^{35}Ca decay
beta-delayed 1- and 2-proton

spokespersons: J. Giovinazzo (CENBG), O. Tengblab (CSIC)

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Dep. of Physics and Astronomy (Aarhus) – univ. Aarhus – **Denmark**

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beta delayed proton(s) emission program

^{31}**Ar** studied at ISOLDE (see next proposal)

Phys. Rev. C 87, 055808 (**2013**), **G. T. Koldste**, H.O.U. Fynbo, *et al*.

^{35}**Ca proposal : first complete decay study**

^{35}Ca previous decay studies

Berkeley, J. Aystö et al. (1985)

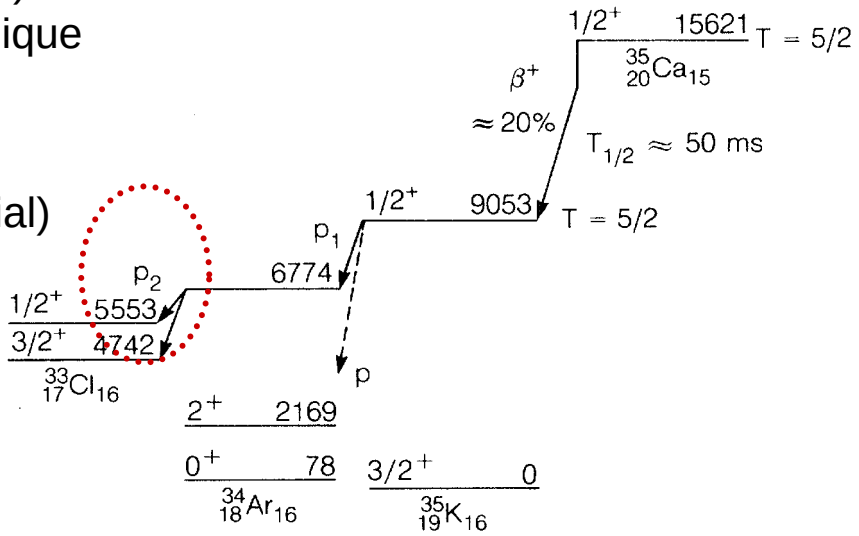
GANIL, W. Trinder et al. (1999)

Previous experiments

1985 Berkeley, J. Aystö *et al.*, PRL 55 (1985) 1384

^{40}Ca(^{3}He,α4n) reaction, helium-jet technique
small angle proton-proton coincidences
with Δ***E-E*** silicon telescope

- only β-2p measurement (sequential)
- first decay scheme



log***ft***(IAS) = 3.09
$\boldsymbol{T_{1/2}}$ = 50 ± 30 *ms*
Δ***m*** = 4463 ± 60 *keV* (IMME)

1999 GANIL, W. Trinder *et al.*, PLB 459 (1999) 67

^{40}Ca fragmentation, LISE implantation / decay experiment
gamma: 3 Ge (70%) and 2 NaI detectors

- 19 β-p(γ) transitions → B(GT) (weaker quenching than ***sd*** shell)
- no β-γ
- no β-2p to excited state in ^{33}Cl

log***ft***(IAS) = **4.1** ← missed strength ?
$\boldsymbol{T_{1/2}}$ = 25.7 ± 0.2 *ms*
Δ***m*** = 4530 ± 66 *keV* (IMME)

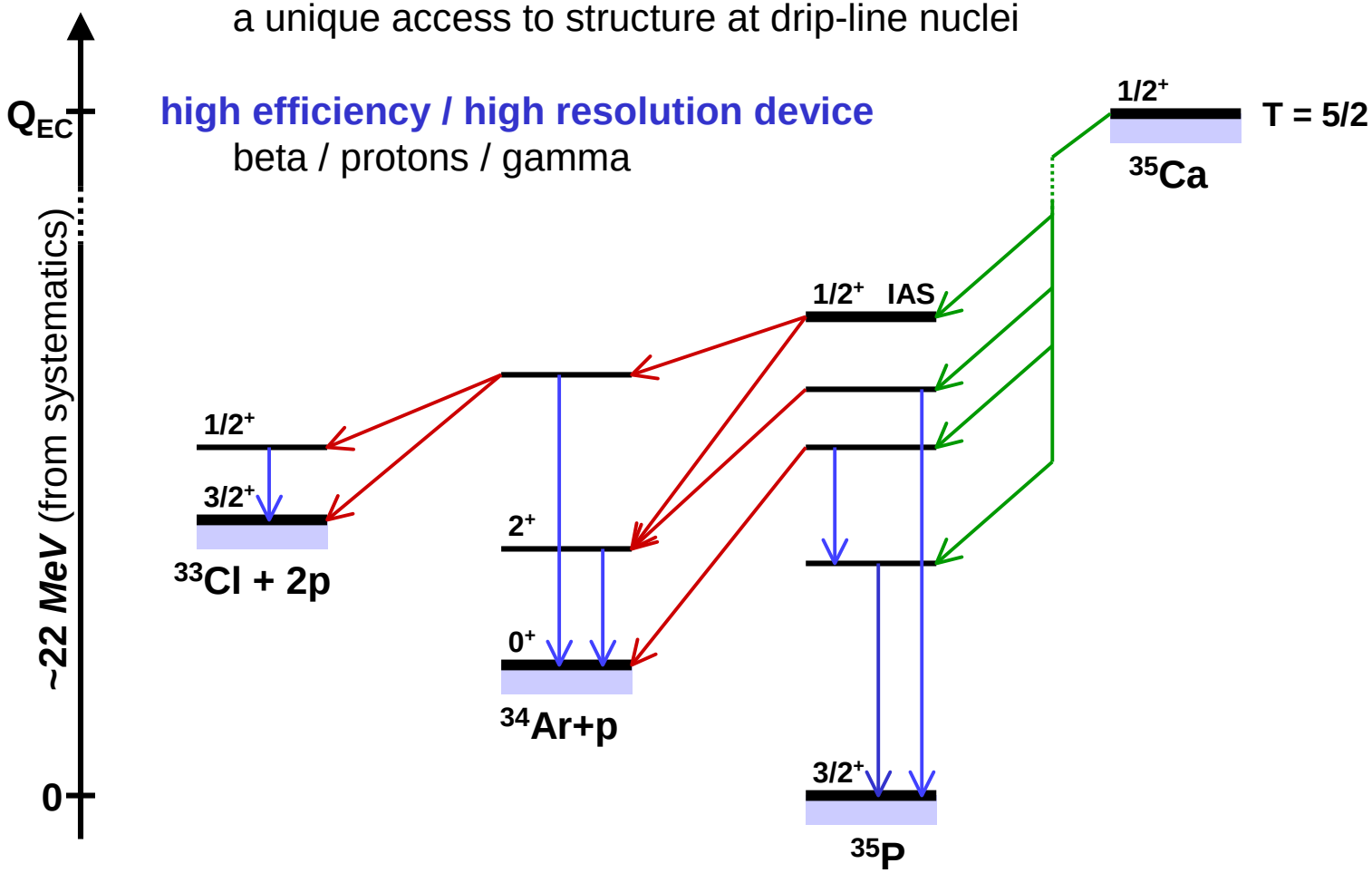
proposal: first complete decay study

decay spectroscopy

a unique access to structure at drip-line nuclei

high efficiency / high resolution device

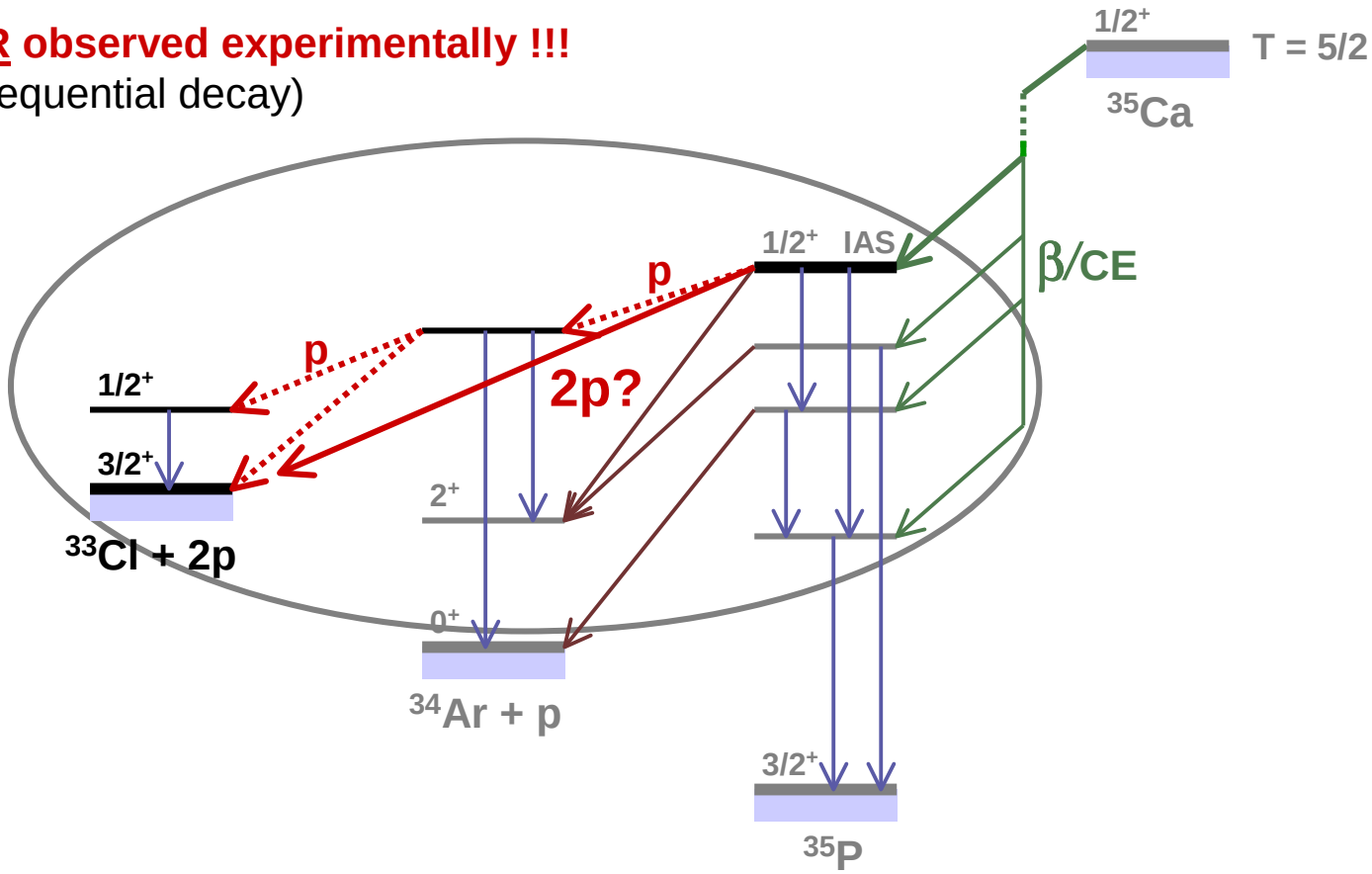
beta / protons / gamma



search for direct 2-proton emission

→ **direct (non-sequential) emission** predicted to exist (B.A. Brown, PRL65,1990)

→ **NEVER observed experimentally !!!**
(only sequential decay)



does the simultaneous emission component exist ?

why searching for direct 2-proton emission ?

very exotic process

sub-system (**2p**) correlated inside nucleus, unbound outside

emission mechanism strongly dependant on:

- **nuclear structure**
- **proton-proton correlations**

(→ 3-body decay formalism – L.V. Grigorenko)

easier access than ground-state 2P radioactivity emitters (like ^{45}**Fe**, ^{48}**Ni**…)

- better produced isotopes → (much) higher statistics
- decay mechanism is not washed by Coulomb barrier

→ **search for direct decay** (no intermediate state) – require few counts

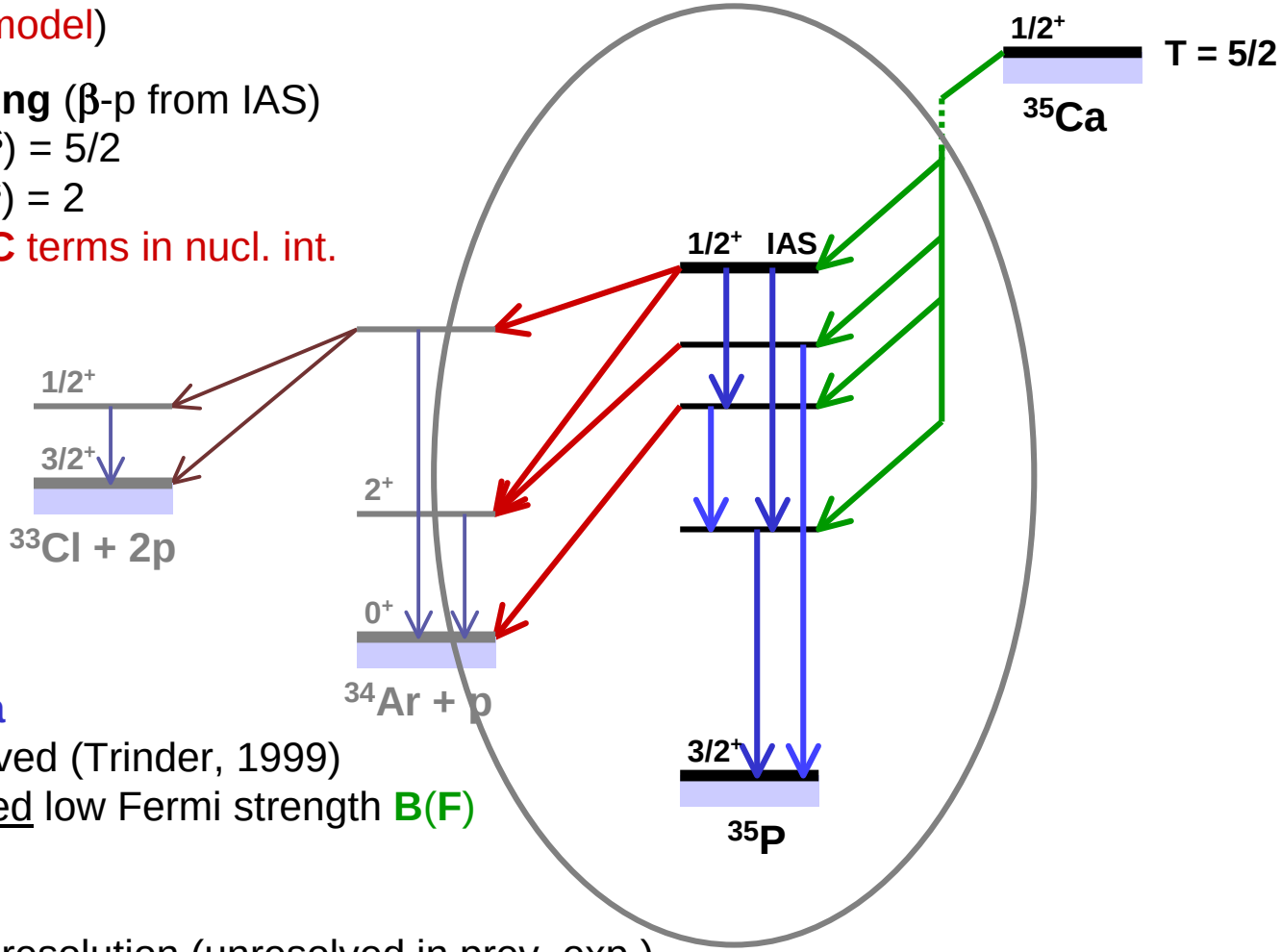
→ **measure energy and angular correlations** – require more statistics

decay spectroscopy: structure of ^{35}P

Half-life, **masses** (IMME),…

Gamow-Teller strength distribution B(GT)
(→ shell model)

Isospin mixing (β-p from IAS)
$T(^{35}P^{IAS}) = 5/2$
$T(^{34}Ar^{gs}) = 2$
test of **INC** terms in nucl. int.



beta-gamma
not observed (Trinder, 1999)
<u>unexpected</u> low Fermi strength **B(F)**

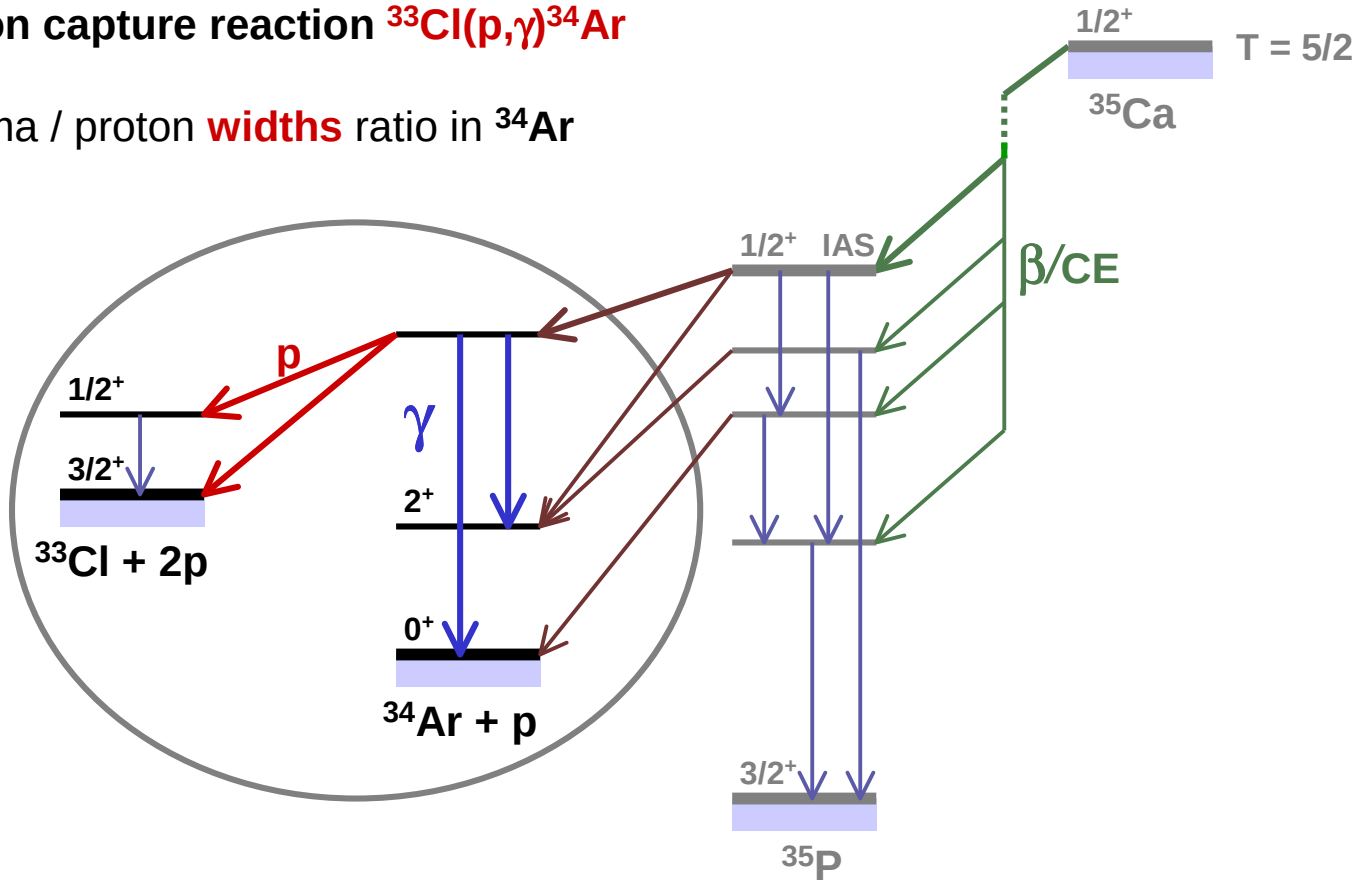
beta-proton
improved resolution (unresolved in prev. exp.)

astrophysics *rp*-process

states close to the proton emission threshold (in ^{34}Ar)

→ **proton capture reaction ^{33}Cl(p,γ)^{34}Ar**

→ gamma / proton **widths** ratio in **^{34}Ar**



β-2p feeding of excited state in ^{33}Cl

disagreement of previous experiments ← to be confirmed

detection set-up (I): charged particles

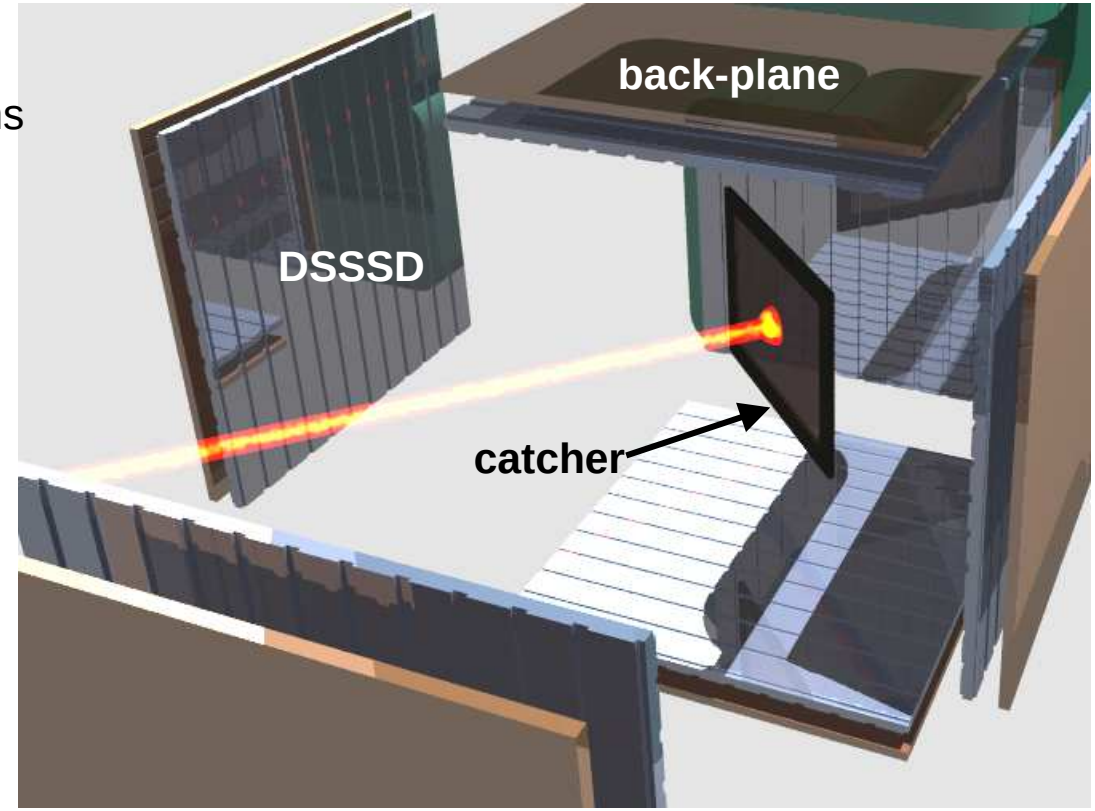
“Silicon-cube” device

6 **DSSSD** for protons → high granularity (2p emission angles)
→ detection efficiency ~60% for 1 proton
→ energy FWHM ~ 25 keV (low noise P.A.)

back-detectors

- beta suppression
- high-energy protons

ions deposited on a thin **mylar catcher**



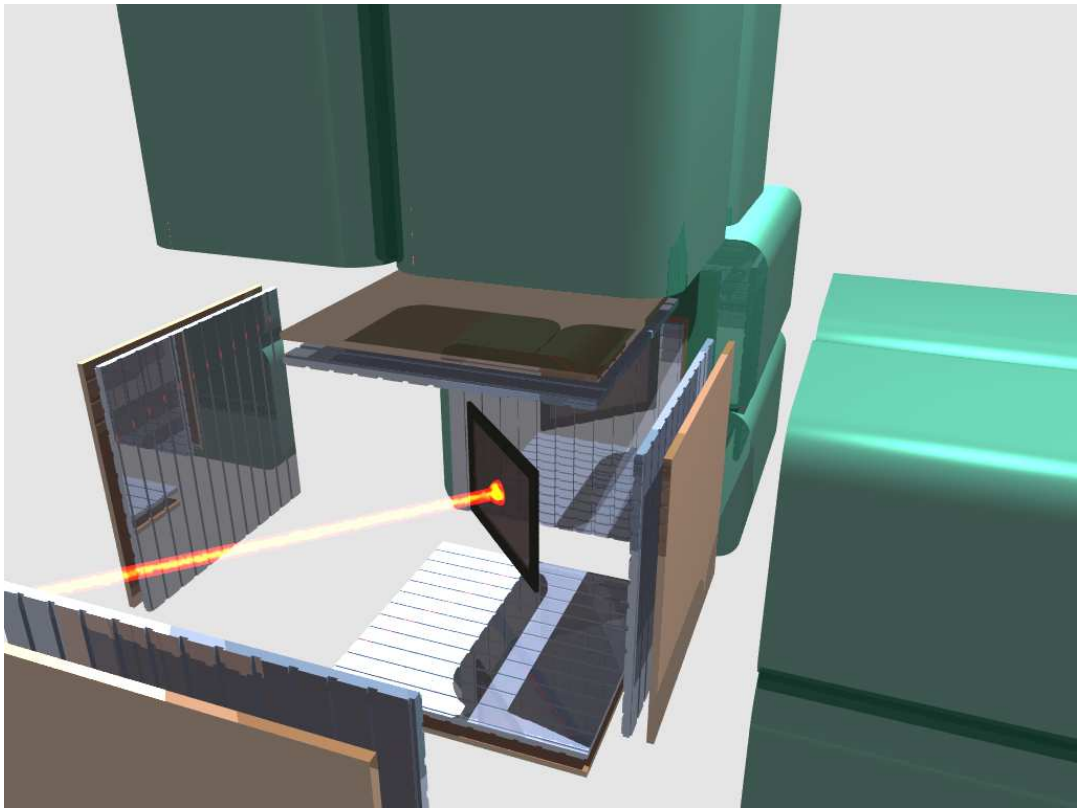
detection set-up (II): gamma-rays

Germanium detectors

2 Ge-clusters (si-cube originally designed for 3 Ge-clovers)
(^{31}Ar experiment with 2 MINIBALL clusters)

- **high resolution**

- **efficiency ~10-15%**
  (at 1 MeV)
  close geometry
  (~8 cm)



beam-time request

production with *TiC* targets (under tests, unknown count rates)

measurements: cycles ($T_{1/2}$) ~ 1 shift (~20% "duty cycle")
continuous production (**100%**)

experiment "duty cycle" **~75 %**

detection efficiency 1 proton **~50 %**
2 protons **~25 %**

count rates

	βp	β2p total	β2p direct	
with **0.1** ^{35}Ca / s	3000	60	**0.6 ?**	**daily**
			~5 ?	**for 24 shifts**

beam-time request

- Beam and separator tuning **3 shifts**
- Set-up tuning and calibration (^{37,36}*Ca*…) **3 shifts**
- Experiment (**^{35}*Ca*** beam) **24 shifts**
- **Total** **30 shifts**

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thank you for your attention…

^{31}Ar and ^{35}Ca at ISOLDE

current proposal is continuation of **β-p** and **β-2p** decay studies at ISOLDE

^{31}Ar experiment : **Phys. Rev. C 87**, 055808 (**2013**)
G. T. Koldste, H.O.U. Fynbo, *et al*.

mainly study of ^{30}S resonances (β-p)

→ nucleosynthesis

→ β-p(γ) and β-2p

→ new experimental method for **Γp / Γγ** estimate