BETA-GAMMA SPECTROSCOPY EXPERIENCE WITH FRAGMENTATION AND ISOL BEAMS

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A great opportunity for nuclear structure and astrophysics research
Also opportunity for undergrad participation in research

A. Thoughts about r process (Peter Hoeflich)

B. Fast fragmentation experience in Island of Inversion (Mantica, Liddick, Tripathi)

C. ISOL experience at A = 94, proton rich (Roeckl, Mukha)

D. Thoughts about CARIBU beta-gamma spectroscopy

R – process thoughts

CENTRAL PUZZLES

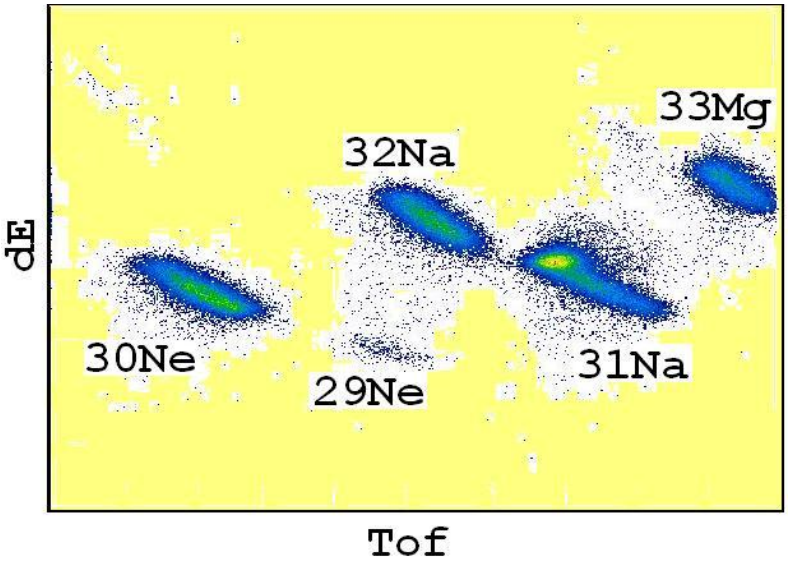
I. Pattern invariance despite factor of 50 variation between abundances of Fe group and r-process nuclei
Nuclear physics?? Astrophysics constraints ??

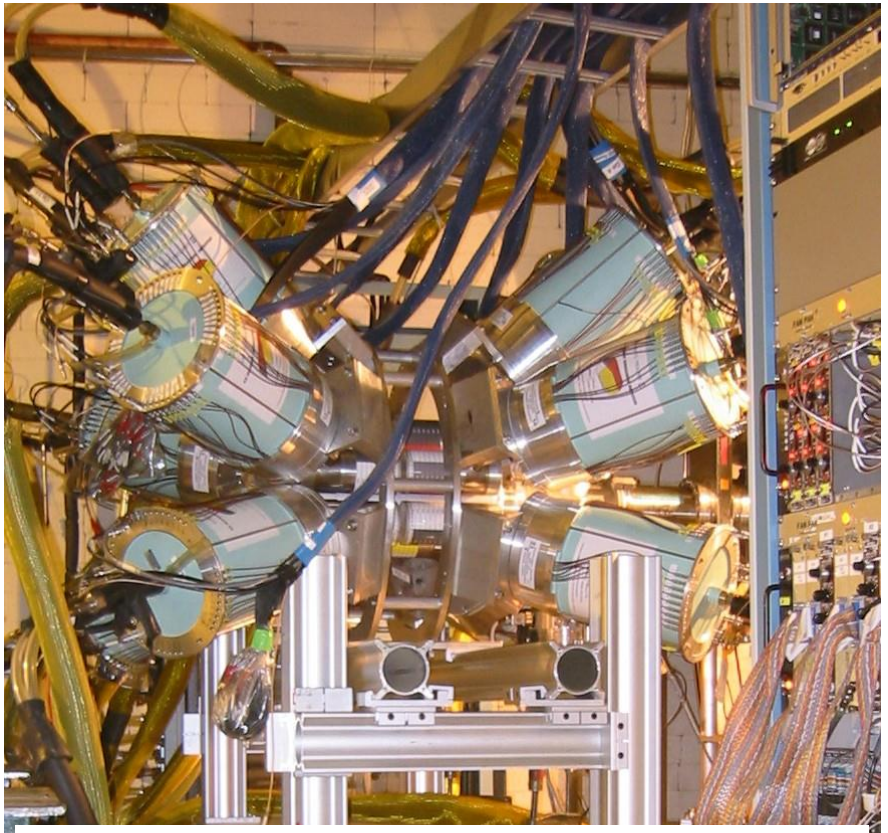
II. Where????
a) Envelope of core-collapse SN – realistic SN models don't explode & order of magnitude more entropy needed for r process
b) Accretion induced collapse – narrow parameter range with $y_e \sim 0.3$ could account for fixed r-process abundance pattern
c) Merging neutron stars – probably order of magnitude too few

Nuclear physics currently based on Hauser-Feshbach calculations
r -process governed by competition between N capture and β decay

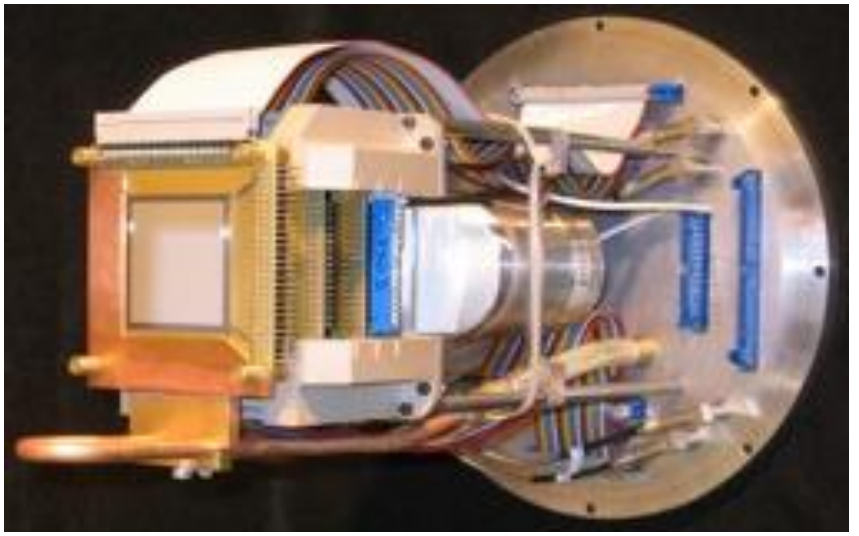
Need:
a) neutron capture rates, especially low-lying s-wave resonances
b) masses
c) β-decay lifetimes

Experiment at NSCL with 3-4 GeV A~30 implants





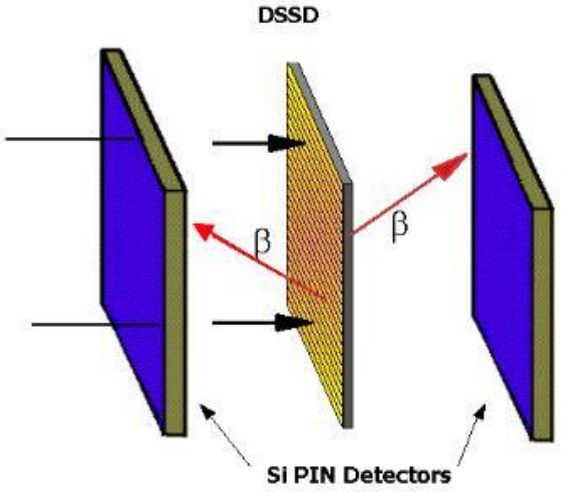
The SEGA array 16 detectors



The Beta Counting Station

Some experiment parameters

40x40 DSSD



MSU Beta Counting Station

140 MeV/amu 48Ca primary beam (25pnA)

98 hours of beam time asked with 52 hours of beam on target

~0.1cps/pnA (110MeV/amu) of ^{30}Ne at the BCS. [2% dp/p of A1900]

~ 14k beta correlated implants collected

γ detection efficiency of ~ 20% for 150 keV and ~5% for 1 MeV photon

→ **7 γ transitions identified in ^{30}Na**

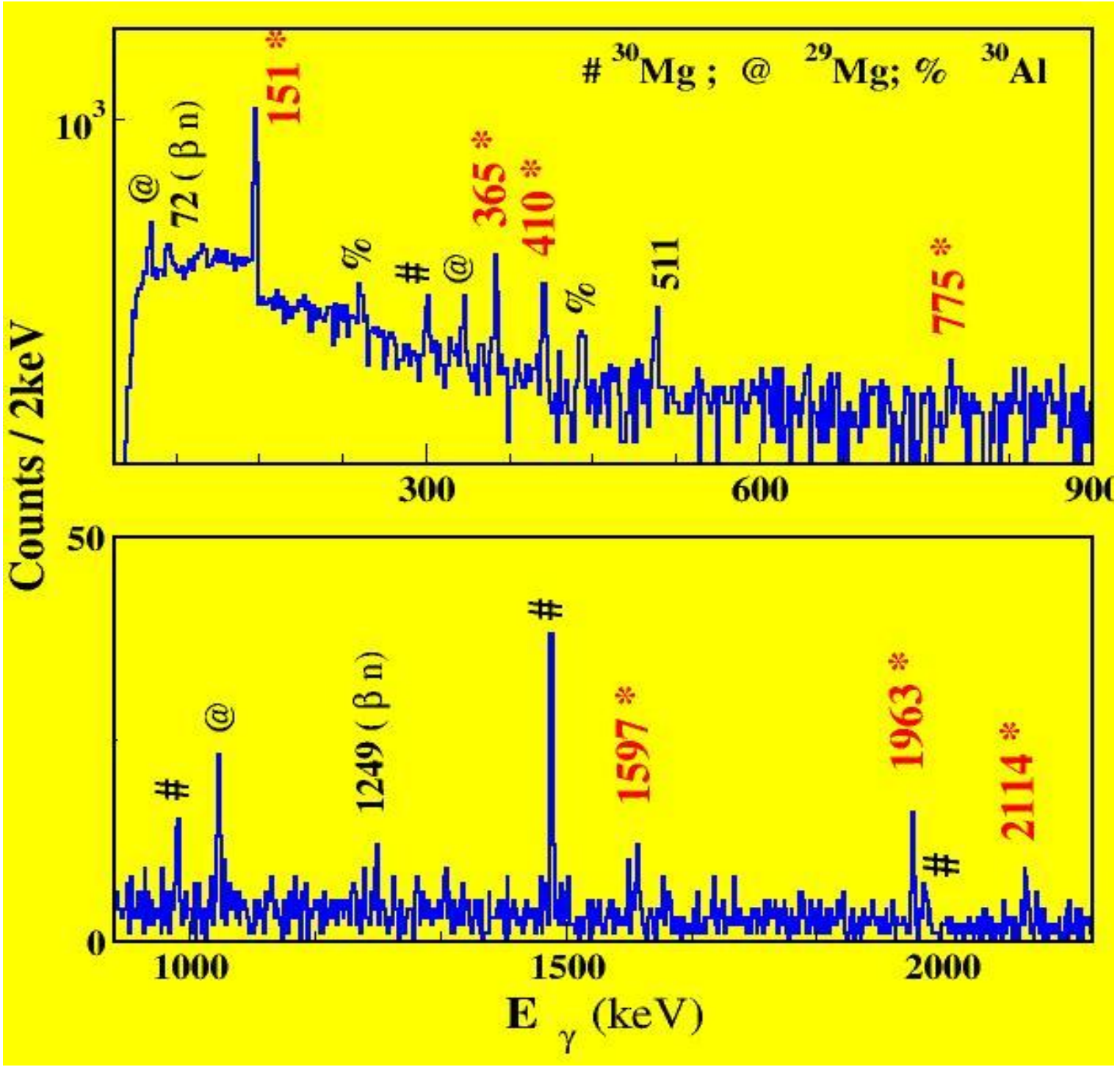
2.5 ^{30}Ne implants/s -> 4.5 x 10^5 total

30% β efficiency x 10% γ efficiency ->14 k implant–β-γ coincidences

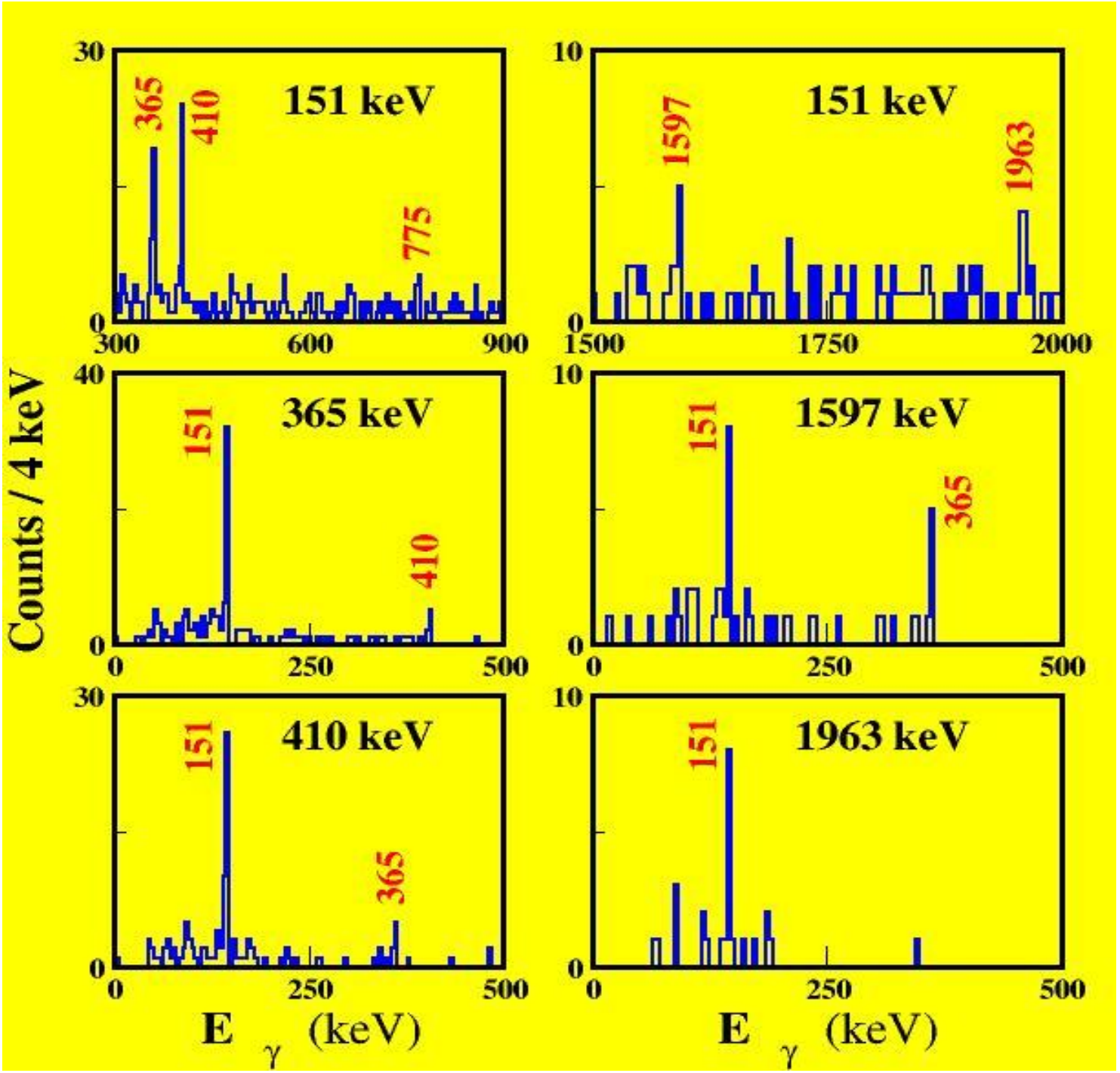
Very clean: allowed implant-β-γ-γ coincidences

Vandana Tripathi FSU

Implant – beta – gamma coincidences

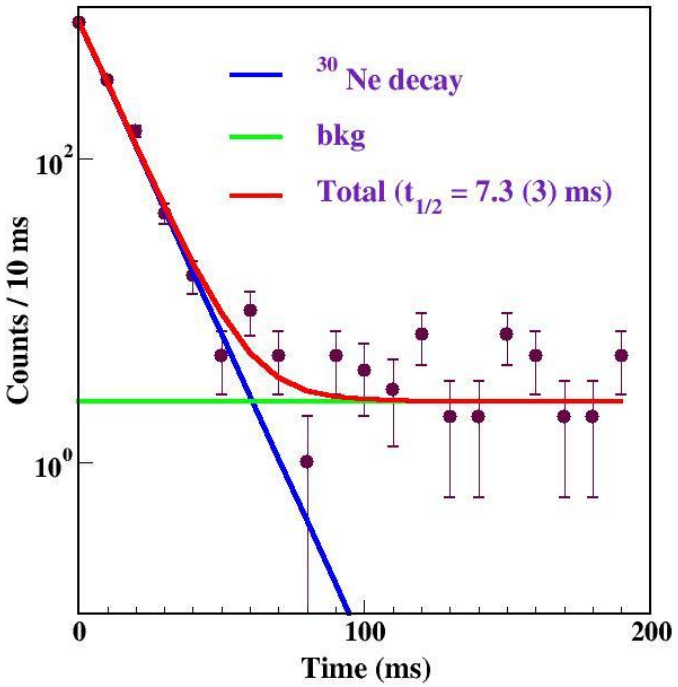


Implant – beta – gamma – gamma coincidences



0+ -> 1+ only allowed

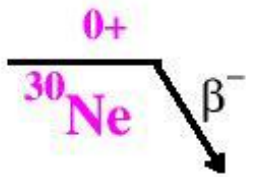
^{30}Na



decay curve for
^{30}Ne+β+151keV γ

Q_β= 14.74(57) MeV

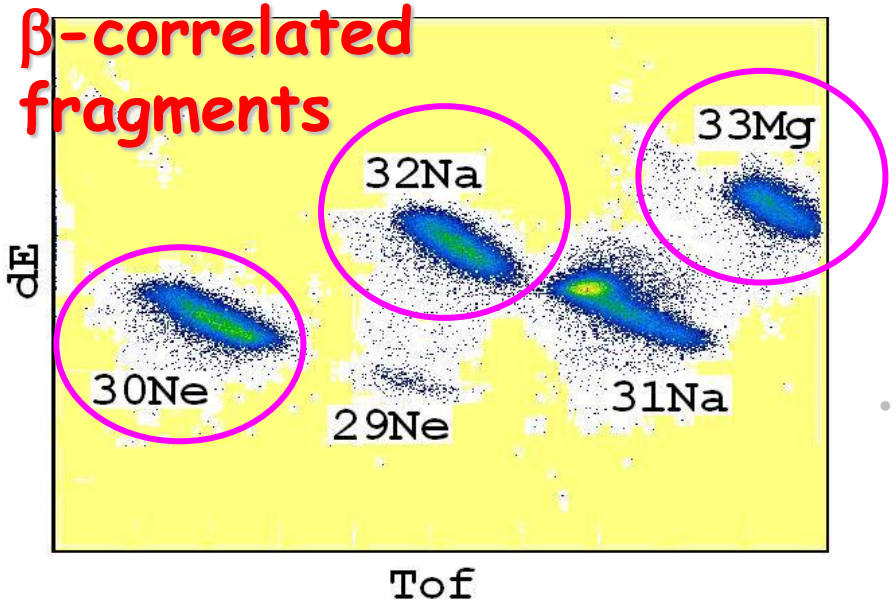
Log ft



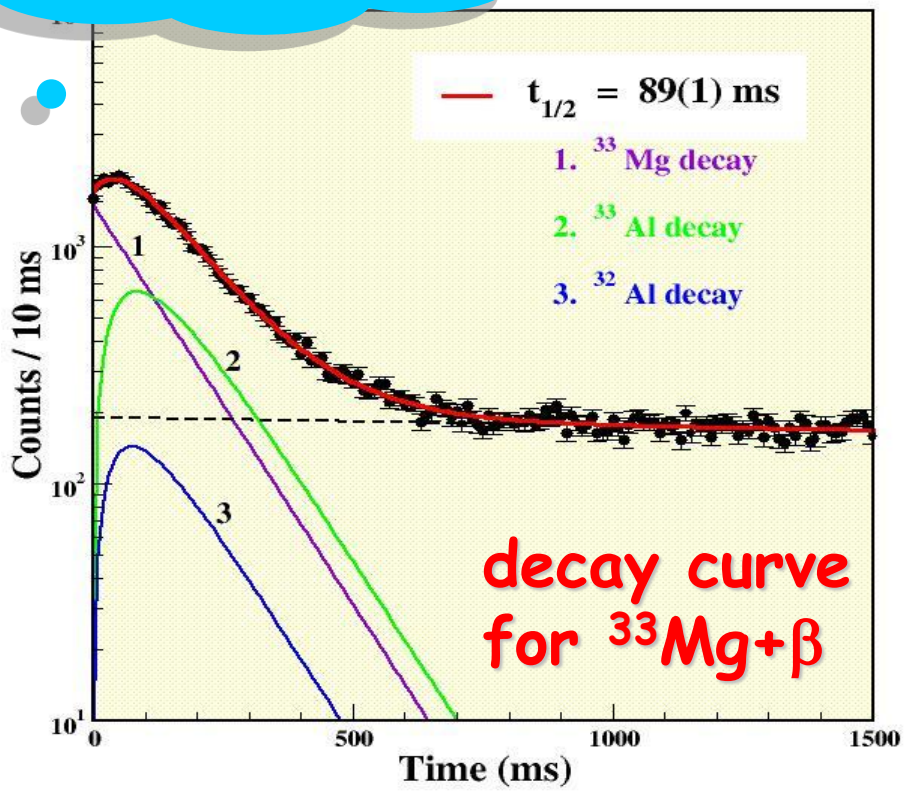
P_{1n} ~ 13 (4) %
P_{2n} ~ 9 (3) %

2-3-4 fold coincidences …

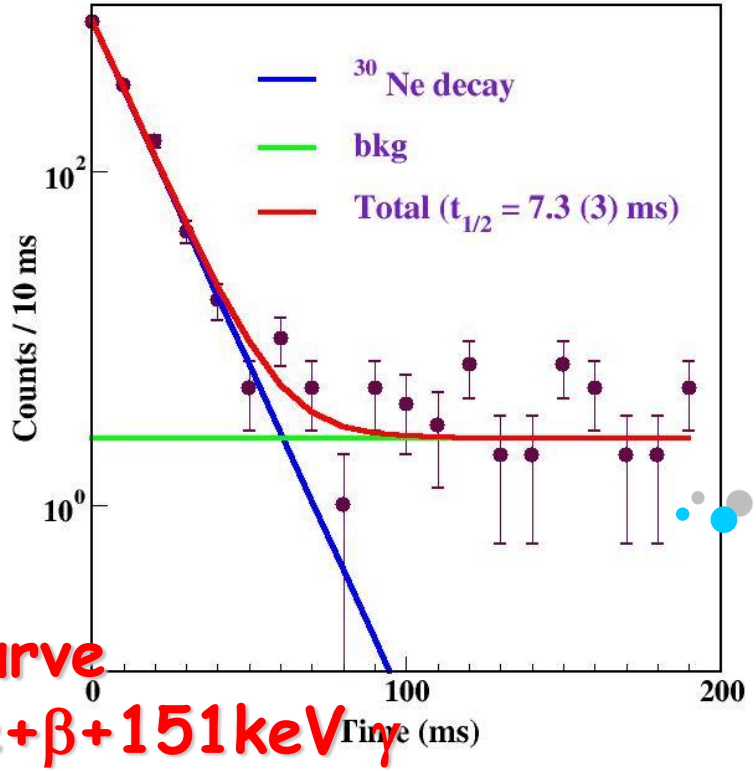
β-correlated fragments



fragment -β



decay curve for ^{33}Mg+β



decay curve for ^{30}Ne+β+151keVγ

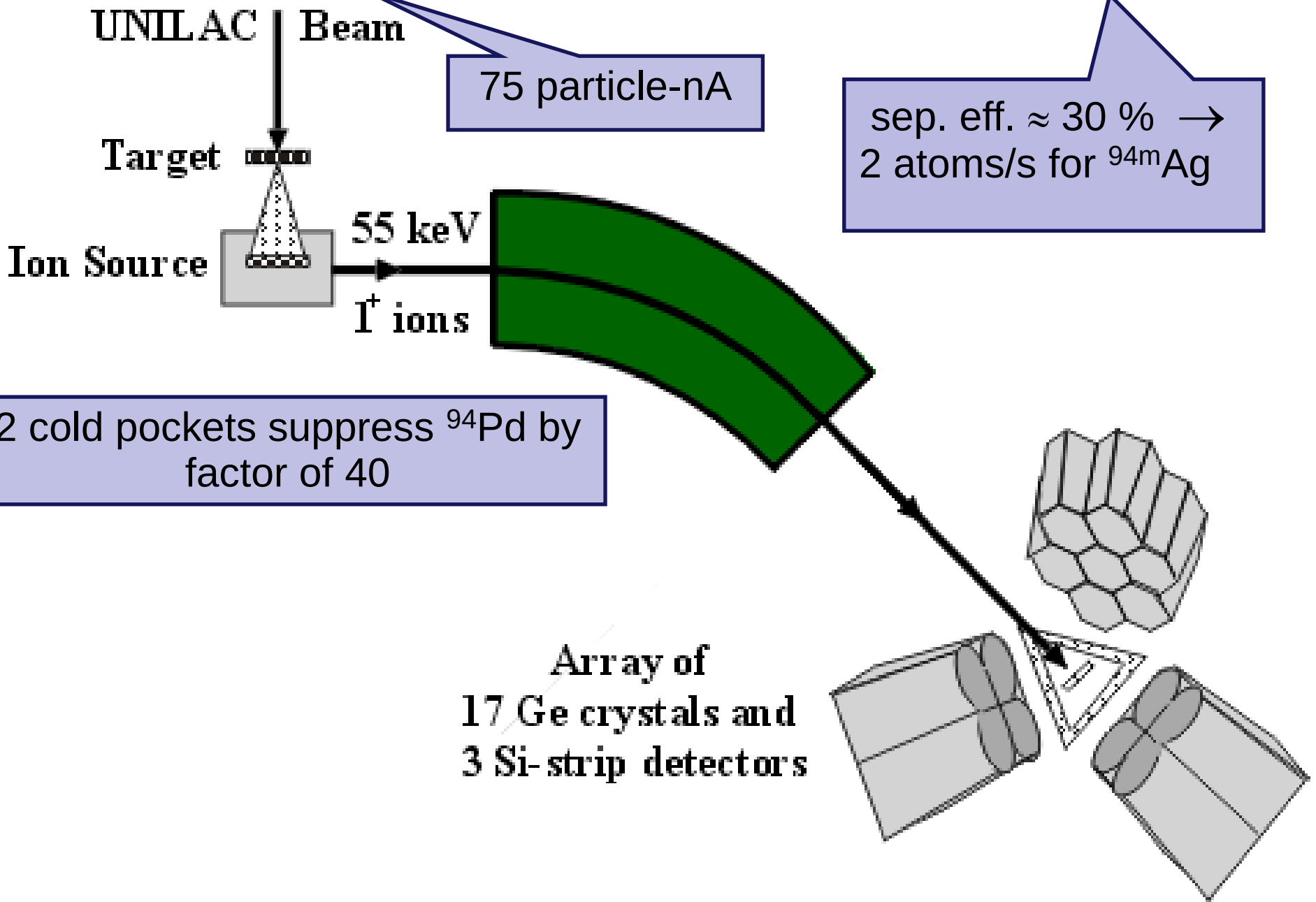
fragment-β-γ

Experiment at the ISOL Facility of GSI Darmstadt

$^{40}Ca(170\ MeV) + {}^{58}Ni \rightarrow {}^{98}Cd^{*} \rightarrow 1p3n + {}^{94}Ag$

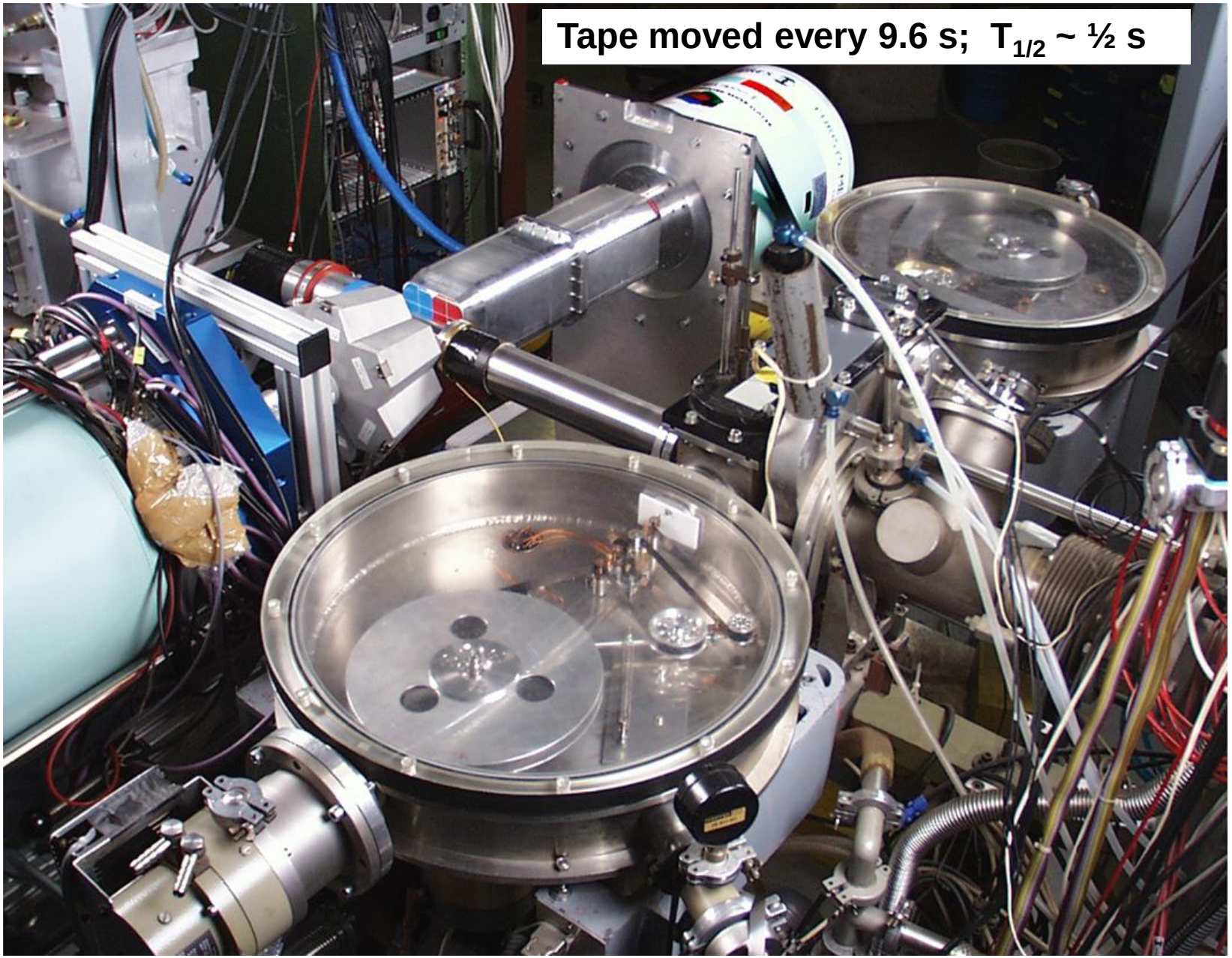
75 particle-nA

sep. eff. ≈ 30 % → 2 atoms/s for ^{94m}Ag

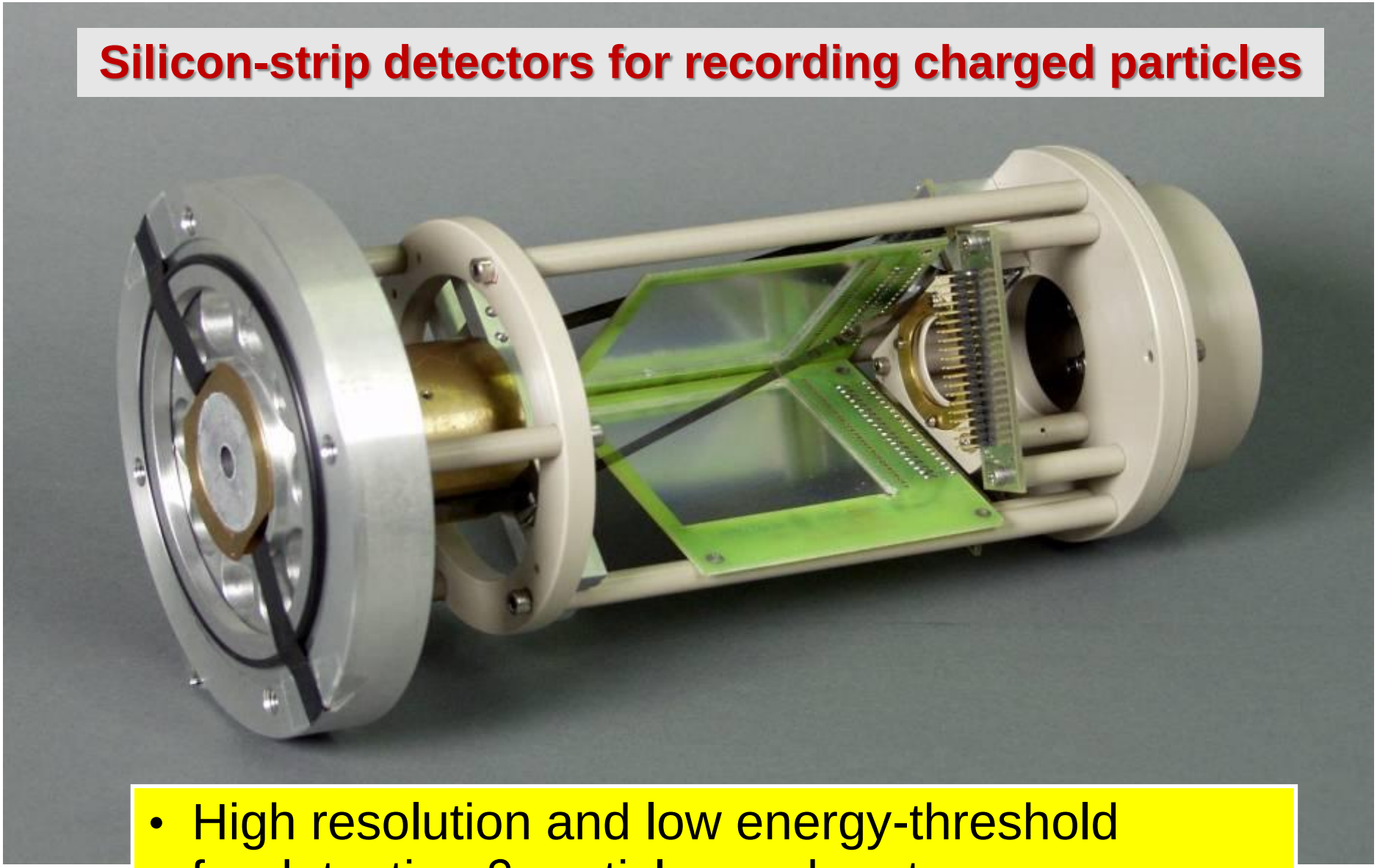


2 cold pockets suppress ^{94}Pd by factor of 40

Detector array used for the ^{94}Ag experiment



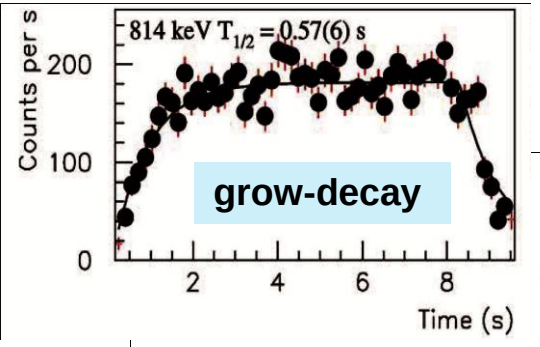
Silicon-strip detectors for recording charged particles

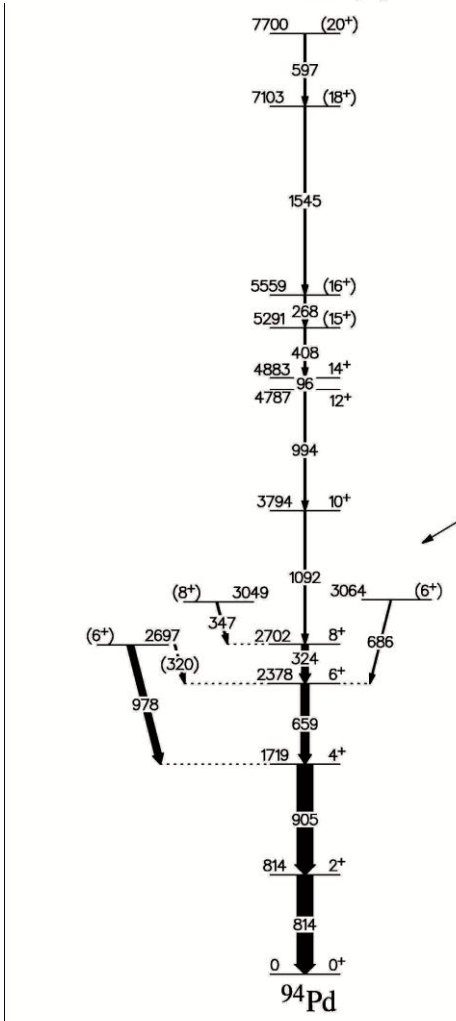


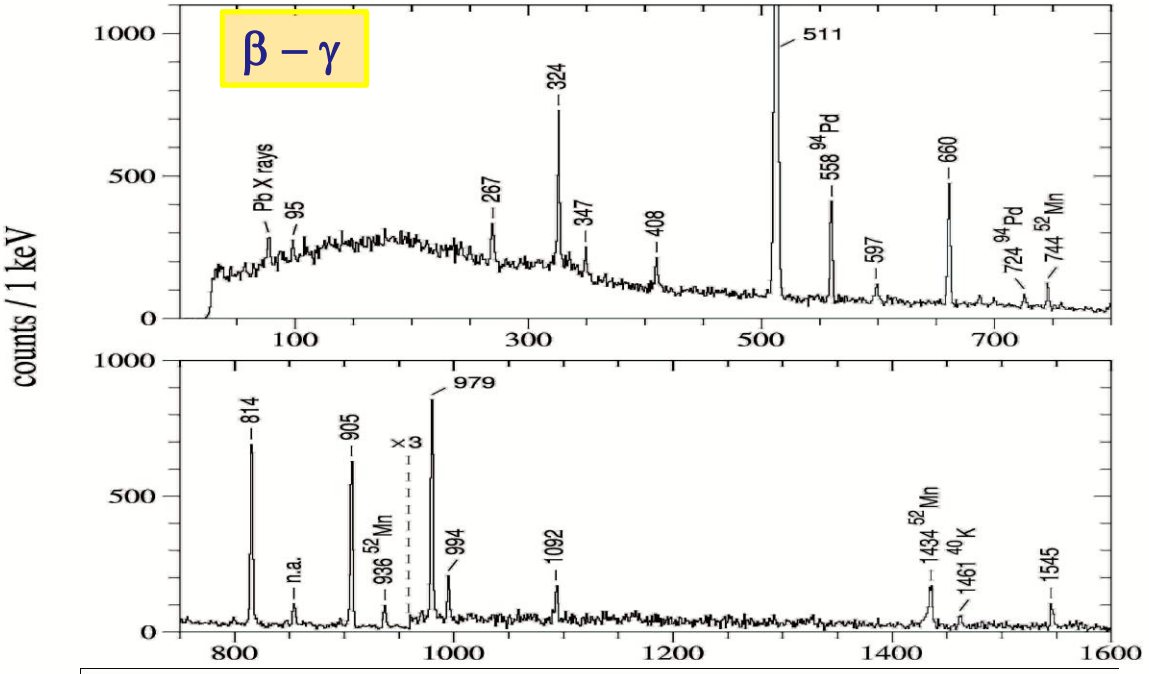
- High resolution and low energy-threshold for detecting β particles and protons
- High granularity → position information

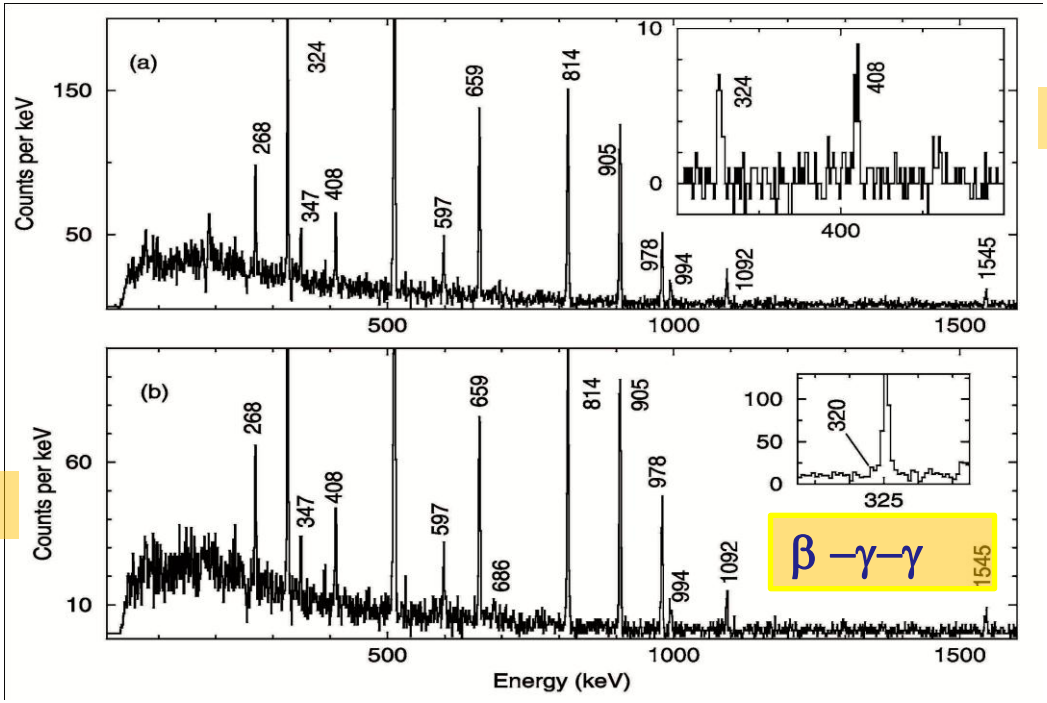
I. Mukha et al., Nucl. Phys. A 745, 9285 (2004)

γ spectrum following ^{94}Ag beta decay to high spin states in ^{94m}Pd







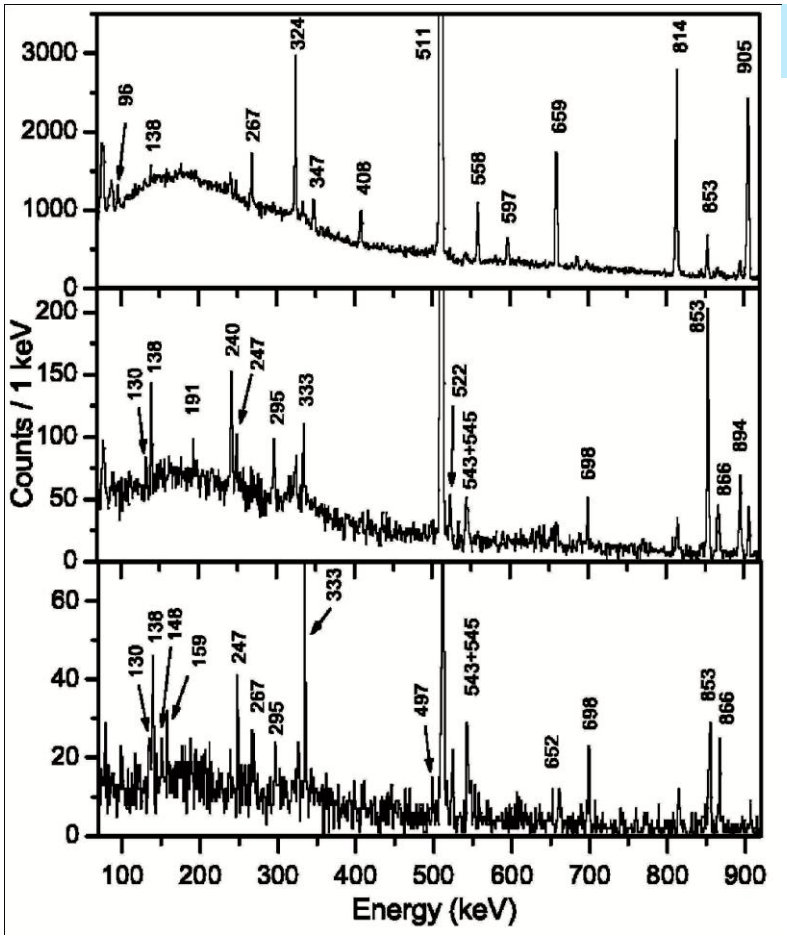


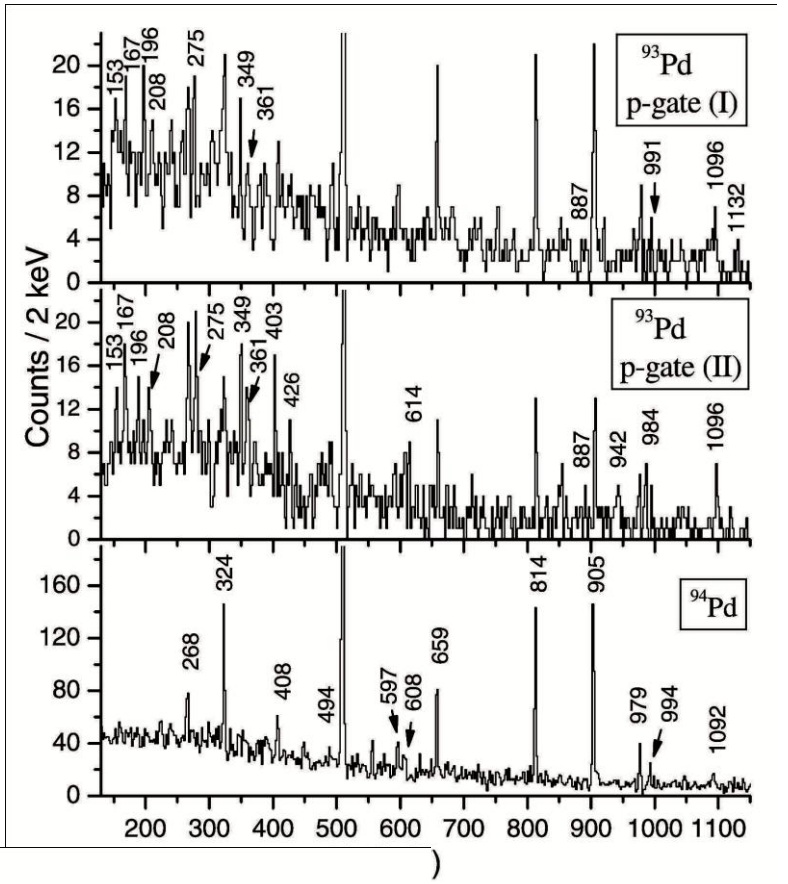
814+905+659+324

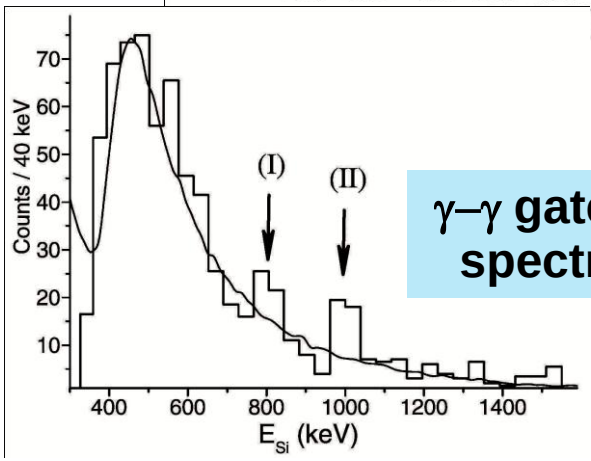
814+905+659

1092

γ spectra following β – p and pure p decay of ^{94m}Ag







γ–γ gated Si spectrum

Thoughts about CARIBU β-γ spectroscopy

Can get useful information down to 1/s, if clean.

Isobaric purity important

Need decay info for contaminants, daughters, granddaughters, …

Need β coincidences with γ's to remove room background

Ensemble vs one by one implant decay correlation

Neutron detectors for β-N branches or can infer from daughter decays

Lifetime range: diffusion time – bunching time; ^{135}In 90 ms

DSSD would allow much greater productivity but what KE needed to penetrate dead layer? 150 keV from accelerate line

Start with engineering runs??