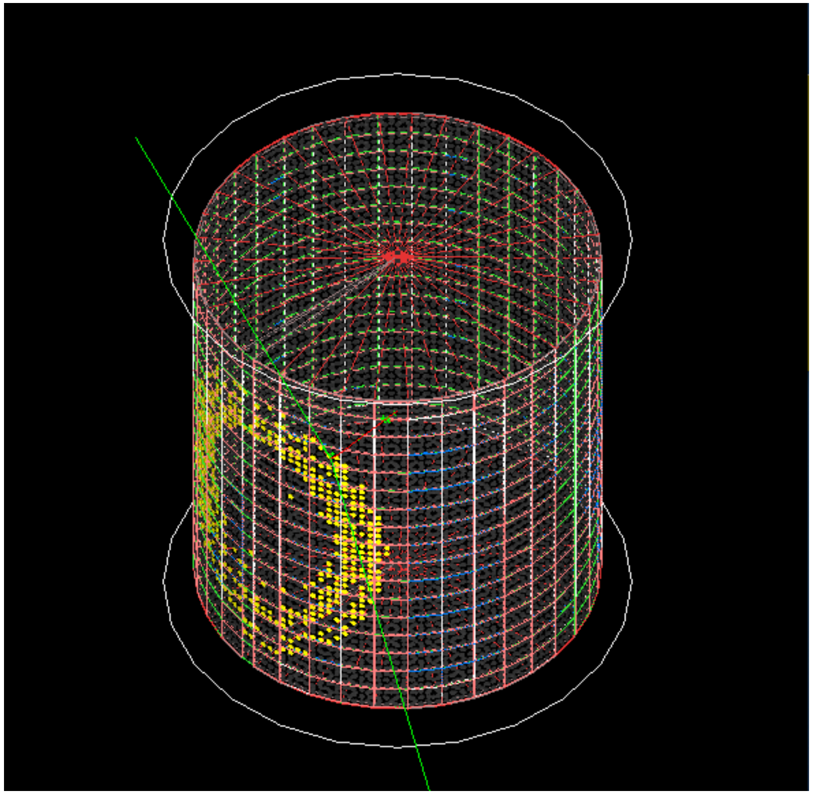
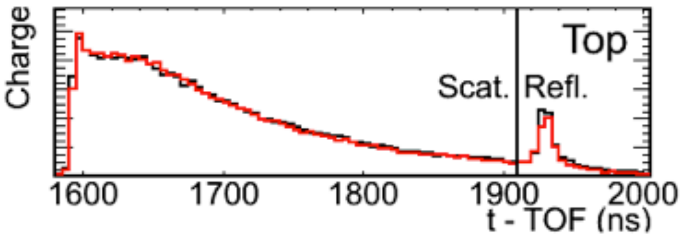
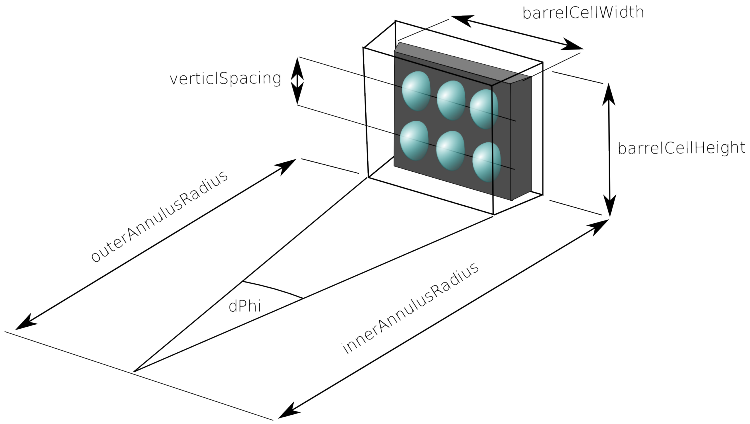
WCSim Strategy and Status

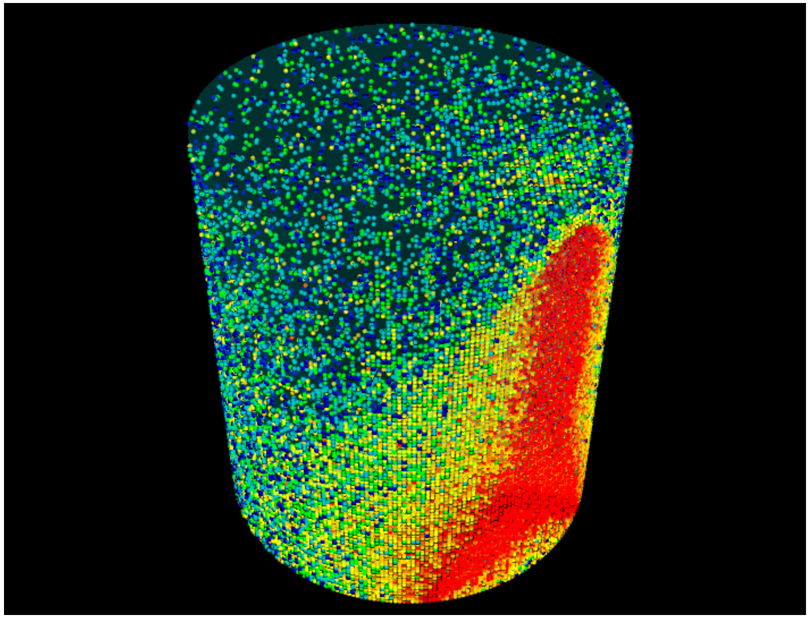






Chris Walter for Software Group
Duke University
2nd Hyper-K Open meeting
Kashiwa Kavli IPMU
1/14/2013

The WCSim simulation package



WCSim is a Geant4 based WC Monte Carlo

We built a flexible system in Geant4 and used it to simulate several geometries including the the SK tank so we can tune the simulation with real data and existing MC.

➔ We are now using this for Hyper-K

Use shared physics properties -> with many geometry configurations
(cavern size / shape / number or tubes / Tube characteristics/hadronic models all adjustable)

Hyper-K software group members from Duke, ICRR, TIT, UBC and UCI are working on various aspects for Hyper-K.

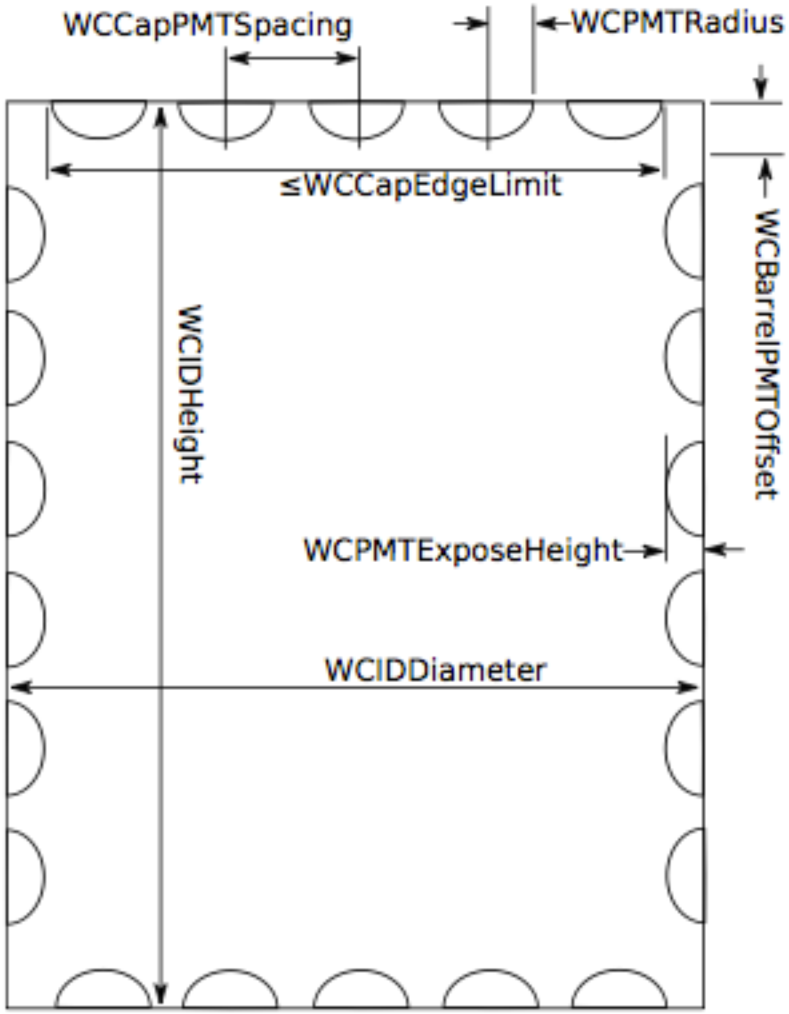
Current Goals and Roadmap

- Create a realistic "one-chamber" Hyper-K geometry. This will allow us to study the performance as a function of chamber size and length.
- We need to tune to the SK MC including simulated calibration sources.
- We need to interface the output into reconstruction code. ➔ See Shimpei's fiTQun talk

We want detector parameterization that describes realistic geometries

Note base 4X3 tube structure

The idea is to describe any detector parametrically.

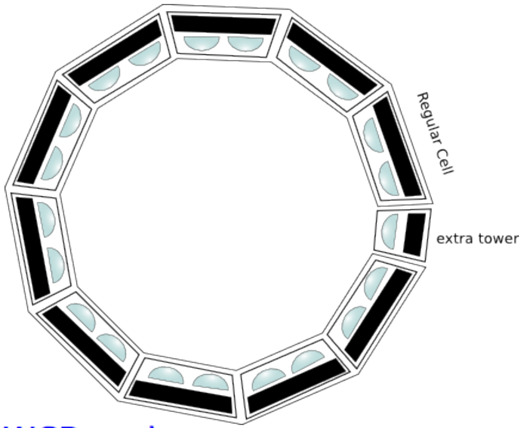


Write one function for each setup (Super-K, 100kton, etc)

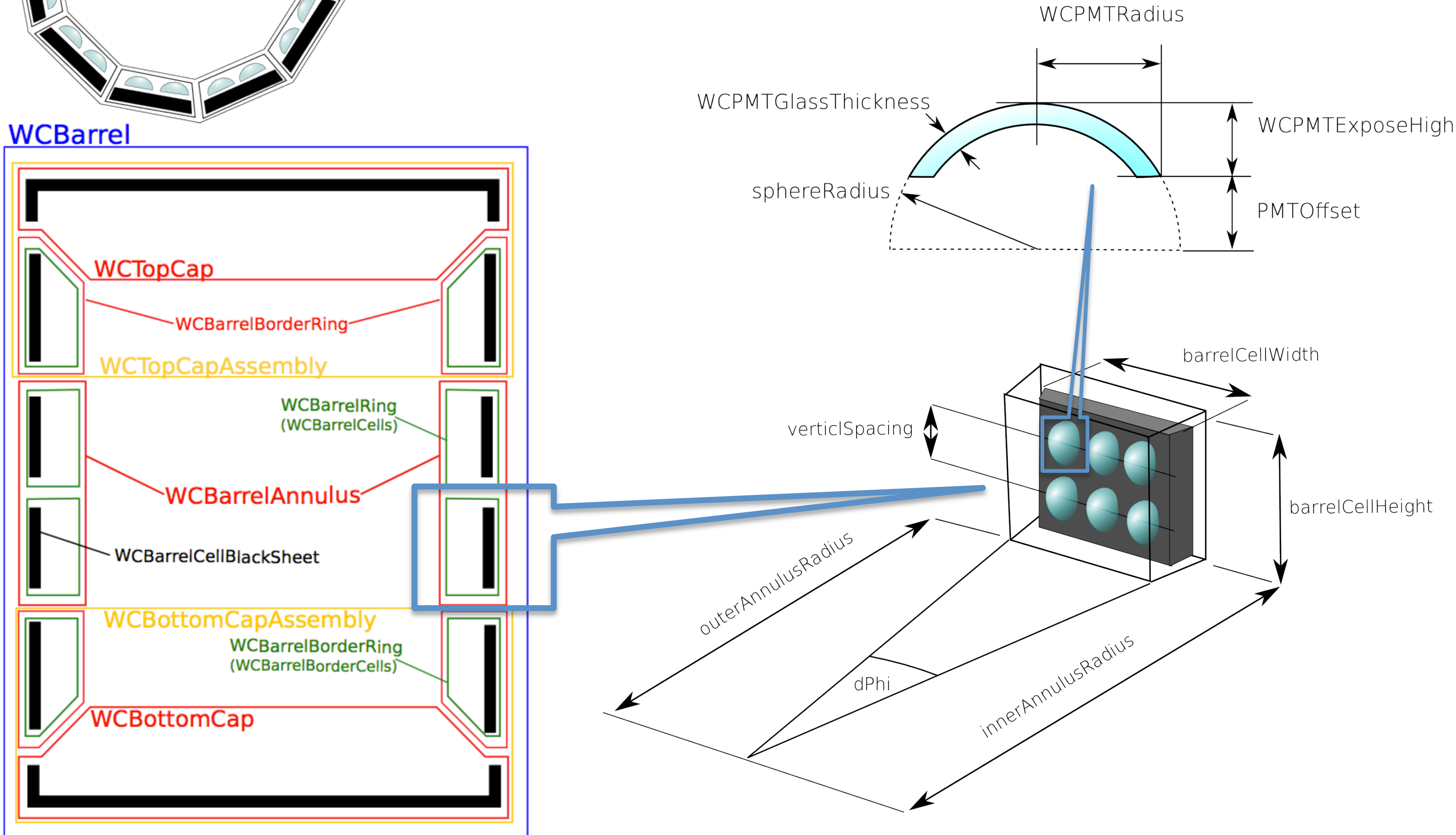
```
void WCSimDetectorConstruction::SetSuperKGeometry()
{
  WCPMTName              ="20inch";
  WCPMTRadius            =.254*m;
  WCPMTExposeHeight      =.18*m;
  WCIDDiameter           = 33.6815*m;//16.900*2*
                                     //cos(2*pi*rad/75)*m;
  WCIDHeight             = 36.200*m;
  WCBarrelPMTOffset      = 0.0715*m; //offset from vertical
  WCBarrelNumPMTHorizontal  = 150;
  WCBarrelNRings         = 17.;
  WCPMTperCellHorizontal= 4;
  WCPMTperCellVertical   = 3;
  WCCapPMTSpacing        = 0.707*m; // distance between centers
                                    // of top and bottom pmts
  WCCapEdgeLimit         = 16.9*m;
  WCPMTGlassThickness    = .4*cm;
  WCBlackSheetThickness  = 2.0*cm;
  WCAddGd                = false;
}
```

Can also be done for Hyper-K type geometry

These parameters describe a cylindrical geometry



The program is extremely flexible. By specifying a set of parameters we can define and simulate any cylindrical geometry and tube combination.



Geometry and physics configurations can be chosen without compilation through macro files.

→ See Peter's talk

Implementing the "egg"

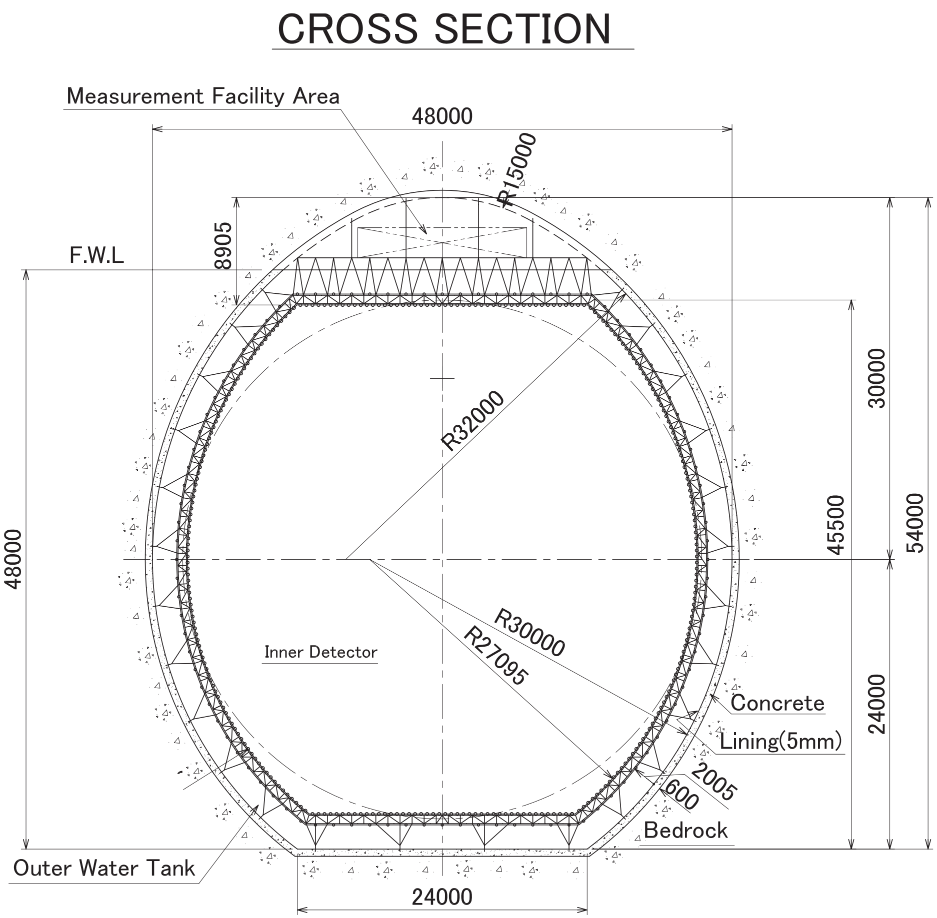
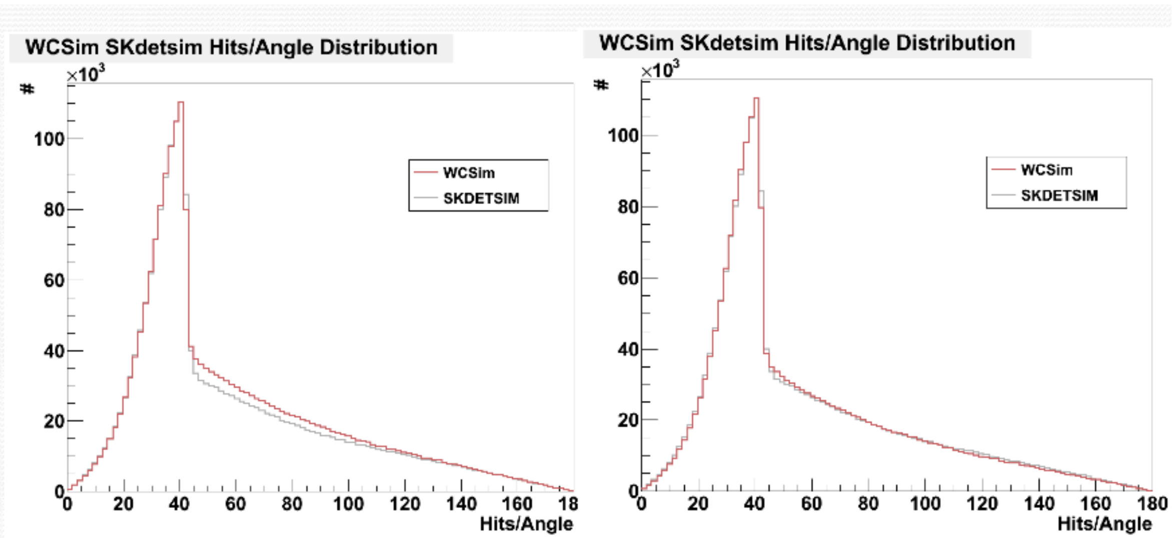


FIG. 6. Cross section view of the Hyper-Kamiokande detector.

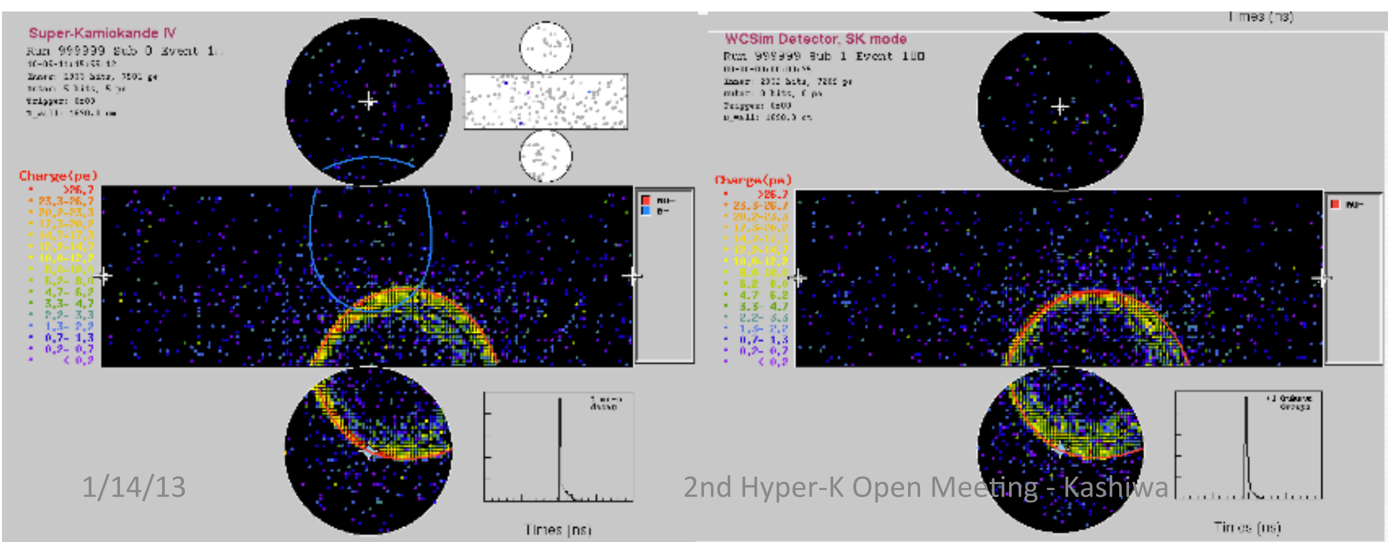
- Hyper-K has an "egg-like" geometry for geo-technical reasons. So the top is not the same as the bottom.
- We are trying to both completely understand and parametrically describe this geometry so we can do studies with different sizes etc.

SK validation/reconstruction work

Our most powerful handle: Tuning and validation against the SK MC.



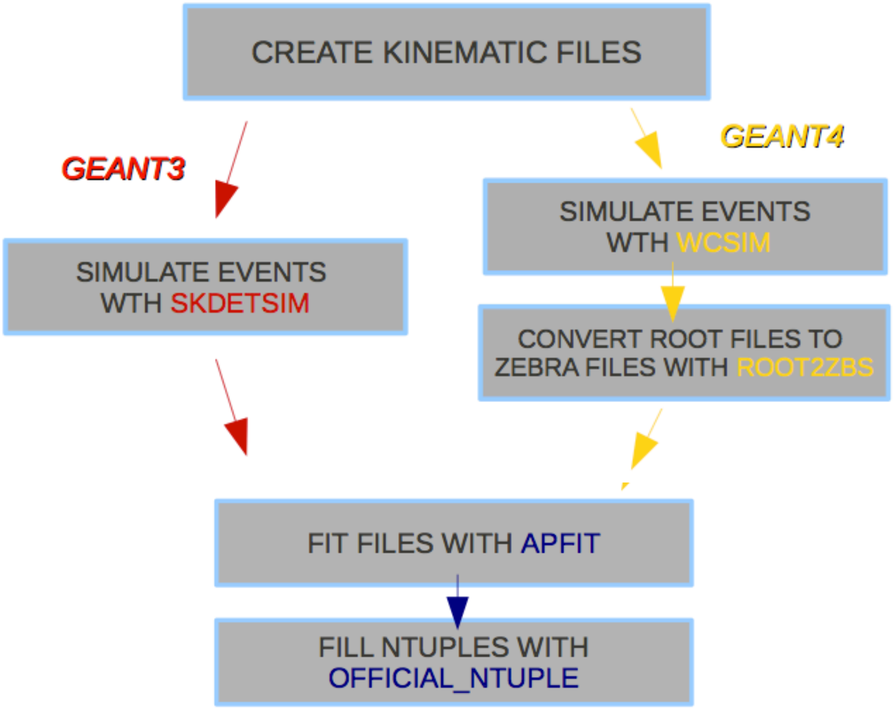
The SK MC is tuned to the 1% level. WCSim includes a SK Mode We can use to tune the MC to the validated SK MC. After tuning only geometry and tube configuration is changed.



This work allowed us both to tune the Monte Carlo and improve the underlying Geant4 optical model.

Technique for HE validation

➔ See Tarek's talk



Tools Developed:

WCSim Geant4 based calibration sources (laser).

Specialized versions of SK library

Specialized version of **Superscan** event display.

Note: Physics models are sometimes different between Geant3 and Geant4 so that parameters we are tuning don't always mean the same thing.

→ See Alex's talk

WCSim Tuning

SK Monte Carlo (Geant3)

- **Goal:** Tune WCSim's optical properties to skdetsim
  - SKDETSIM has been well-tuned to a running water Cherenkov detector

- Parameters being tuned:
  - Black Sheet Reflectivity (higher = more reflection)
  - Glass/Cathode Reflectivity (higher = more reflection)
  - Absorption Length (higher = less absorption)
  - Rayleigh Scattering (higher = less scattering)

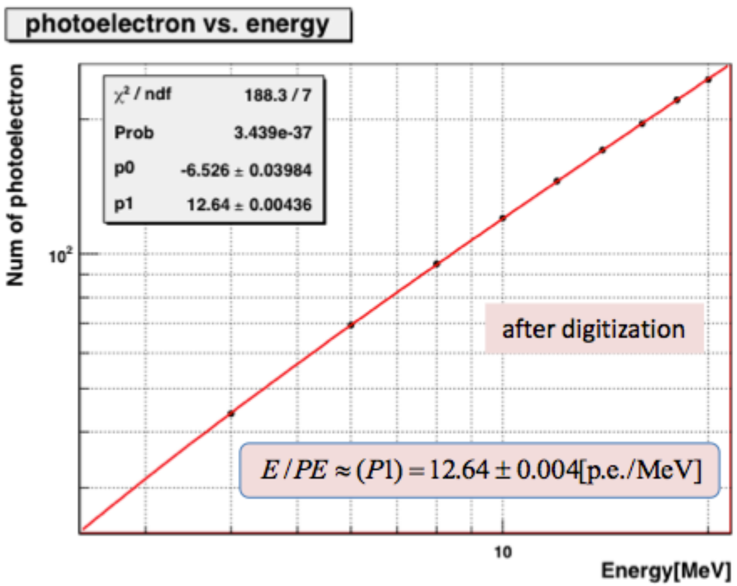
- Tuning against three samples:

– 1 GeV μ- – 1 GeV e-	Particles (produce photons) [Uniform / Isotropic]
– 337 nm calibration laser	Photons (SK laser system)

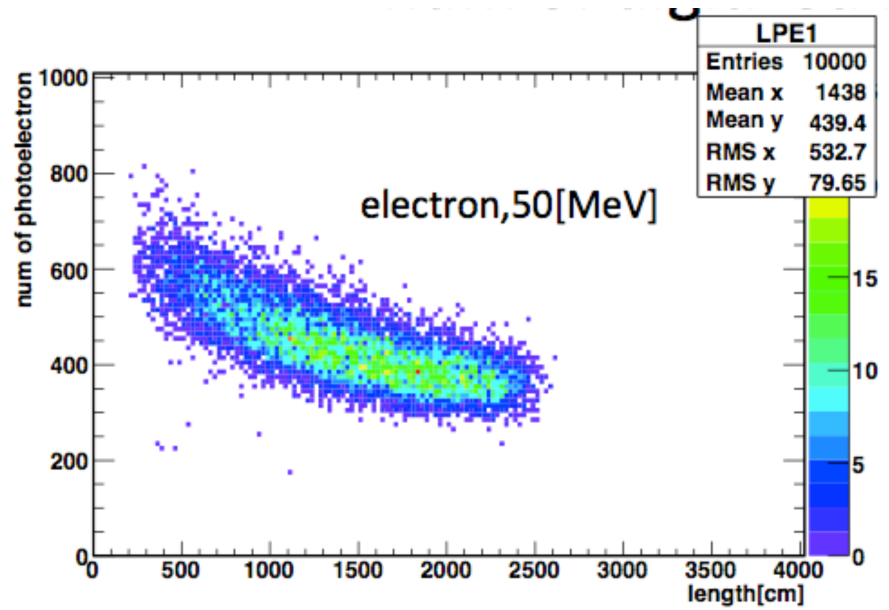
What about at low energy?

- All of our validation work has been done at high energy. One of the studies we want to do soon is low-energy trigger studies as a function of detector size.
- However, the low-energy group in SK handles things quite differently using the number of tubes hit instead of number of photoelectrons. Building on the work that Giada and Michael from UCI did for LBNE, Okajima-san (TIT student with Kuze-san) are working with Koshio-san (SK) to study the response.
- We have also successfully used the **BONSAI** fitter to reconstruct low energy events.
- We are still studying and learning how this works now.

The TIT group is checking basic response and behavior at low energy



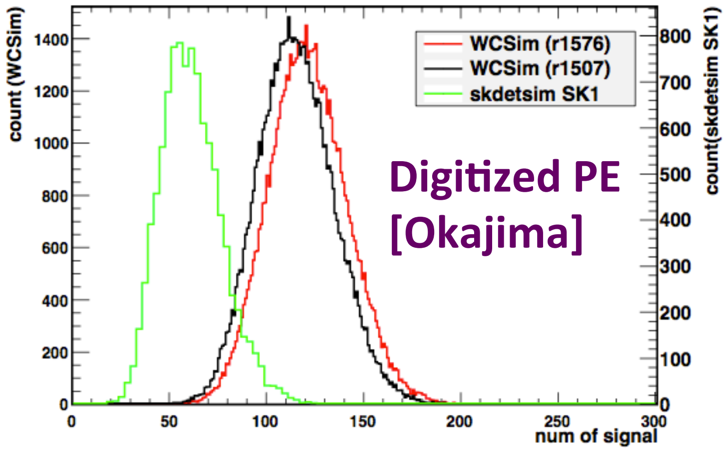
Linearity



Absorption length

Some Examples

Response factors



W/special
Low E factors
(LBNE)
[Giada, Michael]

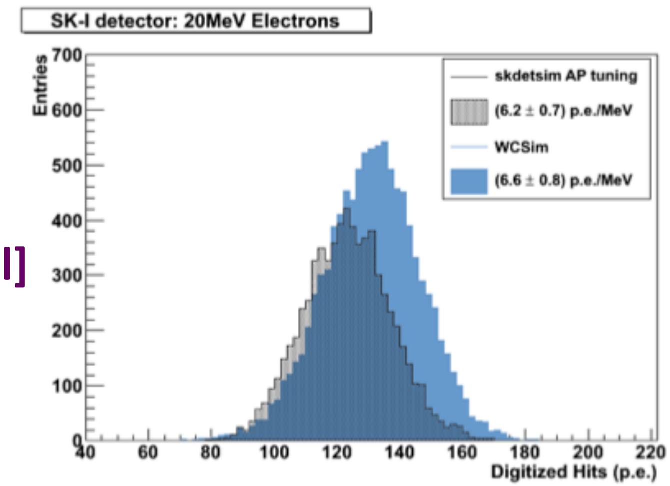
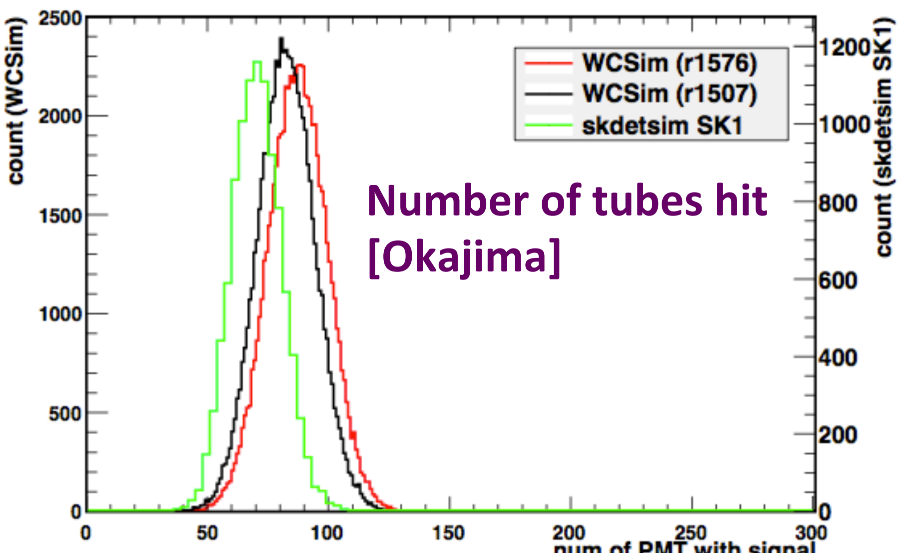


Figure 4: Number of digitized photoelectrons..

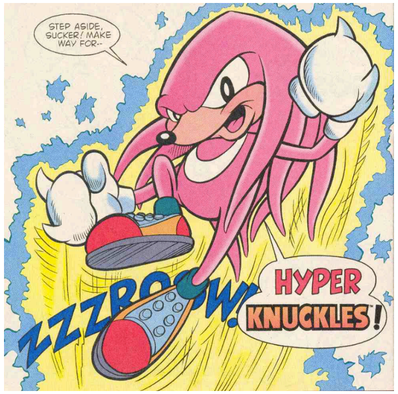


The number of tubes hit **agrees well enough** now (~20%) to start to do studies.

This is very sensitive to details of the 1pe response of the digitizer. The amount of digitized charge (not used by LOW-E) is very wrong without special factors (LBNE study].

We should better separate tube and electronics response.

Conclusions / Plan



Conclusions

- Several interested working group members have started to use WCSim for Hyper-K studies.
- We have started initial work on implementation and validation.
- We still need to complete getting the low energy and high energy fitters to work on the output and confirm that we get correct results in SK mode.

Plan

- The next steps are to implement the egg shaped geometry and then use the validated package to do reconstruction at low and high energy on this geometry.
- The longer term goal for this year is to make MC for for the physics groups.