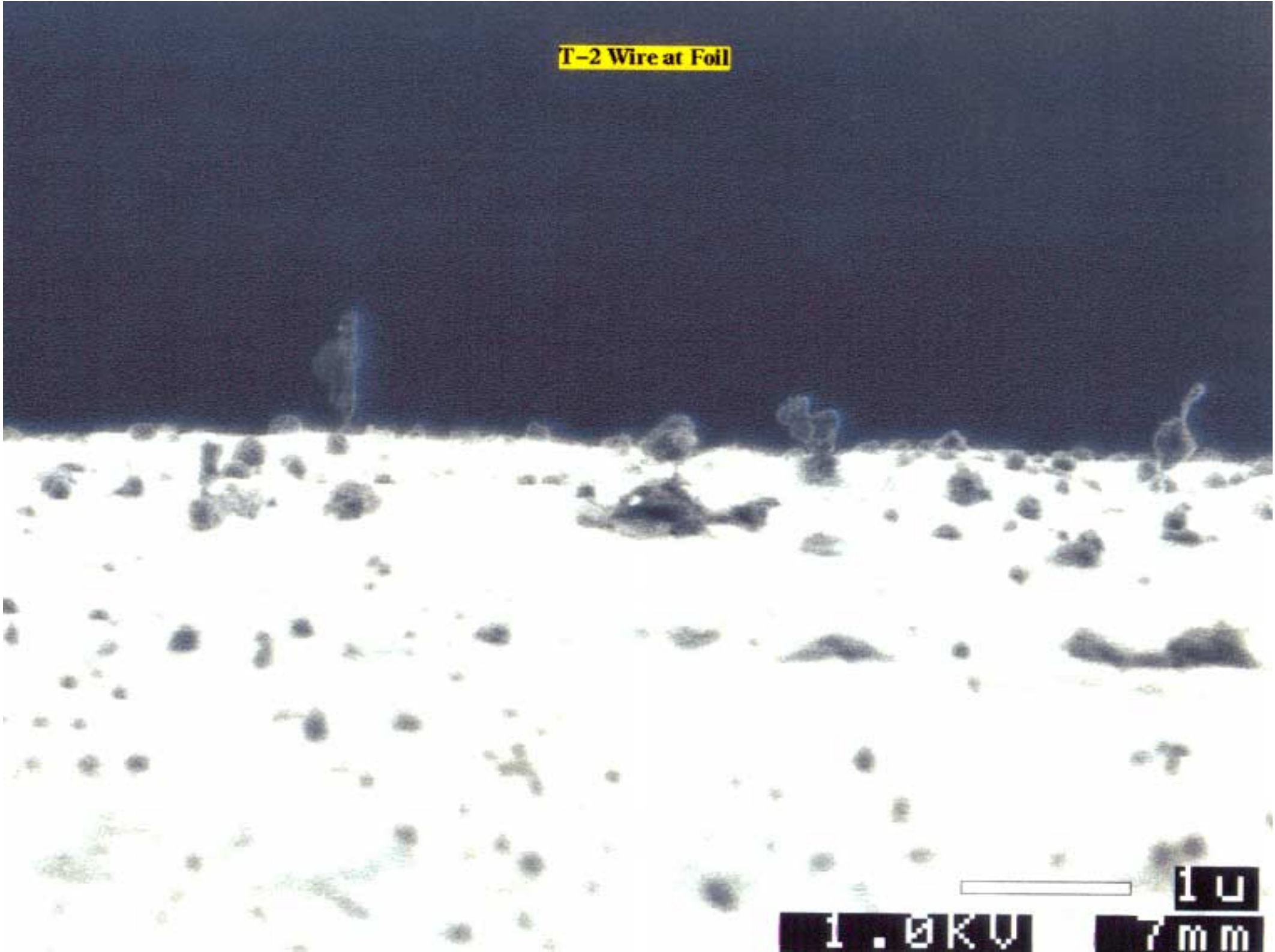

Virgin Wire
1u

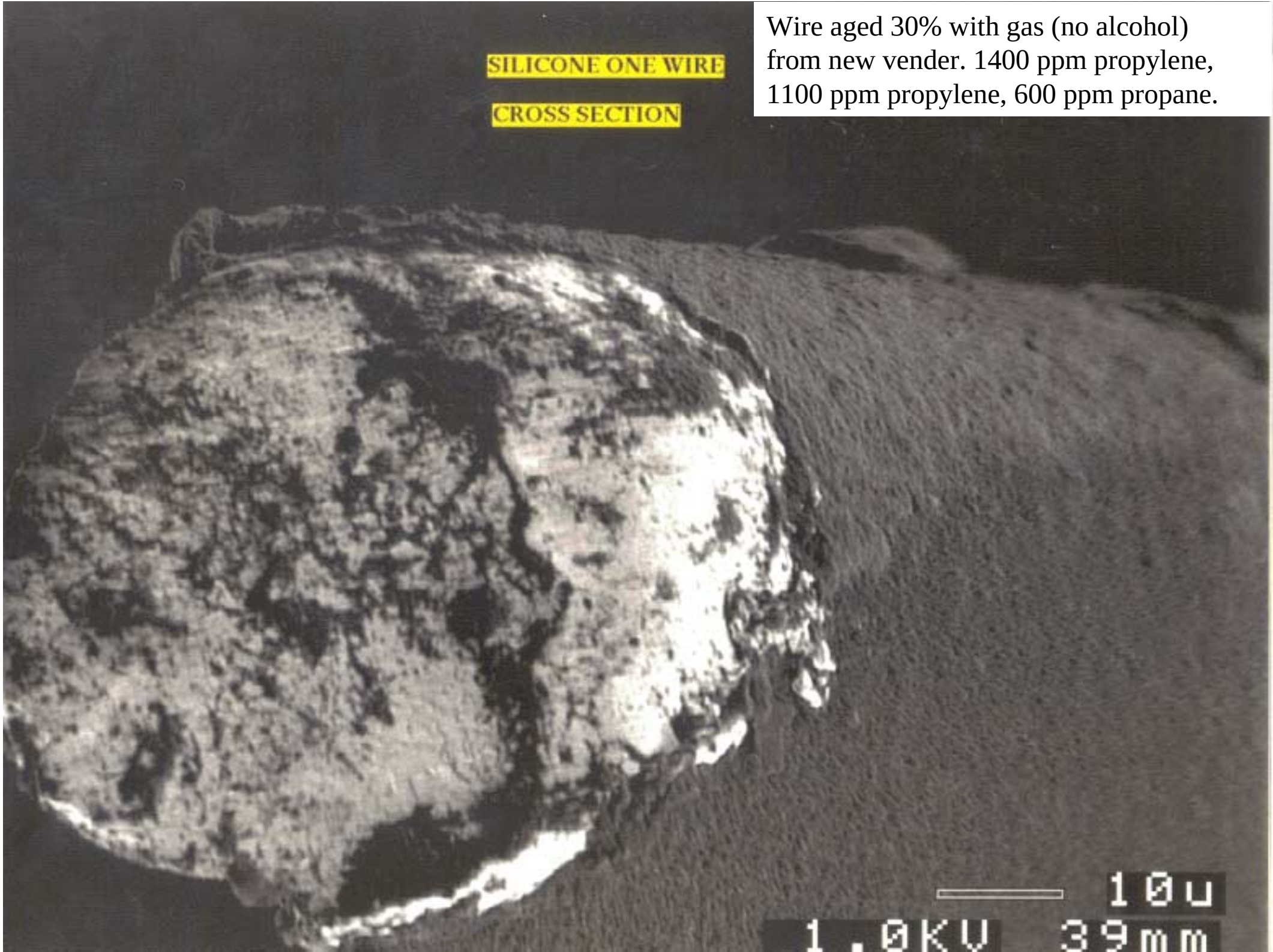


Unprocessed gas from the new vendor: 1400 ppm ethylene, 1100 ppm propylene, 600 ppm propane. Wire aged to 30% gain loss (about 0.13 coulomb/cm).


1u
1.0kV
7mm

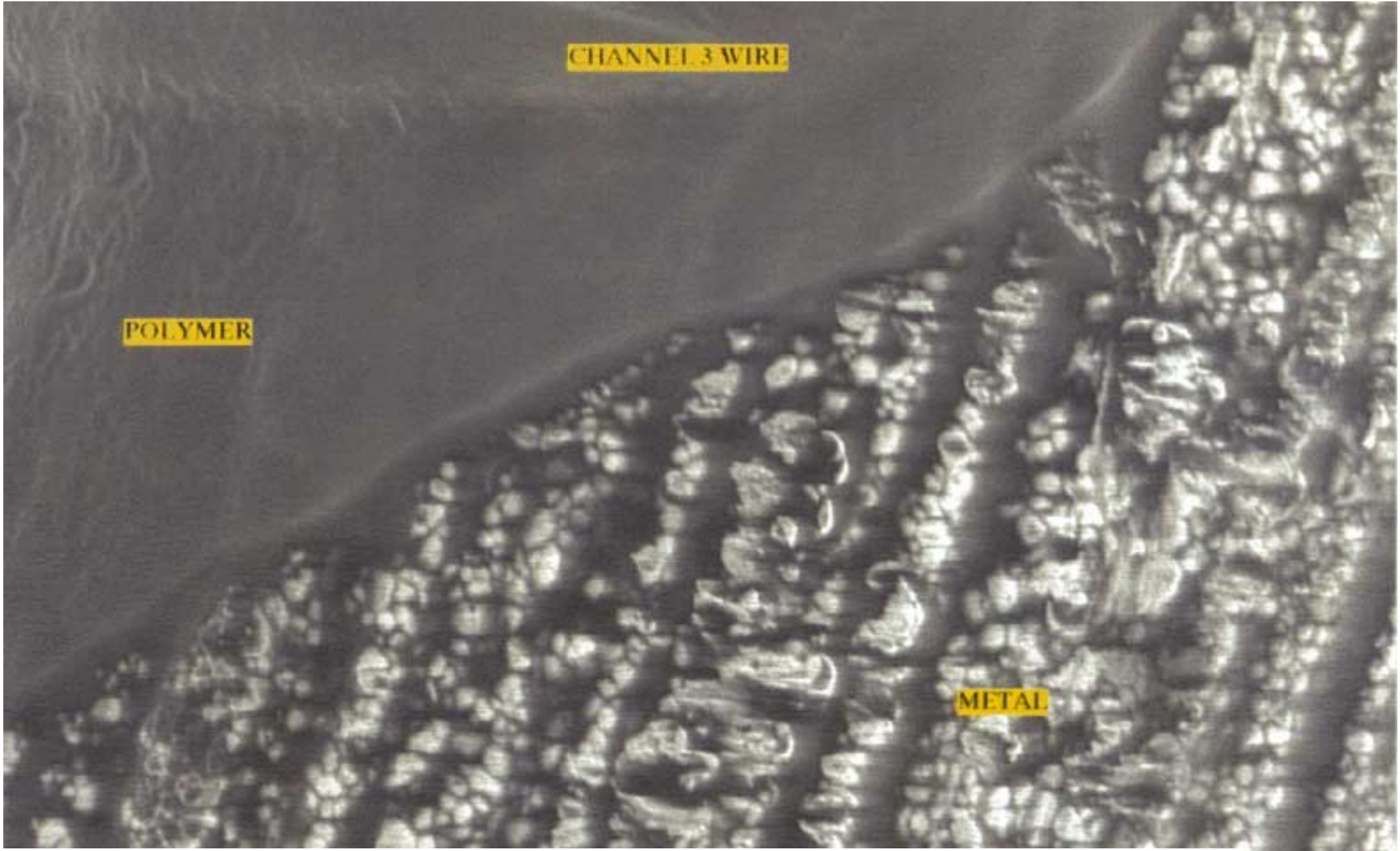

T-2 Wire at Foil (source)
Wire aged 8% with gas (no alcohol) from old vendor.
1 u
1.0kV 24mm


T-2 Wire at Foil
1.0KV
7mm

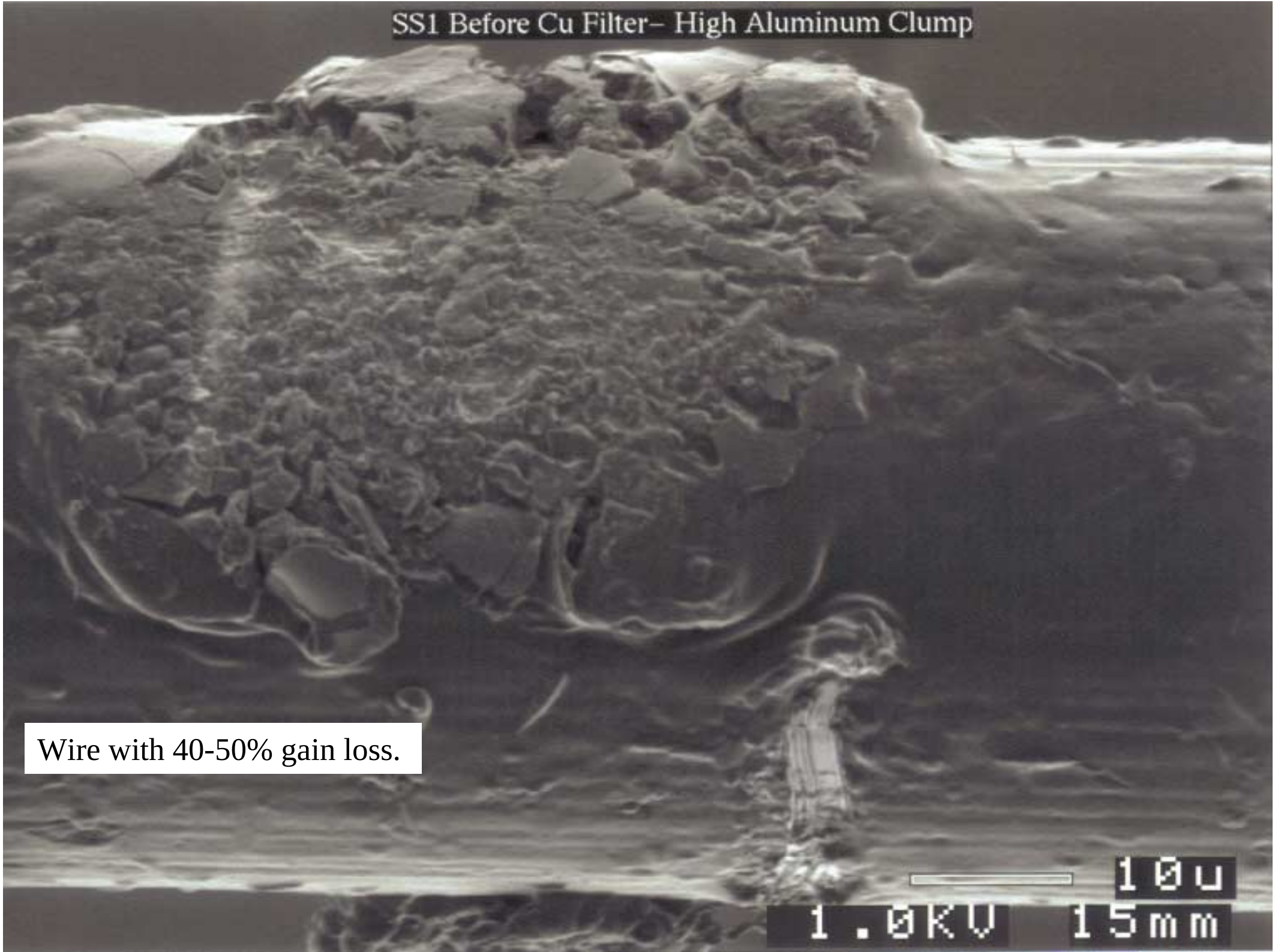


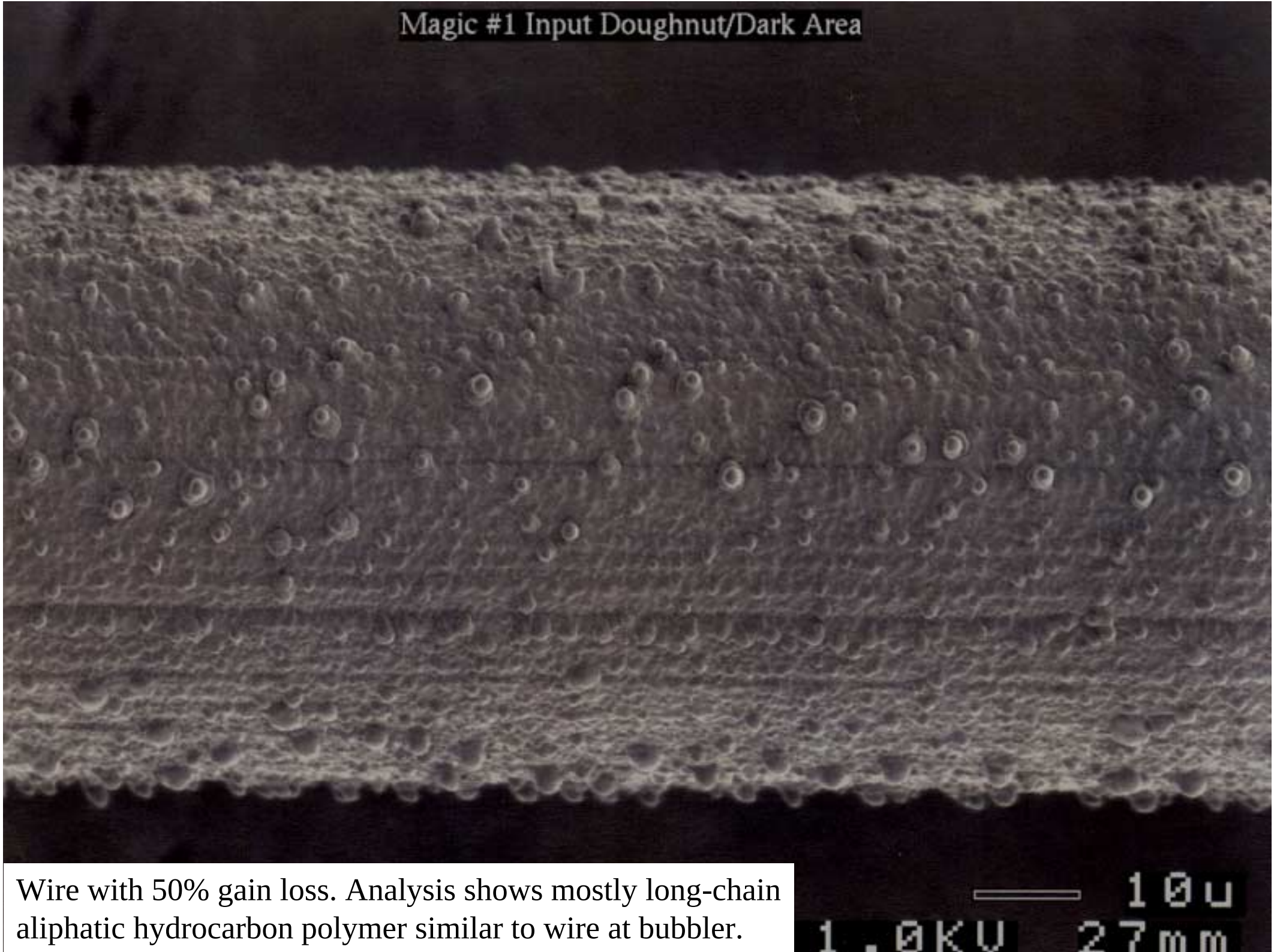
Wire aged 30% with gas (no alcohol) from new vender. 1400 ppm propylene, 1100 ppm propylene, 600 ppm propane.


SILICONE ONE WIRE
1u
1.0KV 3.9mm



Wire from test chamber just after bubbler. Aging at 100k%/C/cm. Smoother film-like coating. Mostly long-chain hydrocarbon polymers. Traces of silicone and OH bonds.

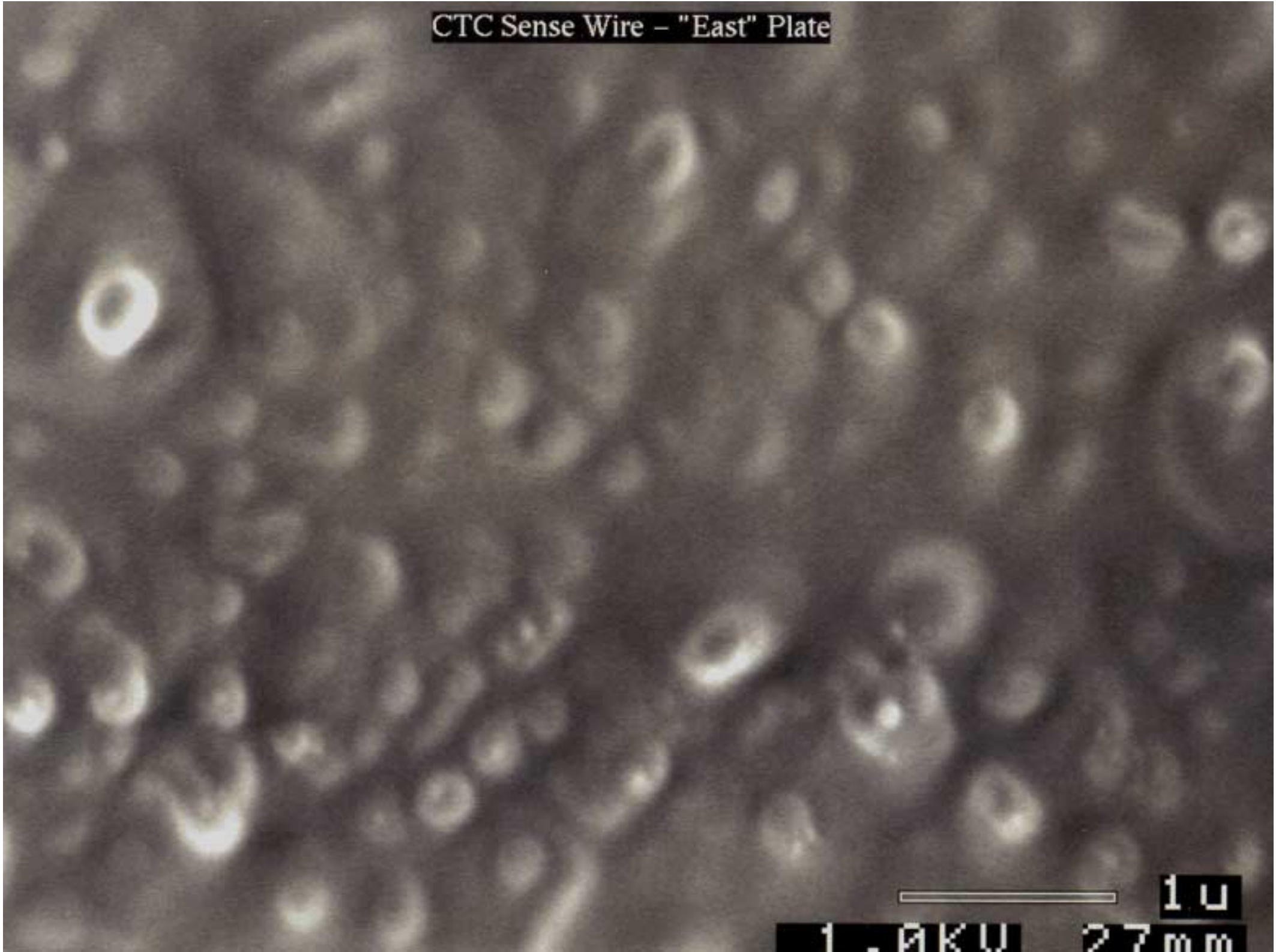

SS1 Before Cu Filter– High Aluminum Clump
Wire with 40-50% gain loss.
10u
1.0KV 15mm



Wire with 50% gain loss. Analysis shows mostly long-chain aliphatic hydrocarbon polymer similar to wire at bubbler.


Magic #1 Input Doughnut/Dark Area
1u
1.0KV 27mm

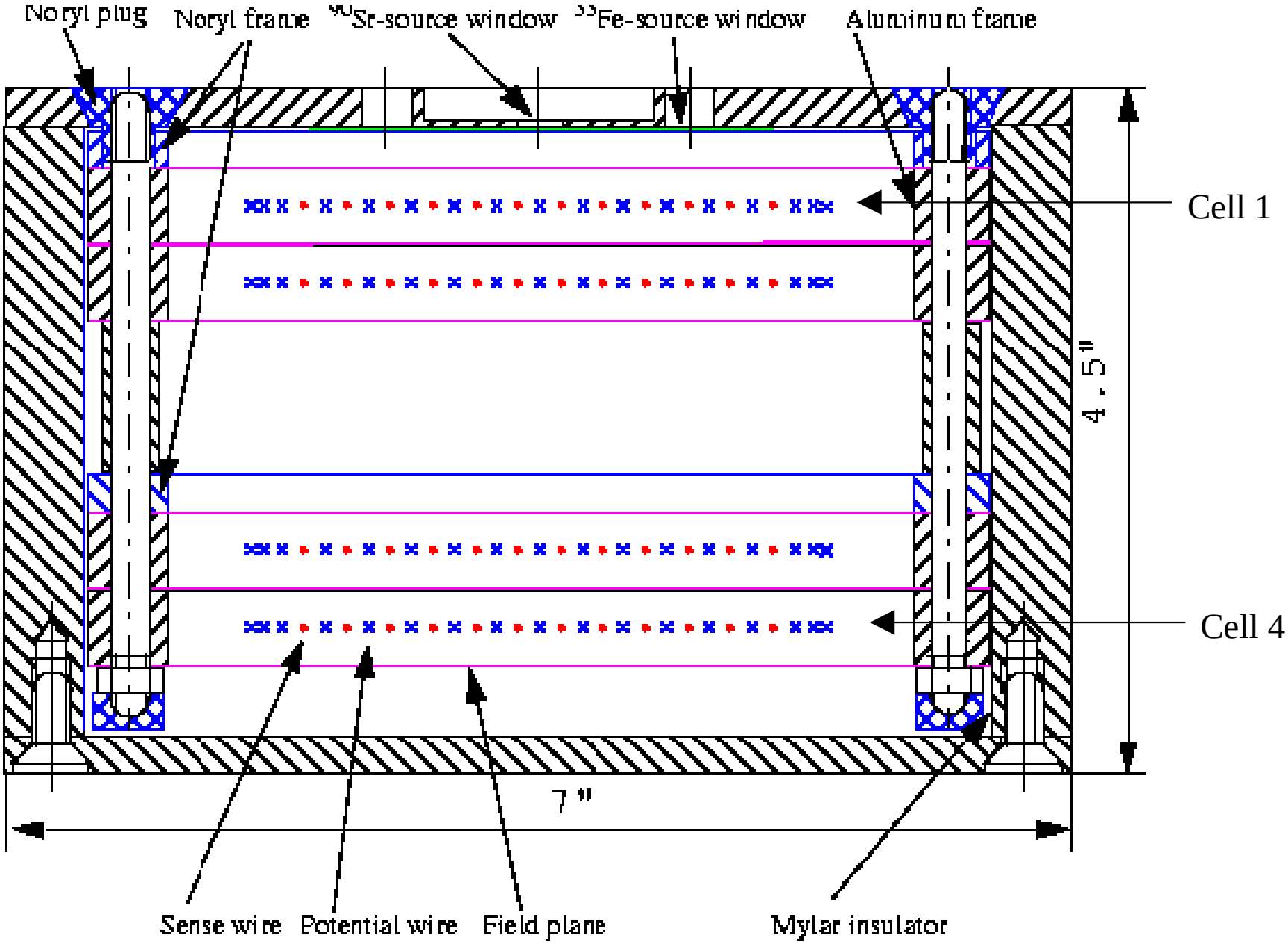

CTC Sense Wire – "West" Plate
1u
1.0kV
8mm


CTC Sense Wire – "East" Plate
1 u
1.0kV 27mm

Aging Summary from CTC in Run 1

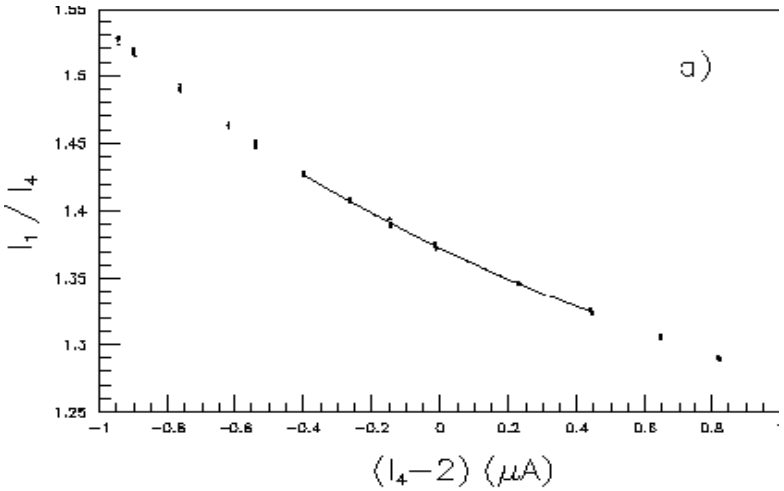
- Associating the observed accelerated aging with aerosols from the alcohol bubbler seems attractive.
  - Heated Cu wool filters and increased distance from the alcohol bubbler gave large reductions in aging.
  - Deposits on wires with accelerated aging was significantly different from that on wires aged without alcohol.
  - This is still not understood. Perhaps silicone and glycol contaminants in the alcohol are important ingredients?
- After cleaning and making changes to reduce aerosols from the alcohol, test chamber aging became small.
- There was not enough CTC data taken after the changes to confirm that the CTC aging was reduced.

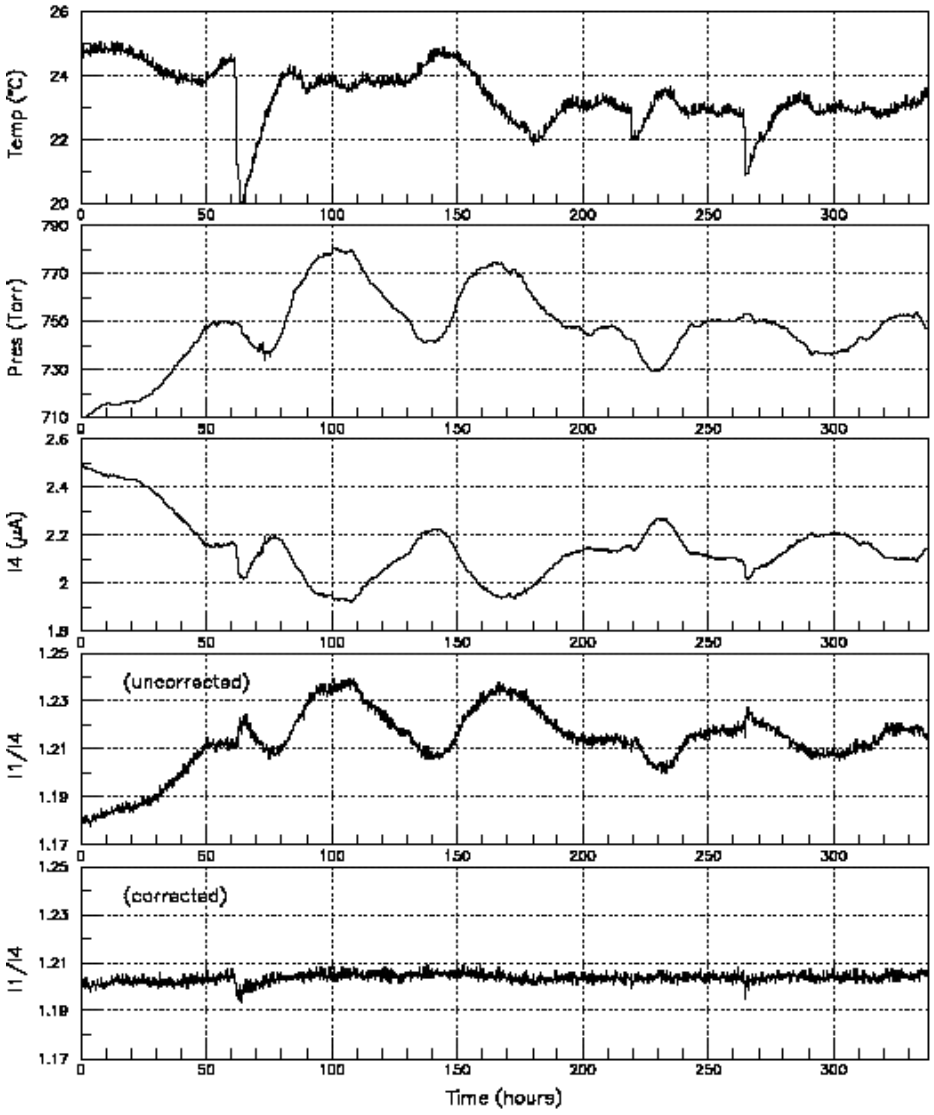
New monitoring chambers for the COT.



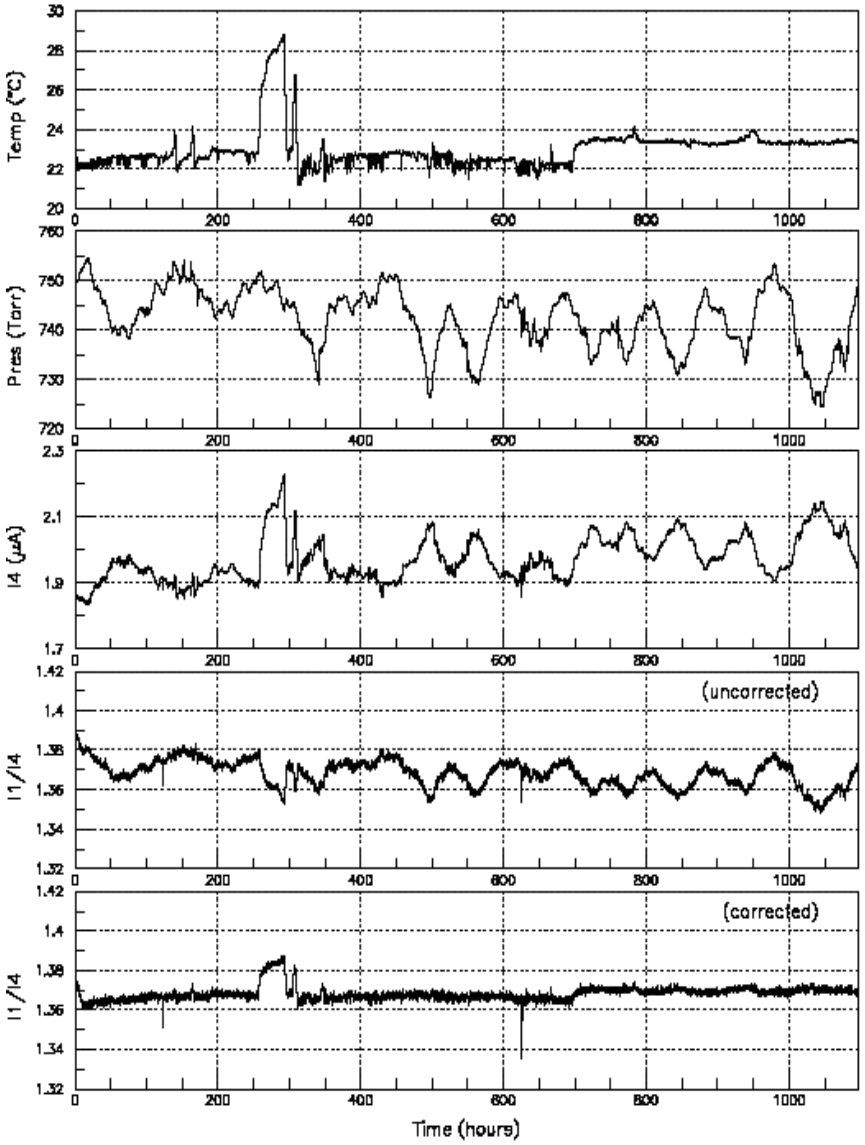
Monitoring procedure for the COT

- Cell 1 aging due to Sr^{90} source.
- Cell 4 is reference cell: ~ 2 μamps
- Wire gain measured by current draw.
- Space charge correction made.
- Aging given by current ratio: I(1)/I(4)
- Pressure / temperature effects cancel.
- Cell 1 accumulates ~0.008 C/cm/day

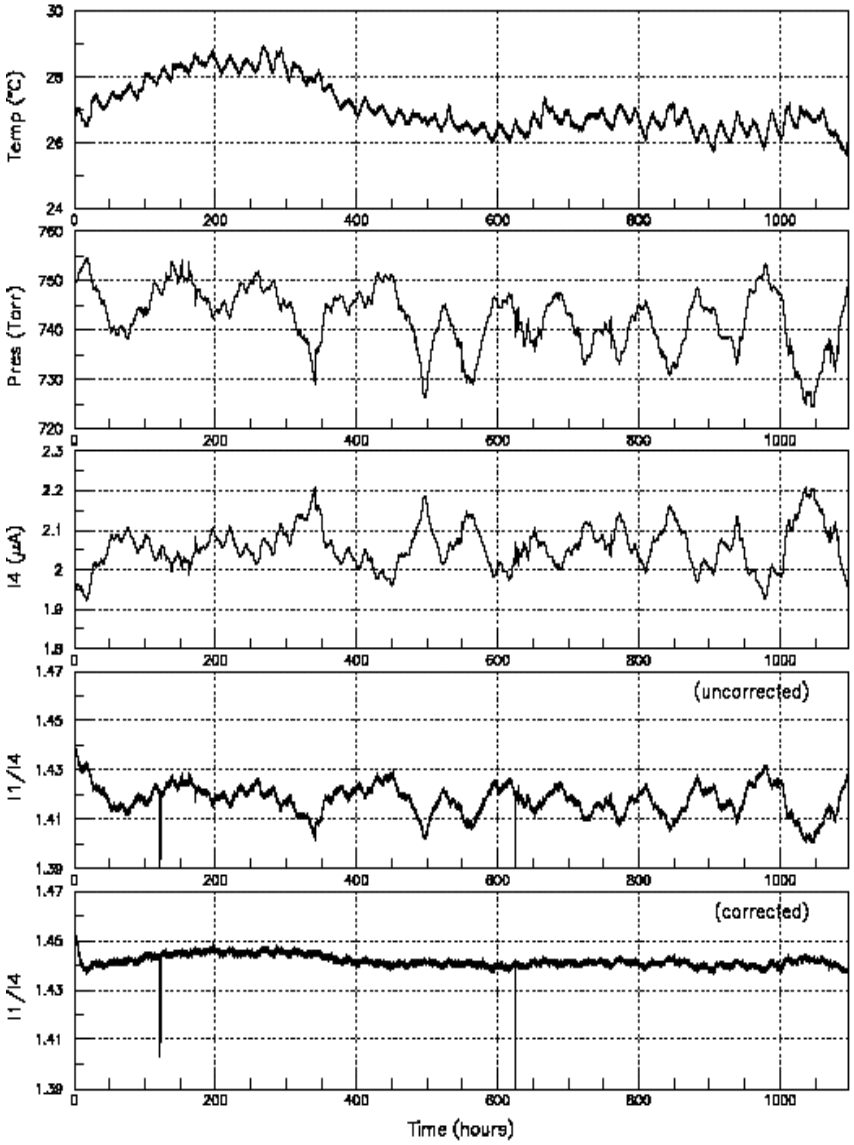




Summary plots for the monitoring chambers after bubbler and at chamber exhaust.



Alcohol Bubbler



COT Exhaust

Results of Current Monitoring

- Monitor chambers show the current aging rate < 1%/C/cm.
- Because of systematic uncertainties, we estimate the aging rate < 5%/C/cm.
- Innermost layer COT accumulates charge at a rate of ~ 0.07 C/cm/fb^{-1}.
- For Run 2 expect 20 fb^{-1} $\Rightarrow$ ~ 1.4 Coulombs.
- If we can maintain an aging rate < 5%/C/cm, then the loss of gain is acceptable for Run 2.