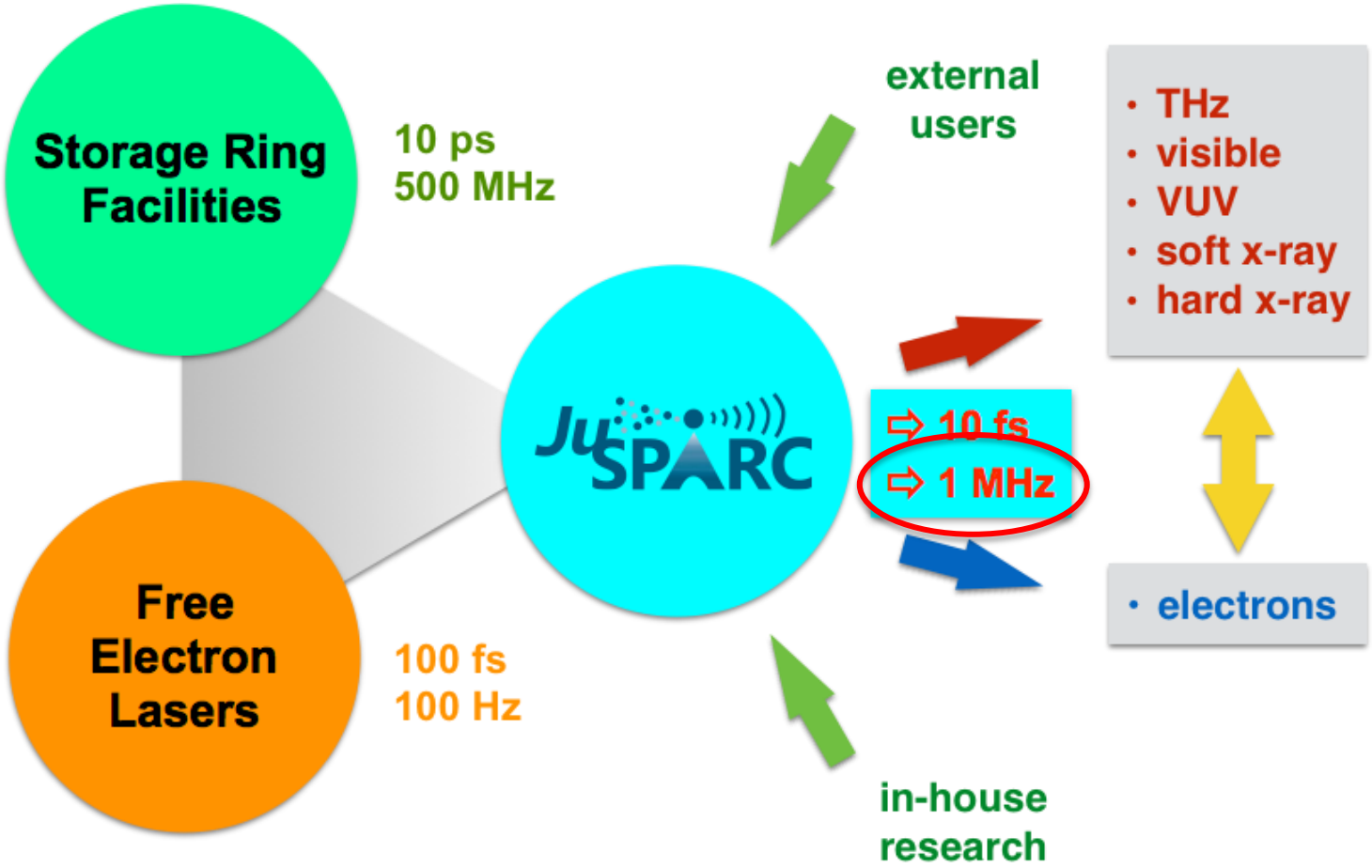
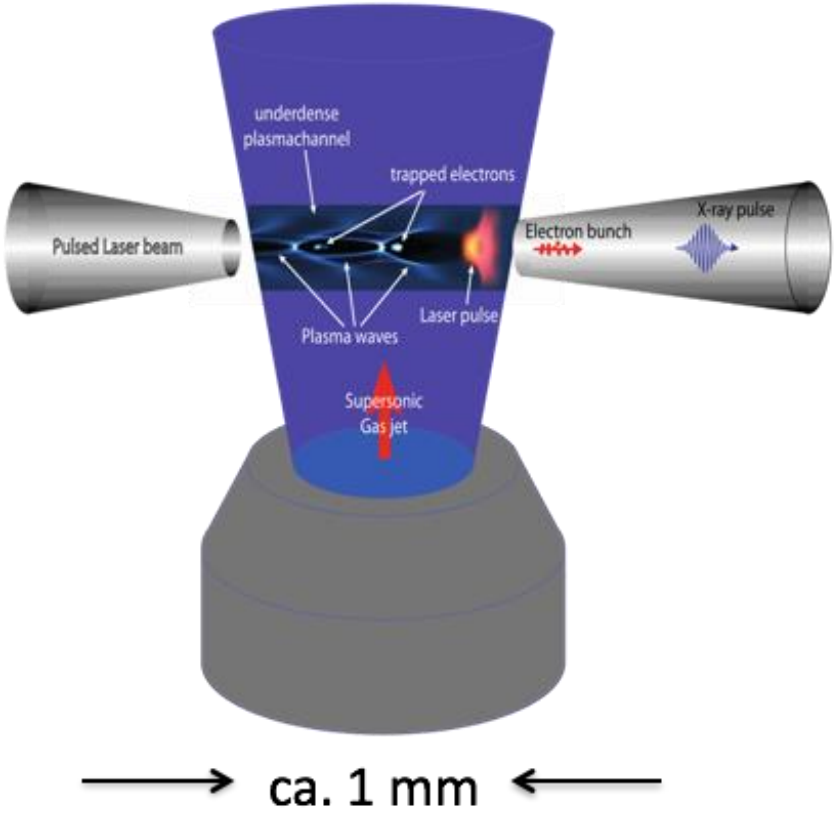
Cryogenic and Polarized Targets for kHz to MHz Laser-repetition Rates

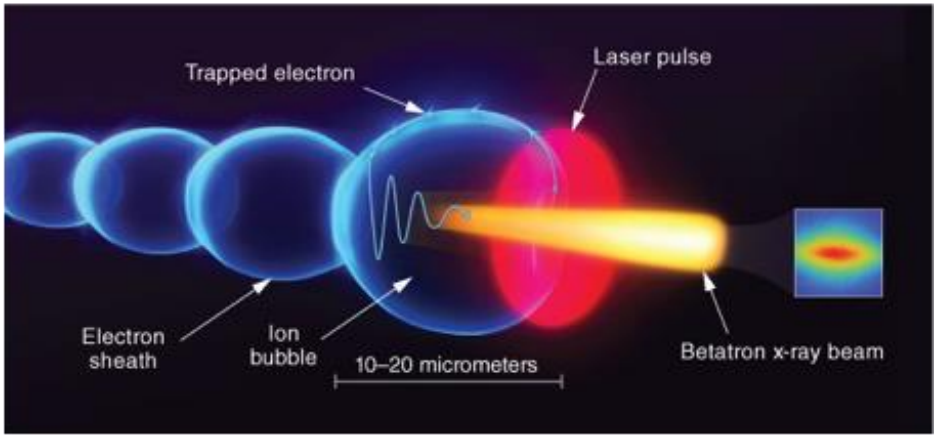
30 Aug. 2016 | Markus Büscher

*Ju*SPARC: third pillar in photon landscape



keV x-rays: Betatron radiation

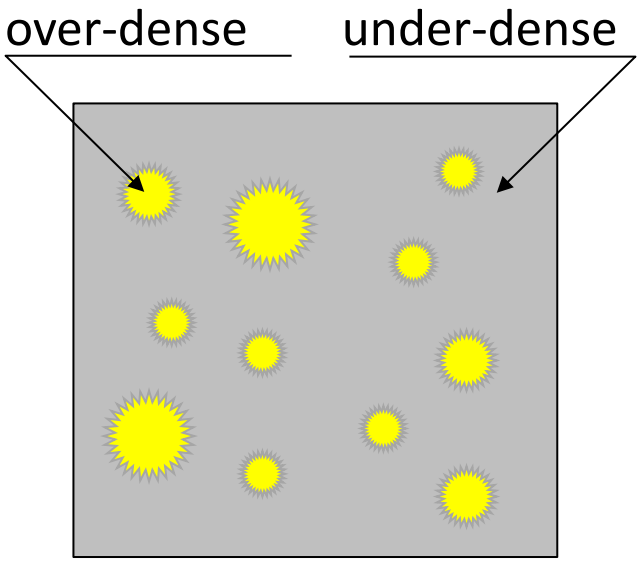




https://str.llnl.gov/january-2014/albert

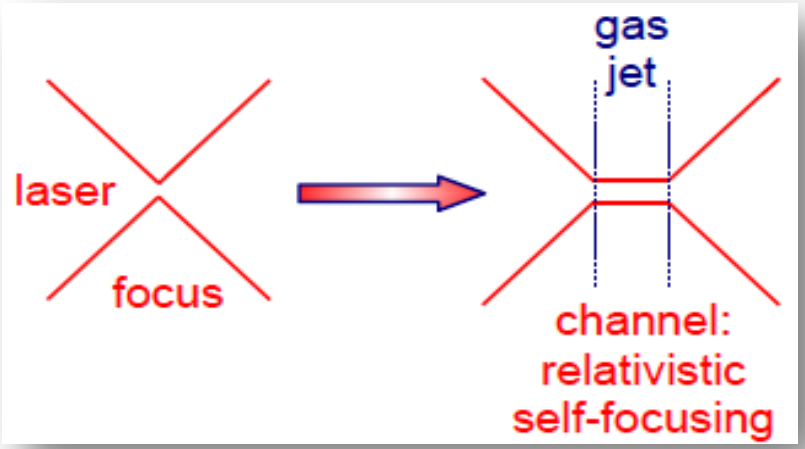
Source size ca. 1 µm !

Target concept: Cluster-gas mixtures

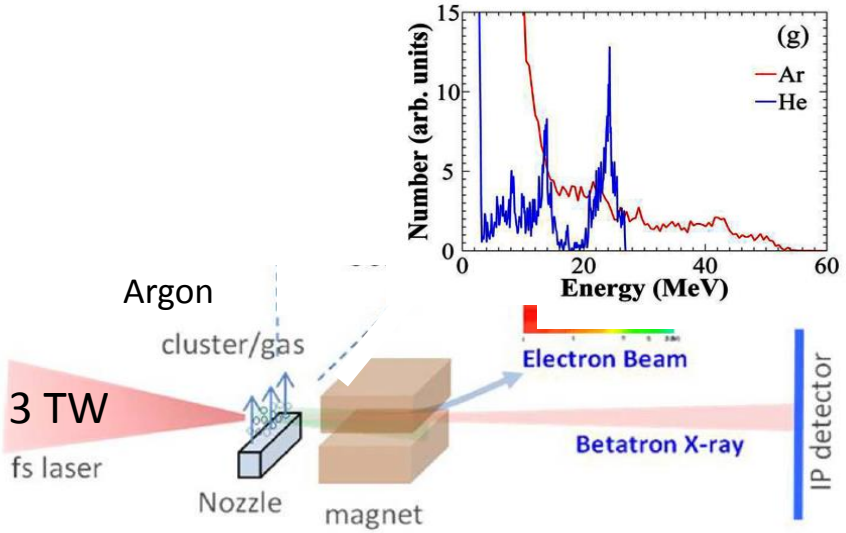


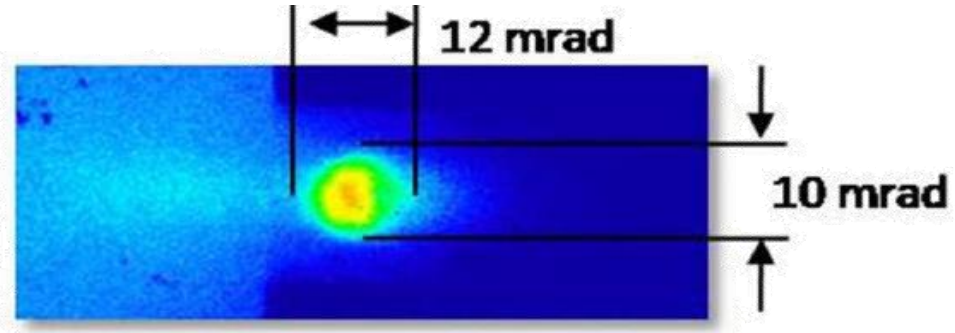
- gas-jet density: 10^{19} /cm^3
- cluster radius: up to few 100 nm
- in (10 µm)^3: 1 – 10 cluster

➥ gas target with localized density enhancement



Synchrotron radiation from cluster/gas targets





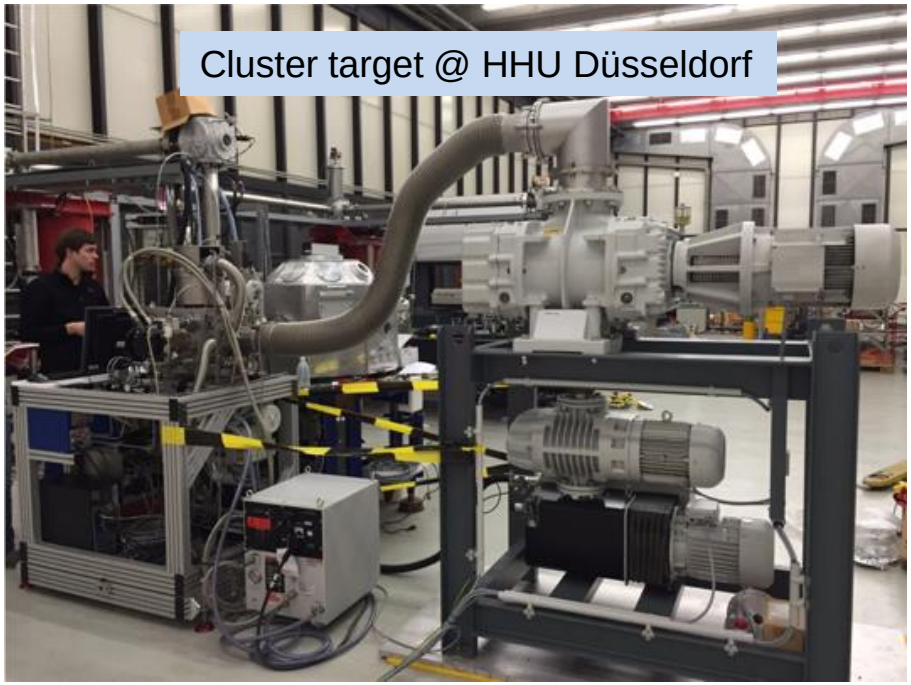
$2 \cdot 10^8$ photons (>2.4 keV) per shot

$5 \cdot 10^{21}$ photons/s/mm^2/mrad^2/0.1%BW

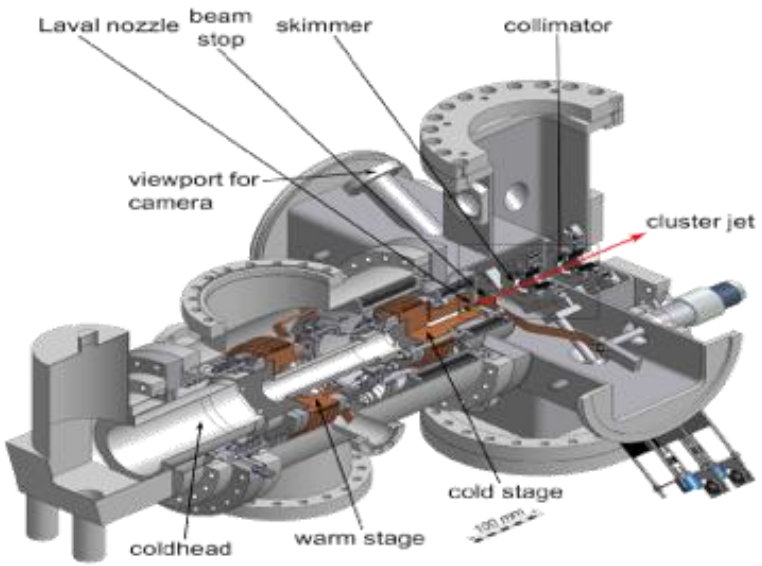
10-fold enhancement compared to gas target

L. M. Chen et al., Scientific Reports | 3 : 1912 | DOI: 10.1038/srep01912

Cryogenic cluster-jet target (WWU Münster)

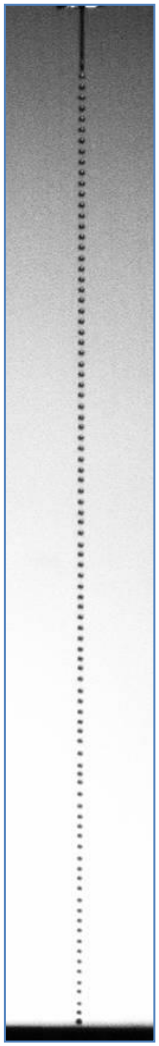


- H_2, D_2 (N_2, Ar, Xe) cluster
- temperature ~20 K
- up to 10^6 molecules/cluster
- cluster jet density: 10^{15} atoms/cm^2
- 'No' background gas



A.Täschner - http://arxiv.org/abs/1108.2653

Frozen-pellet target (FZJ, ITEP Moscow)



Frozen pellets ∅ ~ 20 µm

H_2, D_2, N_2, Ar, Kr, Xe

Pellet velocity ~80 m/s

Pellet beam Ø < 1 mm

<u>Pellet rate up to 100 kHz</u>

A. Boukharov, MB et al., Phys. Rev. Lett. **100**, 174505 (2008)

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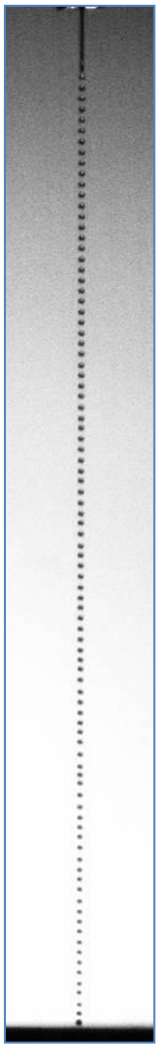

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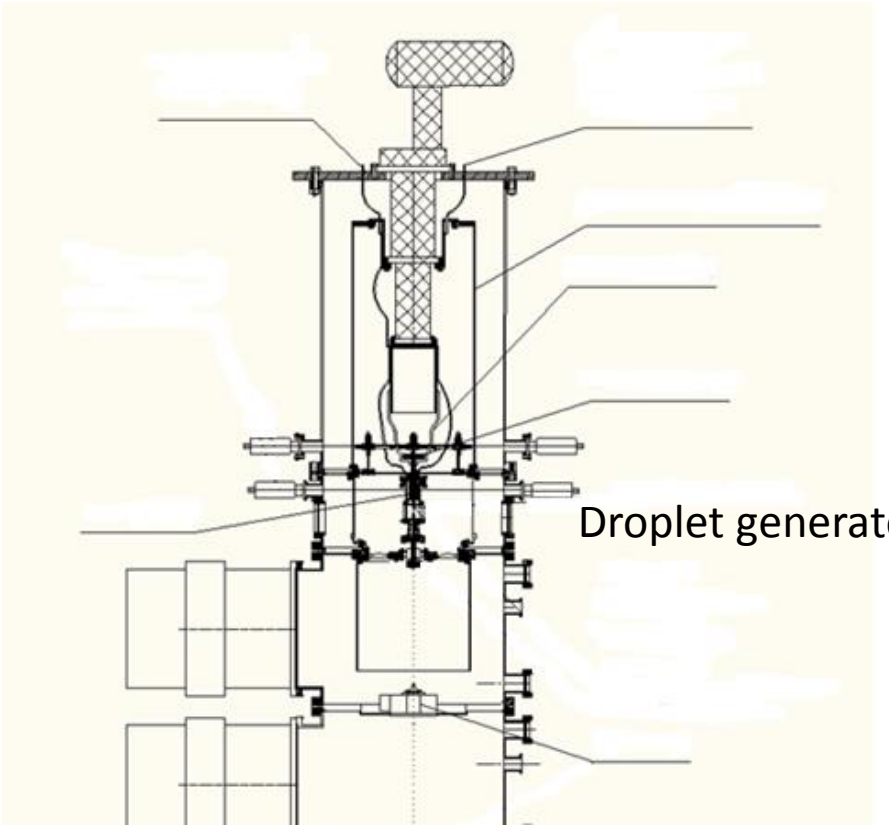
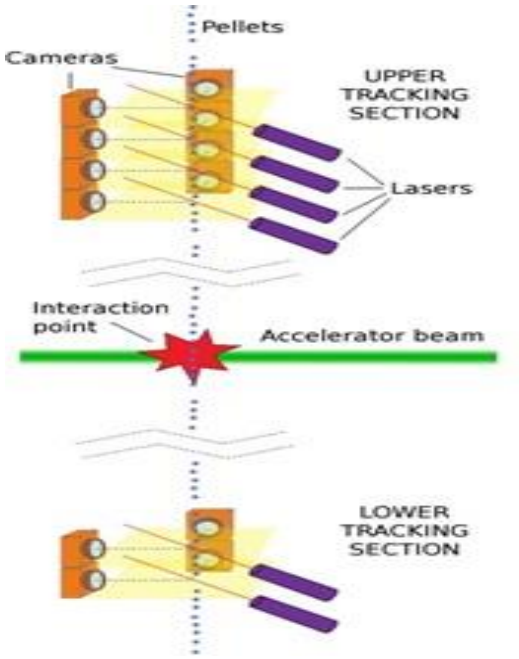
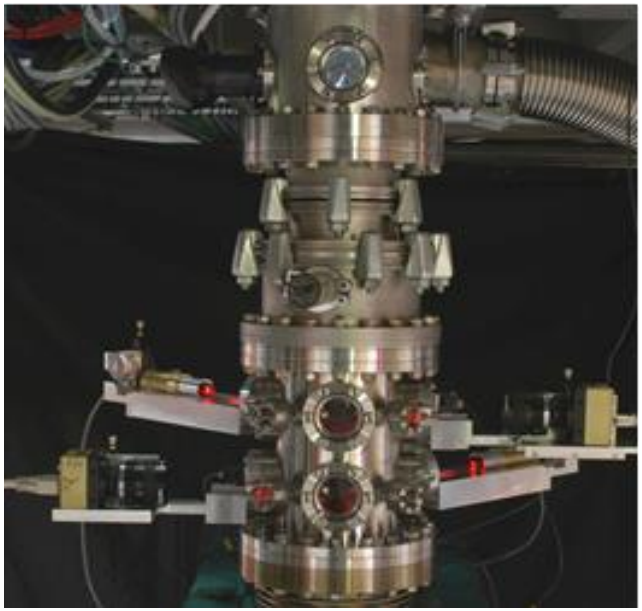


Pellet tracking system (Uppsala Univ.)





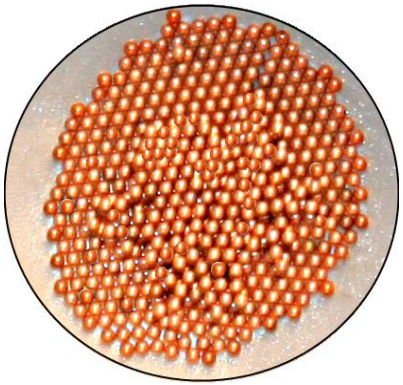
- Est. accuracy for laser applications:
  - ~50 µm/~20 µm (vert./hor)
- Pellet rate ~100 /s

A. Pyszniak: *Development and Applications of Tracking of Pellet Streams*
http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-235671

Metallic micro-spheres (FZJ, MPEI Moscow)

Metal spheres in a hourglass-like setup

Cu $T_{schm.}$ = 1084 °C



D=150 µm

Al $T_{schm.}$ = 660 °C

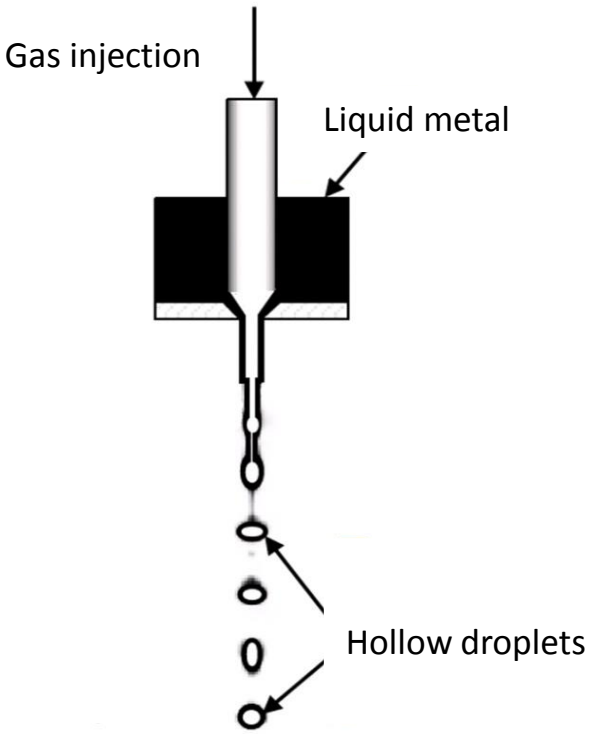
D=400 µm

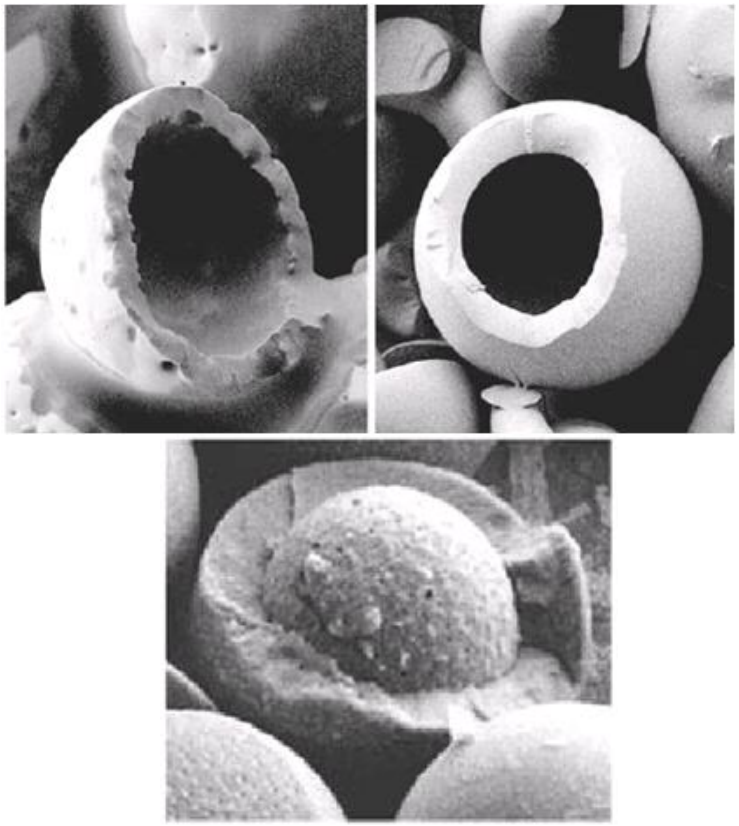
Er_3Ni $T_{schm.}$ = 1450 °C

D=500 µm

Metallic micro-spheres (FZJ, MPEI Moscow)

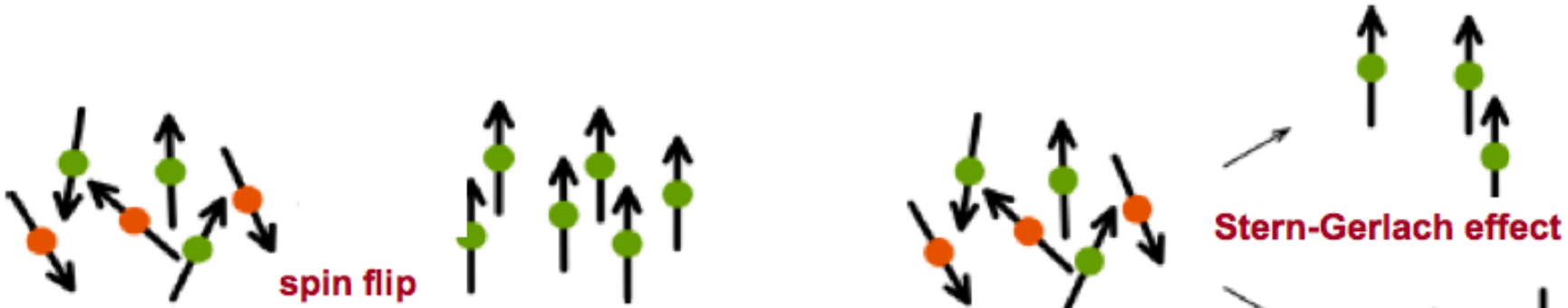
Spheres from different materials (*e.g.* gas-filled)



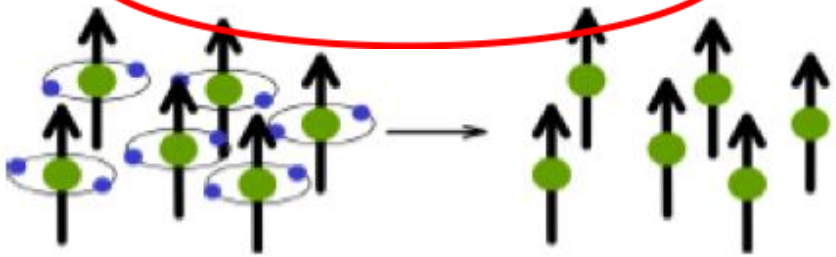


Possible scenarios:

Polarization is generated



Polarization is preserved



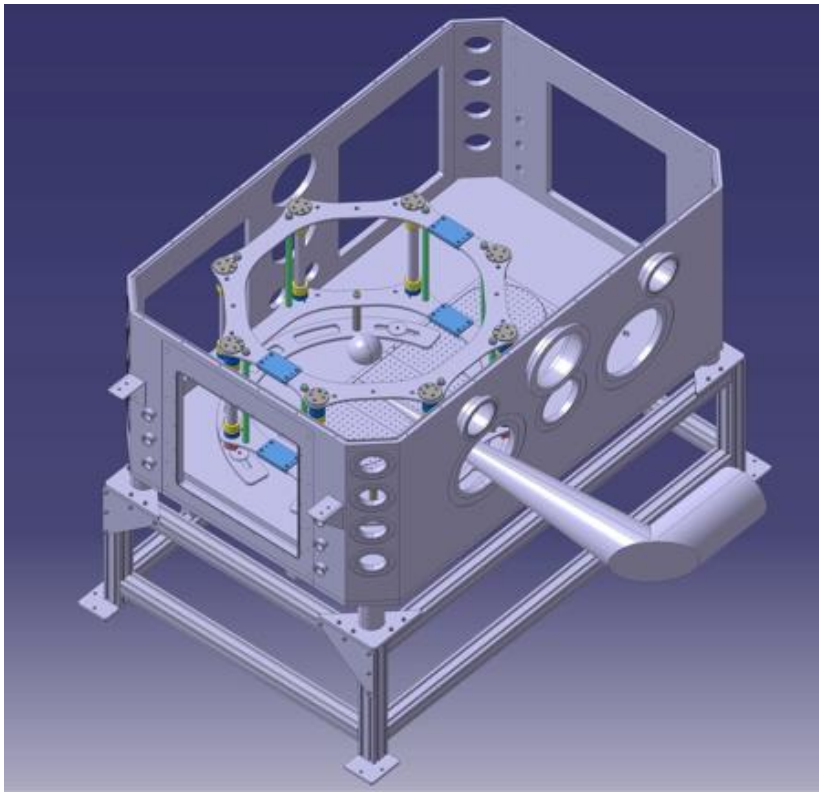
Polarized target
@room temperature:
^{3}He gas

Polarized ^{3}He gas: Transport

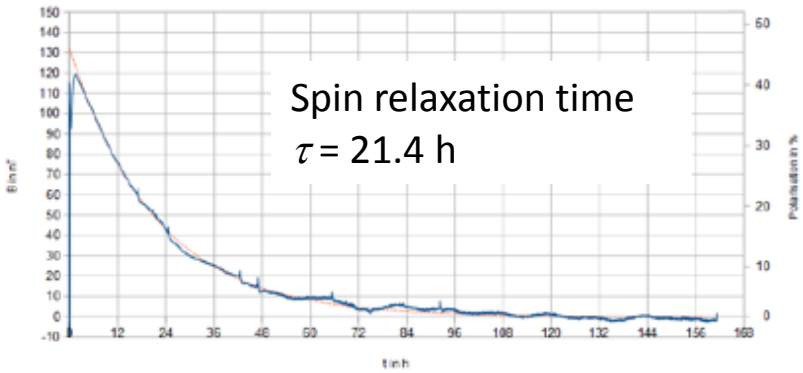
Glass vessels surrounded by permanent magnets

Halbach array of permanent magnets

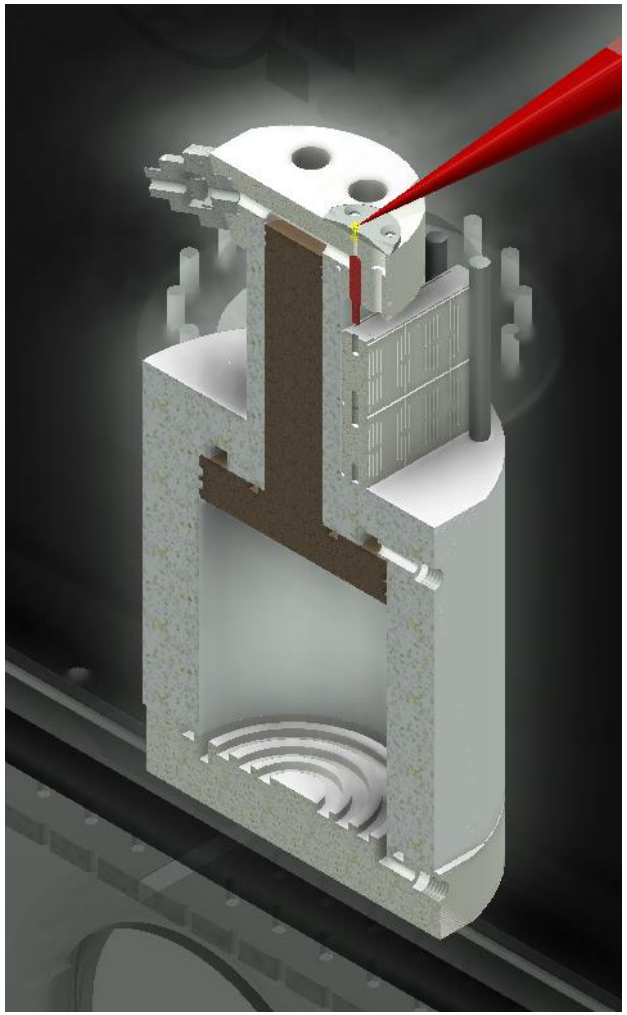
☞ Homogeneous field at target location

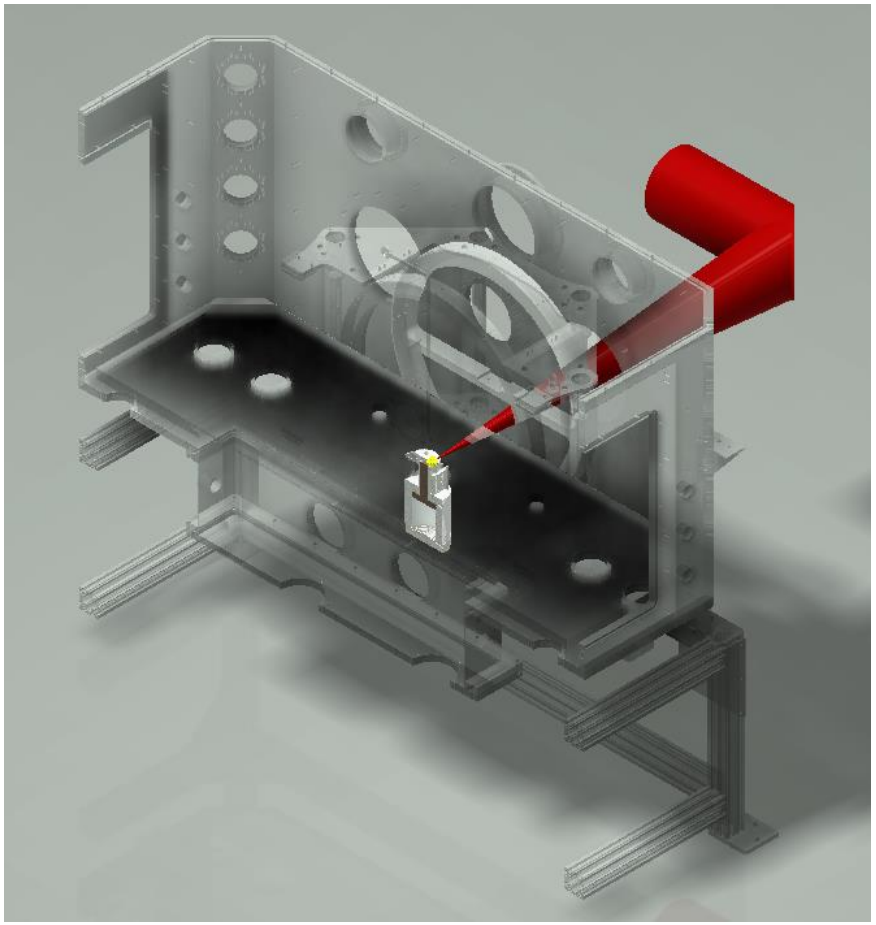


Phelix vacuum chamber, GSI Darmstadt

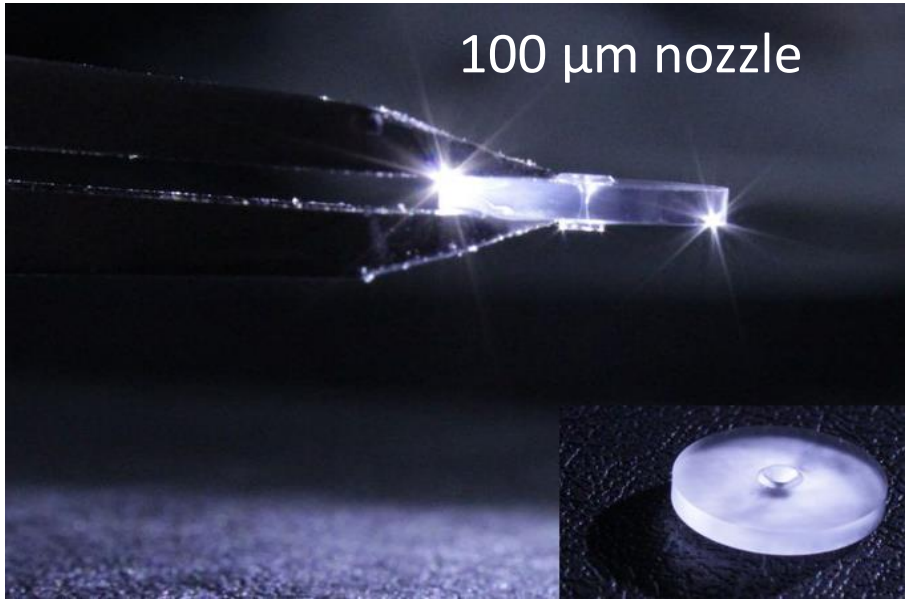


B.Nauschütt,
Bachelorarbeit FH Aachen (Aug. 2014)





Glass nozzles



LightFab UG Aachen (2013)
www.lightfab.de

Some “Science Fiction”

Films of polarized solid D_2

Das Physikportal

pro-physik.de

Simulation im Hochfrequenzbere
dem RF Module von COMSOL Mu
29. September 2016, 14:00 Uhr

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Fusion mit dem gewissen Dreh

12. August 2016

Kernspinpolarisiertes Deuterium soll Verschmelzungsrate bei Kernfusion deutlich erhöhen.

In Fusionsexperimenten sollen die Atomkerne der Wasserstoffvarianten (Isotope) Deuterium und Tritium zu Heliumkernen verschmelzen, um dabei große Mengen Energie zu gewinnen. Physiker aus Düsseldorf, Jülich und vom russischen Budker-Institut – einem international bekannten Beschleuniger-zentrum in Novosibirsk – wollen gemeinsam eine Anlage entwickeln, mit der sie die Wahrscheinlichkeit und damit die Reaktionsrate für diese Fusionsprozesse deutlich erhöhen: Sie wollen in den nächsten Jahren eine Strahlquelle für kern-spinpolarisierte Deuterium-Moleküle aufbauen. Das Projekt wird gemeinsam von der Deutschen Forschungsgemeinschaft (DFG) und der Russian Science Foundation (RSF) in den nächsten drei Jahren mit insgesamt mehr als 500.000 Euro gefördert.

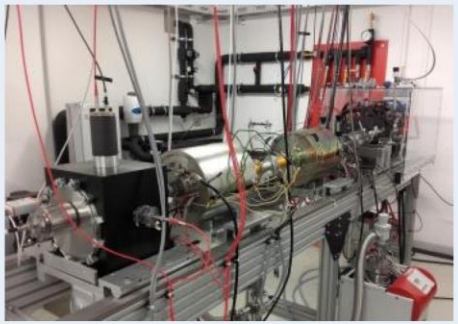

Abb.: Lamb-Shift-Polarimeter, gebaut am Forschungszentrum Jülich (Bild: R. Engels)

Questions?