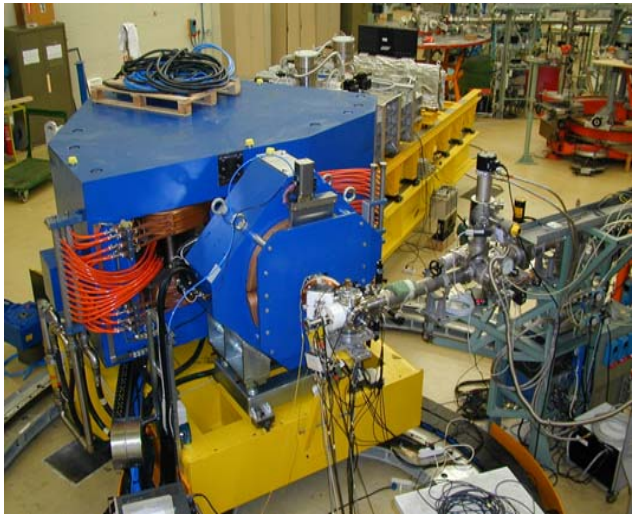
Coupling the CLARA Clover Array with PRISMA : status of the project

A.Gadea INFN-LNL Legnaro

for the EUROBALL-GAMMA & PRISMA collaborations

- **Status of the PRISMA magnetic spectrometer.**
- **Status of CLARA.**
- **Measuring with the Clover array.**
- **Scheduling.**
- **Experimental program.**

The PRISMA magnetic spectrometer

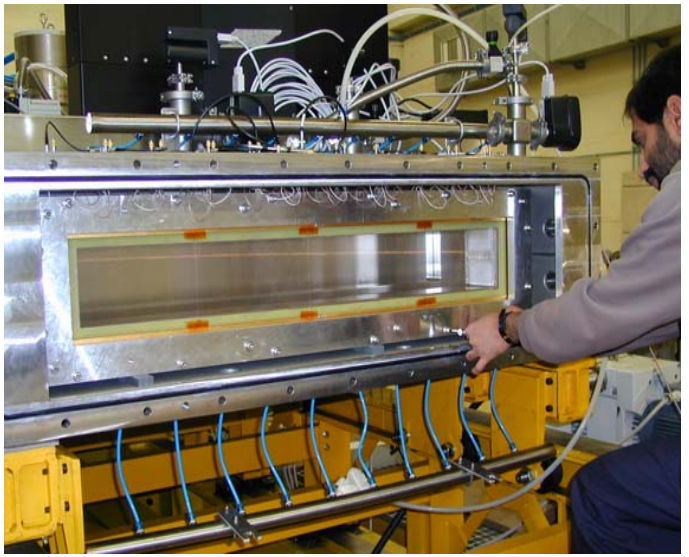


Broad acceptance tracking magnetic spectrometer with 7m flight path.

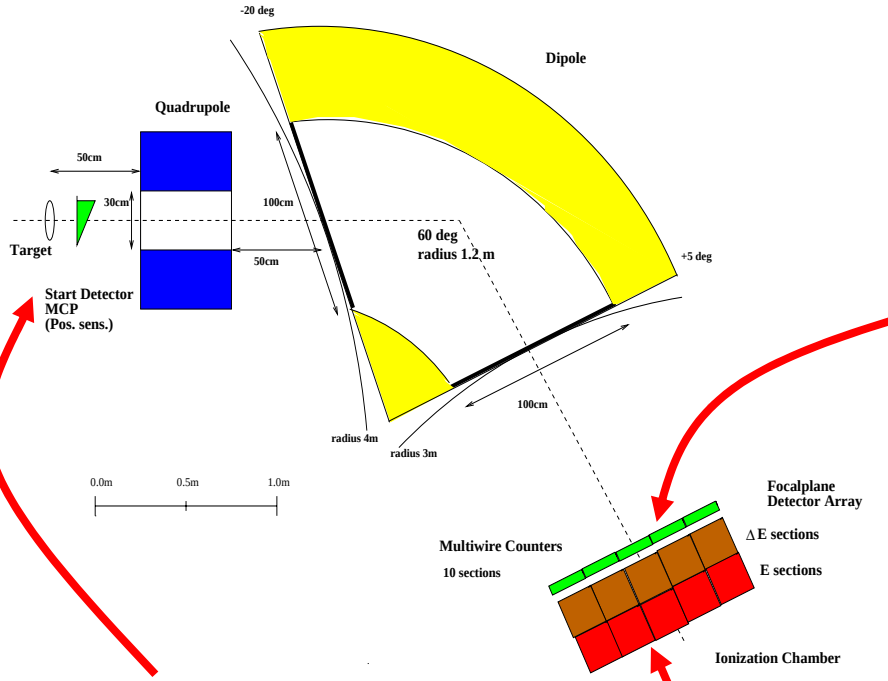
Solid angle	≃ 80 msr
Energy acceptance	± 20%
Resolving power	p/Δp ≃ 2000
Mass resolution	1/300 (via TOF)
Energy resolution	1/1000 (via TOF)
Z resolution	≦ 1/60
Mass energy product	ME/q^2 = 70 MeV amu
Kinematical correction	via software
Aberrations correction	via software
Dispersion	4 cm/%
Count rate capability	up to $2x10^5$ sec^{-1}

The PRISMA Spectrometer Detectors

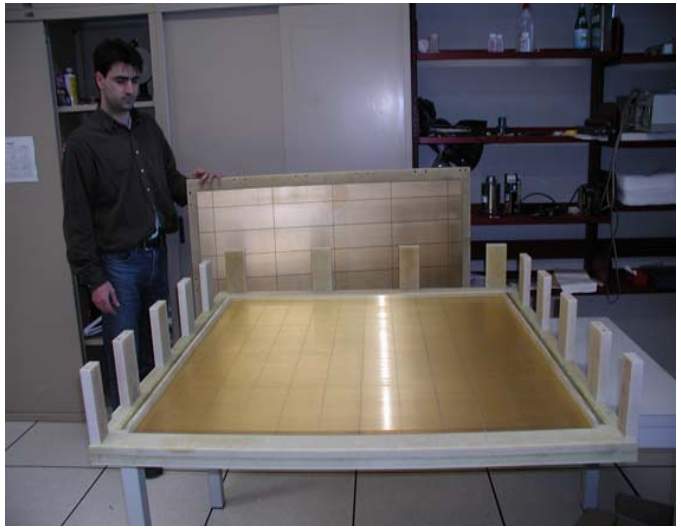
10 sections Multiwire PPAC



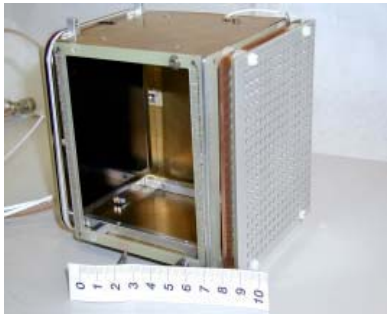
S.Beghini et al. LNL annual Report 2000 pg.163



10 x 4 sections Ionization Chamber

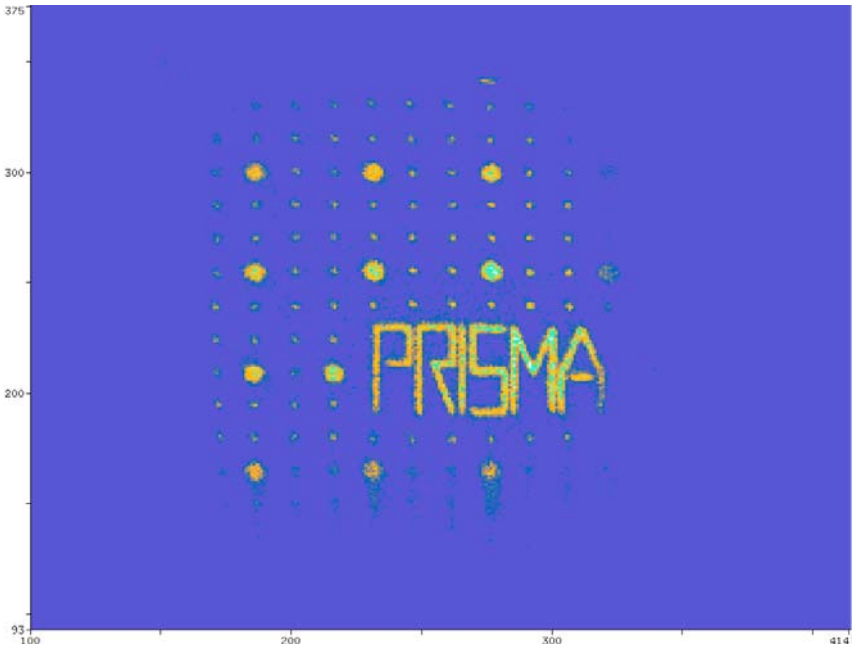


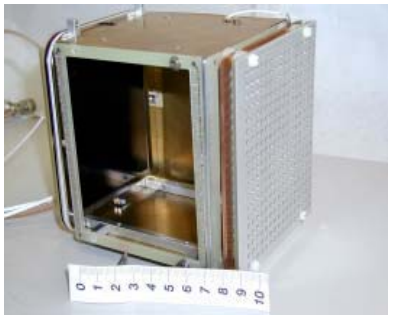
Position sensitive MCP



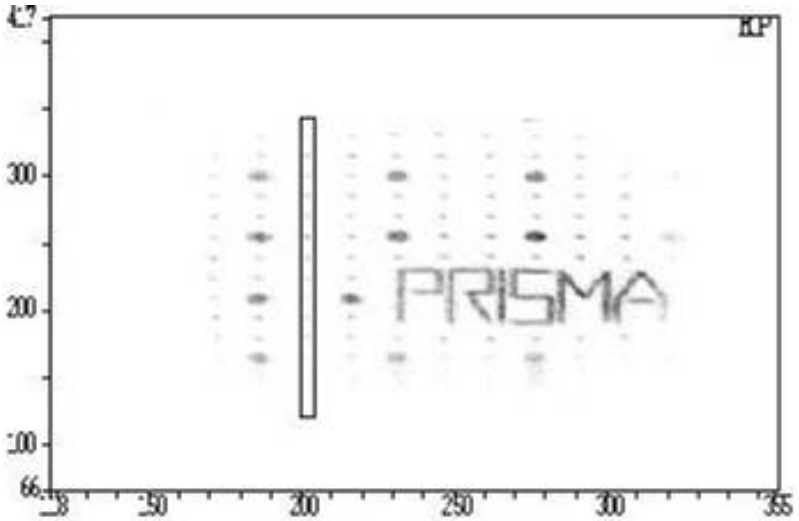
G.Montagnoli et al. LNL annual Report 2000 pg.165

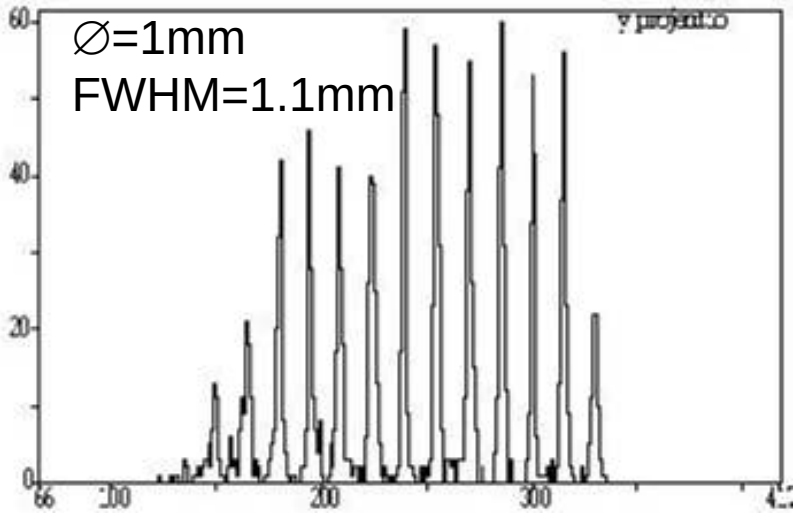
Position sensitive MCP



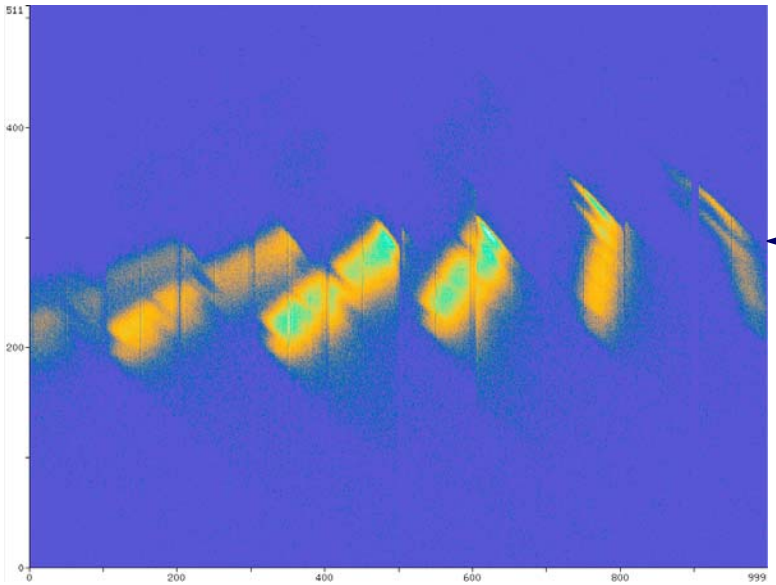


Developed in the collaboration: INFN-Padova, JINR Dubna, INFN-LNL



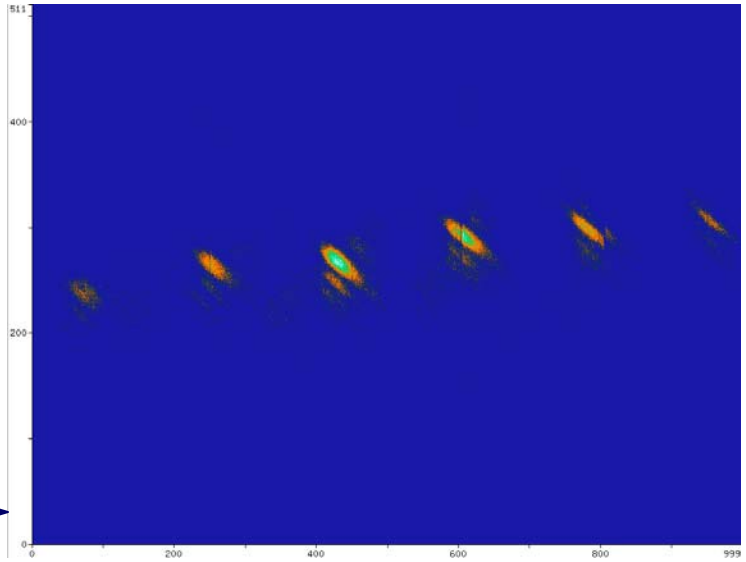


PPAC X-TOF matrix for: 56Fe + 197Au 242MeV $\theta_{PRISMA} = 70^{\circ}$



Without condition in the entrance MCP detector

With gate 69.7-70.3 in the entrance MCP detector



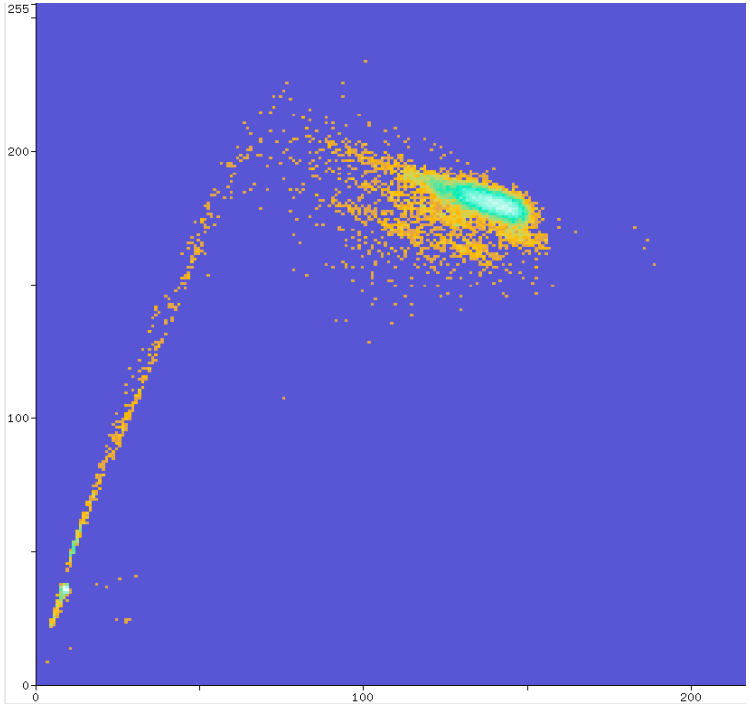
Ionization Chamber

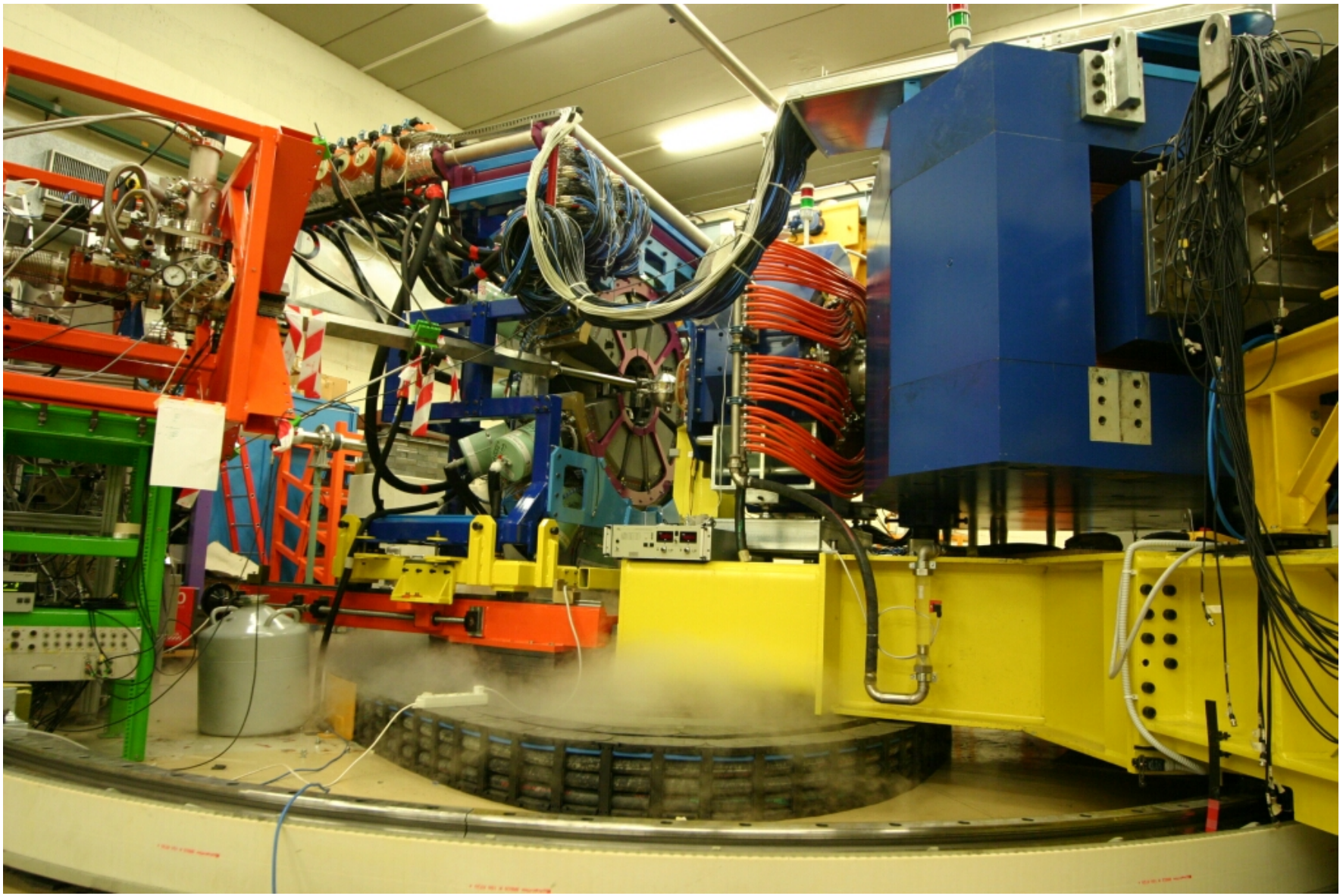
ΔE-E matrix

56Fe + 124Sn 242MeV

$\theta_{PRISMA} = 70^{\circ}$

Analysis performed by A.Latina





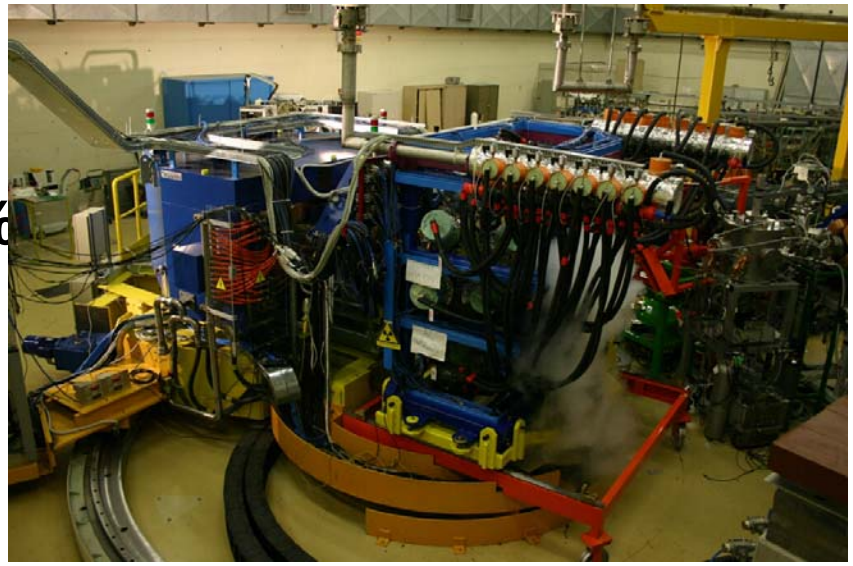
CLARA status update

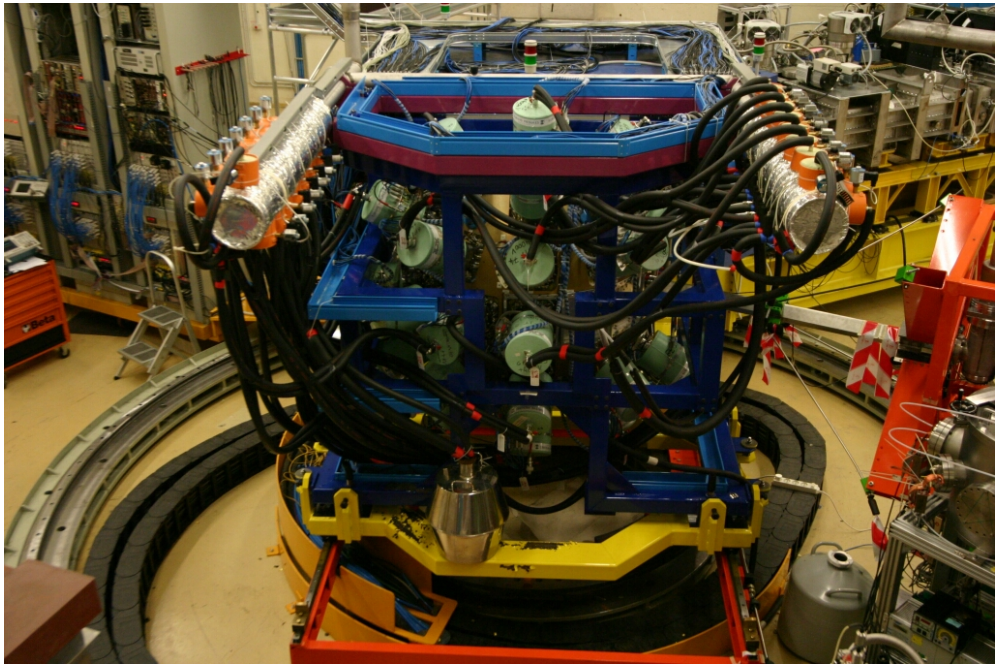
22 CLOVER detectors installed in the frame. Two crystals not working. Peak efficiency ~ 2.8%

Average resolution ~2.3 keV

Experimental P/T ratio ~44%

New beam line mechanics ready.





LN2 Filling system stable.

Data acquisition, merging and VXI electronics stable.

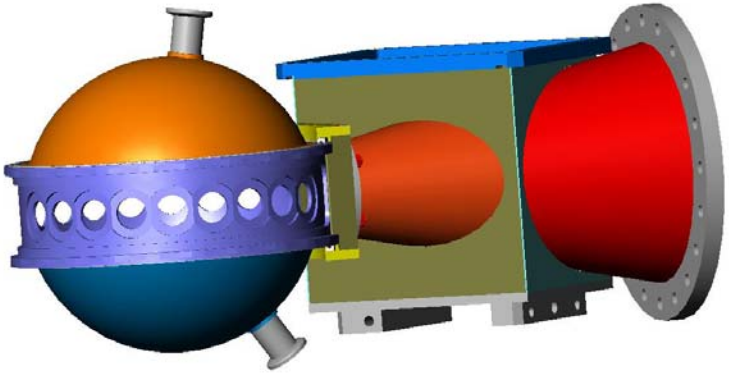
DAQ rates ~20KHz at ~50% dead time

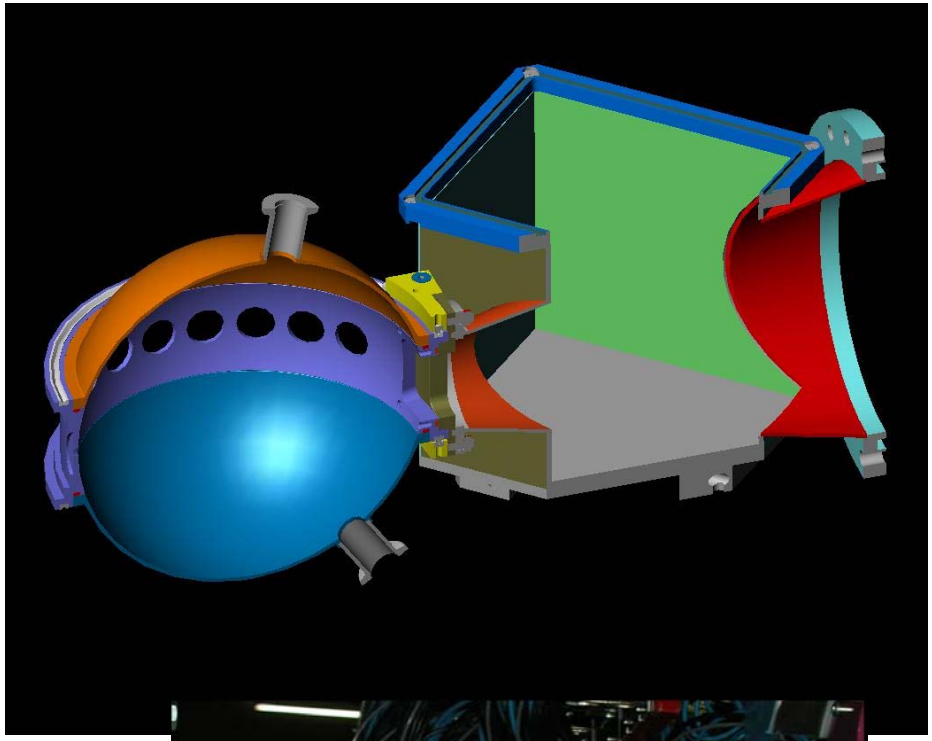
GUI (OCP + MIDAS) ready.

HV control in progress

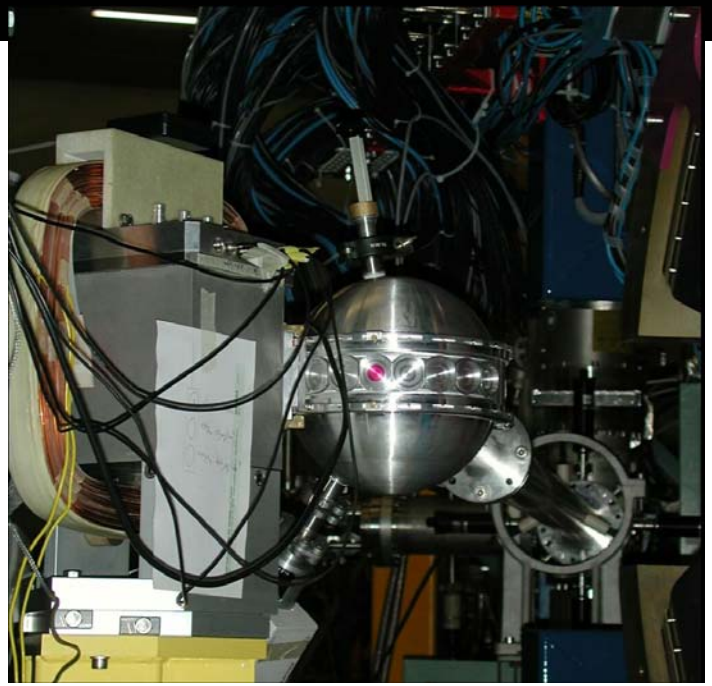
Trigger electronics ready

Reaction Chamber:



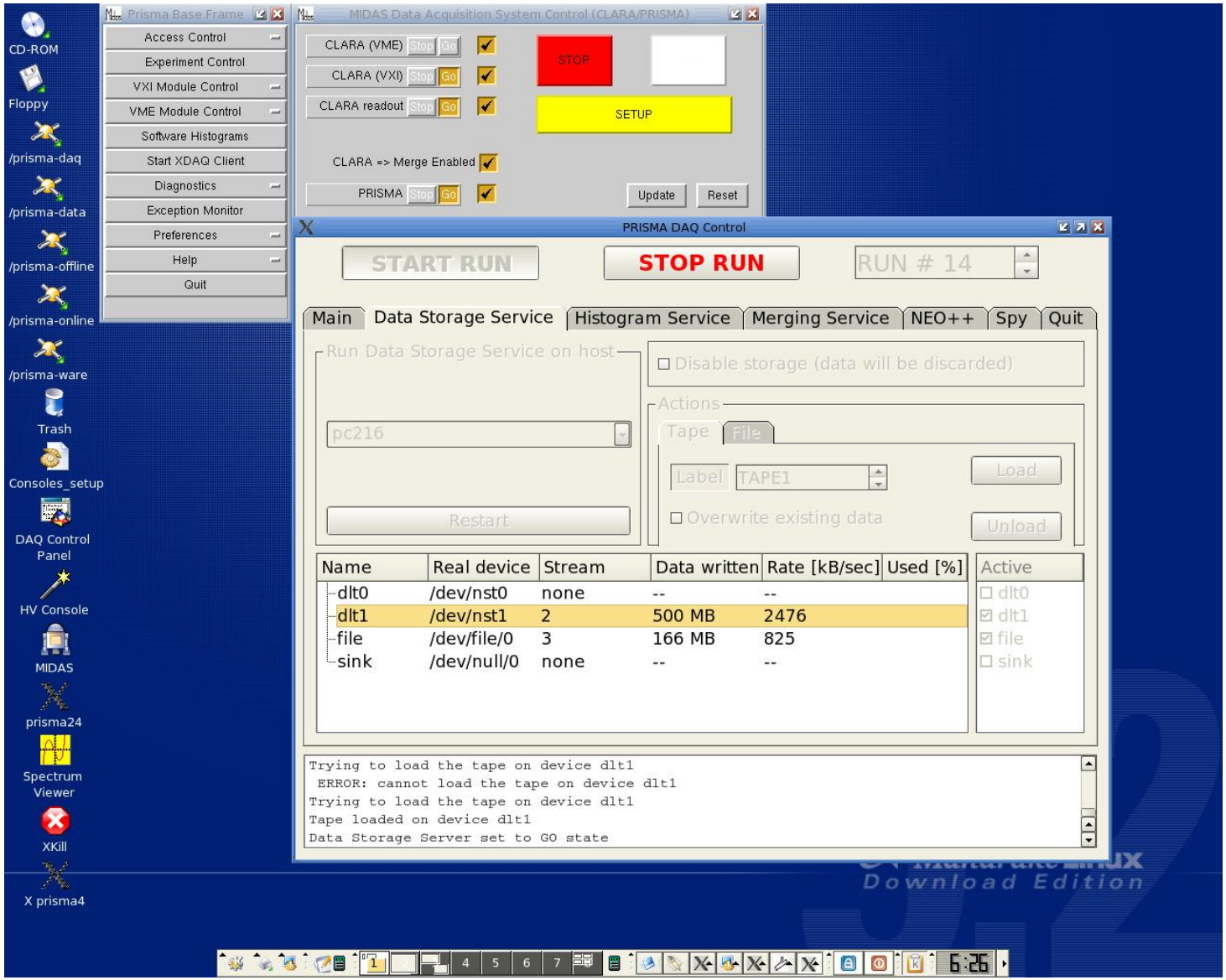


Design and build at LNL

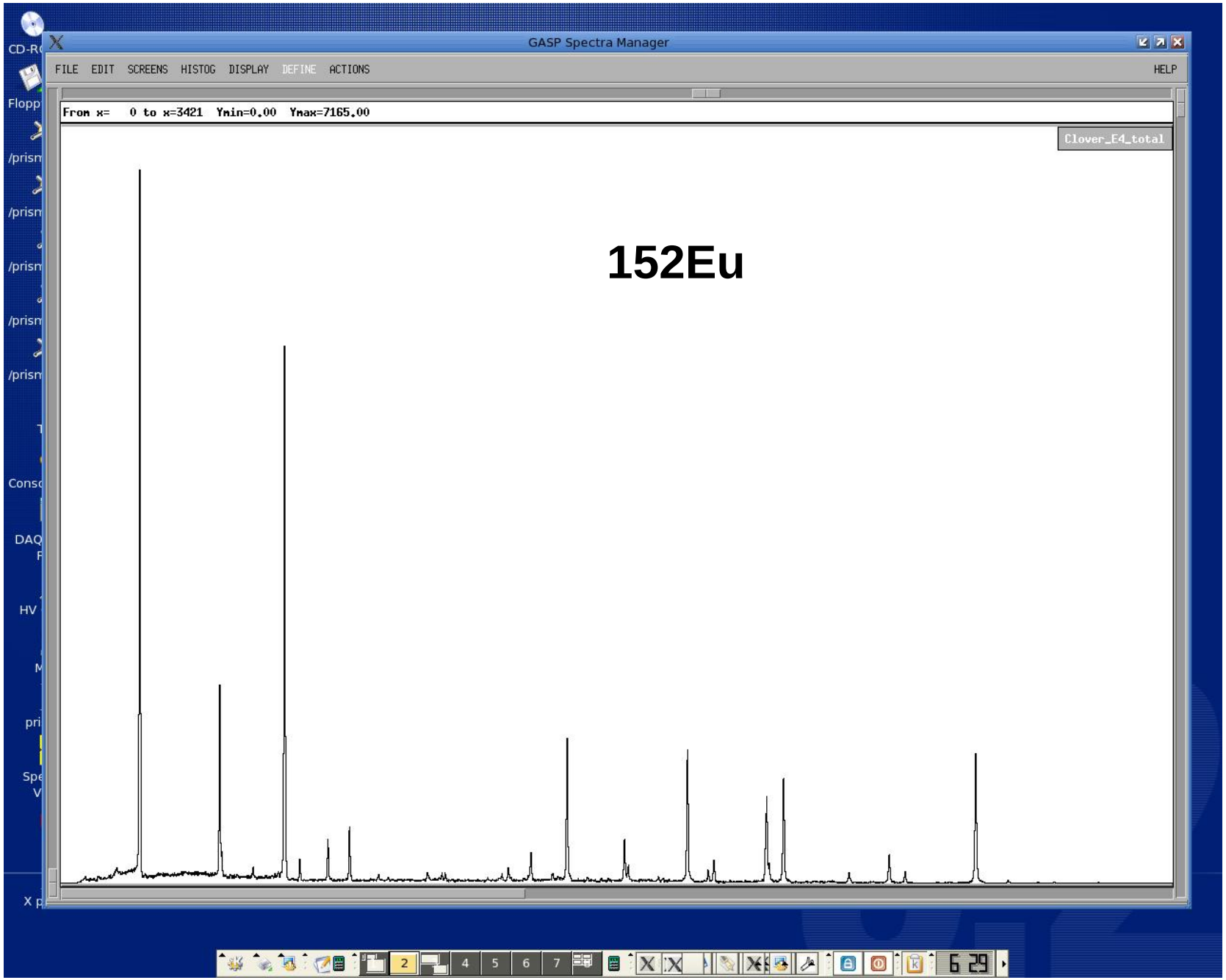


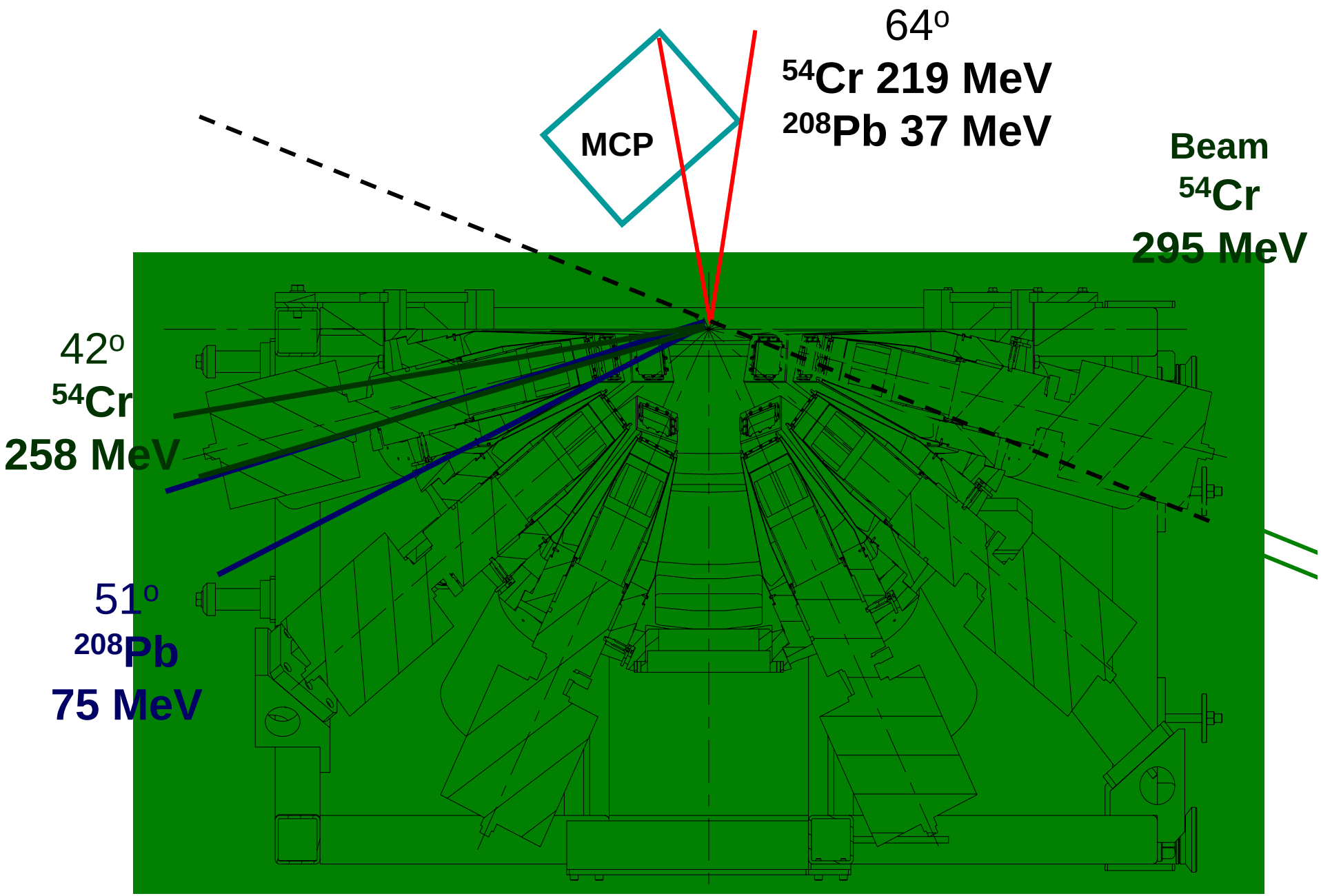
- Sliding-seal + multiple input/output design
- Inputs in 16˚ steps, from ~0˚ up to 144˚ (with respect to the PRISMA entrance)
- Rotation in vacuum ±8˚
- Acceptance at any position ±6˚in θ.
- Possibility to install external beam dump up to ~40˚

Experiment Control GUI:

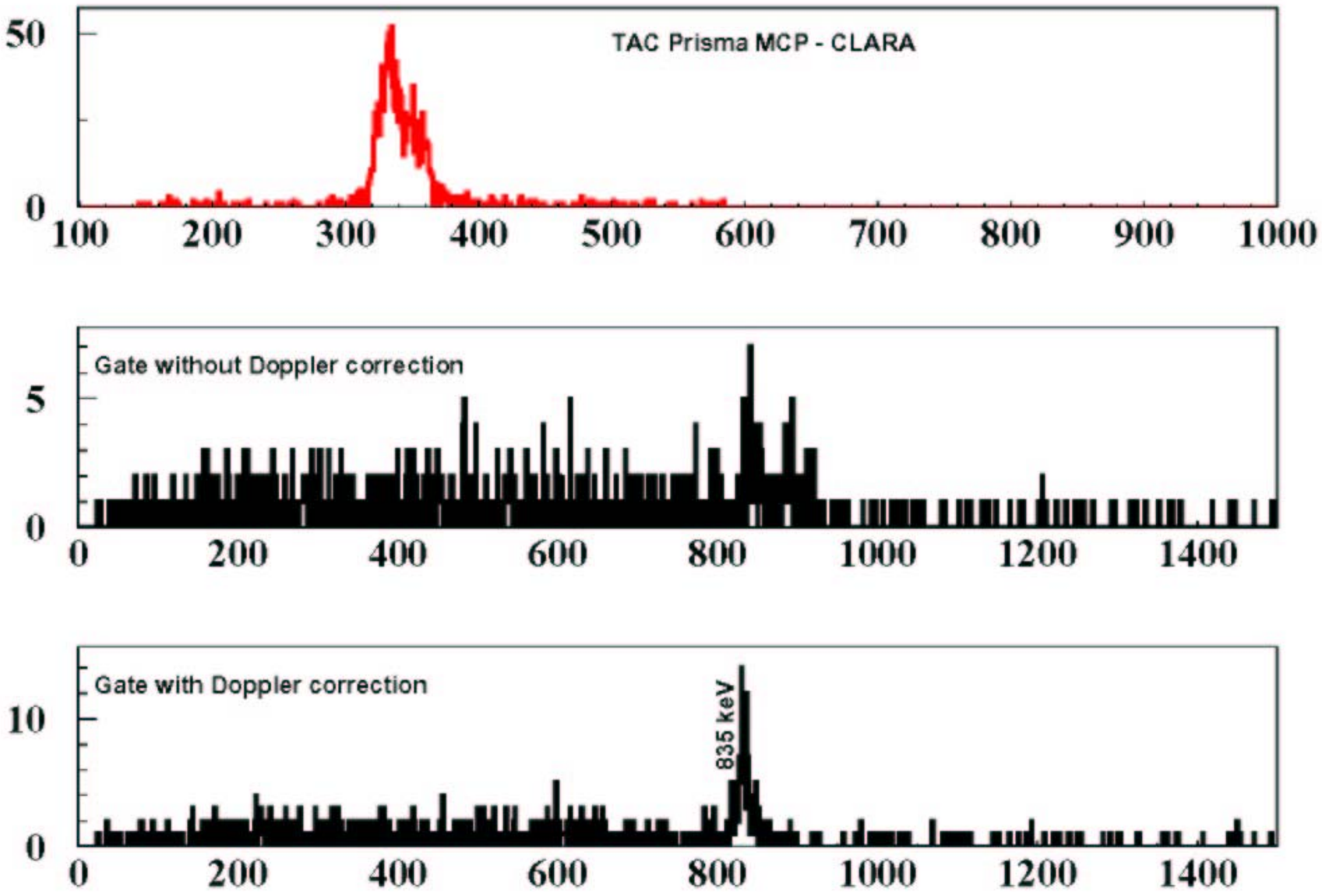


MIDAS by V.F.Pucknell (Daresbury) and PRISMA DAQ Control


GASP Spectra Manager
FILE EDIT SCREENS HISTOG DISPLAY DEFINE ACTIONS HELP
From x= 0 to x=3421 Ymin=0.00 Ymax=7165.00
Clover_E4_total
152Eu

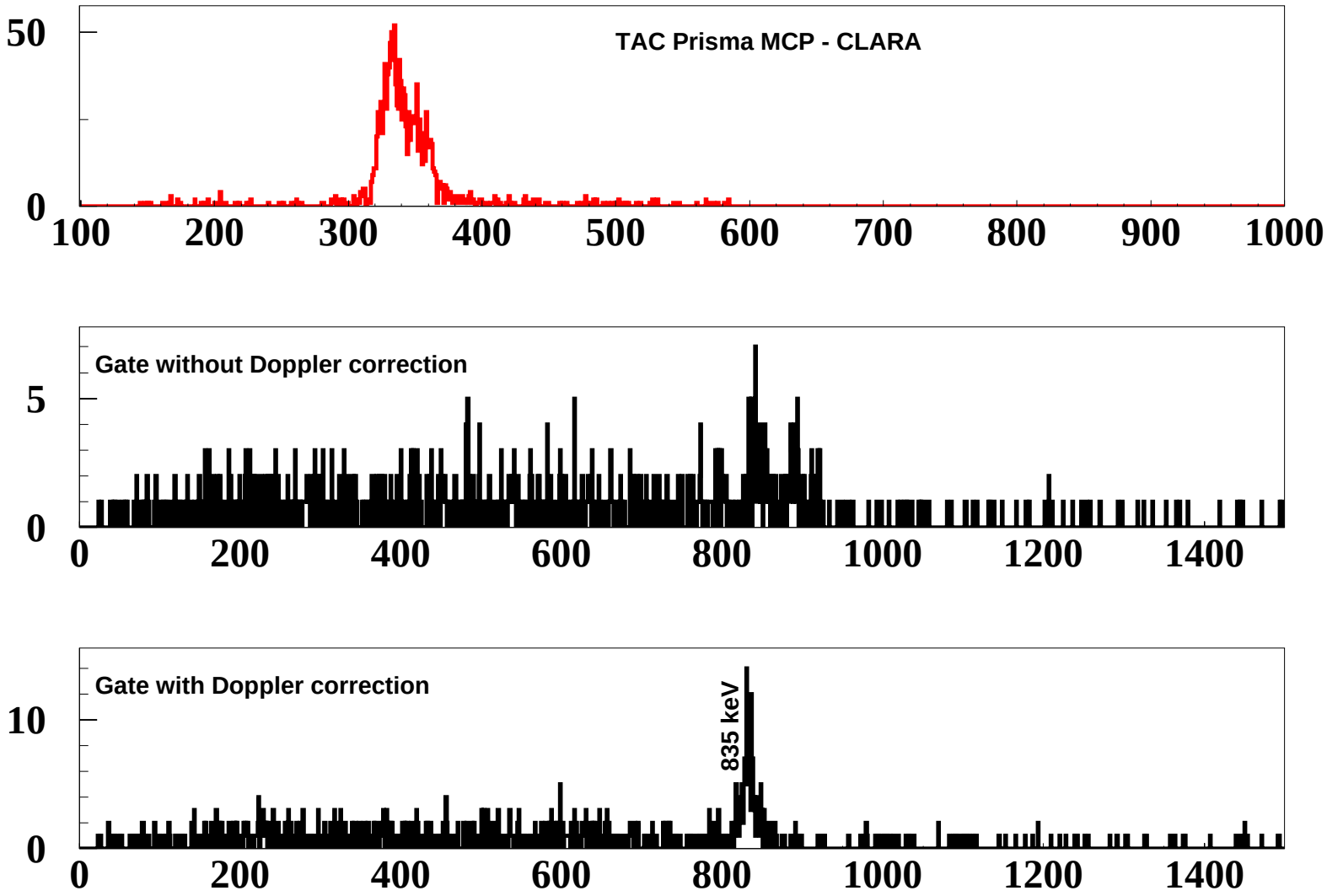

64º
54Cr 219 MeV
208Pb 37 MeV
MCP
Beam
54Cr
295 MeV
42º
54Cr
258 MeV
51º
208Pb
75 MeV

PRISMA-CLARA coincidences 54Cr + 208Pb 295MeV



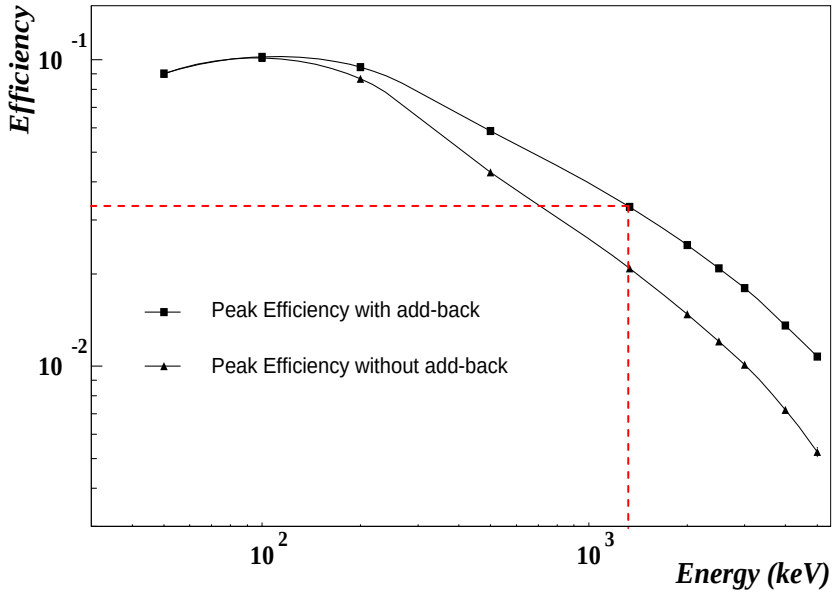
Analysis performed by N.Marginean

PRISMA-CLARA coincidences 54Cr + 208Pb 295MeV



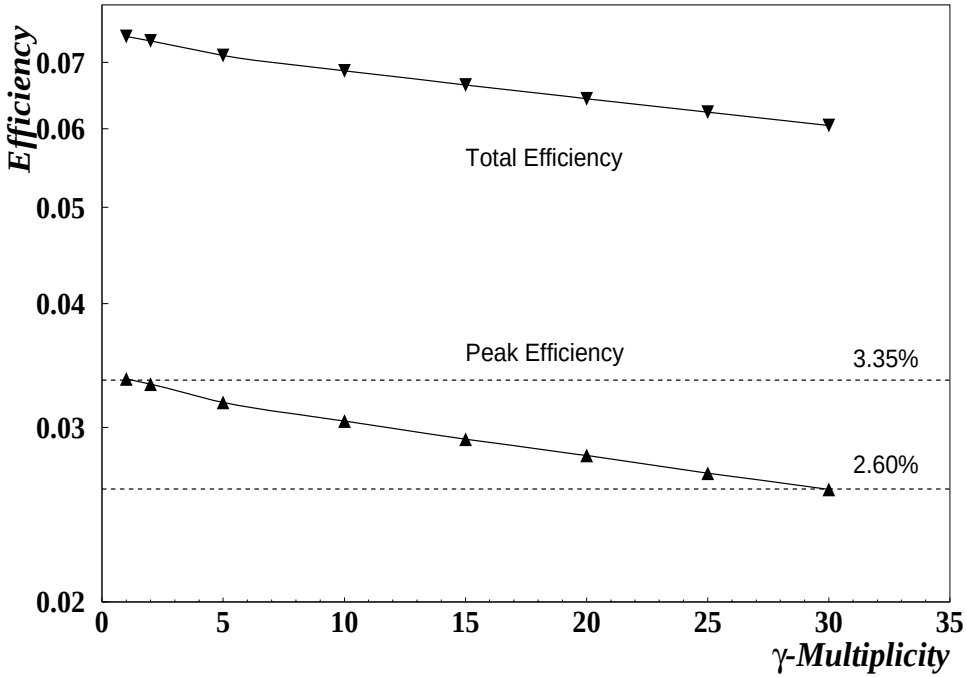
Analysis performed by N.Marginean

Simulated Performance Figures for CLARA



CLARA efficency as a function of the γ energy, with and without add-back

CLARA peak and total efficencies as a function of the γ-cascade multiplicity for 1.3 MeV γ-rays



Lifetime measurements with the Clover array at Prisma

- Recoil Shadow anisotropy method:

  Based on the array-collimator geometry.

  Lifetimes ranging from ~0.5 to ~20 ns.

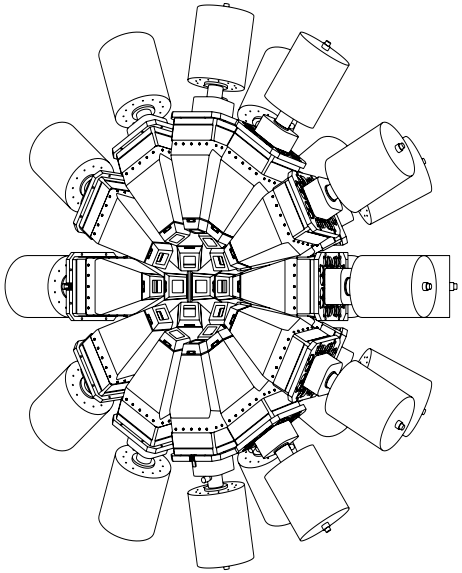
  E.Gueorguieva et al. NIM A 474 (2001) 132.

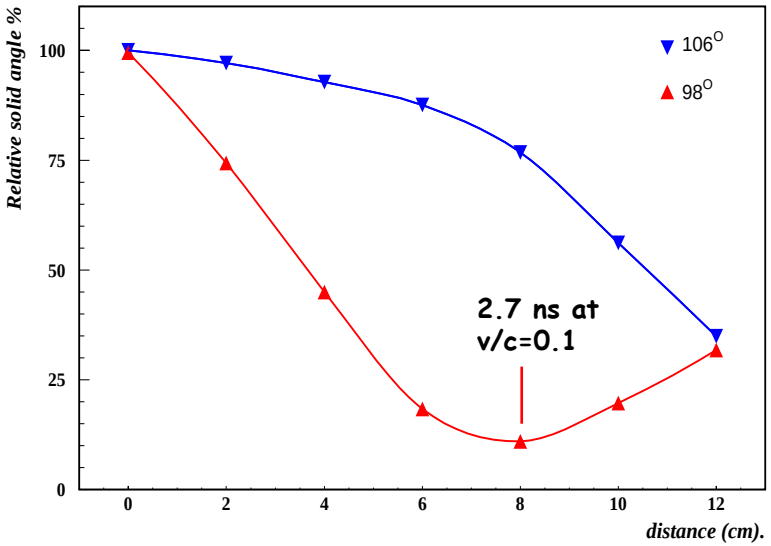
- RFD method:

Developed for the Krakow Recoil Filter Detector. Based on the line shape analysis of the Doppler shifted lines and the change of momentum introduced by the straggling of the products in the target. Needs an accurate position sensitive detector as the PRISMA start MCP . Lifetimes ranging from ~50 fs to ~1 ps.

P.Bednarczyk, W.Meczynski, J.Styczen et al.

Recoil Shadow Anisotropy Method

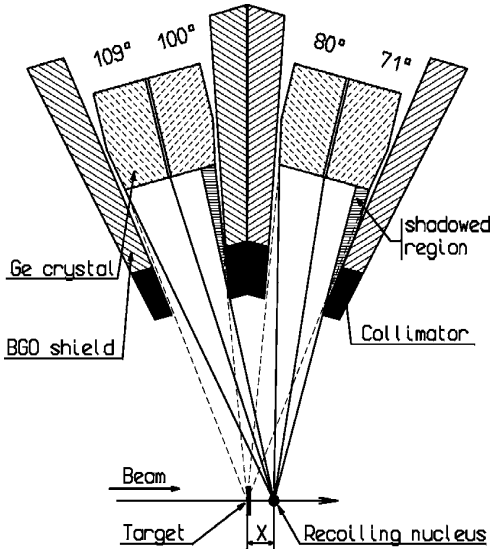


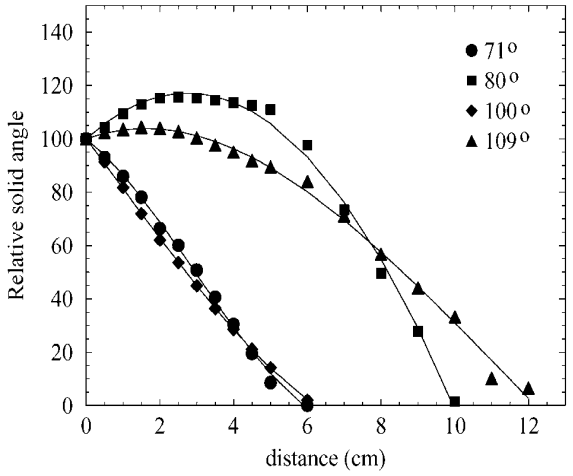


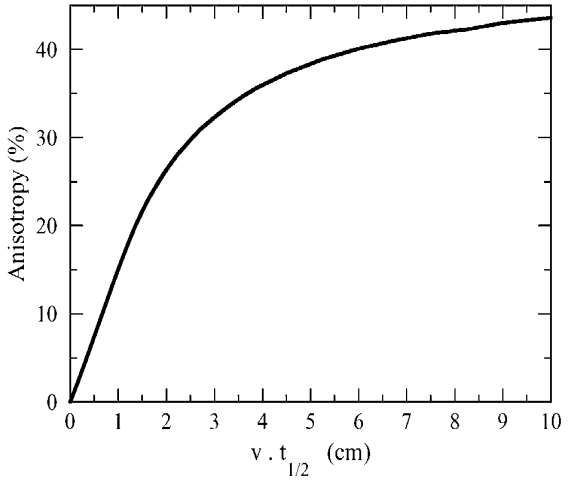
Angles for the Ge crystals of the Clover array ring:

$\theta = 106^{o}$

$\theta = 98^{o}$

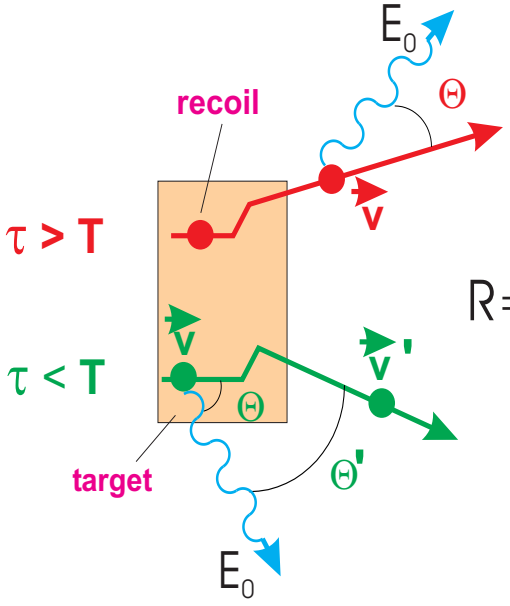




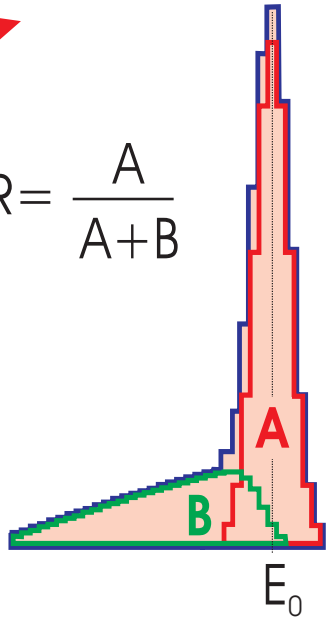


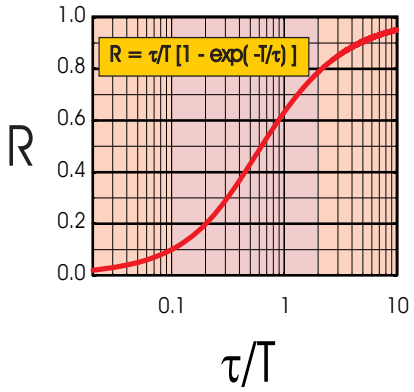
E.Gueorguieva et al. NIM A 474 (2001)

A short lifetime determination with RFD



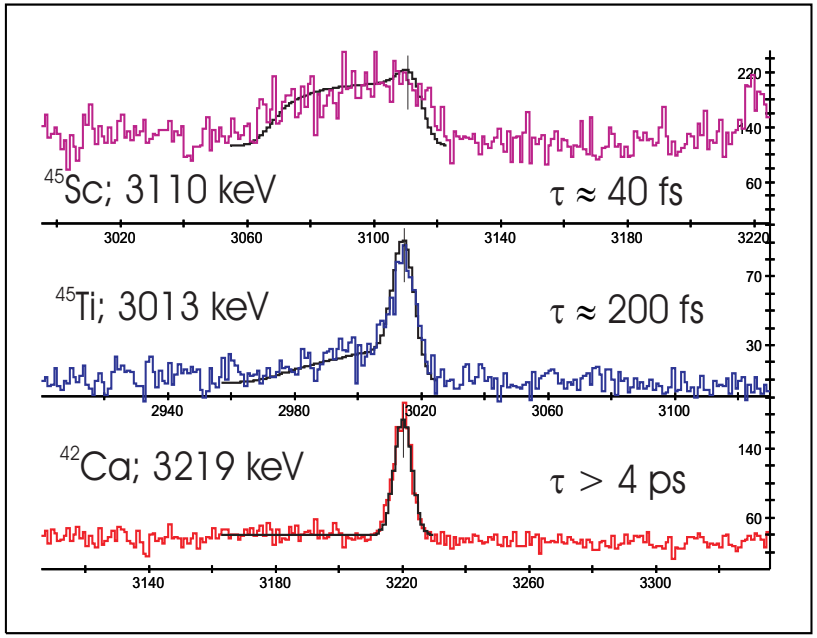
$$R = \frac{A}{A+B}$$





The range of measured lifetimes can be chosen by a selection of the target thickness.

68MeV ^{18}O + 0.8mg/cm^2 ^{30}Si;
Recoil transit time ≈ 0.4 ps



In the measurement τ ranging from 40 to 800 fs could be determined.

P.Bednarczyk, W.Meczynski, J.Styczen et

Scheduling:

- The CLARA-PRISMA setup is ready to perform experiments since January 2004.
- Replacement of the two damaged Clover detectors, present in the array, expected before 15th March. To complete the setup (23-25 clover detectors) we have to wait for repaired Clover . Therefore this semester we expect to run all experiments with a CLARA efficiency of ~2.8-2.9%
- The next experiment (Spokesperson S.Lunardi) will start 15th March.

Physics Program

- **Already approved:**

  Shell model in the ^{48}Ca and in the N=50 A=80 region.
  Shell closure in n-rich nuclei at N=20 and N=32.
  CED from states populated by 1 or 2 nucleon transfer reactions in the sd and fp shells

- **Perspectives:**

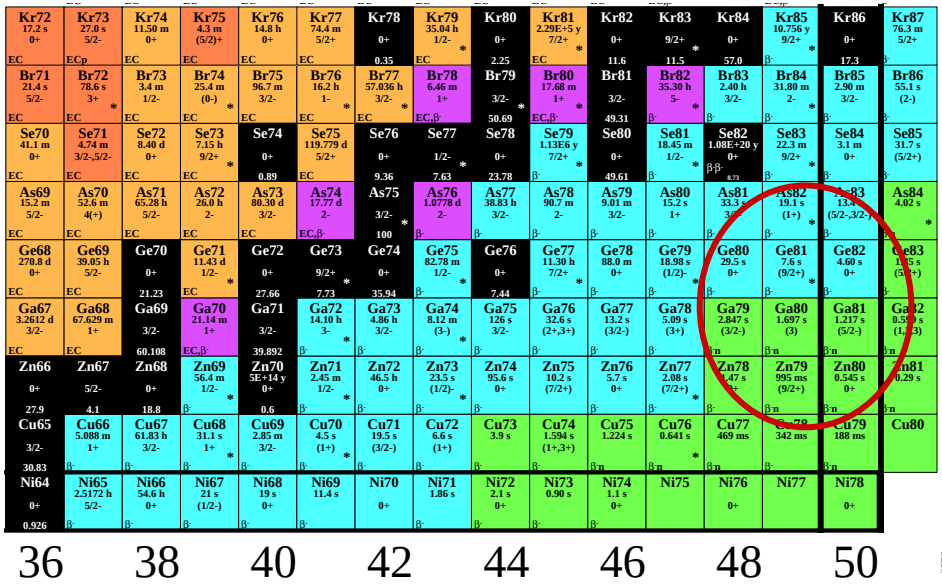
  •Collective properties in n-rich nuclei

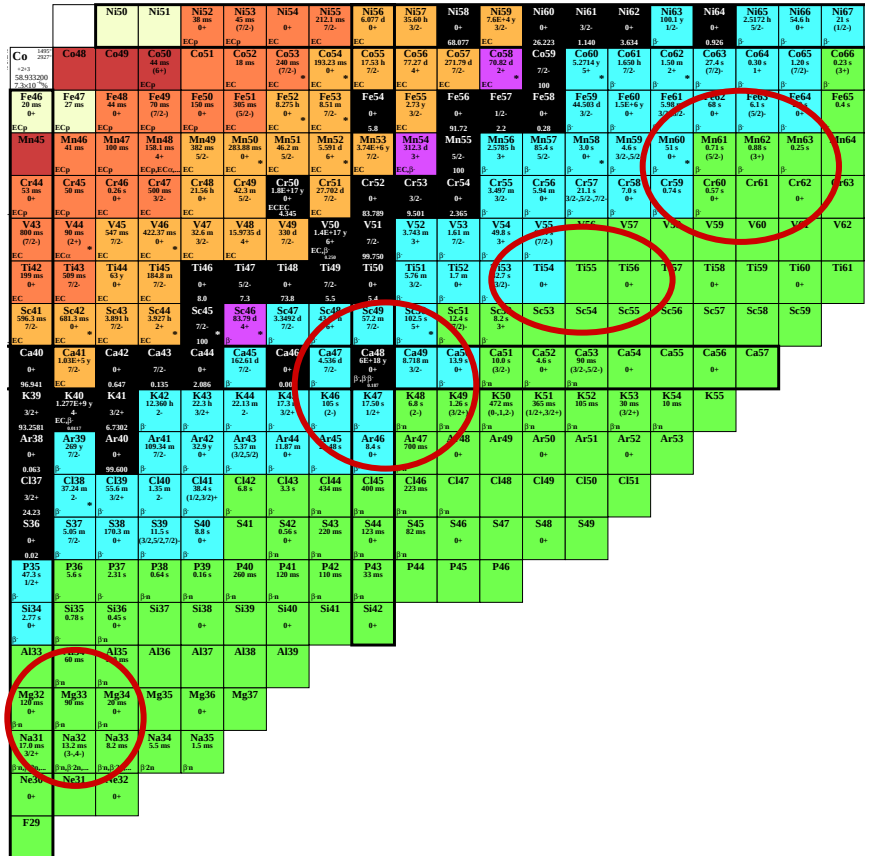
  •Dynamic symmetries

  • Non-yrast exotic shapes

  • Shell model in the ^{132}Sn region (PIAVE-ALPI) and in the neighbourhood of ^{78}Ni

  •etc…


Kr72 17.2 s 0+ EC
Kr73 27.0 s 5/2- ECp
Kr74 11.50 m 0+ EC
Kr75 4.3 m (5/2)+ EC
Kr76 14.8 h 0+ EC
Kr77 74.4 m 5/2+ EC
Kr78 0+ 0.35
Kr79 35.04 h 1/2- EC
Kr80 0+ 2.25
Kr81 2.29E+5 y 7/2+ EC
Kr82 0+ 11.6
Kr83 9/2+ 11.5
Kr84 0+ 57.0
Kr85 10.756 y 9/2+ β-
Kr86 0+ 17.3
Kr87 76.3 m 5/2+ β-
Br71 21.4 s 5/2- EC
Br72 78.6 s 3+ EC
Br73 3.4 m 1/2- EC
Br74 25.4 m (0-) EC
Br75 96.7 m 3/2- EC
Br76 16.2 h 1- EC
Br77 57.036 h 3/2- EC
Br78 6.46 m 1+ EC,β-
Br79 3/2- 50.69
Br80 17.68 m 1+ EC,β-
Br81 3/2- 49.31
Br82 35.30 h 5- β-
Br83 2.40 h 3/2- β-
Br84 31.80 m 2- β-
Br85 2.90 m 3/2- β-
Br86 55.1 s (2-) β-
Se70 41.1 m 0+ EC
Se71 4.74 m 3/2-,5/2- EC
Se72 8.40 d 0+ EC
Se73 7.15 h 9/2+ EC
Se74 0+ 0.89
Se75 119.779 d 5/2+ EC
Se76 0+ 9.36
Se77 1/2- 7.63
Se78 0+ 23.78
Se79 1.13E6 y 7/2+ β-
Se80 0+ 49.61
Se81 18.45 m 1/2- β-
Se82 1.08E+20 y 0+ β-β- 8.73
Se83 22.3 m 9/2+ β-
Se84 3.1 m 0+ β-
Se85 31.7 s (5/2+) β-
As69 15.2 m 5/2- EC
As70 52.6 m 4(+) EC
As71 65.28 h 5/2- EC
As72 26.0 h 2- EC
As73 80.30 d 3/2- EC
As74 17.77 d 2- EC,β-
As75 3/2- 100
As76 1.0778 d 2- β-
As77 38.83 h 3/2- β-
As78 90.7 m 2- β-
As79 9.01 m 3/2- β-
As80 15.2 s 1+ β-
As81 33.3 s 3/2- β-
As82 19.1 s (1+) β-
As83 13.4 (5/2-,3/2-) β-
As84 4.02 s β-
Ge68 270.8 d 0+ EC
Ge69 39.05 h 5/2- EC
Ge70 0+ 21.23
Ge71 11.43 d 1/2- EC
Ge72 0+ 27.66
Ge73 9/2+ 7.73
Ge74 0+ 35.94
Ge75 82.78 m 1/2- β-
Ge76 0+ 7.44
Ge77 11.30 h 7/2+ β-
Ge78 88.0 m 0+ β-
Ge79 18.98 s (1/2)- β-
Ge80 29.5 s 0+ β-
Ge81 7.6 s (9/2+) β-
Ge82 4.60 s 0+ β-
Ge83 1.85 s (5/2+) β-
Ga67 3.2612 d 3/2- EC
Ga68 67.629 m 1+ EC
Ga69 3/2- 60.108
Ga70 21.14 m 1+ EC,β-
Ga71 3/2- 39.892
Ga72 14.10 h 3- β-
Ga73 4.86 h 3/2- β-
Ga74 8.12 m (3-) β-
Ga75 126 s 3/2- β-
Ga76 32.6 s (2+,3+) β-
Ga77 13.2 s (3/2-) β-
Ga78 5.09 s (3+) β-
Ga79 2.847 s (3/2-) β-n
Ga80 1.697 s (3) β-n
Ga81 1.217 s (5/2-) β-n
Ga82 0.599 s (1,2,3) β-n
Zn66 0+ 27.9
Zn67 5/2- 4.1
Zn68 0+ 18.8
Zn69 56.4 m 1/2- β-
Zn70 5E+14 y 0+ 0.6
Zn71 2.45 m 1/2- β-
Zn72 46.5 h 0+ β-
Zn73 23.5 s (1/2)- β-
Zn74 95.6 s 0+ β-
Zn75 10.2 s (7/2+) β-
Zn76 5.7 s 0+ β-
Zn77 2.08 s (7/2+) β-
Zn78 1.47 s 0+ β-
Zn79 995 ms (9/2+) β-n
Zn80 0.545 s 0+ β-n
Zn81 0.29 s β-n
Cu65 3/2- 30.83
Cu66 5.088 m 1+ β-
Cu67 61.83 h 3/2- β-
Cu68 31.1 s 1+ β-
Cu69 2.85 m 3/2- β-
Cu70 4.5 s (1+) β-
Cu71 19.5 s (3/2-) β-
Cu72 6.6 s (1+) β-
Cu73 3.9 s β-
Cu74 1.594 s (1+,3+) β-
Cu75 1.224 s β-n
Cu76 0.641 s β-n
Cu77 469 ms β-n
Cu78 342 ms β-
Cu79 188 ms β-n
Cu80 β-n
Ni64 0+ 0.926
Ni65 2.5172 h 5/2- β-
Ni66 54.6 h 0+ β-
Ni67 21 s (1/2-) β-
Ni68 19 s 0+ β-
Ni69 11.4 s β-
Ni70 0+ β-
Ni71 1.86 s β-
Ni72 2.1 s 0+ β-
Ni73 0.90 s β-
Ni74 1.1 s 0+ β-
Ni75 β-n
Ni76 0+ β-n
Ni77 β-n
Ni78 0+ β-n
36
38
40
42
44
46
48
50


Ni50
Ni51
Ni52 38 ms 0+ ECp
Ni53 45 ms (7/2-) ECp
Ni54 0+ EC
Ni55 212.1 ms 7/2- EC
Ni56 6.077 d 0+ EC
Ni57 35.60 h 3/2- EC
Ni58 0+ 68.077 EC
Ni59 7.6E+4 y 3/2- EC
Ni60 0+ 26.223
Ni61 3/2- 1.140
Ni62 0+ 3.634
Ni63 100.1 y 1/2- β-
Ni64 0+ 0.926
Ni65 2.5172 h 5/2- β-
Ni66 54.6 h 0+ β-
Ni67 21 s (1/2-) β-
Co 1495/2621 +2+3 58.933200 7.3x10^-8 %
Co48
Co49
Co50 44 ms (6+) ECp
Co51
Co52 18 ms EC
Co53 240 ms (7/2-) EC
Co54 193.25 ms 0+ EC
Co55 17.53 h 7/2- EC
Co56 77.27 d 4+ EC
Co57 271.79 d 7/2- EC
Co58 70.82 d 2+ EC
Co59 7/2- 100
Co60 5.2714 y 5+ β-
Co61 1.650 h 7/2- β-
Co62 1.50 m 2- β-
Co63 27.4 s (7/2-) β-
Co64 0.30 s 1+ β-
Co65 1.20 s (7/2-) β-
Co66 0.23 s (3+) β-
Fe46 20 ms 0+ ECp
Fe47 27 ms ECp
Fe48 44 ms 0+ ECp
Fe49 70 ms (7/2-) ECp
Fe50 150 ms 0+ ECp
Fe51 305 ms (5/2-) EC
Fe52 8.275 h 0+ EC
Fe53 8.51 m 7/2- EC
Fe54 0+ 5.8
Fe55 2.73 y 3/2- EC
Fe56 0+ 91.72
Fe57 1/2- 2.2
Fe58 0+ 0.28
Fe59 44.503 d 3/2- β-
Fe60 1.5E+6 y 0+ β-
Fe61 5.98 m 3/2-,5/2- β-
Fe62 68 s 0+ β-
Fe63 6.1 s (5/2-) β-
Fe64 2 s 0+ β-
Fe65 0.4 s β-
Mn45 ECp
Mn46 41 ms ECp
Mn47 100 ms ECp
Mn48 158.1 ms 4+ ECp,β,ECα,...
Mn49 382 ms 5/2- EC
Mn50 283.88 ms 0+ EC
Mn51 46.2 m 5/2- EC
Mn52 5.591 d 6+ EC
Mn53 3.74E+6 y 7/2- EC
Mn54 312.3 d 3+ EC,β+
Mn55 5/2- 100
Mn56 2.5785 h 3+ β-
Mn57 85.4 s 5/2- β-
Mn58 3.0 s 0+ β-
Mn59 4.6 s 3/2-,5/2- β-
Mn60 51 s 0+ β-
Mn61 0.71 s (5/2-) β-
Mn62 0.88 s (3+) β-
Mn63 0.25 s β-
Mn64 β-
Cr44 53 ms 0+ ECp
Cr45 50 ms ECp
Cr46 0.26 s 0+ EC
Cr47 500 ms 3/2- EC
Cr48 21.56 h 0+ EC
Cr49 42.3 m 5/2- EC
Cr50 1.8E+17 y 0+ ECEC 4.345 EC
Cr51 27.702 d 7/2- EC
Cr52 0+ 83.789
Cr53 3/2- 9.501
Cr54 0+ 2.365
Cr55 3.497 m 3/2- β-
Cr56 5.94 m 0+ β-
Cr57 21.1 s 3/2-,5/2,7/2- β-
Cr58 7.0 s 0+ β-
Cr59 0.74 s β-
Cr60 0.57 s 0+ β-
Cr61 β-
Cr62 0+ β-
Cr63 β-
V43 800 ms (7/2-) EC
V44 90 ms (2+) EC
V45 547 ms 7/2- EC
V46 422.37 ms 0+ EC
V47 32.6 m 3/2- EC
V48 15.9735 d 4+ EC
V49 330 d 7/2- EC
V50 1.4E+17 y 6+ EC,β- 0.250
V51 7/2- 99.750
V52 3.743 m 3+ β-
V53 1.61 m 7/2- β-
V54 49.8 s 3+ β-
V55 (7/2-) β-
V56 β-
V57 β-
V58 β-
V59 β-
V60 β-
V61 β-
V62 β-
Ti42 199 ms 0+ EC
Ti43 509 ms 7/2- EC
Ti44 63 y 0+ EC
Ti45 184.8 m 7/2- EC
Ti46 0+ 8.0
Ti47 5/2- 7.3
Ti48 0+ 73.8
Ti49 7/2- 5.5
Ti50 0+ 5.4
Ti51 5.76 m 3/2- β-
Ti52 1.7 m 0+ β-
Ti53 32.7 s (7/2-) β-
Ti54 0+ β-
Ti55 β-
Ti56 0+ β-
Ti57 β-
Ti58 0+ β-
Ti59 β-
Ti60 0+ β-
Ti61 β-
Sc41 596.3 ms 7/2- EC
Sc42 681.3 ms 0+ EC
Sc43 3.891 h 7/2- EC
Sc44 3.927 h 2+ EC
Sc45 7/2- 100
Sc46 83.79 d 4+ β-
Sc47 3.3492 d 7/2- β-
Sc48 43.7 h 6+ β-
Sc49 57.2 m 7/2- β-
Sc50 102.5 s 5+ β-
Sc51 12.4 s (7/2-) β-
Sc52 8.2 s 3+ β-
Sc53 β-
Sc54 β-
Sc55 β-
Sc56 β-
Sc57 β-
Sc58 β-
Sc59 β-
Ca40 0+ 96.941
Ca41 1.03E+5 y 7/2- EC
Ca42 0+ 0.647
Ca43 7/2- 0.135
Ca44 0+ 2.086
Ca45 162.61 d 7/2- β-
Ca46 0+ 0.004
Ca47 4.536 d 7/2- β-
Ca48 6E+18 y 0+ β-,β+β+ 0.187
Ca49 8.718 m 3/2- β-
Ca50 13.9 s 0+ β-
Ca51 10.0 s (3/2-) β-n
Ca52 4.6 s 0+ β-n
Ca53 90 ms (3/2-,5/2-) β-n
Ca54 0+ β-n
Ca55 β-n
Ca56 0+ β-n
Ca57 β-n
K39 3/2+ 93.2581
K40 1.277E+9 y 4- EC,β- 0.0117
K41 3/2+ 6.7302
K42 12.360 h 2- β-
K43 22.3 h 3/2+ β-
K44 22.13 m 2- β-
K45 17.3 m 3/2+ β-
K46 105 s (2-) β-
K47 17.50 s 1/2+ β-
K48 6.8 s (2-) β-n
K49 1.26 s (3/2+) β-n
K50 472 ms (0-,1,2-) β-n
K51 365 ms (1/2+,3/2+) β-n
K52 105 ms β-n
K53 30 ms (3/2+) β-n
K54 10 ms β-n
K55 β-n
Ar38 0+ 0.063
Ar39 269 y 7/2- β-
Ar40 0+ 99.600
Ar41 109.34 m 7/2- β-
Ar42 32.9 y 0+ β-
Ar43 5.37 m (3/2,5/2) β-
Ar44 11.87 m 0+ β-
Ar45 21.48 s β-
Ar46 8.4 s 0+ β-
Ar47 700 ms β-
Ar48 0+ β-
Ar49 β-
Ar50 0+ β-
Ar51 β-
Ar52 0+ β-
Ar53 β-
Cl37 3/2+ 24.23
Cl38 37.24 m 2- β-
Cl39 55.6 m 3/2+ β-
Cl40 1.35 m 2- β-
Cl41 38.4 s (1/2,3/2)+ β-
Cl42 6.8 s β-
Cl43 3.3 s β-
Cl44 434 ms β-n
Cl45 400 ms β-n
Cl46 223 ms β-n
Cl47 β-n
Cl48 β-n
Cl49 β-n
Cl50 β-n
Cl51 β-n
S36 0+ 0.02
S37 5.05 m 7/2- β-
S38 170.3 m 0+ β-
S39 11.5 s (3/2,5/2,7/2) β-
S40 8.8 s 0+ β-
S41 β-
S42 0.56 s 0+ β-n
S43 220 ms β-n
S44 123 ms 0+ β-n
S45 82 ms β-n
S46 0+ β-n
S47 β-n
S48 0+ β-n
S49 β-n
P35 47.3 s 1/2+ β-
P36 5.6 s β-
P37 2.31 s β-
P38 0.64 s β-n
P39 0.16 s β-n
P40 260 ms β-n
P41 120 ms β-n
P42 110 ms β-n
P43 33 ms β-n
P44 β-n
P45 β-n
P46 β-n
Si34 2.77 s 0+ β-
Si35 0.78 s β-
Si36 0.45 s 0+ β-n
Si37 β-n
Si38 0+ β-n
Si39 β-n
Si40 0+ β-n
Si41 β-n
Si42 0+ β-n
Al33 41.7 ms β-
Al34 60 ms β-n
Al35 37 ms β-n
Al36 β-n
Al37 β-n
Al38 β-n
Al39 β-n
Mg32 120 ms 0+ β-n
Mg33 90 ms β-n
Mg34 20 ms 0+ β-n
Mg35 β-n
Mg36 0+ β-n
Mg37 β-n
Na31 17.0 ms 3/2+ β-n,β-2n,...
Na32 13.2 ms (3-,4-) β-n,β-2n,...
Na33 8.2 ms β-n,β-2n,...
Na34 5.5 ms β-2n
Na35 1.5 ms β-n
Ne30 0+ β-2n
Ne31 β-2n
Ne32 0+ β-2n
F29 β-2n

The CLARA-PRISMA collaboration

•France

IReS Strasbourg

•U.K.

University of Manchester
Daresbury Laboratory
University of Surrey
University of Paisley

•Germany

HMI Berlin

•Romania

Horia Hulubei NIPNE
Bucharest

•Italy

INFN LNL-Legnaro
INFN and University Padova
INFN and University Milano
INFN and University Genova
INFN and University Torino
INFN and University Napoli
INFN and University Firenze
University of Camerino

•Spain

University of Salamanca

The CLARA-PRISMA collaboration

•France
IReS Strasbourg

LN2 control system, support for the VXI electronics and Clover detectors

•U.K. University of Manchester Design work for the CLARA frame, structure and collimator
Daresbury Laboratory
Support and developments connected with the MIDAS data acquisition system.

FEA Calculation for the frame.
University of Surrey
University of Paisley

•Germany
HMI Berlin
GSI Darmstadt

•Italy

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