The COMPASS++/AMBER program for $\bar{p}$ production cross-sections measurements

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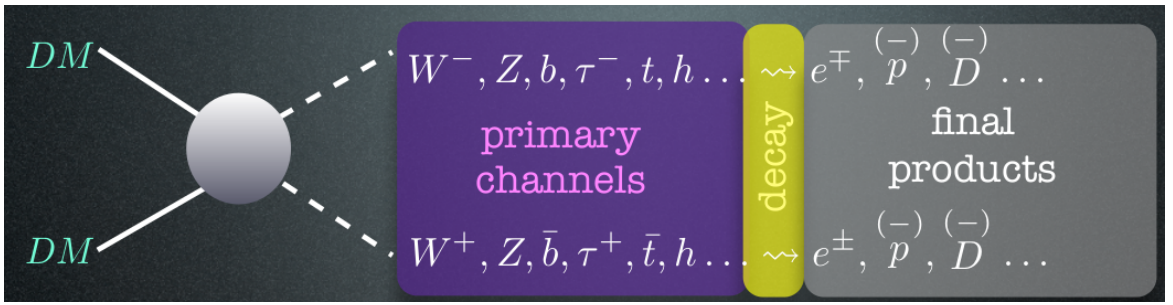

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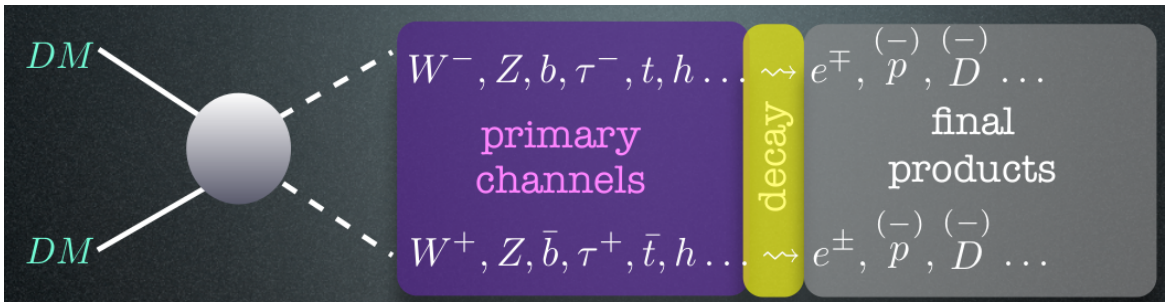

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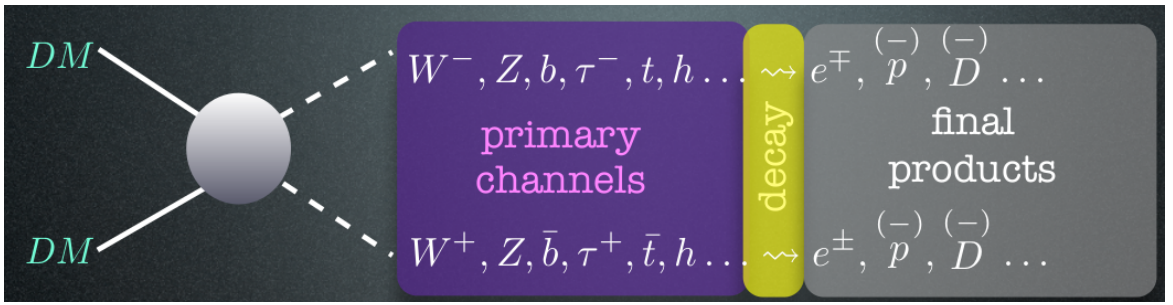
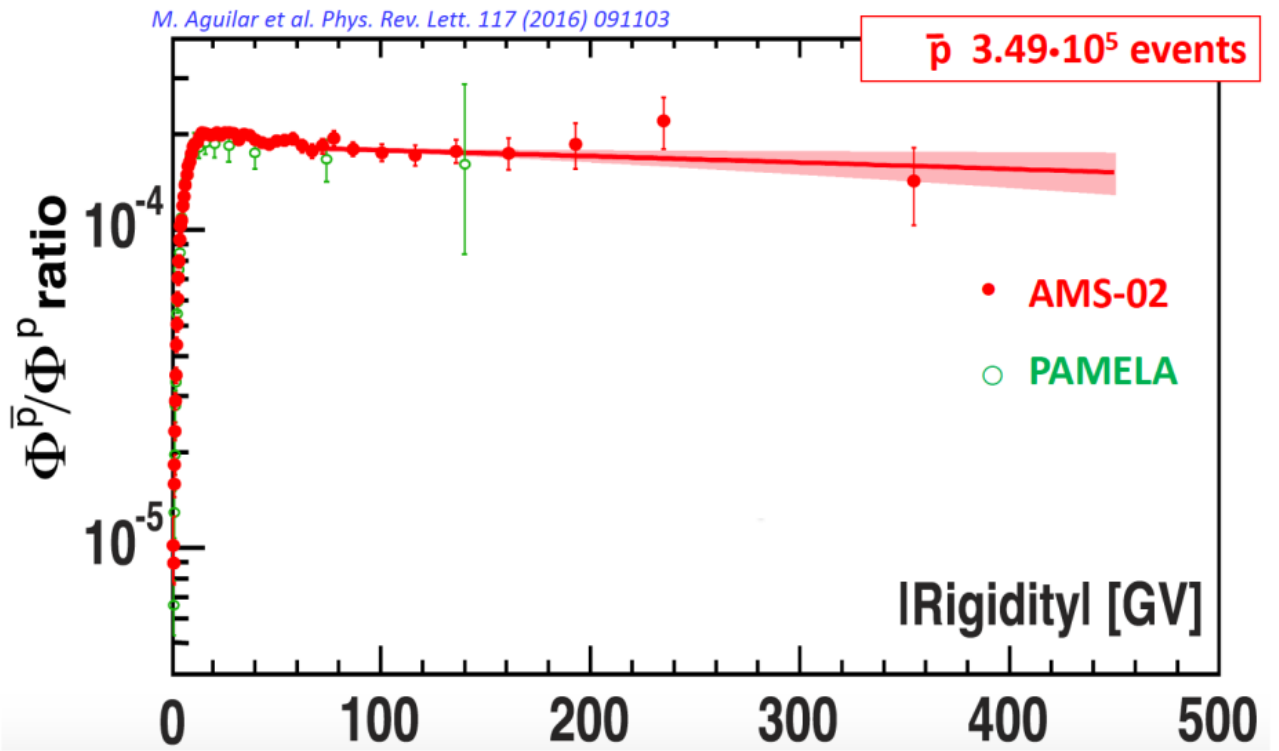


- indirect detection of dark matter (DM) is based on the search for **products of DM annihilation or decay** $\rightarrow$ distortions in the spectra of rare cosmic ray components like positrons, antiprotons
- necessity to distinguish signal from background: need of higher accuracy of the **predicted natural flux** (spallation of primary cosmic rays with interstellar medium)

AMS-02 Data on $\bar{p}/p$



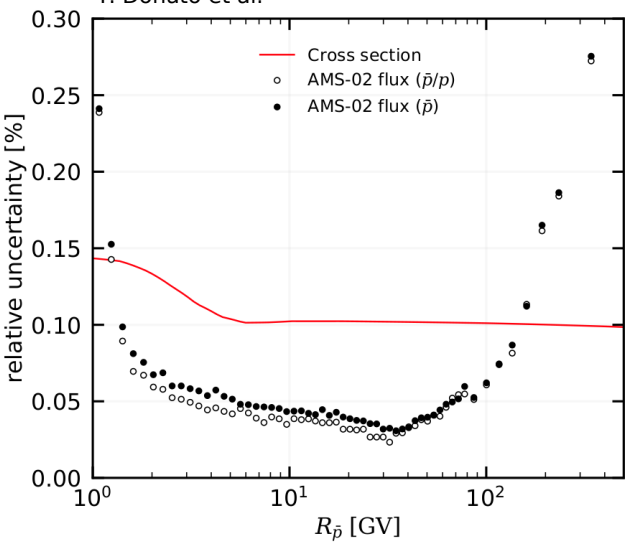
AMS-02 published high precision data ($< 5\%$) on $\bar{p}$ flux in 2016 over 1-500 GV range in rigidity.

Uncertainties on $\bar{p}$ flux

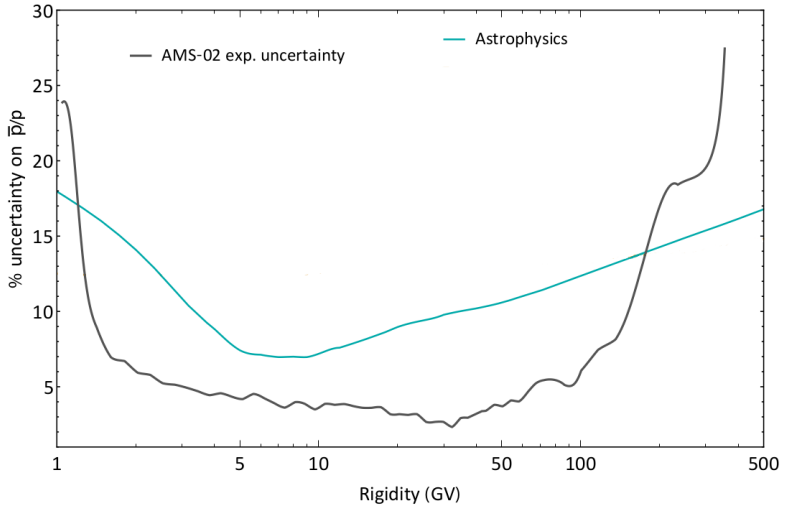
The proposed measure reflects the growing necessity of the astrophysical community for a more precise prediction on the $\bar{p}$ natural flux .

$$q_{ij}\left(T_{\bar{p}}\right) = \int_{T_{\rm th}}^{\infty} dT_i \; 4\pi \; n_{{\rm ISM},j} \; \phi_i\left(T_i\right) \frac{d\sigma_{ij}}{dT_{\bar{p}}}\left(T_i, T_{\bar{p}}\right)$$

F. Donato et al.



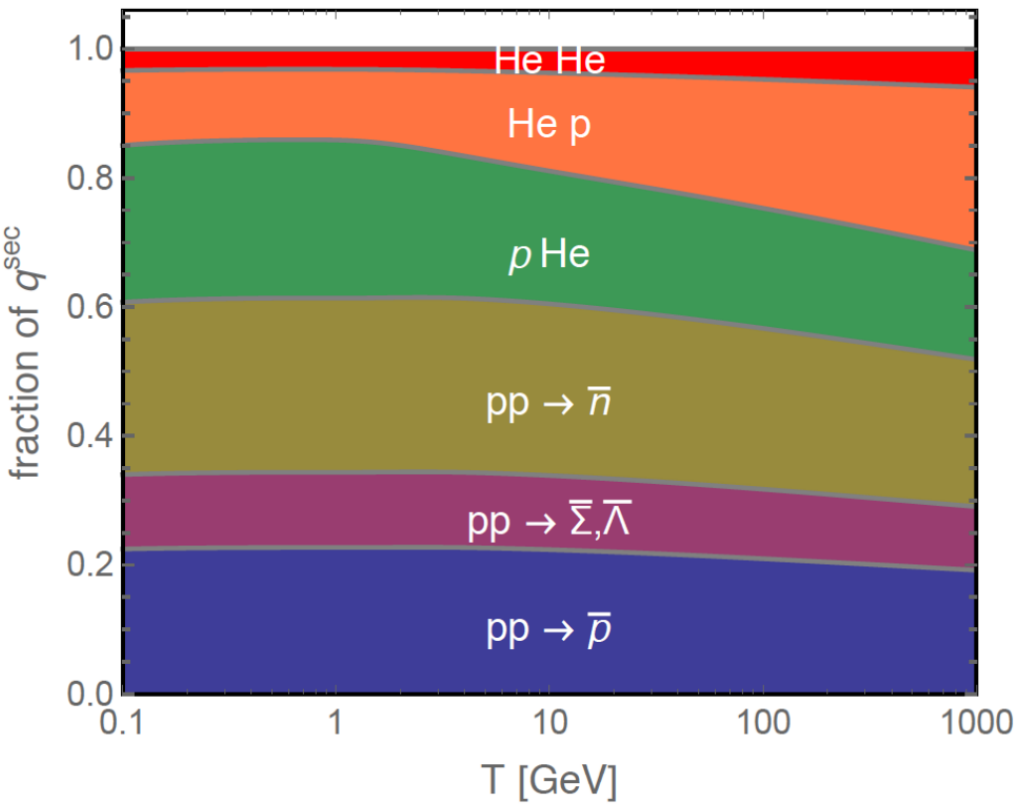
COMPASS++/AMBER,Proposal for Measurements at the M2 beam line of the CERN SPS 4 Phase-1: 2022-2024,



Two major uncertainties limit the prediction of the $\bar{p}$ flux from CR interaction with Interstellar Medium:

- production cross sections p-p $\rightarrow \bar{p}$ +X and p-He $\rightarrow \bar{p}$ + X
- CR propagation in the galaxy

Various contributions



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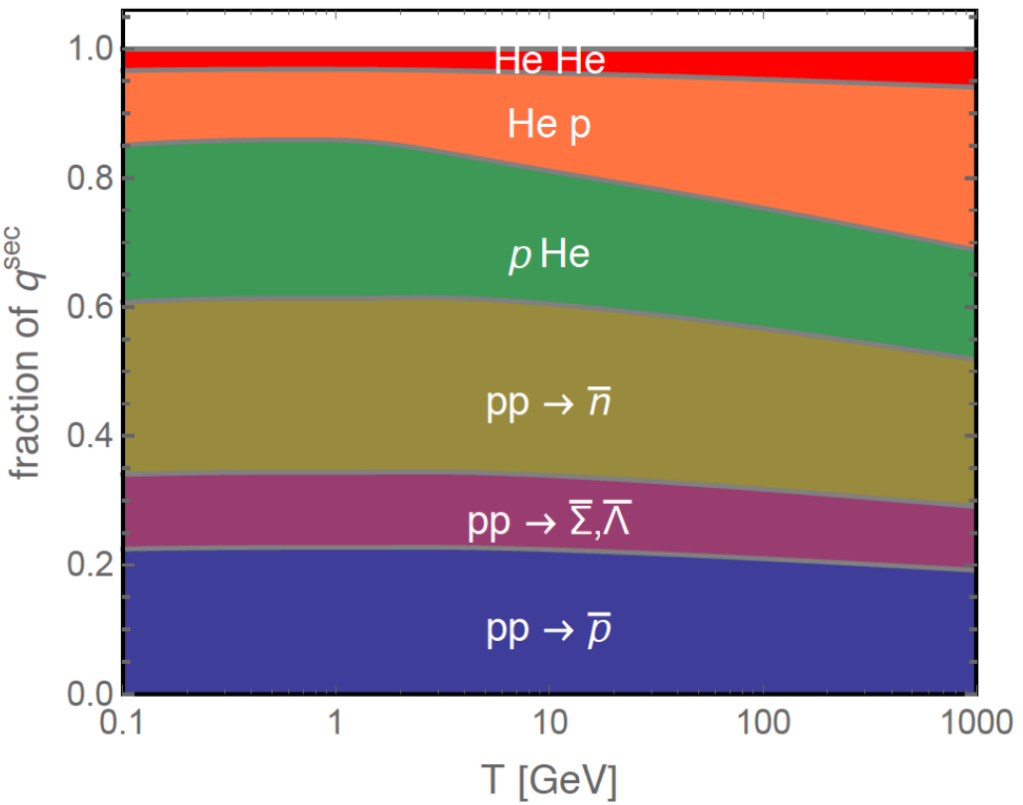

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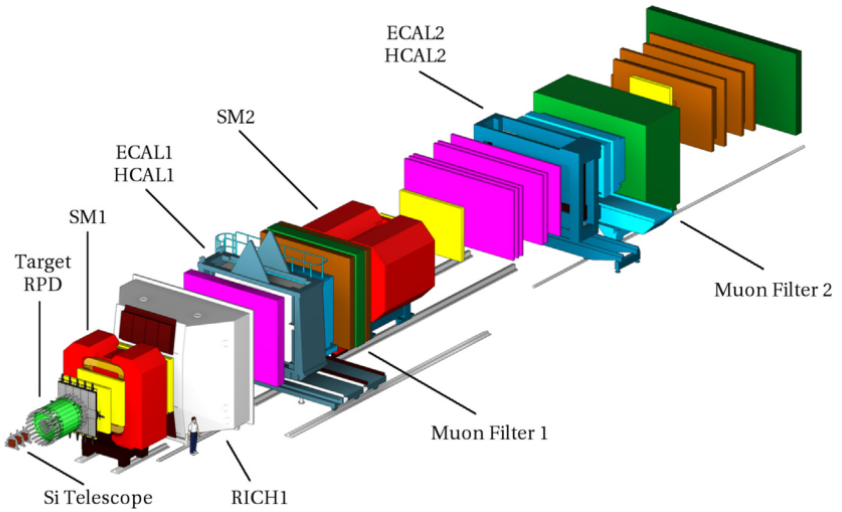
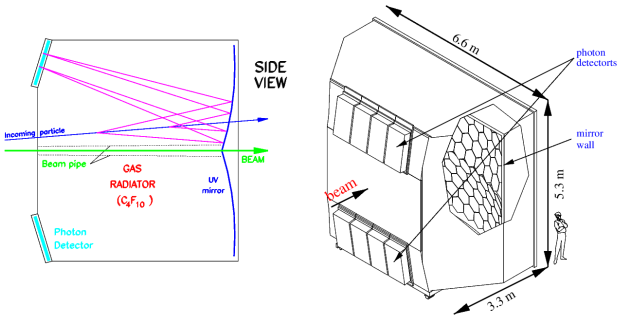
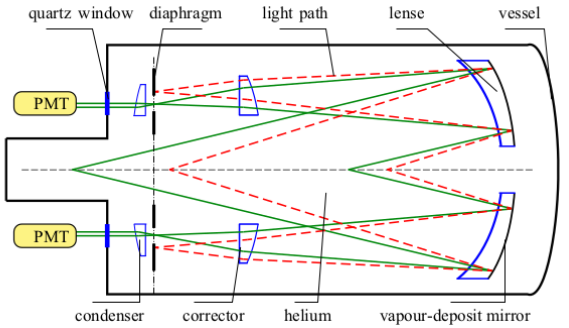
$\Rightarrow$ $\sigma\left(p+p \rightarrow \bar{p}+X\right)$, done recently by NA-61, the future one extends source term covered
$\Rightarrow$ $\sigma\left(p+^4 He \rightarrow \bar{p}+X\right)$ no data available in AMS range (only LHCb at $\sim$ TeV)

COMPASS @CERN







- using COMPASS setup for hadron physics (2009)
- Large-acceptance two-stage spectrometer
- Precise tracking ($\sim$ 350 planes) and PID (CEDAR, RICH-1, calorimeters, muon system)

XS Measurement in COMPASS++/AMBER

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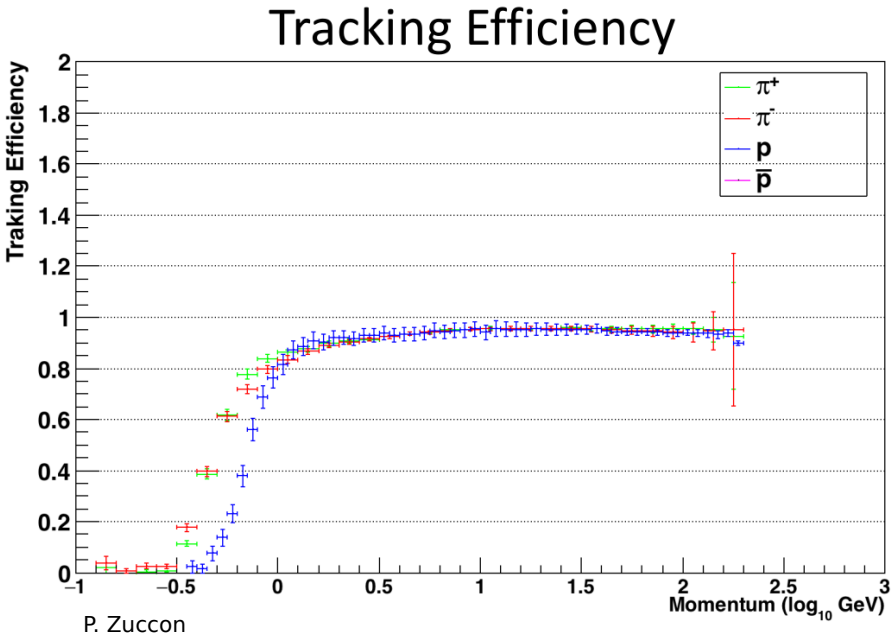
- Identify events with one (or multiple) anti-p vs reconstructed momentum and angle ($N_{\bar{p}}(p, \theta)$)
- Calculate the double differential cross section as

$$\frac{d\sigma_{\bar{p}}}{dpd\theta}(p, \theta) = \sigma_{pp} \frac{N_{\bar{p}}(p, \theta)}{N_{\text{tot}}} \frac{1}{\Delta p \Delta \theta}$$

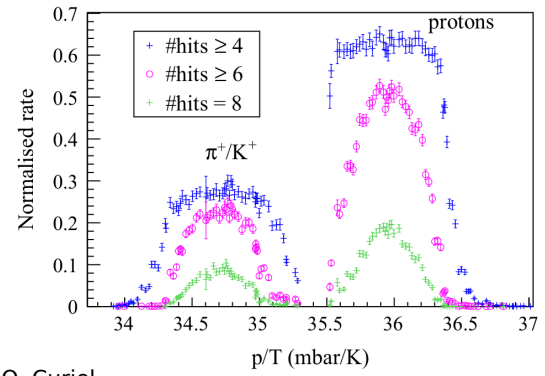
Expected systematic uncertainty $\simeq$ 5 % per data point and statistic error $\simeq$ 0.5 %

Experimental requirements

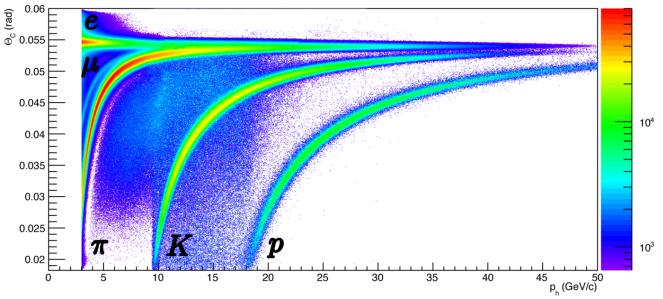
- fast beam PID $\rightarrow$ provided by 2 CEDARs
- precise tracking system (vertex resolution $\leq$ 4 mm and hit spatial resolution 4-11 μm)
- PID system: a RICH detector for outgoing $\bar{p}$ PID (over 90 % efficiency in 10-45 GeV/c range), calorimetry and muon walls
- new DAQ compatible with triggerless event read



P. Zuccon



Q. Curiel



Summary

- poor knowledge of $\bar{p}$ production cross sections influences dark matter signals sensitivity
- possible p-p and p-He cross section with $\bar{p}$ production measurement @CERN with COMPASS++/AMBER spectrometer
- possibile schedule: pilot run in 2022, run in 2023