Danish CANS workshop 2016

Isotope Production from Compact Neutron Sources

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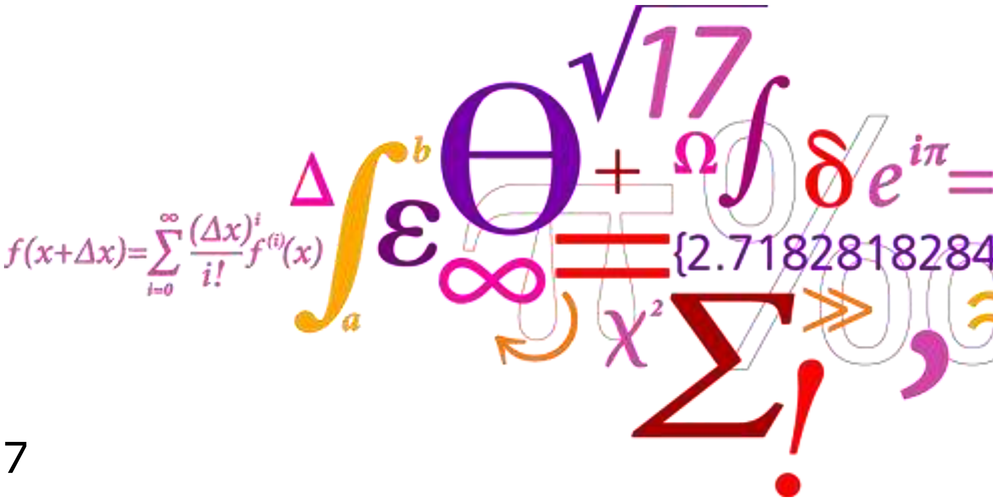
~ 10^6 n/sec

One of the 6 Ra/Be NBI sources

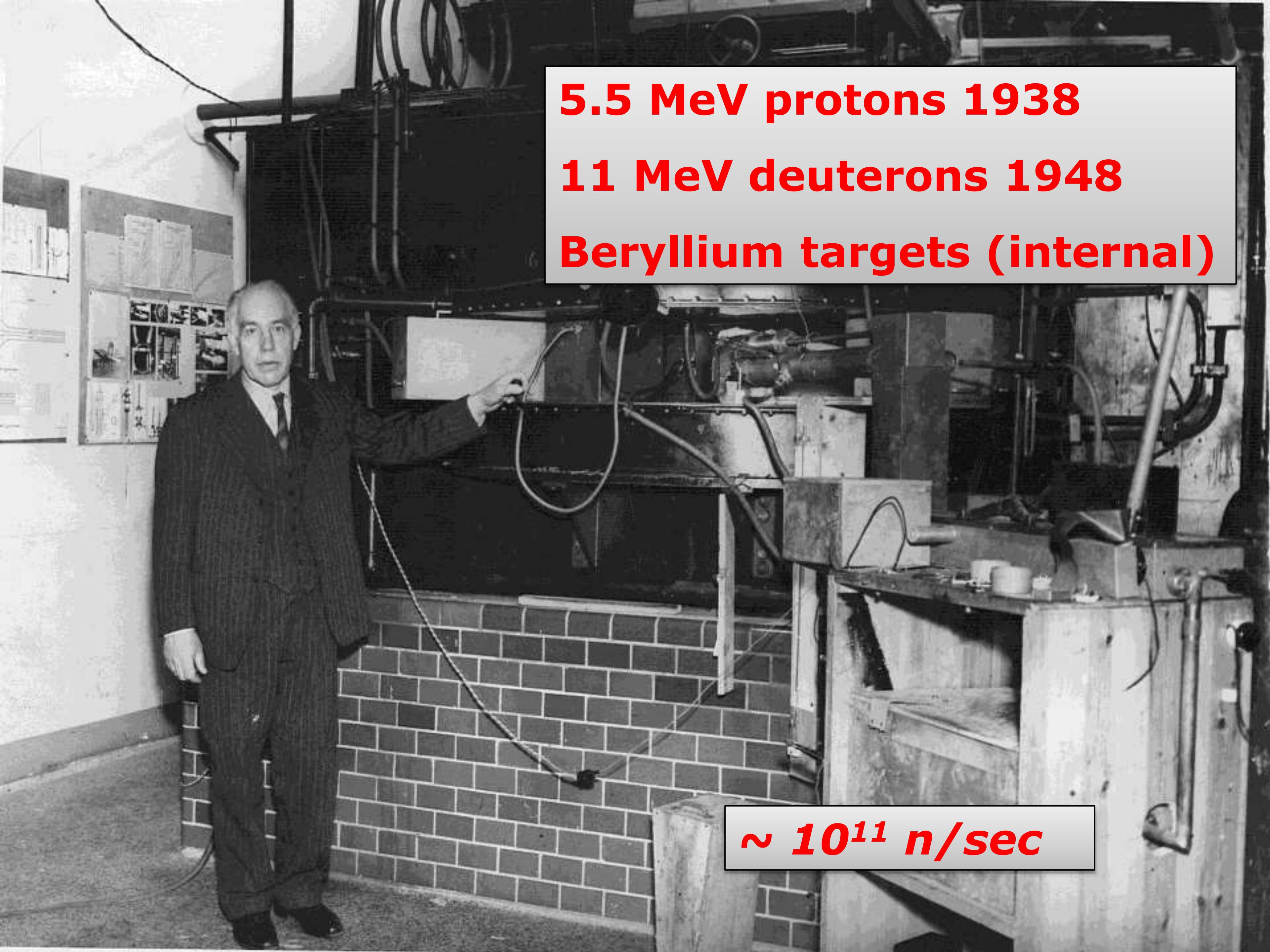
made by professor Jacobsen 1936-37

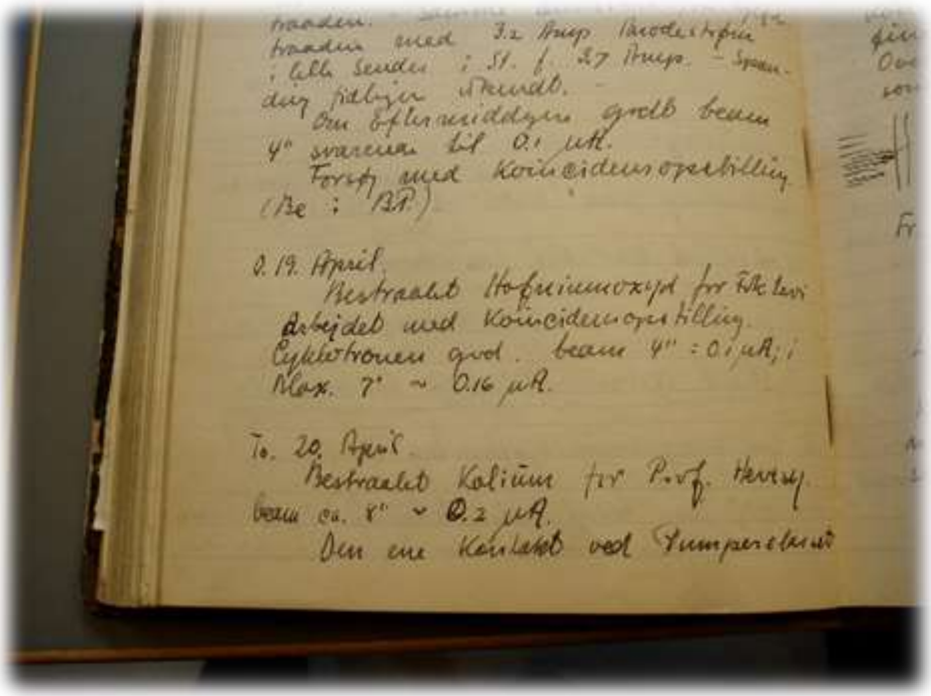
125 mg Ra-226



Overview of talk:

- Need for radioactive isotopes and the ”medical” situation
- Isotopes needed
- Isoptope production using CANS
- CANS using isotope production


5.5 MeV protons 1938
11 MeV deuterons 1948
Beryllium targets (internal)
~ 10^11 n/sec

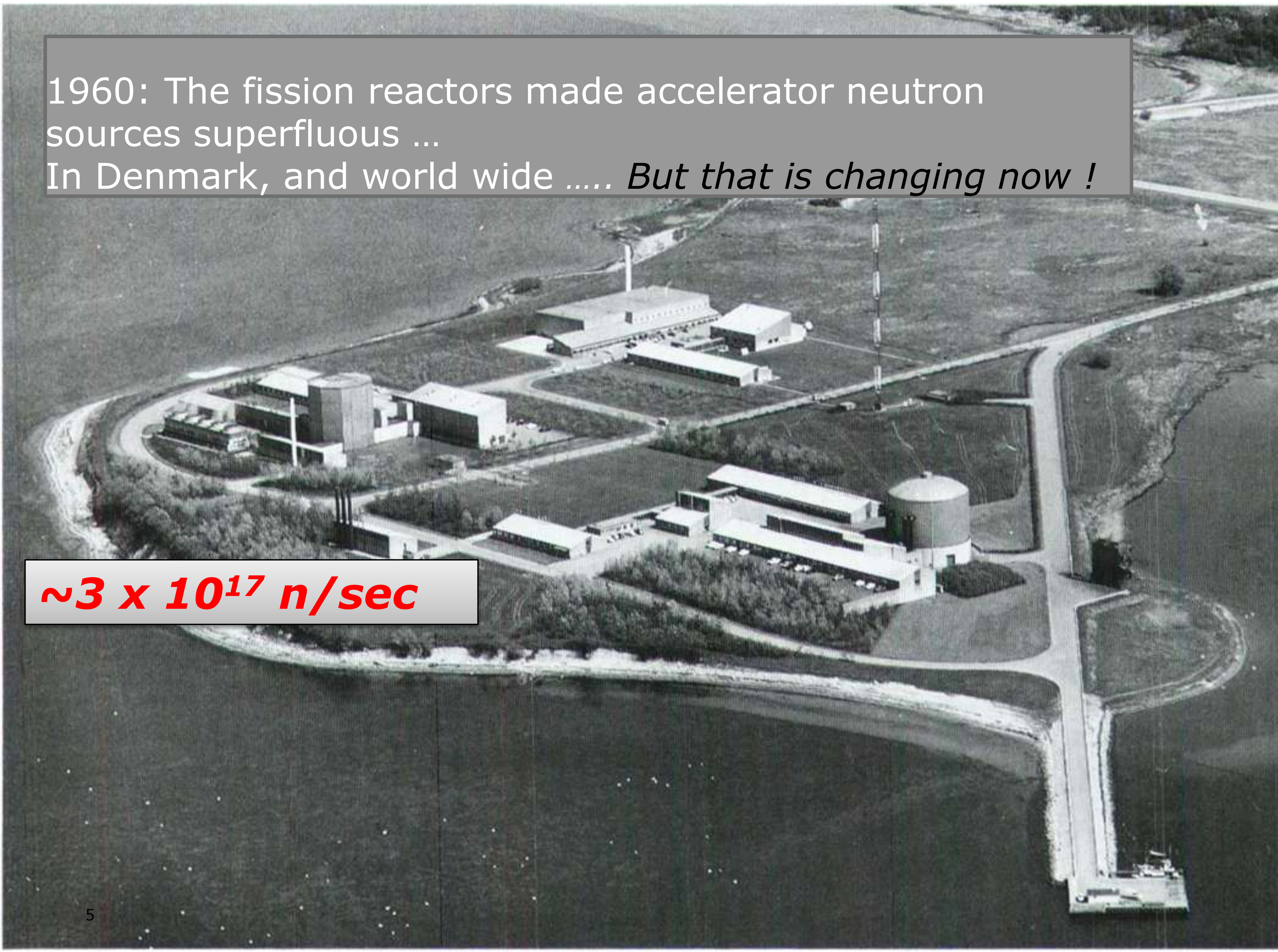


Hilde Levi and George Hevesy : Neutron Activation Analysis (1936)

34 Publications in Nature by Hevesy (1936 to 1940) using these neutrons

(350 publications in total, many medical)

1960: The fission reactors made accelerator neutron sources superfluous …
In Denmark, and world wide ….. *But that is changing now !*



~3 x 10^{17} n/sec

The death of the research reactors
- programmed retirements
- no offspring

Bye, bye cheap neutrons and plentiful fission products

ISOTOPE PRODUCTION :
Who need radioactive isotopes ?

Astrophysics

Physics

Chemistry

Biochemistry

Biology

Geology

Earth Sciences

Technology

Pharmacology

…..

Most of the ”research” isotopes are still available,- if need is really there

- Reactors: ILL, HFIR, MURR, Petten..
- Medium energy research cyclotrons : Aronax, Warsaw, Jülich, Rigshospitalet…
- ISOLDE and FRIB
- More than 100 ”medical cyclotrons”
- PSI

- *Has to be justified and planned*
- *Has to be reviewed and approved by program committees*
- *Take delivery when it suits the production facility*
- *Transport logistics*
- *Failures and second thougths are dificult to handle.*

Hevesy lab can help you to get almost any isotope,….. If T½> 2 days !

AND: MEDICINE

Over 40 million nuclear medicine procedures are performed each year, and demand for radioisotopes is increasing at up to 5% annually.

"I must confess that one reason we have undertaken this biological work is that we thereby have been able to get financial support for all of the work in the laboratory. As you know, it is much easier to get funds for medical research."

—Ernest Orlando Lawrence to Niels Bohr, 1935

Why should you trust a NUCLEAR PHYSICIST trying to change your mind on MEDICAL isotopes ?

There are no NEW isotopes, really ?

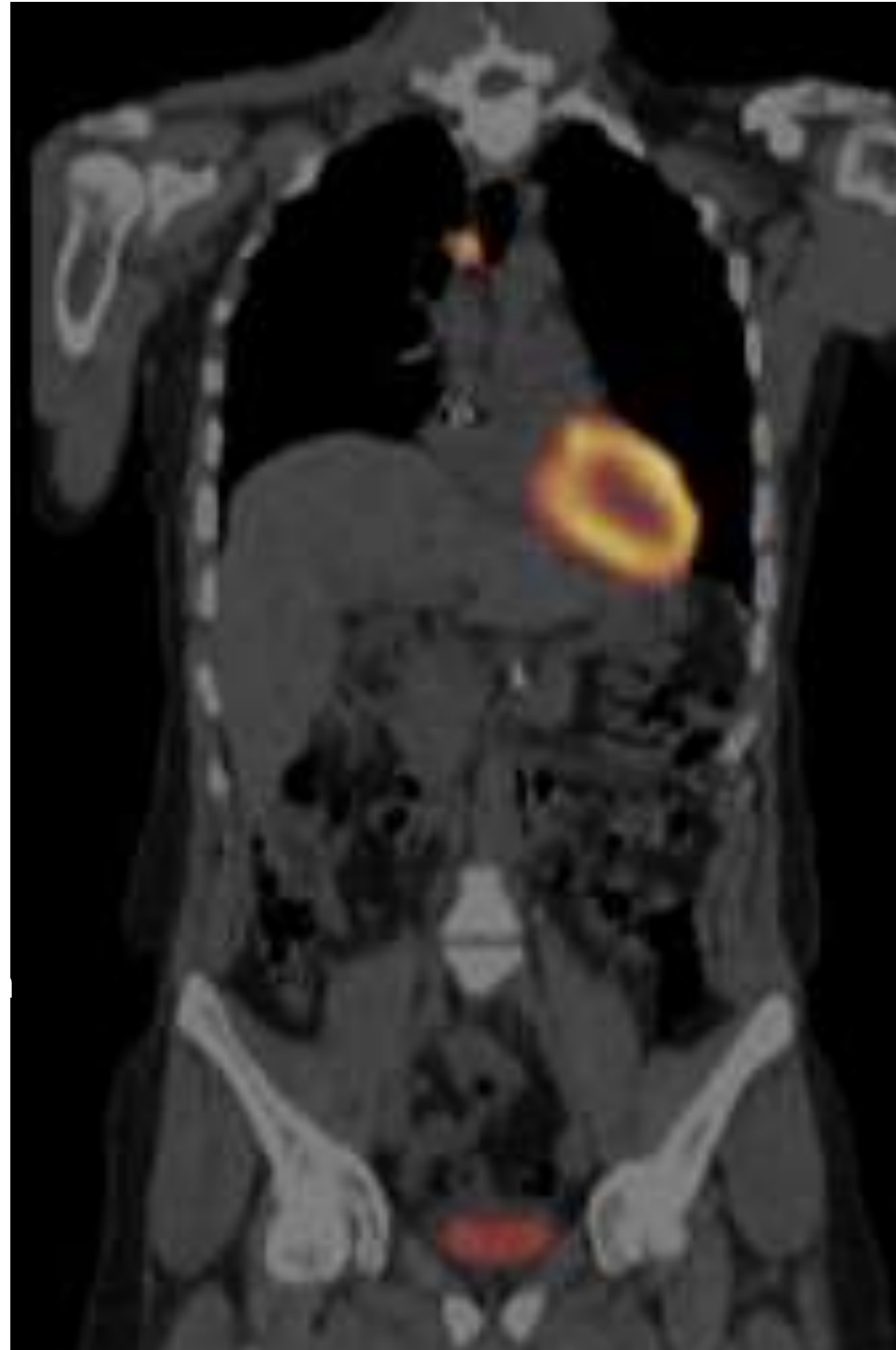
Nuclear medicine :

DIAGNOSTIC

And

THERAPEUTIC

^{64}Cu-DOTATATE



Nuclear medicine cannot work without isotopes. But what isotopes ?

Reasons to rethink the isotope supply :

1. Some isotopes are best made with neutrons
2. The research reactor and Mo-99 “situation”
3. The introduction of “point-of demand” cyclotrons
4. More NM procedures will be needed
5. Present supply chain can not meet global growth

JNM – Nov.2016

NAS Report Warns of U.S. Radioisotope Shortages

EWSLINE

The National Academies of Sciences, Engineering, and Medicine (NAS) on September 12 released a congressionally mandated report on the status of the current and future supply of ^{99}Mo and ^{99m}Tc and on progress made in eliminating highly enriched uranium (HEU) from ^{99}Mo production. Although the current supply of ^{99}Mo and ^{99m}Tc is sufficient to meet U.S. and global demands, the report warned that changes to the supply chain late in 2016 could lead to severe shortages and result in interruptions in nuclear medicine practice.

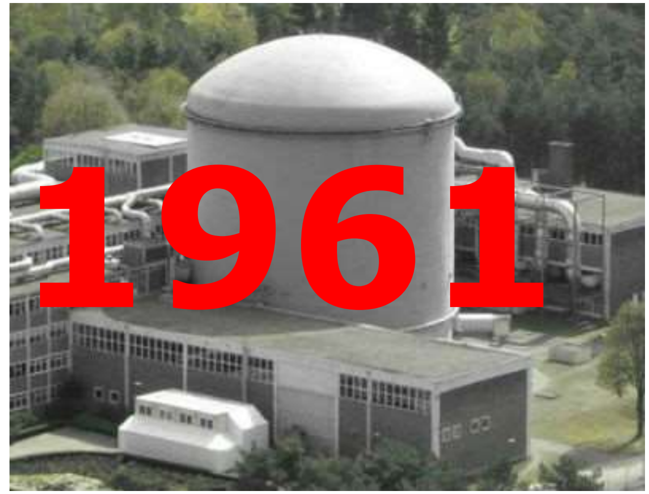
Administration have stimulated private sector efforts to establish U.S. domestic production of ^{99}Mo for medical use. However, no domestic commercial production will be established before Canada stops regular production of the isotope. The report also noted that potential domestic suppliers face technical, financial, regulatory, and market penetration challenges. The market challenges will likely increase after current global ^{99}Mo suppliers expand production.

NAS reported that 4 of 5 global ^{99}Mo suppliers have committed to converting from HEU to low-enriched uranium (LEU)

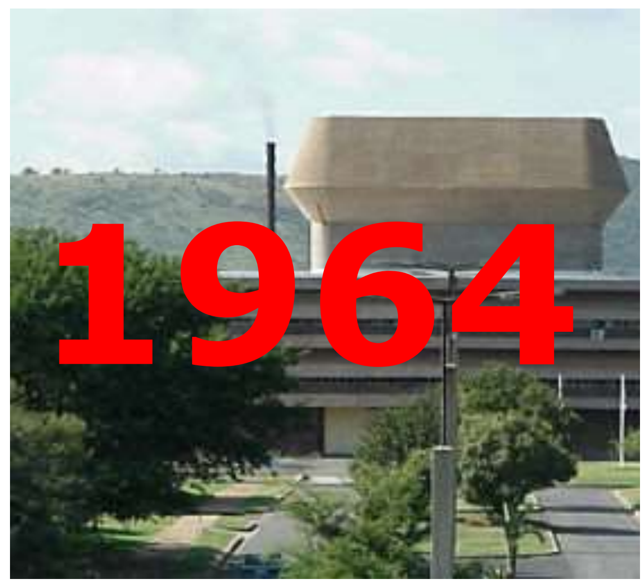
The "Moly" situation: fission products and Mo99 drives >90% of all procedures




The "Moly" situation:



>80% made in these 4 research reactors



Build and operated by public money

…it is not economically sustainable…

We know how to make new reactors, and we know how to make Mo-99 from LEU!

But who's going to pay for the next generation of reactors and separation facilities ?

What's the price and construction time for a new set of research reactors ?

What's the price of waste management and facility decommissioning ?

Not many reactors are needed
…. but there will be a reactor deficit unless policies and economics changes…

Bye, bye cheap neutrons and plentiful fission products

CANS and Isotope Production

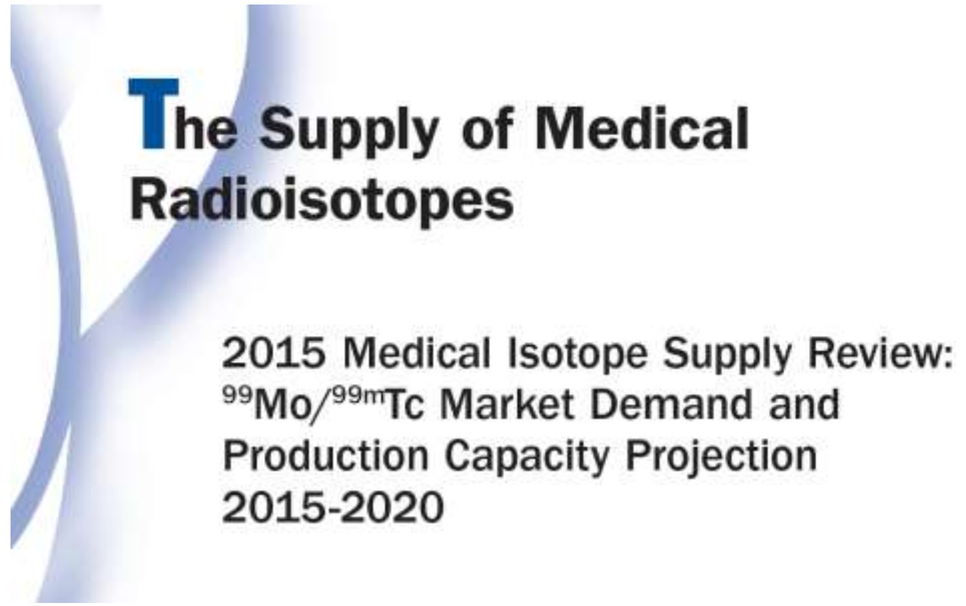
SHINE (US) (that is a CANS)

and

MYRRHA (BE) (that is ADS)

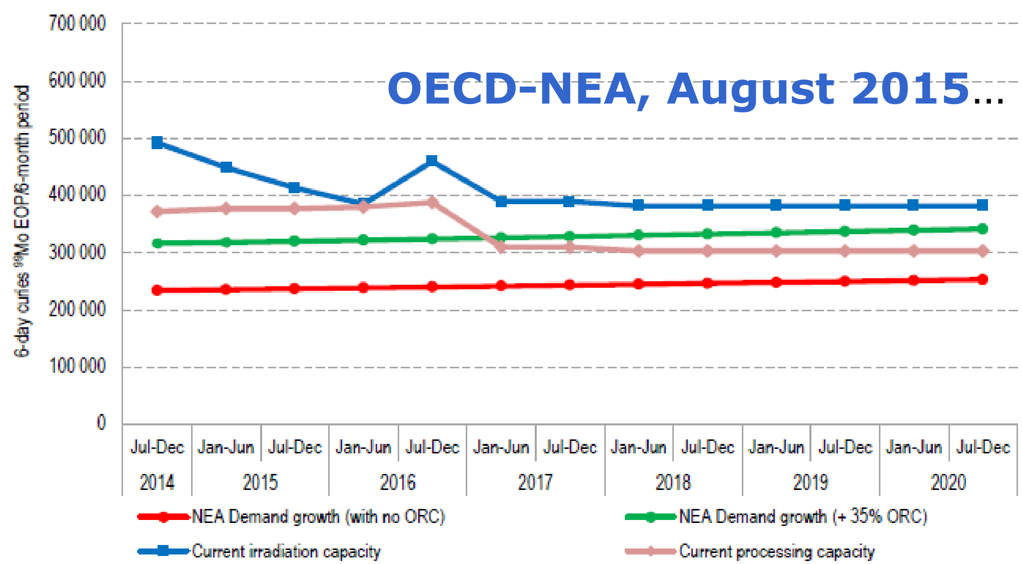
may help resolve the

problem.



BUT PERHAPS TOO LATE !

Mo-99 ?



We still need neutrons for I-131, Lu-177 and new important therapeutic isotopes

Cyclotrons and PET may take over some or most of the Tc-99m load by shifting to F-18, Ga-68, Sc-44 and Cu-63,64.

But it will take many new powerful cyclotrons + local or regional distribution

Tc-99m, I-123, In-111…

F-18, Ga-68, Rb-82, C-11…

New cyclotrons to serve the future of Nuclear Medicine

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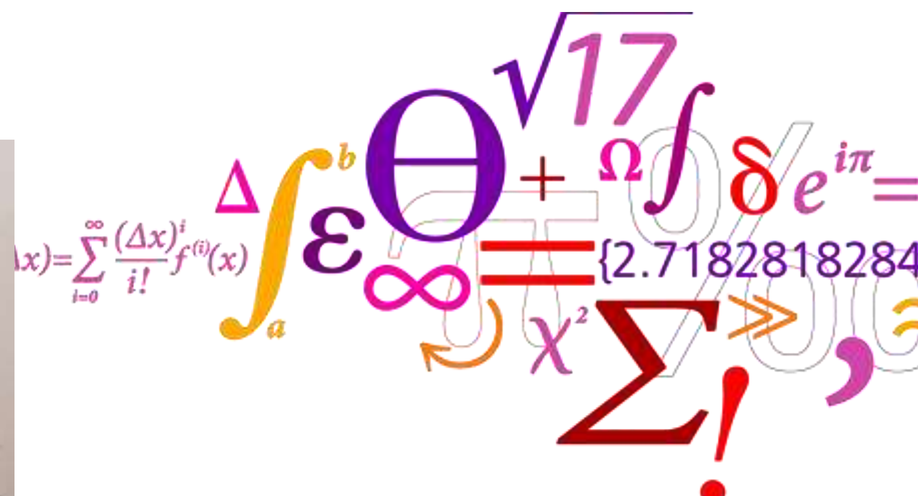


George Hevesy

Some isotopes needs neutrons

Medium half-life and beta- emission for therapy

TBq amounts

Fission products

Actinide alpha emitters and decay chains

CANS can help us with some isotopes, locally

But we mostly use THERMAL neutrons.

We need large moderators.

Thermal flux (n/cm2/sec) is at best 1% of neutron production rate (n/s).

We irradiate for hours and days, continuously.

To make useful therapeutic isotopes (GBq , $T_{½}$~1 day) 10^{13} n/cm2/sec

To make useful research isotopes 10^{12} n/cm2/sec

To make Br-82 and Na-24 … $5x10^{11}$ n/cm2/sec

But we cannot justify a CANS with production and sale of such isotopes. !

Neutrons *from* ISOTOPE production ?

The PT-600 :

7.8 MeV protons only

Negative ions

Short beamline

3 targets

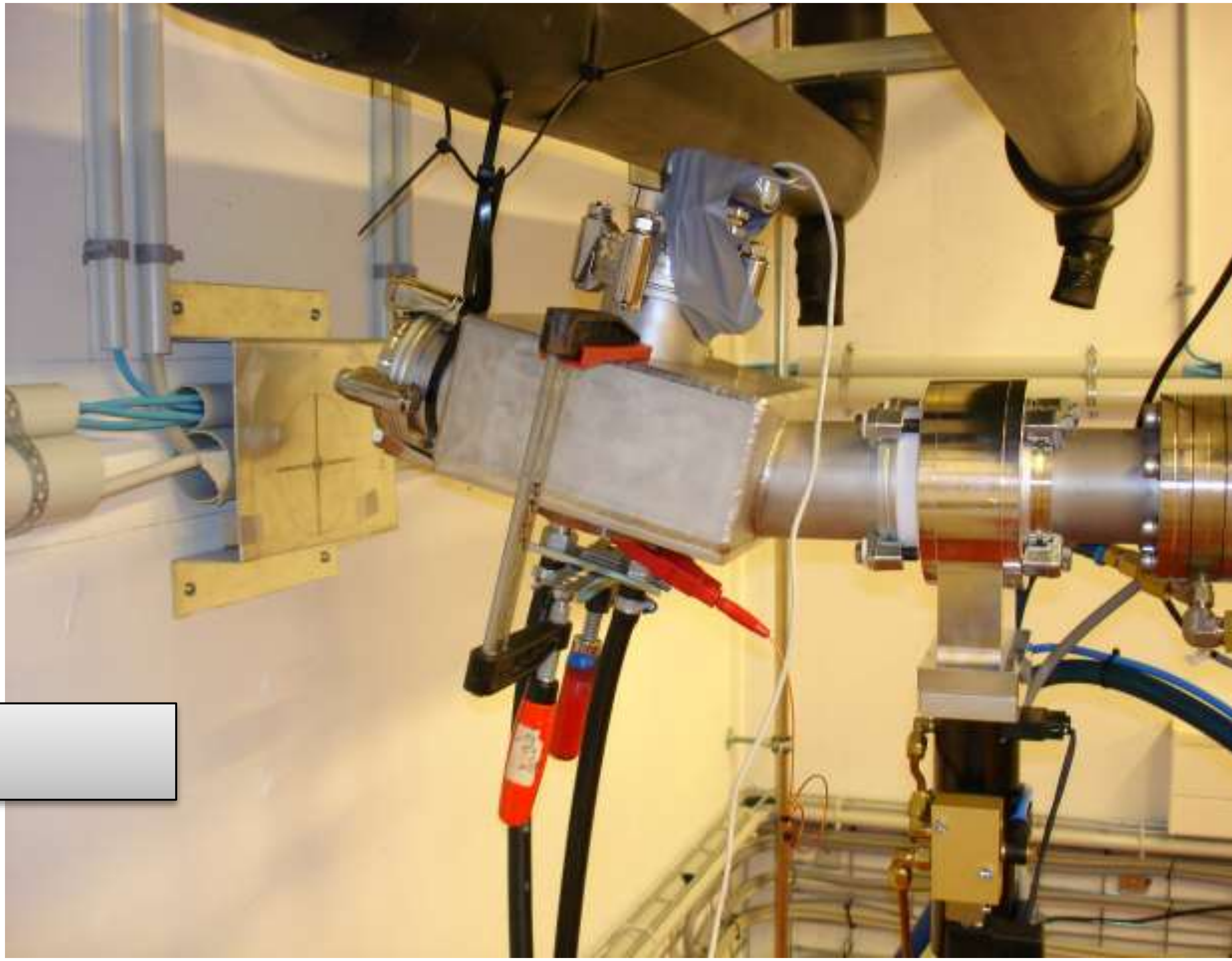
35-50 uA beam current

~ 10^{11} n/sec

Hevesy Lab PT-800 cyclotron

100 uA 16.5 MeV p

O-18 water target



~ 10^{12} n/sec

With D2O moderator :Would make ***10^{10} n/cm2/sec thermal***

The next cyclotron ? for Medical Isotopes

30 MeV p 350 uA – 500 uA

IBA cyclone 30 ”industrial”

Ge-68

Ac-225

~ 10^{14} n/sec