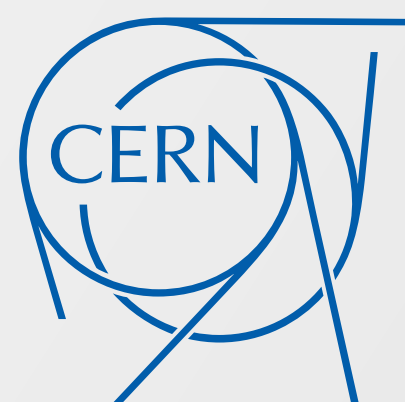


Pixel Chip Production and Series Test

마거 매그너스 (CERN)

*12th ALICE ITS upgrade, MFT and O2 Asian Workshop
Inha University, Incheon, Korea
19-21 November 2018*

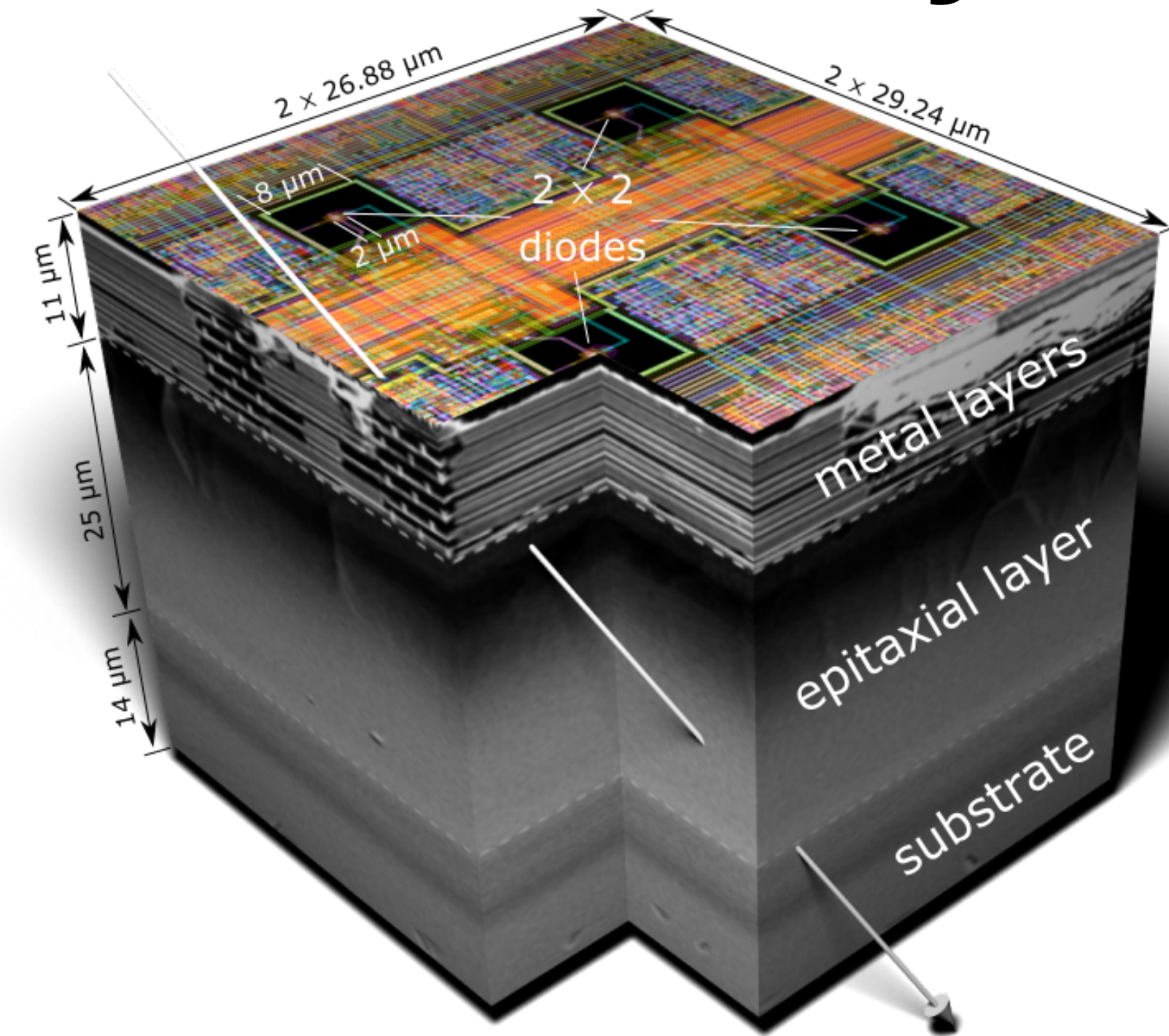
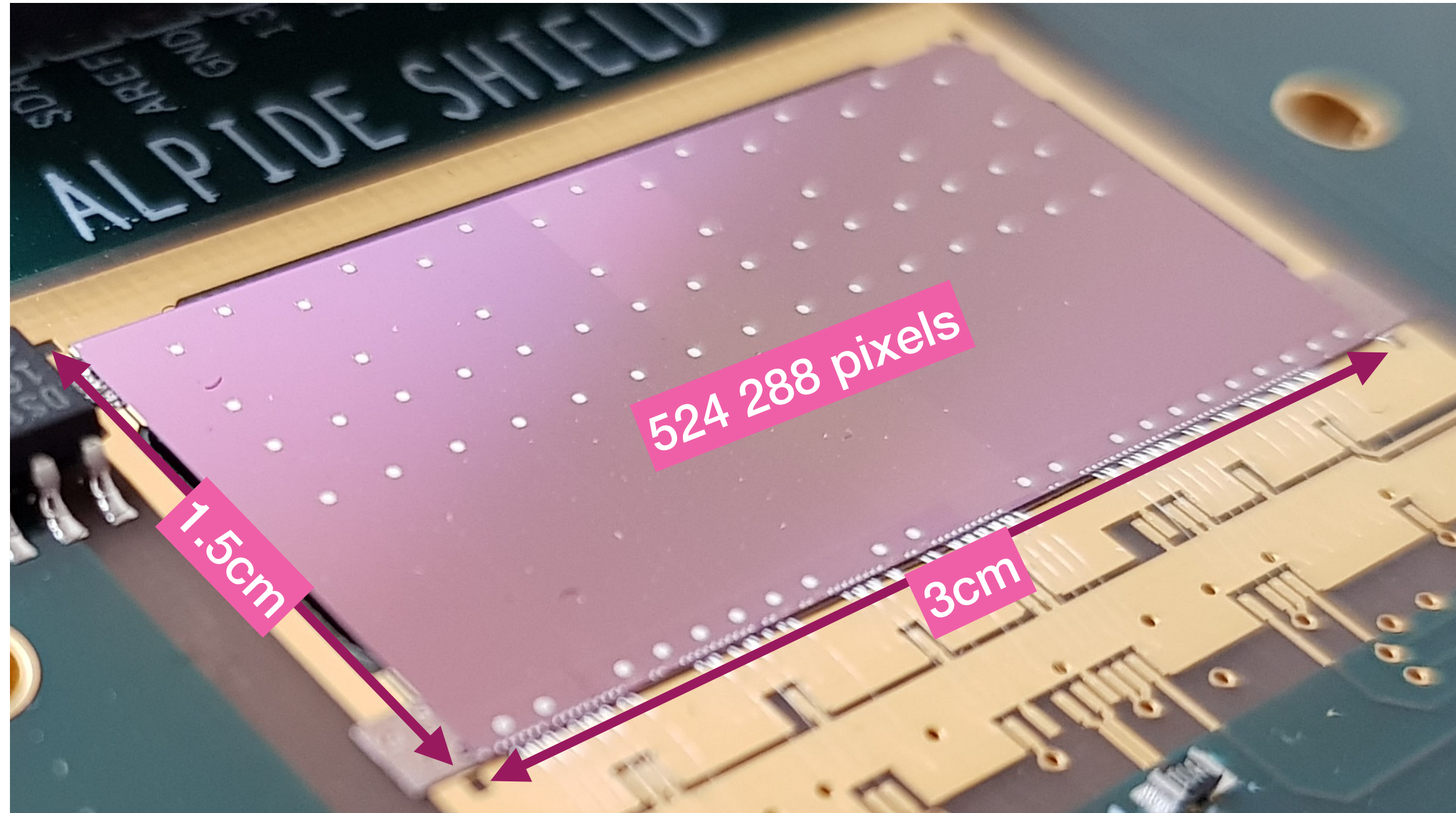




Outline

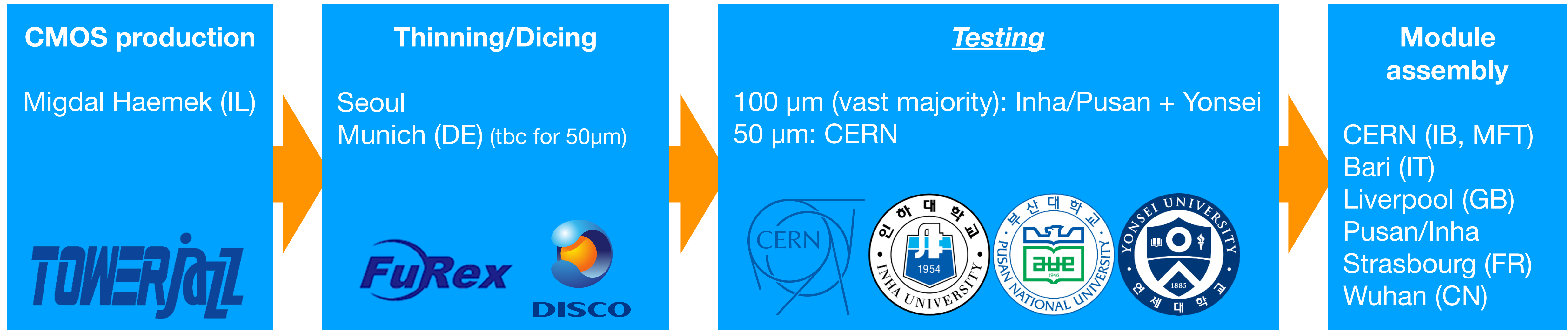
- ➔ Overview
- ➔ A bit of history
- ➔ Plans
- ➔ Yields
- ➔ Distribution

Overview: testing objective/subject



- delicate objects (mechanical + electrical)
- custom design requiring custom test systems
- lots of analogue + digital functionality to be assessed
- more than 60 000 chips to be tested!

Overview: flow



- ~ 60 lots, ~1500 wafers produced
 - Production ongoing of more chips is ongoing: 15 lots (346 wafers) by end-2018, more to come next year
 - Module assembly requires continuous testing of ≥ 1 lot (25 wafers) / week
- + wafer QA (TMEC) + CMOS wafer testing (CERN)

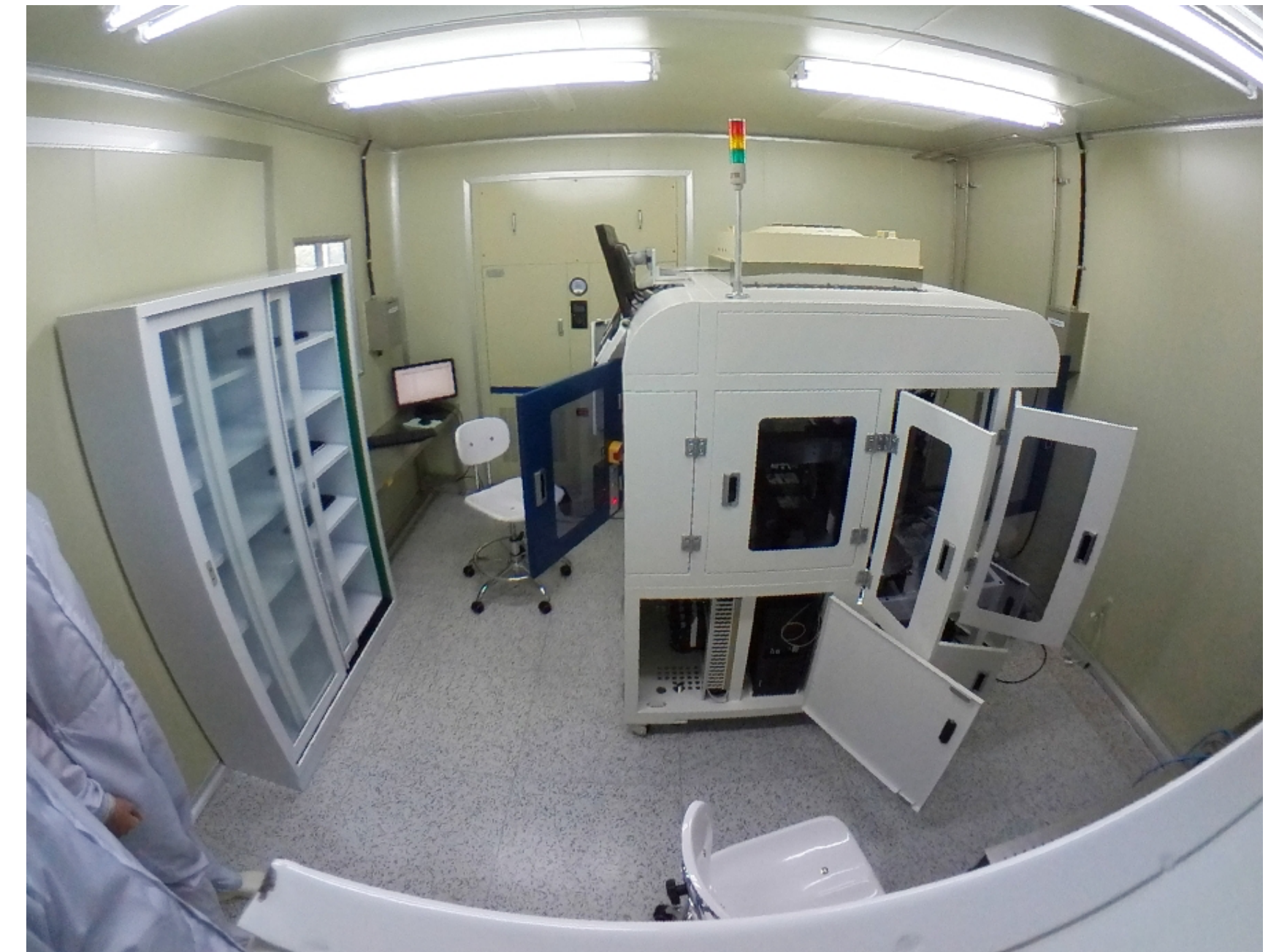
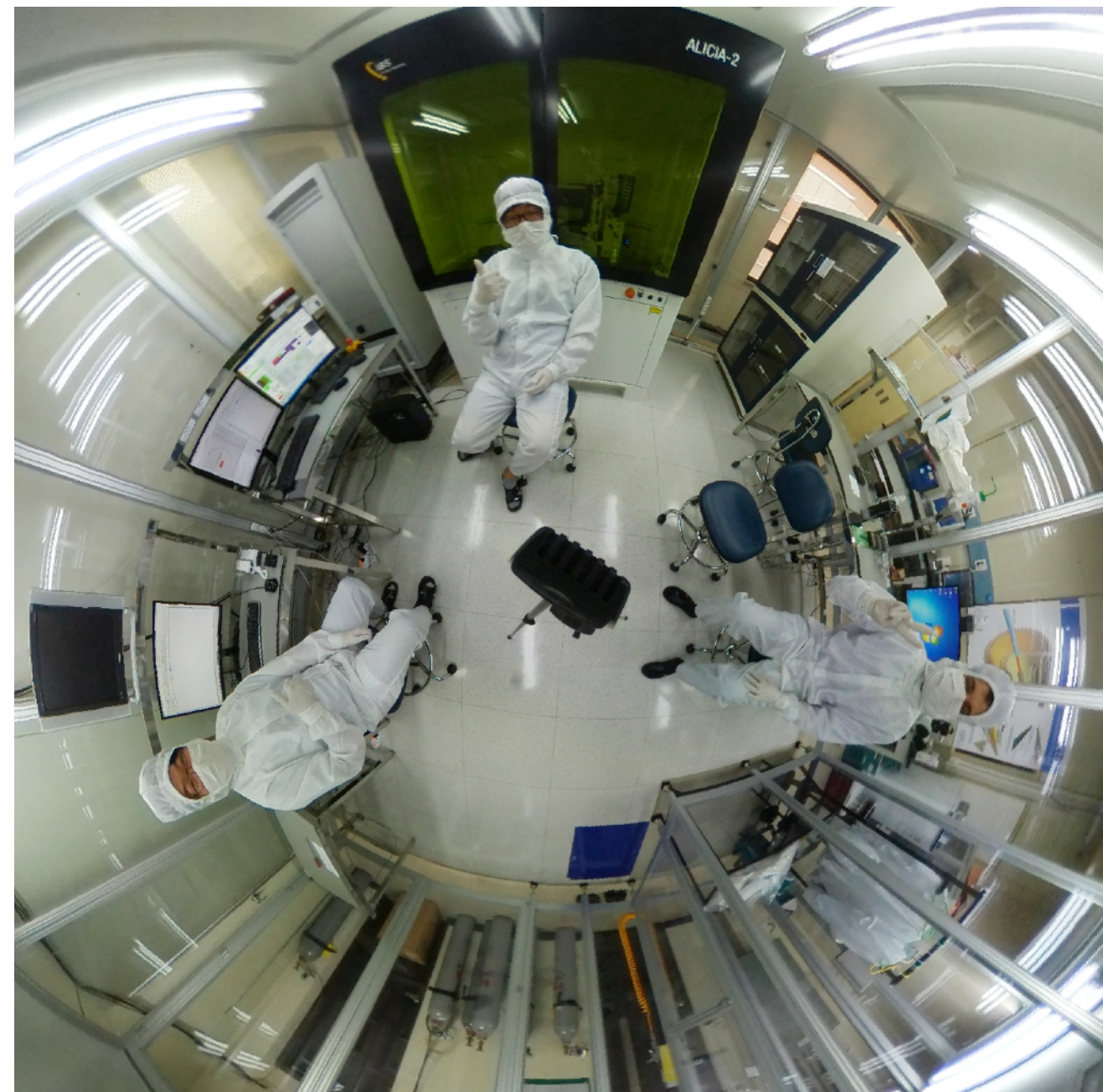
History

- Today, we have these beautifully working setups and teams operating them smoothly
- But, we really started from scratch
- Here a few selected moments – starting some 40 thousand tested chips ago...

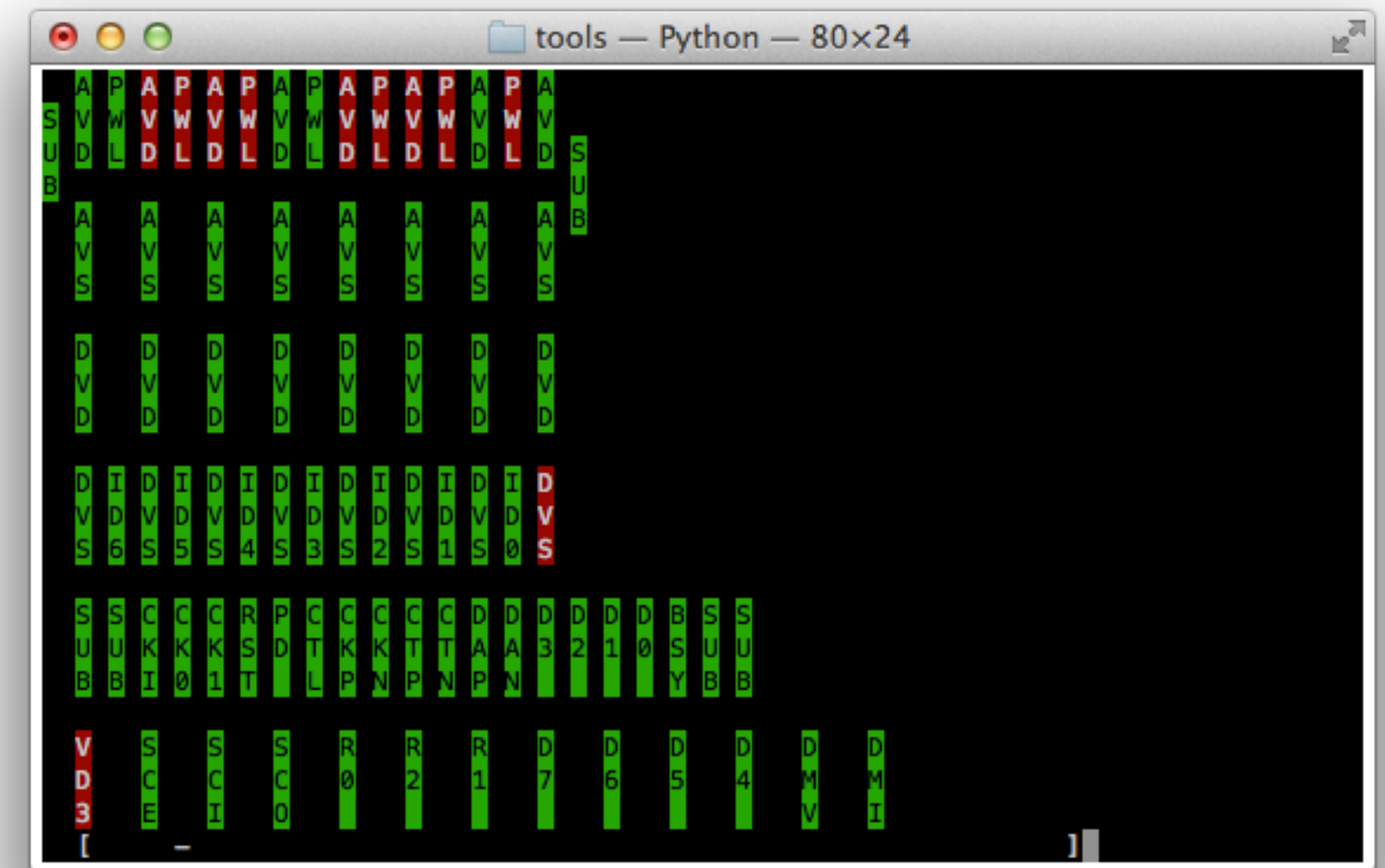


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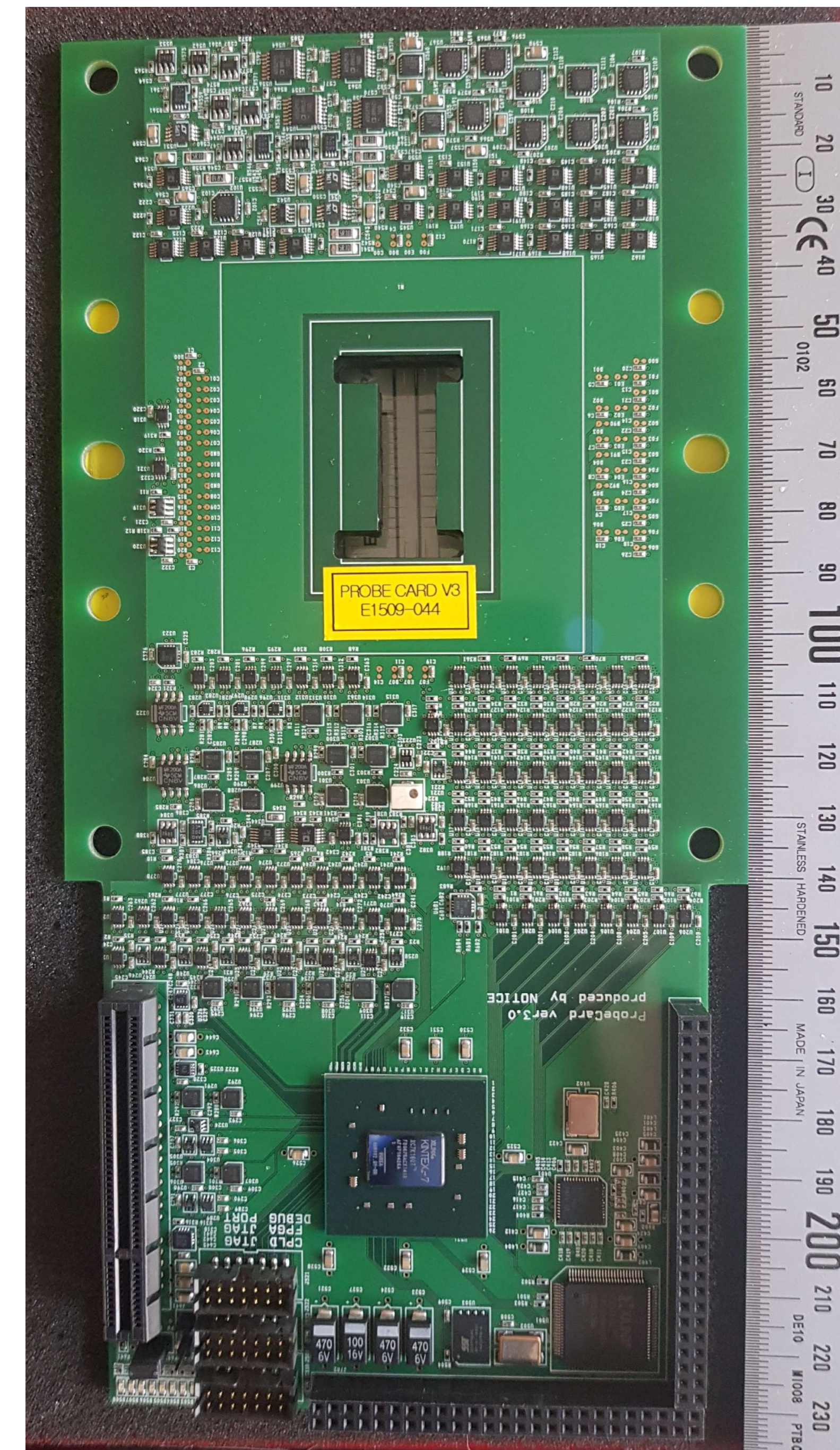


- First probing system (pALPIDE-2) is commissioned
- Based on “DAQ board” + probe card
- Rudimentary contact test logic, turned out to be very useful
- Still a lot of trial+error
- For example: chip interface pads were not yet finalised, Ni/Au coating still baseline for Laser-soldering



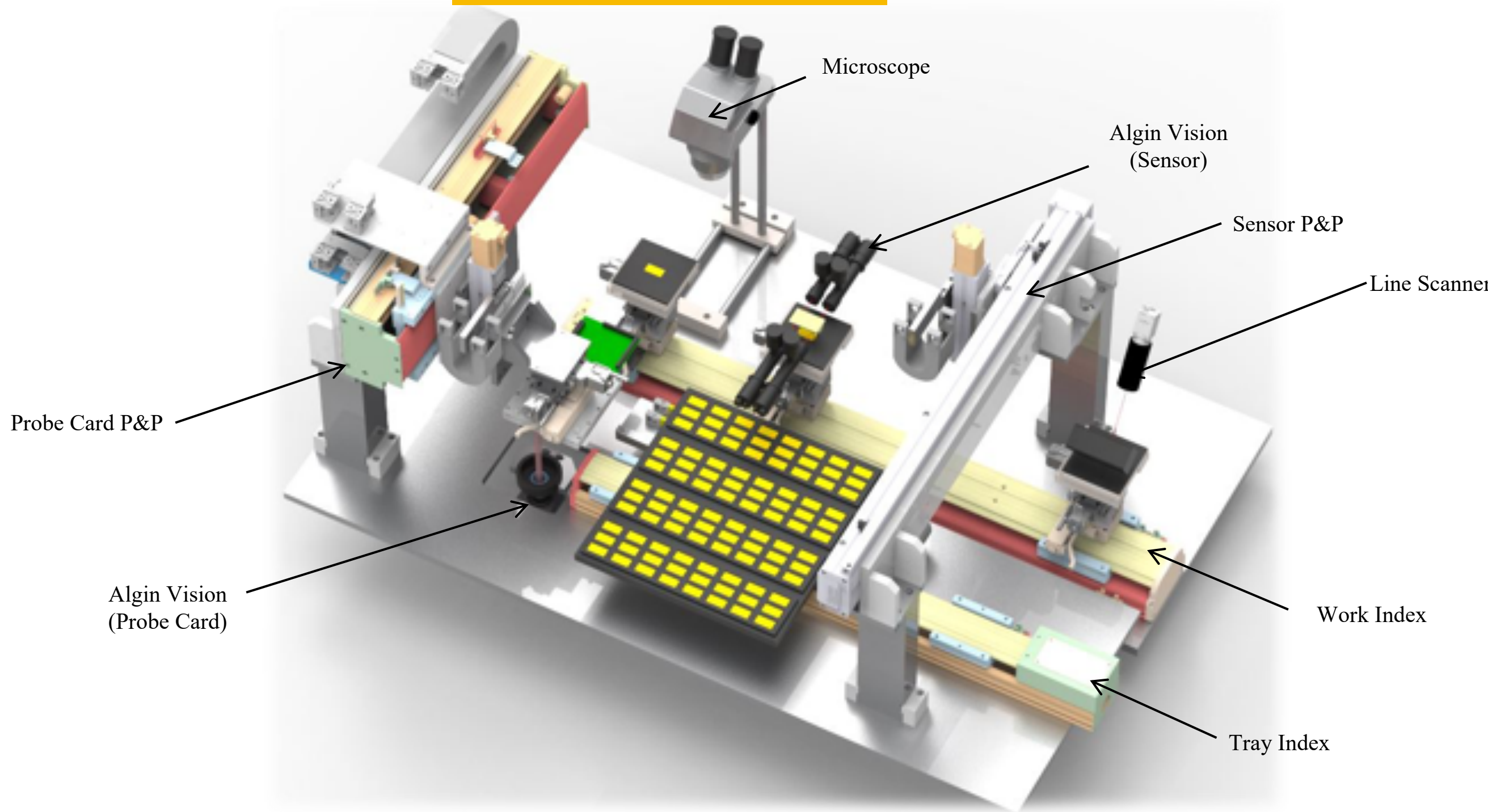
2015-2016

- Redesign of probe card for pALPIDE-3/-4/ALPIDE
- Fully integrated solution
 - Hardware by notice (KR) via Yonsei
 - Firmware by CERN
- Same card for all chip tests (wafer prober + ALICIA machines + Yonsei machine)
- Improved contact test logic

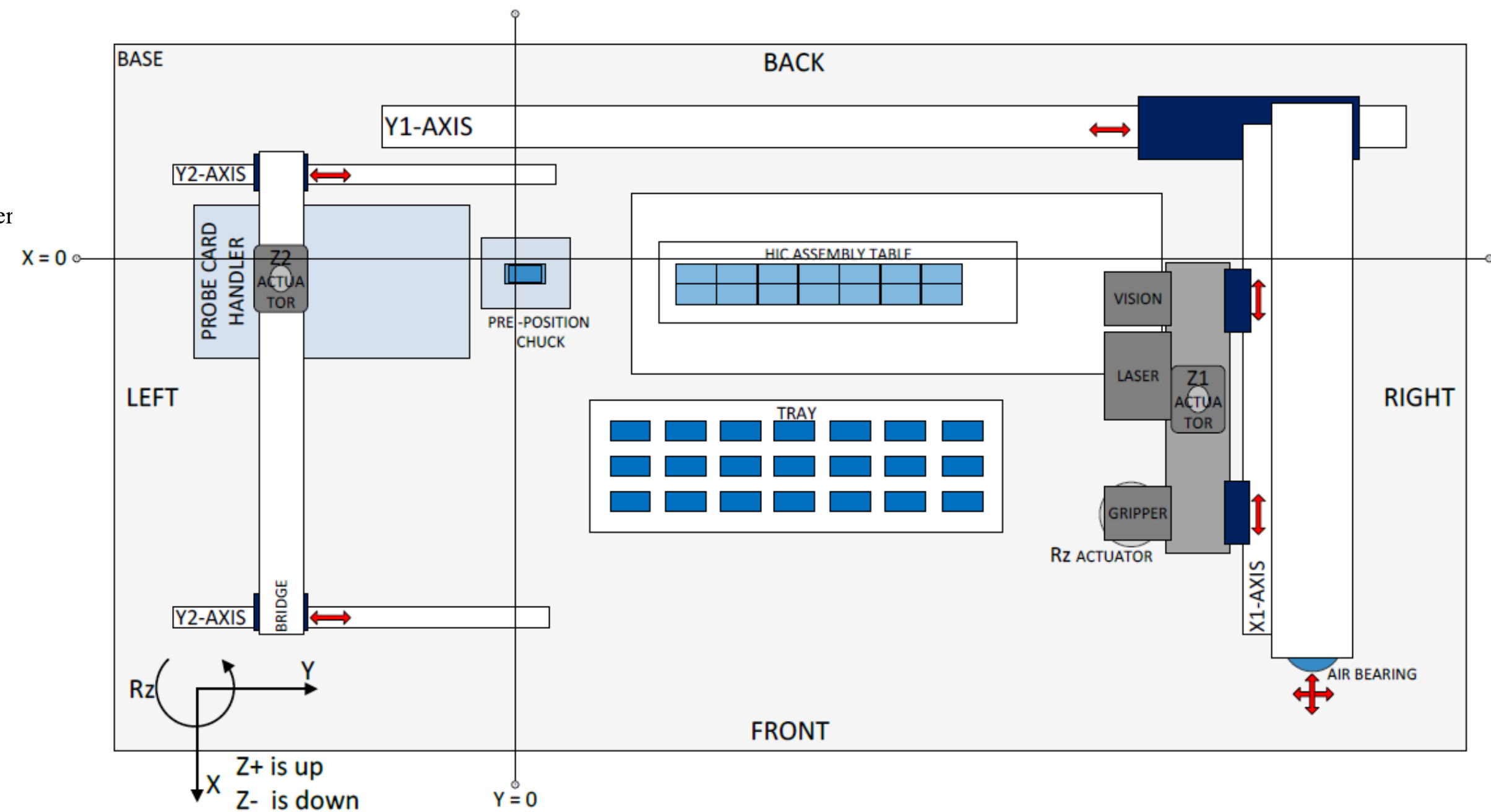


- Machine designs

to-be Corea-YS-01



to-be ALICIA



- Preparation of clean rooms

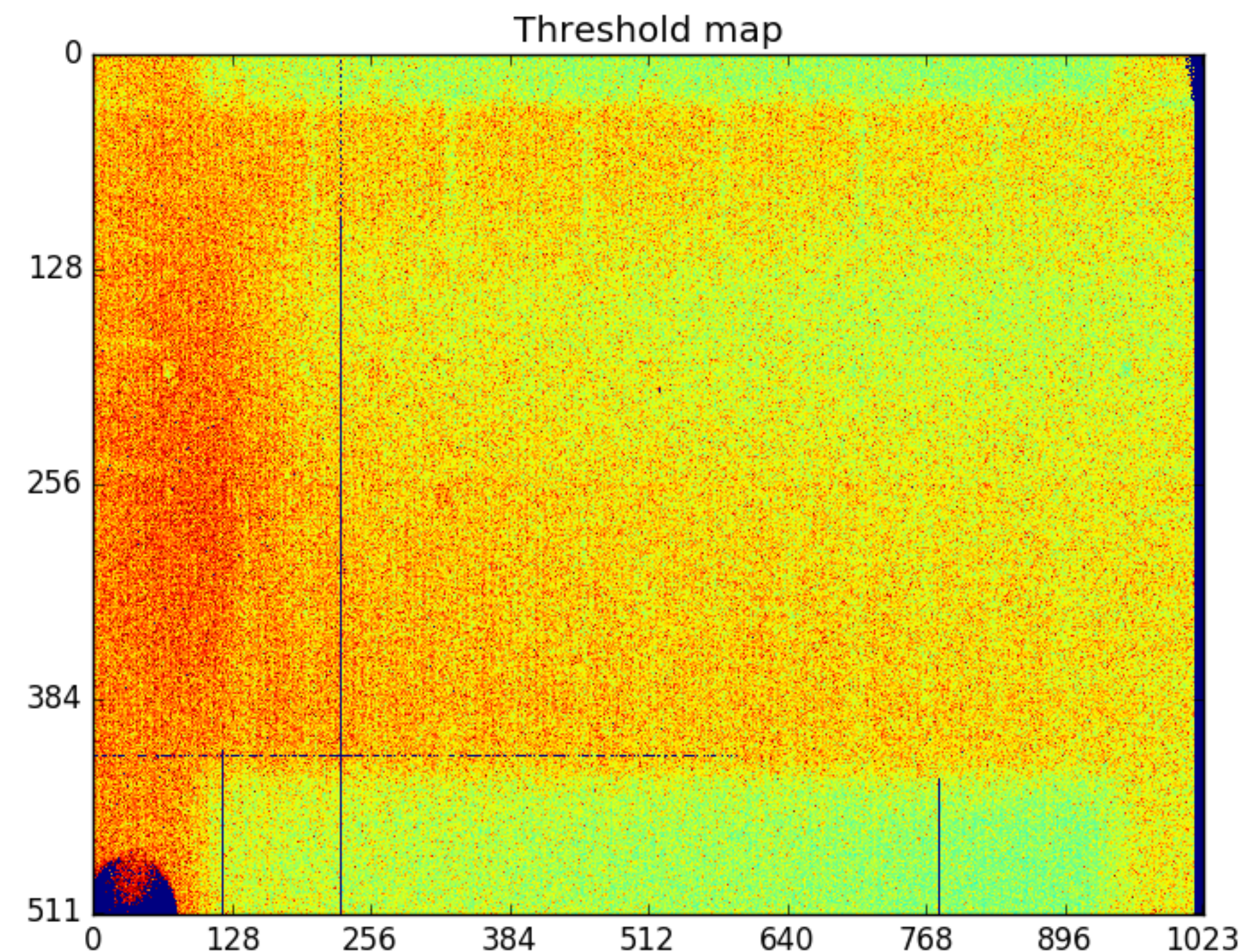
Yonsei

Pusan

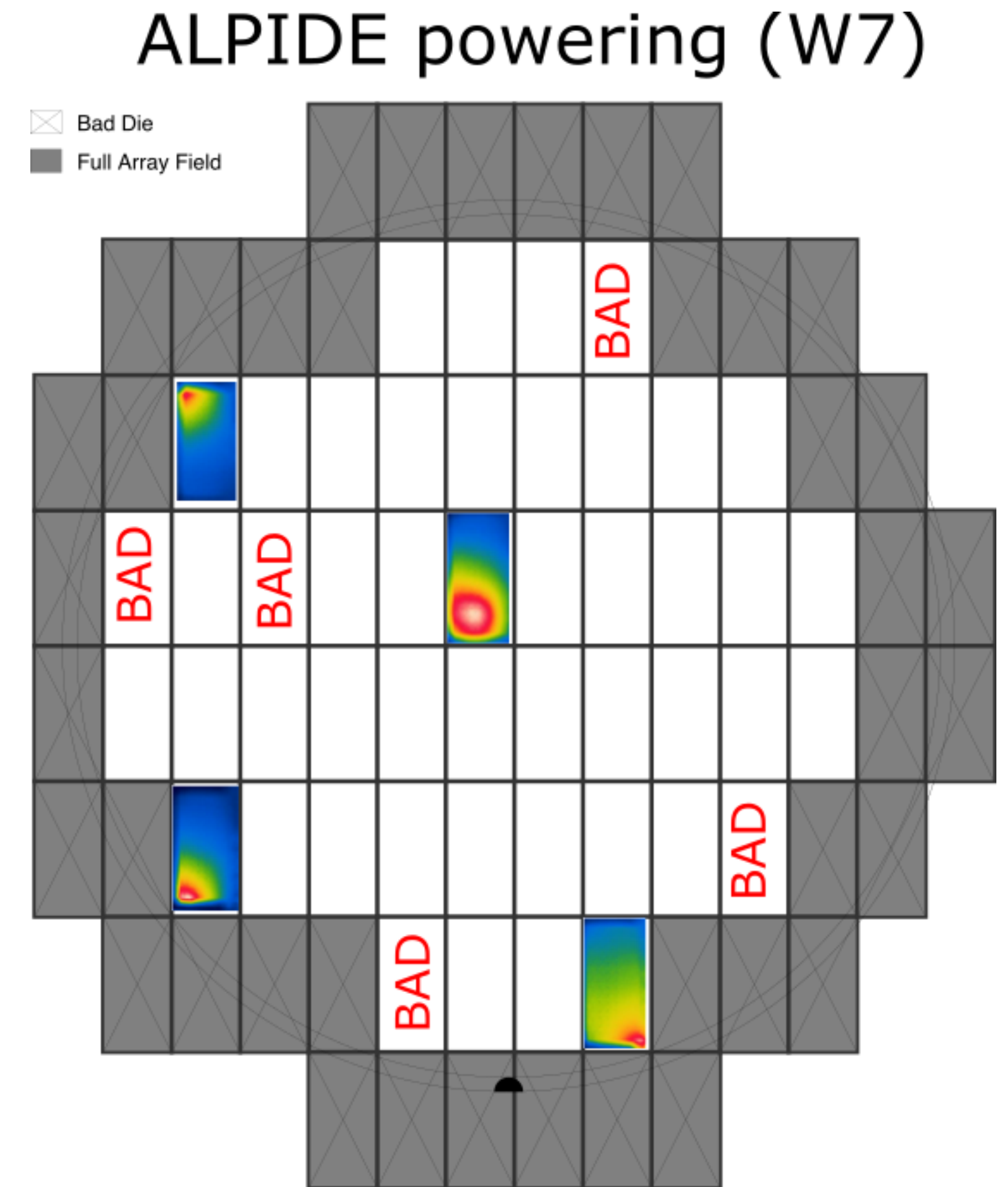


Aug 19 2016

- First ALPIDE pre-production wafer arrive
- Testing result from probe station the same day
- ALPIDE is alive!
- (but light shielding had to be improved....)



- First “real” finding from chip probe testing
- Peculiar failure mode of ALPIDE chips at wafer boundary emerged
- Wafer map was changed to use 46 instead of 48 chips
 - more space to circumference
 - effectively higher yield



Sep 22 2016

- Delivery of Corea-YS-01 to Yonsei Univ.



Nov 7 2016

- Delivery of ALICIA-2 to Pusan Univ.



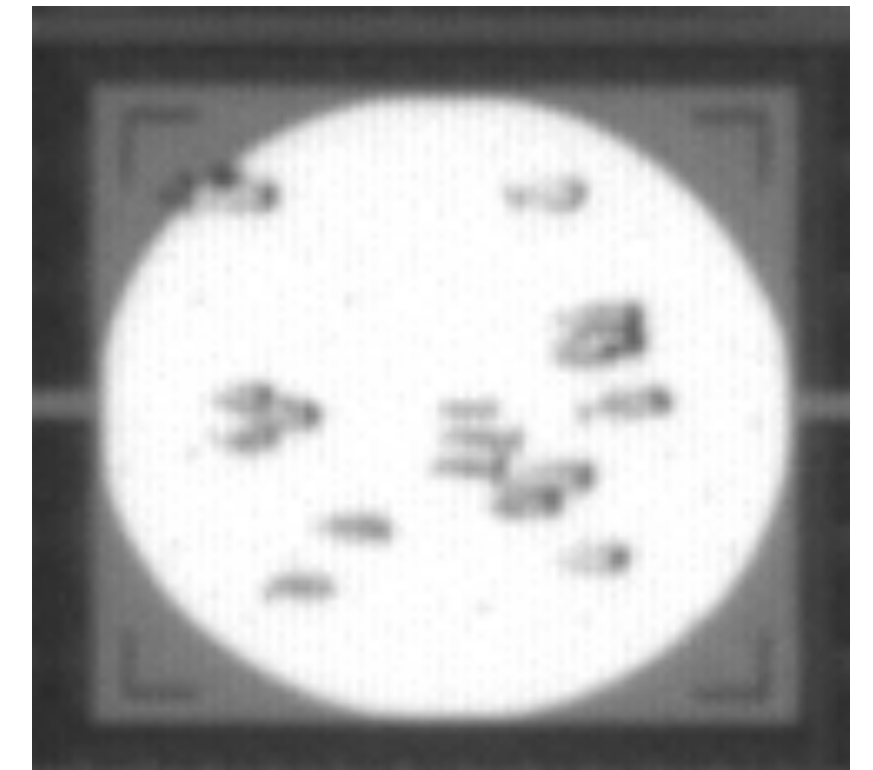
Nov 2016

- Site acceptance test ALICA-2 at Pusan Univ. (Pusan/Inha team)
- All works!
- Test of Corea-YS-01 at Yonsei Univ.
- Probing not reliably (*will eventually turn out to be really bad luck*)



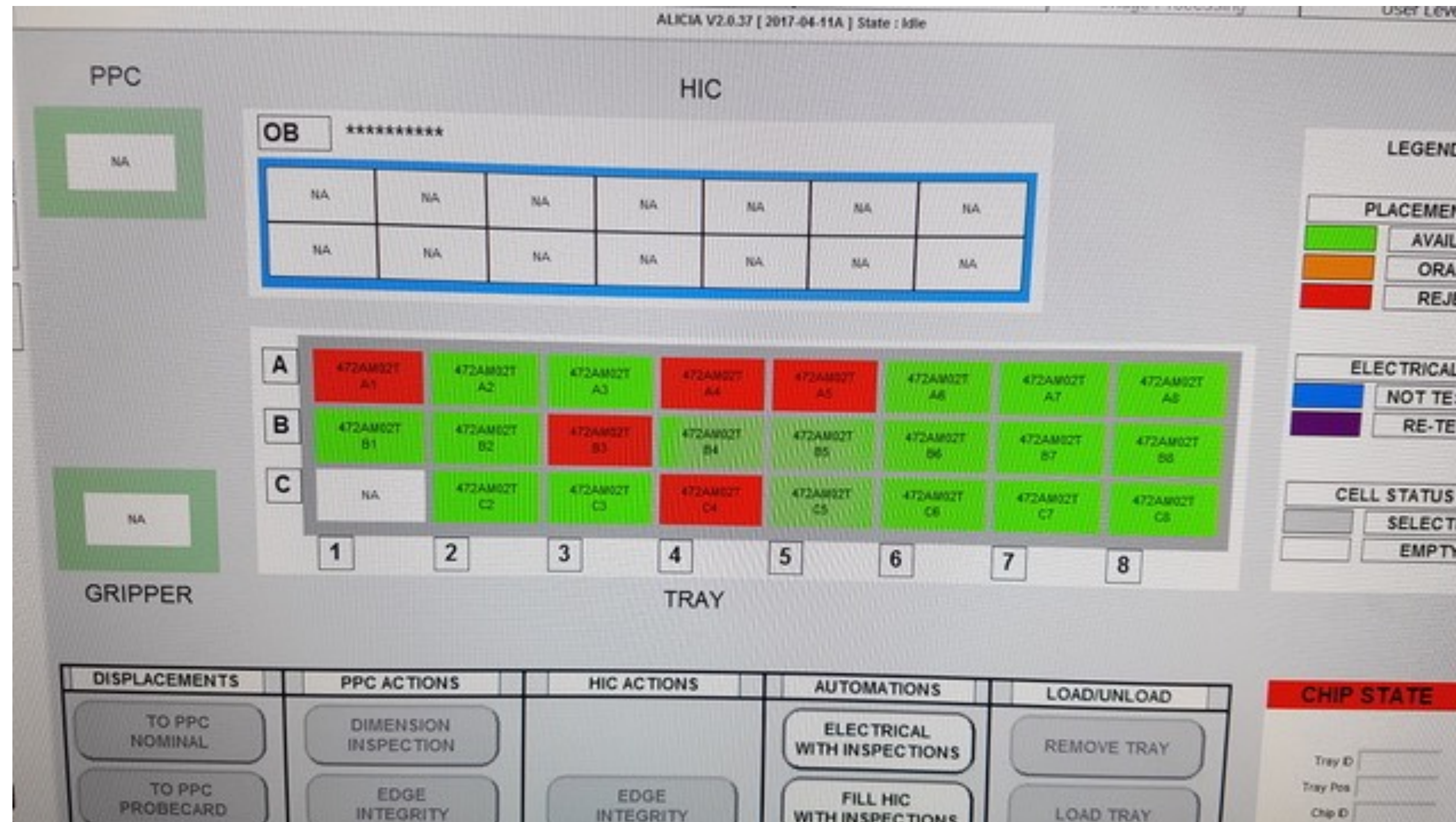
First half of 2017

- Long period with several delays
- Teams in standby
- No production chip testing
- Lots of testing of probe cards at Yonsei



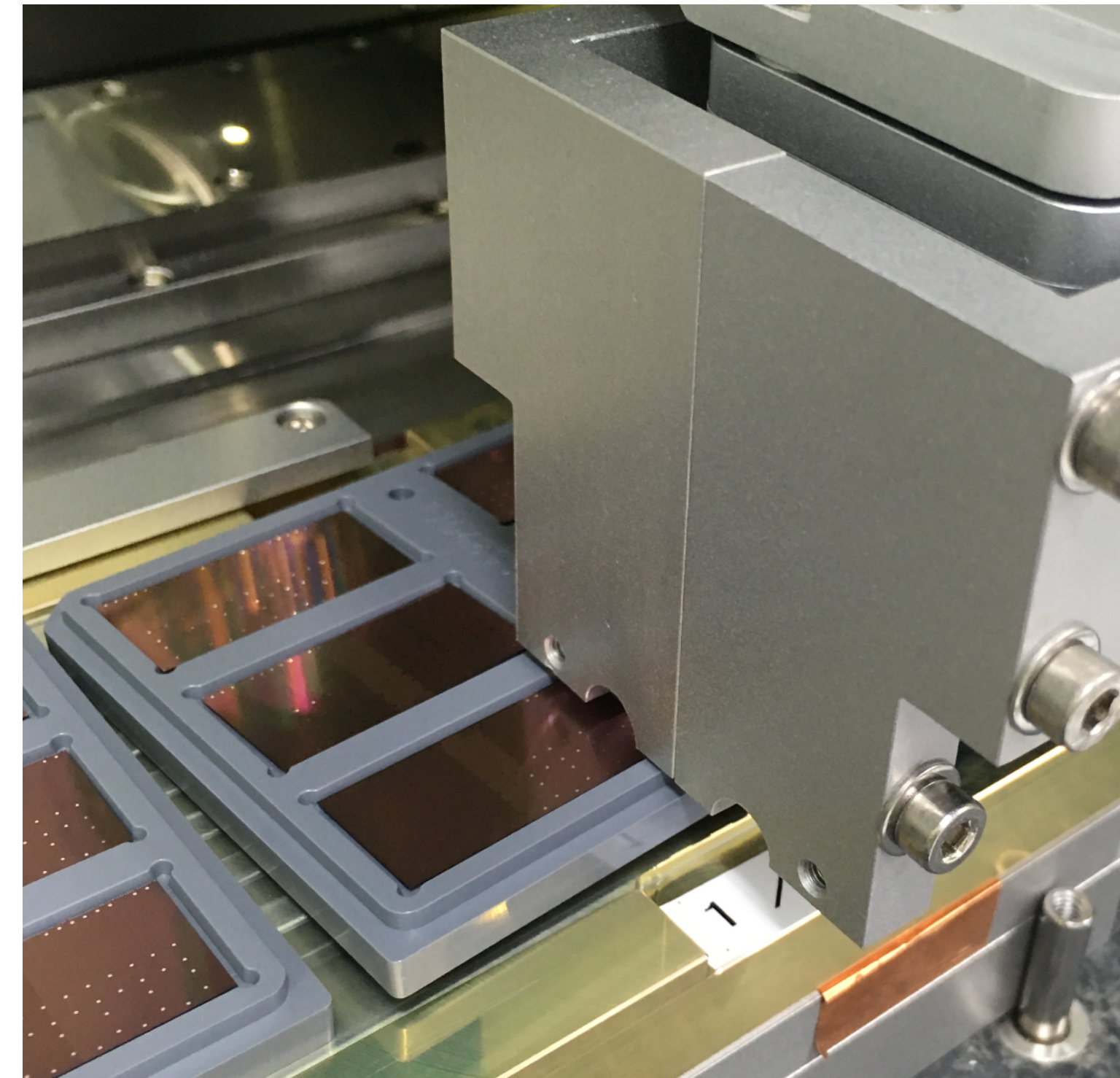
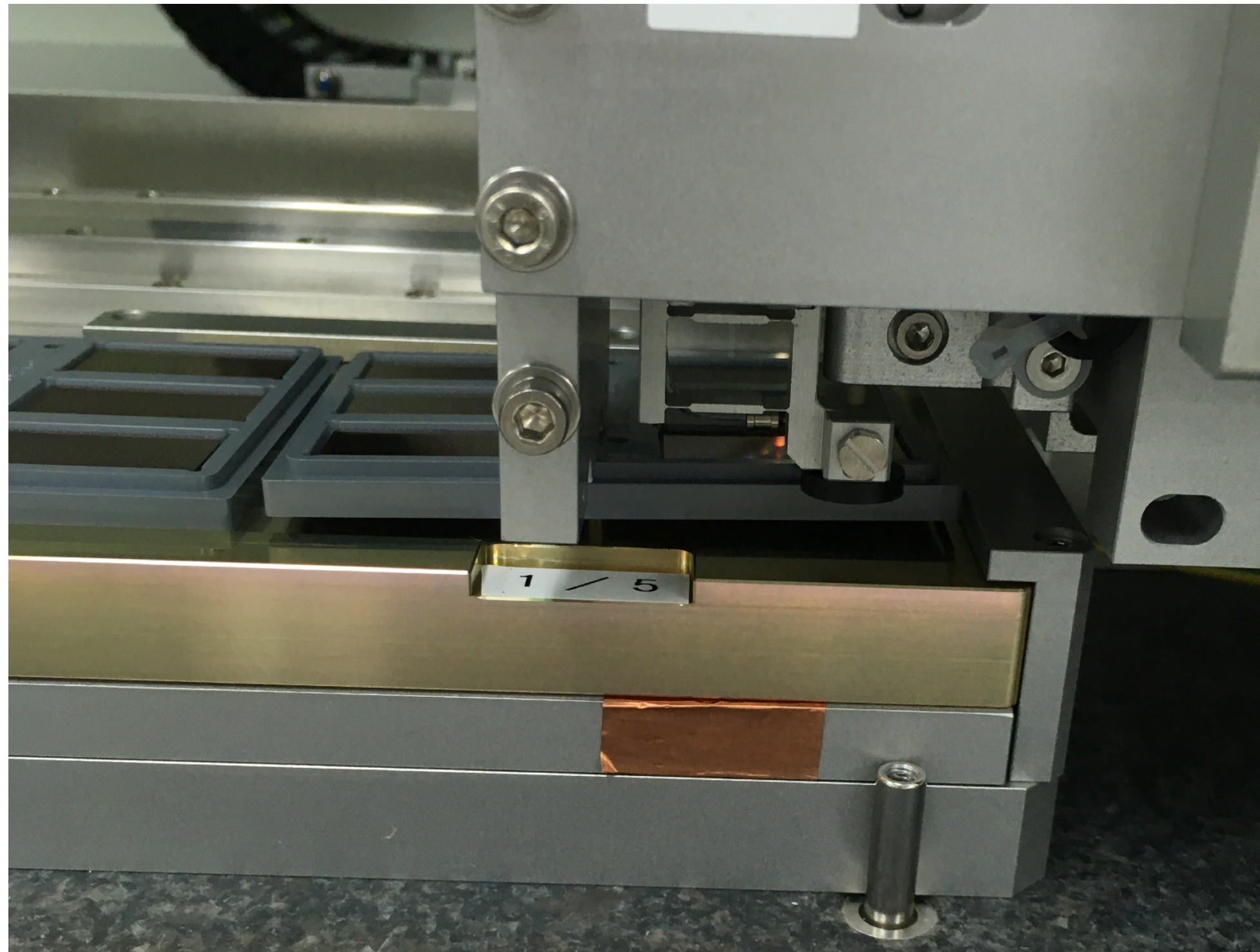
July 28th 2017

- First fully automated ALPIDE test at Inha/Pusan
- Smooth running afterwards



Aug 8+9 2017

- Gripper incidents at CERN and Pusan/Ina

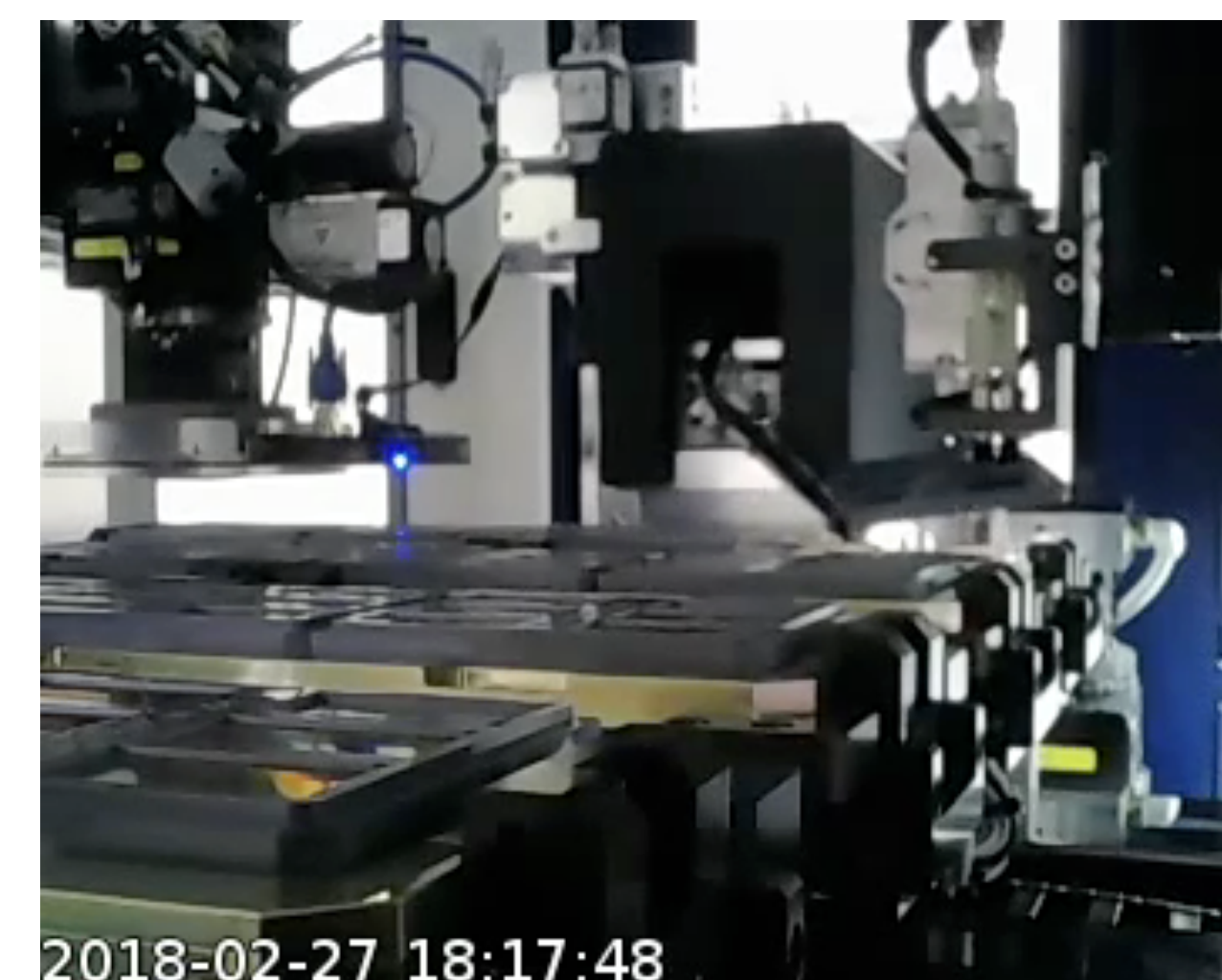
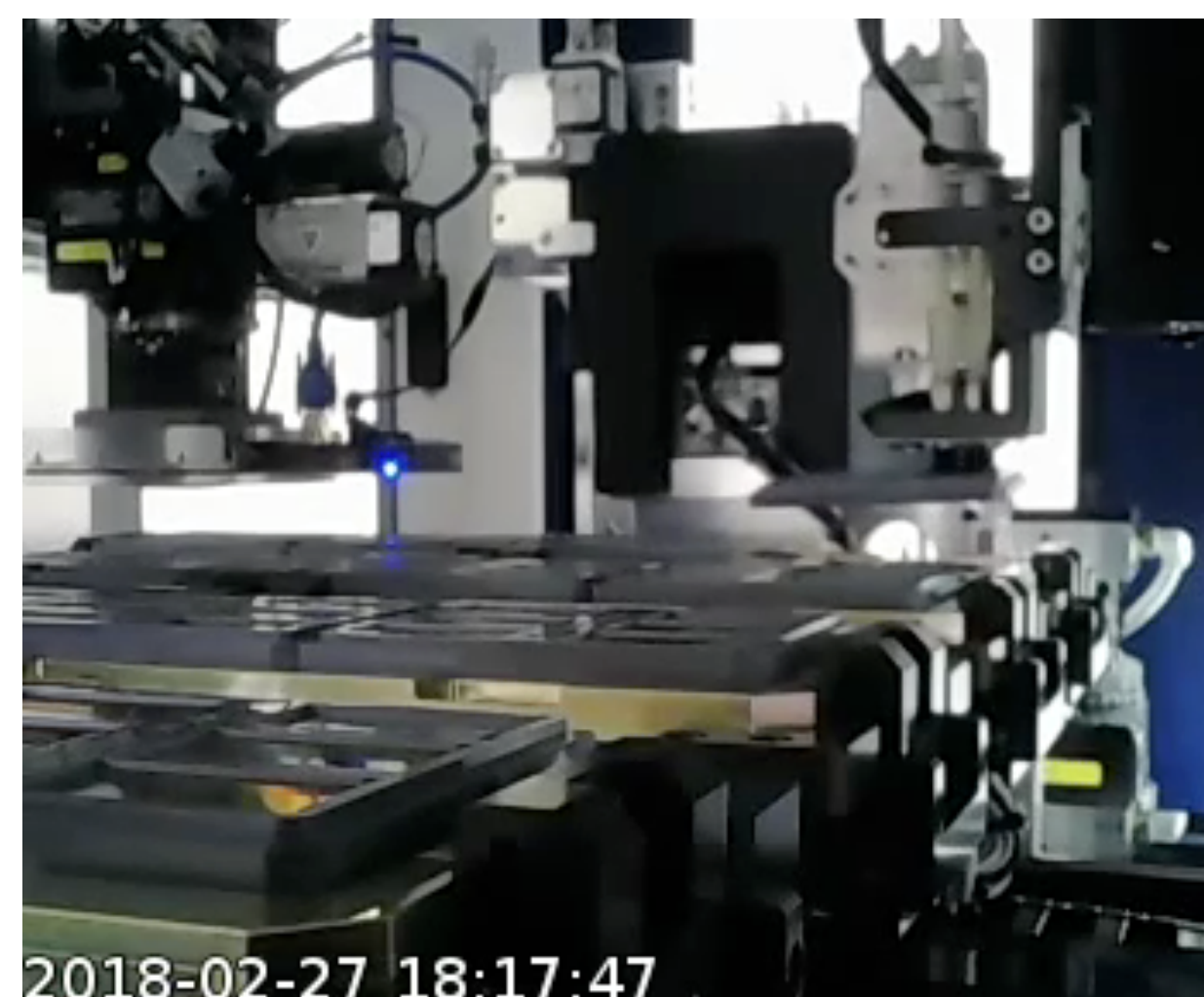
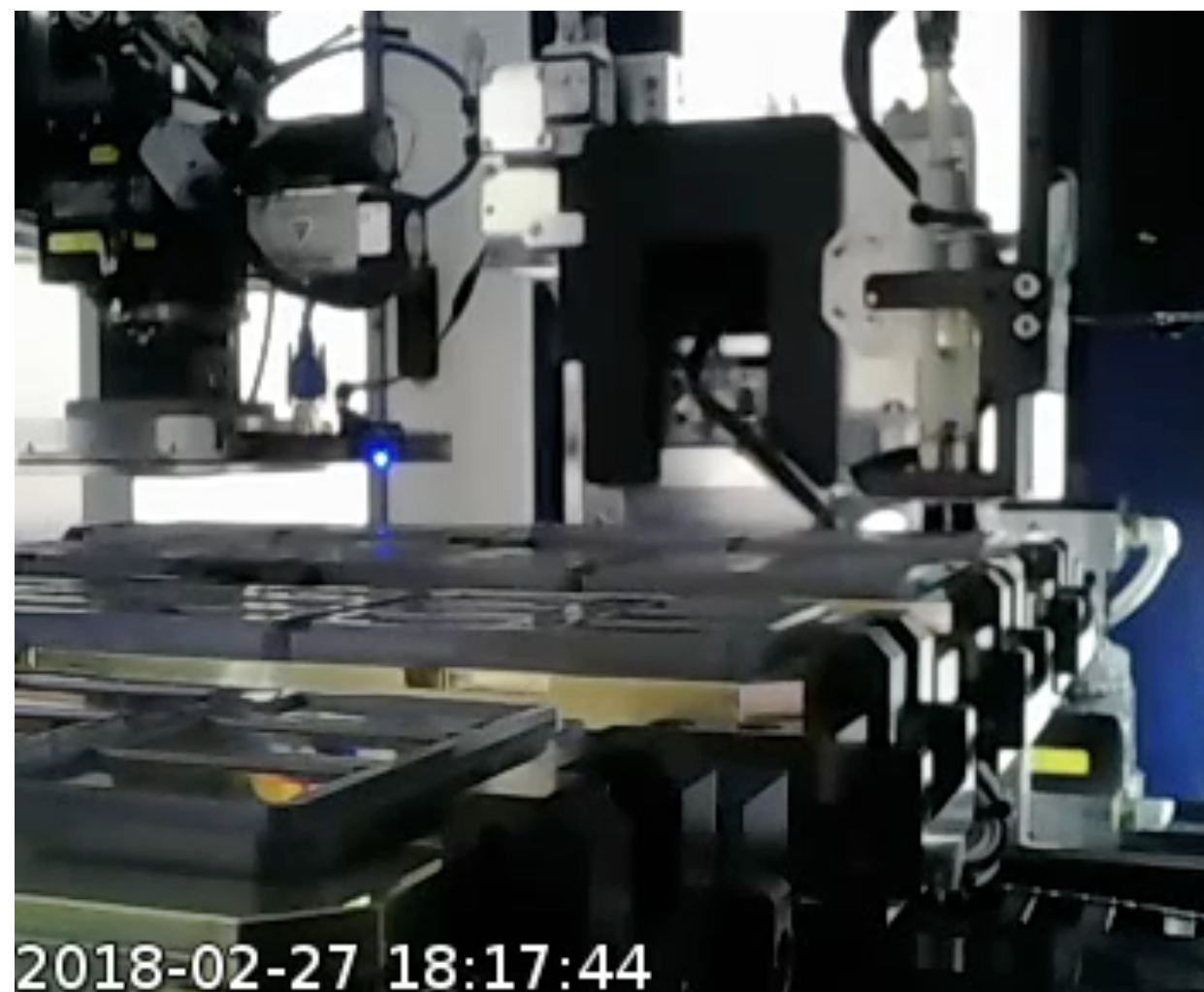


Feb 2018

- Production test starts in Yonsei
- This ends a long trouble-shooting period
- Eventually the two probe cards that were used at Yonsei and produced unreliable results were send to CERN
- They *also behave badly at CERN*, i.e. by now we know that the late start was really due to bad luck

Feb 27 2018

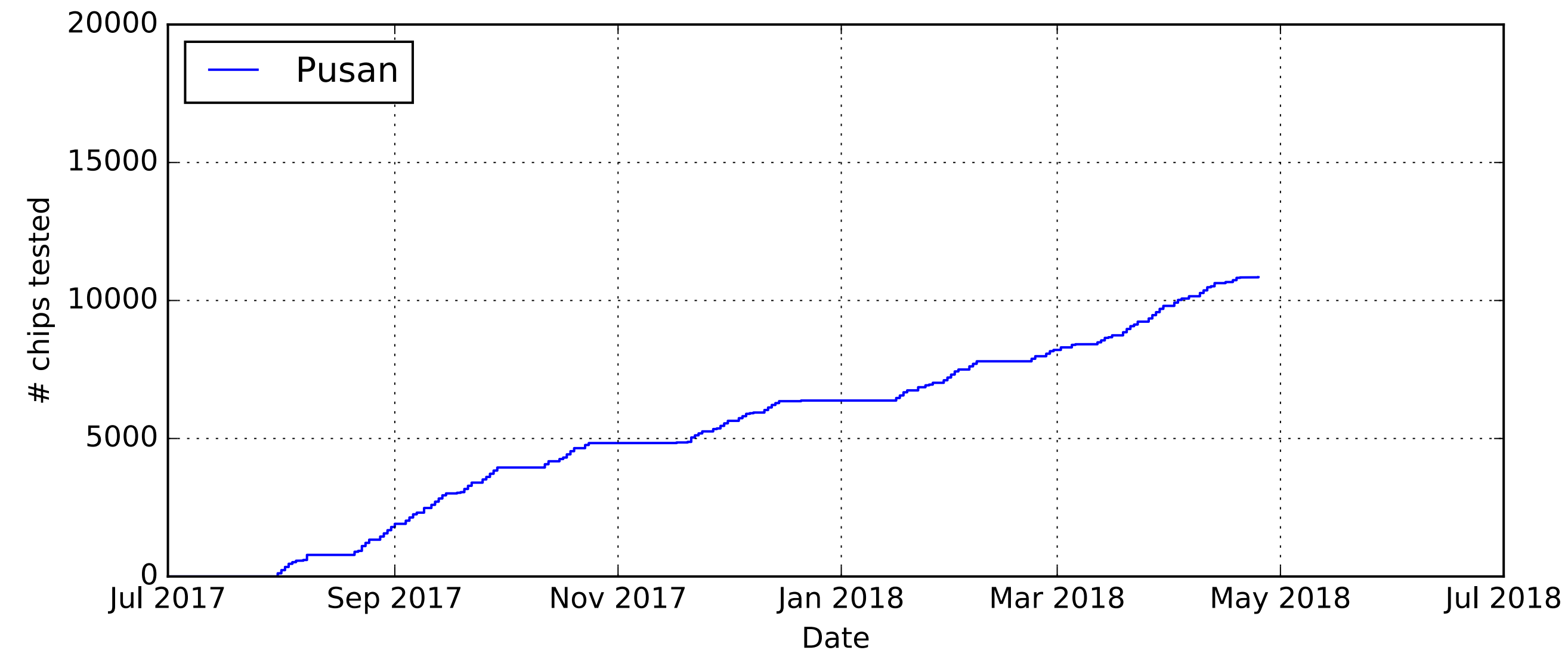
- Near-Incident at Yonsei
- Database content for tray incorrect, chip-picker picks tray and crashes it into machine
- Luckily no damage



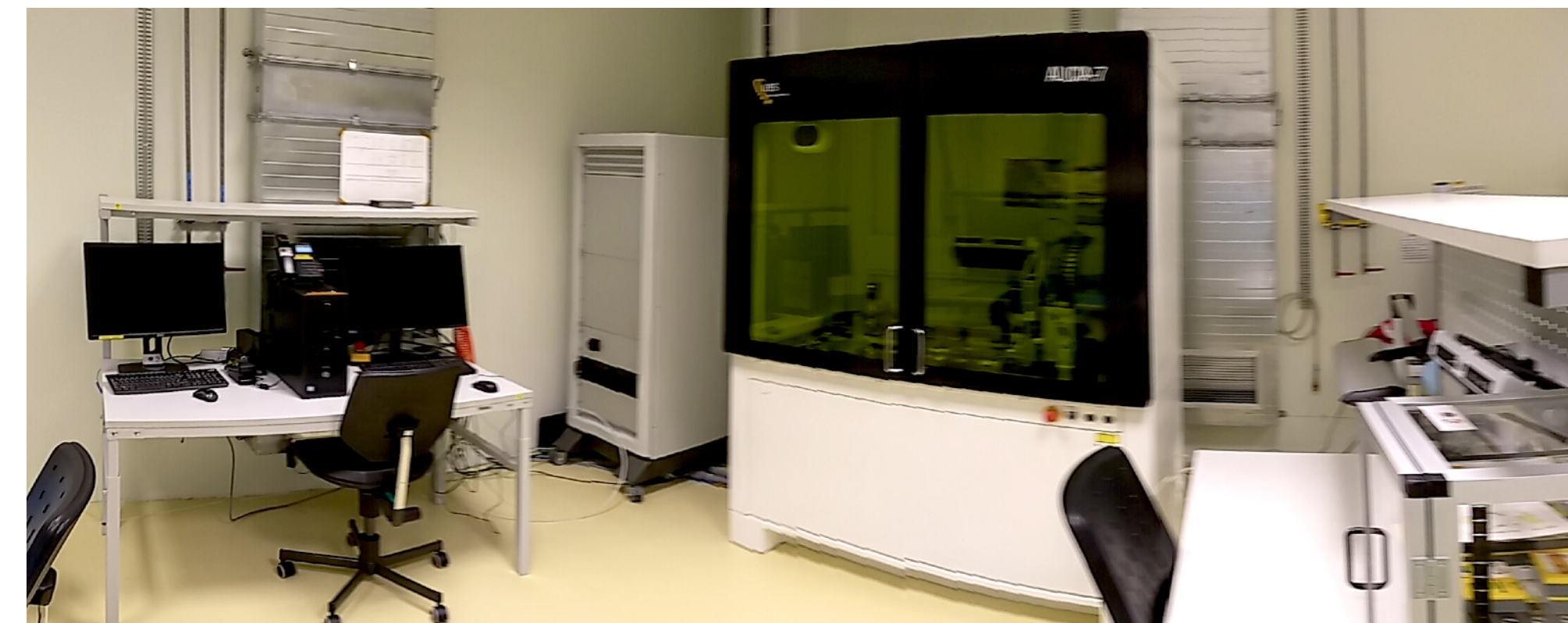
Apr 2018

- Planned stop of chip testing at Pusan/Inha
- Module construction largely relied on the chips tested by Pusan
- Meanwhile, verification of availability as back-up site completed

➡ Congratulations to the Pusan/Inha team!

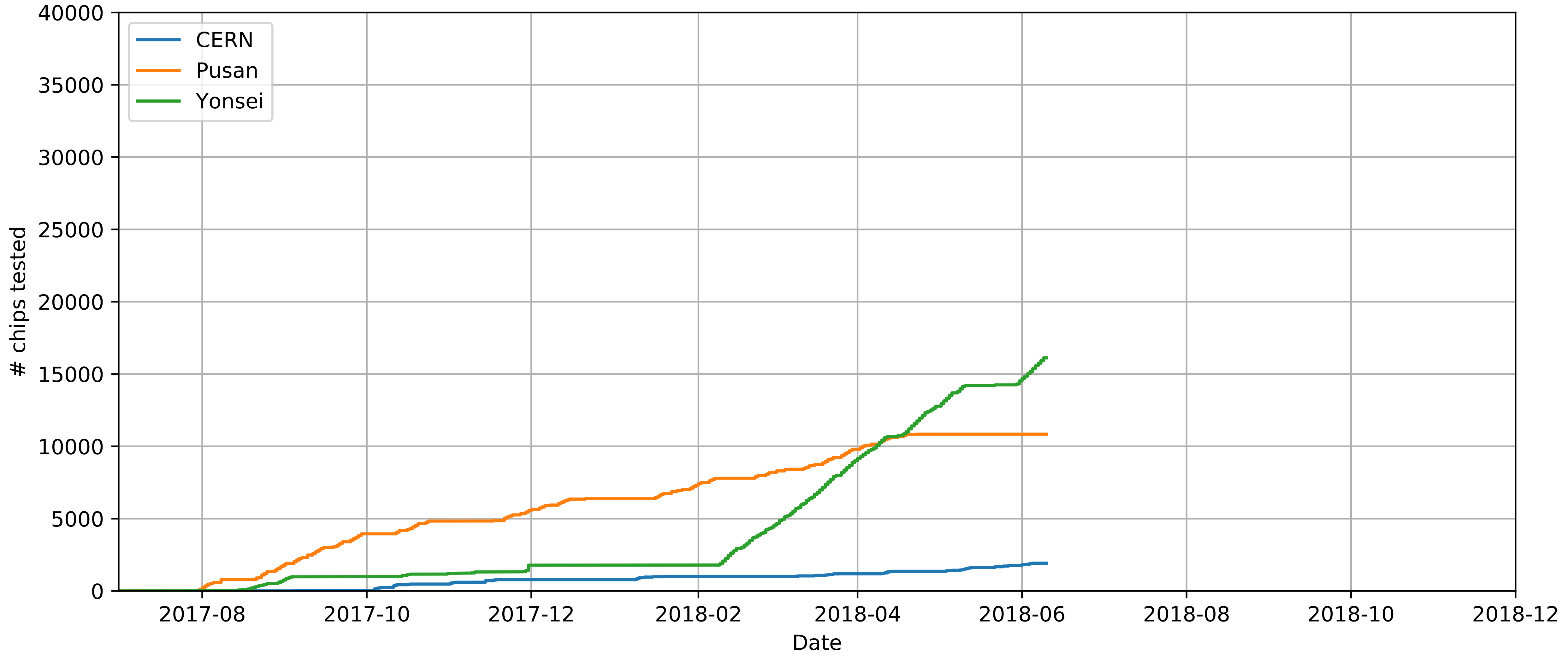


- MFT also joins chip testing
- smooth set-up of soft- and hardware
- Need to discuss spare probe card
 - currently 2 cards at CERN: ITS+MFT
 - Inha/Pusan card could become common spare

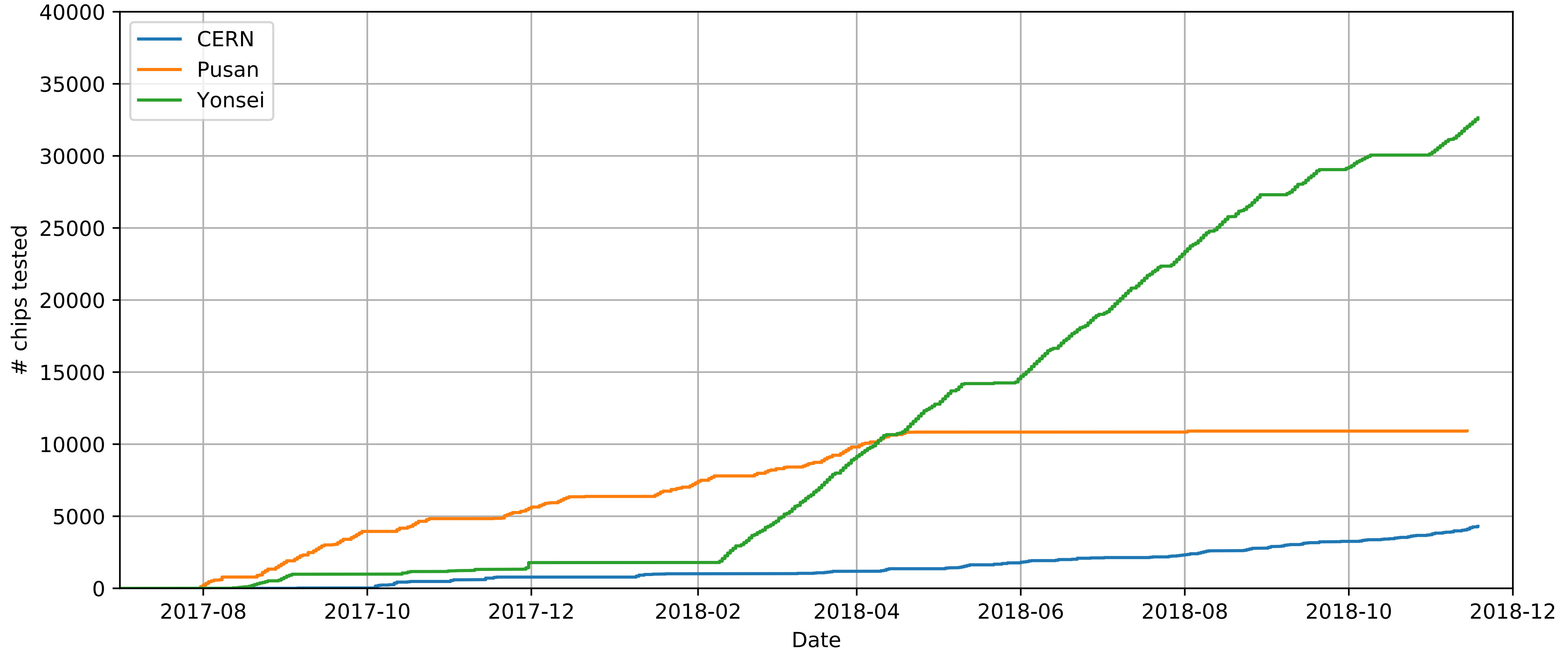




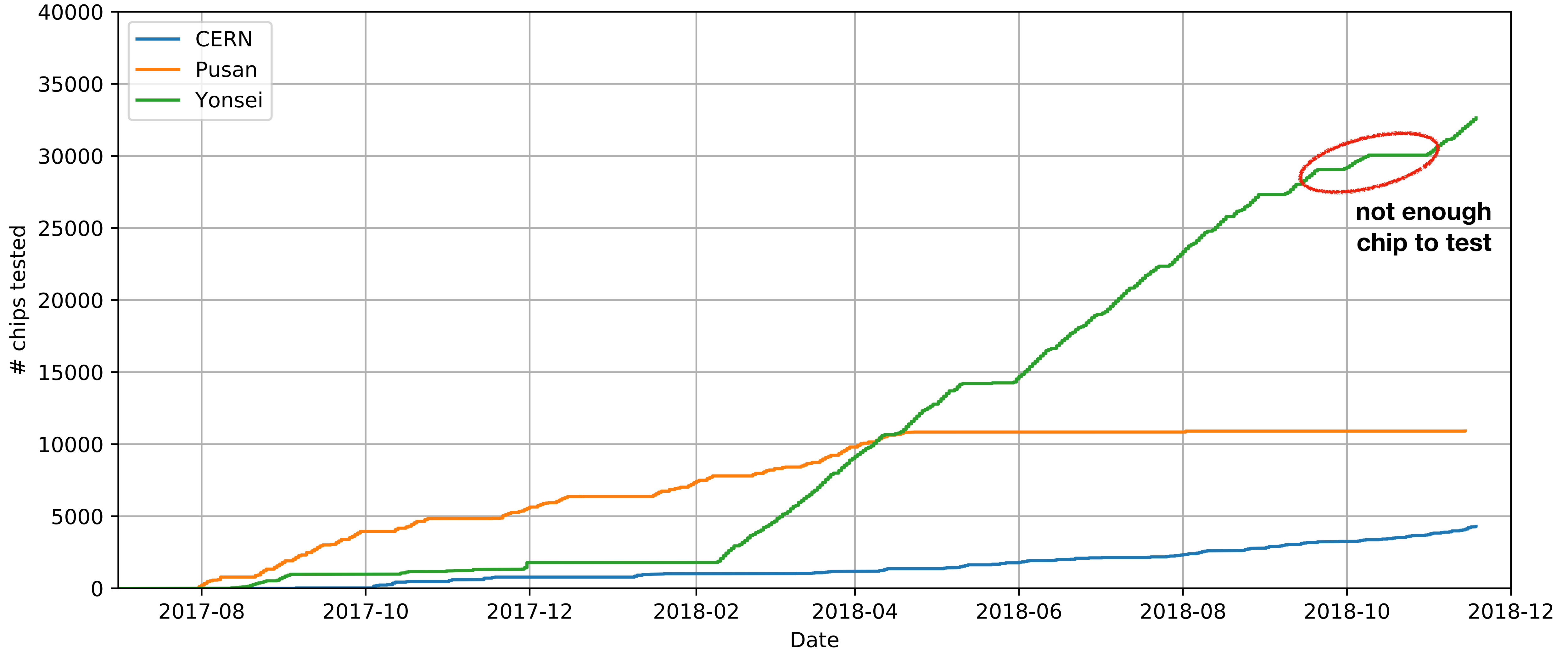
Nov 2018



Nov 2018



Nov 2018

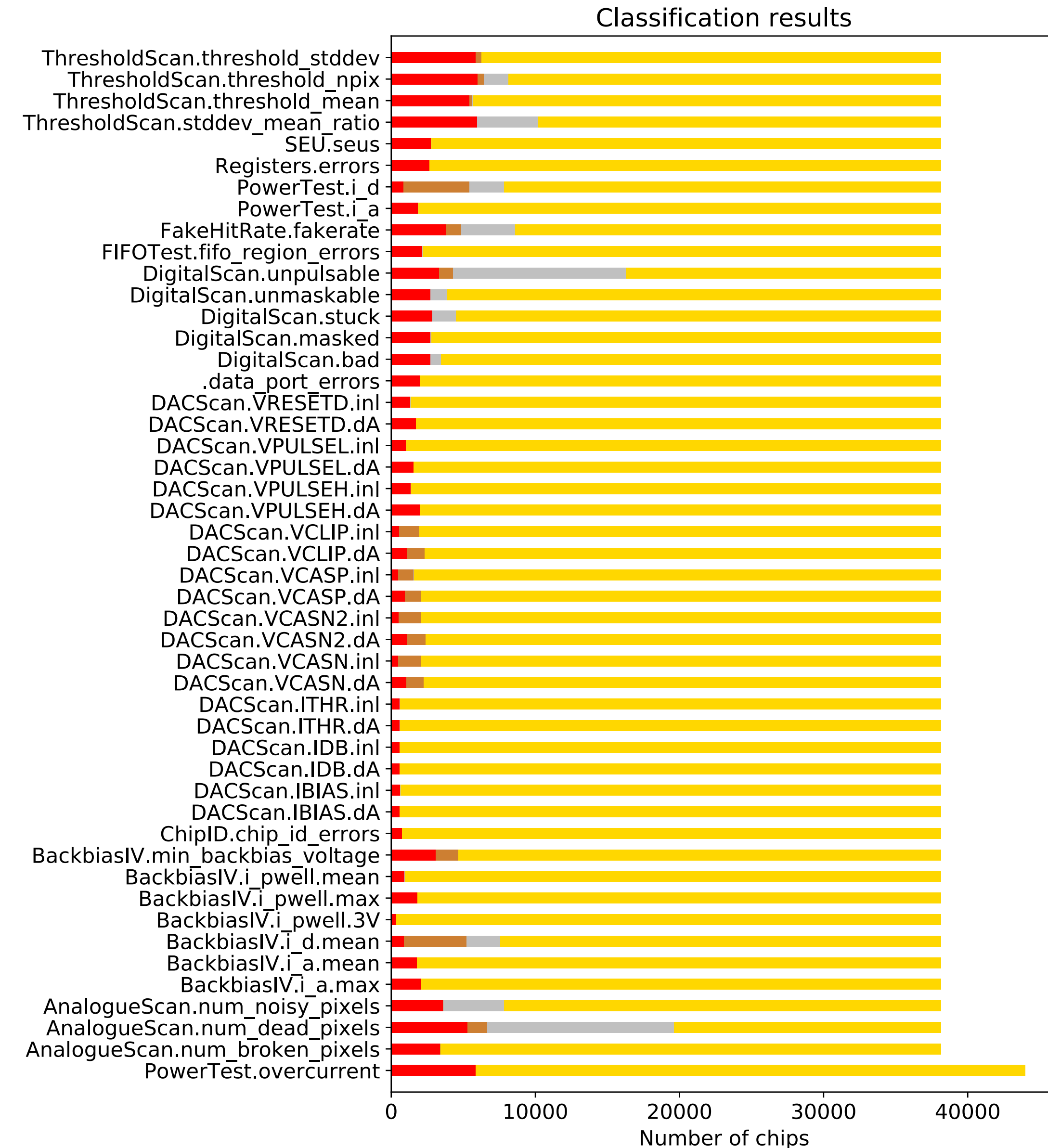


(Near) future

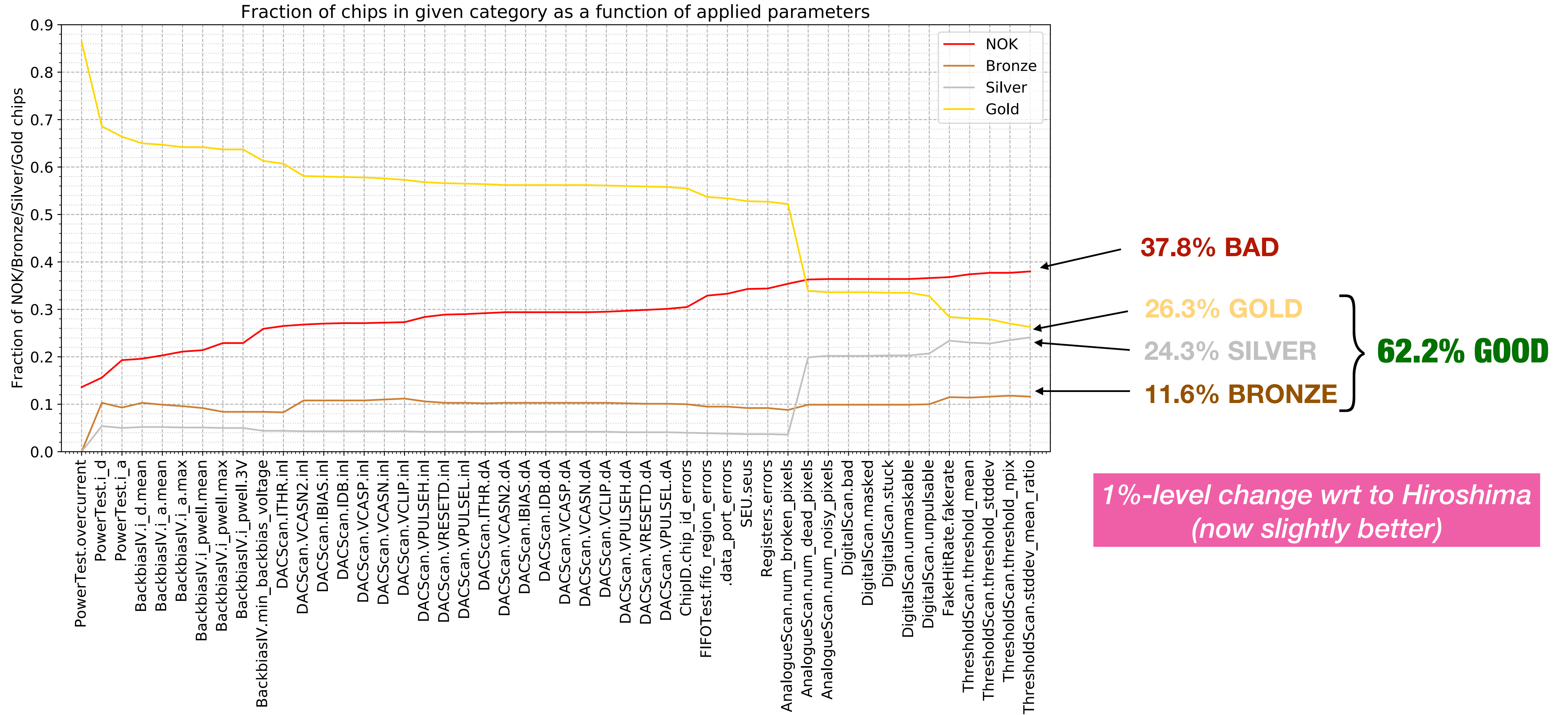
- ALPIDE production continues
 - Rely on Yonsei for full test if 100- μm chips
 - Team is prepared for 24/7 operation (including shifter housing)
- ➡ Congratulations to the Yonsei team for their smooth operation!

Yields

- Comprehensive yield extraction, tuned cut parameters
- document, constantly updated:
<https://www.overleaf.com/read/wkrmkcrjqtfsg>
- Classifying chips as:
 - GOLD:** for IB
 - SILVER:** for OB (also uses GOLD)
 - BRONZE:** for OB spares
 - BRONZE-NOVBB:** for OB spares?)
 - BAD:** rest (could be further split: into “powerable”, “short”)
- NB: IB and OB chips come from different pools and are not interchangeable (different thicknesses)



Yields summary



Distribution

- Smooth distribution to assembly sites
- After initial learning curve, packaging is done very well
- Delivery is in time and chips do not cause delays

```

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3 222717 CLOSED 2017-10-18 2017-10-20 CERN Liv. T704803 6.0 12423W606696940081
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```

> 100 shipments



Summary & Outlook

Satus

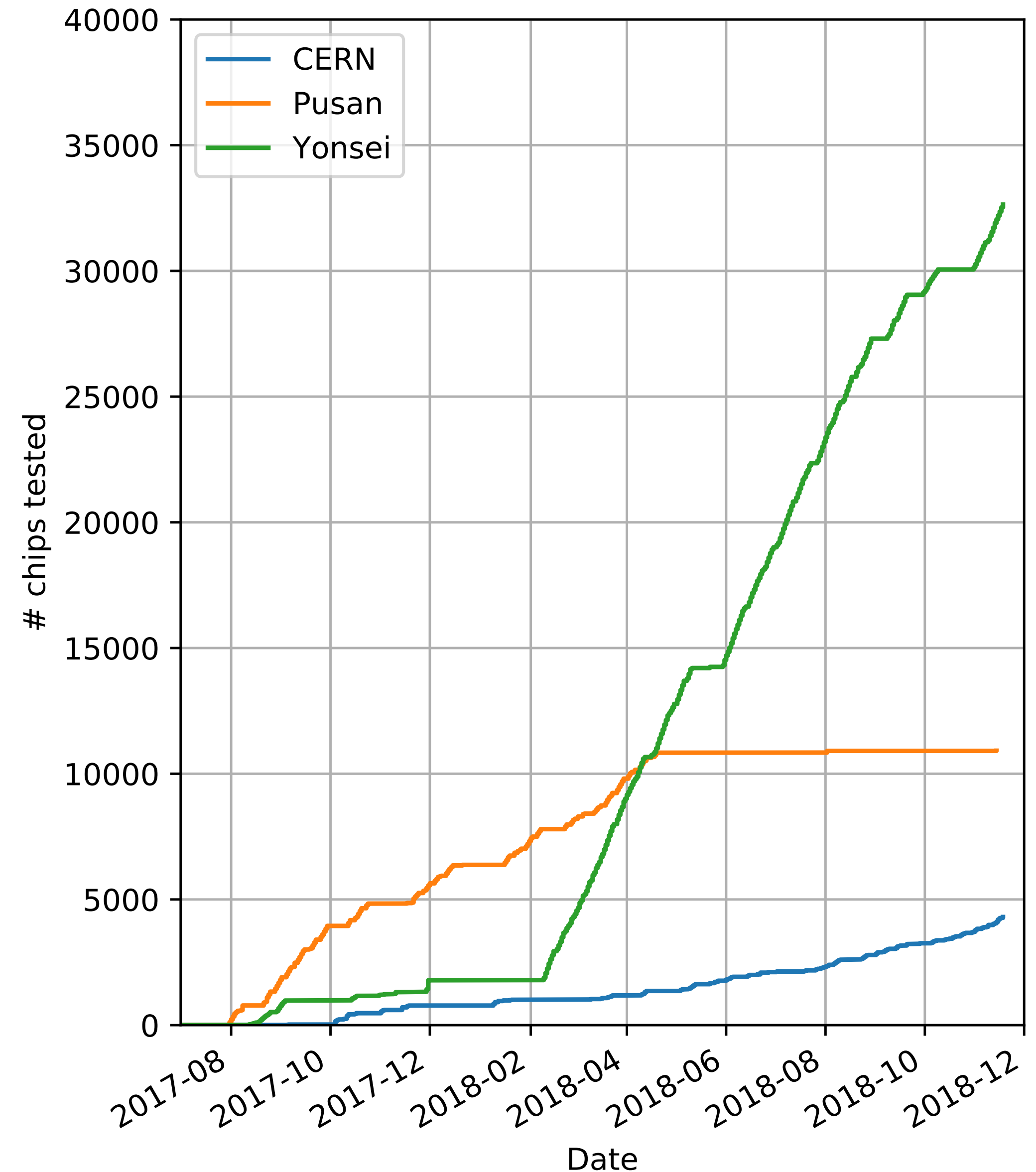
- ✓ **Wafer testing at CERN is completed**
- ✓ **50 μm chip tests at CERN ongoing**
 - **MFT has joined** testing on their machine (ALICIA-7)
- ✓ **100 μm chip tests in Pusan sopped** end-April 2018
 - very productive period
 - now focus on module production
- ✓ **100 μm chip tests in Yonsei started** in Feb 2018
 - smooth operation
 - faster than supply

Summary

- ✓ chip testing is a **very challenging** activity, involving
 - many people (shift crews, developers)
 - many custom made parts (hard-, firm-, software)
 - different institutes and companies
- ✓ we have already **produced** a lot of results
 - yield summary
 - distribution of chips for modules

Outlook

- ✓ Still a lot of work ahead of us. **Keep going!**



Summary & Outlook

Satus

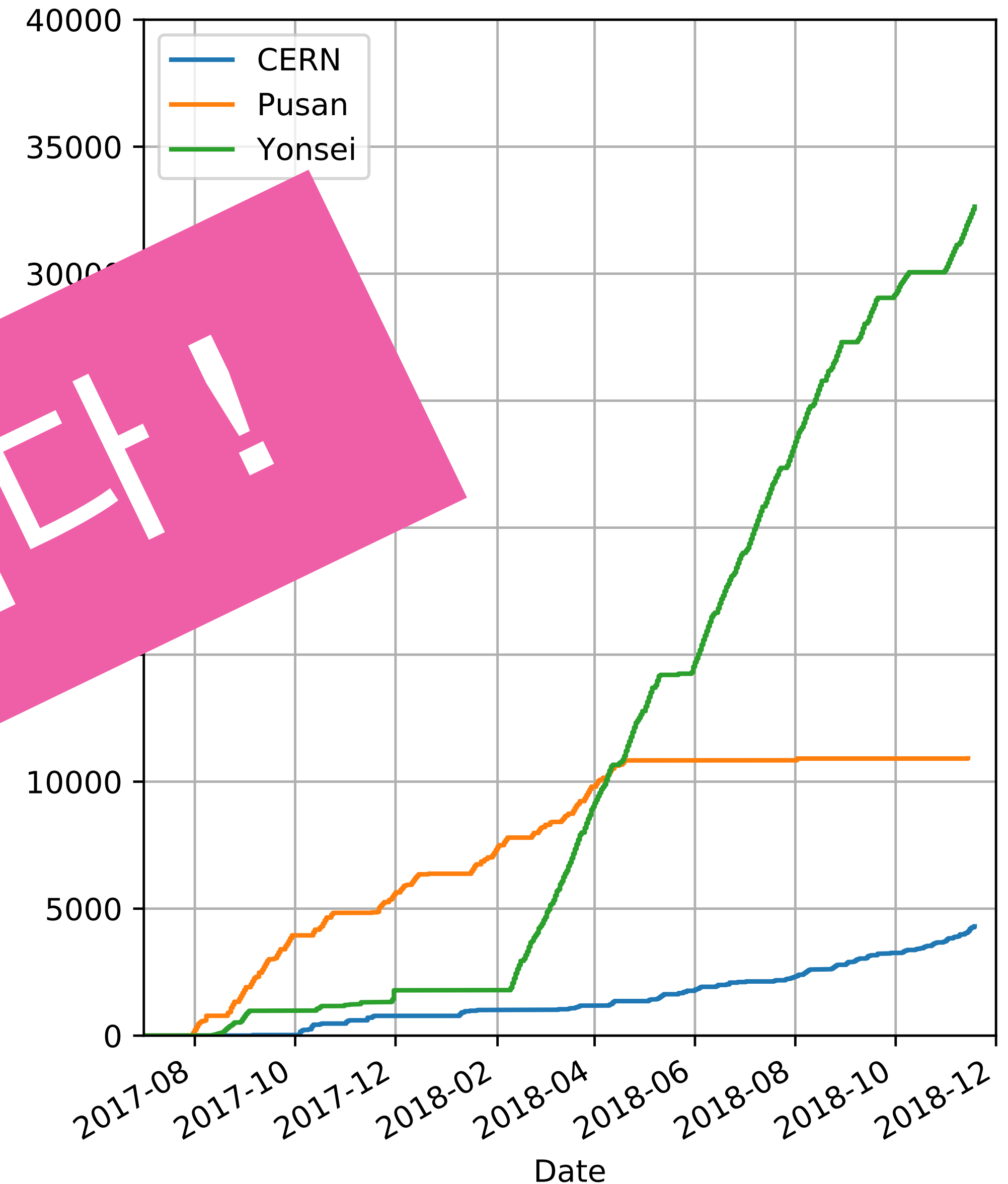
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50 μm -thick chip testing



Wafer probe testing



Wafer storage
Chip storage

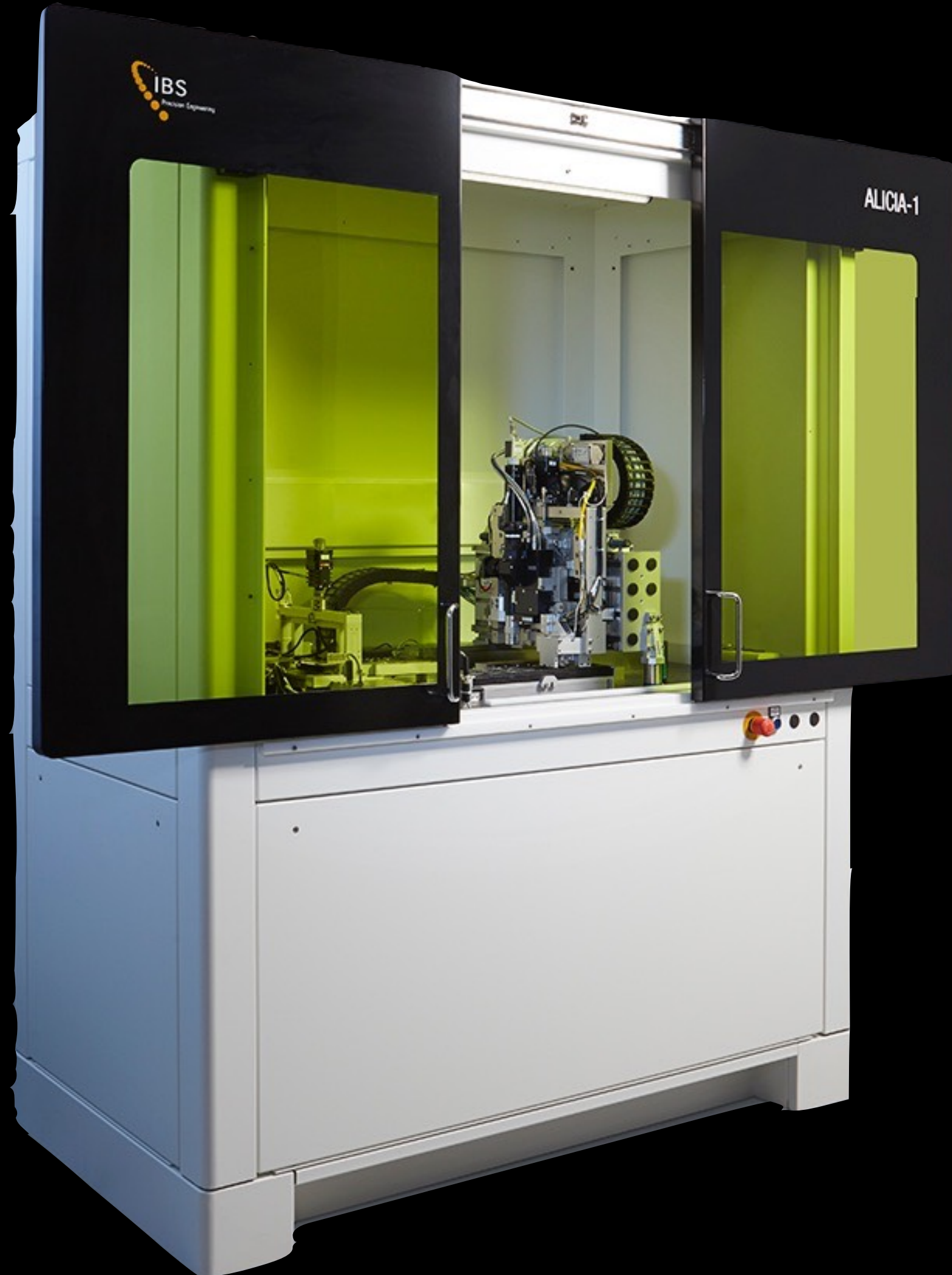
Wafer prober

Data base interface,
Logbook,
Monitoring

Clean room tent
(in clean room)



Inha/Pusan



Machine control

Database interface

Logbook, Monitoring



Chip storage

Tray preparation table



Database interface

Tray preparation table

Chip storage



Corea-YS-01

Vision system
Machine control



Remote control from office

Book keeping

- **Meetings:** <https://indico.cern.ch/category/7312/>
- **Database:** <https://alucms.web.cern.ch> (website),
<https://alucmsapi.web.cern.ch/AlucmswebAPI.asmx> (API)
- **EOS:** <https://cern.ch/alpide>
- **Logbook:** <https://alpide.cern.ch/logbook/>
- **TWiki:** <https://twiki.cern.ch/twiki/bin/view/ALICE/ITSUpgradeProbeCard3>
- **overleaf:** <https://www.overleaf.com/read/wkmcrcrjqtfsq>

Oct 2016

- Chip deliveries for machine commissioning
- Still using old foam trays

