HELSINKI INSTITUTE OF PHYSICS

# Other experimental activities at CERN

World leading ISOL-type facility for basic and applied research with radioactive isotopes
Dr. Janne Pakarinen, JY

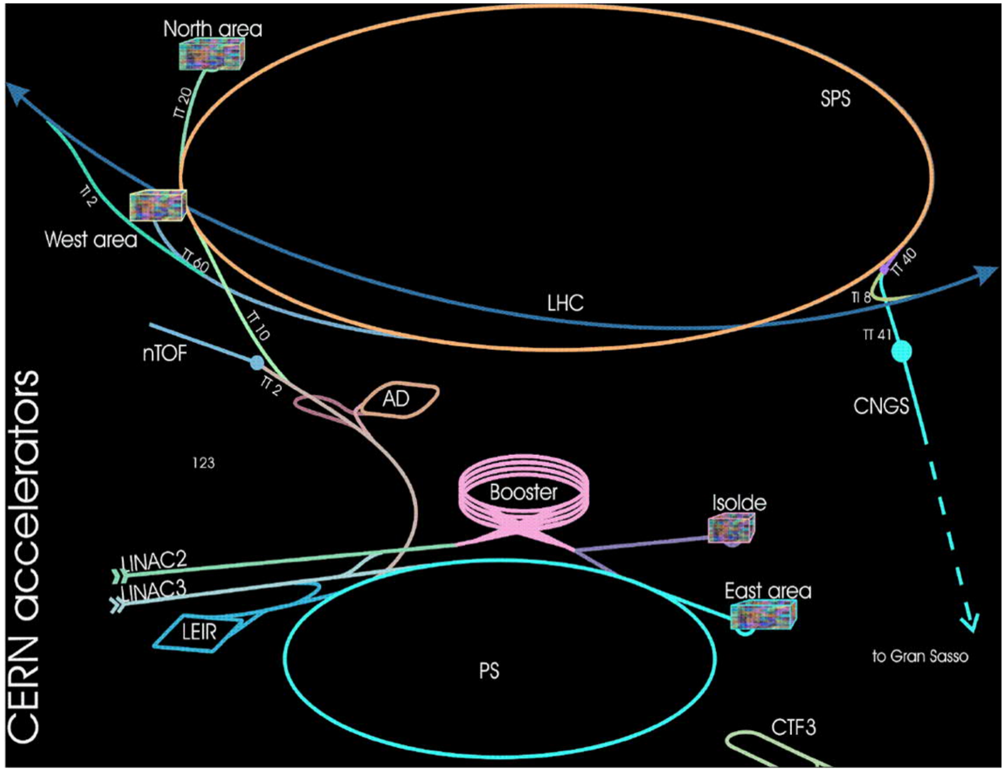
State-of-the-art instrumentation to simulate every step of the particle formation processes in the laboratory
Prof. Markku Kulmala, HY

Ari Jokinen
Department of Physics
UNIVERSITY OF JYVÄSKYLÄ
JYVÄSKYLÄN YLIOPISTO

# Other experimental activities at CERN

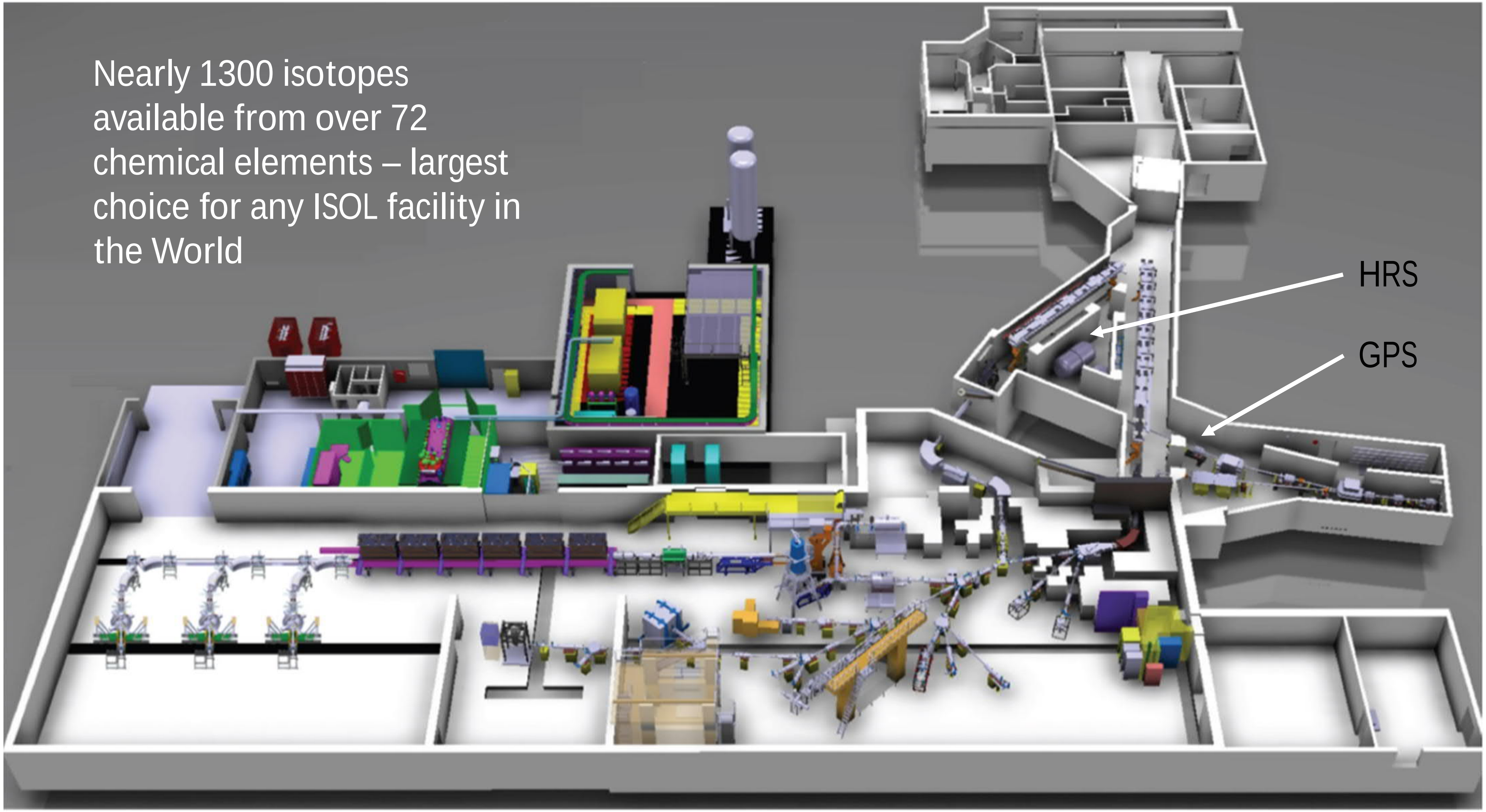
ISOLDE at PS-booster

CLOUD using beam from Proton Synchrotron

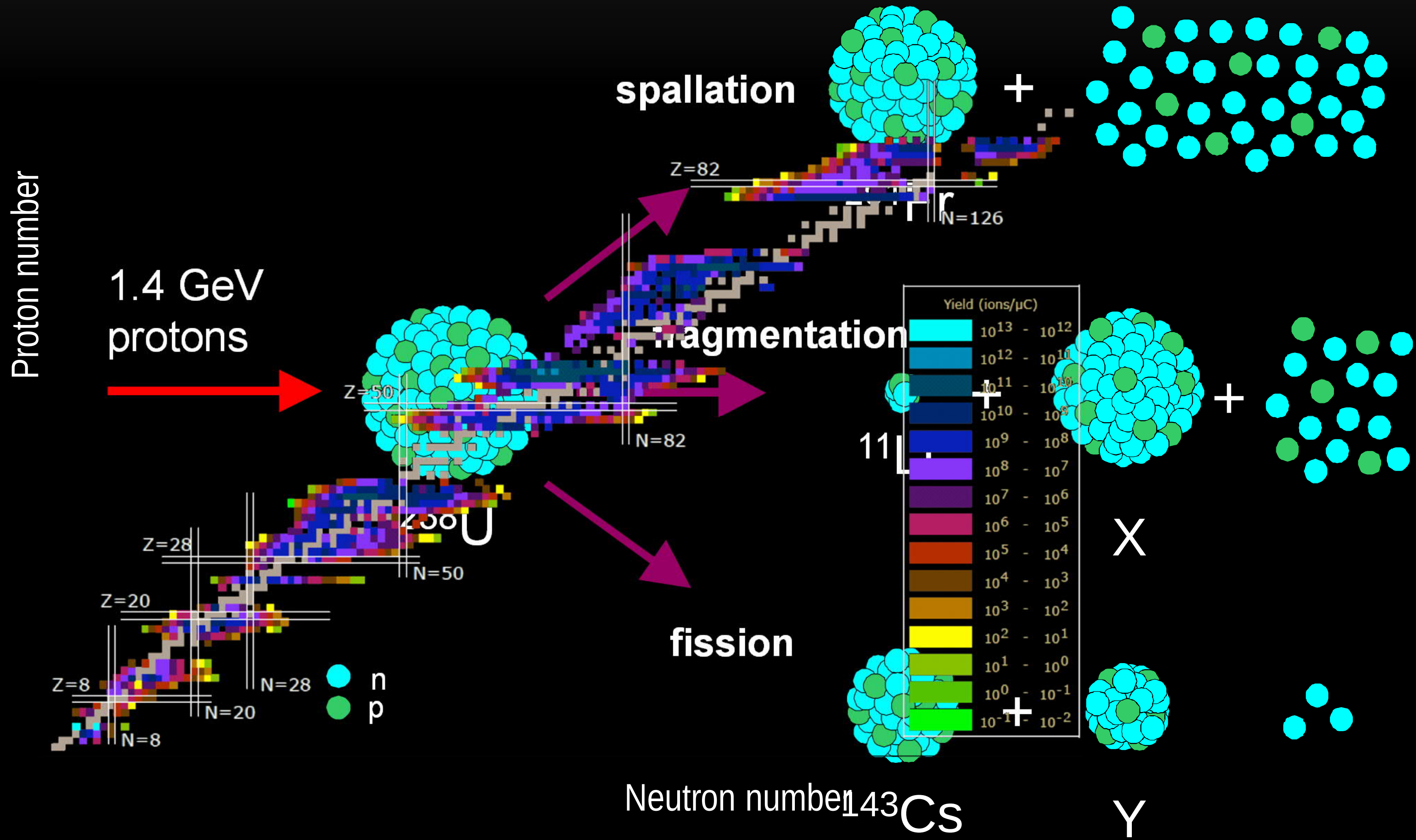


# ISOLDE at CERN

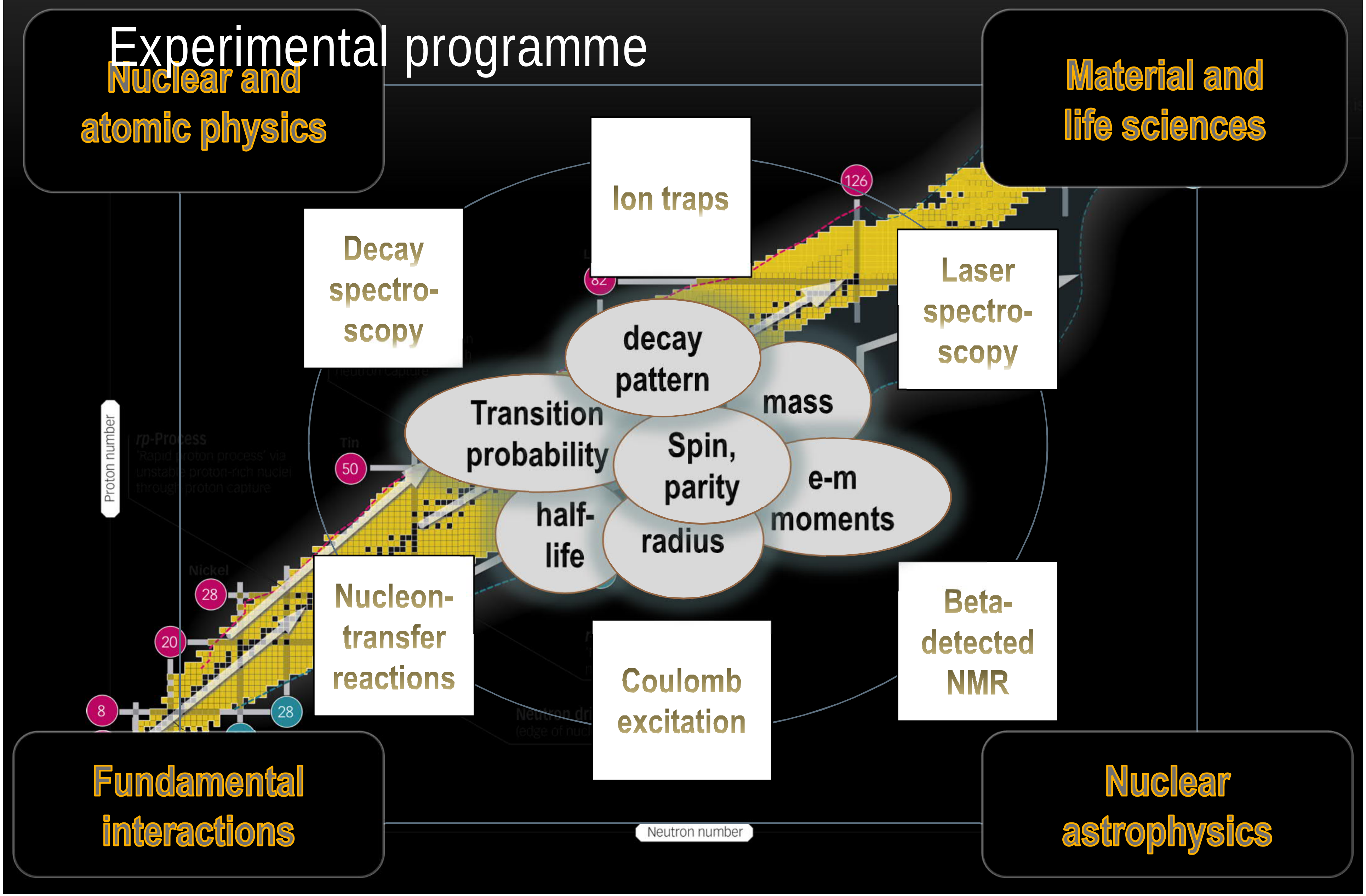
Janne Pakarinen, JY

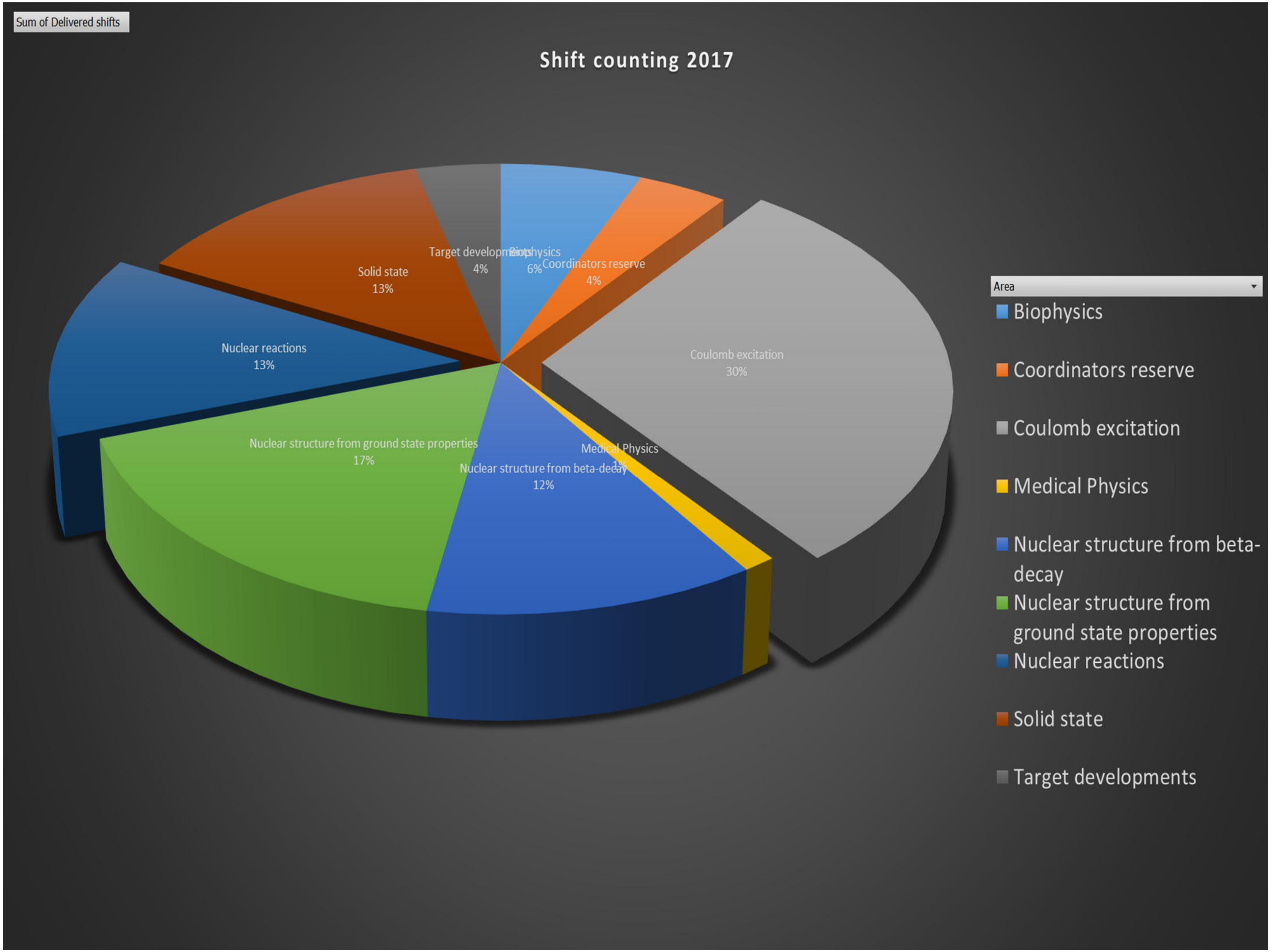


# Isotope production at ISOLDE



# Techniques: all available at ISOLDE




Sum of Delivered shifts
Shift counting 2017
Target developments
4%
Biophysics
6%
Coordinators reserve
4%
Solid state
13%
Nuclear reactions
13%
Coulomb excitation
30%
Nuclear structure from ground state properties
17%
Medical Physics
1%
Nuclear structure from beta-decay
12%
Area
Biophysics
Coordinators reserve
Coulomb excitation
Medical Physics
Nuclear structure from beta-decay
Nuclear structure from ground state properties
Nuclear reactions
Solid state
Target developments

# Finnish participation

- Janne Pakarinen (UJ)
  - HIP-ISOLDE project leader, ISCC representative, SISIN project leader, IDS and MINIBALL steering committee member, ISS collaboration member
- Prof. Iain Moore (UJ)
  - INTC member

Other HIP affiliated active members

- P. Greenlees, prof., adj. senior scientist (UJ)
- A. Jokinen, prof., adj. senior scientist (UJ)
- W. Gins adj. senior scientist (UJ)
- T. Grahn, adj. senior scientist (UJ)
- R. de Groote, adj. scientist (UJ)
- A. Illana-Sison, adj. scientist (UJ)
- M. Reponen, adj. scientist (UJ)
- P. Rahkila, adj. scientist (UJ)
- P. Ruotsalainen, adj. scientist (UJ)
- J. Ojala, adj. grad. Student (UJ)
- K. Helariutta, adj. senior scientist (UH)

CERN fellows with strong JY link:
J. Konki, Applied Fellow 2018 - 2020
M. Vilén, Applied Fellow 2019- 2021

ISOLDE

# HIP physics program

- The SPEDE spectrometer
  - successfully exploited at IDS prior to LS2, to be used at MINIBALL after LS2
- SISIN project (AoF, PI Janne Pakarinen)
  - day one experiment identified and proposal prepared
- Pending MINIBALL experiments
  - JY involved in many experiments, currently spokesperson in two proposals: $^{188}$Pb and $^{182,184}$Hg
- Ground-state properties and decay studies
  - Laser spectroscopy and precision atomic mass measurements

# Recent highlights – probing EDMs

- Short-lived radon and radium atoms candidates for measuring electric dipole moment in atomic nuclei
- Radon atoms provide less favourable conditions for the enhancement of a measurable atomic EDM

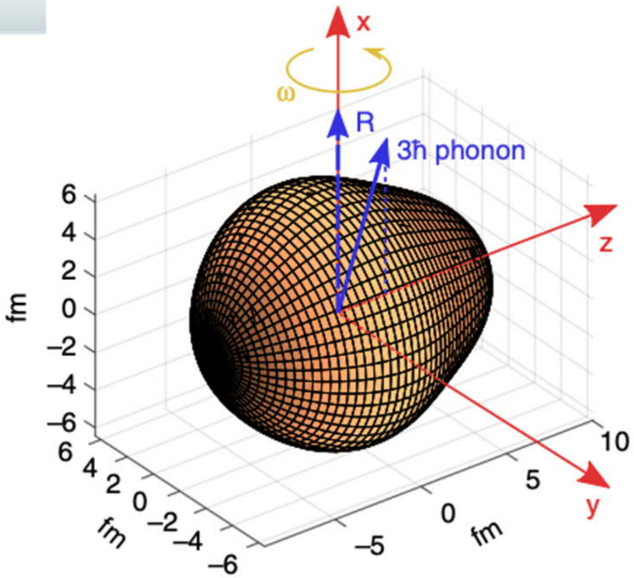
nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-10494-5 OPEN

## The observation of vibrating pear-shapes in radon nuclei

P.A. Butler[1], L.P. Gaffney[1,2], P. Spagnoletti[3], J. Konki[2], M. Scheck[3], J.F. Smith[3], K. Abrahams[4], M. Bowry[5], J. Cederkäll[6], T. Chupp[7], G. de Angelis[8], H. De Witte[9], P.E. Garrett[10], A. Goldkuhle[11], C. Henrich[12], A. Illana[8], K. Johnston[2], D.T. Joss[1], J.M. Keatings[3], N.A. Kelly[3], M. Komorowska[13], T. Kröll[12], M. Lozano[2], B.S. Nara Singh[3], D. O'Donnell[3], J. Ojala[14,15], R.D. Page[1], L.G. Pedersen[16], C. Raison[17], P. Reiter[11], J.A. Rodriguez[2], D. Rosiak[11], S. Rothe[2], T.M. Shneidman[18], B. Siebeck[11], M. Seidlitz[11], J. Sinclair[3], M. Stryjczyk[9], P. Van Duppen[9], S. Vinals[19], V. Virtanen[14,15], N. Warr[11], K. Wrzosek-Lipska[13] & M. Zielinska[20]



# Recent highlights – Coulex of $^{132}$Sn

- The first publications from HIE-ISOLDE
- ”…the confirmation that the tin-132 nucleus belongs to the doubly magic group of nuclei” – CERN courier

PHYSICAL REVIEW LETTERS **121,** 252501 (2018)

**Enhanced Quadrupole and Octupole Strength in Doubly Magic $^{132}$Sn**

D. Rosiak,[1] M. Seidlitz,[1,*] P. Reiter,[1] H. Naïdja,[2,3,4] Y. Tsunoda,[5] T. Togashi,[5] F. Nowacki,[2,3] T. Otsuka,[6,5,7,8,9] G. Colò,[10,11] K. Arnswald,[1] T. Berry,[12] A. Blazhev,[1] M. J. G. Borge,[13,†] J. Cederkäll,[14] D. M. Cox,[15,16] H. De Witte,[8] L. P. Gaffney,[13] C. Henrich,[17] R. Hirsch,[1] M. Huyse,[8] A. Illana,[8] K. Johnston,[13] L. Kaya,[1] Th. Kröll,[17] M. L. Lozano Benito,[13] J. Ojala,[15,16] J. Pakarinen,[15,16] M. Queiser,[1] G. Rainovski,[18] J. A. Rodriguez,[13] B. Siebeck,[1] E. Siesling,[13] J. Snäll,[14] P. Van Duppen,[8] A. Vogt,[1] M. von Schmid,[17] N. Warr,[1] F. Wenander,[13] and K. O. Zell[1]

(MINIBALL and HIE-ISOLDE Collaborations)

# The Future of (HIE-)ISOLDE

The EPIC project:

Exploiting the Potential of ISOLDE at CERN

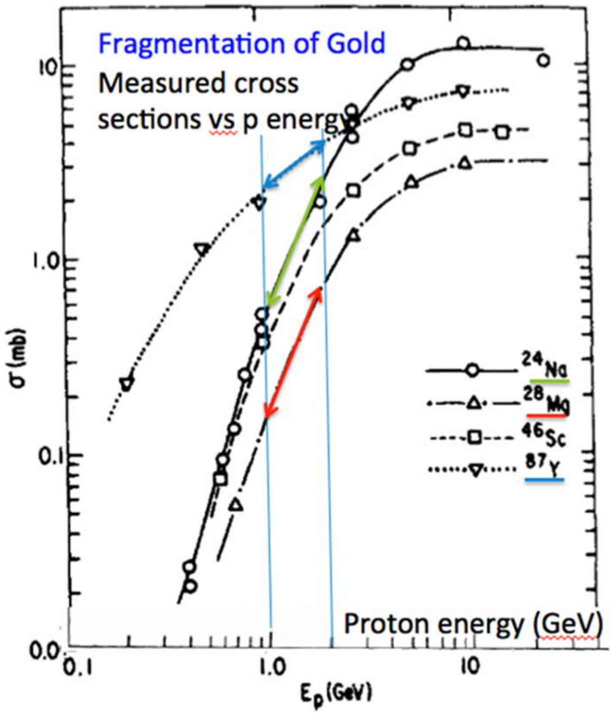
(the ISOLDE Collaboration input to the European Particle Physics Strategy update)

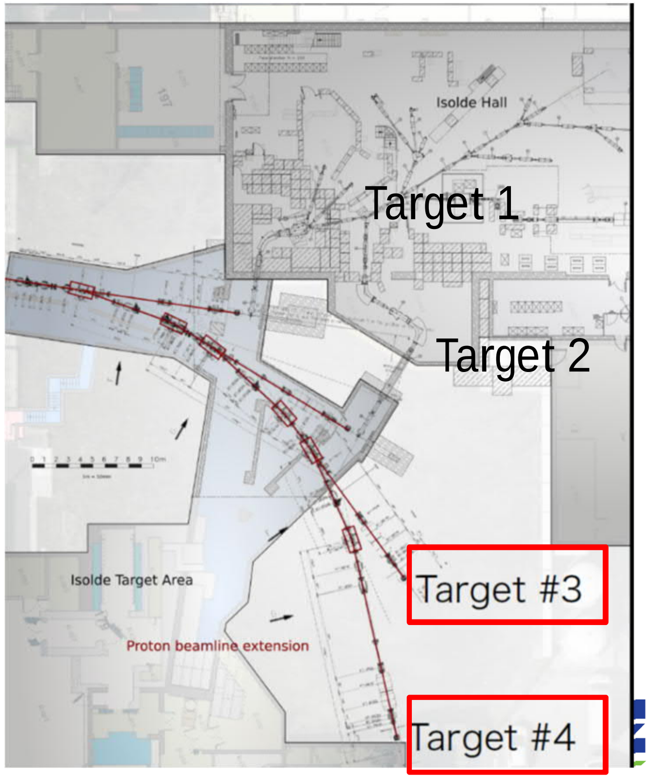
http://europeanstrategyupdate.web.cern.ch/process-0

The EPIC project Workshop
December 3-4, 2019

# EPIC objectives

- Improve the exploitation of the existing infrastructure
  - With all SC cavities running after LS2 → 10 MeV/u RIB's
- Profit from increased driver beam energy and intensity (2 GeV, 4 μA)
- A new storage ring for short-lived light and heavy ions
- Have multiple simultaneous beams for users
- Meet modern radioprotection standards.



# CLOUD experiment at CERN

Prof. Markku Kulmala
Ass. Prof. Katrianne Lehtipalo

HIP and INAR

# CLOUD

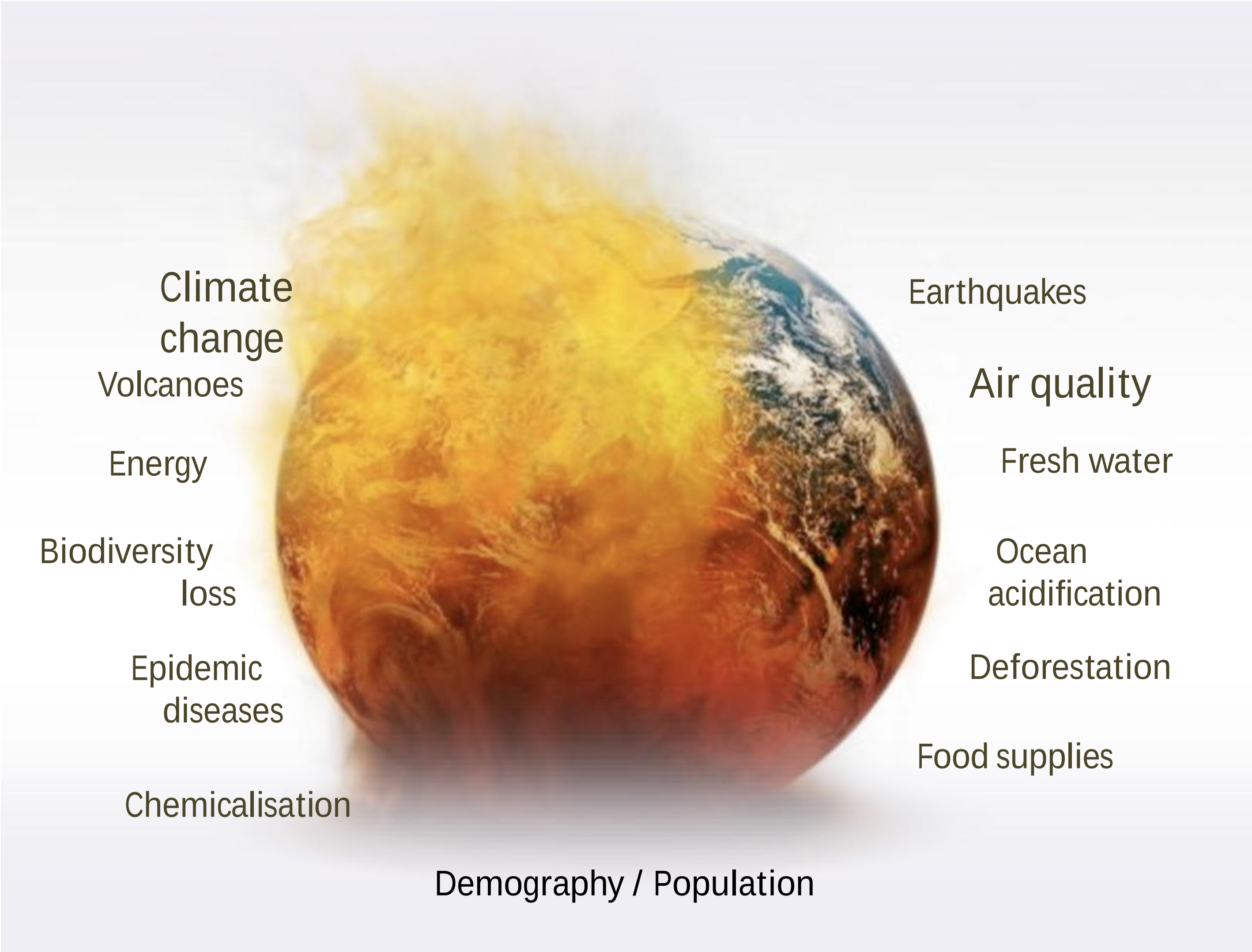
# Cosmics Leaving Outdoors Droplets

Main purpose:
study the influence of cosmic rays on clouds and climate

- Study new particle formation and growth in a highly controlled manner
- Study ice nucleation and aqueous phase processes in cloud droplets

- Collaboration of 17 institutes in 9 countries
- 3 Horizon 2020 MSCA Initial Traning Networks: CLOUD-ITN (2008-2012), CLOUD-TRAIN (2012-2016), CLOUD-MOTION (2017-2021), connected also to several Finnish Academy and ERC projects

# CONTRIBUTION TO Solving GRAND CHALLENGES




DISCIPLINES

Natural Sciences

Social Sciences

Medicine

Technology

IEAS

Sofia Earth Forum

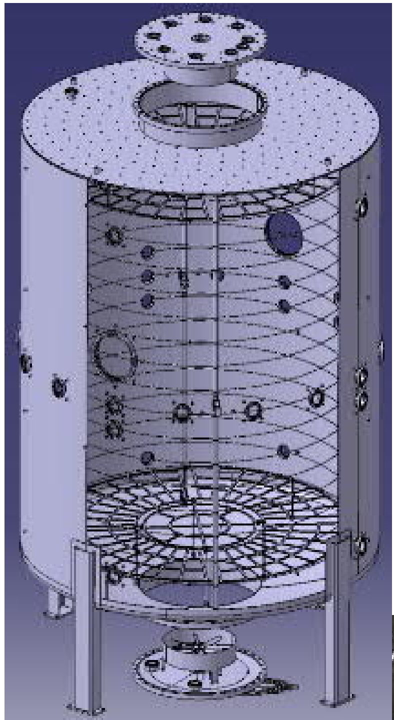
Science Diplomacy

From ideas
To implementation

# CLOUD Aerosol chamber

- 27 $m^3$
- Pressure: Atmospheric ± 0.3 bar
- Only metallic seals
- Electropolished inner surfaces

# The CLOUD chamber allows studying the effect of ionization on aerosol formation

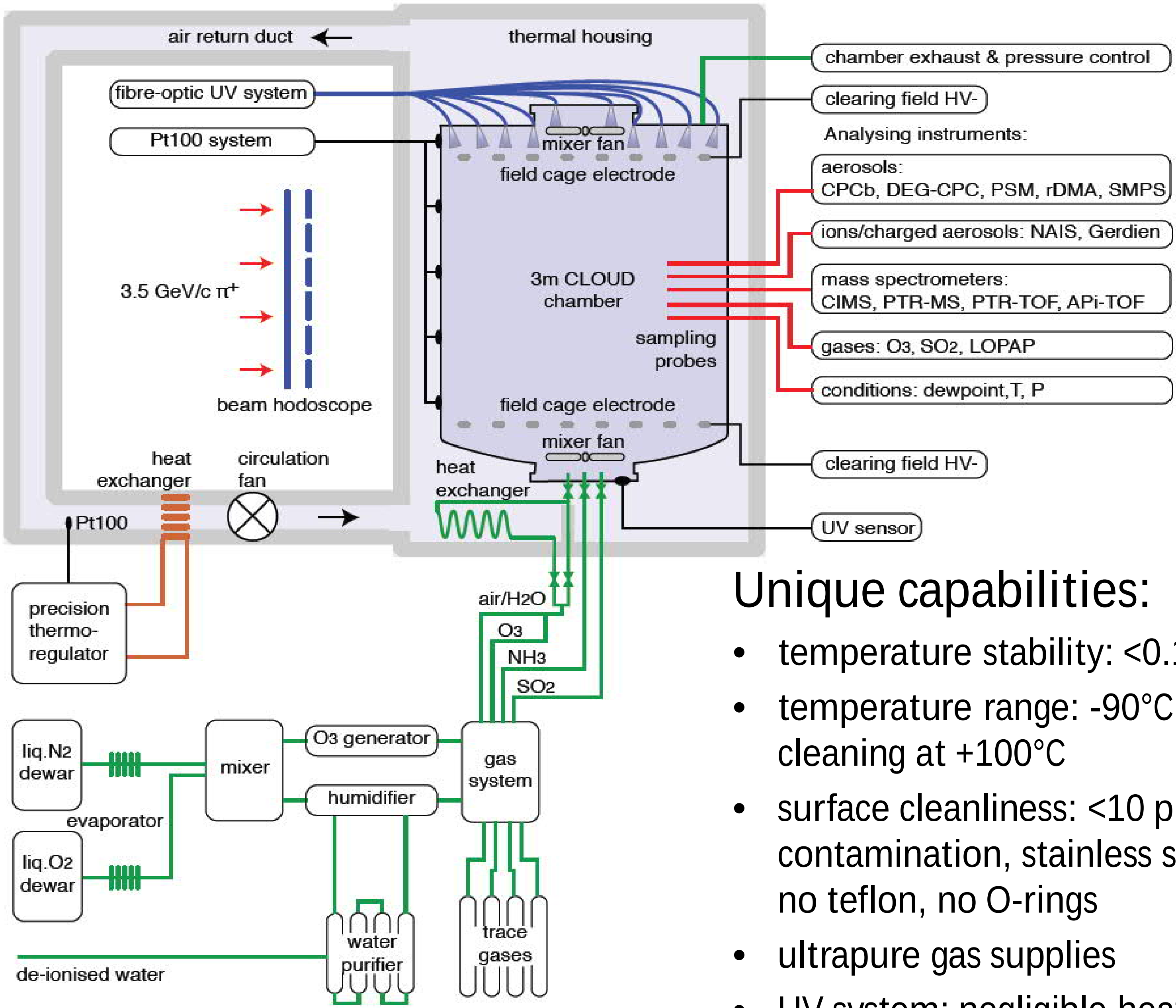


High-voltage clearing field

CLOUD, A.Onnela & J. Duplissy

- Ions are created in the chamber naturally due to galactic cosmic rays (GCR) (~500/cm$^3$)
- Additional ionization from proton syncrotron beam (<3000/cm$^3$)
- High-voltage clearing field can be used to remove all the ions (~0/cm$^3$)

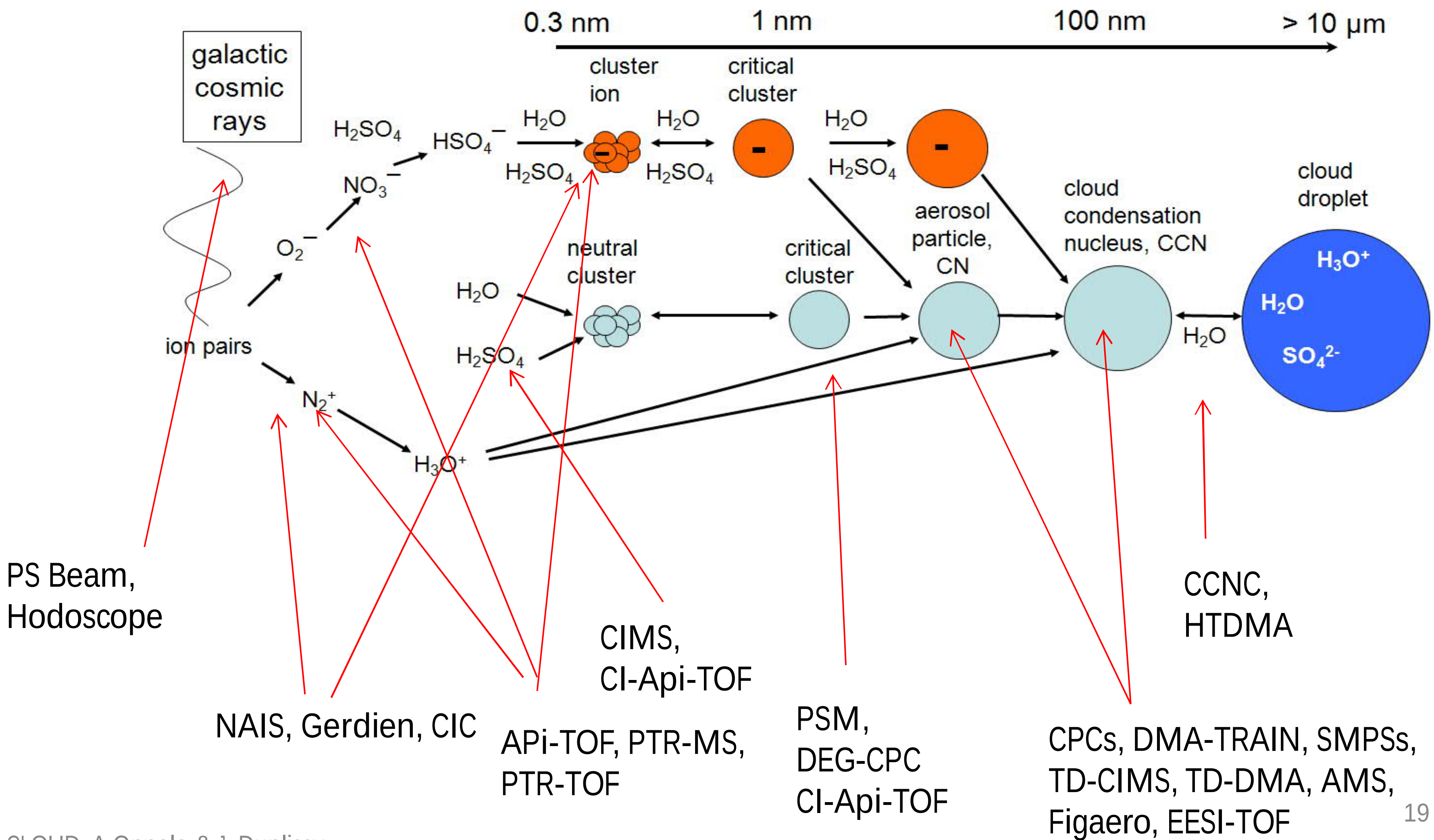
- →neutral, gcr and beam runs to simulate ionization at different altitudes of the atmosphere



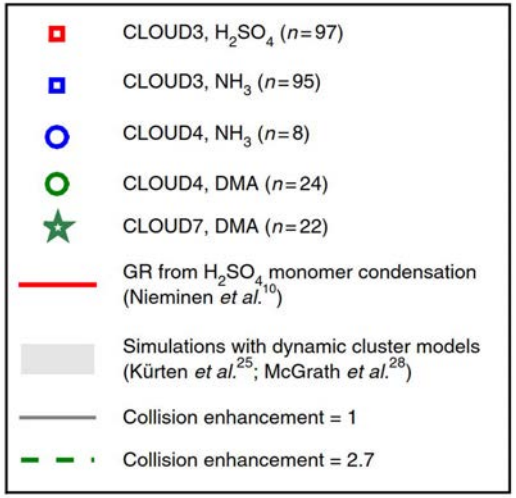

# Unique capabilities:

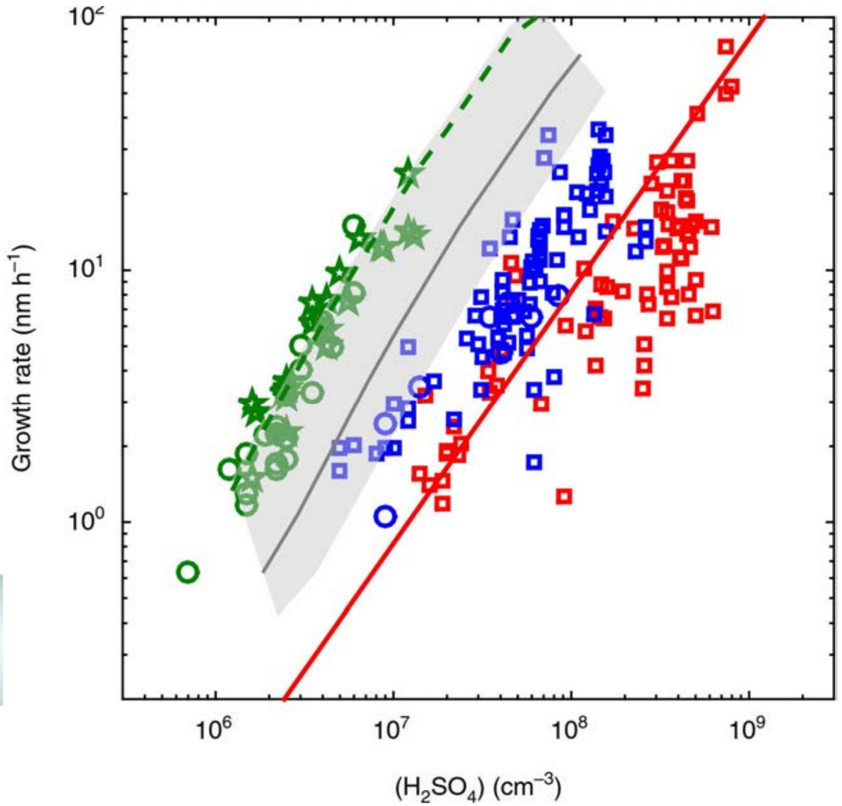
- temperature stability: <0.1°C
- temperature range: -90°C to +30°C; cleaning at +100°C
- surface cleanliness: <10 pptv organics contamination, stainless steel (and gold), no teflon, no O-rings
- ultrapure gas supplies
- UV system: negligible heat load by use of fibre optics.
- field cage 30 kV/m

# State-of-the-art instrumentation for following every step of the particle formation process



# First results on initial particle growth





nature COMMUNICATIONS

ARTICLE

Received 21 Sep 2015 | Accepted 12 Apr 2016 | Published 20 May 2016 DOI: 10.1038/ncomms11594 OPEN


## The effect of acid-base clustering and ions on the growth of atmospheric nano-particles


Katrianne Lehtipalo et al.#


$NH_3$ and amines accelerate growth due to acid-base clustering
→ significantly increase the survival of the recently formed clusters to aerosol particles and further to cloud condensation nuclei.

# Hyytiälä simulation in CLOUD: interaction of $H_2SO_4$-$NH_3$ and organics

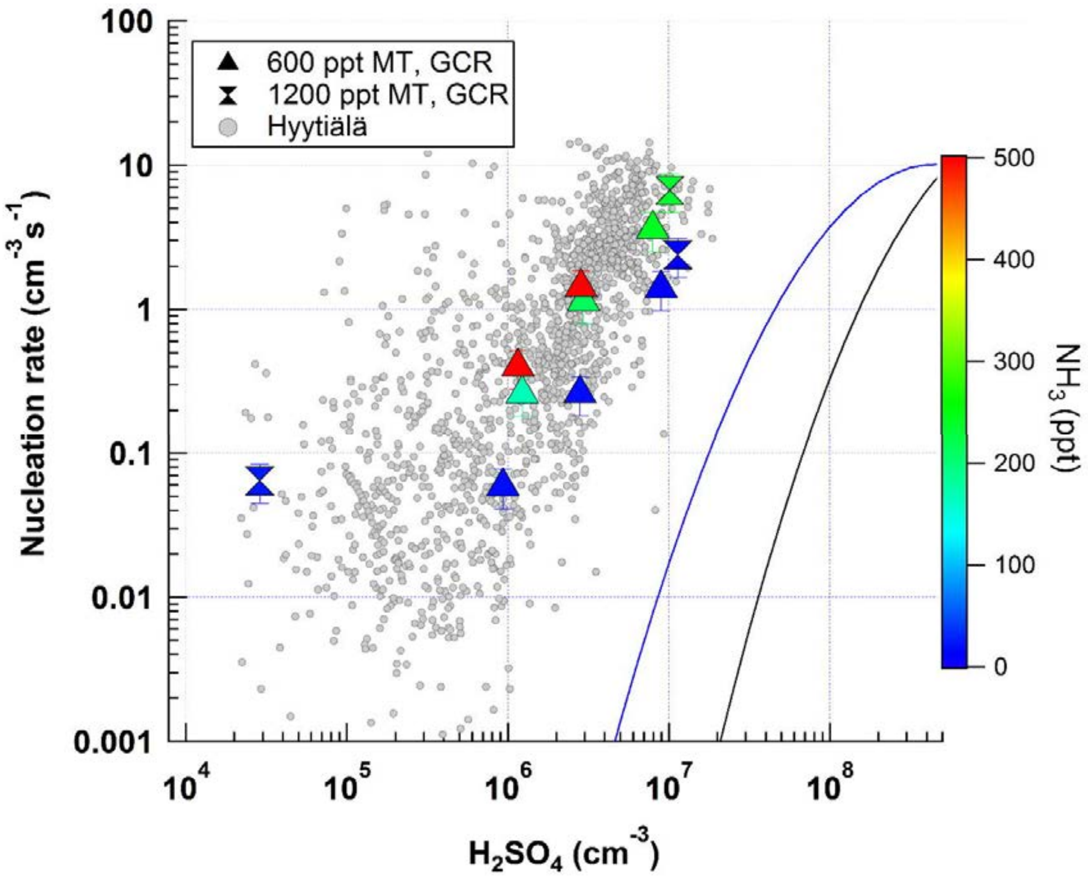
Science Advances
AAAS's open-access journal

**" Multicomponent new particle formation from sulfuric acid, ammonia, and biogenic vapors"**

K. Lehtipalo *et al.*

eaau5363

December 12, 2018



# Recent and next CLOUD campaigns

- CLOUD10 &11 (Sep-Dec 2015, 2016)
  - Pure biogenic nucleation in different conditions
  - Effect of NOx on particle formation
  - Hyytiälä simulation
  - Amazon
- CLOUD12 & 13 (Sep-Dec 2017, 2018)
  - Marine new particle formation
  - Biogenic-anthropogenic mixture
  - Urban new particle formation
- CLOUD14 (Sep-Dec 2019)
  - Particle growth from clusters to cloud condensation and ice nuclei
  - Ice nucleation and cloud droplet activation
- CLOUD 15 (fall 2021)

Red: led by Univ. Helsinki

# Summary

- One ca. 10 week intensive campaign/year
  - Thousands of successful runs
  - UHEL had a leading role in specific parts of each campaign
  - New CLOUD-MOTION ITN (2 new PhD students started at UHEL last year)
- CLOUD has produced a lot of high-level publications
  - 6 in 2015
  - 21 in 2016 (2 Nature, 1 Science, 1 Nature Comm., 1 PNAS)
  - 9 in 2017
  - 7 in 2018 (1 PNAS, 1 Science Advances) + 2 submitted
- 2-3 Annual data analysis work shops + summer and winter schools
- 3-5 days  consortium meeting annually