LYNRED

Radiation test overview for Infrared cooled detectors at LYNRED

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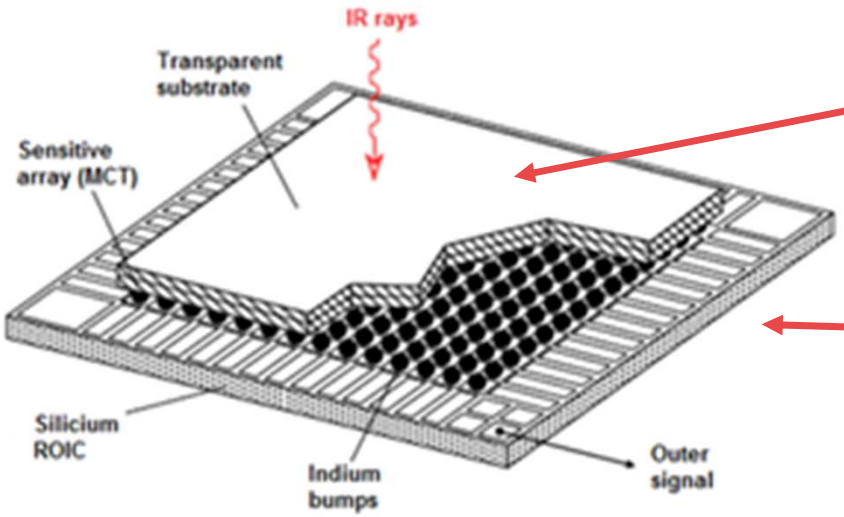
Agenda

1) **Context and problematic of the radiation test on cooled IR Lynred detectors**
2) **Single Events Effect on the cooled IR Lynred detectors**
3) **Cumulated effects :**
    1) TID
    2) TNID
4) **Conclusions**

Introduction



Detection circuit (MCT):

- TNID
- TID

ROIC (silicon):

- TID
- SEE

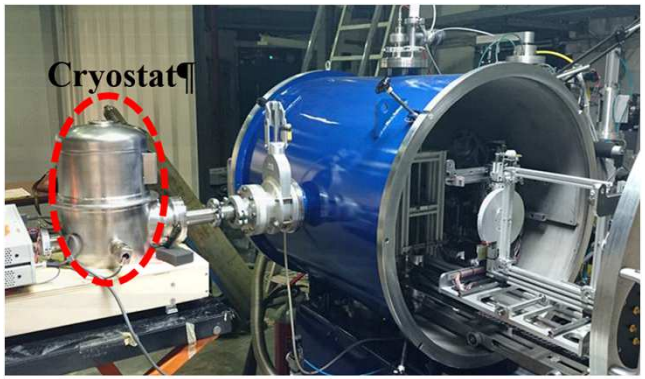
- **For space application, we have to test 3 kind of radiations effect on our IR detector:**
  - SEE
  - TID
  - TNID
- **Specificity of our product is the cryogenic temperature**

Constraints to performed radiation test on cooled IR detectors:

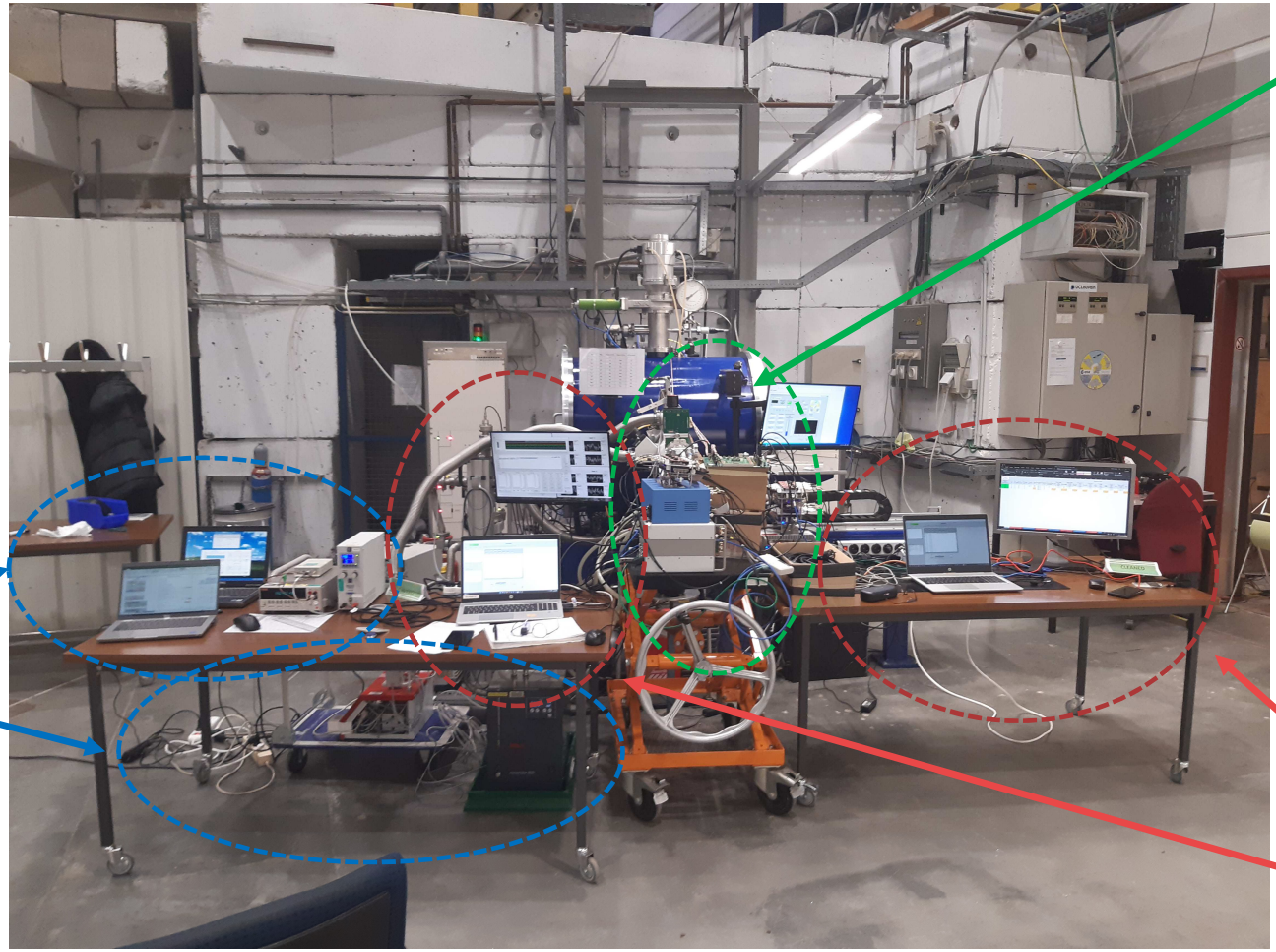
- **Cryogenic temperature [45 K ; 200 K]**
  - Manage dewar, cryo cooler, chiller, vaccum, on the radiation site
  - A lot of material => logistical aspect not to neglect:
    - More than 1000 kg of equipment
    - Up to more than 20 transport crates
  - Time: all, take more time at cryogenic Temp !
  - Risk of damage the DUT (freeze …)
- **Limited number of sample available**
- **Time measurements on radiation site**
- **Limited radiation data available at cryogenic temperature**
- **Radiation standards not always fully applicable on our products**

SEE radiation test, baseline

- **SEE test done at ROIC level as soon as possible**
- **SEE radiation test performed with:**
  - Heavy ions (baseline)
  - Proton (if necessary)
- **Different kind of event are possible on Lynred detectors:**
  - SEU
  - SET
  - SEFI
  - SEL
- **Baseline SEE conditions test**
  - Cryogenic temperature (baseline = mission temperature)
  - Polarization according specifications and standards
- **A Specific test bench is developed for each project/product**
  - Monitoring and recording of events in real time



Example of a SEE test bench for heavy ions irradiation (1/2)

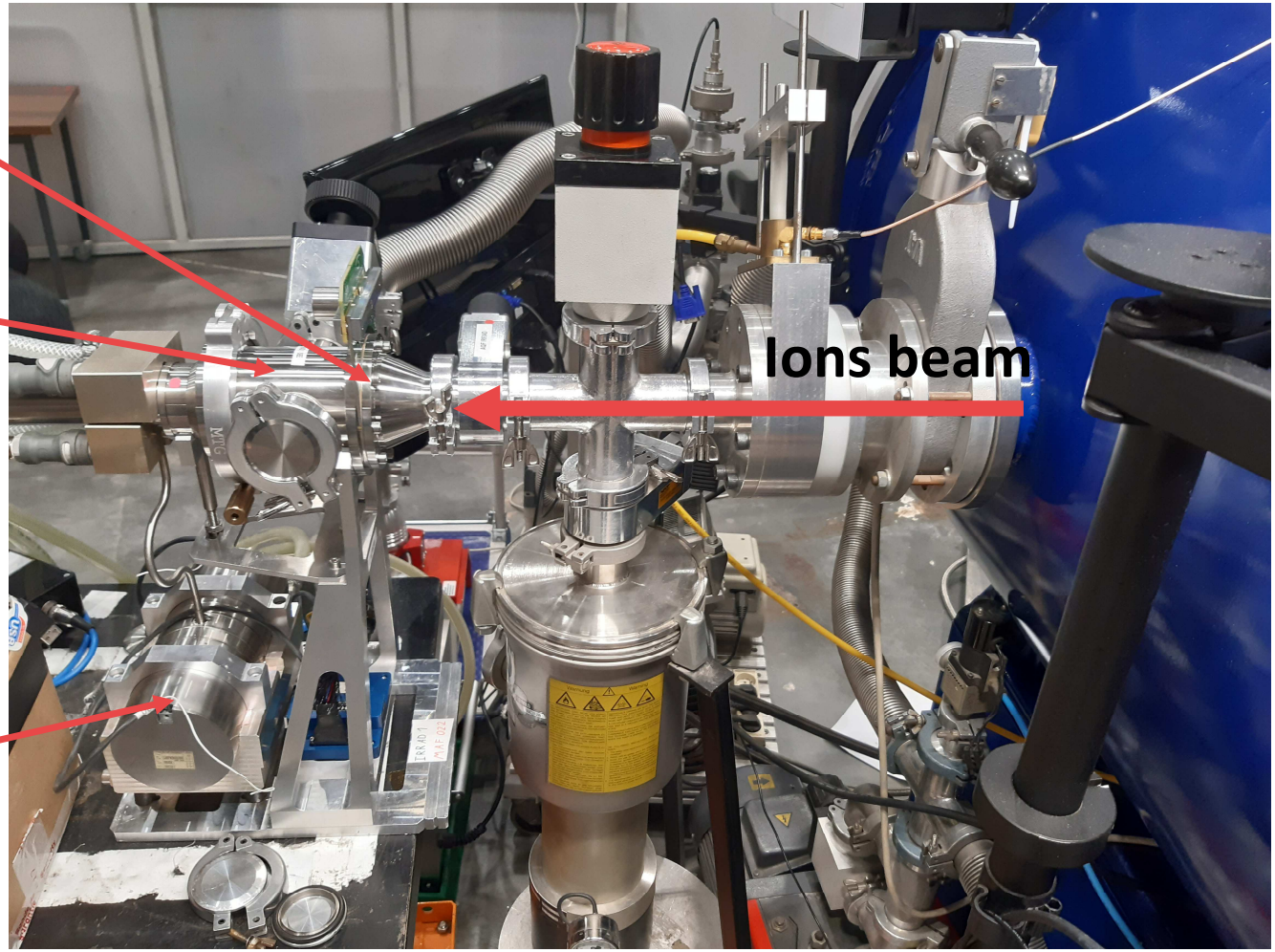


DUT with :
- o electronics boards
- o Power supply
- o delatcheur

Cryogenic temperature Management and monitoring

SEE test bench management and monitoring

Example of a SEE test bench for heavy ions irradiation (2/2)



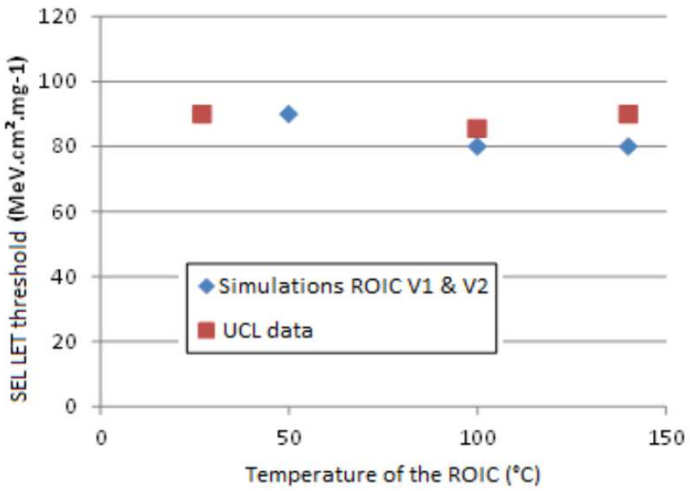
SEL sensitivity:

- **One destructive event on our detector : SEL**
  - Specific design rules applied at Lynred
  - R&D focus on this event, with onera lab

See IEEE TNS Vol 66, n°7 , pp.1510-1515, 2019

- **No SEL detected at room and Cryogenic Temperature, with our last ROIC technology and design:**
  - No SEL detected on full ROIC at cryogenic temperature
  - No SEL detected up to 100°C and LET = 62 MeV.cm²/mg

- **Experimental & simulation study done to find the SEL threshold**
  - Submitted to RADECS 2023

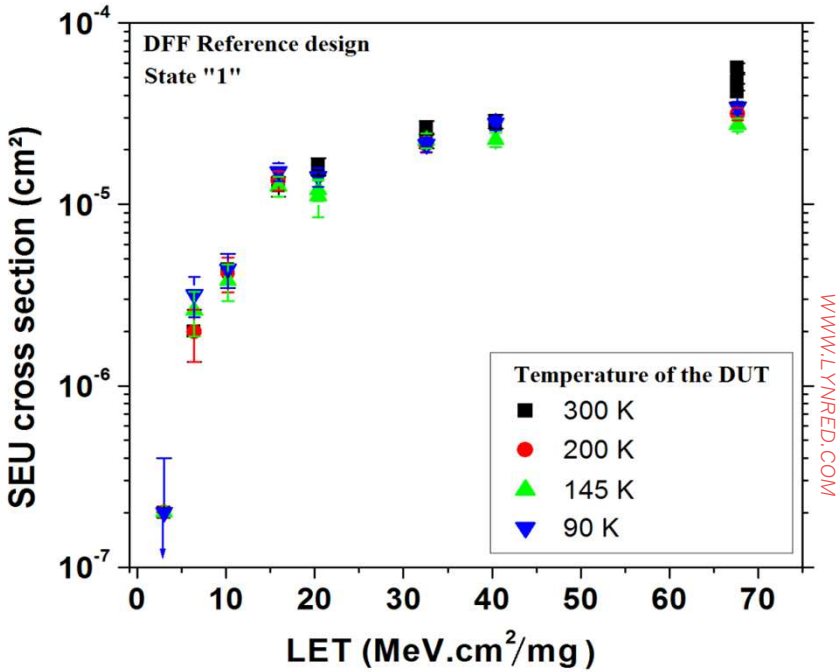


Impact of cryogenic temperature on SEU, SET, SEFI

- **R&T studies (simulations and experimental test) have been done on the effect of radiation cryogenic temperature on SEU, SET, SEFI**

- **Experimental SEE data at different radiation T on:**
  - flip flop test chip
  - Full ROIC

- **Very limited impact of cryogenic temperatures on the occurrence of SET, SEU and SEFI**



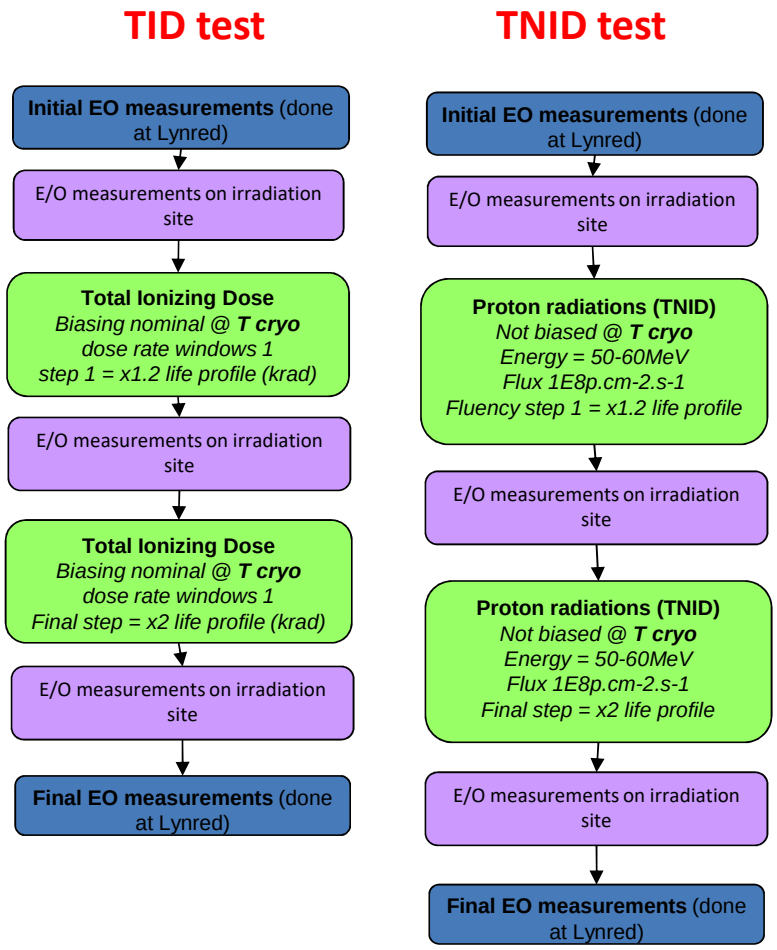
- **Different publications on the subject: See *"MDPI, sensors 2018, 18, 2338"* for a synthesize of these results**

TID and TNID : E/O measurements on radiation site

- **E/O measurements done on radiation site (on IRFPA)**
  - Dark current
  - Power Consumption
  - ROIC noise
  - RTS noise
- **Specific test bench with DVR and black body**
- **Specific test bench for specific test vehicle:**
  - I=f(V) for photodiodes
  - Vth, leakage currents for MOS transistors
- **Measurements done at cryogenic temperature**
- **Need to keep the cryogenic temperature all along the radiation steps and the measurements steps. Without temperature variation.**

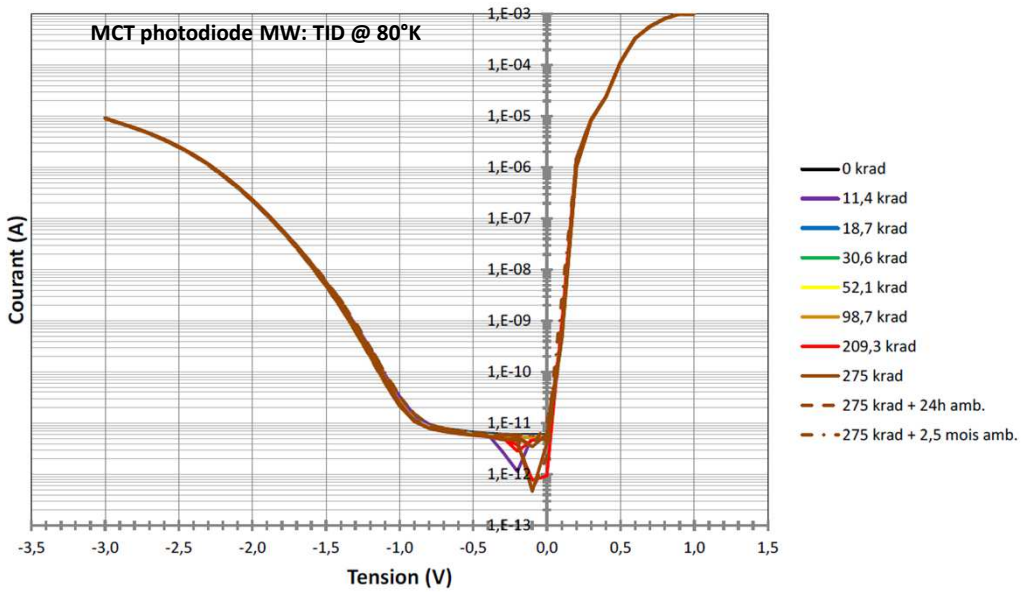
TID / TNID radiation test: baseline conditions

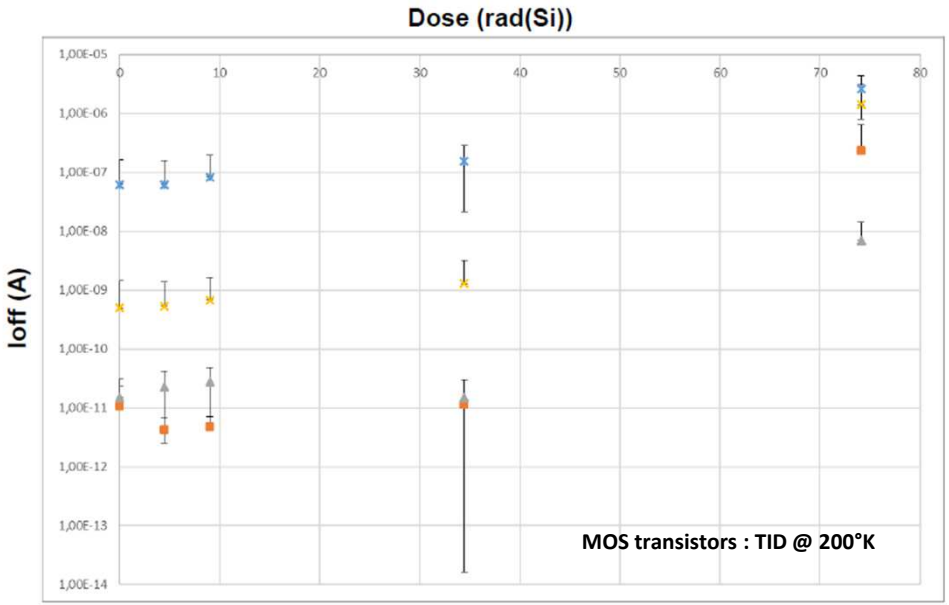
- **TID & TNID test done on:**
  - The full IRFPA
  - Samples representative of FM (same lot)
- **Baseline TID radiation conditions test**
  - TID tests are done with gamma ray at cryogenic temperature (baseline = mission temperature)
  - Polarization ON during irradiation
  - Dose rate in Window 1 ("Standard Rate") of ESCC22900 radiation standard
    - No dose rate effect on the ROIC technology
- **Baseline TNID radiation conditions test**
  - TNID tests are done mainly with proton at cryogenic temperature
  - Polarization OFF during irradiation



TID degradation driven by ROIC

- **TID performance limited by the ROIC part**





Lynred radiation methodology summary

- **Investigate radiation effect as soon as possible for a given space project:**
  - Choice of the good level of design hardening versus mission needs
  - Radiation test

- **First: radiation test performed at test vehicles level:**
  - Radiation levels above the typical level requested for IR space product
  - Assess the different technologies and design radiation performance
  - Investigate the Temperature and polarization effect
  - Adjust the qualification test plan and improve our irradiation degradation knowledge

- **Second: radiation test performed on IRFPA:**
  - On IRFPA fully representative of FM for qualification
  - Radiation level according mission profile (minimum margin = x2)
  - Tests done at cryogenic temperature (mission temperature)

Conclusions

- **Our detector is sensitive to 3 kind of radiation effect :**
  - SEE
  - TID
  - TNID

- **For qualification, we have to perform 3 different kind of radiation test at cryogenic temperature**

- **Performing radiation test at cryogenic temperature is quite difficult and challenging**

- **Lynred detectors are compliant with customers radiation specifications**
  - More than 20 space project qualified for space application
  - 50 FM in flight

- **Improved capacity and “know how” to perform radiation test at cryogenic temperature**
  - Specific test bench and dedicated equipment
  - Development of collaboration on the radiation thematic (R&D studies)

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