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Particle formation in process plasmas

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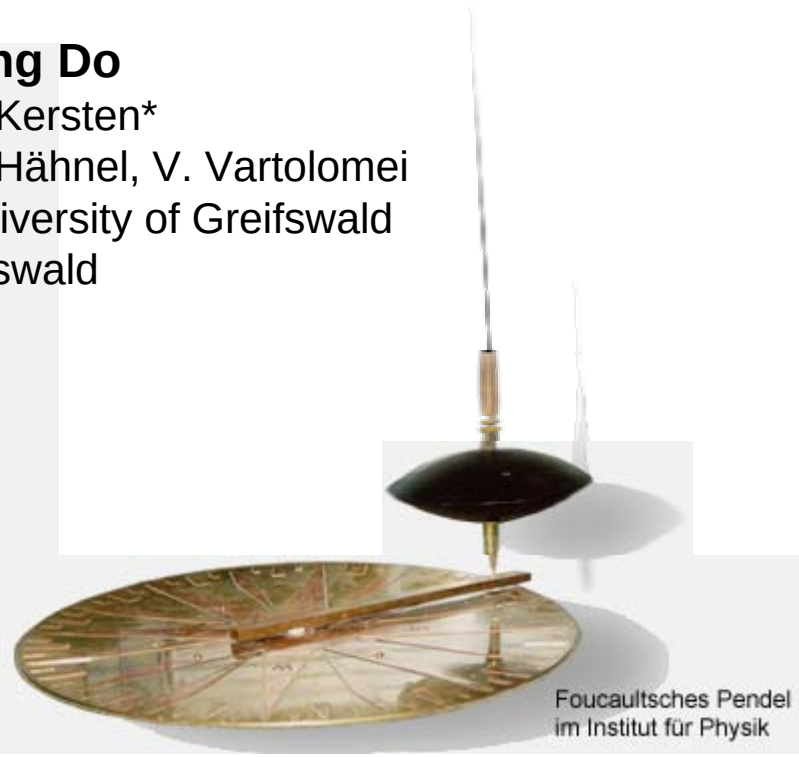

Contents

Introduction: Complex plasma

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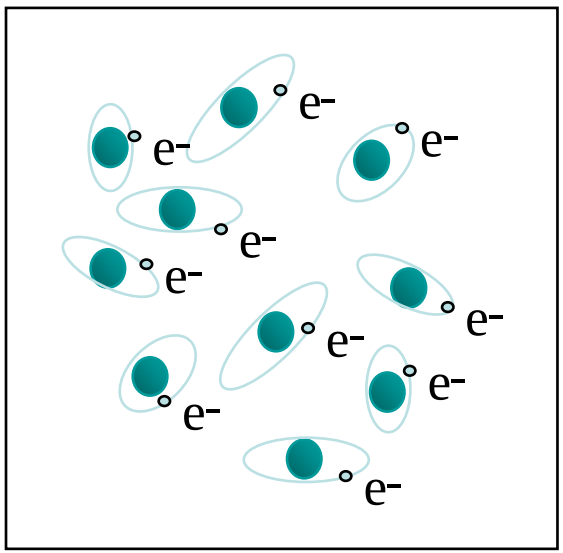
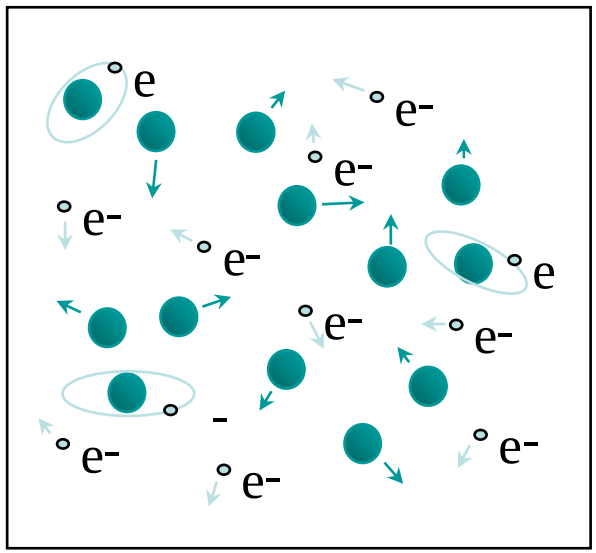
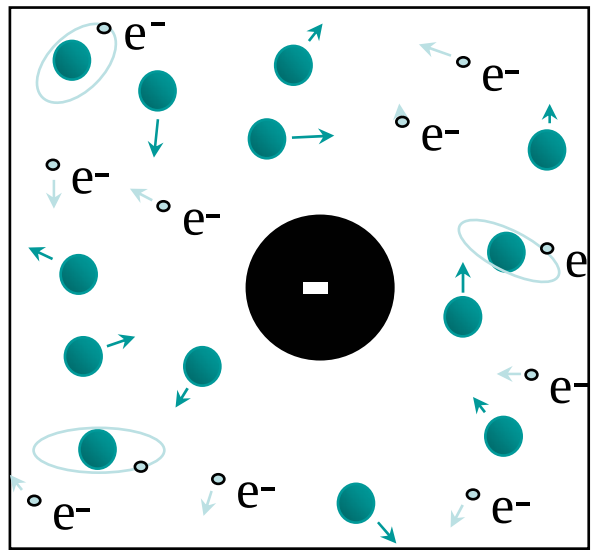
Neutral gas → **Plasma** → **Dusty plasma**



electrons are bound



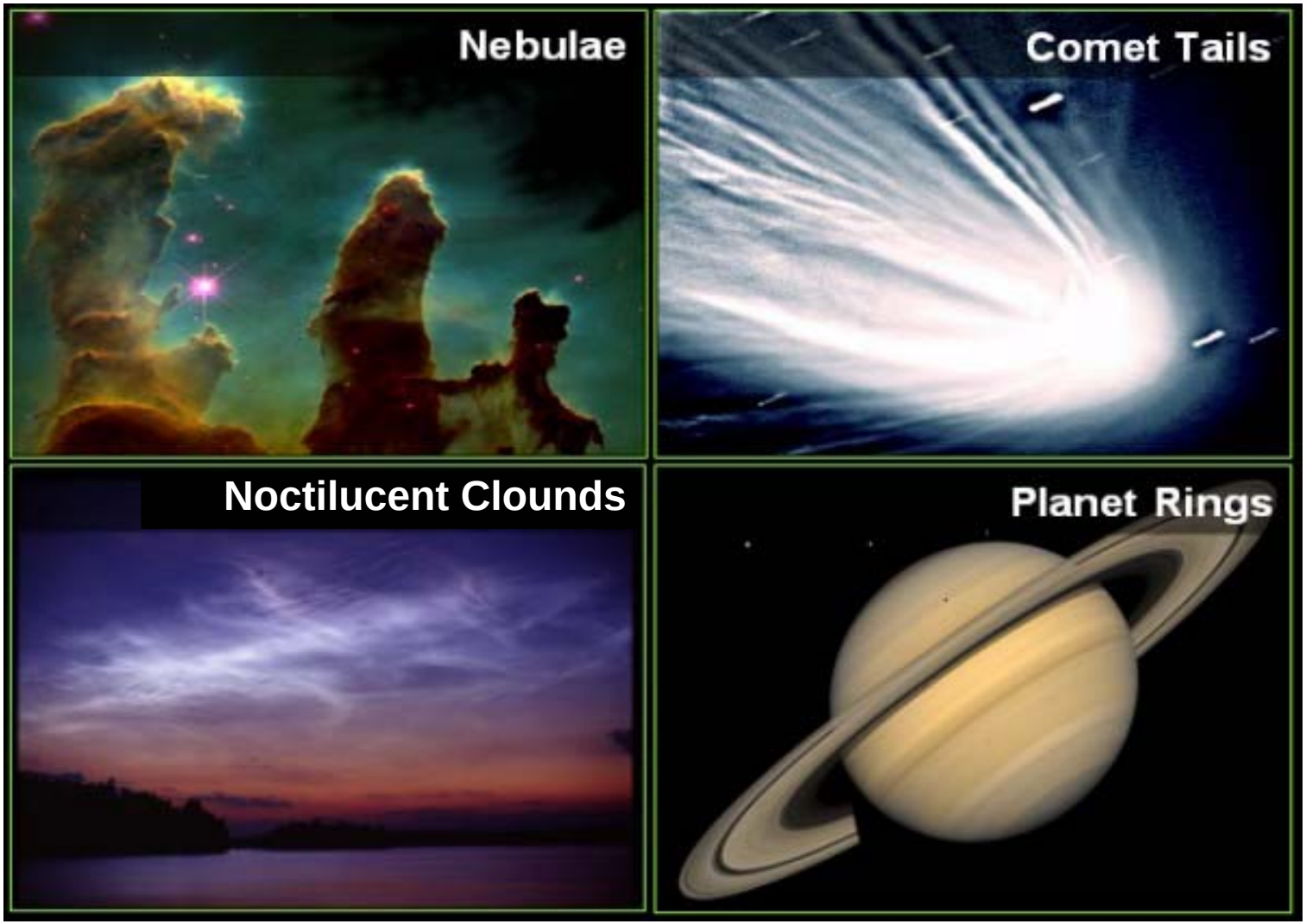
neutrals and free charge carriers



Neutrals, free charge carriers and dust particles

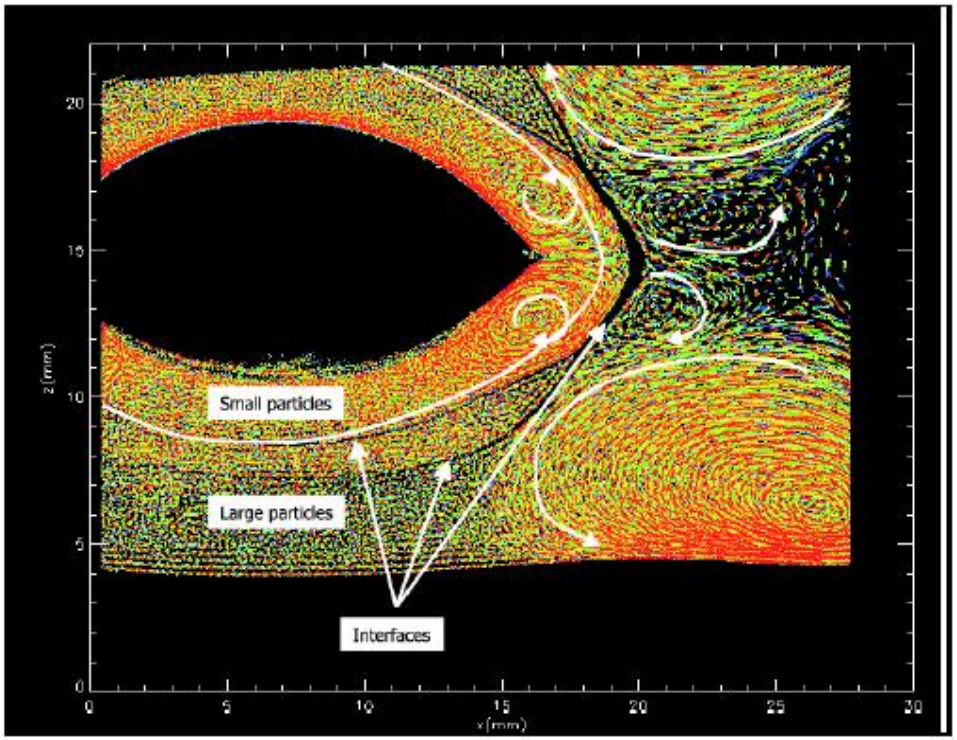
➡ **COMPLEX !!!**

Introduction: Complex plasma in nature

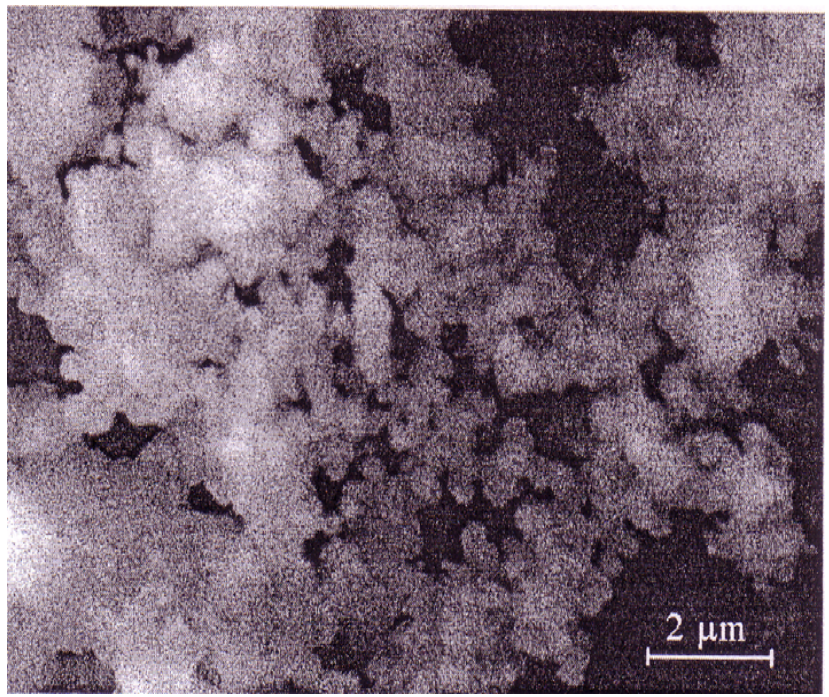


Complex plasma in nature

Introduction: Motivation

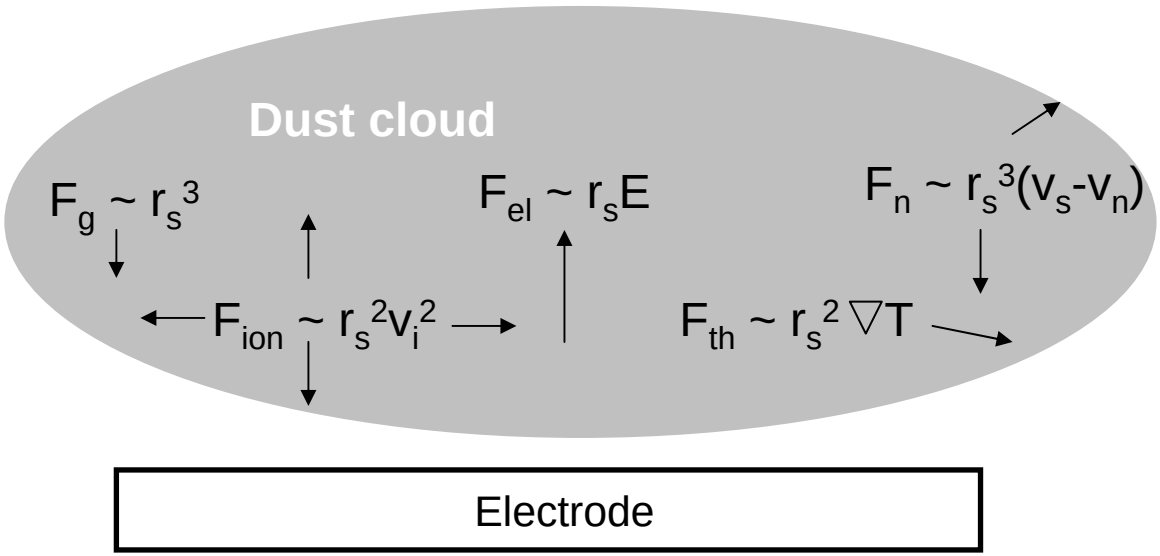


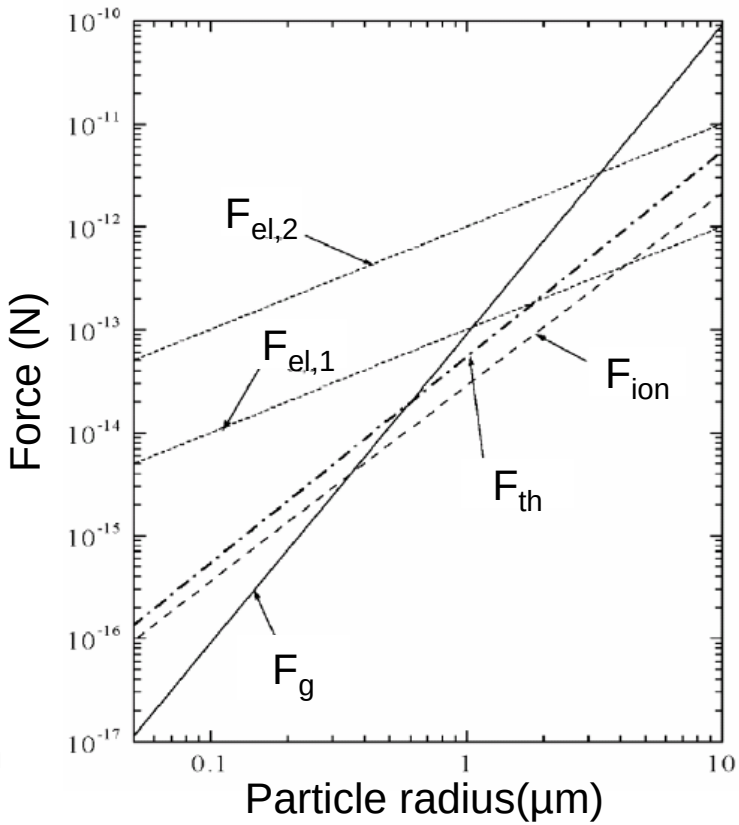
Dust cloud under micro-gravity



Particles created in Acetylen plasma (its size is about 50nm):
• structures in particles cloud are formed
during C-particle formation in laboratory

Introduction: Force balance

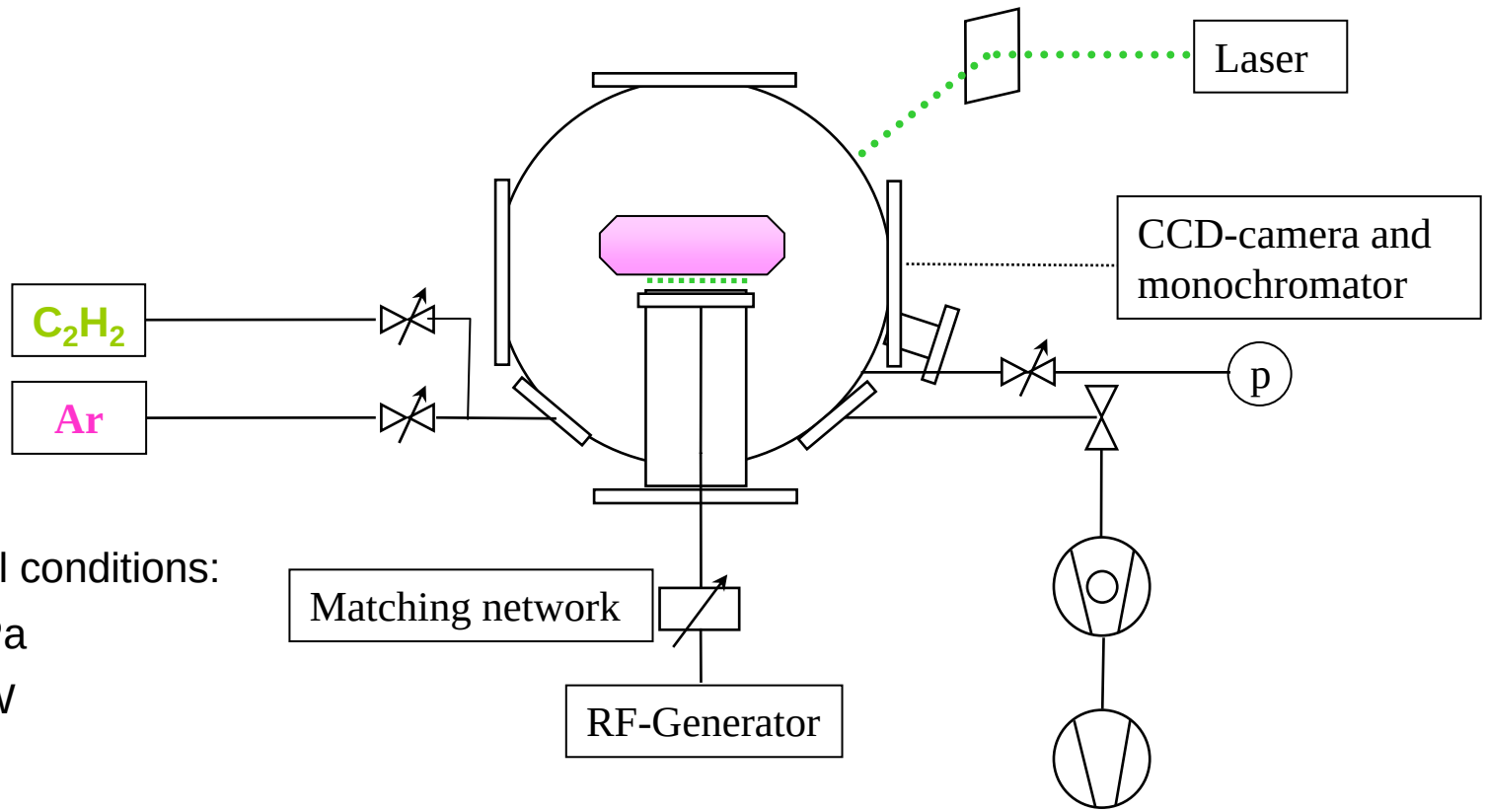




Wall (1) : E = 1400V/m
Sheath (2) : E = 10^4V/m

In our conditions electric field force is dominant and ion drag force is responsible for dust void formation. Dust particles are not situated only in sheath region but in the whole chamber.

Experimental setup: PULVA 1



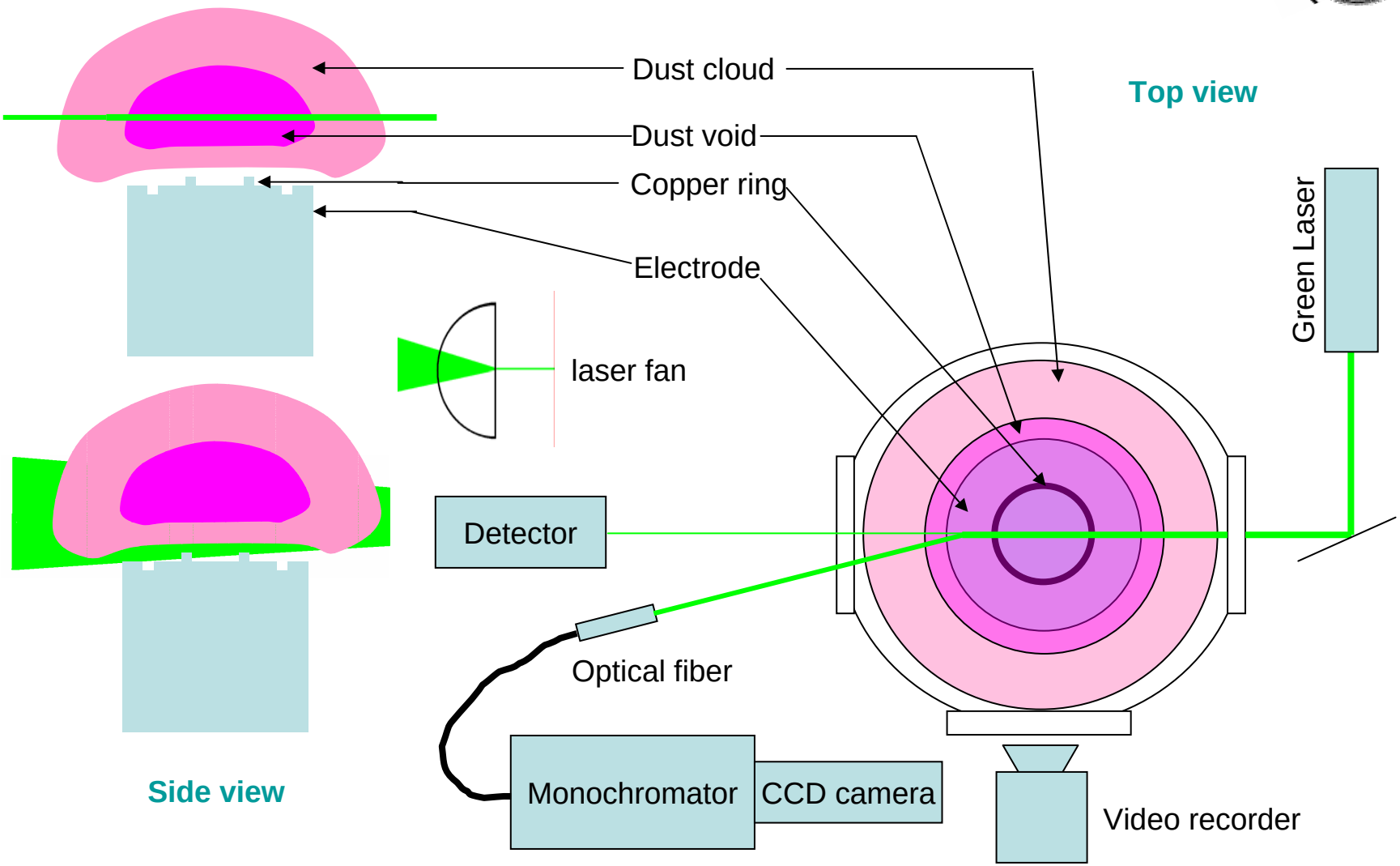
Experimental conditions:

p = 2 ... 20 Pa

P_{rf} = 5 - 50 W

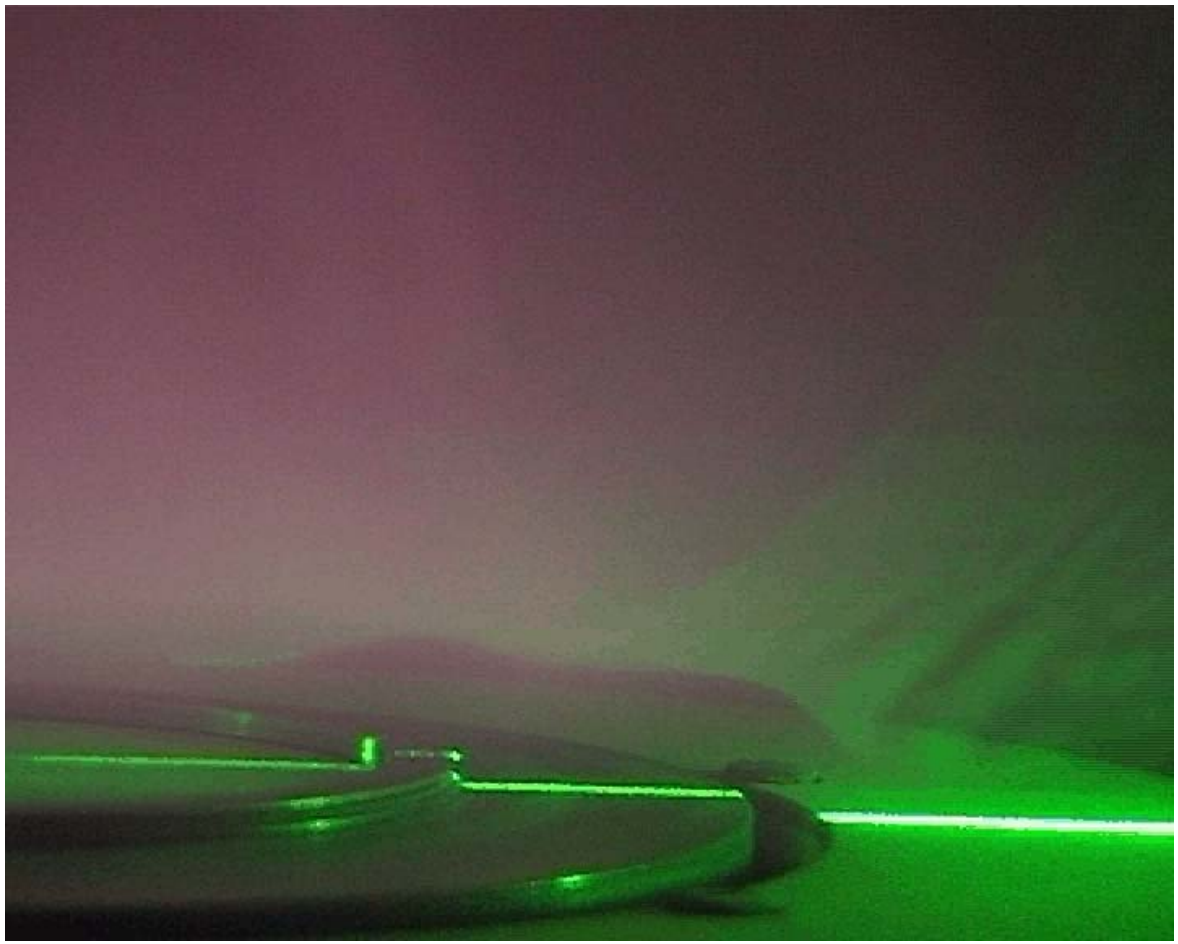
PULVA1. Scheme of the experimental setup.

Experimental Setup



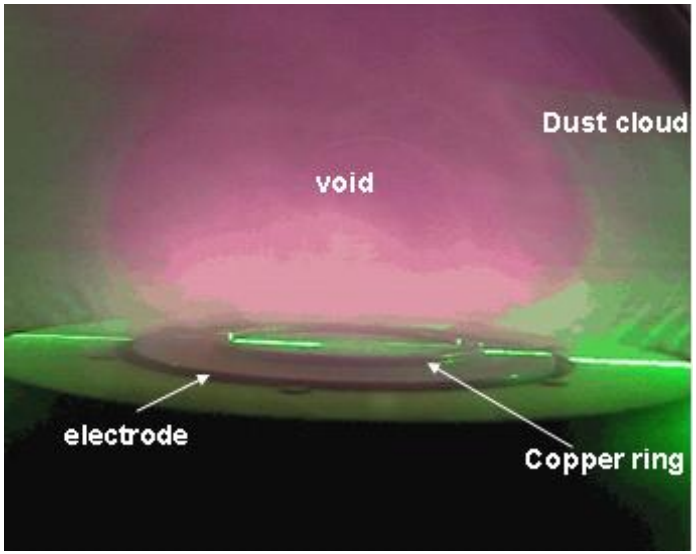
Scheme of *transmitted* and *scattered* laser detection setup

Results and discussion



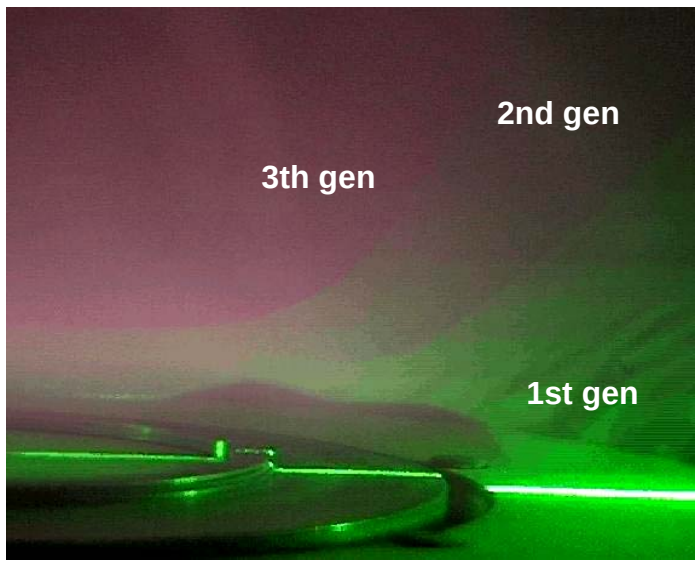
Multi-generations dynamics of dust growing in plasma

Results and discussion



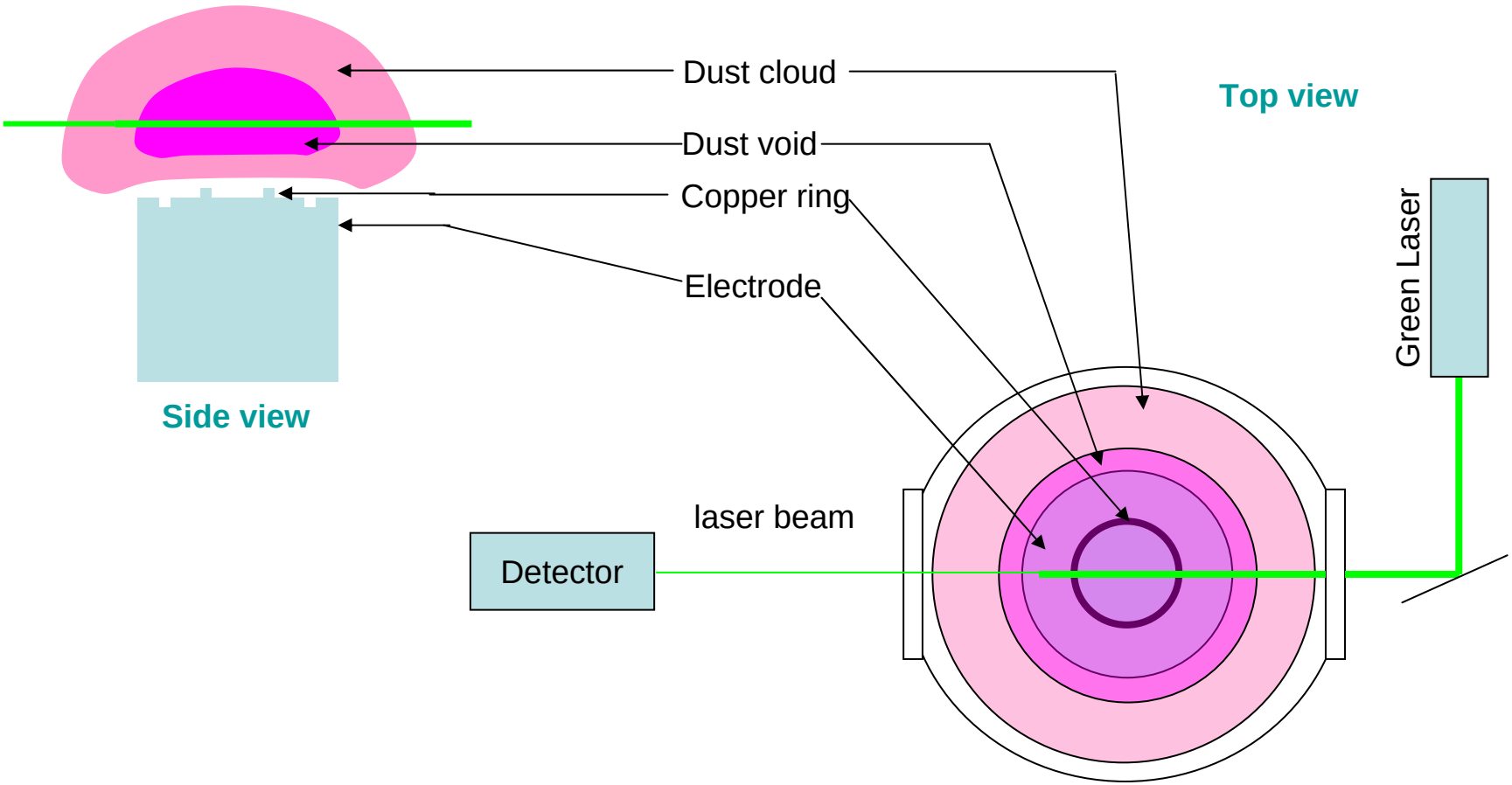
- **Particle formed effectively in Acetylene/Argon plasma.**
- **Particle‘s size is small enough to form 3D dust structure.**
- **And big enough to form dust void**

- **Particle are formed continuously in the dust void by subsequent generations**



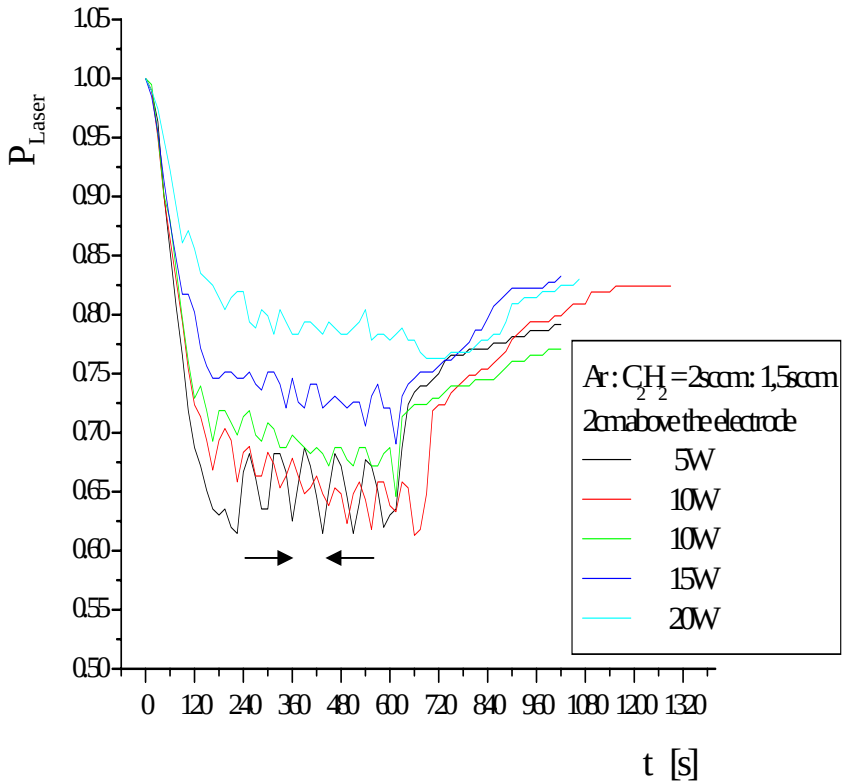
Movement of dust in plasma is dependent on the dust formation rate and plasma power

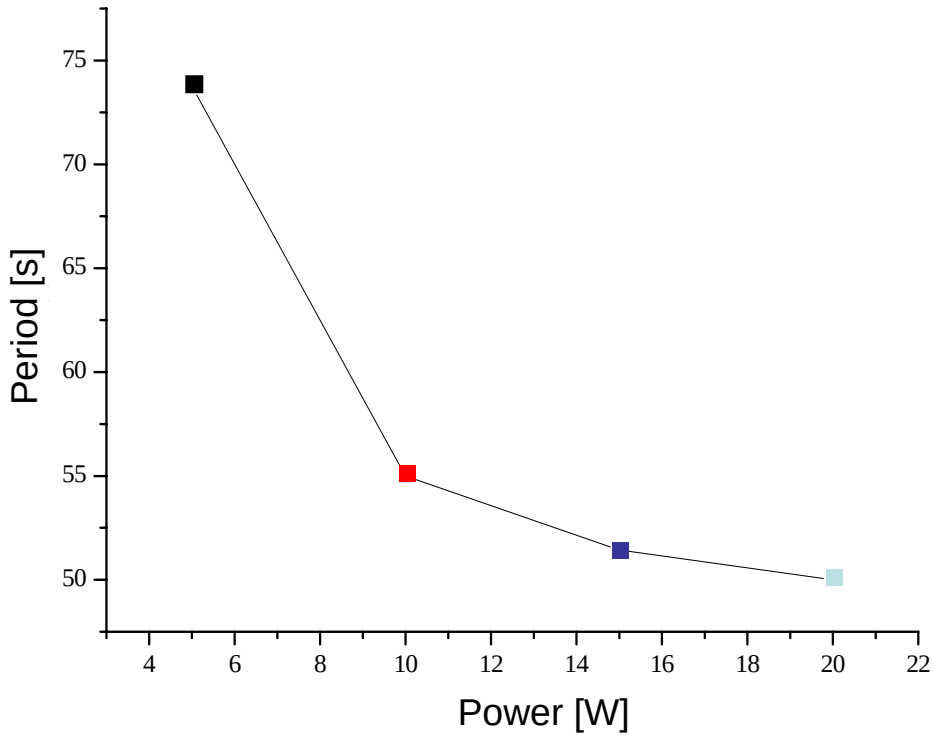
Results and discussion



Scheme of *transmitted* laser detection setup

Results and discussion

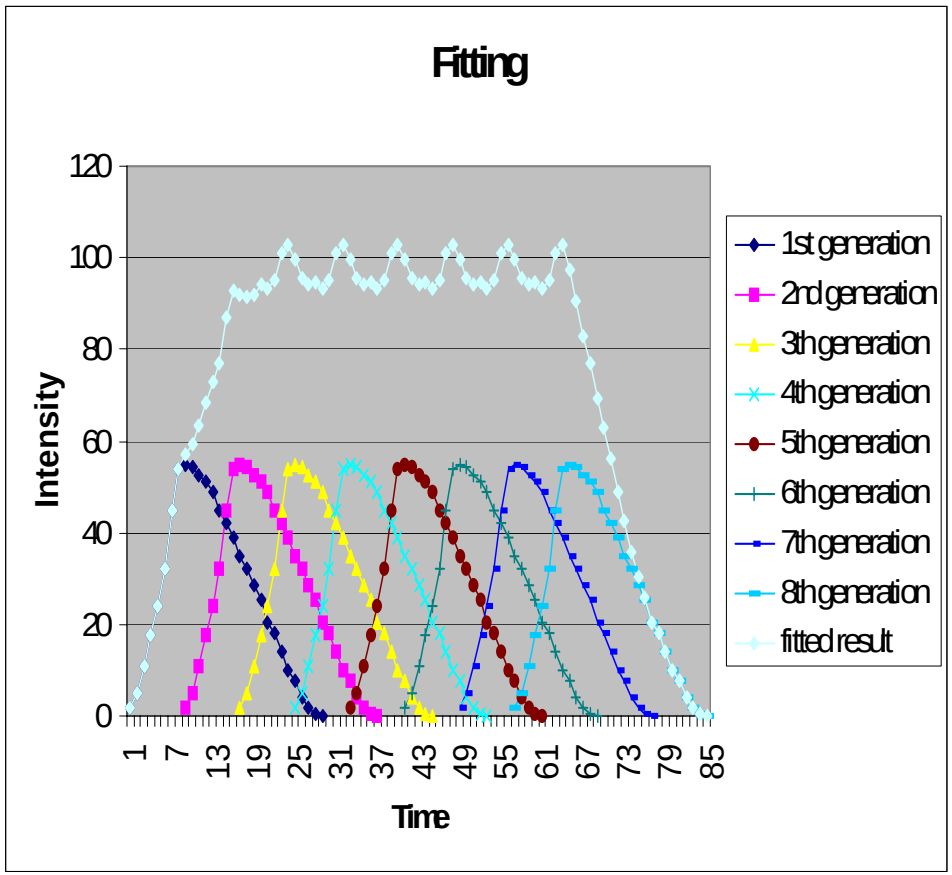


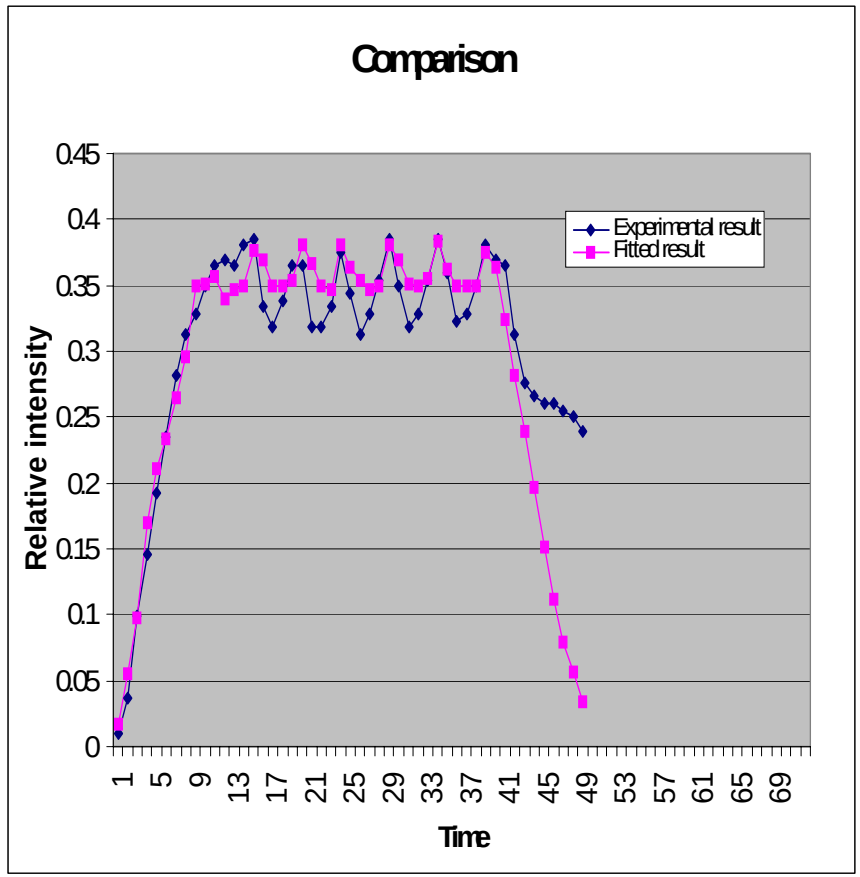


Transmitted laser intensity

Results and discussion

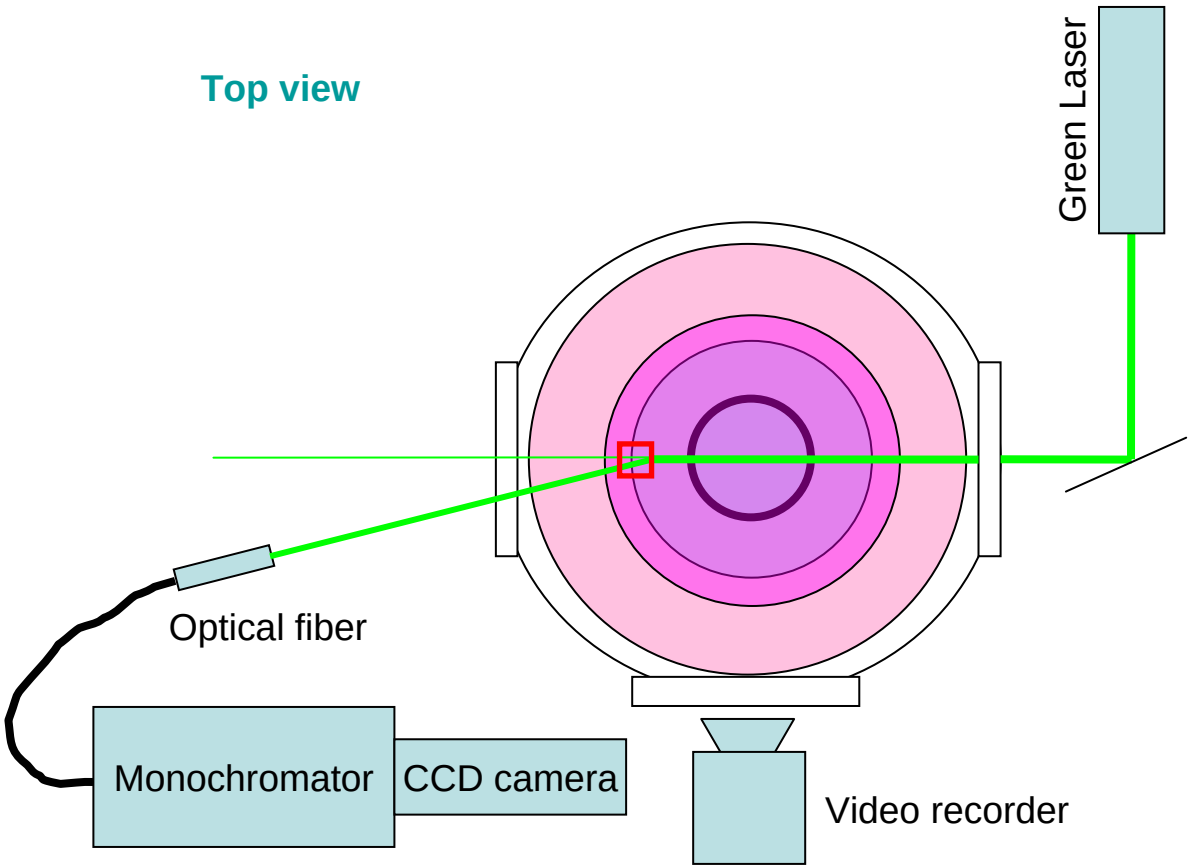
Simple assumption





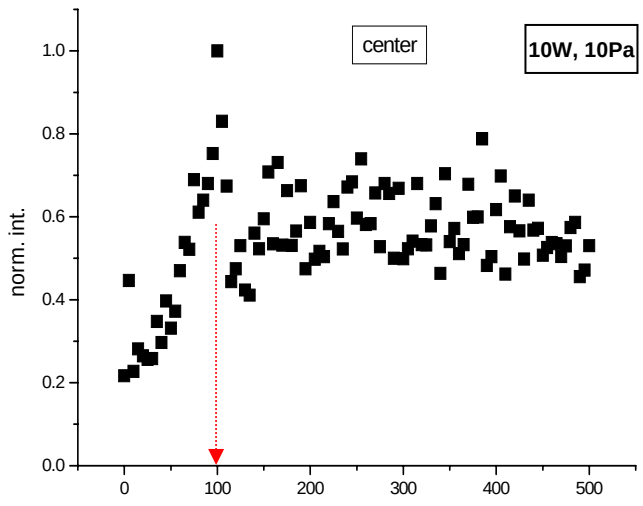
Fitting for transmitted laser experiment (5W)

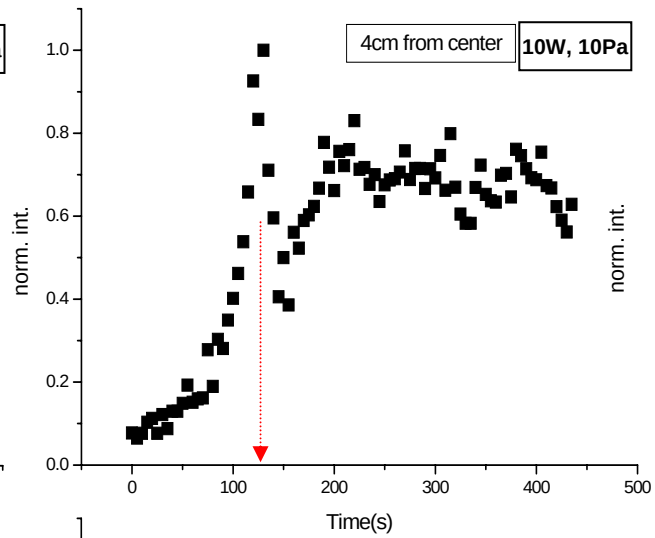
Results and discussion

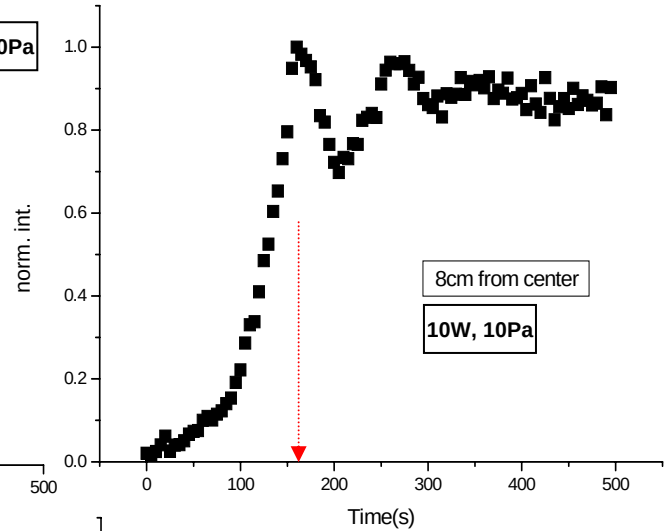


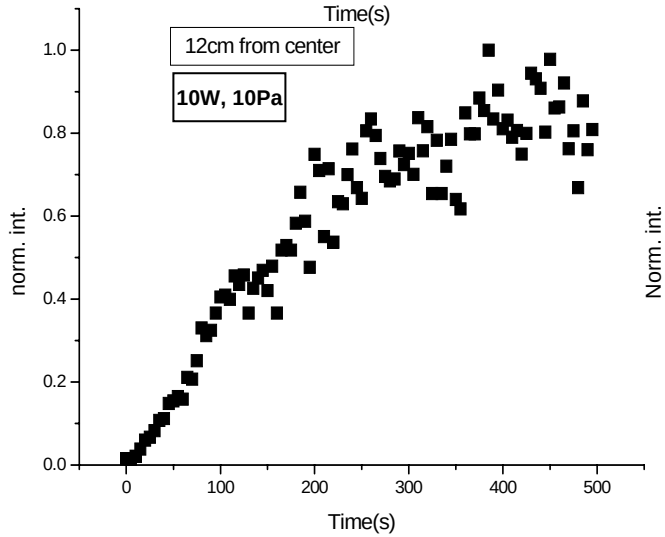
Schematic setup of *scattered* laser detection

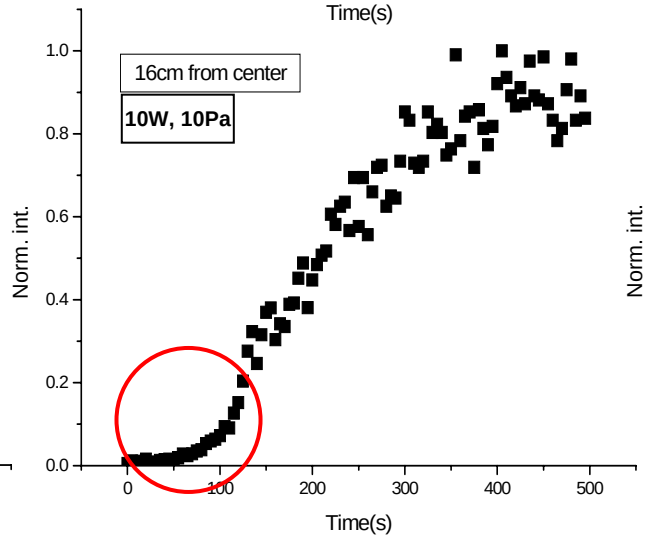
Scattered laser result

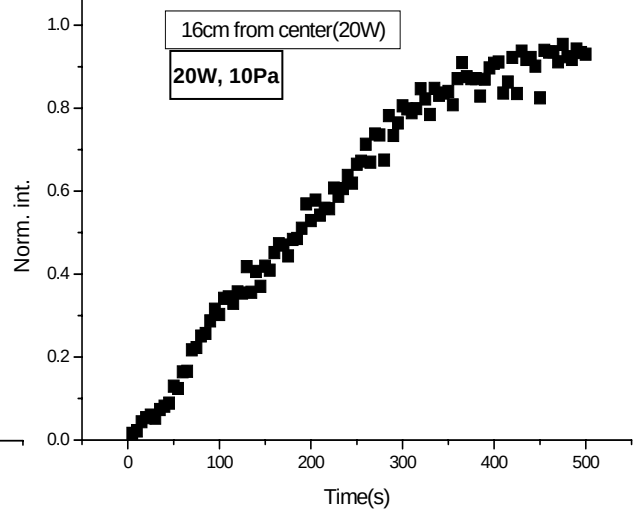






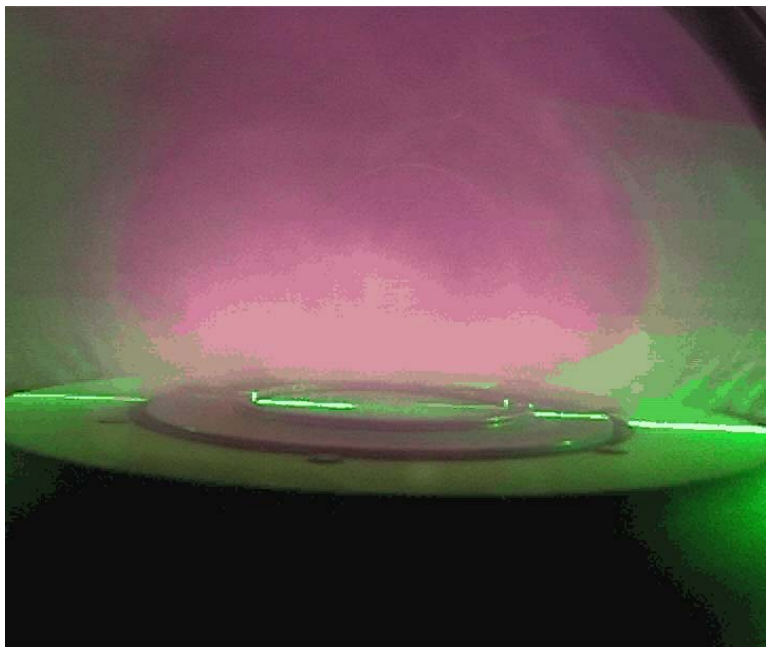




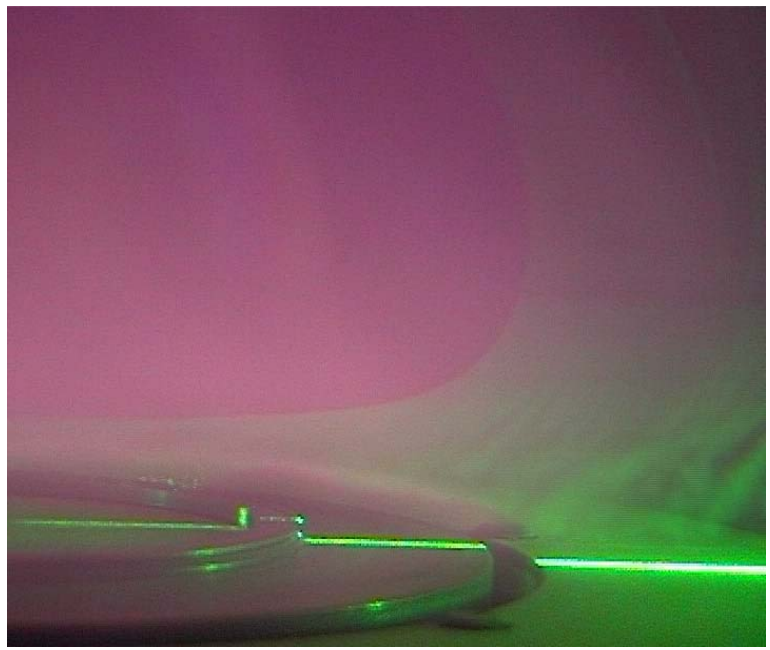


Results

Plasma power
10 ... 50W
Particles in Ar plasma



Plasma power 10W
Particle formtion in C_2H_2 /Ar plasma
1.5 / 4sccm



Due to Acetylene addition (e.g. particle formation)
the void boundary moves faster than
for increasing plasma power

Results

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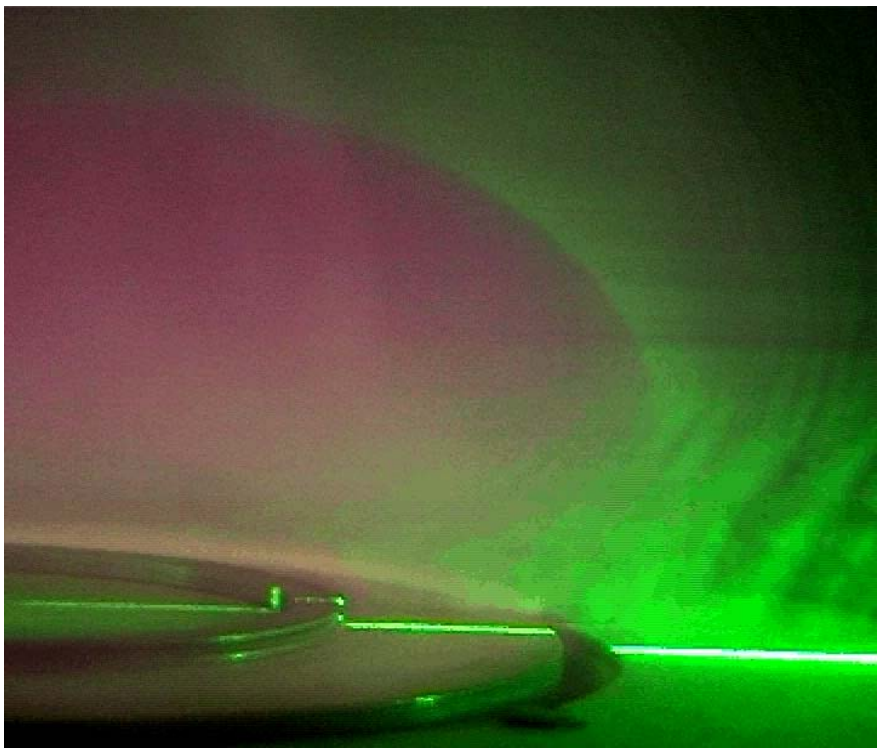
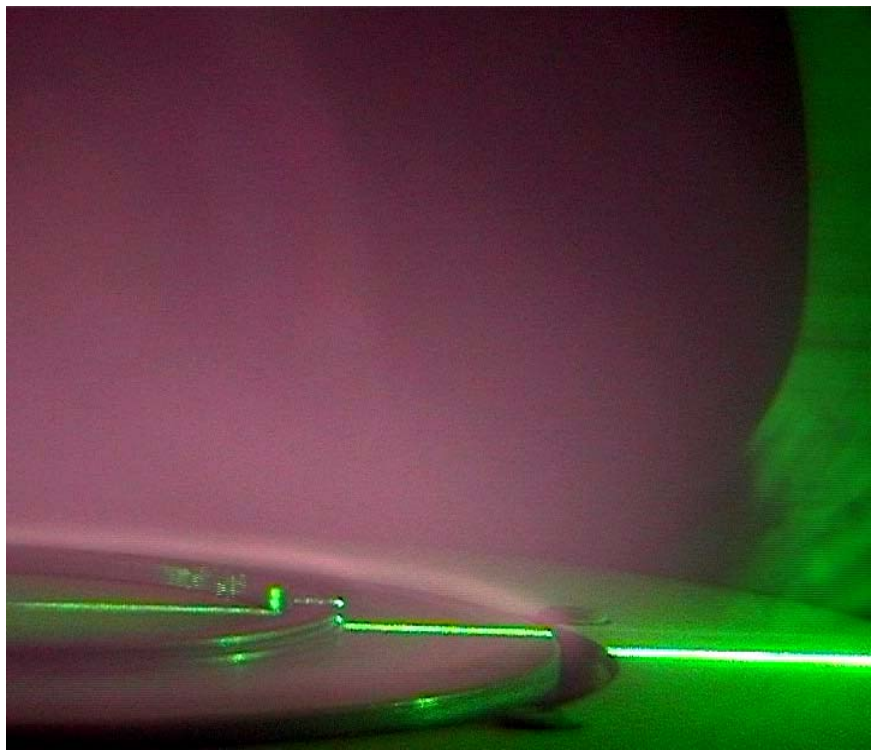
Wave phenomenon



Circulation



Wave phenomenon and circulation can also be observed

Summary & Outlook

- Dust void and 3D dust structure can be formed without micro-gravitational condition
- In Acetylene plasma the term „Dust void“ is only valid for each dust generation (with different sizes)
- The growing mechanism of dust cloud in the plasma is a multi-generation growing dynamics
- Wave phenomenon and circulation can also be observed in such condition

- Improvement of recording videos and images from plasma
- Quantitative investigation on wave phenomena, circulation and dust void dynamics
- Combination with other techniques: OES and Plasma monitor
- A good modeling which takes into account plasma parameters