The CLAS g14 HDIce experiment

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for the CLAS COLLABORATION

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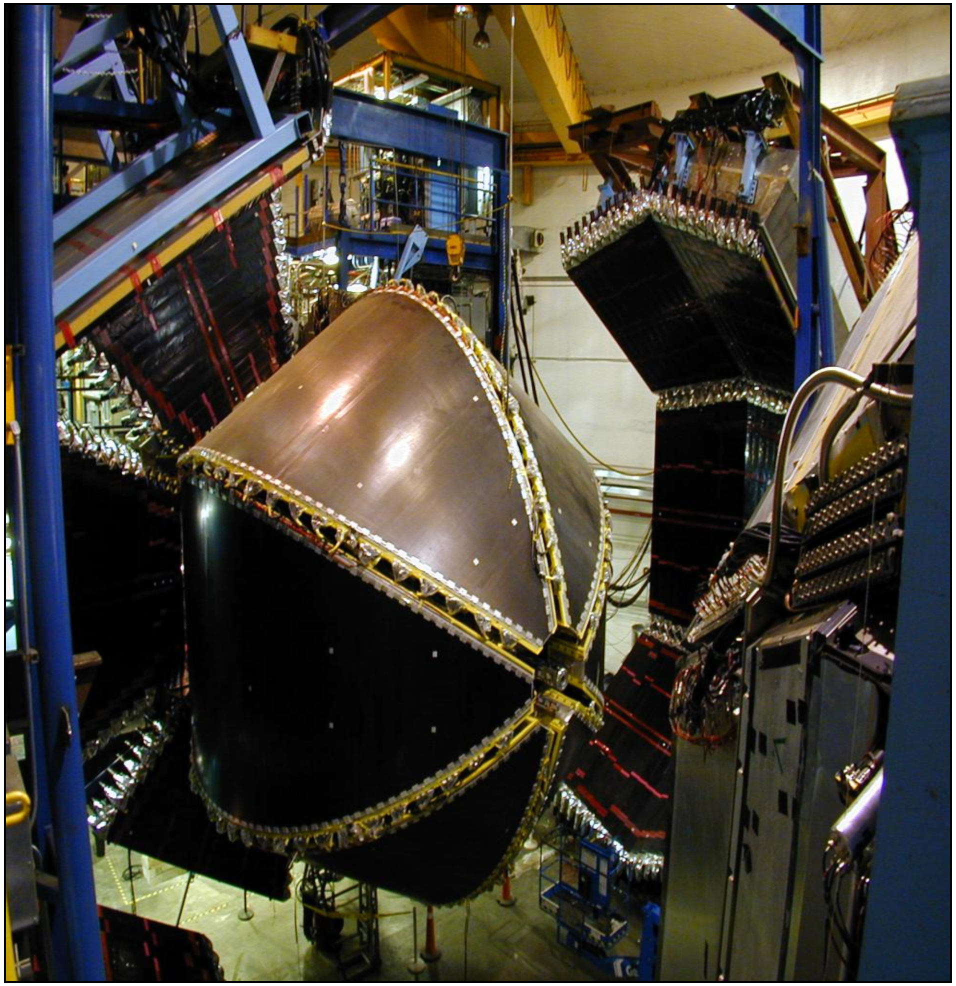
Outline

- Motivation: the N* spectrum
- Detail about g14 HDIce experiment
- E asymmetry for $\pi^- p$
- E asymmetry for $\pi^+\pi^- n$
- E asymmetry for $K^0\Lambda$
- Future Works

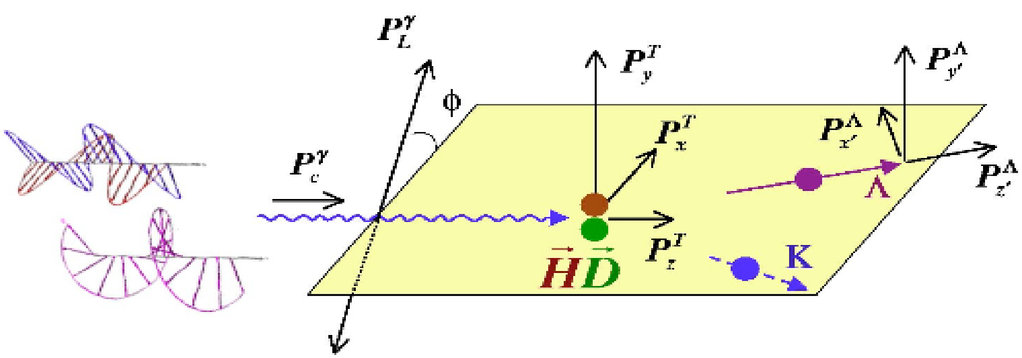


Motivation: 16 observables from **polarize neutron[1]**

→→→Need both p and n data to unravel the N* spectrum

Polarization observables in $J^\pi = 0^-$ meson photo-production : (SHKL, J Phys G38 (11) 053001)

Photon beam		Target			Recoil			Target - Recoil								
					x'	y'	z'	x'	x'	x'	y'	y'	y'	z'	z'	z'
		x	y	z				x	y	z	x	y	z	x	y	z
unpolarized	σ_U		T			P		$T_{x'}$		$L_{x'}$		Σ		$T_{z'}$		$L_{z'}$
$P_L^\gamma \sin(2\phi_\gamma)$		H		G	$O_{x'}$		$O_{z'}$		$C_{z'}$		E		F		$-C_{x'}$	
$P_L^\gamma \cos(2\phi_\gamma)$	$-\Sigma$		$-P$			$-T$		$-L_{z'}$		$T_{z'}$		$-\sigma_U$		$L_{x'}$		$-T_{x'}$
circular P_c^γ		F		$-E$	$C_{x'}$		$C_{z'}$		$-O_{z'}$		G		$-H$		$O_{x'}$	



16 different observables, each appearing twice:

- *single-pol observables can be measured from double-pol asy*
- *double-pol observables can be measured from triple-pol asy*

[1] Talk given by A. Sandorfi @ Messina Oct. 2012

Introduction: Why HD ?

- **Easily polarize** ortho-H_2 (symmetric spin state)
- Can't polarize para-H_2 (antisymmetric spin state)
- Decay time from ortho H_2 to para H_2 ≈ **6 days**
- **NOT practical**

- **Easily polarize** para-D_2 (S=1 and L=1)
- Very hard to polarize ortho-D_2 (S=0,2 and L=0)
- Decay time from para-D_2 to ortho-D_2 ≈ **18 days**
- **NOT practical**

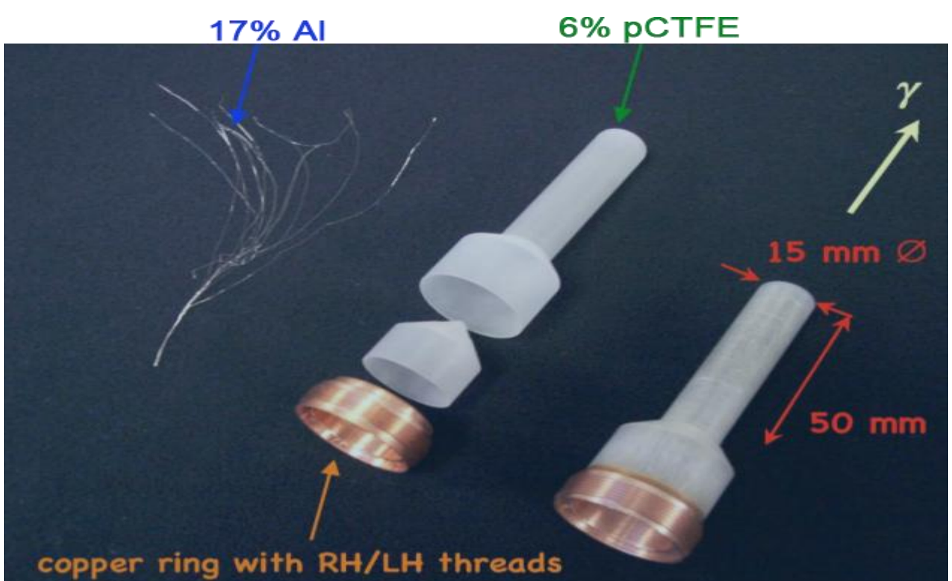
HD: **Extremely long relaxation time (years)**→direct polarization is impractical. **Using ortho-H_2 and para-D_2 to indirectly polarize the H, and the D in the H-D molecule[2].**

HD: **Provide both polarized neutron (D) and proton (H) target**

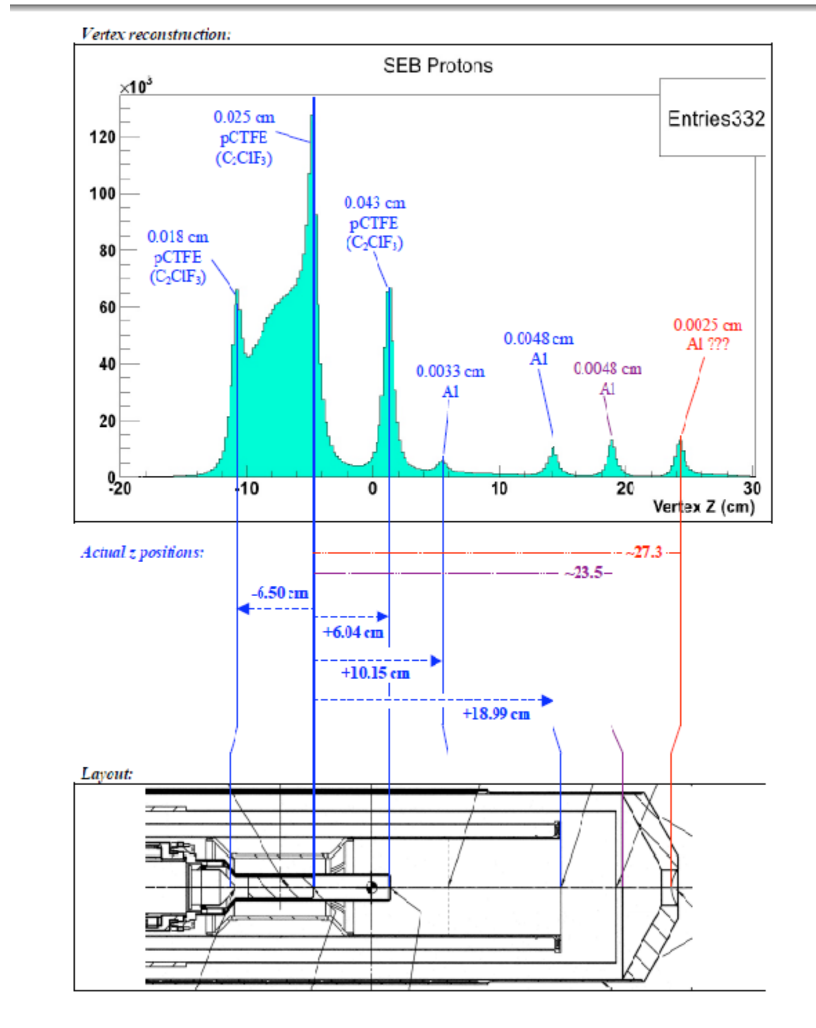
[2] A.Honig, Phy. Rev. Lett. 19 (1967)

g14 target in a nutshell

- Condense in **production dewar** (PD) and calibrate NMR.
- Polarize HD in **dilution refrigerator** (DF).
- After 3-6 months, measure polarization.
- Store polarized target in **storage dewar** (SD) to transfer to Hall B.
- Put target cell into **In-Beam Cryostat** (ICB).
- Run the beam and collect data.



Target cell and Al cooling wires



z vertex of target and IBC

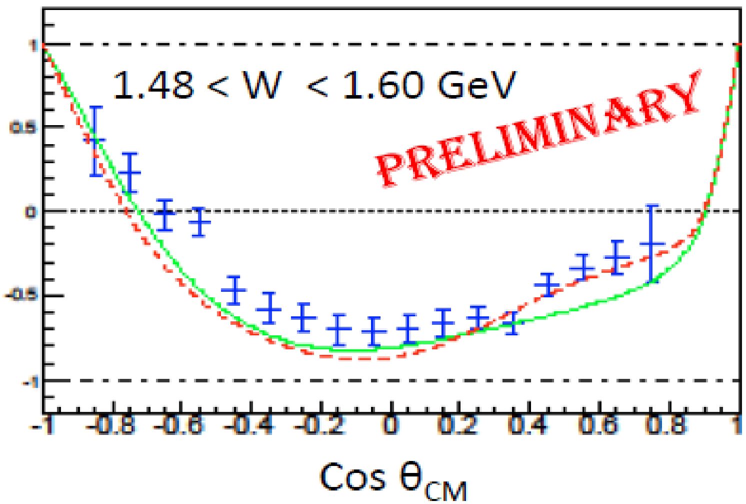
$\vec{\gamma}\vec{n}(p_s) \rightarrow \pi^- p\ (p_s)$*

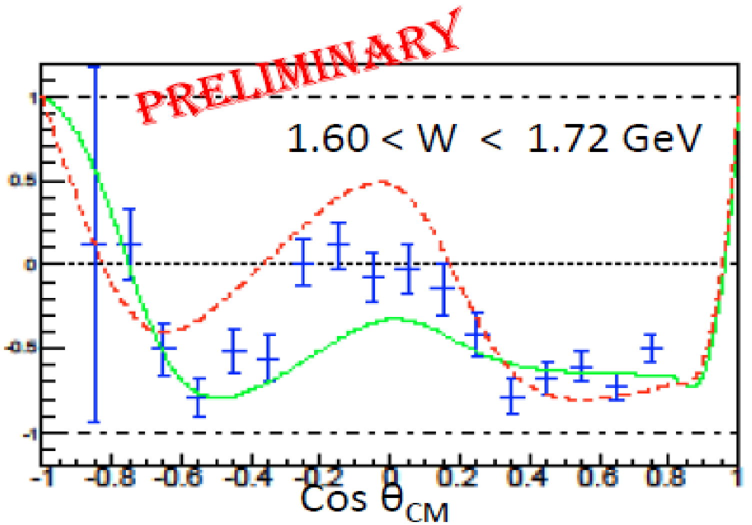
Preliminary E asymmetries for $\gamma + n\,(p) \rightarrow \pi^- + p$

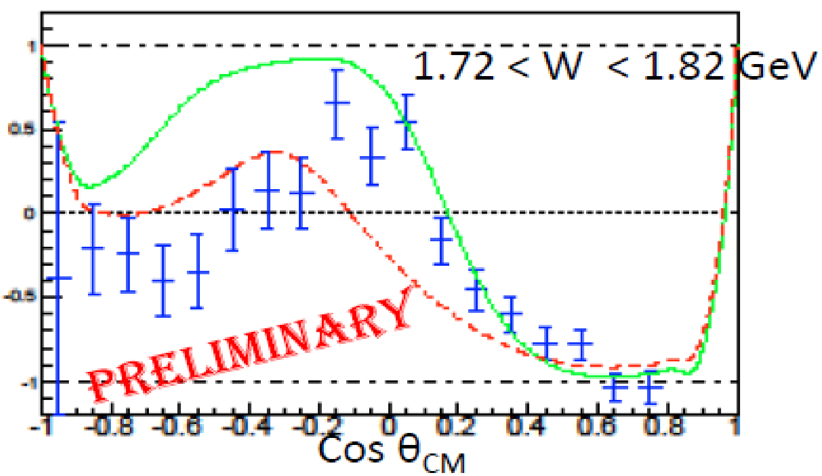
$$E = p_{target}\, p_{\gamma} \left[\frac{Y_{\rightarrow\leftarrow} - Y_{\leftarrow\leftarrow}}{Y_{\rightarrow\leftarrow} + Y_{\leftarrow\leftarrow}} \right]$$

SAID----------

MAID---------

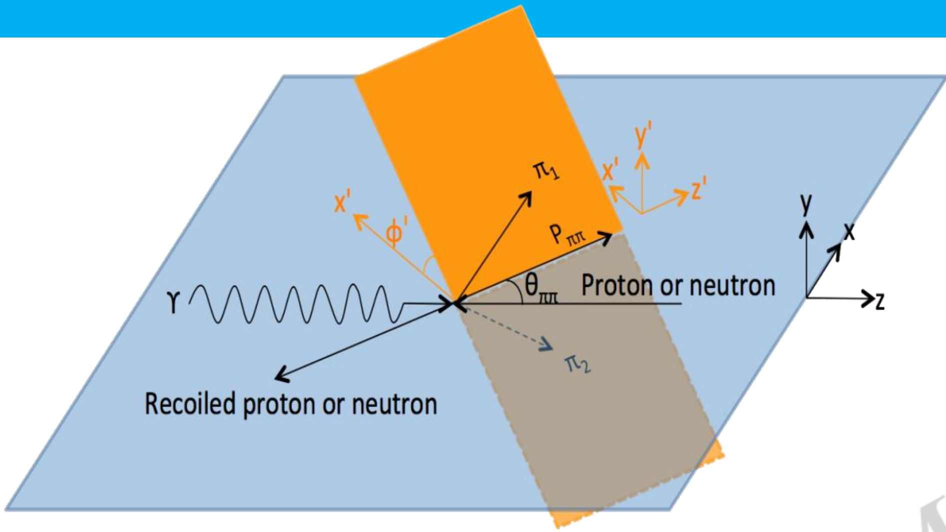




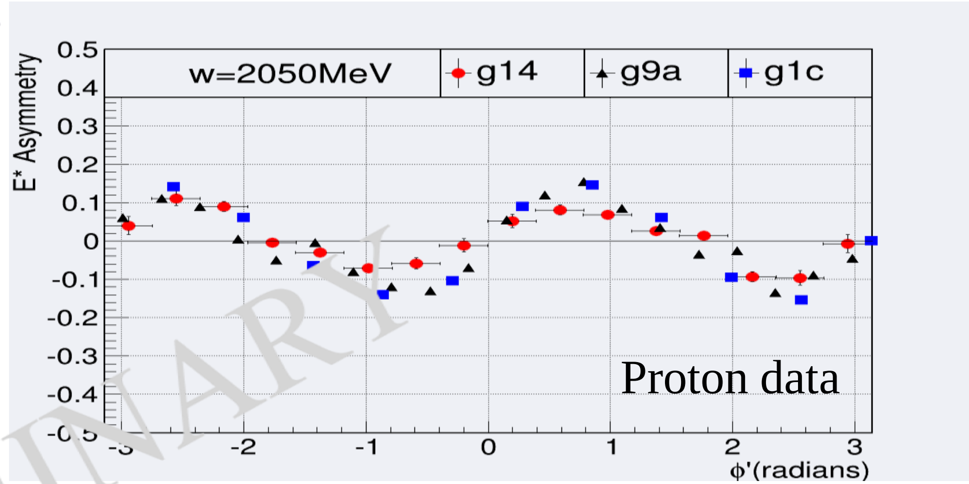


*Analyzed by T. Kageya using g14 data, presented @NSTAR 2013

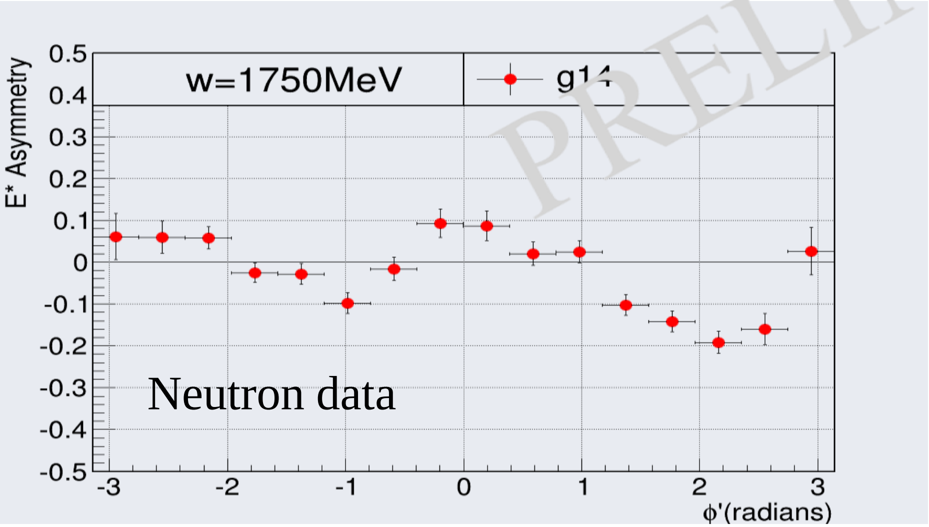
$\vec{\gamma}\vec{p}(n_s) \rightarrow \pi^+ \pi^- p\ (n_s)$ and $\vec{\gamma}\vec{n}(p_s) \rightarrow \pi^+ \pi^- n\ (p_s)$*

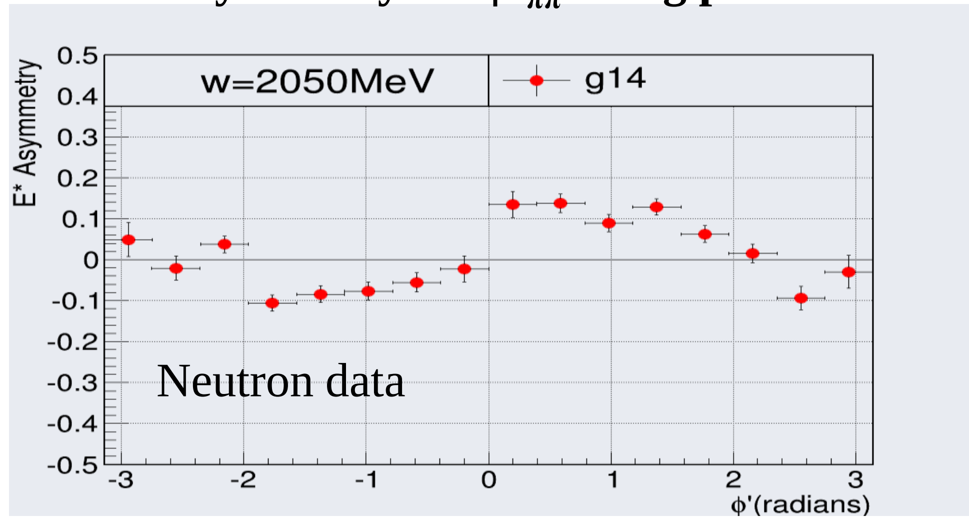


Double pion photoproduction kinematics



E asymmetry vs. $\phi'_{\pi\pi}$ using proton data





E asymmetry vs. $\phi'_{\pi\pi}$ using neutron data

*Analyzed by P. Peng using g14 data, presented @MeNu 2013

$\vec{\gamma}\vec{n}(p_s) \rightarrow K^0\Lambda \rightarrow \pi^+ \pi^- p\, \pi^-(p_s)$

Analysis task:

- Select correct PID: $\pi^+\pi^- p\pi^-$
- Pick the correct pair, i.e., which π^- go with p
- Using Boosted Decision Trees algorithm[3]:

→Remove events from target walls and Al cooling wires

→Reject 4-body phase space background

- Loosely reject $K^0\Sigma^0$ and select $K^0\Lambda$ events
- Compute the E asymmetry for $K^0\Lambda$ reaction

[3] TMVA- *Toolkit for Multivariate Data Analysis*, arXiv:physics/0703039

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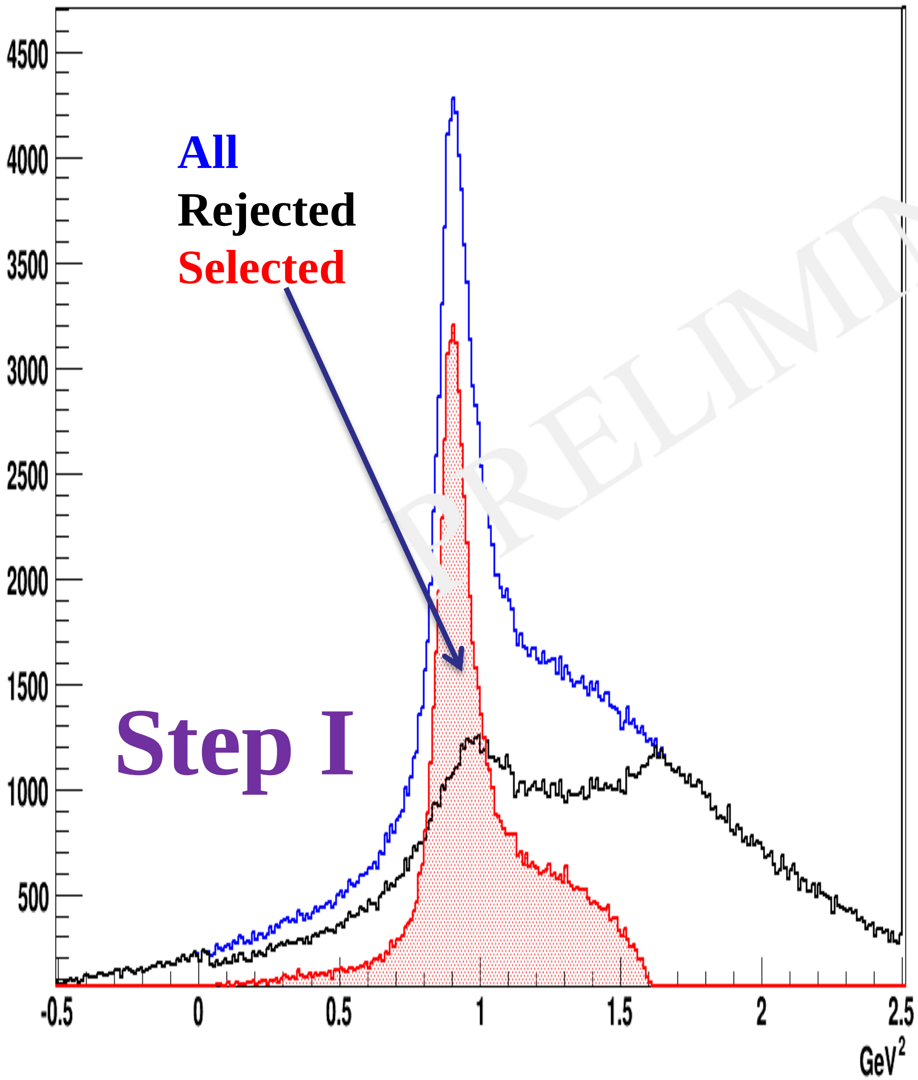
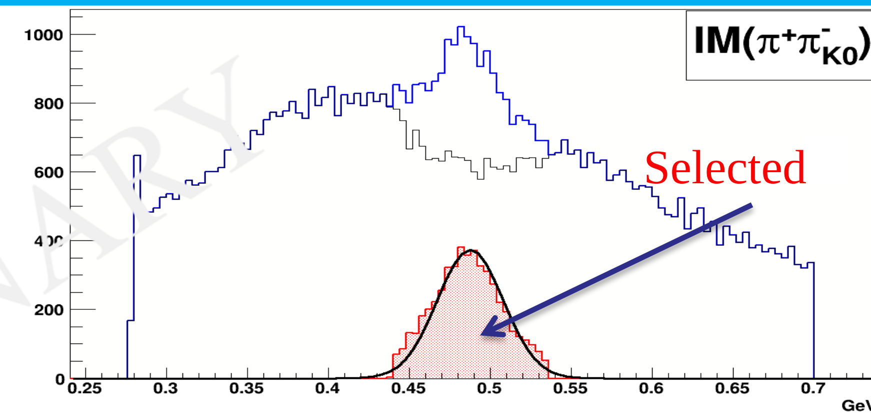
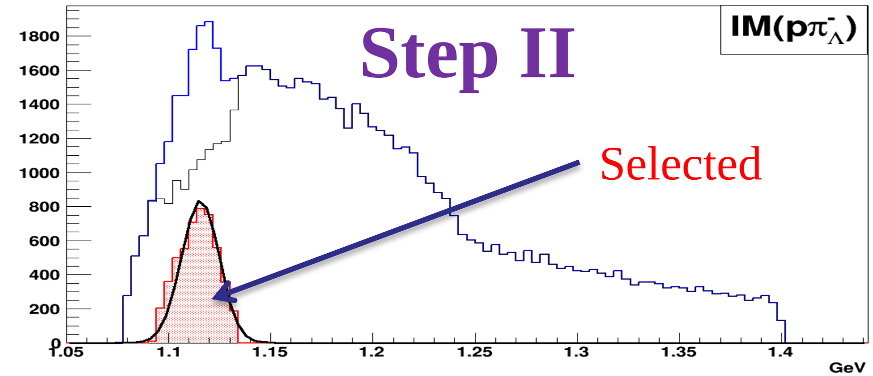
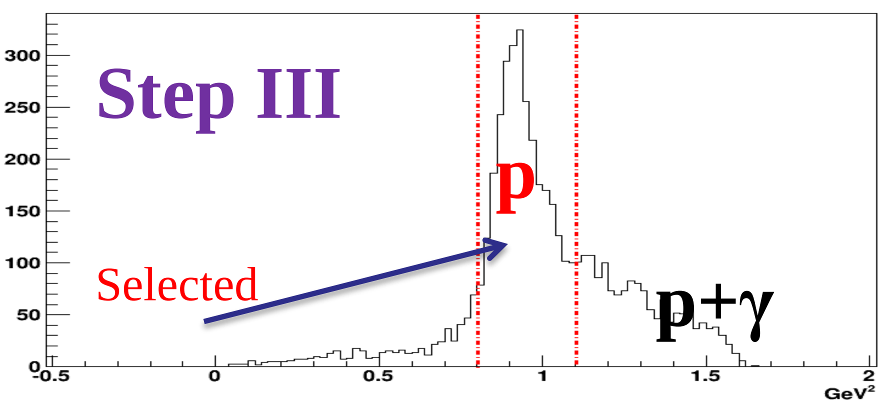


Squared Spectator Mass

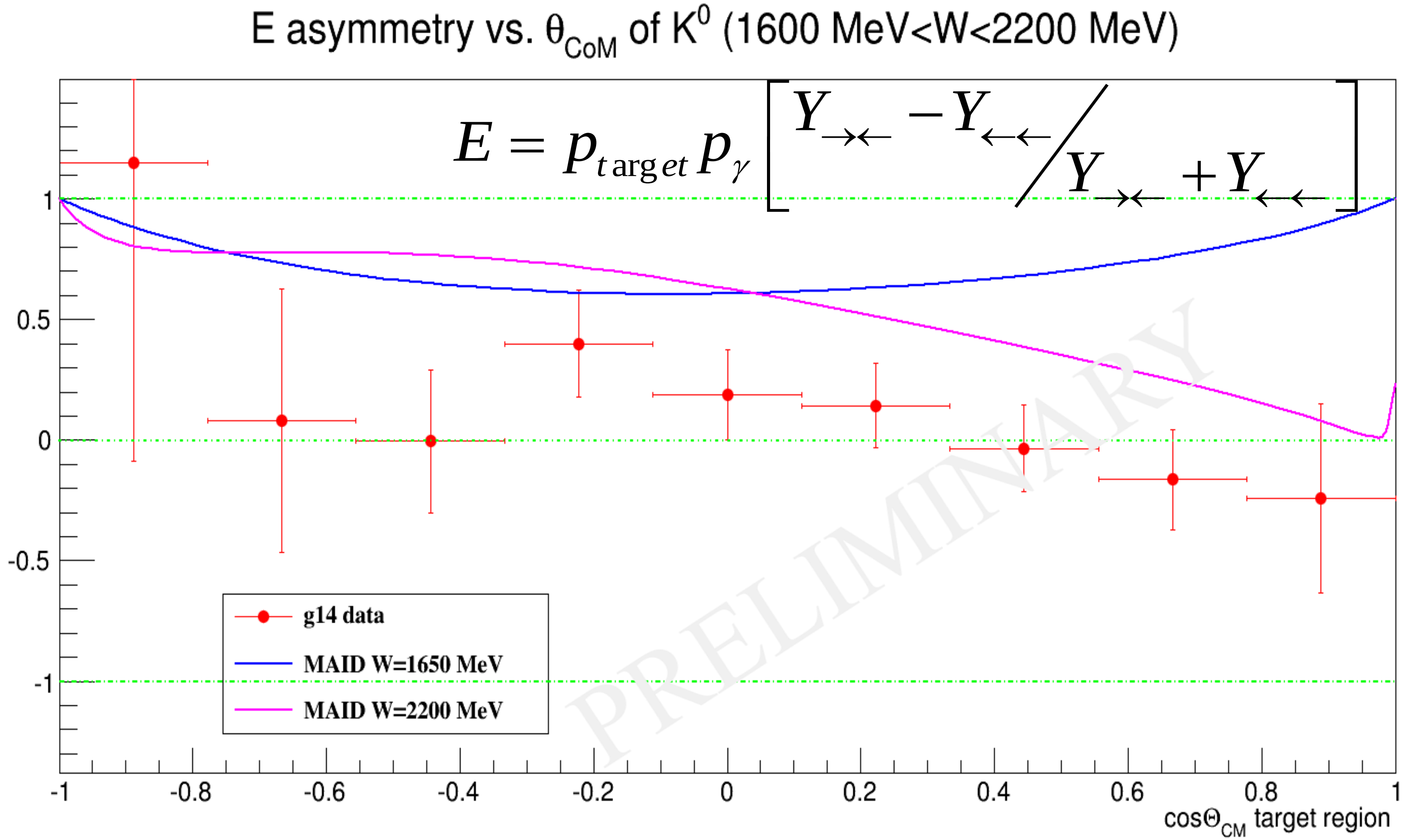






Squared Spectator Mass **after selecting $K^0\Lambda$**

$\vec{\gamma}\vec{n}(p_s) \rightarrow K^0\Lambda(p_s) \rightarrow \pi^+ \pi^- p\, \pi^-(p_s)$



After selecting $K^0\Lambda$ (rejecting possible $K^0\Sigma^0$) events

Conclusion/Future Plans:

- Measurements on a low background polarized neutron target.
- Promising preliminary results for E asymmetry measurements of $K^0\Lambda$, $\pi^- p$, $\pi^+\pi^- n$ channels.

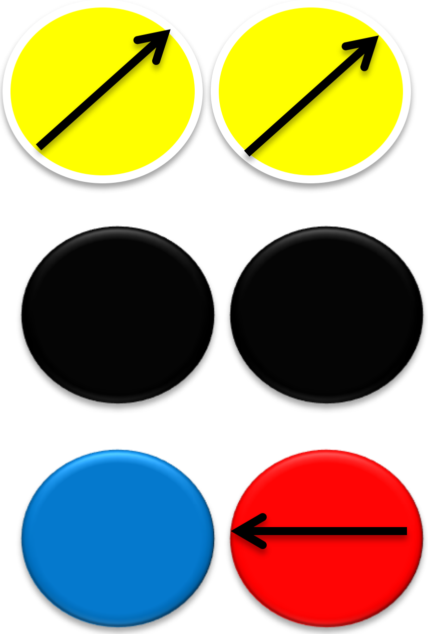
- Calibration, energy and momentum correction.
- Improve Monte Carlo simulation for g14 setting.
- Improve analysis results (uncertainty study).
- Work on other channels or other asymmetry measurements.

BACK UP SLIDES

Cartoonish illustration: Polarizing H in HD

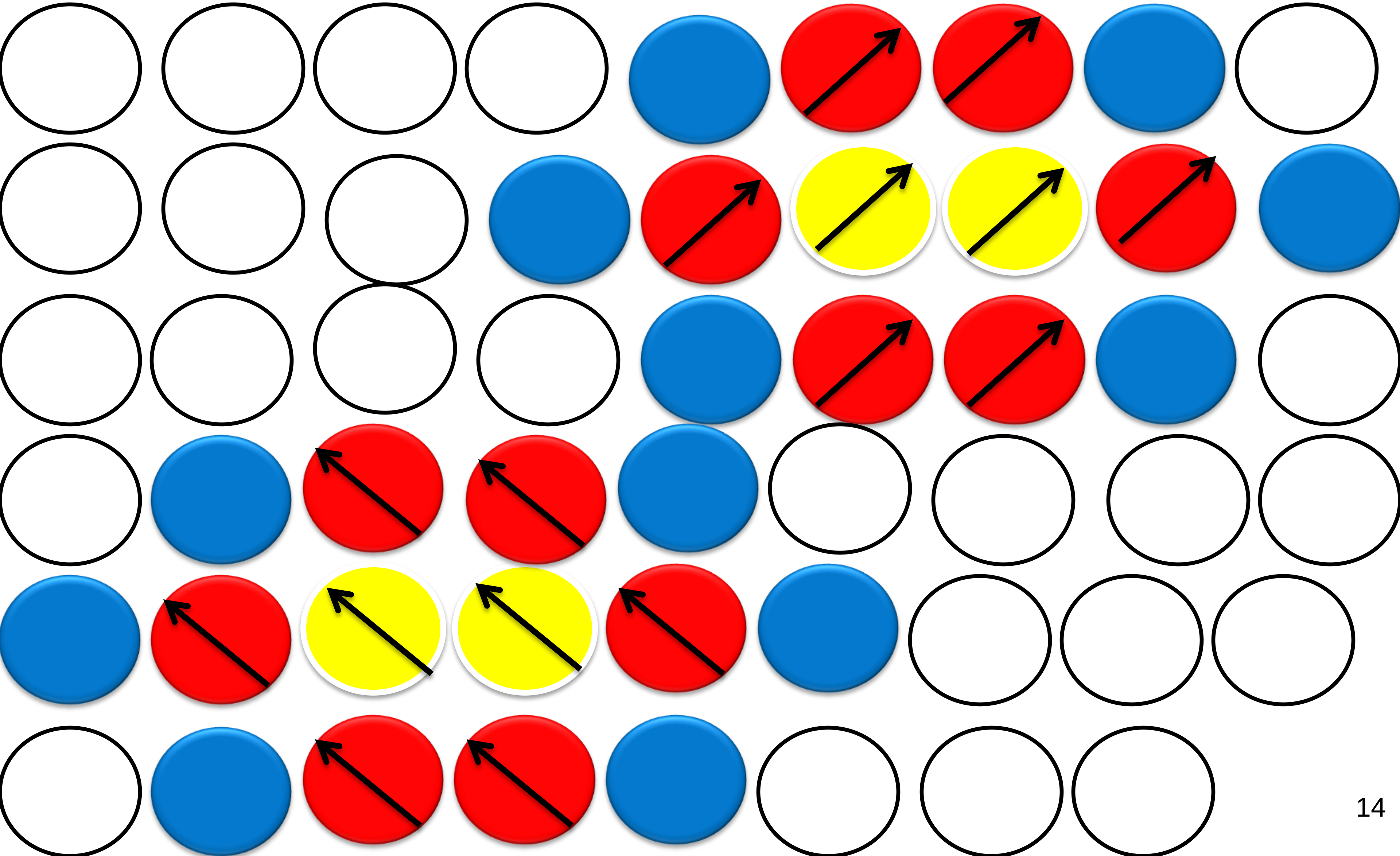
NOTATIONS:

- **Poralizable H_2 (I=1, J=1)**, χ_s symmetric.
- Ground-state H_2 (I=0, J=0), χ_s antisymmetric.
- HD molecule.

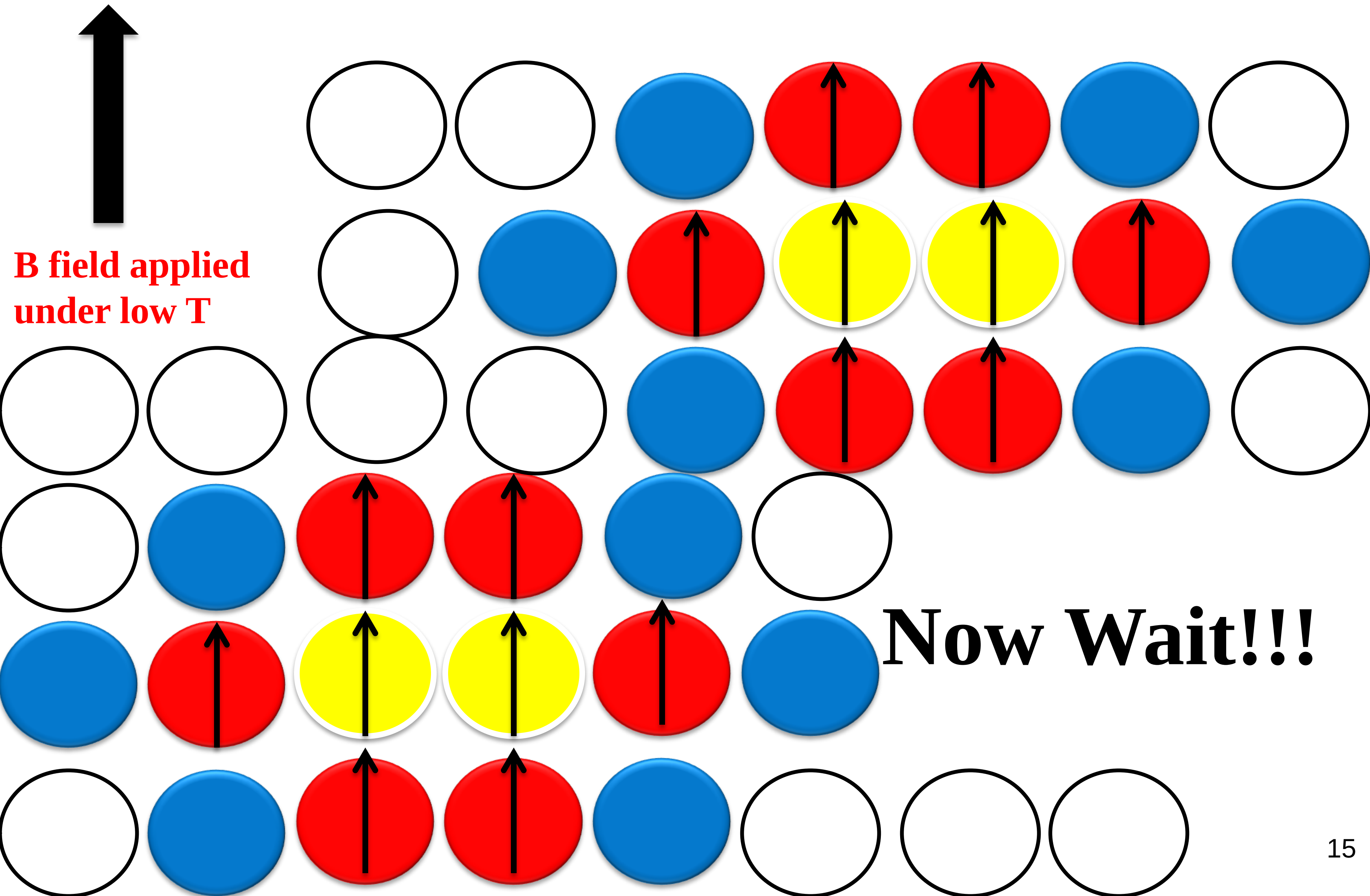


- Small amount of H_2 to help polarize the H.
- Small amount of D_2 to help polarize the D.

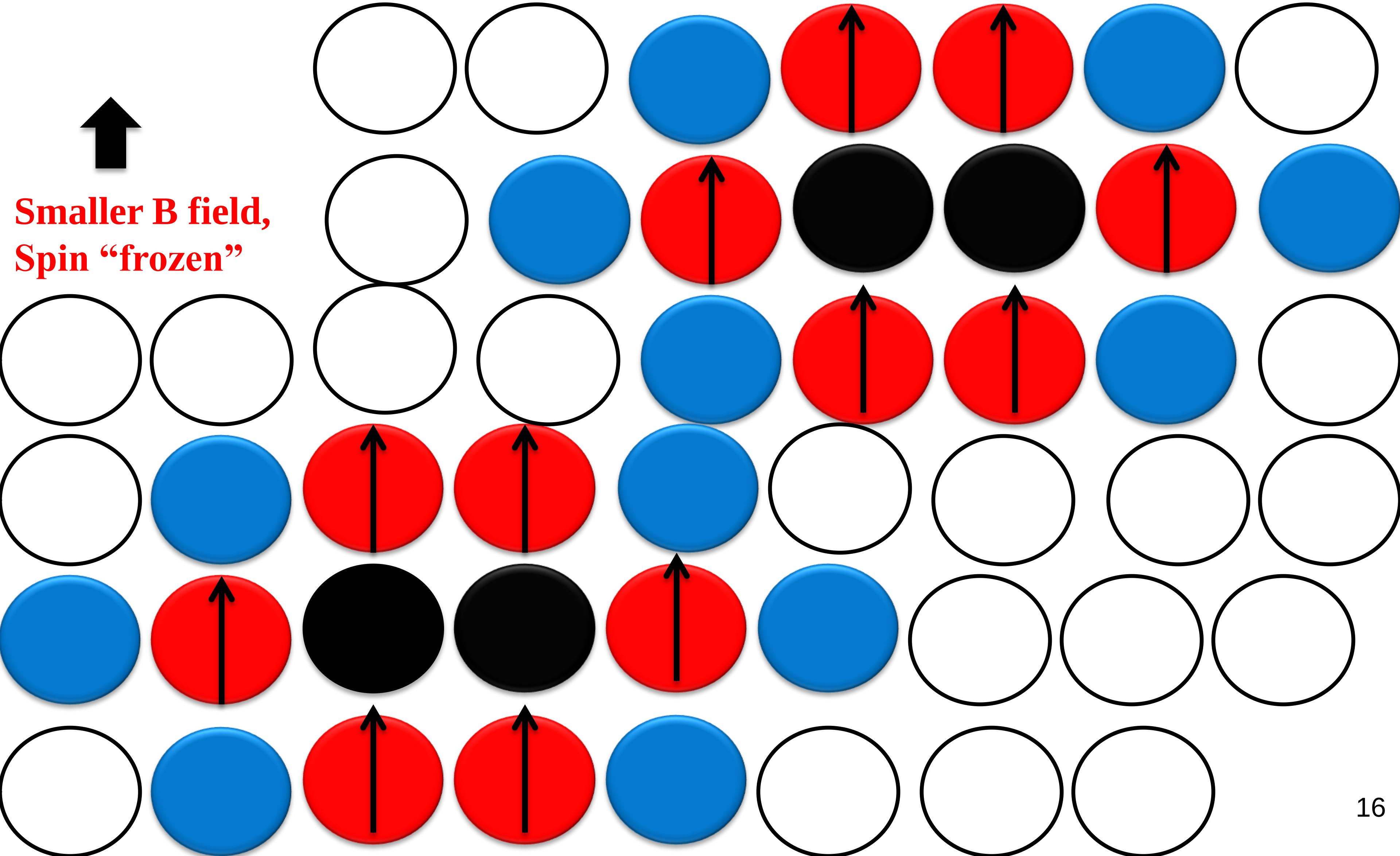
Cartoonist illustration: Under no B field



Cartoonist illustration: Under high B field



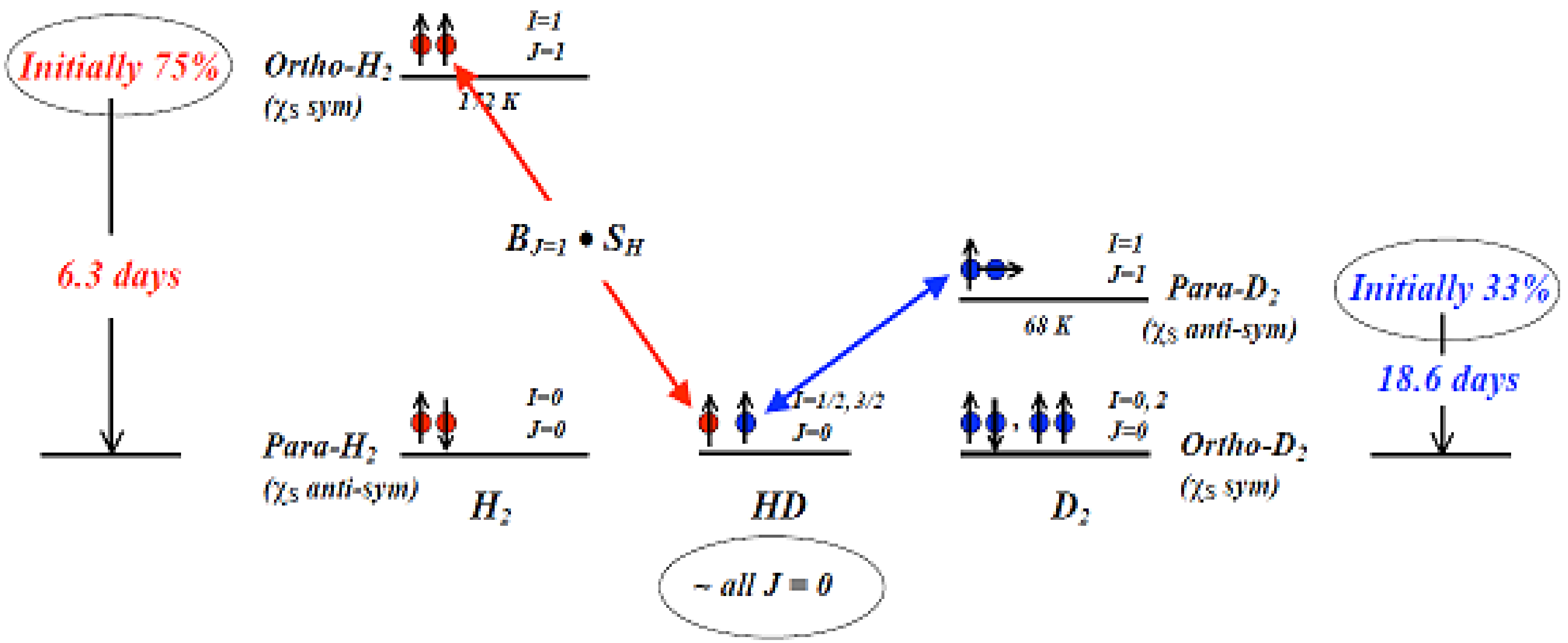
Cartoonist illustration: H is in **frozen** spin state



Intro.: "Freezing" spins in solid HD

External Magnetic field rapidly aligns Ortho-H_2 and Para-D_2

then spin-exchanges with H and D in HD



• relaxation switch – A. Honig, Phys. Rev. Lett. 19 (1967).

* From A.M. Sandorfi -JLab

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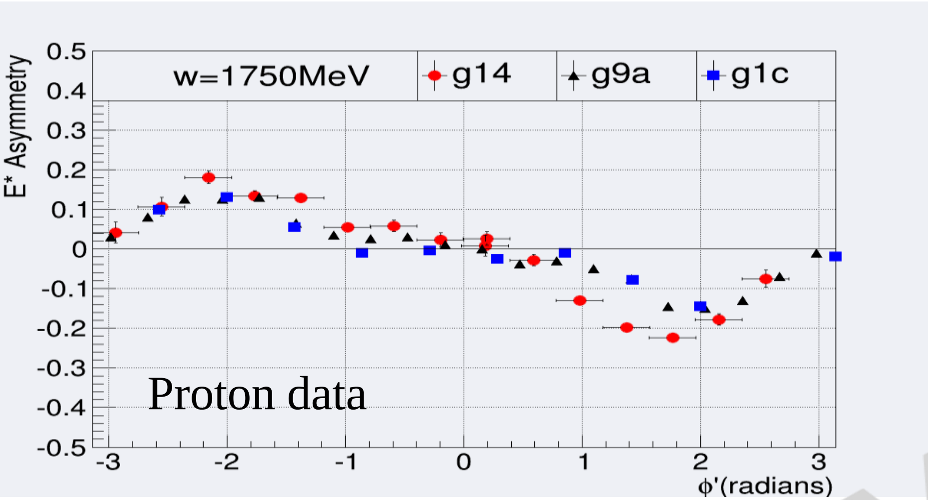
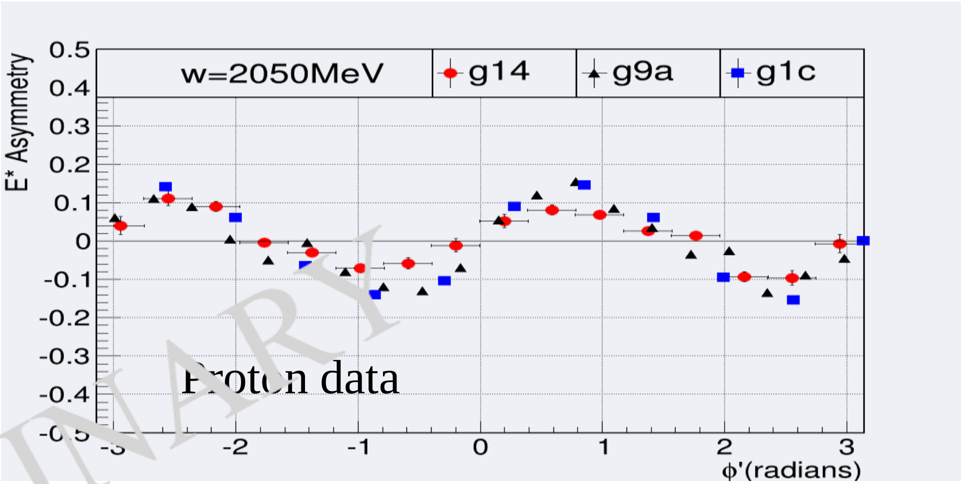
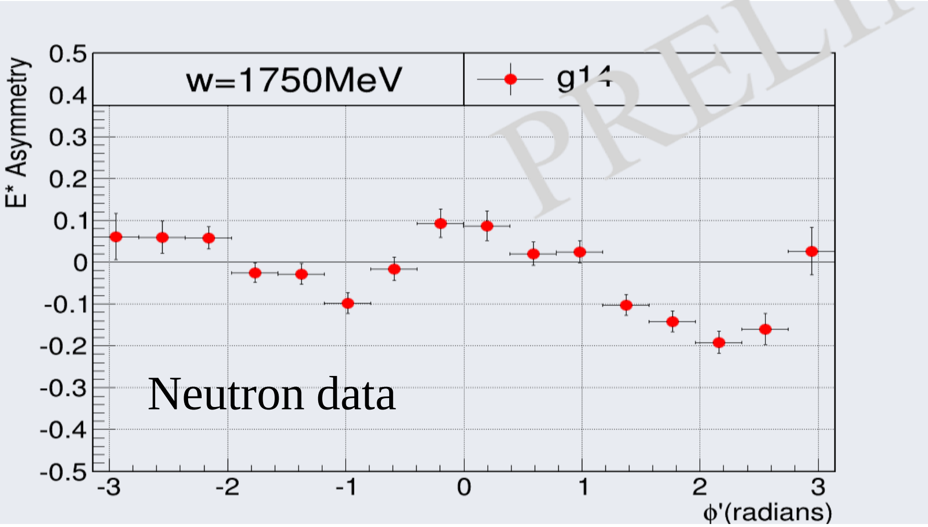
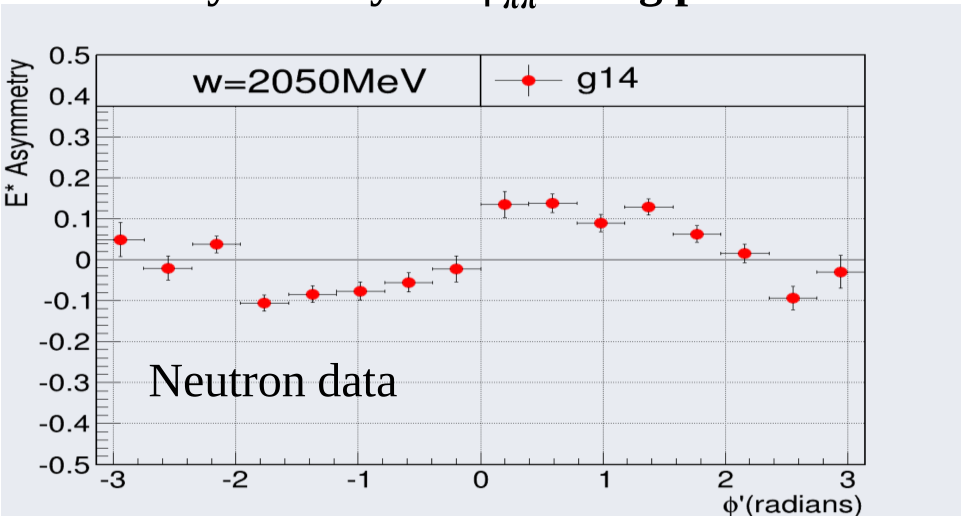




E asymmetry vs. $\phi_{\pi\pi}$ using proton data





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