

ECFA - DRD3 (solid state detectors)

Synthesis about in2p3 possible involvements

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- DRD3 organization and milestones
- IN2P3 involvements in each labs & each WP
- Synthesis on human resources and funding needs

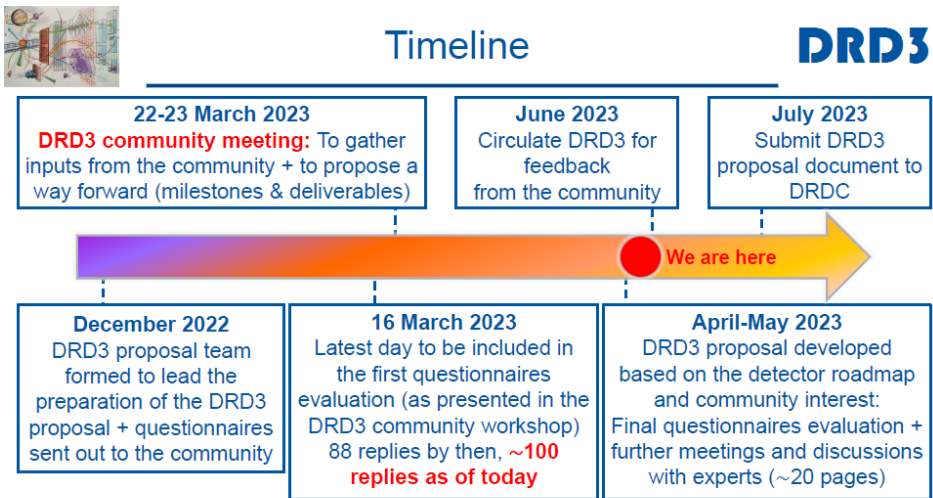
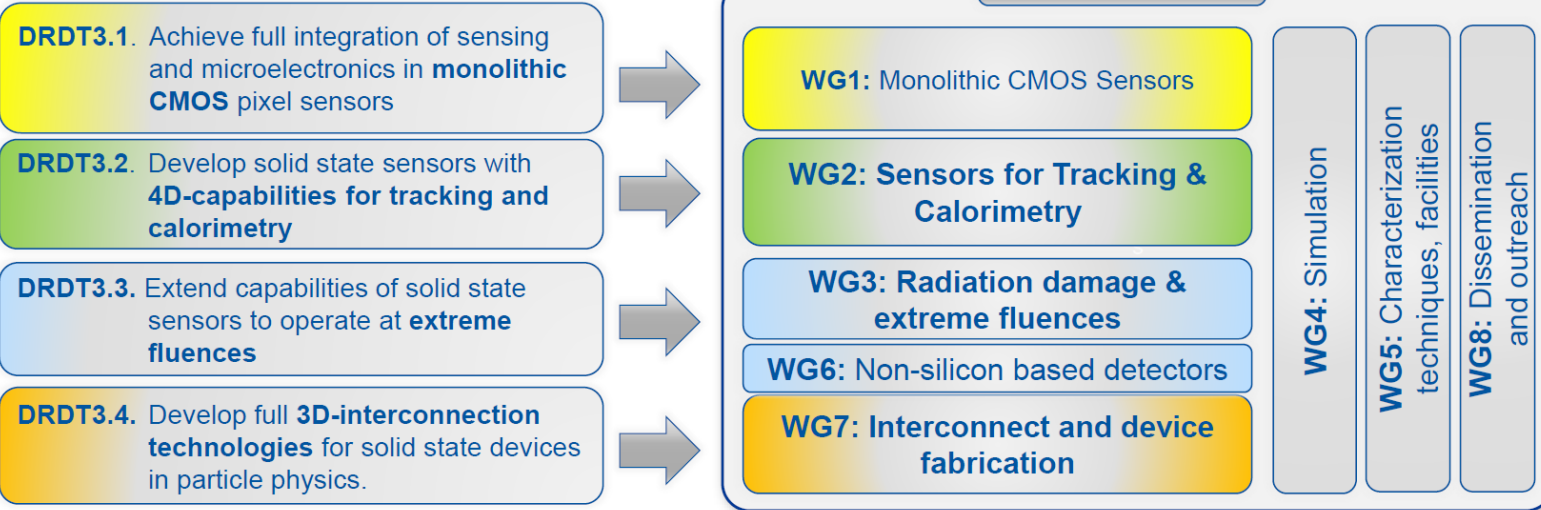
Special thanks to G. Calderini, D. Contardo, M-L. Gallin-Martel

DRD3 organisation

(WG2 includes LGADS & hybrids)

Within the ECFA roadmap
4 Detector R&D Themes (DRDTs)
 have been identified for the
 Solid State Detectors in particle physics.

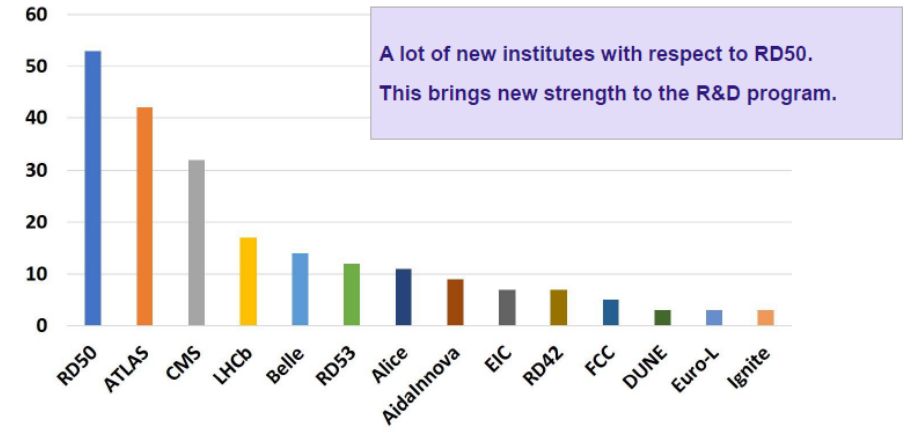
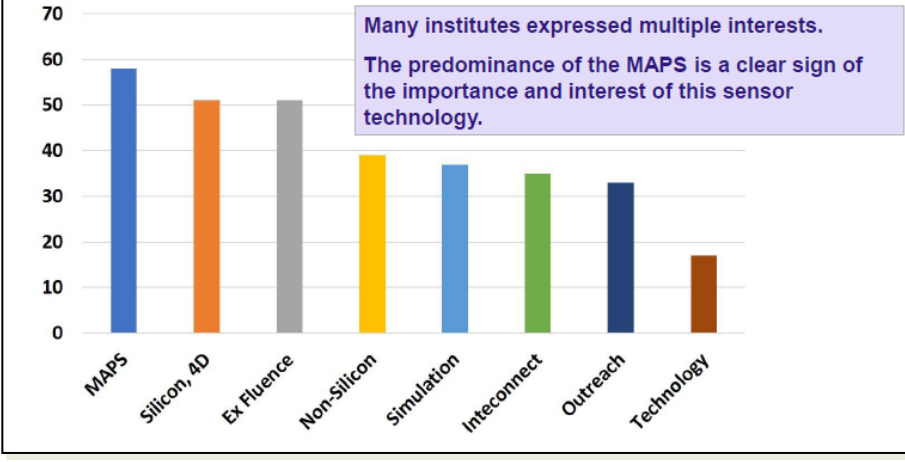
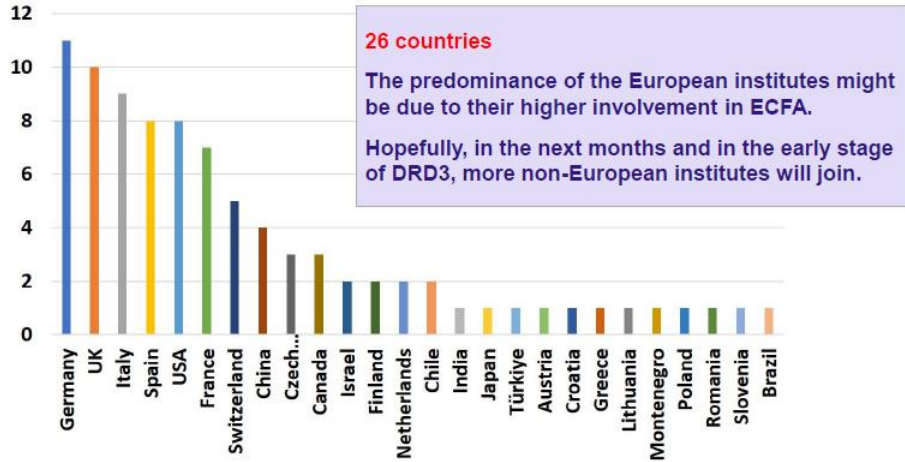
- We are covering all ECFA DRDTs
- Additional WGs were added to cover simulations, facilities and dissemination corresponding to **General Strategic Recommendations (GSRs)** in the ECFA roadmap



Lab	Main WGs	Secondary WGs
APC	WG3.1; WG3.3	WG3.2, 3.8
CPPM	WG3.1; WG3.3	WG3.3, 3.5, 3.7, 3.8
IJCLab	WG3.2; WG3.3	WG3.5, 3.7, 3.8
IP2I	WG3.1; WG3.2	WG3.7
IPHC	WG3.1	WG3.5, 3.7, 3.8
LPNHE	WG3.2	WG3.1, 3.3, 3.5, 3.7, 3.8
LPSC	WG3.6	WG3.5
IRFU		WG3.1, WG3.2, WG3.7

- **WG 3.1: Monolithic CMOS sensors**
 - ✓ Spatial resolution of 3 μm
 - ✓ Timing precision of 20 ps
 - ✓ Readout architectures for 100 MHz/cm²
 - ✓ Radiation tolerance of 10^{16} n_{eq}/cm²NIEL and 500 MRad
- **WG 3.2: Sensors for tracking and calorimetry**
 - ✓ Spatial and temporal resolutions at extreme radiation levels
 - ✓ Reduction of pixel cell size for 3D sensors
 - ✓ 3D sensors with a temporal resolution of about 50 ps
 - ✓ Spatial and temporal resolutions at low radiation levels and low material and power budgets
 - ✓ LGAD sensors with very high fill factor and an excellent spatial and temporal resolution
 - ✓ LGAD sensors for Time of Flight applications
- **WG 3.3: Radiation damage and extreme fluence operation**
 - ✓ Build up data sets on radiation induced defect formation in WBG materials
 - ✓ Develop silicon radiation damage models based on measured point and cluster defects
 - ✓ Provide measurements and detector radiation damage models for radiation levels faced in HL-LHC operation
 - ✓ Measure and model the properties of silicon and WBG sensors in the fluence range 10^{16} to 10^{18} n_{eq}/cm²
- **WG 3.4: Simulation**
 - ✓ Flexible CMOS simulation of 65 nm to test design variations
 - ✓ Implementation of newly measured semiconductor properties into TCAD and MC simulation tools
 - ✓ Definition of benchmark for the validation of the radiation damage models with measurements and benchmark different models
 - ✓ Developing of bulk and surface model for 10^{16} n_{eq}/cm² to 10^{17} n_{eq}/cm² NIEL
 - ✓ Collate solutions from different MC tools and develop algorithms to include adaptive electric and weighting fields
- **WG 3.5: Measurement and characterization techniques**
 - ✓ Development of new semiconductor characterization techniques is a priority for future detector developments
 - ✓ These techniques should enable high-resolution imaging and defect spectroscopy of semiconductor materials, as well as advanced characterization of charge transport properties
 - ✓ The Two Photon Absorption –TCT setup, Caribou DAQ system and the Ion Beam testing and irradiation facility at RBI have been identified as good examples and further improvements are being proposed
- **WG 3.6: Wide bandgap and innovative sensor materials**
 - ✓ 3D diamond detectors, cages/interconnects, base length 25 μm , impact ionisation
 - ✓ Fabrication of large area SiC and GaN detectors, improve material quality and reduce defect levels
 - ✓ Improve tracking capabilities of WBG materials
 - ✓ Apply graphene and/or other 2D materials in radiation detectors, understand signal formation
- **WG 3.7: Sensor interconnection techniques**
 - ✓ Yield consolidation for fast interconnections
 - ✓ Demonstration of small pitch (< 30 μm) pixel interconnections
 - ✓ Demonstration of radiation hardness and thermomechanical constraints
 - ✓ Development of maskless post-processing for commonly-used interconnection technologies
 - ✓ Bring part of the commonly-used interconnection technologies to specialised academic groups
 - ✓ Develop device-to-wafer interconnection technologies
 - ✓ Develop wafer-to-wafer in presently advanced interconnection technologies
 - ✓ Develop VIAS in multi-tier sensor/front-end assemblies
 - ✓ Develop connection techniques for post-processed devices
- **WG 3.8: Outreach and dissemination**
 - ✓ Disseminating knowledge on solid-state detectors to people working in high energy physics
 - ✓ Disseminating knowledge on solid-state detectors to high-school students and the general public
 - ✓ Design and set-up of the DRD3 website
 - ✓ Collection of the outreach material
 - ✓ Set-up and organize schools and exchange programs
 - ✓ Set-up of the DRD3 conference committee

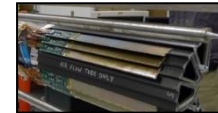
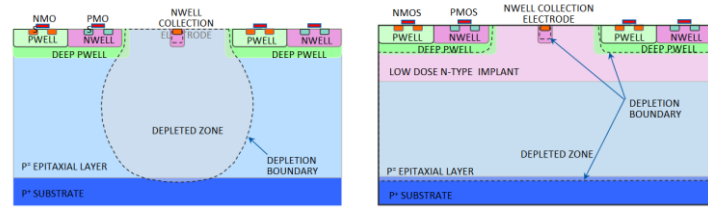
DRD3



DRDT 3.1	CMOS sensors	DRDT 3.2	Sensors for 4D tracking
WP1.1	TPSCo 65 nm	WP2.1	3D sensors
WP1.2	TowerJazz 180 nm	WP2.2	LGADs
WP1.3	LFoundry 150 nm		
WP1.4	TSI 180 nm		
WP1.5	LFoundry 110 nm		
WP1.6	IHP 130 nm		
			<i>In progress</i>
DRDT 3.3	Sensors for extreme fluence	DRDT 3.4	Demonstrator for 3D-integration
WP3.1	Wide bandgap (SiC, GaN)	WP4.1	
WP3.2	Diamond	WP4.2	
WP3.3	Silicon		

Lab	Involved experiments related to DRD3/DRD7	WG 3.1 (CMOS)	WG 3.2 (4D tracking & Calorimetry)	WG 3.3 (Radiation damage & high fluences)	WG 3.6 (Non silicon - Diamond)	WG 3.4 (simulations)	WG 3.7 (interconnect & fabrication)	WG 3.5 (Characterization technics)	WG 3.8 (outreach)
APC	ATLAS, FCC	TPSCo 65nm							
CPPM	RD50, RD53, AIDAInnova, ATLAS, Belle 2	TPSCo 65nm, TJ180nm							
IJCLab	ATLAS, EIC		AC-LGADs, planar				TSV		
IP2I	CMS	TPSCo 65nm							
IPHC	ALICE, CMS, Belle II, CBM-MVD, e+e- colliders (FCC, ILC, etc.)	TPSCo 65nm, TJ180nm							
LPNHE	ATLAS, RD50, RD53, AidaInnova		3D, LGADS, planar				ACF, 3D		
LPSC	RD42				Diamonds				
IRFU	RD51, ATLAS, CMS, ALICE, LHcb, T2k, DUNE, CUPID, BINGO, NUCLEUS, GBAR, DESI, HESS,	LF150							
Strong interest		Expressed interest		No expressed interest					

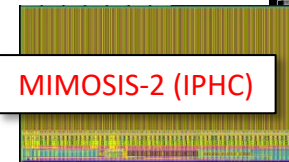
WG 3.1: CMOS



STAR-HFT (IPHC)



EUDET telescope



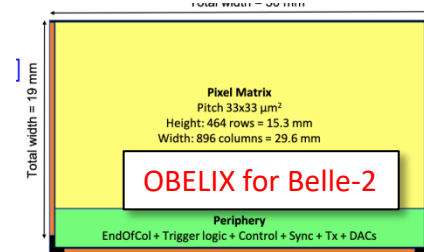
MIMOSIS-2 (IPHC)



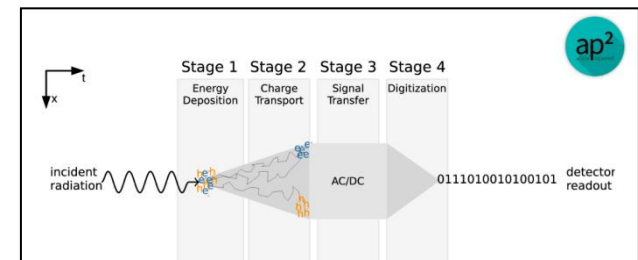
ER1 for ALICE ITS-3



Ring Oscillator (CPPM)



OBELIX for Belle-2



IN2P3: MP GRAM & DEPHY (since end 2022)

- ✓ DEPHY: high fluences, high flux for CMOS & hybrid pixels
- ✓ GRAM: granularity, material budget, low power

IPHC (C4PI, PICSEL, Belle-2, ALICE)

- ✓ 20 years: STAR HFT, EUDET telescopes, ALICE ITS-2, Aidalnova, etc.)
- ✓ 3 teams in HEP are pursuing a CMOS R&D activity:
 - PICSEL: MIMOSIS for CBM-MVD $\Rightarrow e^+e^-$ colliders (TJ180 nm & TPScO 65nm)
 - Belle-2 upgrades (TJ180 nm and beyond)
 - ALICE ITS3 (TPScO 65nm)
- ✓ DRD3: focus on TPScO 65nm
- ✓ IPHC Scientific council June 27th

CPPM

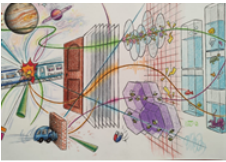
- ✓ > 10 years: (ITK ATLAS, Belle-2, RD50, RD53, Aidalnova)
 - Depleted CMOS
 - LF150nm, TSI180nm, TJ 180 nm, TPScO 65nm, etc.
 - high fluences, high flux

IP2I

- ✓ Interest for fast timing (< 100 ps)
- ✓ Growing activity in digital micro-electronics with C4PI (TJ 180 nm)
 - Contribution to DRD3.1 (TPScO TJ 65 nm)
 - Digital on Top methodology for read-out (with DRD7)
 - Low power architecture with ToF measurement
 - interconnection 3D (wafer stacking) (with DRD7)

APC

- ✓ Tests for the TPScO 65nm prototypes
- ✓ Possible contributions to design (TPScO 65nm)
- ✓ Expertise in simulations (TCAD, Allpix2) and radiation damages



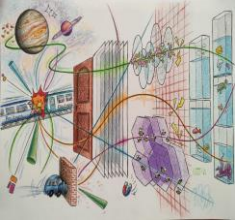
Ball park performance targets MCMOS

Three main time scales/phases to define program up to: 2027-28, 2029-2035, >2035

Ball park generic performance targets*
mandatory/desireable

	Tracking VD/CT	Timing Layer + Calorimeter
Heavy Ion	ultralight low power tracker pitch 10 - 30 μm @ 0(100) MHz/cm ² , 0(1) μs	0(20) ps (TL)
Flavour collider	ultralight low power tracker pitch 10 - 30 μm @ 0(100) MHz/cm ² , 0(1) ns	0(20) ps in (TL)
Lepton collider	e-e : ultralight low power tracker pitch down to $\lesssim 10 \mu\text{m}$, @ 0(100) MHz/cm ² timing driven by power timing driven by power dissipation $\mu\text{-}\mu$: 0(20) ps rates and irradiation tbc	0(10) ps in TL 0(< 50) ps in calorimeter driven by power power dissipation
pp collider	HL-LHC: 25-50 μm @ 0(5) GHz/cm ² 5×10^{15} to 5×10^{16} neq/cm ² , 250 - 500 MRad timing 0(<50) ps timing 0(<50) ns	HL-LHC: pitch 0(<1) mm 0(20) ps in TL, NIEL 5×10^{15}
	FCC-hh: < 10 - 20 μm @ 30 GHz/cm ² 4D tracking 4D tracking 0(<10)ps up to 0(10 ¹⁸) to 0(10 ¹⁸) neq/cm ² , up to 0(50) GRad	FCC-hh: 5D calorimeter 0(<10)ps up to 0(10 ¹⁸) neq/cm ² , up to 0(50) GRad 0(50) GRad

* ranges representative, ex. for VD and CT with more stringent constraints to be achieved in VD



MCMOS 1st R&D phase up to 2027-2028

Deliverables: MPW submissions/**reviews**/milestones (ex. MCMOS TPSC 65 nm)

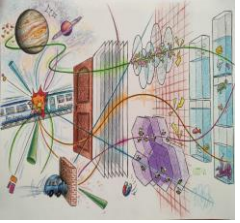
Work Packages

DRD3.1 Monolithic CMOS	Phase-1: sensors with 3 μm position precision, sensors with timing precision 20 ps, readout architectures for 100 MHz/cm ² , radiation tolerance 10*16 neq/cm ² NIEL and 500 MRad					
Timeline	2024	2025	2026	2027-28		
Work Packages	Deliverable	Deliverable	Deliverable	Review Milestones MPW1.1 MPW1.2	Deliverable	Review Milestones MPW1.2 MPW1.3
Technology TPSCo (TJ) 65 nm	prepare MPW1.1	submit MPW1.1 mid-2025 start to prepare MPW1.2		Internal/DRDC reviews mid-2025 results of MPW1, specifications of MPW1.2	qualify MPW1.2 prepare/submit MPW1.3a prepare/submit MPW1.3b prepare/submit MPW1.3c	internal/ DRDC reviews Q4 2027 results of MPW2, specifications of MPW3 (consider other techno. progress) establish 2nd DRD phase program
WP1 position precision	ER 12" 4 splits process/epitaxial layer, with variants of electrode size/shape/pitch on small matrix	MPW1.2 selected features of MPW1.1 and/or new features		M1 mid-2026 establish position precision versus pitch, sensor active thickness and readout mode (digital/binary) establish technology for application in CT, TL, Si/W calo		M5 handle large size high density sensor technical options for ALICE-3, LHCb-2, BELLE-3, VD
WP2 timing precision	specific features in splits	MPW1.2 selected features of MPW1.1 and/or new features	qualify MPW1.1 submit MPW1.2 Q4-2026	M2 mid-2026 establish timing precision versus electrode size and pitch, sensor active thickness (w/o amplification)	MPW1.3a wafer size matrices in selected features of WP1/WP2/WP3 (pixel/strip/pad configurations)	M6 handle large size sensors for Central Tracking, Timing Layers, Si/W calo (DRD6 proto)
WP3 readout architecture common to DRD7	common IP block components architecture implementations: synchro/asynchro. modes; adapted to channel density, readout features of WP1- WP2 (digital/binary/timing) and target rates power distribution and control in large size wafers	MPW1.2 selected features of MPW1 for further studies scale matrix size		M3 mid-2026 qualified IP blocks establish power dissipation of architecture options	MPW1.3b - MPW1.3c design wafer for interconnect	M7 handle architecture option for low power in wafer scale size, expand to other technologies M8 deliver SoA sensors for beam area infrastructure
WP4 radiation tolerance	specific feature in splits	MPW1.2 selected features of MPW1.1 and/or new features		M4 establish SoA radiation tolerance		
Interconnection and data transfer common to DRD3/DRD7	prepare prototypes for 3D integration					
Integration common to DRD3/DRD8	cooling systems, light mechanical designs, system prototypes					
Non-silicon materials common to DRD3/DRD7	qualify radiation tolerance					
Simulation and characterization common to DRD3	develop and test simulation models, develop tools and telescopes					

Ball park goals

- explore all performance aspects in several technologies against design/process parameters
- develop few architectures with low power consumption for different work packages
- prepare (start?) 3D integration
- **Review achievements, narrow down technology options**
- **Handle :**
 - technical solutions for initial strategic programs: ALICE-3, LHCb-2, Belle-3, ATLAS/CMS...
 - sensors for DRD6 High Granularity Calorimetry prototypes
 - telescope for beam-test infrastructure

common areas within DRD3 and with DRD7



MCMOS 2nd and 3rd R&D phases

Deliverables: to be redefined through reviewing of Phase I progress and achievements

Work Packages

DRD3.1 Monolithic CMOS	Phase-2: 4D tracking <3 μm and <20 ps precisions, O(1) GHz/cm ² rates		Phase-3: 4D tracking <1 μm and <10 ps precisions, O(50) GHz/cm ² rates, radiation	
Timeline	2029-2034		≥ 2035	
Work Packages	Deliverable	Review Milestones	Deliverable	Review Milestones
Technology TPSCo (TJ) 65 nm		internal/ DRDCreviews results of MPWs, establish 3rd DRD pahse program		internal/ DRDCreviews results of MPWs, establish 4th DRD pahse program
WP1 position precision				
WP2 timing precision	technology nodes ≤ 65 nm wafer size ≥ 12" 3D interconnection non Si-materials	handle technical options for lepton colliders (ILC, CLIC, FCC-ee, MC) including 4D tracking performance	technology nodes ≤ 16 nm wafer size ≥ 12" 3D interconnection non Si-materials	handle technical options for hadron colliders ultimate rates and radiation tolerance in 4D tracking
WP3 readout architecture common to DRD7				
WP4 radiation tolerance				
interconnection and data transfer common to DRD3/DRD7	tbd		tbd	
Integration common to DRD3/DRD8	tbd		tbd	
Non-silicon materials common to DRD3/DRD7	tbd		tbd	
Simulation and characterization common to DRD3	tbd		tbd	

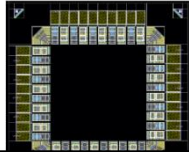
Ball park goals

- Integrate WP features in same sensors at low power consumption
- Evolve to further technologies/lower nodes toward full 4D tracking
- Implement 3D integration
- Reach ultimate timing precision, rates and rad. tol. for in 3rd phase

common areas within DRD3 and with DRD7

WG3.1: CMOS TPSCo-65 nm submissions and connexion with DRD3/DRD7

IPHC, CPPM, APC, IP2I



DRD project: Fine-pitch CMOS pixel sensors with precision timing for vertex detectors at future Lepton-Collider experiments

DRD technology area

DRDT 3.1 - Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors.

Proposing participants

Institute	Contact	Foreseen main areas of contribution
APC Paris	M. Bomben	Simulations, testing
CERN	D. Dannheim	Testing, DAQ, ASIC design support
DESY	S. Spannagel	ASIC design, testing, DAQ, simulations
IPHC Strasbourg	A. Besson	ASIC design, testing
Oxford University	D. Hynds	Testing, simulations
Zurich University	A. Macchiolo	Testing, DAQ, simulations

CMOS TPSCo 65nm (ALICE ITS-3 + EP R&D WP1.2)

- ✓ Offers attractive perspectives w.r.t. TJ180nm
 - Stitching (12 inches wafers)
 - Potentially smaller pitch, faster, less power consumption, etc.
- ✓ Main CMOS technology supported by CERN in the coming years
- ✓ IPHC & CPPM already in the consortium participating to the technology validation
- ✓ TJ 180nm probably less (or not) supported in the future

2 lines of submissions in CMOS TPSCo 65nm

- ✓ Submissions dedicated to ALICE ITS-3 (ER2 & ER3) ⇒ stitching, bent sensors
- ✓ Submissions for generic R&D, supported by CERN EP R&D WP1.2 (« MLR2 » and beyond)

Generic R&D possible contributions

- ✓ One expression of interest submitted with M1/M5 main driver (future e+e- colliders vertex detectors)
 - Goal: gather groups to reach a critical size
 - Targets 3 μm spatial resolution, improved time resolution (5-500 ns), controlled Power (< 50 mW/cm²), data flow (10-100 MHz/cm²) and low material budget (50 μm thickness)
 - Demonstrator to equip new generation beam telescope
 - Proposing Institutes: CERN, DESY, IPHC, APC, etc.
 - Open to other participations
- ✓ Other projects in discussion (tracking, timing, calorimeters, link to MP DEPHY ?)
 - e.g. Fast timing (<100 ps); low power architecture, etc.

Last news:

- ✓ MLR2 submission: ~ end 2025 (2nd expected > 2027 ; then a 3rd ?)
- ✓ EP R&D WP 1.2 will support >~50% of the submission cost for "MLR2" of ~600k (+ dicing)
- ✓ The rest (~300k) has to be contributed by the participating projects
- ✓ Expected allowed surface ∝ financial contribution
 - reticle of ~3 cm x 2.5 cm ~ 7 cm²

CMOS 65nm funding needs

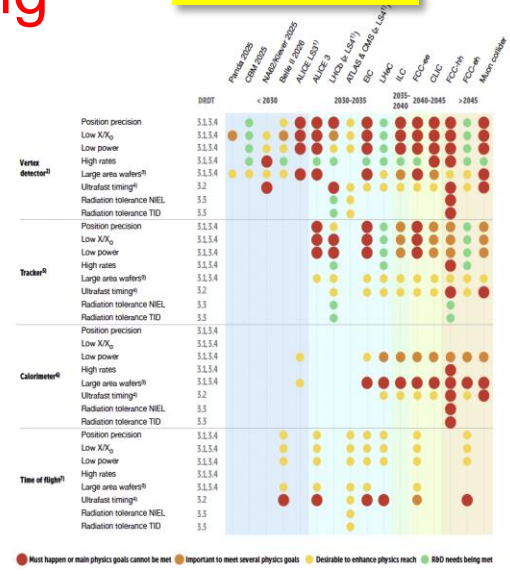
- ✓ Yearly budget for operation on the basis of existing master project (GRAM, DEPHY)
 - + Some additional needs for new comers (e.g. IP2I, APC)
- ✓ Multi-year plan on the national level needed to allow significant contributions to the targeted submissions
 - One should target a in2p3 global contribution of the order of 100 keuros / submission
 - Can one spread out expenses on several years ?
- ✓ AAPs (ANR, etc. e.g. APICS)
 - Should target additional manpower whenever possible

WG 3.2: High resistivity and timing

- High resistivity
 - ✓ presently the only solution for very high fluences
 - (FCC-hh, $\mu\mu$ colliders)
- Timing $O(10\text{ ps})$
 - ✓ milestone of the next 20 years in several applications
- Radiation hardness + 4D capability
 - ✓ necessary typically for high multiplicity environments & high rate experiments (both for tracking and for calorimetry)

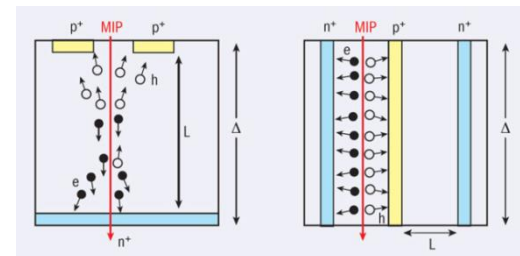
⇒ Interplay with material budget, power, rates, occupancy, area and radiation hardness, interplay with electronics (capacitance, signal shape, etc)

- Thin sensors for increased radiation hardness in large surfaces
 - ✓ (standard planar sensors but also thin LGADs cf. RD50)
 - ✓ LGAD for timing capabilities (also for calorimetry)
 - ✓ 3D sensors for 4D at extreme fluences



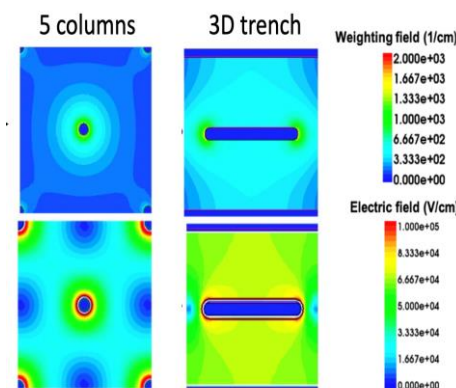
3D sensors

- ✓ Decouples active thickness to collection distance
- ✓ Demonstration of fine pitch cell size
- ✓ Demonstration of innovative more performant processes (flat trenches)



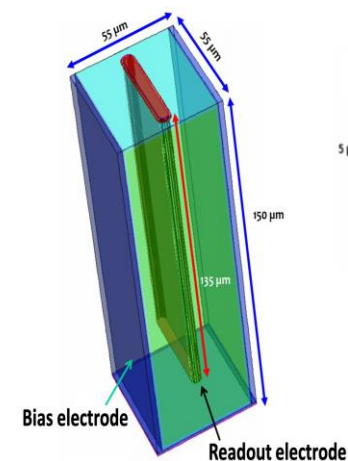
Applications

- ✓ ATLAS/CMS Phase-3 (Run5 ~2035)
 - use of 28 nm CMOS technology for the ASICs could allow for finer pixel sizes to improve hard scattering track reconstruction and pile-up rejection
- ✓ VELO vertex detector at LHCb (Upgrade-II).
- ✓ All future experiment with timing capability required in extreme fluence



Deliverables

- ✓ Short-term: development of small matrices optimized for timing properties and reduced pixel size at high and extreme fluences (10^{17} n_{eq}/cm^2)
- ✓ longer-term: development of full-scale larger sensors matched to future timing performant front-end chips (28nm)



LGADs

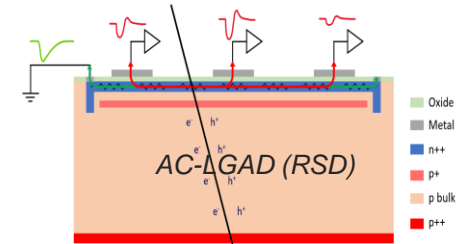
- ✓ Demonstration of the feasibility of producing pixelated LGAD sensors to achieve a position resolution better than $10\ \mu\text{m}$, with a timing resolution of the order of 30 ps before irradiation.

Possible applications

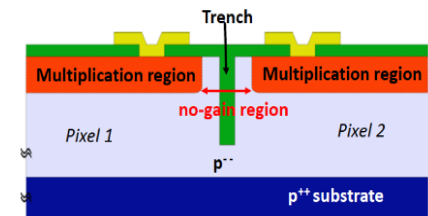
- ✓ replacement of outer pixel layers or disks in the CMS/ATLAS pixel systems in Phase-3. The requested radiation tolerance is in the order of at least $3\text{-}5 \times 10^{15}\ \text{neq/cm}^2$.
- ✓ Large areas (cheap)
- ✓ Fast timing layers in Higgs factories

Deliverables

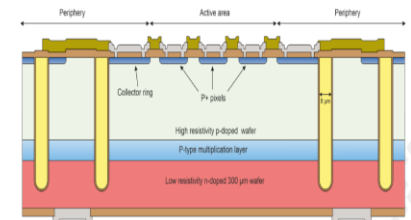
- ✓ Short-term: characterization of the different technological solutions through small matrices connected with timing-performant matching chips (28nm)
 - Improvement of fill-factor
 - Optimization of spatial and time resolution
 - Development of radiation-hardening technologies (implantations and design)
- ✓ Long term: development of full-scale sensors and connection to matching electronics
 - Optimization of system parameters (e.g. power dissipation)



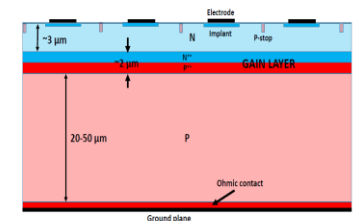
Trench Isolated LGAD



Inverse-LGAD (I-LGAD)



Deep junction LGAD



WG 3.7: Interconnection techniques

LPNHE, CPPM, IJCLab, IP2I, IPHC

Different technological levels for different scopes

- ✓ Cheap and fast interconnection for prototyping applications
- ✓ Improvements of “standard” interconnection technologies
- ✓ Development of “advanced” technologies in collaboration with industrial vendors

In-house fast connections (*Anisotropic Conductive Film/Paste (ACF/ACP)*)

- ✓ Ideal for testing and fast prototyping
- ✓ Also useful for permanent interconnections
- ✓ Avoid turnaround time with interconnection vendors
- ✓ Short-term deliverables: consolidation of connection yield and small pitch
- ✓ Mid-term deliverable: demonstration of radiation hardness

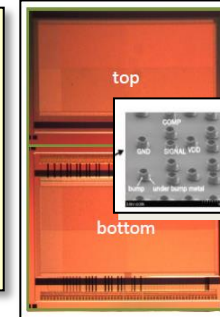
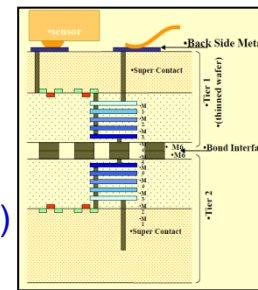
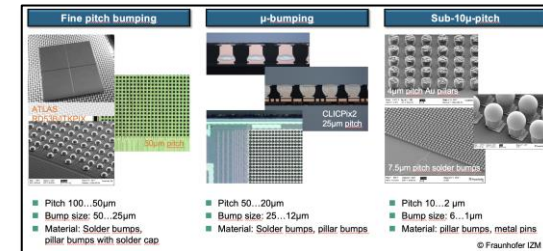
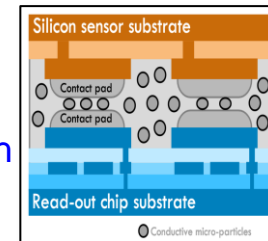
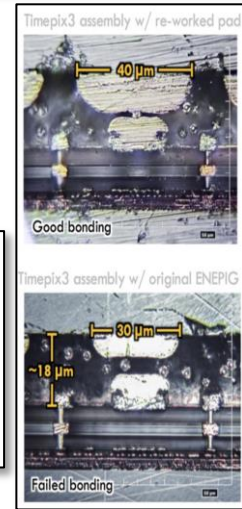
Bringing “standard” technologies to lab capability

- ✓ Issues: costs and availability
 - Move part of process to laboratories
- ✓ Studies
 - small pitch
 - process-temperature constraint
 - electrical properties (current, C)
 - connection flow

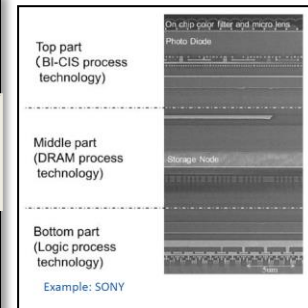
- ✓ Short-term: develop maskless post-processing
- ✓ Mid-term: process possible in selected labs

Advanced 3D and vertical integration

- ✓ Commercially driven
- ✓ Allows Multi-tier, mixed-technology (e.g. stack digital/analog)
- ✓ Allows power/reading transmission
- ✓ Short term: TSV
- ✓ Mid-long term: connection made possible for post-processed devices



Double tier
(CMOS TJ 180nm, IPHC)

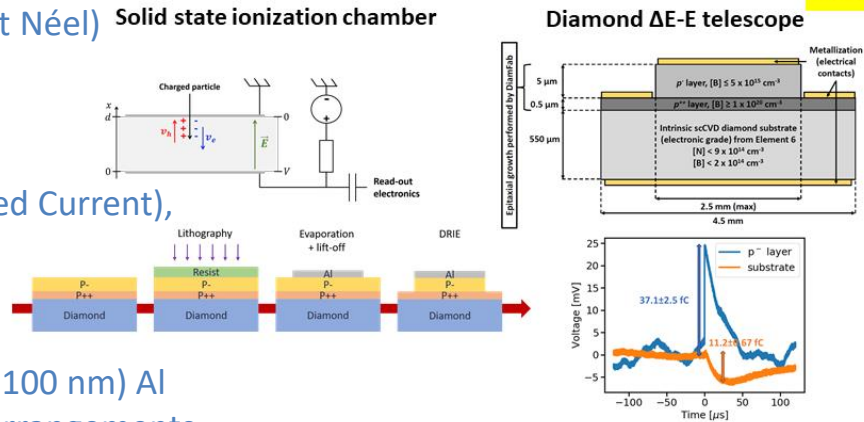


Industrial wafer
stacking
in CMOS

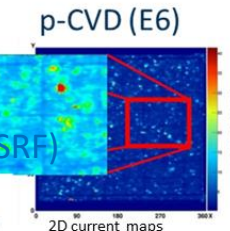
WG 3.5 & 3.6 : New characterization techniques & Wide bandgap and innovative sensor materials

LPSC

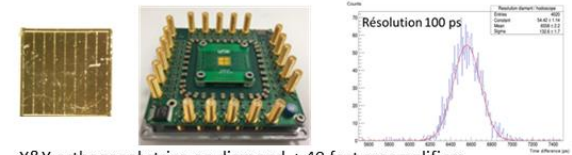
- Diamond monolithic telescope for short range particle detection
- ✓ Fabrication in collaboration with DIAMFAB (start-up Institut Néel)
- ✓ Epitaxial growth of the p- and p++ layers, etching, contacts (NANOFAB - Institut Néel)
- ✓ Diamond instrumentation on PCB (LPSC)
- ✓ Characterization in laboratory: eBIC (electron Beam Induced Current), ToF – eBIC & alpha spectroscopy



- Beam monitors
- ✓ Diamond technology sCVD and pCVD metallized with thin (100 nm) Al layer by laser lithography mounted on a PCB with various arrangements (single, 4x4 mosaic or 9x1)
- ✓ FE electronic developments: e.g fast preamps, DFC, QDC
- ✓ BE electronic developments e.g TDC (40 on a single Cyclone 10 FPGA - STD 25 ps / CMOS 130 nm STD 12 ps)



CLARYS-UFT: Ion beam hodoscope 4x4 sCVD mosaic



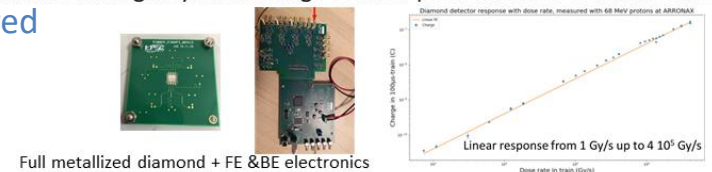
X&Y orthogonal strips on diamond + 40 fast preamplifiers

IDSYNCHRO: Xrays microbeam monitor ESRF ID17



150 channels 9x1 sCVD mosaic μstrips diamonds + integrated FE electronics (QDC) CMOS 130 nm

DIAMMONI: High Dynamic Range 68 MeV proton Pulsed Beam Monitor



- New characterization techniques
- ✓ ToF eBIC (« pulsed » SEM - Institut Néel) & XBIC (BM05 - ESRF)
- IBIC (Ion Beam Induced Current – AIFIRA)

Application

- ✓ All future experiments with timing capability or particle counting required in extreme fluence

Deliverables

- ✓ Short-term: single crystal and polycrystalline CVD diamond beam monitors
- ✓ Long-term: development of full scale sensors with integrated electronics

DRD3 Letters (2024-28) FTE/year projection: permanent/non permanent.

Lab	Involved experiments related to DRD3/DRD7	WG 3.1 (CMOS)	WG 3.2 (4D tracking & Calorimetry)	WG 3.3 (Radiation damage & high fluences)	WG 3.6 (Non silicon - Diamond)	WG 3.4 (simulations)	WG 3.7 (interconnect & fabrication)	WG 3.5 (Characterization technics)	WG 3.8 (outreach)
APC	ATLAS, FCC	0.1/0.15		0.1/0.1					0.1
CPPM	RD50, RD53, AIDAInnova, ATLAS, Belle 2	0.8/1.6*		0.3/0.3*				0.3/0.1*	
IJCLab	ATLAS, EIC		0.6/0.15	0.15/0.15*			0.1		
IP2I	CMS	1.5/0.5*	1.5/0.5*						
IPHC	ALICE, CMS, Belle II, CBM-MVD, e+e- colliders (FCC, ILC, etc.)	15♦/3.3*					0.5*	0.2/0.2	0.2
LPNHE	ATLAS, RD50, RD53, AidaInnova	TBD	4.5/1.5*	1/0.5*			1.5/1*		*
LPSC	RD42				6/2			2/1	

Perimeter subject to interpretation

* = To Be Confirmed
 TBD = To Be Defined
 ♦ = includes all R&D CMOS activities

Strong interest Expressed interest No expressed interest

DRD3 Letters (2024-28) Funding projection: operation/investment. (in keuros/yr)

Lab	Involved experiments related to DRD3/DRD7	WG 3.1 (CMOS)	WG 3.2 (4D tracking & Calorimetry)	WG 3.3 (Radiation damage & high fluences)	WG 3.6 (Non silicon - Diamond)	WG 3.4 (simulations)	WG 3.7 (interconnect & fabrication)	WG 3.5 (Characterization technics)	WG 3.8 (outreach)
APC	ATLAS, FCC	10							
CPPM	RD50, RD53, AIDAInnova, ATLAS, Belle 2	10 / 20*		TBD / 10*	through DEPHY			TBD / 10*	
IJCLab	ATLAS, EIC		20	3.3			20*	20*	
IP2I	CMS	20-30* / 50*					TBD		
IPHC	ALICE, CMS, Belle II, CBM-MVD, e+e-colliders (FCC, ILC, etc.)	100/90*	through GRAM + C4PI					10	5 + 5*
LPNHE	ATLAS, RD50, RD53, Aidalnnova	TBD / TBD	50 / 50 TBD / TBD	TBD / TBD			30 TBD / TBD		TBD / TBD
LPSC	RD42				30				



Operation + O(100 keuros/submission) e.g. 65nm, 180nm

Perimeter subject to interpretation

Strong interest

Expressed interest

No expressed interest

- * = to be requested
- TBD = To Be Defined

Budget discussion

On the basis of the available information

- Figures based on DRD3 questionnaire
 - ✓ Yearly « Operation » / « Investment » projections for 2024/2028
 - *Operations (consumables, investment into sensor production, operation of equipment, ...)*
 - *Capital investments (new infrastructure and equipment, ...)*
 - ✓ Not necessarily adapted to the in2p3 context
- In2p3 framework
 - ✓ Identify **existing** fundings
 - Established activities
 - ✓ Identify **new** requests dedicated to DRDs
 - Emerging activities (e.g. APC, IP2I in CMOS ⇒ O(50 kEuros ?))
 - Identify **additional** Operation/Investment
 - May concerns chip submission but also large equipment
 - Identify **common** funding for operations (possibly at the national level)
 - Mainly concerns chip submission ? ⇒ e.g. TPSCo 65 nm ~ O(100keuros) / submission
 - Not necessarily on a yearly basis ⇒ may includes other technologies (e.g. TJ 180 nm)
- Project calls (ANR, etc.)
 - ✓ Common requests for additionnal manpower ?
- Master project roles (GRAM, DEPHY, etc.) w.r.t. DRD3 ?
 - ✓ Structuration of in2p3 R&D should be maintained
 - ✓ Contribution to operations and **investment** ?

Summary

Not all solid state R&D @ in2p3 are in the DRD3 !

IN2P3 Themes summary

- ✓ WG1 (CMOS)
 - Strong historical R&D & emerging activities
 - Focus on TPSCo 65nm in the DRD3 context
- ✓ WG2 (calo/tracker/timing) & WG3 (rad.hardness/high flux)
 - Past and present development of thin sensors for tracking
 - Interest in LGAD sensors for calorimetry and fast timing
 - Interest in 4D tracking and timing applications: after construction of LHC Phase-II upgrades, coherent
 - re-organization of the community is expected to give a unitary contribution to future projects
- ✓ WG6 (non silicon)
 - LPSC in Diamonds (sCVD and pCVD)
- ✓ WG4/5/7/8 Transversal themes are also strategic e.g. interconnection, simulations
 - Past and present involvement of French groups, mainly via independent projects (AIDA, AIDA-2020, AIDAInnova)
 - Cornerstone of ECFA tasks
 - Different technological levels aiming to different applications
 - Strategic positioning of the community in a multidisciplinary field

DRD3 organization

- ✓ Milestones for different applications
- ✓ Inherited from RD50
 - French teams representation : good but not in all themes ⇒ Activities not in the original RD50 themes needs to be recognized
- ✓ DRD3-DRD7 strong relation in particular in the CMOS area
 - DRD7 expertise needed for global architectures/design
 - Small prototypes⇒DRD3 / Large prototypes⇒DRD7
 - This connection needs to be preserved for large scale prototypes

Integration & mat. budget

- ✓ Mat. Budget not explicitly in the DRD3 themes (e.g. bent sensors, stitching)
- ✓ Integration R&D (wireless, additive manufacturing, etc.)

Budget

- ✓ The strategy should allow to
 - Consolidate the position of historical in2p3 activities in DRD3
 - Allow new activities to emerge
 - Guarantee the in2p3 visibility through a national effort for submissions

Back-up

Technologies / Detector types in DRD3/DRD7

Lab	CMOS TJ 180nm (WP 3.1)	CMOS TPSCO 65nm (WP 3.1)	DepCMOS LF150 nm (WP 3.1)	Hybrid 65 nm	Hybrid TSMC 28 nm	LGAD	Trenched 3D	Diamonds (WP 3.3)
APC								
CPPM								
IJCLab								
IP2I								
IPHC								
LPNHE								
LPSC								
IRFU								

Main Interest in DRD3 framework	Interest not necessarily in DRD3	No expressed interest
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DRDT 3.1	CMOS sensors	DRDT 3.2	Sensors for 4D tracking
WP1.1	TPSCO 65 nm	WP2.1	3D sensors
WP1.2	TowerJazz 180 nm	WP2.2	LGADs
WP1.3	LFoundry 150 nm		
WP1.4	TSI 180 nm		
WP1.5	LFoundry 110 nm		
WP1.6	IHP 130 nm		
DRDT 3.3	Sensors for extreme fluence	DRDT 3.4	Demonstrator for 3D-integration
WP3.1	Wide bandgap (SiC, GaN)	WP4.1	
WP3.2	Diamond	WP4.2	
WP3.3	Silicon		

