

# Dark Matter with AMS-02

## Aachen, 17 July 2003

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on behalf of AMS collaboration











• Cosmic Rays : p, D, He, C, ...,e+, e-, γ

Will Collect ~ $10^{10}$  CRs in Near-Earth Orbit from few GV to few TV

- Direct Search for Cosmic Anti-matter
- Indirect Searches for Dark Matter
- Other searches:

strangelets, Primordial Black Holes,  $\mu$ Quasars,  $\gamma$ -Astronomy, ...

A Particle Physics Experiment on the International Space Station for 3 Years (Launch October 2005).



### AMS-02 on ISS

#### HEP - NASA experiment



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GAM



#### Detector





**TRD** Transition Radiation Detector Germany

**TOF: (s1, s2)** Time Of Flight Detector Italy

**TRACKER** Silicon Tracker Germany, Holland, Italy, Switzerland

ACC Anticoincidence Counter Germany

MAGNET U.K.

**TOF: (s3, s4)** Time Of Flight Detector Italy

#### RICH

Ring Image Cherenkov Counter Italy, Portugal, Spain France

EMC Electromagnetic Calorimeter China, France, Italy

y2K269b Becker R.

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### Aachen, July 17, 2003 AMS-02 Completeness

300 GeV	e-	e+	Р	He	γ	γ
TRD	····· >>>>	****				
TOF	•	T	т	r	٢	ç
Tracker	/	$\langle \rangle$	λ	/	$\wedge$	
RICH	0	0	0	Ø	00	
Calorimeter	Â	A		ŧ		A





## Performances

#### Angular and Energy resolution for γs



Overall proton/ $\gamma$  suppression factor > 10<sup>5</sup>





#### ~ 200 scientists + dozens of contractors

U. of Aarhus (DK); Academia Sinica (Taiwan); U. of Bucharest (RO); Chinese Academy of Sciences, Inst. of High Energy Physics IHEP (Beijing); Chinese Academy of Sciences, Inst. of Electrical Engineering IEE (Beijing); Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas CIEMAT (Madrid, ES); Chung Shan Inst. of Science and Technology CSIST (Taiwan); EHWA Women's University (Seoul, KR) ETH Zurich (CH); Florida A&M U. (Tallahassee, FL); U. of Geneva (CH); Helsinki U. of Technology (FI); INFN Bologna & U. Bologna (IT); INFN Milano (IT); INFN Perugia, (IT); & U. Perugia (IT); INFN Pisa & U. Pisa (IT); INFN Roma & U. Roma (IT); INFN Siena & U Siena (IT); Inst. Superior Technico (Lisbon, PT); Inst. di Ricerca sulle Onde Elettromagnetiche IROE (Florence, IT); Inst. des Sciences Nucleaires de Grenoble ISN (FR); Inst. for Theoretical and Experimental Physics ITEP (Moscow, RU), Jiao Tong U. (Shanghai); Johns Hopkins U. (Baltimore, US); U. of Karlsruhe (DE); Kurchatov Institute (Moscow, RU); Kyungpook National University CHEP (Taegu, KR); Laboratoire d'Annecy-le-Vieux de Physique des Particules LAPP (FR); Laboratório de Instrumentaço e Física Experimental de Partículas LIP (Lisbon, PT); U. Maryland (College Park, US); Max Planck Inst. (Garching, DE); Massachusetts Inst. of Technology MIT (Cambridge, US); U. Montpellier (FR); Moscow State University (RU), Nat'l Aerospace Laboratory NRL (Amsterdam, NL); U. Nacional Autonoma de Mexico (MX); Nat'l Space Program Office (Taiwan); Nat'l Central University NCU (Taiwan); Nat'l Inst. for Nuclear Physics and High Energy Physics NIKHEF (Amsterdam, NL) I. Physikalisches Inst., RWTH Aachen (DE); III. Physikalisches Inst., RWTH Aachen (DE); Southeast U. (Nanjing); U. of Turku (FI); Yale U. (New Haven, US); Lockheed Martin, USA; Space Cryomagnetics LTD, UK; Arde, Inc., USA; CAEN Aerospace, IT; Carlo Gavazzi Space SpA, IT; ISATECH Engineering GmbH, DE; OHB GmbH, DE; Linde; NASA; ESA





## Cosmic Rays

### Protons Dominant Component

- He 5% of P flux at10 GeV
- p<sup>-</sup> ~ 10<sup>-3</sup> % of P Flux
- D-, heavier anti-nuclei unobserved
- Power Spectra: Supernova
  Shock Acceleration
- Propagation  $\rightarrow$  Magnetic Fields
- $\bullet$  Cosmic Rays & atmospheric  $\nu$



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Astroparticle studies embedded in Cosmic Ray Physics



- Universe Matter budget 90 % is Dark & non baryonic
- Structure formation Dark Matter is Cold (CDM)
- SUSY provides an excellent WIMP candidate neutralino :  $\chi^{0}_{1}$

$$\chi^{0}_{1}\chi^{0}_{1} \rightarrow qq^{-}$$
, W<sup>+</sup>W<sup>-</sup>, H<sup>+</sup>H<sup>-</sup>, ...  
 $\rightarrow$  p- ,anti-D ,  $\gamma$  , e<sup>+</sup>, +X

- Completeness of AMS-02:
  - $p^-$ : Excess at Energy of a few GeV
  - D-: Excess Below 1 GeV
  - e<sup>+</sup>: Structure in Spectra above few GeV

-  $\gamma$  : Energy Spectra differ from "power laws", or  $\gamma$  line detection  $\chi^{0}_{1}\chi^{0}_{1} \rightarrow \gamma\gamma$ ,  $Z\gamma$ 



## Anti-protons

In case of a SUSY contribution at high energy, this could be measured



Full 3 yr (MC) AMS sensitivity without considering any DM signature.

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Heat Data : a bump in energy at 7 GeV, no standard astrophysical interpretation of e+/e- energy distribution

Precise data extended to higher energies will be provided by AMS MSSM simulation for AMS-02 need high "boost factors"





### MSSM: Donato, Fornengo, Salati, 1999 Promising for long exposures large acceptance in space



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#### Aachen, July 17, 2003 Dark Matter - γ ray case

#### EGRET map Ey>100 MeV





#### Aachen, July 17, 2003 Dark Matter - γ ray case



- diffuse D M : galactic as v, e+, p-, D-, Direct Detection extragalactic
- source D M : Galactic Centre (G. C.)
  - Nearby Spiral Galaxies : e. g. M31
  - Dwarf Spheroidals : e. g. DRACO
  - Globular Clusters :  $\varpi$  centauris, Palomar13

 $\rightarrow$  Enhancement factors from cuspy halos, clumpiness or/and SBH



mSUGRA simulations for large m<sub>0</sub> G. C. Navarro-Frenk-White profile with various parameters "wild scan", flux above 3 GeV





(mSUGRA models proposed by Battaglia et al, 2002)

Numbers of photons expected in AMS-02 in 1 year from GC

Model	В	С	G	I	L
<b>m</b> <sub>χ</sub> (GeV)	99	<b>162</b>	155	145	836
NFW standard	1.5	0.1	0.6	3.6	15
NFW max	83	6	45	258	597
Moore	156	18	111	525	1416



- AMS-02 will provide data from October 2005 and at least 3 years on
- The completeness of AMS-02 detector will allow to measure simultaneously the Astroparticle Signals and Cosmic Backgrounds
- AMS-02 will probe
- Dark Matter content in various channels (p-, D-, e+,  $\gamma$ )
- Barzon Asymmetry
- Cosmic Rays and  $\gamma$ -Astrophysics (not covered here)
- Exotics, strangelets, PBHs,

and unexpected ...