



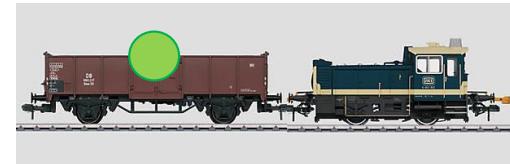
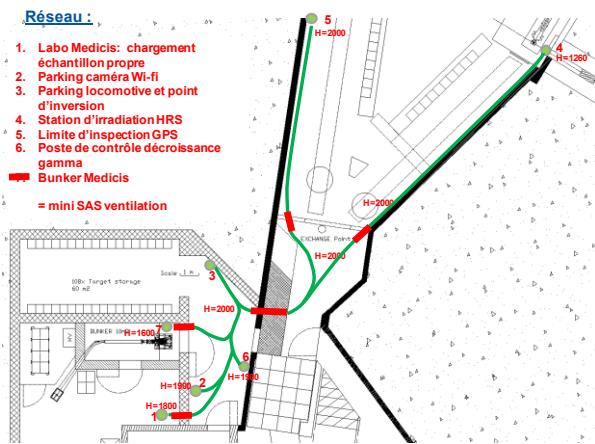
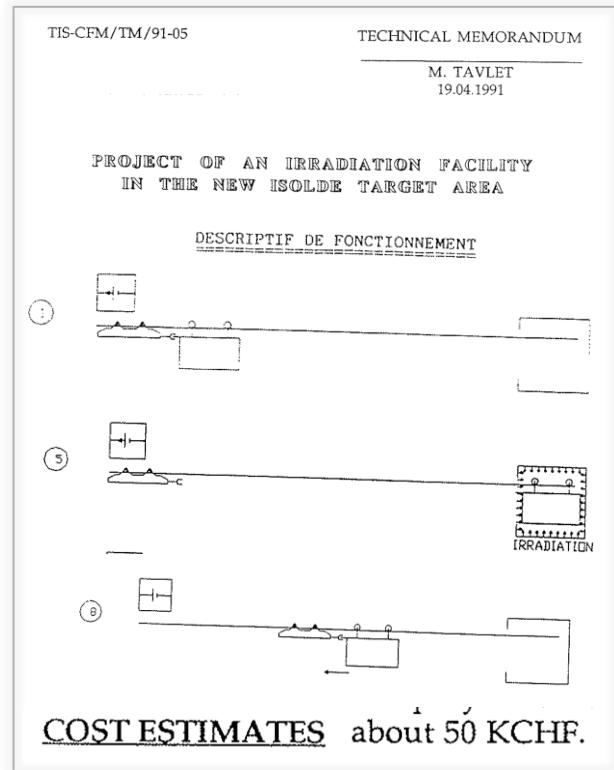
Isotope production in the beam dumps: Present and future options

Thierry Stora



- E. Aubert, M. Ballan, A. P. Bernardes, R. Catherall, J. Cruikshank, C. Duchemin, A. Dorsival, S. Gilardoni, K. Kershaw, L. Lambert, S. Marzari, C. Mitifiot, J.P. Ramos, V. Samothrakis, J. Vollaire

Back in history : 1st system and little train initial studies in 2012



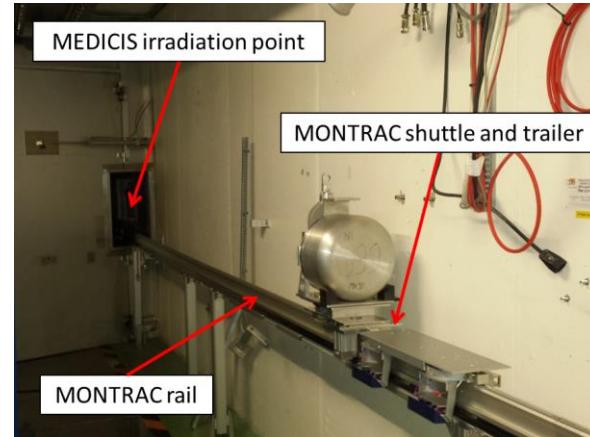
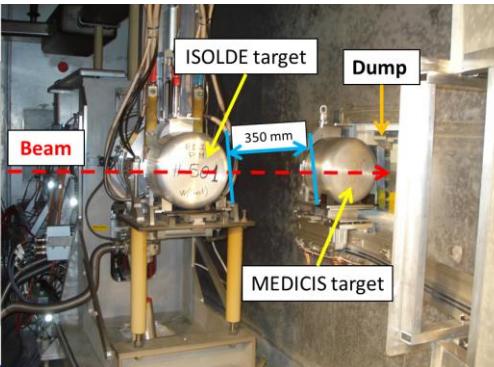
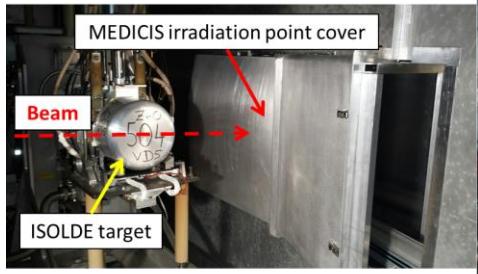
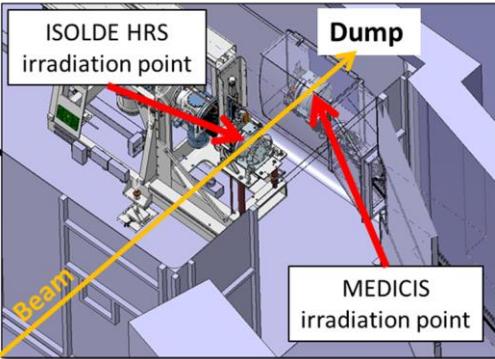
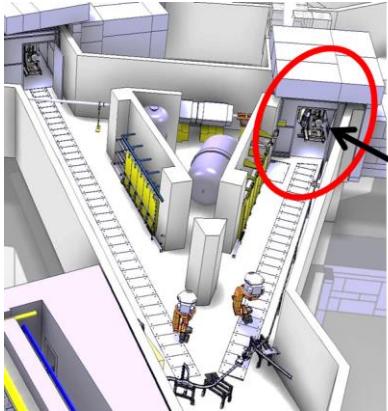
Some obvious limitations
to this design
(extract from the report
/ never communicated)

- 3 minutes (ISOLDE)
- 0.3 minutes (HIE-ISOLDE) !!

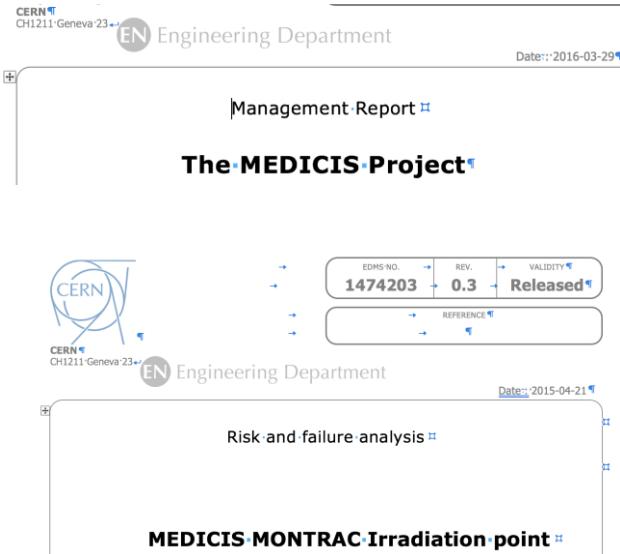
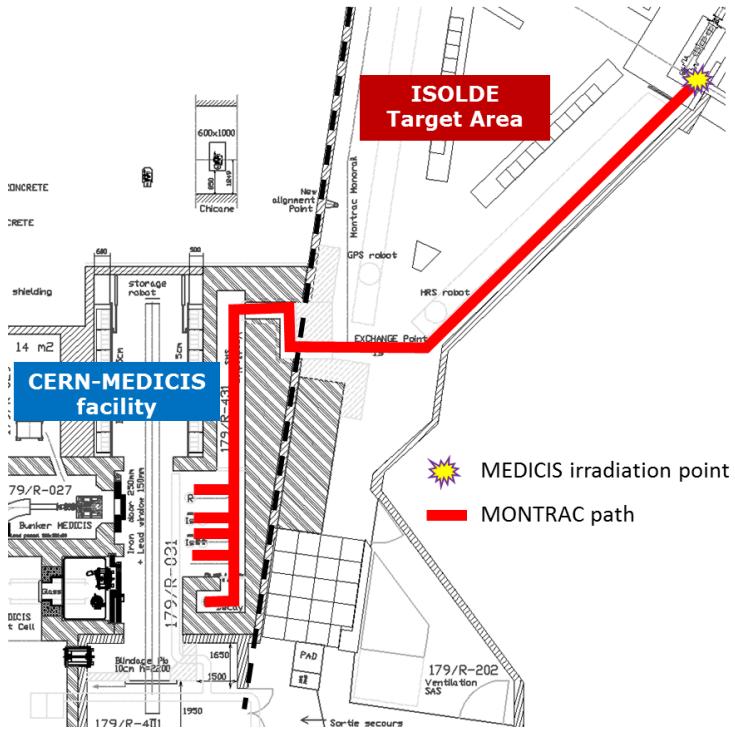
Conclusion:
impossible d'utiliser une
locomotive conventionnelle
Märklin ou LGB !

EPIC PSB upgrade

System finally selected : Rad-hard modified commercial Montratec rail conveyor



Finally integrated within the MEDICIS Project



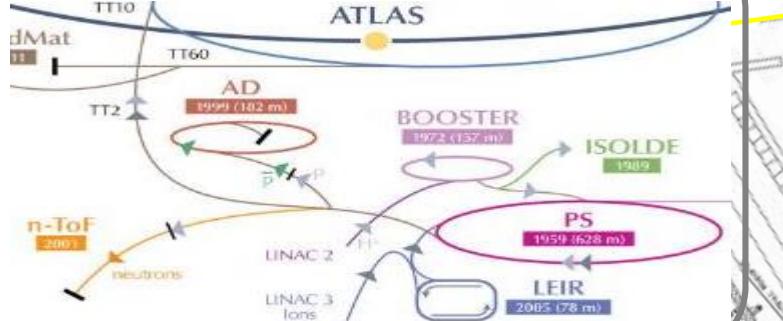
Implemented switches, cameras, rescue shuttle,
Recovery scenarios, etc

Cycle during operation

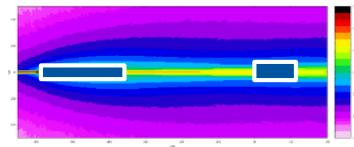


CPS Beam Permits

CERN protons

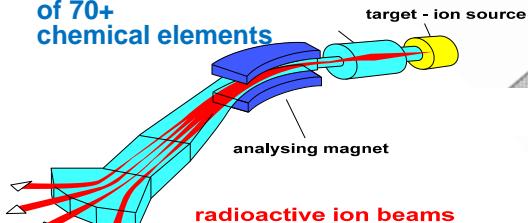


**MEDICIS
Target
Irradiation**



**Rail
Conveyor
System**

1000+ isotopes
of 70+
chemical elements



**MEDICIS
Laboratory**



Operation

Insert target

- 12 min – protons stopped
(only at HRS)

Irradiation

- Transparent to ISOLDE

Retrieve target

- 12 min – protons stopped
(only at HRS)

EoB+12min

Decay

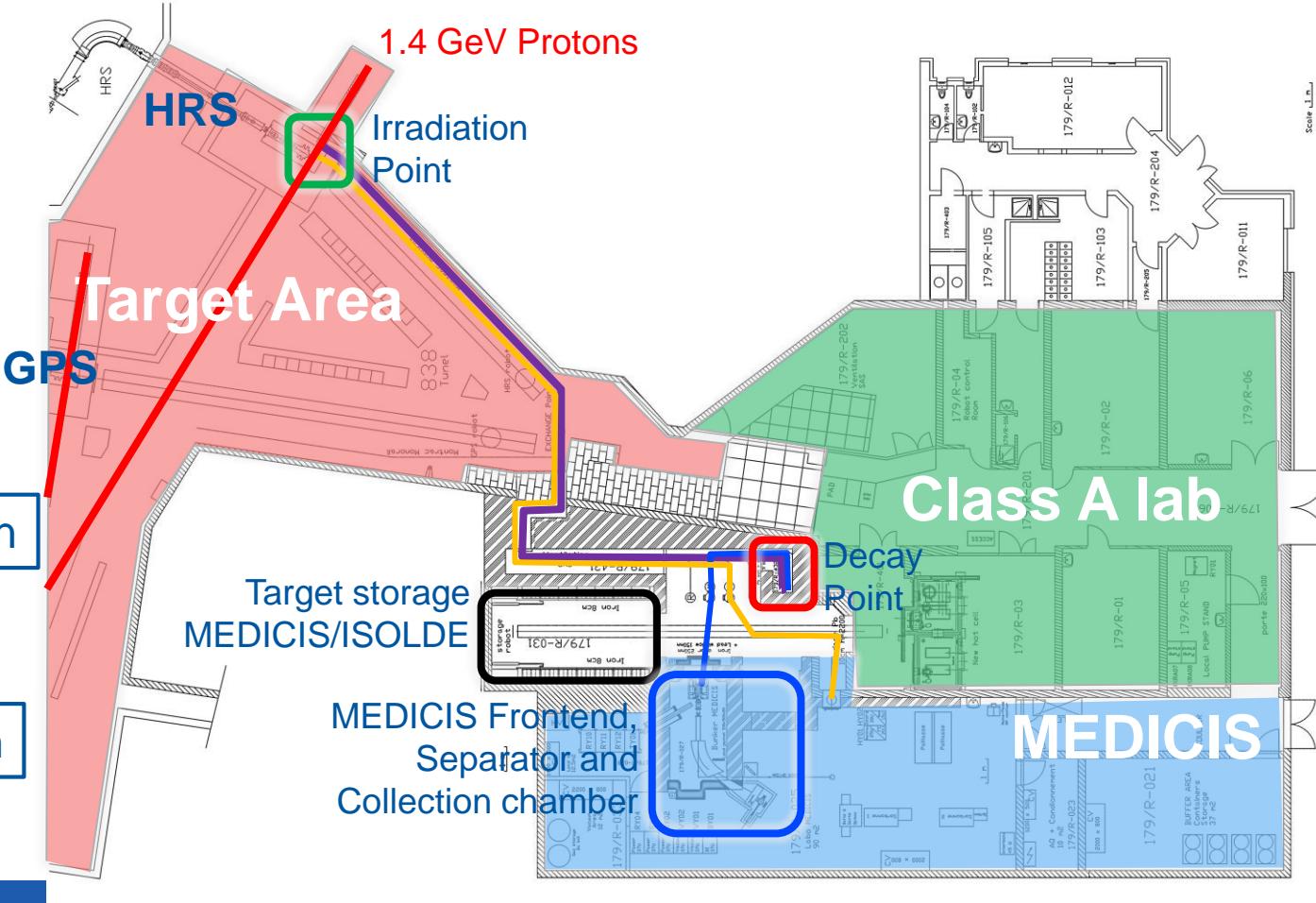
- Until target reaches <1Sv/h
(at 26 cm)

Install in Frontend

- Isotope Extraction

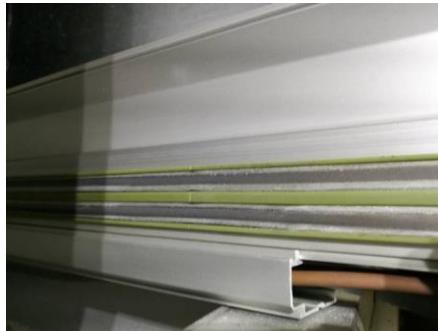
EoB+4h

From JP Ramos



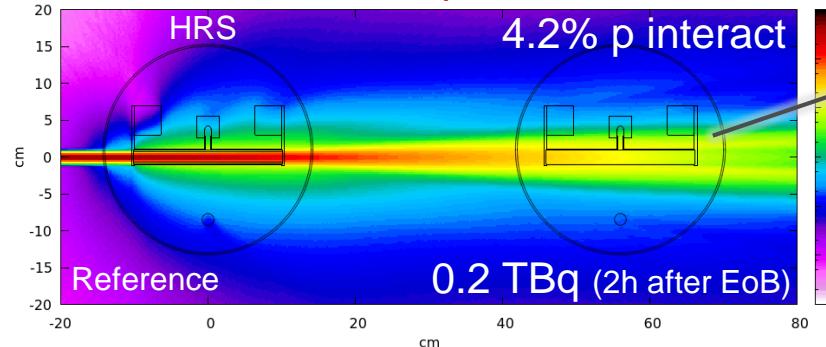
Operation feedback

- Only 2 issues found during operation of Rail Conveyor:
 - Rail oxidation at irradiation point
(→ change material)
 - One target stuck at parking position
(→ recovered and new trajectory)

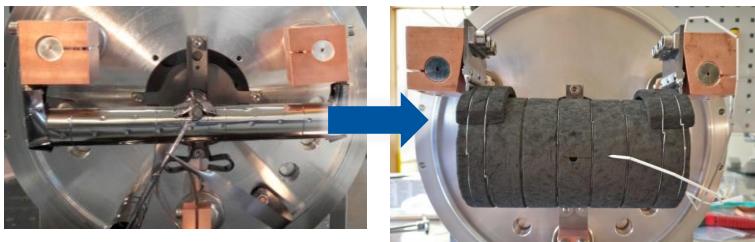


Irradiation modes

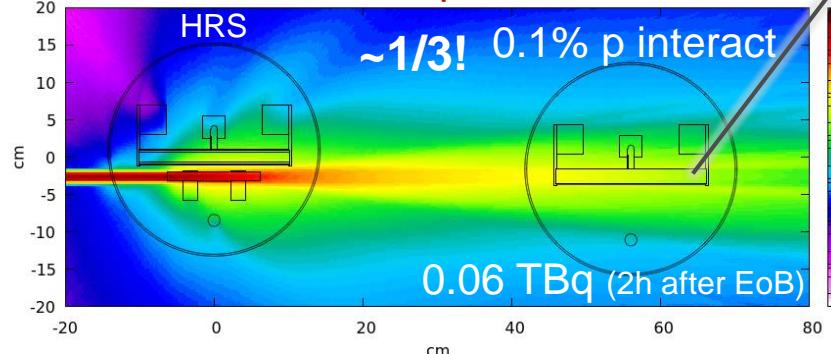
Standard mode of operation



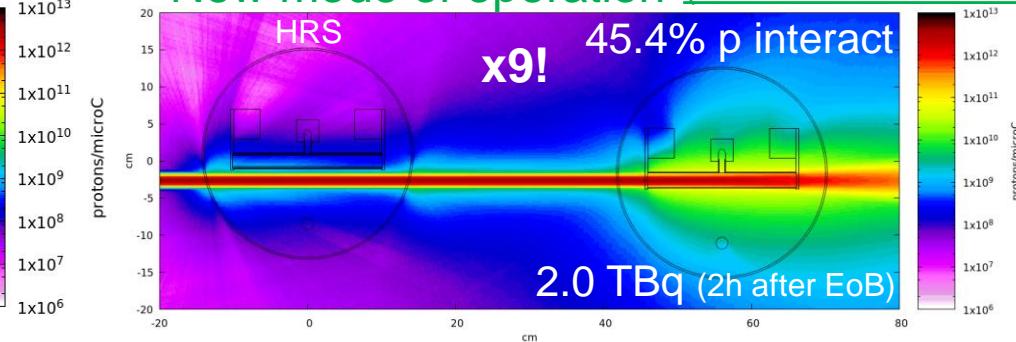
Need large diameter target



Standard mode of operation - converter

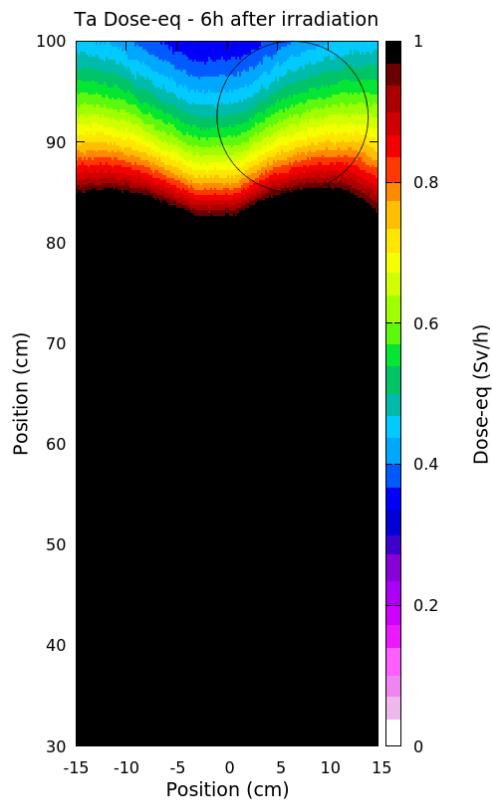
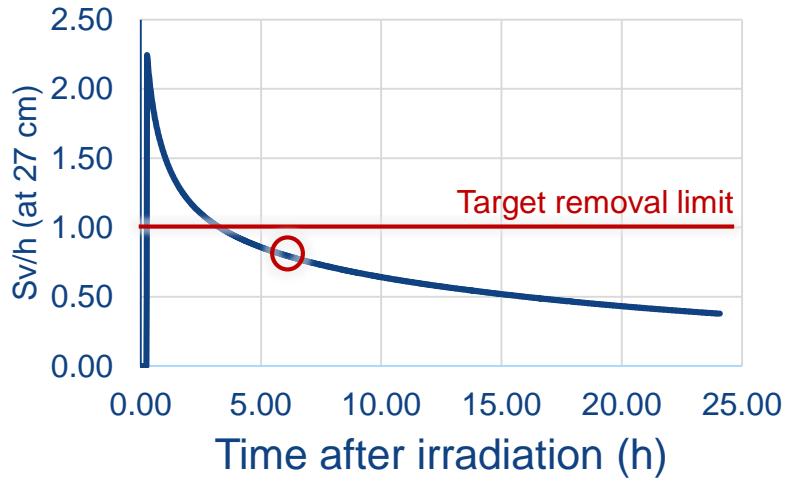


New mode of operation (if no n-conv in HRS)

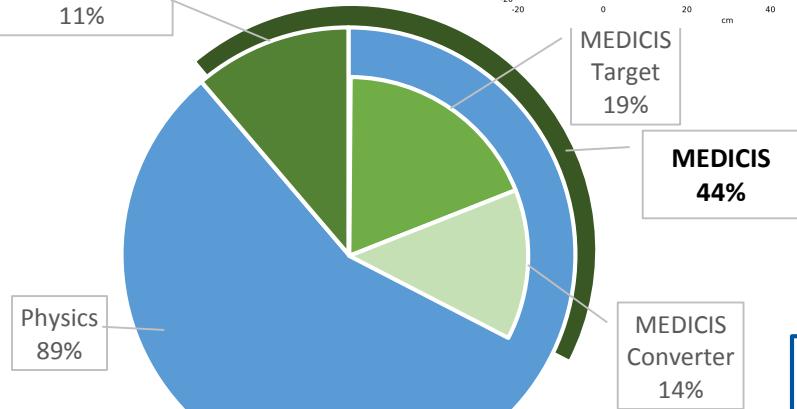
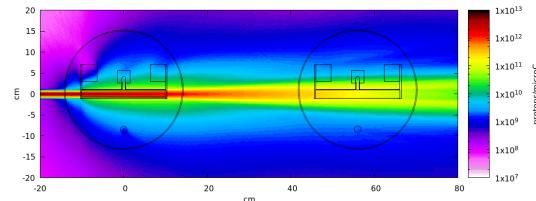
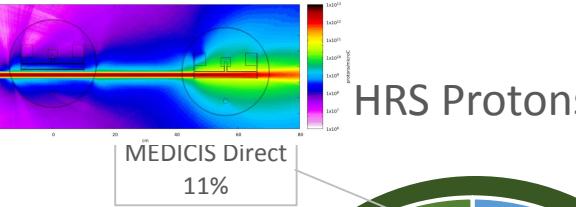


Example : MD4 – 155Tb – Mid August 2018

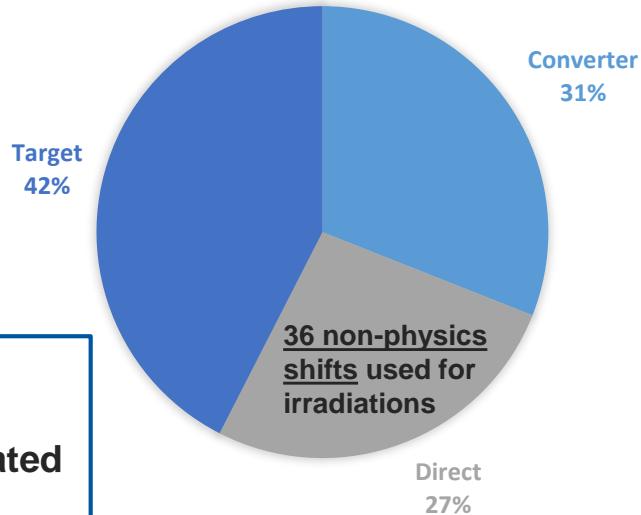
Irradiation for 2 days (1.5E18 protons)



MEDICIS Operation for 2018



26 irradiations
1092 HOURS OF IRRADIATION
138 shifts - 45.5 days



From ISOLDE physics run,
MEDICIS Irradiated
~5 hours/day
~1.5 days/week

Not always very well centered

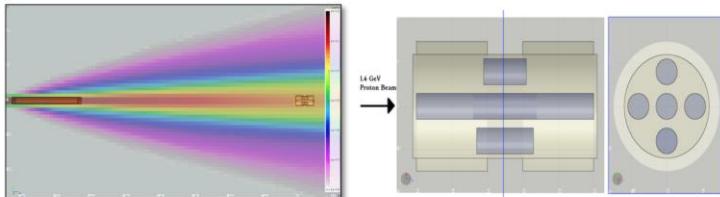


Figure 1(a,b) Geometry implemented for FLUKA simulations

Table 2
Counts of ^{7}Be in the HD polyethylene lids

Lid, mm	Weight of lid, g	Area counts of 477.5keV photopeak in 2000s	Normalised counts(counts/g)	Ratio of the total beam assigned to target assembly
8+10	1	2599±55	2599±55	1.0
12	1	1006±35	1006±35	0.41
16	1	1892±47	1892±47	0.73
20	1	834±30	834±30	0.32
50	0.7	1748±44	2497±63	0.96

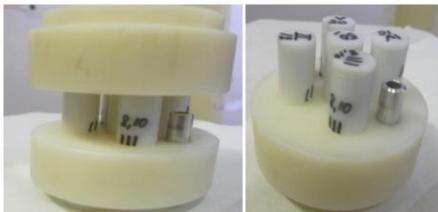


Fig. 2 Target assembly put in HD polyethylene holders.

S. Lahiri et al.,
To be published

Irradiations for ISOLDE in 2018

^{7}Be (53.22d) @ HIE-ISOLDE
(IS554)

#635-UCx - 7.96E17 p (direct)
+4 indirect irradiations
2.2 days – EoB 23/10/2018

^{223}RaF (11.4d), ^{225}RaF (14.8d),
 ^{226}RaF (1600 a) for IS657

#637-UCx - 6.74E17 p (direct)
3.4 days – EoB 19/10/2018



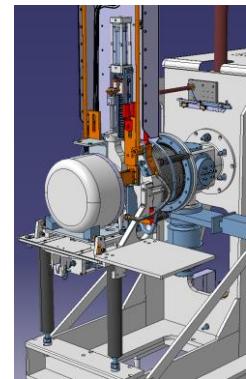
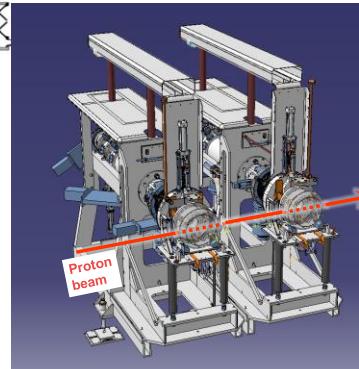
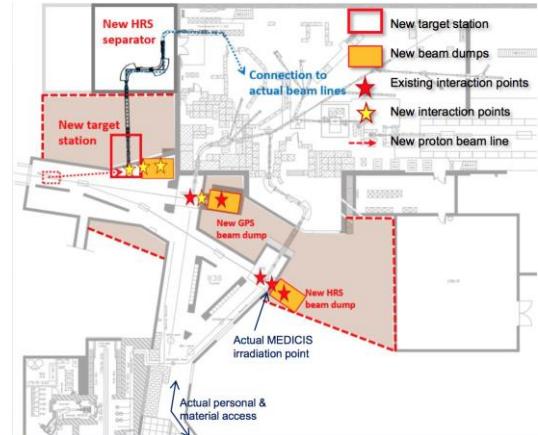
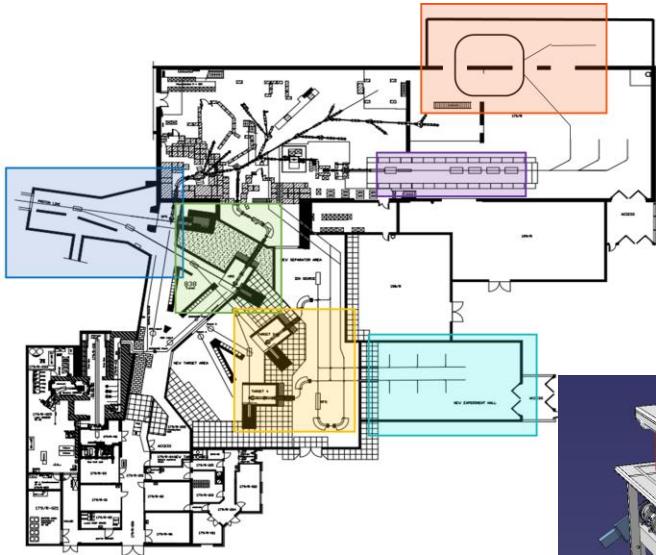
12 extra days of beamtime (21/11->03/11) for
ISOLDE
IS657

$I_{\text{RIB}} \sim 30\text{fA}$
→

>1% Ra separation efficiency

Total of 18 days (~54 shifts) of extra
ISOLDE physics thanks to MEDICIS!

Future options

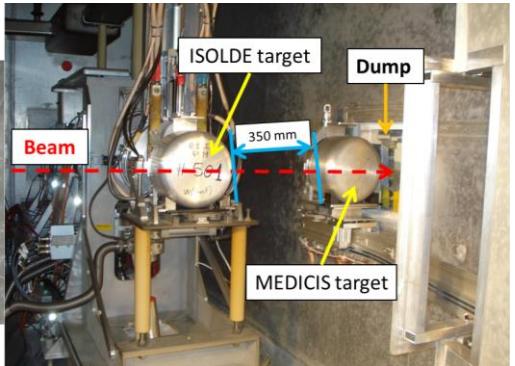


This may need some more investigations ?

Improvements



Large container target



On GPS

2GeV, high intensity



Isotope half-life	Parent isotope beam	Target ion source	ISOLDE ⁺		$\epsilon_{ext}^{**} (%)$	CERN-MEDICIS ⁺		CERN-MEDICIS 2GeV 6 μA				
			In-target			RIB	In-target Activity _{EOB} (Bq)	Extracted Activity# _{EOB} (Bq)	Possible gain $\epsilon_{ext} (%)$	In-target Activity _{EOB} (Bq)	Extracted Activity# _{EOB} (Bq)	
			Production rate (pps)	Activity _{EOB} (Bq)								
²¹³ Bi 45.6 m	²²⁵ Ac	UC _X -Re	1.5 E9 *	7.2 E8	²²¹ Fr 10	2.8 E8	2.8 E7	50	8.4 E8	4.2 E8		
²¹² Bi 60.6 m	²²⁴ Ac	UC _X -Re	1.5 E9*	1.4 E9	²²⁰ Fr 10	1.7 E9	1.7 E8	50	5.1 E9	2.5 E9		
¹⁷⁷ Lu 6.7 d	¹⁷⁷ Lu RILIS/VD	Ta-Re/ Re-VD5	3.3 E9	7.4 E8	¹⁷⁷ Lu I	6.4 E8	6.4 E6	20	8.3 E8	1.7 E8		
¹⁶⁶ Yb 56.7 h	¹⁶⁶ Yb	Ta-Re	1.4 E10	5.4 E10	¹⁶⁶ Yb 5	4.1 E10	2.1 E9	20	5.4 E10	1.1 E10		
¹⁶⁶ Ho 25.8 h	¹⁶⁶ Ho	Ta-Re	1.4 E7	1.2 E7	¹⁶⁶ Ho 5	9.6 E6	4.8 E5	20	2.9 E7	6.0 E6		
¹⁶¹ Tb 6.9 d	¹⁶¹ Tb	UC _X -Re	2.1 E7	2.7 E7	¹⁶¹ Tb 5	1.9 E7	9.5 E5	20	2.7 E7	5.4 E6		
¹⁵⁶ Tb 5.35 d	¹⁵⁶ Tb	Ta-Re	2.5 E8	8.9 E7	¹⁵⁶ Tb 1	5.5 E7	5.5 E5	20	6.3 E7	1.3 E7		
¹⁵⁵ Tb 5.33 d	¹⁵⁵ Dy/ Tb	Ta-Re	3.2 E9/ 7.4 E8	7.9 E9	¹⁵⁵ Dy 1	5.3 E9	5.3 E7	20	3.4 E9	6.8 E8		
¹⁵³ Sm 46.8 h	¹⁵³ Sm	UC _X -Re	1.5E8	2.2 E9	¹⁵³ Sm 5	2.8 E9	1.4 E8	20	5.2 E9	1.0 E9		
¹⁵² Tb 17.5 h	¹⁵² Dy/ Tb	Ta-Re	1.3 E10/ 3.3 E9	5.6 E10	¹⁵² Dy 1	3.7 E10	3.7 E8	20	1.1 E11	2.2 E10		
¹⁴⁹ Tb 4.1 h	¹⁴⁹ Tb	Ta-Re	1.1 E10	6.0 E10	¹⁴⁹ Tb 1	3.8 E10	3.8 E8	20	1.2 E11	2.4 E10		
¹⁴⁰ Nd 3.4 d	¹⁴⁰ Nd	Ta-Re	1.8 E9	2.0 E10	¹⁴⁰ Nd 5	1.2 E10	6.0 E8	20	2.0 E10	4.0 E9		



Impact of EPIC options*

Higher intensity : +++

2GeV : ++

New dump irradiation station (GPS, 3rd) : +++

Short ISOLDE targets : ++

Low density ISOLDE targets (nanoUCx) : ++

A new storage ring : neutral

HIE-ISOLDE low energy upgrade : neutral

New EPIC target stations w/o irradiation dump station : -

Less beam time or protons: -

* Very preliminary assessment

Thank you *



Epic Crystal Co.,Ltd is a manufacturer of scintillation crystals in China, mainly included the CsI(Tl), NaI(Tl), LYSO(Ce), BGO and CdWO₄, within the application of nuclear medicine, security inspection, radiation detection, high energy physics and geological exploration.

* : I received this Email yesterday : Our chinese colleagues are already on “Epic”





Large Ta container



ISOLDE

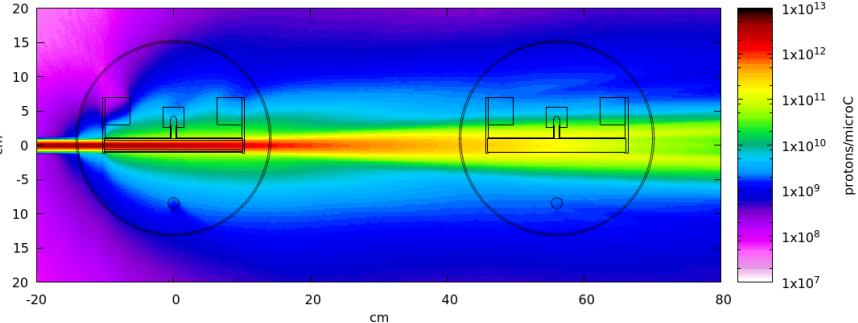
2 cm diameter
20 cm length
60 cm³ volume

V. Samothrakis, M. Ballan, S. Marzari, et al.



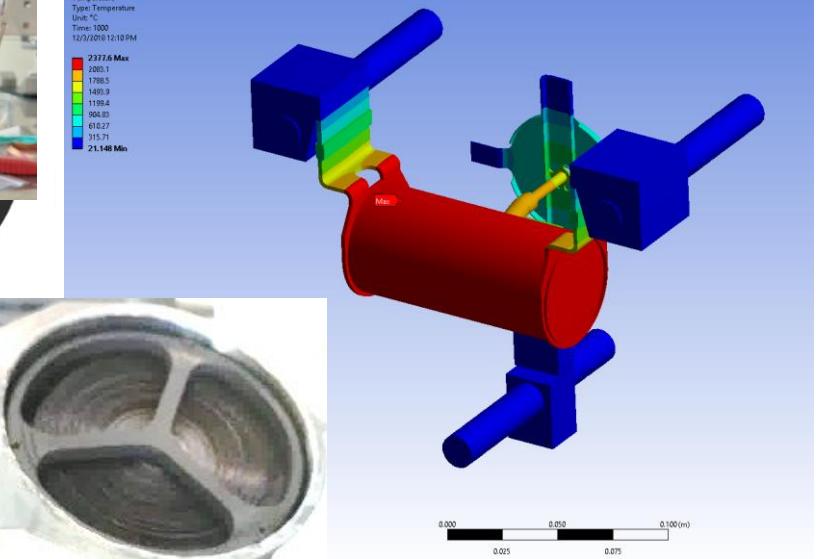
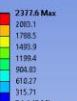
MEDICIS

5 cm diameter
10 cm length
200 cm³ volume



B: Thermal-Electric Steady State (optimal BUSH)

Temperature
Type: Temperature
Unit: °C
Time: 1000
12/7/2018 12:10 PM



1000A (normally ~750A)

Reach 400-800



1919

MEDICIS Scheduling

Wk23

1st wk



June

GPS

HRS



MO	4	4	
TU	#626 Ta - W	IS610	
WE			
TH			
FR	COLLAPS	#634 LIST	
SA			
SU	IS649	Sc RILIS	RILIS: In

Machine setup time

No protons necessary at GPS or HRS

Switch protons on for MEDICIS

MEDICIS has its target at HRS

Normal mode
Experiment (radioactive)
Protons are already in HRS

No irradiation

Experiment in GPS
No protons available

