MPGDs for future high energy physics colliders

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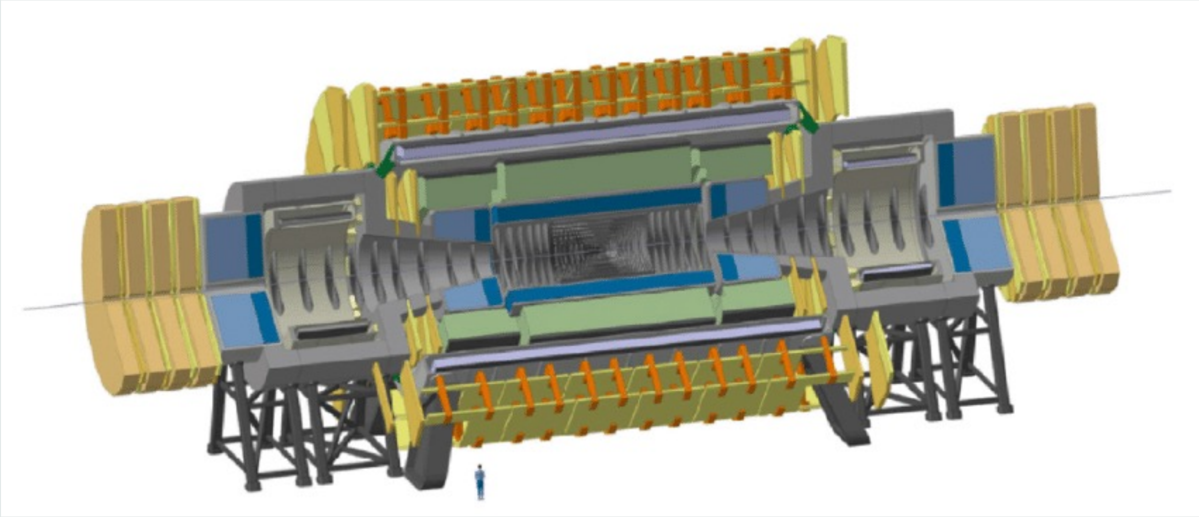
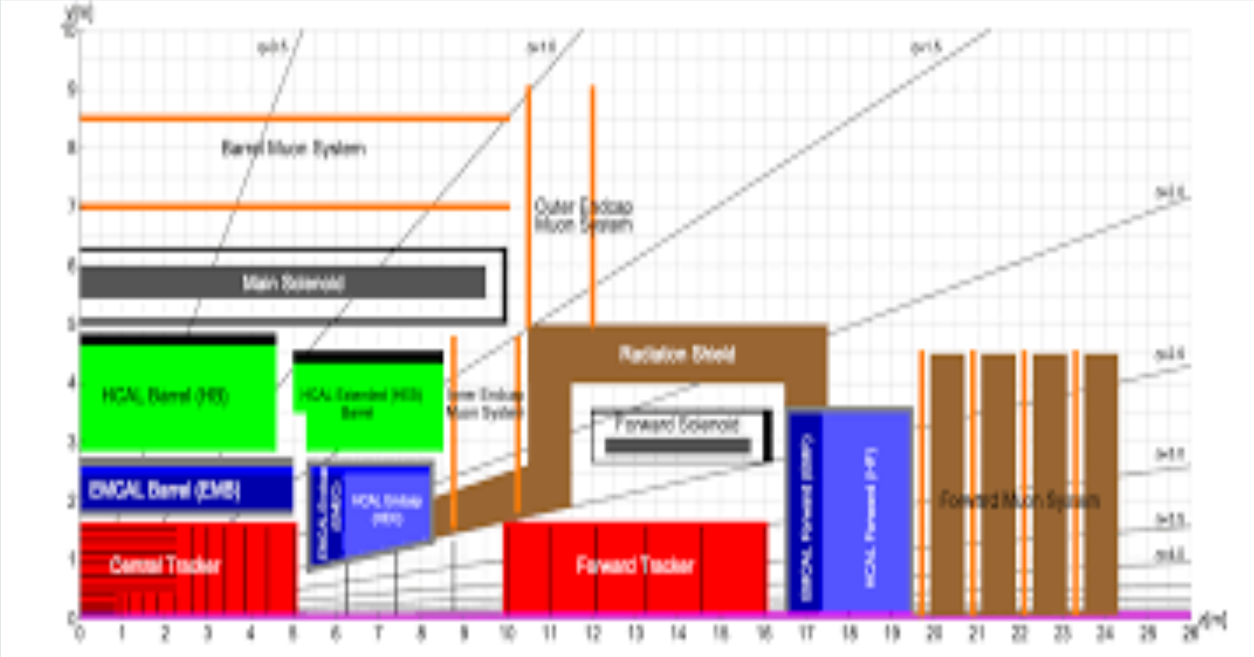
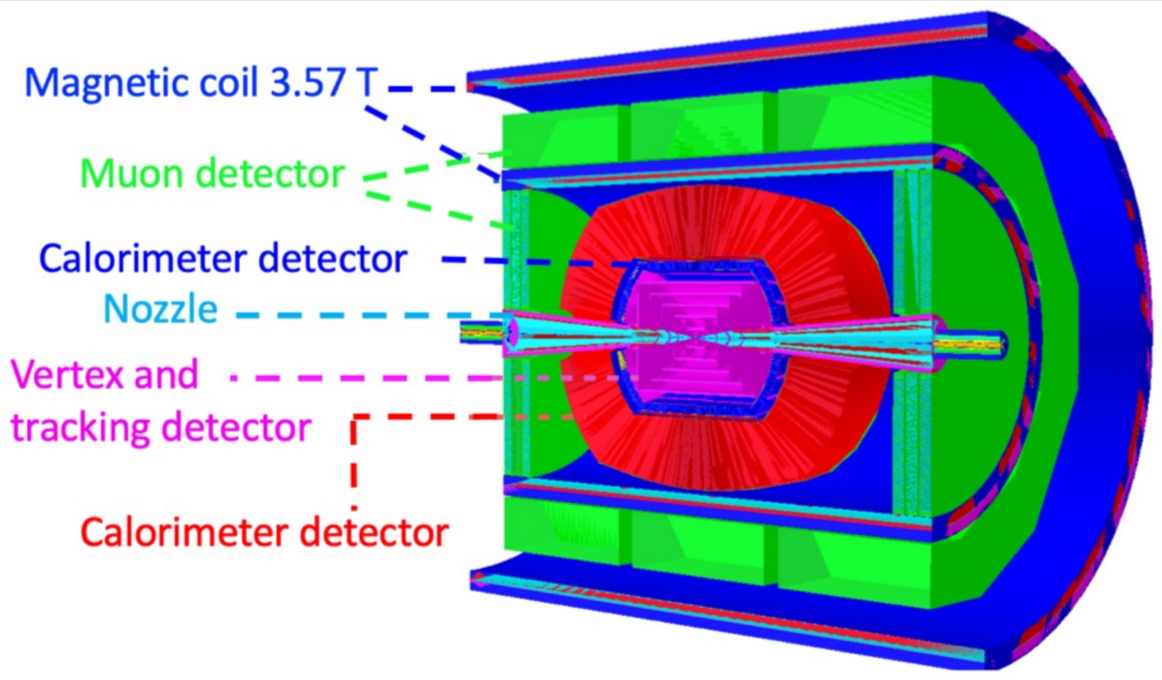
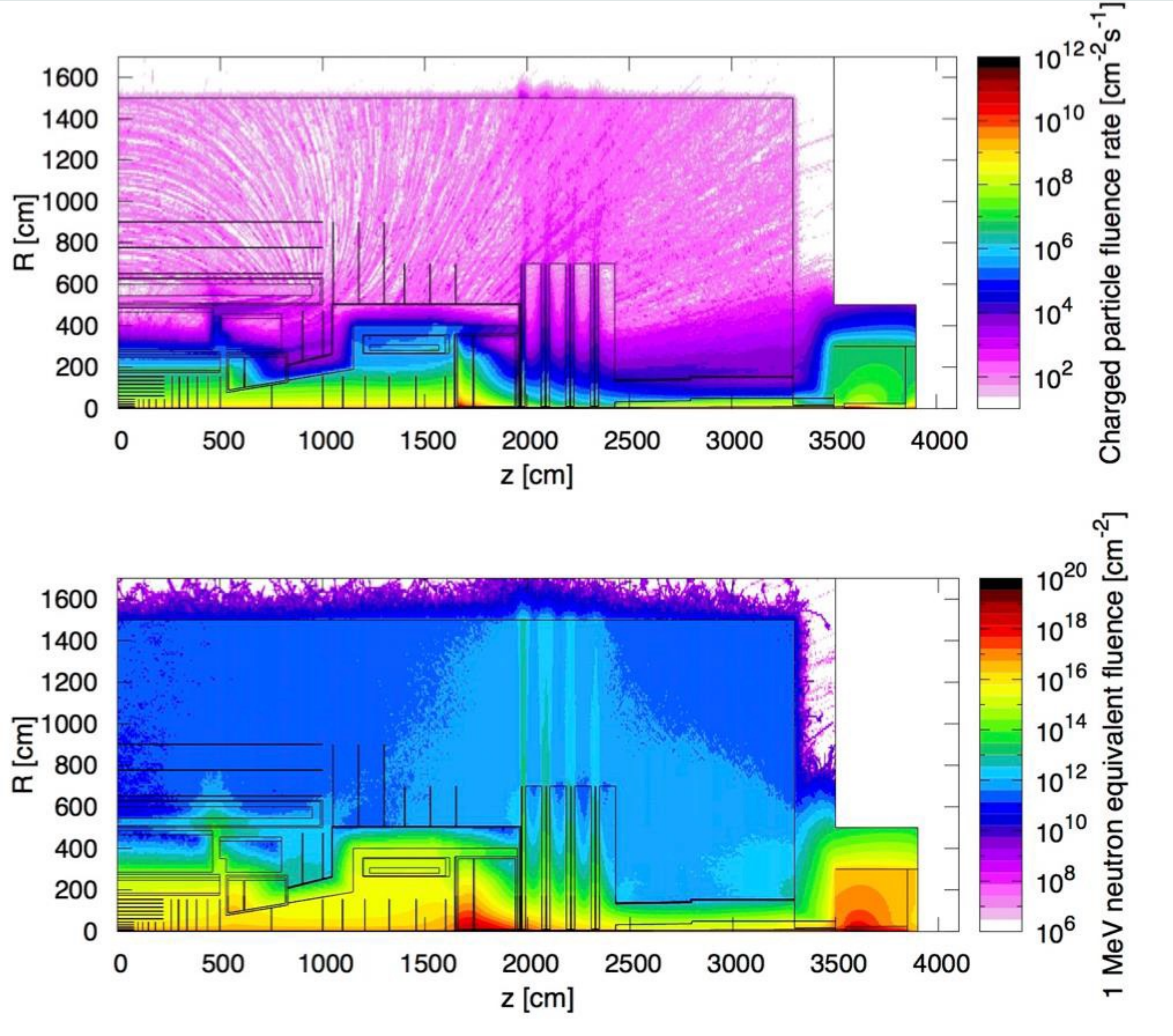


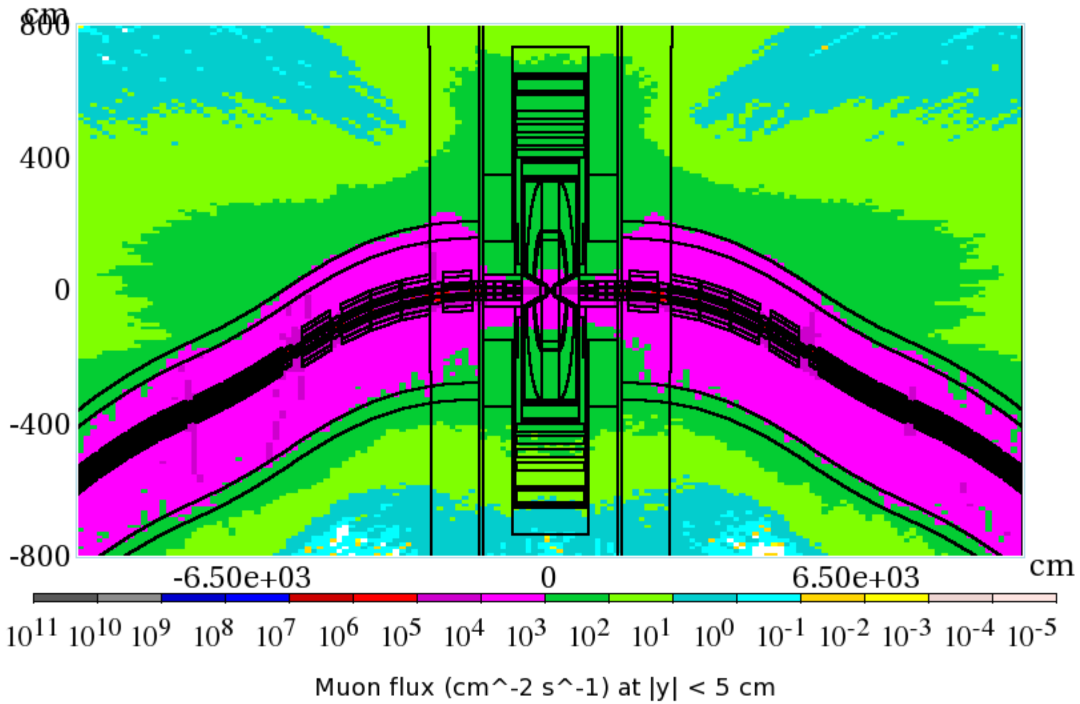
- Future collider detectors will continue to need to instrument large volumes, deal with high rate environments, and have excellent spatial and timing resolution

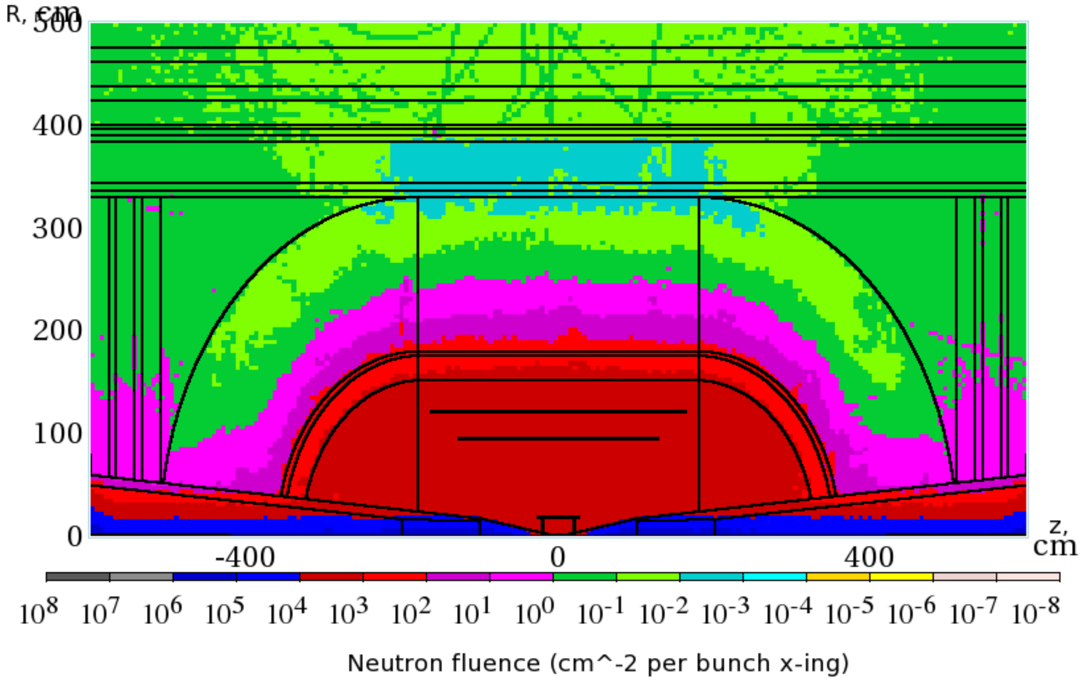






- Charge particle fluxes on the order of HL-LHC in the forward muon regions
- Backgrounds dominated by neutron and photon from 'cavern background' in the muon systems (does not point to the IP and not in time with beam)
- Additional charged particles from punch through (points either back to IP or from secondary interactions)





- Muons Decay!
- Creation of large number of electrons and muons which come downstream which create secondary showers when interacting with accelerator elements, machine detector interface, beam pipe and surrounding material around the tunnel
- Would be ideal to have ~50 ps timing resolution or better

Contributions to Summary Report:

MPGD for tracking and Muon detection at future high energy physics colliders

MPGDs for tracking and Muon detection at future high energy physics colliders

Snowmass Instrumentation Frontier: MPGD White paper 5

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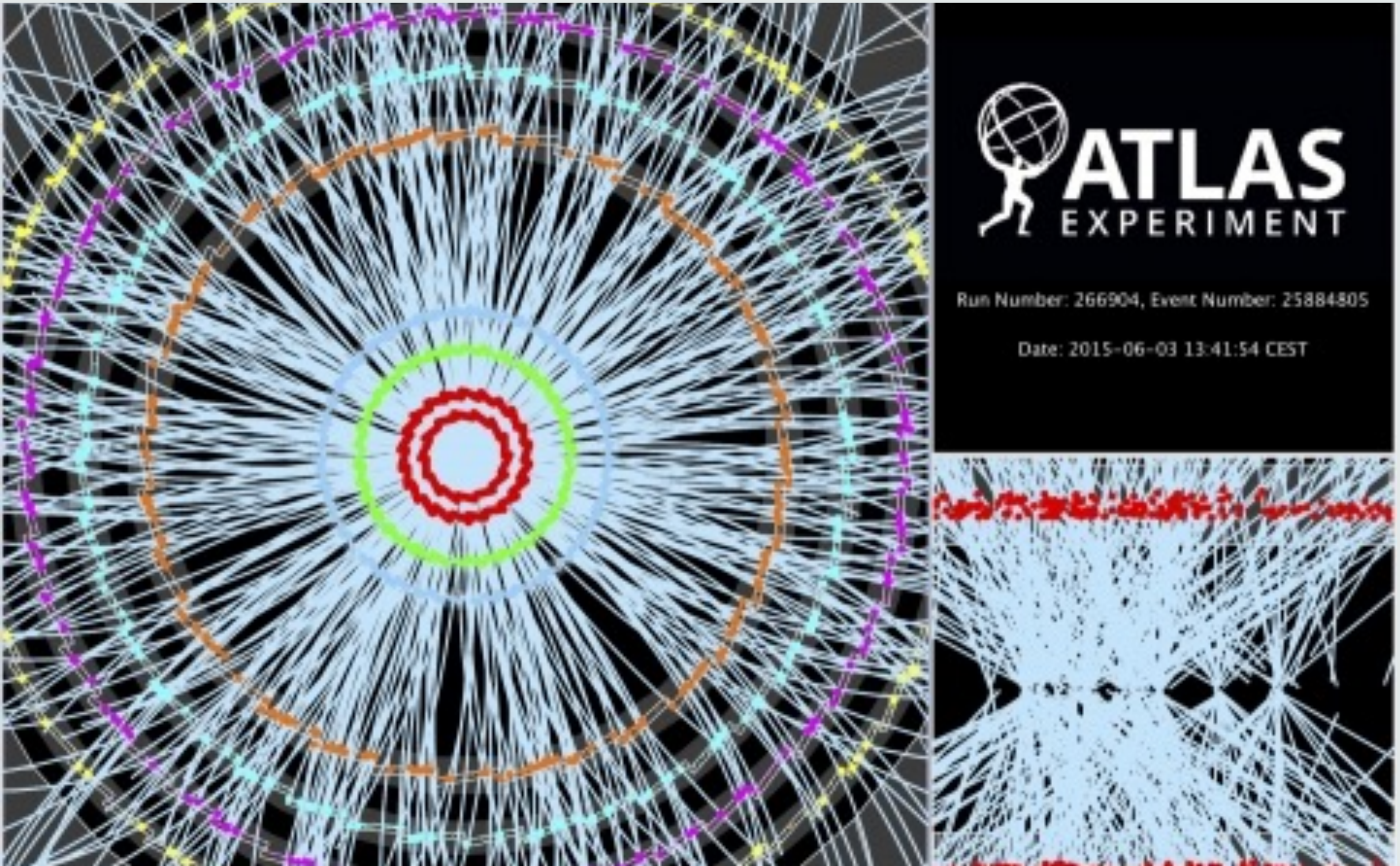
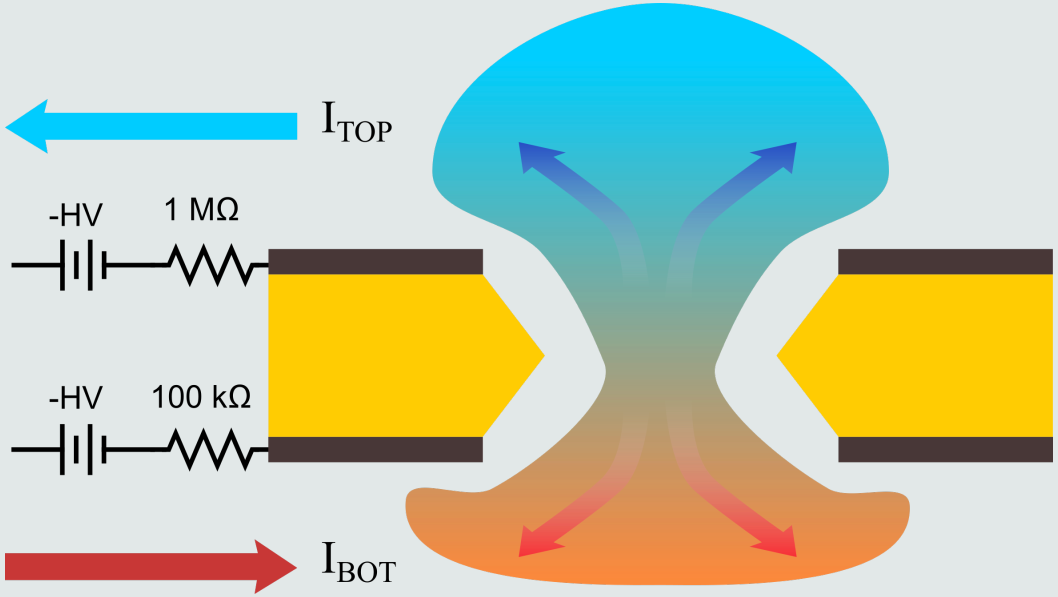
- High granularity resistive Micromegas for high rates
- Advanced GEM detectors for future collider detectors
- μ- Rwell detectors for HEP experiments
- Gas systems for particle detector systems

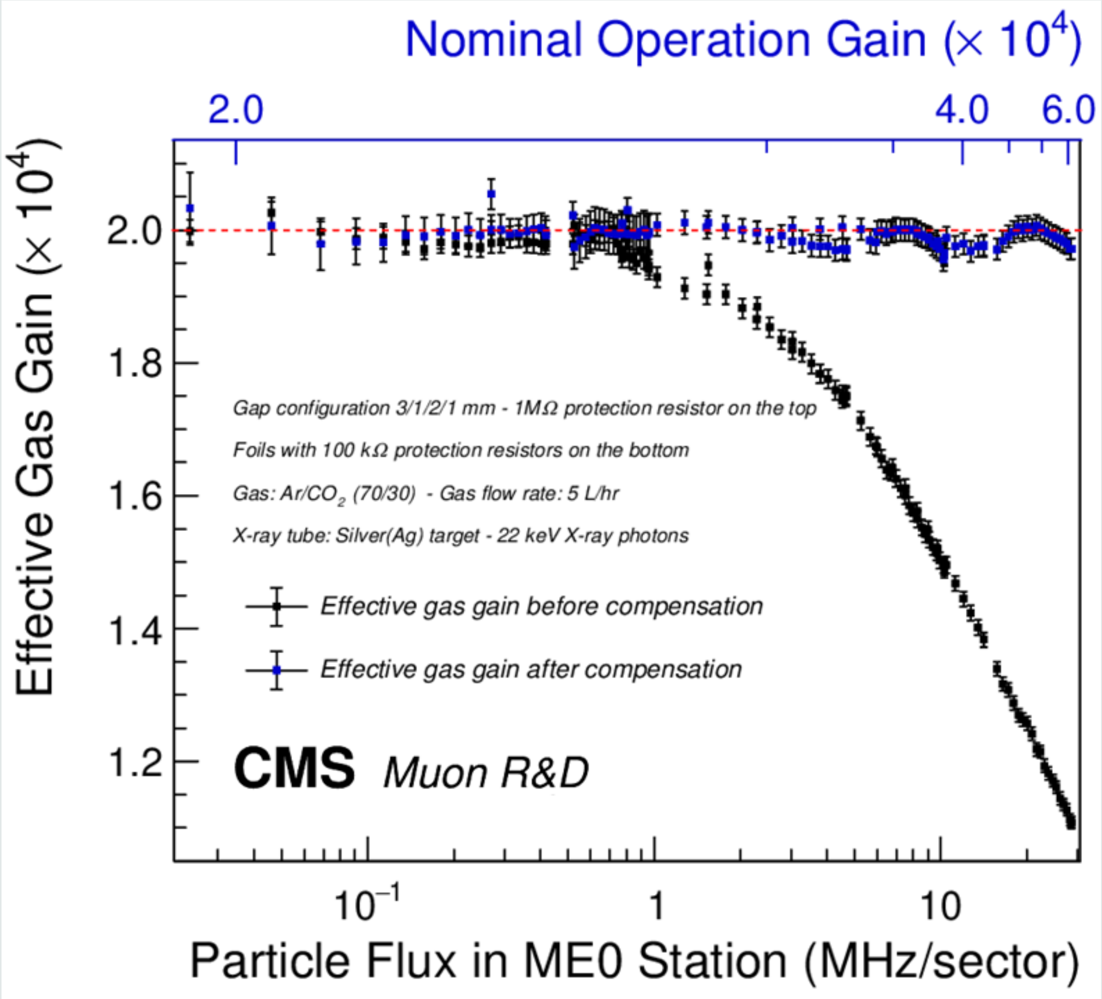


- Rate capability over large areas
- Limit discharge propagation and protection
- Continued improvement to spatial resolution
- Improved timing resolution
- Integrated fast timing electronics and trigger

Space Charge with large particle fluxes

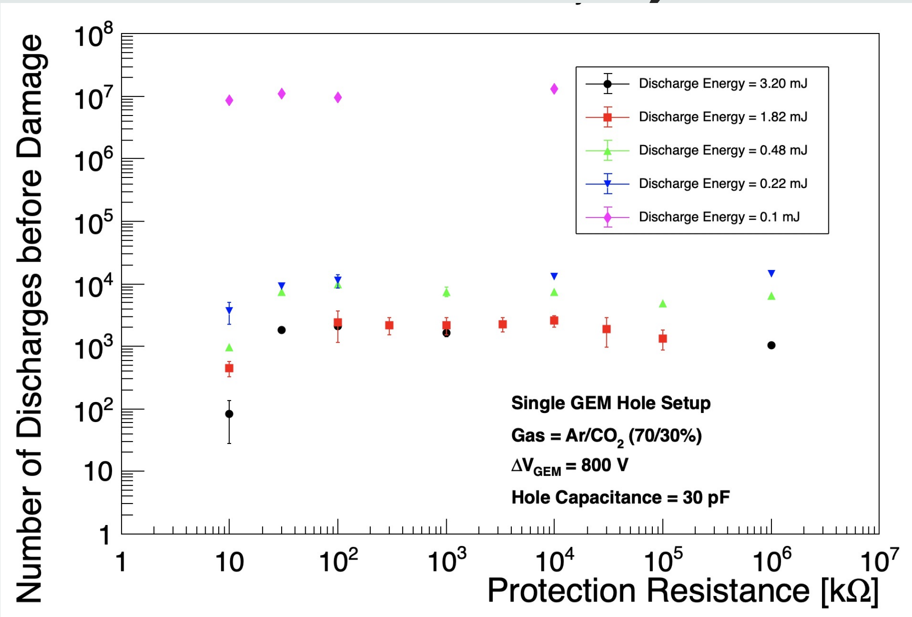
- Over small areas MPGDs electric fields can be distorted by the presence of space charge from irradiation which reduces the effective gain

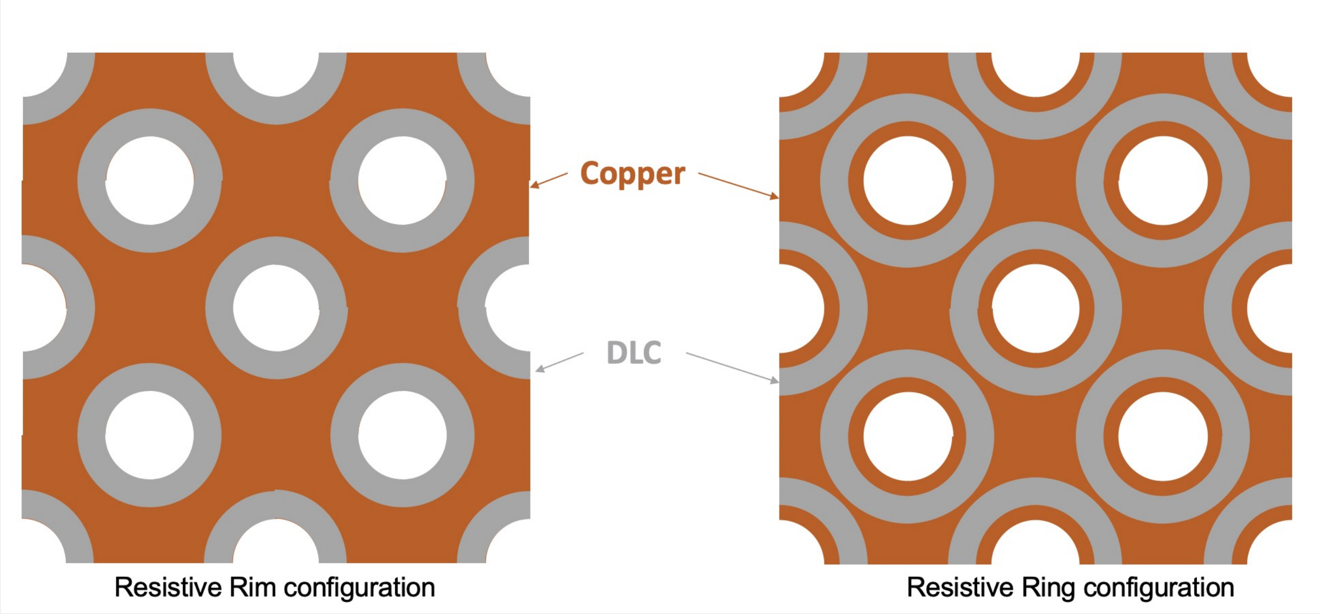


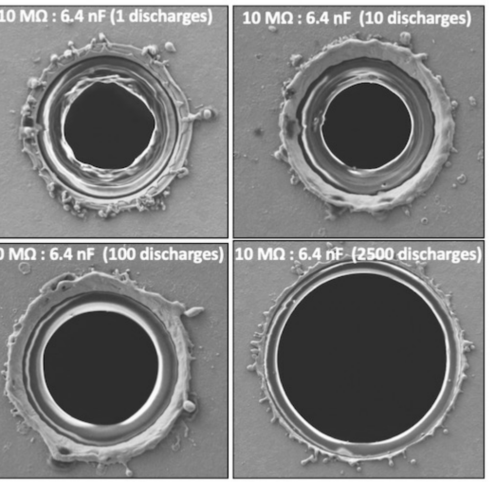


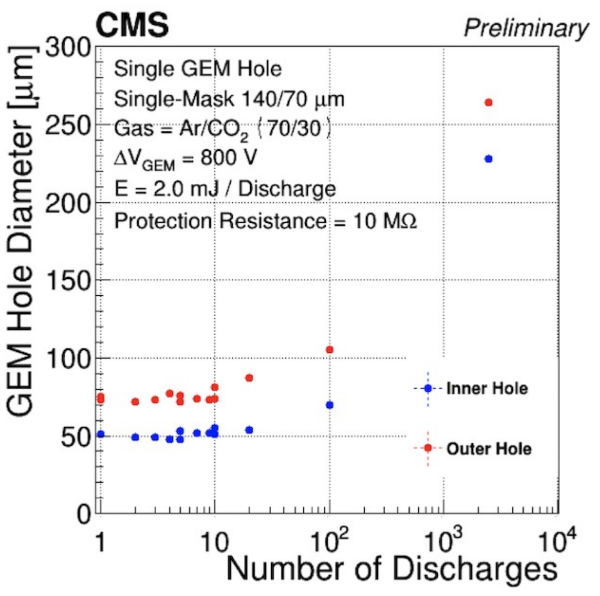
- For larger area detectors, ohmic effects from protection circuits can dominate this by inducing currents through the protection circuits and reducing the gain

Discharges



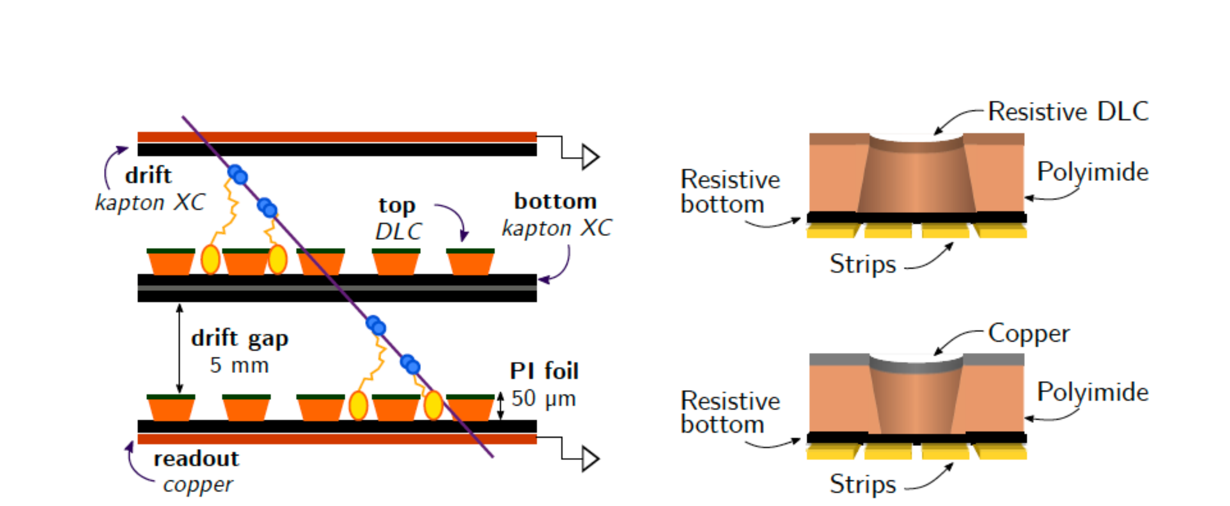




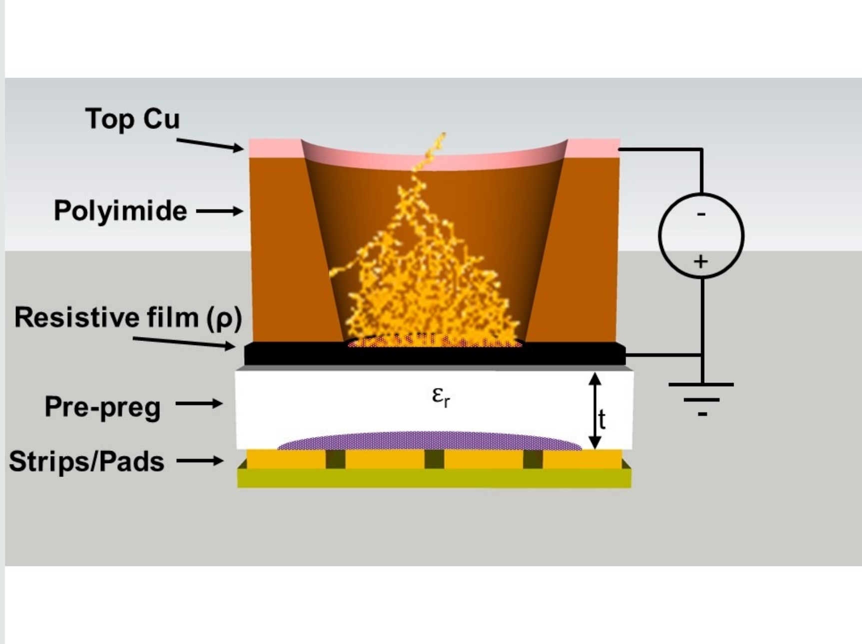


- Addition of Protection resistance , geometry , segmentation
- Lowers the number of discharges, limit the damage they do, and make them work for longer with defects.

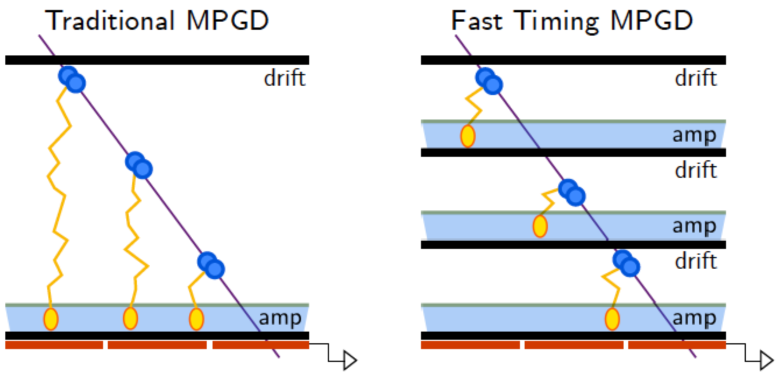
Discharge Protection



- μ- Rwell detectors build in a resistive layer
- Still allows good segmentation but protects from large discharge events and current evacuation
- Technology transfer to industry and can be built by standard PCB fabrication techniques (greatly improve the large scale production of MPGDs)



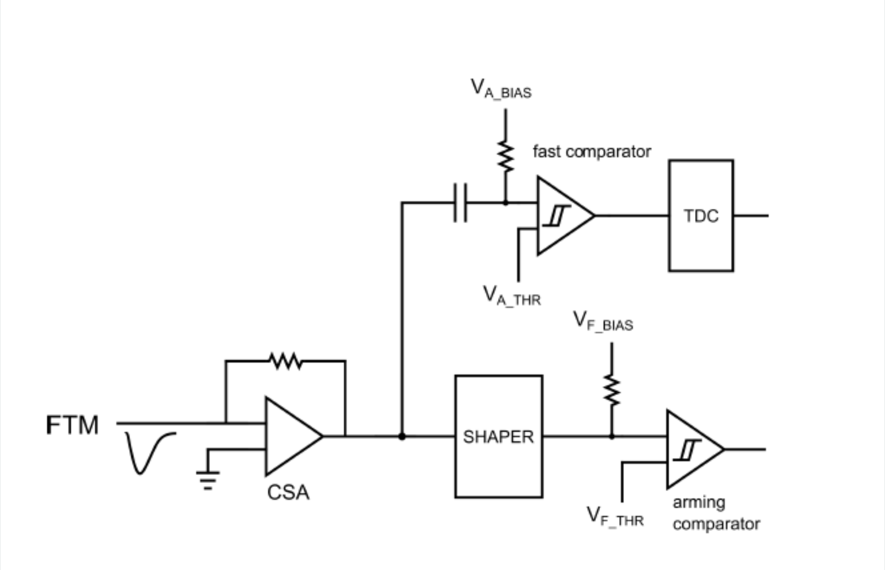
Timing Resolution



- New detector ideas to reduce the drift time, eg add multiple multiplication layers before readout
- Continued development to get sub nano-second timing , perhaps 10s of picoseconds
- Critical to machines that require rejection of pile up or beam induced background
- Could also be used to improve 4D tracking, identification of slow particles

Electronics

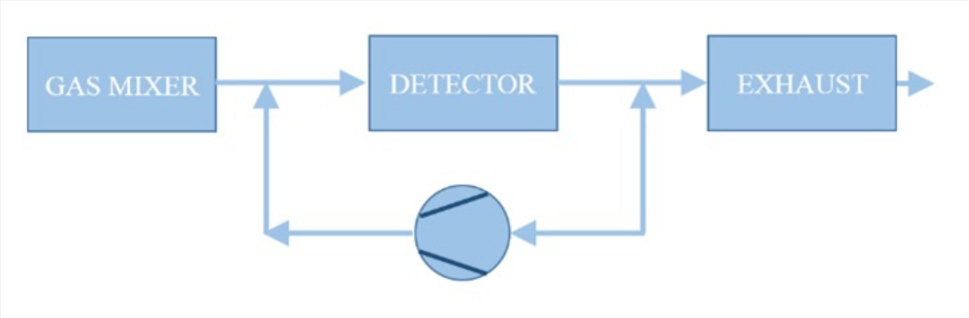
- Evolution towards fast rise time for front end amplifying, shaping, and discriminator circuits
- Reduction of time jitter to allow sub nano second resolution
- Improved sensitivity to smaller charges
- Similar to other detector technologies moving to more radiation hard integrated readout and trigger
- Continued development needed to improve timing resolution, smarter logic on detector to reduce bandwidth in very large channel systems

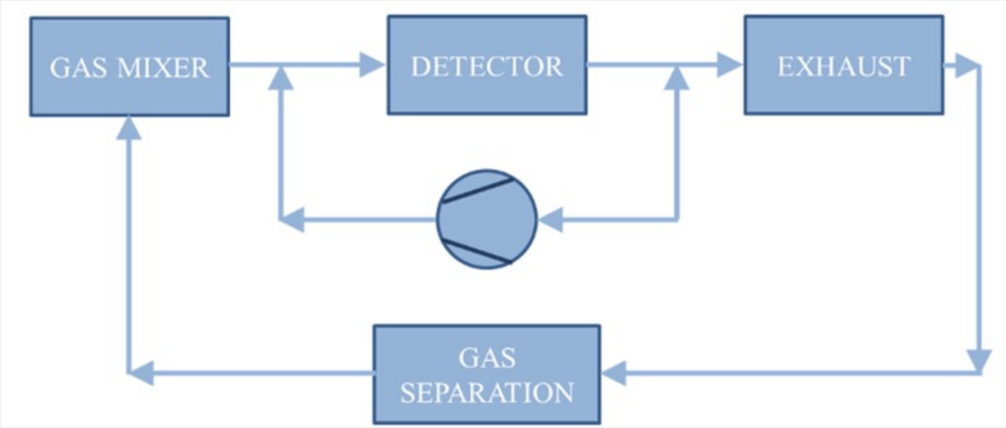


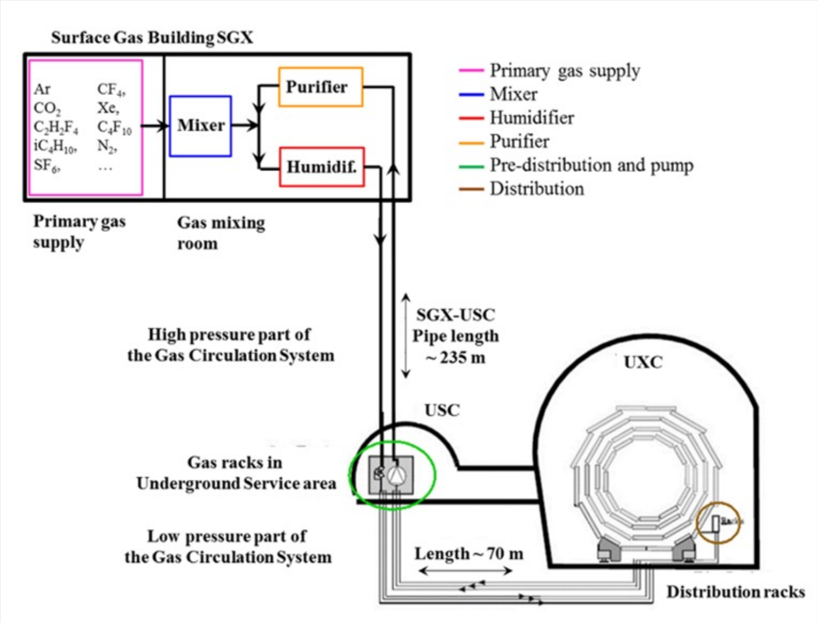
	Rise time	Sensitivity	ENC	Time jitter
VFAT2 [76]	22 ns	60 mV/fC	1500 e-	12 ns
VFAT3 [75]	15-45 ns	48 mV/fC	620 e-	12 ns
VMM3 [78]	25-200 ns	16 mV/fC	600 e-	/
NINO [79]	1 ns	/	2000 e-	25 ps
Cardarelli [80]	300-600 ps	2-3 mV/fC	4000 e-	/
FATIC [77]	7 ns	50 mV/fC	500 e-	300 ps

Gas Systems

- 3 basic models of gas systems
  - Mix, detect, exhaust
  - Mix, detect, recycle/exhaust
  - Mix, detect, recycle, exhaust/separate/recycle







Development of novel micropattern gas detectors remains an important goal to improved precision (position and timing) in large systems

Increased 'pixelization' of detectors continues to improve the spatial resolution of these detectors, new ideas to improve timing resolution

As the increased miniaturization of the detectors occurs particular attention needs to be paid to protection against discharge, improving integrated readout systems

Use of greenhouse gases call for future development and research in less destructive gases and systems that are less lossy