Experimental Studies of the phi-nucleon interaction at SPring-8 and J-PARC

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Contents

Introduction

ϕN interaction

Knowledge on $\phi[s\bar{s}]$-$N[uud/udd]$ interaction is controversial

Weak?

1. Photoproduction I.I. Strakovsky, L. Pentchev, A.I. Titov, PRC101, 045201 (2020).

$$|a_{\phi p}| = 0.063 \pm 0.010 \text{ fm}$$

$$|a_{\phi p}| \sim 0.15 \text{ fm}$$ W.-C. Chang et al., PLB658, 209 (2008).

Not weak?

2. A-dep. of photoproduction

$$|a_{\phi N}| \simeq 0.5 \pm 0.1 \text{ fm}$$ T. Ishikawa et al., PLB608, 215 (2005).

ϕN interaction

Strong?

3. Correlation function

ALICE collaboration, PRL127, 172301 (2021).

$$a_{\phi p} = (0.85 \pm 0.34) + i(0.16 \pm 0.10)\ \text{fm}$$

4. Lattice QCD calculation

$$a_{\phi N}^{(3/2)} =\sim 1.43\ \text{fm}$$

Y. Lyu et al., PRD106, 074507 (2022).

Very Strong?

5. $K^{+}\Sigma(1385)$ photoproduction peaking just below the ϕN threshold

$$a_{\phi N}^{(3/2)} < 0$$

Mrunmoy Jena, Master thesis, Bonn Univ. (2024).

$\gamma d \rightarrow \phi p \pi N$ at SPring-8

T. Ishikawa

$\gamma d \to \phi p \pi N$ at SPring-8

We try to determine ϕp scattering length ($a_{\phi p}$) from the LEPS data using the final state interaction (FSI) in $\gamma d \to \phi p \pi N$

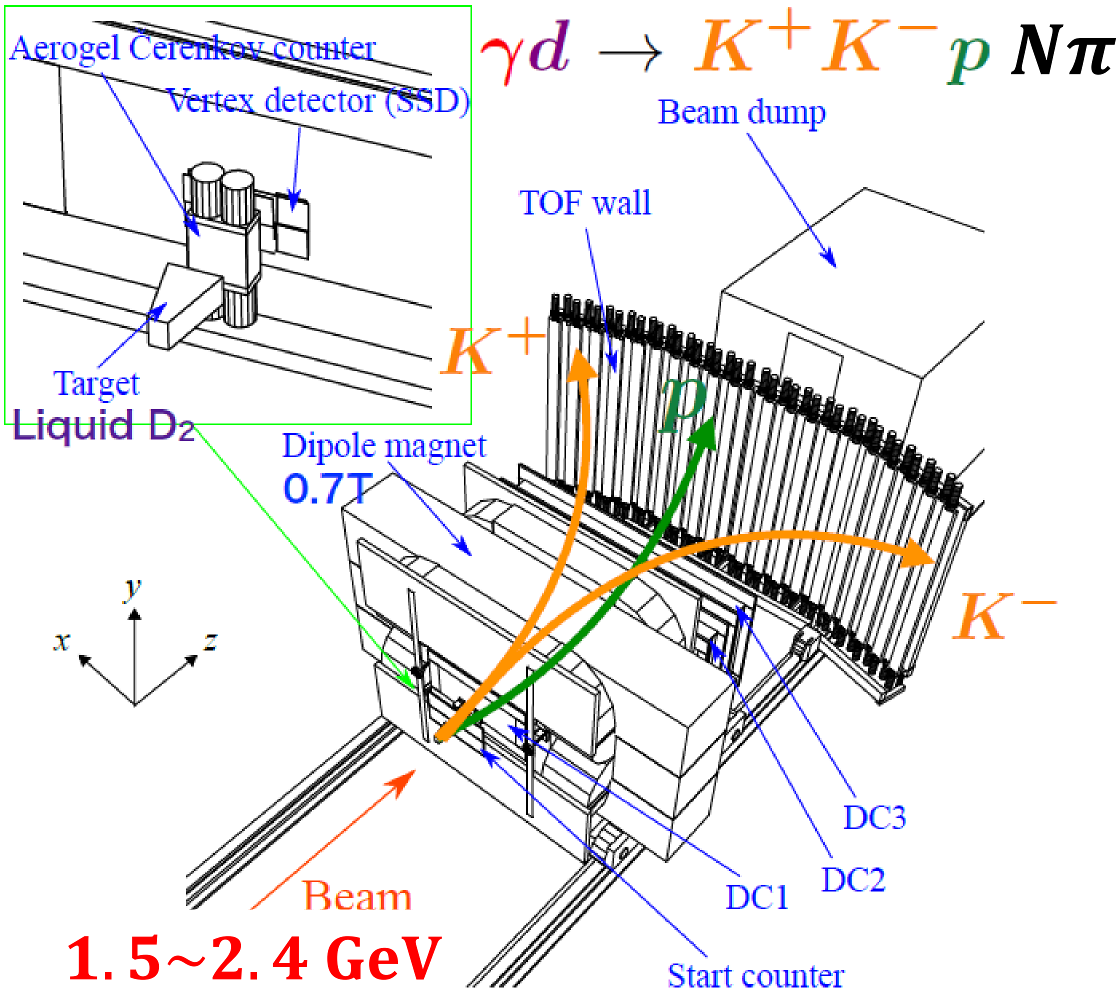
Why deuterium target?

Difficult to determine $a_{\phi p}$ using FSI in $\gamma p \to \phi p$ since it takes place t-channel exchange dominantly and since t distribution shows a steep exponential function

Little is acceptance of three charged particles detection (K^+K^-p and $K^+K^-\pi^+$) for $\gamma p \to \phi p \pi^0$ and $\gamma p \to \phi n \pi^+$

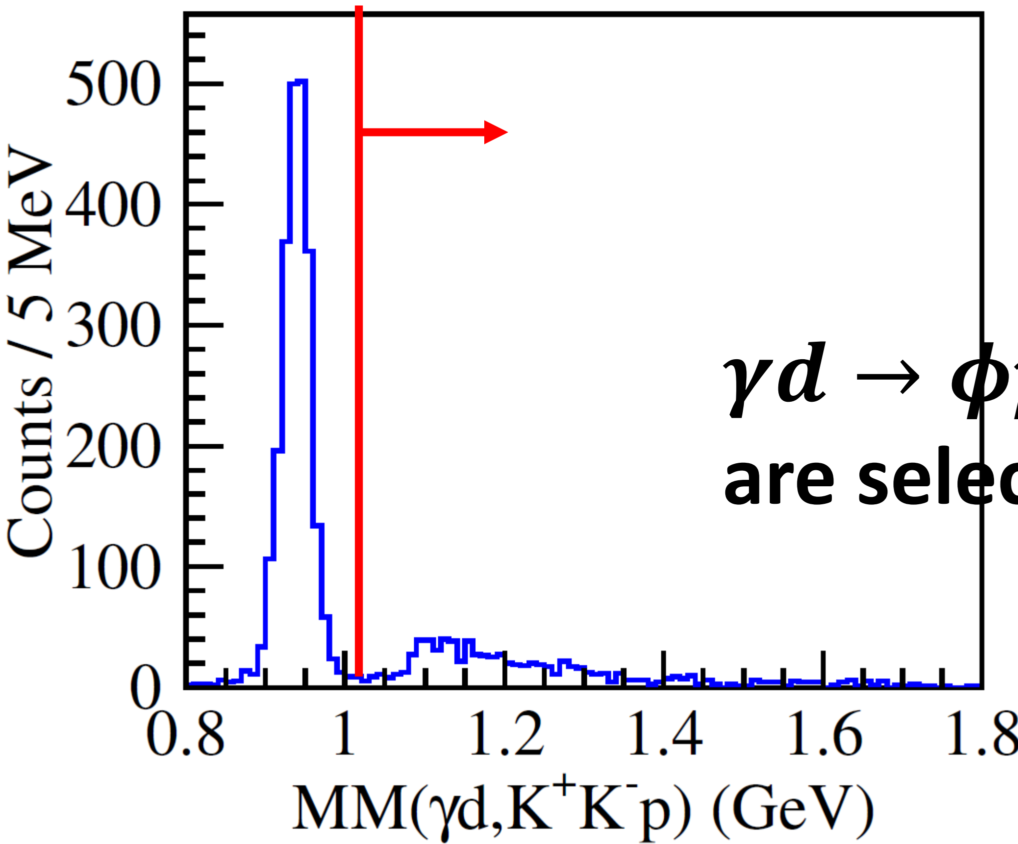
$\gamma d \to \phi p \pi N$ at SPring-8

We analyze the data collected using the forward magnetic spectrometer.



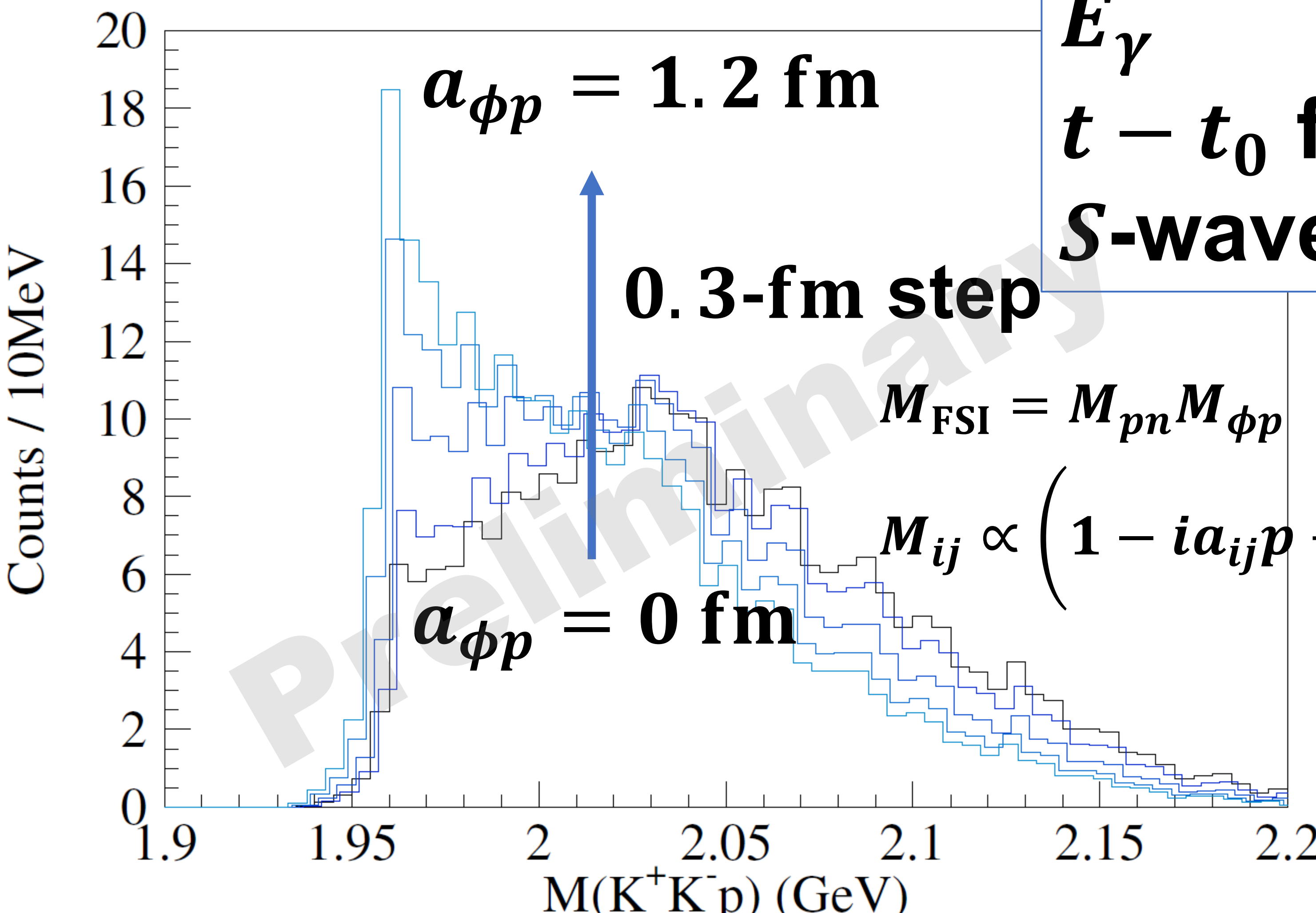
$\gamma d \to \phi p \pi N$ at SPring-8

1) K^+K^-p detection
2) vertex corresponding to LD_2
3) ϕ identification



$\gamma d \to \phi p \pi N$ events are selected

Expected ϕp invariant mass distributions



E_γ

$t - t_0$ for ϕ

S-wave pn FSI

$$M_{\mathrm{FSI}} = M_{pn} M_{\phi p}$$

$$M_{ij} \propto \left(1 - i a_{ij} p + \frac{1}{2} a_{ij} r_{ij} p^2\right)^{-1}$$

$\gamma d \to \phi p \pi N$ at SPring-8

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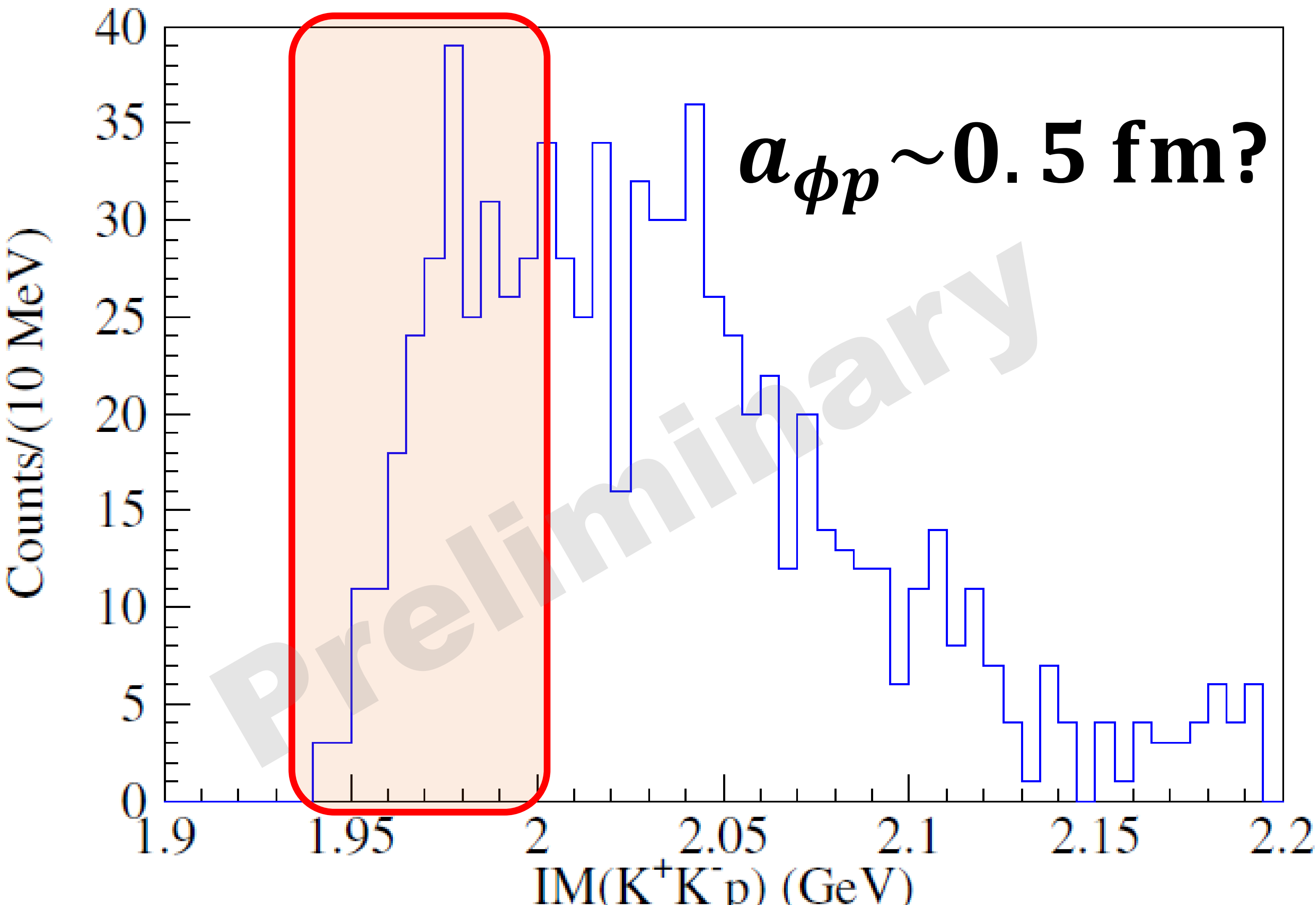
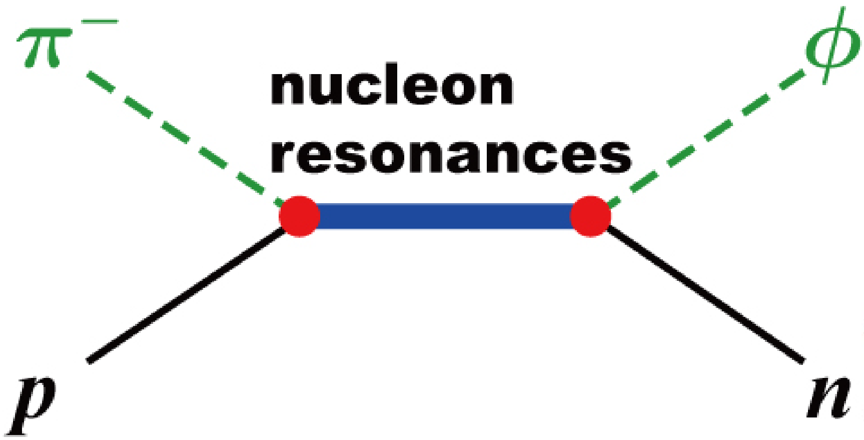
Obtained ϕp invariant mass distribution



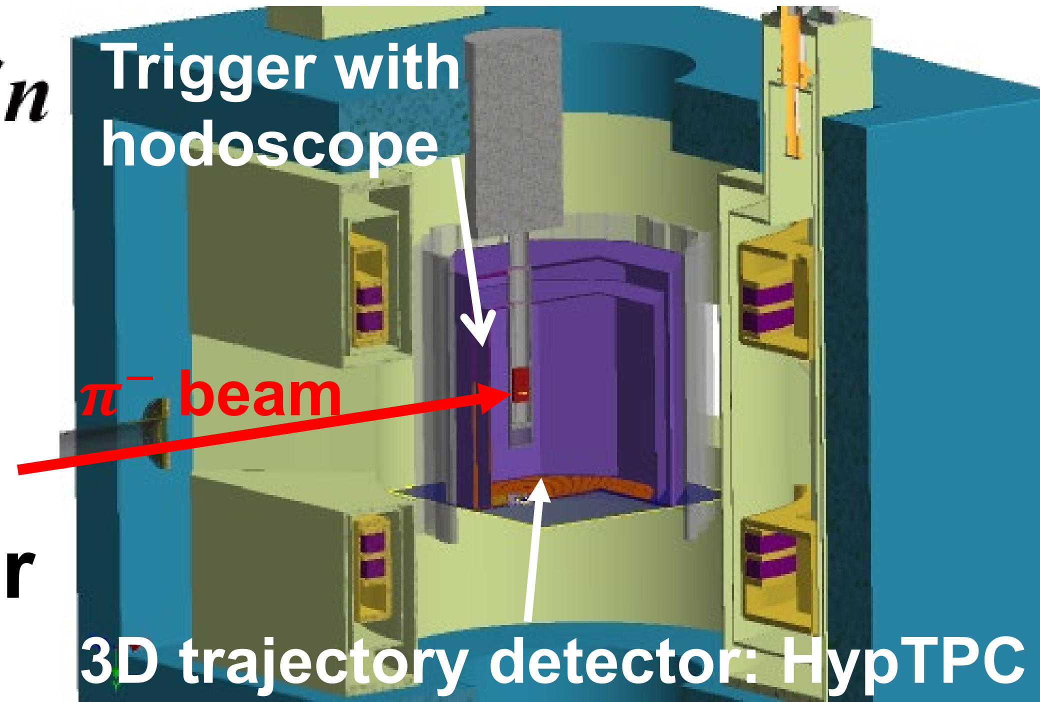
$\pi^- p \to \phi n$ at J-PARC

$\pi^- p \to \phi n$ near the threshold

s-channel seems to be dominant near the threshold, different from photoproduction

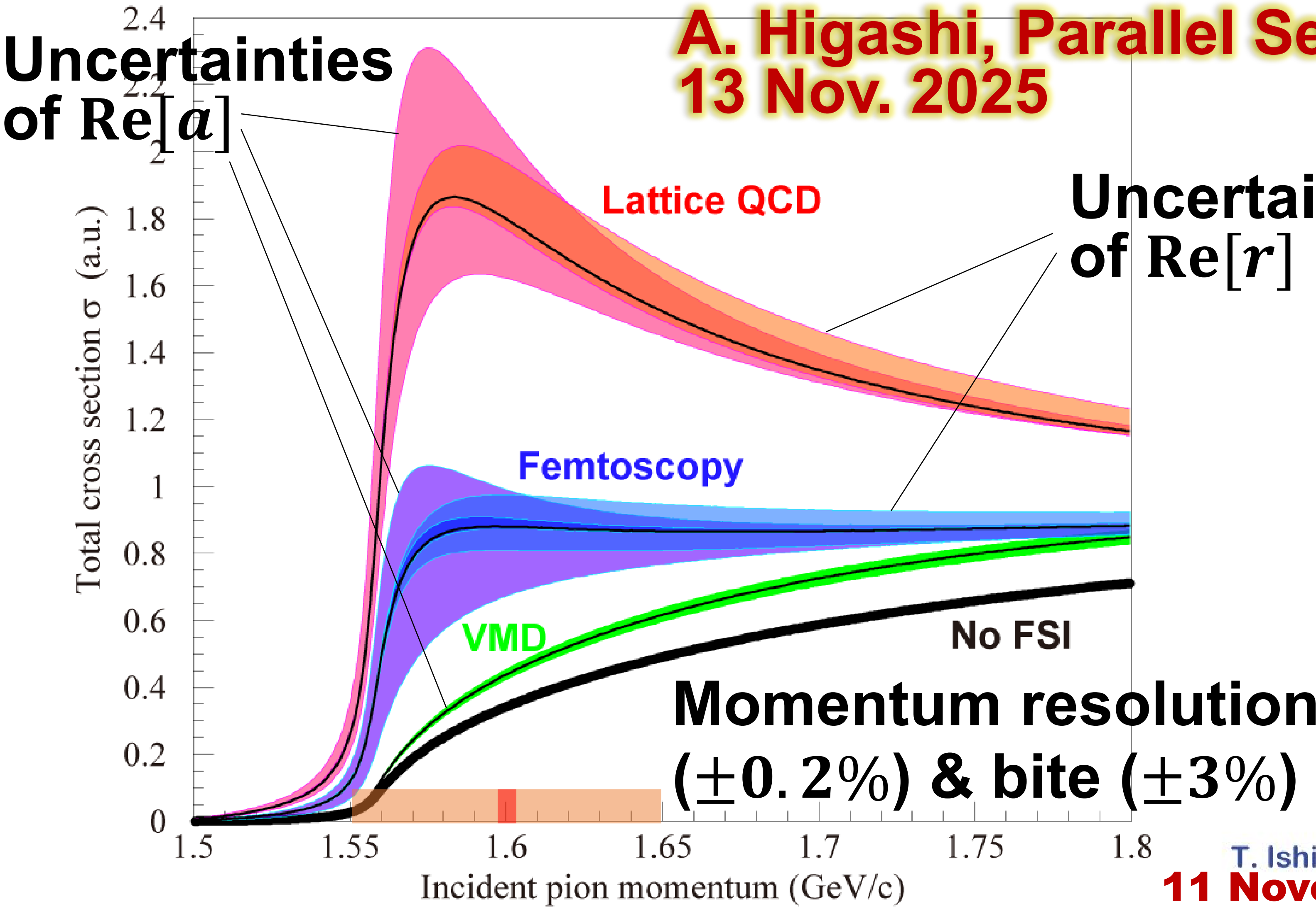


Cross sections are planned to be measured at J-PARC (E45) using the HypTPC spectrometer



$\pi^- p \to \phi n$ near the threshold

Expected excitation functions



Summary

Summary and prospects

- ϕN interaction is studied at
  - SPring-8 (photon beam, $\gamma d \to \phi p \pi N$) and
  - J-PARC (π^- beam, $\pi^- p \to \phi n$)
- ϕp invariant mass distribution in $\gamma d \to \phi p \pi N$ seems to suggest $a_{\phi N} \sim 0.5\ \mathrm{fm}$
- We also plan to study open s channels: $KY^{(*)}$ as well as ϕN
- If only $a_{\phi N}$ from $\gamma N \to \phi N$ is different from others, current understanding of $\gamma N \to \phi N$ based on the vector-meson dominance model should be reconsidered.