



**Systems Research & Technology Department
CBR Science & Technology Branch, B54
Special Projects and Systems Engineering Section**



New and Novel Technologies in Particulate Filtration

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Why should we look at particulate filtration improvements?

Old goals are not yet achieved

- Provides ZERO pressure drop
- Is self cleaning and never loads up
- Never needs to be changed
- Occupies no more than 1/10 cubic inch of space
- Is weightless – but certainly no more than a few micrograms
- Is undetectable by any method – invisible

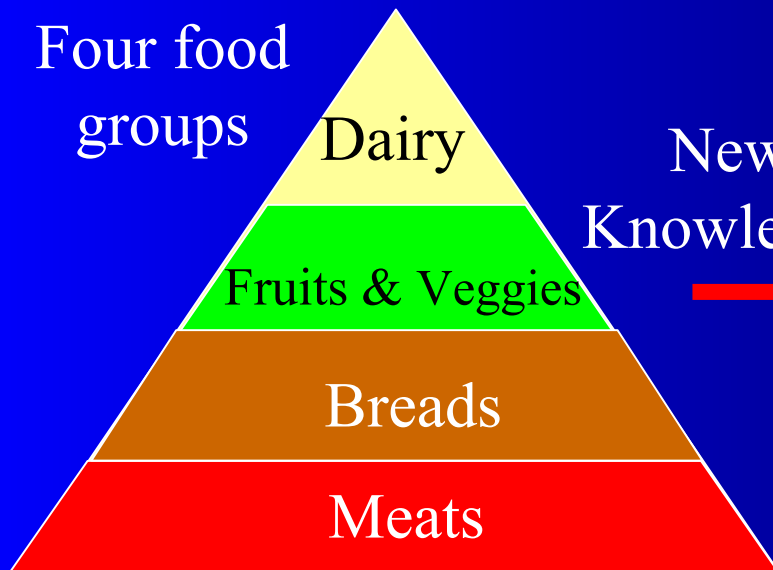
Research is changing paradigms

Testing is revealing areas for improvement

Paradigms must change as we learn new information. Perhaps the best known is the food group pyramid

1980

Four food groups

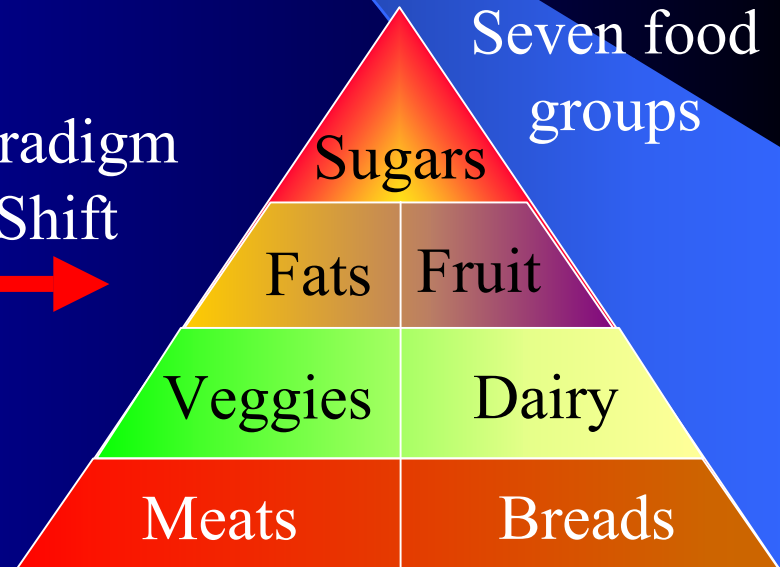


New Knowledge = Paradigm Shift



2003

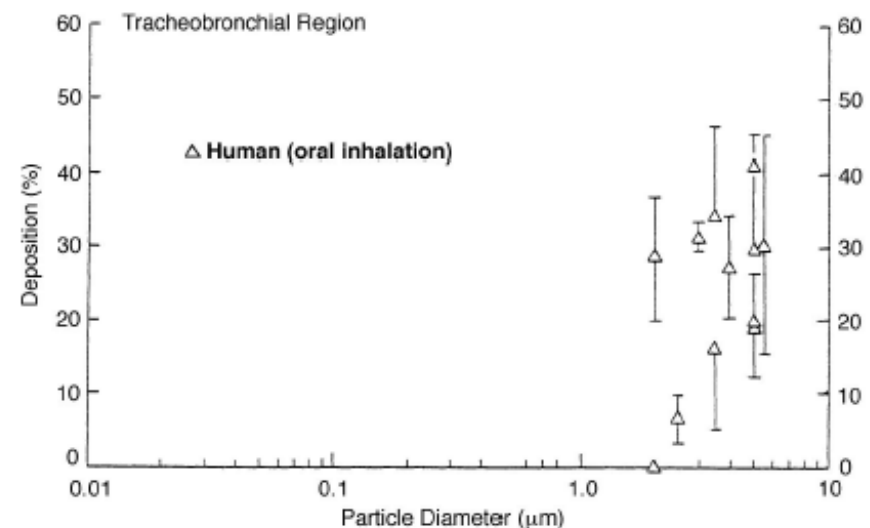
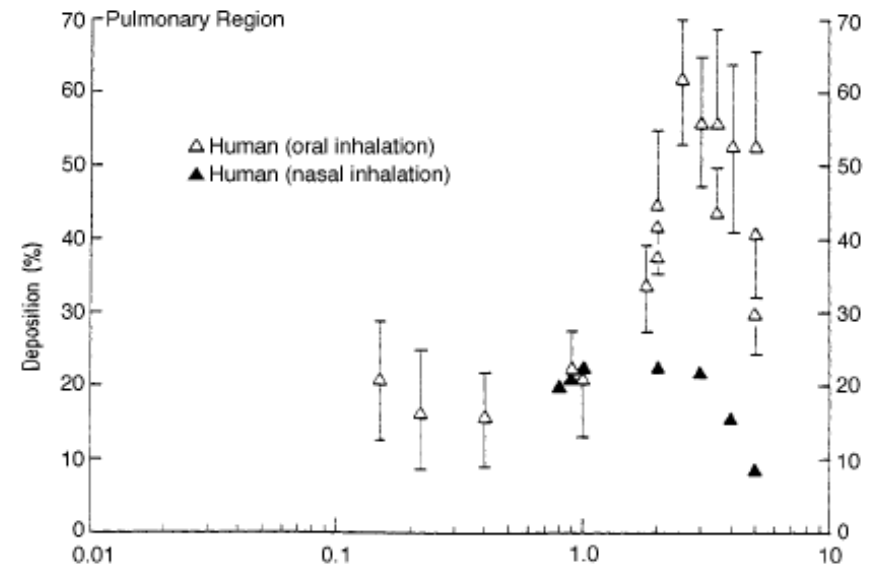
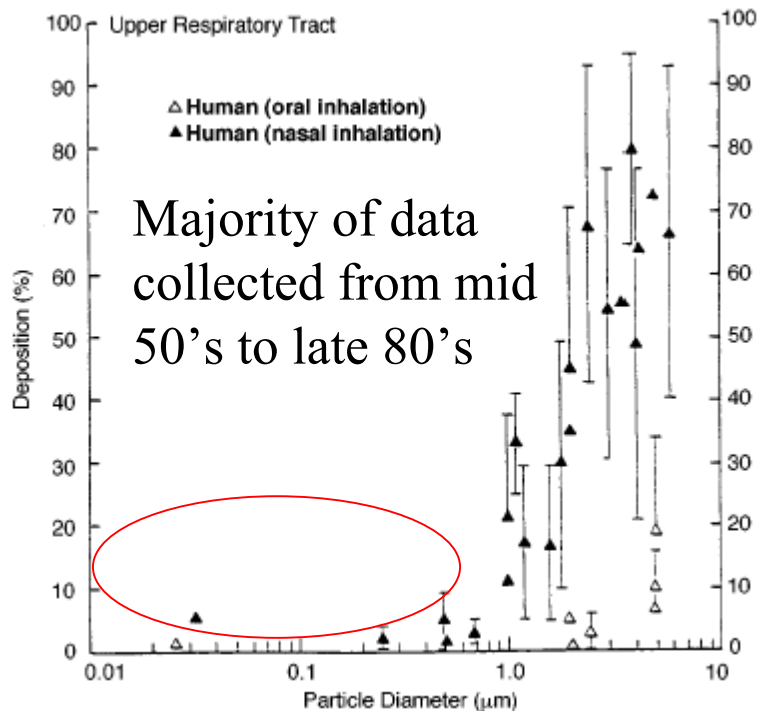
Seven food groups



Its amazing to see the nutritional expertise a ten year old has the day after Halloween when they can recite the daily recommended allowance for candy.

**“Anything below 0.3 μ m is
breathed back out”!**

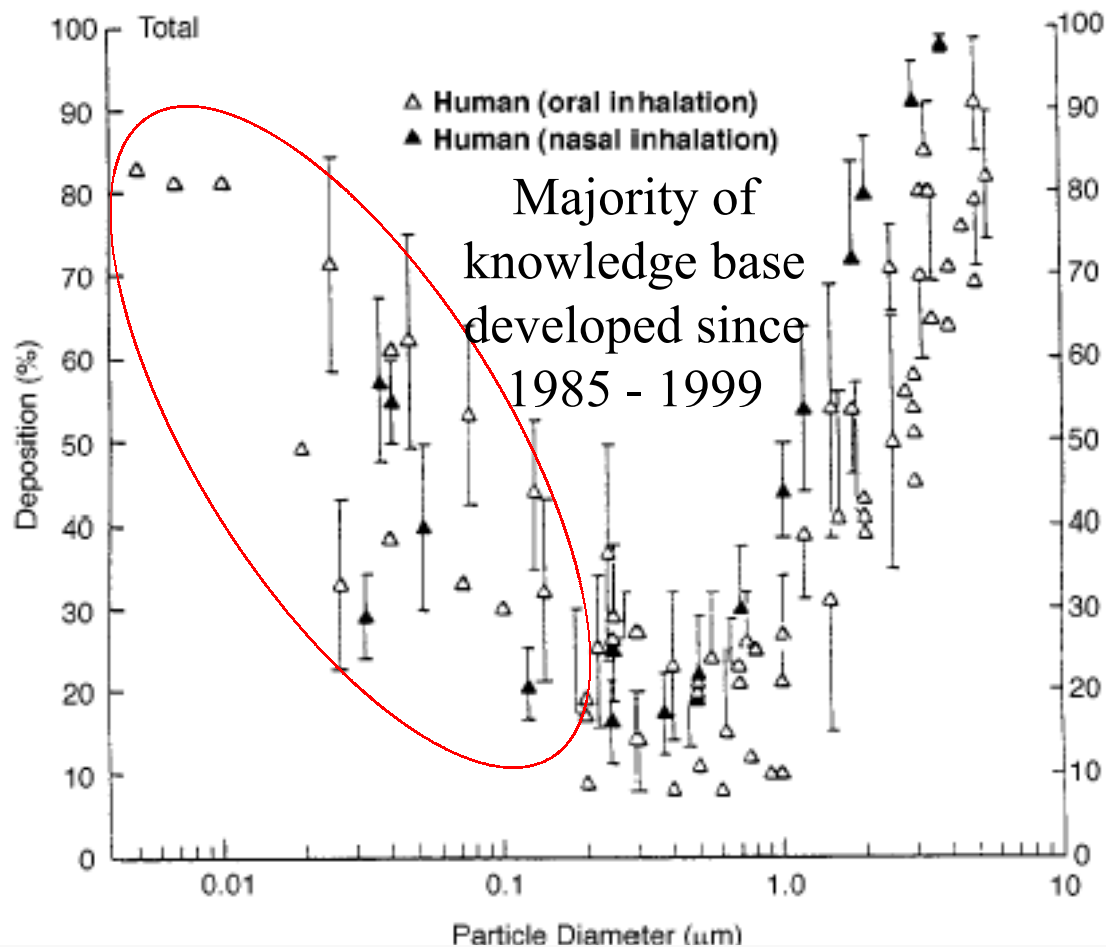
This old paradigm was supported by
limited research, testing, evaluation,
and modeling tools.



Just as our understanding of nutritional requirements have changed, our understanding of particulate retention in the lungs has changed.

We have the obligation to take this new knowledge and evaluate it relative to each of our respective fields of study and determine what impact this will have on dependent and interrelated technologies as well as their foundational theories.

In many cases there may be no impact, but in some, such as epidemiology, toxicology, biological dispersion modeling and simulation, war gaming theory, and filtration issues, there might.



Schlesinger, Richard B., Ben-Jebria, A., Dahl, Alan R., Snipes, M. B., and Ultman, J., *Disposition of inhaled Toxicants*, **CRC Handbook of Human Toxicology**, p12, CRC Press LLC, 1999

Primary Drivers for New Media Development

Lower Energy Consumption

Longer Filter Life

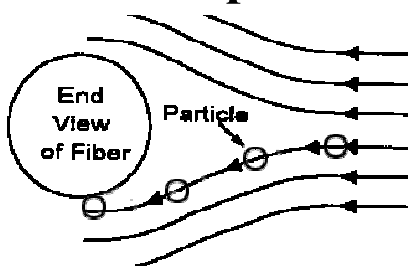
**Reducing the contamination threat posed by bio agent
exposed media**

Higher Dust Load Capability

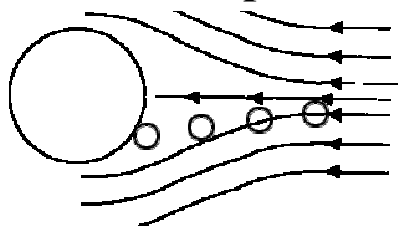
Toxic Industrial Chemicals

Regenerative Capabilities

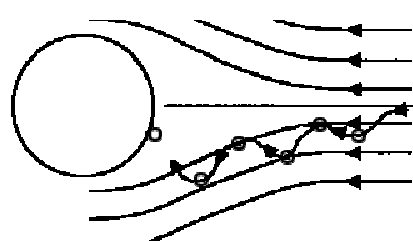
Interception



Inertial Impaction

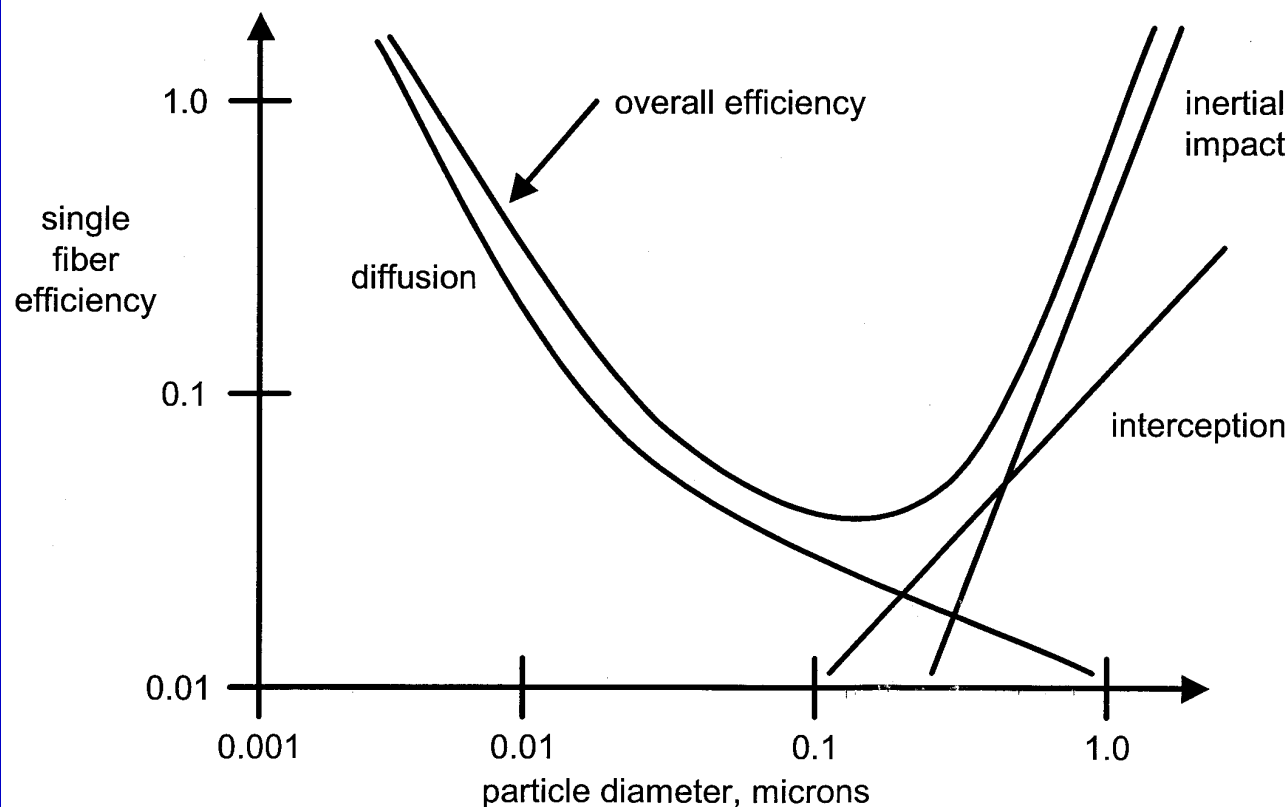


Diffusion



Physics of Fiber Filtration

conditions: 1.0 μm fiber radius;
0.1 packing density; 10 cm/s air velocity



Particulate filter technologies of interest

New Filter Materials

Composite Materials

Irregularly shaped fibers

Nanofibers

New Filtration Concepts

Electrically enhanced filters

Sacrificial prefilters

Electrostatic Precipitation

Regenerable Filters

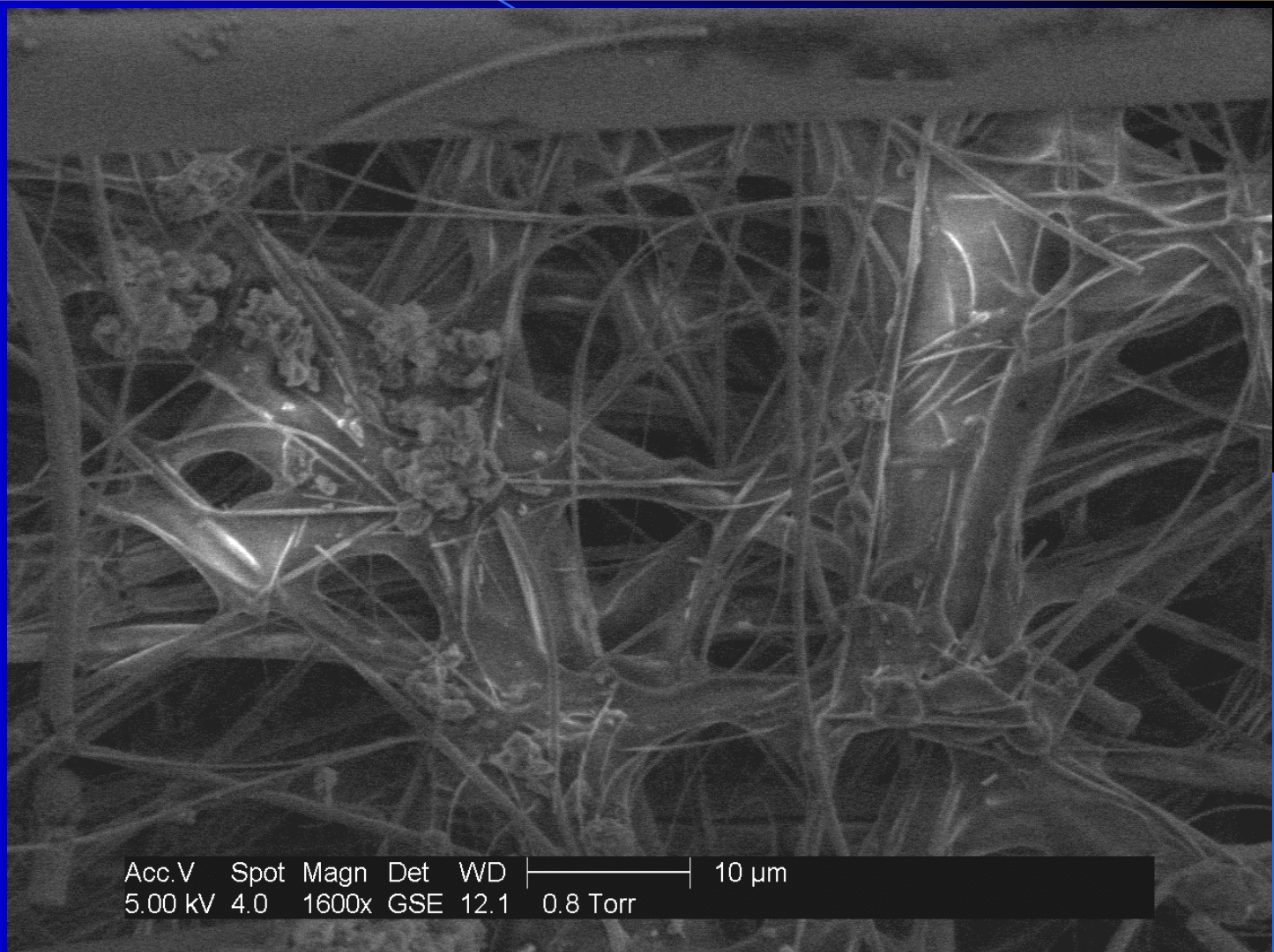
New and in progress Filter Assessment and Design Tools

Filter Media Design and Evaluation Model

CFD Flow Model

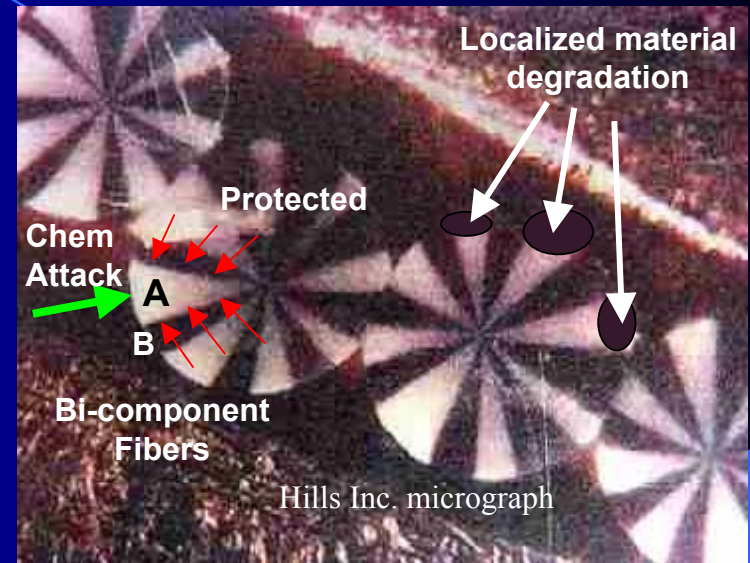
Filter Material is typically a polymer and glass matrix

This media is used in all fixed sites, ships, and mobile land vehicles that use the M98 filter set.



Micro-fiber Coating & Composite Material Technology:

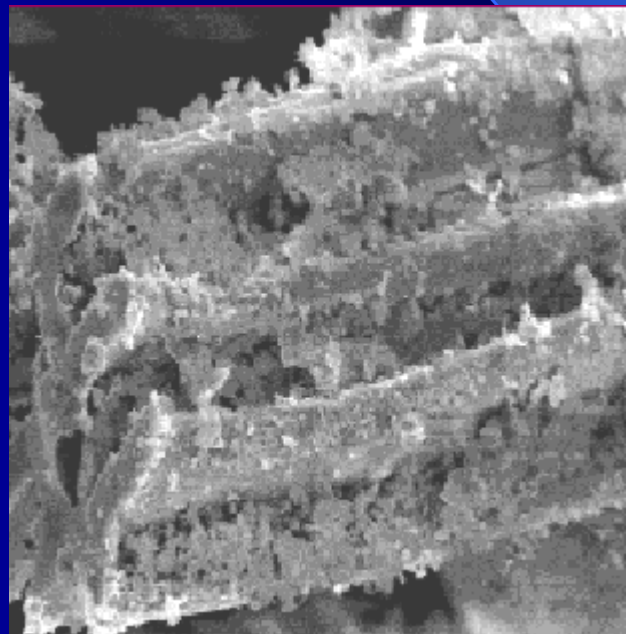
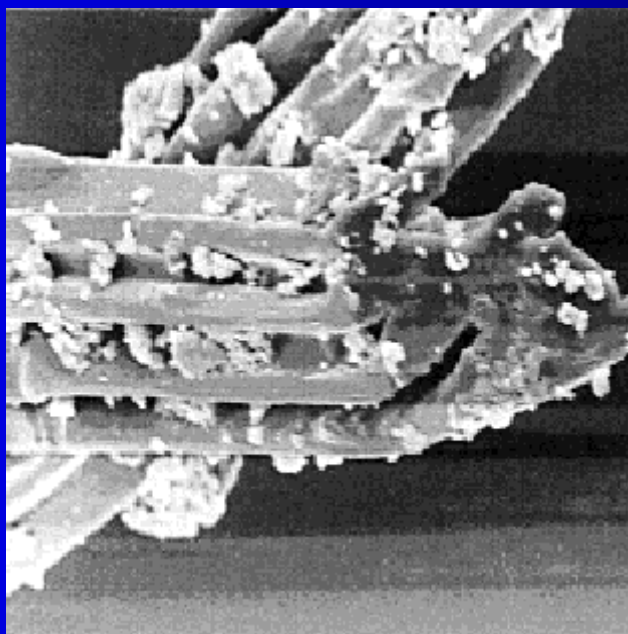
- Technology being used and developed
 - Primarily focuses on polymer fibers.
 - Produce a bi-component fiber via an extrusion process. “Teflon like” material either as a coating or single fiber is a goal for chemical resistance enhancement. Teflon coatings of glass fibers using this method may not be possible.
 - Emerging technology is a coating technologies based on a plasma sublimation/condensation process for both polymer and glass micro-fibers, and electrospun materials.



Hills Inc. micrographs

Irregularly Shaped Fiber Technology:

- Clemson University
- Hills Inc.



Used by permission of Dr. Edward Vaughn, Clemson University

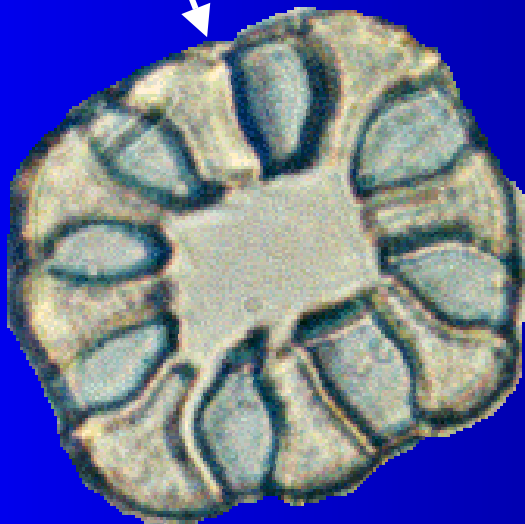
Fiber Fragmentation Process

Extrude

**Lay Down
Fabric Base**

Wash

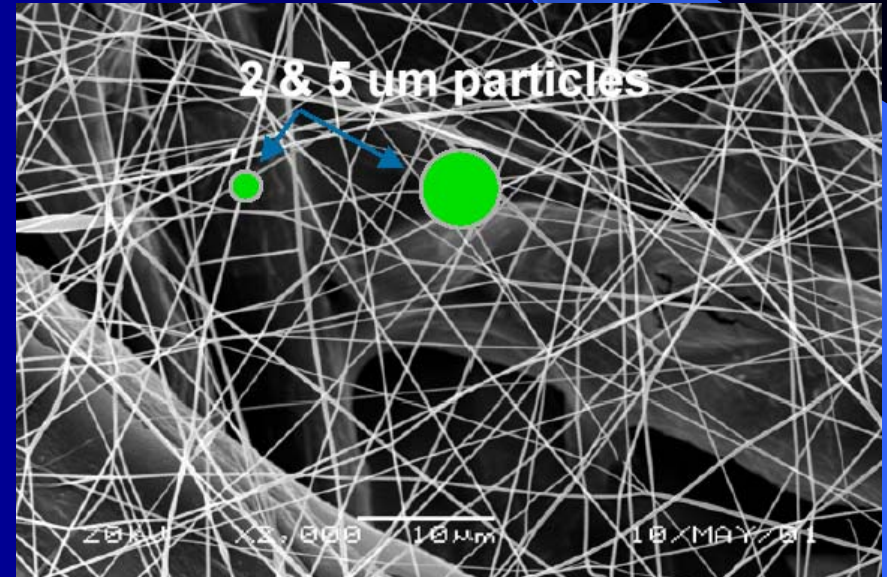
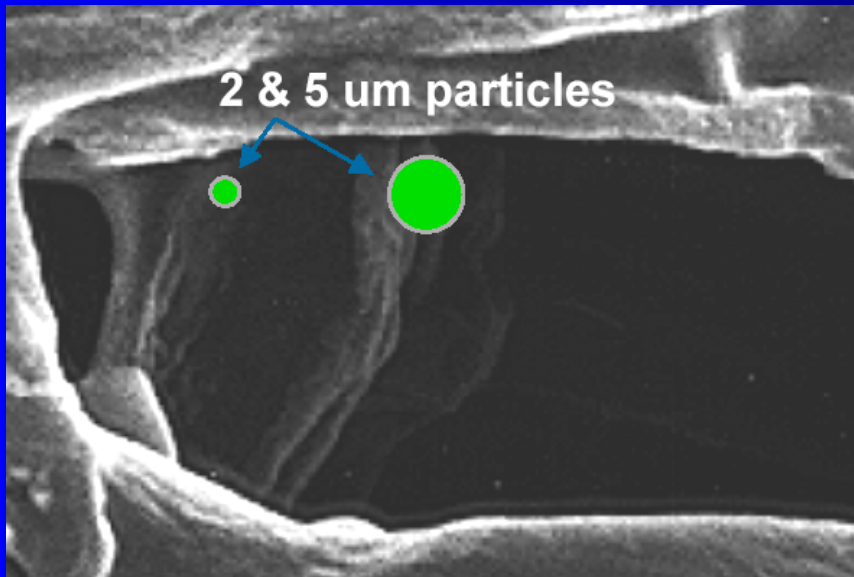
Dry & Finish



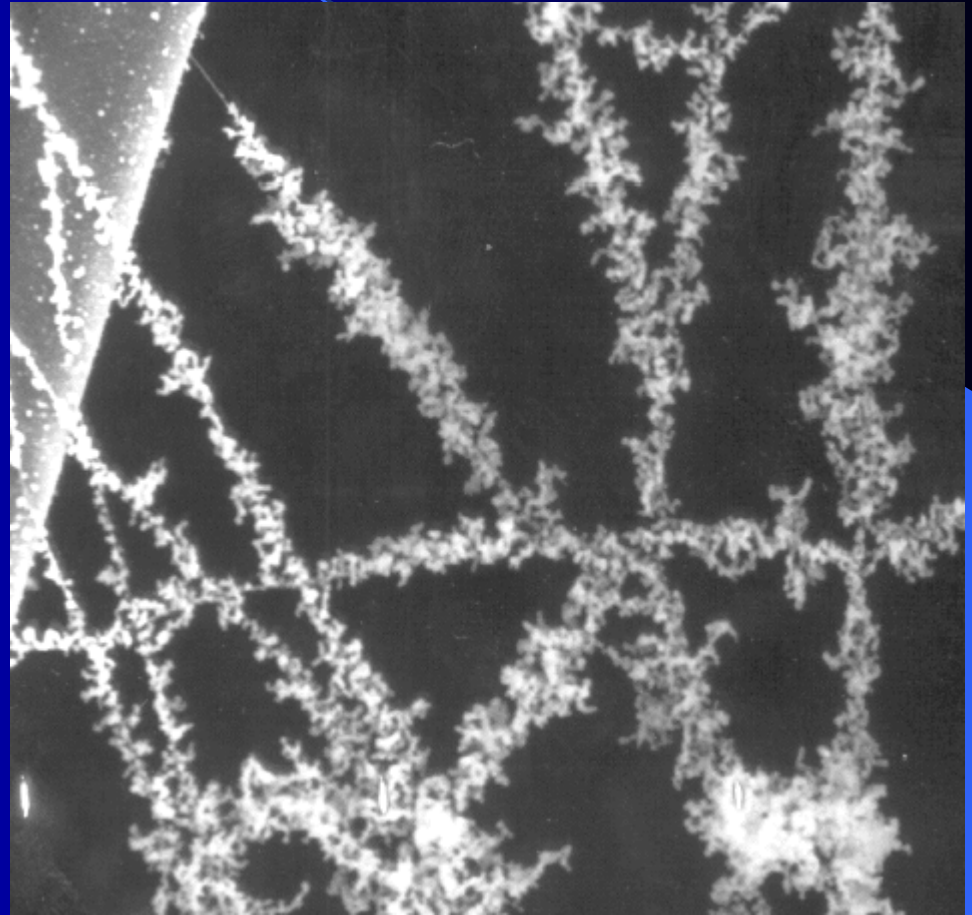
Hills Inc. micrograph



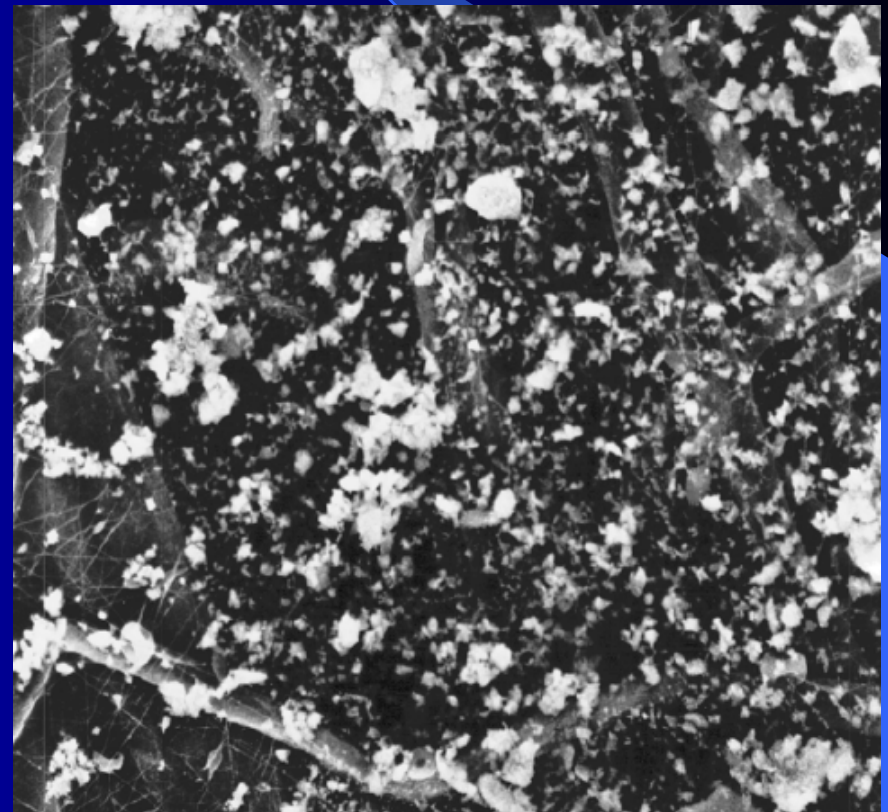
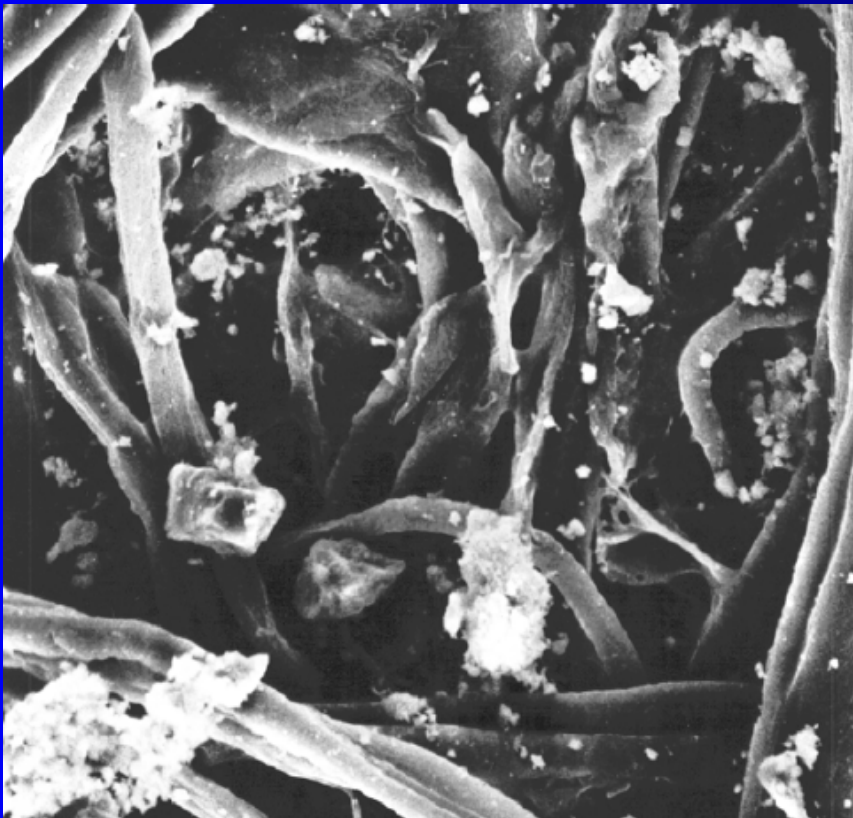
Nano sized polymer fibers laid up over base filter material



Salt crystals captured by nano polymer fibers



Comparison of particle capture of standard filter material and standard material with nano fiber overlay

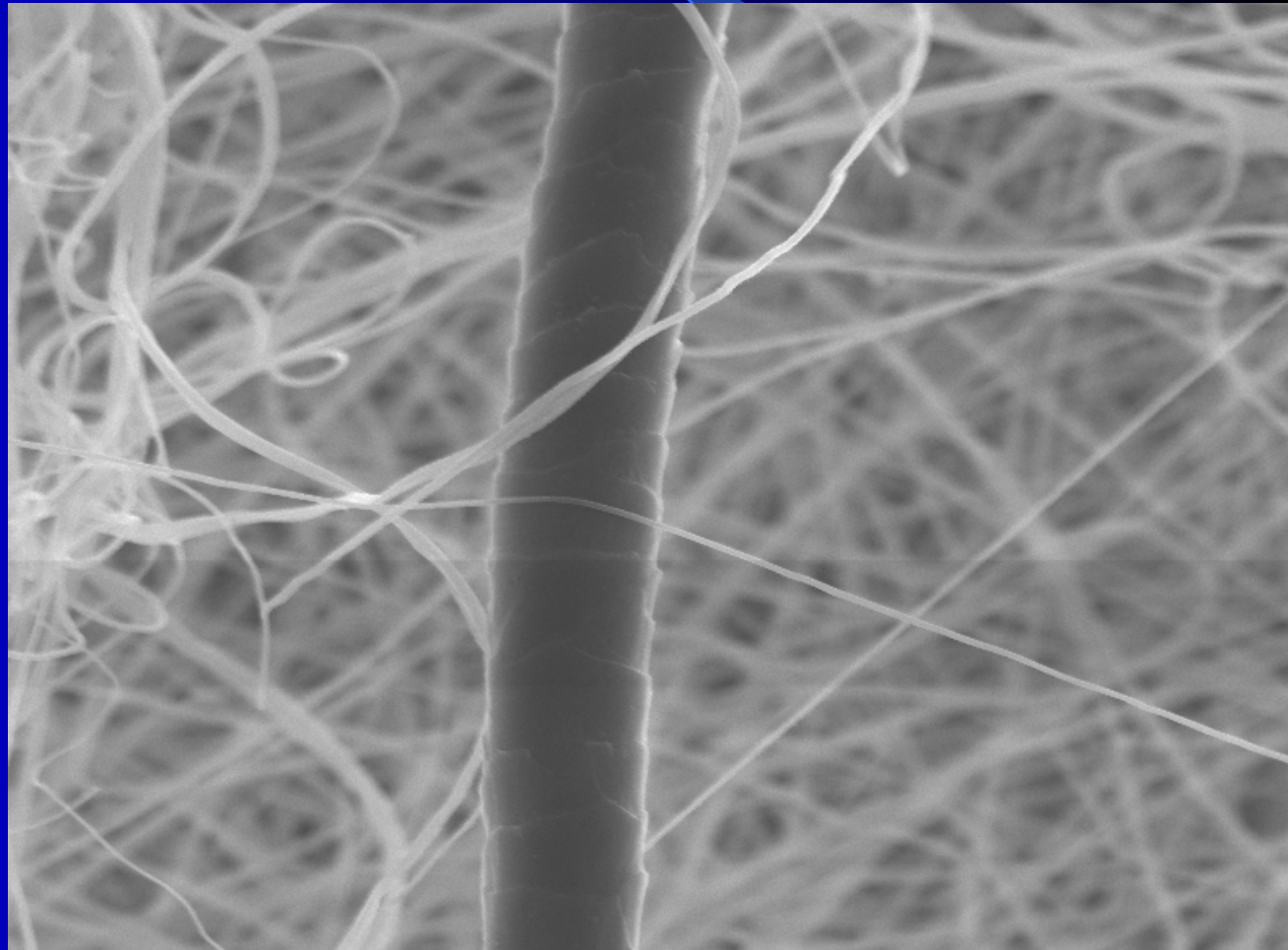


Images Courtesy of Timothy Grafe, Donaldson Company Inc.

NSWCDD spun nanofibers for DARPA funded effort

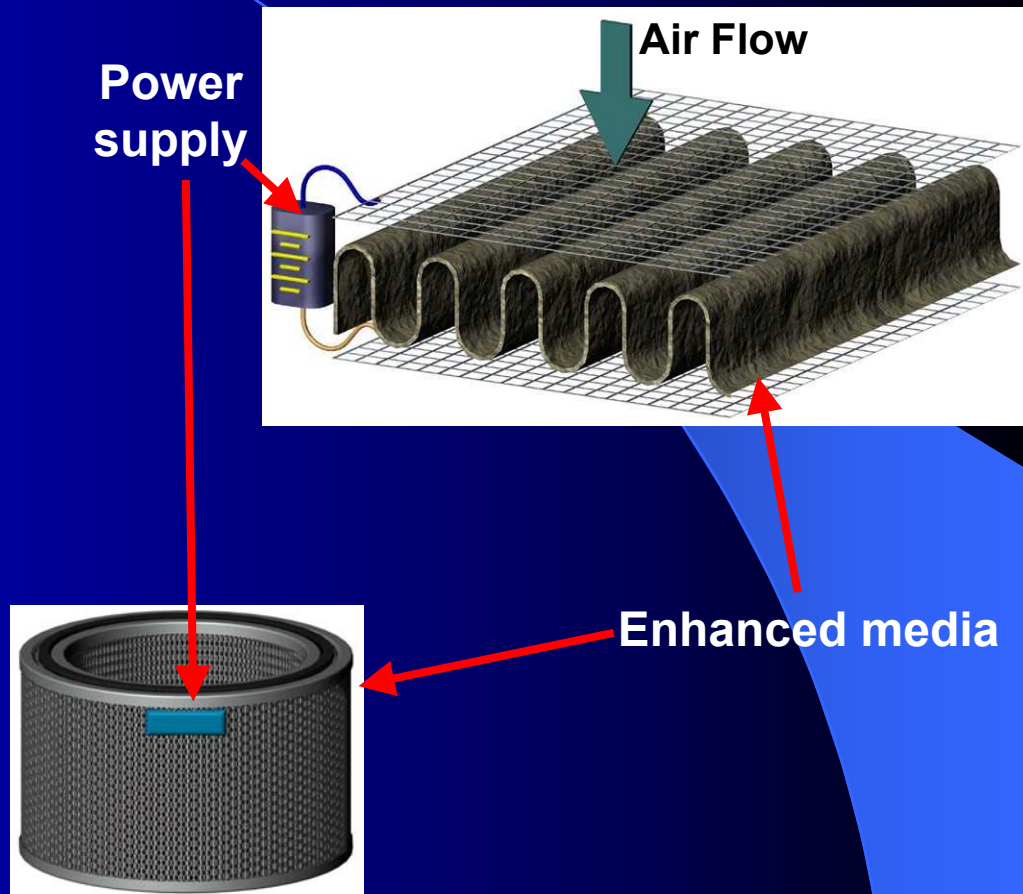
Significant since this is a “first off” for this process, which produced uniform fibers 0.2um in diameter.

Through better process control, significant diameter reduction may be possible.

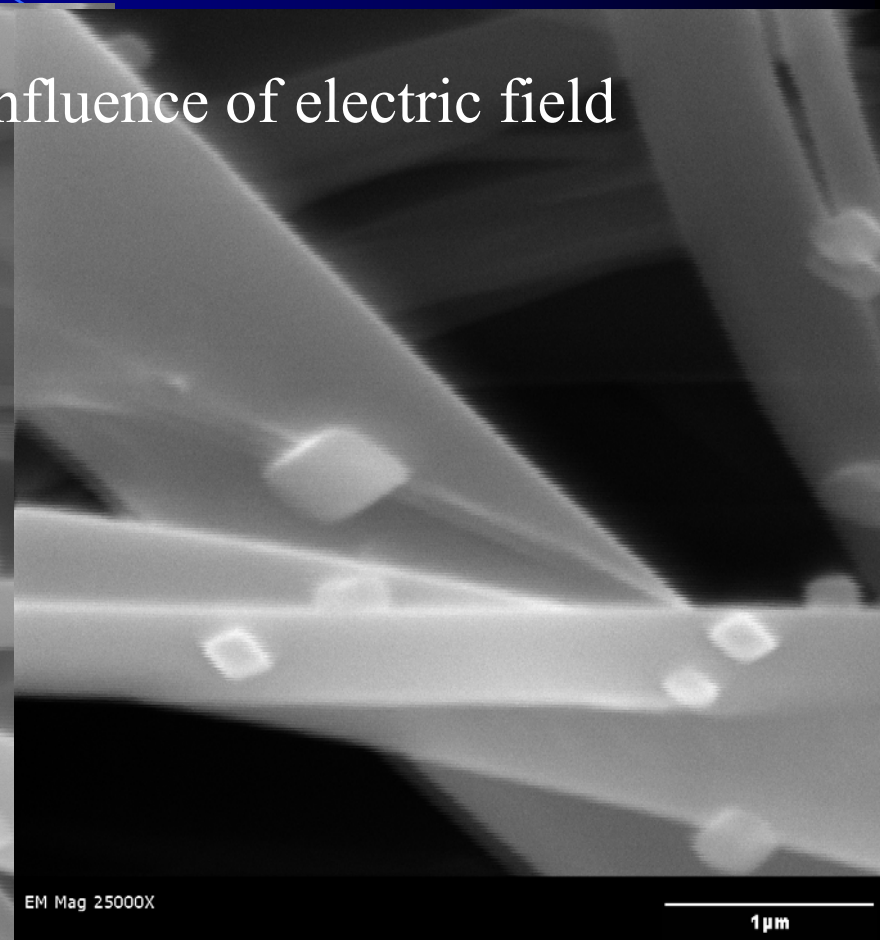
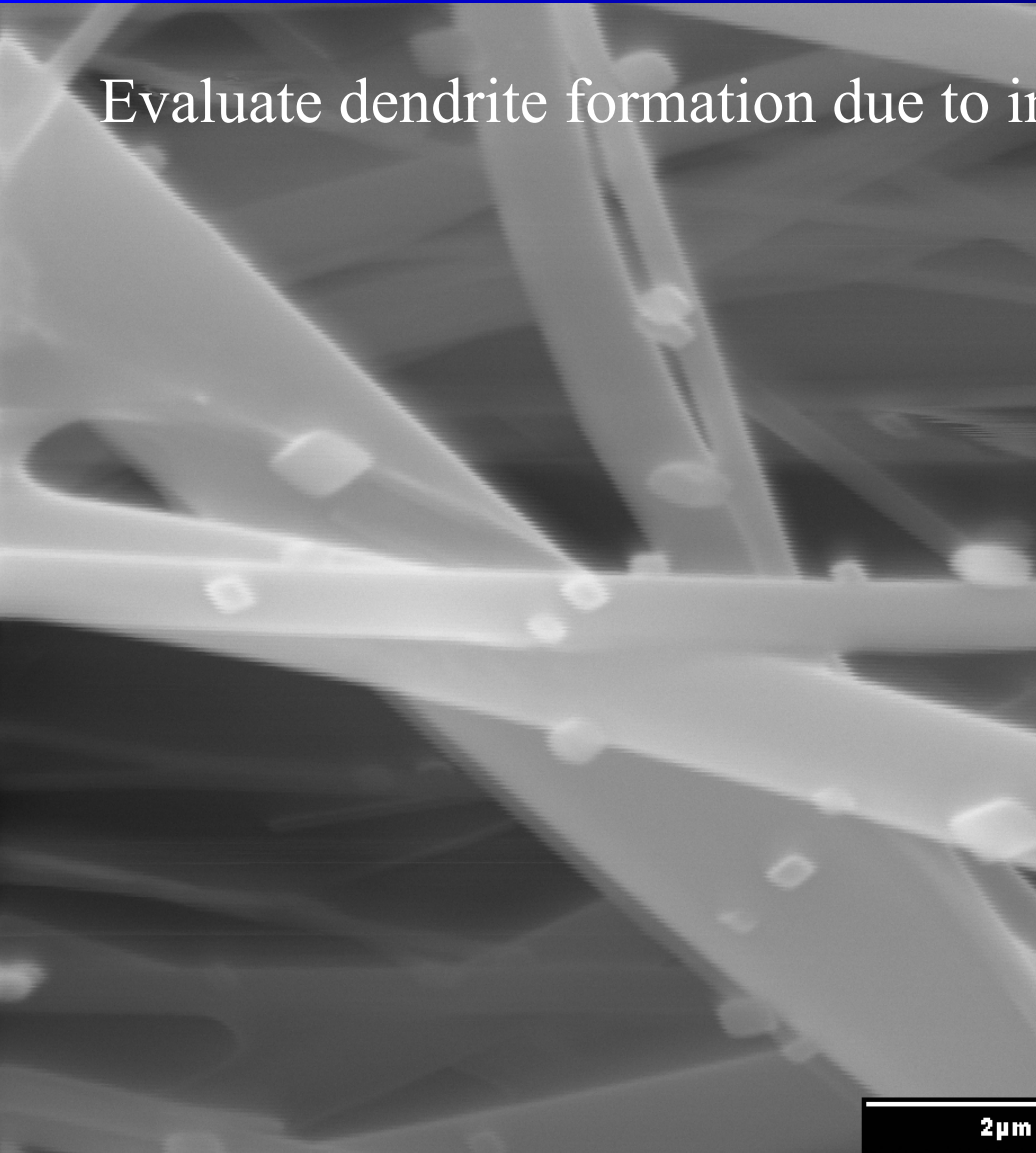


Electrically Enhanced Filter Media

- Can use existing design configuration
- Provides for drastic increase in filter life
- Very low power consumption
- Alternate filter media options



Evaluate dendrite formation due to influence of electric field



2µm

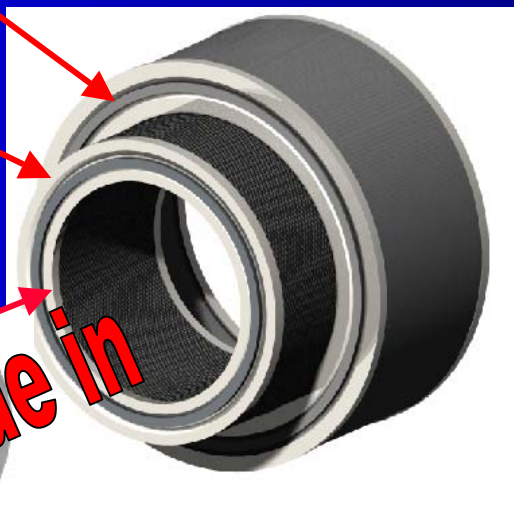
Sacrificial Prefilters

Existing
Gas Filter

Existing
HEPA Filter

Proposed
Pre-Filter

Slide in

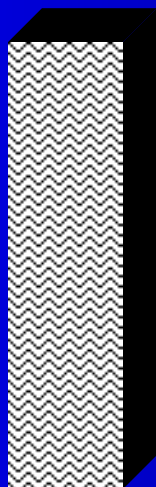


Proposed
Pre-Filter

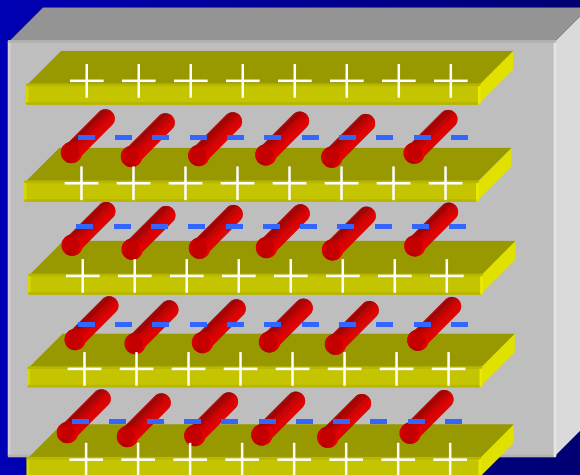
**Velcro or other
attachment method**

Porton Down UK Electrostatic Precipitation

**Roughing
Filter**



**Electrostatic
Grid**



99%

**HEPA
Filter**



Regenerative Particulate Removal

• Humidity Control

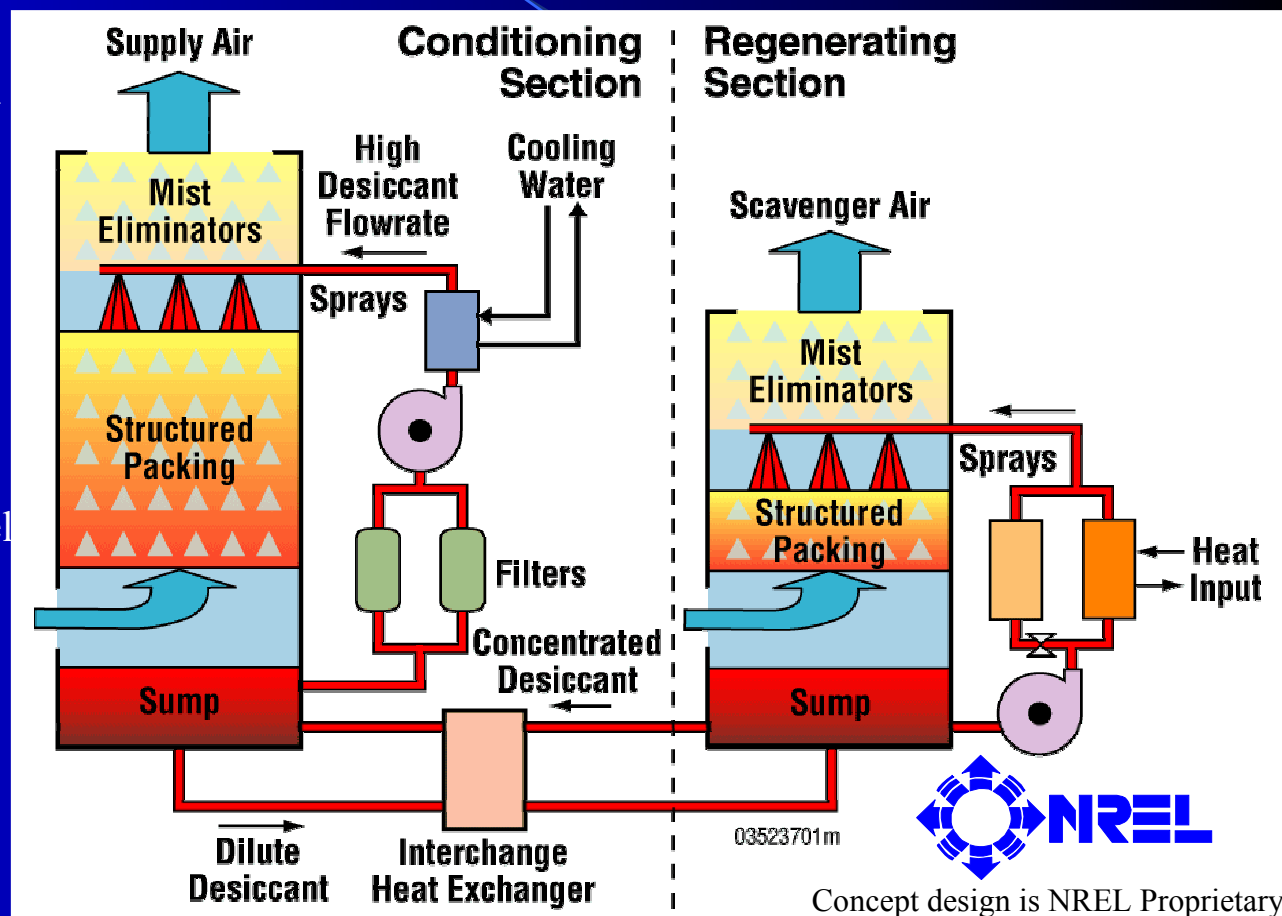
- Reduced HVAC loading
- More predictable carbon filter performance
- Possible chem removal – i.e. reduced carbon bed size

• Proven baseline HVAC

Technology which integrates novel particulate filtration technology

• Integrated HVAC provides:

- Constant DP – no fan control
- Smoke removal capability
- Possible bio and rad particle concentrator – detection
- Decon issues reduced since disposable is contained in liquid suspension

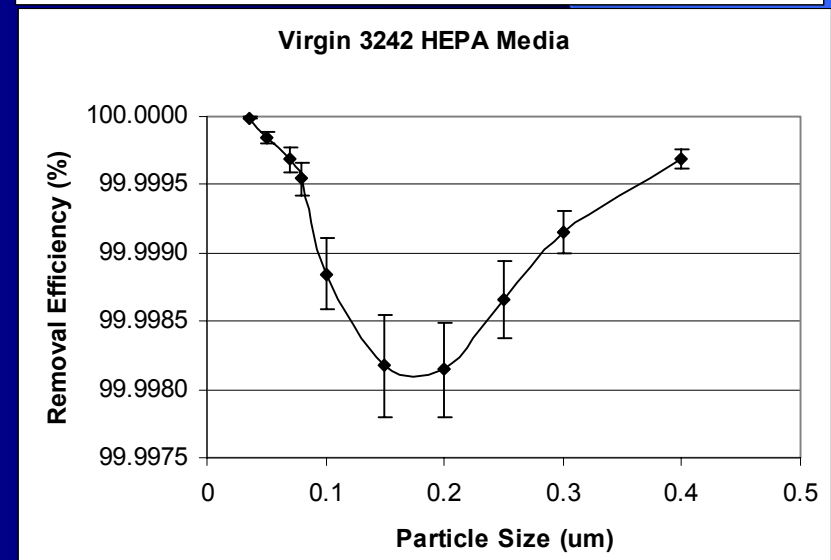
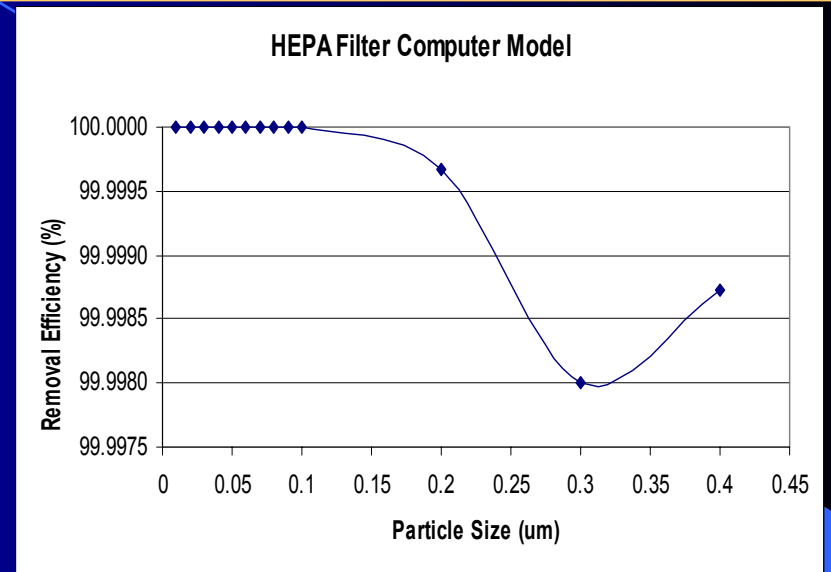
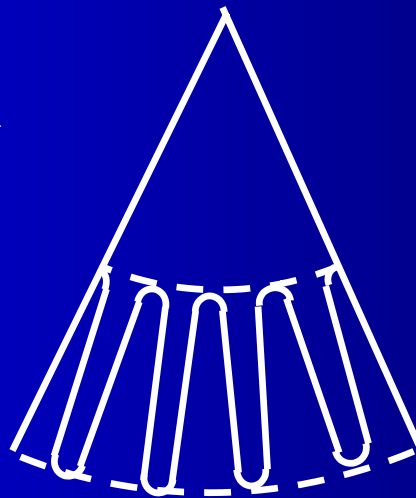


Industrial Packed Tower Design

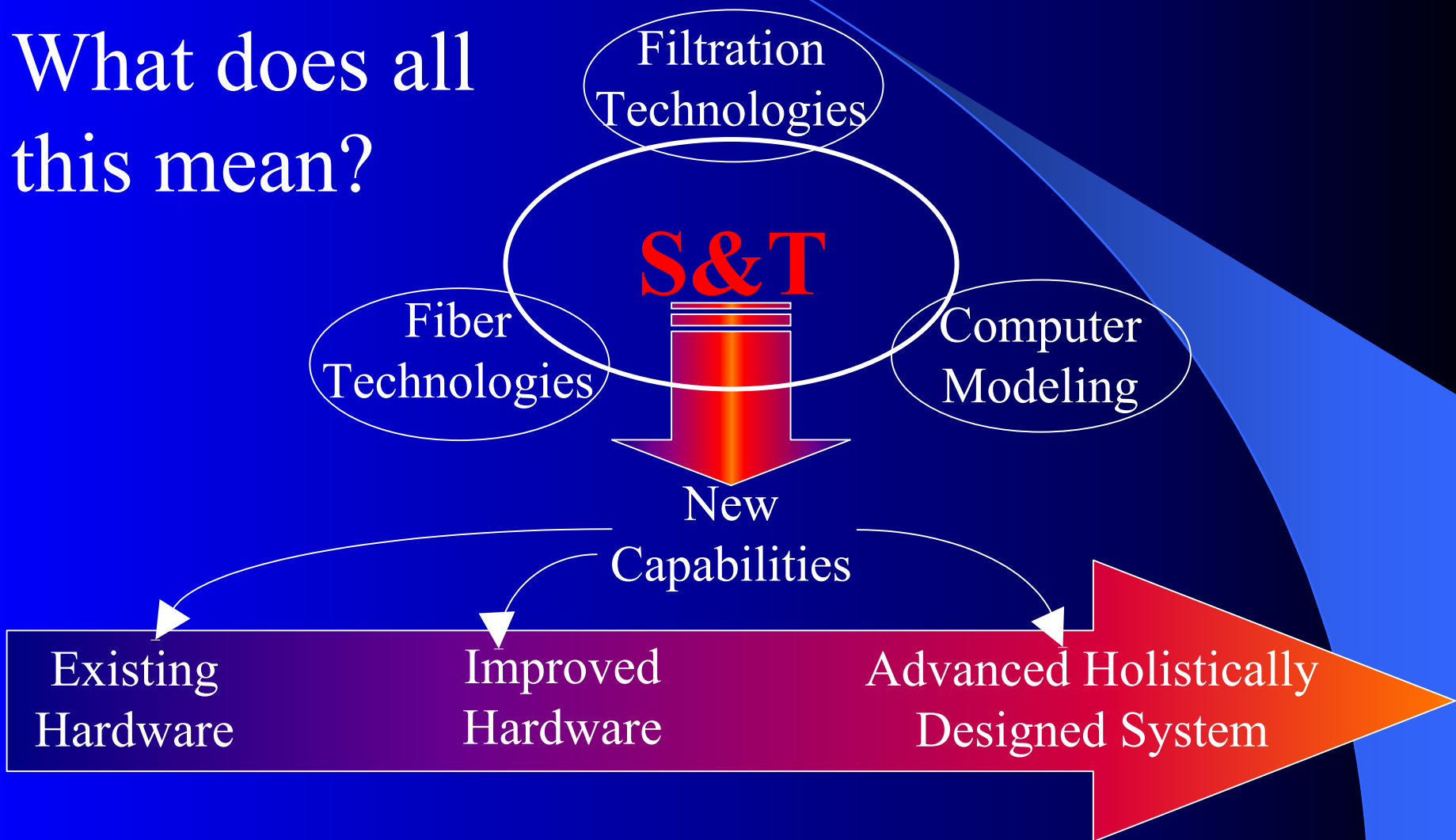
Concept design is NREL Proprietary

Initial computer model shows promise for predicting filter efficiency based on flat filter- 3D fiber matrix configuration, but more work is needed.

Computational Fluid Dynamics (CFD) will be used to analyze filter pleat geometry.



What does all this mean?





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Porton Down Chem Bio Laboratory