

# Comparison of the various path of $^{44}\text{Sc}$ isomeric pair production



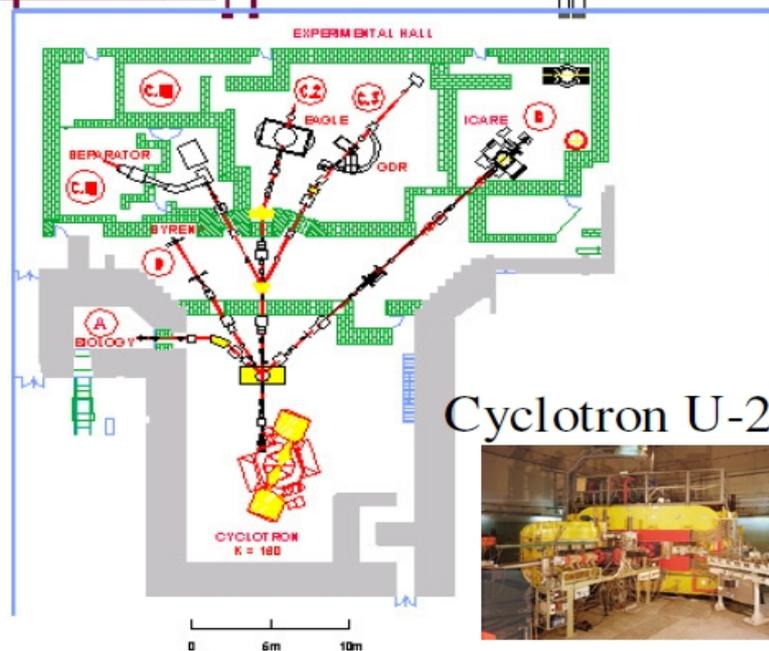
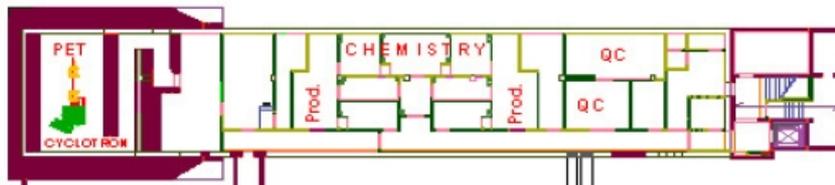
*Jerzy Jastrzębski*

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# Layout of the ground floor of the HIL building

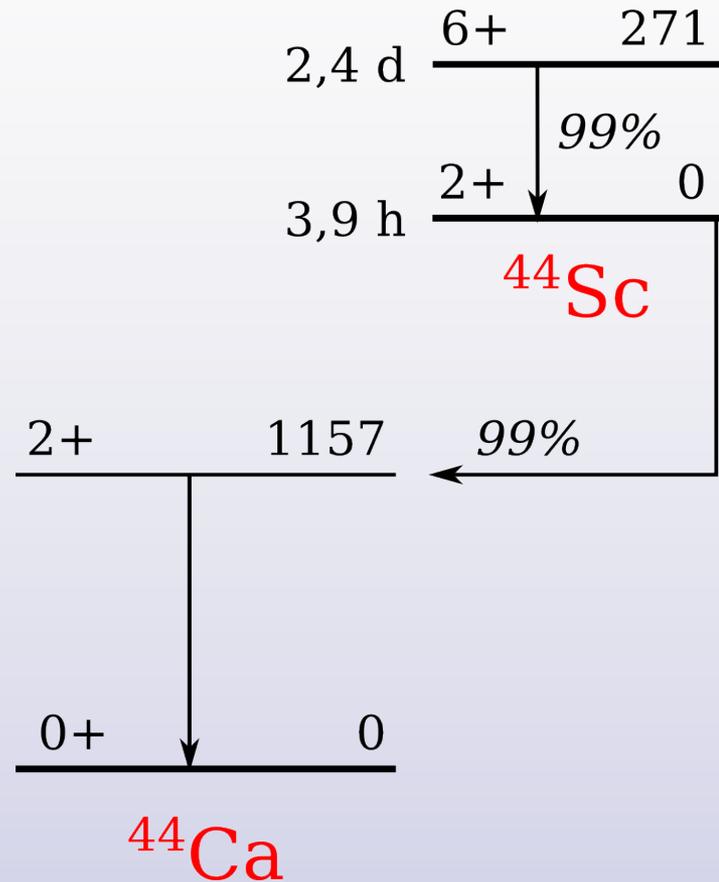
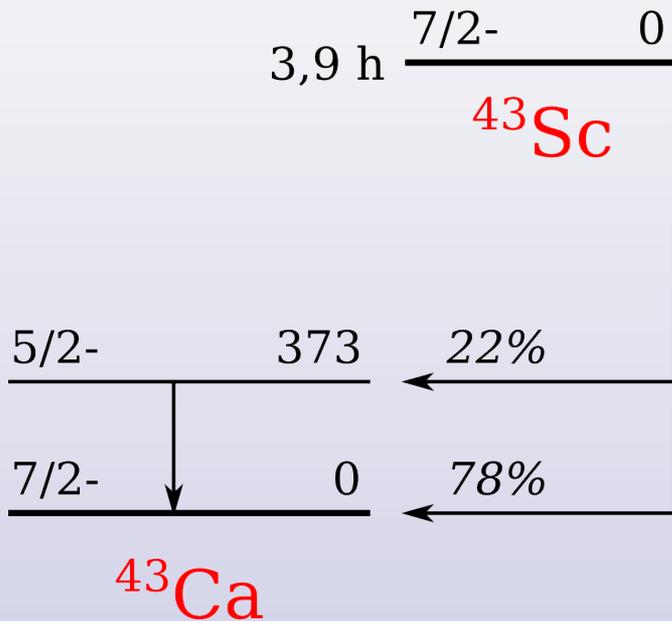


PETtrace

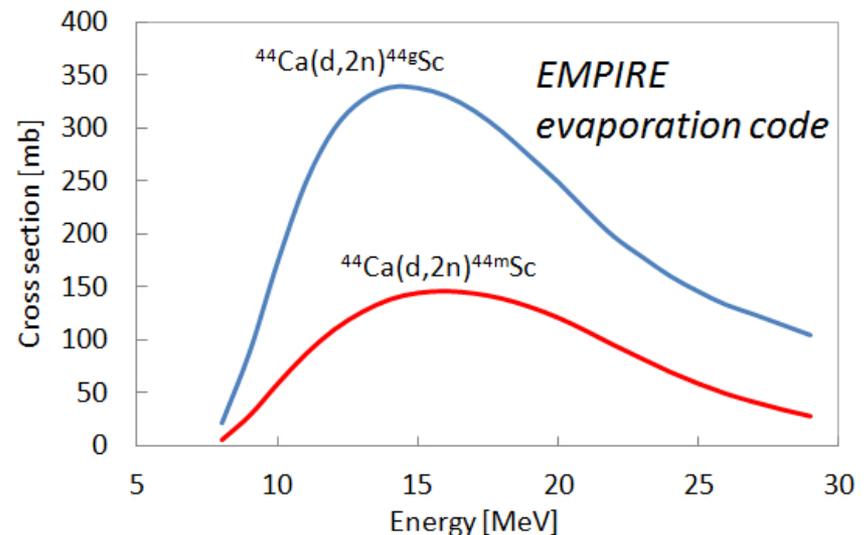
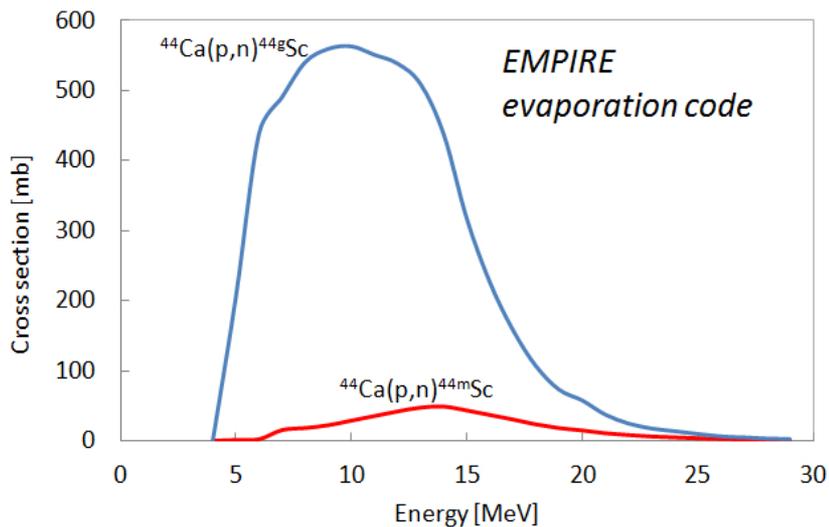


Cyclotron U-200P

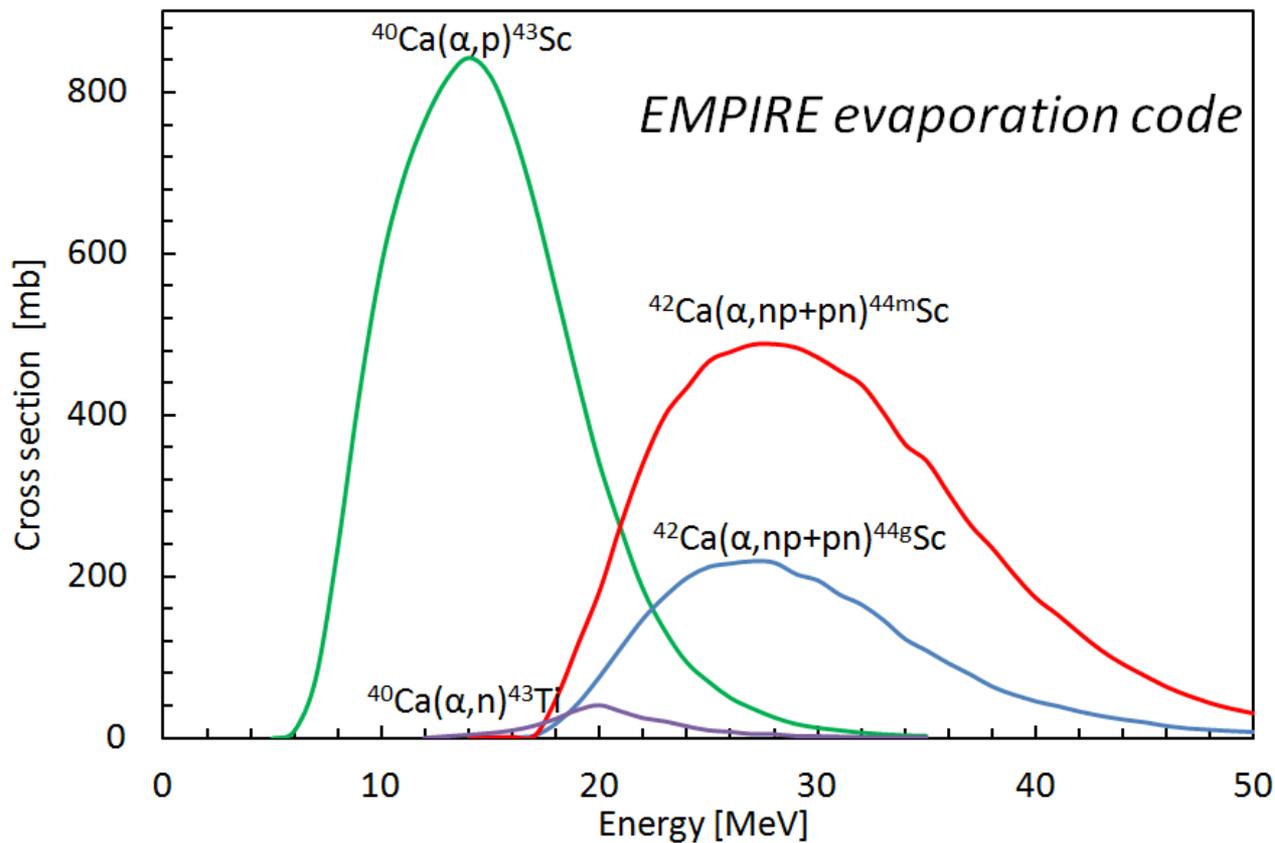




# Calculated cross-sections for proton and deuteron induced reactions with Ca isotopes

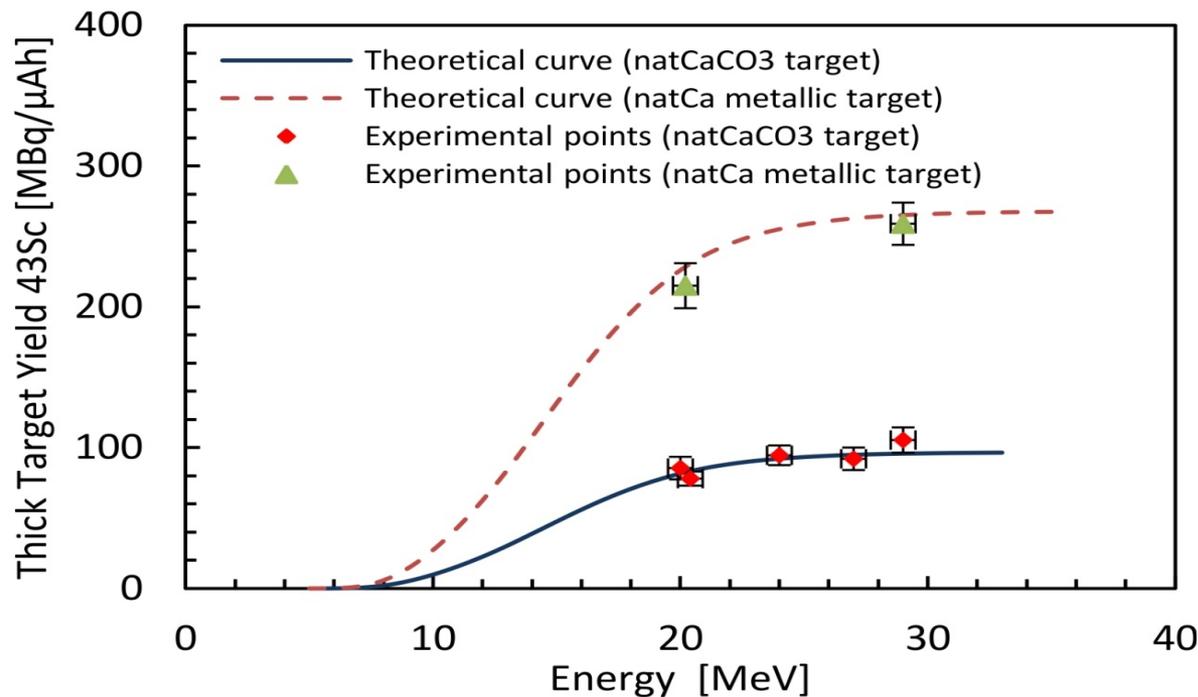


# Calculated cross-sections for $\alpha$ -particle induced reactions with Ca isotopes



# $^{43}\text{Sc}$ production via $(\alpha, n)$ reaction with metallic and $^{\text{nat}}\text{CaCO}_3$ targets

For 20 MeV bombarding energy the EOB isotopic purity of produced  $^{43}\text{Sc}$  is about **99.95%** (see also *POSTER* presentation)



# Experimental studies of the $^{44}\text{Sc}$ isomeric pair production

## p for 3-photon PET

- C. Grignon et al. *Nucl. Inst. and Meth. A* 571 (2007) 142

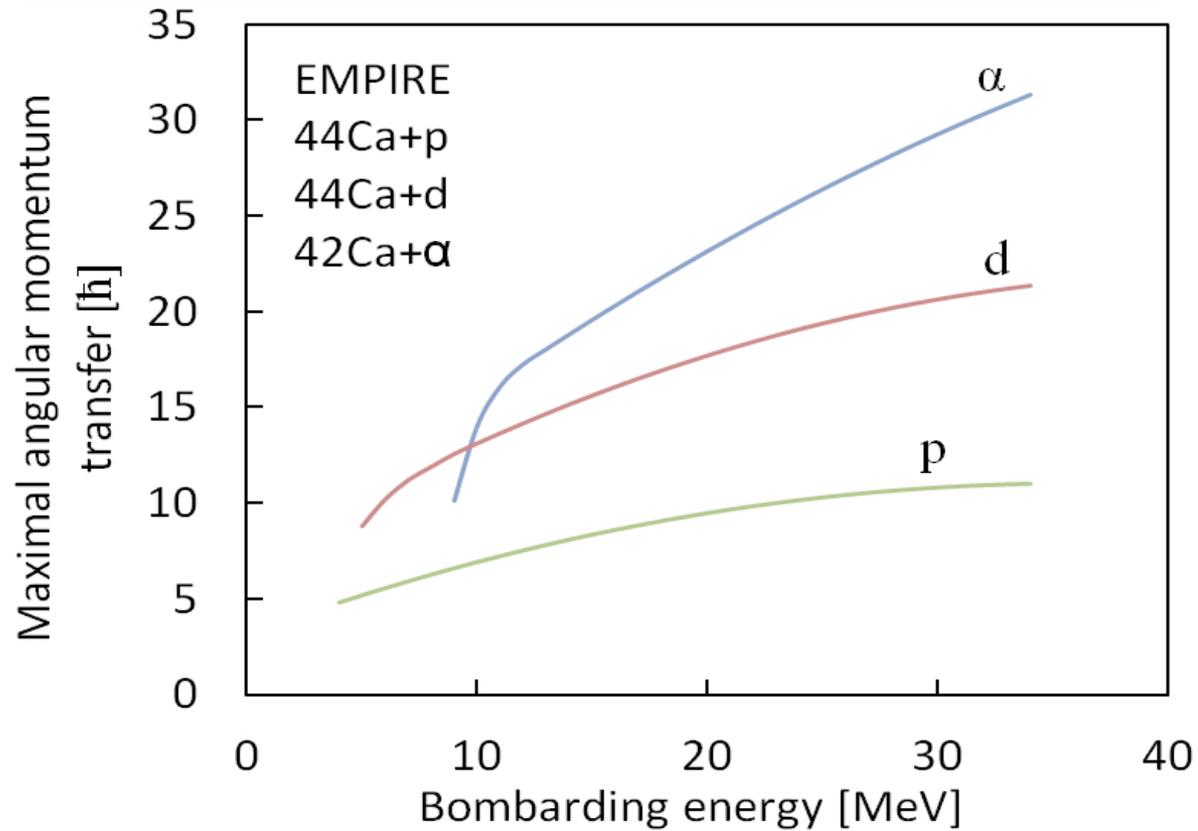
## p with Ca (metal) for PET

- G.W. Severin et al. *Appl. Rad. Isot.* 70 (2012) 1526
- H.F. Valdovinos et al. *Appl. Rad. Isot.* 95 (2015) 23

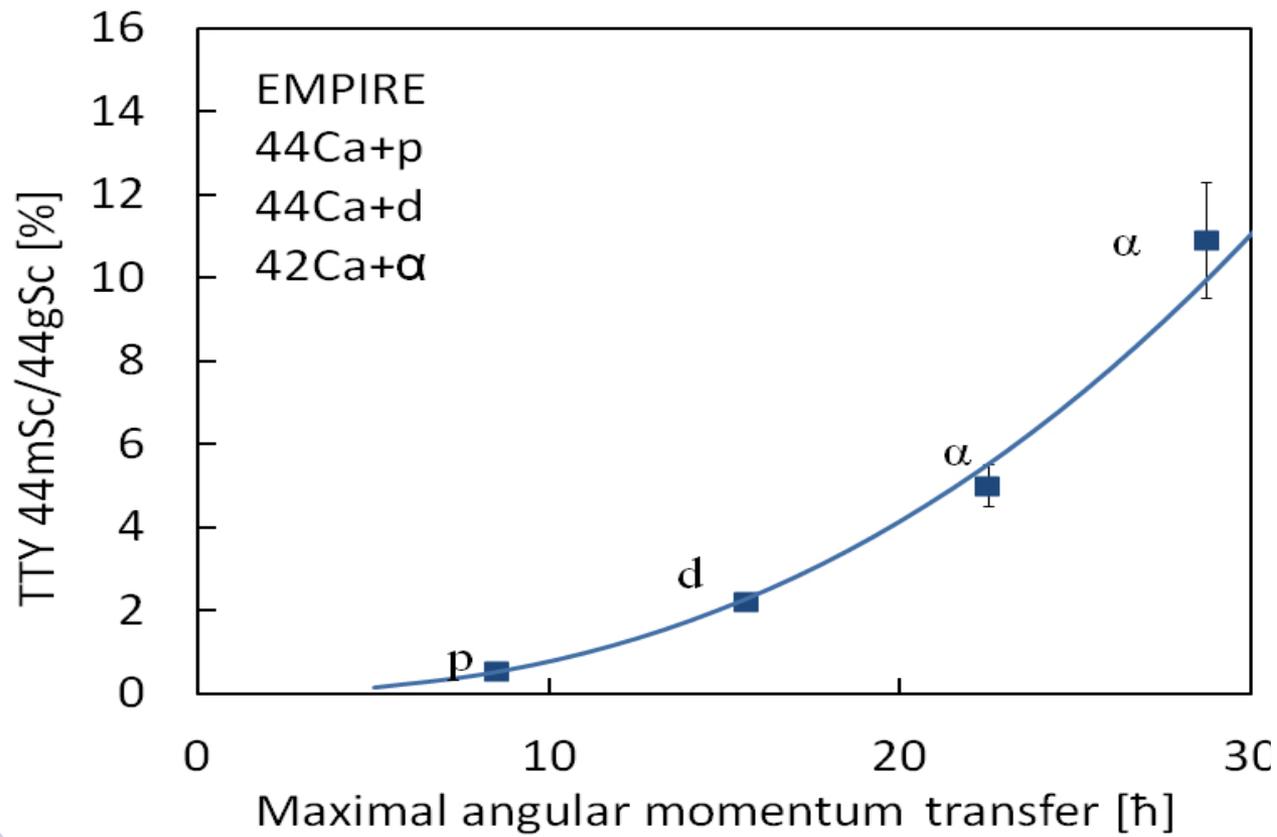
## d with $^{44}\text{CaCO}_3$ for *in vivo* $^{44\text{m}/44\text{gd}}\text{Sc}$ generator

- S. Huclier-Markai et al. *Nucl. Med. Biol.* 41 (2014) e36
- C. Alliot et al. *Nucl. Med. Biol.* 42 (2015) 524
- C. Duchemin et al. *Phys. Med. Biol.* 60 (2015) 6647

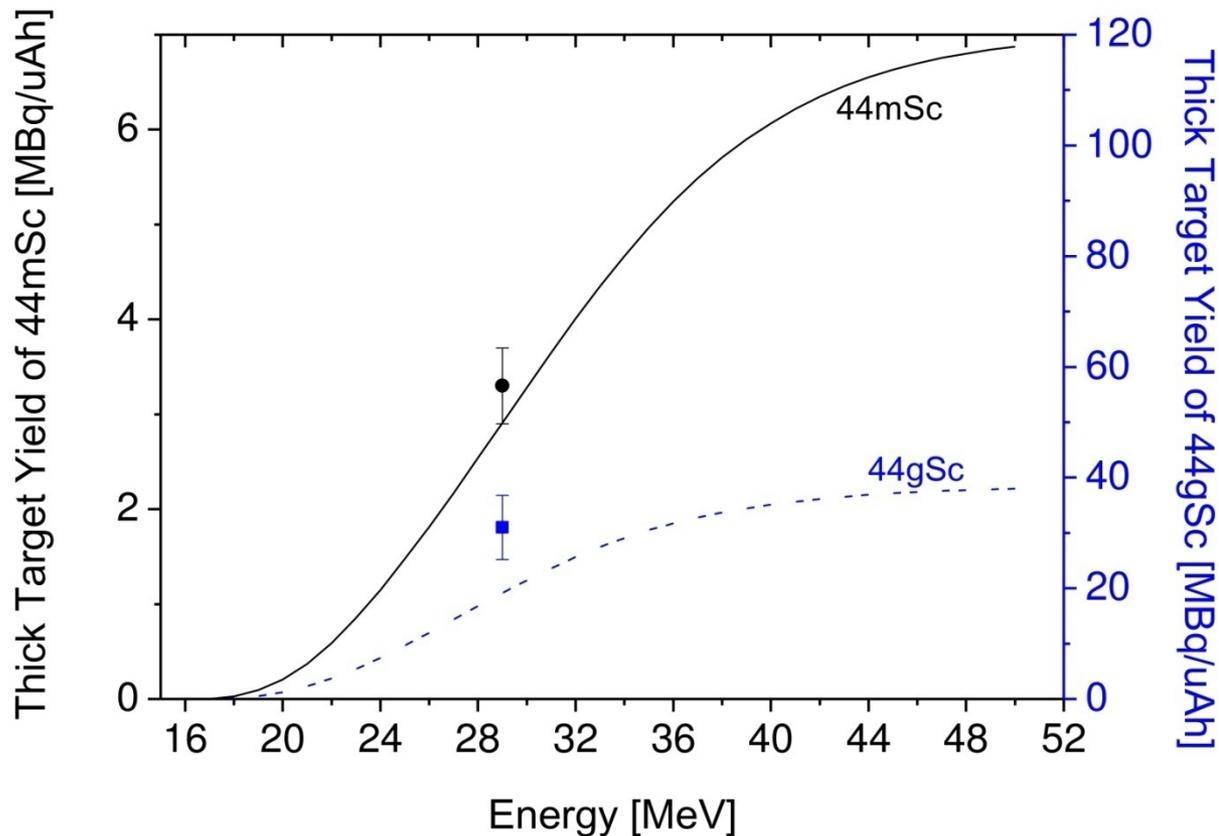
# Maximal angular momentum transfer as a function of the projectile bombarding energy



# Isomeric ratio of $^{44}\text{Sc}$ radioisotopes as a function of the maximal transferred angular momentum



# Experimental Thick Target Yield of the $^{44}\text{Sc}$ isomeric pair $\alpha$ -production compared with the EMPIRE evaporation code calculations



## Comparison of p, d and $\alpha$ production routes of $^{44}\text{Sc}$ isomeric pair using highly enriched $^{44,42}\text{CaCO}_3$ targets

Projectile	<b>p</b>	<b>d</b>	<b><math>\alpha</math></b>
Energy [MeV]	15.6	14.9	29
TTY $^{44\text{gd}}\text{Sc}$ [MBq/ $\mu\text{Ah}$ ]	630	220	44(5)
TTY $^{44\text{m}}\text{Sc}$ [MBq/ $\mu\text{Ah}$ ]	3.4	4.9	4.8(6)
TTY m/g [%]	0.54	2.21	10.9(1.4)
<i>A(EOB) <math>^{44\text{m}}\text{Sc}</math> [MBq] for 1<math>\mu\text{A}</math> and 12h irradiation</i>	38	55	52

# Technical summary Cyclone<sup>®</sup> 30 XP

## **2 exits ports (dual beam)**

- Proton 15-30 MeV 400  $\mu$ A
- Deutons 9-15 MeV 50  $\mu$ A

## **1 exit (common with one proton)**

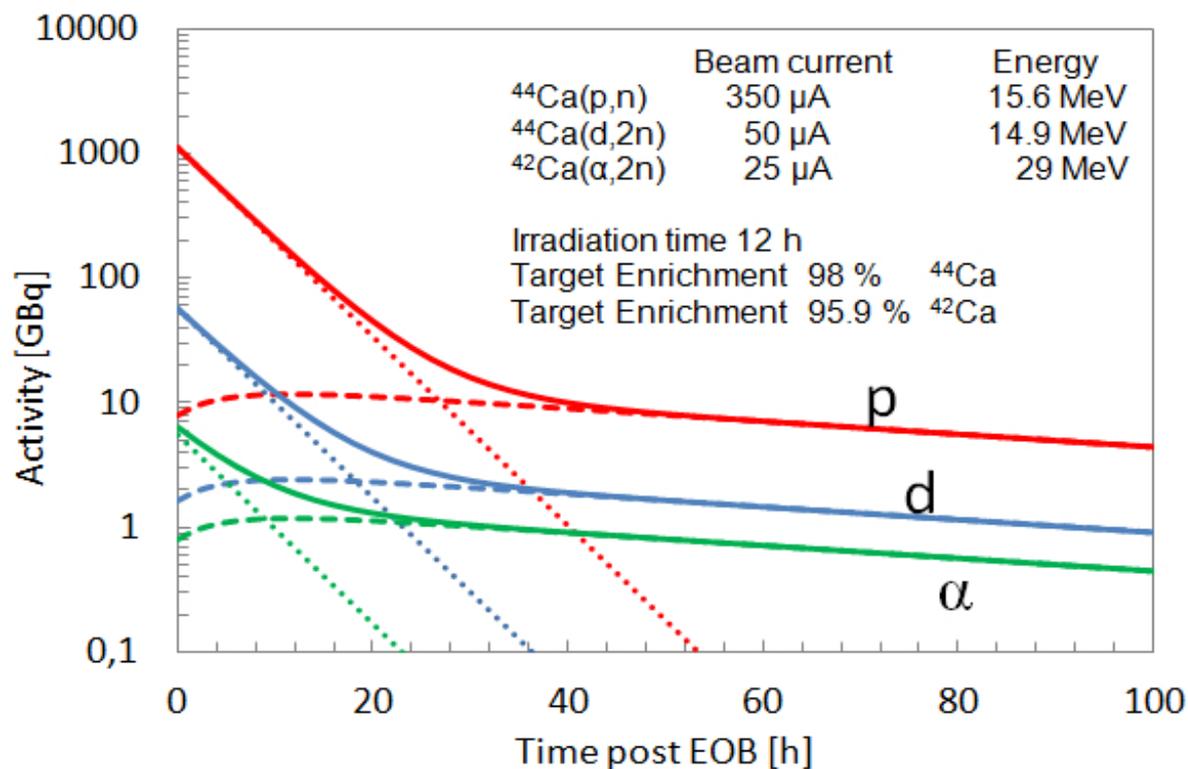
- Alpha 29- 30 Mev 50  $\mu$ Ae

Electrical ~ 120 kW

Water cooling ~ 100 kW

Size: 2.5 m dia \* 3.9 m h – 55 Tons

# Activity of $^{44m}\text{Sc}$ samples produced with proton, deuteron and alpha particle beam available from the commercial C30XP cyclotron



# Estimate for popular medical cyclotrons

Proton current                      100  $\mu\text{A}$

Irradiation time                      8 h

cooling time after EOB              48 h

$^{44\text{m}}\text{Sc}$  activity       1.5 GBq

## Summary and conclusions

- The alpha particle beam was employed for the production of medical  $^{43}\text{Sc}$ ,  $^{44\text{gd}}\text{Sc}$  and  $^{44\text{m}}\text{Sc}$  isotopes;
- a very pure and intense  $^{43}\text{Sc}$  samples were produced with  $^{\text{nat}}\text{CaCO}_3$  targets;
- the isomeric ratio of the high spin/low spin  $^{44}\text{Sc}$  "ARRONAX" pair produced with alpha particles using  $^{42}\text{CaCO}_3$  target is much larger than that with proton or deuteron projectiles;
- however, the particle beam intensities from the currently available commercial C30XP cyclotron or popular medical cyclotrons clearly favorise the proton beam for these aims;
- much higher  $\alpha$ -particle beam intensities are expected from the presently build facilities (SPIRAL2).

*The discussions with Ulli Koester are appreciated*

# Collaborators

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**THANK YOU FOR YOUR ATTENTION**