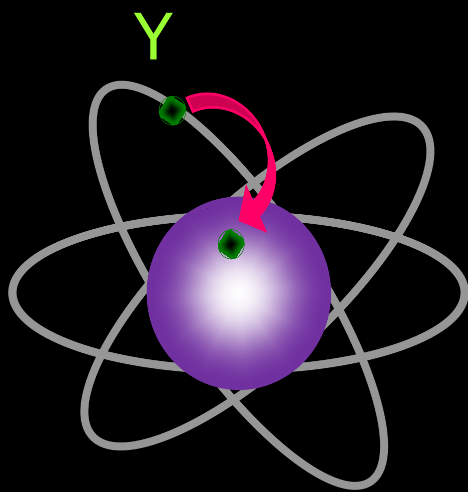
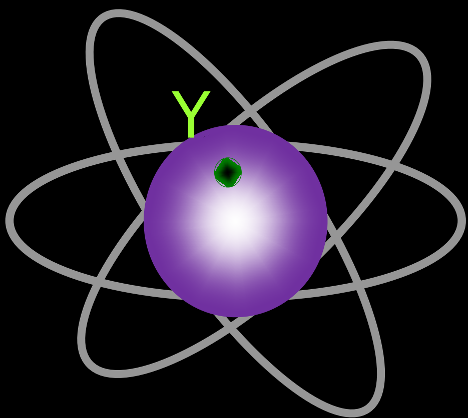
Strangeness Nuclear Physics

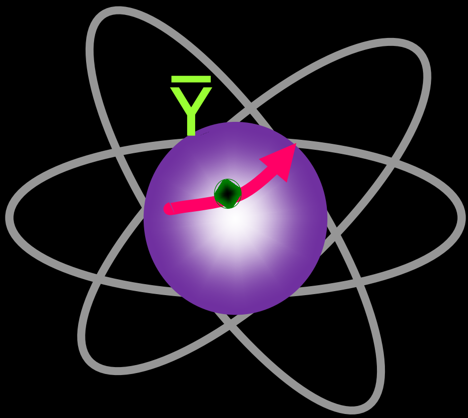
= Strangeness in cold nuclei



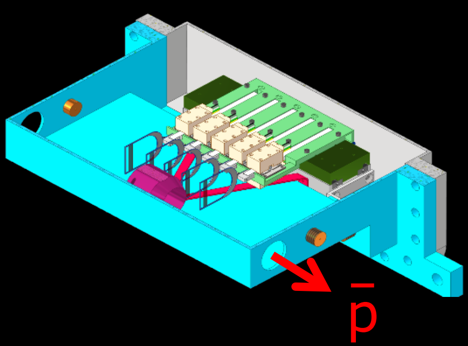
hyperatoms

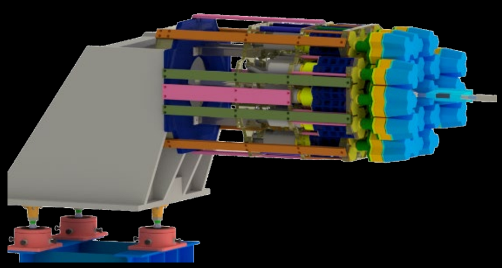


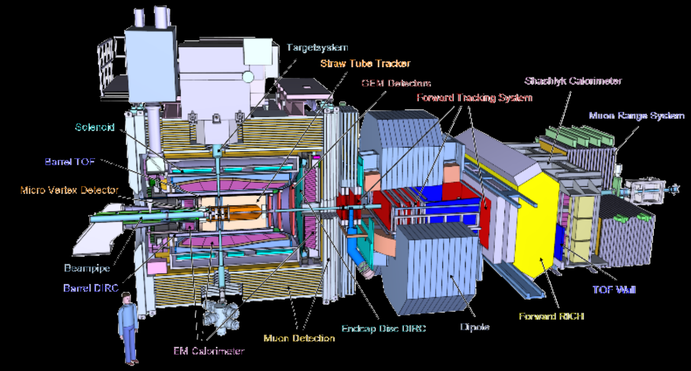
hypernuclei



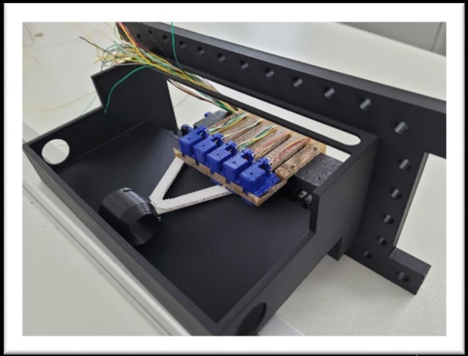
(anti)hyperon
scattering



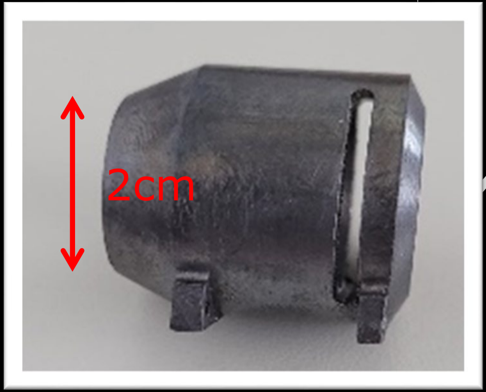




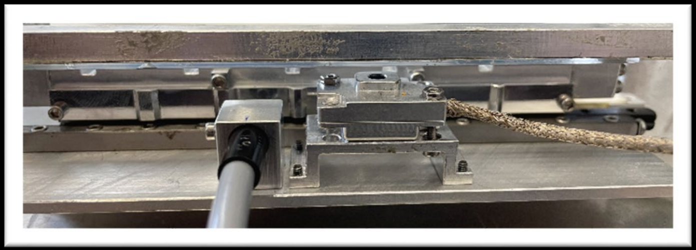
Primary Target



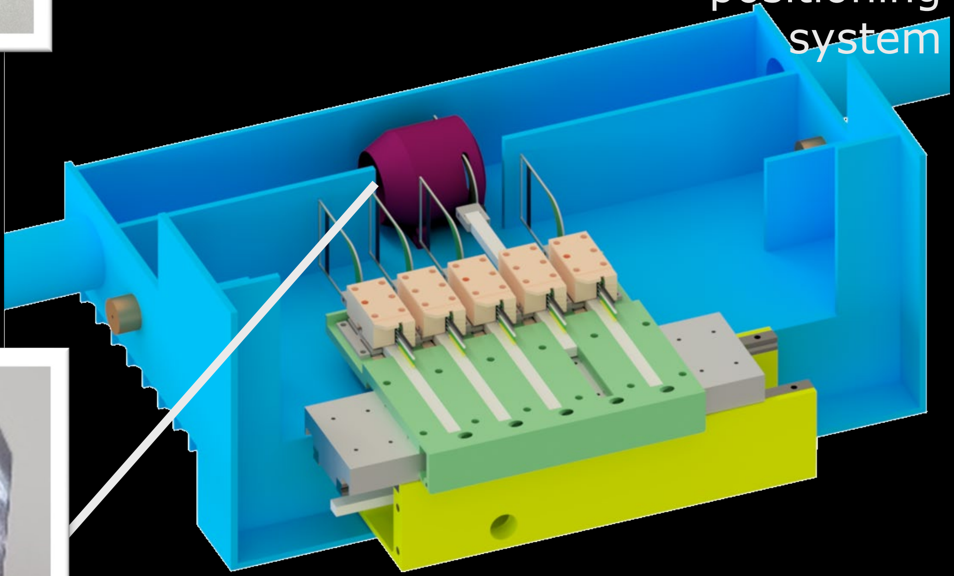
3D-printed Al vacuum chamber

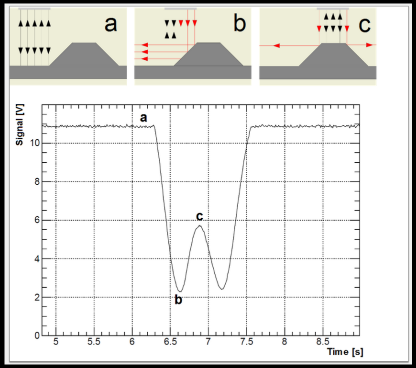


Pb secondary target



Radiation hard positioning system

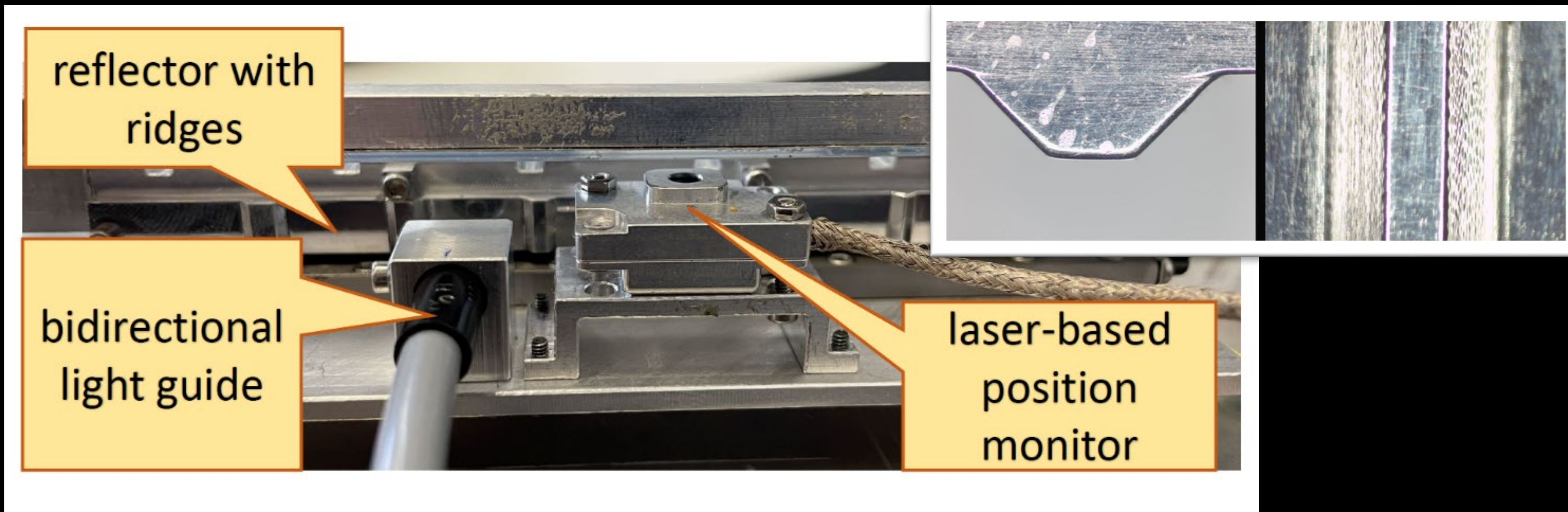


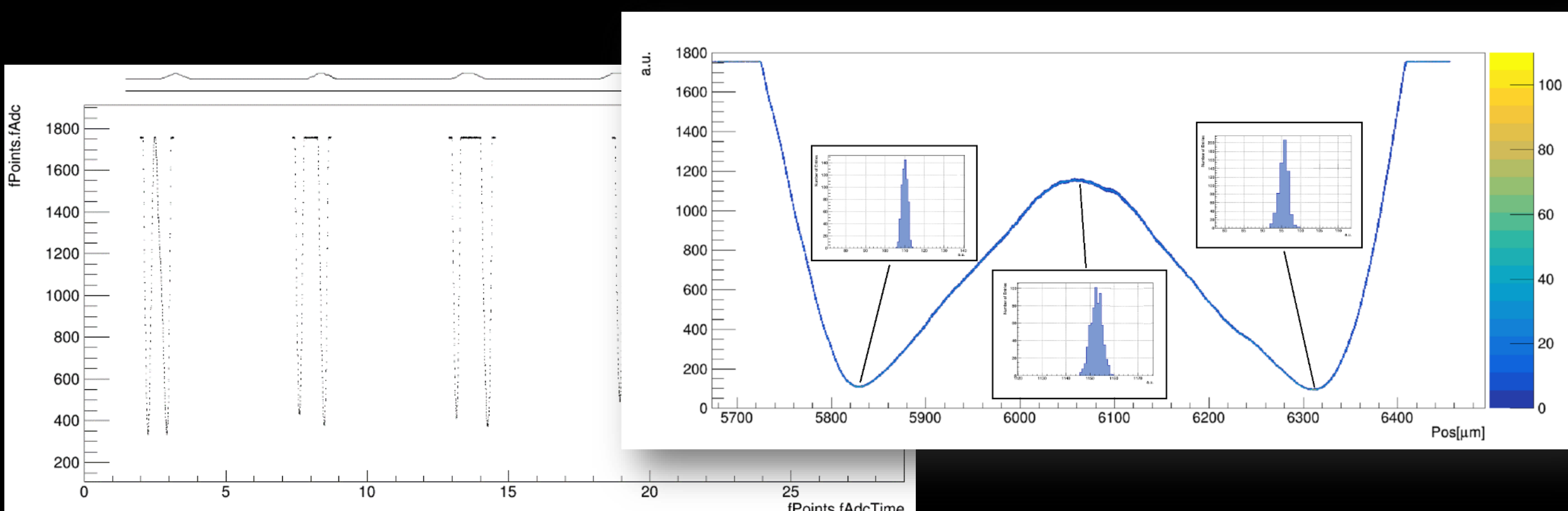


Precision < 3.3μm

- most components available for assembly
- rmaining parts ordered
- stability and leak rate tests for 3D chamber
- cable routing

Positioning system

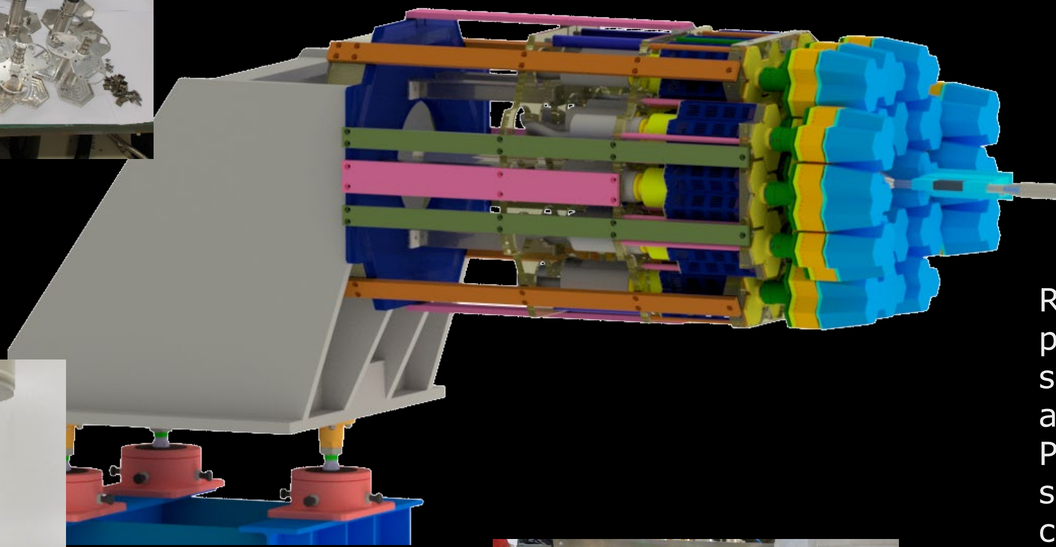


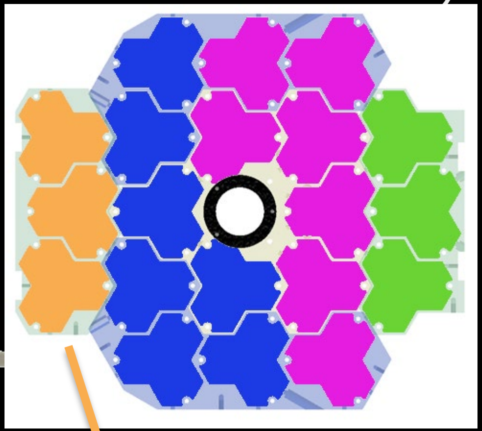


PANGEA

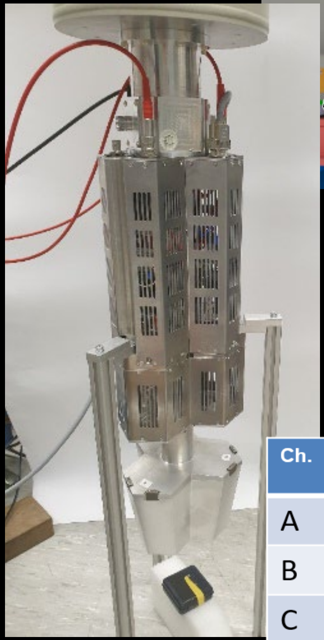
- PANGEA: PANda GErmanium Array (in collaboration with DEGAS)

Components for 25 cryostats available for assembly, ordered for 5 more, PANGEA uses 20 detectors



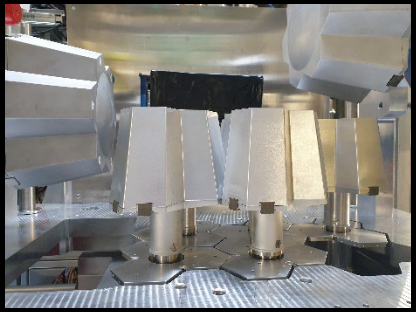


Redesign of the holding frame in progress, switching from 5 to 4 submodules (easier maintenance and installation)
Prototype of first submodules successfully tested with new LN2 cooled detector design

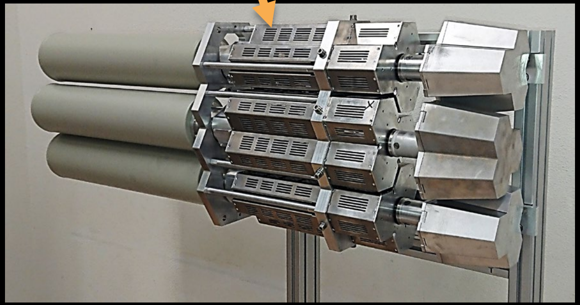


Successfull test of detector design with preliminary electronics

Ch.	HEX	Bias [V]	FWHM [keV]
A	152	3000	2.02
B	163	3000	1.96
C	39	3500	2.18

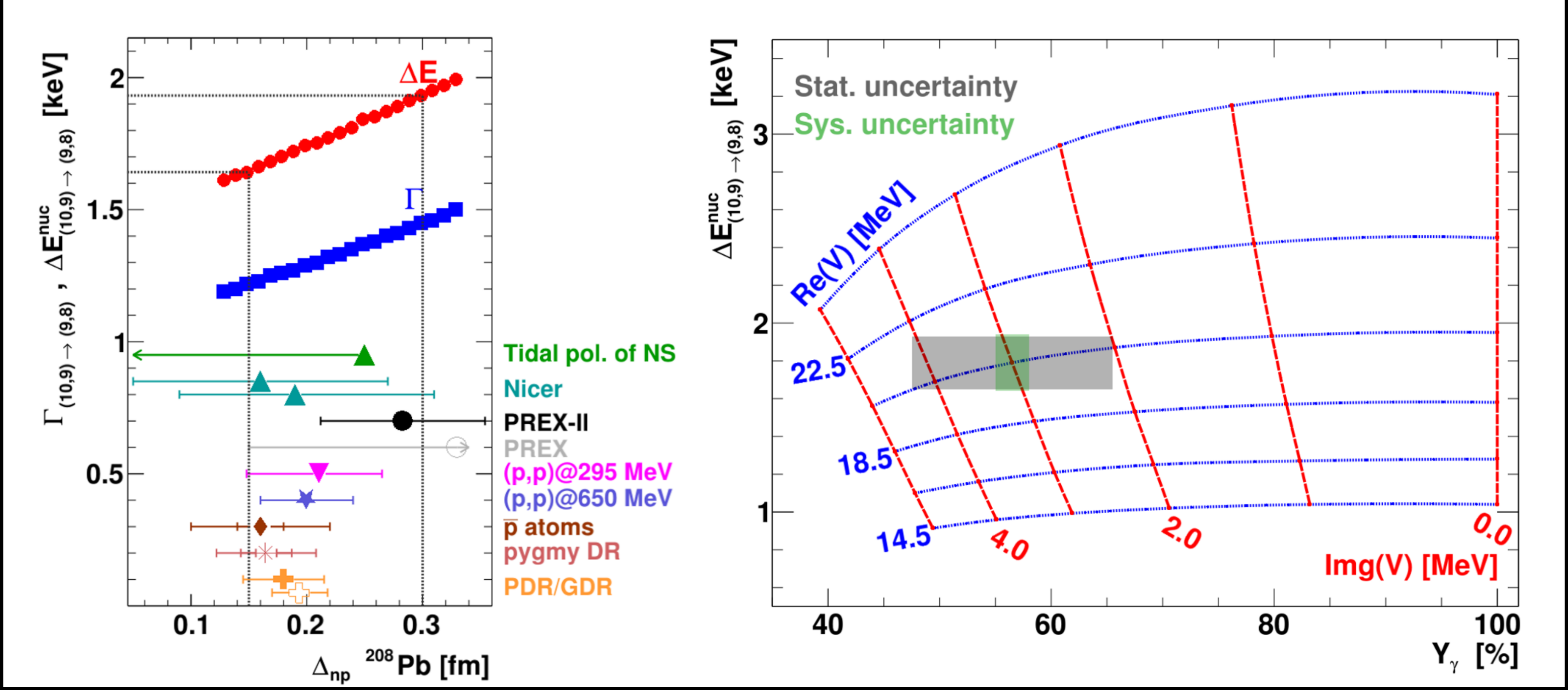


8 triple detectors used in experiment DESPEC S450 at FSR(GSI) in since 09.05.2022



Sensitivity to ^{208}Pb structure

- changing thickness of neutron skin artificially in calculations



$$\delta(\mathrm{Re}(V_\Xi))_{stat} \approx \delta(\mathrm{Im}(V_\Xi))_{stat} \approx 1\ \mathrm{MeV}$$

- Need to understand nuclear structure of core nuclei
- Exploring also the possibility of Σ^- and $\bar{\Sigma}$-hyperatoms

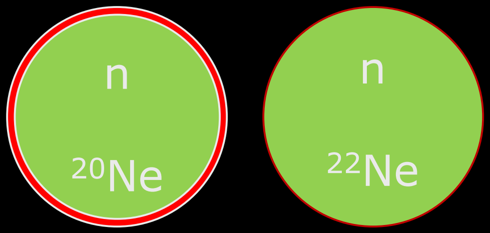
Probing the Neutron Skin of Nuclei

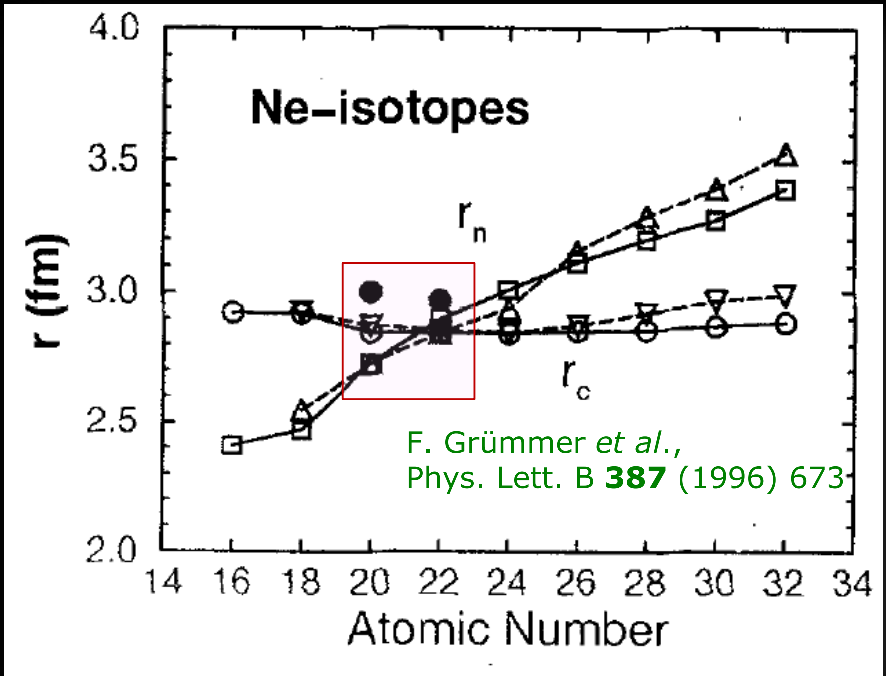
- $\bar{p}+p\rightarrow\bar{\Lambda}+\Lambda$ $\bar{p}+p\rightarrow\bar{\Sigma}^0+\Lambda$ $\bar{p}+n\rightarrow\bar{\Lambda}+\Sigma^-$ $\bar{p}+n\rightarrow\bar{\Sigma}^++\Lambda$

  absorption length of $\bar{p}$ $r_{abs} = \frac{1}{\sigma_{abs}\rho} \sim \frac{1}{100mb \cdot 0.17fm^{-3}} \approx \frac{\rho_0}{\rho} 0.6fm$

  survival probability $p_{survival} = \exp(-\Delta r / r_{abs})$

- going from ^{20}Ne vs. ^{22}Ne





- additional absorption of antiprotons in neutron skin:
  - $\bar{\Lambda}+\Sigma^-$ will increase in ^{22}Ne with respect to ^{20}Ne by $1+p_{abs} \approx 1.16$
  - $\bar{\Lambda}+\Lambda^-$ will decrease in ^{22}Ne with respect to ^{20}Ne by $1-p_{abs} \approx 0.84$

BUU predictions

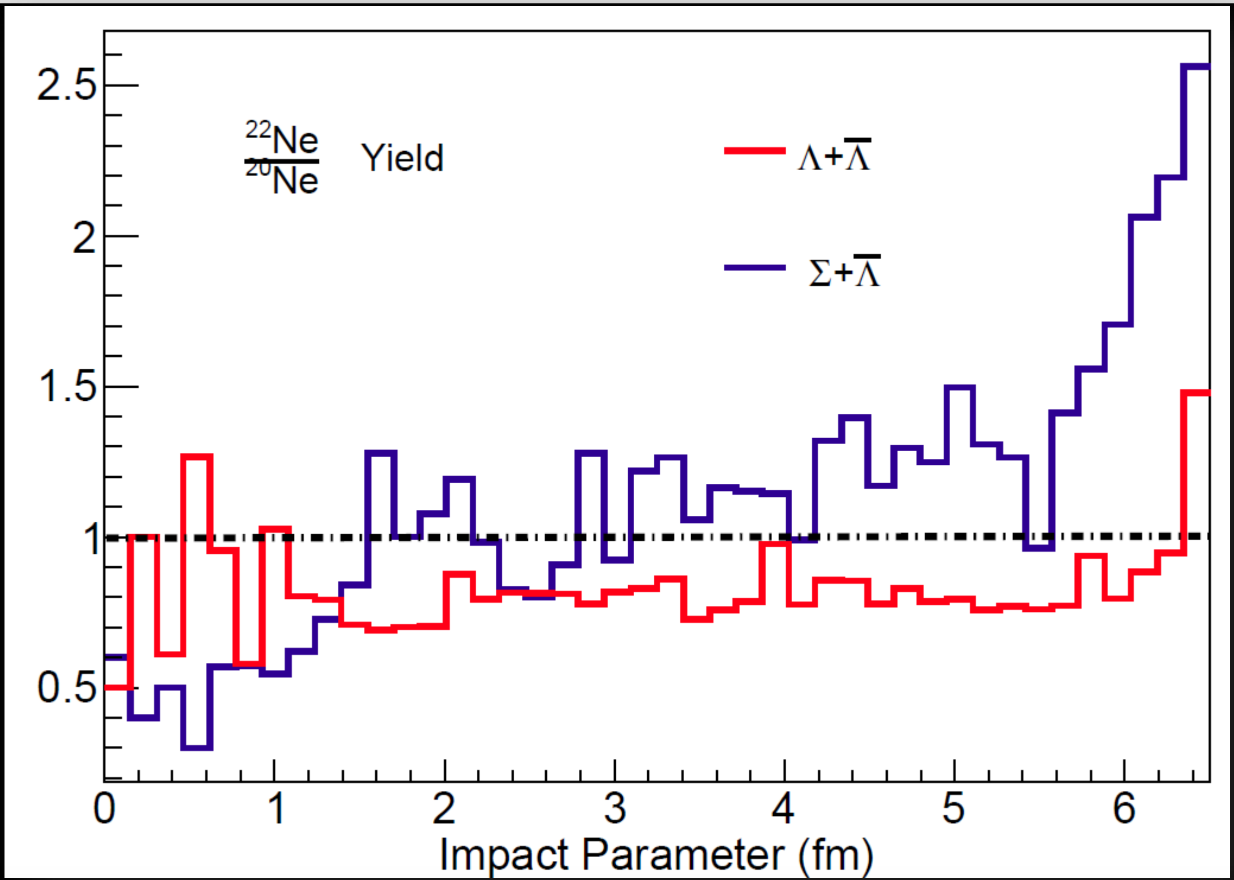


Table I. Production yield of $\overline{\Lambda}\Lambda$ and $\overline{\Lambda}\Sigma^-$-pairs in $\overline{p}$-Ne interactions. The last line gives the double-ratio for $\overline{\Lambda}\Sigma^-$ and $\overline{\Lambda}\Lambda$ production.

Target	$\overline{\Lambda}\Sigma^-$	$\overline{\Lambda}\Lambda$
^{20}Ne	3667	18808
^{22}Ne	4516	15733
ratio ^{22}Ne/^{20}Ne	1.23	0.84
ratio($\overline{\Lambda}\Sigma^-$)/ratio($\overline{\Lambda}\Lambda$)	1.46	

Krypton (Z=36) Isotopes

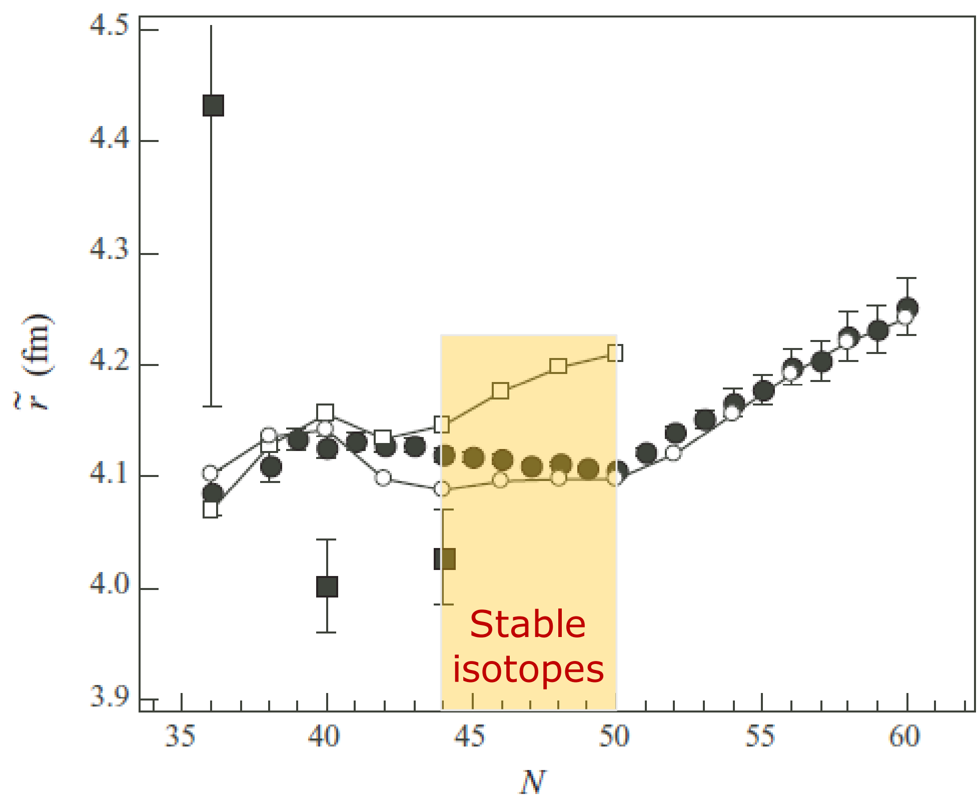


FIG. 5. Neutron number dependence of rms matter and proton radii. Closed symbols indicate the experimental data of $\tilde{r}_m$ (squares) and $\tilde{r}_p$ (circles) from $\tilde{r}_{ch}$ [20]. Corresponding open symbols connected by lines show theoretical predictions [35].

T. Yamaguchi et al., Phys. Rev. C 77, 034315 (2008)

Neutron skin of Sn

A. Krasznahorkay et al.,
Nucl. Phys. A 731, 224 (2004)

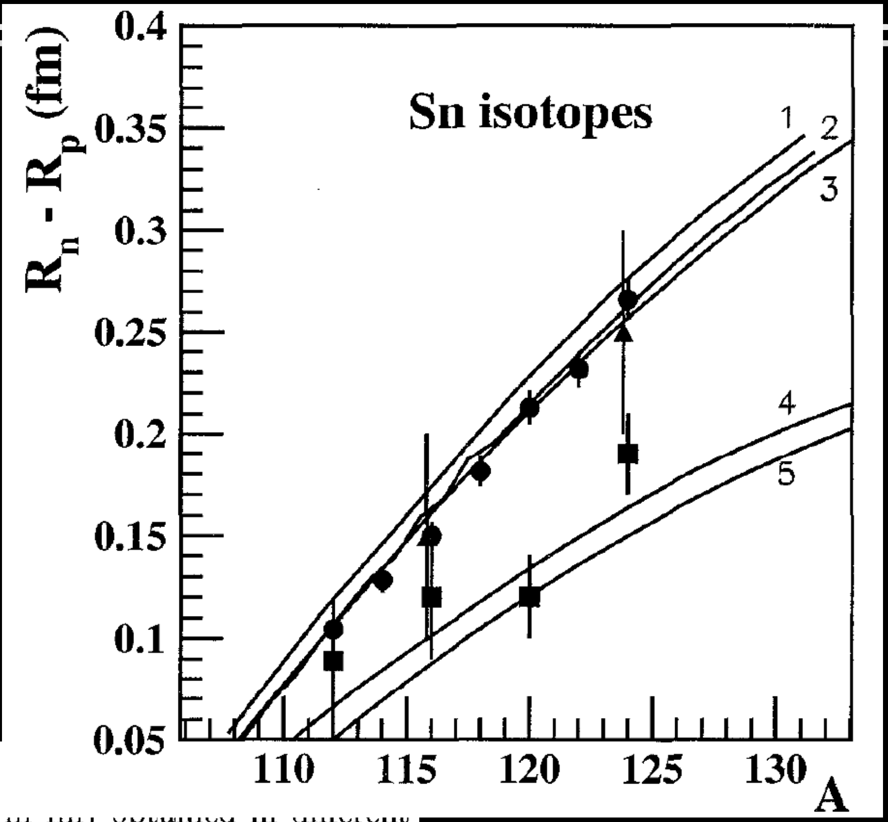


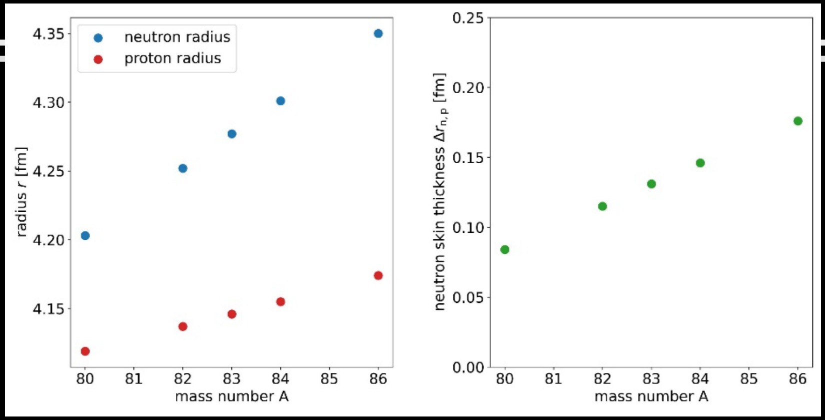
Table 1
Summary of the neutron-skin thicknesses ($\langle r_n^2 \rangle^{1/2} - \langle r_p^2 \rangle^{1/2}$ in fm) obtained in different methods.

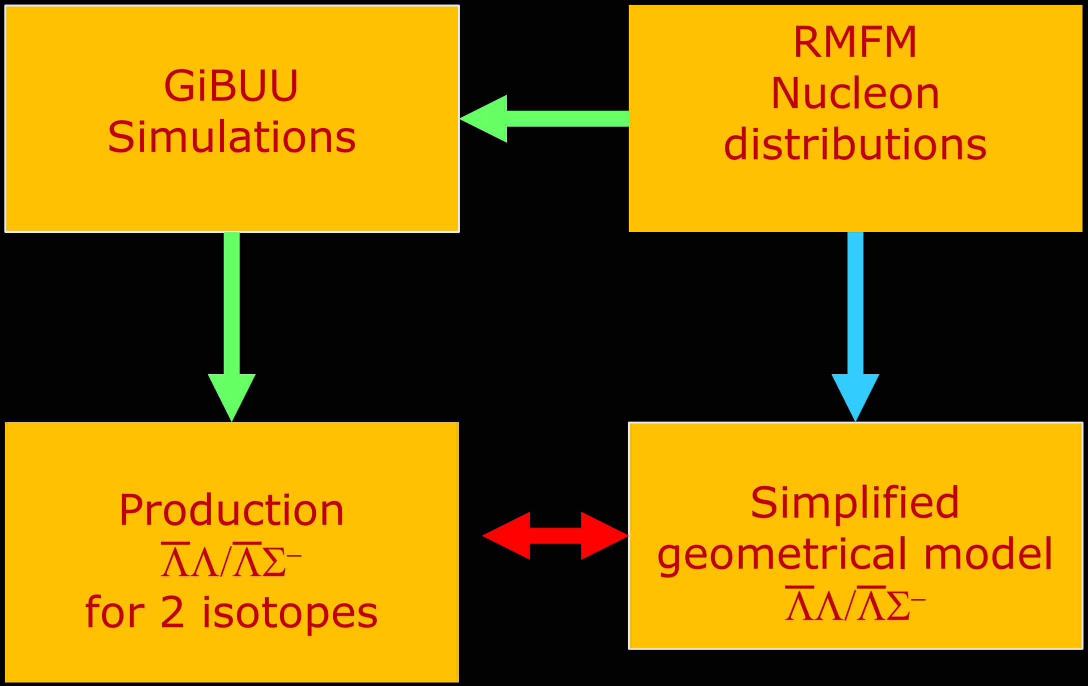
Isotope	(p,p) [4,5]	(p,p) [7]	GDR [16]	SDR [18]	antiproton [11]
^{112}Sn					0.09±0.02
^{114}Sn				≤0.09	
^{116}Sn	0.15±0.05		0.02±0.12	0.12±0.06	0.12±0.02
^{118}Sn				0.13±0.06	
^{120}Sn				0.18^{a})	0.12±0.02
^{122}Sn				0.22±0.07	
^{124}Sn	0.25±0.05		0.21±0.11	0.19±0.07	0.19±0.02
^{208}Pb	0.14±0.04	0.20±0.04	0.19±0.09		0.15±0.02

^{a}) Normalized to the theoretical value of Angeli et al. [21].

Method

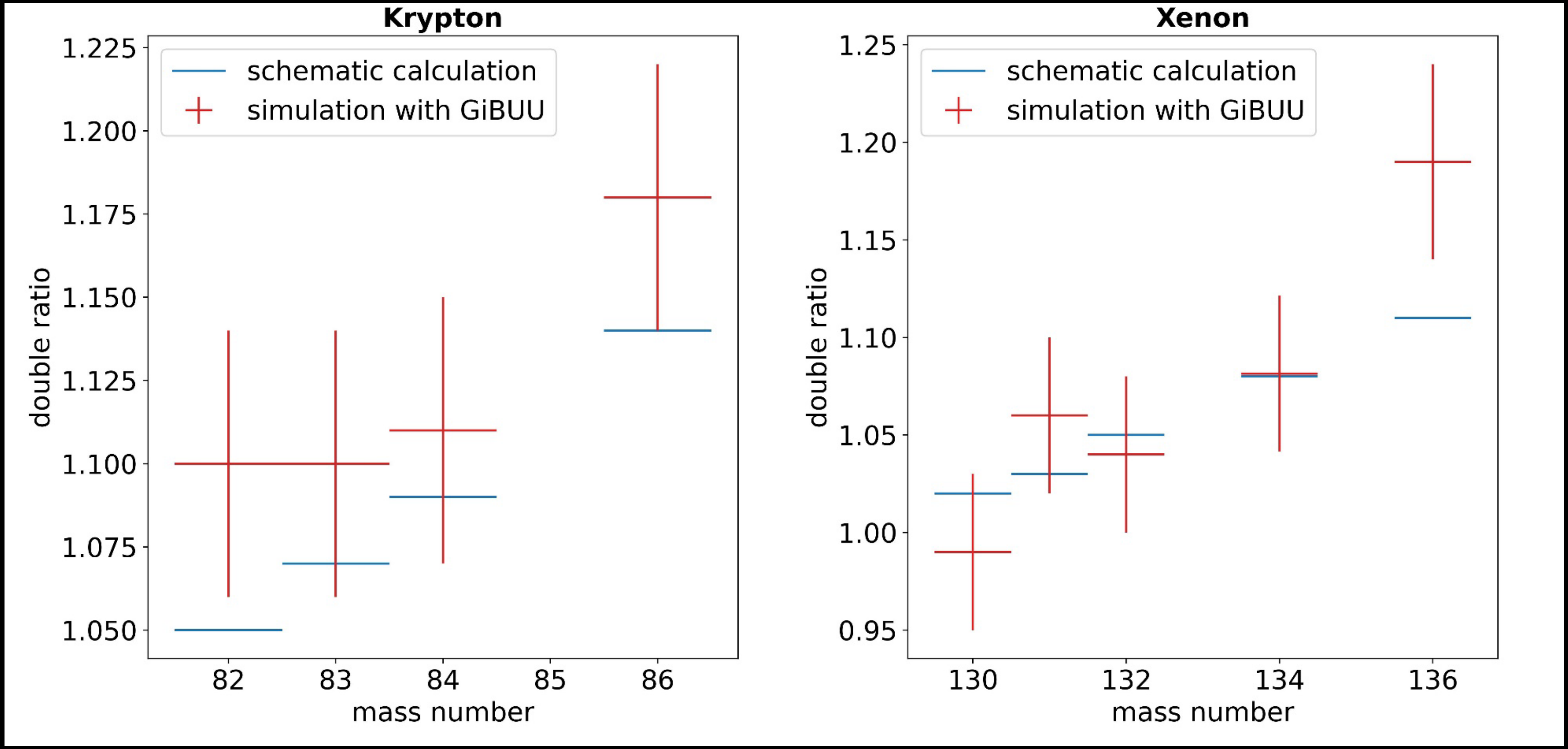
BA thesis
Martin Christiansen





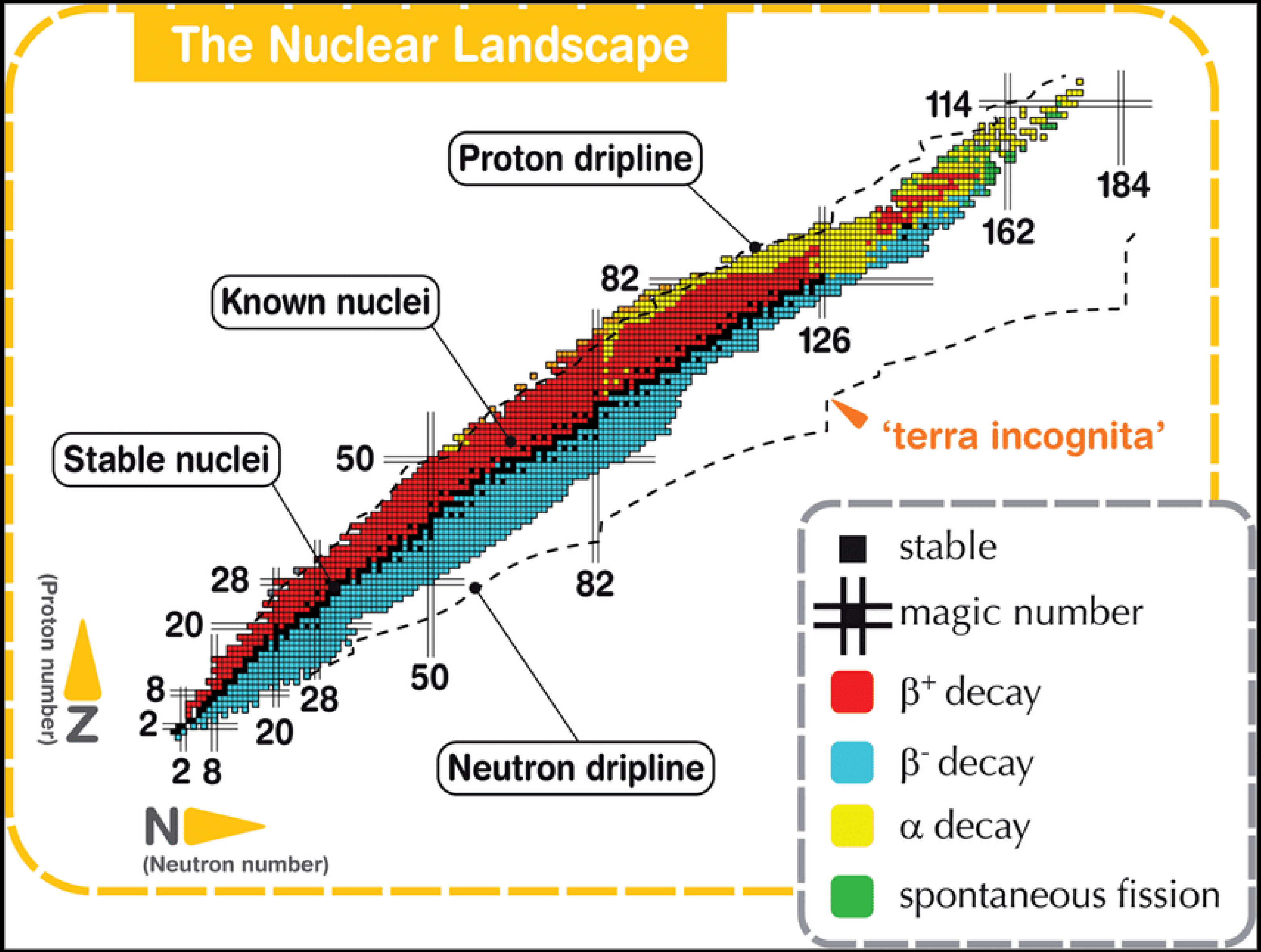
$$DR = \frac{1+p_{abs}}{1-p_{abs}} = -1 + 2\cdot\exp(\Delta r_{ns}\cdot\rho_n\cdot\sigma_{\bar{p}n\to\bar{\Lambda}\Sigma})$$

Result



Approx 3·10^7 events per target simulated
Assuming 1% efficiency ⇒ 1h of PANDA at 10^6 interaction rate
Problem: cost for gas!!!

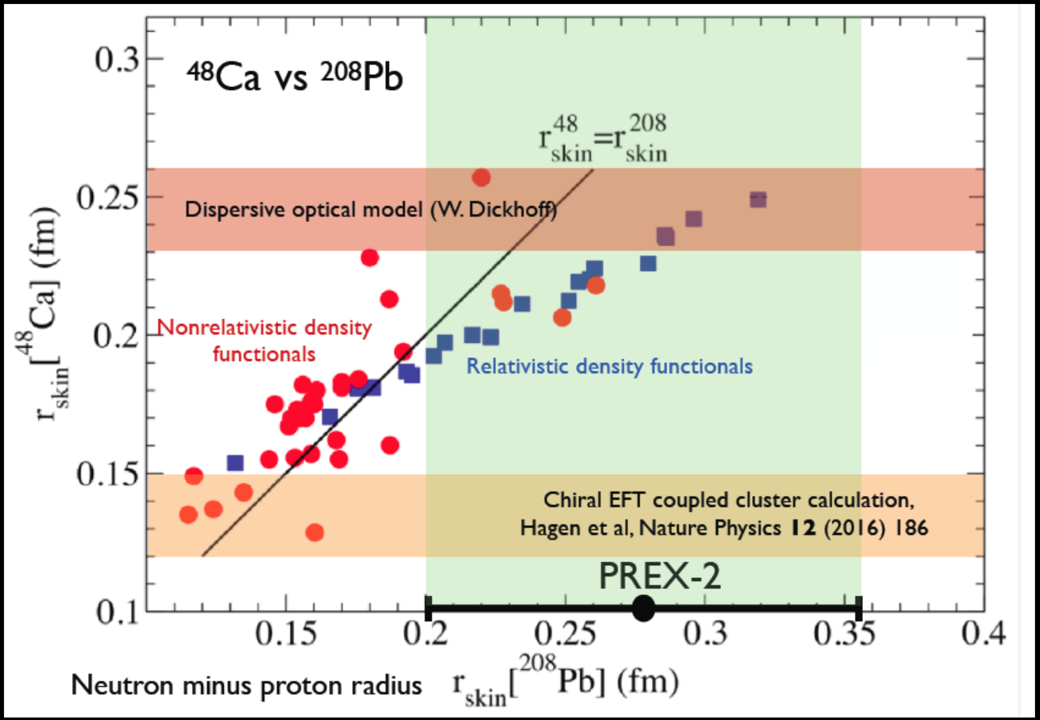
Doubly Magic Nuclei



Realistic Option for PANDA

- Replace gas target with solid target (like for the hyperatom study)
  - Straight forward mechanics

    ⇒ < mg target material needed
- Physics case: ^{48}C a vs. ^{40}Ca (c.f. CREX @ Jlab)
  - melting point 842°C



Chuck Horowitz (2021)