Development of next generation particle beam telescope using OBELIX chips

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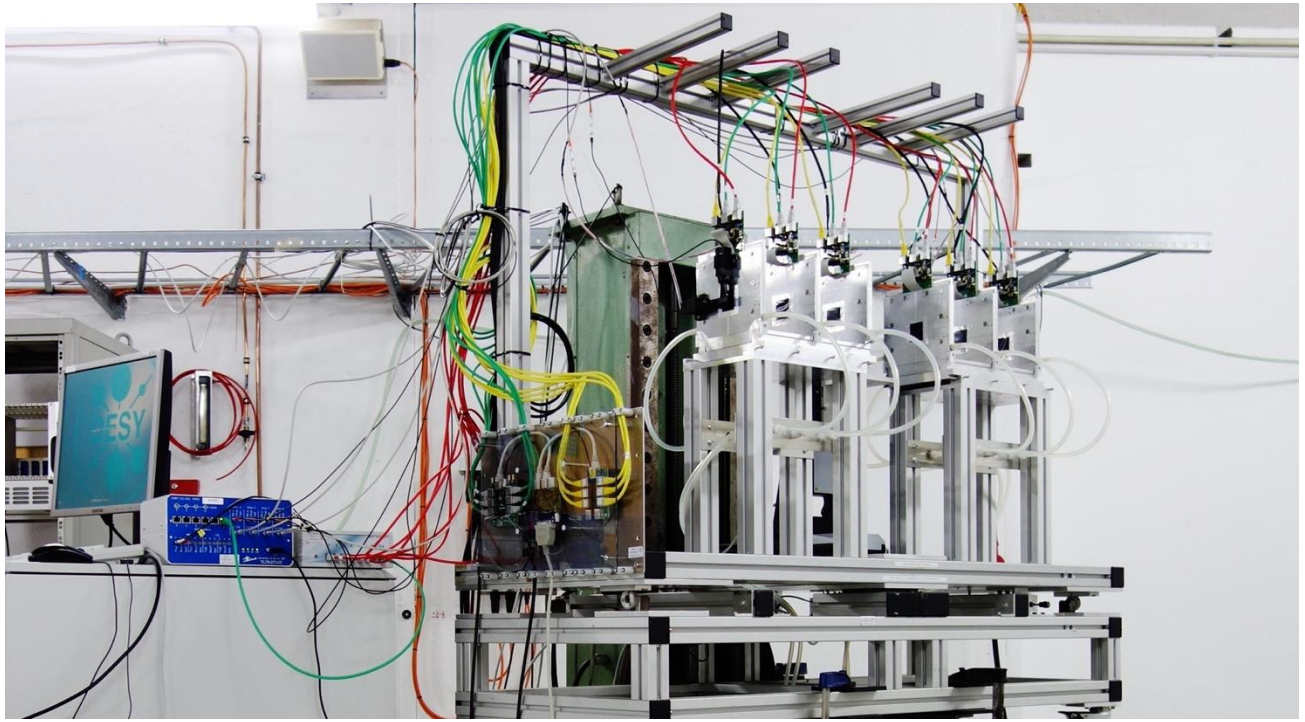
OBELIX-based Telescope

Intelligent, thin, fine-pitch vertex detector prototype in the context of a *full* e^+e^- tracker demonstrator design

→ In other words: A large area (multi-chip assemblies) DMAPS particle beam telescope



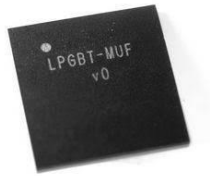
Bring the existing infrastructure to the next level, together with a number of international partners:

- 6 large area high-resolution detector planes
- DAQ and TRG
- Compact integration
- Software, monitoring, interlocks, …

Plan to request a permanent location at CERN SPS H6 line and a copy for the new test beam line at KEK. DESY test beam infrastructure for development and commissioning.

System Configuration – Some choices (TBD)

- Sensors: OBELIX -1 – Versatile tracker matrix (2x3 cm^2)
  - 33x33 μm^2 pitch, 50 µm thick, 100 ns time stamps
  - Trigger handling 30 kHz, 120 MHz/cm^2
  - Precision timing module (5 ns for < 10 MHz/cm2)
  - Low granularity hit information for track trigger



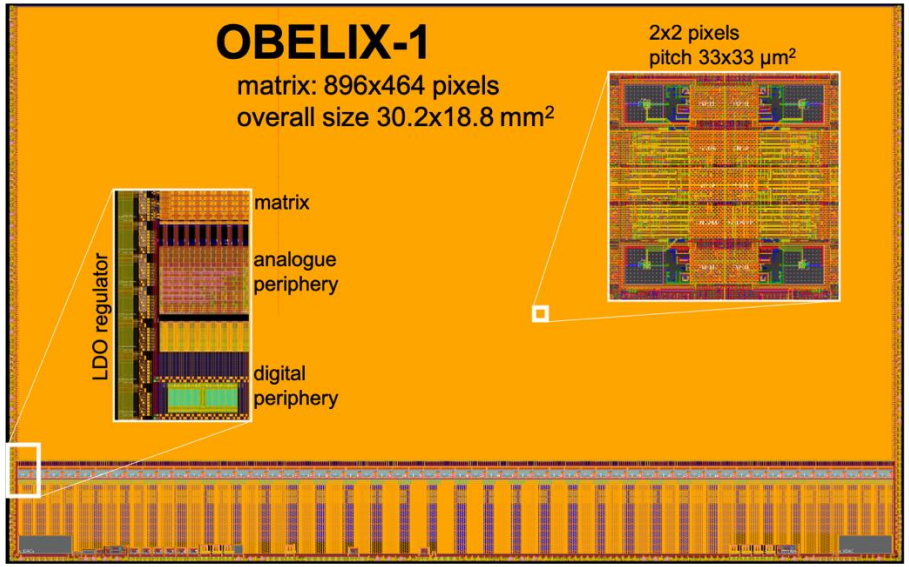
- Transceiver: lpGBT, GBTX,…

- (Timing: Scintillators, SiPM, LGADs, PicoPix, …)

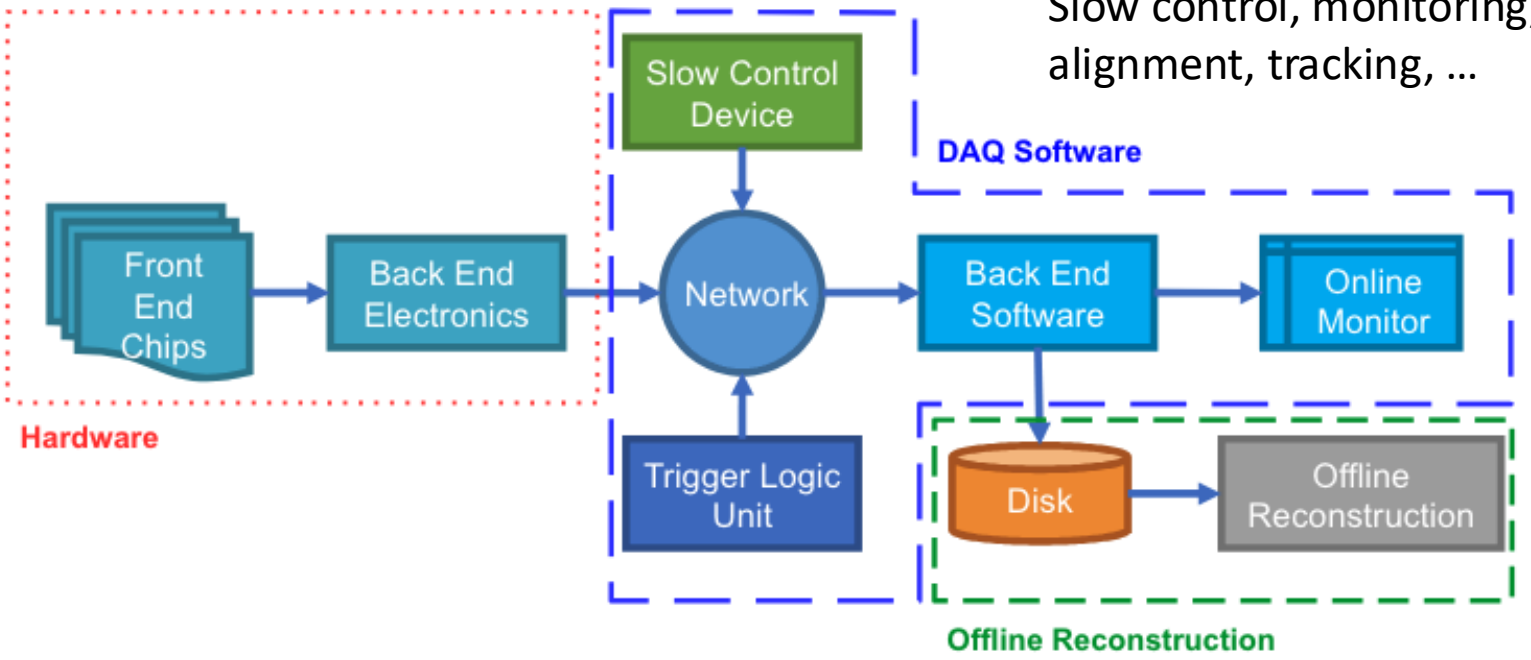
- DAQ: PCIe40 miniDAQ
  - Real time event reconstruction
  - System to handle large heterogeneous detectors

- Synchronization: AIDA TLU

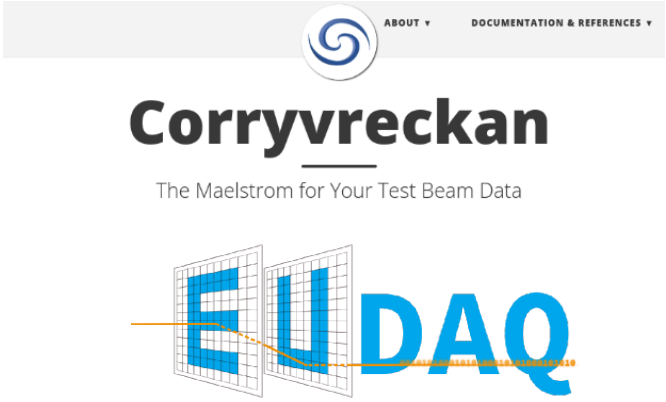
- Power supplies, cooling ,…



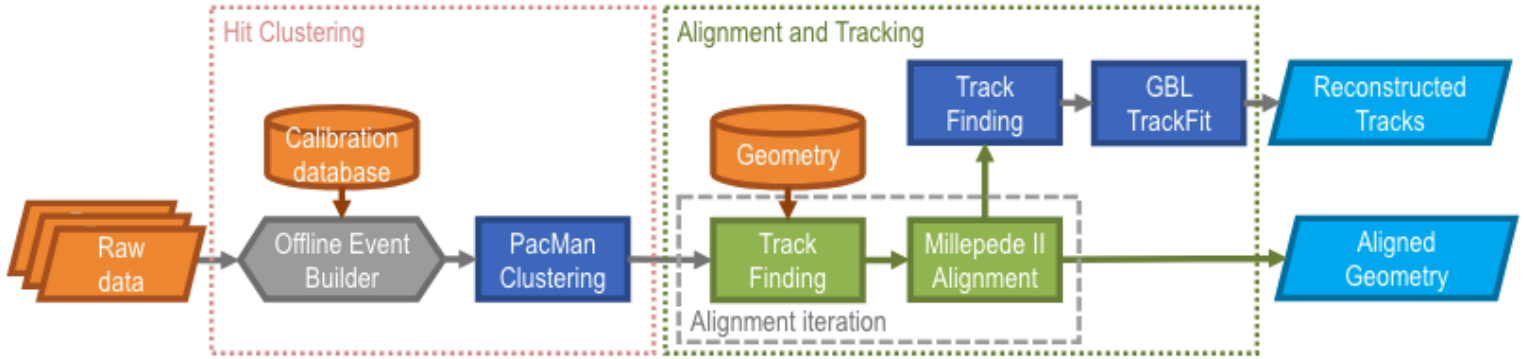
System Configuration – Much more than hardware



Slow control, monitoring, alignment, tracking, …



Reuse as much as possible
- Run control
- Data collector
- Producers



Schedule and Milestones

Identify critical components and secure them as soon as possible (lpGBT, PCIe40, TLU)

	H1	H2	H3	H4	H5	H6	H7	H8
Verification OBELIX (test beams, irradiations)								
Integration lpGBT on miniDAQ								
OBELIX full chain								
Multiple OBELIX chip readout								
Synchronization TLU (TRG, busy/data)								
Slow Control and Monitoring								
Mechanics (module and overall)								
Integration (Laser, beam)								
Including DUT								

→ Need to think in long term maintenance and support after delivery and commissioning

Summary

OBELIX-based telescope is a natural step forward in the DMAPS family to equip our test beam lines

→ Interesting added value wrt available systems. Large area, fast, handling complete detector systems.

Case for DRD3 Common Project, linking with AIDAInnova activities

DRD3 groups working on OBELIX are interested in pursuing this development. First informal contacts with:

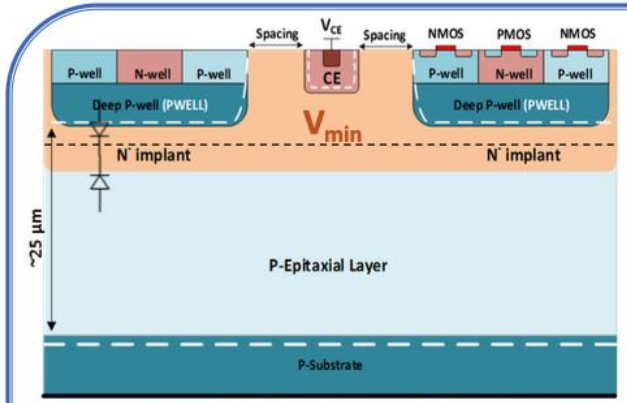
France, UK, Germany, Austria, Italy, Japan, Spain, China

Call for kick-off meeting will happen soon to start defining concrete action plan. Get in touch if interested.

OBELIX Telescope Working Groups:

- WG1: Sensor characterization
- WG2: Interfaces
- WG3: DAQ
- WG4: Integration
- WG5: Mechanics and cooling
- WG6: Software (configuration, slow control, …)
- WG7: Alignment and Tracking
- **WG8: Long term operation and support**

TJ-Monopix Family



W. Snoeys et al. https://doi.org/10.1016/j.nima.2017.07.046

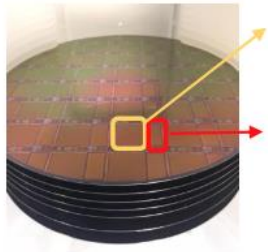
$C_d \leq 3fF$

$P \approx \frac{S}{N} \approx \frac{Q}{C_d}$

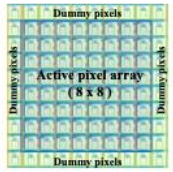
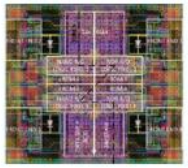
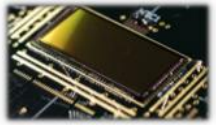
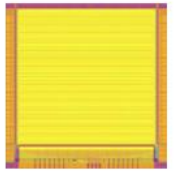
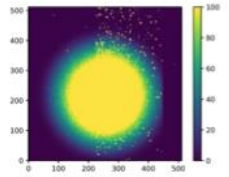
DMAPS in TJ 180 nm: Concept

- Small sensor capacitance (Cd)
  - Key for low power/low noise
- Radiation tolerance challenges
  - Modified process
  - Small pixel size
- Design challenges
  - Compact, low power FE
  - Compact, efficient R/O

Large scale demonstrator chip development

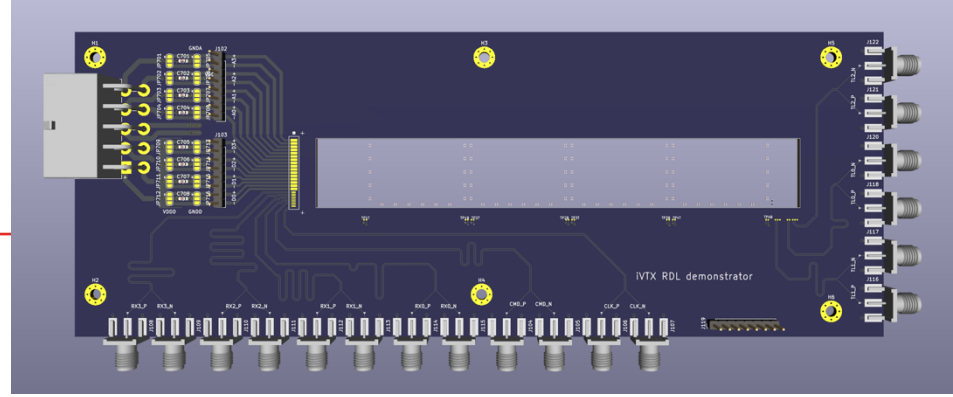


- MALTA
  - Asynchronous readout
- TJ-Monopix1
  - Synchronous column-drain R/O
- Process modification enhancements, Cz substrate ⟹ improved efficiency
- TJ-Monopix2: Improved full-scale DMAPS

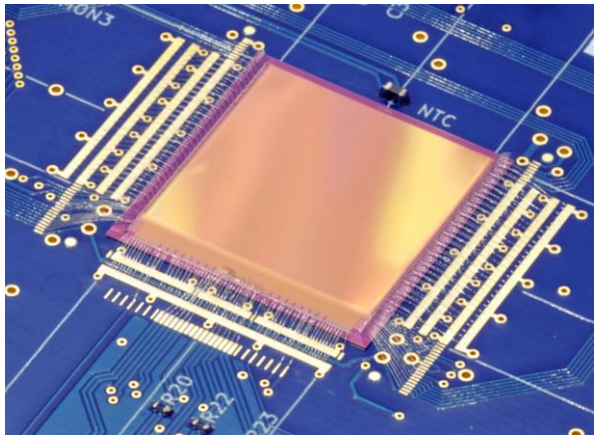
TJ-Investigator characterization	*TJ-Monopix1* & MALTA Design	*TJ-Monopix1* & MALTA Submission	Mini-MALTA sub. with process fixes	*TJ-Monopix1* resub. process fixes & Cz	*TJ-Monopix2* & MALTA2 Design	*TJ-Monopix2* & MALTA2 Submission	*TJ-Monopix2* Characterization	*"OBELIX"* Design
								Full scale System-ready: LDO, CDR, memory etc.
Q2 2016	Q4/2016	Q3/2017	Q3/2018	Q2/2019	Q2/2019	Q3/2020	Present	~~Future plans~~

Present

Increasing Complexity

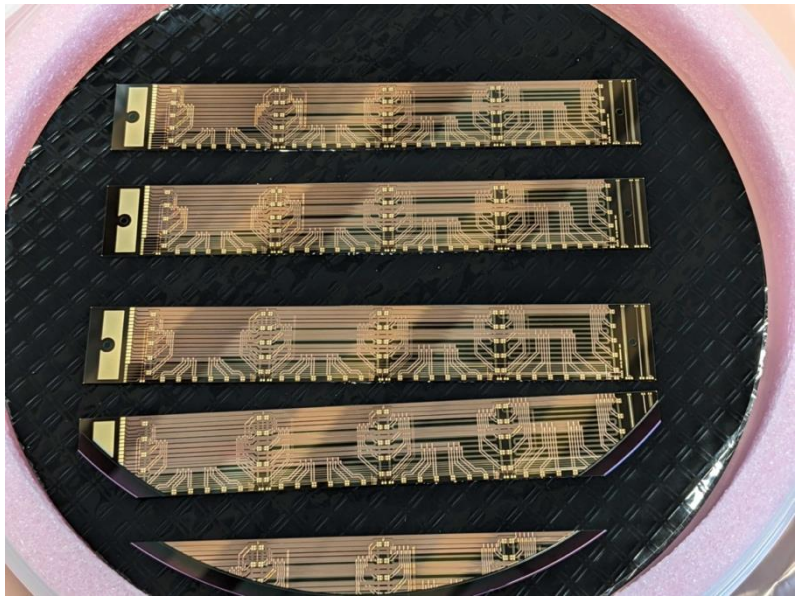


From single reticles to all-silicon ladders



TJ-Monopix2 single chip → OBELIX1 (TowerJazz 180 nm)
Size: 3x2 cm^2
Pitch: 30x30 μm^2
Time: 25-100 ns

Resolution, efficiency, charge collection properties, radiation hardness



Multi-reticle ladder
Size: 12x2 cm^2 (4x chips interconnected)

Full front and backside processing
Impedance, continuity of the RDL, integrity data lines
Selective etching

VTX Readout Concept