SEL Characterisation of SRAMs for the TDM Latch-up Experiment

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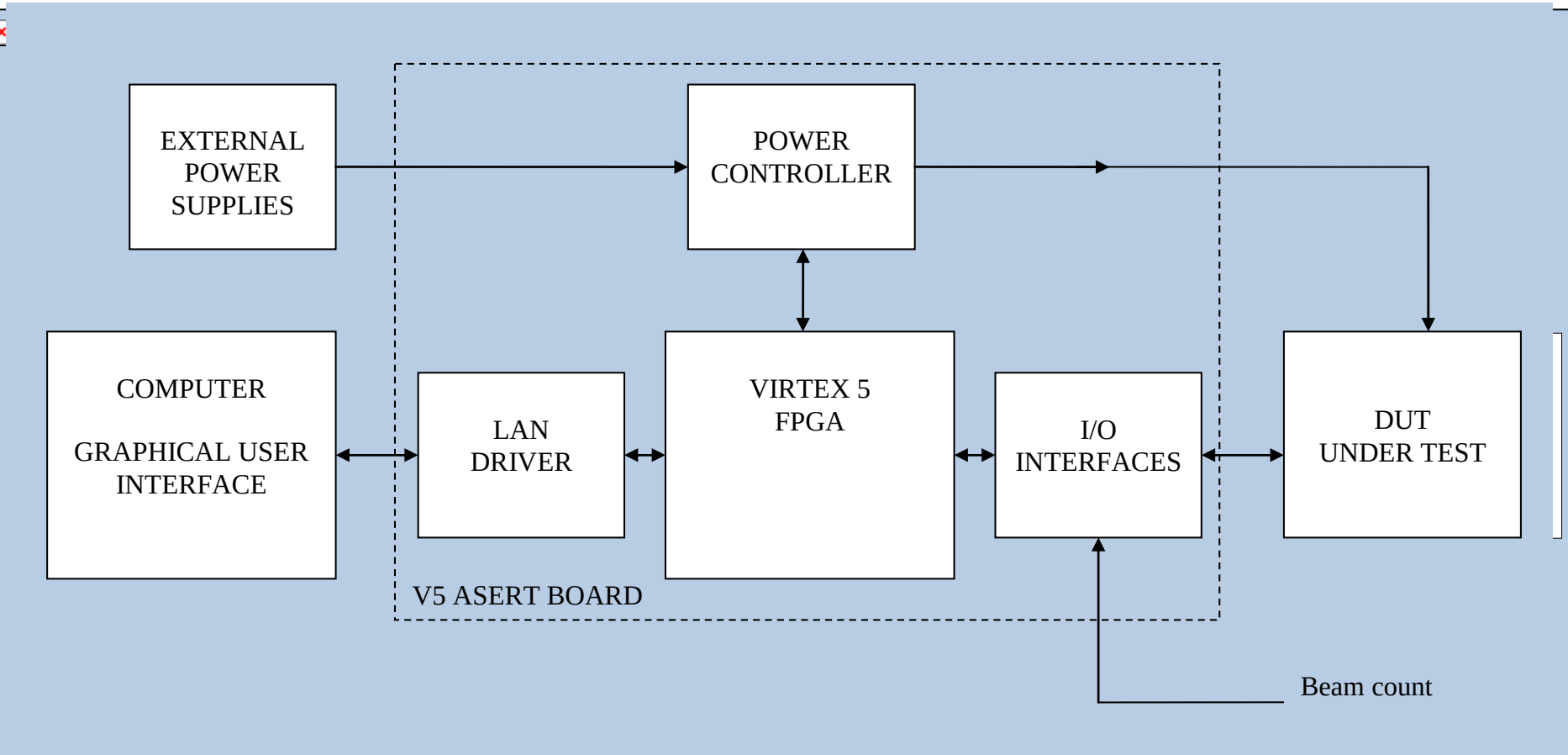
Outline

- Hirex test system
- SEL monitoring vs SEU monitoring
- Key numbers
- Purposes of this study
- SEL cross-section graphs (19...)
- Summary

Hirex test system



SEL vs SEU

- Power-down of the device as soon as a latchup is detected (after a 1 ms hold time)
- Power-up after a short time (1s)

- High flux means:
  - Many SELs but no SEU data
- Low flux means:
  - Long runs for good SEL statistics but SEU data

Key numbers (1/2)

- 6 campaigns
  - JYFL (W50 2007, W06 2008, W45 2008)
  - UCL (W27 2008, W42 2008)
  - TAMU (W47 2008)
- 5 SRAM models (limited to TSSOP2-44 packages and 3.3V devices)
- Opened and thinned devices (about 40 µm)

Key numbers (2/2)

- 170 hours beam schedule in total
- 57 hours beam time used while running
- About **45 000 latchups** in 45 hours effective beam time (device powered)
- No device destroyed

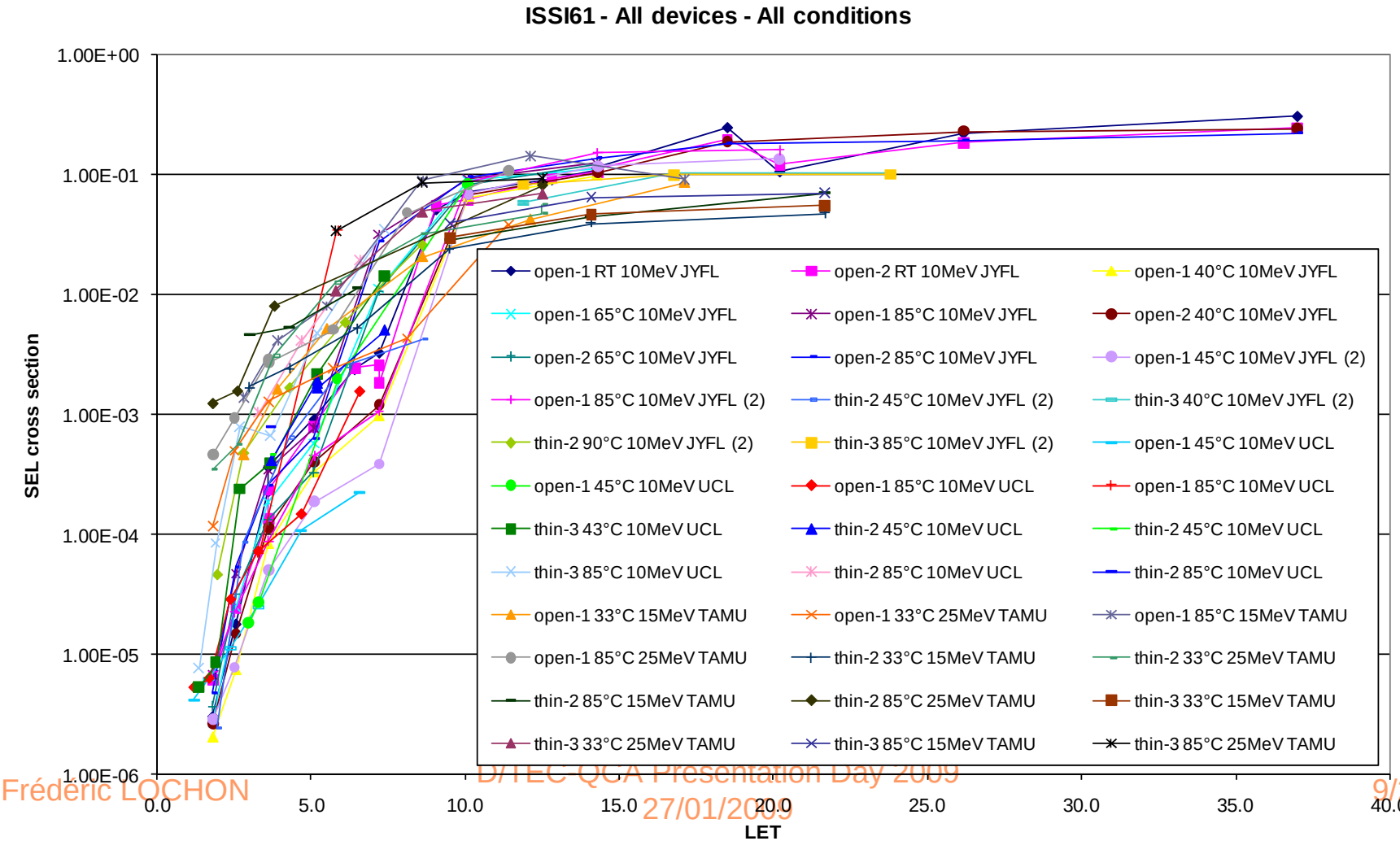
Purposes of this study

- Main goal: comparing different SRAMs and characterizing the SEL dependence
- Secondary goals:
  - Temperature influence
  - Thin devices vs open devices
  - S/N to S/N mismatch
  - Tilt axis influence
  - Facility comparison
  - SEU data

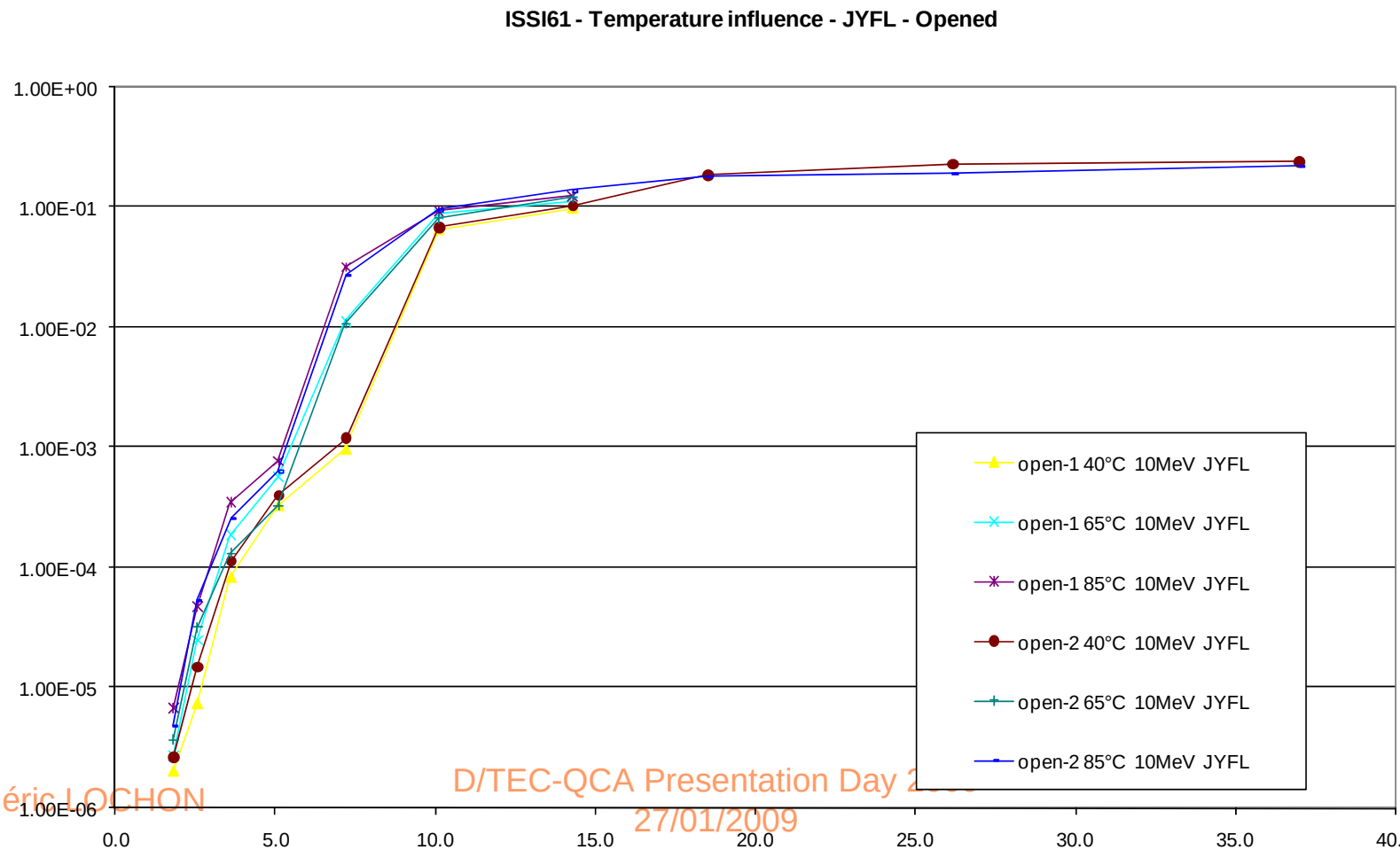
Characterized devices

- “ISSI61” (4 Mib)
- “K6R” (4 Mib)
- “AS7C” (4 Mib)
- “ISSI62” (8 Mib)
- “BSI” (not a flying device – incompatible pinout)

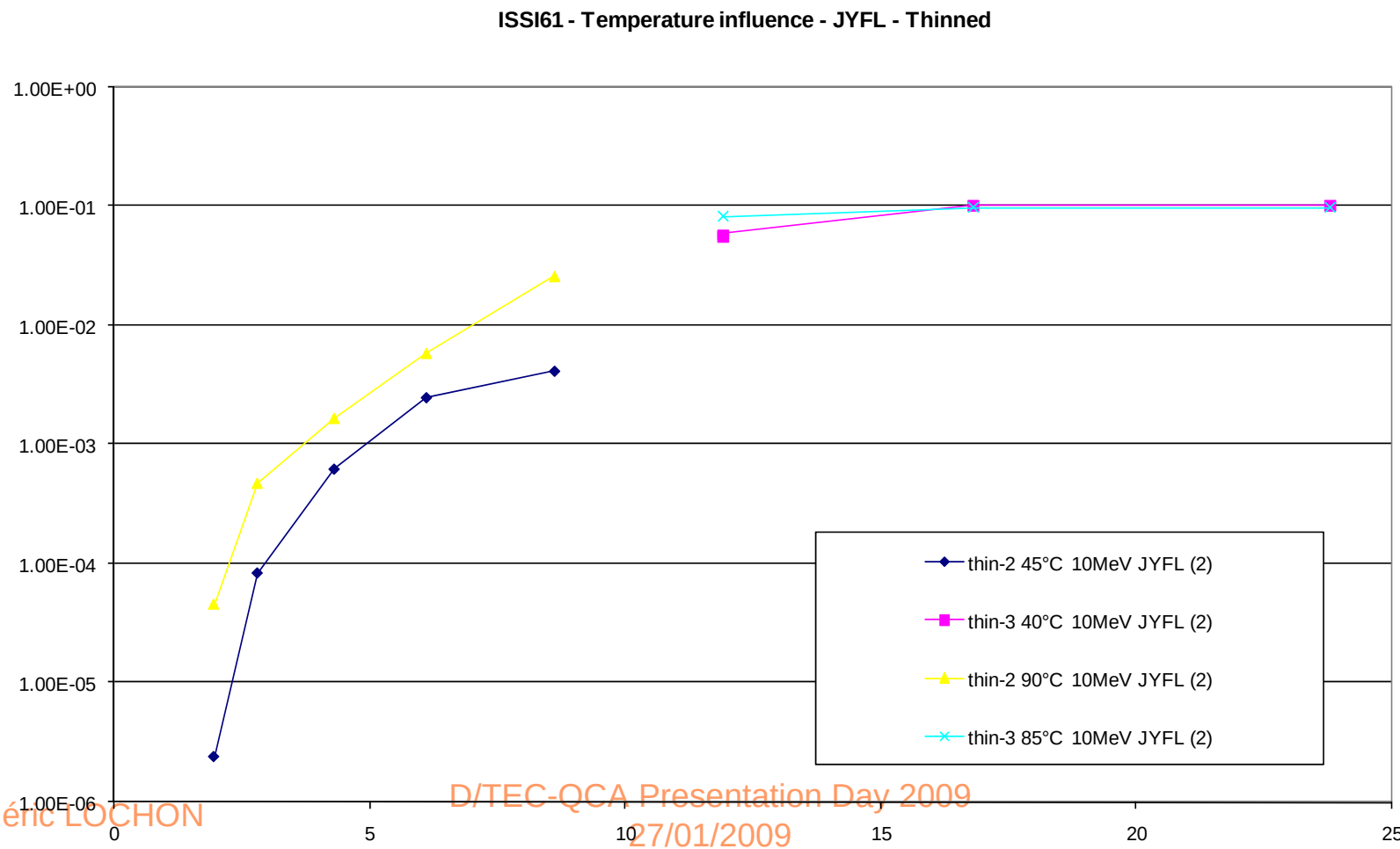
ISSI61 (1/11)


ISSI61 - All devices - All conditions
SEL cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
LET
open-1 RT 10MeV JYFL
open-2 RT 10MeV JYFL
open-1 40°C 10MeV JYFL
open-1 65°C 10MeV JYFL
open-1 85°C 10MeV JYFL
open-2 40°C 10MeV JYFL
open-2 65°C 10MeV JYFL
open-2 85°C 10MeV JYFL
open-1 45°C 10MeV JYFL (2)
open-1 85°C 10MeV JYFL (2)
thin-2 45°C 10MeV JYFL (2)
thin-3 40°C 10MeV JYFL (2)
thin-2 90°C 10MeV JYFL (2)
thin-3 85°C 10MeV JYFL (2)
open-1 45°C 10MeV UCL
open-1 45°C 10MeV UCL
open-1 85°C 10MeV UCL
open-1 85°C 10MeV UCL
thin-3 43°C 10MeV UCL
thin-2 45°C 10MeV UCL
thin-2 45°C 10MeV UCL
thin-3 85°C 10MeV UCL
thin-2 85°C 10MeV UCL
thin-2 85°C 10MeV UCL
open-1 33°C 15MeV TAMU
open-1 33°C 25MeV TAMU
open-1 85°C 15MeV TAMU
open-1 85°C 25MeV TAMU
thin-2 33°C 15MeV TAMU
thin-2 33°C 25MeV TAMU
thin-2 85°C 15MeV TAMU
thin-2 85°C 25MeV TAMU
thin-3 33°C 15MeV TAMU
thin-3 33°C 25MeV TAMU
thin-3 85°C 15MeV TAMU
thin-3 85°C 25MeV TAMU

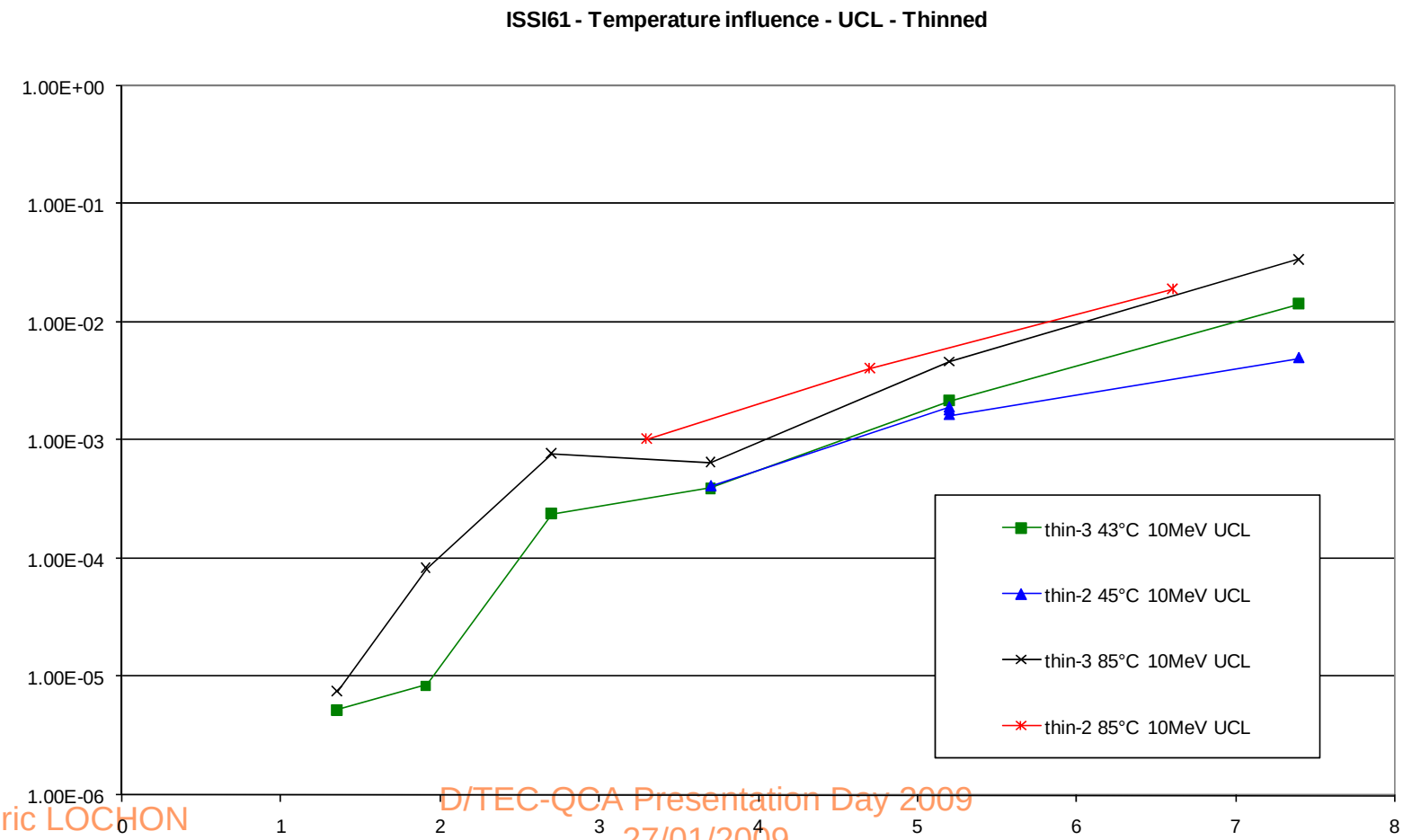
ISSI61 (2/11)


ISSI61 - Temperature influence - JYFL - Opened
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
open-1 40°C 10MeV JYFL
open-1 65°C 10MeV JYFL
open-1 85°C 10MeV JYFL
open-2 40°C 10MeV JYFL
open-2 65°C 10MeV JYFL
open-2 85°C 10MeV JYFL

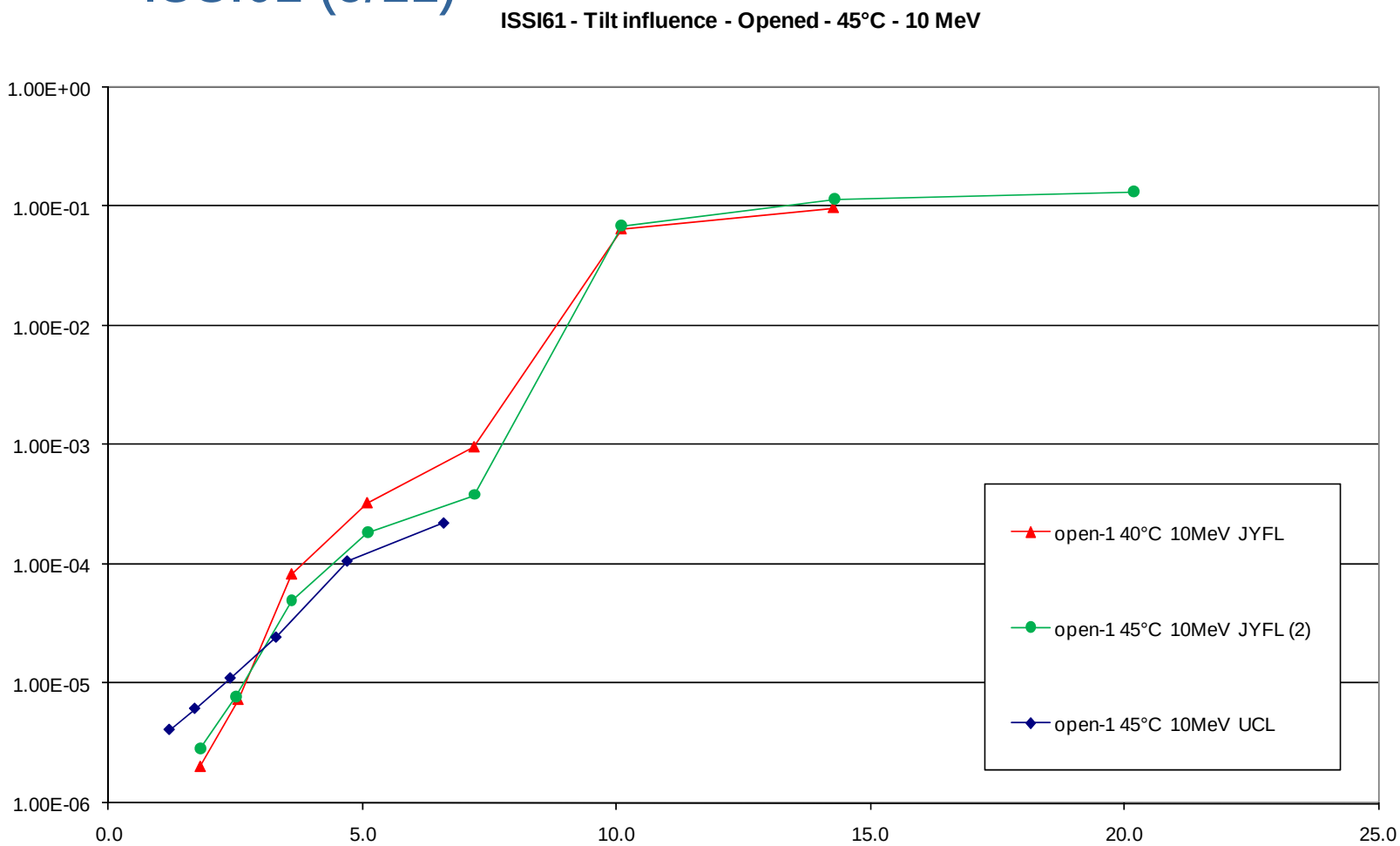
ISSI61 (3/11)


ISSI61 - Temperature influence - JYFL - Thinned
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0
5
10
15
20
25
thin-2 45°C 10MeV JYFL (2)
thin-3 40°C 10MeV JYFL (2)
thin-2 90°C 10MeV JYFL (2)
thin-3 85°C 10MeV JYFL (2)

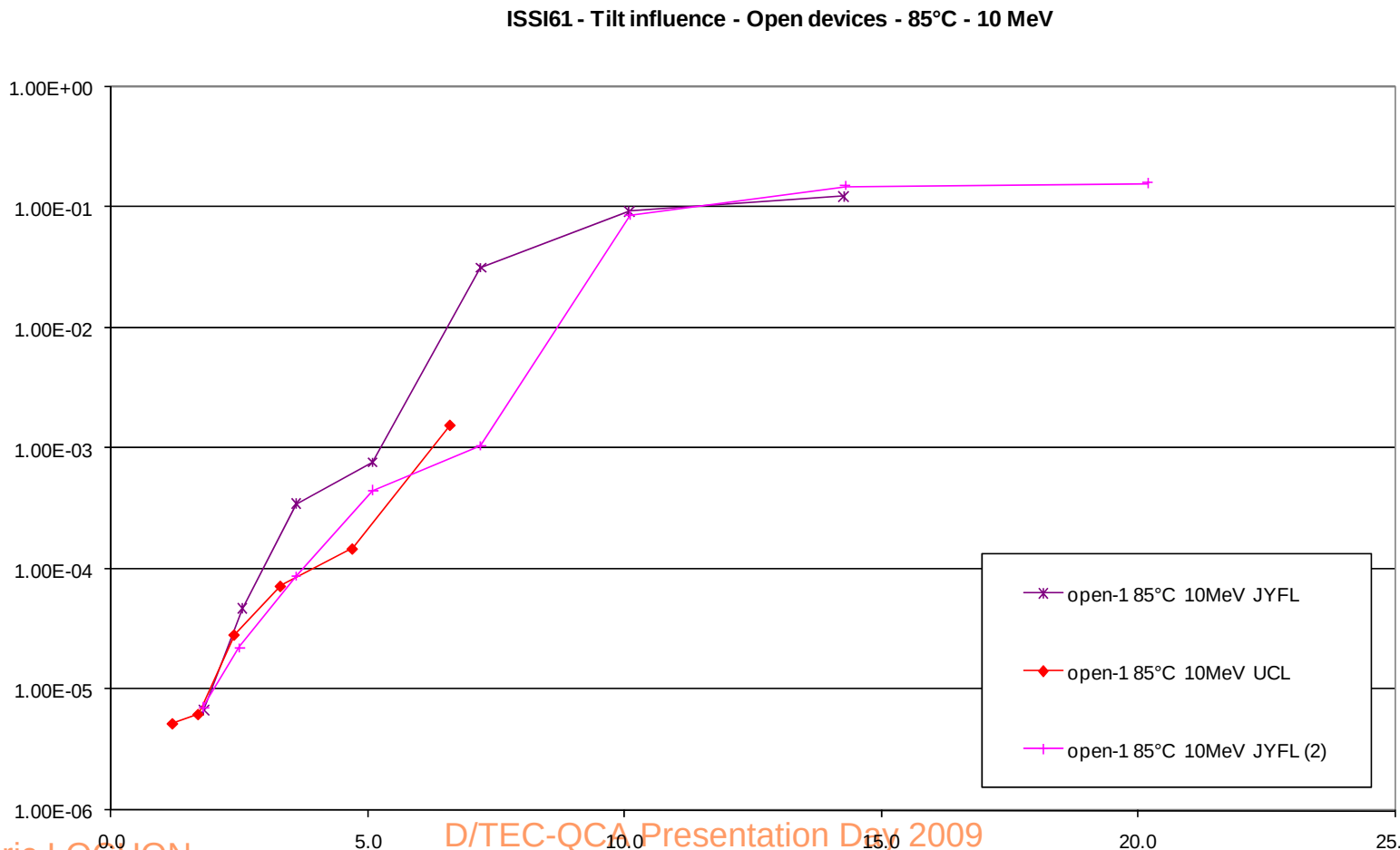
ISSI61 (4/11)


ISSI61 - Temperature influence - UCL - Thinned
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0
1
2
3
4
5
6
7
8
thin-3 43°C 10MeV UCL
thin-2 45°C 10MeV UCL
thin-3 85°C 10MeV UCL
thin-2 85°C 10MeV UCL

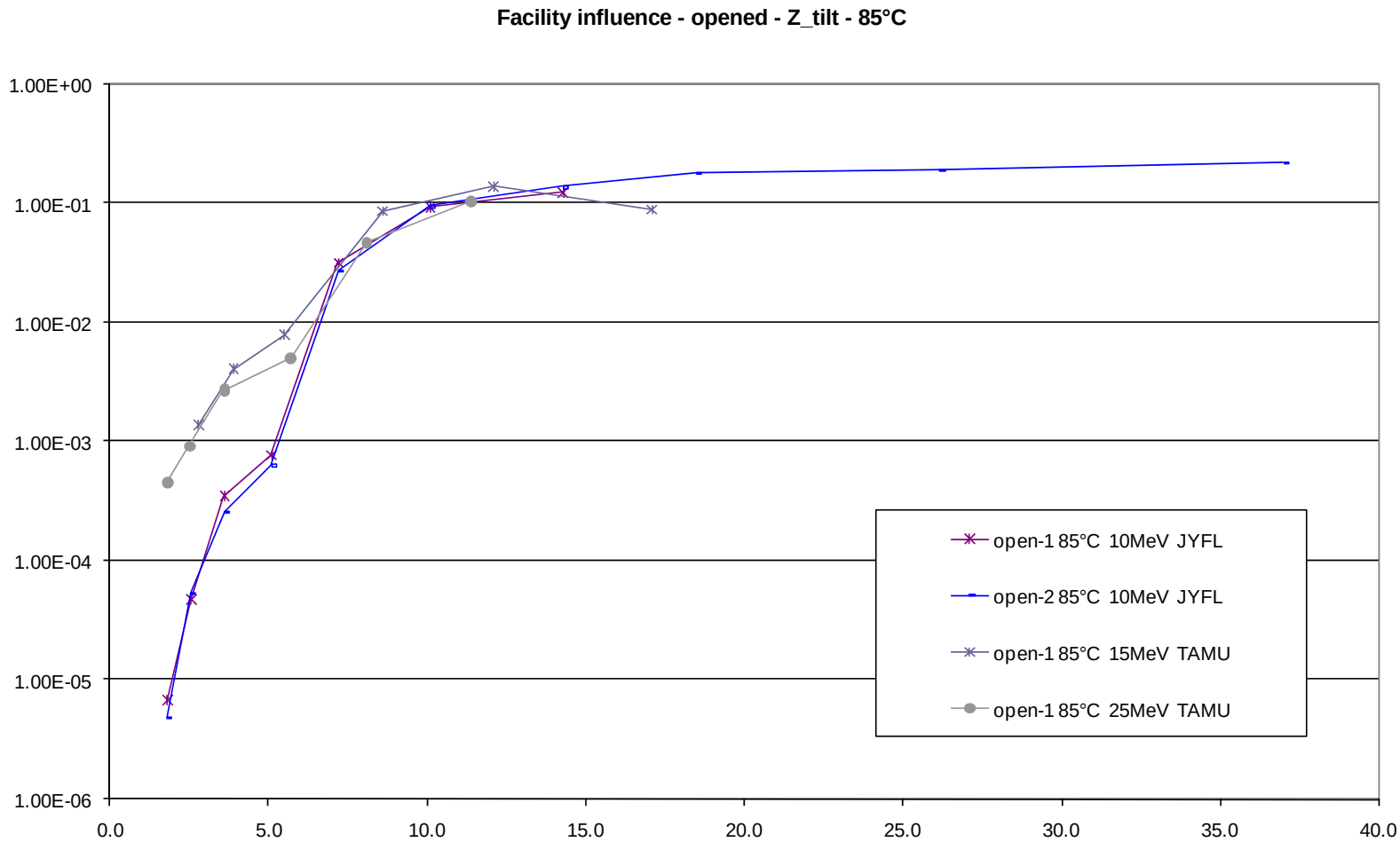
ISSI61 (5/11)


ISSI61 - Tilt influence - Opened - 45°C - 10 MeV
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0.0
5.0
10.0
15.0
20.0
25.0
open-1 40°C 10MeV JYFL
open-1 45°C 10MeV JYFL (2)
open-1 45°C 10MeV UCL

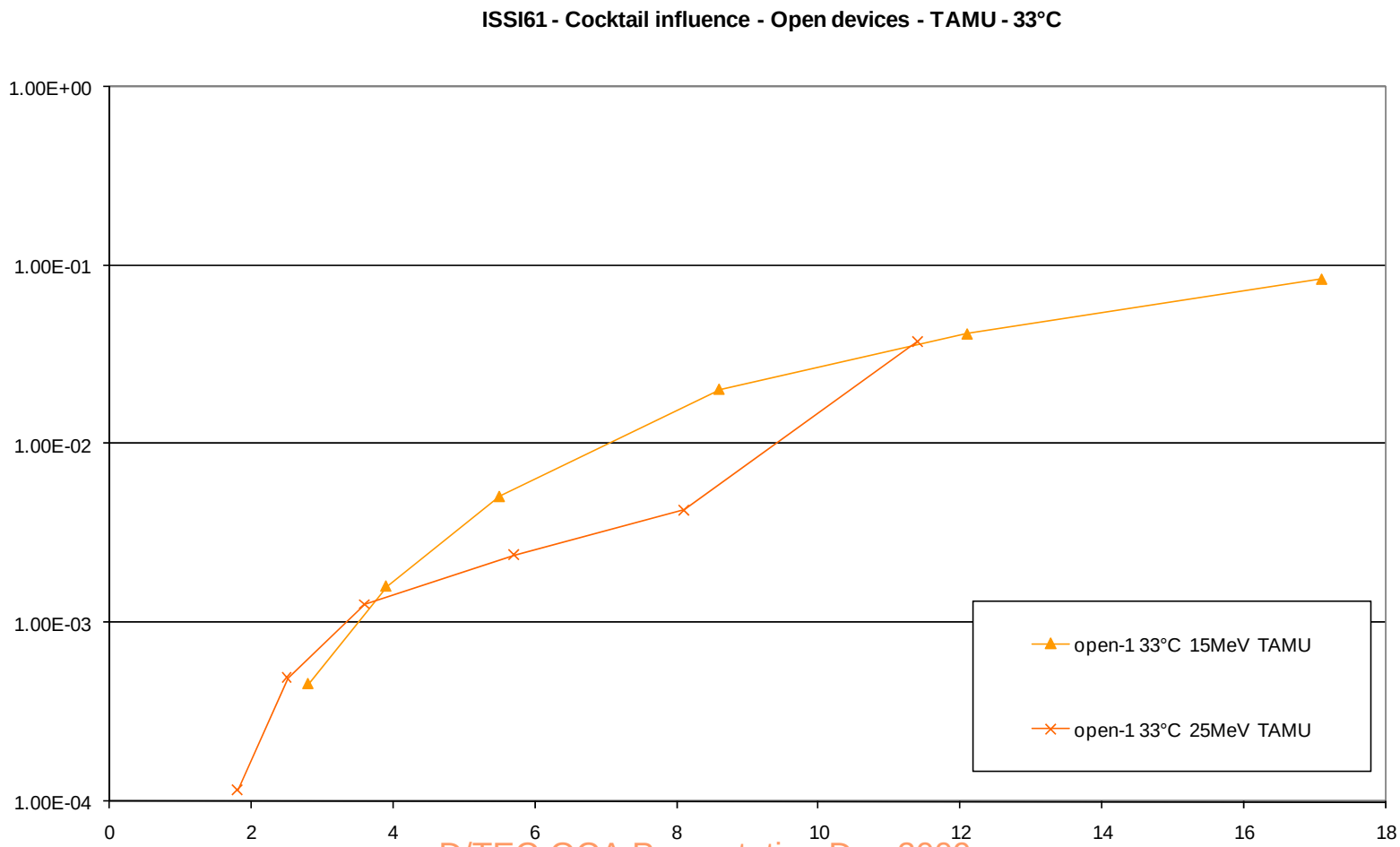
ISSI61 (6/11)


ISSI61 - Tilt influence - Open devices - 85°C - 10 MeV
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0.0
5.0
10.0
15.0
20.0
25.0
open-1 85°C 10MeV JYFL
open-1 85°C 10MeV UCL
open-1 85°C 10MeV JYFL (2)

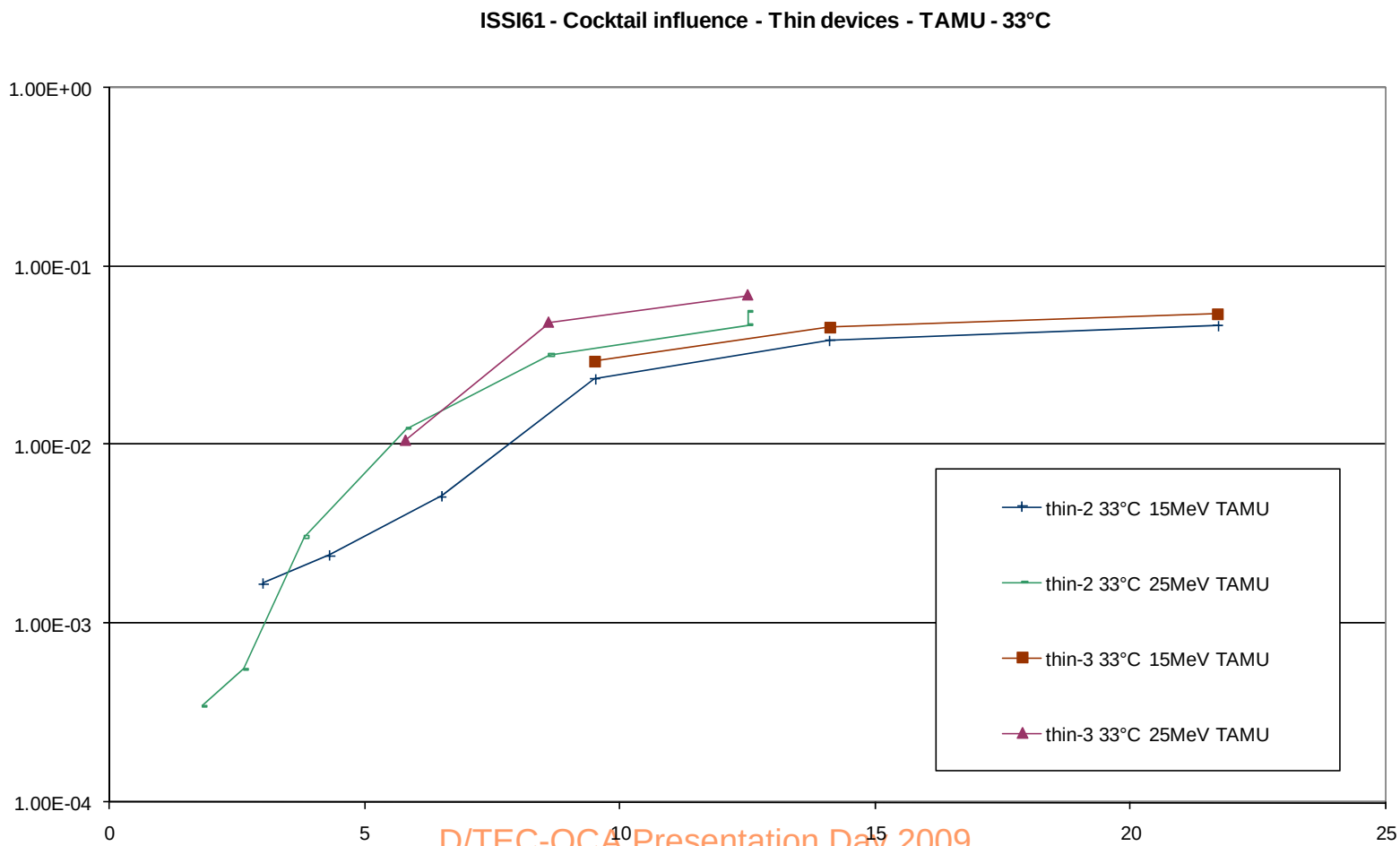
ISSI61 (7/11)


Facility influence - opened - Z_tilt - 85°C
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
open-1 85°C 10MeV JYFL
open-2 85°C 10MeV JYFL
open-1 85°C 15MeV TAMU
open-1 85°C 25MeV TAMU

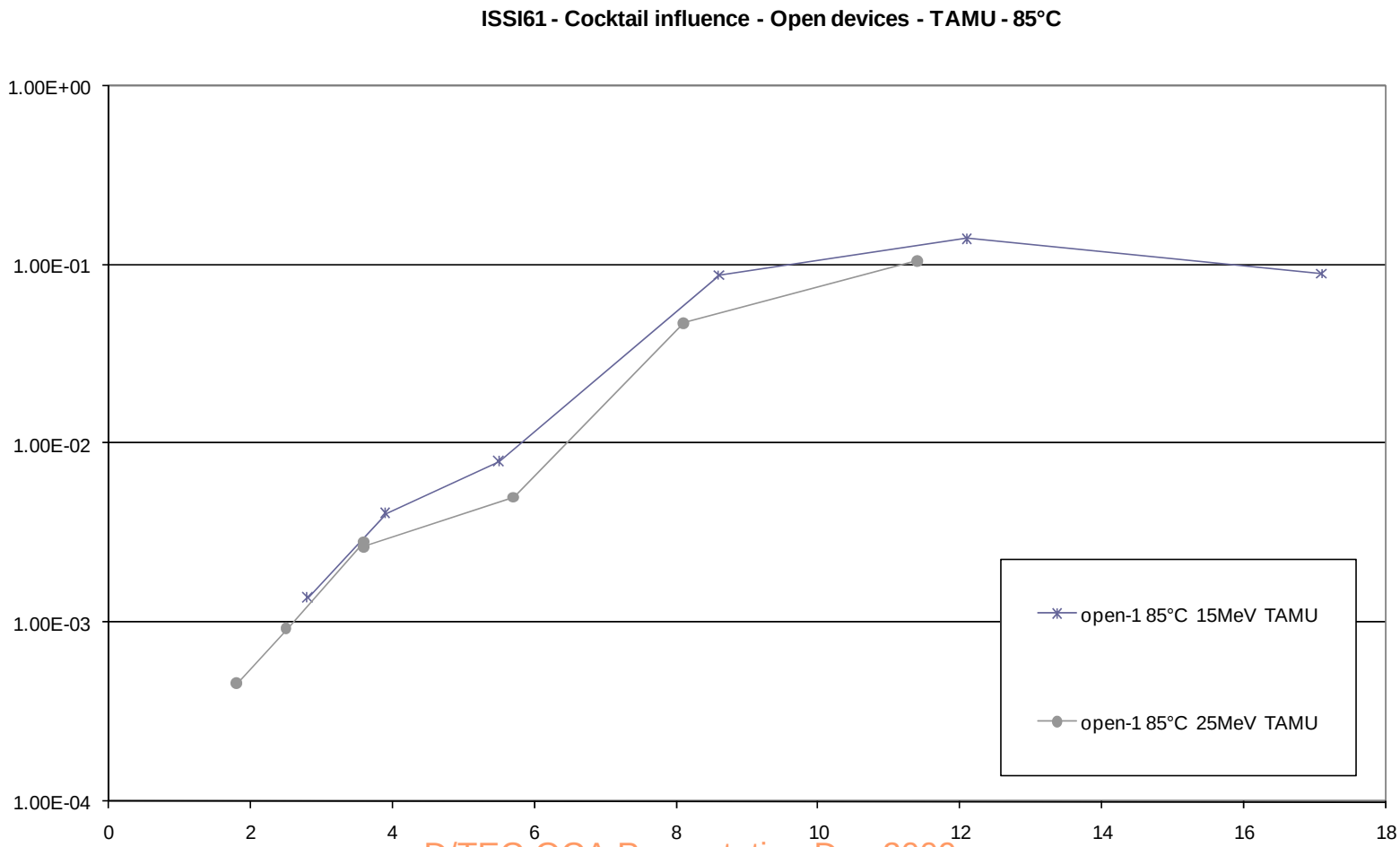
ISSI61 (8/11)


ISSI61 - Cocktail influence - Open devices - TAMU - 33°C
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
0
2
4
6
8
10
12
14
16
18
open-1 33°C 15MeV TAMU
open-1 33°C 25MeV TAMU

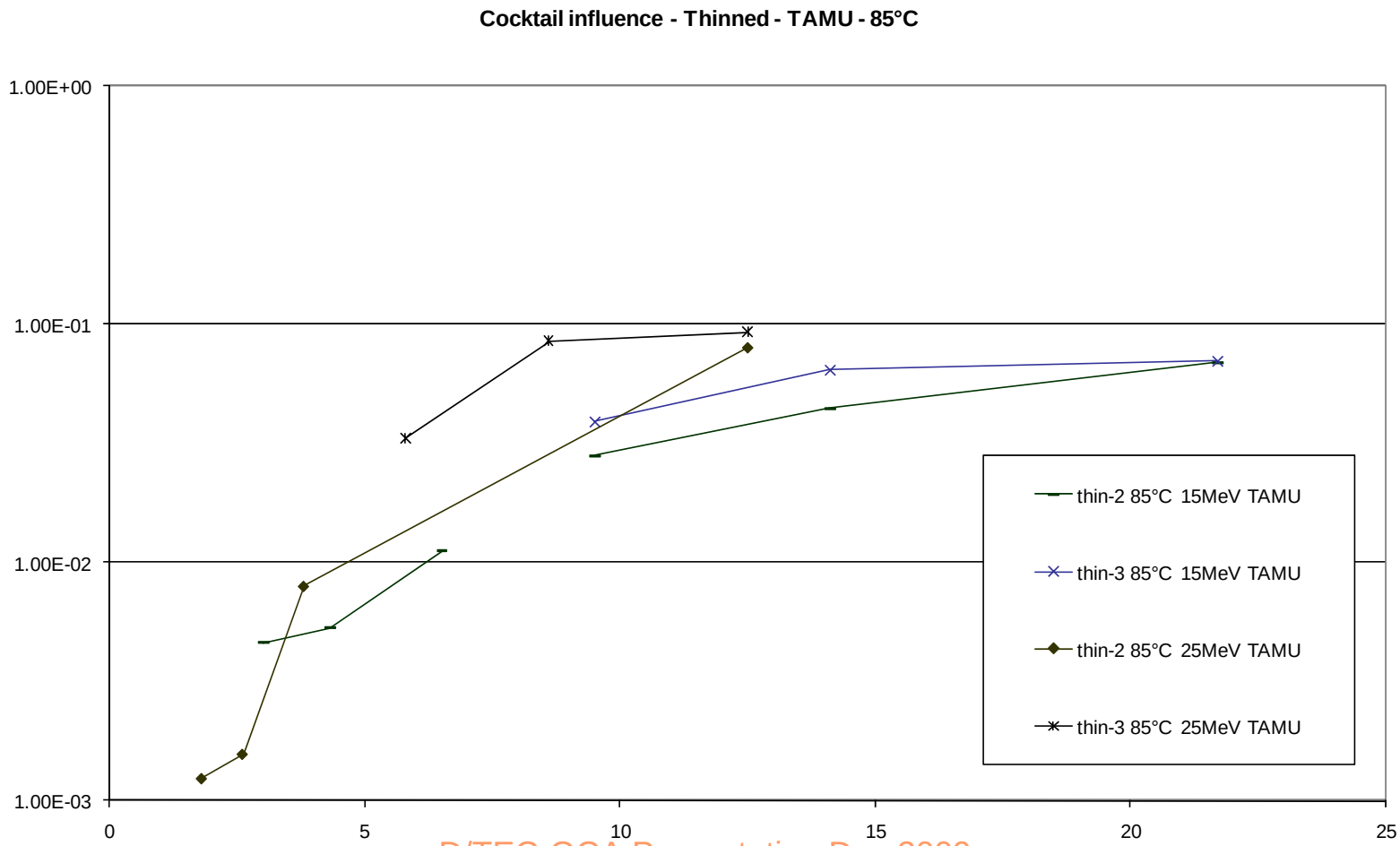
ISSI61 (9/11)


ISSI61 - Cocktail influence - Thin devices - TAMU - 33°C
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
0
5
10
15
20
25
thin-2 33°C 15MeV TAMU
thin-2 33°C 25MeV TAMU
thin-3 33°C 15MeV TAMU
thin-3 33°C 25MeV TAMU

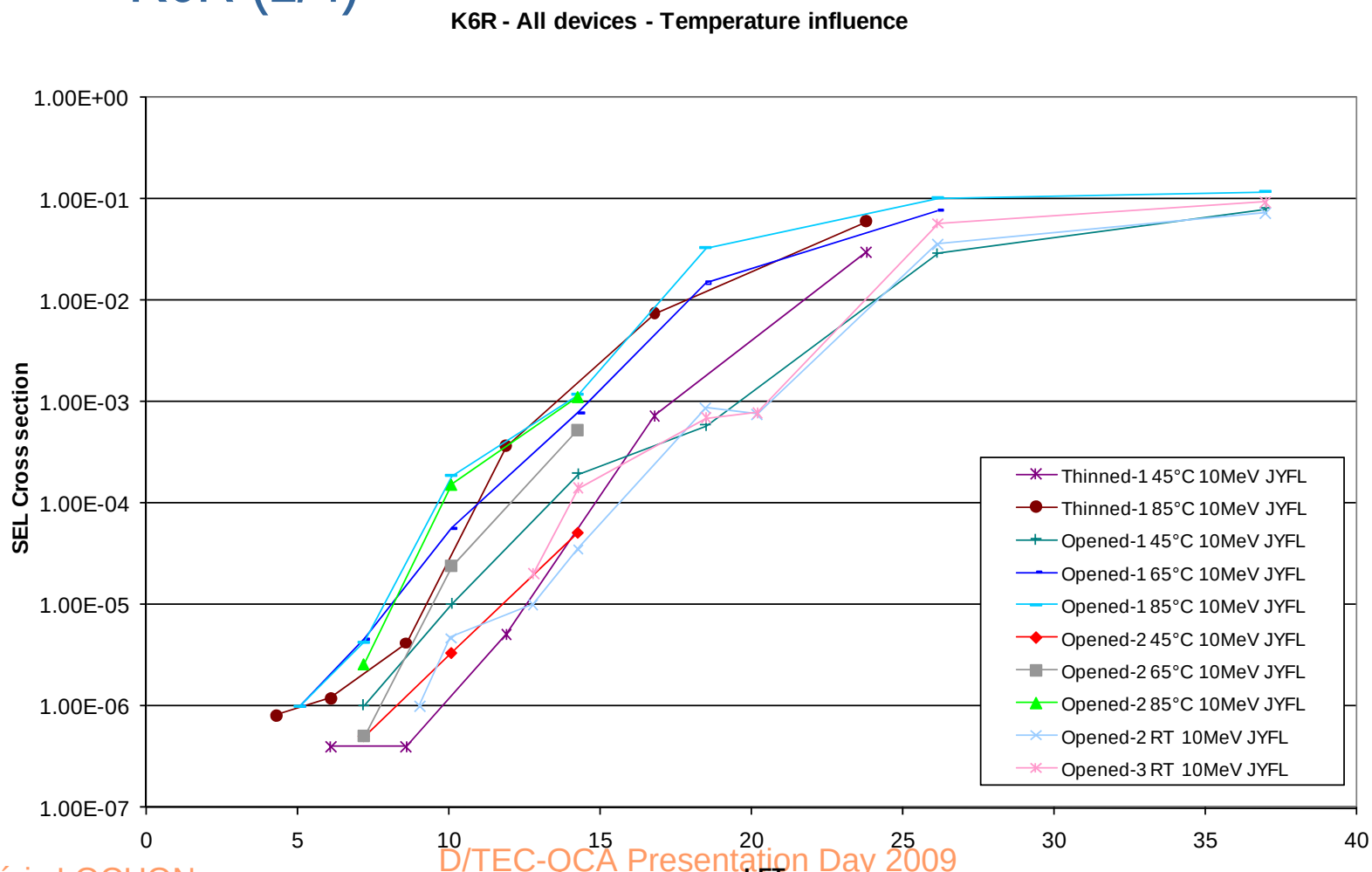
ISSI61 (10/11)


ISSI61 - Cocktail influence - Open devices - TAMU - 85°C
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
0
2
4
6
8
10
12
14
16
18
open-1 85°C 15MeV TAMU
open-1 85°C 25MeV TAMU

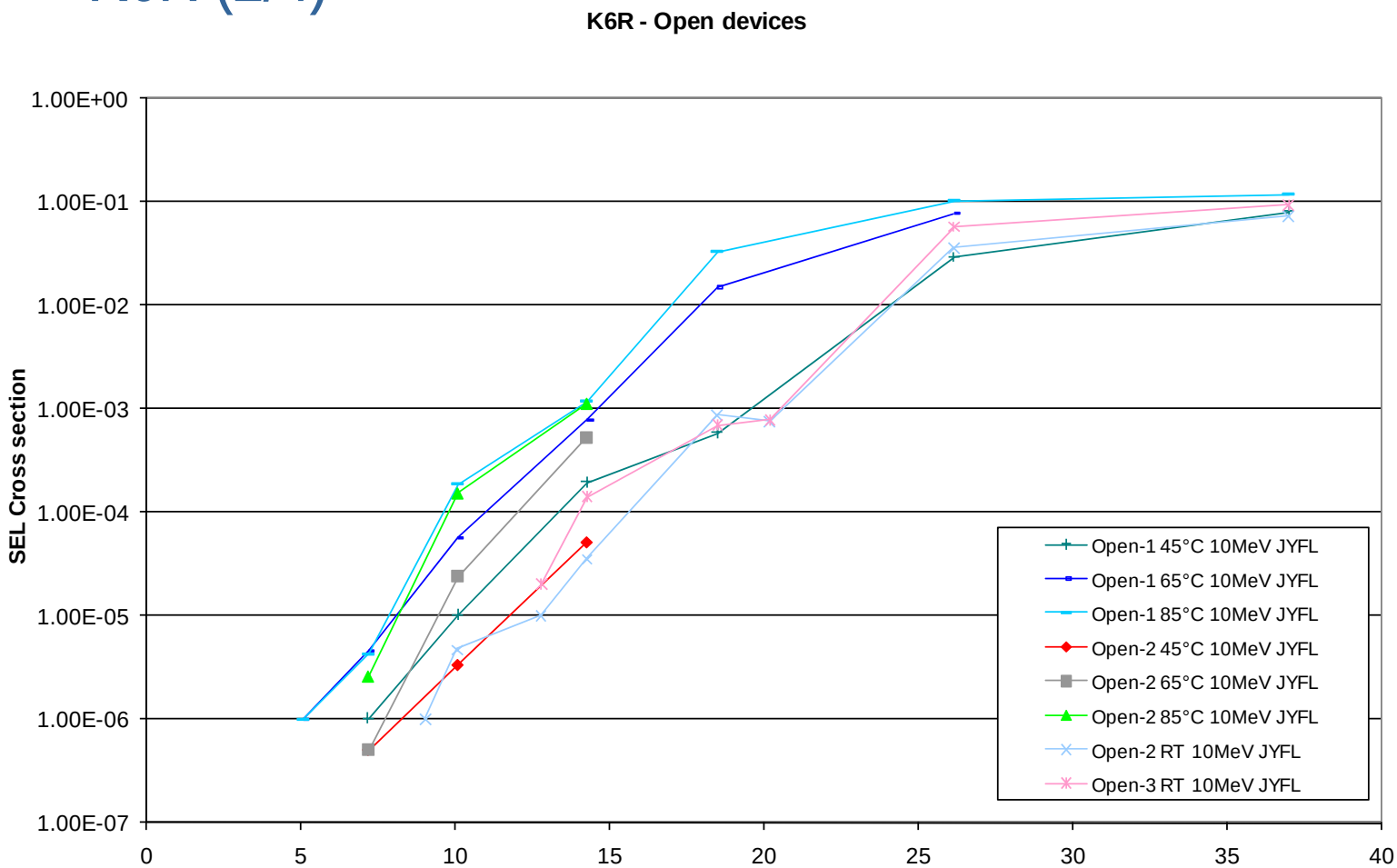
ISSI61 (11/11)


Cocktail influence - Thinned - TAMU - 85°C
1.00E+00
1.00E-01
1.00E-02
1.00E-03
0
5
10
15
20
25
thin-2 85°C 15MeV TAMU
thin-3 85°C 15MeV TAMU
thin-2 85°C 25MeV TAMU
thin-3 85°C 25MeV TAMU

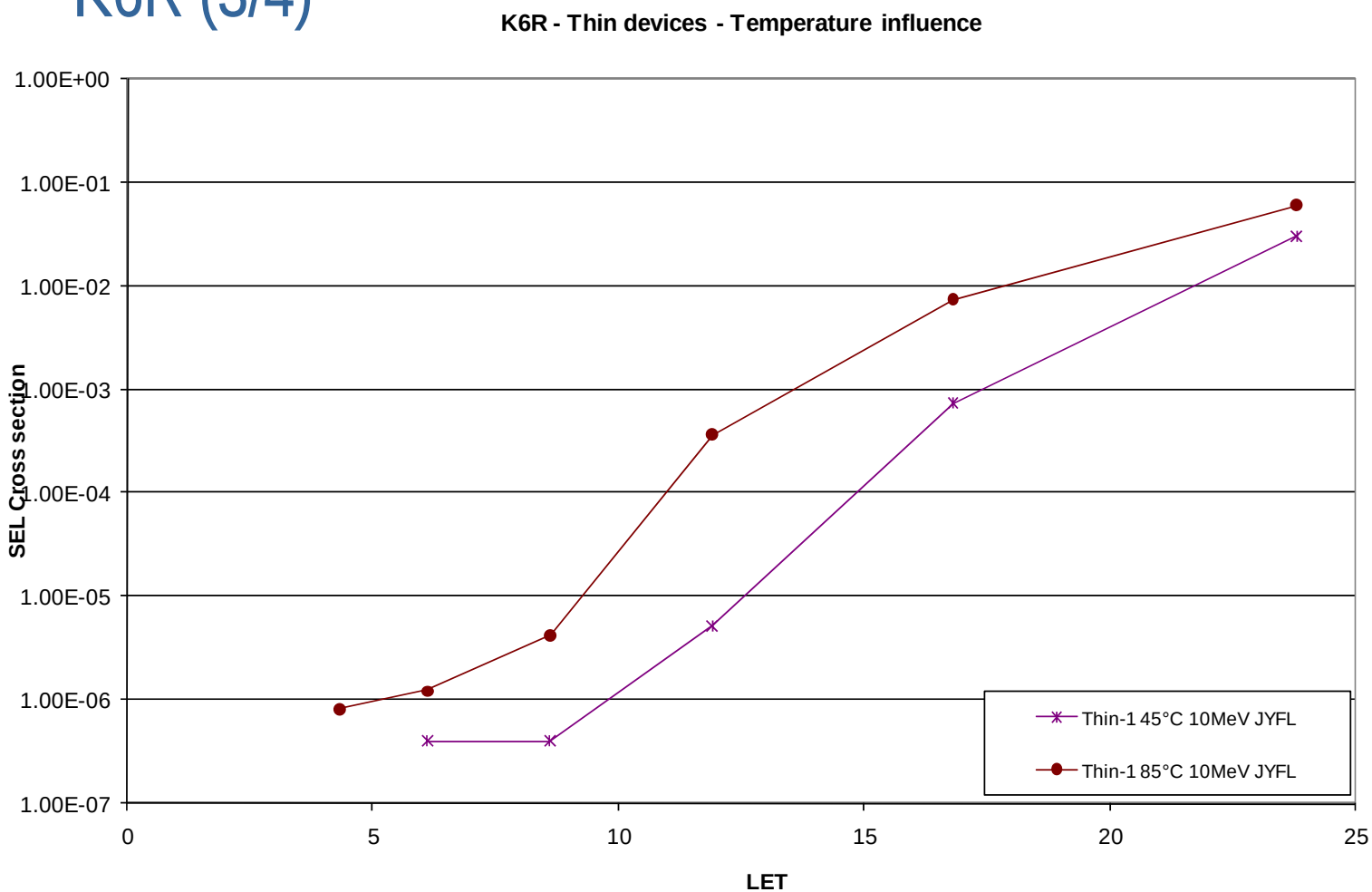
K6R (1/4)


K6R - All devices - Temperature influence
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
30
35
40
LET
Thinned-1 45°C 10MeV JYFL
Thinned-1 85°C 10MeV JYFL
Opened-1 45°C 10MeV JYFL
Opened-1 65°C 10MeV JYFL
Opened-1 85°C 10MeV JYFL
Opened-2 45°C 10MeV JYFL
Opened-2 65°C 10MeV JYFL
Opened-2 85°C 10MeV JYFL
Opened-2 RT 10MeV JYFL
Opened-3 RT 10MeV JYFL

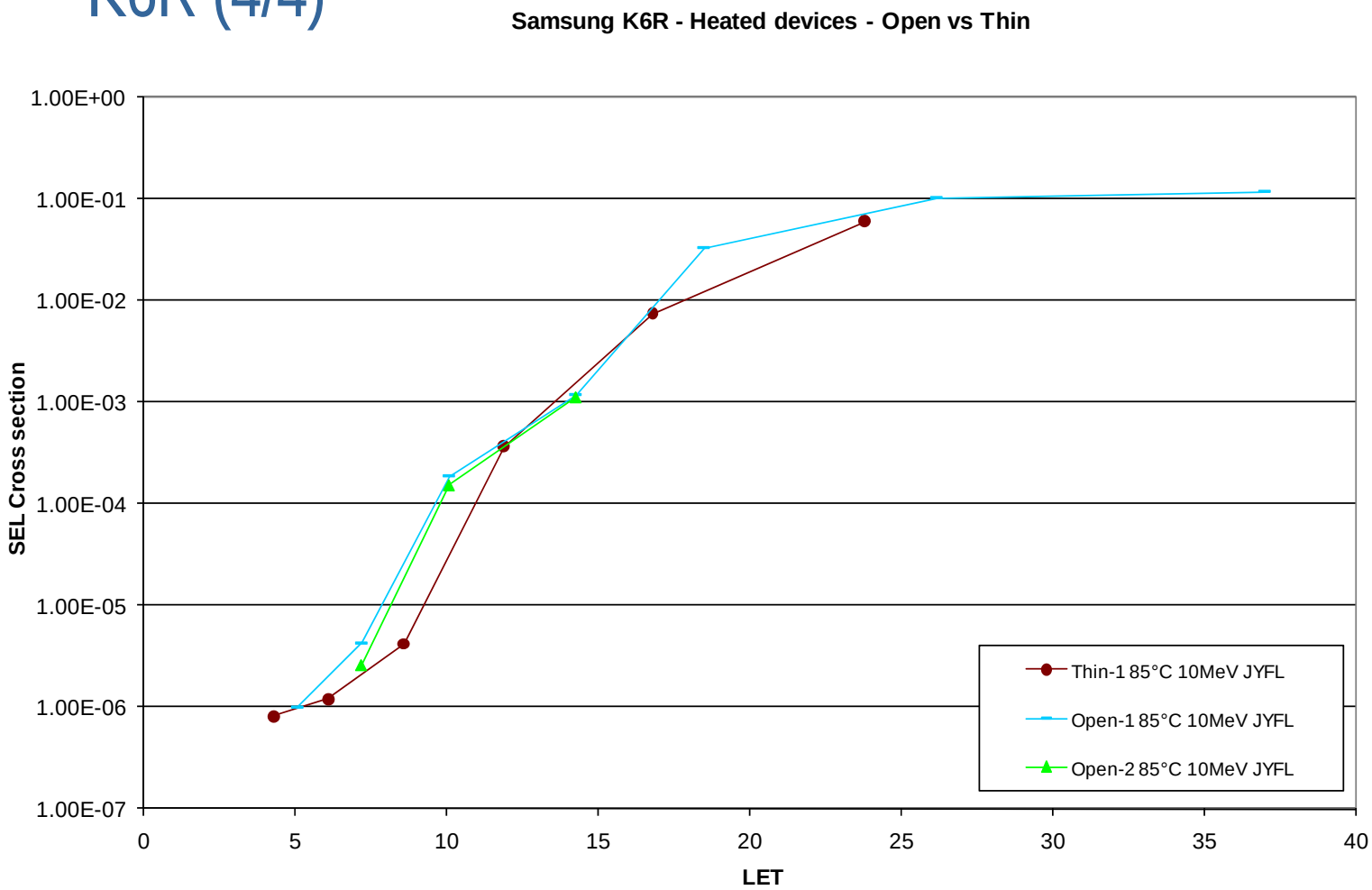
K6R (2/4)


K6R - Open devices
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
30
35
40
LET
Open-1 45°C 10MeV JYFL
Open-1 65°C 10MeV JYFL
Open-1 85°C 10MeV JYFL
Open-2 45°C 10MeV JYFL
Open-2 65°C 10MeV JYFL
Open-2 85°C 10MeV JYFL
Open-2 RT 10MeV JYFL
Open-3 RT 10MeV JYFL

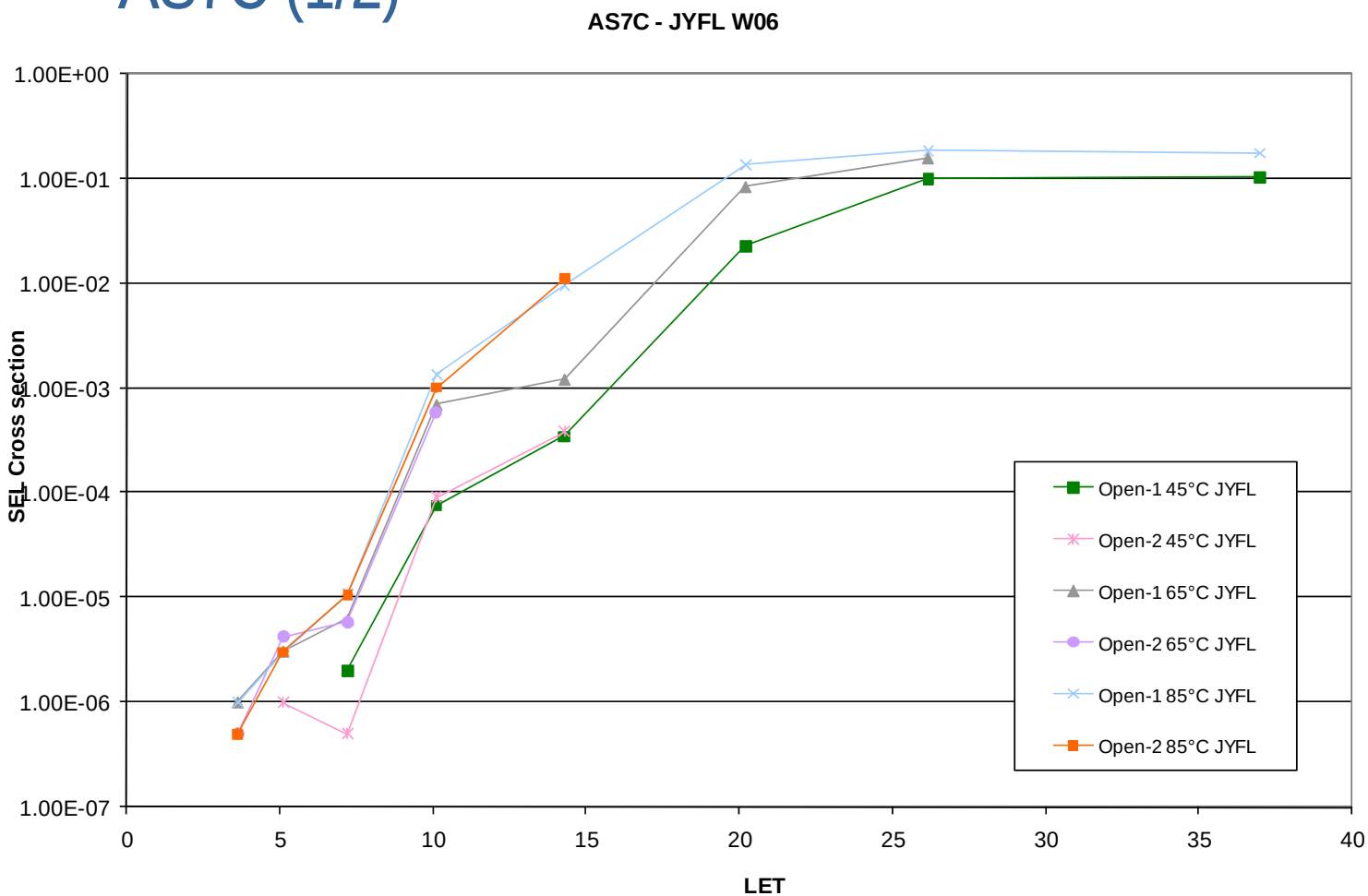
K6R (3/4)


K6R - Thin devices - Temperature influence
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
LET
Thin-1 45°C 10MeV JYFL
Thin-1 85°C 10MeV JYFL

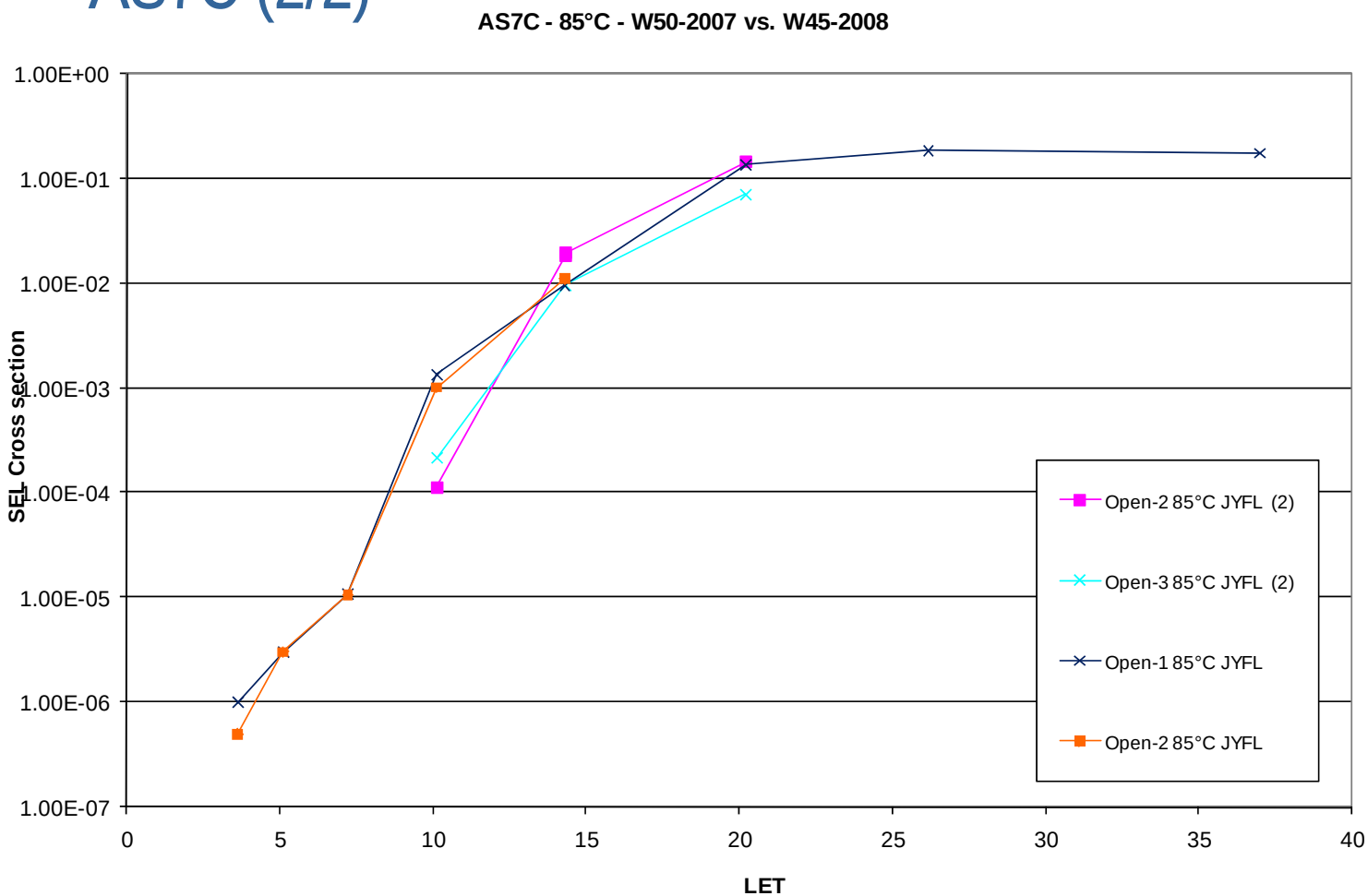
K6R (4/4)


Samsung K6R - Heated devices - Open vs Thin
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
30
35
40
LET
Thin-1 85°C 10MeV JYFL
Open-1 85°C 10MeV JYFL
Open-2 85°C 10MeV JYFL

AS7C (1/2)

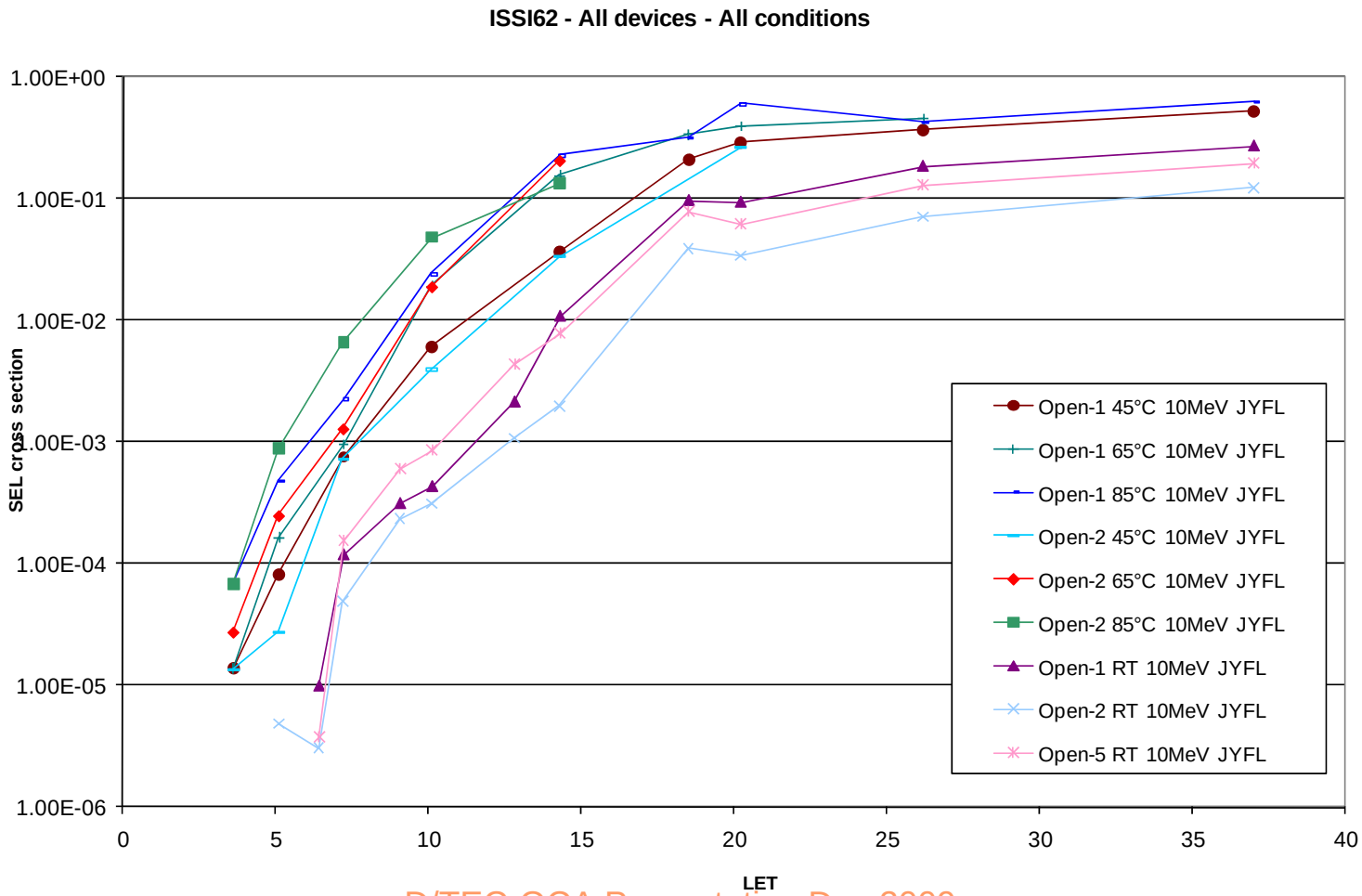

AS7C - JYFL W06
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
30
35
40
LET
Open-1 45°C JYFL
Open-2 45°C JYFL
Open-1 65°C JYFL
Open-2 65°C JYFL
Open-1 85°C JYFL
Open-2 85°C JYFL

AS7C (2/2)

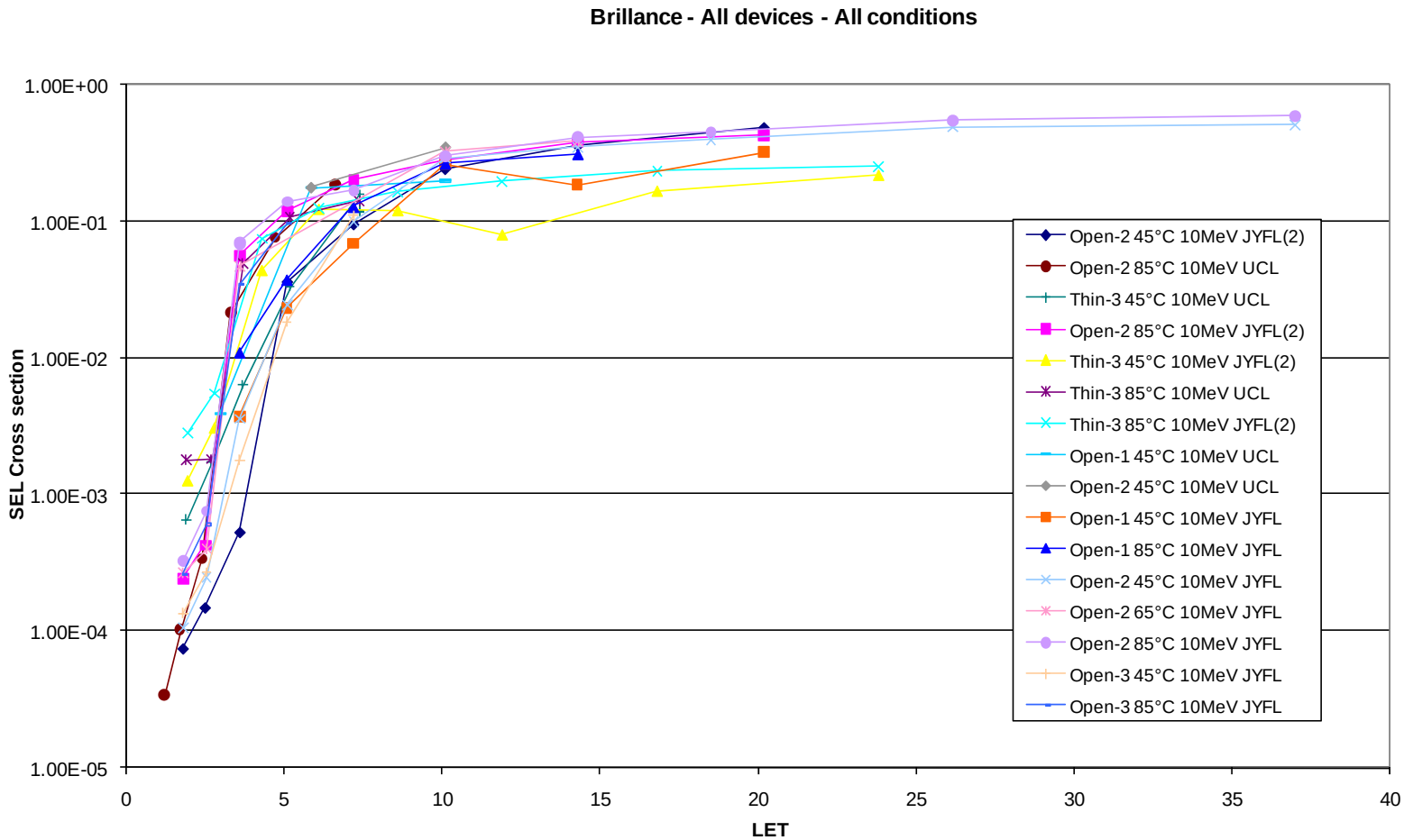

AS7C - 85°C - W50-2007 vs. W45-2008
SEL Cross section
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
0
5
10
15
20
25
30
35
40
LET
Open-2 85°C JYFL (2)
Open-3 85°C JYFL (2)
Open-1 85°C JYFL
Open-2 85°C JYFL

SEL Characterisation of SRAMs for the TDM Latch-up Experiment

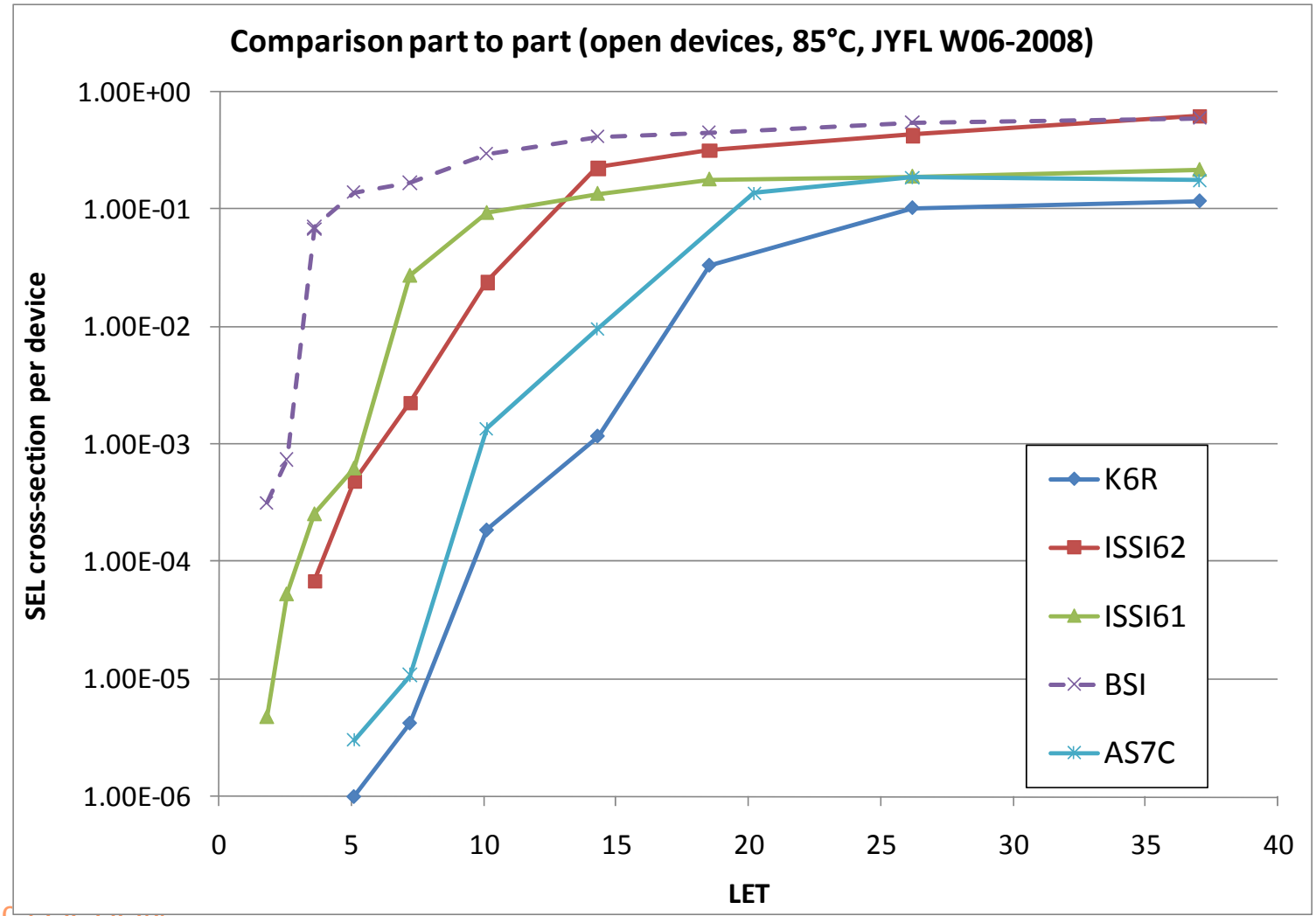
ISSI62



BSI (not flying)



Part to part


Comparison part to part (open devices, 85°C, JYFL W06-2008)
SEL cross-section per device
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
0
5
10
15
20
25
30
35
40
LET
K6R
ISSI62
ISSI61
BSI
AS7C

Summary

- Quite good SEL database for 5 devices
- Good SEU database (not presented here)
- SEL dependence on thickness observed but no clear general trend
- Tilt-axis influence observed
- Some differences observed between facilities