Shape Coexistence in ^{100}Zr Studied by Low-Energy Coulomb Exciation Energy

D.T. Doherty[1], W. Korten[1], R.V.F. Janssens[2], S. Zhu[2], A.D. Ayangeakaa[2], B. Bucher[3], C.M. Campbell[4], M.P. Carpenter[2], J. Chen[5], H.M. David[2], C. Dickerson[2], A. Drouart[1], A Görgen[6], E.T. Gregor[7], J.L. Harker[2,8], M. Hendricks[2], F. Kondev[5], T. Lauritsen[2], R. Pardo[2], R. Vondrasek[2], G. Savard[2,9], R. Scott[2], D. Seweryniak[2], S. Siem[6], R. Stegmann[10], A. Wiens[4], K. Wrzosek-Lipska[11], C.Y. Wu[3], M. Zielińska[1]

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ISOLDE Workshop and Users Meeting 2014

(16th December 2014)

Shape Coexistence in ^{100}Zr (and ^{110}Ru) Studied by Low-Energy Coulomb Exciation Energy

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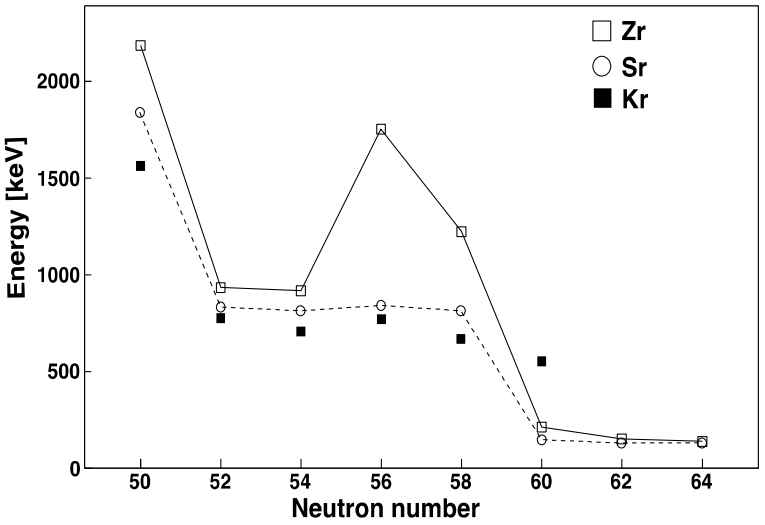
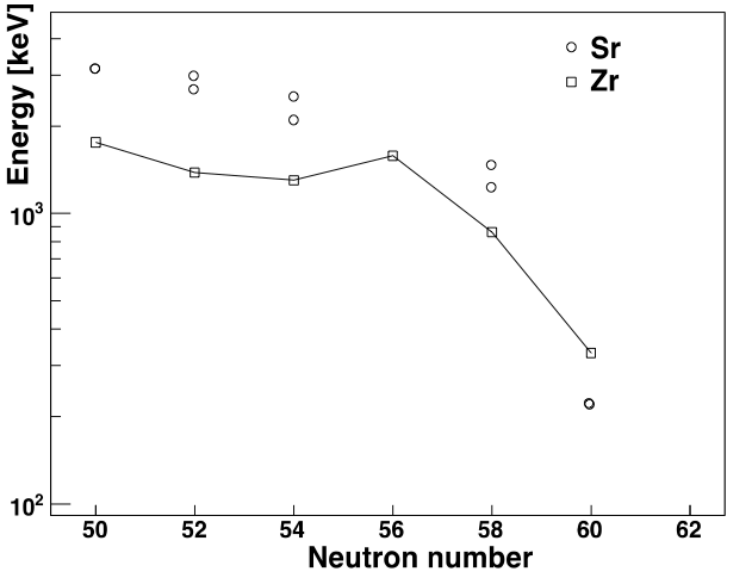
Motivation

Excitation energies for the first 2^+ states in neutron-rich Zr, Sr and Kr isotopes. Large excitation energies => **Spherical shell closures** ($N = 50$, $N = 56$)



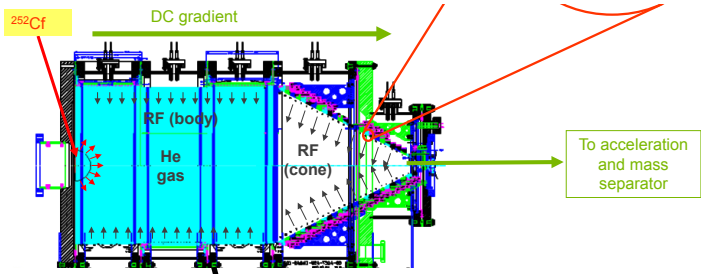
M. Albers *et al., Phys. Rev. Lett. 108, 062701 (2012)*

Excitation energy of excited 0^+ states in neutron-rich Zr and Sr isotopes beyond $N = 50$ showing a similar drop in excitation energy at N=60 as the 2+ states.



CARIBU at ANL

CAlifornium **R**are **I**sotope **B**reeder **U**pgrade

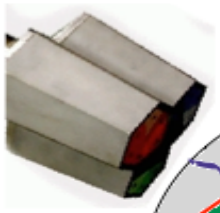


GRETINA-CHICO2

^{100}**Zr** from CARIBU accelerated to **3.84 MeV/u**

γ-ray spectroscopy

GRETINA



Particles
- **angles**
- **energies**

CHICO2

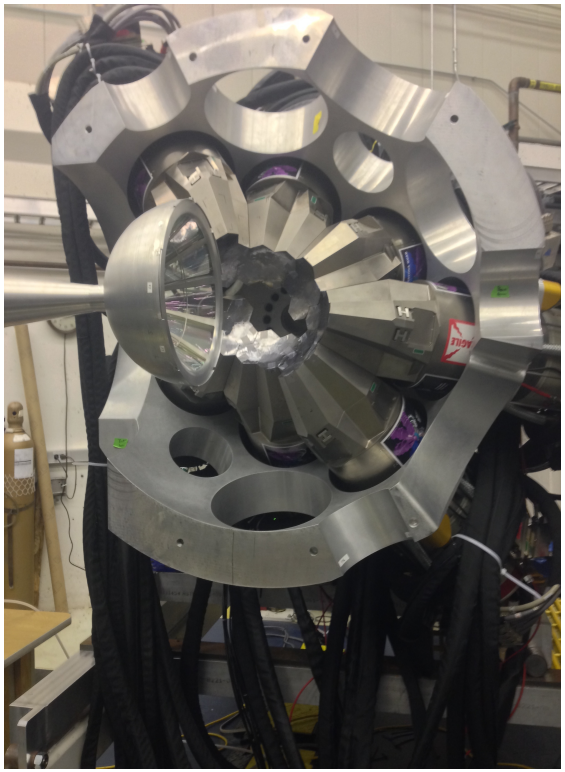
Beam Impurities and monitoring

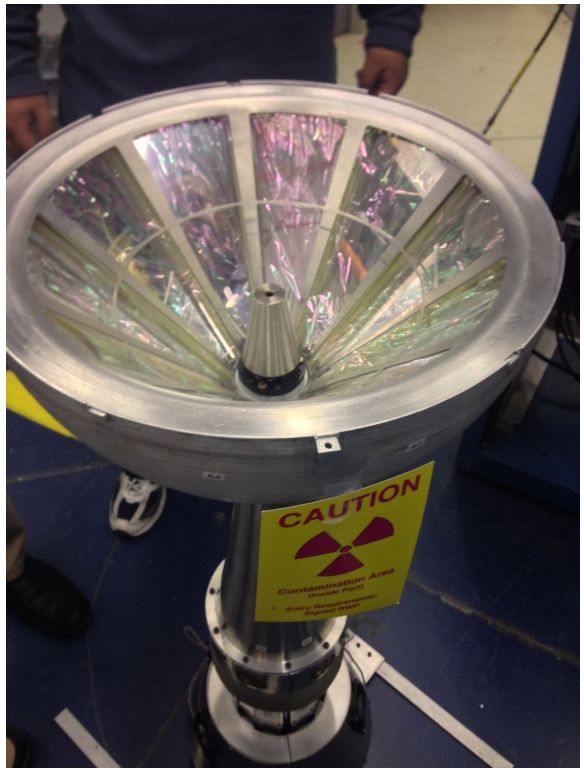
PPACs

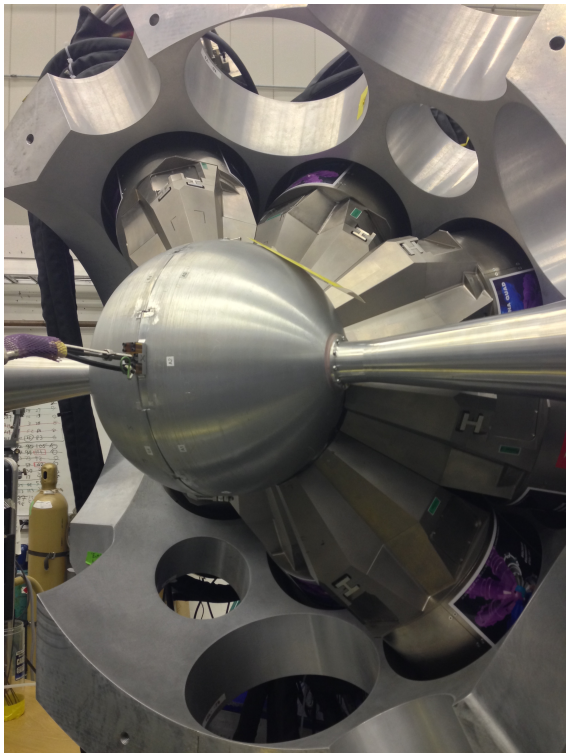
Ge beam Dump Detector

Accelerated CARIBU beam from ATLAS

1.5 mg/cm^2 ^{208}Pb target

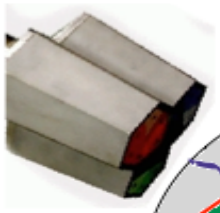






γ-ray spectroscopy

GRETINA



Particles
- **angles**
- **energies**

CHICO2

Beam Impurities and monitoring

PPACs

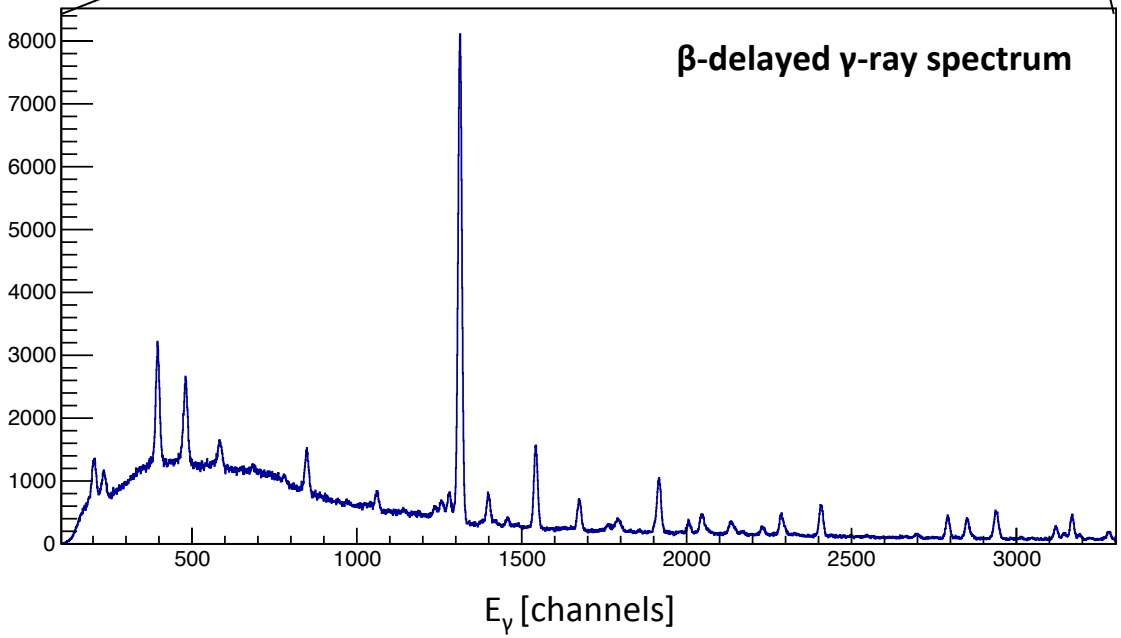
Ge beam Dump Detector

Accelerated CARIBU beam from ATLAS

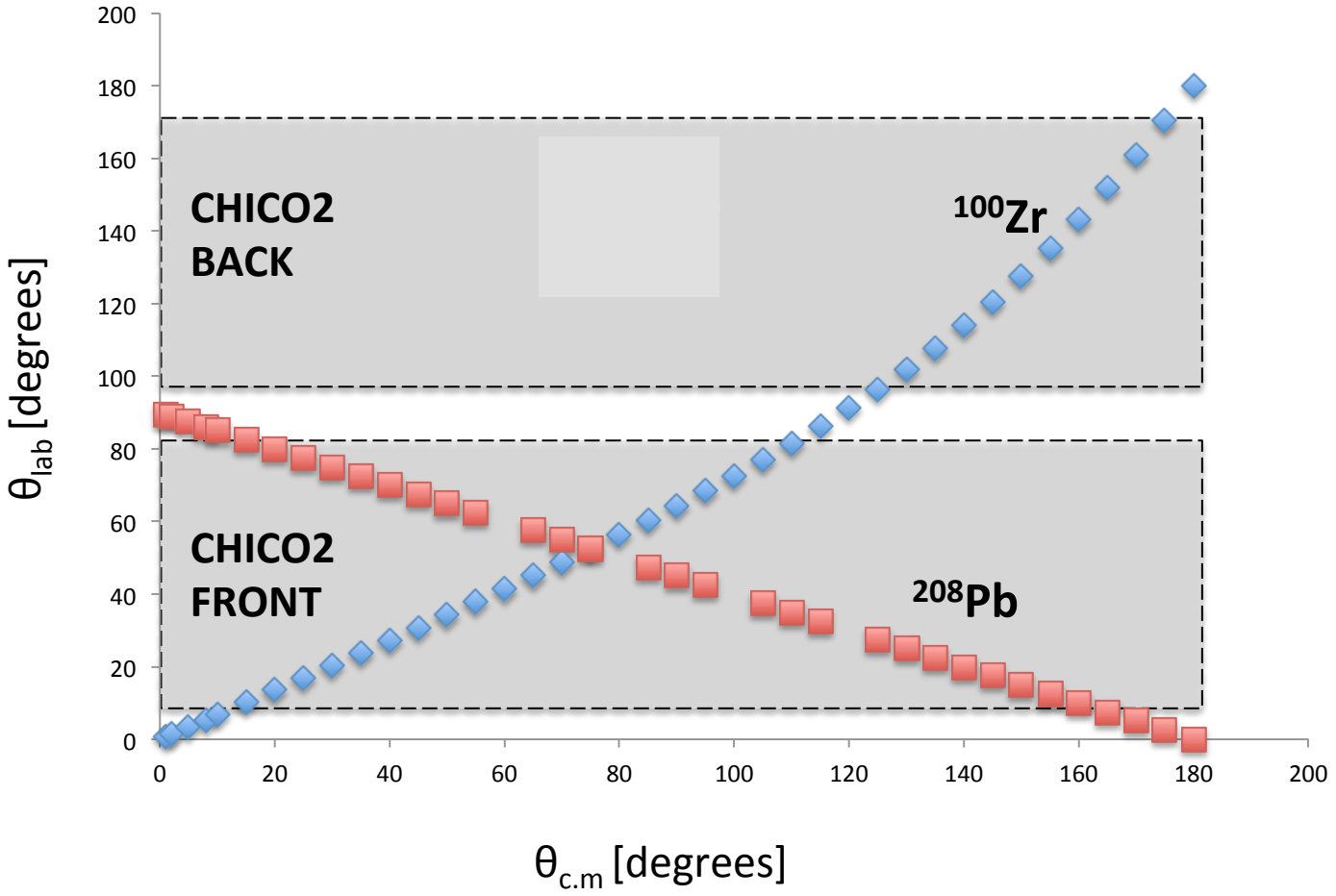
1.5 mg/cm^2 ^{208}Pb target

Rate determined from number of counts in 504-keV line of daughter nucleus (^{100}Nb).

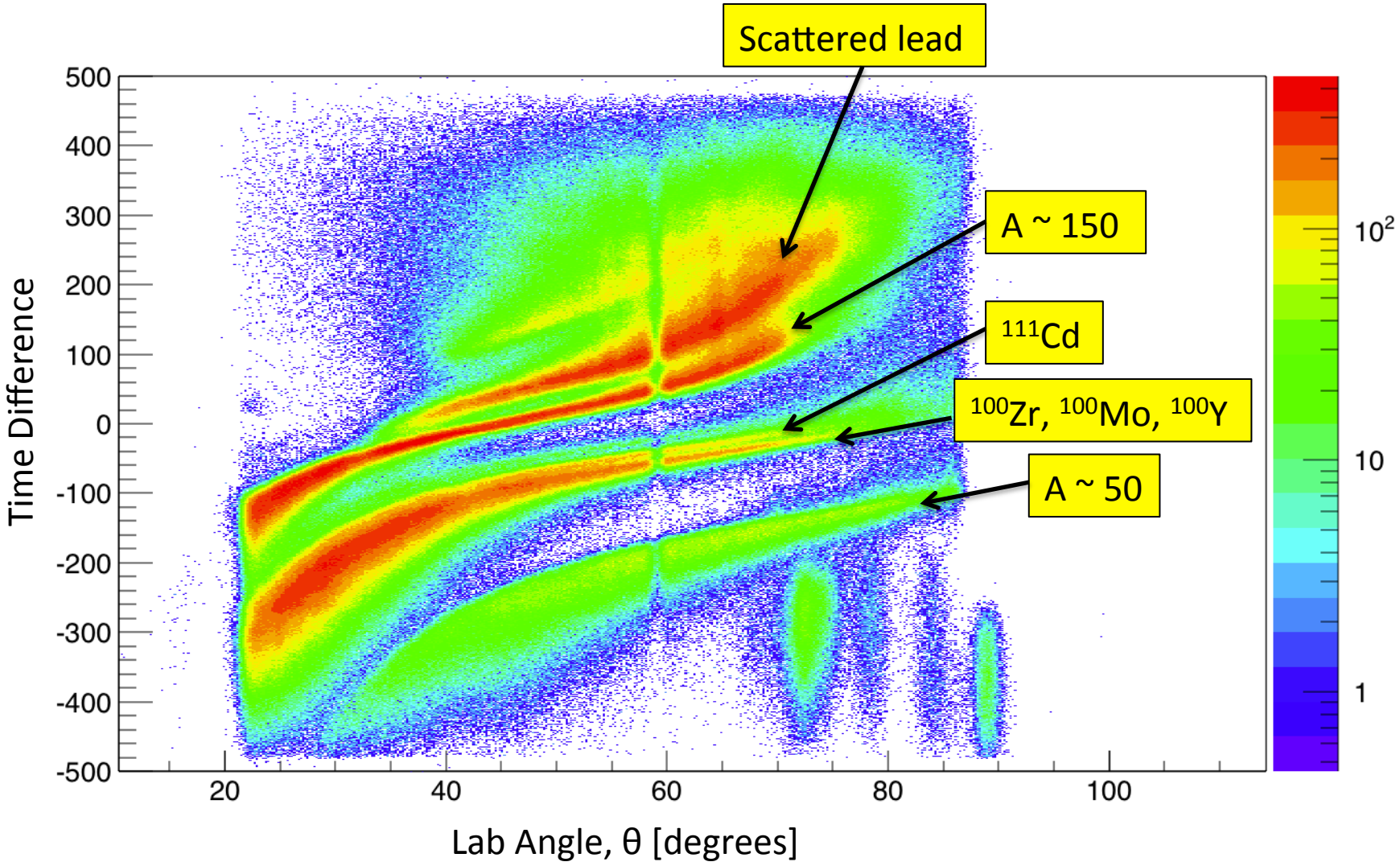
Taking into account efficiency, branching ratios etc



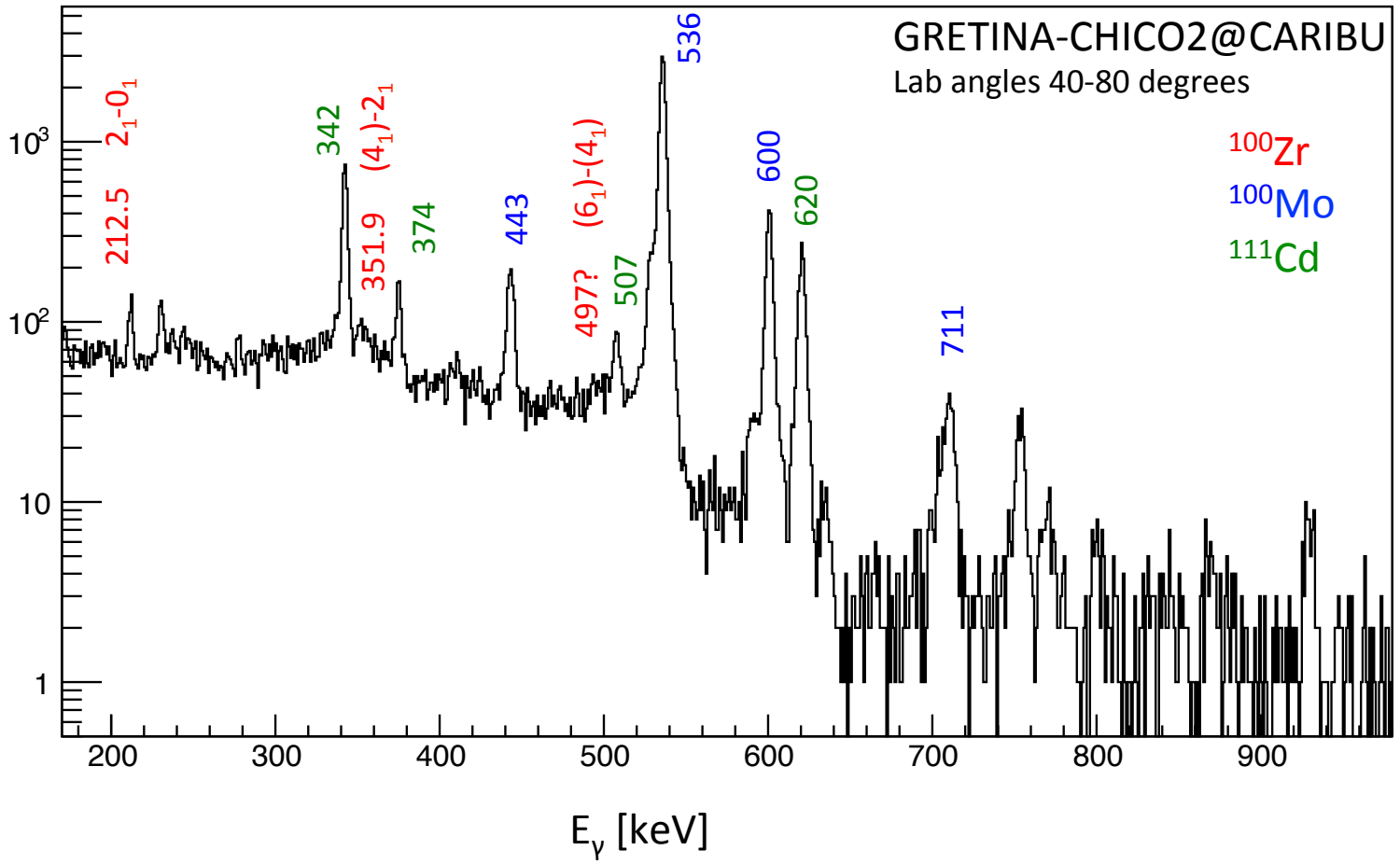
Reaction Kinematics



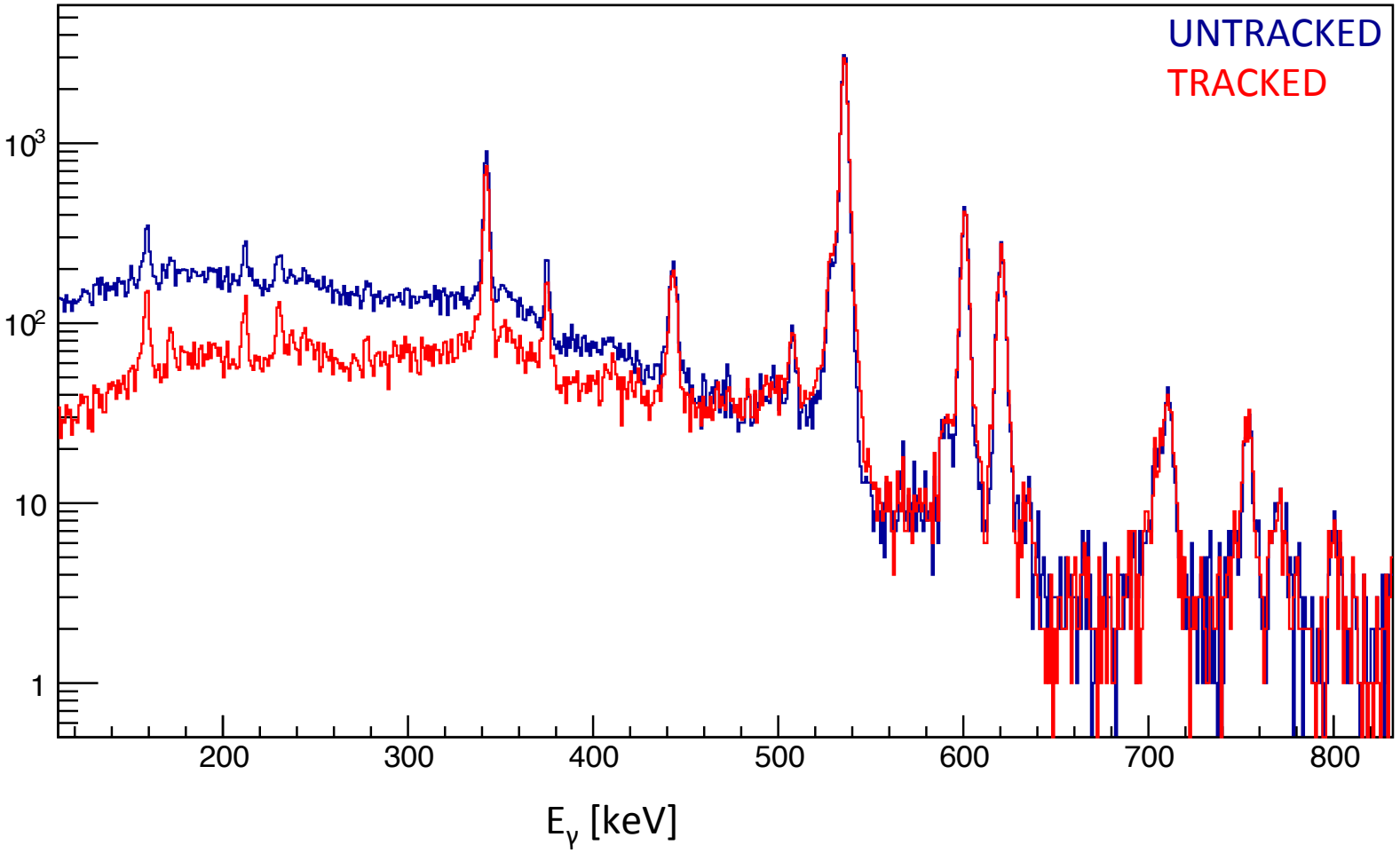
CHICO Particle I.D Plot



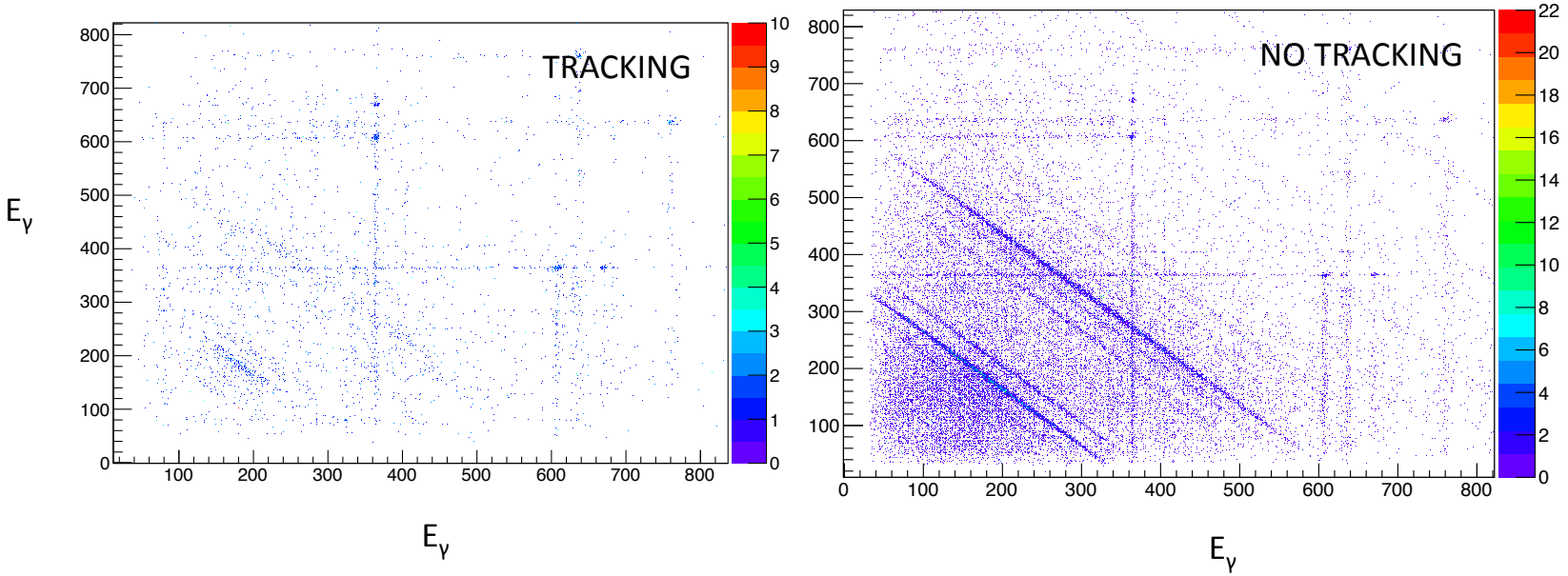
Doppler corrected γ-ray spectrum



Tracking (1)


UNTRACKED
TRACKED
10^3
10^2
10
1
200
300
400
500
600
700
800
E_γ [keV]

Tracking (2)



γ-γ matricies obtained in coincidence with A ~ 100 particles in CHICO

New lifetime results neutron-rich isotopes

Prompt γ-ray spectroscopy with **EXOGAM** in coincidence with Z/A selection in **VAMOS @ GANIL**

⇒ **>10 new half-life values obtained**, e.g. $T_{1/2}(^{98}Zr; 2^+)=5.0(\pm2.5)$ ps
Some discrepancies with previous experiments observed, e.g. **$T_{1/2}(^{100}Zr; 4^+)=20(2)$ps**

			^{110}Pd 2⁺ 44 ps(7) 4⁺ 4.1 ps(0.3) 6⁺ 1.40 ps(0.14)	^{112}Pd 2⁺ 84 ps(14) 4⁺ **7.0 ps (1.5)** 6⁺	^{114}Pd 2⁺ 82 ps(14) 4⁺ **5.4 ps (1.0)** 6⁺	^{116}Pd 2⁺ 0.11 ns(0.03) 4⁺ **8.7 ps (1.3)** 6⁺ **2.6 ps (0.9)**
	^{104}Ru 2⁺ 56.4 ps(1.0) 4⁺ 5.6 ps(0.6) 6⁺ 1.33 ps(1.2)	^{106}Ru 2⁺ 0.20 ns(0.03) 4⁺ **???** 6⁺ **???**	^{108}Ru 2⁺ 0.36 ns(0.03) 4⁺ 13.4 ps(1.0) **13.4 ps (1.0)** 6⁺ **2.9 ps (0.3)**	^{110}Ru 2⁺ 0.32 ns(0.02) 4⁺ 15.4 ps(1.7) **14.9 ps (1.2)** 6⁺ 2.4 ps(1.0) **3.2 ps (0.5)**	^{112}Ru 2⁺ 0.32 ns(0.03) 4⁺ **14.4 ps (2.2)** 6⁺	
	^{102}Mo 2⁺ 125 ps (4) 4⁺ 12.5 ps (2.5) **9.4 ps (1.1)** 6⁺ **3.7 ps (0.5)**	^{104}Mo 2⁺ 0.97 ns(0.08) 4⁺ 26.1 ps(0.3) **18.6 ps (1.2)** 6⁺ 4.73 ps(0.15) **2.7 ps (0.3)**	^{106}Mo 2⁺ 1.25 ns(0.03) 4⁺ 25.4 ps(5.1) **27.5 ps (1.9)** 6⁺ 4.2 ps(1.8) **3.1 ps (0.4)**	^{108}Mo 2⁺ 0.5 ns(0.3) 4⁺ **23.3 ps (5.3)** 6⁺		
^{98}Zr 2⁺ <11ps **5.0 ps (2.5)** 4⁺ 28 ps(3)	^{100}Zr 2⁺ 0.59 ns(0.03) 4⁺ 37 ps(3) **18.1 ps (1.6)** 6⁺ 4.9 ps(1.1) **3.0 ps (0.4)**	^{102}Zr 2⁺ 1.8 ns(0.4) 4⁺ **32.0 ps (3.7)** 6⁺ **4.7 ps (0.6)**	^{104}Zr 2⁺ 2.0 ns(0.3) 4⁺ 6⁺			

L. Grente (thesis work)
Figure courtesy Wolfram Korten

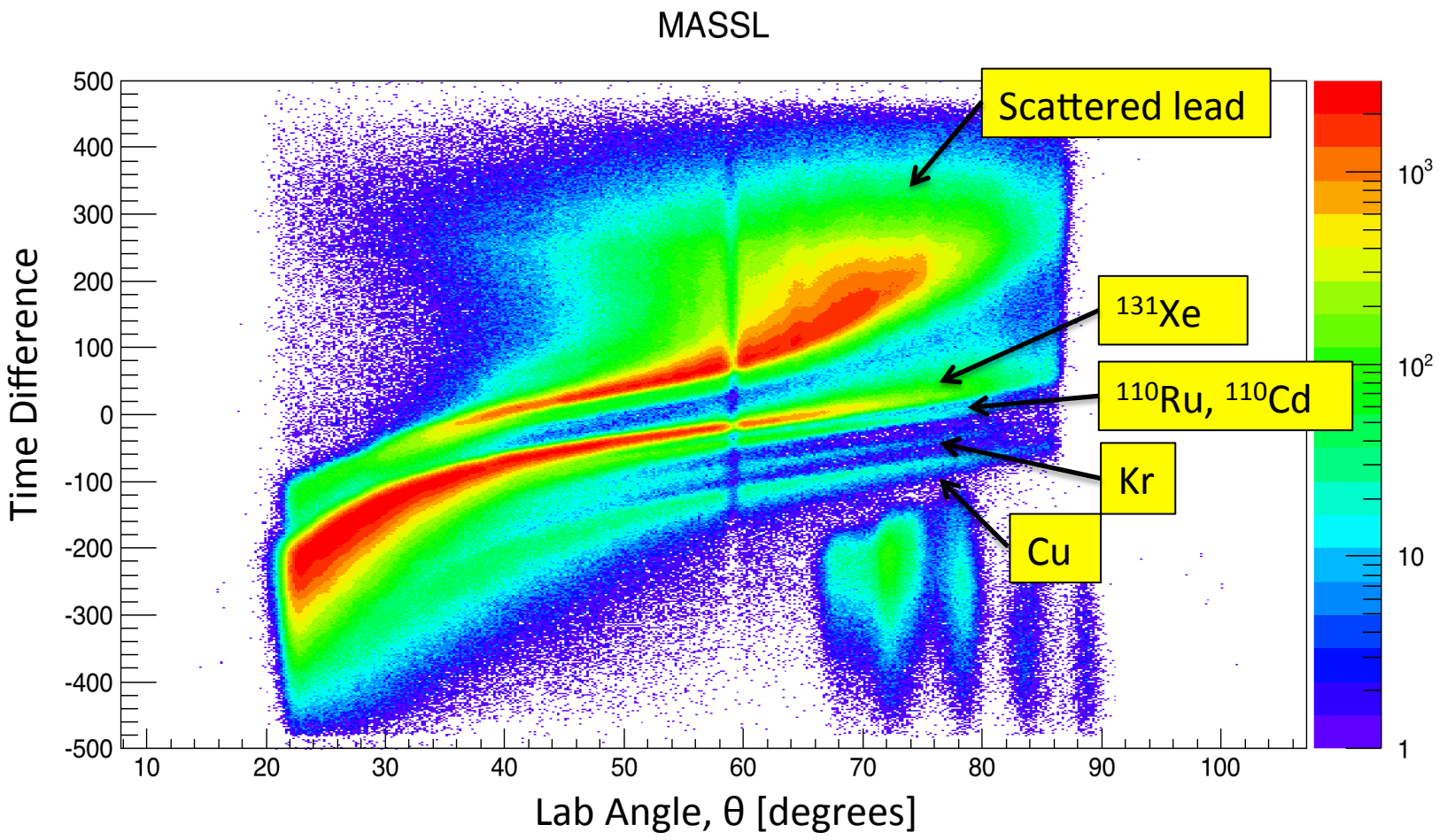
Irfu

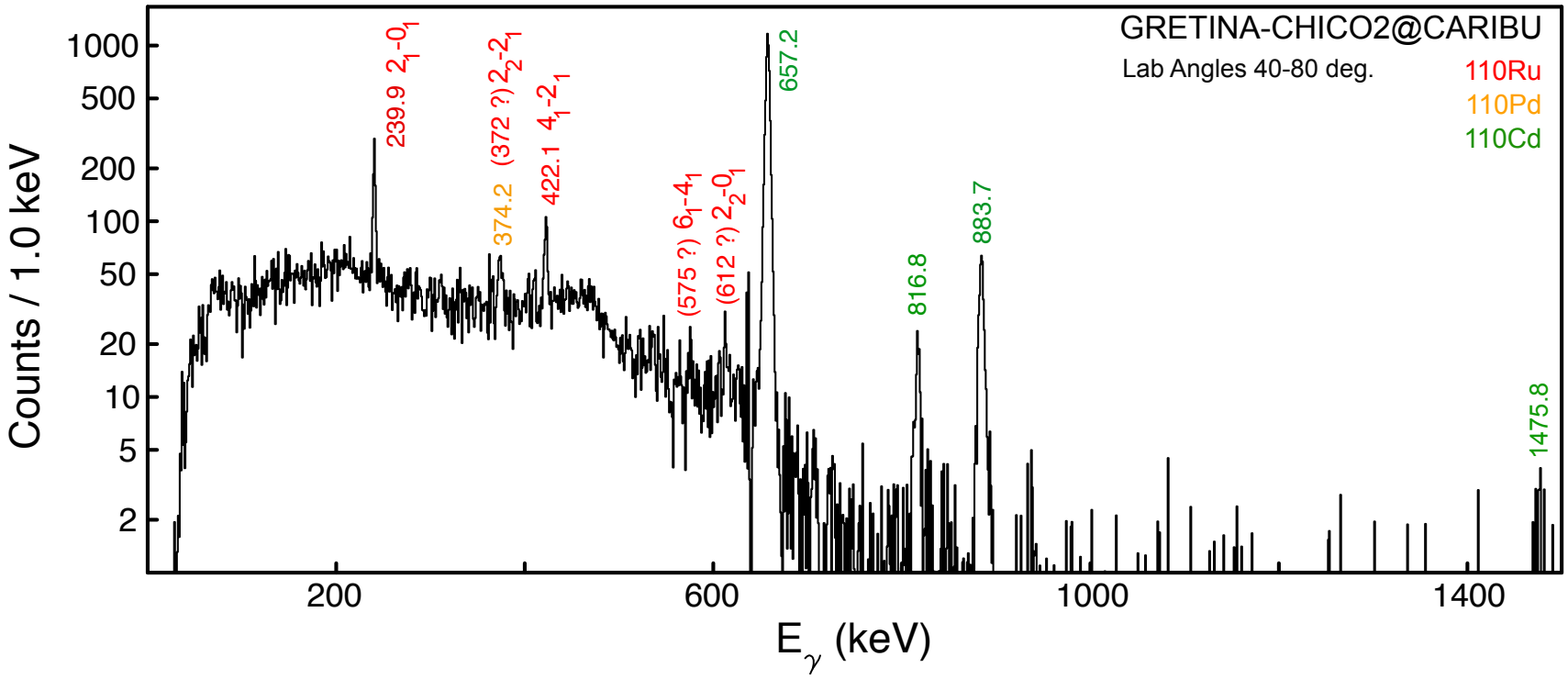
cea

saclay

^{110}Ru

CHICO TOF v Angle

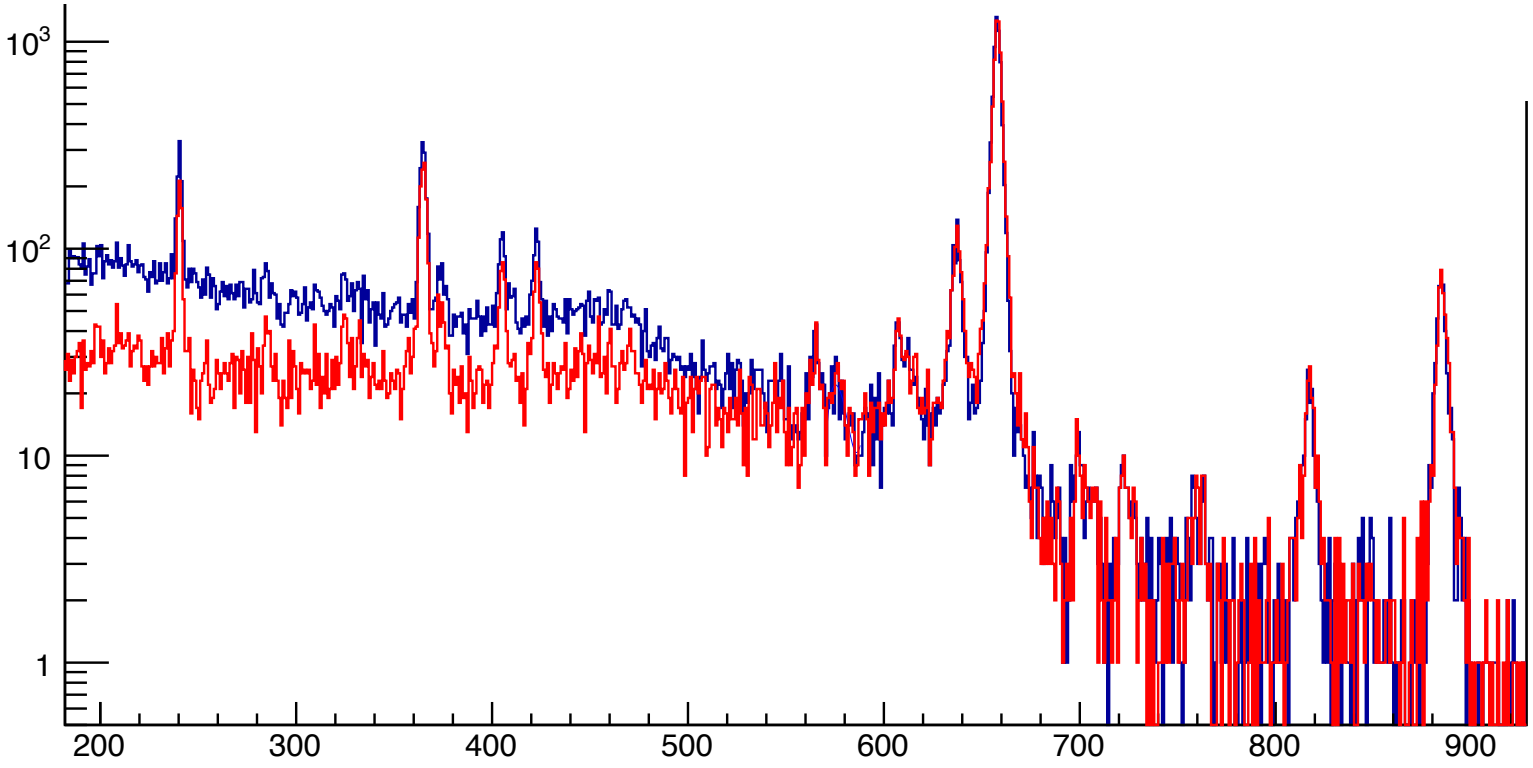




~75% of the total statistics for the ^{110}Ru run. Background from ^{131}Xe has been subtracted.

GRETINA-CHICO@CARIBU
TRACKED + UNTRACKED DATA

TRACKED
UNTRACKED



E_γ (keV)

Thank you for your attention!!

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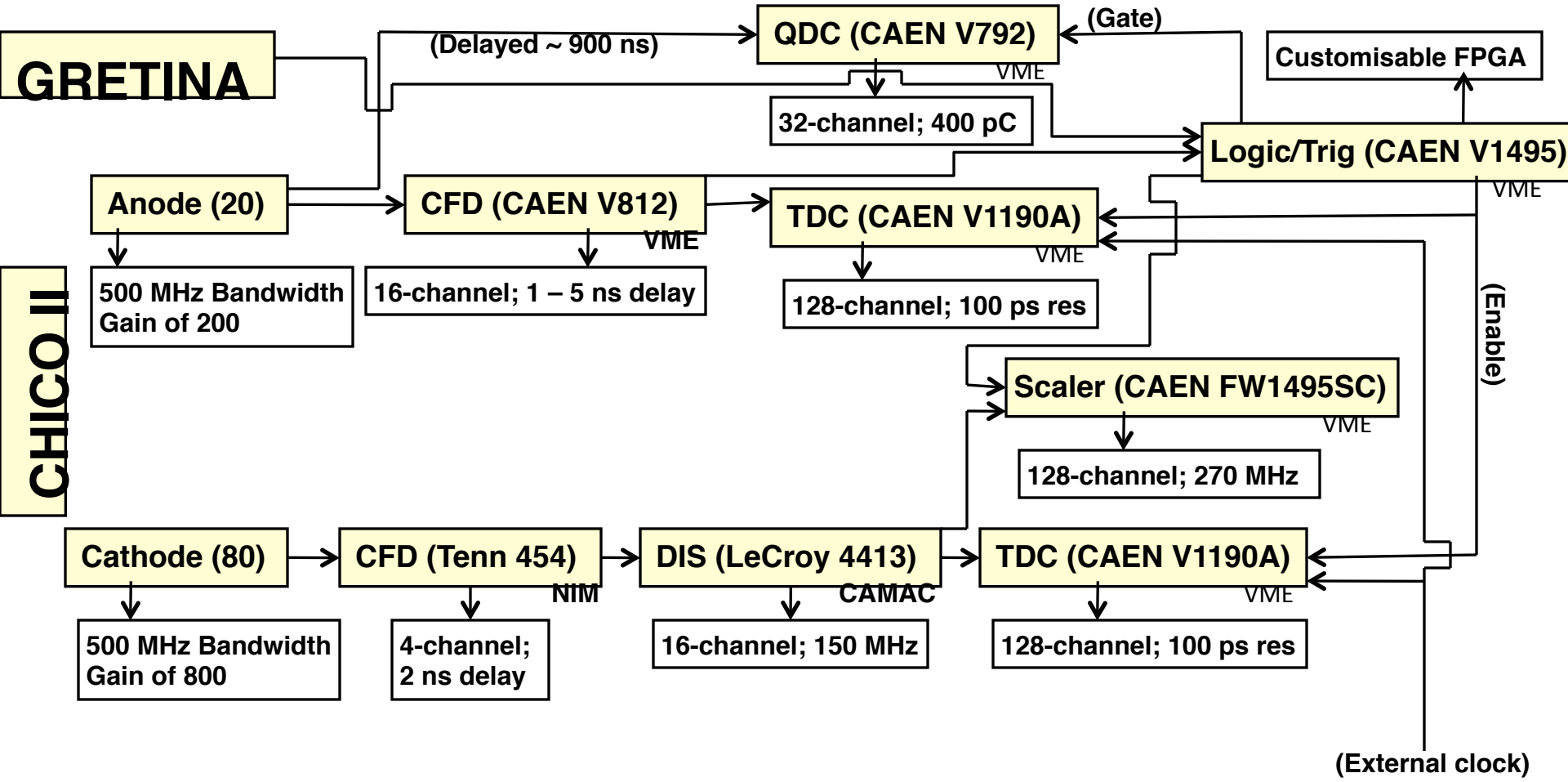
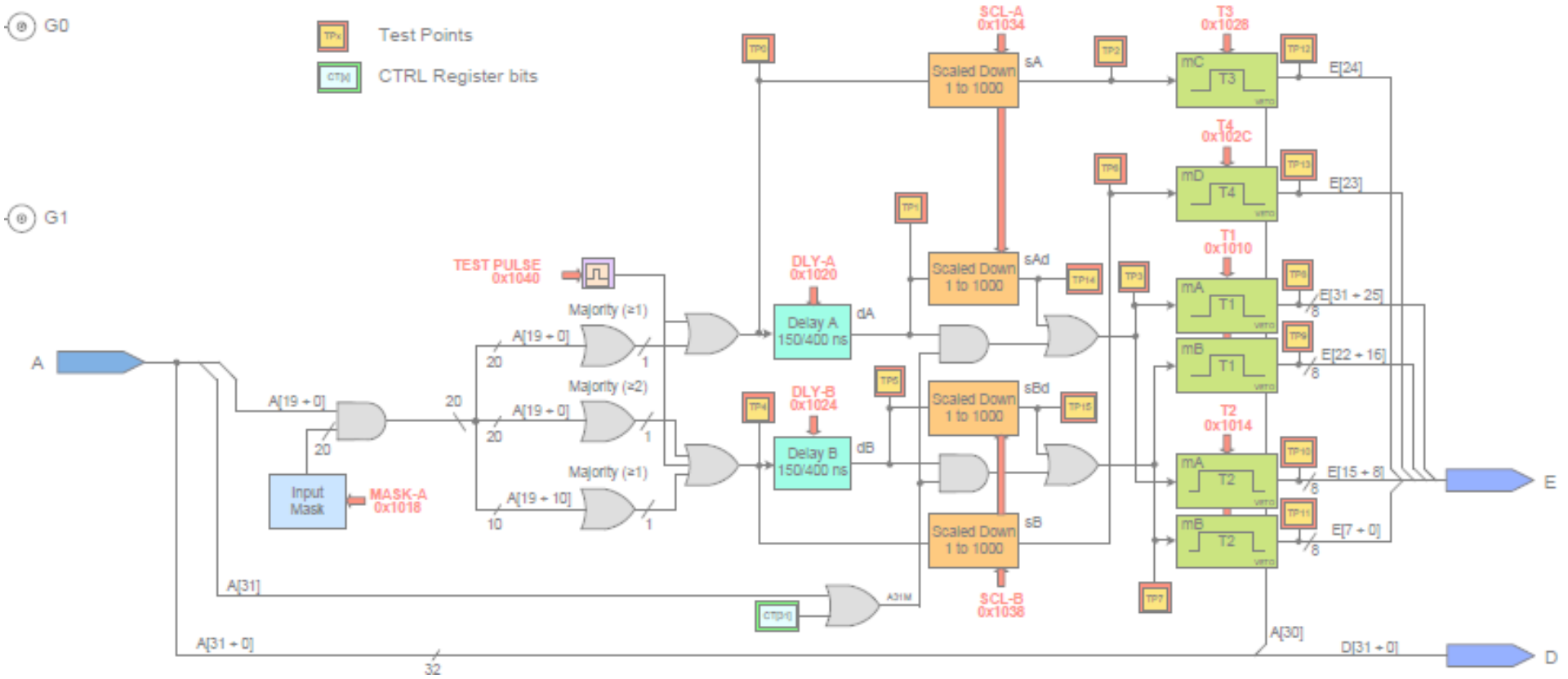
Proposed electronics diagram for CHICO II



Specifications for the firmware for V1495

- Inputs: 32 channels to group A from the outputs of V812 (Ch. 0 – 19) with the width ~ 50 ns and one gamma input (Ch. 31) with the width ~ 600 ns
- Outputs; no unnecessary delay
  1) All channels in group D are the duplication of the inputs to the scaler (FW1495SC)
  2) Channel 16 – 22 in group E are the fan-out outputs with the width ~ 50 ns when any one in the inputs is true. [Multiplicity(Ch. 0 – 19)>0]
  3) Channel 25 – 31 in group E are the fan-out outputs with the width ~ 50 ns when any two in first 20 inputs (Ch. 0 – 19) overlapped OR any one in the second10 inputs (Ch. 10 – 19) is true. [Multiplicity(Ch. 0 – 19 >=2 OR Multiplicity(Ch. 10 – 19 >0]
  4) Channel 0 – 7 in group E are the fan-out outputs with the width ~ 250 ns for the condition set in 2).
  5) Channel 8 – 15 in group E are the fan-out outputs with the width ~ 250 ns for the condition set in 3).
  6) In Group E, Ch. 23 is the particle single flag with the condition set in 2) and Ch. 24 is the particle single flag with the condition set in 3)

Firmware diagram



Species extracted so far…

- **Neutron-deficient isotopes**
  Cs, Xe, Te, Sb, Sn, In, Cd, Ag, Rh, Ru, Pd, Tc, Mo, Nb, Se, As, Ge, Ga, As, Zn, Co, Fe, V, Ti, K, Al, Mg, Na, O, C, B**
- **Neutron-rich isotopes**
  Nd*, Ce*, Pr*, La*, Ba*, Pm*, Sm*, Eu*, Gd*, Rh, Ru, Tc, Mo, Zr, Sr, Cs, Xe, I, Te, Sb, Sn, In, Li**

*Extracted as singly or doubly charged ions

** Extracted as molecules.