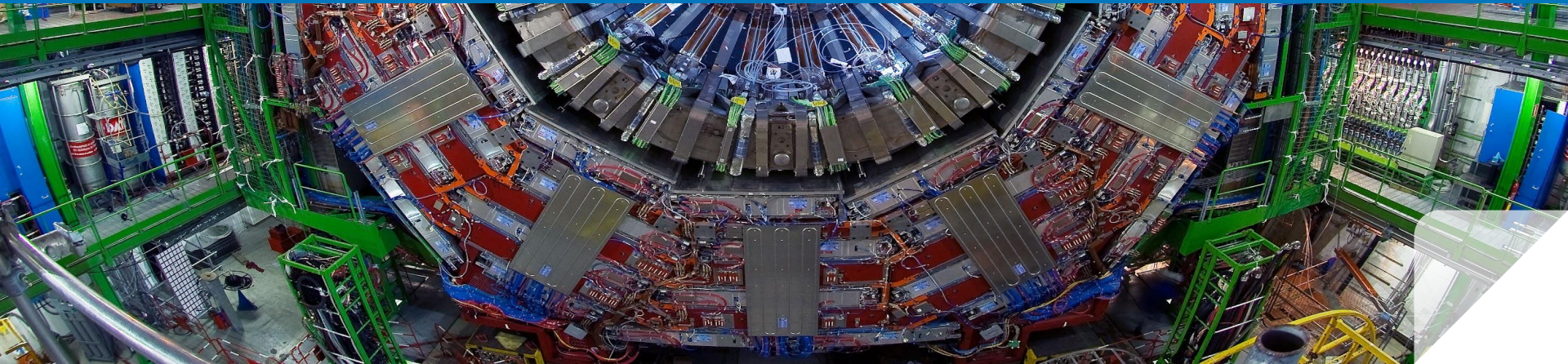


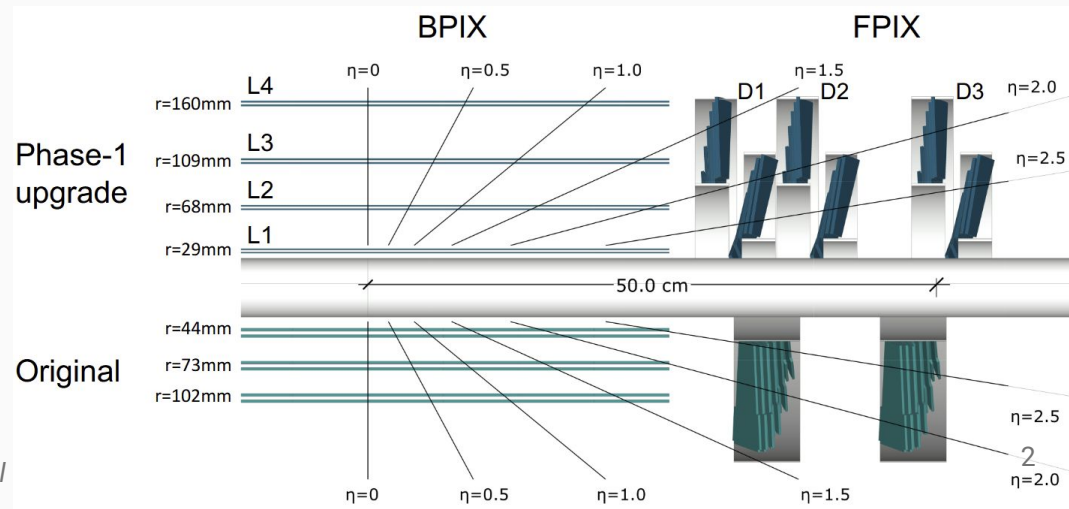


# CMS Phase-1 Pixel Detector



# Detector Goal

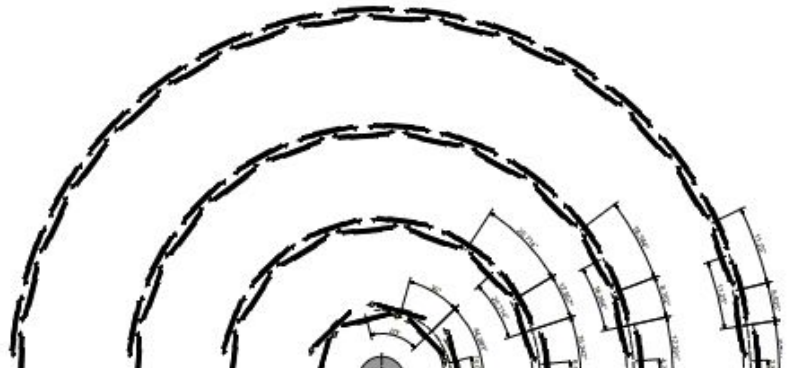
- 3D tracking of charged particles
- Vertex Reconstruction
- Increased luminosity and Radiation Levels
- Four layers and three forward disks
- Reduced material budget
- Run 3
- $|\eta| < 2.5$



Courtesy W. Adam et al

# Pixel detection

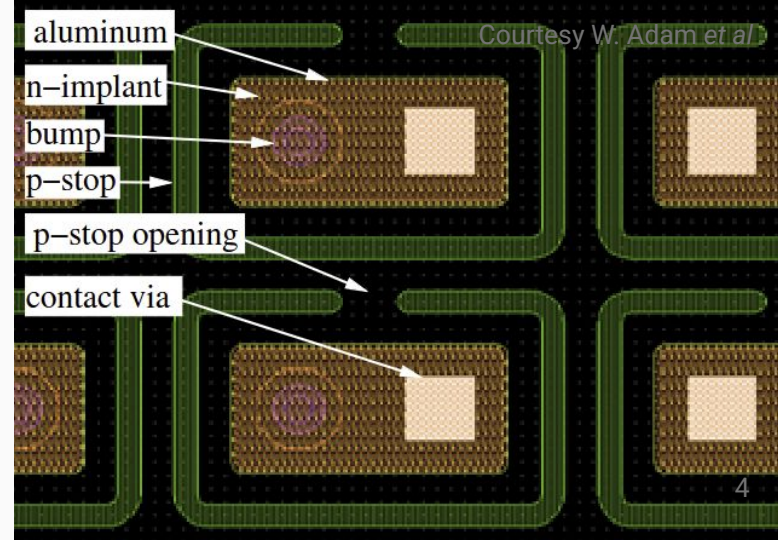
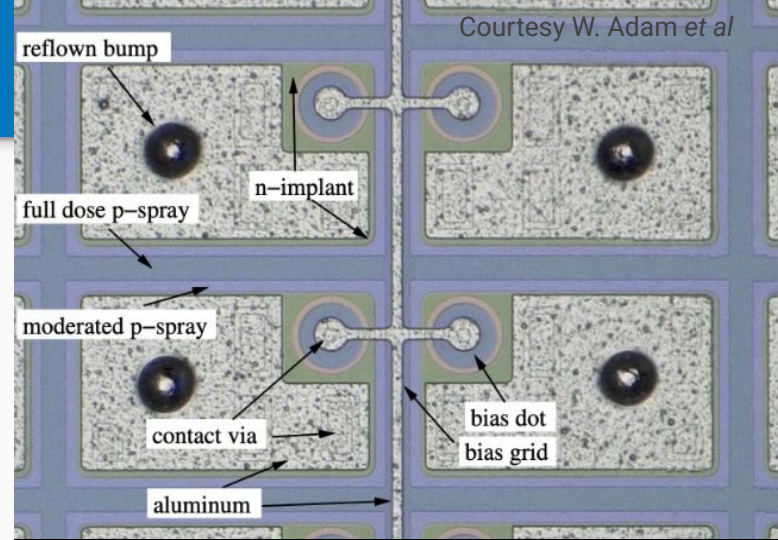
- Pixel sizes are  $100 \times 150 \mu\text{m}^2$
- Each pixel detects charge deposited by traversing charged particles
- Readout chips (ROCs) process charge information to determine hit positions.
- Same 250 nm CMOS technology as the original ROC
- Material interaction minimization
- azimuthal



	PSI46dig	PROC600
Detector layer	BPIX L2–L4 and FPIX	BPIX L1
ROC size	$10.2 \times 7.9 \text{ mm}^2$	$10.6 \times 7.9 \text{ mm}^2$
Pixel size	$100 \times 150 \mu\text{m}^2$	$100 \times 150 \mu\text{m}^2$
Number of pixels	$80 \times 52$	$80 \times 52$
In-time threshold	$< 2000 e^-$	$< 2000 e^-$
Pixel hit loss	$< 2\%$ at $150 \text{ MHz/cm}^2$	$< 3\%$ at $580 \text{ MHz/cm}^2$
Readout speed	160 Mb/s	160 Mb/s
Maximum trigger latency	6.4 $\mu\text{s}$	6.4 $\mu\text{s}$
Radiation tolerance	120 Mrad	120 Mrad

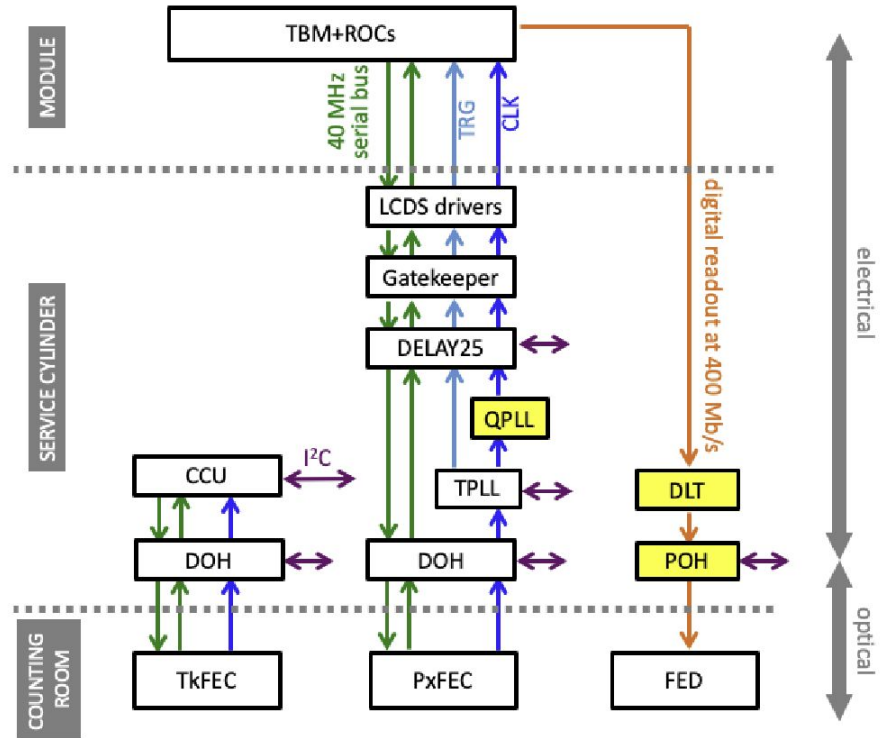
# Detector Workings

- Electron-hole pair production
- Proportional to energy deposited by Charged particle
- Electrons generated are collected by readout chips
- Electron vs. Hole Mobility and Charge trapping
- Radiation Hardening



# Data Processing

- Readout chips
- 48 readout groups serving up to 39 modules
- Auxiliary chips for clock, trigger signals, clock jitter etc.
- Detector to DAQ in counting via optical links
- Data rates up to 10 Gb/s

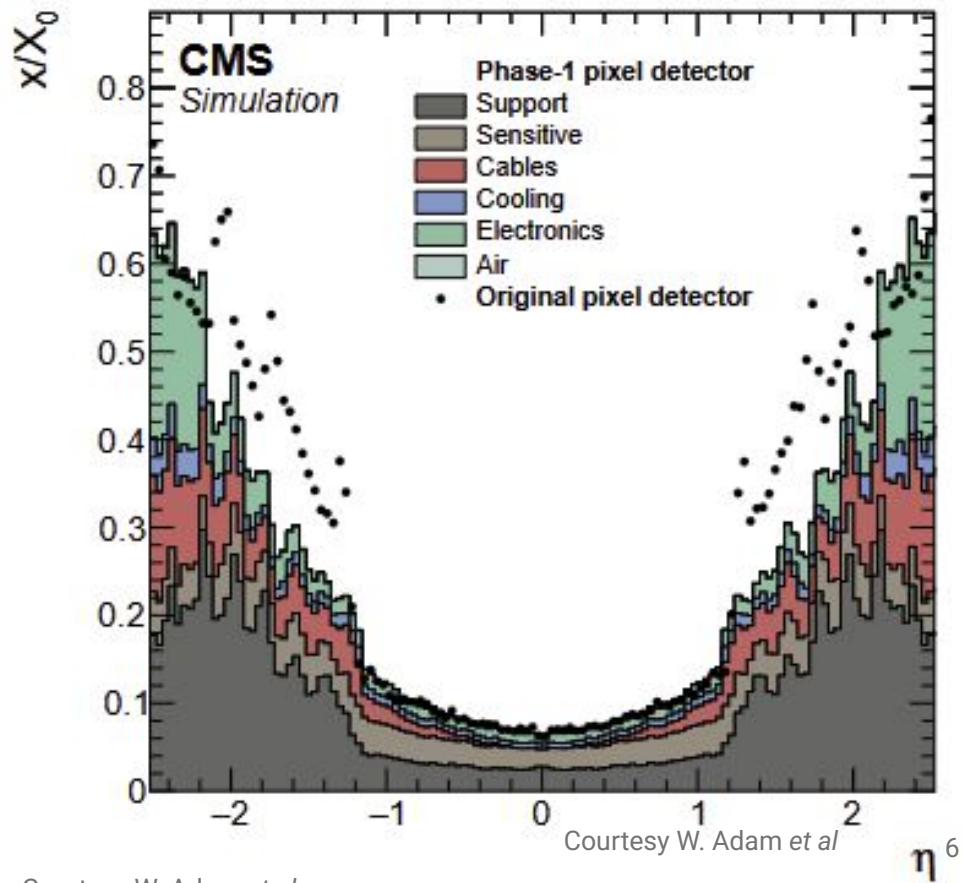


Courtesy W. Adam et al

# Material Budget & Conditions

- Material budget
  - Improvement
  - Carbon fiber
  - Two-phase CO2 Cooling system
  - Forward region
- Conditions
  - Radiation Hardened Chips

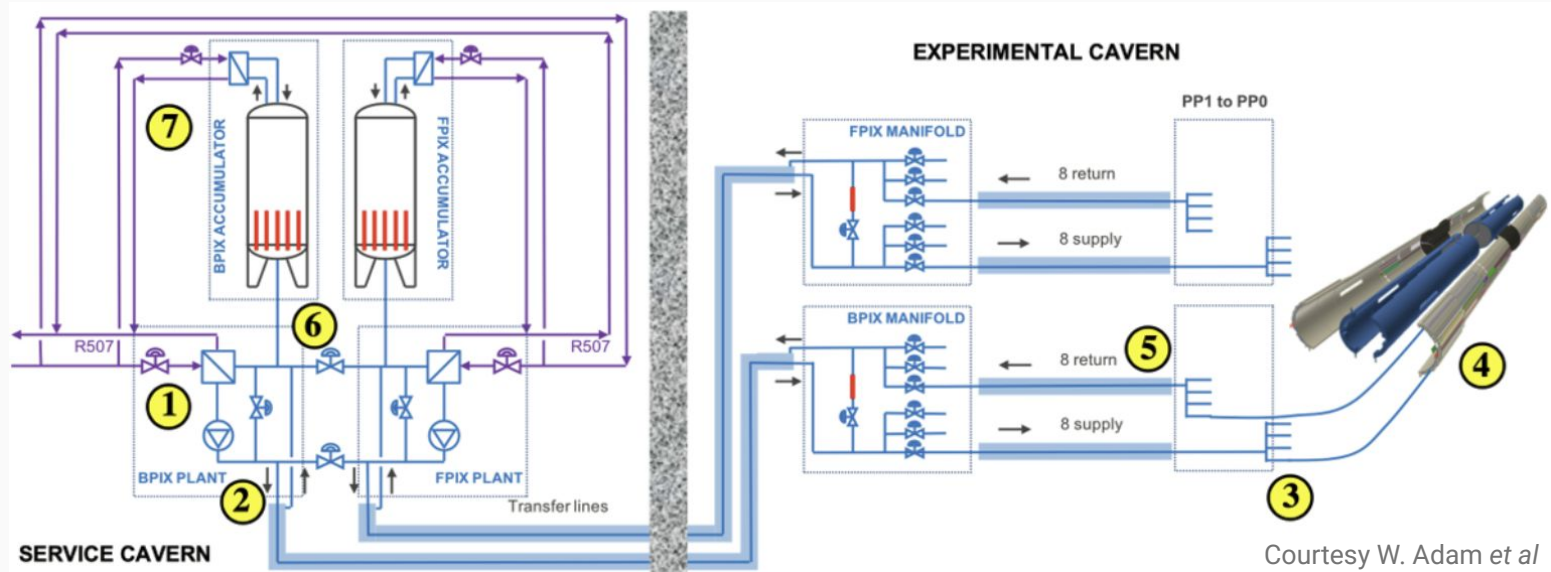
	Pixel hit rate [MHz/cm <sup>2</sup> ]	Fluence [10 <sup>15</sup> n <sub>eq</sub> /cm <sup>2</sup> ]	Dose [Mrad]
BPIX L1	580	2.2	100
BPIX L2	120	0.9	47
BPIX L3	58	0.4	22
BPIX L4	32	0.3	13
FPIX inner rings	56–260	0.4–2.0	21–106
FPIX outer rings	30–75	0.3–0.5	13–28



Courtesy W. Adam et al

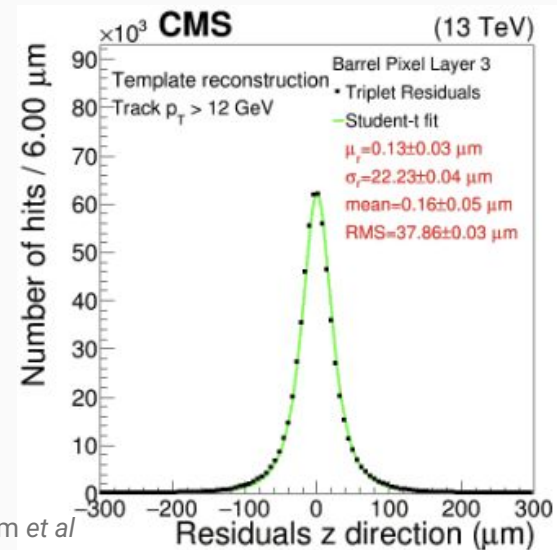
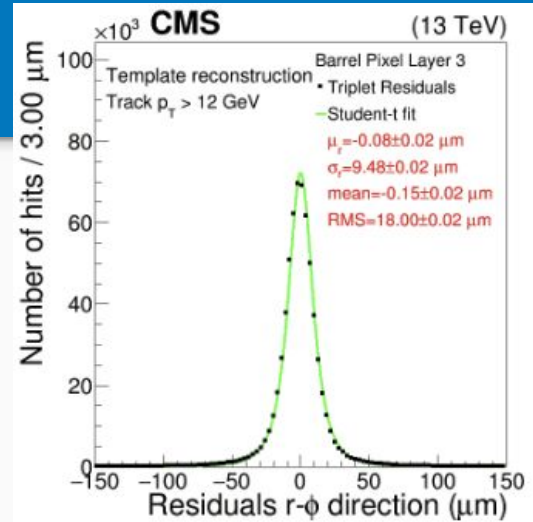
# Operational Conditions: Cooling

- ❖ Two phase accumulator controlled loop (2-PACL)
- ❖ Approach developed at Nikhef; Similar for AMS Tracker and LHCb VELO
- ❖ Designed for 15kW; Operates at  $-22^{\circ}\text{C}$ 
  - FPIX generates 3kW, BPIX 6kW and Heat leakage 2kW



# Detector Performance

- Detector hit efficiency, important
- Position resolution
- Time resolution is
- Data losses in FPIX and BPIX are less than 2%
- Succeed at taking position and charge of all pixels with 25 ns time resolution
- Integrated luminosity of  $100 \text{ fb}^{-1}$
- Inner layer hit rates up to almost  $600 \text{ MHz/cm}^2$





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