Matter and the Universe

Topic 2: *Cosmic Matter in the Laboratory*

Investigations of the charge symmetry breaking reaction dd → ^{4}Heπ^0 with WASA-at-COSY

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Motivation

Probing hadronic effects of u and d quark mass difference

Tool: Charge Symmetry (CS) → interchange of u and d quarks

dd → ^{4}Heπ^0: CSC ⇒ $\sigma = 0$ CSB ⇒ $\sigma \neq 0$, $\sigma \propto |M_{CSB}|^2$

Stephenson et al. (PRL 91 (2003) 142302)

σ_{tot} (Q=1.4 MeV) = 12.7 ± 2.2 pb

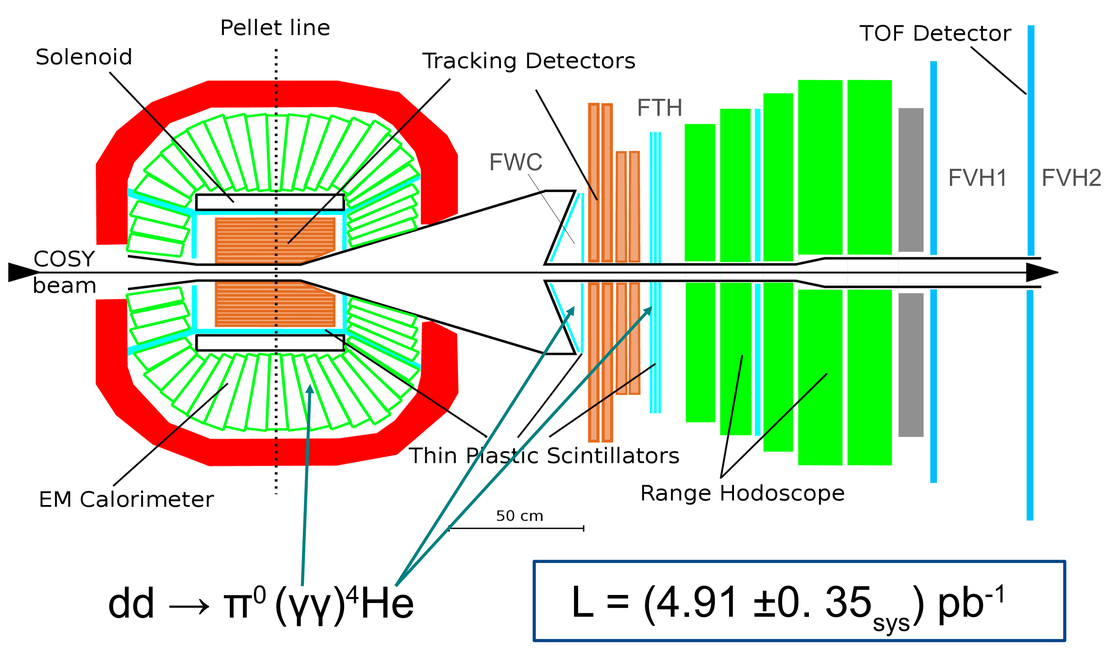
σ_{tot} (Q=3.0 MeV) = 15.1 ± 3.1 pb

→ consistent with **s-wave** π production

Theoretical predictions

Next step: Eperimental determination of **p-wave** contribution at Q=60 MeV

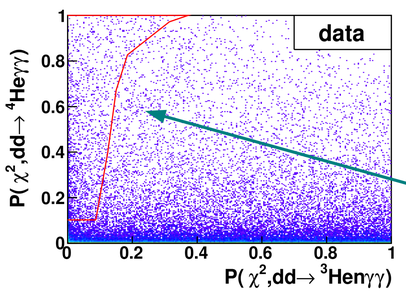
Previous experiment



dd → π^0 ($\gamma\gamma$)^{4}He

L = (4.91 ±0. 35$_{sys}$) pb^{-1}

Background: dd→pndπ^0, dd→tpπ^0, dd→pnpnπ^0,
dd→^{3}Henπ^0, **dd→^{4}He$\gamma\gamma$**



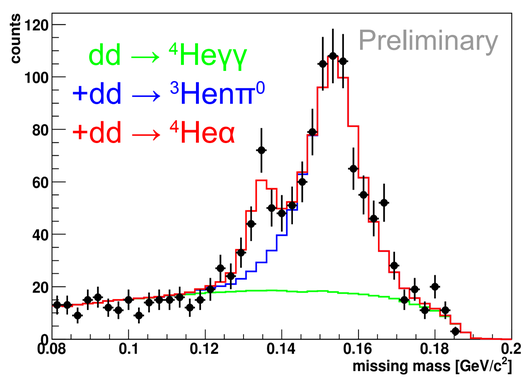
^{4}He identification: overall kinematic fit

2 hypothesis fitted:
dd → ^{4}He$\gamma\gamma$ and dd → ^{3}He$n\gamma\gamma$

Cut on cumulative probability distribution

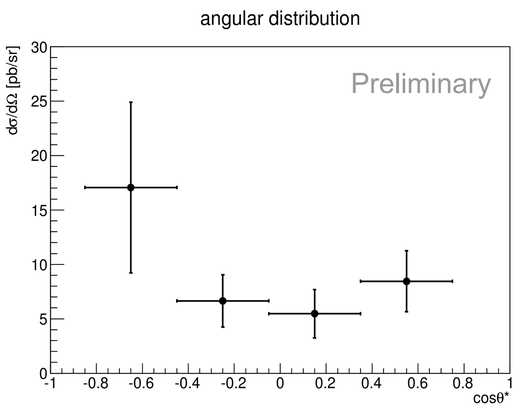
Suppression of dd→^{3}Henπ^0 better than 10^{-4}

Results

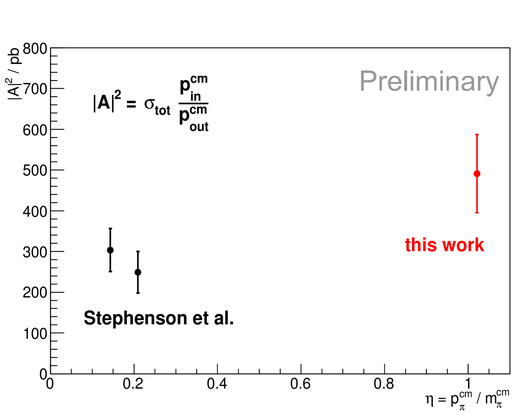


^{4}He missing mass

dd→^{4}Heπ^0: $\sigma_{tot,\,prel}$ = 118 ± 18$_{stat}$ ± 13$_{sys}$ ± 8$_{norm}$ pb



Resulting angular distribution



Phase space corrected total cross section

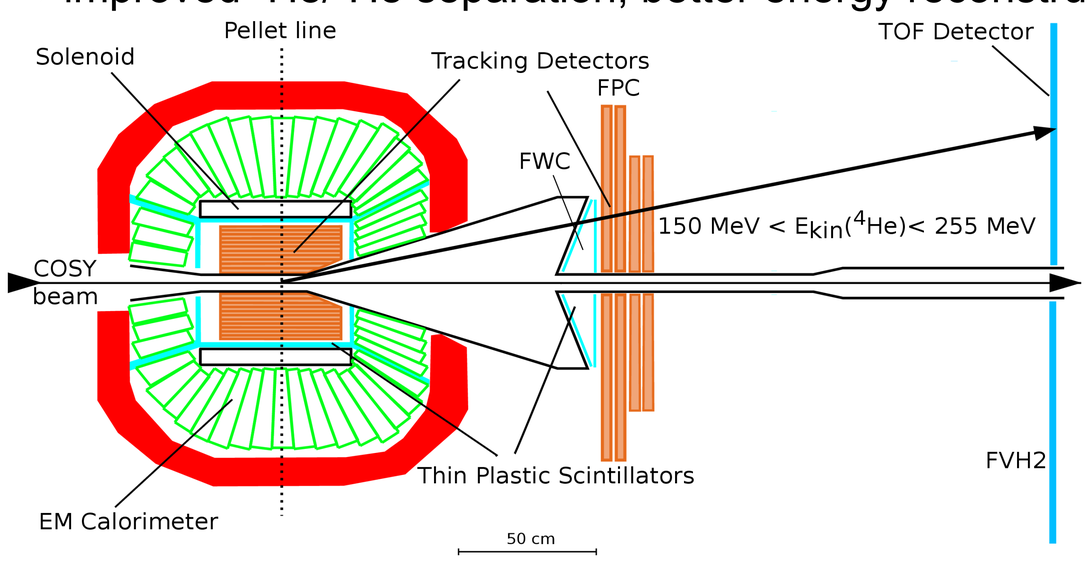
Consistent with s-wave:

higher statistics and increased sensitivity needed

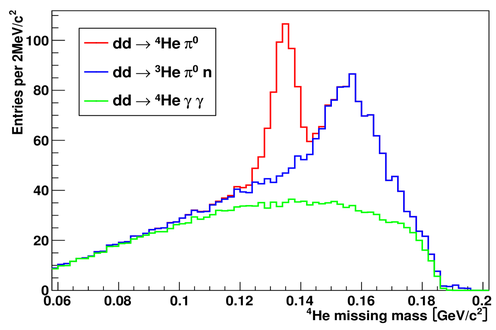
Current approach

Modified setup: using **time-of-flight**

→ improved ^{3}He/^{4}He separation, better energy reconstruction



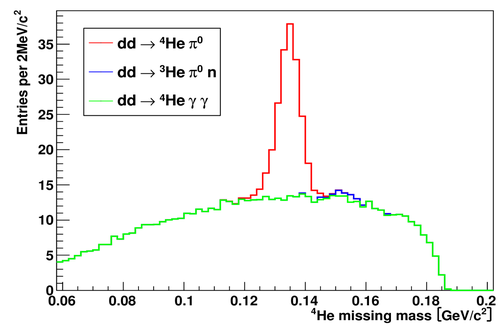
Expected results



Time-of-flight cut only

→ Similar level of ^{3}He bg reduction

→ Higher efficiency for signal



Time-of-flight + probability cut

→ Bg from ^{3}He basically disappears

→ remaining (flat) bg - dd→^{4}He$\gamma\gamma$

8 week long experimental run with new detector setup in 2014

Expected 4x higher integrated luminosity than in the previous experiment

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