Summary of the 10th. International Workshop on Meson Production, Properties and Interaction KRAKÓW, POLAND 6 - 10 June 2008.

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Exotic Atoms + related Topics

(1) η–Atoms: Urban+Khoukaz / COSY

(2) K-Atoms: Hayano/KEK; Iwasaki/RIKEN/KEK;
Widmann/DAΦNE; DAΦNE Upgrade: C. Milardi

Λ-Hypernuclei: Camerini /DAΦNE;

Hyperon Production: Hartmann/FOPI

(3) Kaon decay in pions , photons and leptons

Vendetti NA48

(4) ($\pi^+ \pi^-$) scattering length and isospin violation:
Ruselsky (non-relativistic effective Field theory);

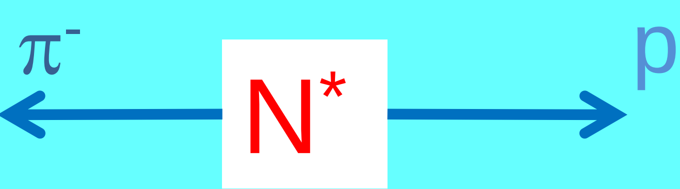
Urban, Cosice, Exp. with COSY
η –nucleus bound state ?

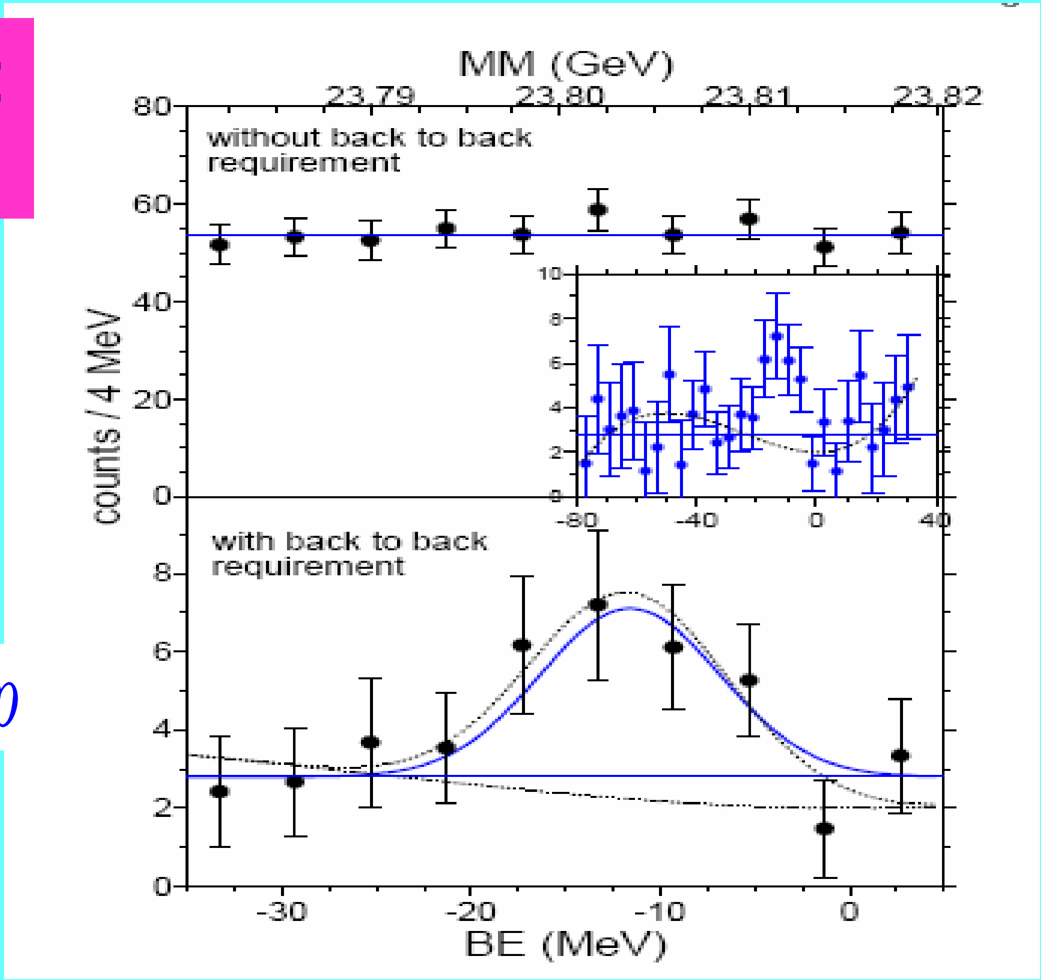
$$p + {}^{A}Z \rightarrow {}^{3}He + {}^{A-2}(Z-1) * \eta$$

Recoil-free η production:
T_p = 1745 MeV

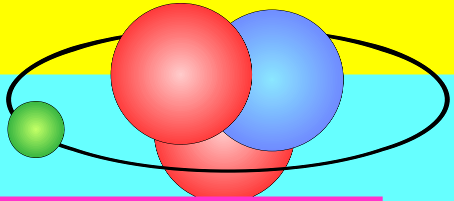
$$p + {}^{27}Al \rightarrow {}^{3}He + \eta\, {}^{25}Mg$$

$$\eta + n \rightarrow N^*(1535) \rightarrow \pi^- + p$$

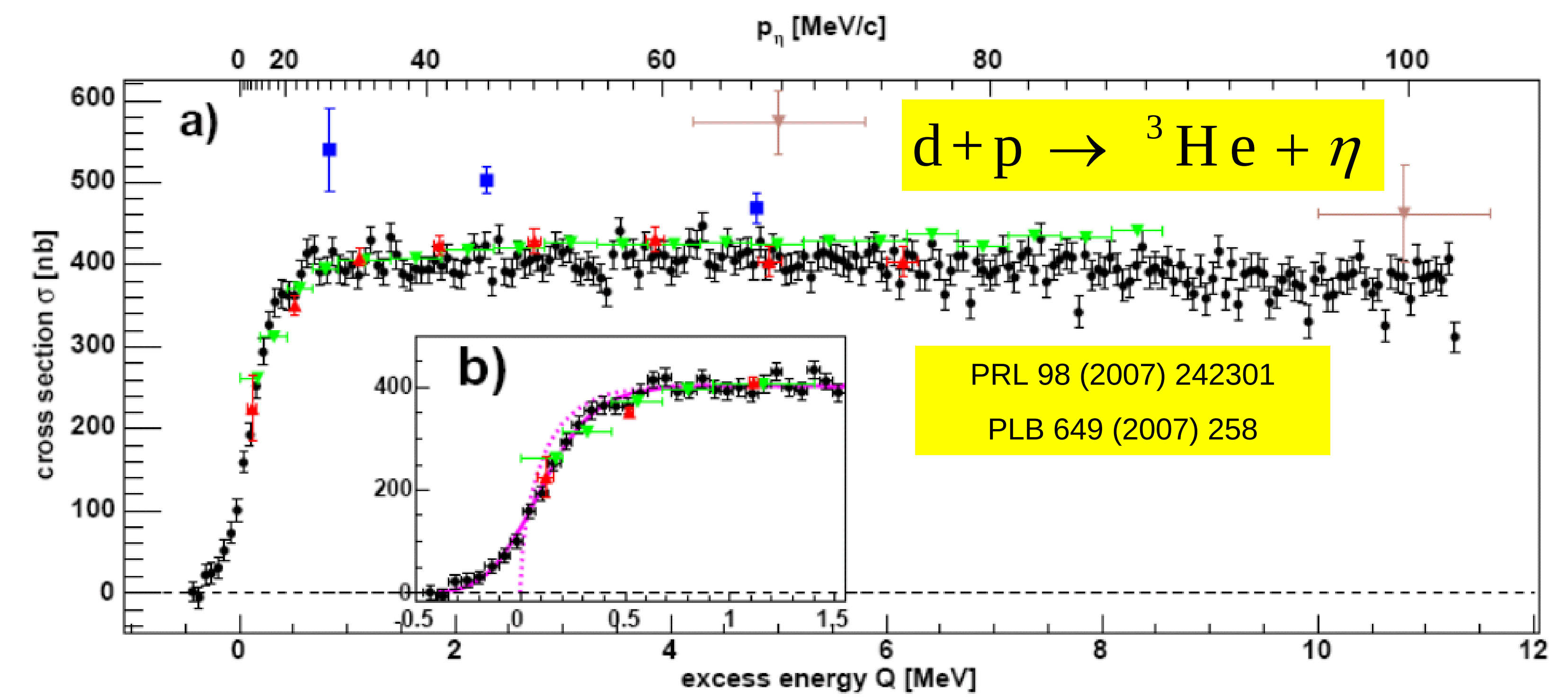




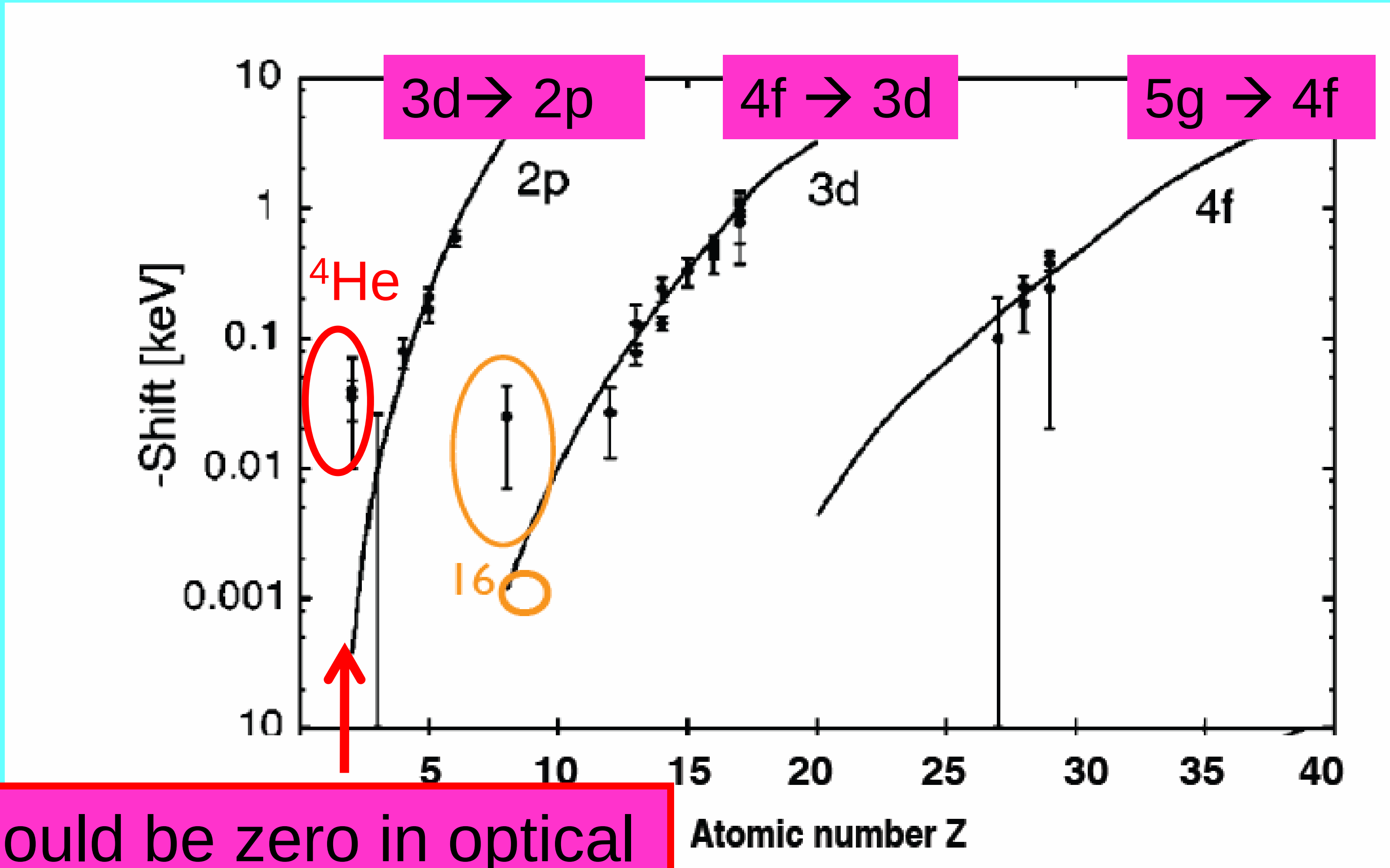
Khoukaz: η–³He Interaction Studies



- Indications for a quasi-bound η-³He state at SATURNE (pd) and MAMI (γ³He)



Hayano: K-mesic He^4 - Anomaly

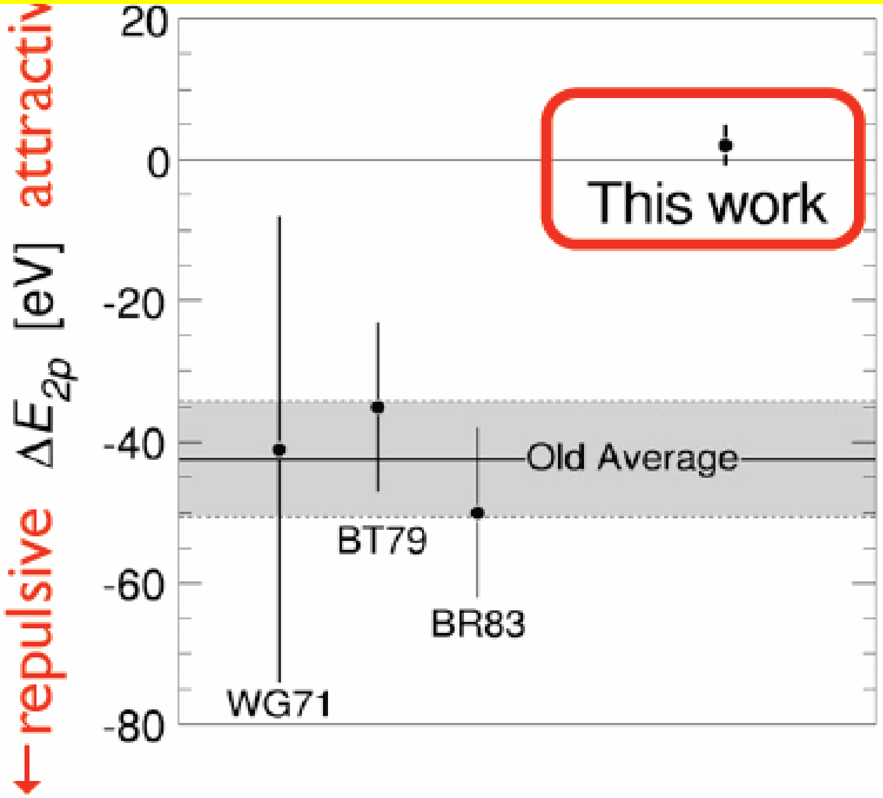


Should be zero in optical model, but -43 eV

Hayano

$\Delta E2p = 2 \pm 2(stat) \pm 2(sys)$ eV

What about the ^{16}O-Anomaly ?



Okada et al., PLB 653 (2007) 387

Naohito Saito: In the Future Hyper-Nuclear and K-Meson Physics at J-Park

Multi-Purpose Facility;

Neutrino Physics: Theta(1,3) of Mass to Flavor Neutrinos

Leupold: $a_1 = \chi$–partner of ρ ?

- Leupold: Is the $a_1(1260)$,I=1, $J^\pi = 1^+$ the chiral partner of the $\rho(770)$ I=1, $J^\pi = 1^-$ or a molecule $\rho(770) + \pi(140)$?
- Sibirtsev: Can a_1 be the chiral partner of the ρ-meson ?

ρ: G = +; P = -; C = - ;

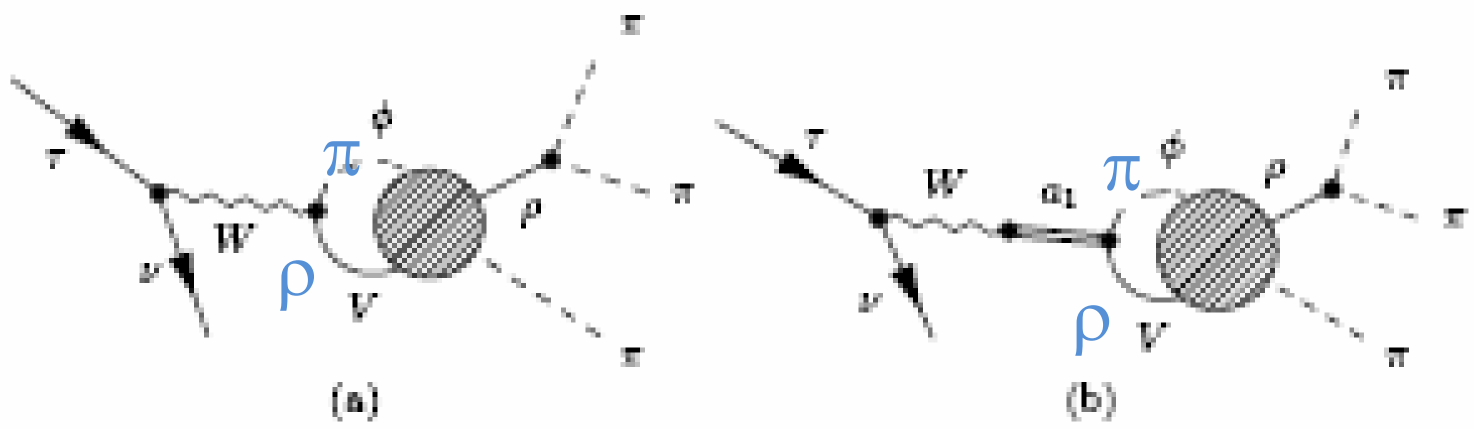
π: G = -; P = -; C = + ;

a_1: G = -: P = +; C = + ;

C = $(-)^{L+S}$, only for neutral mesons. Is it irrelevant or a k.o. criterion?

Leupold: Is $a_1(1260)$ I=1, $J^\pi = 1^+$ the chiral partner of the $\rho(770\ \mathrm{MeV})$ $J=1^-$ or is a_1 molecule $\rho(770)+\pi(140)$?

$a_1(1260)$ dynamically formed by $\pi-\rho$ or a quark-antiquark meson?



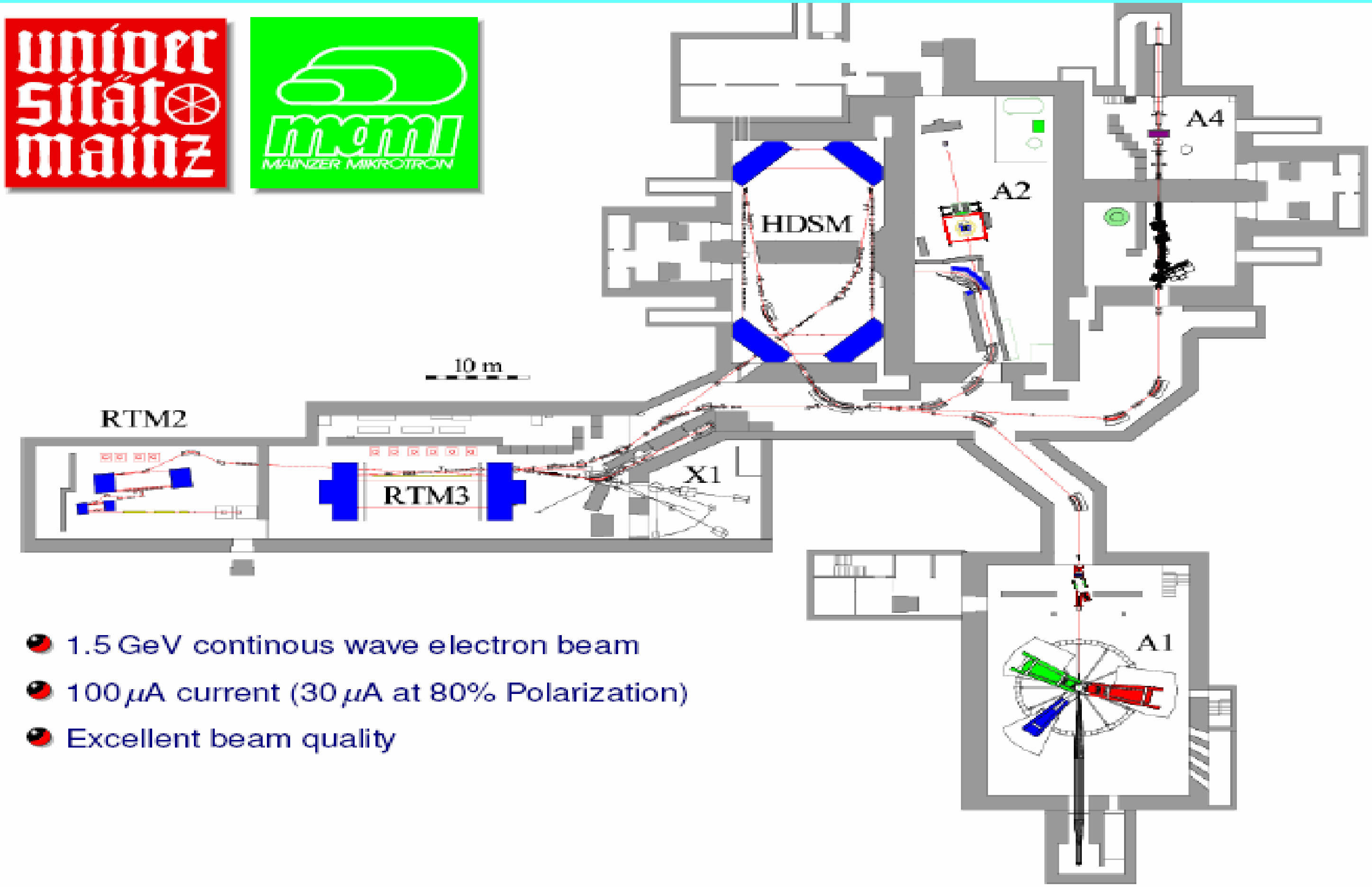
$$\Phi = \pi \ and\ V = \rho \quad \phi = K \ and\ V = K^*$$

Hadron Physics with Electron Beams: MAMI, ELSA, J-Lab,BES, SPring8, BELLE, BaBar, CLEO.

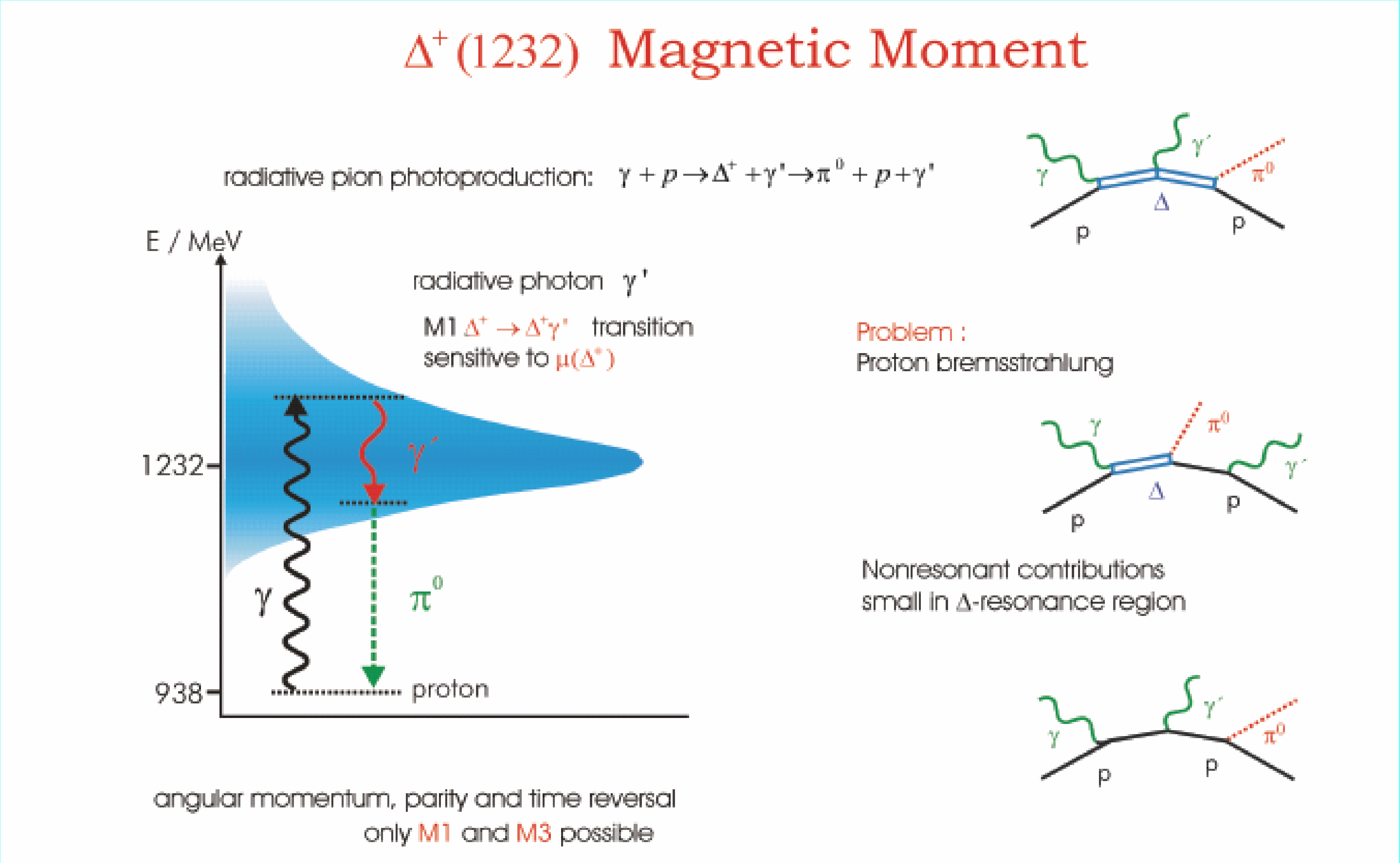
- Harald Merkel, Mainz (Exp.: MAMI)
- Alexandr Starostin, UCLA (Exp.: MAMI)
- Michael Lang, Bonn (Exp.: ELSA)
- Chaden Djalali, South Carolina (Exp.: CEBAF)
- Marco Battalieri, Genova (Exp.: J-Lab)
- Xiaoyan Shen, IHEP Beijing (Exp.: BES II)
- Fred Harris, Hawai (Exp.: BES III)
- Tomoaki Hotta, Osaka (Exp.: SPring8)
- Marco Bracko, Maribor(Exp.: BELLE)
- Antimo Palano, Bari (Exp.: BaBar)
- Tomasz Skwarnicki, Syracuse (Exp.: CLEO)

Hadron Physics at MAMI B and C

Harald Merkel,Alexandr Starostin



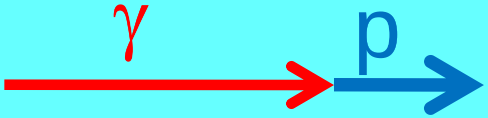
- 1.5 GeV continous wave electron beam
- 100 μA current (30 μA at 80% Polarization)
- Excellent beam quality



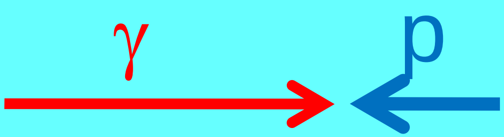
Similar Method: $S_{11}(1535)$ and Roper $P_{11}(1440)$

Lang, Bonn: Double Polarisation

MAMI and ELSA: Polarised Photon and Electron Beams and polarised Proton Target

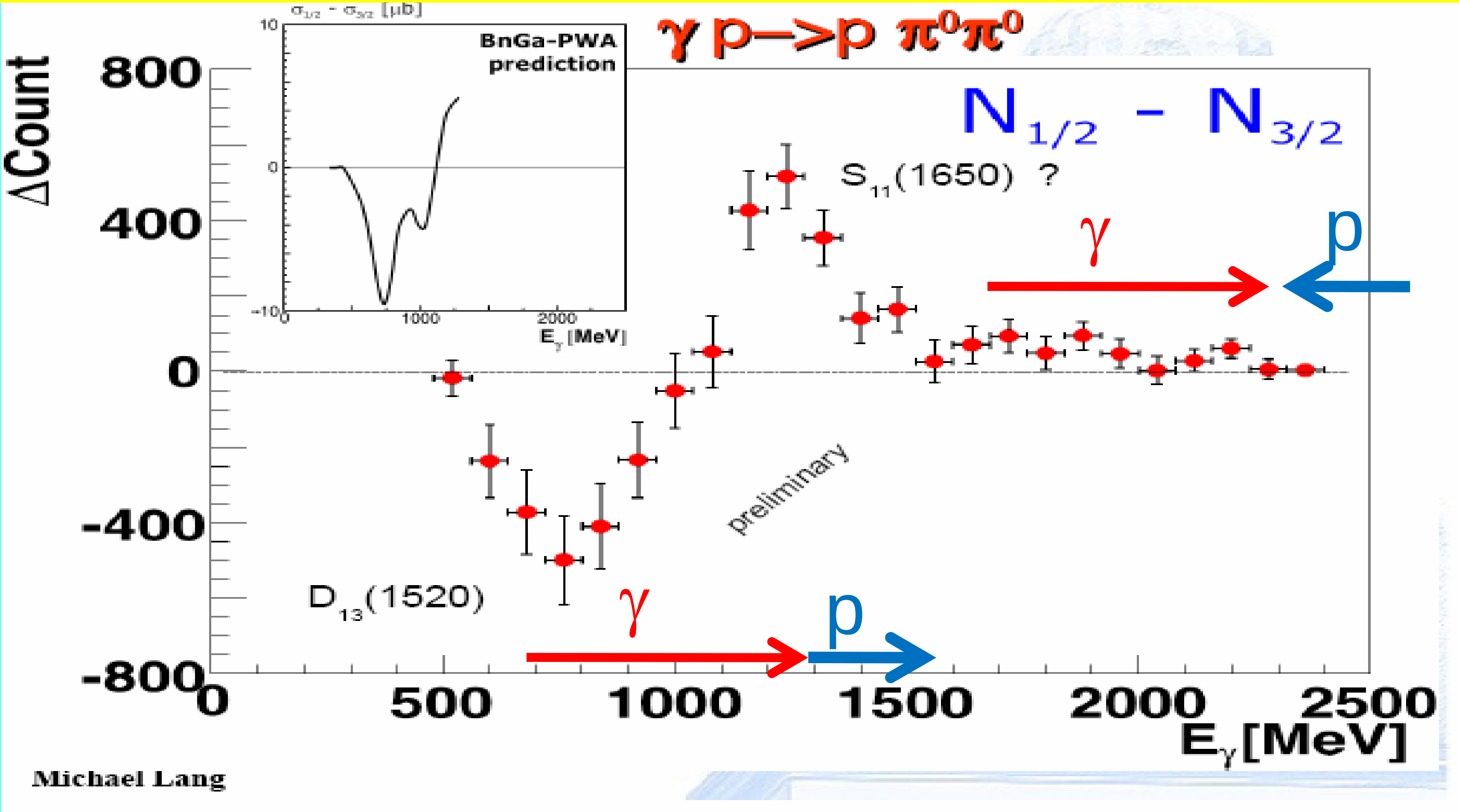


Spin 3/2-Resonance



SPIN ½ and 3/2-Resonance

Photo Excitation of the $D_{13}(1520)$ and $S_{11}(1650)$ [γ → ← p] - [γ → p →]



Medium Modifications of Meson Masses by the (1) Quark Condensate B in Nuclear Matter.

Gell-Mann-Oaks-Renner relat.:

$$m_\pi^2 = 2\hat{m}B$$

$$m_K^2 = (\hat{m} + m_s)B$$

$$m_\eta^2 = \frac{2}{3}(\hat{m} + 2m_s)B$$

with:

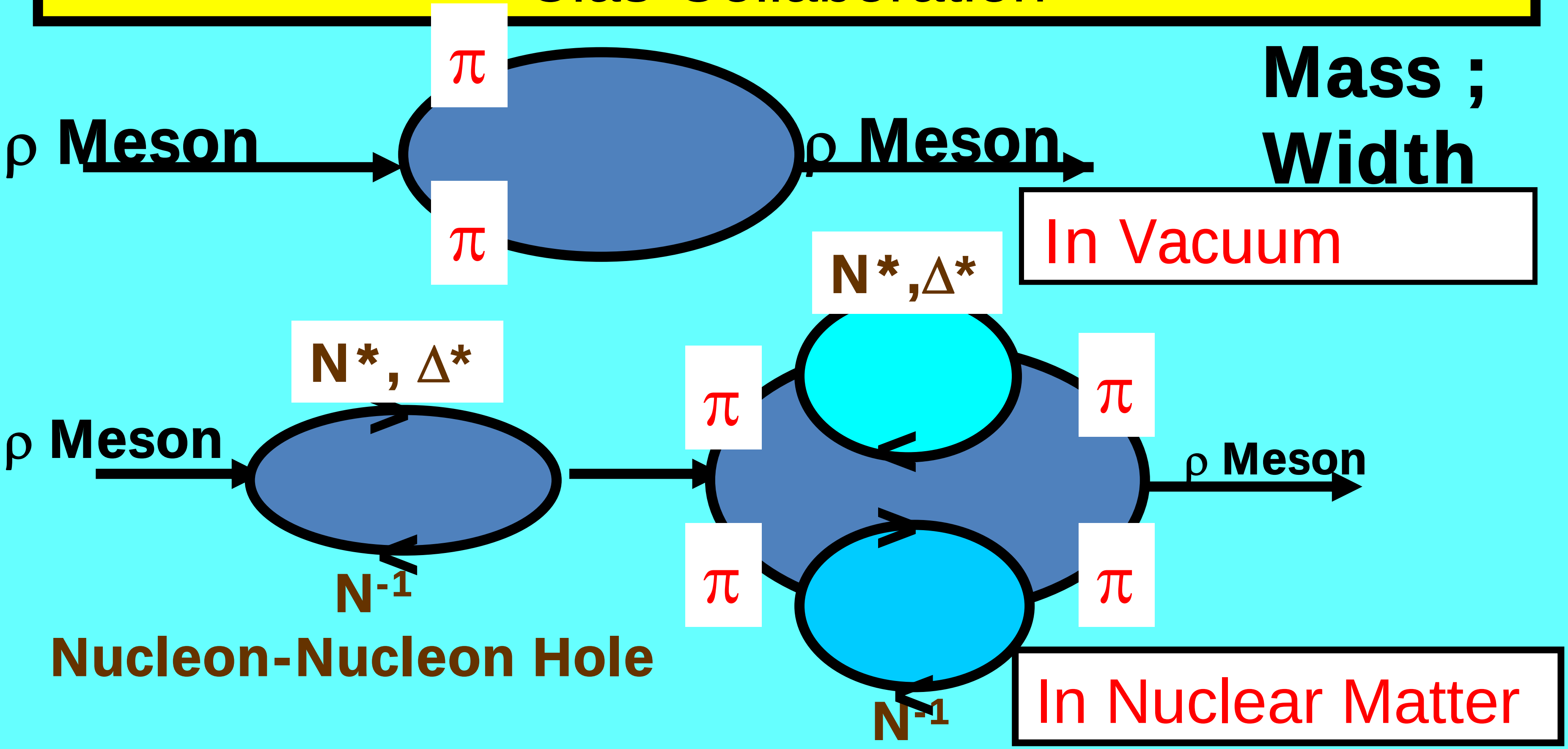
$$\hat{m} = \frac{1}{2}(m_u + m_d) = 7MeV$$

$$m_s/\hat{m} = 25; m_s = 175MeV$$

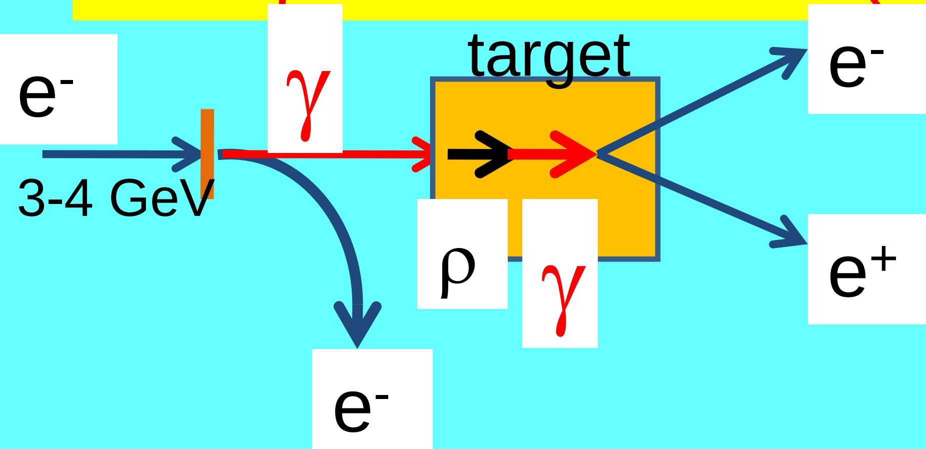
$$B = -\frac{< 0|\bar{u}u|0 >}{f_\pi^2} = \frac{m_\pi^2}{2\hat{m}} = 1.4[GeV]$$

Medium Modifications of VectorMesons in Nuclear Matter: (2)Nuclear structure Effects;

Clas-Collaboration



Djalali (J-Lab): Medium Dependence of ρ-Meson Mass (776 MeV, Γ= 150 MeV),

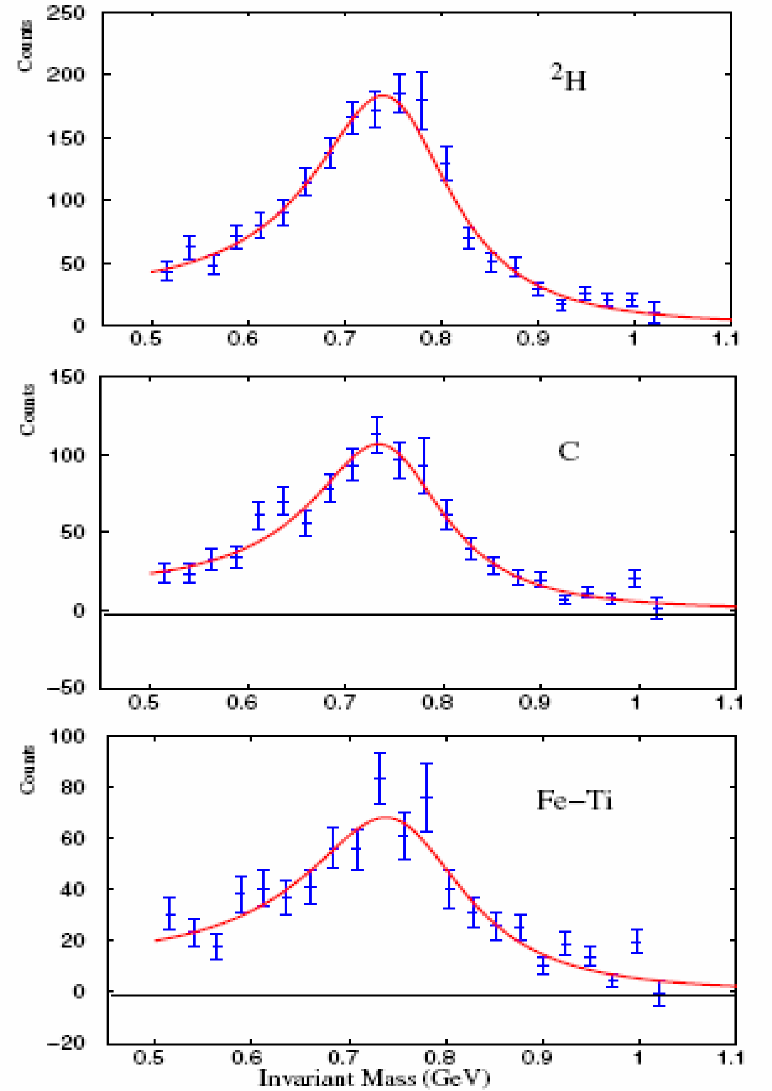


$$\frac{m_{VM}(\rho)}{m_{VM}(\rho = 0)} = 1 - \alpha \frac{\rho}{\rho_0}$$

Theory QCD sum: α = 0.16

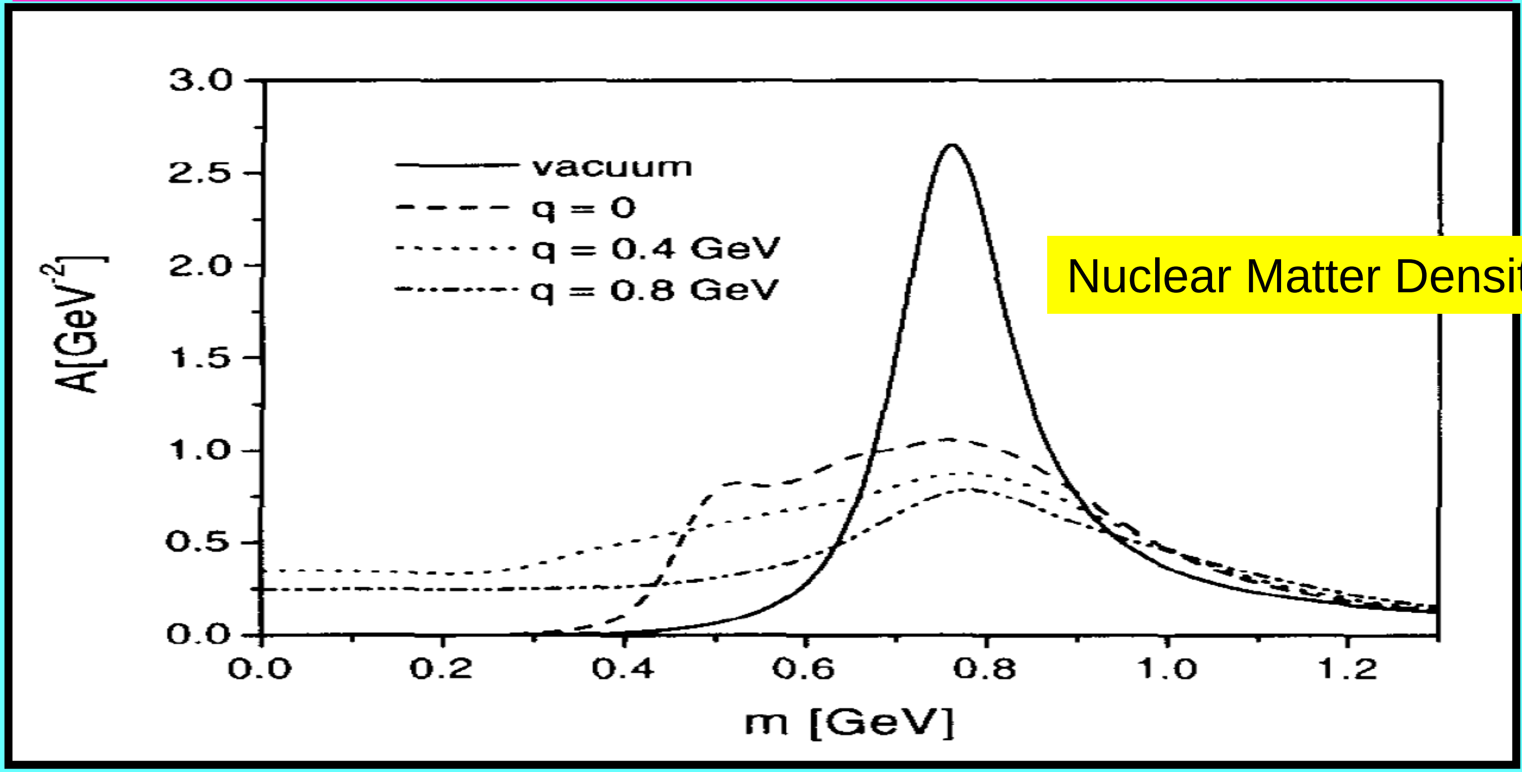
Experiment: α = 0.02 +- 0.02

Target	Mass CLAS data	Width CLAS data
^{2}H	770.3 ± 3.2	185.2 ± 8.6
C	762.5 ± 3.7	176.4 ± 9.5
Fe-Ti	779.0 ± 5.7	217.7 ± 14.5



Spectral Function of the ρ–Meson as a Function of the invariant e^-e^+ Mass $M(e^+e^-)$ and of the momentum q relative to Nuclear Matter (Data: q = 0.8 GeV — · · — · · ·).

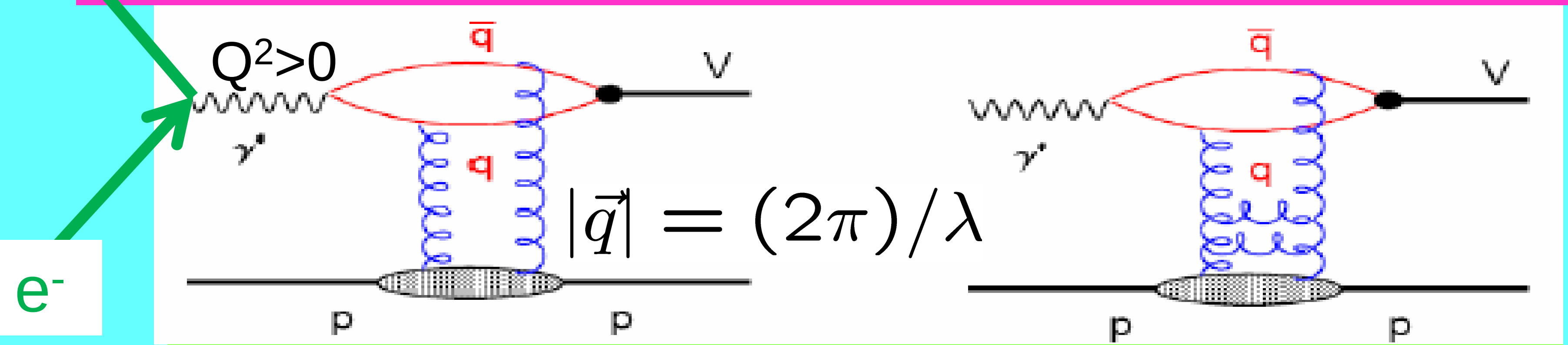
Transversal Spectral Function (Giessen)



Nuclear Matter Density

Battalieri+Marage: Vector-Meson Production at Clas/J-Lab + HERA/DESY

Color Dipole Universality



$$|\vec{q}| = (2\pi)/\lambda$$

Hard (perturbative QCD) versus soft (non-perturbative QCD) processes.

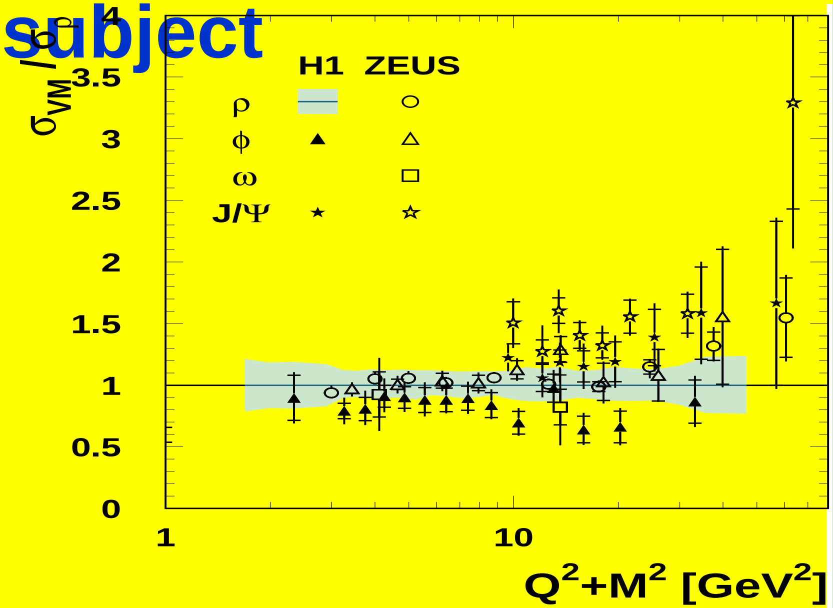
$$Q^2 = -q^2 = \vec{q}^2 - \Delta E^2; \quad \text{space like}$$

Color Dipole Moment of Meson

$$\propto \; r_{q\bar{q}} \; \sim \; \frac{1}{Q^2 + M^2}$$

Marage + Battalieri: Universality of real and virtual Photo- Production of Mesons as a Function of ($Q^2 + M^2$)

Color Dipole needs gluons of wave length of r(quark-antiqaurk) and smaller mass of the probing subject



σ(mesons)/ $\sigma(\rho$-mesons)

$\sigma(\rho)/\sigma(\rho$mesons) = 1

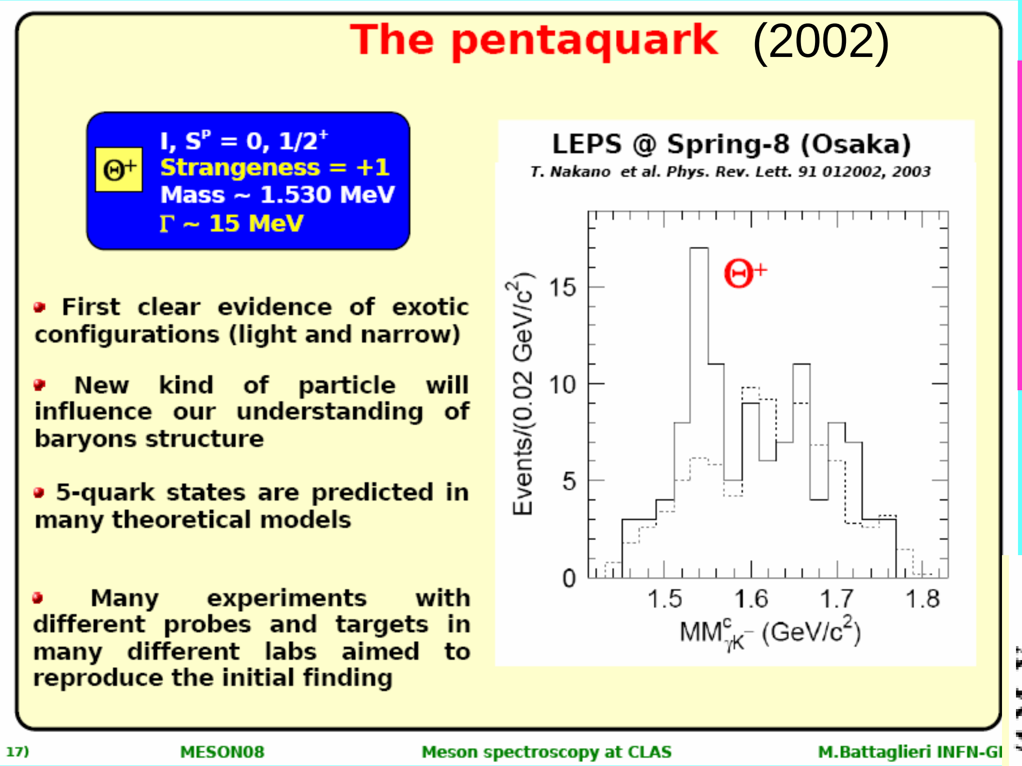
Φ-mesons

ω-mesons

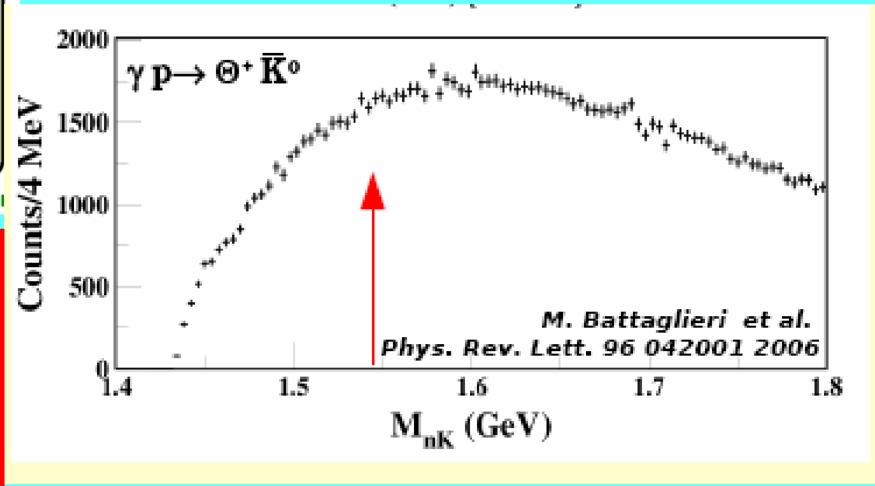
J/ψ–mesons

Battalieri/Genova and Hotta/Osaka asked:

Is the Penta-Quark Θ^+[1530; (udd)(u anti-s)] really dead ?

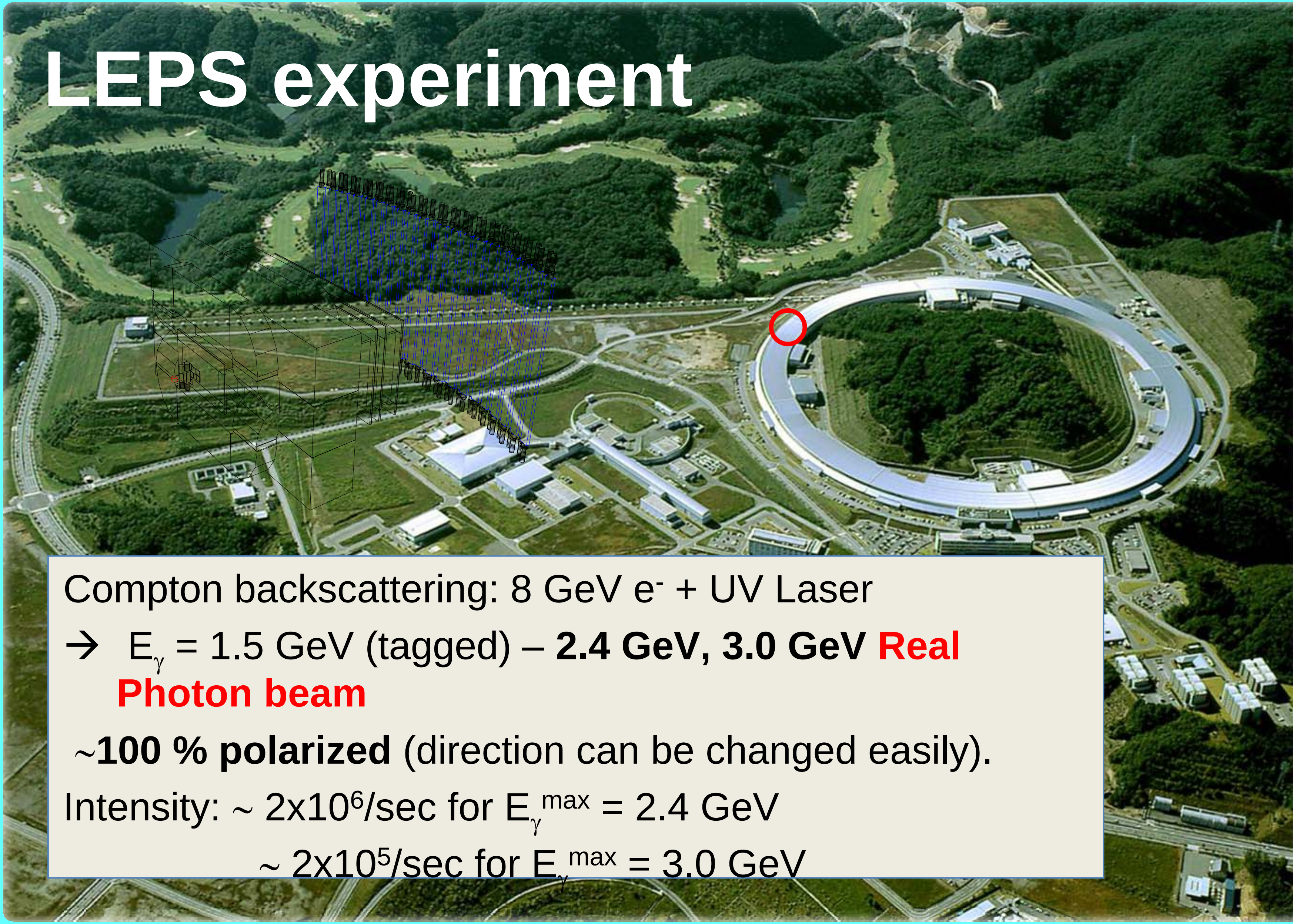


Hotta from SPring8:
Not completely dead.
SPring8 data



Battalieri:
Completly dead
CLAS/J-Lab data

LEPS experiment



Compton backscattering: 8 GeV e^- + UV Laser

→ E_γ = 1.5 GeV (tagged) – **2.4 GeV, 3.0 GeV** **Real Photon beam**

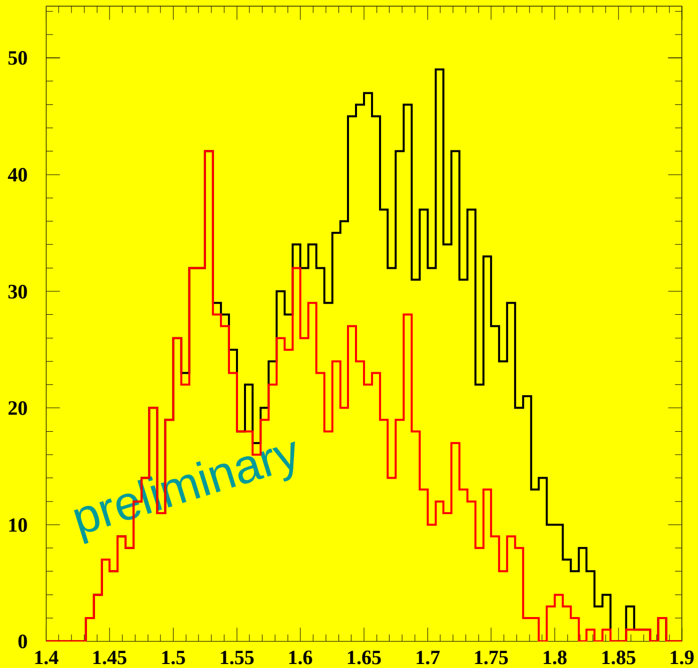
~**100 % polarized** (direction can be changed easily).

Intensity: ~ 2×10^6/sec for E_γ^{max} = 2.4 GeV

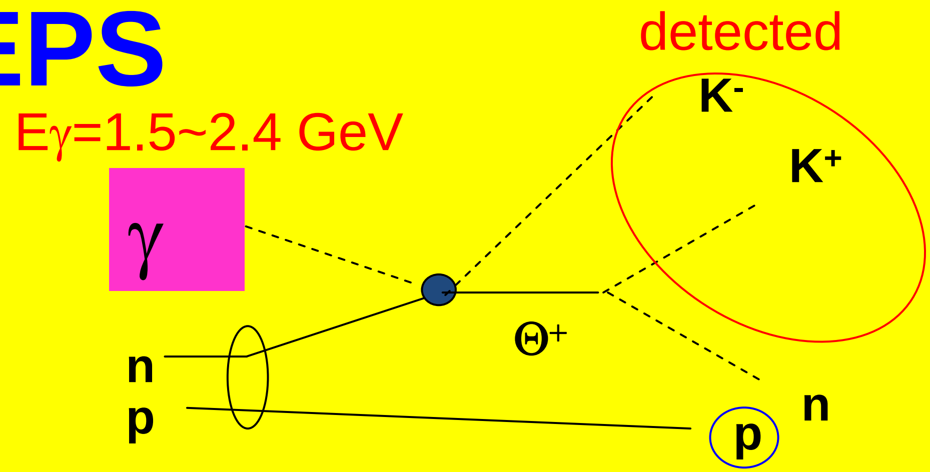
~ 2×10^5/sec for E_γ^{max} = 3.0 GeV

Θ^+ Signal at LEPS

Data taken in 2002-2003.



Inv. Mass[nK$^+$] (GeV/c^2)



- could be inconsistent with CLAS-g10 results.
- Θ^+ in the LEPS kinematical region is not completely excluded by CLAS.
- Blind analysis of new (x3 statistics) data is underway.
- **LEPS2** with larger acceptance detector, higher beam intensity

Hadron Spectroscopy with e- e+ Colliding Beams

- BEPC with BES II and in the future with BES II: Mrs Shen, IHEP/Beijing and Harris, Hawaii

- BELLE at KEK: Marco Braco/Maribor.

- BaBar at Stanford: Antimo Palano, Bari.

- CLEO: Tomasz Swarnicki, Syracuse Univ.:

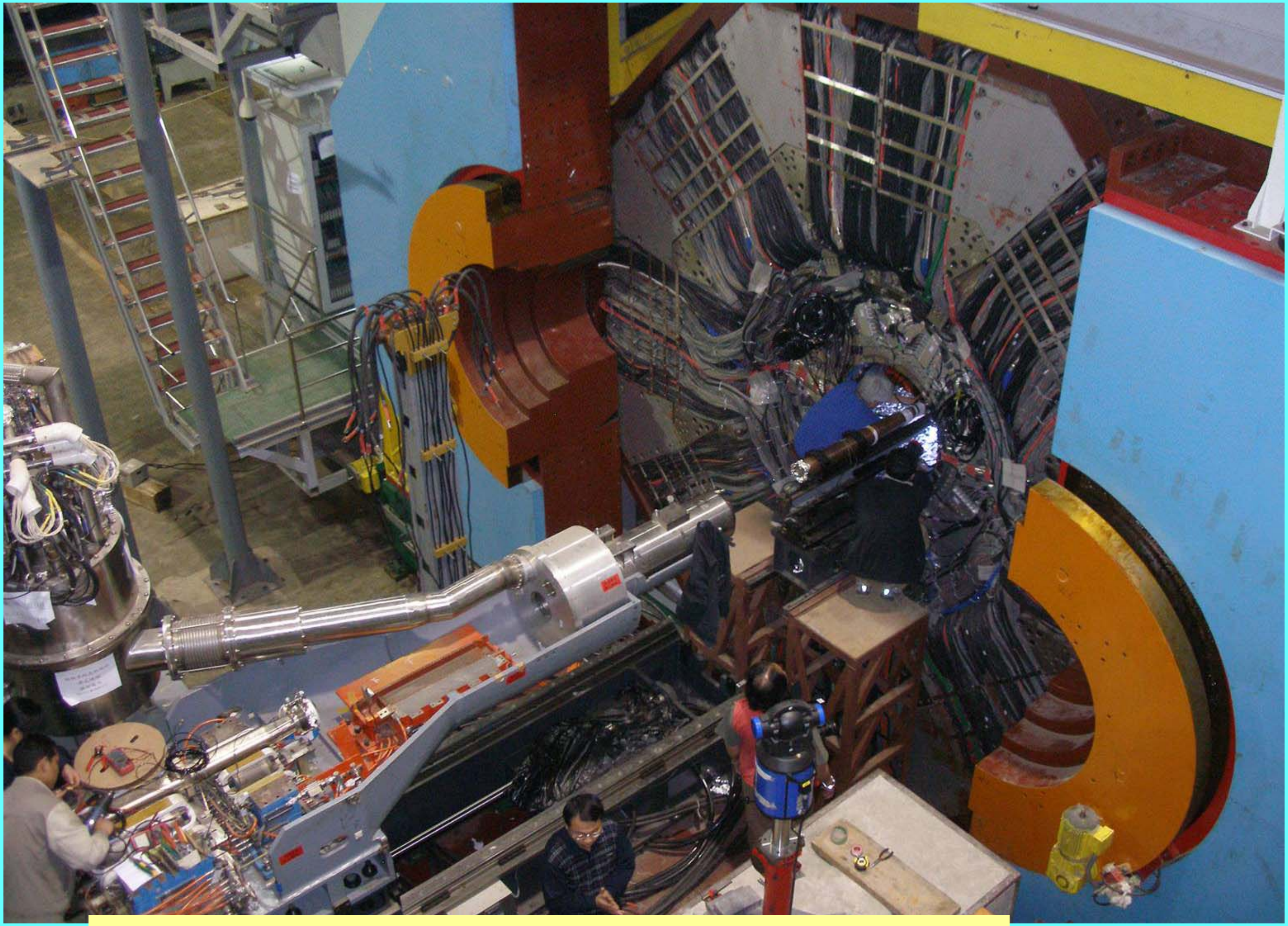
BEPC: $e^+ e^-$ at Beijing

- Xiaoyan Shen BES2 – Results
- Fred Harris: BES3 starts July 2008
- Luminosity= $5*10^{30}$ /[cm^2 sec]
- E(beam) = 1 – 2.5 GeV

Nicolaenko / Protvino: VES-Detector

Harris: BES-III Status

- May 15, 2008: detector at IP; installing SC quads and beam pipe.



- July 2008: expect collisions.

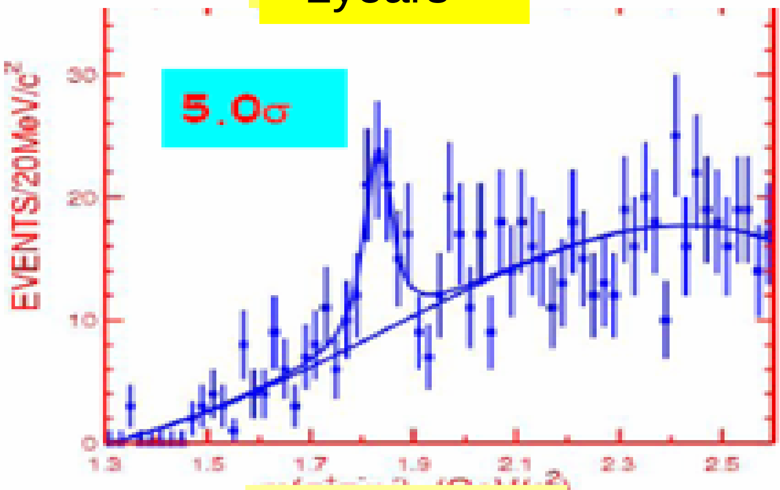
X(1835)

Study of X(1835) at BES3 using $J/\Psi \rightarrow \gamma\eta'\pi^+\pi^-$, $\eta' \rightarrow \eta\pi^+\pi^-$

using 58 M events

At BES2

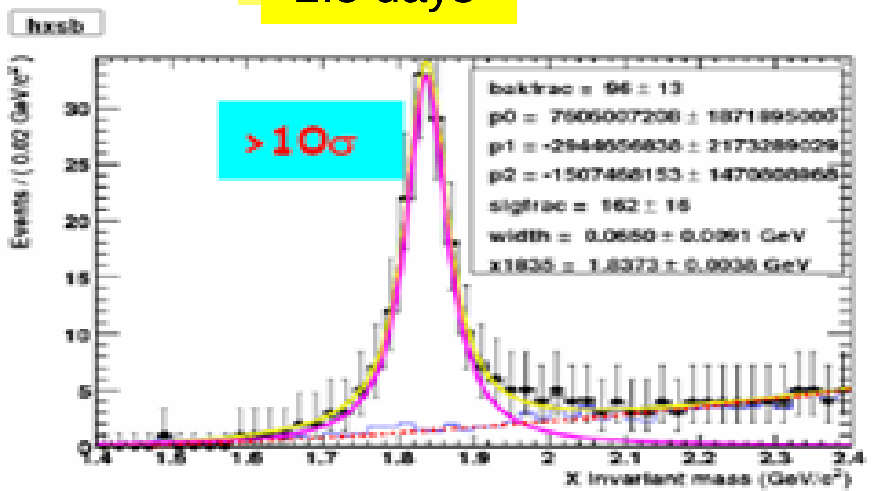
2years



$m(\eta'\pi^+\pi^-)$

At BES3

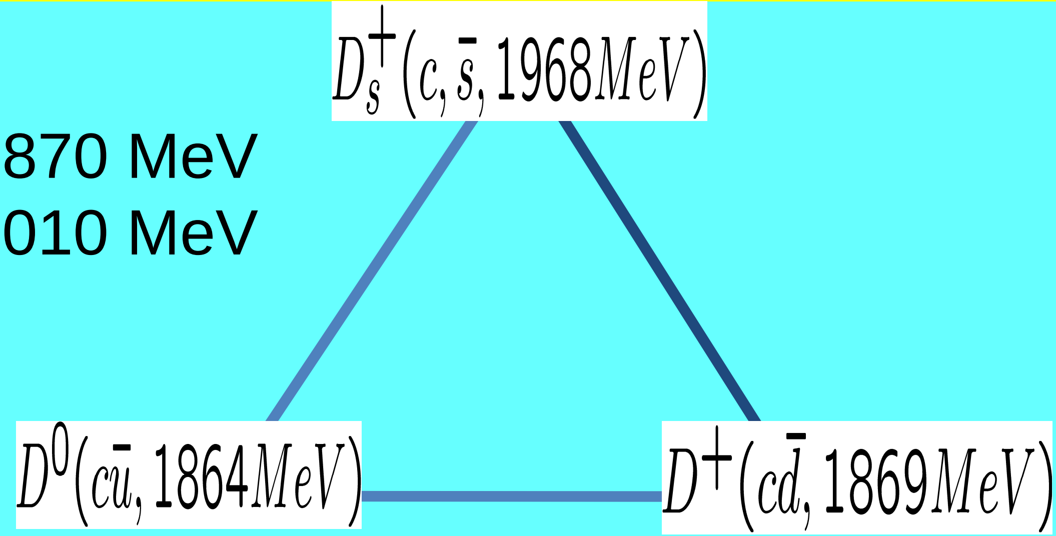
2.5 days



$m(\eta'\pi^+\pi^-)$

Have we to remeasure the Hydrogen Atom with Quarks?

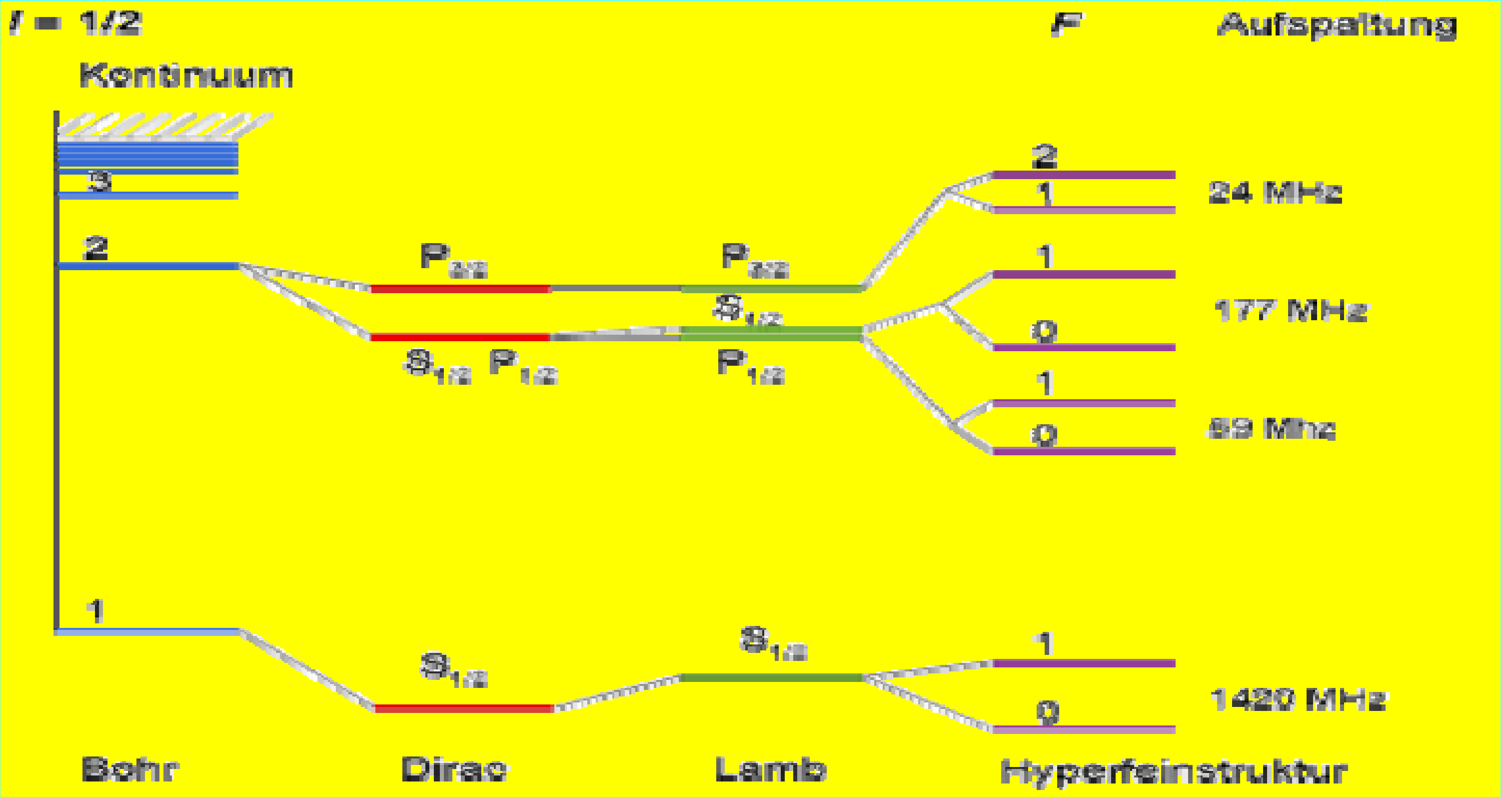
Spin = 0; M~ 1870 MeV
Spin = 1; M~ 2010 MeV



$c\bar{c}-$Mesons; Bottom-Mesons

They all follow the „Bohr-Atom“.

Hydrogen Spectrum

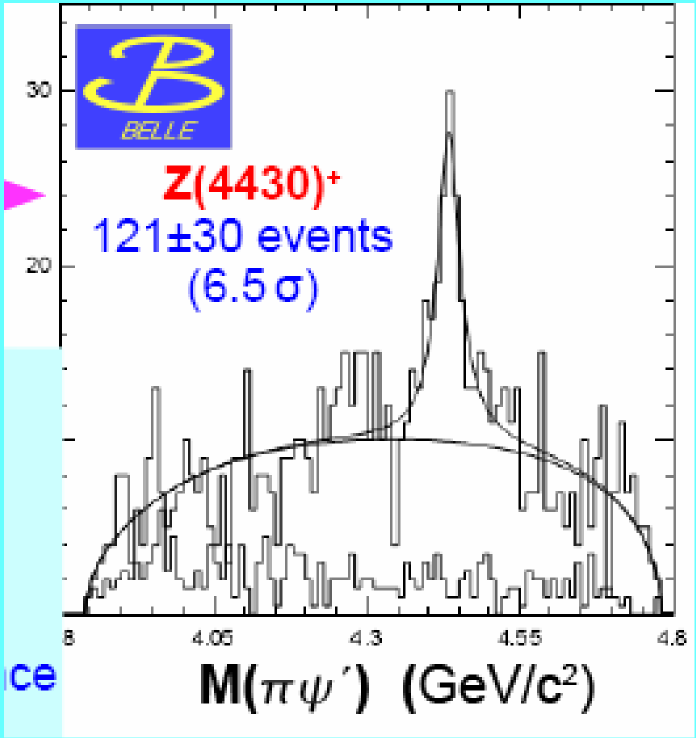


We must look for states outside the quark-antiquark picture to learn something new.

States outside the Quark-Antiquarks

BELLE: Marco Braco

I. Conventional mesons ($q\bar{q}$)
II. Hybrid states ($q\bar{q}g$)
III. Multiquark states ($q\bar{q}$ $q\bar{q}$ or $qq\,\bar{q}\bar{q}$)
IV. Glueballs (gg, ggg)
V. Mixtures of states above
VI. More exotic states?

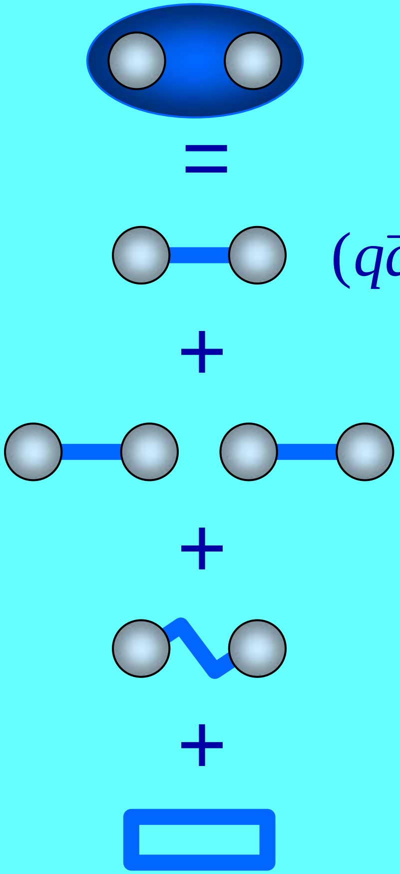


New state observed in $B \to K\pi^{\pm}\psi(2S)$ decays

- $B \to K\pi^{\pm}\psi'$ ($K=K^{\pm}$, K_S^0; $\psi' \to l^+l^-$ or $J/\psi\pi^+\pi^-$)

Tetraquark: $[cu][\bar{c}\bar{d}]$? ? ?

Ketzer: Meson Spectroscopy at COMPASS



$=$ $(q\bar{q})_0$

$+$ $(q\bar{q})(q\bar{q})$

$+$ $(q\bar{q})_8\, g$

Hybrids

$+$ gg

Glueballls

$+ \ldots$

Quark model: bound state of quark-antiquark

Quantum numbers: $I^G\,(J^{PC})$

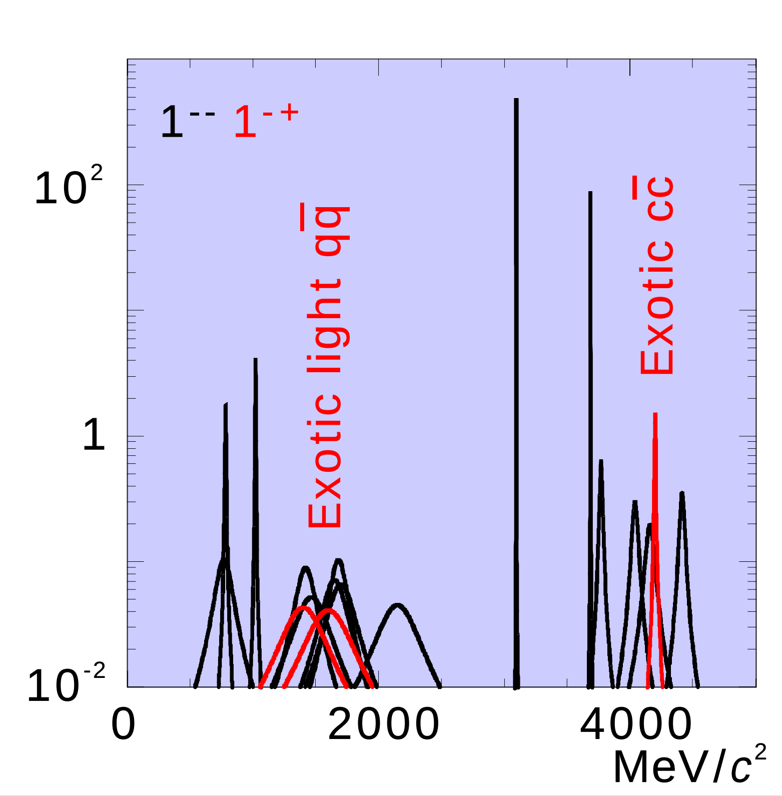
$P=(-1)^{l+1}$, $C=(-1)^{l+s}$, $G=(-1)^{I+l+s}$

Exotic J^{PC} = $0^{--}, 0^{+-}, 1^{-+}, 2^{+-}, \ldots$

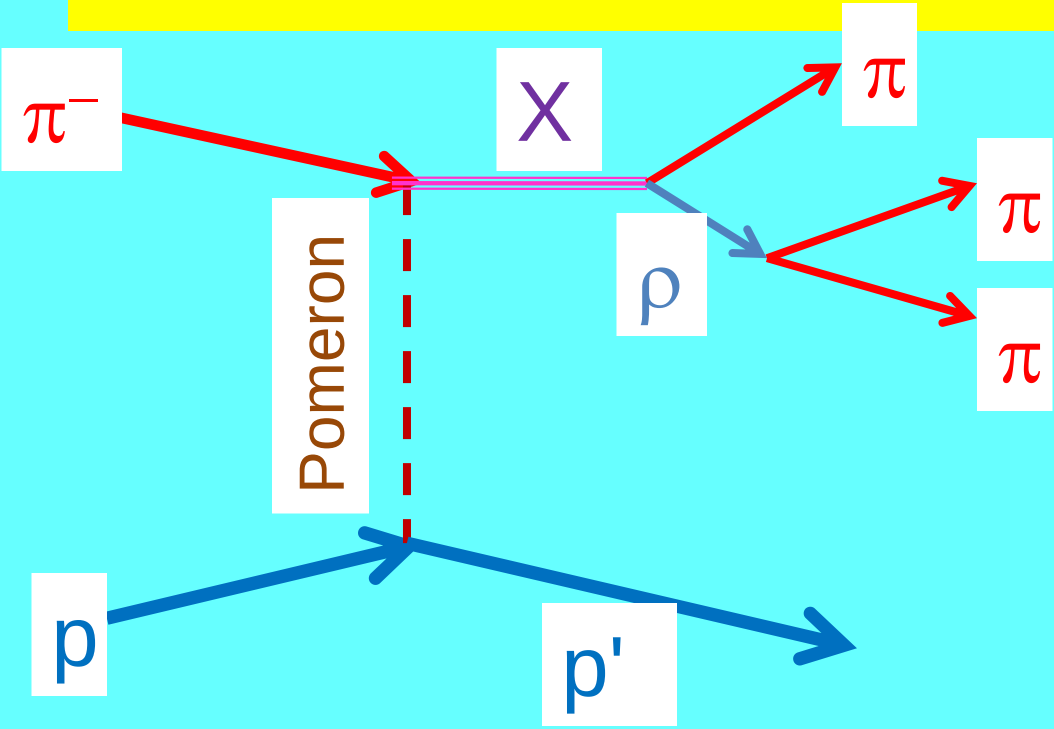
Compass; Ketzer:
Hybrid: Quark-Antiquark + nGluons

- π_1(1400) (VES, E852, Crystal Barrel)
- π_1(1600) (E852, VES) still controversial...

COMPASS



Compass: Ketzer, München

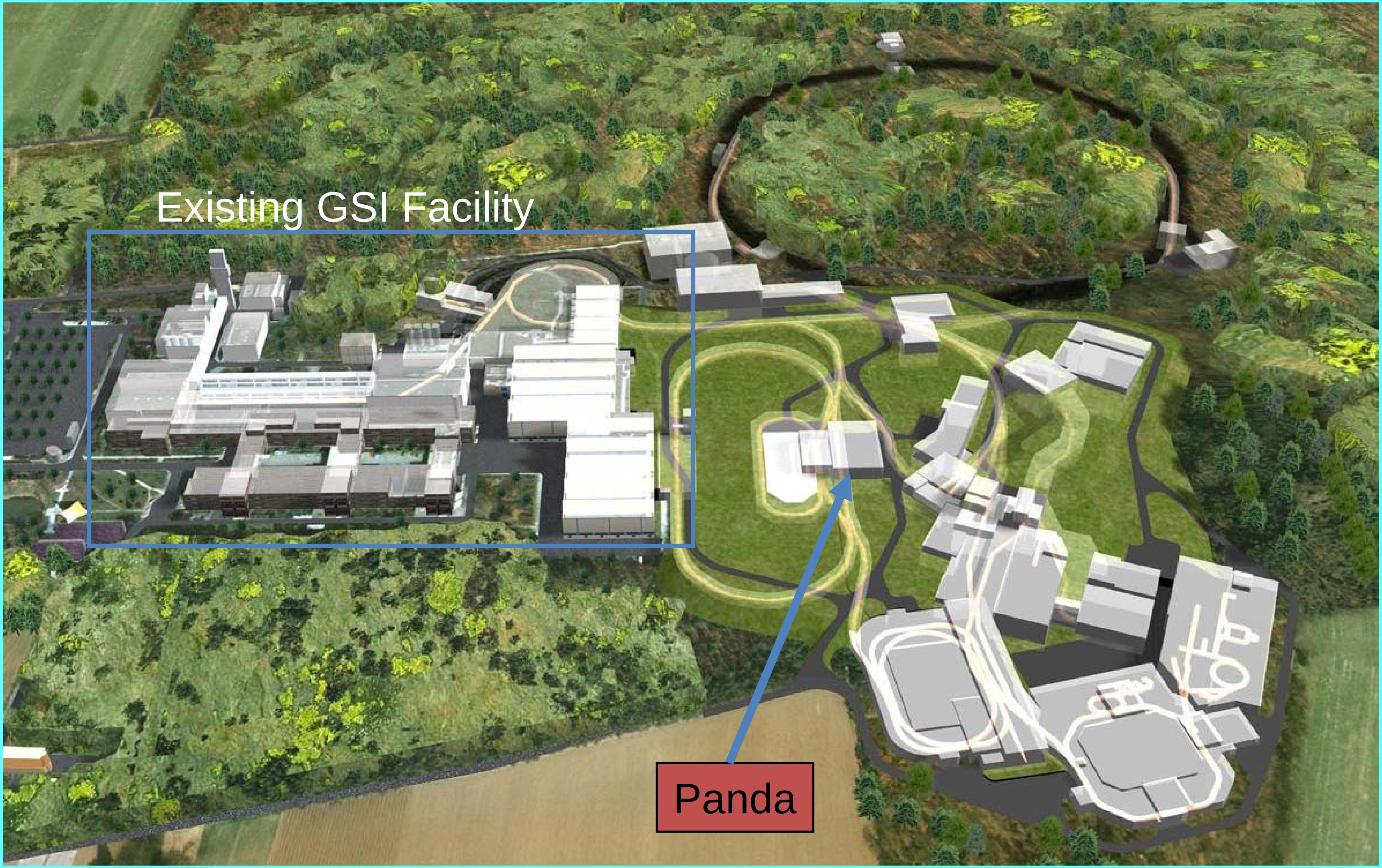


Partial Wave Analysis

Exotic Quantum numbers → Hybrid ?

$$X: \quad J^{PC} = 1^{-+}$$

Lange: PANDA Proton-Antiproton Physics at GSI



Lange/Giessen and Maas/Mainz: Panda (Proton-Antiproton) Physics

Charm spectroscopy

- charmonium: Positronium of QCD
- charm hybrids
- c-states narrow, understood
- mass 4–4.5 GeV
  - c c g narrow
  - little interference between ccg and cc-states
- charm meson spectroscopy

Hypernuclei

- 3rd dimension in nuclear chart
- study interactions of nucleons in the nuclear potential
- PANDA: Double Hypernuclei
  - production via Ξ- capture
- Λ Λ interaction in nucleus

Charm in the Medium

- mesons in nuclear matter
- masses change in nuclei
- D-mass lower
- enhanced charmonium states due to lower D D threshold
- J/ψ absorption in nuclei

Maas

Electromagnetic formfactors

- discrepancy between timelike and spacelike region
- Measure pp $\rightarrow e^+e^-$

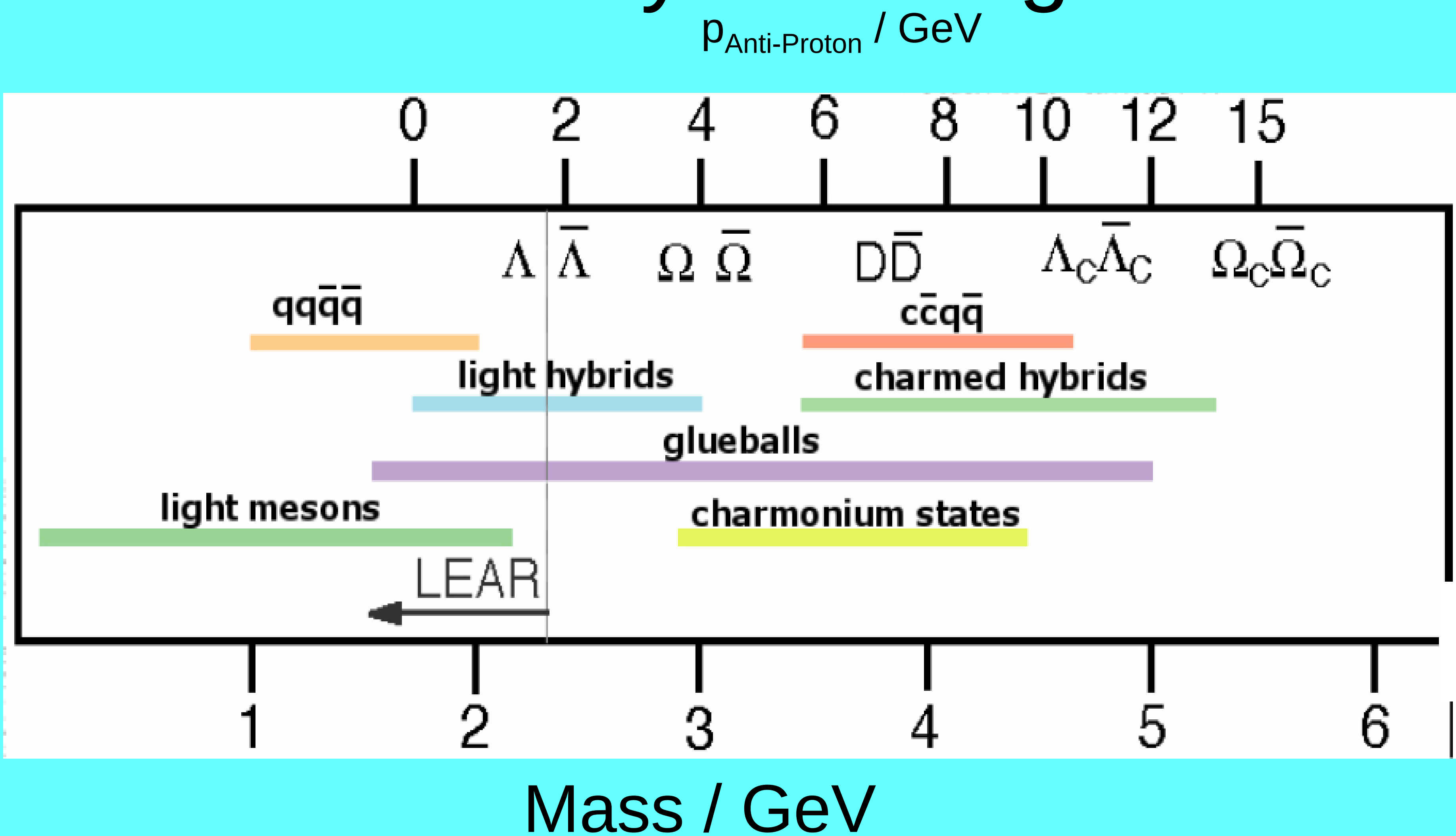
Generalized Parton Distributions

- wide angle Compton scattering
- hard exclusive meson production

Transverse nucleon spin

- Drell Yan Process
- *(full PWA or polarized beam/target)*

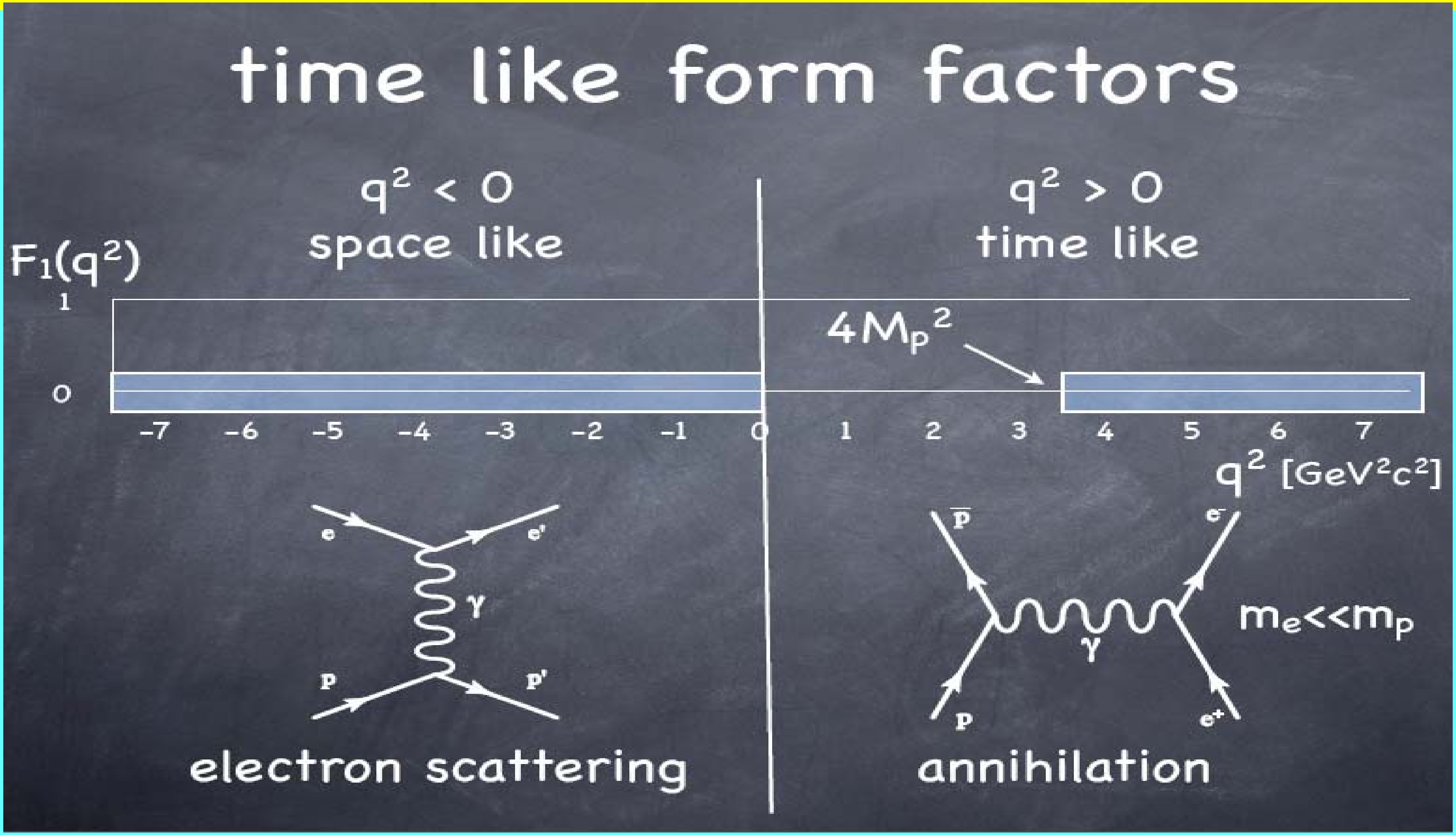
Panda Physics Program



Frank Maas: Time like

$$q^2 = \Delta E^2 - \vec{q}^2 > 0$$

nucleon form factors with antiprotons at PANDA



Thanks to the organizers:

Scientific Secretary: Staszek Kistryn

Organizers: Carlo Guaraldo
Hartmut Machner
Andrzej Magiera

and to all other members of the organizing committee

Have a safe trip back!

The END