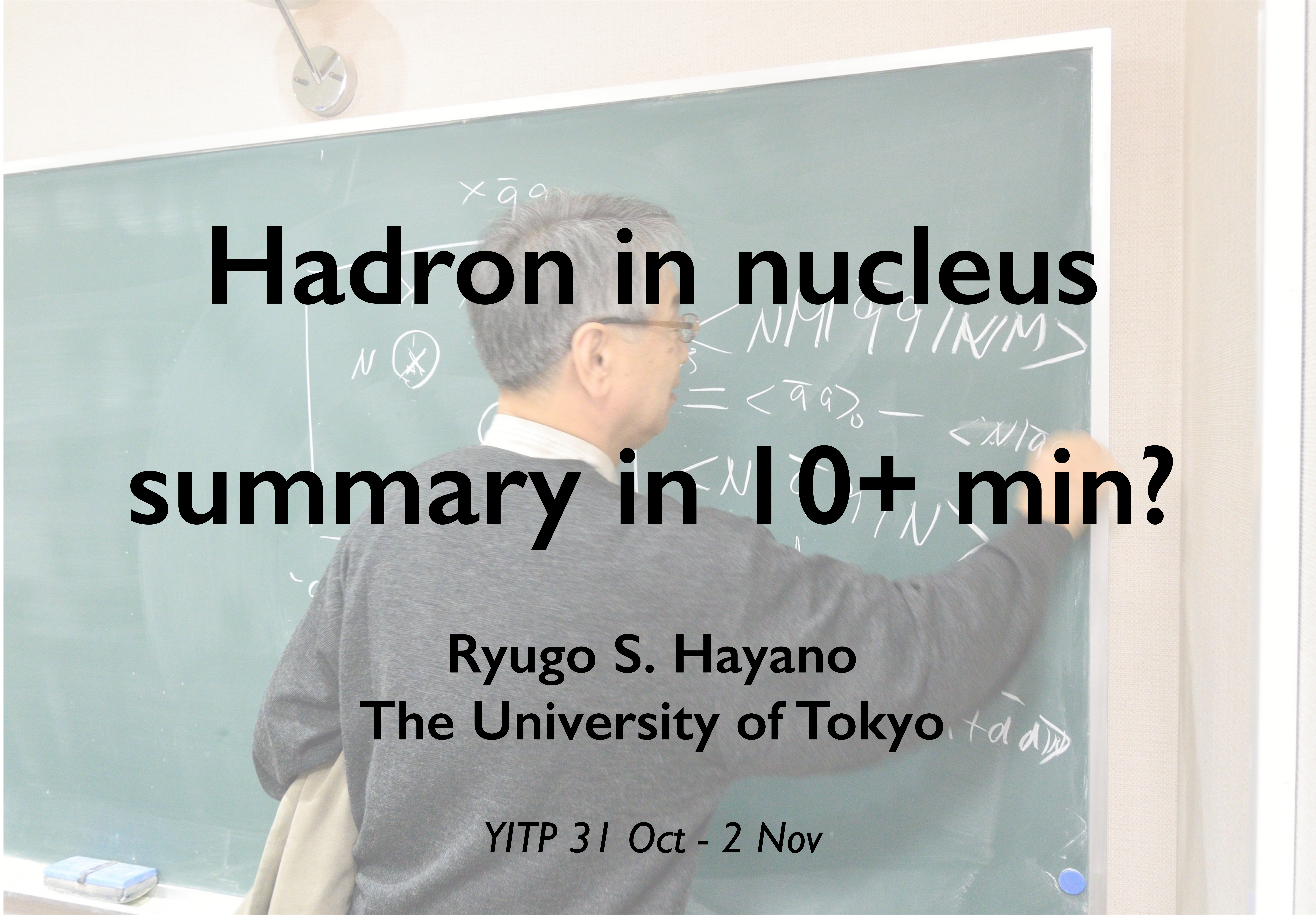


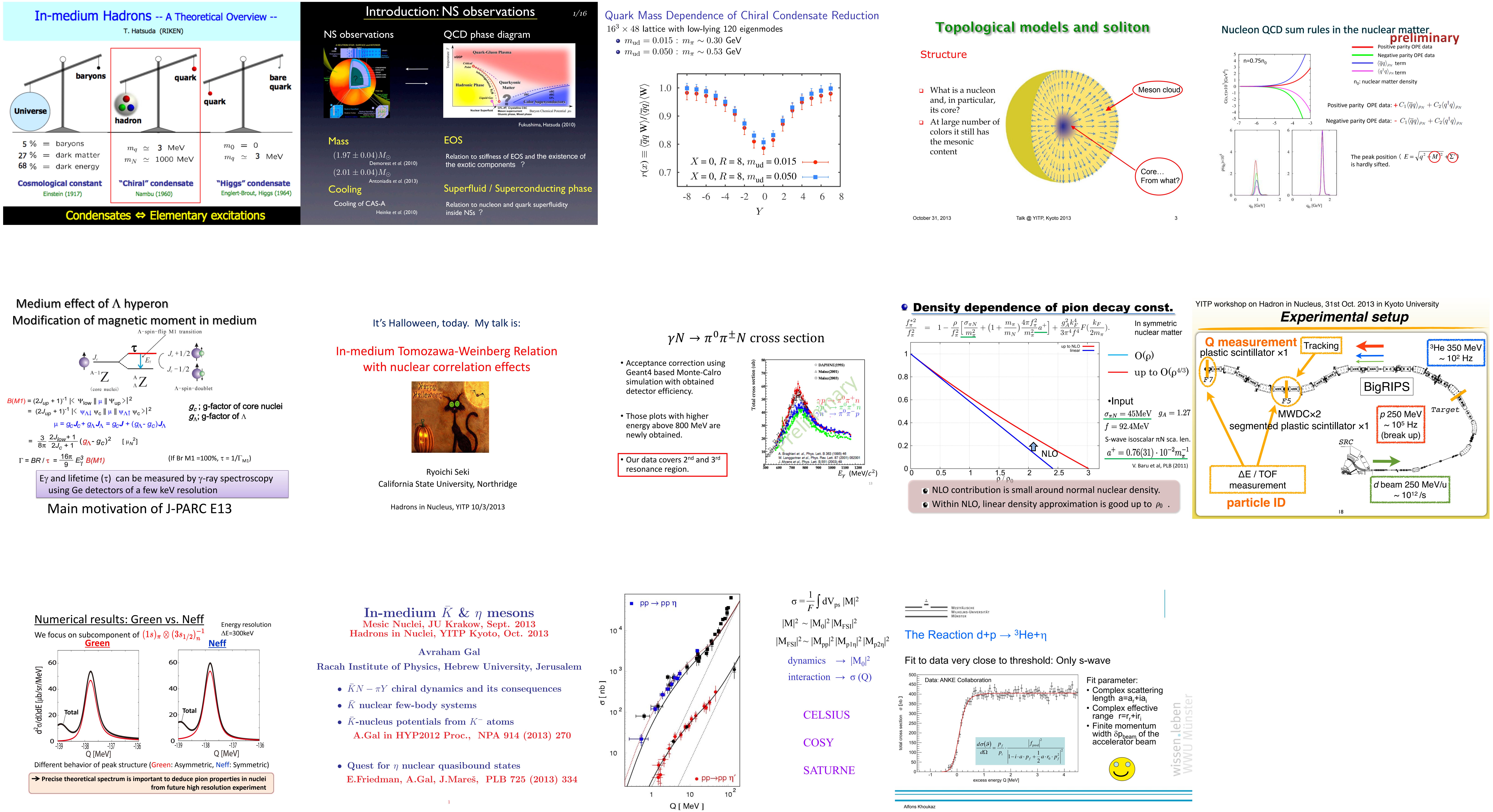
Hadron in nucleus

summary in 10+ min?

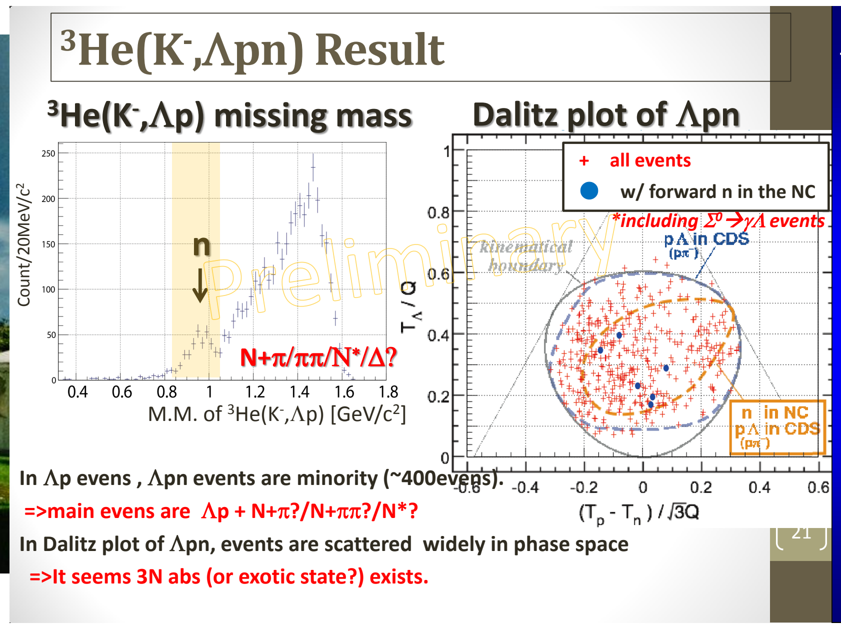
Ryugo S. Hayano
The University of Tokyo

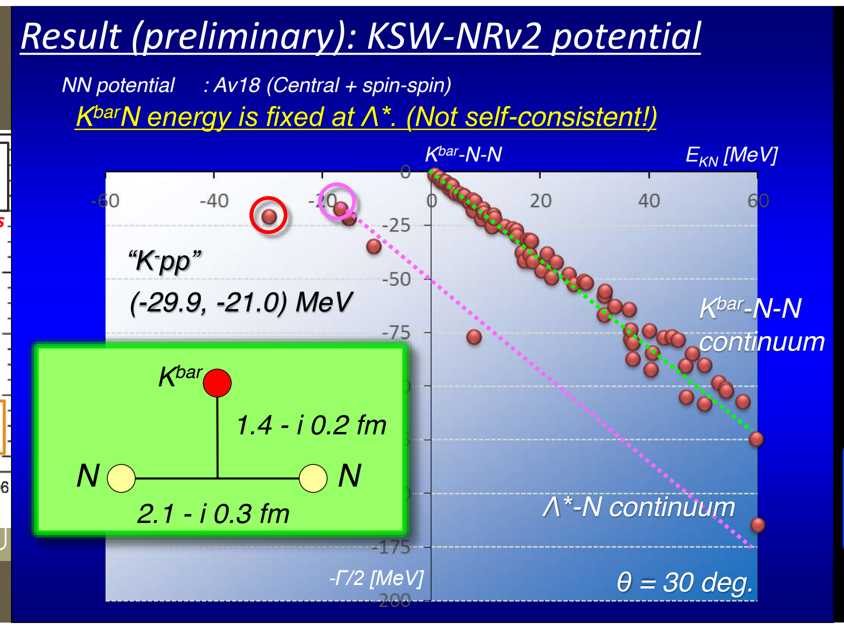
YITP 31 Oct - 2 Nov

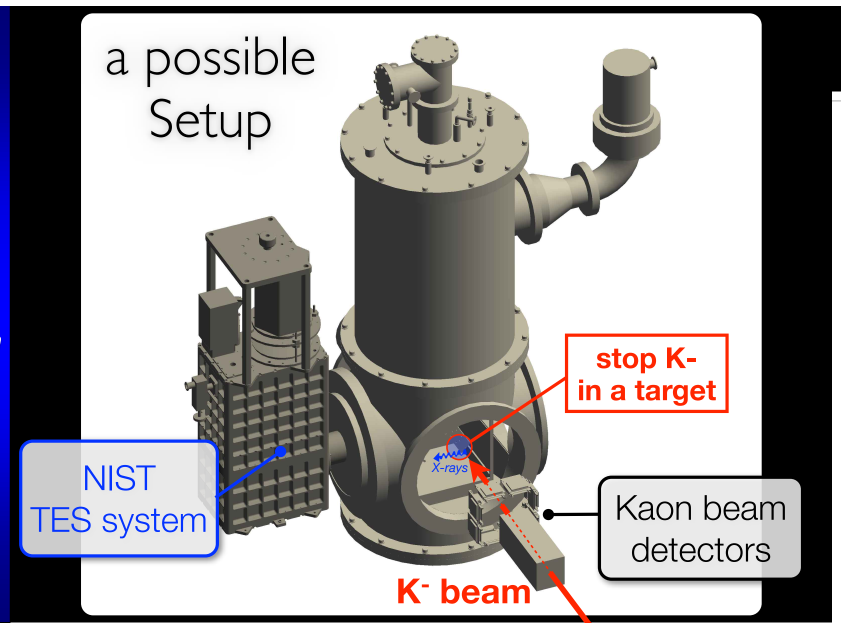
Excellent talks, many by young participants

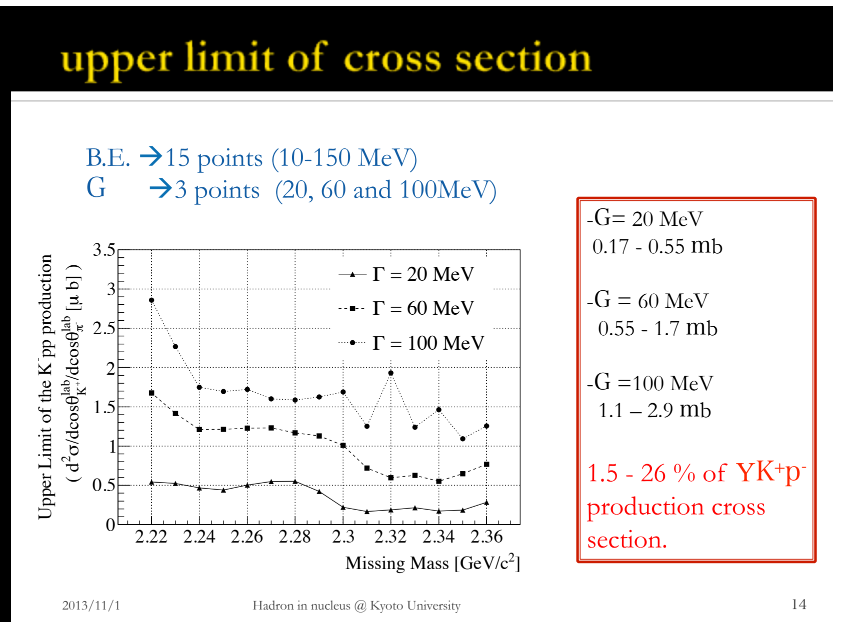


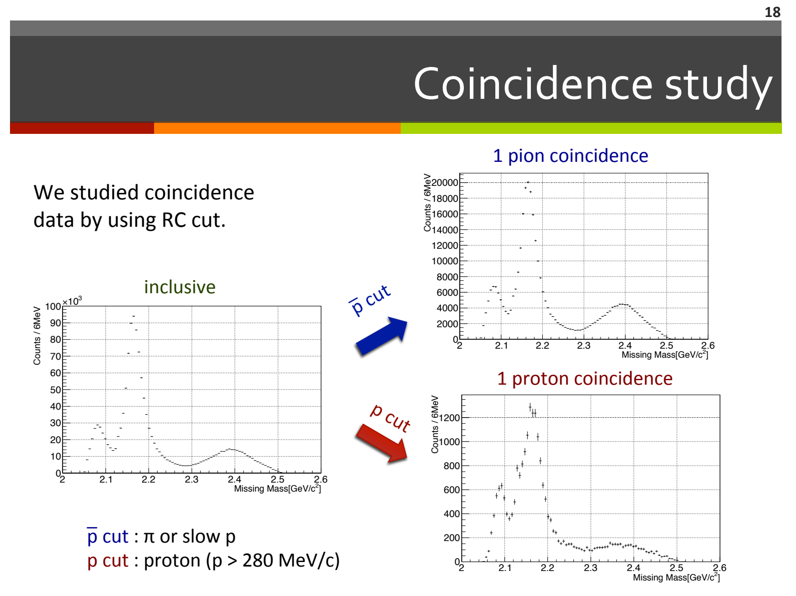
Excellent talks, many by young participants

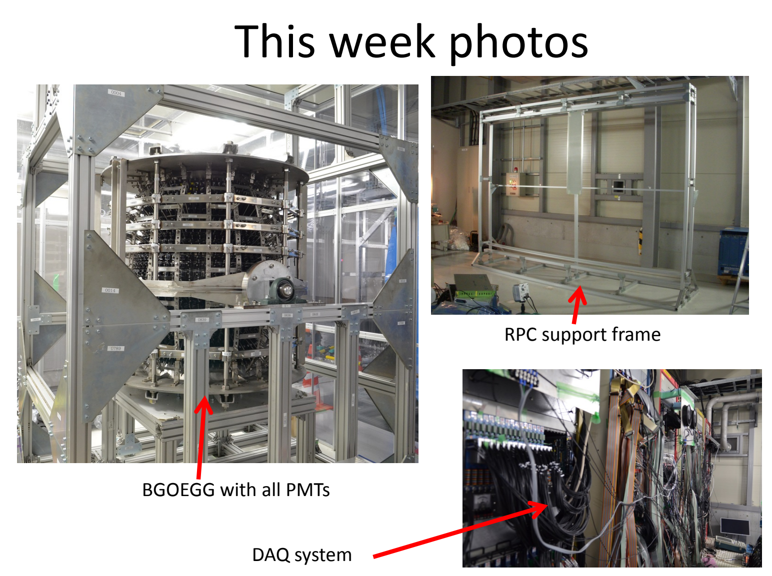


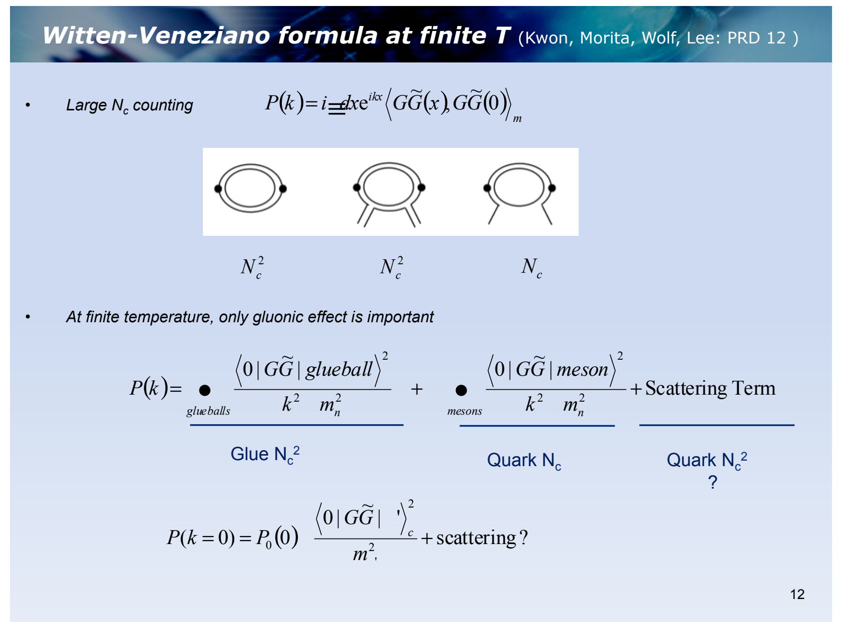


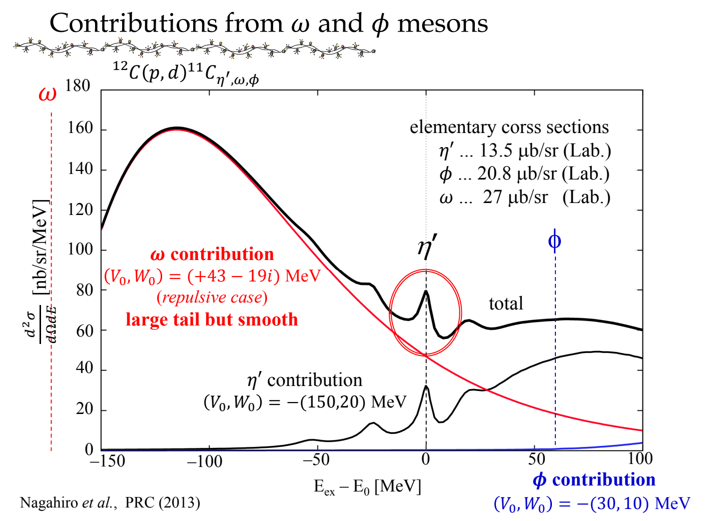


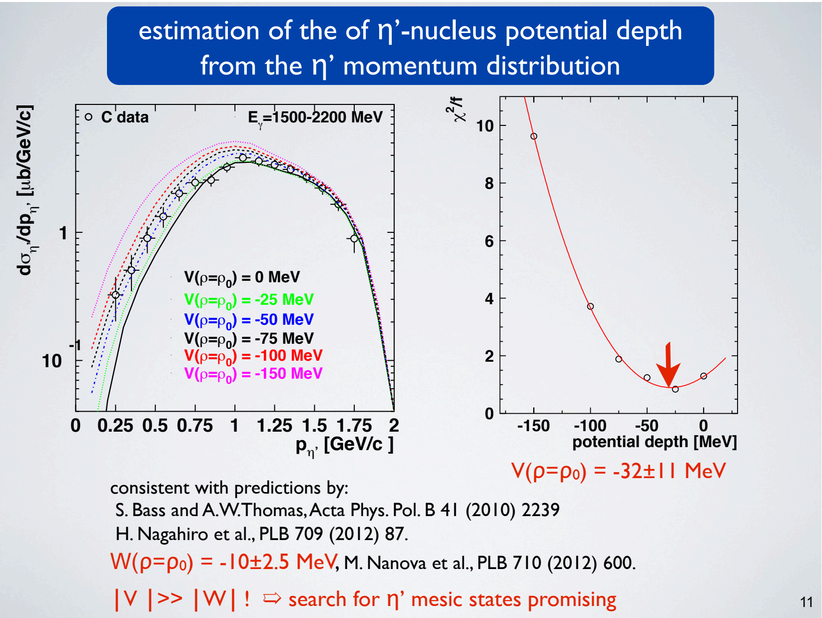


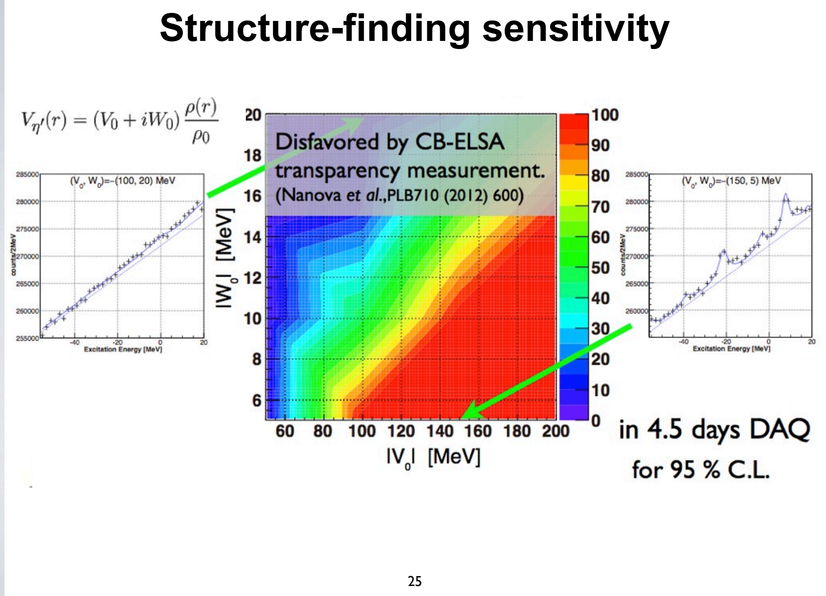


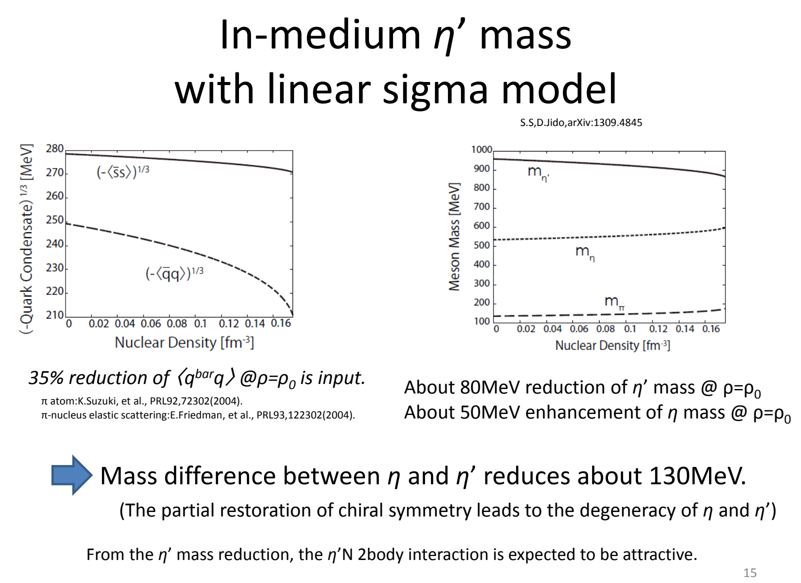


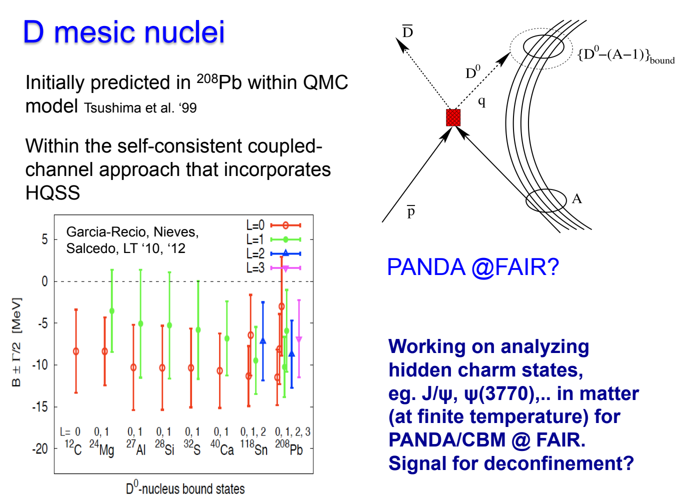


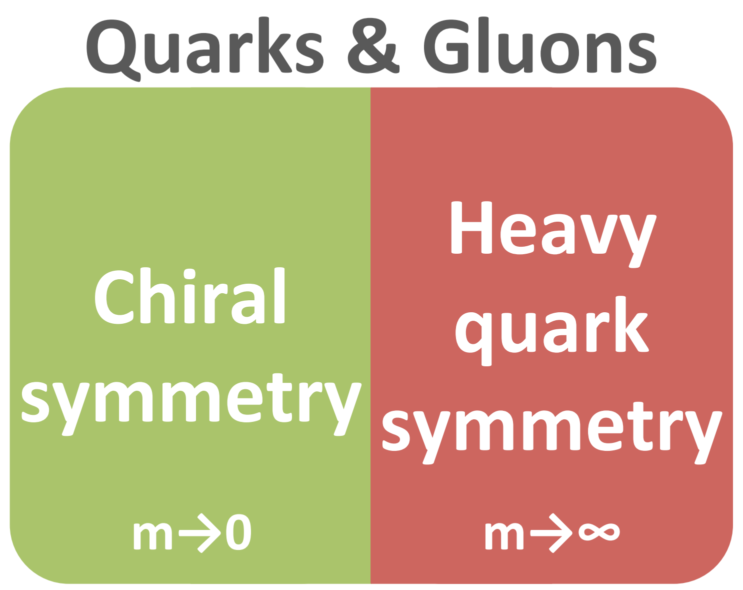


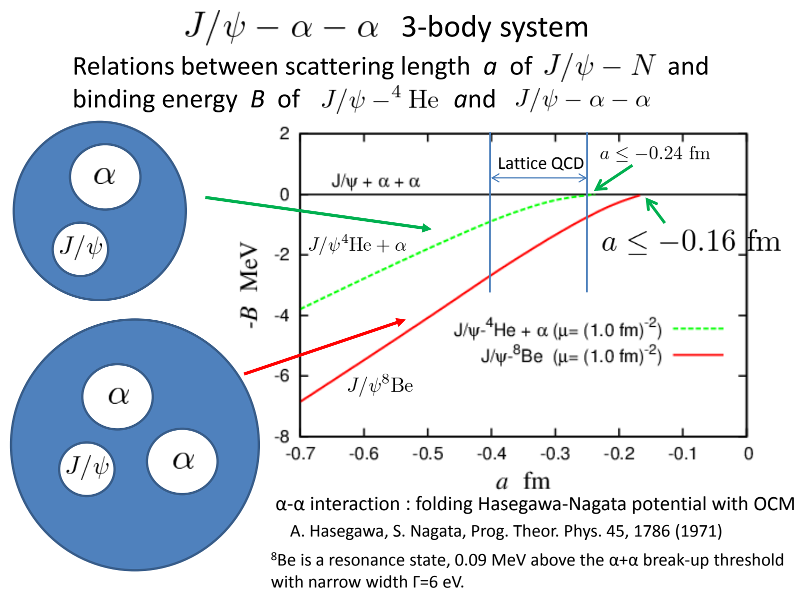


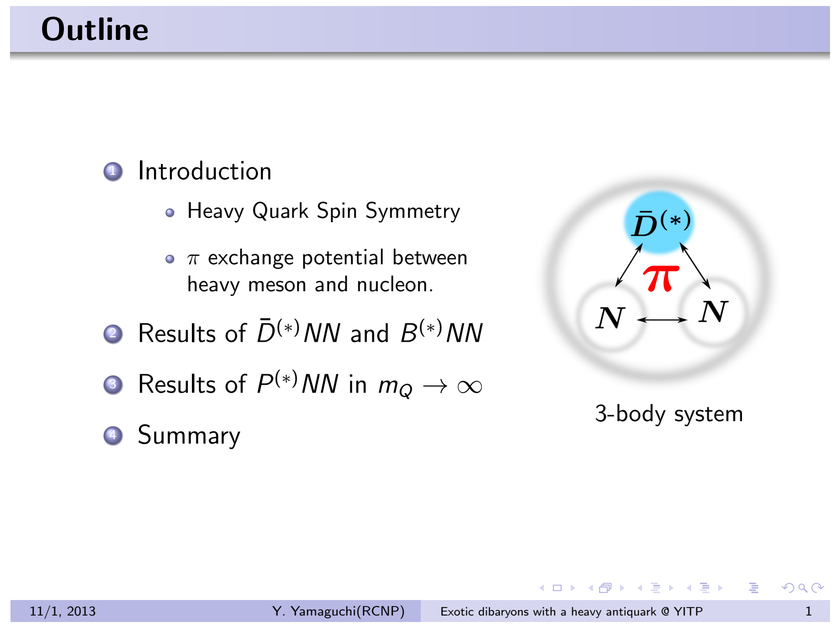


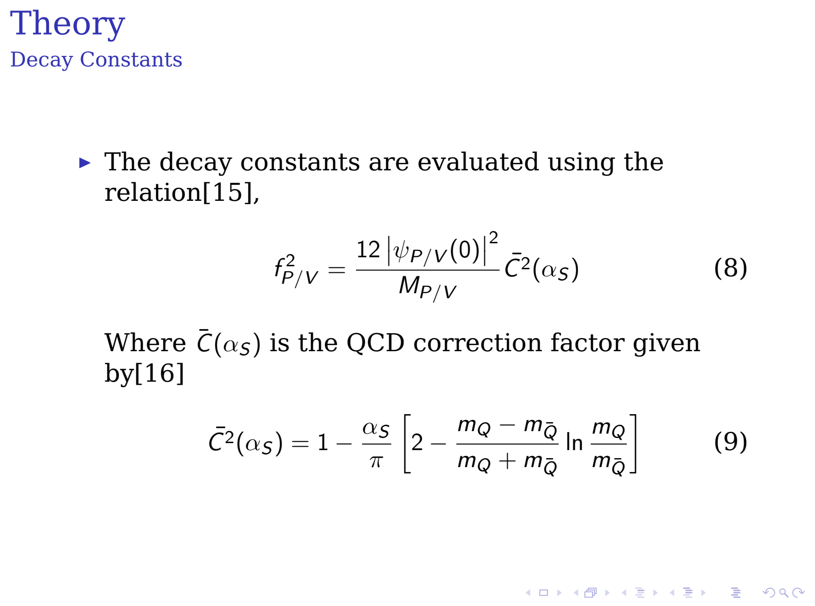




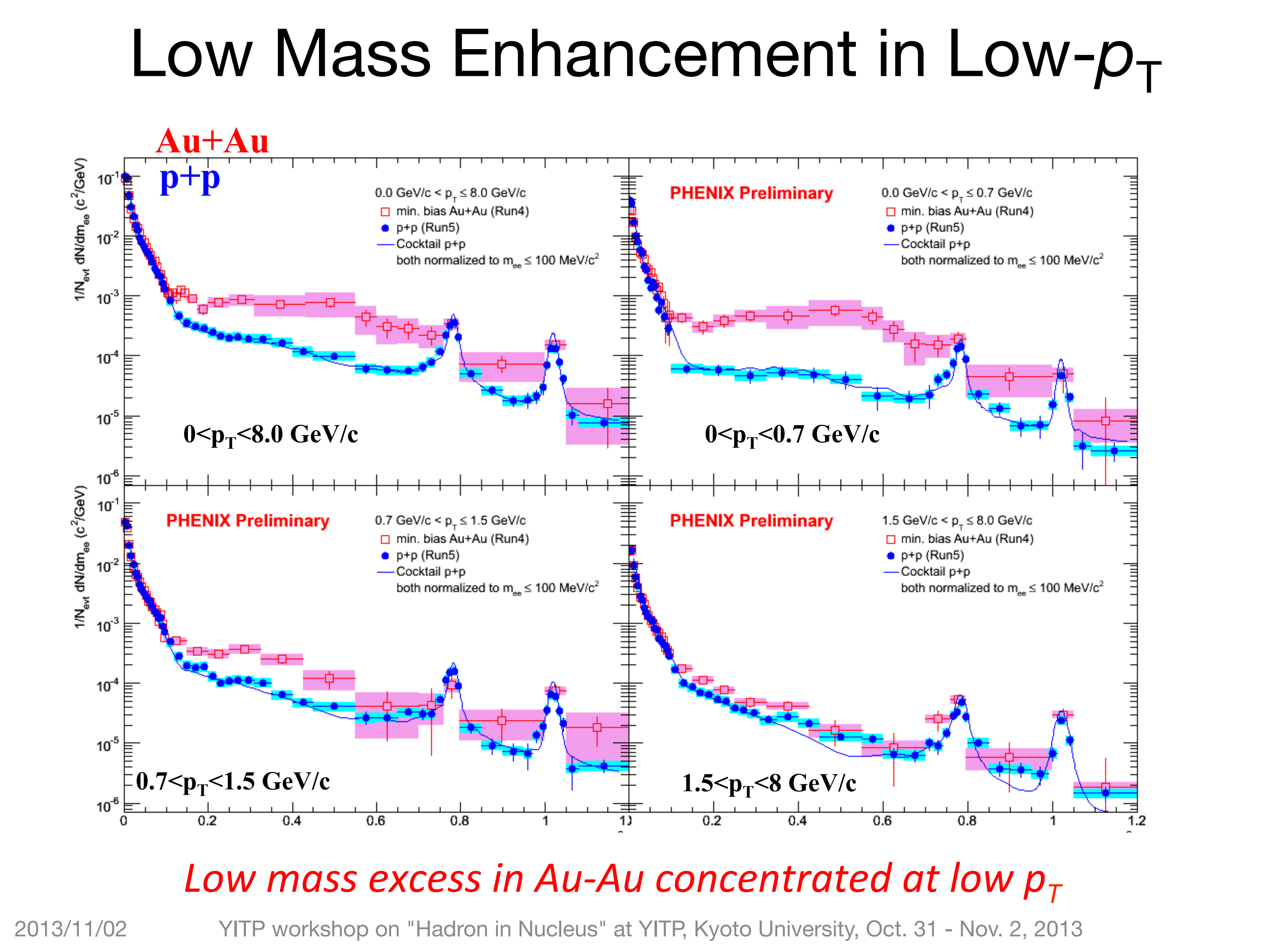


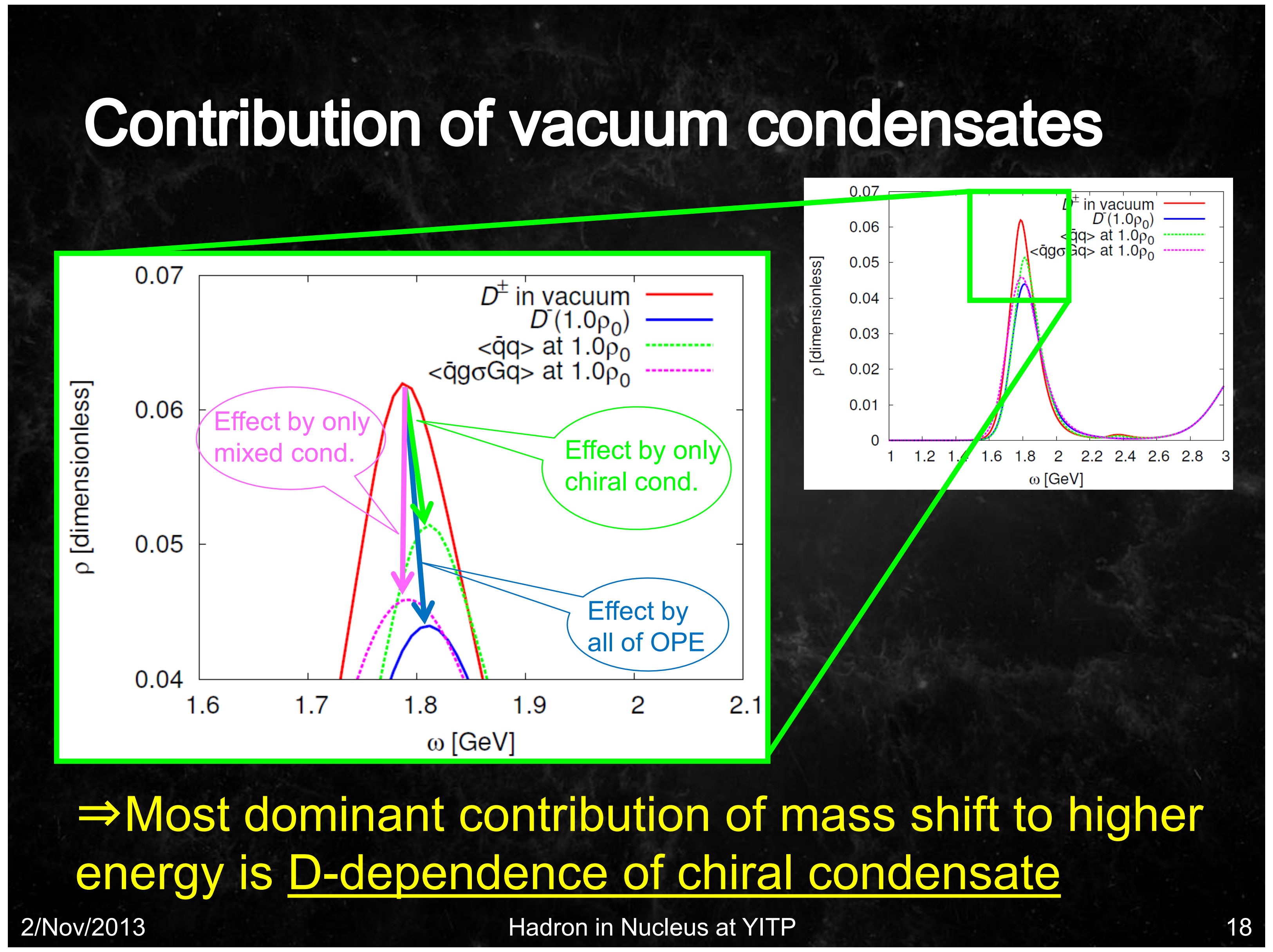


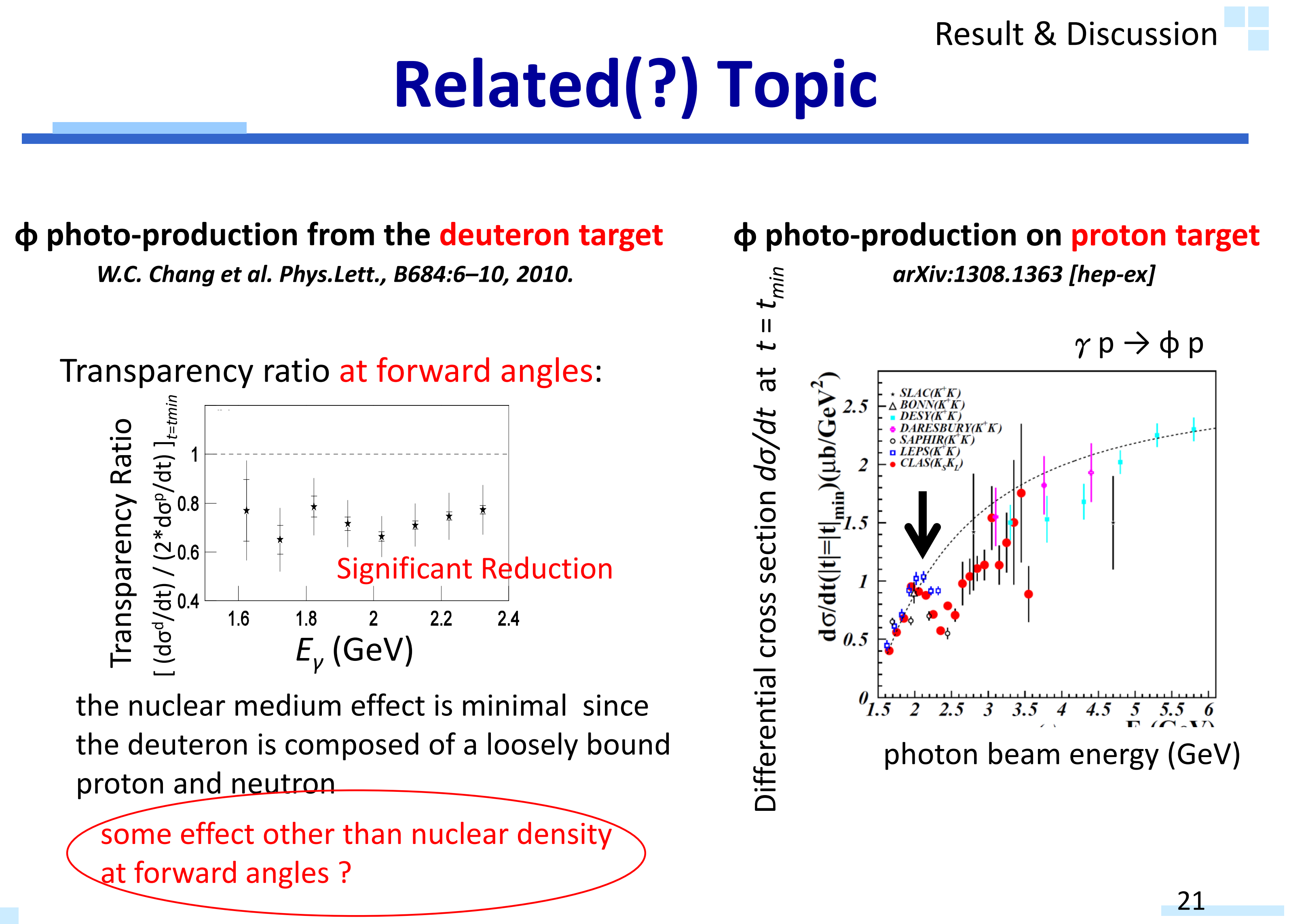


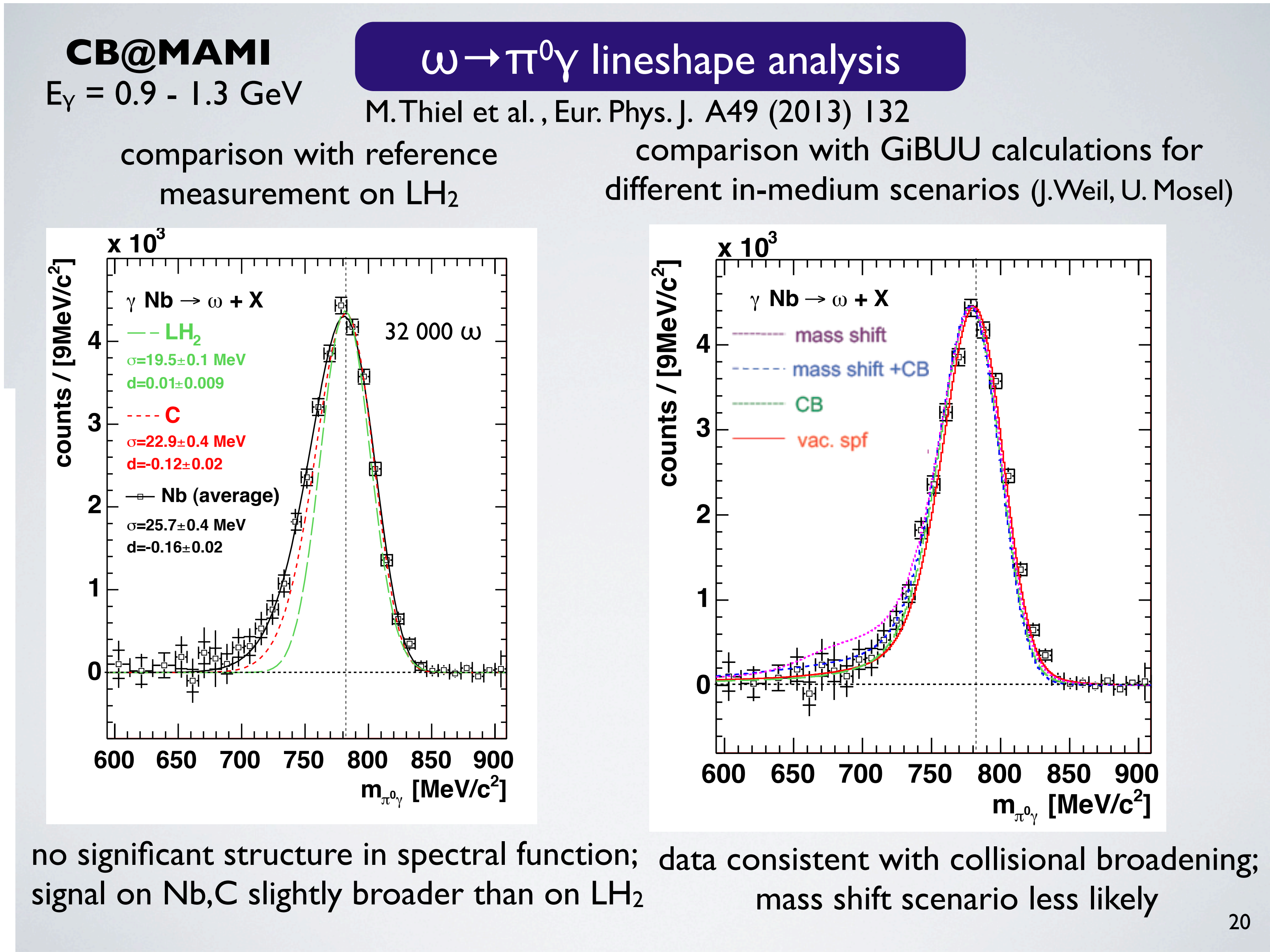


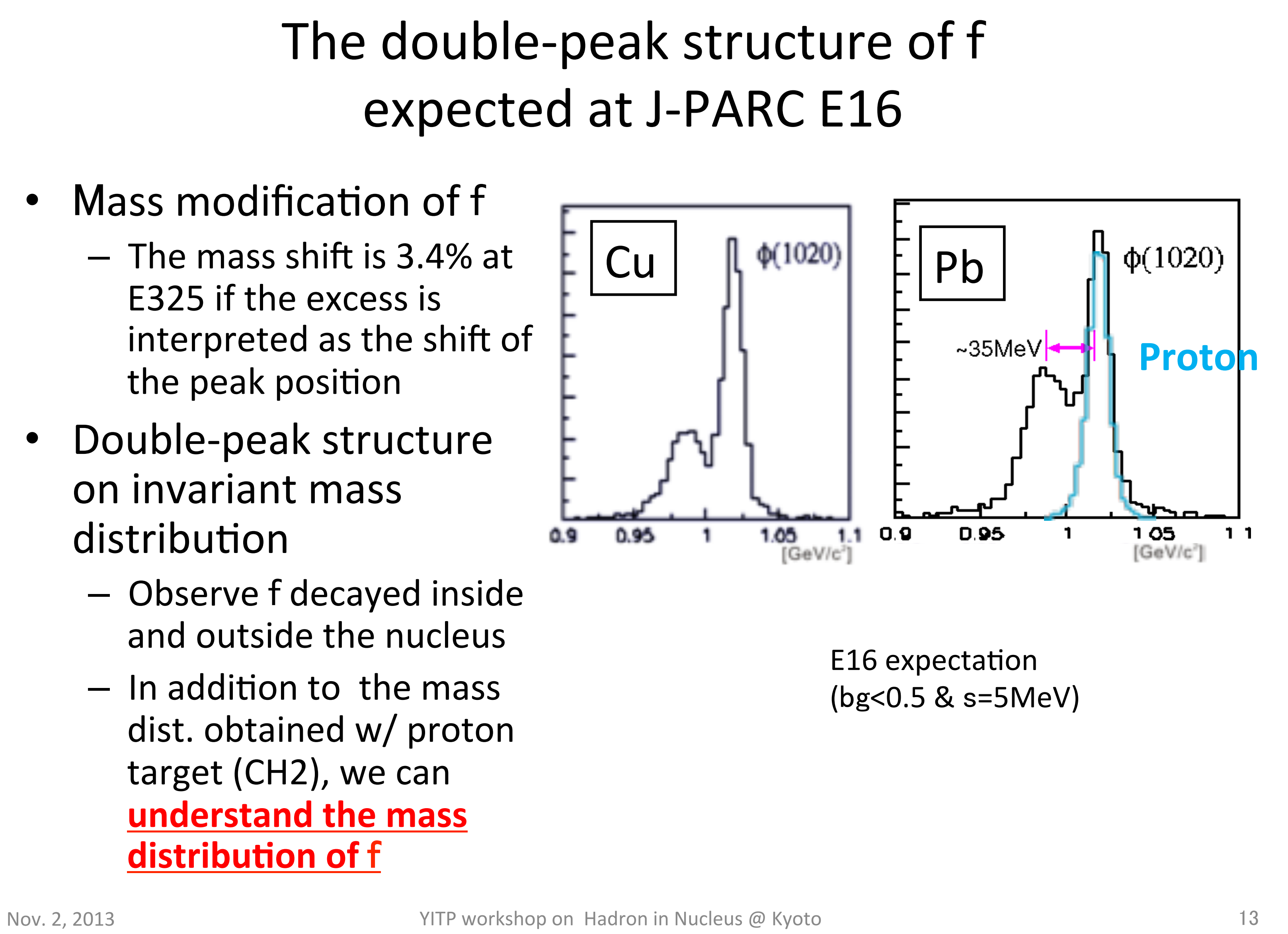
Excellent talks, many by young participants

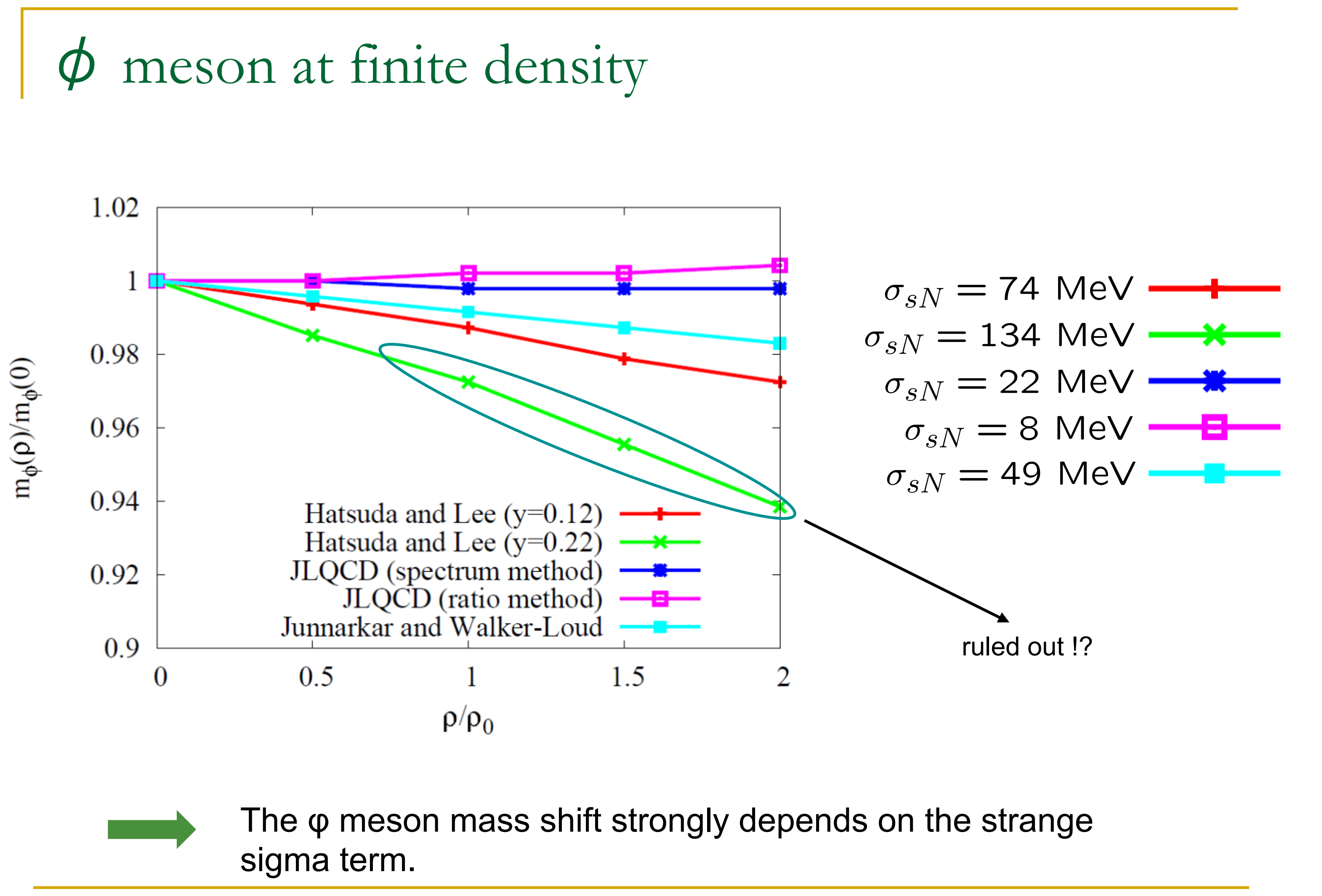












π, K, η, η’

vector mesons

N, Λ

$K^{-}pp$

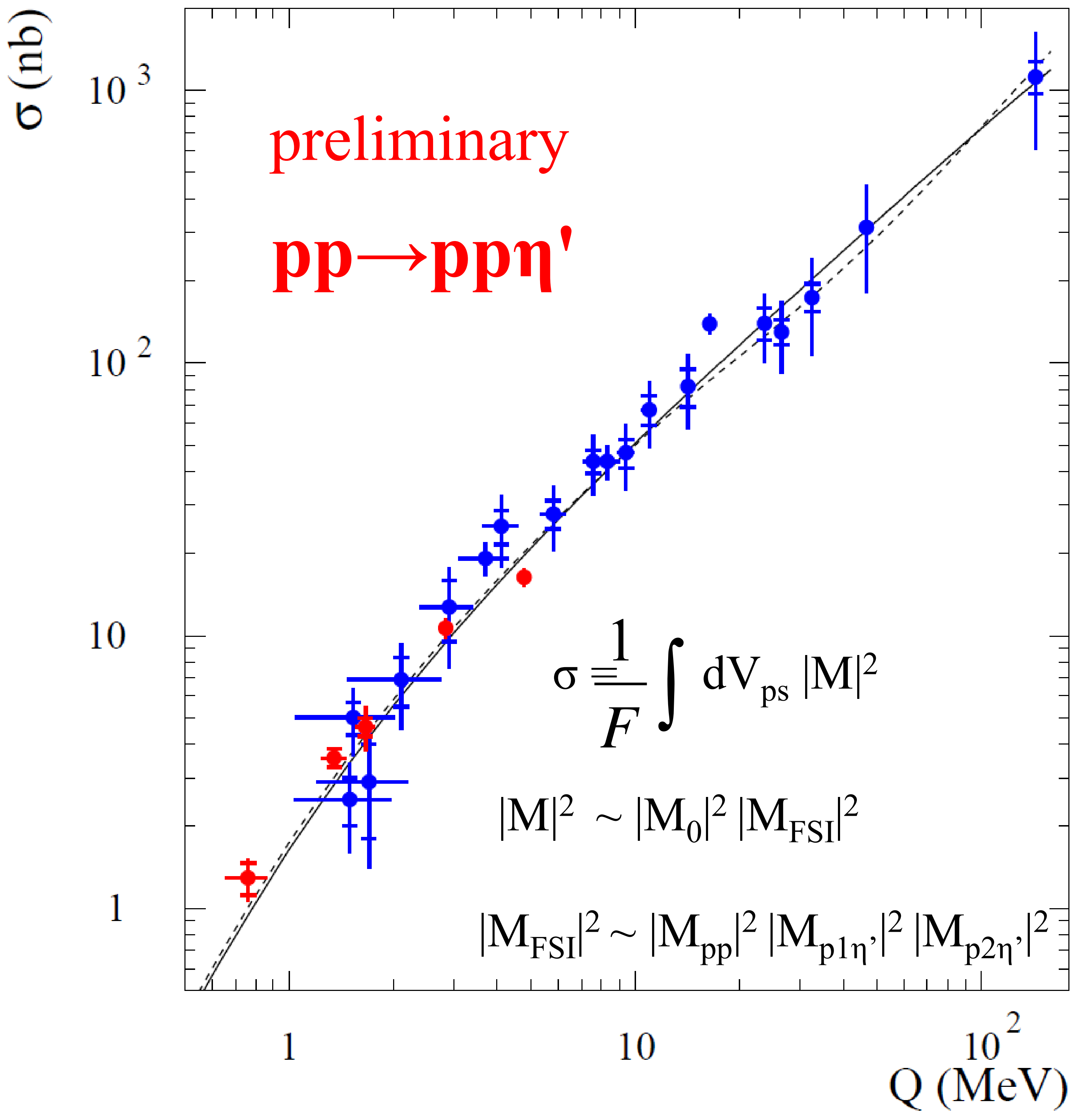
c, b, ..

HEHI

neutron star

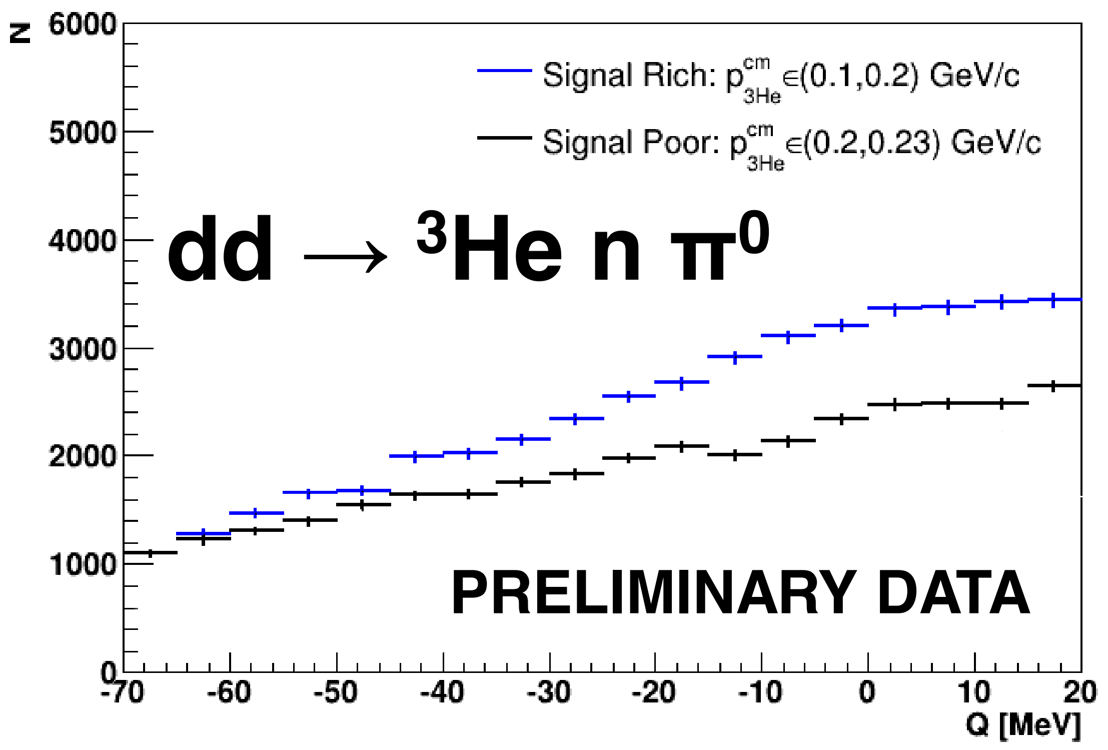
new data

η & η'



SOLID LINE (CFS)
|Re_a| = 0.3 +0.1 -0.2 [fm]
Im_a = -0.1 +- 0.1 [fm]

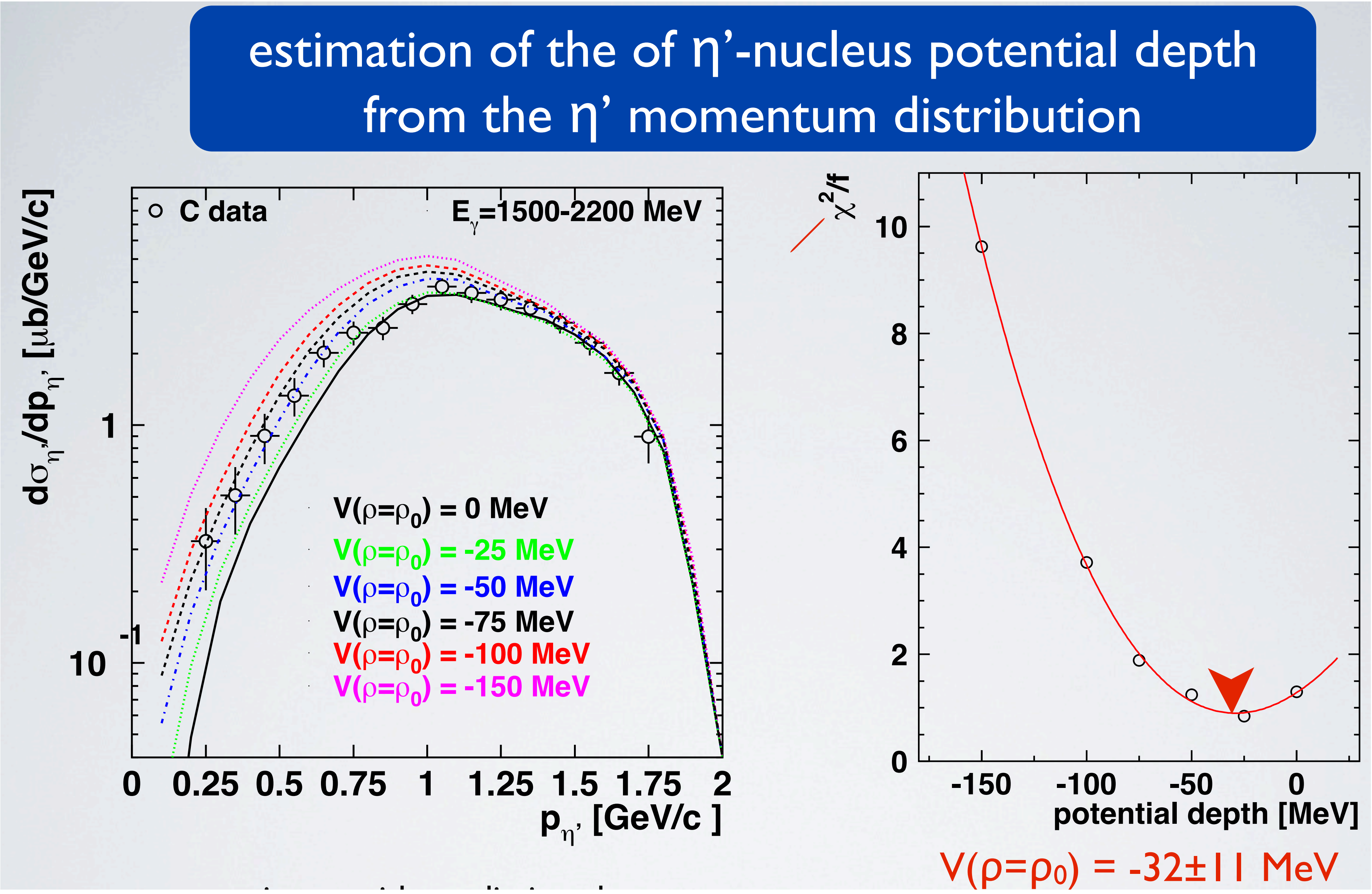
DASHED LINE
|Re_a| = 0.2 +-0.2 [fm]
Im_a = -0.0 +- 0.1 [fm]



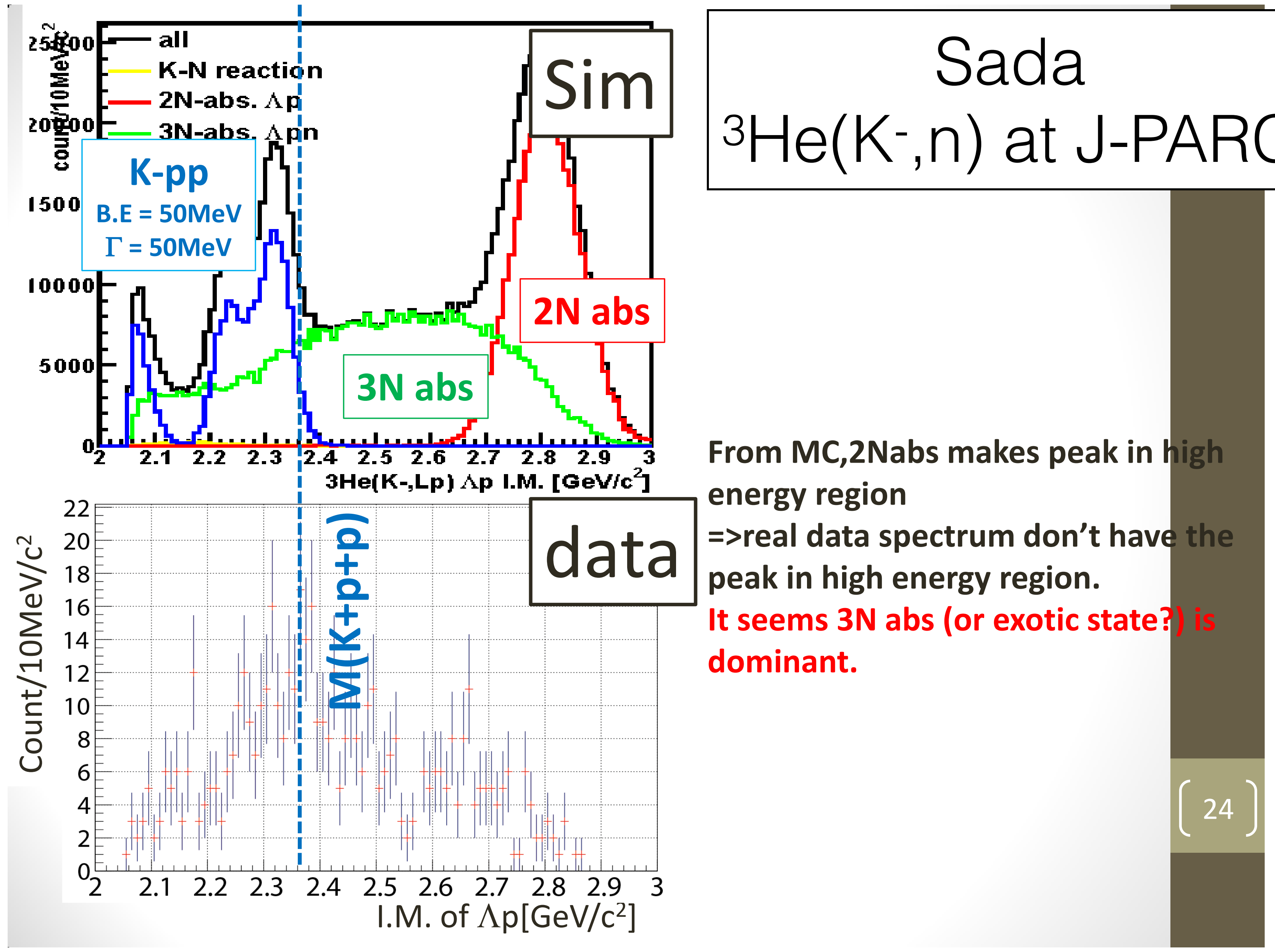
η-^{4}He

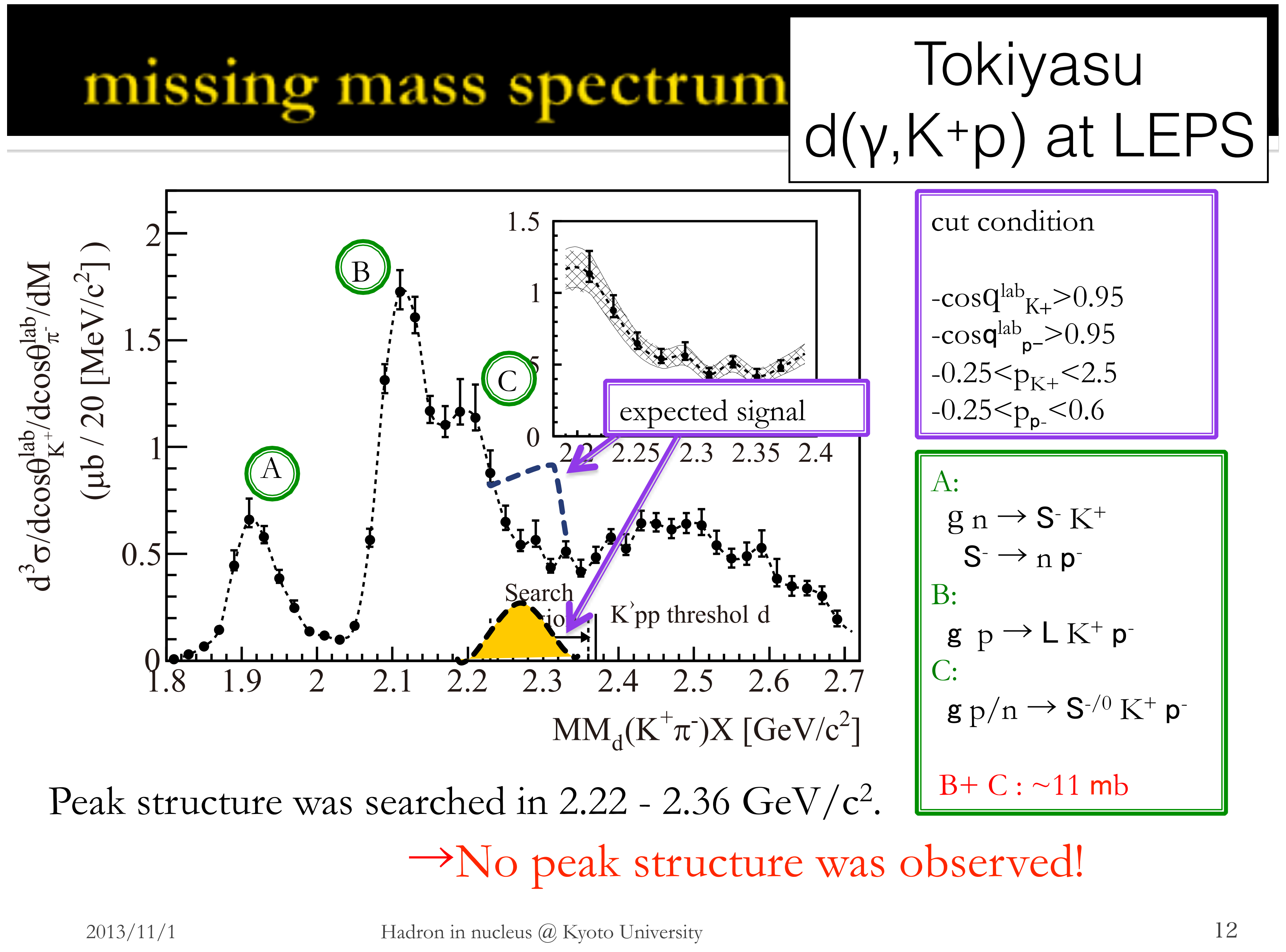
Moskal

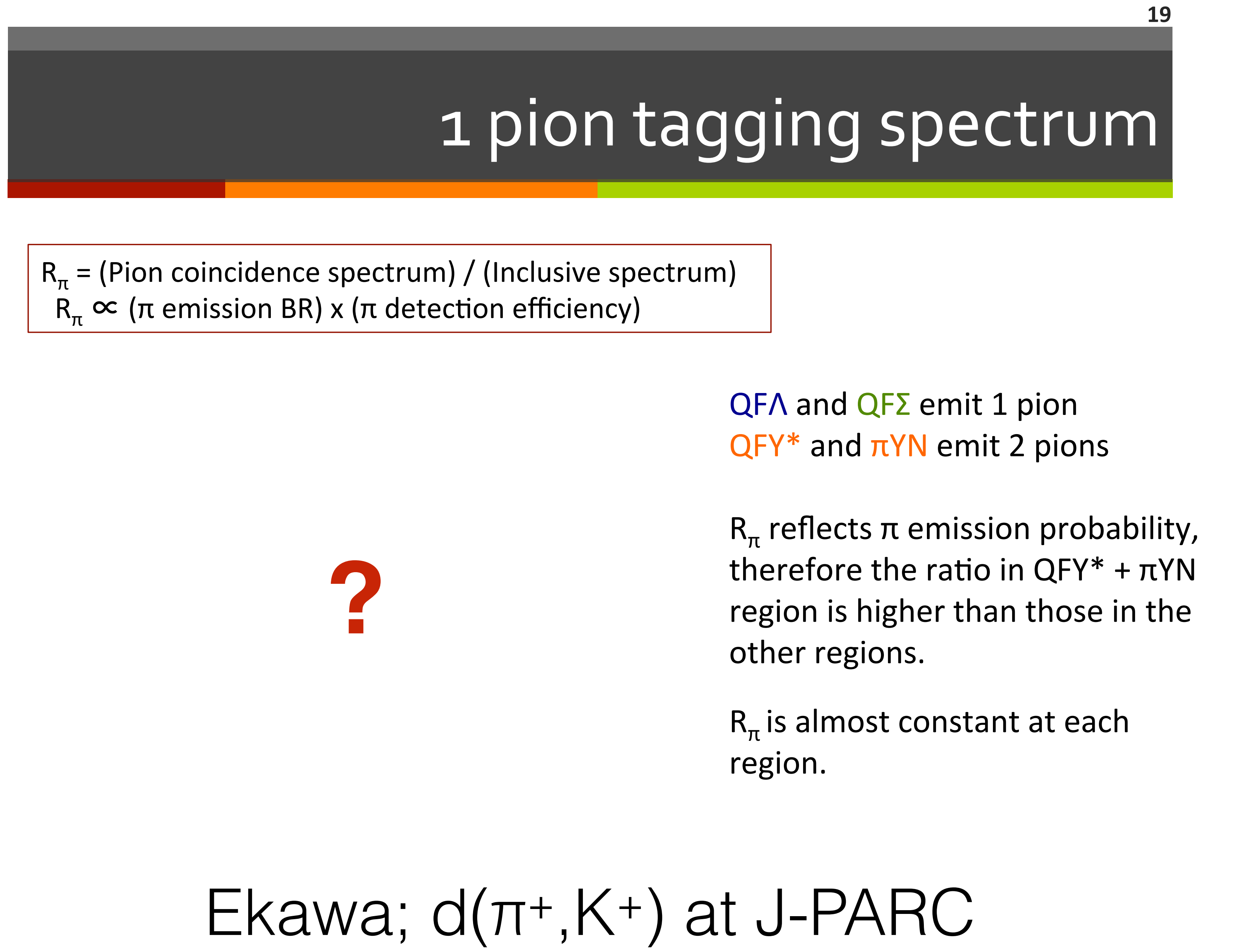
Nanova



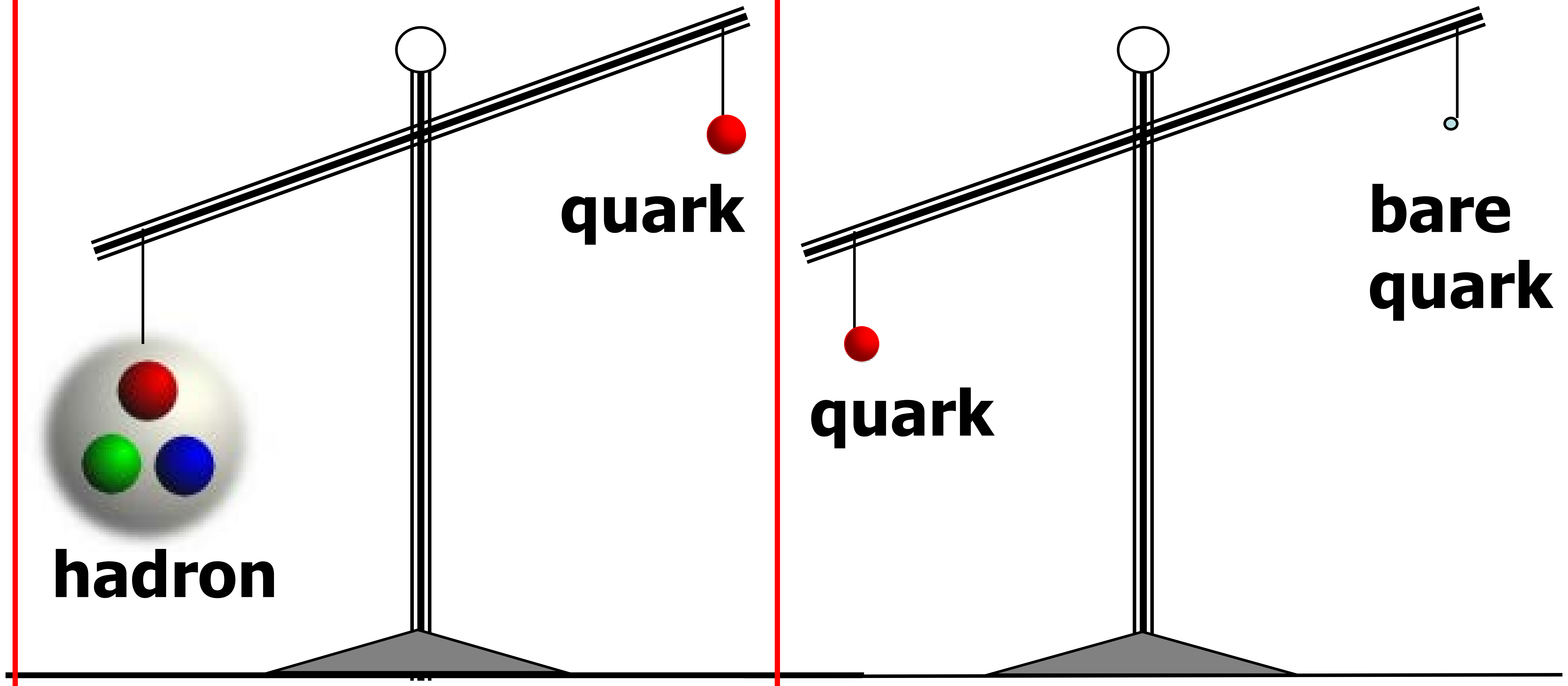
K-pp


Sada
^{3}He(K$^-$,n) at J-PARC
all
K-N reaction
2N-abs. Λp
3N-abs. Λpn
K-pp
B.E = 50MeV
Γ = 50MeV
Sim
2N abs
3N abs
3He(K-,Lp) Λp I.M. [GeV/c^2]
data
M(K+p+p)
Count/10MeV/c^2
I.M. of Λp[GeV/c^2]
From MC,2Nabs makes peak in high energy region
=>real data spectrum don't have the peak in high energy region.
It seems 3N abs (or exotic state?) is dominant.
24


missing mass spectrum
Tokiyasu
d(γ,K$^+$p) at LEPS
cut condition
-cosq$^{lab}_{K+}$>0.95
-cosq$^{lab}_{p-}$>0.95
-0.25<p$_{K+}$<2.5
-0.25<p$_{p-}$<0.6
expected signal
A:
g n → S$^-$ K$^+$
S$^-$ → n p$^-$
B:
g p → L K$^+$ p$^-$
C:
g p/n → S$^{-/0}$ K$^+$ p$^-$
B+ C : ~11 mb
K$^-$pp threshold
MM$_d$(K$^+$π$^-$)X [GeV/c^2]
(μb / 20 [MeV/c^2])
Peak structure was searched in 2.22 - 2.36 GeV/c^2.
→No peak structure was observed!
2013/11/1
Hadron in nucleus @ Kyoto University
12


19
1 pion tagging spectrum
R$_π$ = (Pion coincidence spectrum) / (Inclusive spectrum)
R$_π$ ∝ (π emission BR) x (π detection efficiency)
?
QFΛ and QFΣ emit 1 pion
QFY* and πYN emit 2 pions
R$_π$ reflects π emission probability, therefore the ratio in QFY* + πYN region is higher than those in the other regions.
R$_π$ is almost constant at each region.
Ekawa; d(π$^+$,K$^+$) at J-PARC

T. Hatsuda (RIKEN)



$$m_q \simeq 3 \ \text{MeV}$$
$$m_N \simeq 1000 \ \text{MeV}$$

"Chiral" condensate

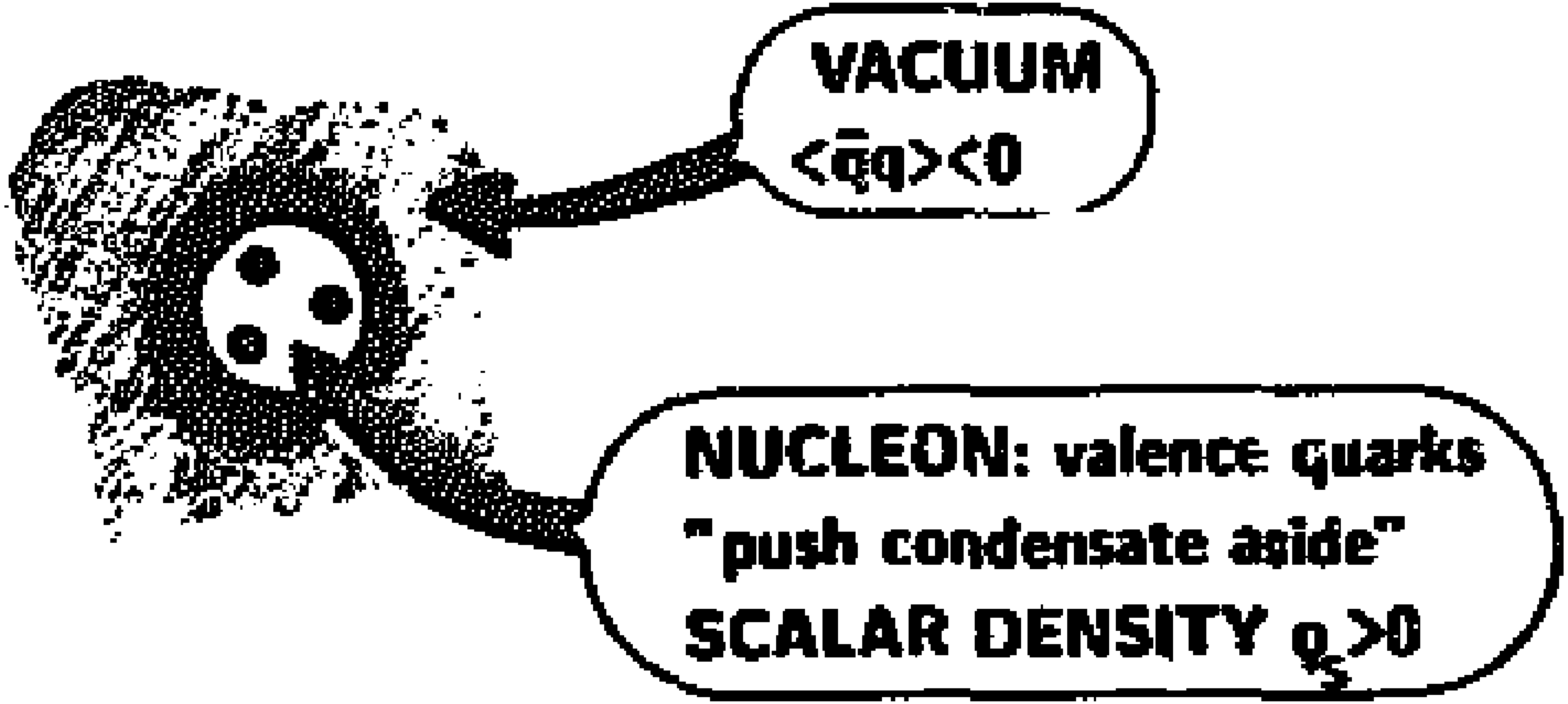
Nambu (1960)

$$m_0 = 0$$
$$m_q \simeq 3 \ \text{MeV}$$

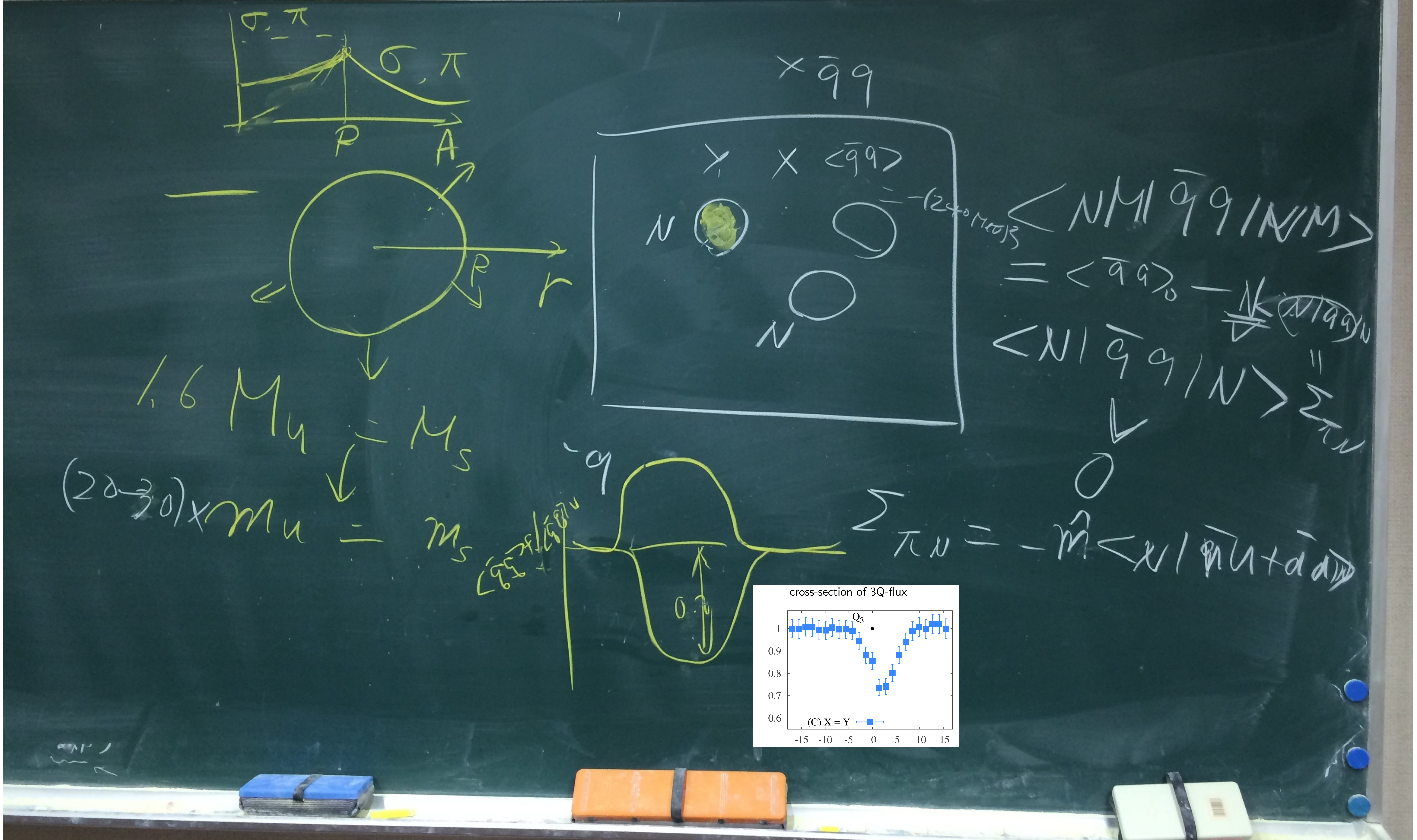
"Higgs" condensate

Englert-Brout, Higgs (1964)

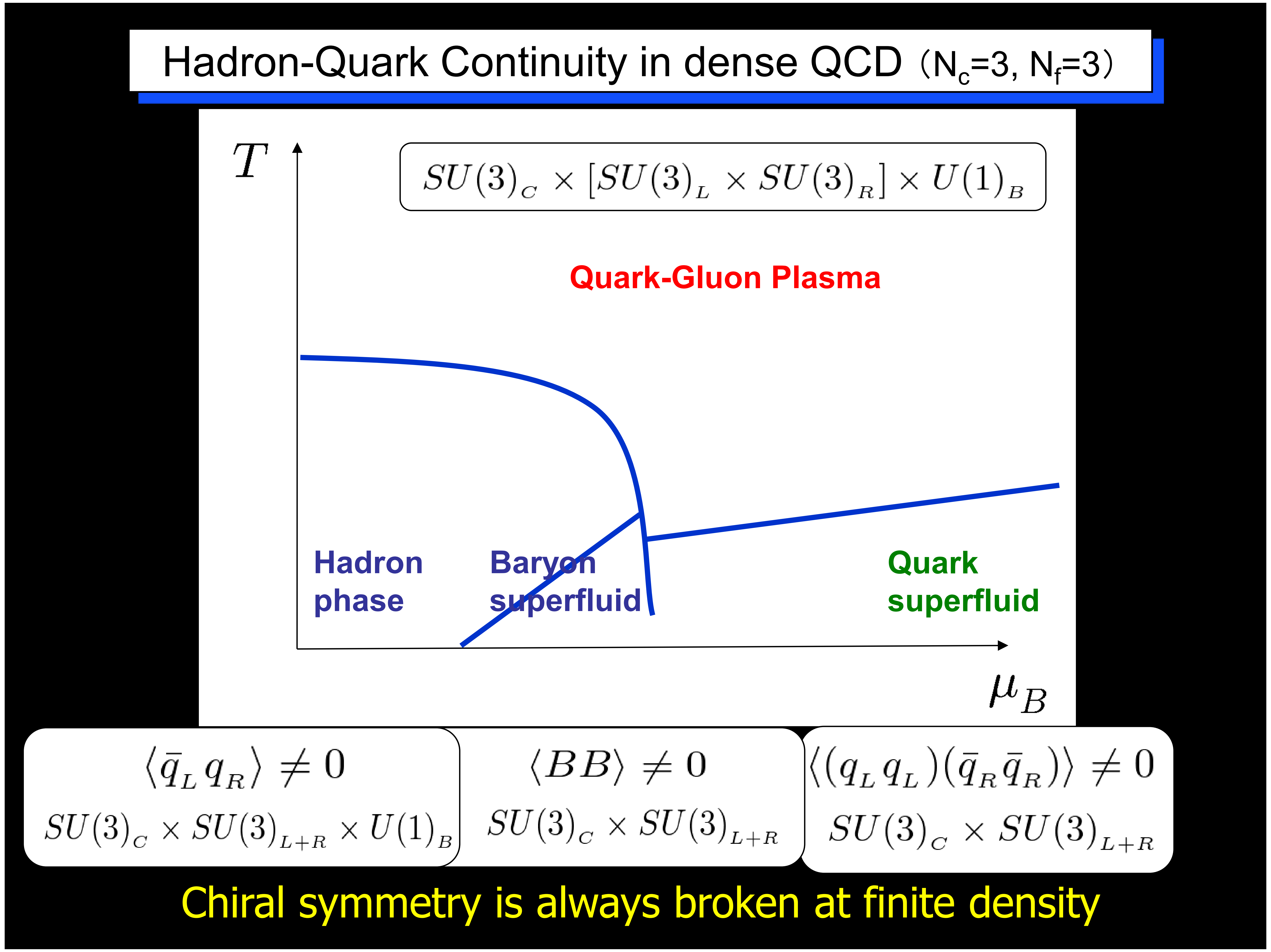
$$\langle \overline{q}q \rangle_\rho = \langle \overline{q}q \rangle_0 + \langle N|\overline{q}q|N\rangle \rho = \langle \overline{q}q \rangle_0 + \frac{\sigma_{\pi N}}{2m_q}\rho$$

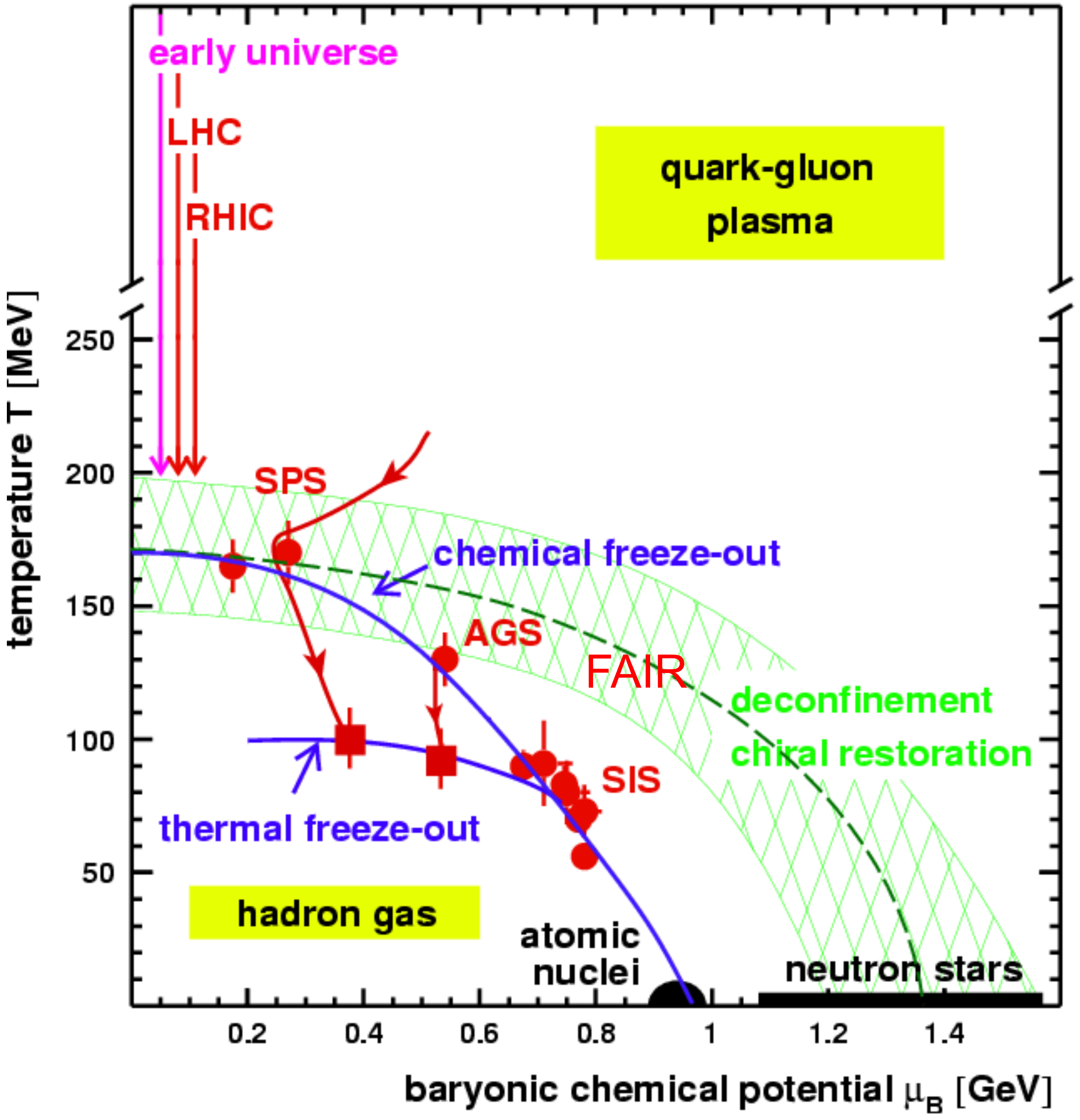


W. Weise, NPA 553 (1993) 59


σ, π
R
A
r
N
N
1.6 Mu = Ms
cross-section of 3Q-flux
Q3
1
0.9
0.8
0.7
0.6
(C) X = Y
-15
-10
-5
0
5
10
15

Experimentally-accessible region is rather limited
Lattice is powerful, but is also limited for $\mu_B \sim 0$

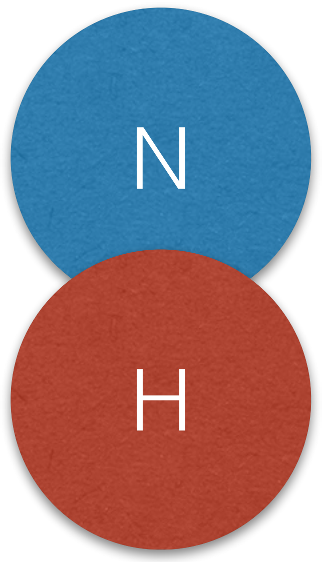


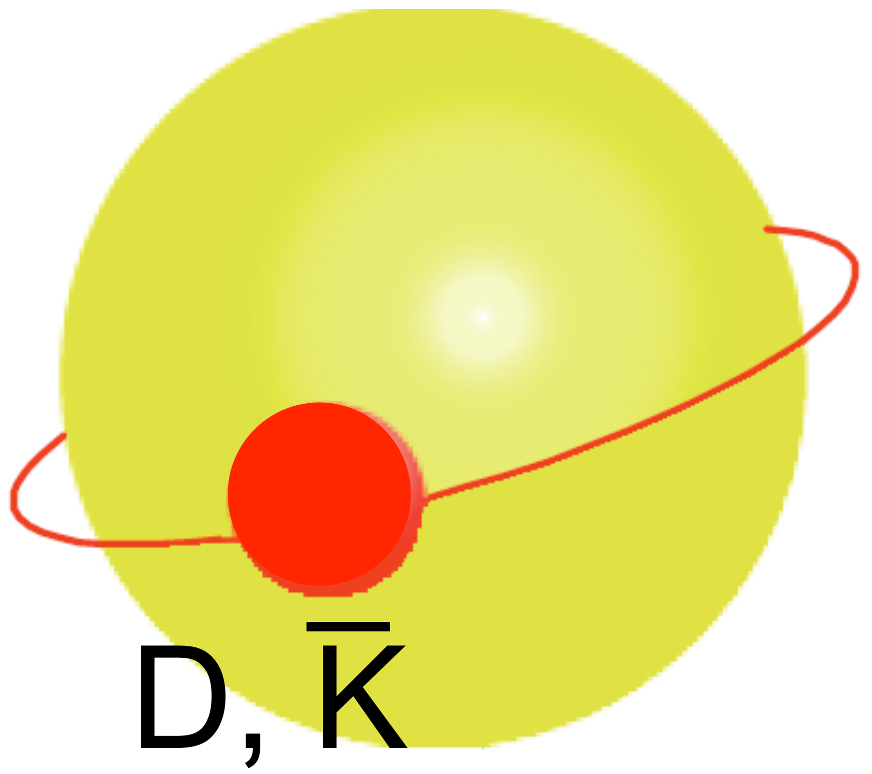


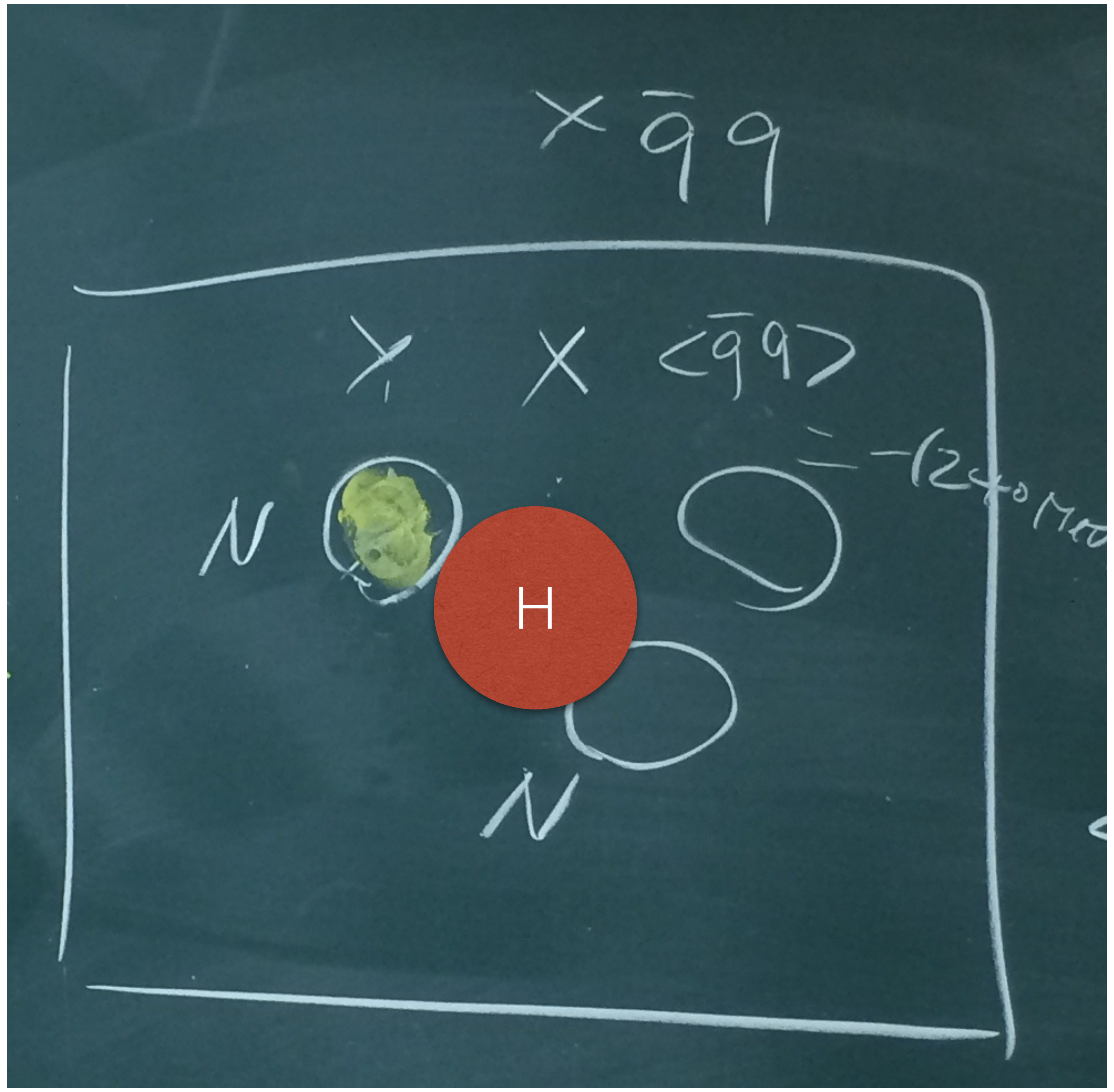
NuPECC report

HIN - Hadron in Nucleus

how does this “probe” modify the environment?





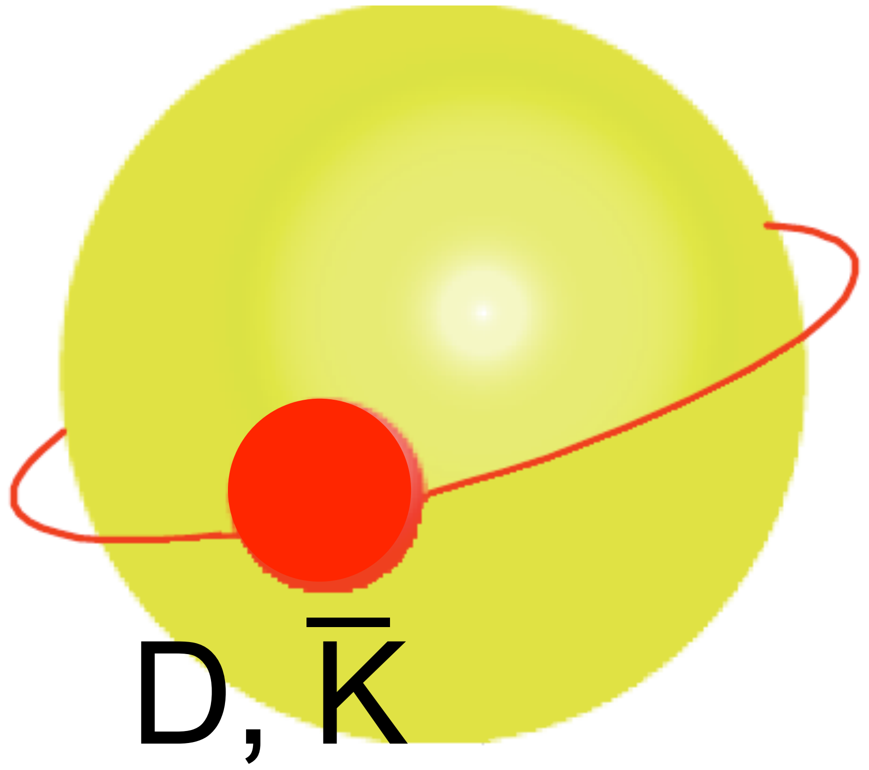


hadron-nucleon
2-body
baseline
n.b. hypernuclei

missing mass
invariant mass
transparency ratio
excitation energy
…

nuclear matter

HIN - Hadron in Nucleus



- π

  pionic atom - assisted by Coulomb & recoilless

  mass shift ~0, it is f_π (f_t) which gets modified

- Λ

  hypernuclei (in-medium μ_Λ)

- ω, Φ, …

  η, η', …

  mass reduction + ~recoilless ?

- charmed, $c\bar{c}$???

mass reduction?

- Chiral order parameters; not unique : Dim.3 condensate, Dim.6 condensate, etc
- ~30% reduction in $\frac{\langle \bar{q}q \rangle}{\langle \bar{q}q \rangle_0}$; what does this mean for mass?

<u>hadronic side</u> <u>QCD side</u>

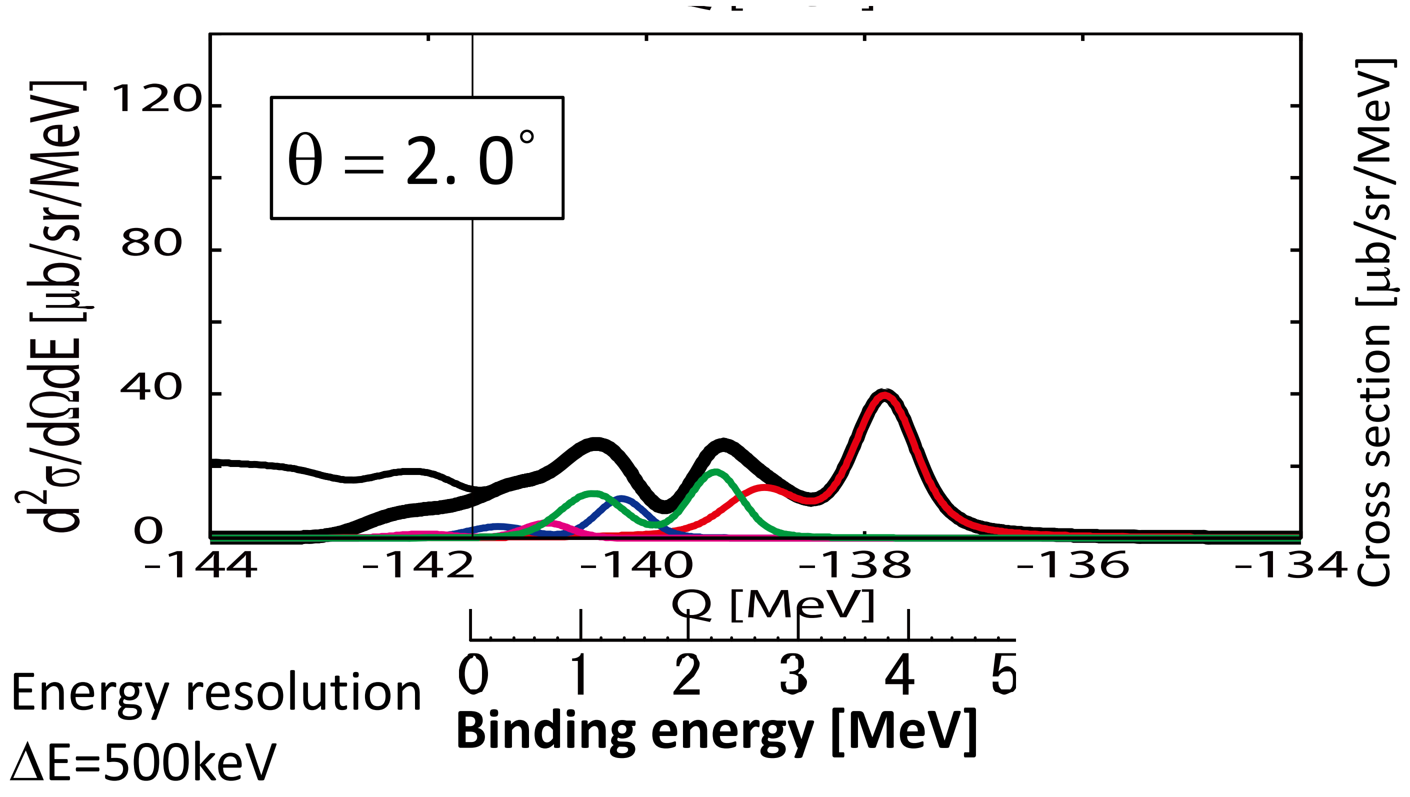
$$\frac{Q^2}{\pi}\int_0^\infty ds \frac{Im\Pi(s)}{s(s+Q^2)} = -\frac{1}{8\pi^2}(1+\frac{\alpha_s}{\pi})ln\frac{Q^2}{\Lambda^2} + \frac{m_q\langle \overline{q}q \rangle}{Q^4} + \frac{1}{24}\frac{\langle \frac{\alpha_s}{\pi}G^2 \rangle}{Q^4} - \frac{112}{81}\alpha_s \pi \frac{\langle \overline{q}q \rangle^2}{Q^6} + ...$$

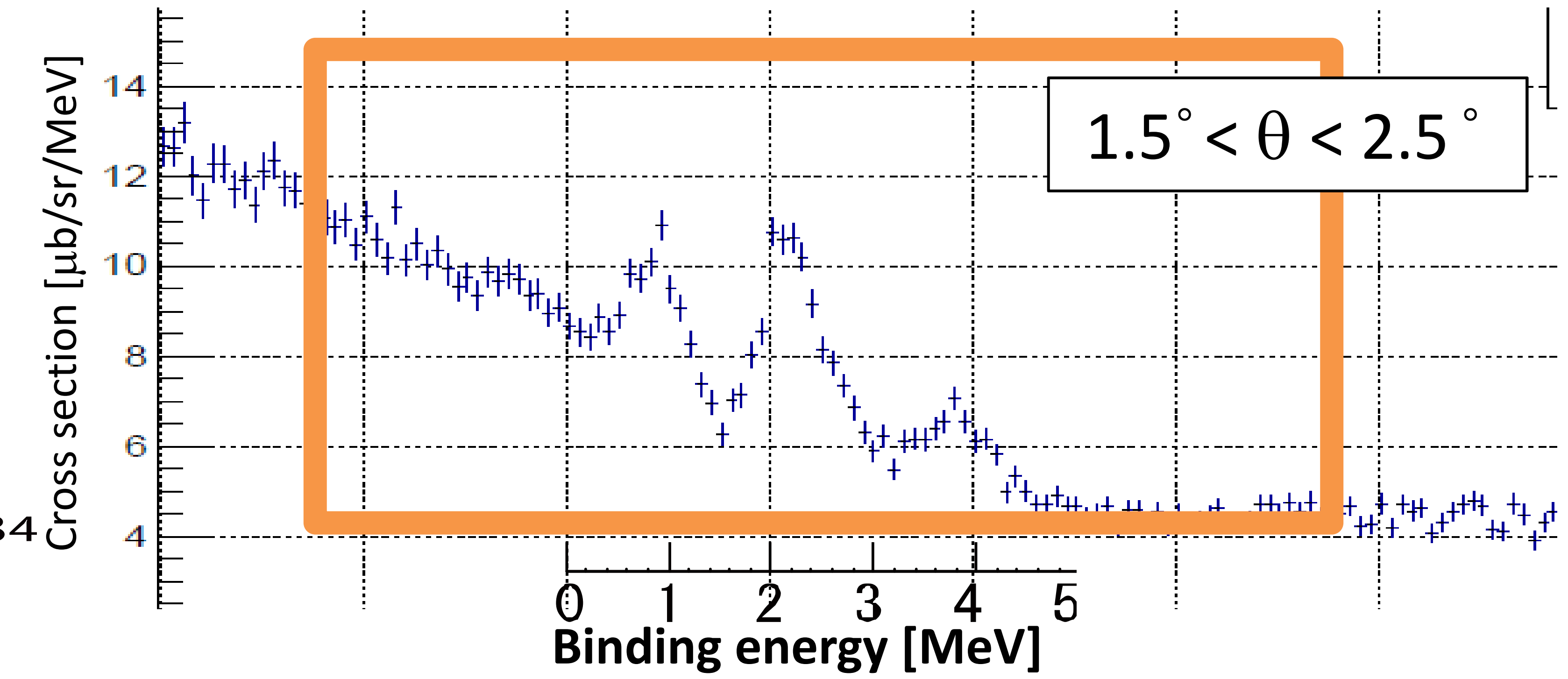
Metag

- Subthreshold behavior (energy dependence) of $f_{\eta N, \ldots}$ is crucial
- imaginary part W << real part V?

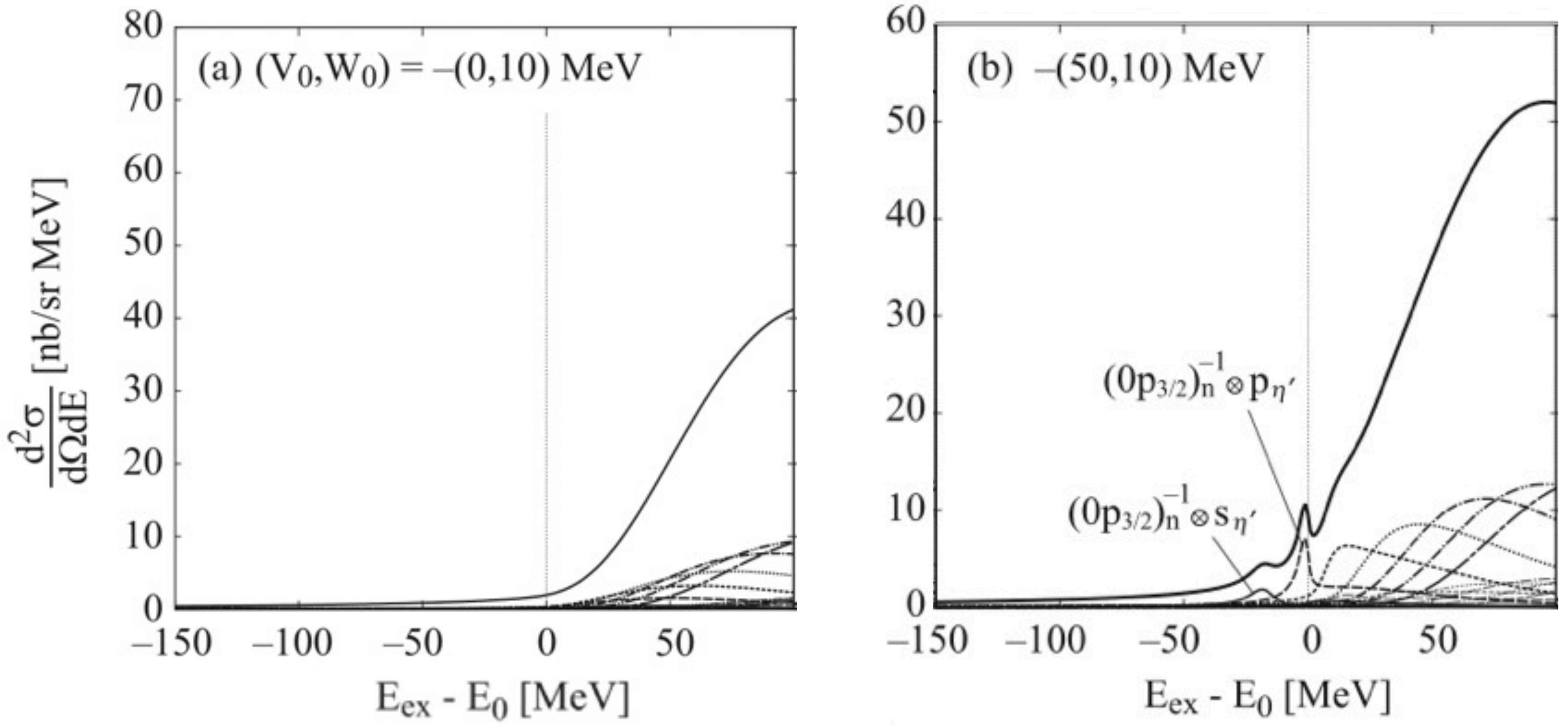
How well do we understand QF?

not easy even for pionic atoms



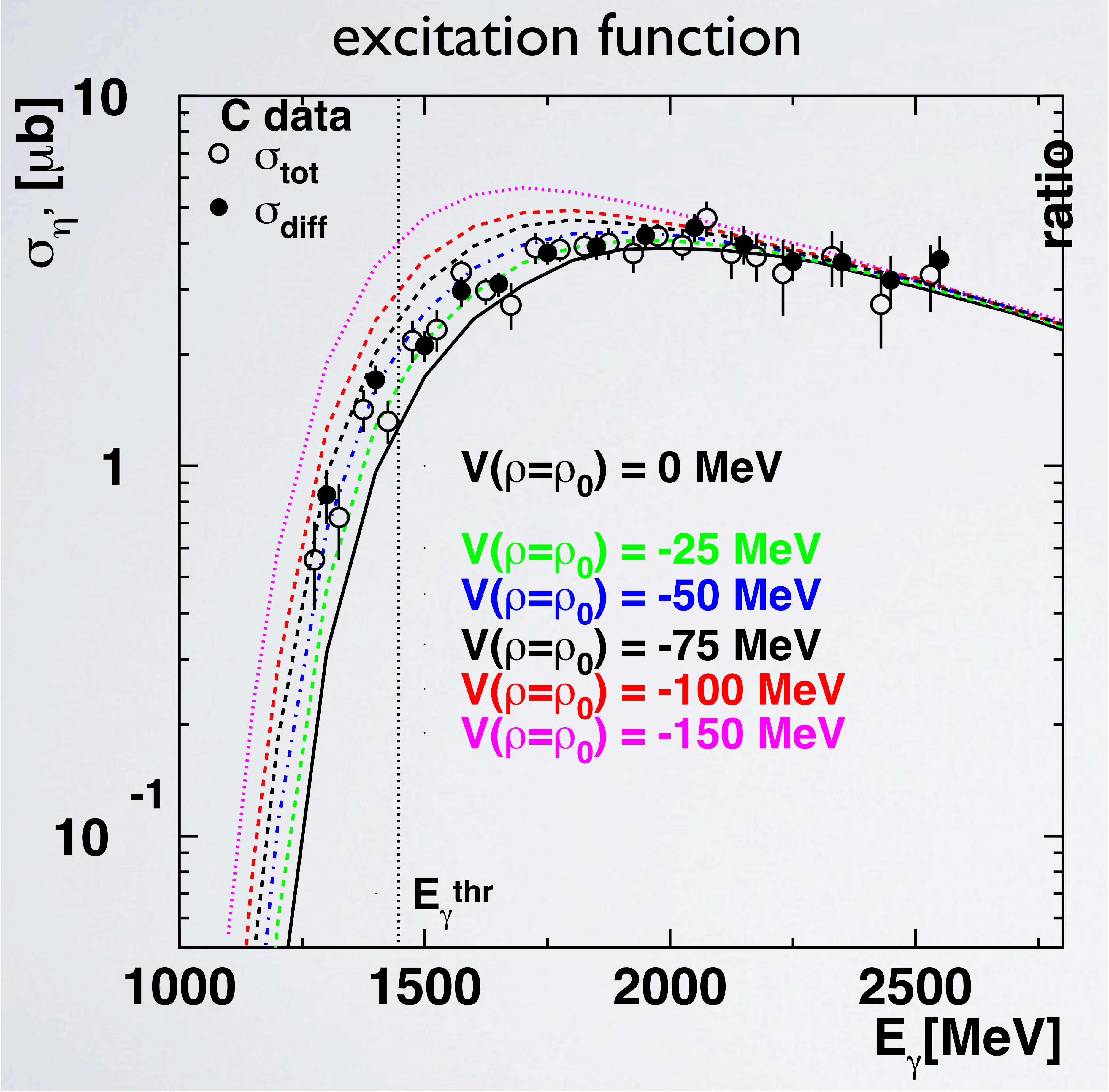


good understanding of QF, (and good energy resolution) essential for shallow V, large W



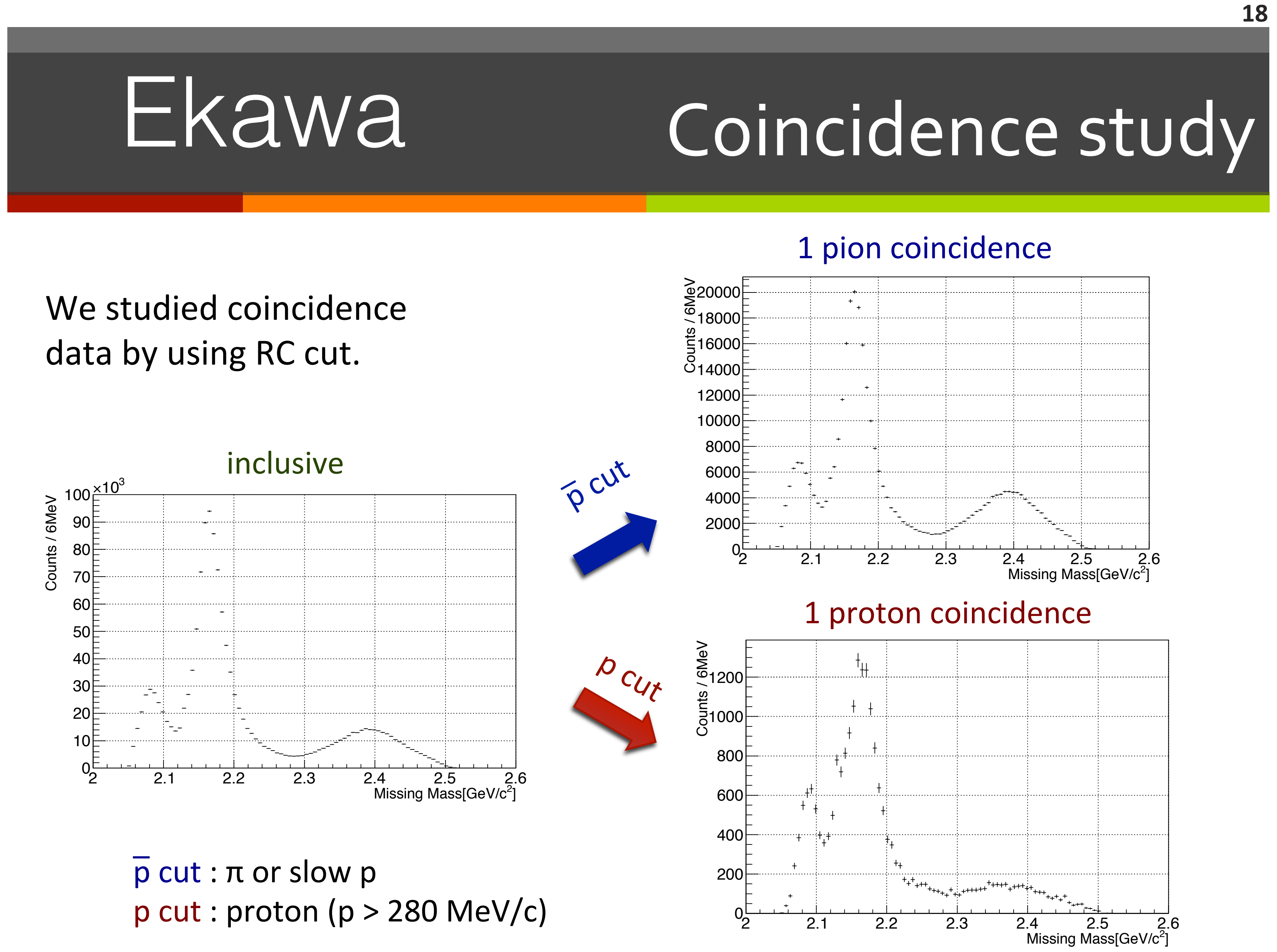
H.Nagahiro et al.,PRC 87 (2013) 045201

or the excitation function?



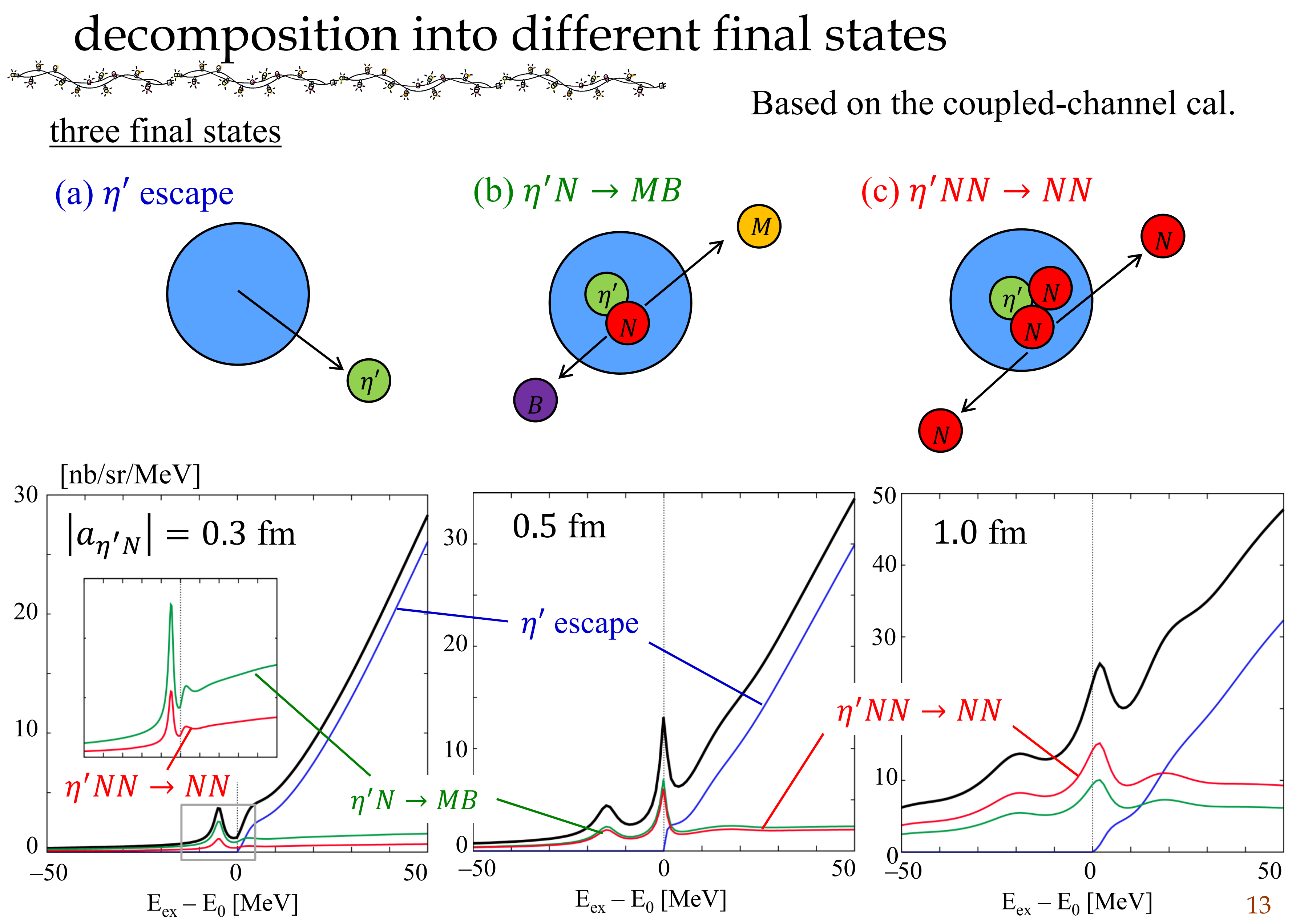
Nanova

To tag, or not to tag, that is the question



how to understand
(1-p tagged)/(inclusive)

"2 proton tagging rate is very low"

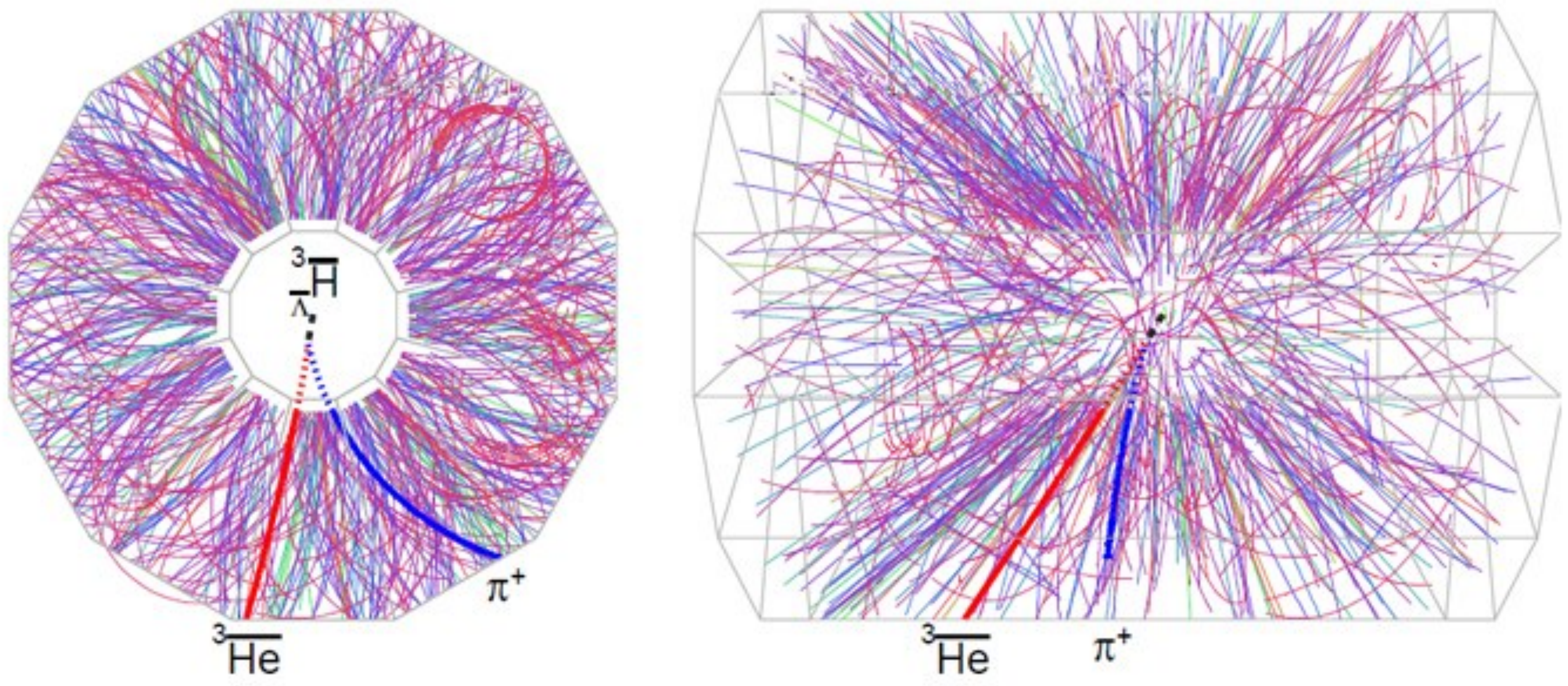


nagahiro

exotics in HEHI collisions

- exotics such as antihypertriton found in HEHI

STAR



- other exotics may have been formed, but not reconstructed - (Hamagaki, private comm.) such as strange-strange-strange dibaryon

$\Omega^{-}p$

A final remark

Theorist's dreams are…

Wish list by an innocent theorist

1 Spectral difference between chiral partners
π-σ, ρ-a_1, ω-f_1, etc

Determination of D=6 chiral condensates in the vacuum?
Tau-decay in nuclei ?

2 Individual properties of NG and "Higgs" bosons
π, K, η (NG), σ (Higgs), η' (anomaly)

$\sigma \rightarrow 2\gamma$, $\eta \rightarrow 2\gamma$, $\eta' \rightarrow 2\gamma$

Mesic nuclei
Dipion

3 Individual properties of vector bosons
ρ, ω, K* and φ

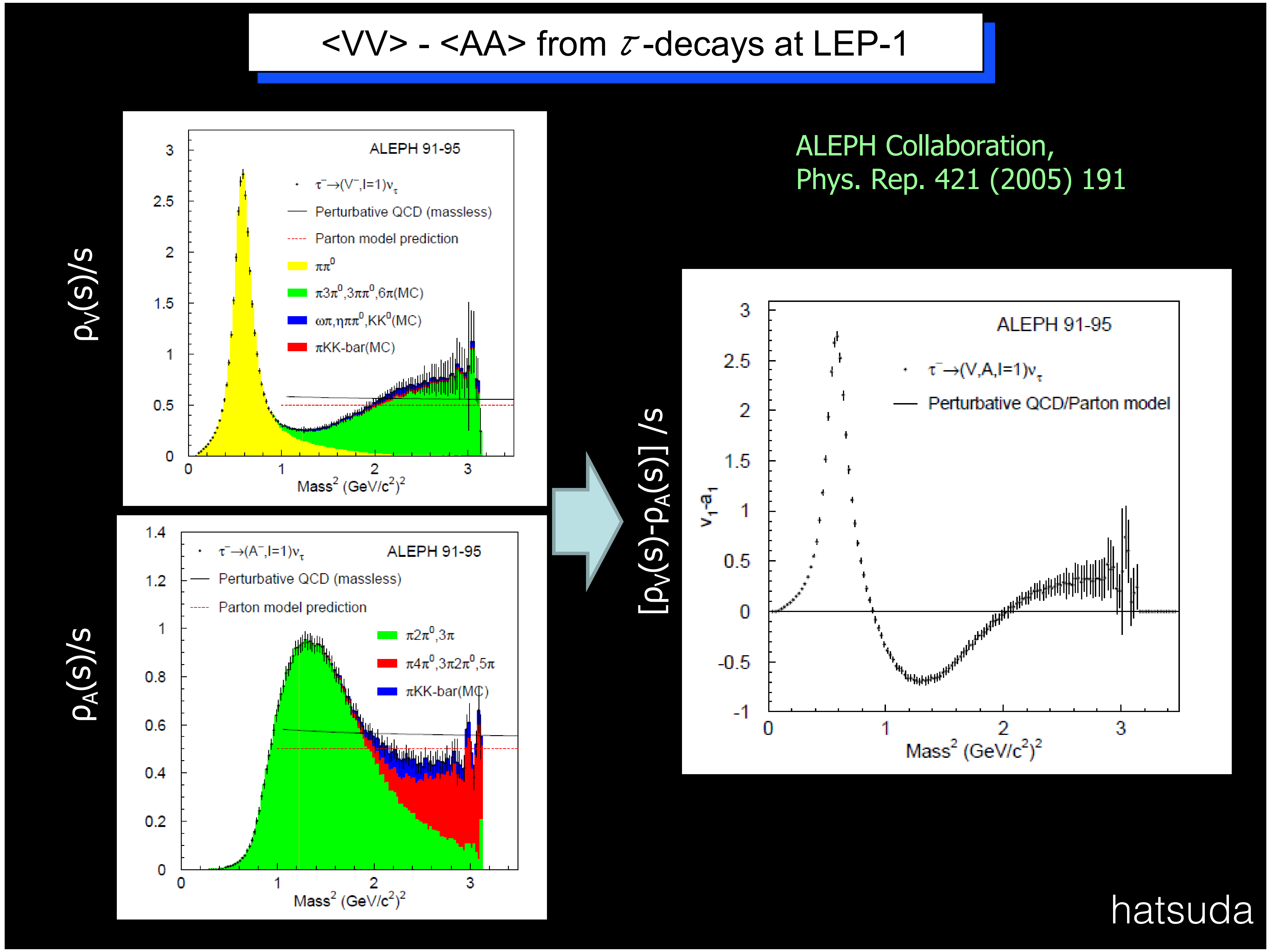
Dileptons
Hadronic decay

Precision/systematic studies
(dispersion relation, different targets, …)

hatsuda

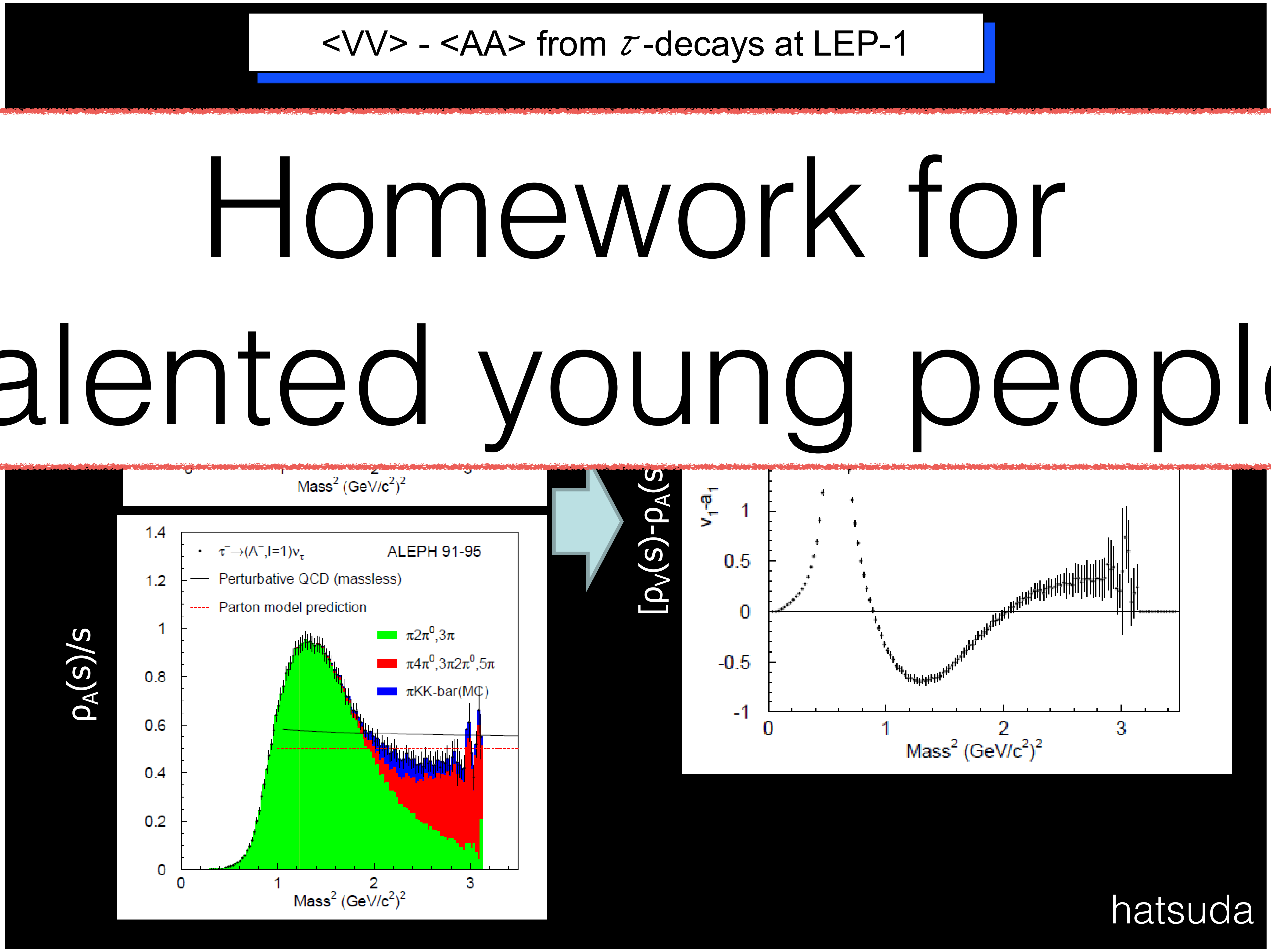
Experimentalist’s nightmare

e.g., how to do this ↓ in medium??



Experimentalist’s nightmare

e.g., how to do this ↓ in medium??



Homework for talented young people

Excellent program!!

Let us all thank the organizers