Review of DERA XMM Background Modelling

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XMM Radiation Workshop
VILSPA/ESA, 29 November, 2000

DERA

- Introduction
- Background Components
- Software Tools
- Simulation and Results
- Discussion

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Introduction

- This work was performed for ESTEC under Contract No. 10932/94/NL/RE

- It was carried out between 94/95, by Clive Dyer, Pete Truscott, Howard Evans and Clare Peerless in Space Department, DERA

- Results of this work have been reported in the Final Report to ESTEC (DRA/CIS(CIS2)/CR95032/1.0) and have been published in IEEE Trans. On NS.

Background Components

- Secondary electrons & photons from spacecraft & shield material leading to partial energy losses in CCD
- Fluorescent X-rays from local material
- Prompt production from cosmic rays
  - electromagnetic cascades
  - photonuclear de-excitation
  - neutron capture & inelastic scatter
- Prompt production from energetic Solar Flare particles
- Delayed production (Radioactivity) from cosmic rays, solar flares trapped protons

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Software Tools

- IRTS, Integrated Radiation Transport suite
  - HETC/LHI
  - Morse
  - EGS
  - Radioactive decay
  - Analysis and Control code
- ITS
  - for CCD response
- CRÈME and UNIRAD
  - for radiation environment

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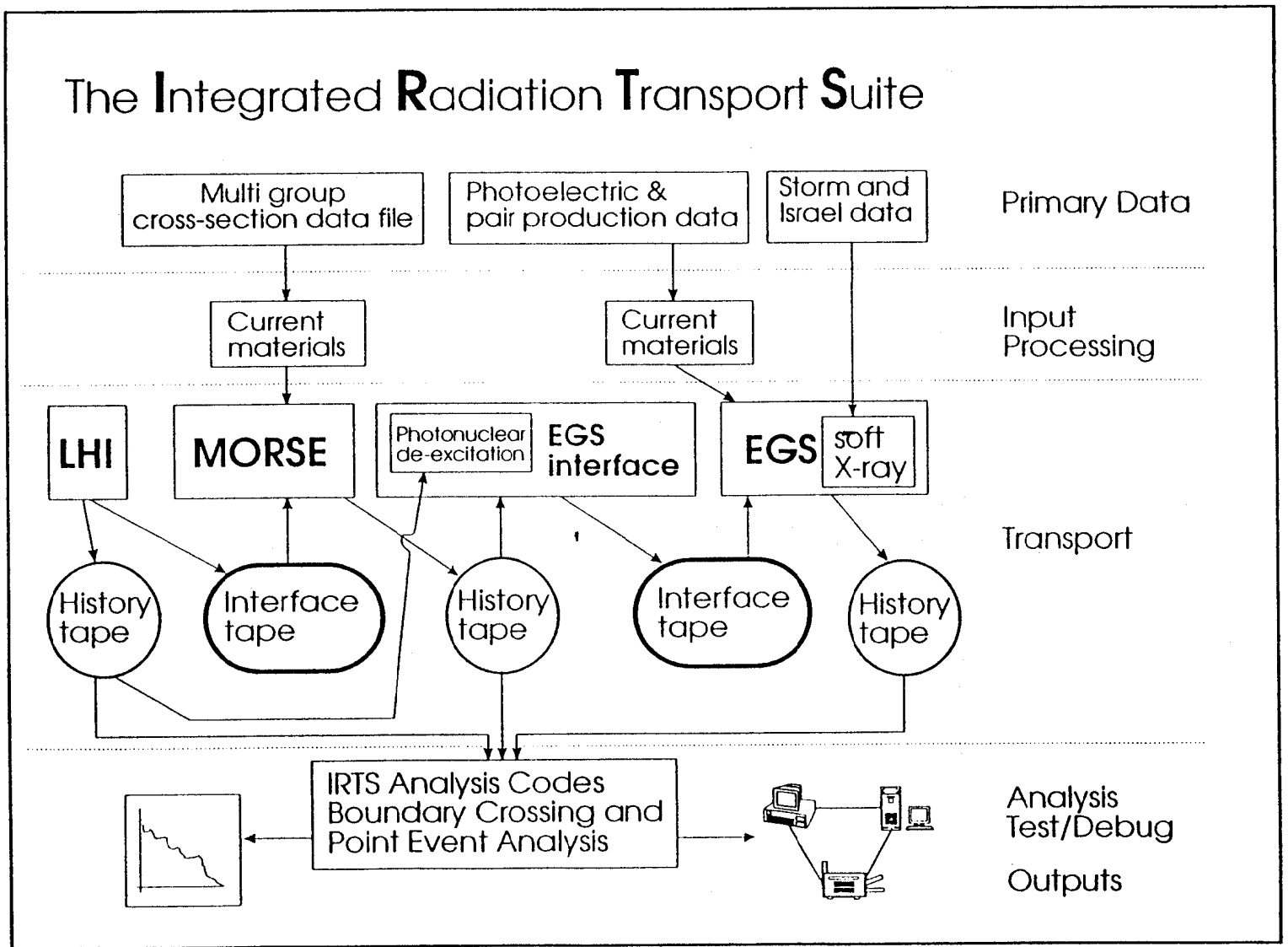

Figure 2 IRTS and interfaces

Simulation & Results (I)

- One Dimensional Simulation of source Functions
  - 2mm CF + 3cm Al
  - 2mm CF + 5cm Al
  - 2mm CF + 10cm Al
  - 2mm CF + 3cm Al + 2mm invar
  - 2mm CF + 3cm Al + 0.5cm W
  - 2mm CF + 3cm Al + 10um Au
- 100, 300, 2000 MeV monoenergetic proton beams

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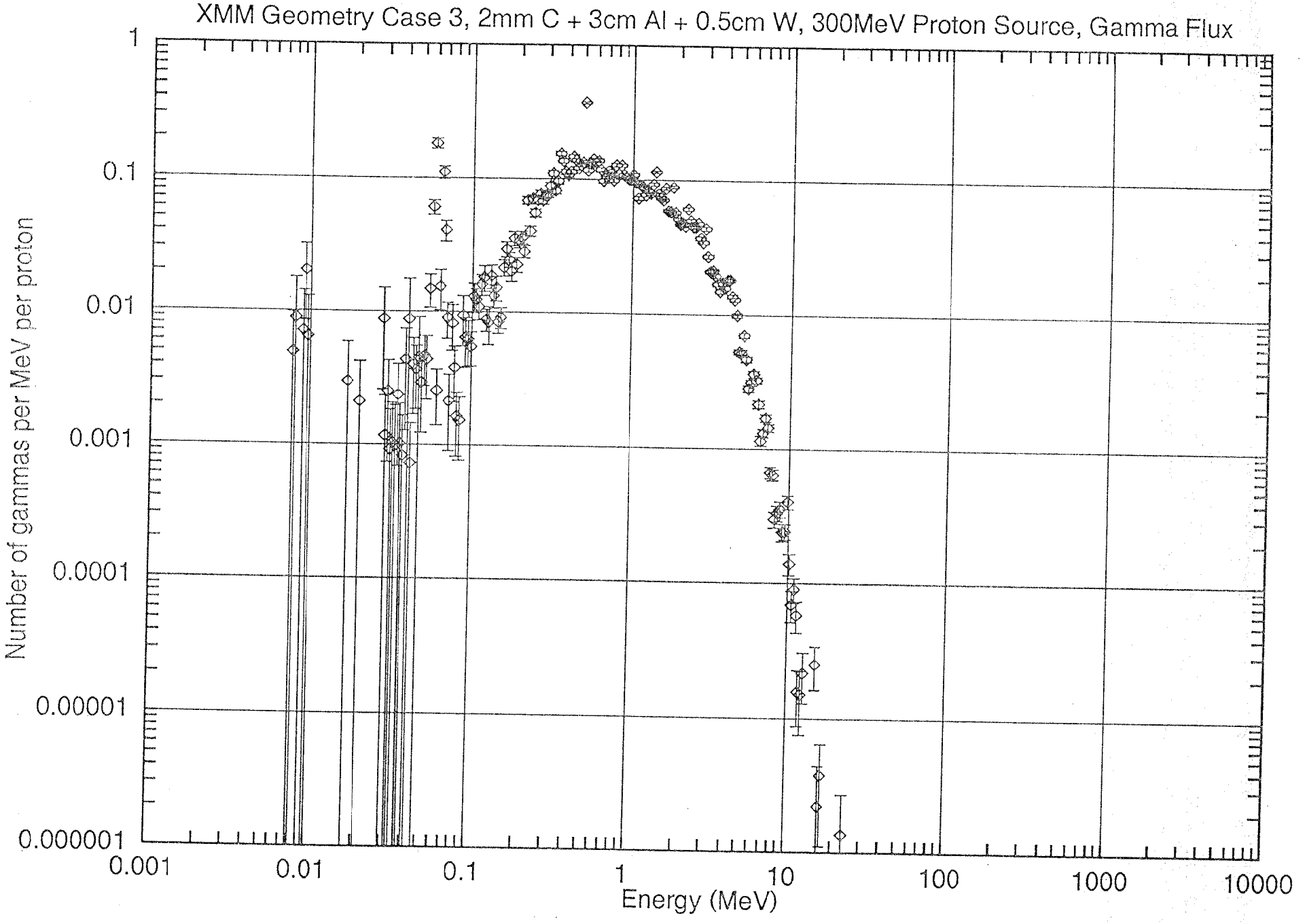
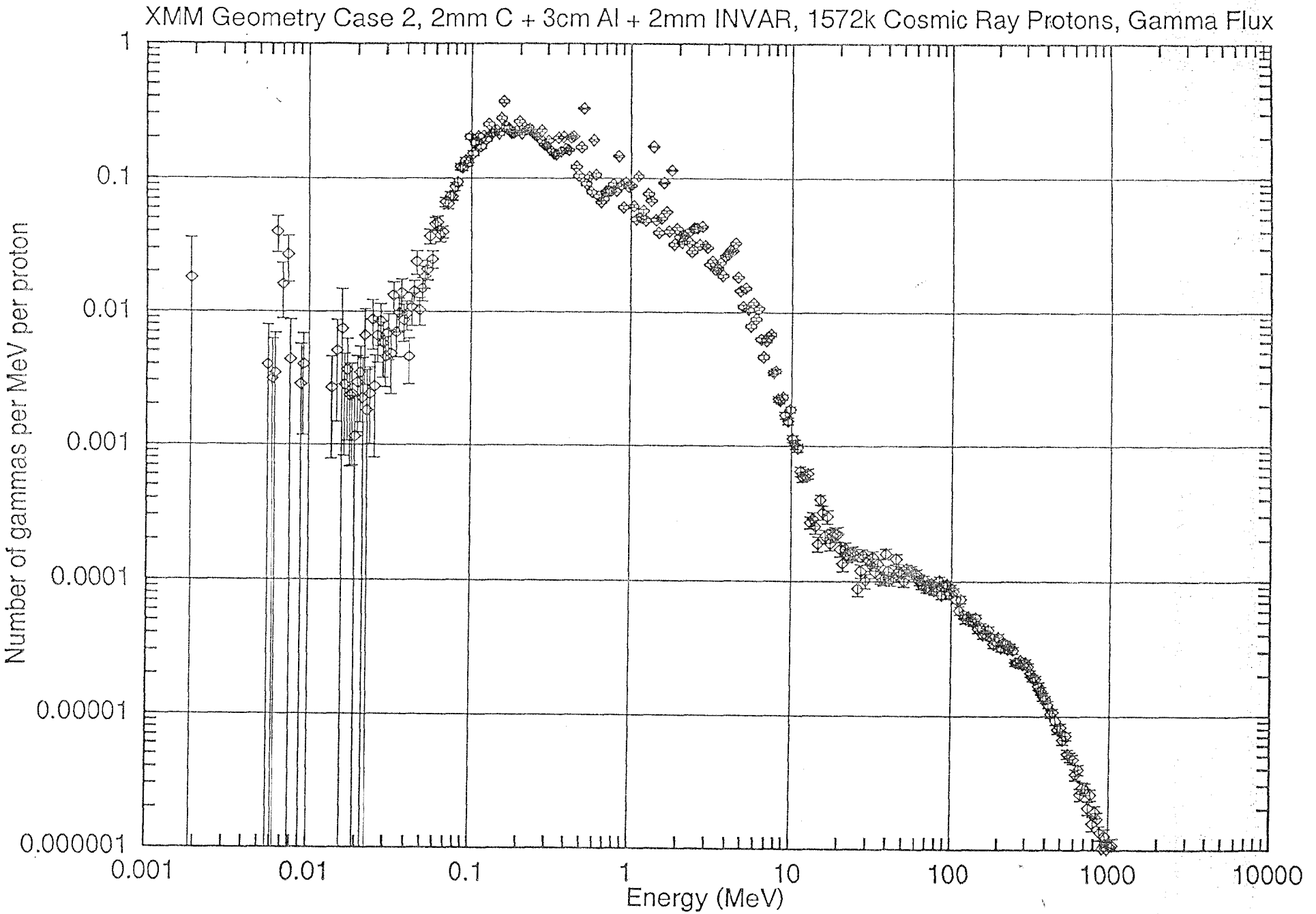
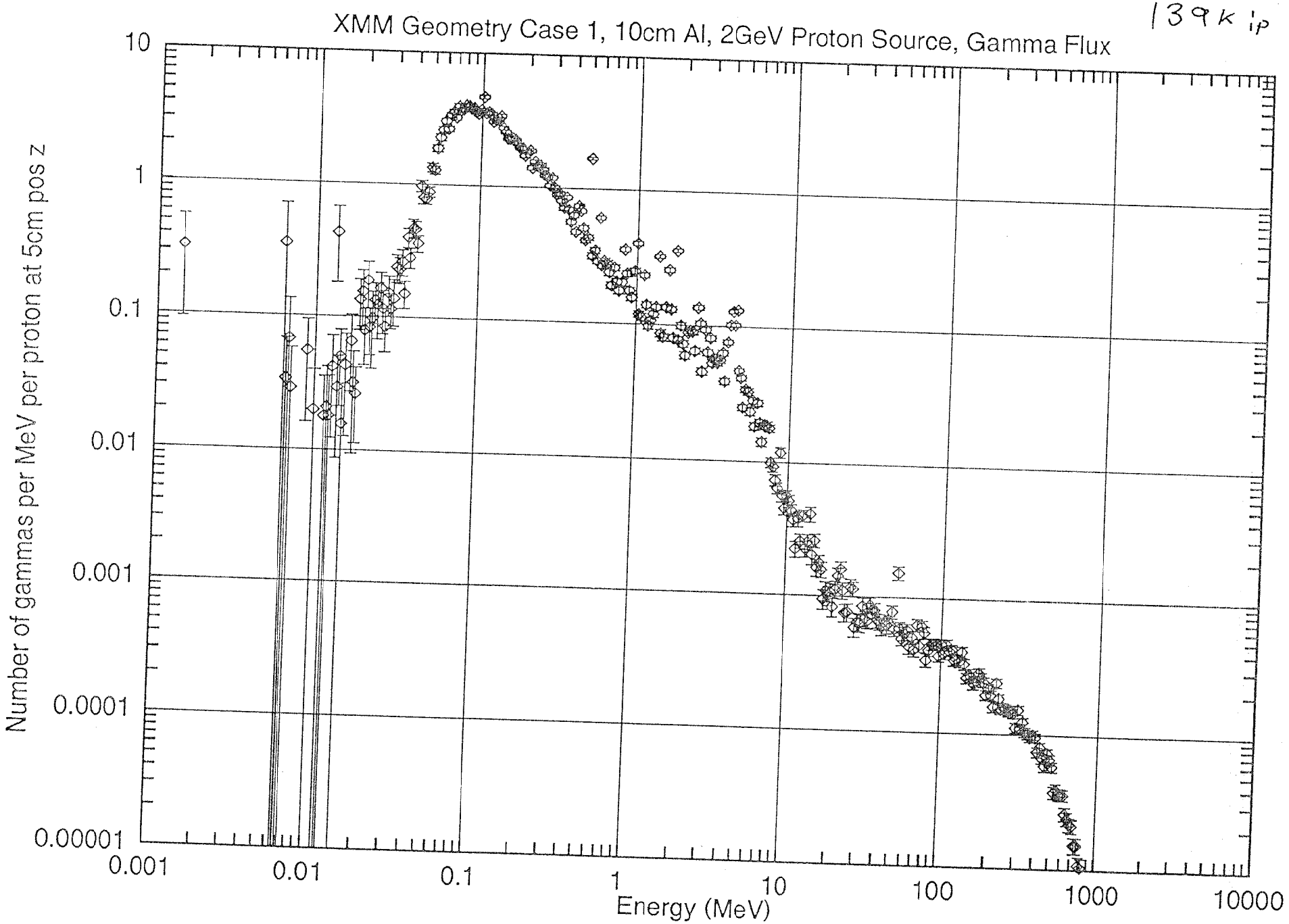
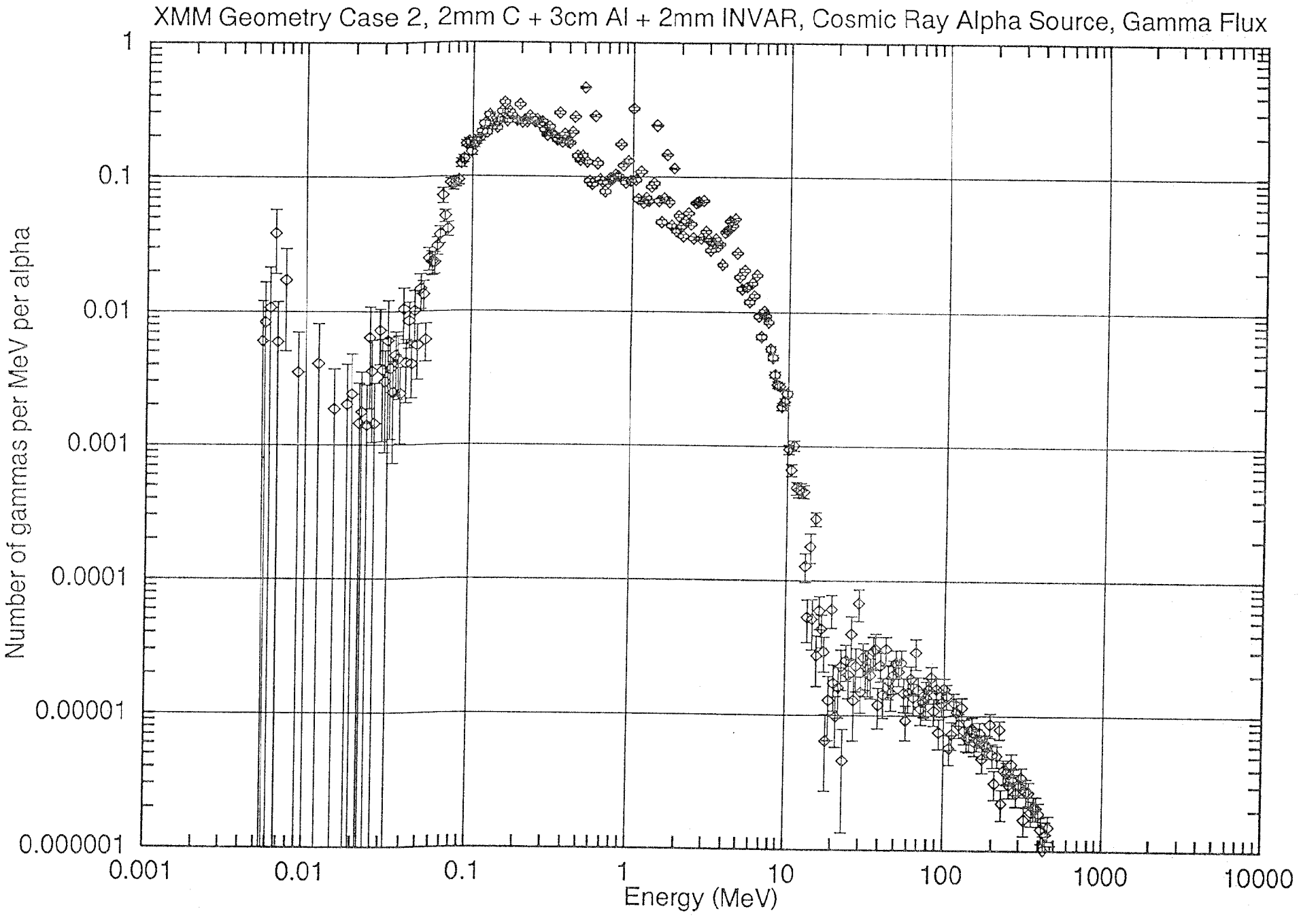

XMM Geometry Case 3, 2mm C + 3cm Al + 0.5cm W, 300MeV Proton Source, Gamma Flux
Number of gammas per MeV per proton
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.001
0.01
0.1
1
10
100
1000
10000
Energy (MeV)


XMM Geometry Case 2, 2mm C + 3cm Al + 2mm INVAR, 1572k Cosmic Ray Protons, Gamma Flux
Number of gammas per MeV per proton
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.001
0.01
0.1
1
10
100
1000
10000
Energy (MeV)

139k ip


XMM Geometry Case 1, 10cm Al, 2GeV Proton Source, Gamma Flux
Number of gammas per MeV per proton at 5cm pos z
Energy (MeV)
10
1
0.1
0.01
0.001
0.0001
0.00001
0.001
0.01
0.1
1
10
100
1000
10000

2/12/94


XMM Geometry Case 2, 2mm C + 3cm Al + 2mm INVAR, Cosmic Ray Alpha Source, Gamma Flux
Number of gammas per MeV per alpha
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.001
0.01
0.1
1
10
100
1000
10000
Energy (MeV)

EMITTED PHOTONS PER INCIDENT PROTON

Geometry	Energy (MeV)	Total Photons	1-15 keV Photons All x 10^{-5}
A. CF/3 cm Al	100	0.282	0.52
"	300	0.204	0.58
"	2000	0.497	8.63
B. CF/5cm Al	100	0.235	0.86
"	300	0.311	0.59
"	2000	0.884	11.1
Mid-point of 10cm Positive Direction	2000	1.45	42.0
Mid-point of 10cm Negative Direction	2000	1.44	14.7
C. CF/10cm Al	100	0.144	0.49
"	300	0.513	1.63
"	2000	1.95	46.8
D. CF/3cm Al/ 2mm invar	100	0.300	1.88
"	300	0.240	0.66
"	2000	0.637	19.4
"	Cosmic Ray Protons	0.328	3.0
"	Cosmic Ray Alphas	0.404	2.3
"	Solar Flare Protons	0.087	0.51
E. CF/3cm Al/ 5 mm tungsten	100	0.119	0.91
"	300	0.252	1.53
"	2000	1.46	64.0
F. CF/3cm Al/ 10μm gold	300	0.200	6.55

Ranges are approx : 9.98, 65.5, 1000 gm cm^{-2} for 100, 300, 2000 MeV protons.

Thicknesses are A:8.5; B:13.9; C:27.4; D:10.1; E:18.1 gm cm^{-2}

Simulation & Results (II)

- CCD response functions
  - 60 um bare silicon, and + 10um Au
  - 280 um bare silicon
- Carbon line contribution
  - 4.43 MeV due to proton inelastic scattering on carbon

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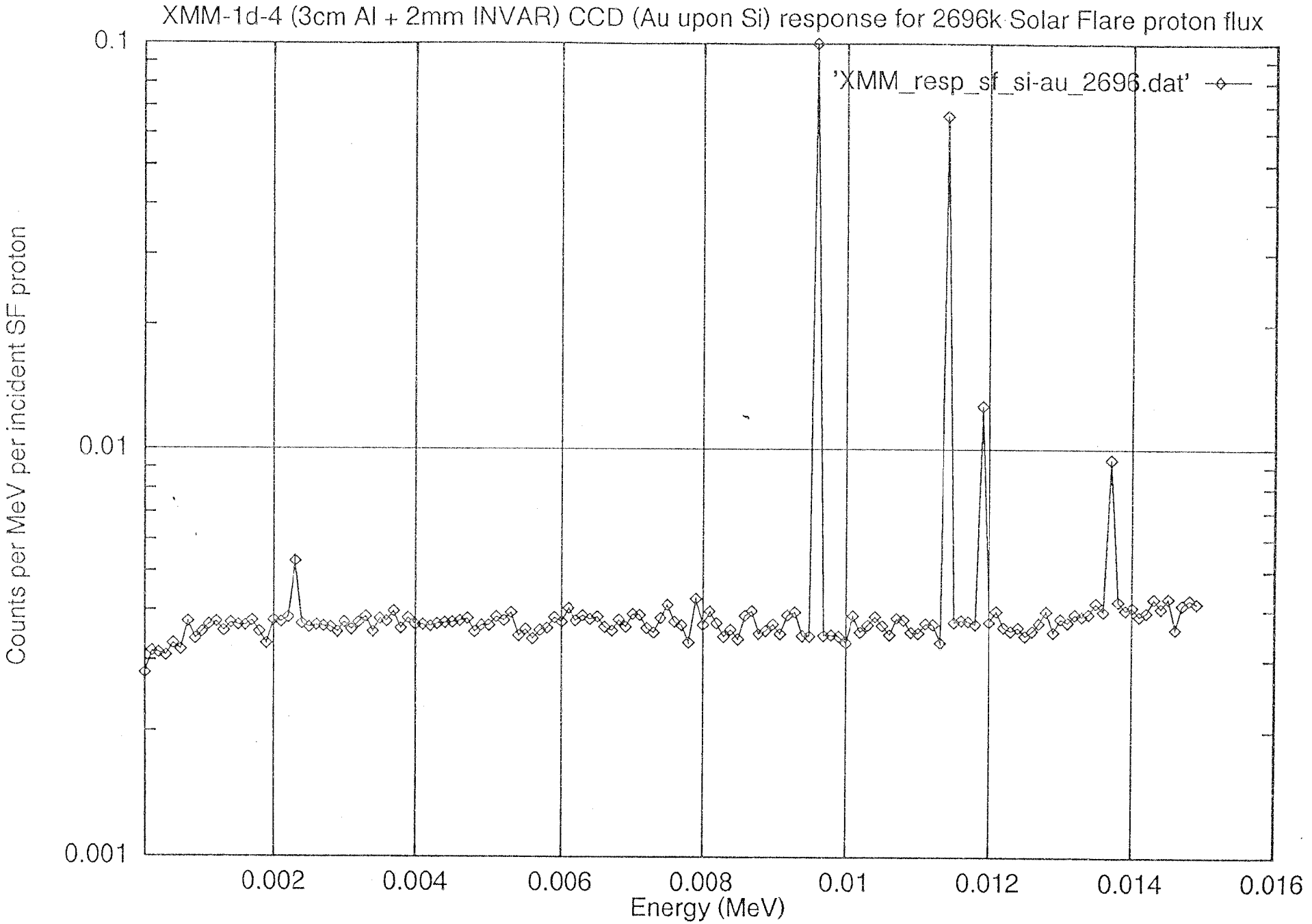
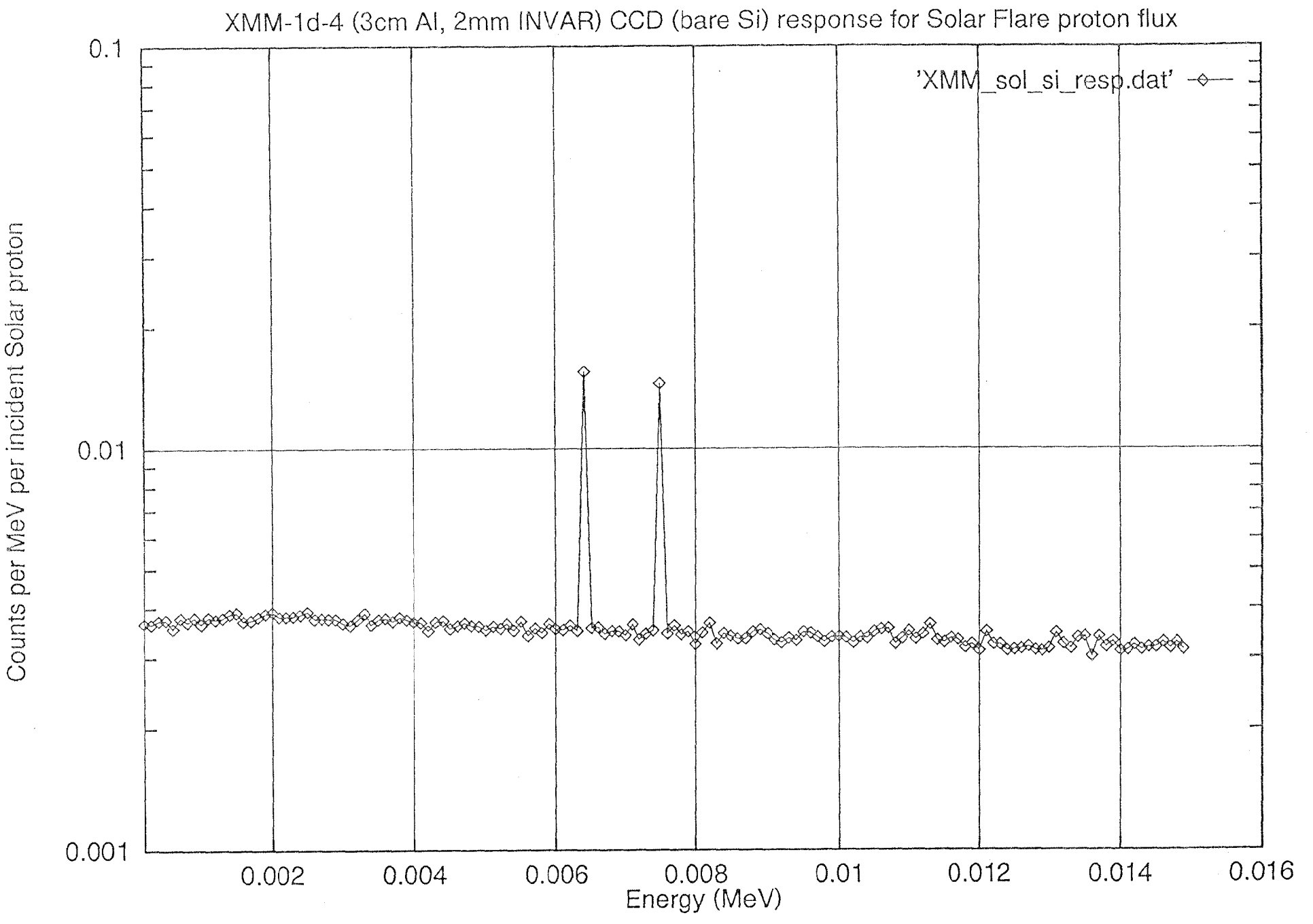

XMM-1d-4 (3cm Al + 2mm INVAR) CCD (Au upon Si) response for 2696k Solar Flare proton flux
'XMM_resp_sf_si-au_2696.dat'
Counts per MeV per incident SF proton
0.1
0.01
0.001
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
Energy (MeV)


XMM-1d-4 (3cm Al, 2mm INVAR) CCD (bare Si) response for Solar Flare proton flux
'XMM_sol_si_resp.dat'
Counts per MeV per incident Solar proton
0.1
0.01
0.001
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
Energy (MeV)

Simulation & Results (III)

- 3-D Simulation
  - Geometry model
  - Cosmic Ray prompt
  - Solar Flare prompt
  - Comic ray induced
  - Solar Flare induced

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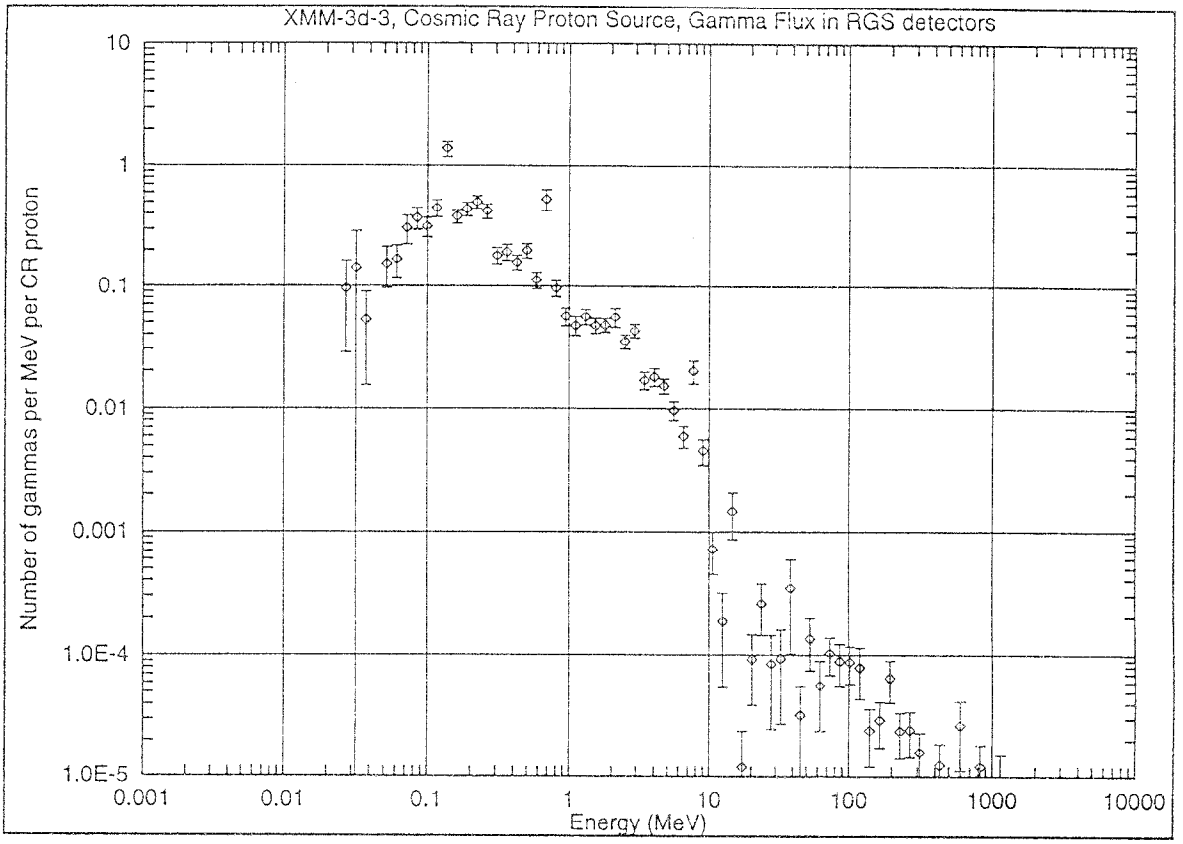

Figure 29 Cosmic-ray proton induced photon spectrum at RGS detector

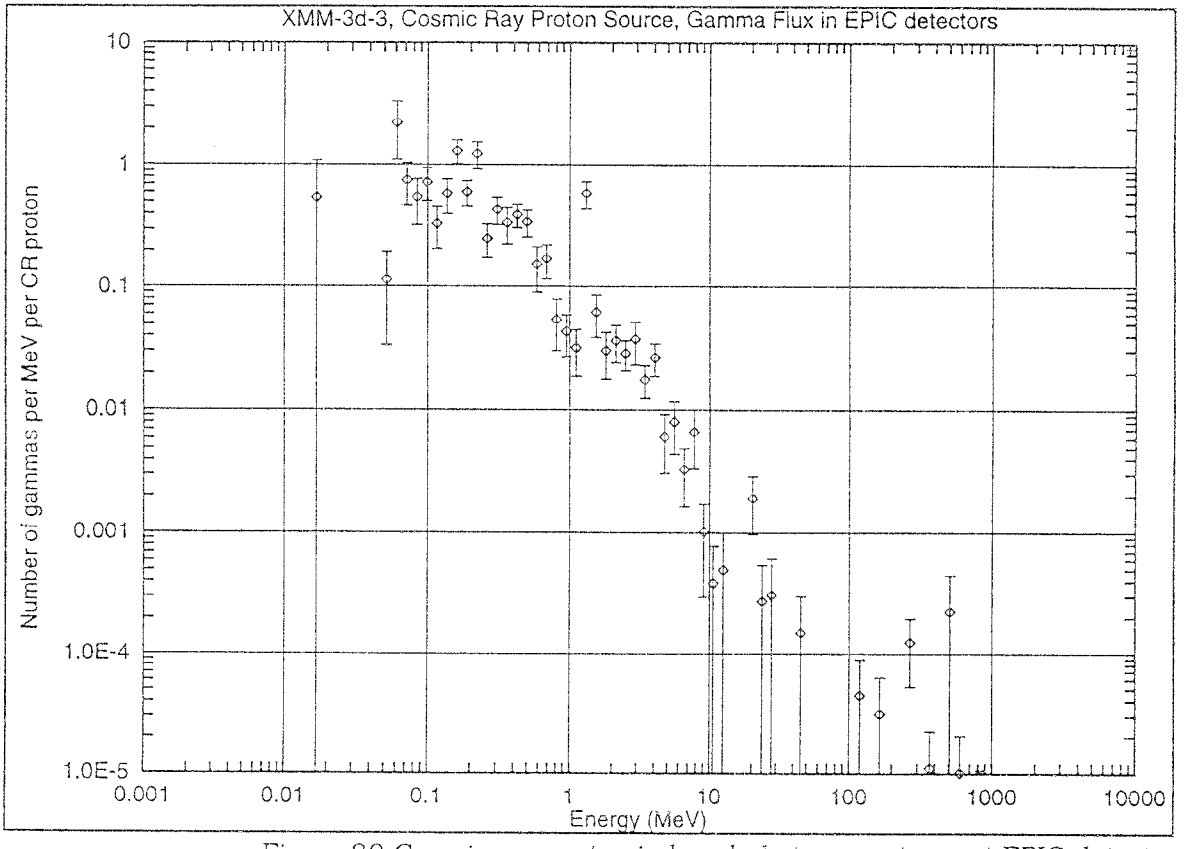

Figure 30 Cosmic-ray proton induced photon spectrum at EPIC detector

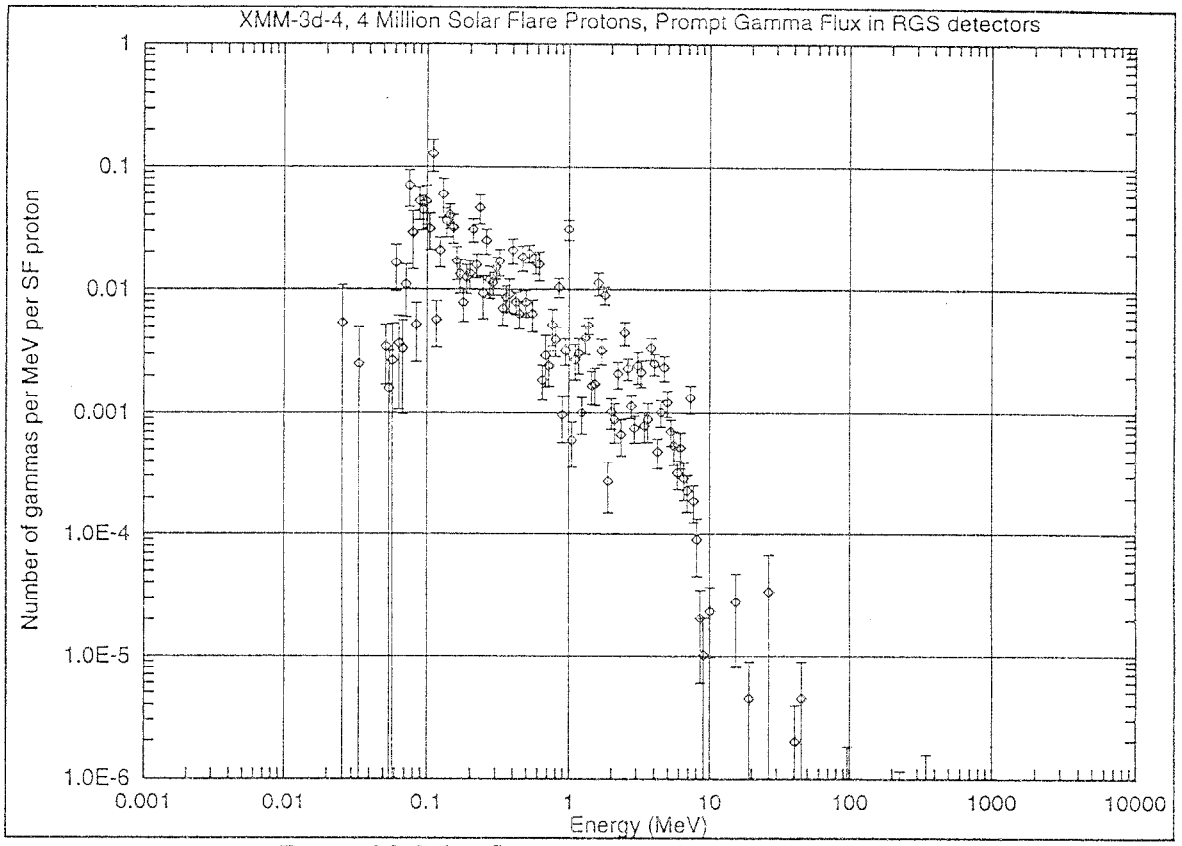

Figure 33 Solar flare proton induced photon spectrum at RGS detector

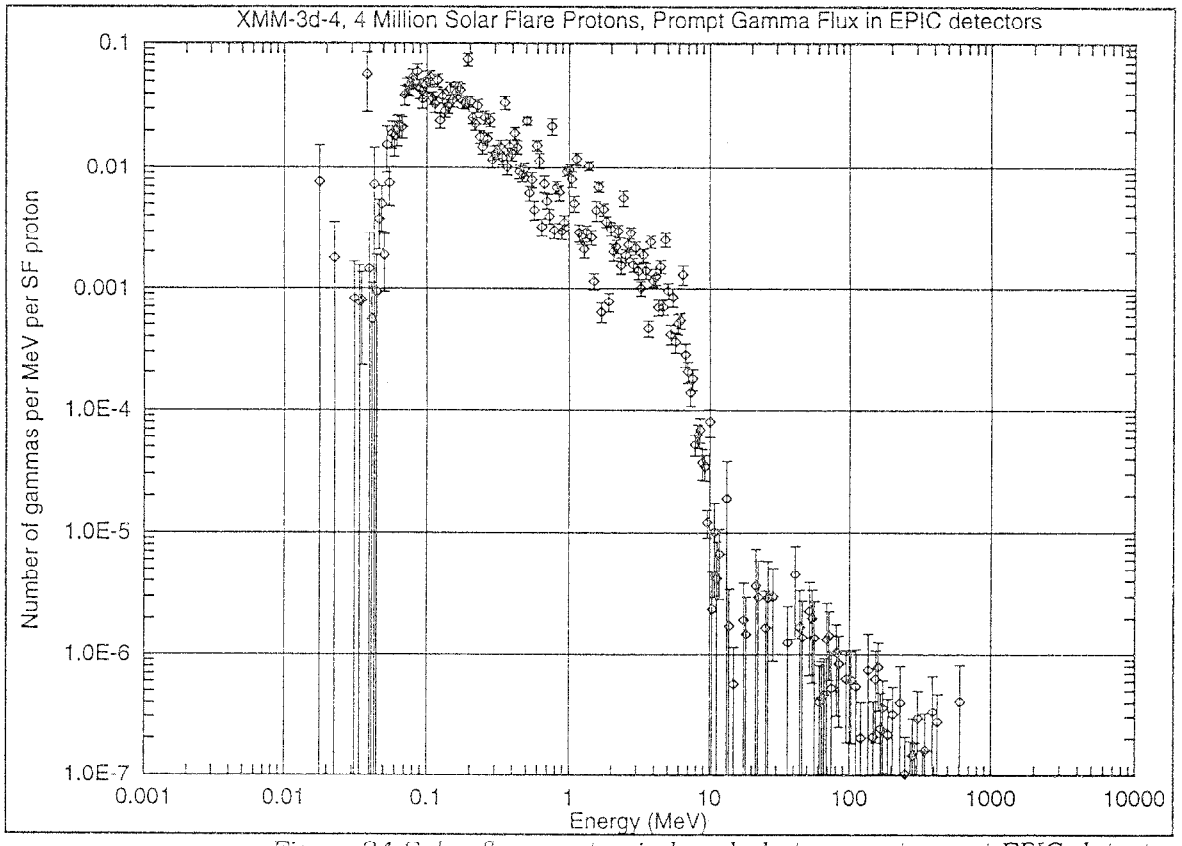

Figure 34 Solar flare proton induced photon spectrum at EPIC detector

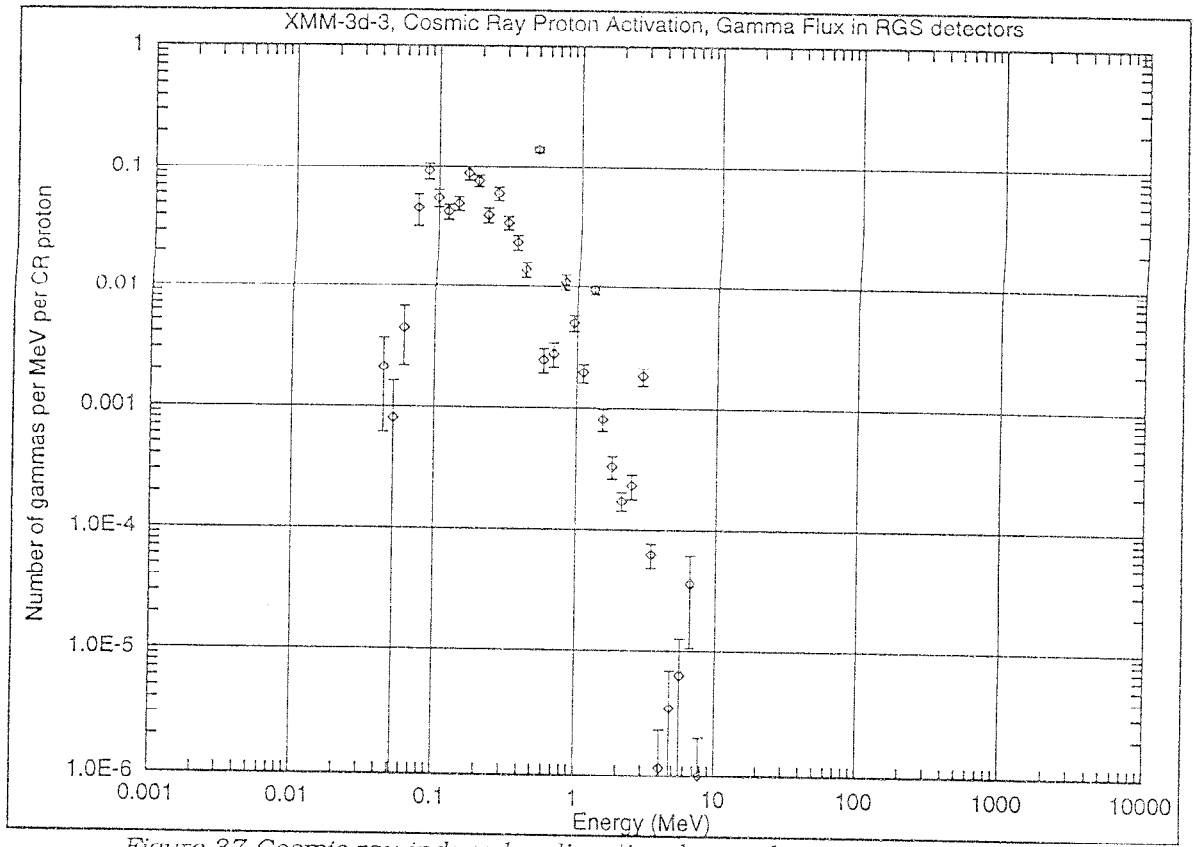

Figure 37 Cosmic-ray induced radioactive decay photon spectrum at RGS detector

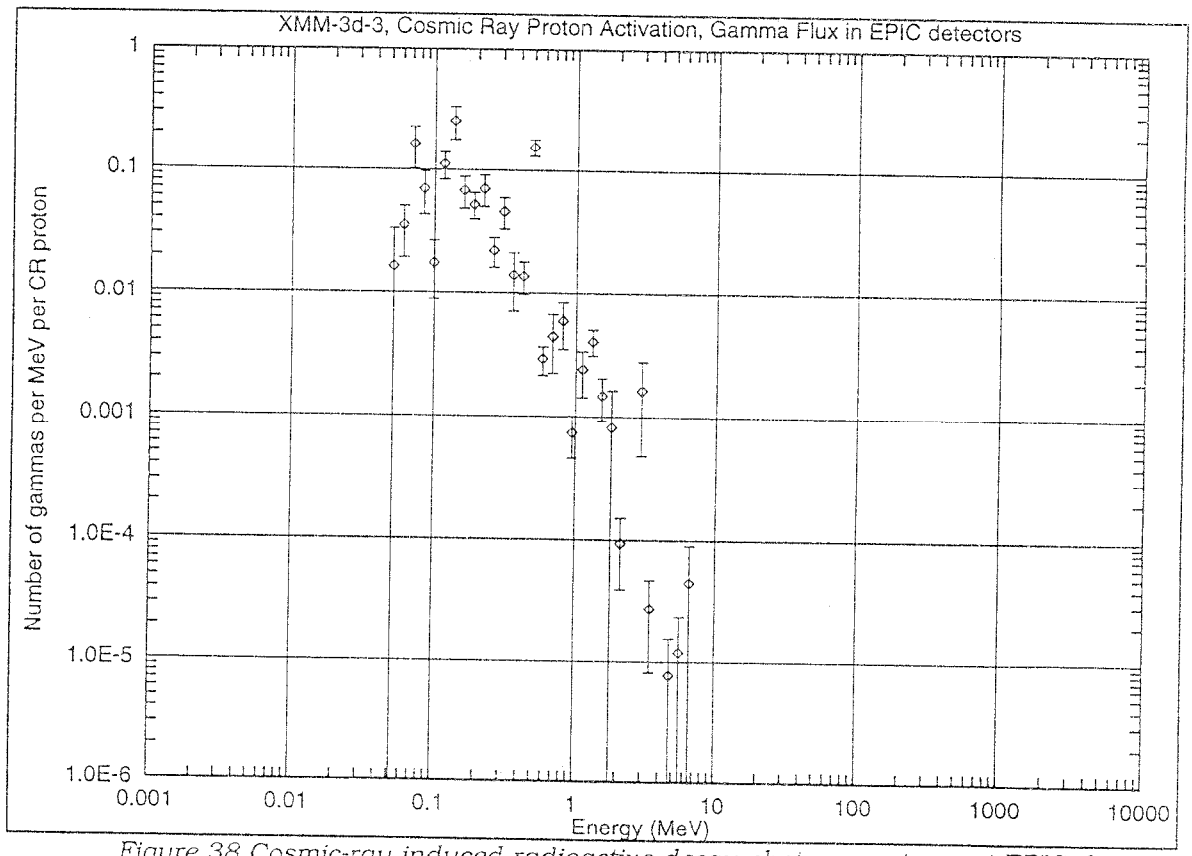

Figure 38 Cosmic-ray induced radioactive decay photon spectrum at EPIC detector

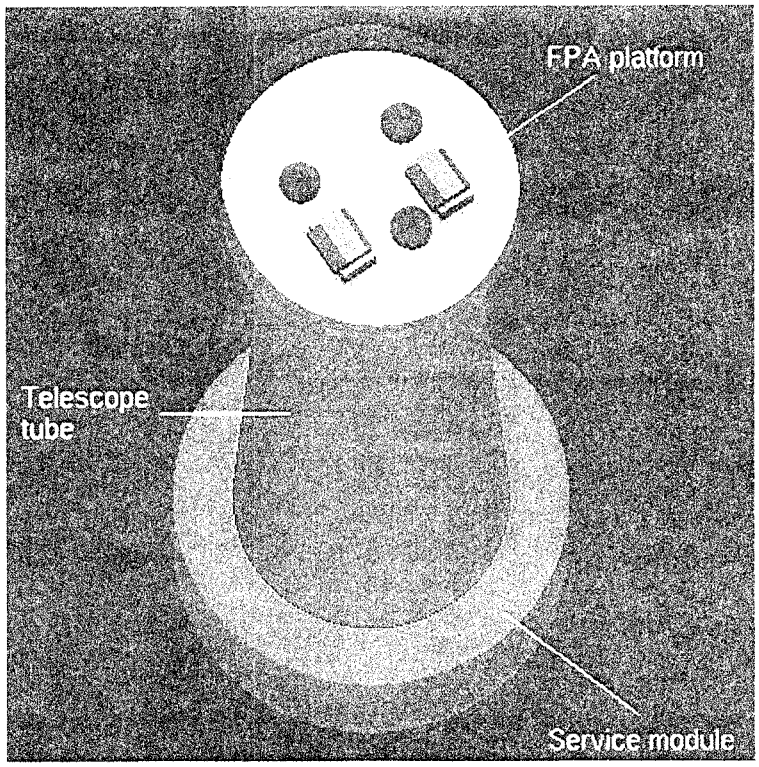

Fig 1 XMM spacecraft viewed from the top.

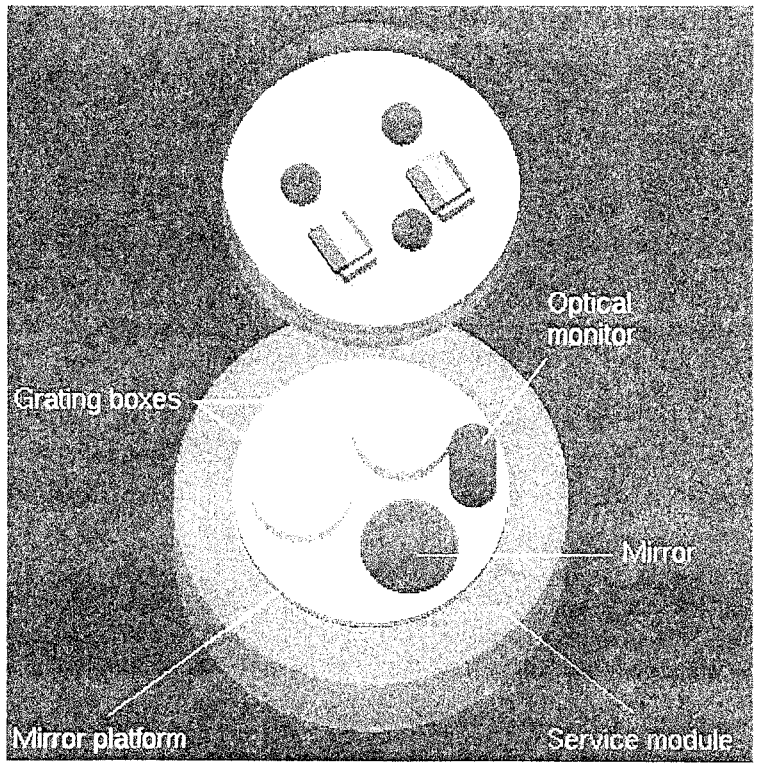

Fig 2 XMM spacecraft viewed from above with the telescope tube removed permitting a view of the mirror platform.

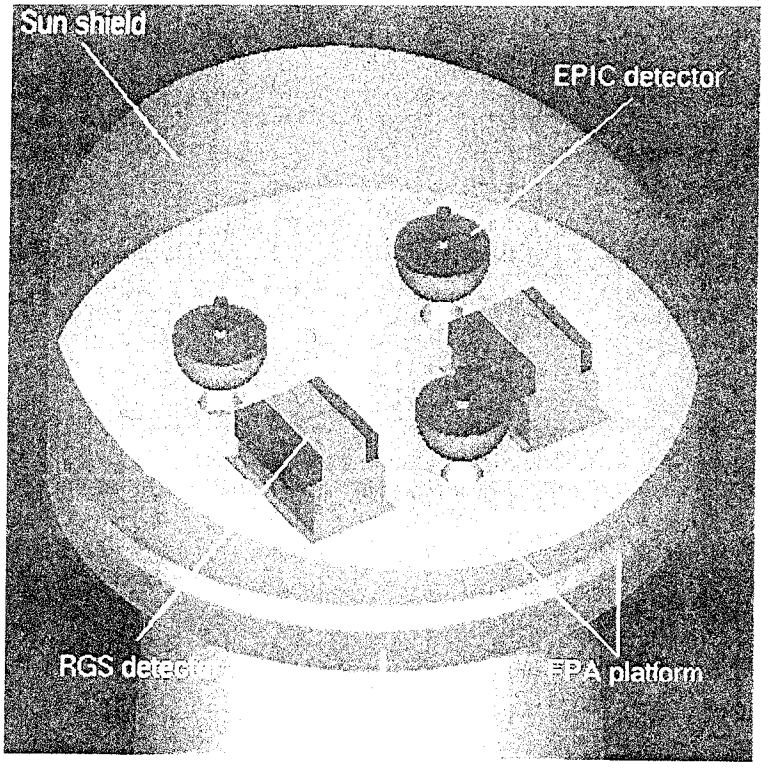

Fig 5 View of the FPA structure without the +Z electronics

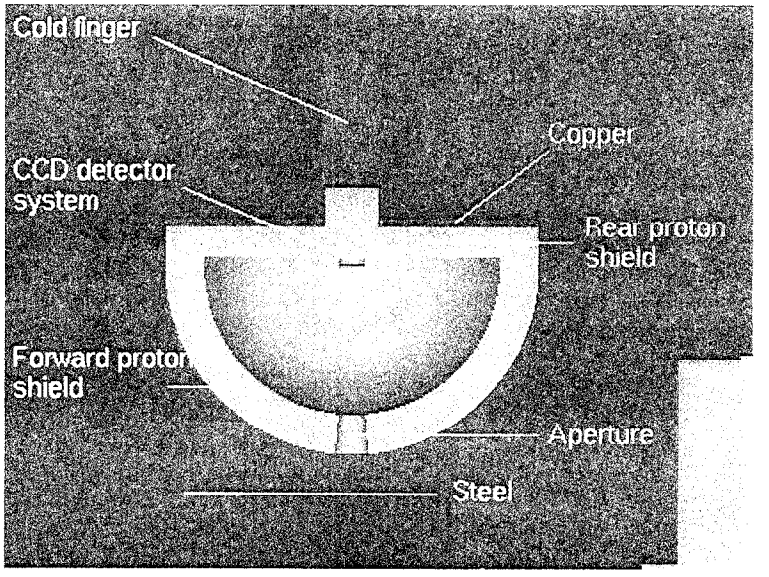

Fig 6 Sectioned side view of the EPIC detector.

Conclusions.

1) total response of EPIC to CR

3.5×10^{-5} counts / keV / proton

⇒ 1.5×10^{-4} cts / (cm^2) s / keV

rather flat spectrum

It becomes the dominante source above 7-9 keV [illegible] of the [illegible] energy background.

Solar flare:

EPIC 1.5×10^{-6} per [illegible]

proton flux needs to be > [illegible]

2) RGS

CR [illegible] is 20% lower [illegible]

(than CCD)

SF ~20% lower the EPIC

3) Induced radioactive decay

very small contribution