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Particle-Nucleus and Nucleus-Nucleus Scattering at Relativistic Energies

22 - 26 May 2006

Final state interaction in 3He(e'p)d and 4He(e, e'p) 3H within a generalized eikonal approximation

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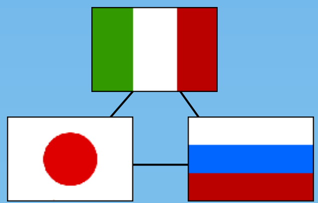
ICTP Workshop, Trieste, Italy 23 May, 2006

Hadron Propagation in the Medium

― The Exclusive Process A(e,e'p)B in few-nucleon systems ―



H. Morita for

< Perugia-Dubna-Sapporo Collab. >

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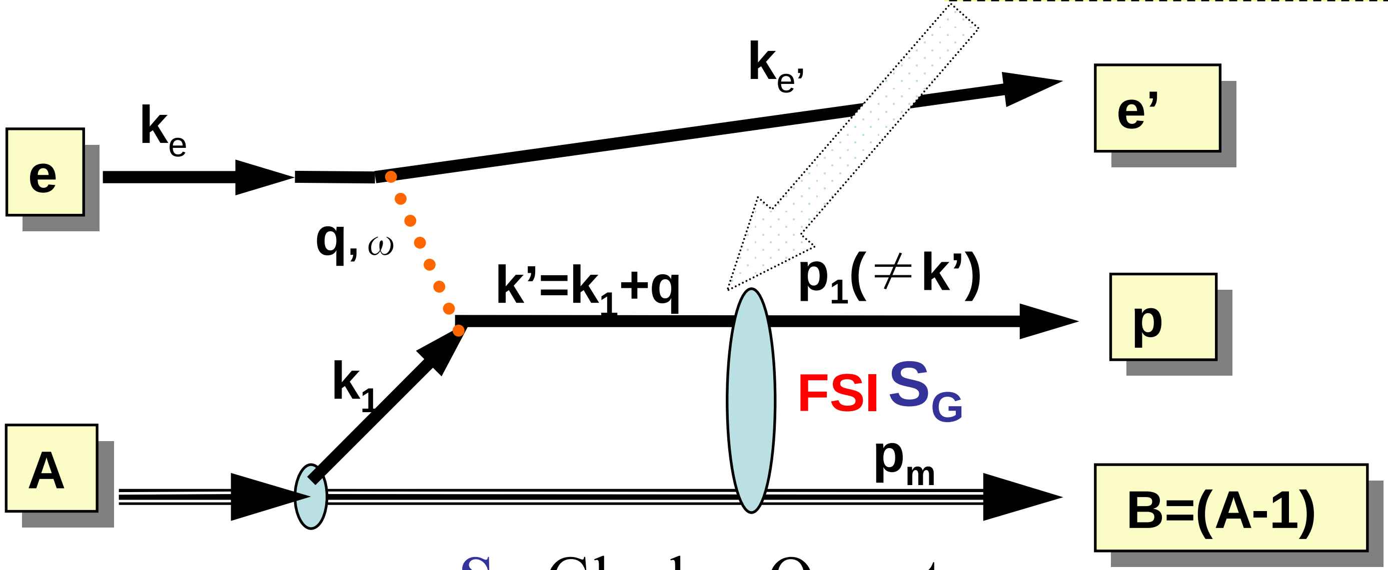
1. Introduction

A(e,ep')B Reaction

How can we describe the p propagation in medium?



S_G:Glauber Operator

< Subject of this talk >

Study of the (knocked out) p propagation in the process of $^3He(e,e'p)d(pn)$ and $^4He(e,e'p)^3H$ reaction.

Outline of my talk

1. Introduction
2. Framework of the calculation for the A(e,e'p)B Reaction -Generalized Eikonal Approximation-
3. Results of $^3He(e,e'p)^2H(pn)$ Reaction
4. Results of $^4He(e,e'p)^3H$ Reaction
5. Finite Formation Time Effect on $^4He(e,e'p)^3H$ Reaction -at higher Q^2 region-
6. Summary

2.Framework of the Calculation for the A(e,e'p)B Reaction

< Cross Section of A(e,e'p)B >

∗We use Factorization Ansatz.
(here only unpolarized cross section will be discussed)

$$\frac{d^6\sigma}{d\omega d\Omega_e dp d\Omega_p} = K \sigma_{ep} S_D(p_m, \mathrm{E}_m)$$

e-N cross section

nuclear **distorted** spectral function

distorted by FSI

If "**B**"(recoil system) is bound state

nucleon **distorted** momentum distribution

$$\frac{d^5\sigma}{d\omega d\Omega_e d\Omega_p} = K' \sigma_{ep} \left|\Phi_D(p_m)\right|^2$$

Nuclear Distorted Spectral Function in ^{3}He(e,e'p)^{2}H(pn) process

C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev.* **C71**, 024005 (2005)

S_G: Glauber operator

^{3}He(e,e'p)^{2}H

$$S_D(p_m, E_m) = \sum_f \left| \Psi_D^{M_2 +}(\mathbf{r}) S_G(\mathbf{r},\boldsymbol{\rho}) \Psi_{^3He}^{M_3}(\mathbf{r},\boldsymbol{\rho}) d\boldsymbol{\rho} d\mathbf{r} \right|^2$$

$$\times \delta(E_m - (E_D - E_{^3He}))$$

$\Psi_{^3He}^{M_3}$:Pisa Group's w.f. with AV18 pot.

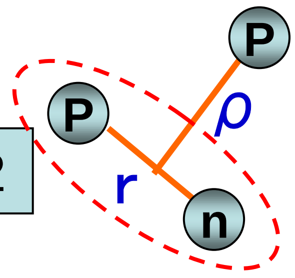
A. Kievsky et al., *Nucl. Phys.* **A551**(1993) 241

^{3}He(e,e'p)pn

$$S_D(p_m, E_m) = \sum_f \int \frac{d^3\mathbf{t}}{(2\pi)^3} \left| \int e^{i\boldsymbol{\rho}\cdot\mathbf{p}_m} \chi_{\frac{1}{2}s_1}^{+} \Psi_{np}^{\mathbf{t}\,+}(\mathbf{r}) S_G(\mathbf{r},\boldsymbol{\rho}) \Psi_{^3He}^{M_3}(\mathbf{r},\boldsymbol{\rho}) d\boldsymbol{\rho} d\mathbf{r} \right|^2$$

$$\times \delta\left(E_m - \left(\frac{\mathbf{t}^2}{M_N} - E_{^3He}\right)\right)$$

$t=(P_p-P_n)/2$



Glauber Operator S_G

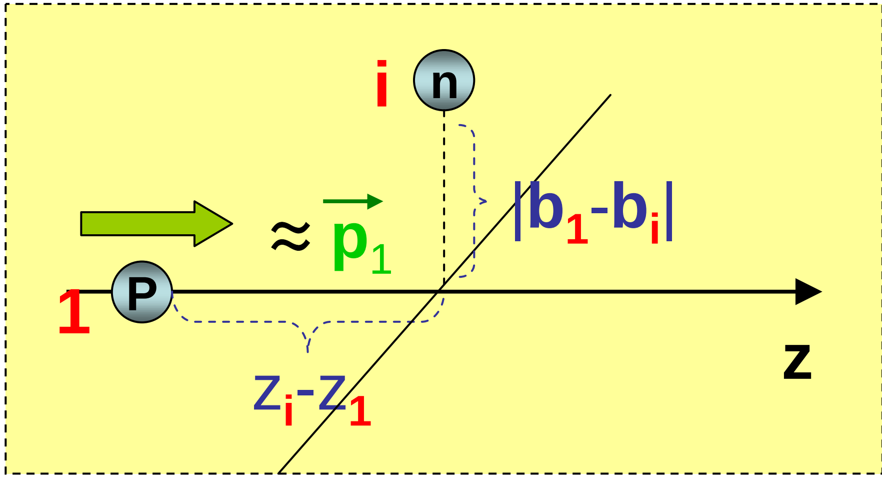
1st nucleon ⇨ Struck proton

$$S_G = \prod_{i=2}^{3} G(1i), \qquad G(1i) = 1 - \theta(Z_i - Z_1)\Gamma(\mathbf{b}_1 - \mathbf{b}_i),$$

$$\Gamma(\mathbf{b}) = \frac{\sigma_{tot}(1 - i\alpha)}{4\pi b_0^{\,2}} \exp(-\mathbf{b}^2 / 2b_0^{\,2})$$

Usual Parameterization

σ_{tot} ← Particle Data Group (http://pdg.lbl.gov/)
α ← Partial-Wave Analysis Facility (http://lux2.phys.va.gwu.edu/)



<Choice of Z-axis>

$\mathbf{p}_1$ // z

ejected proton's Momentum

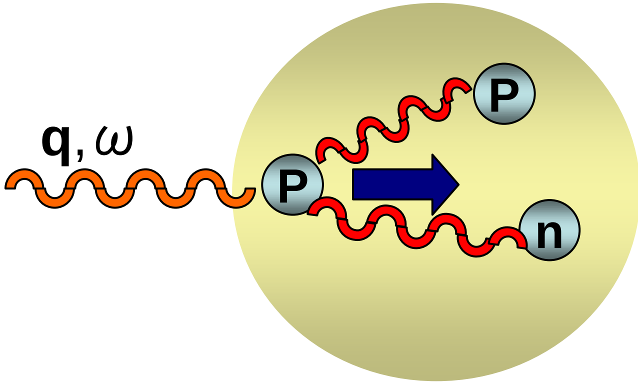
not **q** !!

Generalized Eikonal Approximation

L.L.Frankfurt et al., *Phys. Rev*. **C56**, 1124(1997) and M.M. Sargsian et al, *Phys. Rev.* **C71** 044614(2005)

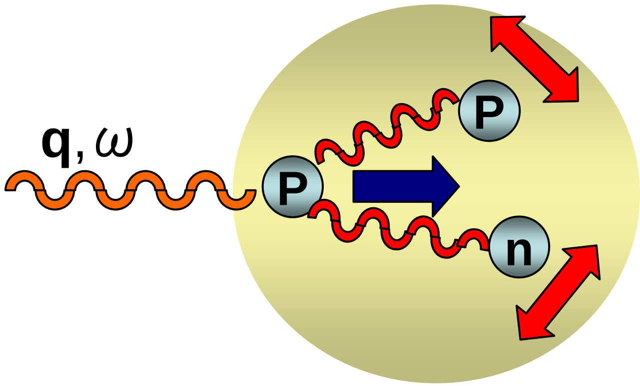
C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev.* **C71**, 024005 (2005)

Conventional Glauber Approximation



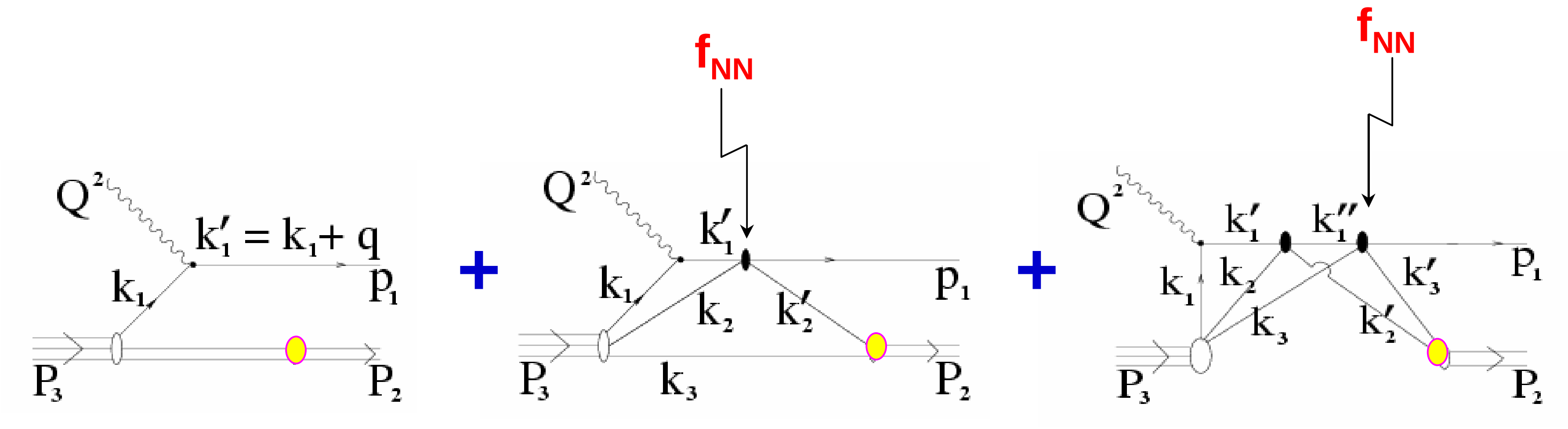
Frozen Approximation

Generalized Eikonal Approximation



Consider the Fermi motion

Diagramatic representation of the process $^3He(e,e'p)^2H(pn)$



PWIA

$\Im^{(0)}$: **IA** Amplitude

Single resc.

$\Im^{(1)}$: **Single** Resc. Amp.

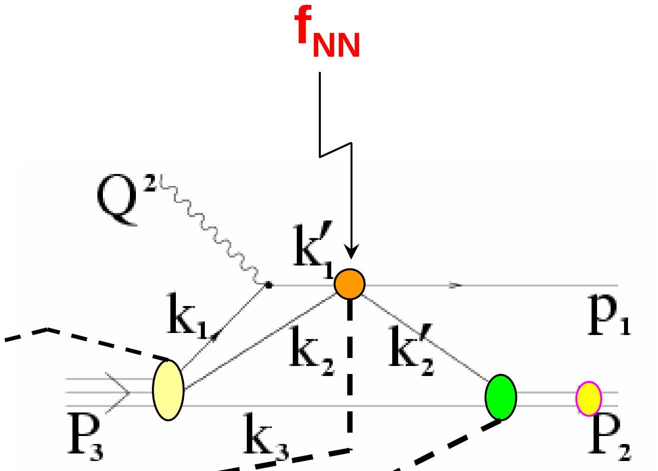
Double resc.

$\Im^{(2)}$: **Double** Resc. Amp.

$$S_D(p_m,E_m)=\frac{1}{2J_{^3He}+1}\sum_f\left|\sum_{n=0}^{2}\Im^{(n)}(M_f,s_1)\right|^2\delta\left(E_m-\left(E_2^f-E_{^3He}\right)\right)$$

Single Rescattering Amplitude $\mathfrak{I}^{(1)}$

$$S_D(p_m,E_m)=\frac{1}{2J_{^3He}+1}\sum_f\left|\sum_{n=0}^{2}\mathfrak{I}^{(n)}(M_f,s_1)\right|^2\delta\left(E_m-\left(E_2^f-E_{^3He}\right)\right)$$



$$\mathfrak{I}^{(1)}=\int d\tau_{23}\frac{G_{He\to1(23)}(k_1,k_2,k_3,s_1,s_2,s_3)}{(k_1^2-M_N^2)}\frac{f_{NN}(p_1-k_1')}{k_1'^2-M_N^2}\frac{G^+_{(23)\to f}(k_2',k_3,s_2,s_3)}{(k_1'^2-M_N^2)}$$

$$<s_1,s_2,s_3\,|\,\Psi^{M_3}_{^3He}(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)>$$

$$<s_2,s_3\,|\,\Psi^{M_{23}}_{23}(\mathbf{k}_2,\mathbf{k}_3)>$$

$$\kappa\equiv\mathbf{p}_1-\mathbf{k}_1'$$

$$\mathfrak{I}^{(1)}\approx\int\frac{d^3\boldsymbol{\kappa}}{(2\pi)^3}\left\langle s_1\,|\,\Psi^{M_3}_{^3He}(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)\right\rangle\frac{f_{NN}(\kappa_\perp)/4M_N|\mathbf{p}_1|}{\kappa_z+\Delta_z+i\varepsilon}\Psi^f_{(23)}(\mathbf{k}_2',\mathbf{k}_3;S_{23})$$

$$\Delta_z=\frac{E_{\mathbf{k}_1+\mathbf{q}}+E_{\mathbf{p}_1}}{2|\mathbf{p}_1|}E_m\approx\frac{E_{\mathbf{p}_1}}{|\mathbf{p}_1|}E_m$$

Effect of residual nucleon's Fermi motion.

Single Rescattering Amplitude $\Im^{(1)}$ (cont.)

Using the coordinate space representation of the propagator

$$\Im^{(1)} \approx \int \frac{d^3\boldsymbol{\kappa}}{(2\pi)^3} \left\langle s_1 \,|\, \Psi^{M_3}_{^3He}(\mathbf{k}_1, \mathbf{k}_2, \mathbf{k}_3) \right\rangle \frac{f_{NN}(\kappa_\perp)/4M_N|\mathbf{p}_1|}{\kappa_z + \Delta_z + i\varepsilon} \Psi^{f}_{(23)}(\mathbf{k}'_2, \mathbf{k}_3; S_{23})$$

$$\frac{1}{\kappa_z + \Delta_z + i\varepsilon} = -i\int \theta(z) e^{i(\kappa_z + \Delta_z)\cdot z} dz$$

Finally we get

$$S_D^{(0+1)}(p_m, E_m) = \sum_f \left| \Psi^{f\,+}_{23}(\mathbf{r}) \left(S^{(0)}(\mathbf{r}, \boldsymbol{\rho}) + S^{(1)}_{GEA}(\mathbf{r}, \boldsymbol{\rho}) \right) \Psi^{M_3}_{^3He}(\mathbf{r}, \boldsymbol{\rho}) d\boldsymbol{\rho} d\mathbf{r} \right|^2 \times \delta\left(E_m - \left(E^f_{23} - E_{^3He}\right)\right)$$

$$S^{(0)}(\mathbf{r}, \boldsymbol{\rho}) = 1$$

$$S^{(1)}_{GEA}(\mathbf{r}, \boldsymbol{\rho}) = -\sum_{i=2}^{3} \theta(z_i - z_1) e^{i\Delta_z (z_i - z_1)} \Gamma(\mathbf{b}_1 - \mathbf{b}_i)$$

GEA Operator

Double Rescattering Case

$$S^{(2)}_{GEA}(\mathbf{r},\boldsymbol{\rho}) = [\theta(z_2 - z_1)\theta(z_3 - z_2)e^{-i\Delta_3(z_2-z_1)}e^{-i(\Delta_3-\Delta_z)(z_3-z_1)} + \theta(z_3 - z_1)\theta(z_2 - z_3)e^{-i\Delta_2(z_3-z_1)}e^{-i(\Delta_2-\Delta_z)(z_2-z_1)}]\Gamma(\Delta_z,\mathbf{b}_1-\mathbf{b}_2)\Gamma(\Delta_z,\mathbf{b}_1-\mathbf{b}_3)$$

$$\Delta_i = \frac{q_0}{|\mathbf{q}|}(E_{\mathbf{k}'_i} - E_{\mathbf{p}_i}) \qquad \Gamma(\Delta_z,\mathbf{b}_1-\mathbf{b}_i) \equiv e^{i\Delta_z}\Gamma(\mathbf{b}_1-\mathbf{b}_i)$$

Ref) L.L.Frankfurt et al., *Phys. Rev*. **C56**, 1124(1997)

In the following calculation, we put

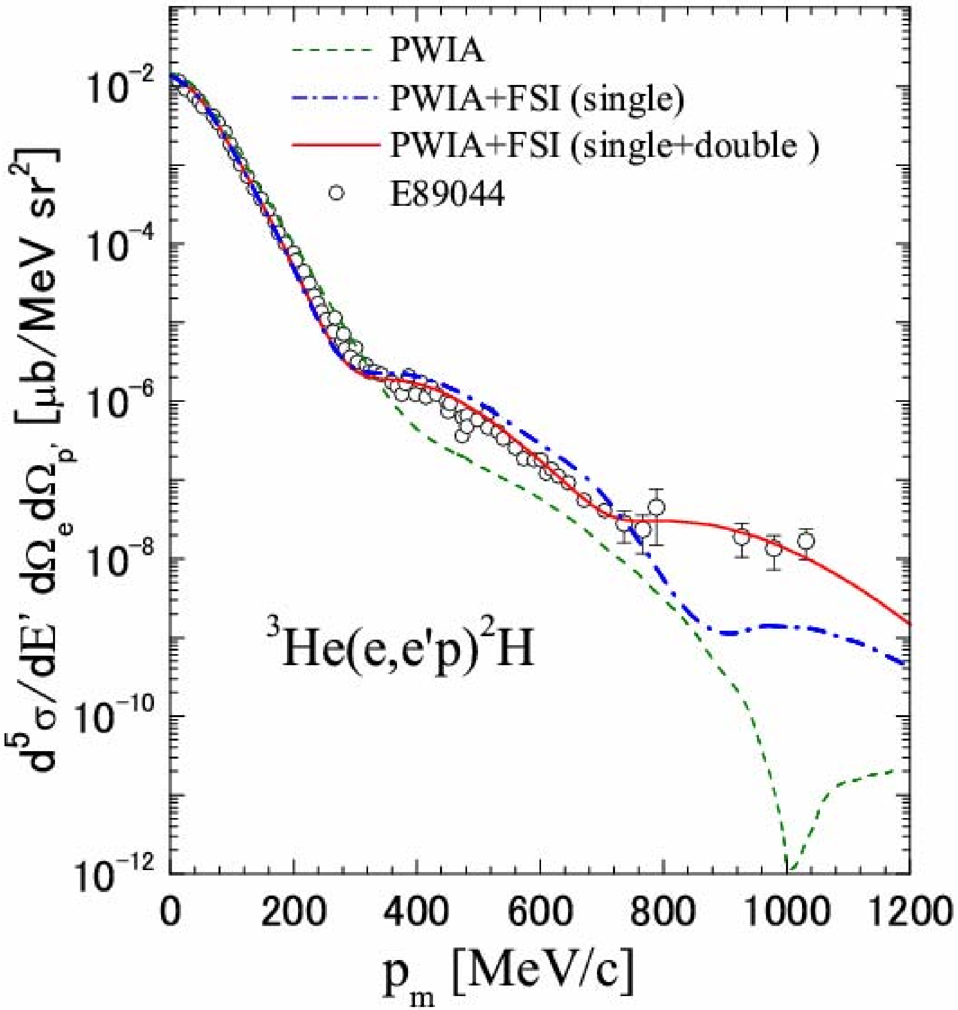
$\Delta_i = \Delta_z / 2$ for the double rescattering

Finally we get the distorted spectral function

$$S_D(p_m,E_m) = \sum_f \left| \Psi^{f\,+}_{23}(\mathbf{r})\left(S^{(0)} + S^{(1)}_{GEA} + S^{(2)}_{GEA}\right)\Psi^{M_3}_{^3He}(\mathbf{r},\boldsymbol{\rho})d\boldsymbol{\rho}d\mathbf{r} \right|^2 \times \delta(E_m - \left(E^f_{23} - E_{^3He}\right))$$

3.Results of ^{3}He(e,e'p) ^{2}H(pn) Reaction

C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev. Lett*. **95**, 052502 (2005)



Data: JLab E89044

$Q^2 \sim 1.55 (GeV/c)^2$, x=1

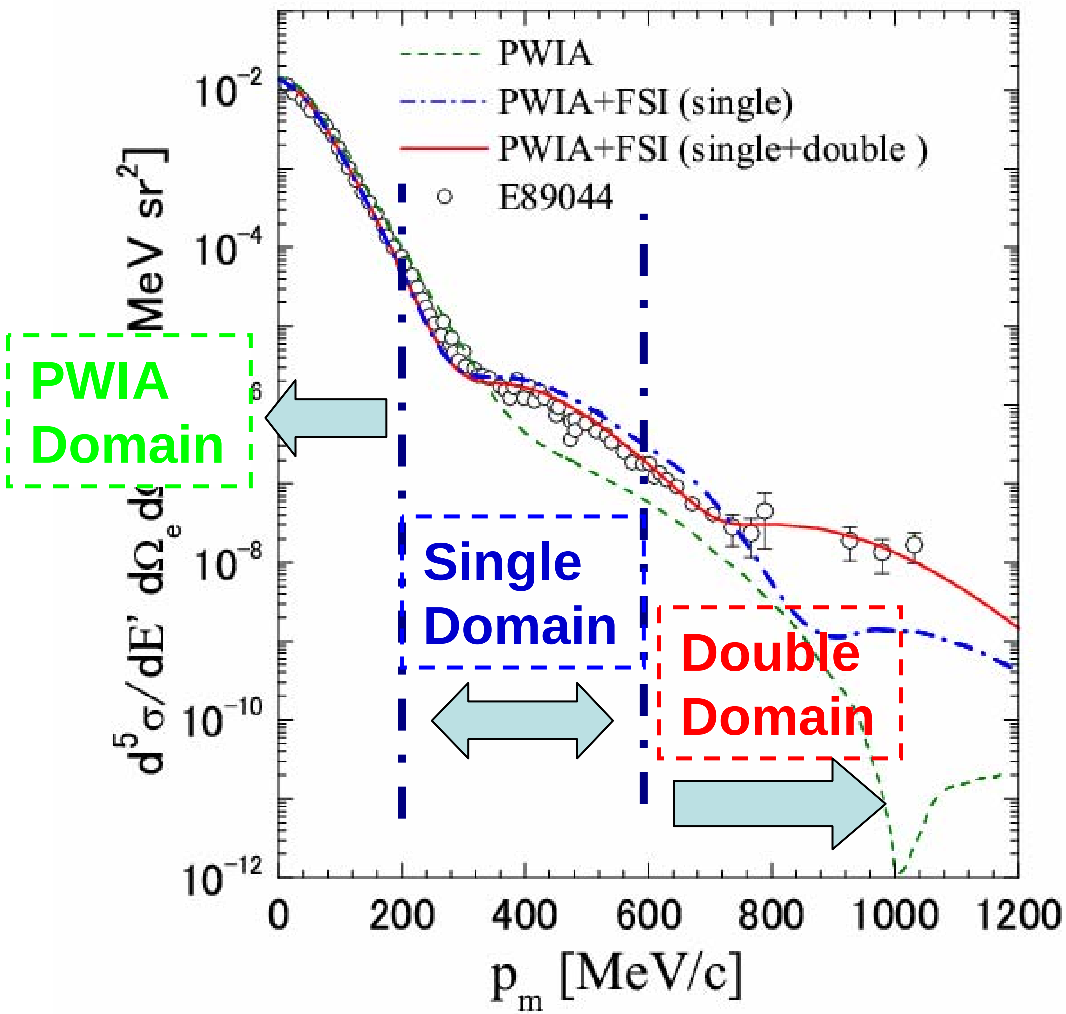
M.M. Rvachev et al., *Phys. Rev. Lett.* **94**(2005) 192302

GEA(GA) Calculation reproduces the data almost perfectly.

$$\left| d^5\sigma(GEA) - d^5\sigma(GA) \right| \approx \text{a few } \%$$

Multiple Scattering Contributions

C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev. Lett*. **95**, 052502 (2005)

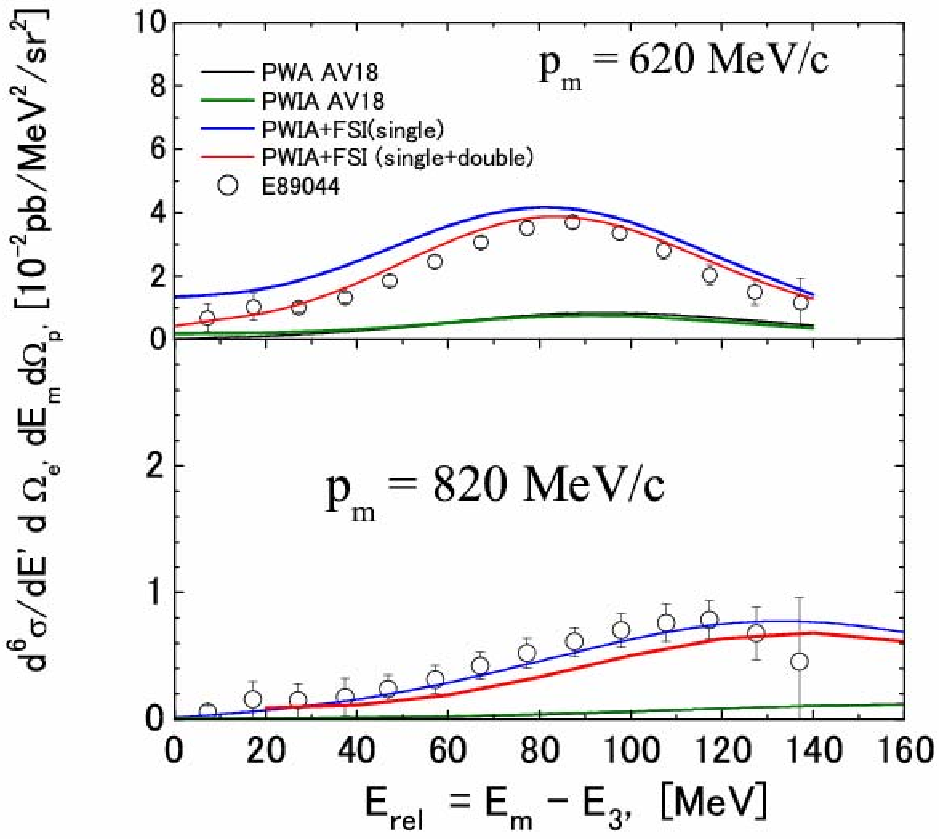


$d\sigma(p_m)$ has different (three) slopes

different Multiple Scattering Component

Results of $^3He(e,e'p)\,pn$

C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev. Lett*. **95**, 052502 (2005)



Data: JLab E89044

$Q^2 \sim 1.55 (GeV/c)^2$, x=1

F. Benmokhtav et al., *Phys. Rev. Lett.* **94**(2005) 082325

GEA(GA) Calculation reproduces the data quite well.

4. Results of ^{4}He(e,e'p)^{3}H Reaction

< Extension to ^{4}He(e,e'p)^{3}H Reaction >

We extend the same calculation as ^{3}He-case to ^{4}He(e,e'p)^{3}H reaction

But, for the realistic wave function we adopted the **ATMS** method

ATMS method

M. Sakai et al., Prog.Theor.Phys.Suppl.56(1974)108.

H. Morita et al., Prog.Theor.Phys.78(1987)1117.

$\Psi_{^3H}, \Psi_{^4He}$:ATMS wave function

NN force :Reid Soft Core

Variational wave function

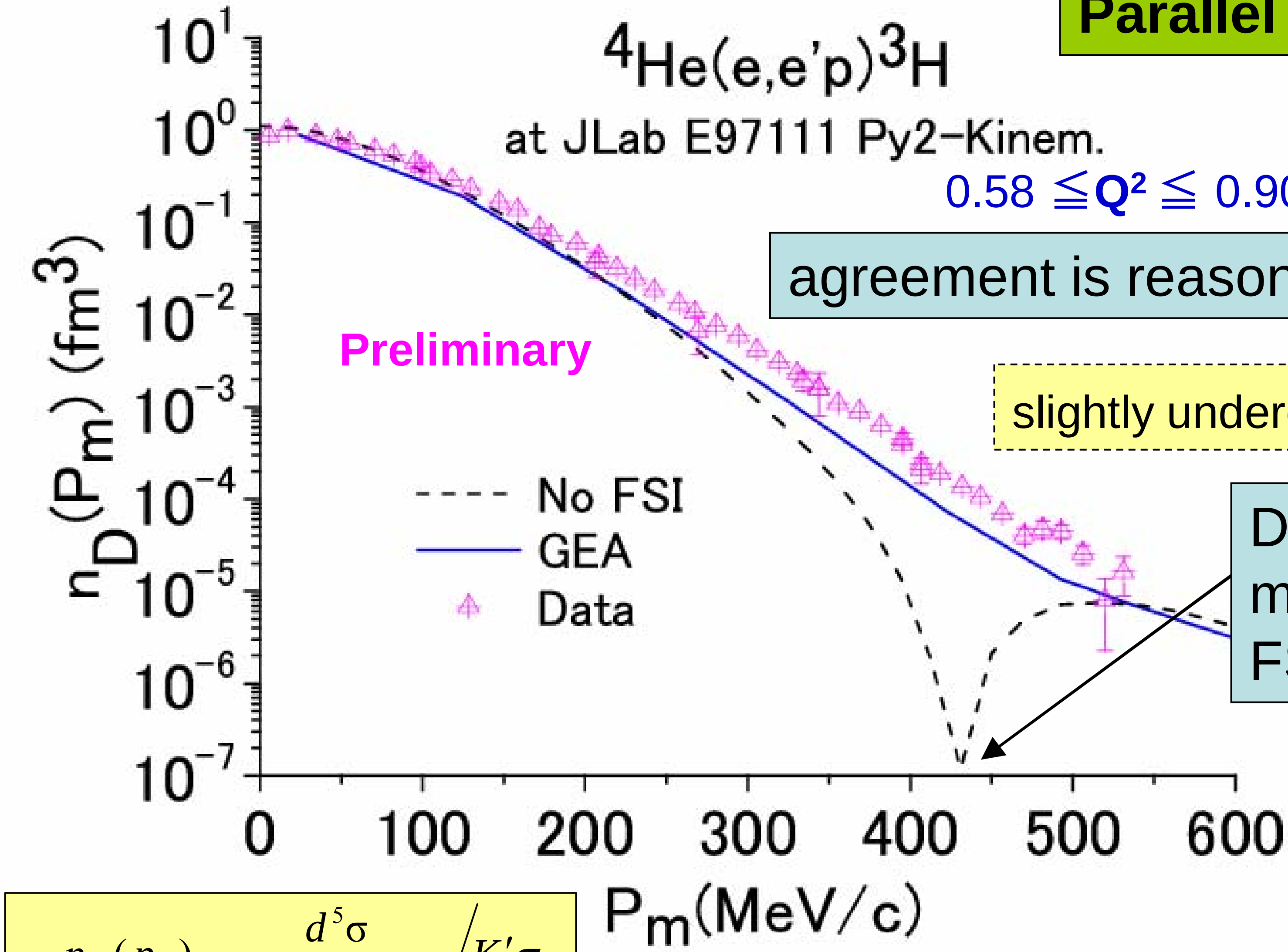
< Experimental Data >

JLab E97-111: B. Reitz et al., Eur. Phys. J. A S19(2004) 165

1. **Py2 Kinematics**—Parallel Kinematics
2. **CQω2 Kinematics**—Perpendicular Kinematics

Results at Py2-Kinem.

Parallel Kinem.



$0.58 \leqq Q^2 \leqq 0.90$ (GeV/c)^2

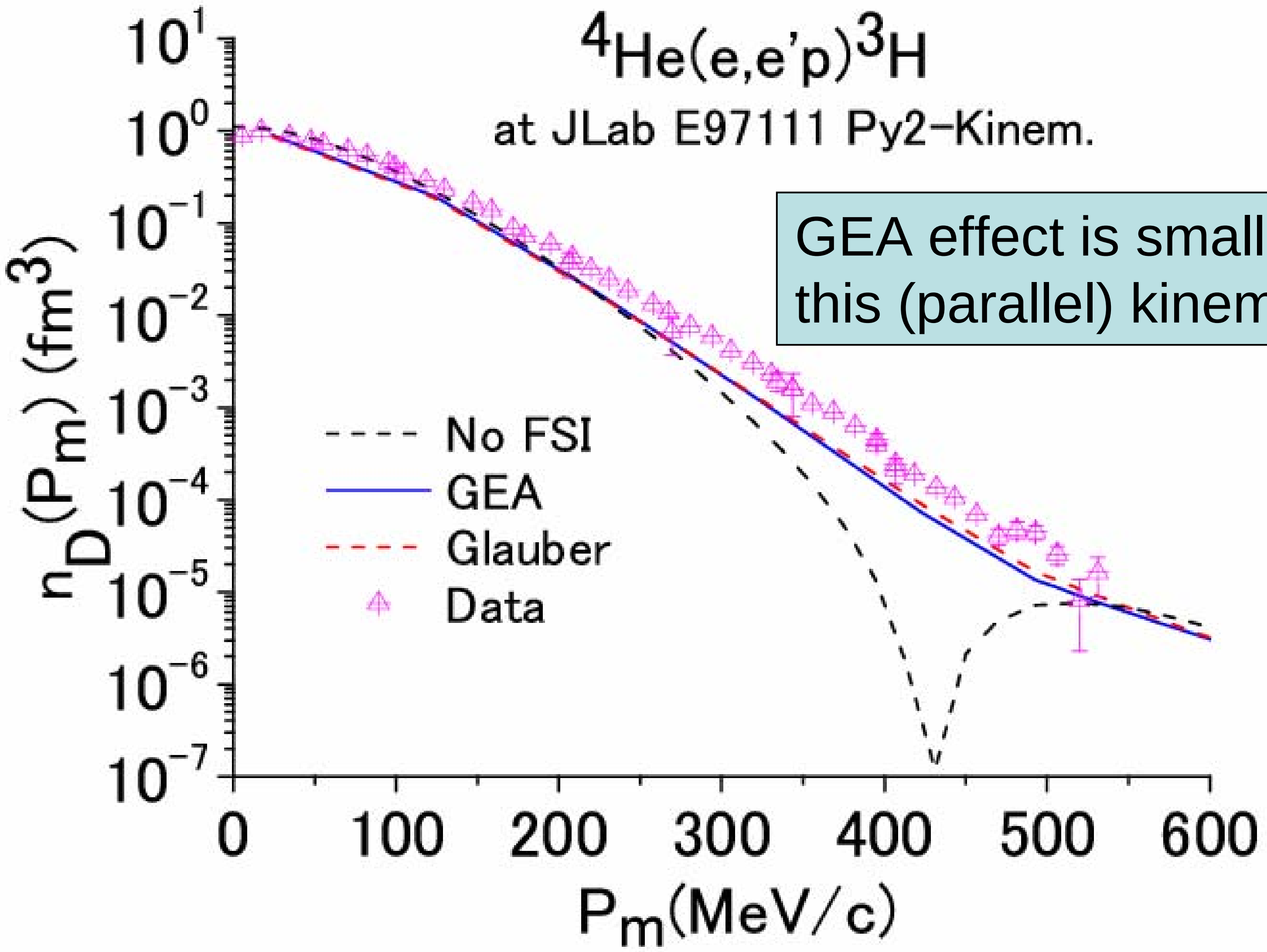
agreement is reasonably well.

slightly underestimate

Dip is masked by FSI

$$n_D(p_m) = \frac{d^5\sigma}{d\omega d\Omega_e d\Omega_p} \Big/ K'\sigma_{ep}$$

Effect of the GEA on GA

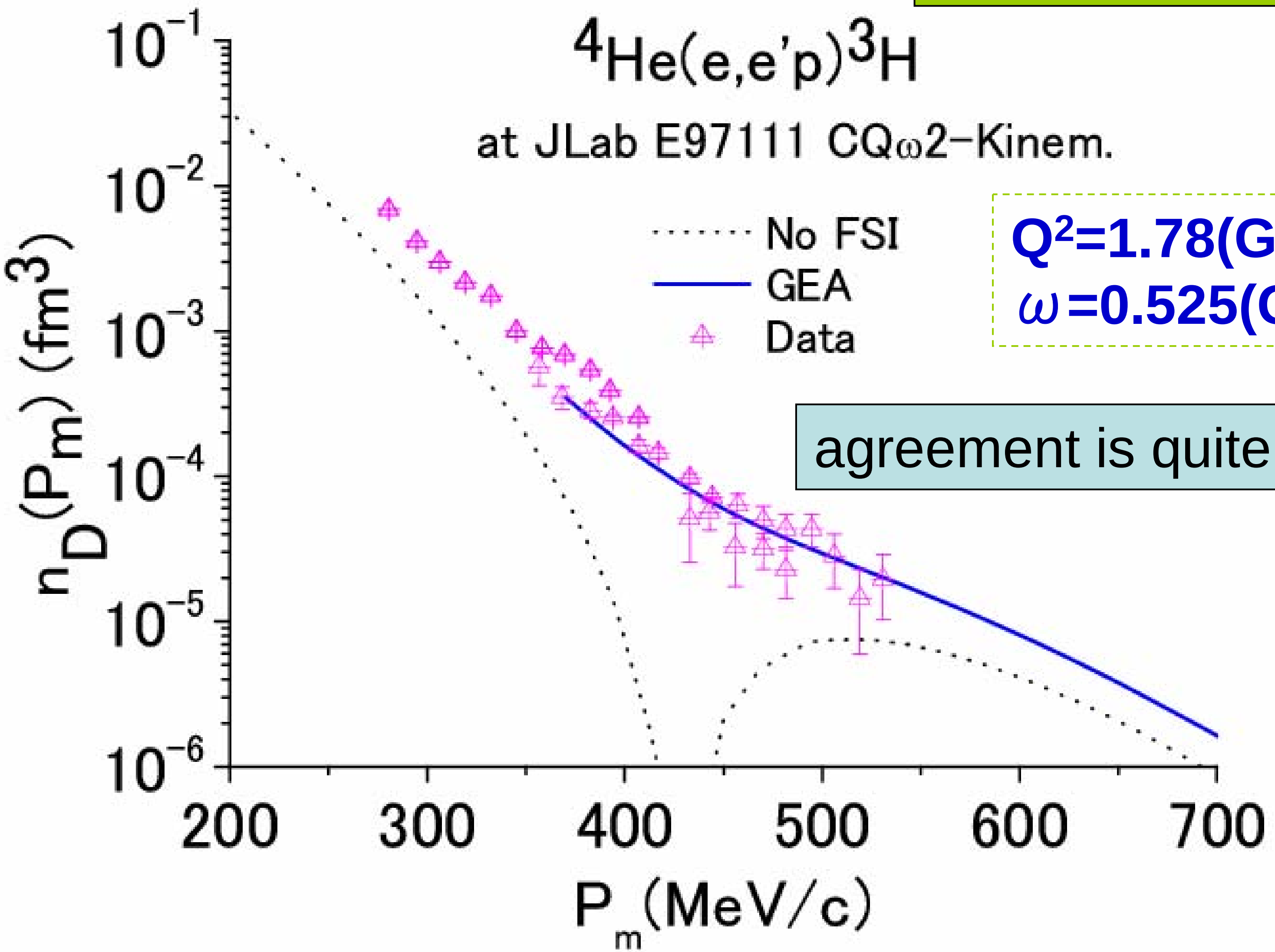


GEA effect is small at this (parallel) kinematics

M.S.

Results at CQω2-Kinem.

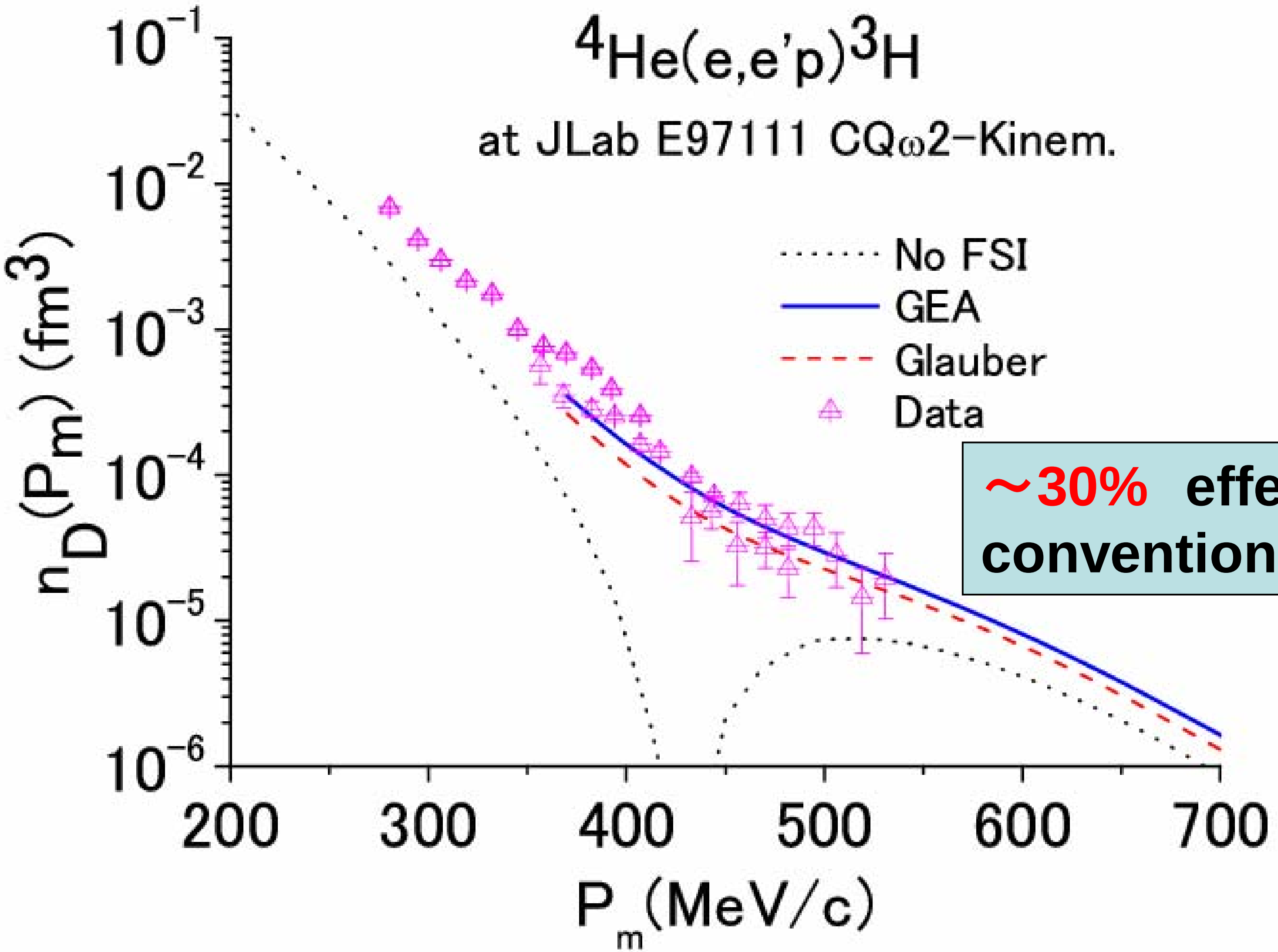
Perpendicular Kinem.



Q^2=1.78(GeV/c)
ω=0.525(GeV)

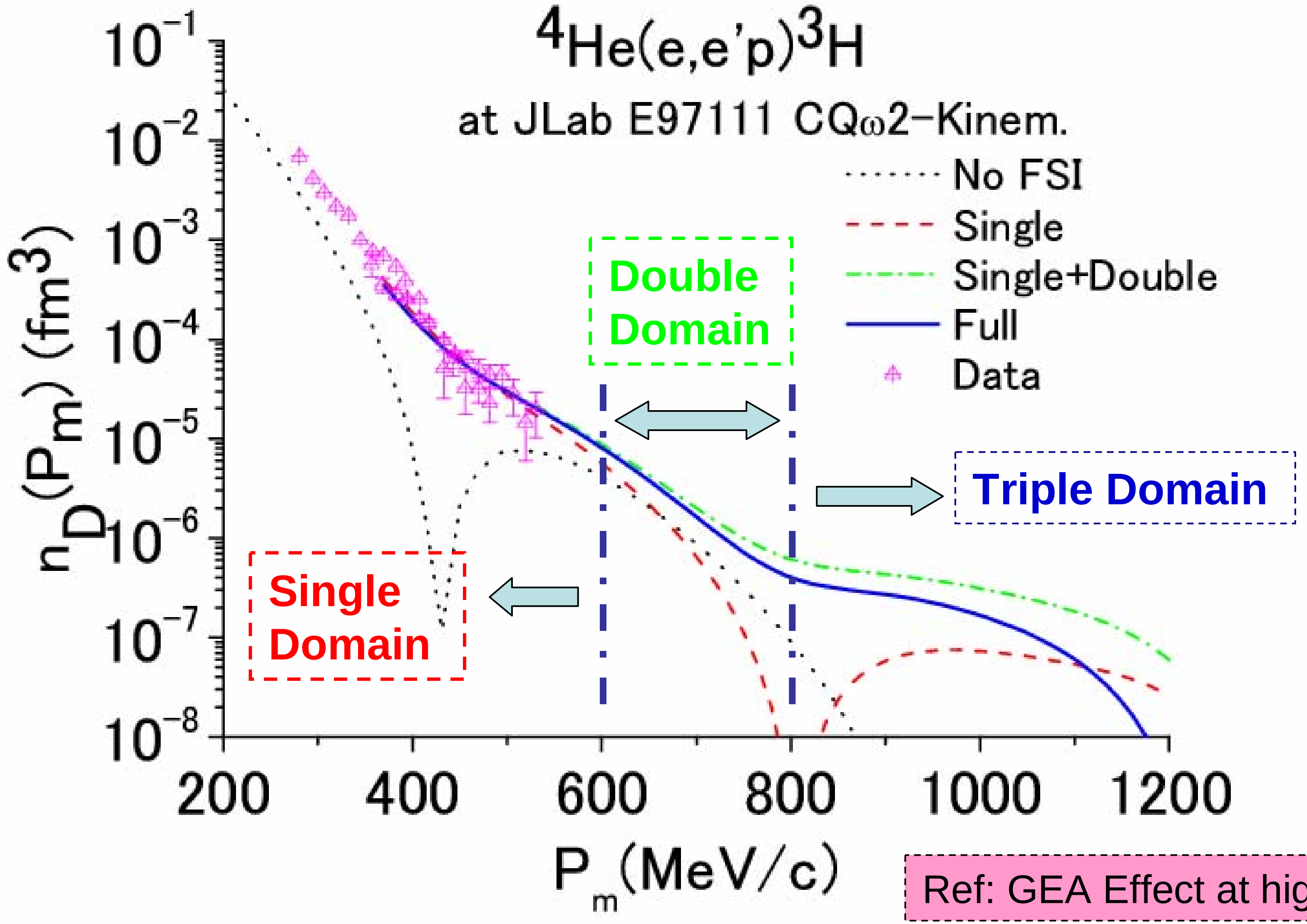
agreement is quite good.

Effect of the GEA on GA



～30% effect on conventional Glauber

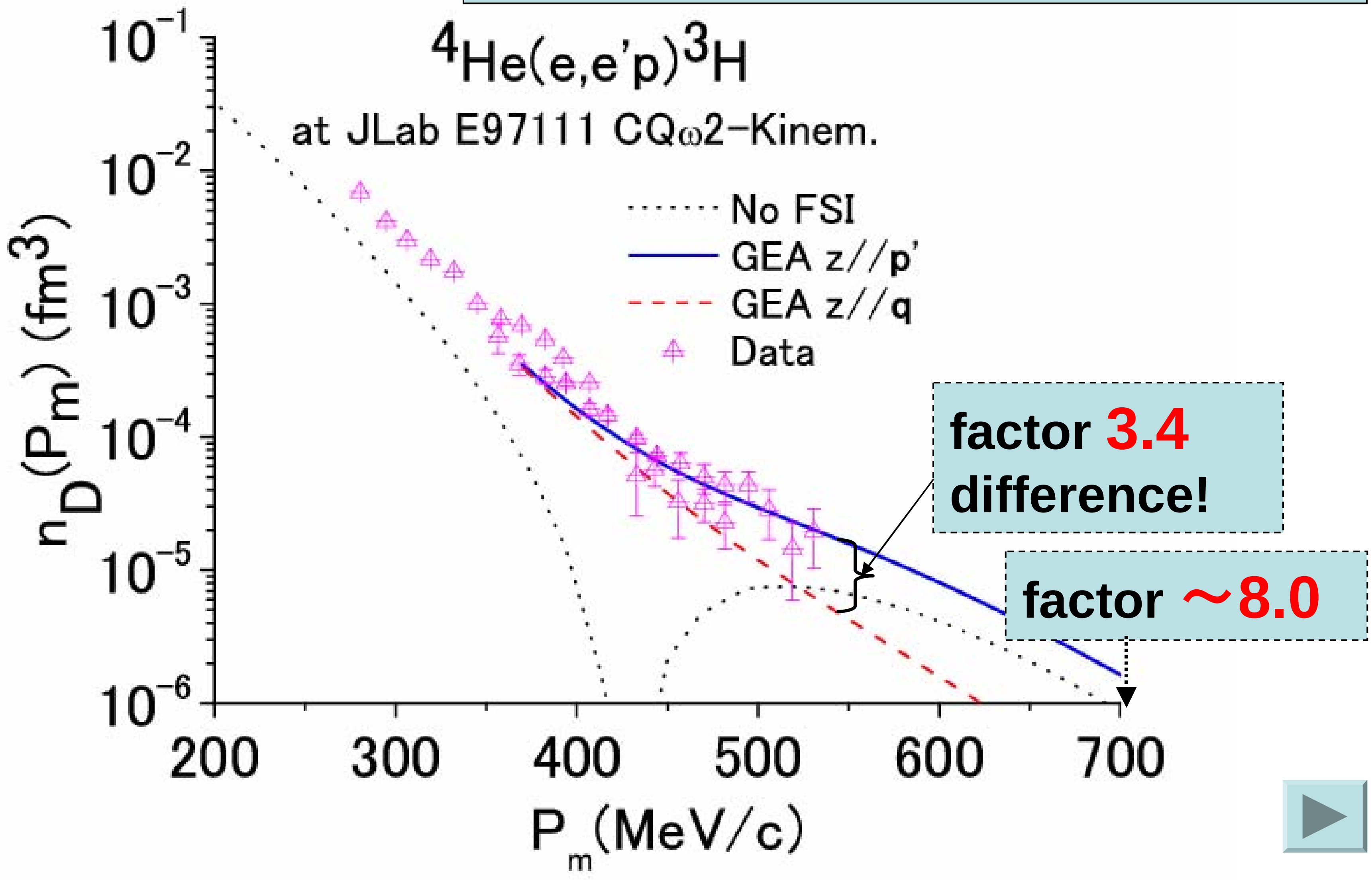
Multiple Scattering Contributions



Ref: GEA Effect at higher p_m

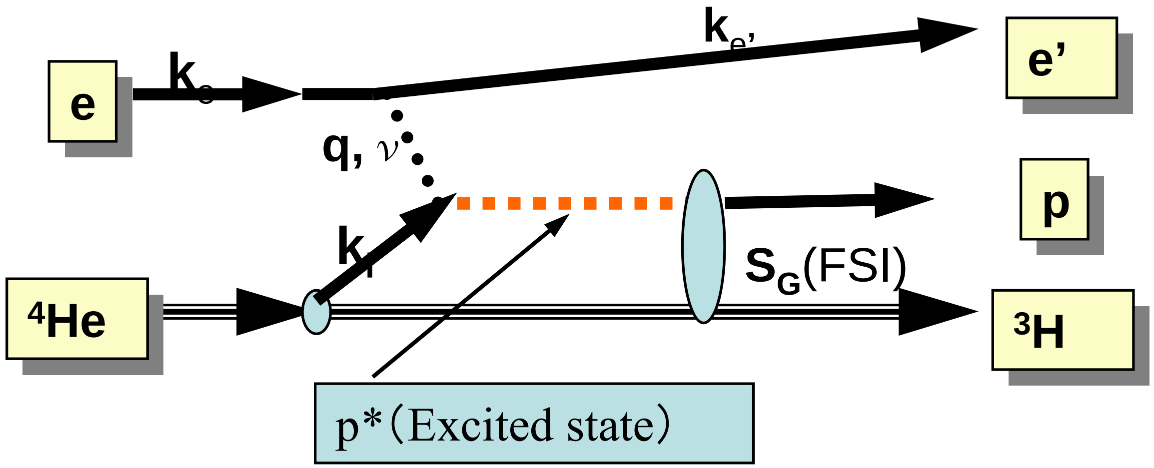
Comment on the choice of Z-axis

correct choice of z-axis is important!



5. Finite Formation Time Effect on $^4He(e,e'p)^3H$ Reaction

at High Q^2 region



One must take into account the effect of **p***

Finite Formation Time (**FFT**) effect

M.A.Braun et al. Phys. Rev. **C62**, 034606(2000)

$$S(\vec{r}_j) = 1 - J(z_j - z_1)\Gamma(\vec{b}_j - \vec{b}_1), \qquad J(z) = \vartheta(z)\left(1 - \exp\left(-\frac{z}{l(Q^2)}\right)\right),$$

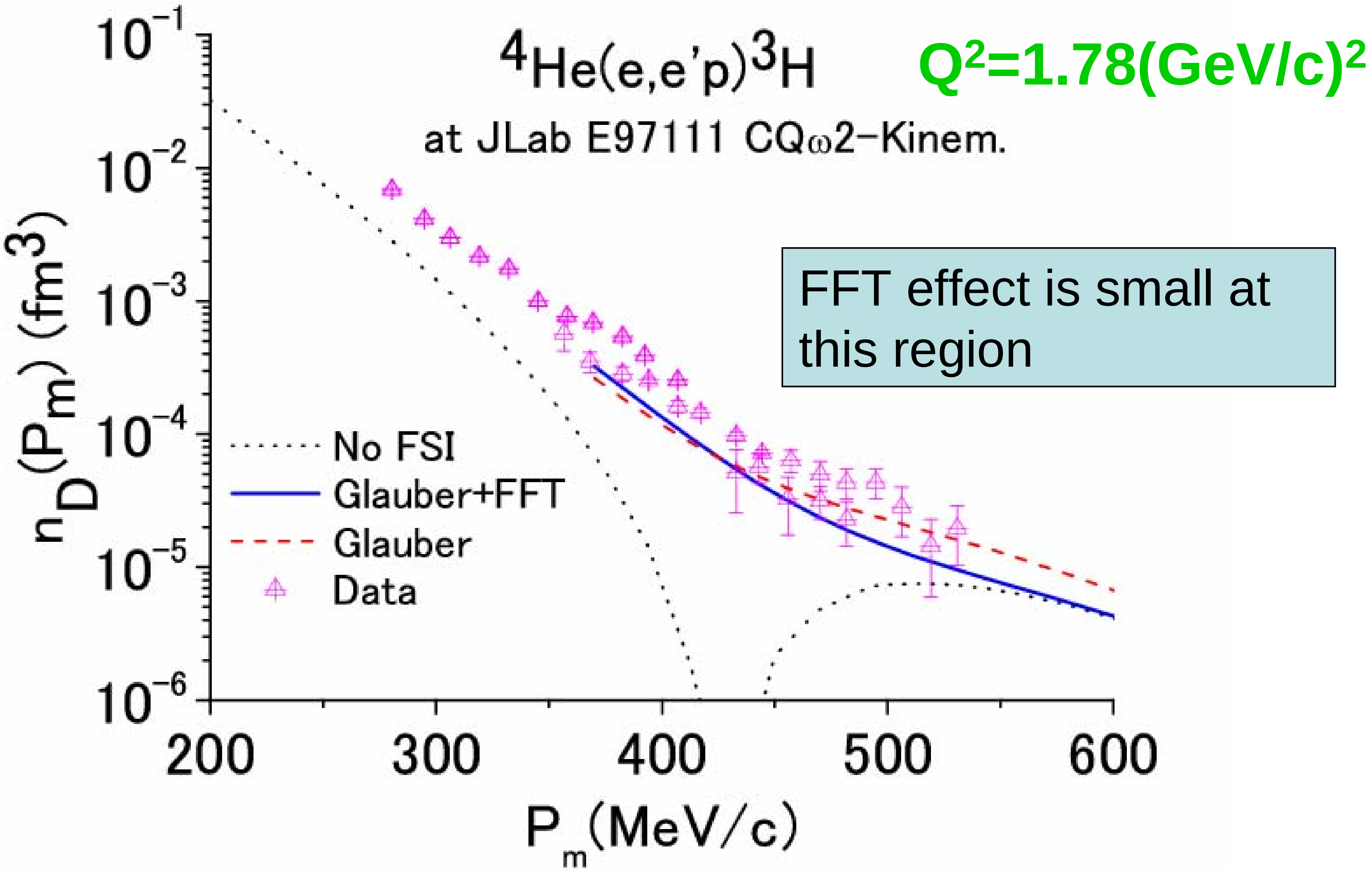
damping factor

$$l(Q^2) = \frac{Q^2}{xmM^2}$$

Formation length

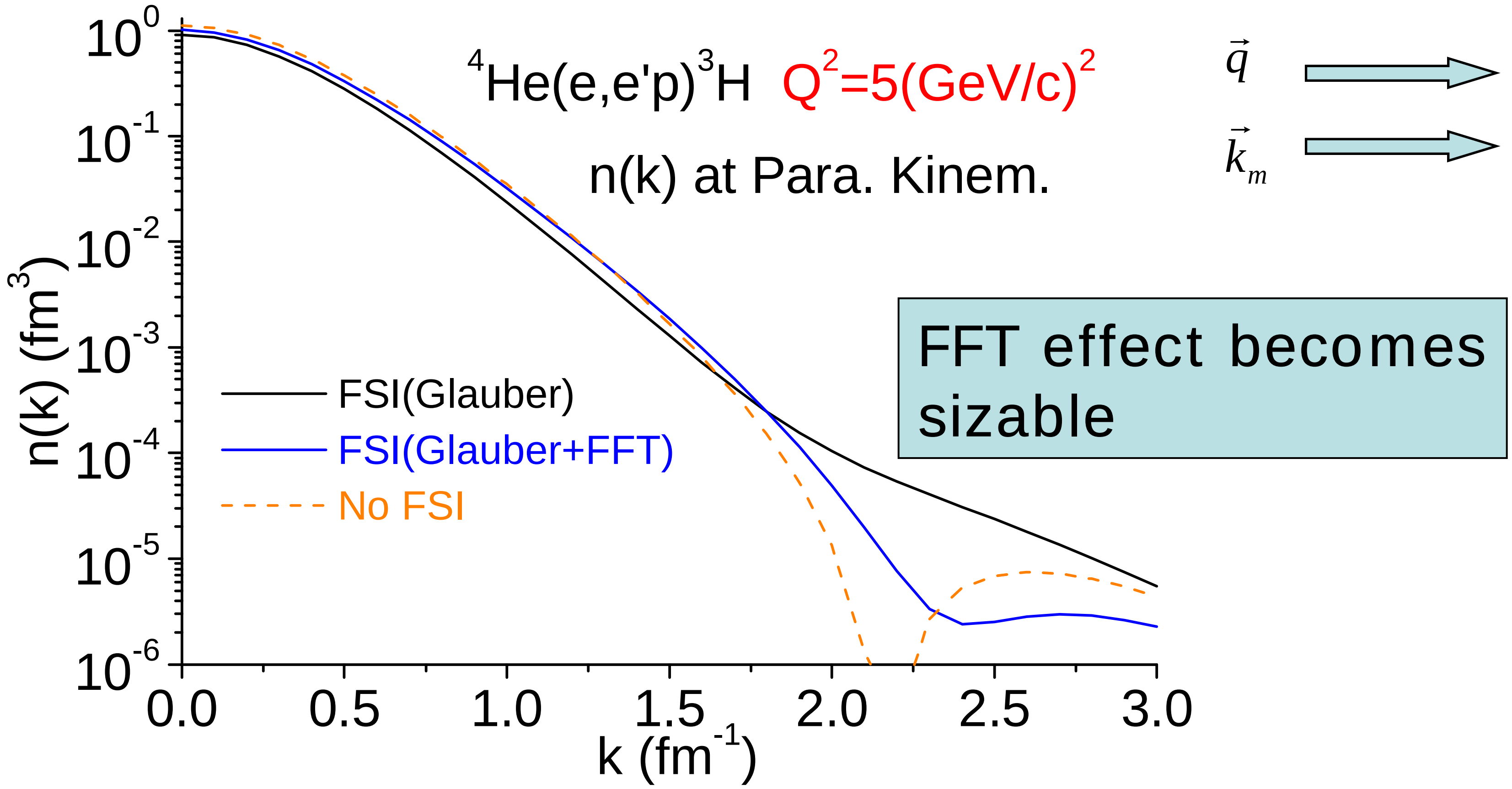
Q^2→higher, FSI→weaker

Effect of the FFT



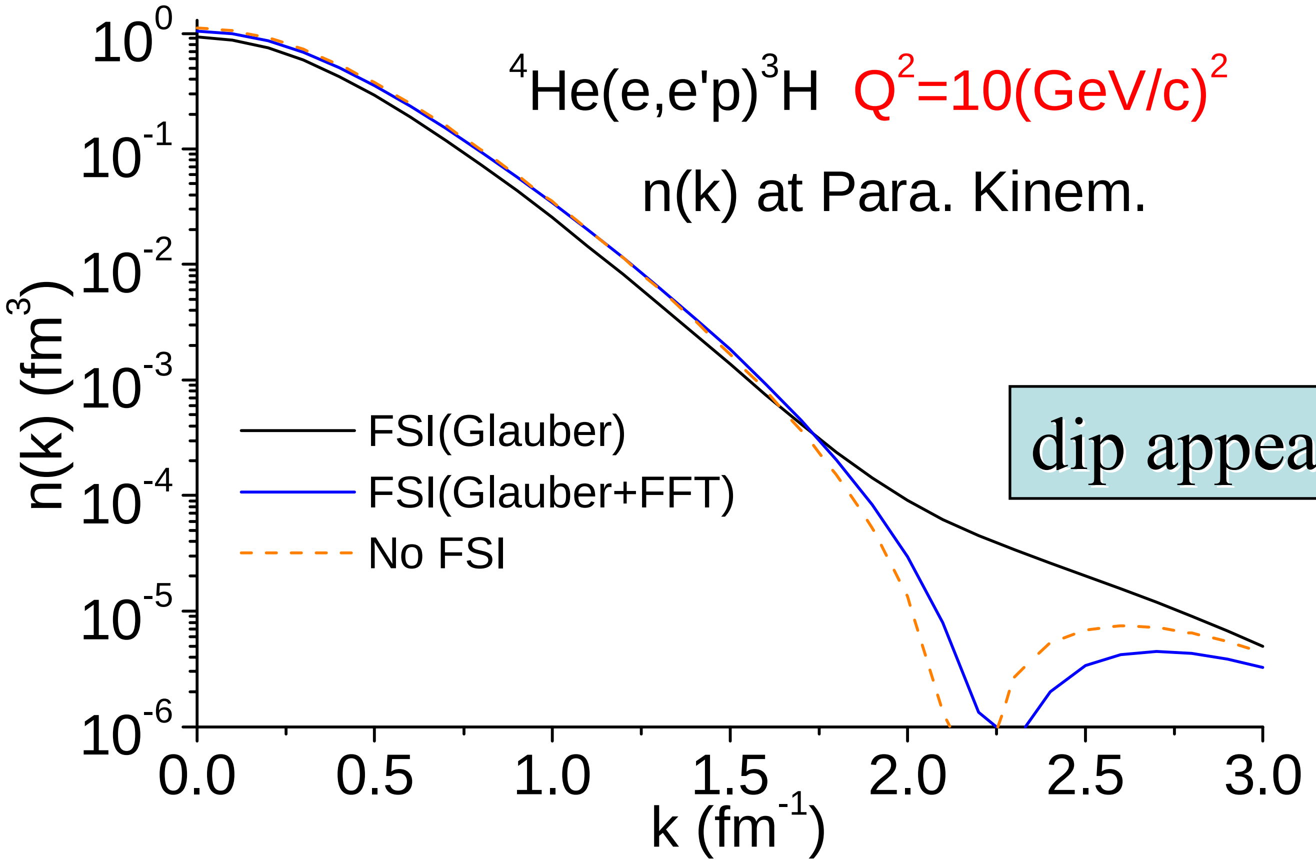
Para. Kinem. at Q^2=5(GeV/c)^2 ,x=1

Parallel Kinematics



FFT effect becomes sizable

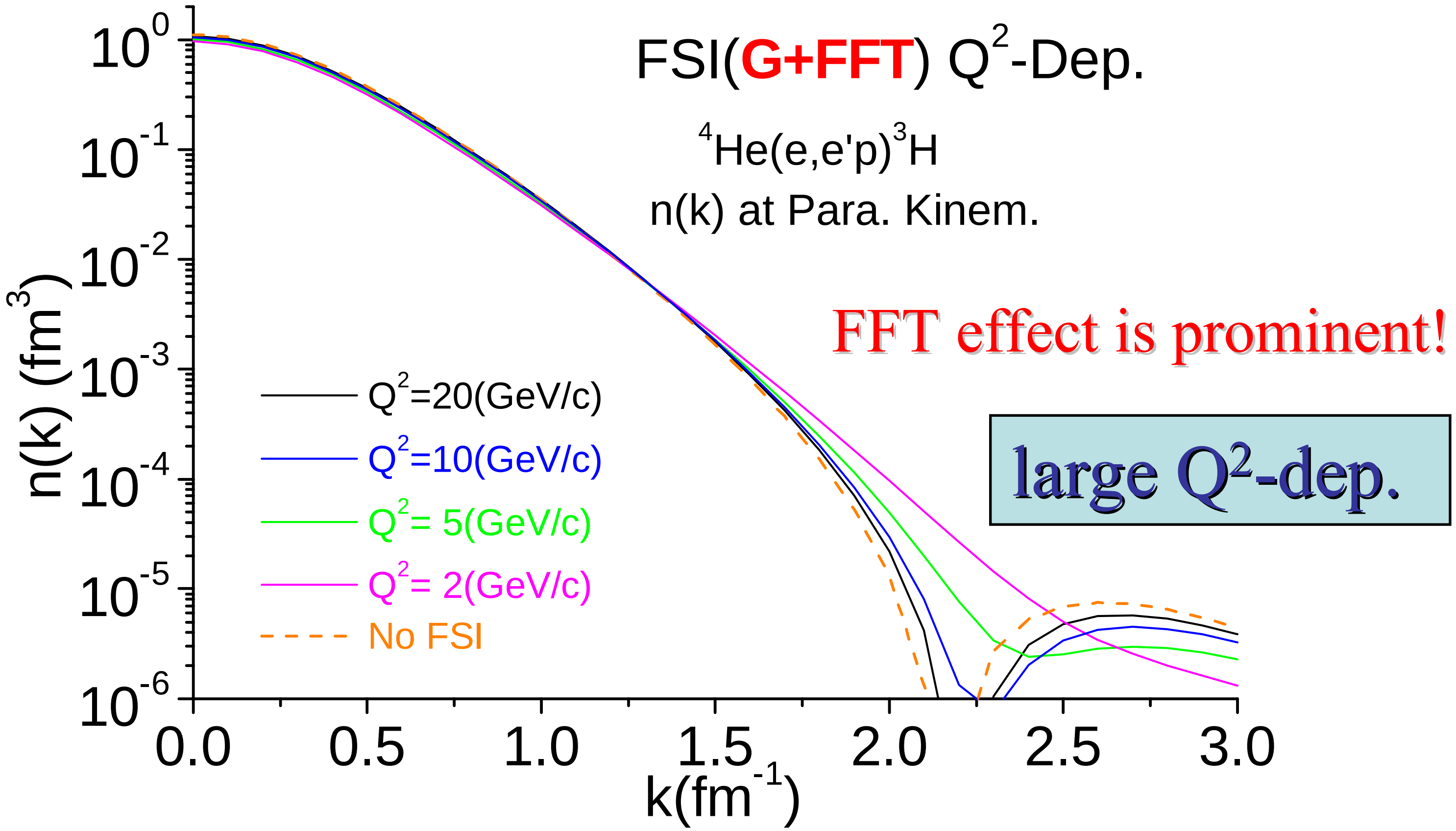
Q^2-dep. -Parallel Kinem.- at Q^2=10(GeV/c)^2



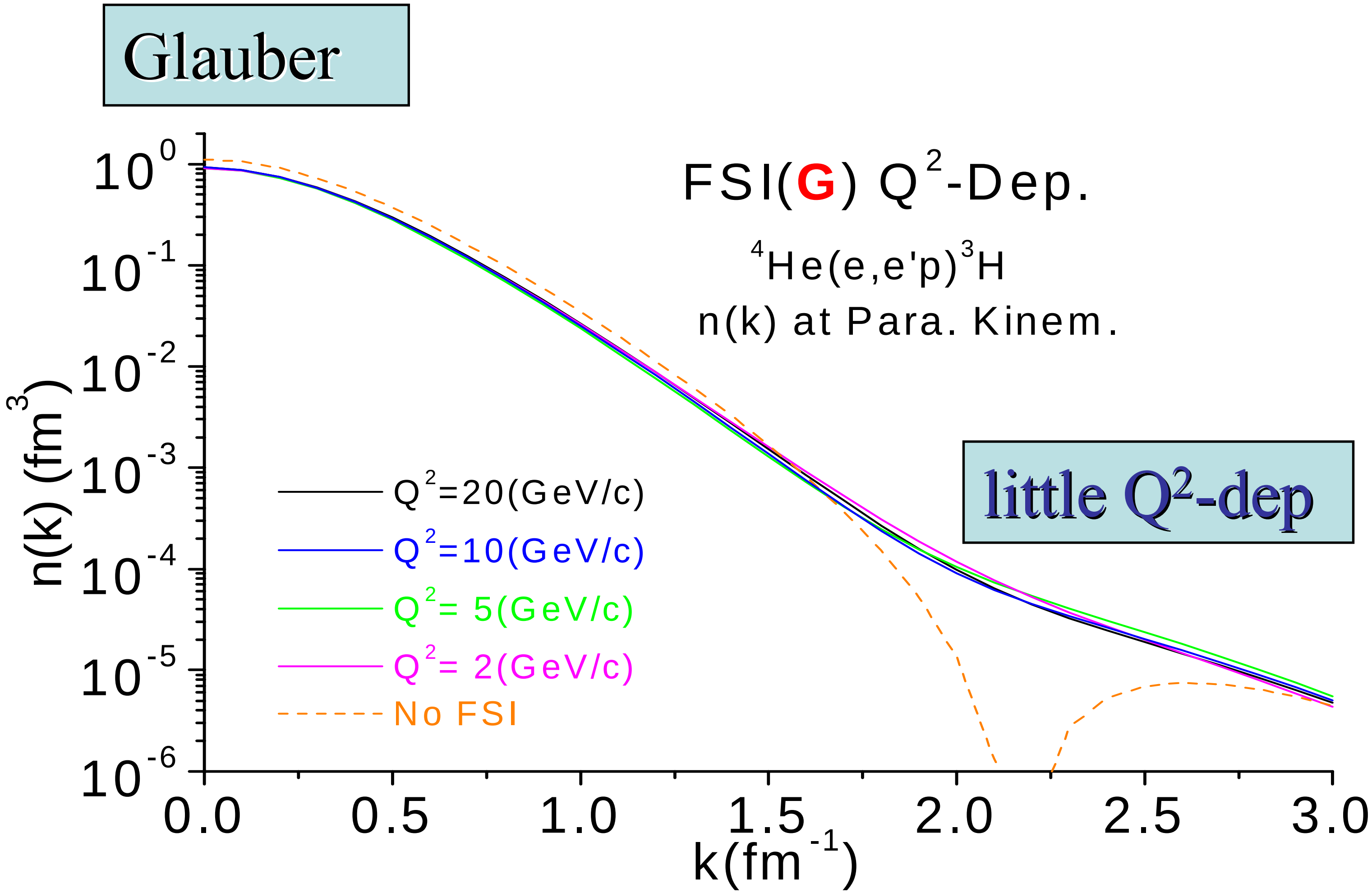
dip appears!

Q^2-dep. -Parallel Kinem.- Glauber +FFT

Glauber + FFT

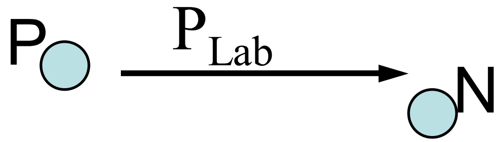


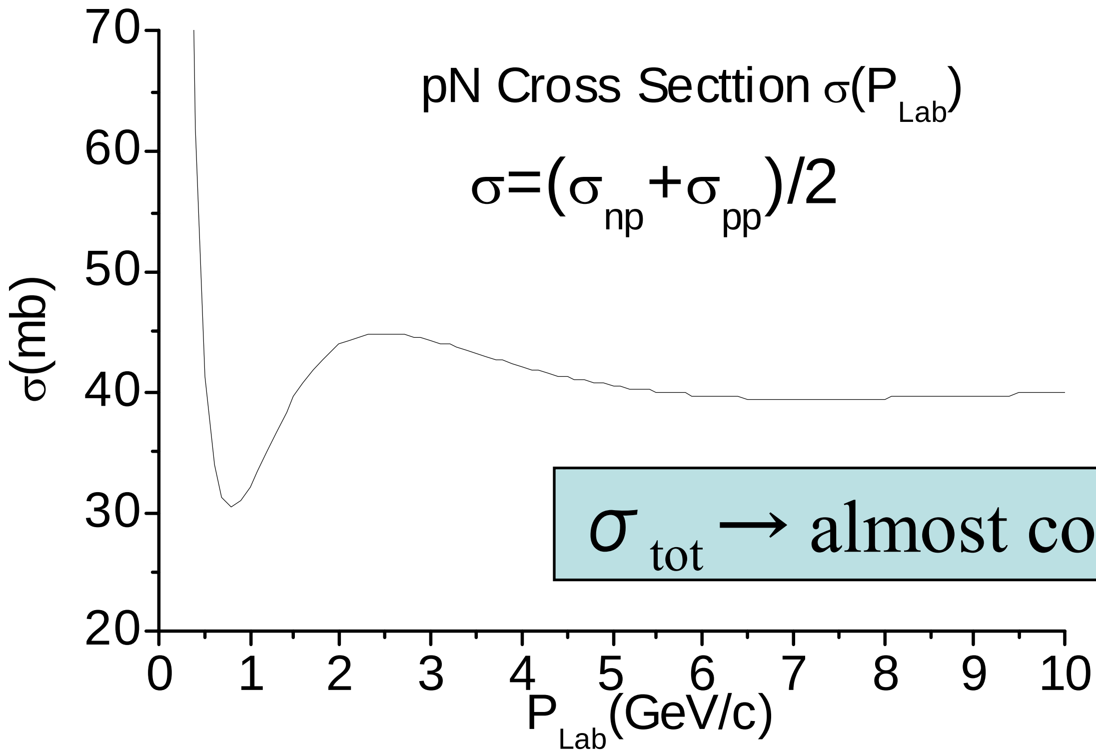
Q^2-dep. -Parallel Kinem.- Glauber



P_{lab}-dep. of σ_{tot}

σ_{pN}





$\sigma_{tot} \rightarrow$ almost const. at high P_{Lab}

6. Summary

1. Ability of the GA/GEA to describe the FSI

- Without any free parameter, the data of $^3He(e,e'p)^2H(pn)$ and $^4He(e,e'p)^3H$ were **well reproduced** by the Glauber/GEA calculation.
- This means that in the energy-momentum range covered by the data, FSI (**propagation of knocked out proton in medium**) can be described within the GA/GEA.
- In the case of $^3He(e,e'p)^2H(pn)$, the **effect of GEA** on GA (conventional Glauber approximaion) is **rather small** at considered kinematics.
- In the $^4He(e,e'p)^3H$ reaction it gives **～30 % effect** at (JLab E97-111) CQω2 kinematics.

Summary -2

2. Multiple Scattering Feature of the GA/GEA

- In the $^{3}He(e,e'p)^{2}H$ reaction, the p_m-dep. of $d\sigma_{exp}$ exhibits different slopes (p_m<1200(MeV/c)), which correspond to **PWIA**, **single** rescattering and **double** rescattering contributions produced by the GA/GEA.
- Such features correspond to the data very well.
- Rather similar features are seen in $^{4}He(e,e'p)^{3}H$ (theoretical) results, but we also found that the **triple** rescattering stars to contribute at **p_m>800(MeV/c)** .

Summary -3

3. FFT Effect on $^4He(e,e'p)^3H$

- FFT effects are **small** at JLab E97-111 CQω2 Kinematics (**Q^2=1.78(GeV/c)^2**)
- We extend theoretical calculation to higher Q^2 region and found..
- FSI is almost diminished by FFT effect at around **$Q^2 \geqq 10$(GeV/c)^2** region.
- FFT effect will be appeared as a **prominent Q^2-dep. of $n_D(p_m)$** around dip region (p_m ～2.2(fm-1)).

Future Developments

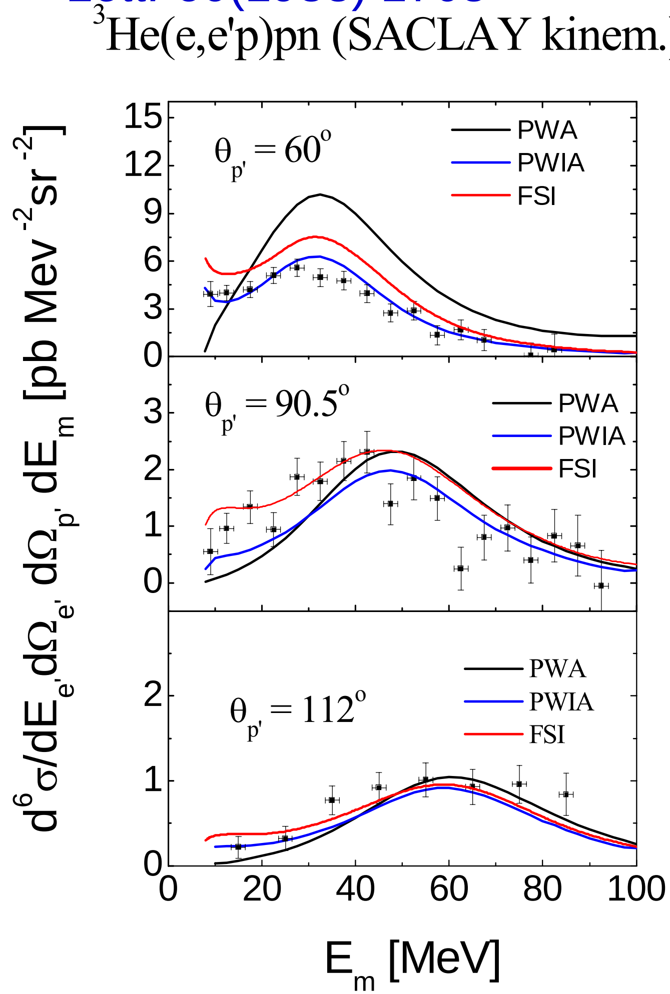
- Calculations without factorization are now in progress.
- Under such calculation we will derive each nuclear response functions: R_L,R_T,R_{TT},R_{TL}
- Then we will calculate A_{TL}(left-right asymmetry) , which is consider to be sensitive to the theoretical prescription.

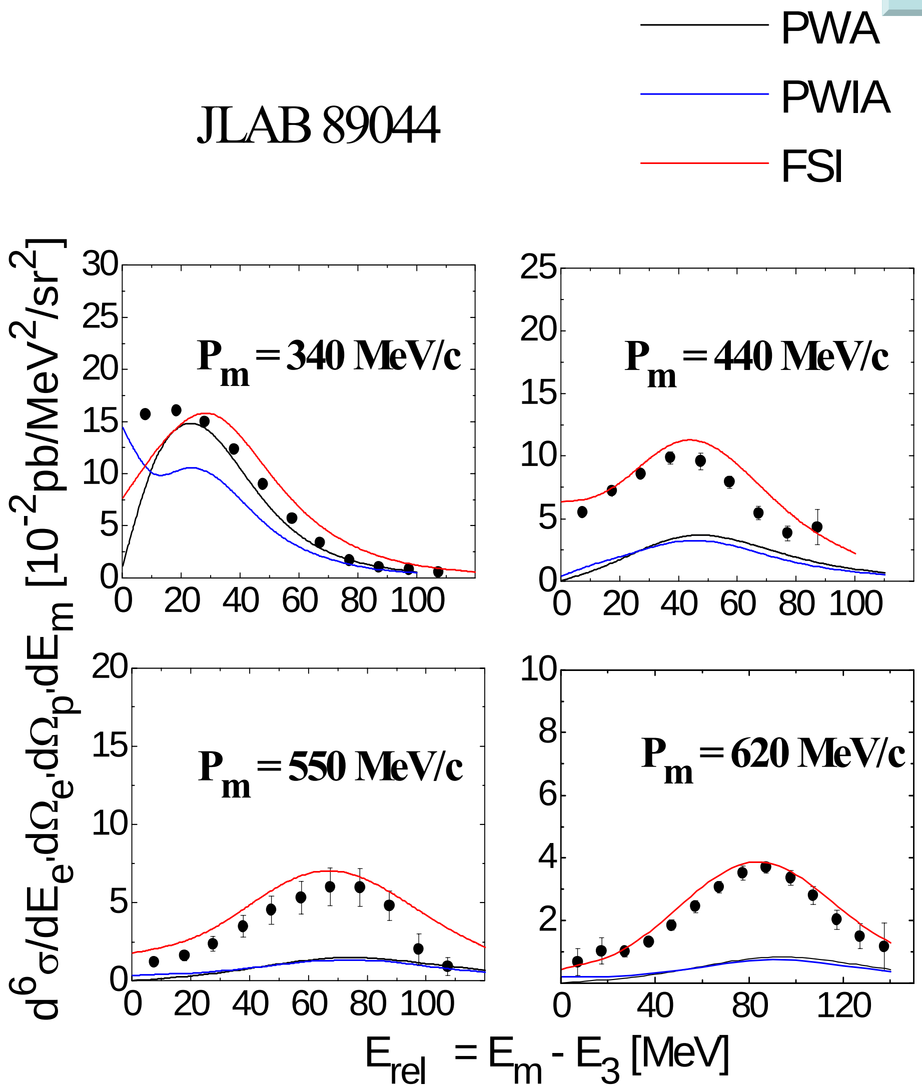
$$A_{TL} = \frac{\sigma(\varphi = 0^\circ) - \sigma(\varphi = 180^\circ)}{\sigma(\varphi = 0^\circ) + \sigma(\varphi = 180^\circ)} = \frac{v_{TL}\Re_{TL}}{v_L\Re_L + v_T\Re_T + v_{TT}\Re_{TT}}$$

Results of $^3He(e,e'p)pn$ ②

C. Ciofi degli Atti, L.P. Kaptari, *Phys. Rev.* **C71**, 024005 (2005)

C. Marchand et al., *Phys. Rev. Lett.* **60**(1988) 1703





ATMS Few-body Wave Function

ATMS method

M. Sakai et al., Prog.Theor.Phys.Suppl.56(1974)108.

H. Morita et al., Prog.Theor.Phys.78(1987)1117.

$\Psi_{ATMS} = F \cdot \Phi,$ Φ : mean-field w.f. $\Phi = \Phi_S \cdot \{S=0, T=0\}_A$

$$F = D^{-1} \sum_{ij} \left(w(ij) - \frac{(n_p - 1)}{n_p} u(ij) \right) \prod_{kl \neq ij} u(kl),$$

$$D = \sum_{ij} \left(1 - \frac{(n_p - 1)}{n_p} u(ij) \right) \prod_{kl \neq ij} u(kl), \qquad n_p = A(A-1)/2$$

w(ij): on-shell correlation function

u(ij) : off-shell correlation function

Introduction of the State dependence

$$w(ij) = {}^{1}w_S(ij)\hat{P}^{1E}(ij) + {}^{3}w_S(ij)\hat{P}^{3E}(ij) + {}^{3}w_D(ij)\hat{S}_{ij}\hat{P}^{3E}(ij)$$

Euler-Lagrange eq.

$$\delta_u[\langle\psi_{ATMS}|H|\psi_{ATMS}\rangle - E\langle\psi_{ATMS}|\psi_{ATMS}\rangle] = 0$$

δ_u:performed respect to {w,u}

The radial form of {w(r),.u(r)} are directly determined from Euler-Lagrange eq.

Results

$V_{NN}(r)$: Reid Soft core V8 model potential

$\langle H\rangle = -21.2$ MeV, $\langle r^2\rangle^{1/2} = 1.57$ fm

PS=87.94%, PS'=0.24%, PD=11.82%

Experimental Data

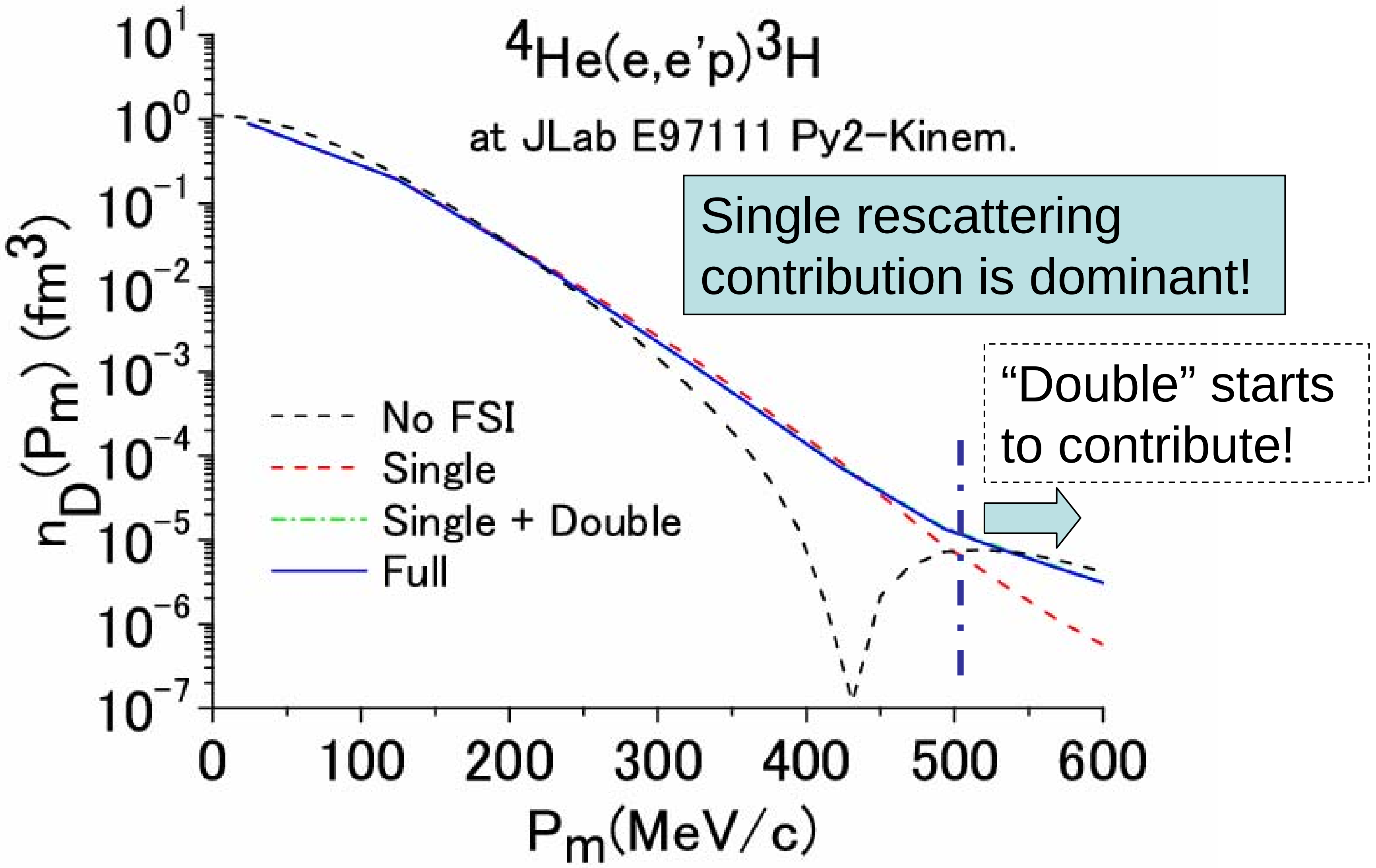
JLab E97-111: B. Reitz et al., Eur. Phys. J. A S19(2004) 165

1. Py2 Kinematics－Parallel Kinematics

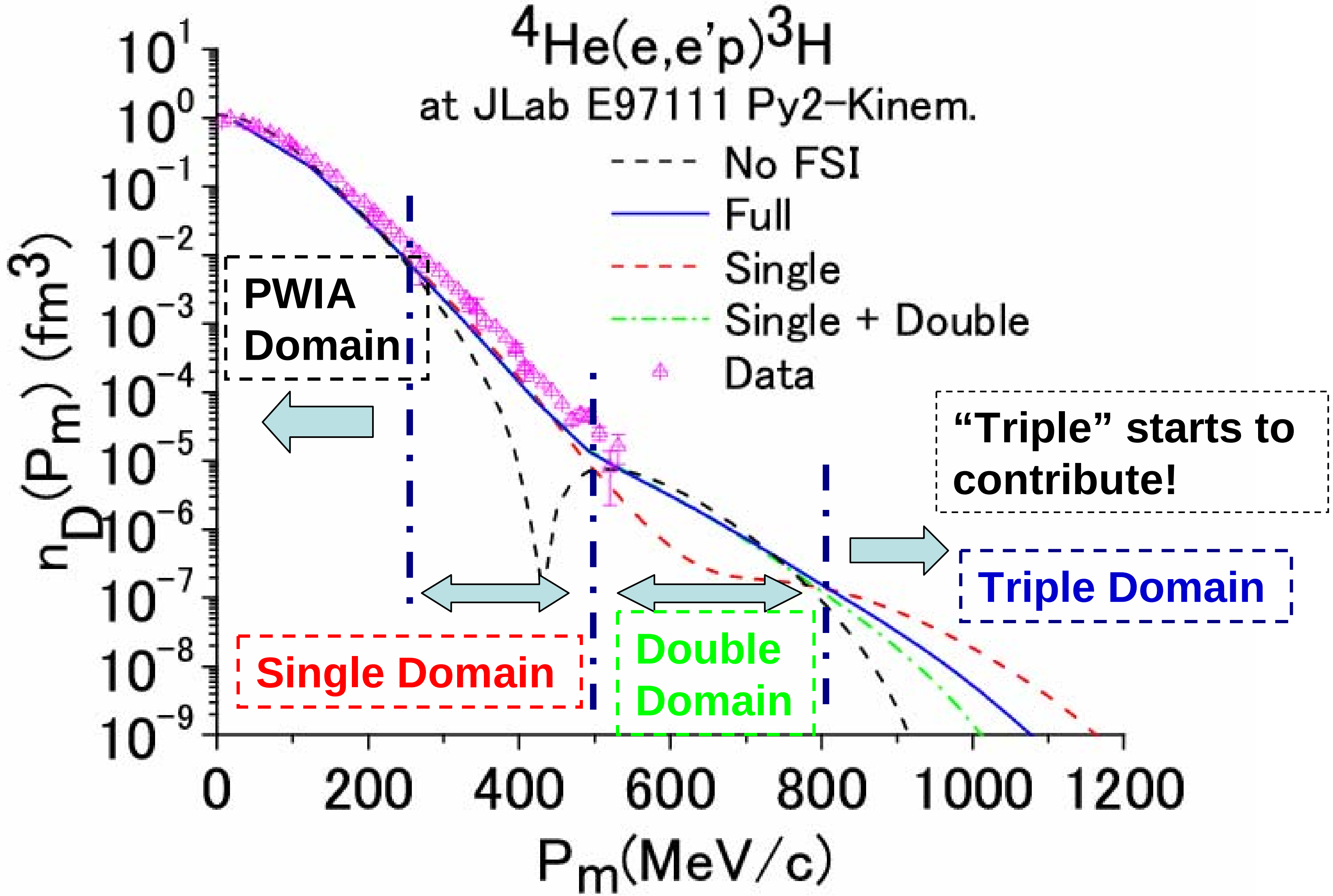
2. CQω2 Kinematics－Perpendicular Kinematics

Kinem.	**E_e(GeV)**	**ω(GeV)**	**q(Gev/c)**	**Q^2(GeV/c)^2**	**p_m(MeV/c)**
CQω2	3.952	0.525	1.43	1.78	395
CQω2	3.952	0.525	1.43	1.78	446
CQω2	3.952	0.525	1.43	1.78	495
PY2a	3.17	0.537	1.09	0.908	24
PY2b	3.17	0.653	1.14	0.868	124
PY2c	3.17	0.798	1.21	0.818	223
PY2d	3.17	0.985	1.31	0.753	323
PY2e	3.17	1.239	1.48	0.666	423
PY2f	3.17	1.481	1.67	0.582	493

Multiple Scattering Contributions



Multiple Scattering Contributions 2



Note: Choice of z-axis

Momentum transfer

Missing Mom.

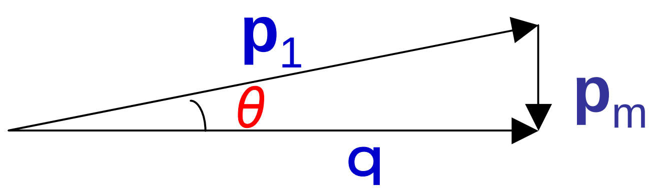
$$\mathbf{q} = \mathbf{p}_1 + \mathbf{p}_m$$

Mom. of ejected proton

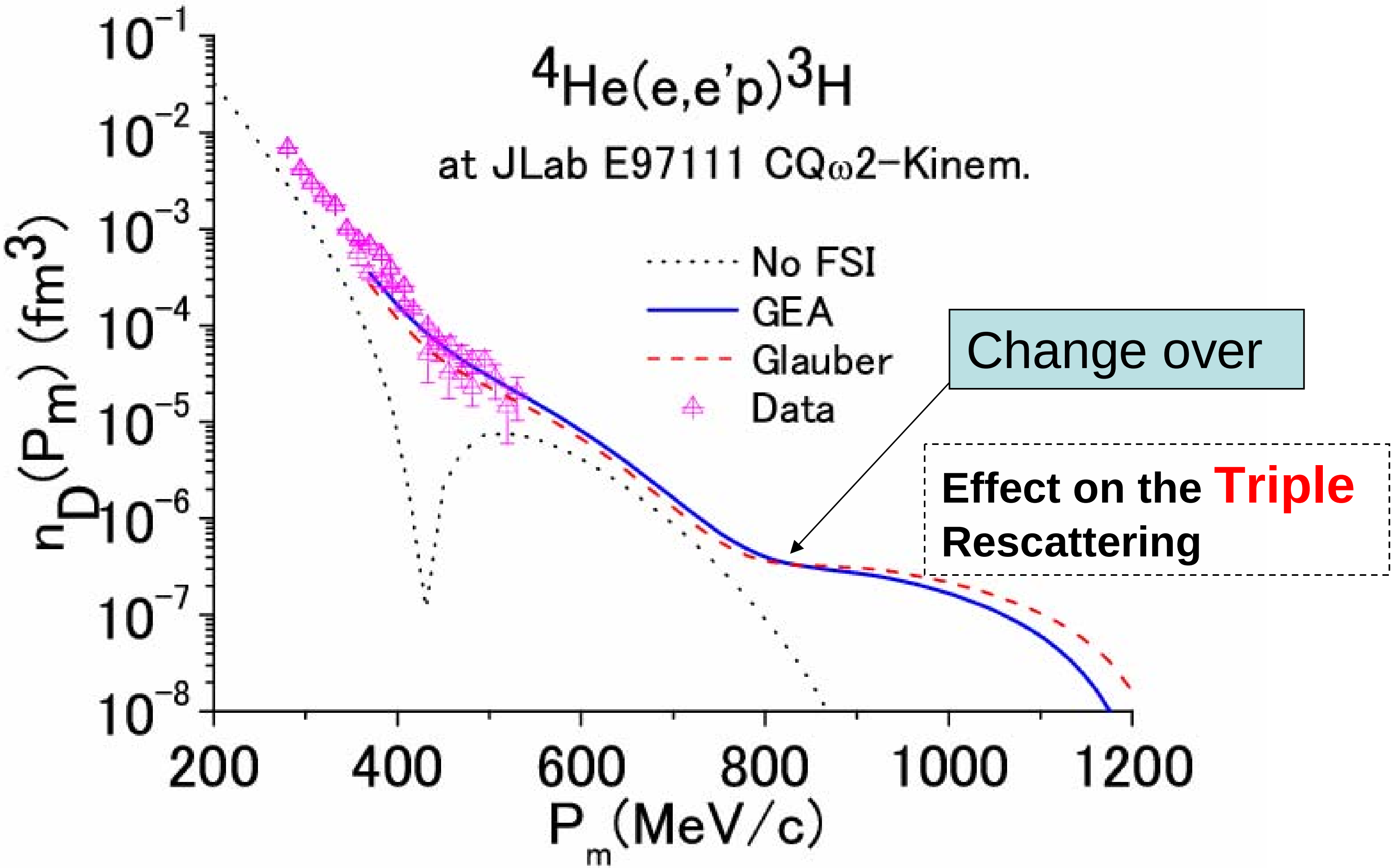
In many cases **q**-direction is taken to be z-axis assuming $\mathbf{q} >> \mathbf{p}_m$

However, in the Glauber theory z-axis should be the direction of the incident particle ~ p_1 direction

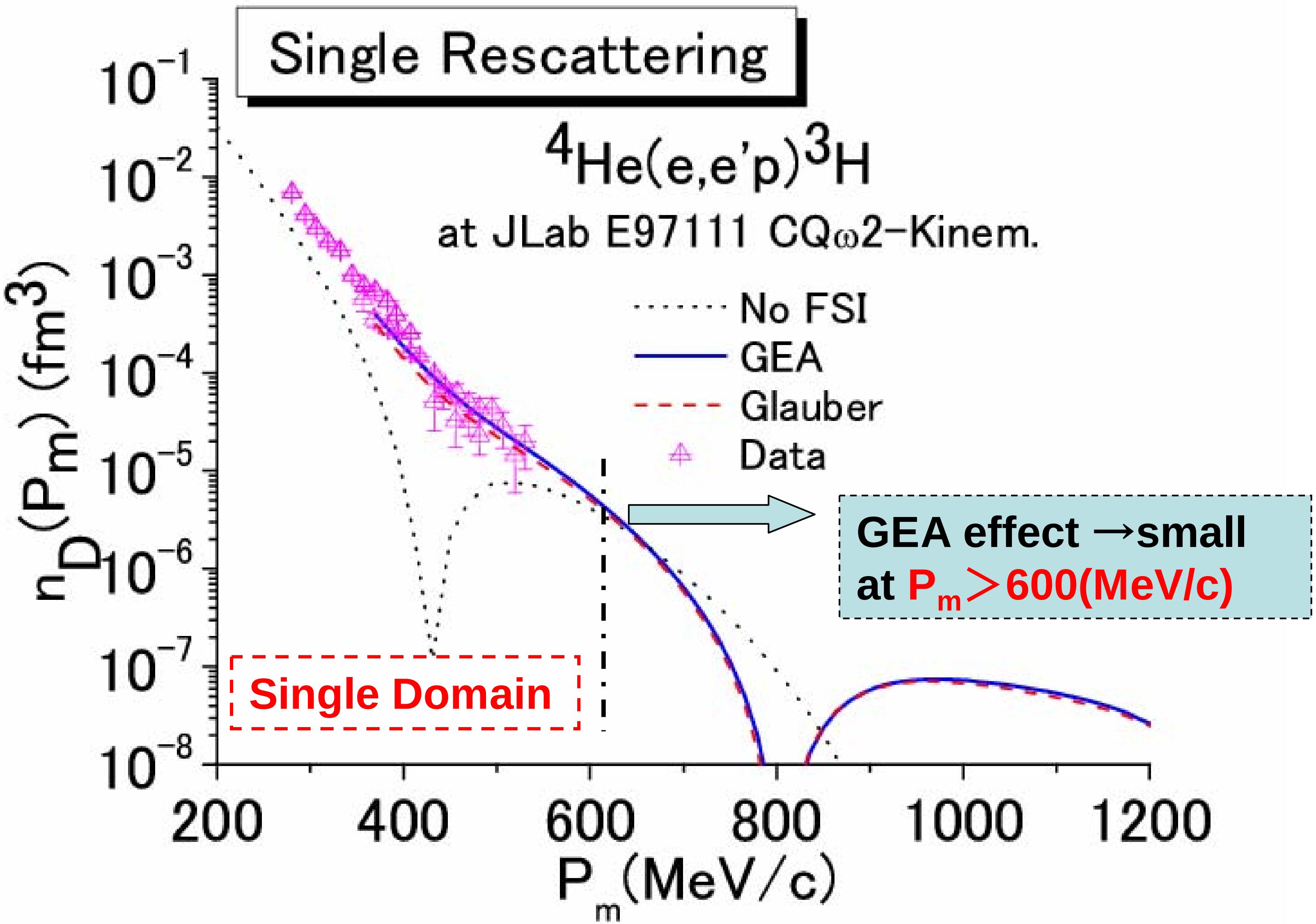
The deviation by θ will make some different results especially at perpendicular kinematics ($\mathbf{q} \perp \mathbf{p}_m$)



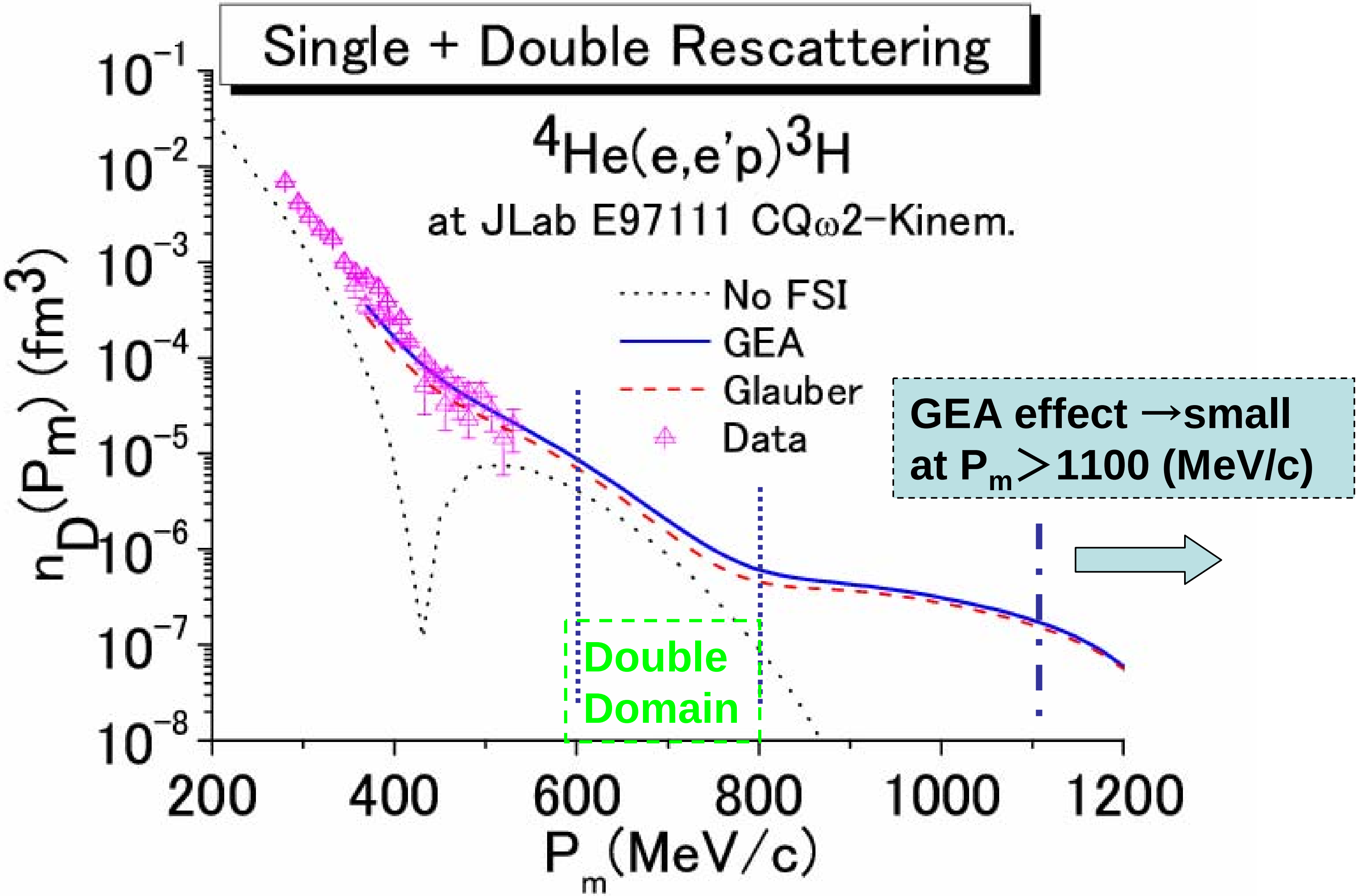
GEA Effect at higher P_m



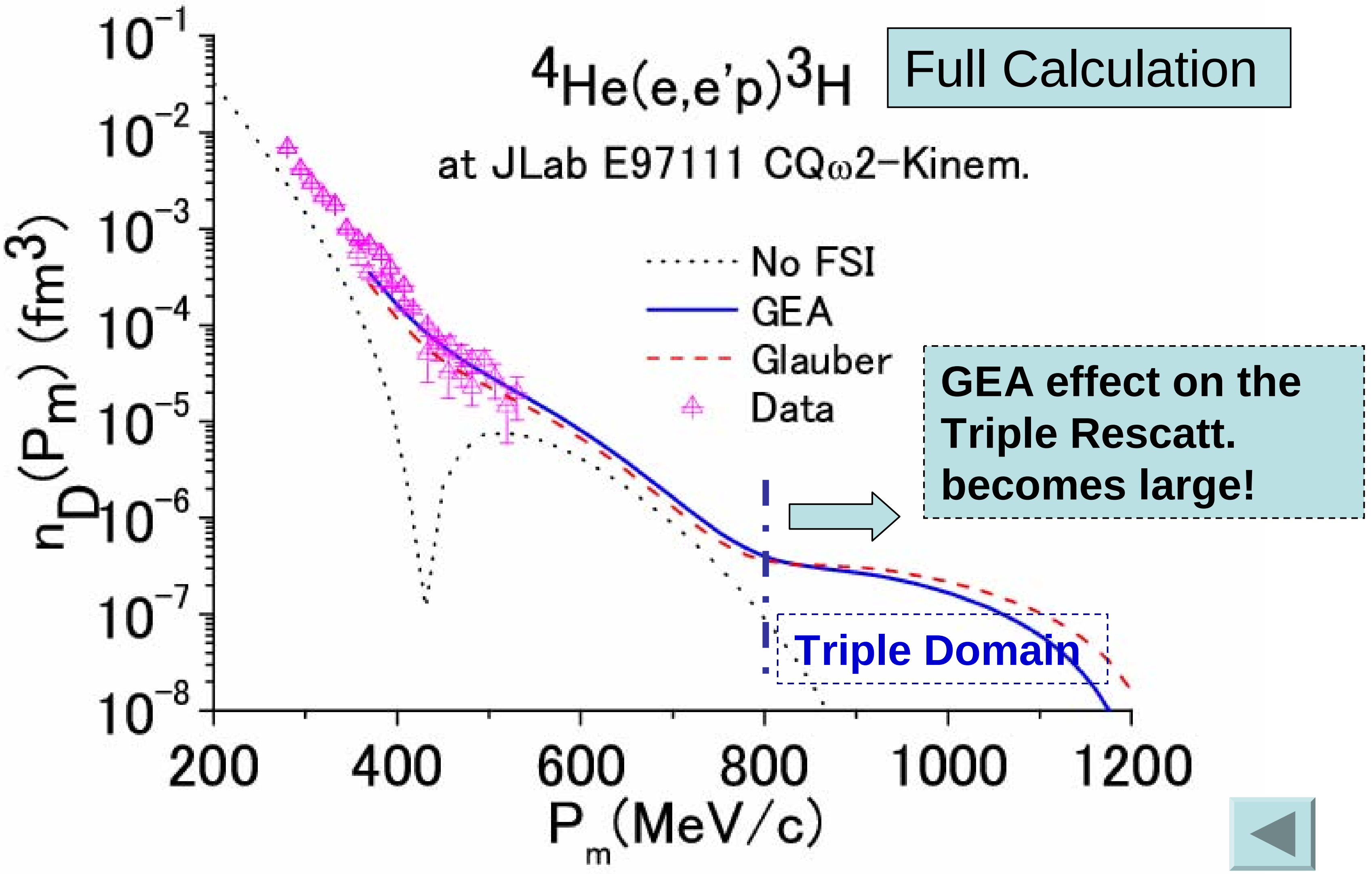
GEA Effect on the Single Rescatt.



GEA Effect on the Double Rescatt.

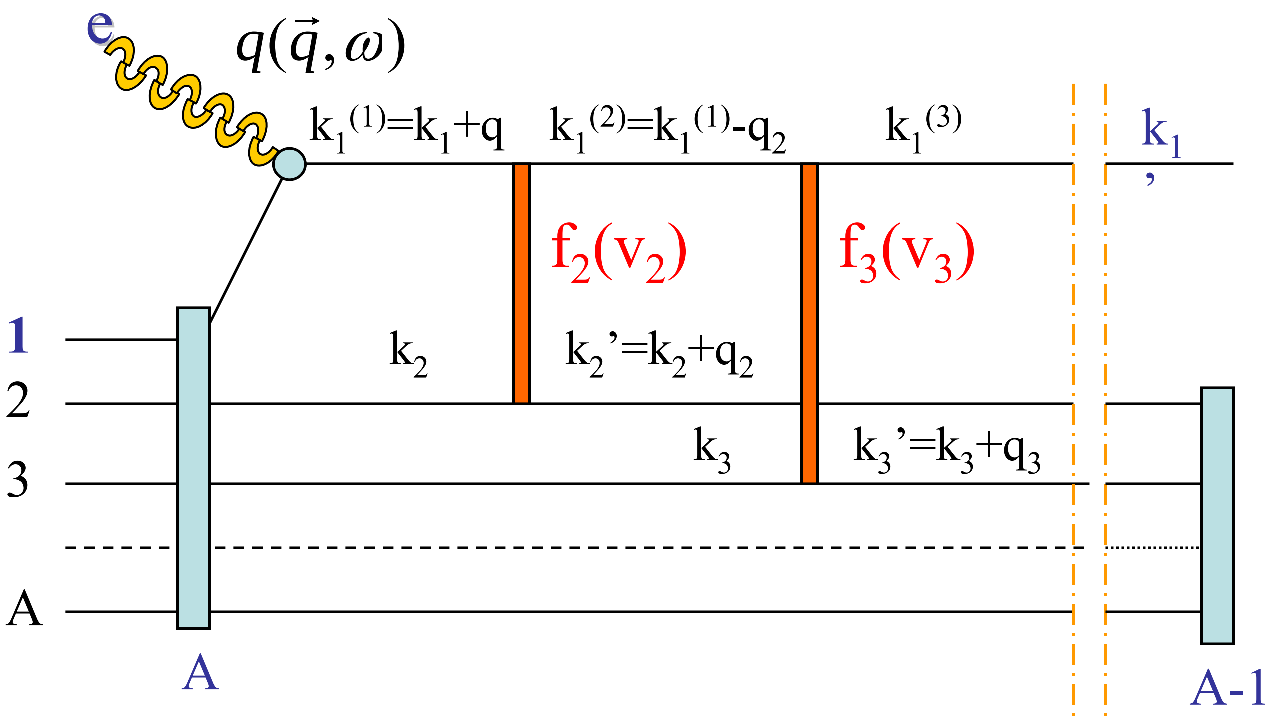


GEA Effect on the Triple Rescatt.



§ 5. Formulation of FFT effect

M.A.Braun et al. Phys. Rev. **C62**, 034606(2000).



Virtuality of particle "1"

$$v_i = (k_1^{(i)})^2 - m^2 = Q^2\left(\frac{1}{x}-1\right) + \frac{Q^2}{xm}\left(\sum_{j=2}^{i} q_{jz} - k_{1z}\right), \quad Q^2 = \vec{q}^{\,2} - \omega^2, \quad x = Q^2/(2k_1\cdot q)$$

m:Nucleon Mass

Bjorken variable

Scattering Amplitude

$\boldsymbol{f_j = F(v_{j-1})F(v_j)f}$, f :on-shall Amplitude

F(v) → F.F. for Vertuality dep.

F(0)=1

Scattering Matrix

$$S(r_2, r_3, \cdots, r_A) = \prod_{j=2}^{A} S(\vec{r}_j), \qquad S(\vec{r}_j) = 1 - J(z_j - z_1)\Gamma(\vec{b}_j - \vec{b}_1)$$

Vertuality dep.

J(z) (Virtuality dep. Factor)

$$\int_0^\infty dv\, \tau(v) = 1$$

$$J(-z) = -i \int \frac{dv}{2\pi} \frac{F^2(v)}{-v - i0} \exp(i \frac{xmv}{Q^2} z), \quad F^2(v) = \int_0^\infty dv' \frac{v' \tau(v')}{v' - v - i0}$$

$$J(z) = \theta(z) \int_0^\infty dv\, \tau_1(v) (1 - \exp(-\frac{xmv}{Q^2} z))$$

$$\tau_1(v) = -i\, \tau(-iv)$$

Here if we take

$$\tau_1(v) \to \delta(v - M^2), \quad (M^2 = m^{*2} - m^2)$$

M2 : Average Virtuality

then

$$J(z) = \vartheta(z)(1 - \exp(-\frac{z}{l(Q^2)})),$$

$$l(Q^2) = \frac{Q^2}{xmM^2}$$

Formation length

In the following calculation…

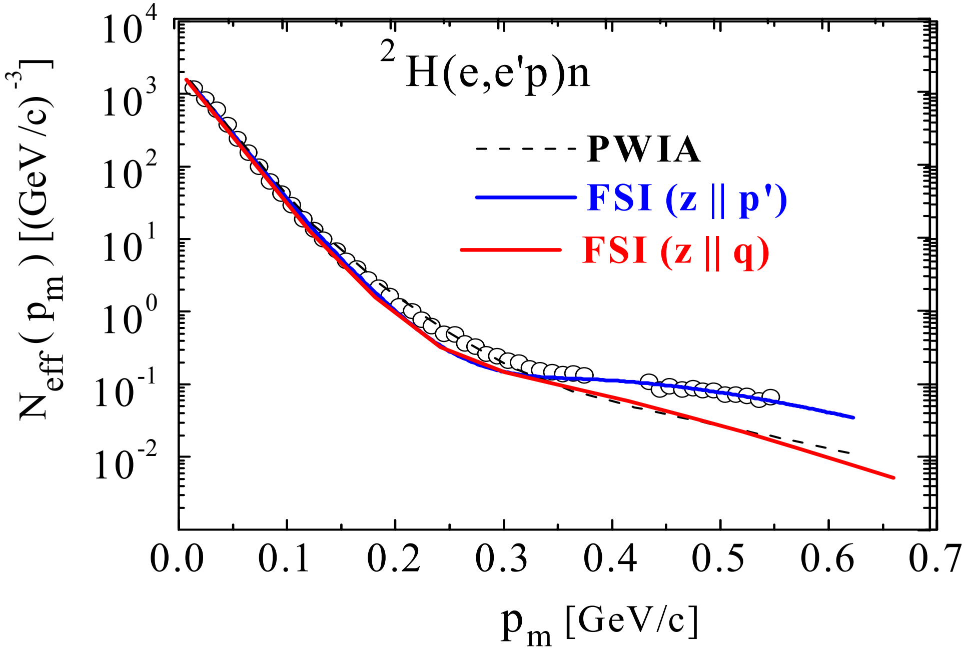
$$M^2 = (m^*_{Av})^2 - m^2, \quad m^*_{Av} \to 1.8(GeV)$$

(Braun et al.)

“z-axis” effects

Ref) $^2H(e,e'p)n$ case

Calculation by L.Kaptari



$\theta_{p_m q}$	$\theta_{p_m p'}$	$p_m[GeV/c]$
180.0	180.0	0.011
95.1	99.1	0.063
85.5	93.5	0.135
79.2	91.2	0.196
73.8	89.8	0.257
68.7	88.7	0.316
63.9	87.9	0.364
59.3	87.3	0.420
54.9	86.9	0.485
50.6	86.6	0.537
46.0	86.4	0.586
42.4	86.4	0.623
38.5	86.4	0.676

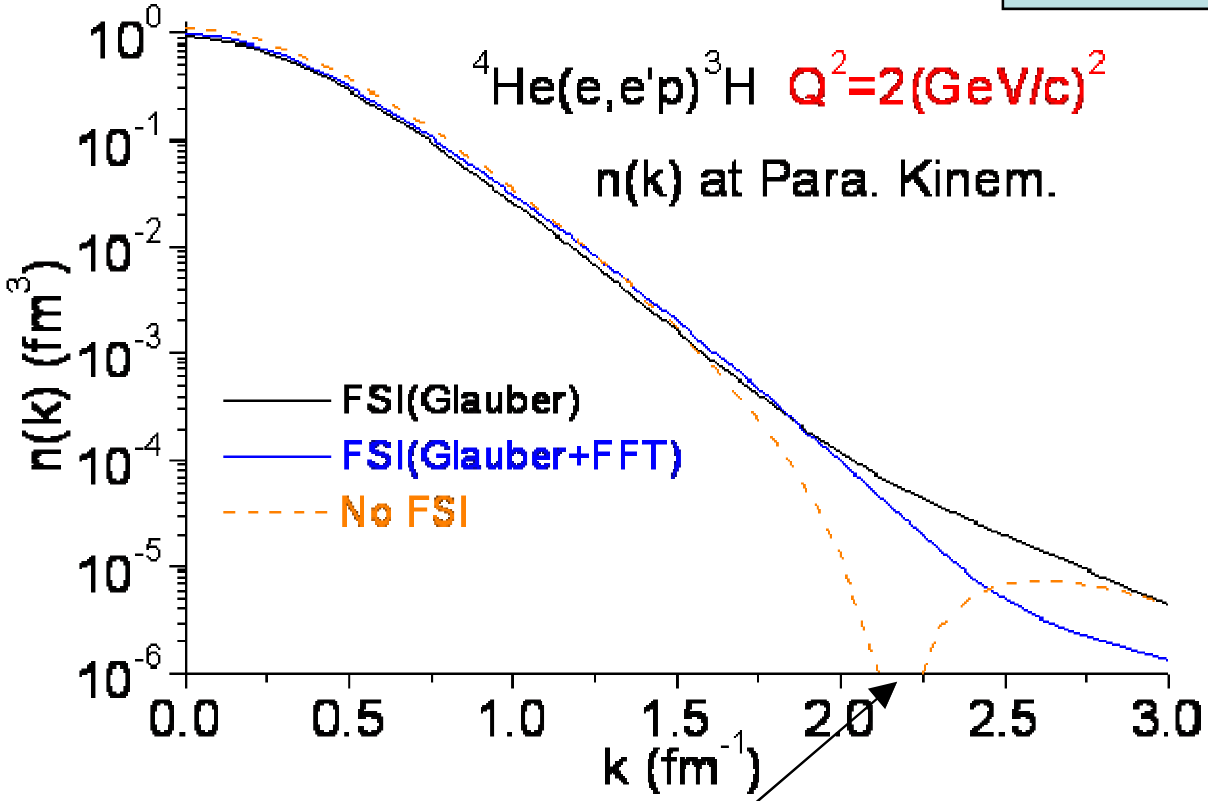
Jlab **data (Ulmer *et al.* Phys. Rev. Lett. 89 (2002)) at *perpendicular* kinematics, with:**

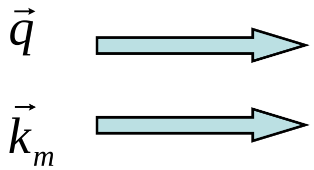
$$Q^2 \simeq 0.665\ (GeV/c)^2, \quad |\boldsymbol{q}| \simeq 0.7\ GeV/c, \quad x \simeq 0.96$$

$$N_{eff} = \frac{d^4\sigma^{exp}}{d\Omega'\, dE'\, d\Omega_{\boldsymbol{p}_m}} \left[f_{rec}\, \mathcal{K}\, \sigma^{eN}_{cc1} \right]^{-1}$$

Para. Kinem. at $Q^2=2(GeV/c)^2$,x=1

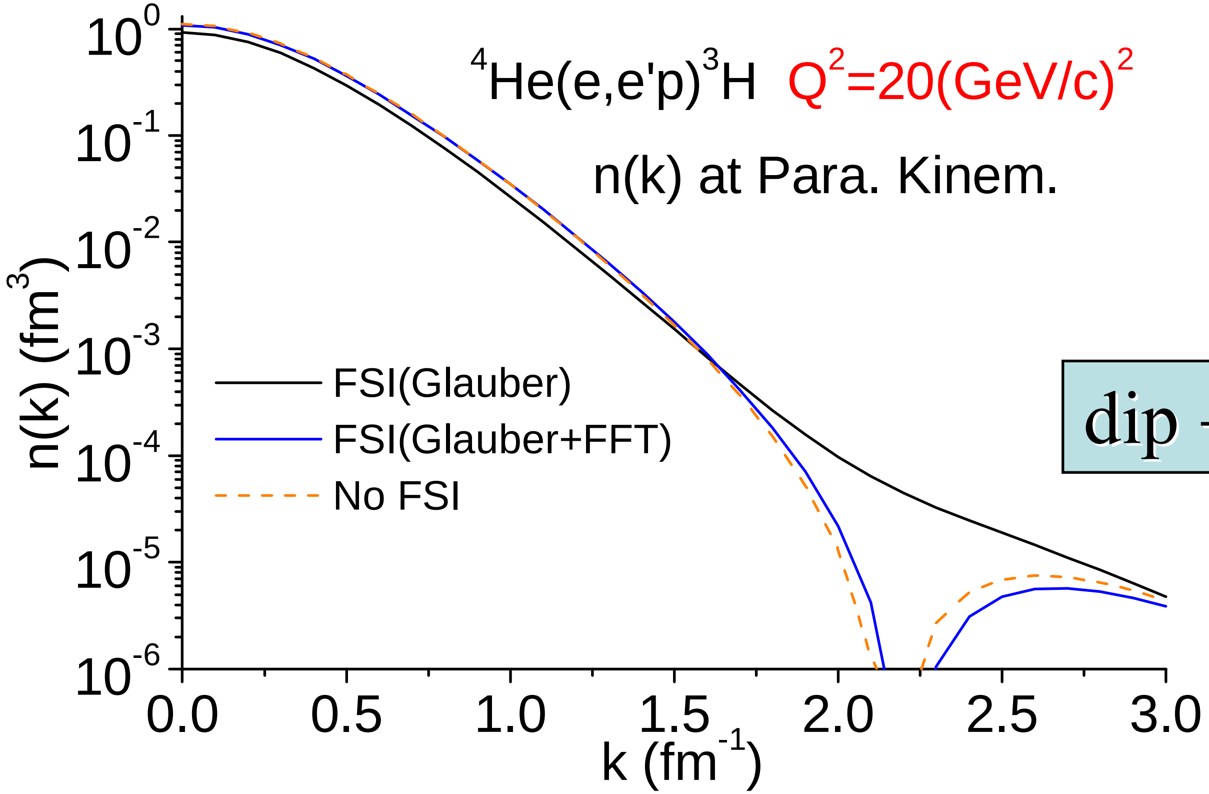
Parallel Kinematics





Dip → masked by FSI

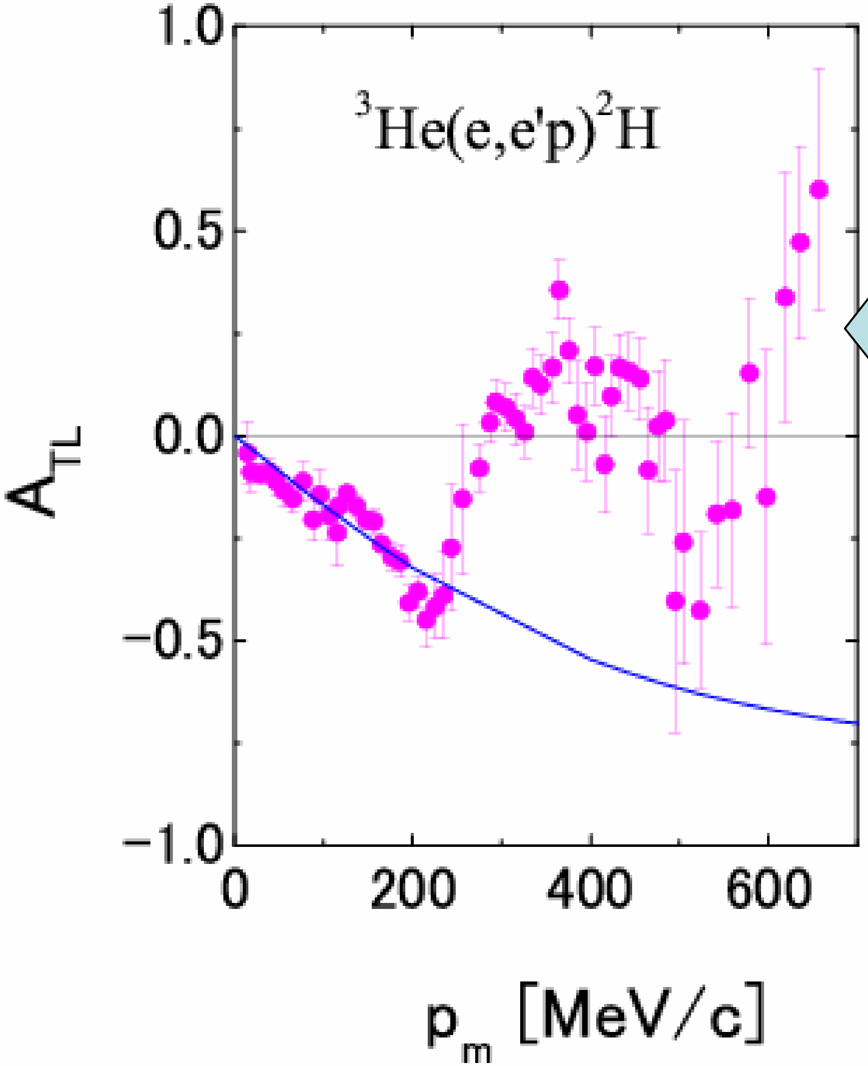
Q^2-dep. -Parallel Kinem.- at Q^2=20(GeV/c)^2



dip → apparent!

FSI → diminished by FFT effect!

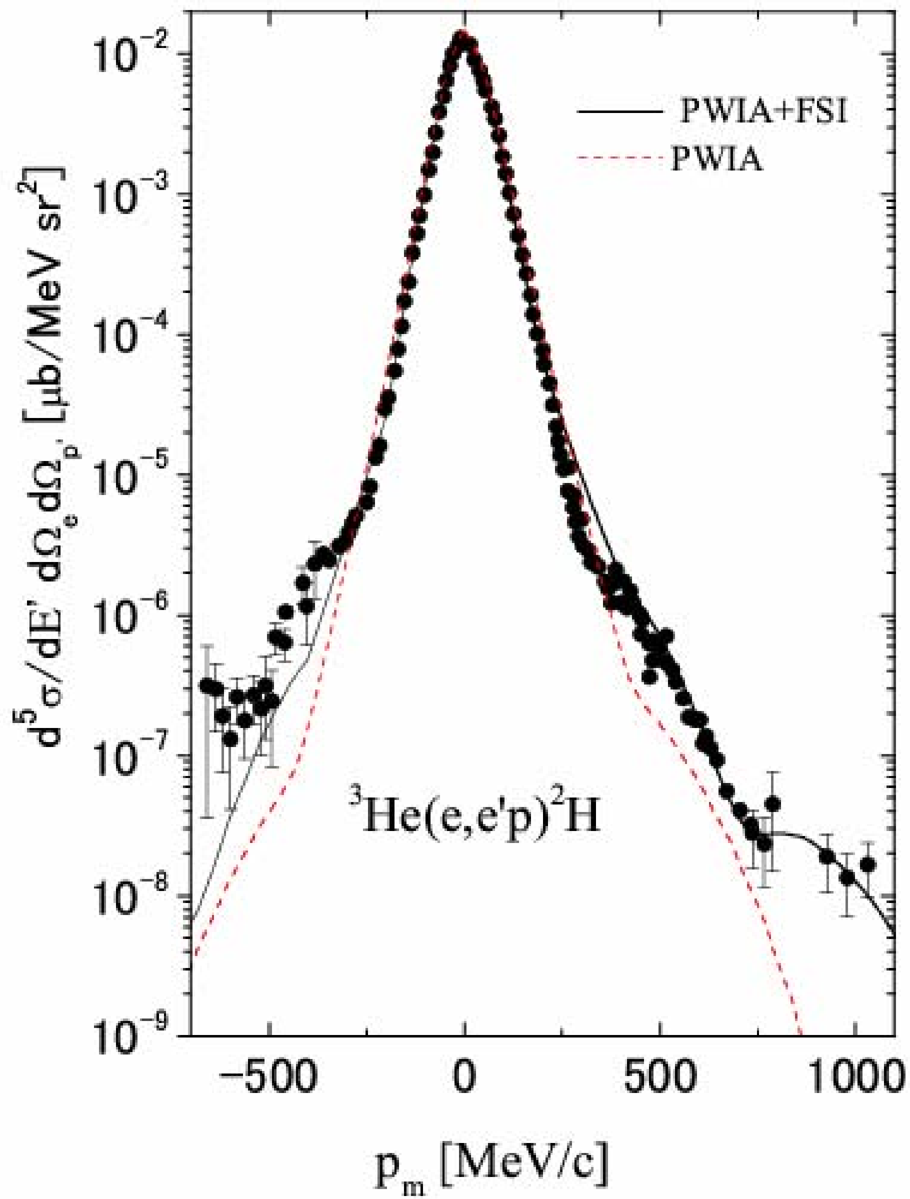
A_{TL} within Factorization Calc.



Data
M.M. Rvachev et al.,
Phys.Rev.Lett. **94** (2005) 192302

Factorization calculation can not reproduce these structures.

Calculations with no factorization are now in progress.



PWIA+FSI
PWIA
$^3He(e,e'p)^2H$
$d^5\sigma/dE'\,d\Omega_e d\Omega_{p'}$ [μb/MeV sr^2]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
−500
0
500
1000
p_m [MeV/c]