EXOTIC NUCLEAR PHYSICS: FROM COLD FUSION TO ANTIKAONIC NUCLEAR CLUSTERS

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One of the more controversial recent issues in Hadronic and Nuclear Physics is the possible existence of the so-called AntiKaonic Nuclear Clusters (AKNC). They are strange (S=-1, -2) nuclear systems composed by nucleons strongly bound to one or two AntiKaons: This topic is connected with the possible existence of exotic nucleon bound states like pp or ppp, with the possibility that a high-density nuclear medium will be created around the AntiKaon, that could l seed for the understanding of the dense nuclear matter in the neutron stars.
In 2002 Akaishi and Yamazaki (1) predicted the appearance of discrete, narrow bound states of Kbar in few-body nuclear systems. The search for such systems started quite soon with non-dedicated experiments at Laboratories of KEK (Japan), Frascati (Italy) , CERN (Switzerland). Saclay (France)
The results are somehow contradictory concerning the statistical significance of the reported pe interpreted as the signature of the existence of AKNC, not exceeding 5 sigmas, as well as the va of the Binding Energies and Widths (2). Also from the theoretical point of view several authors argue strongly against the possible existence of such systems.
A few dedicated experiments were approved with the aim of ascertaining the existence of AKN and will give the first results by next year.
The situation is somehow reminiscent of the first beginning of Cold Fusion (conflicting experimental results, conflicting theoretical approaches). Similarities and differences will be discussed in the talk, in particular concerning the acceptance by the physicist' s community..

1) Y. Akaishi and T. Yamazaki, Phys. Rev. C65 (2002), 044005
2) T. Bressani, Nuclear Physics News Int. 17, No.3 (2007), 11

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SUMMARY

1 . Introduction

2. The case of Antikaonic Nuclear Clusters (AKNC's)

3. Experimental results with K^-

4. Experimental results with $\bar{p}$

5. Conflicting conclusions

6. Similarities and differences between the Cold Fusion and
   AKNC's scientific cases

1. Introduction

- Very active with my Group on experiments in Cold Fusion (gas loading, neutron and ^4He detection) from 1989 to 1998

- Attended all ICCF from 1 to 7 (organized ICCF2)

- Activity stopped in 1999, mainly for not enough personal expertise in Condensed Matter Physics (I was always and I am a nuclear/particle physicist). Difficulty also in obtaining positions for young reasearchers

- Never denied the reality of Cold Fusion (for scientific case, not applications)

2. The case of Antikaonic Nuclear Clusters (AKNC's)

- Starting point: the interaction $\bar{K}$-N in the I=0 channel is strongly attractive at threshold

1986 – S. Wychech – NPA 450 (1986), 399c

1997 – T. Waas, M. Rho e W. Weise,- NPA 617 (1997), 449

2000 – A.Ramos ed E. Oset, NPA 671 (2000), 401

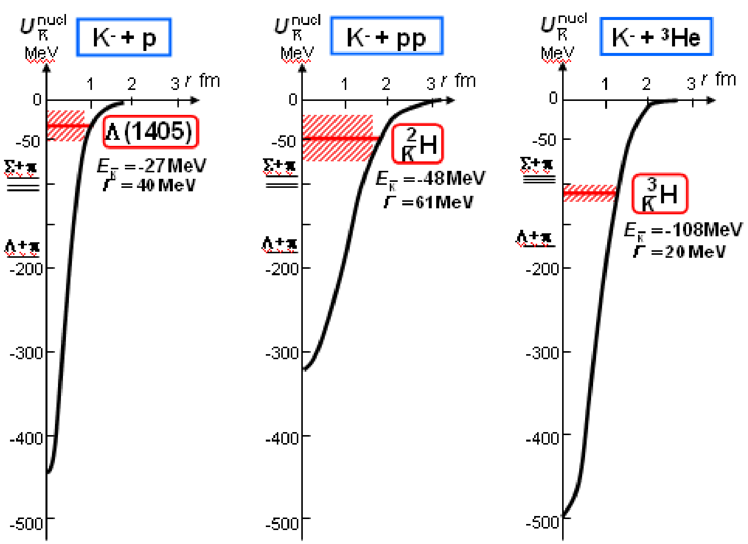
- Different theoretical approaches but similar conclusions: B.E. ~20 ÷100 MeV

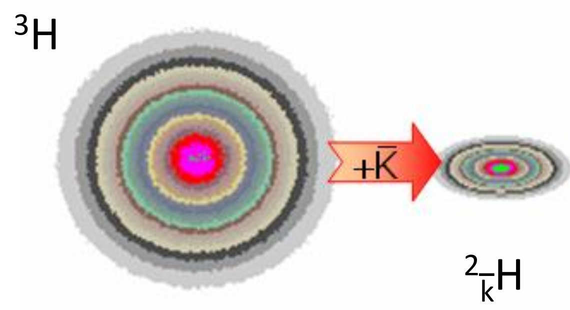
but large Γ (100 MeV). Experimentally non interesting.

The start-up of the story:

2002 – Y. Akaishi e T. Yamazaki (recently involved in CF too!!), PRC 65 (2002), 0044005

B.E. 100 ÷200 MeV but small Γ (20 ÷30 MeV)

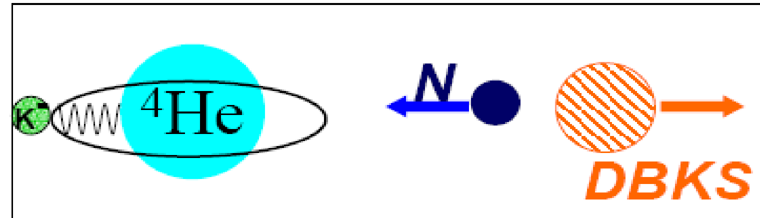




Trigger of the experiments but also of theoretical confutations

3. Experimental results with K$^-$

Triumphant title of the paper: “Discovery of…”

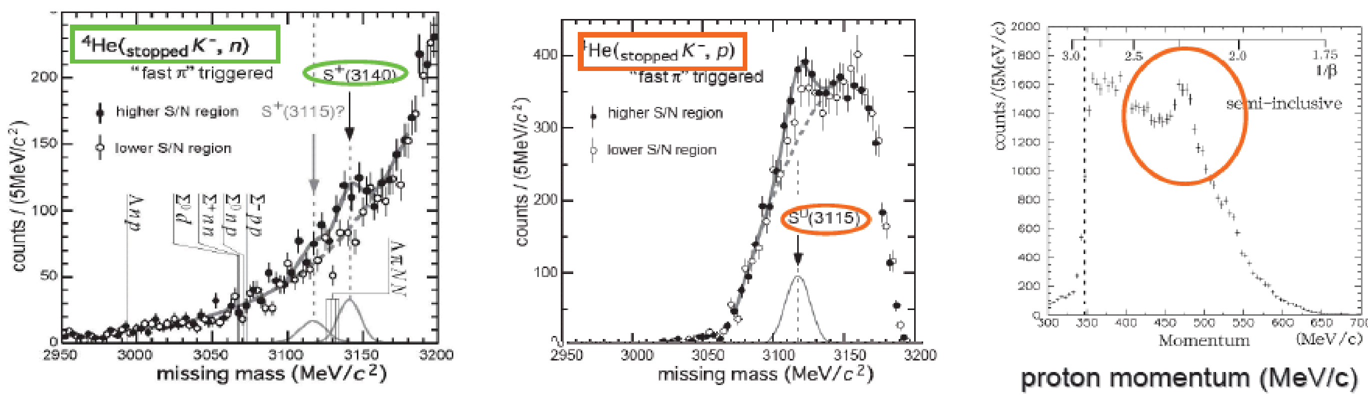


KEK, AGS, FINUDA

First Observation By Missing Mass

KEK-PS E471 *miss. mass method*
Suzuki et al, Phys. Lett. B597 (2004) 263

KEK-PS E471 *miss. mass method*,
Suzuki et al, NPA 754 (2005) 375

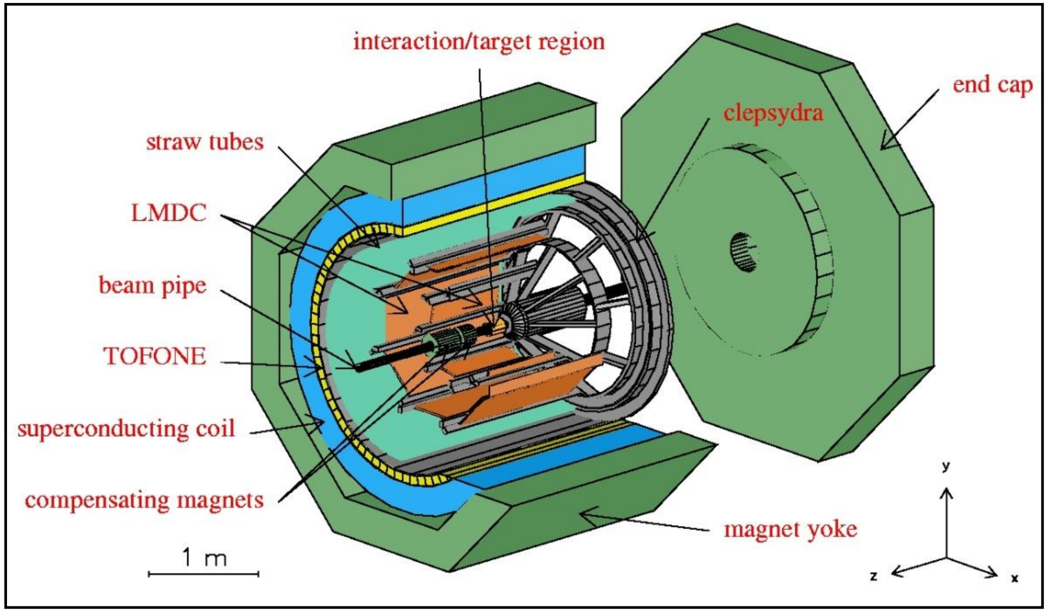


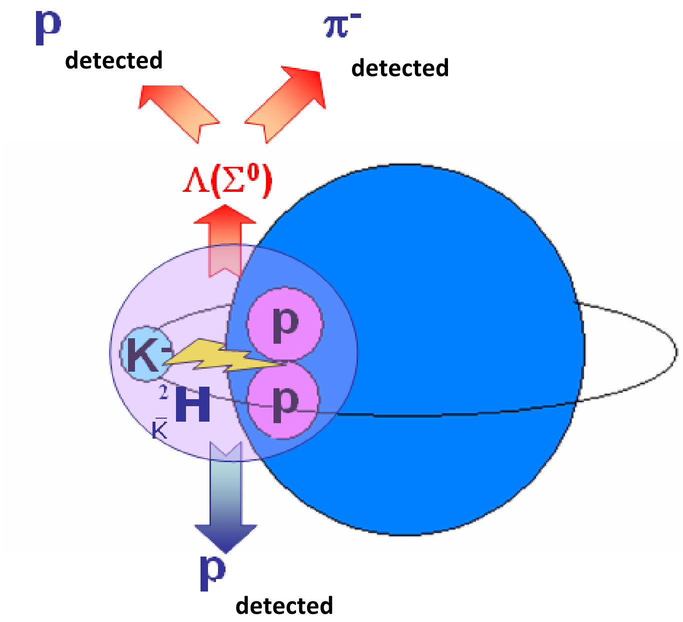
Remarks from an experimentalist:
Dedicated experiment; stopped K$^-$, LHe target, good neutron detector, scarce π^- momentum identification (light release in scintillators)

Unexpected result (proton peak around 500 MeV/c) – momentum measured by TOF
Narrow width<21 MeV → resemblance with AY prediction, but not exactly

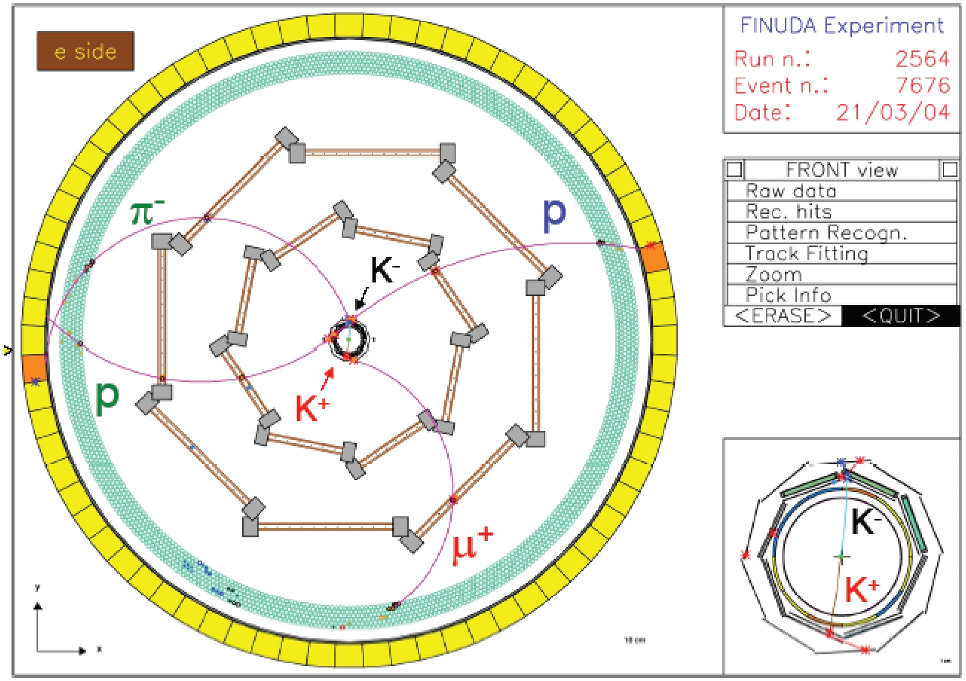
NOTE:
only dedicated experiment

Observation with experiments on Invariant Mass (Λ-p) system

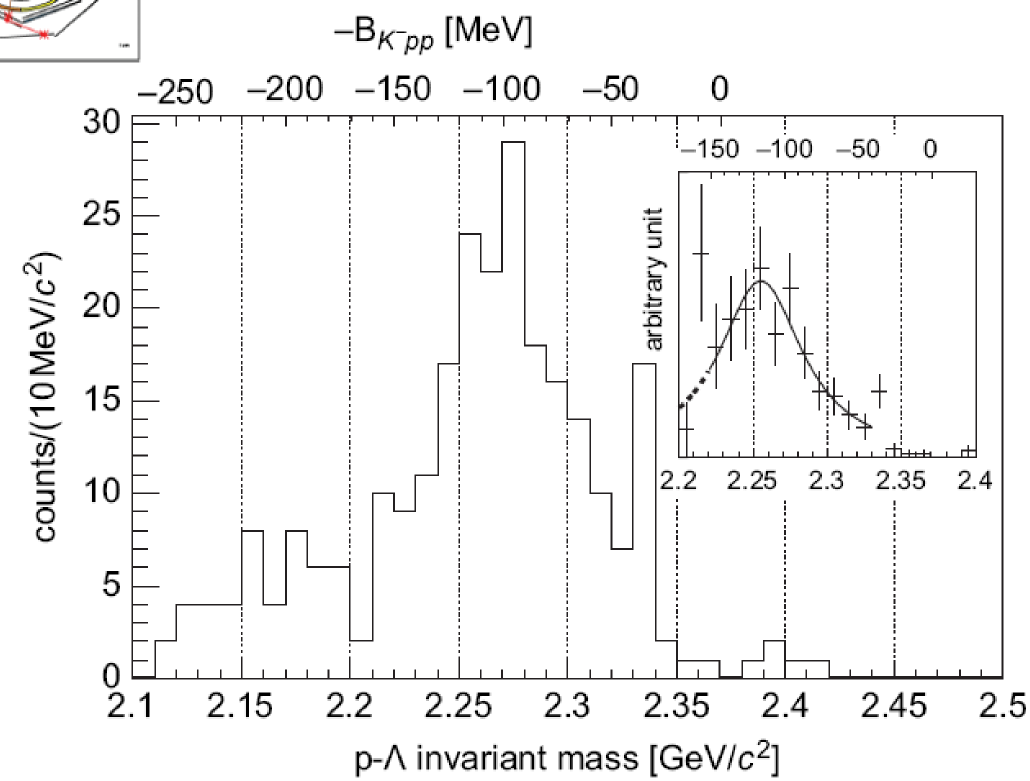




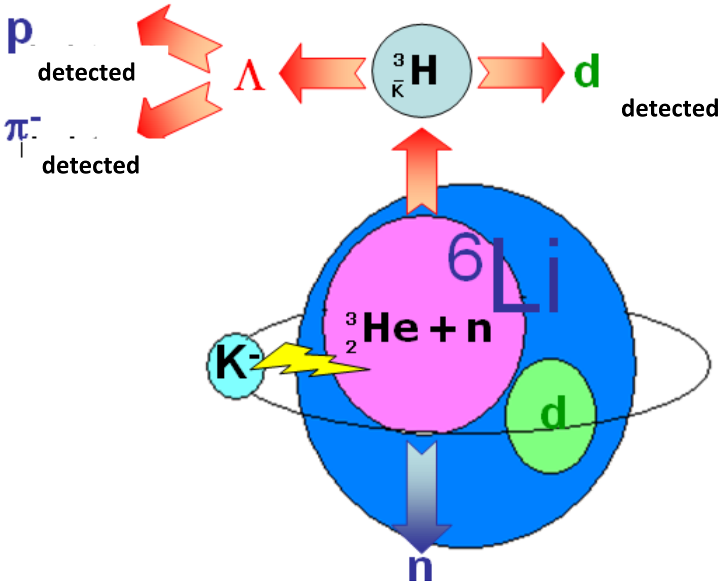
Not dedicated experiment

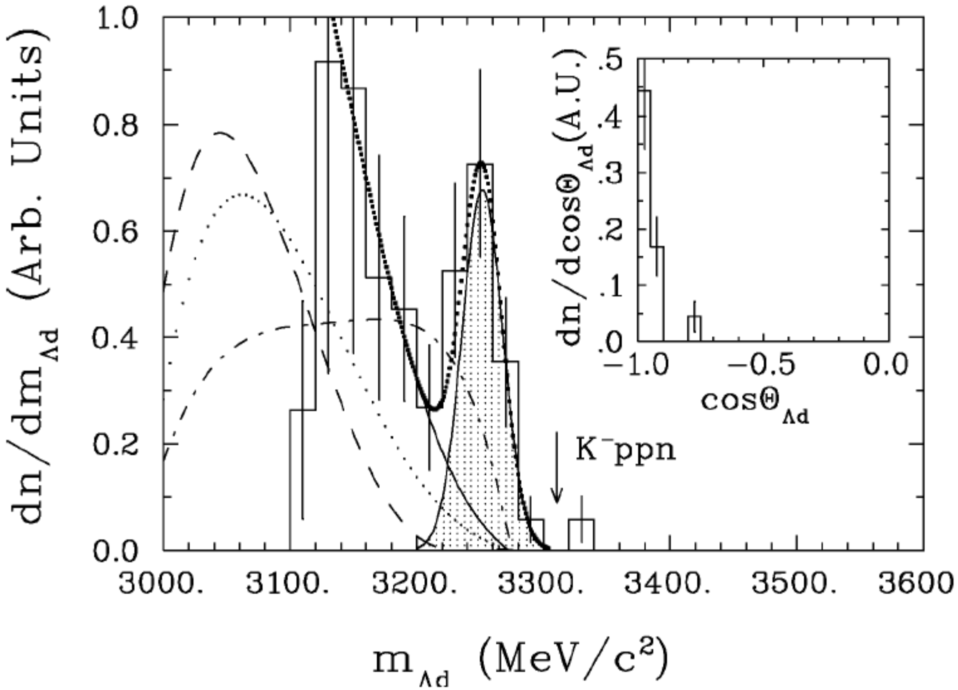


FINUDA Coll., PRL 94(2005)212303



(Λ-d) system

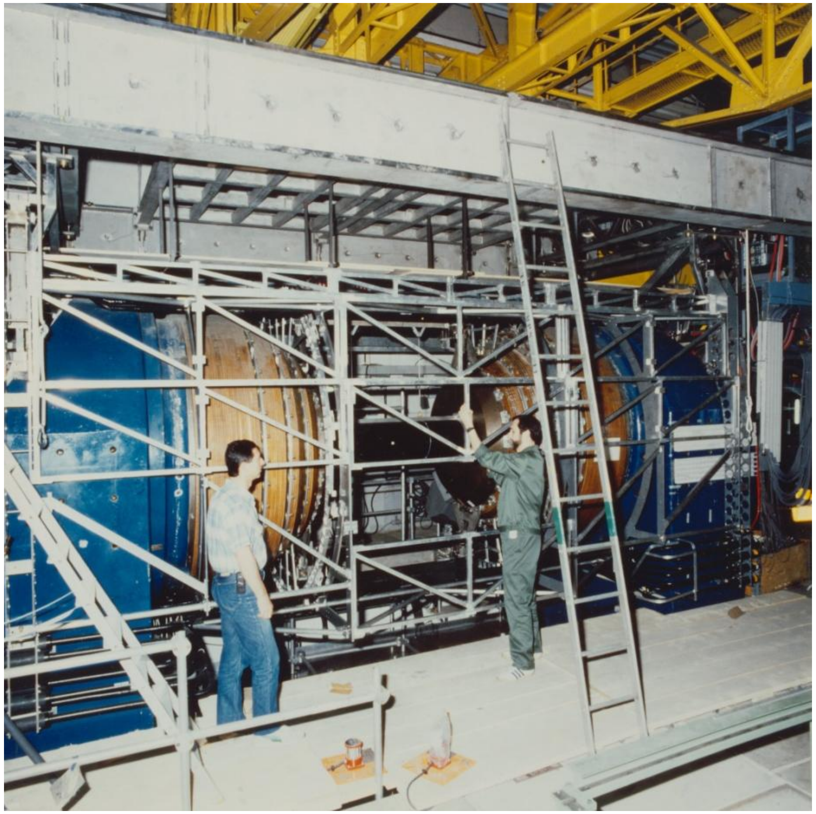




B= -58 ± 6 MeV   Γ = 36.5 ± 14.1 MeV

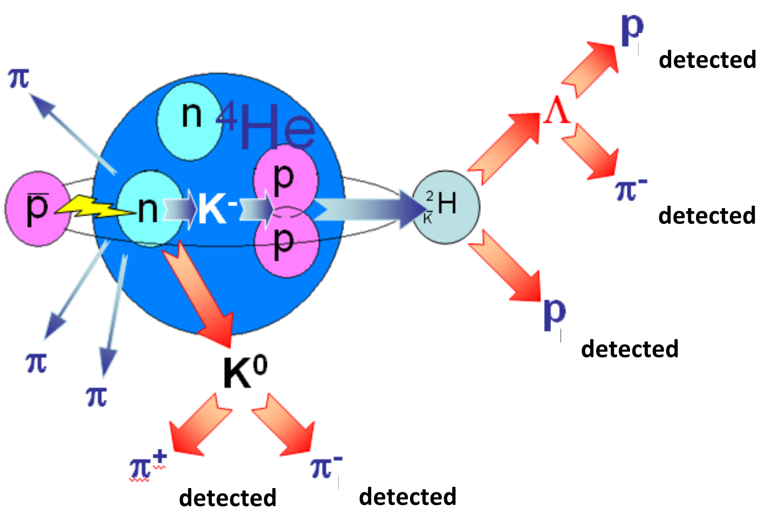
FINUDA Coll., PLB 654 (2007), 80

4. Experimental results with $\bar{p}$

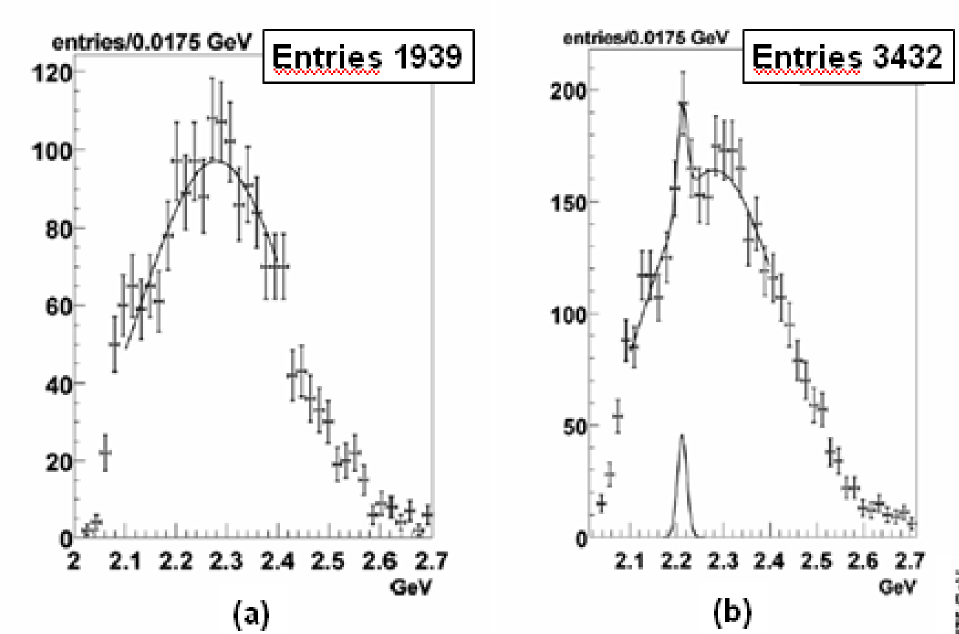


OBELIX

M.I. Λ-p

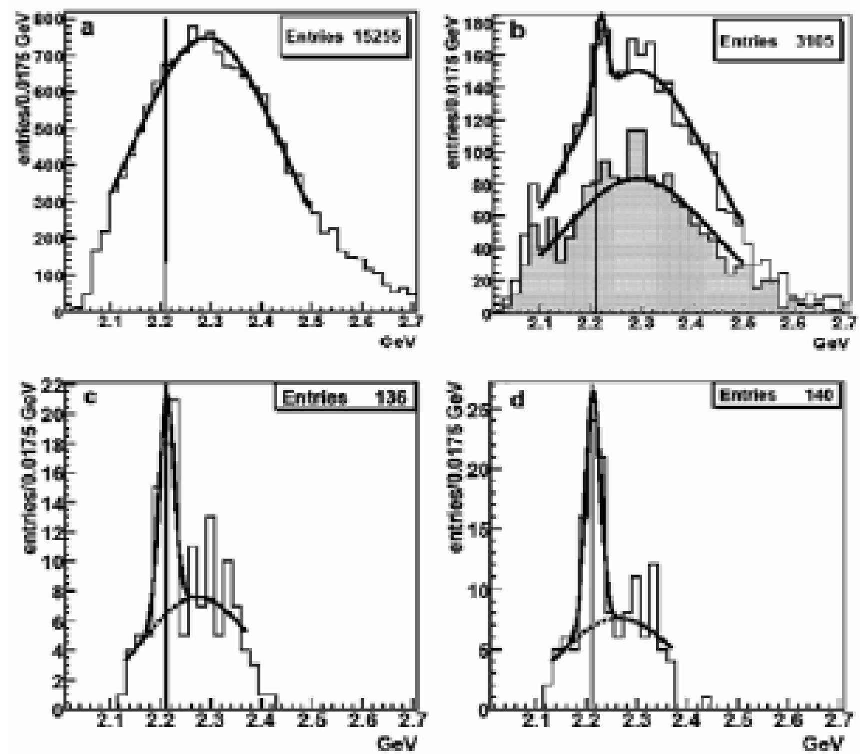


Not dedicated experiment



Statistical Sign. =3.0 σ

G. Bendiscioli, T. Bressani et al., NPA 789 (2007), 222

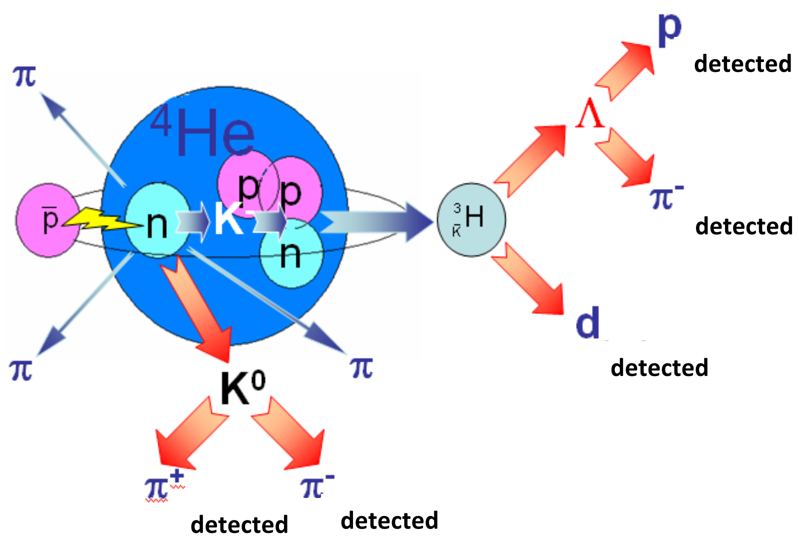


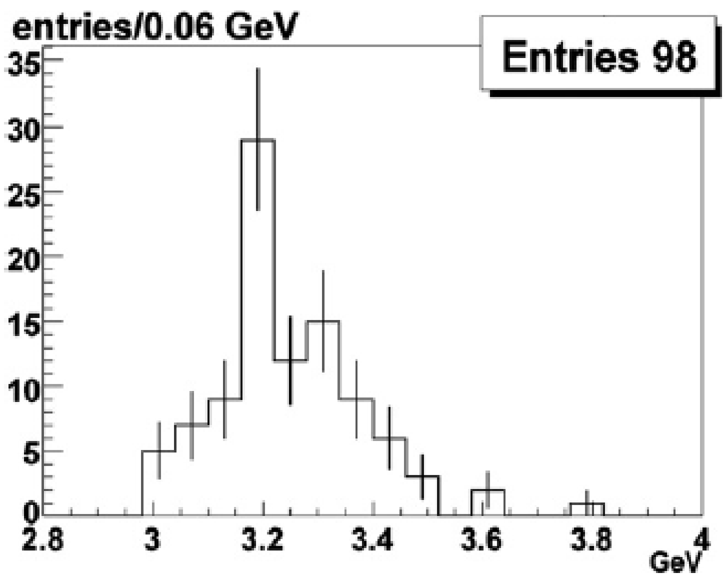
Statistical Sign. =4.7 σ

Final Result: -151.0± 3.2(stat.) ±1.2 (sist)

G. Bendiscioli, T. Bressani et al.,EPJ A 40 (2009) 100878

Invariant Mass (Λ-d)





Statistical Sign. = 2.6 σ

Final Result: B=-121.0± 15

Γ< 60 MeV

5. Conflicting Results

We compare the results reported in experiments with k^- at rest (FINUDA) with those with $\bar{p}$ (OBELIX)

Binding energies and widths:

		B(MeV)	Γ(MeV)	Ref.
${}^{2}_{k}$H (k^-pp)	K^- at rest	- 115 9	- 67 15	PRL 94 (2005),212303
	$\bar{p}$ at rest	- 151.9 3.2±1.2(sist.)	<39.4 6.2	EPJ A 40 (2009),100878
	Theory	- 48	61	Phys. Rev.C 65 (2002), 044005
${}^{3}_{k}$H (k^-ppn)	K^- at rest	- 58 6	-36.6 14.1	PLB 654 (2007),80
	$\bar{p}$ at rest	- 121 15	<60	Phys. Rev.C 65 (2002), 044005
	Theory	- 108	20	PLB 535 (2002),70

Even worse concerning the capture rates

Some other results by non-dedicated experiment (DISTO) also not in agreement

Other dedicated experiments approved and ready to run

E15 → J-PARC K^- in flight → I.M.+M.M.

FOPI :→ GSI $pp \to pK^+\Lambda$ → I.M.+M.M.

Ratio of the theo./exp. published papers > 10

6. Similarities and differences between the Cold Fusion and AKNC's scientific case

	C.F.	AKNC
Applications	*****	*
Impact on media	*****	*
Scientific interest	*****	****
Acceptance by theoreticians	*	****
Acceptance by experimetalist	**	*****
Papers on Physics journals	*	*****
Financement by Public Agencies	*	*****
Positions for young reaserchers	*	***
Interest by students	*****	***

Hope that in a (near) future C.F. physicists will again be part of the broad Nuclear Physicists community