Spectroscopy of η' Mesic Nuclei with (*p*,*d*) Reaction

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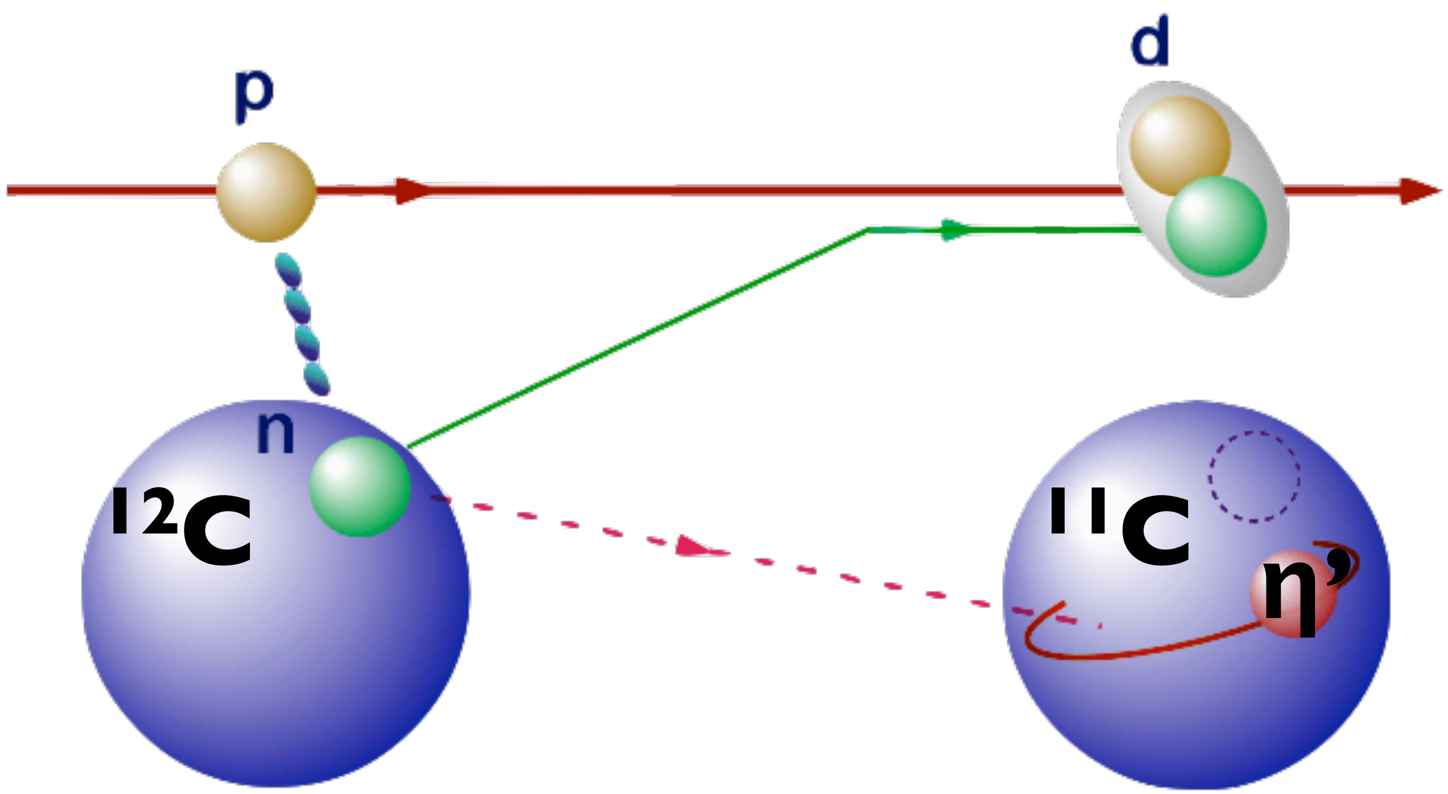
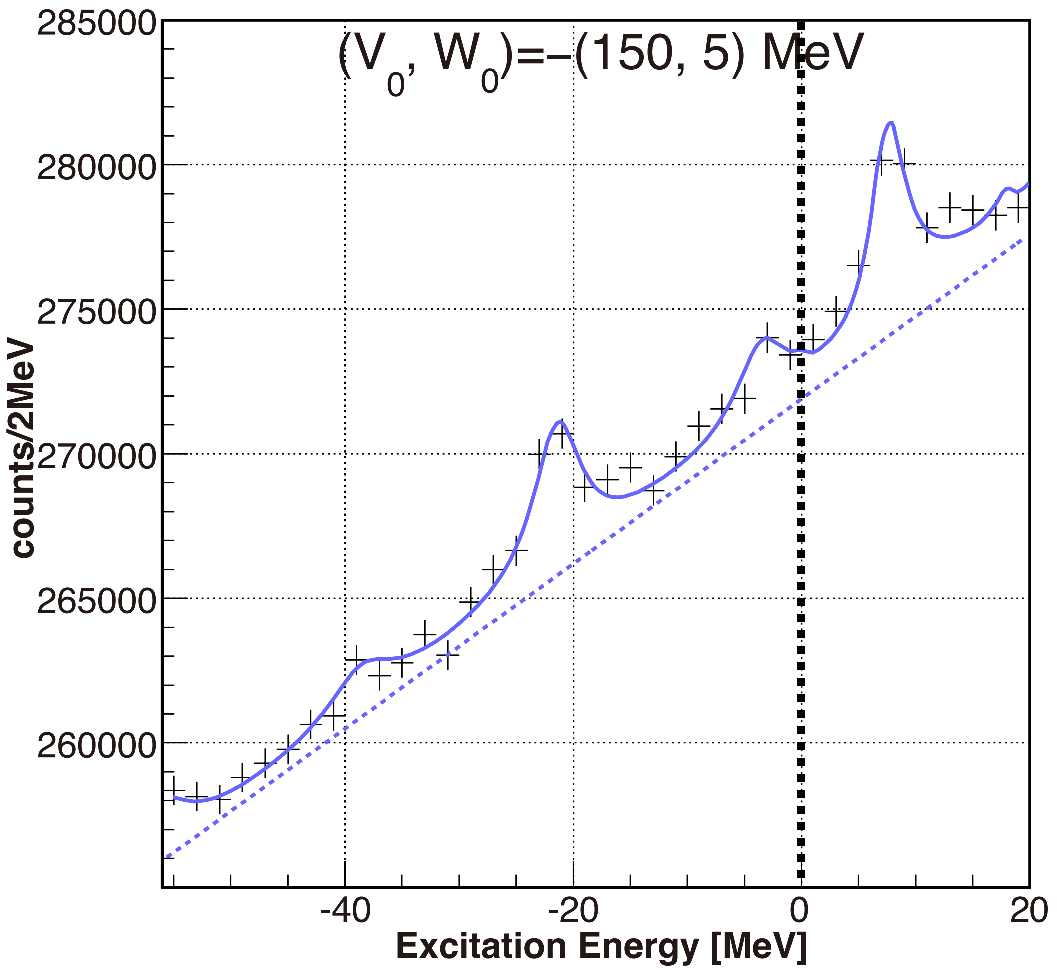
GSI

Summary

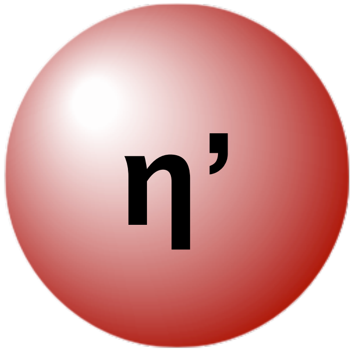
Missing mass spectroscopy by (*p*,*d*) reaction
to study η' meson bound states



η' meson bound states



η' Meson



Pseudo scalar meson ($J^{\pi}=0^{-}$)

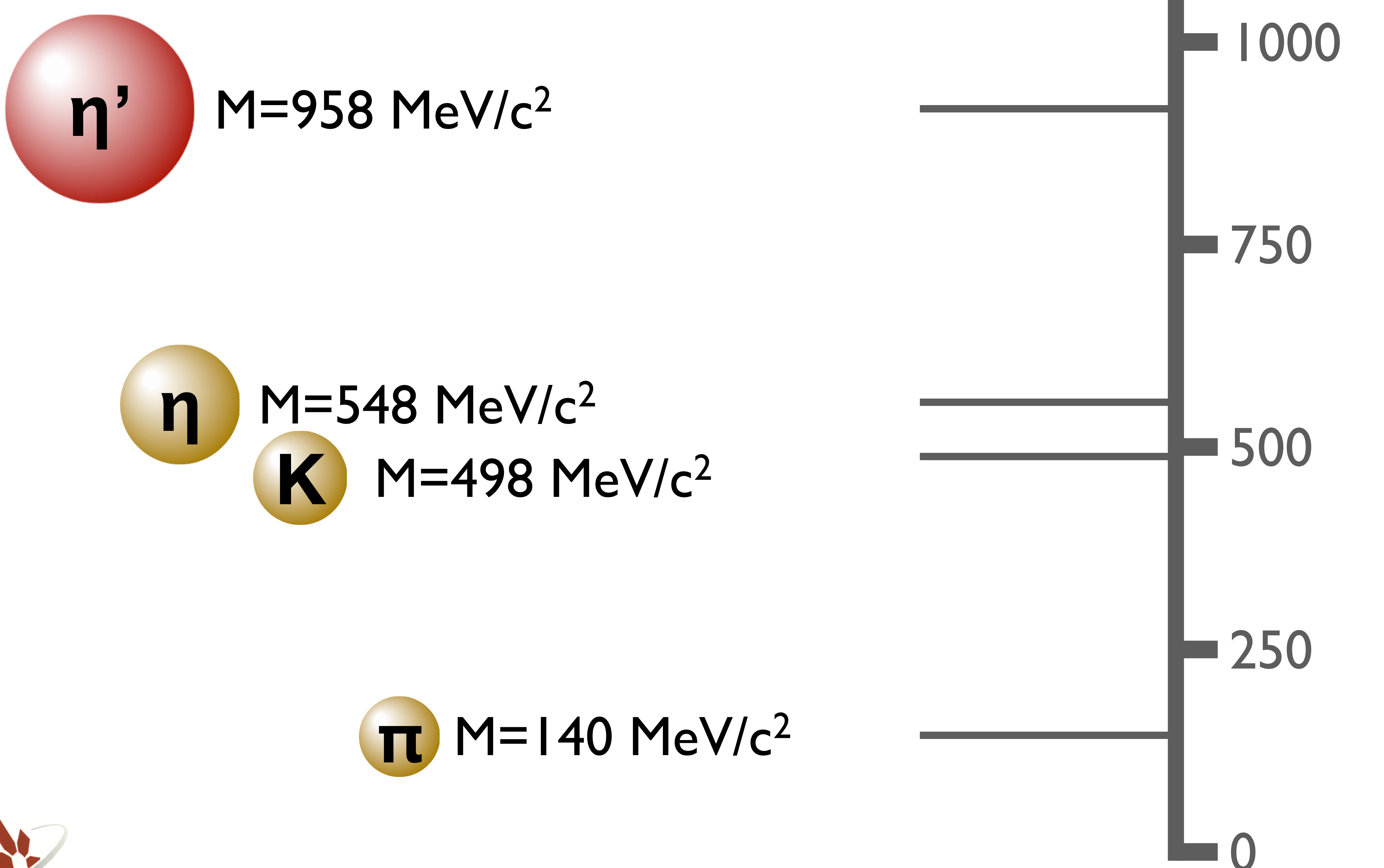
$M=958\ \mathrm{MeV}/c^2$

$\Gamma=0.199\ \mathrm{MeV}$

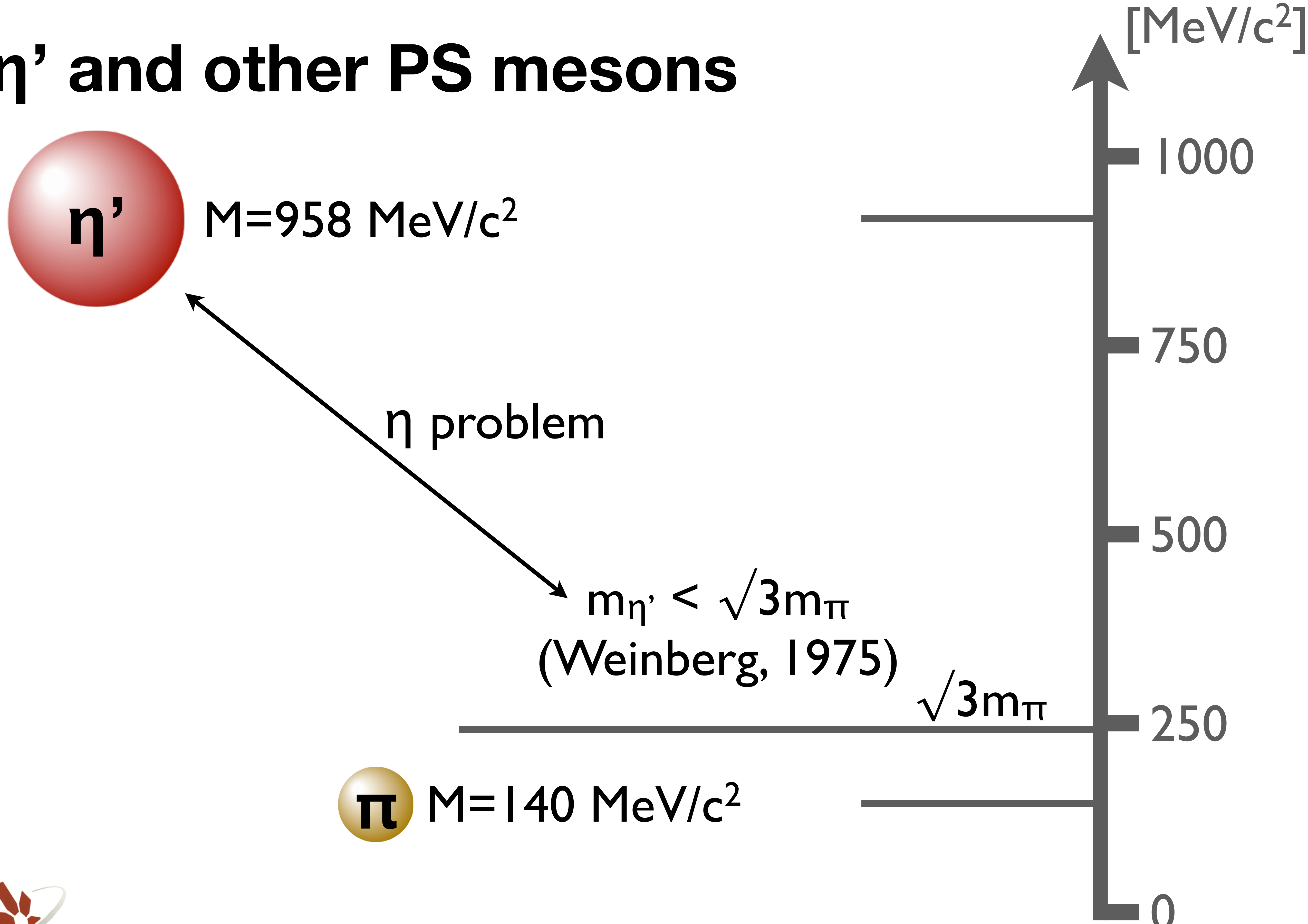
Decay: $\pi^{+}\pi^{-}\eta$(43%),

$\rho\gamma$(29%), $\pi^{0}\pi^{0}\eta$(22%)

η’ and other PS mesons

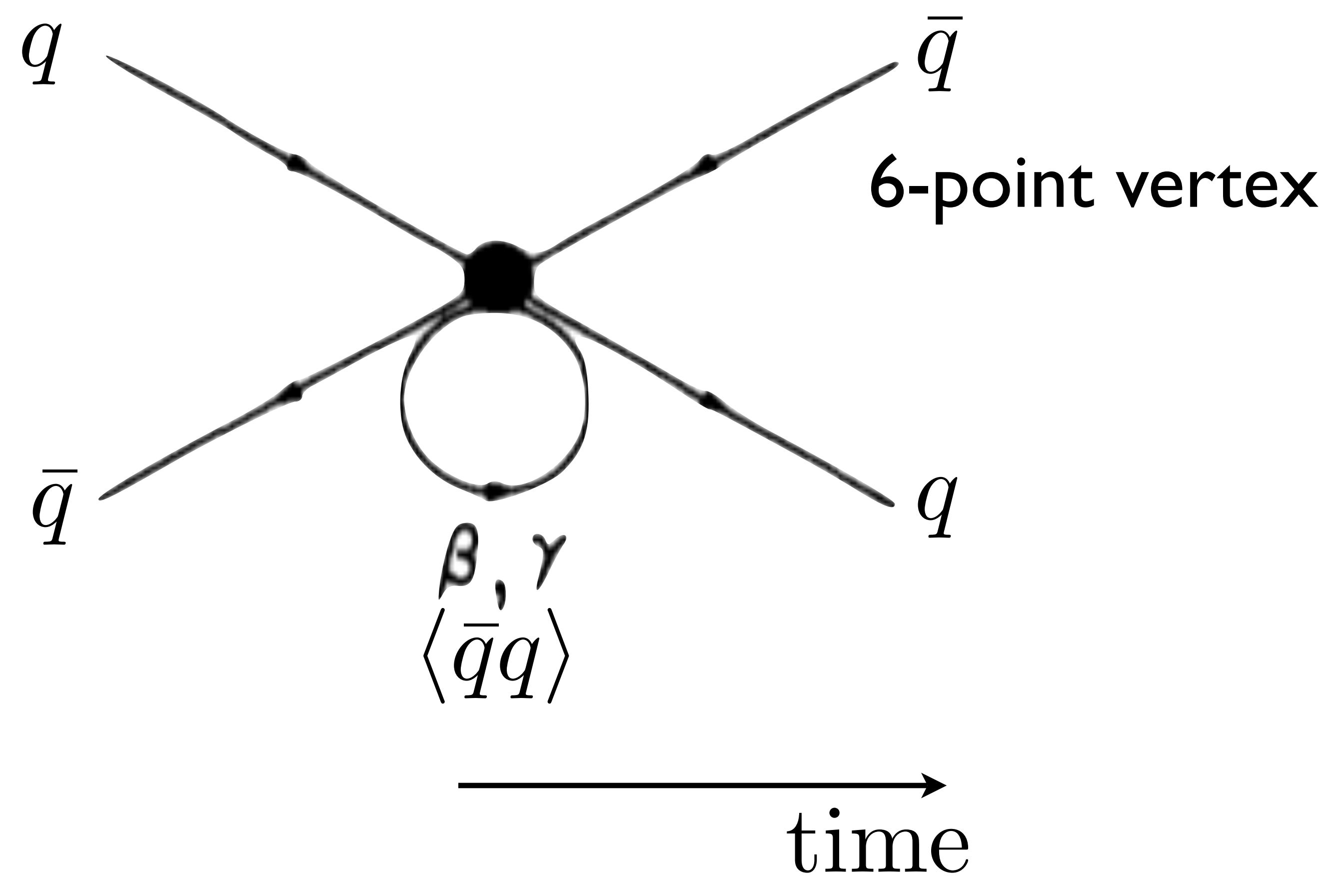


η’ and other PS mesons



Large η' mass can be explained

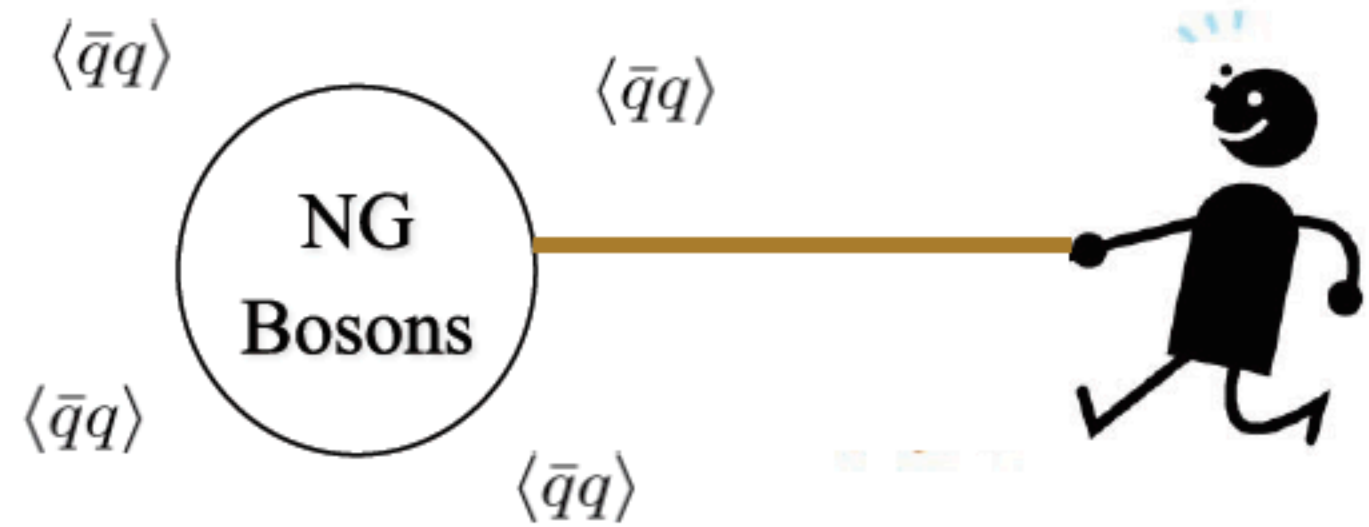
$U_A(1)$ symmetry breaking term of
effective Lagrangian

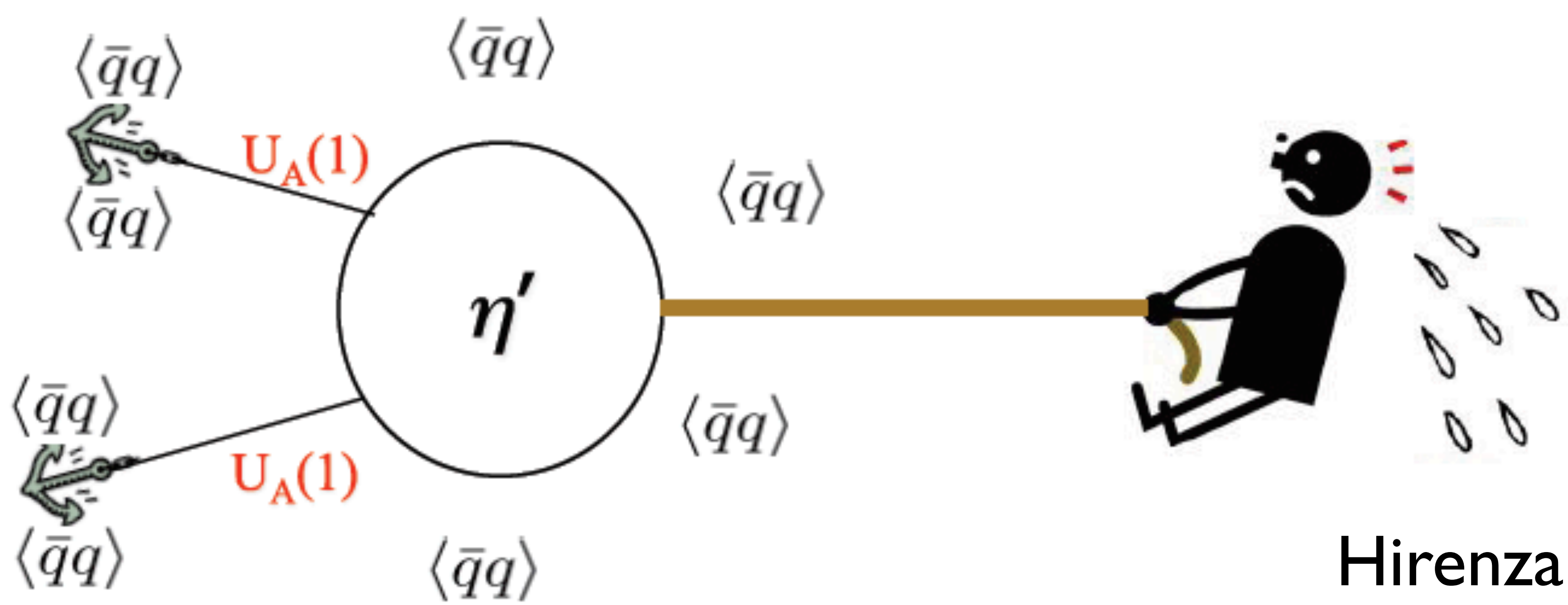


Kobayashi-Maskawa-'t Hooft-type interaction

Kobayashi, Maskawa, PTP44(70)1422
't Hooft, PRD14(76)3432.
T. Kunihiro, Phys. Lett. B219(89)363.
Klimt, Lutz, Vogl, Weise, NPA516(90)429.

η’ Meson

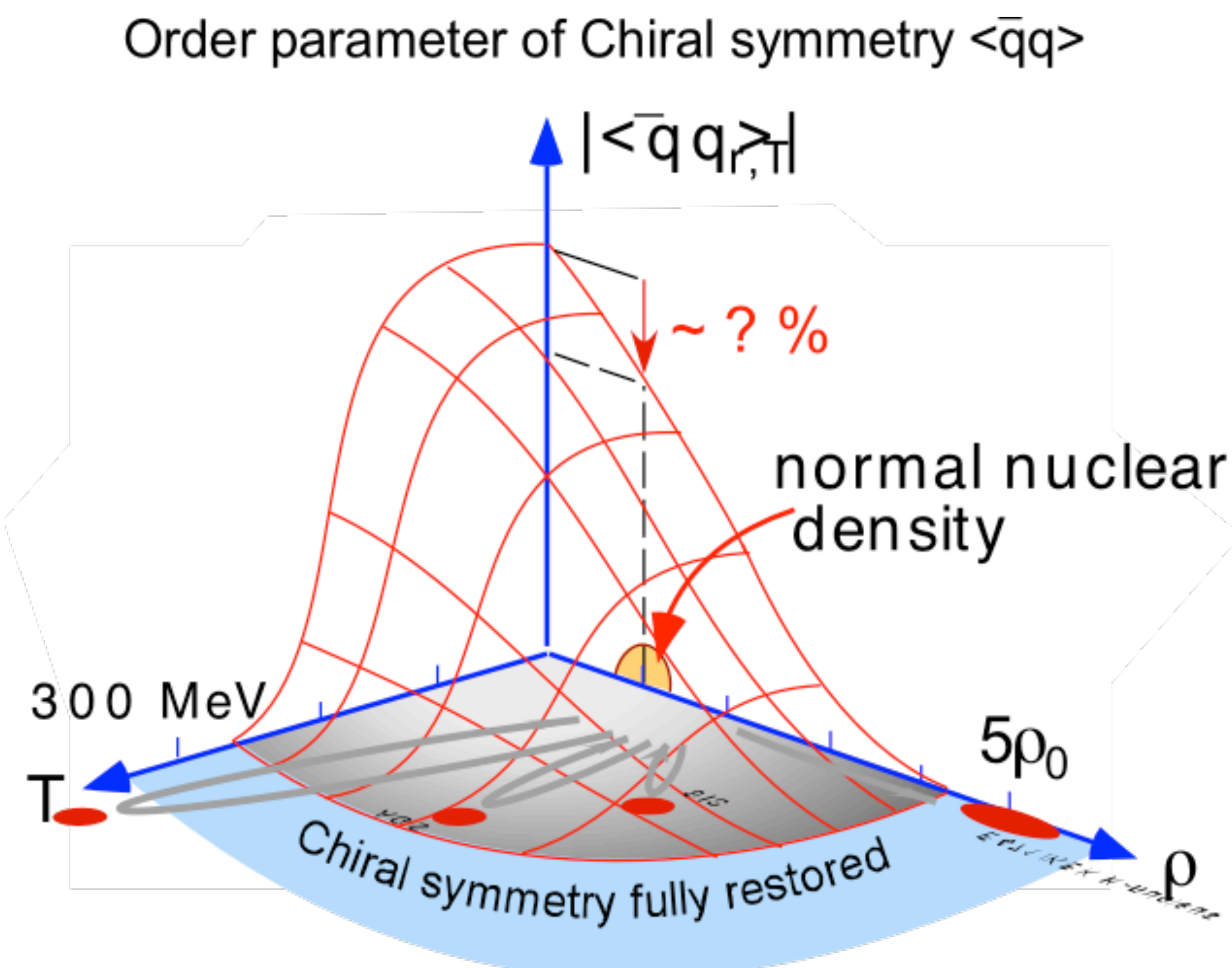




Hirenzaki

η' in medium

Chiral Condensate in Finite T/ρ

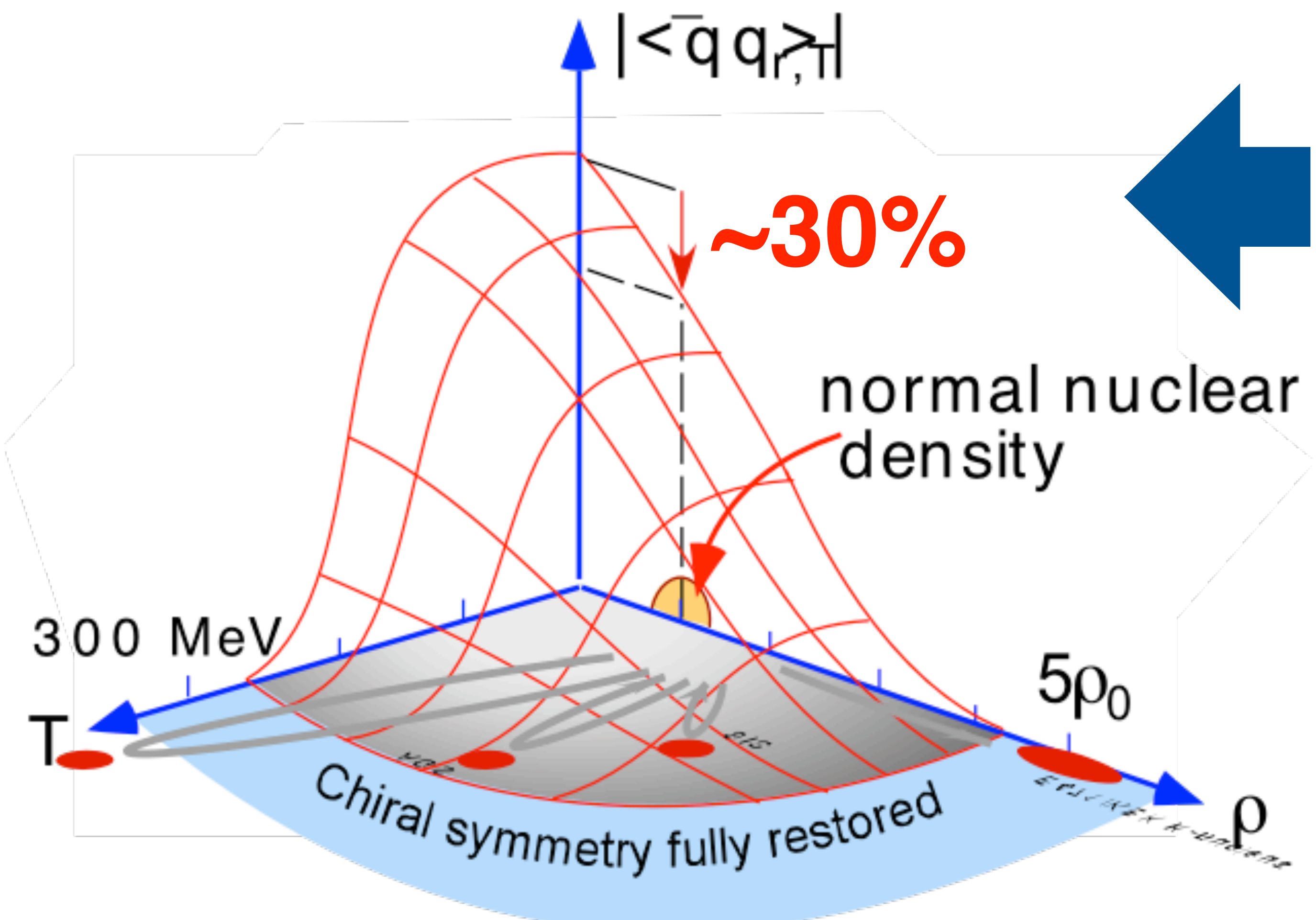


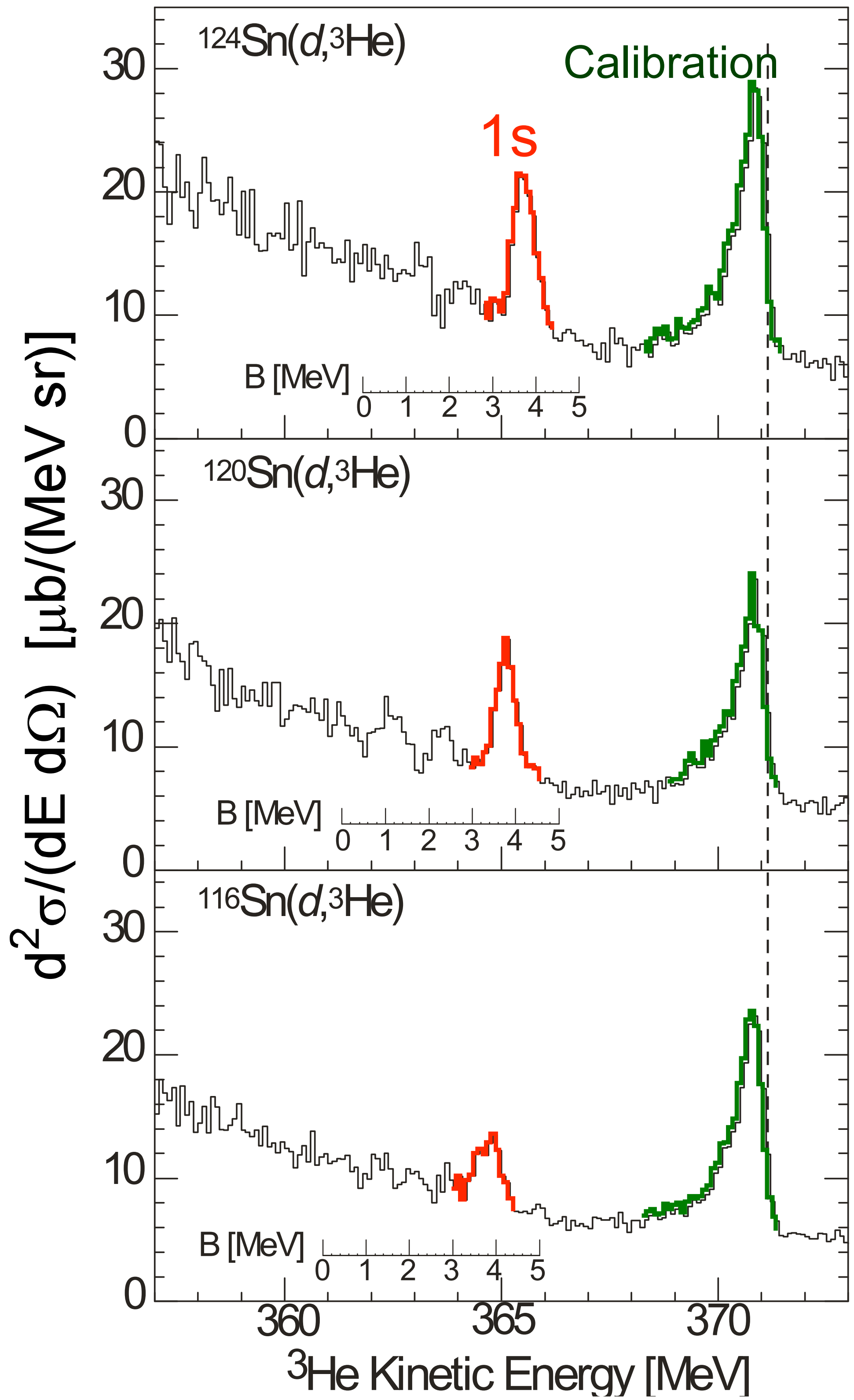
W.Weise, NPA553(93)59.

Chiral Symmetry and Pionic Atoms

S236: Pionic Atom Spectroscopy at FRS

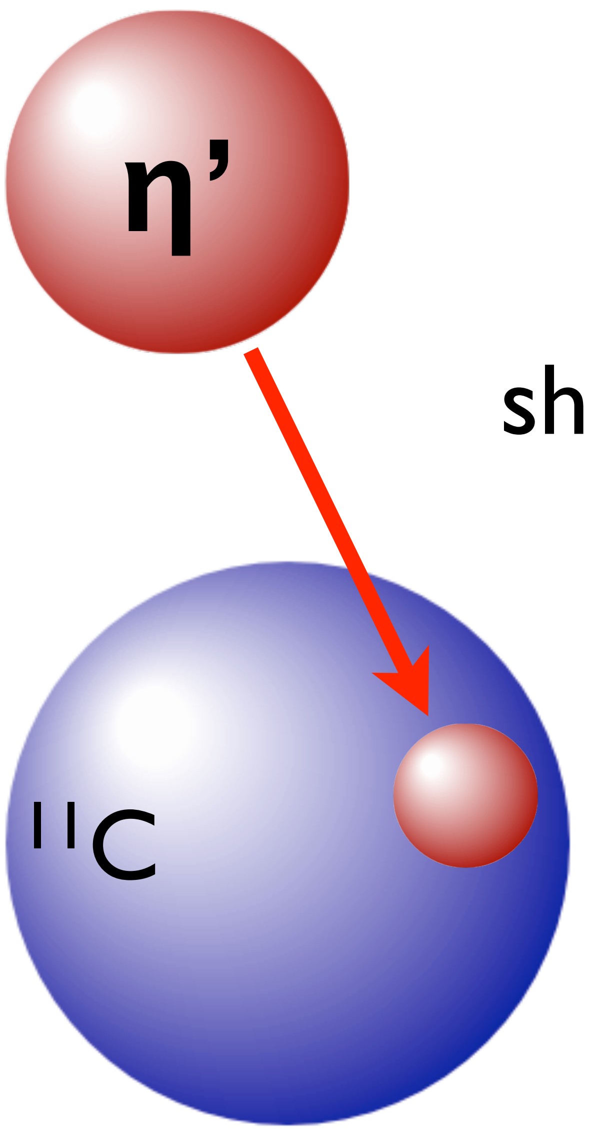
Order parameter of Chiral symmetry <$\bar{q}q$>



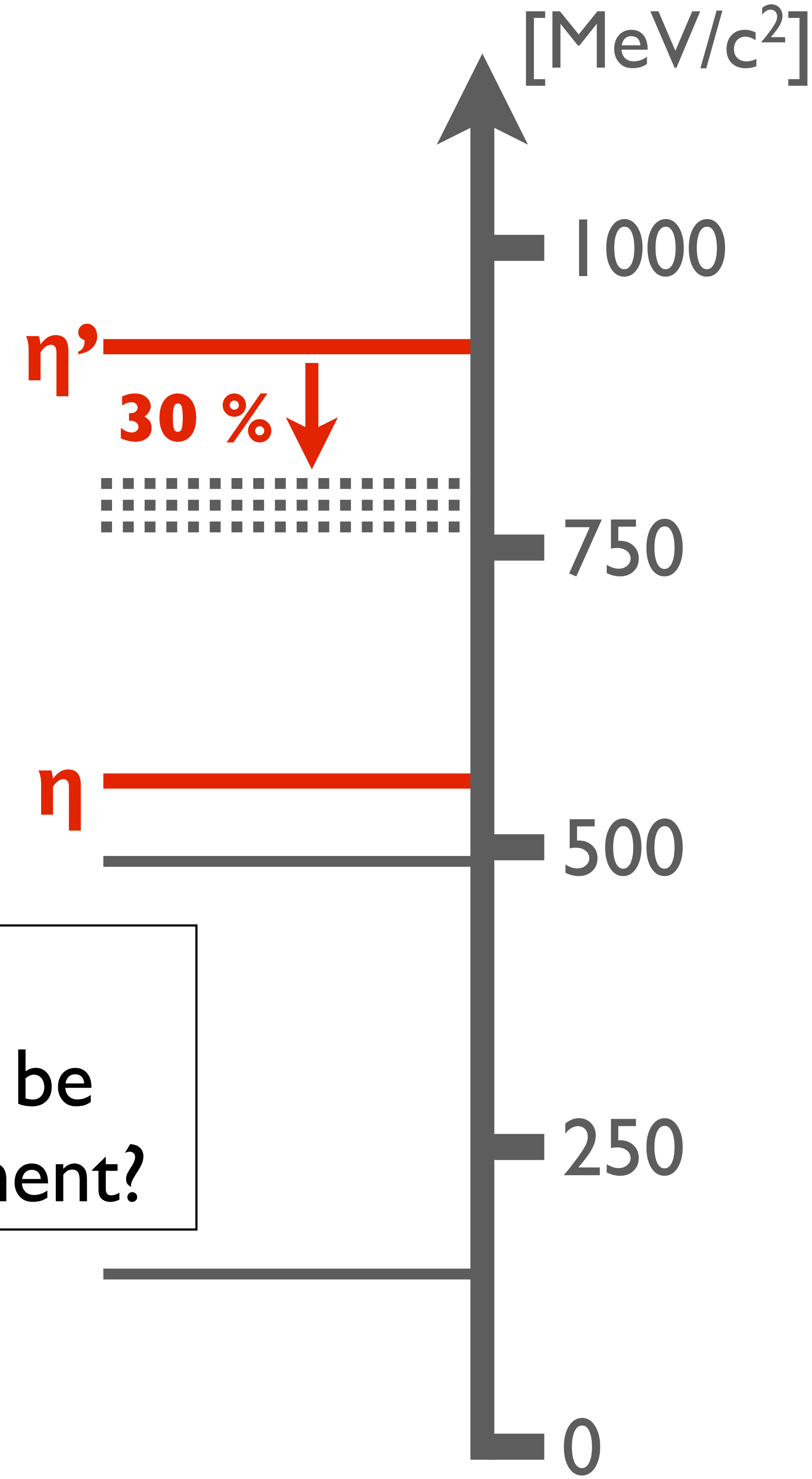


K.Suzuki et al., PRL92(04)072302

η’ in-medium



Naive estimation
shows 30% reduction
of $|m_{\eta'} - m_{\eta}|$



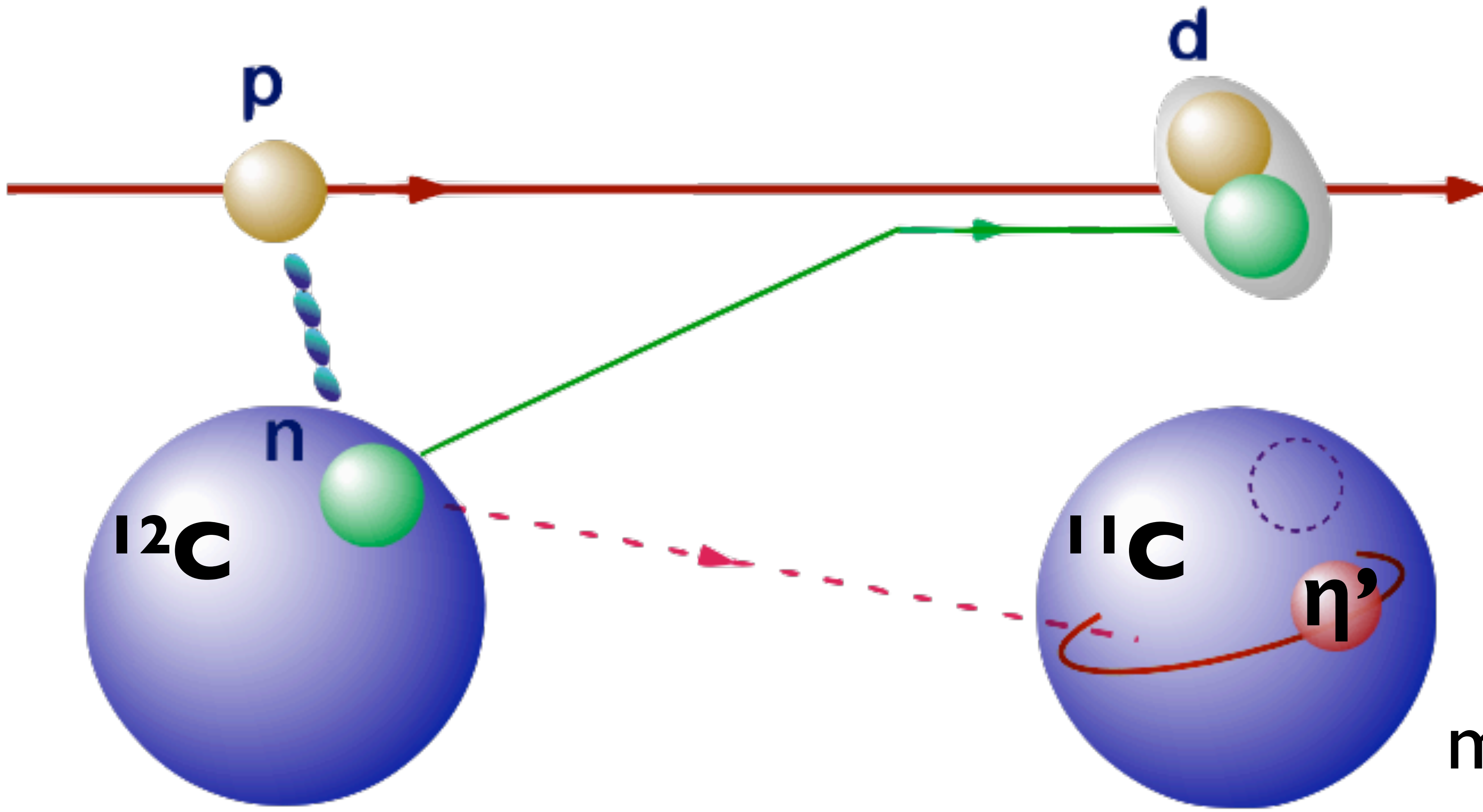
Q. Mass shift of
~ 140 MeV/c^2 can be
observed in experiment?

Jido, Nagahiro,
Hirenzaki,
arxiv 1109.0394

Experimental spectroscopy of η' mesic nuclei

η' Mesic Nuclei in (*p,d*) Reaction

η' transfer reaction + Missing mass measurement



η' × ^{11}C
mesic nuclei

T_p = 2.50 GeV → q ~ 400 MeV/c

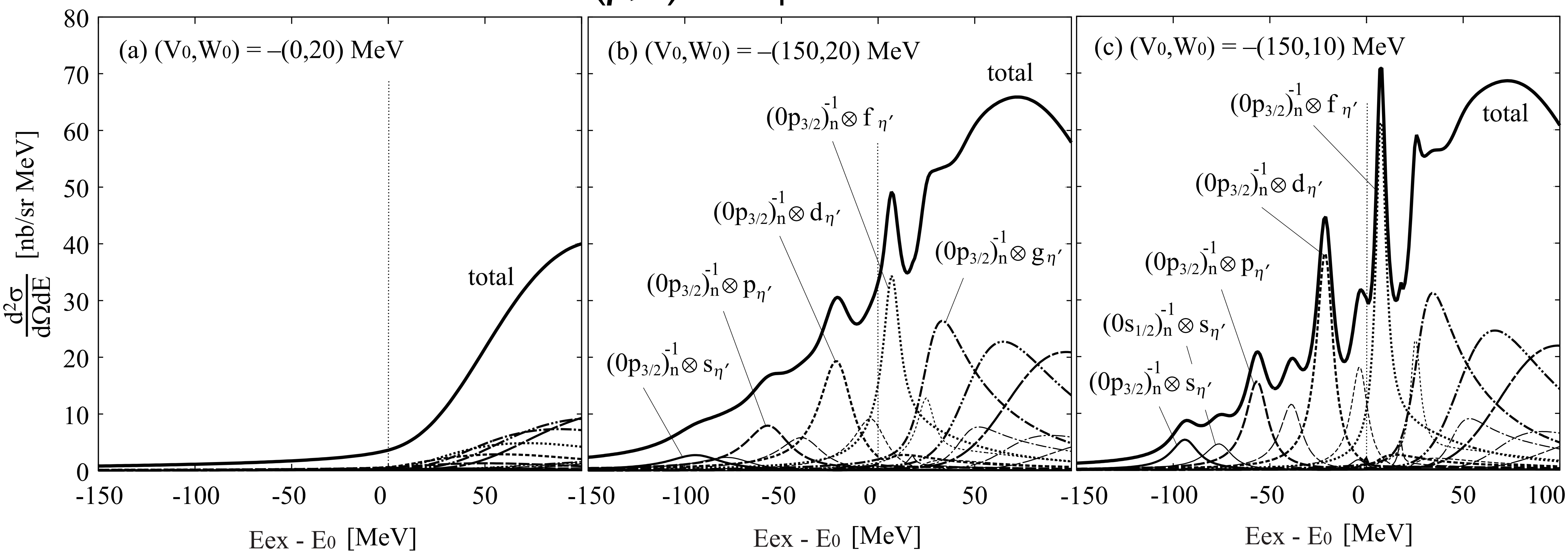
Theoretical Prediction

η'-nucleus potential:

$$V_{\eta'}(r) = (V_0 + iW_0)\,\frac{\rho(r)}{\rho_0}$$

ρ: nucleon density
V_0: Real potential depth
W_0: Imaginary potential depth

$^{12}C(p,d)$ at T_p = 2.50 GeV



Nagahiro, Hirenzaki, Jido, private communication

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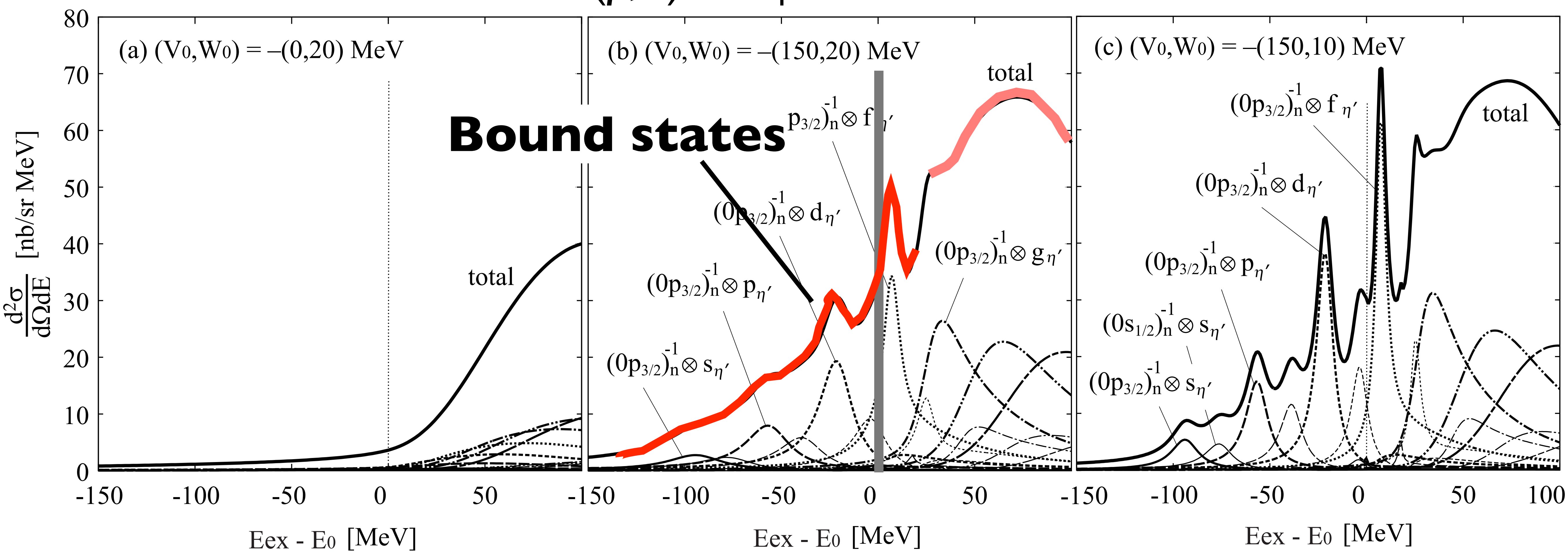
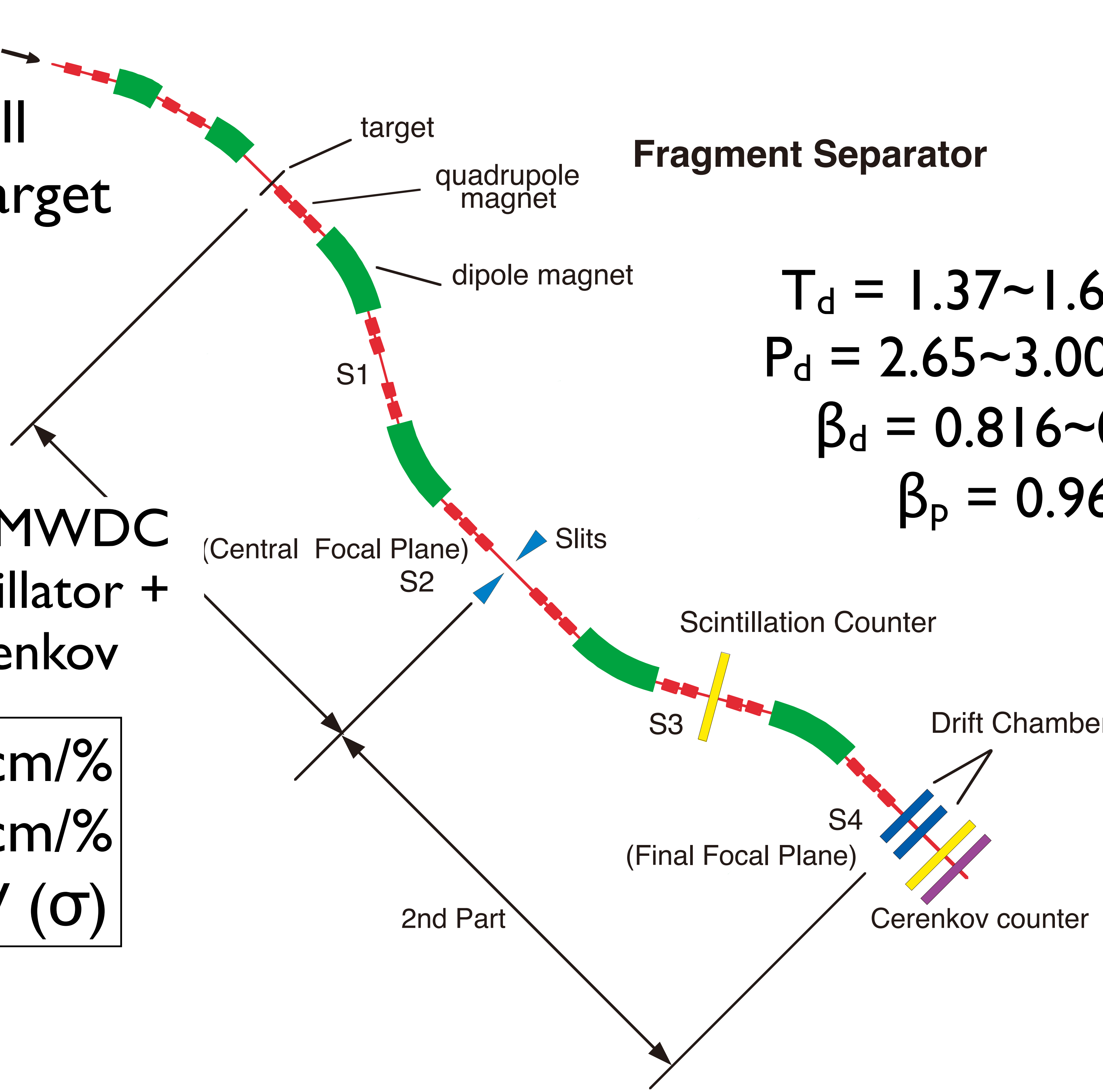


Nagahiro, Hirenzaki, Jido, private communication

Experimental Setup

$I_p = 10^{10}$/spill
4 g/cm^2 ^{12}C target



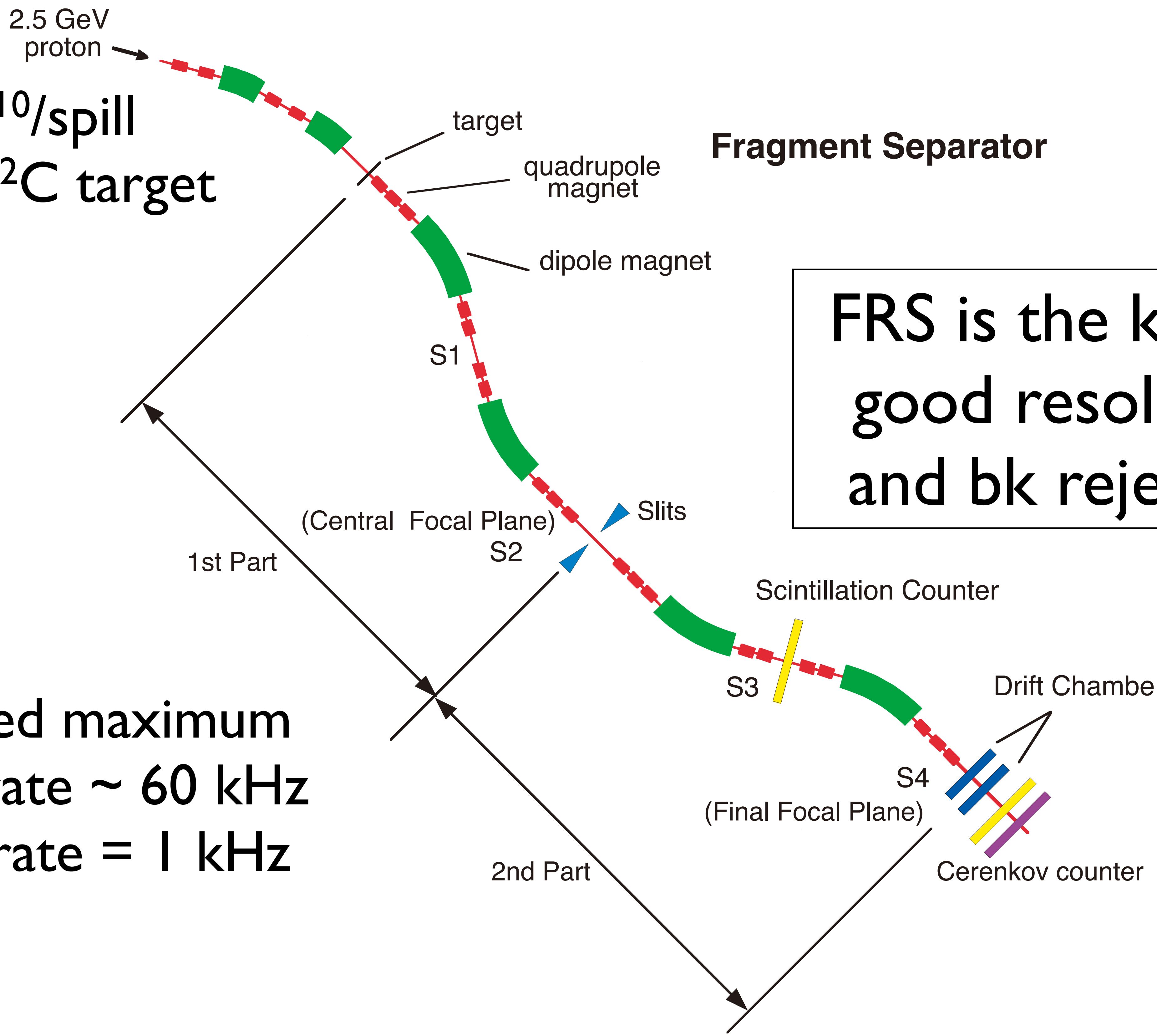
T_d = 1.37~1.66 GeV
P_d = 2.65~3.00 GeV/c
β_d = 0.816~0.848
β_p = 0.962

Tracking = 2 x MWDC
PiD = 2 x Scintillator + Aerogel Cerenkov

TA-S2 0.3 cm/%
TA-S4 5.5 cm/%
→ 1.6 MeV (σ)

Experimental Setup

$I_p = 10^{10}$/spill
4 g/cm^2 ^{12}C target



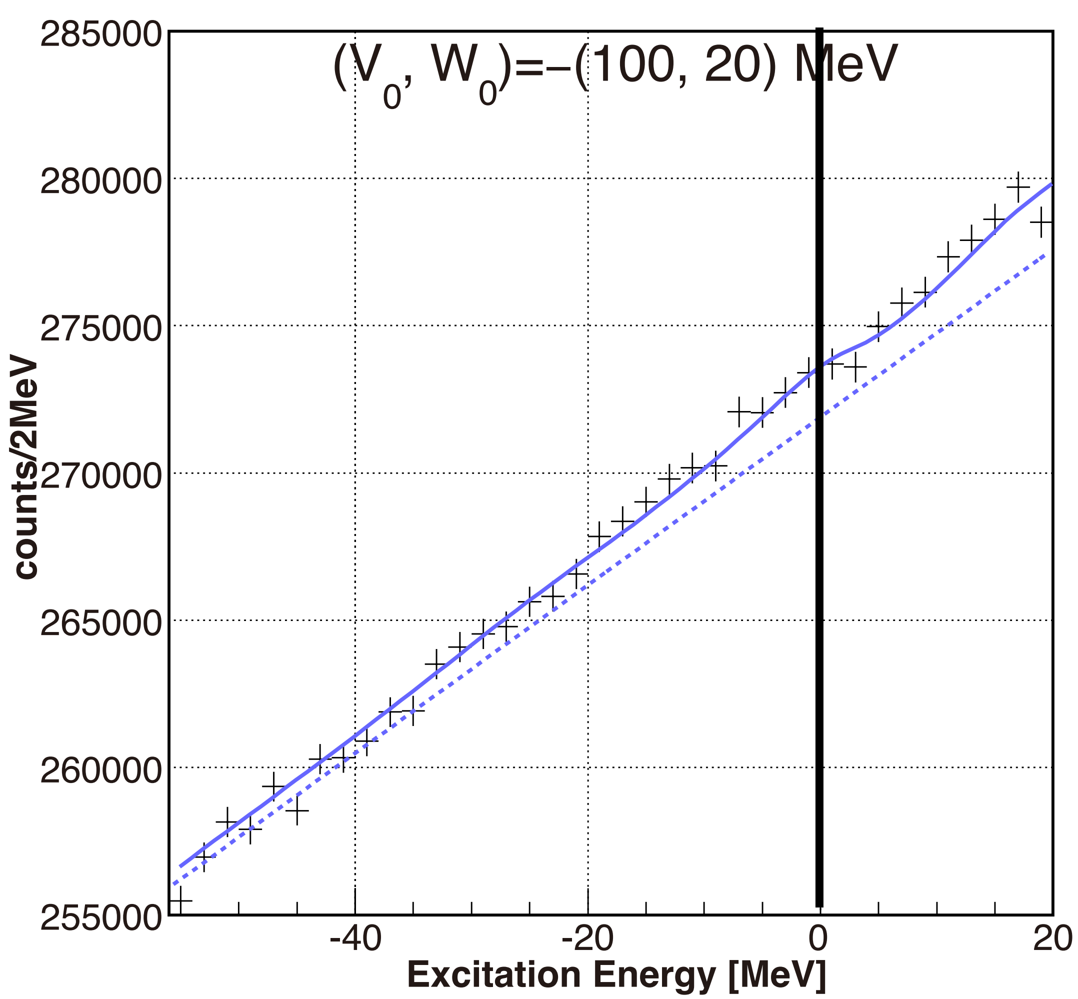
FRS is the key for good resolution and bk rejection

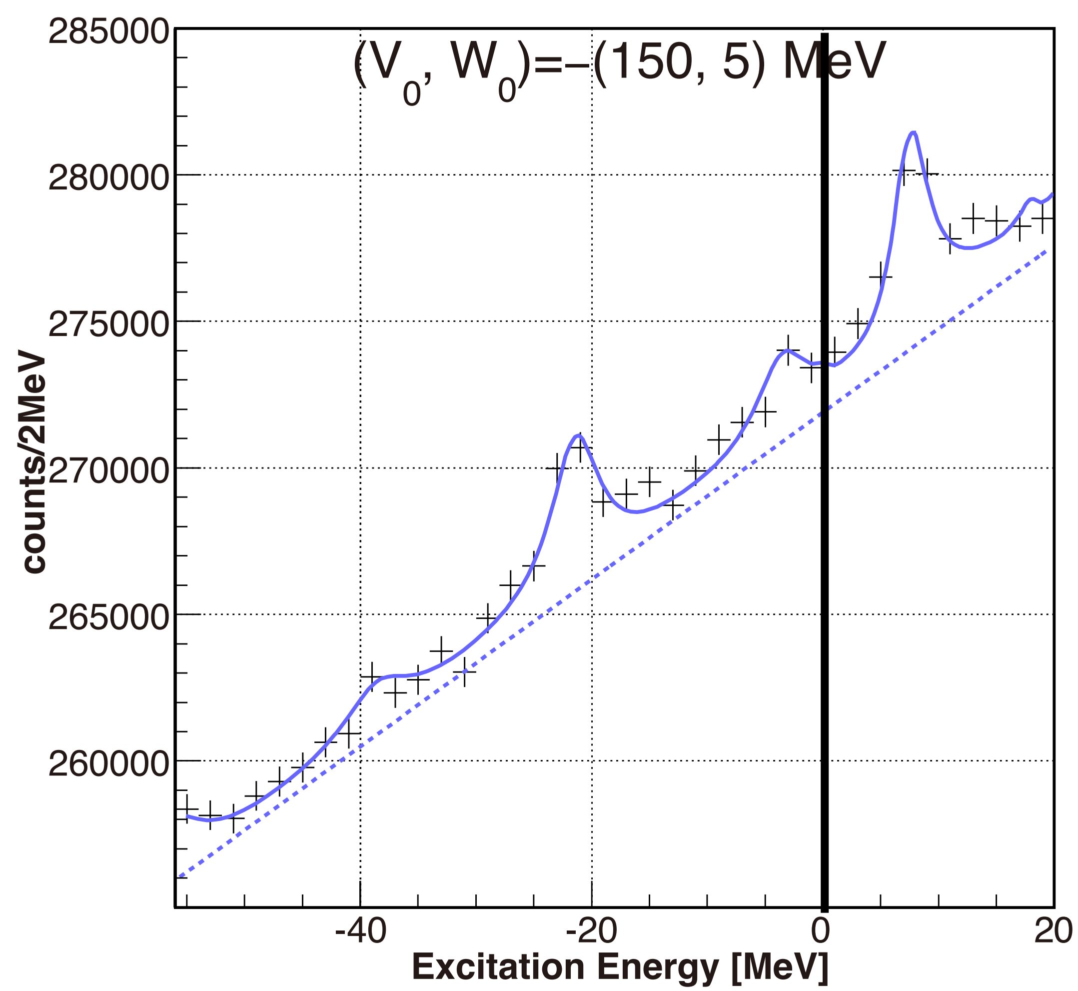
Estimated maximum proton rate ~ 60 kHz
trigger rate = 1 kHz

Expected Spectra

$$V_{\eta'}(r) = (V_0 + iW_0)\,\frac{\rho(r)}{\rho_0}$$

ρ: nucleon density
V_0: Real potential depth
W_0: Imaginary potential depth

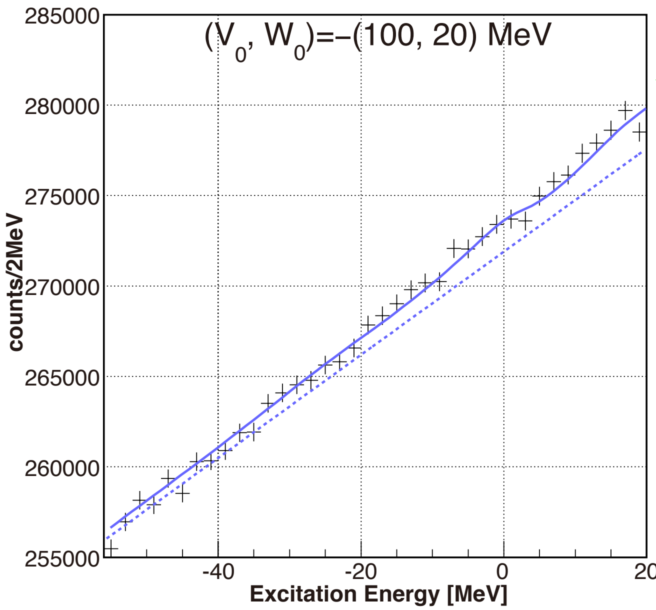


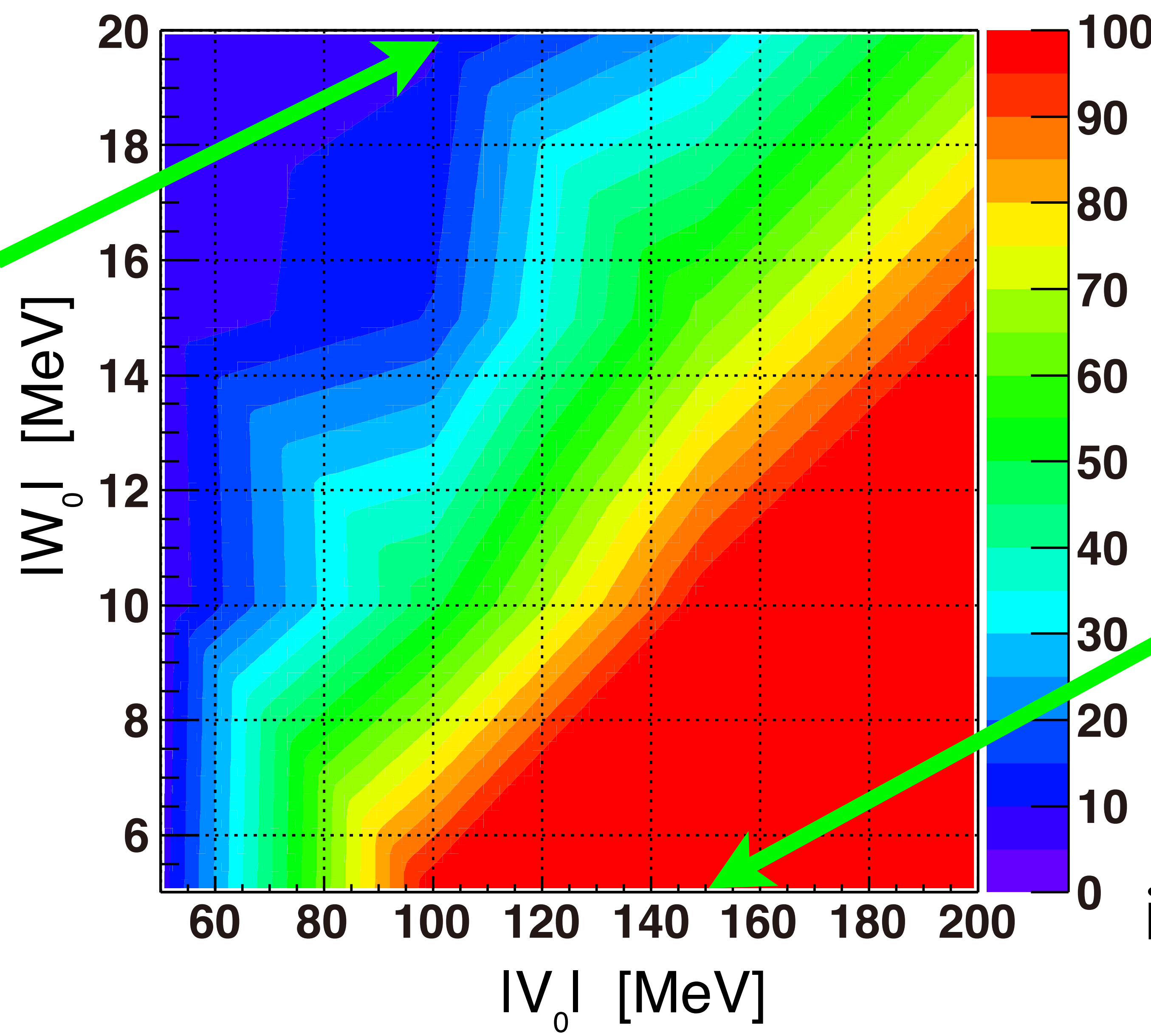


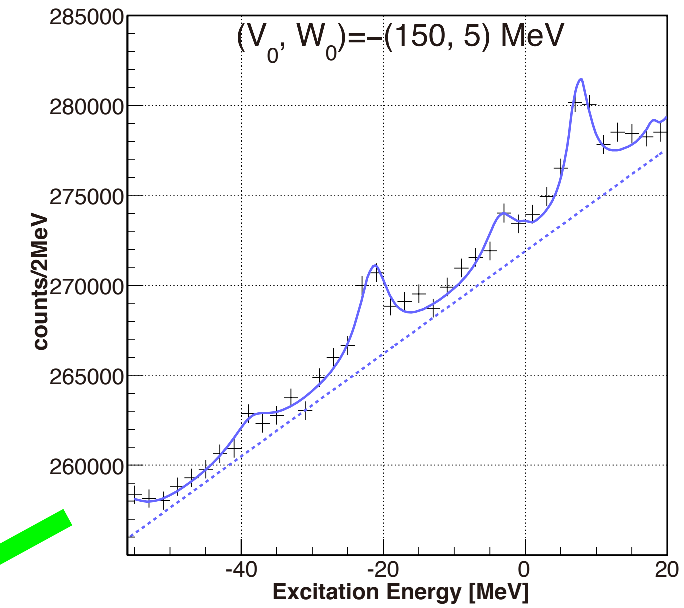
in 4.5 days DAQ

Structure-finding Probability

$$V_{\eta'}(r) = (V_0 + iW_0)\,\frac{\rho(r)}{\rho_0}$$





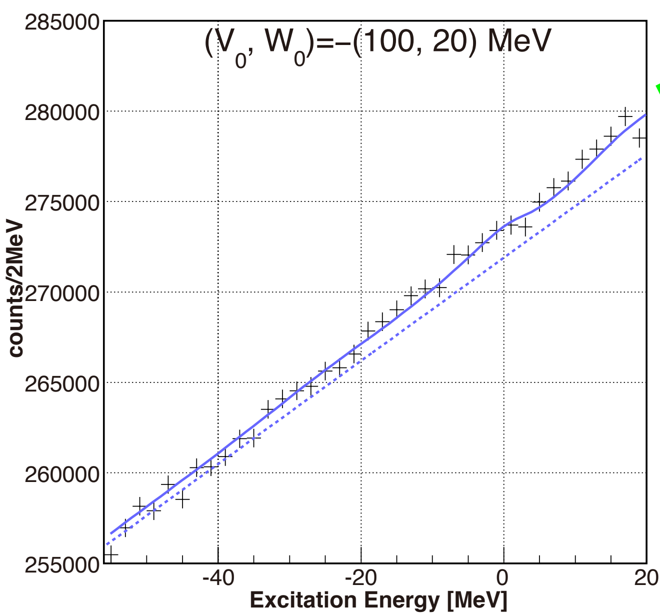


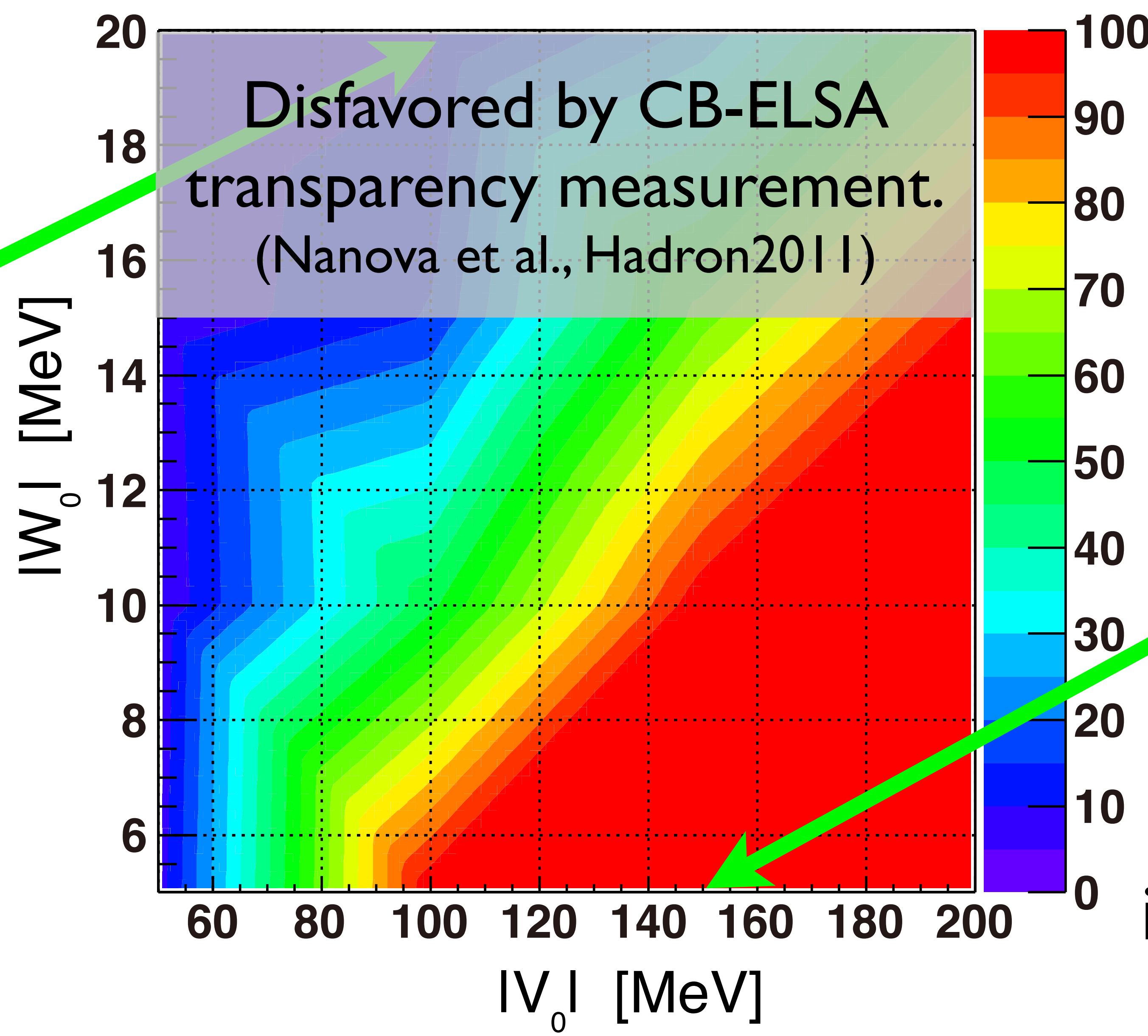
in 4.5 days DAQ

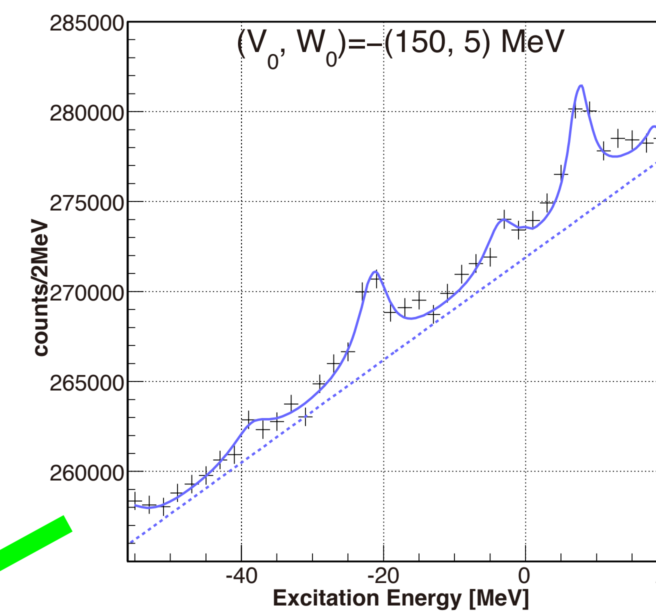
for 95 % C.L.

Structure-finding Probability

$$V_{\eta'}(r) = (V_0 + iW_0)\,\frac{\rho(r)}{\rho_0}$$







in 4.5 days DAQ

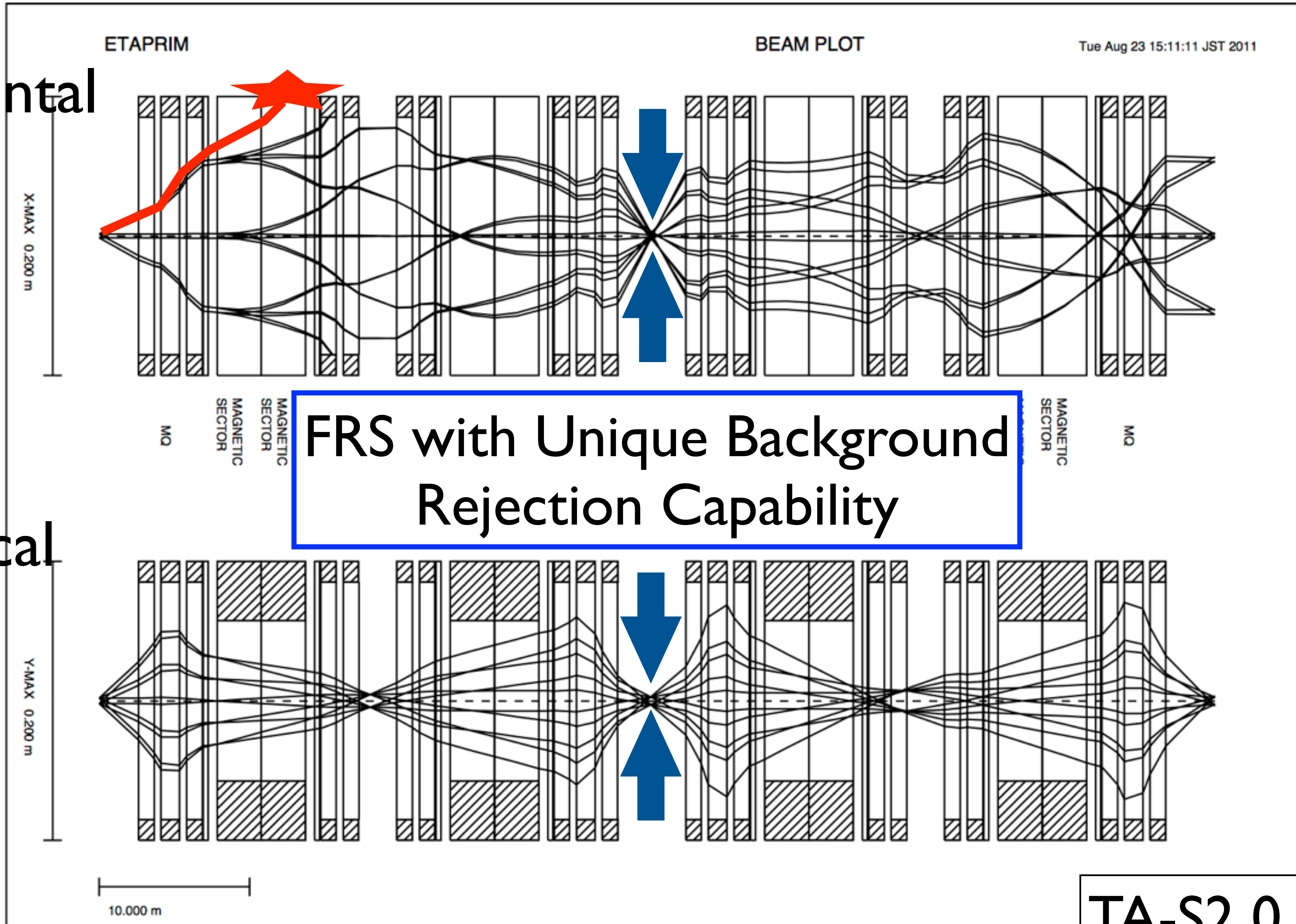
for 95 % C.L.

Presented as LoI to GPAC last week,
but with request for 3 day test beam time

We aim at

- ✓ Measurement of cross section levels of signal + background
- ✓ Test of new beam optics
- ✓ Detector system integrity check + overall test

New Beam Optics

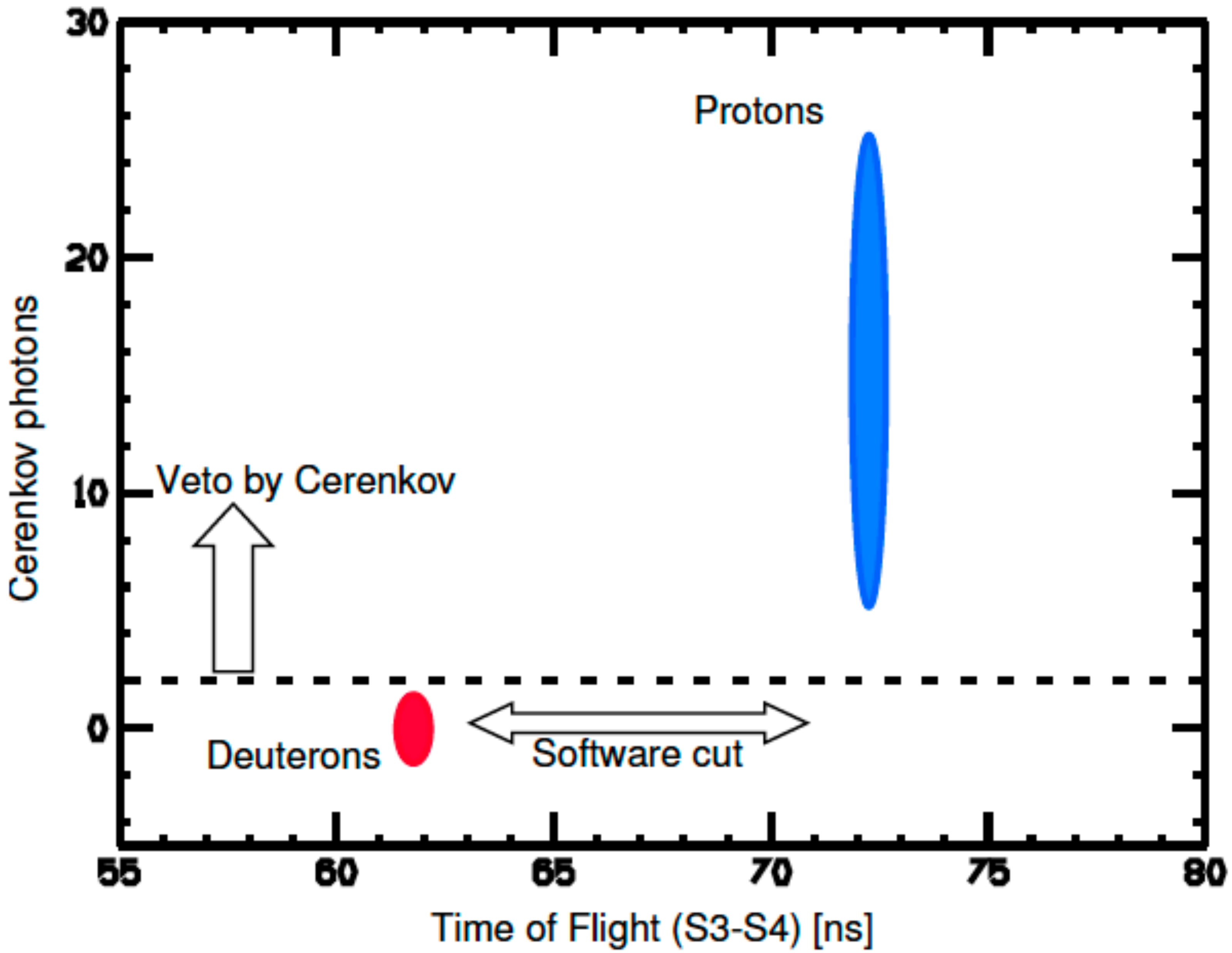


FRS with Unique Background Rejection Capability

TA-S2 0.3 cm/%
TA-S4 5.5 cm/%

Particle Identification

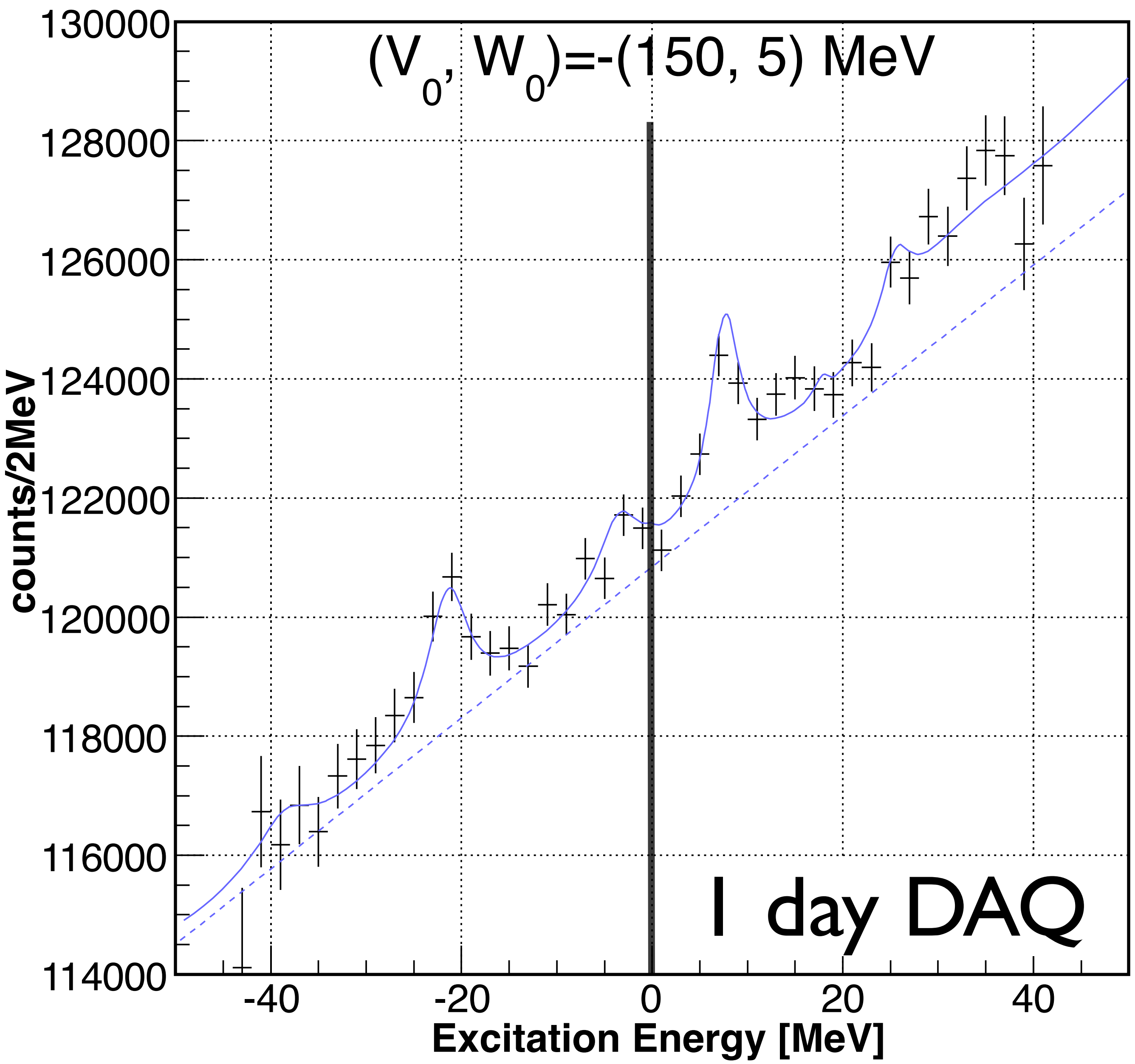
Aerogel
(n=1.12)



Fine tuning will enable adoption of
<u>TOF based hardware trigger</u>

Chances in 3-Day Beamtime

$$V_{\eta'}(r) = (V_0 + iW_0)\,\frac{\rho(r)}{\rho_0}$$



ρ: nucleon density
V_0: Real potential depth
W_0: Imaginary potential depth

We have chances to observe peaks in 1-day

Summary

- Spectroscopy of in-medium η’ is in preparation.
- We set ambitious goals to understand fundamental symmetry of vacuum and QCD.
- Experiment is possible only in GSI.
- 3-day preceding beamtime is requested to figure out crucial parameters for the experiment. We even have chances to observe peaks in the 3 days.

Collaboration

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