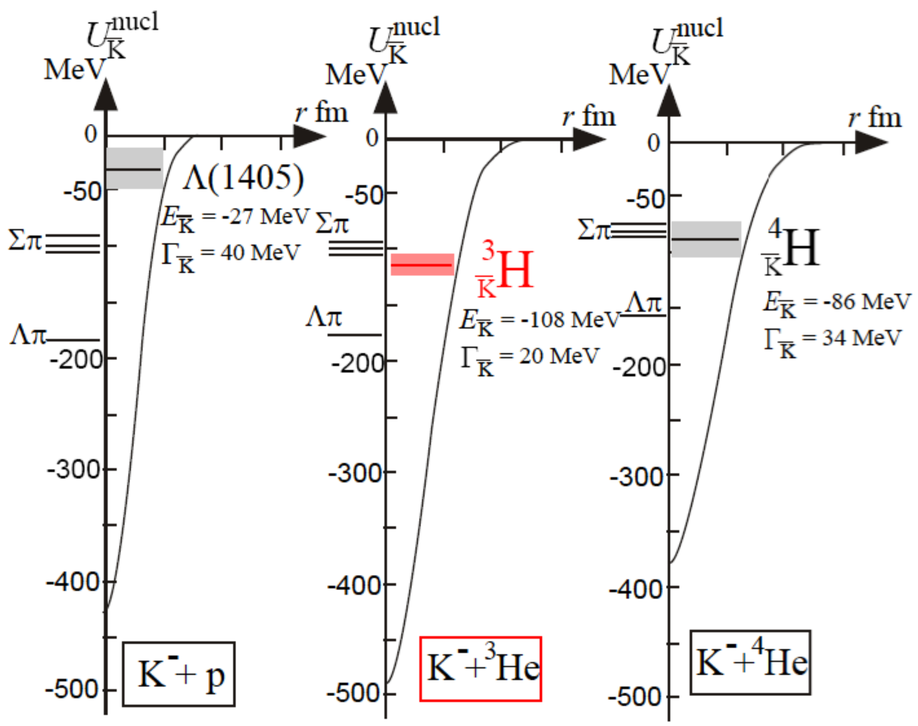
Staging strategy of E15

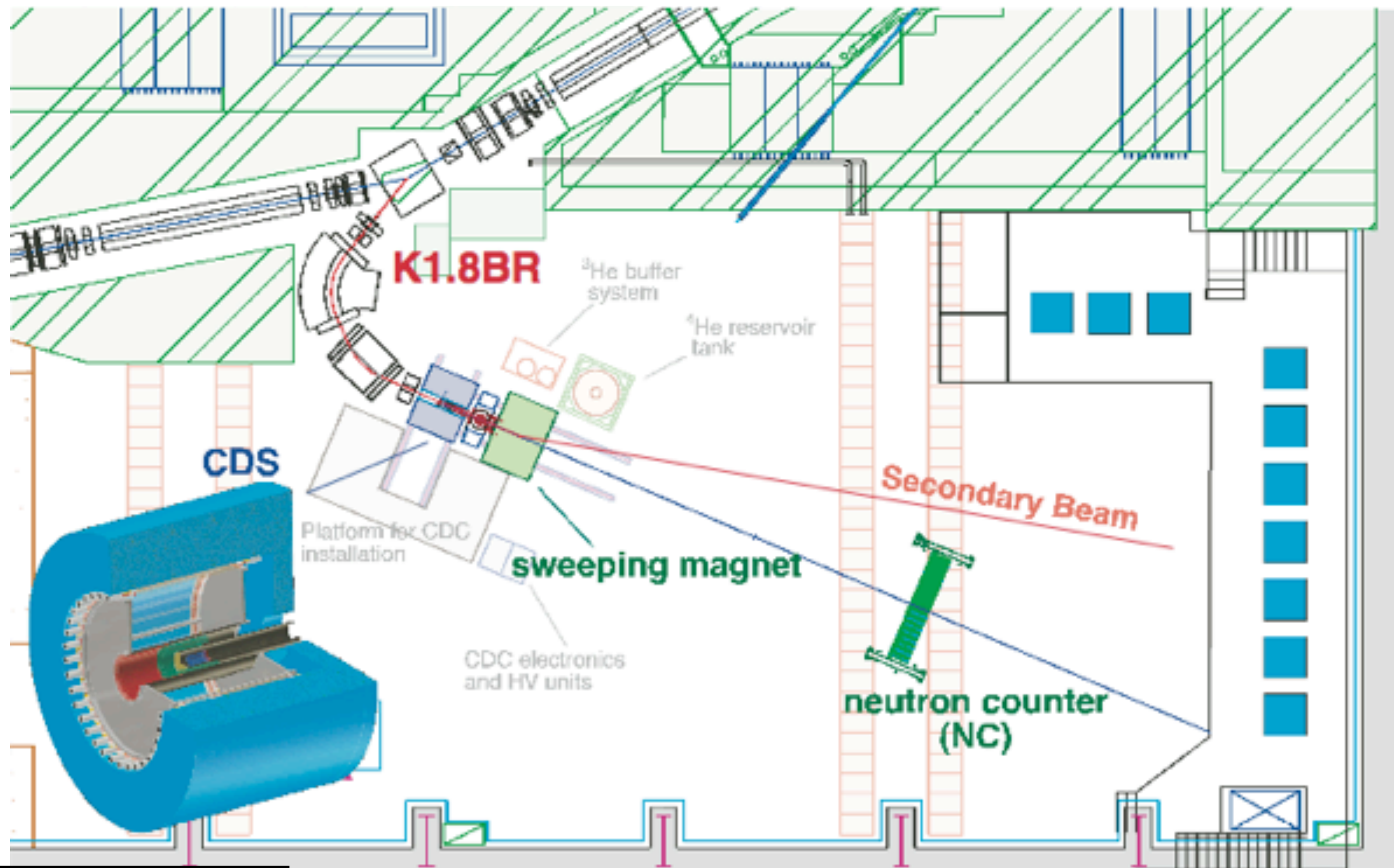
M. Iwasaki

RIKEN Nishina Center & TITech

for J-PARC E15 Collaboration

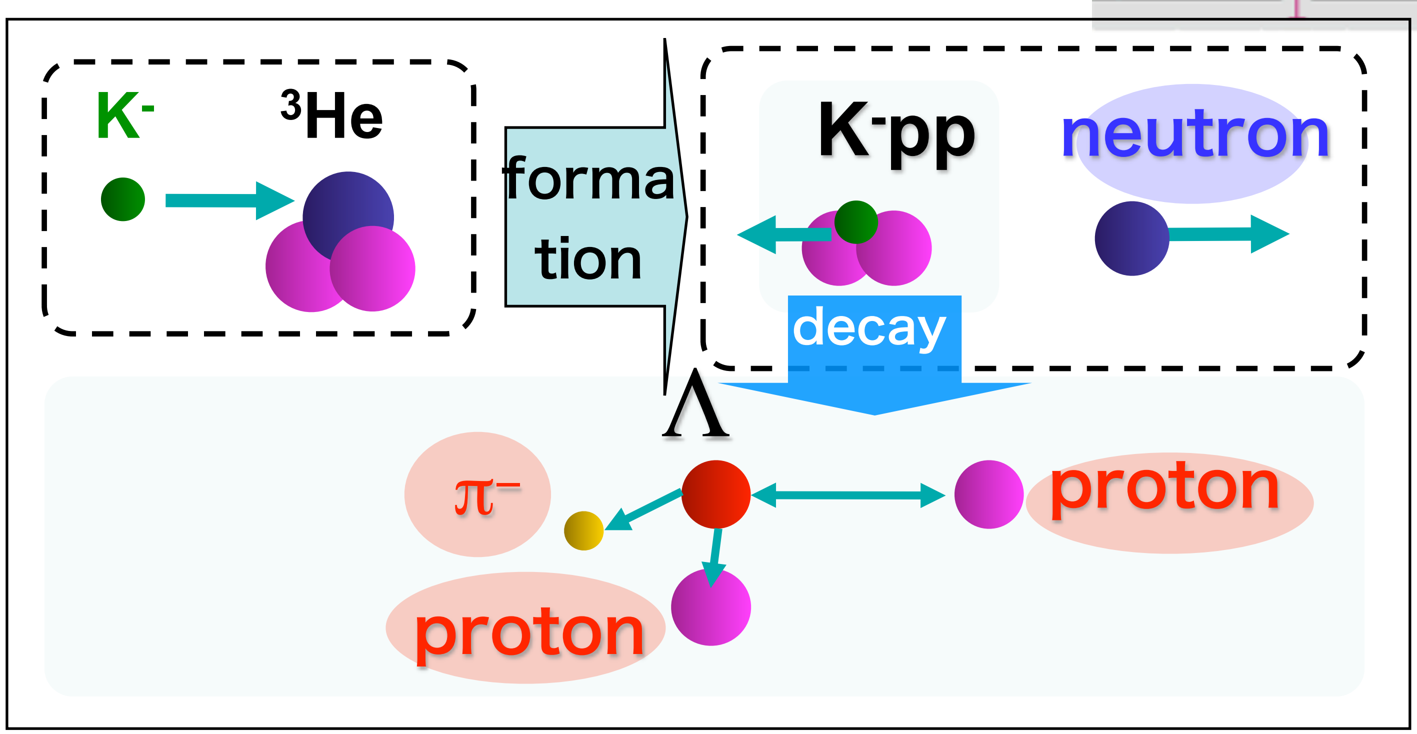
E15: $\bar{K}N$ interaction study by nuclear bound state

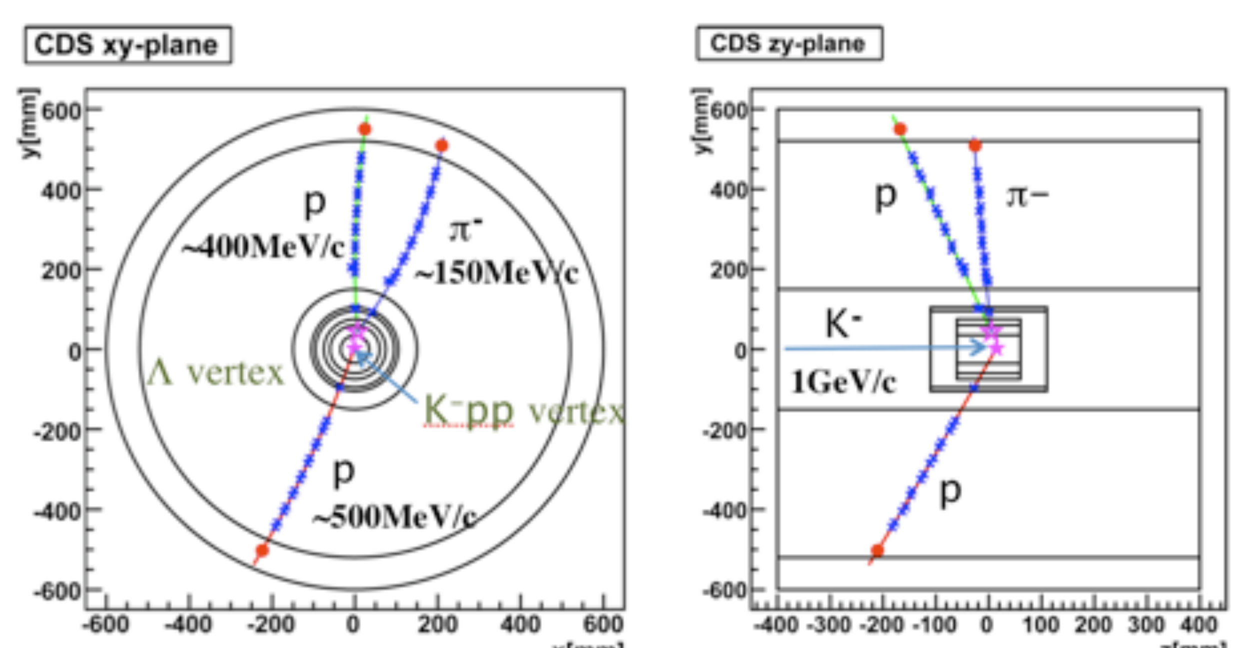




$K^{-}\,{}^{3}He$ -> “pp K^{-}” + n

at 1 GeV/c by both
missing & invariant mass





E15 staging strategy

E15[1st] ~ 30kW*week

motivated by

1) *Production cross section can be as large as few mb/sr in bound region!*

T. Koike, T. Harada, Phys. Rev. C80, 055208 (2009)

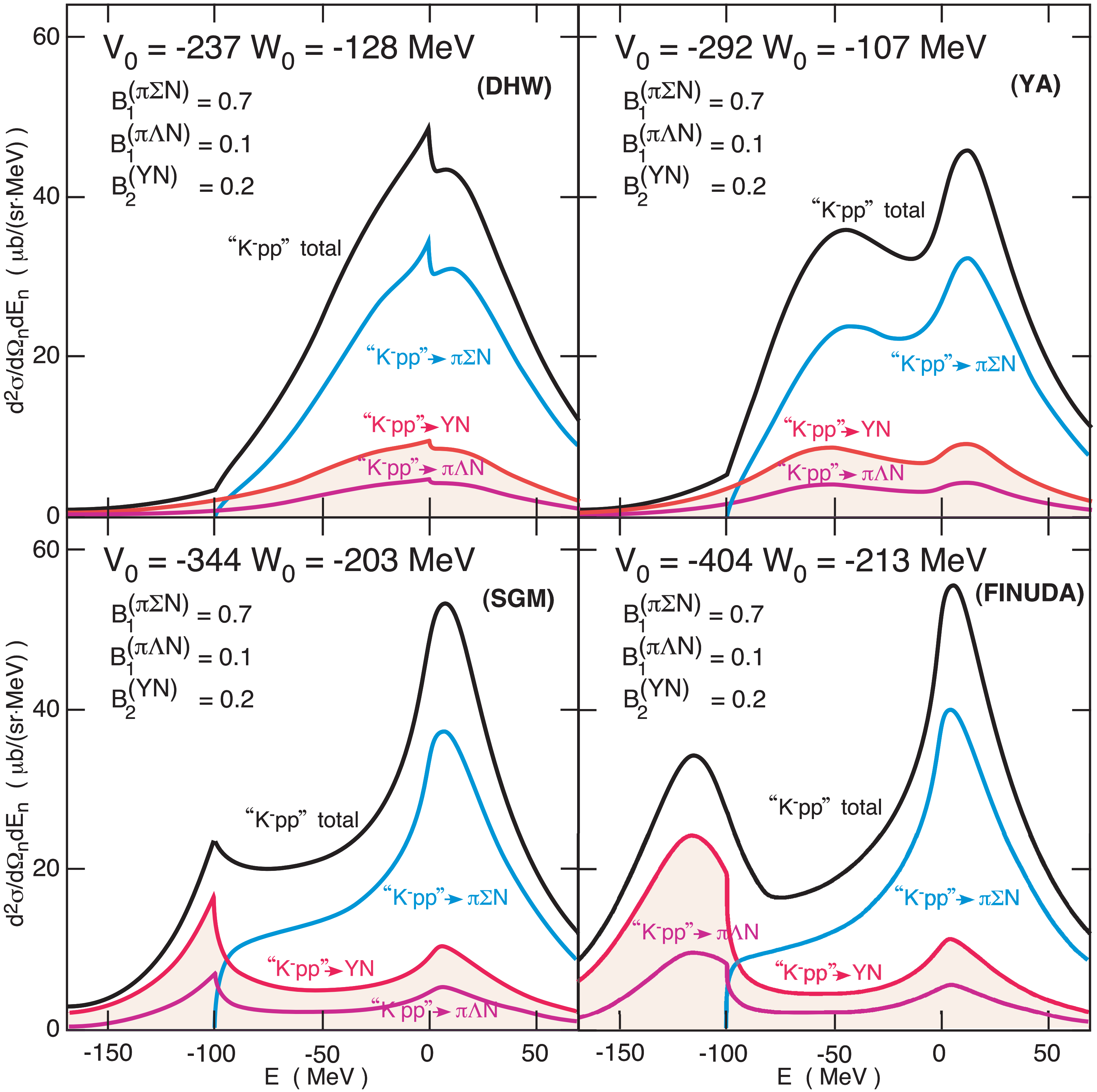
2) *DISTO DATA*

T. Yamazaki, M. Maggiora, P. Kienle, et al, PRL 104, 132502 (2010)

3) *Background Study*

Production cross section (KH)

^{3}He (K$^-$, n) X @ 1 GeV/c **Excluding K$^-$ escape process** T. Koike, T. Harada, Phys. Rev. C80, 055208 (2009)



few mb/sr in bound region!

cf. 10 μb/sr assumed in prop.

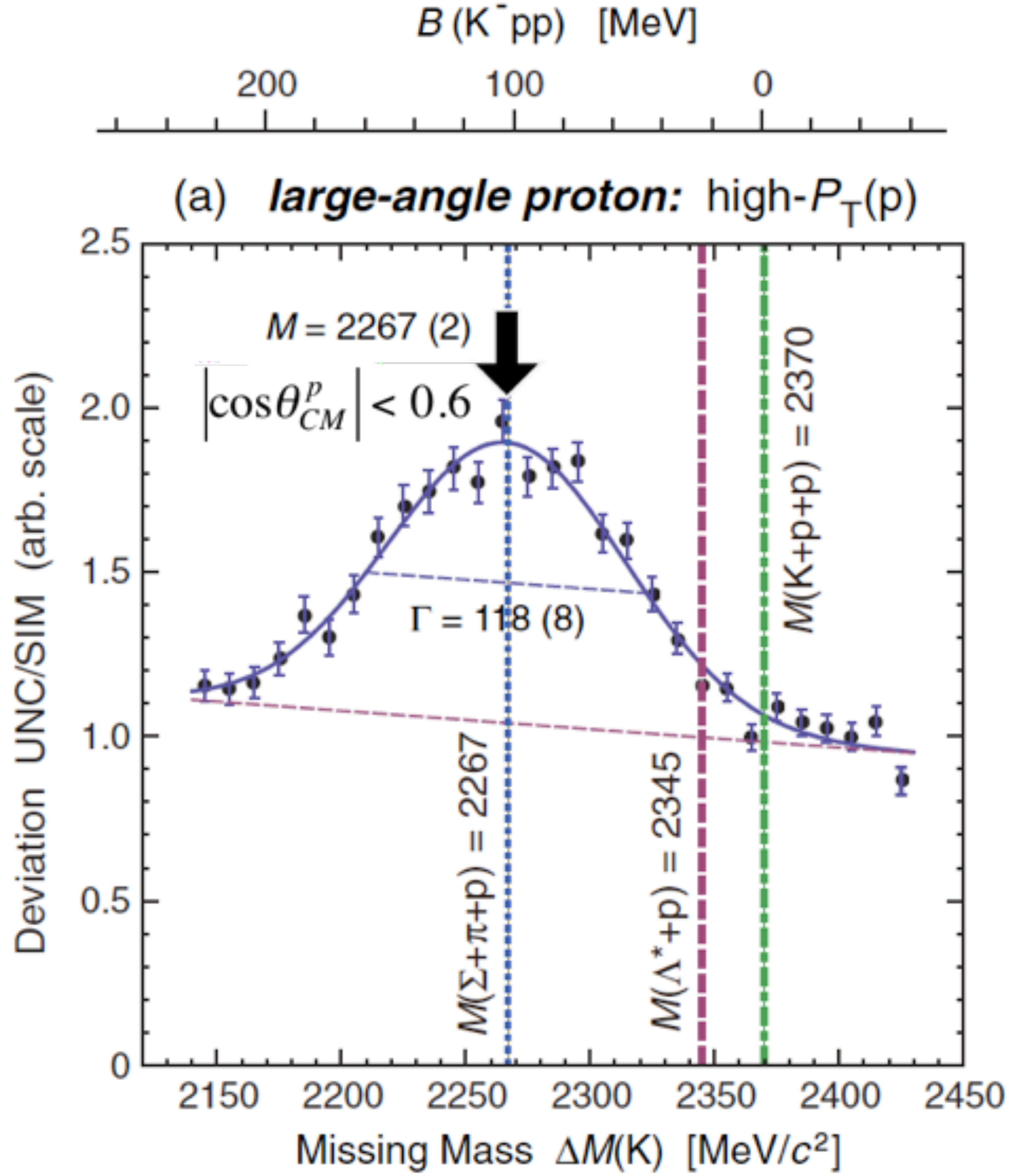
limiting to nYN final states

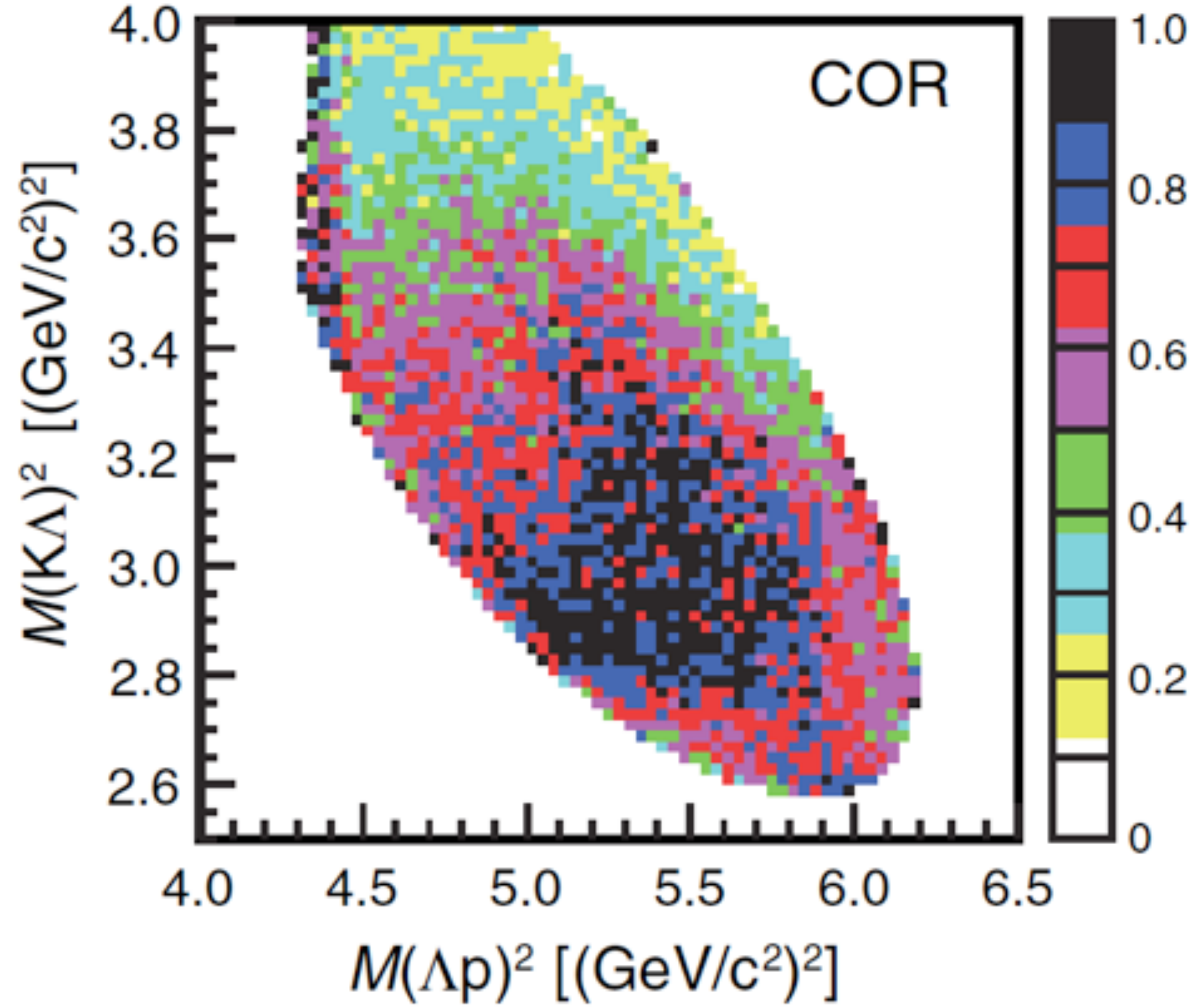
≳1mb/sr!

DISTO DATA

exclusive

$pp \rightarrow K^{+}\Lambda p$ at T_p = 2.85 GeV

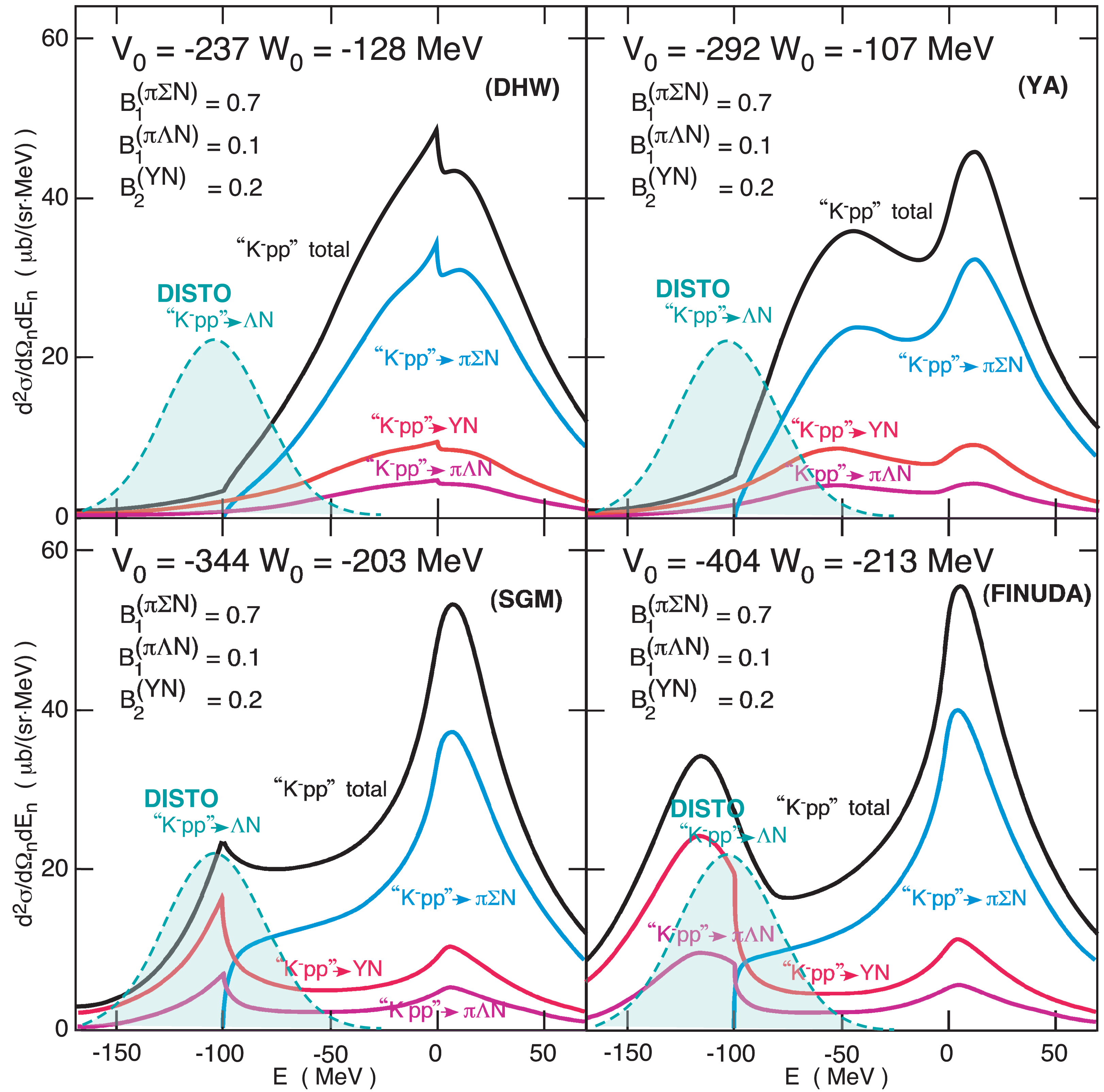




T. Yamazaki, M. Maggiora, P. Kienle, et al,
PRL 104, 132502 (2010)

B_K~100MeV and Γ_K~100MeV

KH vs DISTO



DISTO

B_K~100MeV and Γ_K~100MeV

- only for Λp decay ch.

private communication

- does not fit in KH scheme

easy to observe,

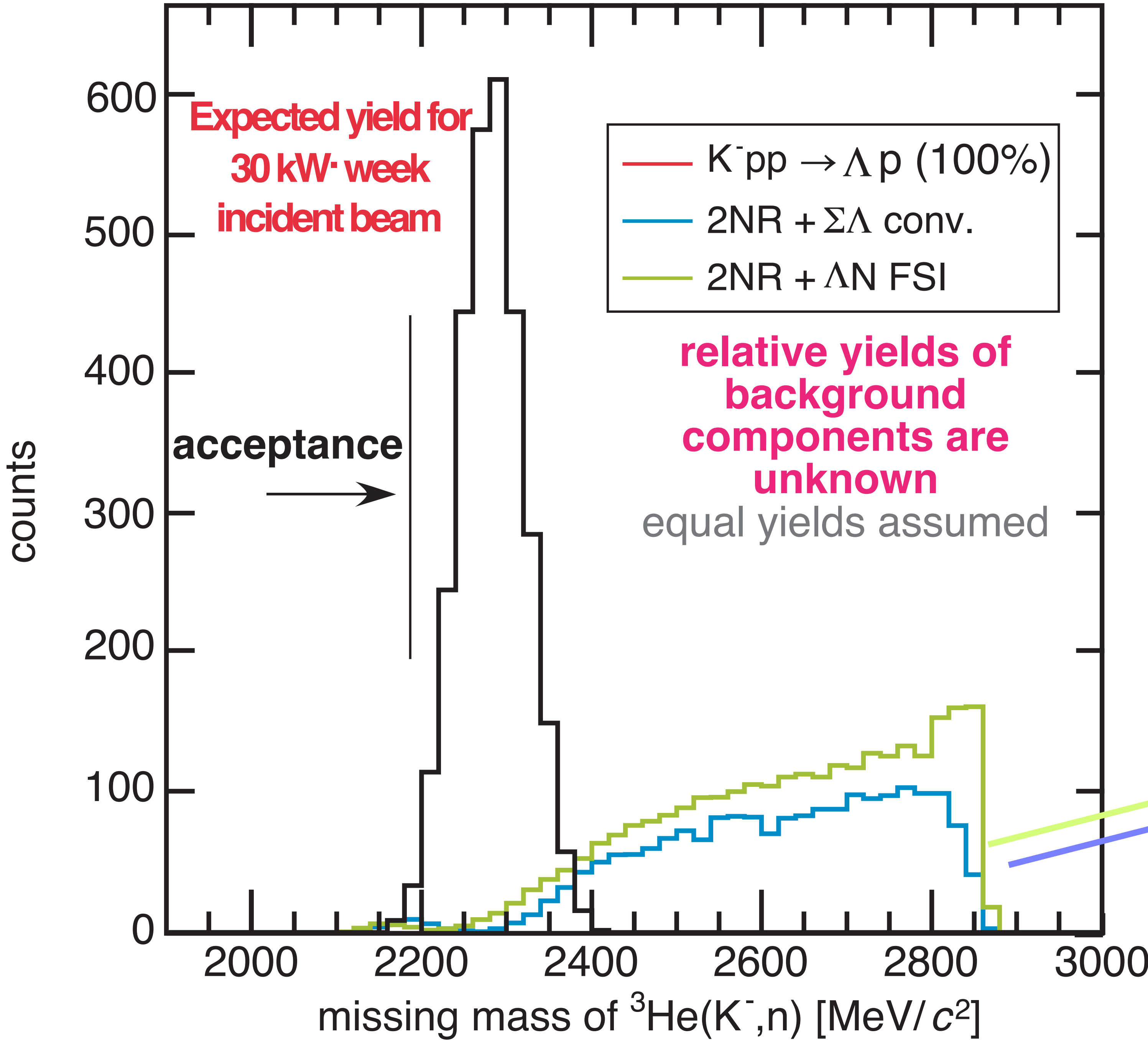
if dσ/dΩ ≳ 1mb/sr

and Λp decay channel

(n + Λp final state)

Neutron missing mass spectra @ 30kW*week

^{3}He(K^{-},n) Λ p : fully reconstructed



signal

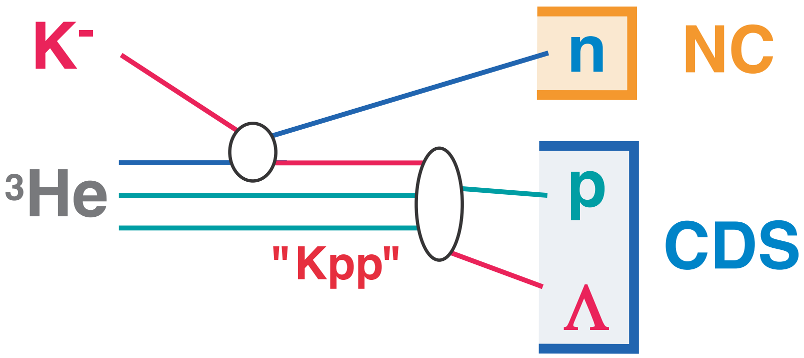
Assume DISTO like data,

B_K~100MeV and Γ_K~100MeV

$d\sigma/d\Omega^{\theta=0}$ = 1 mb/sr

BR(Λp) = 100 %

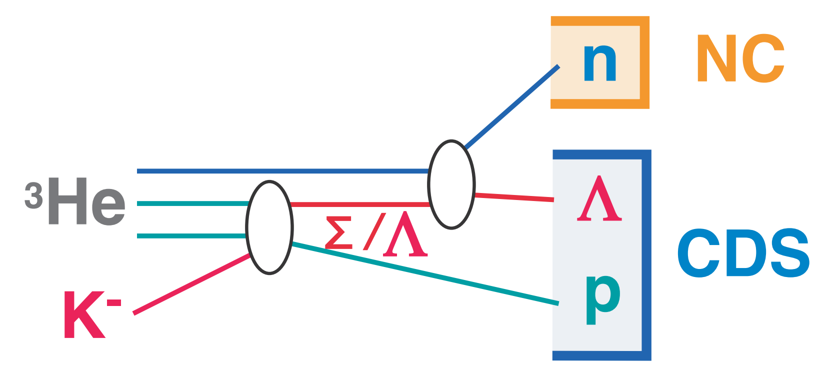
for simplicity



backgrounds

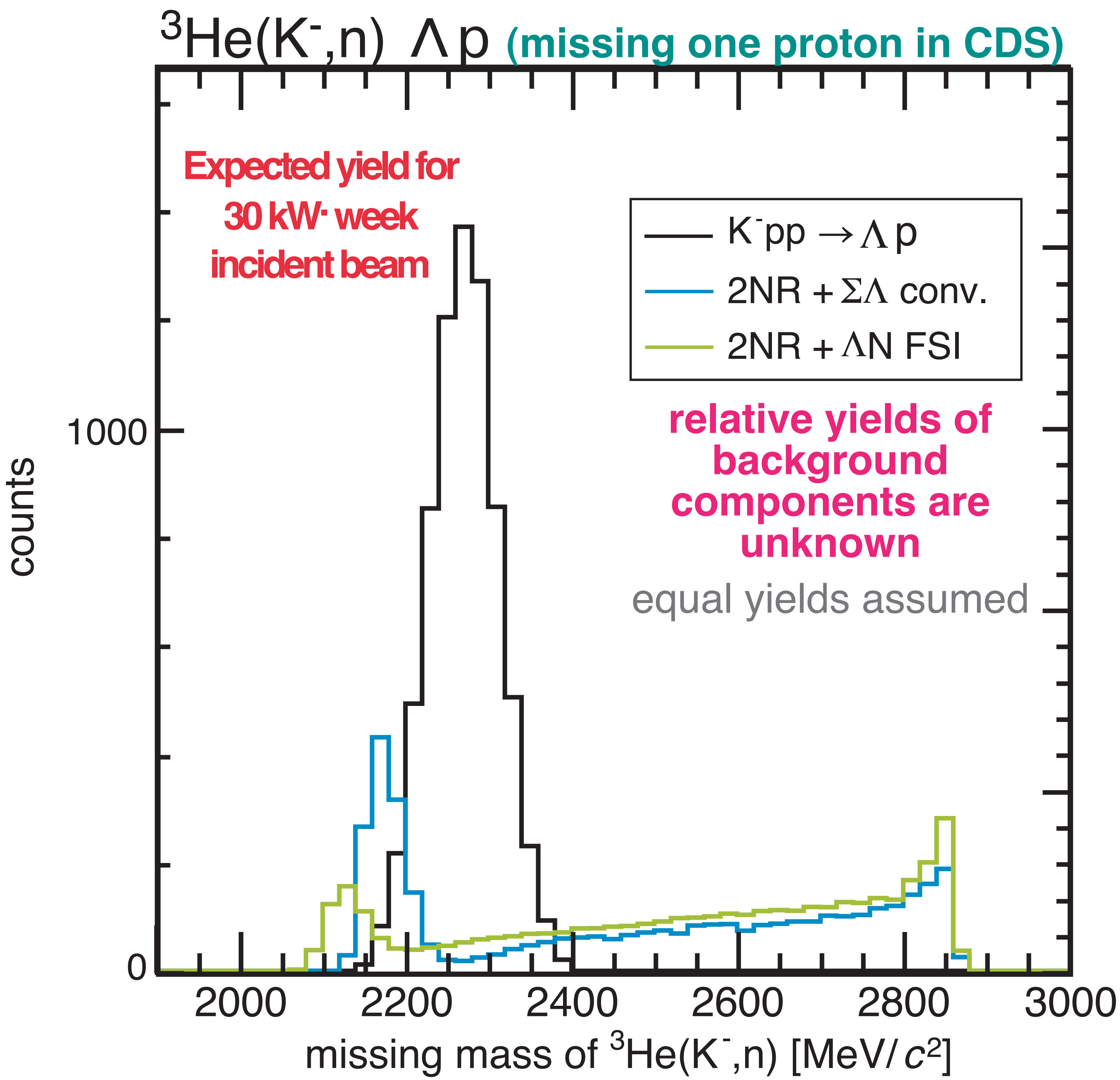
2NR initiated reactions

σ ~ 10 mb each



simulated by T. Hiraiwa

Neutron missing mass spectra @ 30kW*week



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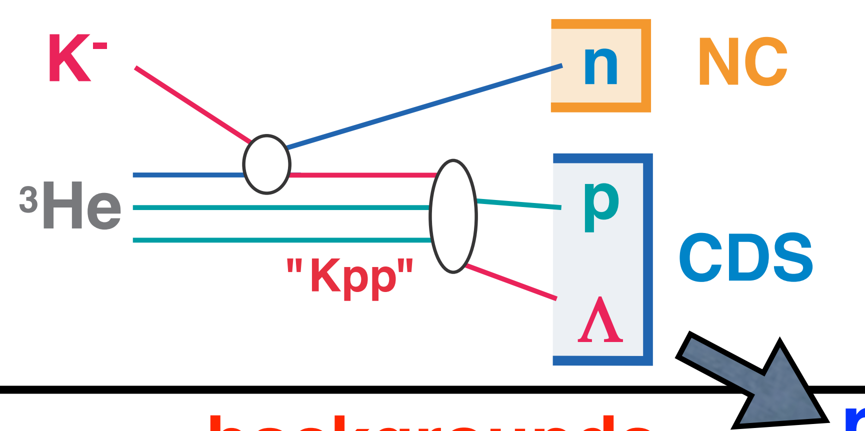

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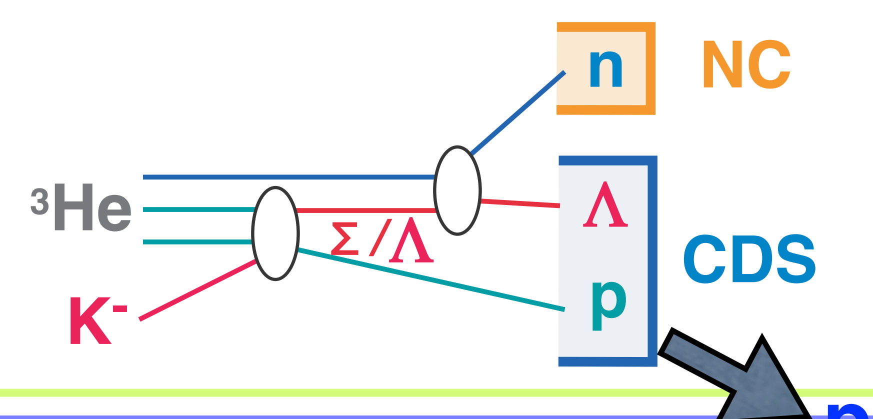
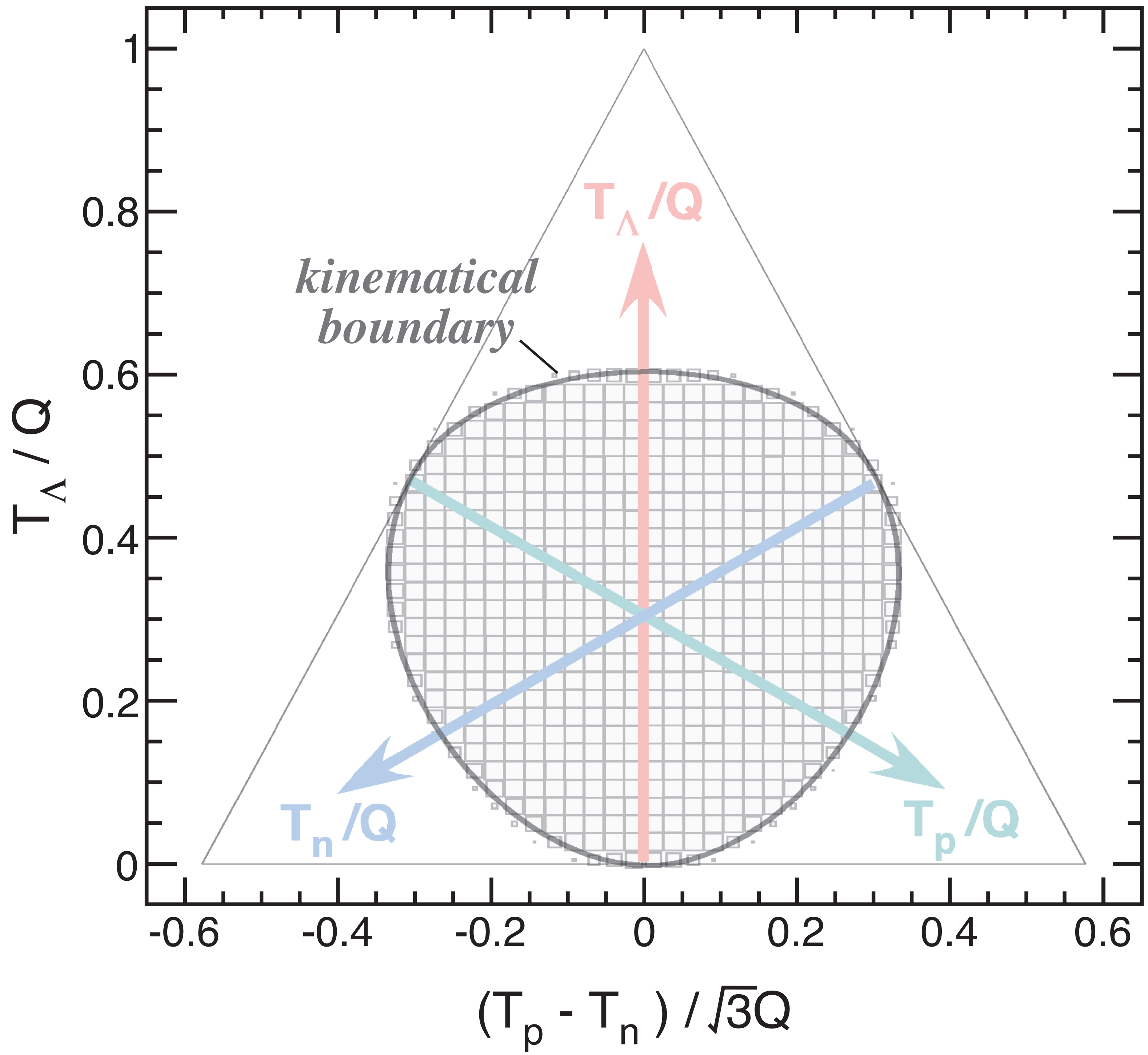


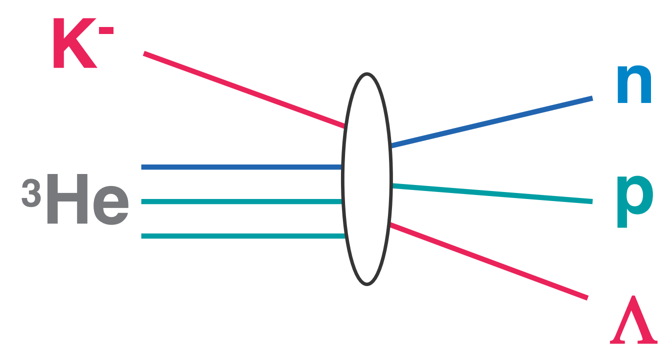
simulated by T. Hiraiwa

Λpn event distribution on Phase Space

In-flight Kinematics

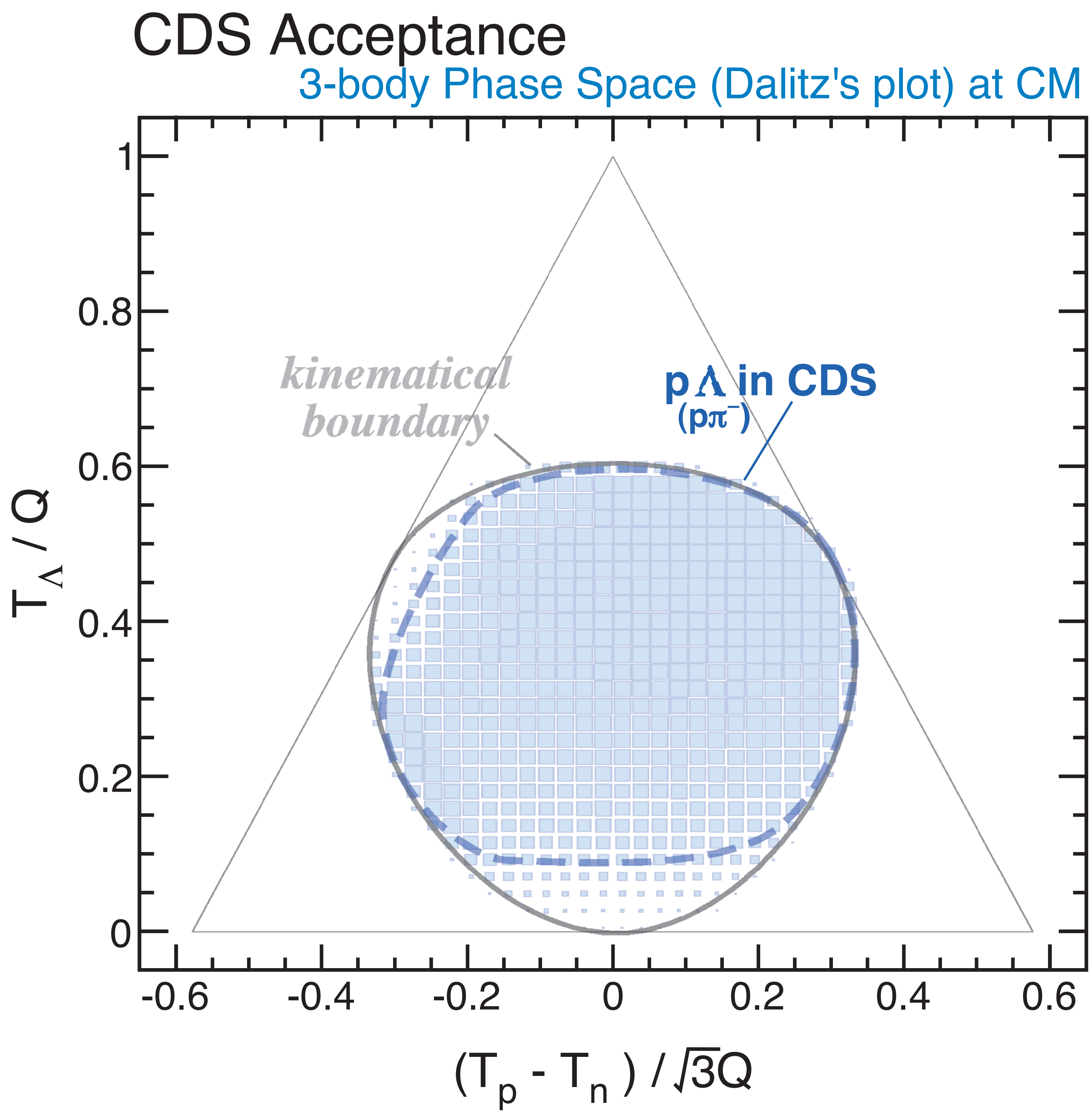
3-body Phase Space (Dalitz's plot) at CM

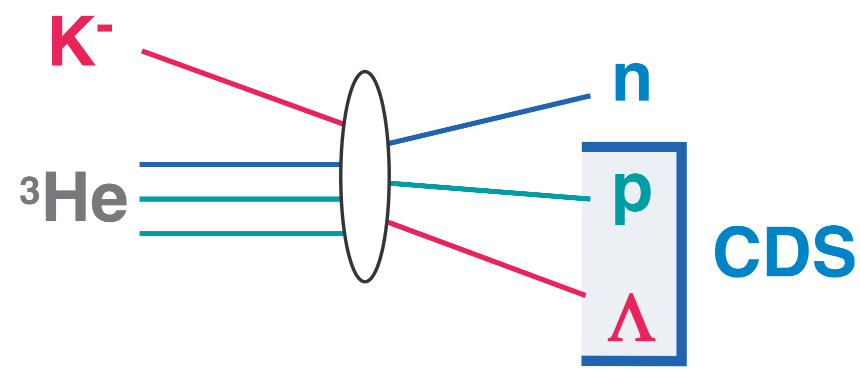




simulated by T. Hiraiwa

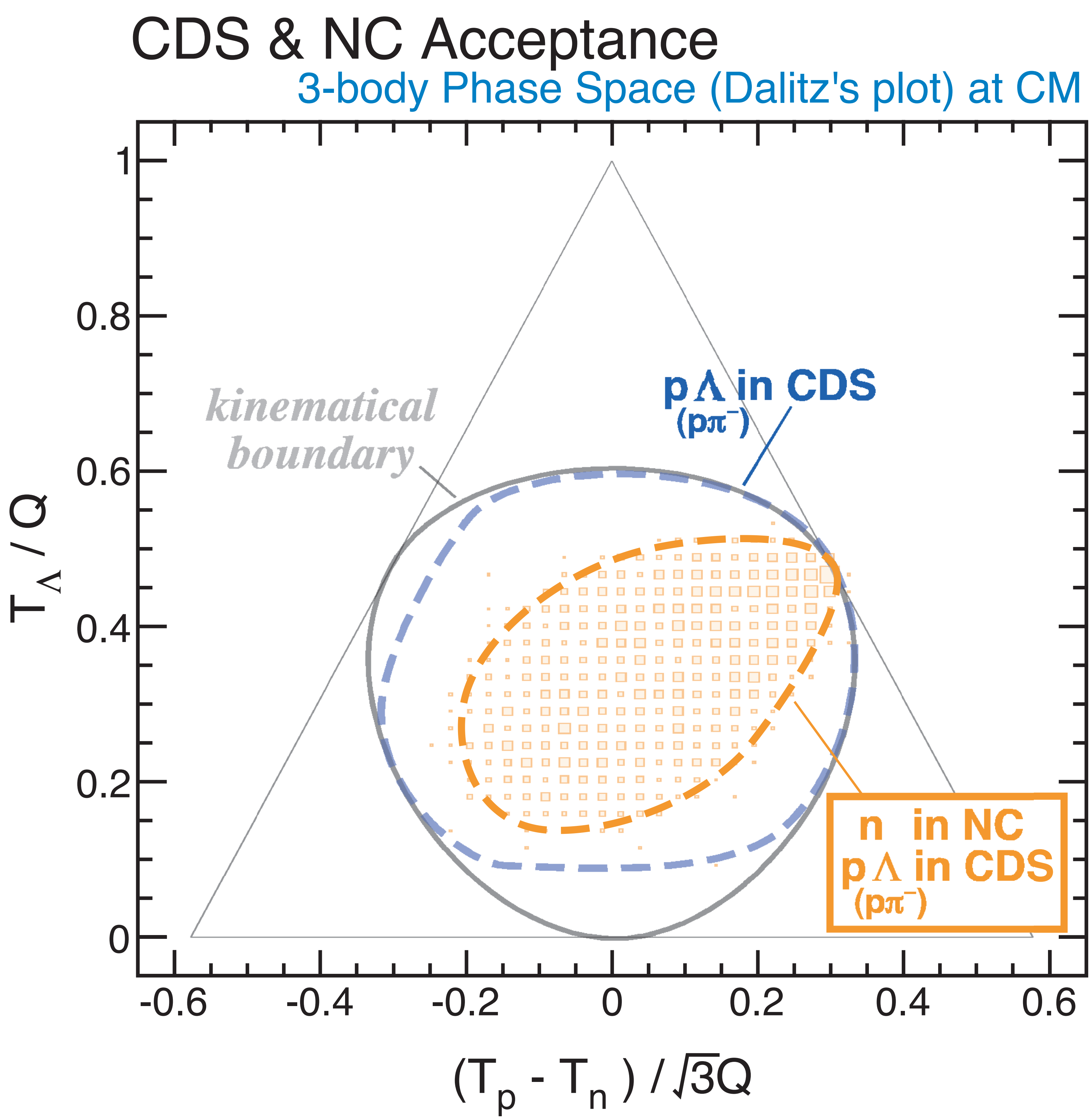
CDS Acceptance

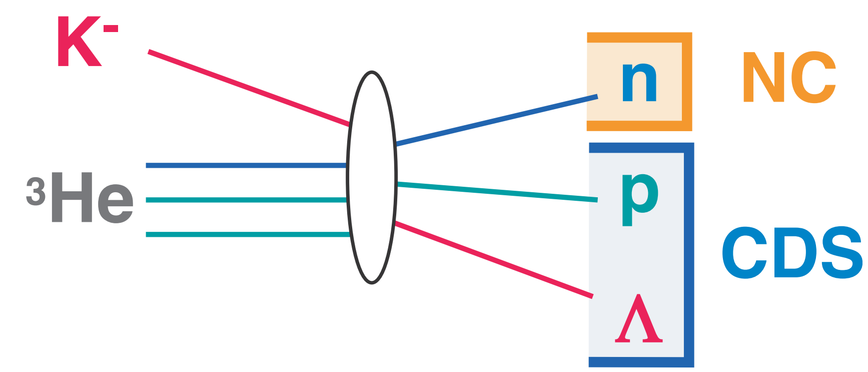




simulated by T. Hiraiwa

CDS & NC Acceptance

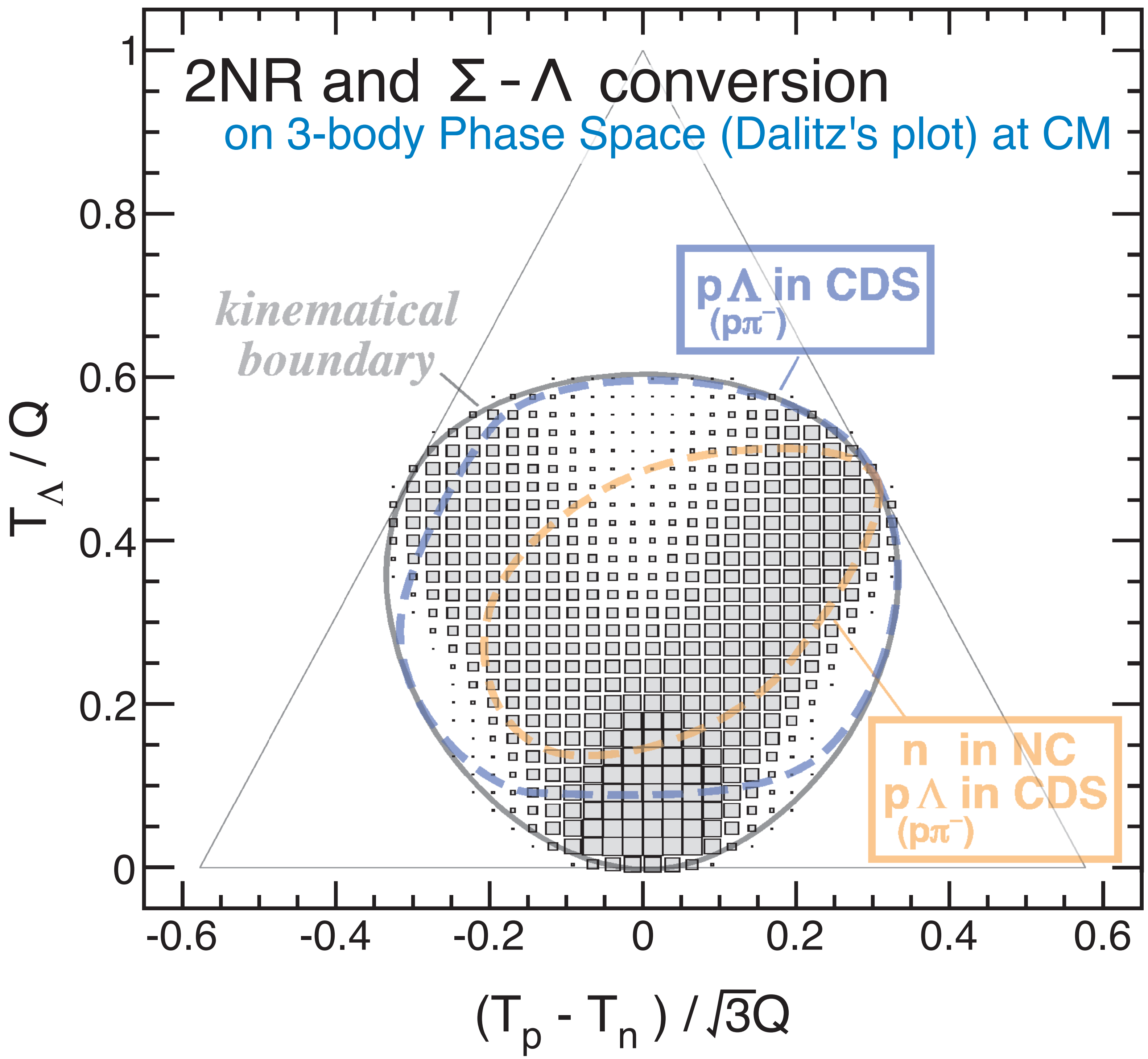


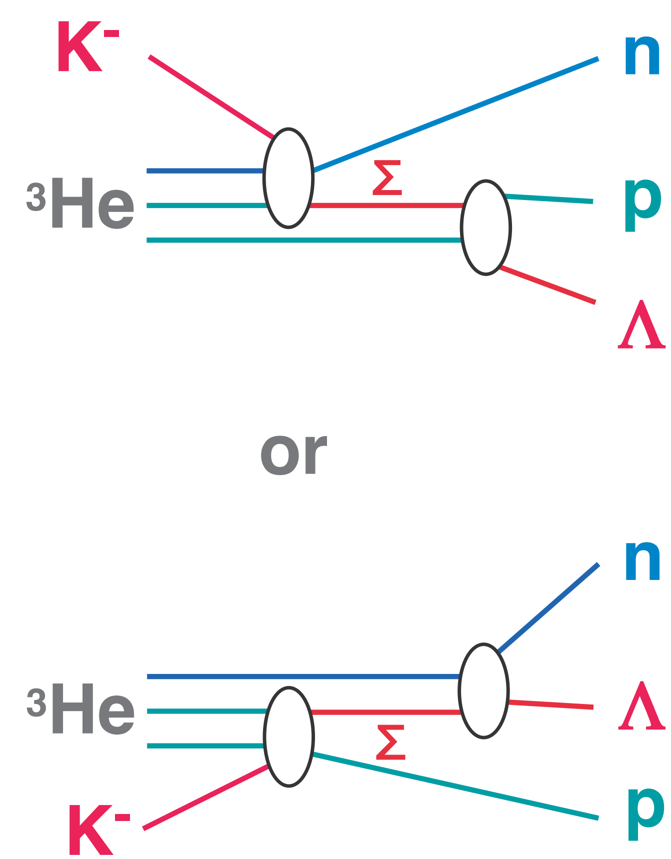


simulated by T. Hiraiwa

Background?

Two Nucleon Reaction and FSI (Σ-Λ conversion) ***multi-step PWIA***





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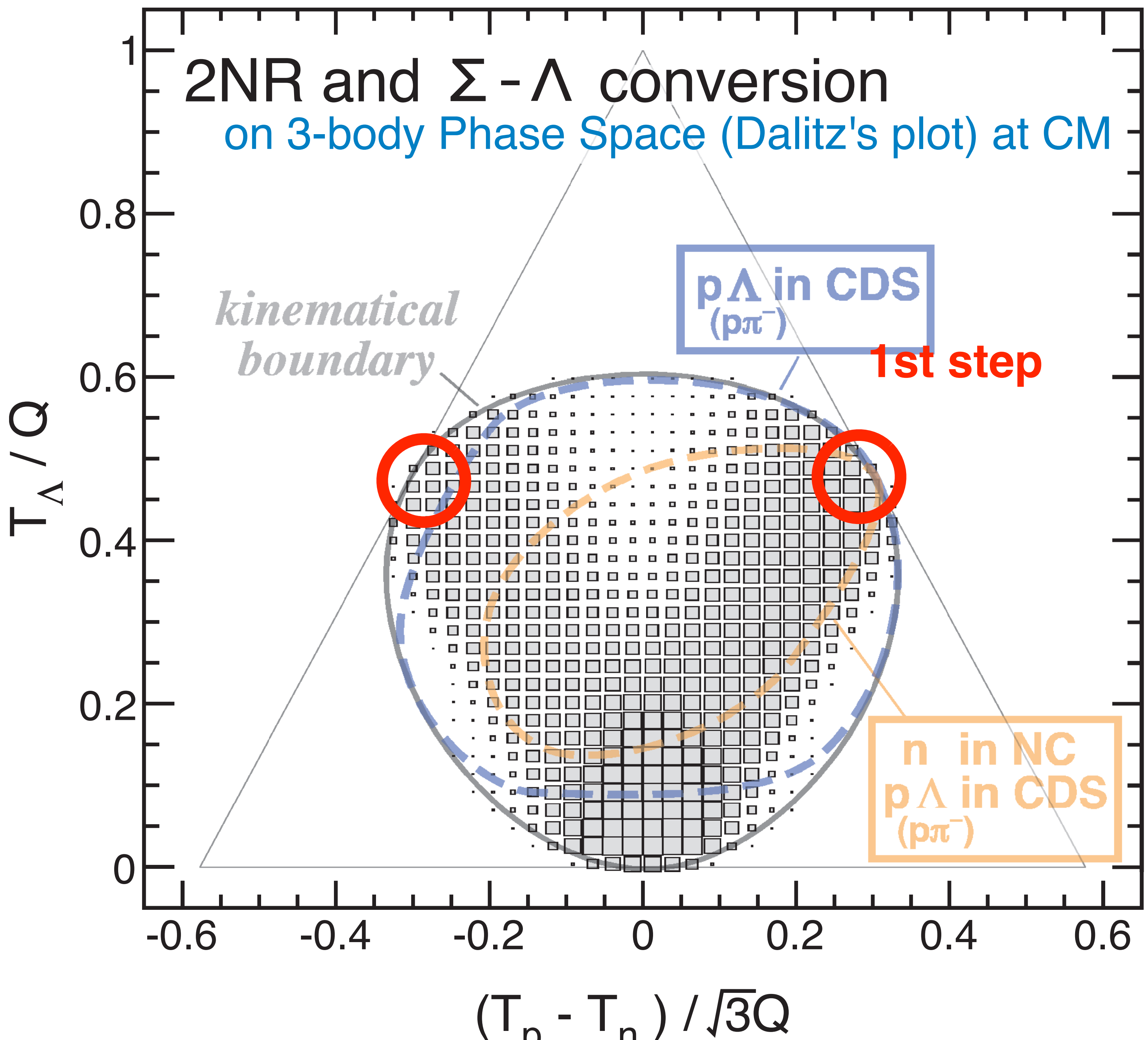

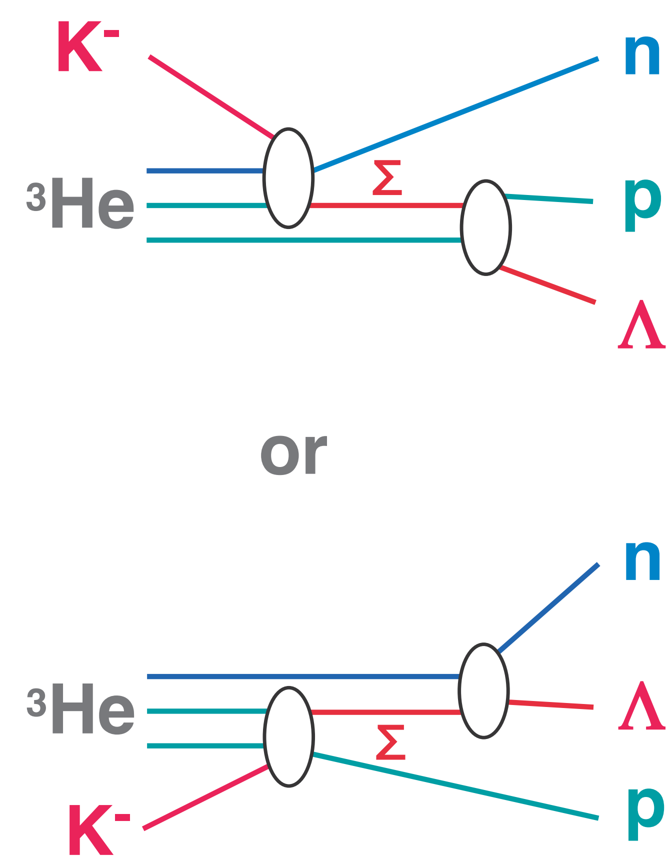

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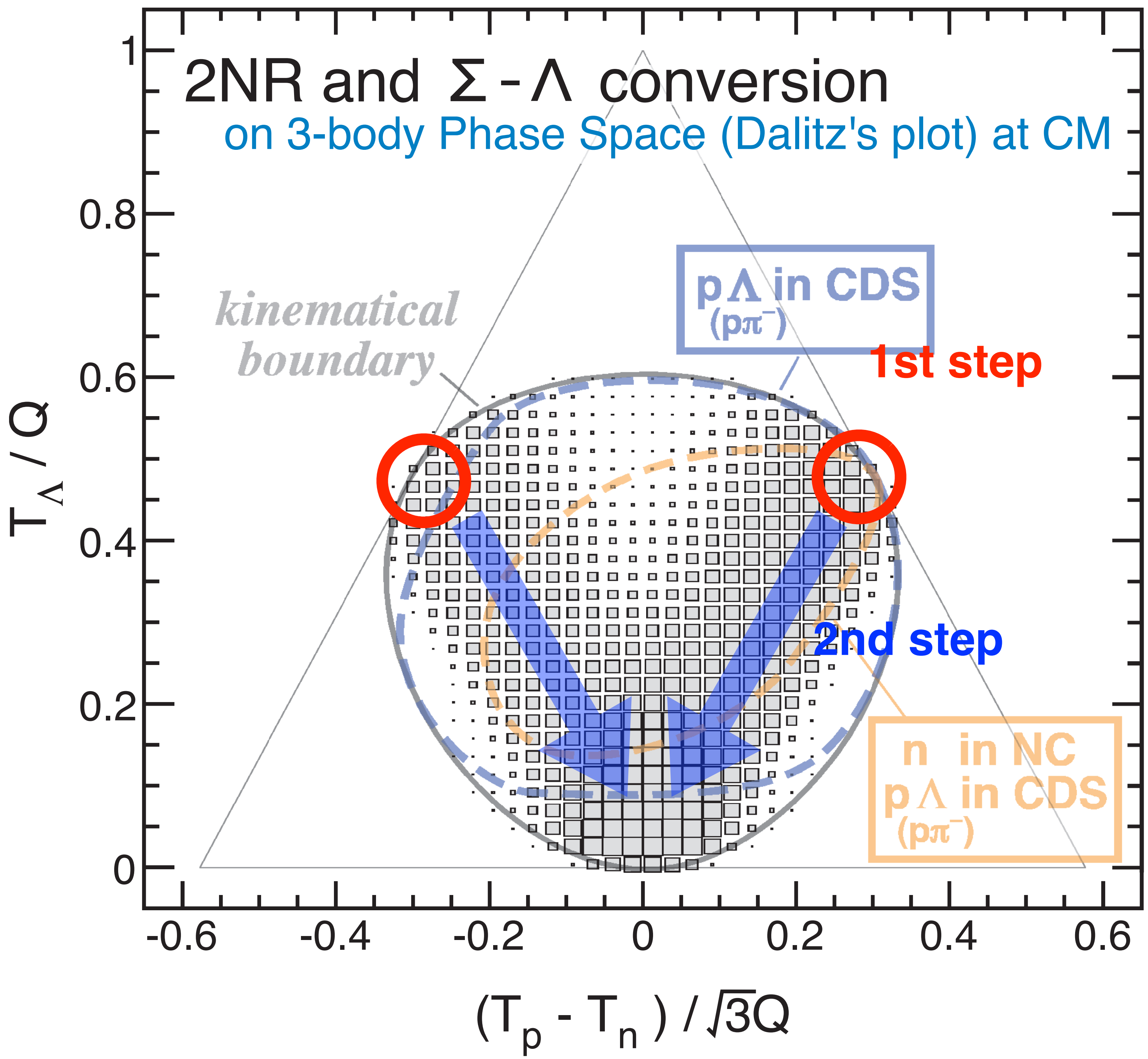

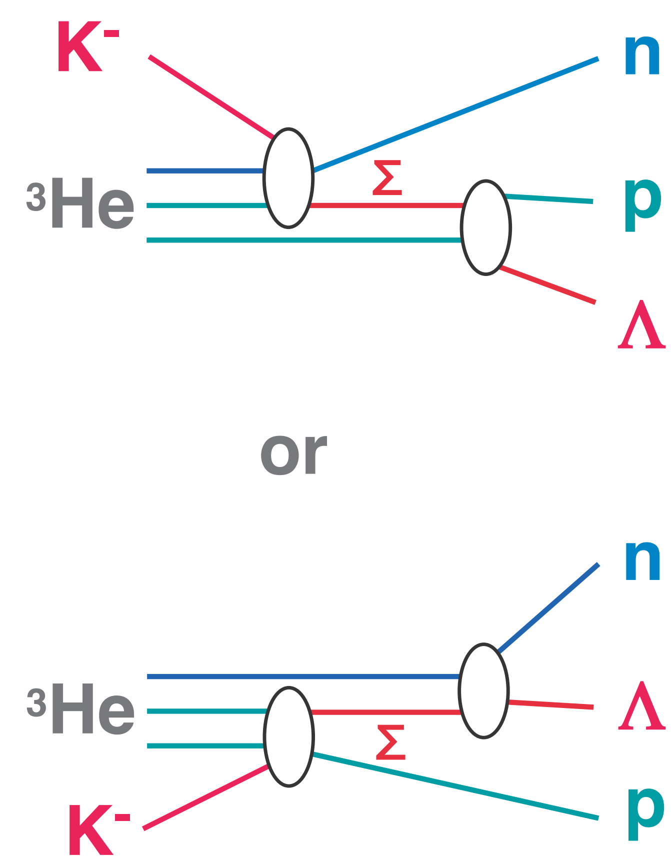

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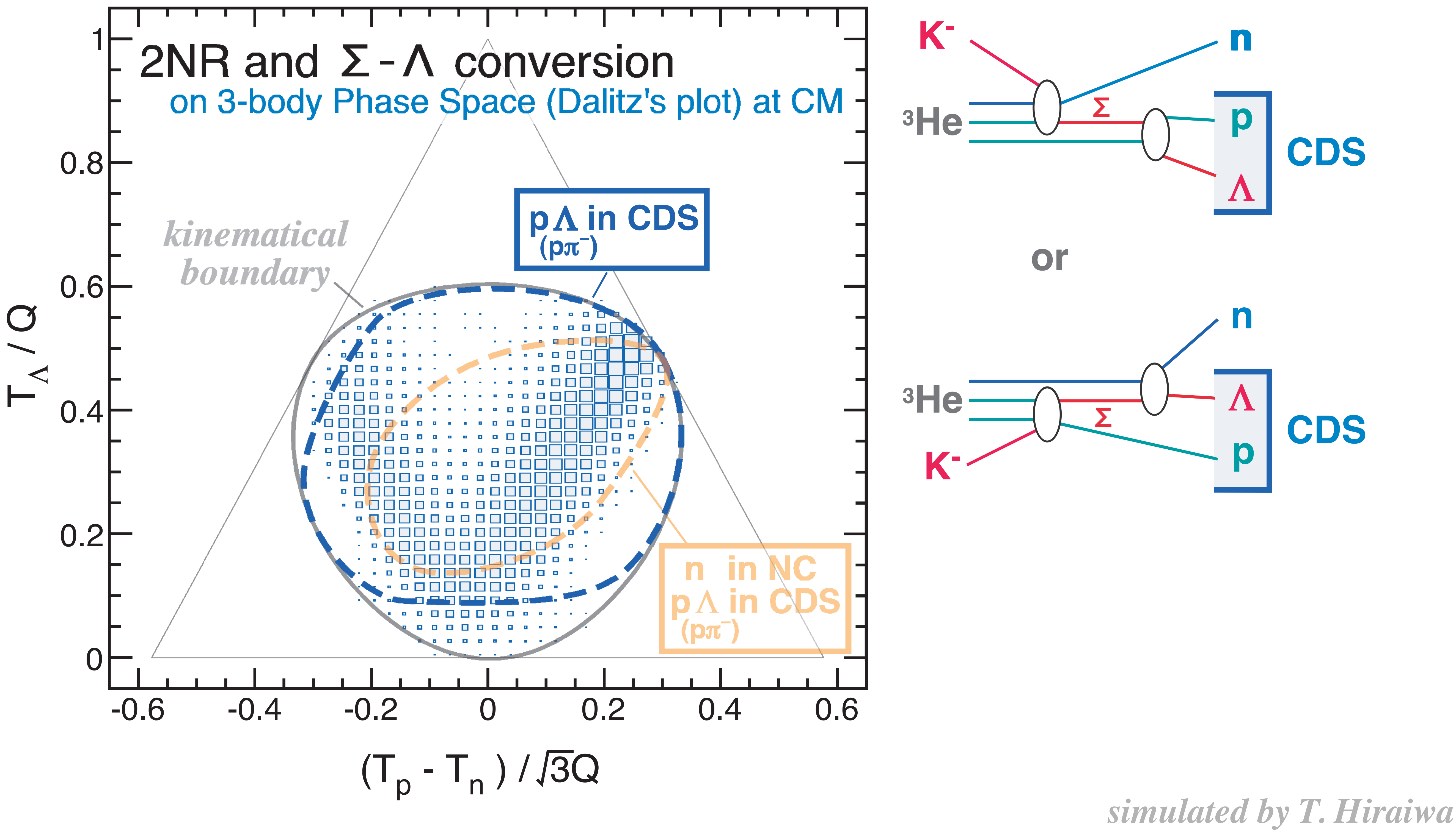

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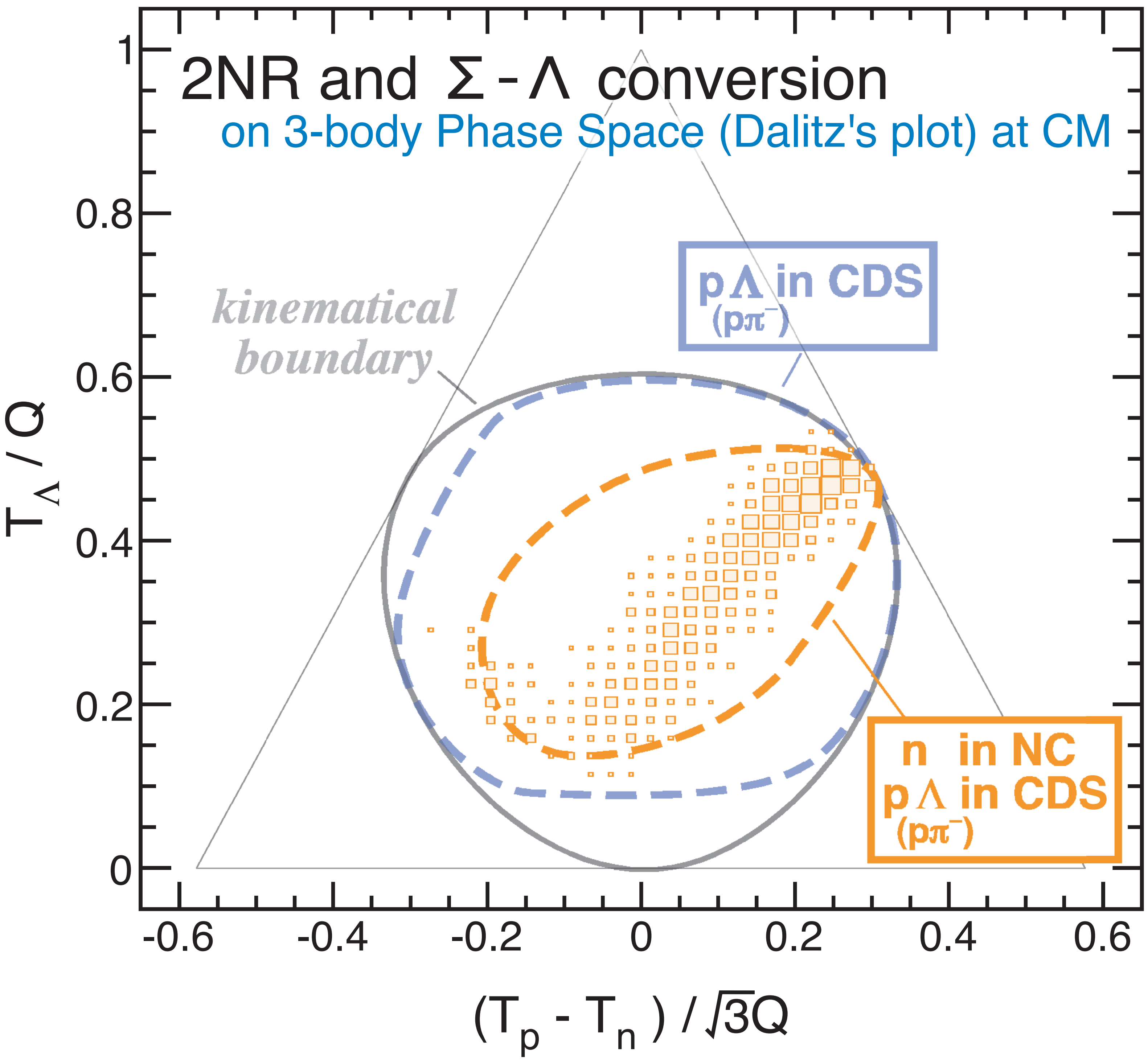
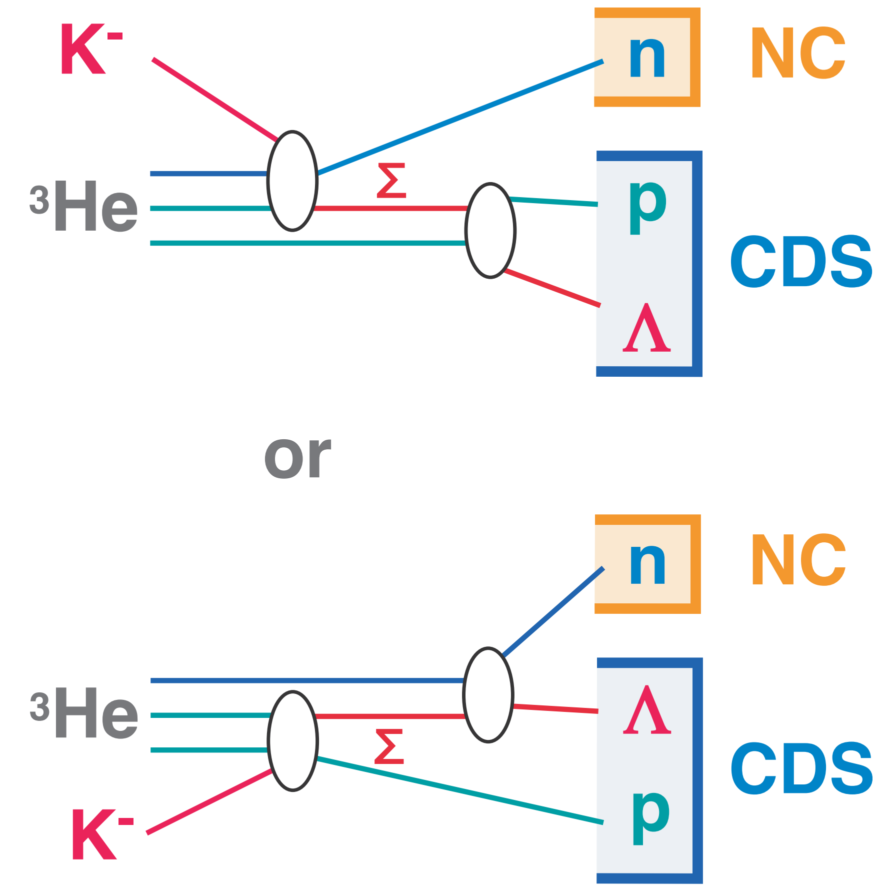
Two Nucleon Reaction and FSI (Σ-Λ conversion) ***multi-step PWIA***



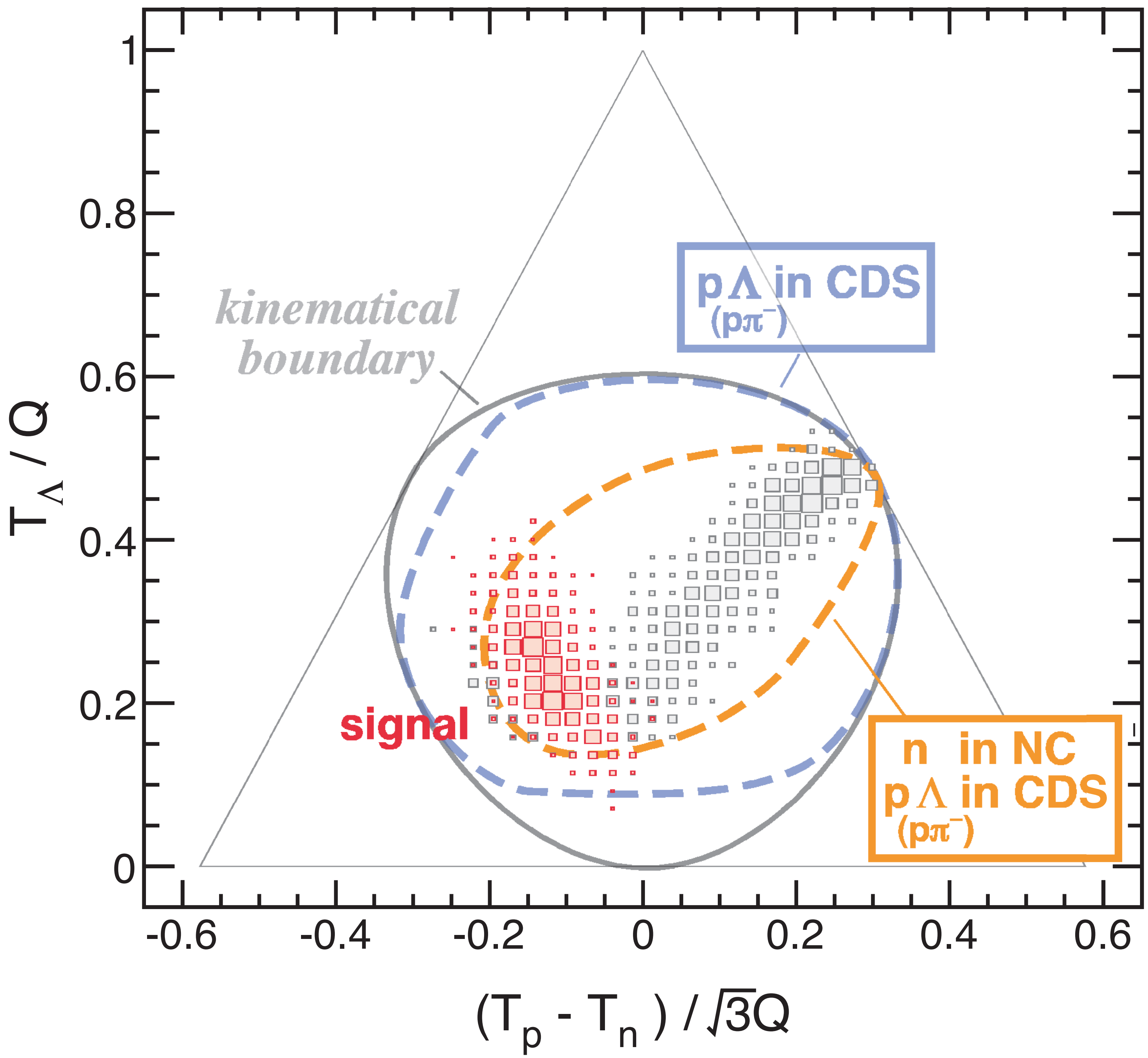


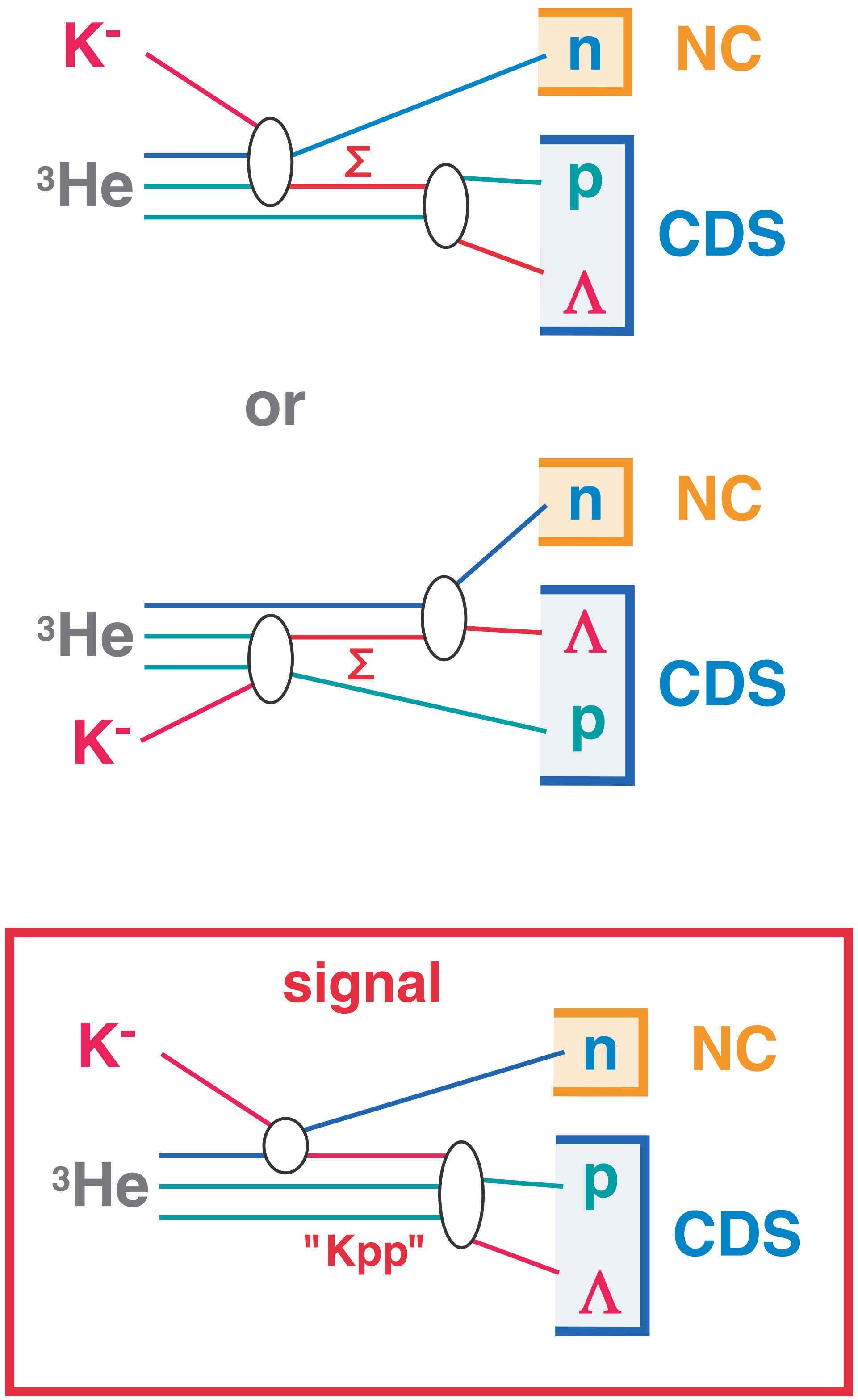
simulated by T. Hiraiwa

Background? *vs* signal *(ratio arbitrary)*

Two Nucleon Reaction and FSI (Σ-Λ conversion) ***multi-step PWIA***

2NR and Σ - Λ conversion
on 3-body Phase Space (Dalitz's plot) at CM





simulated by T. Hiraiwa

Is two nucleon reaction possible?

in in-flight kinematics @ 1GeV/c

Not very likely... *cf.*

De Broglie wave length @ 1 GeV/c ~ 1.2 fm

$\wedge$

Nucleon distance ~ 1.5 fm

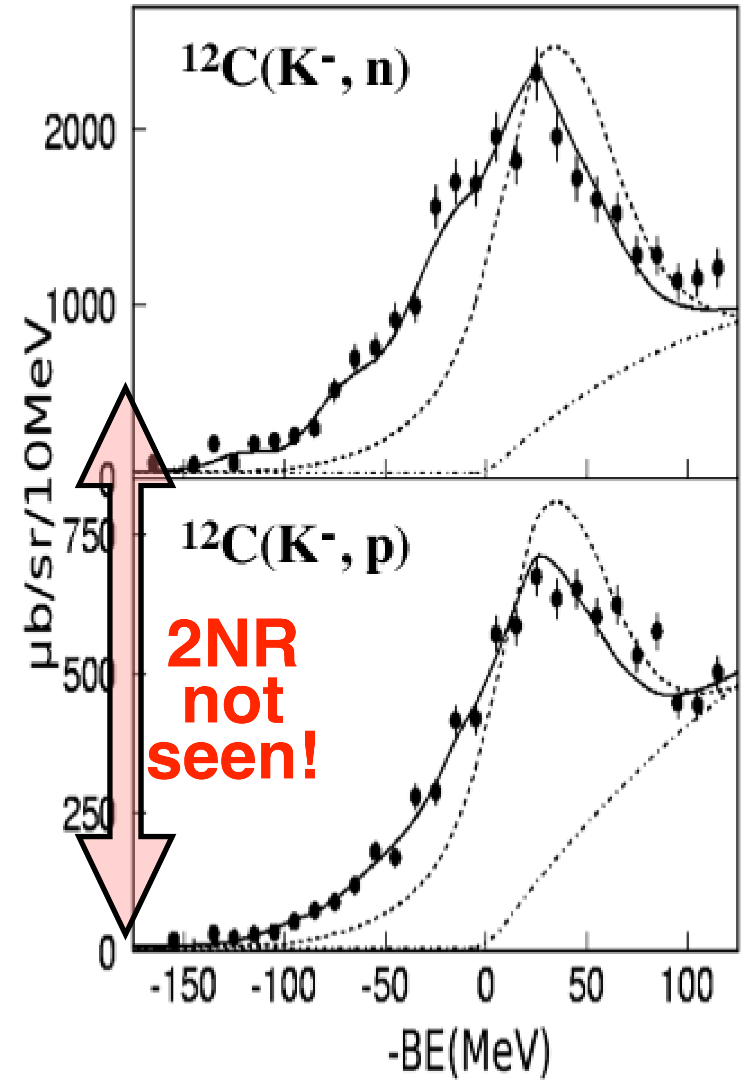
*although 2NR process **should be** examined on*

Two successive reaction after KNN

1) nucleon or hyperon scattering

2) Σ→Λ conversion

by reducing the trigger level.

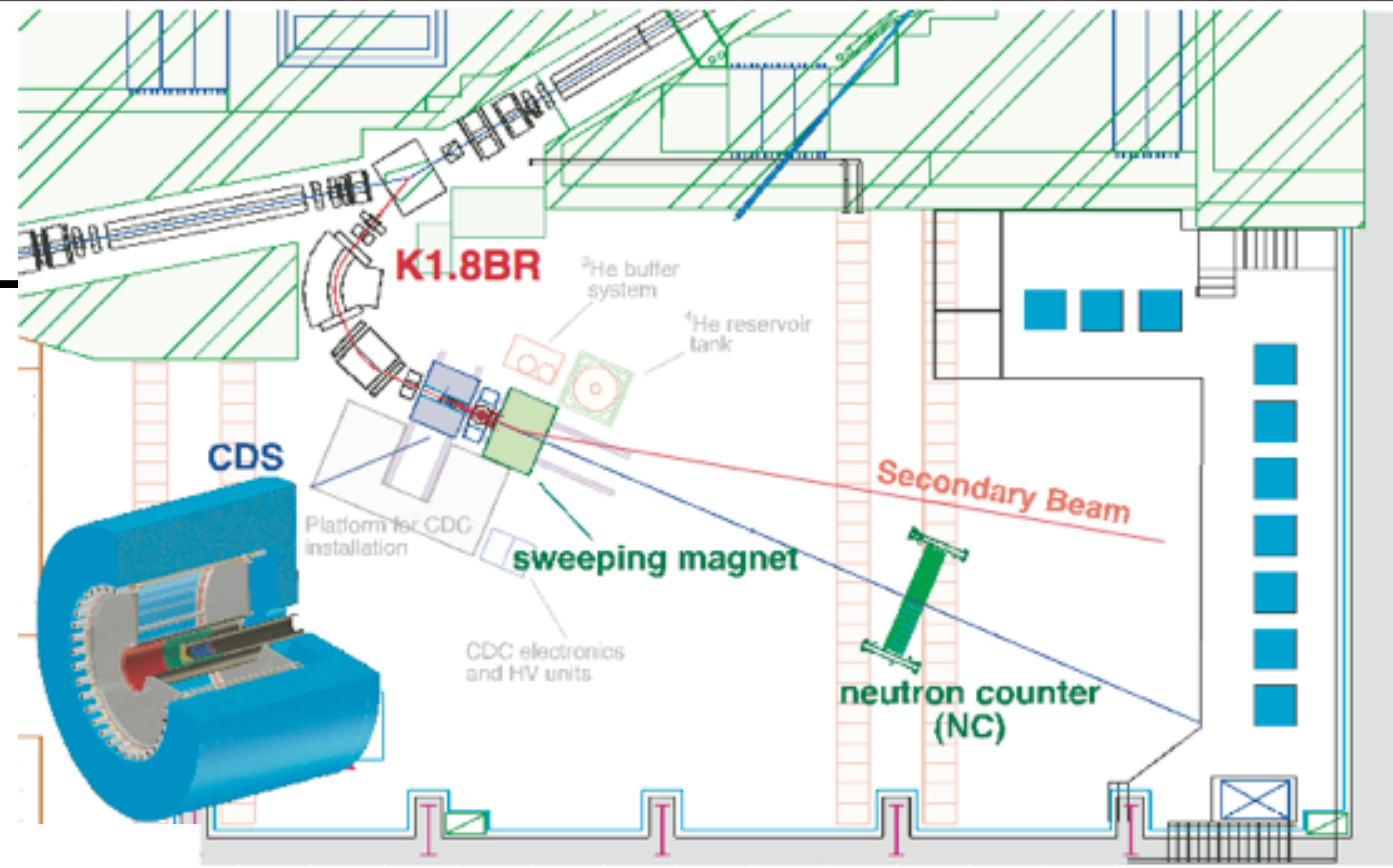


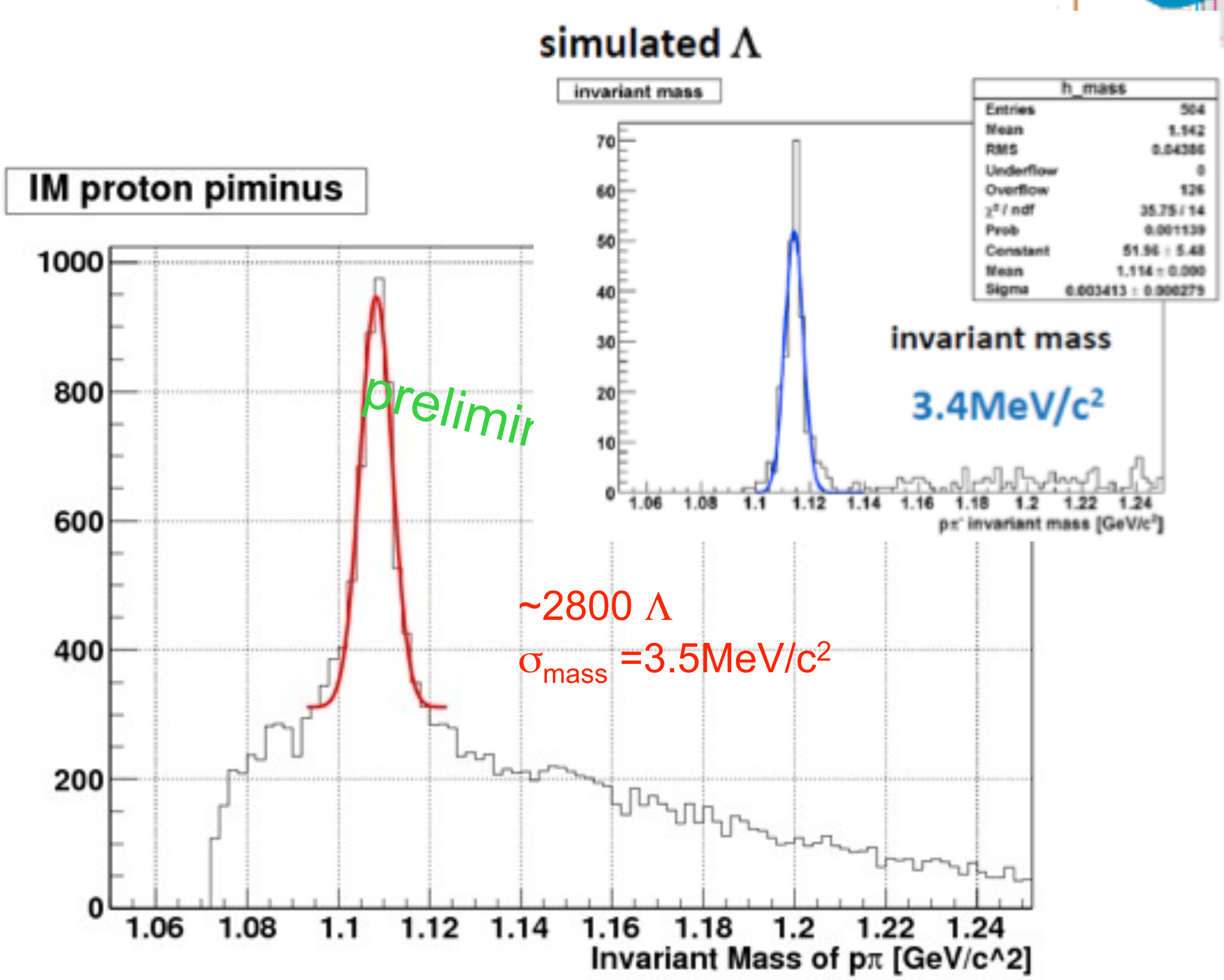
T. Kishimoto et al., Prog. Theor. Phys. 118 (2007) 181

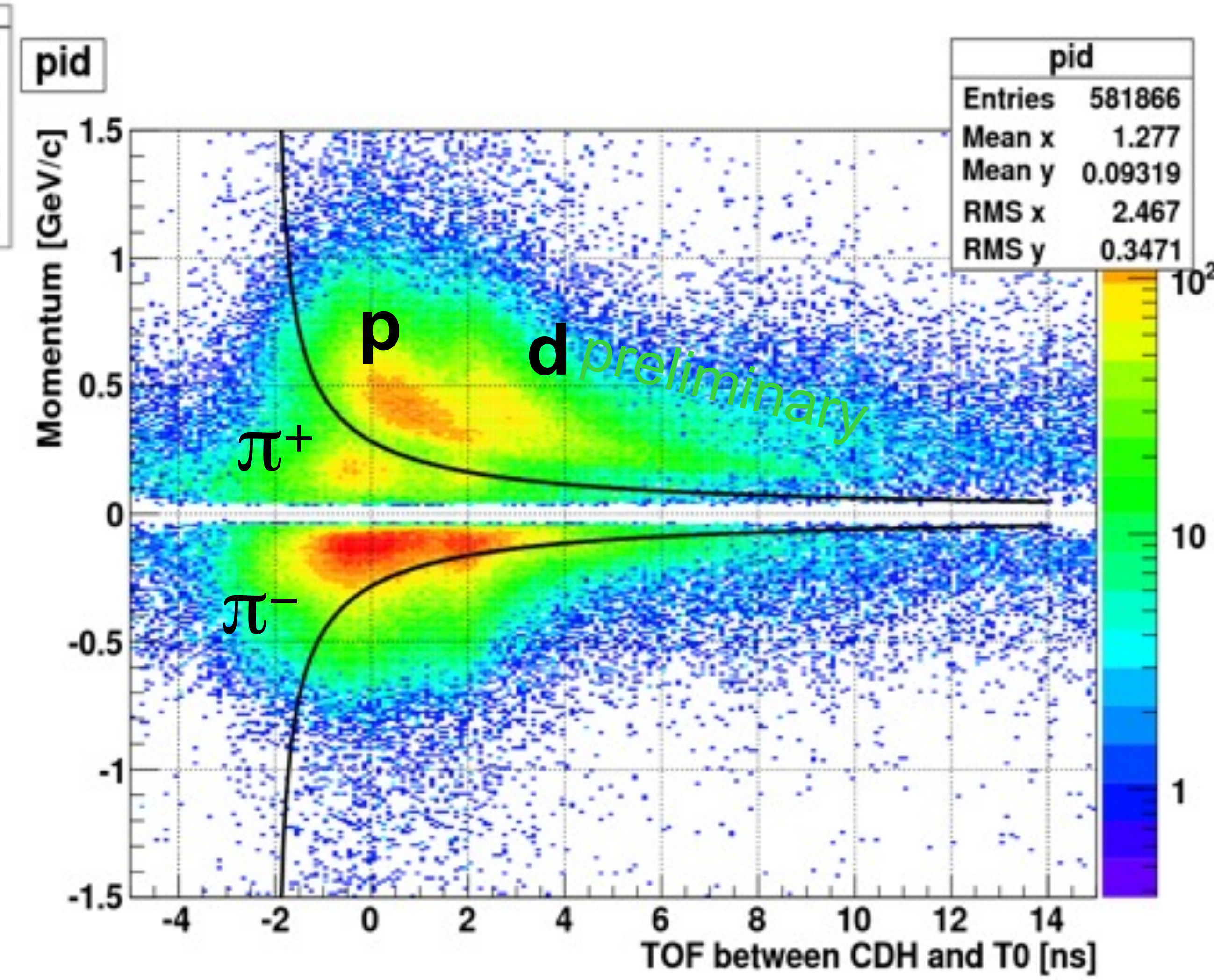
Note: Simple KNN channel excluded: Because it is easy to discriminate

Present?

missing:
transportation of
SW Magnet and NC







E15 staging strategy

apparatus preparation is ready

E15 approved = 1500kW*week (@ Pt equiv.)

not easy to realize

divide into 3 periods

E15^{1st} ~ 30kW*week (2% in terms of No. proton on target)

1) to know the background processes
2) to evaluate the realistic beam time for E15^{full}
3) present an information of the $\bar{K}N$ interaction
   ^{3}He(K$^-$, n) spectrum below $\bar{K}N$ threshold
4) a hint of signal in $\Lambda + p + n$ final states

E15^{1st} realize before long shutdown in 2012

J-PARC E15 Collaboration

http://ag.riken.jp/J-PARC/collaboration/

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(*) Spokesperson

Thank you
for attention!

spare

K1.8BR with Pt (@50% loss)

All K incident experiments:
Present Duty Factor will be OK up to few 10th of kW

required power

E17 ~ 10kW*week > 2kW?

KN by x-ray via K^{-} ^{3}He

E15 1st ~ 30kW*week (first stage) > 10kW?

cf. 1500kW*week (E15 full @ Pt equiv.) > 100kW?

KN by bound state via K^{-} ^{3}He

E31 ~ 180kW*week > 20~40kW?

$\Lambda(1405)$ via K^{-} d

Signal can be easily discriminated from signal in both FSI cases !

Two successive reaction after KNN

1) nucleon or hyperon scattering

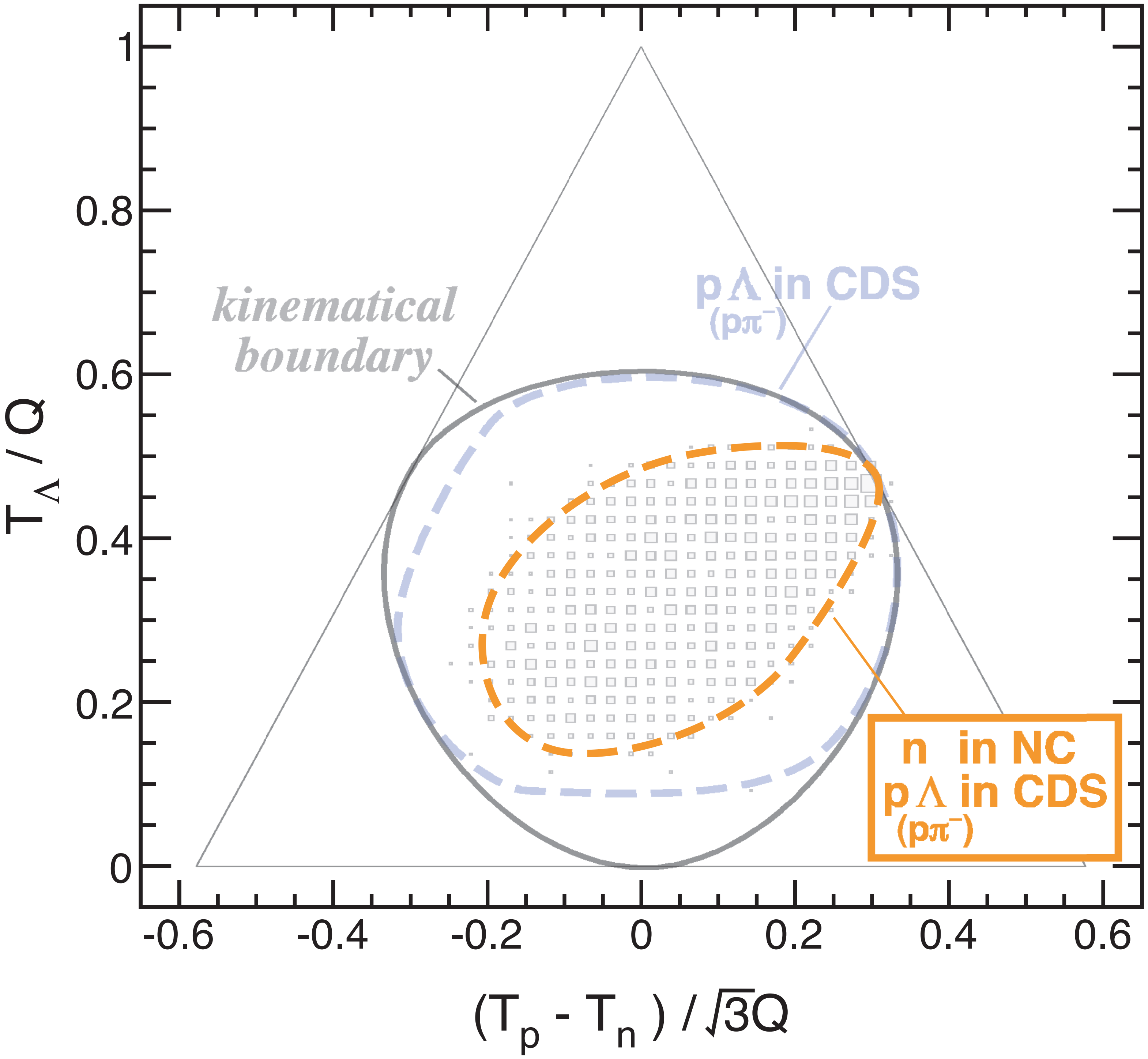
2) $\Sigma \rightarrow \Lambda$ conversion

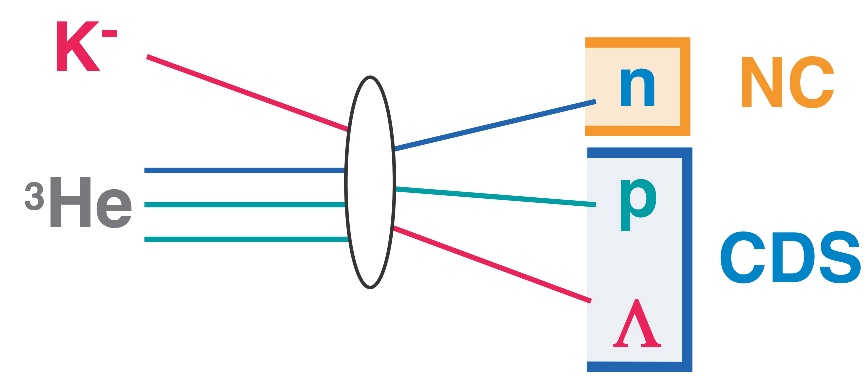
Note: Simple KNN channel excluded: Because it is easy to discriminate

Can we extend the detection capability?

CDS & NC Acceptance

3-body Phase Space (Dalitz's plot) at CM



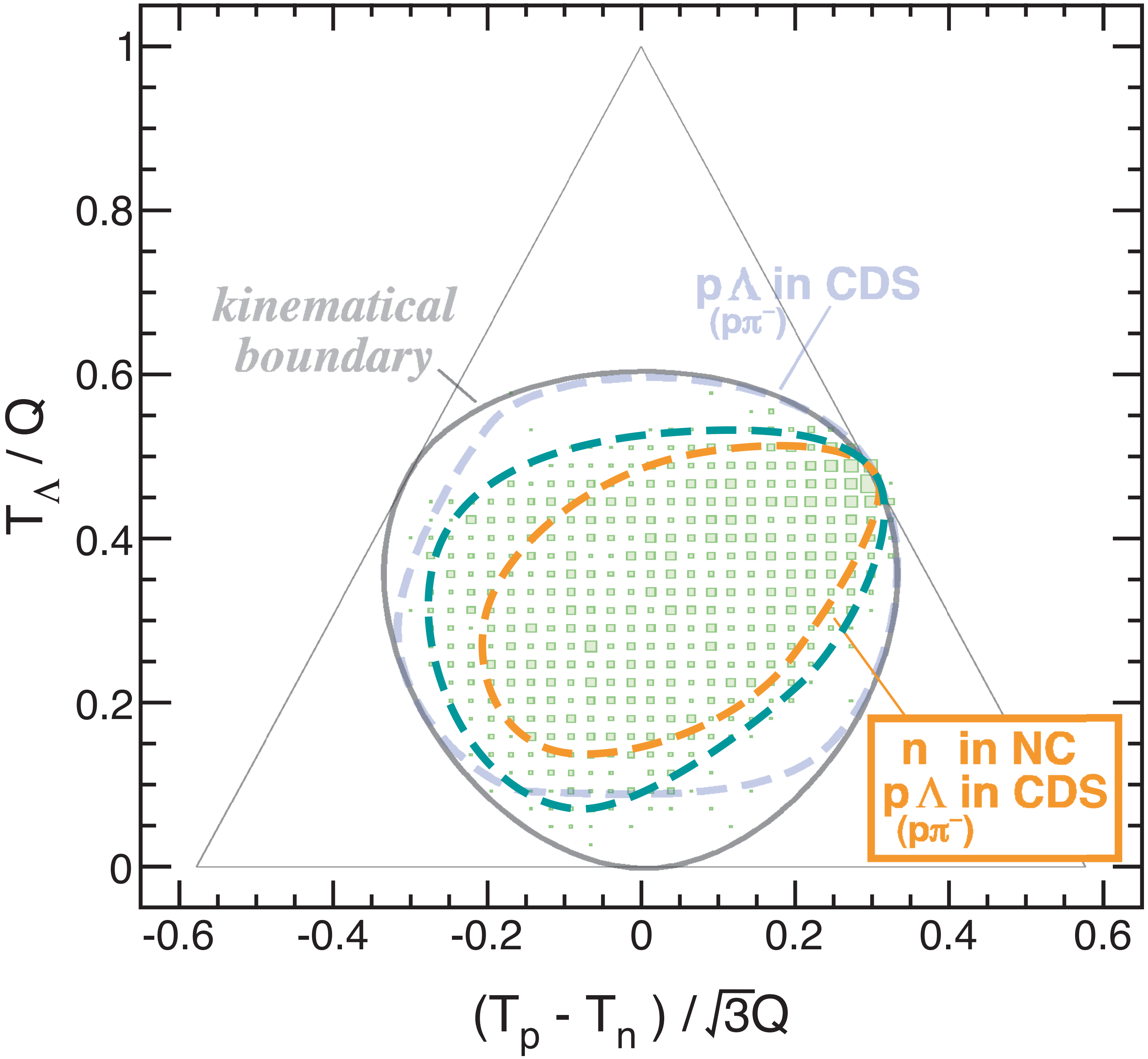


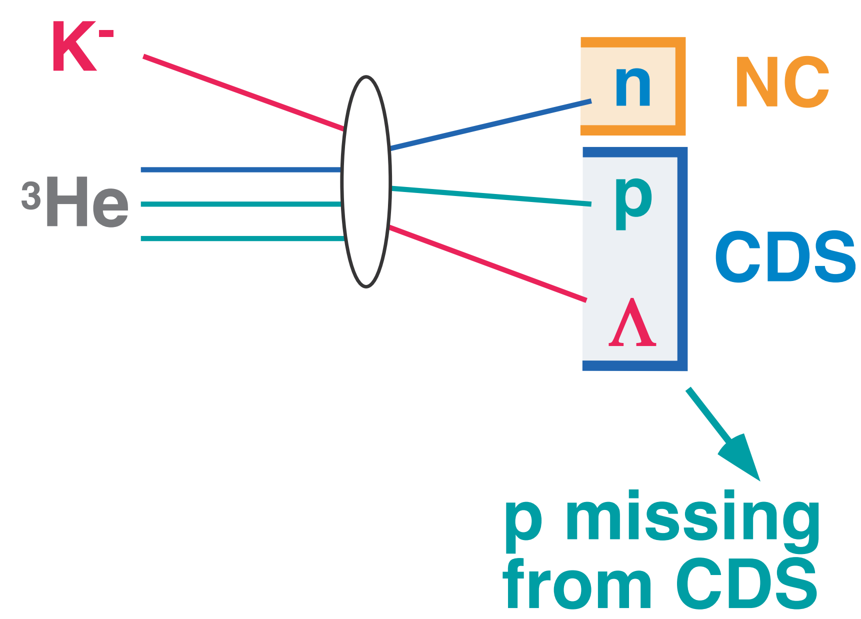
simulated by T. Hiraiwa

Can we extend the detection capability?

CDS & NC Acceptance **with one proton missing**

3-body Phase Space (Dalitz's plot) at CM





simulated by T. Hiraiwa

Can we extend the detection capability?

"Kpp"

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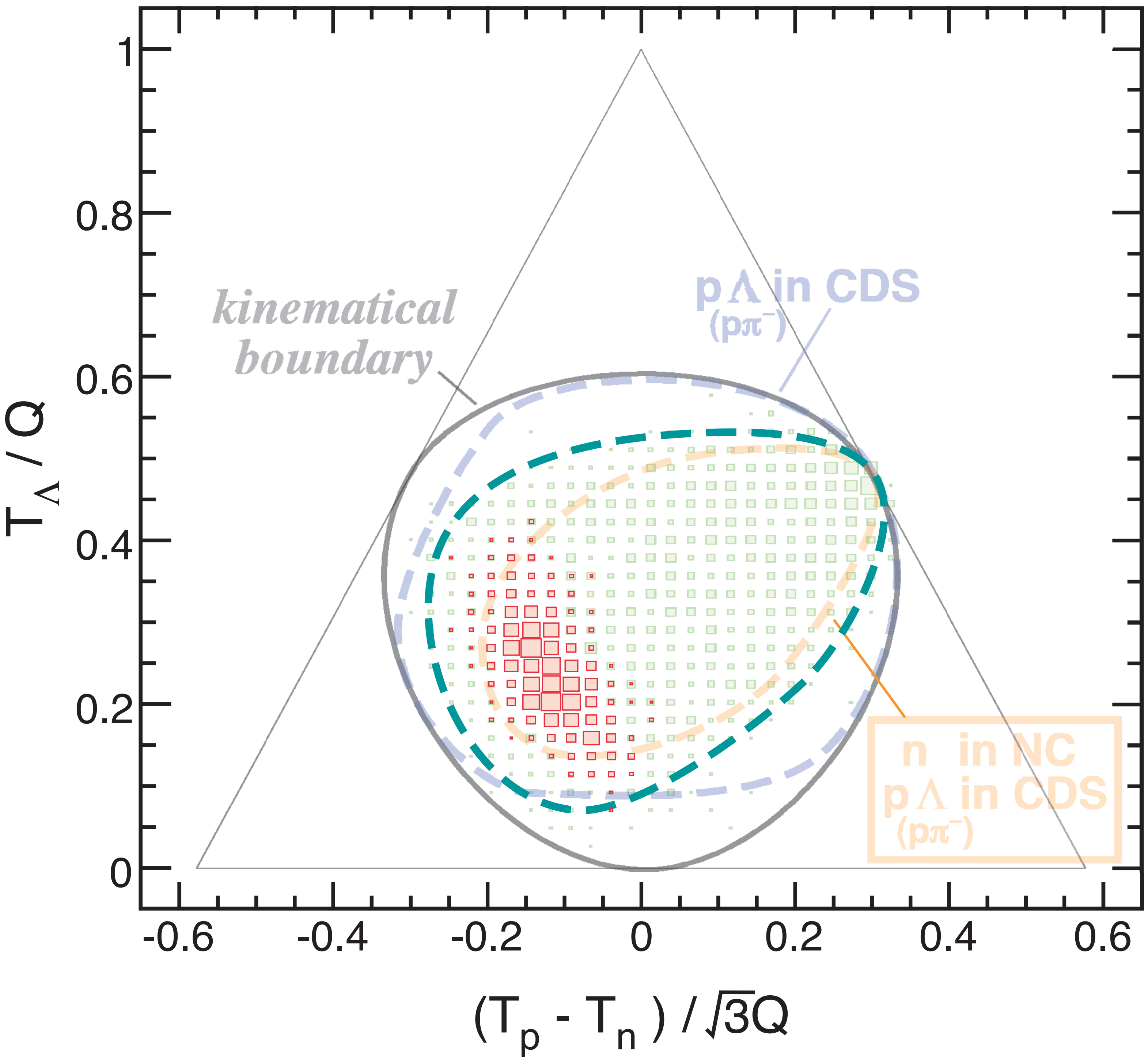
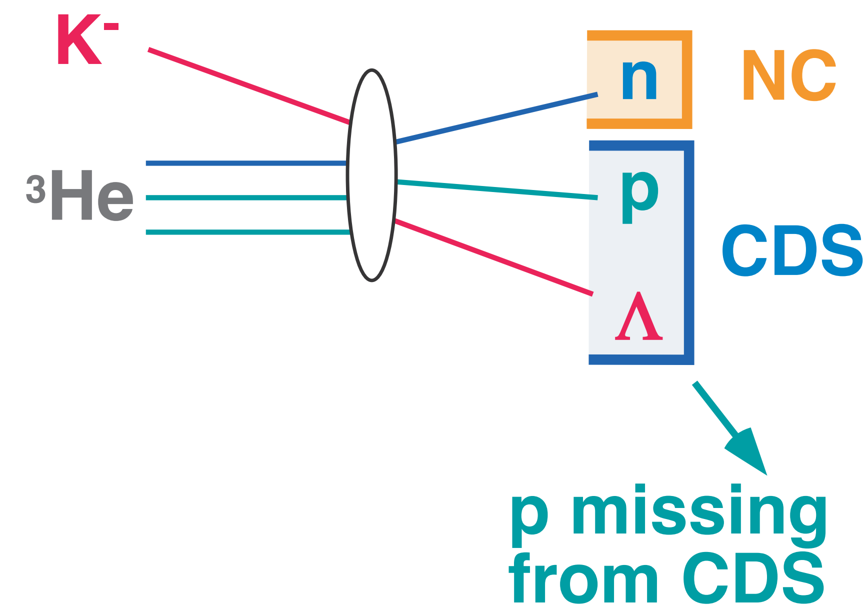
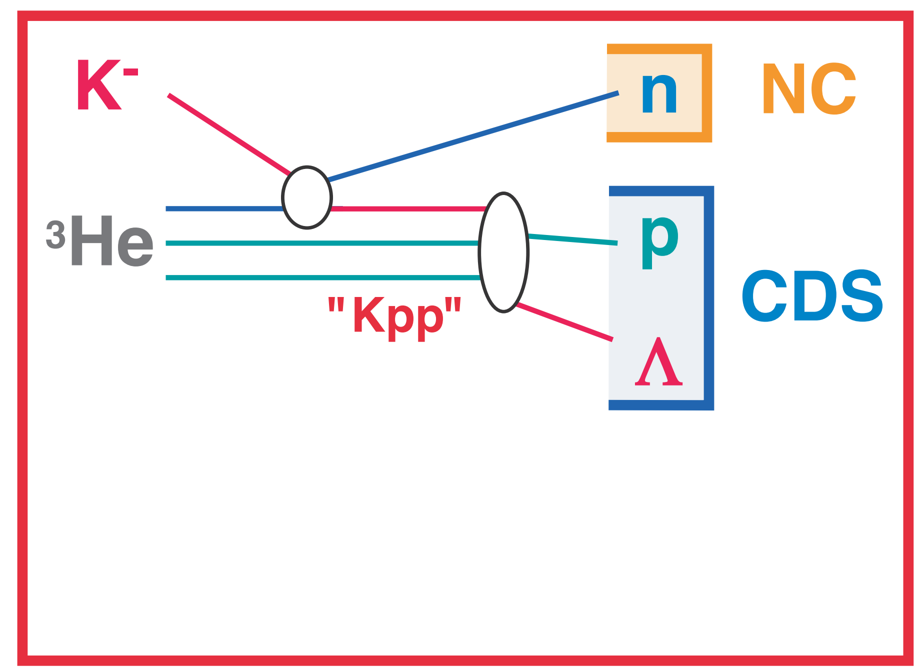






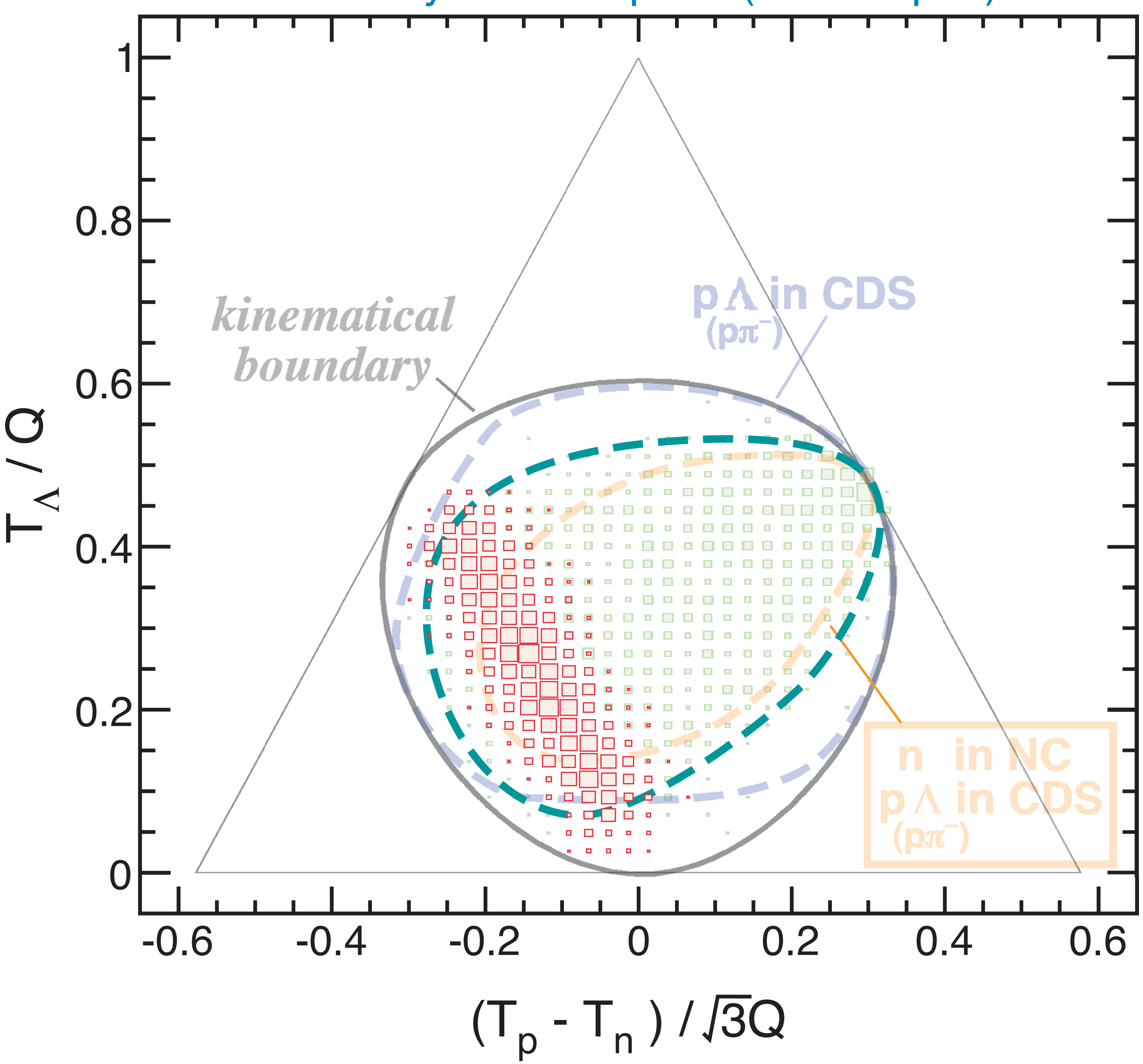
B_K~100MeV, Γ_K~100MeV
(like DISTO data)

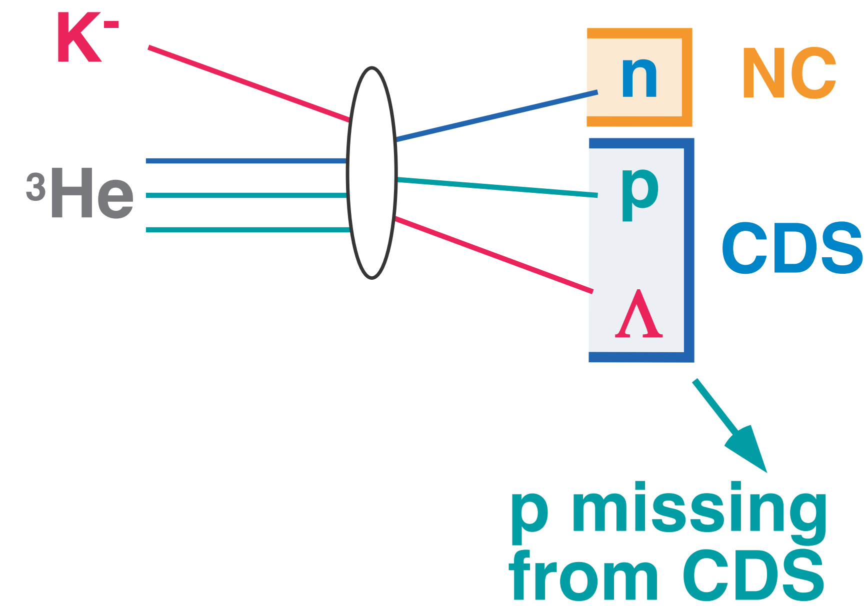
simulated by T. Hiraiwa

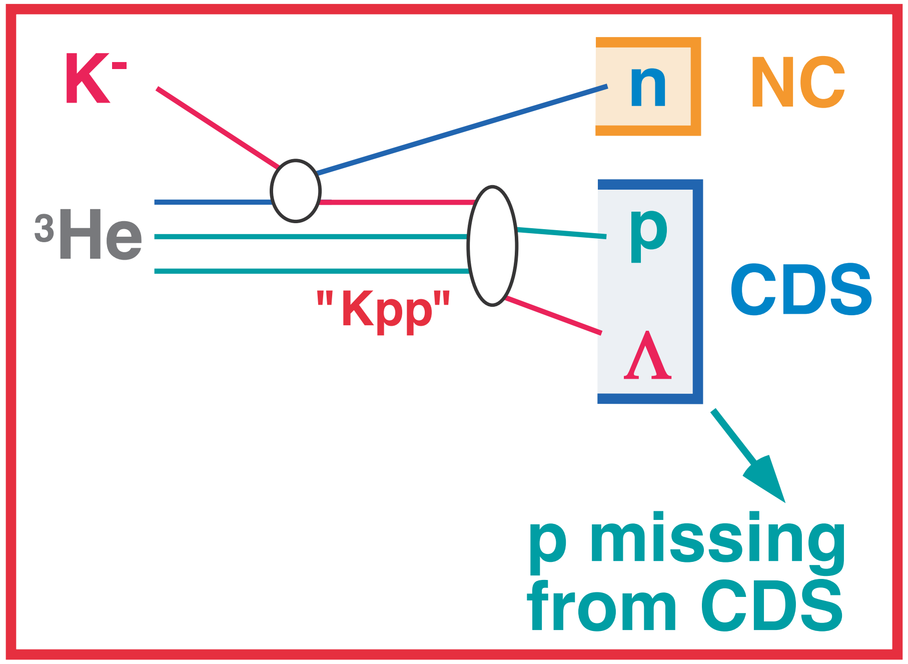
Can we extend the detection capability?

"Kpp" **with one proton missing**

3-body Phase Space (Dalitz's plot) at CM







B_K~100MeV, Γ_K~100MeV
(like DISTO data)

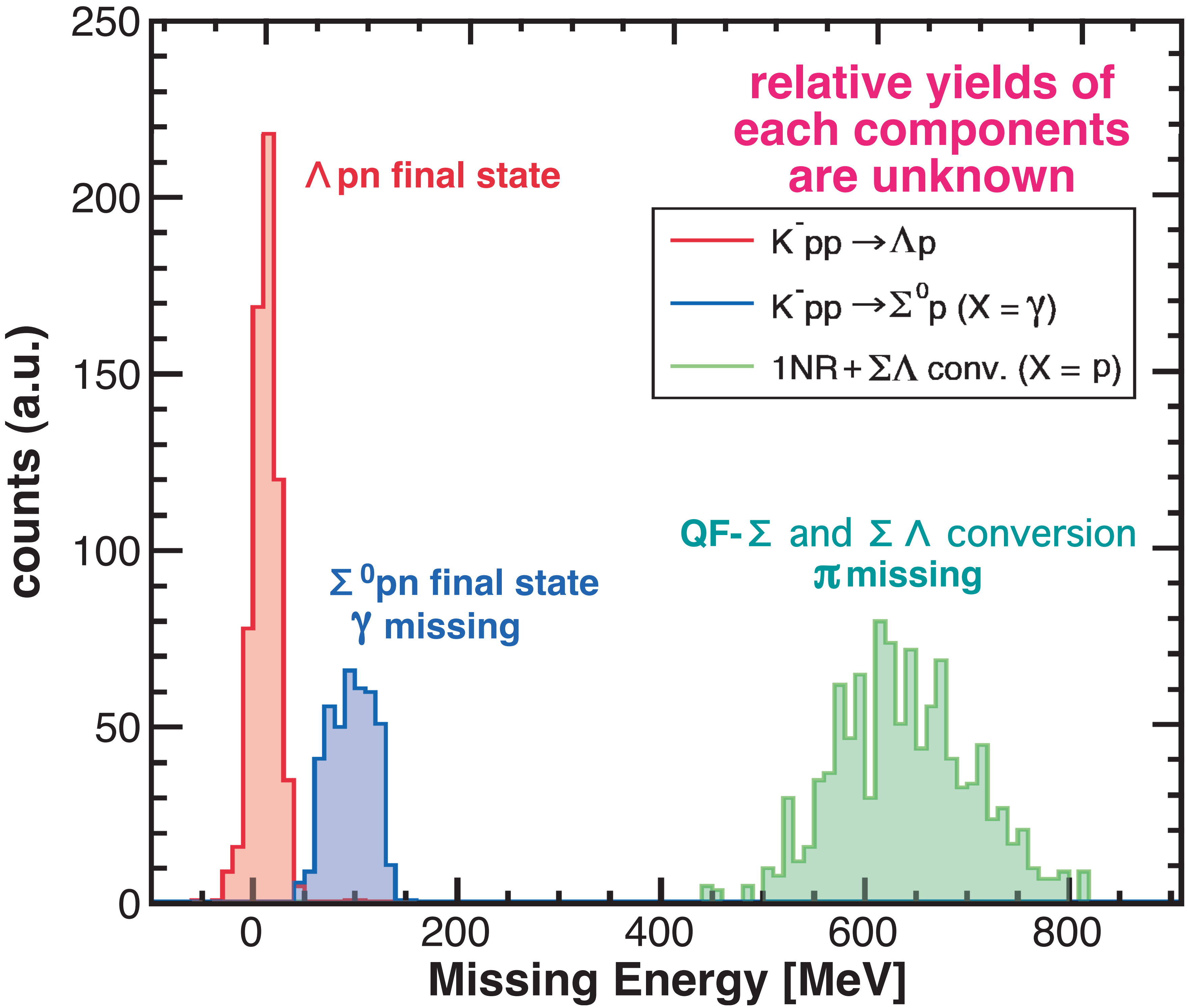
simulated by T. Hiraiwa

2011年1月17日月曜日

Λpn final state selection by CDS & NC

What happens if we miss other particles?

other than Λpn



Other processes can be clearly separated!

simulated by T. Hiraiwa

Improvement by one proton missing

- Missing proton resolution: 28.4 ±0.3 MeV/c^2
- Efficiency (NC eff. Is not included.)-

3body phase space →0.079 % (all detected)

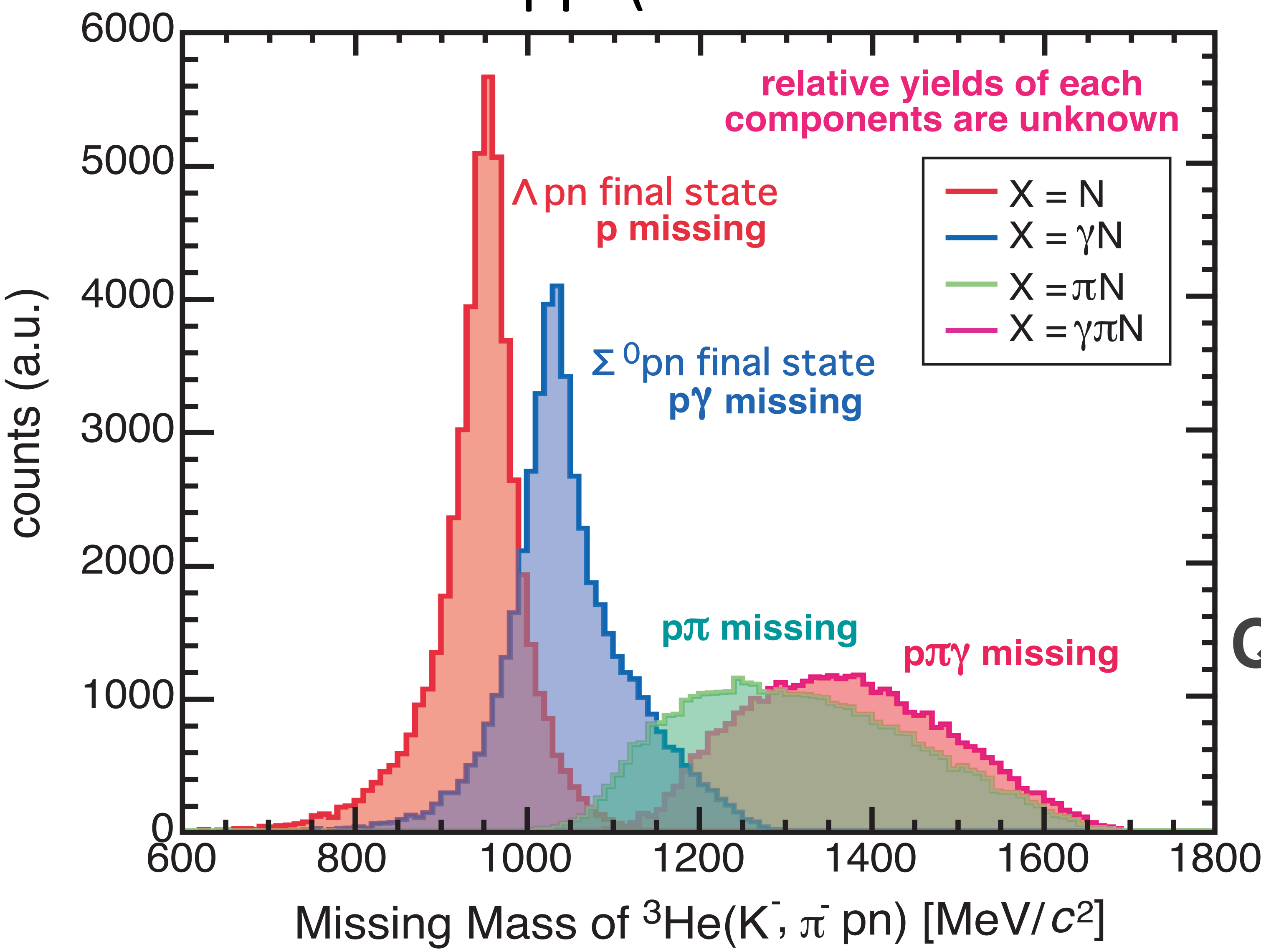
→0.12% (one proton missing)

"Kpp"(B=100MeV Γ=100MeV) →0.042 % (all detected)

→0.098 % (one proton missing)

||

x 2 improvement



Are they perfect?

Λpn / Σ^0pn still be separated

QF-Y production also separated

but partial overlap with pπ missing

simulated by T. Hiraiwa

Summary of the beam time requirement of the E15 first-stage run

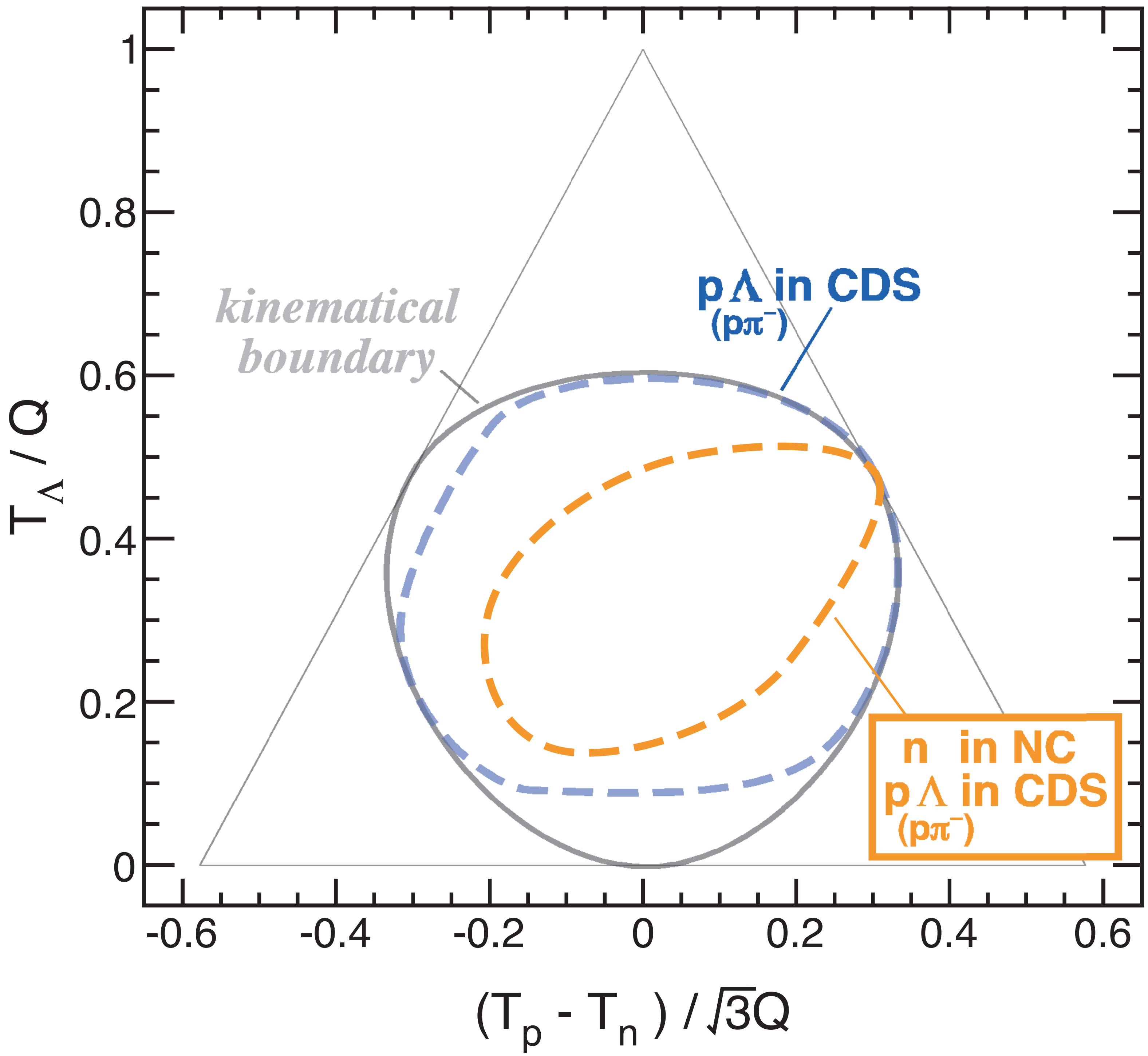
Beamline: K1.8BR
Primary beam: ~ 10 kW proton
Secondary beam : 1.0 GeV/c K^-
Reaction : In-flight (K^-, n)
Target : Liquid ^{3}He
Primary beam : integrated proton of 30 kW·week
Duration : more than three weeks including beam tuning for 1 GeV/c kaon

Background?

Two Nucleon Reaction and FSI (Σ-Λ conversion)

CDS & NC Acceptance

on 3-body Phase Space (Dalitz's plot) at CM



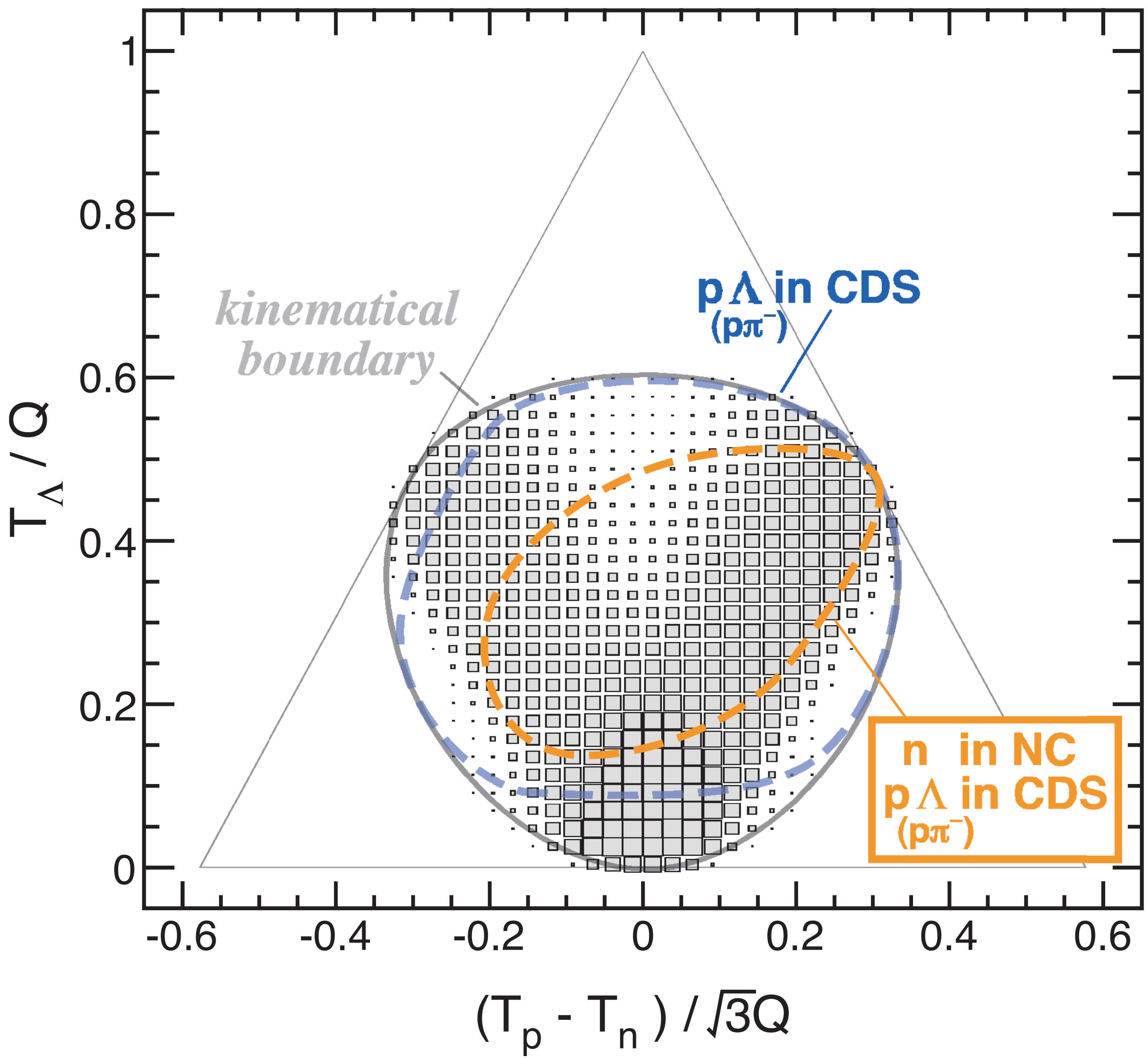
simulated by T. Hiraiwa

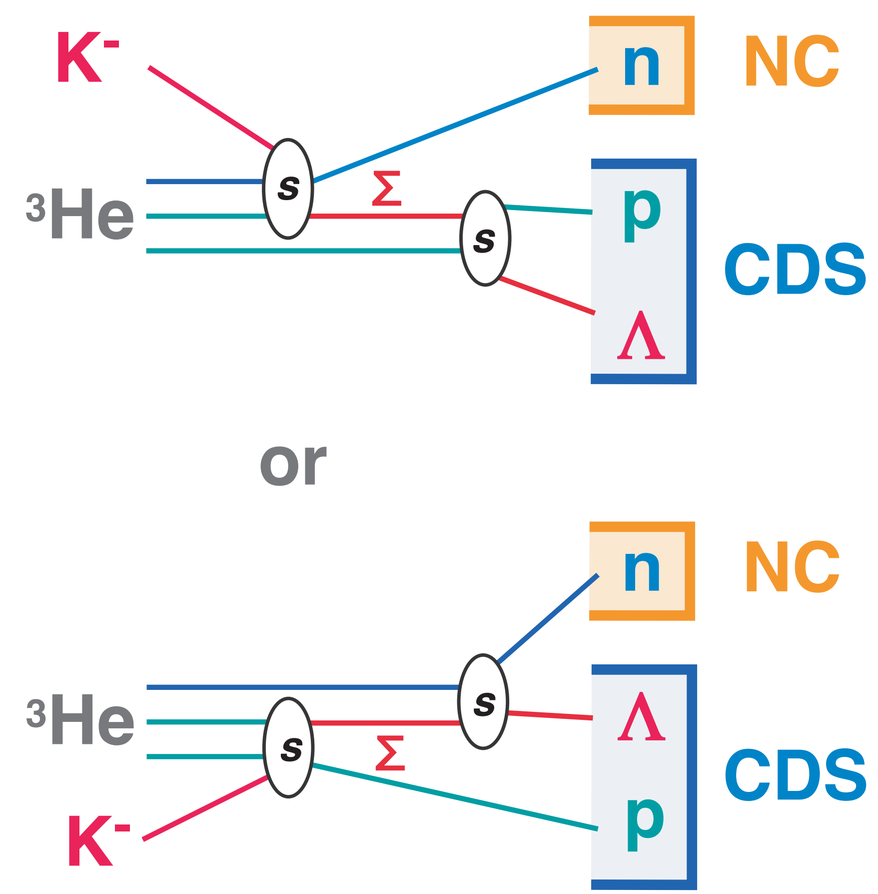
Background?

Two Nucleon Reaction and FSI (Σ-Λ conversion)

2NR and Σ - Λ conversion

on 3-body Phase Space (Dalitz's plot) at CM





multi-step PWIA

simulated by T. Hiraiwa

Background?

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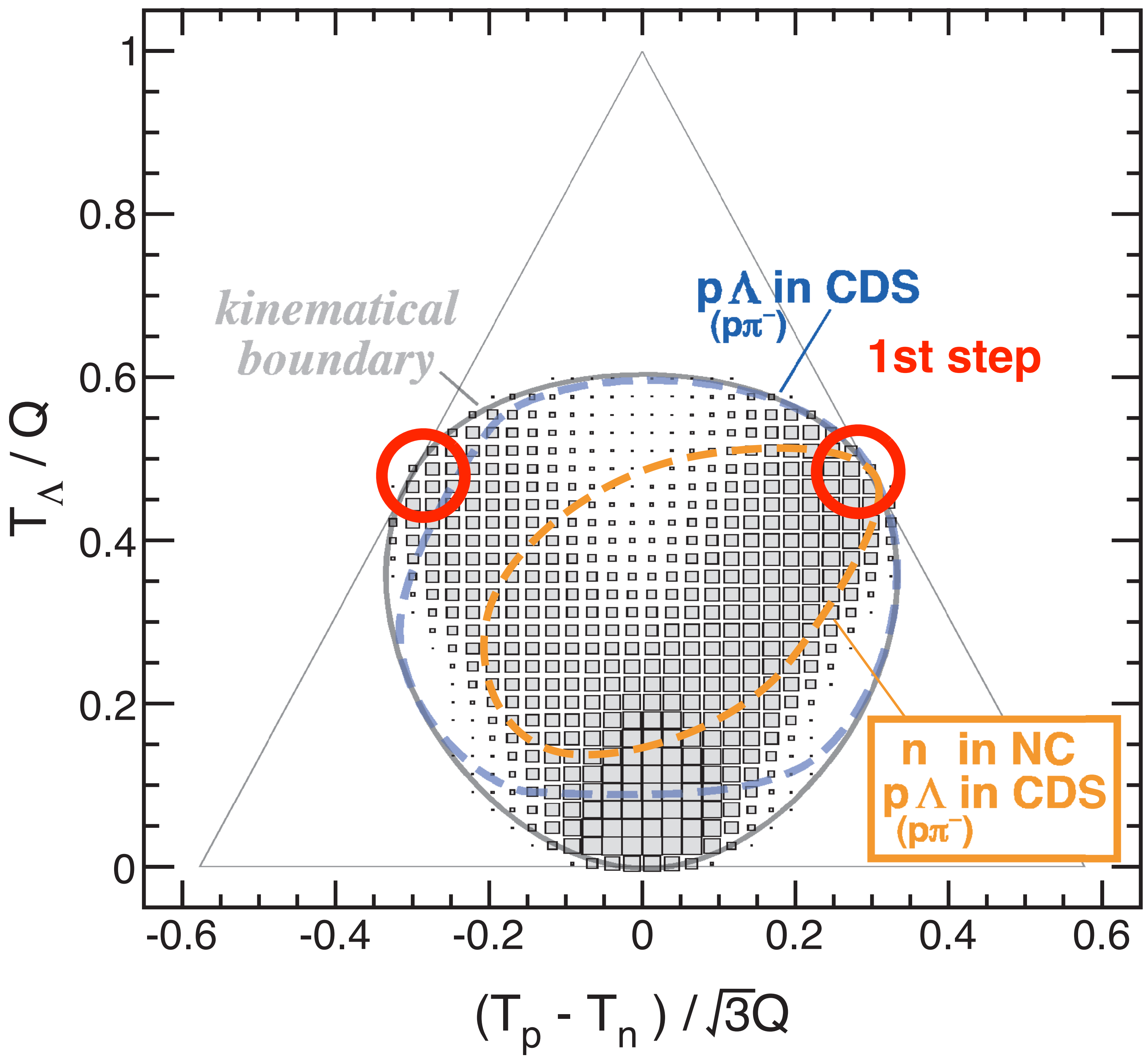

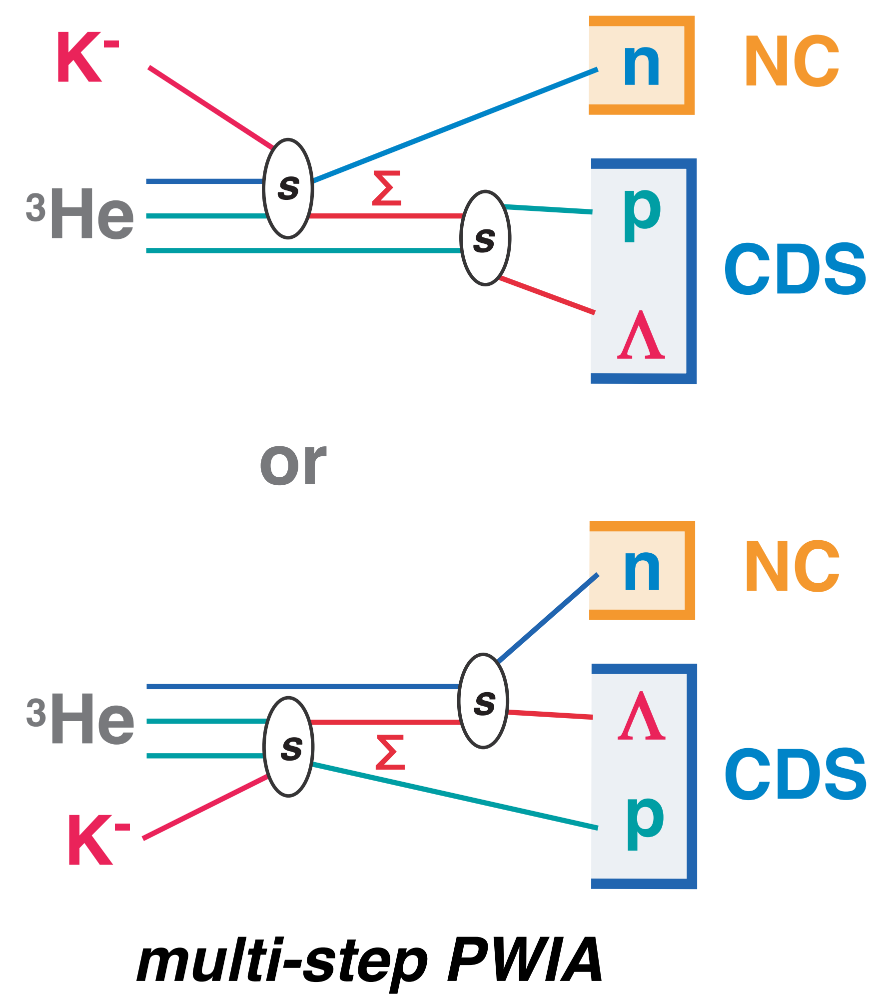

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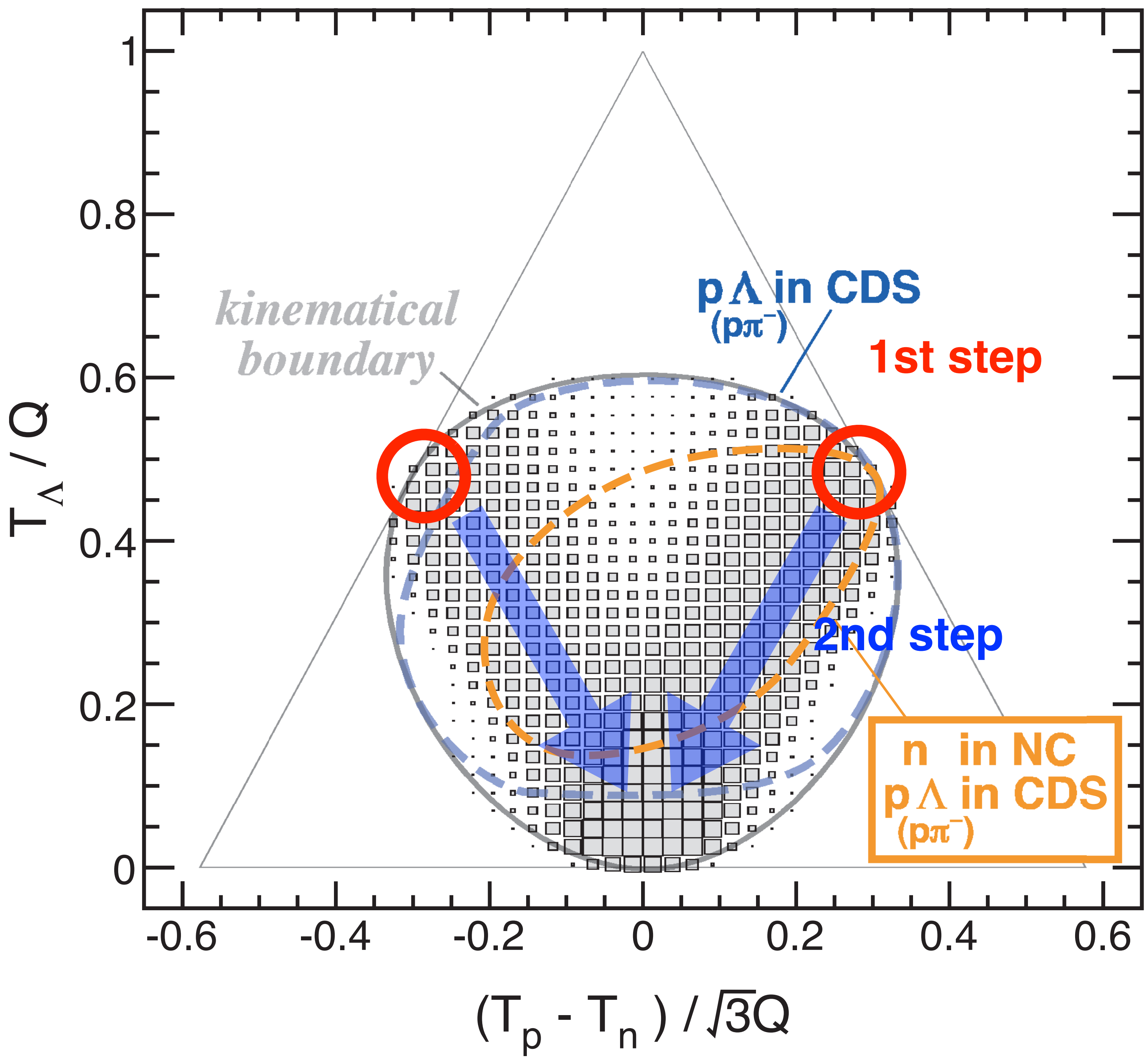

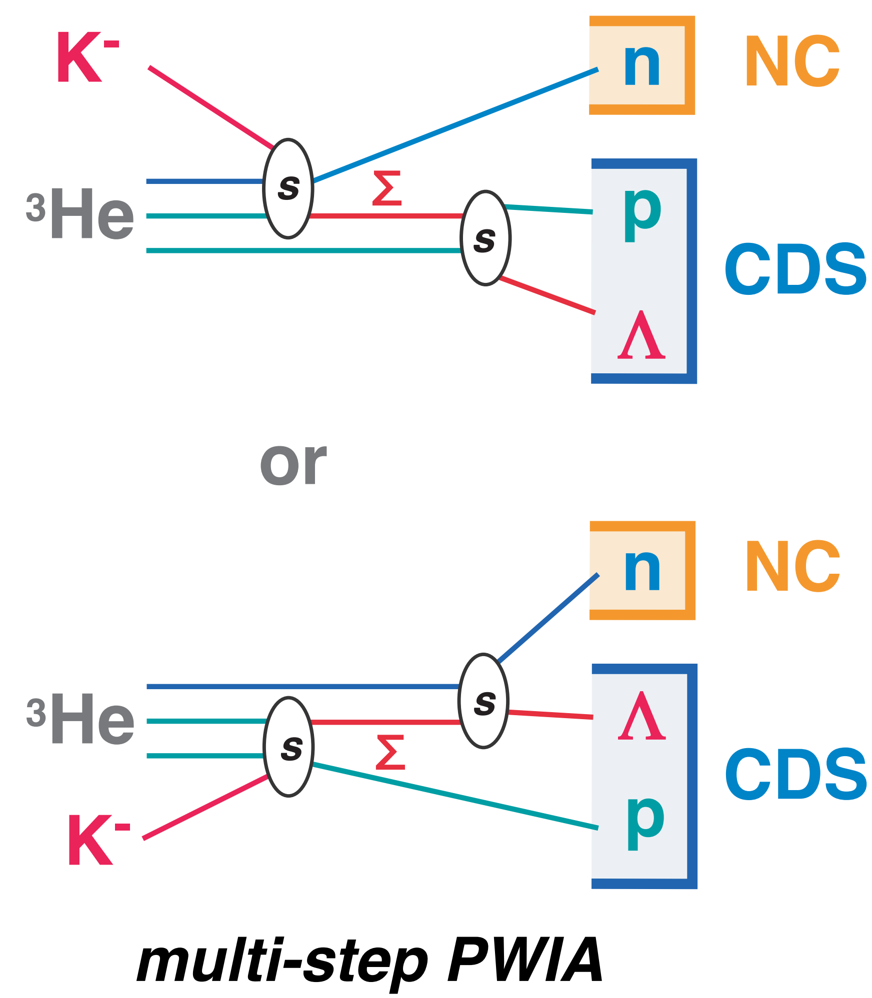

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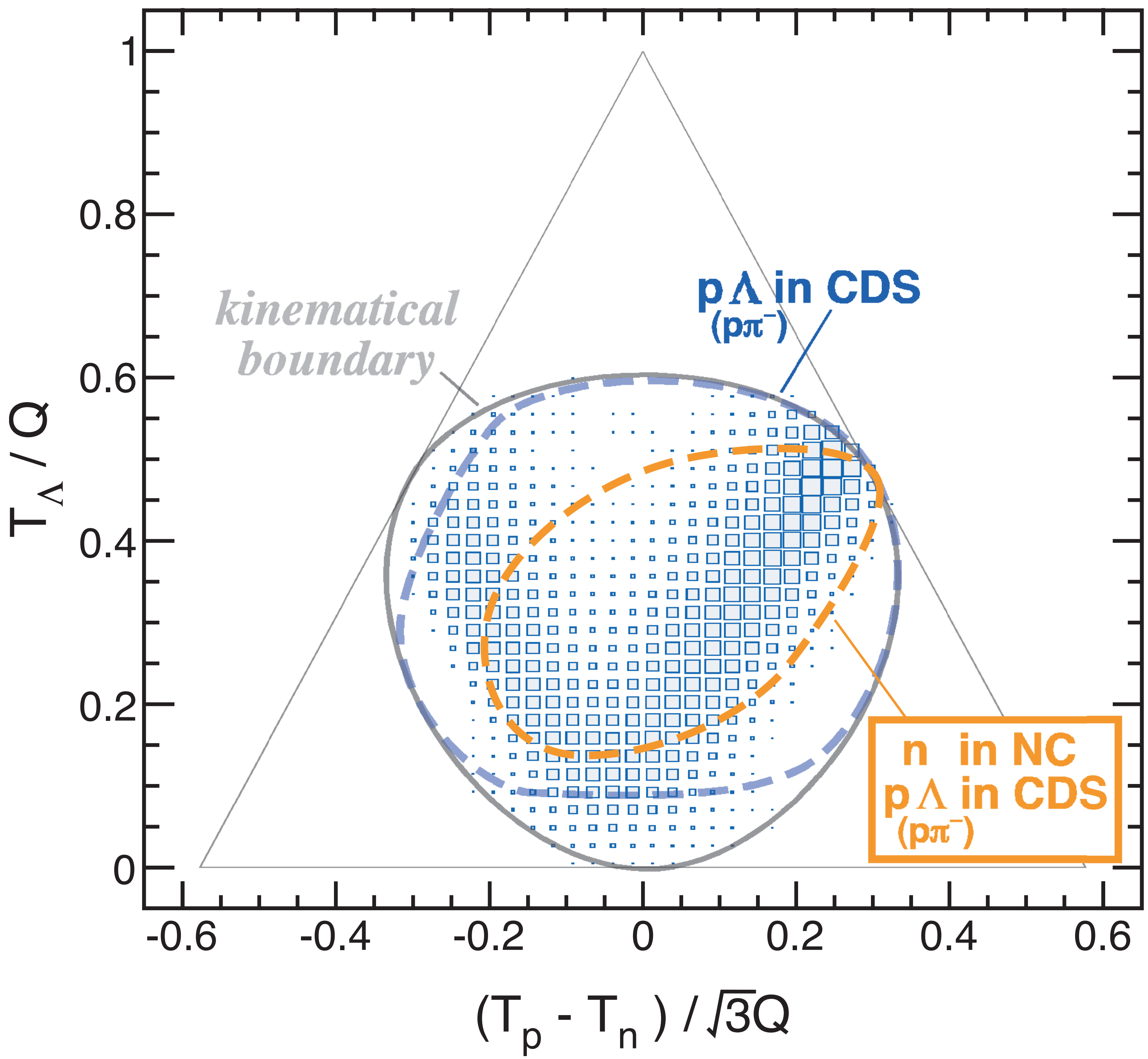

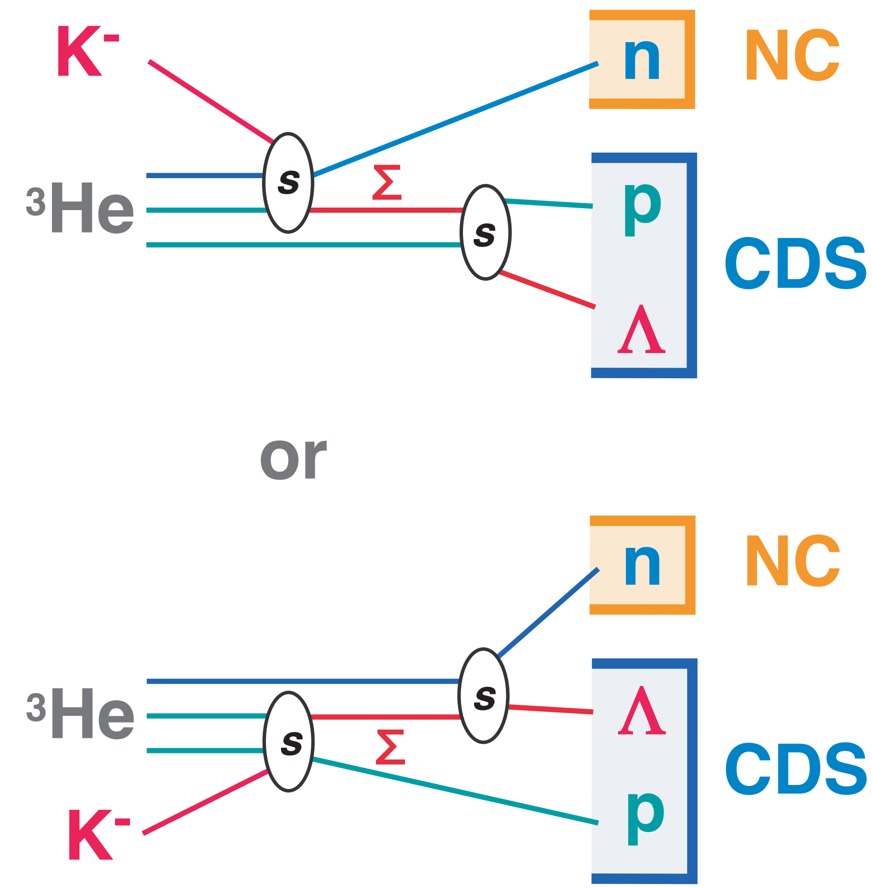

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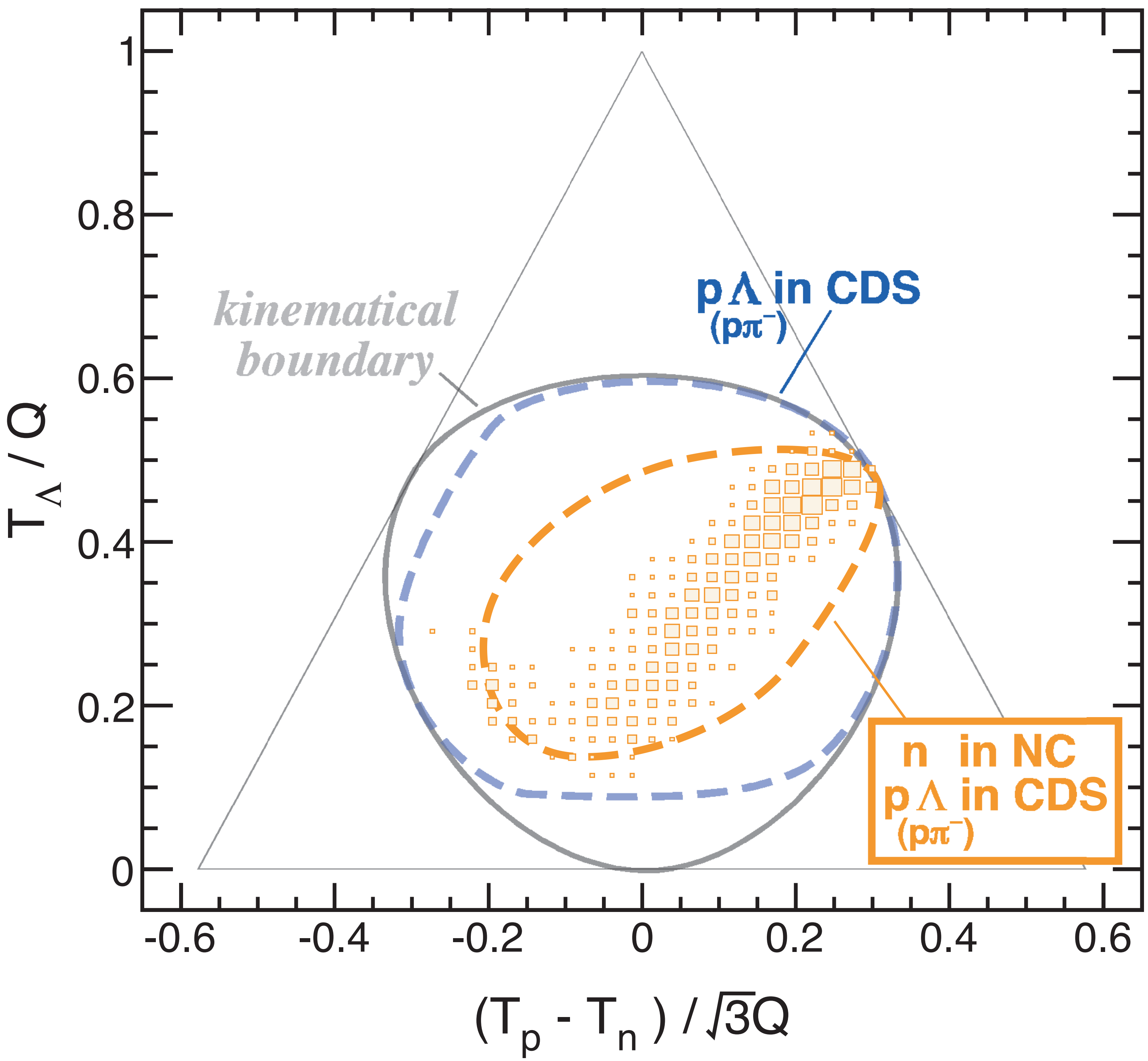

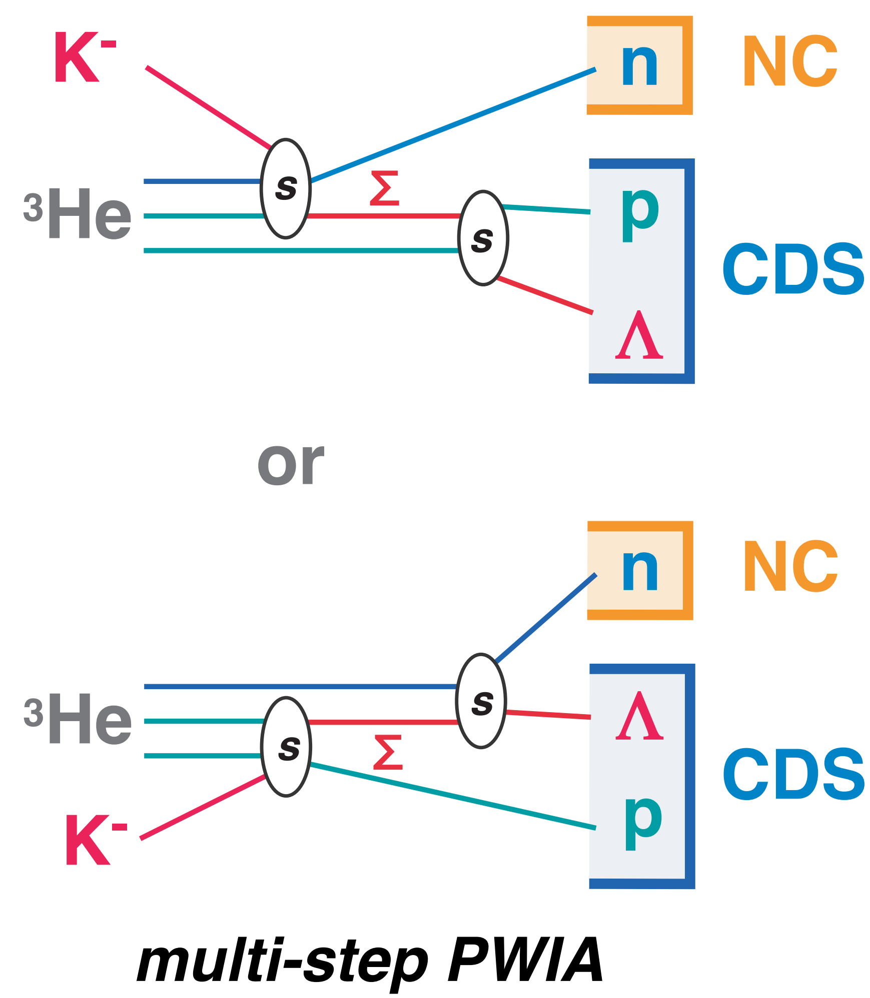

simulated by T. Hiraiwa

Background? *vs* signal *(ratio arbitrary)*

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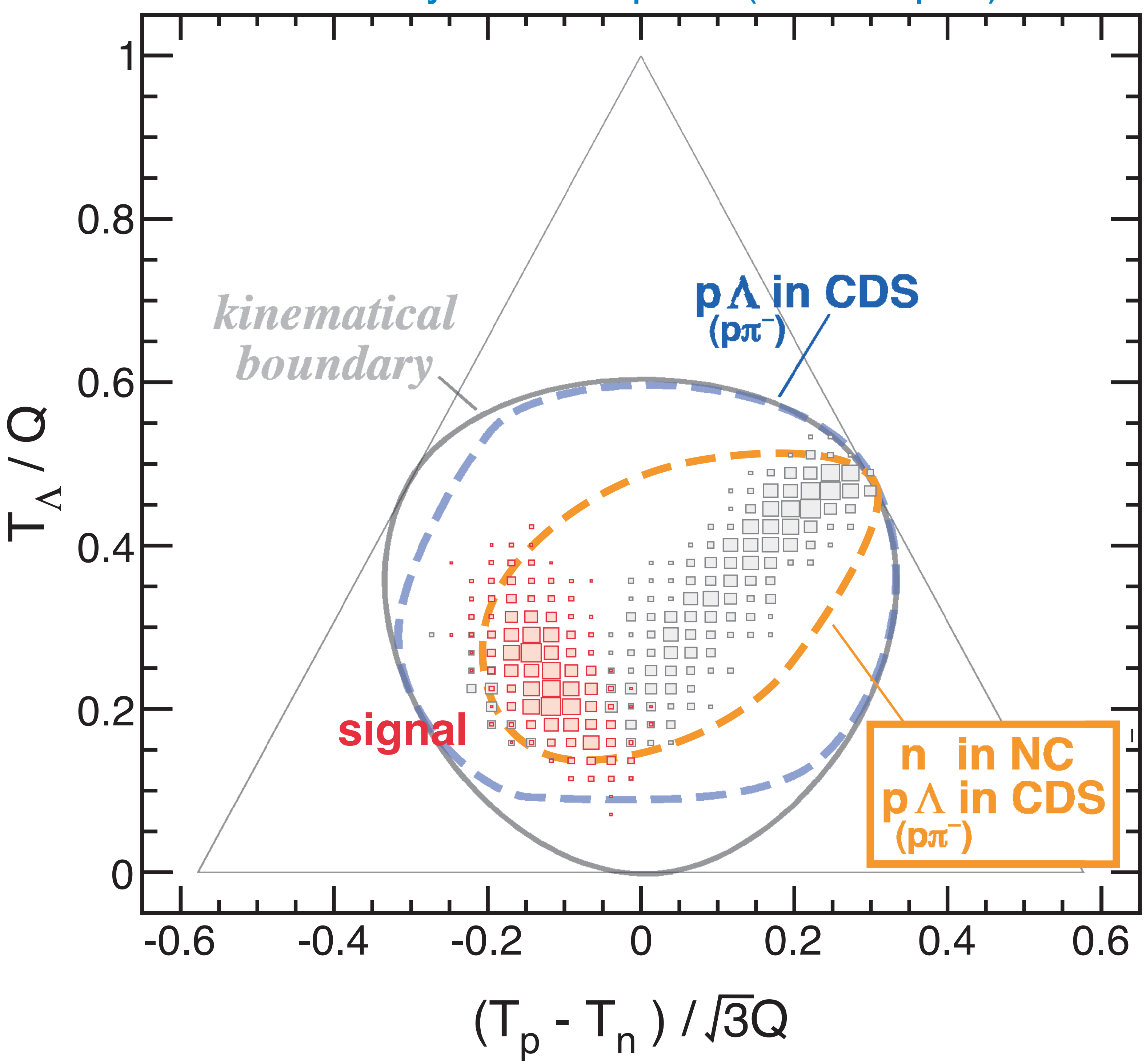
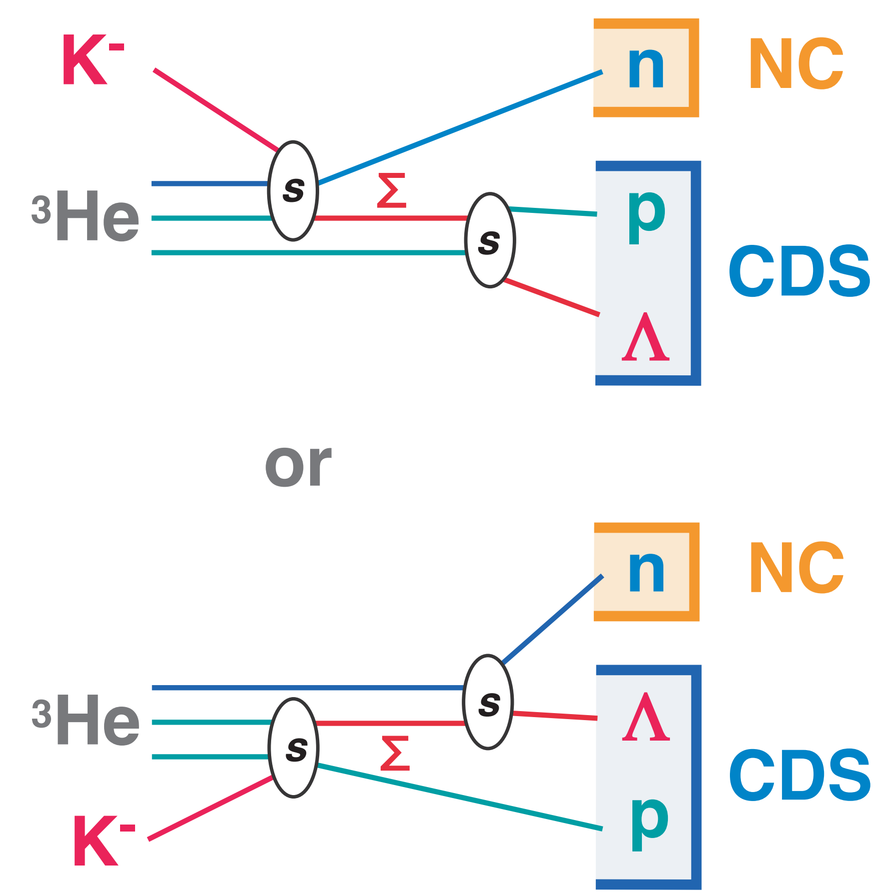
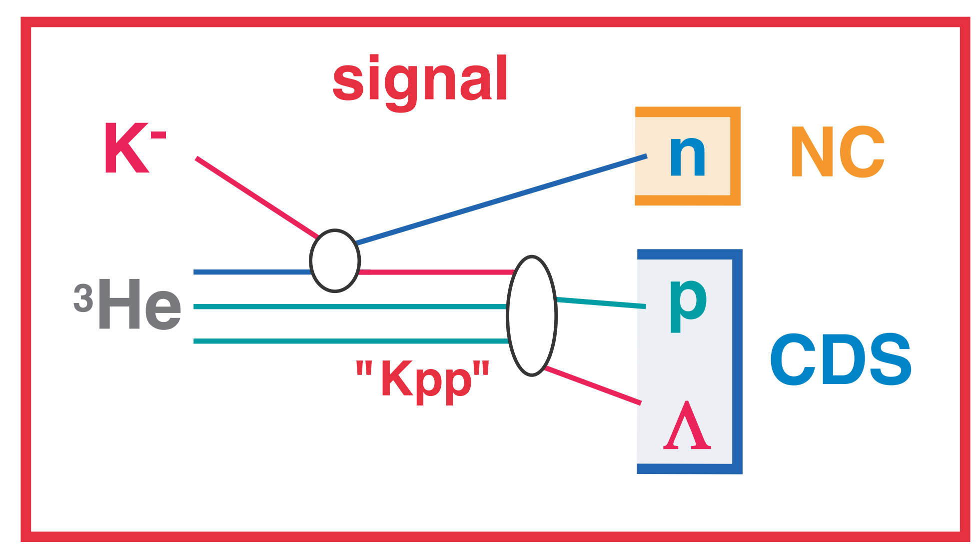




multi-step PWIA



simulated by T. Hiraiwa

Estimated yield by one proton missing

- **Yield = N_{kaon} x *t* x $d\sigma/d\Omega_{(\theta=0)}$ x *r* x R x A x *e* x ε**
  - **N_{kaon}** : kaon per spill → **300k/spill** (30 kW operation)
  - ***t*** : target → 0.08 [g/cm^3] / 3 [g/mol] x 6.02 x 10^{23} [mol^{-1}] x 9.3 [cm] ~ **1.4 x 10^{23} [cm^{-2}]**
  - **$d\sigma/d\Omega$** (@ $\theta = 0$) → **3 [mb/sr]**
  - ***r*** : branching ratio ($\Lambda \rightarrow \pi^- p$) → **0.63**
  - **R** : "Kpp" decay branch → **Br(Λp) + Br(Σ^0p) ~ 1**
  - **A** : NC acceptance → **12 [msr]**
  - ***e*** : NC efficiency → **0.3**
  - ε : overall efficiency (trigger, detector, ana., etc) → **0.7**

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- **2.1 x 10^4 signals on missing mass spectrum (by 1 week run)**

(Λp + Σ^0p branch)