December 2006 SPE as seen by the CPDS Instruments

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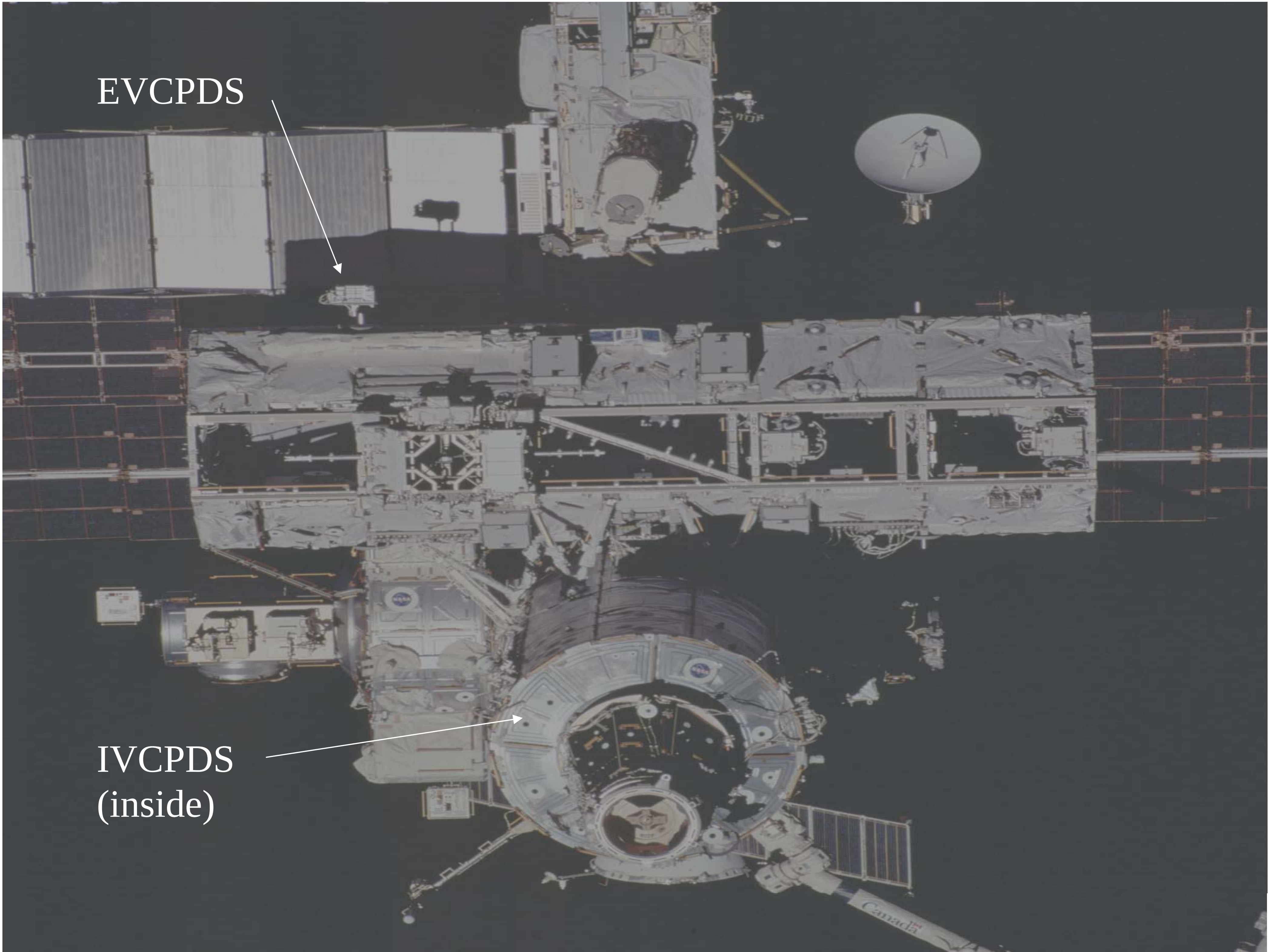
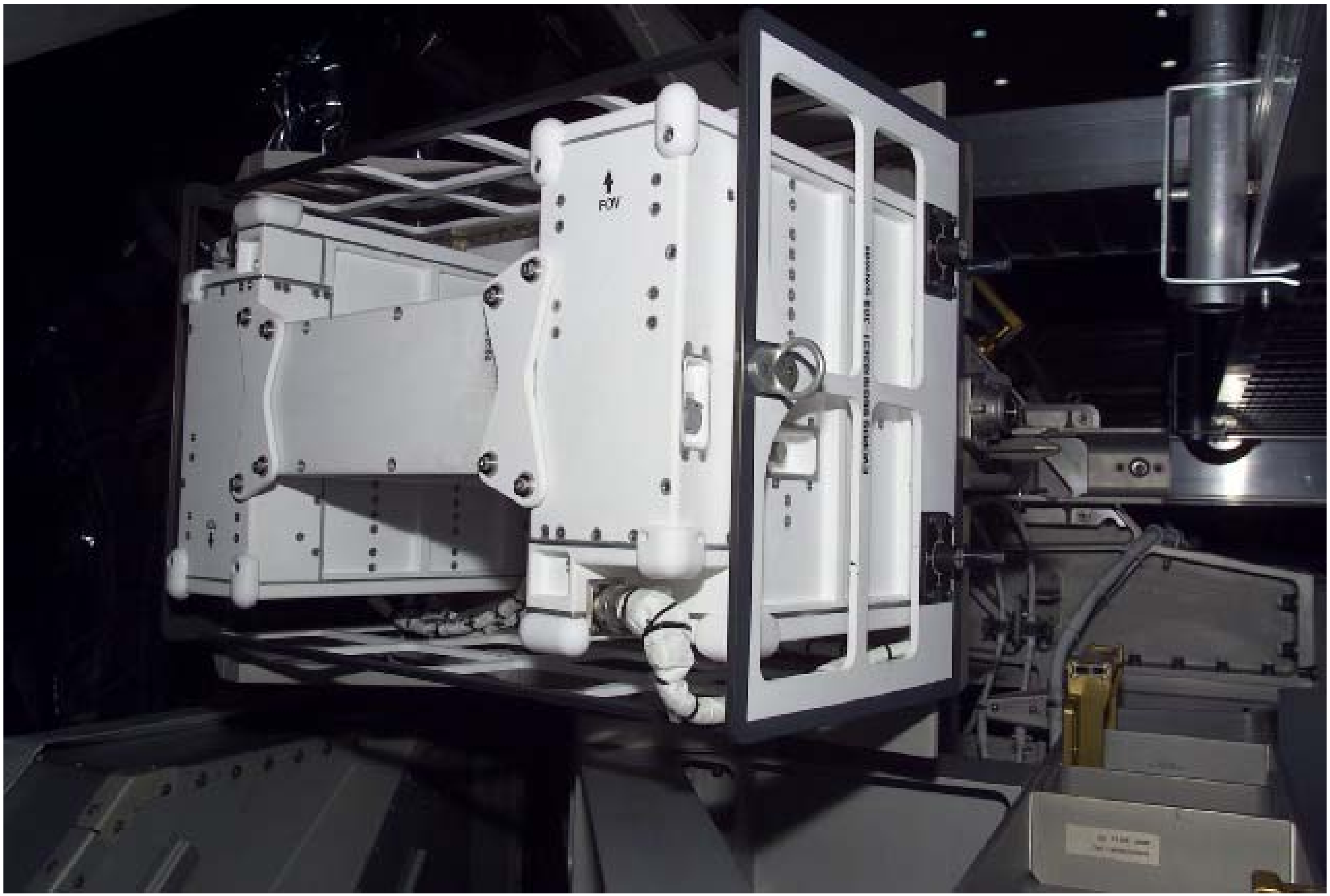
Outline

- IVCPDS and EVCPDS instruments
- CPDS Data
- Operational Use
- Event Rate Dec. 2006
- Particle Flux Dec. 2006


EVCPDS
IVCPDS
(inside)
Canada

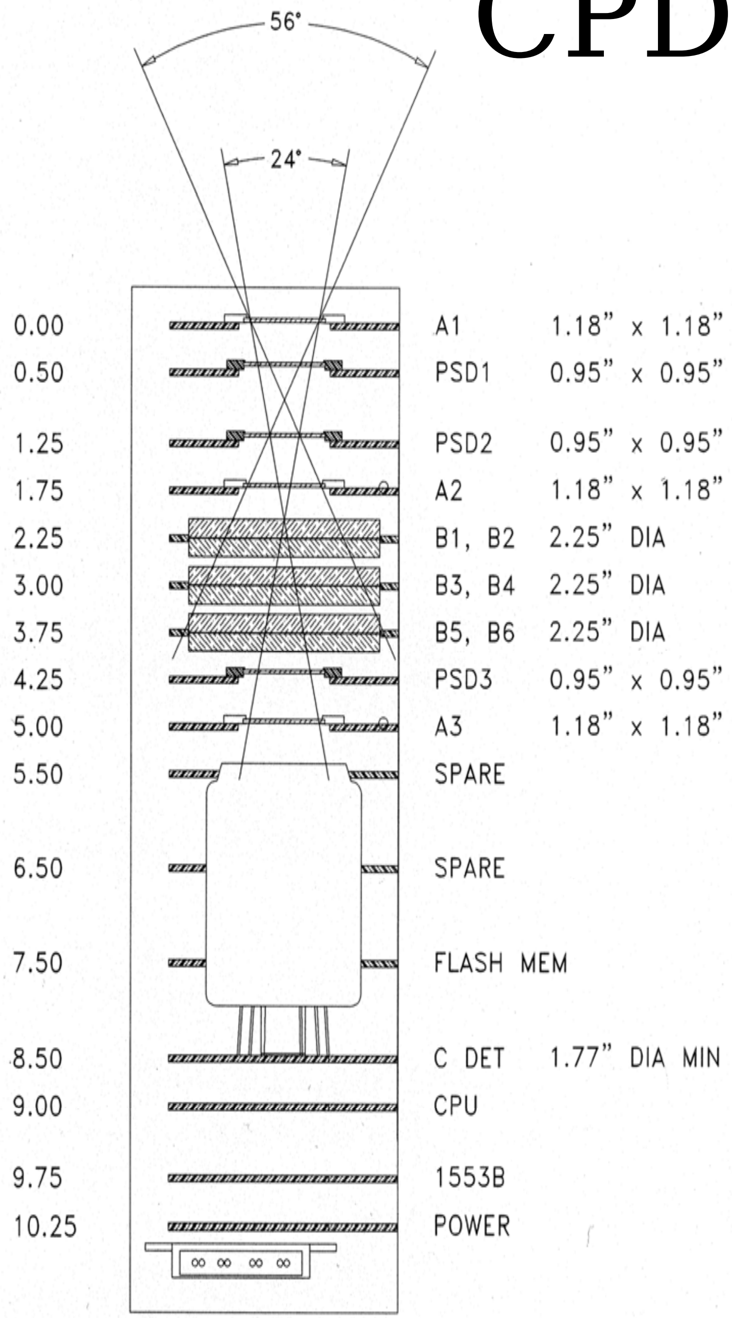
EVCPDS

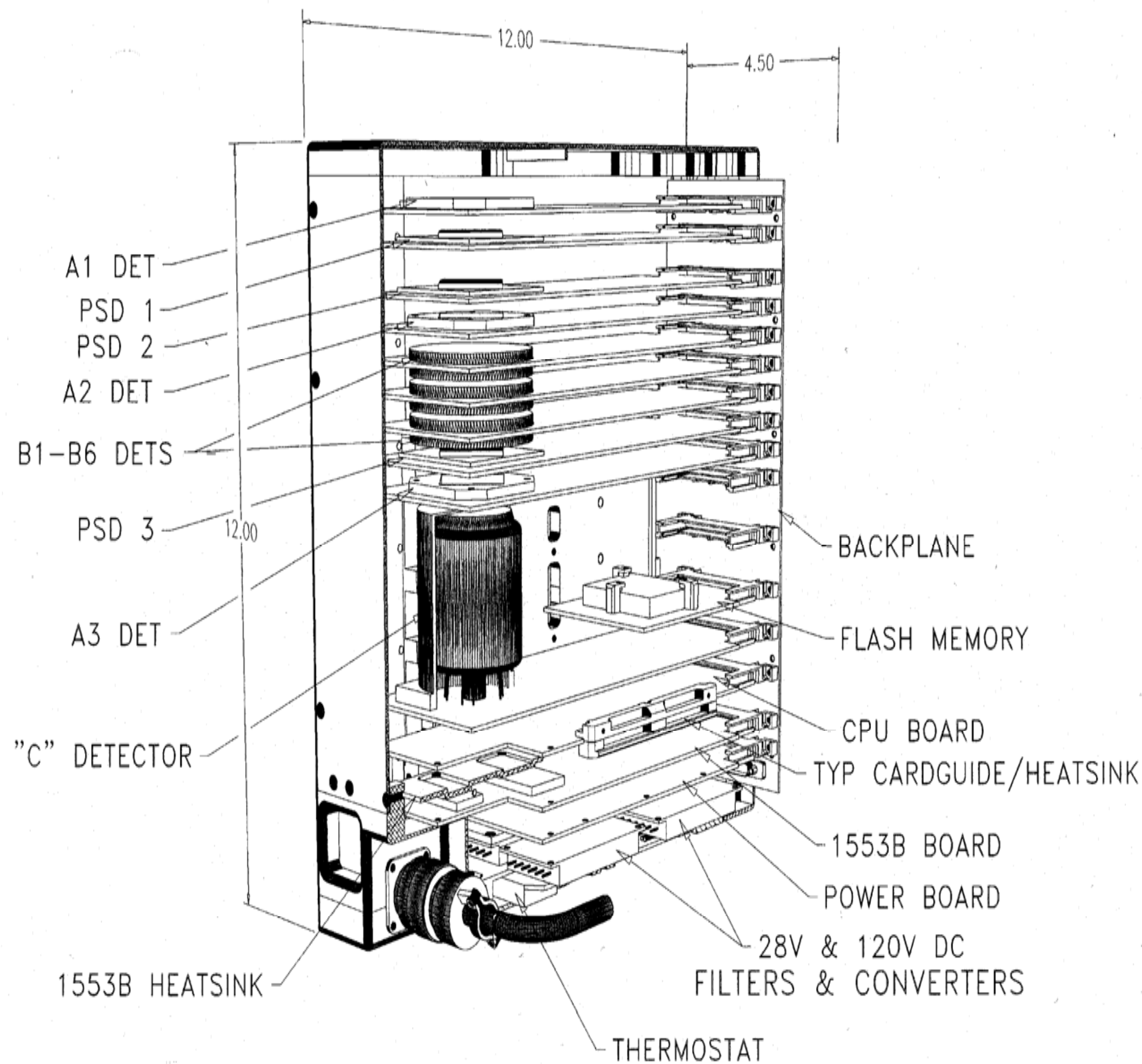


IVCPDS

ISS012E18656

CPDS Instruments





Detector Details

- A Detectors
  - Square Si detector, 30.0x30.0mm, 1.0mm thick
  - Top and bottom Al noise shield
- PSD Detectors
  - Square Si strip detector, 24.0x24.0mm, 0.300mm thick
  - 24 strips on top surface and 24 strips on bottom surface, perpendicular to each other
- B Detectors
  - Cylindrical Lithium drifted Si detector, 58.4mm in diameter, 5mm thick.
- C Detector
  - Sapphire 50mm in diameter, and 10mm thick
  - Hamamatsu PMT

CPDS Data Collection

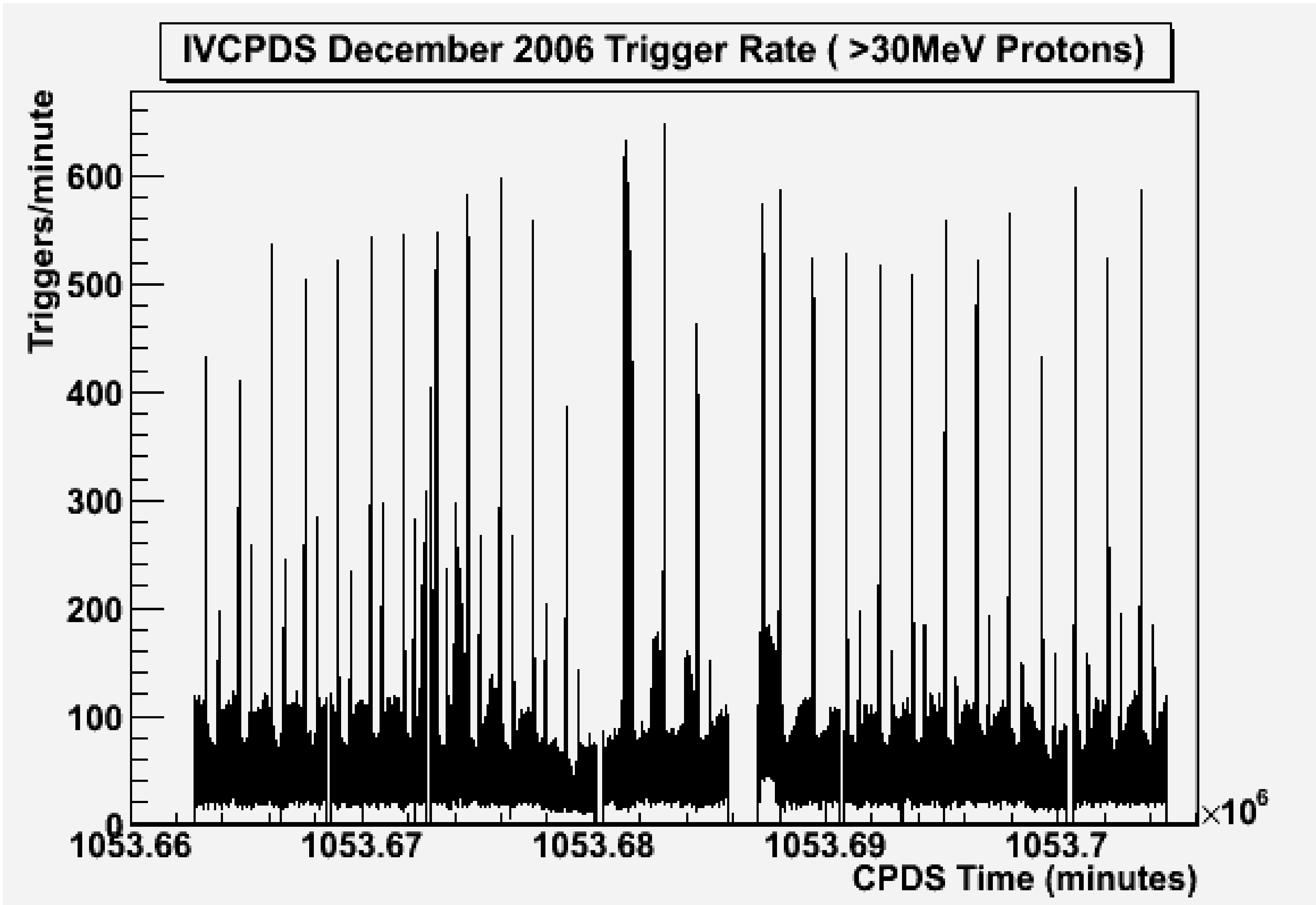
- Counter Data
  - Individual one minute count rates for A1-A3, and B1, B3, B5, and C detectors.
- Event Data (Requires Trigger, A1 A2 coincidence)
  - Energy loss in A, B, and C detectors
  - Energy loss and strip location of hit on PSD detectors
- Engineering Data
  - Board and Detector temperatures, power consumption, etc. recorded every 30 minutes.
- Cyclic Data
  - Dose Rate(A1 counter * constant), Cumulative Dose, Time stamp, and more are downlinked directly every minute.

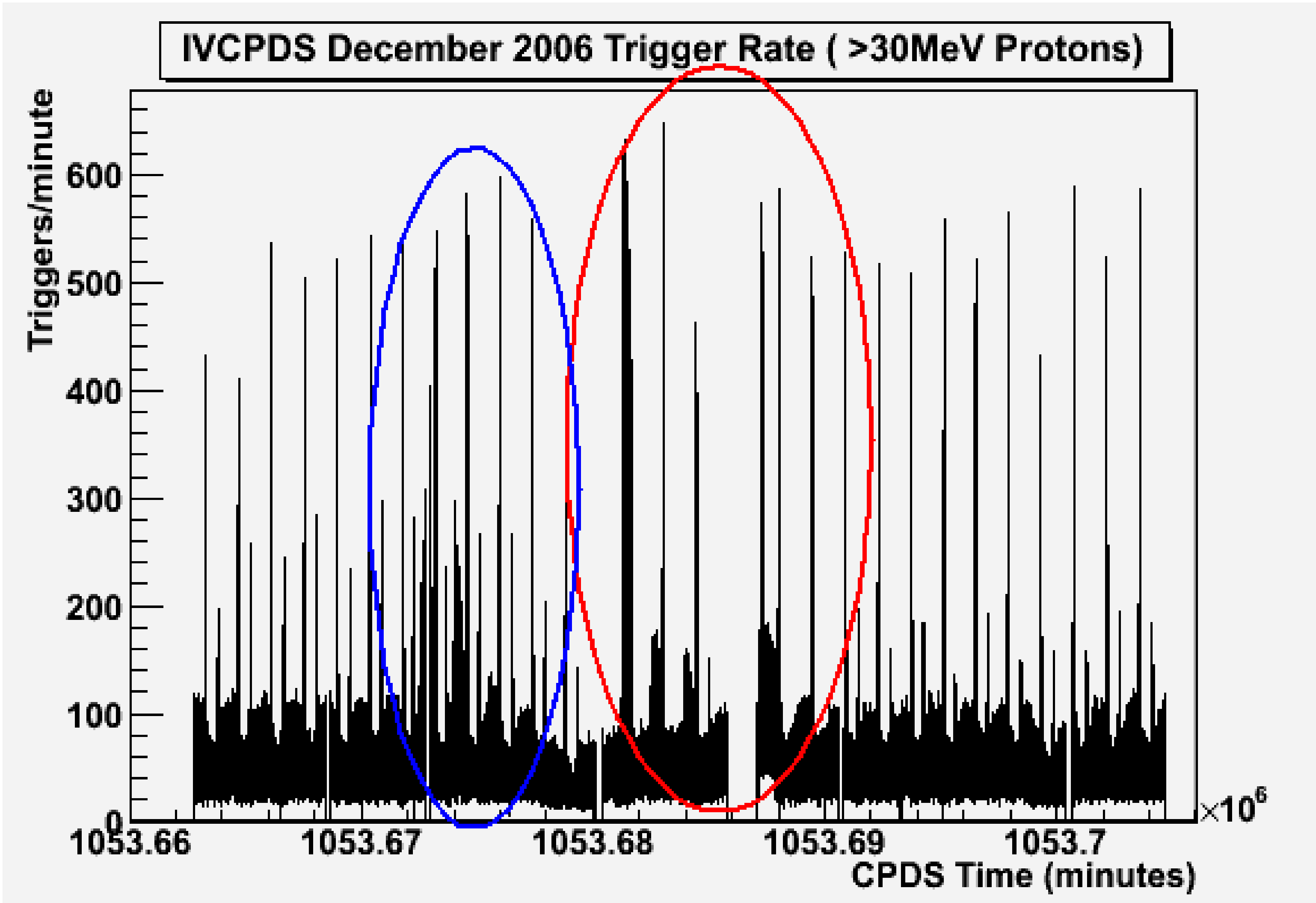
Data Difficulties

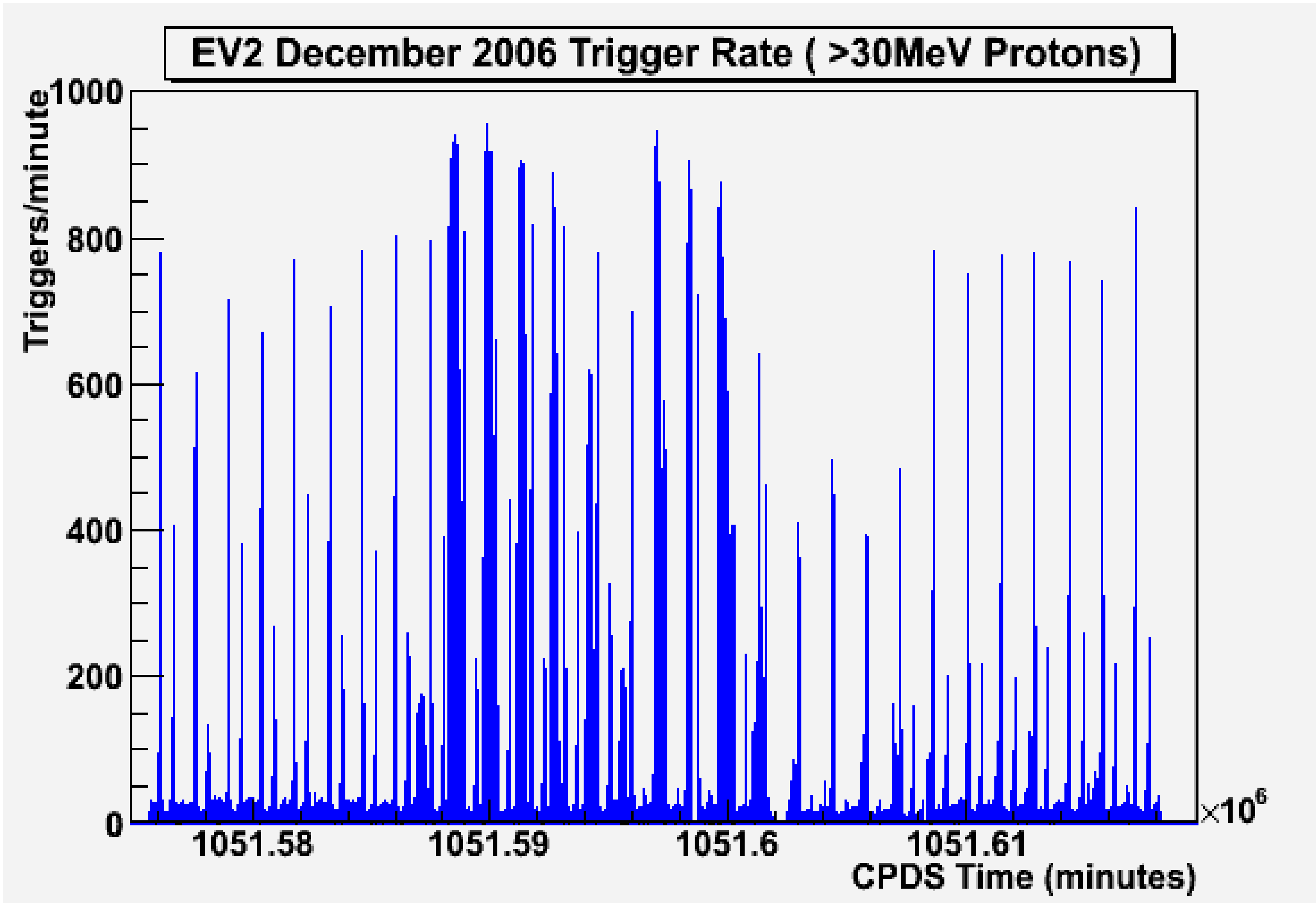
- Timestamp is always incorrect and IV, EV2, and EV3 corrections are all different and not always constant.
- During data download the buffer is read faster than it is written to so multiple writes are required to ensure full data set is received. This can also cause repeat data that must be filtered.
- Data can be scrambled, but there is enough information in the records to put them back together, and this is where the current effort has been placed. Dec. 2006 SPE data had periods of data scrambling and 1/3 has been recovered.

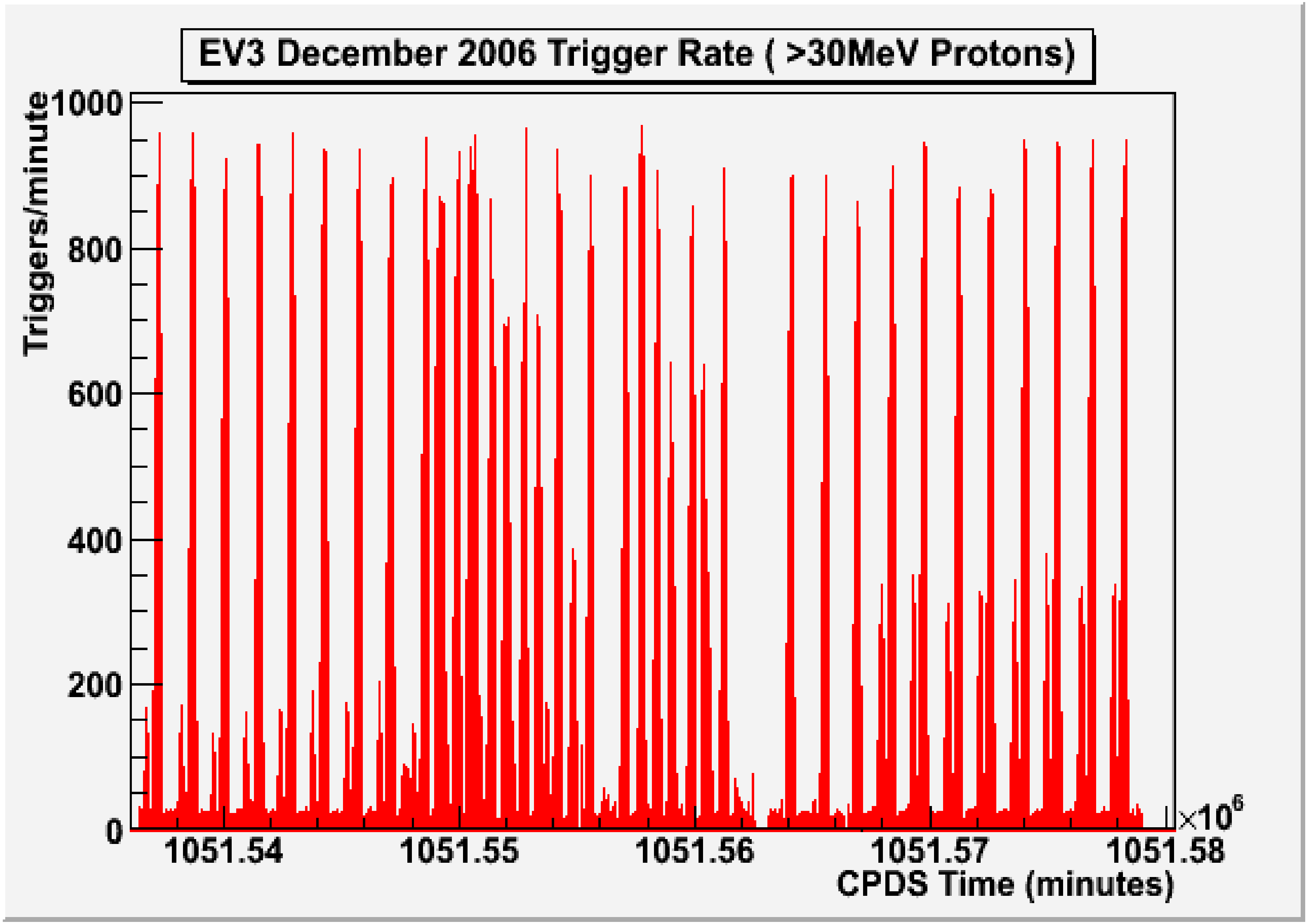
Operational Usage

- A1 counter used to measure dose and yields cumulative dose and dose rate.
- The measured value can be different from other instruments due to shielding location, anisotropies, and LET threshold and cutoff differences.

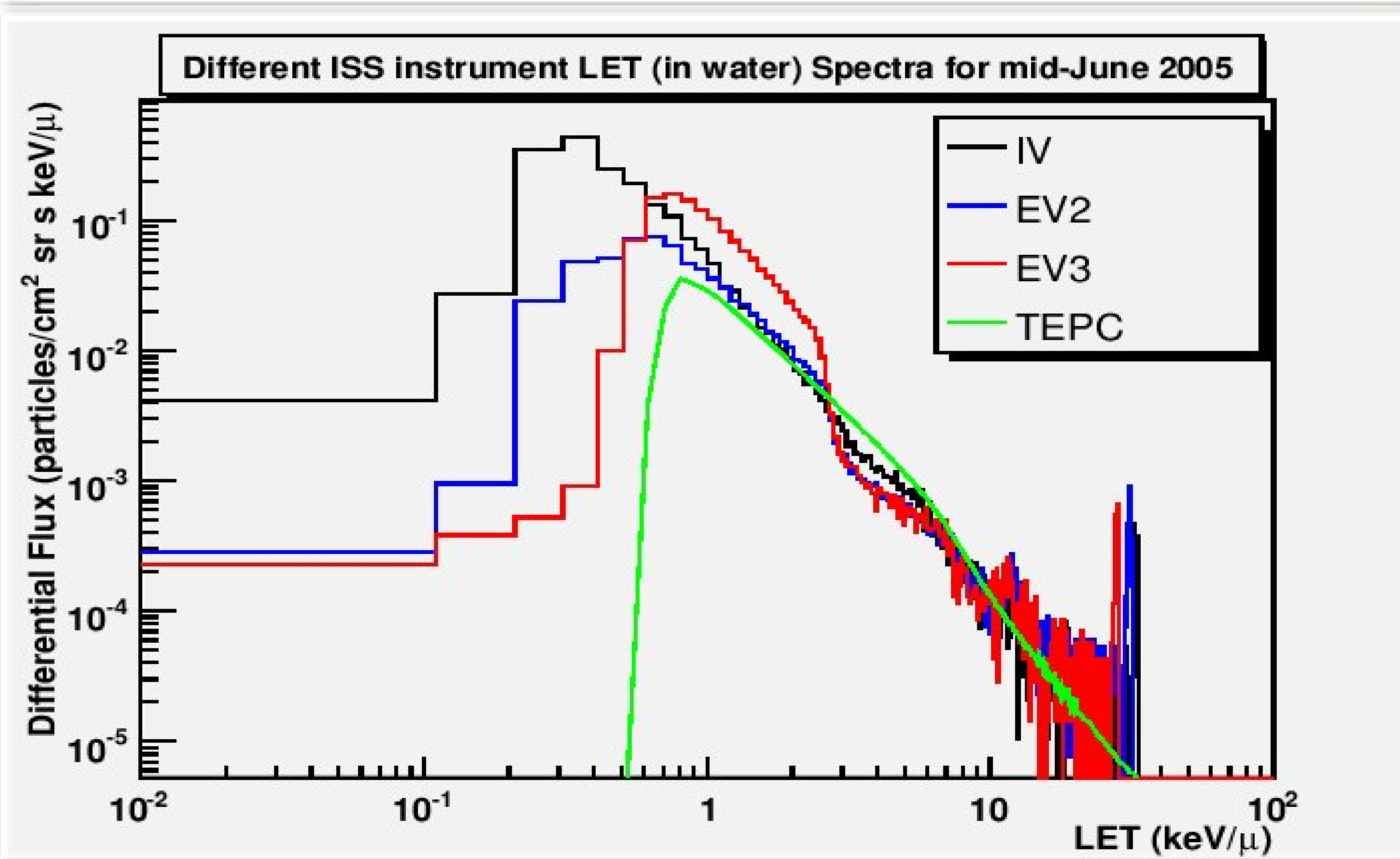

IVCPDS December 2006 Trigger Rate (>30MeV Protons)
Triggers/minute
0
100
200
300
400
500
600
1053.66
1053.67
1053.68
1053.69
1053.7
×10^6
CPDS Time (minutes)


IVCPDS December 2006 Trigger Rate (>30MeV Protons)
Triggers/minute
600
500
400
300
200
100
0
1053.66
1053.67
1053.68
1053.69
1053.7
×10^6
CPDS Time (minutes)

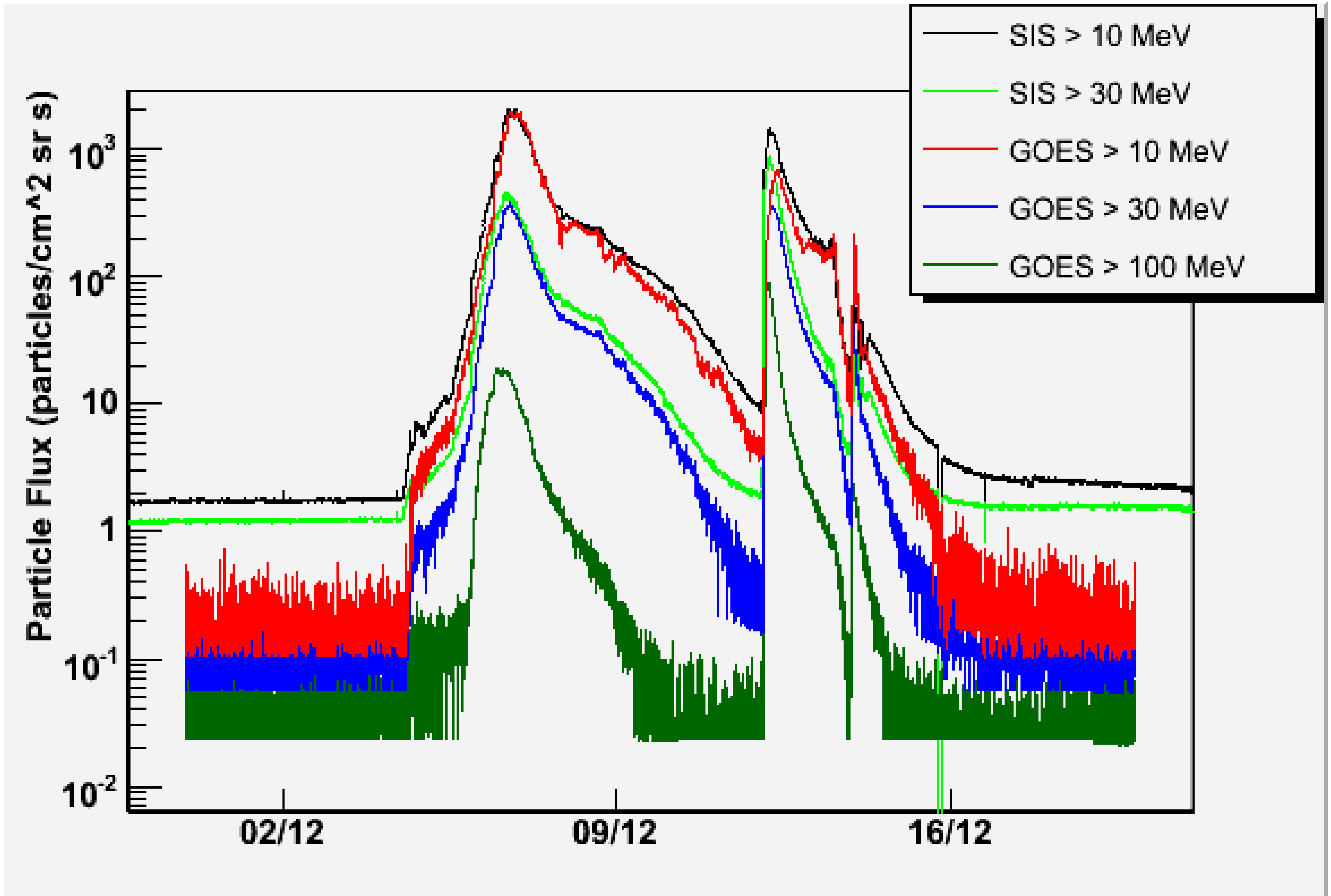

EV2 December 2006 Trigger Rate (>30MeV Protons)
Triggers/minute
1000
800
600
400
200
0
1051.58
1051.59
1051.6
1051.61
$\times 10^6$
CPDS Time (minutes)


EV3 December 2006 Trigger Rate (>30MeV Protons)
Triggers/minute
1000
800
600
400
200
0
1051.54
1051.55
1051.56
1051.57
1051.58
×10^6
CPDS Time (minutes)

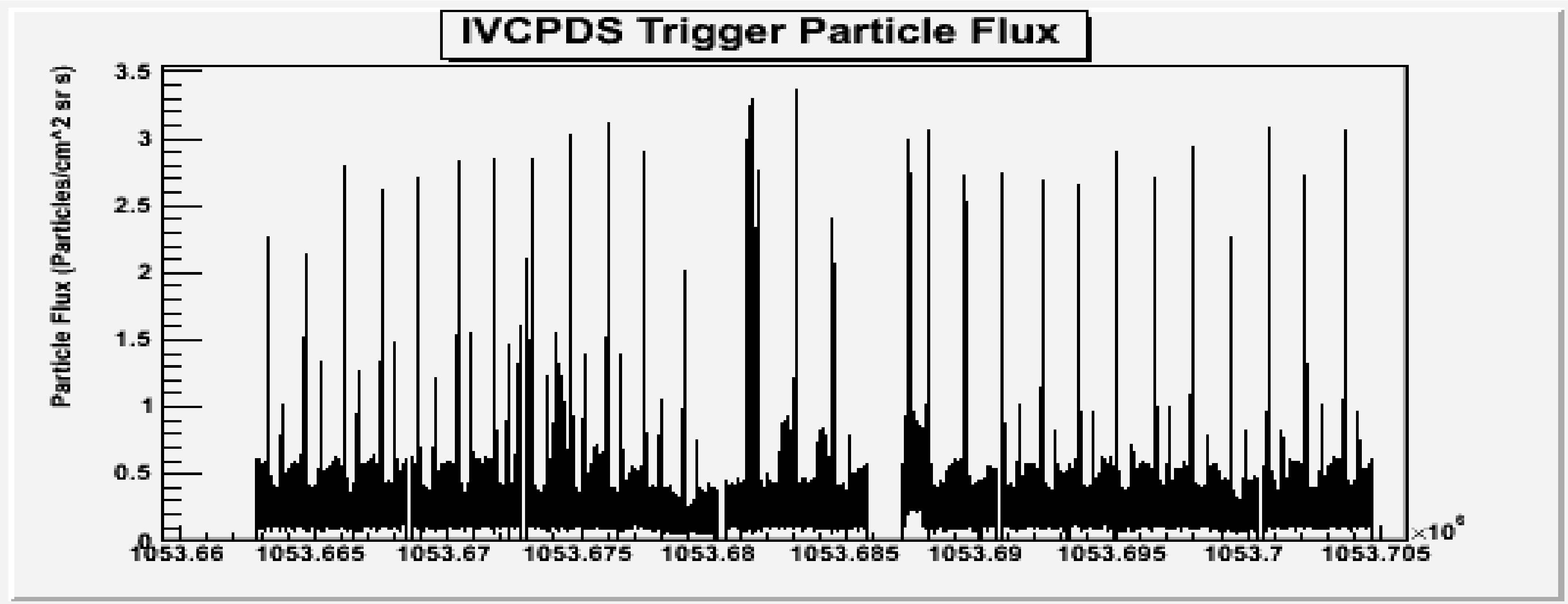
CPDS and TEPC LET Spectra

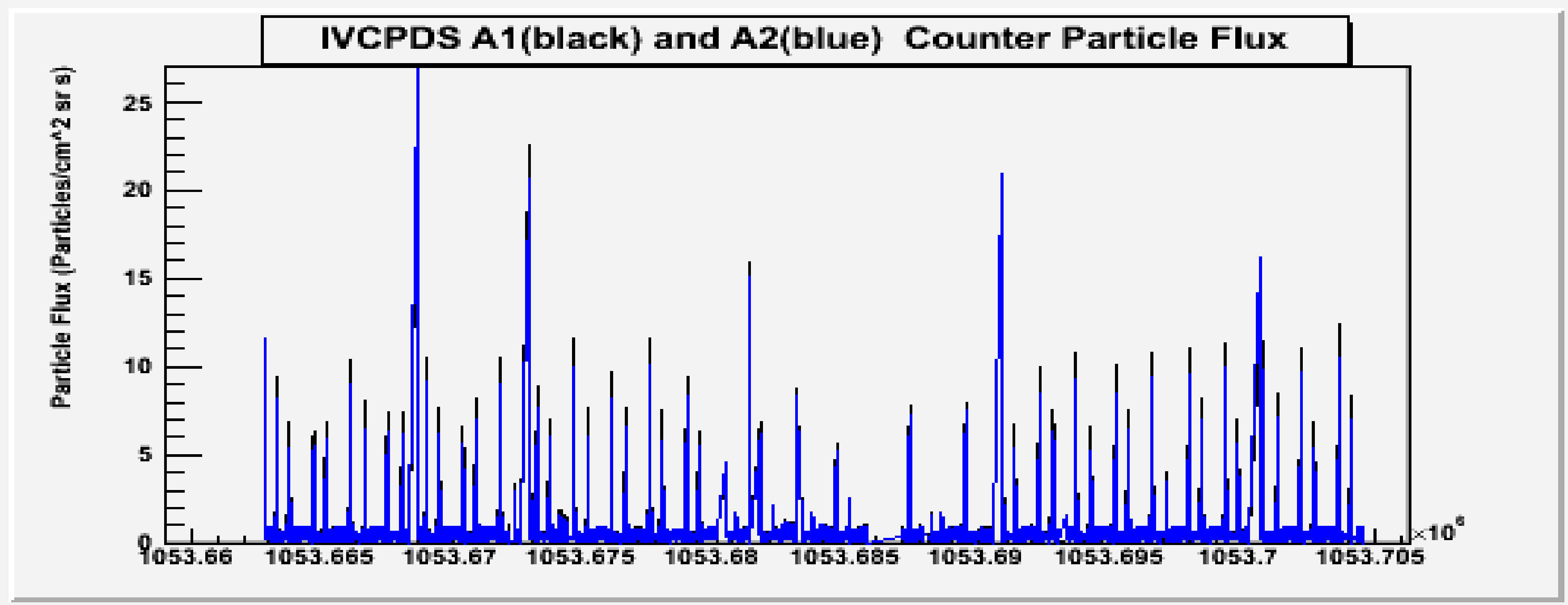


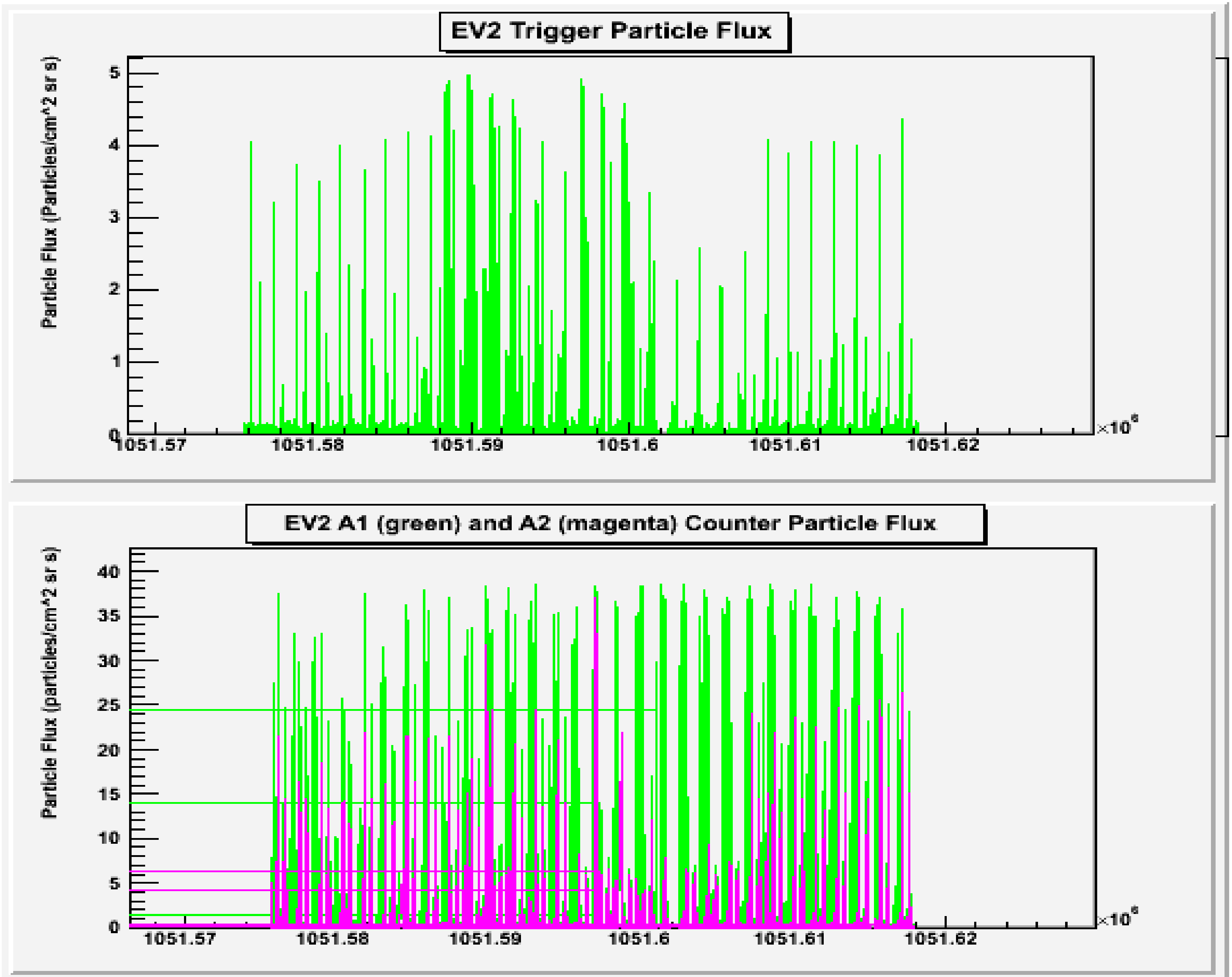
Note: Based on Event (trigger) data

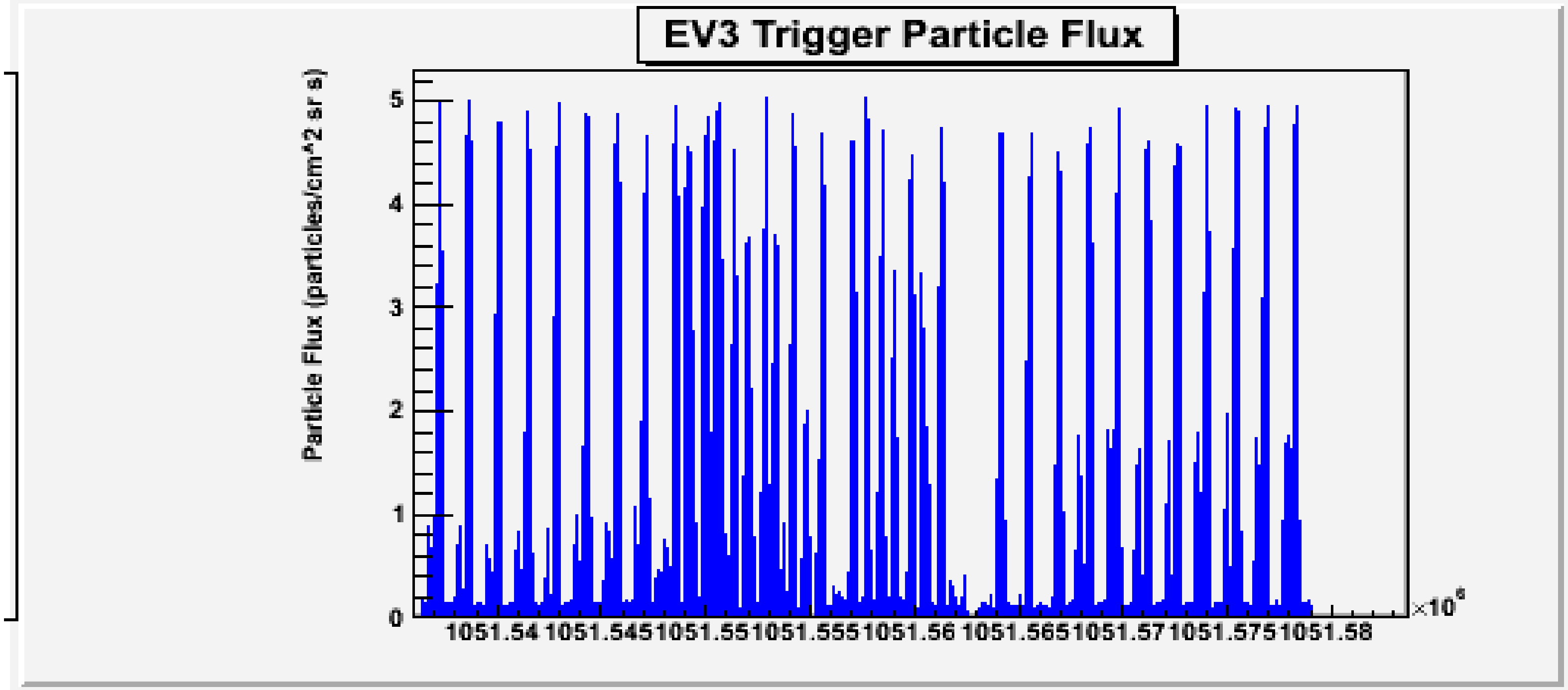


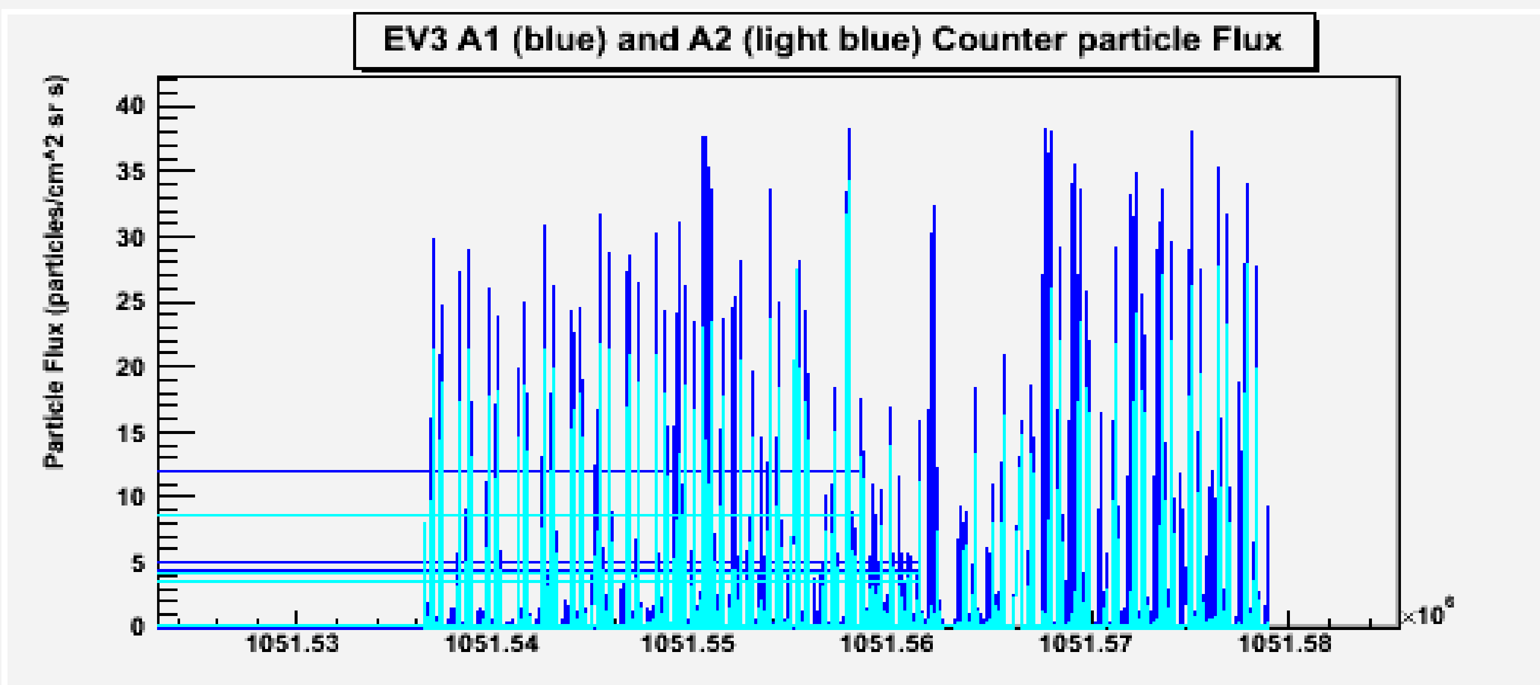
SIS > 10 MeV
SIS > 30 MeV
GOES > 10 MeV
GOES > 30 MeV
GOES > 100 MeV
Particle Flux (particles/cm^2 sr s)
10^3
10^2
10
1
10^{-1}
10^{-2}
02/12
09/12
16/12


IVCPDS Trigger Particle Flux
Particle Flux (Particles/cm^2 sr s)
3.5
3
2.5
2
1.5
1
0.5
0
1053.66
1053.665
1053.67
1053.675
1053.68
1053.685
1053.69
1053.695
1053.7
1053.705
×10^6


IVCPDS A1(black) and A2(blue) Counter Particle Flux
Particle Flux (Particles/cm^2 sr s)
25
20
15
10
5
0
1053.66
1053.665
1053.67
1053.675
1053.68
1053.685
1053.69
1053.695
1053.7
1053.705
×10^6


EV2 Trigger Particle Flux
Particle Flux (Particles/cm^2 sr s)
0
1
2
3
4
5
1051.57
1051.58
1051.59
1051.6
1051.61
1051.62
×10⁶
EV2 A1 (green) and A2 (magenta) Counter Particle Flux
Particle Flux (particles/cm^2 sr s)
0
5
10
15
20
25
30
35
40
1051.57
1051.58
1051.59
1051.6
1051.61
1051.62
×10⁶


EV3 Trigger Particle Flux
Particle Flux (particles/cm^2 sr s)
0
1
2
3
4
5
1051.54
1051.545
1051.55
1051.555
1051.56
1051.565
1051.57
1051.575
1051.58
×10^6


EV3 A1 (blue) and A2 (light blue) Counter particle Flux
Particle Flux (particles/cm^2 sr s)
0
5
10
15
20
25
30
35
40
1051.53
1051.54
1051.55
1051.56
1051.57
1051.58
×10^6

Summary

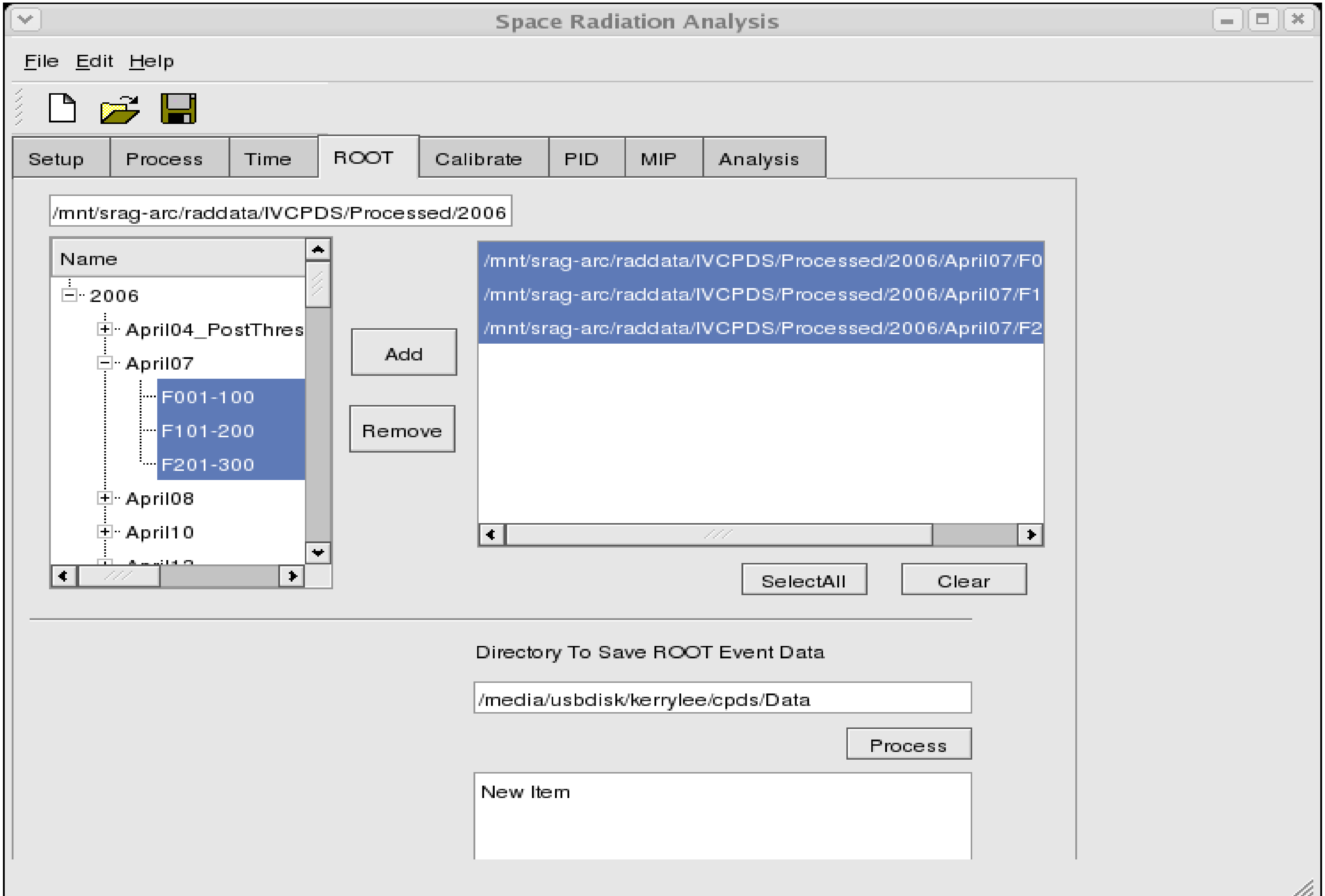
CPDS Capabilities

- Minimum proton A1 count energy of ~20 MeV
- Minimum proton coincident energy of ~30 MeV
- Maximum stopping proton energy of ~95 MeV
- Low energy H and He ion separation (stopping particles)
- Charged particle separation for minimum ionizing particles up to Z=11
- Energy spectrum for charges with Z<4
- Proton spectrum up to ~120 MeV and He up to ~300 MeV/n

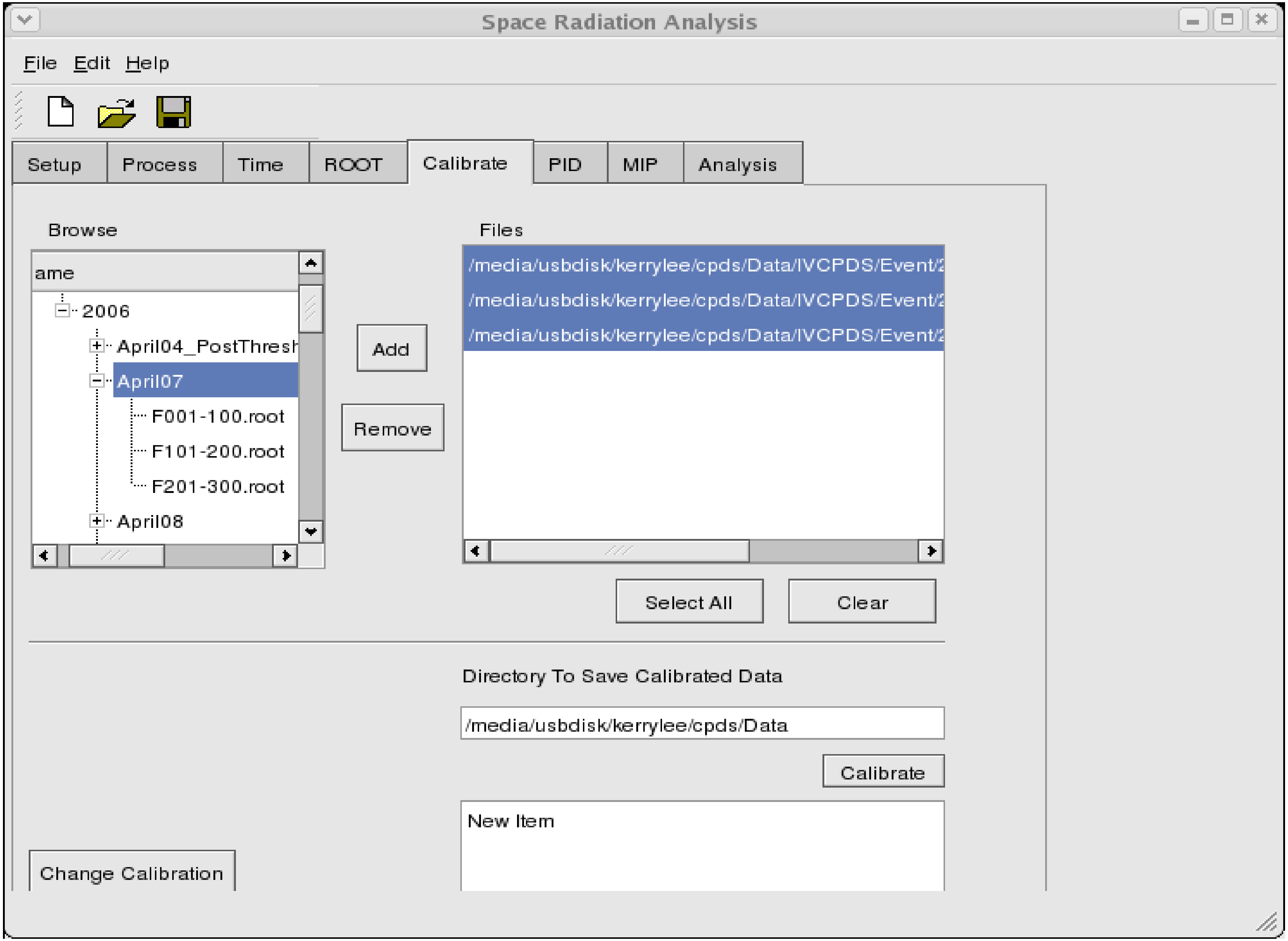
Analysis GUI

- Tool to allow non-experts to get operational information from new data in an almost automated fashion.
- Time correction algorithm uses cyclic data and automates what was once done manually.
- Some expert tools exist for calibration changes and cut selection in making the spectra.

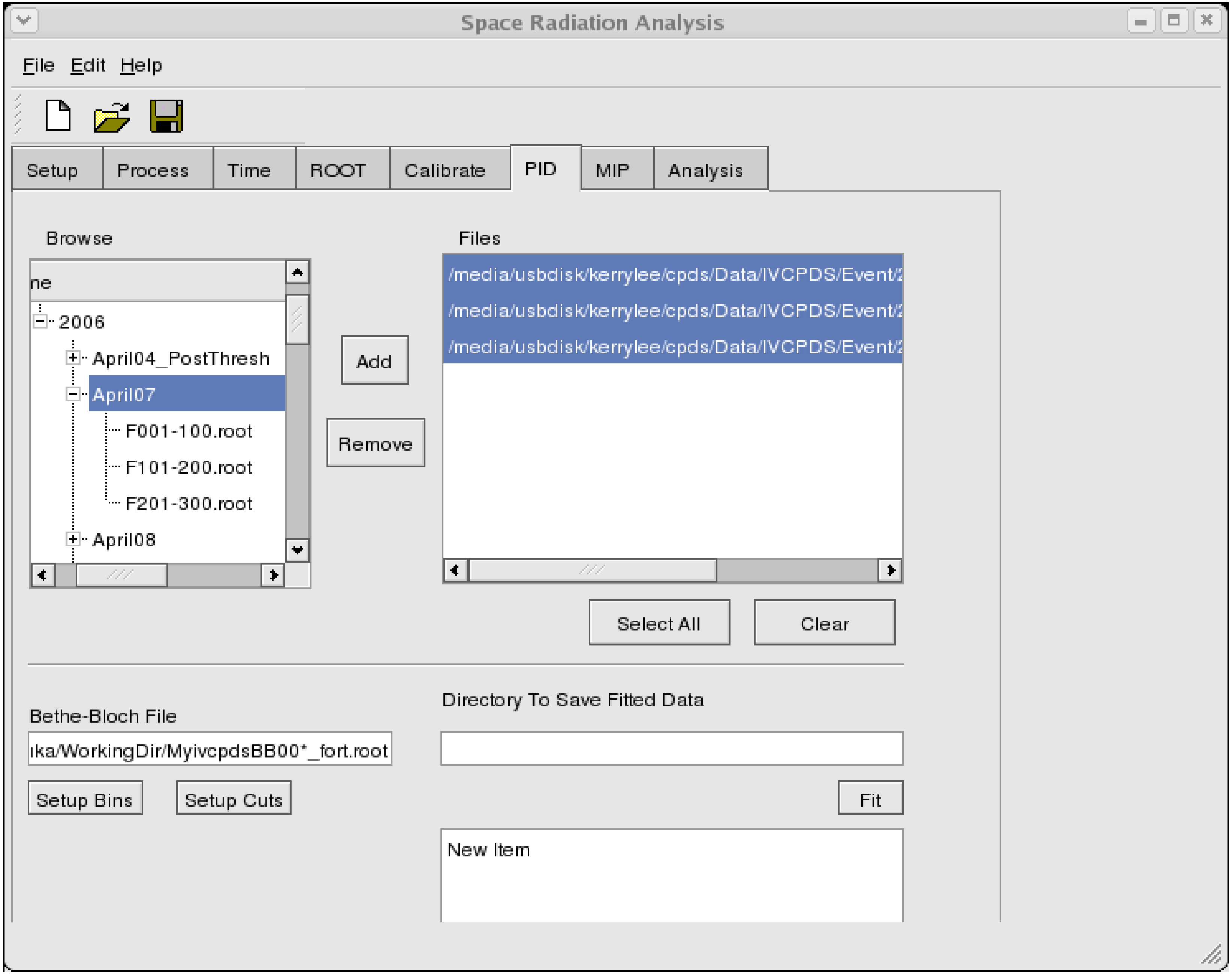
Raw Data to ROOT Files



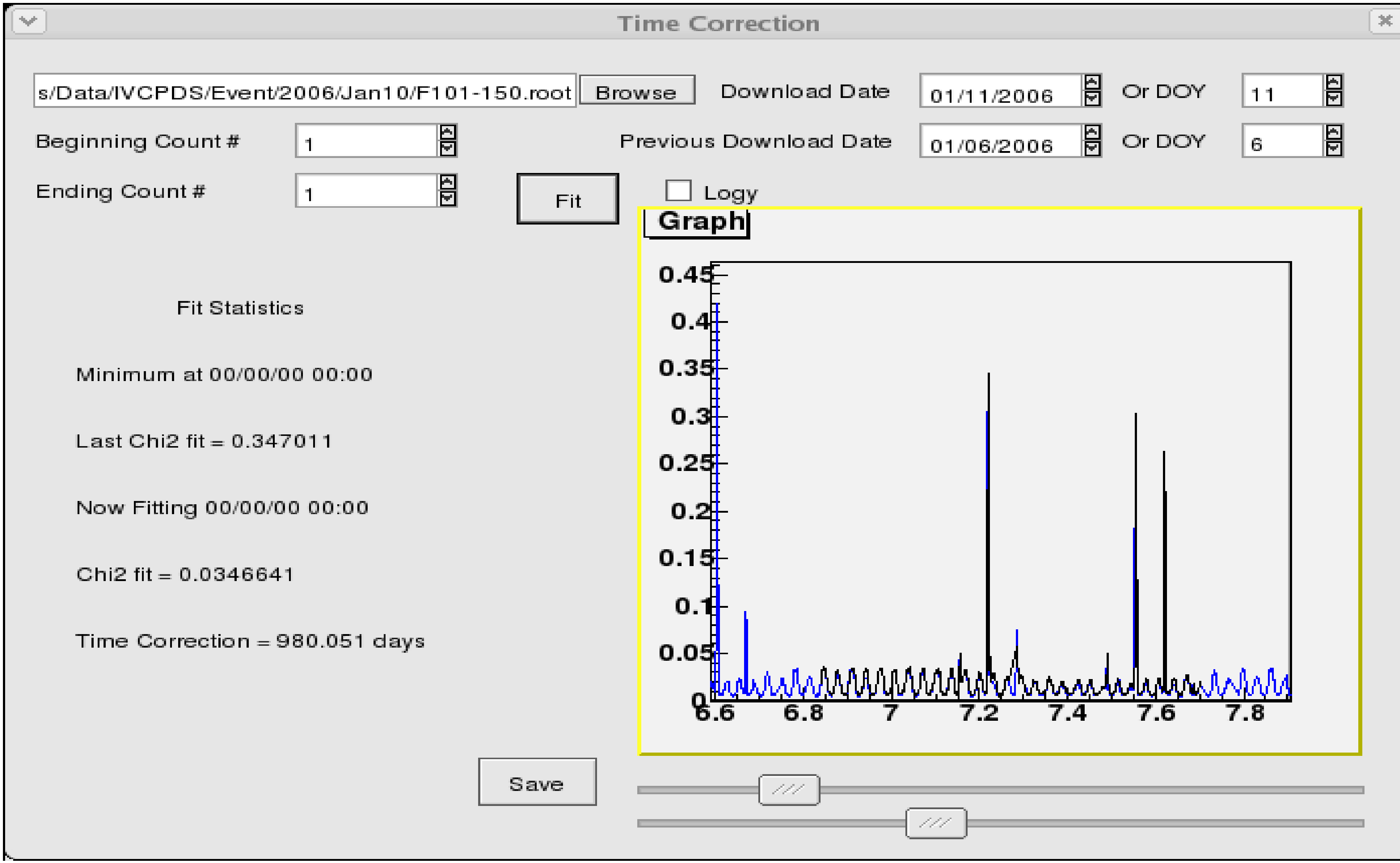
Calibration

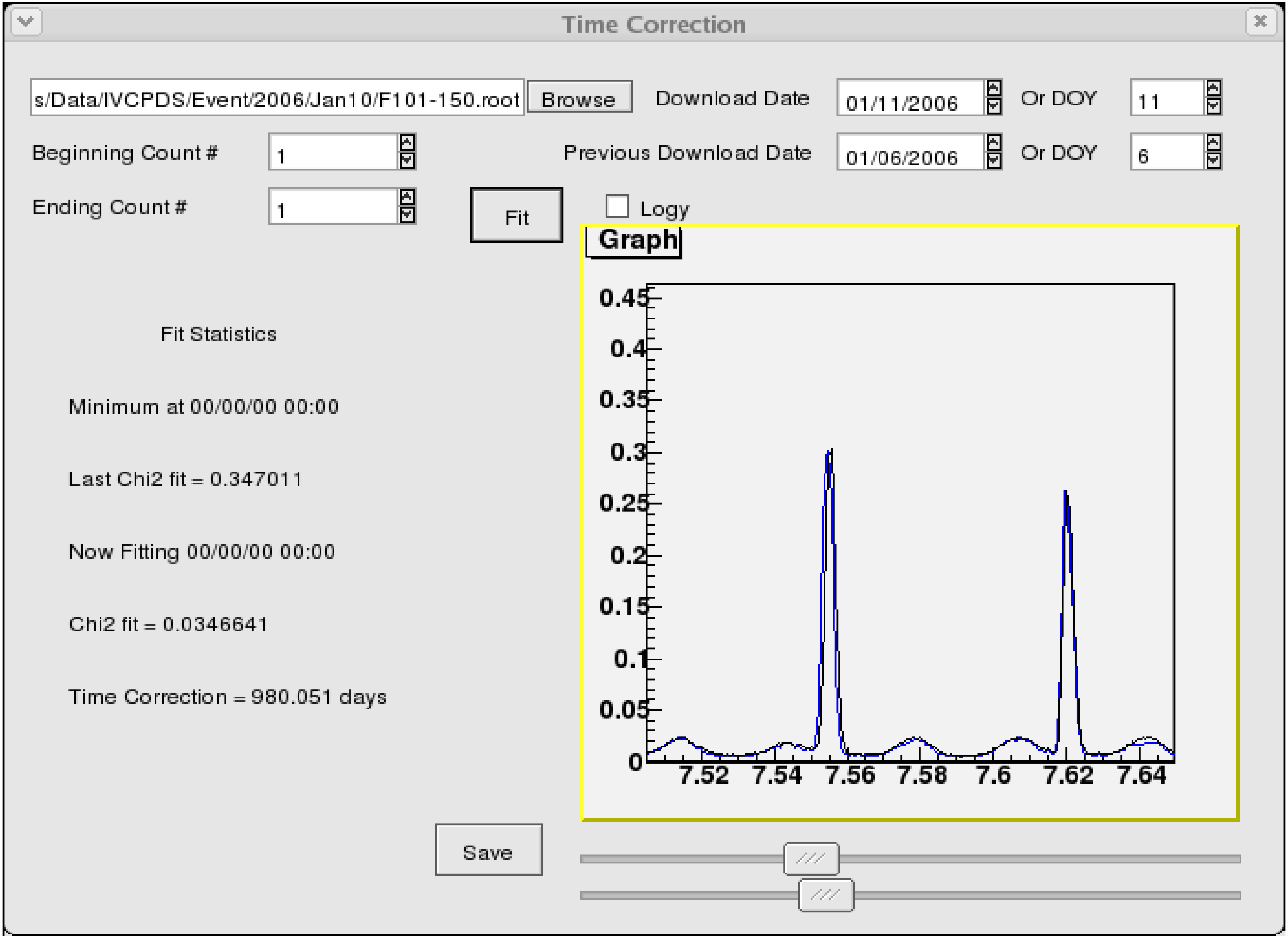


Particle and Energy ID



Time Correction





Time Correction
s/Data/IVCPDS/Event/2006/Jan10/F101-150.root
Browse
Download Date
01/11/2006
Or DOY
11
Beginning Count #
1
Previous Download Date
01/06/2006
Or DOY
6
Ending Count #
1
Fit
Logy
Graph
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
7.52
7.54
7.56
7.58
7.6
7.62
7.64
Fit Statistics
Minimum at 00/00/00 00:00
Last Chi2 fit = 0.347011
Now Fitting 00/00/00 00:00
Chi2 fit = 0.0346641
Time Correction = 980.051 days
Save

What About Helium?

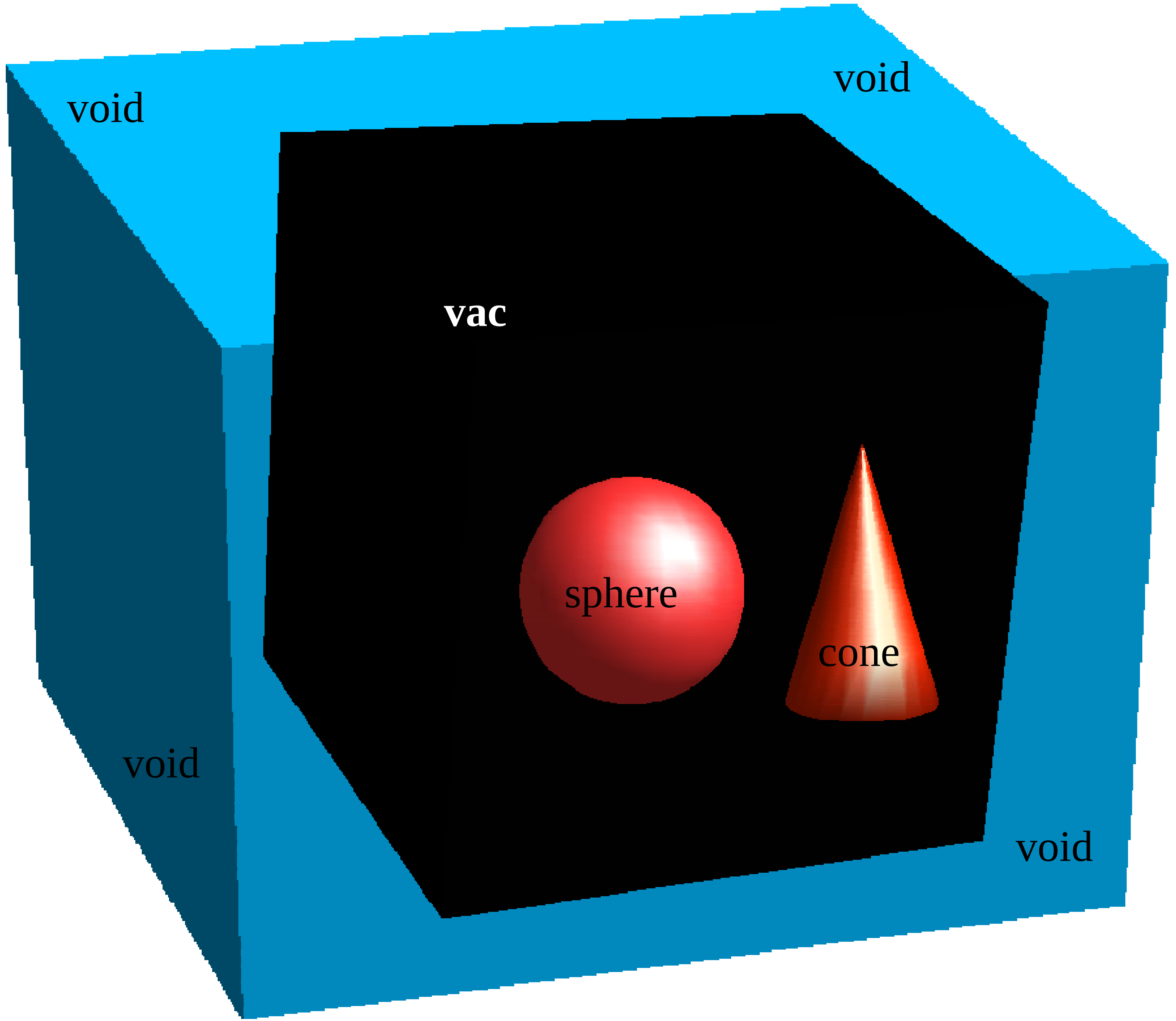
- He requires tighter cuts due to additional heavy ion contamination in the particle ID method.
- A good simulation is required to understand what part of the signal is being cut while removing the heavy ion contamination component.

Good Simulation Requirements

- Does physics well for particles and energy range that is encountered
  - Ions up to Z=26
  - Energies of few MeV – 10's of GeV.
- Input relatively detailed geometry
- I choose to use FLUKA (note: choice might be biased due to PhD advisor influence)

FLUKA Geometry

- Combinatoric Geometry that uses logic identical to algebra of sets (union, intersection, complement) to describe regions of space. Also, all of space must be defined with no overlapping regions.
- Detailed geometry is possible if you have lots of time, patience, and no interruptions for hours on end. This is fine for huge experiments with lots of graduate students and 10 years between detector upgrades, but not small space based detectors with frequent shielding changes.
- I have made an attempt to make FLUKA geometry input simpler.

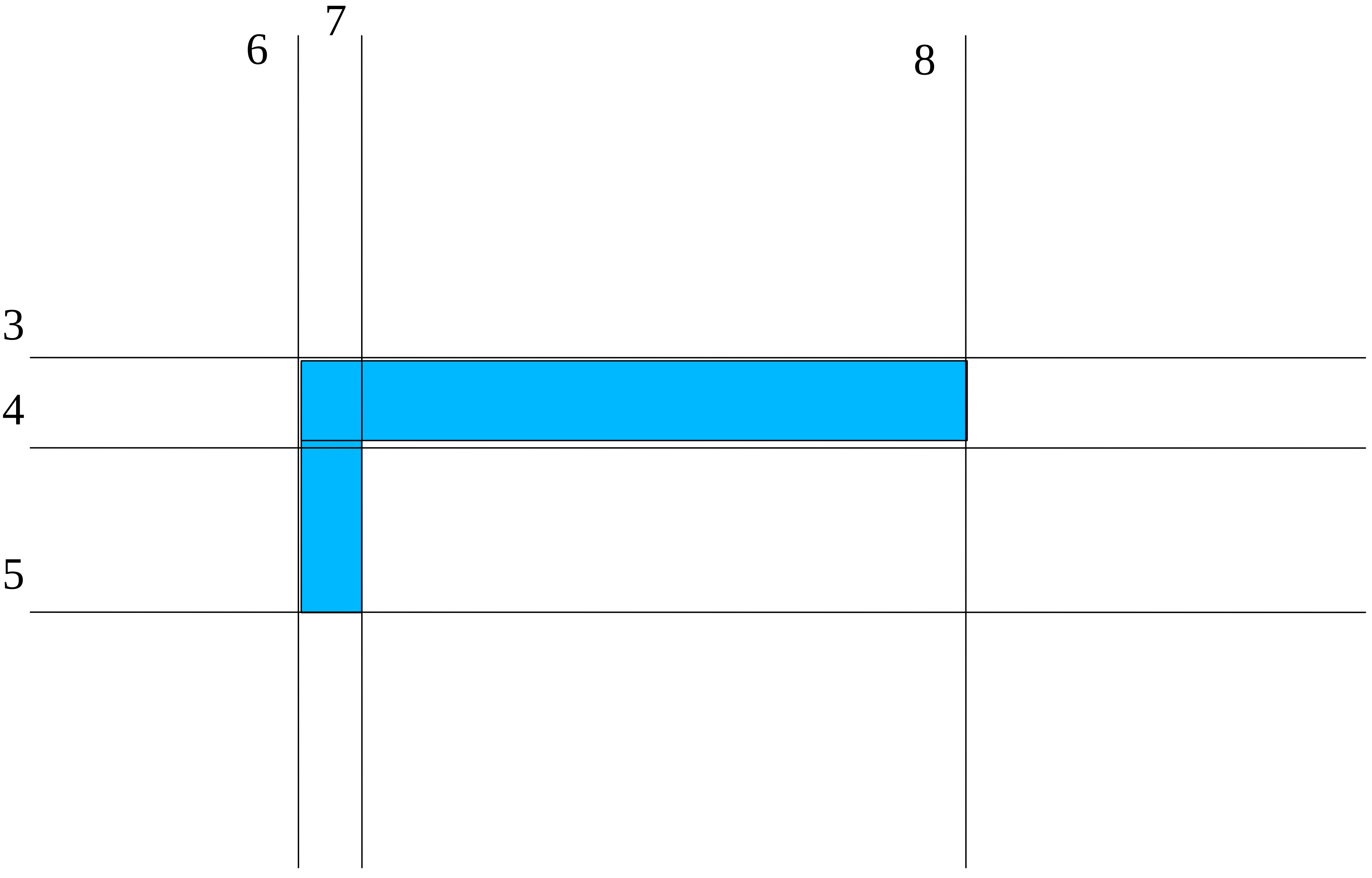

void
void
vac
sphere
cone
void
void

Fluka Geometry cont.

- The hardest part about a FLUKA geometry is not defining the components of the detector, but defining the air or vacuum that surrounds all the components.
- The algebra is easy though
  - Vacuum = +vac – all components
  - OR Vacuum = +vac - $\sum \text{component}_i$
- FLUKA allows use of parentheses so in theory one can do exactly this.
  - Vacuum = +vac - (+sphere | +cone)

FLUKA Parentheses

- Component_i can be complicated (i.e. +BodyA -BodyB | +BodyC - BodyD)
- Handing something complicated to FLUKA using parentheses produces redundantly defined zones. These redundant zones come from the expansion of the parentheses following the rules for algebra of sets (these redundant zones are supposed to be removed in the new FLUKA, but only after the full expansion)


7
6
8
3
4
5

Example

```
RPP A1 -5000000 5000000 -5000000 5000000 -5000000 5000000
RPP A2 -1000000 1000000 -1000000 1000000 -100 1000000
XZP A3 0
XZP A4 -1
XZP A5 -5
YZP A6 0
YZP A7 1
YZP A8 10
XYP A9 0
XYP A10 10
END
VOID +A1 -A2
LSHAPE +A3 -A4 +A8 -A6 +A10 -A9 | +A4 -A5 +A7 -A6 +A10 -A9
VACUUM +A2 - (+A3 -A4 +A8 -A6 +A10 -A9 | +A4 -A5 +A7 -A6 +A10 -A9 )
```

FLUKA Interpreted Regions

Region n. 1 void

	1	-2

Region n. 3 Lshape

OR	3	-4	8	-6	10	-9
OR	4	-5	7	-6	10	-9

Region n. 2 vacuum

OR	2	-3	-4
OR	2	-4	-8
OR	2	-10	-4
OR	2	6	-4
OR	2	9	-4
OR	2	5	-3
OR	2	5	-8
OR	2	5	-10
OR	2	4	5
OR	2	5	6
OR	2	5	9
OR	2	-3	-7
OR	2	-7	-8
OR	2	-10	-7
OR	2	4	-7
OR	2	6	-7
OR	2	9	-7
OR	2	6	-3
OR	2	6	-8
OR	2	6	-10
OR	2	4	6
OR	**2**	**6**	
OR	2	6	9
OR	2	-10	-3
OR	2	-10	-8
OR	2	4	-10
OR	**2**	**-10**	
OR	2	9	-10
OR	2	9	-3
OR	2	9	-8
OR	2	4	9
OR	**2**	**9**	

Of the 32 zones defining VA1 3 zones with two bodies are redundant with 21 other zones.

Getting more complex

- Adding an addition complex object (addition of two bodies) produces over 400 zones, and adding a 3rd causes FLUKA to crash (array overflow is likely).
- A large majority of the 400 zones are redundant.

Solution

- Implemented parentheses expansion in my own code, remove redundant zones, then write FLUKA geometry file.
- As the parentheses are expanded redundant zones are taken out at the same time.
  - Very fast expansion
  - Keeps memory usage down

Solution cont...

- Example with 3 complicated regions
  - Full Expansion gives over 46000 regions, and takes approximately 30 seconds to run without integrated optimization
  - With integrated optimization the result is 17 regions and runs in less than 100ms
  - Further optimization is possible based on the type of bodies. So far infinite plane optimization has been implemented and takes the 17 regions down to 9 regions, which is the minimum number one can write by hand.

Current Goal

- A library with the ability to build geometries in terms of volumes and assemblies of volumes.
- Supply a set of simple volumes
- Supply access to recommended FLUKA bodies to build user defined volumes
- User will need to write C++ class for new volumes.

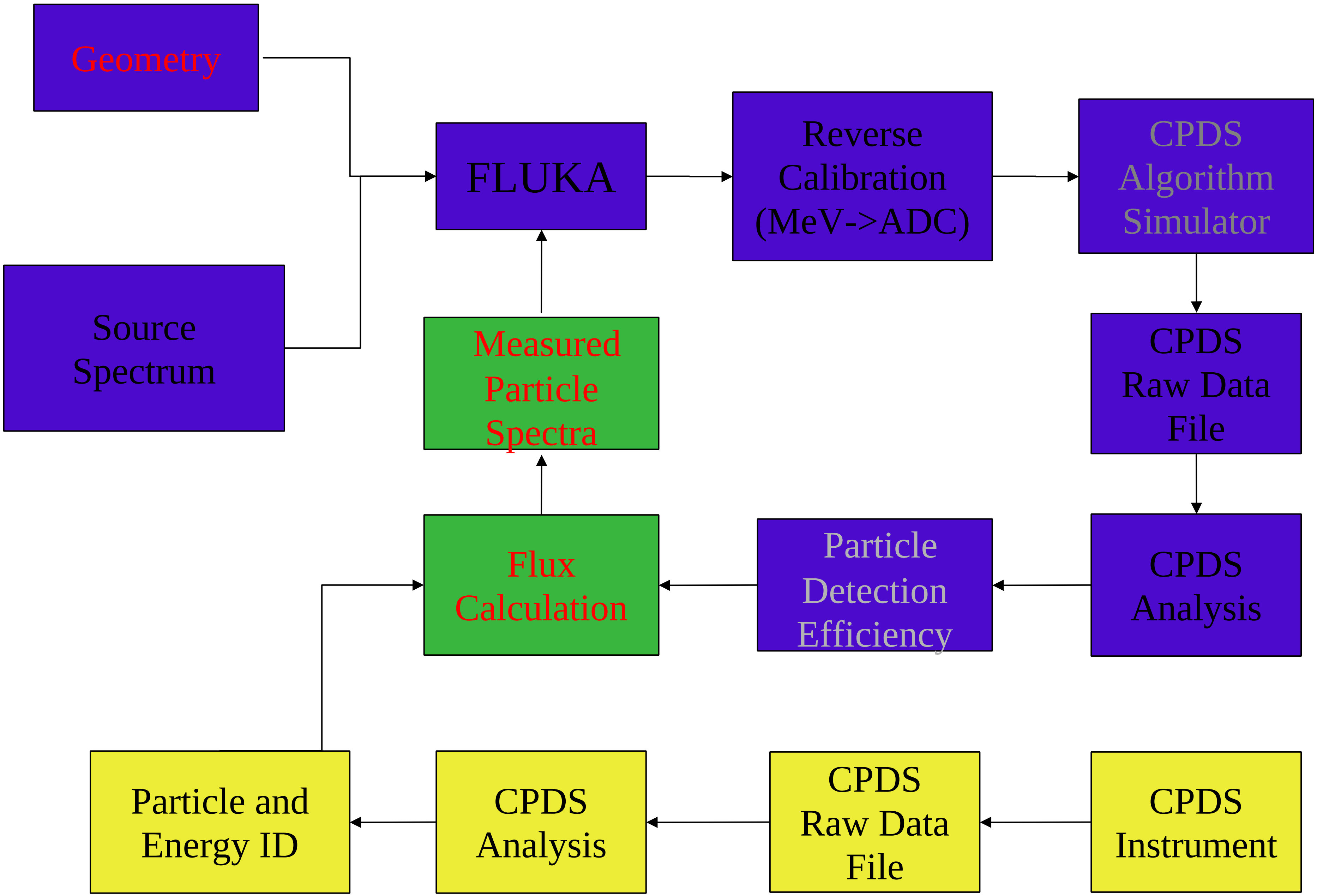
Future Potential

- A simple module can be written to go from GEANT, ROOT and other geometry descriptions to convert existing geometries to a FLUKA geometry
- A GUI allowing user to build user defined volumes from FLUKA bodies (or already created volumes).
- Removal of all user coding requirements
- CAD like interface with ability to create and view geometry in real time.

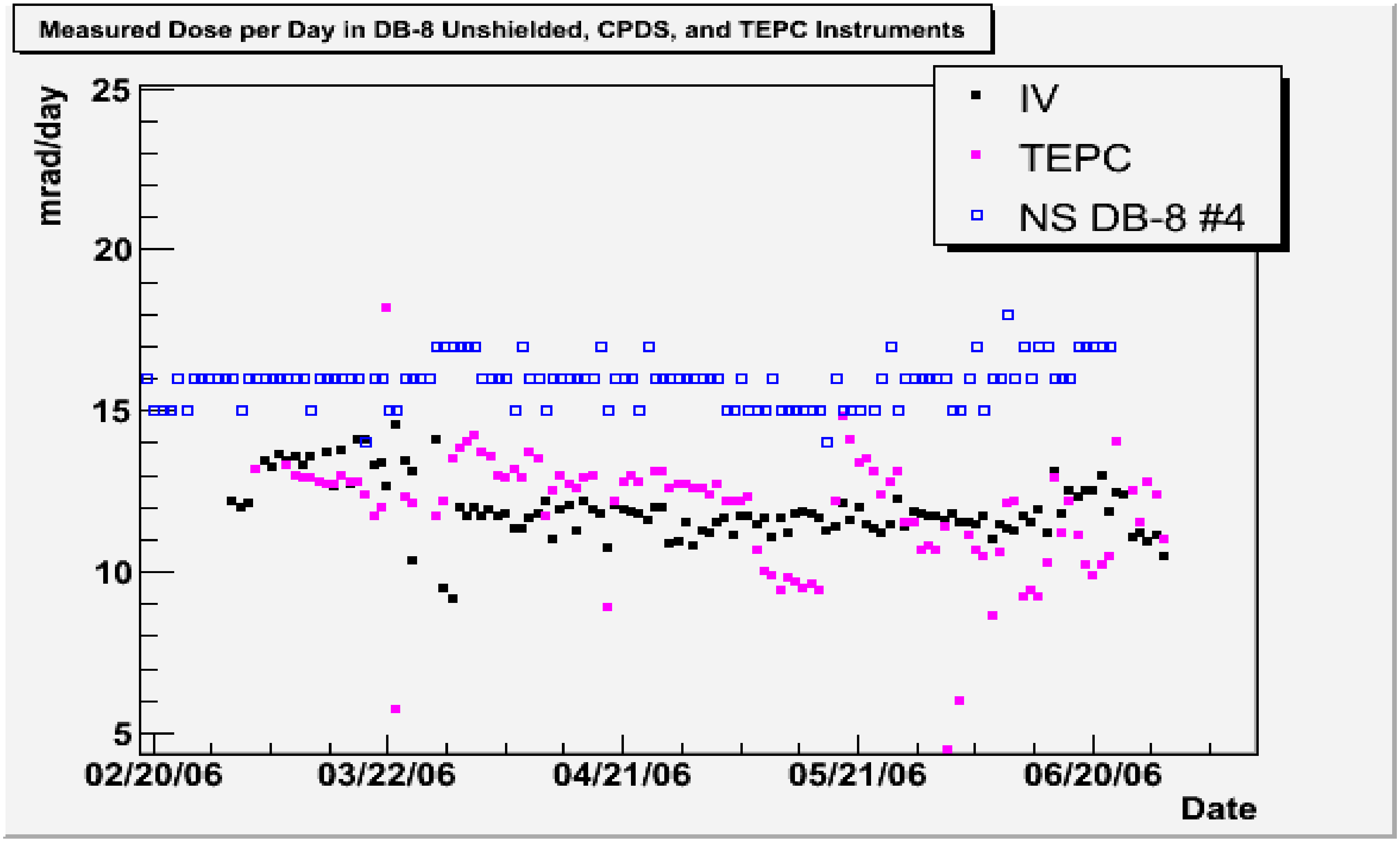
Summary

- IV and EV data analysis is underway
- Comparisons with other ISS instruments will continue
- Full Monte Carlo simulation of instruments is underway to optimize data selection and correct for selection efficiencies.
- Goal is to be able to produce H and He spectra, CNO abundances, daily dose rate, and LET spectra in a short time frame after each download.

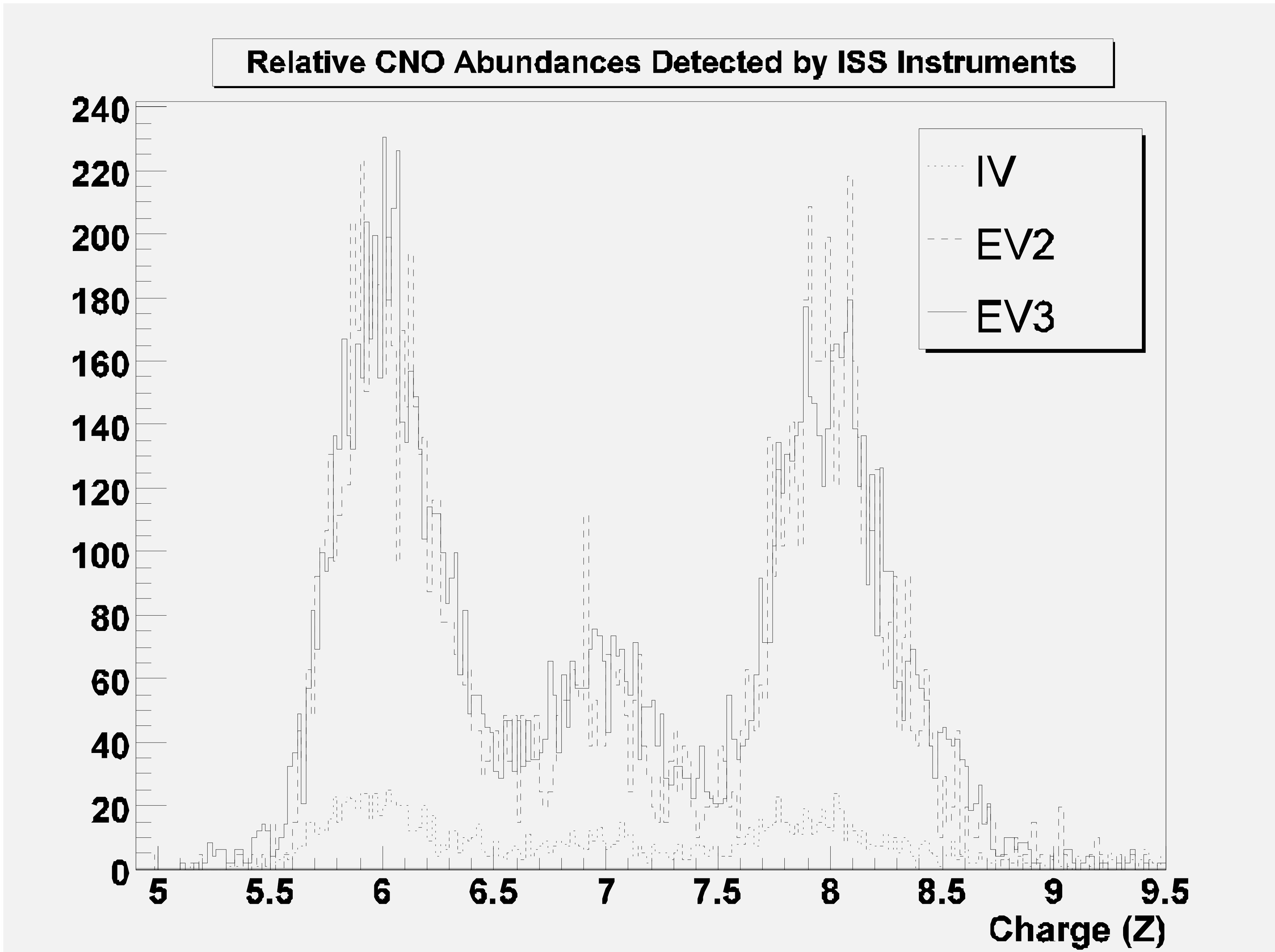
CPDS Analysis



IVCPDS, TEPC and DB-8 Dose Rate Comparison



Note: IV dose rate is based on A1 counter data


Relative CNO Abundances Detected by ISS Instruments
IV
EV2
EV3
0
20
40
60
80
100
120
140
160
180
200
220
240
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Charge (Z)

Preliminary Proton Energy Spectrum