

# HYPER-I

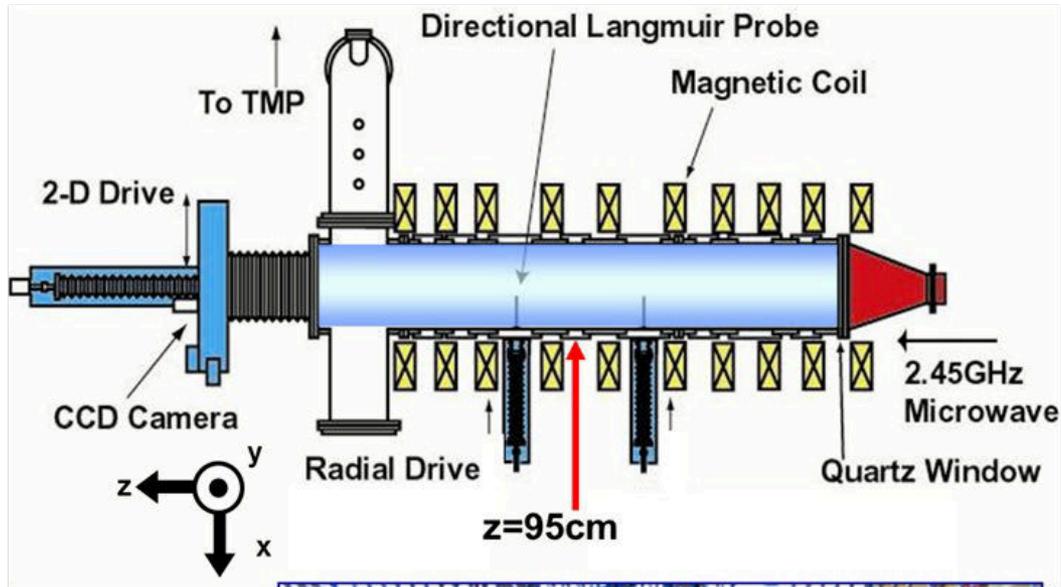
## および

# 大気圧プラズマ発生装置

高密度プラズマ物理研究系 吉村信次

# 大口径高密度プラズマ発生装置 (HYPER-I)

## The HYPER-I device ( High densitY Plasma ExpeRiment – I )



Plasma production:

**Electron Cyclotron Resonance**

Size:  $\phi 30\text{cm} \times 200\text{cm}$

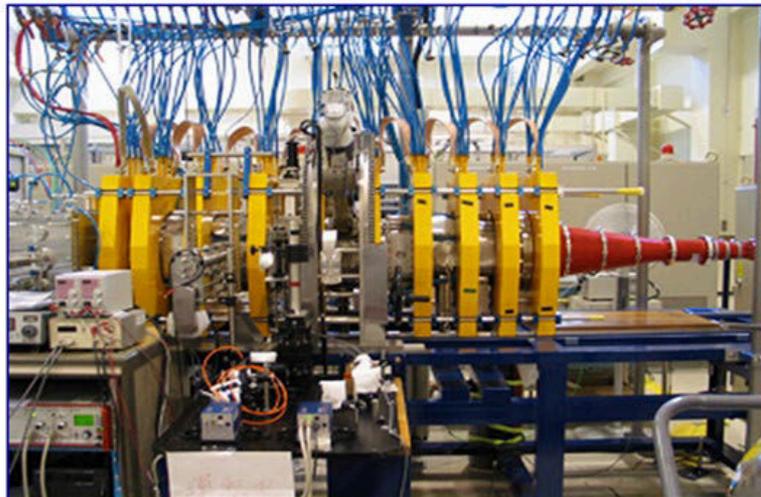
Microwave : 2.45GHz

Input power: up to 80 kW

Magnetic field:  $\sim 0.1\text{T}$

Gas pressure: 0.01 Pa - 3 Pa

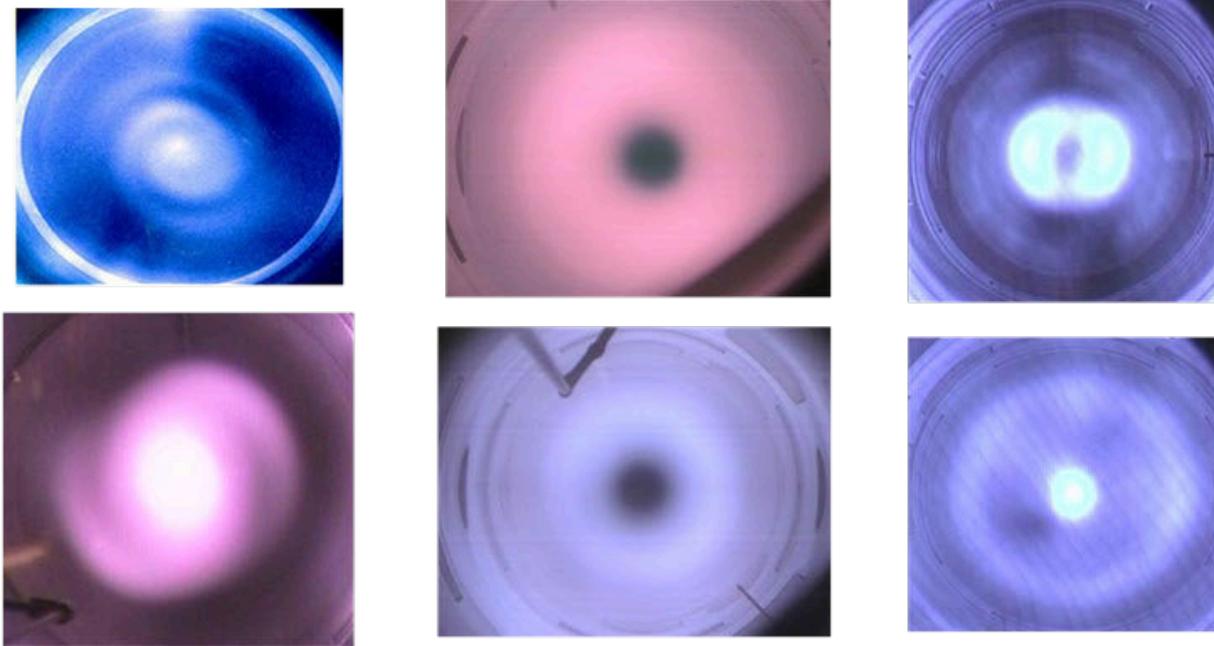
(He, Ne, Ar, Xe, H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub> ...)



多数のポートが使用できる、計測のフレキシビリティが特長

様々な構造が自発的に形成される

## Various Plasma Structures in the HYPER-I Plasmas



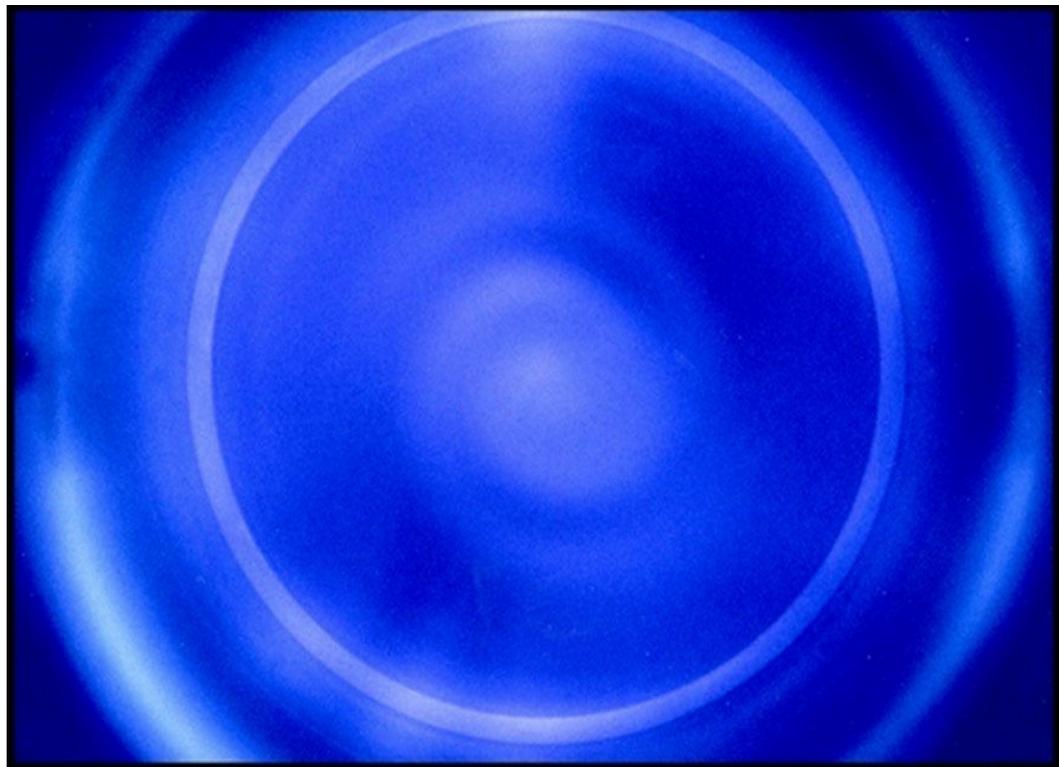
M. Kono and M. Y. Tanaka, Phys. Rev. Lett. 84 (2000) 4369.

K. Nagaoka, A. Okamoto, S. Yoshimura, M. Kono and M. Y. Tanaka, Phys. Rev. Lett. 89 (2002) 075001.

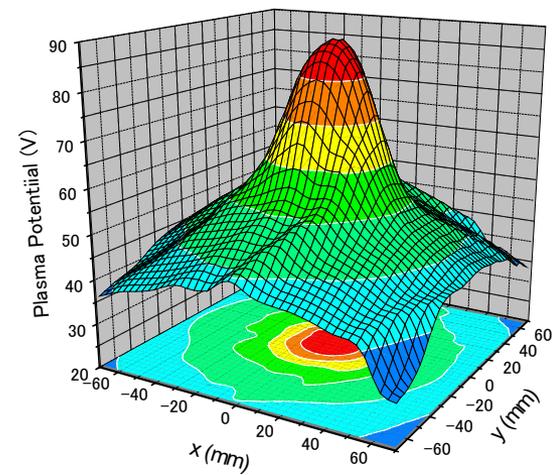
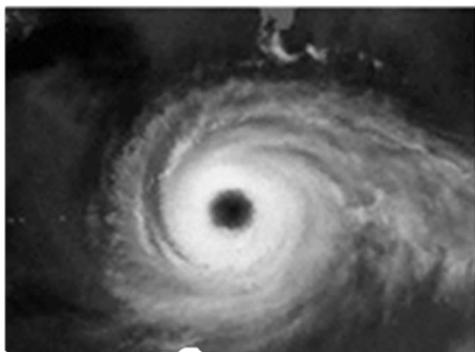
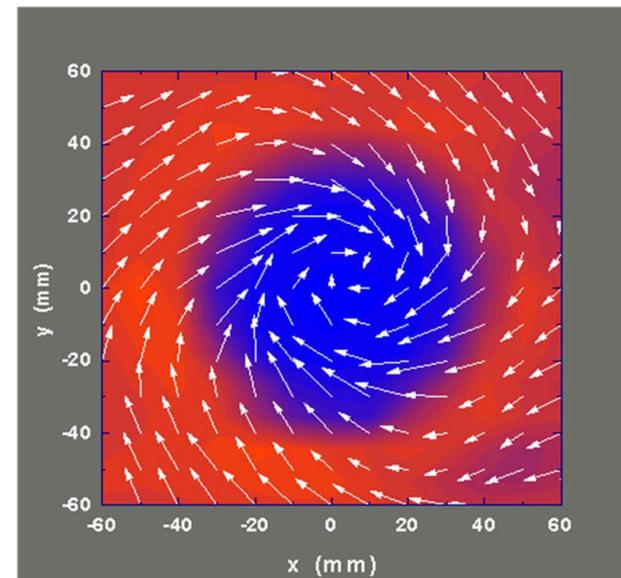
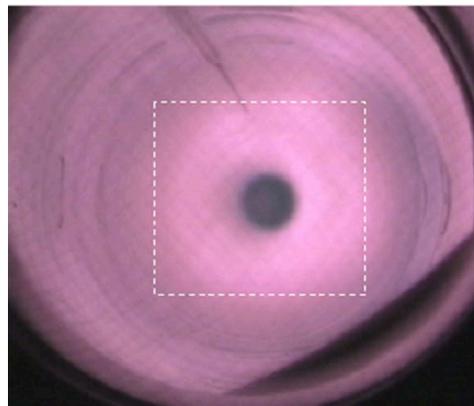
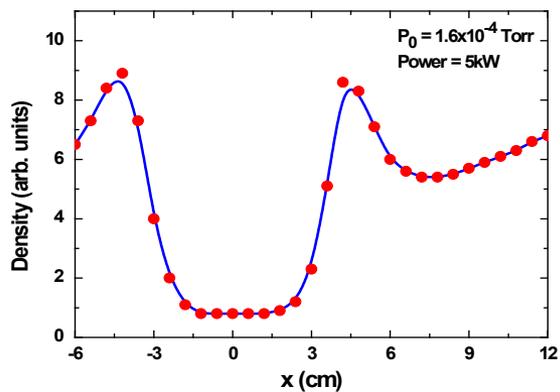
A. Okamoto, K. Hara, K. Nagaoka, S. Yoshimura, J. Vranjes, M. Kono and M. Y. Tanaka, Phys. Plasmas 10 (2003) 2211.

J. Vranjes, A. Okamoto, S. Yoshimura, S. Poedts, M. Kono and M. Y. Tanaka, Phys. Rev. Lett. 89 (2002) 265002.

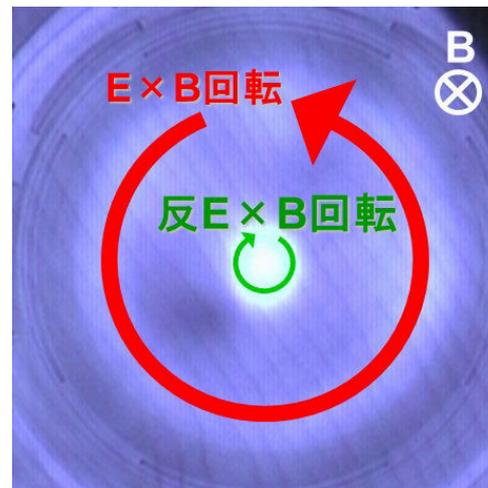
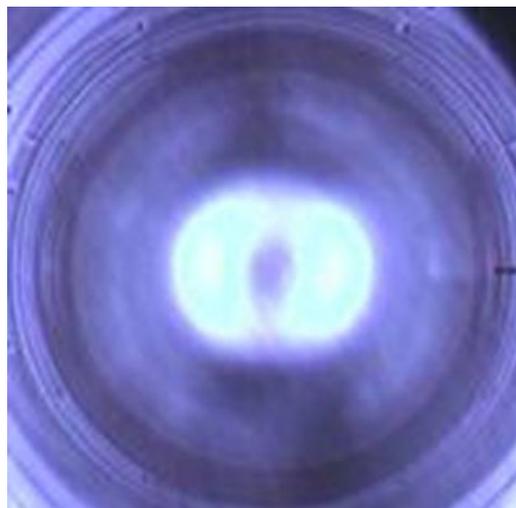
スパイラル渦 回転するプラズマの不安定性がつくる渦



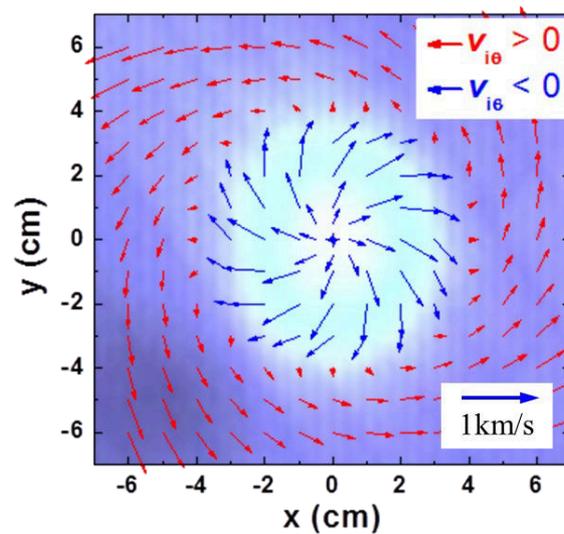
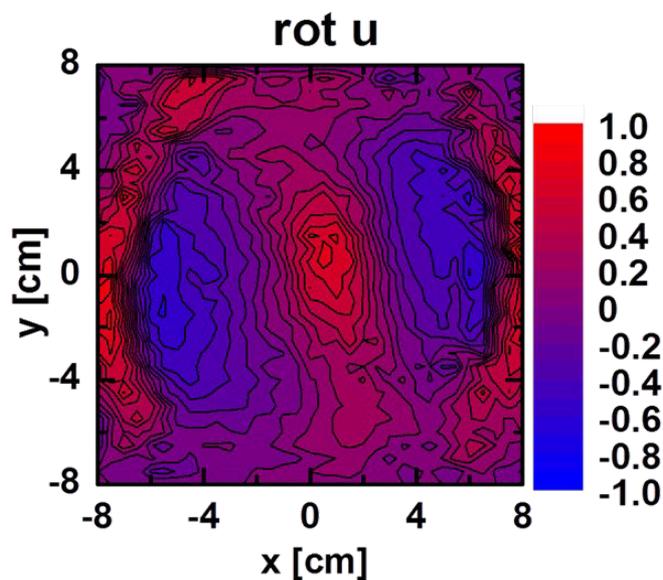
# プラズマホール 異常粘性のつくる渦、プラズマ台風



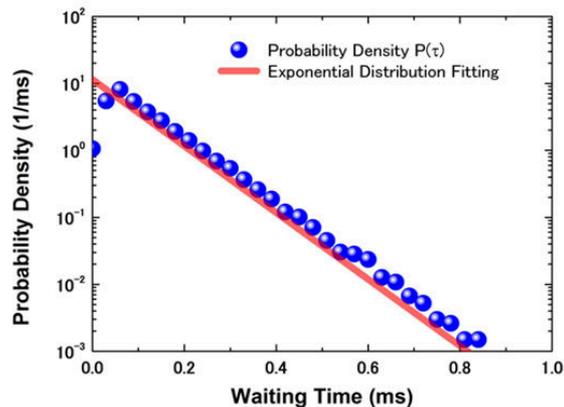
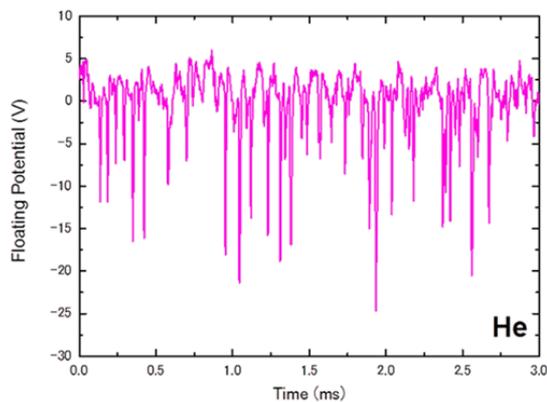
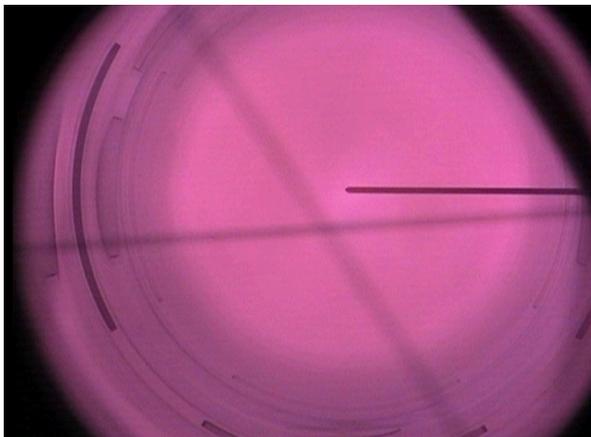
# 三極渦, 単極渦 中性粒子との相互作用がつくる渦



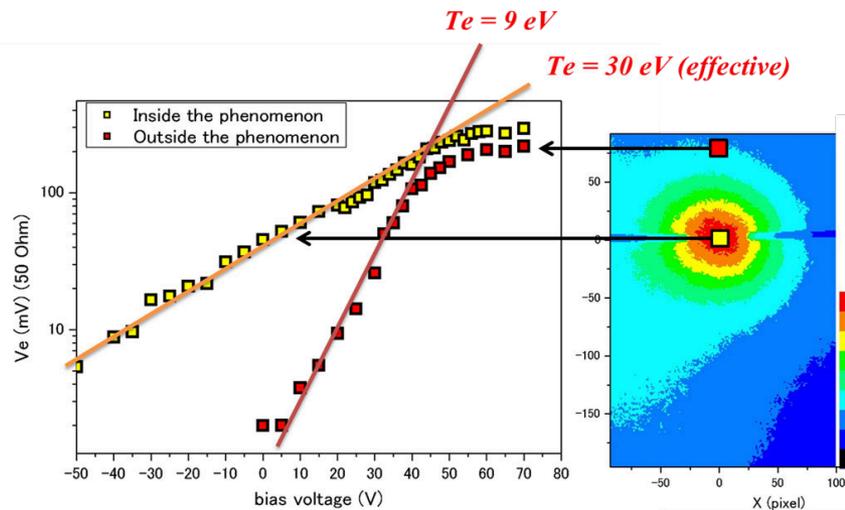
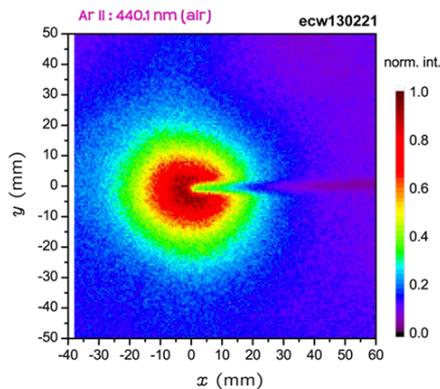
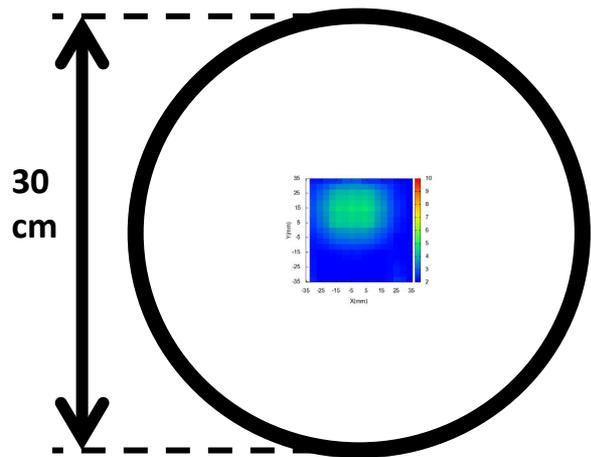
単極渦構造



# 熱的不安定性？による 間欠的高温電子バブルの発生



Waiting Time 指数分布  $\rightarrow$  定常ポアソン過程



# 中性ガス圧を変化させることで様々な現象が観測される

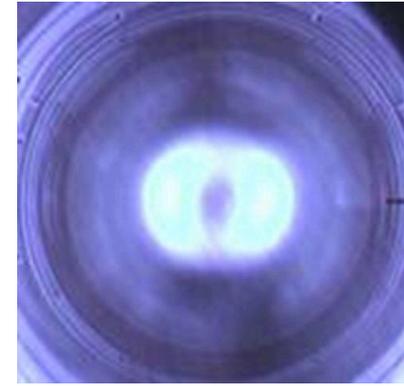
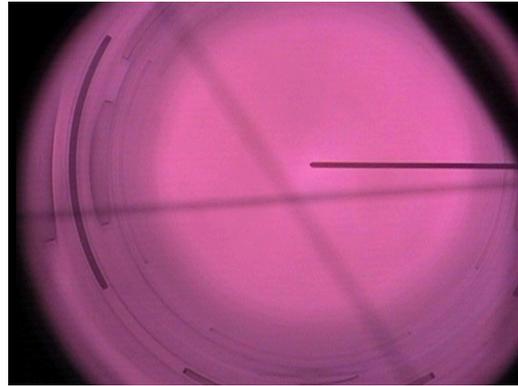
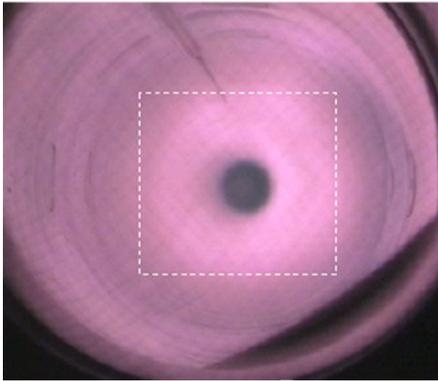
0.1 mTorr



1 mTorr



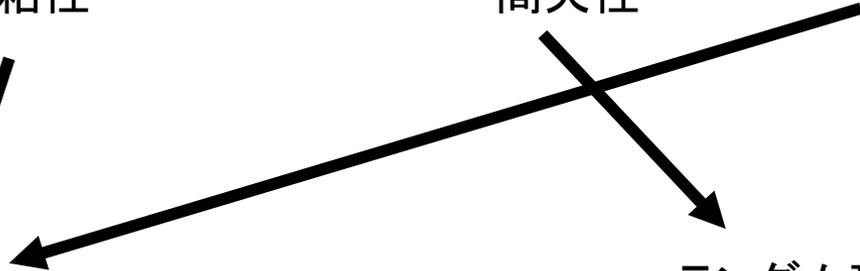
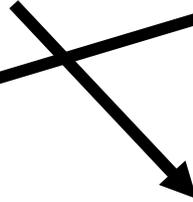
10 mTorr



異常粘性

間欠性

中性粒子との相互作用



流れ場の計測が重要

ランダム現象の観測、統計解析



先進レーザー計測

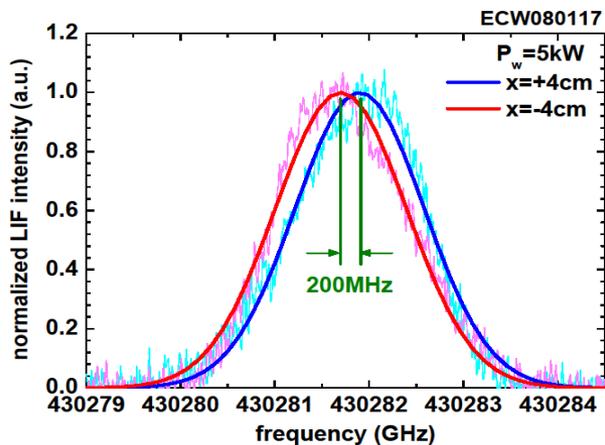
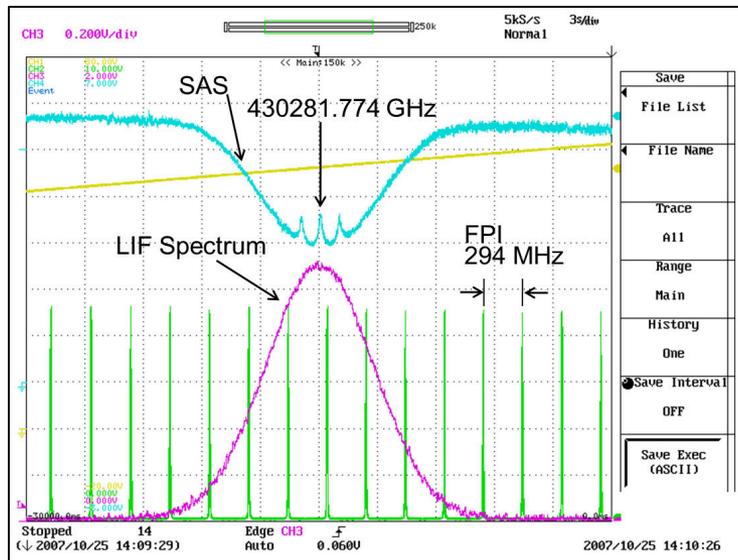


予測は可能か？

# 先進レーザー計測

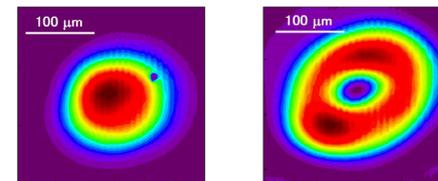
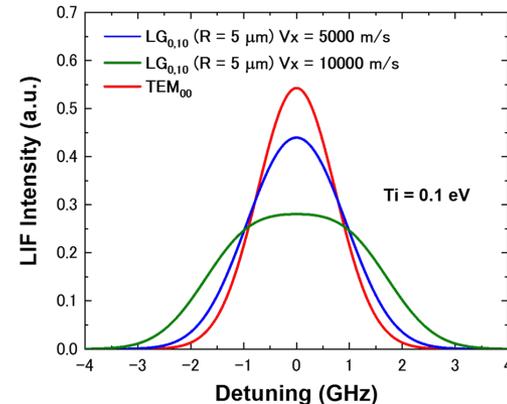
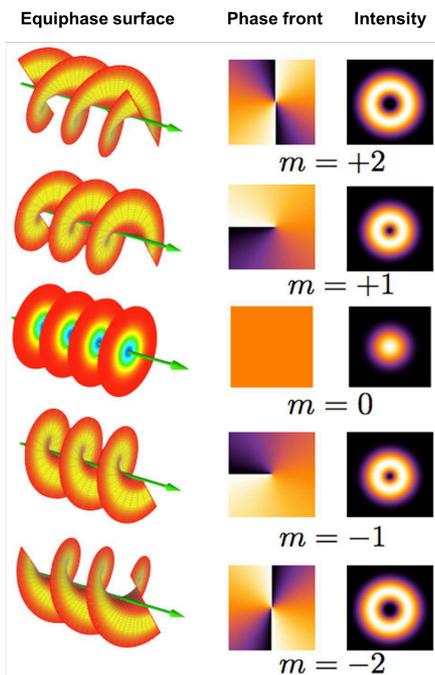
## 飽和吸収分光+レーザー誘起蛍光法

数m/s の遅い中性粒子流れの計測



## 光渦レーザー誘起蛍光法

光路に垂直な流れのドップラー計測



(From [http://en.wikipedia.org/wiki/File:Helix\\_oam.png](http://en.wikipedia.org/wiki/File:Helix_oam.png))

$$\delta_{LG} = \left[ -k + \frac{kr^2}{2(z^2 + z_R^2)} \left( \frac{2z^2}{z^2 + z_R^2} - 1 \right) - \frac{(2p + l + 1)z_R}{z^2 + z_R^2} \right] V_z$$

Axial

$$- \left( \frac{kr}{z} \right) V_r - \left( \frac{l}{r} \right) V_\phi \approx -kV_z - \left( \frac{l}{r} \right) V_\phi$$

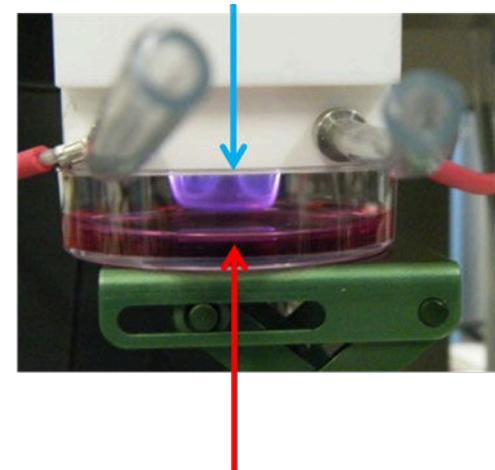
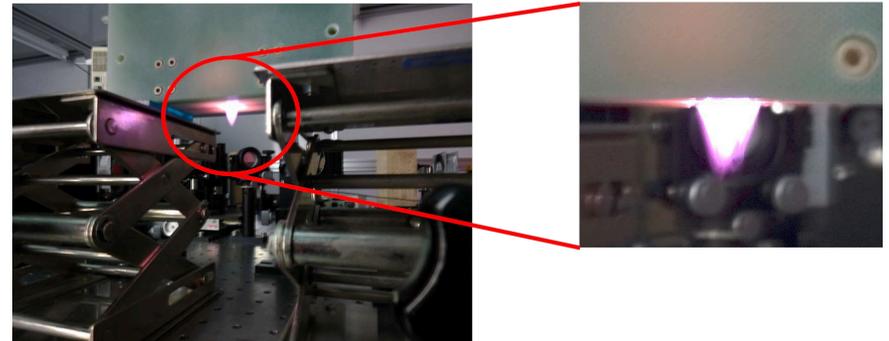
Radial      Azimuthal

# プラズマバイオ研究のための大気圧プラズマ源

ペン型大気圧プラズマジェット装置

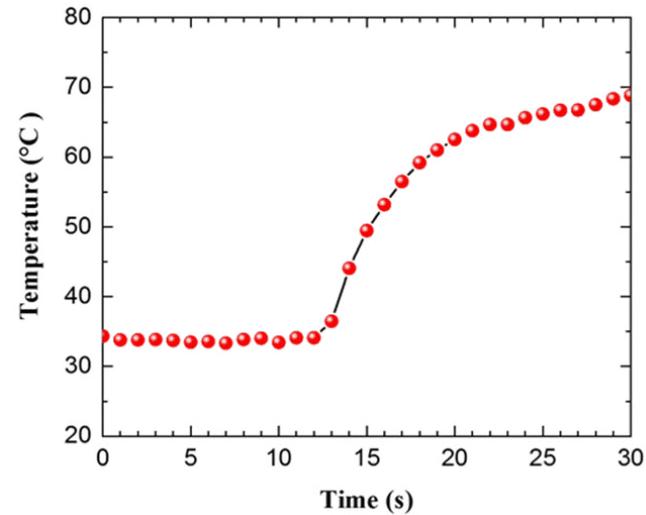
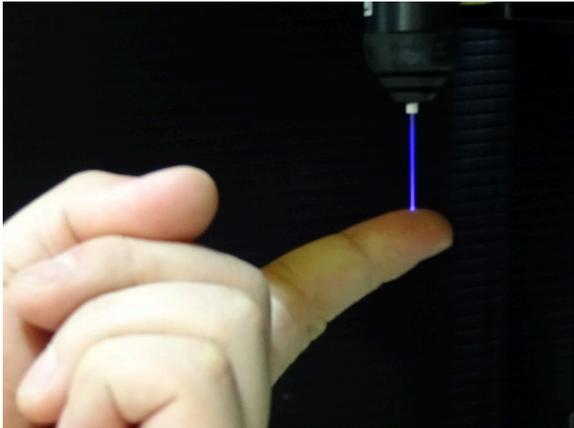


ワイドストライプ型高密度室温大気圧プラズマ装置

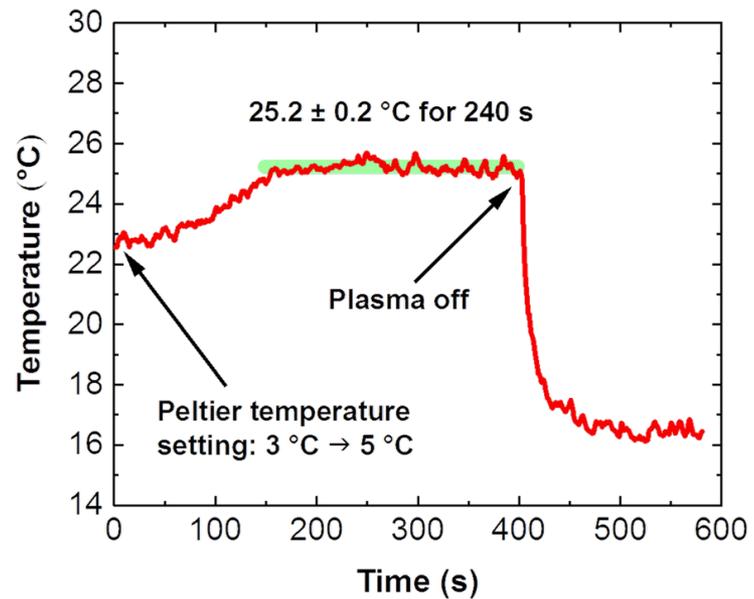
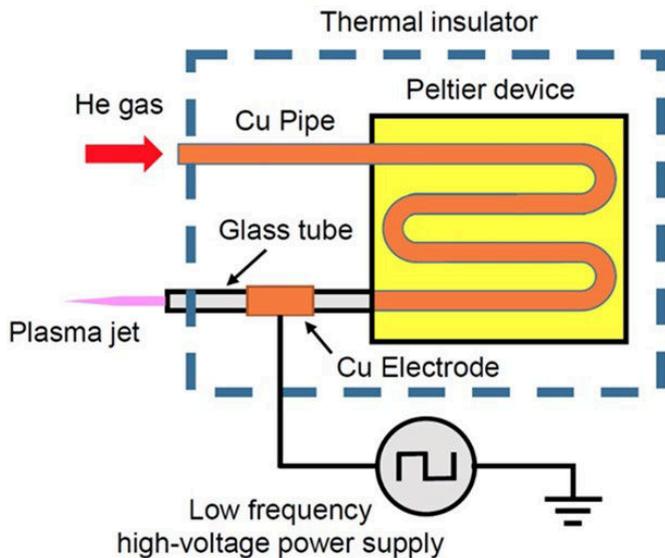


プラズマ活性培養液  
Plasma-activated medium (PAM)

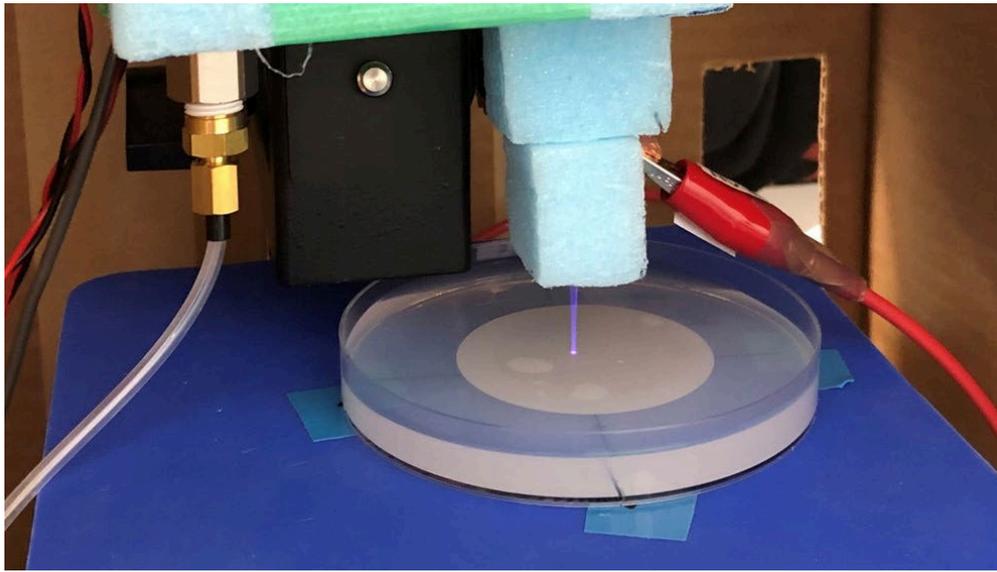
ただし、ペン型ジェットは時間とともに温度が70°C以上まで上昇する



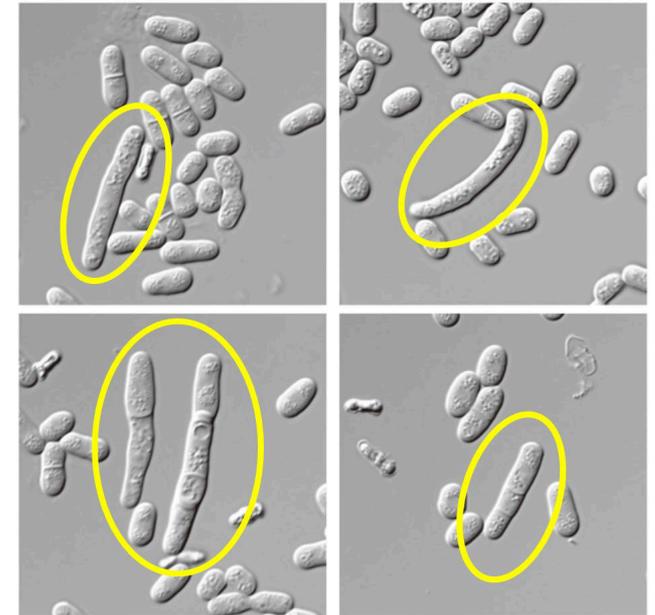
そのため、ペルチェ素子を用いてガスを冷却するジェットを自作した



# 生体（分裂酵母細胞）への大気圧プラズマジェット照射

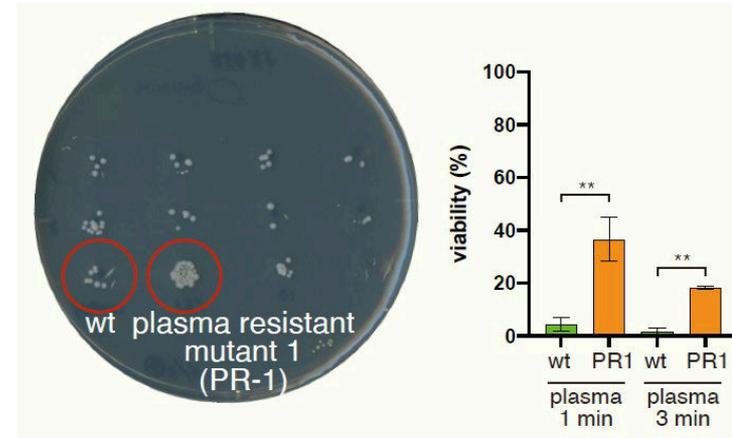
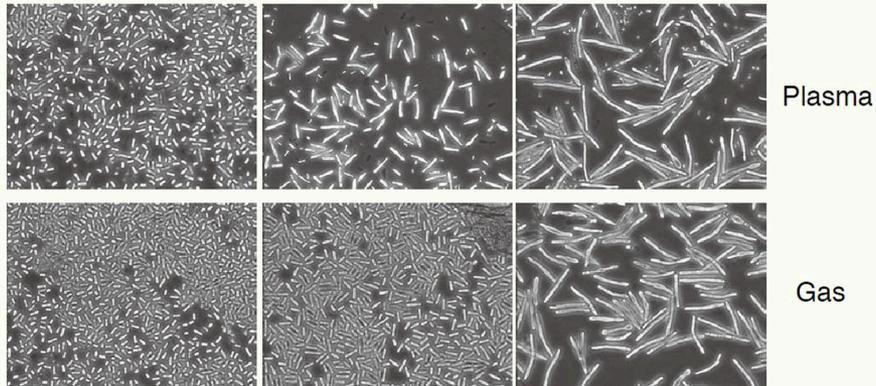


plasma 1 min, 2cm, 3L / min - proximal

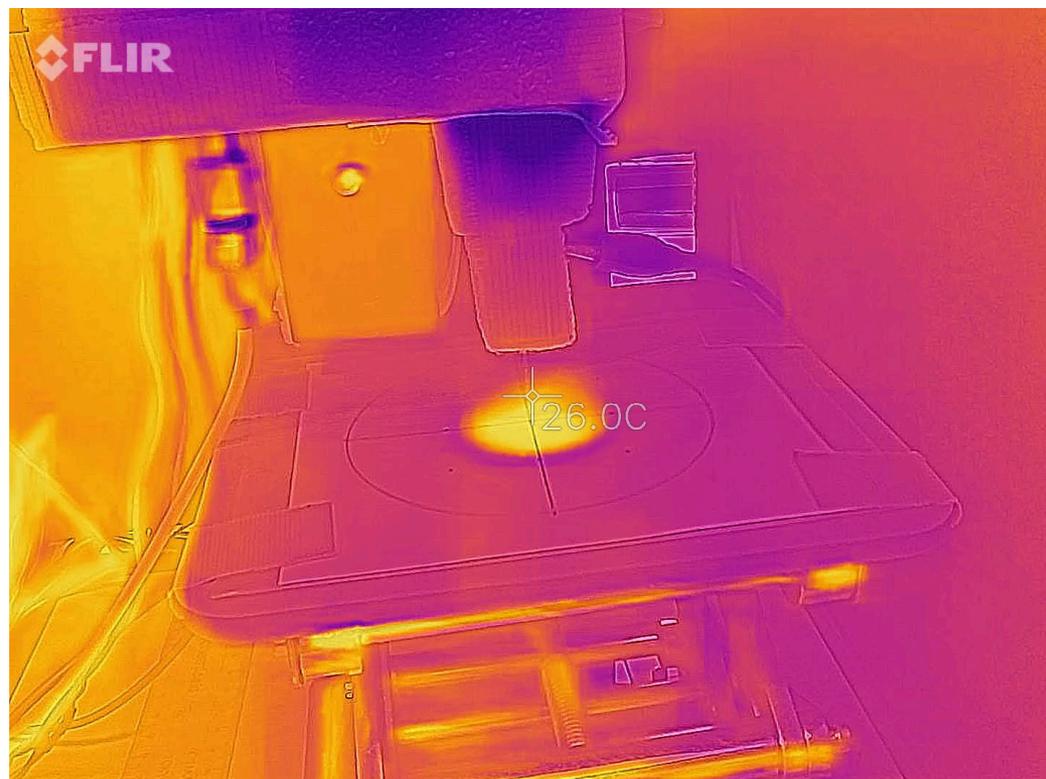
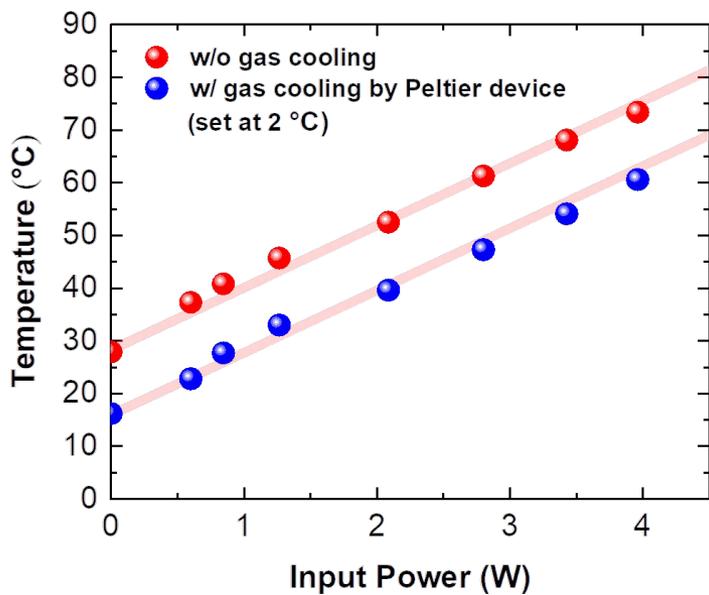
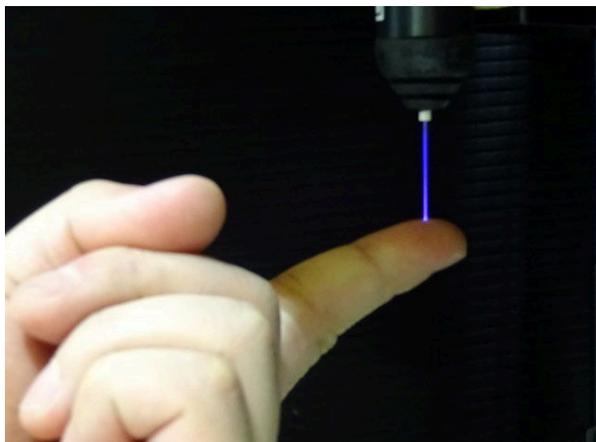


10 μm

allowable ← → restrictive  
32°C                      34°C                      36°C



## 照射時の温度が重要



これって本当？非平衡定常状態ならあり得る  
蒸発熱を考慮に入れる必要？