Radioactive ion beam production at other facilities

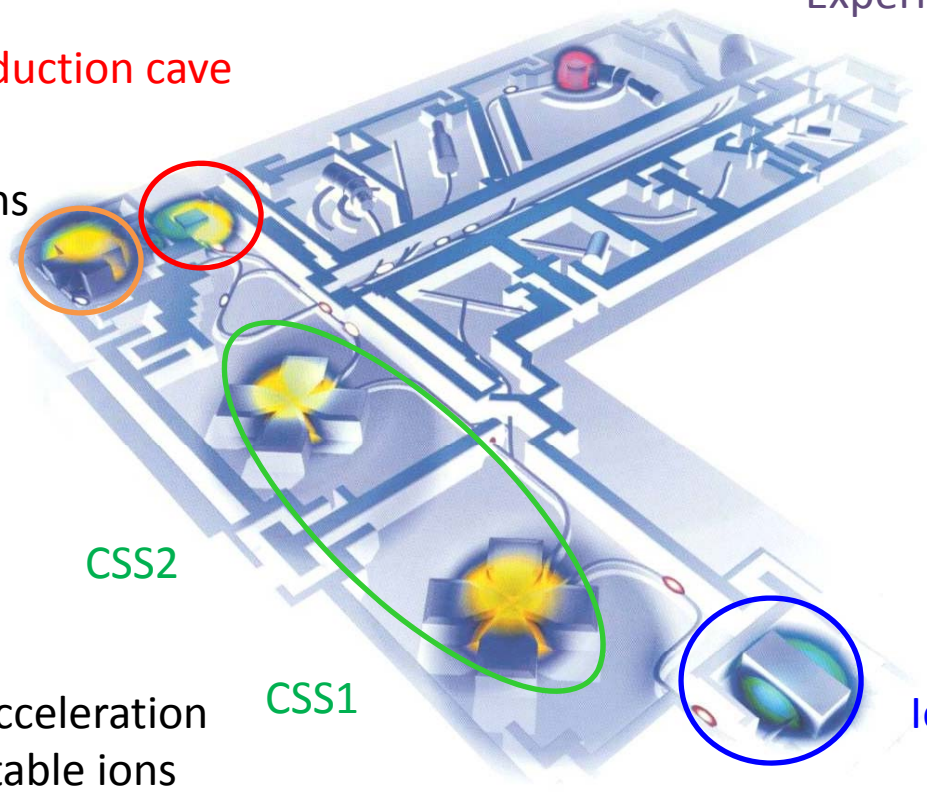
P. Delahaye, GANIL

And M. Hass, Weizmann Institute/SOREQ

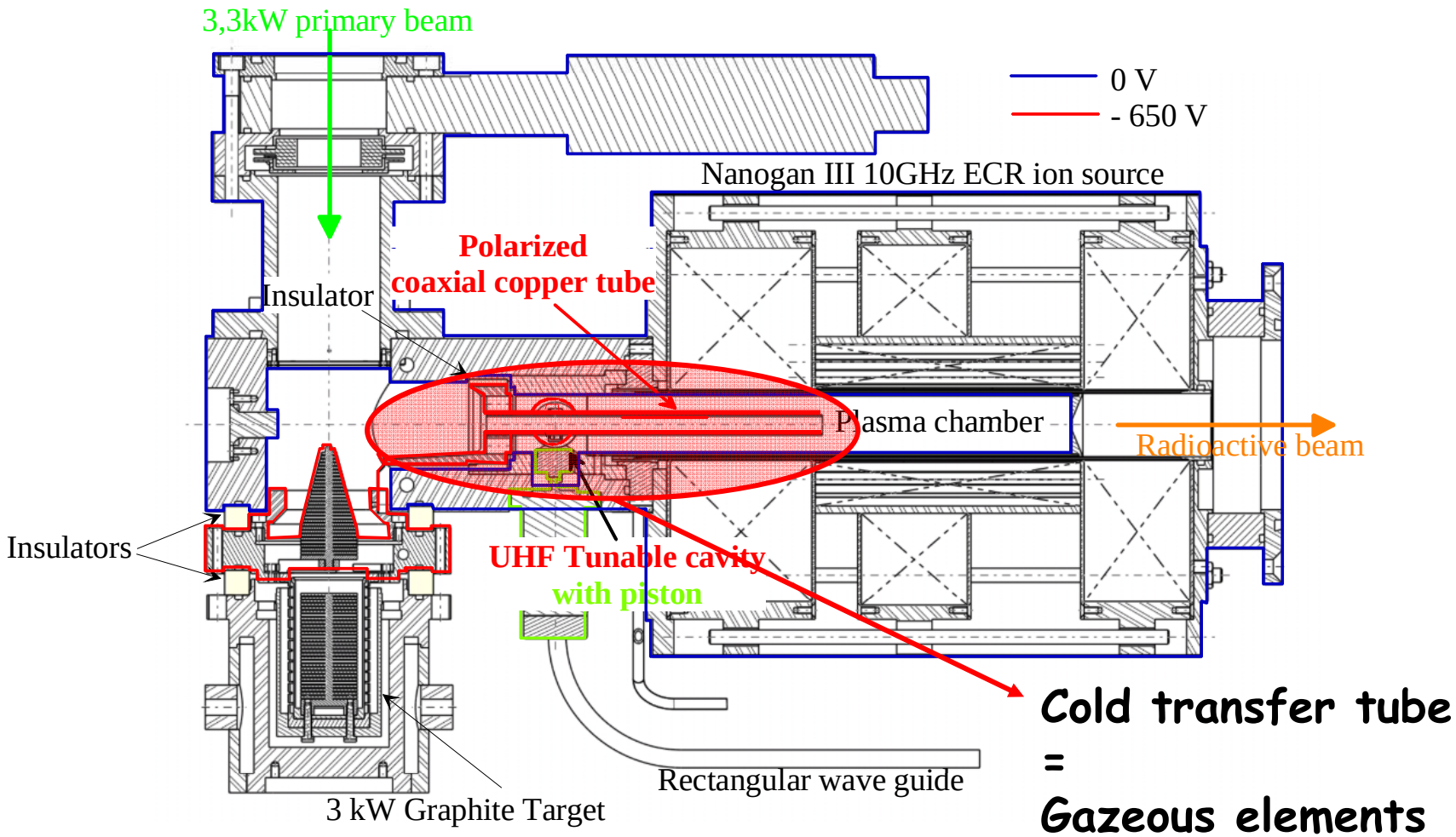
GANIL – SPIRAL 1

- Most intense beams of ^{6}He and ^{18}Ne
- ^{6}He
  - 2.10^{8}/s at low energy, 3.10^{7} post-accelerated
  - ^{13}C beam 75AMeV on a graphite target (1.5 - 3kW)
- ^{18}Ne
  - 10^{7}/s at low energy (2+), 3.10^{6} post-accelerated
  - ^{20}Ne beam 95AMeV on a graphite target (1.5 - 3kW)
- Graphite target, very efficient ionization with an ECR source

GANIL – SPIRAL 1

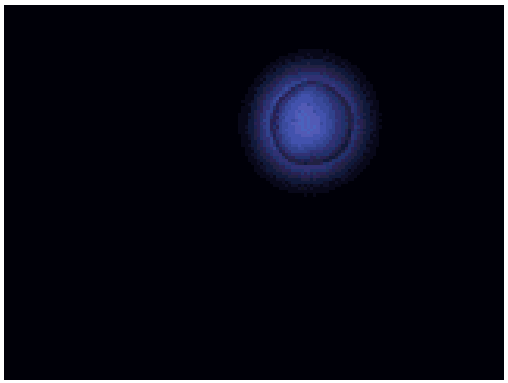


Gaseous elements with Nanogan 3 and cold transfer tube



Graphite targets

Projectile fragmentation!

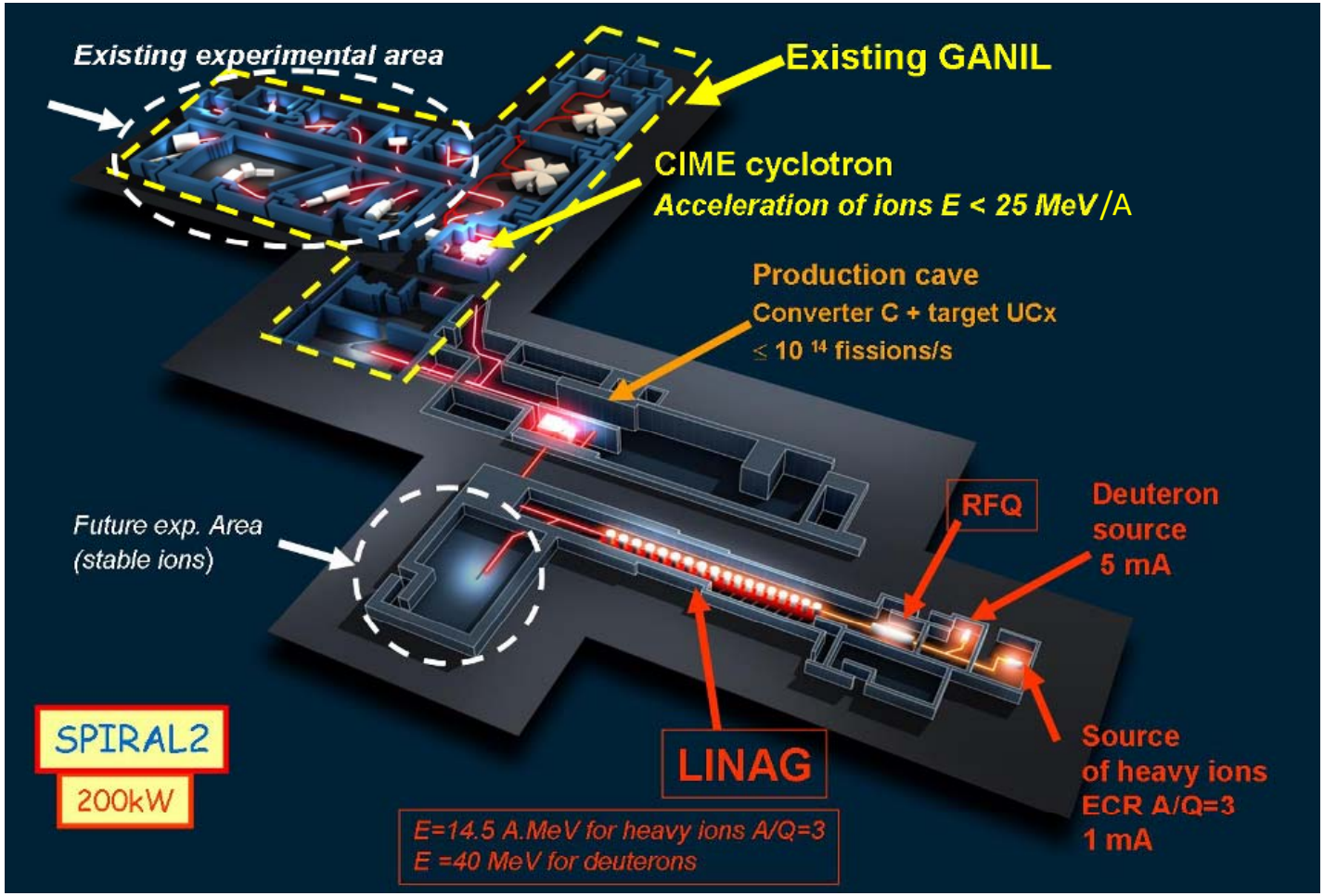


Ne, Ar, Kr, N, O, F

He

Projects at SOREQ and GANIL

- GANIL - SPIRAL 1: new target materials for target fragmentation and fusion – evaporation
- GANIL – SPIRAL 2:
  - UCx targets with 5mA 40 MeV d hitting a neutron converter in ^{12}C
  - Fusion – evaporation and transfer reactions with light - or medium heavy - intense beams
- SOREQ - SARAF:
  - Phase 1: 2mA 5 MeV d on neutron converter (Li)
  - Phase 2: 2mA 40 MeV d on neutron converter (Li)


Existing experimental area
Existing GANIL
CIME cyclotron
Acceleration of ions E < 25 MeV/A
Production cave
Converter C + target UCx
≤ 10 14 fissions/s
Future exp. Area
(stable ions)
RFQ
Deuteron
source
5 mA
SPIRAL2
200kW
LINAG
Source
of heavy ions
ECR A/Q=3
1 mA
E=14.5 A.MeV for heavy ions A/Q=3
E =40 MeV for deuterons

SARAF - Soreq

deuterons / protons
linear accelerator

5 MeV at Phase 1
with only 1 SM (2008)

40 MeV at Phase 2
with 6 SMs (2013)

2 mA current

2008

- Nagler, LINAC2008
- Piel, EPAC2008
- Pekeler, LINAC2006

40 MeV , 2 mA
Lithium Converter

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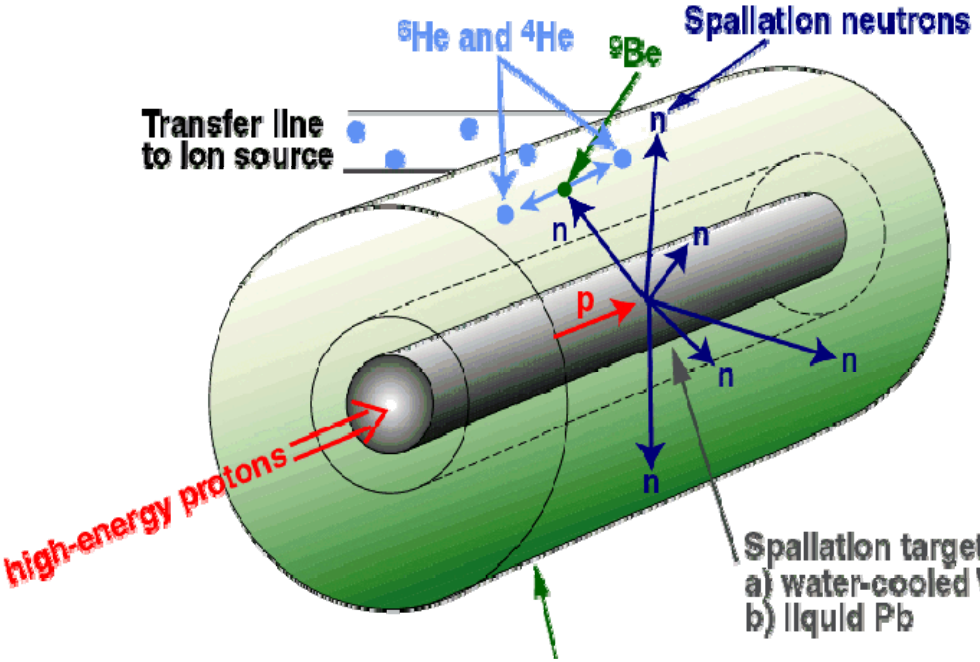
What interests for beta-beams?

- Development of light RIBs for nuclear physics
  - Joint (SOREQ+GANIL) development and tests of BeO targets with ISOLDE for high intensity ^{6}He beams
  - SOREQ: tests of a BN target for ^{8}Li production
  - GANIL: possibilities for testing (production) diffusion, effusion and ionization of ^{8}B and ^{8}Li beams at SPIRAL 1

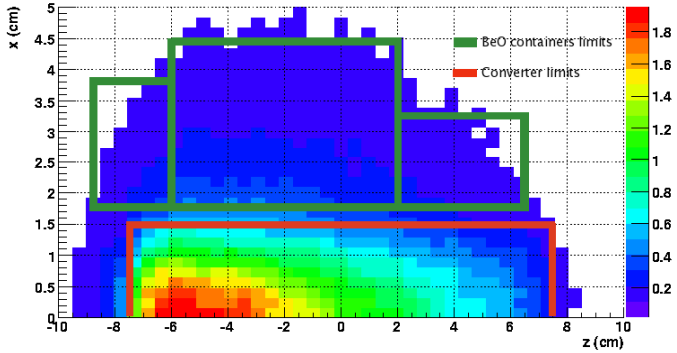
BeO and ^{6}He: EURISOL

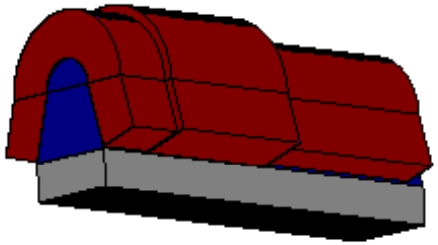
^{9}Be(n,α)

Converter technology:
(*J. Nolen, NPA 701 (2002) 312c*)



CEA Saclay Optimized Geometry



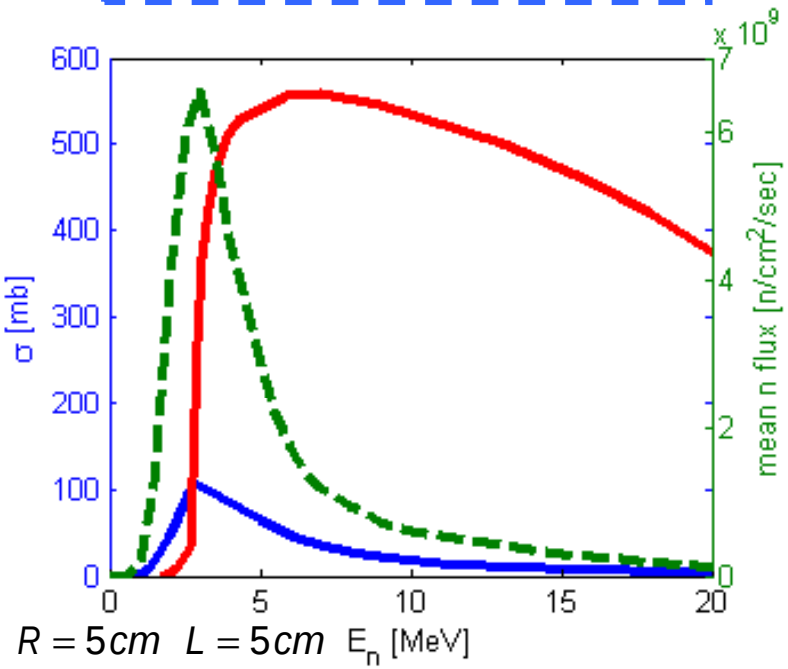


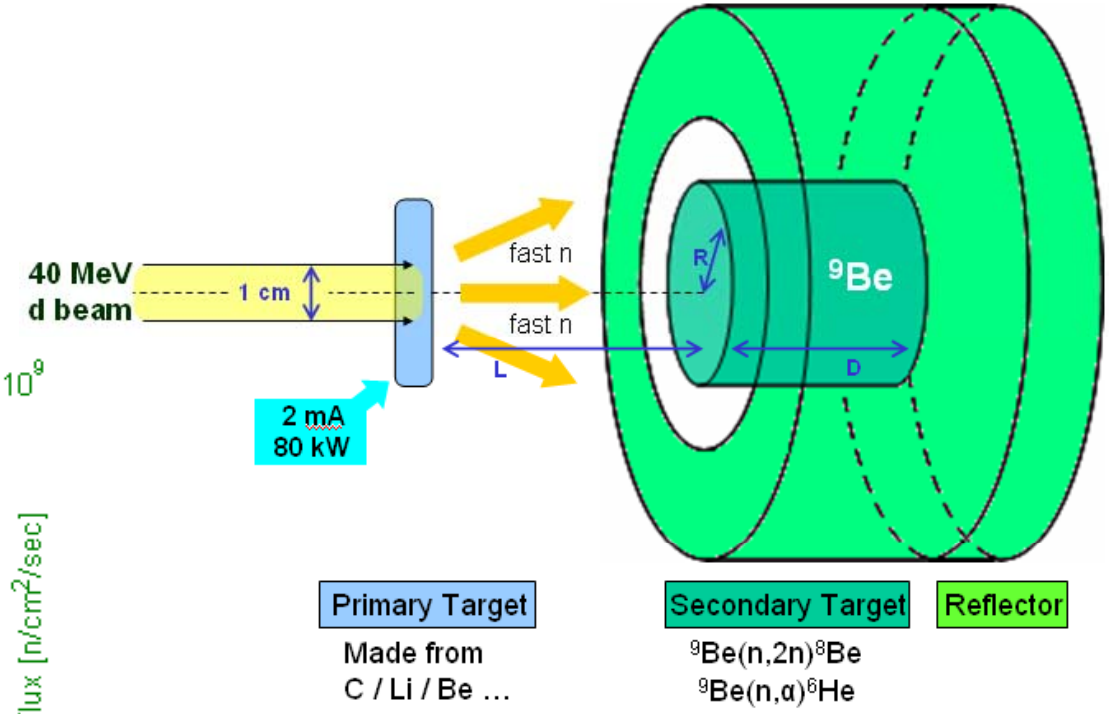
T. Stora et al, EURISOL-TN03-25-2006-0003 N Thollieres et al. EURISOL-TN03-25-2006-0004

- **Preferred to direct irradiation (heat transfer and efficient cooling allows higher power)**
- **^{6}He in target yield is ~2x10^{13} ions/s (dc) for ~200 kW on target**
- **Use of a 4MW target is a priori possible**

SARAF and GANIL
Optimization Calculations (SOREQ/WI)

MCNP™
Monte Carlo N-Particle transport code

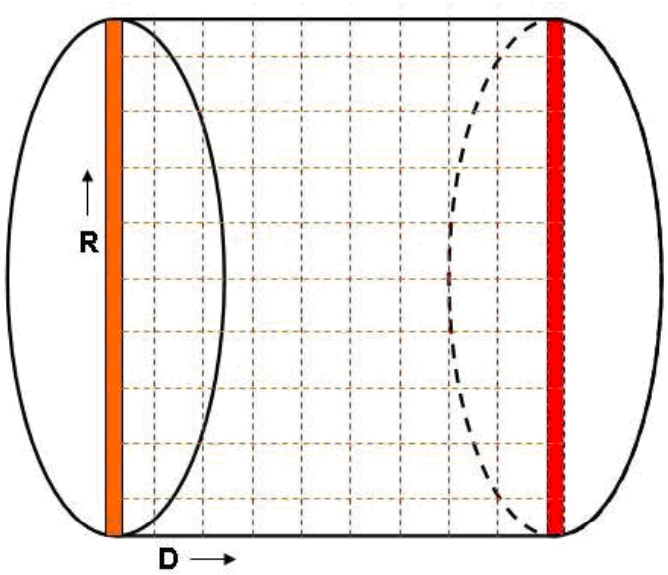


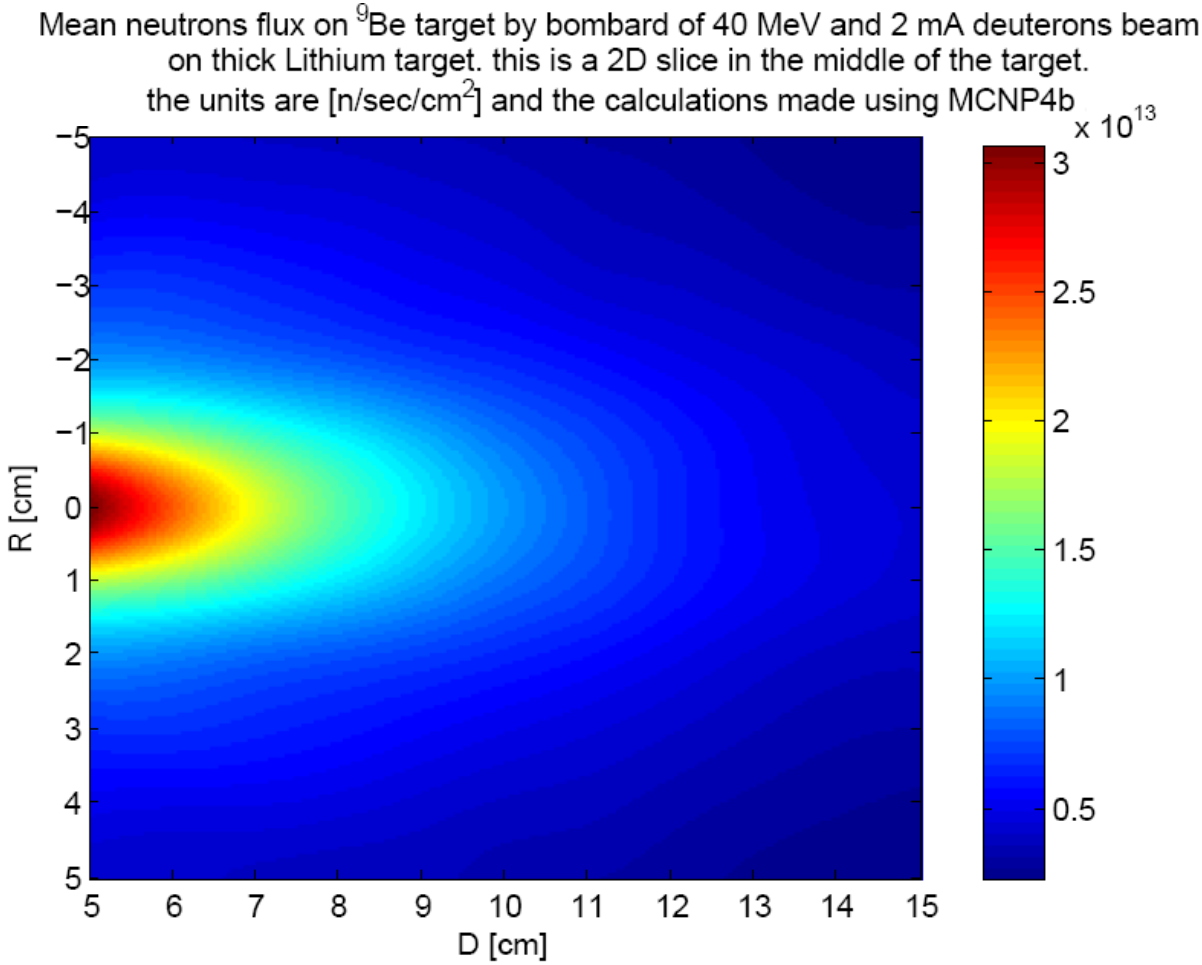


Expected in target yields for BeO:
SARAF (40 MeV, 2 mA): **$8\cdot10^{12}$** [^{6}He/sec]
SPIRAL2 (40 MeV, 5 mA): **$2\cdot10^{12}$ -$2\cdot10^{13}$** [^{6}He/sec]
Expected in target Yields for a BN target:
SARAF (40 MeV, 2 mA): **$2\cdot10^{12}$** [^{8}Li/sec]

Hass et al., J. Phys. G: Nucl. Part. Phys., **35, 014042 (2008).**

SOREQ/WI: neutron flux simulation





2D slice inside the secondary target

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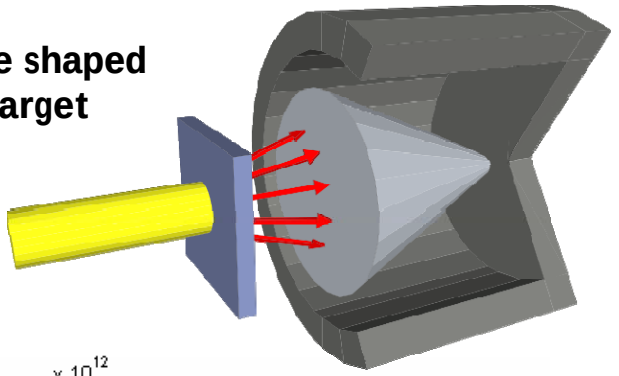
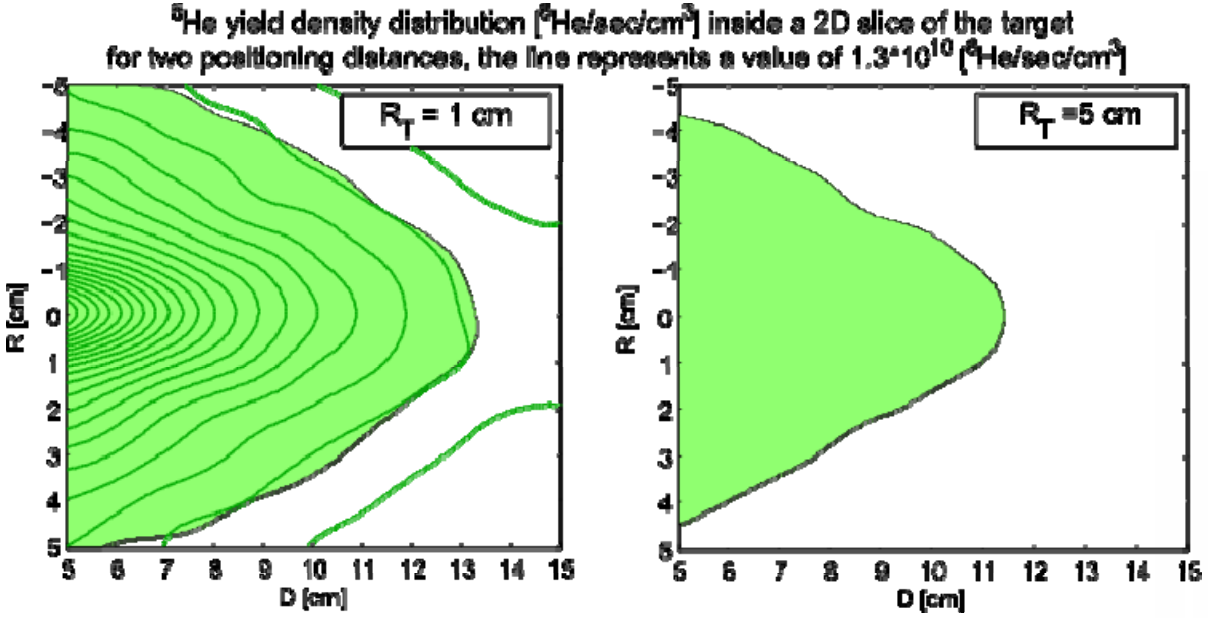
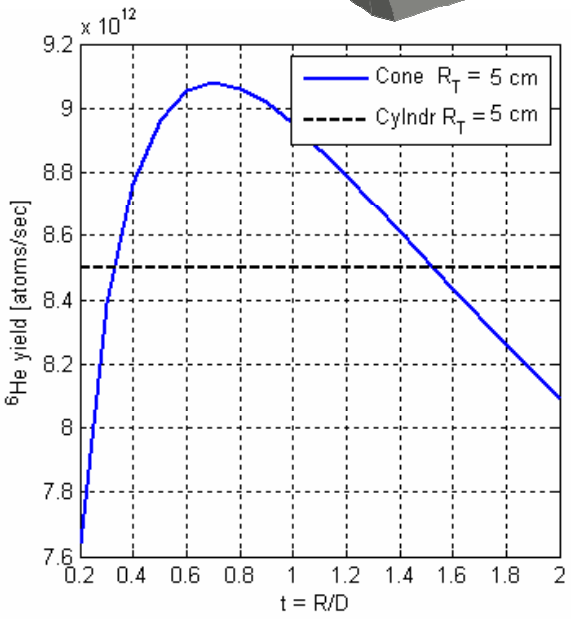
SOREQ/WI: target geometry

Cone shaped target





2D slice of the target



^{6}He production yields for a constant target volume and for different R to D ratios
These results are for a 785.4 cm^3 cone target and for R_T = 5 cm

* R_T stands for the distance between the two targets

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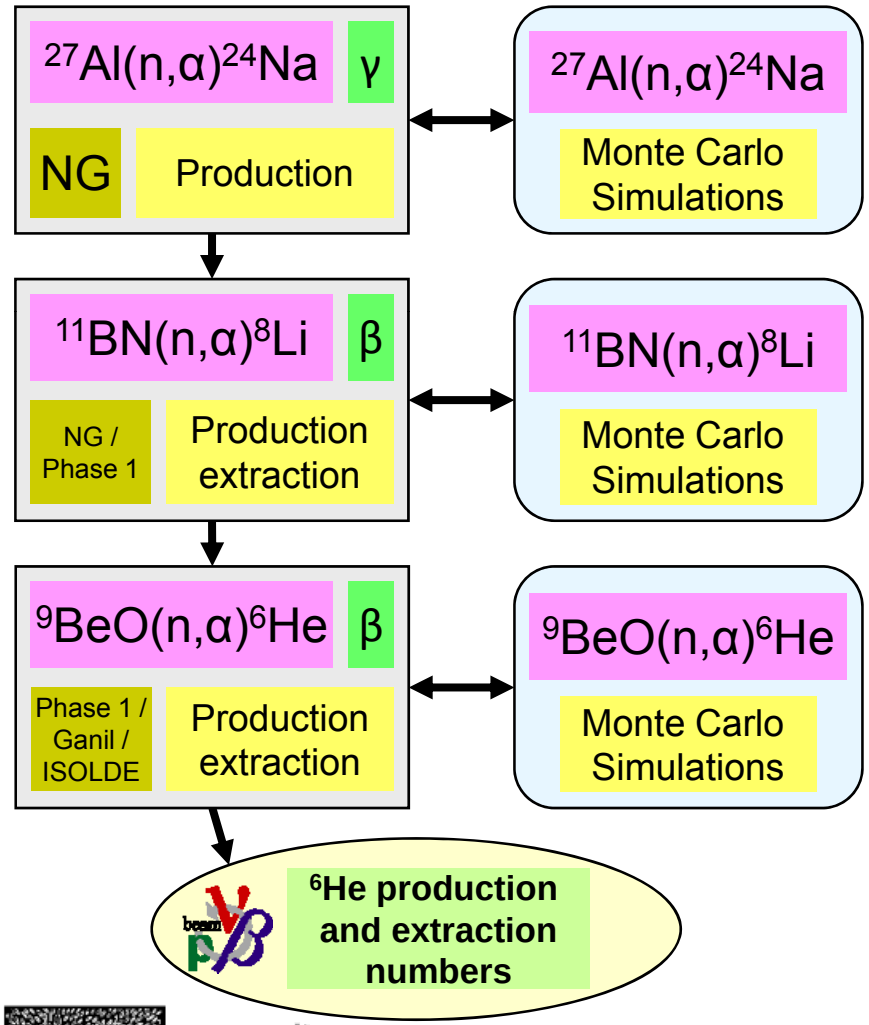
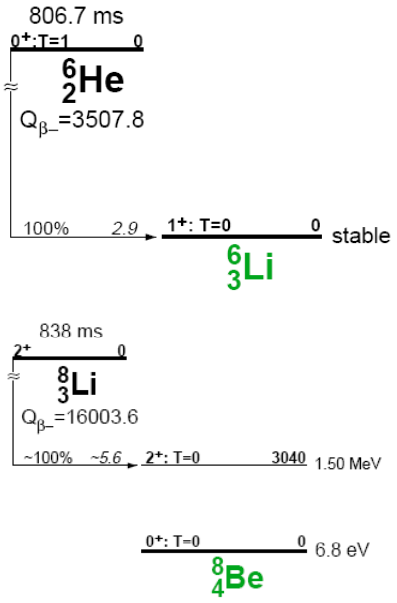
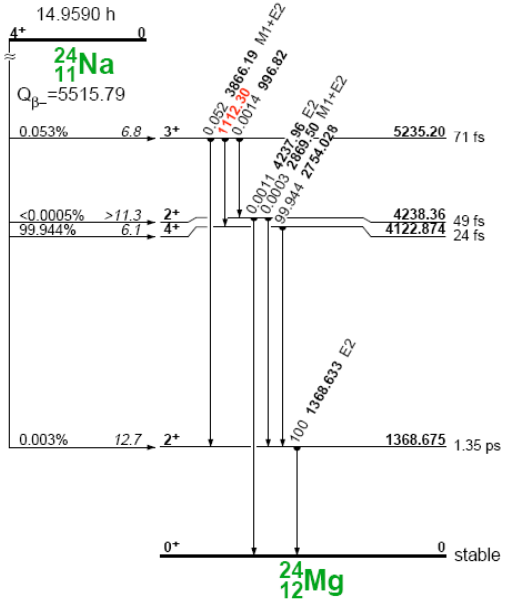
Plans SOREQ







15.2.2008 Aluminum cubes irradiation experiment number 1.
Preliminary experiment for verification of target geometry in compare to Monte Carlo simulations.

28.4.2008 Aluminum cubes irradiation experiment number 2.
Preliminary experiment for verification of target + reflector geometries in compare to Monte Carlo simulations and previous experiment.

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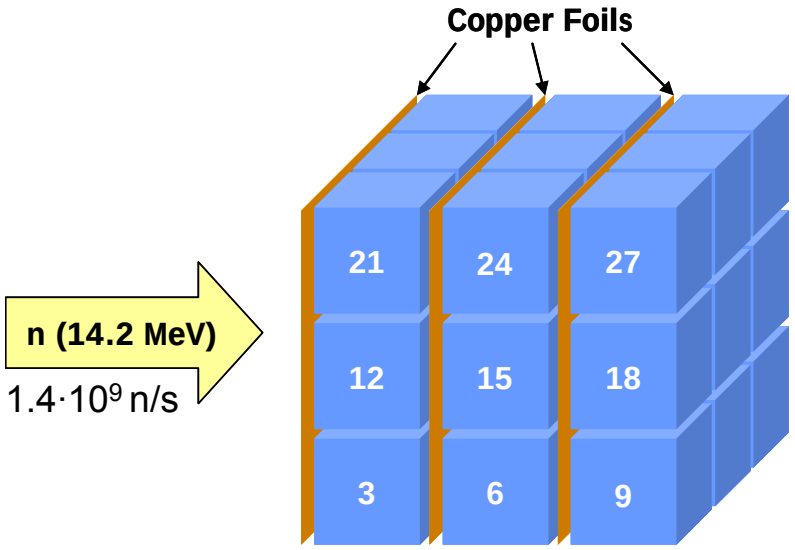
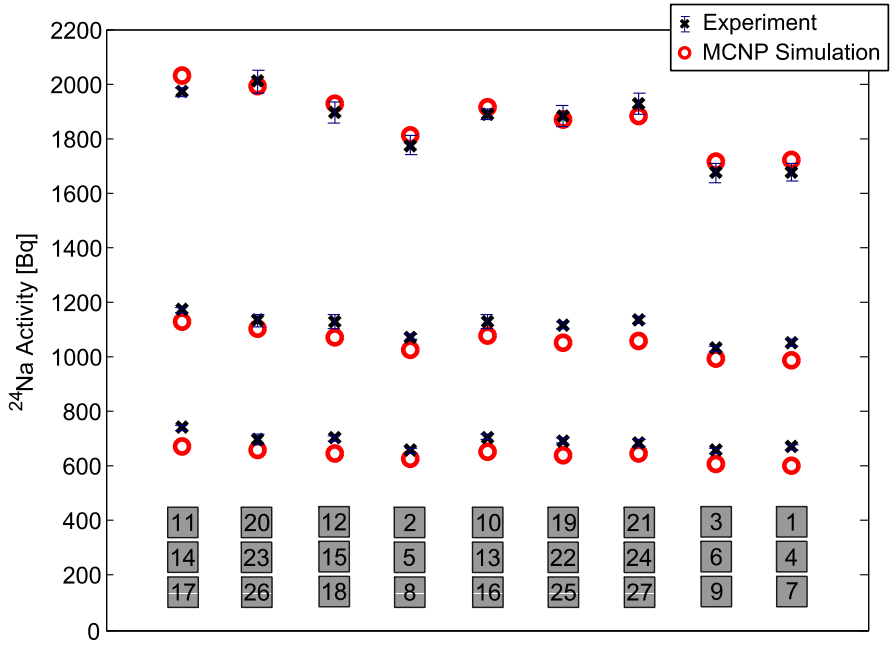
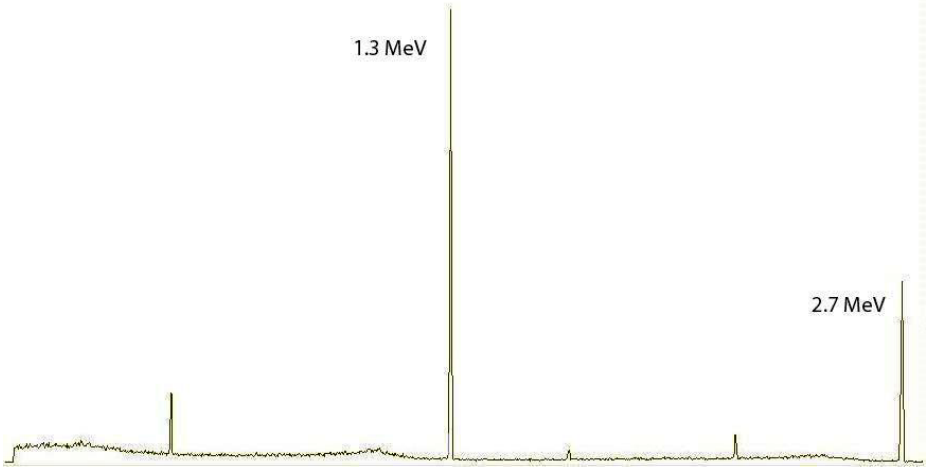
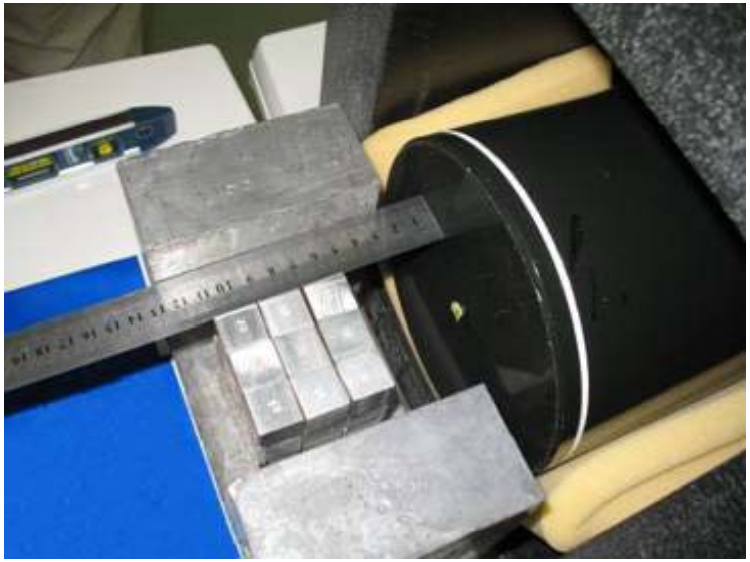
Aluminum Cubes Experiment









T.Y.Hirsh et al. PoS(NUFACT08)090, 2008.

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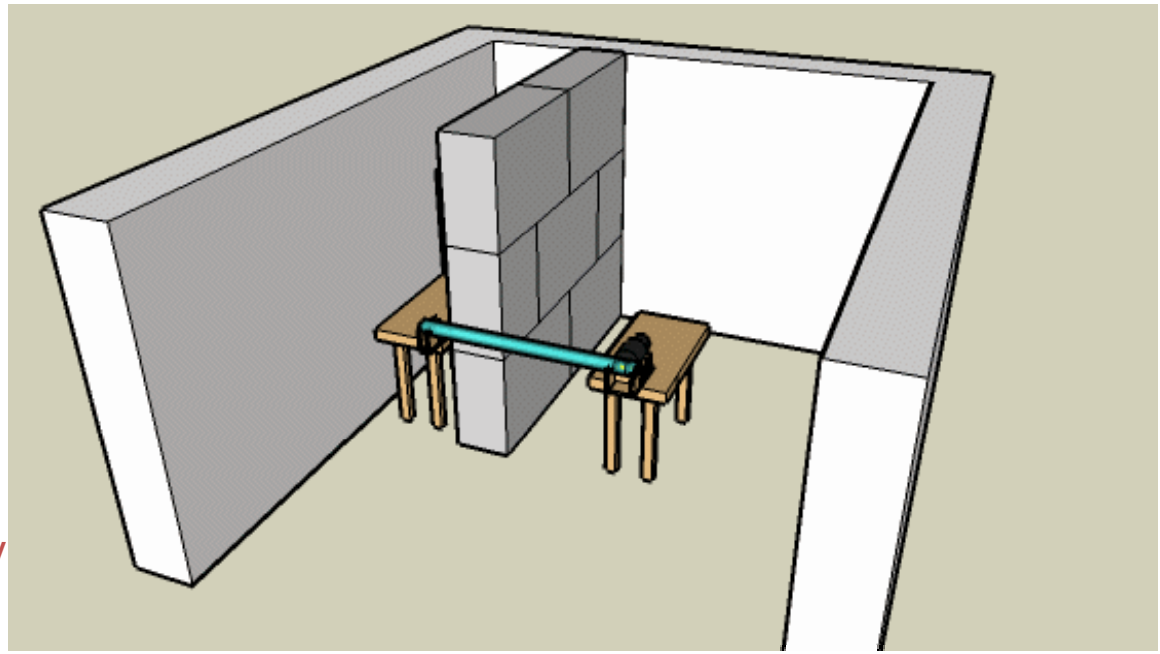
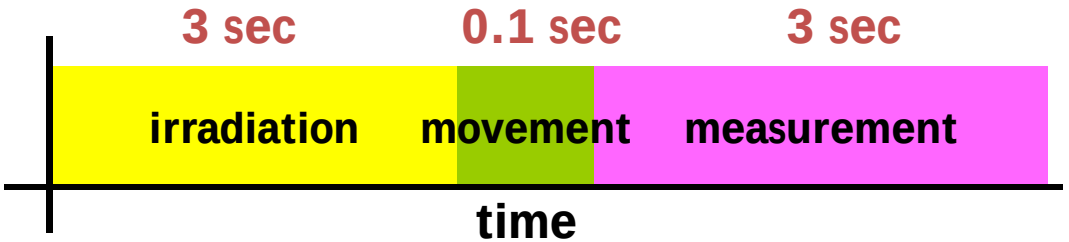
^{8}Li Production Experiment

- ^{8}Li production measurement.
- ^{11}BN(n,α)^{8}Li by fast neutrons.
- Automatic measurement system using a fast air-pressure rabbit.
- Detection of betas from ^{8}Li decay.
- A benchmark for simulations.
- ^{6}He production is also possible by replacing the target by BeO.





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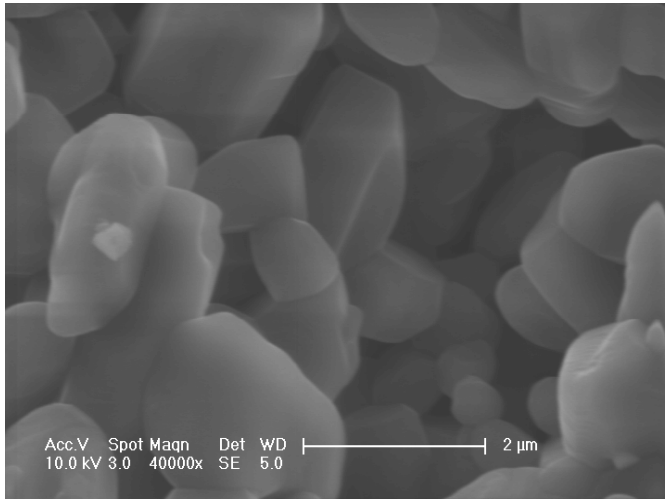
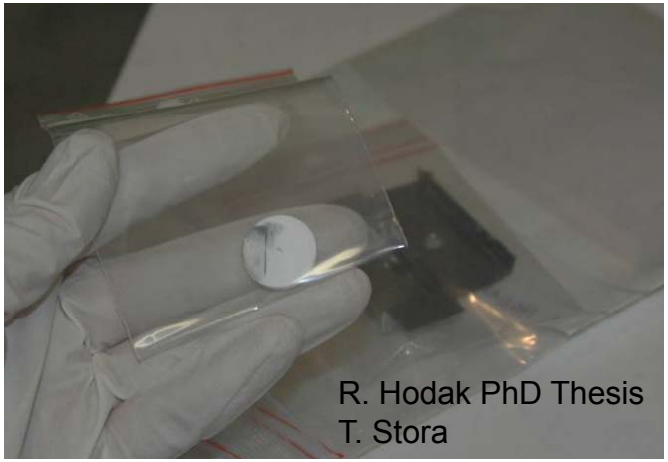
Joint efforts BeO

SEM BeO SOREQ/WI



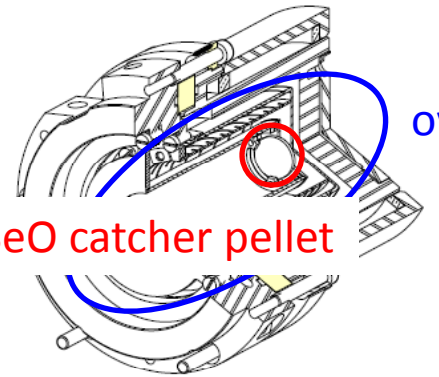
Heating tests with Ta or Mo container at ISOLDE



ISOLDE CERN

CERN

On line experiment foreseen mid of April with Ta converter



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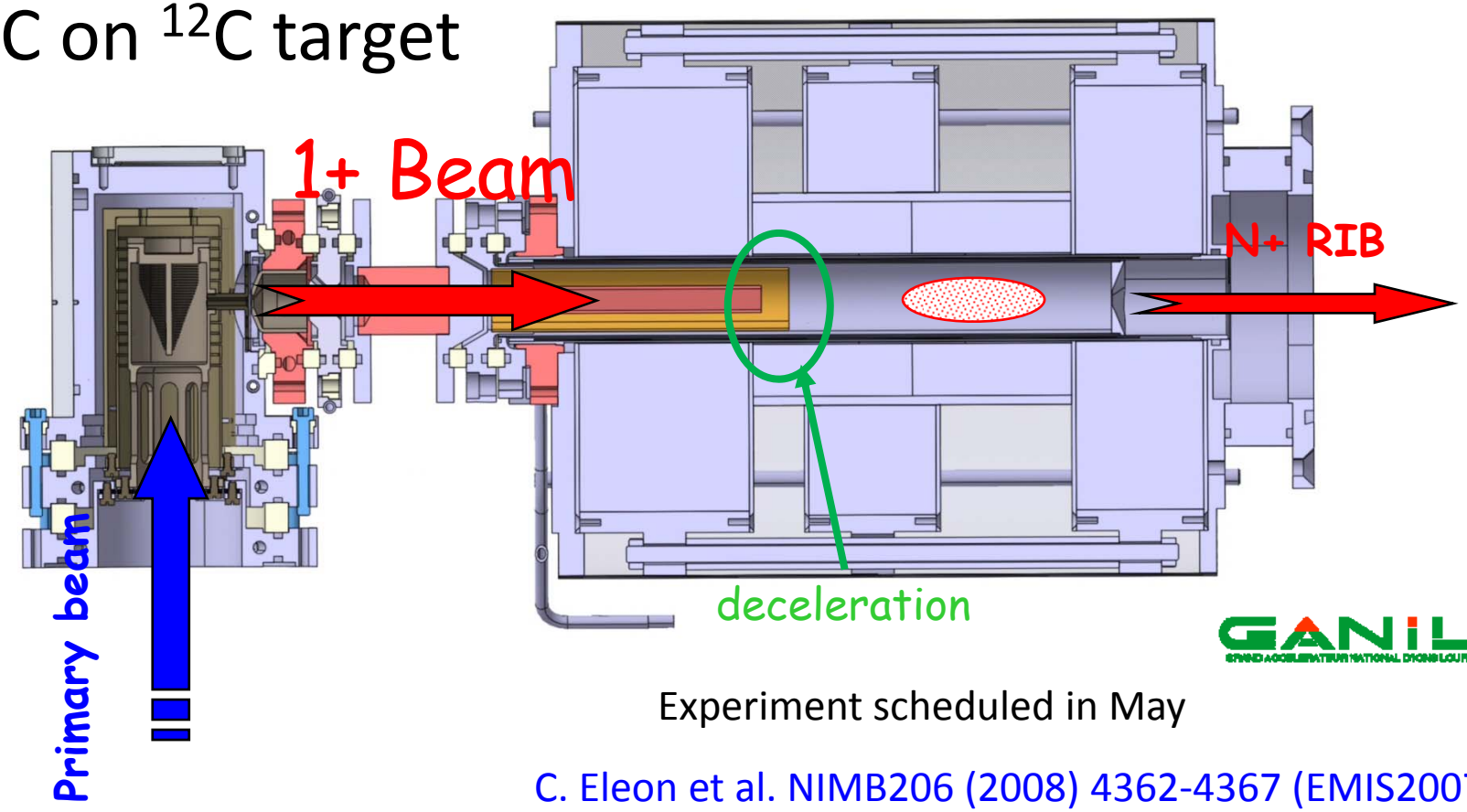
GRAND ACCELERATEUR NATIONAL D'IONS LOURDS

Diffusion and effusion test of ^{6}He produced by SPIRAL 1 in a BeO pellet
Target is becoming a catcher – experiment at SIRA for mid 2010
Safety issues are being addressed

Future possibilities GANIL SPIRAL 1

- 1+ N+ ^{8}Li ions in “Nanonake”
- ^{13}C on ^{12}C target



Experiment scheduled in May

C. Eleon et al. NIMB206 (2008) 4362-4367 (EMIS2007)
C. Eleon et al RSI 79, 02A904 (2008)

Testing a difficult beam: ^{8}B

- Production using fragmentation of ^{13}C on ^{12}C
- Flushing CF4 in the target surrounding to produce BF_3
- Ionization in Nanogan (0 to N+)
  - Was already tested with ^{32}S and ^{36}Ar on graphite target but high background of ^{24}Na

Summary

- In the frame of EUROnu
  - Production tests of 8Li from a BN target irradiated by fast neutrons at SOREQ with neutron generator and SARAF phase 1 (2009)
  - Production tests of ^{6}He from a BeO target irradiated by fast neutrons at SOREQ from SARAF phase 1
  - Diffusion of ^{6}He in BeO at GANIL (2010)
  - ^{8}Li (production) diffusion in graphite and ECR-ionization tests possible at GANIL (May – June 2009)
  - Possibility of testing diffusion and ECR-ionization of ^{8}B in a parasitic beam time at GANIL (?)

People and institutes

Michael Hass

Tsviki Hirsh

Vivek Kumar

Kuljeet Singh

Dan Berkovits

Leo Weissman

Yoram Nir-El

F. De Oliveira

M.G. St Laurent

P. Delahaye

H. Franberg

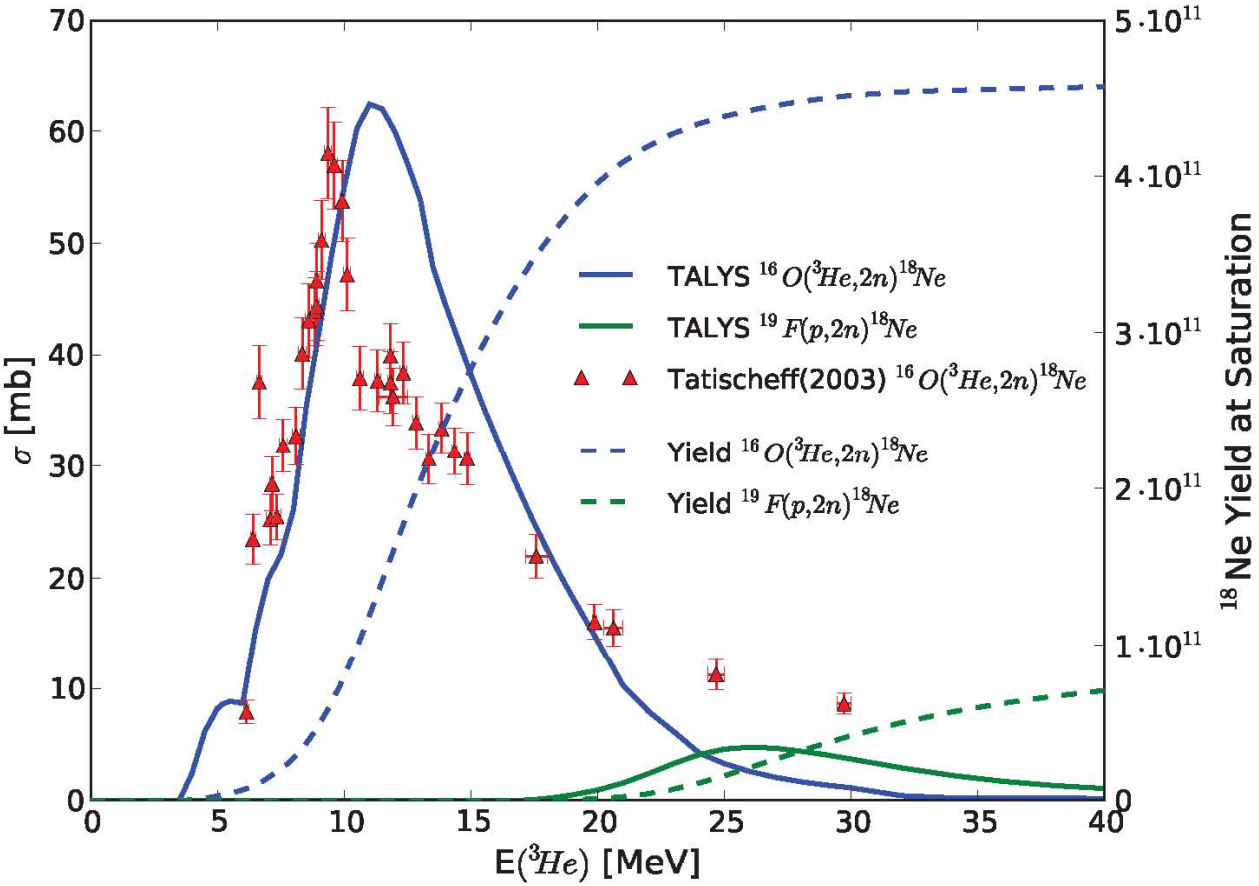
R. Leroy

A. Pichard

G. Lhersonneau

Thanks a lot for your attention!

What about ^{18}Ne?..



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