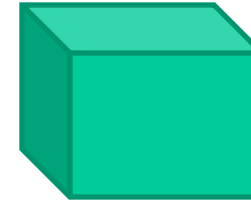


Measurement and simulation of radionuclide product yields in iron from 400 AMeV carbon ions

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The university of Tokyo

Abstract

400 MeV
C ion

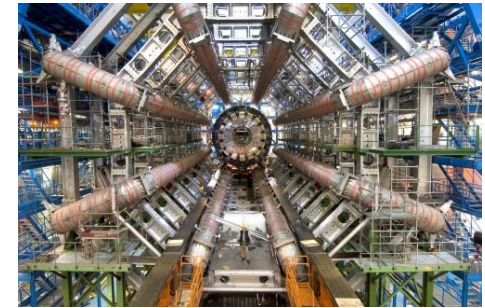


In-Target
 γ -emitting
fragments

Experiment
Simulation (FLUKA)

- Target fragment in Fe target
- Bombarded by 400MeV/u C ion
- Experiment and calculation with FLUKA
- FLUKA
 - Projectile fragment, deep fragmentation
: Underestimation (50%)
 - Isomer : Reasonable
 - Others : Good agreement

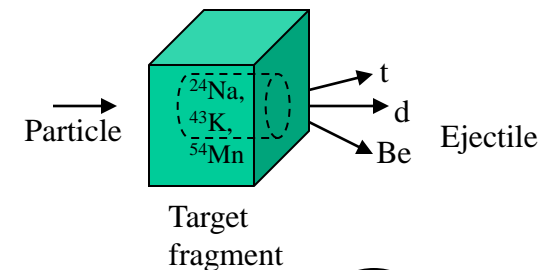
Background



- Activation in intermediate ~high energy
 - Problem in decommissioning
- Monte-Carlo calculation codes
 - Ejectile yield ← Good measurements
 - Target fragment ← Few benchmark data

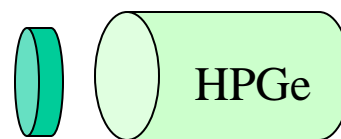
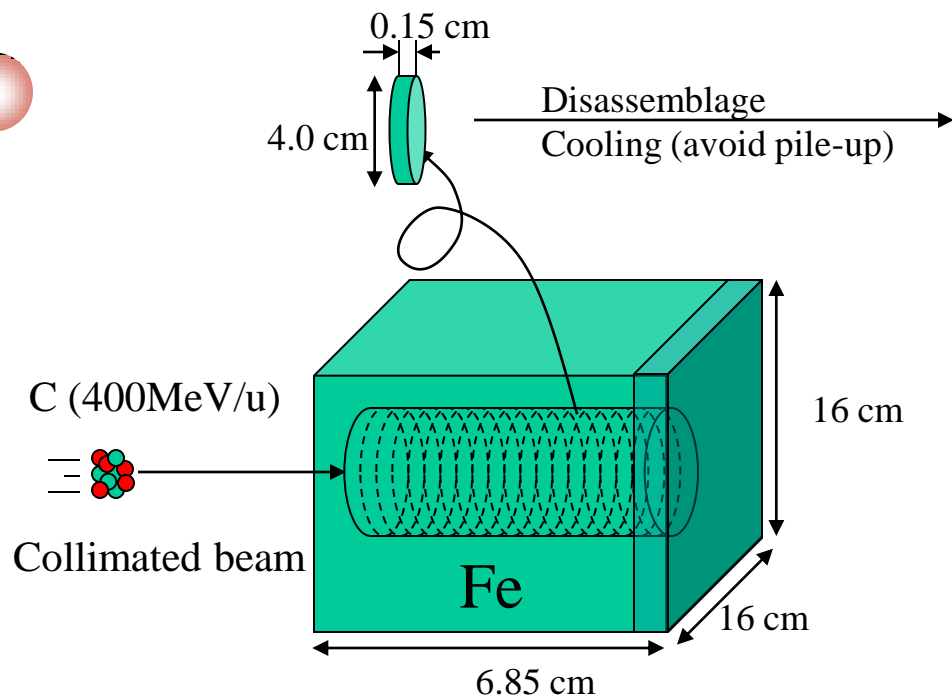


Essential in activation estimation



Experiment

- Irradiation (~10 h, Cooling)
- Gamma spectrometry



Measure activity one by one

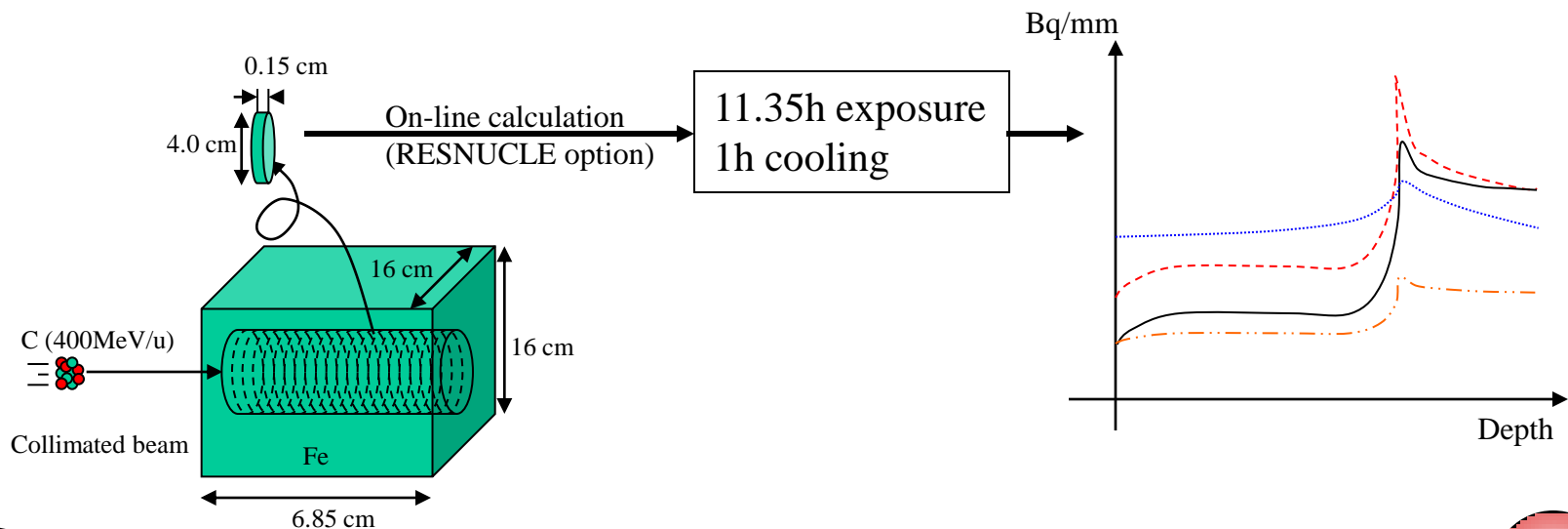
- ☆ Only decay γ -emitting
- ☆ detectable intensity
- ☆ Medium ~ Long half-lived nuclides were measured

Be-7, Na-22, Na-24, Mg-28, K-42, K-43, Sc-44_m, Sc-46, Sc-47, Sc-48, V-48, Cr-48, Cr-51, Mn-52, Mn-54, Co-55, Co-56, Co-58

Simulation

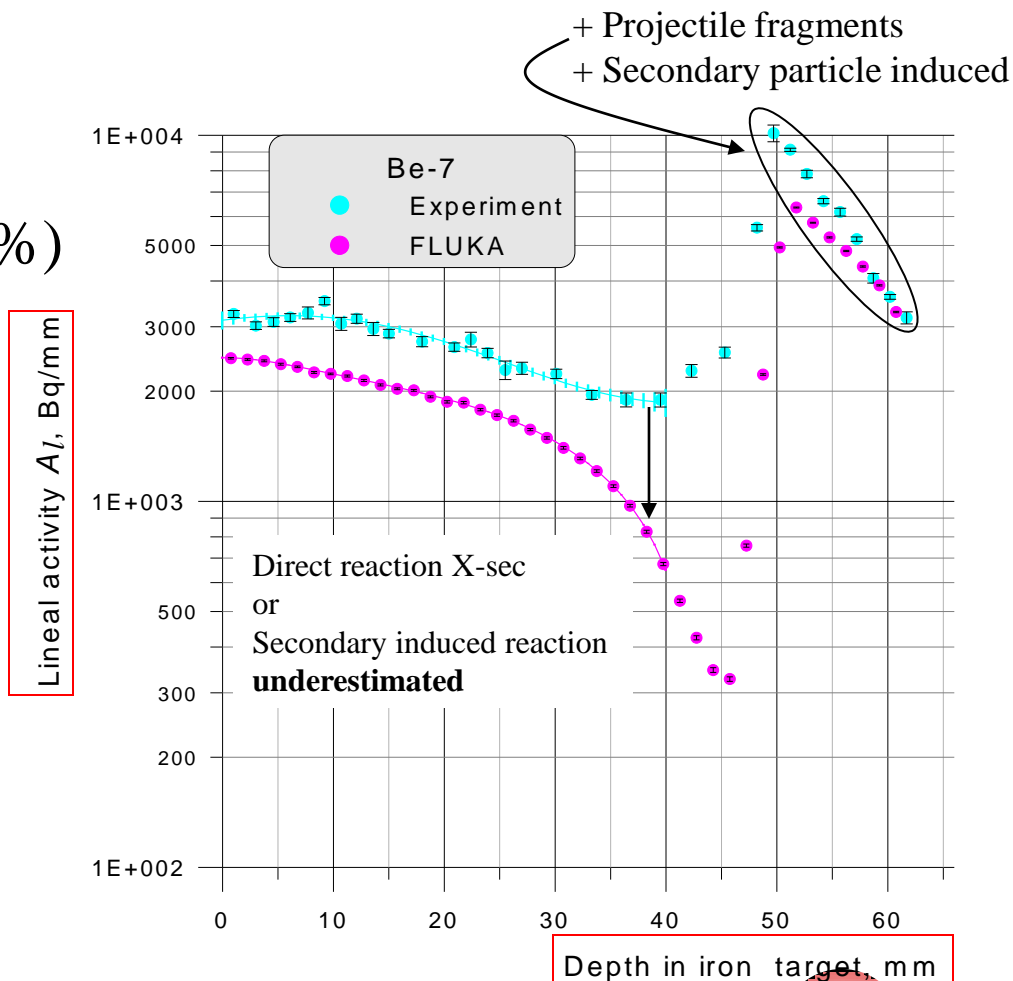
~~FLUKA-2008~~

- Fe: Natural isotope composition
- Impurities (C, P, Mn, S, Si) ← Minor effect
- RQMD (A-A interaction) model



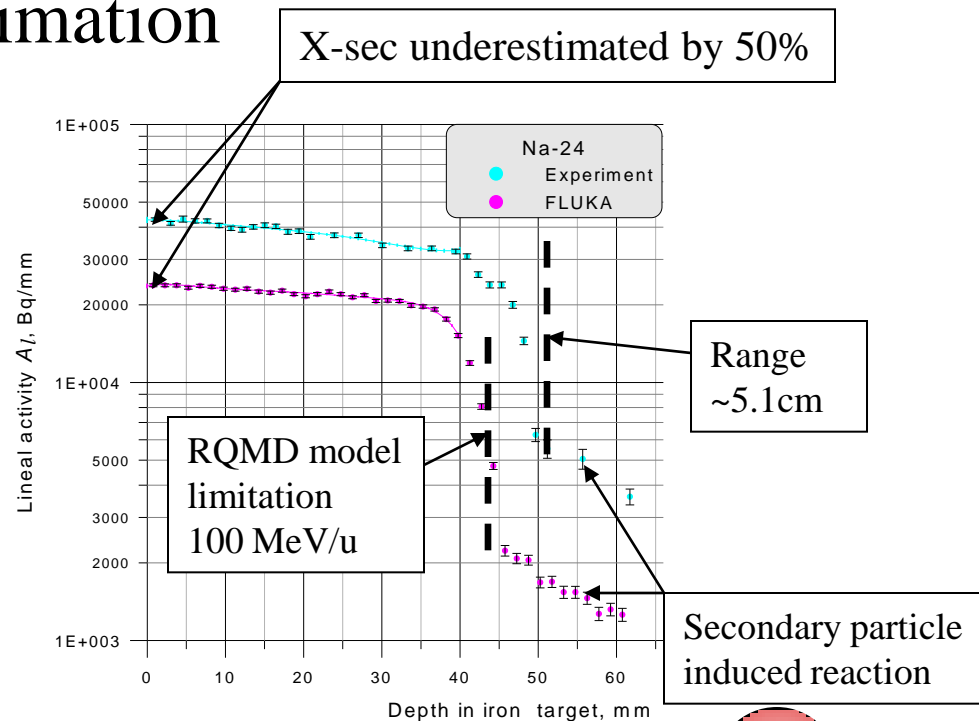
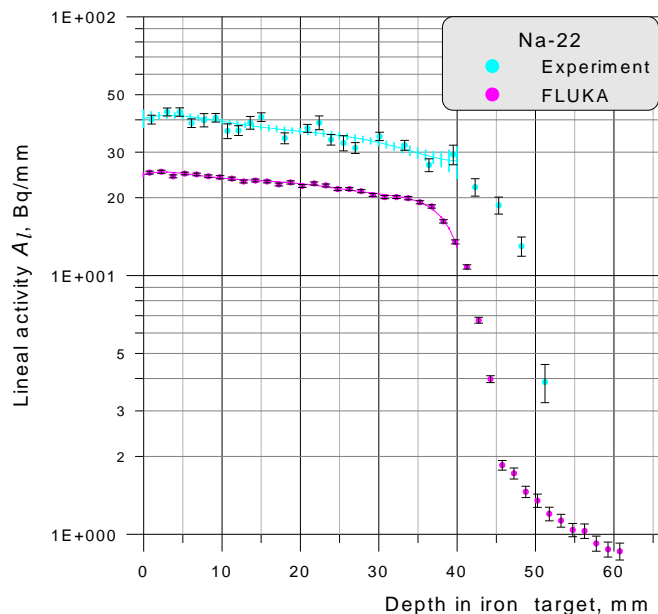
Results ~Lighter than projectile~

- Projectile fragments
 - Underestimated (~50%)
- Production in range
 - Underestimated
 - Direct or indirect



Results ~ Deep fragmentation ~

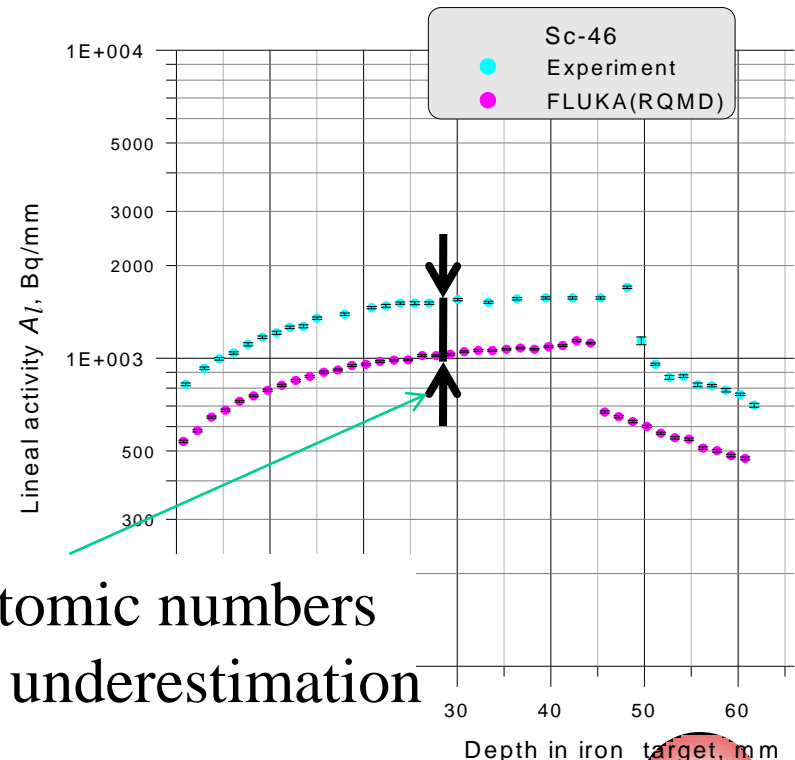
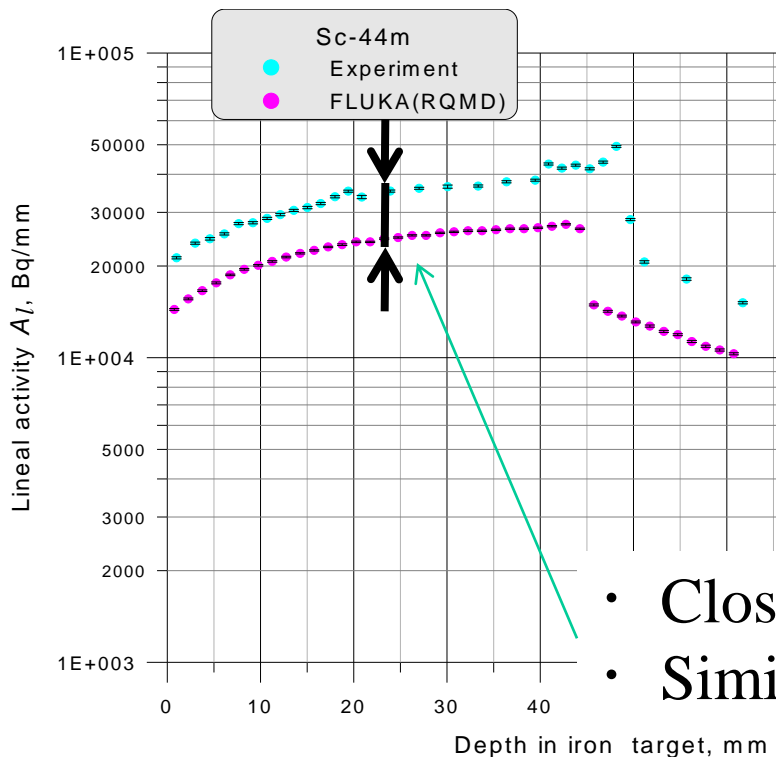
- X-section underestimated
 - Secondary particle induced : underestimated
- End of range: Underestimation



Results ~ Isomer ~

- Isomer production

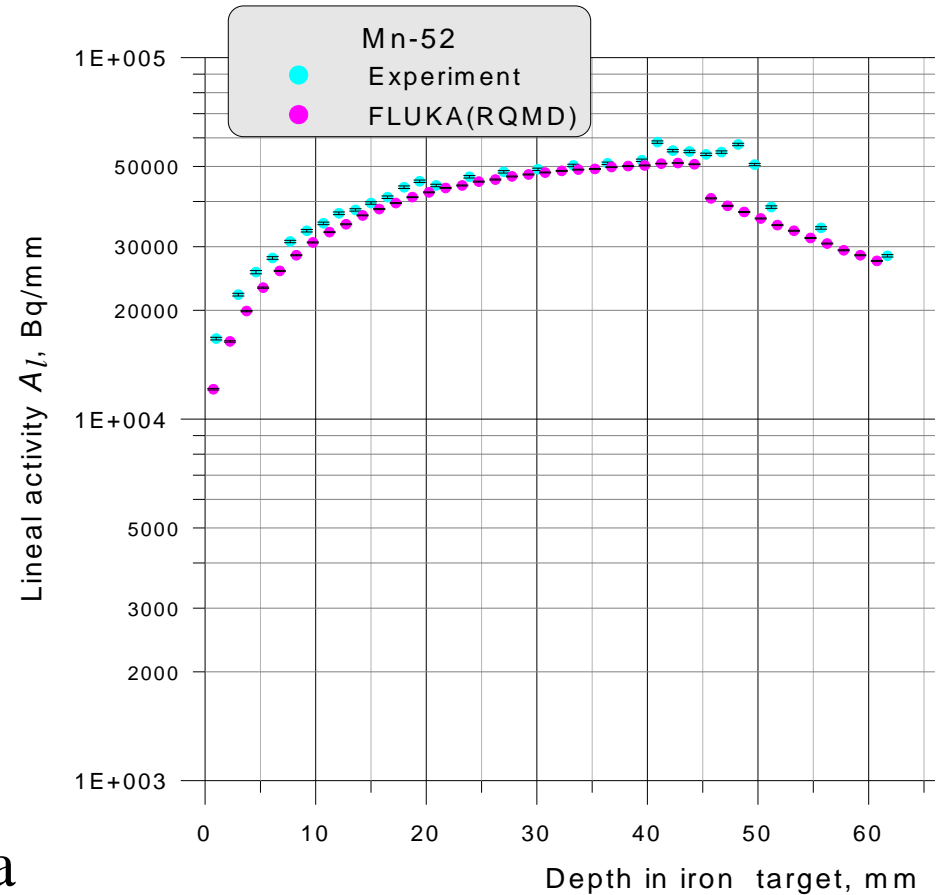
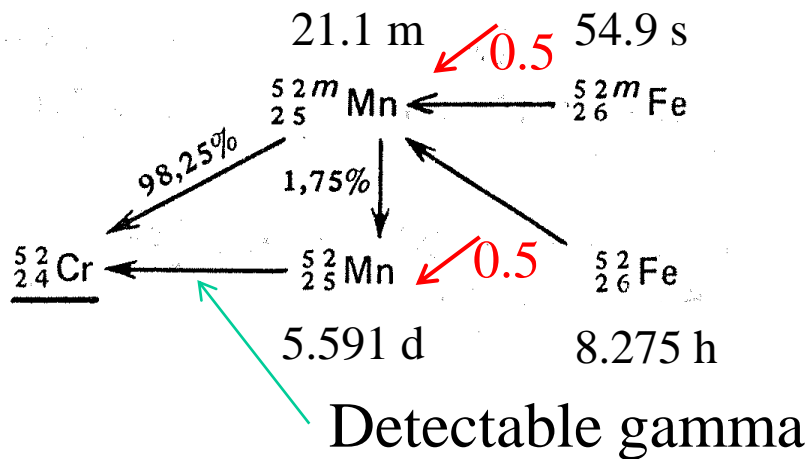
- 1/2 ground, 1/2 meta-stable assumption : Not critical



- Close atomic numbers
- Similar underestimation

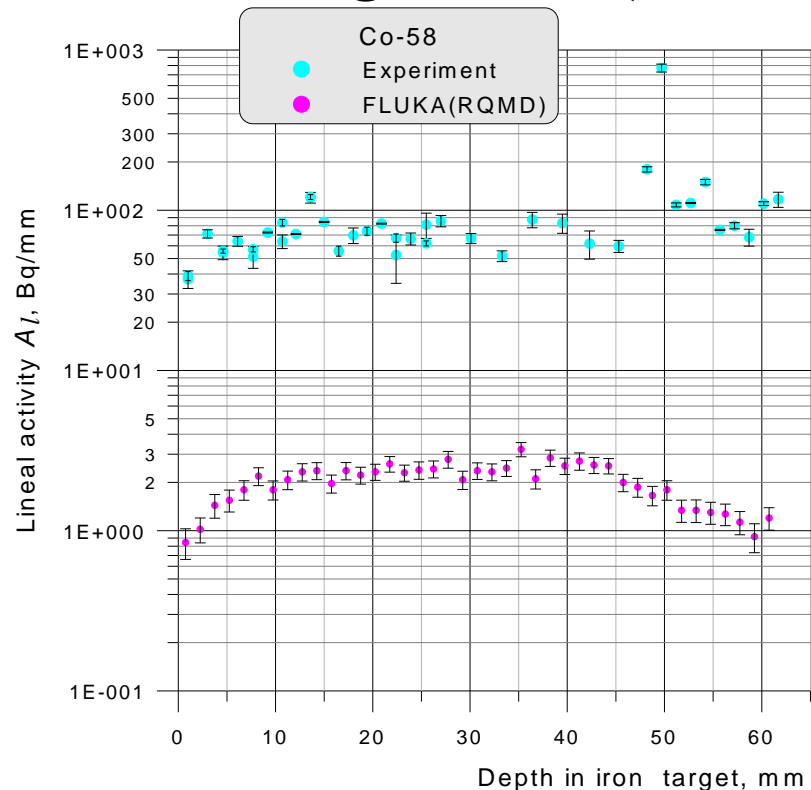
Results ~ ~ Isomer-2 ~ ~

- Isomer production
 - Mn-52 g
- Very good agreement →



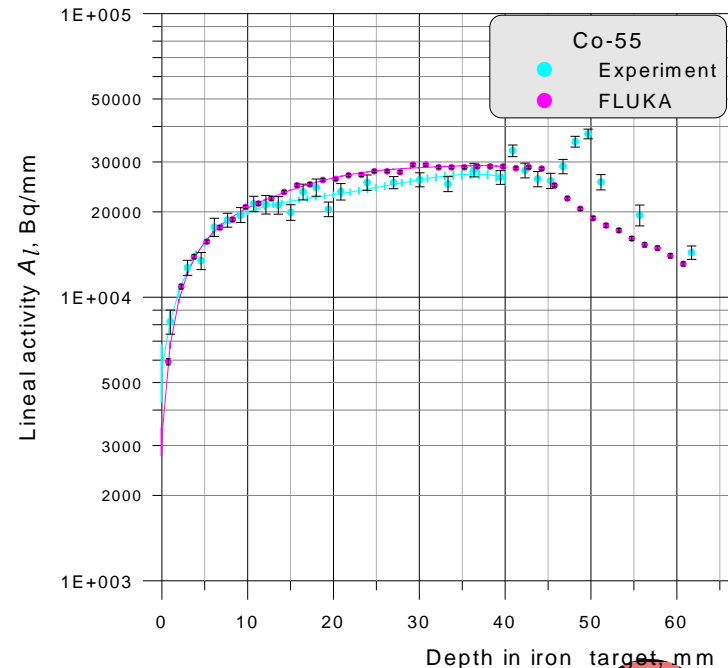
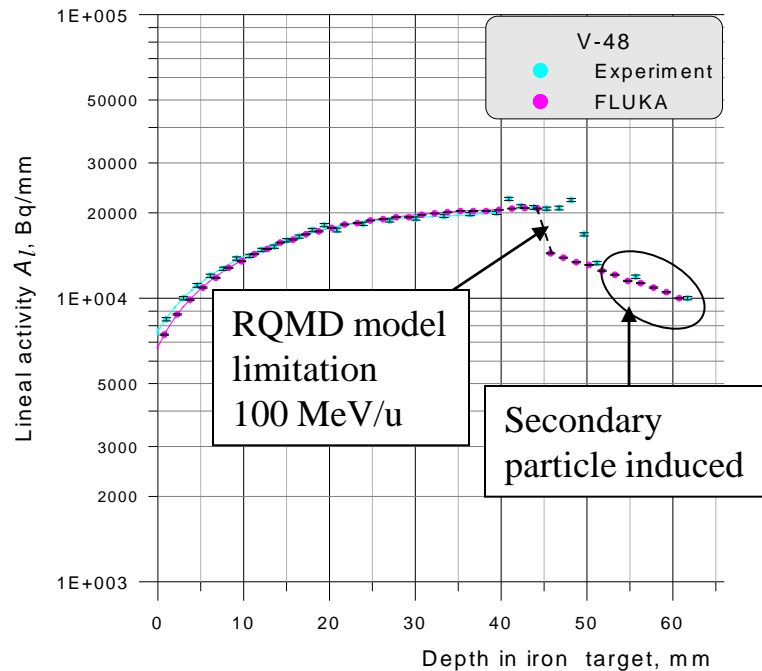
Results ~As heavy as target~

- Severely underestimated ($\sim 1/300$)
- Low E light ion (α , t, etc) induced reactions?



Results ~other nuclides~

- Higher contribution from secondary particles



Conclusion

- Fe target + 400MeV/u C ion
- Experiment & Simulation
- Overall good agreement
 - Projectile fragment : Under? (50%)
 - Deep fragmentation : Under (50%)
 - Shallow fragmentation
by secondary particles : Good agreement
 - Isomer assumption : Reasonable
 - Others : Good agreement



Acknowledgement

- We gratefully acknowledge the support and assistance of the accelerator operation staff at HIMAC and Dr. Murakami.
- We wish to thank the FLUKA authors Dr. Francesco Cerutti, Dr. Vasilis Vlachoudis and Dr. Alfredo Ferrari for fruitful discussions