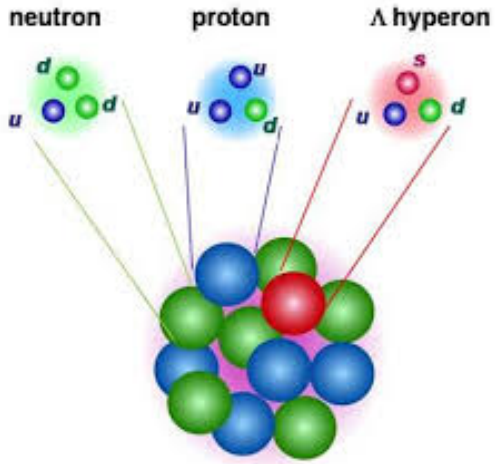
L'étrangeté dans les noyaux : les hypernoyaux



Elias Khan

IPN
INSTITUT DE PHYSIQUE NUCLÉAIRE
ORSAY

UNIVERSITÉ PARIS SUD
université PARIS-SACLAY

avec l'aide de A. Obertelli

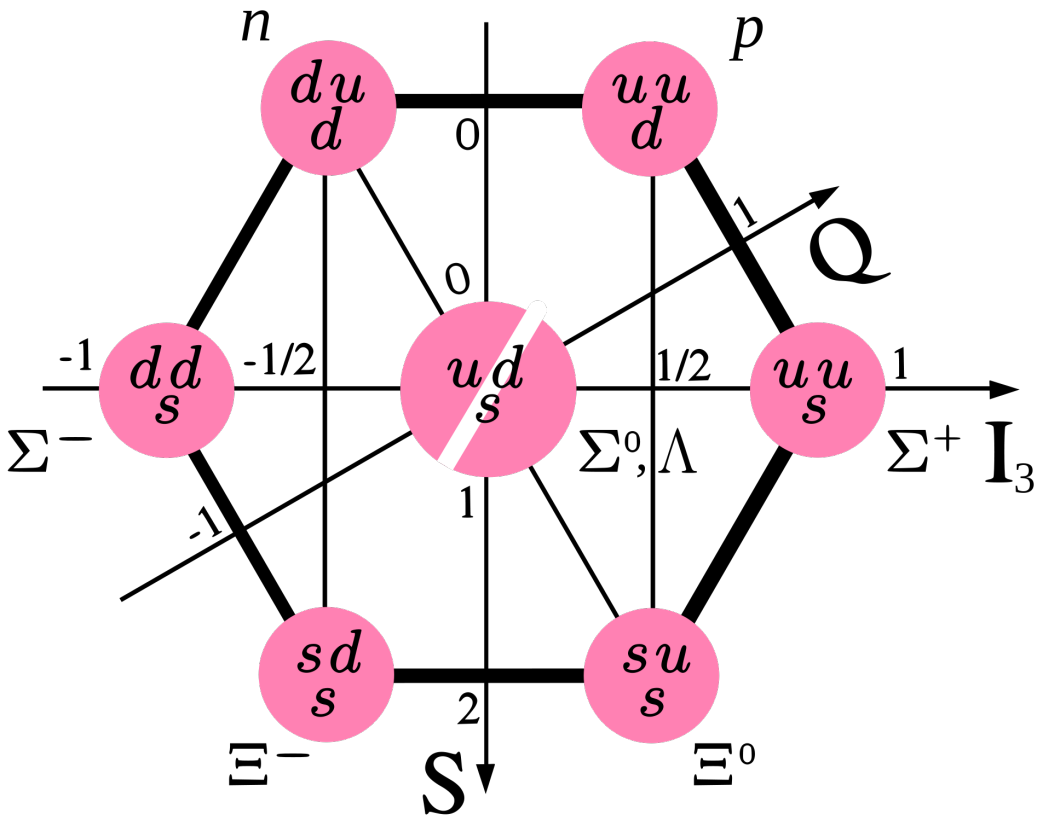
cnrs dépasser les frontières
IN2P3
Les deux infinis

SFP-BTPN « Les grandes questions en physique nucléaire »
21, 22 Juin 2016, Paris

Les hypernoyaux

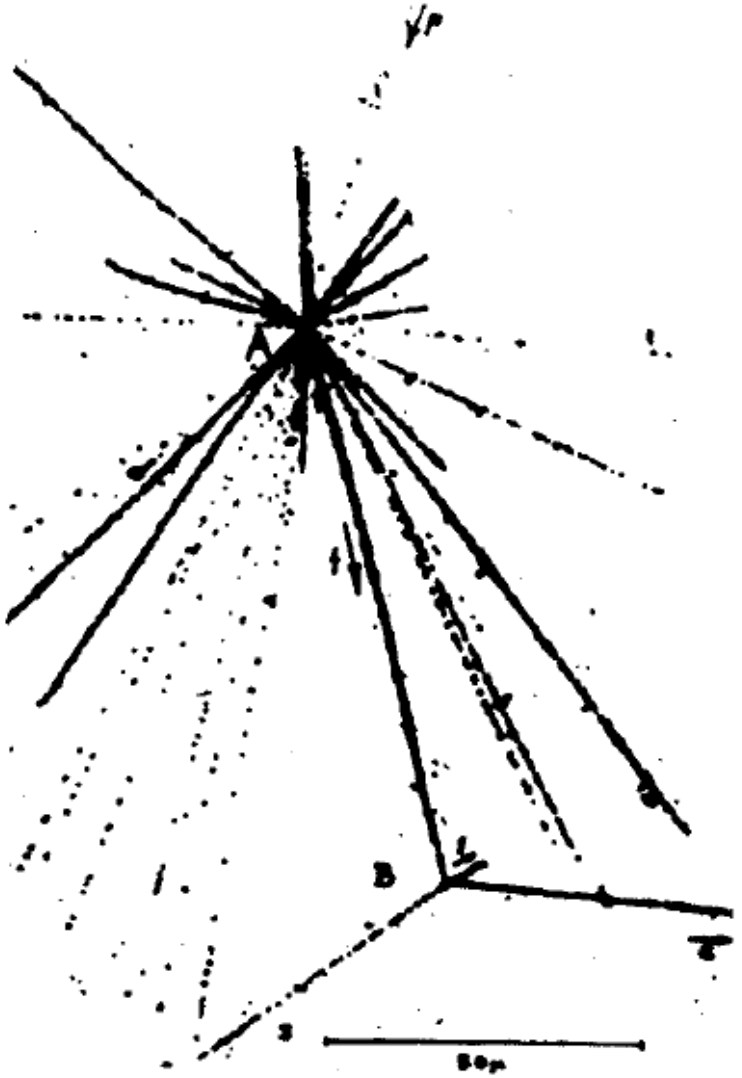
Qu'est ce qu'un hypernoyau ?

Λ découvert en 1951



Hypernuclei discovery (1952)

Jerzy Pniewski and Marian Danysz (Varsovie)



Very first event

Hypernuclei

- Bound by strong interaction
- Desexcitation by electromagnetic interaction
- Decay by weak interaction ($\tau(\Lambda)$ = 263 ps)

Why to study hypernuclei ?

Deep and central probe: «Pauli-free impurity» in nuclei

- **Conjectures** : strangelets, strange stars

- **Puzzles**: hyperons in neutron stars
  lifetime of Λ+n+p compared to free Λ
  charge symmetry breaking in $^{4}He_{\Lambda}$
  Existence of n+n+Λ ?

- **Open/studied questions** : Low energy QCD in the strange sector
  3 body forces: Λ+Λ+Λ, Λ+N+N, …
  Σ-N interaction
  Ξ-Nuclei
  impact on the drip lines: $^{6}He_{\Lambda}$, $^{8}He_{\Lambda}$
  impact on the shape of the nucleus
  impact on giant resonances
  strange clusters states

=> Explore the N,Z,S ($\overline{S}$) chart

Hypernuclei facilities

From T.R. Saito

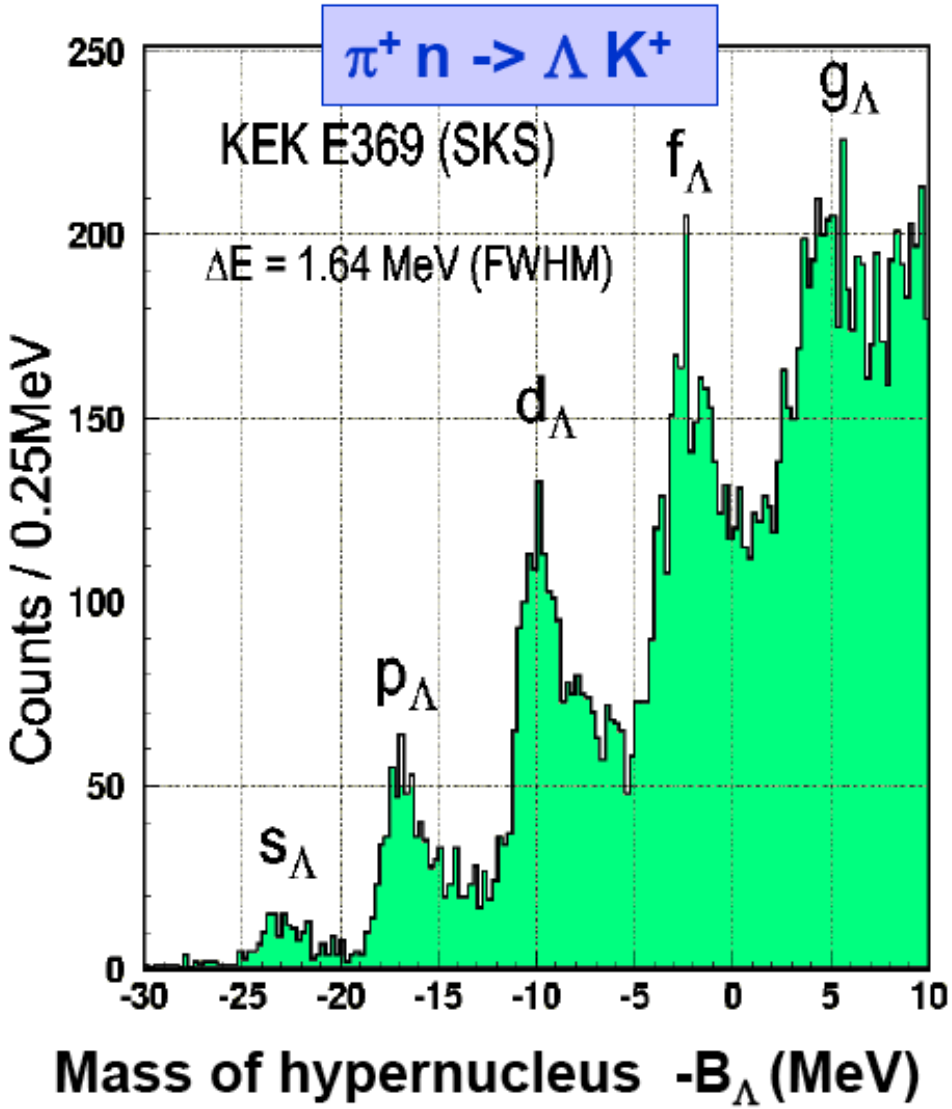
Measurements

- **Observables**: binding energy
  gamma spectroscopy

- **Detection**: need for large rigidity and high resolution spectrometer
  gamma: a la AGATA

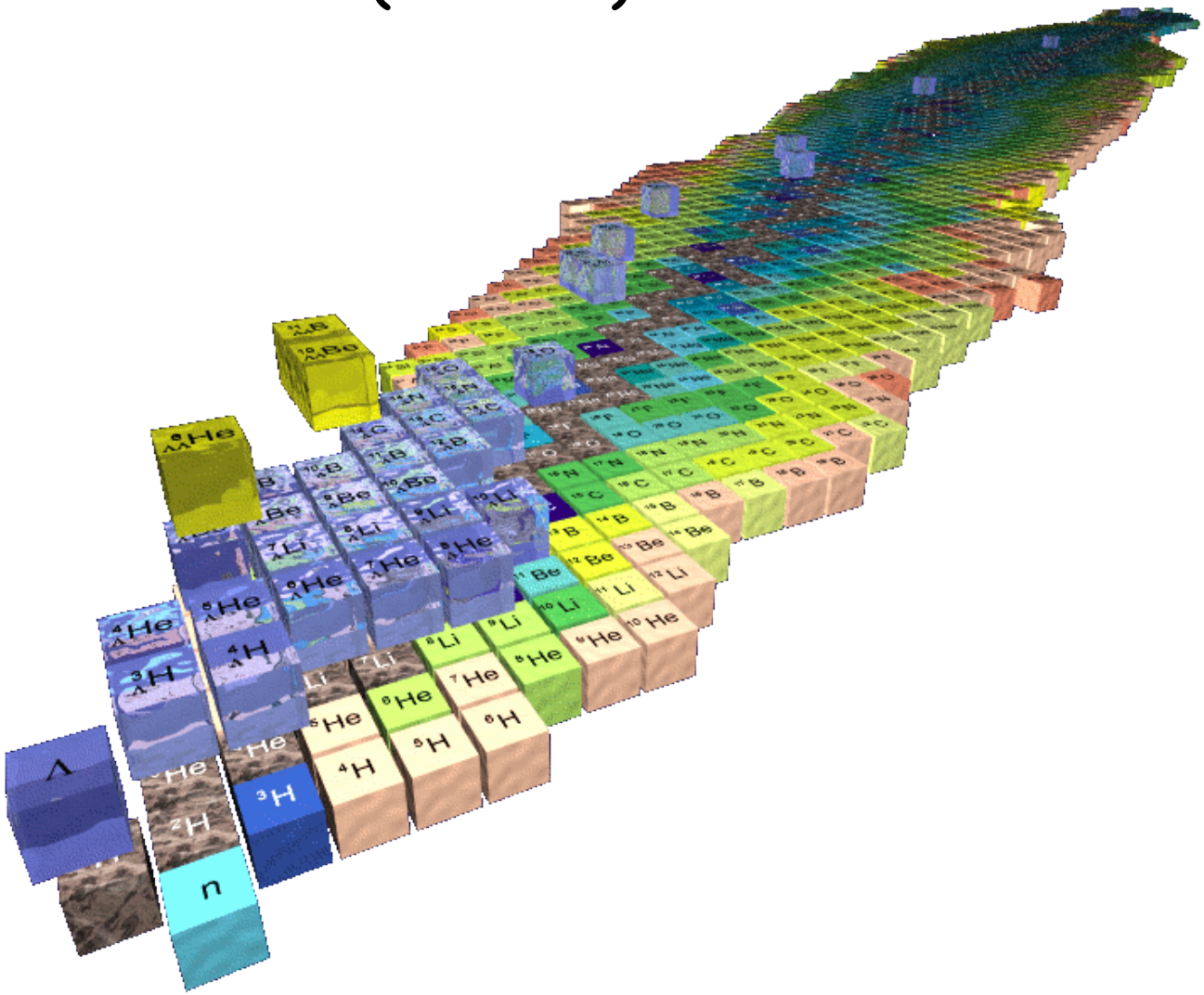
SKS at KEK-PS

$^{89}Y\ (\pi^+,K^+)\ ^{89}{}_{\Lambda}Y$



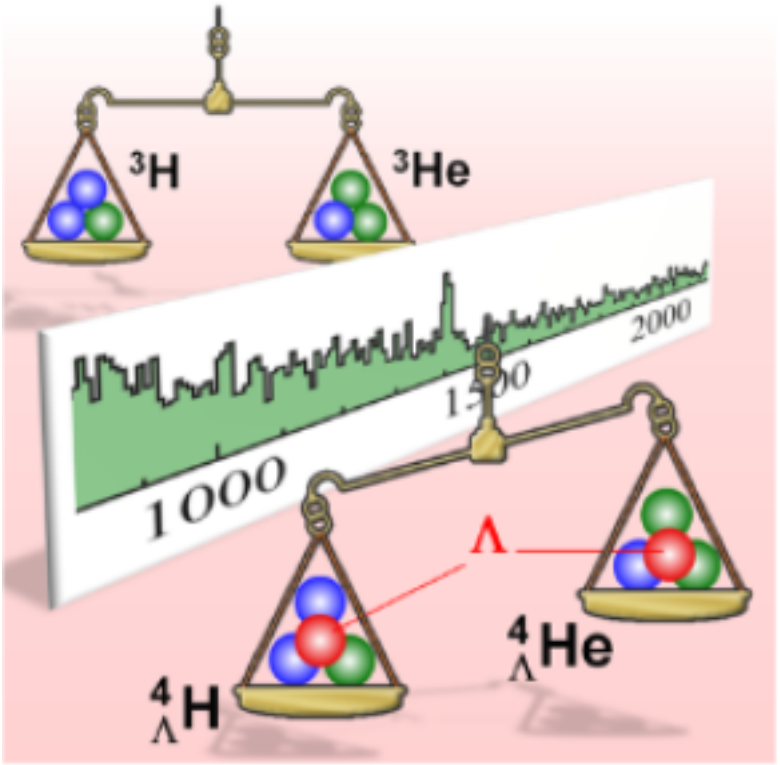
Hotchi et al., PRC 64 (2001) 044302

Example of measured hypernuclear chart (J-Parc)

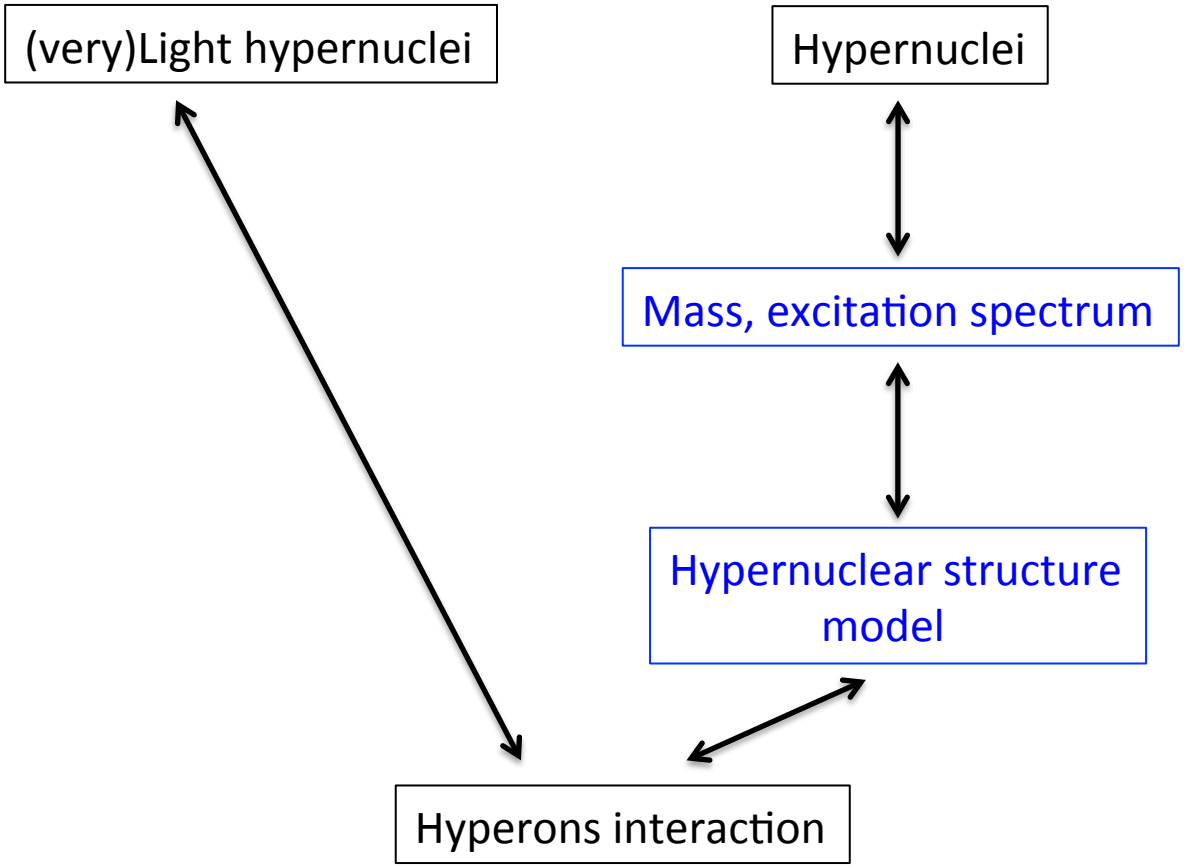


Theory

- Hyperon interactions: QCD in the strange low-energy sector
  3BF, EDF design, ab initio & few body
- Neutron stars: hyperon puzzle
- Strangeness-driven phase transition in matter
- Hyperons nuclear clusters



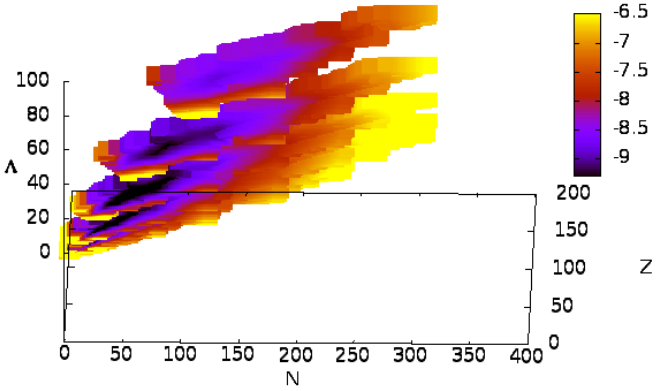
Theory sketch



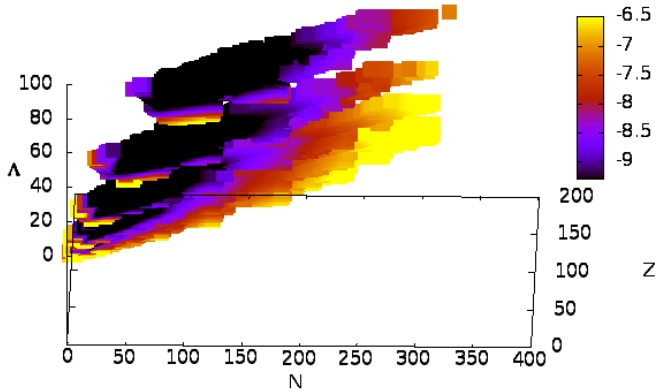
Where are the limits ?

x=1/2

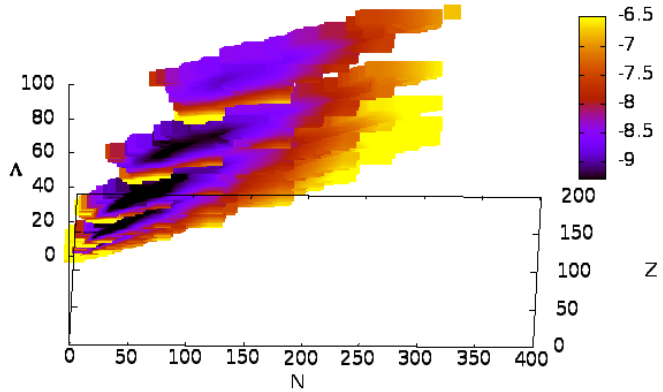
The hypernuclear chart
B/A (MeV)



VPRSO



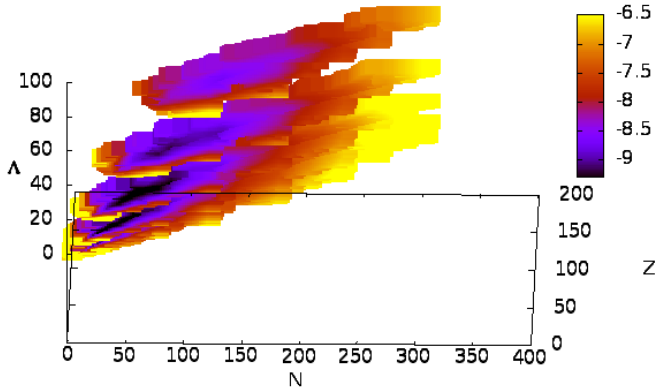
VPRSA

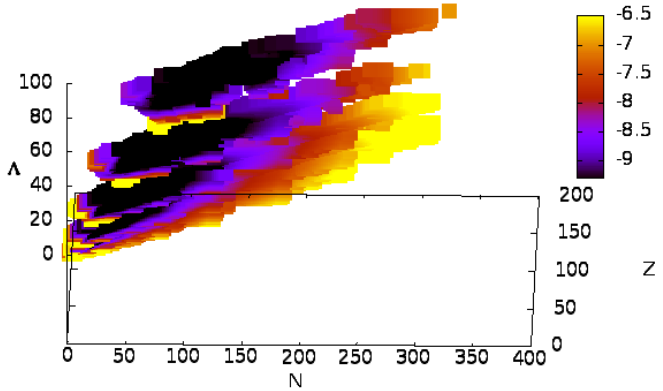


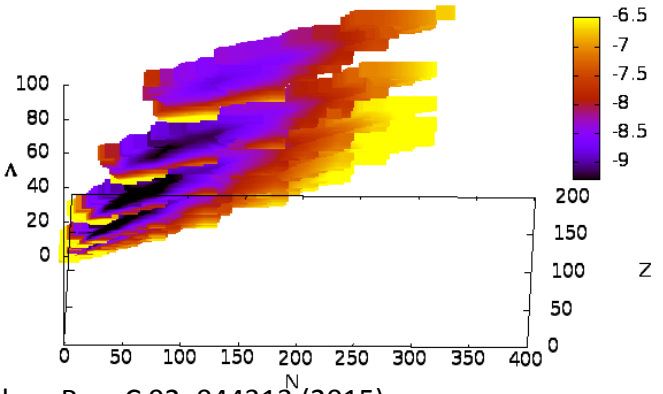
VPRSF

The hypernuclear chart
B/A (MeV)

x=4







E. Khan, J. Margueron, F. Gulminelli, and Ad. R. Radut,a Phys. Rev. C 92, 044313 (2015)

Conclusion

- The experimental field of hypernuclei production is in accelerated expansion
- Several major issues: hyperon puzzle ; lifetime of $^{3}H_{\Lambda}$, charge symmetry breaking
- Observables are masses and spectra. Needs for hypernuclear structure models
- Future of reactions: nuclei+exotic nuclei ; Λ+n scattering

Key questions (personal opinion)

1) What is the behavior of (muti)strange light nuclei ?

2) Impact of strangeness on exoticity ?

1) -High precision measurements (large rigidity spectrometer, AGATA-like devoted setup)
   -Theoretical description of hyperon-nucleons interactions (including 3 BF)

2) -Exotic nuclei with hyperons
   -Hypernuclear structure models at same level of accuracy than the nuclear one