Search for Dark Matter at the LHC and with astrophysical experiments.

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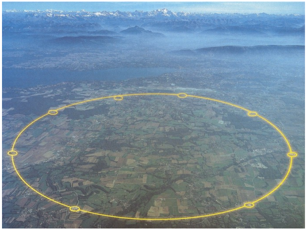
Search for new physics

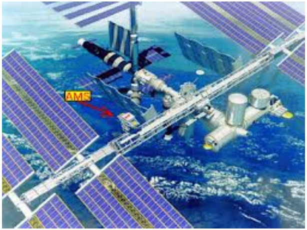
Huge experimental effort in the search for signals of **physics beyond the Standard Model.**

Exploration of nature of DARK MATTER (WIMPs)

high energy colliders, e.g. LHC



astrophysical sources, e.g. AMS



Search for new physics

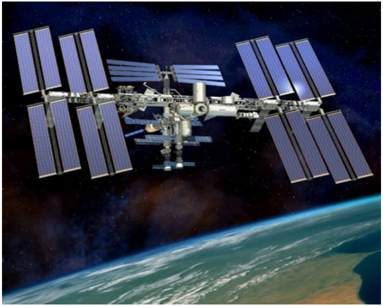
Huge experimental effort in the search for
signals of **physics beyond the Standard Model.**

Exploration of nature of DARK MATTER (WIMPs)

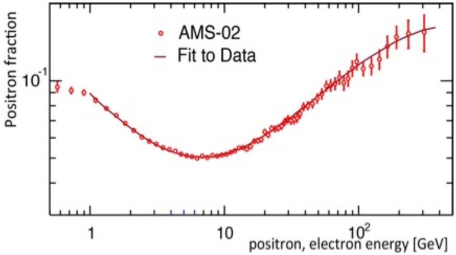
In principle there are three ways of discovering Dark Matter:

- **production** at LHC
- **direct** detection, interaction with ordinary matter (scintillators, bolometers, etc.)
- ***indirect* detection, annihilation products, AMS.**

AMS: the Alpha Magnetic Spectrometer Experiment



AMS detector on the International Spatial Station (ISS)



First results for the positron fraction

Search for antimatter,

high precision measurements of composition and fluxes of cosmic rays, ...

From a theoretical perspective

Dark Matter is mostly believed to be

- multi TeV mass particle;
- leptophilic;
- large annihilation cross section in light final states.

Candidates:

- byproduct of a more comprehensive model (e.g. SUSY)
- ad hoc models (e.g. Minimalistic Models, New Dark Forces, Decaying DM, ...)

No detection of possible DM candidate at LHC (so far):
exclusion of certain regions of the parameter space/certain models.

AMS:
detection of dark matter or exclusion of some other regions of the parameter space/models.

Prediction for AMS

AMS: measures the fluxes of secondary antimatter particles (positrons, antiprotons, . . .) produced by DM annihilation.

THEORETICAL PREDICTION FOR THE FLUXES

FLUX AT PRODUCTION

(DM + DM annihilation is parametrized by the cross section σv)

$+$

PARTON SHOWER AND HADRONIZATION

$+$

PROPAGATION THROUGH THE GALAXY

(several astrophysical uncertainties)

We are interested (for the time being) in the calculation of the flux at the production point.

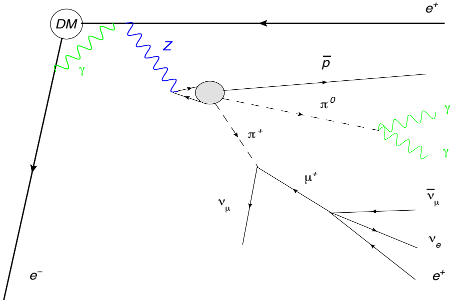
Prediction for AMS - in particular:

Our first focus

Importance of the inclusion of EW radiation in the calculation of the energy spectra.
We want to implement this for CONCRETE MODELS.

At the $\sim$ TeV scale EW corrections can be extremely relevant:

the DM mass M is much larger than the EW scale
$\Rightarrow$ the emission is enhanced by factors $\ln M^2/M_W^2$



from ArXiv: 1009.0224v1

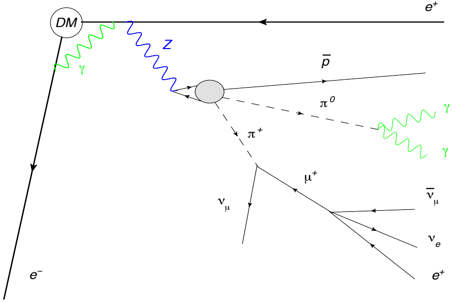
Prediction for AMS - in particular:

EW corrections from the DM initial state are *model dependent*.

EW corrections from the SM final state are *model independent*.

We restrict ourselves to this second subset of EW corrections.

TO INCLUDE EW CORRECTIONS WE NEED THE PARTONIC SPLITTING FUNCTIONS TO MASSIVE PARTONS (W AND Z BOSONS)



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Generalized partonic splitting functions

$$\frac{dN_{I\to f}}{d\ln x}(M,x) = \sum_J \int_x^1 dz\, D^{EW}_{I\to J}(z) \frac{dN^{MC}_{J\to f}}{d\ln x}(zM, \frac{x}{z}),$$

with

$$D^{EW}_{I\to J}(z) = \delta_{IJ}\delta(1-z) + \frac{\alpha_2}{2\pi}\int_{M_W^2}^{s} \frac{d\mu^2}{\mu^2} P^{EW}_{I\to J}(z,\mu^2),$$

where

- I is the generic pair of SM particles produced via DM DM annihilation (e.g. $e^+e^-, \nu\bar{\nu}, \ldots$);
- $\frac{dN_{I\to f}}{d\ln x}$ is the energy spectrum of the stable SM particle f and $x = E_f/\sqrt{s}$;
- $D^{EW}_{I\to J}(z)$ is the $I \to J$ parton distribution;
- $P^{EW}_{I\to J}$ is the generalized splitting function;

Note: in these expressions $D^{EW}_{I\to J}$ and $P^{EW}_{I\to J}$ contain all EW corrections.

Generalized partonic splitting functions

First step:

computation of all possible SM splitting functions $P^{EW}_{I \to J}$, as done in Arxiv: 1009.0224v1 [Ciafaloni, Comelli, Riotto, Sala, Strumia, Urbano].

Then:

- exact calculation of the EW radiation of Z and W in the MSSM;
- same calculation in the splitting function approximation;
- Propagate the resulting flux and compare the expectations for the AMS.