Preparations for the first EXL experiment
FRS-User Meeting, 28 November 2011

Spokesperson: N. Kalantar (KVI), Co-spokesperson: P. Egelhof (GSI), GSI contact: H. Weick (GSI)

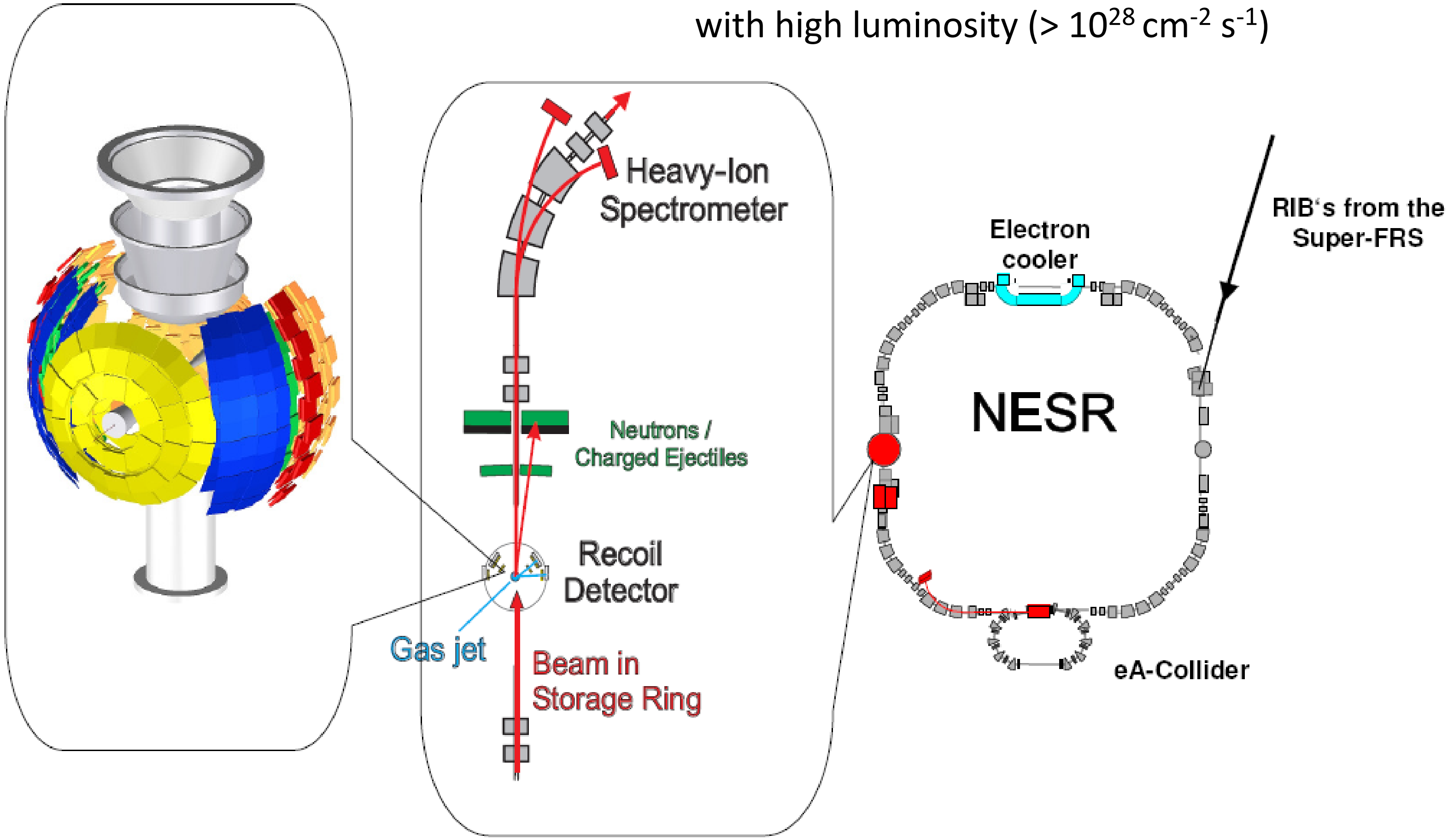
We will update the collaboration list in the coming months

Detection systems for:

- ✓ Target recoils and gammas (p,α,n,γ)
- ✓ Forward ejectiles (p,n)
- ✓ Beam-like heavy ions

Design goals:

- ✓ Universality: applicable to a wide class of reactions
- ✓ Good energy and angular resolution
- ✓ Large solid angle acceptance
- ✓ Specially dedicated for low q measurements with high luminosity (> 10^{28} cm^{-2} s^{-1})



Physics goals of the EXL program :

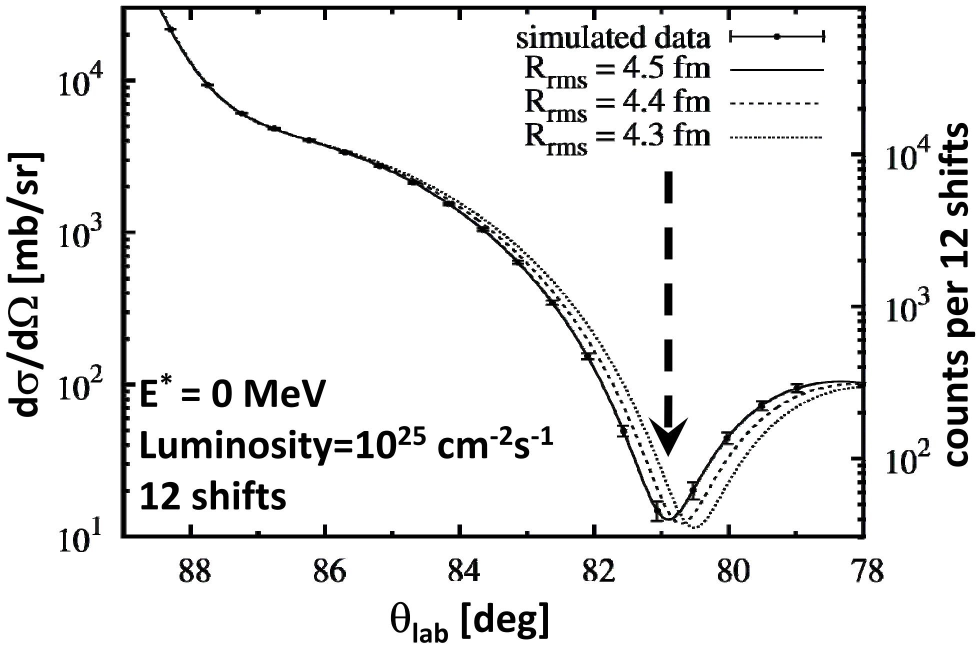
- ✓ **Nuclear Matter Distributions along Isotopic Chains** (ex. halo, skin structure)
  method: *elastic proton scattering at low q:*

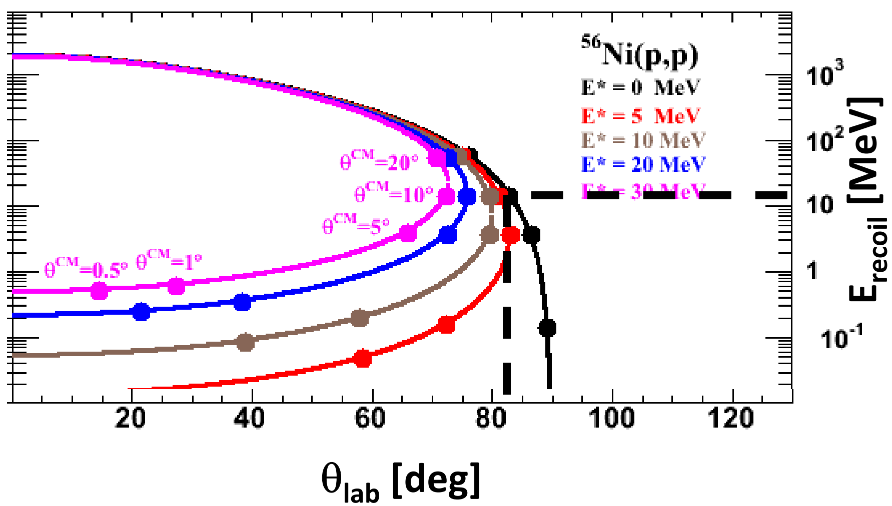
  - ✓ **Giant Monopole and Iso-Scalar Dipole Resonances** (ex. nuclear compressibility)
    method: *inelastic α scattering at low q*

    - ✓ **Gamow-Teller Transitions** (ex. weak interaction rates for N=Z waiting point nuclei)
      method: *(^{3}He,t), (d,^{2}He) charge exchange reactions at low q*

Accepted experiment (42 shifts) at the ESR with "scaled-down" EXL version: ^{56}Ni

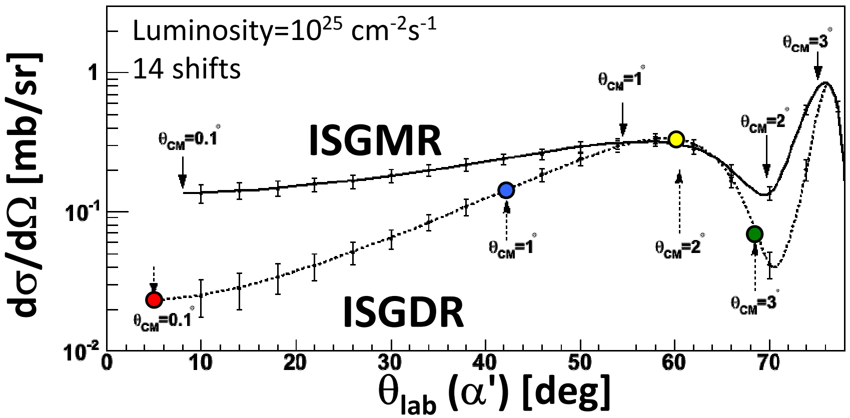
✓ **Nuclear Matter Distributions along Isotopic Chains: : ~10 MeV for θ_{lab}~80-82°**

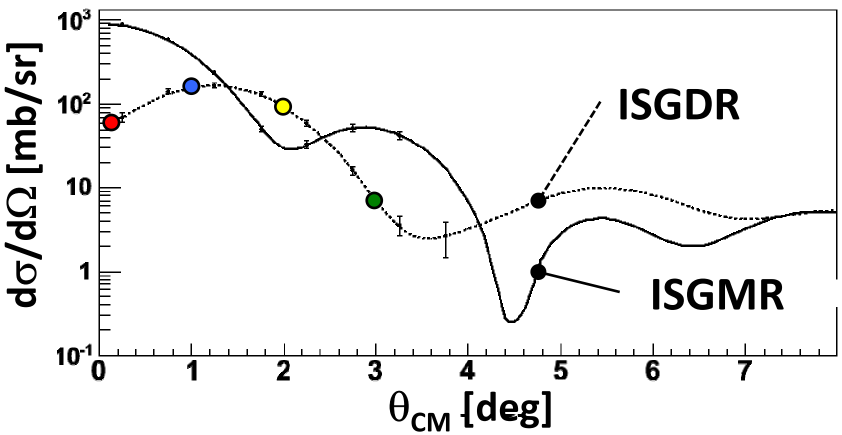




Accepted experiment at the ESR with "scaled-down" EXL version: ^{56}Ni

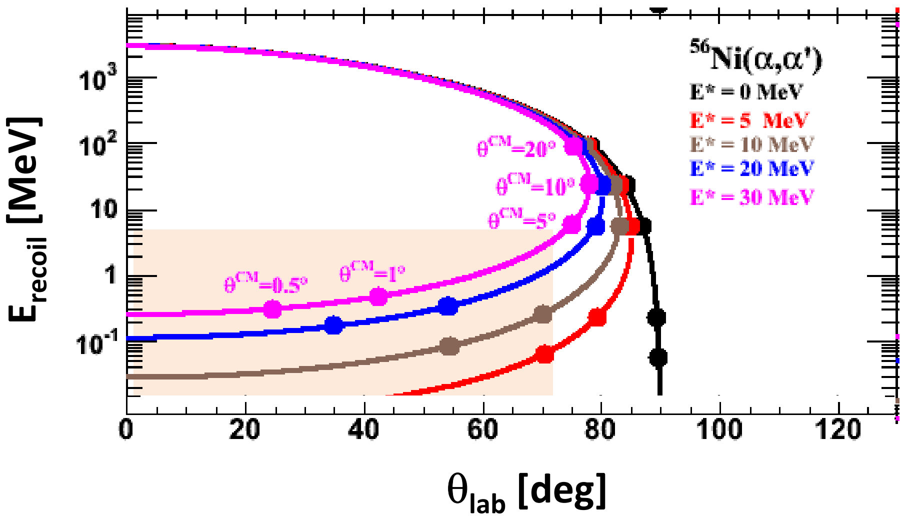
- ✓ **Nuclear Matter Distributions along Isotopic Chains: : ~10 MeV for θ_{lab}~80-82°**
- ✓ **Giant Monopole and Iso-Scalar Dipole Resonances: 0.1→5 MeV for θ_{lab}=0→70°**

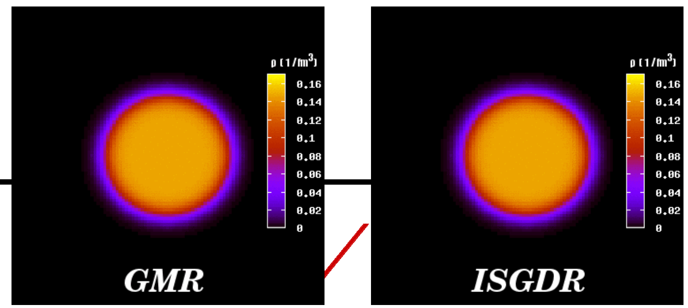




ISGMR: 19.5 MeV (Monrozeau *et al.*, PRL 100, 042501 (2008))

ISGDR: 30 MeV





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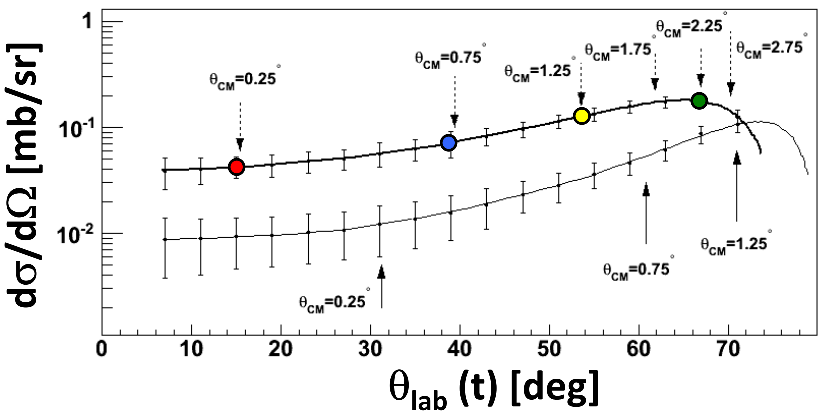
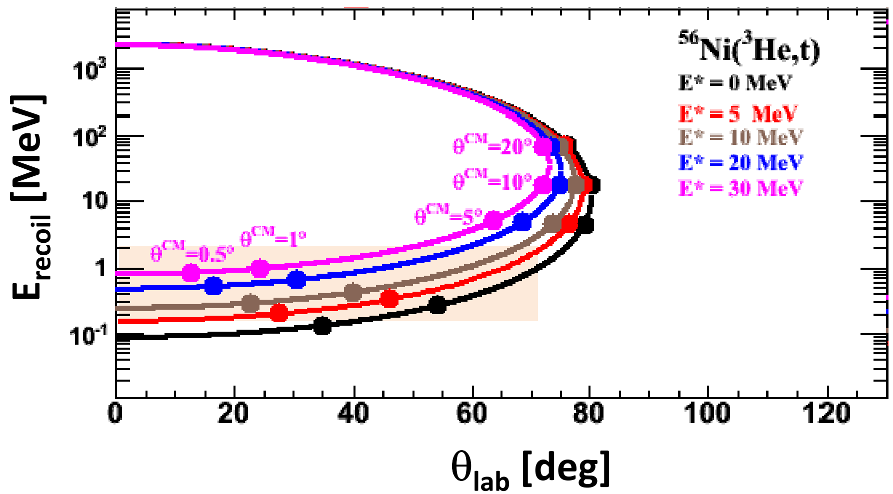
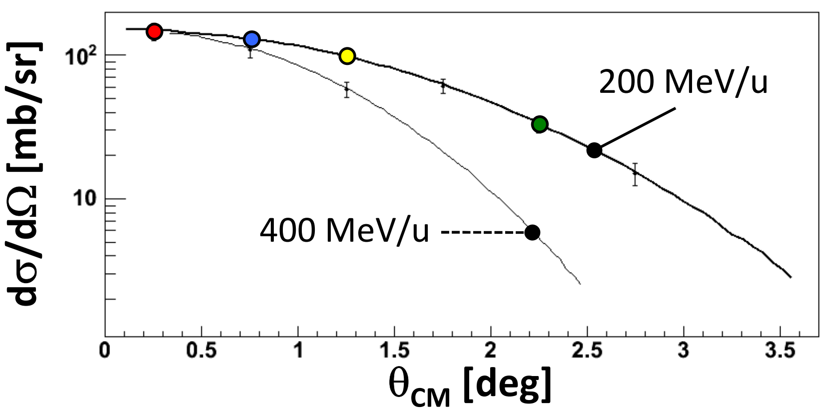


Luminosity=10^{25} $cm^{-2}s^{-1}$
14 shifts
E*=4 MeV





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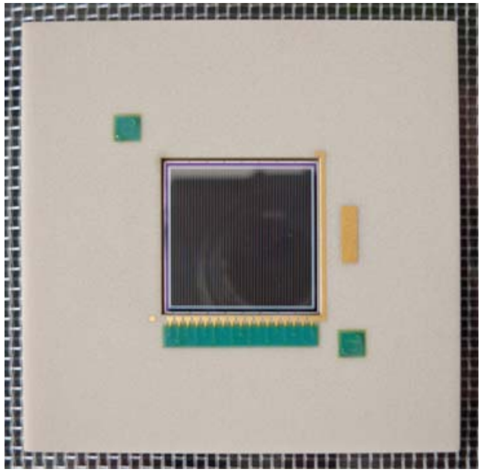
Other experimental challenges

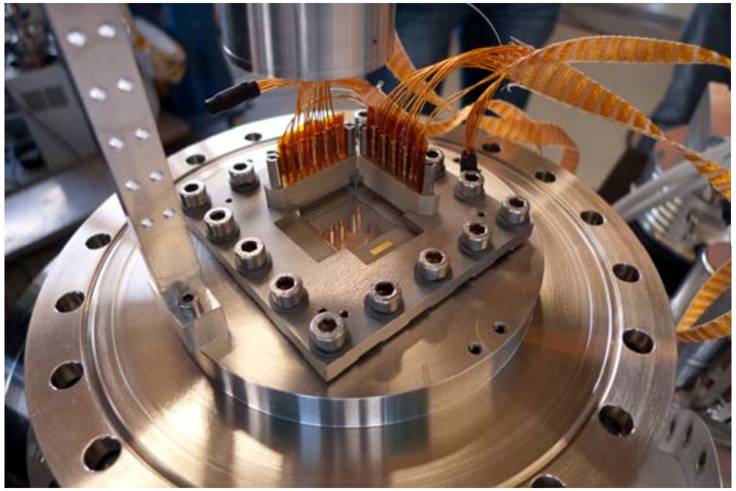
- ✓ **Utlra high vacuum**
  - → "Active flanges" : DSSDs are used as buffer between HV and UHV areas;
  - → target density and vacuum compatibility
- ✓ **Half-life of the beam**
  - → half-life of the radioactive ions (6 days in the case of ^{56}Ni);
  - → beam cooling ⇔ multiple scattering in the dense target;
- ✓ **energy and angular resolution**
  - → energy threshold on DSSDs ~ 100 keV minimal;
  - → target size;

✓ *vacuum solution with DSSDs [courtesy : B. Streicher (KVI/GSI) and M. Mutterer (GSI)]*



p-side (21x21 mm^2) DSSD
64x64 strips
AlN PCB (ceramic – UHV)
good heat conductivity
< 5µm roughness after polishing

test setup :
n-side facing auxiliary vacuum
spring-pin connectors



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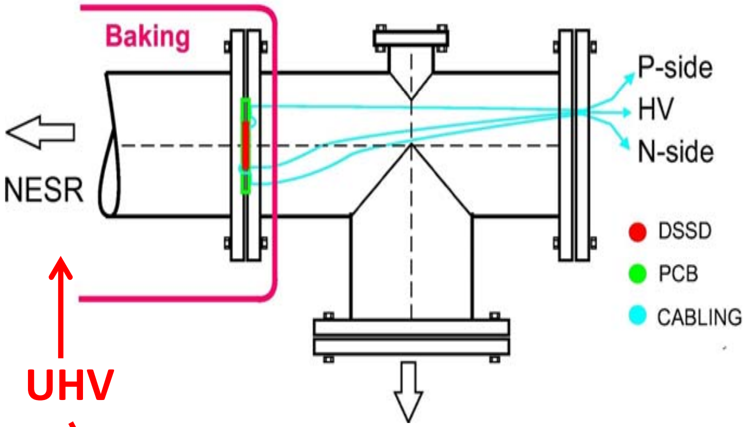
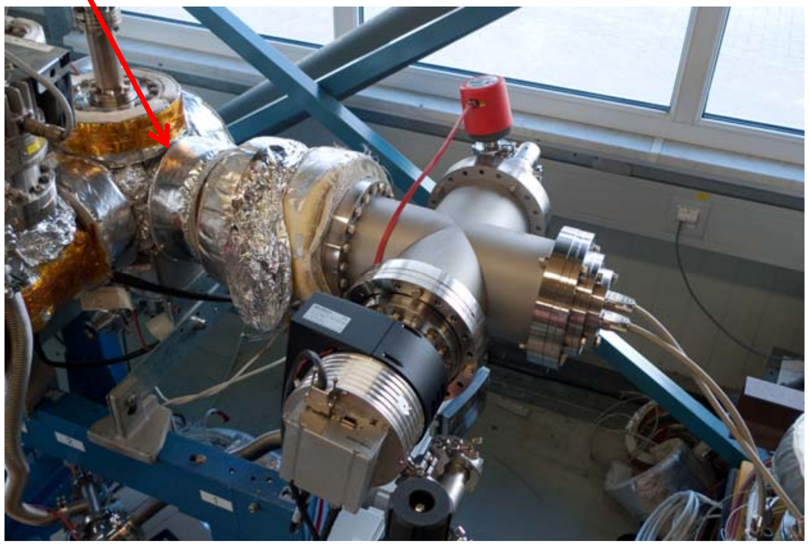
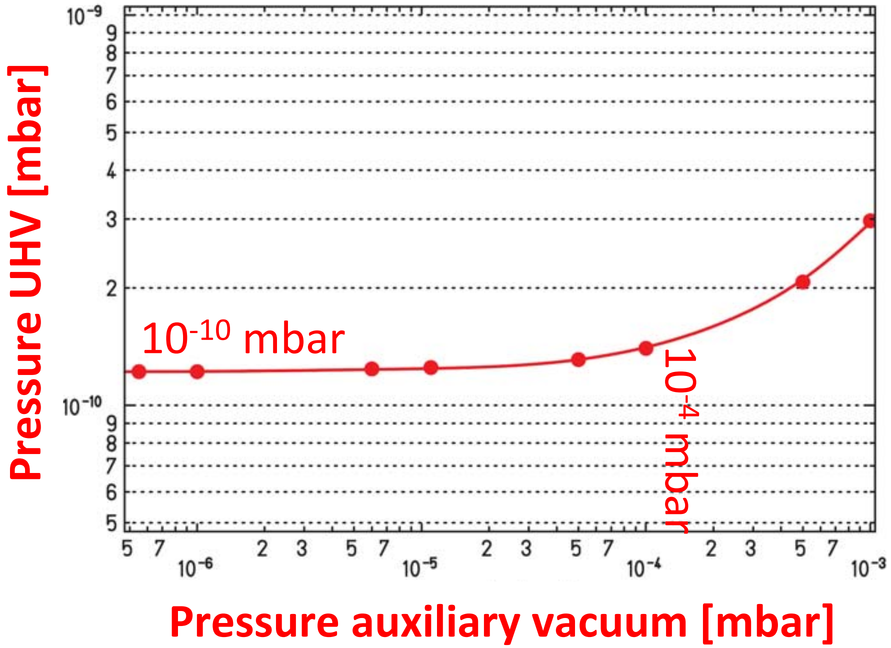
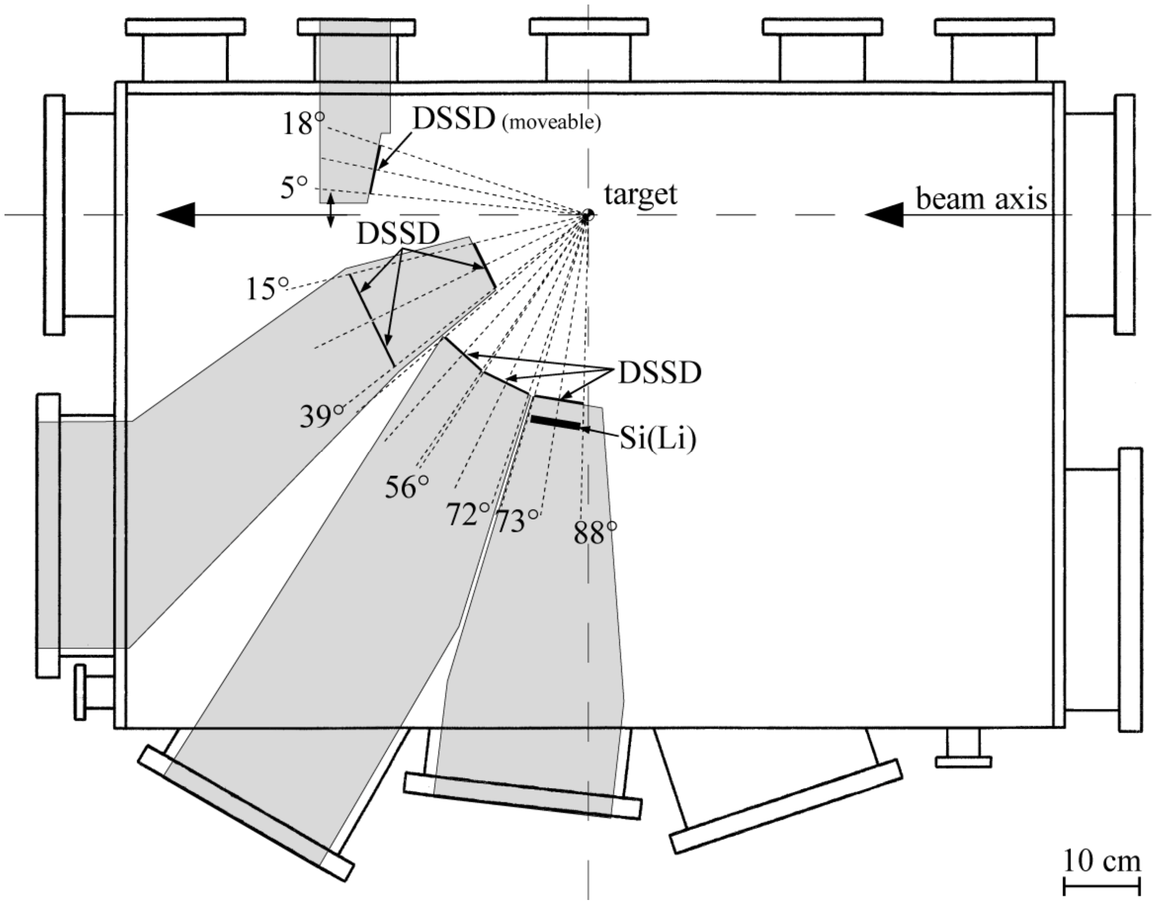




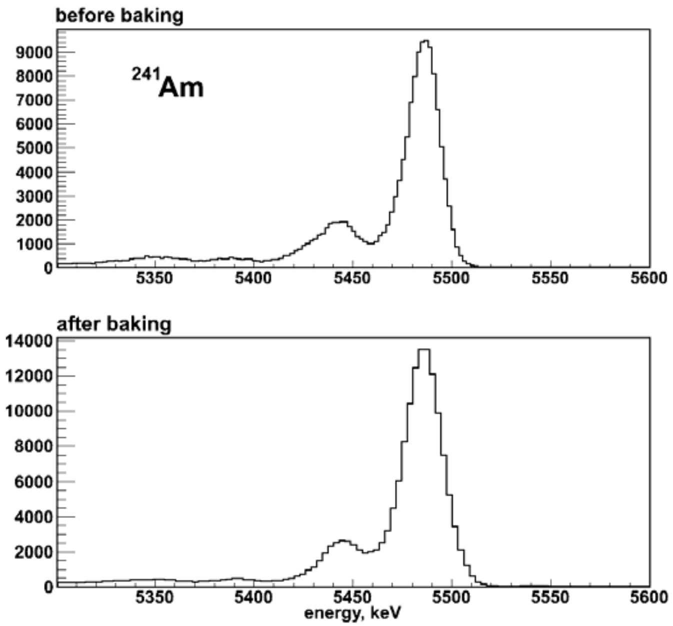


Streicher et al., NIM A 654 (2011) 604

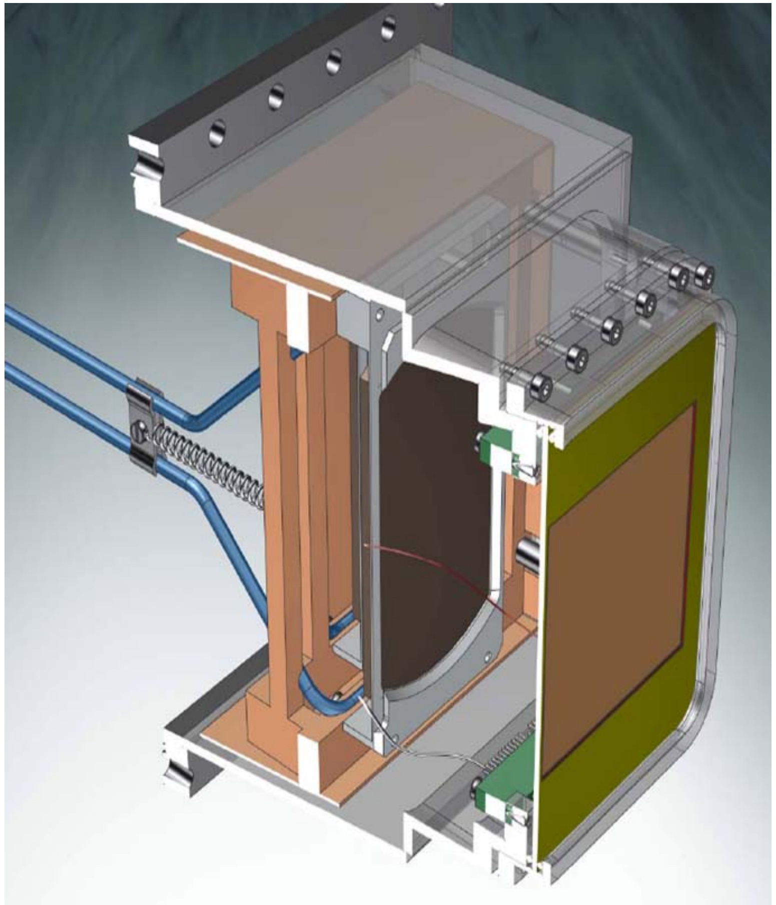
✓ *existing chamber to be installed in the ESR*



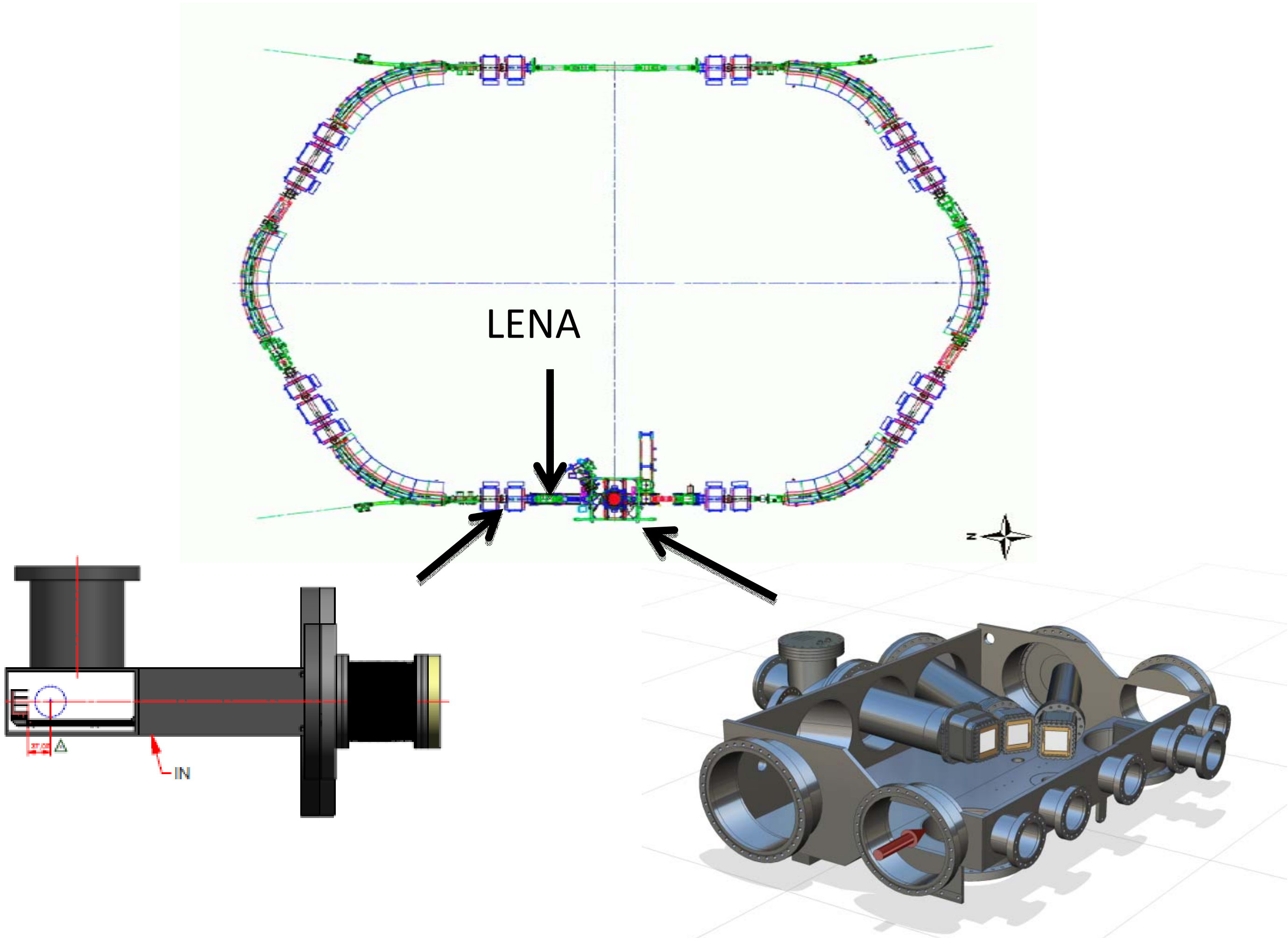
✓ *mechanical design status [courtesy : M. Lindemuller (KVI)]*



Spectral response unchanged after <u>three</u> baking cycles (to 200 ºC)



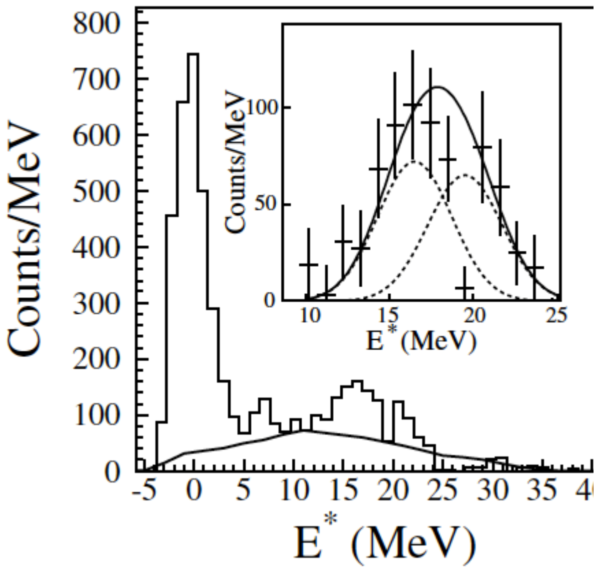
E105 Arrangement at ESR

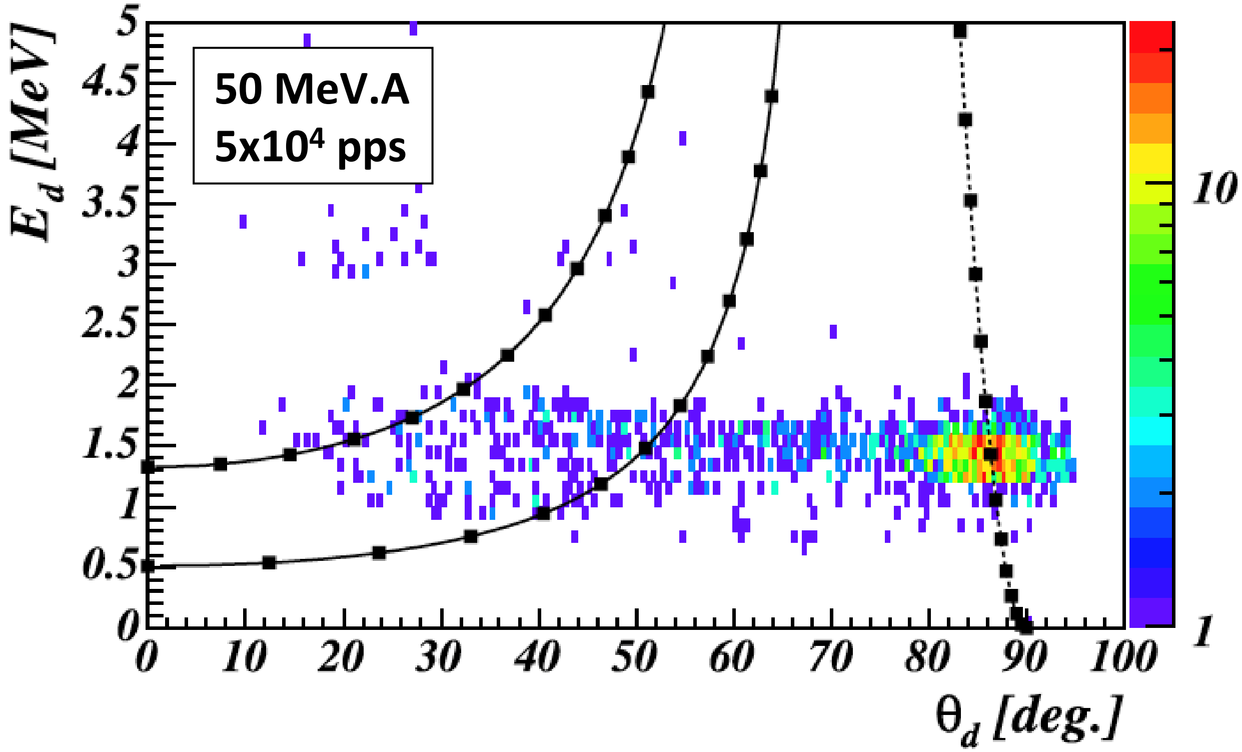


PRL **100,** 042501 (2008)   PHYSICAL REVIEW LETTERS   week ending 1 FEBRUARY 2008

First Measurement of the Giant Monopole and Quadrupole Resonances in a Short-Lived Nucleus: ^{56}Ni

C. Monrozeau,[1] E. Khan,[1] Y. Blumenfeld,[1] C. E. Demonchy,[2] W. Mittig,[3] P. Roussel-Chomaz,[3] D. Beaumel,[1] M. Caamaño,[4] D. Cortina-Gil,[4] J. P. Ebran,[1] N. Frascaria,[1] U. Garg,[5] M. Gelin,[3] A. Gillibert,[6] D. Gupta,[1,*] N. Keeley,[6] F. Maréchal,[1] A. Obertelli,[6] and J-A. Scarpaci[1]





Selected for a Viewpoint in *Physics*
PRL **107,** 202501 (2011) PHYSICAL REVIEW LETTERS week ending 11 NOVEMBER 2011

Gamow-Teller Transition Strengths from ^{56}Ni

M. Sasano,[1,2] G. Perdikakis,[1,2] R. G. T. Zegers,[1,2,3] Sam M. Austin,[1,2] D. Bazin,[1] B. A. Brown,[1,2,3] C. Caesar,[4] A. L. Cole,[5] J. M. Deaven,[1,2,3] N. Ferrante,[6] C. J. Guess,[7,2] G. W. Hitt,[8] R. Meharchand,[1,2,3] F. Montes,[1,2] J. Palardy,[6] A. Prinke,[1,2,3] L. A. Riley,[6] H. Sakai,[9] M. Scott,[1,2,3] A. Stolz,[1] L. Valdez,[1,2,3] and K. Yako[10]

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[10]*Department of Physics, University of Tokyo, Tokyo, 113-0033, Japan*

(Received 2 August 2011; published 7 November 2011)

Experiment E087

Breakout from the hot CNO cycles in X-ray bursters: determination of the $^{15}O(\alpha,\gamma)^{19}Ne$ reaction rate via a transfer study on the ESR

PJ Woods, T Davinson, D Doherty, GJ Lotay (**University of Edinburgh**)
T Aumann, C Dimopolou, P Egelhof, R. Flag, H Geissel, M Heil, C Kozhuharov, J Kurcewicz, **Y Litvinov**, M Mutterer, C Nociforo, F Nolden, B Pfeiffer, R Reifarth, B Riese, C Scheidenberger, H Simon, M Steck, B Streicher, H Weick (**GSI**)
N Kalantar, **C Rigollet** (**KVI**)
S Bishop, T Faestermann, A Parikh (**TU Munich**)
B Davids (**Triumf**)
R Kanungo (**St Mary's College, Halifax**)
RC Lemmon (**Daresbury Laboratory**)
M Chartier (**University of Liverpool**)
U Datta Pramanik (**Saha Institute of Nuclear Physics**)

KVI

for the EXL collaboration

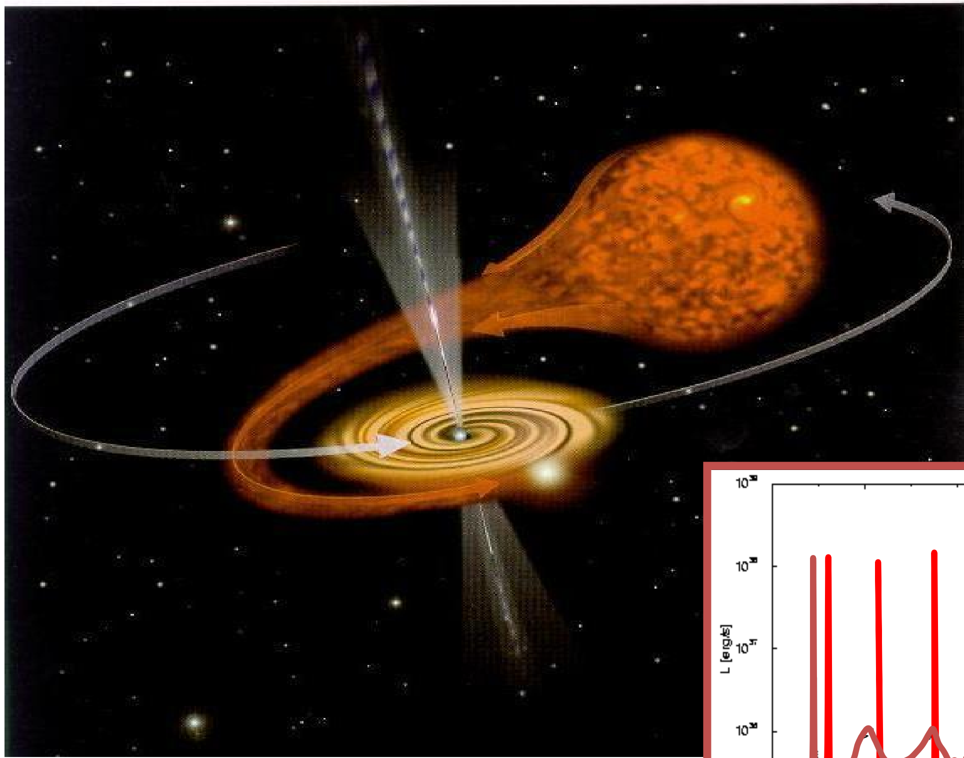
GSI

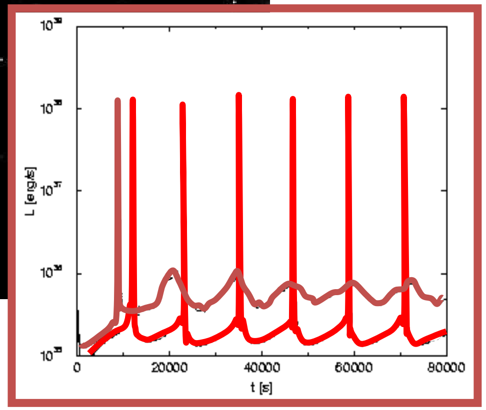
rijksuniversiteit groningen

The $^{15}O(\alpha,\gamma)^{19}Ne$ reaction: the nuclear trigger of X-ray bursts

The observation of X-ray bursts is interpreted as thermonuclear explosions in the atmosphere of a neutron star in a close binary system.

As temperature and density at the surface of the neutron star increase, the CNO cycles leak through the $^{15}O(\alpha, \gamma)^{19}Ne$ reaction.





Reaction regulates flow between the hot CNO cycles and rp process
→ critical for explanation of amplitude and periodicity of bursts

THE ASTROPHYSICAL JOURNAL, 301:629–633, 1986 February 15

A NEW ESTIMATE OF THE ^{19}Ne(p, γ)^{20}Na AND ^{15}O(α, γ)^{19}Ne REACTION RATES AT STELLAR ENERGIES

K. LANGANKE,[1] M. WIESCHER,[2] AND W. A. FOWLER
W. K. Kellogg Radiation Laboratory, California Institute of Technology, Pasadena
AND
J. GÖRRES
Department of Physics, University of Pennsylvania, Philadelphia
Received 1985 May 24; accepted 1985 August 19

Rate dominated by a single $3/2^+$ resonance in ^{19}Ne at 504 keV

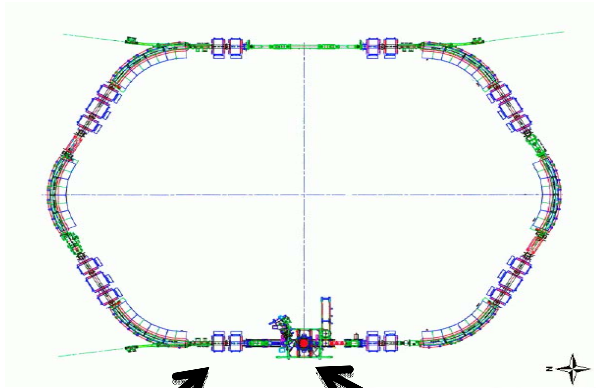
Γ_α (eV)	Γ_γ (eV)	$w\gamma$ (eV)
7.2(−6)	0.073	1.44(−5)

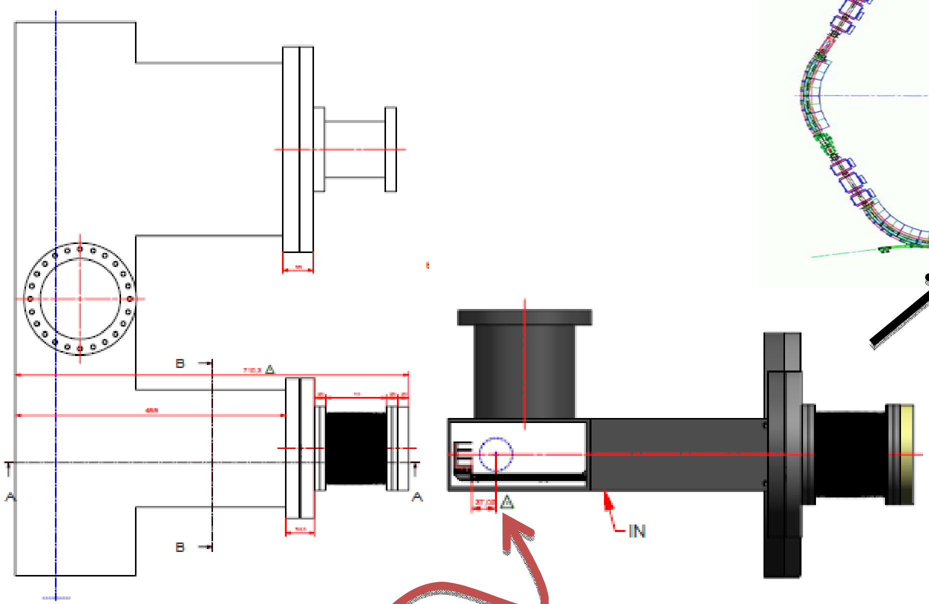
$$\omega\gamma = \omega \frac{\Gamma_a \Gamma_b}{\Gamma} .$$

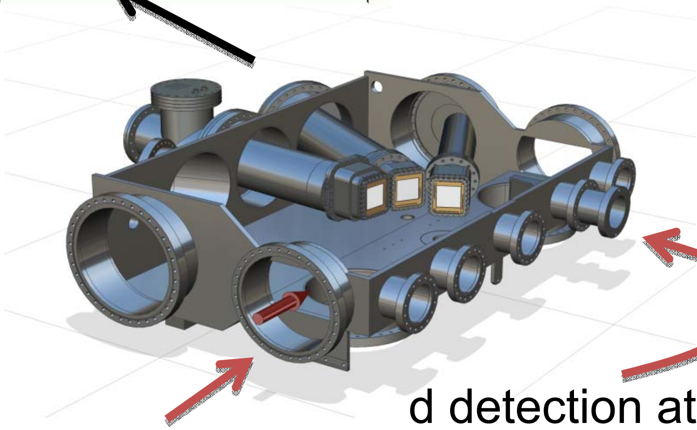
Key experimental uncertainty, alpha branching ratio, $b_\alpha \sim 10^{-4}$

E087 Arrangement at ESR

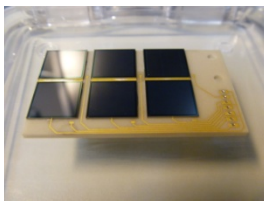
- Using the same experimental setup as E105
- Reaction: $^{20}Ne(p, d)^{19}Ne^{*} \rightarrow {}^{15}O + \alpha$ in inverse kinematics at 800 MeV (40 MeV/u)
- Shifts: 21







coincident ^{15}O or ^{19}Ne detected at ~ 1° with 6 pin diodes in UHV



^{20}Ne at 40 MeV/u

d detection at ~ 6-7° with 2 x 1 mm Si detectors in pocket

Plan for 2012

- First week of E105 with stable ^{58}Ni
- One week of E087 while understanding the first results of E105
- Second week of E105 with radioactive ^{56}Ni
- The same setup will be used for these experiments (target and detectors) making it very efficient.