

4 4 Fxy 가 Operating Experience of YGN-4 Cycle 4 Fxy Anomaly

150

167

4 4 Fxy 가
ICI-16 Level 1
가 Fxy 가 가 . CECOR Consistency Test,
Box Power Comparison Test, Fxy List-up 가
가 . Background
ICI-16 Level 1
Fail
Rhodium

Abstract

During the nuclear physics test and power operation of Yonggwang Unit 4 Cycle 4 which is Korean Standard Nuclear Power Plant, the unexpected Fxy increment measured by fixed incore detector system was observed and the reason was analyzed. The maximum Fxy occurred at In-Core Instrument (ICI) number #16 (full core box #59) Level 1, and the main reason was the highly measured incore detector signal. CECOR consistency test, box power comparison test, Fxy list-up test, and the evaluation of the core power distribution result in much difference between the predicted and the measured. The evaluation of the ICI depletion history, sensitivity and background signal, however, shows that there are no problems of incore detector system in operability. From the result of evaluation, even though ICI#16 Level 1 is very suspect, there is no clear evidence for detector failure, and it is considered that the Fxy increment was induced by the Rhodium detector unusual signal. The objective of this study is to guide to setup the procedures for the determination of Rhodium detector failing and the Rhodium detector operability through the experience of Fxy anomaly in order to keep the core maintaining an operating thermal margin.

1.

4 4
 Fxy 가 가 .
 4 3 4 가 가
 가 1,000 MWD/MTU
 가 (1). 4 4 ICI-16(FC#59)
 Level 1 Fxy 가 3 4 ICI-25(FC#101) Level 1
 Fxy 가 Level 1 .
 4 4 3 4 가 Fxy 가
 가 (1). 3 4
 ICI 4 .
 90 MWD/MTU(80%) CECOR Consistency Test ICI-16
 Level 1 4 가 , 100% Assembly
 by Assembly Comparison Test ICI-16 Level 4
 가 ICI-16 Level 1 가 .

2.

가
 Fail Wedge Test Consistency Test
 . Wedge Test Consistency Suspect ICI
 Fail 가 가 . 가
 Symmetric Detector Comparison Test 8 가

1) Wedge Test

Wedge test CECOR
 Fail Signal CECOR
 CECOR
 $10^{12} \sim 10^{15} (n/cm^2)$. 4 4 ICI-1 Level
 1 121 MWD/MTU 'Wedge Test Fail' , ICI-16 Level 1

2) Consistency Test

Off-line CECOR 45
 . Level 45 Signal-to-Power
 Conversion Factor W' 가
 Coupling Coefficient(CC) 가
 . 가 Fail <CC>
 . Consistency Test 1 45
 Fail 가 <CC> W'
 Fail .

Consistency Test Criteria

- + PASS: ±5%
- + SUSPECT: ±5 ~ ±15%
- + FAIL: ±15%

90MWD/MTU(80%) Consistency Test

- + ICI-16 Level 1: 6.3%,
 - + ICI-16 Level 4: 8.7%. (-)
- 'SUSPECT' , .

3) Symmetric Detector Comparison Test

ICI-16

Symmetric Detector Comparison Test

가 ±3% 'Suspect Signal'

가 .

4) Symmetric Box Power Comparison Test

Fxy 가 ICI-16(FC#59) FC#87, #91 #119
 . ICI-16 1 .

1 Symmetric Box Power Comparison

| 80 % (90 MWD/MTU) | | | 100 % (381 MWD/MTU) | | |
|-------------------|--------|-----------|---------------------|--------|-----------|
| BOX# | POWER | DEVIATION | BOX# | POWER | DEVIATION |
| 59 | 1.4727 | 4.3% | 59 | 2.0391 | 4.8% |
| 87 | 1.3945 | -1.3% | 87 | 1.9219 | -1.3% |
| 91 | 1.3921 | -1.4% | 91 | 1.9104 | -1.8% |
| 119 | 1.3895 | -1.6% | 119 | 1.9137 | -1.7% |

5) Assembly by Assembly Comparison Test of the CECOR powers to ROCS at Each Level

2 Consistency Test ICI-16 Level 4
 ROCS
 가 ICI-16 Level 4
 Level 1 2 가
 , 1 Fxy 가
 . Level 1 Signal
 Fxy 'Suspect
 Signal'

1 ICI-16 Level 1 Signal Fail Fxy
 3 4

2 CECOR and ROCS Power Comparison

| ICI-16 | | | | | | |
|--------|------------|--------|-------|-------------|--------|-------|
| Level | 90 MWD/MTU | | | 381 MWD/MTU | | |
| | CECOR | ROCS | %Diff | CECOR | ROCS | %Diff |
| 1 | 1.4598 | 1.3381 | -8.34 | 1.4685 | 1.3428 | -8.56 |
| 2 | 1.3679 | 1.3198 | -3.52 | 1.3530 | 1.3254 | -2.04 |
| 3 | 1.3579 | 1.3232 | -2.55 | 1.3416 | 1.3288 | -0.95 |
| 4 | 1.4136 | 1.3348 | -5.58 | 1.3950 | 1.3388 | -4.03 |
| 5 | 1.3716 | 1.3484 | -1.69 | 1.3632 | 1.3481 | -1.10 |

6) Fxy List-Up Comparison Test

3 가 Fxy 20
 . Fxy ICI-16 Fxy

7) Axial Power Shape Comparison Test

4 ICI-16
 ROCS . CECOR ROCS
 Bottom Region 가 , ICI-16

(FC#59) Bottom Region

가

Fxy가

8) Neighboring ICI Consistency Comparison Test

3 ICI-16 Consistency Test
 ICI-16 Level 1 Consistency Test
 , ICI-16 Consistency Test
 . ICI-16 Level 1

3 Neighboring ICI Consistency Test

| ICI-16 Level 1 at 90 MWD/MTU | | | | | |
|------------------------------|-----|----------|------------|---------|---------|
| ICI# | FC# | Measured | Calculated | %Diff. | Remarks |
| 9 | 31 | 1.2722 | 1.2644 | -0.6198 | PASS |
| 10 | 34 | 1.1927 | 1.2446 | 4.1682 | PASS |
| 16 | 59 | 1.4694 | 1.3823 | -6.3028 | SUSP |
| 17 | 61 | 1.1448 | 1.1519 | 0.6122 | PASS |
| 20 | 72 | 1.1570 | 1.1468 | -0.8835 | PASS |
| 23 | 89 | 0.8841 | 0.9086 | 2.6957 | PASS |

| ICI-16 Level 1 at 381 MWD/MTU | | | | | |
|-------------------------------|-----|----------|------------|---------|---------|
| ICI# | FC# | Measured | Calculated | %Diff. | Remarks |
| 9 | 31 | 1.7331 | 1.7381 | 0.2851 | PASS |
| 10 | 34 | 1.6328 | 1.6972 | 3.7901 | PASS |
| 16 | 59 | 2.0251 | 1.8966 | -6.7742 | SUSP |
| 17 | 61 | 1.5565 | 1.5697 | 0.8436 | PASS |
| 20 | 72 | 1.5847 | 1.5688 | -1.0169 | PASS |
| 23 | 89 | 1.2236 | 1.2362 | 1.0240 | PASS |

9) Detector Signal vs. Burnup

가 ,
가

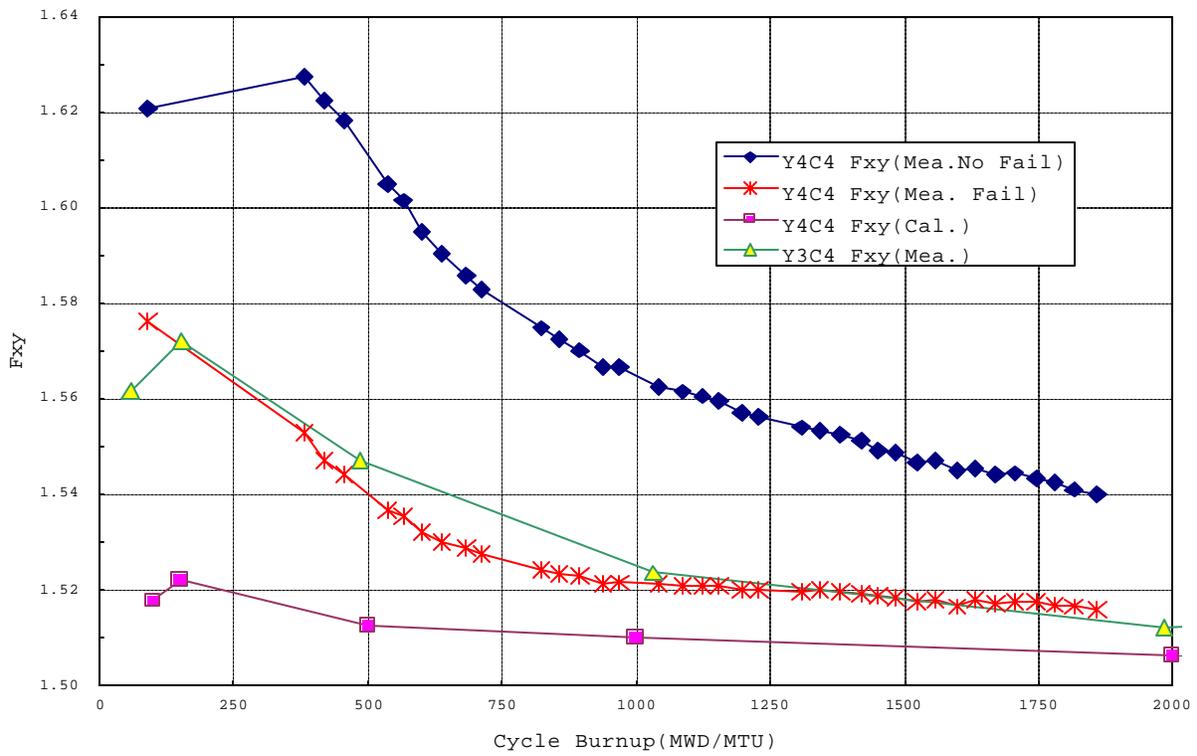
가

5

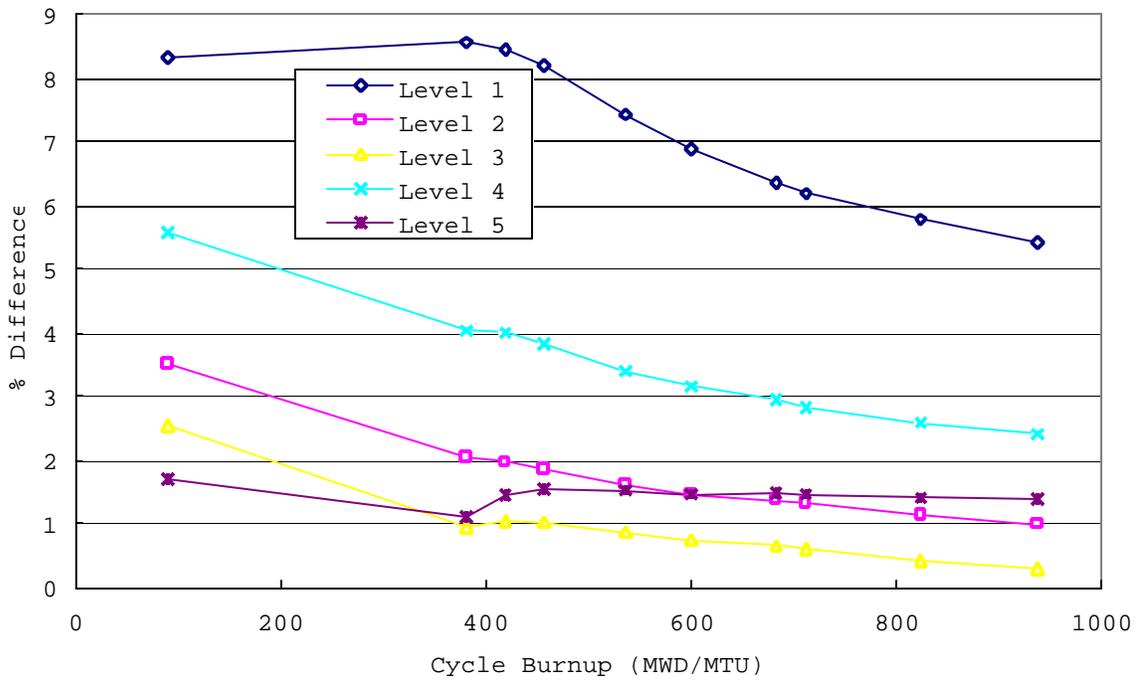
ICI-16

가

Fail

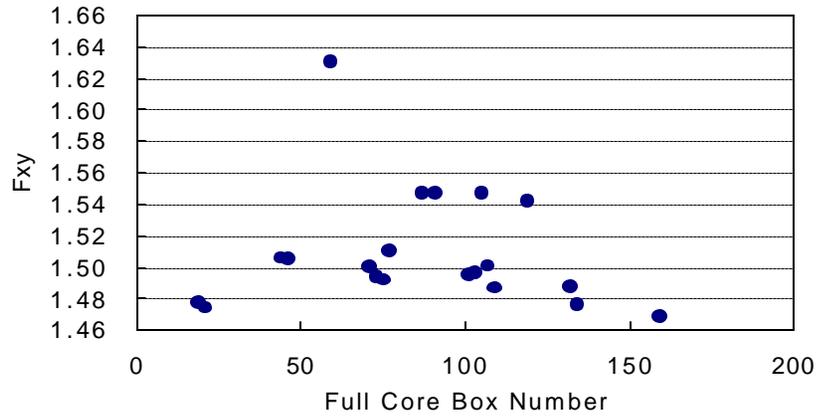


1. Fxy vs. Burnup for YGN-3/4 Cycle 4

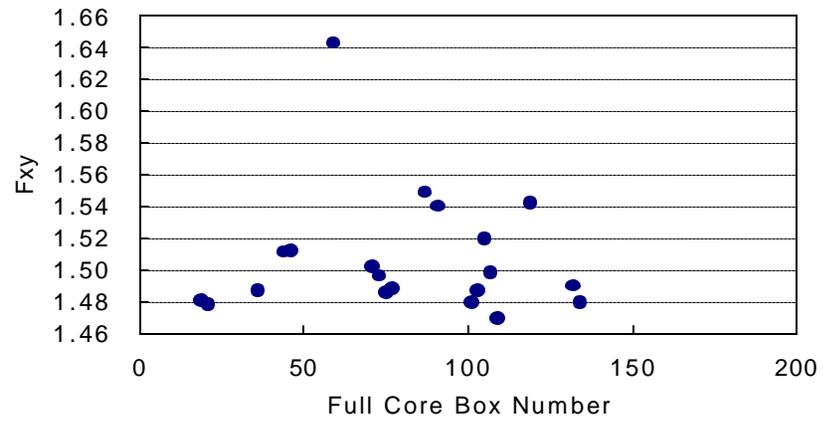


2. ROCS and CECOR Power Comparison for ICI-16

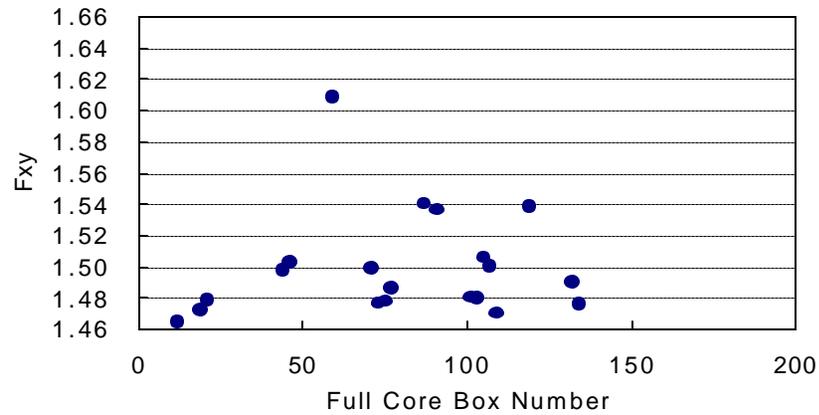
TOP 20 of Fxy at 90 MWD/MTU



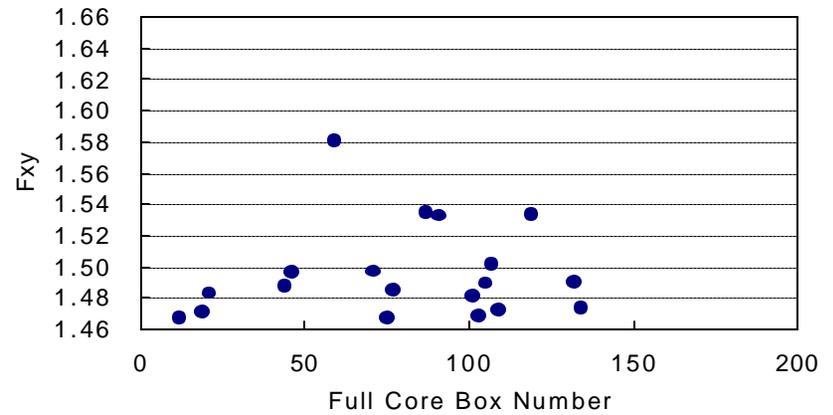
TOP 20 of Fxy at 380 MWD/MTU



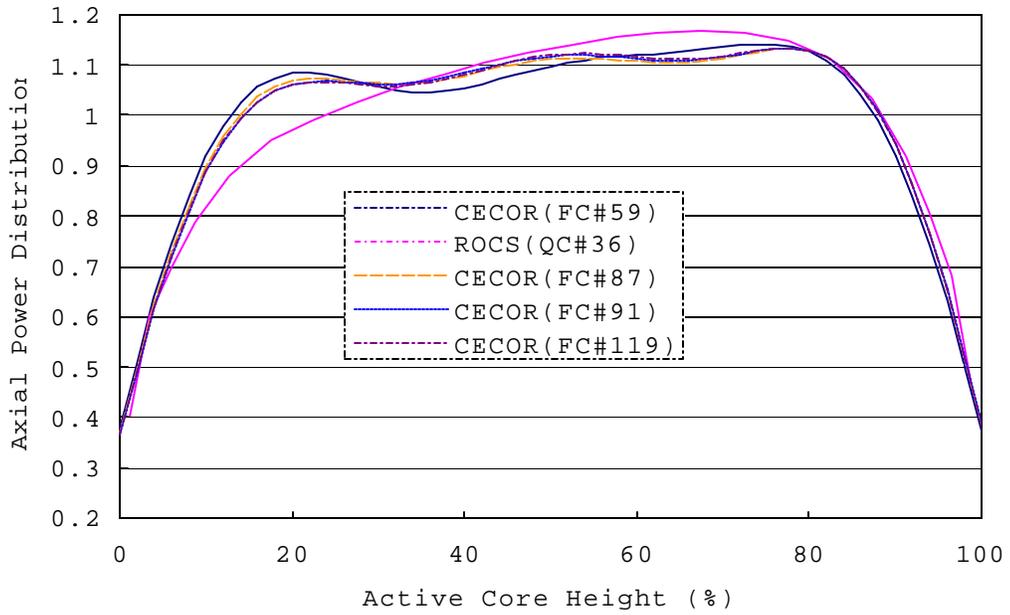
TOP 20 of Fxy at 600 MWD/MTU



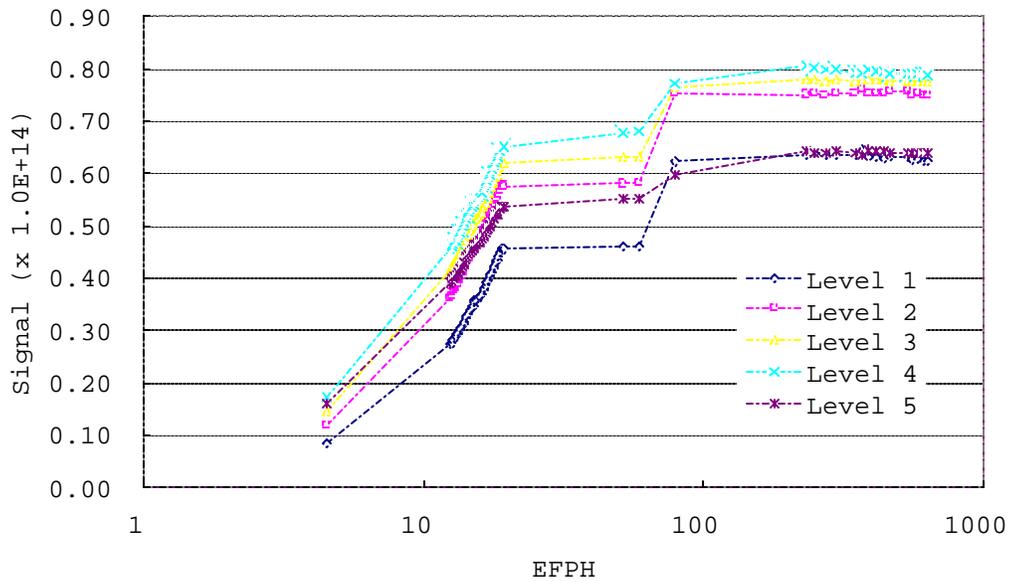
TOP 20 of Fxy at 970 MWD/MTU



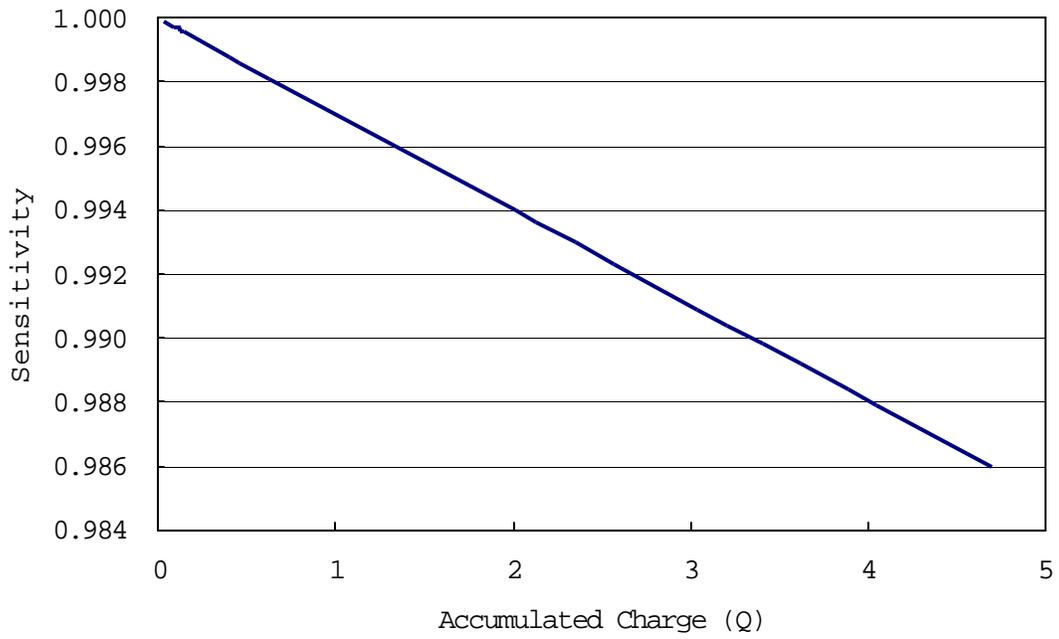
3. Fxy List-up vs. Burnup of YGN-4 Cycle 4



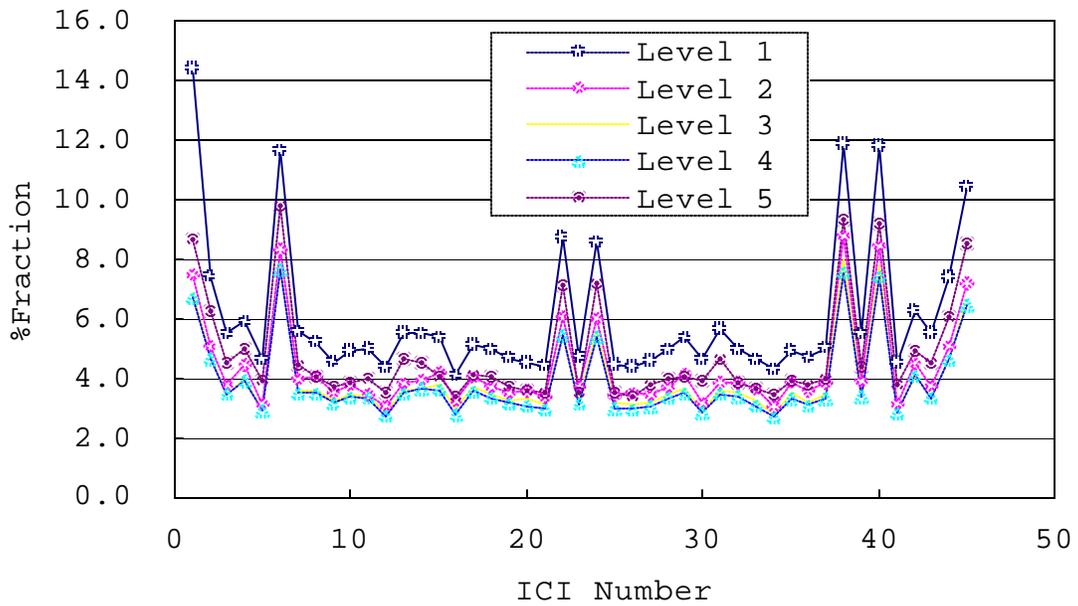
4. Axial Power Comparison between CECOR and ROCS at 381 MWD/MTU



5. ICI-16 Detector Signal vs. EFPH



6. ICI-16 Level 1 Sensitivity vs Accumulated Charge



7. Background Signal Fraction at 90 MWD/MTU