Search for the eta-mesic helium in the deuteron-deuteron fusion reaction

Paweł Moskal
Jagiellonian University, Cracow, Poland

YITP Workshop on Hadron in Nucleus
Kyoto, Japan, 31 November 2013

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„We will present new preliminary result from the search for the eta-mesic helium with the WASA detector at COSY.

In addition a preliminary result on the eta-prime meson interaction with proton will be presented."

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We will present new preliminary result from the search for the eta-mesic helium with the WASA detector at COSY.

NEW !

In addition a preliminary result on the eta-prime meson interaction with proton will be presented.

NEW !

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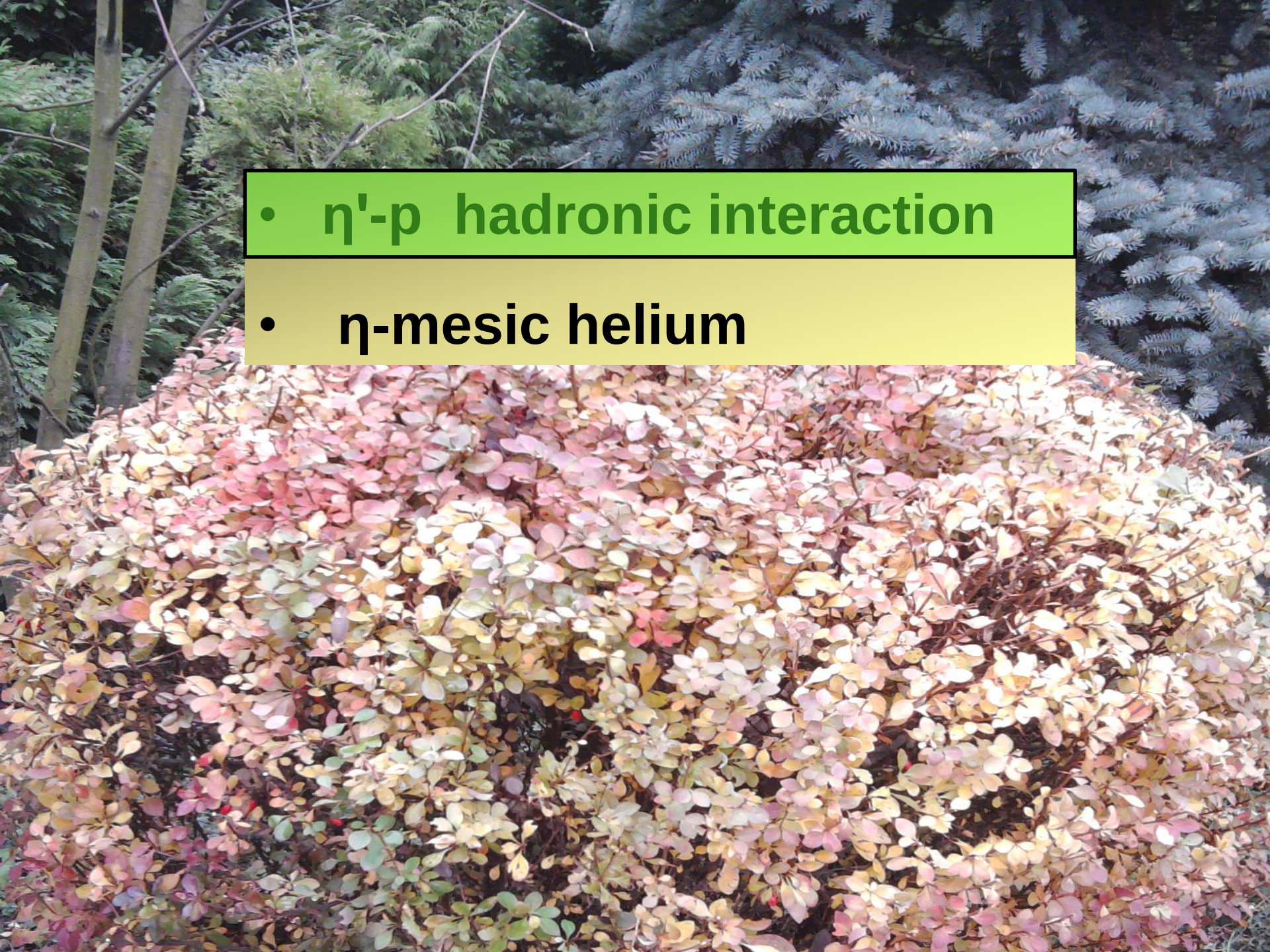
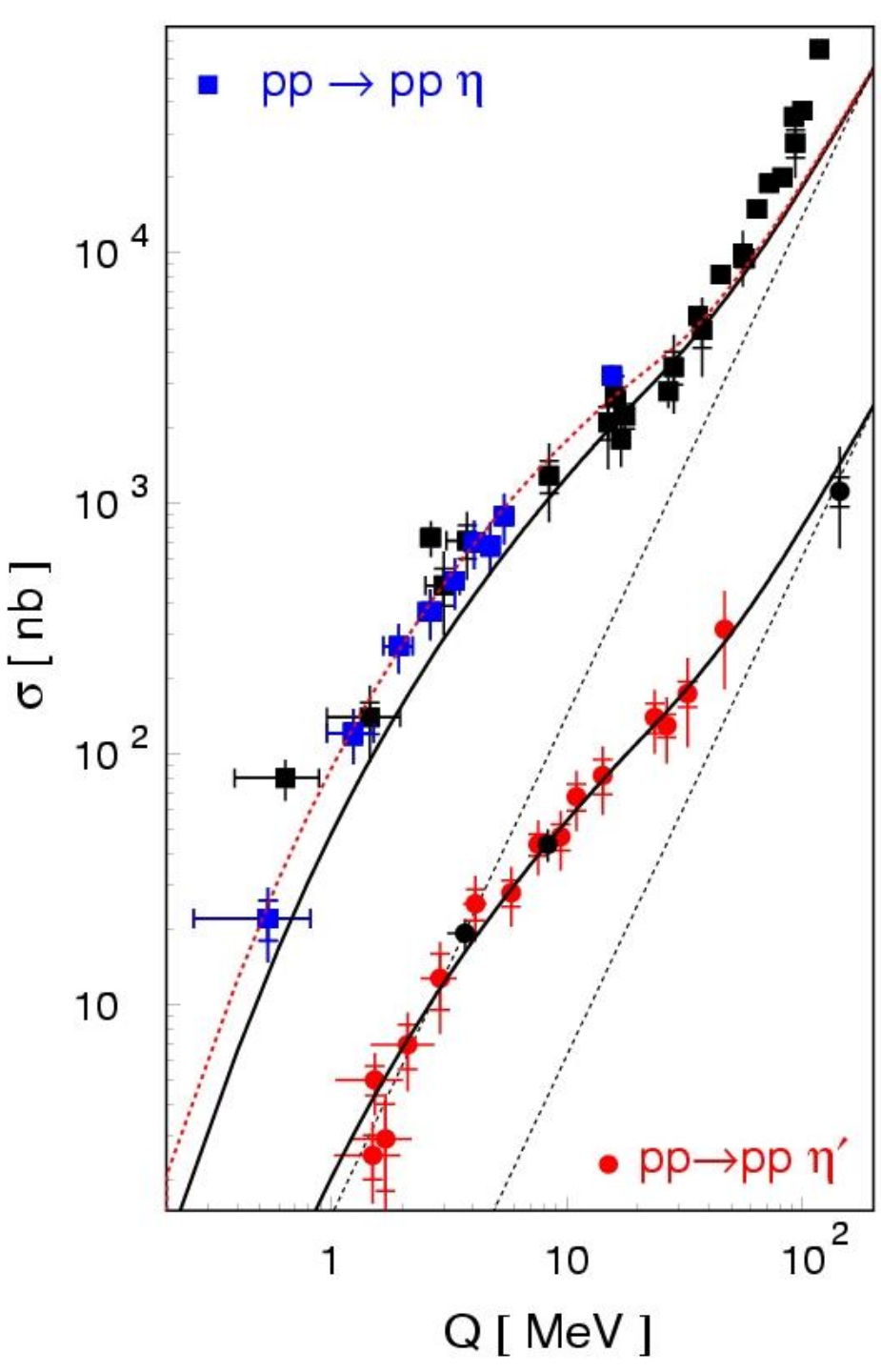

• η'-p hadronic interaction
• η-mesic helium



$$\sigma = \frac{1}{F}\int dV_{ps}\,|M|^2$$

$$|M|^2 \sim |M_0|^2\,|M_{FSI}|^2$$

$$|M_{FSI}|^2 \sim |M_{pp}|^2\,|M_{p1\eta}|^2\,|M_{p2\eta}|^2$$

dynamics → $|M_0|^2$

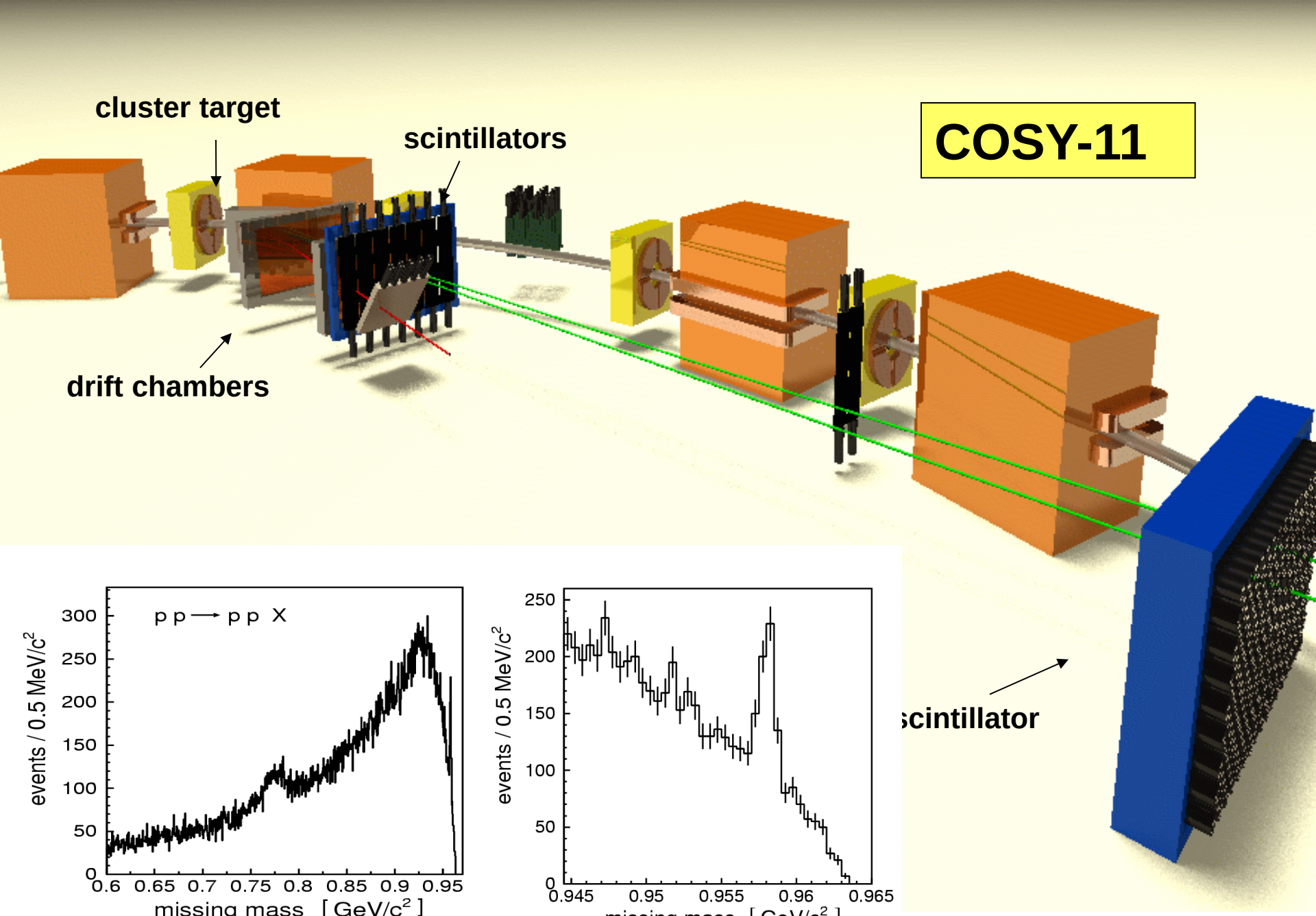
interaction → σ (Q)

CELSIUS

COSY

SATURNE

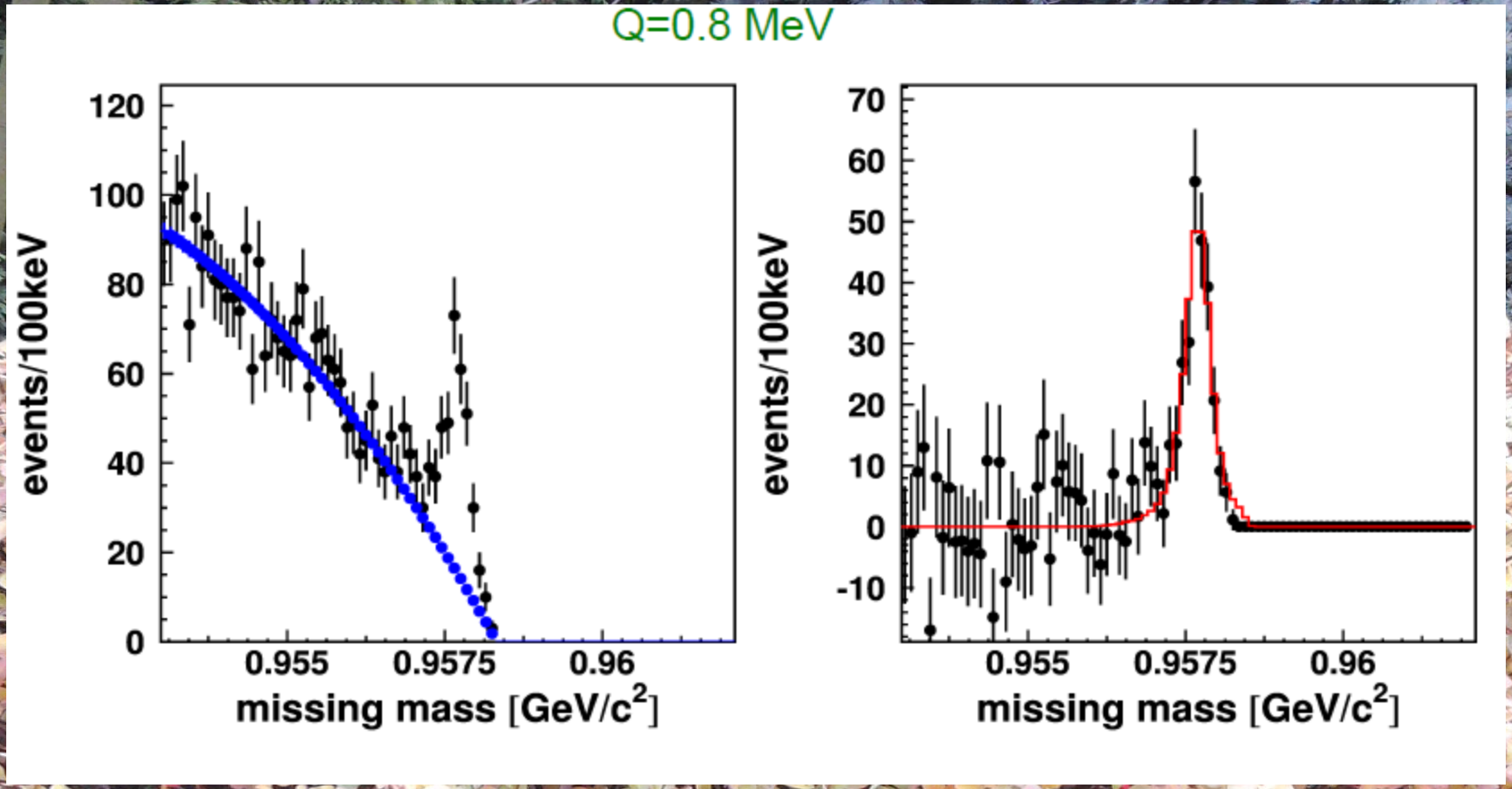
COoler SYnchrotron COSY


cluster target
scintillators
drift chambers
COSY-11
scintillator

p p ⟶ p p X
events / 0.5 MeV/c²
missing mass [GeV/c²]

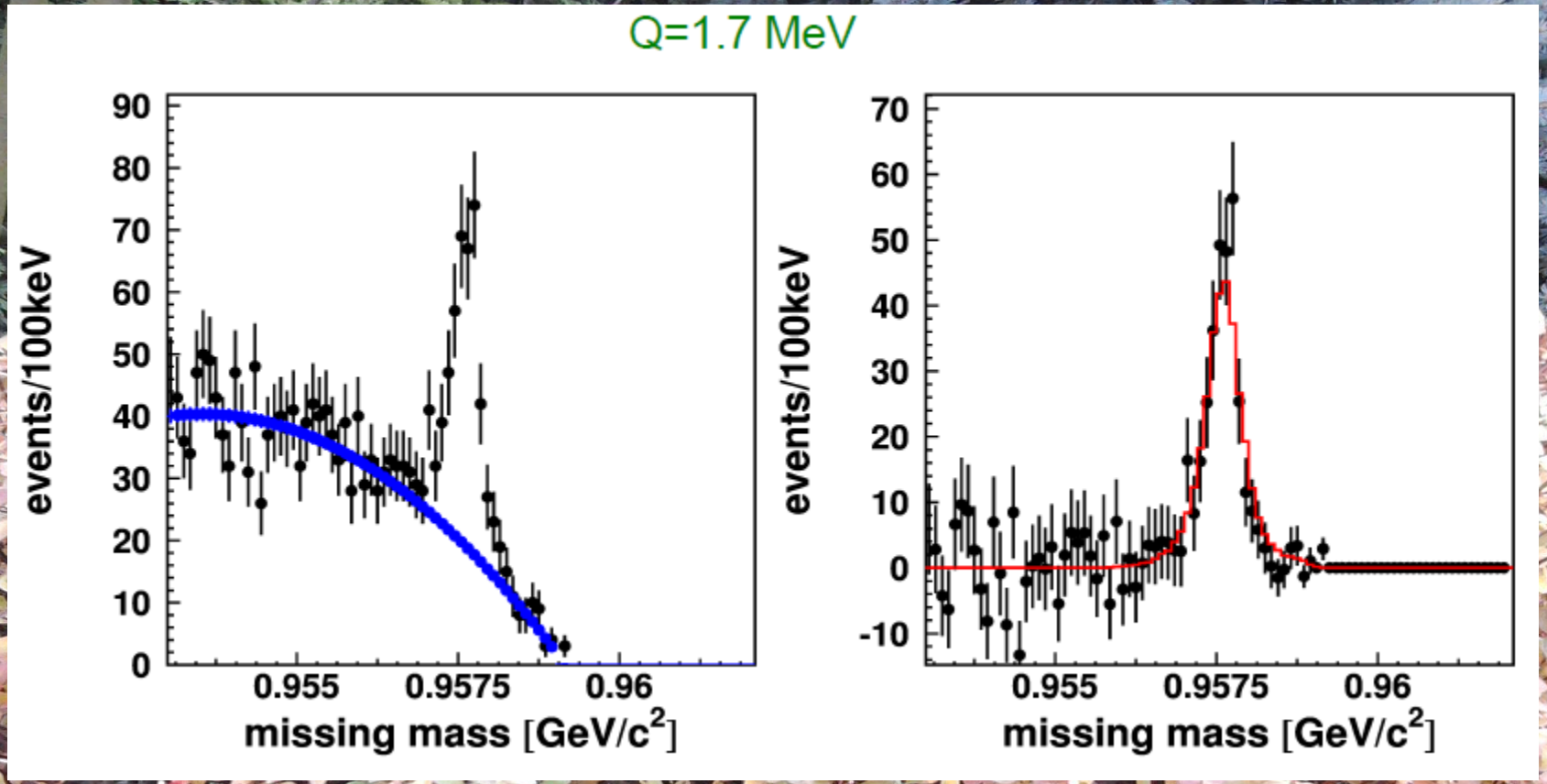
events / 0.5 MeV/c²
missing mass [GeV/c²]

COSY-11

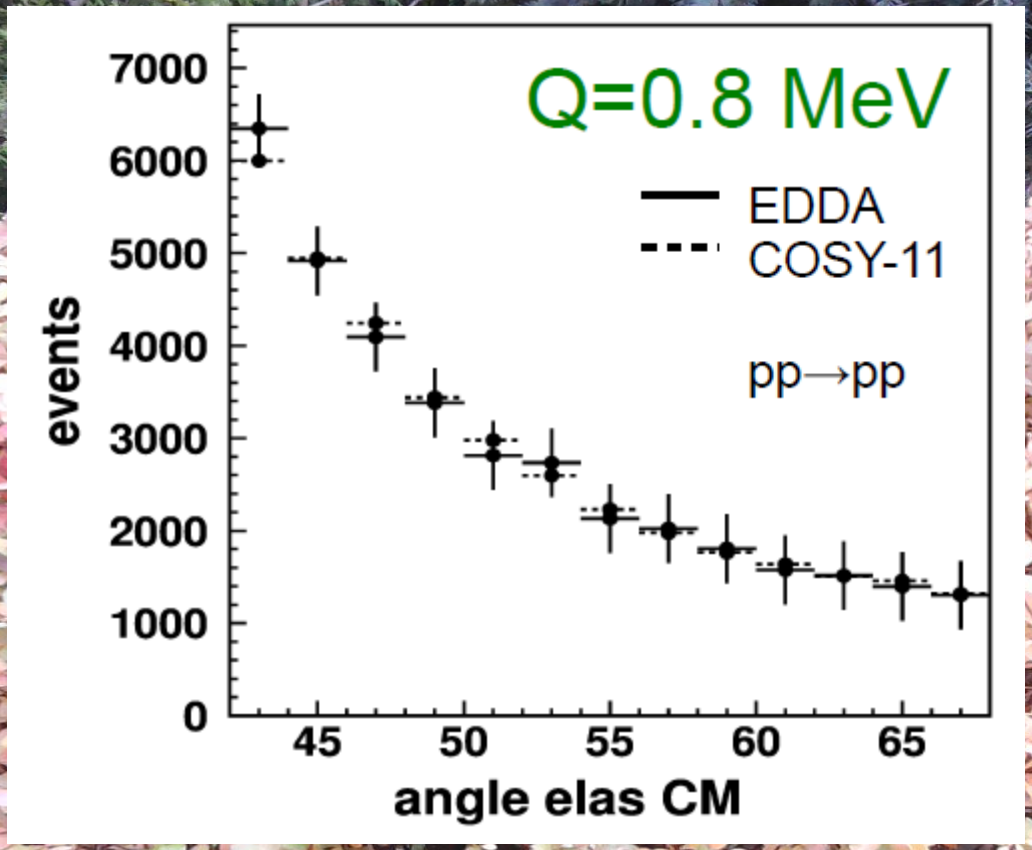


Determination of the total width of the η′ meson
COSY-11 : Phys.Rev.Lett. 105 (2010) 122001

COSY-11

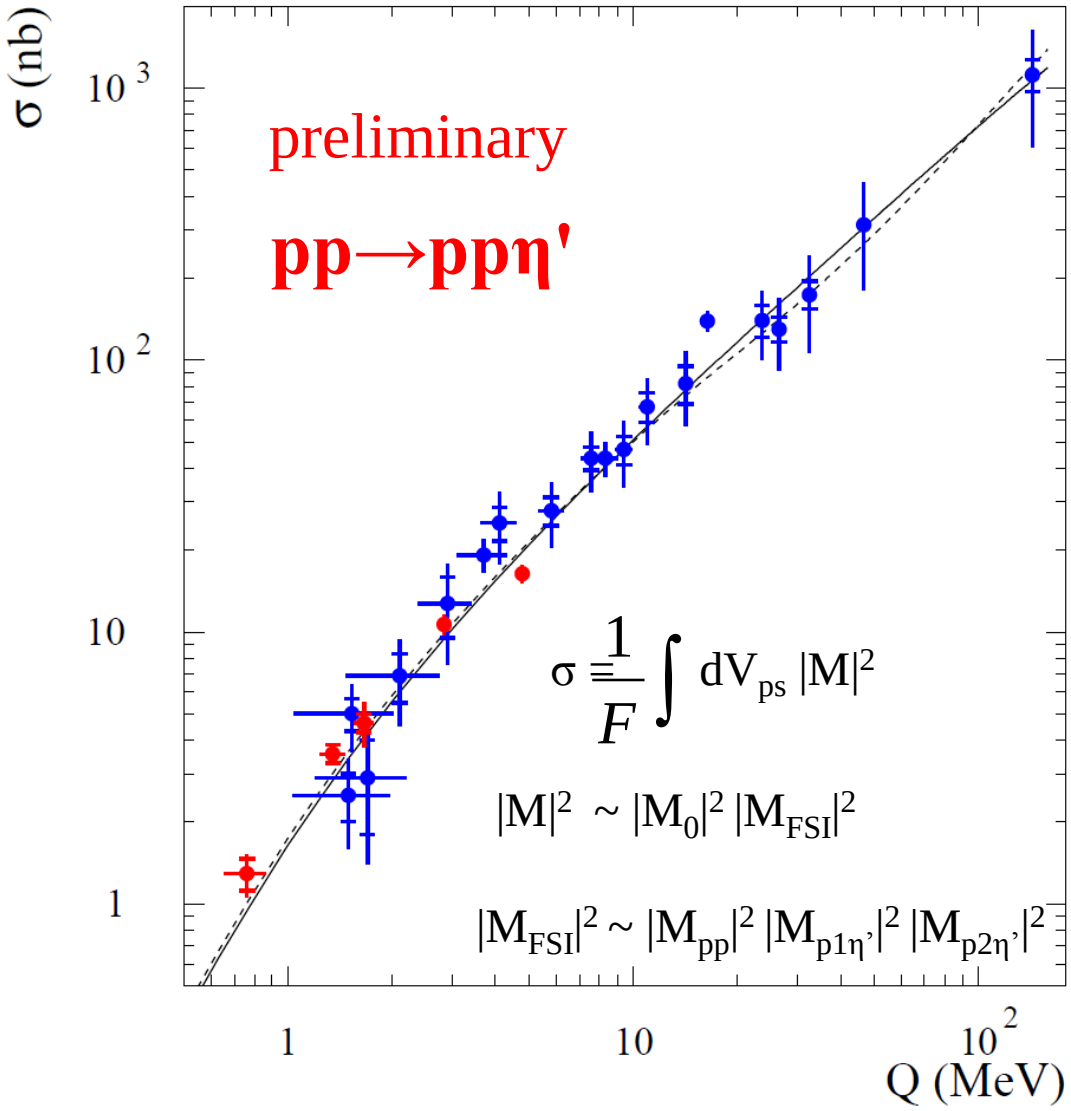

Q=1.7 MeV
events/100keV
missing mass [GeV/c^2]
events/100keV
missing mass [GeV/c^2]

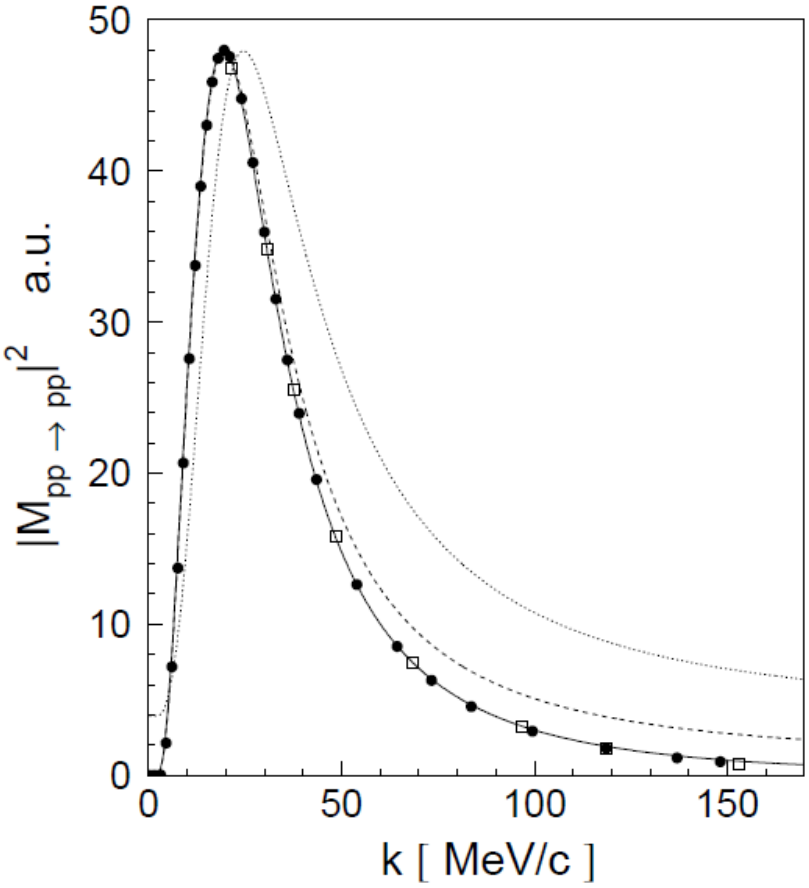
COSY-11



Comparison with differential cross-section
for elasticaly scattered pp from EDDA collaboration
Eur. Phys. J. A 22, 125 (2004)
Phys. Rev. Lett. 78, 1652 (1997)

COSY-11



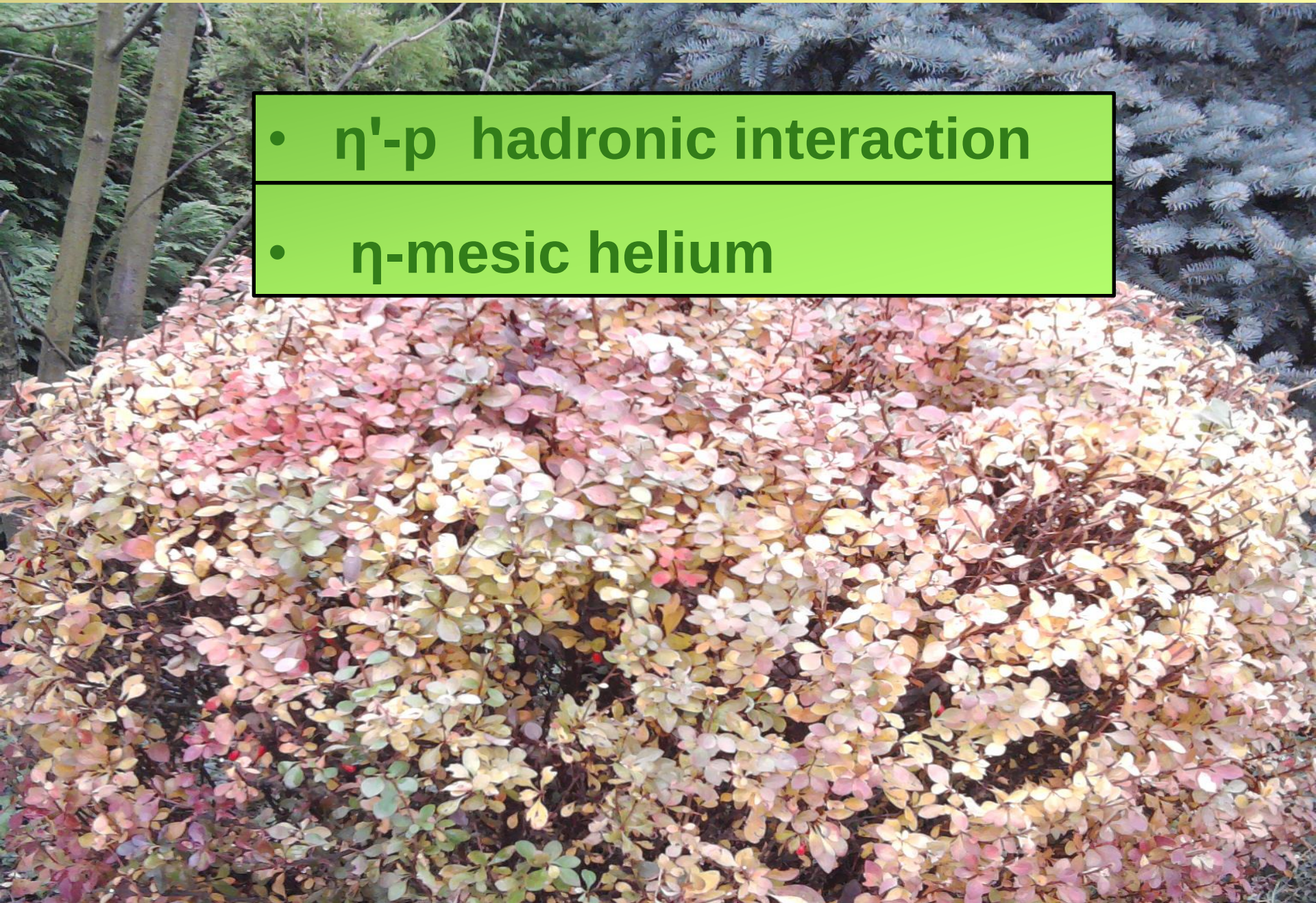


—— J.P. Naisse, Nucl. Phys. A 278 (2997) 506
---- B.L. Druzhinin et al., Z. Phys. A 359 (1997) 205
…. R. Shyam, U. Mosel, Phys. Lett B 436 (1998) 1.

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]

search for eta-mesic helium



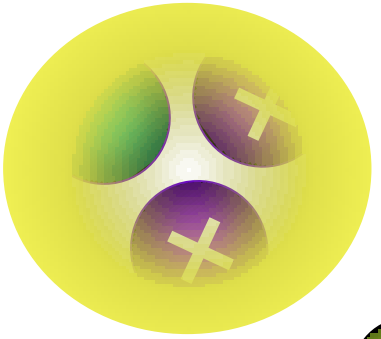
- η'-p hadronic interaction
- η-mesic helium

Possibility for the study of η-N interaction

Study of properties of N*(1535) resonance in nuclear matter

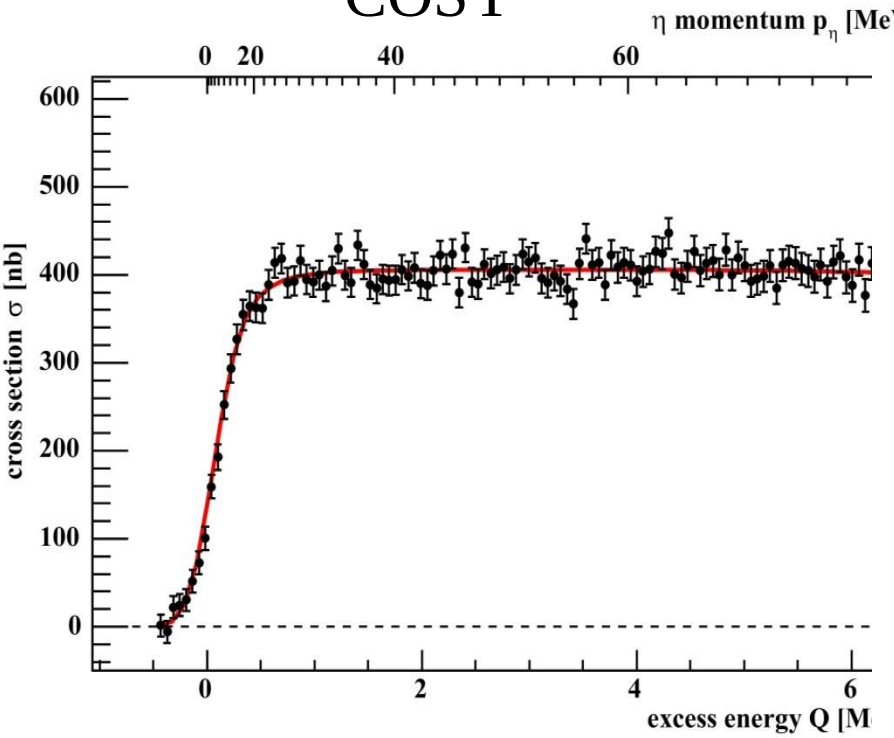
Some information about η meson structure

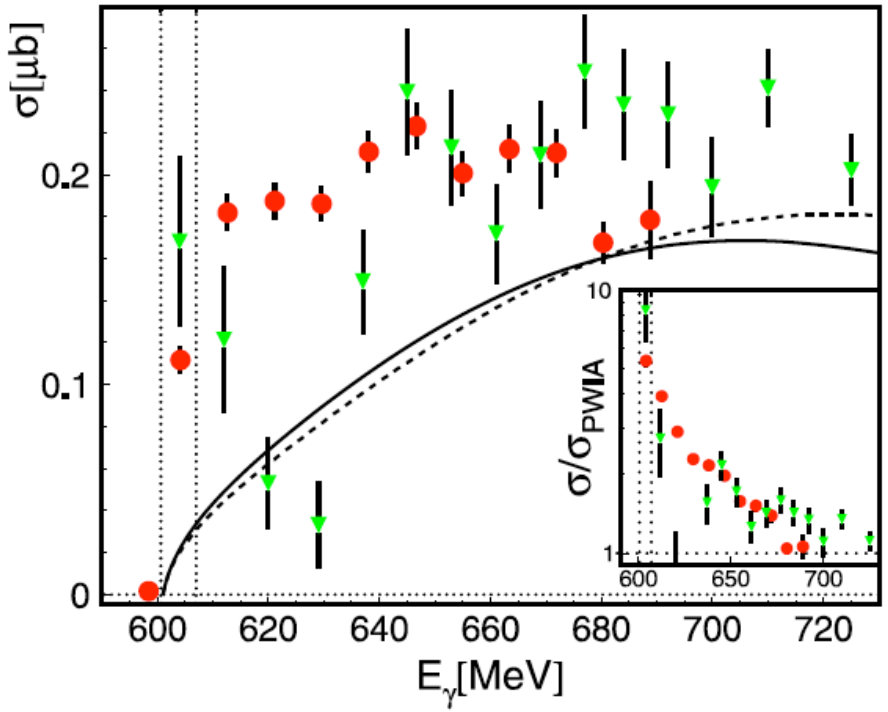
η - ^{3}He



- $dp \rightarrow {}^3\mathrm{He}\eta$

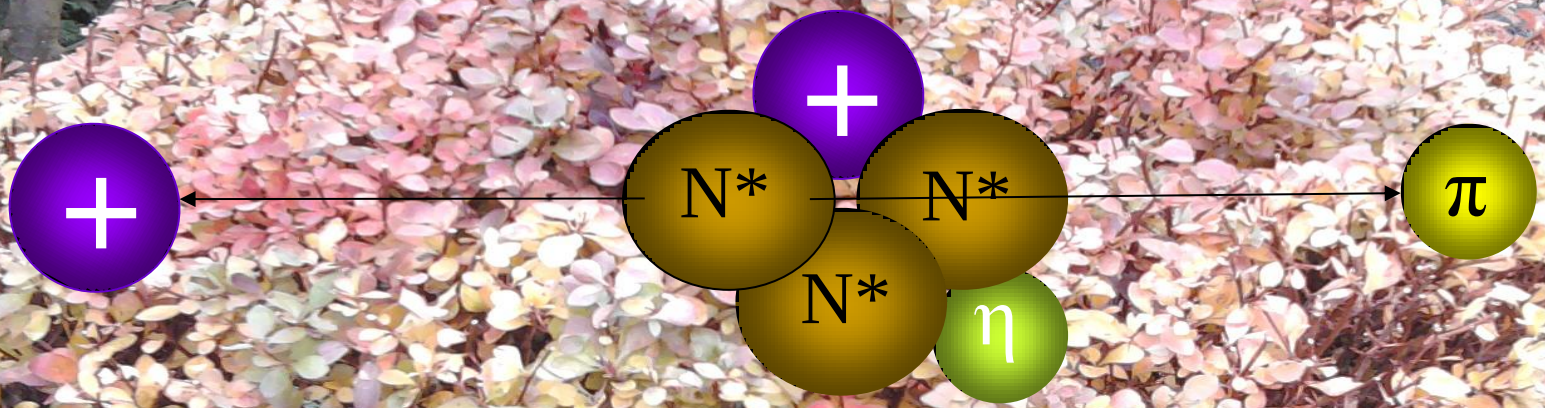
COSY



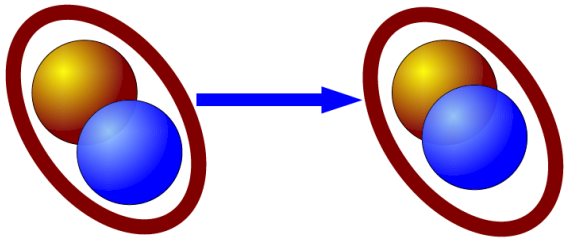


THE ETA-MESIC NUCLEUS

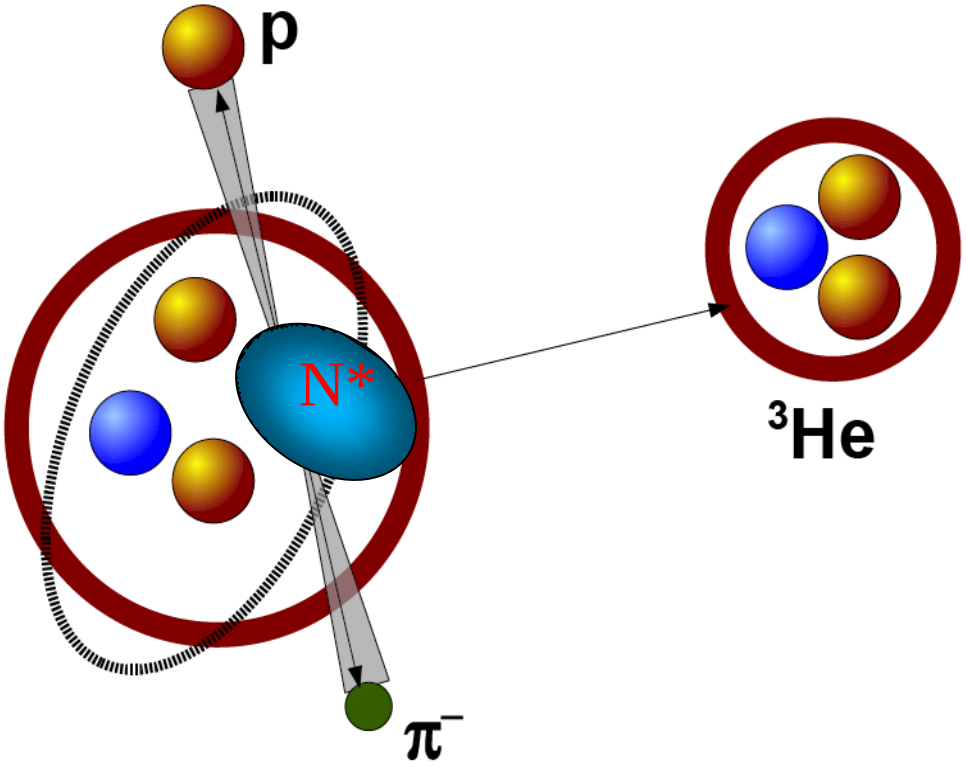
η meson bound with nucleus via STRONG INTERACTION



$$d+d \rightarrow (^4He\text{-}n)_{bound} \rightarrow {}^3He + p + \pi^-$$



p-π^- emission: $\theta_{cm} \sim 180^\circ$

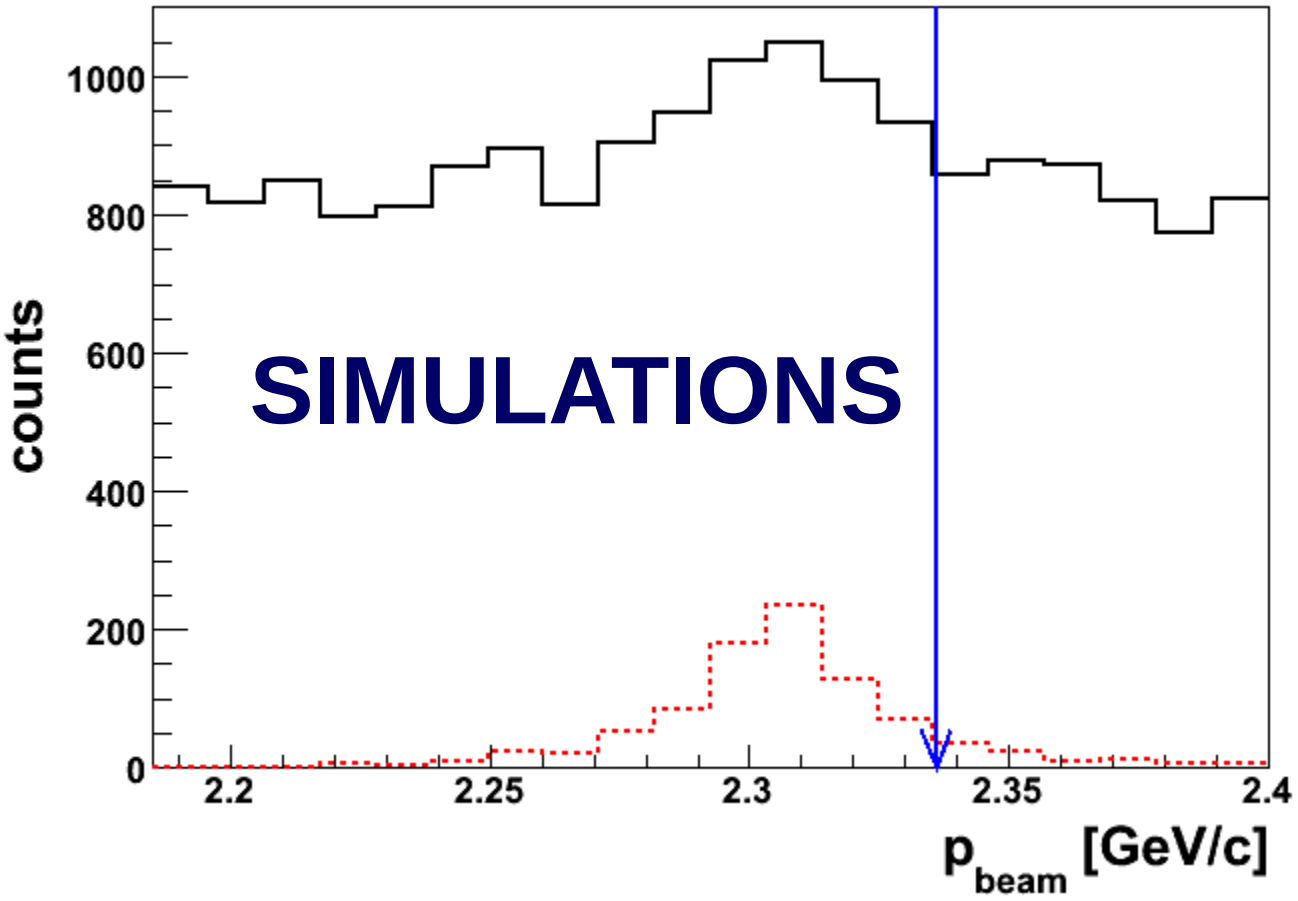


Measurement of the excitation function of

$$d+d \rightarrow (^4He\text{-}n)_{bound} \rightarrow p + \pi^- + {}^3He$$

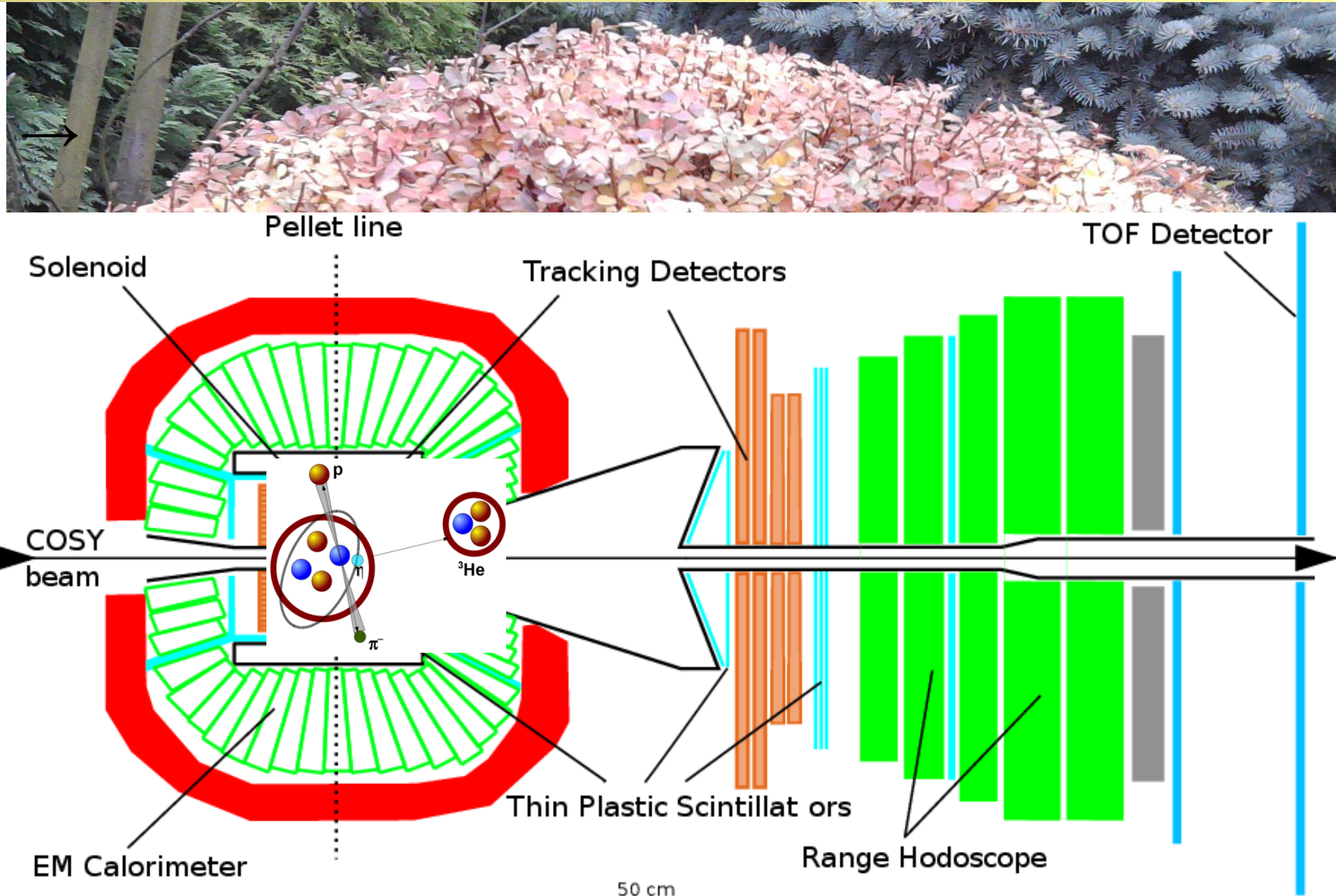
$$d+d \rightarrow ({}^4He\text{-}n)_{bound} \rightarrow {}^3He + p + \pi^-$$

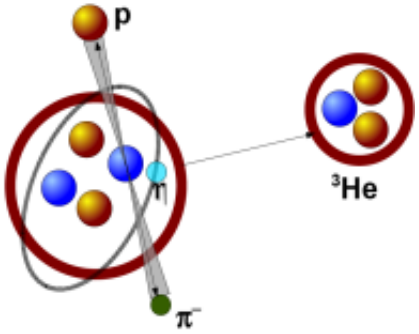
$$d+d \rightarrow {}^3He + p + \pi^-$$



COoler SYnchrotron COSY

WASA-at-COSY


Pellet line
Solenoid
Tracking Detectors
TOF Detector
COSY
beam
p
η
³He
π⁻
Thin Plastic Scintillat ors
EM Calorimeter
Range Hodoscope
50 cm



WASA

gives

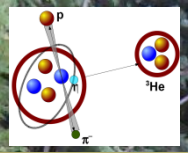
UNIQUE OPPORTUNITY TO DETECT ALL EJECTILES

EXCLUSIVE MEASUREMENT

COSY

enables measurement of the excitation function with continuous change of the beam momentum

RAMPED BEAM MOMENTUM



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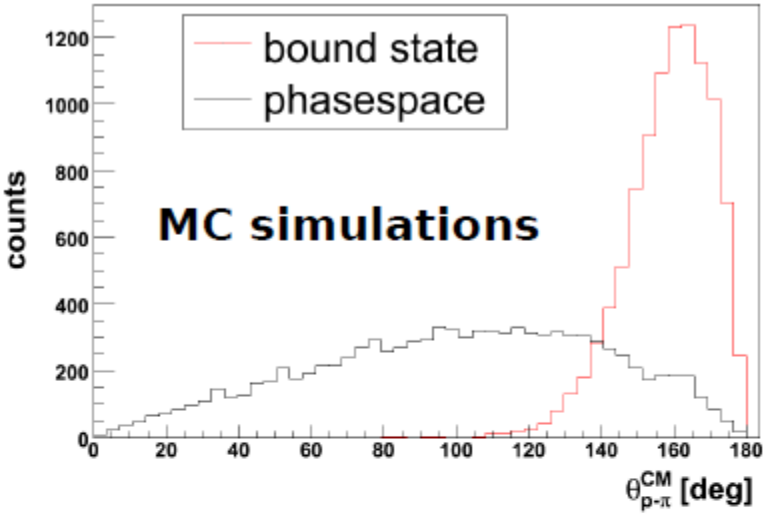
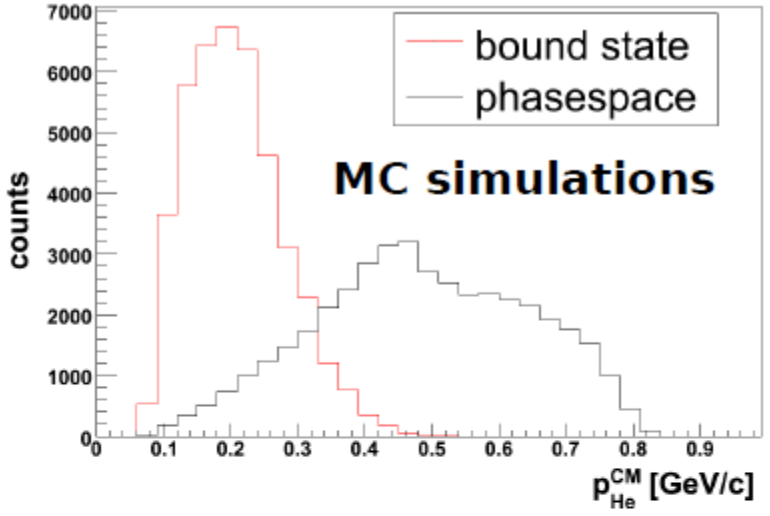
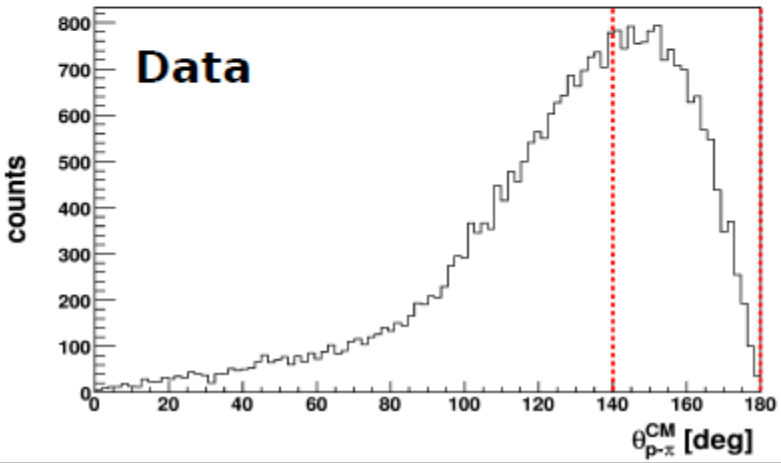
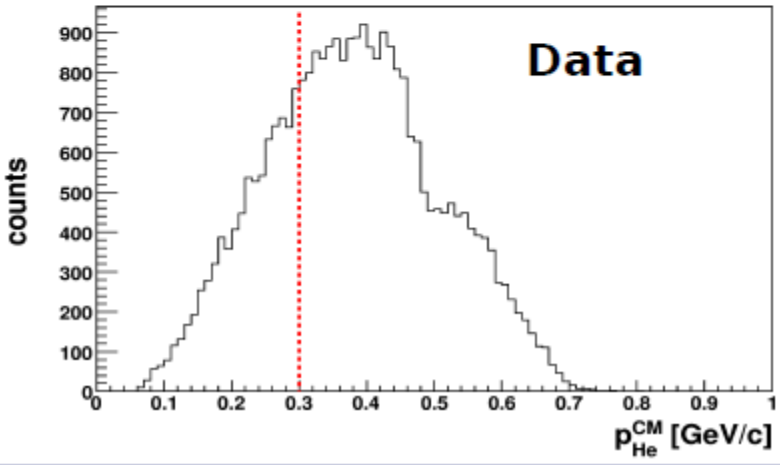


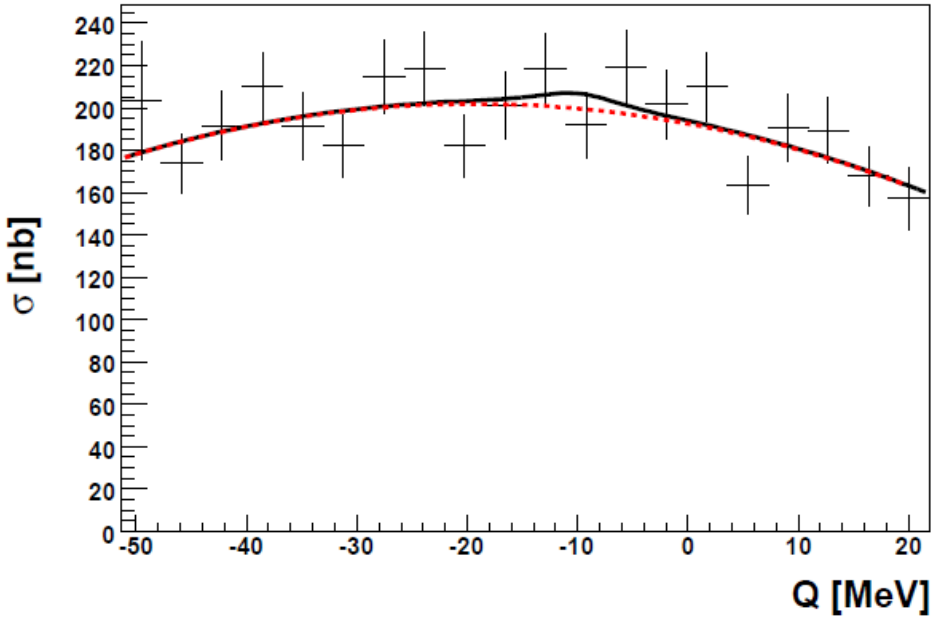


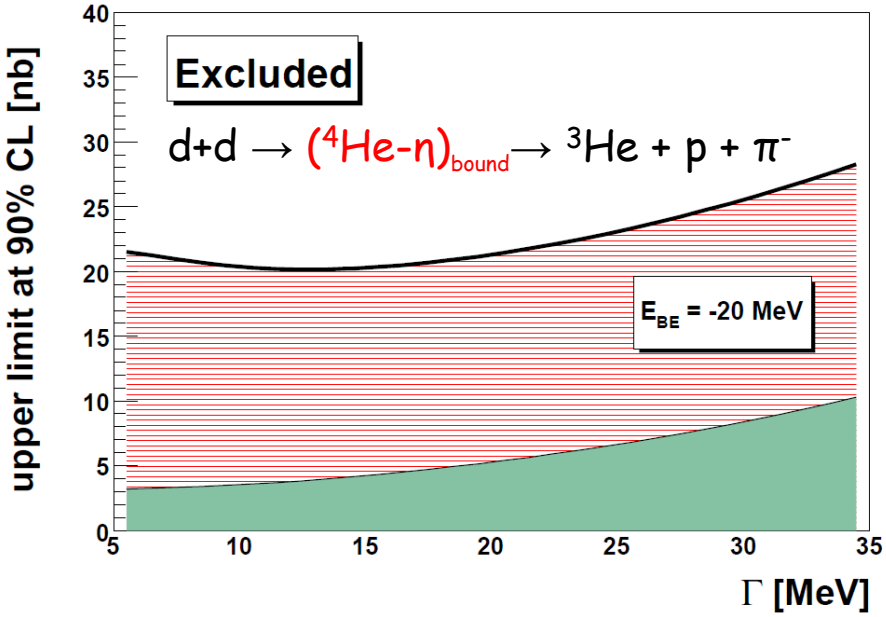


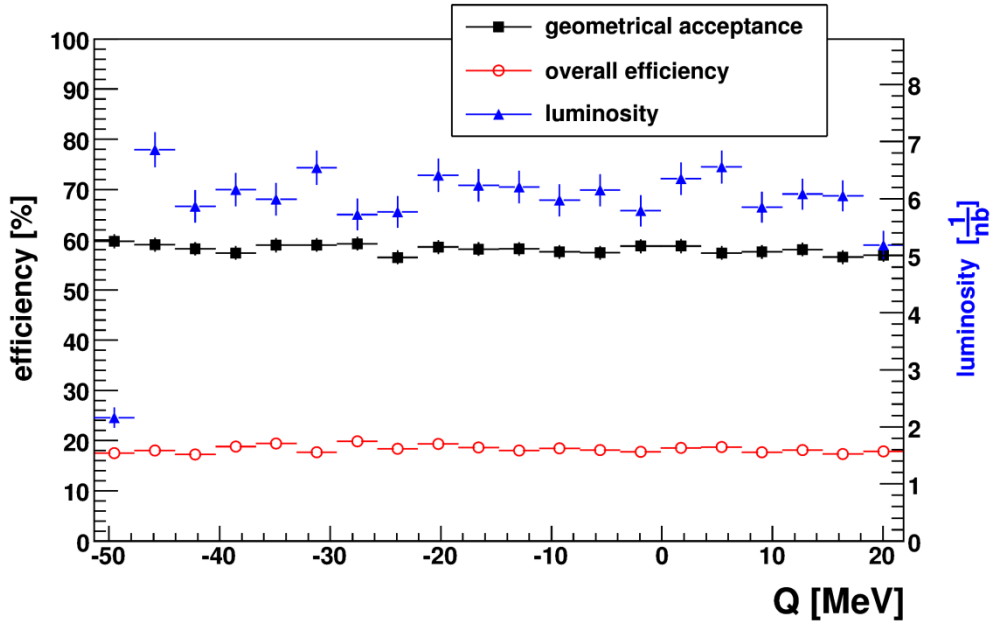


ETA MESIC NUCLEUS, COSY

$d+d \rightarrow {}^3He + p + \pi^-$







WASA-at-COSY:
Phys. Rev. C 87, 035204 (2013)

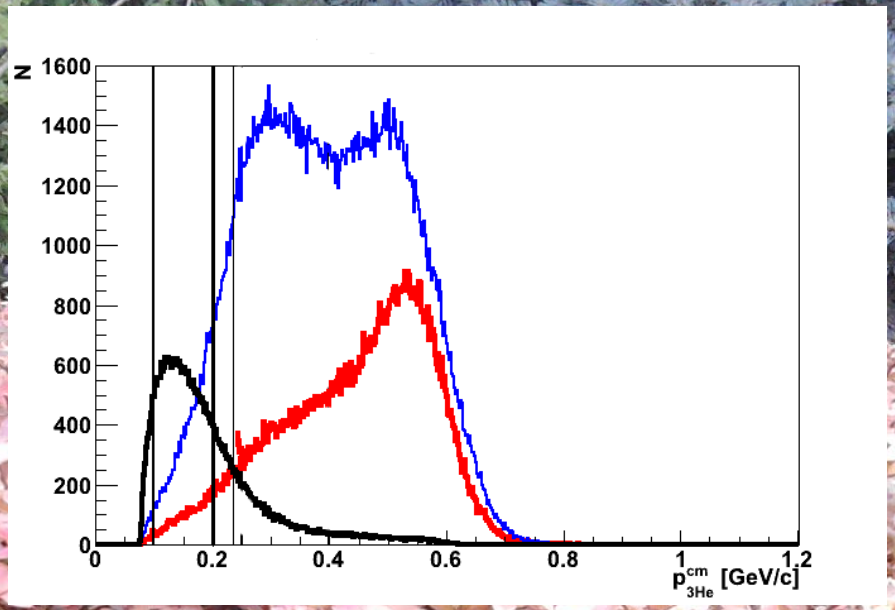
In 2010 we performed new measurement

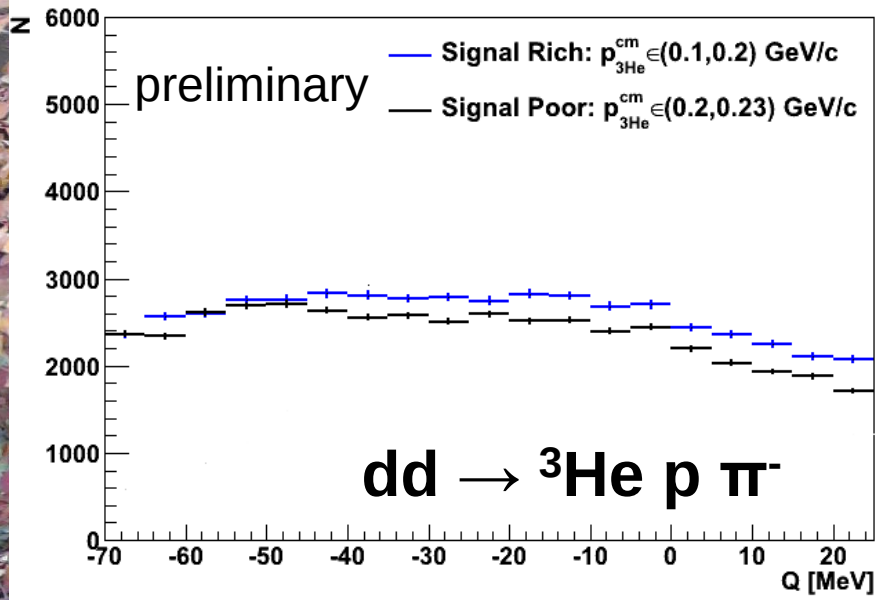
$$d+d \rightarrow ({}^4He\text{-}n)_{bound} \rightarrow {}^3He + p + \pi^-$$

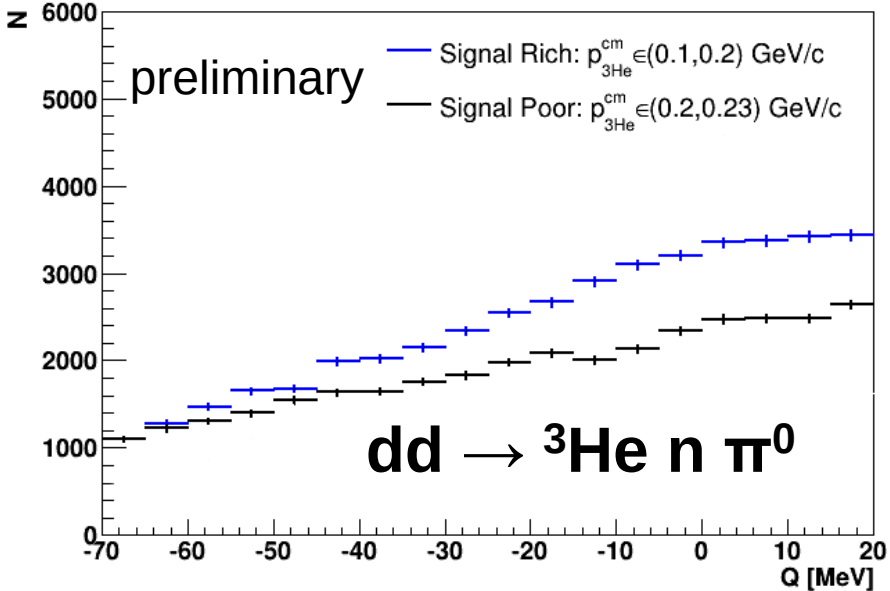
$$d+d \rightarrow ({}^4He\text{-}n)_{bound} \rightarrow {}^3He + n + \pi^0$$

40 times larger statistics

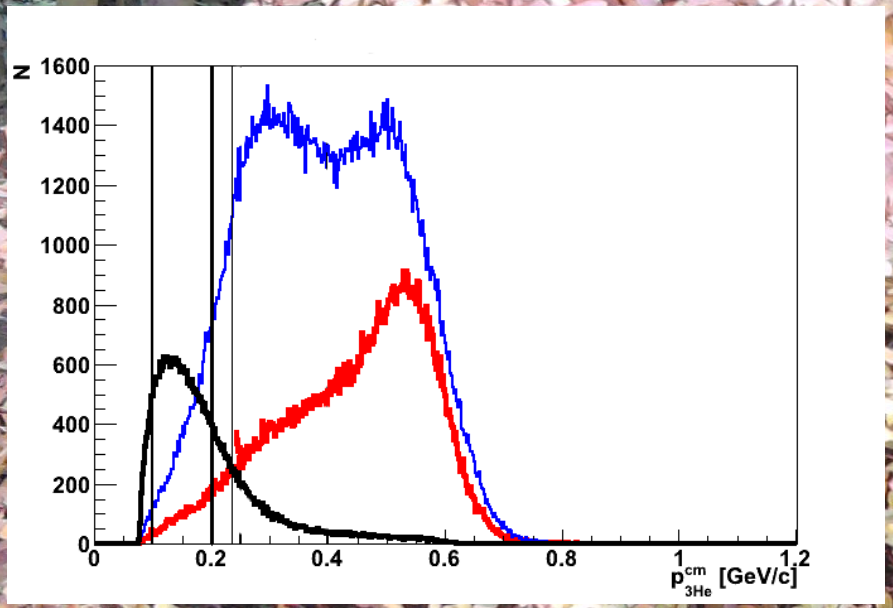
WASA-at-COSY

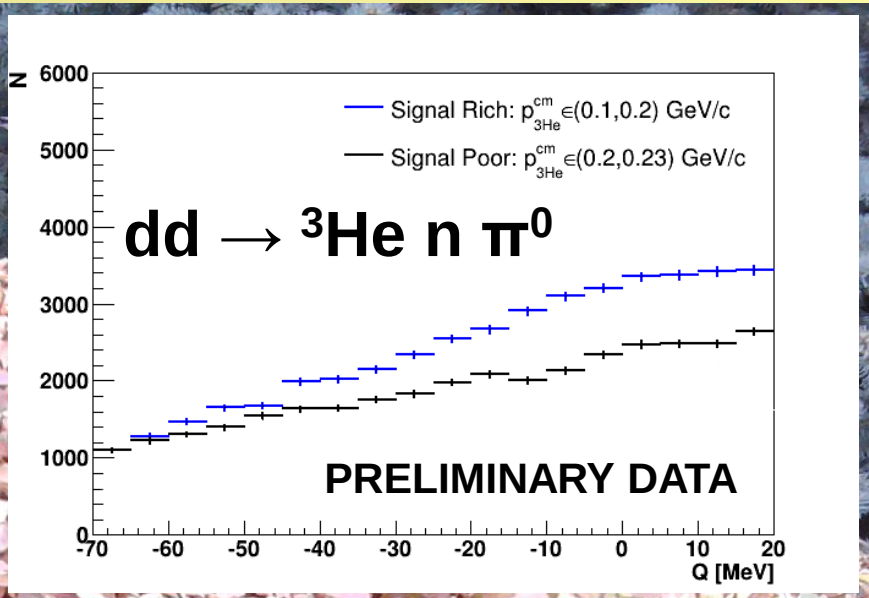

N
1600
1400
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
p^{cm}_{3He} [GeV/c]

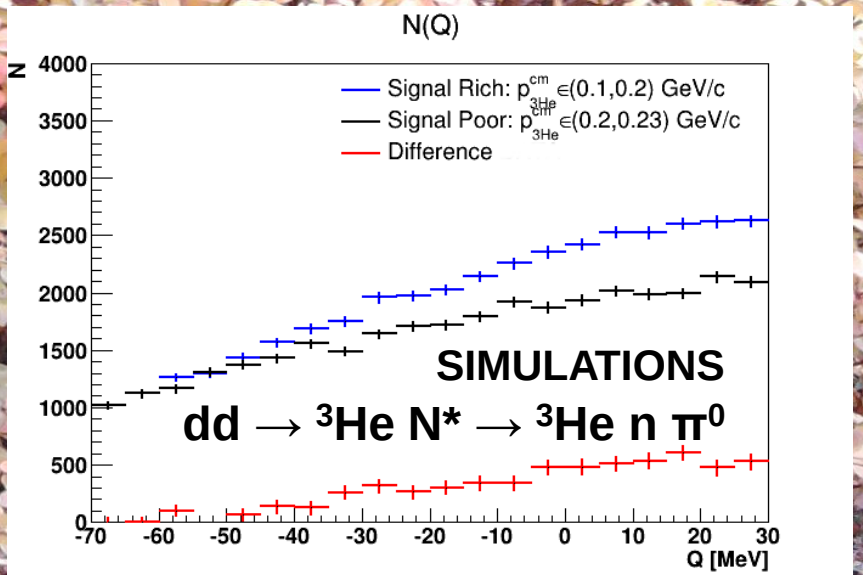

N
6000
5000
4000
3000
2000
1000
0
preliminary
Signal Rich: p^{cm}_{3He}∈(0.1,0.2) GeV/c
Signal Poor: p^{cm}_{3He}∈(0.2,0.23) GeV/c
dd → ^{3}He p π$^-$
-70
-60
-50
-40
-30
-20
-10
0
10
20
Q [MeV]


N
6000
5000
4000
3000
2000
1000
0
preliminary
Signal Rich: p^{cm}_{3He}∈(0.1,0.2) GeV/c
Signal Poor: p^{cm}_{3He}∈(0.2,0.23) GeV/c
dd → ^{3}He n π^0
-70
-60
-50
-40
-30
-20
-10
0
10
20
Q [MeV]

WASA-at-COSY


N
1600
1400
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
p^{cm}_{3He} [GeV/c]


N
6000
5000
4000
3000
2000
1000
0
Signal Rich: $p^{cm}_{3He} \in (0.1,0.2)$ GeV/c
Signal Poor: $p^{cm}_{3He} \in (0.2,0.23)$ GeV/c
dd → ^{3}He n π^0
PRELIMINARY DATA
-70
-60
-50
-40
-30
-20
-10
0
10
20
Q [MeV]


N(Q)
N
4000
3500
3000
2500
2000
1500
1000
500
0
Signal Rich: $p^{cm}_{3He} \in (0.1,0.2)$ GeV/c
Signal Poor: $p^{cm}_{3He} \in (0.2,0.23)$ GeV/c
Difference
SIMULATIONS
dd → ^{3}He N* → ^{3}He n π^0
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
Q [MeV]


THANK YOU
FOR YOUR ATTENTION