What is inside?

Detail description of all G4 features

Bars & Endblock

- Mirror at the end (reflectivity depends on wavelength)
- Epotek between bars and bar-endblock (thickness of 0.001”)
- Refractive indices for epotek and bar material (depend on wavelength)
- Internal reflection coefficient for 1 bounce
- Absorption in both materials (wav. dependence)
- Roughness of surface (will be discussed later)

Kamland Oil & Mirror

- Refractive index (wavelength dependence)
- Absorption probability (wavelength dependence)

- Mirror reflectivity (wavelength dependence)

PMT’s

- Quantum efficiency (wav. dependence)
- Average efficiency of each pad (dependence on position inside each pad)
- Borosilicate window absorption
- Charge sharing in close future

What else is missing?

Roughness

- Why do I start entering roughness into G4?
- Jose’s analysis showed that the hits outside the ring have “time property” of cherenkov hits
- The ch. ring is much broader from test beam data

Roughness

- Two (?) possibilities could cause the broadening of the ring

1) Roughness of the bar itself

2) Rough surfaces between bar-epotek, endblock-epotek, or "Berkeley cookie"

- I started simulating the first possibility

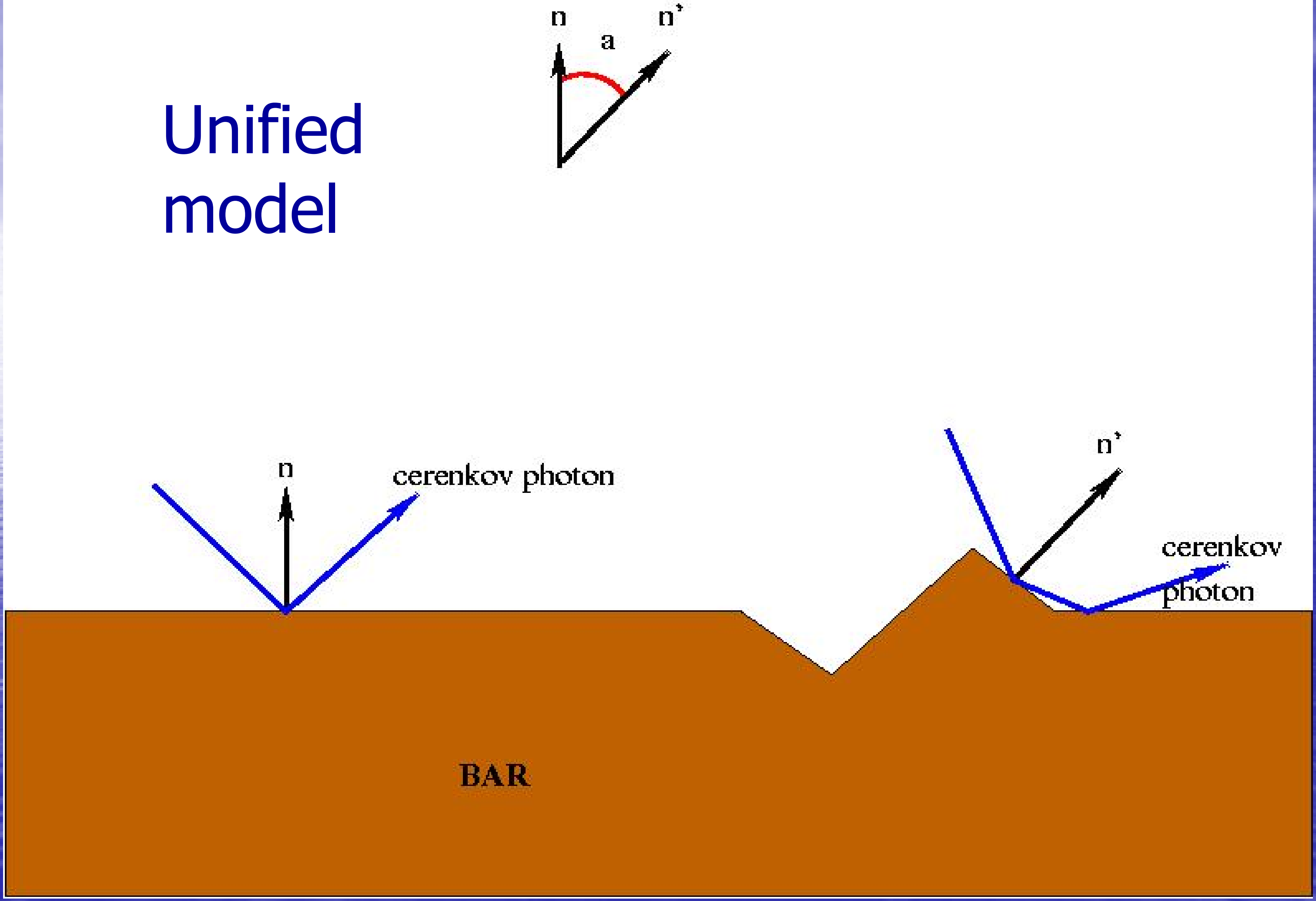
Two models in G4

- G3 – model – just one parameters called “polish” <0,1>
- if this parameter is <1, a random point is generated in a sphere of radius 1-polish and the corresponding vector is taken as a normal vector

Unified model

- New model in G4 called unified (taken from DETECT MC code)
- More parameters for tuning

Unified model



- Generates α-angle according gaussian distribution with σ_α and mean value equal to zero
- φ – generates randomly (0-2PI)
- Setting of how many times the photon reflects according normal vector (n) and how many times according normal vector (n’)
- How to set or tune σ_α and probability for reflection according n and n’? – not a simple task

Scattering from optical surfaces

(J.Melson, H.E.bennet and J.M. Bennet, Applied optics and Optical engineering, Vol. VII, 1979, SLACX library: QC371:K48 v.9)

The fraction of the total reflected light (specular plus nonspecular) scattered away from the specular direction by microirregularities is described by a simple scallar scattering theory based on the Kirchoff difraction integral. The total integrated scater **TIS**:

$$TIS = 1 - (R/R_o) = 1 - \exp[-(4\,\pi\,\delta\,\cos\,\theta_o/\lambda)^2 \sim (4\,\pi\,\delta\,\cos\,\theta_o/\lambda)^2$$

where

R_o is the fraction of the incident light which is reflected into all angles including the specular direction.

R is the fraction which is specularly reflected at an angle θ_o, the angle of incidence.

δ is the rms height of surface microirregularities (4-8A in our case)

TIS (λ=410 nm, δ = 8 A) ~ 3×10^{-4}

Probability of reflection according n or n′ (=TIS)

- Too many reflections according n′ => it doesn’t spread the Cherenkov angle resolution because the mean value of α-angle is zero
- Only few reflection according n′ => it depends significantly on σ_α

Choices of σ_a

- If σ_a too big (big change in angle) => it changes drastically the photon angle and photon is mostly kicked out of the bar (instead of reflection, refraction occurs and photon leaves the bar)
- If σ_a too small (small change in angle) =>it just augments the cherenkov angle resolution, however too little

Conclusion

- Not any significant progress in solving hits outside the ring
- It is needed farther investigation, but I am a little bit pessimistic that roughness of bars will solve this issue => new approach