"Physics of the Deuteron"

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Research Foci:

Structure of Protons, Pions, Neutrons -

- **Polarizabilities of proton and neutron**

  $\vec{p},\vec{d}\,(\vec{\gamma},\gamma')$ **HI$\vec{\gamma}$S** **(New?)**

- **Threshold production of π^0's**

  $p(\vec{e},e'p)\pi^0$ **JLAB** **(KC)**

- **Structure and dynamics of ^{3}He**

  $^3\overrightarrow{He}(\vec{e},e'd)p$ **JLAB** **(GJ*)**

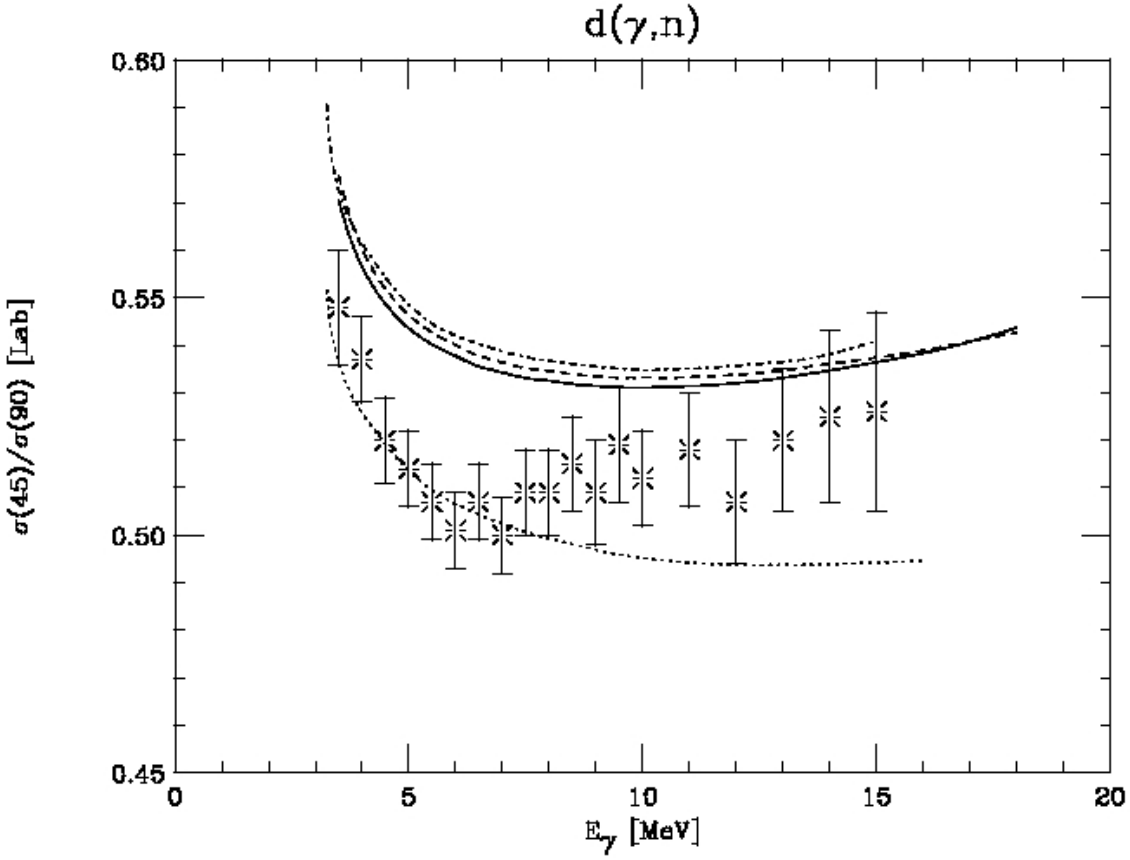
Properties of the Deuteron

In 1934 J. Chadwick and M. Goldhaber stated, "Heavy hydrogen was chosen as the first to be examined, because the diplon has a small mass defect and also because it is the simplest of all nuclear systems and its properties are as important in nuclear theory as the hydrogen atom is in atomic theory."

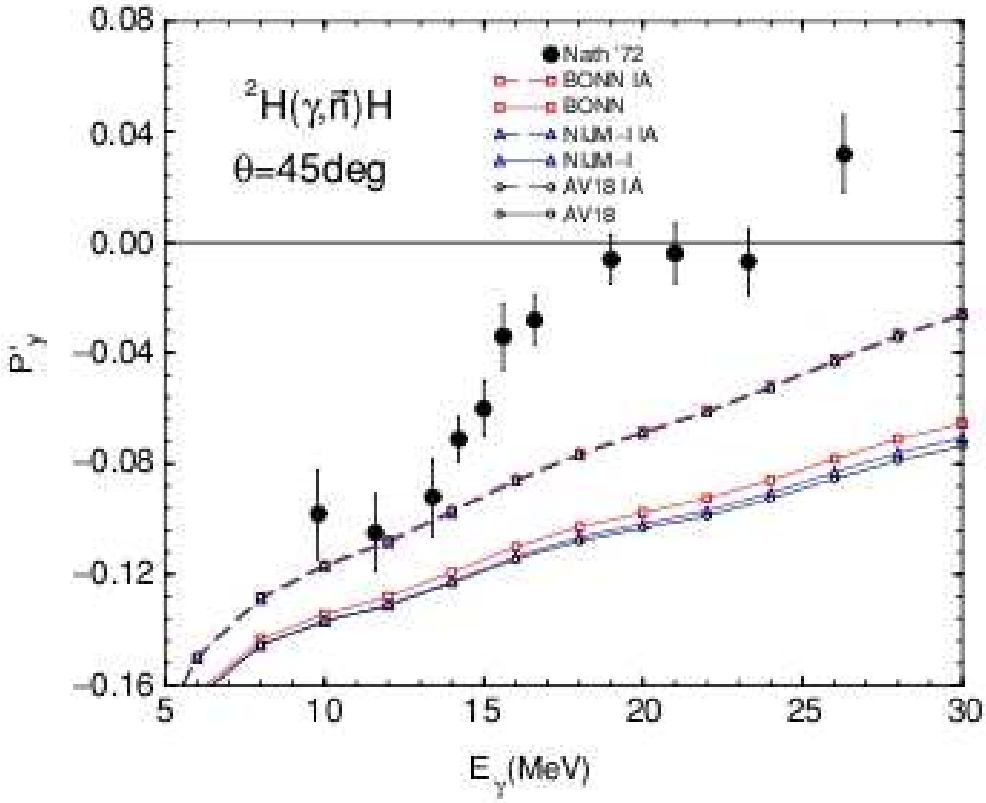
- **Simplest system**
- **First step in nucleosynthesis**

Great amount of work over last 70^{+} years!

Serious problems exist –



Neutron polarization –



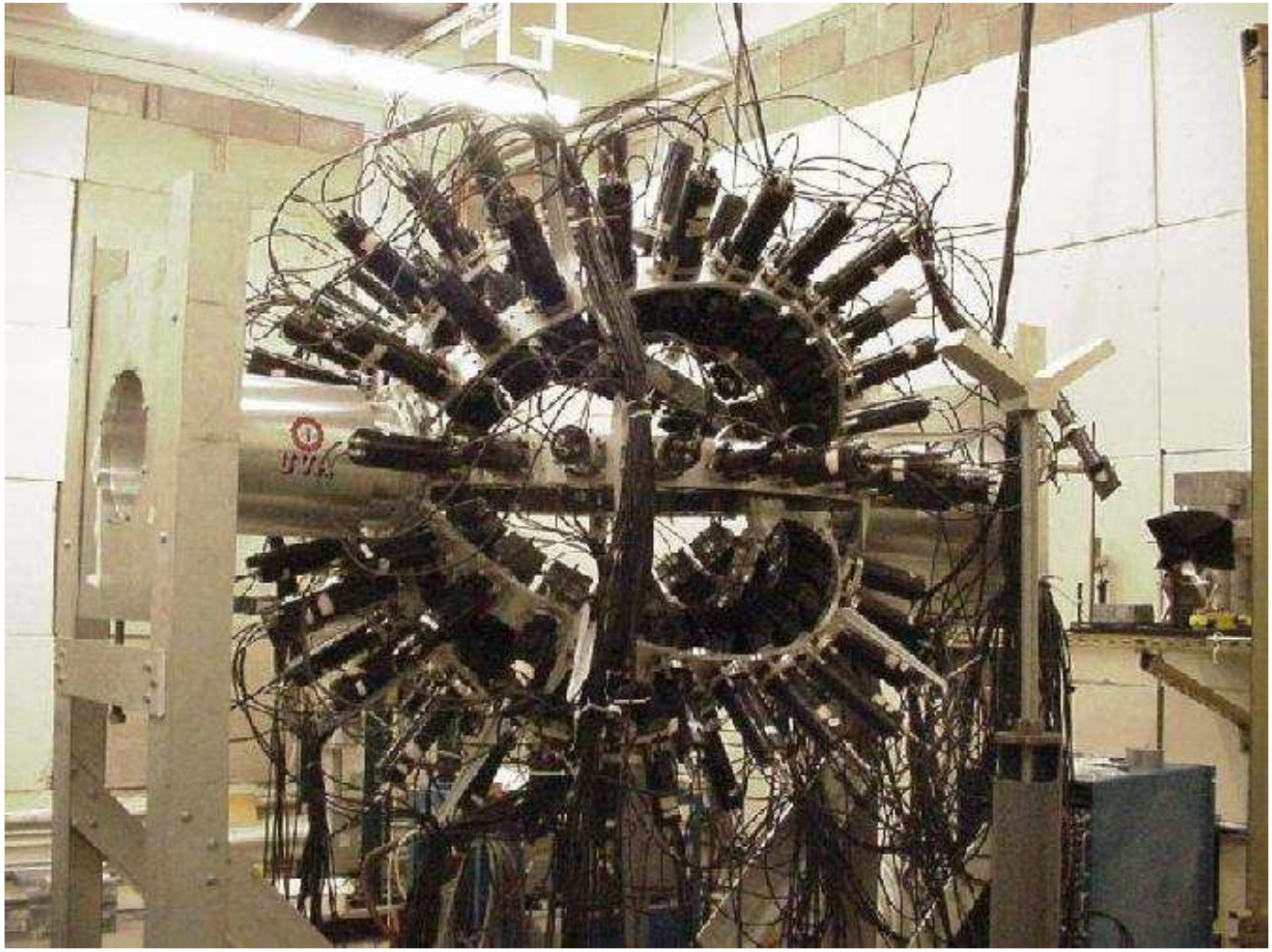
Theories give same results, independent of approach:
→ data wrong or input to theory wrong

Deuteron Photodisintegration at HI$\vec{\gamma}$S

Original Goal: test fundamental Gerasimov-Drell-Hearn (GDH) Sum Rule

- built large solid angle detector

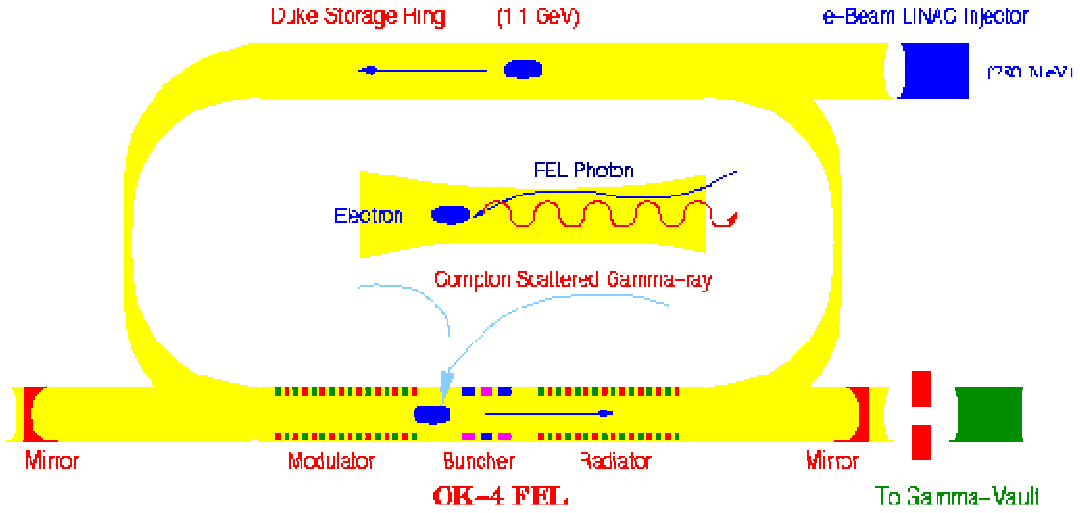
- building (with D. Crabb) polarized target



Blowfish Detector

Polarized H and d Target

Duke Free Electron Laser Laboratory



HI$\vec{\gamma}$S Schematic

Threshold d Electrodisintegration

Calculations include many several effects:

- **Potential**
- **Meson exchange**
- **Excited nucleons (Δ's)**
- **Relativistic effects**

Can be isolated when deuteron just given enough energy to break up via

$d\left(\vec{e},e'\,p\right)n$ **JLAB, Hall A (2011)**

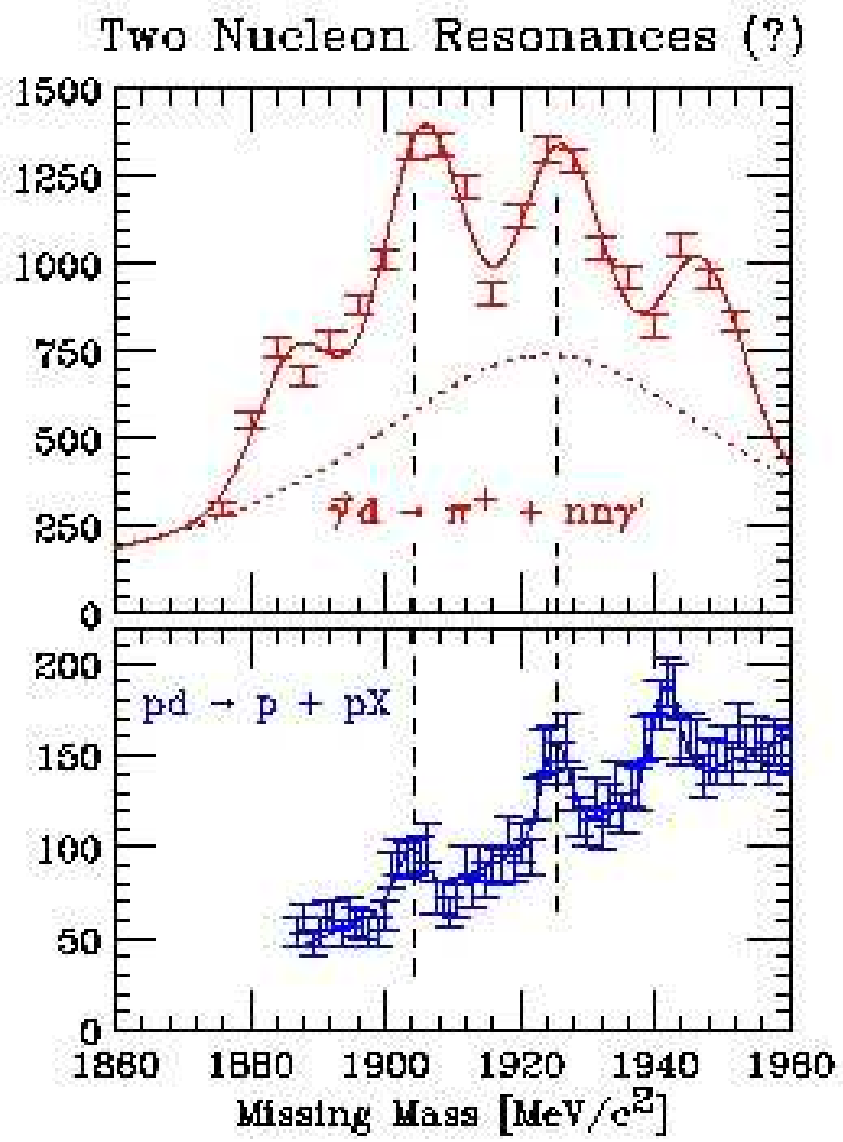
Dibaryon Search at JLAB

- current understanding of NN force gives one NN bound state – deuteron
- other bound or quasi-bound states have been searched for for > 20 years
- come and go
- recent evidence from MMF and LEGS

Energy levels:

E = 1878 MeV (2n)
= 1887 MeV
= 1906 MeV
= 1926 MeV
= 1947(?) MeV

$$\Delta E_n = \left(n + 1/2\right)\hbar\omega!$$



Inputs to Theory of Deuteron

- **Binding energy** √
- **Magnetic moment** √
- **Size of deuteron** √

- **n-p phase shifts and scattering lengths (characterize n-p potential)**

But haven't these been measured long ago?

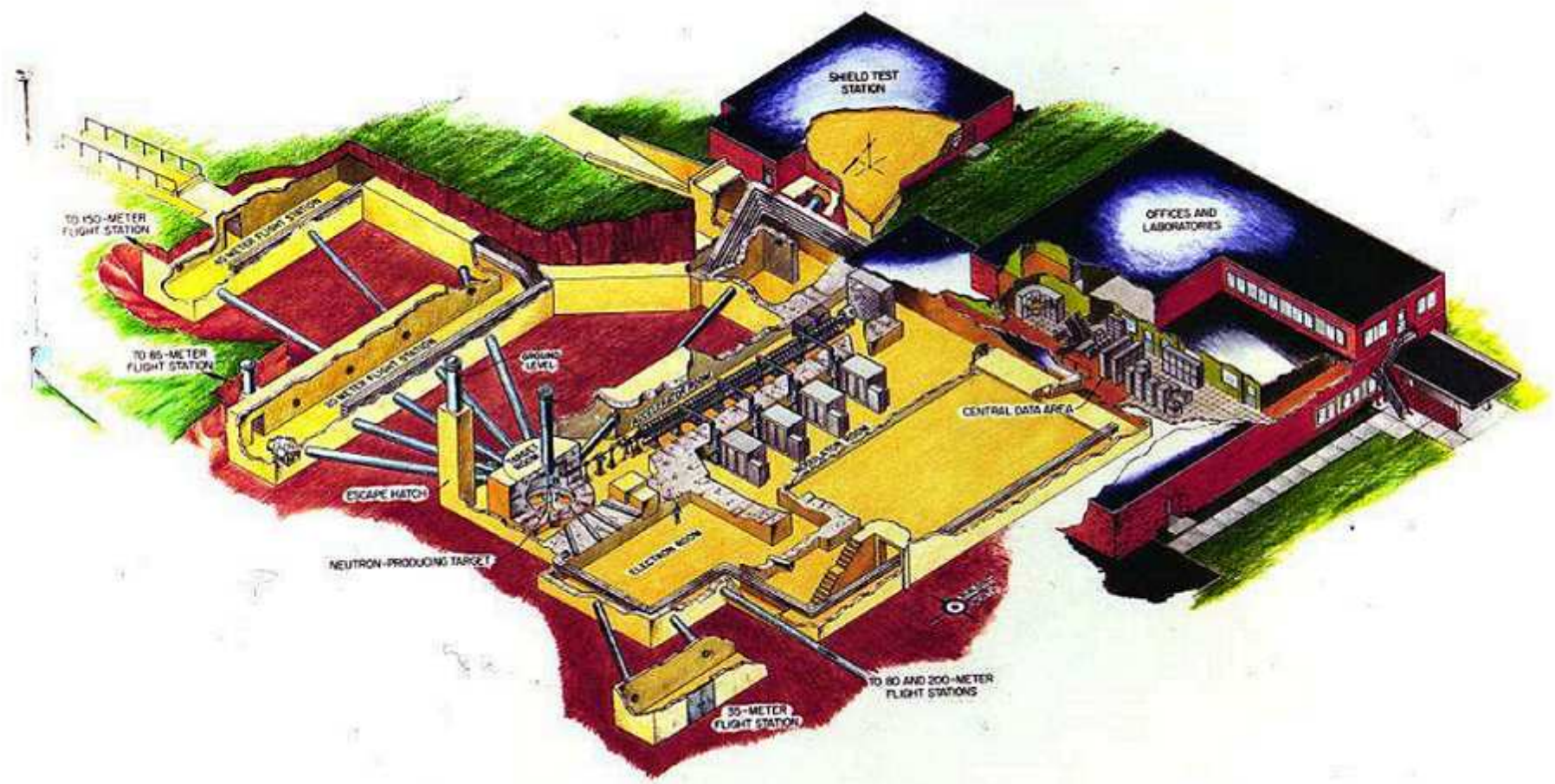
Yes! Last measurements of angular distributions (from which we get multipole composition of the interaction) in 1971!!

Accurate detection of neutrons, especially low energy neutrons notoriously difficult. Much progress in last 36 years.

Time to remeasure with modern precision:

- **points to solution of several discrepancies in understanding of MANY few-body systems, not just the deuteron**

- **understanding of NN interaction critical to fission and fusion reactors (AFC)**



Oak Ridge Electron Linear Accelerator (ORELA)

Research Talk - August 28, 2009

Structure and dynamics of ^{2}H
- upcoming experiments

- $\overset{(\rightarrow)}{d}(\vec{\gamma},n)p$ HI$\vec{\gamma}$S (2010) (SK, New)
- $d(\vec{e},e'p)n$ JLAB (2011) (New)
- $d\left(\vec{e},e'\pi^+[\gamma']\right)nn;\quad e+d\rightarrow e'+\pi^++d^*$ (New?)

$$\downarrow$$

$$n+n+\gamma' \quad \text{(2010)}$$

Nucleon interactions

- $p(n,n)p$ and $d(n,n)d$ ORELA(?) (New?)