



V. Barozier, E. Aubert, A.-P. Bernardes, P. Bertreix, R. Catherall, T.E. Cocolios, E. Chevallay, B. Conde-Fernandez, B. Crepieux, K. Dockx, A. Dorsival, V. Fedosseev, P. Fernier, C. Ferrari, R. Formento Cavaier, V. Gadelshin, S. Gilardoni, M. Khan, L. Lambert, G. Lilli, G. Lunghi, Y. Martinez Palenzuela, B. Marsh, S. Marzari, N. Menea, F. Pozzi, F. Riccardi, J.M. Riegert, N. Riggaz, V. Samothrakis, S. Stegemann, J. Thiboud, J.M. Vuallat, N.-T. Vuong, S. Wilkins, T. Stora and others!



João Pedro Ramos

<http://www.joaopedroramos.com>

[@cern.ch](mailto:joao.pedro.ramos@cern.ch) / [@kuleuven.be](mailto:joao.pedro.ramos@kuleuven.be)

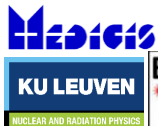


MEDICIS Run
Coordinator

The **MEDICIS** facility

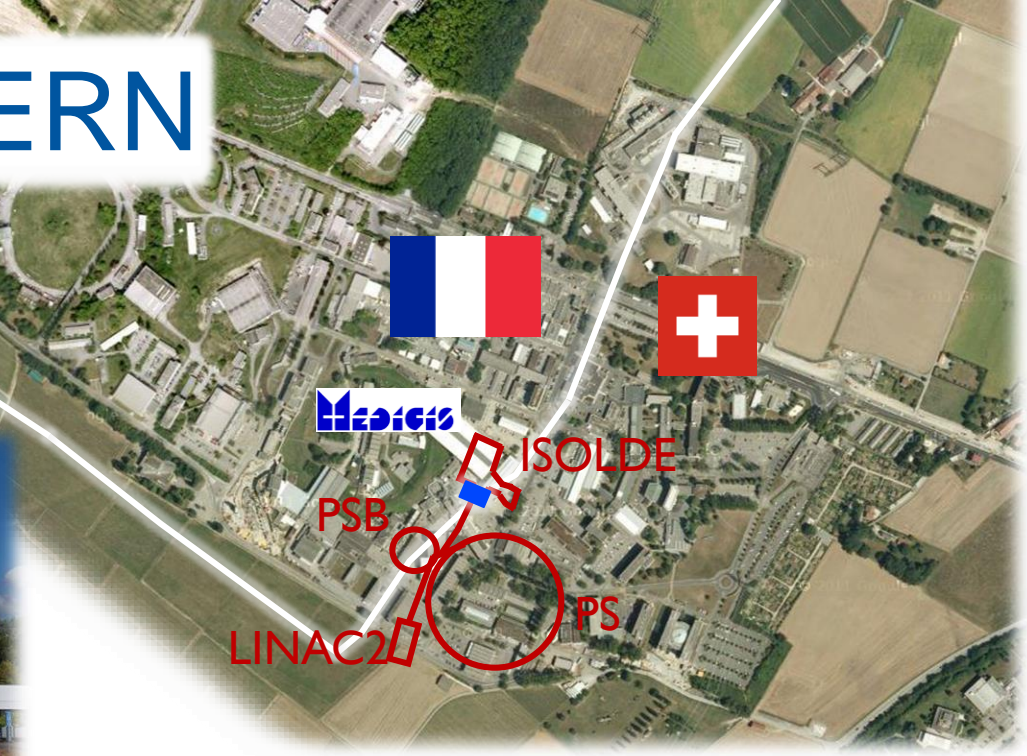
First operation year, current and future plans

3rd of May 2019
MEDICIS-Promed Final
Conference
Erice, Italy

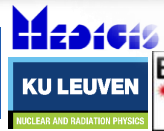


MEDICIS at CERN

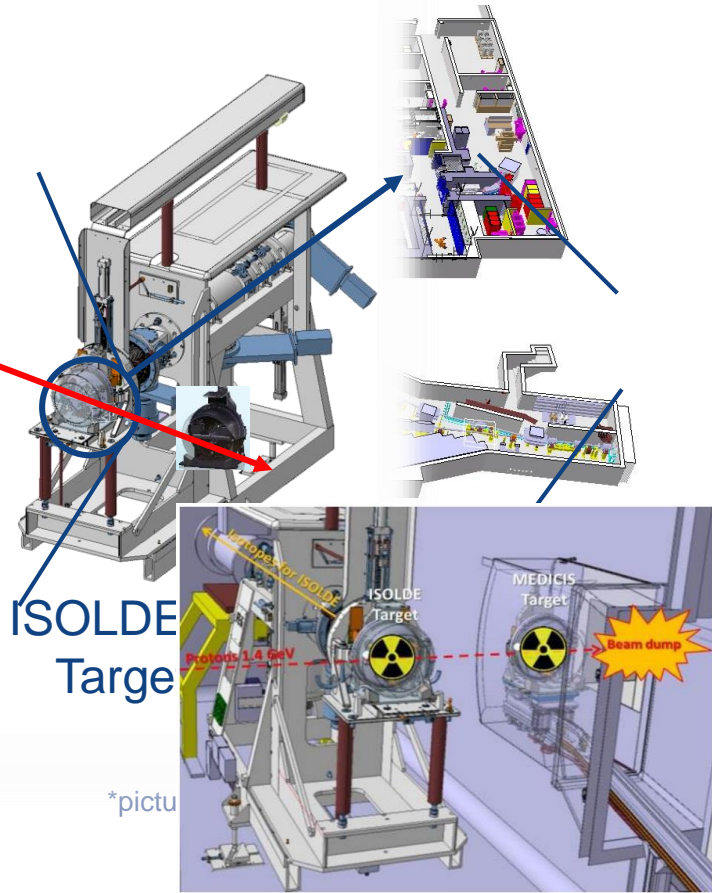
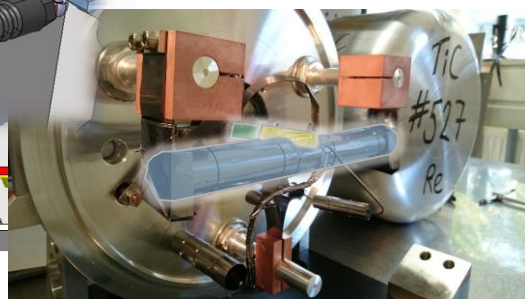
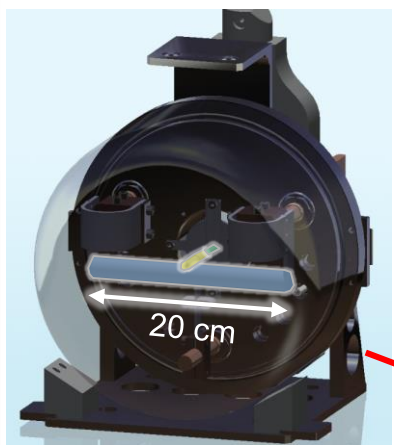
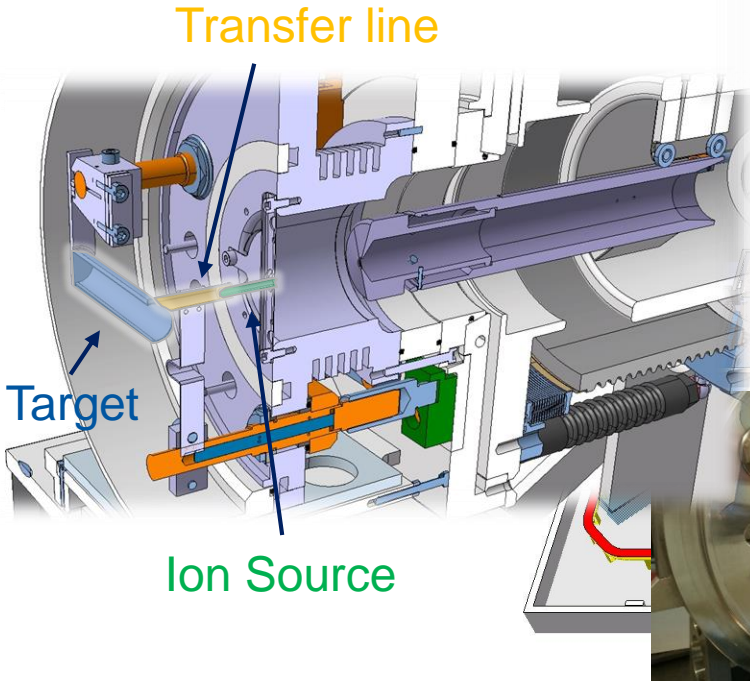
Operates ~8 months/year and during Long Shutdown



ISOLDE takes ~50% of CERN protons and MEDICIS “recycles” about 20% of the ISOLDE protons

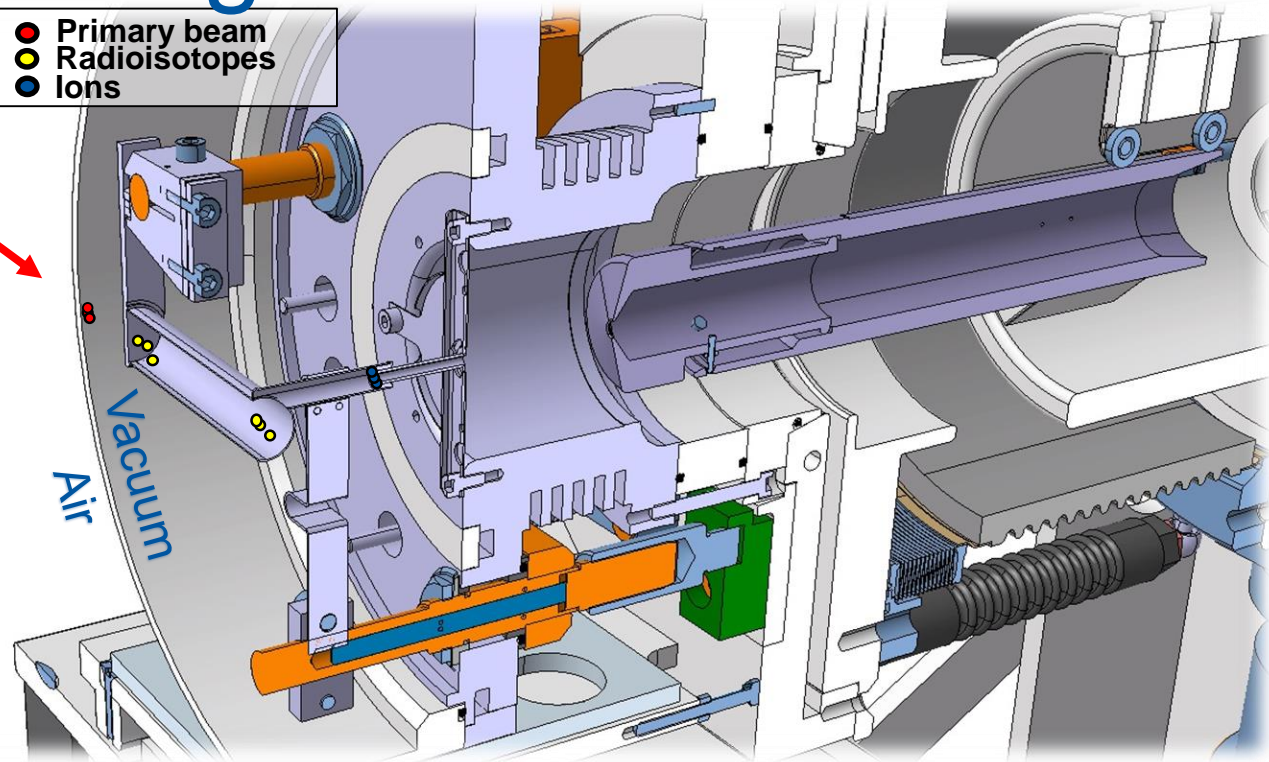


Target Unit – Heart of



Target Unit – Heart of

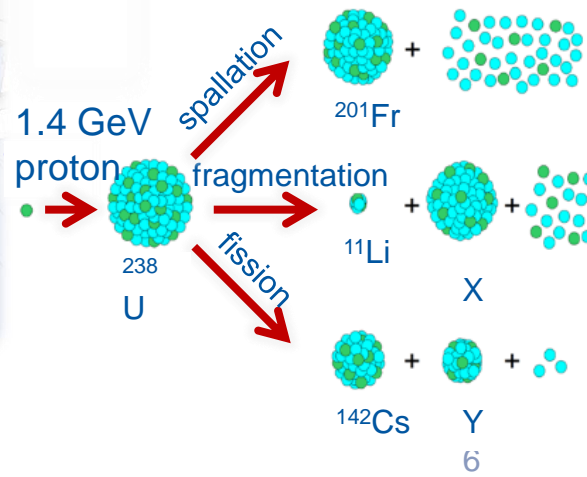
- Primary beam
- Radioisotopes
- Ions



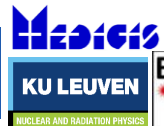
$$Beam\ Int. = \sigma \cdot j \cdot N_t \cdot \epsilon$$

$$\epsilon = \epsilon_{diff} \epsilon_{eff} \epsilon_{is} \epsilon_{sep} \epsilon_{trans}$$

N_t – Nr of exposed atoms [dim]
 j – Proton flux [cm⁻²]
 σ – Cross section [mb]
 ϵ – Efficiency [%]



*picture and animation courtesy of M. Delonca



Operation

Insert target

- 12 min – protons stopped (only at HRS)

Irradiation

- Transparent to ISOLDE

Retrieve target

- 12 min – protons stopped (only at HRS)

Decay

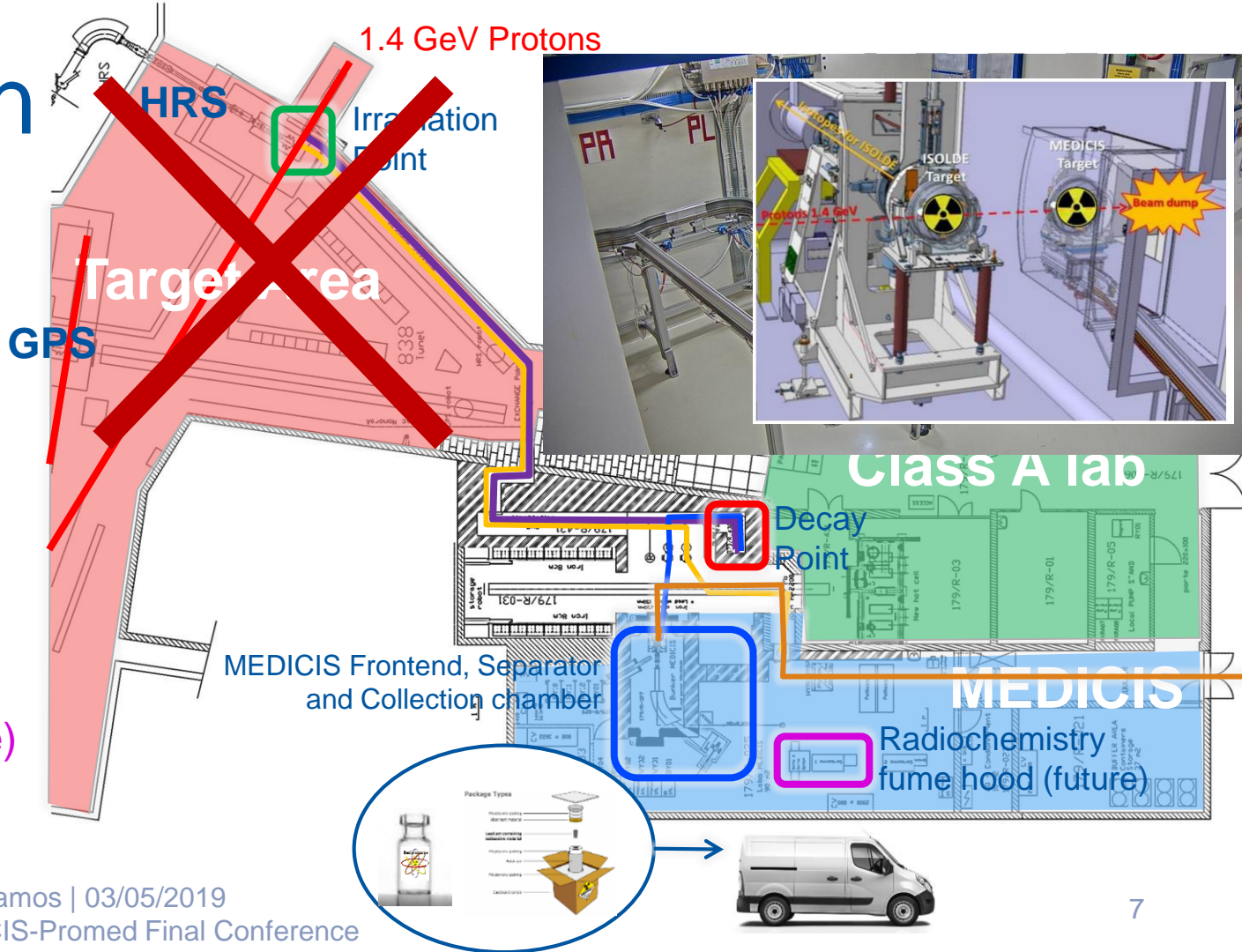
- Until target reaches $<1\text{ Sv/h}$ (at 26 cm)

Install in Frontend

- Isotope Extraction

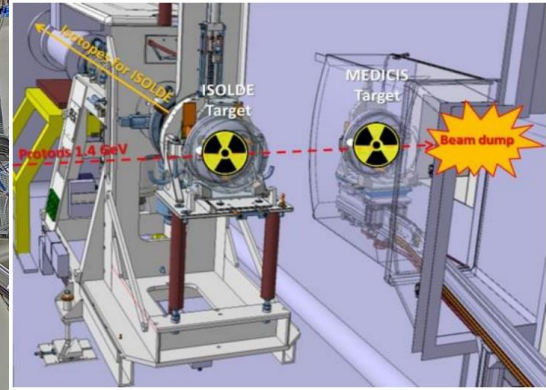
Radiochemistry (future)

- Chemical purification
- Shipping

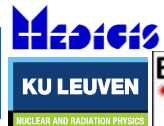
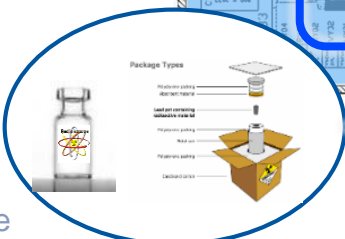


1.4 GeV Protons

HRS
Irradiation Point
Target Area
GPS



Class A lab
MEDICIS



How many isotopes?

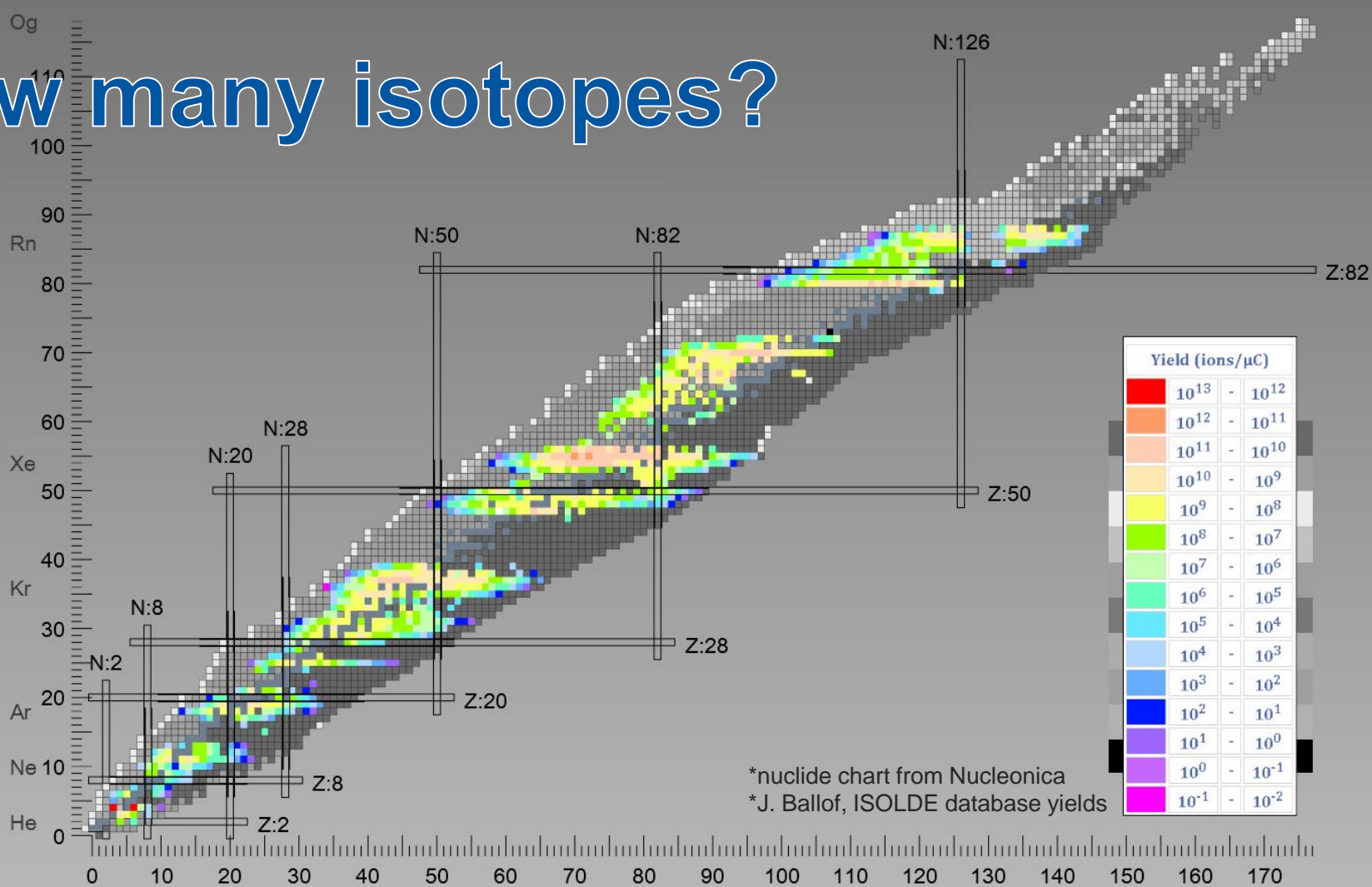
Predicted
~6000

Discovered
~3000

ISOLDE
~1000

Elements
74

$t_{1/2}$
>tens of ms



Isotopes

Cyclotron

Tb 149
 4.2 m 4.1 h
 e
 β^+
 α 3.99
 γ 796;
 165...

Tb 152
 4.2 m 17.5 h
 γ 283;
 160...
 e
 β^+ 2.8...
 γ 344;
 586;
 271...
 e; β^+ ...
 γ 344;
 411...

Tb 155
 5.32 d
 e
 γ 87;
 105;...
 180, 262

Tb 161
 6.90 d
 β^- 0.5; 0.6...
 γ 26; 49; 75...
 e⁻

Cyclotron

Reactor



Cyclotron

Sc 47
 3.3492 d
 β^- 0.4, 0.6
 γ 159

Cu 67
 61.9 h
 β^- 0.4, 0.6...
 γ 185, 93, 91...

Sc 44
 58.61 h 3.97 h
 IT 271
 e
 γ 1002
 1126, 1157
 β^+ 1.5...
 γ 1157...

Tm 165
 30.06 h
 e
 β^+ ...
 γ 243, 47, 297
 807...

Reactor

Er 169
 9.392 d
 β^- 0.4...
 γ (8, 110...)
 e⁻

Accelerator

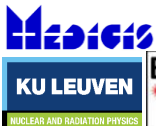
Ac 225
 9.920 d
 α 5.830, 5.793
 5.732..., C14
 γ 100, (150, 188
 63...), e⁻

Ra 225
 14.9 d
 β^- 0.3, 0.4
 γ 40, e⁻

ISOLDE All except 161Tb
 1.4 GeV protons and 169Er



MEDICIS Collaboration



J. P. Ramos | 03/05/2019
MEDICIS-Promed Final Conference

In the process of joining:



Two boards per year, for reporting, mission and proposal discussion

Collaboration funds MEDICIS operation and defines priorities





facility timeline

2010 – Idea for facility



Oct-2014 – Building ready



Building reception
15th October 2014

Nov-2017 – First beam (stable)



2011 – Concept and design started

Sep-2013 – Construction started



Groundbreaking
3rd September 2013

Mar-2015
kick-off



Dec-2017 – First radioactive beam



Feb-2018 – First collaboration board

May->Nov2018 – First operation year

Dec-2018 – Technical stop

May-2019 Lasers
Radiochemistry

Operation with
external sources



CERN Long –shutdown 2

2010

2011

2012

2013

2014

2015

2016

2017

2018

2019

2020

2021

Today

11

KU LEUVEN

NUCLEAR AND RADIATION PHYSICS



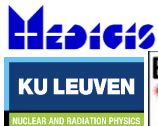
J. P. Ramos | 03/05/2019

MEDICIS-Promed Final Conference





2018 operation and future plans



MEDICIS Tb extraction efficiency

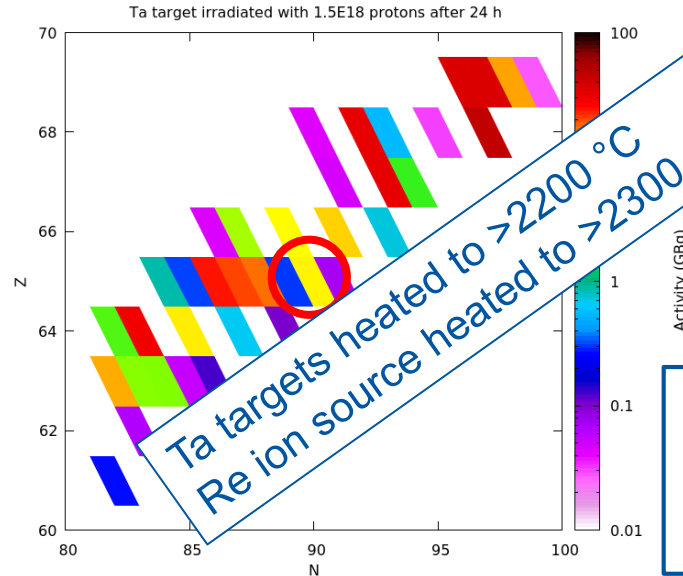
Irradiation for 2 days
($1.5E18$ protons)

6.9 GBq – $155Tb$
24 h after EoB

Extracted:
49.7 MBq
(5 days after EoB)

Extraction efficiency:
1.2%*
(4.1 GBq in target)

ISOLDE – 1.5% $149Tb$
(600 MeV – 80s-90s)

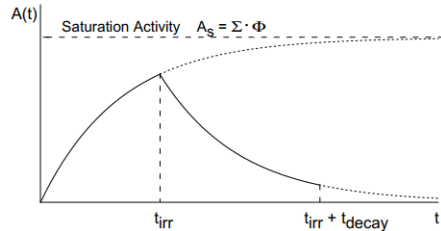
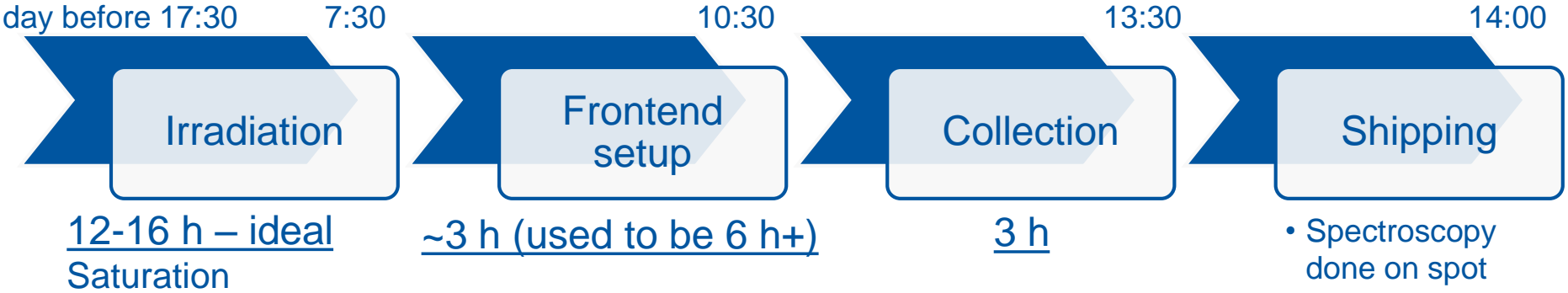


Already reached 5%
End of September

**Lasers should
largely increase
this number**

*value fluctuates from target to target

^{149}Tb – race against time

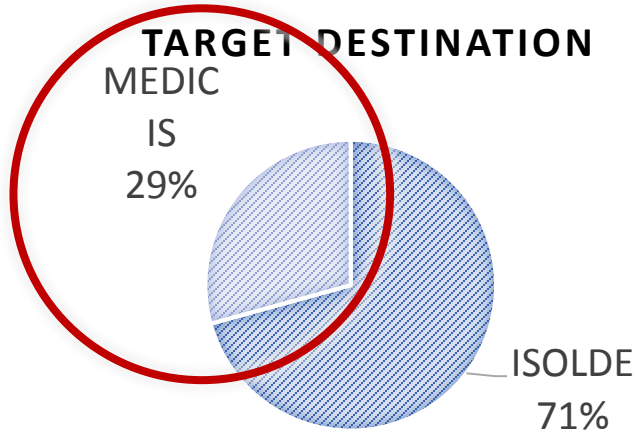


1. Vacuum pumping (30 min)
2. Water cooling (HV operation) – used to be 4 h, now is 15 min
3. Target heating (~1.5 h)
4. Beam setup (with target below optimum release T) – 1h

Challenging! Need efficient coordination and good team!

Target production

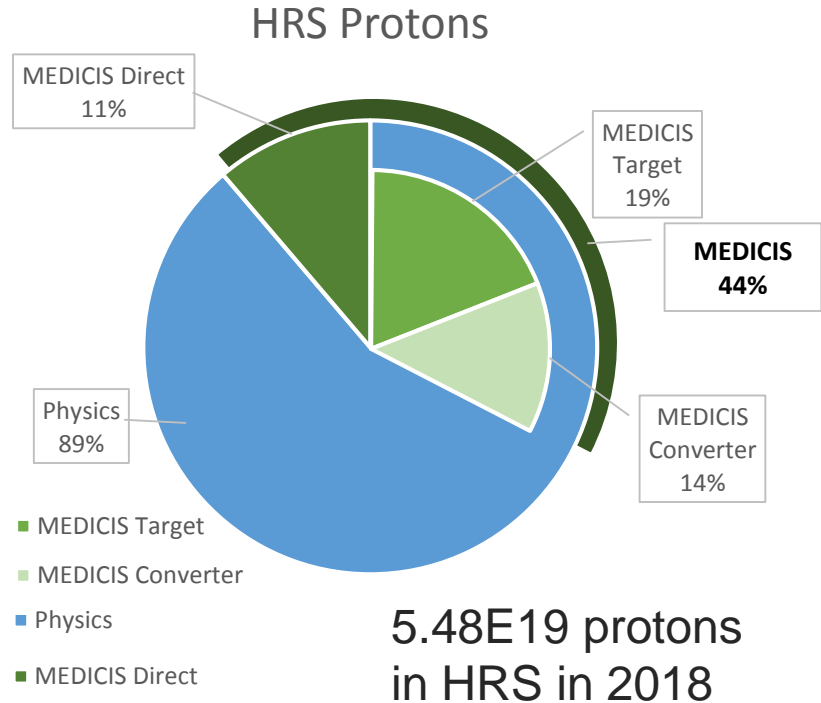
Targets reused up to 5 times!



MEDICIS budget and manpower contribution

Total targets assembled end of 2018 : **49**

- Delivered to ISOLDE: **29**
- Delivered to MEDICIS: **10** + 2 in December
- Used for development: **8** (16%)



Gaining operational experience (2018)

Main achievements:

- **155,152Tb**
- **149Tb (and 149Tb+16O)**
- **169Er** (external source)
- **11C**
- **165Tm**

4 isotope batches shipped:

- 2x to CHUV (CH)
- 2x to NPL (UK)

Up to 1GBq of extracted activity has been handled at MEDICIS



MEDICIS

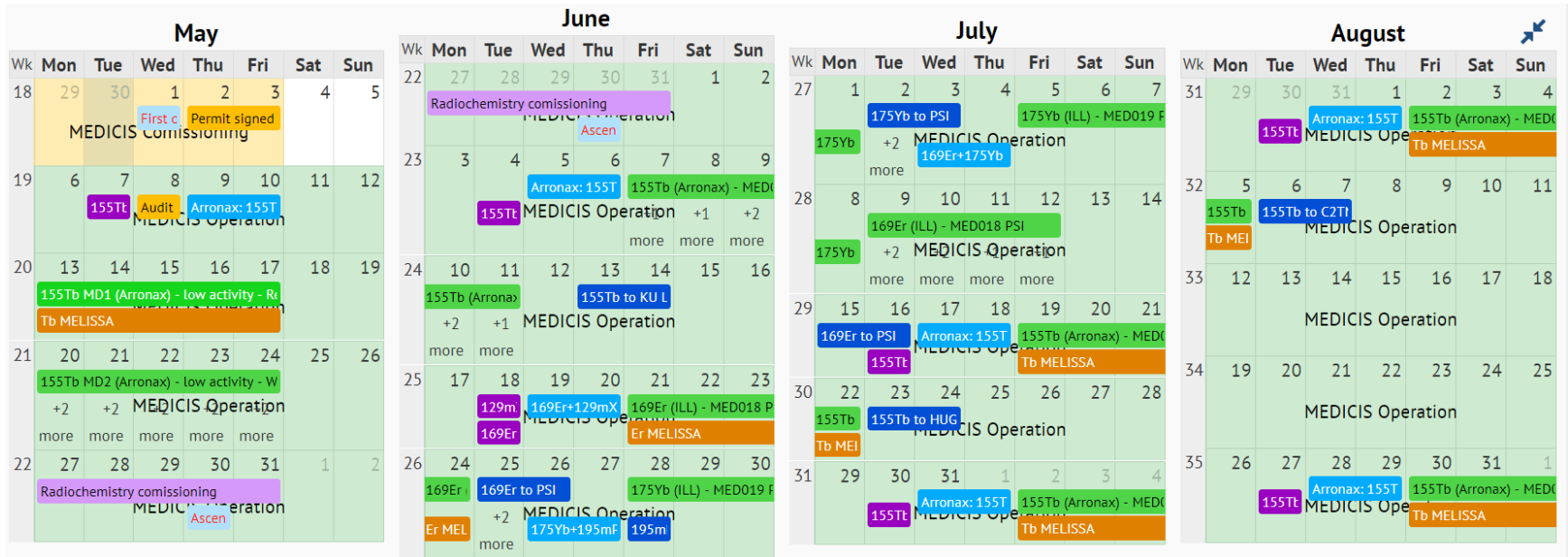
Machine development runs:

- Test Tb extraction runs (optimization) ✓
- Target oven prototype – needs improvement ✓
- 47ScF, 67Cu and 225Ra/Ac – technical issues with target units ✓

Issues during 2018:

- Frontend electrode stuck ✓
- Mass resolution at high masses ✓
- Collection chamber arm ✓

MEDICIS in 2019

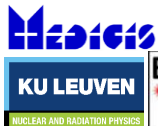


Start in 2 weeks with 2x 150 MBq of 155Tb sources from



Objective is to reach 1 GBq of 155Tb source

169Er, 175Yb, 129mXe



J. P. Ramos | 03/05/2019
MEDICIS-Promed Final Conference

Laser ionization + radiochemistry!

Thank you! Merci! Obrigado! Grazie!

A **big thanks** to the MEDICIS local team (**the dream team**):

Thierry Stora (project leader), Cristina Ferrari (secretary), Richard Catherall (Section leader)

Radiochemistry: Moazam Khan, Nhat-Tan Vuong

Robot Operation: Giordano Lili, Giacomo Lunghi, Jean Luis Grenard

Safety: Ana Paula Bernades, Julien Riegert, Beatriz Conde Fernandez

Operation: Laura Lambert, Eric Chevally, Pascal Fernier

Spectro and shipping: Nicolas Riggaz, Philippe Bertreix

RP: Fabio, Pozzi, Alexandre Dorsival, Matthieu Deschamps, Elodie Aubert

Engineering: Stefano Marzari, Vasileos Samothrakis, Vincent Barozier

LabVIEW and controls: Kevin Develle, Cedric Charrondiere, Christophe Mitifiot

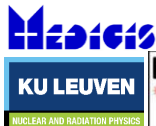
ISOLDE: Karl Johnston and ISOLDE operation team

ISOLDE technicians: Julien Thiboud, Bernard Crepieux, Ermanno Barbero, Andres Vietez Suarez

Lasers (MELISSA): Valentine Fedosseev, Vadim Gadelshin, Bruce Marsh, Thomas Cocolios, Kristof Dockx, Klaus Wendt, Shane Wilkins

and Julien Para-Lopez, Simon Stegemann, Marco Buzio, Roberto Formento Cavaier, Simone Gilardoni, Jose Somoza,

MEDICIS Promed team (especially: Roberto Formento, Vadim Gadelshin, Simon Stegemann), the *MEDICIS Collaboration* (especially: Thomas Cocolios, Ulli Koester, Ferid Haddad, Nathalie Michel) and many others!



J. P. Ramos | 03/05/2019

MEDICIS-Promed Final Conference