Westfälische
Wilhelms-Universität
Münster

Investigation of different normalization reactions for dp collisions at ANKE

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DPG Heidelberg (HK 37.5)

March 24th, 2015

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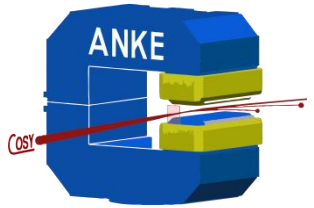

Motivation

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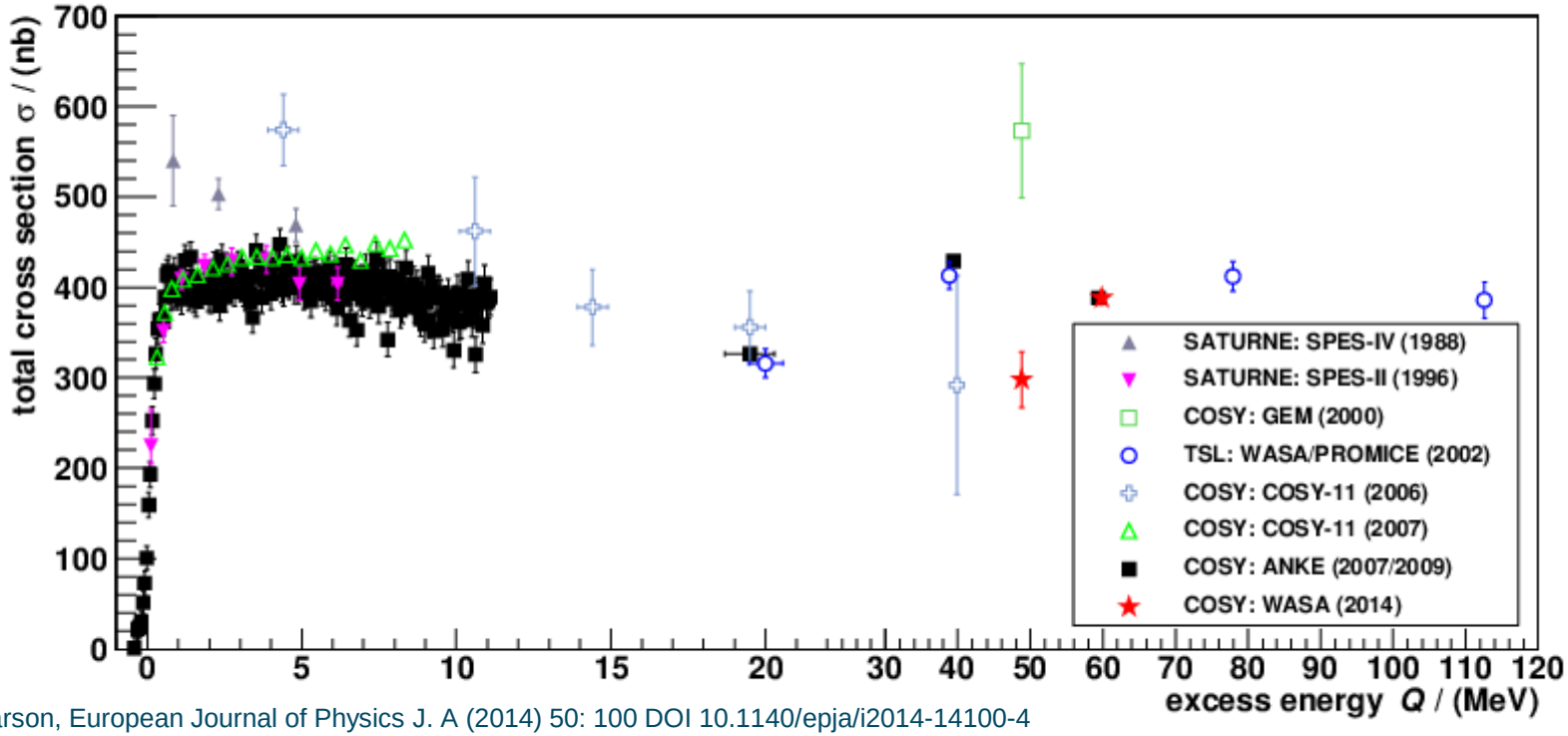

P. Adlarson, European Journal of Physics J. A (2014) 50: 100 DOI 10.1140/epja/i2014-14100-4

- total and differential cross sections of the reaction $dp \rightarrow {}^3\mathrm{He}\eta$ are of special interest
- indication of a quasi bound state of the ${}^3\mathrm{He}\eta$-system
- high precision data from the ANKE spectrometer at COSY up to $Q = 15\ \mathrm{MeV}$

  ⇒ extraction of total and differential cross sections

  ⇒ careful luminosity determination is necessary

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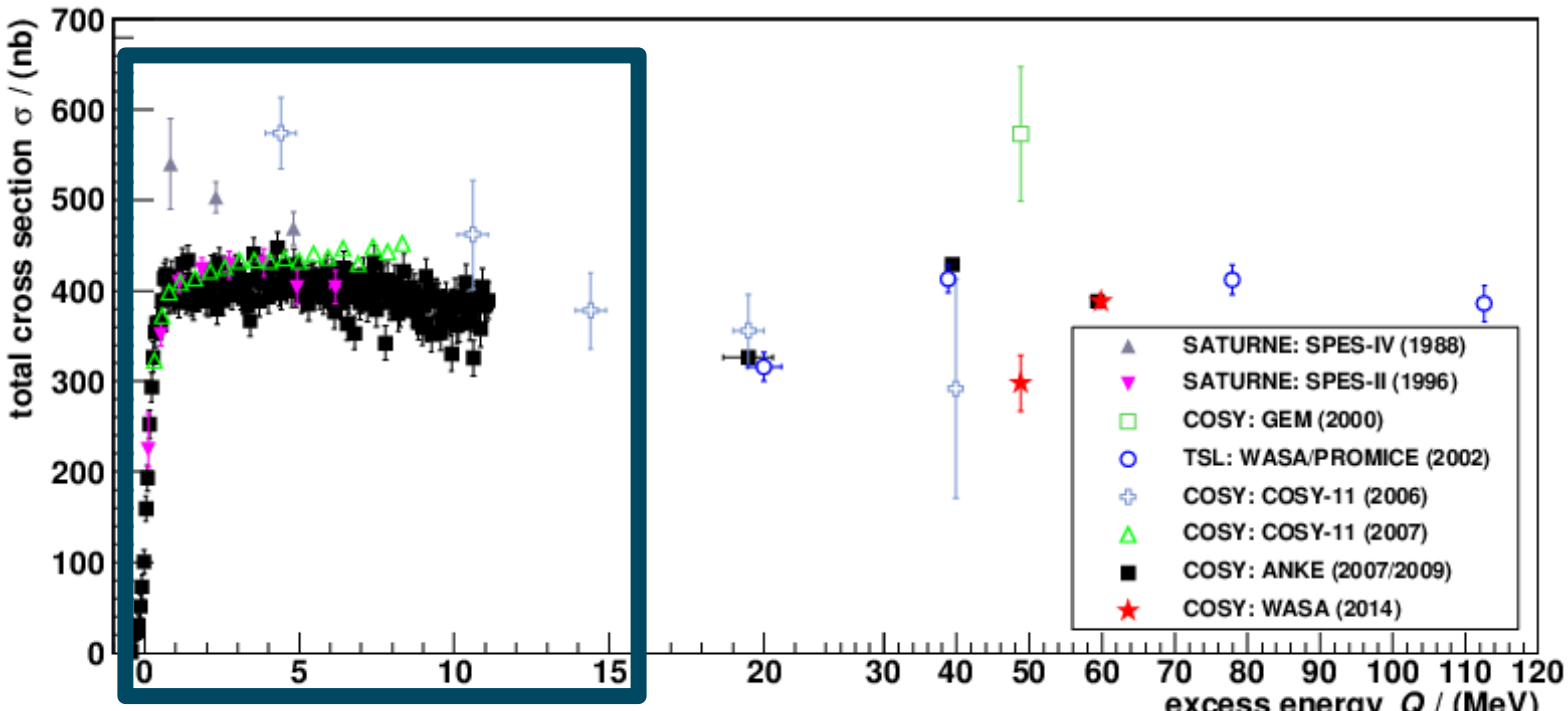

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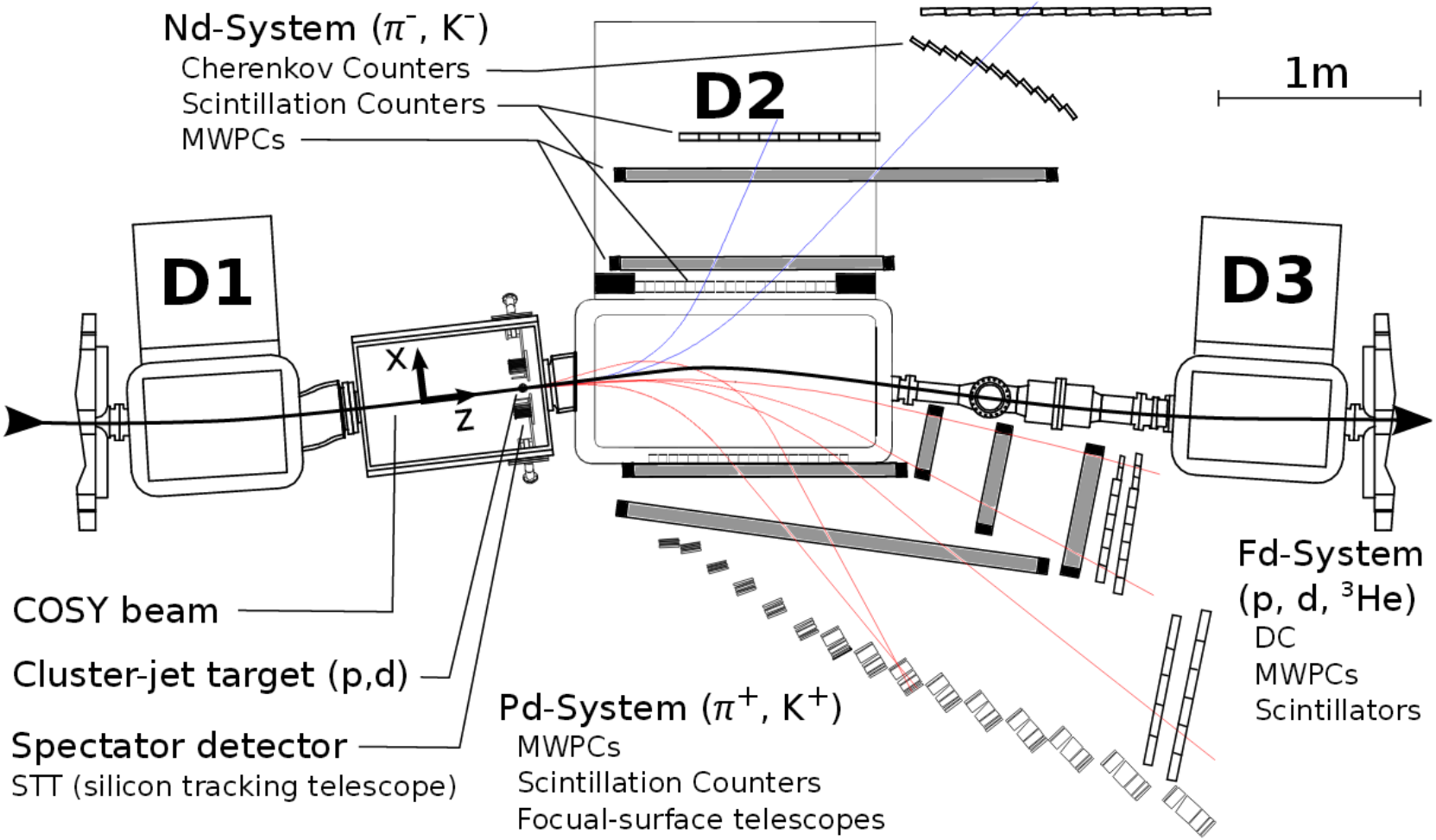
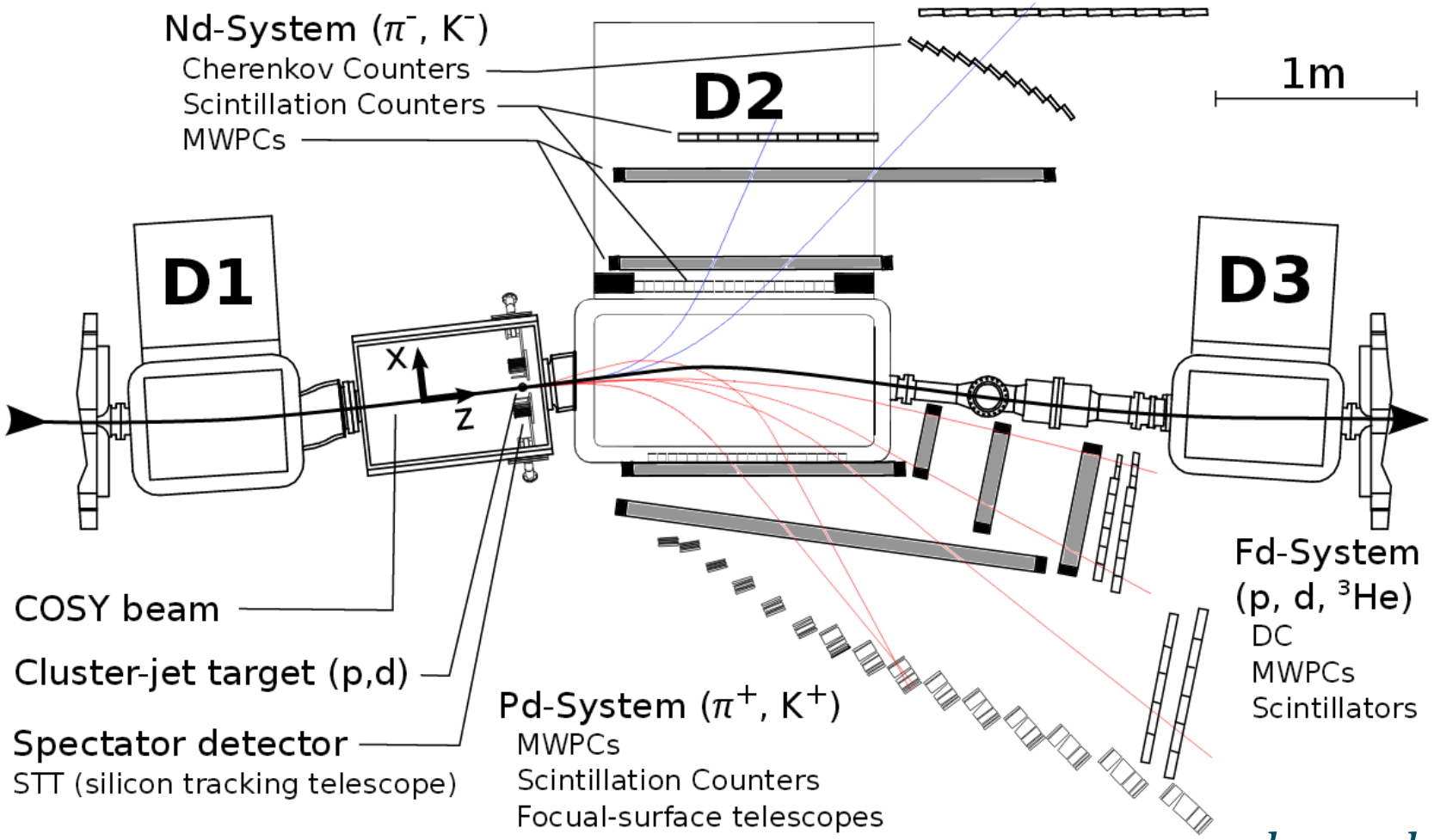
ANKE spectrometer



S. Barsov, Nuclear Instruments and Methods in Physics Research A 462 (2001) 364-381

ANKE spectrometer



$dp \rightarrow dp$

$dp \rightarrow dp_{spec}\pi^0$

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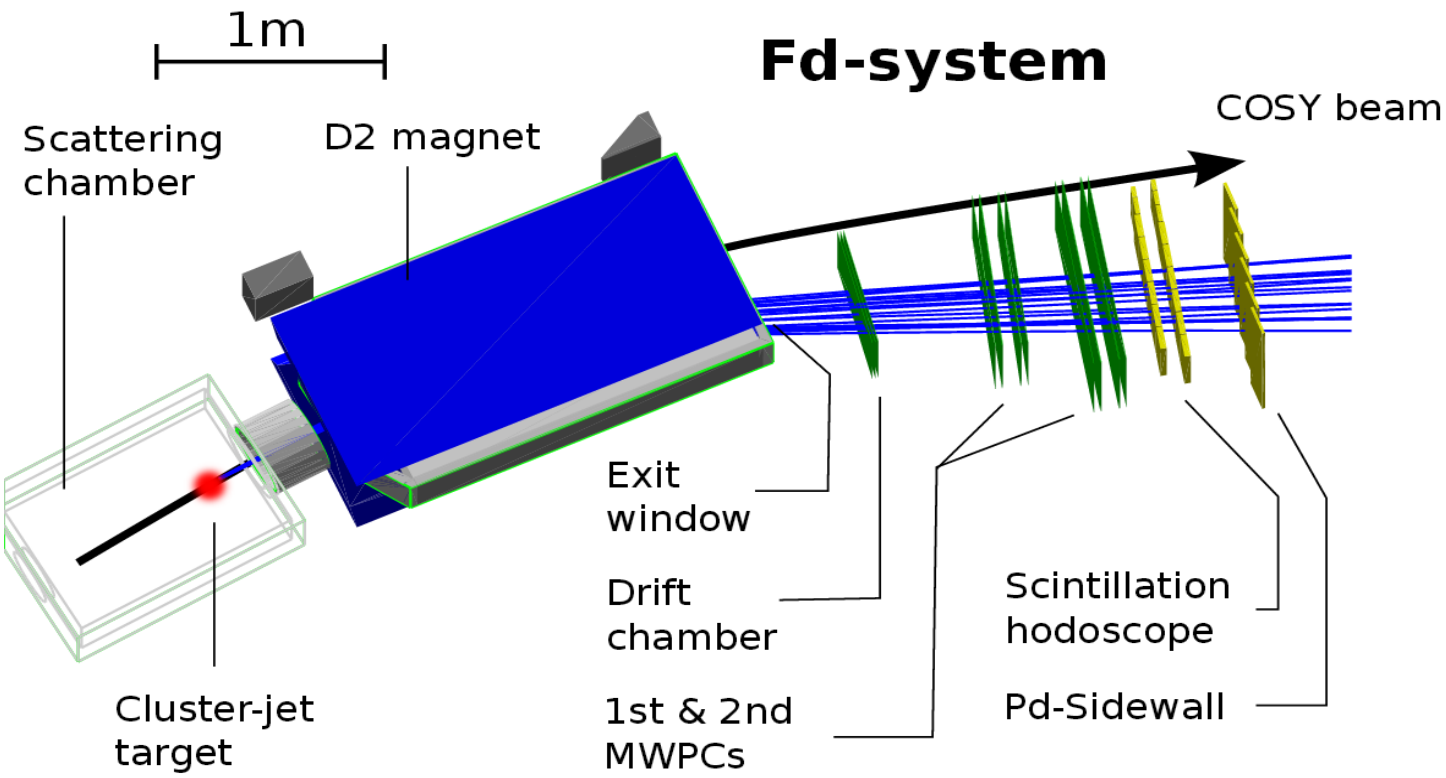
Forward detection system (Fd)



- track reconstruction

  ⇒ one multiwire drift chamber and two multiwire proportional chambers

- energy loss measurements

  ⇒ two layers of scintillator hodoscopes

Beam time details

- main goals: high precision determination of the η meson mass ($dp \rightarrow {}^3\mathrm{He}\eta$) and studies on the two pion production ($dp \rightarrow {}^3\mathrm{He}\pi^+\pi^-$)
- supercycle mode: one supercycle consists of up to 7 different beam momenta

  ⇒ 19 beam momenta overall

flattop	1st supercycle p_d / (MeV/c)	2nd supercycle p_d / (MeV/c)	3rd supercycle p_d / (MeV/c)
0	3120.17(17)	3120.00(22)	3125
2	3146.41(17)	3147.35(17)	3146
3	3148.45(17)	3150.42(17)	-------
4	3152.45(17)	3154.49(17)	3157.48(22)
5	3158.71(17)	3162.78(17)	3160.62(22)
6	3168.05(17)	3172.15(17)	-------
7	3177.51(17)	3184.87(17)	3204.16(23)

Beam time details

below η threshold ($dp \rightarrow {}^3\mathrm{He}\eta$) for a smooth background description

flattop	1st supercycle p_d / (MeV/c)	2nd supercycle p_d / (MeV/c)	3rd supercycle p_d / (MeV/c)
0	3120.17(17)	3120.00(22)	3125
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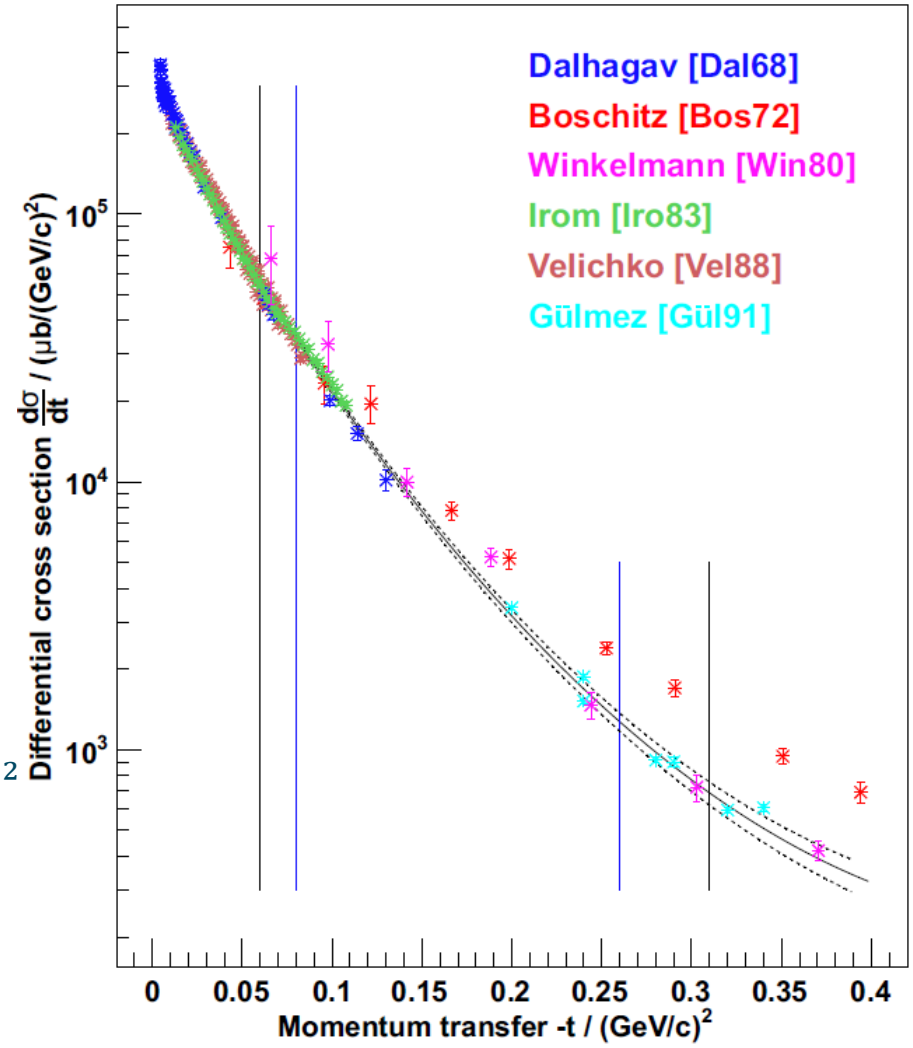
7	3177.51(17)	3184.87(17)	3204.16(23)

Luminosity via $dp \rightarrow dp$

- advantages of the dp-elastic scattering as normalization reaction:
  - ⇒ broad data base of available differential cross section
  - ⇒ high differential cross sections ensure good statistics
  - ⇒ excellent signal-to-background ratio
- differential cross section as function of momentum transfer
  - ⇒ independent of beam momentum
- ANKE acceptance: $-t = (0.06\ -0.31)\ (\mathrm{GeV}/c)^2$
- range for luminosity determination

  $-t = (0.08 - 0.26)\ (\mathrm{GeV}/c)^2$



Identification of $dp \rightarrow dp$

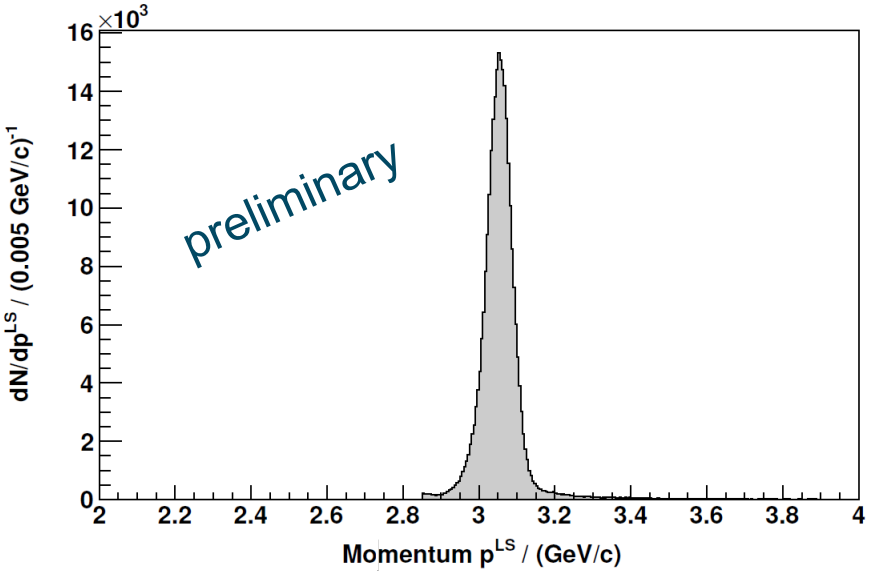
- identification of the reaction via the missing mass technique

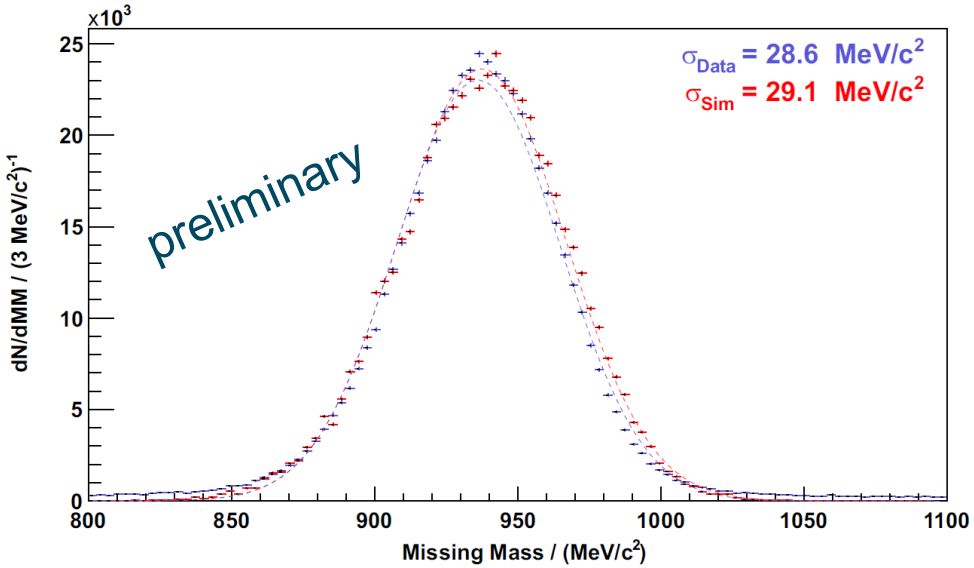
$$\text{Missing Mass} = |\mathbb{P}_{\text{p(ejectile)}}| = |\mathbb{P}_{\text{d(beam)}} + \mathbb{P}_{\text{p(target)}} - \mathbb{P}_{\text{d(ejectile)}}|$$

⇒ deuterons in the Fd-system

⇒ momentum close to beam momentum

⇒ low momentum transfer onto the target proton





Luminosity determination

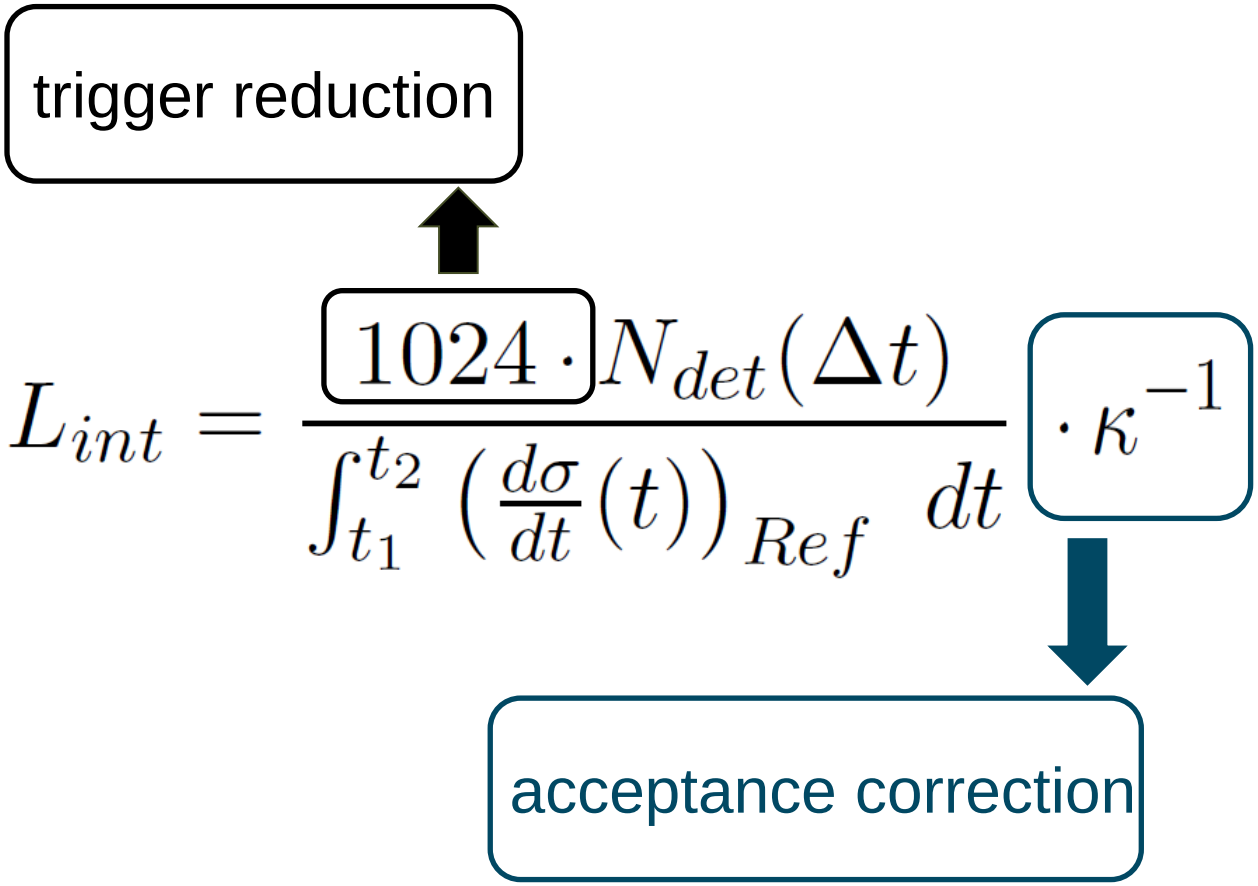
$$L_{int} = \frac{N_{det}(\Delta t)}{\int_{t_1}^{t_2} \left(\frac{d\sigma}{dt}(t)\right)_{Ref} \, dt}$$

Luminosity determination

trigger reduction

$$L_{int} = \frac{1024 \cdot N_{det}(\Delta t)}{\int_{t_1}^{t_2} \left(\frac{d\sigma}{dt}(t)\right)_{Ref} \, dt}$$

Luminosity determination



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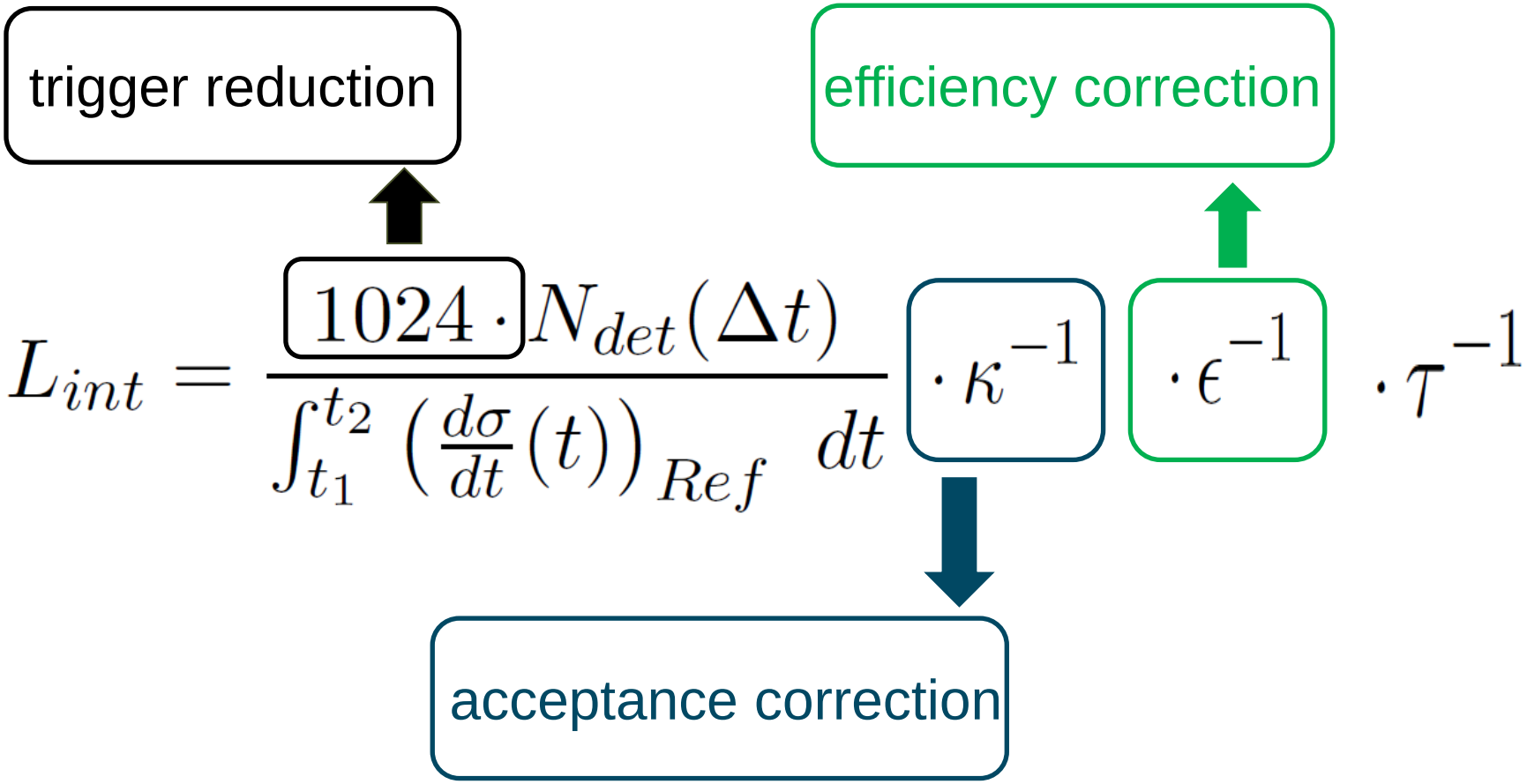

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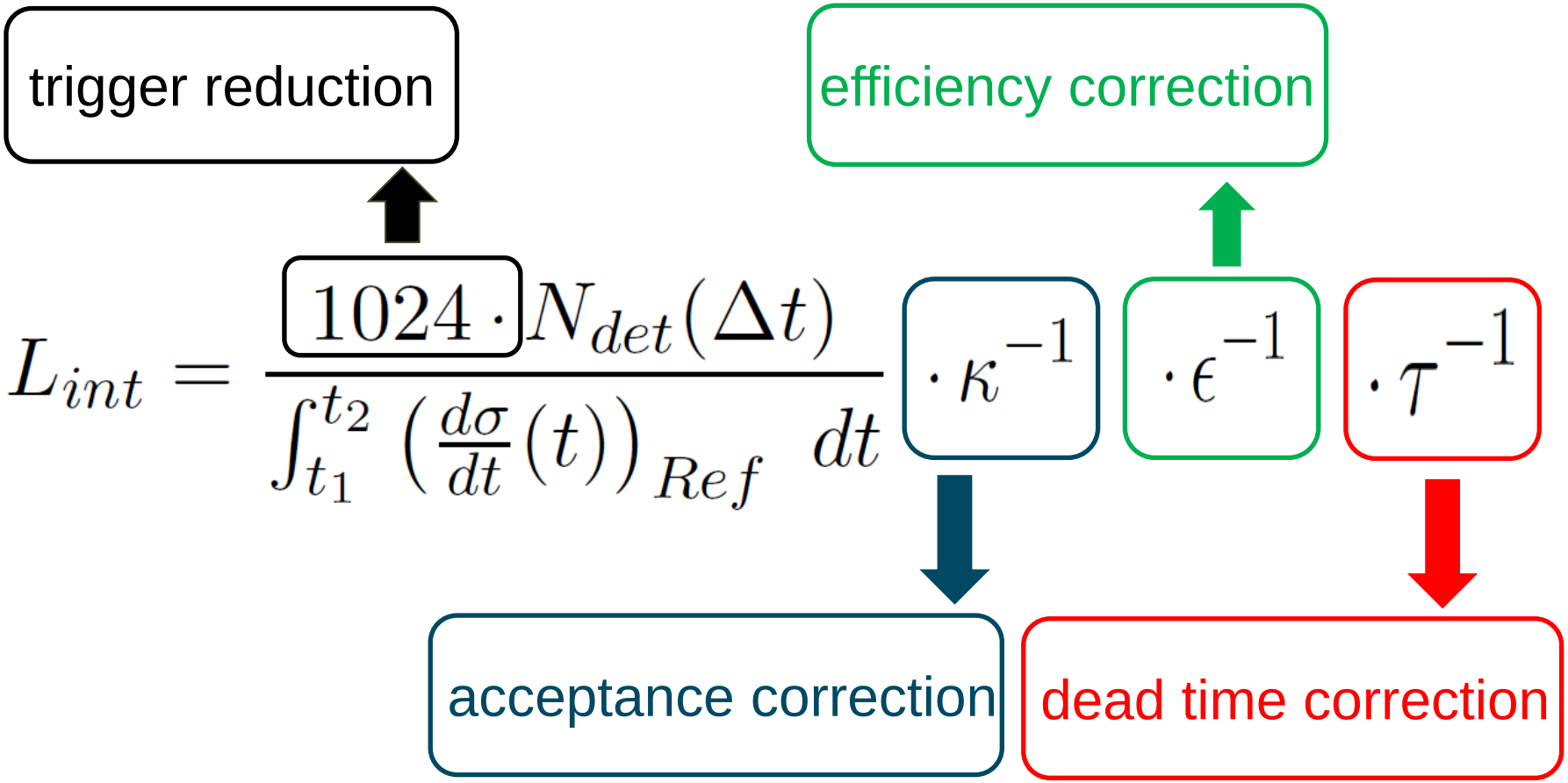
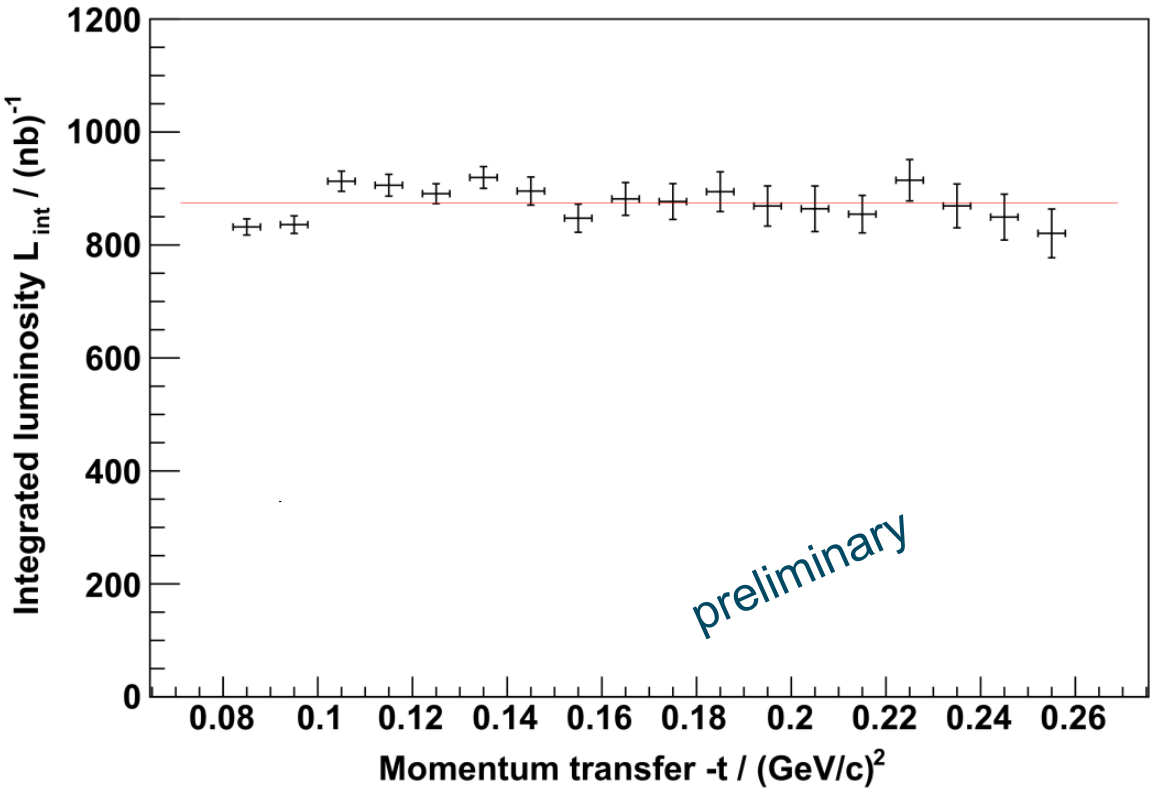


Results for $dp \rightarrow dp$

- luminosity should be independent of momentum transfer
- determination performed for 18 momentum transfer bins ($\Delta t = 0.01\ (\mathrm{GeV}/c)^2$)
  ⇒ for each of the 19 beam momenta
- luminosity precision achieved:

$$\Delta L_{\mathrm{stat}} = 1\%$$
$$\Delta L_{\mathrm{sys}} = 6\%$$

- improvement by at least a factor of two
- relative normalization via the reactions $dp \rightarrow p_{\mathrm{spec}}X$ by determination of the number of spectator protons in the Fd-system



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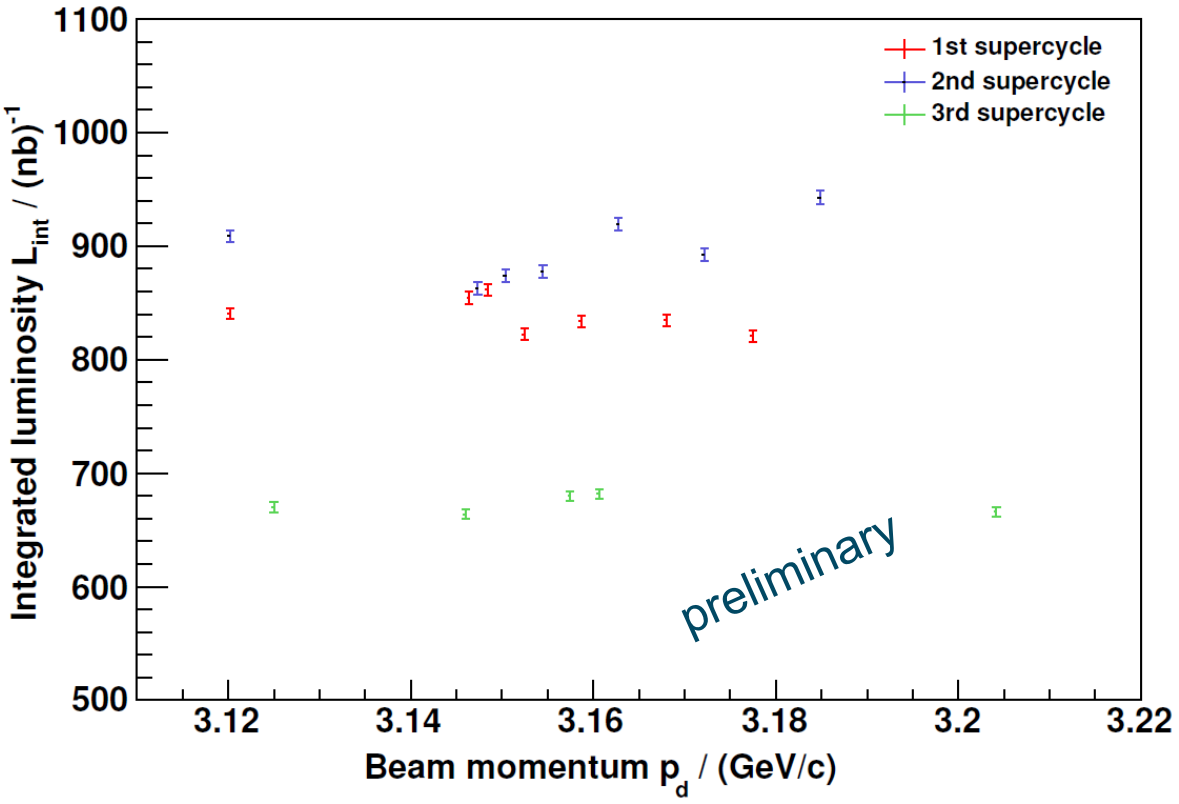

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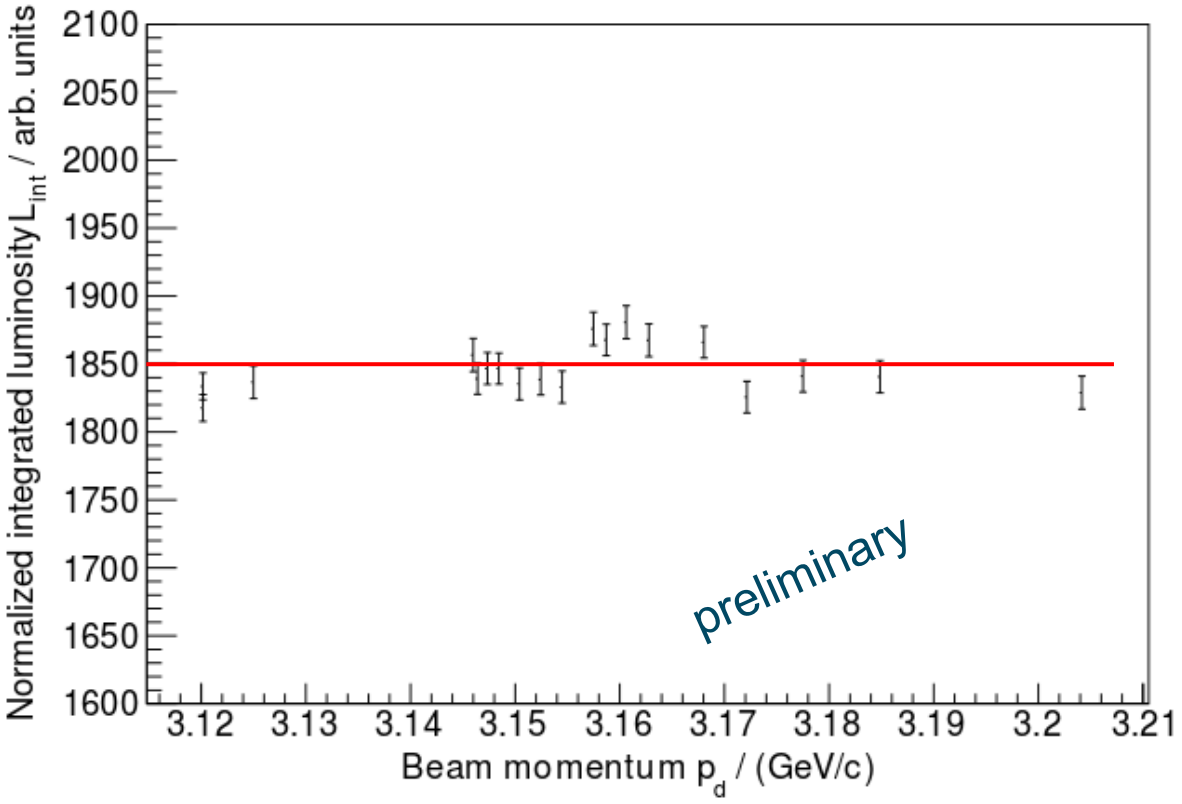


Luminosity via $dp \rightarrow dp_{spec}\pi^0$

- to verify the results of the dp-elastic scattering

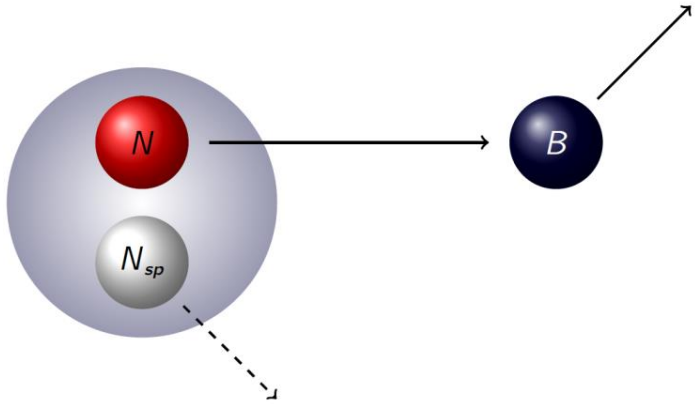
  ⇒ independent normalization required

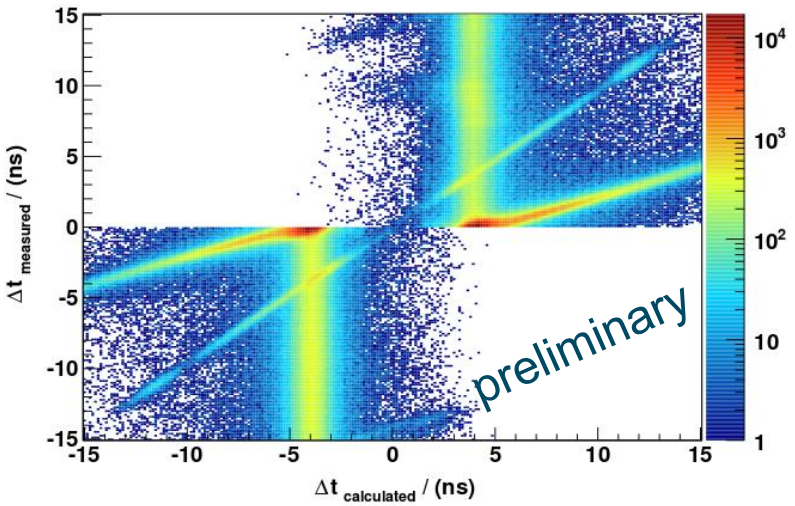
  ⇒ reaction used: $dp \rightarrow dp_{\mathrm{spec}}\pi^0$

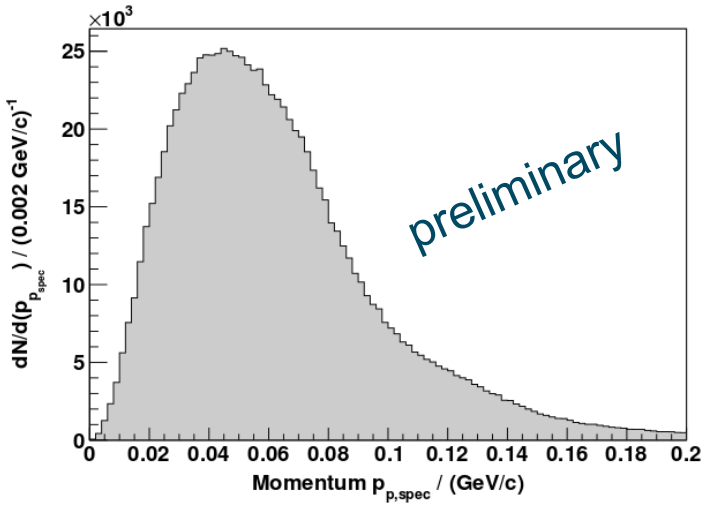
- p_{spec} = half of beam momentum + fermi motion

- identification of the dp pairs in the Fd-system

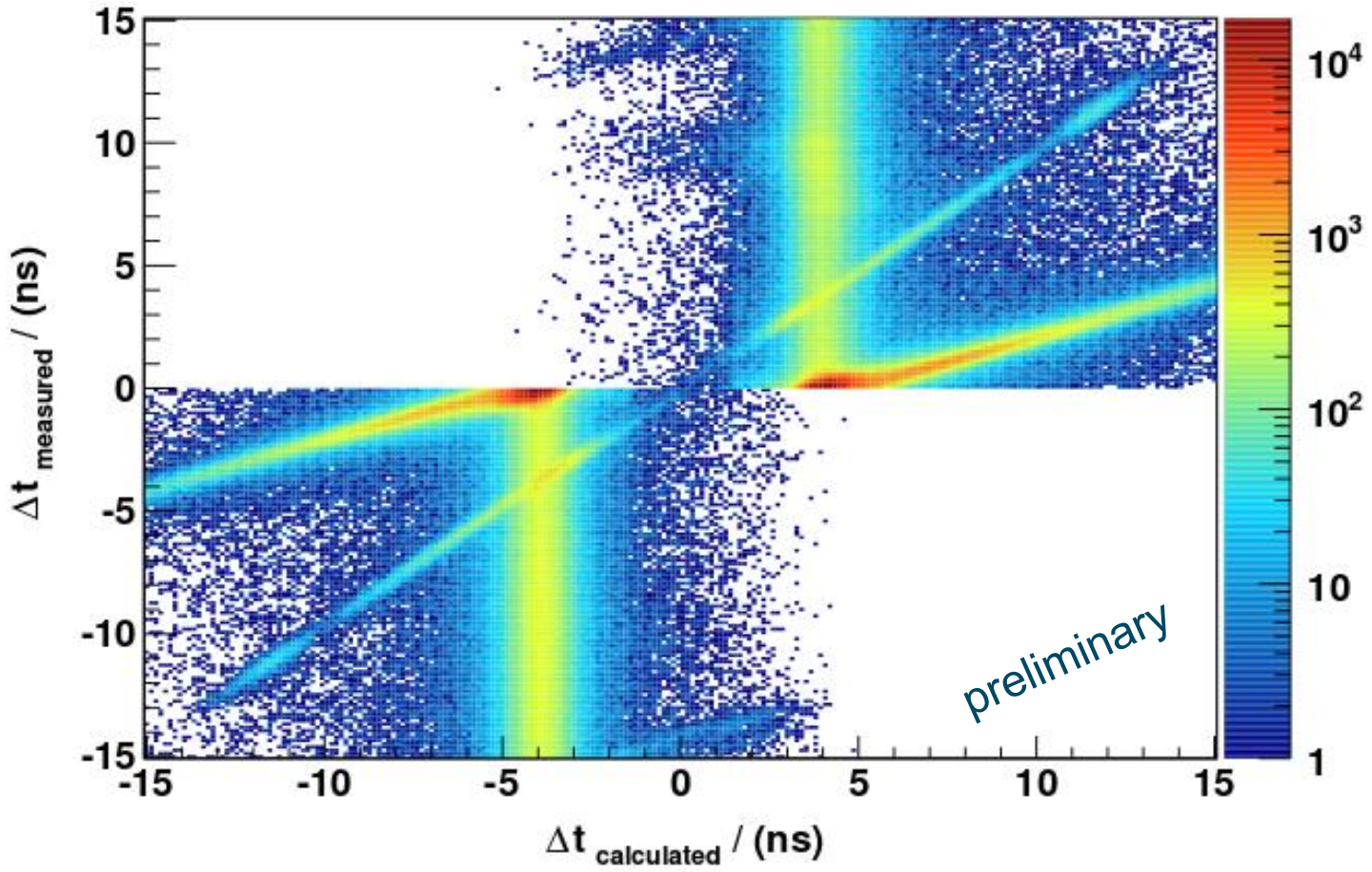
  ⇒ time-of-flight measurement







Identification of dp_{spec} pairs



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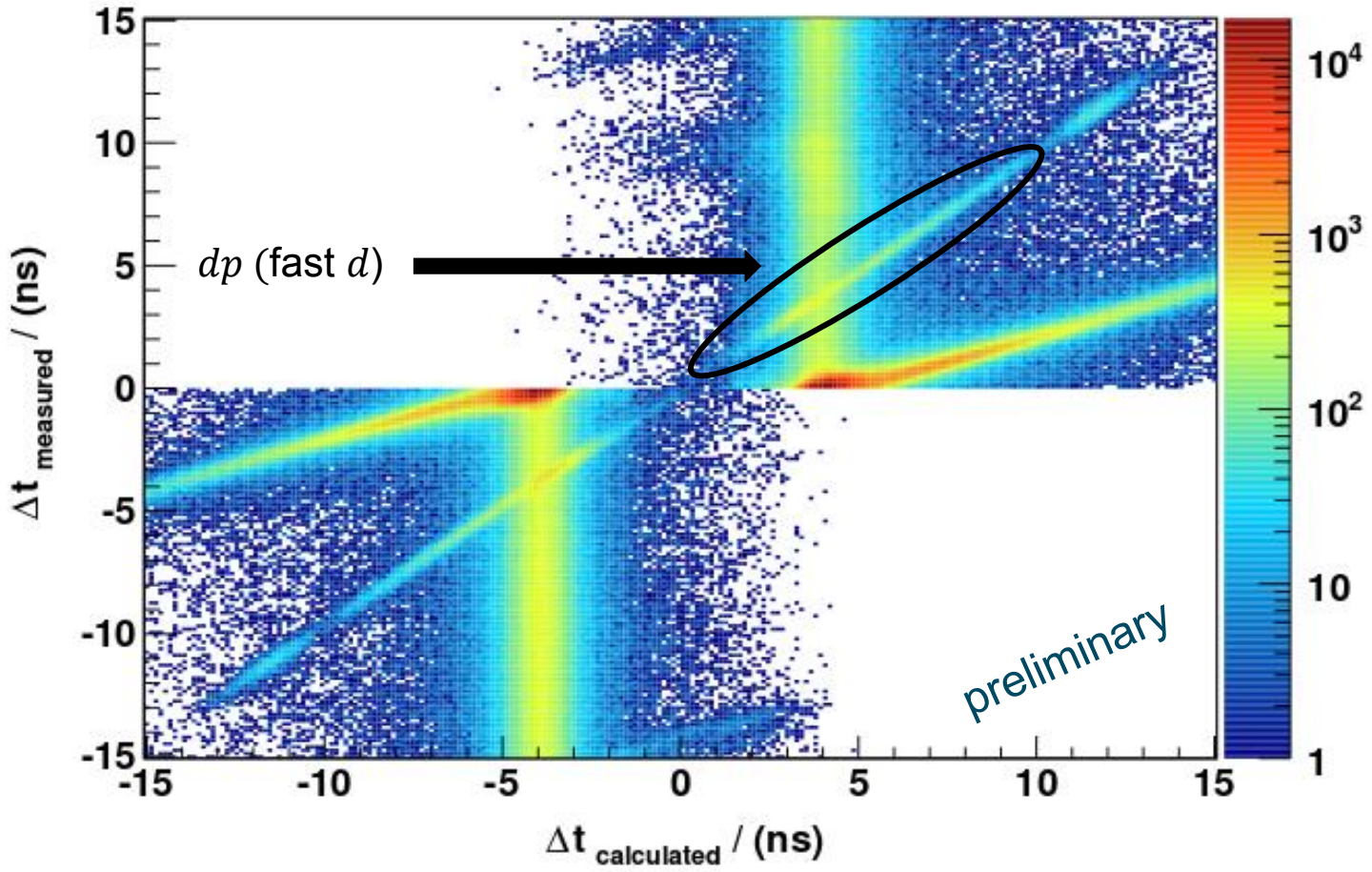

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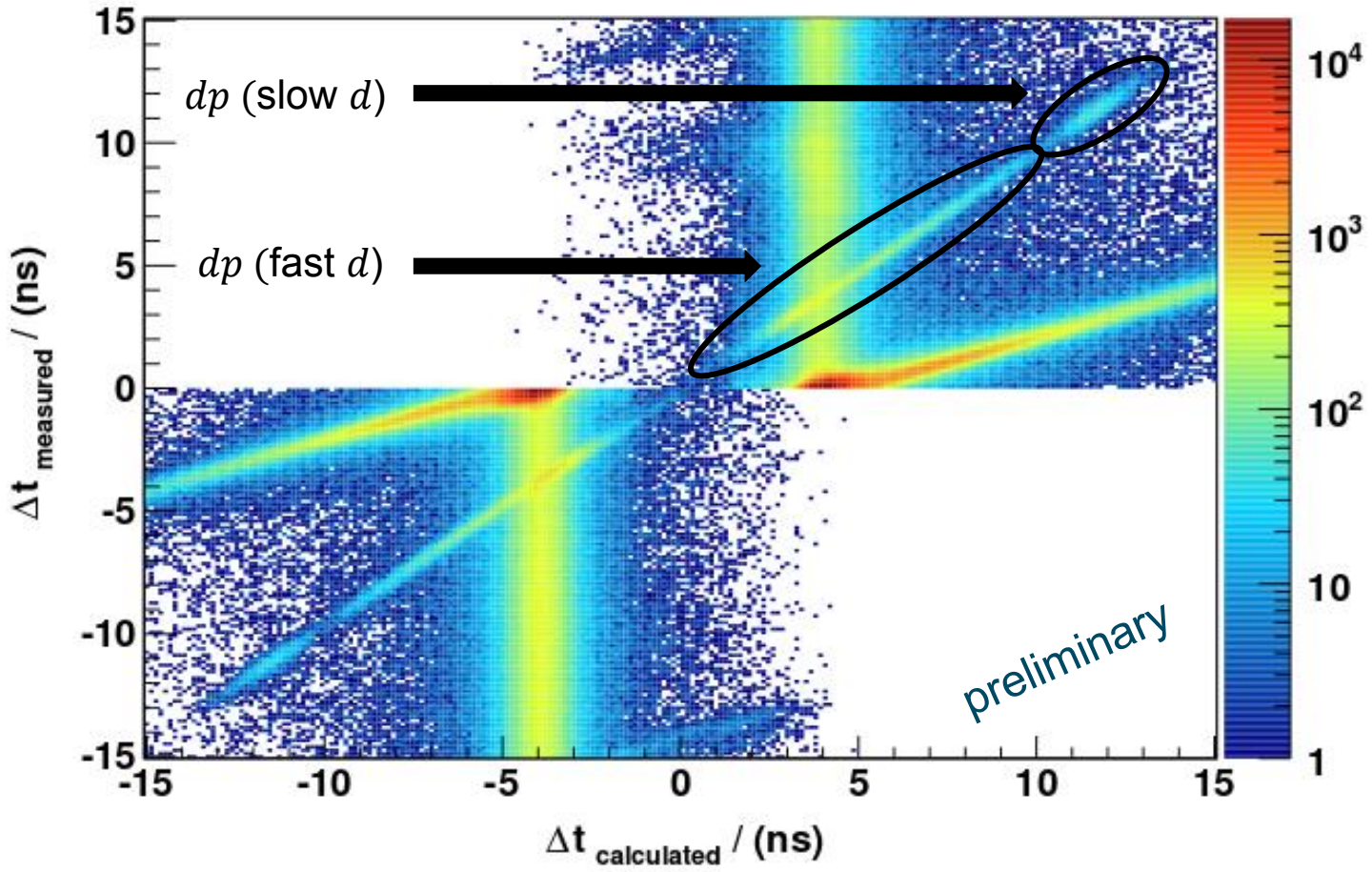

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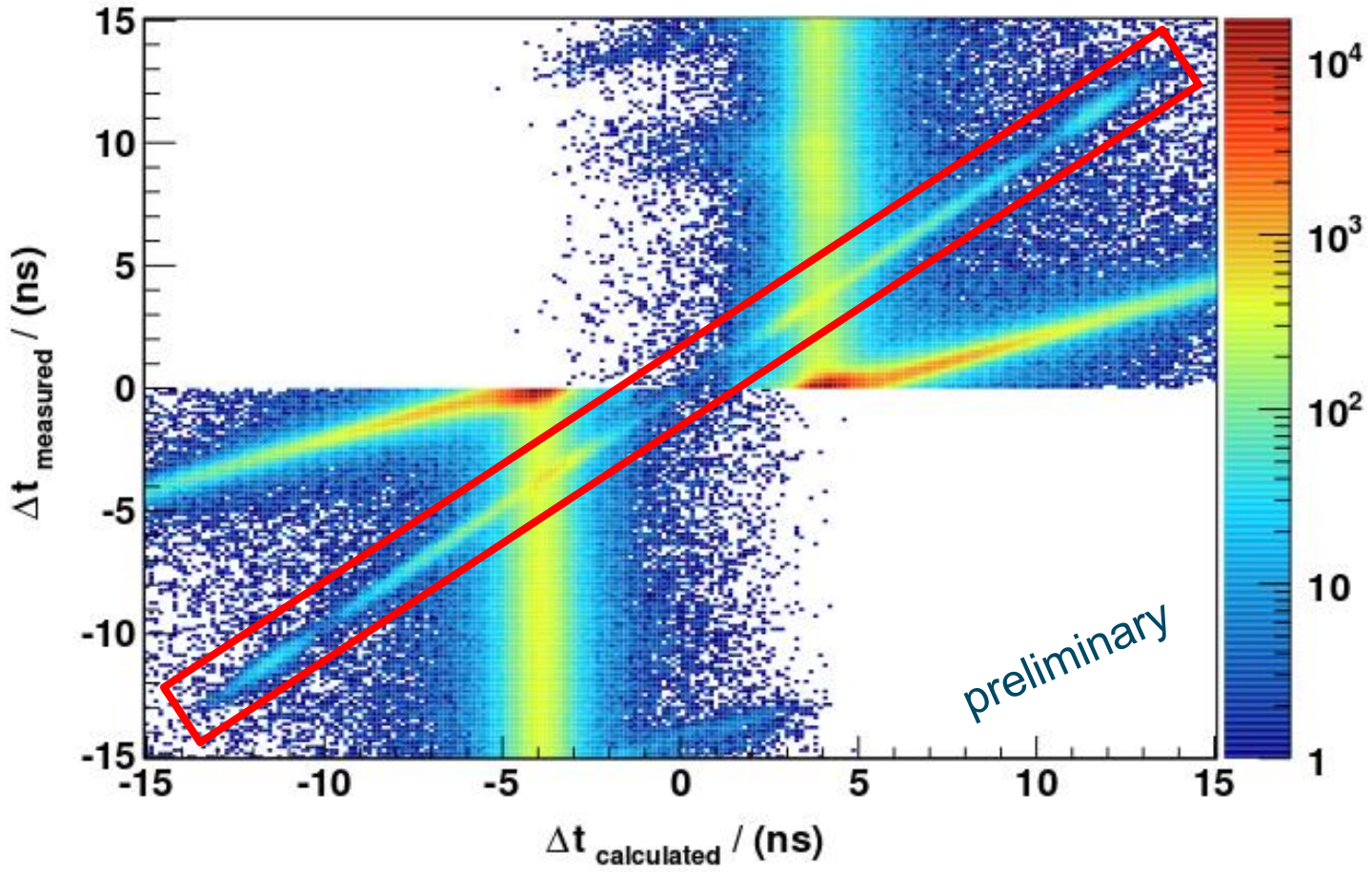

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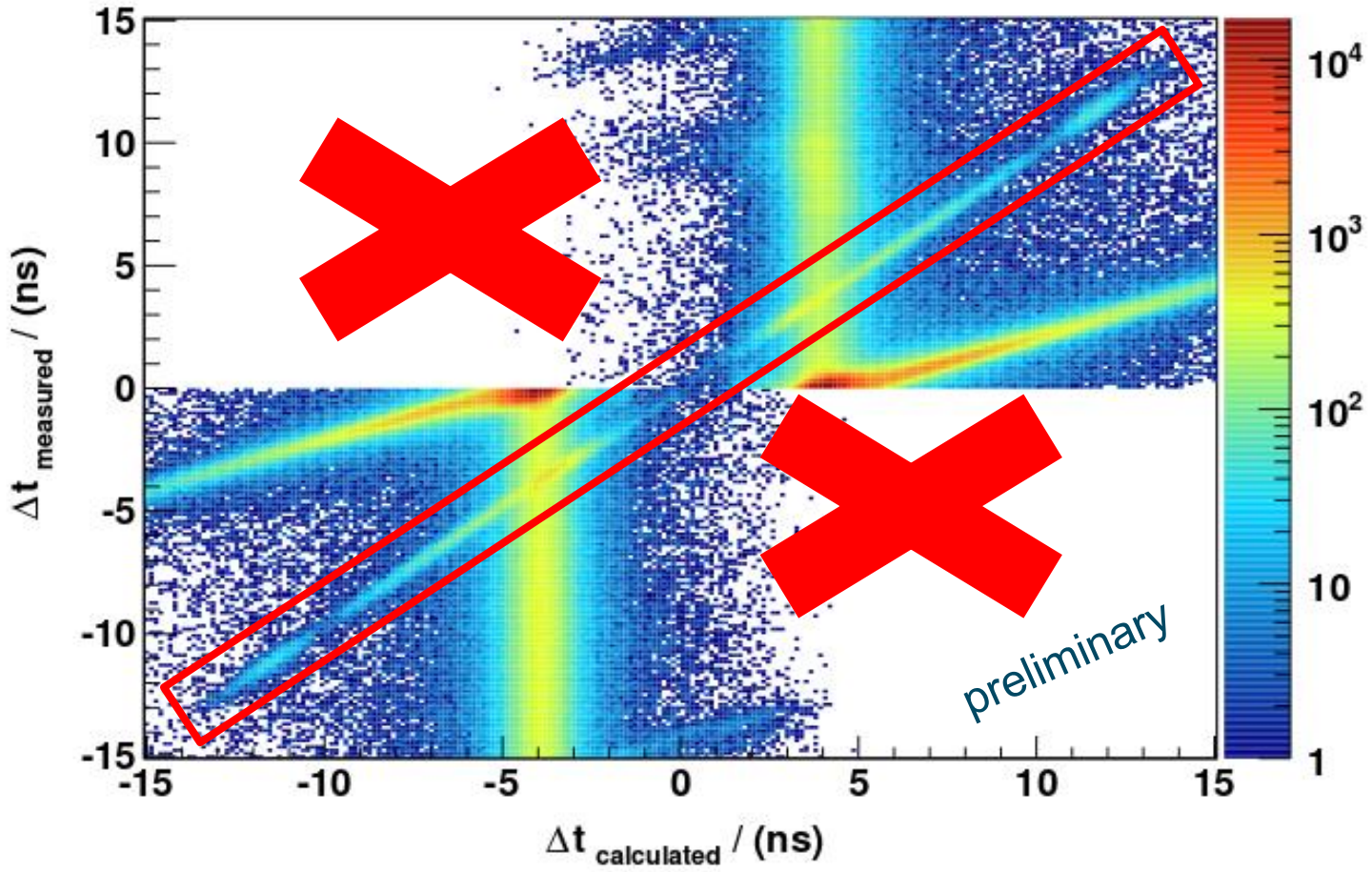

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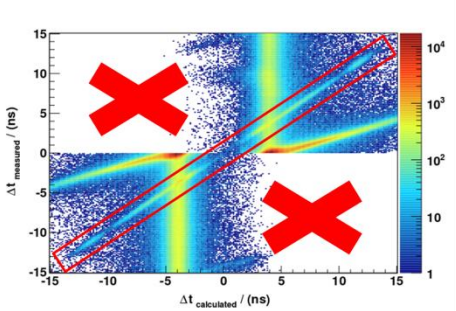
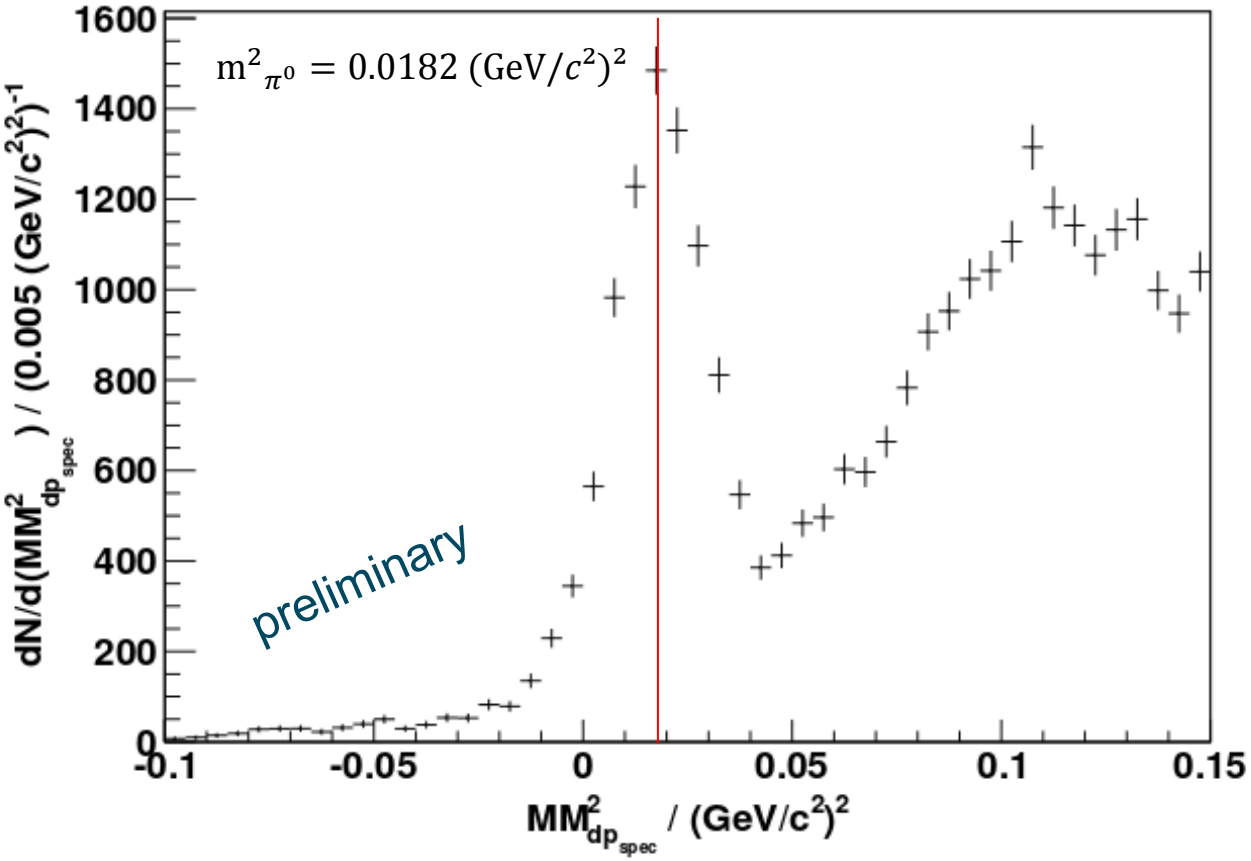
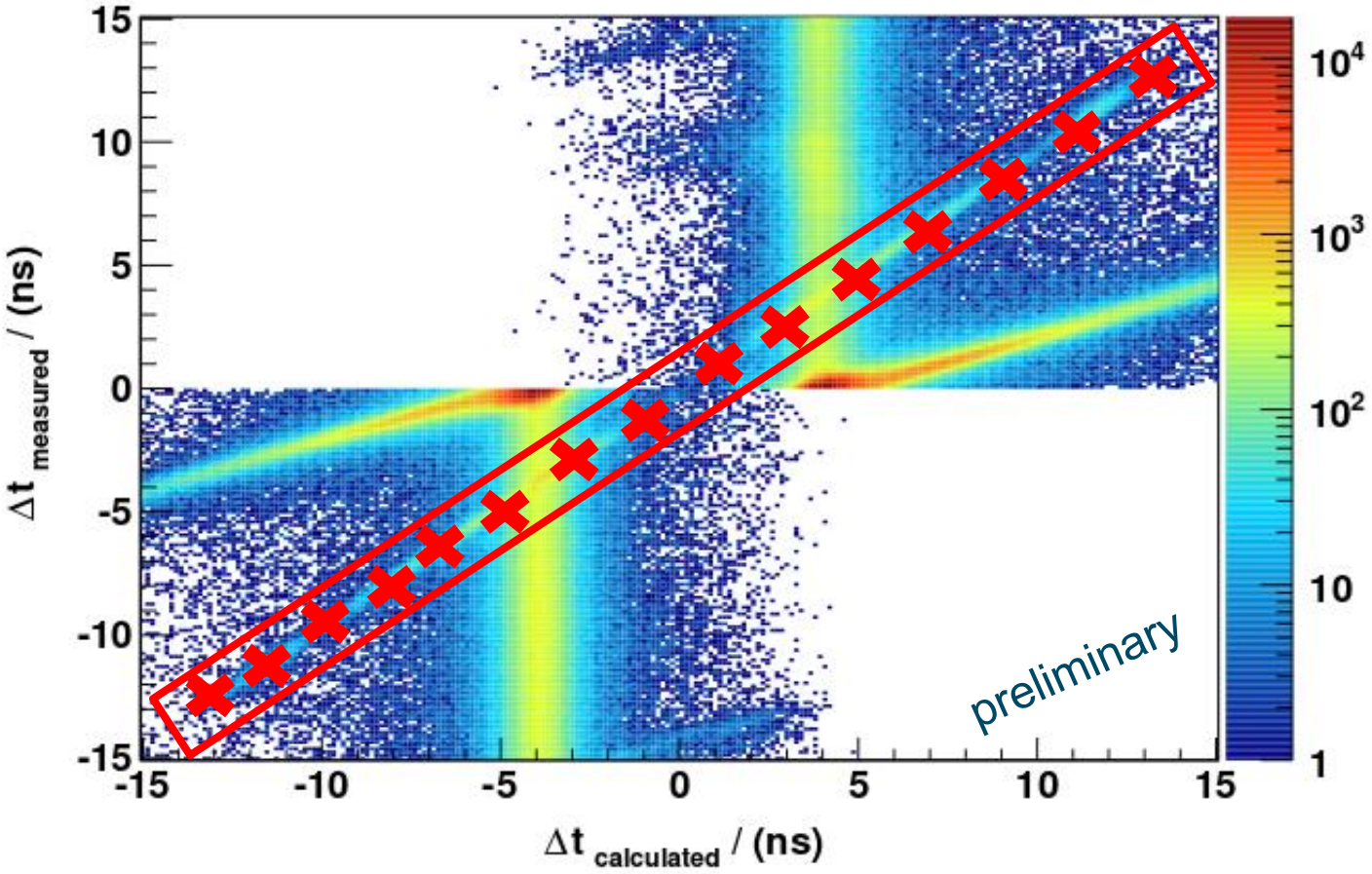




Background description



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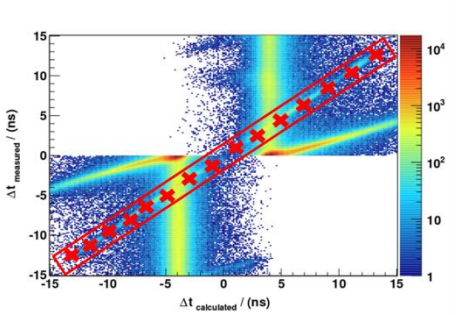
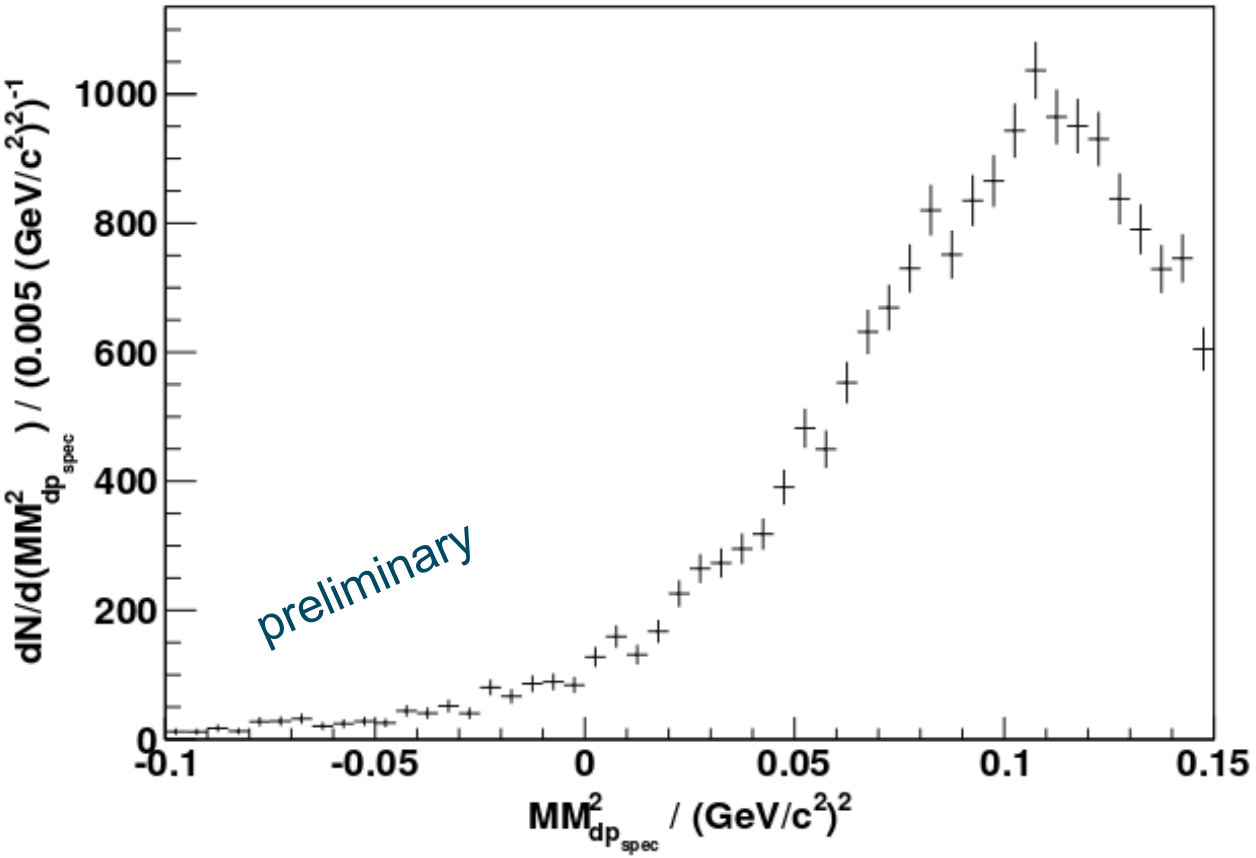


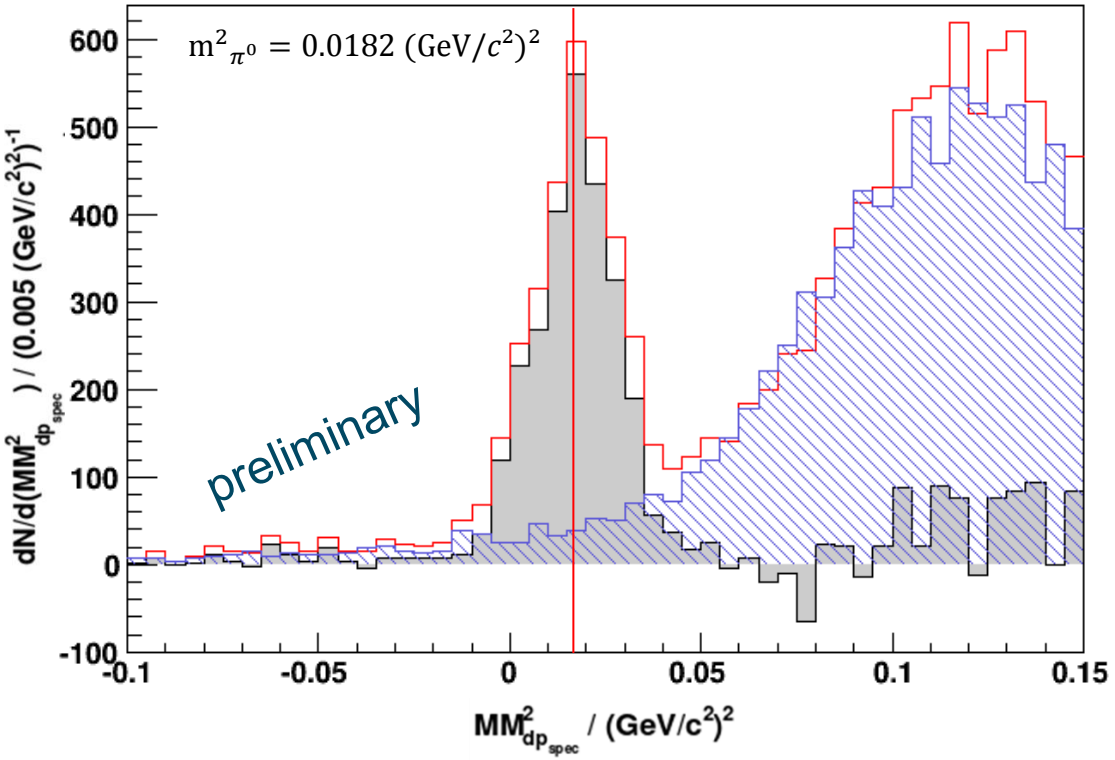


Preliminary results

- accurate signal background substraction
- next steps:
  - determination of correction terms
    - acceptance
    - dead time
    - shadow effect
    - …
  - calculation of uncertainties
  - luminosity determination

    for every beam momentum
  - compare results with

    dp-elastic scattering



Summary & Outlook

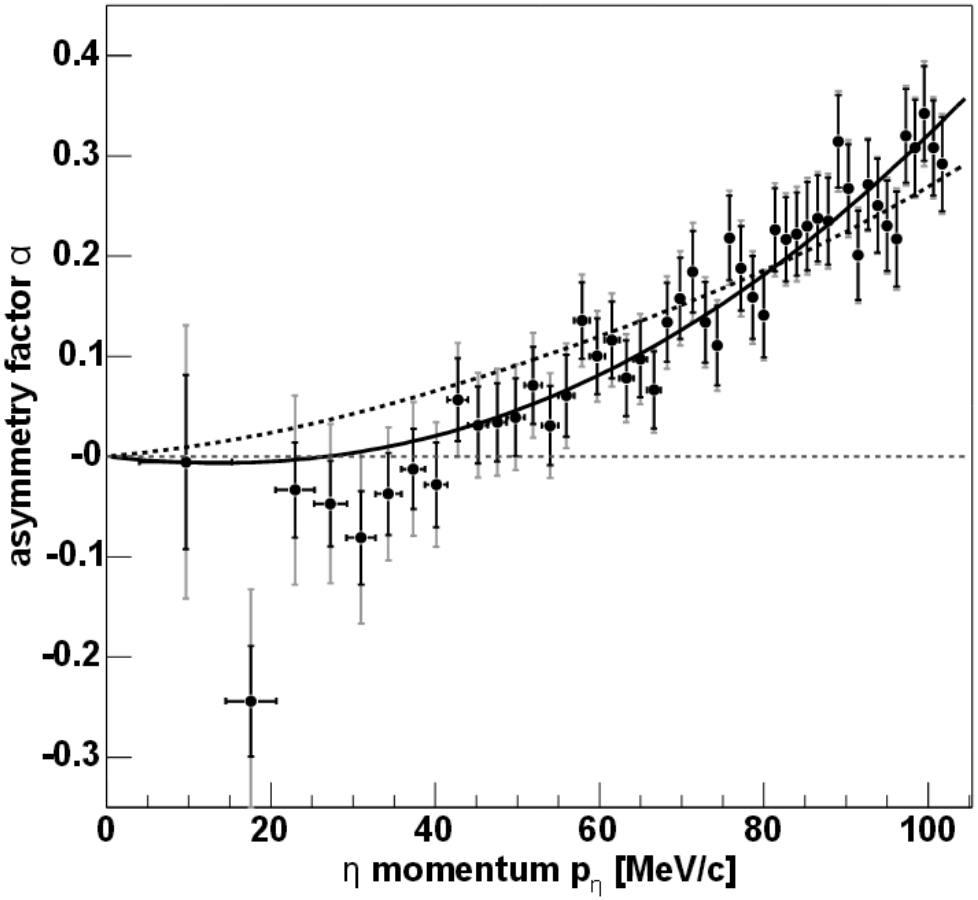
- luminosities were determined via dp-elastic scattering for 18 momentum transfer bins for each of the 19 beam momenta
- precision of $\Delta L_{\mathrm{stat}} = 1\%$ and $\Delta L_{\mathrm{sys}} = 6\%$ achieved

  ⇒ improvement by at least a factor of two compared to previous calculations
- luminosities already used to determine differential and double differential cross sections for $dp \rightarrow {}^{3}\mathrm{He}\pi^{+}\pi^{-}$ M. Mielke et al., European Journal of Physics J. A50 (2014) 102
- relative normalization via spectator protons of reactions of the type $dp \rightarrow p_{spec}X$
- ongoing analysis:
  - independent luminosity determination using the reaction $dp \rightarrow dp_{spec}\pi^{0}$
  - identification of dp_{spec} pairs and background description by time-of-flight measurements
  - next steps: - determination of correction terms

    - luminosity determination for every beam momentum

Thank you for your attention!

Additional slide



$$\alpha = \frac{\mathrm{d}}{\mathrm{d}(\cos\theta_\eta)} \ln\left(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right)\Bigg|_{\cos\theta_\eta=0}$$