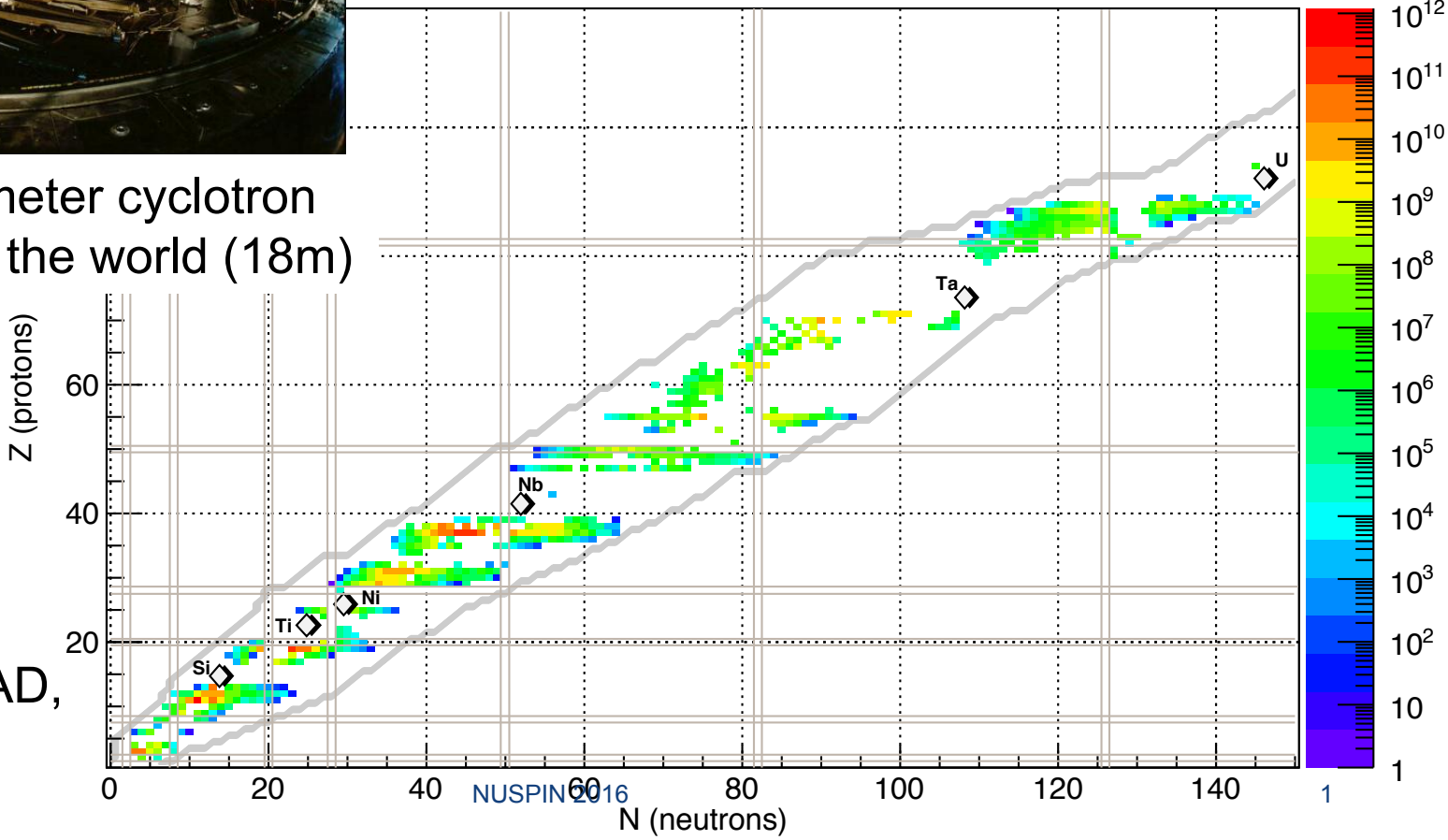
TRIUMF Isotope Separator and ACcelerator

Largest diameter cyclotron accelerator in the world (18m)

500MeV p^+ at 100μA on ISOL target

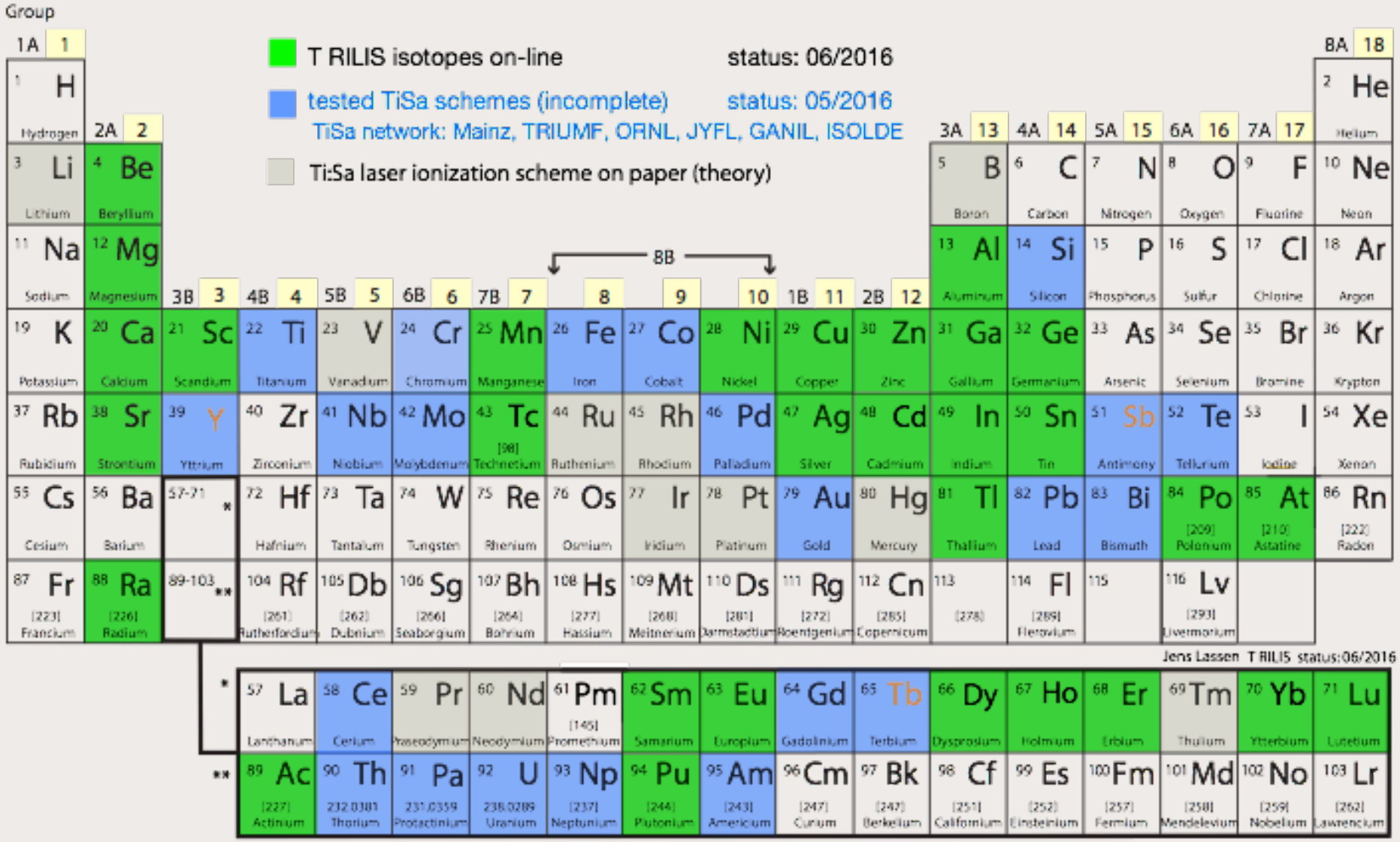
Yield Chart of Nuclides



Targets:
SiC, NiO, Nb, ZrC, Ta, Uc_x

Ion sources:
Surface, FEBIAD, IG-LIS

TRIUMF Resonant Ionization Laser Ion Source



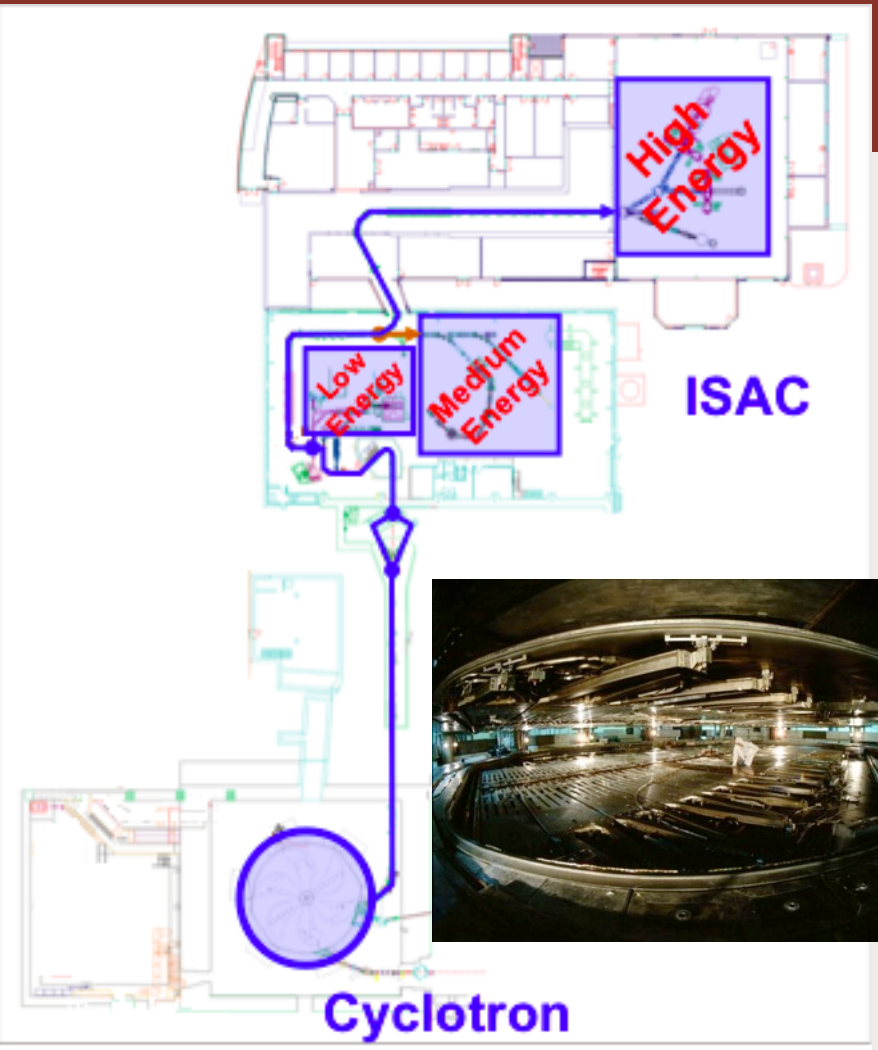
TRIUMF-ISAC

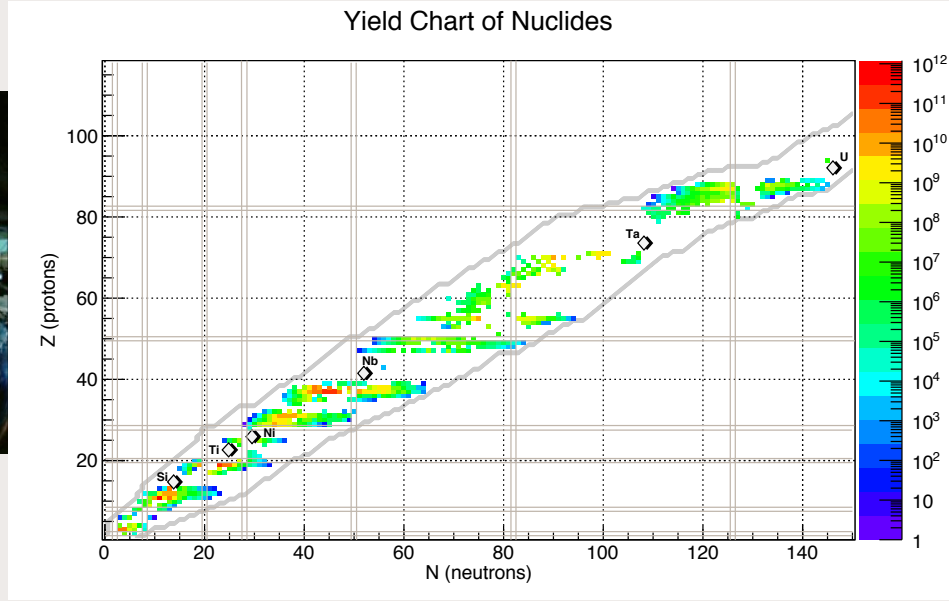
Isotope Separator and ACcelerator

1 RIB delivery to experiments

500MeV p^+ at 100μA on ISOL target

SiC, NiO, Nb, ZrC, Ta, UC_x Targets
Surface, FEBIAD, IG-LIS ion sources





ISAC-I Low-Energy <60keV — Ground state + decay, material science
ISAC-I Medium E <1.5MeV/u — Astrophysics
ISAC-II SC LINAC <10MeV/u — Nuclear reactions and structure

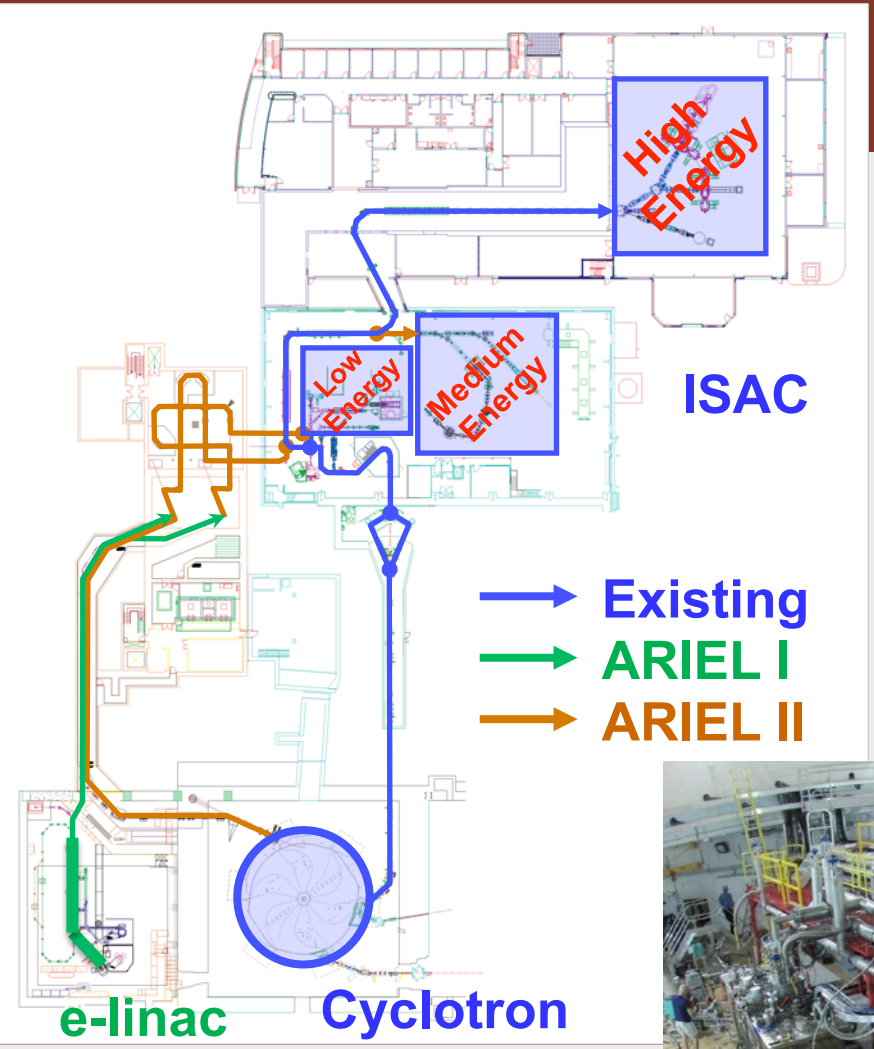
TRIUMF-ARIEL

Advanced Rare-IsotopE Laboratory

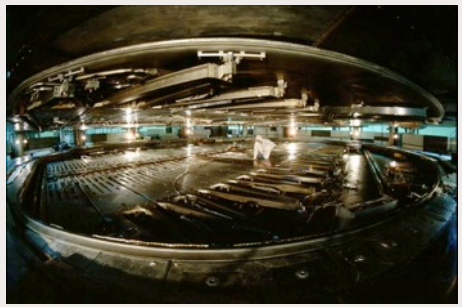
1 RIB ➔ 3 simultaneous RIBs

ARIEL Project:

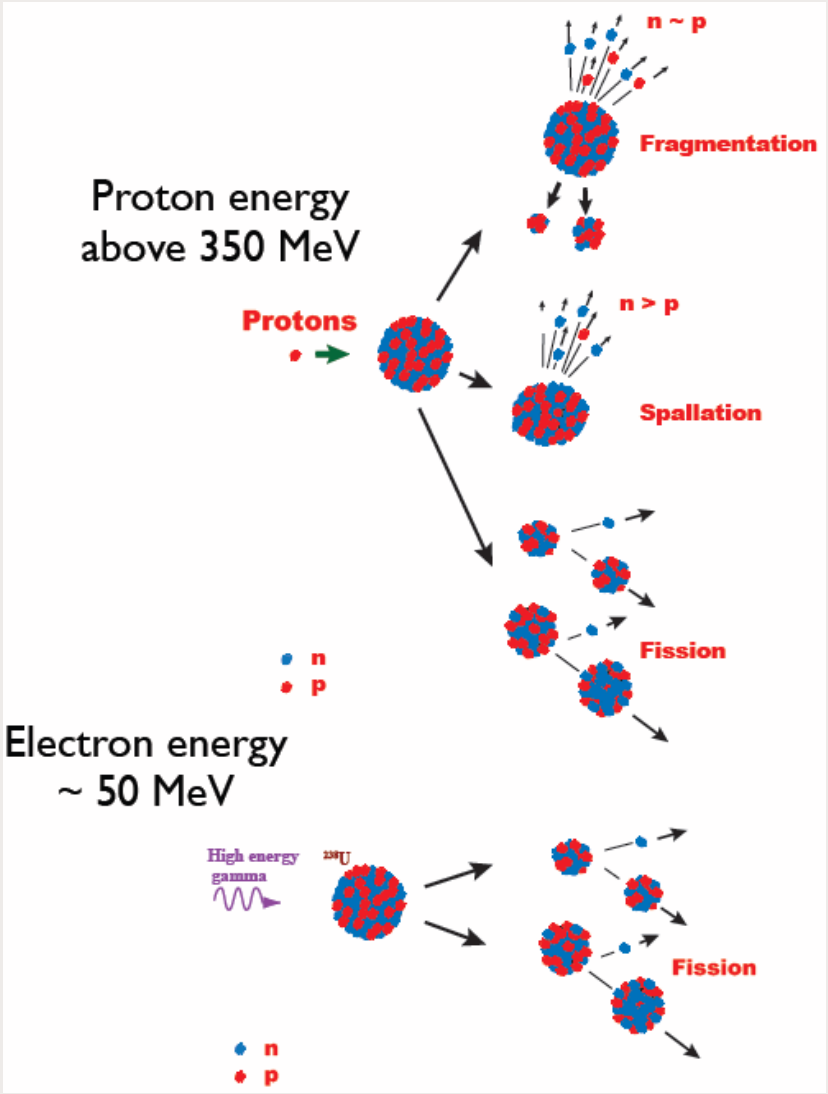
- new electron linac driver for photo-fission
- new target stations and front end
- new proton beamline

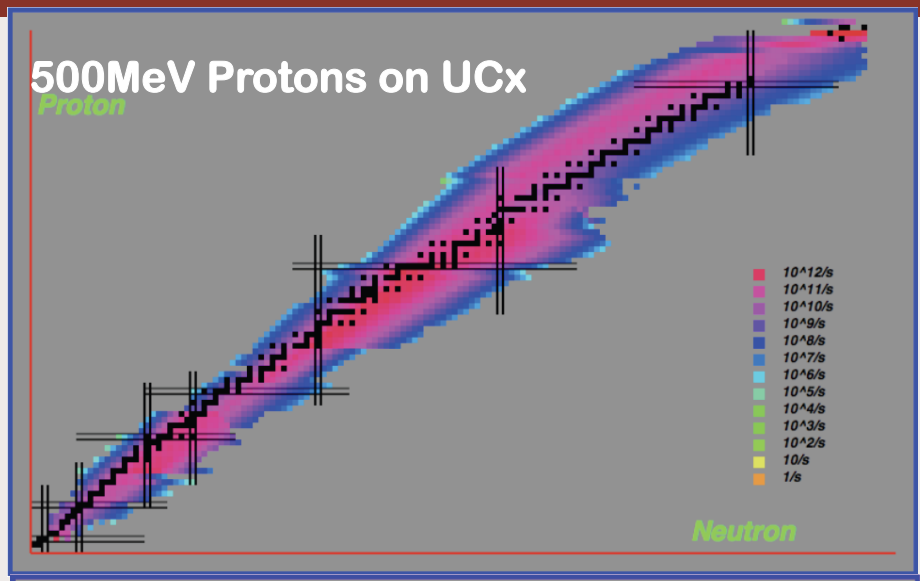


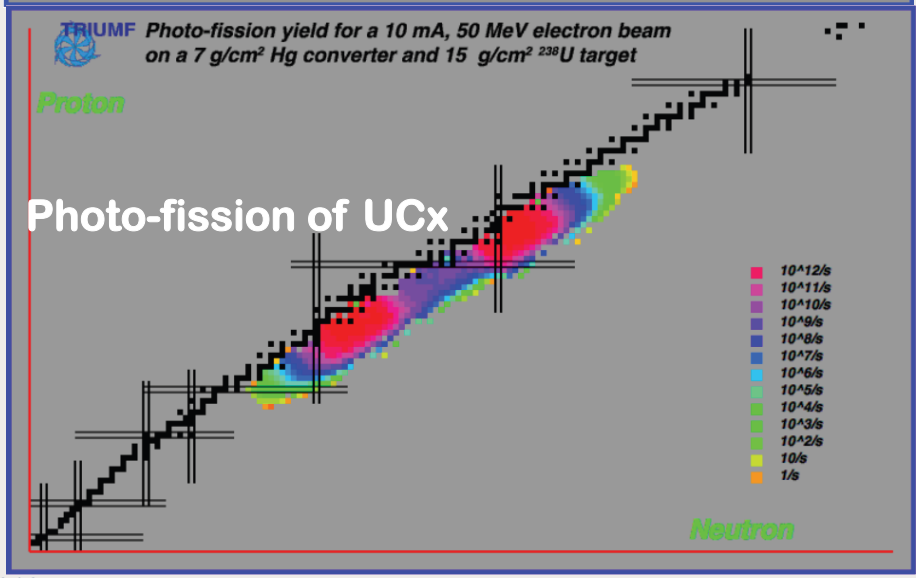
E-linac and electron beamline
Sept. 2014



ARIEL


n ~ p
Fragmentation
Proton energy
above 350 MeV
Protons
n > p
Spallation
Fission
n
p
Electron energy
~ 50 MeV
High energy
gamma
238U
Fission
n
p

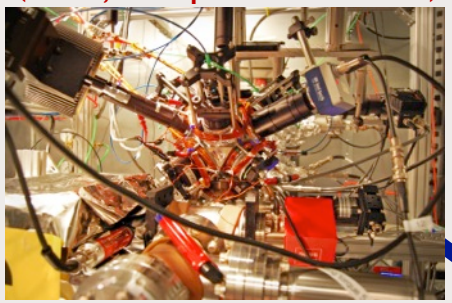

500MeV Protons on UCx
Proton
Neutron
10^12/s
10^11/s
10^10/s
10^9/s
10^8/s
10^7/s
10^6/s
10^5/s
10^4/s
10^3/s
10^2/s
10/s
1/s


TRIUMF Photo-fission yield for a 10 mA, 50 MeV electron beam
on a 7 g/cm² Hg converter and 15 g/cm² 238U target
Proton
Photo-fission of UCx
Neutron
10^12/s
10^11/s
10^10/s
10^9/s
10^8/s
10^7/s
10^6/s
10^5/s
10^4/s
10^3/s
10^2/s
10/s
1/s

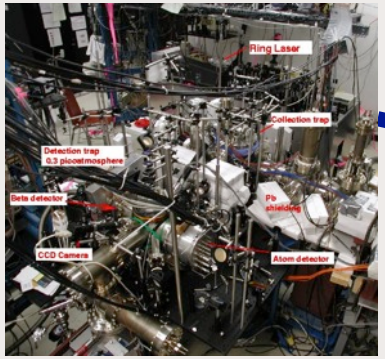
ISAC experimental areas

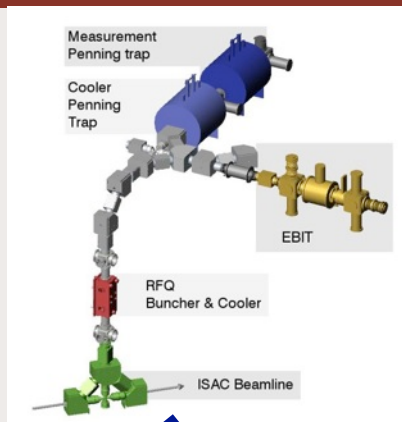
Low energy
< 60 keV

FRANCIUM MOT
(PNC, anapole moment)



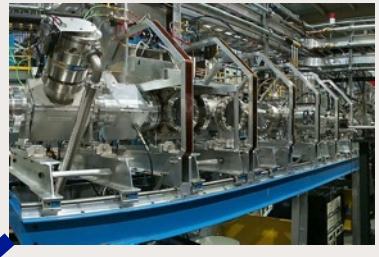
TRINAT
Neutral Atom Trap
(βν-neutrino correlations)

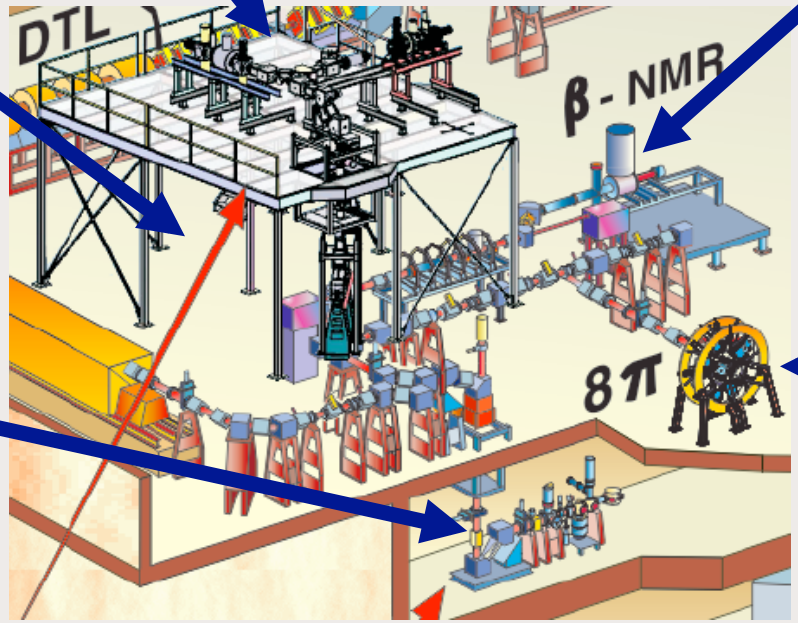




TITAN
Penning Traps
(masses,
in-trap decay)

Polarizer beamline
Laser spectroscopy, MTV
CPT test, betaNMR



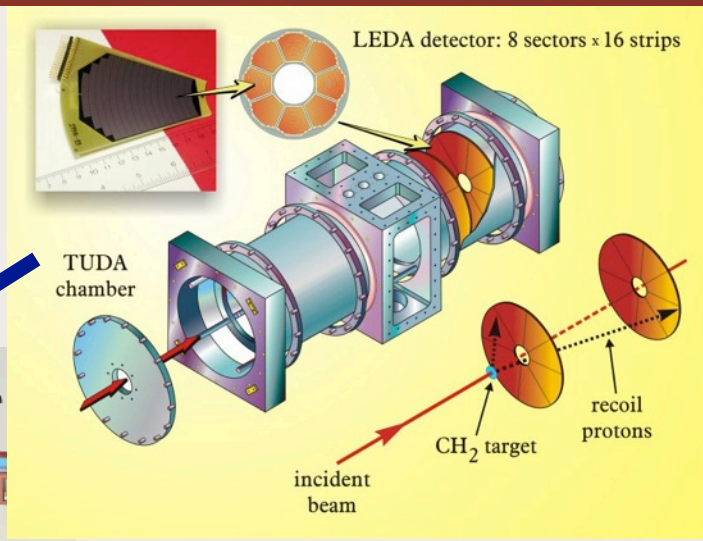


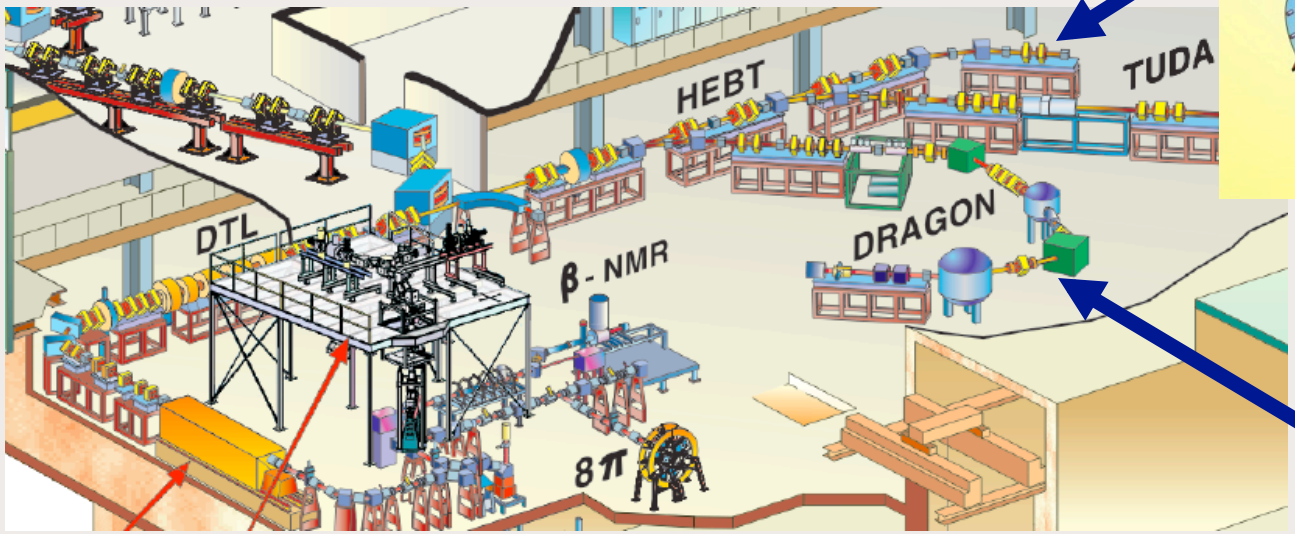
Gamma & Electron spectrometer
(decay spectroscopy,
superallowed decays)

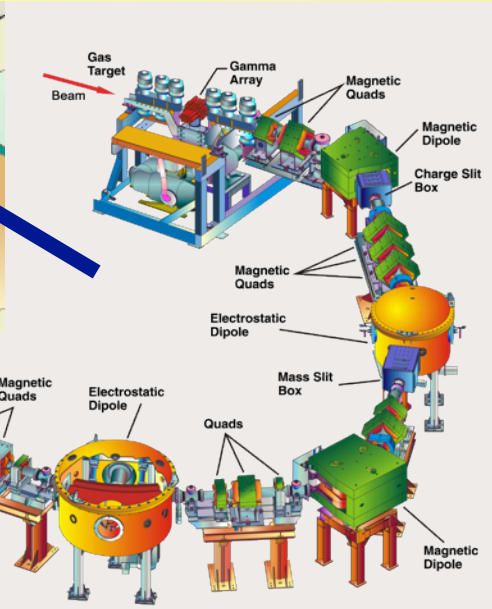
ISAC experimental areas

medium energy
~ 0.15 -1.7 AMeV

TUDA
Astrophysical charged particle reactions







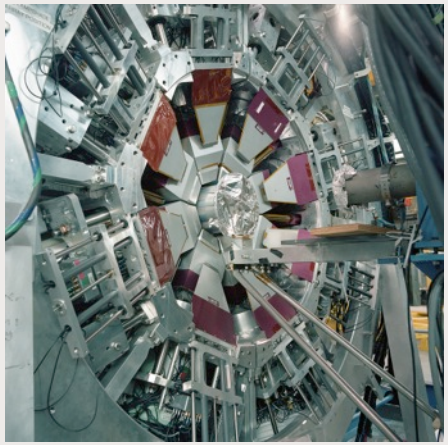
DRAGON
Astrophysical capture reactions

ISAC experimental areas

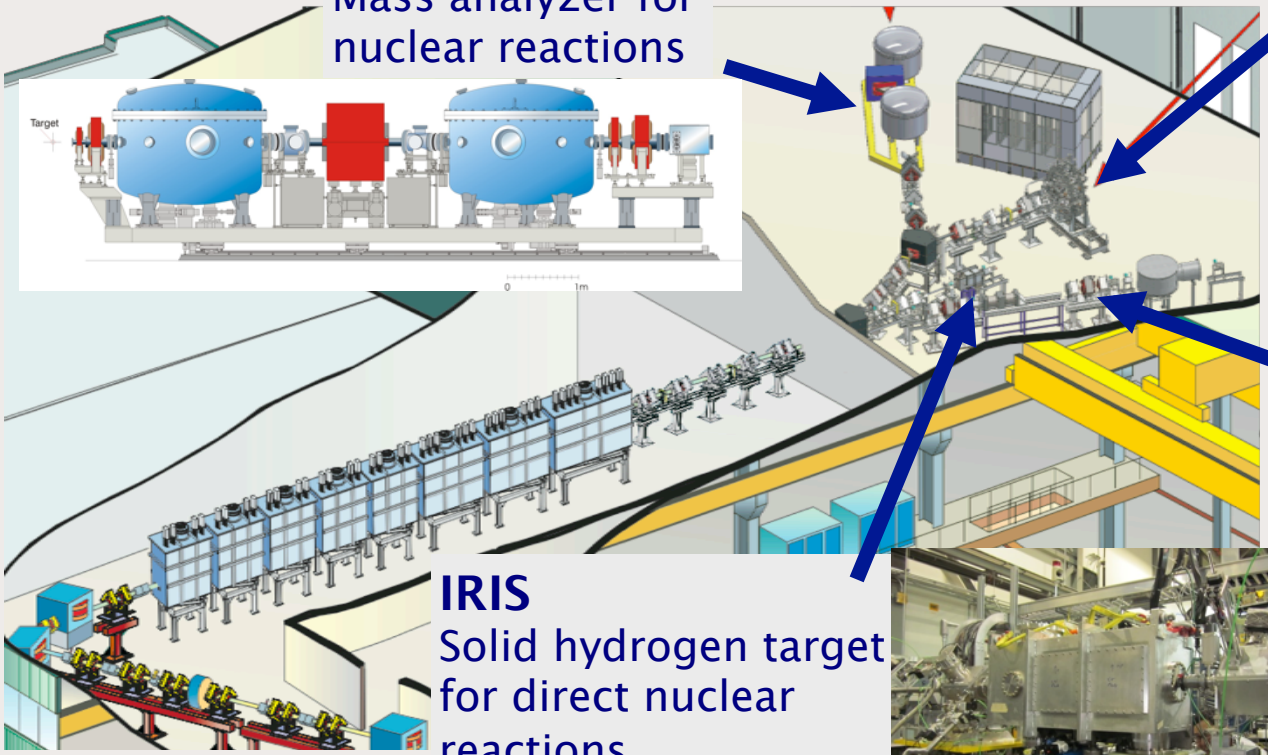
high energy
> 6 AMeV for A < 150

TIGRESS + auxiliary detectors

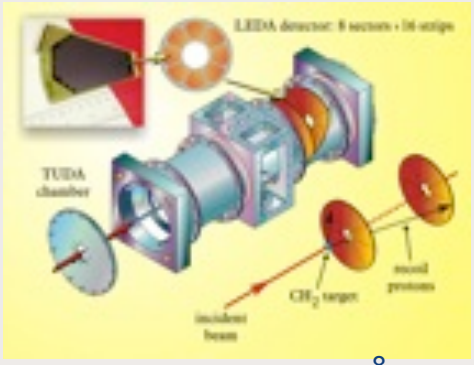
Clover ɣ-ray spectrometer
in-beam spectroscopy
nuclear reactions



EMMA (2016)
Mass analyzer for
nuclear reactions

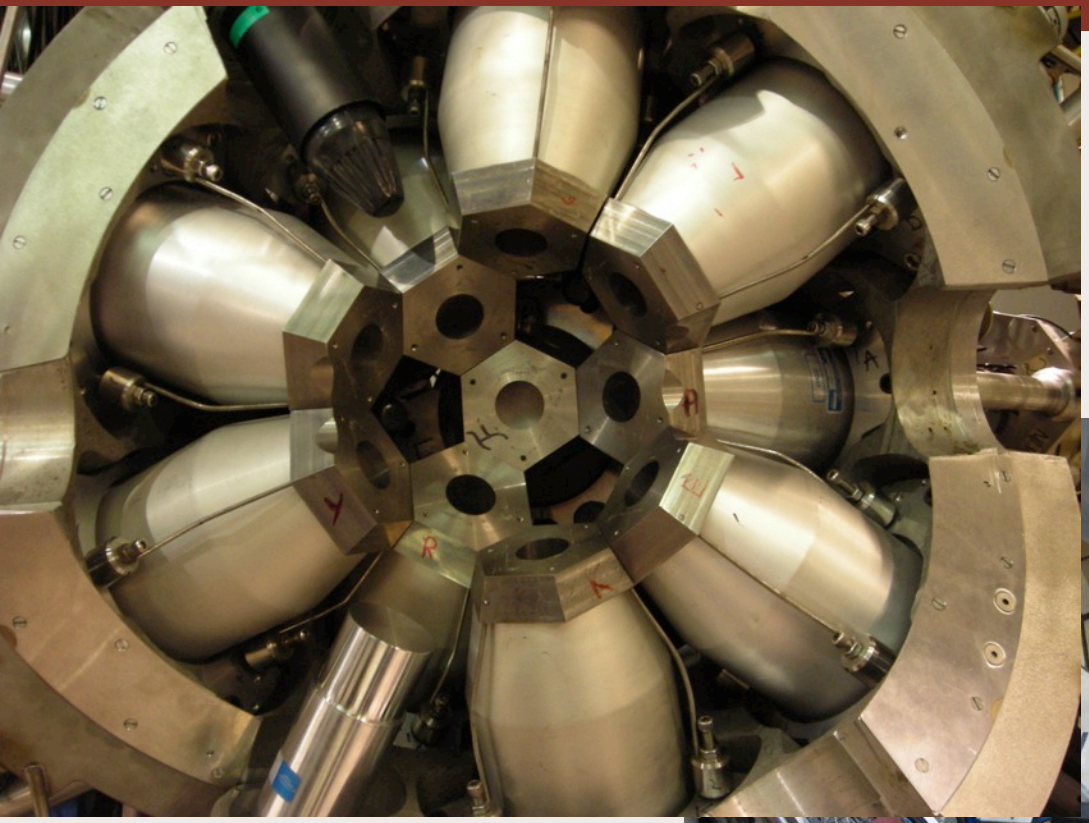


TUDA
Scattering array
for direct reactions

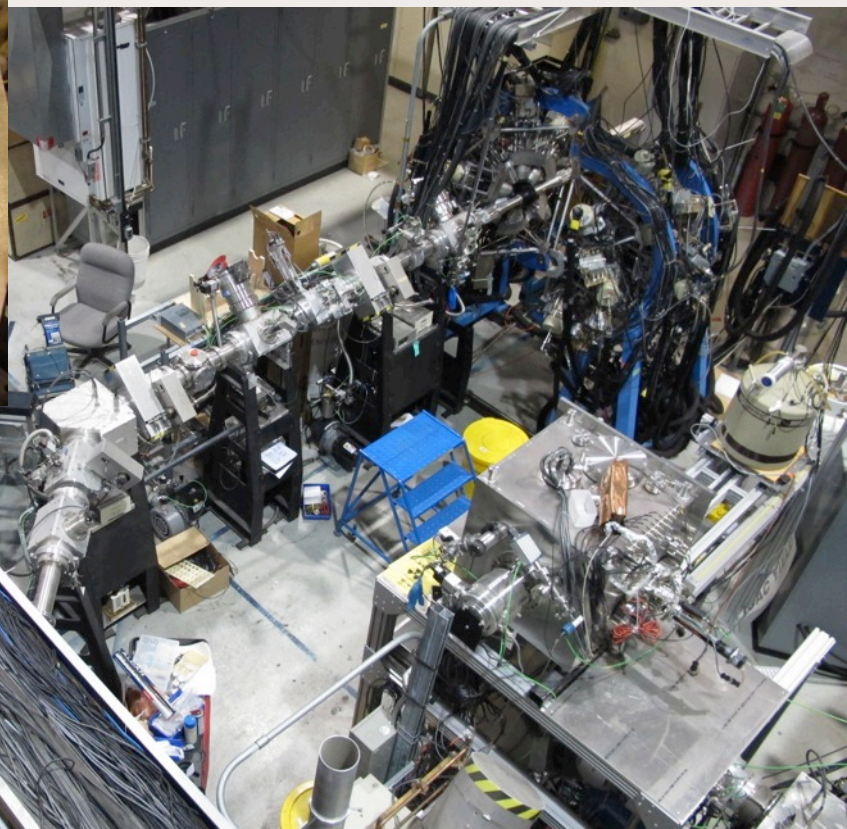


IRIS
Solid hydrogen target
for direct nuclear
reactions

The 8π Spectrometer



Performed decay spectroscopy at TRIUMF-ISAC-I from 2000 to 2013



Researchers from 24 institutions from 8 countries.

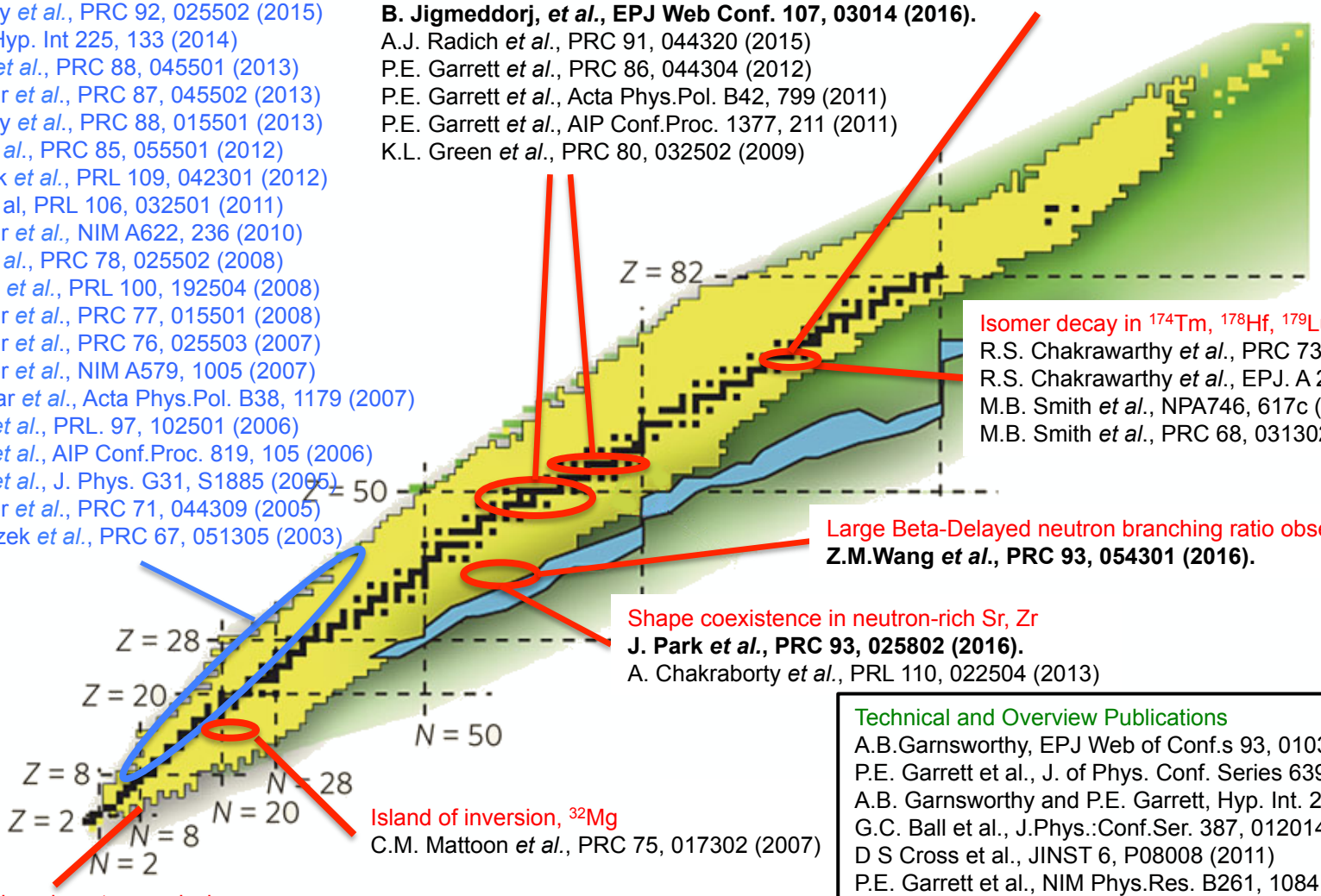
25 post-docs,
5PhD, 12MSc, 1MPhys
12 Grad. Students in progress

The 8π Spectrometer at TRIUMF-ISAC

Superallowed/Mirror Beta Decay
^{10}C, ^{14}O,^{18}Ne, ^{19}Ne, ^{26m}Al, ^{38m}K, ^{62}Ga, ^{74}Rb
M.R. Dunlop et al, PRL. 116, 172501 (2016).
A.T. Laffoley *et al.*, PRC 92, 025502 (2015)
G.C. Ball, Hyp. Int 225, 133 (2014)
R. Dunlop *et al.*, PRC 88, 045501 (2013)
G.F. Grinyer *et al.*, PRC 87, 045502 (2013)
A.T. Laffoley *et al.*, PRC 88, 015501 (2013)
P. Finlay *et al.*, PRC 85, 055501 (2012)
S. Triambak *et al.*, PRL 109, 042301 (2012)
P. Finlay et al, PRL 106, 032501 (2011)
G.F. Grinyer *et al.*, NIM A622, 236 (2010)
P. Finlay *et al.*, PRC 78, 025502 (2008)
K.G. Leach *et al.*, PRL 100, 192504 (2008)
G.F. Grinyer *et al.*, PRC 77, 015501 (2008)
G.F. Grinyer *et al.*, PRC 76, 025503 (2007)
G.F. Grinyer *et al.*, NIM A579, 1005 (2007)
E.F. Zganyar *et al.*, Acta Phys.Pol. B38, 1179 (2007)
B. Hyland *et al.*, PRL. 97, 102501 (2006)
B. Hyland *et al.*, AIP Conf.Proc. 819, 105 (2006)
B. Hyland *et al.*, J. Phys. G31, S1885 (2005)
G.F. Grinyer *et al.*, PRC 71, 044309 (2005)
A. Piechaczek *et al.*, PRC 67, 051305 (2003)

High-statistics studies of Cd, Sn, Xe
B. Jigmeddorj *et al.*, Eur. Phys. J. A 52, 36 (2016).
B. Jigmeddorj, *et al.*, EPJ Web Conf. 107, 03014 (2016).
A.J. Radich *et al.*, PRC 91, 044320 (2015)
P.E. Garrett *et al.*, PRC 86, 044304 (2012)
P.E. Garrett *et al.*, Acta Phys.Pol. B42, 799 (2011)
P.E. Garrett *et al.*, AIP Conf.Proc. 1377, 211 (2011)
K.L. Green *et al.*, PRC 80, 032502 (2009)

Half Life of geochronometer, ^{176}Lu
G.F. Grinyer *et al.*, PRC 67, 014302 (2003)



Isomer decay in ^{174}Tm, ^{178}Hf, ^{179}Lu
R.S. Chakrawarthy *et al.*, PRC 73, 024306 (2006)
R.S. Chakrawarthy *et al.*, EPJ. A 25, S1, 125 (2005)
M.B. Smith *et al.*, NPA746, 617c (2004)
M.B. Smith *et al.*, PRC 68, 031302 (2003)

Large Beta-Delayed neutron branching ratio observed from ^{102}Rb
Z.M.Wang *et al.*, PRC 93, 054301 (2016).

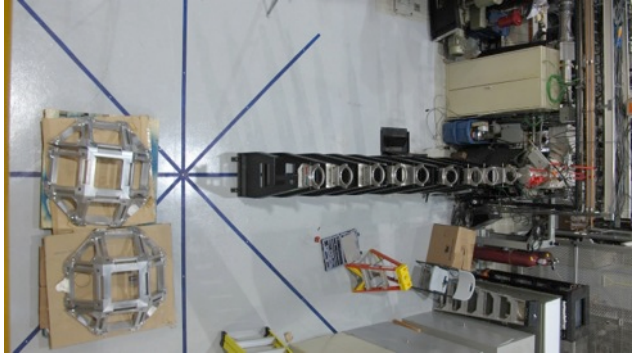
Shape coexistence in neutron-rich Sr, Zr
J. Park *et al.*, PRC 93, 025802 (2016).
A. Chakraborty *et al.*, PRL 110, 022504 (2013)

Island of inversion, ^{32}Mg
C.M. Mattoon *et al.*, PRC 75, 017302 (2007)

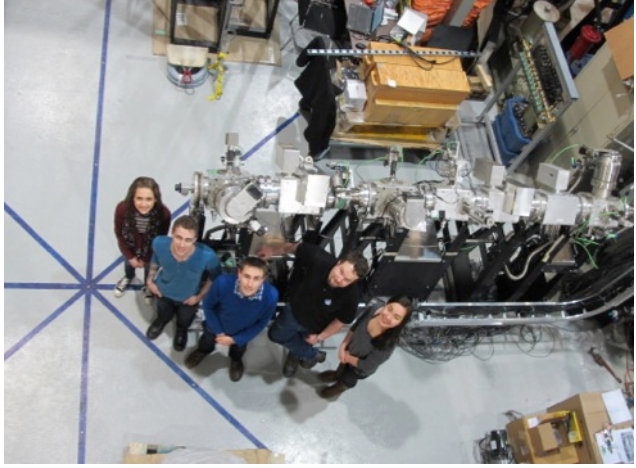
^{11}Li beta-delayed neutron emission
C.M. Mattoon *et al.*, PRC 80, 034318 (2009)
F. Sarazin *et al.*, PRC 70, 031302 (2004)

Technical and Overview Publications
A.B.Garnsworthy, EPJ Web of Conf.s 93, 01032 (2015)
P.E. Garrett et al., J. of Phys. Conf. Series 639, 012006 (2015).
A.B. Garnsworthy and P.E. Garrett, Hyp. Int. 225, 121 (2014)
G.C. Ball et al., J.Phys.:Conf.Ser. 387, 012014 (2012)
D S Cross et al., JINST 6, P08008 (2011)
P.E. Garrett et al., NIM Phys.Res. B261, 1084 (2007)
G.C. Ball et al., J.Phys.(London) G31, S1491 (2005)
S.J. Williams et al., J.Phys.(London) G31, S1979 (2005)
C.E. Svensson et al., NIM Phys. Res. B204, 660 (2003)

Jan →

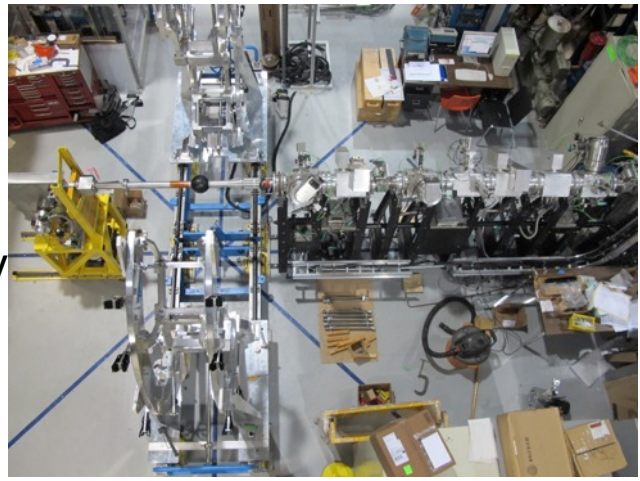


Feb →



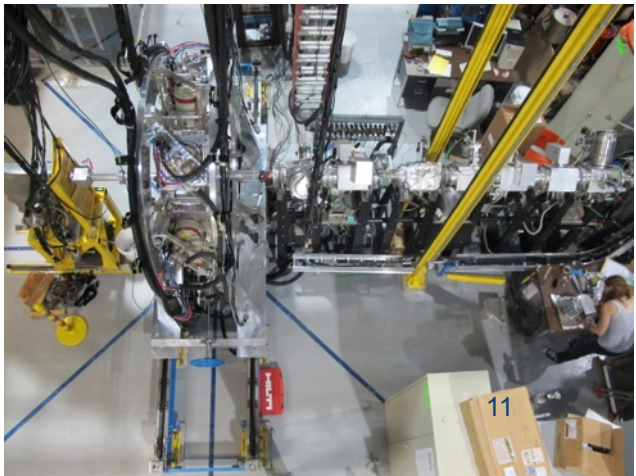
Apr ↓

GRIFFIN Installation in 2014



May ↓

First RIB 24th Sept 2014

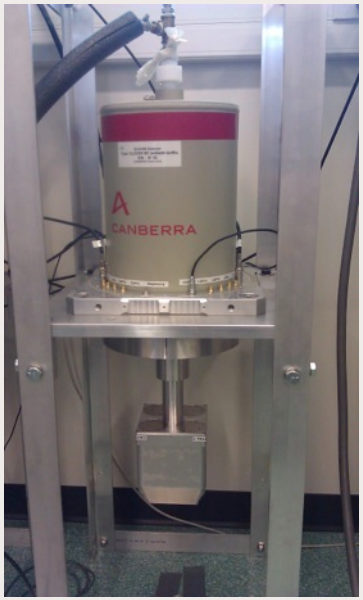


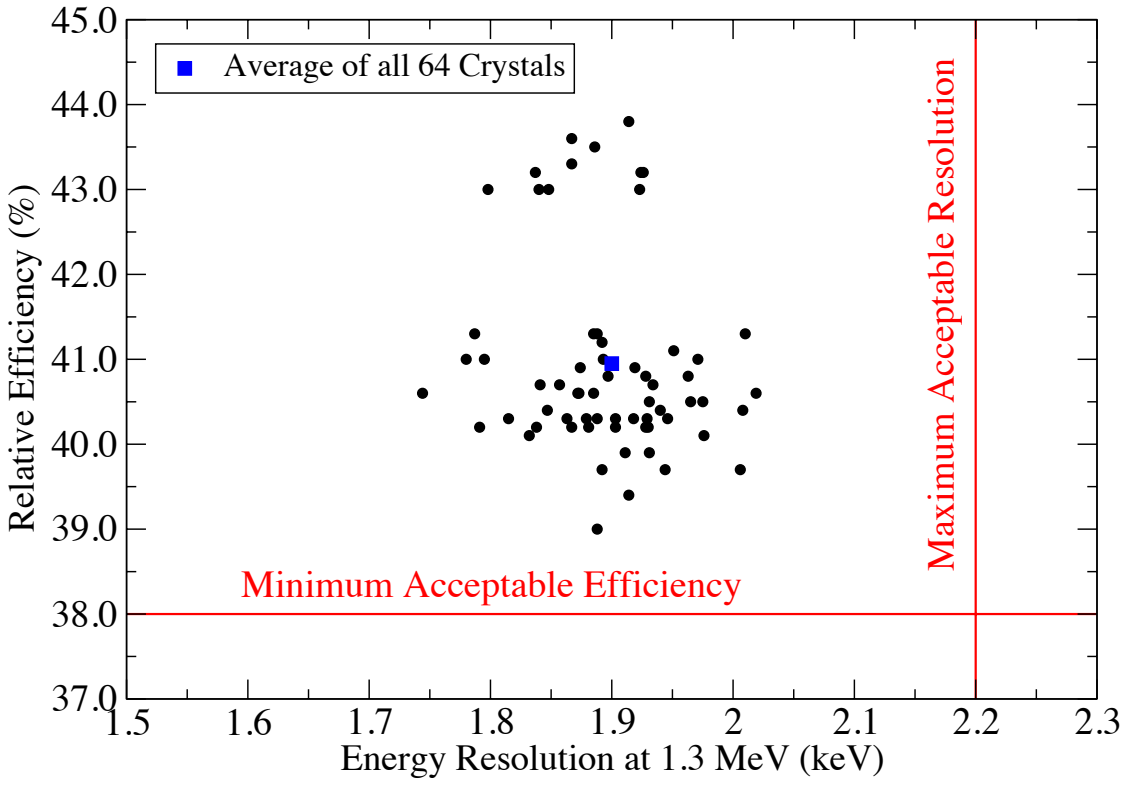
July

GRIFFIN HPGe Clover Detectors

All sixteen GRIFFIN clovers fully accepted

Average Performance of all 64 crystals:
Energy resolution@ 121keV = 1.12(6) keV
Energy resolution@ 1.3MeV = 1.89(6) keV
Photo-peak Rel. Eff. @ 1.3MeV = 41(1) %





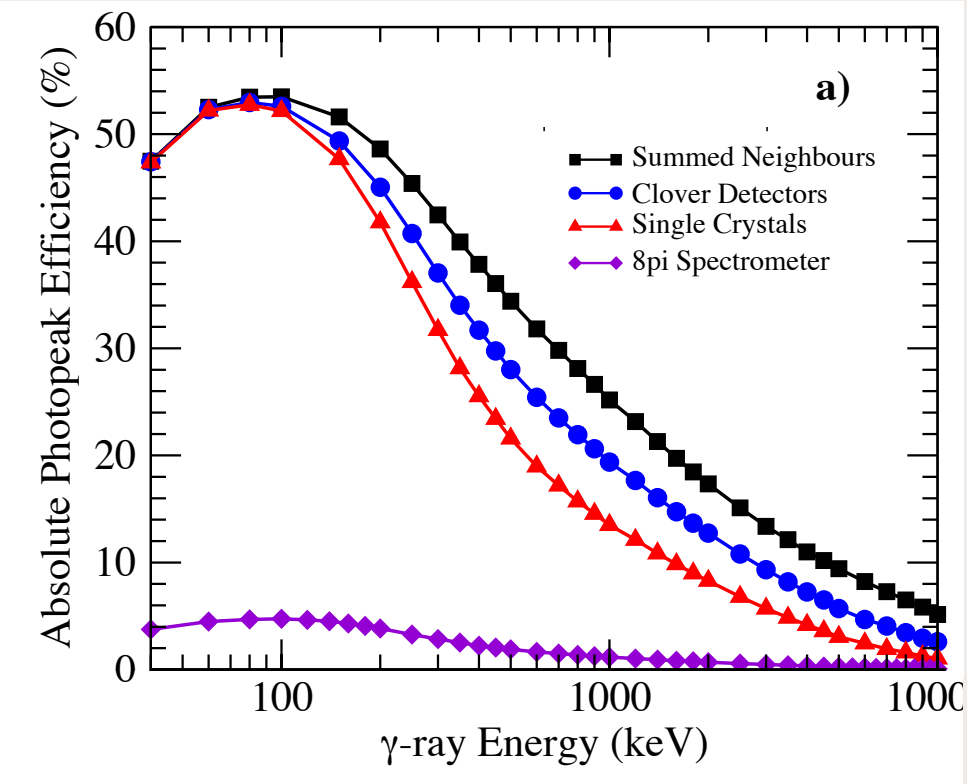
Testing performed at SFU

Dec 2012	4 Accepted
April 2013	8 Accepted
Jan 2014	9 Accepted
May 2014	13 Accepted
Oct 2014	16 Accepted

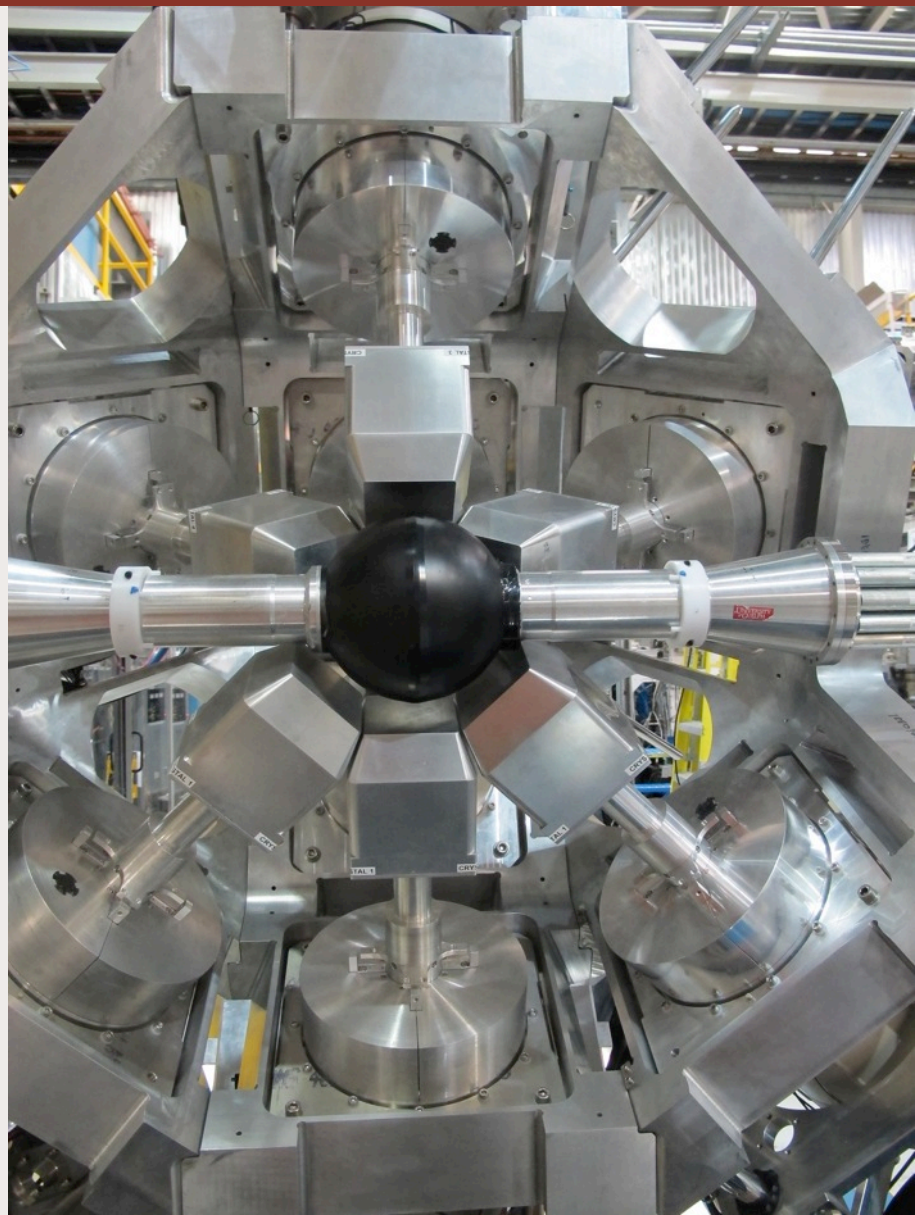
6 months ahead of schedule

GRIFFIN HPGe Clover Detectors

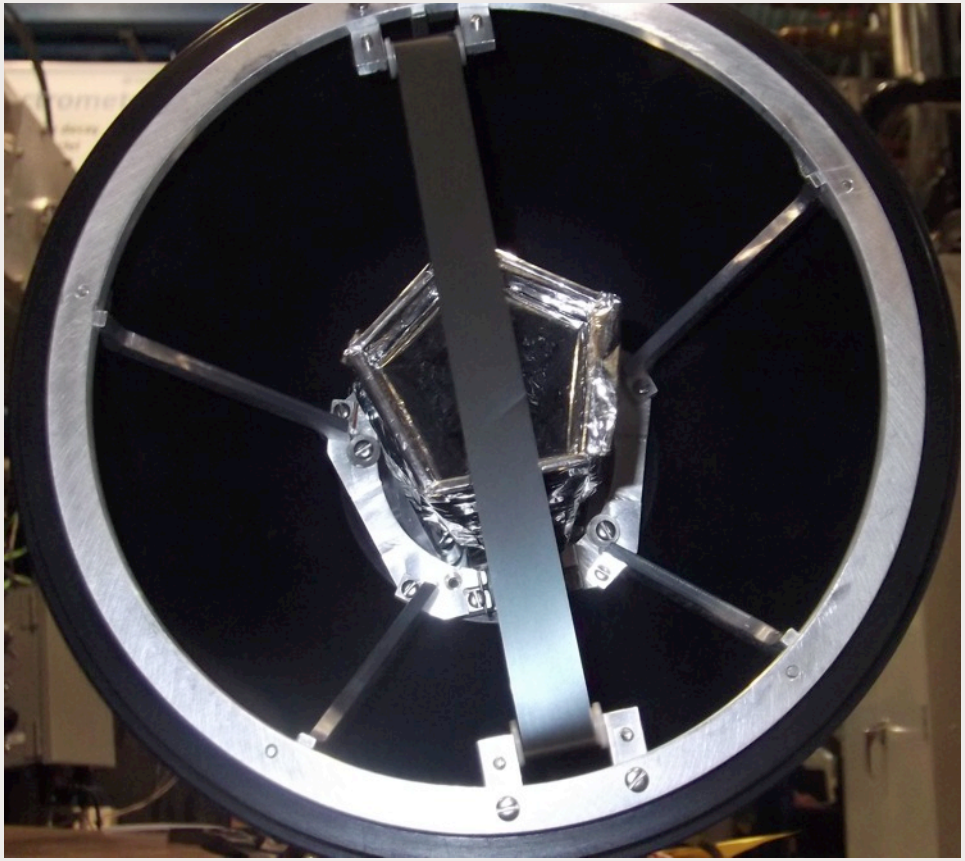
A close-packed array of
16 large-volume HPGe
Clover detectors, 64 crystals



4096 crystal pairs at 52 unique angles
for γ-γ angular correlations

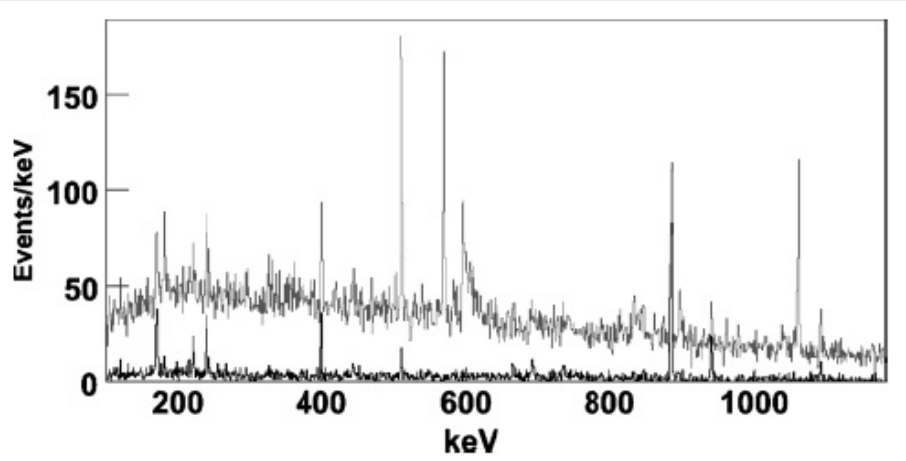


SCEPTAR
SCintillating Electron-Positron Tagging ARray



-Two hemispheres of 10 plastic scintillators

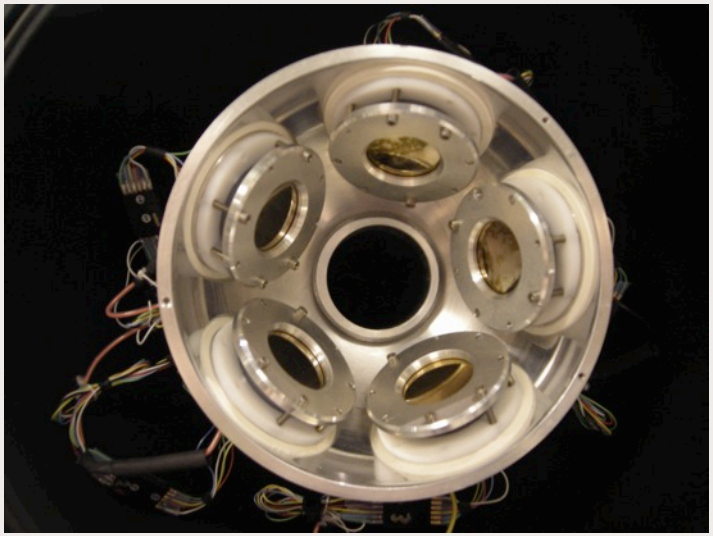
-Detect beta particles with ~80% solid angle coverage



C.M.Mattoon et al., PRC75, 017302 (2007)

PACES

Pentagonal Array for Conversion Electron Spectroscopy

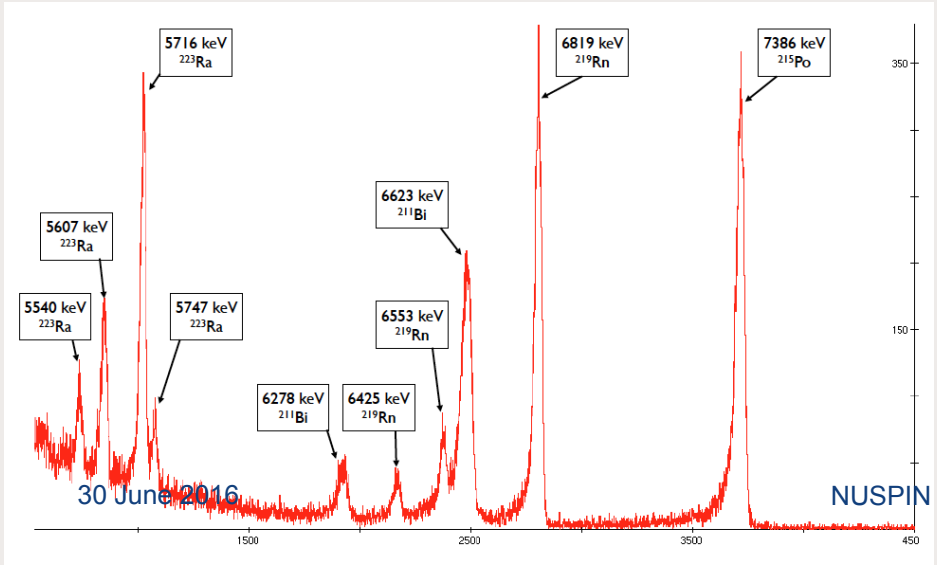


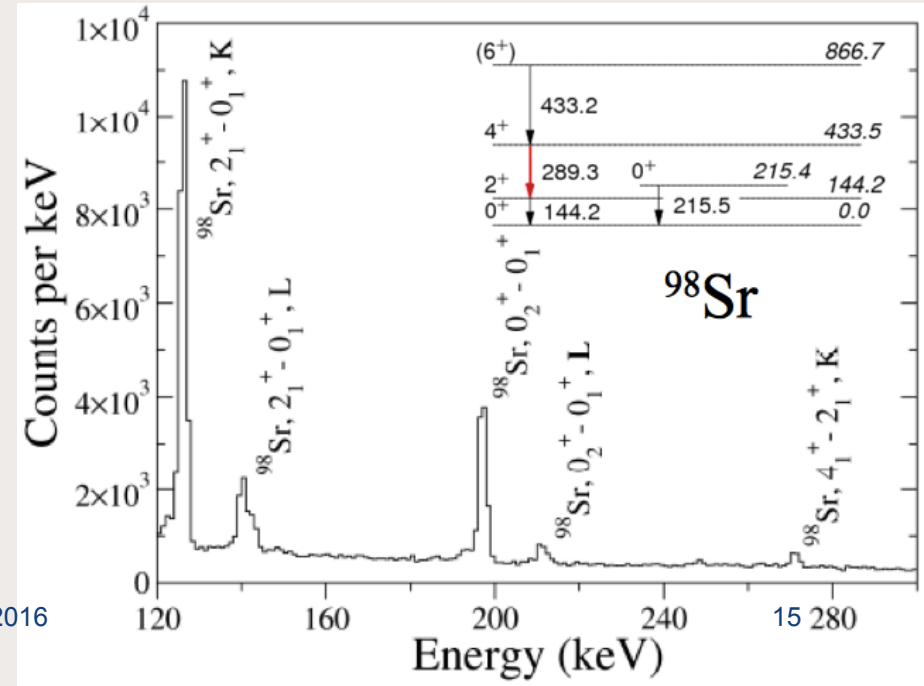
Five 5mm thick, 200mm^2 Si(Li)

LN_2-cooled Si diode and FET

Solid angle coverage: 1.4% each, 7% total

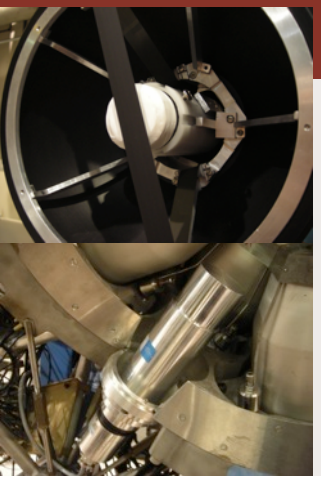
~2keV resolution for electrons
Dual-Gain data readout – electron, alpha

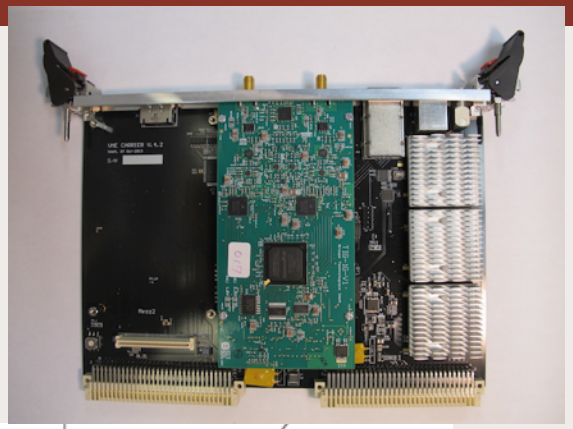




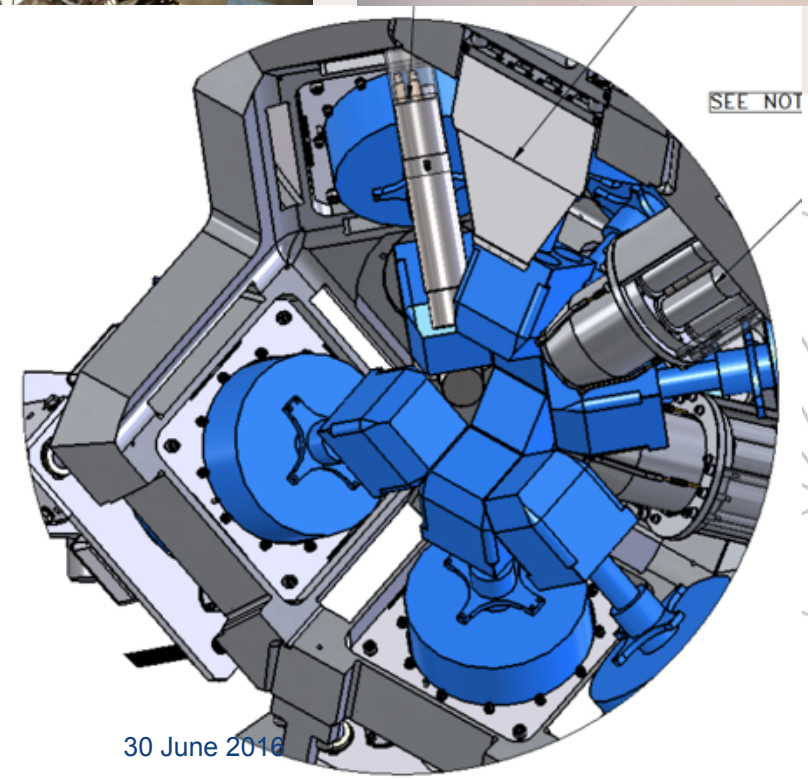
$LaBr_3$

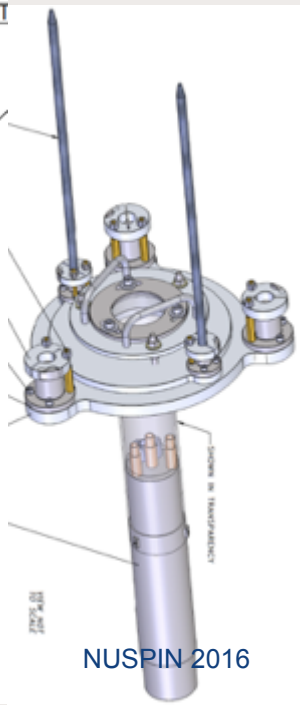
Fast-Scintillator Array for Excited-State Lifetime Timing

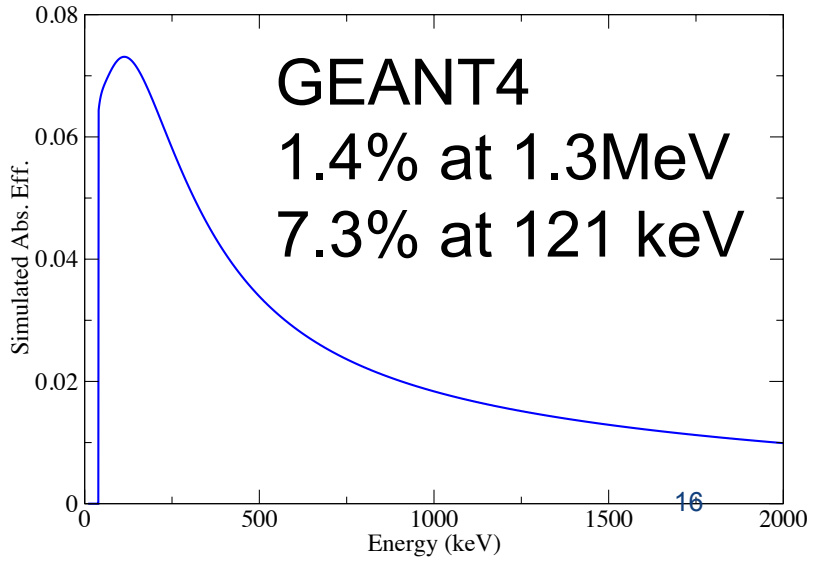




- Eight $LaBr_3$(Ce) 2”x2” cylindrical crystal
- Source-detector distance=12.5 cm.
- GEANT4 simulated efficiency 1.4%@1.3MeV
- LaBr-LaBr FWHM <200 ps achieved in 8pi analogue electronics
- Fast Zero-degree scintillator for β-γ timing. BC422Q = 0.7ns

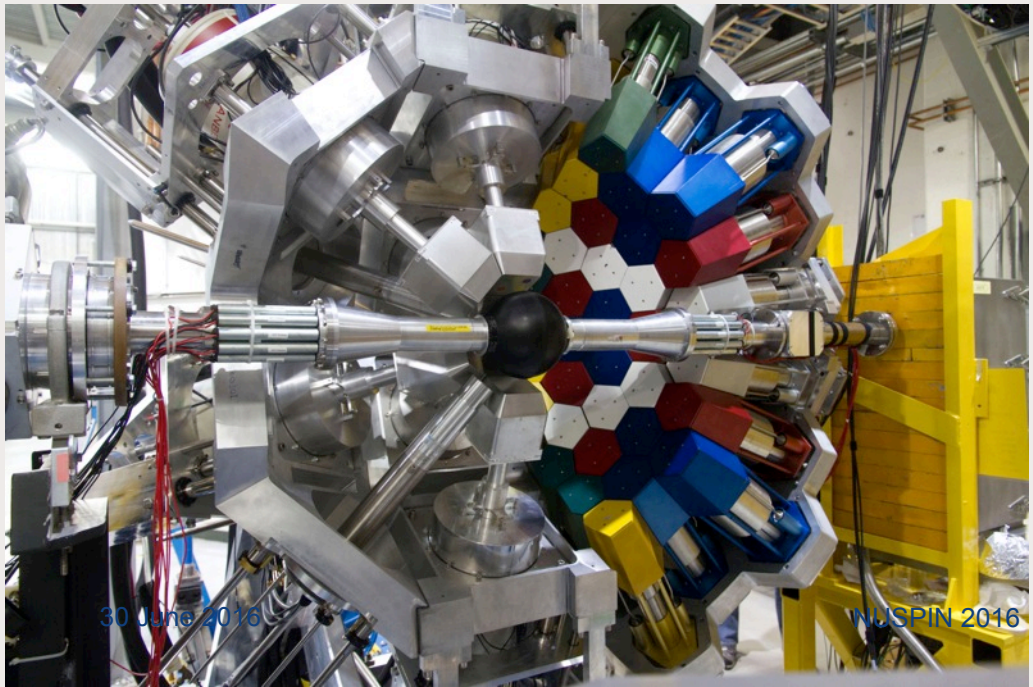


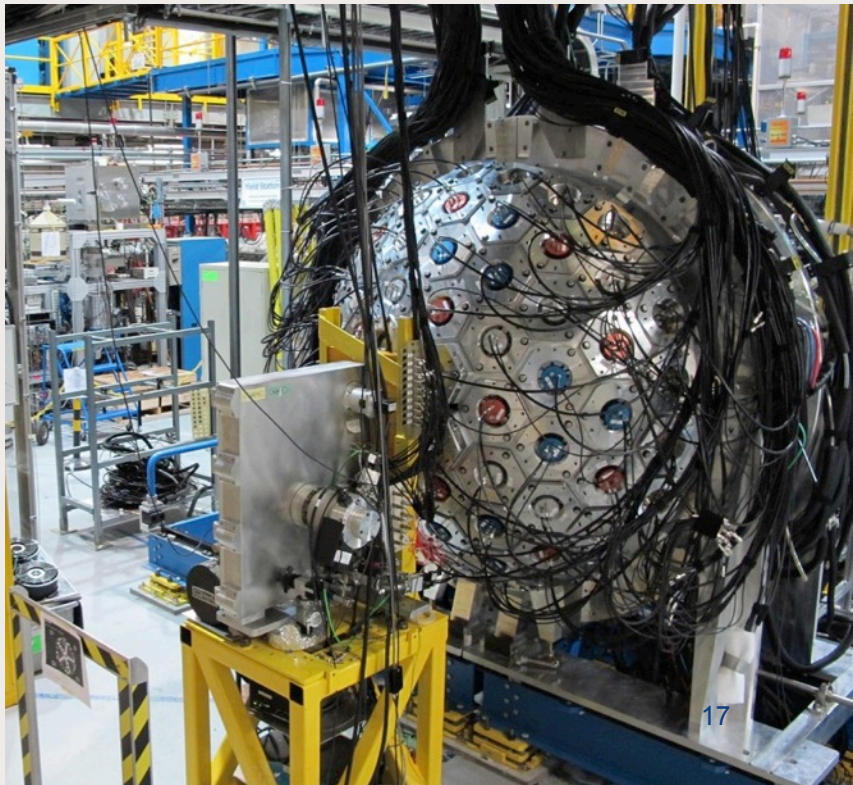


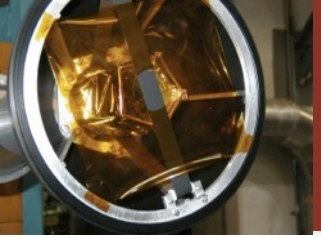


GRIFFIN+DESCANT

- 70 element array of deuterated scintillator for neutron detection
- Enables beta-gamma-ICE-neutron spectroscopy
- ~1π solid angle
- Neutron energy from time-of-flight (50cm flight path)
- Online neutron-gamma discrimination
- Commissioning to be completed in 2016.







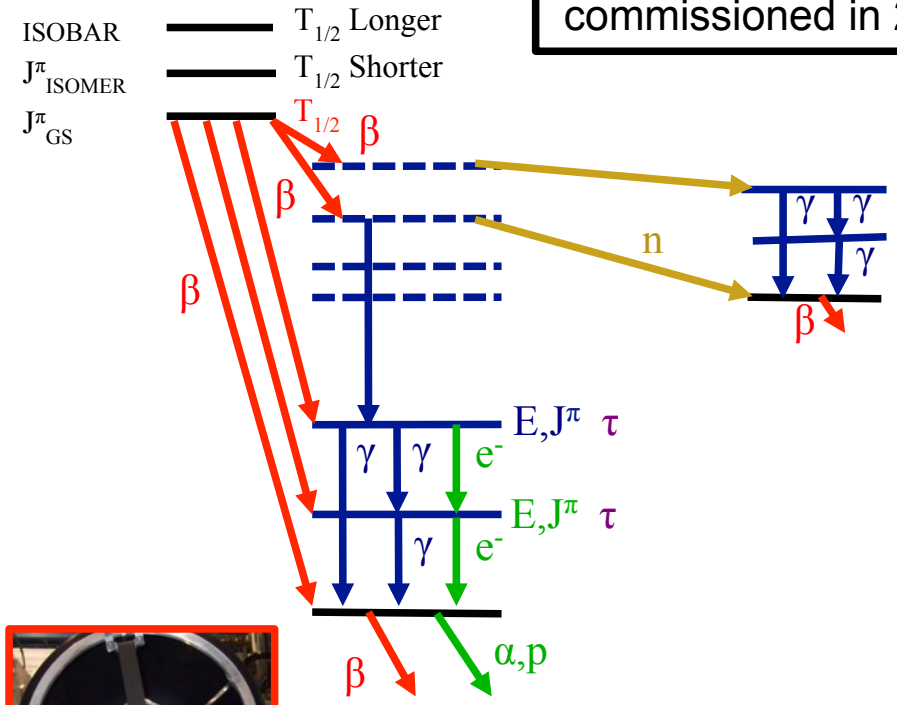
GRIFFIN

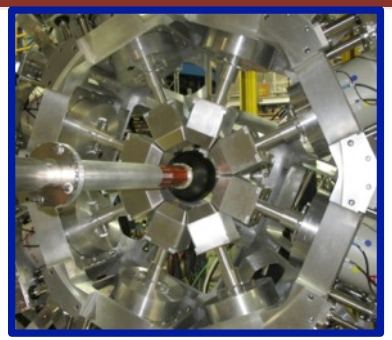
GRIFFIN Facility at TRIUMF
Sensitive Decay Spectroscopy

Fast, in-vacuum tape system

Enhances decay of interest

Initial operation in fall 2014. Fully commissioned in 2015



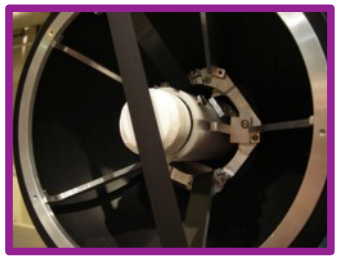


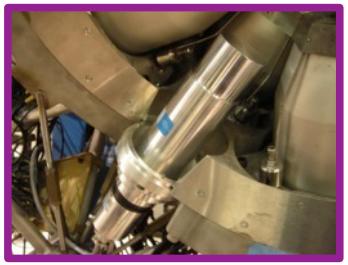
HPGe: 16 Clovers

Detect gamma rays and determines branching ratios, multipolarities and mixing ratios

$LaBr_3$: 8 $LaBr_3$

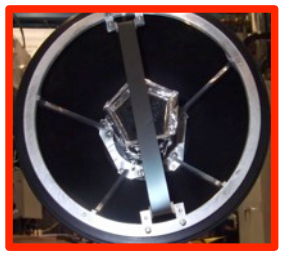
Fast-timing of photons to measure level lifetimes





Zero-Degree Fast scintillator

Fast-timing signal for betas



SCEPTAR: 10+10 plastic scintillators

Detects beta decays and determines branching ratios

DESCANT Neutron array

Detects neutrons to measure beta-delayed neutron branching ratios

PACES: 5 Cooled Si(Li)s

Detects Internal Conversion Electrons and alphas/protons

GRIFFIN DAQ System

Custom Digital Electronics Modules designed and built by TRIUMF and Universite de Montreal

Programmable Logic Pulse Generator

32 Channels
NIM or TTL

Clock Distribution Module

10MHz Atomic Clock
Low-jitter fan-out to all modules

GRIF-16 Module

16 chans
100MHz,
14bit

GRIF-4G Module

4 chans
1GHz,
14bit

Master and Collector Module

- 625MB/s link to each digitizer
- 1.25Gb/s link to data storage.

GRIFFIN DAQ System

Custom Digital Electronics Modules designed and built by TRIUMF and Universite de Montreal

High data through-put:

Each crystal running at 50kHz

300MB/s of filtered data, 1TB per hour

≈ 5×10^9 gamma-gamma coincidences/hour

…to enable ultra-high-statistics studies

High accountability:

Accurate deadtime knowledge

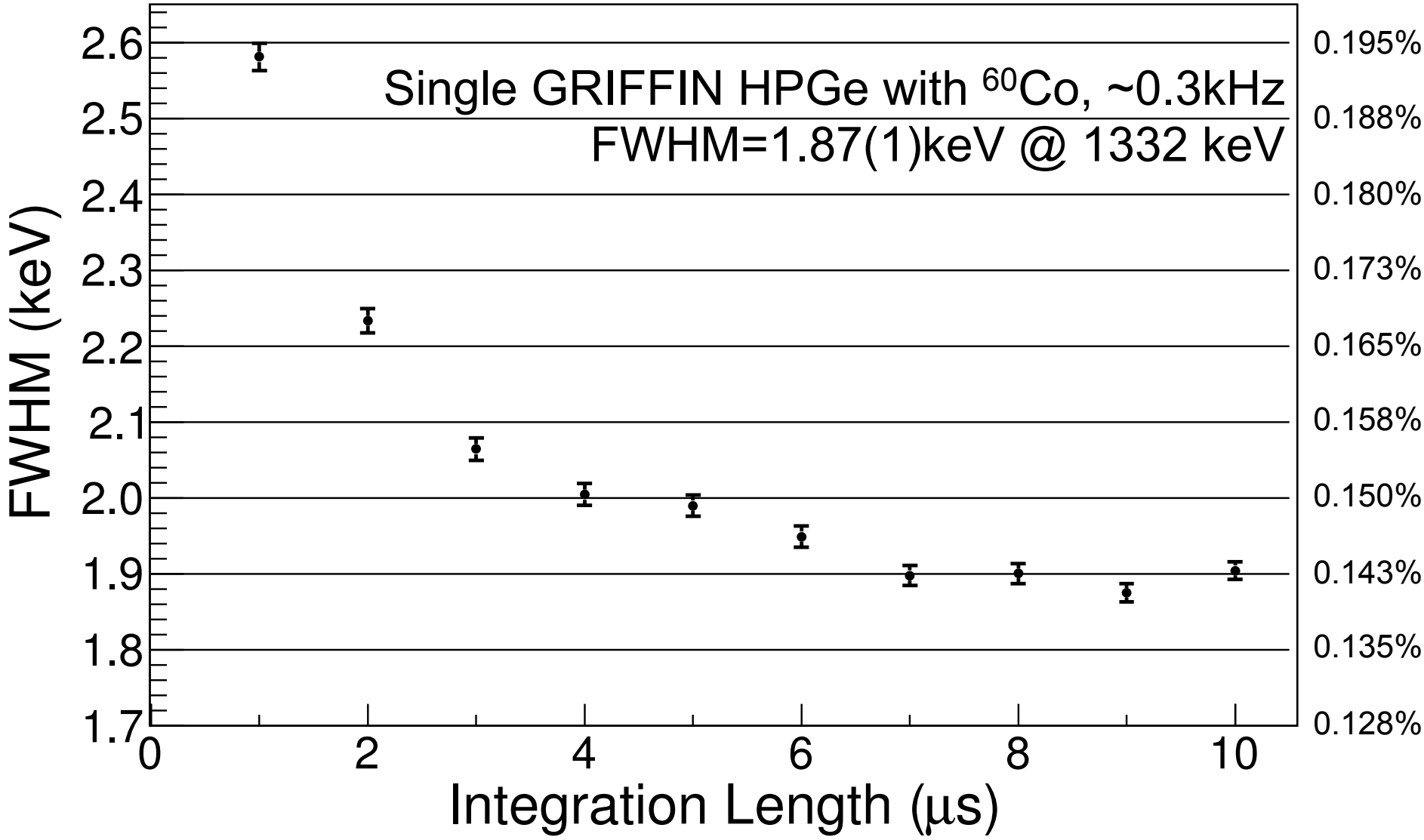
Pile-up handling

Event traceability from threshold crossing to disk

…to enable high-precision half-life/BR measurements

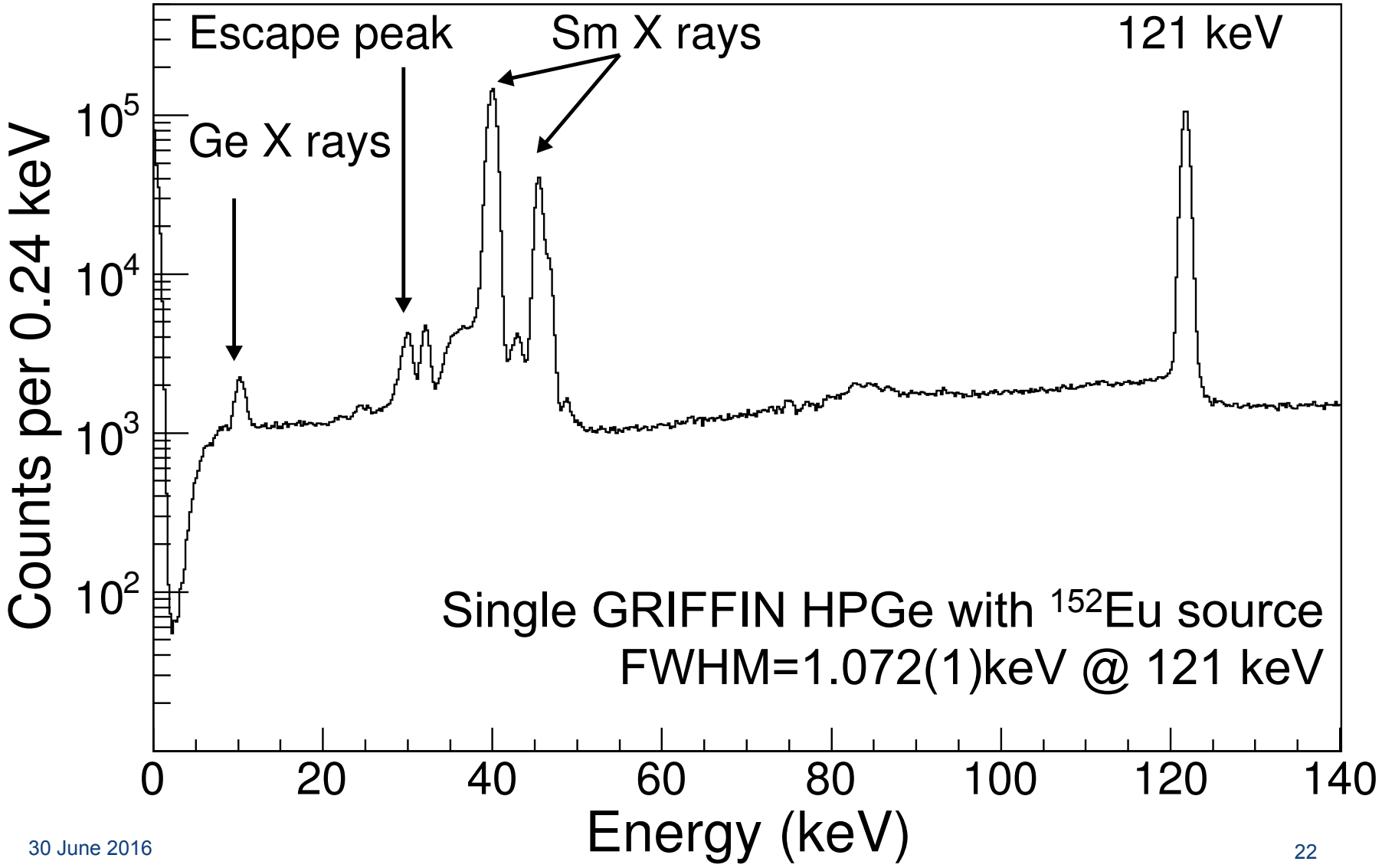
Excellent Energy Resolution

A.B. Garnsworthy *et al., In preparation for NIM A*, (2016).

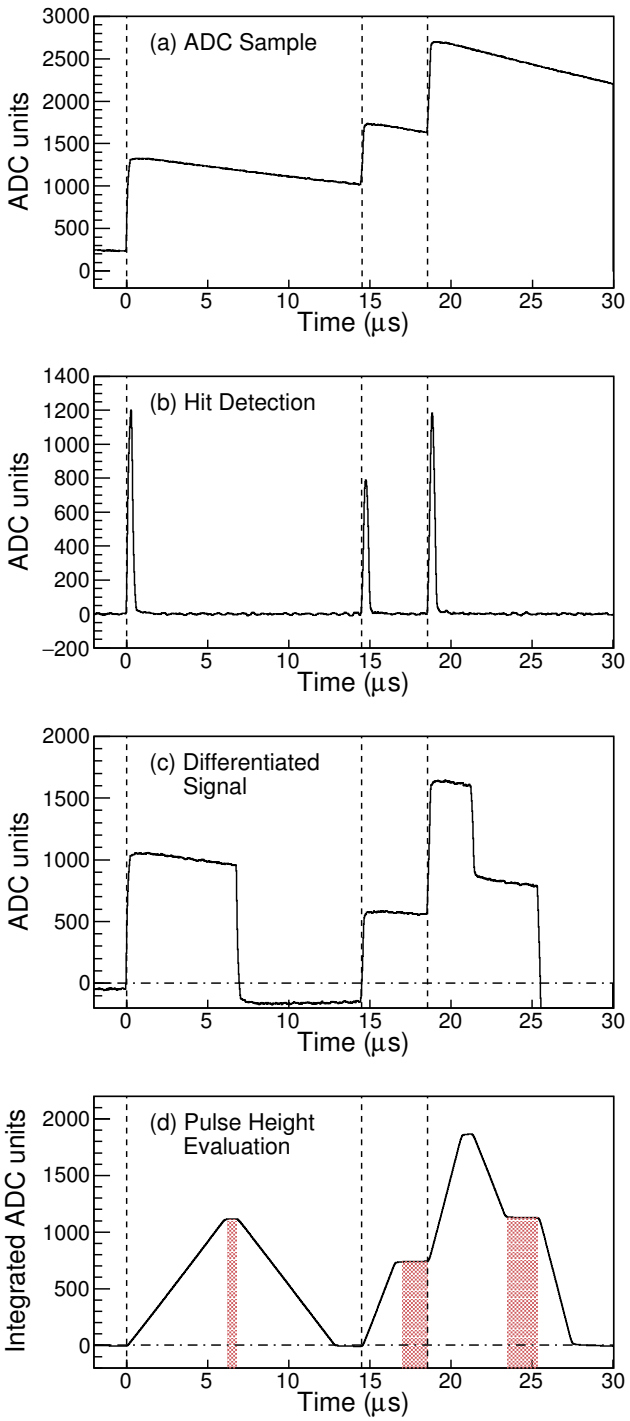


Low-Energy Thresholds

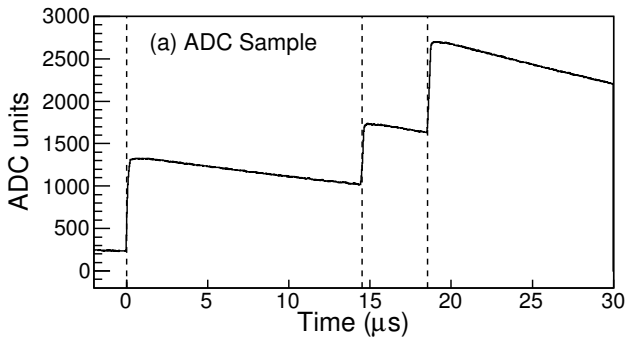
A.B. Garnsworthy *et al.*, *In preparation for NIM A*, (2016).

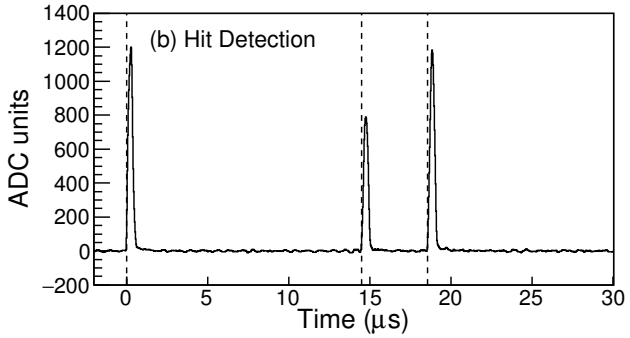


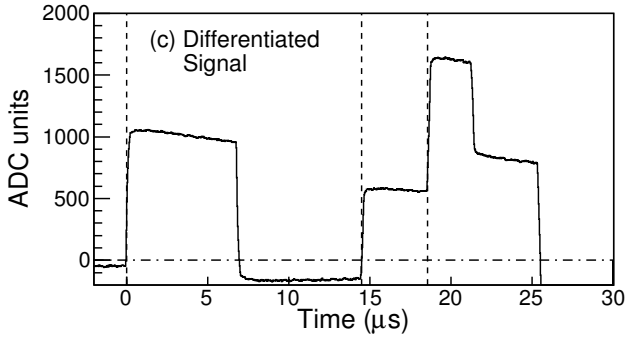
High Counting Rates

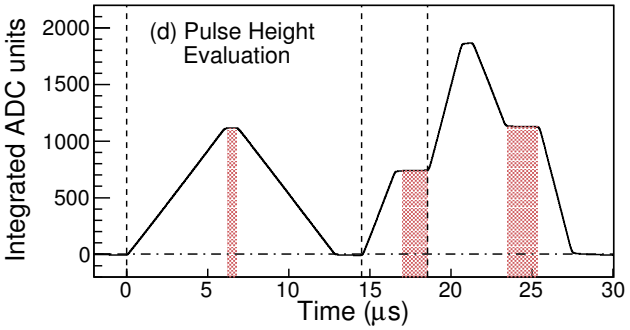


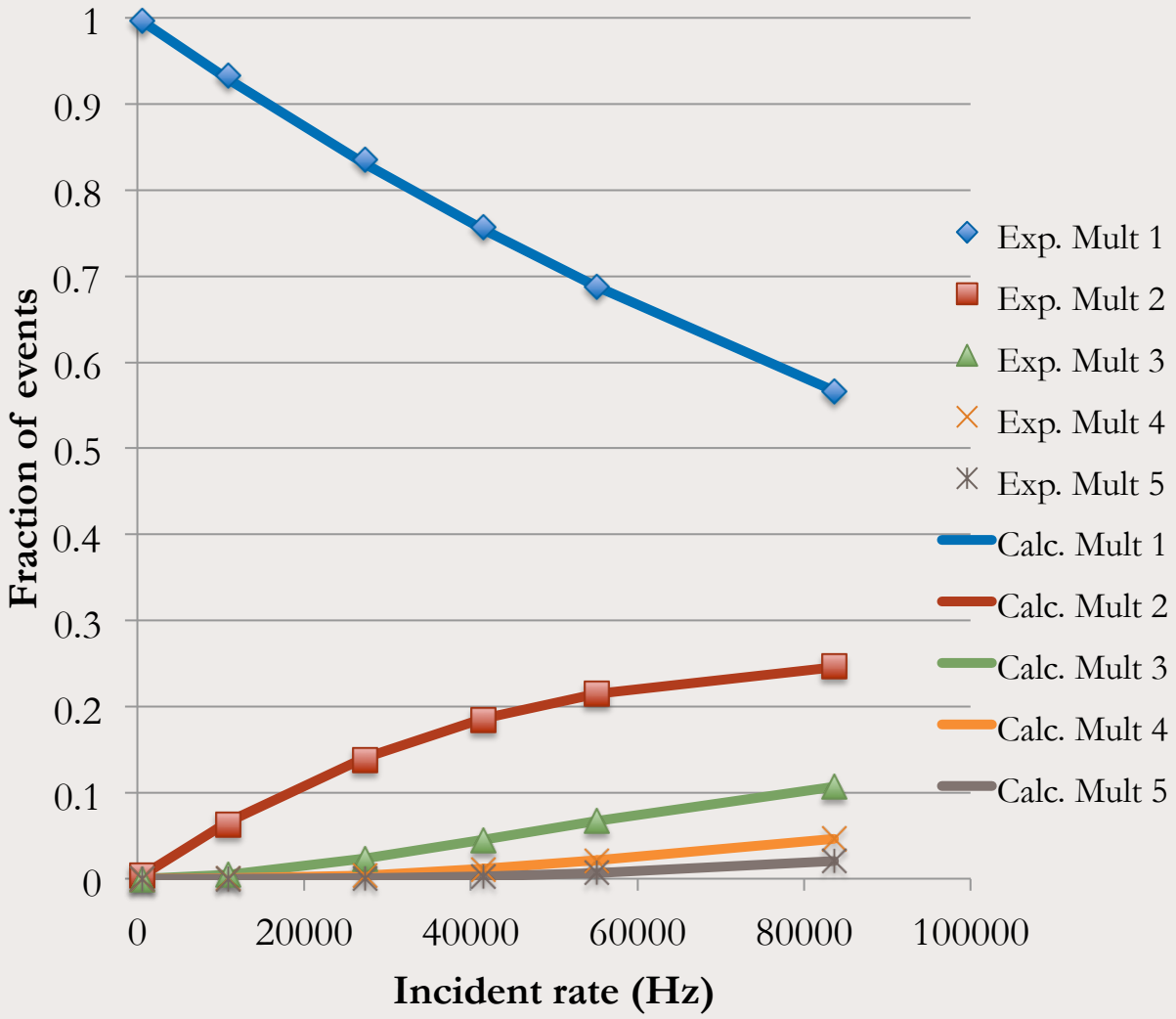
High Counting Rates



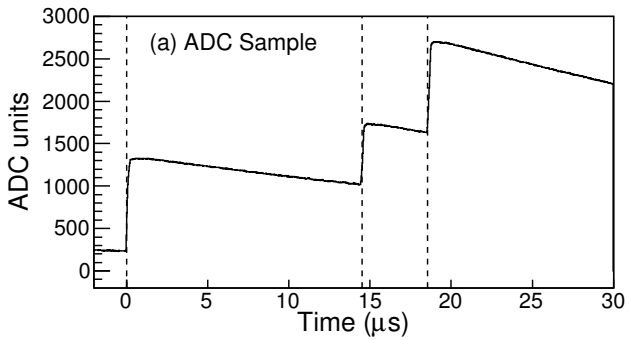


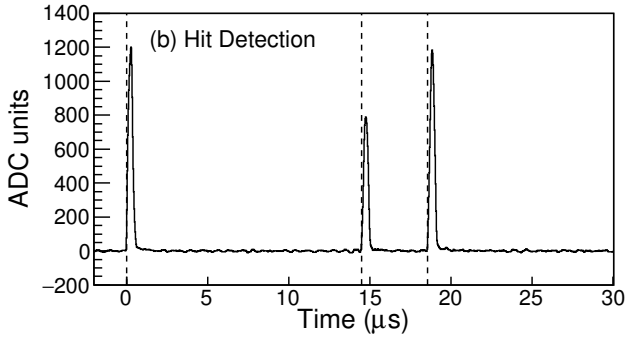


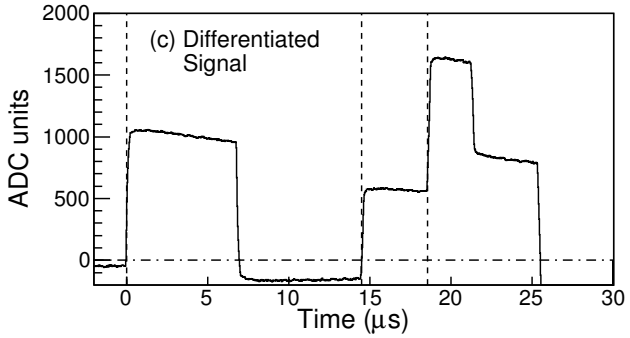


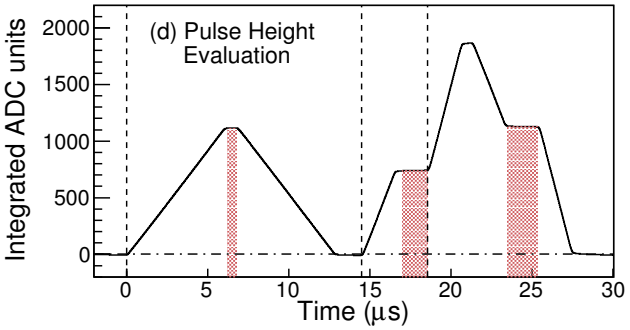


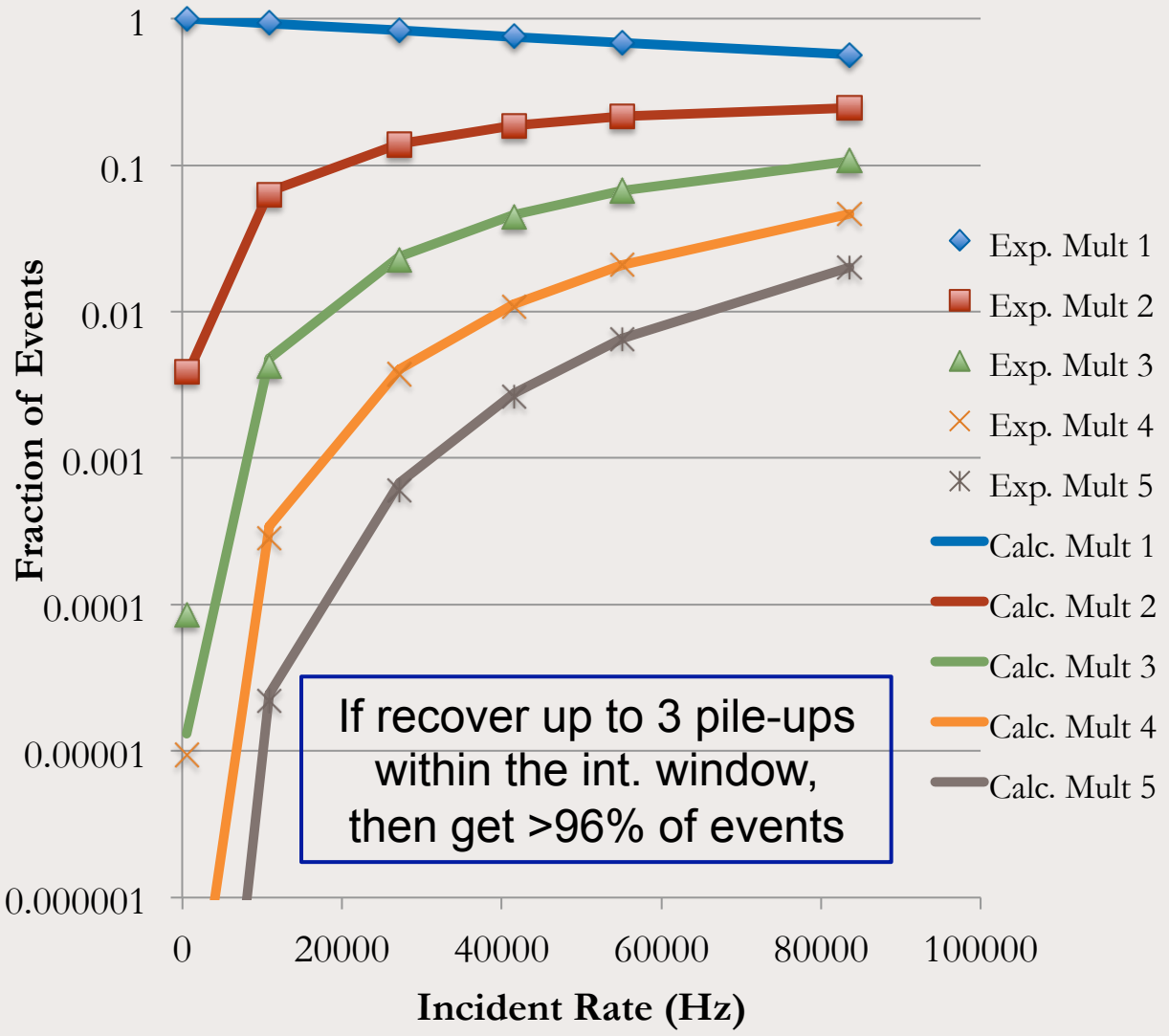
High Counting Rates



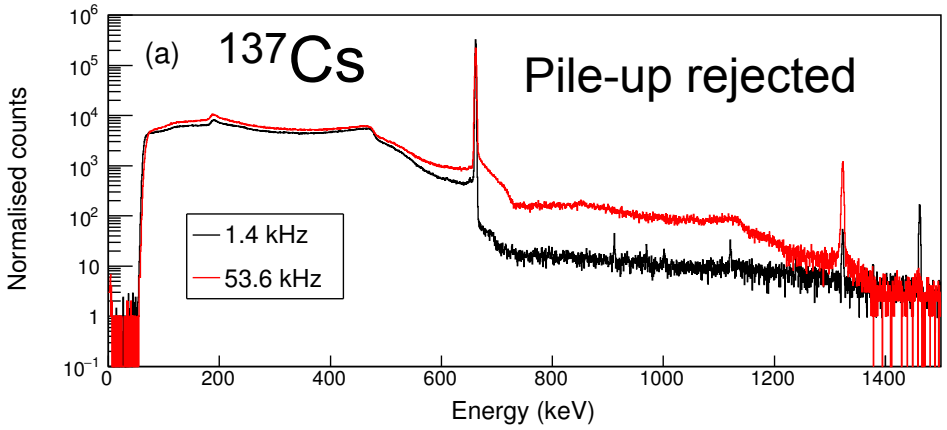


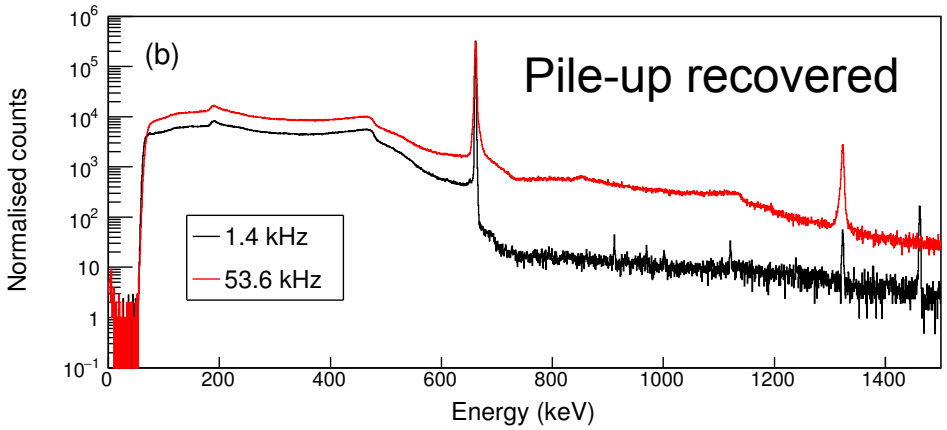


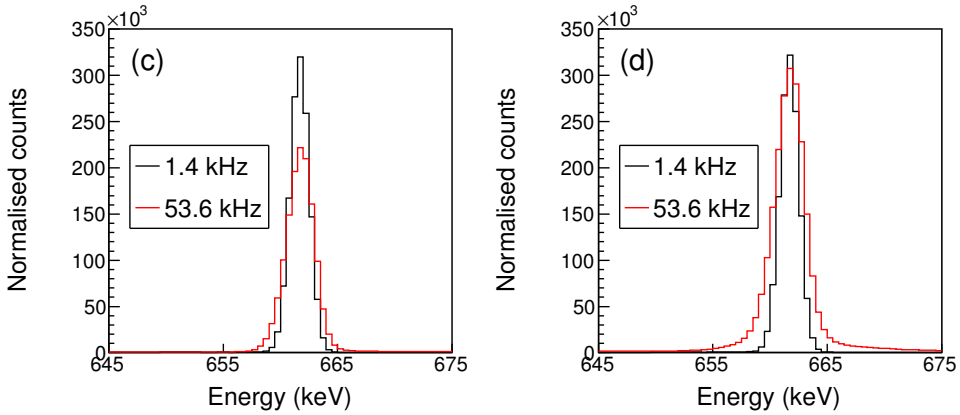


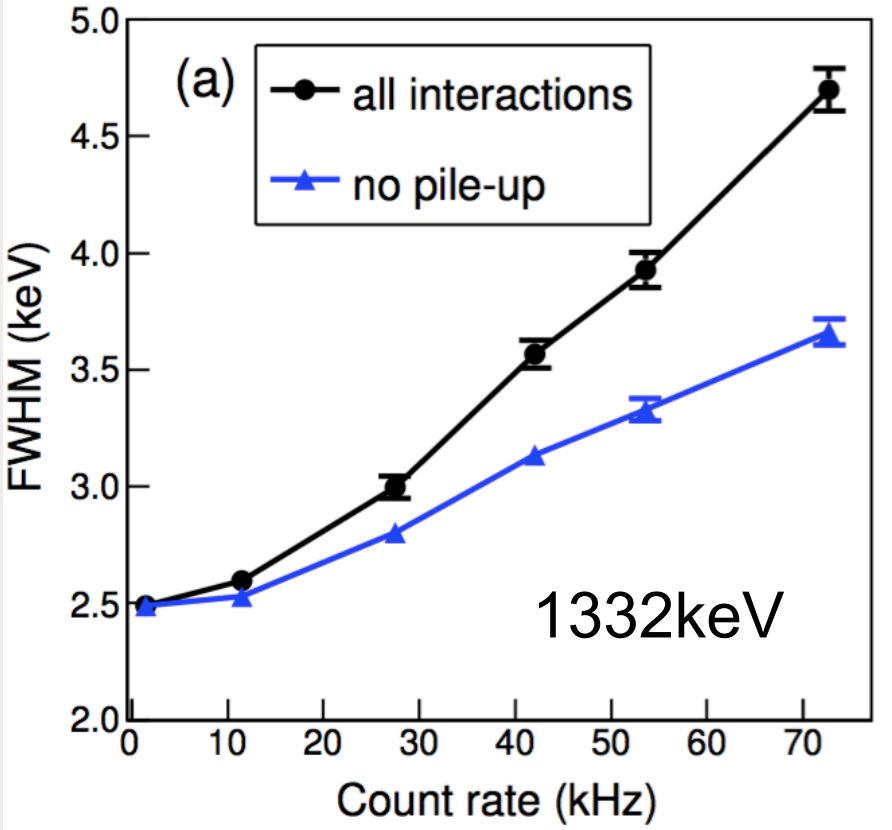


High Counting Rates









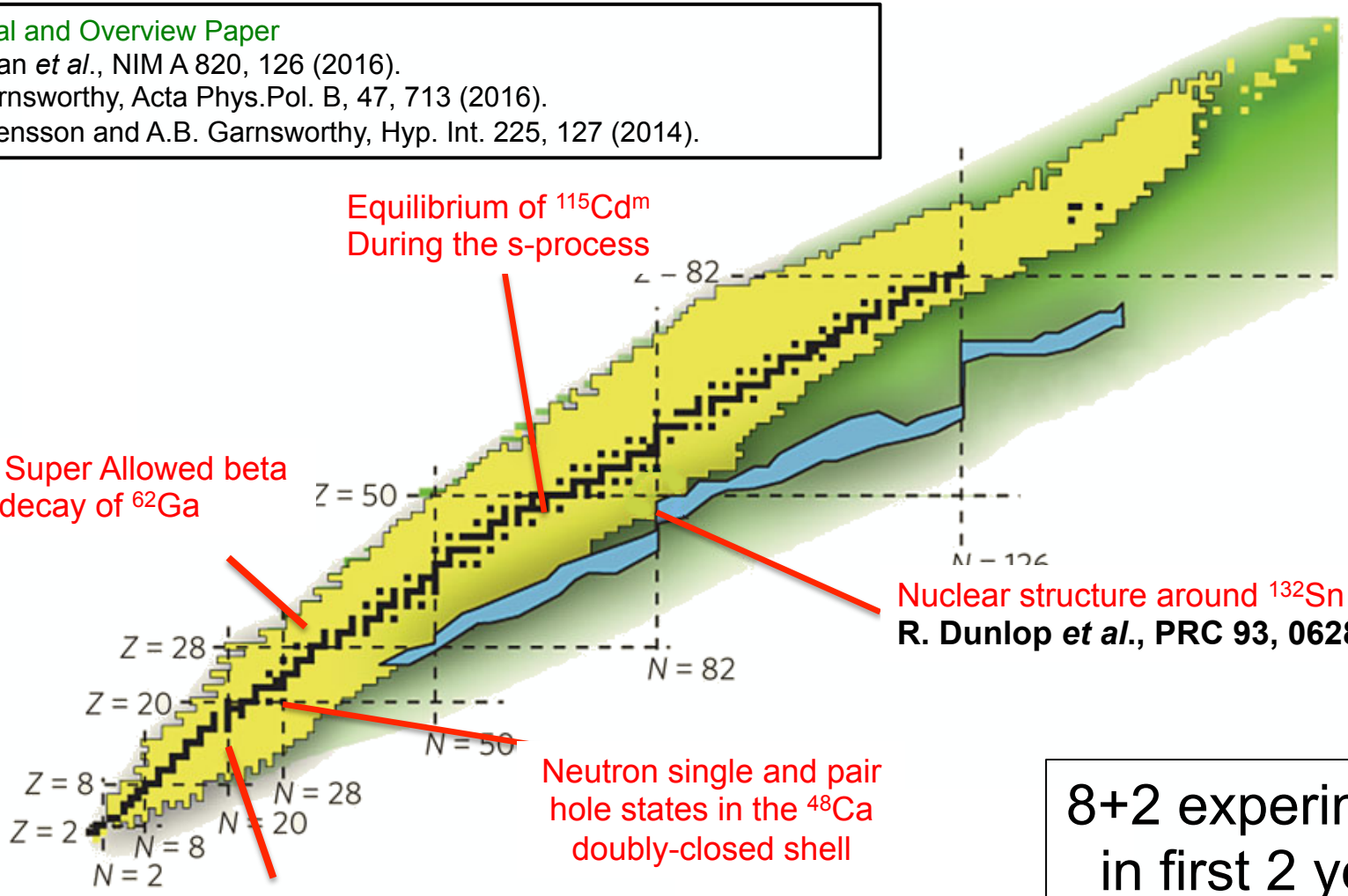
At 50kHz, collect same level of statistics in 3% of time for 1kHz.
1 hour instead of 33 hours.

The GRIFFIN Spectrometer at TRIUMF-ISAC

Technical and Overview Paper
U. Rizwan *et al.*, NIM A 820, 126 (2016).
A.B. Garnsworthy, Acta Phys.Pol. B, 47, 713 (2016).
C.E. Svensson and A.B. Garnsworthy, Hyp. Int. 225, 127 (2014).

Equilibrium of $^{115}Cd^{m}$ During the s-process

Fermi Super Allowed beta decay of ^{62}Ga



Nuclear structure around ^{132}Sn
R. Dunlop *et al.*, PRC 93, 062801(R) (2016).

Neutron single and pair hole states in the ^{48}Ca doubly-closed shell

Island of inversion, ^{32}Mg, $^{32,33,34}Al$

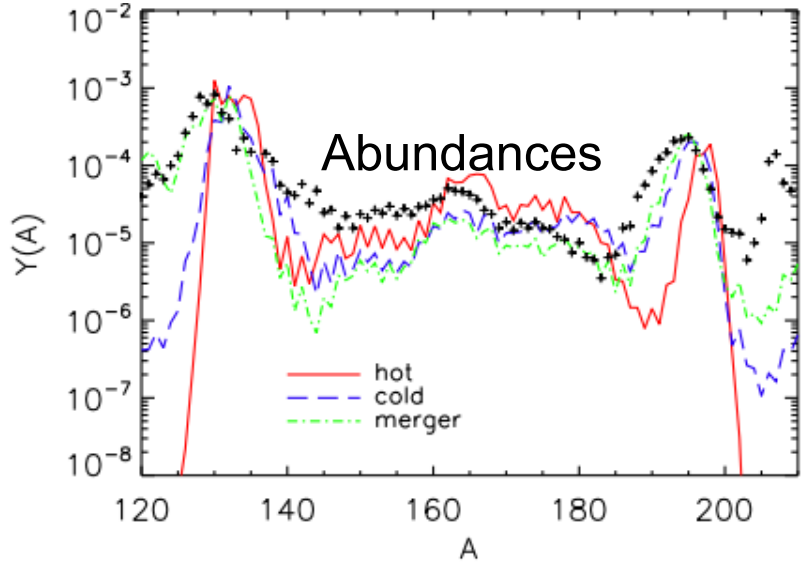
8+2 experiments in first 2 years

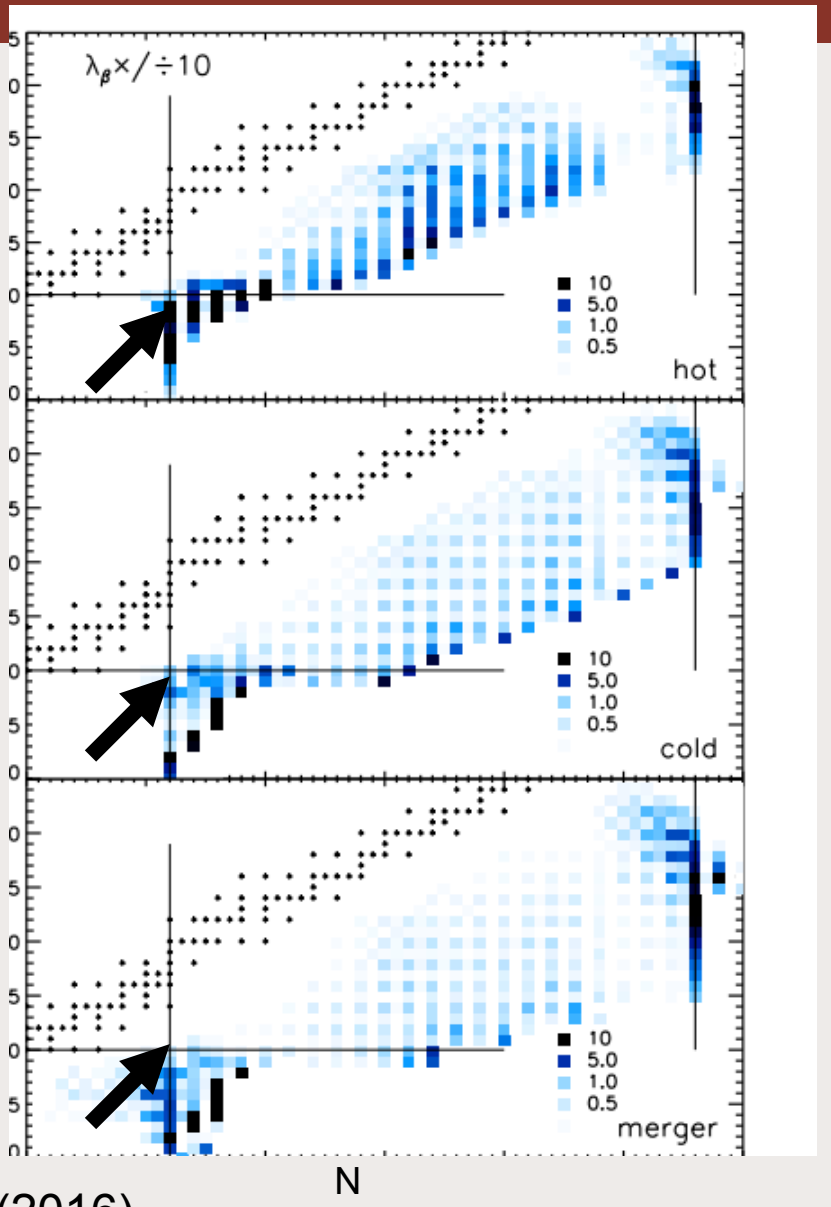
Over 70 scientists from 12 countries have now joined the collaboration

Sensitivity to the r-process beta-decay rates

Nuclei near N=82 are responsible for the A ~130 r-process abundance peak. Half-life calculations for these nuclei have tuned the GT quenching factor to the ^{130}Cd half-life, previously reported as 162(7) ms.

A recent measurement at RIKEN By Lorusso et al., reported a shorter half-life of 127 (2) ms.





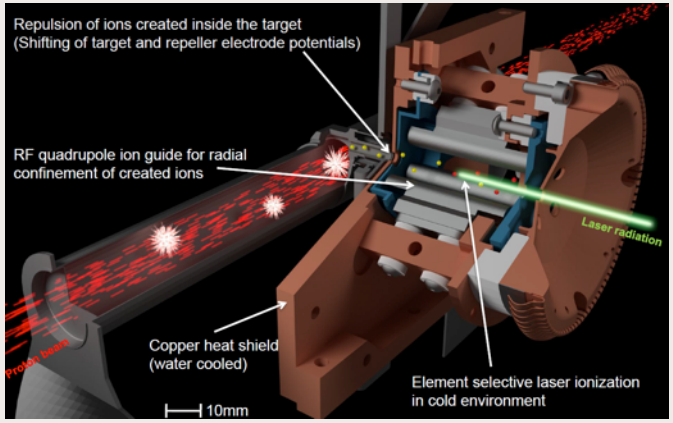
G. Lorusso et al. PRL 114 192501 (2015)

M. Mumpower *et al.*, Prog.Part.Nucl.Phys. 86, 86 (2016)

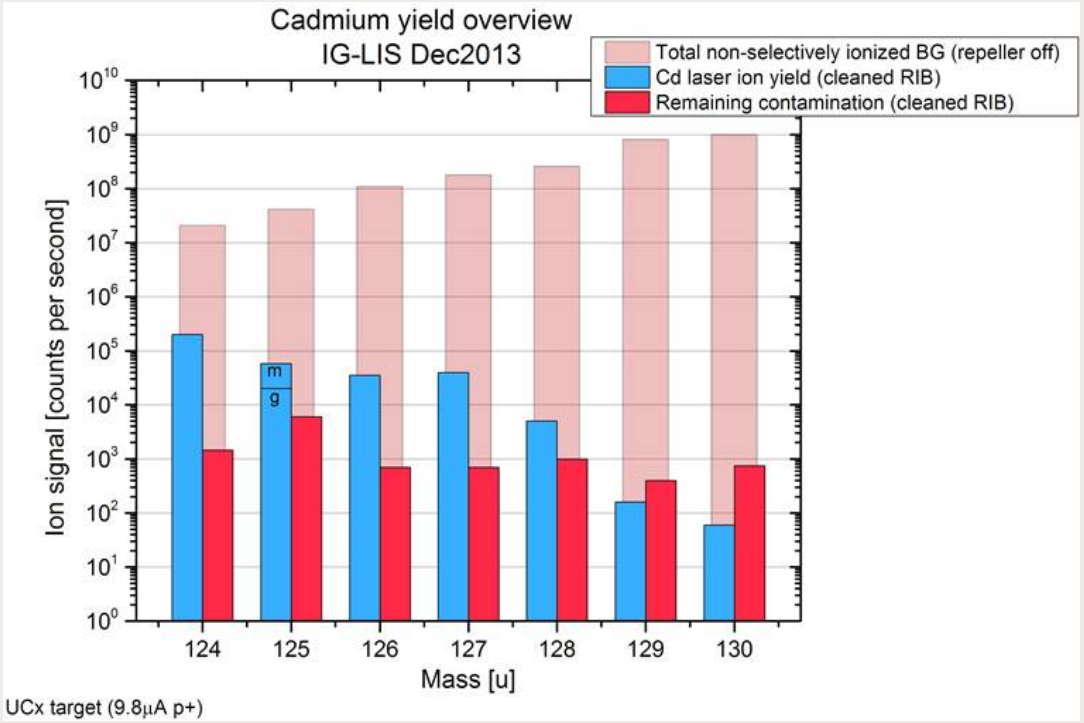
Beam production + Setup

R. Dunlop, et al., PRC 93, 062801(R) (2016).

- Uranium carbide target, requires **IG-LIS** (Ion Guide- laser Ion Source): suppression of surface-ionized species (In, Cs, Ba) by factor 10^5-10^6
- IG-LIS beam development in Dec. 2013:



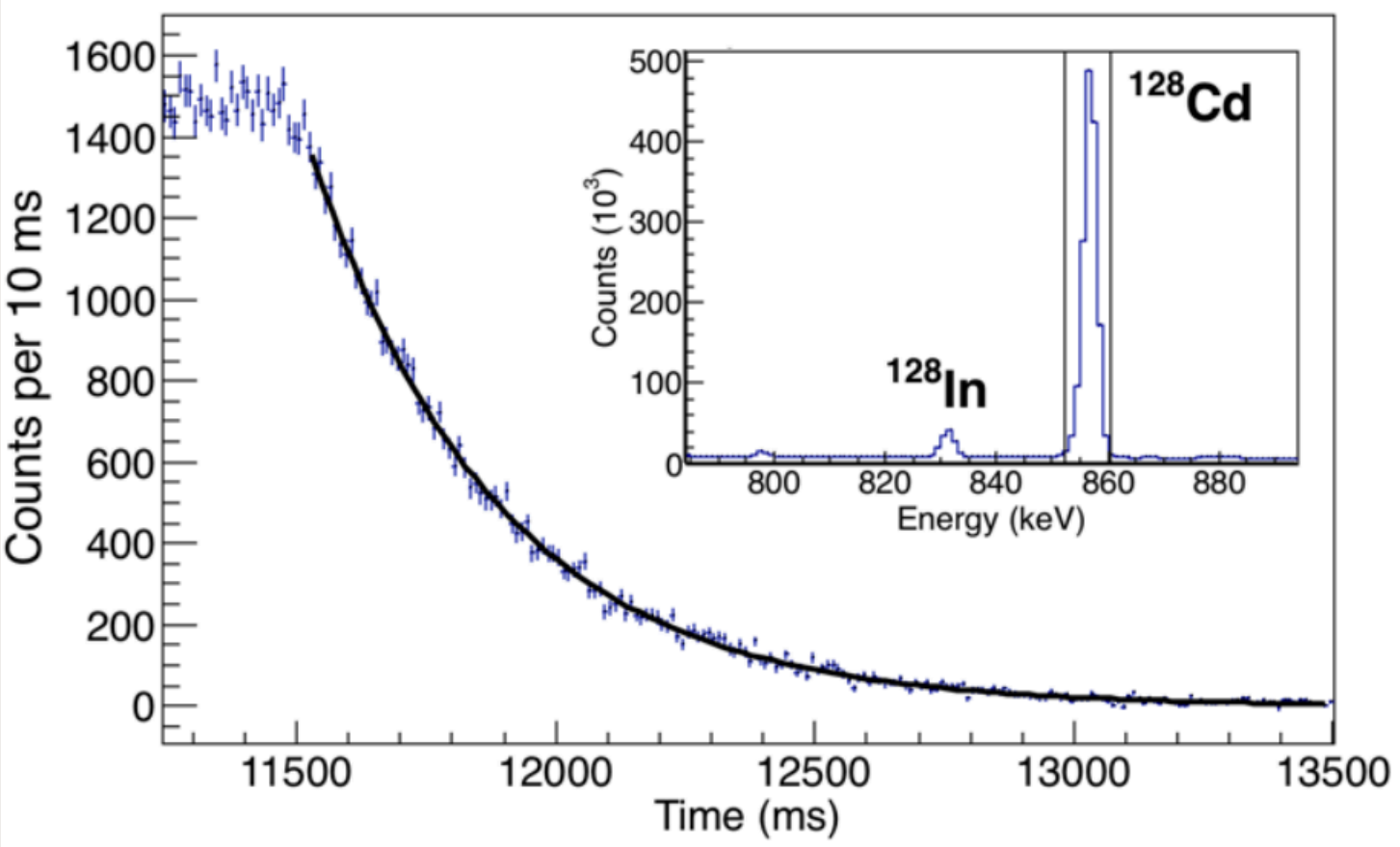
	Measured:
^{128}Cd: 4040 pps	1067 pps
^{129}Cd: 237 pps	122 pps
^{130}Cd: 60 pps	16-29 pps
^{131}Cd: 3 - 15 pps	~0.8 pps
^{132}Cd: 0.15 - 0.75 pps	~0.1 pps



^{128}Cd Half-Life Measurement

R. Dunlop, et al., PRC 93, 062801(R) (2016).

β-γ coincidences

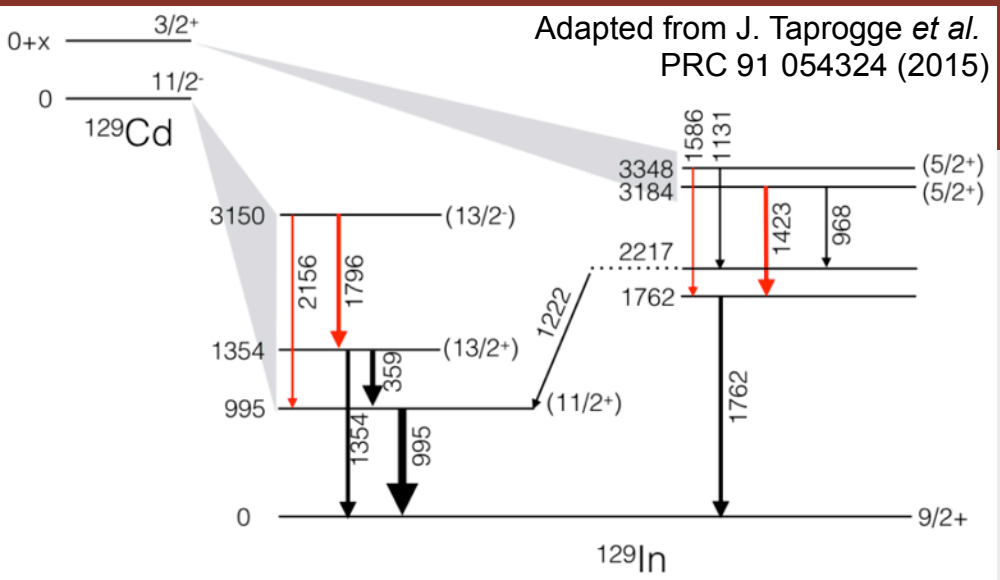


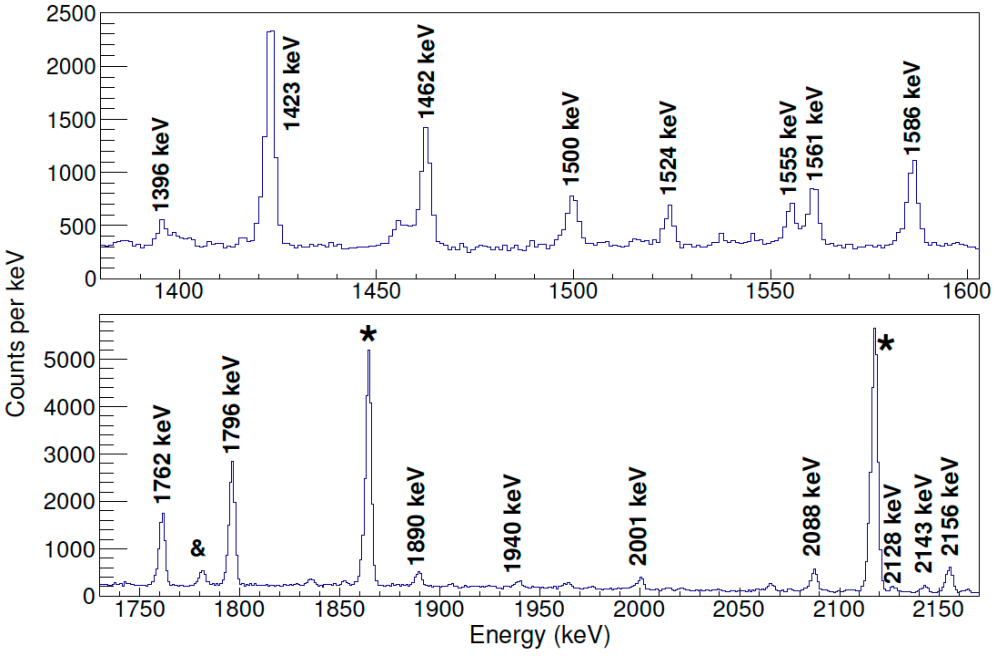
857 keV γ ray, $T_{1/2}$ = 245.8(21) ms

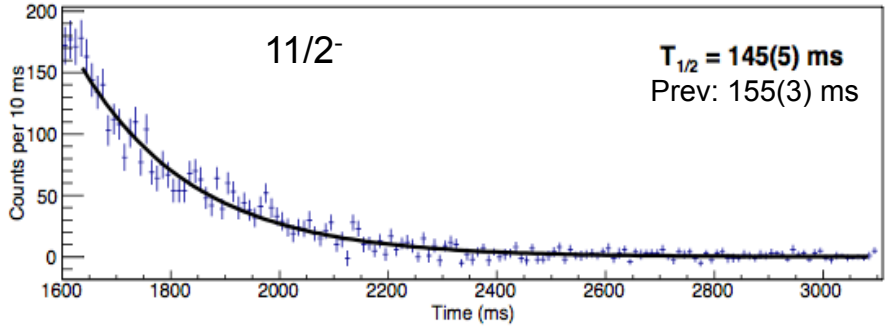
Previous 245(5) ms, from G. Lorusso et al. PRL 114 192501 (2015)

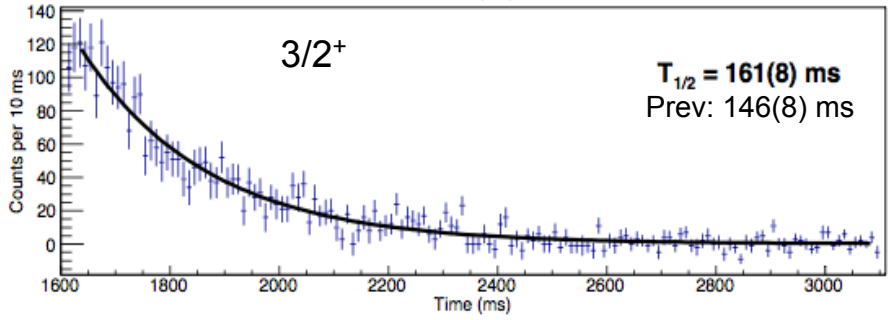
^{129}Cd β-decay

~40 pps of ^{129}Cd
13 hours of data



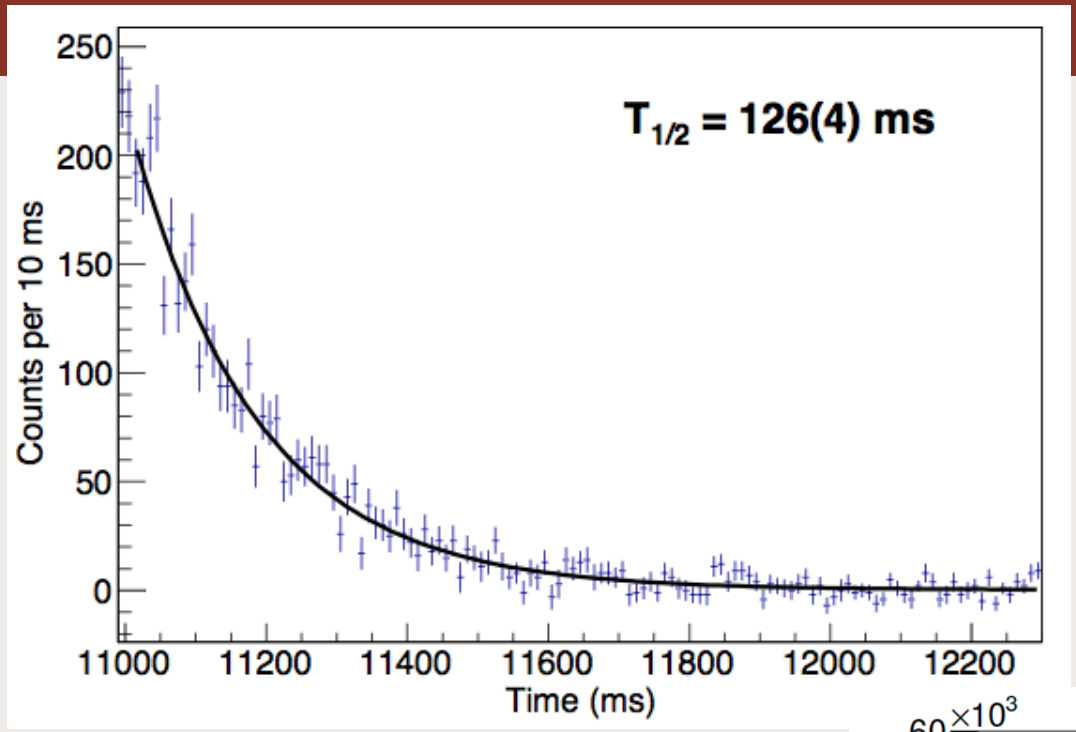






R. Dunlop, et al., PRC 93, 062801(R) (2016).

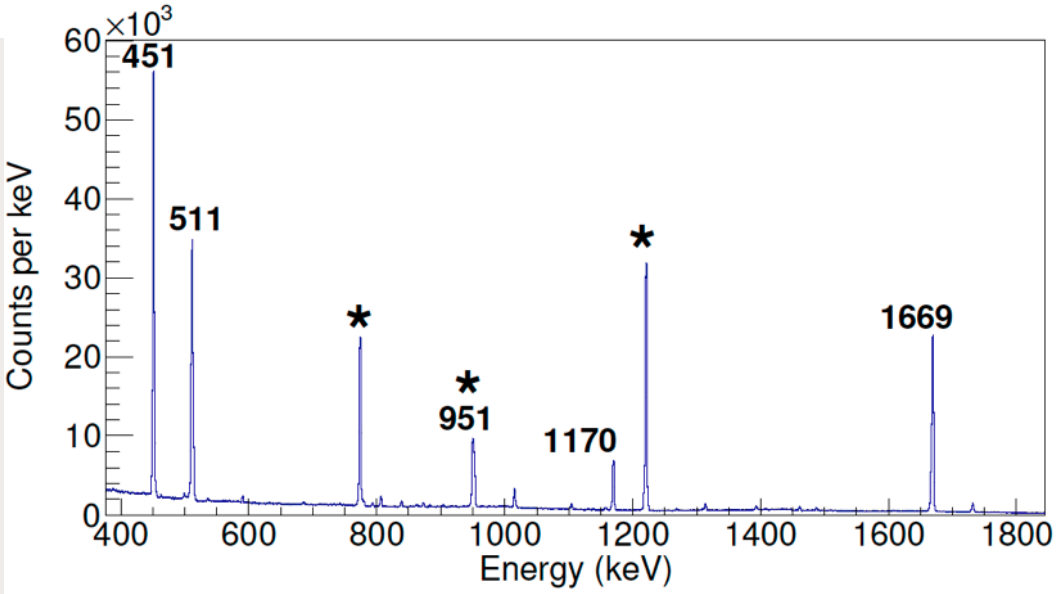
^{130}Cd Half-Life



Gated on 451.0, 1170.3, and 1669.2 keV gamma rays

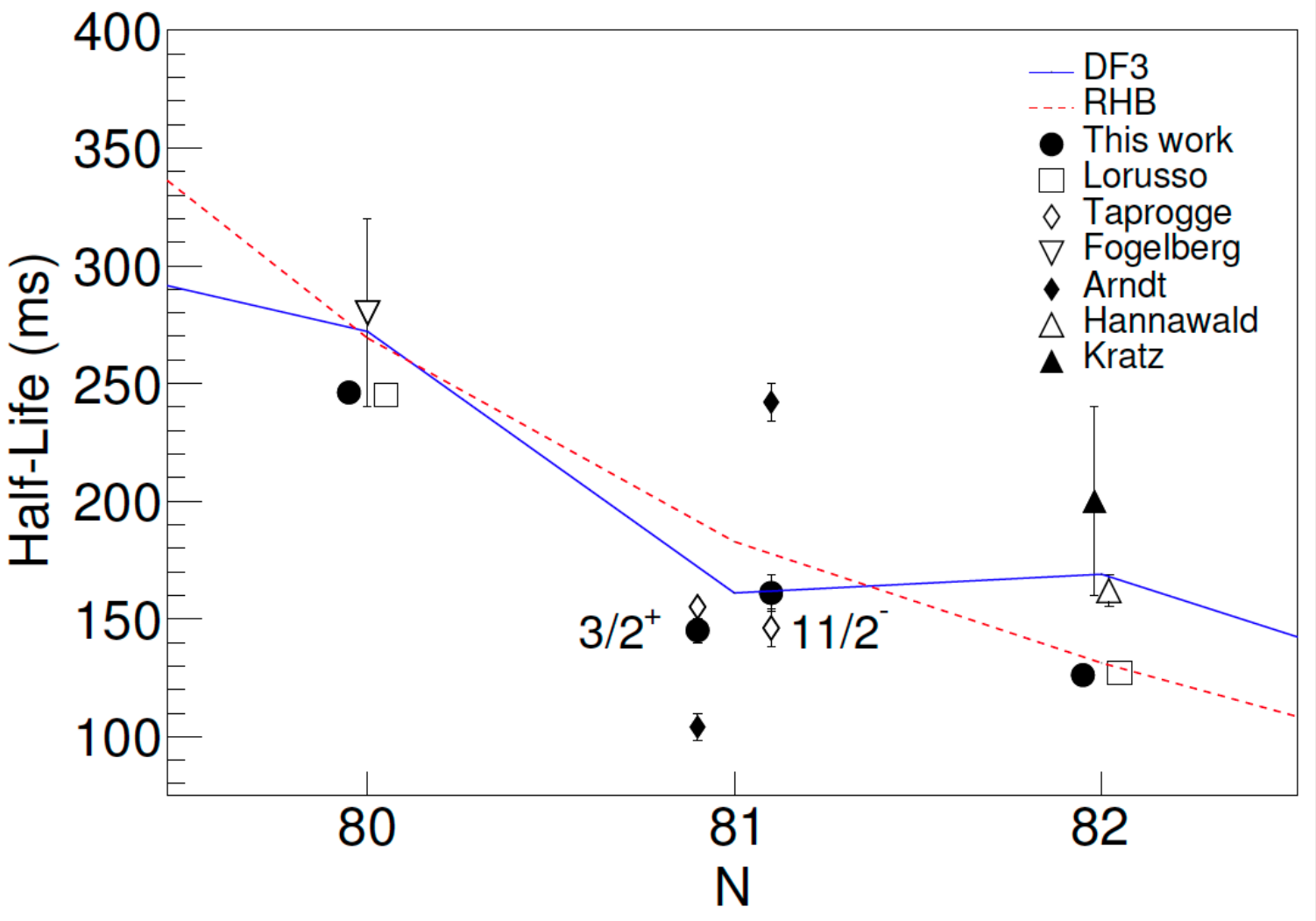
Confirmation of the shorter half-life for ^{130}Cd has important implications for r-process abundance calculations in the vicinity of the A ~130 peak

~20pps of ^{130}Cd
45 hr of data



Confirmation of shorter half lives

R. Dunlop, et al., PRC 93, 062801(R) (2016).

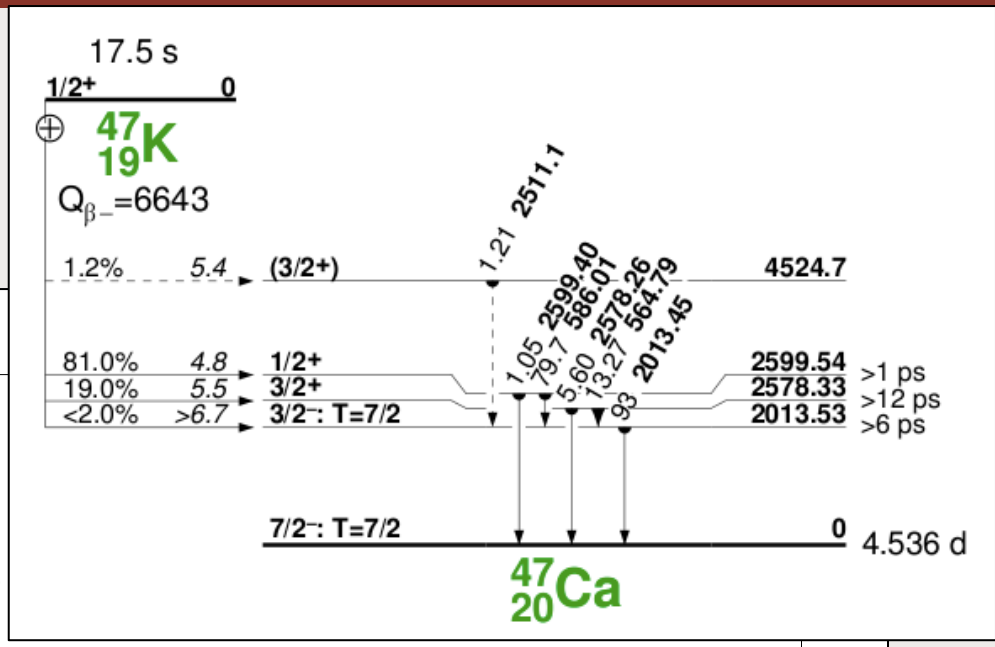


DF3+CQRPA: I. Borzov *et al*, NPA 814, 159 (2008).
RHB+RQPRA: T. Marketin *et al.*, PRC 93, 025805 (2016).

High statistics study of ^{47}K to ^{47}Ca

Jenna Smith, *TRIUMF*

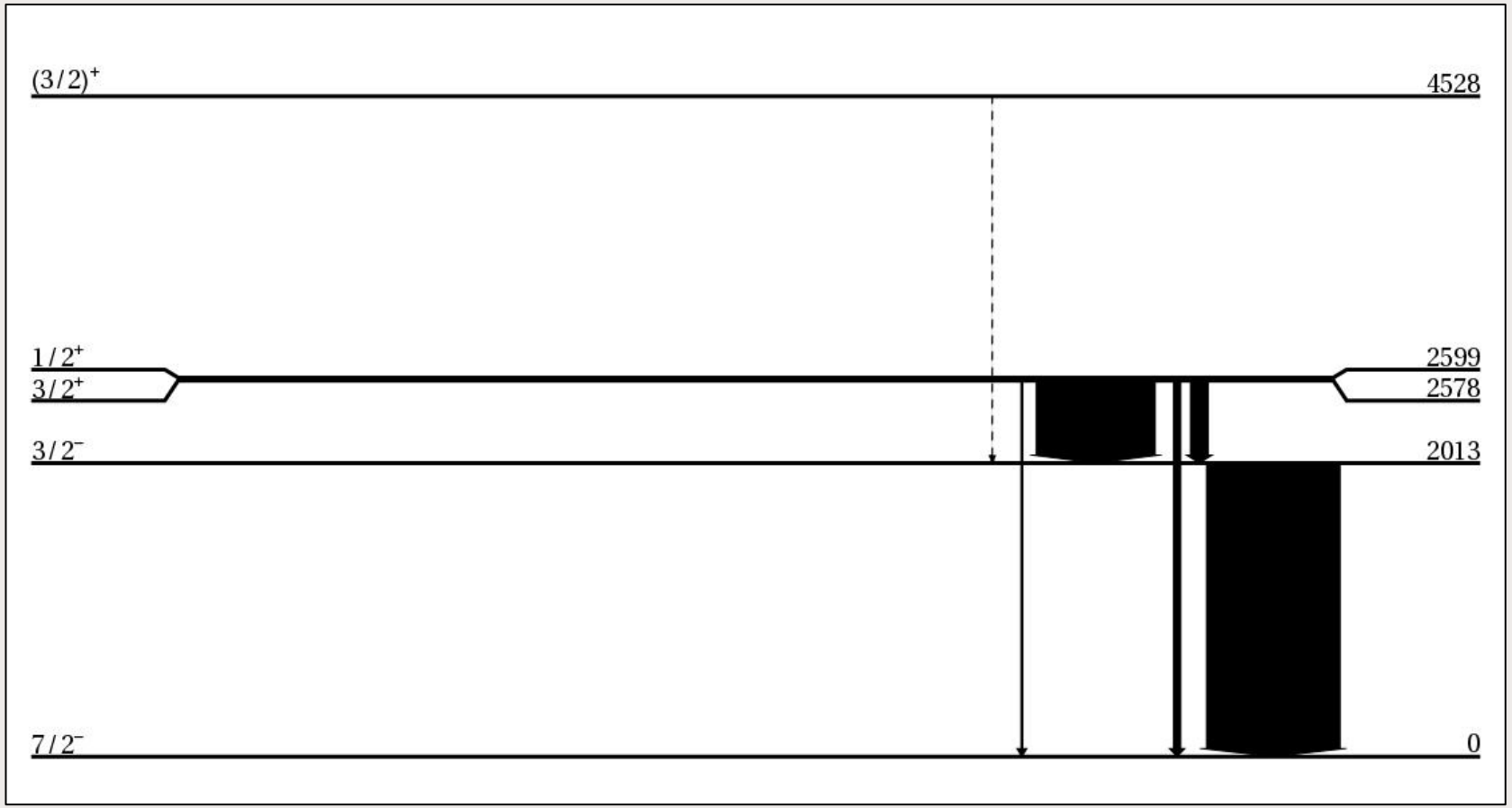
~100,000 pps from TRIUMF-ISAC facility for ~72 hours



Beta decay from ^{47}K to ^{47}Ca at GRIFFIN

- Previously known

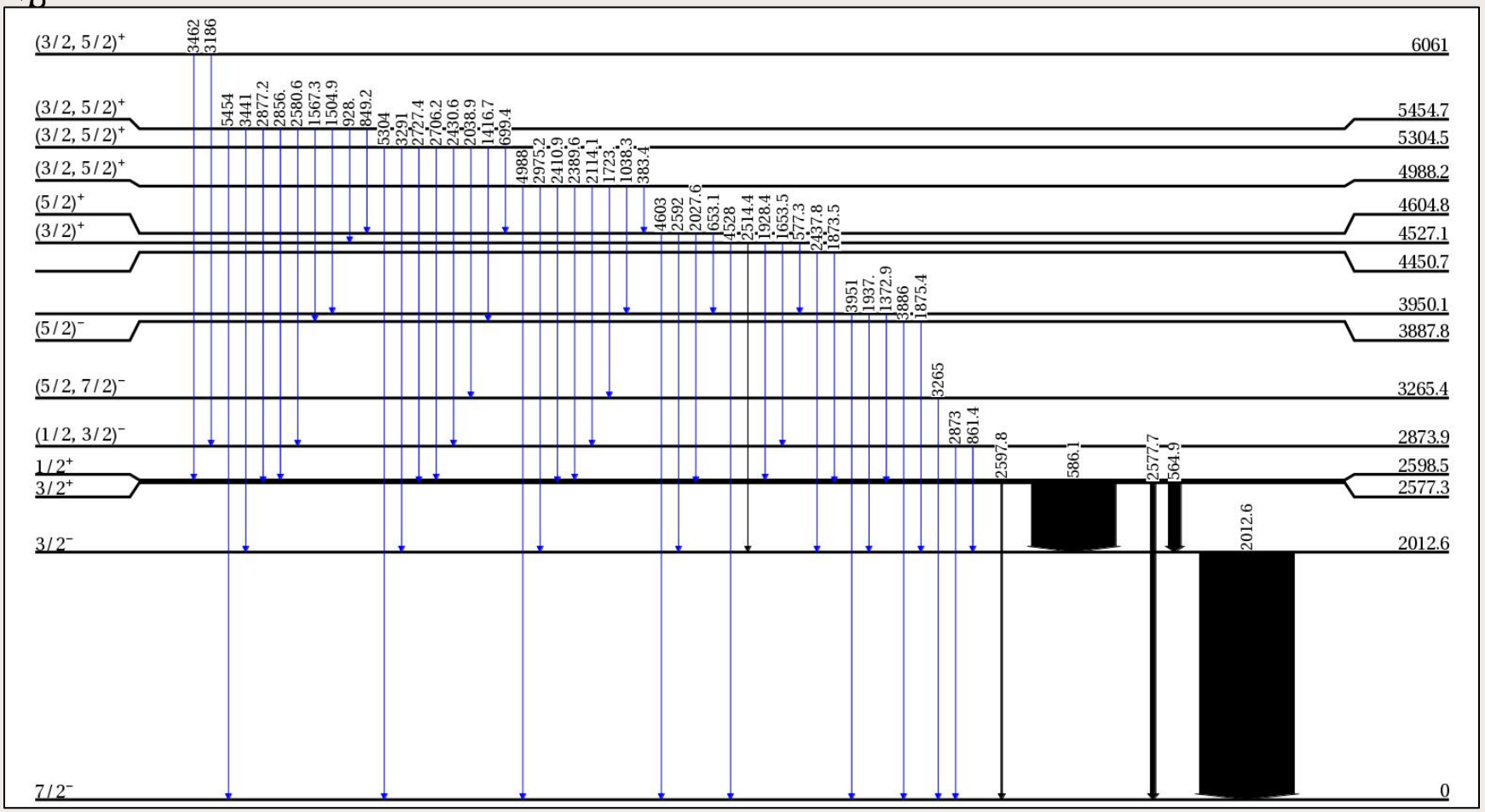
Q_β=6643keV



Beta decay from ^{47}K to ^{47}Ca at GRIFFIN

- Expanded knowledge of beta-decay level scheme

Q_β=6643keV

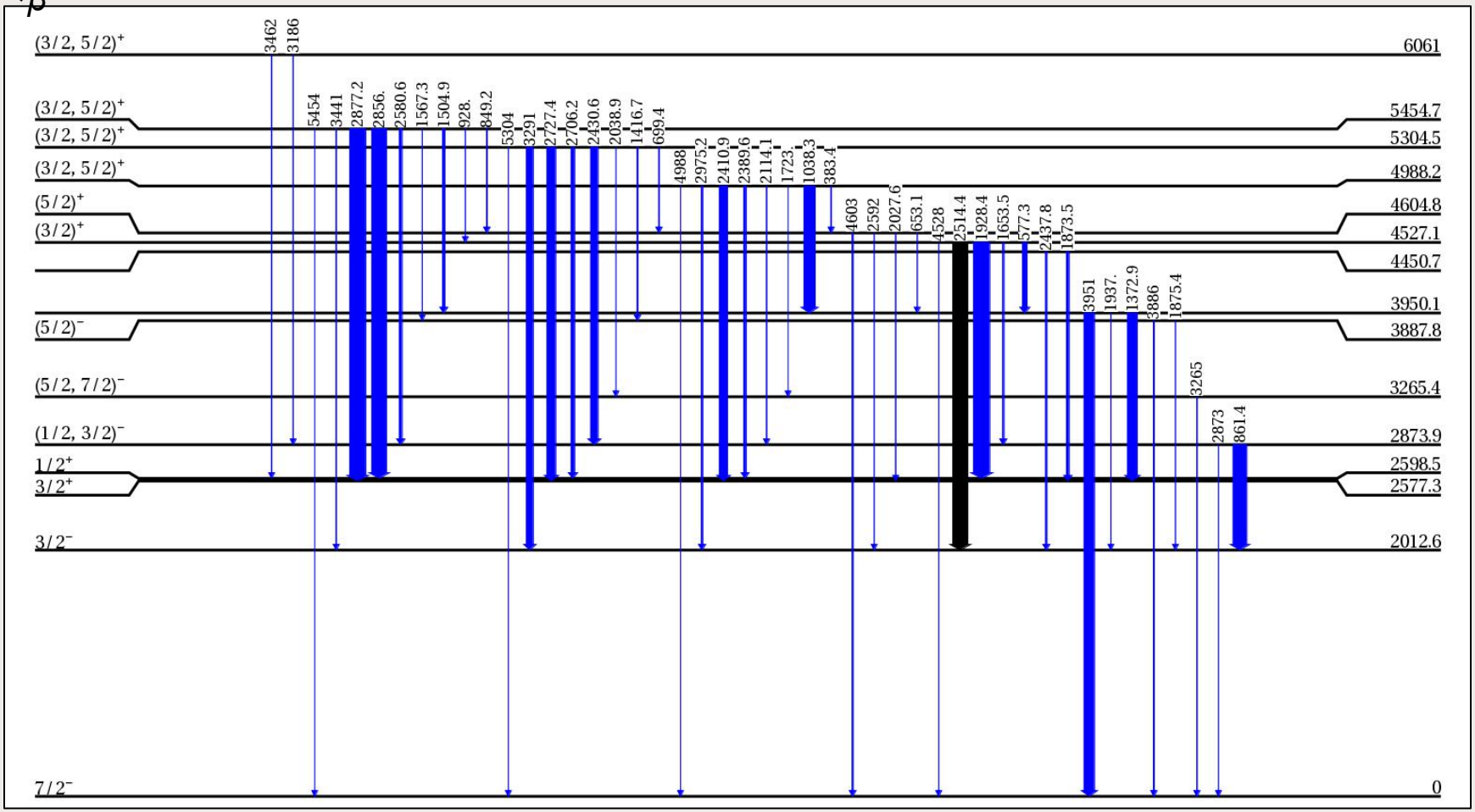


Beta decay from ^{47}K to ^{47}Ca at GRIFFIN

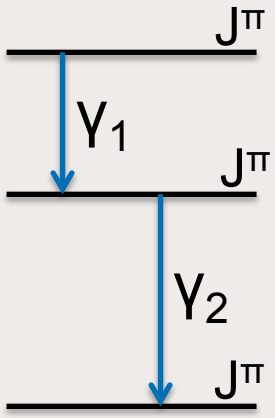
- Goal: Expand known beta-decay level scheme

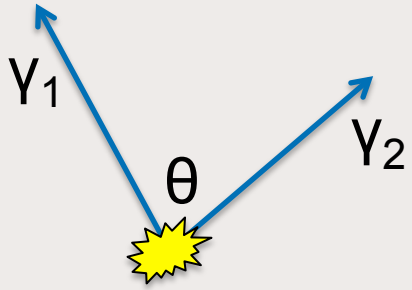
Q_β=6643keV

Intensity x1000



Gamma-gamma angular correlations

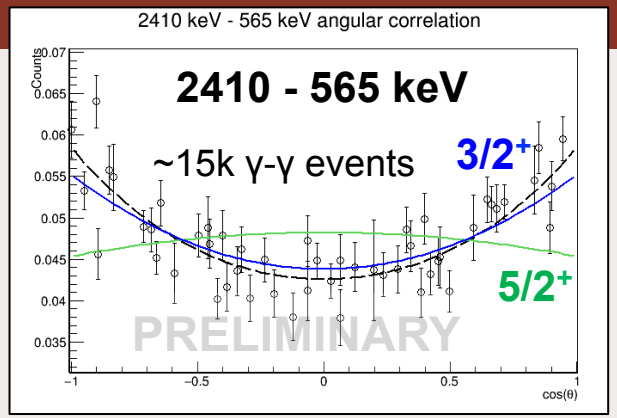


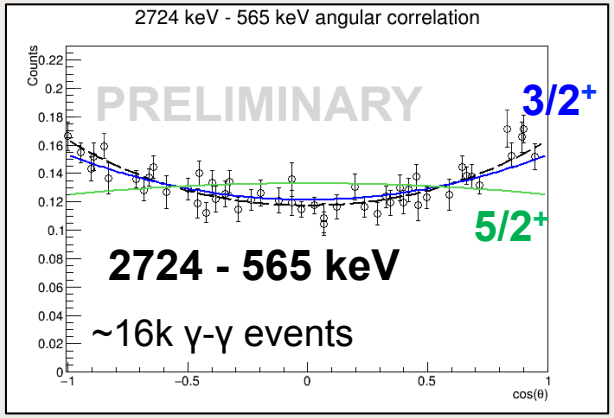


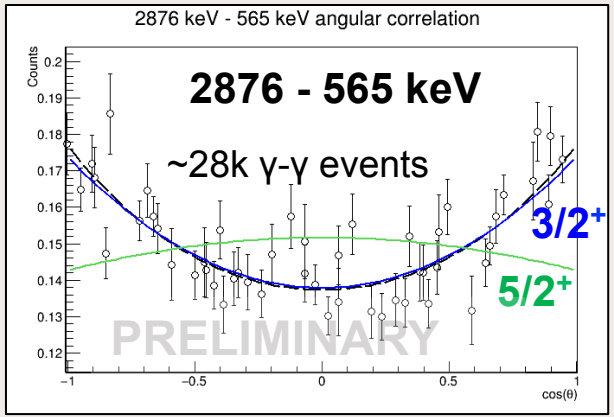
$$W(\theta) = A_0[1 + a_{22}P_2(\cos\theta) + a_{44}P_4(\cos\theta)]$$

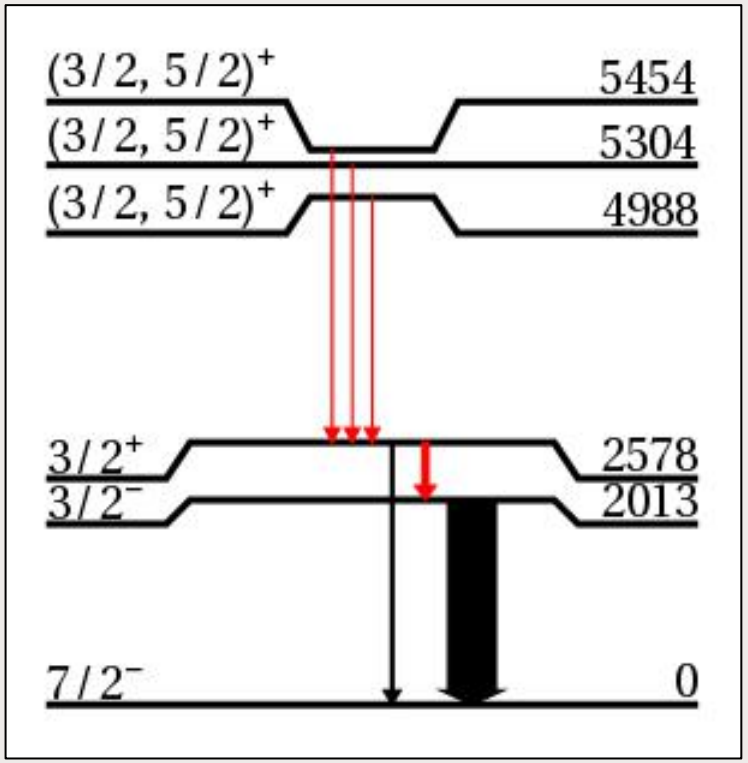
spins, multipolarities, mixing ratios

^{47}K to ^{47}Ca: angular correlations









Log ft

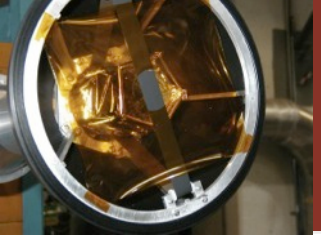
4.91(4)

5.24(5)

5.66(4)

GRIFFIN data suggest spin of **3/2** assignment for these three states.

Statistical errors only



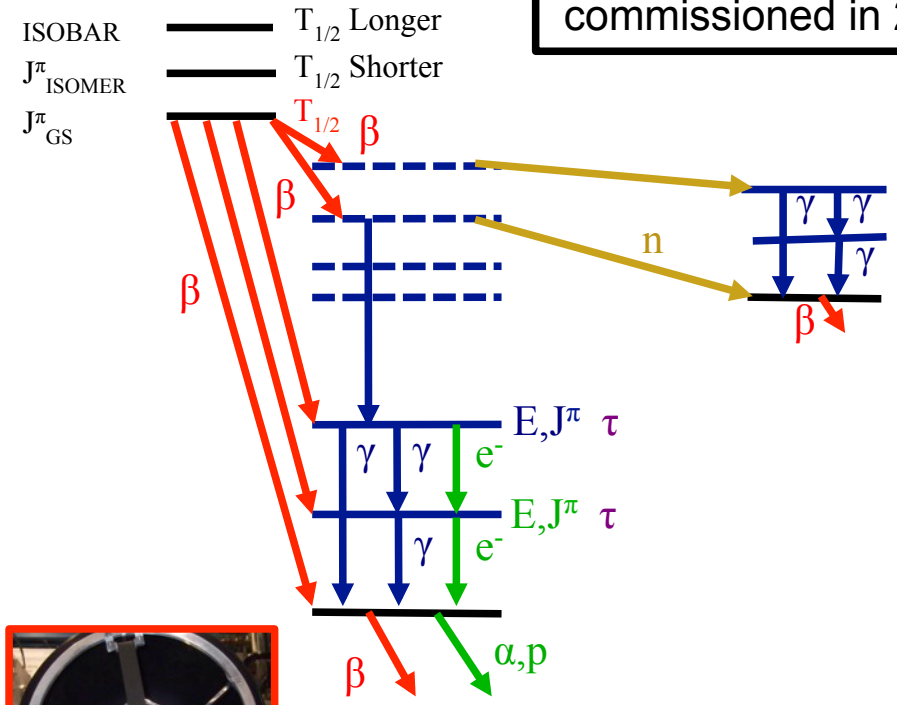
GRIFFIN

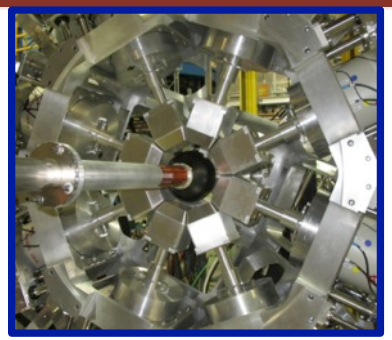
GRIFFIN Facility at TRIUMF
Sensitive Decay Spectroscopy

Fast, in-vacuum tape system

Enhances decay of interest

Initial operation in fall 2014. Fully commissioned in 2015



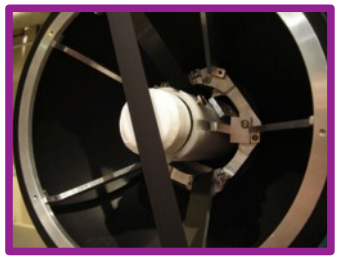


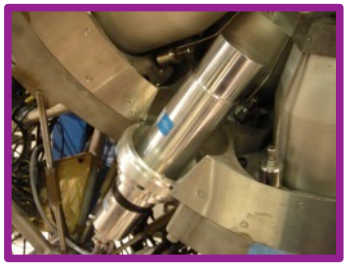
HPGe: 16 Clovers

Detect gamma rays and determines branching ratios, multipolarities and mixing ratios

$LaBr_3$: 8 $LaBr_3$

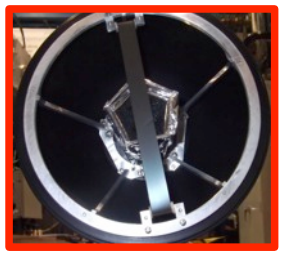
Fast-timing of photons to measure level lifetimes





Zero-Degree Fast scintillator

Fast-timing signal for betas



SCEPTAR: 10+10 plastic scintillators

Detects beta decays and determines branching ratios

DESCANT Neutron array

Detects neutrons to measure beta-delayed neutron branching ratios

PACES: 5 Cooled Si(Li)s

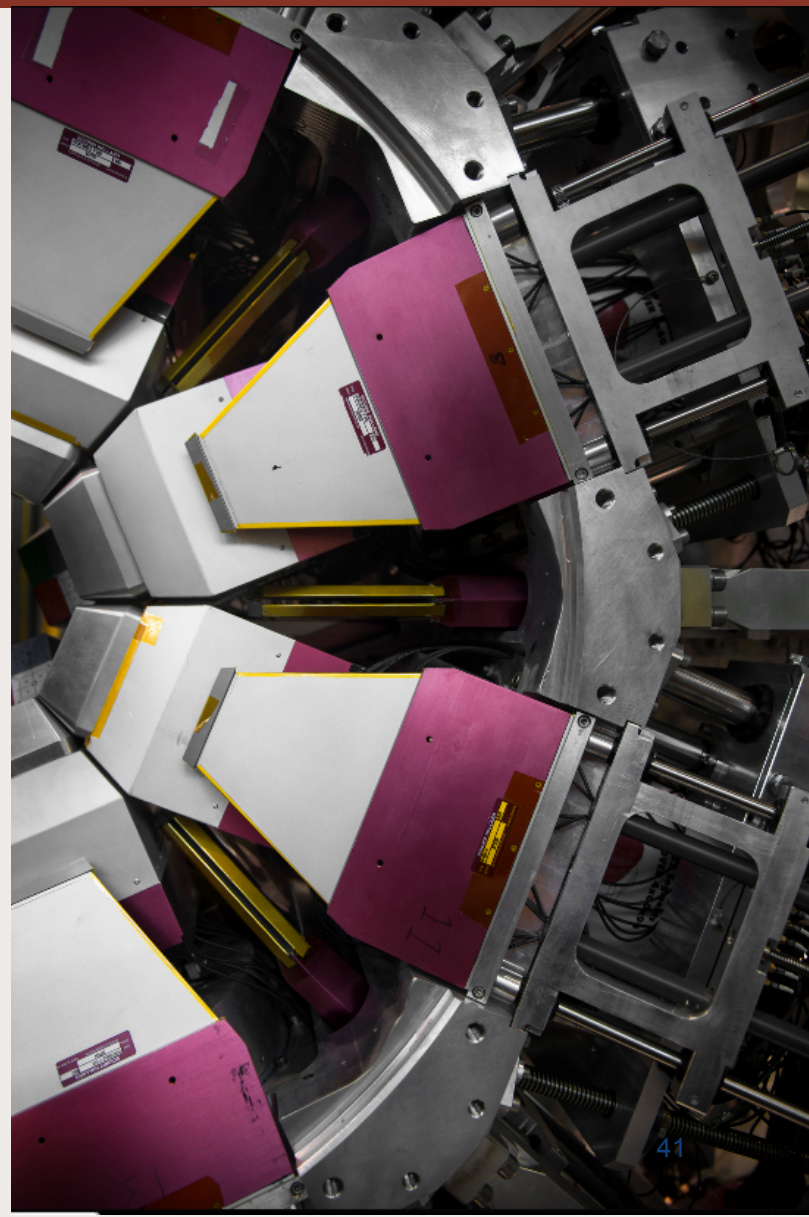
Detects Internal Conversion Electrons and alphas/protons

TIGRESS

16 Compton-Suppressed segmented HPGe Clovers with digital DAQ

SHARC Silicon barrel

Studies with accelerated RIBs 0.5-15MeV/u

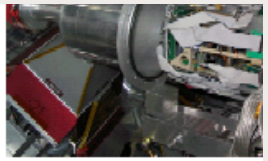


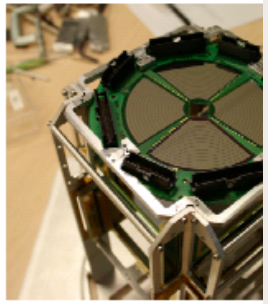
downstream of reaction target (York
d Micron).

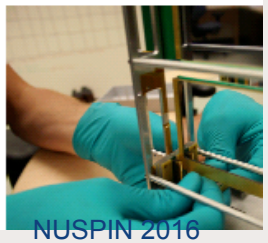
- Length: 72 mm (24 strips)
- Width: 48 mm (48 strips)
- Upstream 1000 μm
- Downstream 140 μm + 1500 μm.

ron QQQ2 CD detector (A.A. Chen,
Master)

- 4 sectors, active area:
- 9.0 mm to 41 mm radius (16 rings)
- 81.6° (24 radial strips)
- Thickness: 300–400 μm.







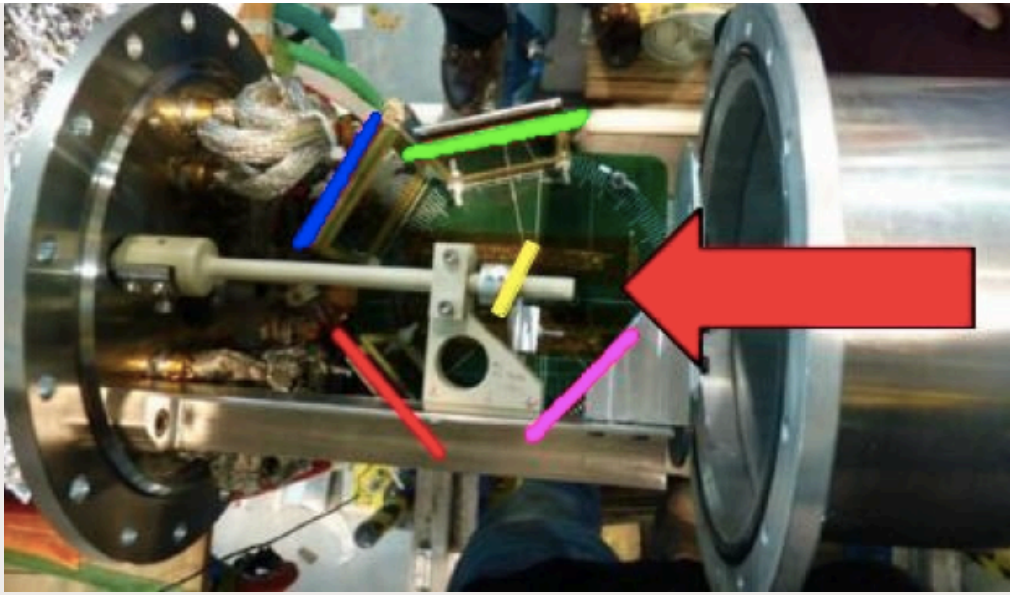
^{11}Be on ^{197}Au at TIGRESS

V. Pesudo, M.L.G. Borge et al., Submitted to PRL.

	Telescope	type	θ, L	Serial number*	Det. Th (μm)	front DL th. (nm)	back DL th. (nm)
ΔE	1	DSSSD	28°, 80 mm	2449-7	42	50+4%(300)	800
	2	DSSSD	45°, 60 mm	2449-10	40	50+4%(300)	800
	3	DSSSD	76°, 60 mm	2561-6	41	50+4%(300)	800
	4	SSSSD	130°, 55 mm	2752-7	20	800	800
E	1	PAD	45°, 60 mm	2712-8	500	800	800
	2	PAD	28°, 80 mm	2331-4	500	800	800
	3	PAD	76°, 60 mm	2712-11	505	800	800
	4	DSSSD	130°, 55 mm	2851-20	295	800	800

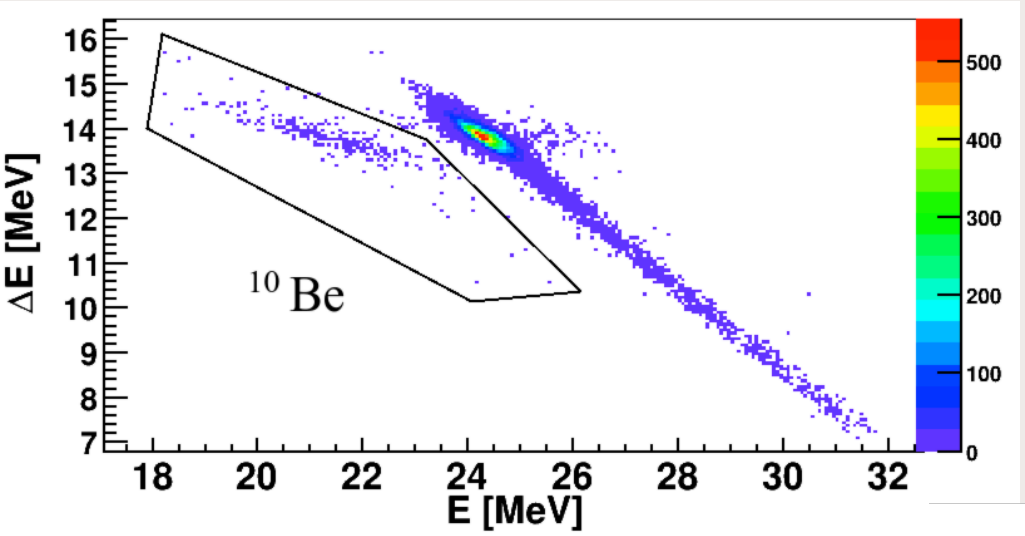
Inelastic scattering of one-neutron-halo ^{11}Be on ^{197}Au around the Coulomb barrier.

10^5pps at 31.9 and 39.6MeV
1.9mg/cm^2 ^{197}Au tilted at 15°



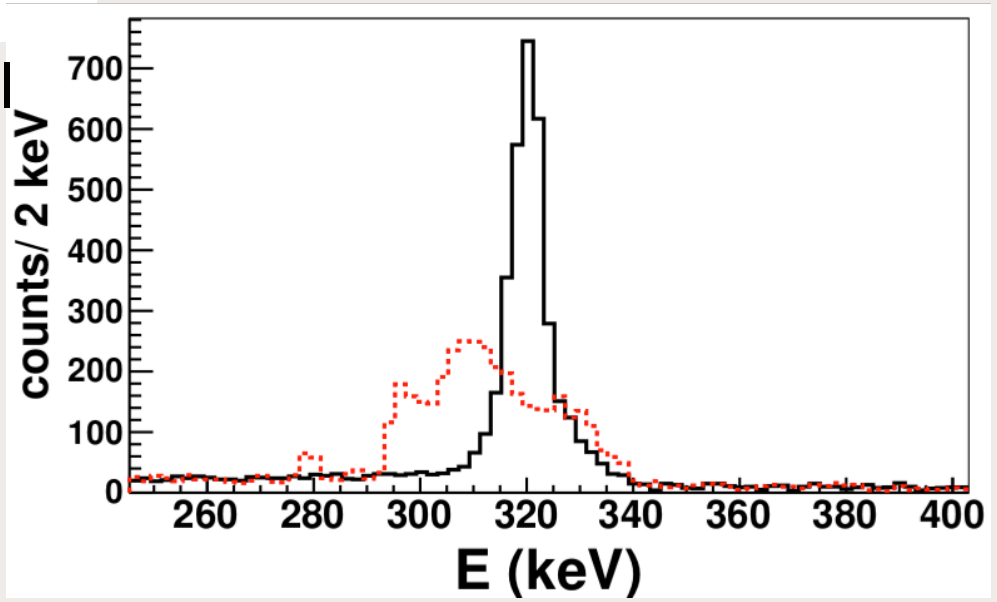
^{11}Be on ^{197}Au at TIGRESS

V. Pesudo, M.L.G. Borge et al., Submitted to PRL.



ΔE-E from a single 3x3mm^2 pixel

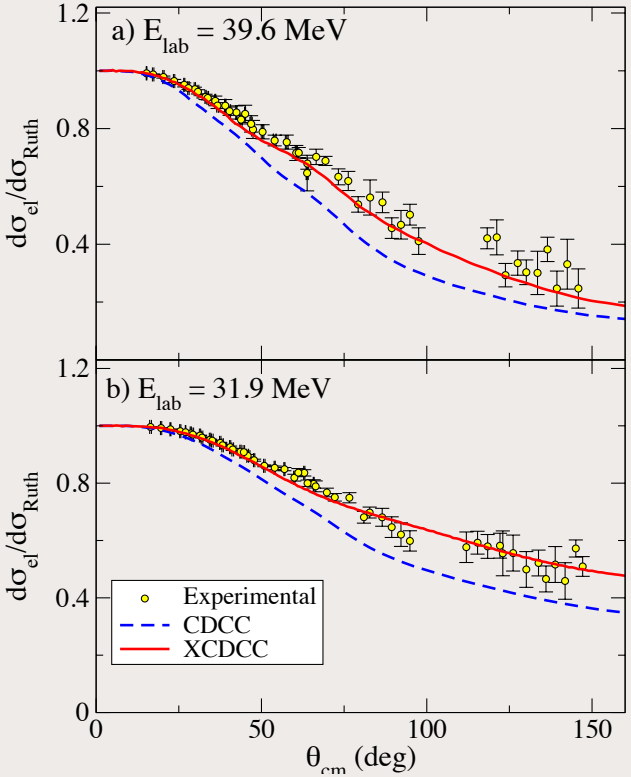
- ^{10}Be from break-up.
- ^{11}Be quasi-elastic can be identified with the coincident 320keV gamma ray in TIGRESS



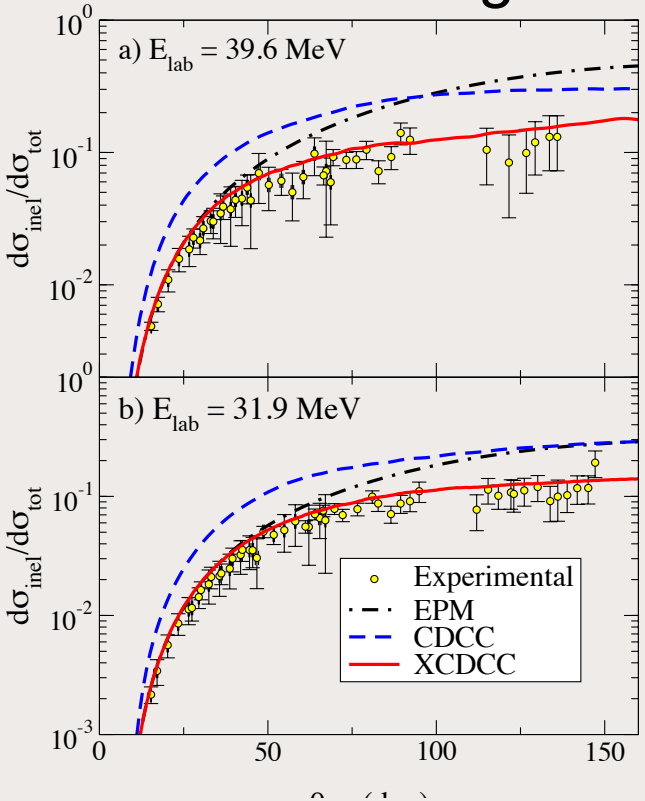
^{11}Be on ^{197}Au at TIGRESS

V. Pesudo, M.L.G. Borge et al., Submitted to PRL.

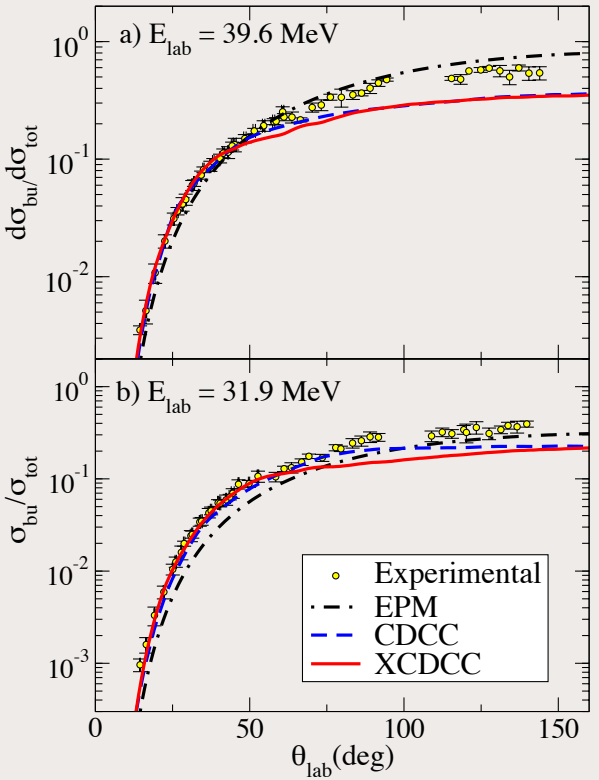
Differential elastic



Inelastic scattering



Differential break-up

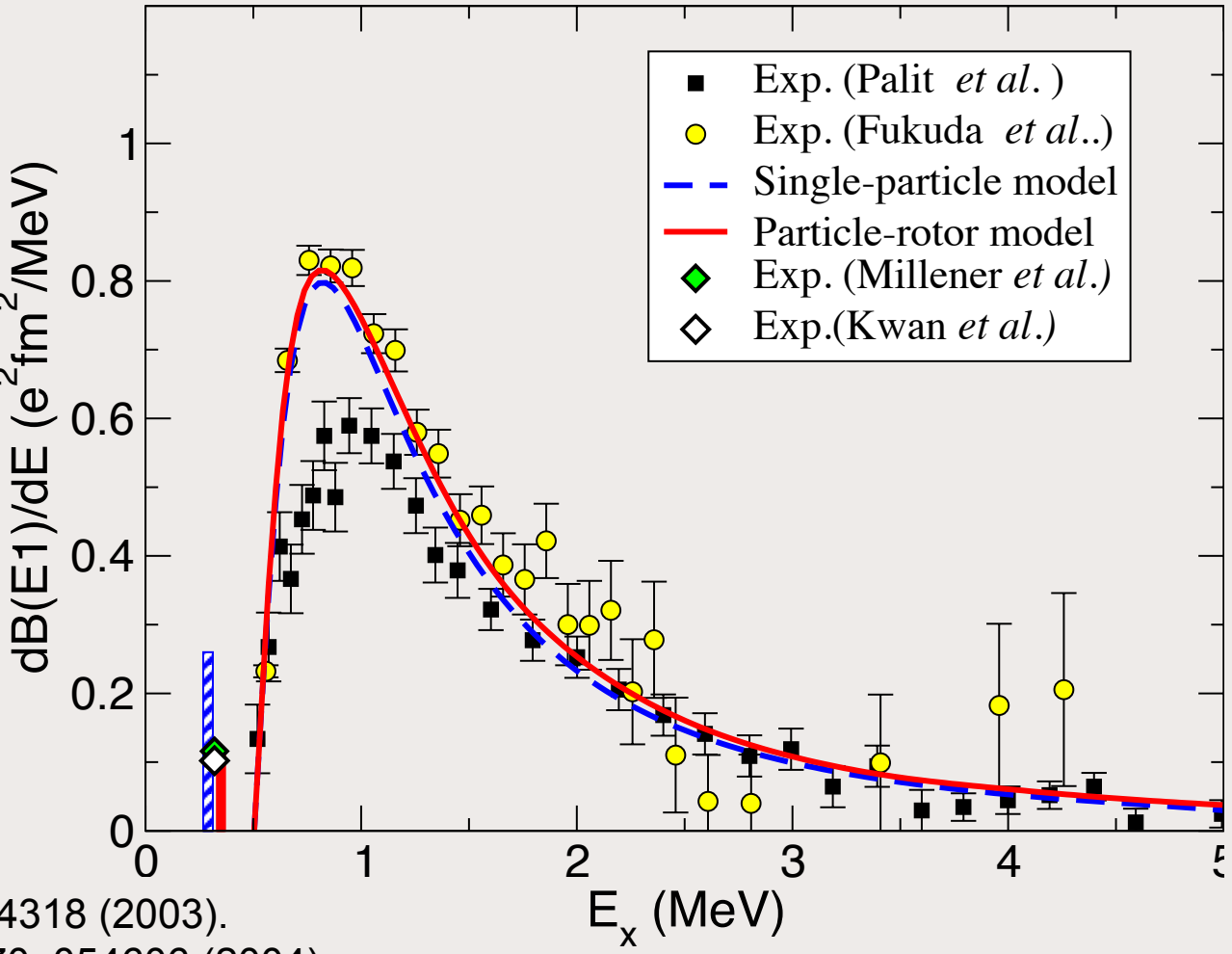


- equivalent photon method (EPM)
- continuum-discretized coupled channels (CDCC)
- (XCDCC) includes core-halo entanglement

^{11}Be on ^{197}Au at TIGRESS

V. Pesudo, M.L.G. Borge et al., Submitted to PRL.

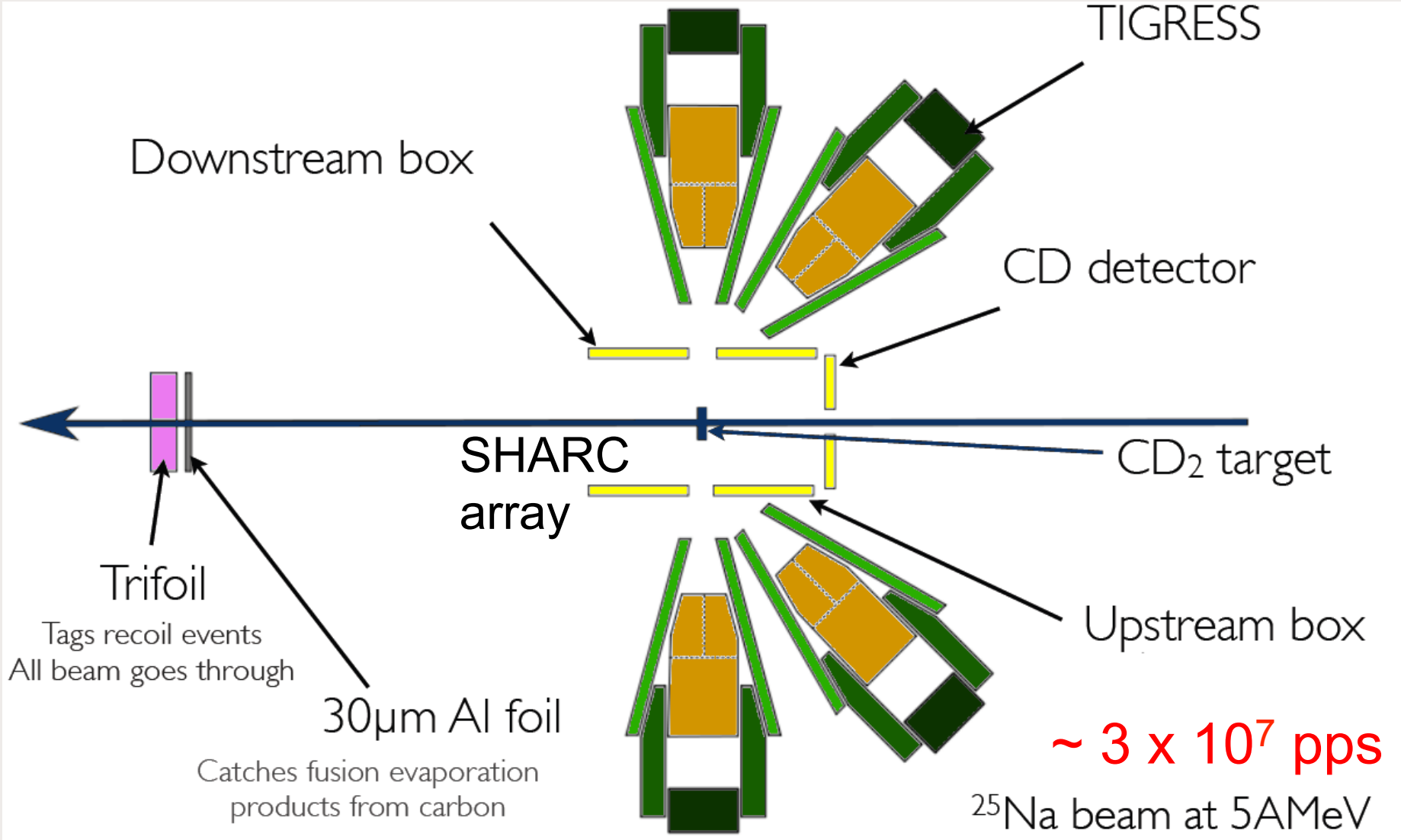
B(E1) strength calculation – coupling of core and halo states are important



R. Palit et al., Phys. Rev. C 68, 4318 (2003).
N. Fukuda et al., Phys. Rev. C 70, 054606 (2004).
D. Millener et al., Phys. Rev. C 28, 497 (1983).
E. Kwan et al., Phys. Lett. B 732, 210 (2014).

Experimental Setup to Measure d(^{25}Na,p)^{26}Na at TRIUMF

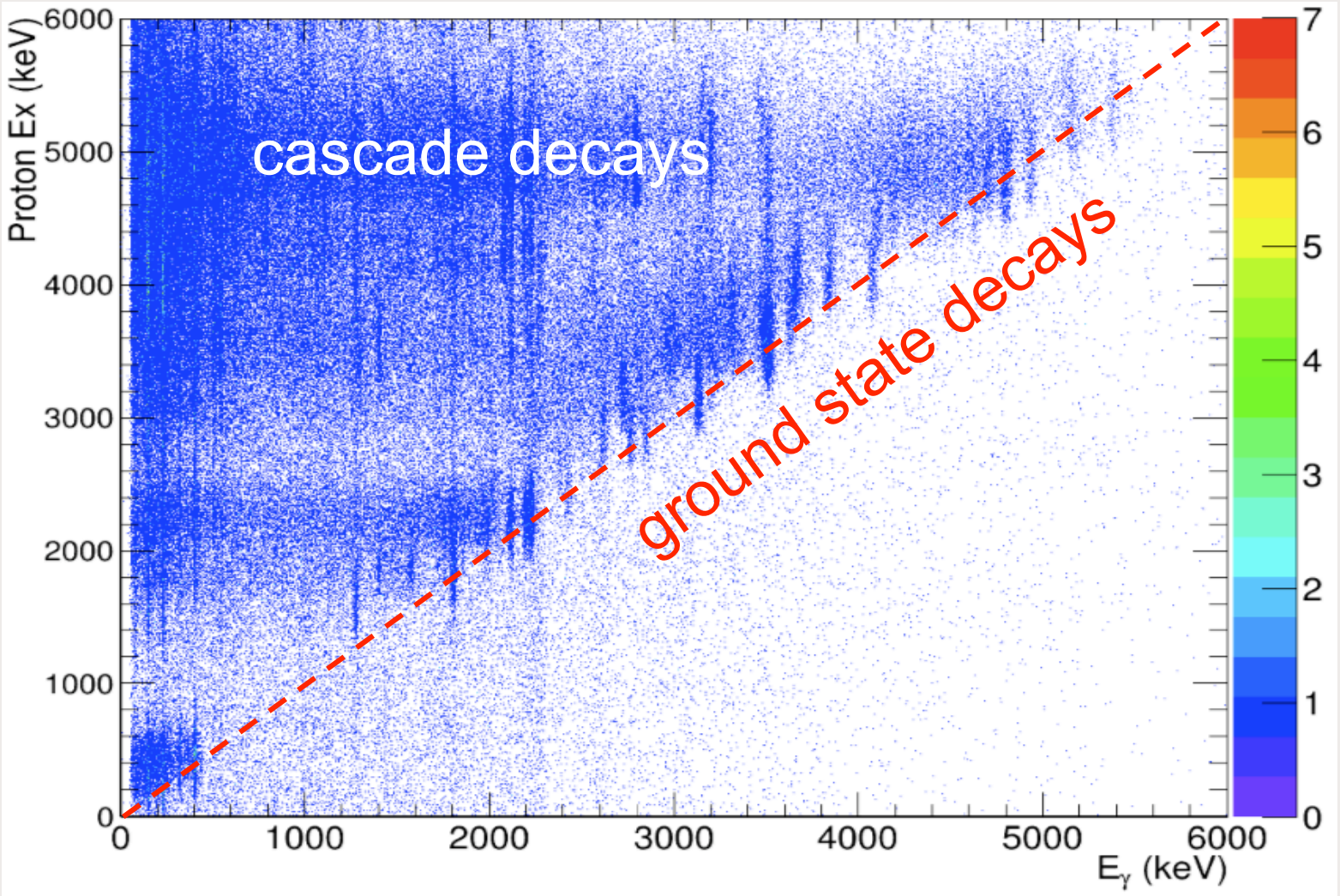
G.L Wilson, et al., Accepted to PLB (2016).



Data from d(^{25}Na,p)^{26}Na at 5 MeV/A using SHARC at ISAC2 at TRIUMF

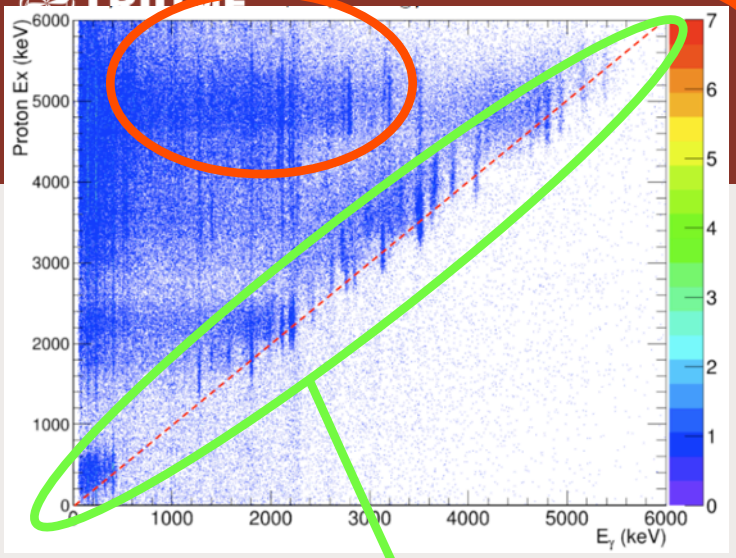
G.L Wilson, et al., Accepted to PLB (2016).

Excitation energy deduced from proton energy and angle



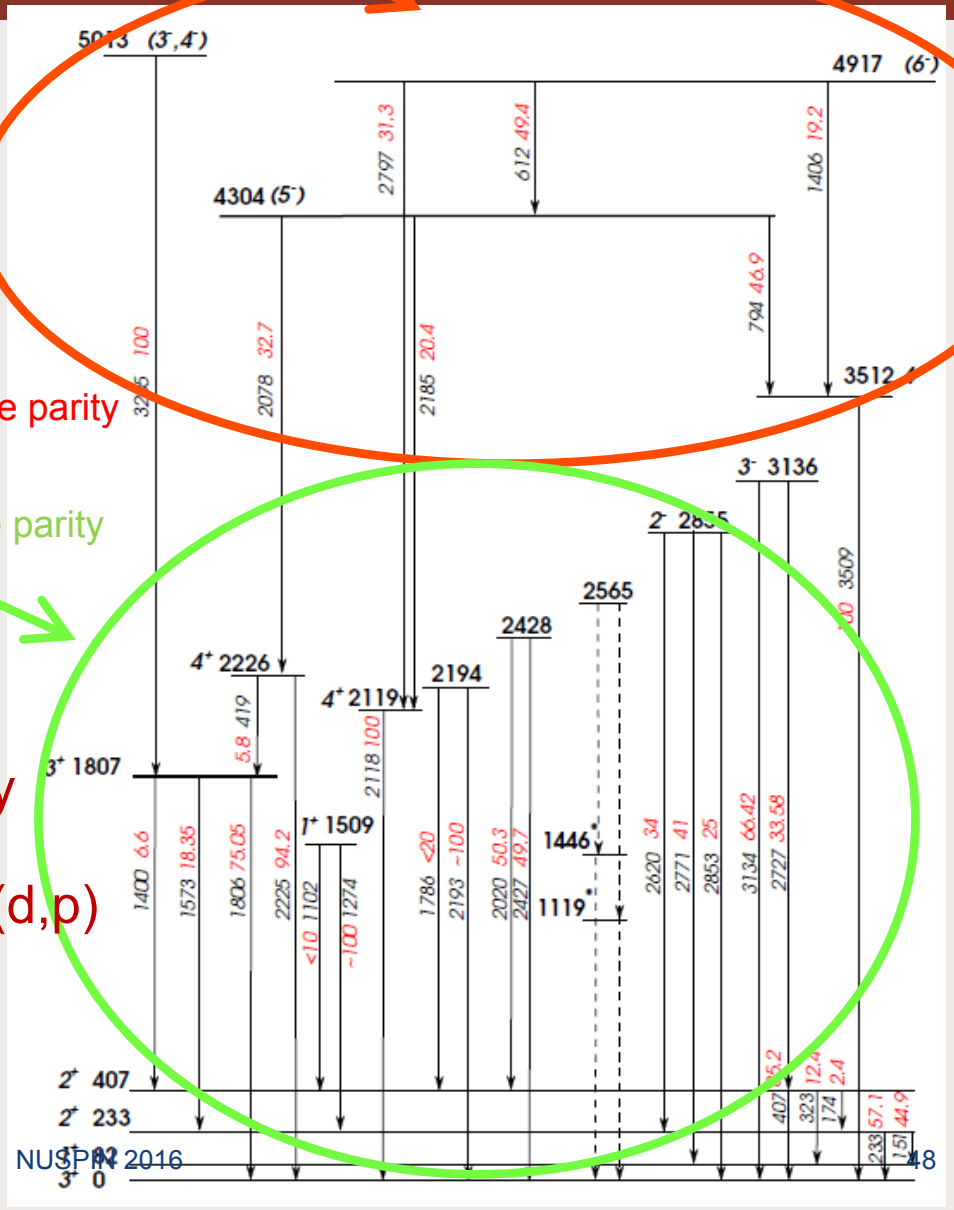
Doppler corrected (β=0.10) gamma-ray energy measured in TIGRESS

combining transfer and gamma-ray decays gives a rich insight into the structure



negative parity

positive parity



results

horizontal axis = gamma-ray energy

with doppler correction applied

vertical axis = energy populated in (d,p)

as calculated from proton angle and energy

^{25}Na (d,p) ^{26}Na

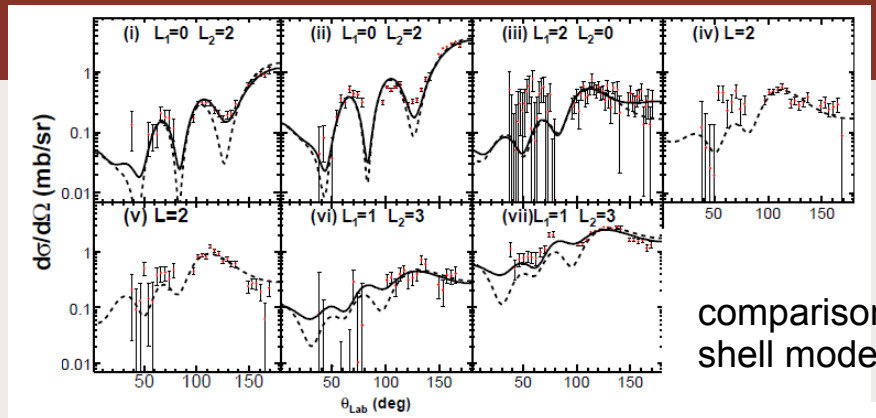
30 June 2016

G.L Wilson, et al., Accepted to PLB (2016).

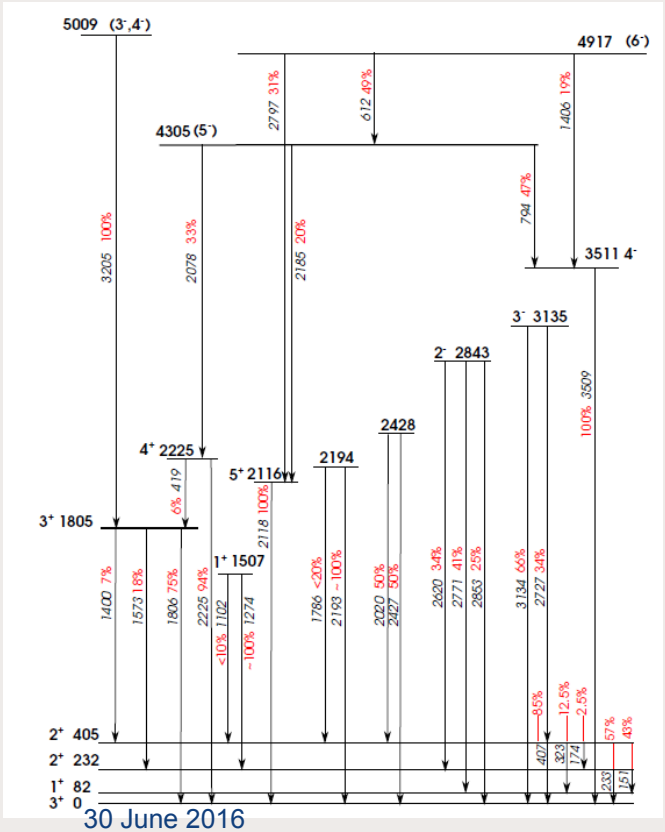
Experimental Results from studying d(^{25}Na,p)^{26}Na at TRIUMF

G.L Wilson, et al., Accepted to PLB (2016).

differential cross section for gamma-gated bound states give ell and SF



observed gamma-ray decays vital in order to determine spin

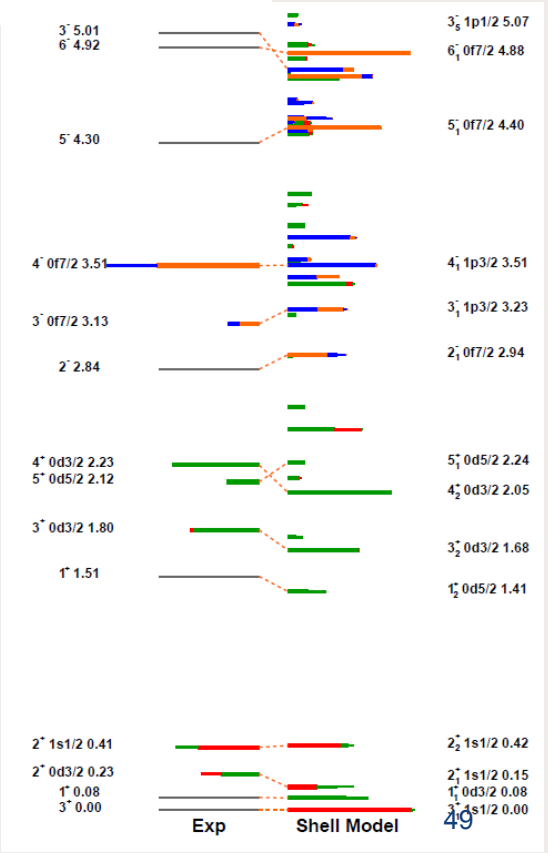


newly seen negative parity states relevant to shell gap

complete positive parity spectrum clarified to 3 MeV

Excitation Energy (keV) present	Excitation Energy (keV) (^{14}C,d) [16]	Excitation Energy (keV) (t,^{3}He) [17, 18]	Excitation Energy (keV) β-decay [19]	Shell	Spin J_i^π
0	0	0	0	0	3_1^+
82.0	82.5	88	82.5	77	1_1^+
232	233	241	233	148	2_1^+
405	406	420	406	416	2_2^+
	1408				
1507	1513		1511	1409	1_2^+
				1522	0_1^+
	1661				
1805		1869		1676	3_2^+
1992	1997	1996		1758	4_1^+
	2046	2048			
2116	2126			2240	5_1^+
	2182	2186			
2194				2142	2_3^+
2225	2232			2048	4_2^+
	2284	2290			
2423				2452	2_4^+
	2454	2456			
	2712	2697	2723	2412	1_3^+
				2600	1_4^+
		2815			
2843				2936	2_1^-
				2930	3_1^+
		2938	2933		

comparison between revised shell model energies and SFs

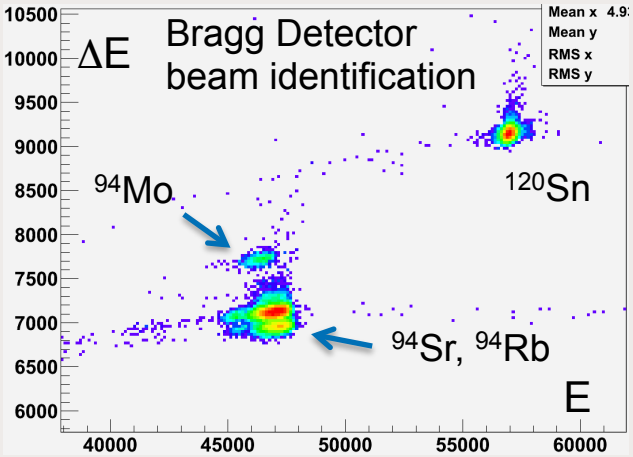


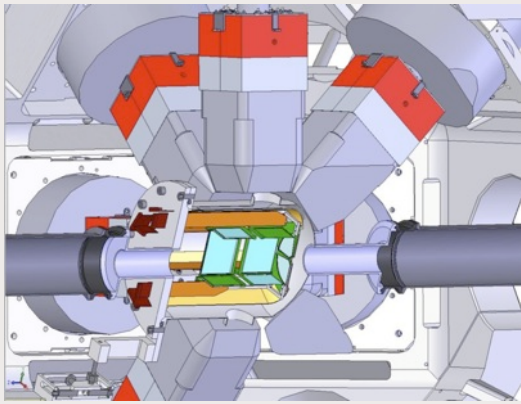
Kruecken, Cruz, Bender *et al.*

Transfer program at ISAC-II

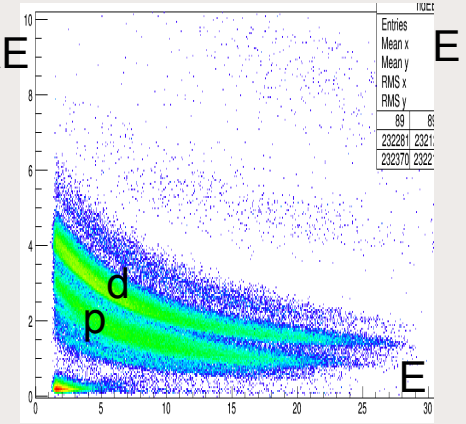
d(^{94}Sr,p)^{95}Sr, 5.5 MeV/u ~10^5 pps
d(^{95}Sr,p)^{96}Sr, 5.4 MeV/u ~10^7 pps
d(^{96}Sr,p)^{97}Sr, 5.5 MeV/u

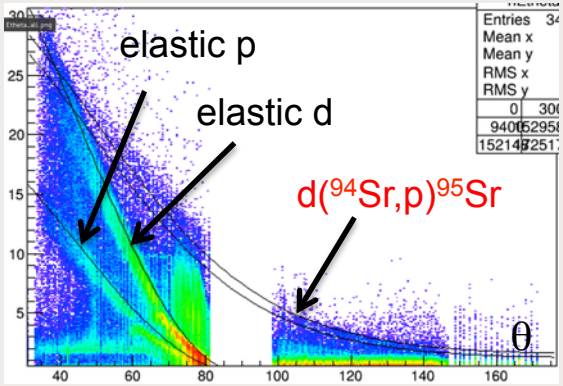
Plans to now perform (t,p) pair transfer studies

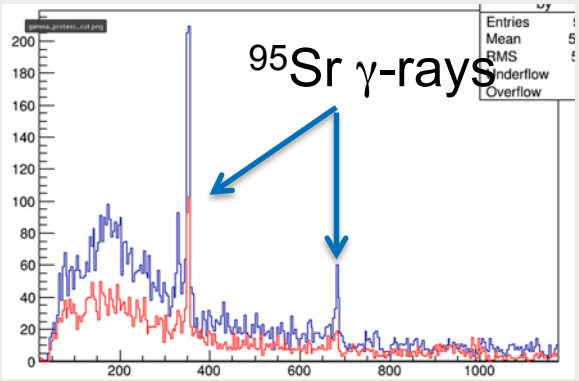




TIGRESS + SHARC

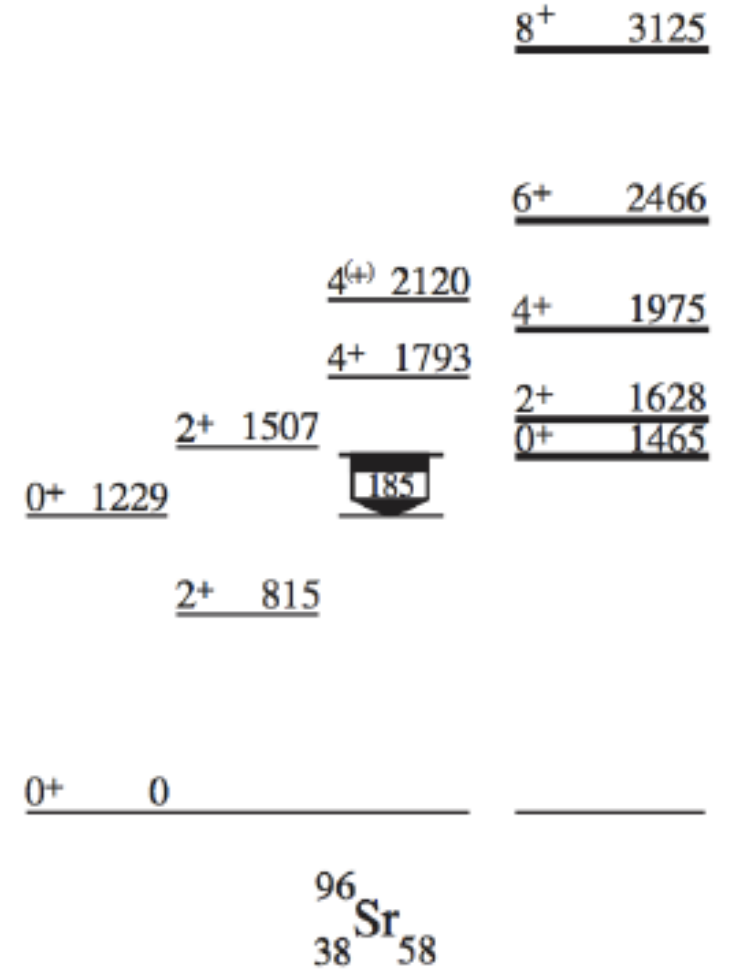


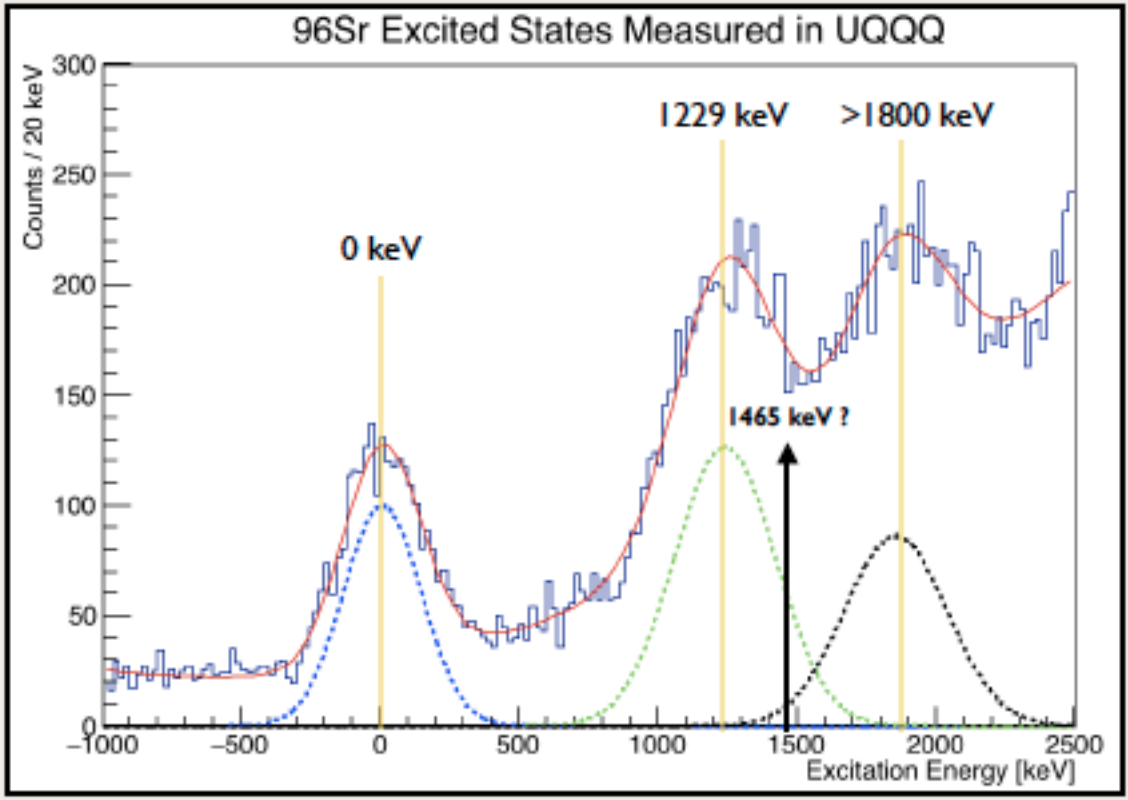




Kruecken, Cruz, Bender *et al*.

$d(^{95}Sr,p)^{96}Sr$

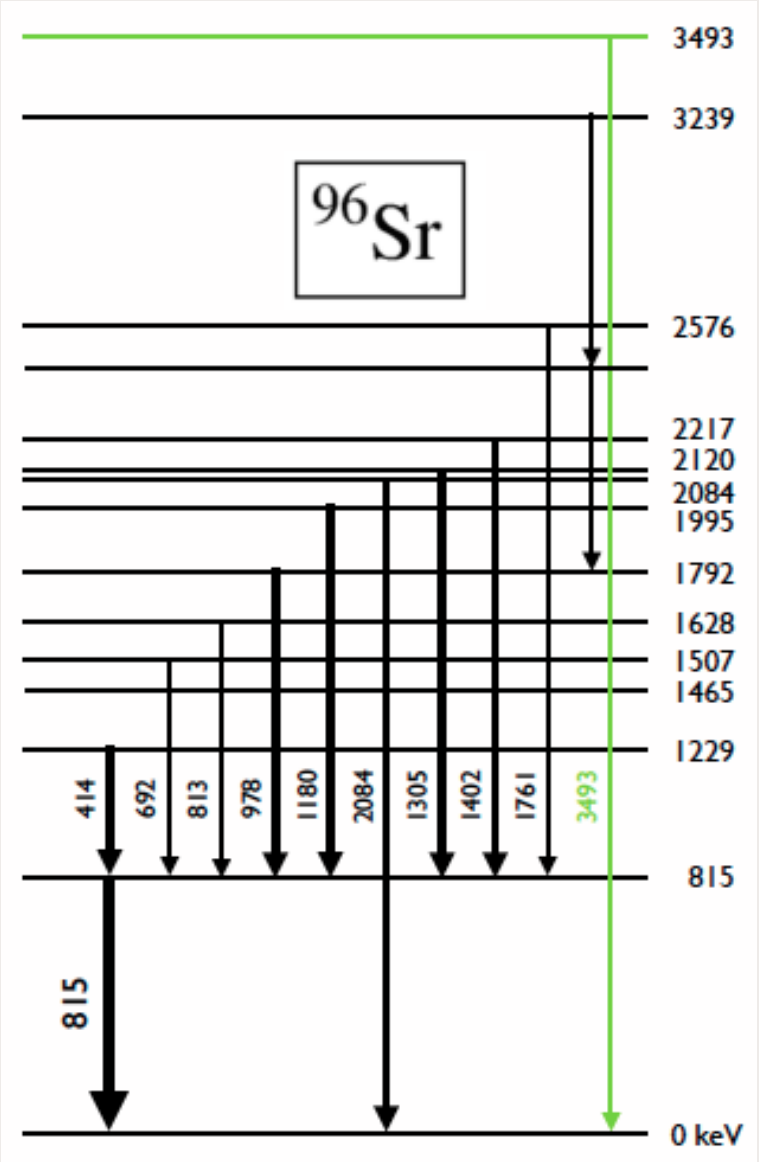


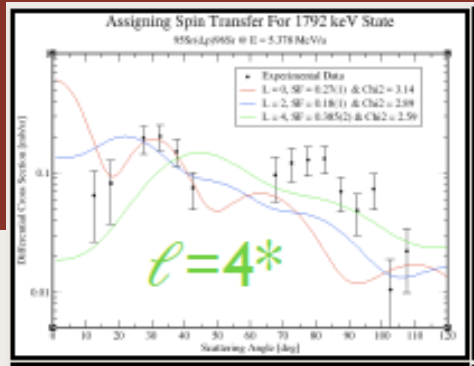


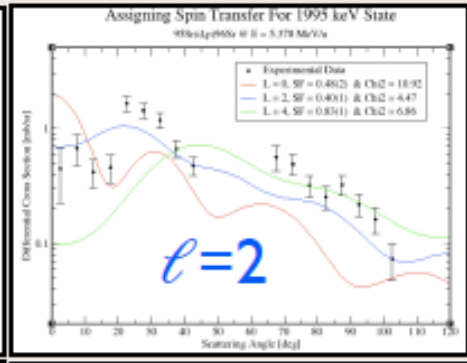
Population of 1465 keV state is very small compared to other 0^+ states, suggesting a different structure.

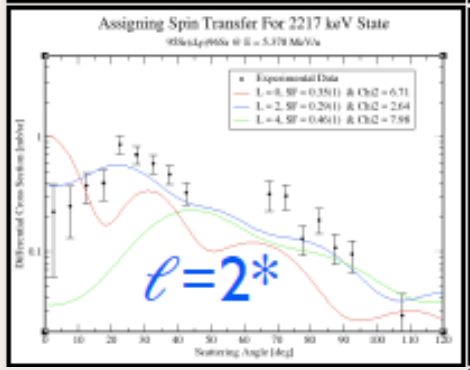
d(^{95}Sr,p)^{96}Sr

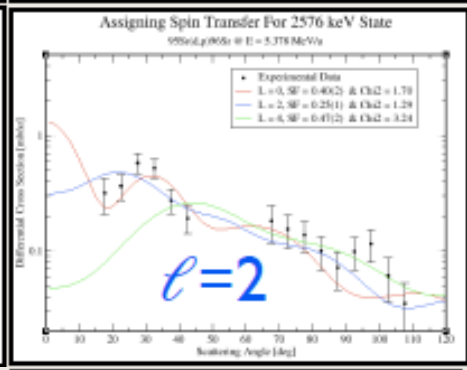
Kruecken, Cruz, Bender *et al*.

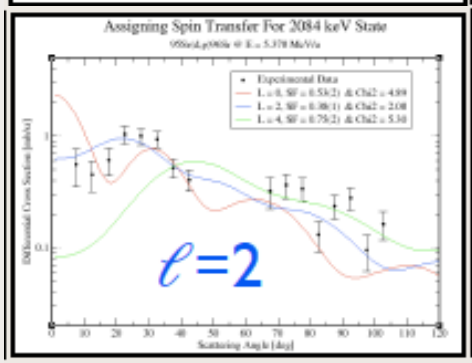


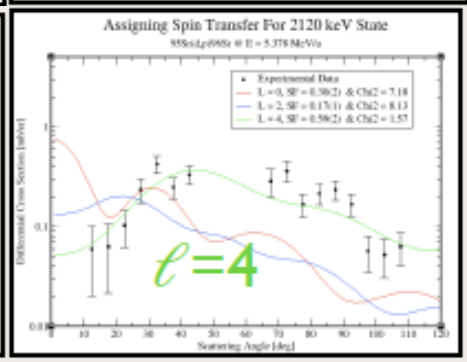


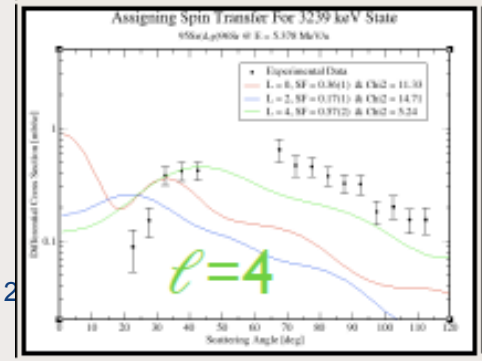


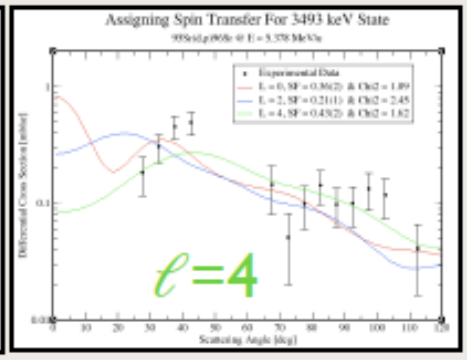






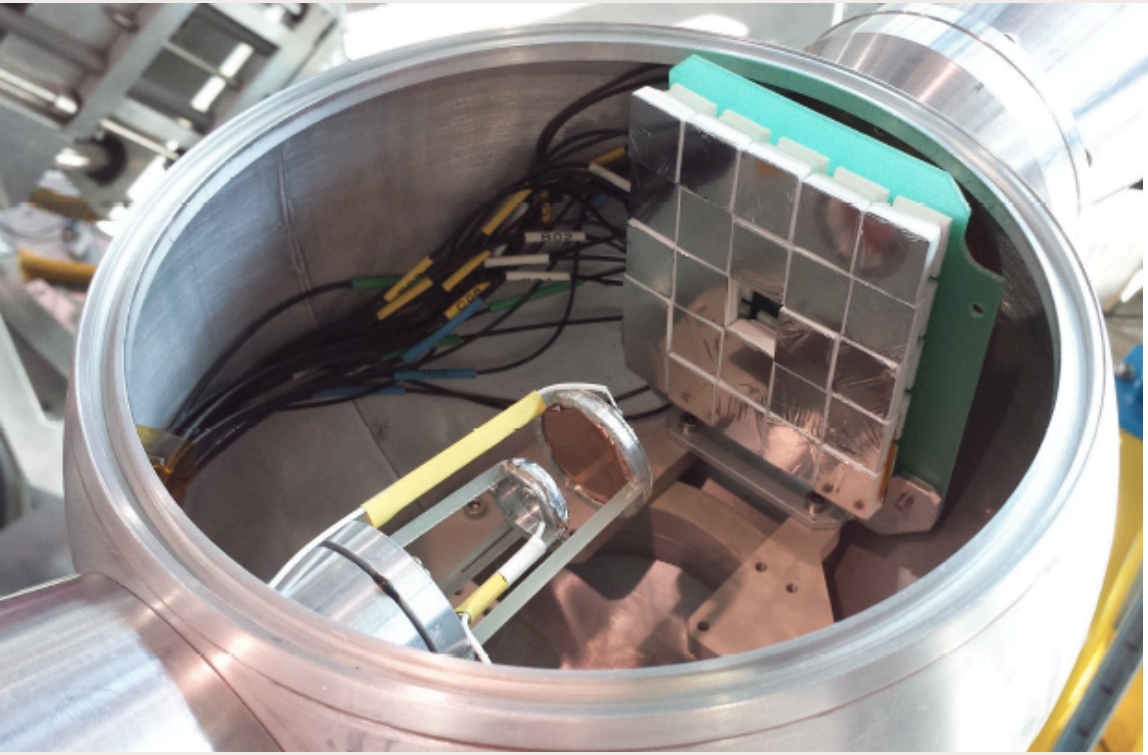


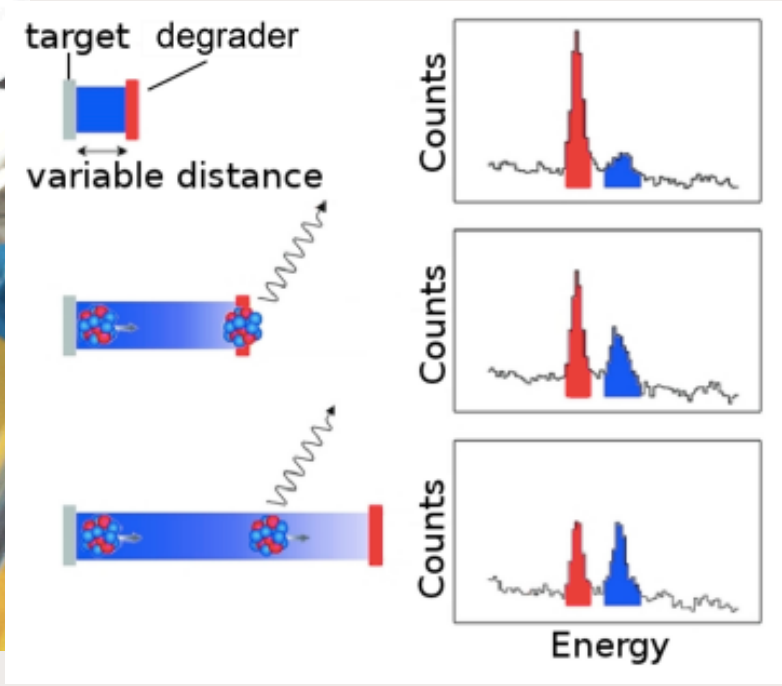




K. Starosta SFU *et al*.

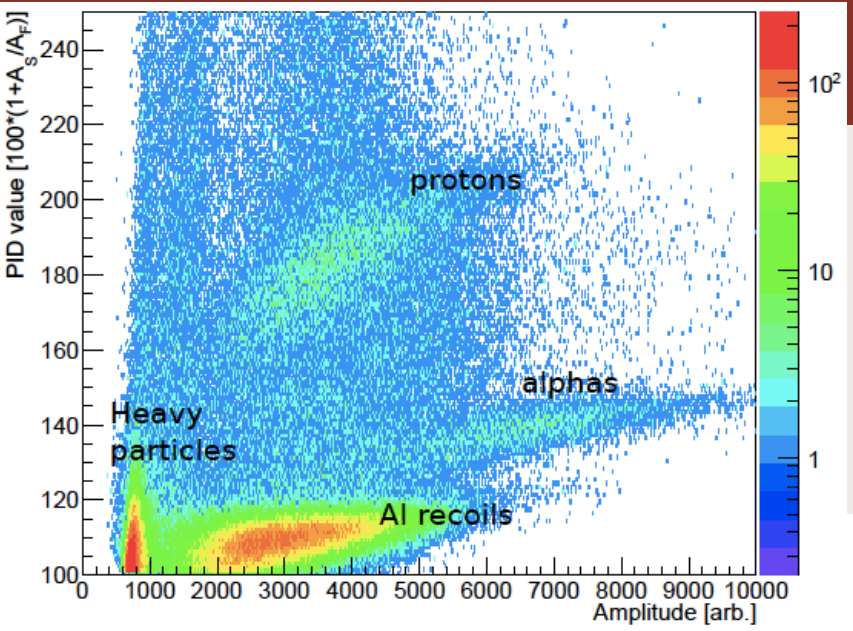
TIGRESS Integrated Plunger



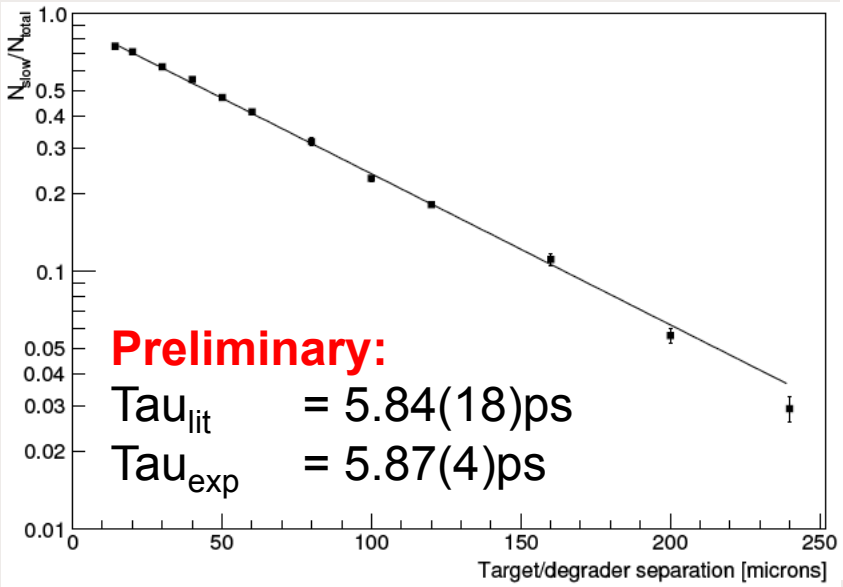


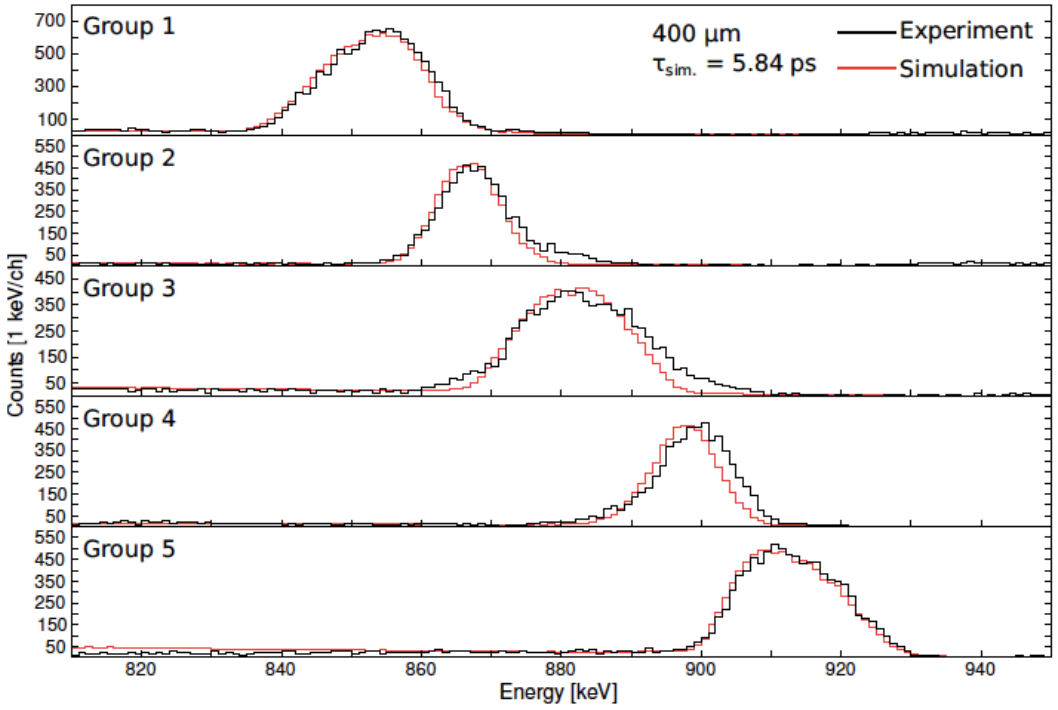
Plunger working well, here with CsI test wall

TIP, ^{84}Kr case



First 2^+ state populated in Coulomb excitation of ^{84}Kr beam





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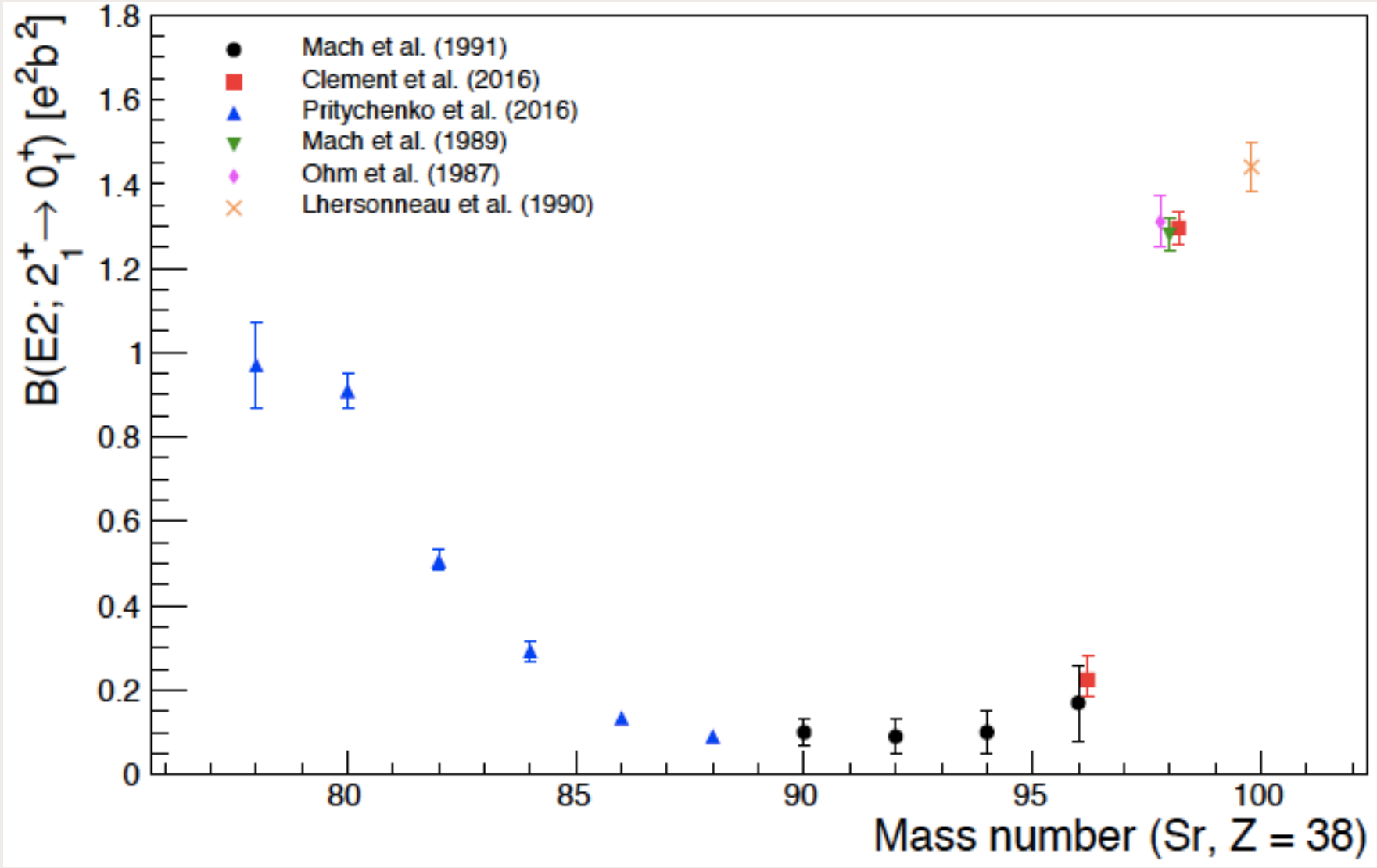
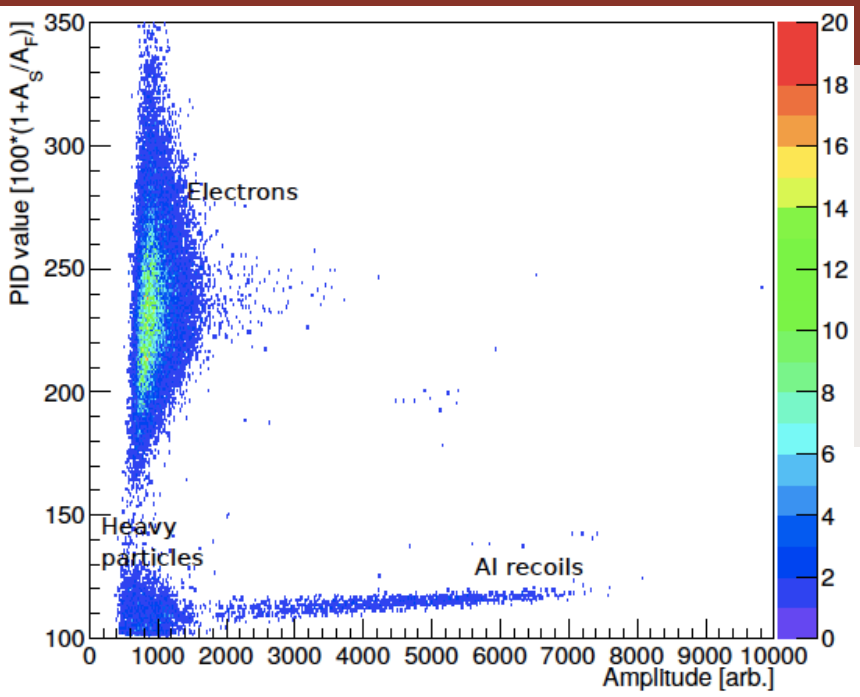
TIGRESS Integrated Plunger

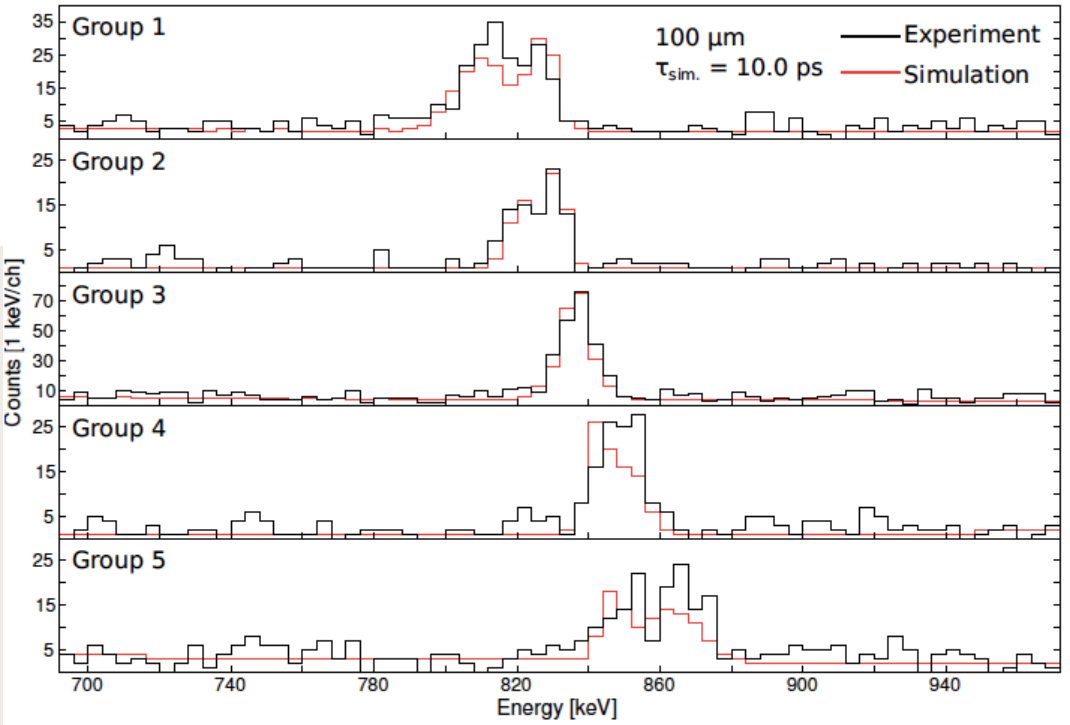


K. Starosta SFU *et al.*

TIP, ^{94}Sr case

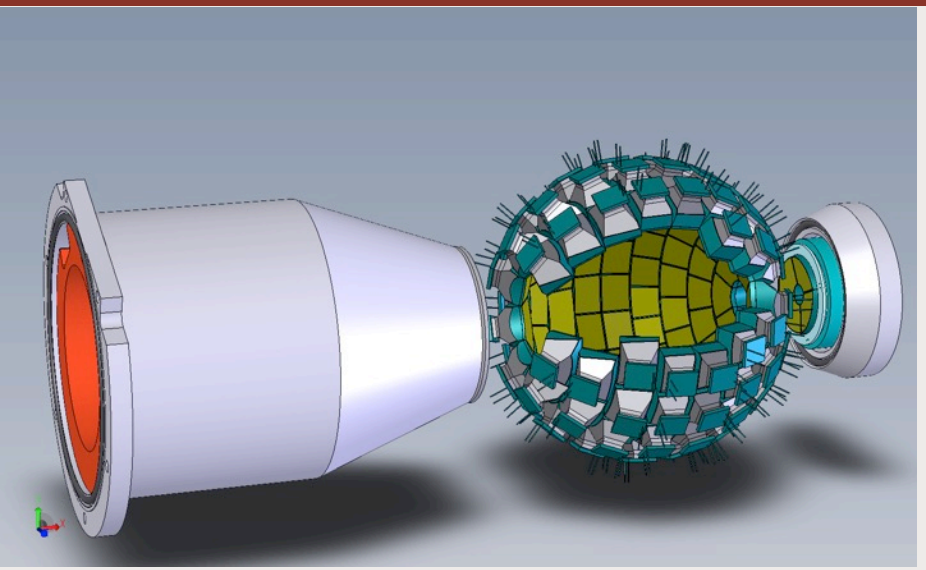


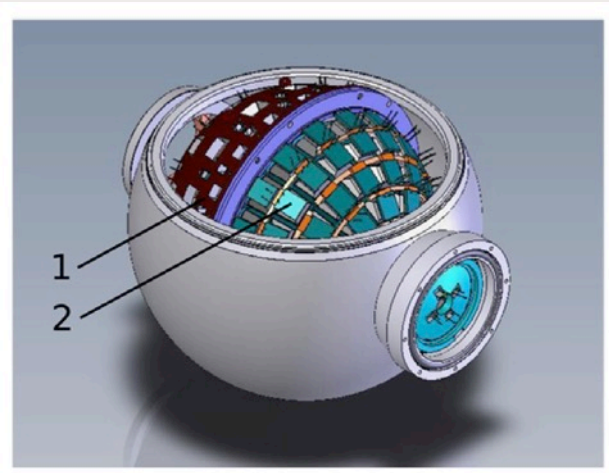
First 2^+ state populated in Coulomb excitation of ^{94}Sr beam

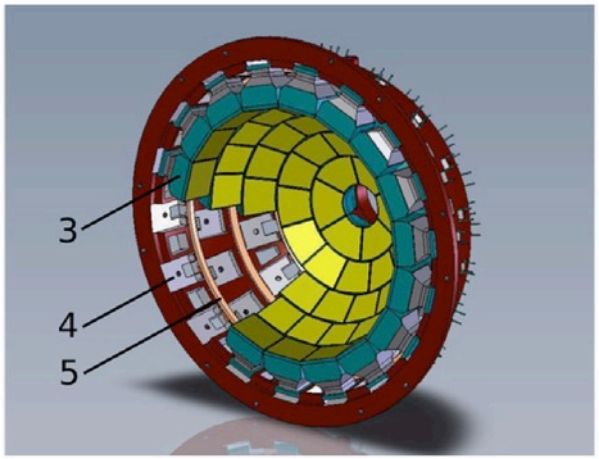


TIGRESS Integrated Plunger

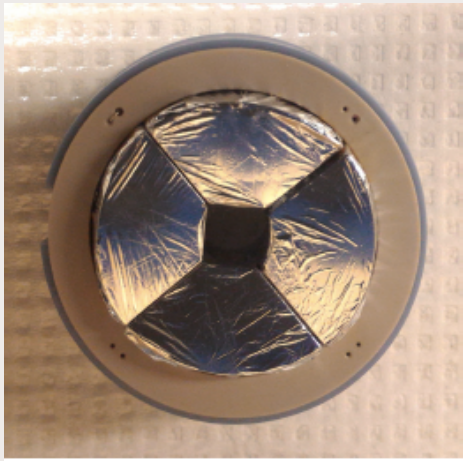
K. Starosta SFU *et al*.



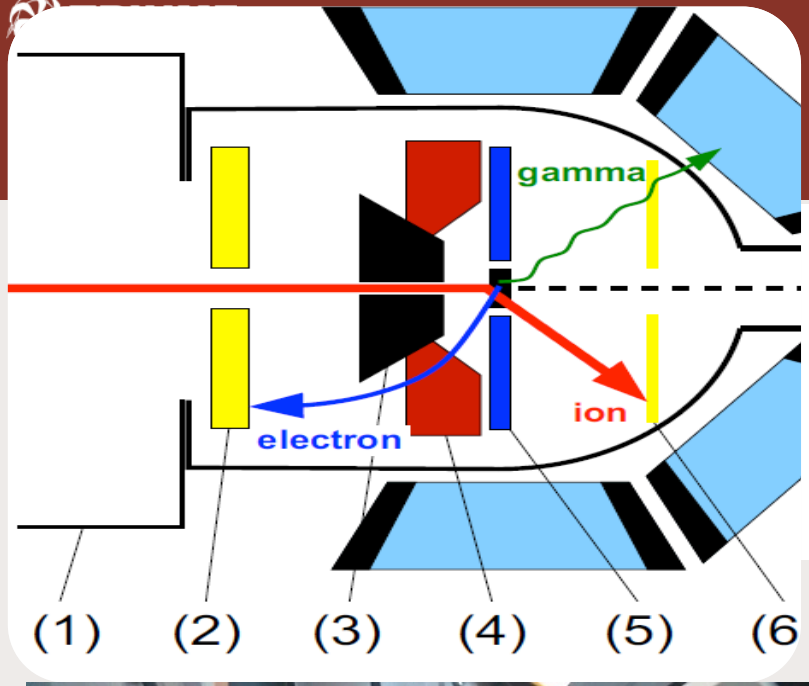




CsI ball under construction

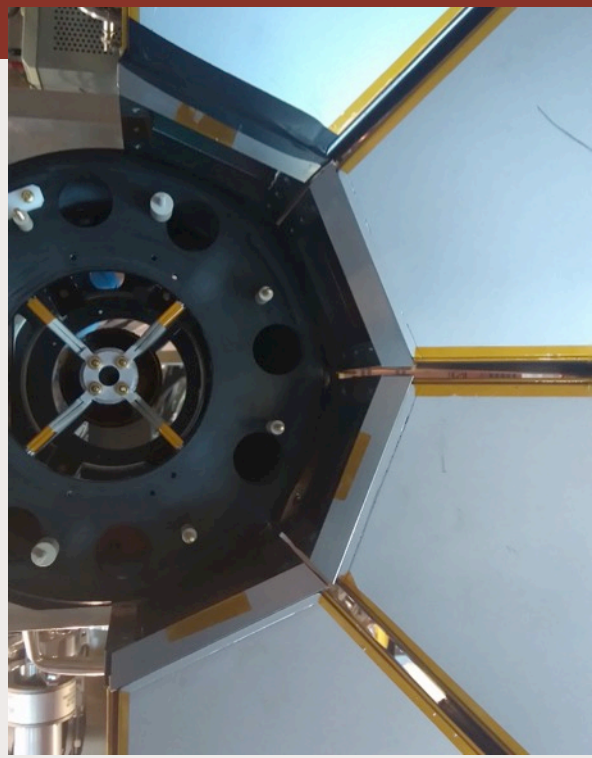


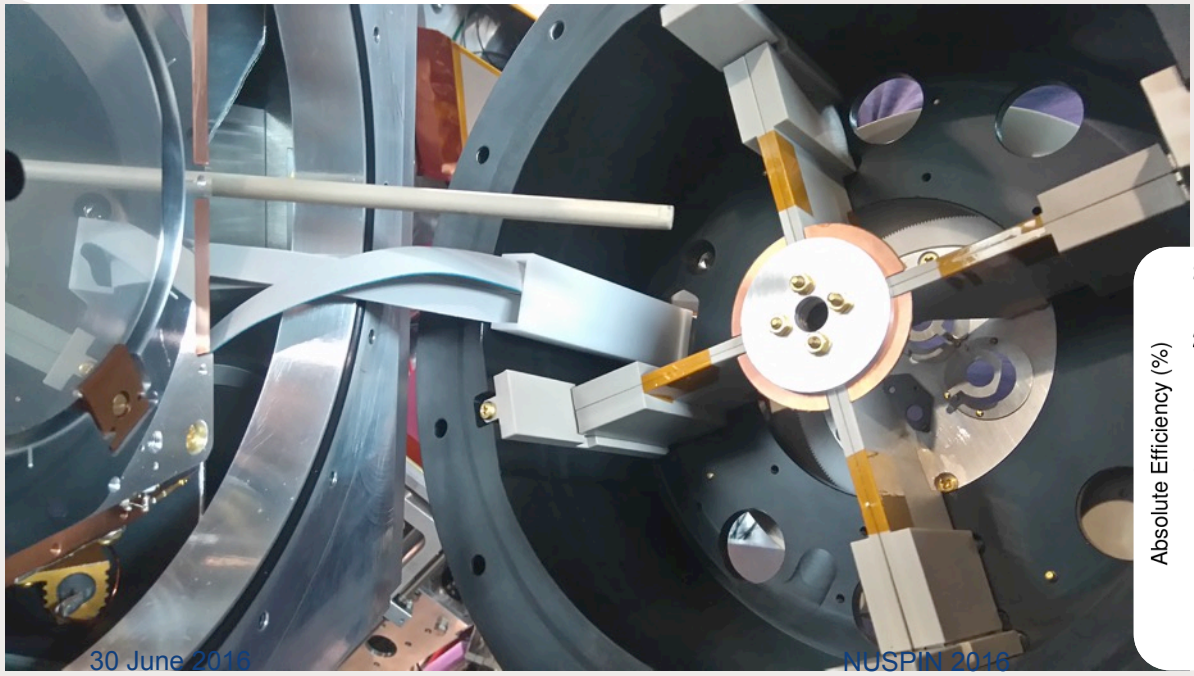
SPICE Design

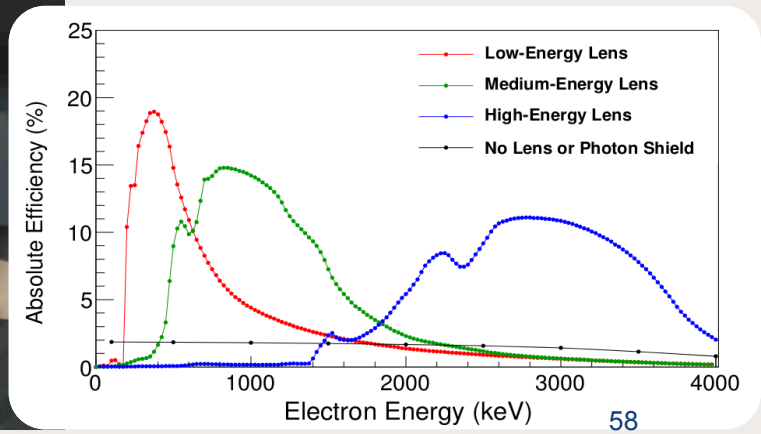


Garnsworthy, Smallcombe *et al*.

1. Vacuum vessel
2. Si(Li)
3. Photon-shield
4. Magnetic lens
5. Target wheel
6. DSSD
7. **HPGe (TIGRESS)**

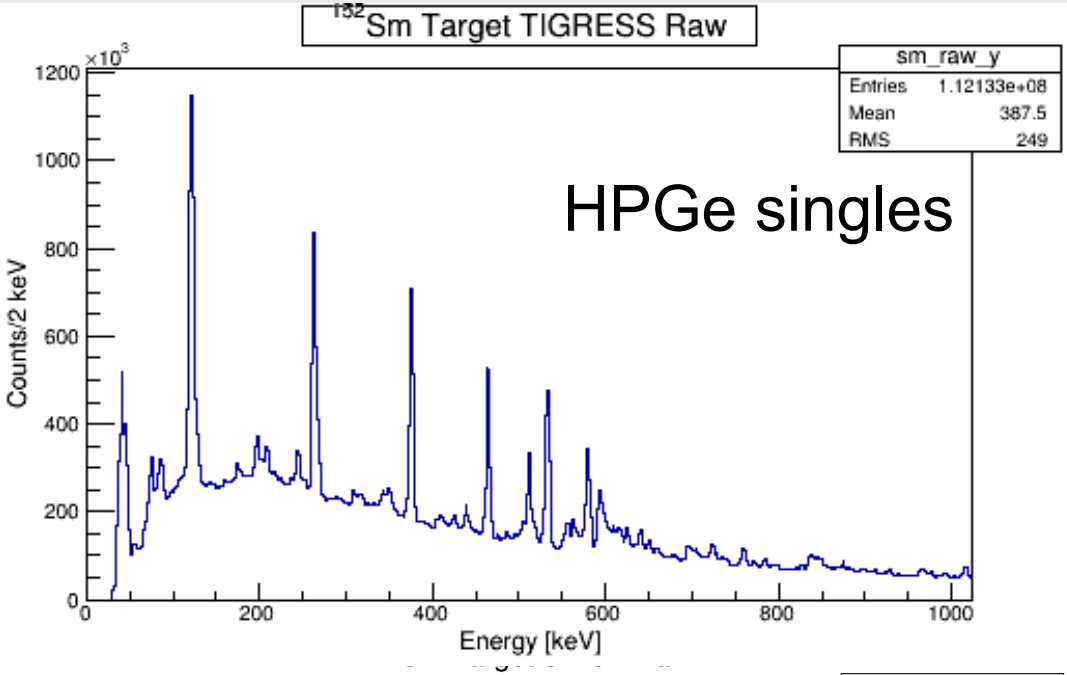


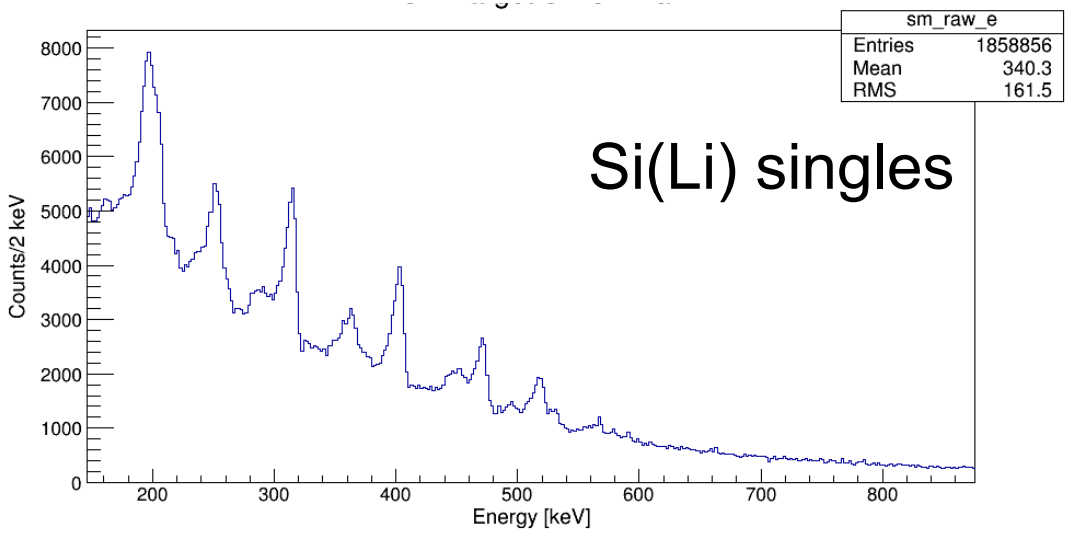




Garnsworthy, Smallcombe *et al*.

SPICE run: Aug 2015





68 MeV ^{12}C beam,
4 mg/cm^2 ^{152}Sm, 300 ppA,
13.5 hours,

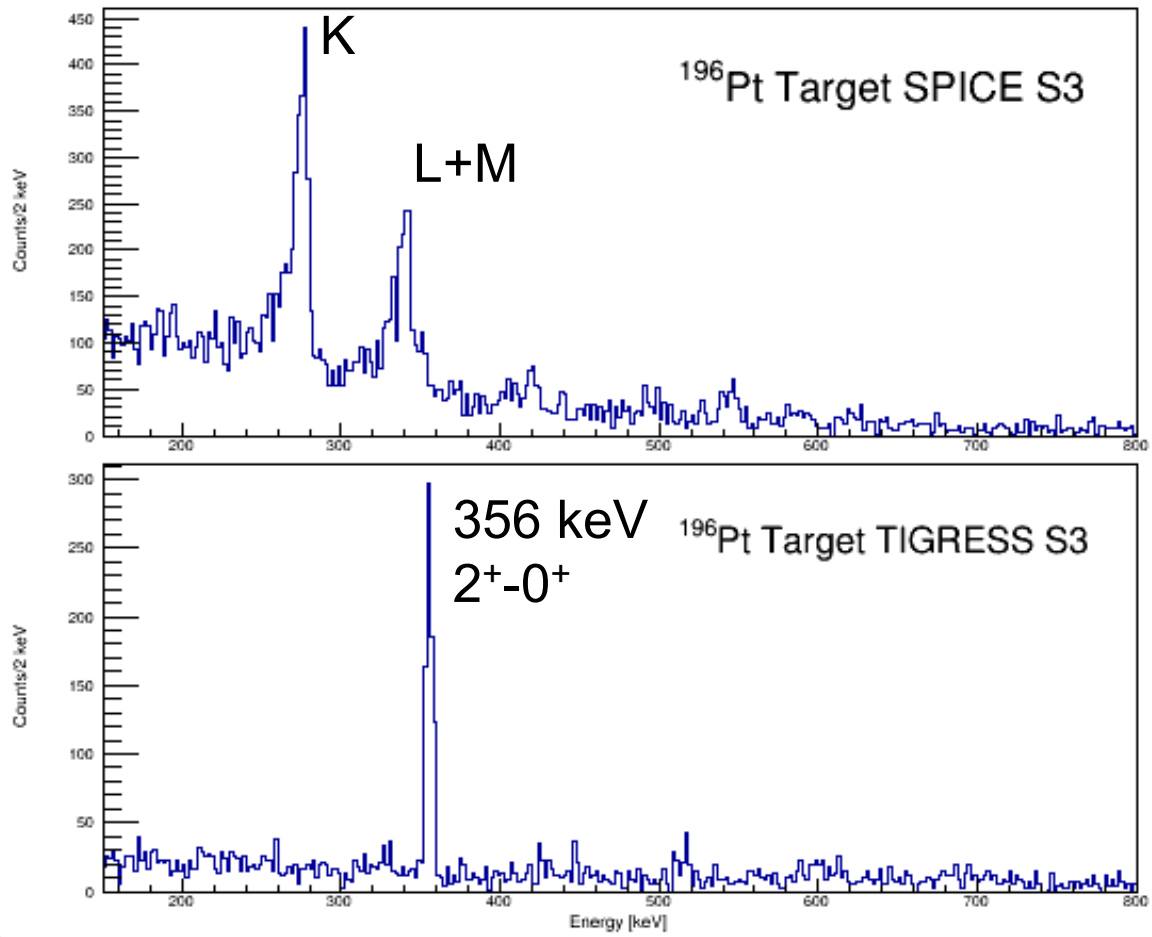
Coulex:
^{152}Sm(^{12}C,^{12}C)^{152}Sm*

Fusion evaporation:
^{152}Sm(^{12}C,4n)^{160}Er*

Garnsworthy, Smallcombe *et al*.

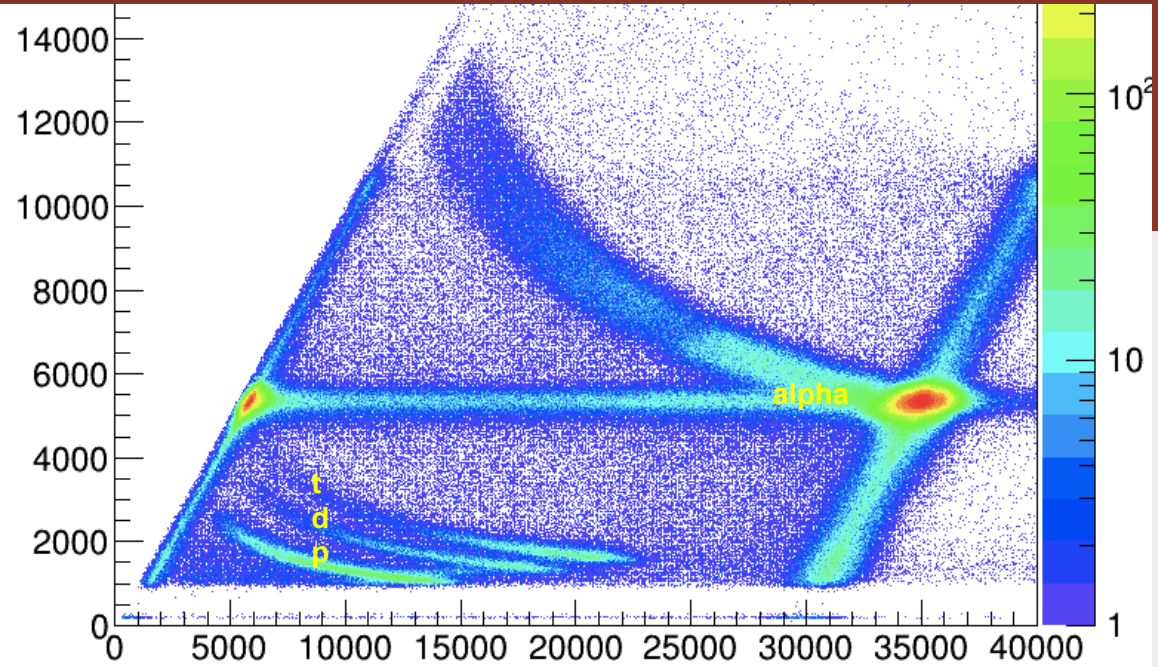
SPICE run: Aug 2015

68 MeV ^{12}C beam, 2.9 mg/cm^2 ^{196}Pt, 10 ppA, 2 hours, $^{196}Pt(^{12}C,^{12}C)^{196}Pt^*$



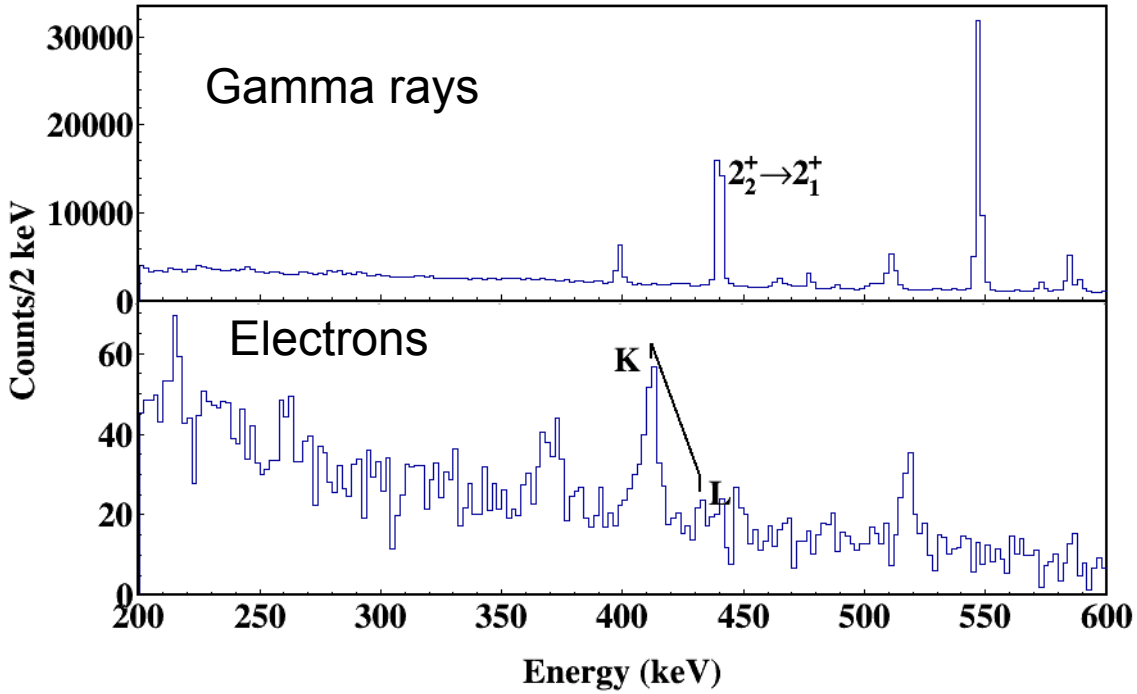
Coincidence with heavy-ion recoil in S3 detector

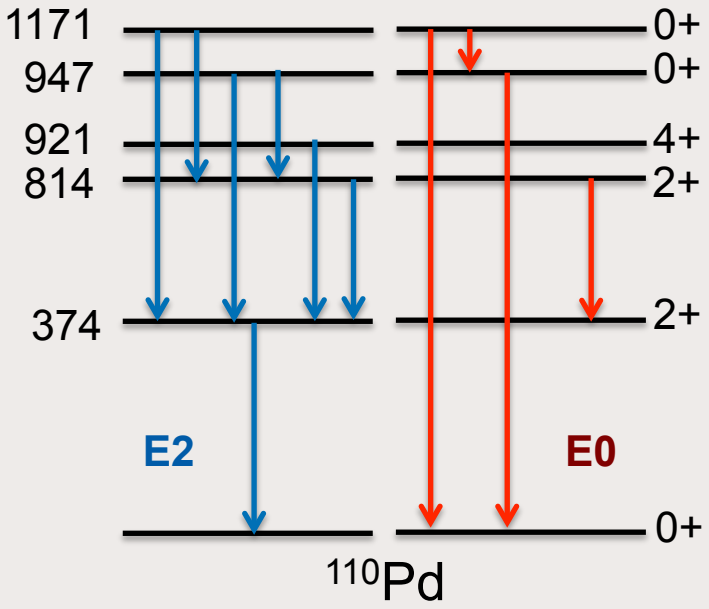
SPICE run: June 21-25 2016



ΔE – E telescope
140um and 1mm S3

250ppA 36MeV alpha beam on 1.6mg/cm^2 ^{110}Pd target





Summary

- ISAC and the future ARIEL facility promises a bright future for ISOL beams at TRIUMF.
- GRIFFIN is operational. First physics result is published in 2016.
  - DESCANT to come online this year
- Several new ancillary detectors now available for TIGRESS.
  - TIP plunger
  - SPICE electron detector
- New collaborations are very welcome!

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We have post-doc openings!
See www.triumf.ca

Thanks to Collaborators

G.C. Ball, T. Ballast, C. Bartlett, P. Bender, N. Bernier, D. Bishop, M. Bowry, D. Brennan, T. Bruhn, R. Caballero, A. Cheeseman, R. Churchman, S. Ciccone, B. Davids, L. Evitts, I. Dillmann, S. Georges, G. Hackman, S. Hallam, J. Henderson, R. Kokke, R. Kruecken, K. Leach, Y. Linn, C. Lim, L. MacConnachie, D. Miller, W.J. Mills, L.N. Morrison, M. Moukaddam, C.A. Ohlmann, O. Paetkau, J. Park, C.J. Pearson, M.M. Rajabali, P. Ruotsalainen, B. Shaw, J. Smallcombe, J.K. Smith, D. Southall, C. Unsworth, Z.M. Wang, S. Wong, *TRIUMF, Canada*;

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A. Jungclaus, CSIC Madrid, Spain

E. Padilla Rodal, UNA Mexico

C. Petrache, University of Paris-Sud, France

and the other members of the GRIFFIN collaboration