Aleck H Alexopoulos

Senior Research Scientist, CPERI

Co-founder of RespiBit Ltd

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Aleck H. Alexopoulos aleck@certh.gr +30 2310498168
Chemical Engineer ➔ Biomedical Engineer ➔ Entrepreneur

Diploma - AUTh Chemical Eng.
PhD - Purdue University
Postdoc - MIT

Rheology of dense dispersions in solid rocket fuels

Free surface flows of complex fluids and liquid crystals

Expertise, Activities, and Interests

As CERTH:

Computational support to LPRE/CPERI/CERTH activities
Fluid mechanics (non-Newtonian, complex fluids, dispersions ,etc.)
Interfacial Mechanics (static/dynamic,, emulsions, suspensions, etc.)
Complex flows (dense dispersion, free-surface flows, micro-flow)
Polymer reaction Engineering (emulsion, dispersion, suspension)
Population Balance Models (dispersions and beyond, compartment models, with CFD, etc.)
Respiratory System studies (drug delivery, virtual twin, deposition)
Biodevices (dry powder inhalers)

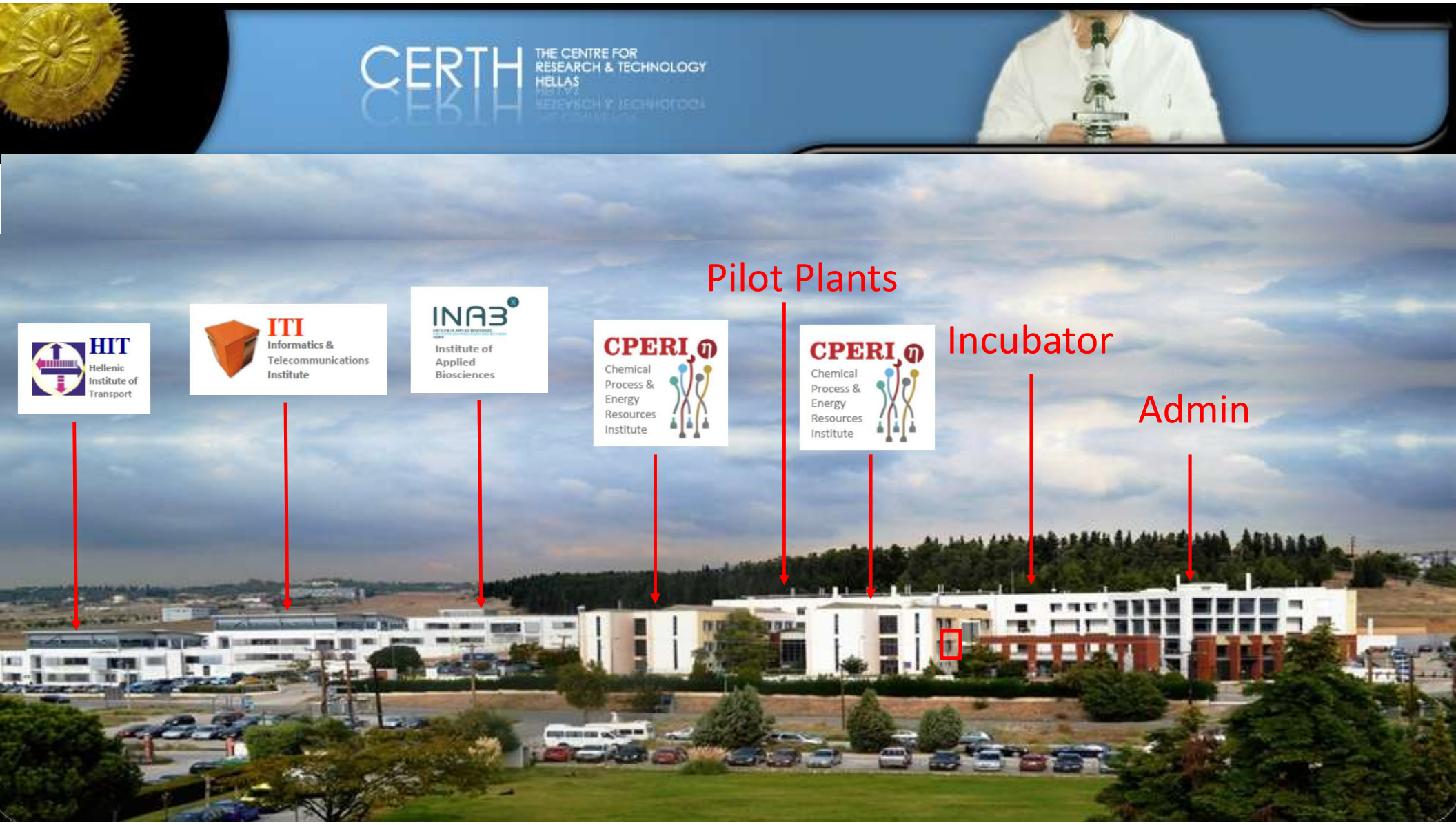
Main interests today at CERTH:

Applications of ***human movement*** algorithms for functional capacity: rehab, ND disease, etc.
Next generation of ***pandemic models*** incorporating aerosol transmission: populations, transport hubs
Virtual Twin of Lungs (drug delivery, next gen ventilators, personalized treatment)

As RespiBit:

Digital Health (***AsthmaFit***: asthma management system) for asthma patients, municipalities, pharma
Medical devices (***TBscan:*** tuberculosis mycobacterium detection via breath analysis)
Drone system for determination of concentration plus rate of transfer: environmental, sustainability, etc.

RespiBit


CERTH
THE CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
HIT
Hellenic Institute of Transport
ITI
Informatics & Telecommunications Institute
INAB
Institute of Applied Biosciences
CPERI
Chemical Process & Energy Resources Institute
CPERI
Chemical Process & Energy Resources Institute
Pilot Plants
Incubator
Admin

1. Human Movement Models and Applications

Originally developed for evaluation of athletes in turn of movement capacity. And for the determination of truly personalized and optimal training programs.

Several applications beyond sports:

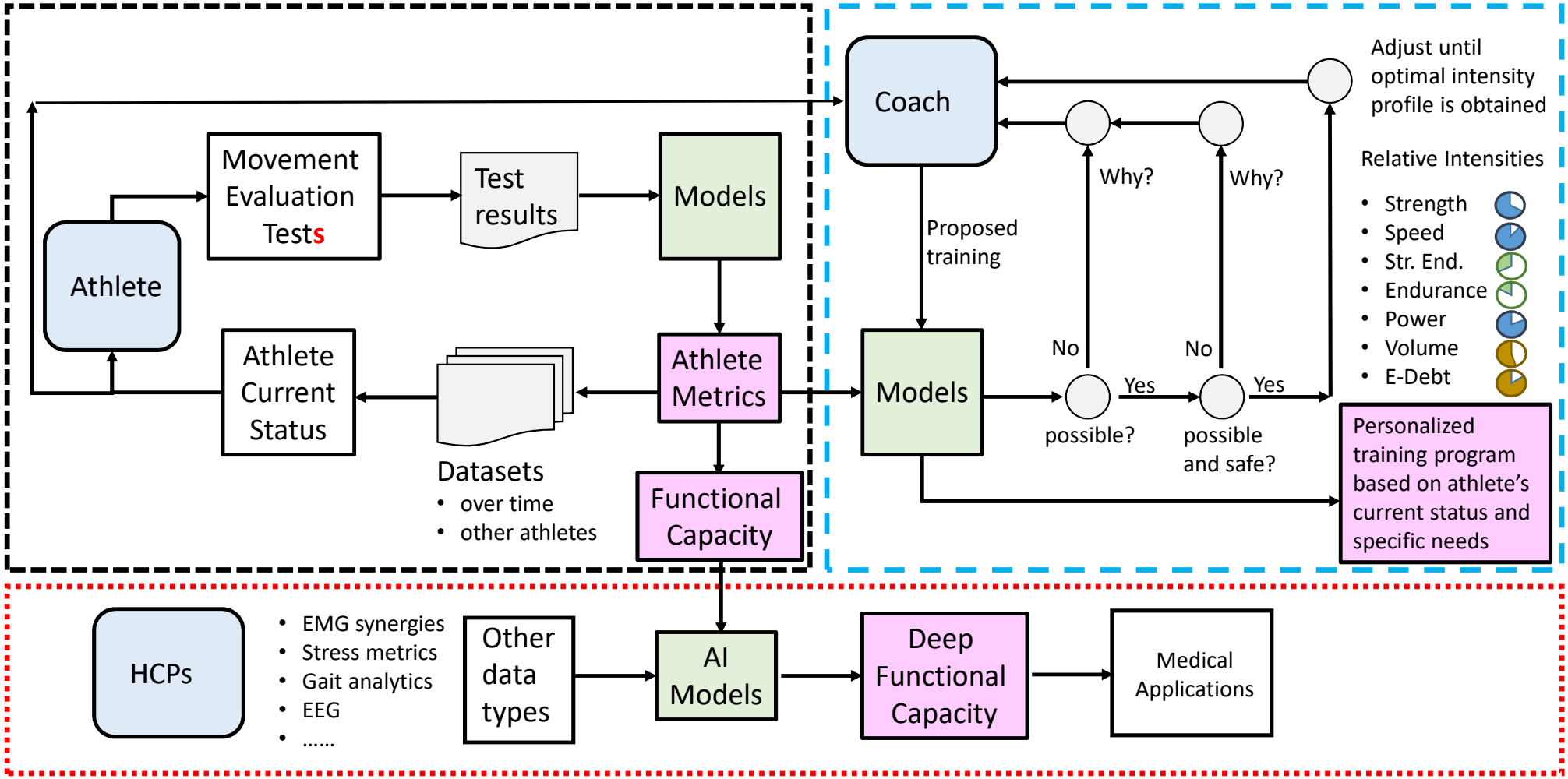
- Rehabilitation
- Muscle wasting
- Patient evaluation and classification (together with other digital tools)
- Post-surgery Recovery
- Pre-surgery Evaluation
- Deep monitoring of ND disease

+ 25%

Democritus University Thrace, Greece
Human Performance Lab
Dr. Thanasis Chatzinikolaou

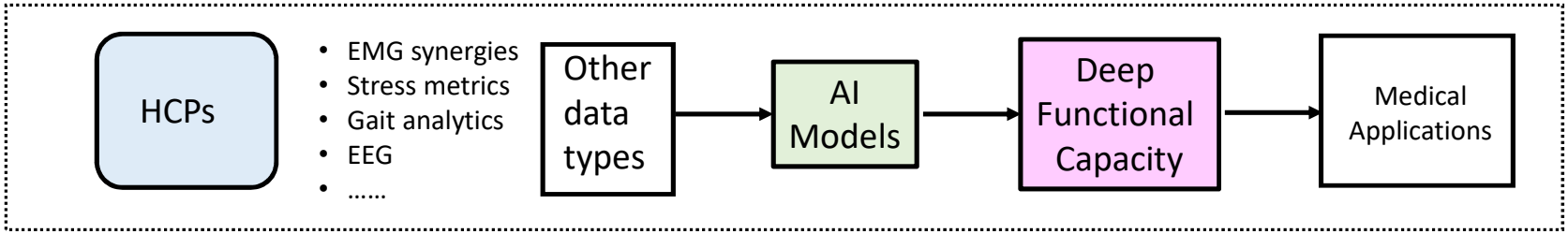
DEMOCRITUS UNIVERSITY OF THRACE

DUTH University Trial:
15 student athletes, @4 weeks
when compared to a traditional program
Ergo produced +26% on average
(up to +79%) increase in strength


Athlete
Movement Evaluation Tests
Test results
Models
Athlete Current Status
Datasets
• over time
• other athletes
Athlete Metrics
Functional Capacity
Coach
Proposed training
Models
Why?
Why?
No
No
Yes
Yes
possible?
possible and safe?
Adjust until optimal intensity profile is obtained
Relative Intensities
• Strength
• Speed
• Str. End.
• Endurance
• Power
• Volume
• E-Debt
Personalized training program based on athlete's current status and specific needs
HCPs
• EMG synergies
• Stress metrics
• Gait analytics
• EEG
• ……
Other data types
AI Models
Deep Functional Capacity
Medical Applications

Some medical applications – Functional Capacity

- Muscle wasting — monitoring + minimization, e.g., disease-associated, microgravity
- Rehabilitation — monitoring + minimization / patient stratification, “art” → “science”
- Post-surgery Recovery — monitoring + management to achieve rapid and full recovery
- Pre-surgery Evaluation — for sarcopenia or frailty / improved outcomes
- Deep monitoring of ND disease — early diagnosis / exacerbation detection / management



Enhanced movement applications:

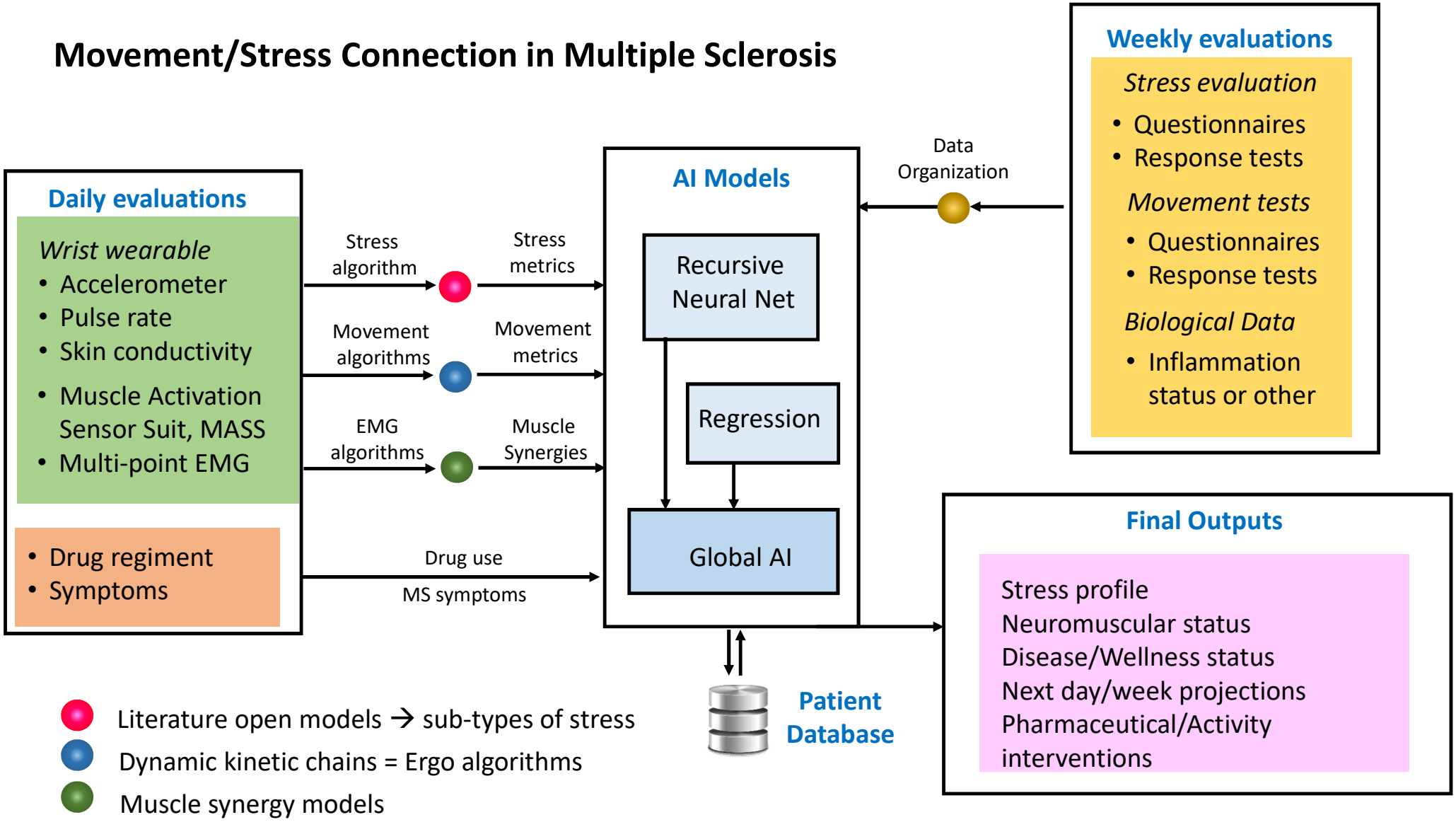
EU proposal on exoskeleton

AFFOA David Fink smart fabrics

This single, elastic fiber contains a series of microdevices, including sensors, a microcontroller, digital memory, bluetooth modules, optical communications, and a battery, making up all the necessary components of a computer. An operating fiber computer shown knotted (left) and hanging with a 1-kilogram weight attached (right). (Courtesy Nikhil Gupta/Fink Lab MIT)

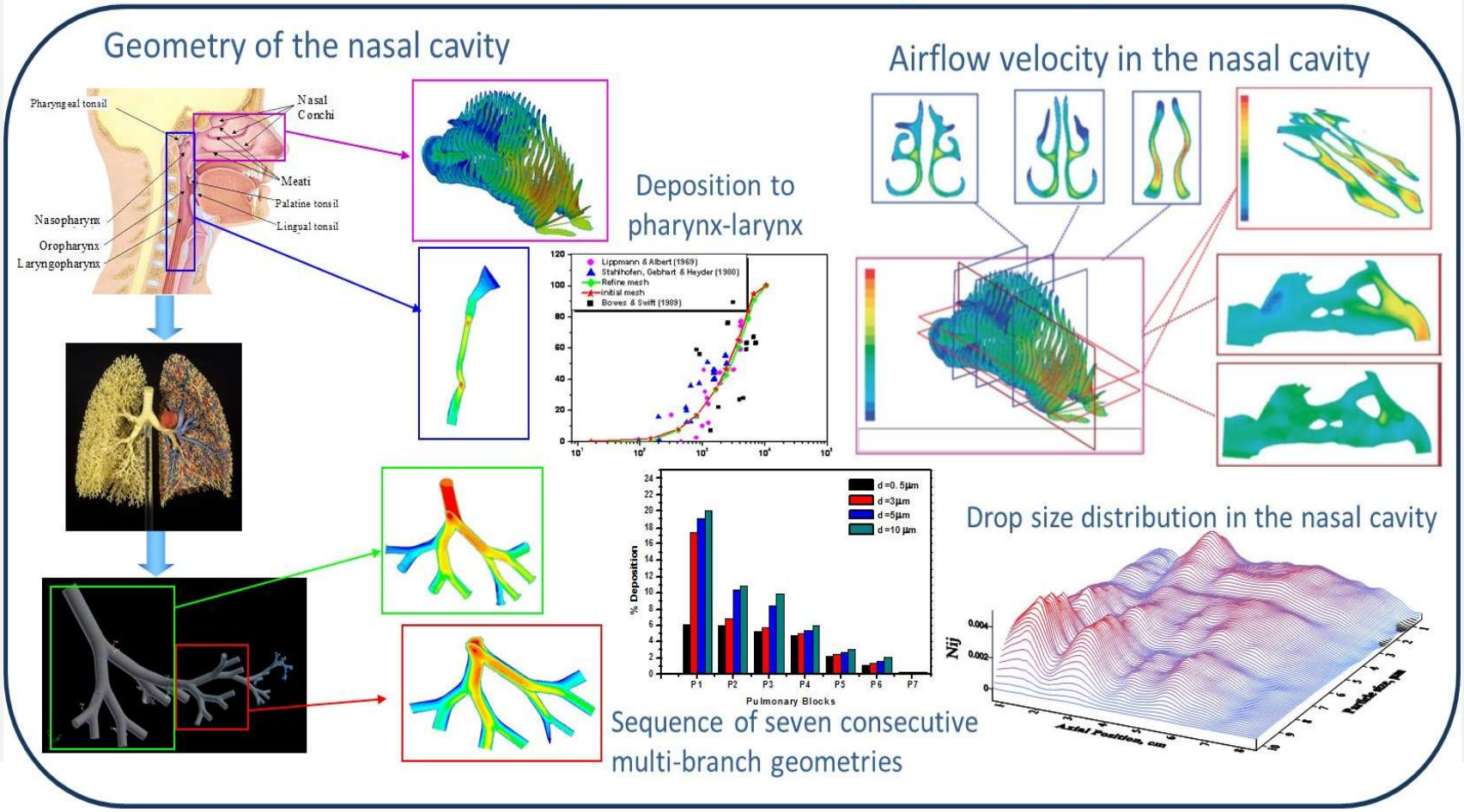
Hugh Herr: soft-robotics

Movement/Stress Connection in Multiple Sclerosis



Respiratory System Simulations: Application to a Dry Powder Inhaler

Background Technology: CFD / particle model

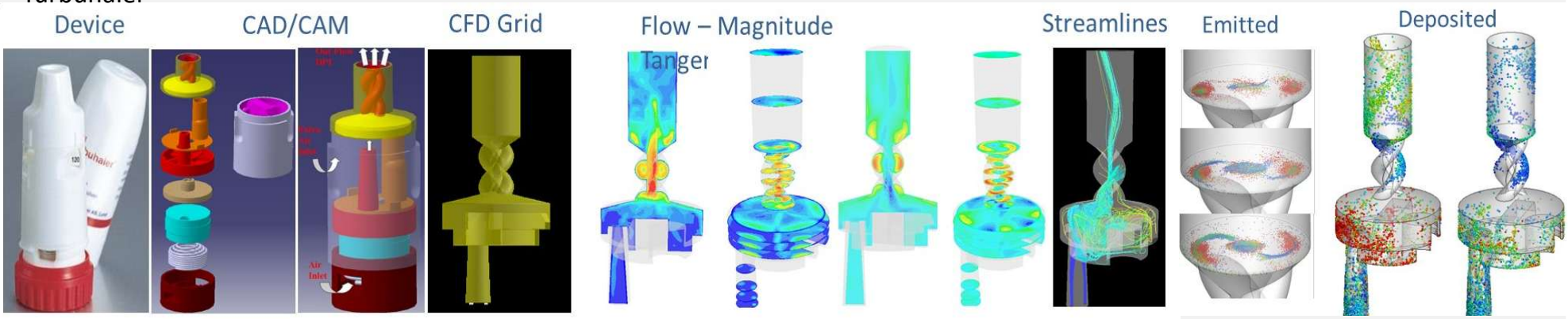


First dynamic particle simulation in the nasal cavity during dynamic inhalation

First dynamic particle simulation in the alveoli during multiple inhalations

Background Technology: CFD Dry Powder Inhalers

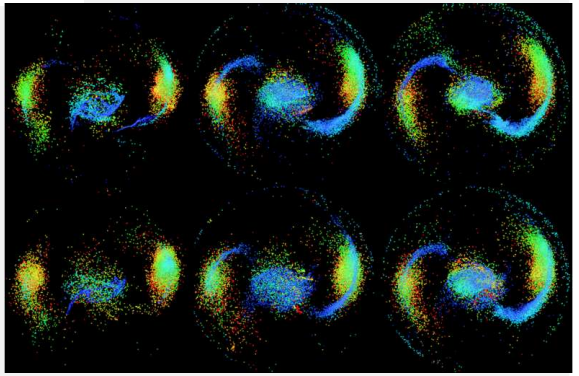
Turbuhaler©



Validation – First ever prediction of emitted dose and fine particle fraction for a commercial DPI

Mechanisms described:
Powder fluidization (empirically or DEM)
Collision with walls
Deposition on walls
Collisional breakage

Determined properties:
Pressure drop
Flow patterns
Depositions
Outlet particulate flow

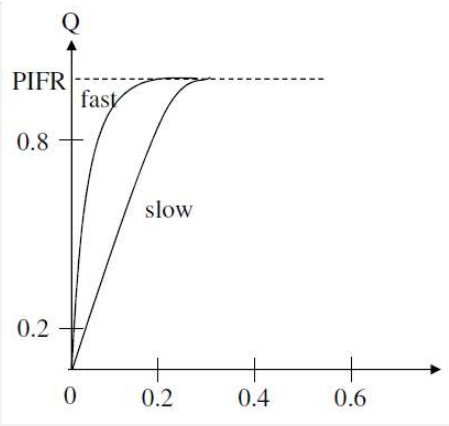


Background Technology: CFD Outflow dynamics from DPI

Instantaneous outflow of particles from a DPI device and instantaneous deposition of particles within the device during a dynamic inhalation from a commercial DPI (Tubuhaler©).

Effect of inhalation dynamics!

First results of this type ever published

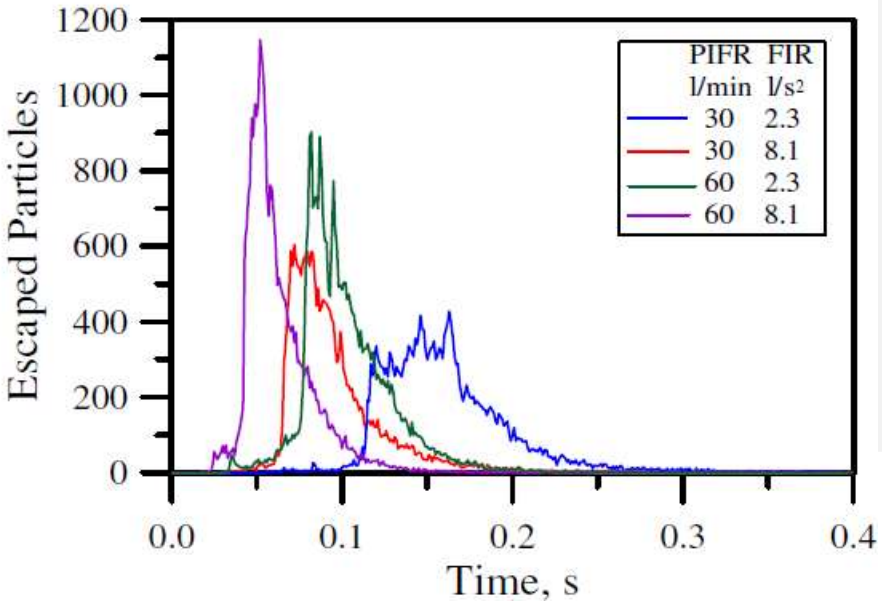


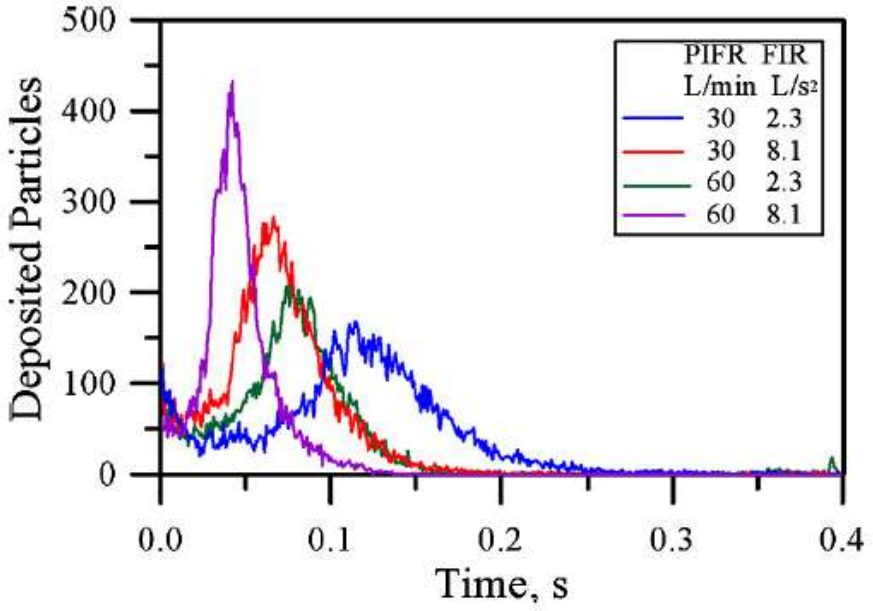
- ✓ PIFR - Peak Inspiratory Flow Rate
- ✓ FIR – Flow Increase Rate

$$Q = \mathrm{PIFR}(1 - e^{-\alpha t})$$

$$\alpha = 2.31 FIR/PIFR$$

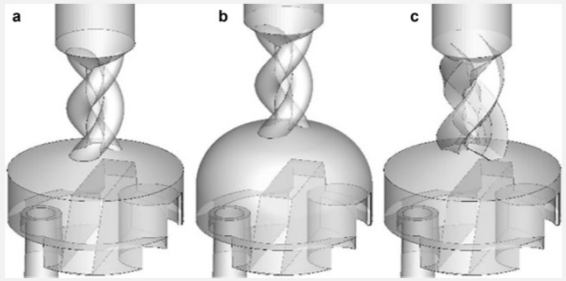
- ✓ a = 5.31, slow FIR = 2.3 l/s²
- ✓ a = 18.46, fast FIR = 8.1 l/s²



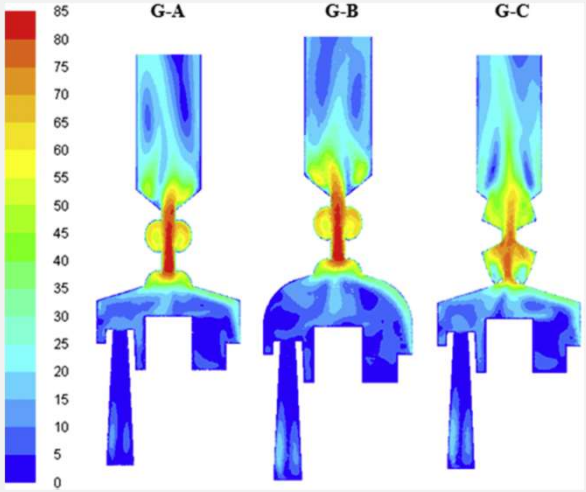


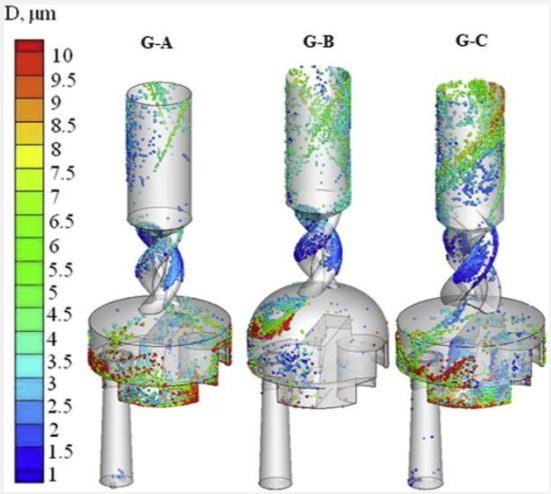
Background Technology: Optimization of a DPI Device

Three geometries are compared



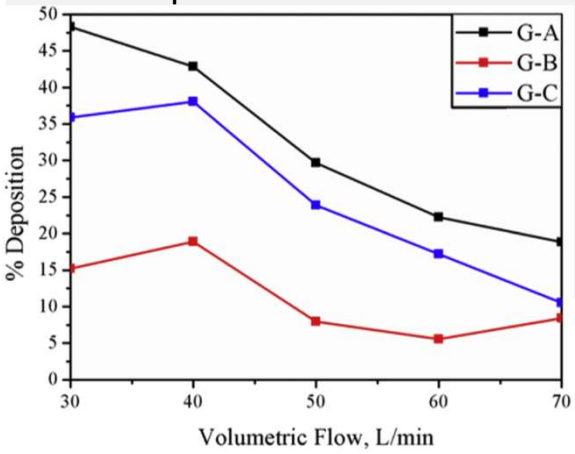
Velocity Magnitude



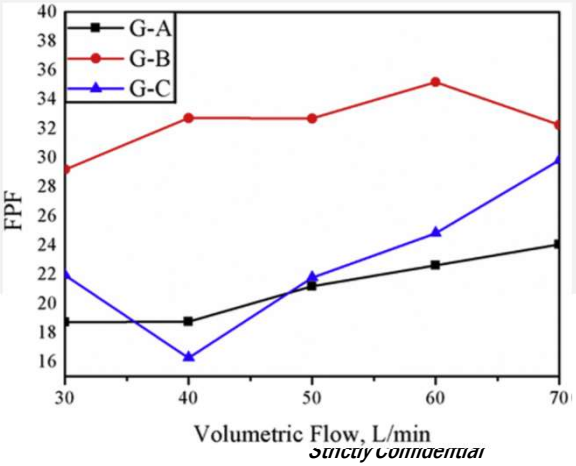


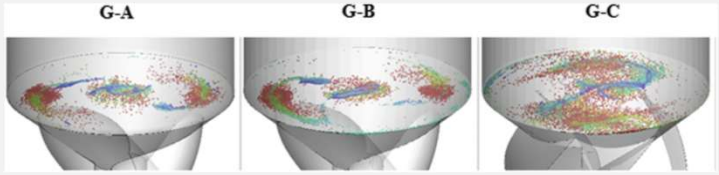
Deposited Particles
Q = 30L/min

Depositional Loss



FPF





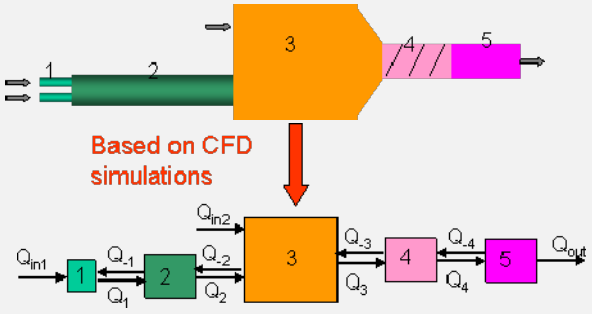
Q = 70L/min

Background Technology: Compartment Models of Powder Processes

Point of this unique technology is that we can perform full simulations within seconds instead of hours/days of CFD time.

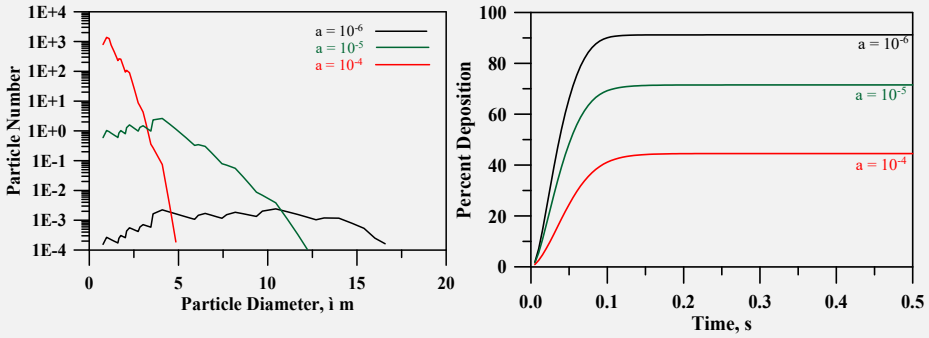
- Compartment models are developed to describe the particle size distribution, PSD, as a function of time in a small number ($N << N_{CFD} \sim 10^6$) of compartments.
- This approach permits the description of dynamic PSD including effects of breakage/aggregation, deposition/re-dispersion.

Extraction of Compartment Model

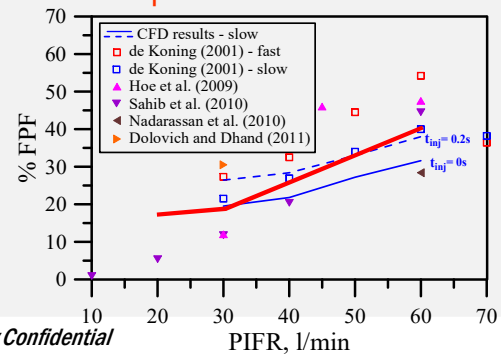


Compartment exchange flow rates, Q_i Q_{i-l}, energy dissipation rates ε_i, and the compartment particle-wall collision and deposition rates are obtained from the CFD solution.

Effect of breakage rate – Consistency check with CFD model



Improved results for FPF



Compartment model is consistent to the CFD-particle model and can be used to describe additional phenomena.

Virtual Lung

Whole lung mechanics
From air-flow (CFD, 1D, 2D, 3D models) and deposition models
from oral and nasal cavities (and devices) down to alveoli
To mucous layer interaction (penetration, entrainment, dissolution, swelling, drug release)
Surfactant layer interaction (at alveoli and terminal bronchiole)
To biological interactions (at the mucous layer, epithelial layers)
and physicochemical (oxidative stress, reactivity)
To biological response (e.g., inflammation, cytokine activation)
and immune system response

Multi-scale in length and time
Multi-model with many unknowns
Integration is problematic

Need a combined data-based + computational model output to develop a digital twin

Cystic Fibrosis

- Mucous layer model, clearance and local dynamics. Very important to understand how mucolytic drugs should be targeted. Improper targeting can make matters worse!
- Mucous layer rheology is non-Newtonian in nature and affected by mucolytics.
- Mucous layer models can be combined with pulmonary models for intelligent drug delivery.
- Largely unsolved problem today

Also

- Exacerbations of symptoms in people with cystic fibrosis can probably be predicted with the system used by RespiFit (monitor exposure/symptom histories and deep AI)