SiMon and μMEGAS test for (n,p) reactions at n_TOF. Letter of Intent?

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Why to measure (n,p)?: neutron capture therapy (astrop).

NCT is an experimental cancer therapy with more than 300 treatments in the last 5 years in Finland (Germany, Italy, Japan, Argentina).

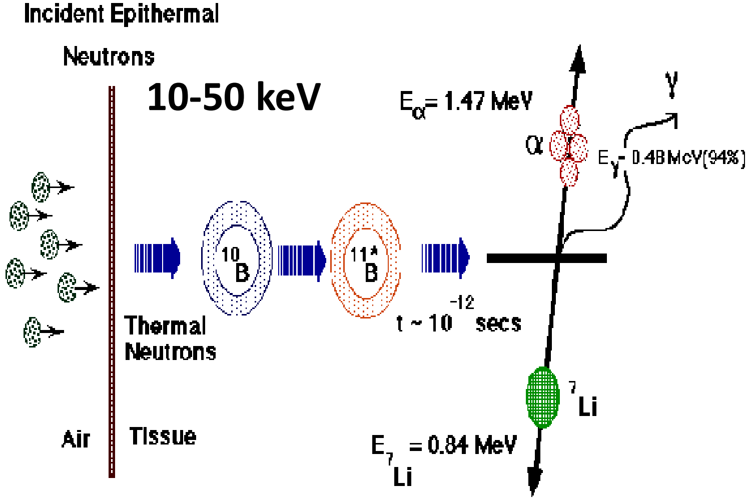
Only 1 or 2 neutron irradiations to destroy tumours.

Possible to combain with other therapies.

Survival over 30% and 2 years life expectancy for **terminal cancers** http://www.euroqol.org/.

Nuclear reactors as neutron sources, so a new era in NCT is coming thanks to the current projects on accelerator-based neutron sources.

TECHNICAL DEVELOPMENTS among others: RFQ accelerators with high intensity and low proton energy. Lithium liquid JETs for neutron generation.



15th ICNCT, held in Japan 2012

$^{33}S(n,\alpha)$ experiment: new capturer for NCT.

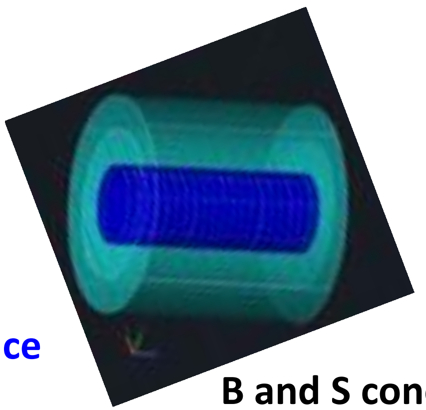
The motivation of our previous proposal was ambitious: to study a possible new capturer for neutron capture therapy. **ONLY, Boron-10 has been used.**

We have performed calculations of the kerma factors and simulations (MCNPX) of the dose using the preliminary results of the analysis (M. Sabate-Gilarte)

Models of head and neck cancers that are resistant to chemo/radiotherapy.

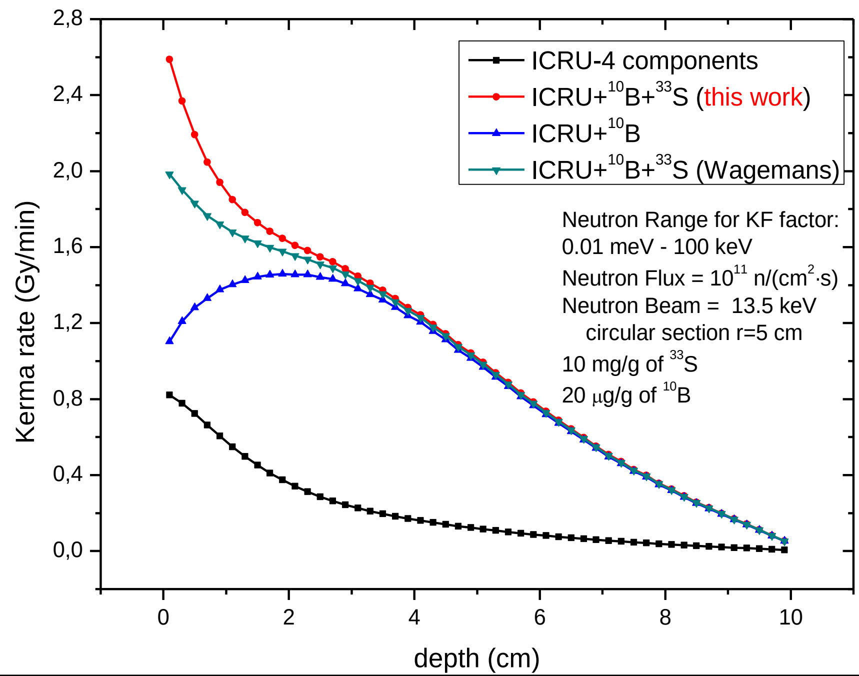
ICRU-4 tissue

Neutron Beam 13.5 keV



1st resonance of the $^{33}S(n,\alpha)$

B and S concentrations as in literature



The presence of S-33 could allow an important enhancement of the dose at the surface and in the 1 cm in depth. This opens new possibilities in NCT.

Accurate dosimetry in NTC: $^{14}N(n,p)$, $^{35}Cl(n,p)$.

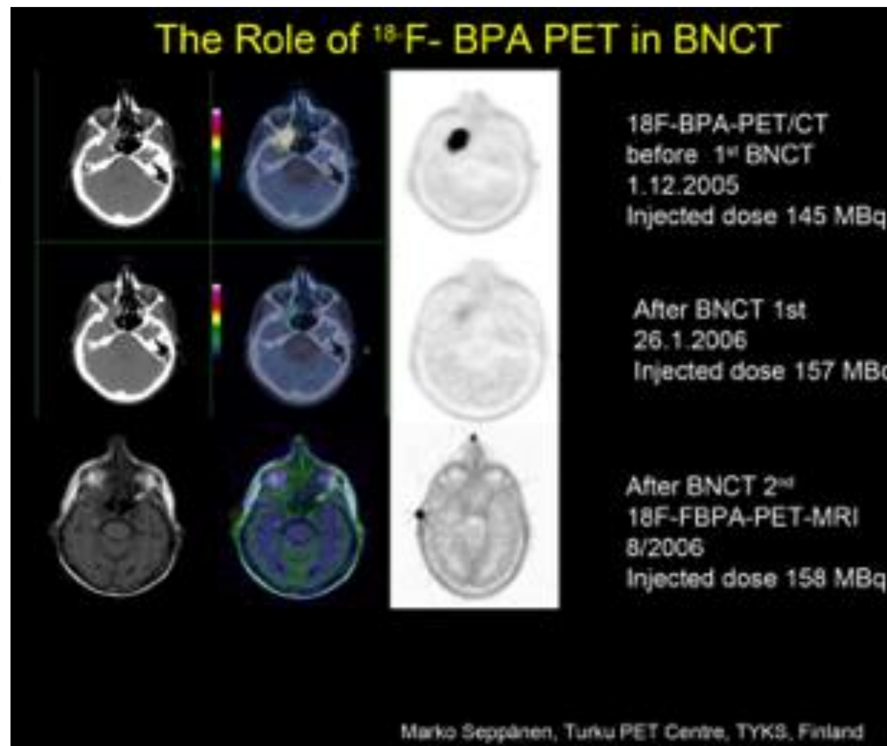
New and more accurate nuclear data. We expect to obtain them at n_TOF.

The treatment planning is based on MCNP simulations and SERA code.

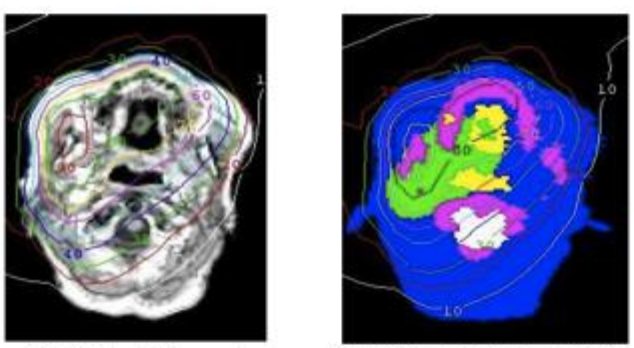
There are 4 main contributions to the total dose:

- Fast Dose: proton recoil due to elastic H scattering, En> 0.5 eV.
- Thermal Dose: **$^{14}N(n,p)^{14}C$**, En<0.5 eV. Poor considered in planning.
- Photon Dose: (n,γ) generated in the medium -> $H(n,\gamma)$ E_γ=2.2 MeV.
- Boron Dose: $^{10}B(n,\alpha)^{7}Li^*$

$^{35}Cl(n,p)^{35}S$ is present in higher concentrations in brain (glyoma).

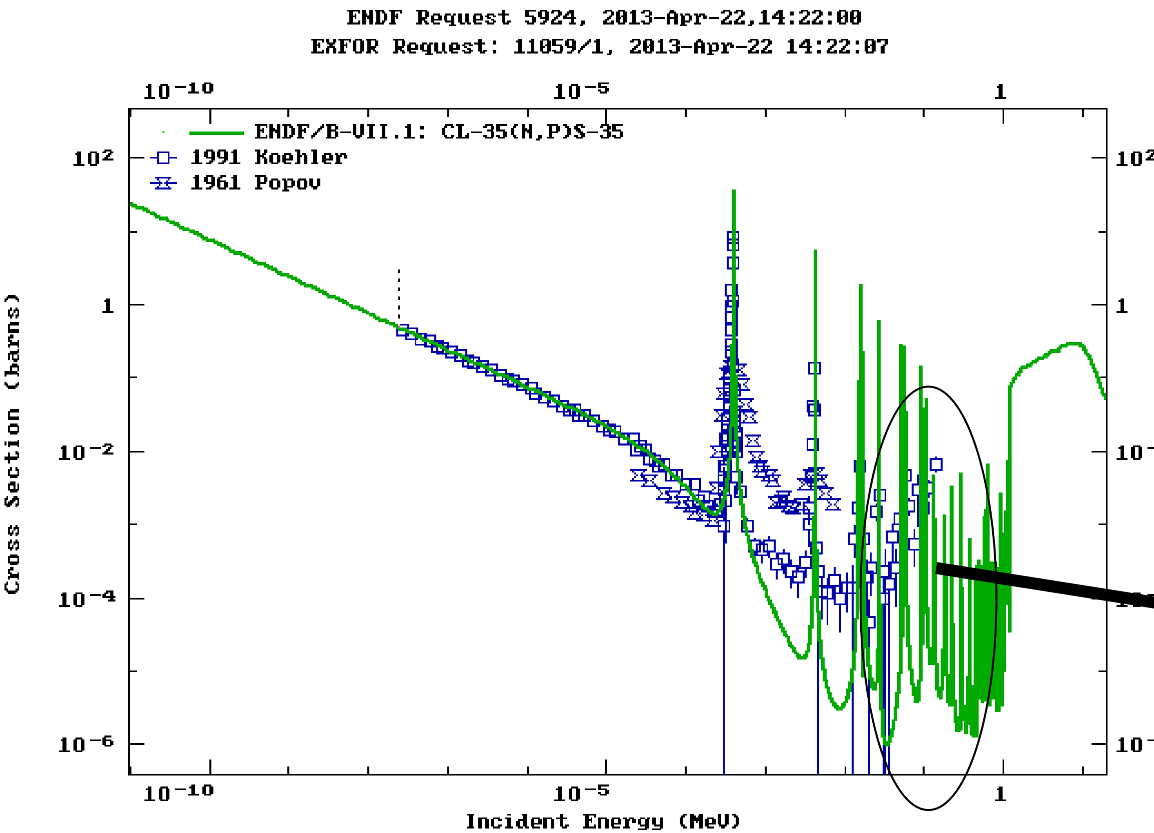


SERA dose planning



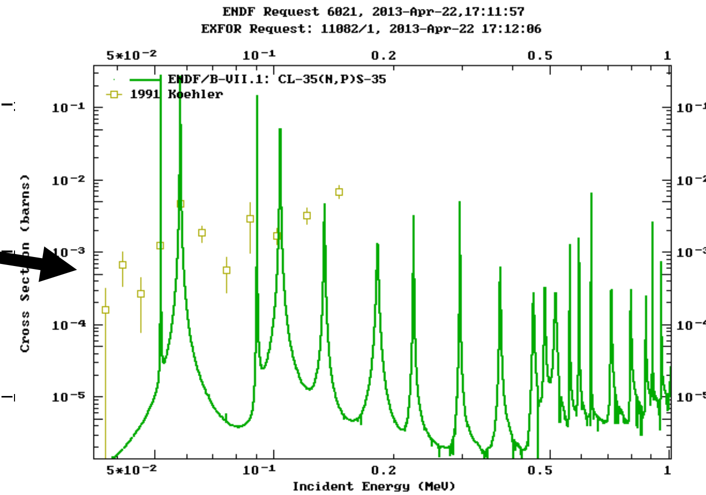
Weighted Target dose (100% = 25.1 Gy (W))
Boron concentration (tumour: blood) 3.5:1
14 cm apertures

$^{35}Cl(n,p)^{35}S$ reaction: status.



Q=615 keV. E_{th}=0.

NO experimental data of the resonances in the keV region



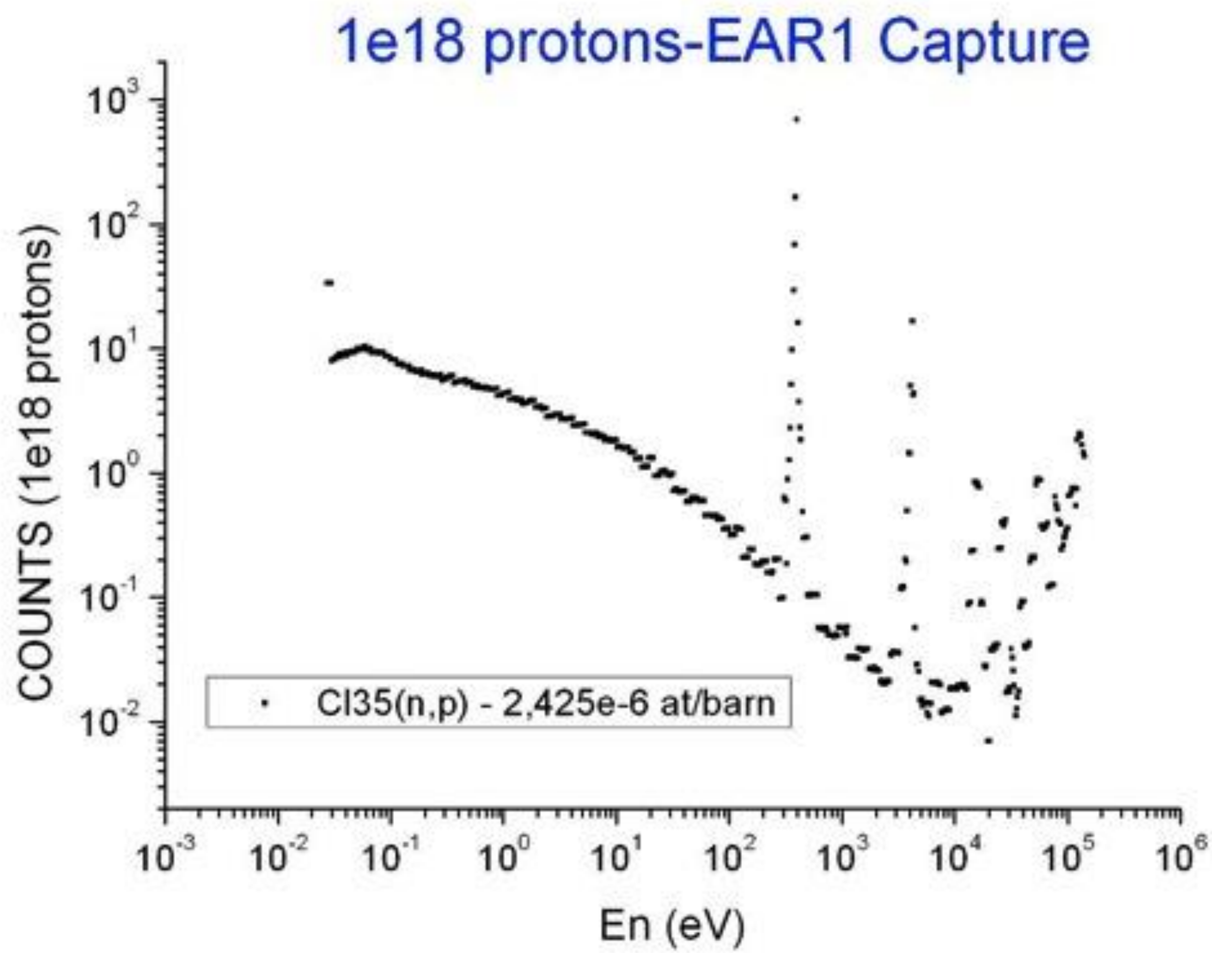
Koehler, PRC 44, 1675 (1991). From thermal to 146 keV.

Popov *et al.*, Journ.: Soviet Physics - JETP, Vol.13, p.1132 (1961). From thermal to 7.4 keV with lower energy resolution than Koehler.

Other measurements: integral at thermal and at 14 MeV.

$^{35}Cl(n,p)^{35}S$ reaction: couting rate.

We have estimated the counts for 1e18 protons at EAR-1 considering the only 1 Cl-35 sample as Koehler, and the collimator for capture campaign.



Koehler sample: KCl, 300 μg/cm².

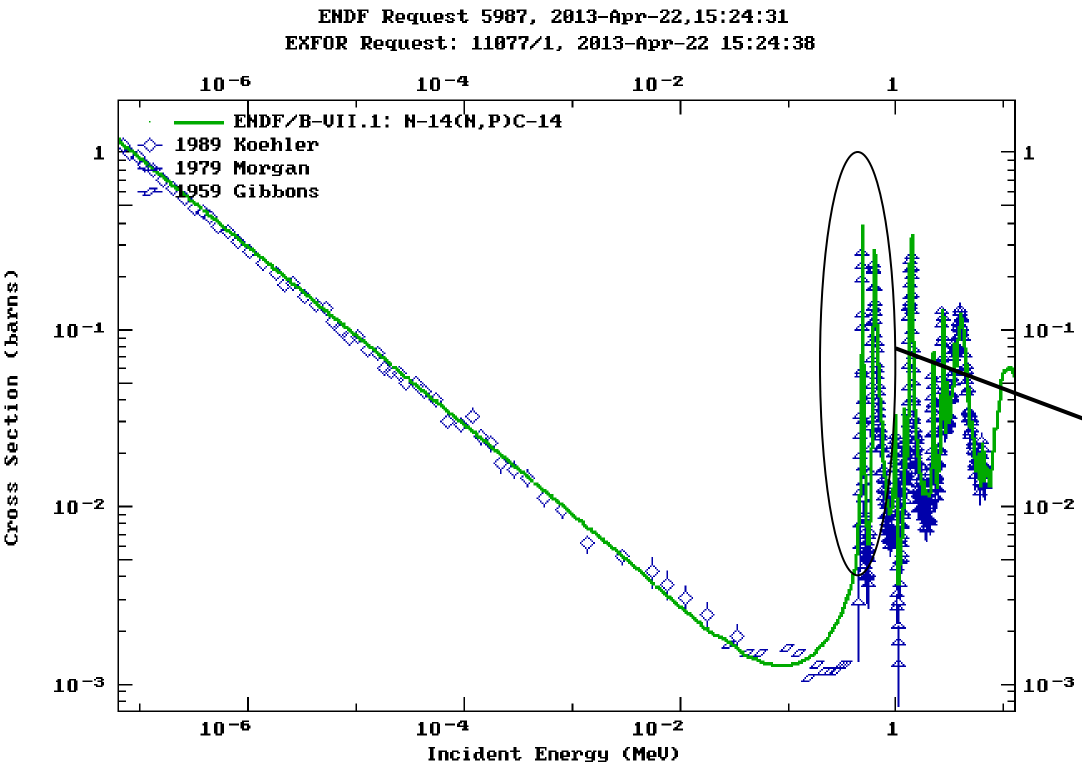
(Vacuum evaporation of natural KCl onto 8.5- μm-thick Al backing. 1.9x0.5 cm²).

En (eV)	ΔE (eV) EAR2	Δ E (eV) EAR1
1	0,0043	0,0003
10^3	8,5	0,54
10^6	41000	3600

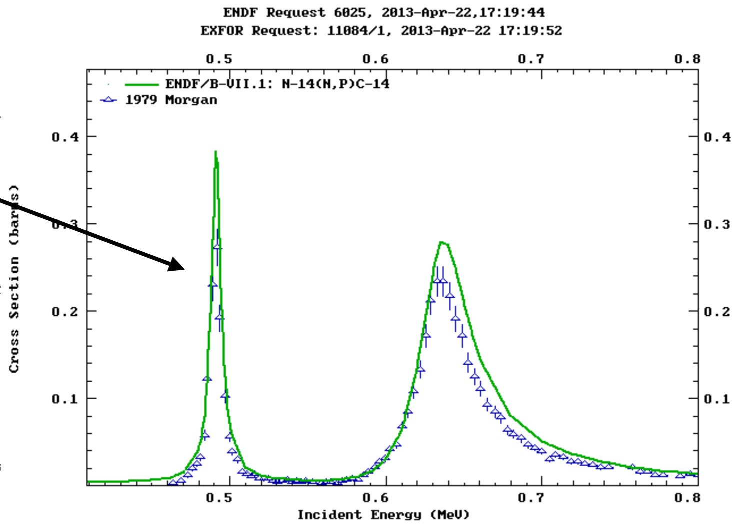
EAR1 Fission (counts x 20) → 18000 counts in the peak of 1st resonance

$^{14}N(n,p)^{14}C$ reaction: status.

Only partial energy ranges have been measured



Q=625 keV. E_{th}=0



There is not an unique measurement in all the energy range.

Johnson and Barschall, PRC 80, 818 (1950). Not included in EXFOR (0.5-1.8MeV).

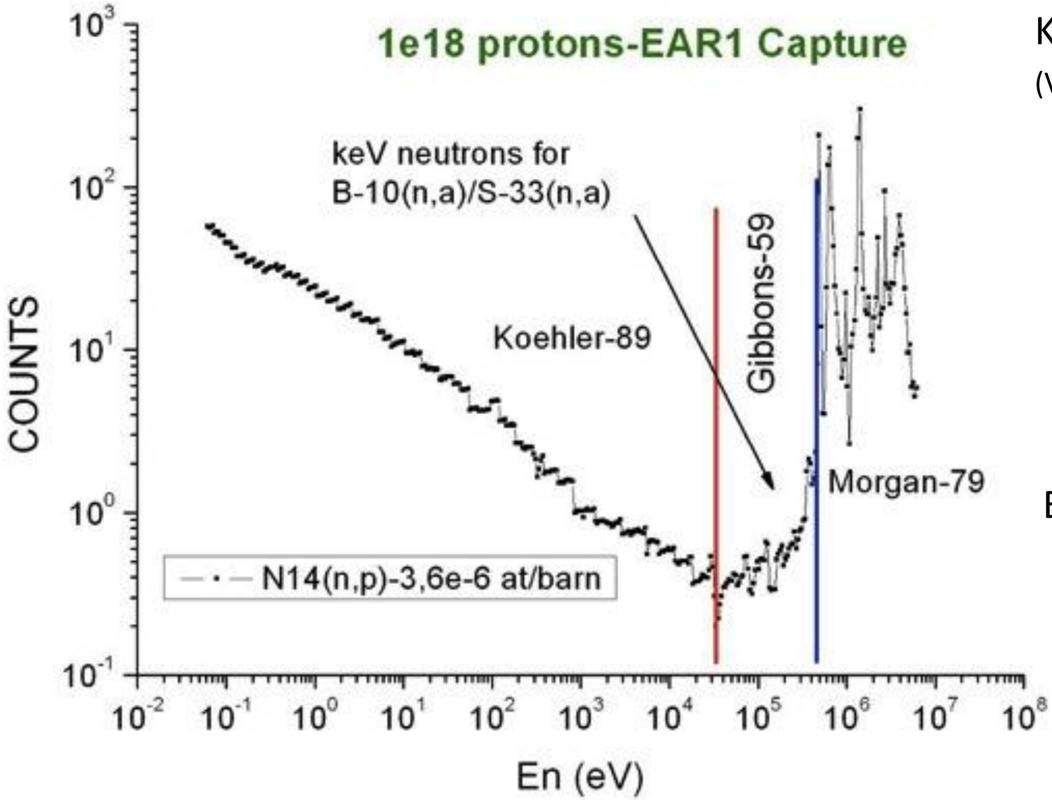
Gibbons and Macklin, PRC 114, p.571 (1959).

Morgan, Nuclear Science and Engineering, Vol.70, p.163 (1979)

Koehler and O’Brien, PRC Vol.39, p.1655 (1989)

$^{14}N(n,p)^{14}C$ reaction: counting.

We have estimated the counts for 1e18 protons at EAR-1 considering the only 1 N-14 sample as Koehler, and the collimator for capture campaign.



Koehler sample: Adenine ($C_5H_5N_5$), 165 μg/cm^2.
(Vacuum evaporation of Adenine onto 8.5- μm-thick Al backing)

ENERGY RESOLUTION

1st, 2nd resonances:
FWHM (492 keV) ~ 17 keV
FWHM (634 keV) ~ 33 keV

En (eV)	ΔE (eV) – EAR2	Δ E (eV) – EAR1
1	0,0043	0,0003
10^3	8,5	0,54
10^6	41000	3600

EAR2 (counts x 27) → 5000 counts in the peak of 1st resonance

SAMPLES: Cl-35, N-14.

Following the same strategy that S-33 we will collaborate with Wil Vollenberg, Sergio Calatroni and Mauro Taborelli in the sample coating.

"We think it is nice project and we are interested in participating in the production of Cl-35 and N-14 samples".

"Our workload is very high, and all jobs for LS1 have the highest priority. Middle of next year…".

We will try to improve the samples performed by previous researchers.

DETECTORS: SiMon.

We will work in the detection system of SiMon and in the detector itself to reduce the background at low energies (<700 keV).

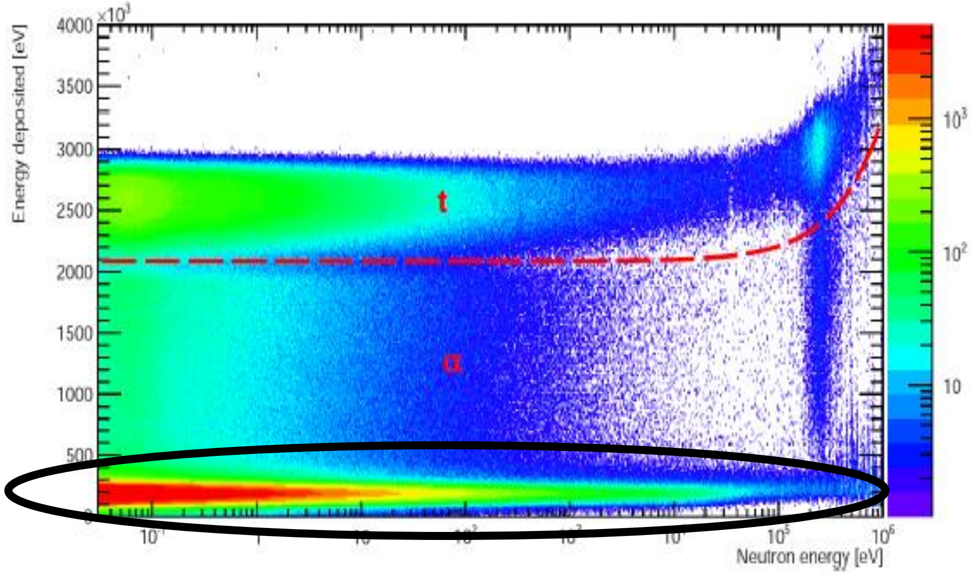
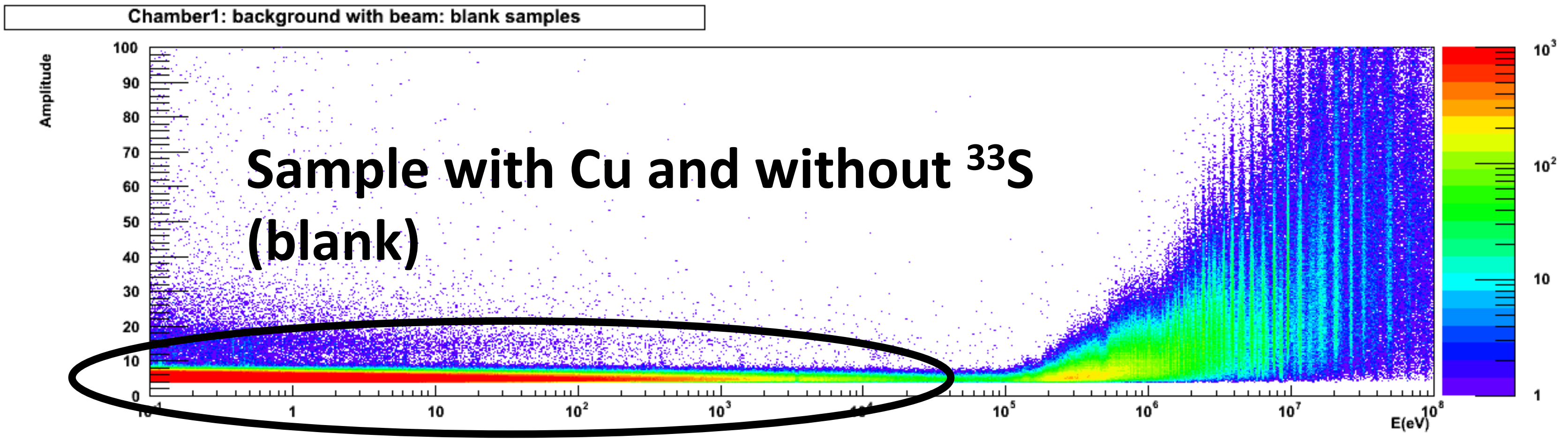


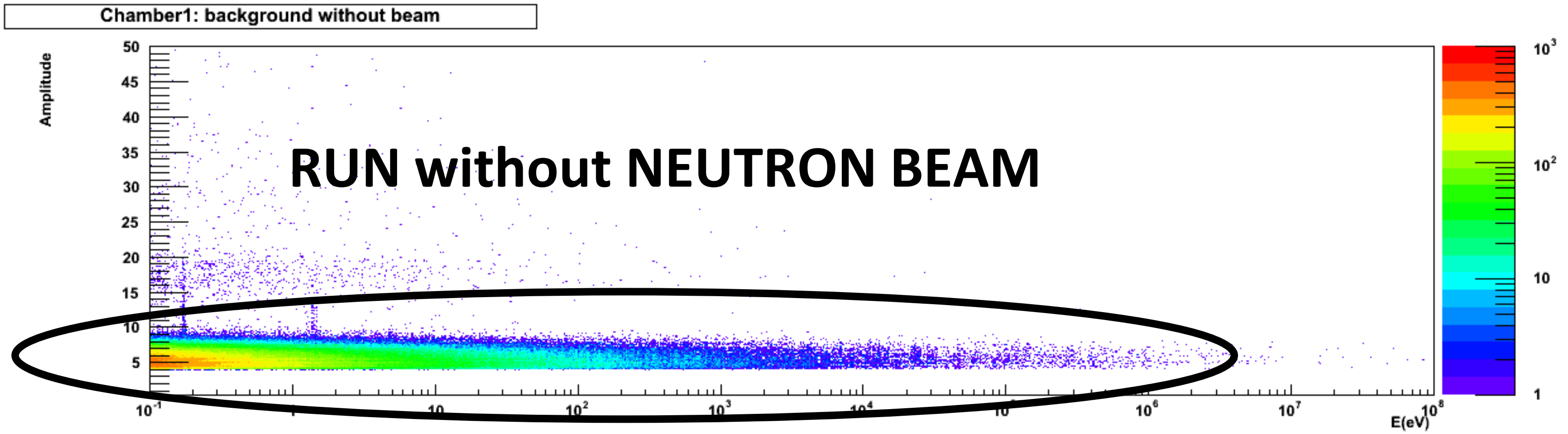
Figure 3.14: 2-D plot showing energy deposition in SiMon as a function of neutron energy. The triton and alpha regions are here more clearly separated, allowing a better selection of tritons (red dashed line).

Courtesy M. Barbagallo

DETECTORS: µMEGAS.

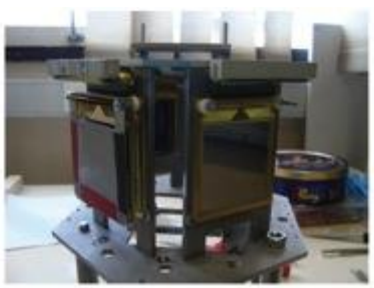
We will work in the detection system of uMEGAS and in the detector itself to reduce the background at low energies (<700 keV).





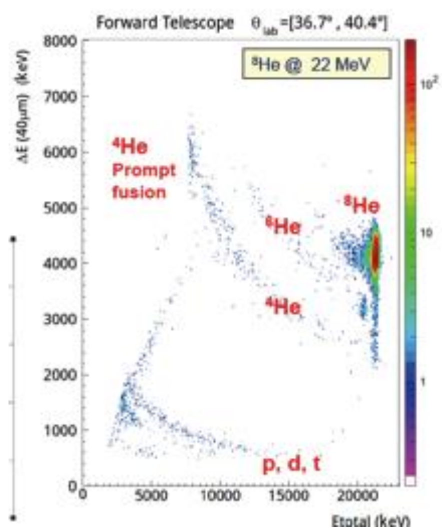
SUMMARY.

- Letter of Intent for upgrading the detector systems at n_TOF (SiMon and uMEGAS) for (n,p) reactions.
- ^{35}Cl and ^{14}N samples will be performed in collaboration with CERN, we will start in the middle of 2014.
- We need some beam time at the end of 2014 for testing the setups.
- **Goal->^{35}Cl(n,p)^{35}S: EAR-1 Fission. 2e18 protons. INTC, Feb 2015.**
- **Goal->^{14}N(n,p)^{14}C: EAR-2. >2e18 protons?. INTC, Feb 2015.**



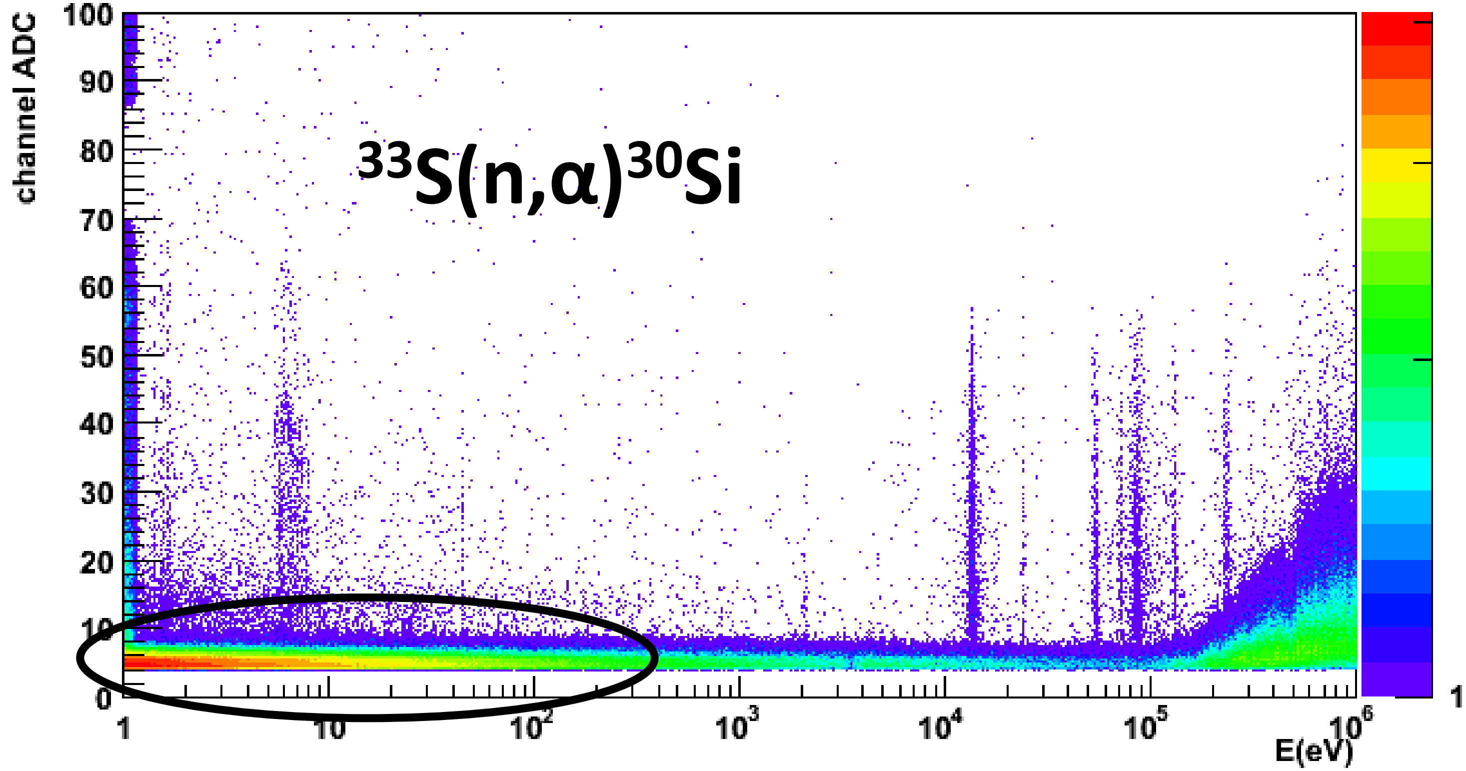
- 12 DSSSD Si detectors arranged in
- 6 particle telescopes (40 um ΔE & 1 mm E)

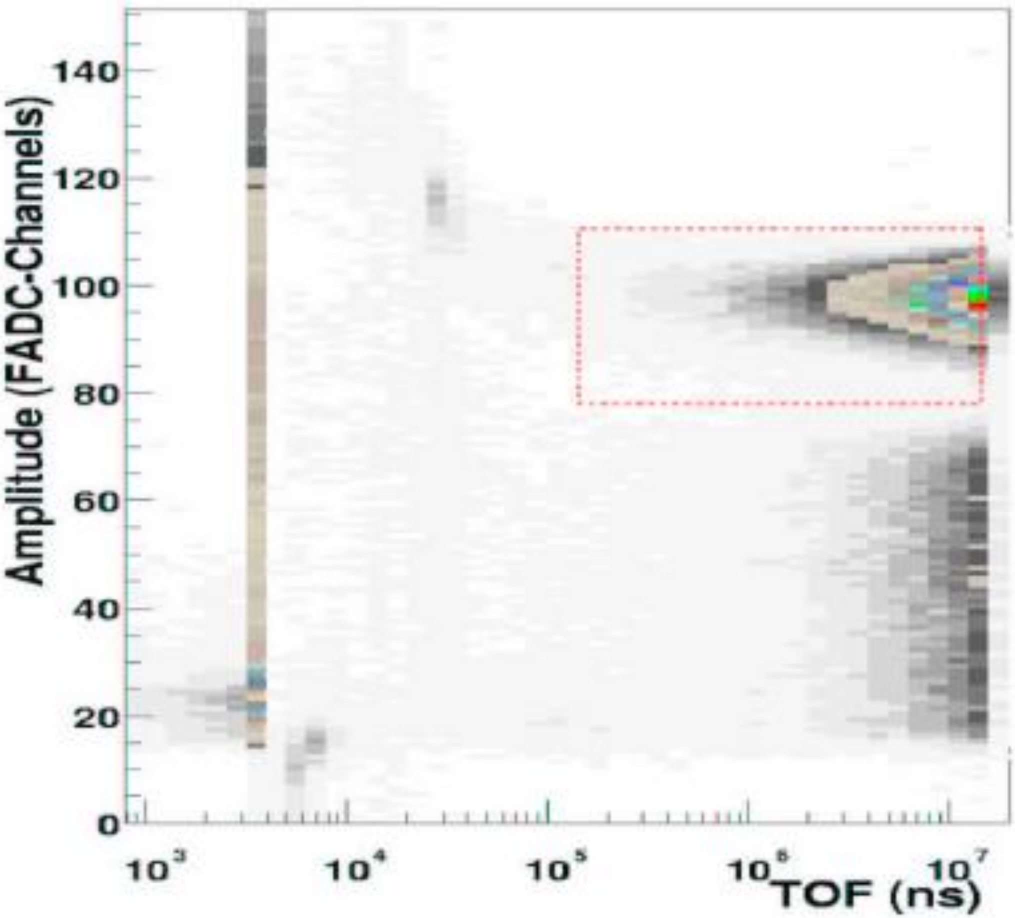
Courtesy I. Martel. B. Fernandez



DETECTORS: μMEGAS.

We will work in the detection system of uMEGAS and in the detector itself to reduce the background at low energies (<700 keV).





Amplitude (FADC-Channels)
140
120
100
80
60
40
20
0
10³
10⁴
10⁵
10⁶
10⁷
TOF (ns)