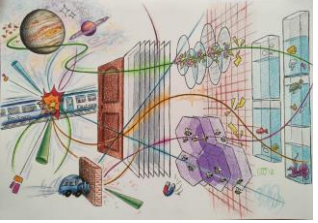
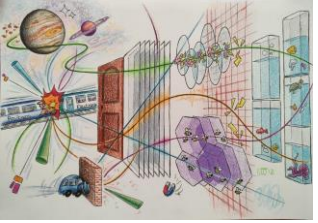


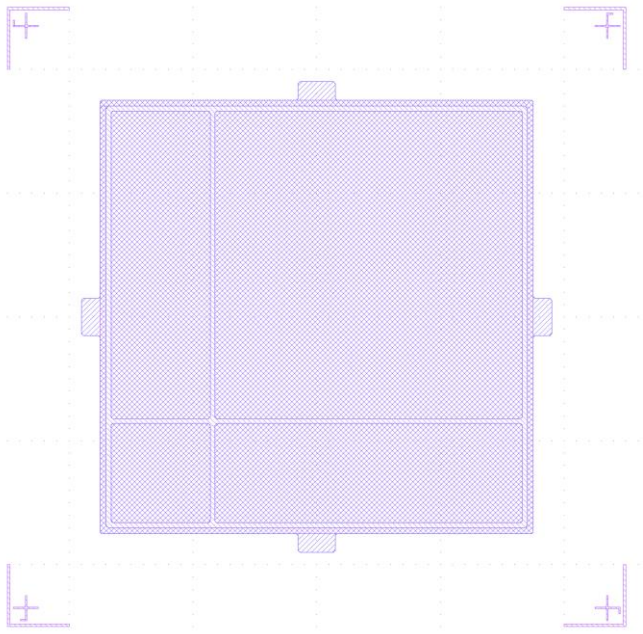
DRD3 WP3 proposal:
3D diamond technology for 10^{17} neq

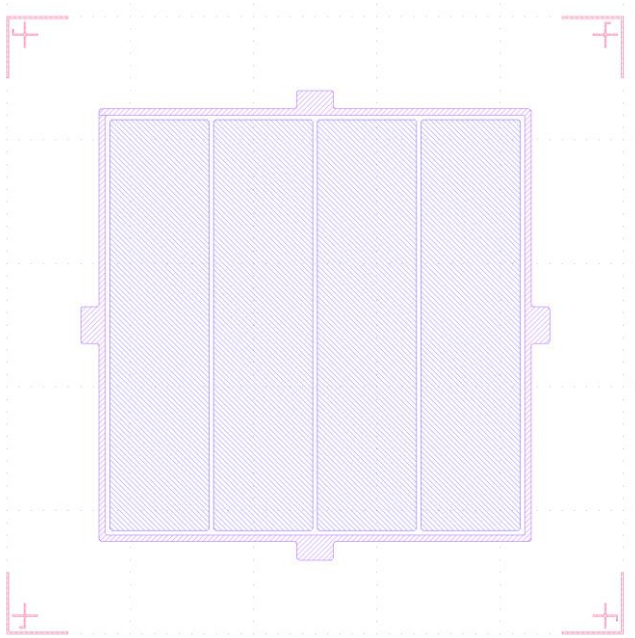


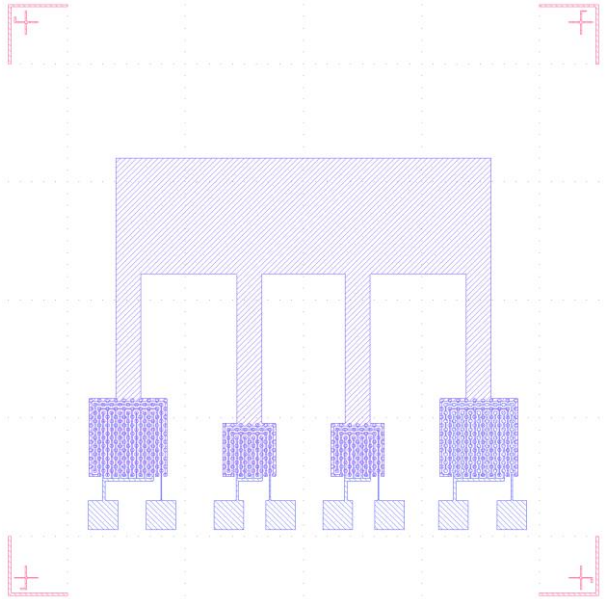
Diamond RD42

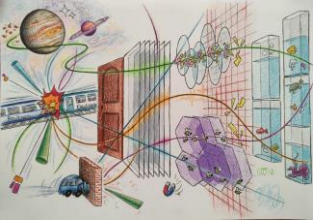
Extensive legacy of RD42. Our job is to facilitate the transition into DRD3 WG6. Latest updates:

- Finalised prototype for ATLAS ITk beam protection monitor BCM’
  - Planar and 3D diamond detectors.
  - 3D detectors fabricated, planar detectors selected, waiting for metallisation.



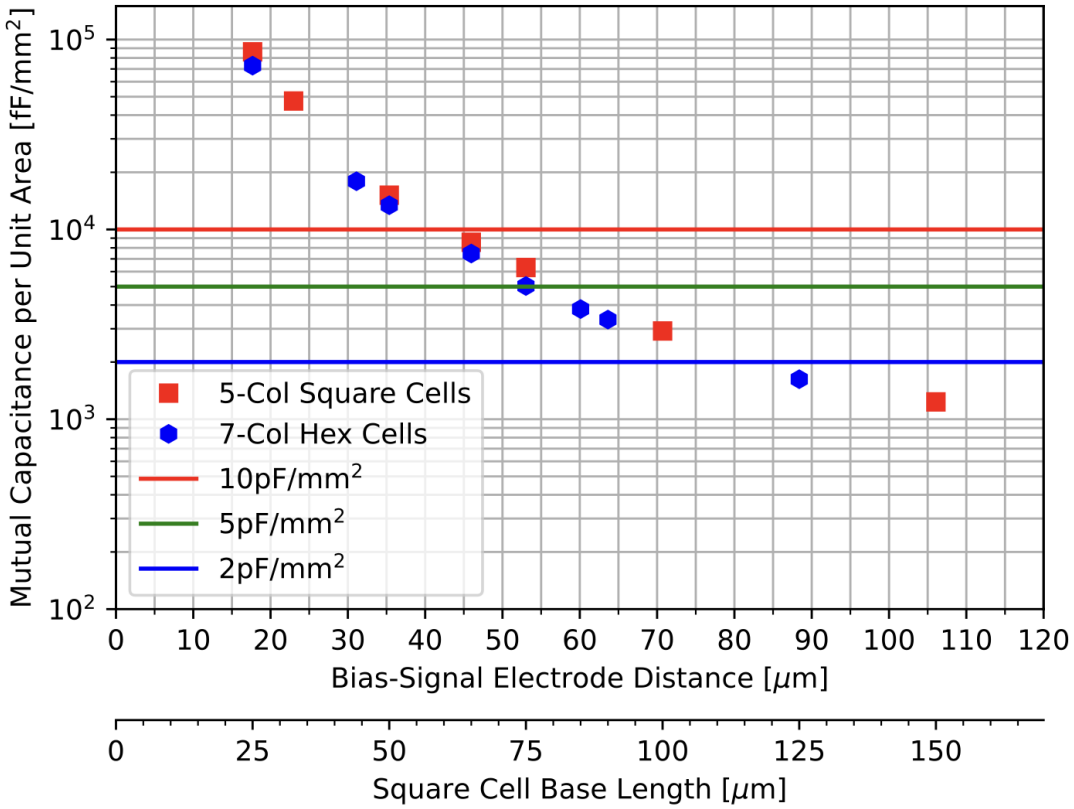


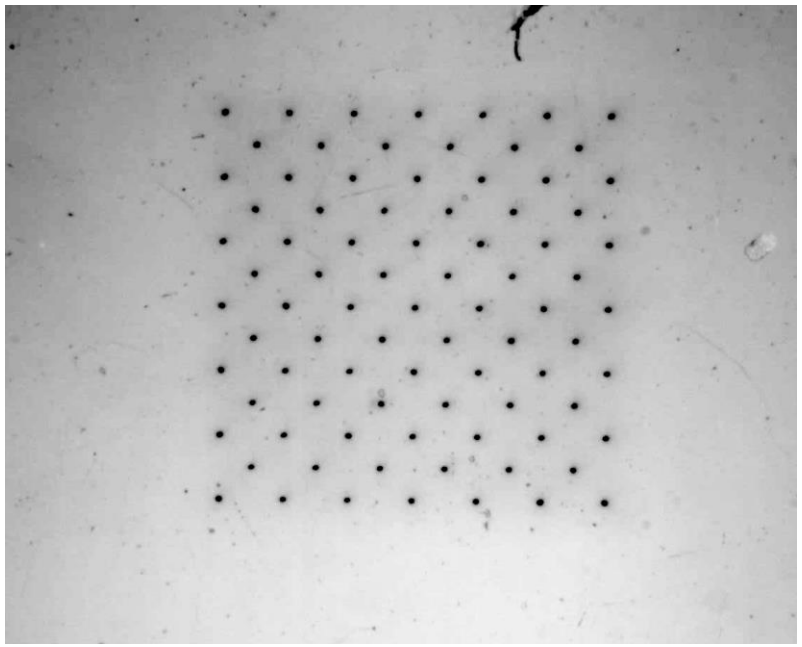




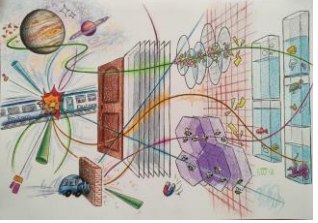
Diamond RD42

- Finalised prototype for ATLAS ITk beam protection monitor BCM’
  - 3D detector used in ganged mode.
    Need to balance area vs cell size vs capcacitance.



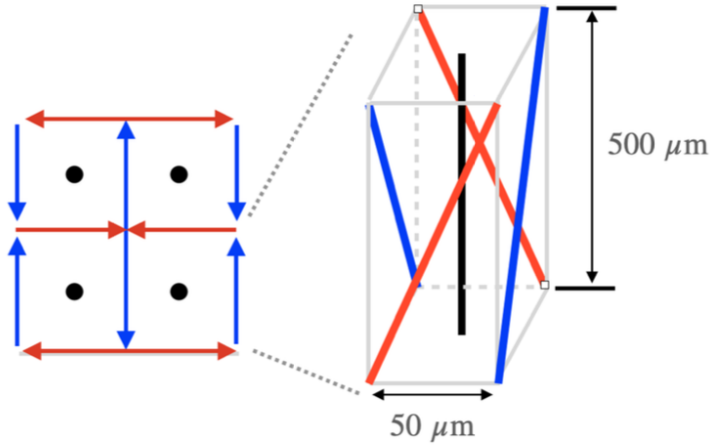


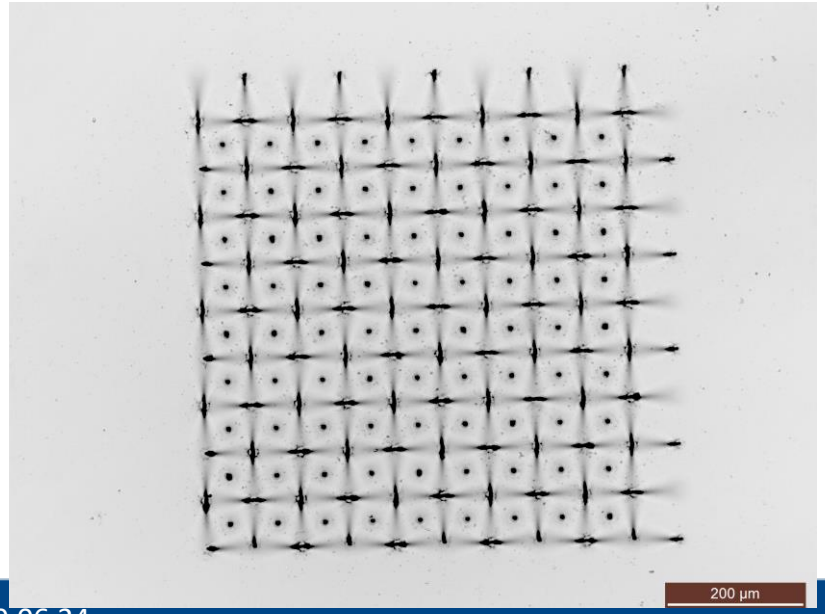
final prototype, base length 70um

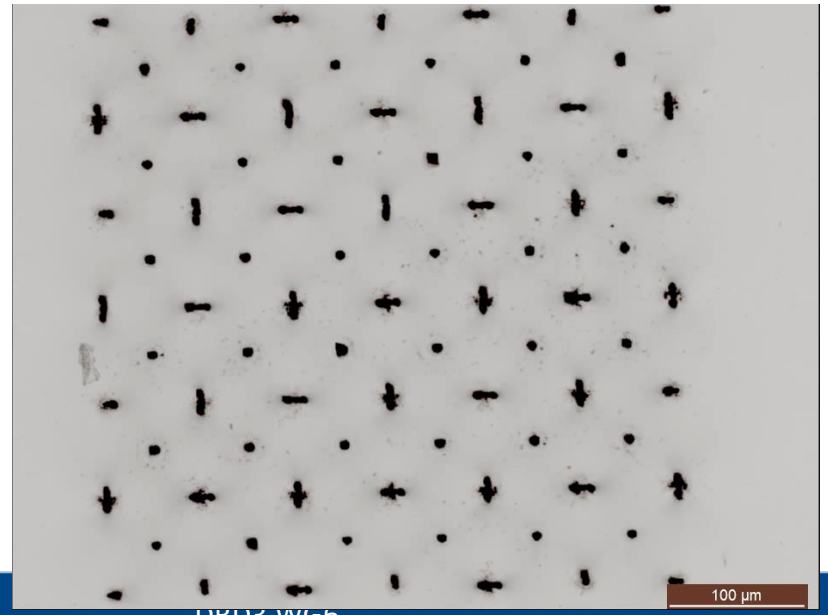


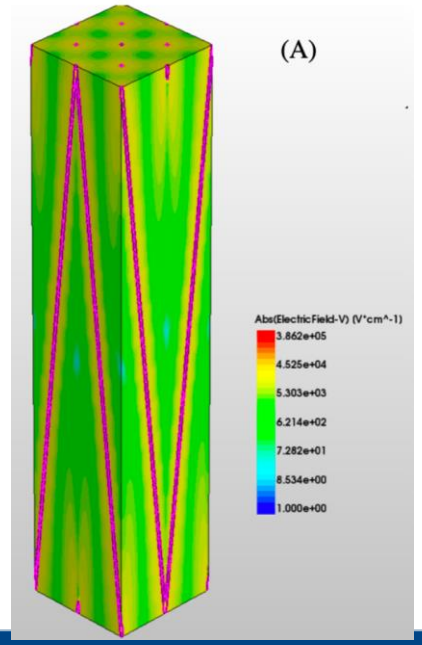
Diamond RD42

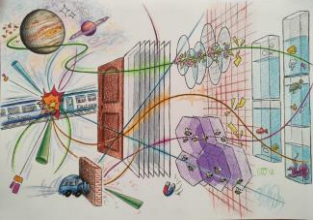
- 3D processing news (Manchester, Oxford)
  - Studies of 3D electrode geometry progressing.
  - New ”twisted” structures produced.
  - Should give an improved timing response to MIPs according to simulation studies.





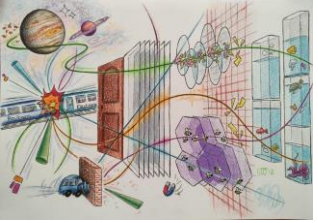






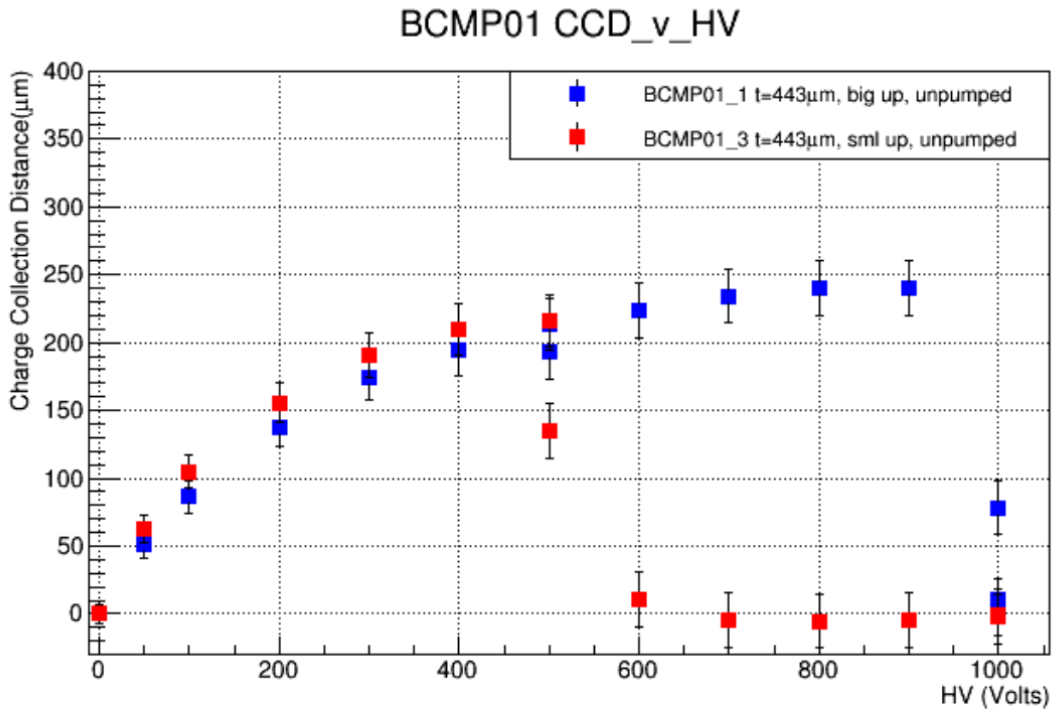
Diamond RD42

- New surface processing (OSU)
  - Reactive Ion Etching/Inductively Coupled Plasma (RIE/ICP) Processing
  - Needed to repair surface after ”grinding” (manufacturer finish)
  - Grinding causes visible surface defects, lower signals, larger leakage currents, HV breakdown, polarization and lower yield.

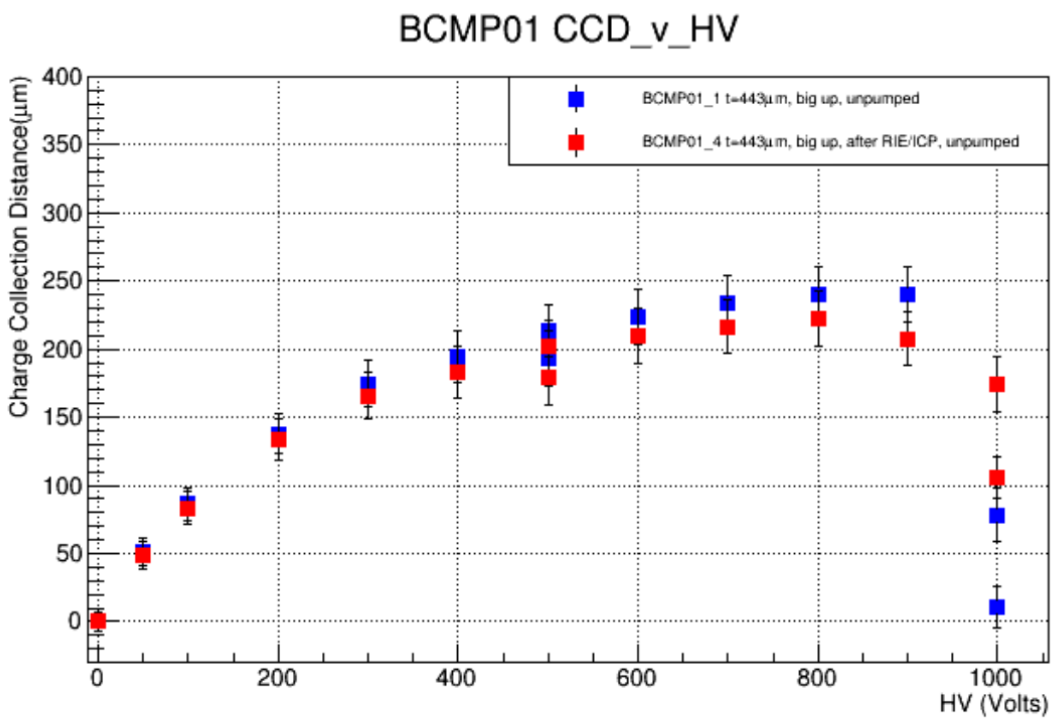


Diamond RD42

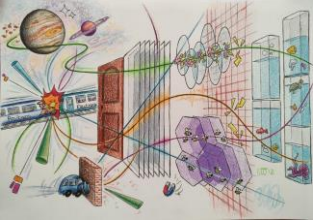
- Example of HV issue due to surface defects and mitigation with RIE/ICP (OSU)



Before RIE/ICP

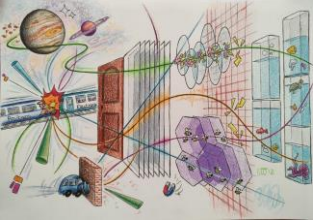


After RIE/ICP



Diamond RD42

- Next steps for 3D diamond
  - Production of final planar and 3D sensors for ITk BCM' (ATLAS)
  - Move to 25x25 μm^2 cell sizes and characterise rad hardness
  - Investigate scaling of column production
  - Investigate gain structures



3D diamond technology for 10^{17} neq

- **Project Goals**:

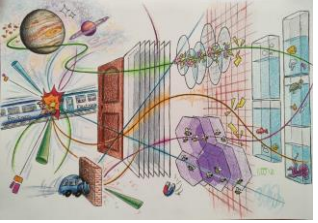
  Demonstrate the radiation hardness of 3D Diamond detector technology for fluences of 10^{17}neq and beyond.

  Develop a 25um cell size 3D diamond detector.

  Investigate charge multiplication.

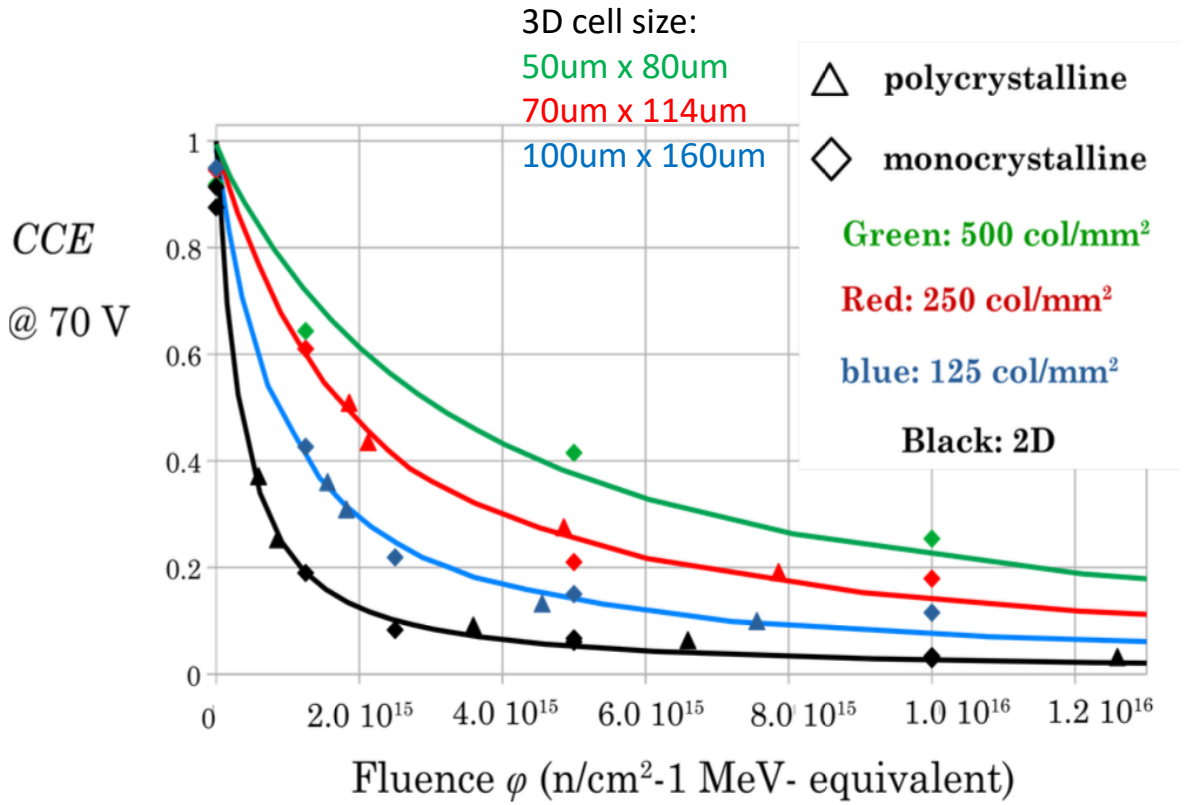
Adresses
WP 3.2 (4d dtracking)
WP 3.3 (extreme fluences)

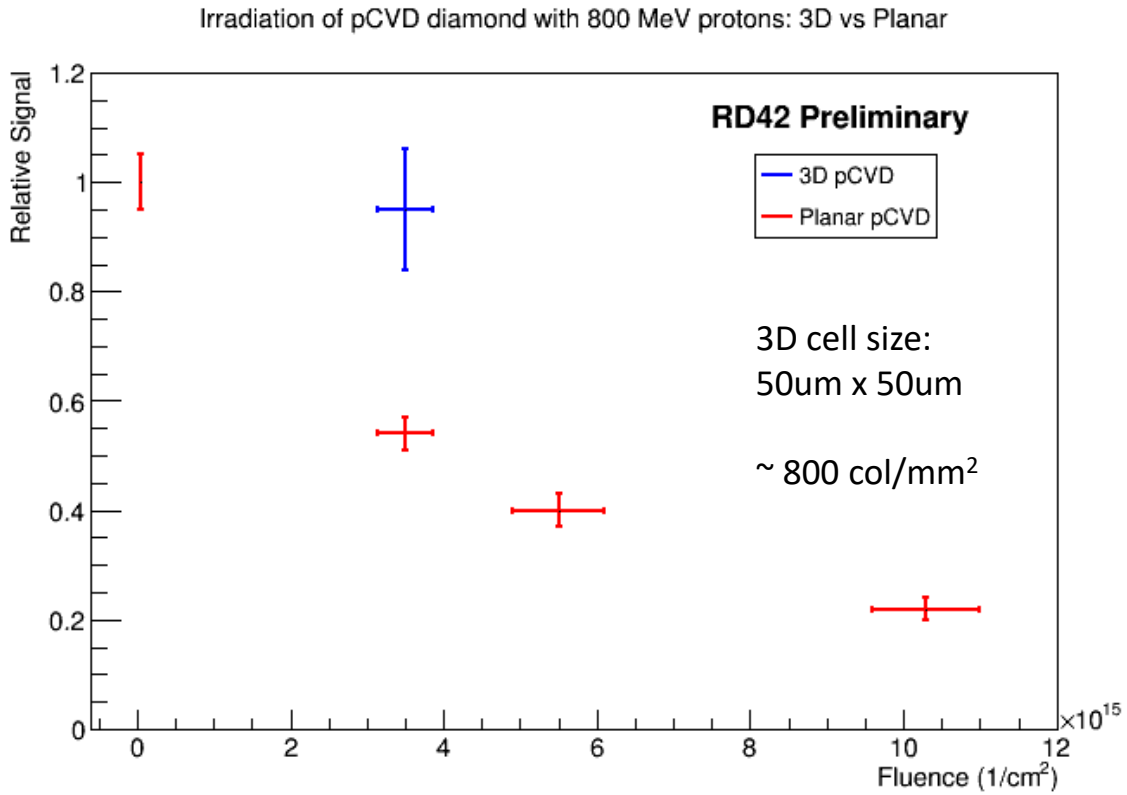
WG6 research goals <2027	
	Description
RG 6.1	Development of small cell 3D diamond detectors (cages / interconnects, base length 25 μm) and possible exploitation of impact ionization



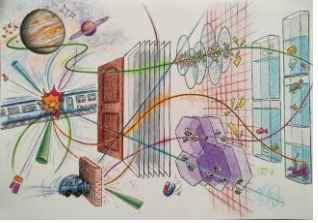
3D diamond technology for 10^{17} neq

- **3D radiation studies :**



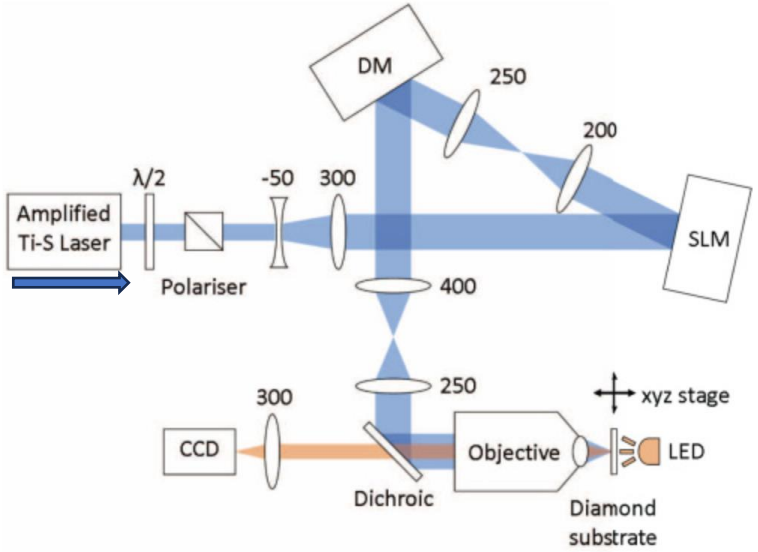


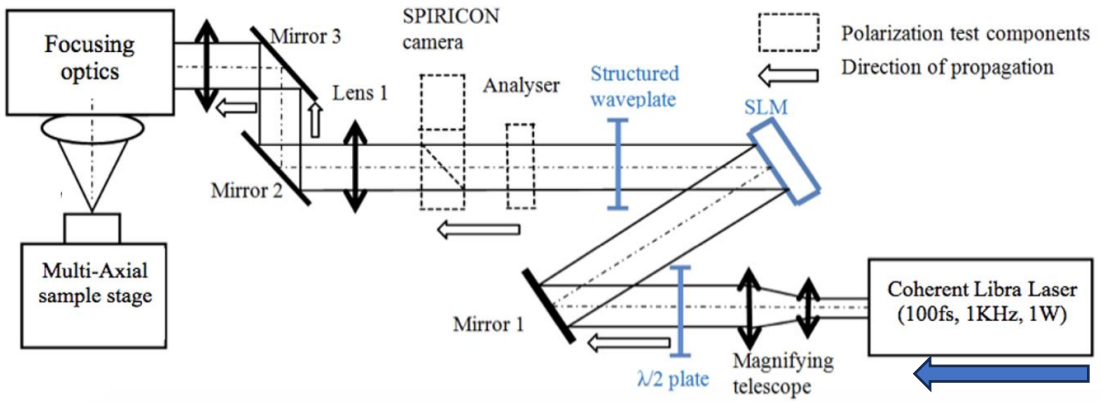
Sensors **2022**, *22*(22), 8722; https://doi.org/10.3390/s22228722

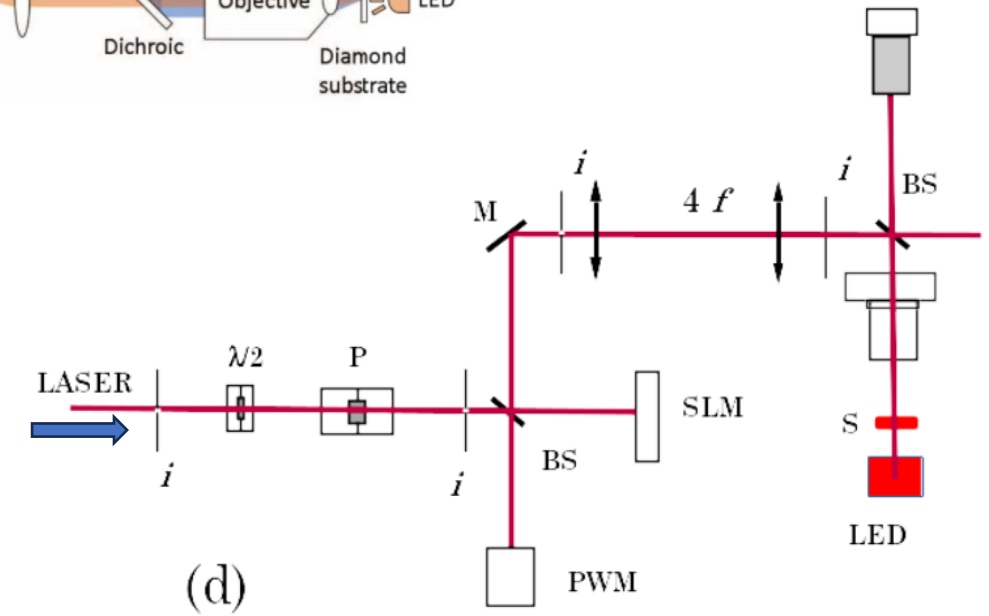


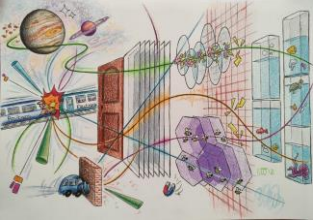
3D diamond technology for 10^{17} neq

- **3D diamond fabrication**
  Several groups in the past
  - Oxford
  - Perugia/Florence
  - Manchester



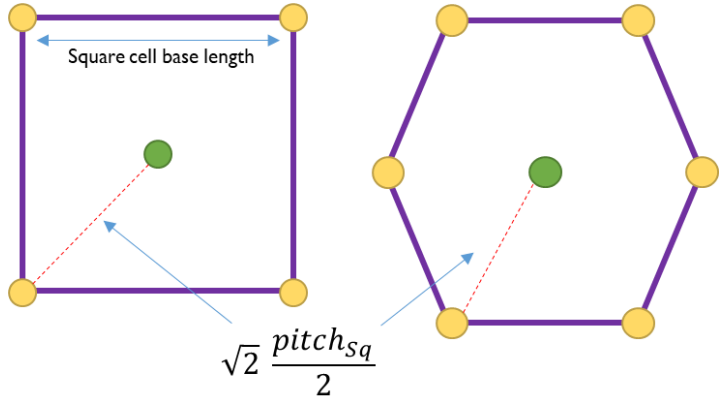


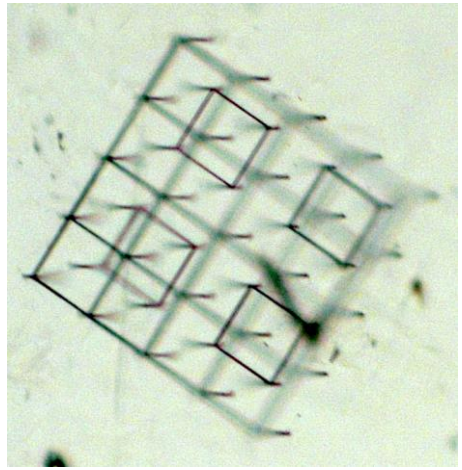


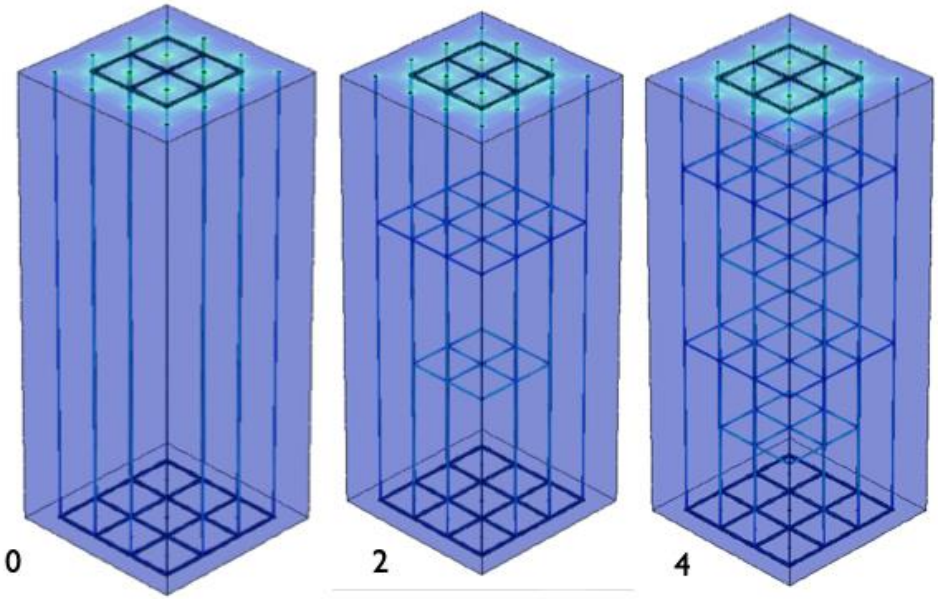


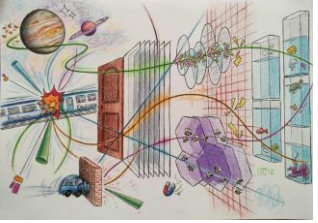
3D diamond technology for 10^{17} neq

- Laser processing allows any geometry, including horizontal wires.
  - Exiting possibility to optimise the electric and weighting field.
  - Small cell sizes realizable, wire diameter at abut 1μm.
  - Simulation studies currently ongoing.
- Future research in this area:
  - Optimise geometry
  - Wire processing
  - cell sizes <$(25\mu m)^2$
  - Simulation – Prototyping – Characterization.



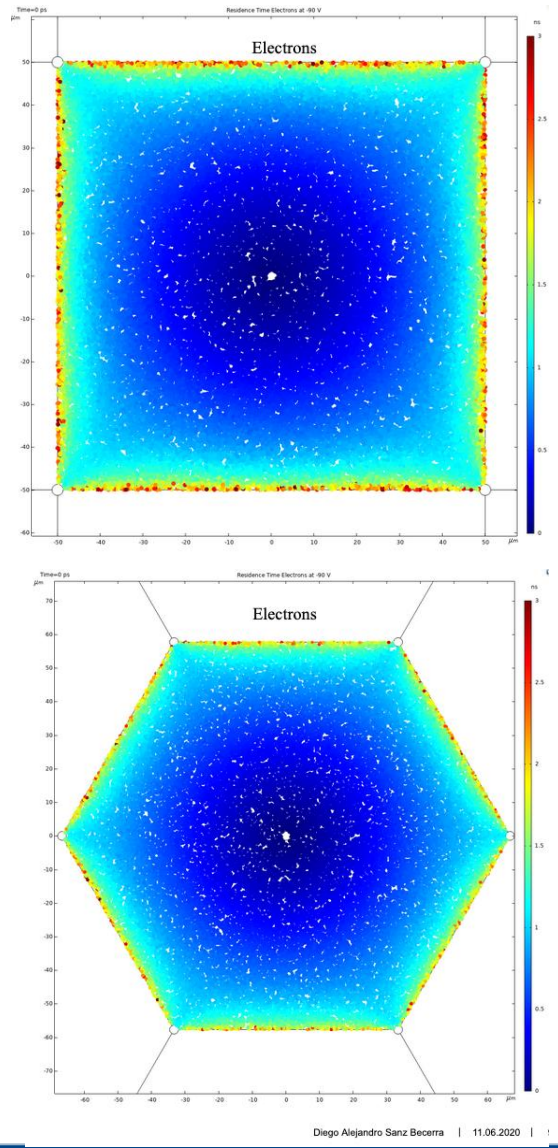


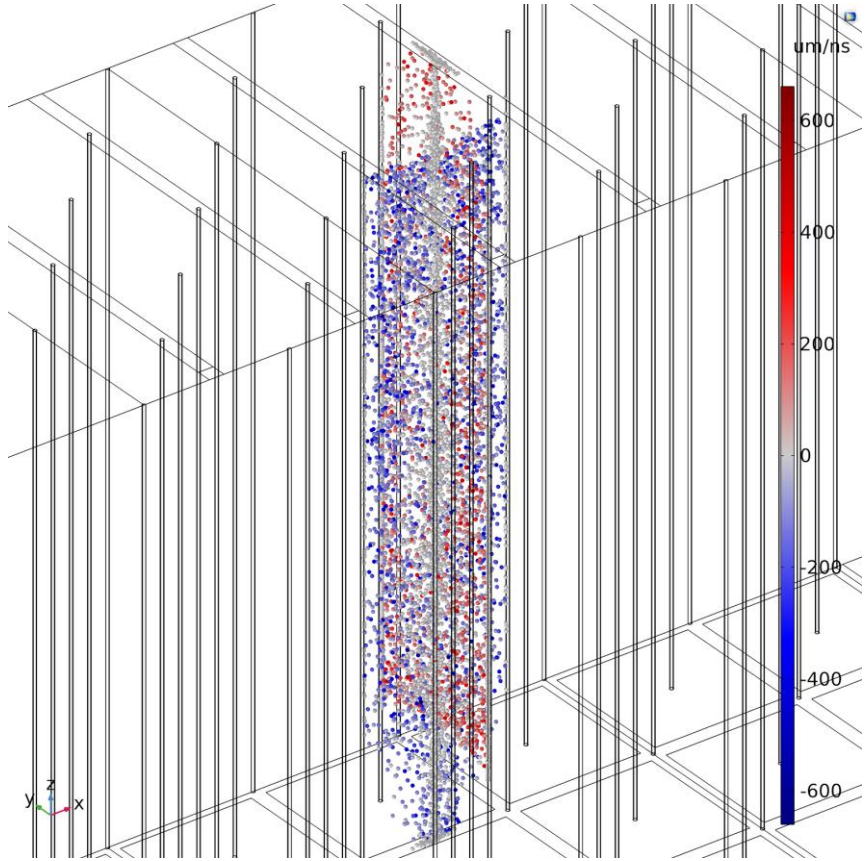




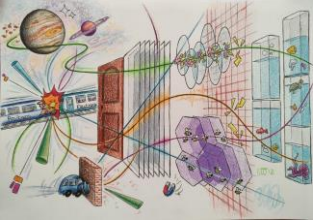
3D diamond technology for 10^{17} neq

- Lack of build-in models, especially pCVD and traps / polarisation in current TCAD tools being addressed.
- Need effort to improve simulations:
  - polycrystalline CVD diamond, grain boundaries.
  - graphitic wire simulation
  - radiation damage
  - new geometries





3D diamond simulation examples from RD42

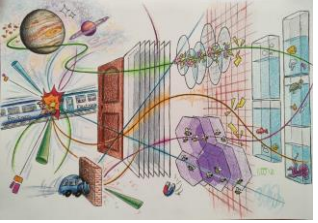


3D diamond technology for 10^{17} neq

- Optimisation of laser processing for 25um base cell size
- Simulation studies for optimal electrode geometry
- Production of small sensors for irradiation and testing
- Bonding to pixel chips or ganged readout.
- Irradiation and test-beam campaign

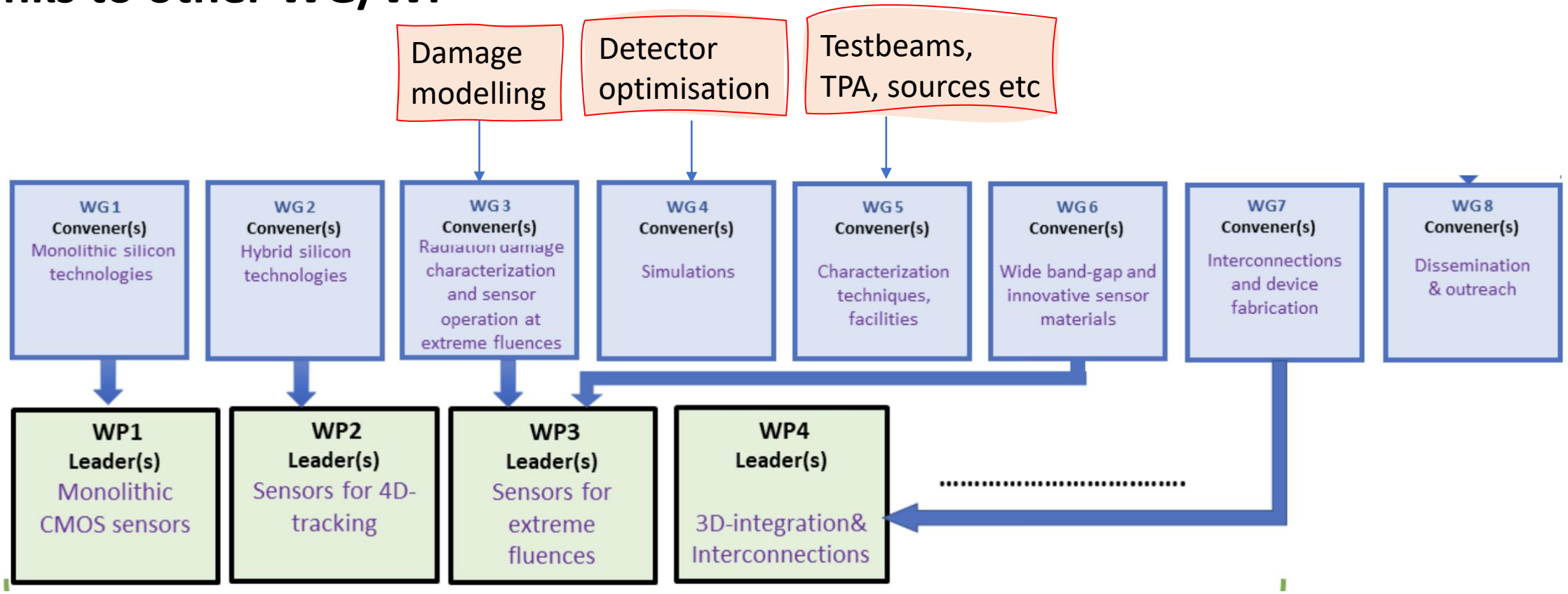
Work-program

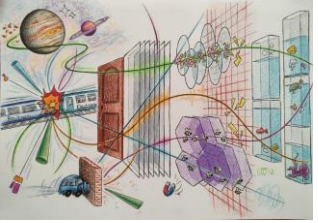
- Many links to other WP/WG.
- Open call for collaboration to all participants.
- Time scale to develop the full proposal is towards autumn.
- Ultimate goal is to demonstrate the radiation hardness to fluences greater $>10^{17}$neq!



3D diamond technology for 10^{17} neq

- **Links to other WG/WP**





3D diamond technology for 10^{17} neq

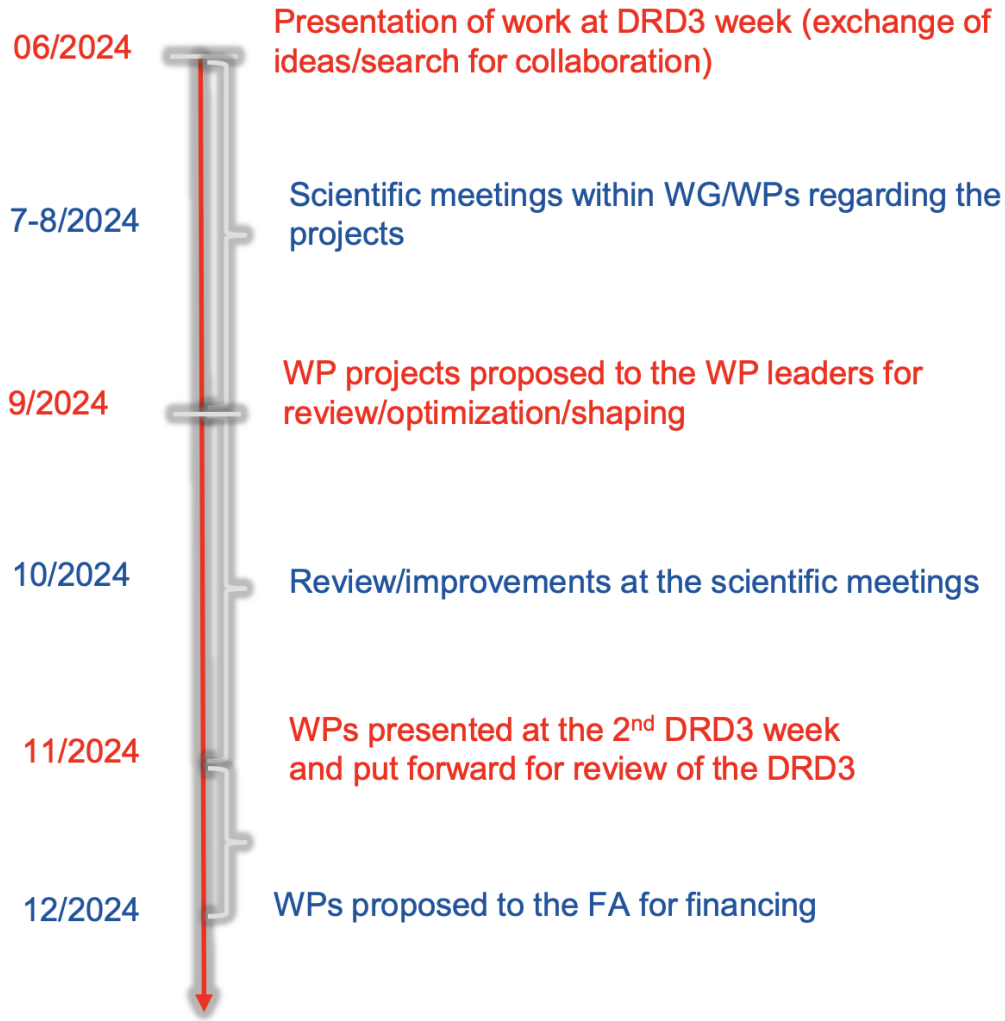
- **Way forward?**
- Timeline set by DRD3 are quite tight, need proposal by September, some time for tweaking:

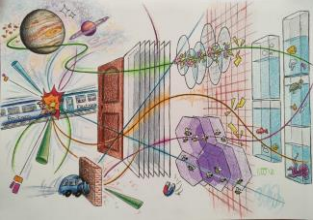
09/24 WP leaders for review

11/24 DRD3 review

Need for first draft already by summer!
Institutes interested so far:
OSU, Manchester, INFN Florence

More collaborators very welcome!





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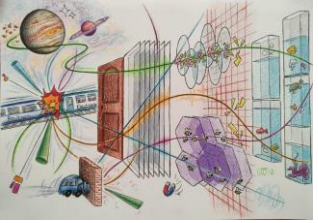

WP milesstones

WG6 research goals <2027	
	Description
RG 6.1	Development of small cell 3D diamond detectors (cages / interconnects, base length 25 μm) and possible exploitation of impact ionization

3	2.1, 3.2	D3.1	Fabricate 3D diamond detectors with cages/interconnects and a base length < 25 μm.

3	3.2.	MS3.1	Evaluate the possibility of achieving CVD diamond wafers with CCD > 500 μm and variation < 2%
3	3.2.	MS3.2	Study radiation hardness and fast timing (< 30 ps) of diamond detectors at $1{\cdot}10^{16}$ n_{eq}/cm^2 (2026), $0.5{\cdot}10^{17}$ n_{eq}/cm^2 (2029), $1{\cdot}10^{17}$ n_{eq}/cm^2 (>2030) in planar and 3D geometries