Parallel 5B:
Tracking Optical Photons

New scheme of calculation of velocity	*KURASHIGE, Hisaya*
Phonon Tracking for CDMS	*BRANDT, Daniel*
Optical photon tracking at XMASS *Kavli 2nd Floor Conference Room, Kavli Bldg. (Bldg. 51)*	*ABE, Ko et al.*
Optical photon processes	*GUMPLINGER, Peter*

Problems in Design

- *GetVelocity* takes care of all particle type
  - 'phonon' is planed to be added. It also require complex calculation for GetVelocity
  - It is waste of time to call *GetVelocity* several times in each step
- Solutions for 9.5
  - Velocity can be set by processes via particle change
  - Calculation of velocity occurs only if necessary

    because a process knows what happens in the step
    - After energy change, for ordinary particles
    - After entering a new volume or changing energy, for optical photon

Details of new design: Track

- Introduce a new member and method of
  - *G4double G4Track::velocity*
  - *void G4Track::SetVelocity(G4double)*

- *GetVelocity* simply gives *G4Track::velocity*

- Calculation of velocity is performed in
  - *G4double G4Track::CalculateVelocity()*
  - *G4double G4Track::CalculateVelocity ForOpticalPhoton()*

Phonon Tracking for the Cryogenic Dark Matter Search

D. Brandt, M. Asai, P. Brink, B. Cabrera, M. Kelsey, S. Leman, R. Resch, D. Wright

Crystal structure in geant4 - II

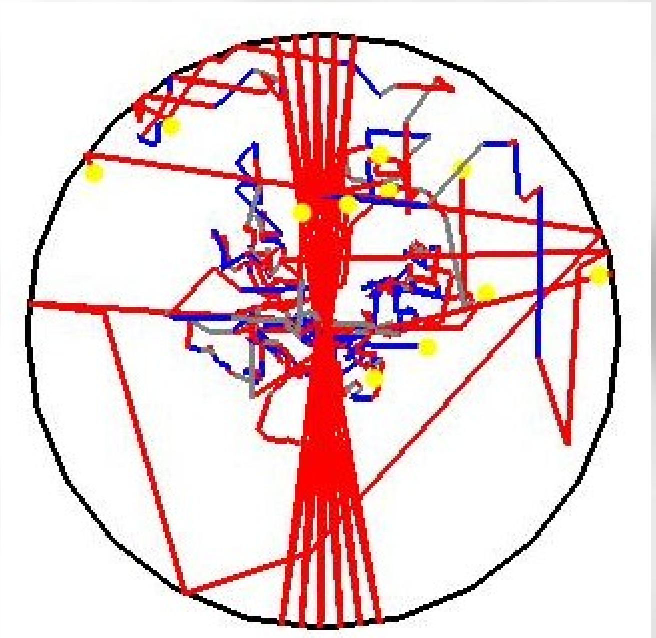
•*LogicalLattice* holds information about elastic constants. *PhysicalLattice* links these to a physical volume. Static *LatticeManager* manages access to lattices.

```
LogicalLattice logical(initialization constants);
PhysicalLattice physical(G4VPhysicalVolume*, LogicalLattice*);
LatticeManager::registerLattice(PhysicalLattice*);
```

•*G4Track* has been modified similarly to optical photons, to allow mapping of k-vector to group velocity.

```
G4Track::GetVelocity() { ...
        If(is_phonon){
                G4ThreeVector kVector=this->GetUserInformation()->getK();
                return LatticeManager::mapKtoV(fpTouchable->GetVolume(), kVector);
        }
```

Simulating phonon propagation



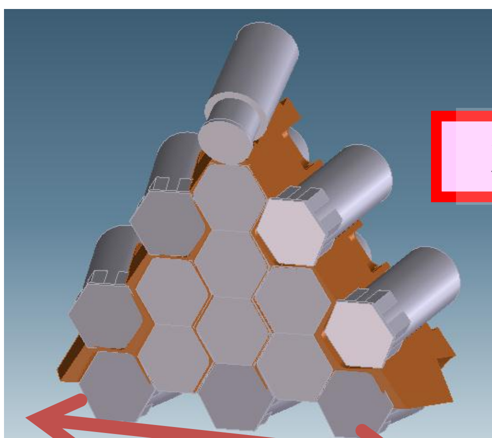
Phonon trajectories in a 75 mm Ge crystal, simulated with geant4. Trajectory color indicates polarization state, dots are absorbtion events.

- Phonons of different energies have vastly different mean free paths

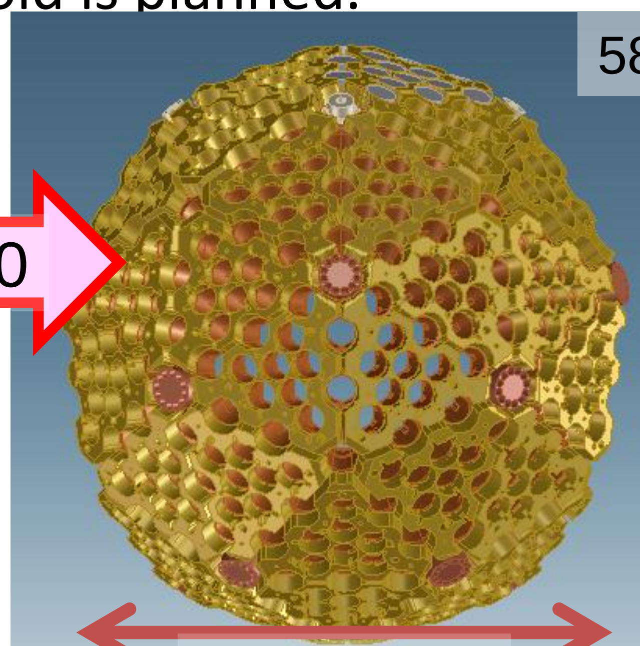
- Down conversion causes phonons to change mean free path dramatically

Structure of the PMT holder

- Made by OFHC copper.
- 835kg of liquid xenon, 100kg in the fiducial volume
- 642 PMTs (630 hex +12 round)
- Photo cathode coverage: 62.4%
- Q.E. : 28-39%
- 3D event reconstruction
- 5keVee threshold is planned.



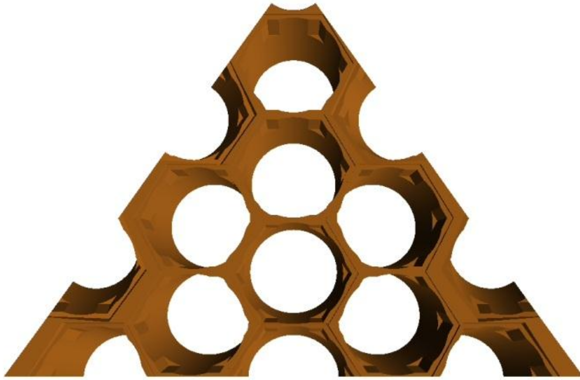
×60



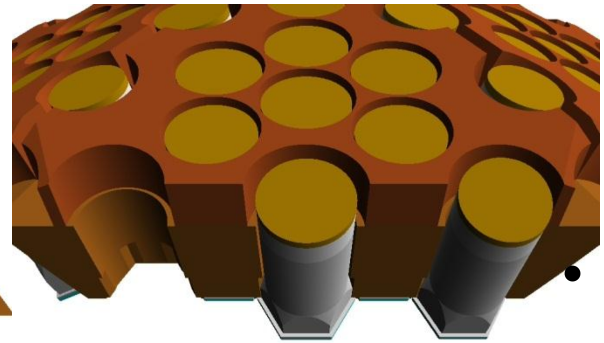
Hex: R10789-11

Round: R10789-11MOD

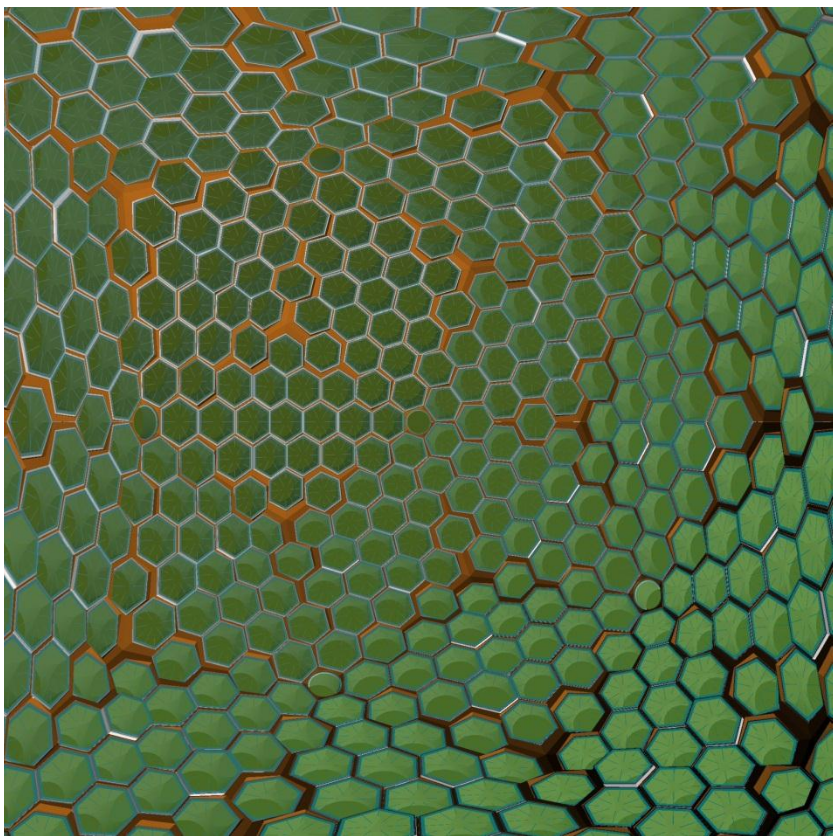
MC Geometry

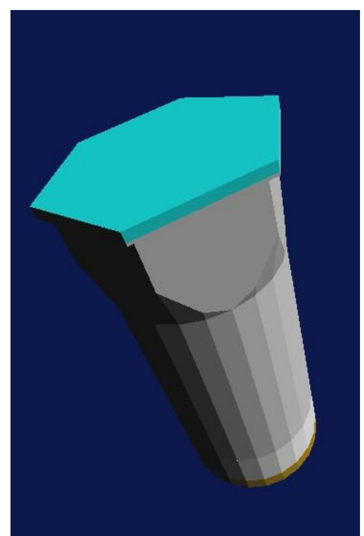


1st layer triangle from inside



- For photon tracking, we need to realize precise geometry, all gaps, bumps are important. We care rare events.
- Very complicated, made by large number of Boolean solids, G4UnionSolid, G4SubtractionSolid…..





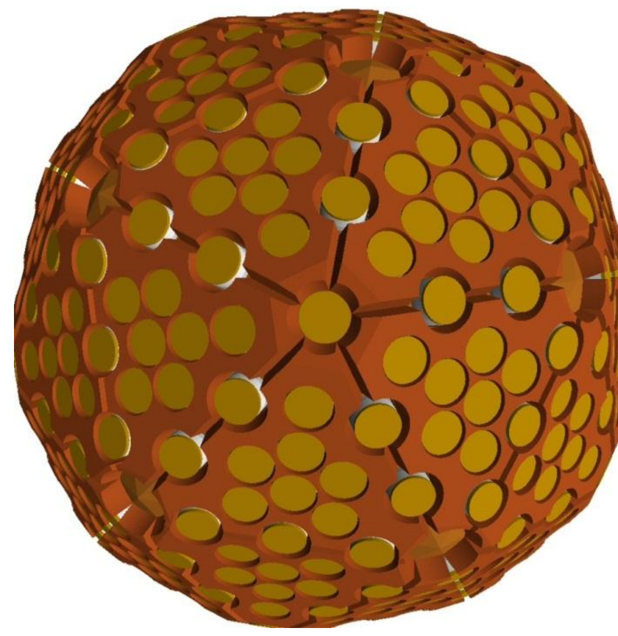
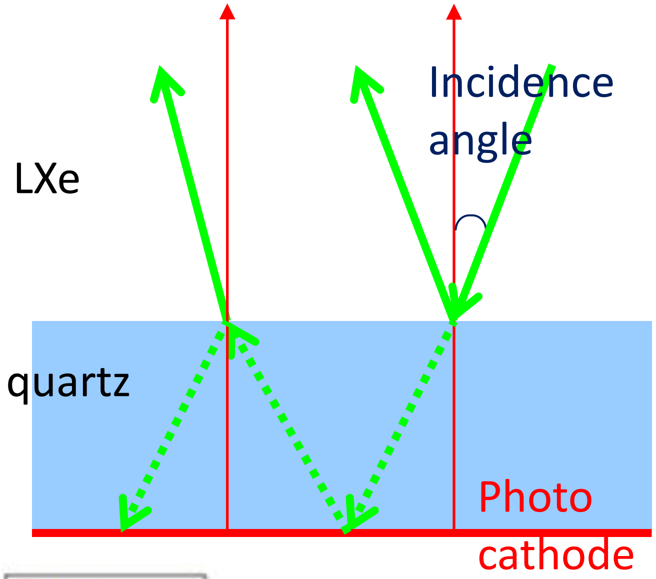
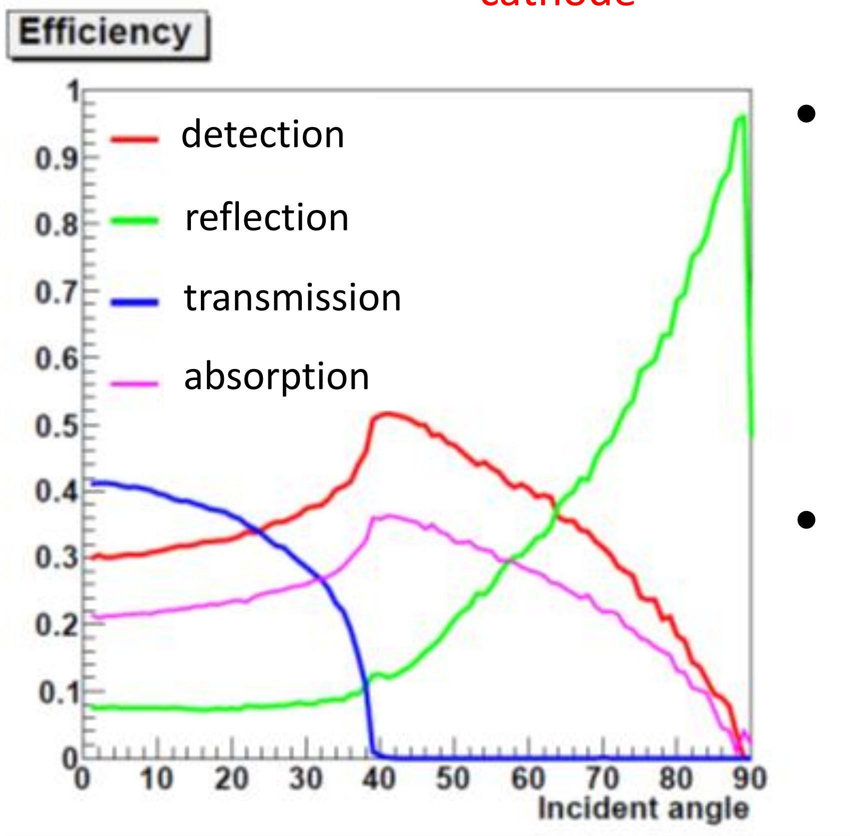


Photo cathode, Reflectivity and absorbance angle dependency.





- Add a function to calculate angle dependent reflection, detection, transmission and absorption probability to OpBoundaryProcess.
- These are calculated by using measured quartz's complex refractive index and the equation for thin film reflection at 175nm wave length.
- No wavelength dependency is considered in current version. This will be implemented in near future.

Summary

✓ In XMASS simulation, process times of optical photons are investigated.

✓ I used GEANT4 transportation sources modified for optical photons.

- Unnecessary if statements are removed.
- 662 keV gamma: original 2.6 -> MOD 2.4 [s/10000]

✓ Process times in each step are obtained as follows.

✓ Process 2 looks dominant in XMASS simulation.

Process	time[s/10000photons]
1. Transport in LXe(/10cm)	~0.1
2. LXe -> PMT quartz	1.3 ~ 1.7
3. Reflection at PMT AlRing	1.5
4. After reflection	2.9
5. Offset	~0.2