AUSTRIAN RESEARCH CENTERS

µPPT- Propulsion Solution for CubeSats

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Austrian Research Centers

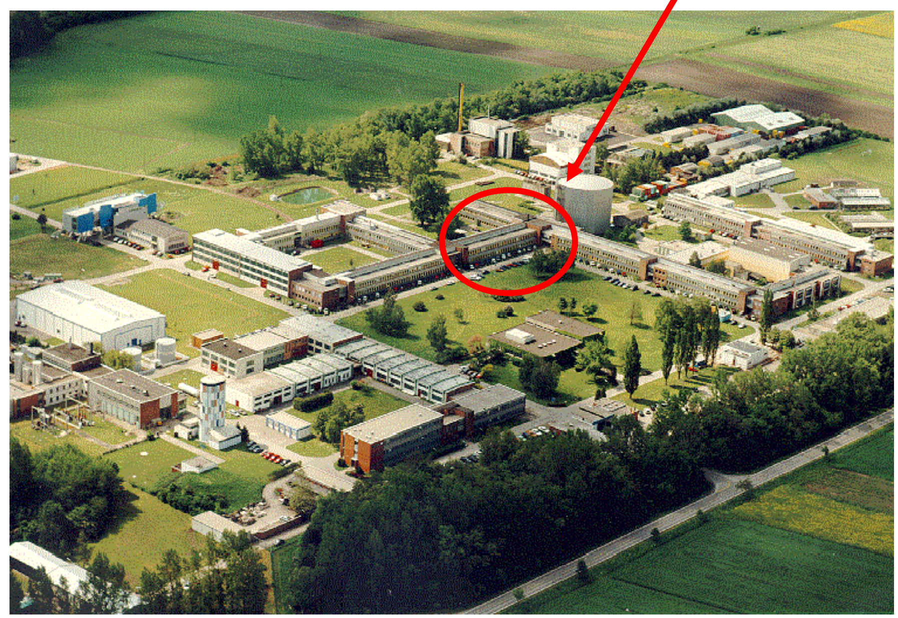
2007 CubeSat Developers Workshop, Huntington Beach, CA

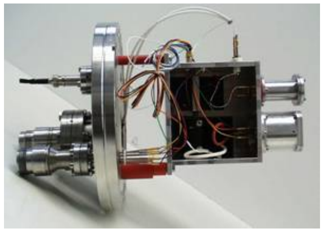
Who are we?

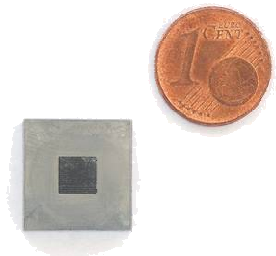
Employees	2005
ARC Holding	123
Seibersdorf research	392
Arsenal research	132
LKR	30
ECHEM	18
ISS	11
ACV	15
Total	721

Space Propulsion & Advanced Concepts

Staff:	12
Ph.D. Students:	3
Undergraduate Students:	2





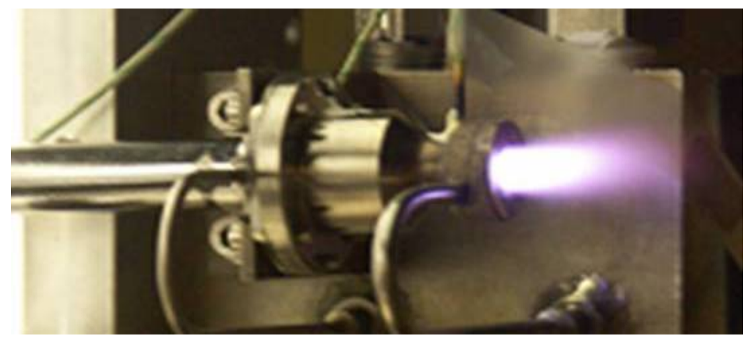


Electric Propulsion / Ion Guns

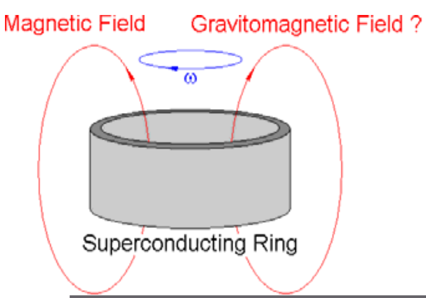
⇒ FEEP / µFEEP Thruster Development (LISA)
⇒ µ-Pulsed Plasma Thruster Development
⇒ Ion Guns for SC Charging/Mass Spectr. Appl.
⇒ EP Plasma Simulations (e.g. SMART-1)

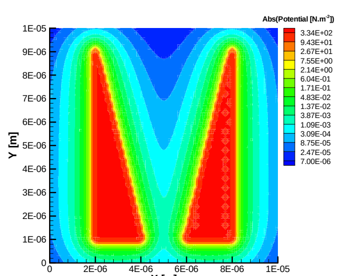
Chemical Propulsion

⇒ Bi-Propellant Micro-Rocket Engine
⇒ Monopropellant Rocket Engine



Advanced Concepts / Leading Edge Concepts





⇒ Gravity in Quantum Materials
⇒ Casimir Force Simulation
⇒ Plasma Mirror for High Power Lasers

Why Propulsion on CubeSats?

- **Compensation for disturbance torques**: Drag, gravity gradient, solar pressure magnetic forces…..
- **Spin-up and spin down**
- **Attitude control**: Communication improvement (antenna pointing)
  Scientific payload requires control/fine-pointing (spectrometry, camera)
  Improved power generation (solar panels)
- **Orbit control**: Improved mission autonomy (compensation for errors during orbit insertion, change of orbit, etc.)
  Broader mission range (formation flying etc.)
  Higher mission pay-off /success
- **De-orbiting** after EOL (to a certain extend). Very important to increase acceptance of CubeSats. De-orbiting ability might become compulsory in the near future!
- Because it is cool!

→ Broader mission range for CubeSats

Propulsion Solutions for CubeSats

What kind of propulsion solution

- Reaction wheels
- Magnetic torque coils
- Cold gas thruster
- Chemical propulsion systems (s/l/h)
- Electrical propulsion systems
  - o Arc jets
  - o Hall Thruster
  - o Ion Thruster
  - o FEEPs
  - o PPT
  - o MPD
  - o Vacuum Arc Thruster
  - o Microdischarge Plasma
  - o ....
- ....

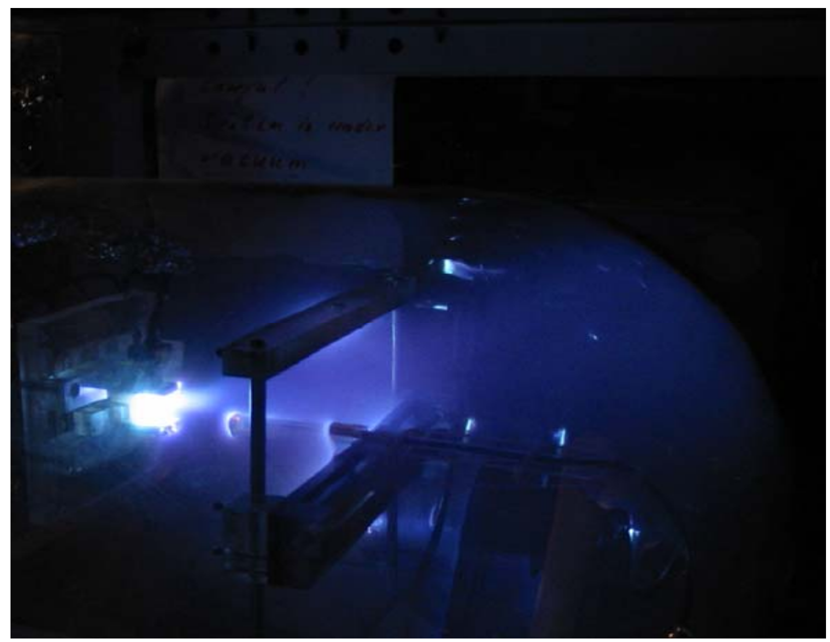
What kind of system requirements (CubeSat)

- Small size (can the system be miniaturized?)
- Low wet mass (high specific impulse)
- Low power consumption
- Modest electrical requirements (e.g. low voltage)
- Propellant: long term storable, non-toxic and non-carcinogenic, high density, cheap, ……
- Maturity/Availability
- Simple
- Reliable
- Cheap
- Flight proven
- Neglegible interference with satellite systems and payload
- ………….
- Last, but not least, the thruster has to fulfill the mission specific requirements (performance)

μ-Pulsed Plasma Thruster (μPPT)

If one additionally requires not only attitude control abilities but also active orbit control and furthermore flight experience this leaves PPT/μPPTs as the best option

- Structural simplicity facilitates miniaturization
- Specific Impulse: 500 – 1000 s
- Low power consumption
- Teflon propellant:
  - o solid → no moving parts (valves etc.)
  - o unlimited storability
  - o easy handling
  - o non-toxic, non-carcinogenic
  - o no degradation in space
  - o no sensitivity to temperature
  - o cheap
- PPT system is a space proven system

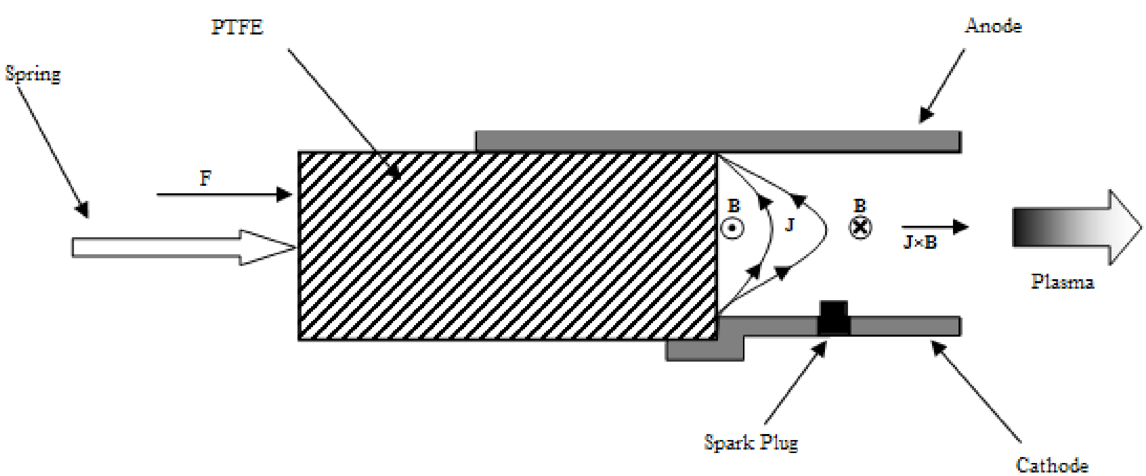


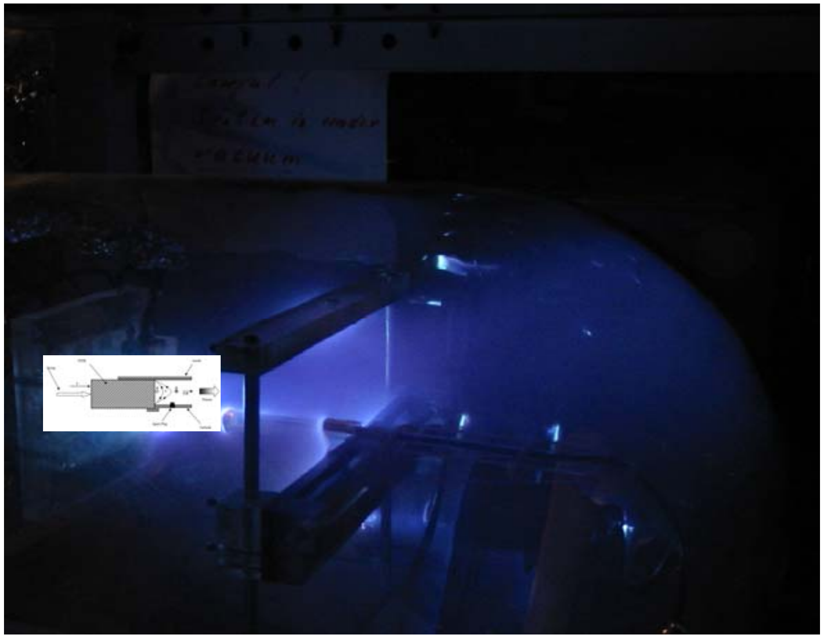
→ μPPTs are the ideal solution for CubeSats

µ-Pulsed Plasma Thruster (µPPT)

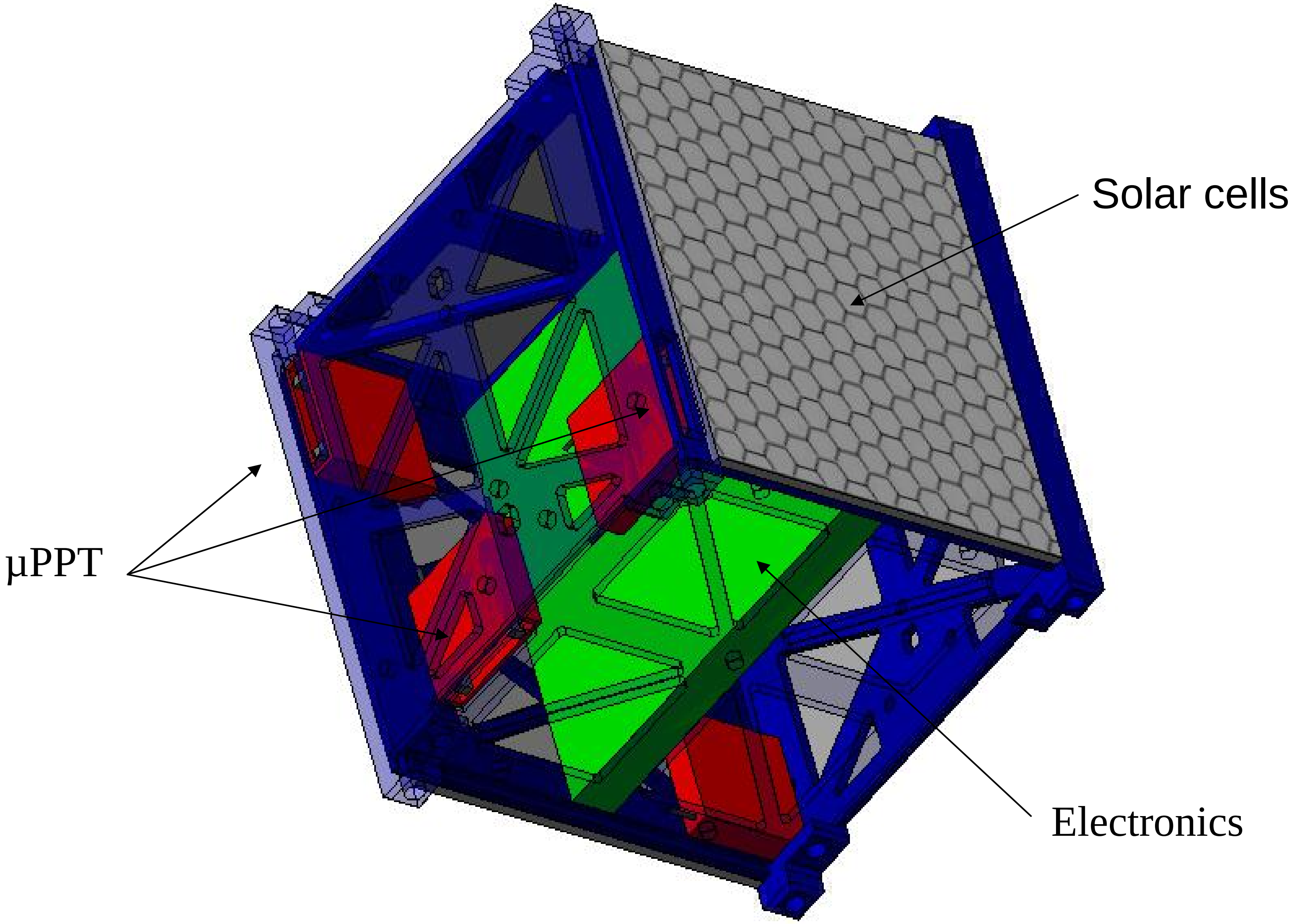
What is a µPPT?

- The **P**ulsed **P**lasma **T**hruster is an electromagnetic thruster
- The main components of a µPPT are the two electrodes, a trigger device, an energy storage system (capacitor), the propellant (Teflon), and supporting electronics.
- A discharge between the electrodes ablates the propellant and accelerates the ionized atoms/molecules by the Lorenz force (j x B).
- First use of a PPT on the Russian spacecraft Zond (1964!), most recent use on the American EO-1





System integration



μPPT Performance design goals:

	Value
Impulse bit	10-20 μNs
Specific impulse	500 -1000 s
Power	0.5 – 1.5 W
Weight (per thruster)	<30 g
Propellant mass	5 g

	I_{sp} = 500 s	I_{sp} = 1000 s
Total Impulse (per thruster)	25.5 Ns	49 Ns
Δv (per thruster)	24.6 m/s	49 m/s
Torque (per thruster)	0.5μNm	1 μNm
Fine pointing	< 1°	< 1°

Based on CubeSat: m=1 kg, 8mNm²

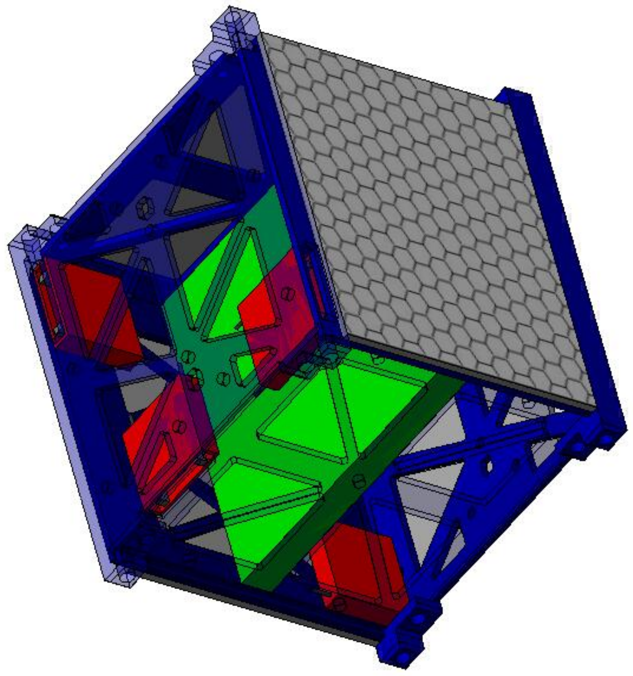
What can a μPPT system do for a Cubesat?

- Attitude control ✓
- Fine pointing (<1° precision) ✓
- Orbit change/insertion ✓
- Spin-up, spin down ✓
- Formation flight ✓
- De-orbiting ✓ (within limits)

Summary

µPPT for CubeSats:

- Sufficient performance to significantly increase mission capability of CubeSats
- Envelope and mass small enough to be accommodated in a CubeSat
- Power requirement is low enough for CubeSats
- Simplicity and non-toxic propellant makes handling at university possible
- Availability of off-the-shelf electronics is major concern
- Availability of prototypes at the end of 2007
- Goal: 2008 cooperation with flight project for 2009-2010



Do you need propulsion on your CubeSat?

What are your mission goals? Think BIG!

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