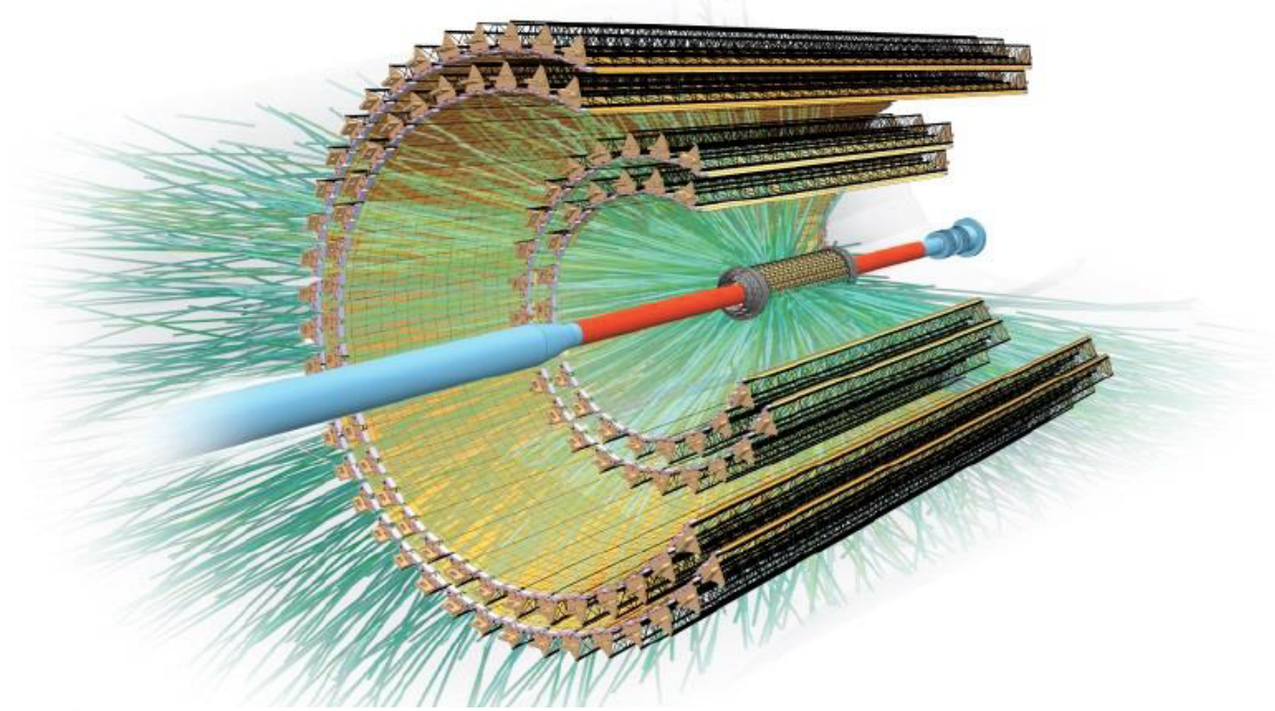
The ALICE ITS Upgrade

In-Kwon YOO - Pusan National Univ.
for ALICE collaboration



ICHEP2018 SEOUL
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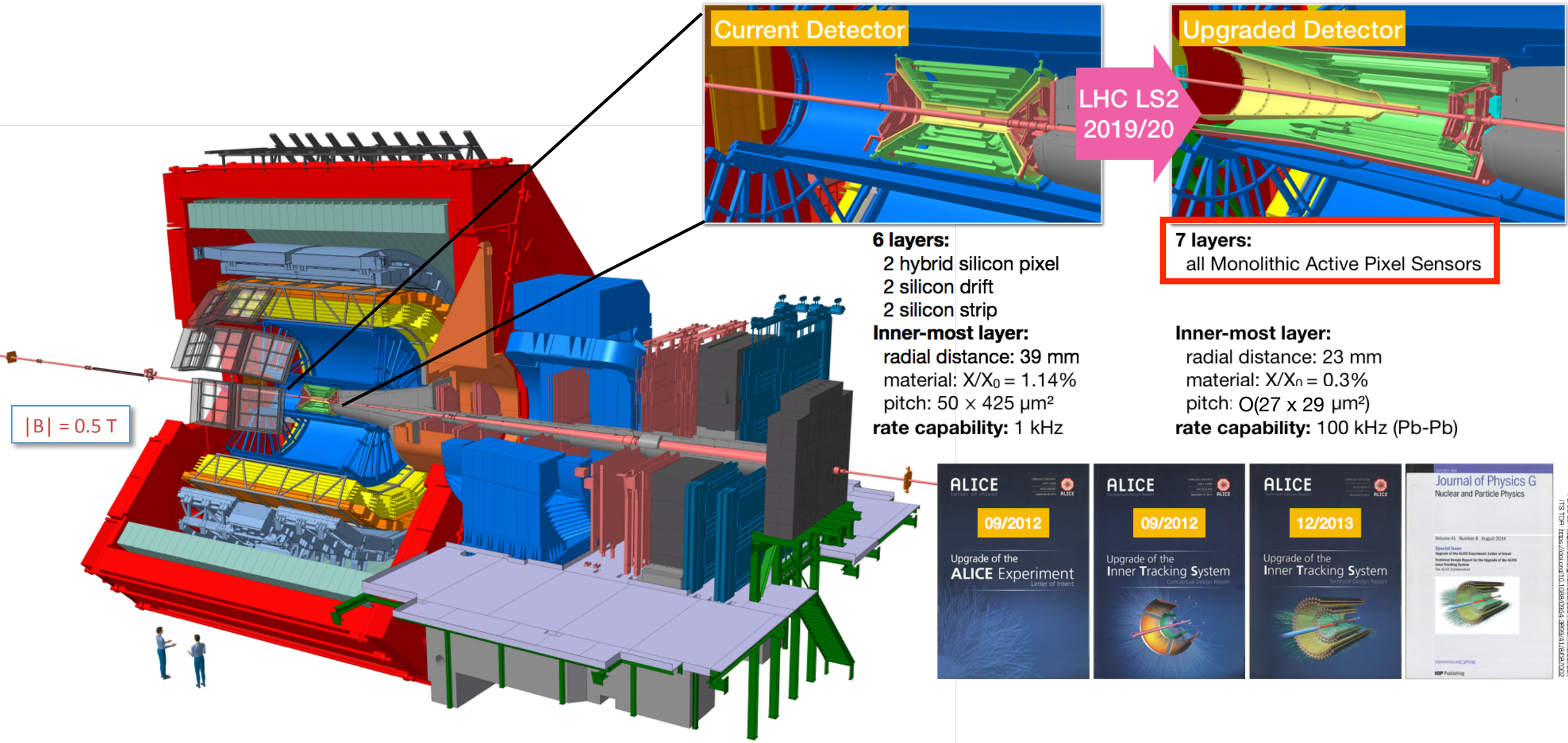
high energy

A New ALICE Inner Tracking System (ITS) with NEW CMOS MAPS

New Inner Tracking System (ITS)

- **Novel Monolithic Active Pixel Sensors (MAPS) Technology**
- **CMOS Pixels**

➡ **improved resolution, less material, faster readout**

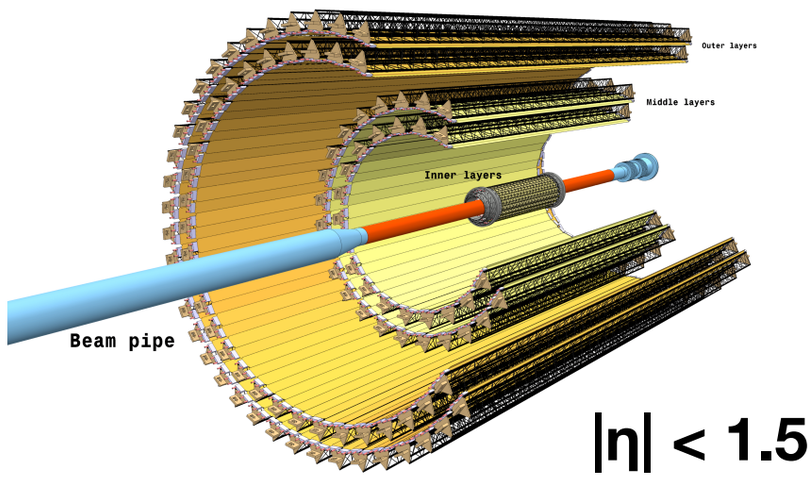


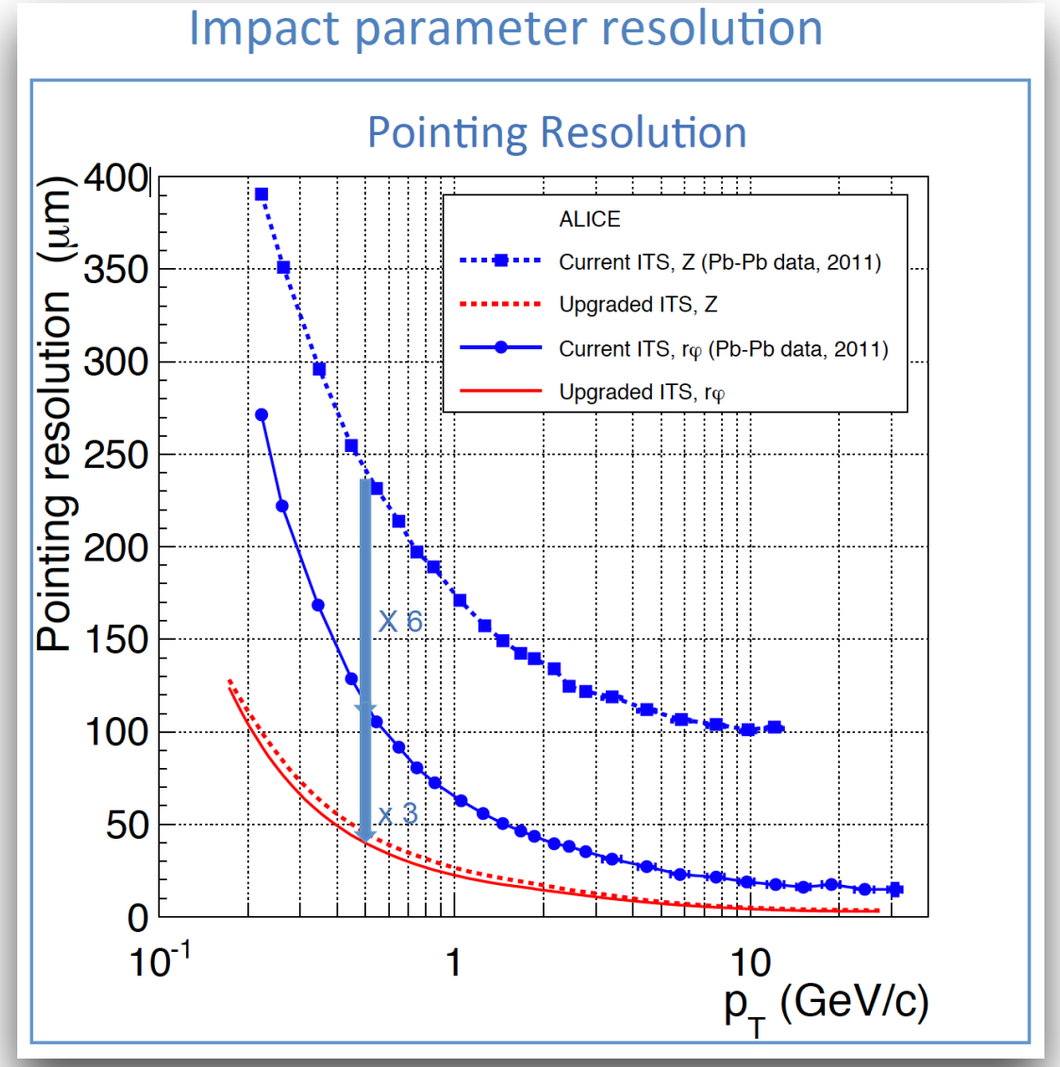
6 layers:
2 hybrid silicon pixel
2 silicon drift
2 silicon strip
Inner-most layer:
radial distance: 39 mm
material: $X/X_0 = 1.14\%$
pitch: 50 × 425 μm²
rate capability: 1 kHz

7 layers:
all Monolithic Active Pixel Sensors

Inner-most layer:
radial distance: 23 mm
material: $X/X_0 = 0.3\%$
pitch: O(27 x 29 μm²)
rate capability: 100 kHz (Pb-Pb)

Closer to IP, Thinner, Higher Granularity & Faster RO

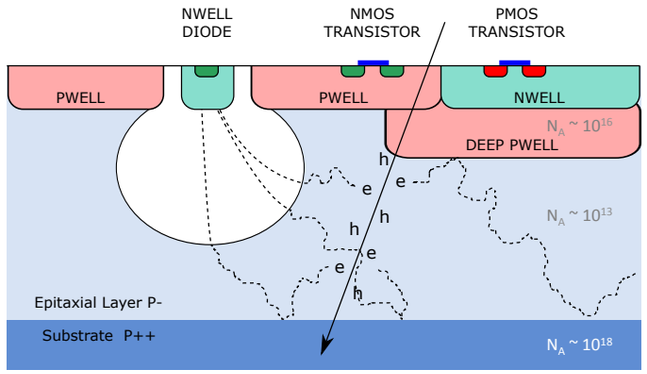


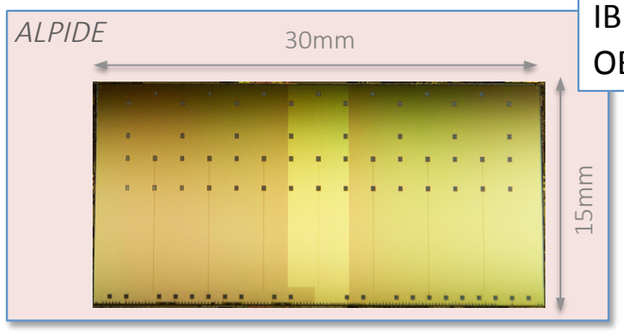


- Closer to IP: 39 - 430mm ➤ 22 - 400mm
- Thinner (X/X0): ~1.14% ➤ ~0.3% (inner)
- Smaller pixel: 50μm x 425μm ➤ 27μm x 29μm
- Higher Granularity (x10³): 20 Ch/cm³ ➤ 2k Pxl/cm³
- **10 m² active area of 12.5 GPxl with σ ~ 5 μm**
- Fast readout: 1 kHz (1kHz) in PbPb (pp) ➤ 100 kHz (400kHz) in PbPb (pp)
- ALice PIxel DEtector (ALPIDE) for other projects as well: MPD@NICA.JINR, sPHENIX@RHIC.BNL and Proton Therapy Tracking etc.

ALPIDE (ALice PIxel DEtector)

- CMOS Pixel Sensor using 0.18μm CMOS Imaging Process
  - High-resistivity (>1kΩ · cm) p-type epitaxial layer (25μm) on p-type substrate
  - Small n-well diode (2μm ϕ) ~ low capacitance (fF)
  - $-6V < V_{BB} < 0V$ to increase depletion zone around n-well diode
  - Deep p-well shields n-well of PMOS transistors
- Full CMOS circuitry within active area

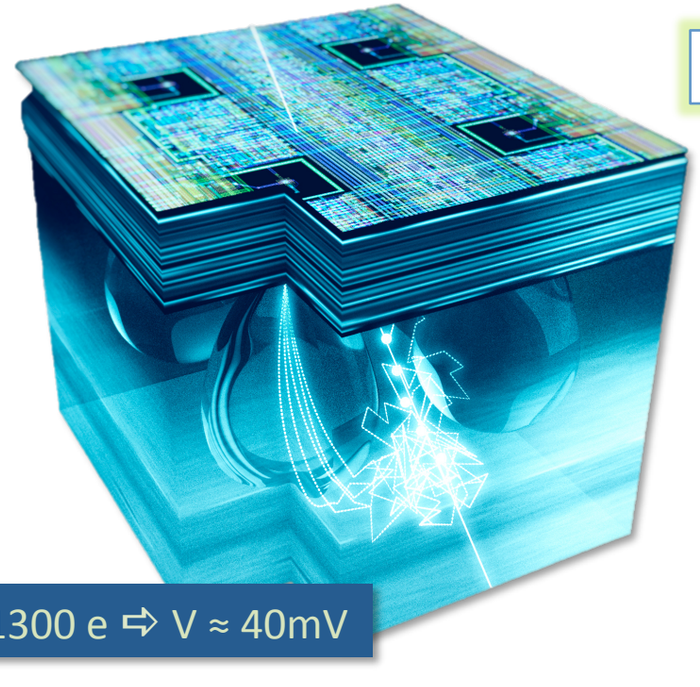




IB: 50μm thick
OB: 100μm thick

- Pixel: 27 x 29 x 25 μm³
- 130 000 pixels/cm² ~ Total 10m², 12.5 G-pixels
- Spatial resolution ~ 5μm in 3D
- Max. particle rate: 100MHz/cm²
- fake-hit rate ~ 10^{-10} pixel/event
- Power ~ 300 nW/pixel

2 x 2 pixel volume

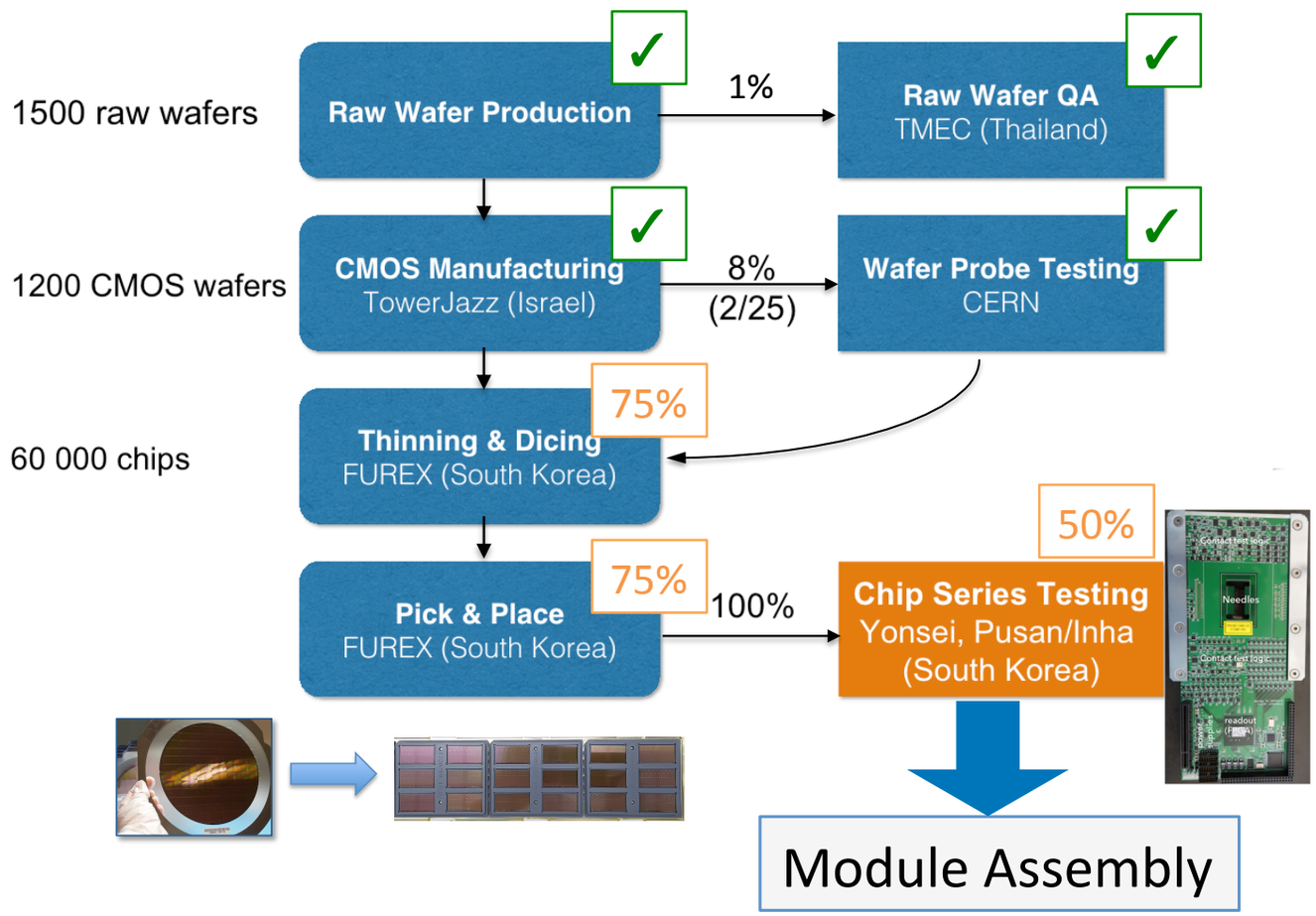


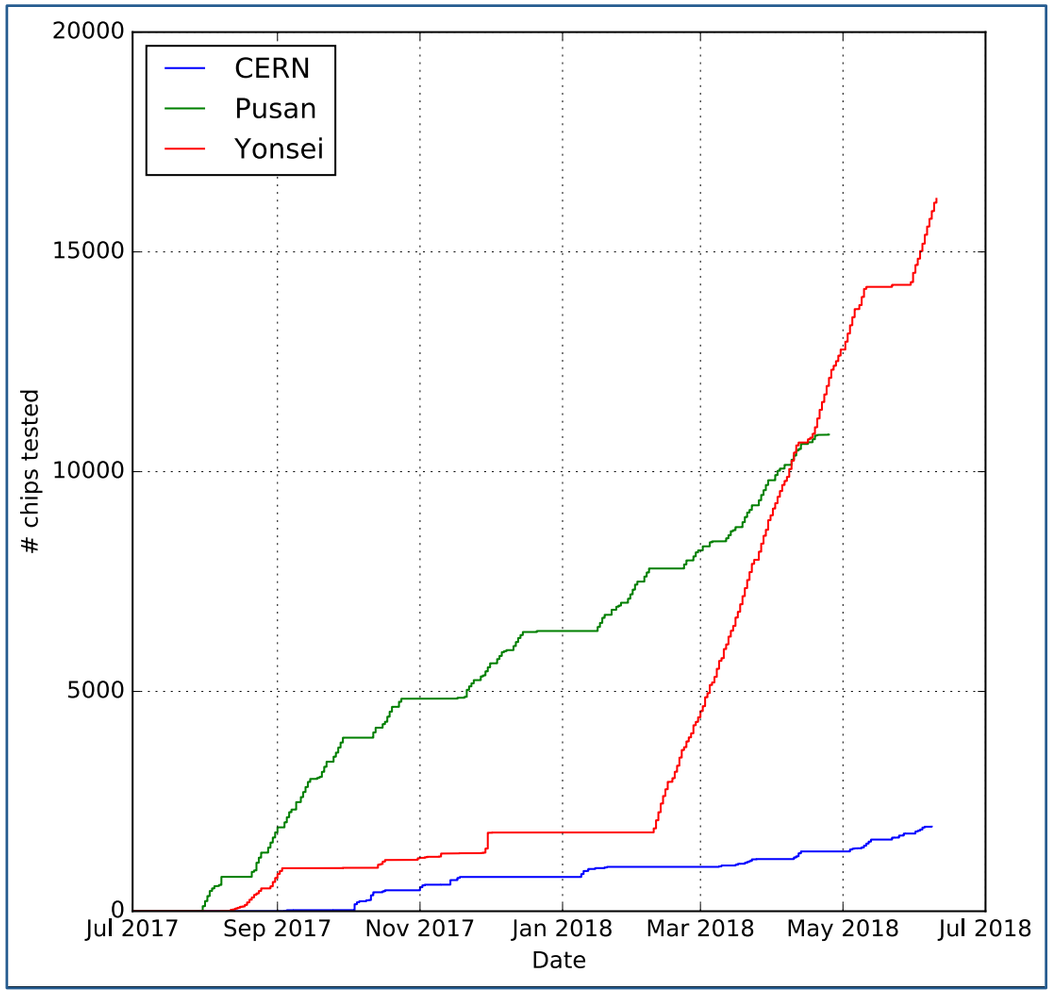
0.3 pJ / bit

$C_{in} \approx 5$ fF

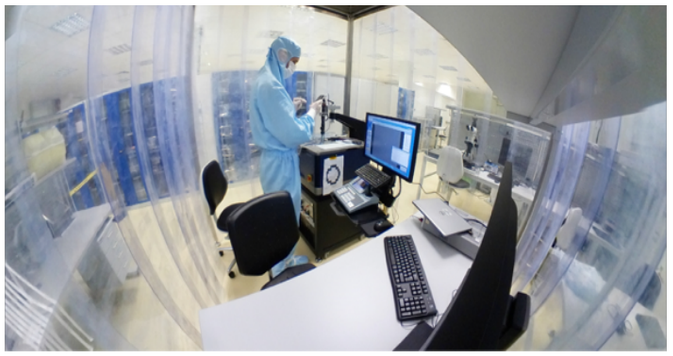
Q_{in} (MIP) ≈ 1300 e ⇨ V ≈ 40mV

ALPIDE Production and Test Flow



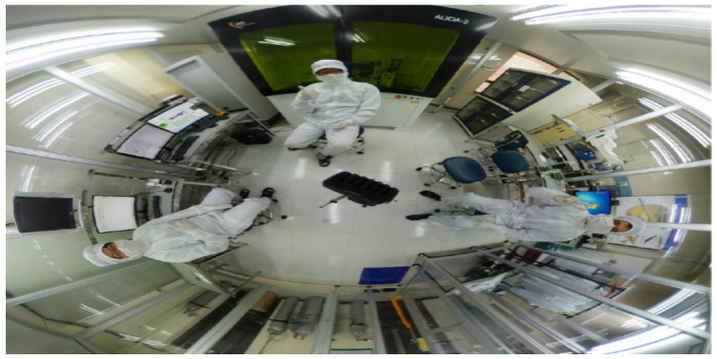


CERN



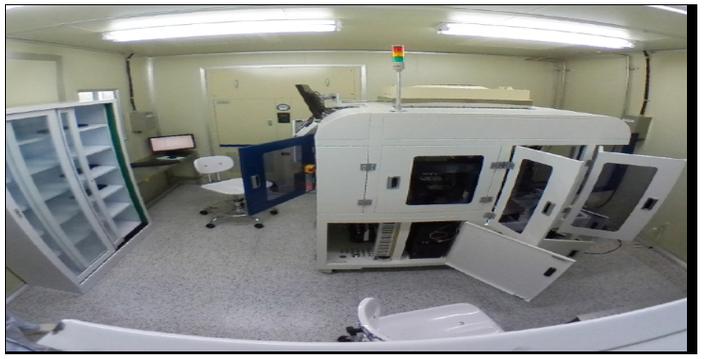
- **50-μm** chip testing: running
- wafer testing: done

Pusan/Inha



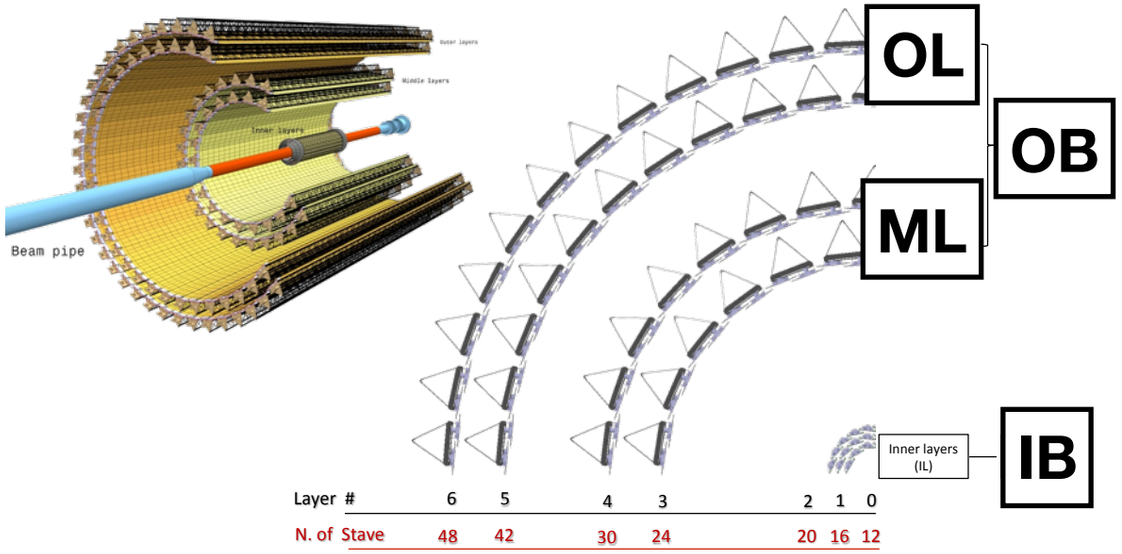
- **100-μm** chip testing: done (end-Apr.'18)
- (switchover to HIC construction)
- Backup site

Yonsei



- **100-μm** chip testing: running
- Working schedule: 24/7
- Test rate: 26 wafers/week
- Smooth operation

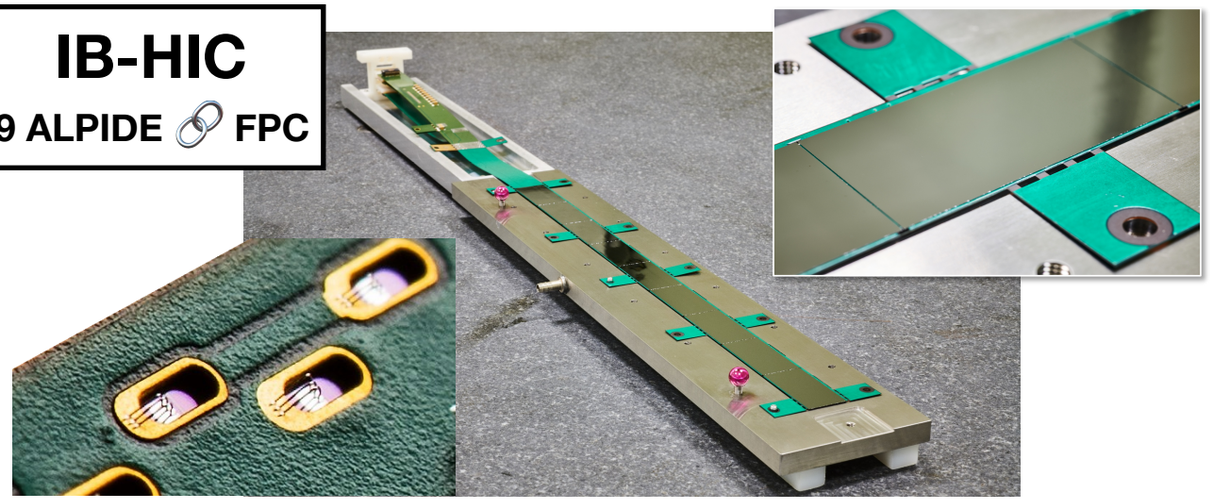
Detector Barrel Staves (IB)



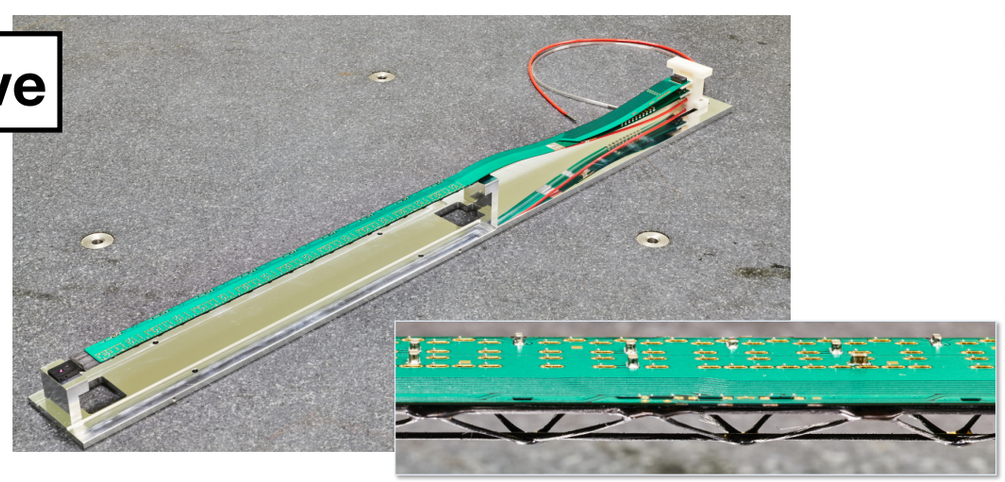
- 7 layers: 3(IB with 50μm-chips), 4(OB with 100μm-chips)
- 192 staves: 48(IL), 54(ML), 90(OL)

IB Q.ty to build: 48 (one full IB) + 48 (spare IB) + 12 (spares)

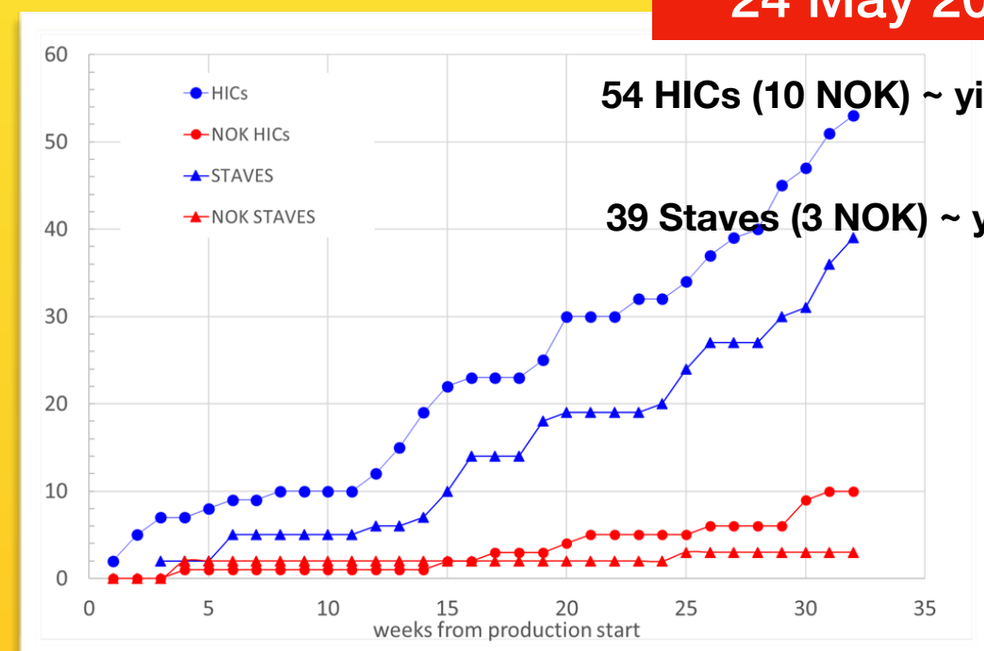
IB-HIC
9 ALPIDE 🔗 FPC

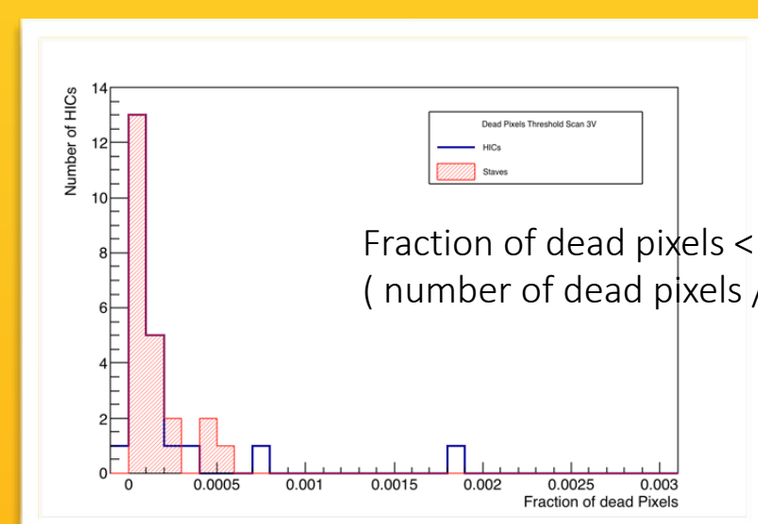


IB-Stave



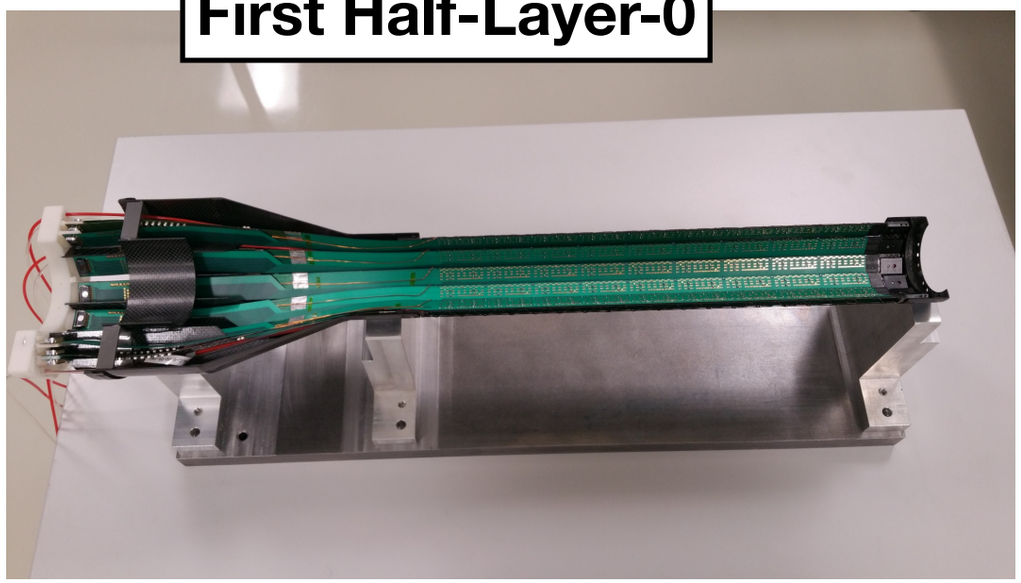
24 May 2018





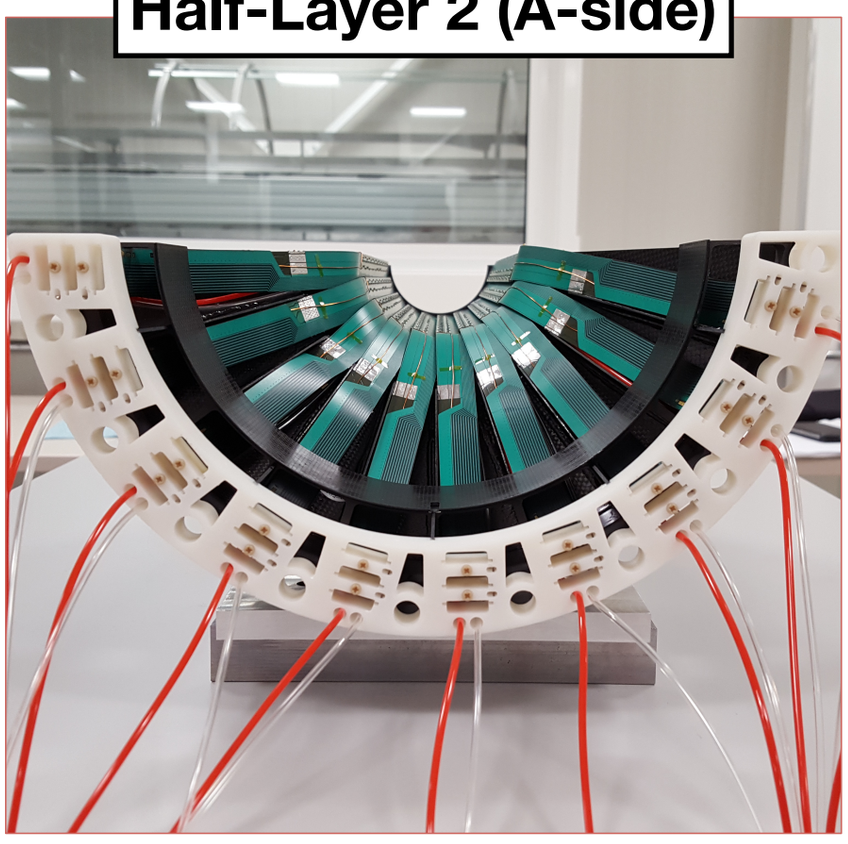
Detector Barrel Staves (IB)

First Half-Layer-0

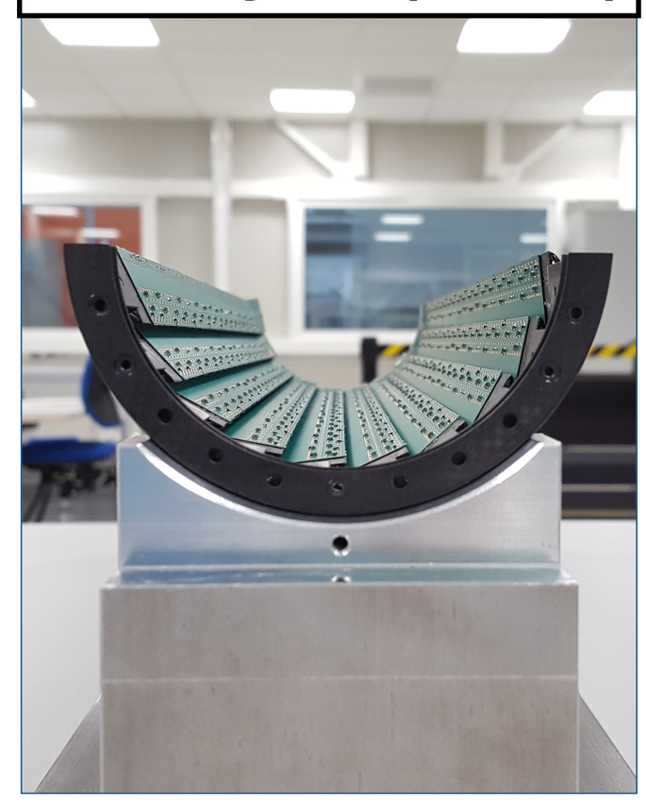


First Inner Half-Barrels

Half-Layer 2 (A-side)



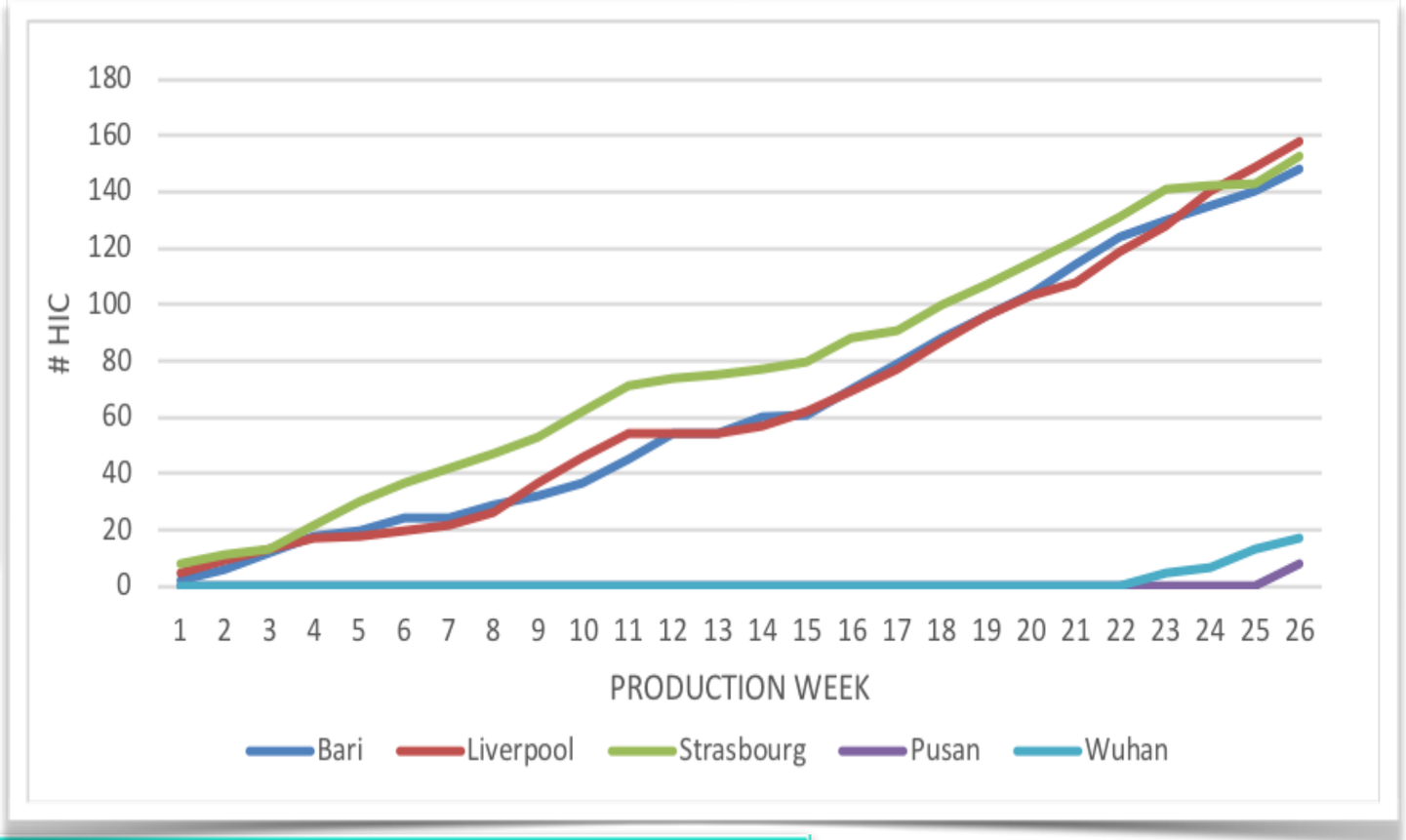
Half-Layer 2 (C-side)



Detector Barrel Staves (OB)

OB-HIC

- 2115 to be produced ➔ 1692 (assuming 80% yield)
- Where: Bari, Liverpool, Pusan/Inha, Strasbourg, Wuhan
- Prod. rate: 2 HICs/day



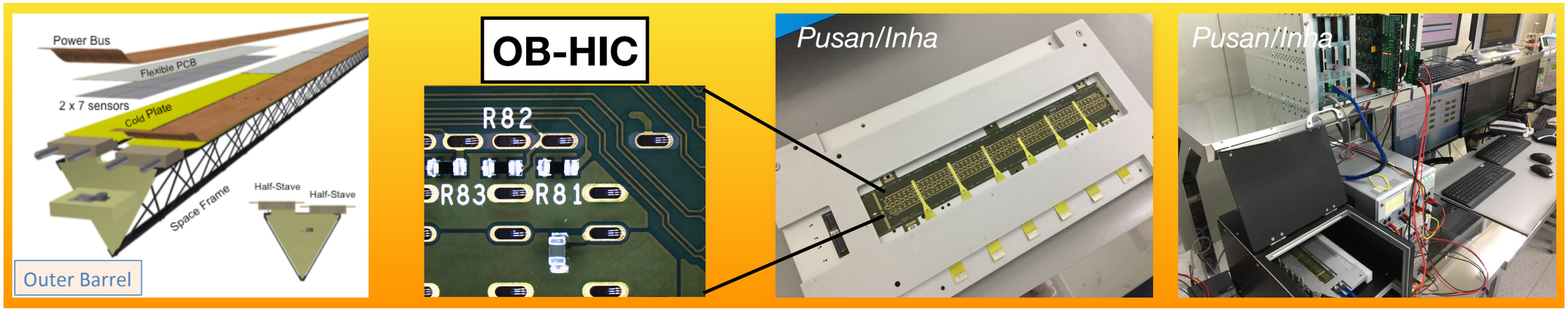
OB-Stave

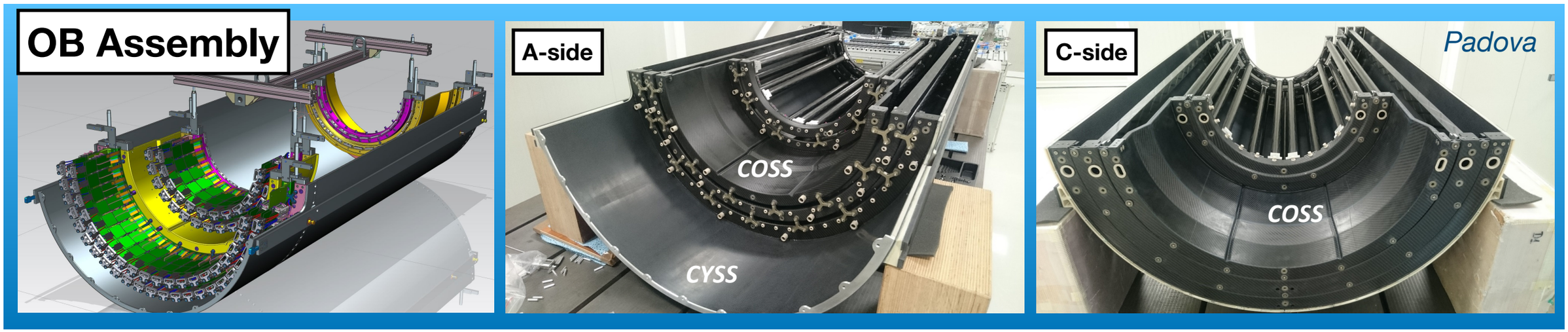
- Where: Torino, Frascati, Daresbury, Nikhef (OL) and Berkley (ML)

year	working weeks	nominal rate per week OL	nominal rate per week ML	stave produced per OL	stave produced per ML
2018	52	1.4	0.7	72.8	36.4
2019	30	1.4	0.7	42	21

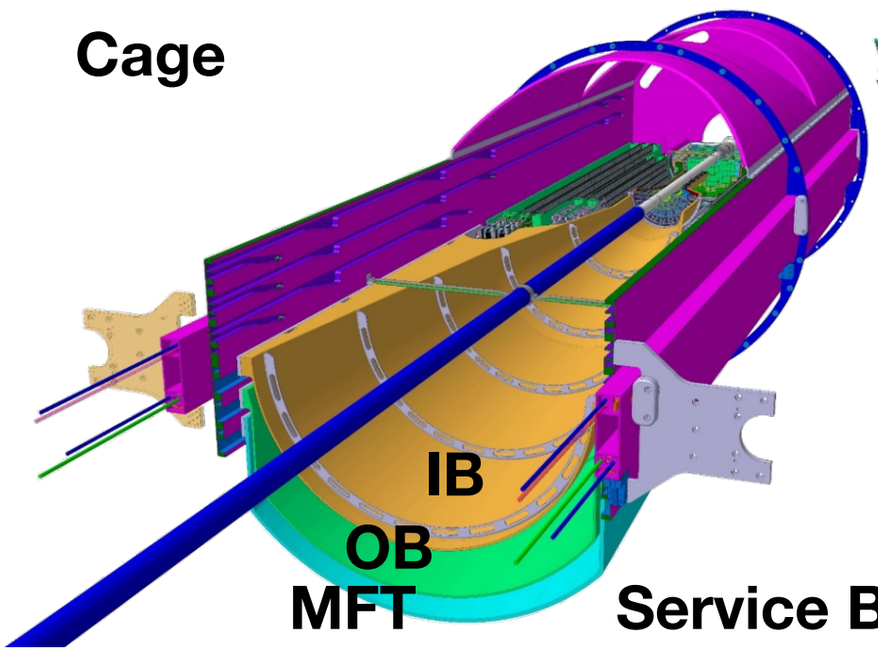
Total (90% yield) **OL: 114.8 (109)** **ML: 57.4 (54.5)**

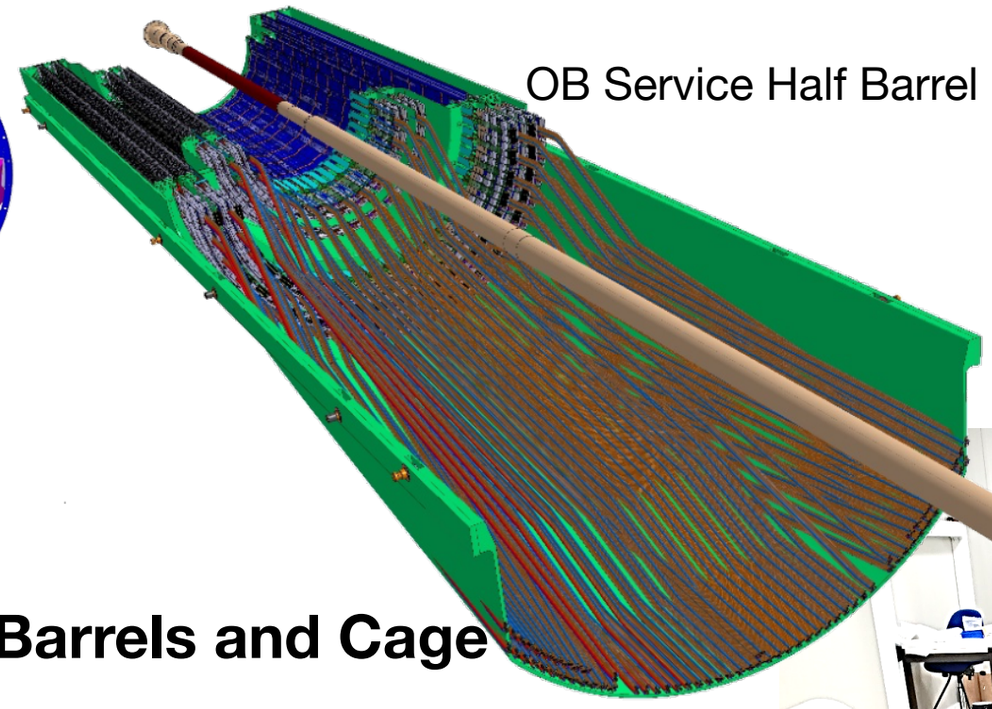
Detector Barrel Staves (OB)



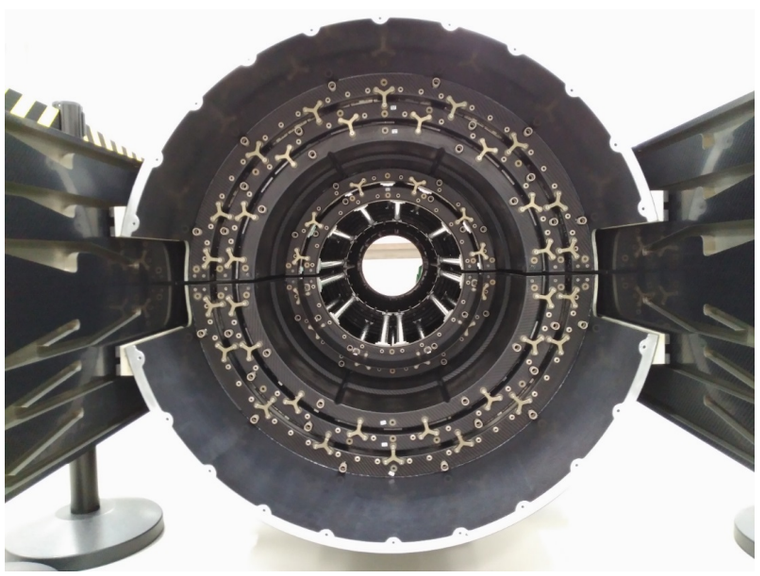


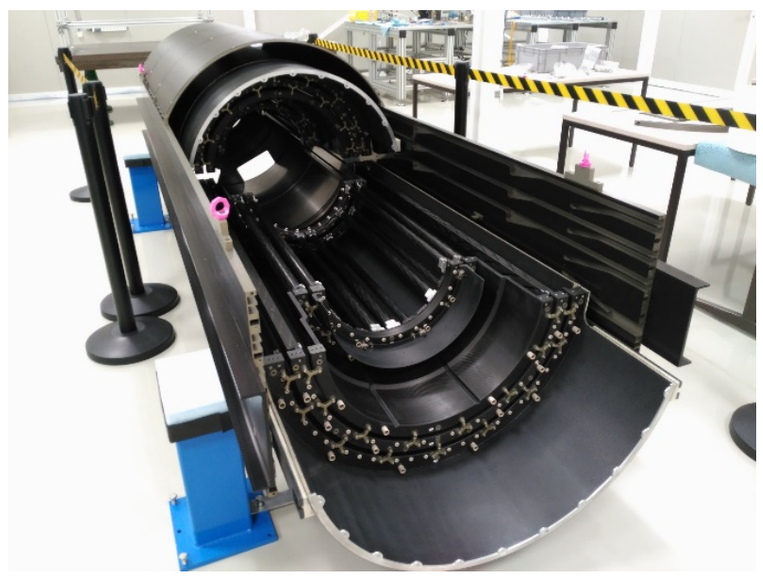
Service Barrel and Cage: Dry Assembly and Insertion Tests: IB and OB

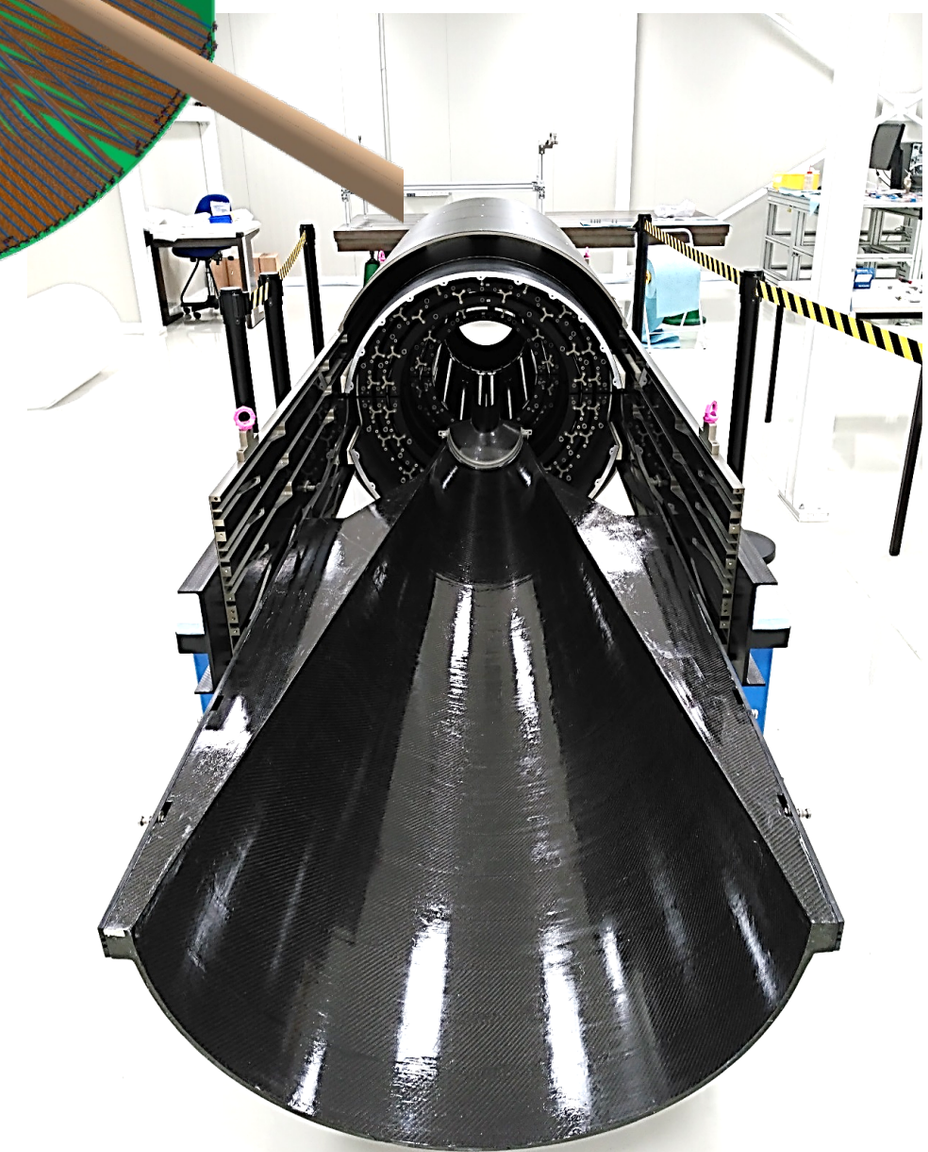




Service Barrels and Cage

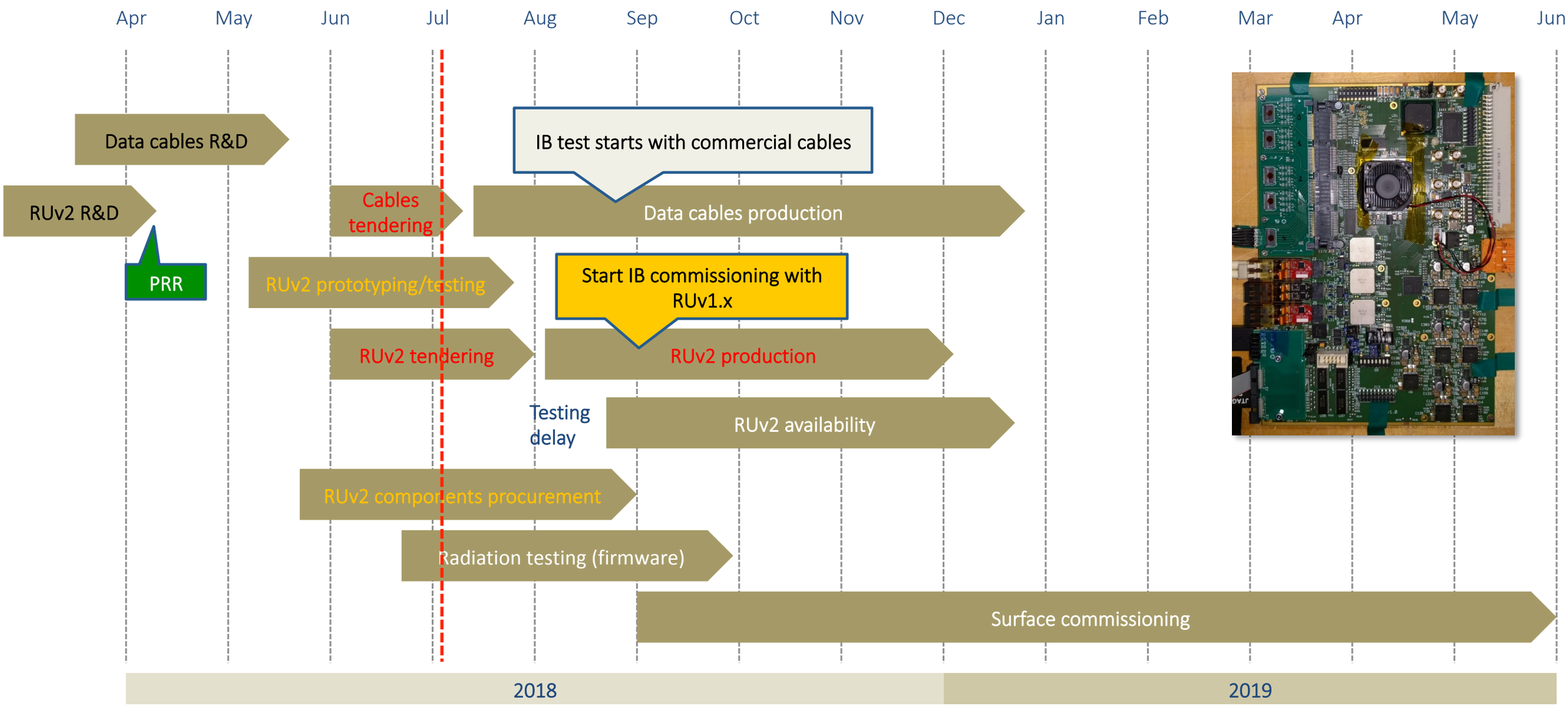




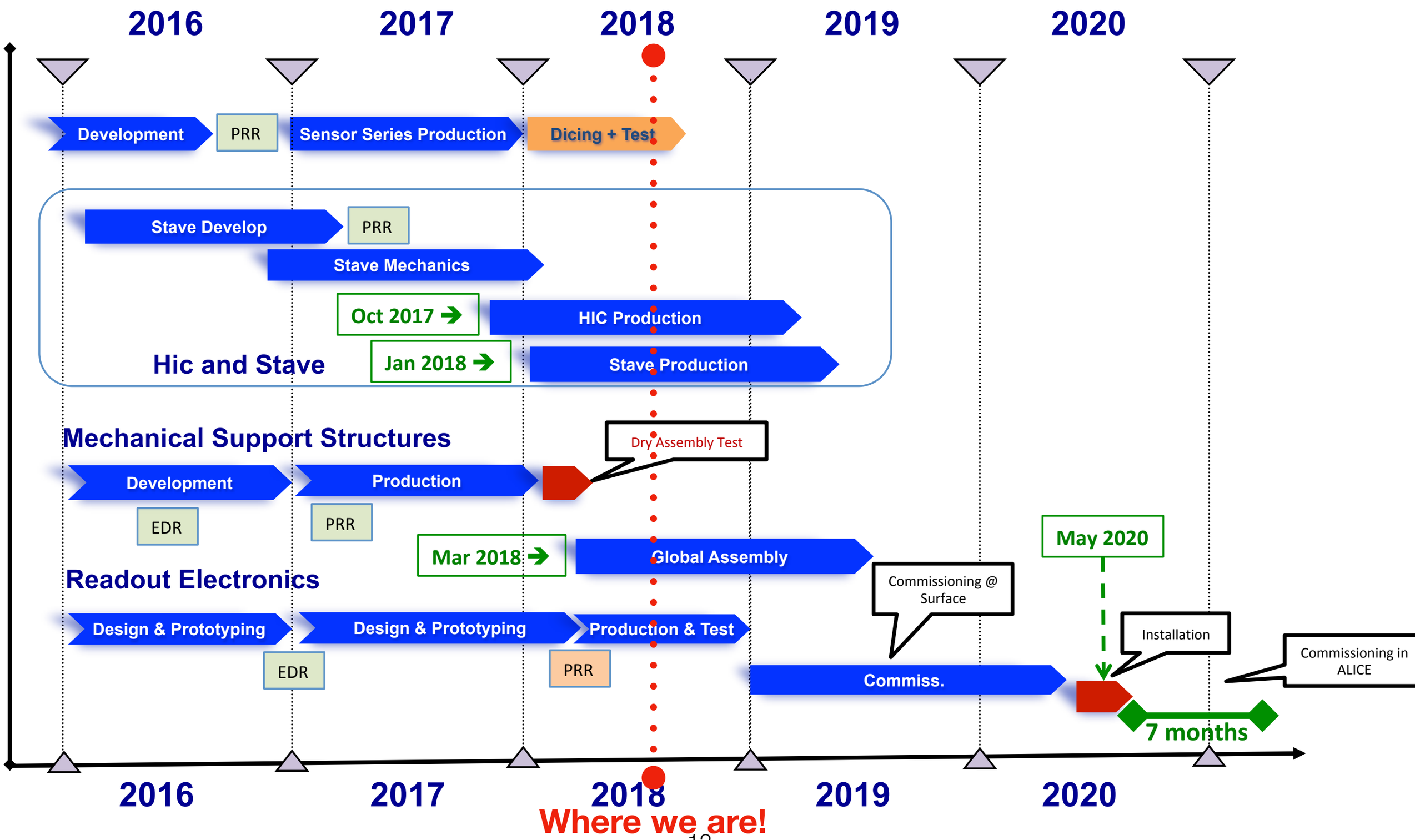


Electronics - Readout Unit Production

- Development Completed
- Production of RUv2 (222 boards + 88 for MFT) will take 3-4 months (batched)



Overall ITS Planning



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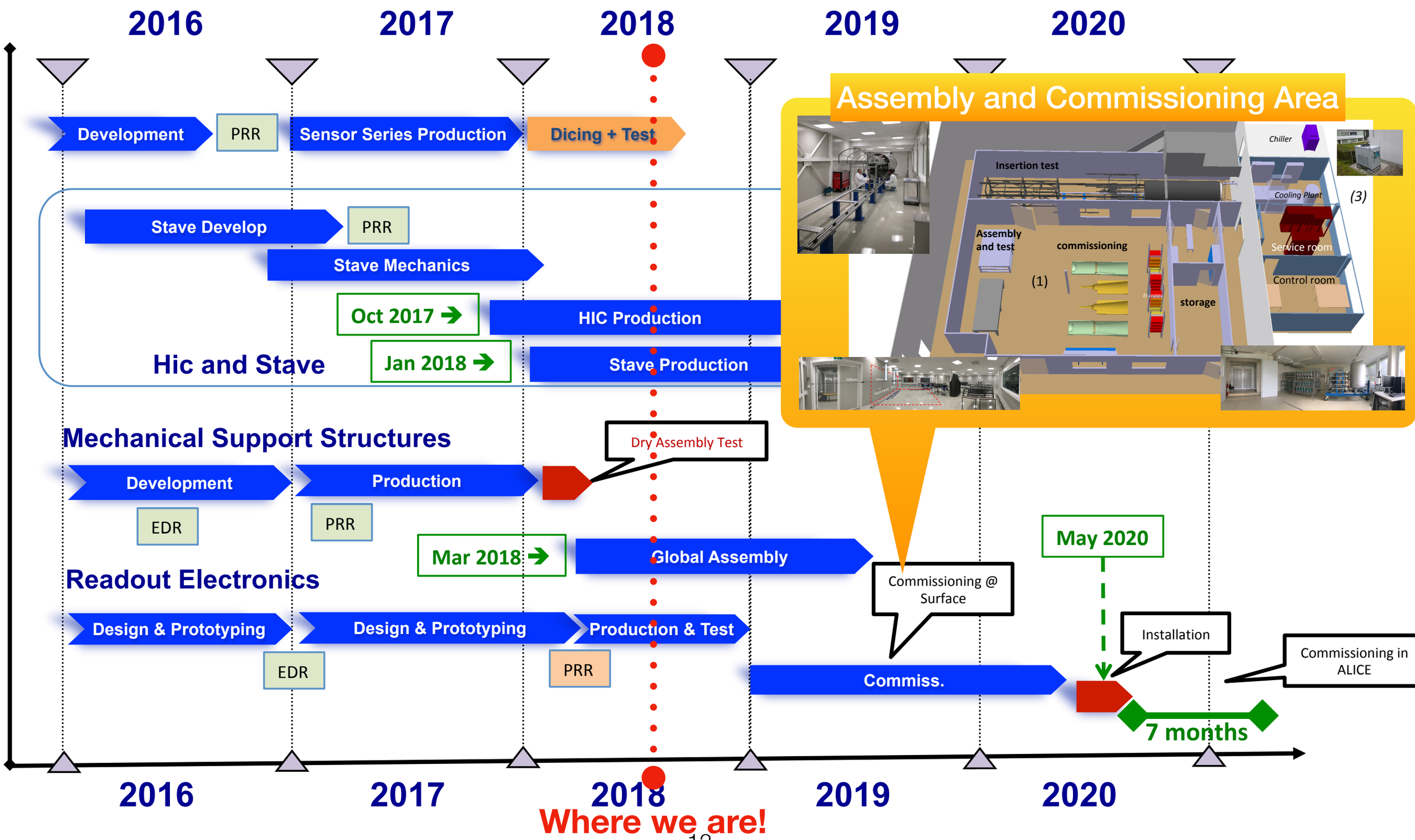
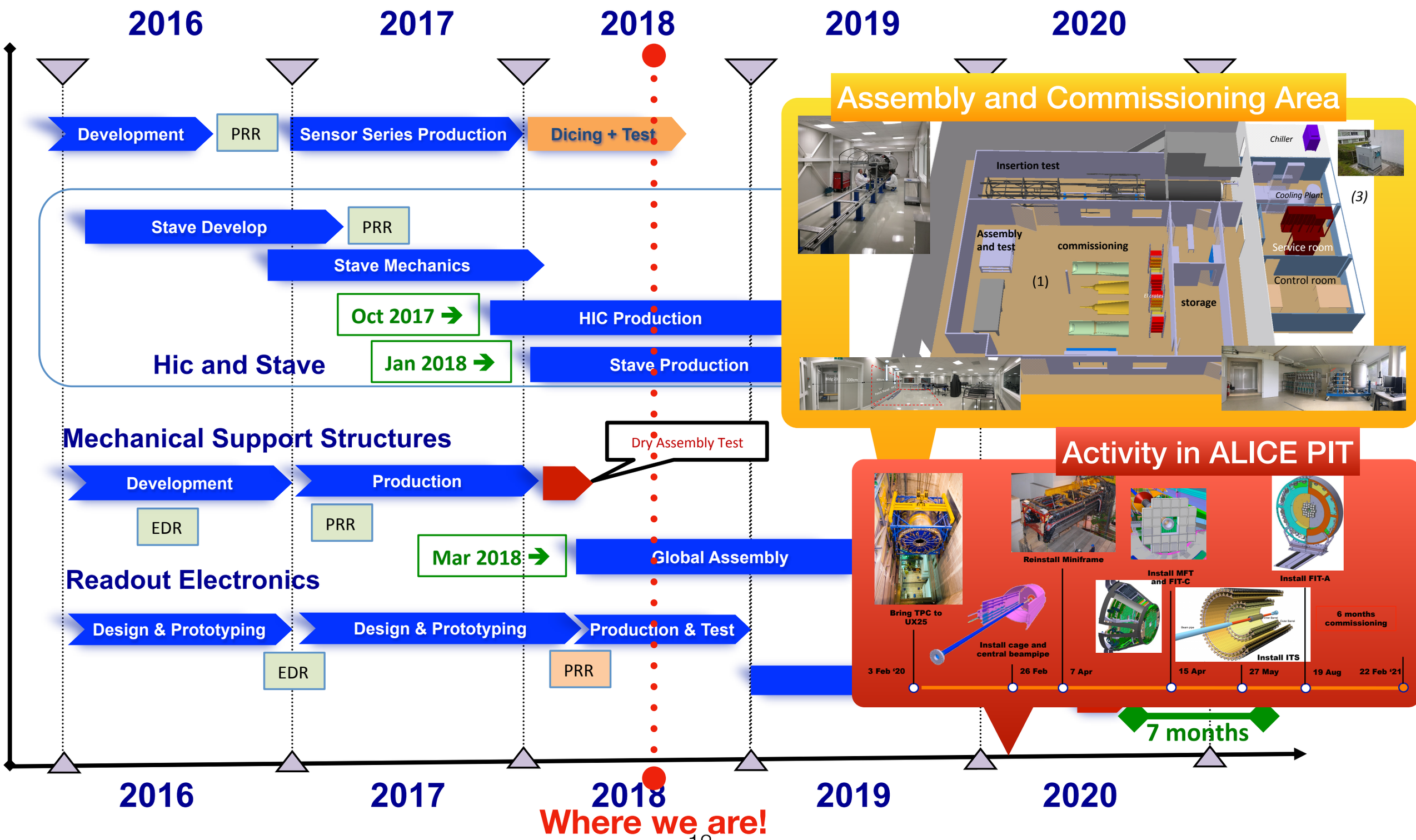


Overall ITS Planning



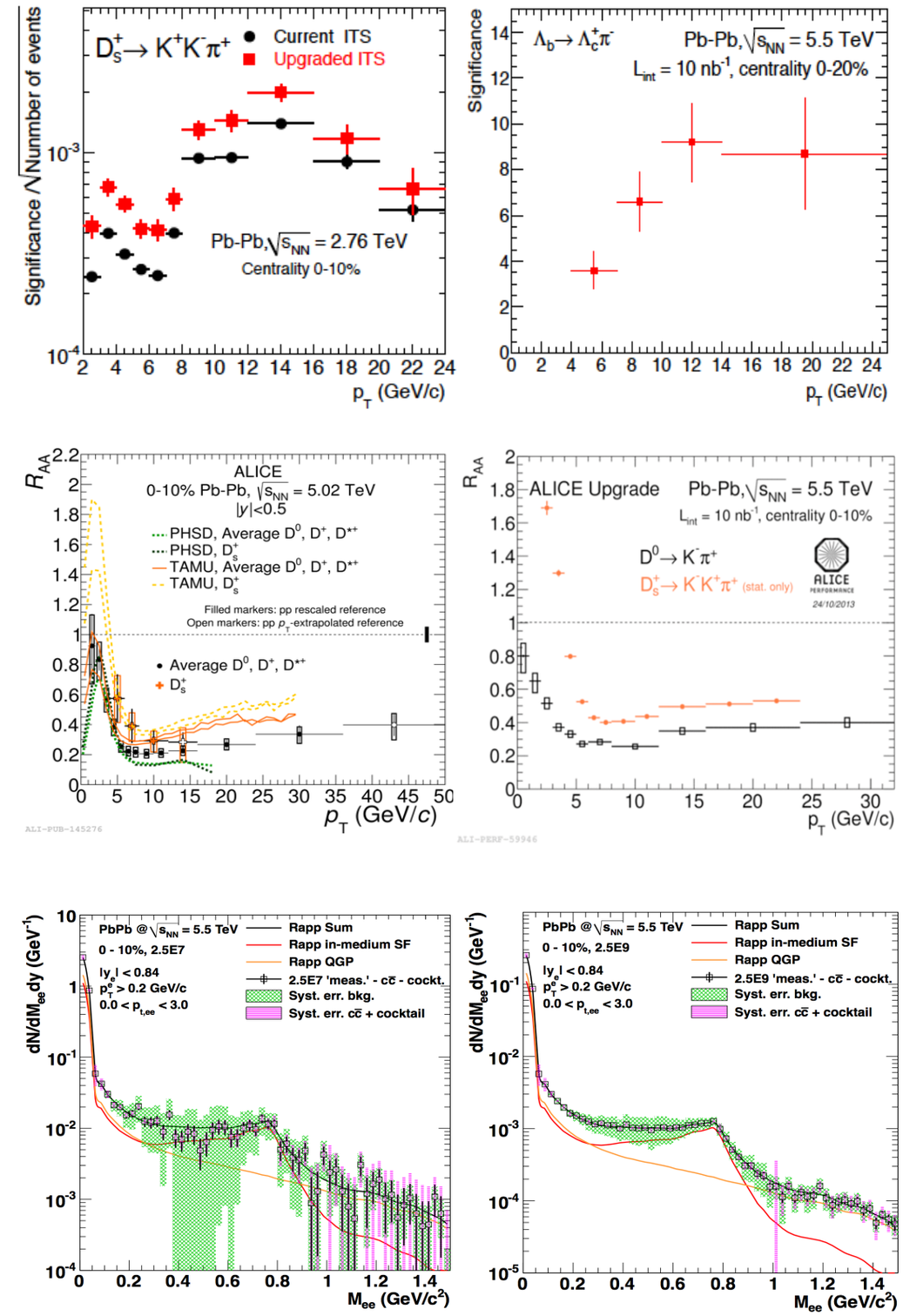
Physics Performance expected in RUN3&4

- ITS - TPC Upgrades ➔ Enhanced tracking

- Heavy-Flavor Production
  - Open Charm (D, Λ_c) / Beauty (B, Λ_b)
  - Strange/non-strange Charm
  - Flavor dependent R_{AA} in low p_T

- Low Mass di-electrons
  - Reduced uncertainty (Photon-Conversion BG)
  - Initial Temperature from EM radiation

- Hypernuclei $^{3}_{\Lambda}H$ $^{4}_{\Lambda}H$ $^{3}_{\Lambda}He$



감사합니다.