Southeast University and AMS-02 Experiment

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Outline

- Background of AMS
- SEU’s contribution to AMS
- Conclusion and future work
The Origin of Dark Matter

~ 90% of Matter in the Universe is not visible and is called Dark Matter.

A Galaxy as seen by telescope

If we could see Dark Matter in the Galaxy
AMS is the only large-scale physics experiment that directly searches for dark matter in the space.
AMS is US Dept of Energy (DOE) led International Collaboration

16 Countries and regions, 60 Institutes and 600 Physicists, 17 years

USA
A&M FLORIDA UNIV.
JOHNS HOPKINS UNIV.
MIT - CAMBRIDGE
NASA GODDARD SPACE FLIGHT CENTER
NASA JOHNSON SPACE CENTER
UNIV. OF MARYLAND-DEPT OF PHYSICS
UNIV. OF MARYLAND-E.W.S. S.CENTER
YALE UNIV. - NEW HAVEN

DENMARK
UNIV. OF AARHUS

FINLAND
HELSINKI UNIV.
UNIV. OF TURKU

FRANCE
GAM MONTPELLIER
LAPP ANNECY
LPC GRENOBLE

GERMANY
RWTH-I
RWTH-III
MAX-PLANK INST.
UNIV. OF KARLSRUHE

ITALY
A.S.I.
CARSO TRIPSTE
I.ROE FLORENCE
INFN & UNIV. OF BOLOGNA
INFN & UNIV. OF MILANO
INFN & UNIV. OF PERUGIA
INFN & UNIV. OF PISA
INFN & UNIV. OF ROMA
INFN & UNIV. OF SIENA

NETHERLANDS
ESA-ESTEC
NIKHEF
NLR

PORTUGAL
LAB. OF INSTRUM.
LISBON

ROMANIA
ISS
UNIV. OF BUCHAREST

RUSSIA
I.K.I.
ITEP
KURCHATOV INST.
MOSCOW STATE UNIV.

SPAIN
C.I.E.M.A.T - MADRID
I.A.C. CANARIAS.

SWITZERLAND
EPJ-ZURICH
UNIV. OF GENEVA

KOREA
EWHANG
KYUNGPOOK NAT.UNIV.

MEXICO
UNAM

JAPAN

CHINA

中

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东南大学

上海交大

山东大学

航天部一院

航天部五院

南方科技大学

中央研究院

中央大学

成功大学

太空计划室

交通大学
5m x 4m x 3m
7.5 tons

300,000 electronic channels
650 microprocessors

Silicon layer

TRD
TOF 1, 2
Magnet

7 Silicon layers

Radiators

TOF
RICH
ECAL

11,000 Photo Sensors

Silicon layer
May 19: AMS installation completed at 5:15 CDT, start taking data 9:35 CDT
AMS Data Flow

Tracking and Data Relay Satellite, TDRS

Marshall Space Flight Center

AMS Scientific Operation Center

POCC
- AMS Flight Status Monitoring

SOC
- Data reconstruction
- Data analysis
- Data distribution
- Monte Carlo production

Regional SOC
- Data storage
- Data reconstruction
- Monte Carlo production
- Data analysis

POCC
- AMS Flight Status Monitoring

Huntsville, AL

KU band

AMS on ISS

JSC

CERN

SEU RWTH Milano CIEMAT •••

AMS Data Flow

POCC
- AMS Flight Status Monitoring

SOC
- Data reconstruction
- Data analysis
- Data distribution
- Monte Carlo production

Regional SOC
- Data storage
- Data reconstruction
- Monte Carlo production
- Data analysis
Missions of AMS-SOC

- Data storage, data reconstruction, Monte Carlo simulation, physics analysis, massive data transfer
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Starting its collaboration with AMS from 2002, SEU is the first Chinese university to join in AMS experiment.
Talents exchange between SEU and AMS

- SEU’s Collaboration with AMS and MIT lasts for more than a decade

- ~40 SEU Professors/Assistant Professors/students visited MIT

- MIT faculties including Nobel laureate Professor Samuel Ting, Research Professor Vitaly Choutko visited SEU regularly in the past few years
Talents exchange between SEU and AMS

Prof. Li Qi at MIT

Prof. Luo Junzhou at NASA

Prof. Vitaly Choutko at SEU

Discussions at CERN
High-tech breakthroughs at SEU

AMS-02 silicon trackers

AMS-02 Control System

AMS-C at SEU

Prof. Samuel Ting at SEU
Starting its collaboration with AMS from 2002, SEU is the first Chinese university to join in AMS experiment.
- SEU’ data center dedicated to AMS experiment
  - 5500 CPU cores (70 TFLOPS at peak) and 920TB storage.
    - Docker、OpenStack、Hadoop
  - 1Gb/s dedicated network between SEU and CERNET Beijing gateway, 2.5Gb between CERNET and CERN
  - Cloud based AMS-SOC for better supporting AMS data storage, computing and data transfer
SEU’s AMS Data Transfer Network

Topology of **China Education and Research NETwork (CERNET)** Backbone

- **CERN**
- **NLAA**
- **Beijing CNGI-6IX**
- **Nanjing SEU**
- **Guangzhou**

Legend:
- **1GPOS** Dedicated for AMS
- **10GPOS**
- **2.5GPOS**
- **IPv6 Link**
- **Tier 1**
- **Tier 2**

Connections:
- 1GPOS Dedicated for AMS
- 10GPOS
- 2.5GPOS
- IPv6 Link
- Tier 1
- Tier 2
A Glance at SEU’s AMS-SOC (cost: RMB 25M)
Prof. Ting and the MIT delegation visited SEU’s AMS-SOC to discuss the data analysis solutions
Data processing at SEU’s AMS SOC

AMS user

Login

Login node

Physics analysis jobs

Job submission

Data analysis

Analysis results

Data Storage

Data Transfer Servers

168 IBM HS22 blade servers

42 IBM Flex240 blade servers

SEU’s AMS SOC

 LS F

Computing resources

ROOT/Geant/...

Software resources
Data processing at SEU’s AMS SOC

- **696TB** data are produced at SEU, including 138TB Raw data, 368TB Monte Carlo data, and 190TB Reconstructed data.
- **1.53M** CPU hours are spent at SEU: 1st place in 6 regional AMS SOC.

Data source: http://ams.cern.ch/ProdPlot/index.php
Data transfer at SEU’s AMS SOC

- Data transfer architecture
  - CERN ⇨ SEU (Raw Data)
    - client: LFTP
    - server: VSFTP
    - Request: 200GB/day
Data transfer at SEU’s AMS SOC

- **Data transfer architecture**
  - SEU -> CERN (MC Simulation Data / Reconstructed Data)
    - client: LFTP
    - server: VSFTP
    - Request: 1~2TB/day

![Diagram showing data transfer architecture between CERN and SEU]
Data transfer improvement by optimizing

- **two parameters:** the size of socket buffer at both sending and receiving sides; the number of parallel connections

- Increasing the socket buffer size of the sending and receiving side will help to improve the data transfer performance

- Increasing the number of parallel connections does not always increase the transfer performance
Data transfer at SEU’s AMS SOC

Data Transfer Status

AMS data transfer reaches 400Mbit/sec after optimization.
Data transfer at SEU’s AMS SOC

SEU is able to transfer more than 1 TB AMS data to CERN per day
Researches on AMS big data processing

AMS application layer
- MC Simulation
- Data Analysis
- Data Reconstruction

Data processing layer
- Data Query
- Graph Processing
- Streaming data processing

Big data storage and management layer
- Pre-processing
- Placement
- Migration

Cloud supporting platform layer
- Virtualization
- Elastic Resource Management

Hardwares in DC
- Computing Resources
- Storage Resources
- Network Resources
Cloud based AMS big data processing platform
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After these 13 years collaborations, we have obtained some fruitful achievements

- Successfully construct AMS-C, AMS-AIS and AMS-SOC at SEU
- Process and transfer more than 700TB scientific data
- Breakthrough several key technologies
- Exchange more than 40 teachers and students
AMS-02 will continuously produce massive data (~4PB in next 10 years of AMS operation), including:
- raw data (~40TB/year)
- reconstructed data (~200TB/year)
- MC data (~200TB/year)

Big data processing techniques need to be further employed including:
- Geo-distributed data analysis among multiple DCs
- High performance data transfer between AMS-SOCs
Thank You!

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