Exploring the HADES Feb22 Run
pp @ 4.5 *GeV*

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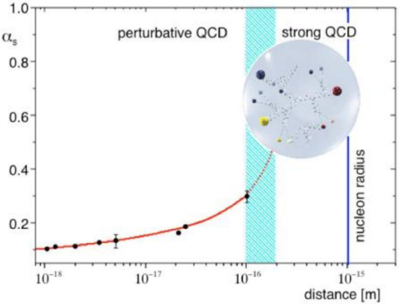
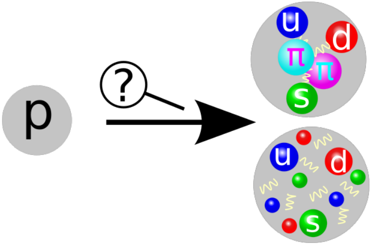
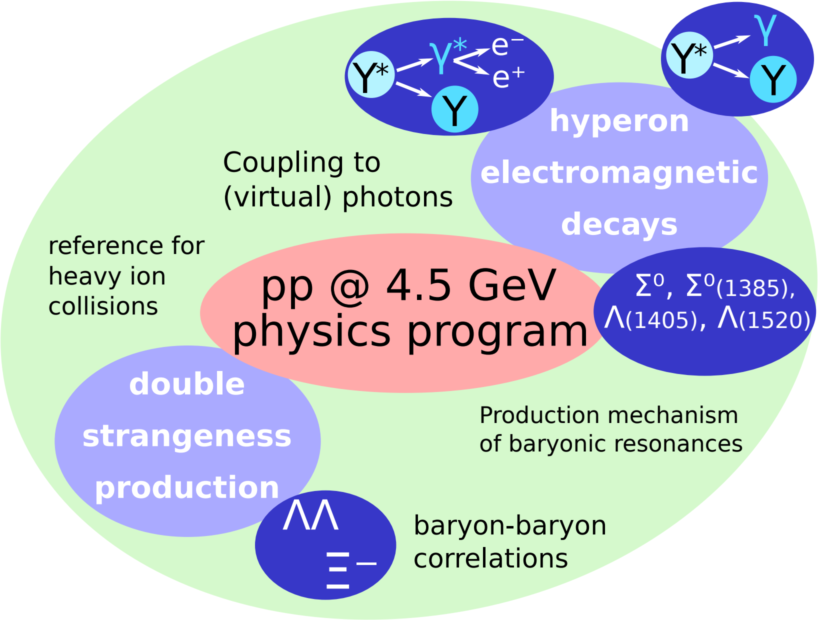
Hadron Structure – Low Energy QCD

Qantum **C**hromo **D**ynamics
has running coupling constant α_s

- Asymptotic freedom
  - Short distances / high energy
  - Perturbation theory
- Confinement
  - Large distances / low energy
    $\rightarrow$Hadron scale
  - Quantitative predictions difficult



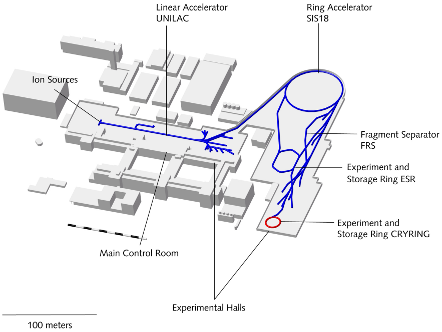




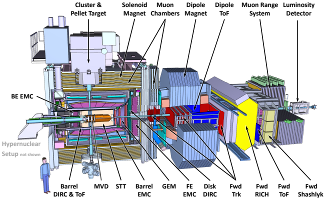
HADES Collaboraton: "Production and electromagnetic decay of hyperons: a feasibility study with HADES as a phase-0 experiment at FAIR", Eur. Phys. J. A (2021) 57: 138

GSI and FAIR

HADES @ GSI: The senior

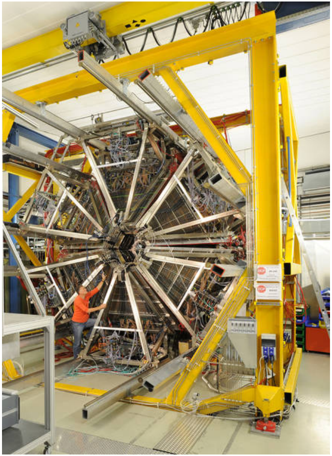


$\bar{\mathrm{P}}$ANDA @ FAIR: The rising star

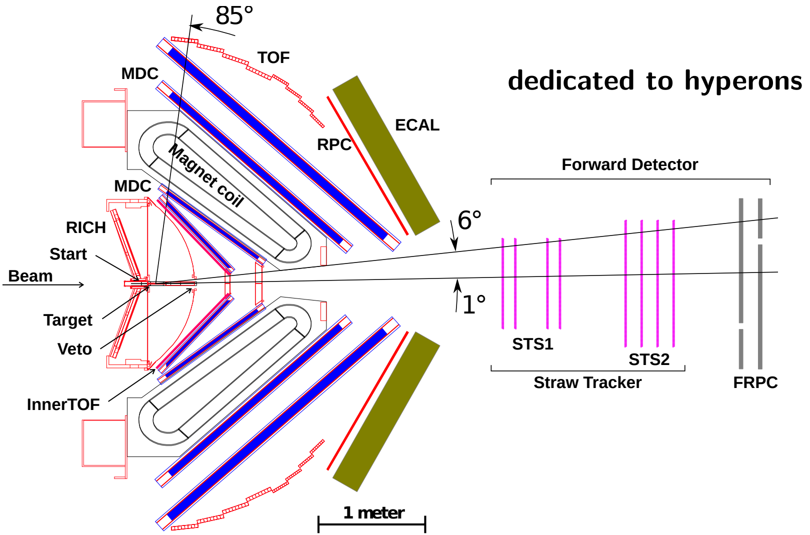


HADES – High-Acceptance DiElectron Spectrometer

- Investigation of hadronic matter
- Dielectron production in pion, proton and heavy-ion induced collisions
- Azimuthal coverage: 85 %, Polar: 18° to 85°
- New features:
  - Electromagnetic calorimeter (2018)
  - Forward detector (2021)

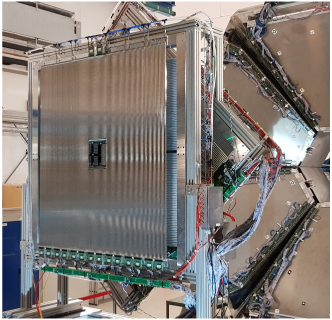


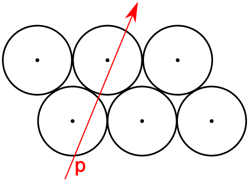
$\bar{\text{P}}$ANDA @HADES – Setup for *pp* @ 4.5 GeV Beam Time in Spring 2022



Straw Tracker Stations – $\bar{\text{P}}$ANDA @ HADES

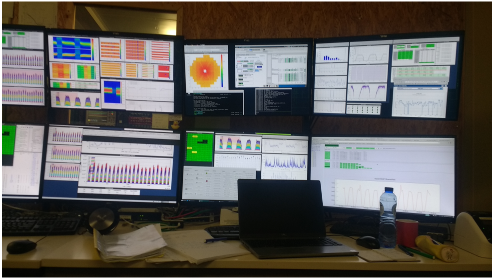
- FAIR Phase-0 experiment
- Self-supporting straw tube detectors
- Polar angular coverage: 1° to 6°
  $\rightarrow$ Increase HADES acceptance for protons
- Higher count rate for hyperon channels at increased beam energy
- Most protons from elastic scattering go forward



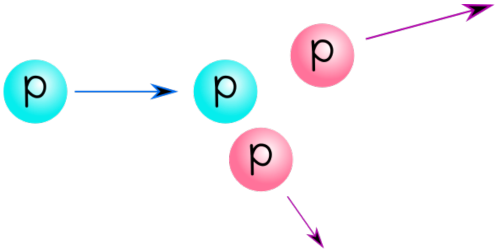


The HADES Feb22 Beam Time

- *pp* collisions at $4.5\,\mathrm{GeV}$ beam kinetic energy
- Hyperon campaign
- Total of 488.25 hours of data taking
- Total amount of data collected:
  41 G Events (all triggers)
  683973.7 GB

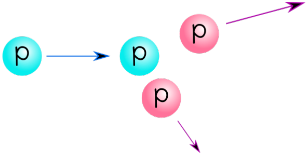


– *pp* Elastic Scattering –



A well defined reaction to explore our data.

pp Elastic Scattering



A well defined reaction

Kinematic relations

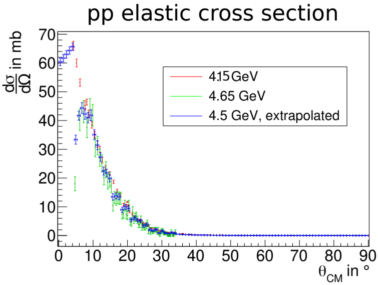
$$p = \frac{p_{\mathrm{beam}}}{\cos\theta \cdot (1 + \tan\theta^2 \gamma_{\mathrm{CM}}^2)}$$

$$\tan\theta_1 \cdot \tan\theta_2 = \frac{1}{\gamma_{\mathrm{CM}}^2} = 0.29429$$

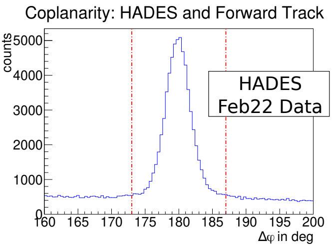
$$\varphi_2 = |180^\circ - \varphi_1|$$

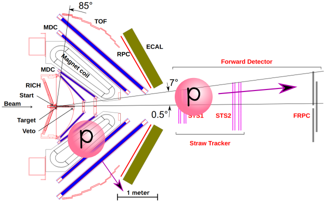
With a lot of existing data

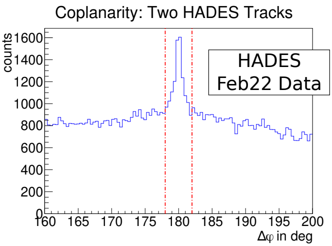
from SAID database

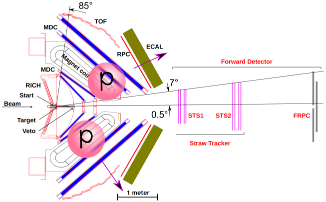


Elastic Scattering Selection









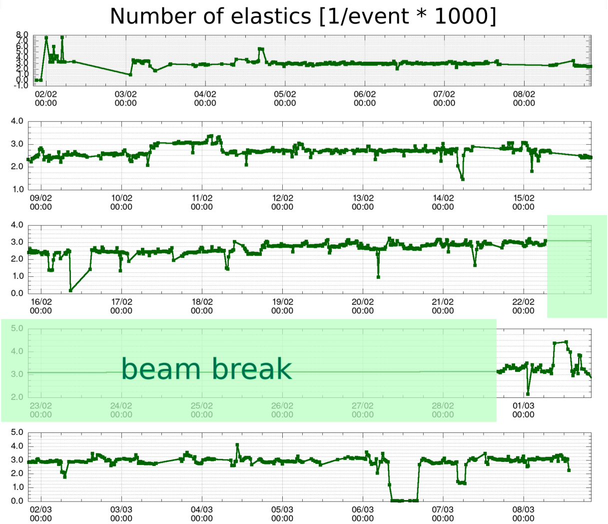
Selection:

$\tan\theta_1 \cdot \tan\theta_2 = 0.294 \pm 0.1$

Selection:

$\tan\theta_1 \cdot \tan\theta_2 = 0.294 \pm 0.015$

Online Monitoring

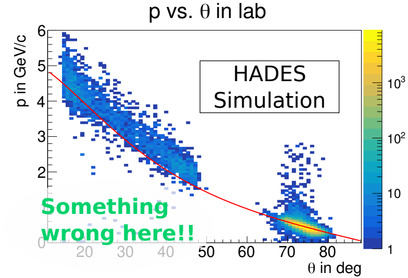


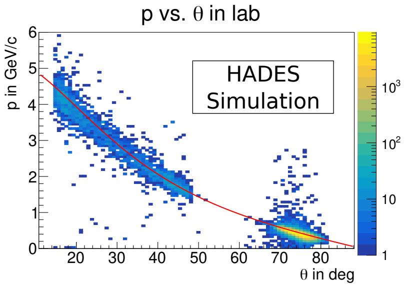
Selection on
$\Delta\varphi$
and
$\tan\theta_1 \cdot \tan\theta_2$

Credits to
Rafał Lalik
and
Konrad Sumara

Quality Assurance

From elastic scattering kinematics: $p = \frac{p_{\mathrm{beam}}}{\cos\theta\cdot(1+\tan\theta^2\gamma_{\mathrm{CM}}^2)}$





Corrected geometry

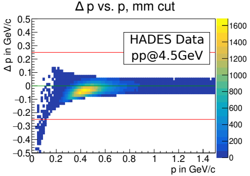
Elastic scattering selection, both protons detected

Efficiency Estimation of New Detectors

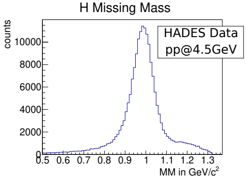
Reconstruct proton in HADES

- PID selection: β vs. p
- Elastic scattering selection:

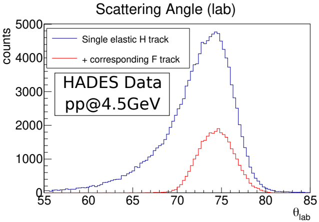
$\Delta p < 250\,\mathrm{MeV}/c$



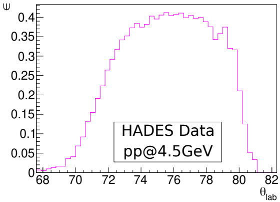
$\Delta\mathrm{MM} < 0.1\,\mathrm{GeV}/c^2$



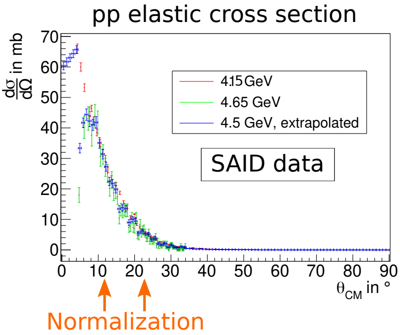
Require additional proton in Forward Detector

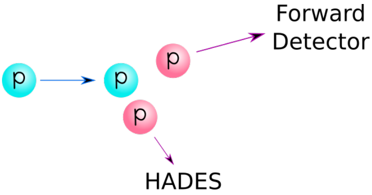


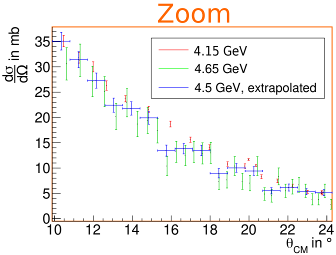
Forward tracking efficiency:



Normalization





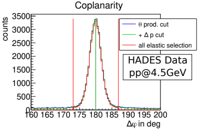


Integrated cross section from $\theta_{CM} = 13° - 22°$ $= 3.7^{+0.7}_{-0.3}\,\mathrm{mb}$

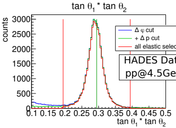
Normalization – HADES + Forward track

Selections

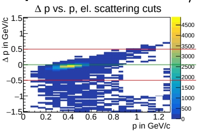
- Coplanarity:



- $\tan\theta_1 \cdot \tan\theta_2$:



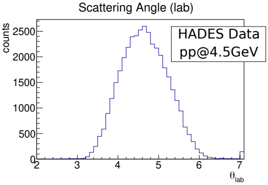
- $\Delta p < 500\,\mathrm{MeV}/c$



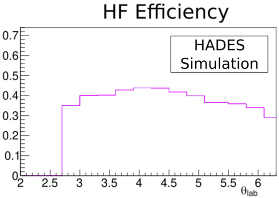
Luminosity:

$L = N_{\mathrm{reco}}/(\epsilon \cdot \mathrm{acc})/\sigma$

- N_{reco} from data

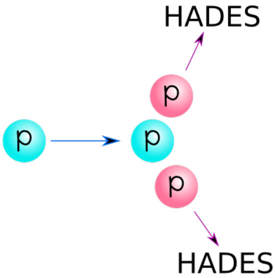


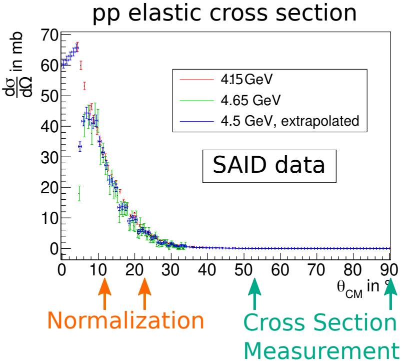
- $(\epsilon \cdot \mathrm{acc})$ from sim + data correction

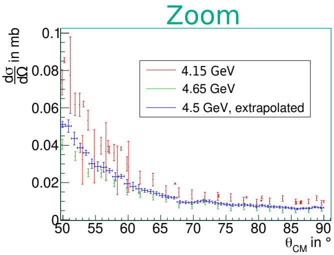


- σ from data base

Cross Section Measurement





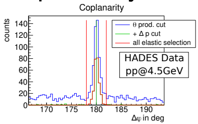


Integrated cross section from $\theta_{CM} = 55° - 90° = 0.04^{+0.02}_{-0.01}\,\mathrm{mb}$

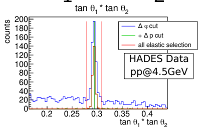
Cross Section Measurement – 2 HADES tracks

Selections

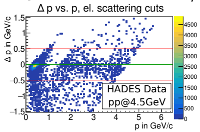
- Coplanarity:



- $\tan\theta_1 \cdot \tan\theta_2$:



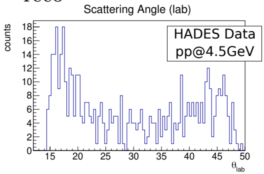
- $\Delta p < 500\,\mathrm{MeV}/c$



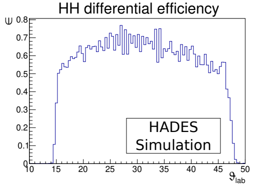
Cross section:

$\sigma = N_{\mathrm{reco}}/(\epsilon \cdot \mathrm{acc})/L$

- N_{reco} from HH data



- $(\epsilon \cdot \mathrm{acc})$ from simulation



- L from HF data

Conclusion

At First: Investigate a well defined reaction

- Understand the data
- Calibrate the data
- Normalize the data
- Analyze the data

Then: Do exciting new measurements

- Measure electromagnetic decays of hyperons
- Study multi-strangeness production
- Better understand the strong interaction