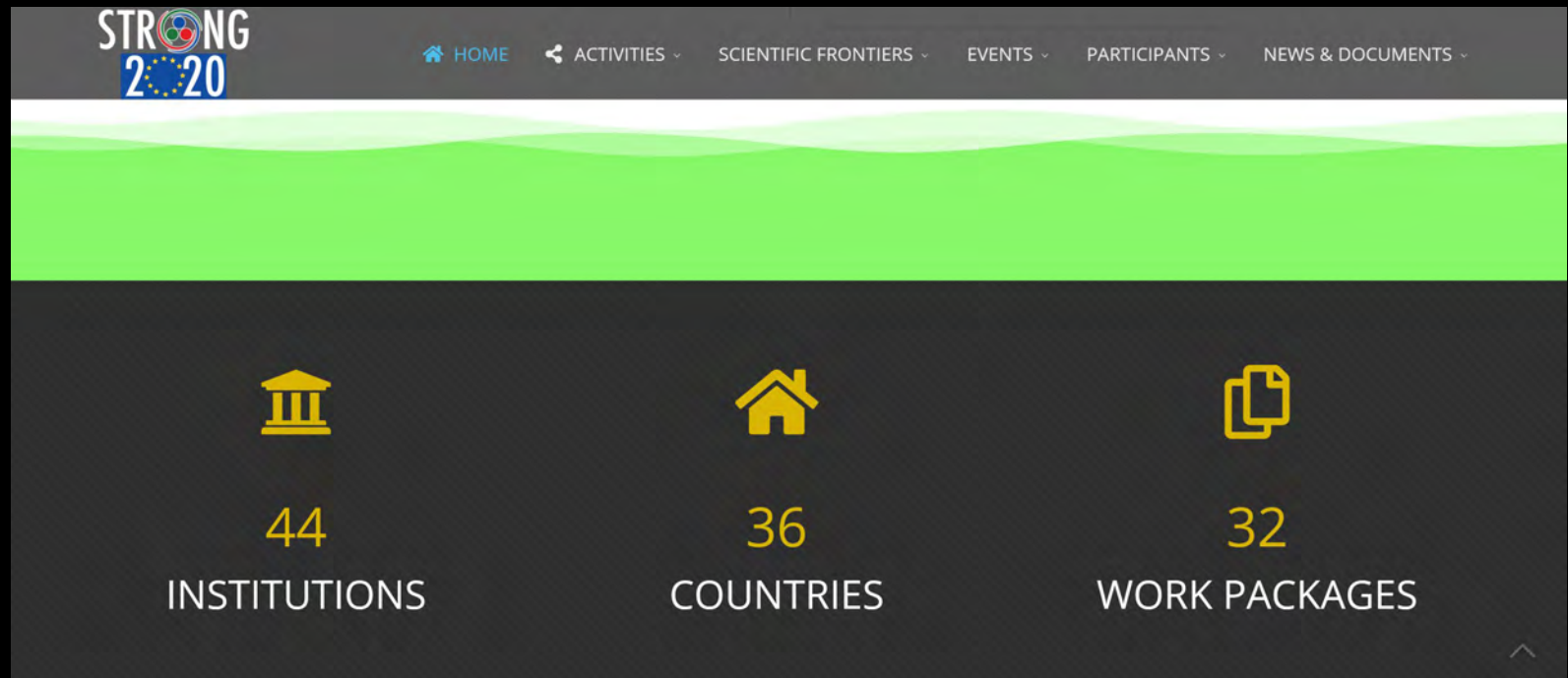


- ▶ <http://www.strong-2020.eu/>
- ▶ The STRONG-2020 project brings together many of the leading research groups and infrastructures involved today in the study of the strong interaction in Europe, and also exploits the innovation potential in applied research through the development of detector systems with applications beyond fundamental physics,



Funding: 10M€ for 4 years

Networking Activity

**THEIA**

# Strange Hadrons and the Equation-of-State of Compact Stars

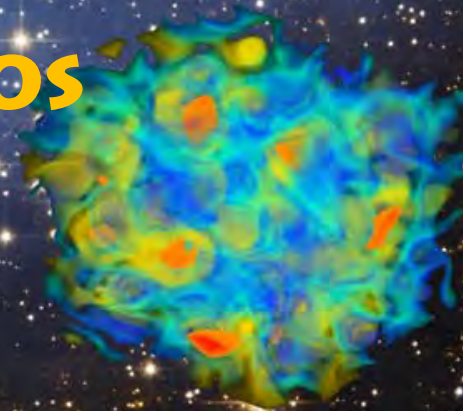
Josef Pochodzalla

JGU Mainz & Helmholtz-Institut Mainz

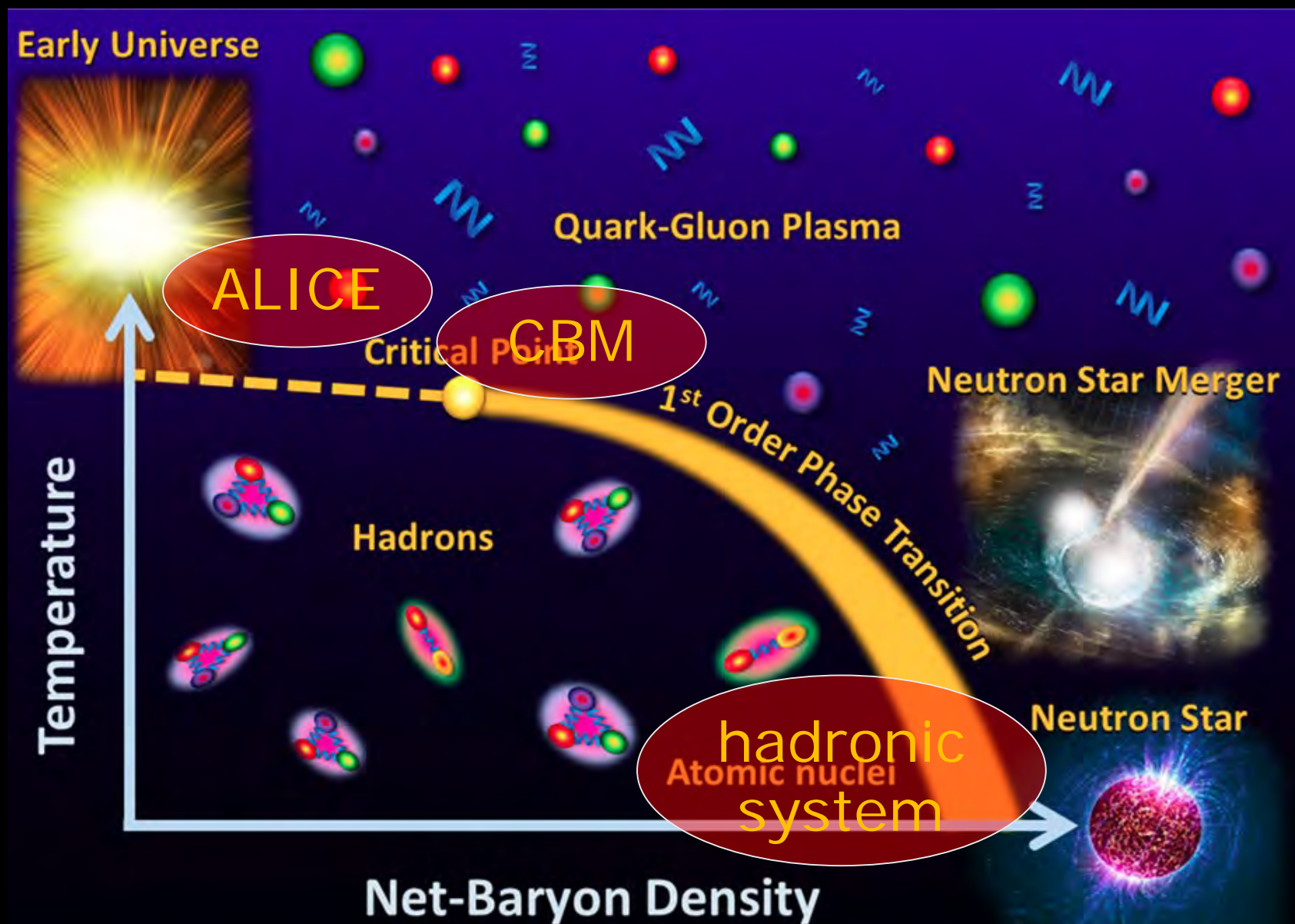
**HYPERION  $\infty$**



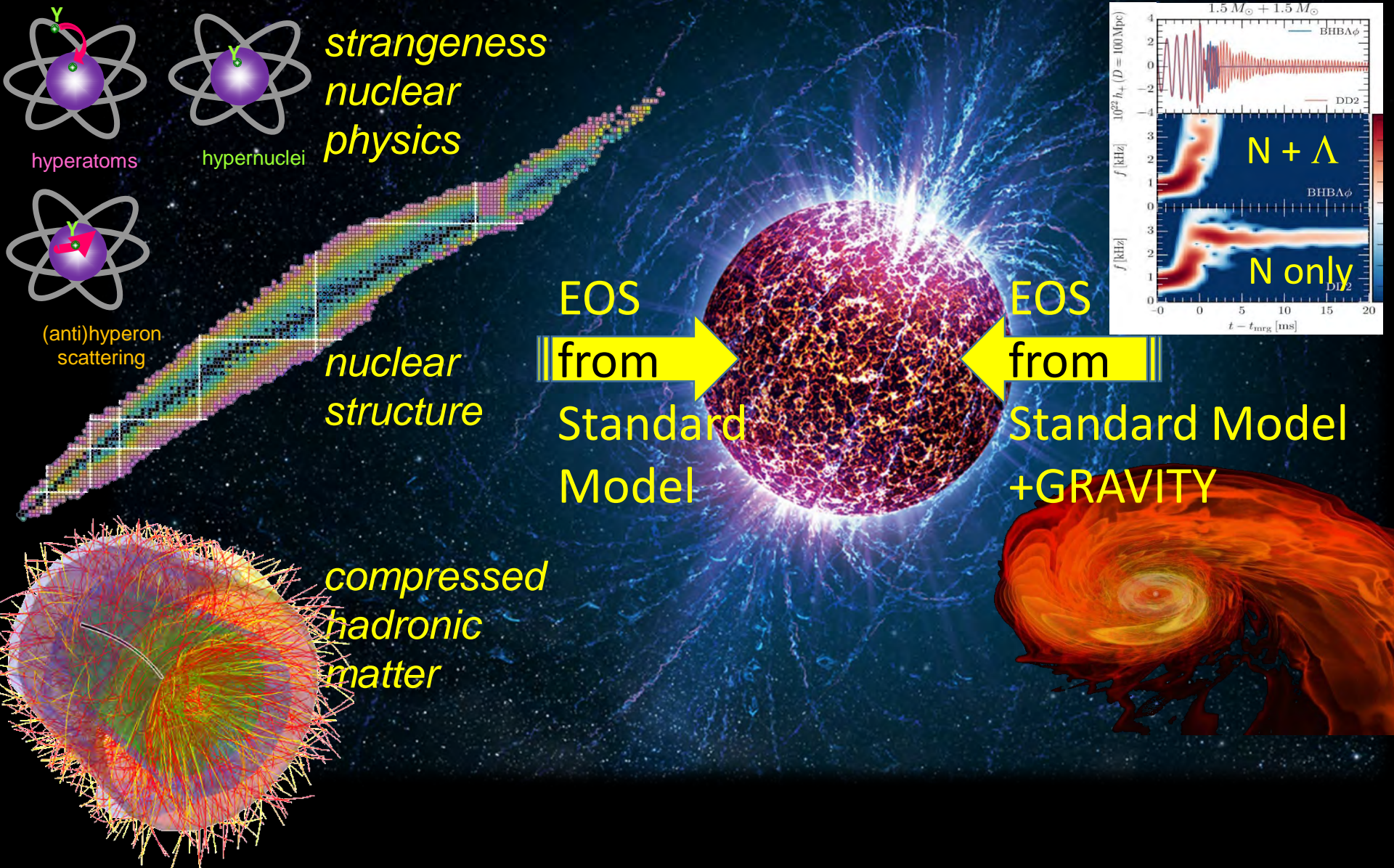
**= EOS**



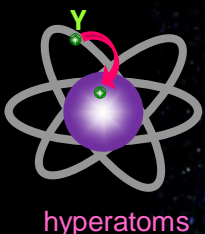




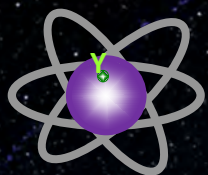






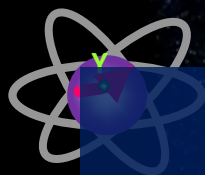


hyperatoms



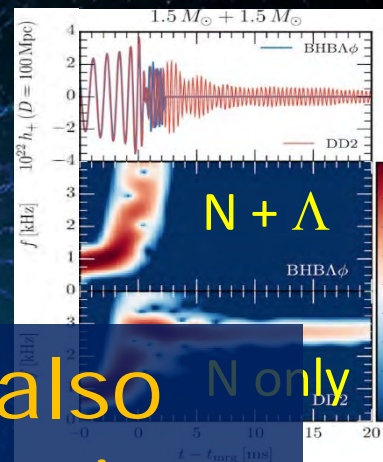
hypernuclei

*strangeness  
nuclear  
physics*



(anti)hyperon  
scattering

Although the hadronic EOS is also related to many other branches in nuclear or hadronic physics, the focus on the strangeness aspect guarantees specific, very effective and fruitful interactions among all participating groups in THEIA.





Universitat de Barcelona  
Institute of Space Sciences Barcelona  
Ruhr-Universität Bochum

- ≥ 24 institutions
- ≥ 8 countries
- ≥ 100 permanent scientists, postdocs
- ≥ 50 active PhD students or master students

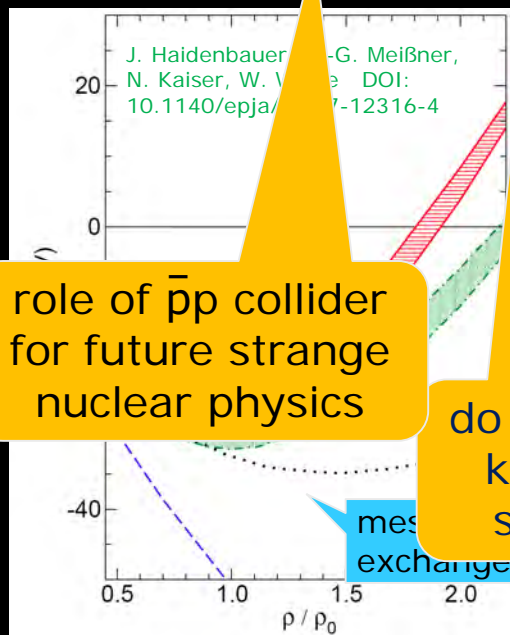


Univ. of Southampton  
Aristotle Univ. Thessaloniki  
Univ. Tohoku  
Univ. Tokyo  
Österreichische Akademie der Wissenschaften Wien



## YN and YY Interaction

- YY vector meson repulsion:  $\phi$  meson coupled only to hyperons; yielding strong repulsion at high  $\rho$
- Chiral forces: YN from  $\chi$ EFT predicts  $\Lambda$  s.p. potential more repulsive than from meson exchange



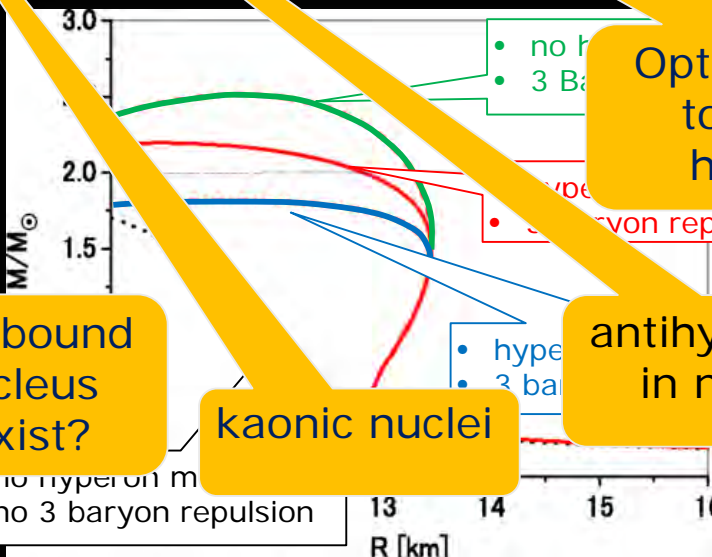
role of  $\bar{p}p$  collider for future strange nuclear physics

do deeply bound kaon-nucleus states exist?

## Hyperonic Three-body force

- Natural solution based on the known importance of NNN forces in conventional nuclear physics

Y. Yamamoto, T. Furumoto, N. Yasutake, T. A. Rijken, Phys. Rev. C 90, 045805 (2014)



kaonic nuclei

antihyperons in nuclei

Hypertriton puzzle

nn $\Lambda$  puzzle

Charge Symmetry breaking  $\Lambda n - \Lambda p$

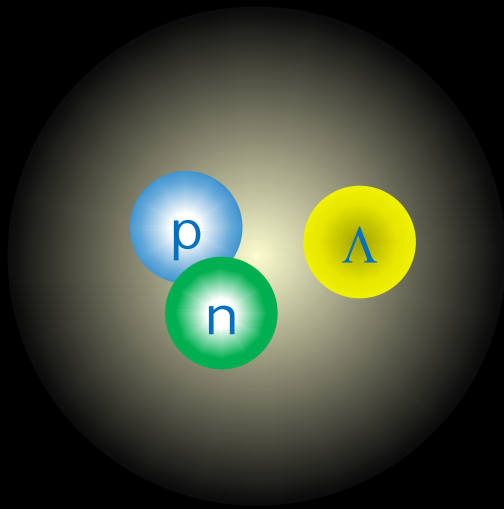
Optimal strategy to study  $\Lambda\Lambda$  hypernuclei



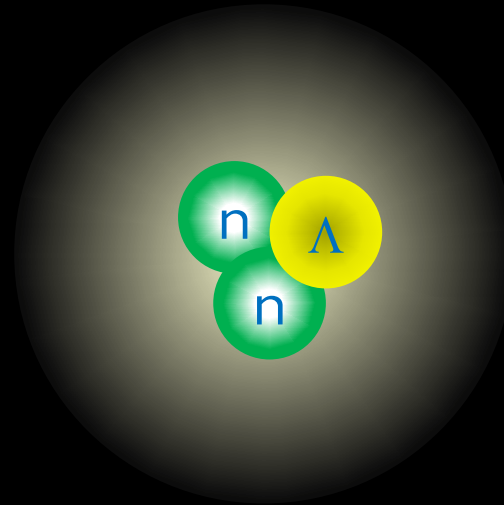
- Study of  $A=3$  hypernuclei  $^3_{\Lambda}\text{H}$  and  $^3_{\Lambda}\text{n}$
- MS: First data taking by WASA@GSI/FAIR searching for  $nn\Lambda$ , tentatively scheduled in February (commissioning) and March (physics run) in 2022
- Study of antihyperons in nuclei; PANDA software tools demonstrator
- MS: Design report for antihyperons in nuclei ready
- Theoretical and experimental studies of bound mesonic systems
- MS: SIDDHARTA-2 progress report
- Annual workshops to guarantee effective and fruitful interactions



# Task1: The $A=3$ Hypernuclei

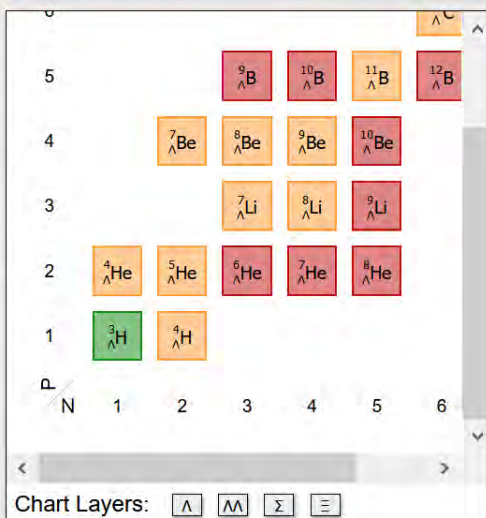


${}^3_{\Lambda}\text{H}$



${}^3_{\Lambda}\text{n}$

## Chart of Hypernuclides - Under Construction -



### ${}^3_{\Lambda}\text{H}$ Hydrogen

- Decays:
  - two body:  ${}^3_{\Lambda}\text{H} \rightarrow {}^3\text{He} + \pi^-$

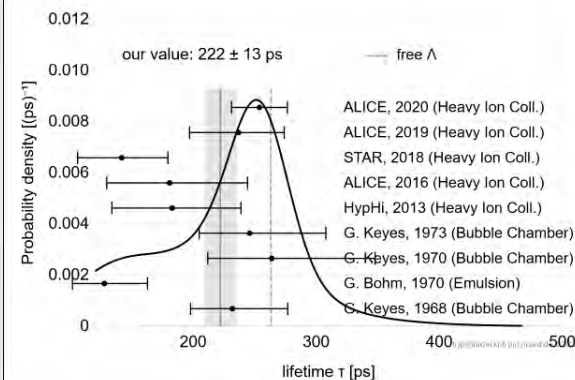
Ground state options:

☐ GS mass ☒  $\Lambda$  binding energy

Life time options:

☒ ps ☐ relative to  $\tau_{\Lambda}$  ☐ decay width

### ${}^3_{\Lambda}\text{H}$ : lifetime $\tau$



### ${}^3_{\Lambda}\text{H}$

Ground State:  $\Lambda$  Binding Energy

evaluated value:  $0.1740 \pm 0.0411$  MeV

Lifetime  $\tau$

evaluated value:  $222 \pm 13$  ps

Two Body Decays

Decay Thresholds

Energy Levels

Export text file, select properties:  vs.

[Information](#)

[Datenschutz](#)

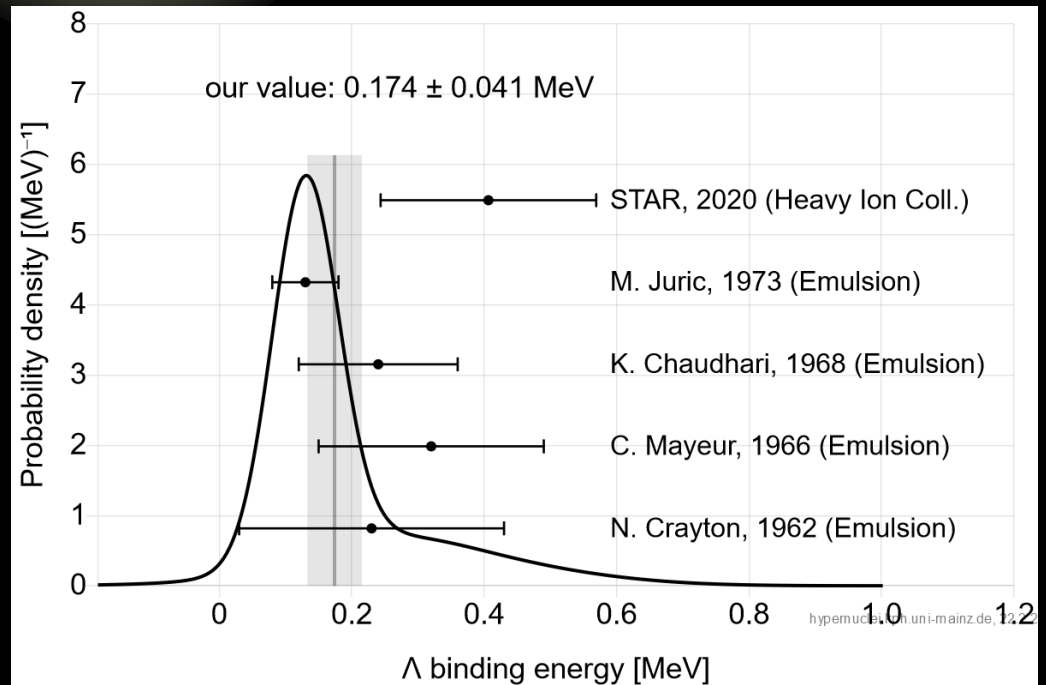
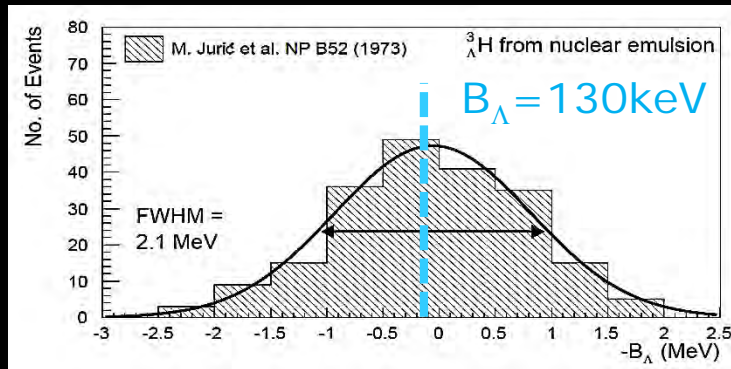
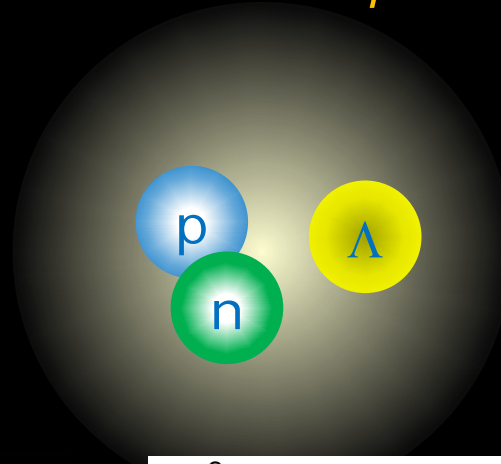
[Impressum](#)

[Back to KPH](#)



*Do we understand the simplest Hypernucleus?*

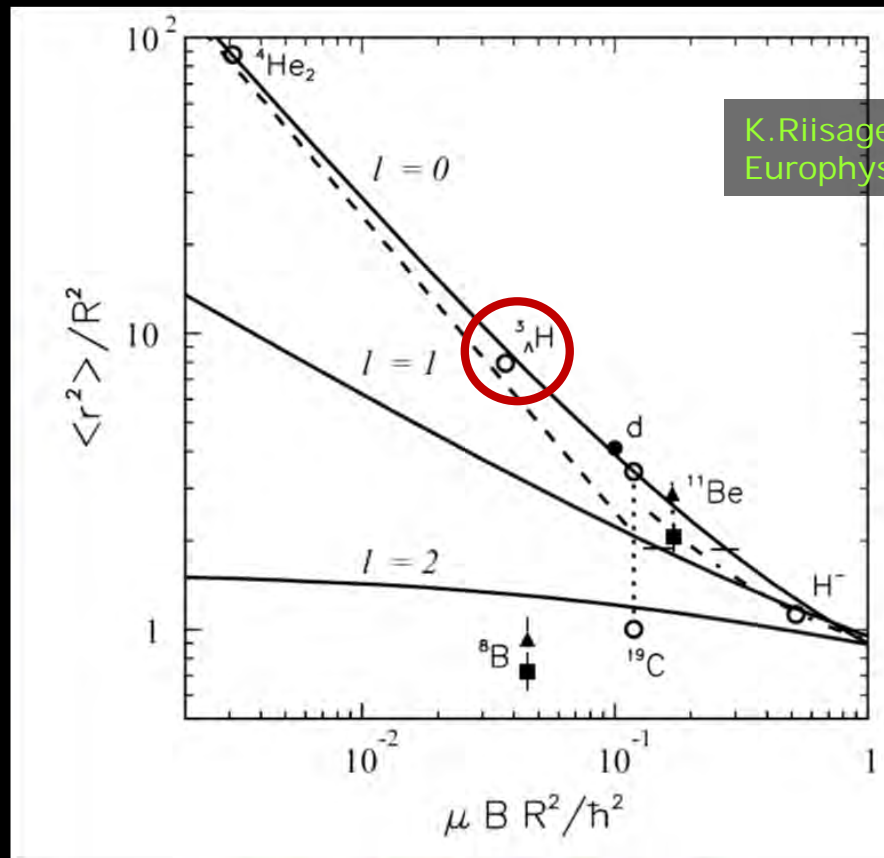
$^3_{\Lambda}\text{H}$



- $^3_\Lambda\text{H}$  is most fascinating halo nucleus
  - Binding energy  $\approx 174\text{keV} \Rightarrow$  Characteristic length of two-body s-wave halo system small

$$\langle \Delta r^2 \rangle = \hbar^2 / (4\mu B) \xrightarrow{^3_\Lambda\text{H}} 9\text{ fm}$$

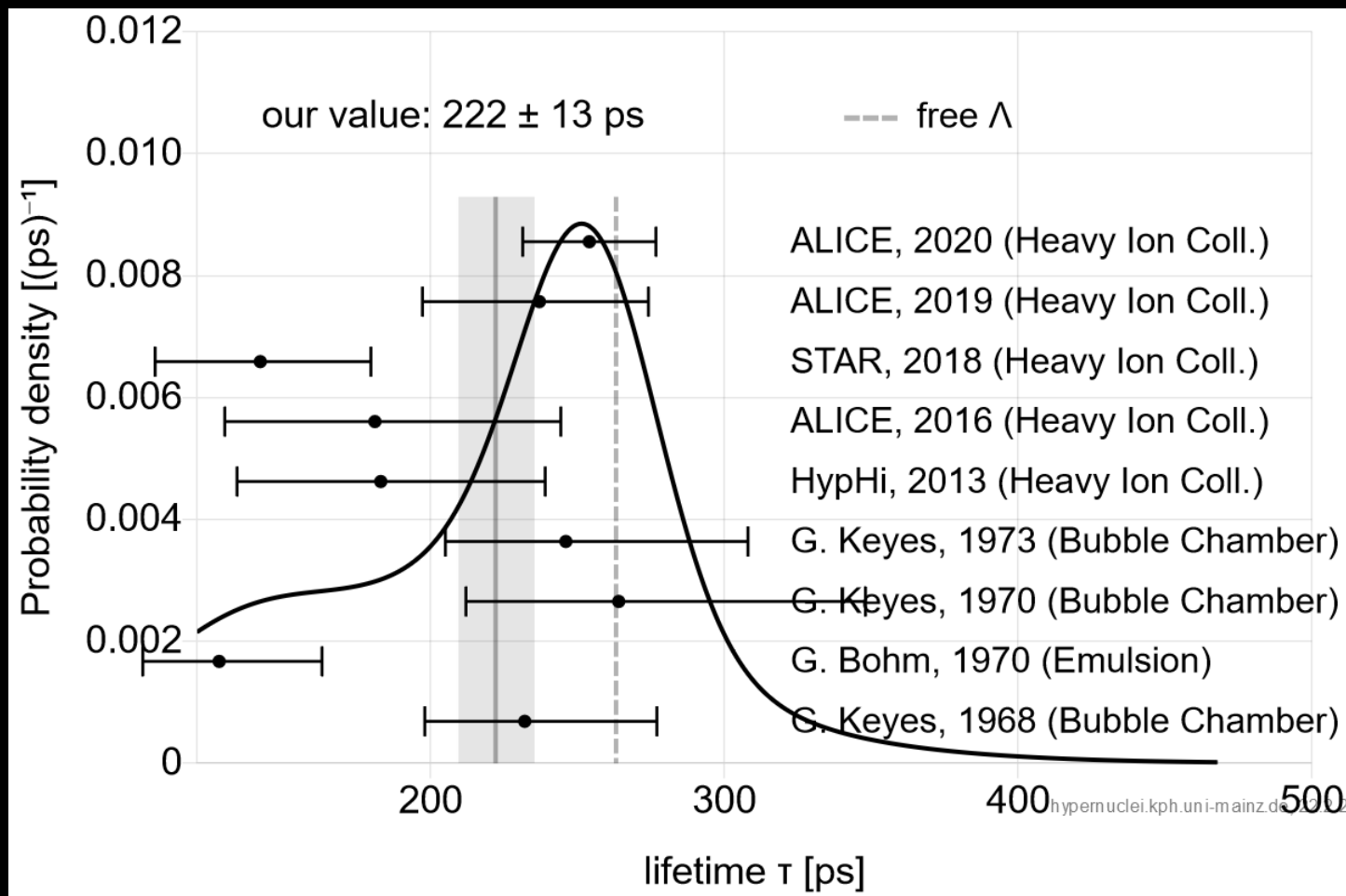
ratio of halo and core-potential  
square radii



K. Riisager, D. V. Fedorov and A. S. Jensen,  
Europhys. Lett 49, 547 (2000)

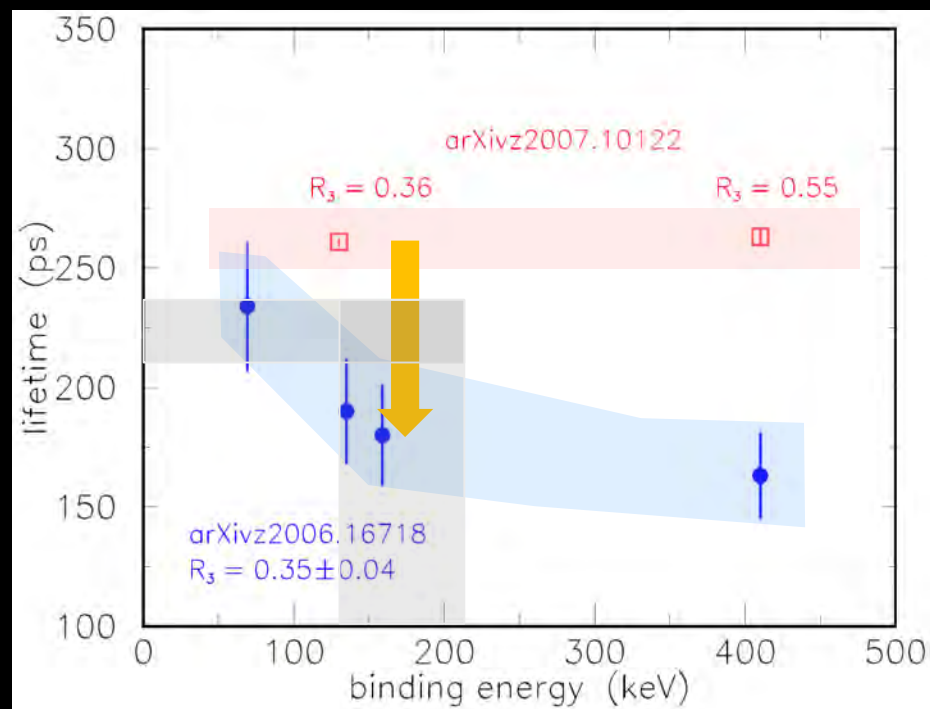
scaled separation energy





small binding energy ? small lifetime

- Hildebrand & Hammer, EFT  
PRC 102, 064002 (2020)
- exp.  $R_3 \approx 0.35$  favors small BE
- Obiol et al., EFT  
PLB 811, 135916 (2020)
  - $\pi$  distorted waves and
  - $\Sigma NN$  admixture important
  - $\Rightarrow$  strong relation between BE and  $\tau$
- Precise measurements of BE and  $\tau$  will provide a stringent test of models



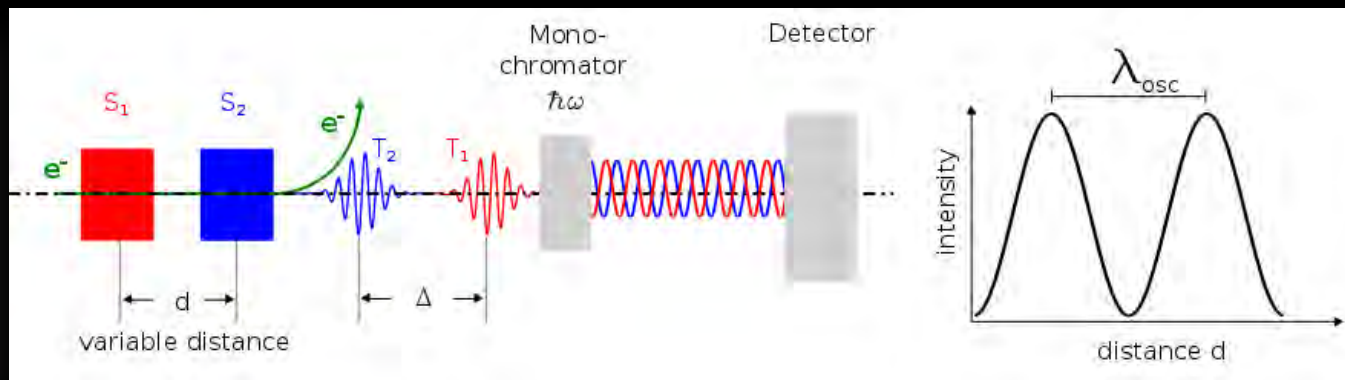
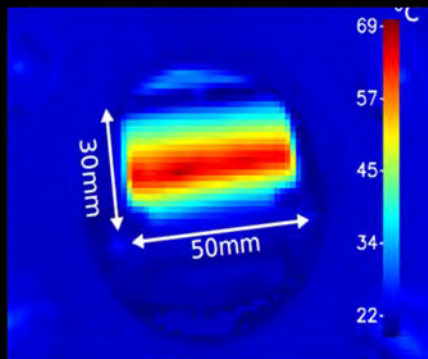


## binding energy

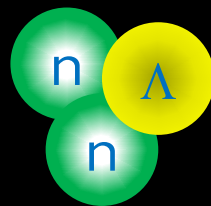
- New precise and accurate mass measurement at MAMI in 2021/2022
- *Mainz & Sendai*
  - Make use of excellent beam quality at MAMI
  - Precision *absolute* energy calibration interference of undulator radiation

## lifetime

- new lifetime measurements
  - 2021: ELPH ( $\gamma, K^+$ )
  - 2022: HYPHI (FAIR Phase 0)
  - 2023: ALICE – end run 3: 200x stat.
  - 202x: J-PARC ( $\pi^-, K^0$ )

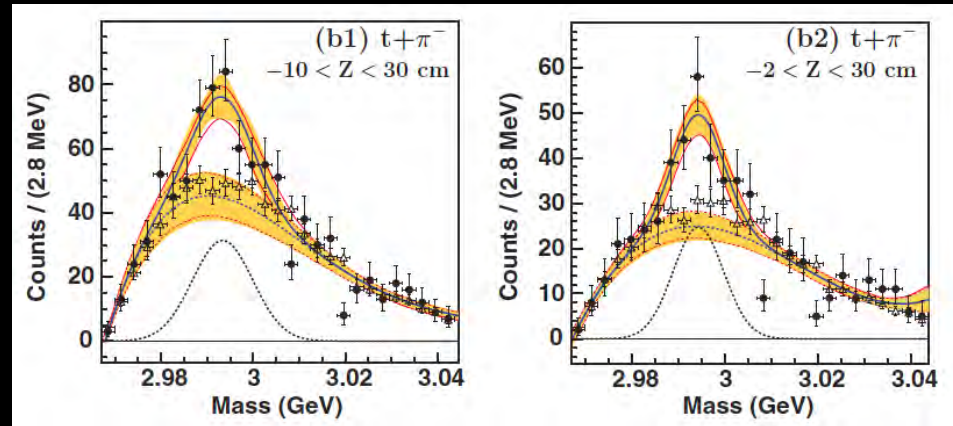


*Does this “Femto Neutron Star” really exist?*

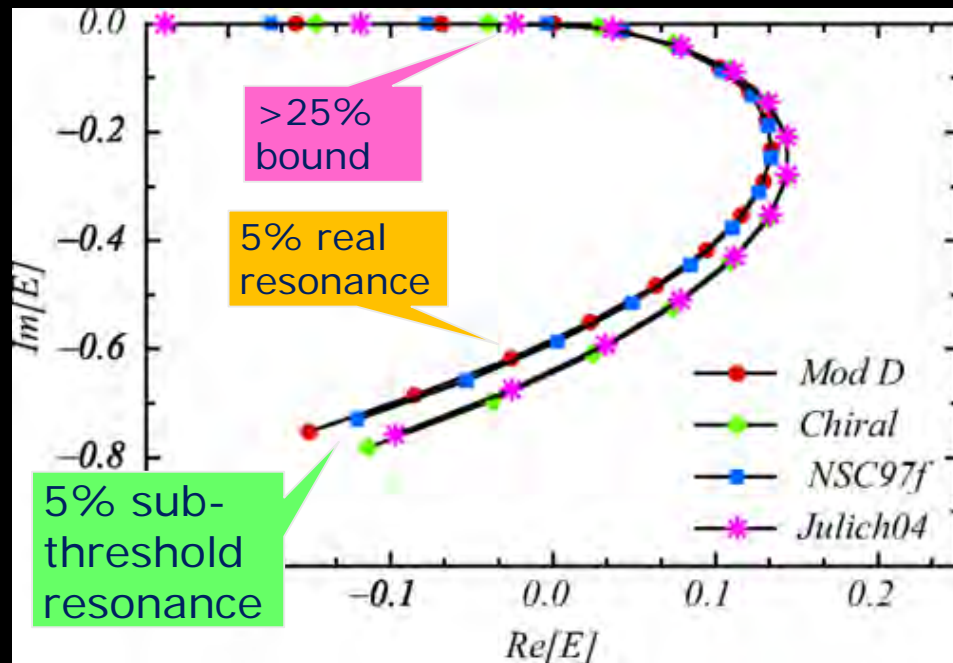




- Such a state has been suggested by the HypHI collaboration
- weak decay  $nn\Lambda \rightarrow \pi - {}^3\text{H}$   
 $\Rightarrow$  bound state
- Statistical Decay Model  ${}^6_{\Lambda}\text{He}^*$  at  $E_x = 40\text{MeV}$ 
  - $\Lambda$  30.7%  $nn\Lambda$  17.3%
  - ${}^3_{\Lambda}\text{H}$  13.9%  ${}^4_{\Lambda}\text{H}$  29.2%
  - ${}^4_{\Lambda}\text{He}$  3.9%  ${}^5_{\Lambda}\text{He}$  4.8%
- but: all modern state of the art ab initio theories do not allow a bound  $nn\Lambda$  state
- Do we really understand the  $\Lambda$ -neutron interaction?
  - N-N scattering: 4000 data
  - Y-p scattering: 100 data
  - Y-n scattering: 0 data



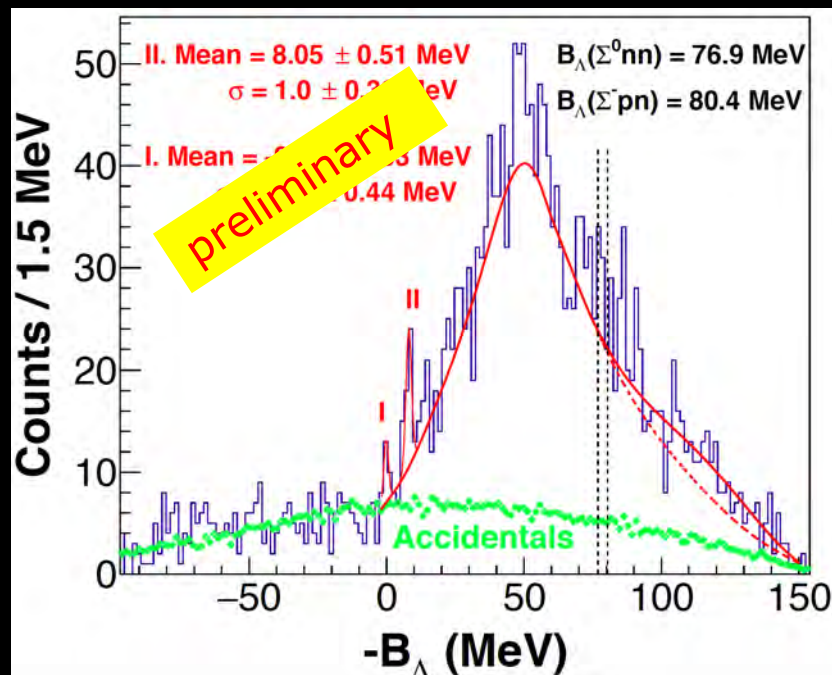
C. Rappold et al., Phys. Rev. C 88 , 041001(R) (2013)



Iraj R. Afnan and Benjamin F. Gibson  
 Phys. Rev. C 92, 054608

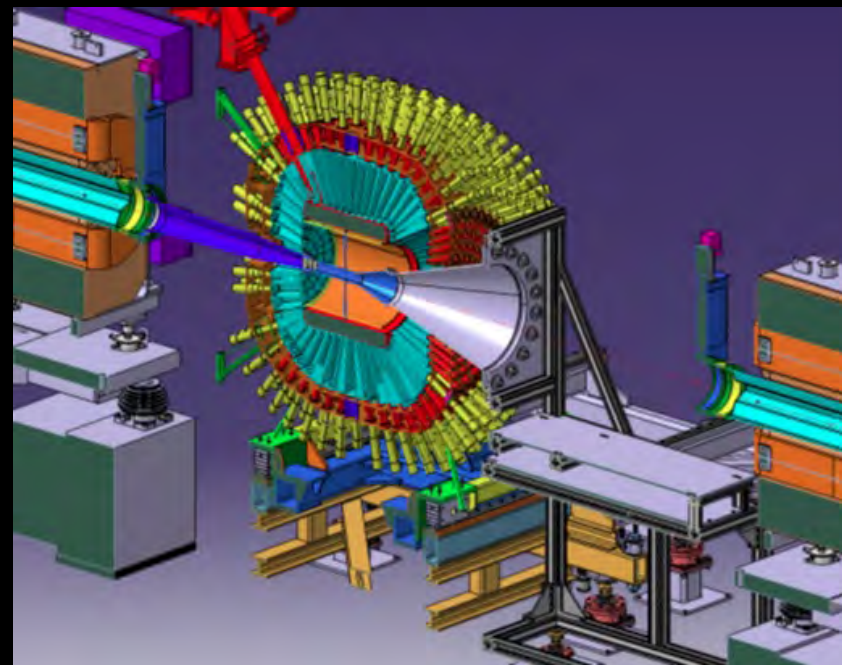
➤ 2018: J-Lab E12-17-003

- $^3\text{H}(e,e'K^+)(nn\Lambda)$
- missing mass experiment
- Preliminary results: *neither solidly confirm nor rule out  $tnn\Lambda$*



➤ 2022: FRS+WASA for S447

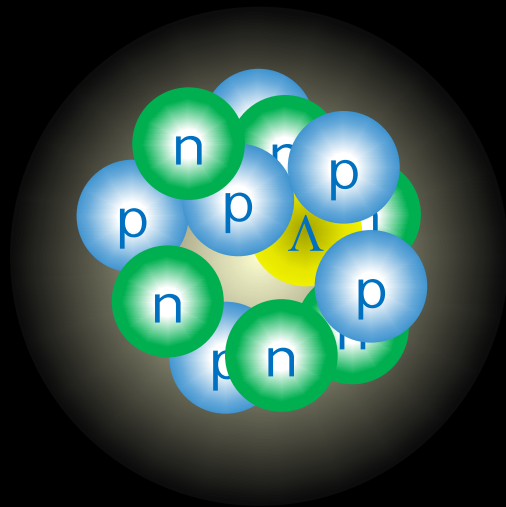
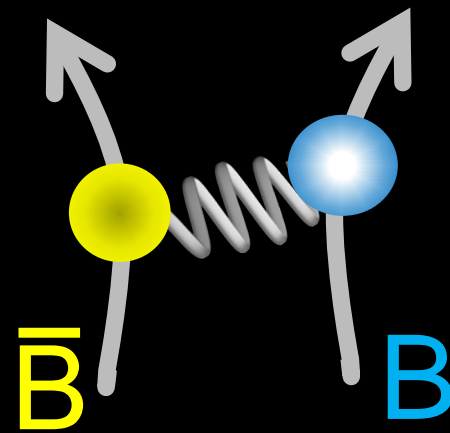
- $^6\text{Li} + ^{12}\text{C}$
- for  $d + \pi$  2 times better mass resolution
- 8 times better S/BG ratio



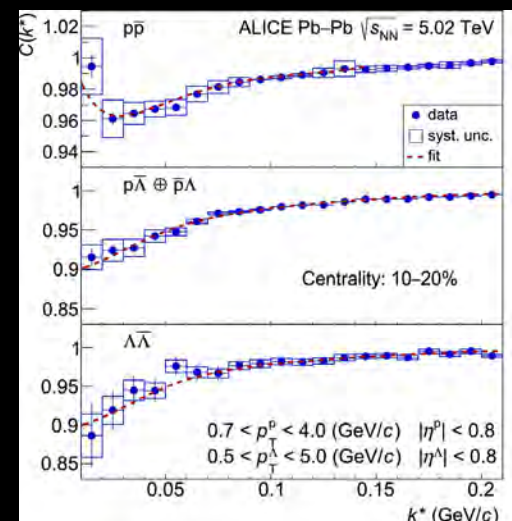
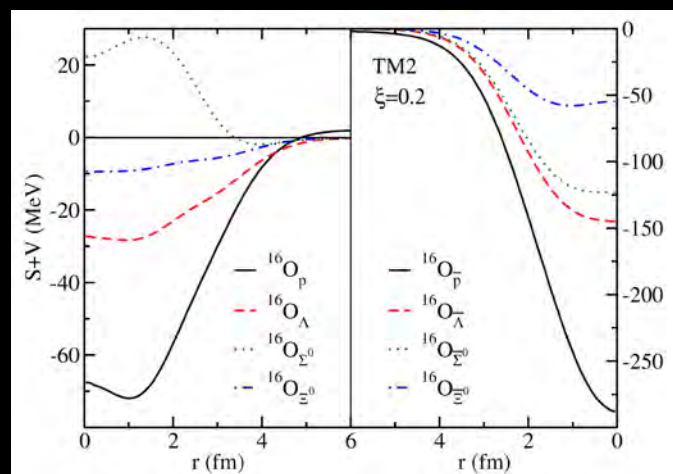
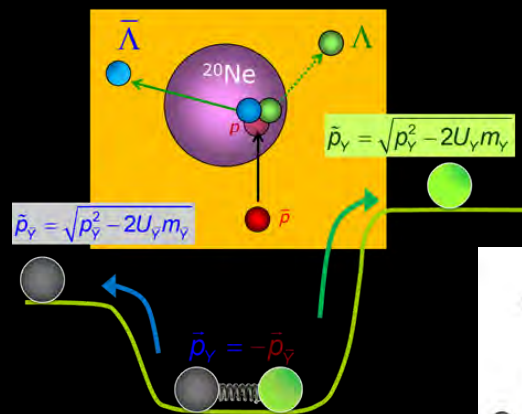
The existence of this „femto-neutron star“ would require to re-think our understanding of three-body interactions



# Task2: $\bar{Y}$ – A interaction


 $A_{\Lambda}Z$ 

 $\bar{Y}$ -N and  $\bar{Y}$ -Y

- Baryon-antibaryon interactions can be studied by two-particle correlation functions in HI
- PANDA will measure the effective potential of  $\bar{\Lambda}$  hyperons by the exclusive  $^{20}\text{Ne}(\bar{p}, \bar{\Lambda}\Lambda)$  reaction during PHASE-1



PANDA Phase One

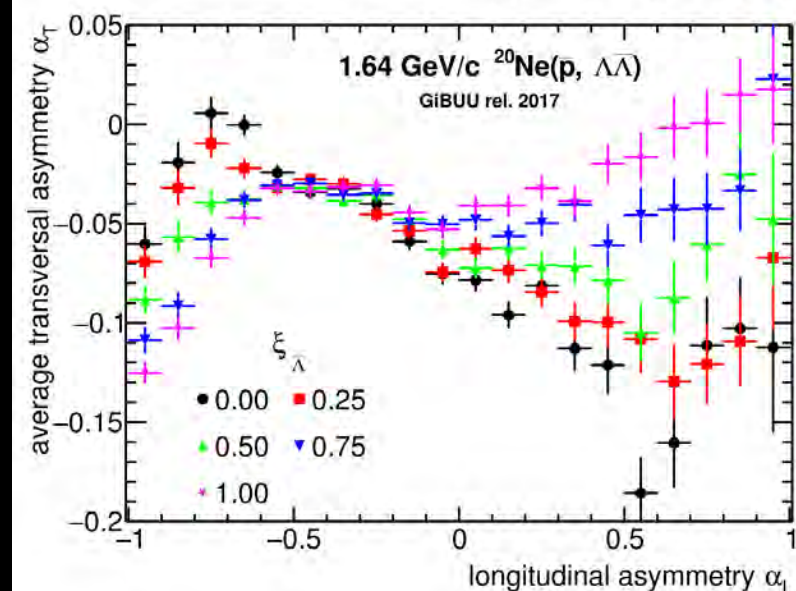
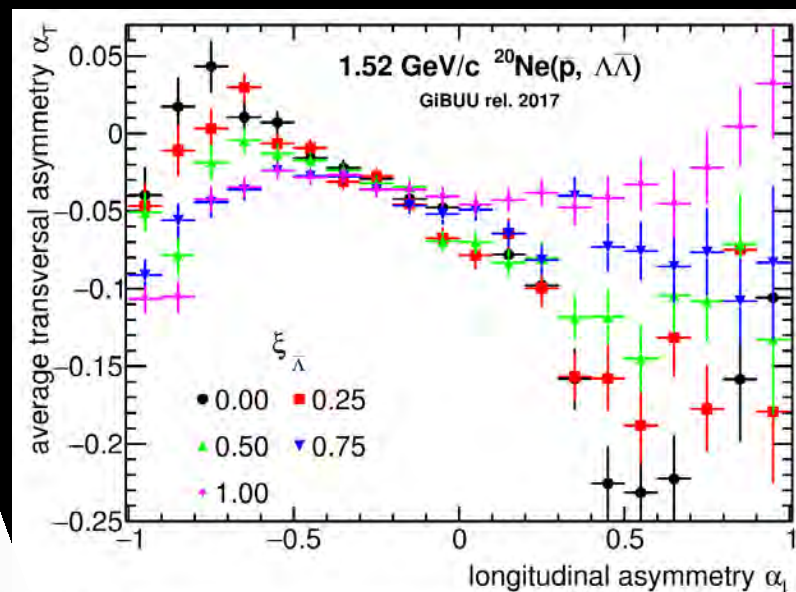
PANDA collaboration  
...<sup>1</sup>, F. Davi  
... M. Ste

**PANDA Phase One**

PANDA collaboration

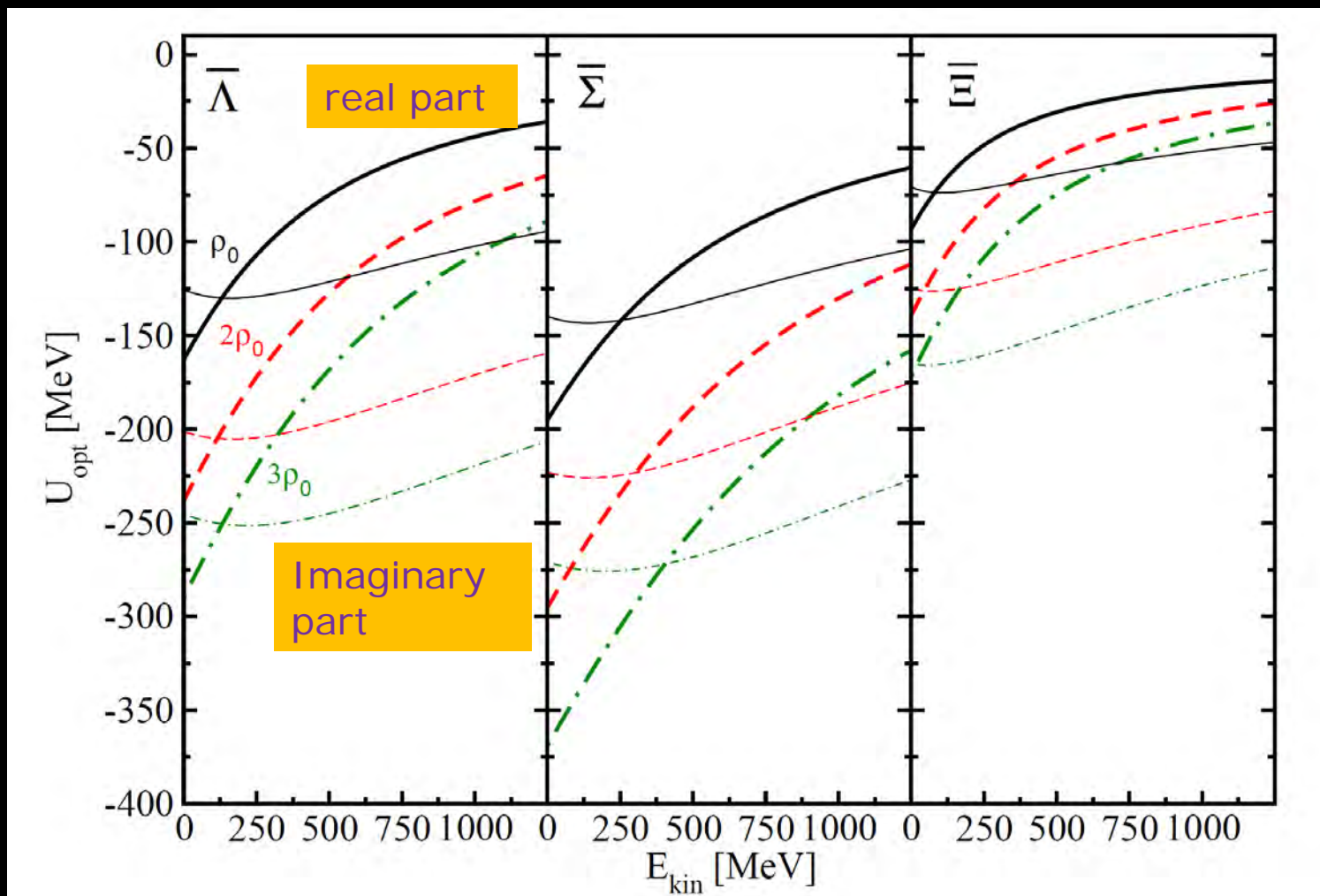
G. Barucci<sup>1</sup>, F. Davi<sup>1</sup>, G. Lancioni<sup>1</sup>, P. Mengucci<sup>1</sup>, L. Montalto<sup>1</sup>, P. P. Natali<sup>1</sup>, P. P. Napol<sup>1</sup>, D. Rinaldi<sup>1</sup>, L. Scialic<sup>1</sup>,  
B. Krusche<sup>2</sup>, M. Steinacher<sup>2</sup>, S. Coen<sup>2</sup>, F. Feldbauer<sup>2</sup>, M. Fink<sup>2</sup>, J. Frech<sup>2</sup>, V. Freudenreich<sup>2</sup>, M. Fritsch<sup>2</sup>,  
W. Alkhalid<sup>3</sup>, R. Haglorn<sup>3</sup>, F. H. Hensius<sup>3</sup>, S. Maldaner<sup>3</sup>, J. Oppotsch<sup>3</sup>, S. Pankonin<sup>3</sup>, T. Holtmann<sup>3</sup>, H. Koch<sup>3</sup>, B. Kopf<sup>3</sup>, M. Kimmel<sup>3</sup>,  
J. Grochowski<sup>4</sup>, J. Li<sup>4</sup>, L. Linzen<sup>4</sup>, M. Steinke<sup>4</sup>, M. Beck<sup>4</sup>, V. Chambari<sup>4</sup>, C. Wenzel<sup>4</sup>, H. Denzli<sup>4</sup>, B. Ketzner<sup>4</sup>, P. Pantea<sup>4</sup>, S. Rimjanov<sup>4</sup>,  
M. Kükner<sup>4</sup>, C. Schmier<sup>4</sup>, U. Thoma<sup>4</sup>, F. Lisowski<sup>4</sup>, M. Urban<sup>4</sup>, A. Szczurek<sup>4</sup>, M. Firlej<sup>4</sup>, T. Fintowski<sup>4</sup>, J. Plazek<sup>4</sup>, K. Korcyl<sup>4</sup>,  
G. Reicherz<sup>4</sup>, A. Yilmaz<sup>4</sup>, C. Schmidt<sup>4</sup>, E. Lisowski<sup>4</sup>, A. Schuler<sup>4</sup>, R. Lalik<sup>4</sup>, I. Augustin<sup>4</sup>, P. Böhm<sup>4</sup>, I. Lehmann<sup>4</sup>, L. Schmitt<sup>4</sup>, V. Varentsov<sup>4</sup>,  
B. Salisburys<sup>5</sup>, G. Filo<sup>5</sup>, E. Schäfer<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>, A. Kozlov<sup>5</sup>,  
M. Domagala<sup>6</sup>, P. Terlecki<sup>6</sup>, G. Korcyl<sup>6</sup>, R. Lalik<sup>6</sup>, I. Augustin<sup>6</sup>, P. Böhm<sup>6</sup>, I. Lehmann<sup>6</sup>, L. Schmitt<sup>6</sup>, V. Varentsov<sup>6</sup>,  
K. Lebedev<sup>7</sup>, K. Pyss<sup>7</sup>, E. Lisowski<sup>7</sup>, A. Schuler<sup>7</sup>, R. Lalik<sup>7</sup>, I. Augustin<sup>7</sup>, P. Böhm<sup>7</sup>, I. Lehmann<sup>7</sup>, L. Schmitt<sup>7</sup>, V. Varentsov<sup>7</sup>,  
N. Rathod<sup>8</sup>, P. Salabura<sup>8</sup>, J. Smyski<sup>8</sup>, R. Dzhigadlo<sup>8</sup>, H. Flemming<sup>8</sup>, J. Lühning<sup>8</sup>, J. Schwenning<sup>8</sup>, A. Tischer<sup>8</sup>,  
M. Al-Turany<sup>9</sup>, A. Beliaev<sup>9</sup>, S. Koch<sup>9</sup>, U. Kurilla<sup>9</sup>, C. J. Schmidt<sup>9</sup>, G. Alexeev<sup>9</sup>, M. Yu. Barabanov<sup>9</sup>, V. Kh. Lobanov<sup>9</sup>,  
P. Jiang<sup>10</sup>, R. Karabaw<sup>10</sup>, G. Schepers<sup>10</sup>, V. Abazov<sup>10</sup>, G. Solovayev<sup>10</sup>, E. K. Koshurnikov<sup>10</sup>, M. Yu. Barabanov<sup>10</sup>, V. Kh. Lobanov<sup>10</sup>,  
K. Peters<sup>11</sup>, B. Voss<sup>11</sup>, P. Wiczorek<sup>11</sup>, A. Samarin<sup>11</sup>, A. Verhees<sup>11</sup>, M. Pfaffinger<sup>11</sup>, P. Gianotti<sup>11</sup>, M. Düren<sup>11</sup>, V. Kühn<sup>11</sup>, V. Metz<sup>11</sup>,  
M. Traxler<sup>12</sup>, A. Fedchenko<sup>12</sup>, A. A. Piskun<sup>12</sup>, L. Brück<sup>12</sup>, F. Khlid<sup>12</sup>, I. Koseoglu<sup>12</sup>, D. Glazier<sup>12</sup>, G. Huang<sup>12</sup>, D. Li<sup>12</sup>,  
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A. Strokosky<sup>15</sup>, M. Krebs<sup>15</sup>, S. Nakhon<sup>15</sup>, L. Brück<sup>15</sup>, F. Khlid<sup>15</sup>, I. Koseoglu<sup>15</sup>, D. Glazier<sup>15</sup>, G. Huang<sup>15</sup>, D. Li<sup>15</sup>,  
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M. Himmelschick<sup>17</sup>, K. T. Brinkmann<sup>17</sup>, S. Kegel<sup>17</sup>, P. Orsich<sup>17</sup>, J. Pereira-Gustafsson<sup>17</sup>, V. Rodin<sup>17</sup>, A. Olgun<sup>17</sup>, Z. Tavukoglu<sup>17</sup>, A. Derichs<sup>17</sup>,  
S. Bodenschütz<sup>18</sup>, J. Hofmann<sup>18</sup>, H. G. Zaimnik<sup>18</sup>, E. Tomasi-Gustafsson<sup>18</sup>, J. Messchendorp<sup>18</sup>, D. Grunwald<sup>18</sup>, E. Phipps<sup>18</sup>,  
S. Hayrapetyan<sup>19</sup>, M. Navon<sup>19</sup>, H. Lochner<sup>19</sup>, M. Kunze<sup>19</sup>, F. Goldenbaum<sup>19</sup>, D. Prasuhn<sup>19</sup>, Z. Stockmanns<sup>19</sup>, V. Rigato<sup>19</sup>, H. Merke<sup>19</sup>,  
M. Moritz<sup>20</sup>, T. Waser<sup>20</sup>, X. Zhou<sup>20</sup>, A. Gillitzer<sup>20</sup>, F. Andrade<sup>20</sup>, V. Serdyuk<sup>20</sup>, Y. Liang<sup>20</sup>, H. H. Leithoff<sup>20</sup>, S. Bleser<sup>20</sup>, O. Noll<sup>20</sup>, D. Rodriguez<sup>20</sup>,  
R. Kappert<sup>21</sup>, H. Ques<sup>21</sup>, Y. Sun<sup>21</sup>, A. Perz-Andrade<sup>21</sup>, T. Seifried<sup>21</sup>, Q. Hu<sup>21</sup>, Y. Liang<sup>21</sup>, H. H. Leithoff<sup>21</sup>, S. Bleser<sup>21</sup>, O. Noll<sup>21</sup>, D. Rodriguez<sup>21</sup>,  
H. Peng<sup>22</sup>, H. Ques<sup>22</sup>, Y. Sun<sup>22</sup>, A. Perz-Andrade<sup>22</sup>, T. Seifried<sup>22</sup>, Q. Hu<sup>22</sup>, Y. Liang<sup>22</sup>, H. H. Leithoff<sup>22</sup>, S. Bleser<sup>22</sup>, O. Noll<sup>22</sup>, D. Rodriguez<sup>22</sup>,  
R. Dossald<sup>23</sup>, S. Orfanitsky<sup>23</sup>, A. Scholl<sup>23</sup>, Y. Zhou<sup>23</sup>, A. Distel<sup>23</sup>, M. Hoek<sup>23</sup>, W. Laur<sup>23</sup>, M. Thiel<sup>23</sup>, C. Motzkov<sup>23</sup>, M. Korzhik<sup>23</sup>, A. Golubev<sup>23</sup>,  
P. Kulassa<sup>24</sup>, R. Schmitz<sup>24</sup>, H. Xie<sup>24</sup>, A. Deng<sup>24</sup>, P. Chodazalla<sup>24</sup>, S. Schlimme<sup>24</sup>, R. Kien<sup>24</sup>, F. Maas<sup>24</sup>, D. Kazlov<sup>24</sup>, P. Fedorov<sup>24</sup>, A. Gerasimov<sup>24</sup>, V. Panchuk<sup>24</sup>,  
S. Schadmand<sup>25</sup>, W. Wüster<sup>25</sup>, A. Ehret<sup>25</sup>, R. Klaser<sup>25</sup>, I. Zimmermann<sup>25</sup>, A. Dolgolenko<sup>25</sup>, F. Luschevsky<sup>25</sup>, V. A. Matveyev<sup>25</sup>,  
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U. Müller<sup>28</sup>, A. Deyss<sup>28</sup>, A. Meiner<sup>28</sup>, A. Demekhin<sup>28</sup>, S. Wolf<sup>28</sup>, E. Ladygina<sup>28</sup>, F. Luschevsky<sup>28</sup>, V. A. Matveyev<sup>28</sup>,  
L. Capozza<sup>29</sup>, F. Schupp<sup>29</sup>, V. Chernetsky<sup>29</sup>, N. Krist<sup>29</sup>, E. Ladygina<sup>29</sup>, F. Luschevsky<sup>29</sup>, V. A. Matveyev<sup>29</sup>,  
P. Balanuta<sup>30</sup>, D. Y. Kirin<sup>30</sup>, N. Krist<sup>30</sup>, E. Ladygina<sup>30</sup>, F. Luschevsky<sup>30</sup>, V. A. Matveyev<sup>30</sup>,  
A. Kantsyren<sup>31</sup>, D. Y. Kirin<sup>31</sup>, N. Krist<sup>31</sup>, E. Ladygina<sup>31</sup>, F. Luschevsky<sup>31</sup>, V. A. Matveyev<sup>31</sup>.

- ▶ Many things to study
  - ▶ Influence of Coplanarity
  - ▶ Other targets (Ar)
  - ▶ ...
  - ▶ Analysis tools





Combines RMF & MDI



- ▶ Kaonic system
- ▶ This workshop

▶ ..old story...

Table 1

Comparison of  ${}^4_{\Lambda}\text{H}$  production rates by stopping  $K^-$  mesons

KEK (Tokyo)		European $K^-$ Collaboration	
Target	Rate ( $\times 10^{-3}$ )	Target	Rate ( $\times 10^{-3}$ )
${}^7\text{Li}$	30		
${}^9\text{Be}$	15.7		
${}^{12}\text{C}$	10.0	C, N, O	7.3
${}^{16}\text{O}$	4.7		
${}^{40}\text{Ca}$	$< 2.7$	Ag, Br	2.4

Observed:  
 $\pi^-$  decay

200 stopped  
 $K^-/s$

Table 2

Production rates of  ${}^3_{\Lambda}\text{H}$  and  ${}^5_{\Lambda}\text{He}$  measured by the European  $K^-$  Collaboration

Target	${}^3_{\Lambda}\text{H}$ rate ( $\times 10^{-3}$ )	${}^5_{\Lambda}\text{He}$ rate ( $\times 10^{-3}$ )
C, N, O	1.62	21.6
Ag, Br	0.54	1.4

C, N, O/Ag, Br  $\approx$   
 $8/58 \approx 0.13$



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TABLE I. Elementary processes to form the  $\Lambda$  compound nucleus from  $K^-$  absorption at rest. The branching ratio of each process,  $R^{(i)}$ , is obtained from the experimental branching ratio of the  $\Lambda\pi$  and  $\Sigma\pi$  productions,  $BR^{(i)}$ , and the conversion probability of  $\Sigma$  (0.5). In the conversion of  $\Sigma^0$ , a factor of 0.5 is assumed as the branching ratio between  $\Sigma^0 p$  and  $\Sigma^0 n$  reactions. In the present model, we considered only one compound hypernucleus for each process as shown in the last column.

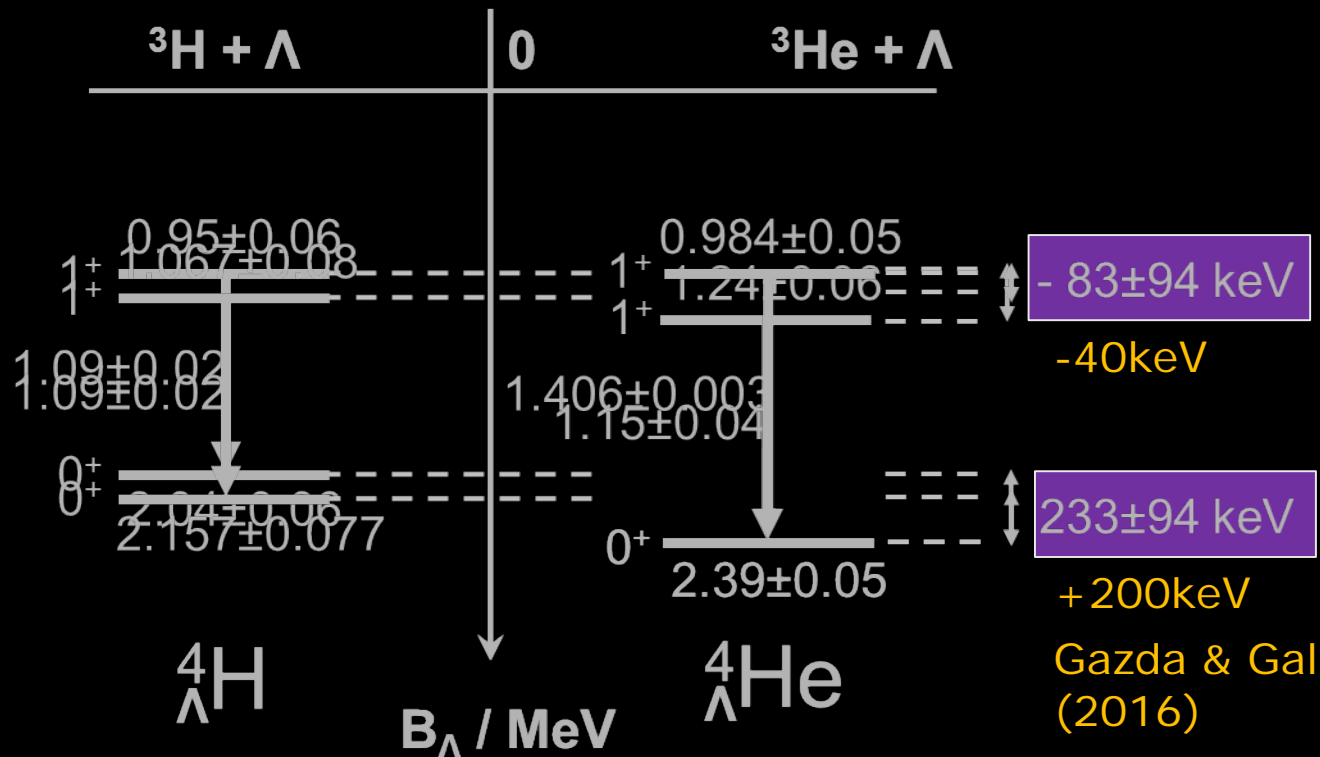
$i$	Elementary process	$BR^{(i)}$	$R^{(i)}$		Compound nucleus
			Conversion probability		$^{12}\text{C}$ target $^{16}\text{O}$ target
1	$K^- p \rightarrow \Lambda\pi^0$	0.044			$^{12}_{\Lambda}\text{B}^*$ $^{16}_{\Lambda}\text{N}^*$
2	$K^- n \rightarrow \Lambda\pi^-$	0.087			$^{12}_{\Lambda}\text{C}^*$ $^{16}_{\Lambda}\text{O}^*$
3	$K^- p \rightarrow \Sigma^-\pi^+, \Sigma^- p \rightarrow \Lambda n$	0.168	$\times 0.5$		$^{11}_{\Lambda}\text{Be}^*$ $^{15}_{\Lambda}\text{C}^*$
4	$K^- p \rightarrow \Sigma^0\pi^0, \Sigma^0 p \rightarrow \Lambda p$	0.129	$\times 0.5 \times 0.5$		$^{11}_{\Lambda}\text{Be}^*$ $^{15}_{\Lambda}\text{C}^*$
5	$K^- p \rightarrow \Sigma^0\pi^0, \Sigma^0 n \rightarrow \Lambda n$	0.129	$\times 0.5 \times 0.5$		$^{11}_{\Lambda}\text{B}^*$ $^{15}_{\Lambda}\text{N}^*$
6	$K^- p \rightarrow \Sigma^+\pi^-, \Sigma^+ n \rightarrow \Lambda p$	0.377	$\times 0.5$		$^{11}_{\Lambda}\text{B}^*$ $^{15}_{\Lambda}\text{N}^*$
7	$K^- n \rightarrow \Sigma^-\pi^0, \Sigma^- p \rightarrow \Lambda n$	0.033	$\times 0.5$		$^{11}_{\Lambda}\text{B}^*$ $^{15}_{\Lambda}\text{N}^*$
8	$K^- n \rightarrow \Sigma^0\pi^-, \Sigma^0 p \rightarrow \Lambda p$	0.017	$\times 0.5 \times 0.5$		$^{11}_{\Lambda}\text{B}^*$ $^{15}_{\Lambda}\text{N}^*$
9	$K^- n \rightarrow \Sigma^0\pi^-, \Sigma^0 n \rightarrow \Lambda n$	0.017	$\times 0.5 \times 0.5$		$^{11}_{\Lambda}\text{C}^*$ $^{15}_{\Lambda}\text{O}^*$

	$^3_{\Lambda}\text{H}$	$^4_{\Lambda}\text{H}$	$^4_{\Lambda}\text{He}$	$^5_{\Lambda}\text{He}$	$^6_{\Lambda}\text{He}$	$^7_{\Lambda}\text{He}$	$^7_{\Lambda}\text{Li}$	$^8_{\Lambda}\text{Li}$	$^9_{\Lambda}\text{Li}$	$^7_{\Lambda}\text{Be}$	$^8_{\Lambda}\text{Be}$	$^9_{\Lambda}\text{Be}$	$^{10}_{\Lambda}\text{Be}$
g.s.	2.6 9.1	2.1 4.0	2.1 1.1	17.3 18.0	5.6 10.4	0.2 1.1	2.1 1,2	2.6	0.3	0.1	0.8	2.5	0.5
1ex		5.4 10.2	5.3 2.5			0.1 2.2	3.6 2.4		0.4			6.5	0.8
2ex						0.2 3.3	4.2 3.5		0.2			4.3	0.7
3ex							5.1 4.6		0.1				1.0

$^{11}_{\Lambda}\text{B}^*$  at  $E_x = 40\text{MeV}$

$^8_{\Lambda}\text{Li}^*$  at  $E_x = 40\text{MeV}$

- before 2015: not compatible with *all* state-of-the-art calculations



- strong, **spin-dependent** charge symmetry breaking (CSB) in  $A = 4$  mirror hypernuclei !
- Compatible with *ab initio* calculations

- First workshop in Speyer Nov. 2019
- <https://indico.gsi.de/event/8950/>
- Second workshop planned in Oct 2020
- ⇒ replaced by web-seminar

- <https://indico.gsi.de/category/513/>
- weekly meeting each Wednesday
- Usually 2 talks

- Future meetings
  - 2021: ???
  - 2022: HYP in Prague
  - 2023: ? ECT\* ?



THEIA-STRONG2020 - Workshop 2019



Joint web-seminar [indico.gsi.de/category/513/](https://indico.gsi.de/category/513/)

REIMAI project  
„Doubly strange systems”  
JAEA & Mainz  
Kiyoshi Tanida & JP



# Important task for you

- ▶ Please acknowledge STRONG2020 and THEIA
- ▶ “This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement STRONG – 2020 - No 824093”.
- ▶ Likewise, for publications, infrastructures, other related results, please put the following acknowledgement:
- ▶ “This [infrastructure][publication/article][insert type of result] is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement STRONG – 2020 - No 824093”.

The background of the slide is a deep space image featuring a dense field of stars of various magnitudes against a dark blue-black sky. On the left side, there is a large, diffuse nebula with a mix of red, orange, and purple hues. In the lower half of the image, there are several colorful, pixelated or simulated galaxy clusters, primarily in shades of blue, green, and red. The text "Thank you for your attention" is centered in the middle of the image, overlaid on a semi-transparent dark band.

**Thank you  
for your attention**

- **Grant Agreement N°824093**
  - 1 June 2020 to 31 May 2023
  - Budget 10 M €
- **32 Work Packages (WPs)**
  - Management and Coordination
  - Dissemination and Communication
  - 7 Transnational Infrastructures (TA)
    - COSY, MAMI, ELSA, GSI, LNF, CERN, ECT\*
  - 2 Virtual Infrastructures (VA)
  - 7 Networking Activities (NA)
  - 14 Joint Research Activities (JRA)

