

Metamaterials as radiators for PID detectors

Michael McCann

Imperial College London

16 May 2023

DRD4 community meeting

Issues with traditional radiators

- Use of fluorocarbons constantly under threat
 - Terrible for the environment
 - Many no longer manufactured
 - Very limited stockpiles
- From experience, gases are a nightmare
- Aerogel hard to make consistently
- Quartz difficult to make high quality at sensible prices
- Can we rethink what we use as radiators completely?

Metamaterials

Metamaterials
as radiators
for PID
detectors

Michael
McCann

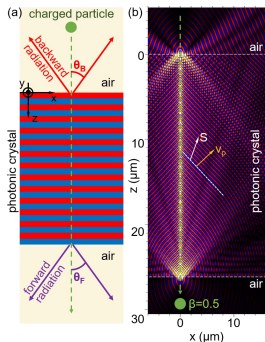
- Huge advances in metamaterials as structures that create bespoke EM environments
- It is a common technique to excite the structures with beams of charged particles
- Instead of using the particles to investigate the structures, we can use the structures to investigate the particles
- Plenty of example materials

Metamaterials examples

Metamaterials
as radiators
for PID detectors

Michael
M^CCann

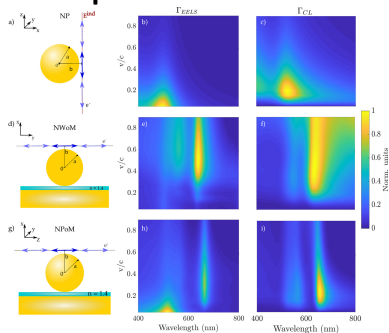
Photonic crystals



Nature Phys. **14**, 816–821(2018)

- Similar to Cherenkov
- Easy to manufacture
- Currently under test

Nanospheres



doi:10.1021/acsp Photonics.9b01338

- Intensity and spectrum function of β
- Not commercially made
- Illustrative of other effects

Why does this fit into DRD4?

- Clearly useful for PID, the customisability means you could churn out radiators optimised for any experiment's momentum ranges
- We've been discussing how to access other particle properties (e.g. accessing helicity by adding a helical structure to the layers)
- **HIGHLY speculative:** has been claimed that you can run this in reverse and get a highly tuned photon detector
- Multidisciplinary
 - Metamaterials is an over-saturated field, and people are keen to engage with new areas

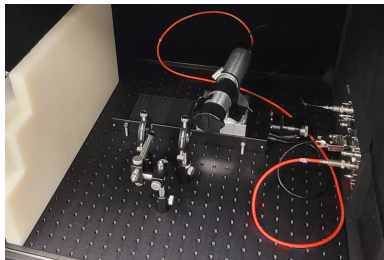
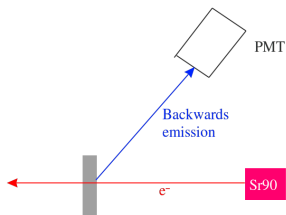
Are there uses beyond HEP?

- If you know the particle type you have a thin, light tracker/spectral analyser. . .
- Perfect for space weather monitoring (becoming more important as commodity hardware is used in cheap satellites)
- Monitoring for radiation therapy beams (they are starting to look at ultra-thin silicon sensors for this)
- Basically, any industrial beam monitoring (e.g. ion beam lithography)

Initial tests

Metamaterials
as radiators
for PID
detectors

Michael
M^cCann

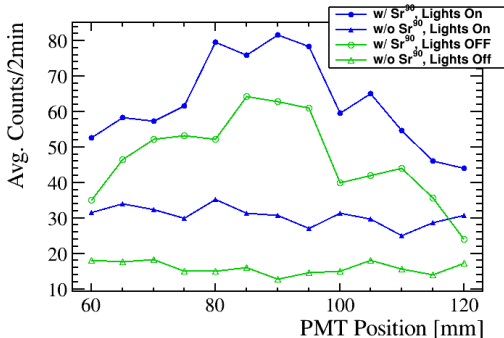


- Commercially available photonic crystal sample (not optimised for any use case)
- Looking for backwards emission
- Scan position of PMT \rightarrow emission angle
- No control over energy spectrum of source
 - Don't expect a sharp peak of emission angle

Initial tests

Metamaterials
as radiators
for PID
detectors

Michael
M^cCann



- Difference between triangles and circles
- See a clear signal from the sample at a particular range of angles
- Still work to do to show this has the expected behaviour
 - Promising start

What long term needs to be done?

Technology at very early state

- Explore the different structures
- Explore the different properties that can be measured
- Links with industry for manufacturing
- Materials' suitability for different uses (experimental and industrial)
 - e.g radiation hardness
- Looking at the new geometries made possible

Summary

- We do actually need new radiators in HEP
- Potentially high impact early-stage technology to develop
- Lot's of scope for different types of R & D
- Ticks a lot of funding agency boxes
- Some promising initial results

Backup

Metamaterials
as radiators
for PID
detectors

Michael
M^cCann