Independent Fission Product Yields from 0.5-20 MeV
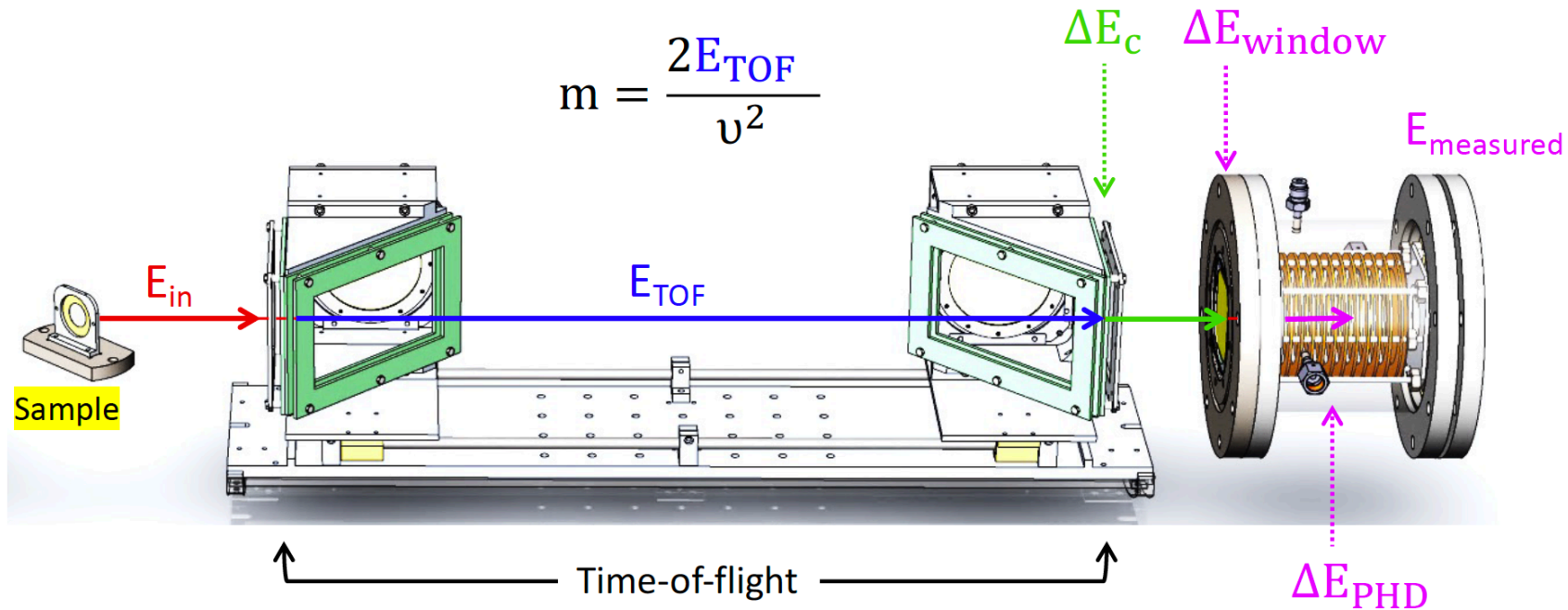
Jack Winkelbauer

March 2, 2023

LA-UR-23-22073

SPIDER: Independent FPY's with E-v method

$$m = \frac{2E_{TOF}}{v^2}$$

ΔE_c ΔE_{window}

$E_{measured}$

E_{in}

E_{TOF}

Sample

Time-of-flight

ΔE_{PHD}

SPIDER: Independent FPY's with E-v method

WNR neutron flux

100 keV – 20 MeV

- Independent FPY's (before beta decay, t<100ns)
- Probe incident energy dependence (neutron tof)
- Potentially extract $\nu(A)$
- *Deceptively* simple

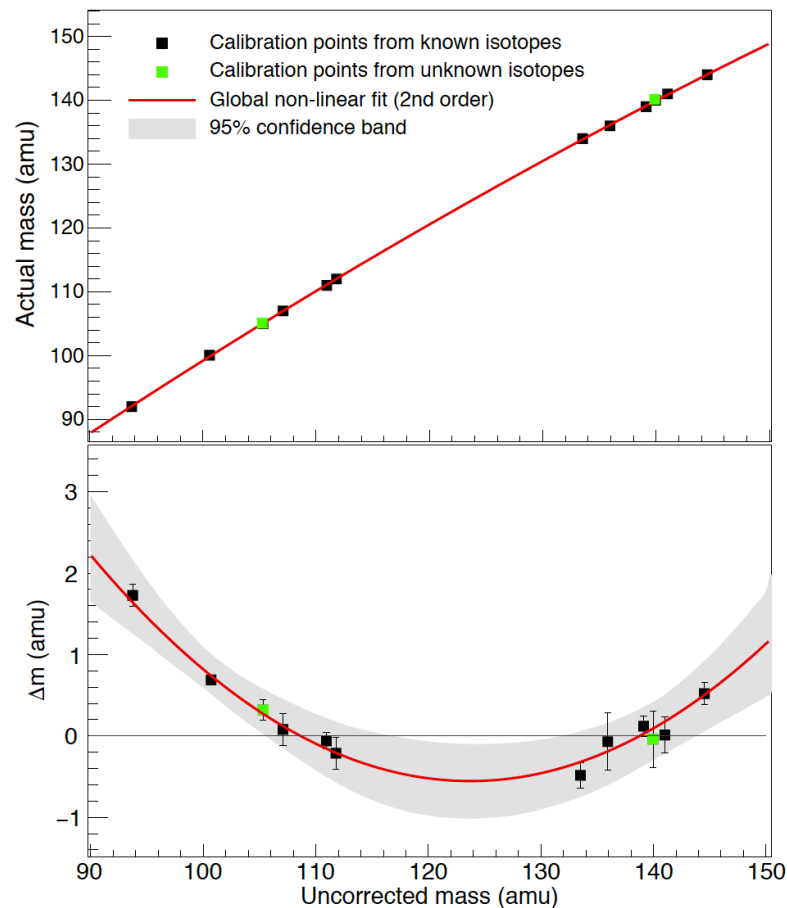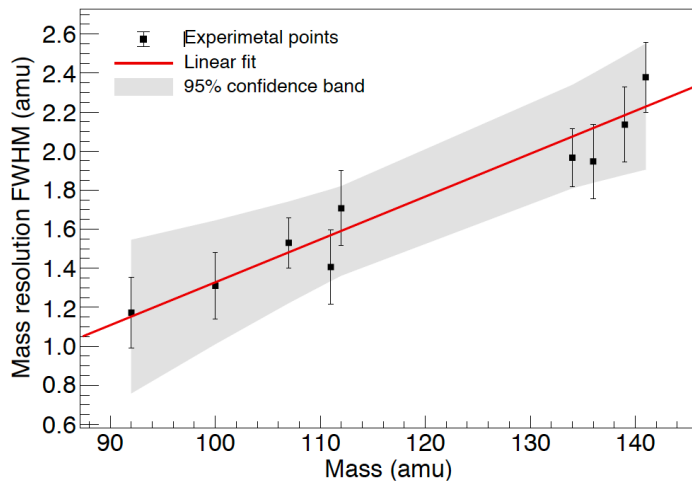^{235}U(n,f) - Simulated

GEF code

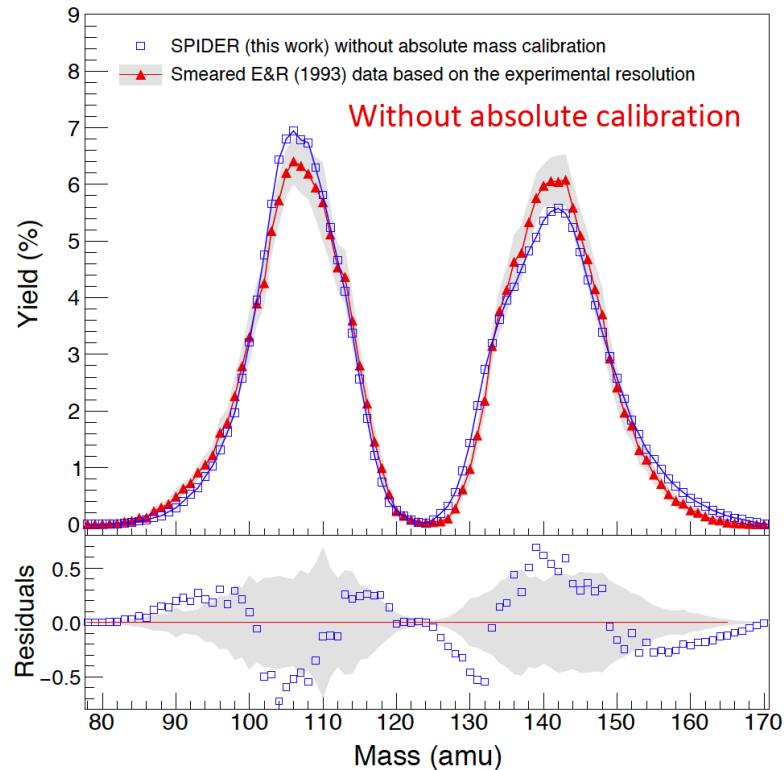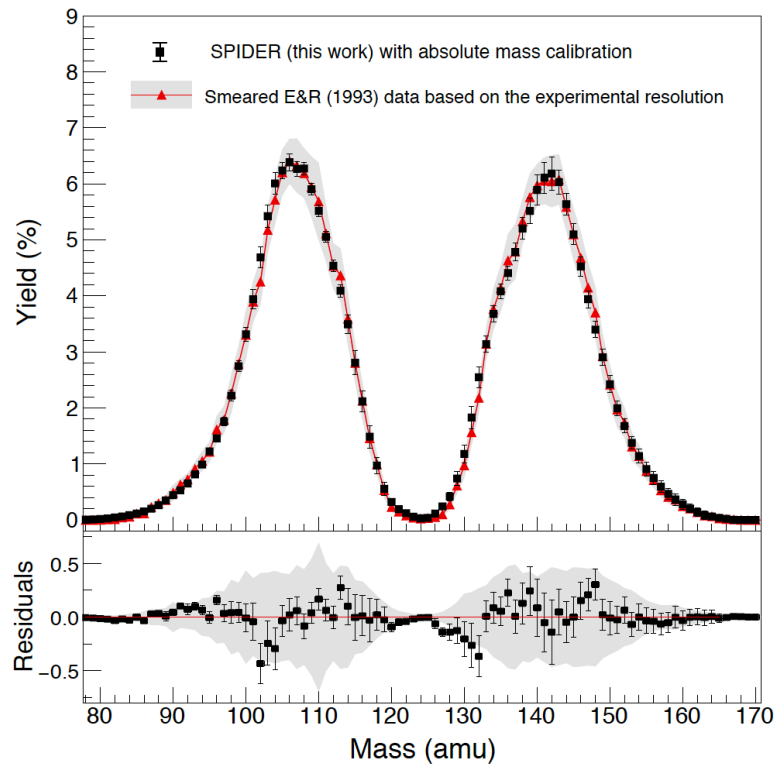
^{235}U(n,f) - Simulated

GEF code
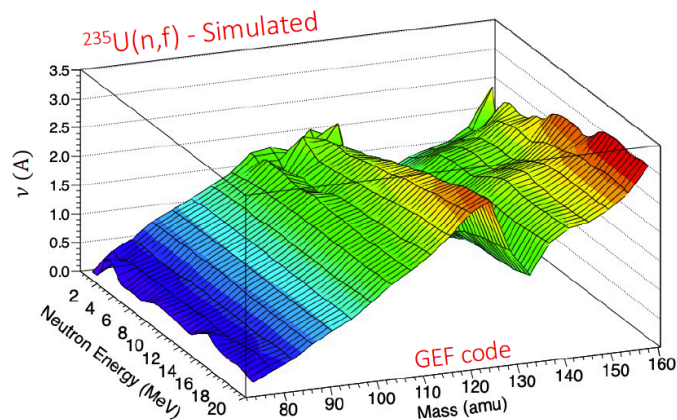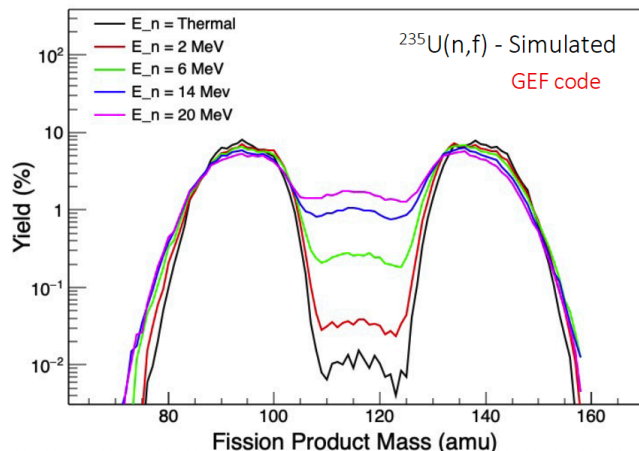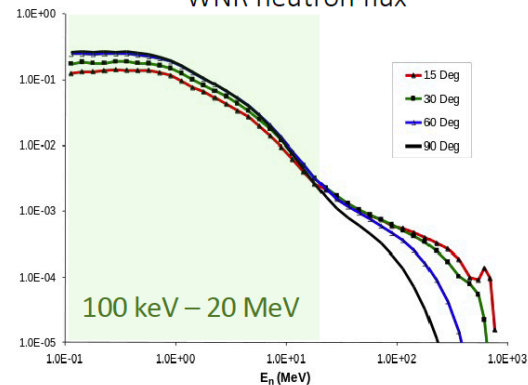
Absolute Calibration with Gamma-ray Tagging

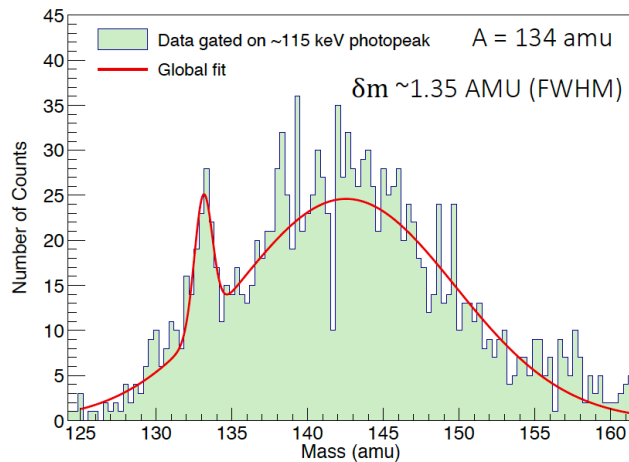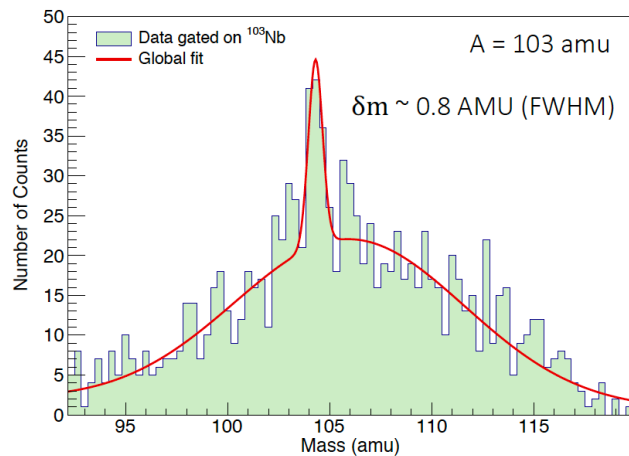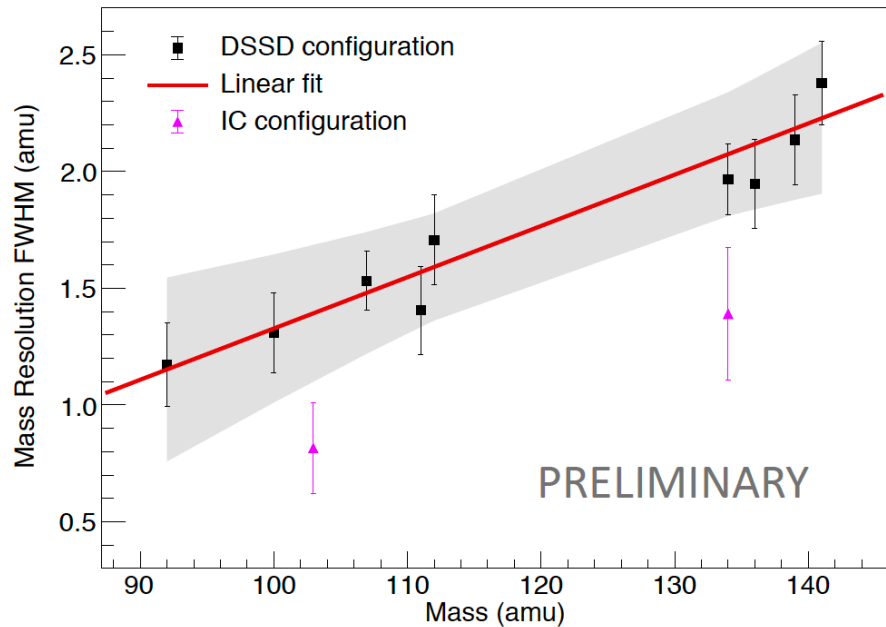1-arm SPIDER system with Si detector

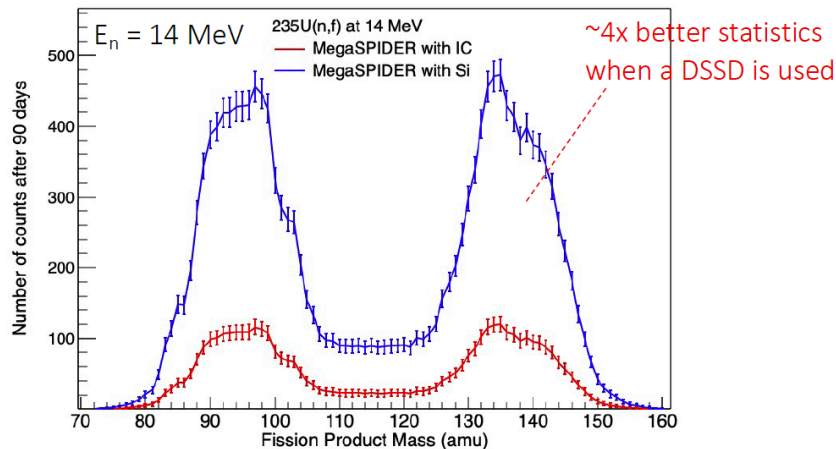P. Gastis et al., NIMA 1037, 166853 (2022)

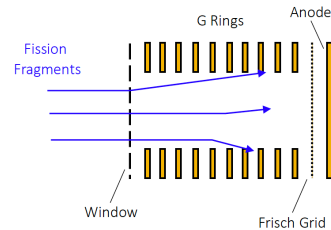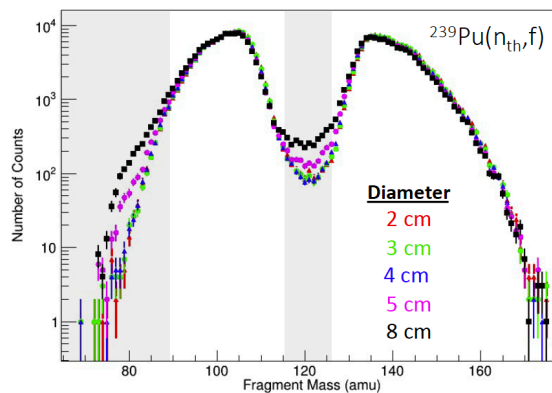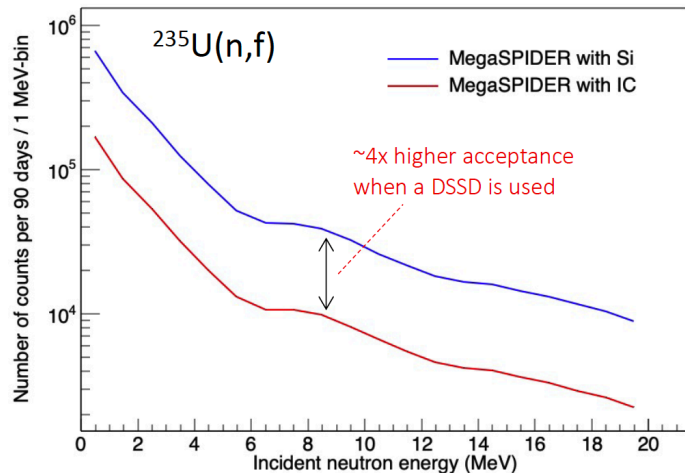# Effect of "Absolute Calibration" (Energy losses, PHD)

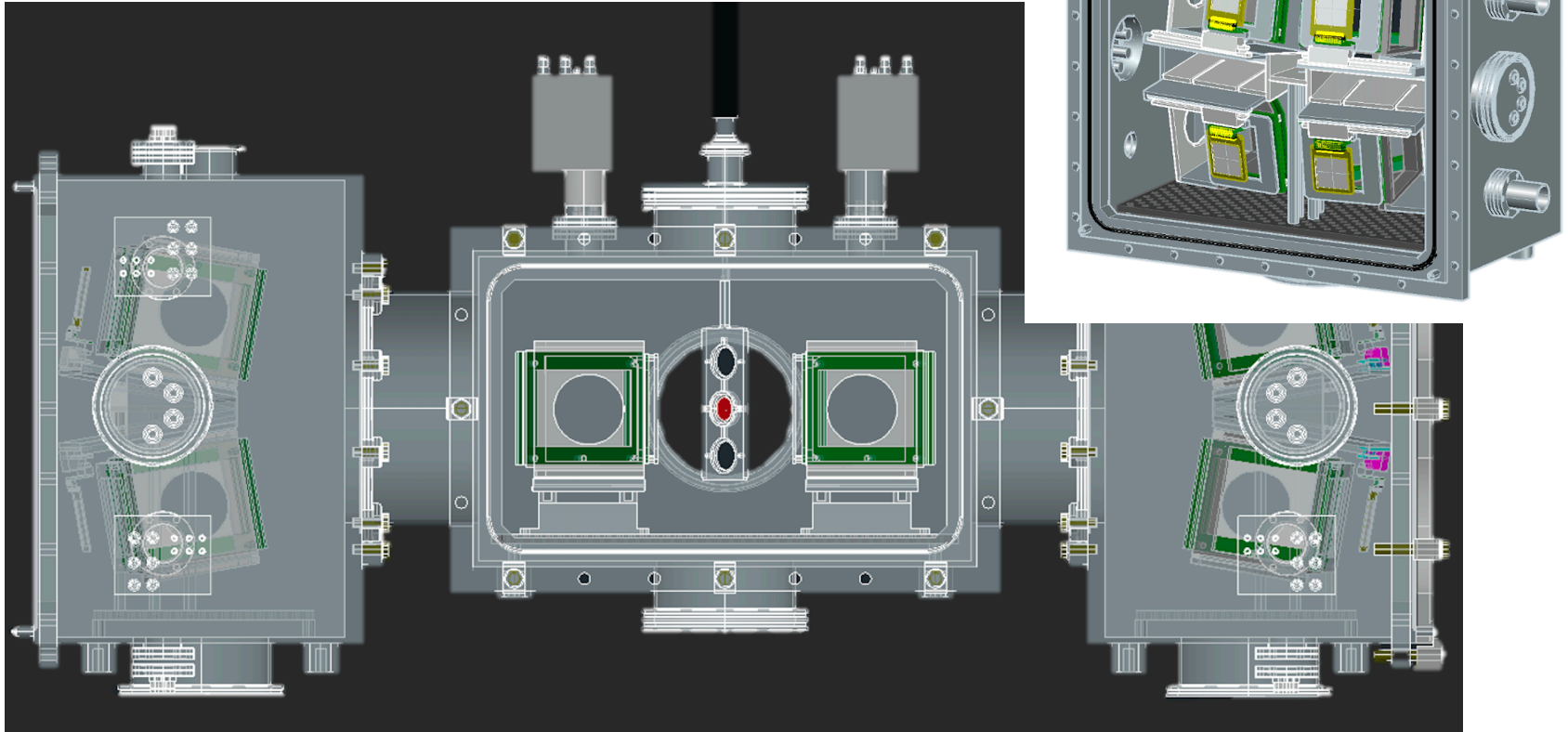# Gamma-ray tagging with ionization chambers

Outstanding issues with ionization chambers

- Edge-effects in IC are significant
- IC severely limits geometric efficiency
- Practical considerations are huge

^{239}Pu(n$_{th}$,f)

Diameter
2 cm
3 cm
4 cm
5 cm
8 cm

^{235}U(n,f)

MegaSPIDER with Si
MegaSPIDER with IC

~4x higher acceptance when a DSSD is used

E$_n$ = 14 MeV

235U(n,f) at 14 MeV
MegaSPIDER with IC
MegaSPIDER with Si

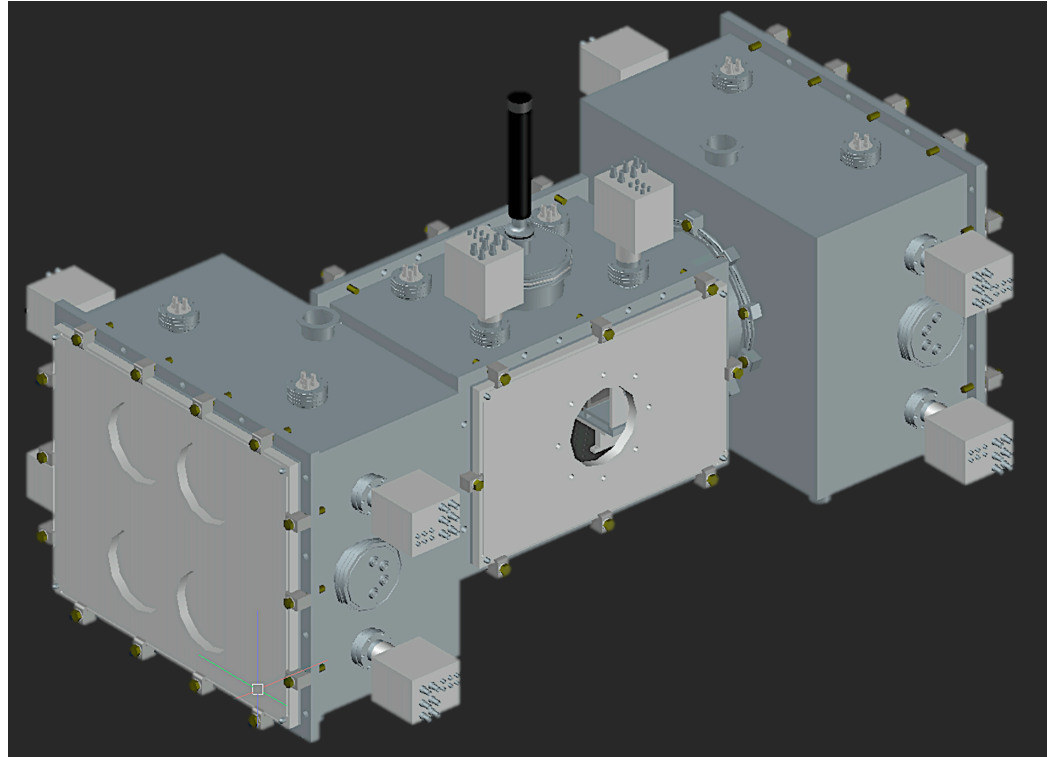~4x better statistics when a DSSD is used
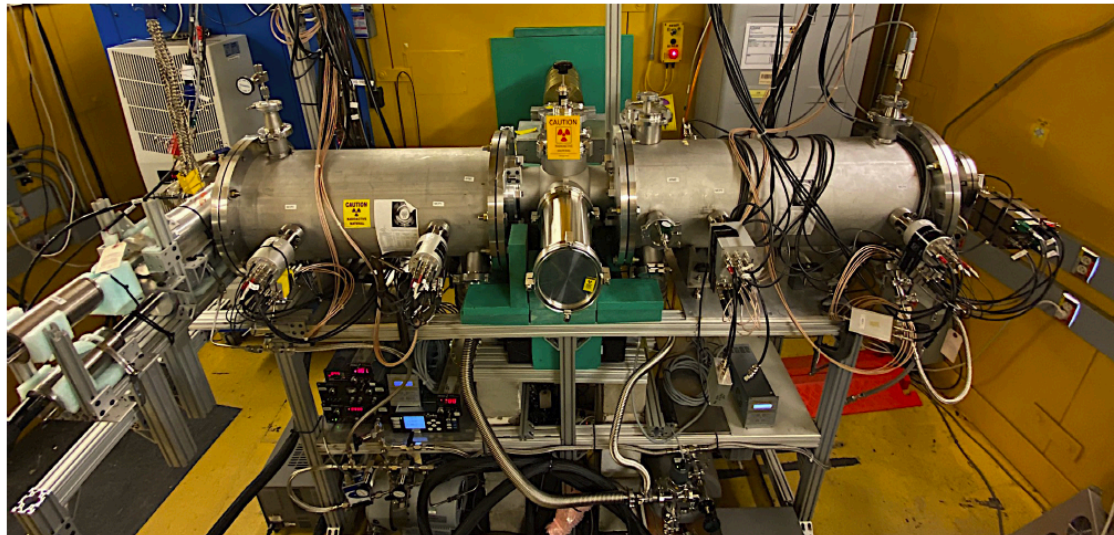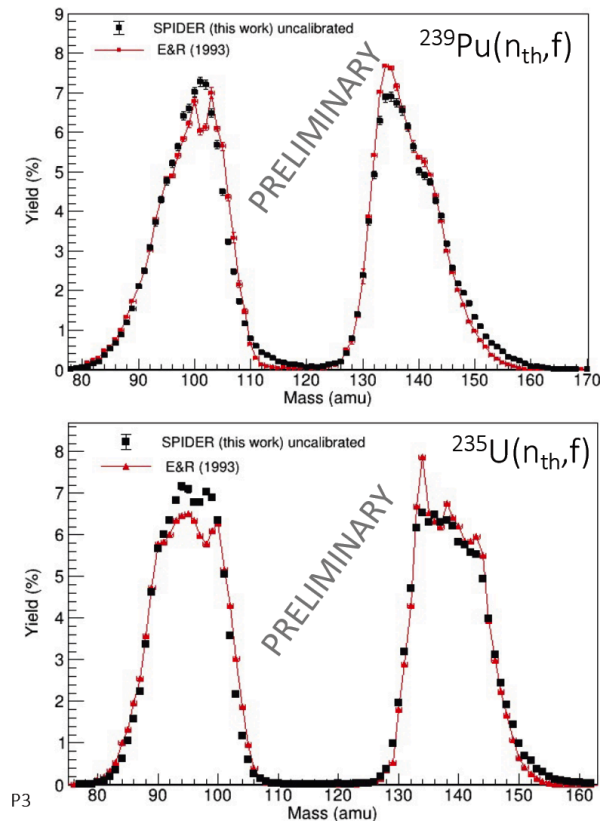
New MegaSPIDER design!

New MegaSPIDER design!

- Final Design/Procurement underway

- Initial WNR scoping tests Fall 2023 (targets, backgrounds, count rates, collimation)

- Planning to have 8 arms (2x IC-MegaSPIDER efficiency) instrumented in 2024

- Further scalable, multiple chambers in series

2-arm SPIDER at Lujan Center (thermal)

$^{239}Pu(n_{th},f)$

SPIDER (this work) uncalibrated
E&R (1993)

PRELIMINARY

$^{235}U(n_{th},f)$

SPIDER (this work) uncalibrated
E&R (1993)

PRELIMINARY

P3

- Data analysis ongoing
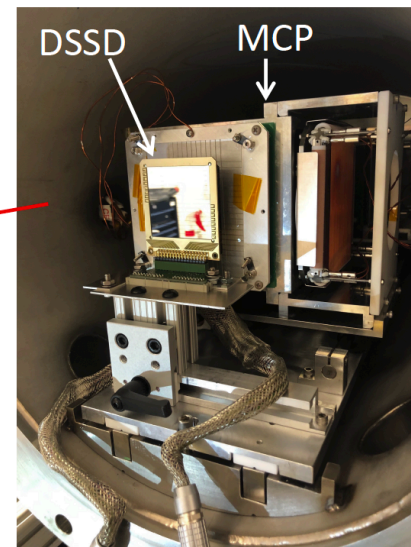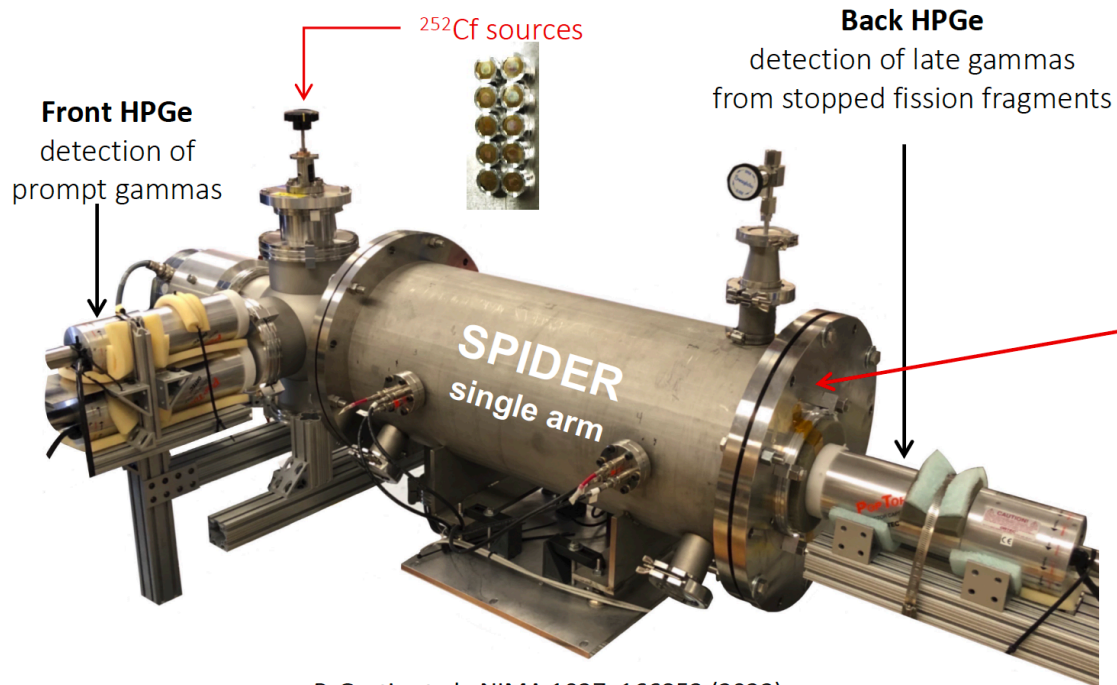- Mark IV Lujan Target (<100 keV)
- Testbed for coincidence analysis

SPIDER Acknowledgements

SPIDER Team (LANL-P3):
- Jack Winkelbauer
- Panos Gastis
- Sean Kuvin
- Chris Prokop
- Shea Mosby

Gamma-ray tagging with Silicon DSSD

^{252}Cf sources

Front HPGe
detection of
prompt gammas

Back HPGe
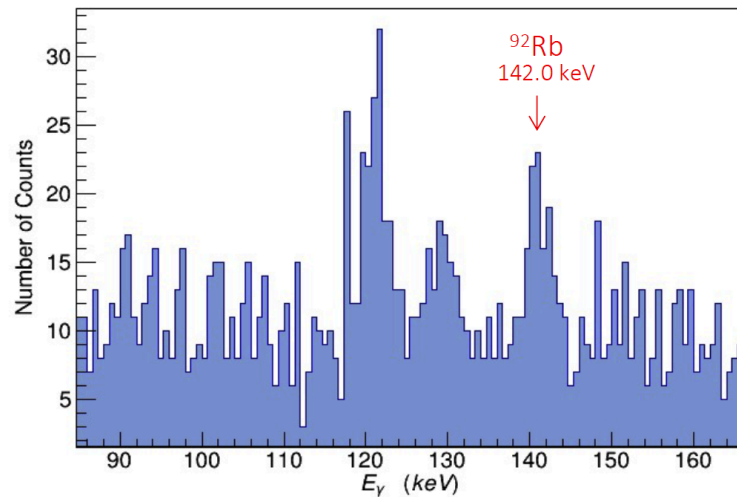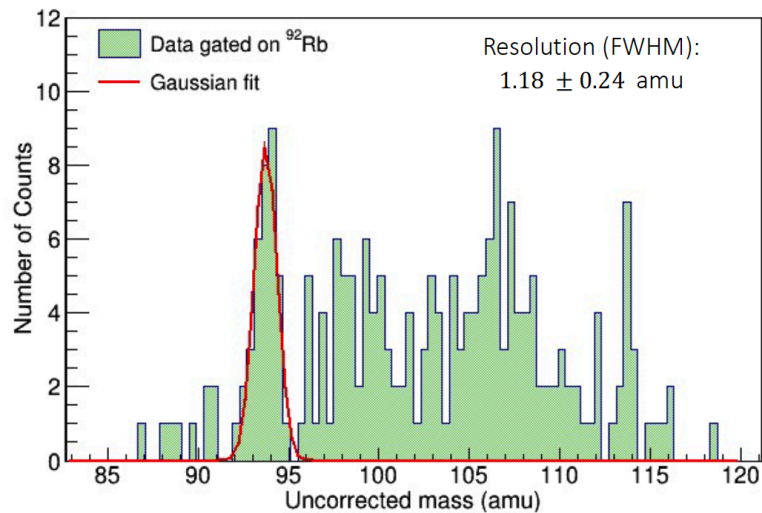detection of late gammas
from stopped fission fragments

SPIDER
single arm

DSSD   MCP

P. Gastis et al., NIMA 1037, 166853 (2022)

Gamma Ray Tagging

1-arm SPIDER system with Si detector
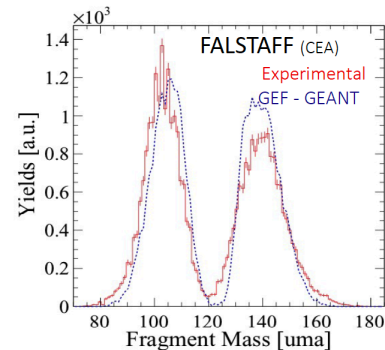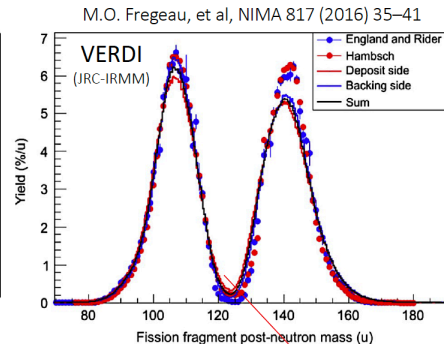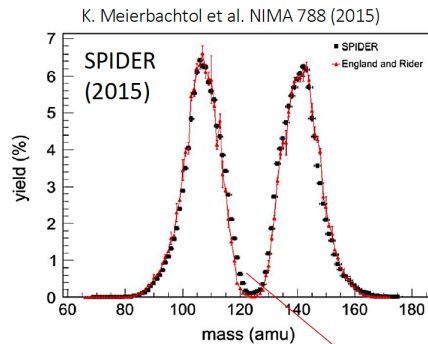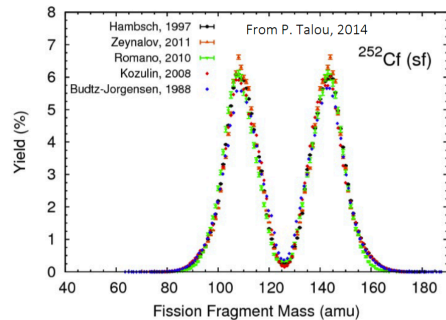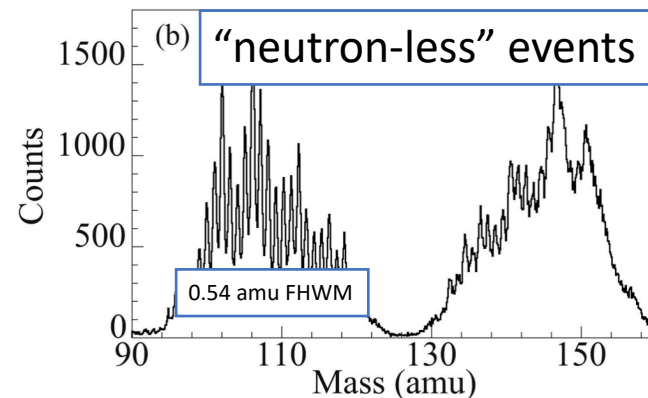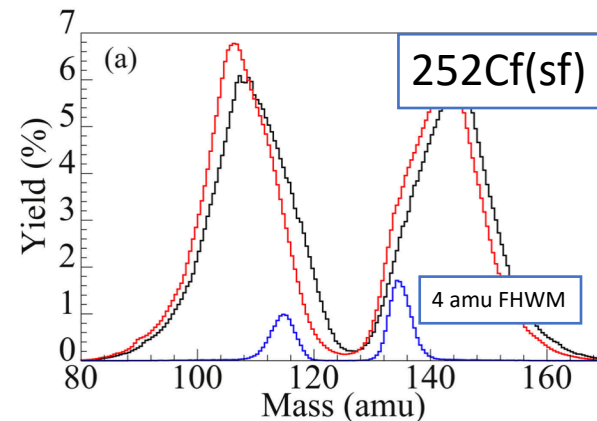
P. Gastis et al., NIMA 1037, 166853 (2022)

Challenges in E-v calibration

K. Meierbachtol et al. NIMA 788 (2015)

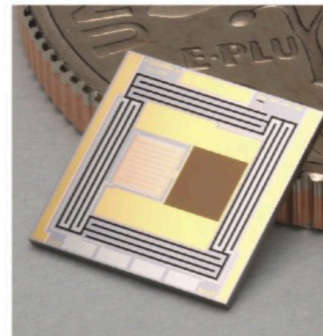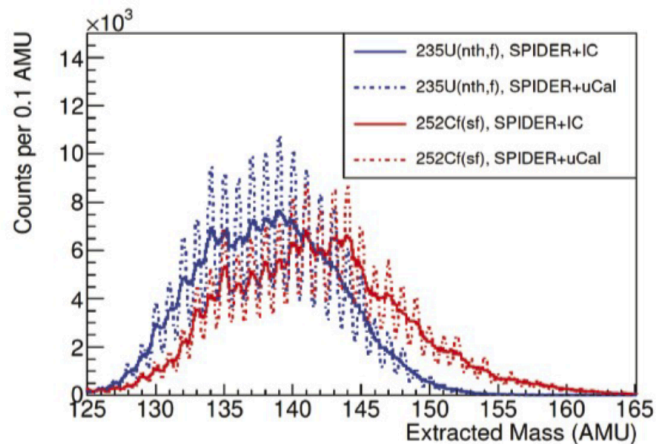M.O. Fregeau, et al, NIMA 817 (2016) 35–41
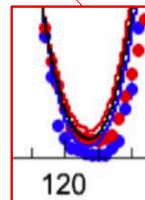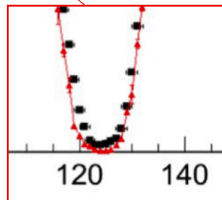
Q. Deshayes, et al, EPJ Web of Conf. **239**, 05012 (2020)

FPYs from 2E Method

- Advantages:
  - Geometric efficiency
  - Operational Simplicity
  - Measure TKE, FPY's simultaneously
- Disadvantages:
  - Requires theoretical $\bar{\nu}(A)$
  - Resolution depends on $\bar{\nu}(A)$
  - $\bar{\nu}(A)$ comes from FPY's!
- Advantage:
  - *Feasibility*

252Cf(sf)

4 amu FHWM

"neutron-less" events

0.54 amu FHWM

Gaudefroy et al, NIM A, 855, 2017

Microcalorimeters for SPIDER?

- Energy resolution @100MeV: 0.02-0.1%
- 0% pulse height deficit
- Windowless
- ~0.6 AMU (FWHM) mass resolution for A>130