Intermediate Energy Physics Experiments at γ-ALBA

C. Fernández-Ramírez[1,2], J.M. Udías[3],E. Moya de Guerra[1], J.R. Vignote[3], F.J. Llanes-Estrada[3], J. López Herraiz[3], A.M. Lallena[4], J. Vijande[5] and A. Valcarce[5]

[1]Instituto de Estructura de la Materia, CSIC

[2]Universidad de Sevilla

[3]Universidad Complutense de Madrid

[4]Universidad de Granada

[5]Universidad de Salamanca

Motivation

- Many research lines on IEP around the world
- Theoretical interest: i.e. (HB)χ PT, MEC, nuclear resonances properties ...
- Experimental interest: fill in the many gaps in data and solve controversies
- A facility like ALBA would put Spain in a **First League** in the IEP international community
- Attract experimentalists from other countries to use (and bring their detectors) our facilities

	ROKK-1M	LEGS	GRAAL	LEPS
Location	Novosobirsk	Brookhaven	Grenoble	Harima
Storage Ring	VEPP-4M	NSLS	ESRF	Spring-8
Energy definning method	tagging	ext. tg.	int. tg.	int. tg.
Electron energy (GeV)	1.4-5.3	2.5	6.04	8
Laser Photon Energy (eV)	1.17-3.51	3.53	3.53	3.5
γ-ray Energy (MeV)	100-1200	180-470	550-1470	500-2400
Energy Resolution (%)	-	2	1.1	1.25
Electron Current (A)	0.1	0.2	0.2	0.1
FWHM (MeV)	-	0.2	0.2	0.1
γ Intensity (s^{-1})	$2 \cdot 10^6$	$4 \cdot 10^6$	$2 \cdot 10^6$	10^7
Date of operation	1993	1987	1996	1999

We are interested in experiments from pion threshold up to the ALBA limit

- Nucleon resonances
- Pionic effects in nuclei
- Meson production (π, 2π, 3π, σ, η, . . .)
- Pentaquark (?)

In Spain there are many groups working in IEP

- CSIC (IEM, IFIC, ...), U. Complutense, U. Granada, U. Salamanca, U. Sevilla, U. Valencia, ...

PROPOSED EXPERIMENTS

- Calibration and measurement
  - Pion photoproduction on free nucleons: comparison with the world database
  - The ^{4}He experiment
- Experimentation
  - Multipoles and resonances properties on free nucleons
  - Resonances properties on light nuclei
  - Meson production (specially threshold properties)
  - Pentaquark (?)

PION PHOTOPRODUCTION:

world (SAID) database up to 1 GeV

http://gwdac.phys.gwu.edu

	$\pi^0 n$	$\pi^0 p$	$\pi^- p$	$\pi^+ n$
$\sigma(\theta)$	120	5119	1686	3868
P	0	363	82	163
Σ	0	530	154	780
T	0	251	89	585
G	0	0	0	32
H	0	0	0	89
σ	0	500	98	70

CALIBRATION: ^{4}He

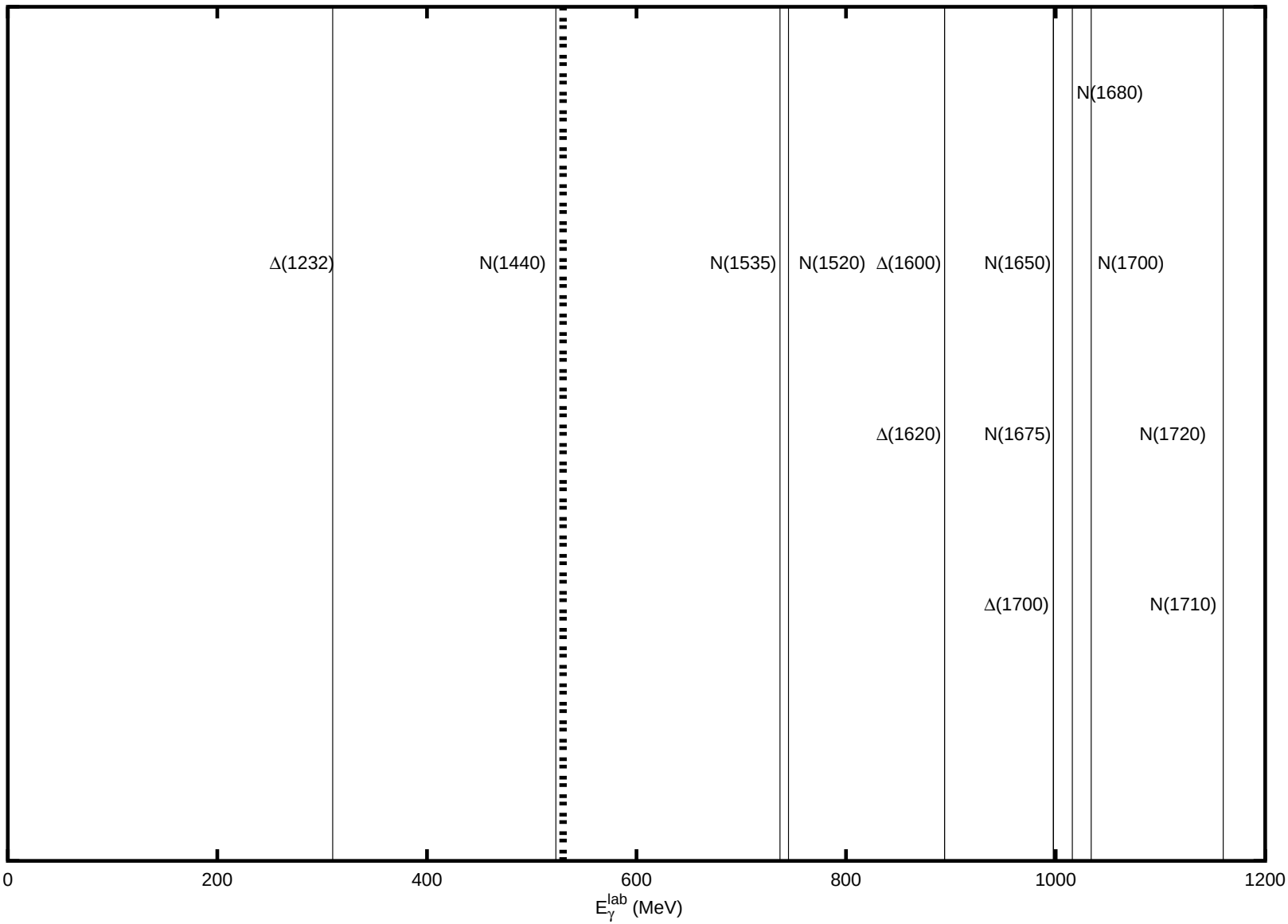
— We take advantage of spin $J = 0$

$$\Sigma = \frac{\sigma_{\shortparallel} - \sigma_{\perp}}{\sigma_{\shortparallel} + \sigma_{\perp}} = -1$$

— Calibration of photon polarisation on target

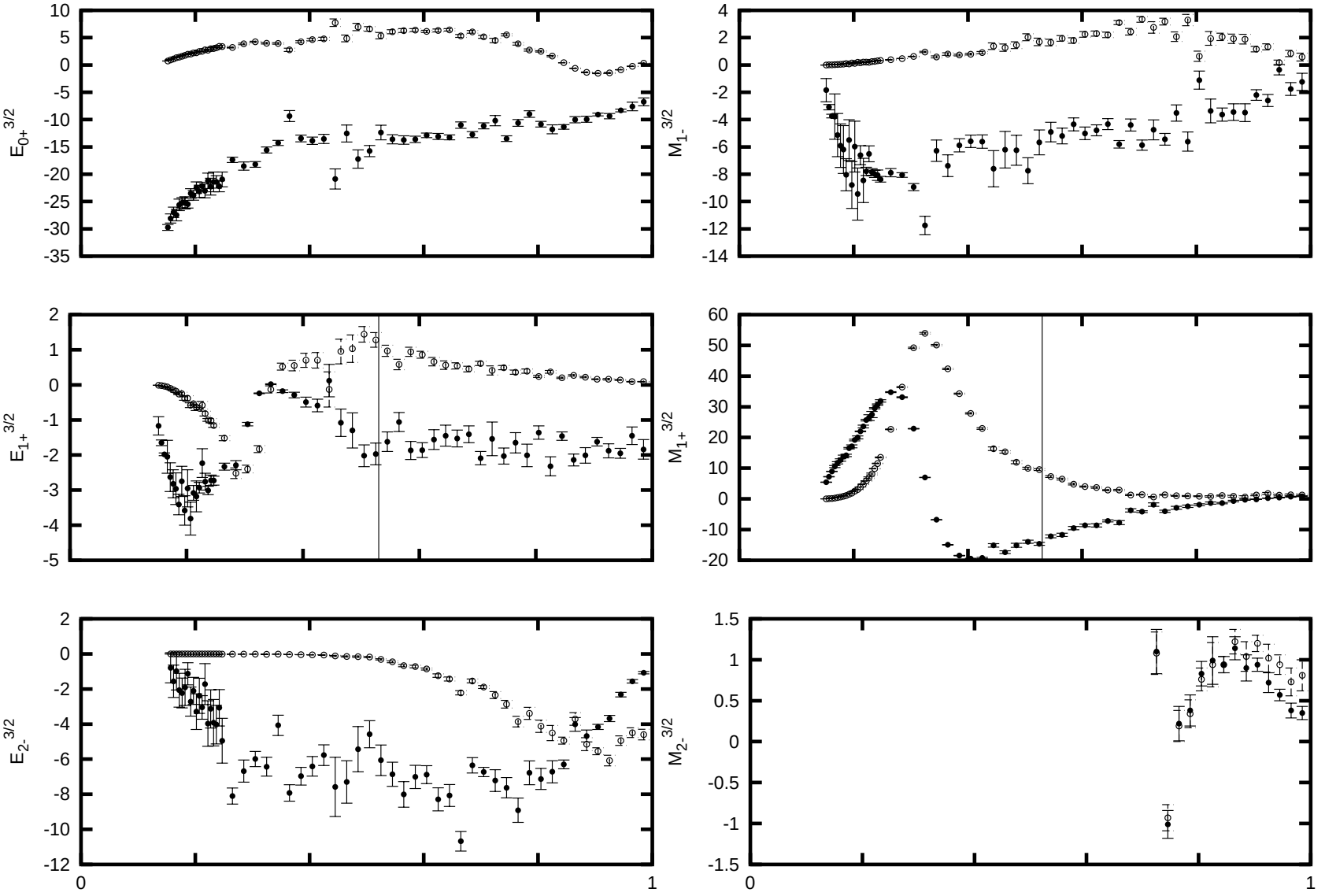
PION PHOTOPRODUCTION ON FREE NUCLEONS

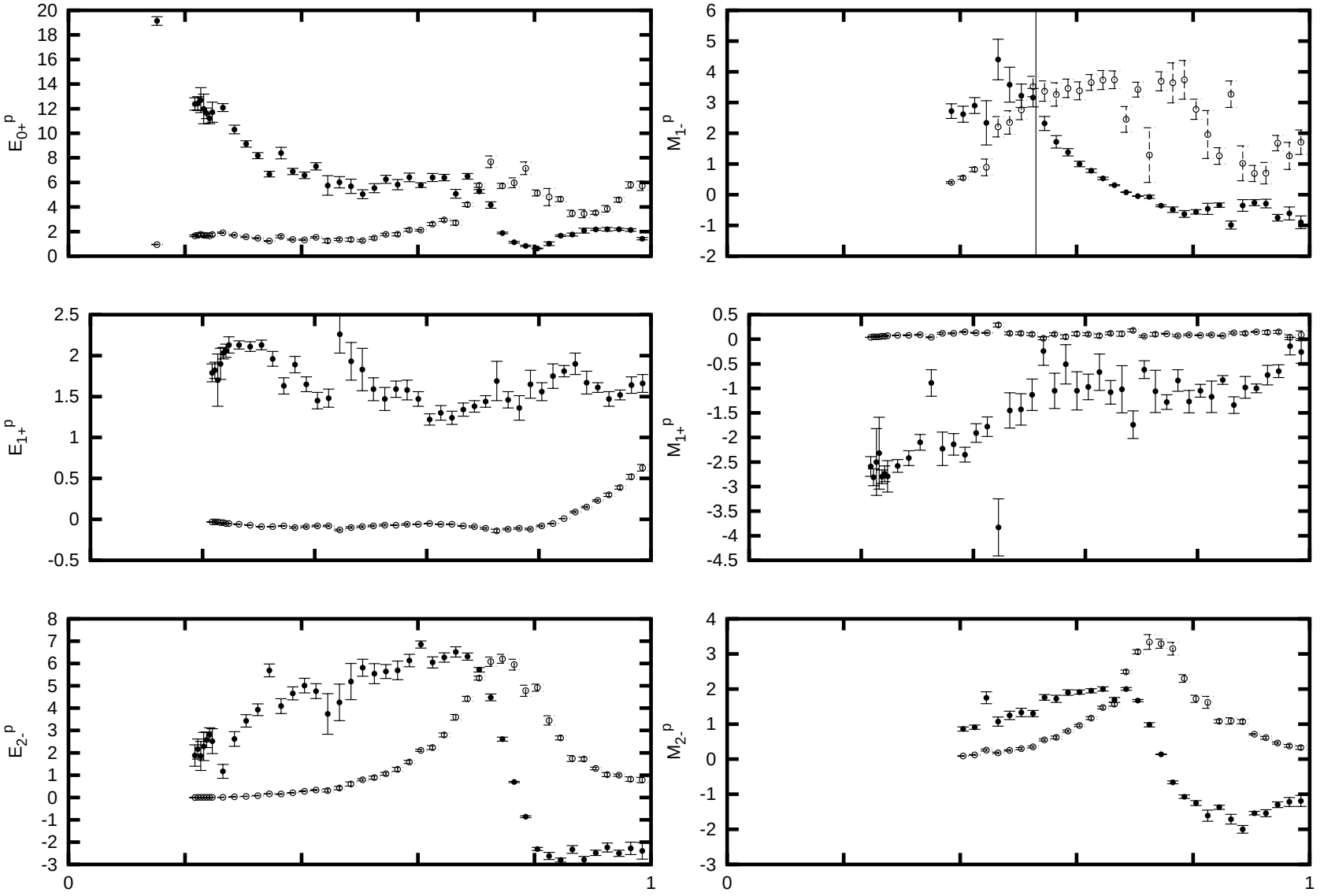
- Extend experiments performed at LEGS (and other places)
  - Compton and pion photoproduction *in the same experiment*
  - Discrepancies between MAMI (*bremsstrahlung*) & LEGS data
  - Δ (1232), E2/M1 ratio (EMR)
  - N(1440) – Roper
- Perform complete analysis of the photoproduction amplitudes
- Increase database
- Fill in gaps in multipoles

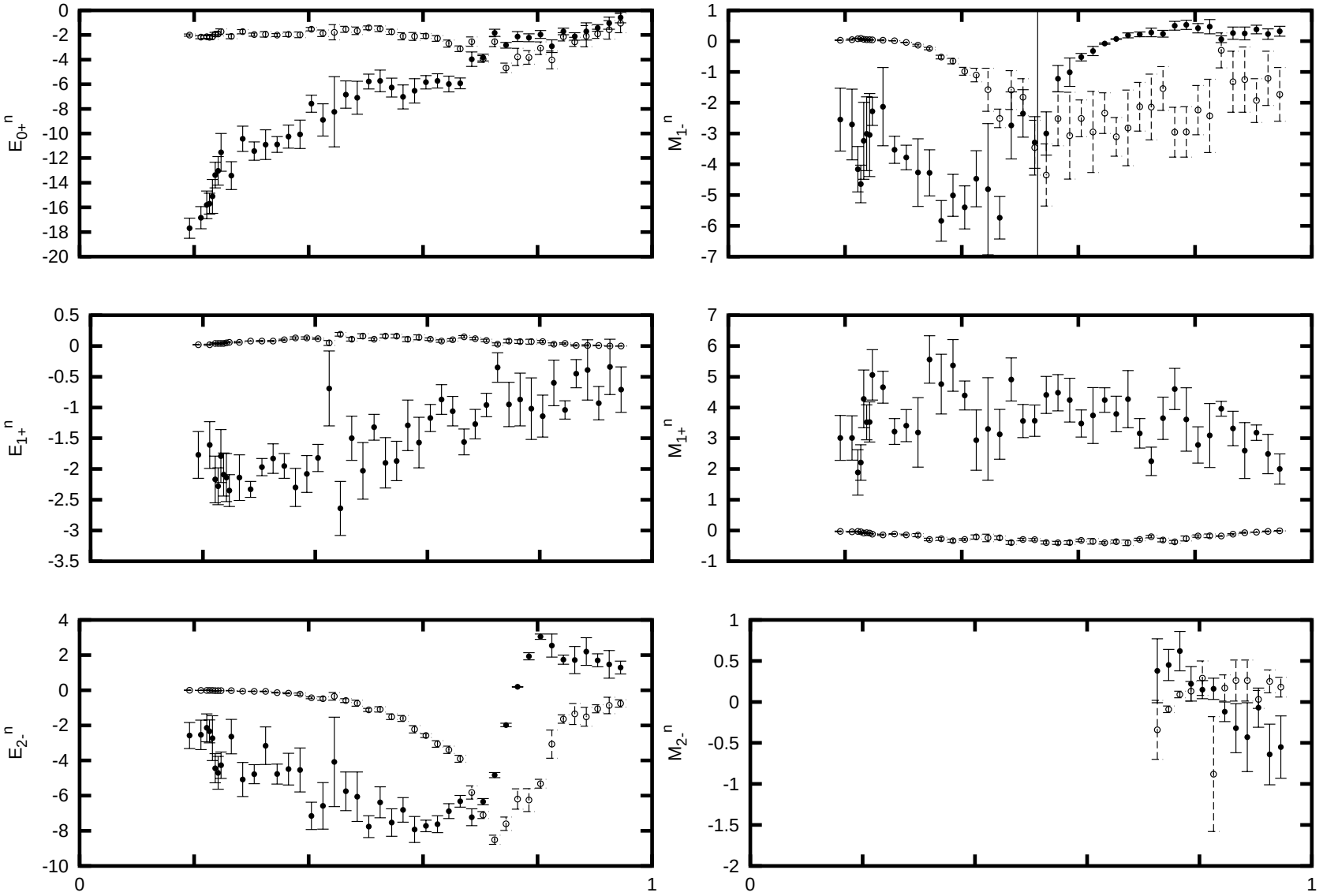

N(1680)
Δ(1232)
N(1440)
N(1535)
N(1520)
Δ(1600)
N(1650)
N(1700)
Δ(1620)
N(1675)
N(1720)
Δ(1700)
N(1710)
0
200
400
600
800
1000
1200
E_γ^{lab} (MeV)

MULTIPOLES

- Obtained from asymmetries and differential cross sections for $\pi^0 p$ experiments
- In the last ten years there has been a great increase in the database
- Three isospin channels: Δ, p and n
- We show multipoles E_{0+}, M_{1-}, E_{1+}, M_{1+}, E_{2-} and M_{2-}


E0+ 3/2
M1- 3/2
E1+ 3/2
M1+ 3/2
E2- 3/2
M2- 3/2
0
1

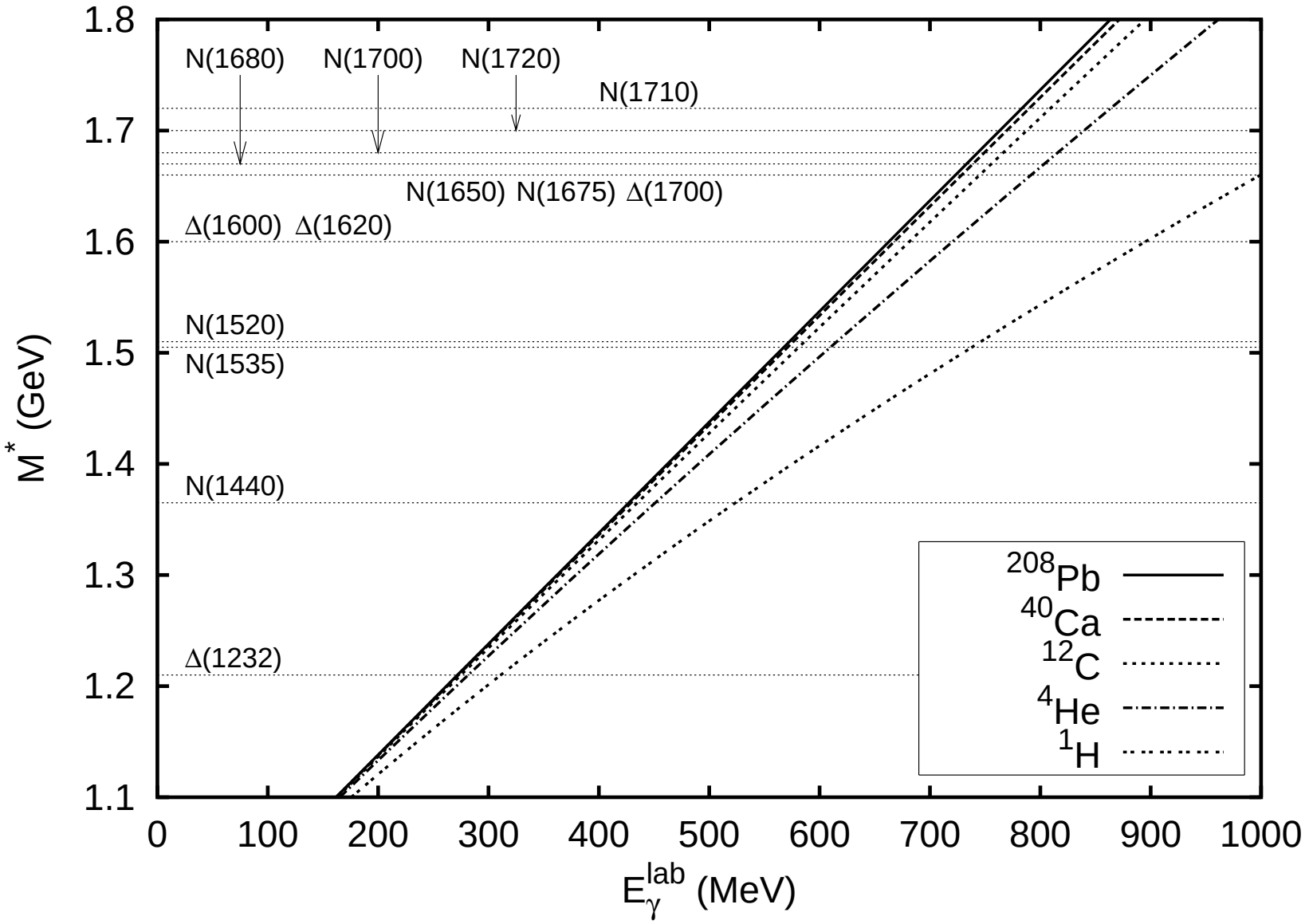

E_{0+}^p
M_{1-}^p
E_{1+}^p
M_{1+}^p
E_{2-}^p
M_{2-}^p
0
1


E_{0+}^n
M_{1-}^n
E_{1+}^n
M_{1+}^n
E_{2-}^n
M_{2-}^n

COMPTON SCATTERING AND PION PHOTOPRODUCTION ON NUCLEI

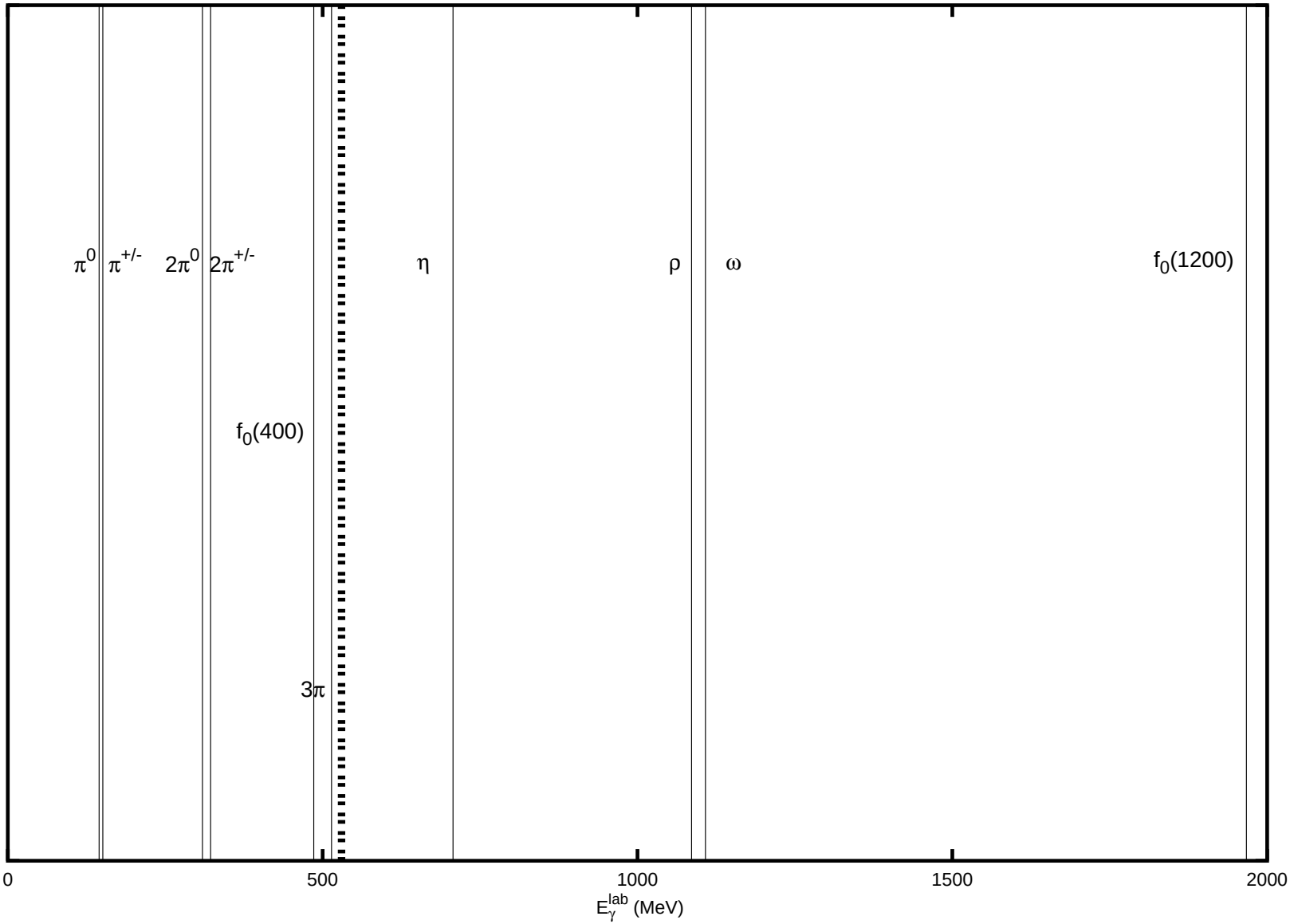
Threshold pion photoproduction energy strongly reduced in nuclei

- ^{2}H
  - old database. Update
  - study of deuteron structure (relativistic)
- ^{3}He
  - experiments?
- ^{4}He
  - calibration
  - asymmetries and structure
  - role of the pion


1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
M* (GeV)
0
100
200
300
400
500
600
700
800
900
1000
E_γ^lab (MeV)
N(1680)
N(1700)
N(1720)
N(1710)
N(1650)
N(1675)
Δ(1700)
Δ(1600)
Δ(1620)
N(1520)
N(1535)
N(1440)
Δ(1232)
208Pb
40Ca
12C
4He
1H

MESON PRODUCTION

- $\gamma\, Z \rightarrow$ (Z-2) $\pi^+\pi^+$
- Roper structure
- σ
- η-photoproduction


π^0
$\pi^{+/-}$
$2\pi^0$
$2\pi^{+/-}$
η
ρ
ω
$f_0(1200)$
$f_0(400)$
3π
0
500
1000
1500
2000
E_γ^{lab} (MeV)

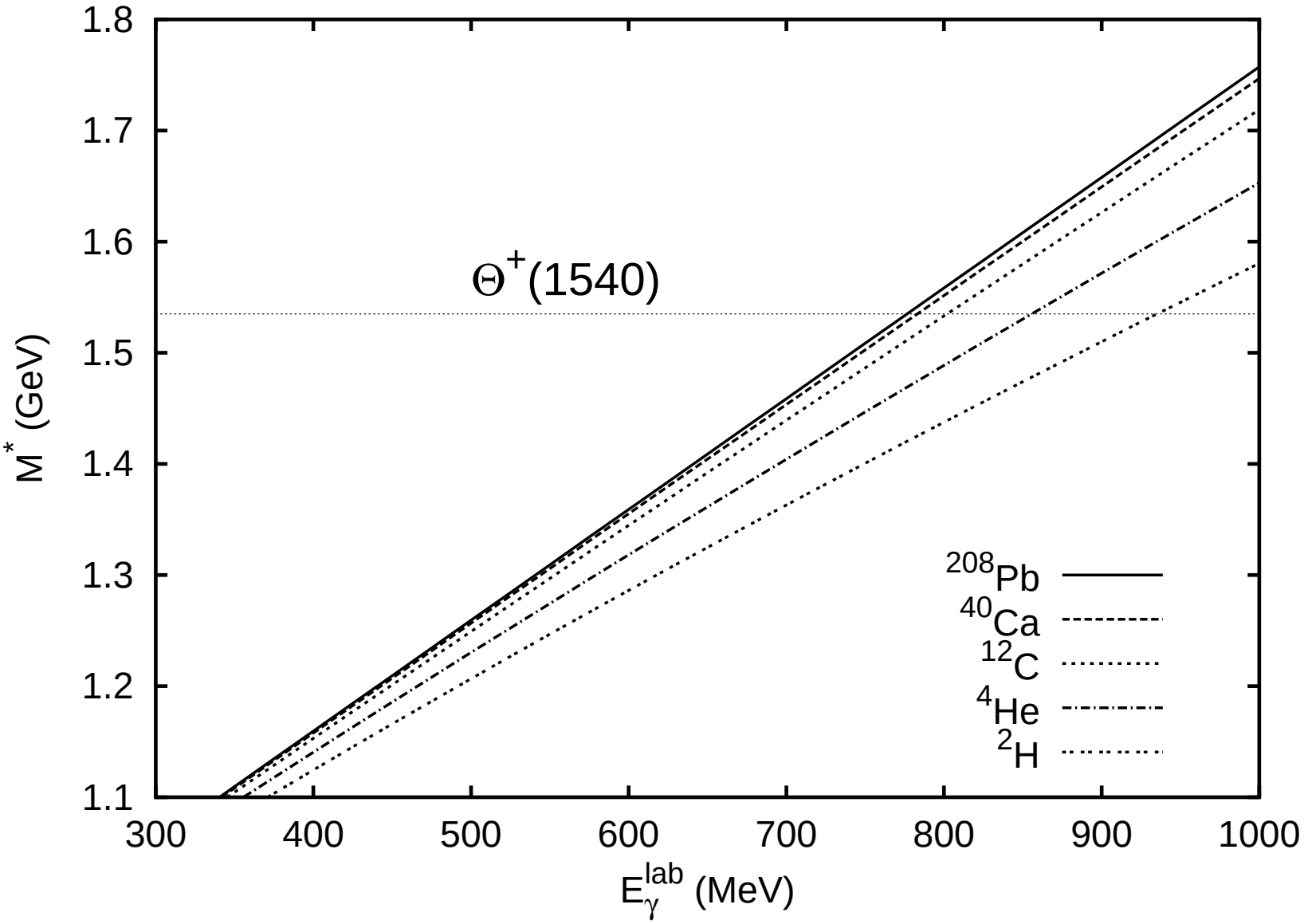
PENTAQUARK (?)

- Hot topic
- Check possibilities of pentaquark search at γ-ALBA
- Free: $\gamma + n \rightarrow K^- + \Theta^+(1540) \rightarrow \ldots$

  Threshold energy: 1738 MeV
- Deuteron: $\gamma + \mathrm{d} \rightarrow \Lambda\,(1116) + \Theta^+(1540) \rightarrow \ldots$

  Threshold energy: 941 MeV
- Nuclei: $\gamma + A \rightarrow \Theta^+(1540) + B \rightarrow \ldots$

  In nuclei the threshold energy is reduced


1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
M* (GeV)
Θ+(1540)
208Pb
40Ca
12C
4He
2H
300
400
500
600
700
800
900
1000
Eγlab (MeV)