

ALFASTEROID: INTRODUCTION AND RECAP OF THE FULL STORY

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Outlook

- Intro: MCT detector for dummies
- Specificity of the astro need
- ALFAsteroid : Early beginning
- ALFA Consortium
- Asteroid Consortium
- Main achievements

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Anatomy of MCT IR photodiode array

Standard n/p VHg process

Extrinsic p/n process

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MCT specificity: a fully integrated fabrication chain

- CZT is the Achille hill of MCT**
 - Zn% drives the lattice match
- US: Teledyne**
 - Substrate from Japan
 - MBE = 211 orientation
- France: Lynred**
 - Home made substrate
 - LPE = 111 orientation

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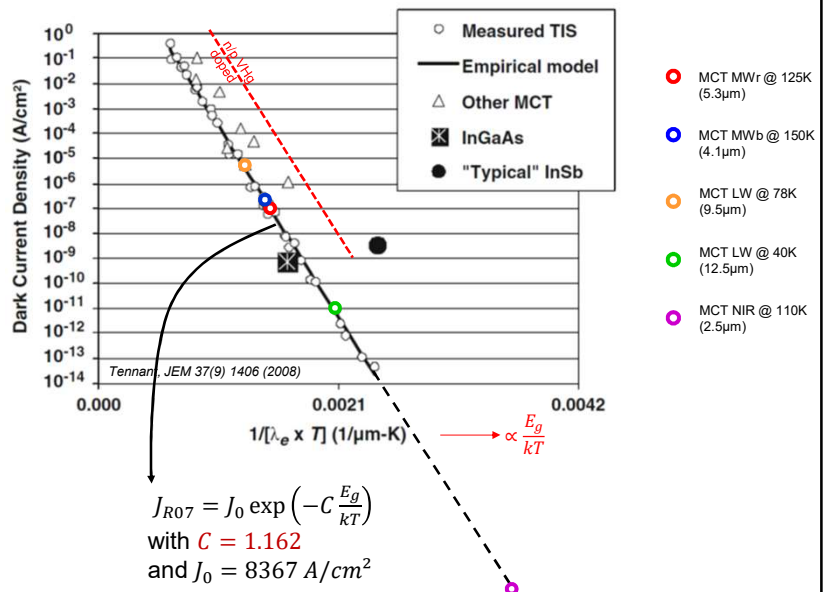
Specificity of the Astro need for IR detectors

- IR MCT production line initially developed for defense:
 - Tactical bands MM LW
 - 300K scenes
 - 1k-10k of detectors per year
 - Me- wells are typical → Direct injection is the king ROIC input stage
 - SWAP trend : smaller pixels / powersize
- Space market dedicated products lean on large tactical production
 - Low volume, high-end
 - Often custom-made
 - Test sequence is often heavy...
 - Lynred is well established for earth observation
 - Sentinel... go to SWIR
 - MTG... go to VLWIR
 - The fluxes are usually lower than in tactical application
- Astronomers are looking at the other side... cold scenes and low to very low fluxes
 - SWIR (2.5μm) is a highly interesting band for astro (red shift...)
 - Sub electron



Specificity for NIR detection

- Rule 07 used as benchmark
- !!! NIR @ 100K is very low compared to other values





ALFAsteroid: Early beginning

- 2010 BAFLU: Demo of an SFD ROIC compatible with low flux
 - Small format ROIC (epsilon format = QVGA p15)
- 2010 NIRLFSA = NIR Large Format Sensor Array
 - First try with BAFLUX ROIC
 - New larger SFD ROIC (VGA format p15)
 - Competition with Selex Galileo
 - MBE vs LPE → demand is a Hawaii Clone
 - 15µm pitch instead of 18µm = 17% smaller
 - Different dopings
 - DEFIR consortium selection
- 2017 NIRLFSA becomes ALFA for full 4Mpx demo
 - First nego unsuccessful → 2nd round of negotiation (space compatibility study removed)
 - 4Mpx ROIC design by lynred (ESA funding)
 - MCT sensitive layer by LETI (FOCUS funding)
 - In bumps Hybridisation and packaging by Lynred (ESA funding)
- 2017 Asteroid 4 inch full production line for large formats

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NIR LFSA-ALFA consortium



NIR LFSA

- LETI
 - PV layer Growth
 - Diode processing
 - ROIC design (TV format)
 - Hybridisation & Packaging
 - First tests (tip test + 80K IRCMOS sorting)
- IRFU
 - Fine characterisation



ALFA

- LETI
 - PV layer Growth
 - Diode processing
 - Diode first tests
- Lynred
 - ROIC design (4Mpx format)
 - Hybridisation & Packaging
- IRFU
 - 4Mpx characterisation





NIR LFSA → ALFA : size matters !



- Baflux : QVGA 15µm pitch = 0.5cm large
- NIR LFSA : VGA 15µm pitch = 1cm large
- ALFA : 2kx2k 15µm pitch = 3cm large

- Scaling standard 36x38mm wafer
- To 47x48mm as a new wafer size standard

- With only one single chip per wafer



TV



3cm
2k x 2k




36x38mm²

➔





47x48mm²

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Asteroid consortium








- LETI
 - Large area CZT growth develop^{nt}
 - Large area CZT surface conditioning (surface and flatness)
 - Large area MCT LPE growth
 - Large area MCT diode process
- Lynred
 - ROIC stiching develop^{nt}
 - Large format hybridisation develop^{nt}
 - Packaging
 - MCT material & process transfer
- EVG
 - ROIC Wafer process / stiching
- ADDL
 - Detector architecture mechanical modeling
- IRFU
 - TV format fine characterisation
- IFAE
 - Large format 4Mpx connectic characterisation / reliability


















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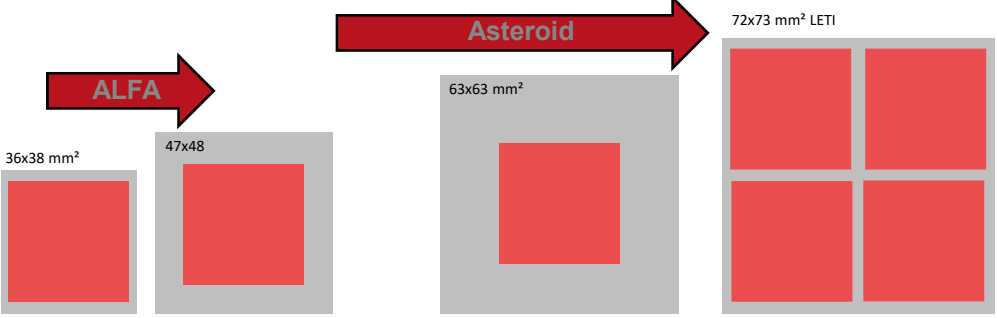
Asteroid target

- Upscaling from 1cm² sensitive area to 10cm², with industrial compatibility

Standard chip size TV ➔ ALFA chip size 2kx2k

- Huge challenge for material growth scaling and diode process uniformity

ALFA ➔ Asteroid ➔ 72x73 mm² LETI



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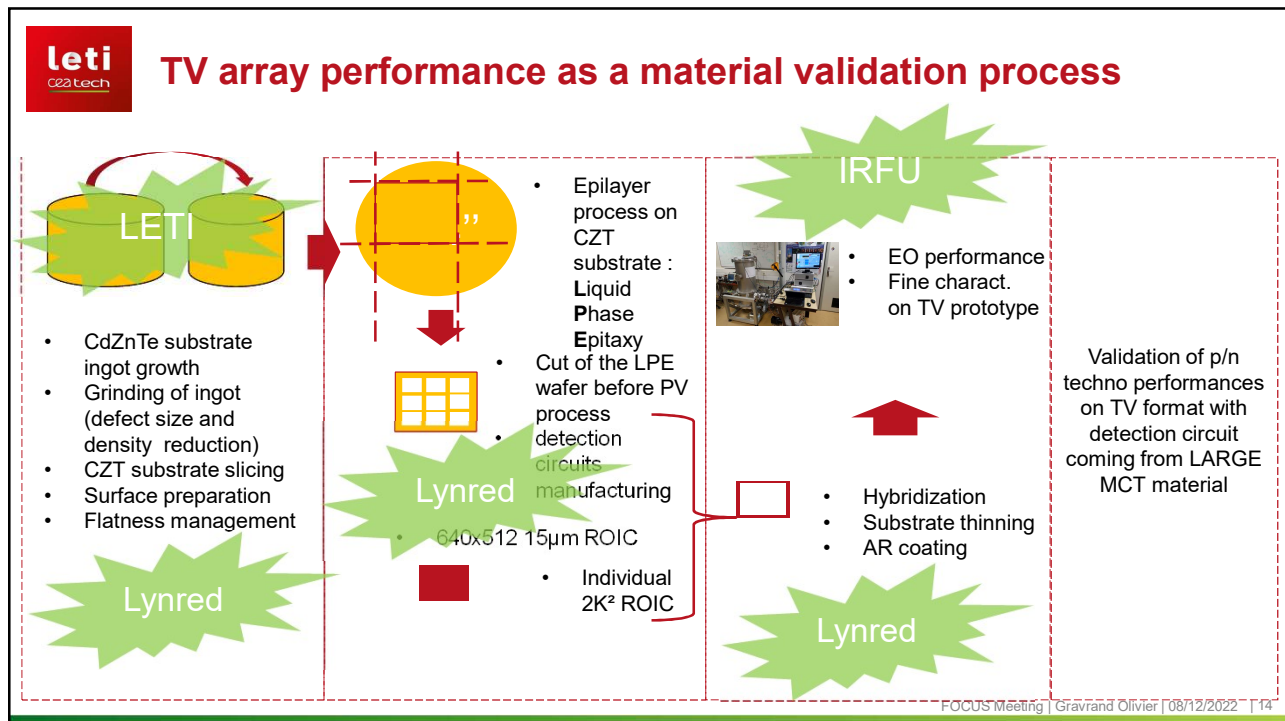
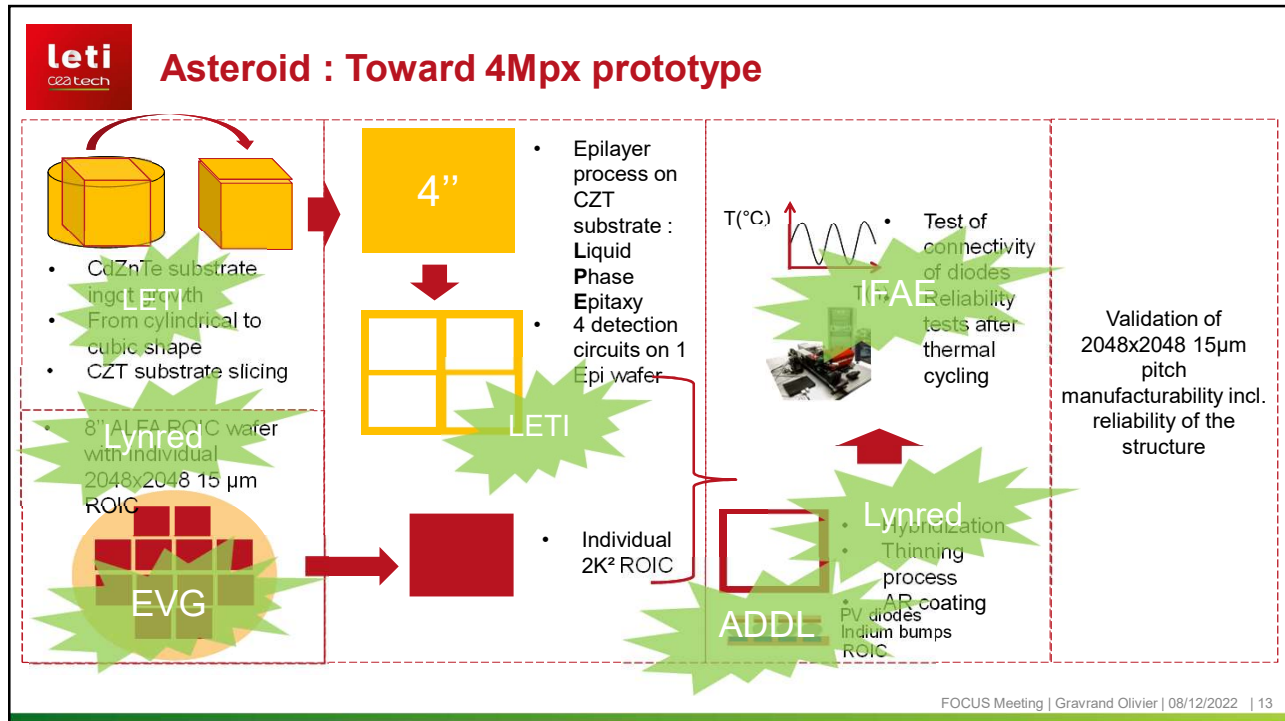


This material scaling adresses all the manufacturing steps



Set-ups and processes evolution required by the increase of material size in ASTEROID project

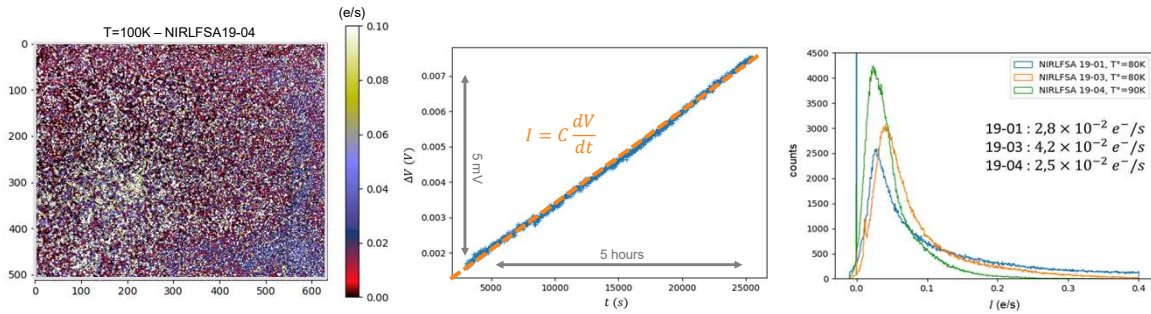
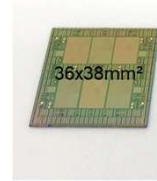
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ALFA : the saga...

- Lot 0 = validation of the new clean rooms + new oven ... NOGO !
- Lot 0bis = Numérobis : OK, nice TV arrays, ...Go!
 - Glow management
 - Dark current validation
 - Persistence study
 - Radiation induced effects

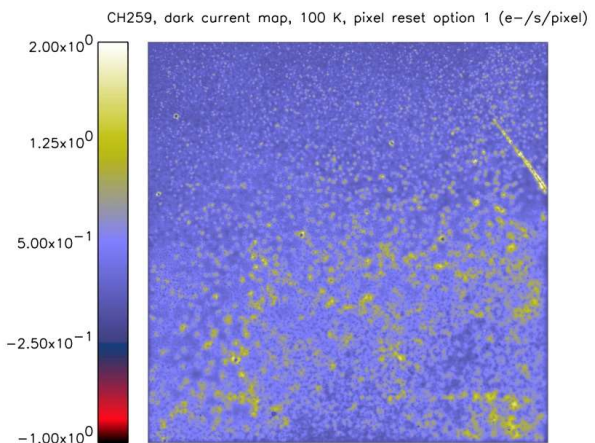
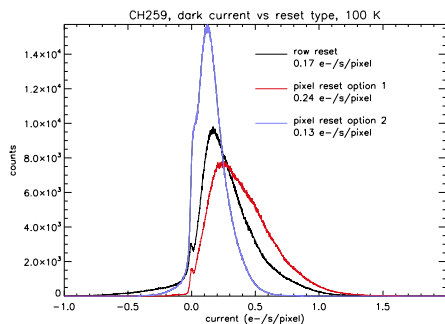
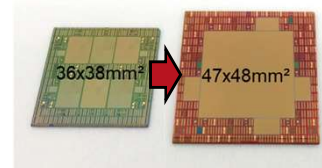


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ALFA : the saga...

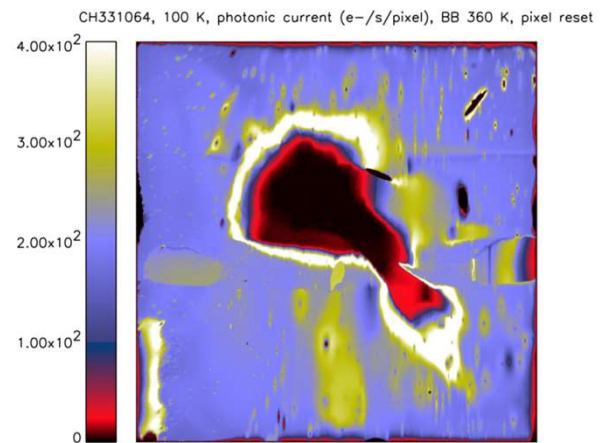
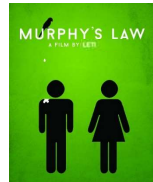
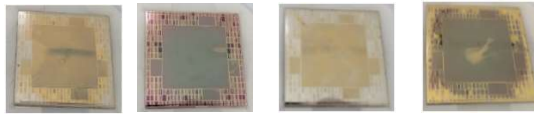
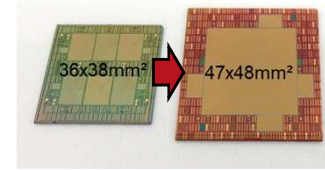
- Lot 0bis = Numérobis : : OK, nice TV arrays, ...Go!
- Lot Premièreskis : A first array is fonctionnal
 - 47x48 wafers
 - ALFA 1st light
 - In terms of dark current...
 - Different rest modes available on the ROIC





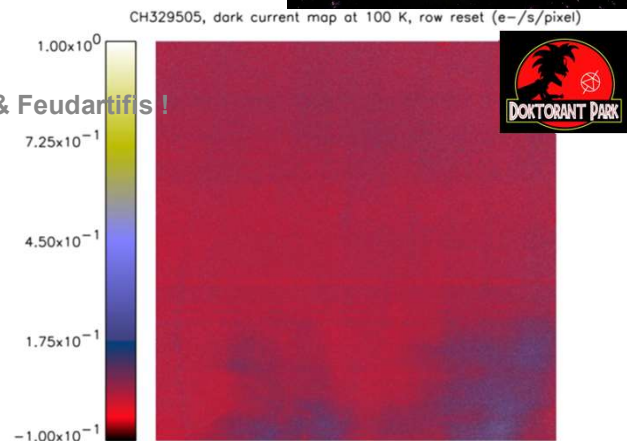
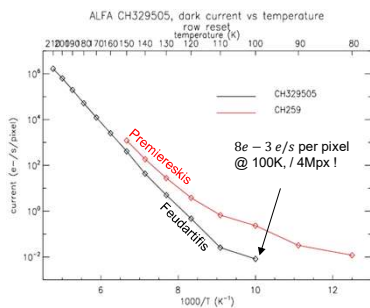
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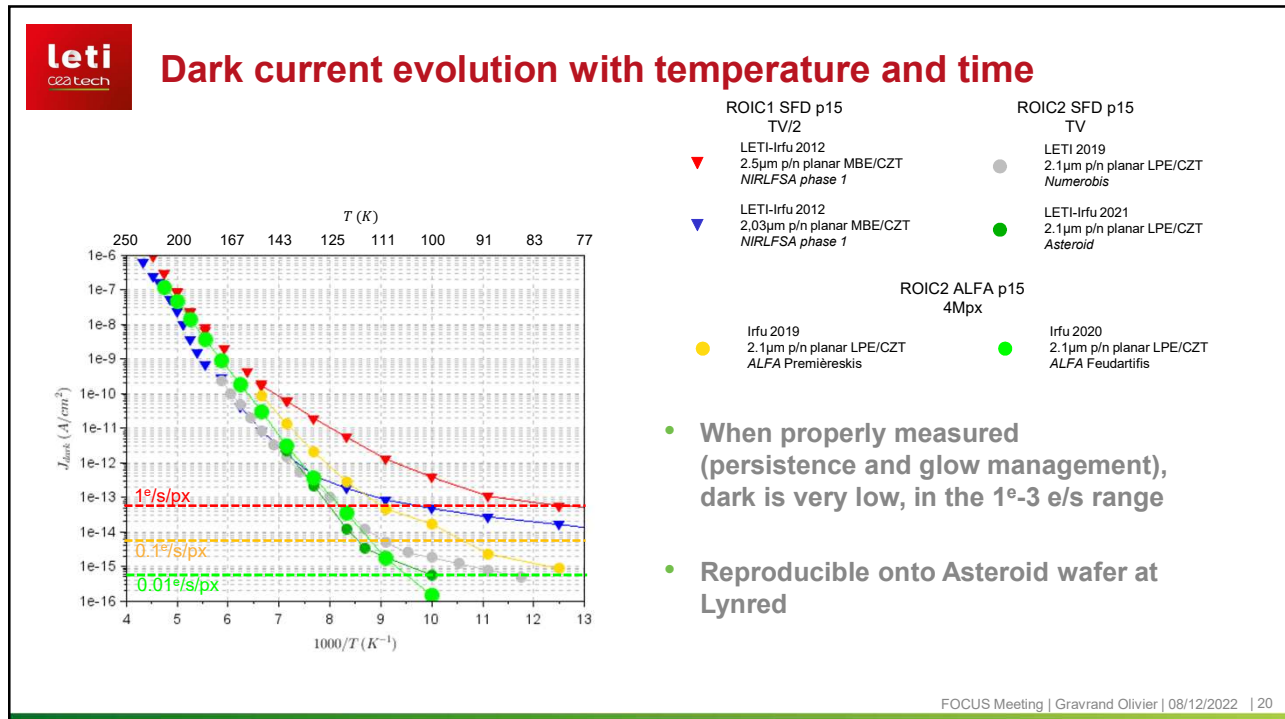
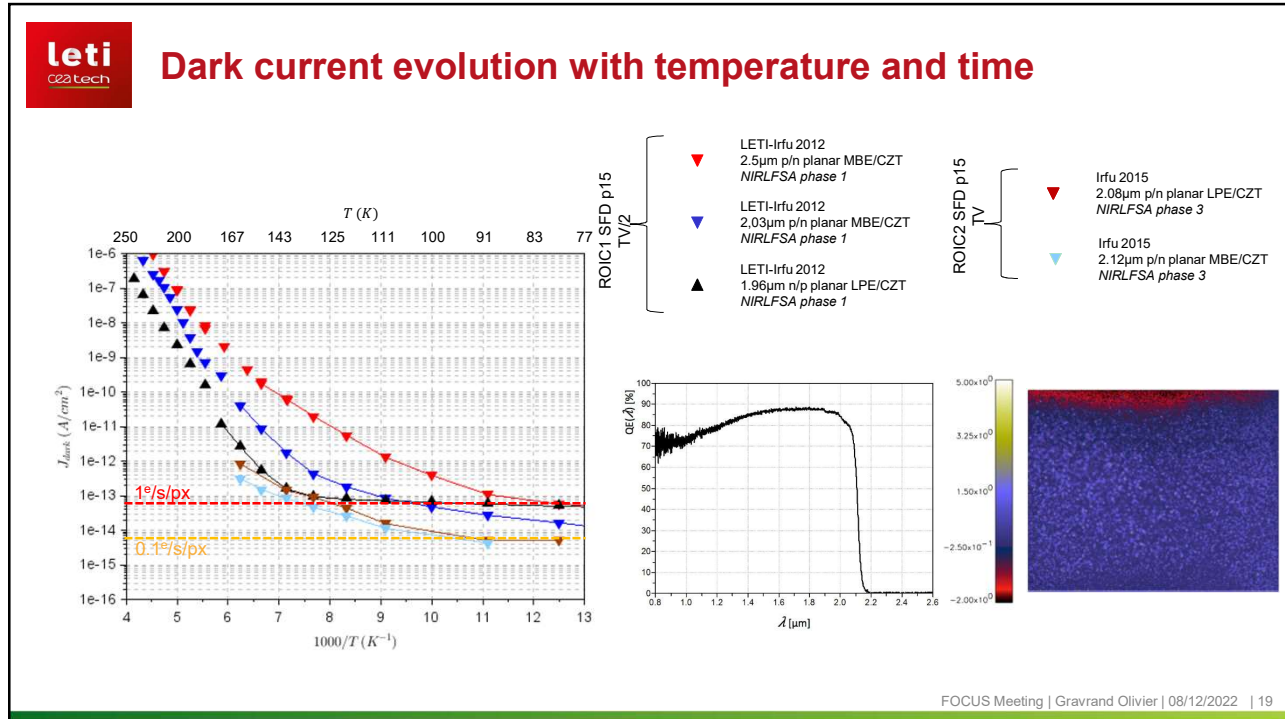
- Lot 0bis = Numérobis : OK, jolies matrices TV, ... TOP départ !
- Lot Premièreskis : A first array is fonctionnal
- Lot Malefis : shit, not supposed to get this !
- Lot Pulapis : oups, another bug?!
- Lot Demalenpis : Aouch not yet OK...

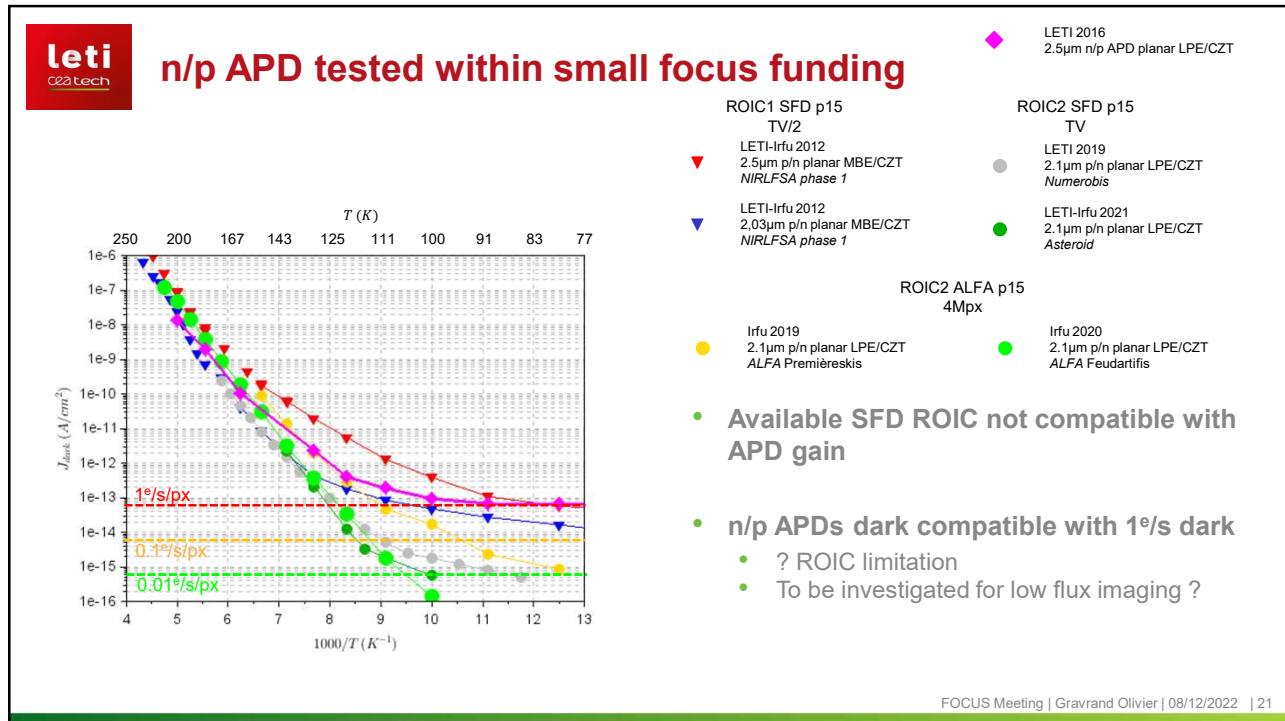


ALFA : the saga...

- Lot 0bis = Numérobis : OK, jolies matrices TV, ... TOP départ !
- Lot Premièreskis : A first array is fonctionnal
- Lot Feudartifs: Yes !... We found the solution
And get a superbe 4Mpx array
 - Uniformity response limited by IRFU bench
 - Dark is good and uniform (Op95%@ 0.5e/s)
- Tremendous progress between Premièreskis & Feudartifs !







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ALFA production yield...

- Teledyne prod. yield (2016) : 10 layers for 1 FM
- ALFA :
 - 12 layers funded
 - 18 layers effectively produced & processed
 - 2 Arrays

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Size matters...

- ROIC stitching demonstrated
- Thermal cycling on study 2k2k arrays
- 4 inches MCT fab demonstrated at LETI
 - From CZT to LPE
 - 4 x 2k2k / wafer demonstrated n/p
 - Xlent material properties
 - 4" p/n uniformity still to be demonstrated

