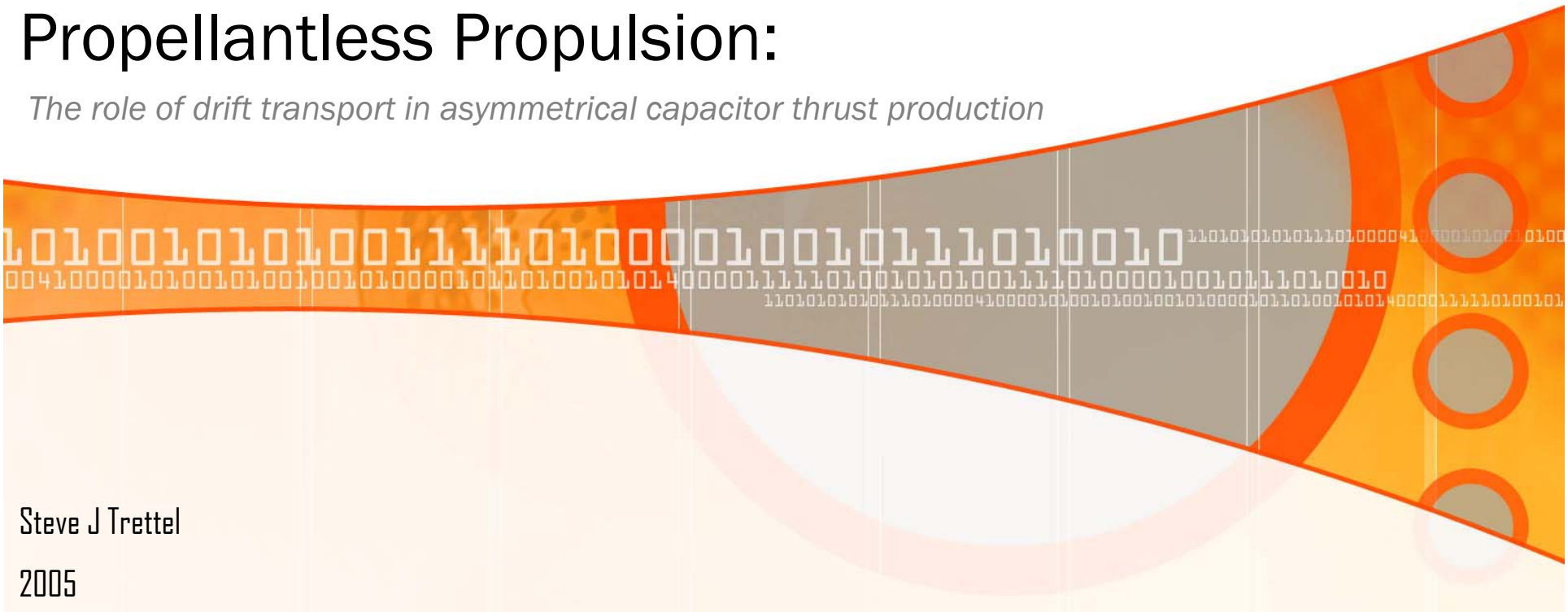
Propellantless Propulsion:

The role of drift transport in asymmetrical capacitor thrust production



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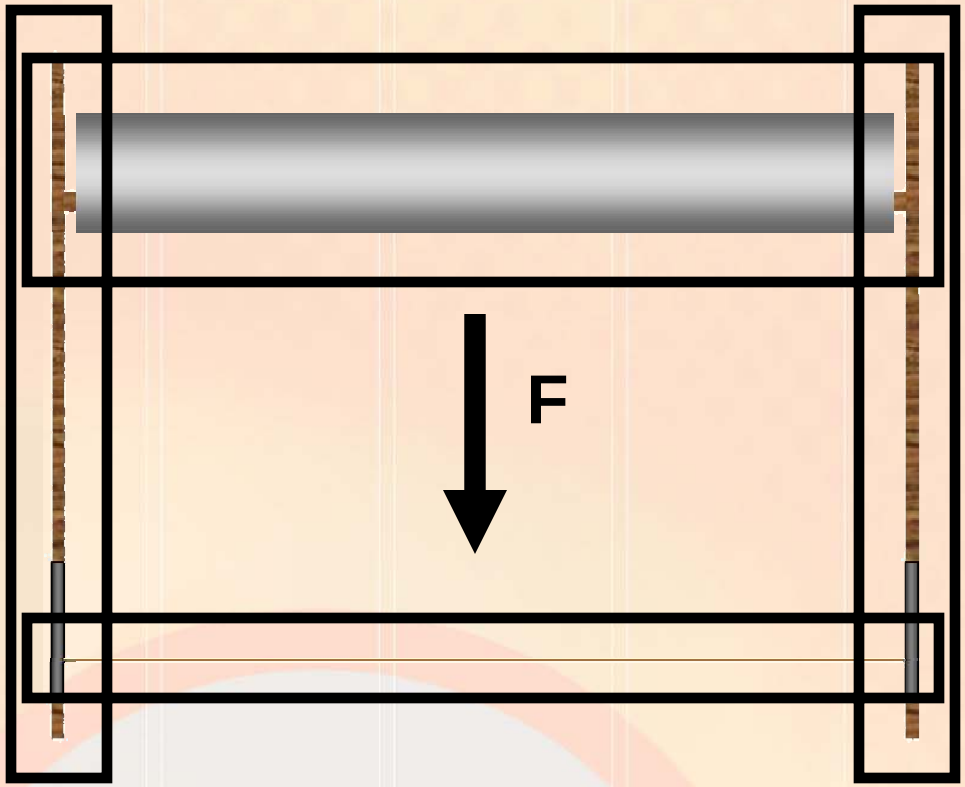
ASYMMETRICAL CAPACITORS

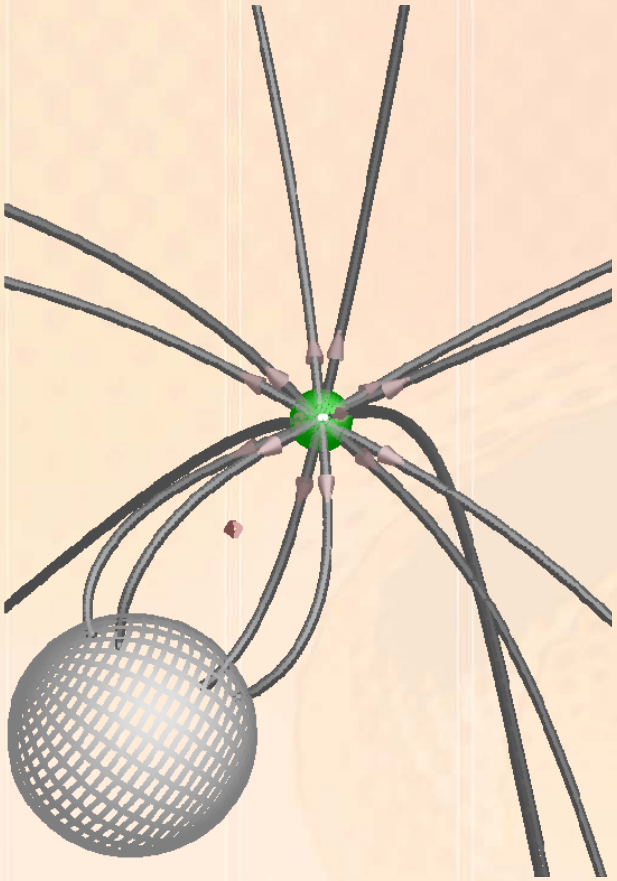
- Produces net force when charged
- No moving parts
- Silent Operation

ASYMMETRICAL CAPACITORS

- Geometrically dissimilar electrodes
- Isolative supports
- High Voltage (26kV, 300uA)
- Force in direction of smaller electrode



PHYSICS



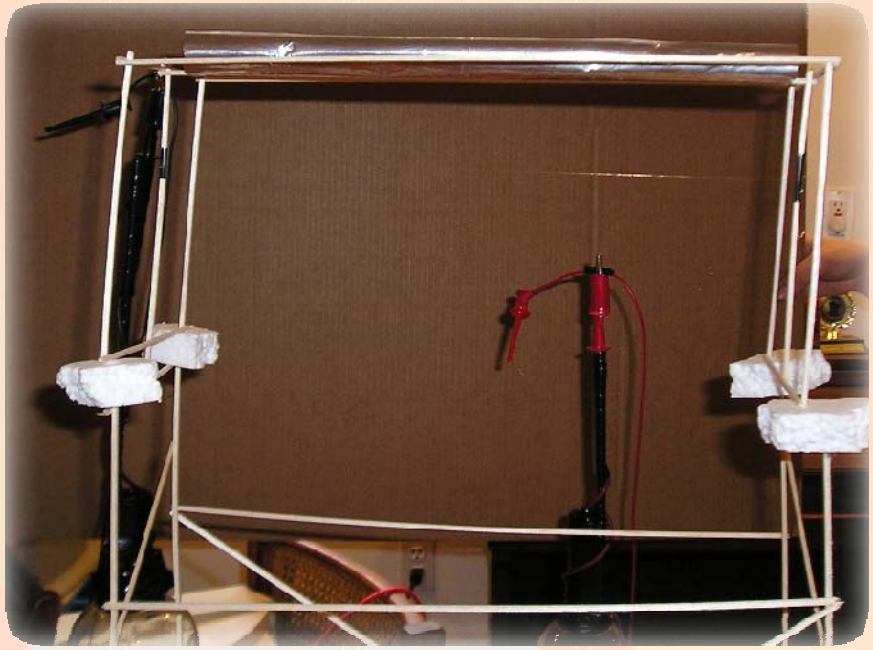
- **“This thrust cannot be presently explained by any previous theories…”**
  - Purdue University, 2000

OBJECTIVE

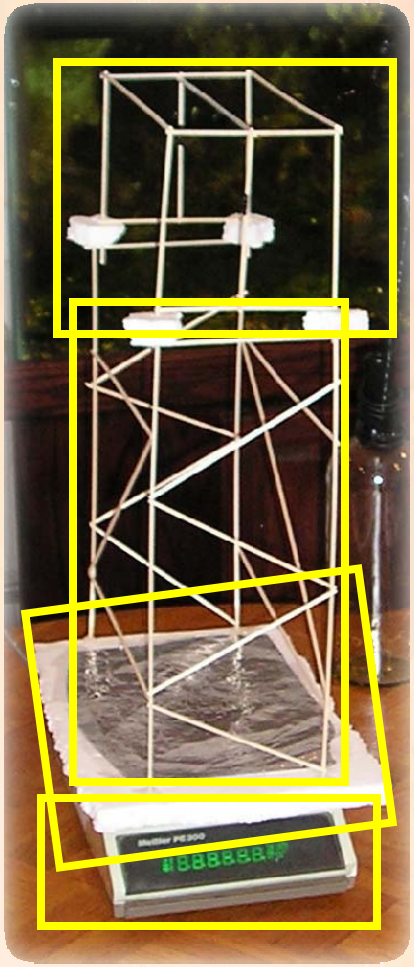
- Evaluate the effect of the following on the direction/magnitude of the resulting thrust:
  - SEPERATION
  - ASYMMETRY
  - POLARITY
- Analyze results mathematically and look for possible theories

HYPOTHESIS

- Force is proportional to the electric field strength and the flux through the foil electrode
- Force will only be produced when the wire electrode is charged



PROCEDURE



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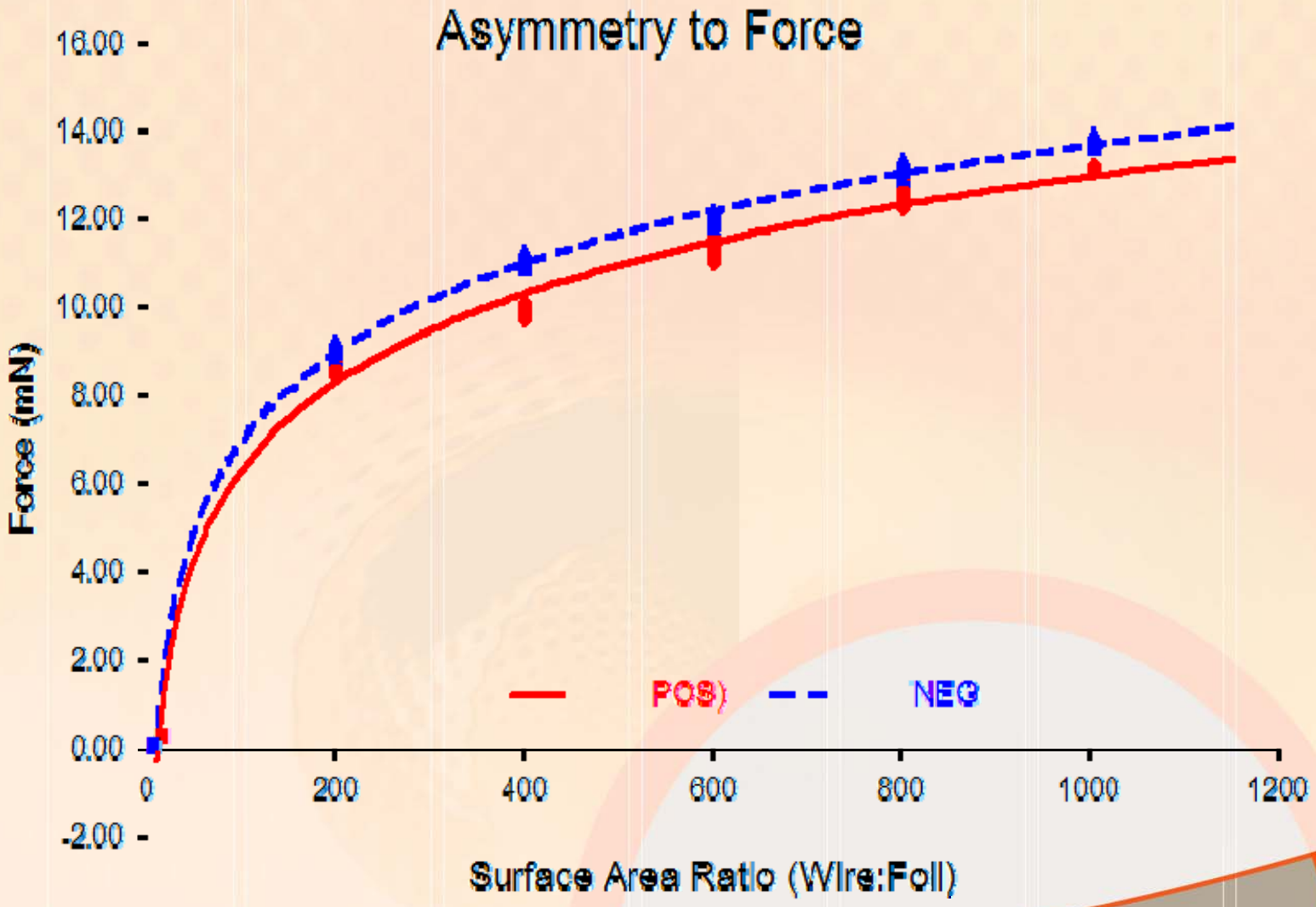
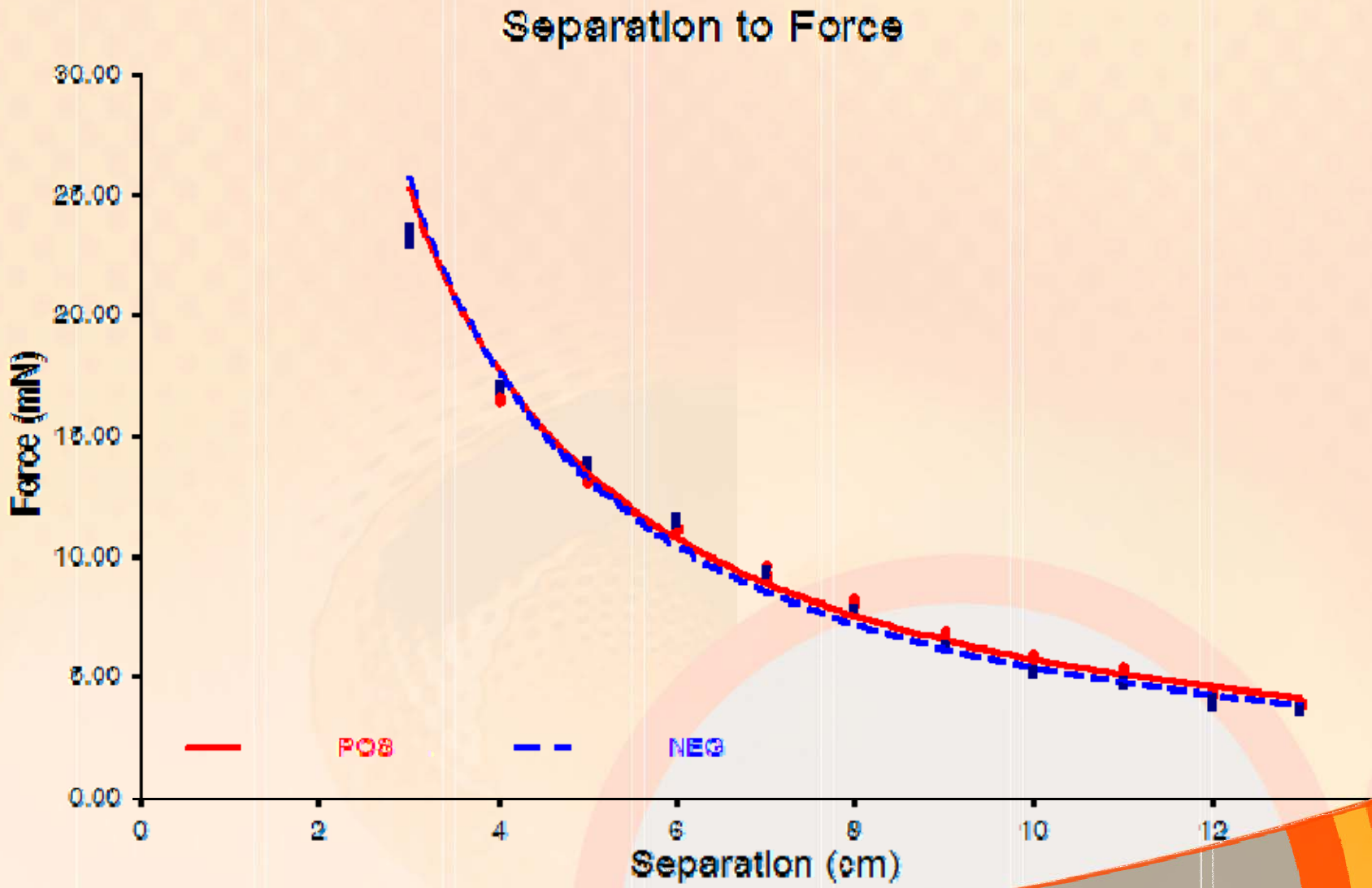
- Configuration positioned so force is downward
- Placed on electronic balance with support stand
- When charged, thrust is measured as an increase in weight
- Quickly and accurately obtained results

ASYMMETRY

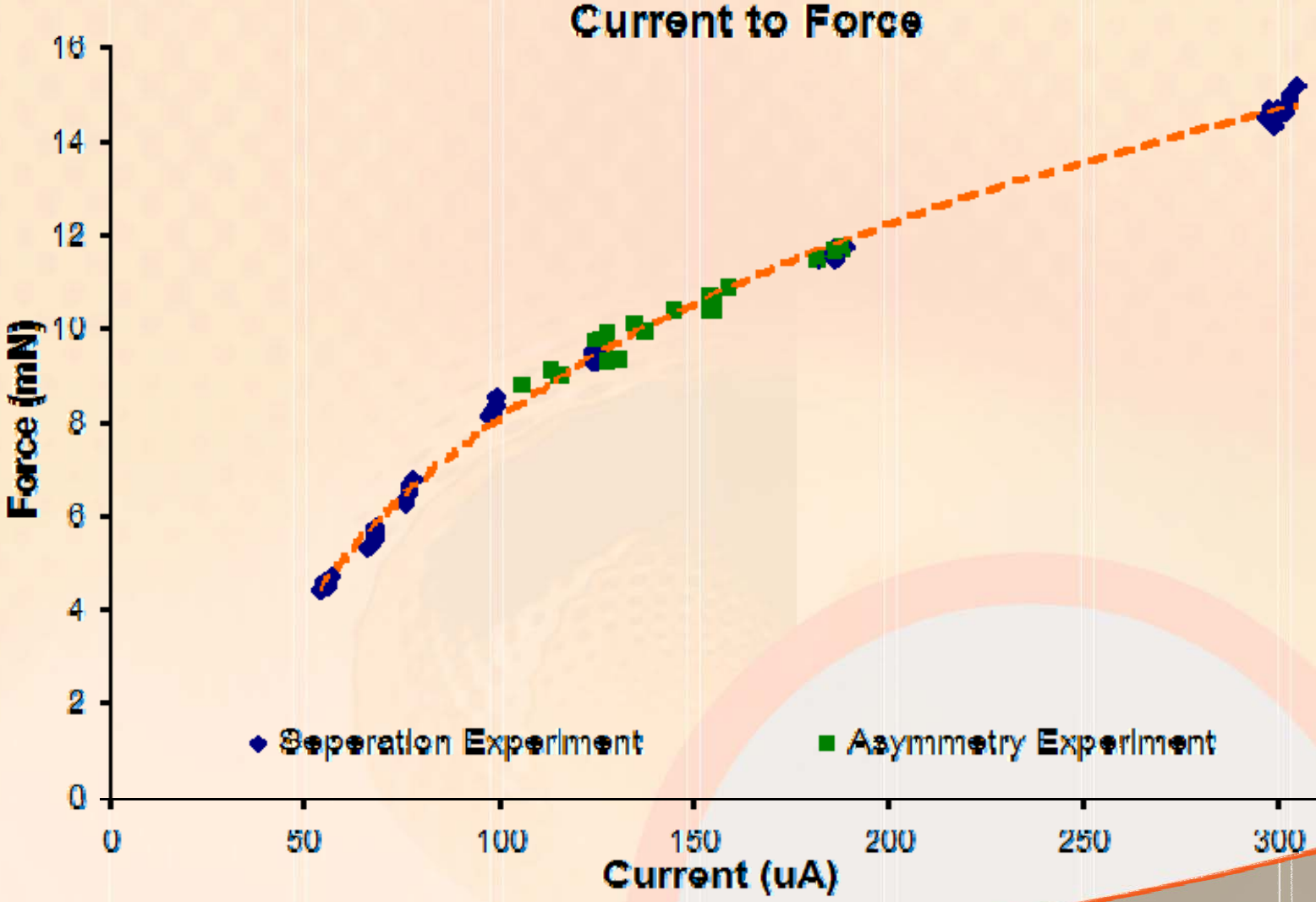

Asymmetry to Force
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Force (mN)
0
200
400
600
800
1000
1200
Surface Area Ratio (Wire:Foil)
POS)
NEG

ELECTRODE SEPARATION

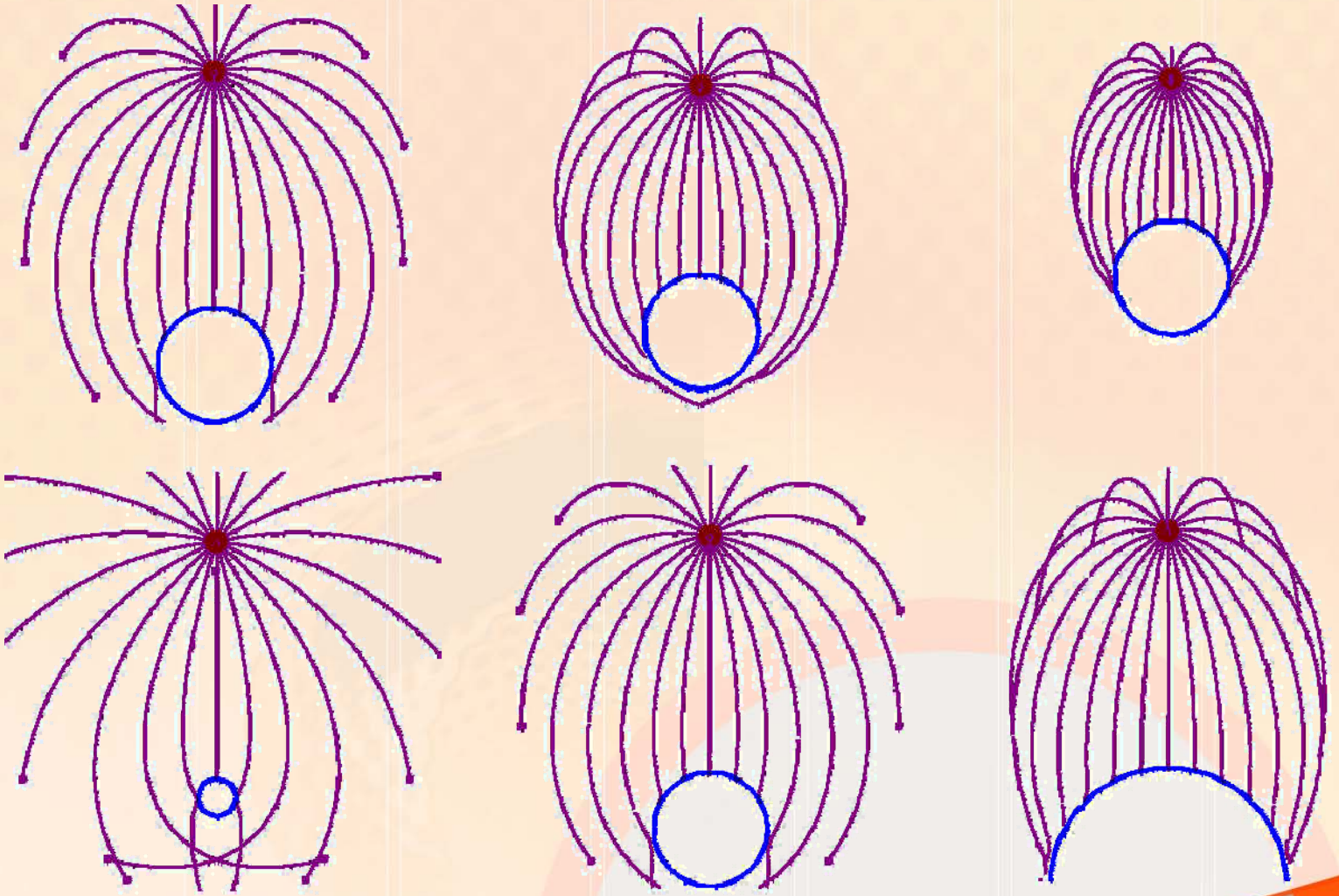


CURRENT

RESULTS



ELECTRIC FIELD



ION WIND

THEORETICAL

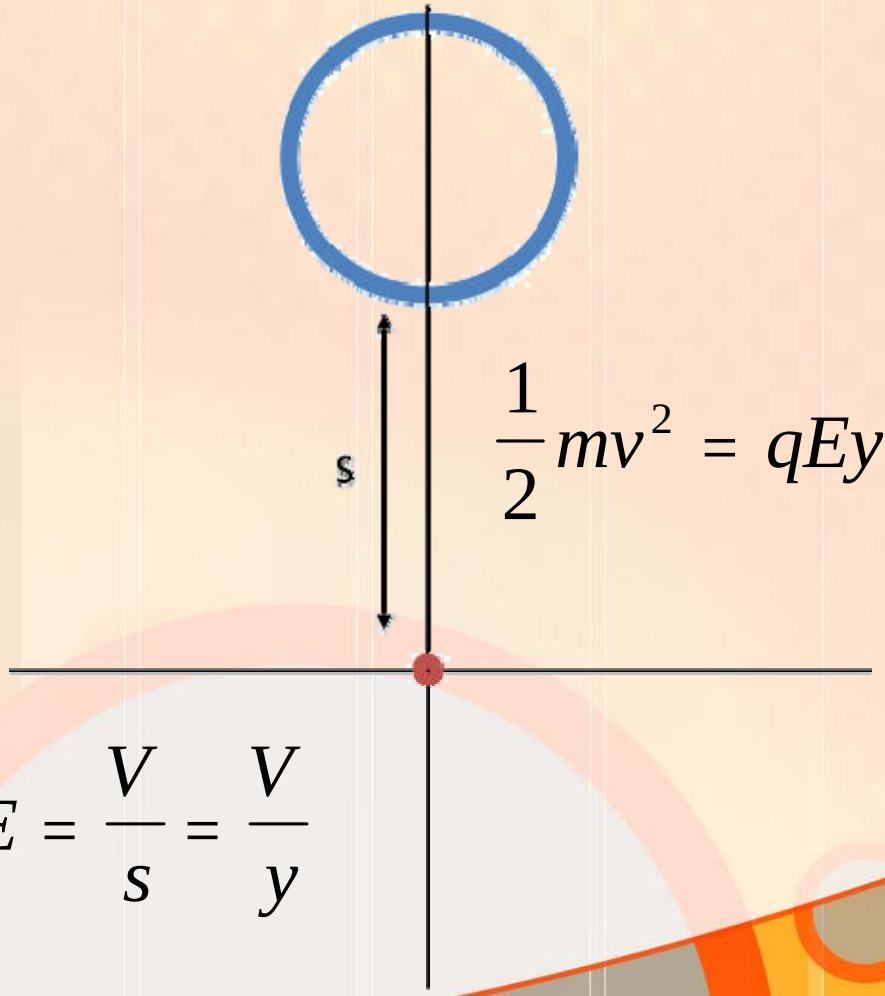
Ions move between ionizing and non-ionizing electrode

Mechanism comparable to ion thruster

$$F = I\sqrt{\frac{2mV}{q}}$$

Theory predicts 0.00007N.

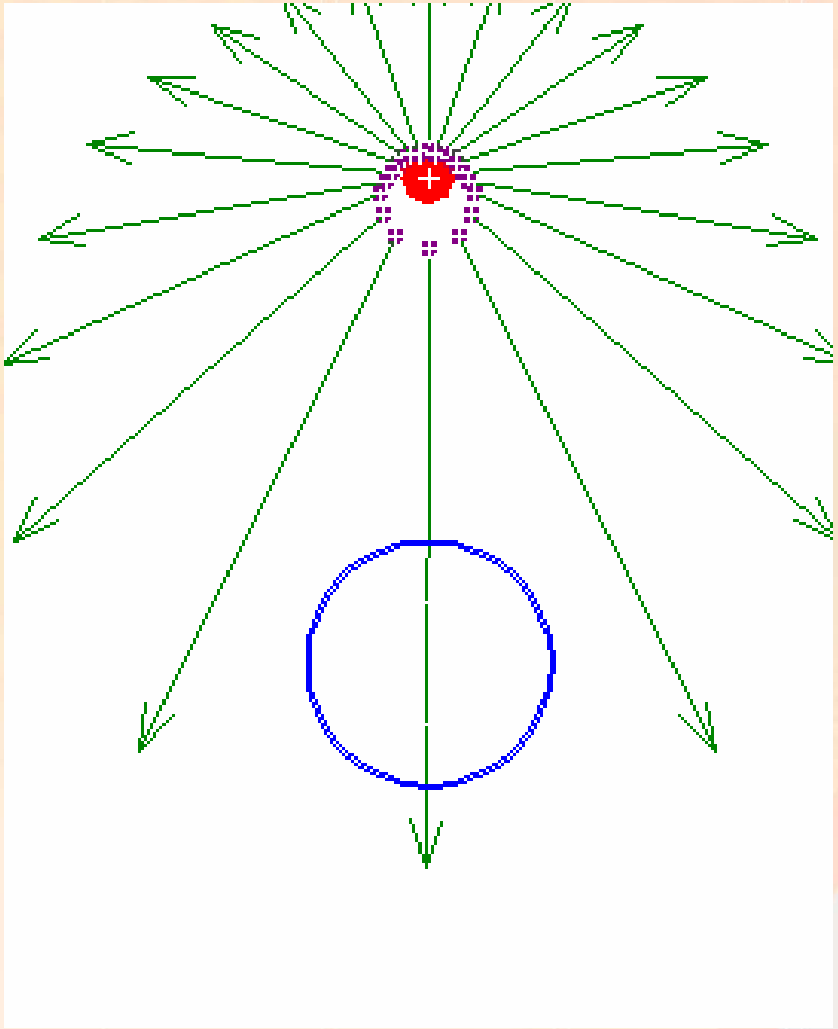
Experiment showed 0.018N



$$\frac{1}{2}mv^2 = qEy$$

$$E = \frac{V}{s} = \frac{V}{y}$$

DRIFT TRANSPORT

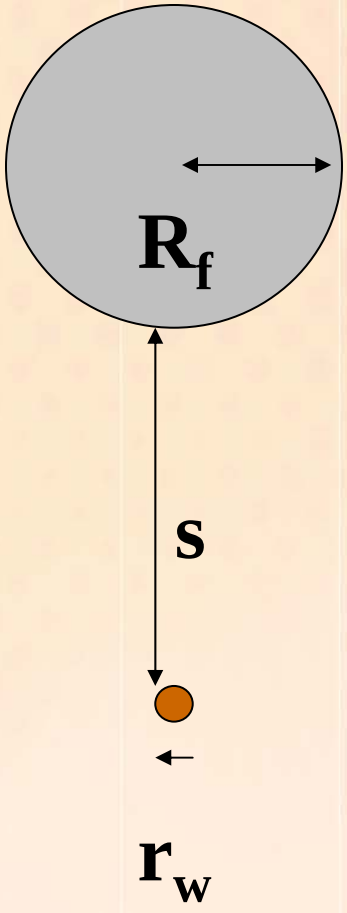


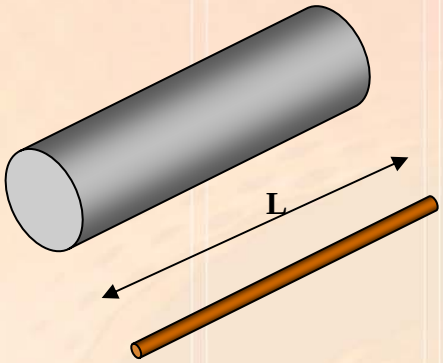
- Single ionizing electrode
- Ions impact molecules of dielectric
- Transfer momentum

$$F = qE = I\frac{s}{k}$$

Current is a complicated function of voltage, separation, and electrode geometry.

BARSOUKOV THEORY





Theory of current flow between two electrodes

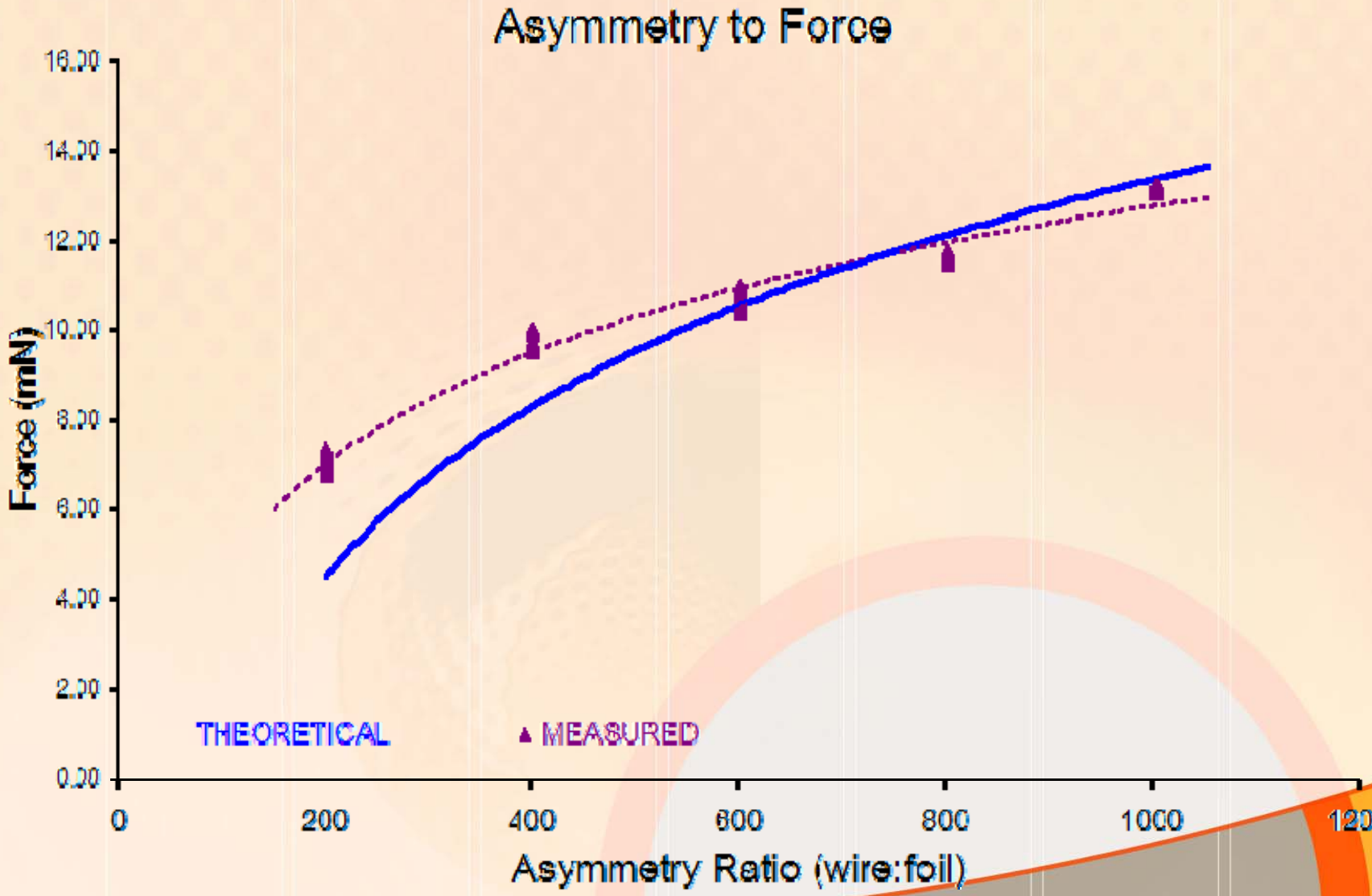
Current is substituted into previous derivation of force

$$F = sGV(V - V_0)$$

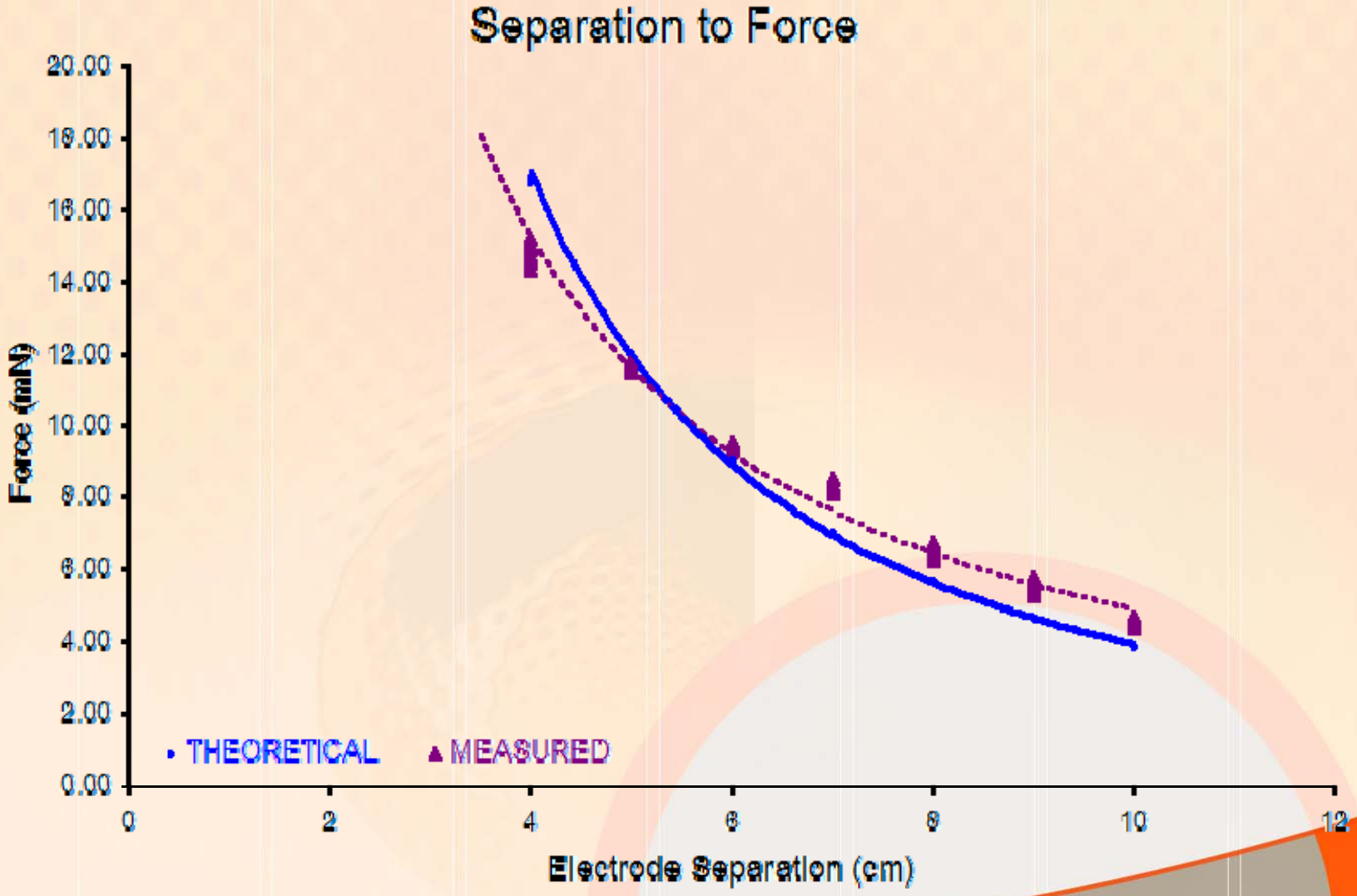
$$F = I\frac{s}{k} = 2\pi\varepsilon_0 VL\frac{V - r_w\delta E_0 \ln(\frac{s}{r_w})(1+\frac{0.301}{\sqrt{\delta r_w}})}{s\ln(\frac{R_f\pi\cdot e^{\frac{2\pi s}{R_f}}}{r_w})}$$

ASYMMETRY

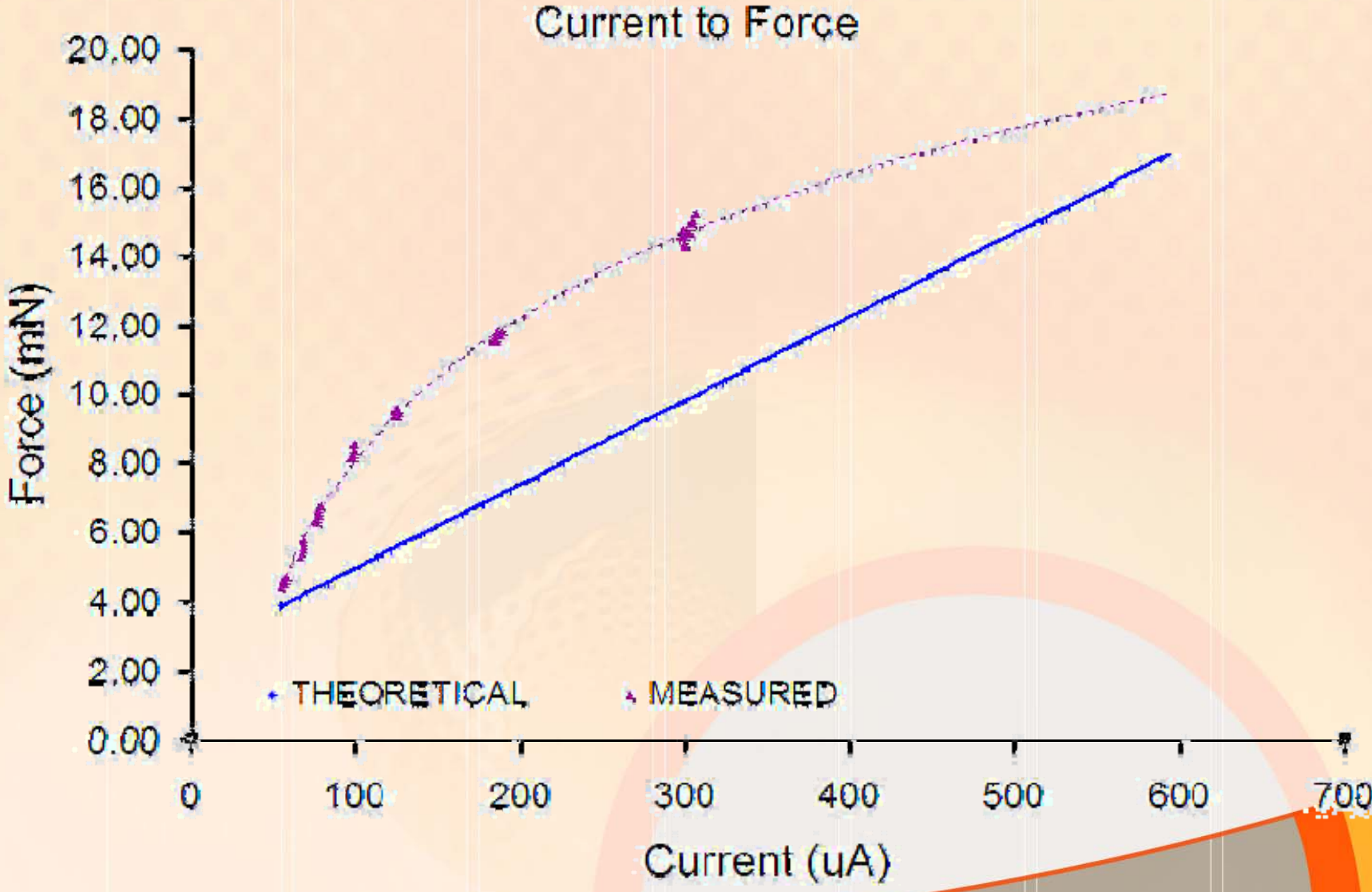
THEORETICAL



ELECTRODE SEPERATION



CURRENT FLOW



CURRENT FLOW MATHEMATICS

Theory assumed only one ionizing electrode

Ion pockets on foil electrode not accounted for—subtract from force

$$f(i) = \sum f_n(i) = f_w(i) + f_f(i)$$

Total force is sum of flow from wire and foil

$$f_f(i) = \phi(i)(i - \xi)$$

Flow from foil is percentage of total flow times the increase in current from initiation

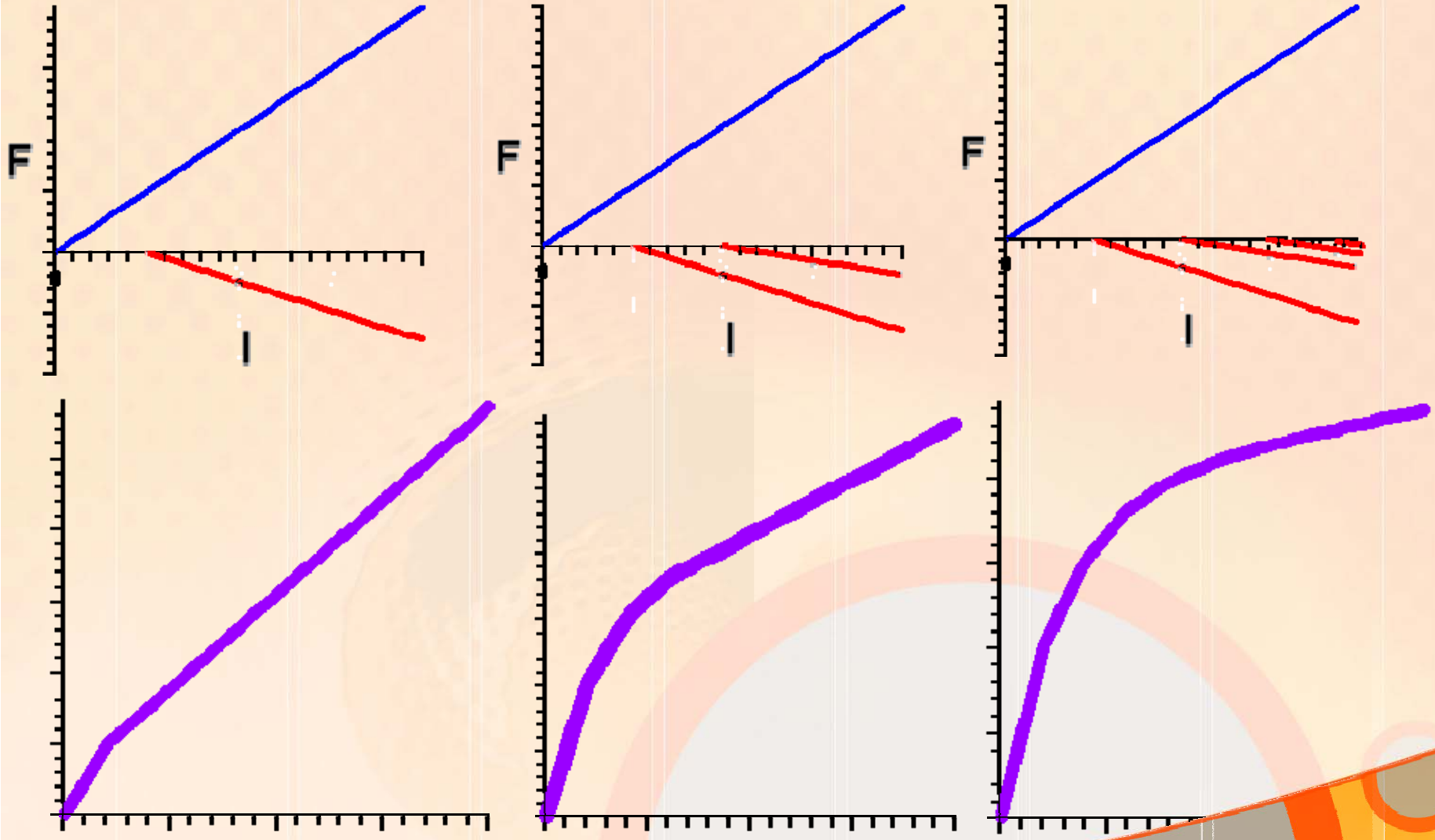
$$f(i) = f_w(i) - \sum_1^P \phi(n)(i - \xi)$$

Total force is magnitude of wire force minus magnitude of foil force.

$$f(i) = \begin{cases} 0 & V < V_w \\ I\dfrac{s}{k} & V \geq V_w \end{cases} - \begin{cases} 0 & V < V_f \\ \sum_1^P \phi(n)(I\dfrac{s}{k} - \xi \circ V_f) & V \geq V_f \end{cases}$$

The revised force equation takes into account counter-current from the foil electrode

CURRENT FLOW MATHEMATICS



POTENTIAL APPLICATIONS

- Atmosphere as sole propulsive medium
- No onboard propellant
- No moving parts
- Silent

CONCLUSION

- Thrust dependent primarily on the current applied
- Polarity was not a major factor in thrust magnitude or direction
- Results of experimentation pointed towards an ionic model for thrust