Seeing nuclear pions at the EIC?
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- One Pion Exchange Potential (OPEP) in the deuteron- binds deuteron

- Relation to deuteron dominance of short ranged correlations

- One Pion Exchange Potential (OPEP) in infinite nuclear matter- binds nuclei

- Diffractive knock out of pion component of the deuteron

$$\sigma(eD \to e'pp\pi^-)$$

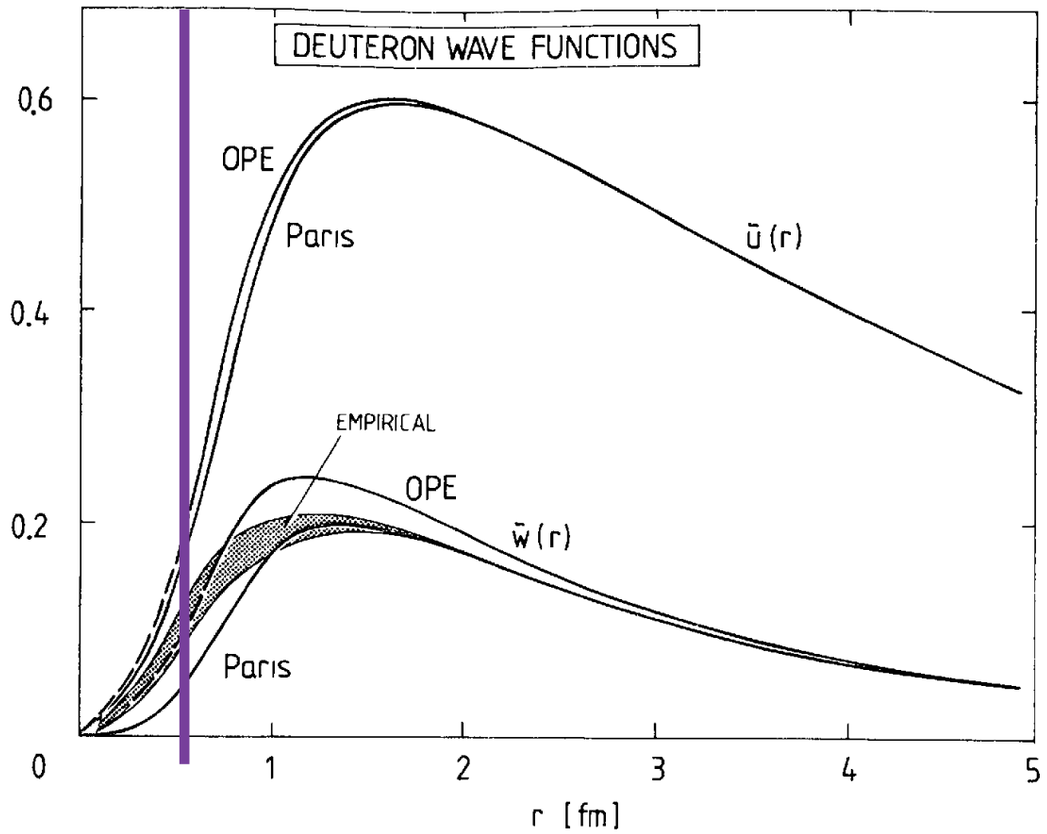
Measure **all** final particles -tag pp move slowly wrt D

- Explicit presence of pion content of Deuteron could be verified

Deuteron and OPEP

$$\psi_{J=1,M} = (4\pi)^{-\frac{1}{2}}\left\{\frac{u(r)}{r} + \frac{w(r)}{r}\frac{1}{\sqrt{8}}S_{12}(\hat{\mathbf{r}})\right\}\chi_{1M}$$

Ericson, T. E. O. and Rosa-Clot, M. (1985). *Ann. Rev. Nucl. Part. Sci.* **35.** 271.



OPEP explains deuteron wave function for distances down to about 0.5 fm

OPEP and High Momentum Tail

$$-(B+H_0)|\Psi_S> = V_T|\Psi_D>$$

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$$V_T|\Psi_D> = V_T\frac{1}{-B-H_0}V_T|\Psi_S>$$

Effective S-State potential V_{SS} Iterated OPEP gets 9 from isospin

Integral diverges linearly without cutoff so V_{SS}
Approximately constant in momentum space
momentum-space wave function $\sim 1/k^2$
Density falls $\sim 1/k^4$, gives reasonable D-state probability

Details in App. A of Hen, Miller et al RMP 89, 045002 (2017)

- Chiral dynamics of Kaiser Fritsch Weise nucl-th/0105057, uses iterated OPEP to bind nuclear matter

Chiral dynamics Kaiser et al

Chiral expansion in powers of Fermi momentum:

$$E/A = \frac{3}{10}\frac{k_F^2}{M} - \alpha\frac{k_F^3}{M^2} + \beta\frac{k_F^4}{M^3}$$

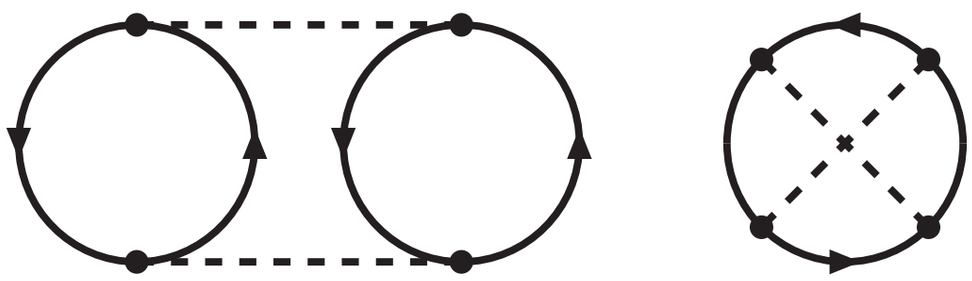
Attraction

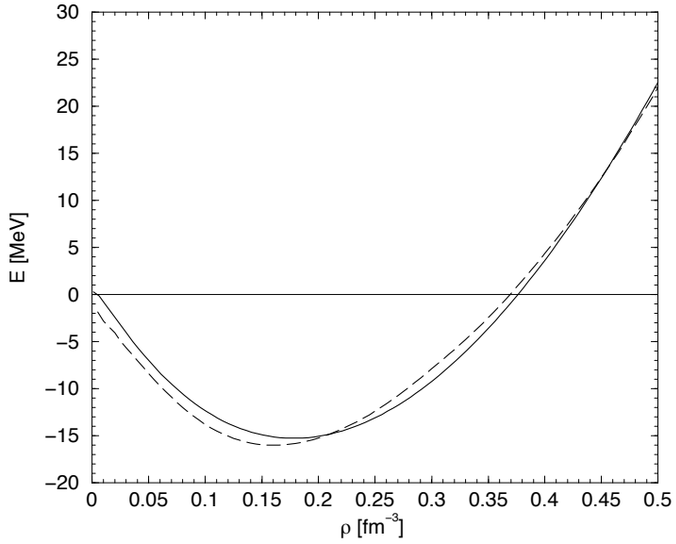
Effects: kinetic energy, Iterated One Pion Exchange,
Irreducible two pion exchange, uses cutoff regularization $\Lambda = 650$ MeV

Chiral limit used to analytically demonstrate feasibility

N=Z infinite nuclear matter:
binding energy, density, compressibility ≈ agrees with measurements

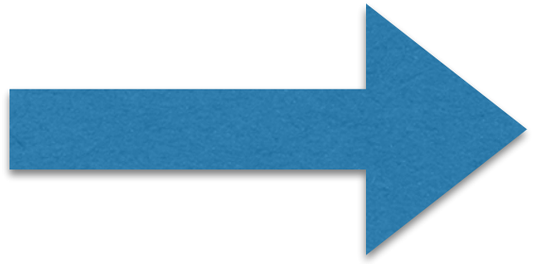
Also get symmetry energy





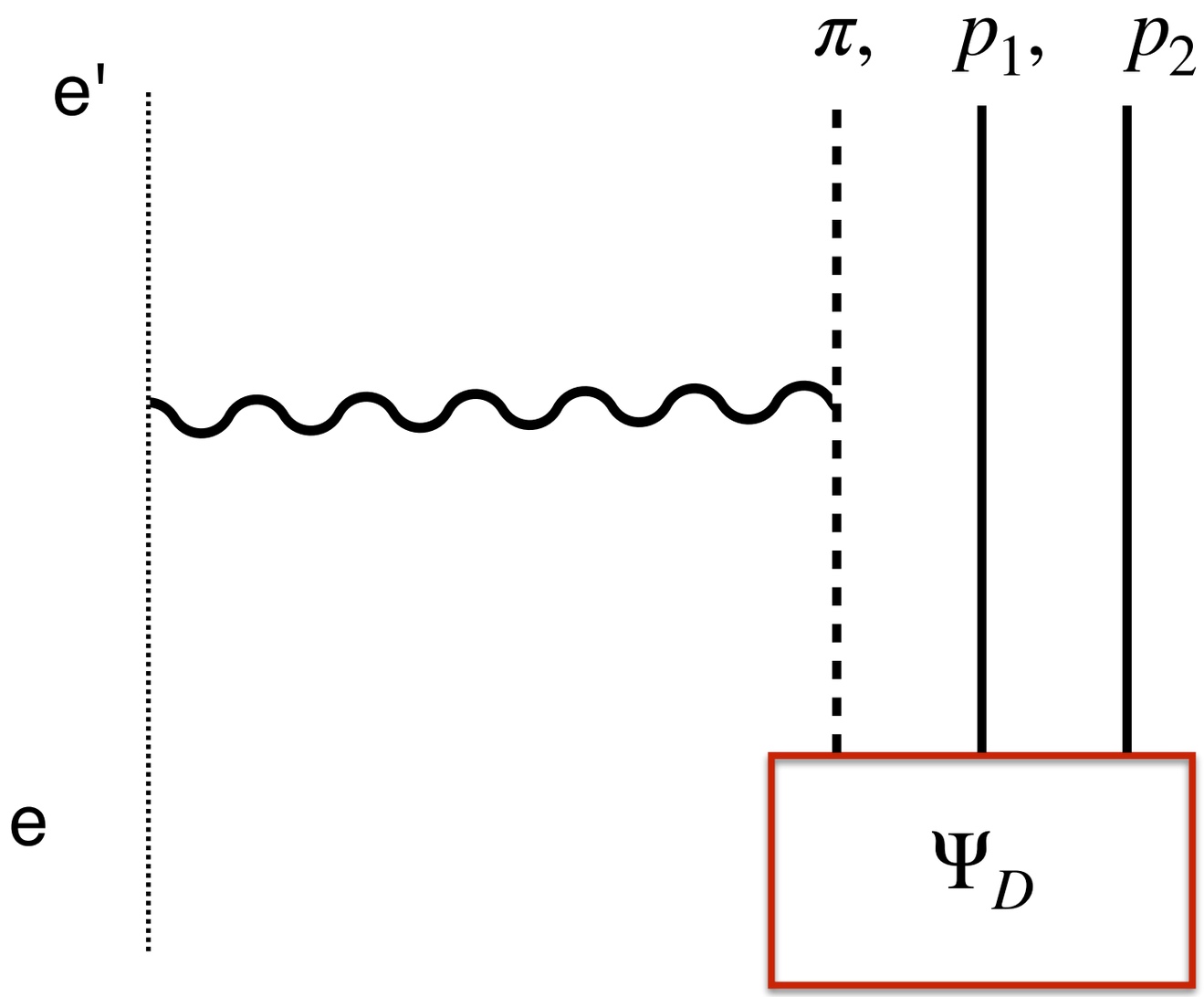
Iterated OPEP

- Binds deuteron
- Binds nuclear matter
- Gives high momentum tail



- Pions are flying around the nucleus
- There must be some probability to catch the one pion +A nucleon component of the nuclear Fock-space wave function
- How to observe?

Diffractive break up of one-pion component of the deuteron wave function



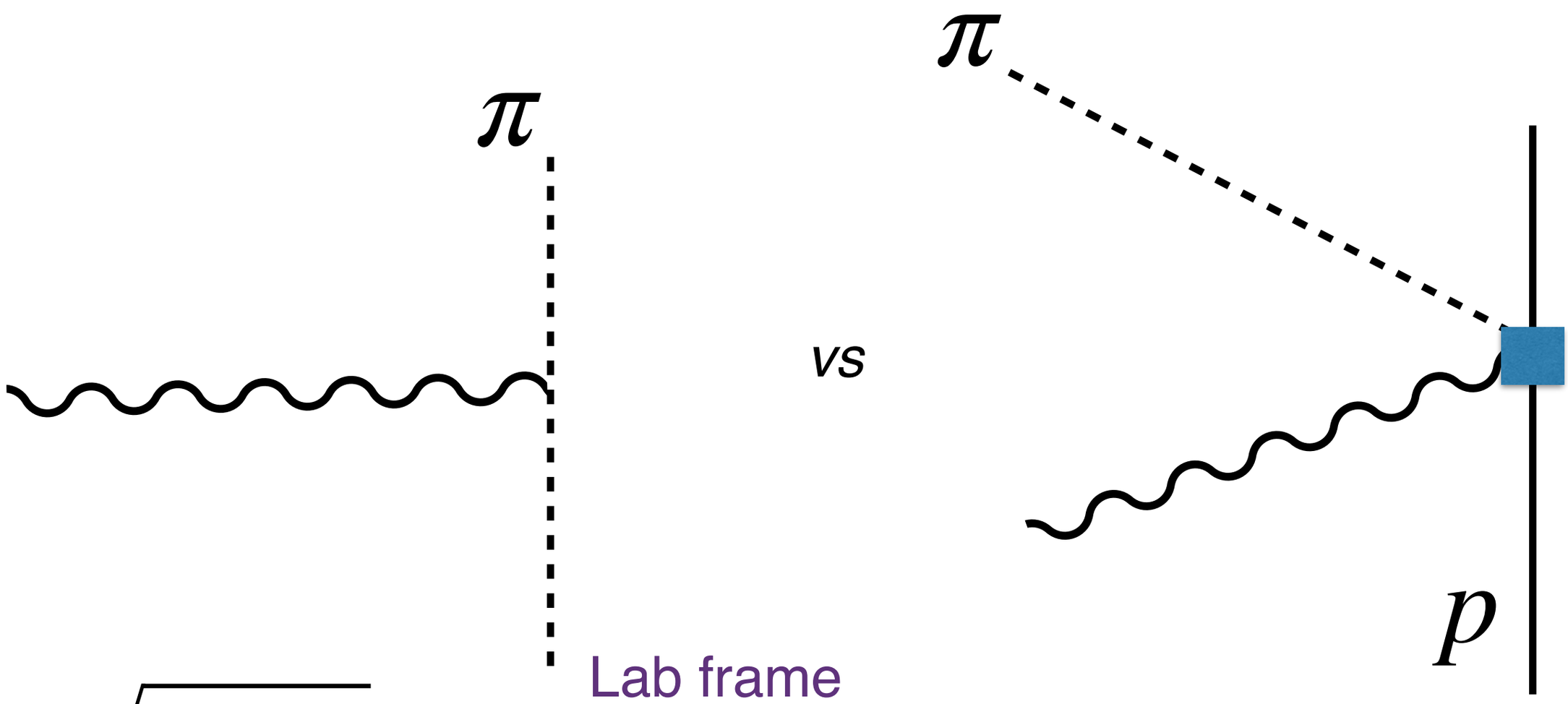
Light-front Fock Space Wave function

$\pi, \quad p_1, \quad p_2$

each on the mass shell

Competing processes ?

Diffractive knockout of pion vs pion production by photon



Lab frame

$$\nu + \sqrt{k_\pi^2 + m_\pi^2)} = E_\pi(\text{final}) \qquad \nu + M = E_\pi(\text{final}) + E_p(\text{final})$$

Take difference, left minus right

$$M - \sqrt{k_\pi^2 + m_\pi^2}\,? = ?\,E_p(\text{final})$$

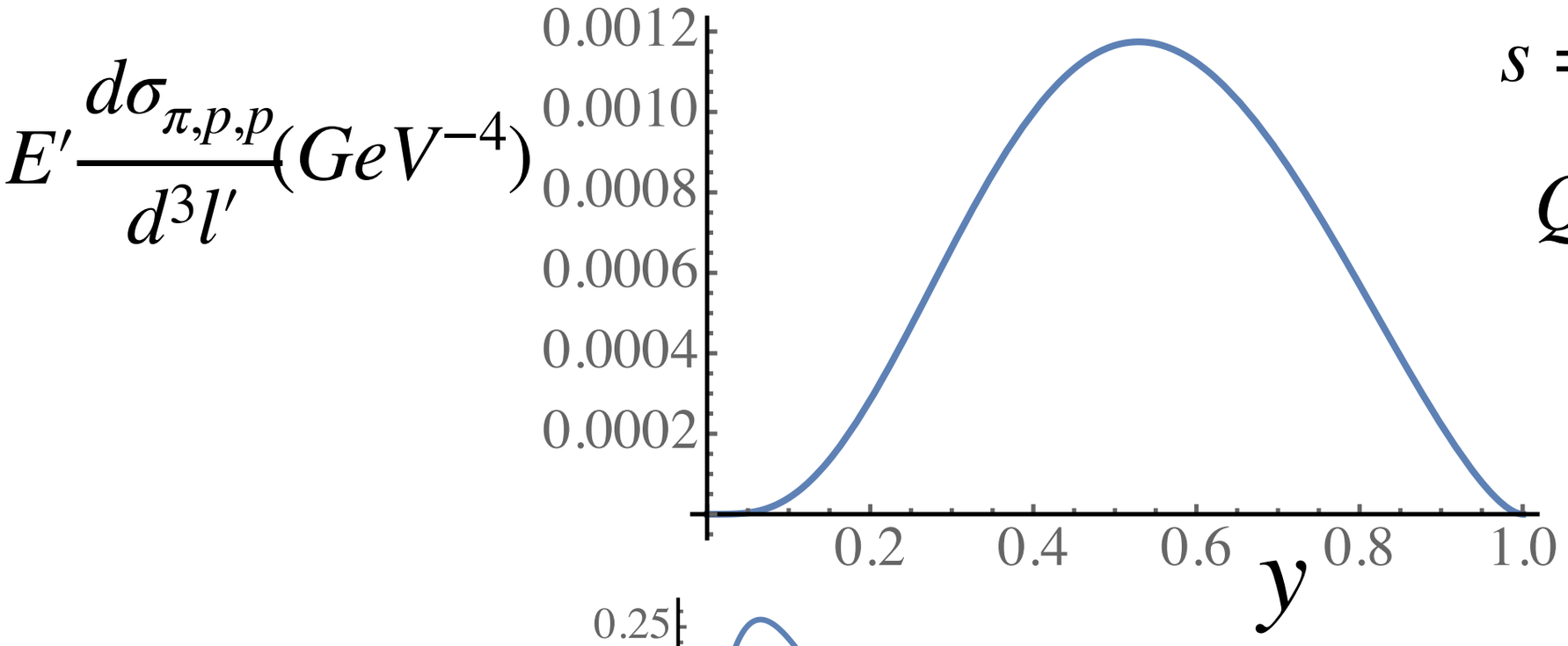
Equality is not possible-pion energies of mechanisms differ

Invariant Cross section

$$E'\frac{d\sigma_{\pi,p,p}}{d^3l'} \propto \frac{\alpha^2 s}{Q^6} F_\pi^2(Q^2) f_\pi(y)$$

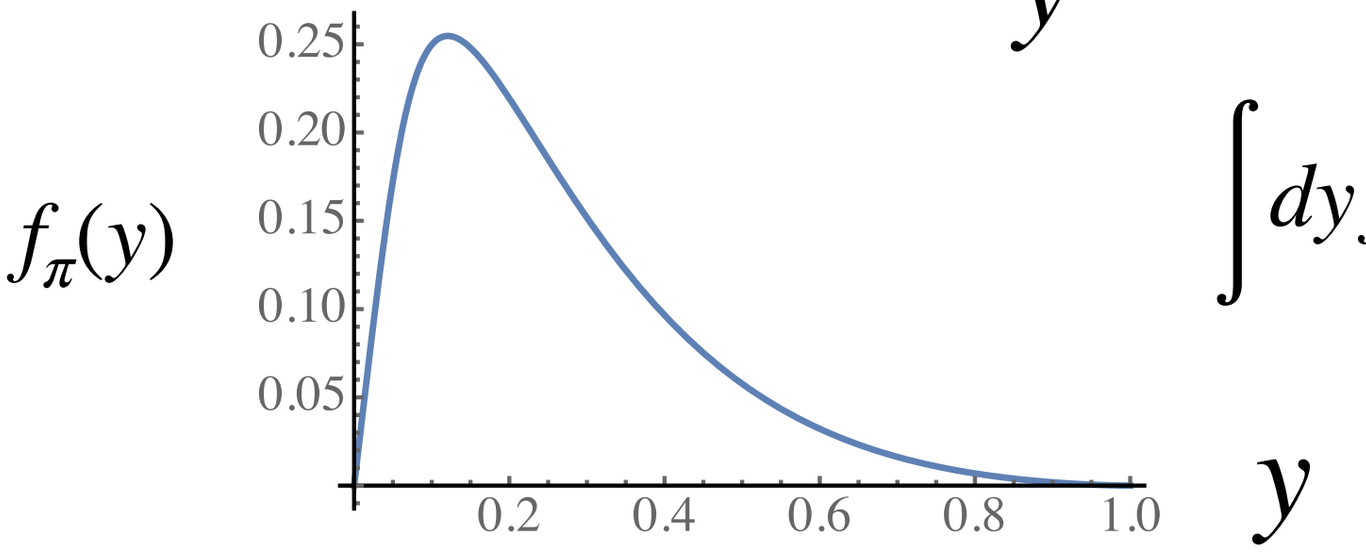
E', l' are lepton coordinates $F_\pi(Q^2)$ pion elastic charge form factor

$f_\pi(y)$ fraction of deuteron momentum carried by π^-



$$s = 2 \times 10^4\, GeV^2$$

$$Q^2 = 0.5\, GeV^2$$



$$\int dy\, f_\pi(y) = 0.09$$

Summary

- Pions (Iterated OPEP) bind the deuteron
- Iterated OPEP gives high momentum tail of nuclear wave function
- Pions (Iterated OPEP) bind the nucleus
- Pions give give high momentum tail
- Diffractive production of pions through $\pi^- pp$ component
- kinematically distinct from production from nucleon?
- production cross section of order 10^{-3} GeV^{-4}