Muon Scattering Tomography with RPCs

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WE LOVE REINFORCED CONCRETE



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[1] source







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WHY SHOULD I CARE ABOUT CEMENT PRODUCTION?

Annual CO2	emissio	ons from	i ceme
1.6 billion t			
1.4 billion t	5%	6 Of	CO_2
1.2 billion t	fron	n cer	ner
1 billion t			
800 million t			
600 million t			
400 million t			
200 million t			
0 t 1880	1900	1920	1940
Source: Our World in D	ata based on the	Global Carbon F	Project (2022)

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CEMENT PRODUCTION: CO₂ MILL

5% CO_2









CEMENT PRODUCTION: CO2 MILL







CEMENT PRODUCTION: CO2 MILL



CEMENT PRODUCTION: CO2 MILL













CEMENT PRODUCTION: CO₂ MILL



CONCRETE LIFETIME







20-50+ years



How can we extend the lifetime of buildings / civil infrastructure?

72,000 bridges alone in UK 4.4% "sub-standard"



Buildings, bridges

interior

50+ years



(REINFORCED) CONCRETE LIFETIME

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20-50+ years



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Buildings, bridges

interior







(REINFORCED) CONCRETE LIFETIME

How can we extend the lifetime of buildings / civil infrastructure?









20-50+ years



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Buildings, bridges

interior







MUON SCATTERING TOMOGRAPHY

- Lifetime of reinforced concrete ultimately depends on steel rebar conditions •
 - So does the lifetime of civil infrastructure •



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MUON SCATTERING TOMOGRAPHY









(SOME) MUON TOMOGRAPHY DEMONSTRATORS







JINST 13 P10028, <u>LINK</u>



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AIP Adv. 2015, 5, 067111, LINK

(SOME) MUON TOMOGRAPHY DEMONSTRATORS

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MUON SCATTERING TOMOGRAPHY FOR REINFORCED CONCRETE

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Antony Swan, Master project 2023, LINK (supervised by Jon Burr, OB)

MUON SCATTERING TOMOGRAPHY FOR REINFORCED CONCRETE

(b) PoCA Summing momentum weighted, XY Cross-section at Z = -56mm, after limiting highest voxel values to the 0.9th quantile

(d) Binned clustering algorithm, XY Cross-section at Z = -56 mm, after limiting highest voxel values to the 0.9th quantile

0.9th quantile.

0.8

0.4 8

0.2

(b) PoCA Summing momentum weighted, ZY Crosssection at X = 16mm, after limiting highest voxel values to the 0.9th quantile.

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(a) Binned clustering algorithm, ZY Cross-section at X = -7mm, after limiting highest voxel values to the

MUON SCATTERING TOMOGRAPHY FOR REINFORCED CONCRETE

(b) Not corroded rebar

Antony Swan, Master project 2023, LINK (supervised by Jon Burr, OB)

MUON SCATTERING TOMOGRAPHY: BEYOND CORROSION

Interconnecting steel rebar missing!

MUON SCATTERING TOMOGRAPHY: THE FUTURE

- A lot of work on Muon Scattering Tomography around the globe
- Focus on Nuclear Security Applications so far
 - Easier (higher Z contrast, more funding)
 - Stationary
- Our focus on reinforced concrete
 - More challenging (lower Z contrast)
 - Ageing / corrosion even more challenging •
 - Construction faults "easy" •
 - Historic secrets (treasure chests?!) exciting... •
 - Portable
 - But many positives:
 - Gigantic market ullet
 - Gigantic potential to reduce human CO₂ footprint!
 - Non-destructive ●
 - No radiation concerns \bullet
 - Semi-commercial partners exist \rightarrow

Stay Tuned

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COSMIC-RAY BASED SOLUTIONS FOR 3D IMAGING

Redefining the boundaries of 3D scanning with our Muon Flux Technology (MFT) detectors. Unparalleled quality, safety, ease-of-use

Detect everything

