Experimental techniques for studying Rydberg matter of Hydrogen

Sveinn Ólafsson
University of Iceland

People Involved

Sweden

Leif Holmlid

Prof. Emeritus

Univ. of Gothenburg

Norway

Sindre Z-Gundersen

PhD. Univ. Iceland

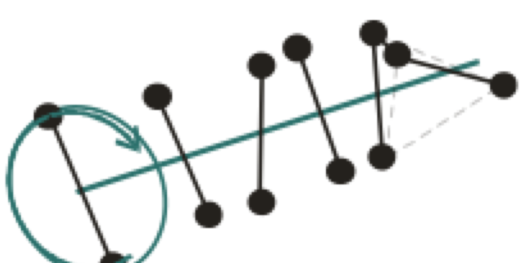
Iceland

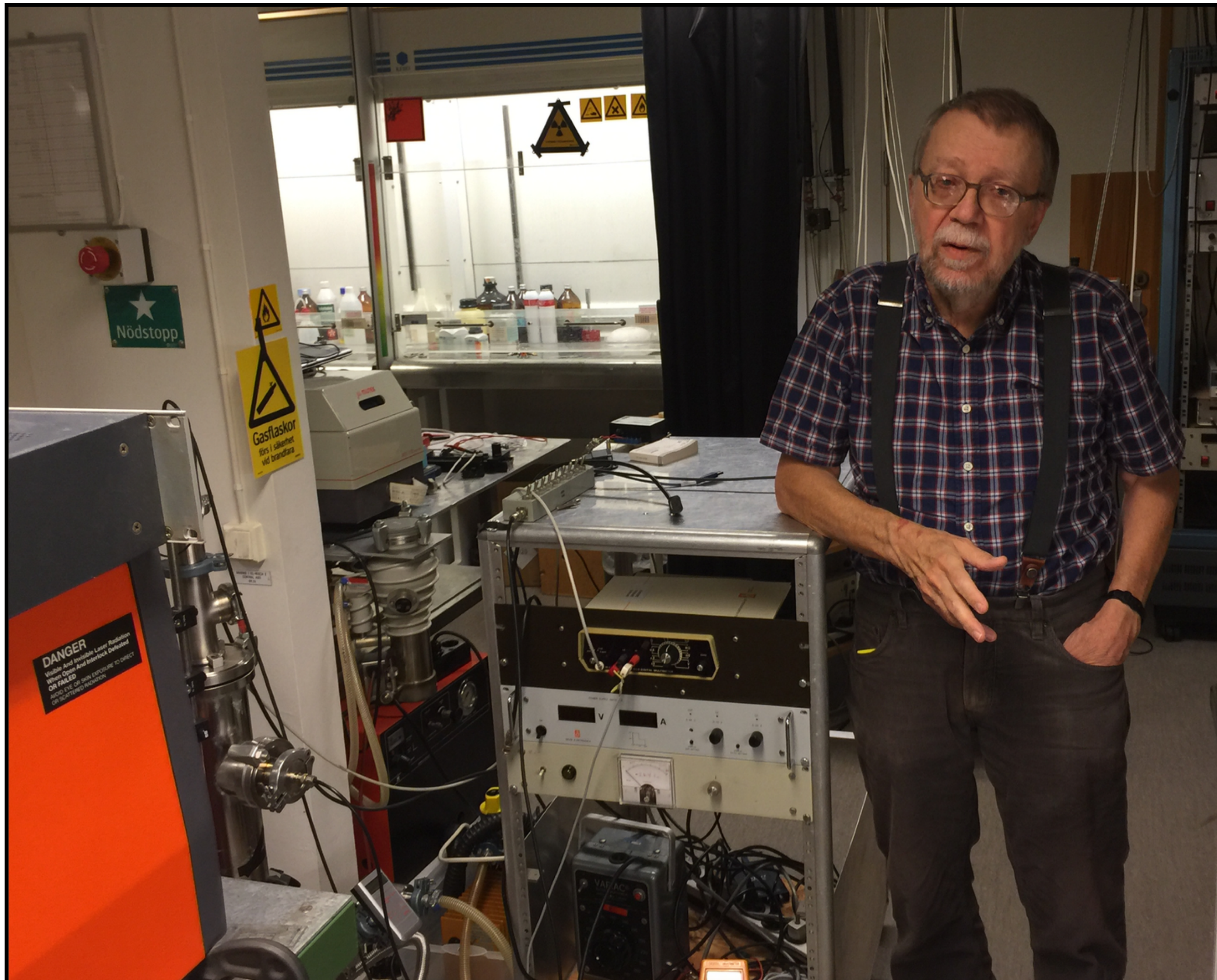
Sveinn Ólafsson

Research Professor

Ultra-dense Hydrogen

2.3 ± 0.1 pm!





Leif Holmlid in his lab at Gothenburg University

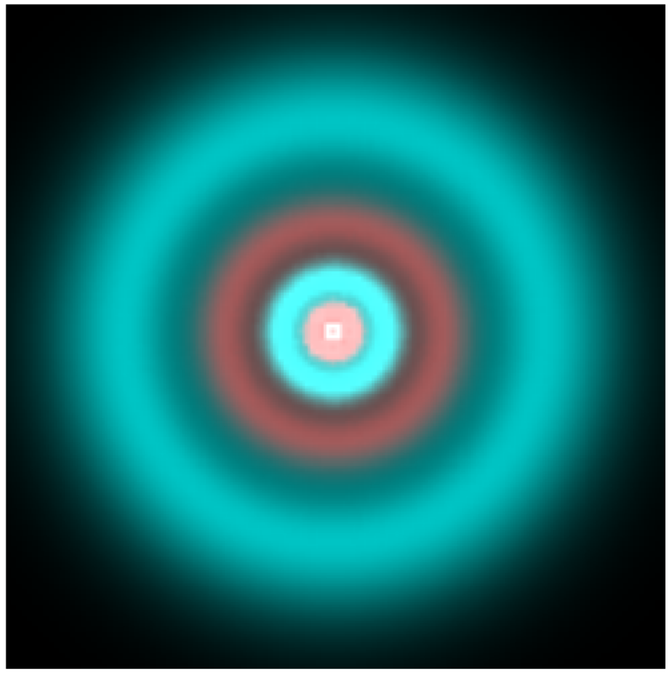
L. Holmlid, "Crossed molecular beam alkali - alkali halide chemical scattering: Apparatus, surface ionization detection and absolute measurements of cross sections".
Ph.D. Thesis, Physical Chemistry, University of Göteborg 1973.

240 Surface Science Publications since 1973

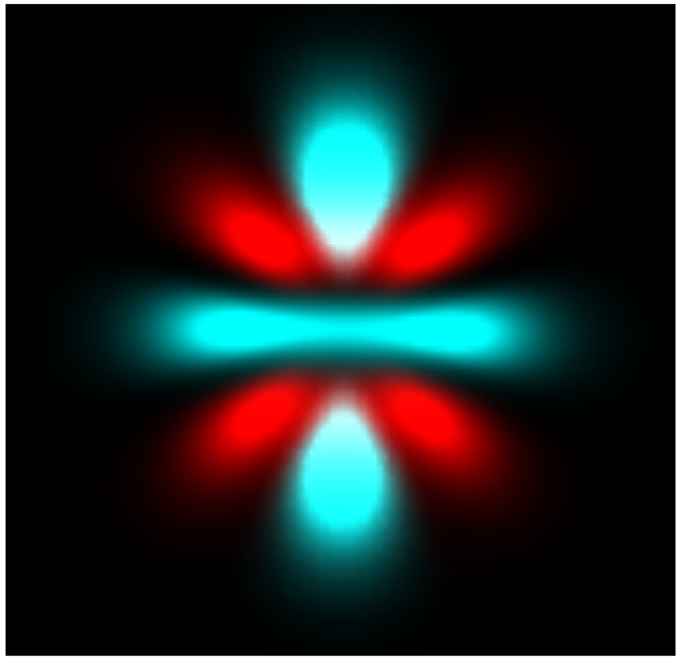
- 1992 Holmlid Highly excited Rydberg states .pdf
- 1998 Holmlied ClassicalCalcRydberg.pdf
- 2002 Leif RydbergMatterFormation.pdf
- 2005 Laser initiated detonation in Rydberg matter.pdf
- 2006 Holmlid Amplification by Stimulated.pdf
- 2006 Holmlid Angular variation.pdf
- 2006 Holmlid dust atmosphere in comets.pdf
- 2006 Holmlid Experimental studies of fast fragments.pdf
- 2007 Holmlid Confocal laser microspectroscopic.pdf
- 2007 Holmlid Direct observation of circular Rydberg.pdf
- 2007 Holmlid Precision bond lengths.pdf
- 2007 Holmlid Stimulated emission spectroscopy.pdf
- 2008 Holmlid Clusters H_N.pdf
- 2008 Holmlid Condensed Atomic Hydrogen.pdf
- 2008 Holmlid MileyClusterRydbLPBsing.pdf
- 2008 Holmlid Rotational spectra of large Rydberg.pdf
- 2008 Holmlid The diffuse interstellar band.pdf
- 2008 Holmlid Vibrational.pdf
- 2009 Holmlid A fast route to small-scale fusion.pdf
- 2009 Holmlid A possible nuclear fuel.pdf
- 2009 Holmlid High-energy Coulomb explosions.pdf
- 2009 Holmlid Internal magnetic field.pdf
- 2009 Holmlid Nuclear spin transitions.pdf
- 2009 Holmlid Ultrahigh-density deuterium of Rydberg.pdf
- 2010 Holmlid Deuteron energy of 15 MK.pdf
- 2010 Holmlid Laser-driven nuclear fusion D+D.pdf
- 2010 Holmlid Laser-induced variable.pdf
- 2010 Holmlid Nanometer interatomic distances.pdf
- 2010 Holmlid Rydberg matter.pdf
- 2011 Holmid Potassium.pdf
- 2011 Holmlid Diffuse interstellar bands.pdf
- 2011 Holmlid High-charge Coulomb.pdf
- 2011 Holmlid Large ion.pdf
- 2011 Holmlid Rydbergmatter source.pdf
- 2011 Holmlid Sub nanometer distances.pdf
- 2012 Holmlid Cluster Ions.pdf
- 2012 Holmlid Detection of MeV particels.pdf
- 2012 Holmlid Deuterium Clusters D_N.pdf
- 2012 Holmlid Experimental studies.pdf
- 2012 Holmlid Fast atoms.pdf
- 2012 Holmlid Fusion Generated.pdf
- 2012 Holmlid Superconductivity.pdf
- 2012 Holmlid Surface Interface.pdf
- 2013 Holmlid LAser fusion.pdf
- 2013 Holmlid Levels in p(-1 and d(1)).pdf
- 2013 Holmlid Two collector.pdf
- 2013 Holmlid ultradense p(-1).pdf
- 2014 Holmlid Intense Ionisation.pdf
- 2014 Holmlid Lepton Pairs.pdf
- 2014 Holmlid Meissner.pdf
- 2014 Holmlid Stability.pdf

Rydberg atom (n,l,m)

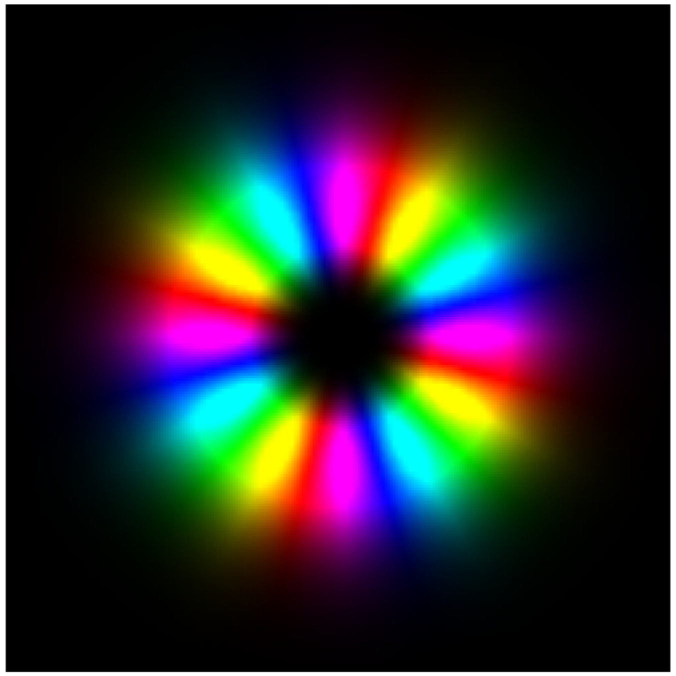
Radiative lifetime goes as n^5



(5,0,0)



(5,4,0)

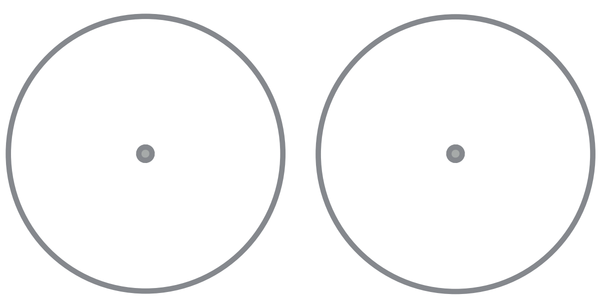


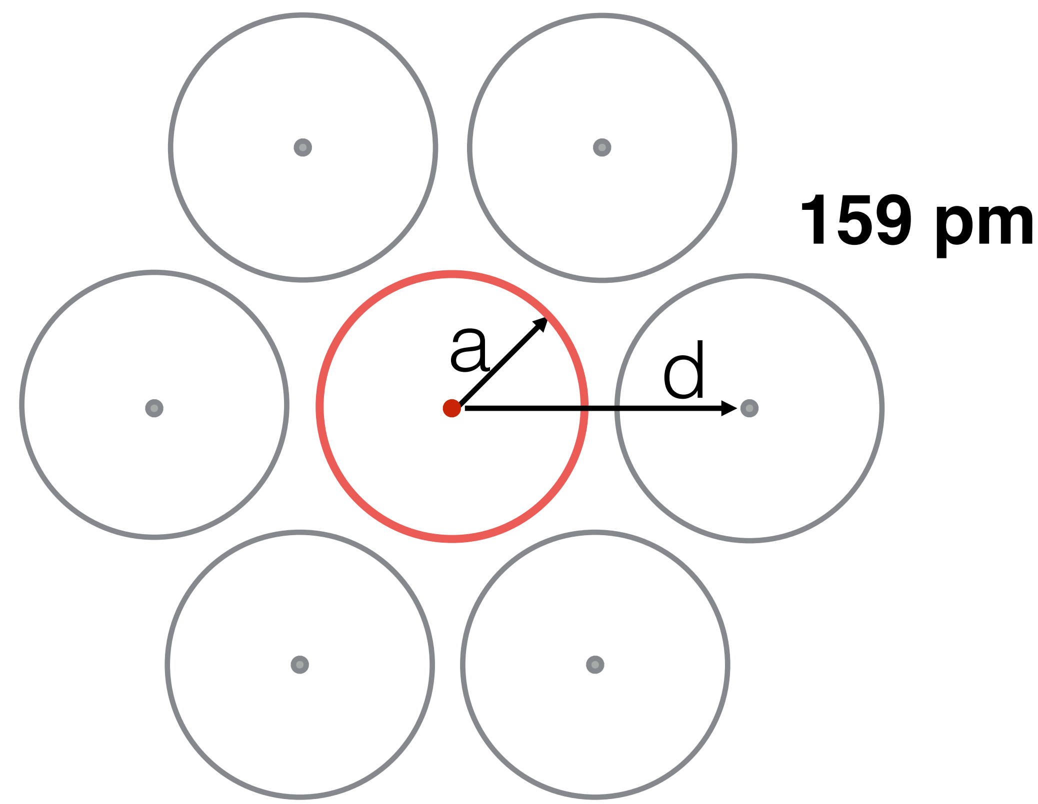
(5,4,4)

Just out in Physica Scripta as manuscript!

Ultradense protium p(0) and deuterium D(0) and their relation to ordinary Rydberg matter: a review
Leif Holmlid and Sindre Zeiner-Gundersen https://doi.org/10.1088/1402-4896/ab1276

Rydberg atom condensation into Rydberg matter





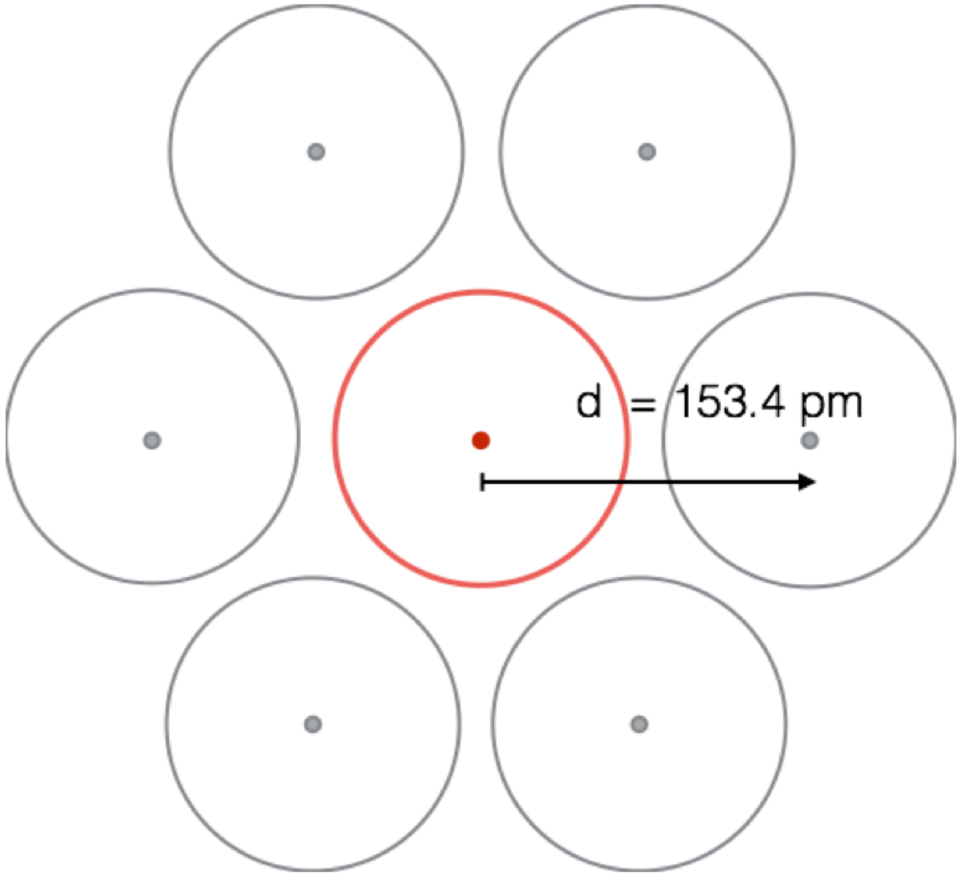
Dimer state is unstable

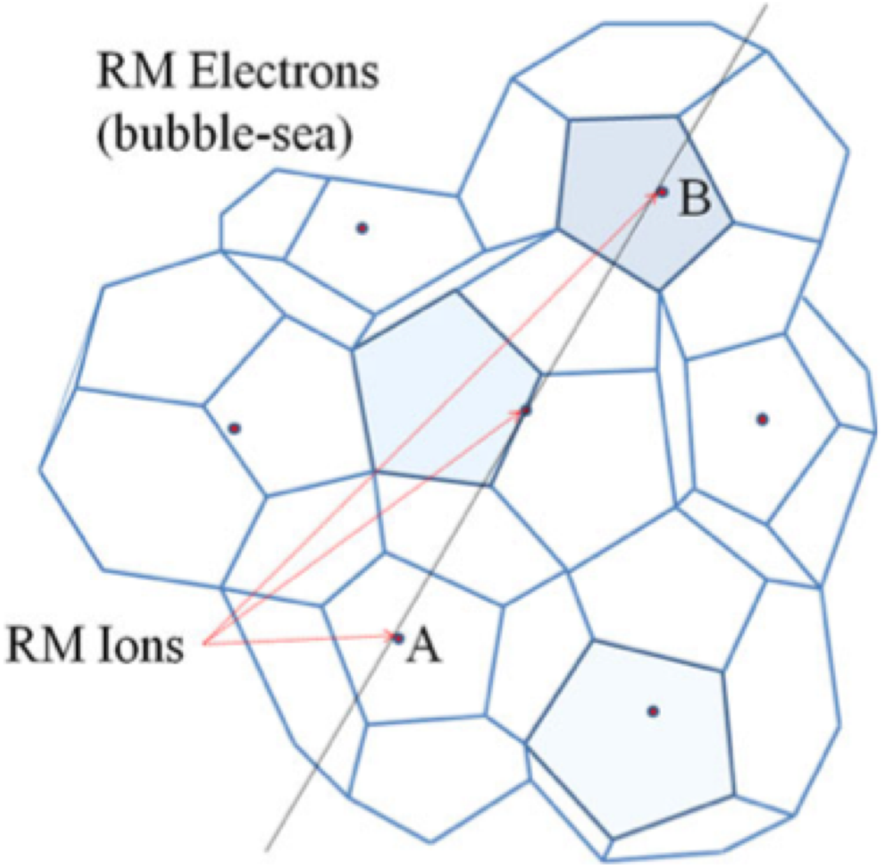
0.2 eV bonding per state possible if d ≈ 2.9a

Theory of the condensed state in a system of excited atoms
E.A. Manykin, M.I. Ozhovan and P.P. Poluektov Zh. Eksp. Teor. Fiz. 84, 442-453 1983

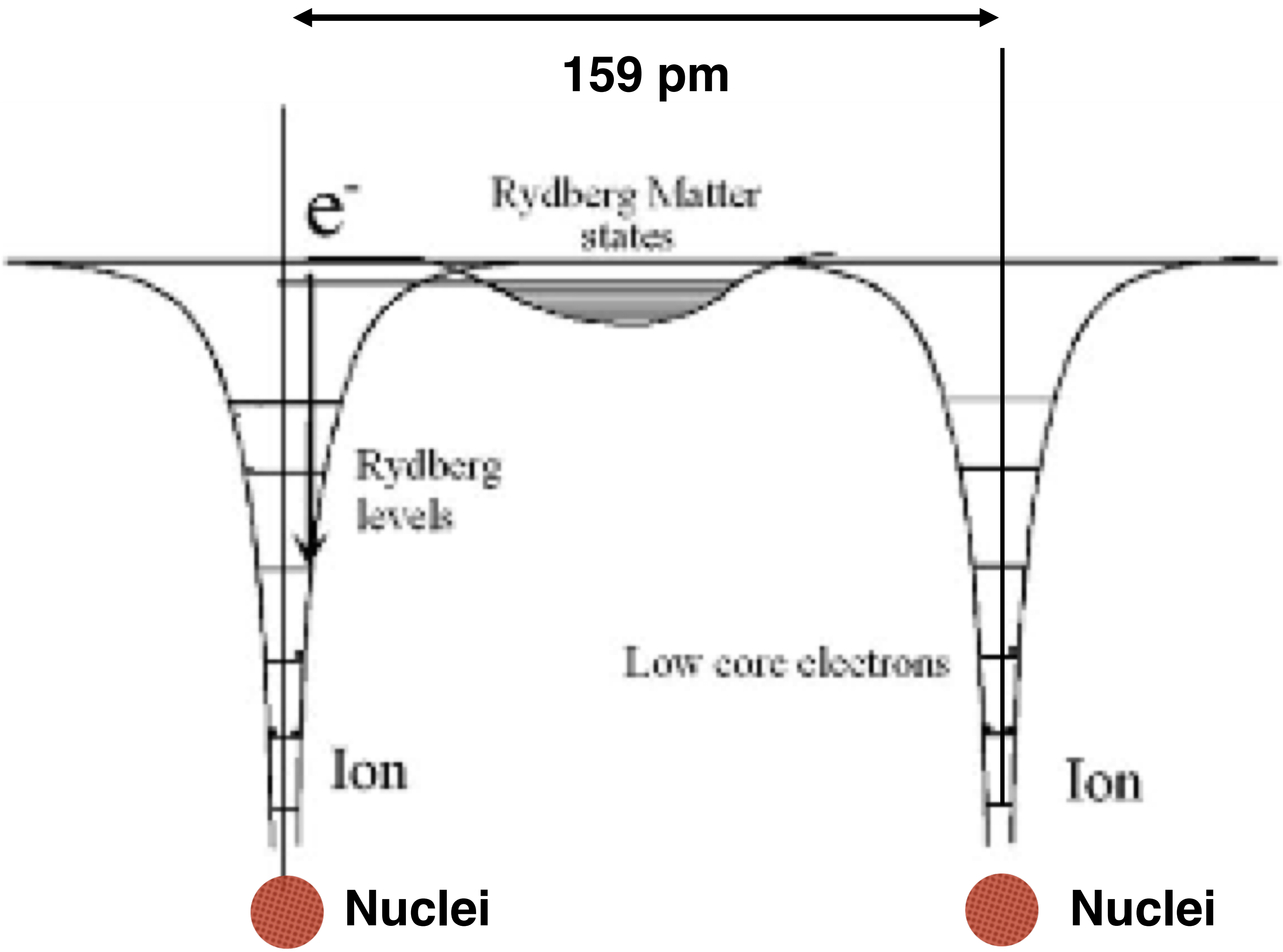
Conditions for forming Rydberg matter: condensation of Rydberg states in the gas phase versus at surfaces Leif Holmlid [Journal of Physics: Condensed Matter](), [Volume 14](), [Number 49]() 2002

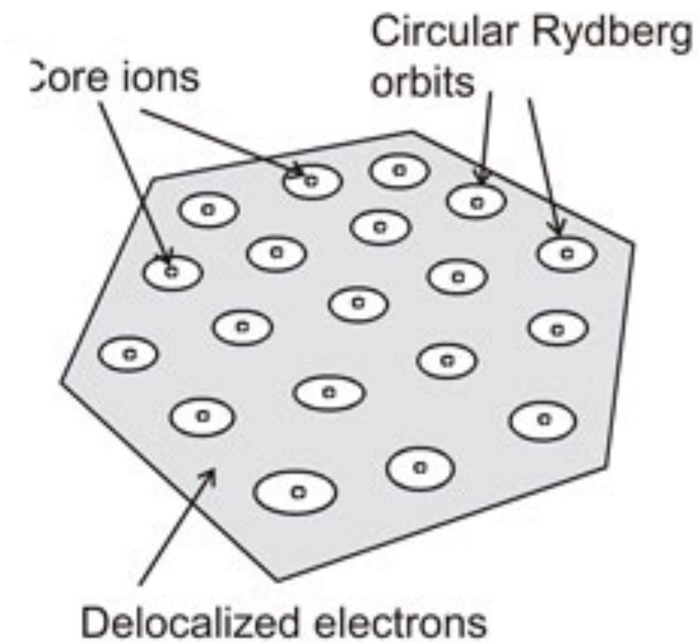
Rydberg matter types





Rydberg matter a frozen plasma state?

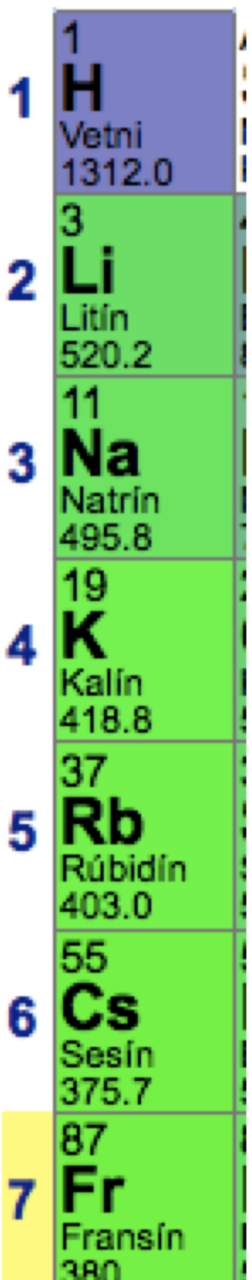


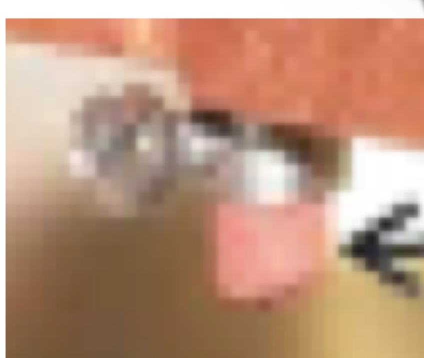


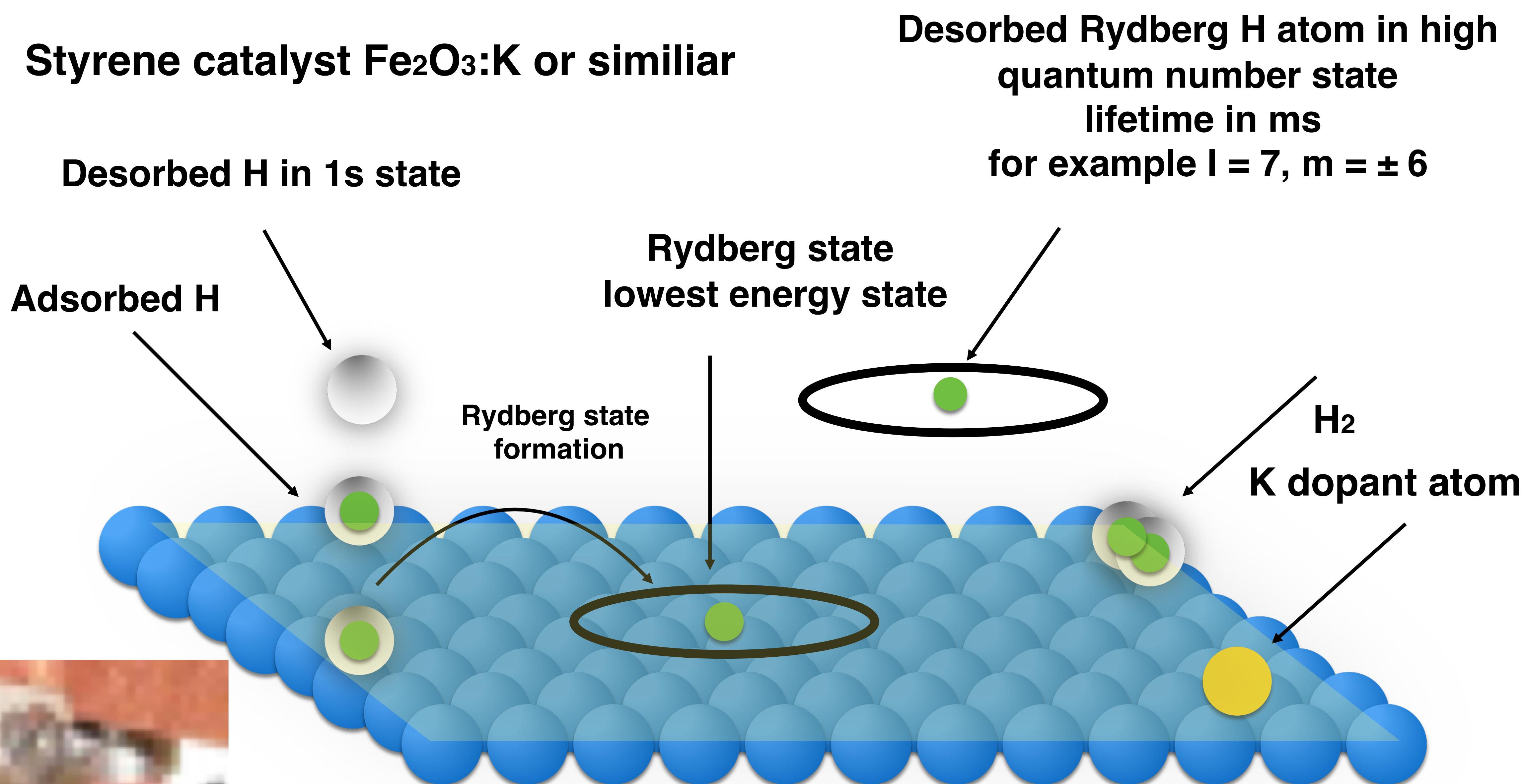
2D hexagonal

Conditions for forming Rydberg matter: condensation of Rydberg states in the gas phase versus at surfaces Leif Holmlid 2002 [Journal of Physics: Condensed Matter](), [Volume 14](), [Number 49]()

Surface catalytic process of formation of Rydberg matter

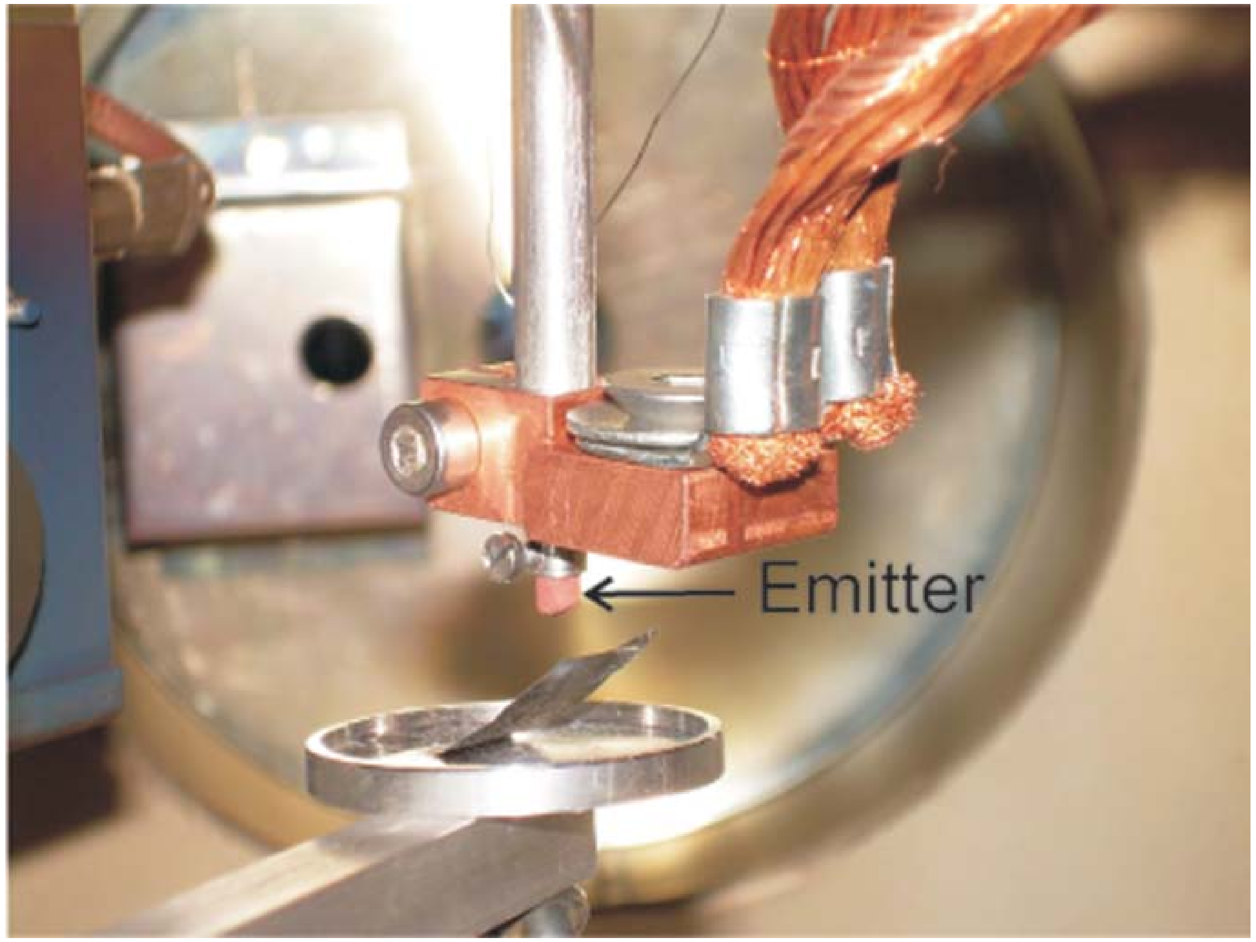


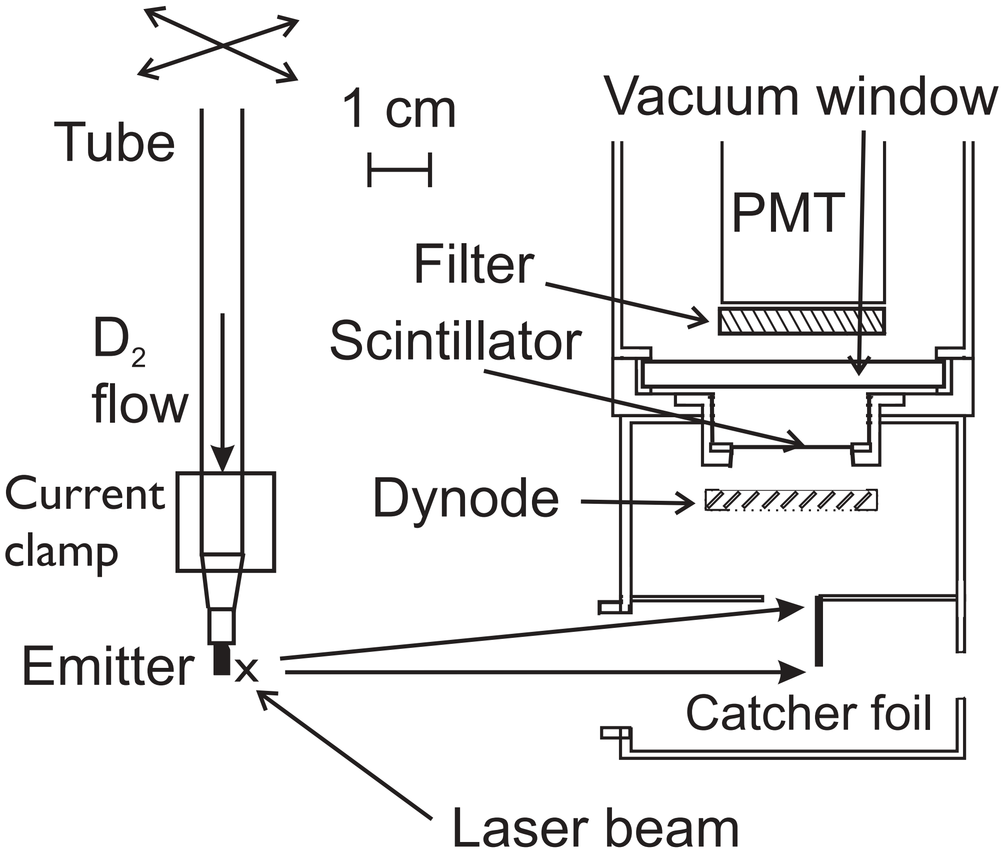




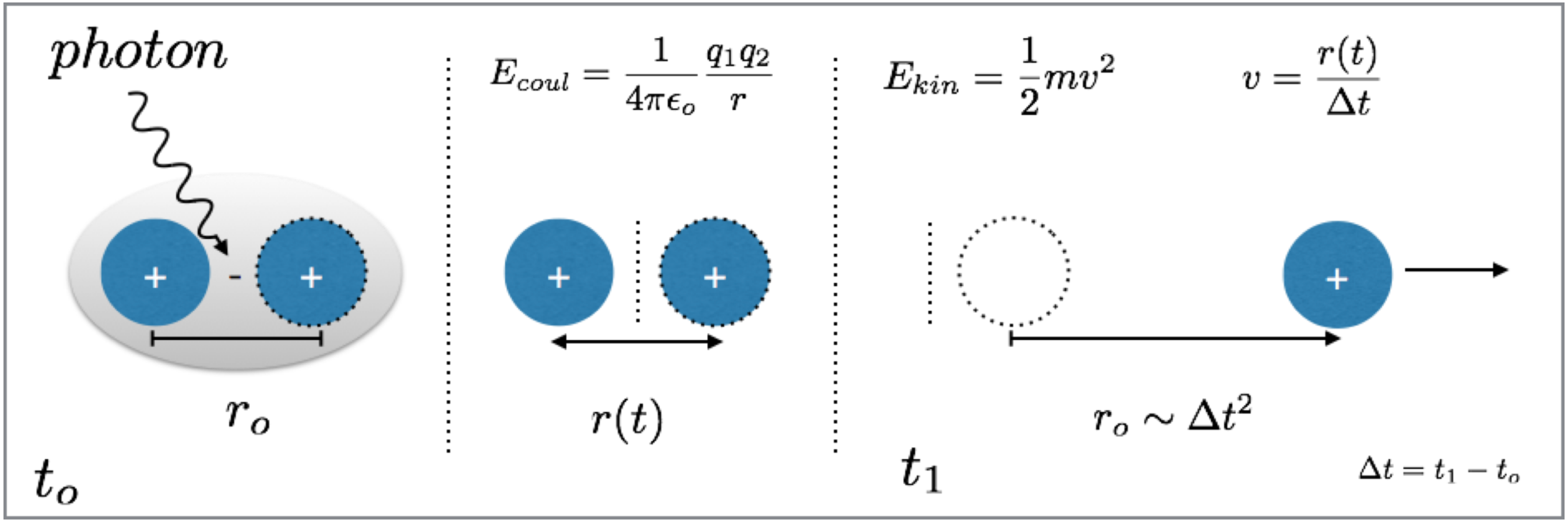
1. Low Kinetic energy (630 eV/u) release results

Bond length experiments with Time of Flight mass spectroscopy





Time of flight analysis



Possible cluster breakups are many.

For example cluster of mass 16 can break up (2 < > 1) 4 < > 12 …

and so on for other total masses.

1. Low Kinetic energy (630 eV/u) release results

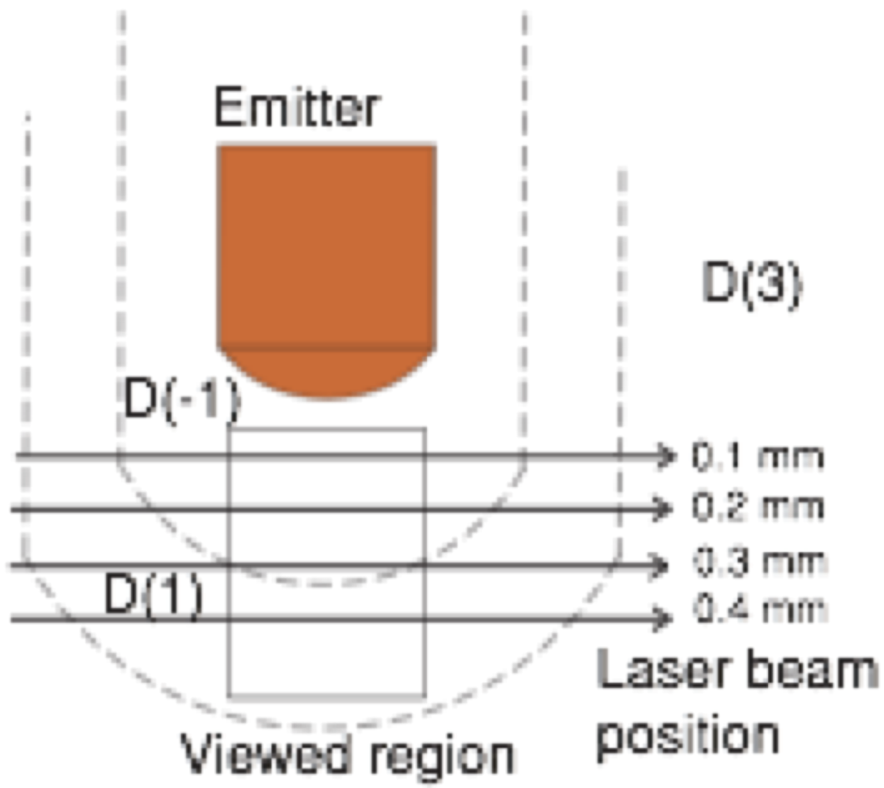
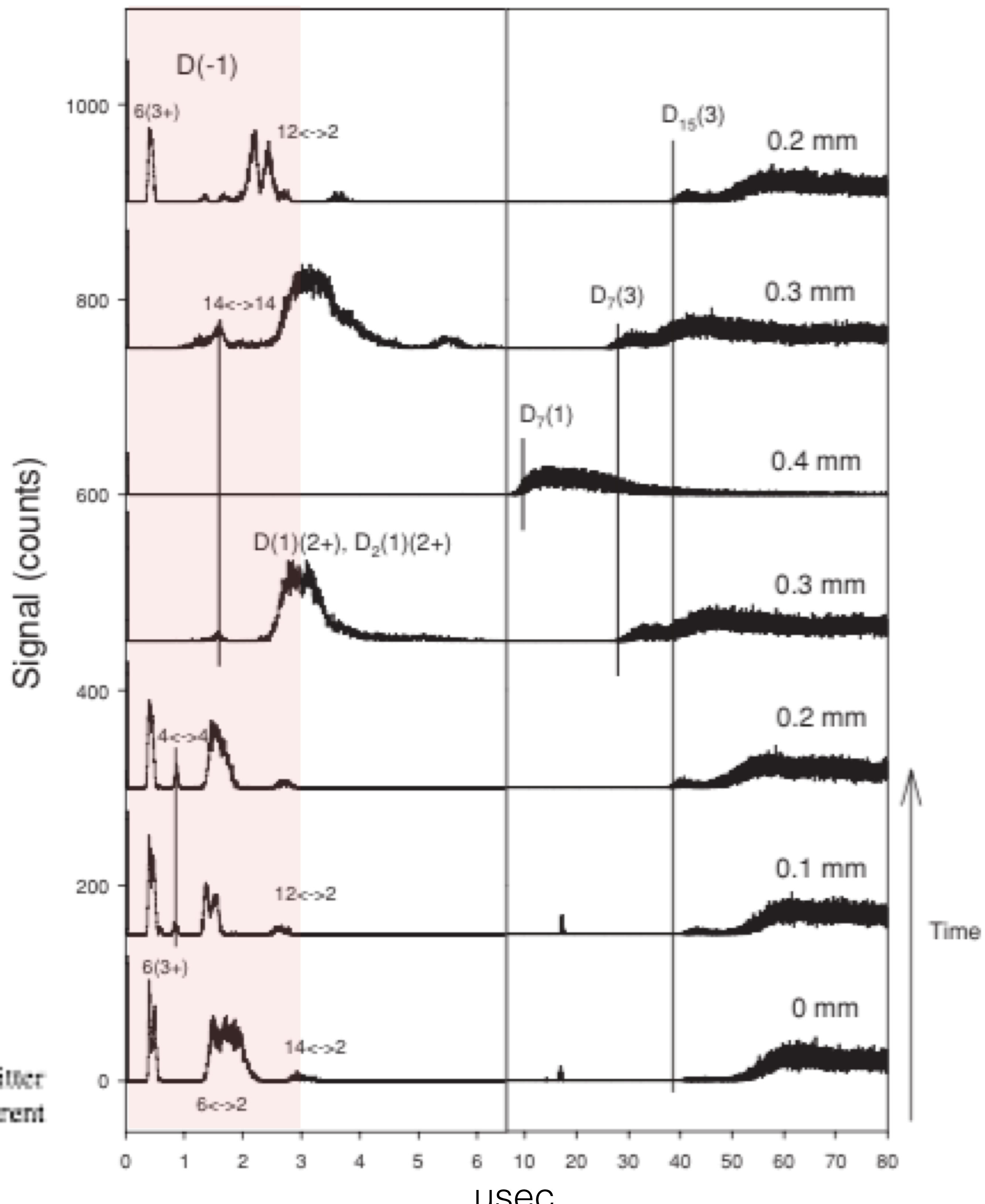
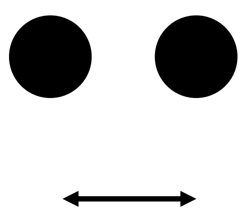


FIG. 5. (Color online) The laser beam position in the cloud below the emitter is shown for the data in Fig. 4. The approximate regions in space for different forms of condensed deuterium are indicated.

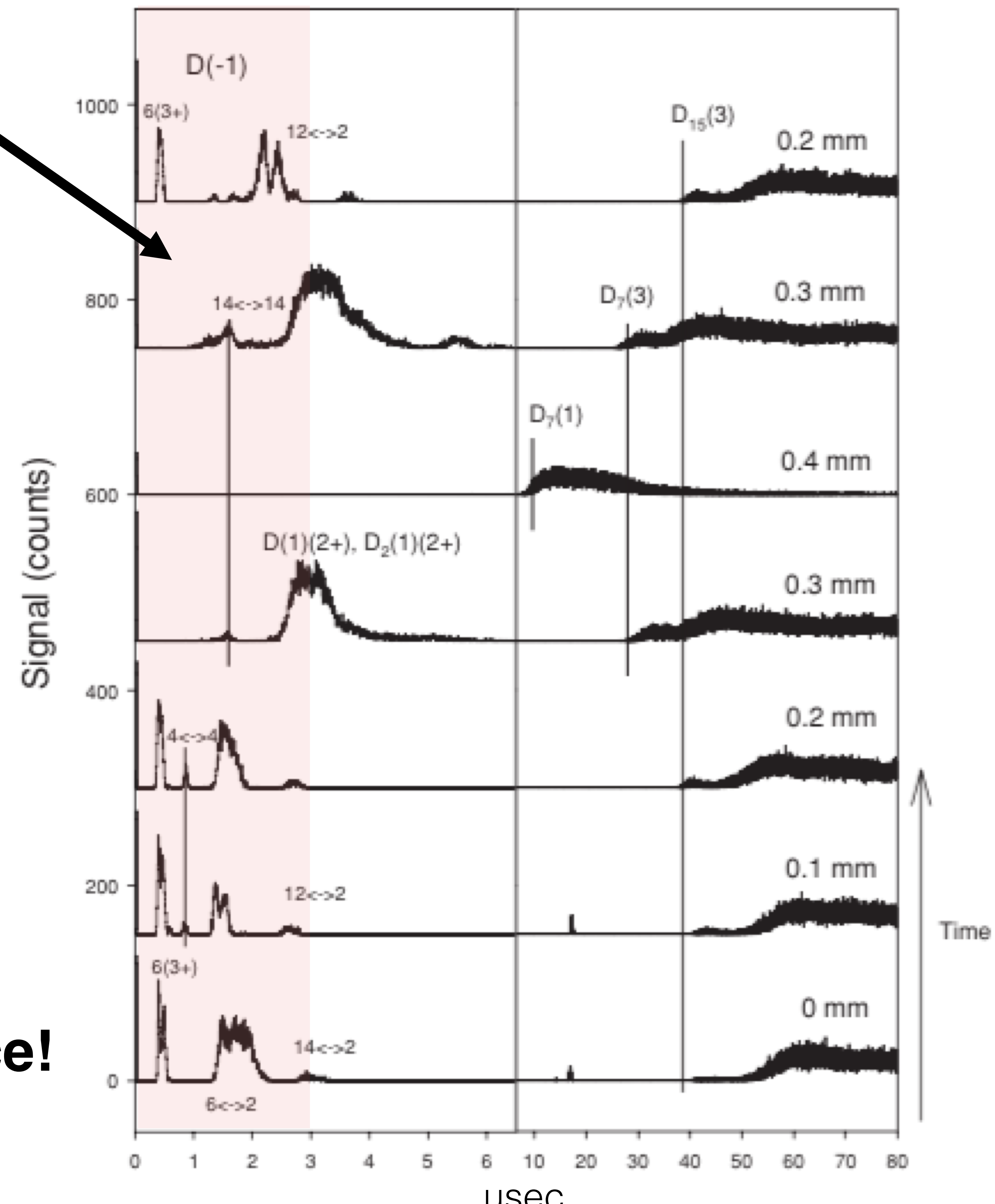


There should be no peaks here!

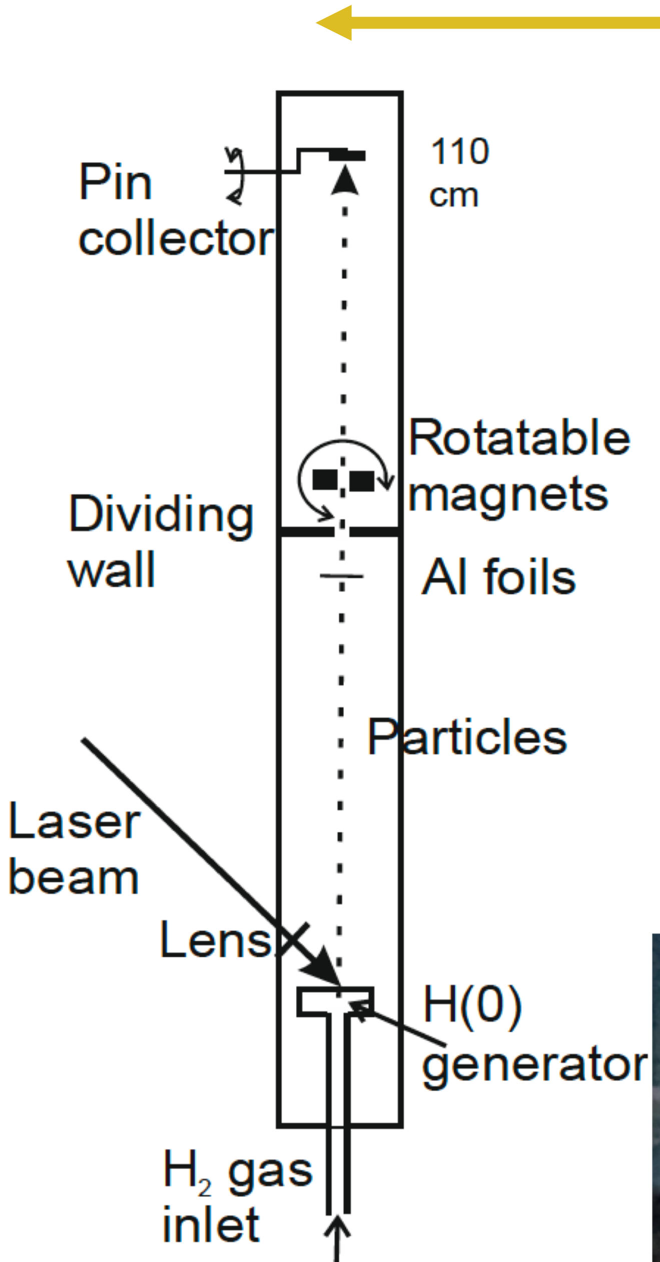


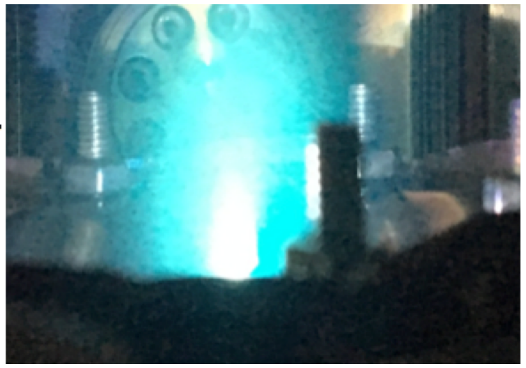
2.3 pm bond distance!

H_2 molecule 72 pm bond distance!

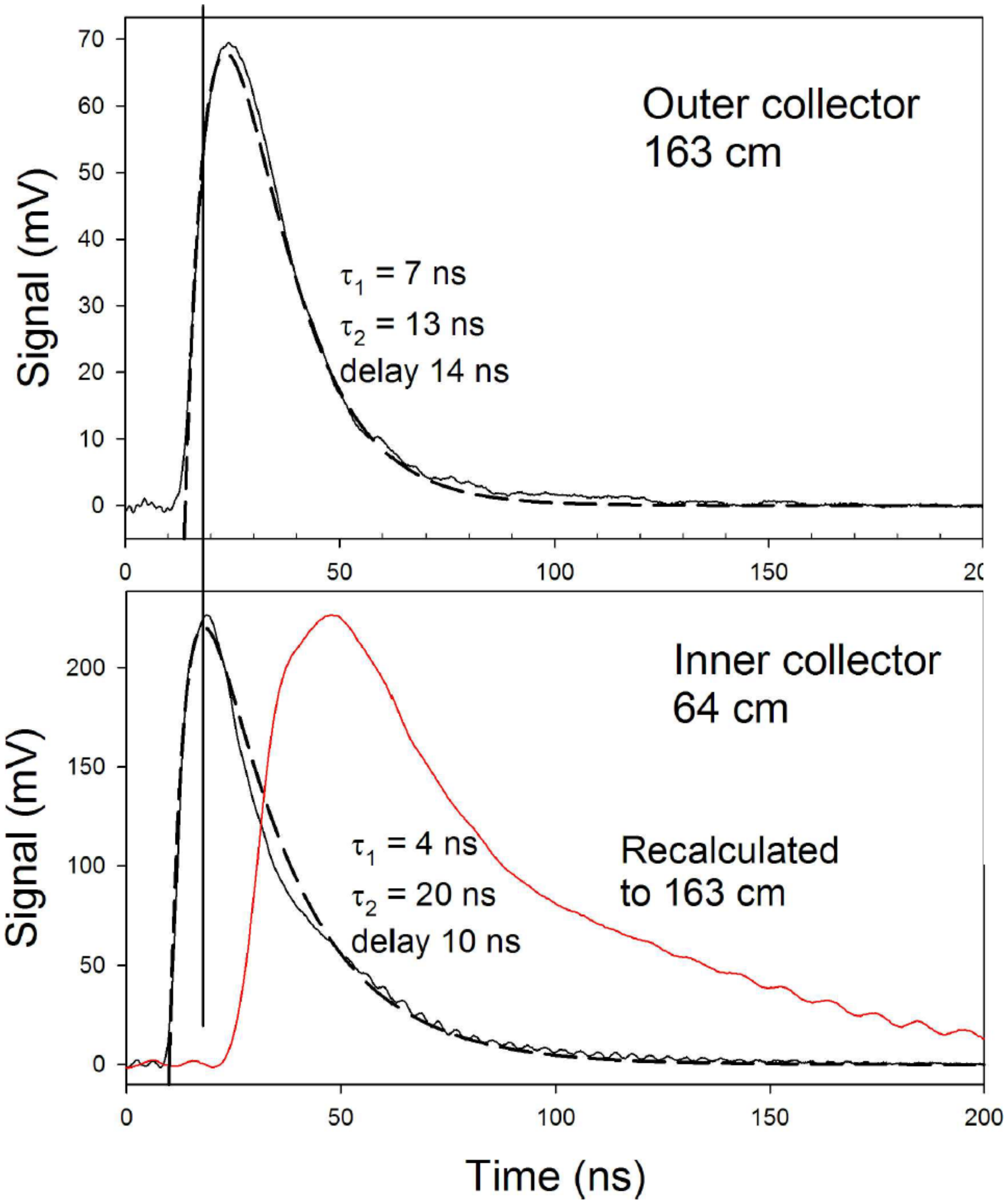


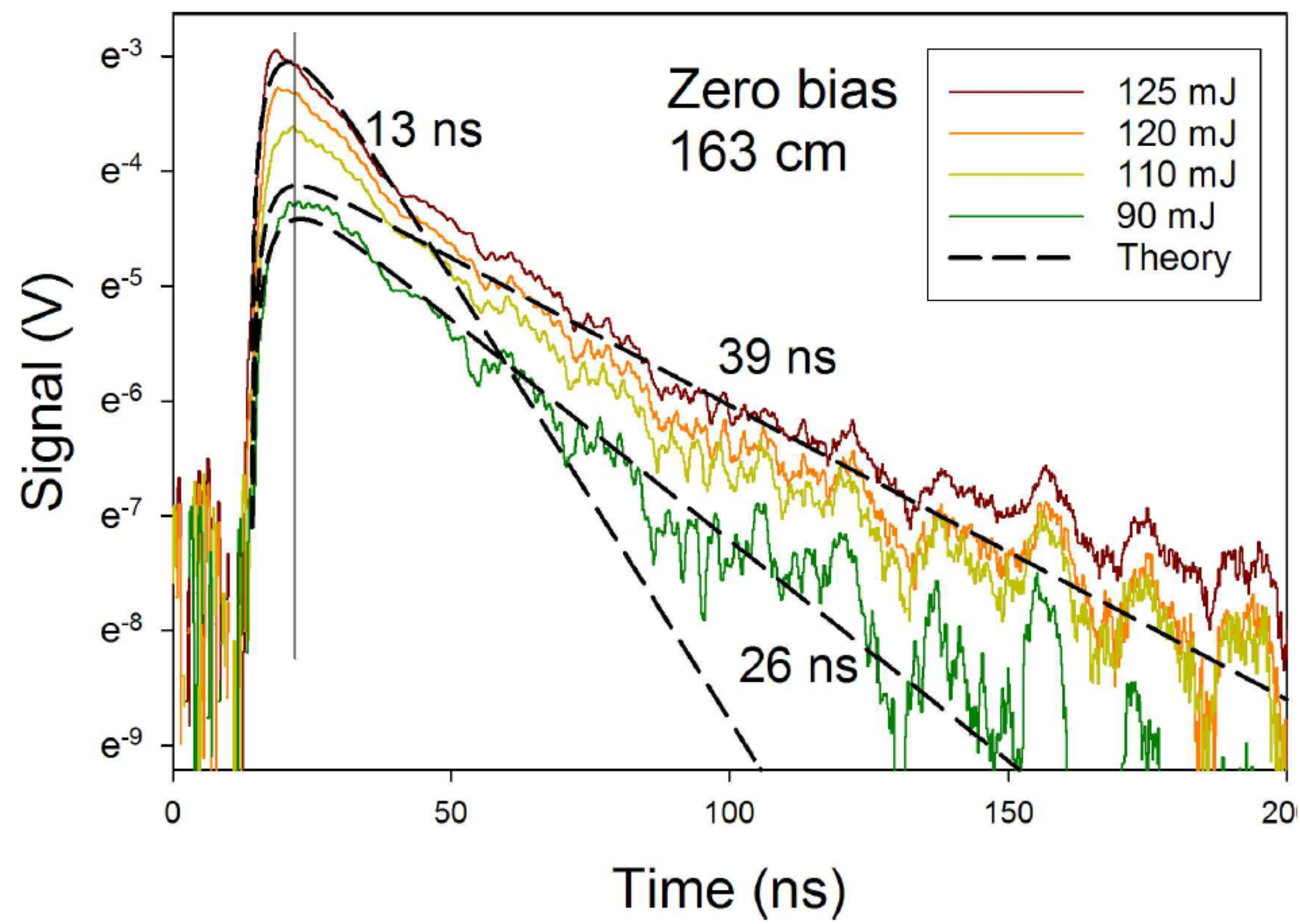
Leif Holmlid High Kinetic energy (MeV/u) release results





Fast kinetic energy release flight signal





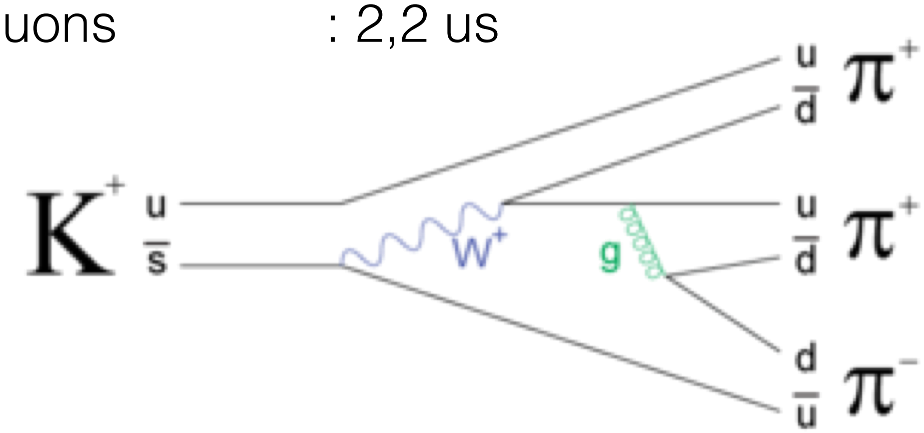
LH high kinetic energy release interpretation

Leif assumes high mass therefore particles with MeV energy are observed, not electrons: 50 KeV energy

H(0) (protons,deuterons) are transformed ! into

μ± Muons → e± electrons
K± kaons → π± pions. → μ± muons → e± electrons

Observed decay time similar to:
K-mesons : 13 ns
π -mesons : 26 ns
Muons : 2,2 us

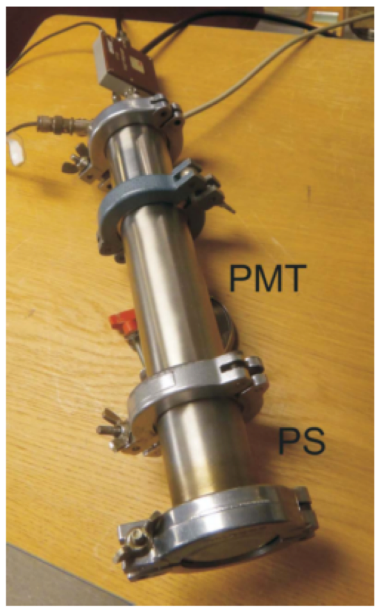


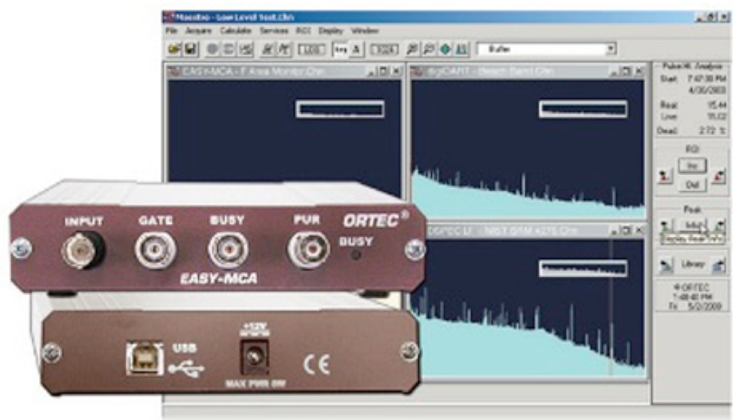
$$\pi^0 \to \gamma_1 + \gamma_2,$$

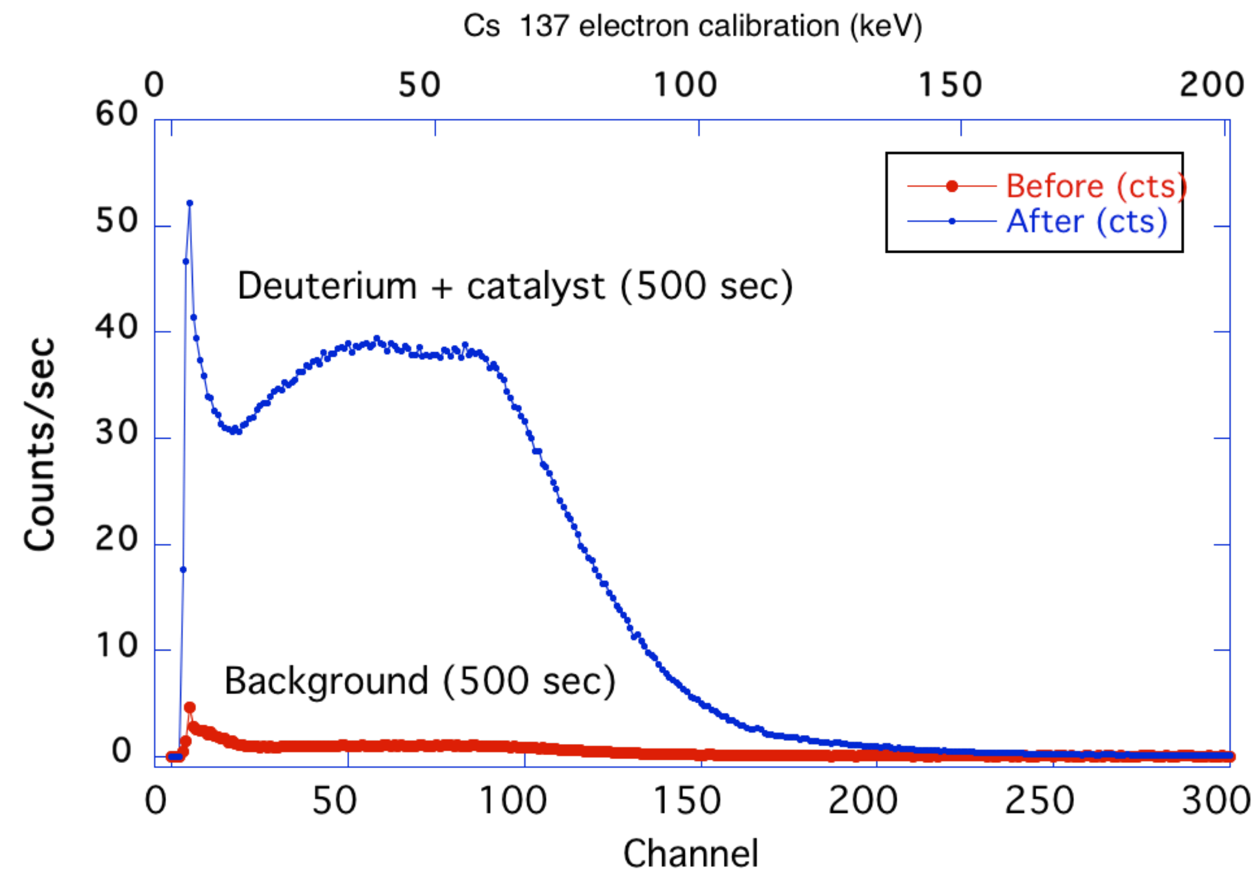
$$\pi^+ \to \mu^+ + \nu_\mu \to e^+ + \nu_e + \bar{\nu}_\mu + \nu_\mu,$$

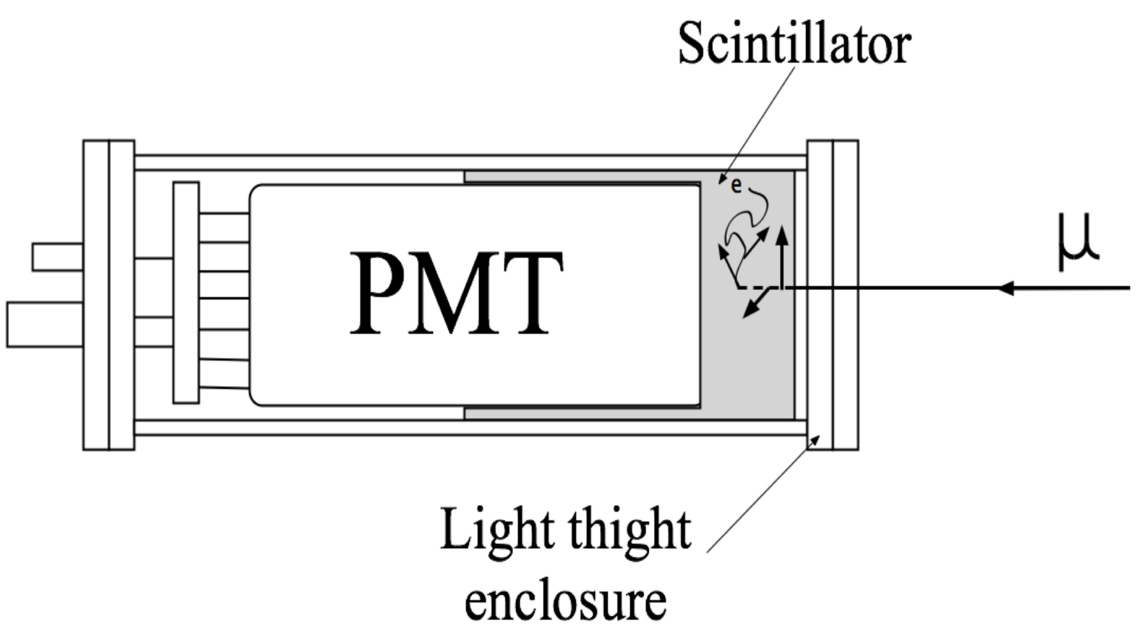
$$\pi^- \to \mu^- + \bar{\nu}_\mu \to e^- + \bar{\nu}_e + \nu_\mu + \bar{\nu}_\mu.$$

Leif Holmlid spontaneous Particle emission









Holmlid, L. & Olafsson, S. Muon detection studied by pulse-height energy analysis: Novel converter arrangements. Rev. Sci. Instrum. 86, (2015).

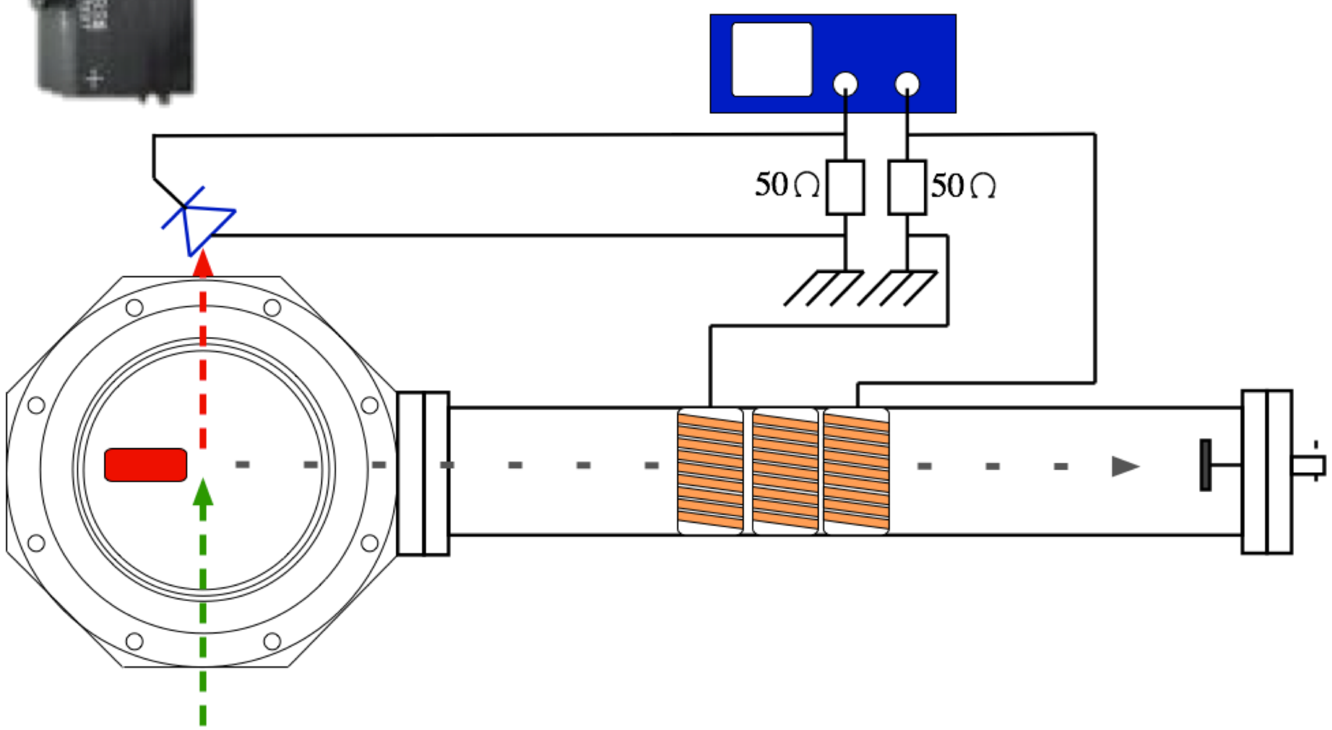
Annihilation of p^+ ?

Following experimental evidence for high energy particle observation Have been published by Leif

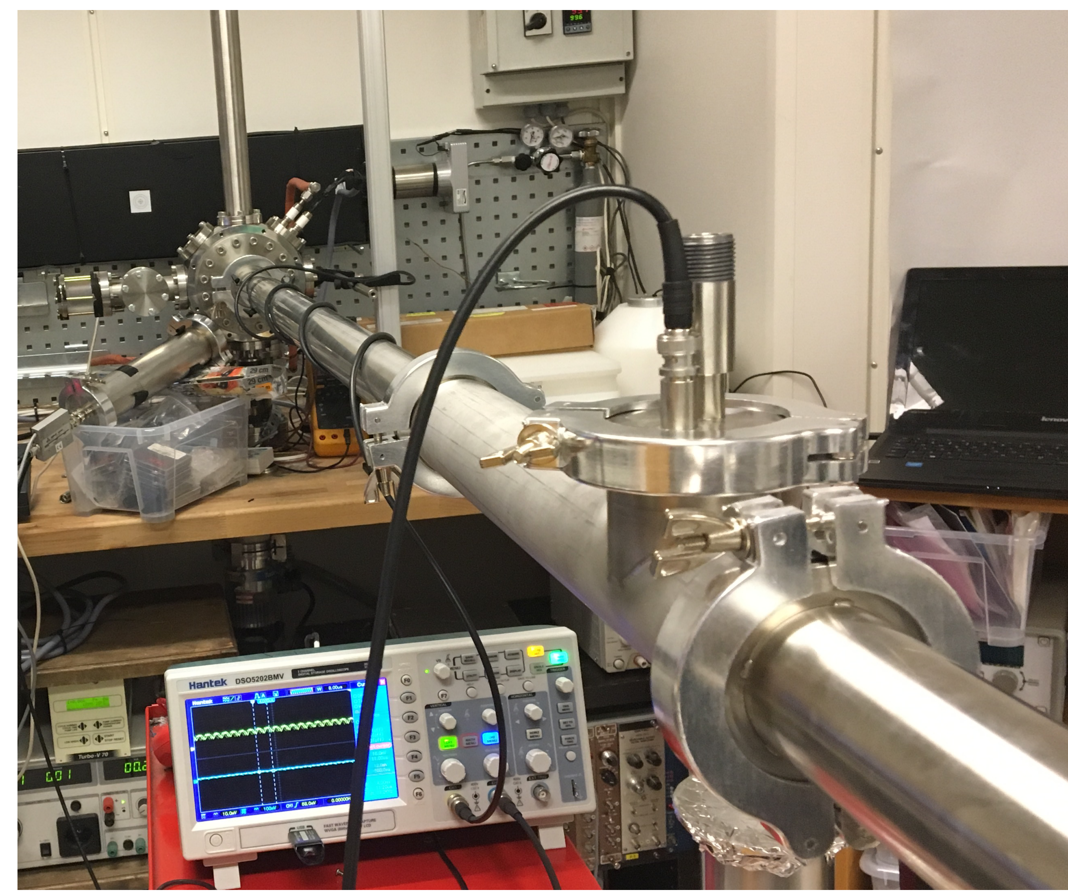
1. Beta electron distributions even after meter distances in air
2. The detection via metal converters
3. Life-time of muons measured
4. The pion and kaon lifetimes measured
5. The current of charged particles detected in air and in vacuum by ferrite coils, with pion lifetimes
6. Expected deflection of muons in magnetic fields

These evidences are still very indirect and therefore weak. The aim with the cooperation is to take the next step and either confirm these results and find better means of performing these experiments in real high energy physics lab or to find alternative explanation for the observed results.

MRD500 ultra fast diode



TOF detectors

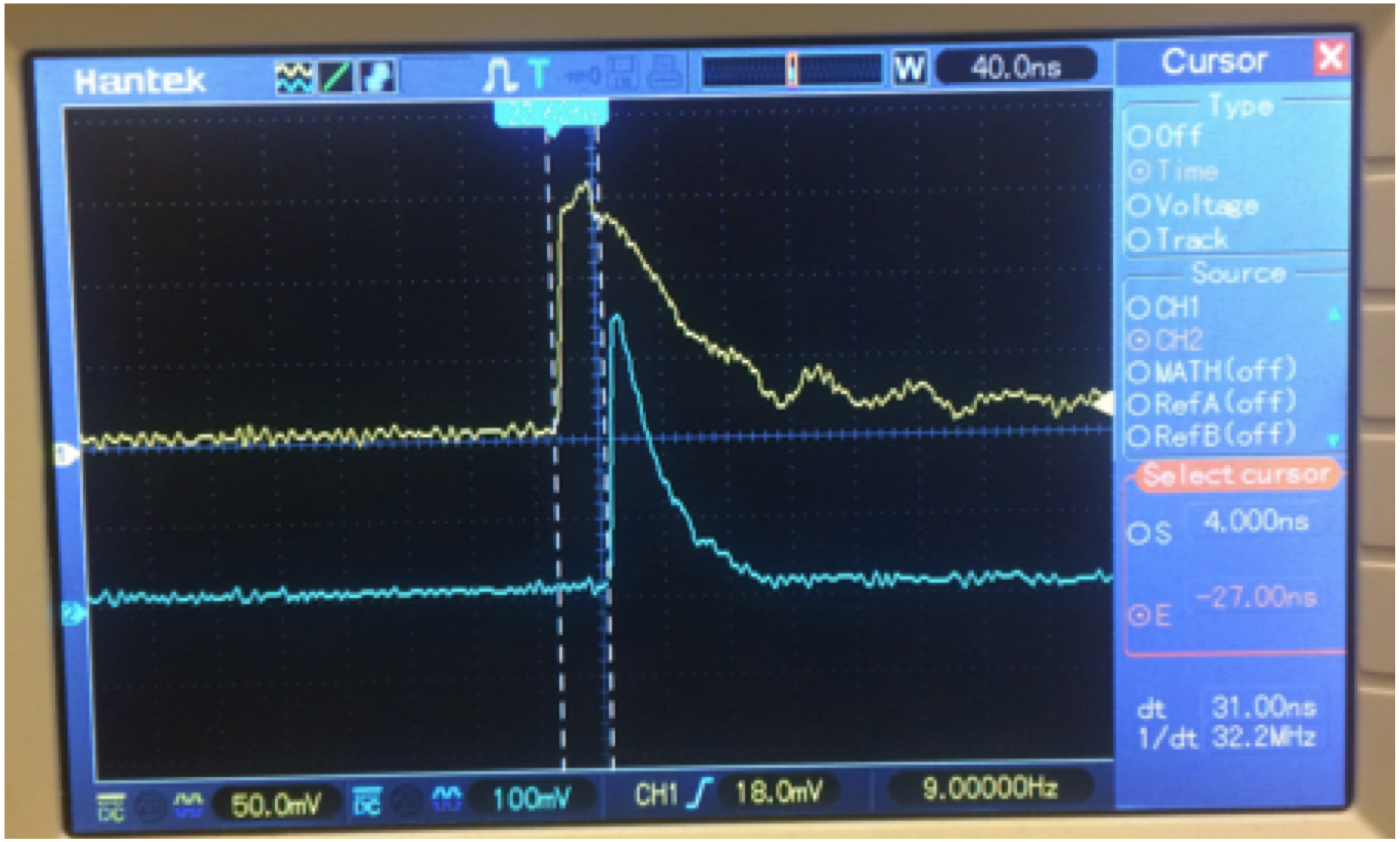


TOF: Coil

TOF: Faraday cup

Sindre Norway 2018
LH high kinetic energy release observed

- TOF length: 236 cm
- TOF: 31 ns
- Lifetime in the range of lifetime of pions π
- If we assume pion π the energy is 7,55 MeV.
- ”Muon” detector shows elevated spectra



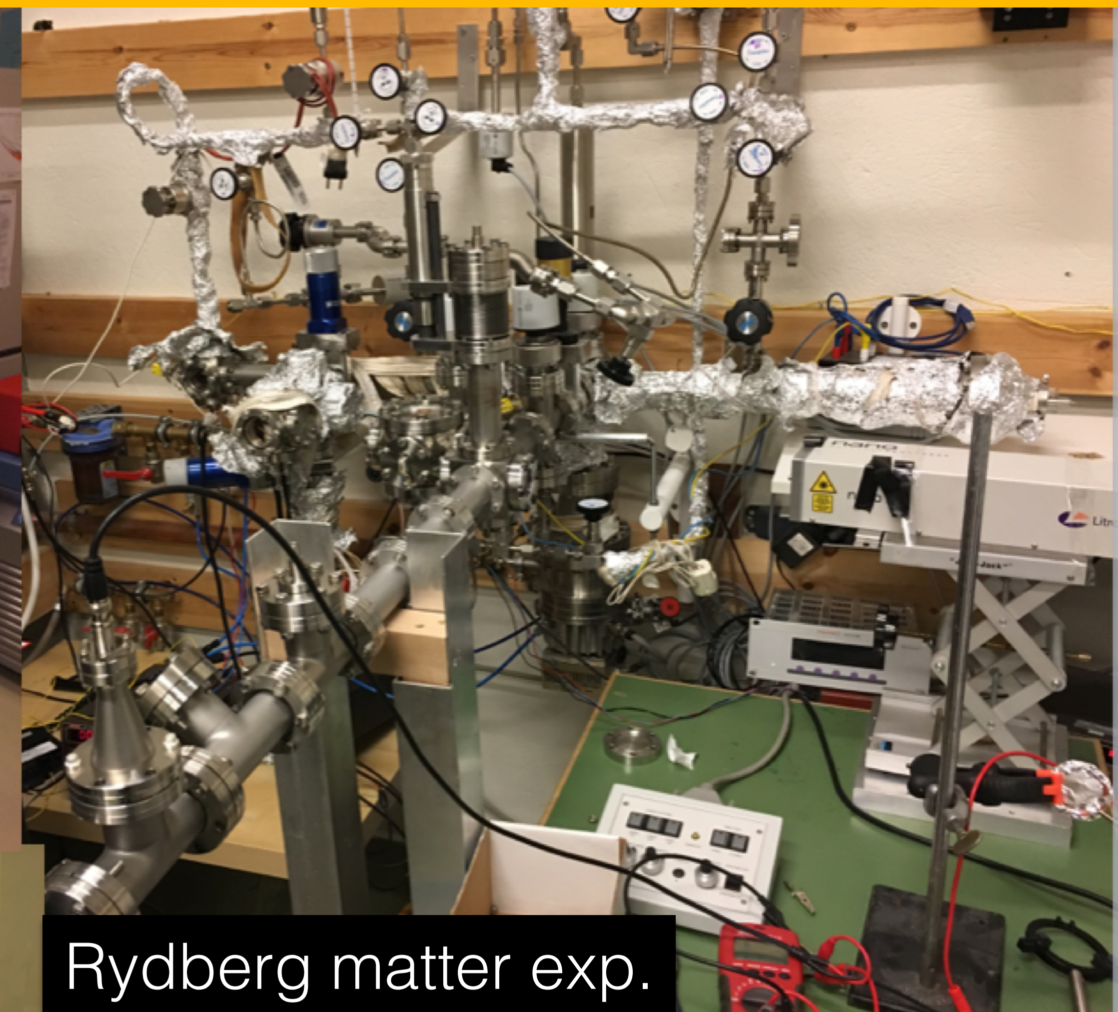
Experimental lab in Iceland

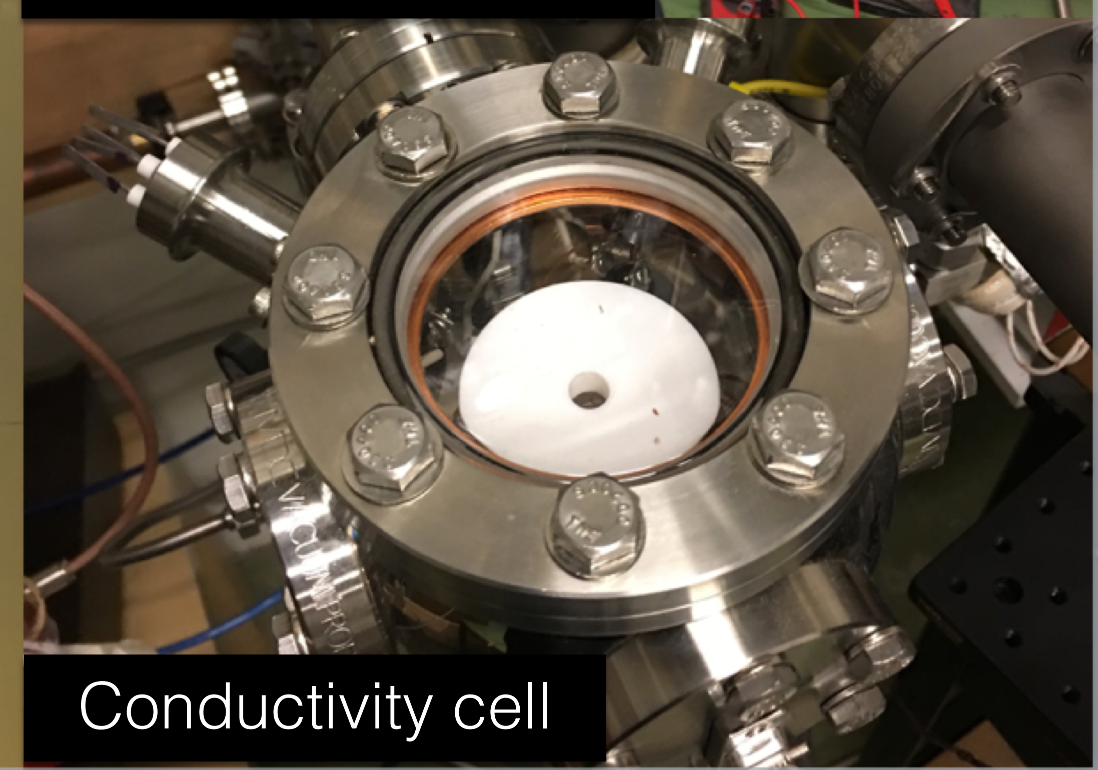
Experimental techniques for studying Rydberg matter of Hydrogen

Sveinn Ólafsson University of Iceland

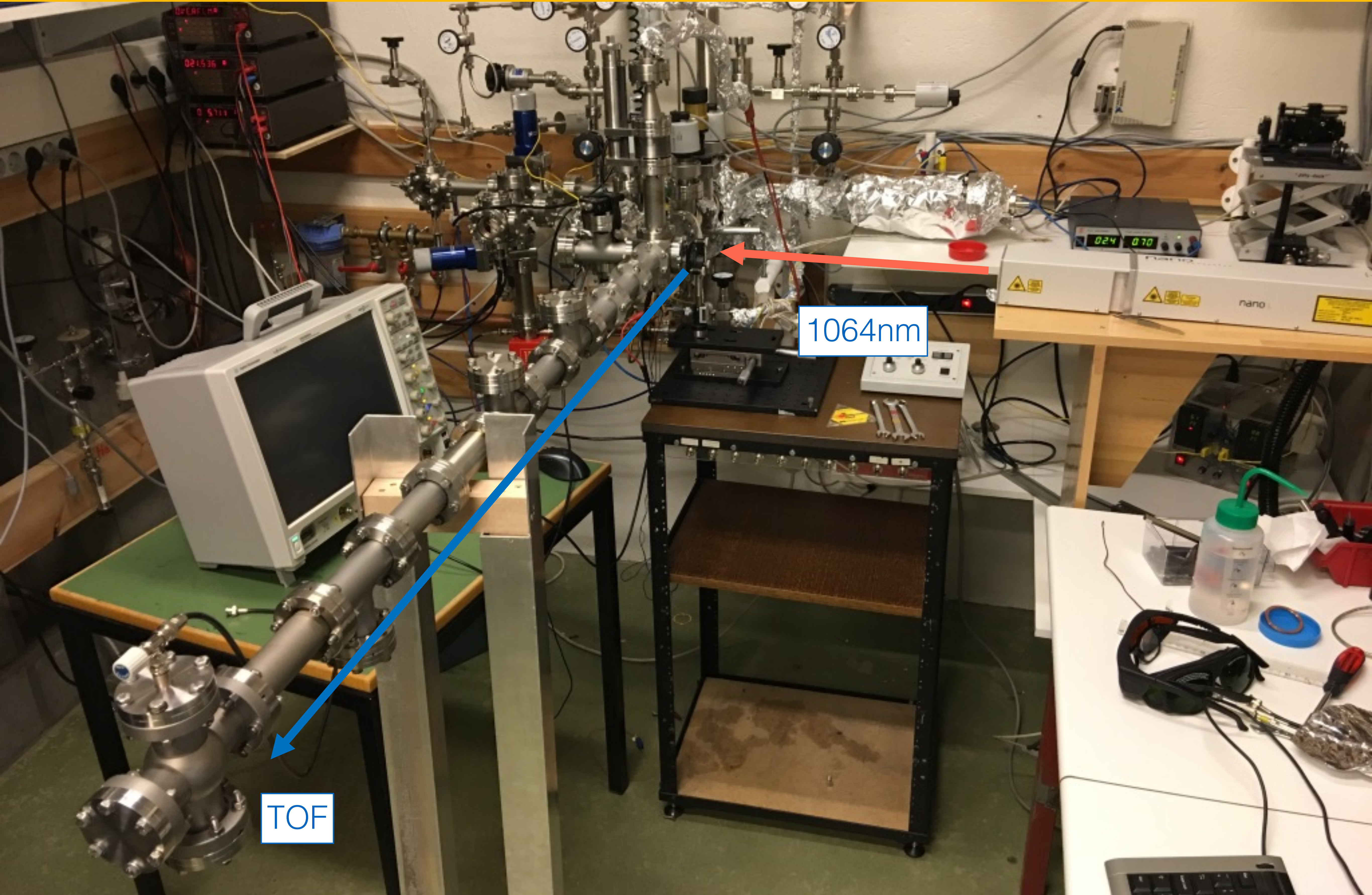
2019 LANR/CF Colloquium at MIT

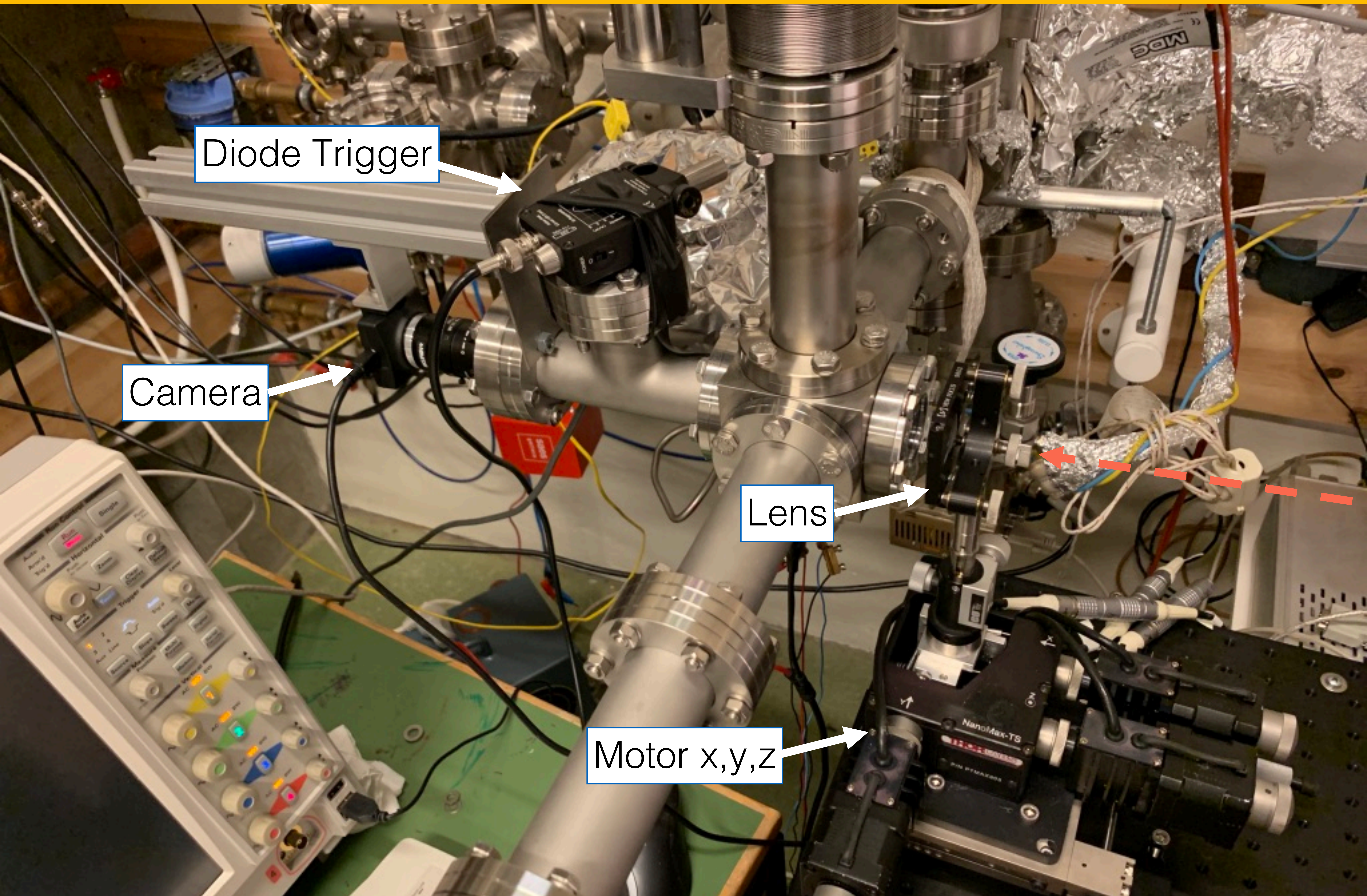
LANR Science and Engineering:From Hydrogen to Clean Energy Production Systems

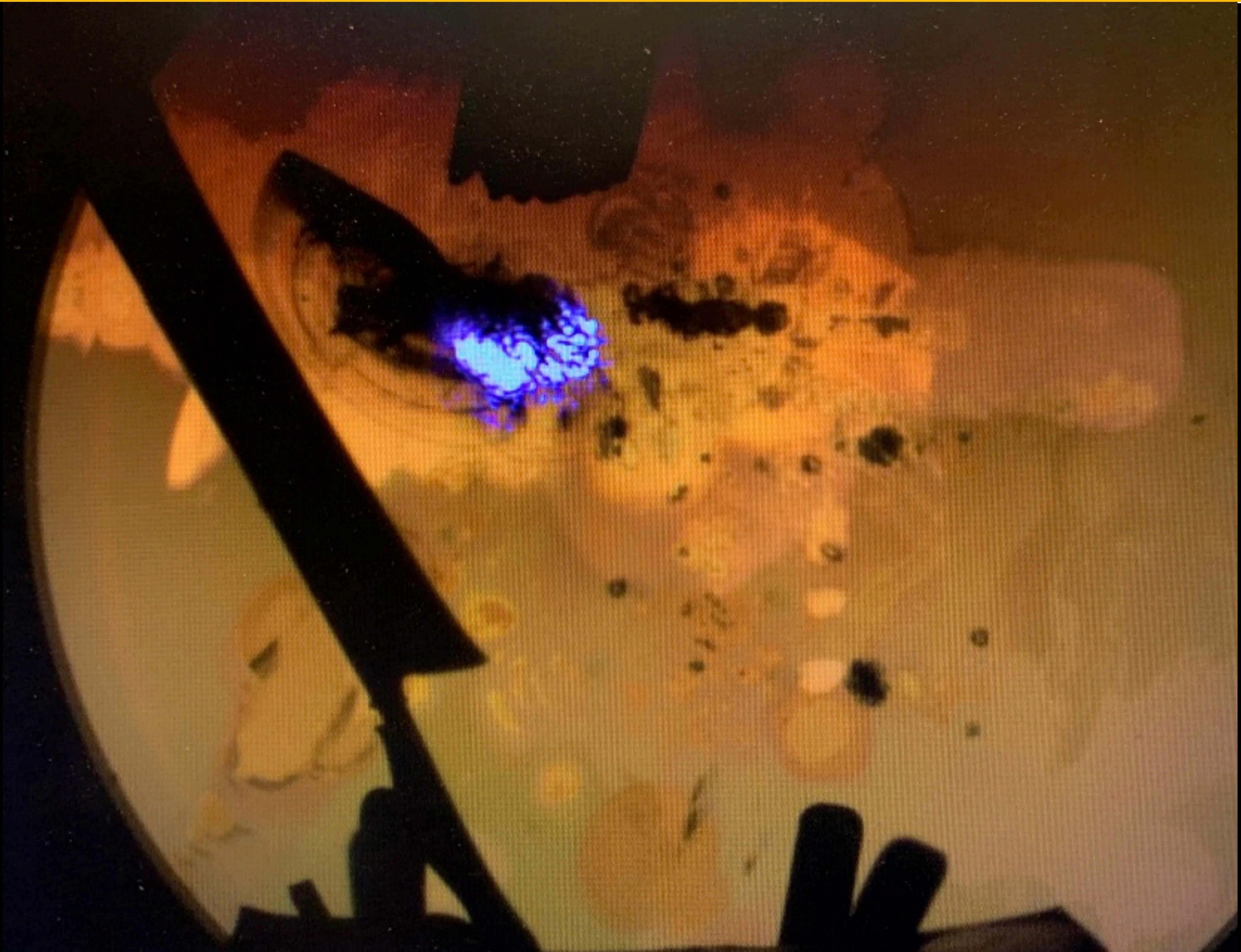




Experimental development last 6 months


1064nm
TOF


Diode Trigger
Camera
Lens
Motor x,y,z
NanoMax-TS



Experimental techniques for studying Rydberg matter of Hydrogen

Sveinn Ólafsson University of Iceland

2019 LANR/CF Colloquium at MIT

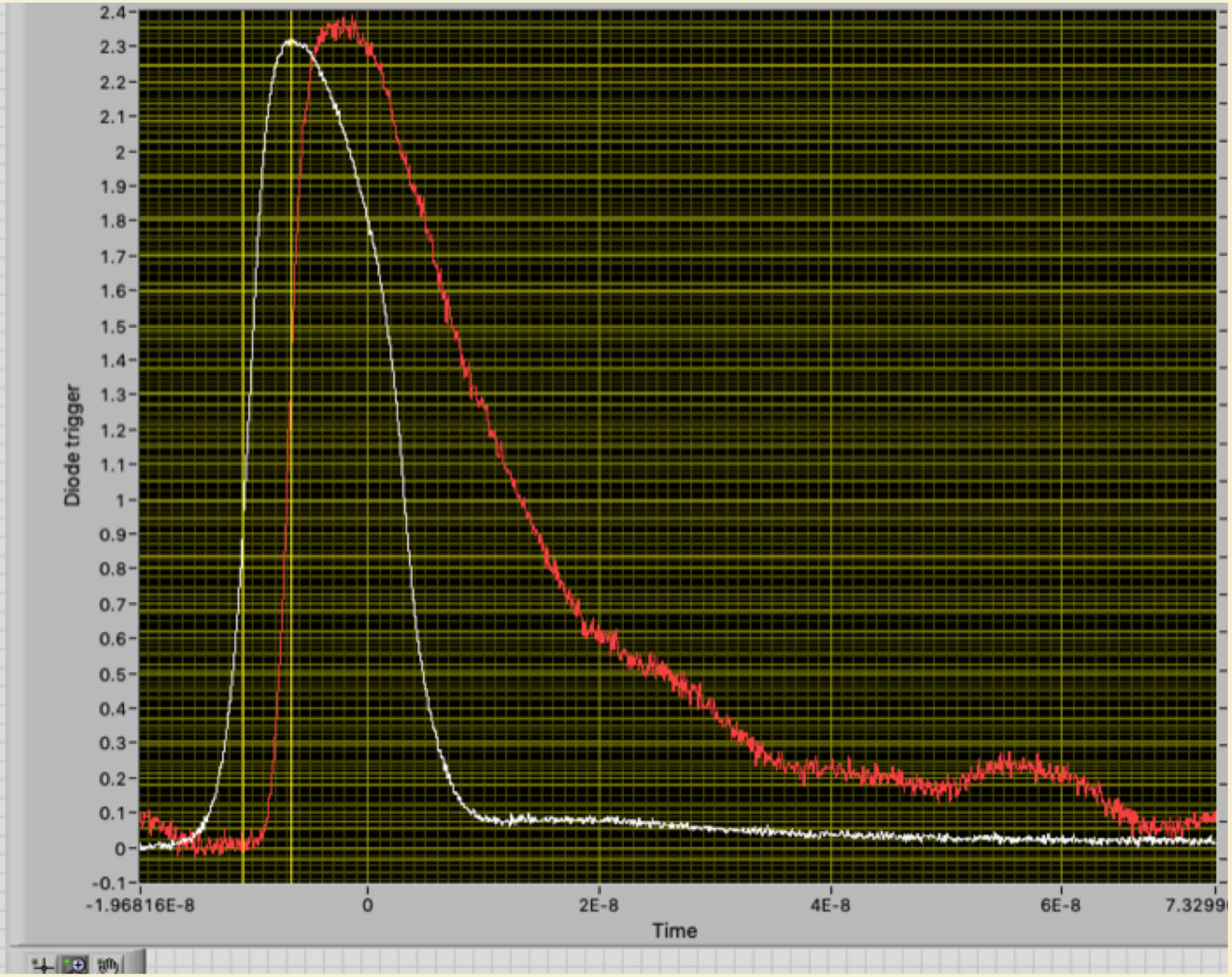
LANR Science and Engineering:From Hydrogen to Clean Energy Production Systems

4GHz scope, 20GS/s 50ps

High Kinetic energy release Iceland January 15, 2019

- TOF : 4.0 ± 0.7 ns
- TOF length: 105 cm
- Speed 0.95c!
- Decay time: ≈26ns
- If we assume π-mesons, the energy is 90 MeV
- ”Muon” detector shows elevated spectra

Observed decay time similar to:
K-mesons : 13 ns
π -mesons : 26 ns
Muons : 2,2 us

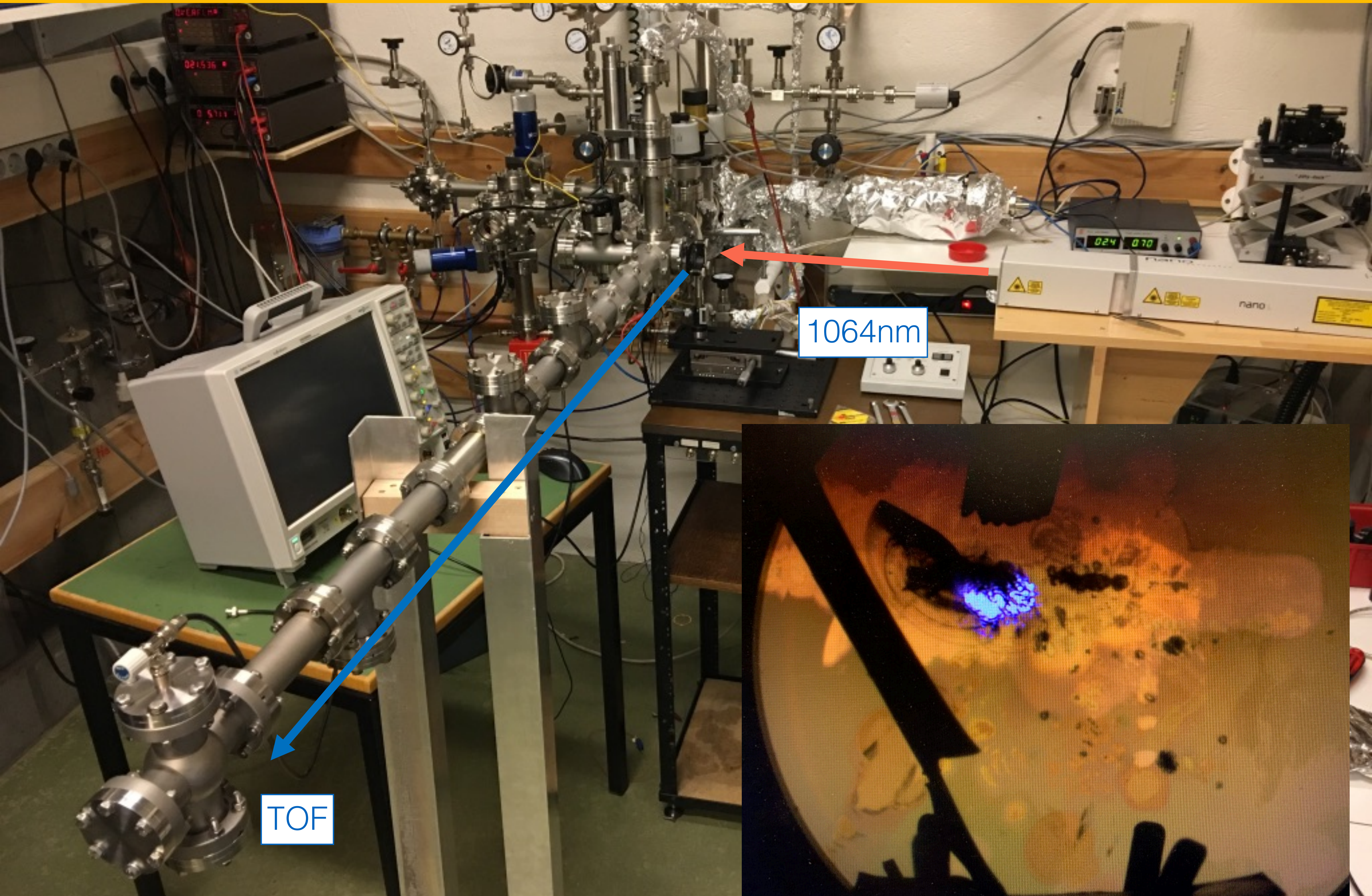


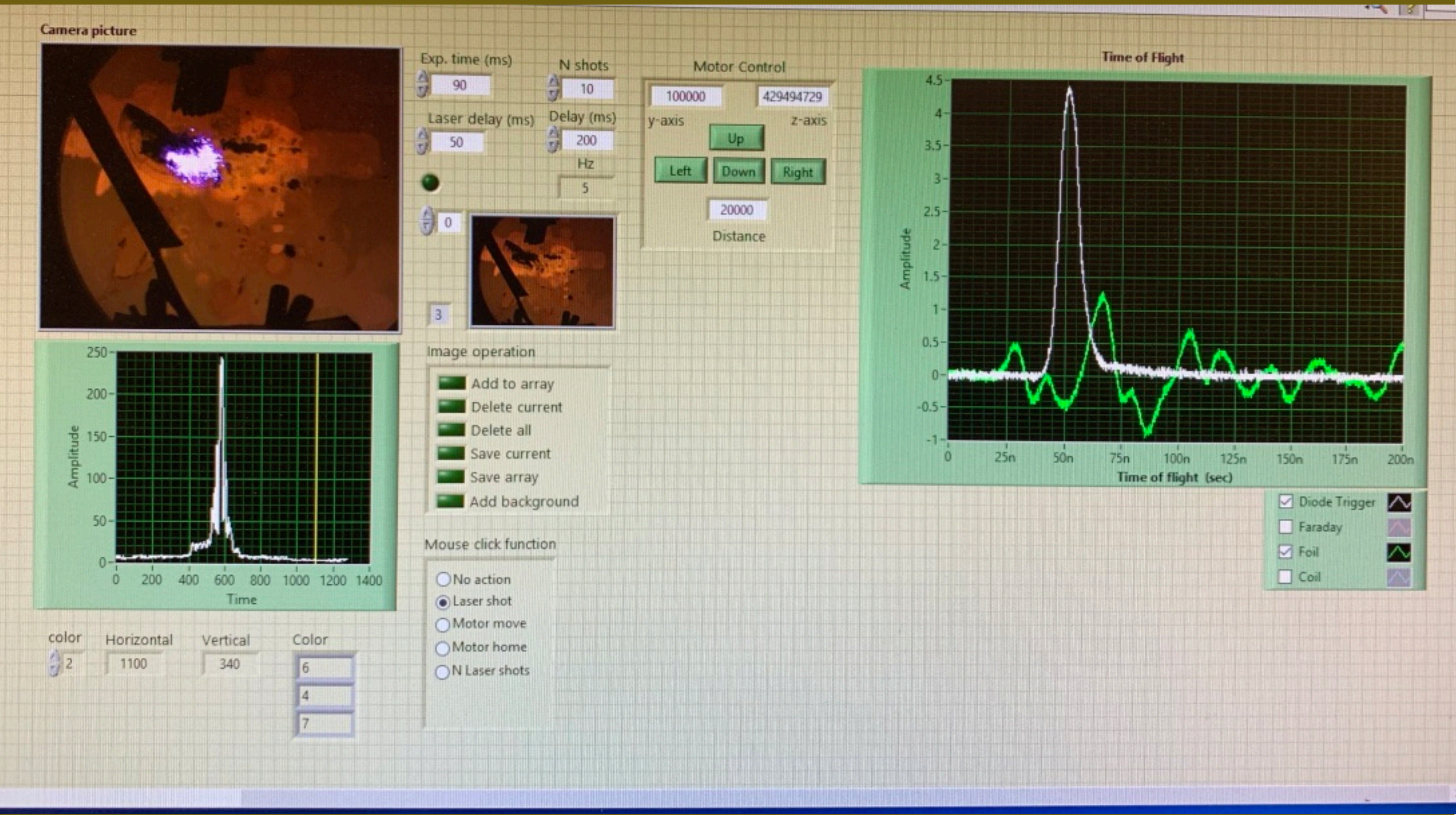
Experimental techniques for studying Rydberg matter of Hydrogen

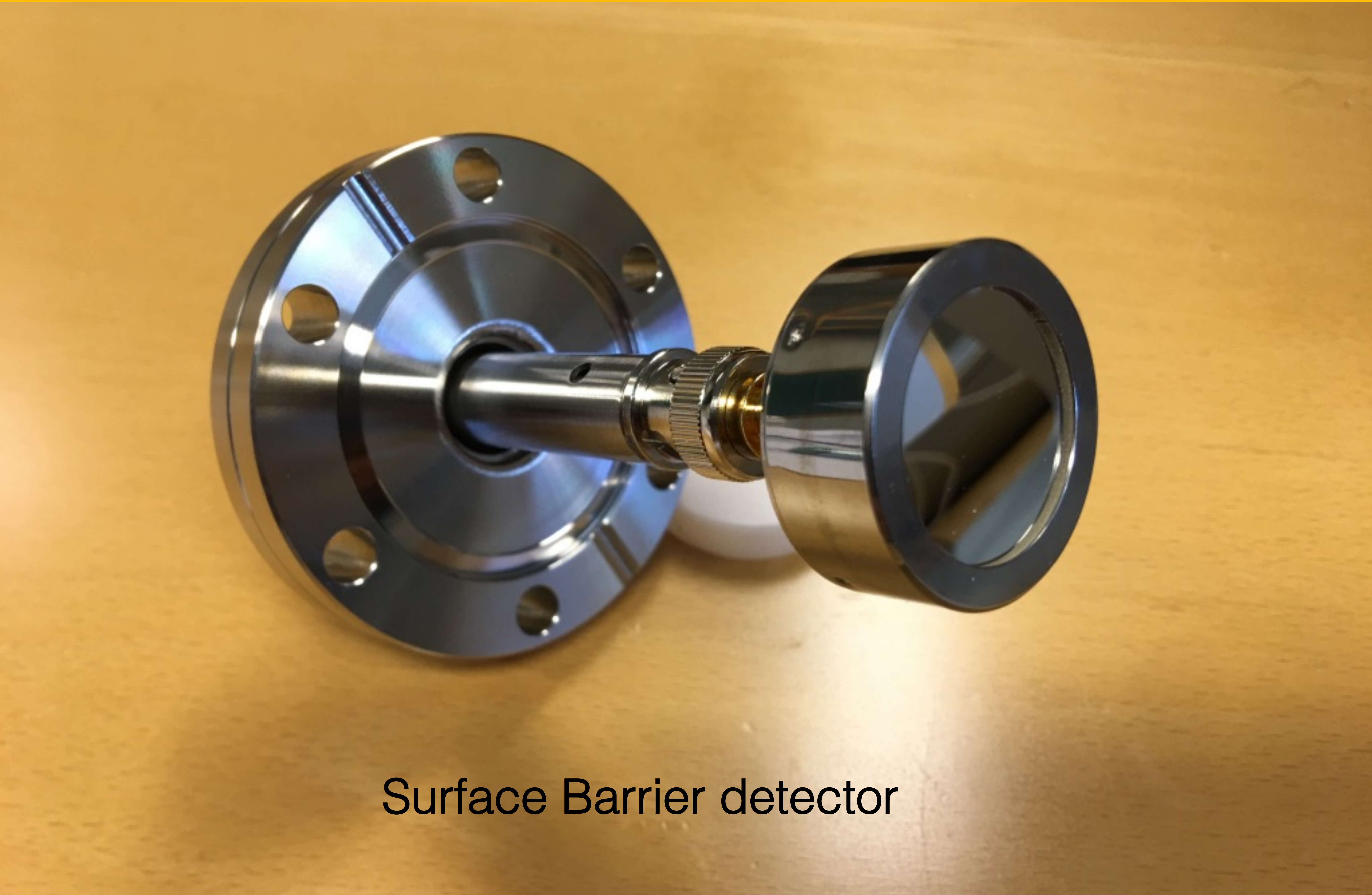
Sveinn Ólafsson University of Iceland

2019 LANR/CF Colloquium at MIT

LANR Science and Engineering:From Hydrogen to Clean Energy Production Systems




Camera picture
Exp. time (ms)
90
N shots
10
Laser delay (ms)
50
Delay (ms)
200
Hz
5
0
3
Motor Control
100000
429494729
y-axis
z-axis
Up
Left
Down
Right
20000
Distance
Time of Flight
Amplitude
Time of flight (sec)
Diode Trigger
Faraday
Foil
Coil
Image operation
Add to array
Delete current
Delete all
Save current
Save array
Add background
Mouse click function
No action
Laser shot
Motor move
Motor home
N Laser shots
Amplitude
Time
color
2
Horizontal
1100
Vertical
340
Color
6
4
7



Surface Barrier detector

Theoretical possibilities for proton annihilation

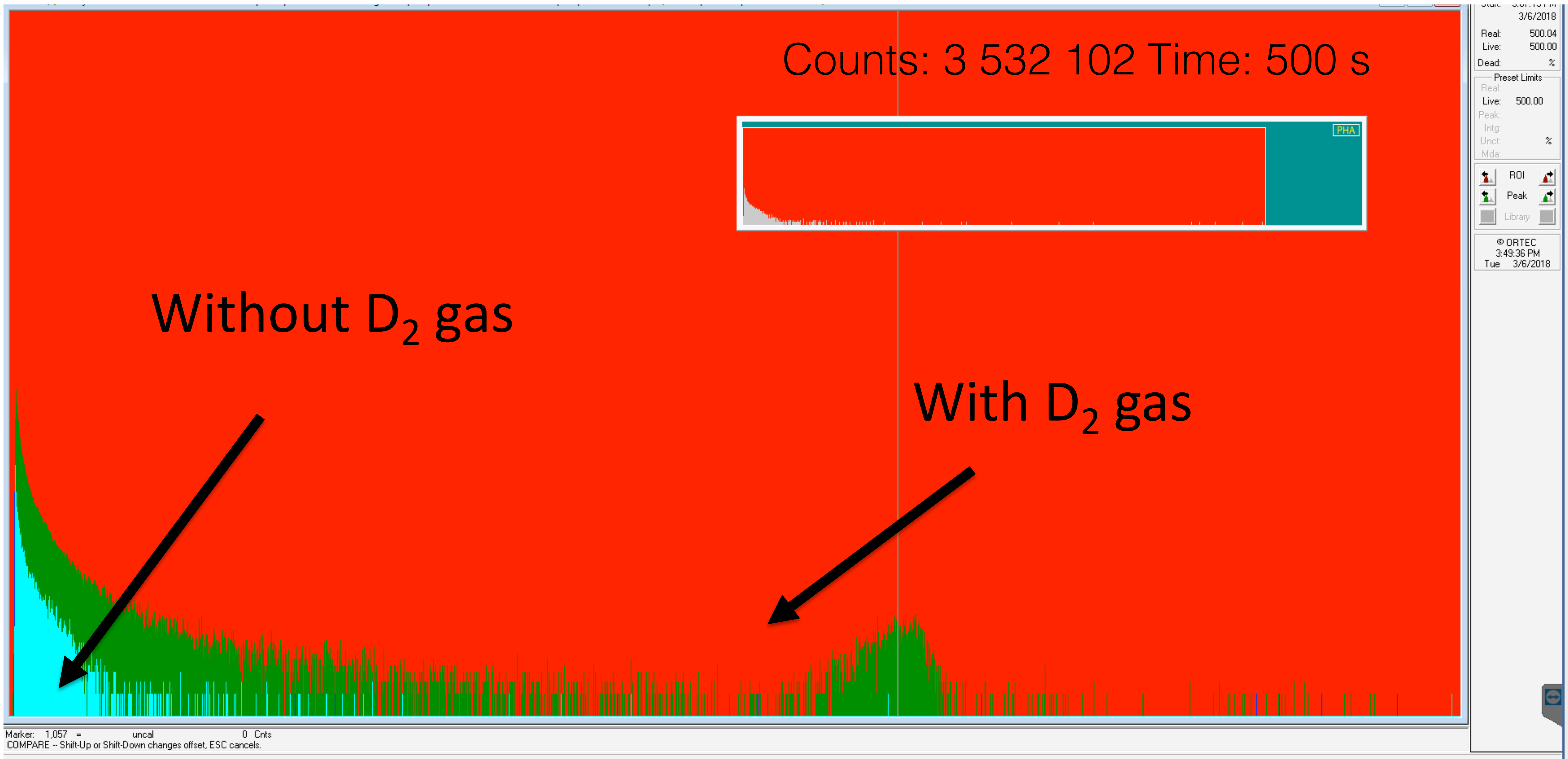
(It is speculation time)

- 3N-proton -> 3N-anti-lepton.
- Allowed according to the Standard Model !
- Never been observed, big bang high temperature conditions >10TeV
- Too high energy for the LHC accelerator at CERN.

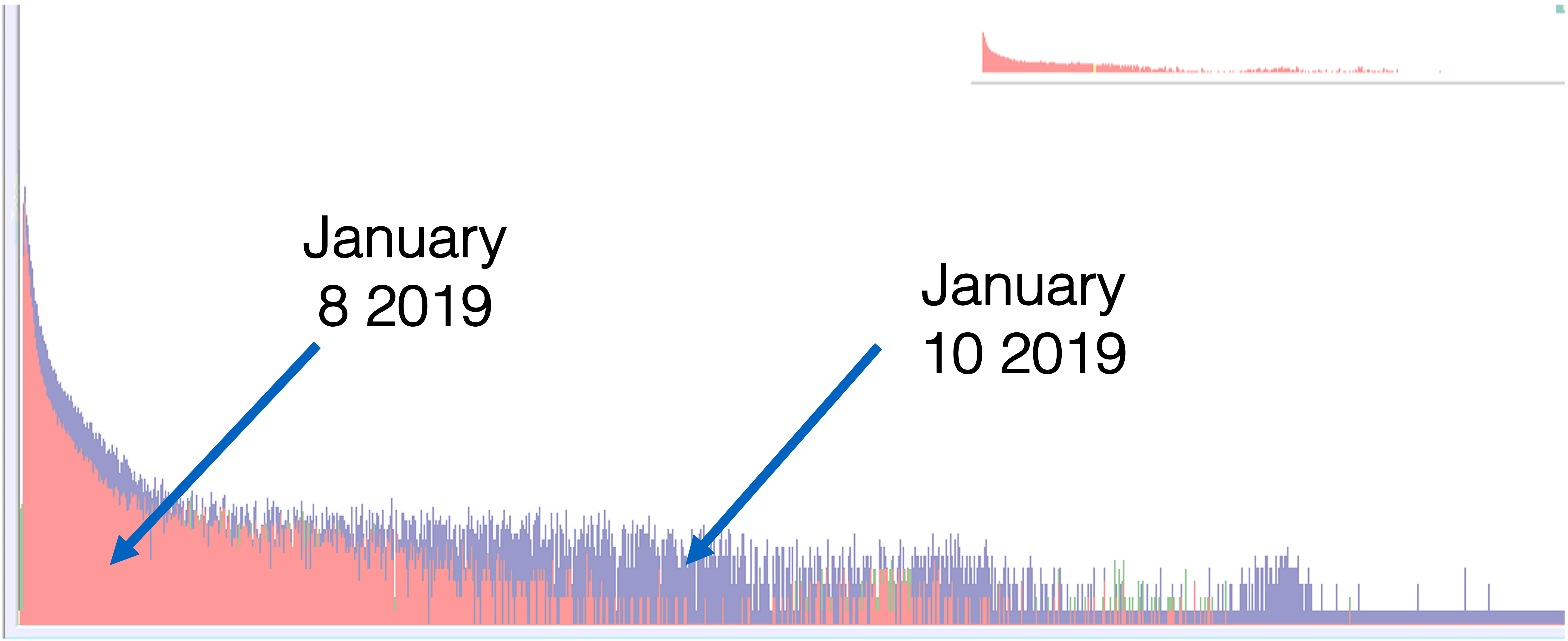
- Candidate to solve mystery in cosmology i.e. Baryogenisis.
- Baryonic asymmetry, i.e. the imbalance of matter and antimatter
- Driven by the Adler–Bell–Jackiw anomaly in electroweak interactions

- Why appearing in LH experiments?
- Quantum Bose Einstein condensation/entanglement in the Ultra-dense phase of protons due to long interaction times (days instead of 10^{-25} sec.)?

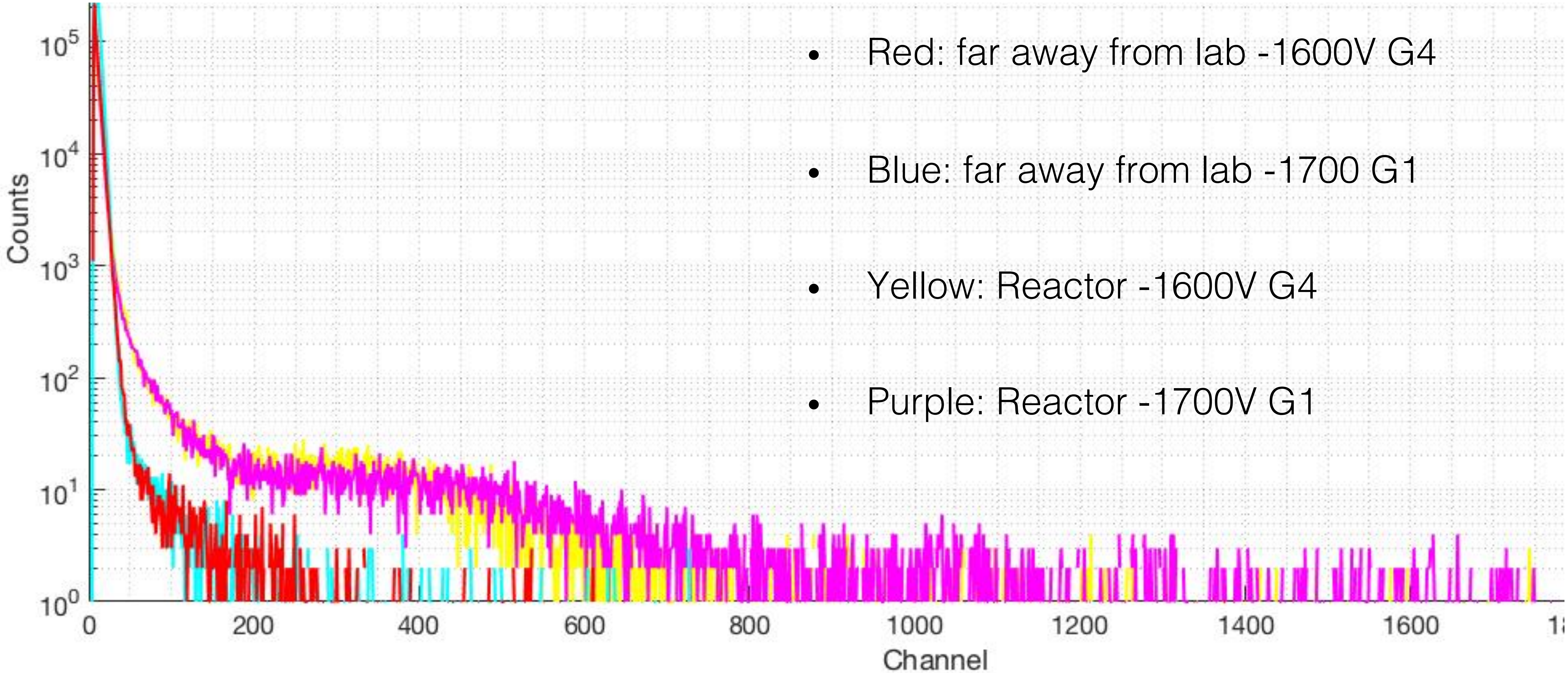
LH "Muon" signal in Norway



LH "Muon" signal in Iceland

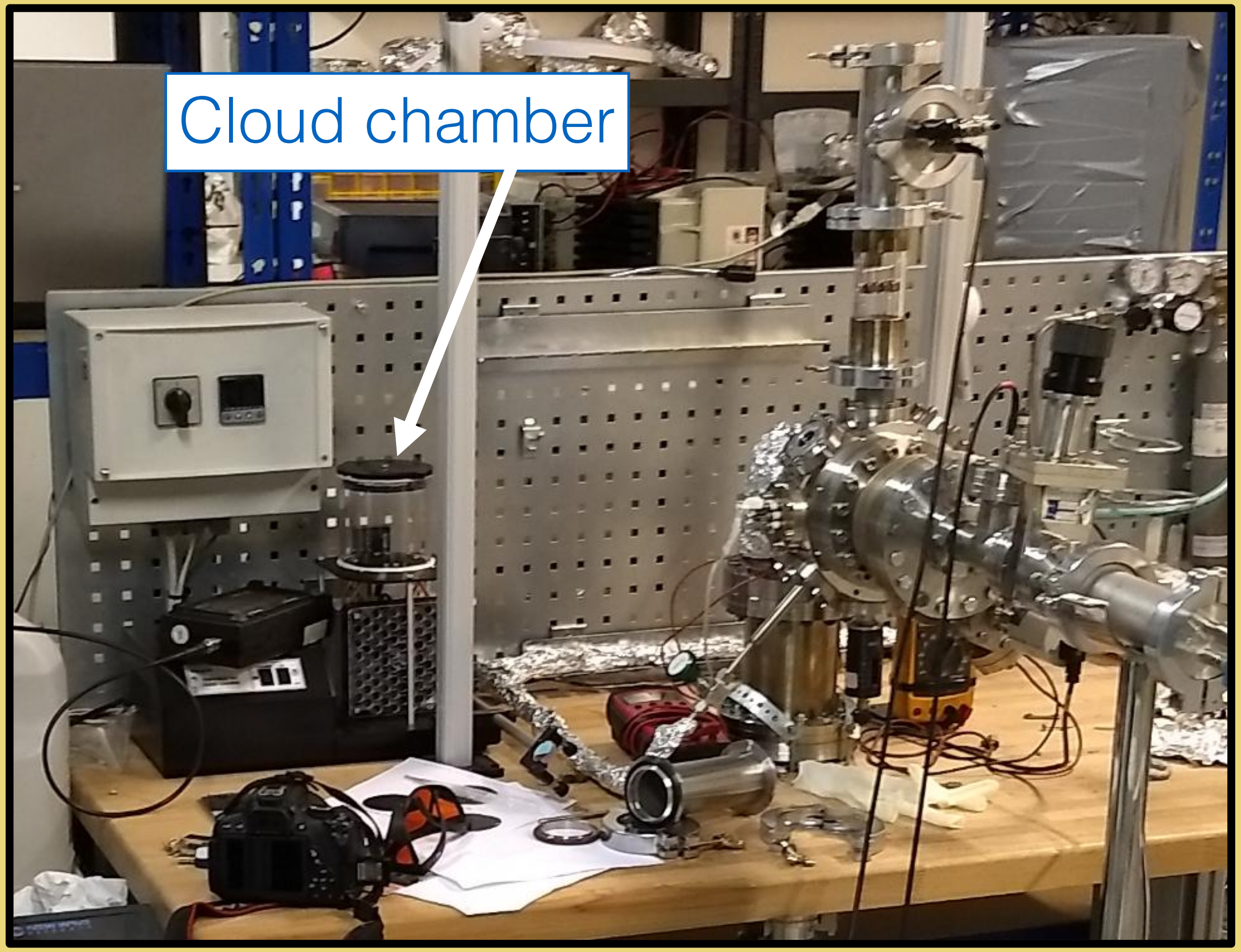


In lab out of lab comparison



- Red: far away from lab -1600V G4
- Blue: far away from lab -1700 G1
- Yellow: Reactor -1600V G4
- Purple: Reactor -1700V G1

Cloud chamber tracks



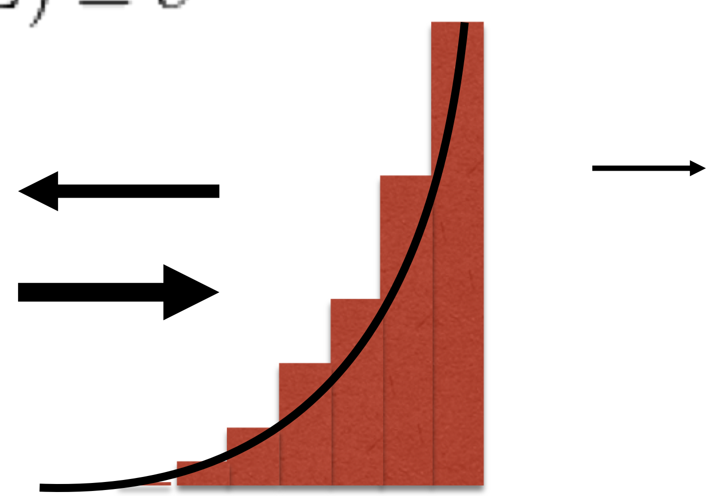
Thank you for listening

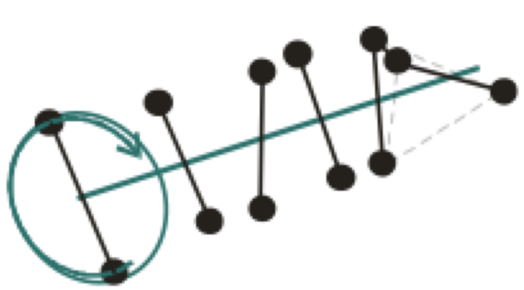
Tunneling fusion rate model for the Coulomb potential

Rate = Gamov probability of crossing the barrier x attempt frequency

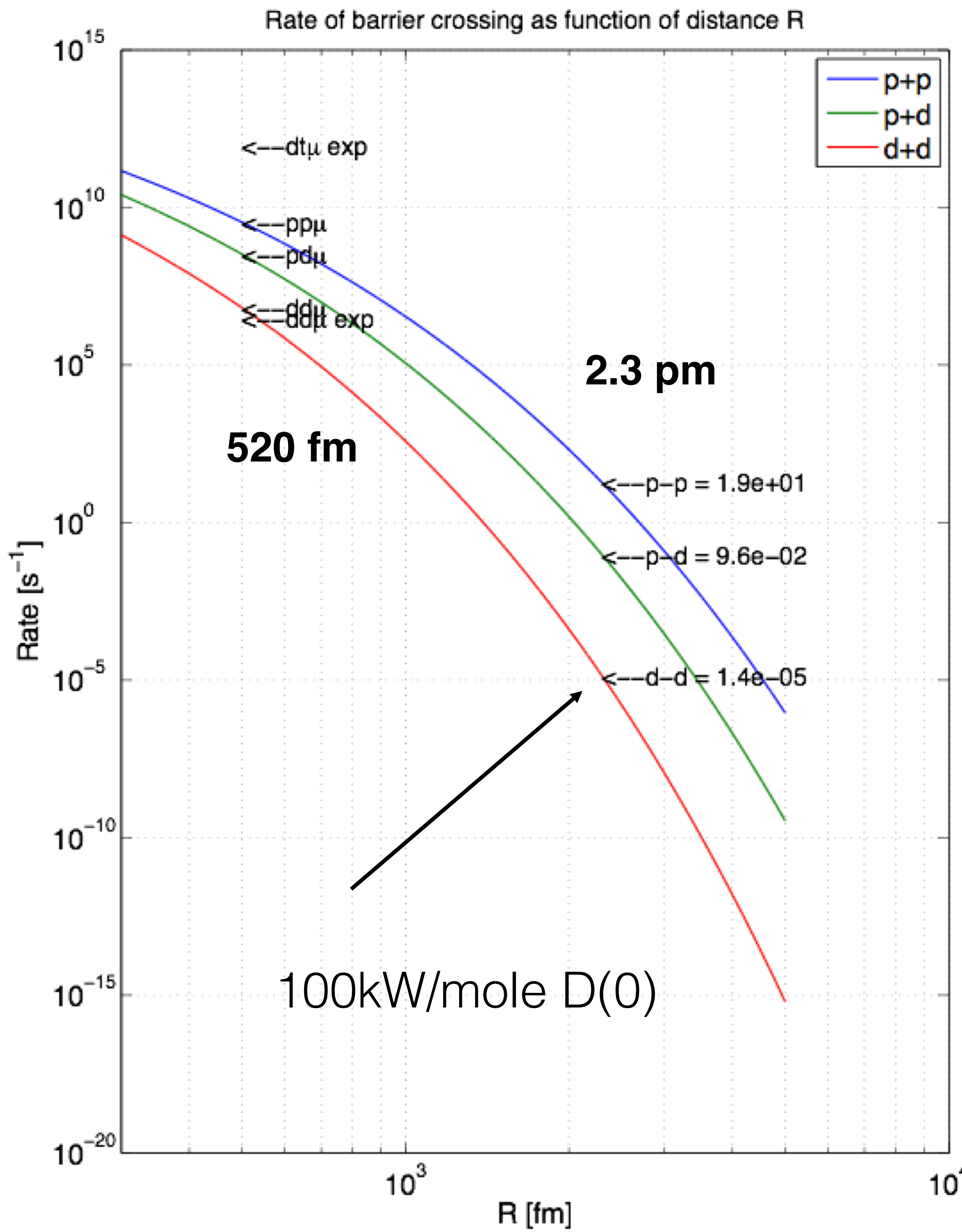
Reaction crossections are not included
Calculation are shown for f = 10^{16}/s.

$$P_g(E) \equiv e^{-\frac{E_g}{E}^{1/2}}$$



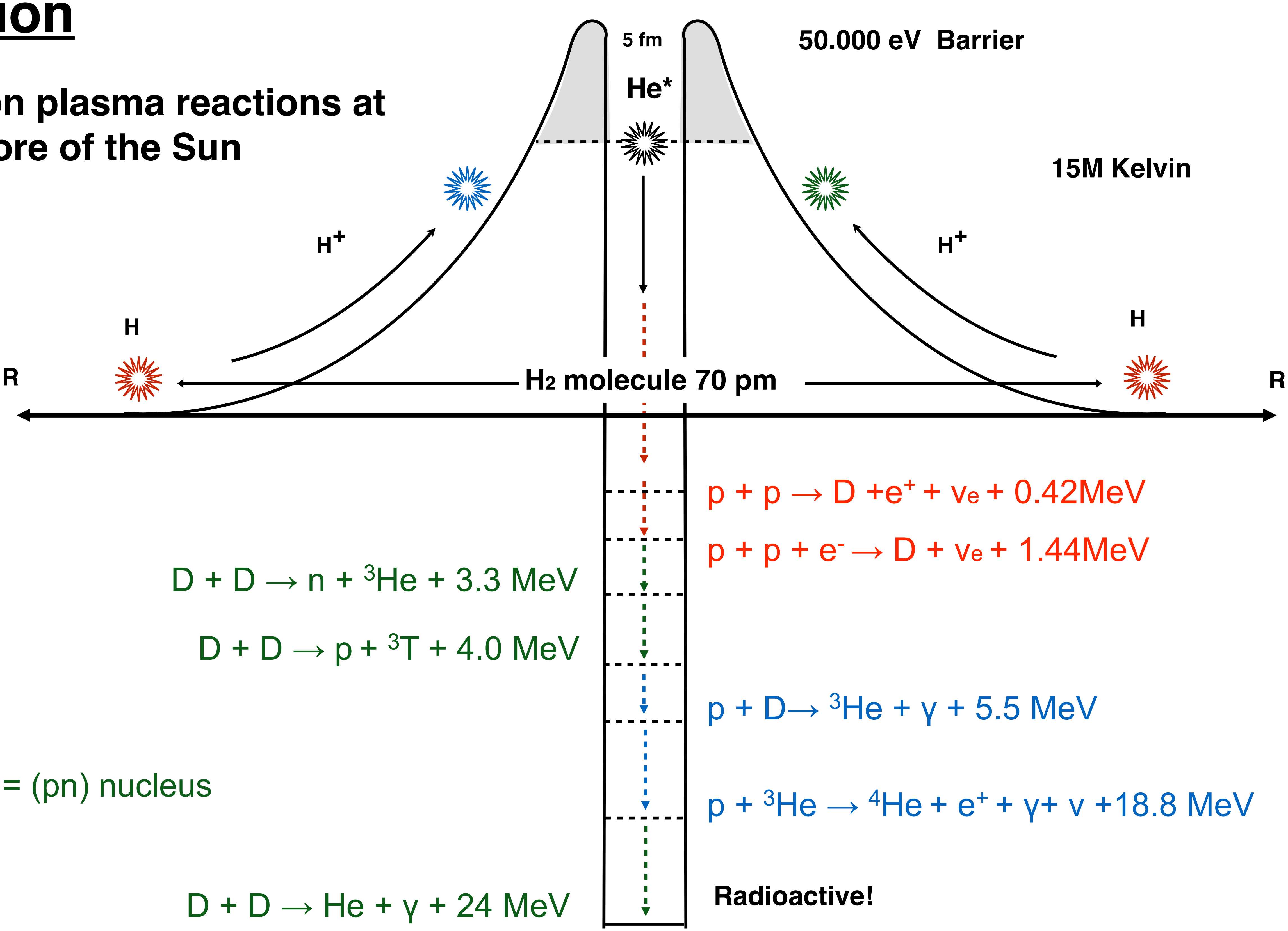


2.3 ± 0.1 pm!



Fusion

Fusion plasma reactions at the core of the Sun



$p + p \rightarrow D + e^+ + \nu_e + 0.42 MeV$

$p + p + e^- \rightarrow D + \nu_e + 1.44 MeV$

$D + D \rightarrow n + {}^3He + 3.3$ MeV

$D + D \rightarrow p + {}^3T + 4.0$ MeV

$p + D \rightarrow {}^3He + \gamma + 5.5$ MeV

$p + {}^3He \rightarrow {}^4He + e^+ + \gamma + \nu + 18.8$ MeV

D = (pn) nucleus

$D + D \rightarrow He + \gamma + 24$ MeV

Radioactive!

Molecular muonium fusion, *μ*-catalysed fusion known since 1947

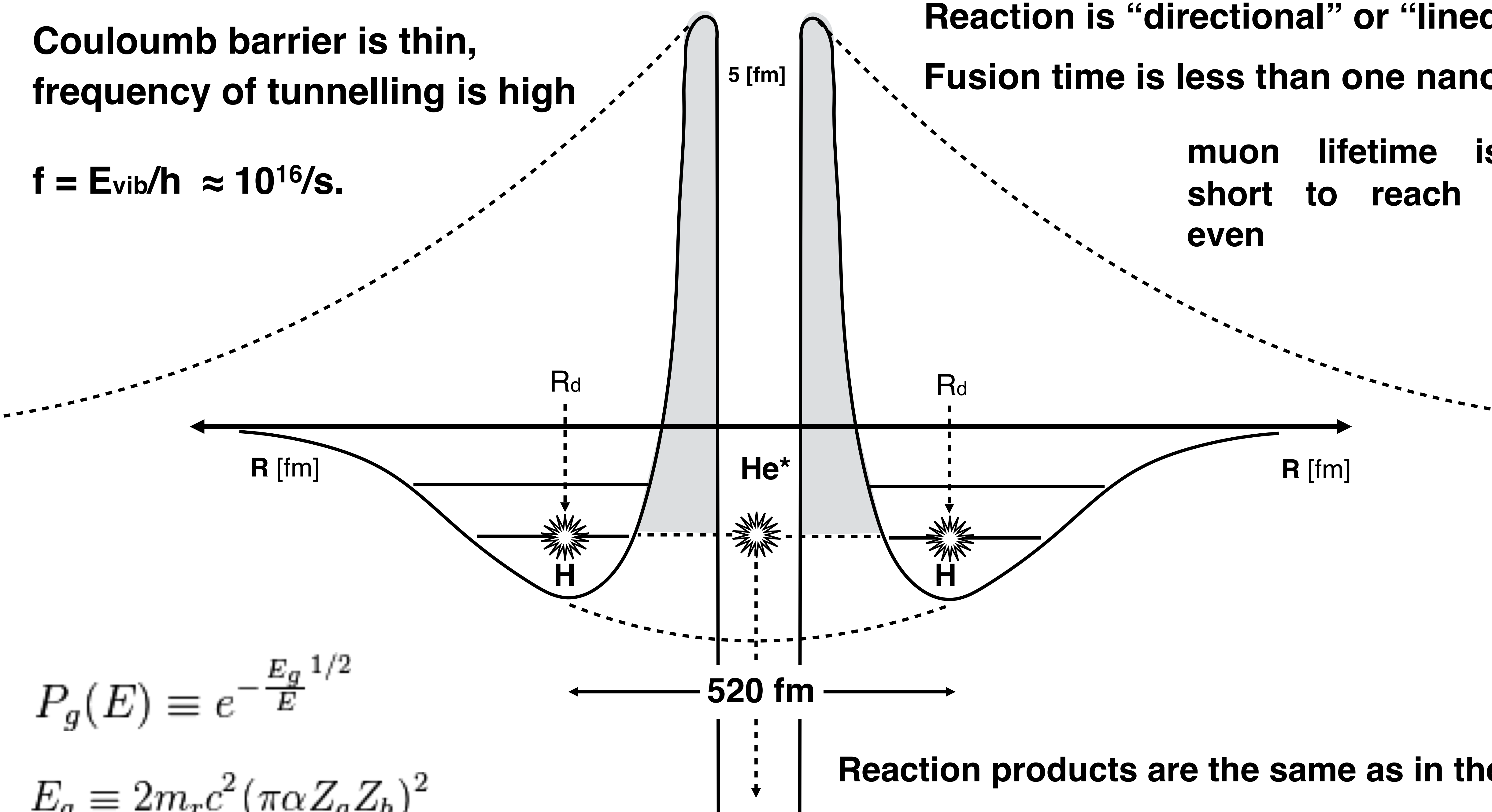
Couloumb barrier is thin, frequency of tunnelling is high

f = E_{vib}/h ≈ 10^{16}/s.

Reaction is "directional" or "lined up"

Fusion time is less than one nanosecond

muon lifetime is to short to reach beak even



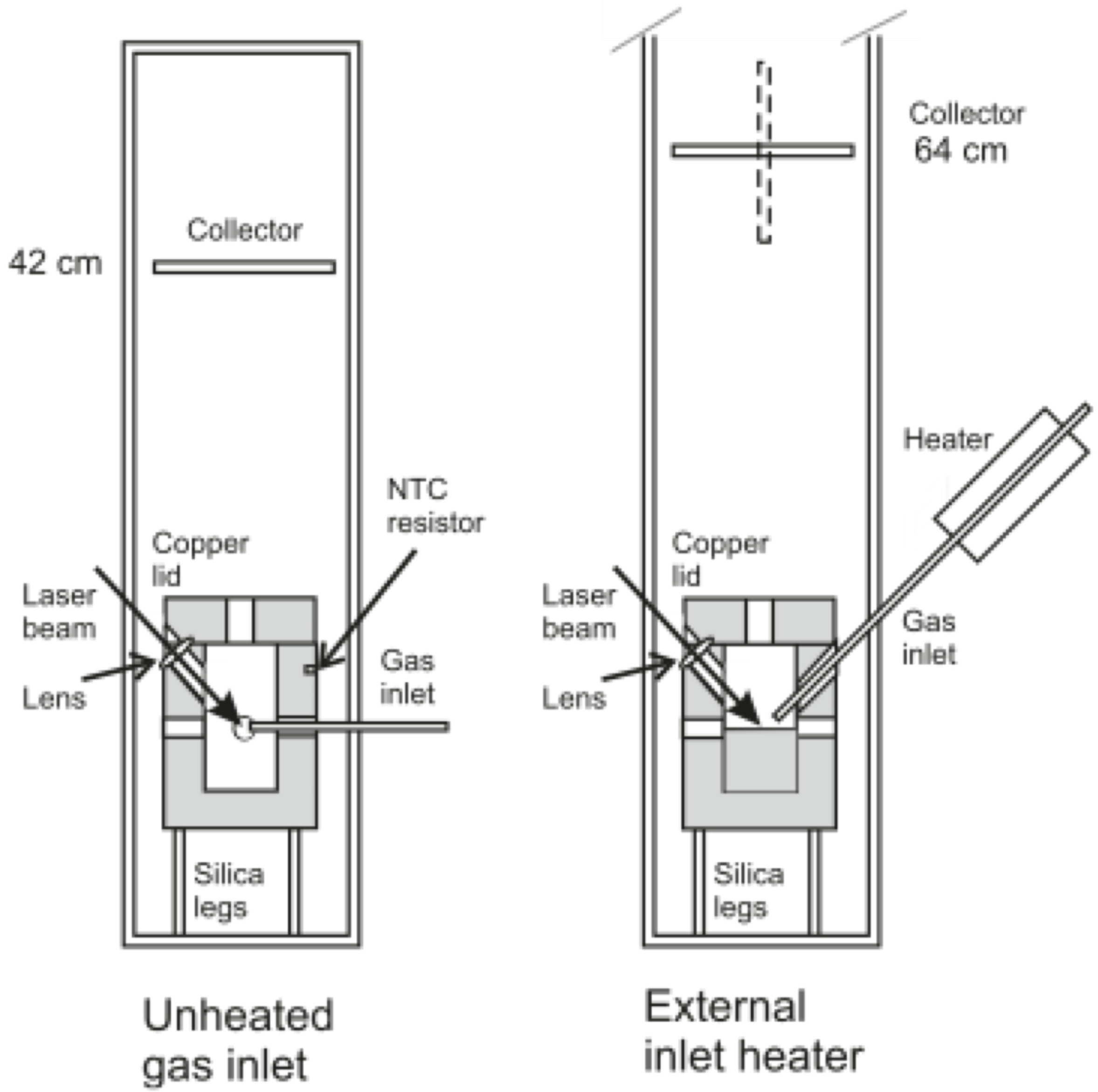
$$P_g(E) \equiv e^{-\frac{E_g}{E}^{1/2}}$$

$$E_g \equiv 2 m_r c^2 (\pi \alpha Z_a Z_b)^2$$

Reaction products are the same as in the Sun !

Not drawn to scale

Rutherford radium "like" calorimetry experiment



Confirms
> break even
energy production

Heat generation above break-even from laser-induced fusion in ultra-dense deuterium
Leif Holmlid AIP Advances, Volume 5, Issue 8, Pages artikel nr 087129 2015