Investigations of the Charge Symmetry conserving reaction d d $\rightarrow$ ^{3}He N π with WASA-at-COSY

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for the
WASA-at-COSY Collaboration

- physics motivation
- concept of measurement
- status of analysis
- summary and outlook

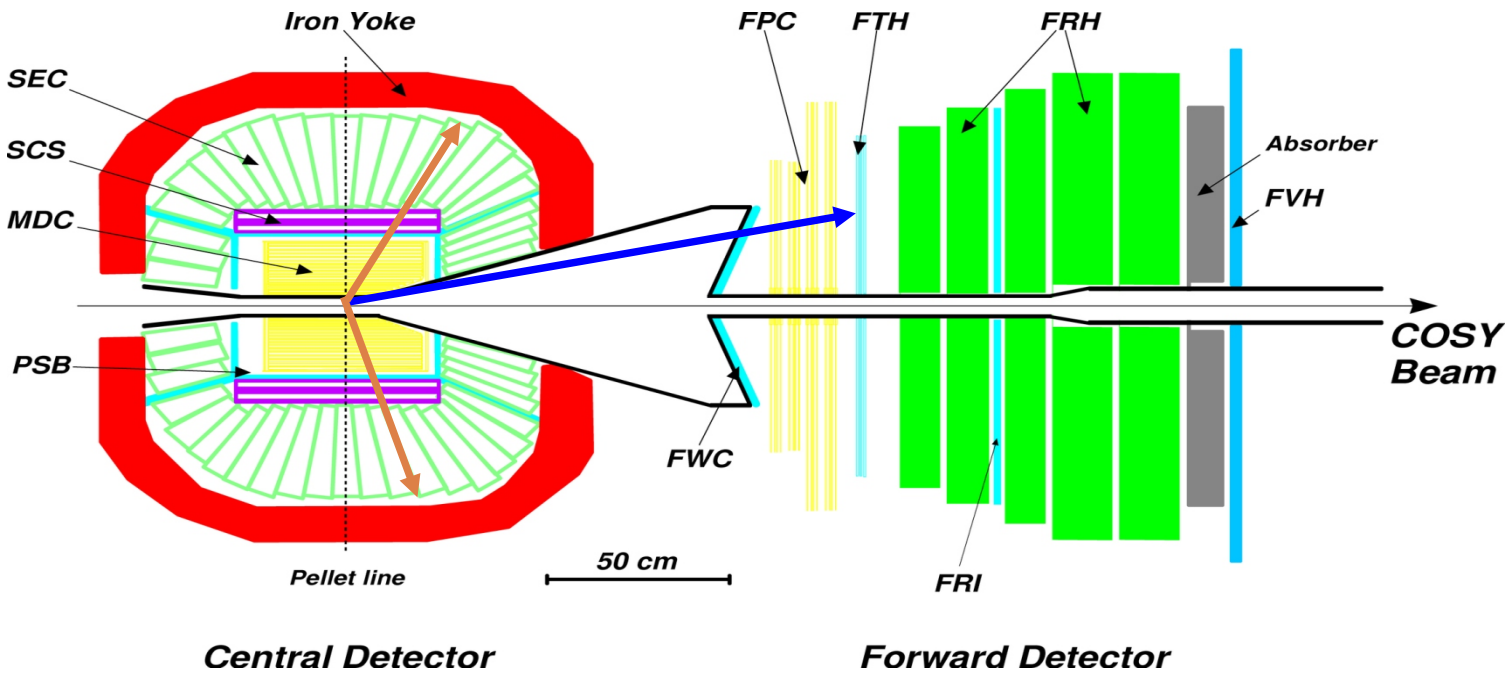
Motivation

WASA-at-COSY: Investigation of fundamental symmetries in hadron physics

Measurement of Charge Symmetry Conserving reaction d d $\rightarrow$ ^{3}He n π^0 at 1.2 GeV/c as a first step towards d d $\rightarrow$ ^{4}He π^0

- the same initial state as in d d $\rightarrow$ ^{4}He π^0
- study the isospin conserving π^0 production in 4N system (the same partial waves) *s-* and *p-* wave pion production: $^3P_0$, $^3P_1$, and $^5D_0$, $^5D_1$, $^5D_2$, $^1S_0$, $^5S_2$ for dd system
- for d d $\rightarrow$ A N π the transition operators can be calculated within ChPT with known amplitudes (since the reaction is isospin conserving)
- unknown cross section

Measurement of the d d → ^{3}He n π^0

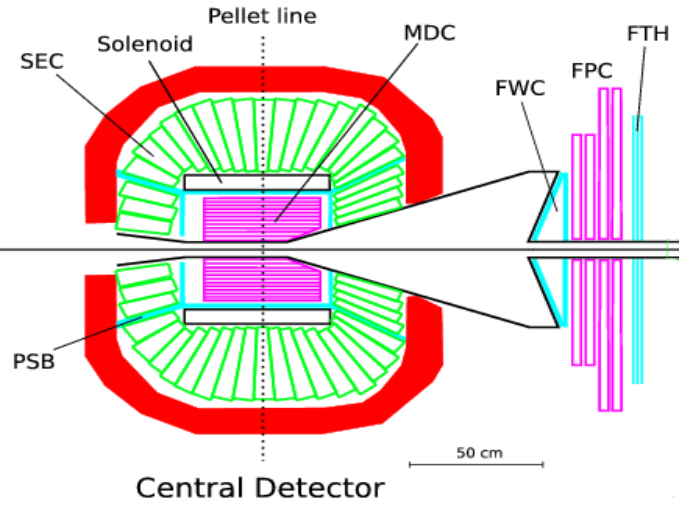


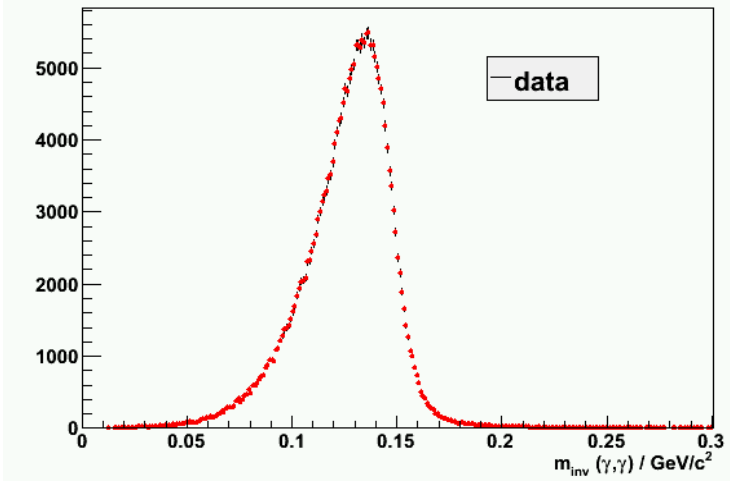
deuteron beam, deuteron target

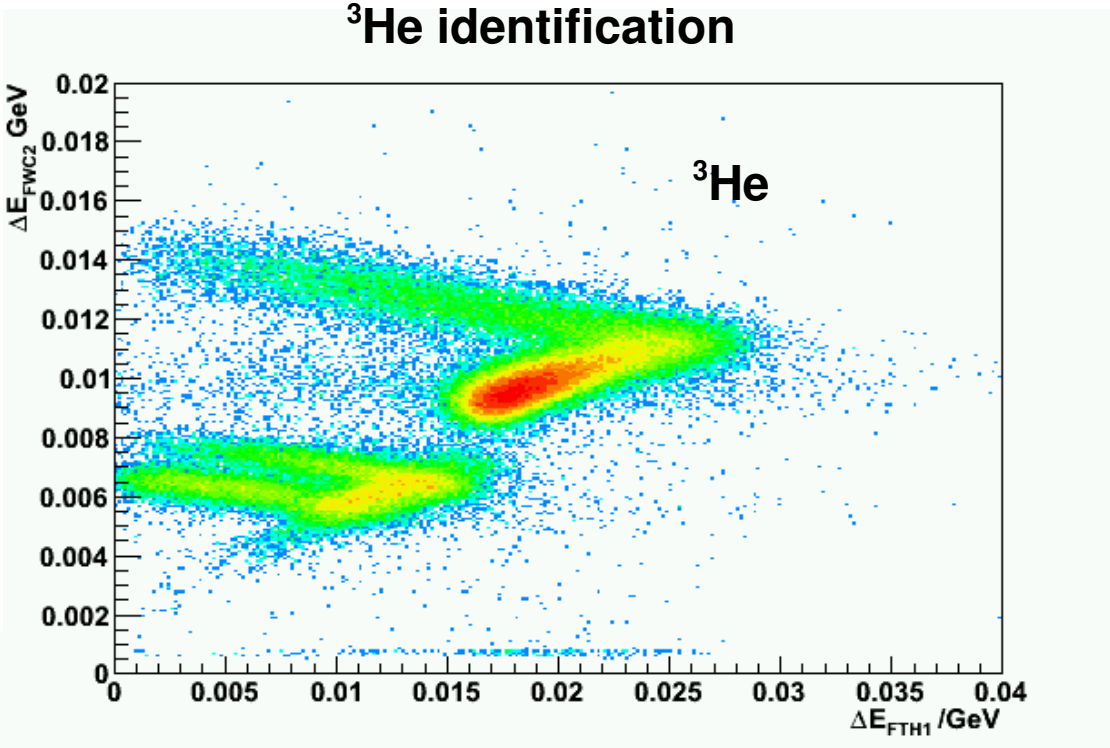
^{3}He identified in FD, mostly stopped in FTH2

$\pi^0 \rightarrow \gamma\gamma$ detected in CD

Signature of the d d → ^{3}He n π^0



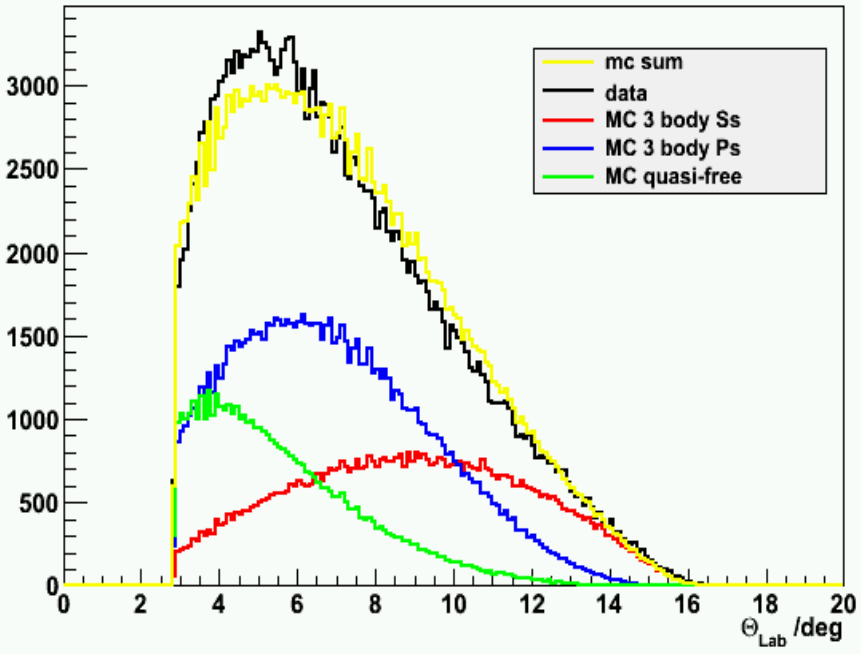


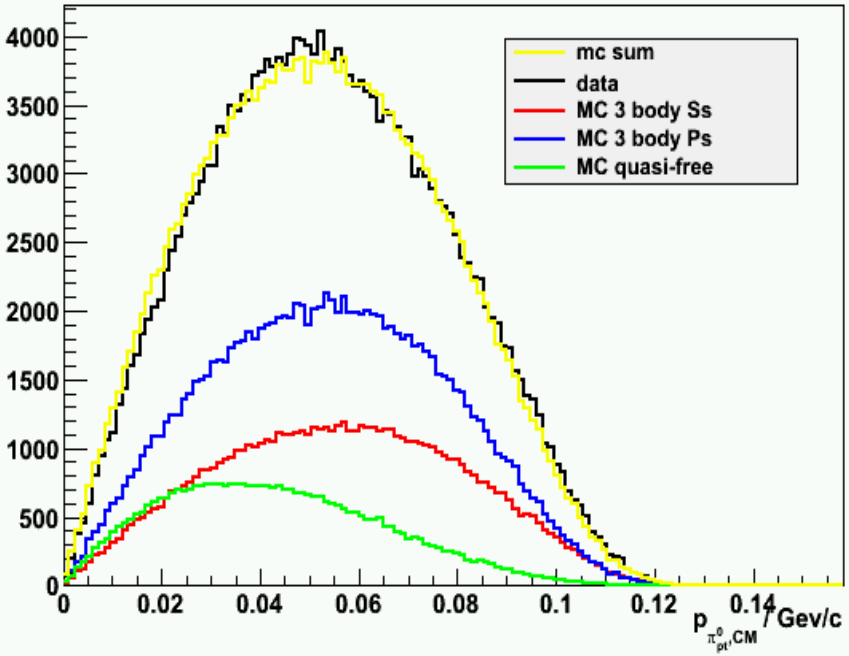


Event selection

- one ^{3}He candidate in Forward Detector
- two neutral clusters in Calorimeter
- no charged hits in Central Tracker

Kinematic studies





3 body phase space:

s- wave in both systems , *s*- wave in π-n system, *p*- wave for ^{3}He

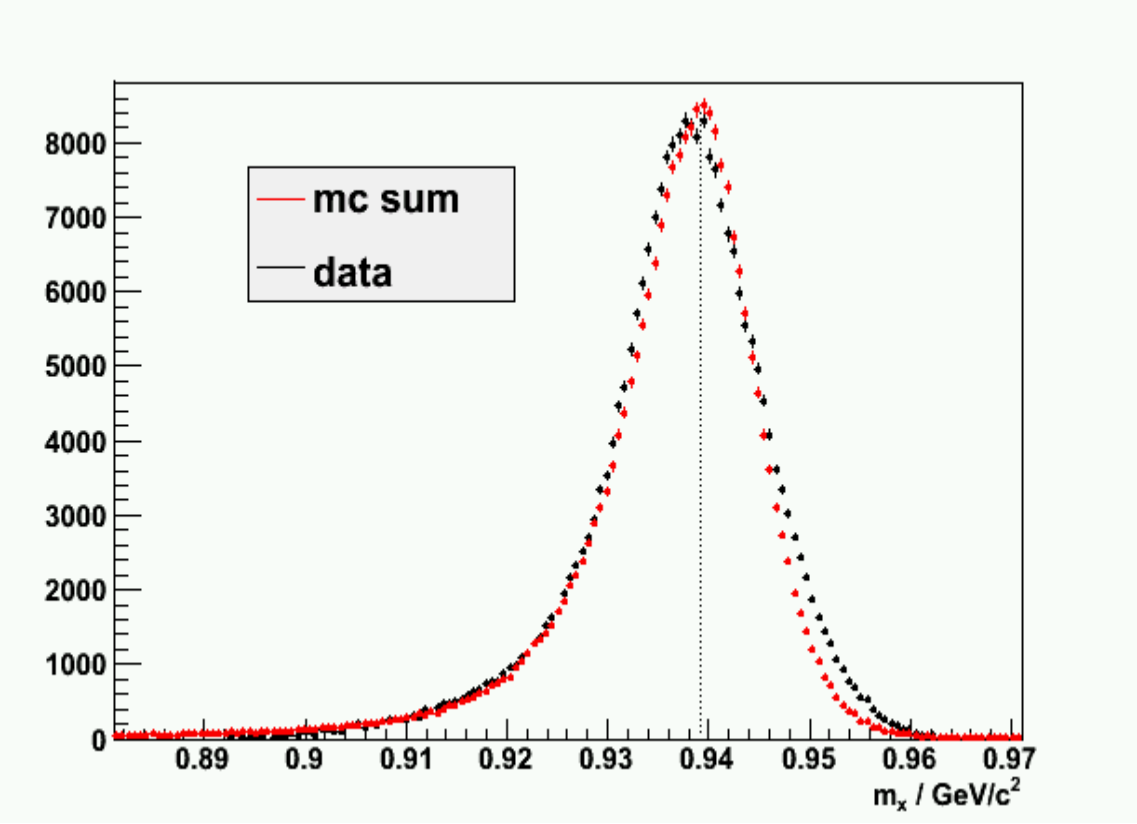
- angular distribution for ^{3}He in CM (for *s*- isotropic , for *p*- quadratic)
- π angular distribution isotropic in π-n

quasi free (n spectator from target)

- π angular distribution from Cameron et al., Nucl. Phys. A472 (1987) 718, pd → ^{3}Heπ^0 @ 350 MeV

Results of analysis

missing mass of $^3He\pi^0$



statistics ≈ 200000 events

neutron undetected

^3He, π^0 measured

Kinematic fit

d d → ^{3}He π^0 n

E_{kin},Θ,φ fixed

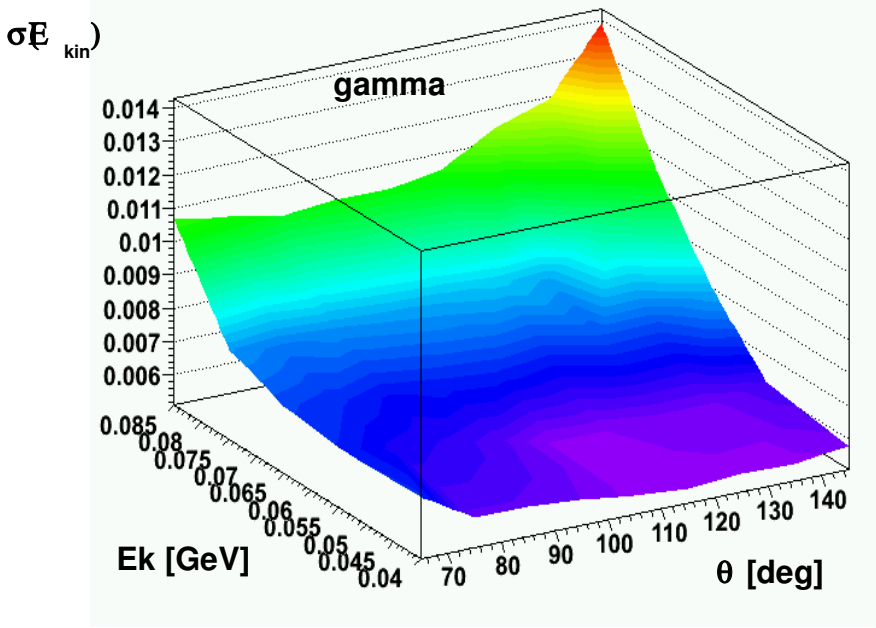
E_{kin},Θ,φ measured

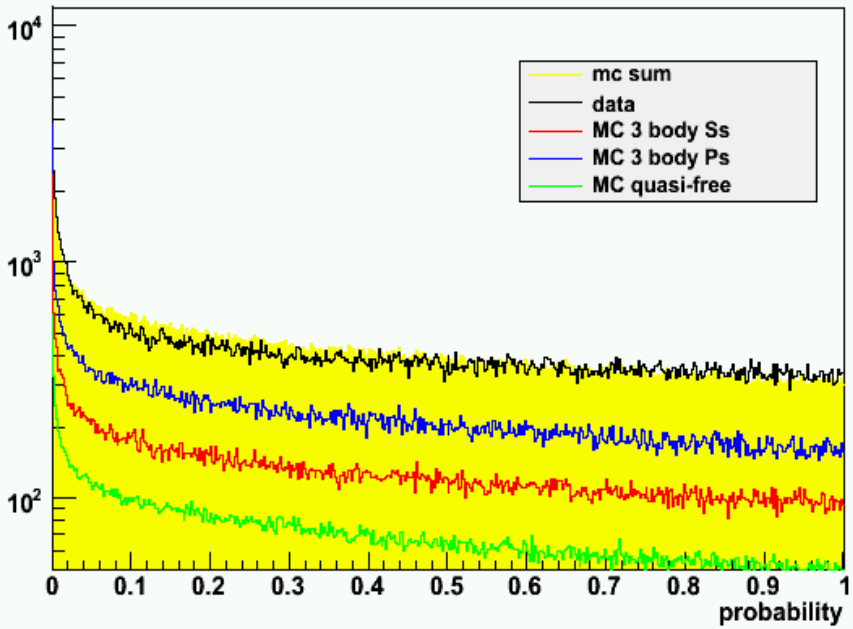
unmeasured

four- momentum conservation law

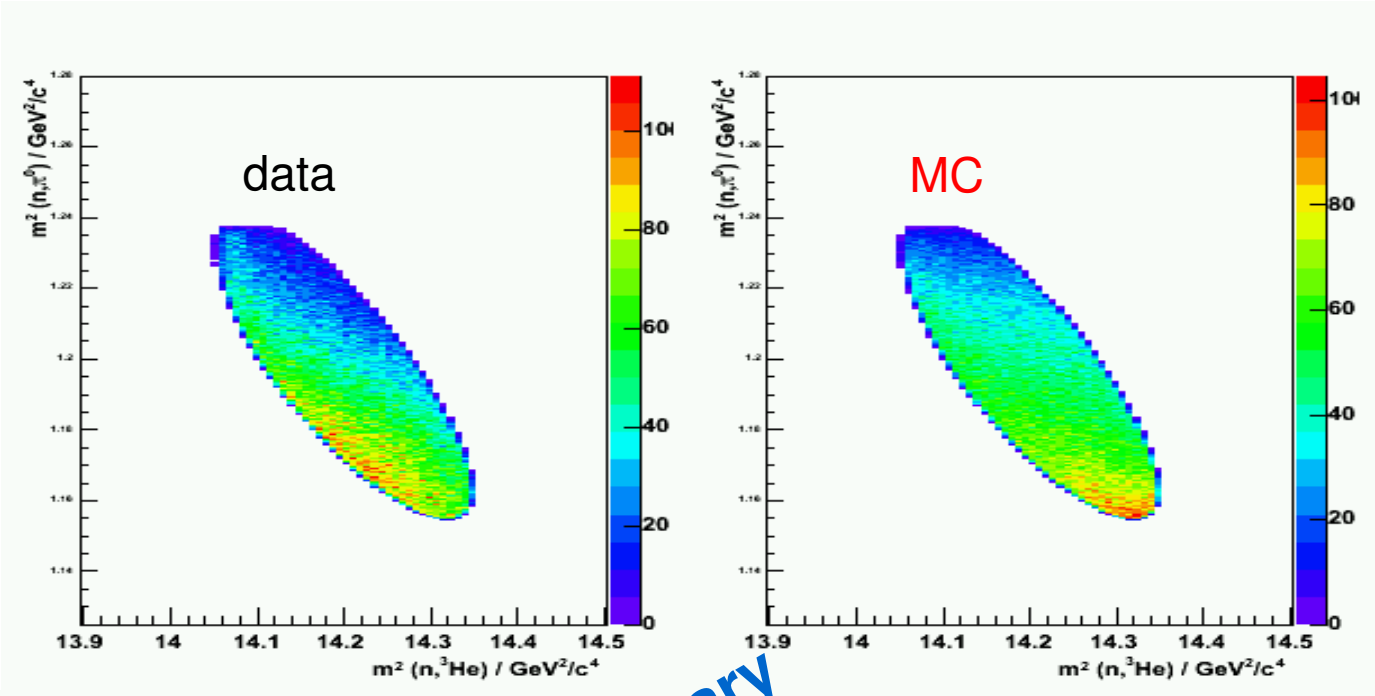
plus constraint on pion mass

error parametrisation

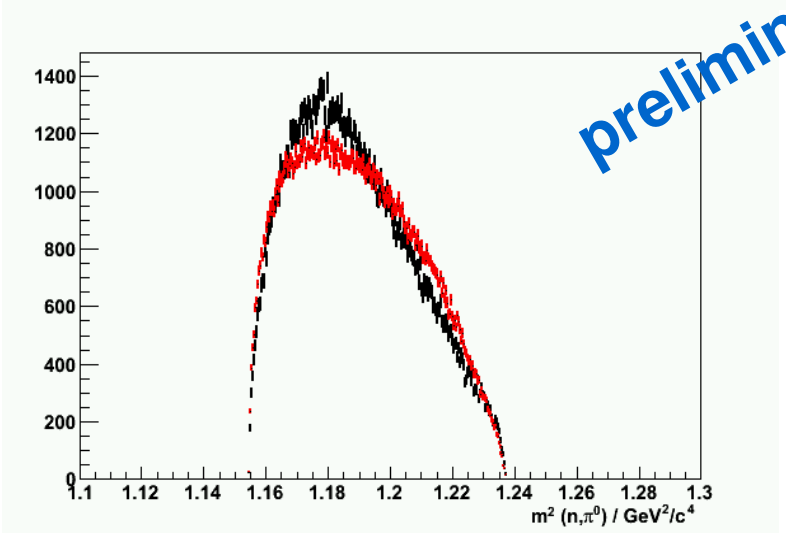


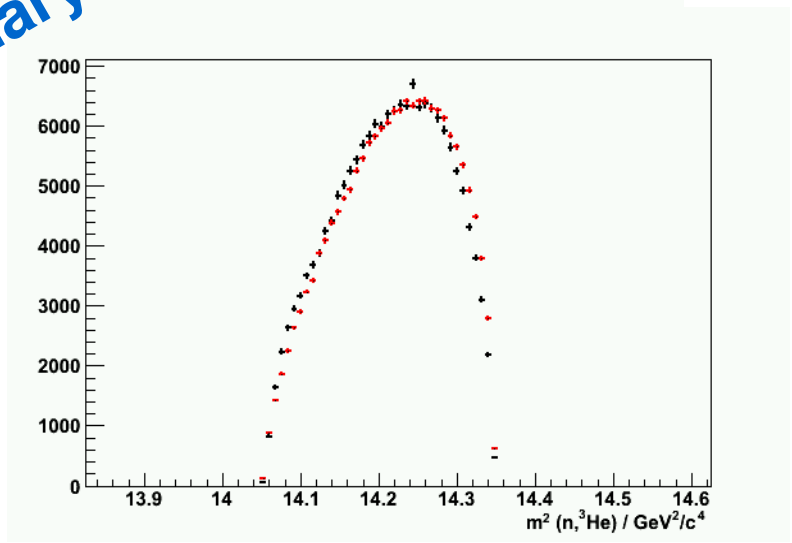


Dalitz Plot



preliminary

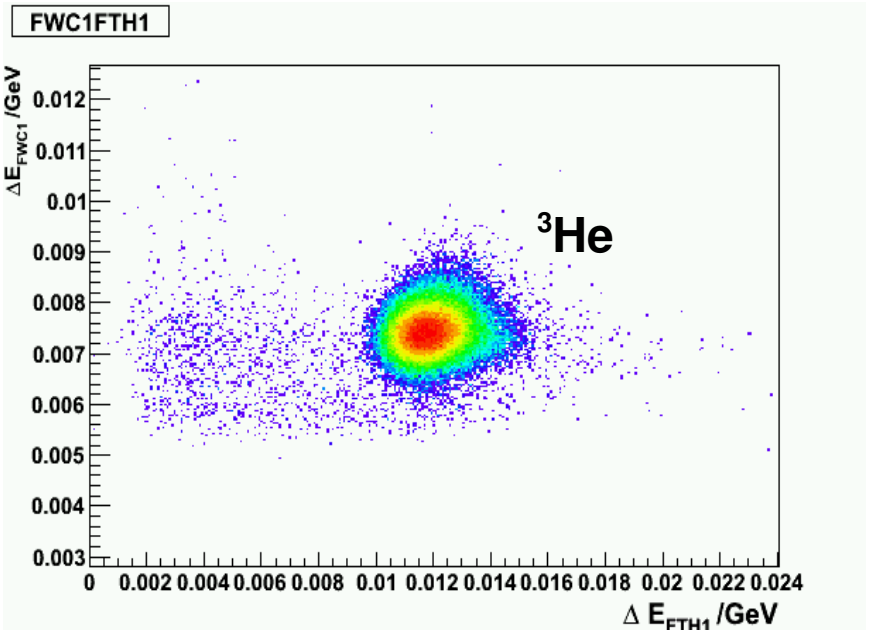




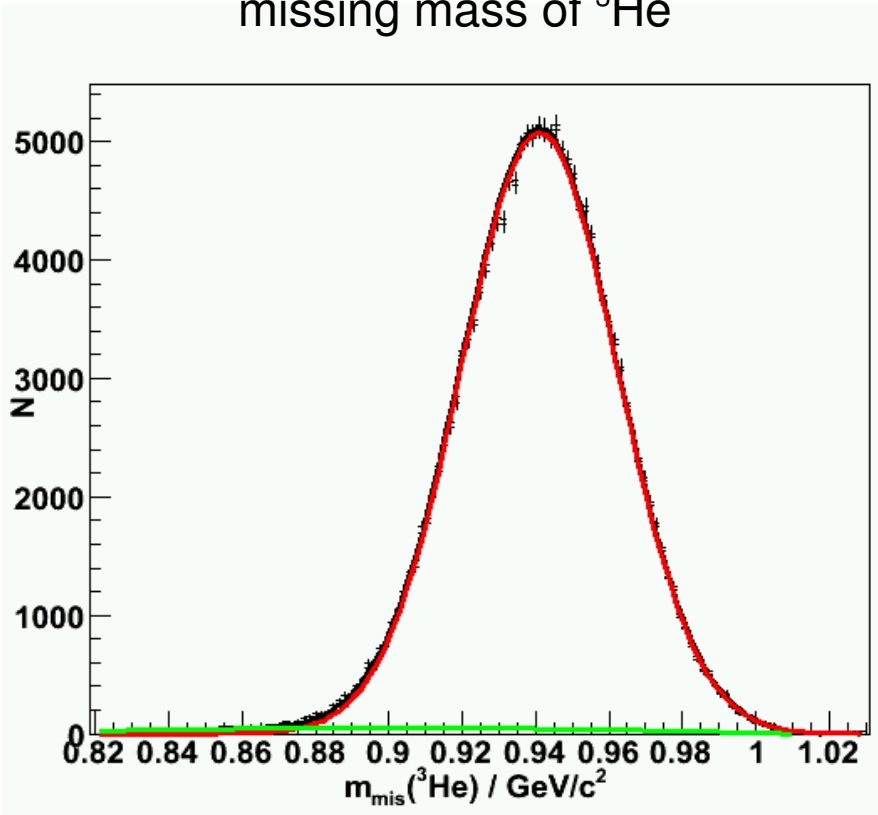
Luminosity determination

identification of binary reaction: d d → ^{3}He n

one ^{3}He candidate in FD,
cut on energy deposit in FRH1



missing mass of ^{3}He

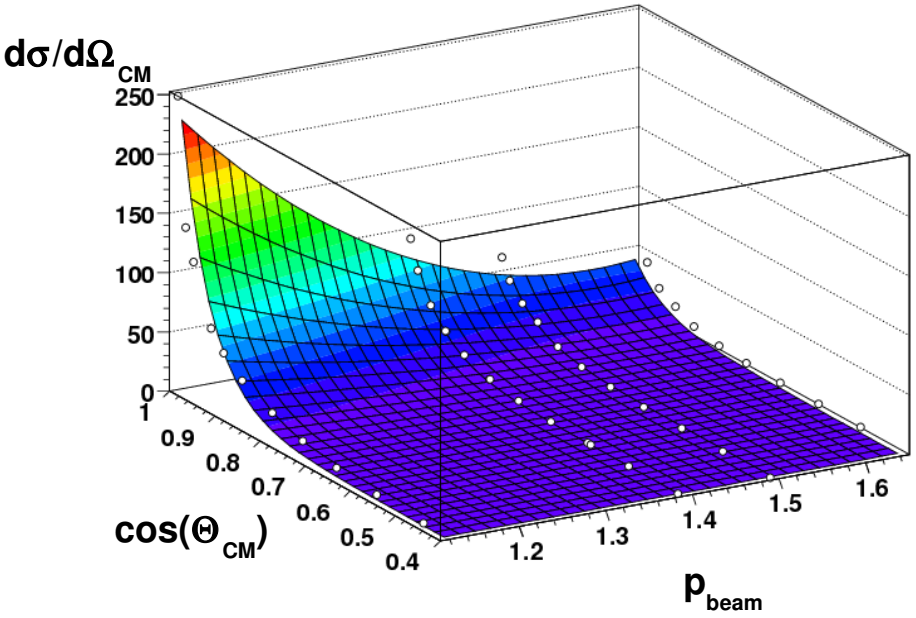


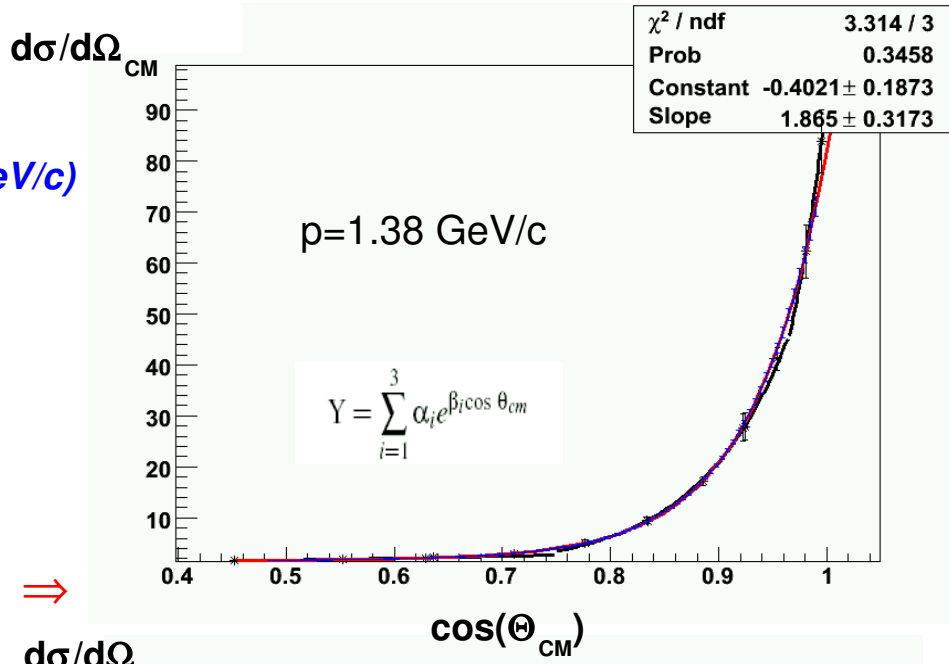
Luminosity determination

G. Bizard et.al., Phys. Rev. C 22 (1980)

d d → ^{3}He n p=1.651, 1.89, 1.992, 2.492 (GeV/c)

d d → ^{3}H p p=1.109, 1.38, 1.493, 1.651, 1.787 (GeV/c)





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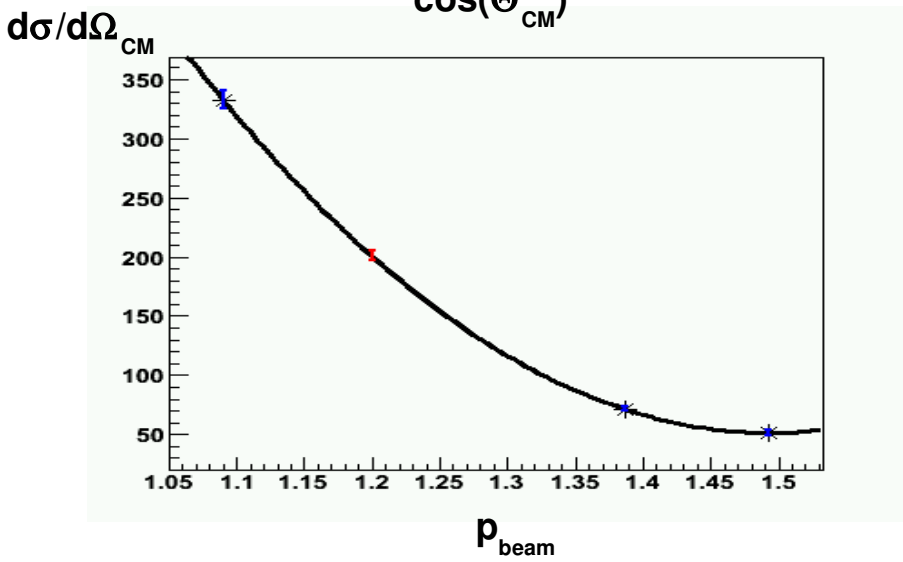


all (4) energies parametrized

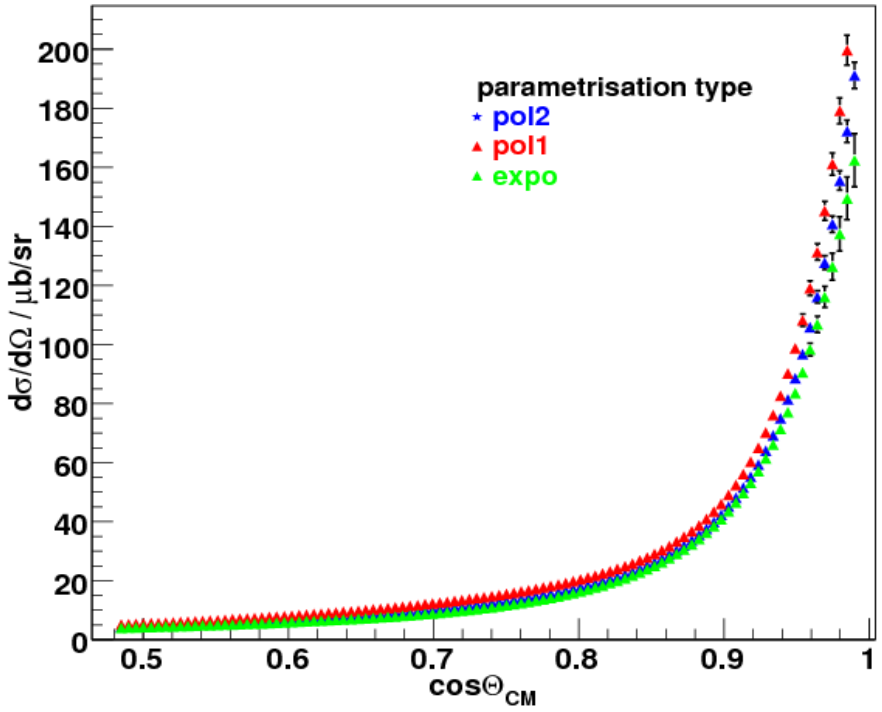
at fixed angles: interpolate to 1.2 GeV/c

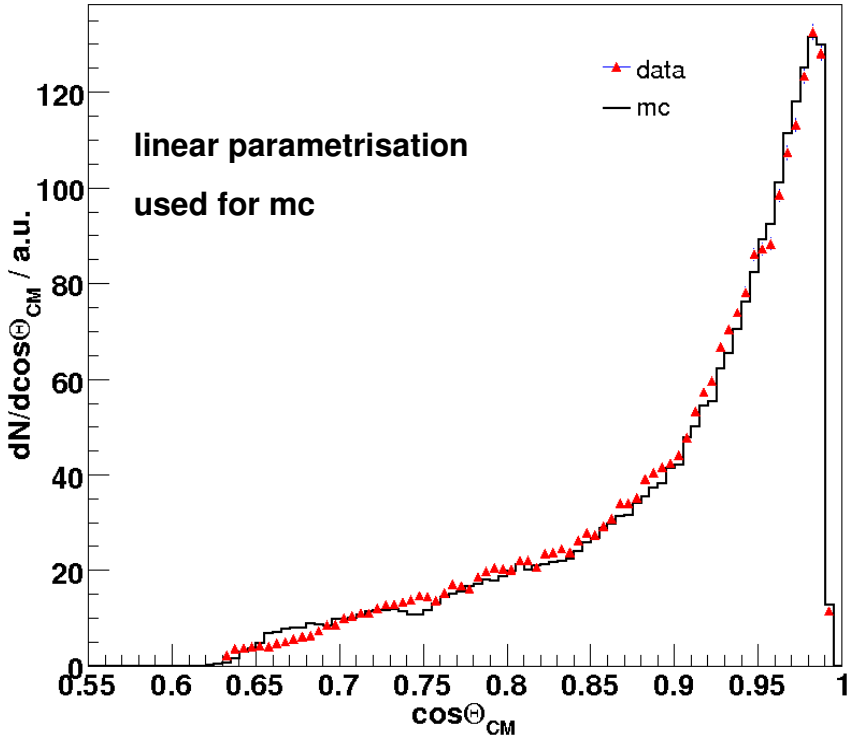
Luminosity determination

cross section at 1.2 GeV/c

σ calculated numerically, range (0.756-0.96)

preliminary



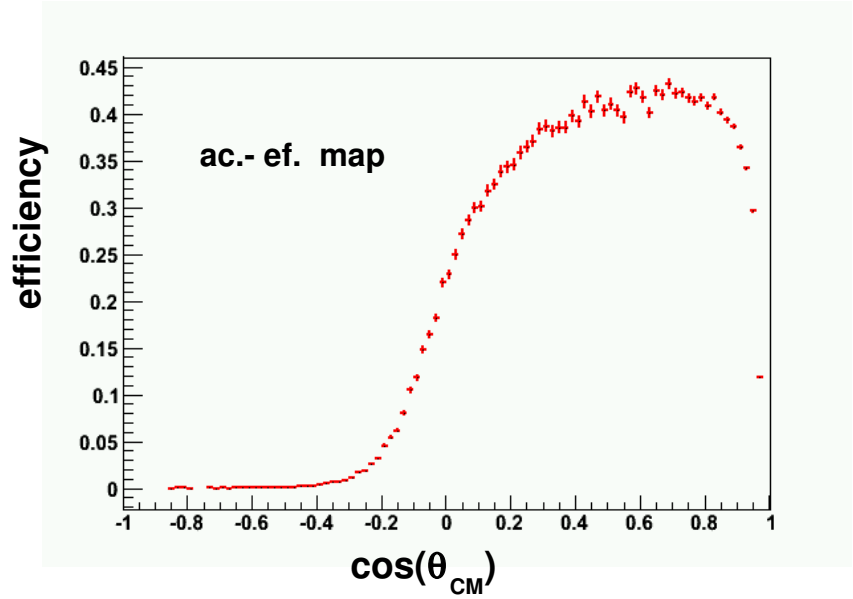


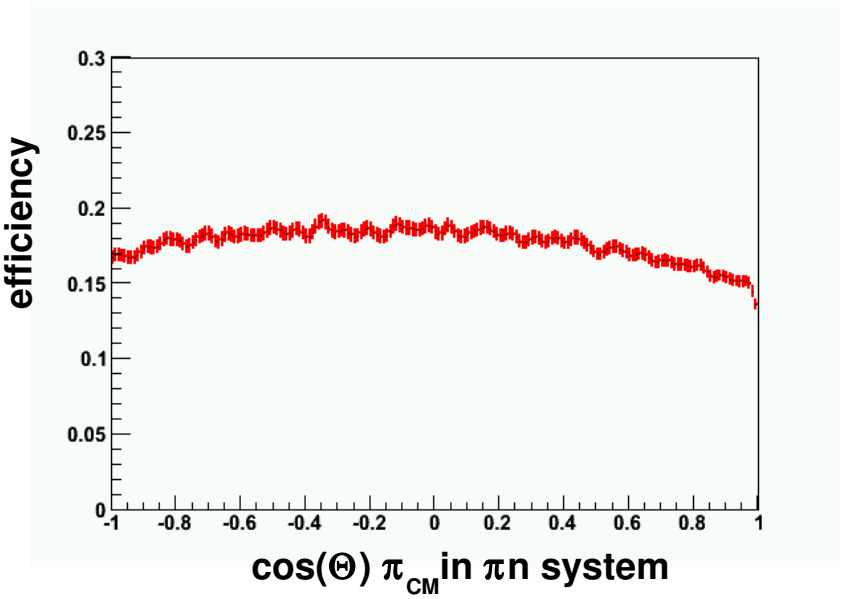
σ_{int} = 53.6 ± 3.8 (sys) → σ(pol1)- σ(expo)

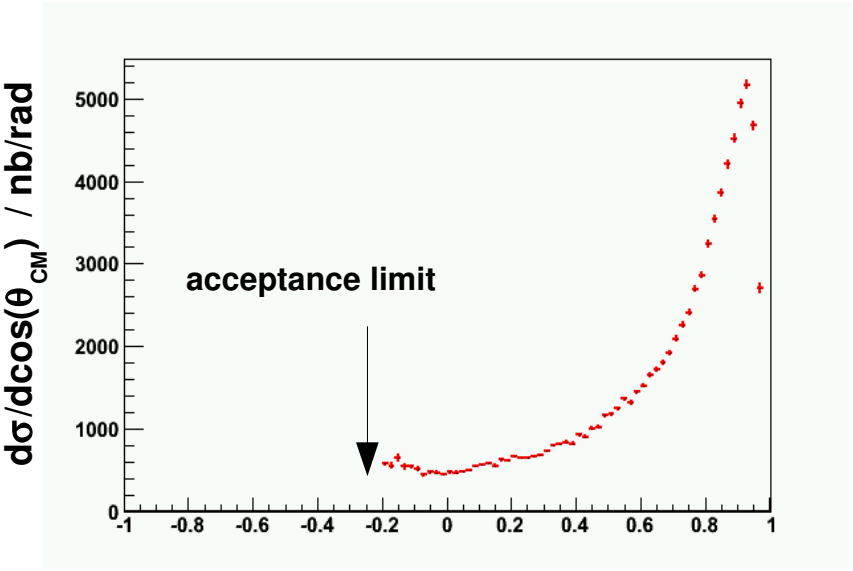
L_{int} = (350.1 ± 1.8(stat) ± 24.8(sys)) nb^{-1}

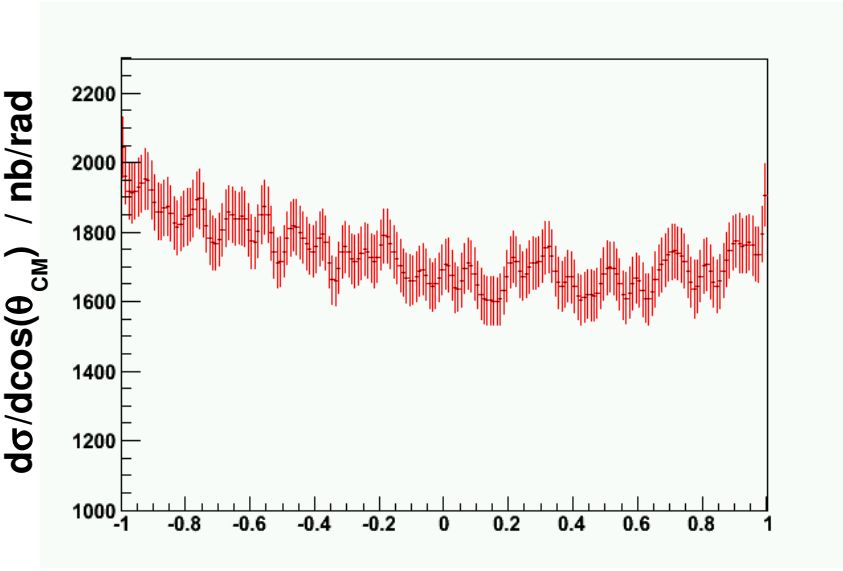
(plus 7% in the absolute normalization of Bizard data)

Differential distributions









Total cross section

L_{int} = (350.1 ± 1.8(stat) ± 24.8(sys)) nb^{-1}

$$\sigma_{TOT} = \frac{N_{exp}}{L_{inte} \cdot \epsilon_{eff-acc}} \qquad \epsilon_{eff-acc} = \frac{A_1 \cdot w_1 + A_2 \cdot w_2 + A_3 \cdot w_3}{G_1 \cdot w_1 + G_2 \cdot w_2 G_3 \cdot w_3}$$

σ_{TOT} = (3.47 ± 0.02(stat) ± 0.40(sys)) μb

preliminary

theoretical estimations for: d d → ^{4}He π^0

σ_{TOT}(1.4/3 MeV) ≈ 12/15 pb **scaling by s- wave ph. sp.** σ_{TOT}(60 MeV) ≈ 100 pb

Taking the amplitude of the Charge Symmetry Breaking channel as reference, which is suppressed by factor α compared to Charge Symmetry Conserving one, the cross section is expected to be approximately a factor $(1/\alpha)^2 \approx 2 \cdot 10^4$ larger

summary and outlook

- high statistics (200000 events) sample of d d $\rightarrow$ ^{3}He n π^0 collected
- preliminary cross section
  - important in the context of d d $\rightarrow$ ^{4}He π^0, main background channel
- preliminary studies of Dalitz plots give a hint that for d d $\rightarrow$ ^{3}He n π^0 at Q $\approx$ 60 MeV

  in final state we have mostly ^{3}He in *p-* wave and pion in *s-* wave in π-n system

outlook

comparison of results with:

d d $\rightarrow$ ^{3}He p π^- WASA (analysis W. Weglorz)

d d $\rightarrow$ ^{3}He N π close to threshold, ANKE (analysis M. Smiechowicz)

Support from Theoreticians needed