ANT'11

Philadelphia
10/10/2011

Winston Cones for LBNE

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ADVANTAGES

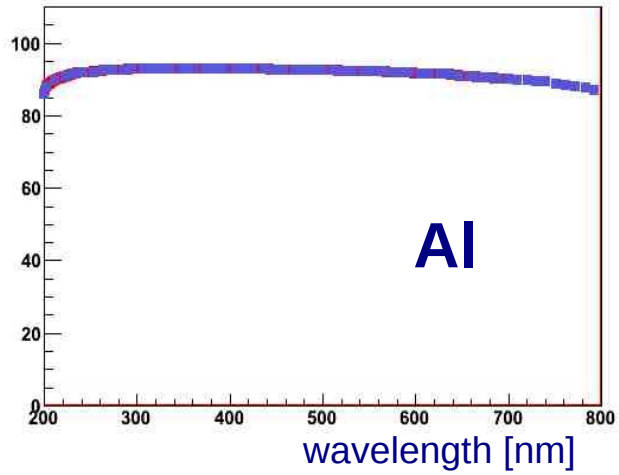
- Largest increase in light collection (up to a factor 3)
- Cheaper than PMTs (~50$ vs ~3000$)
- Already successfully used in other experiments – SNO, Borexino-CTF
  - *R&D for optimization*

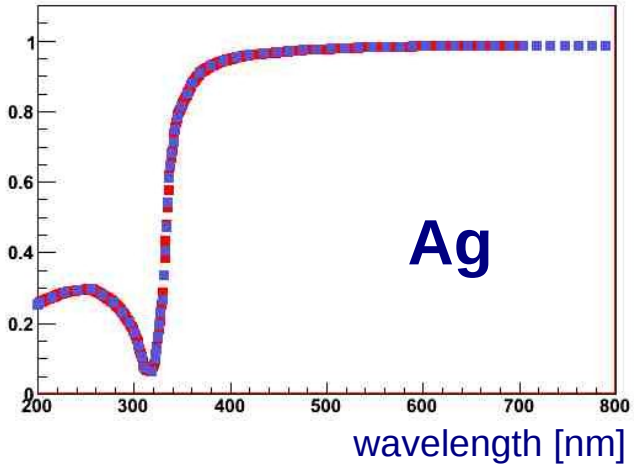
DISADVANTAGES

- Risk of Dregradation in Water
- Light Collection depending on PMT position (light cones limit the PMT field of view)
- May affect timing (=> event reconstruction)
- May affect the FV definition

Materials

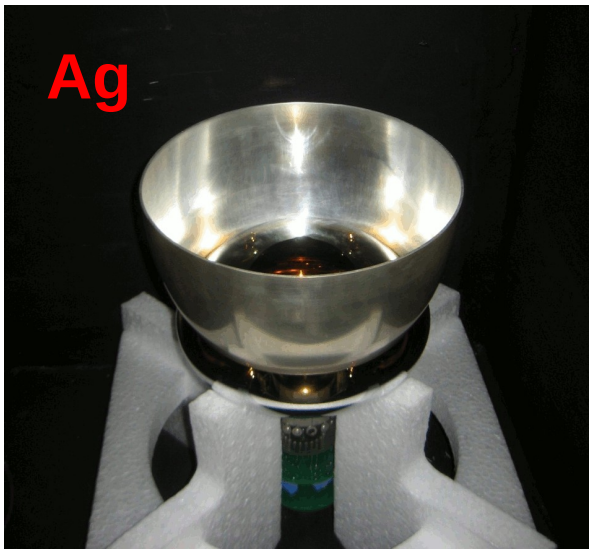
- 3 prototypes produced and tested so far
- Metal coating: Al and Ag
- Compatibility with ultrapure water
  - Al not compatible: need of protective coating (light absorption)
  - Ag compatible – already used for years in Borexino – CTF
- Reflectivity





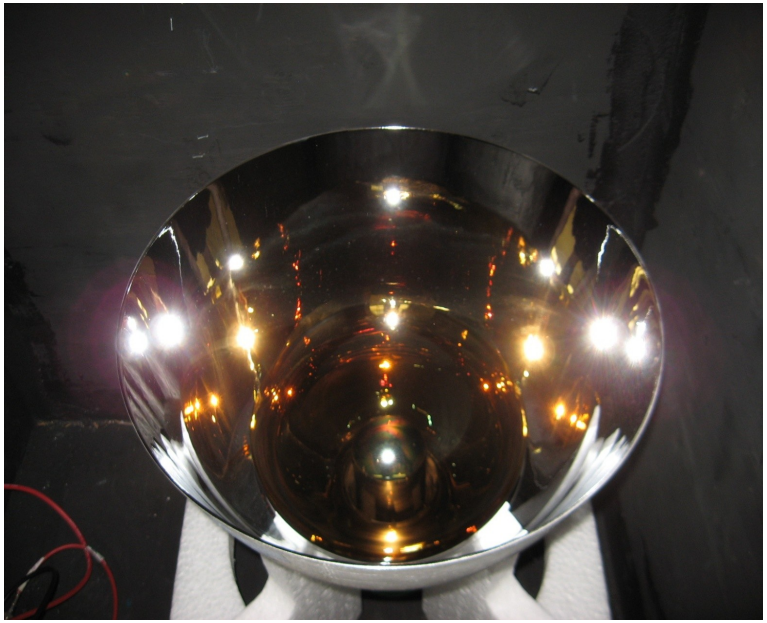
Shape

- First Prototypes
  - Winston cone (paraboloid)
  - Lower radius above the PMT equator (at the end of the photocathode surface guaranteed by Hammamatsu)
  - 60 degrees opening angle



Shape

- Second Prototype
  - Al coated + protective coating
  - Still 60 degrees opening angle
  - Larger upper diameter (16.5”)



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  - Larger upper diameter (16.5”)
  - Winston (paraboloid) → Ellipsoidal (higher light collection efficiency)

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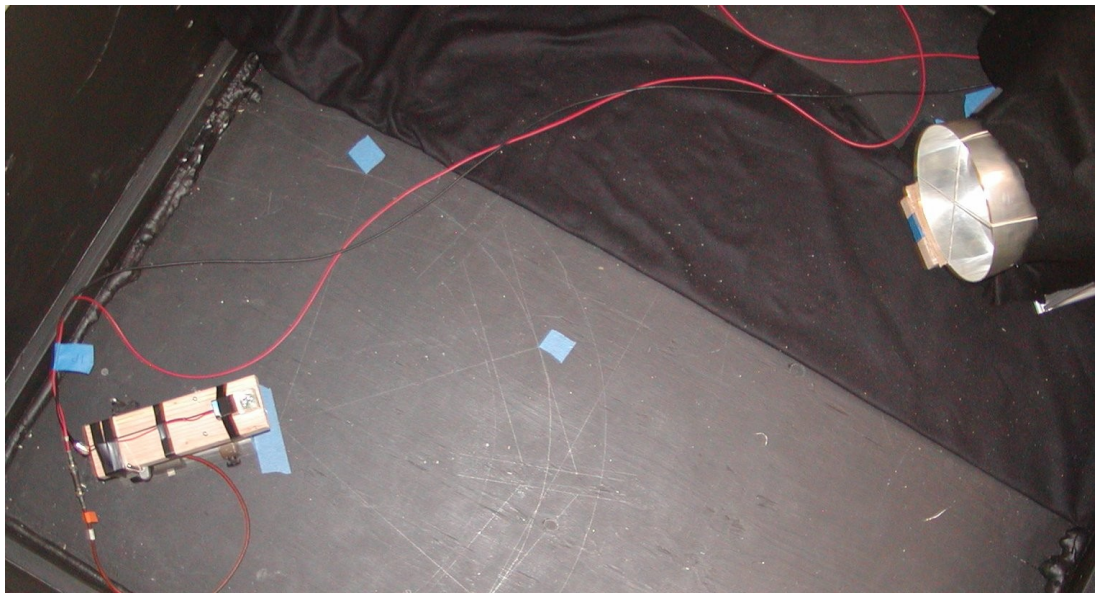
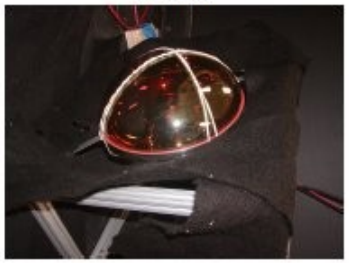
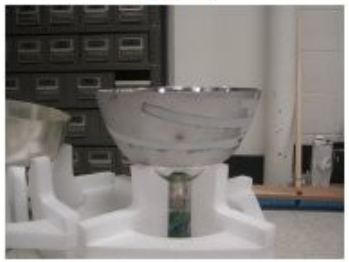
- Second Prototype
  - Al coated + protective coating
  - Still 60 degrees opening angle
  - Larger upper diameter (16.5”)
  - Winston (paraboloid) → Ellipsoidal (higher light collection efficiency)
  - Lower radius on the equator (good QE on the photocathode edge)

Tests of the prototypes @ UPenn

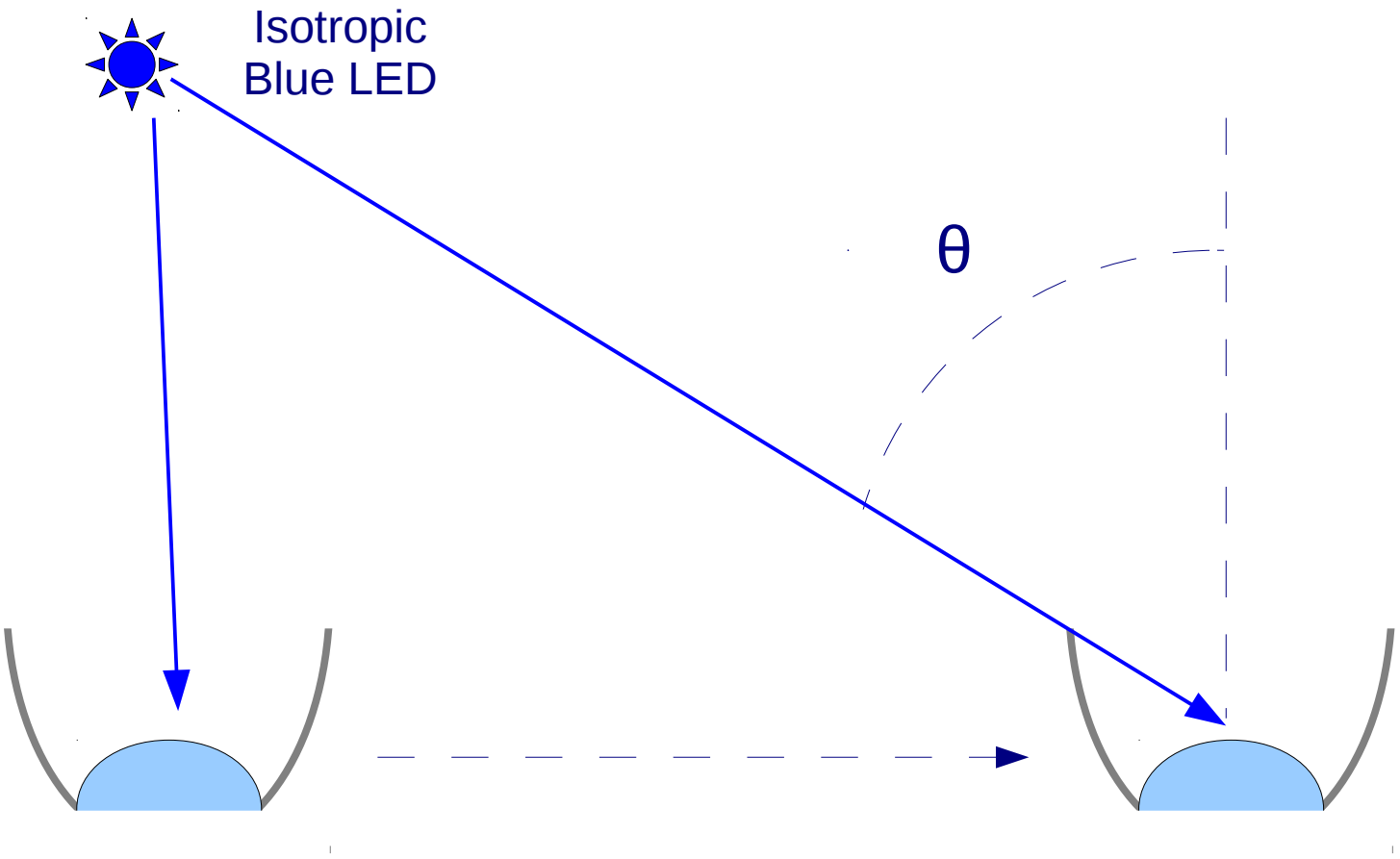


Tests done by the
UPenn Group

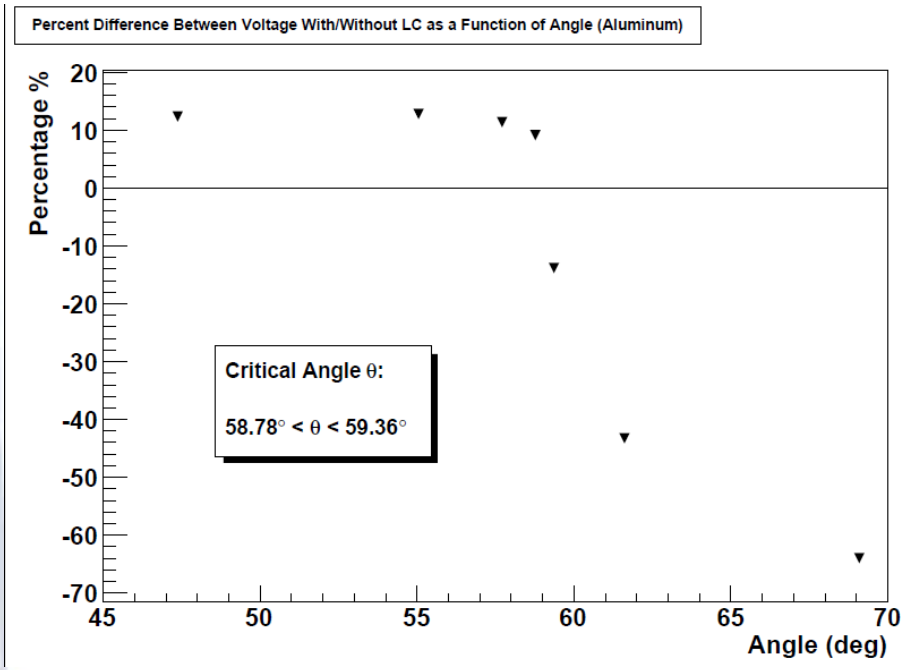
Very particular Configuration:
Source facing the PMT

WC type	None	Aluminum	Silver	Wide
				
Rel. Eff.	1.0 (±0.01)	1.45 (±0.01)	1.43 (±0.02)	3.05 (±0.03)
TTS σ	1.49 ns (±0.05)	1.45 ns (±0.05)	1.49 ns (±0.05)	1.72 ns (±0.06)

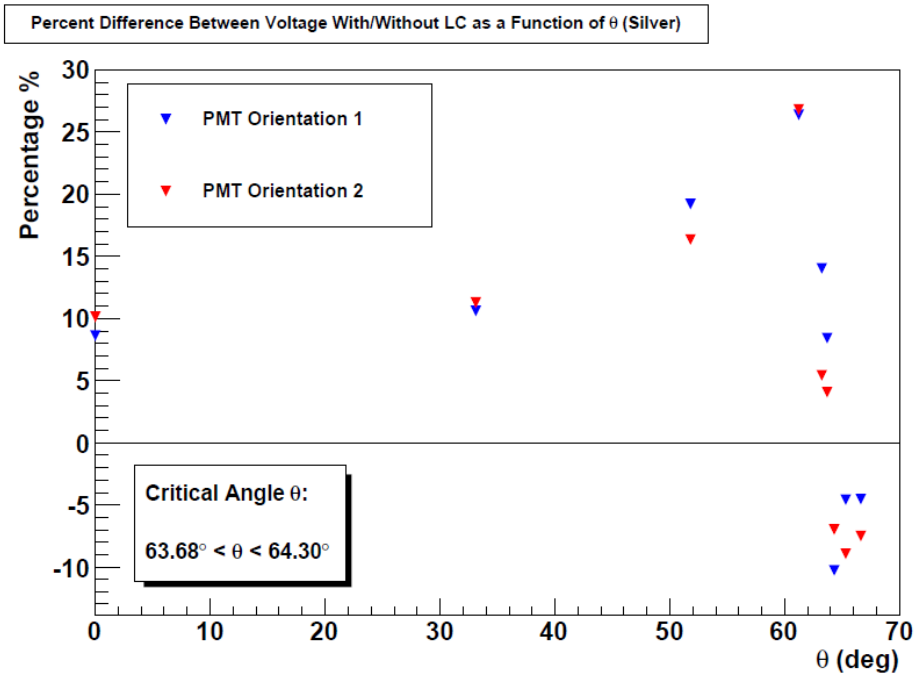
Measure of the Acceptance Angle



Measure of the Acceptance Angle
First Prototypes

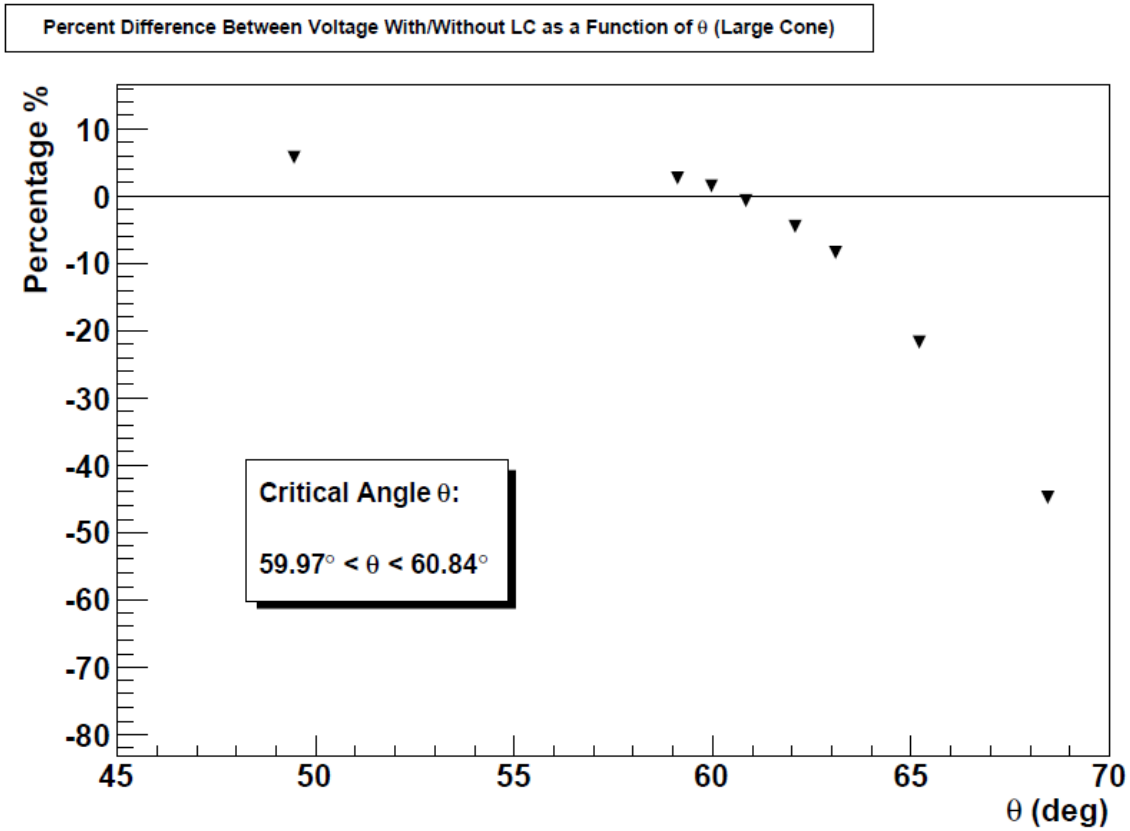


Al



Ag

Measure of the Acceptance Angle Second Prototype



Simulations

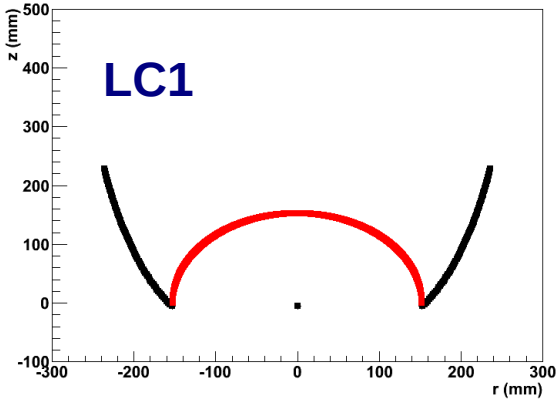
- Aim: use simulations to define the LC best shape in order to not affect the detector response on the GeV scale and improve it on the MeV scale

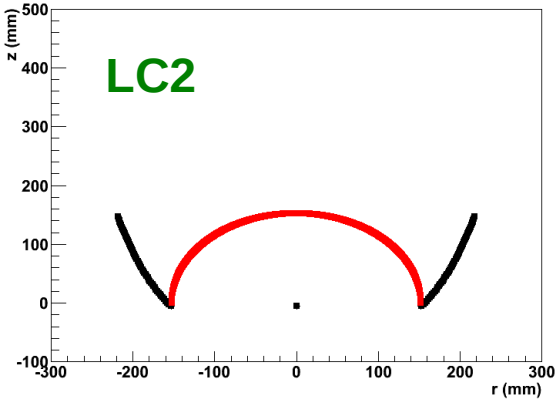
- So far: preliminary study of LC impact on
  - Position reconstruction
  - the FV definition (next future)

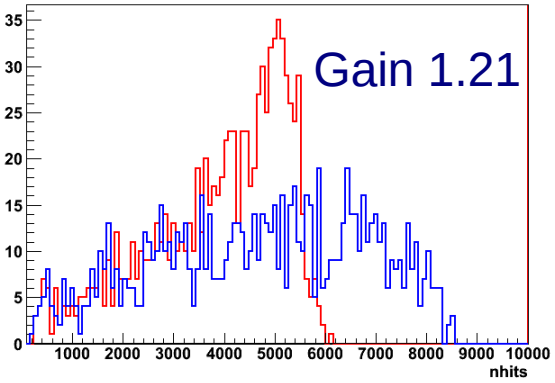
- 3 GeV e^- and μ^- (whole volume, isotropic direction) simulated with and without Lcs
- Reconstruct the events
- Compare the LC/no LC cases, for different LC shapes

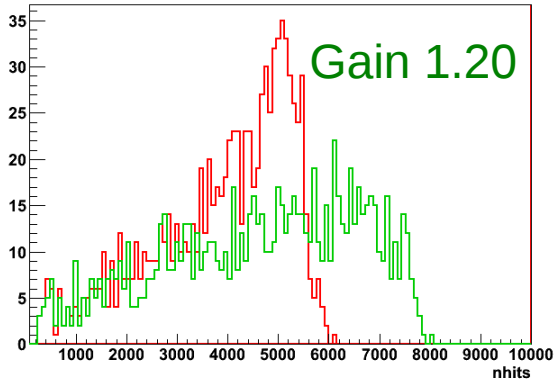
Shape studied

- 2 LC shapes tested
  - Same ellipsoidal profile, different height (and acceptance)







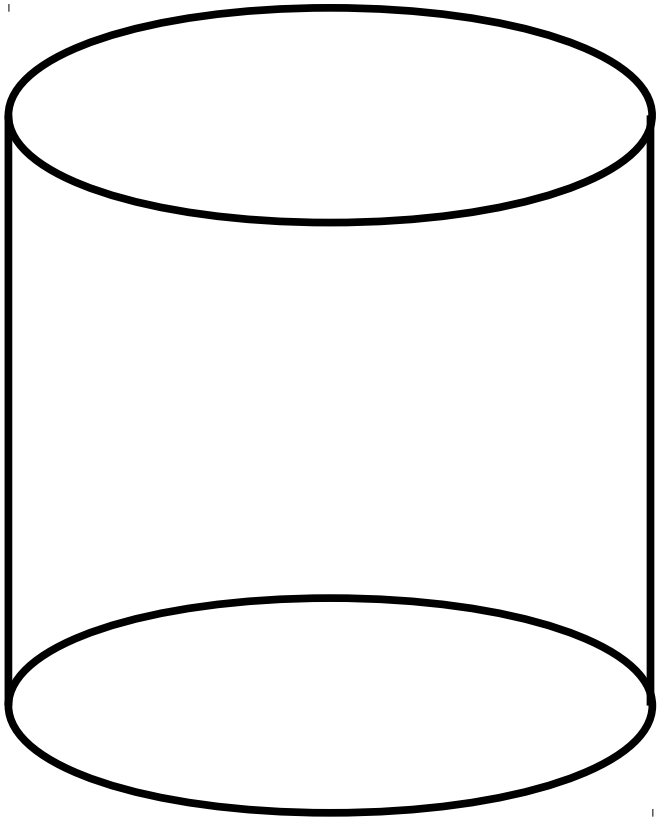


Reconstruction code

- Reconstruction code (by Andy Blake) is still under development
- Tuned for 100kton – 10 inch PMTs configuration
  - Used 200kton – 12 inch PMTs configuration
- At this stage, no tuning is done on reconstruction code (neither for detector configuration, nor for LCs)
  - Tuning the code on LCs can improve a lot!

Simulation Technique

- Difference between the several simulations: LC shape
  - ► use light distribution at 1 m from the detector wall as starting point for the different simulations



Simulation Technique

- Difference between the several simulations: LC shape
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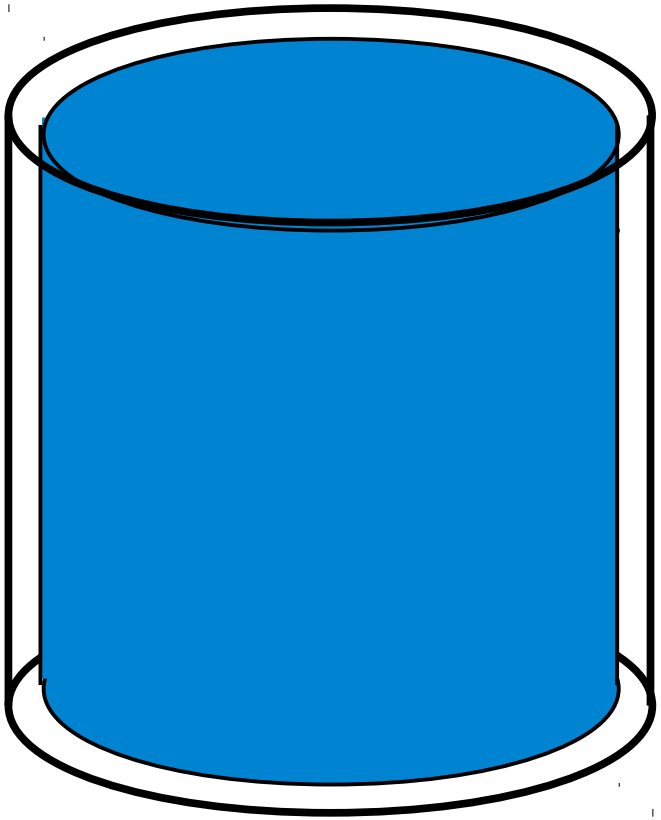
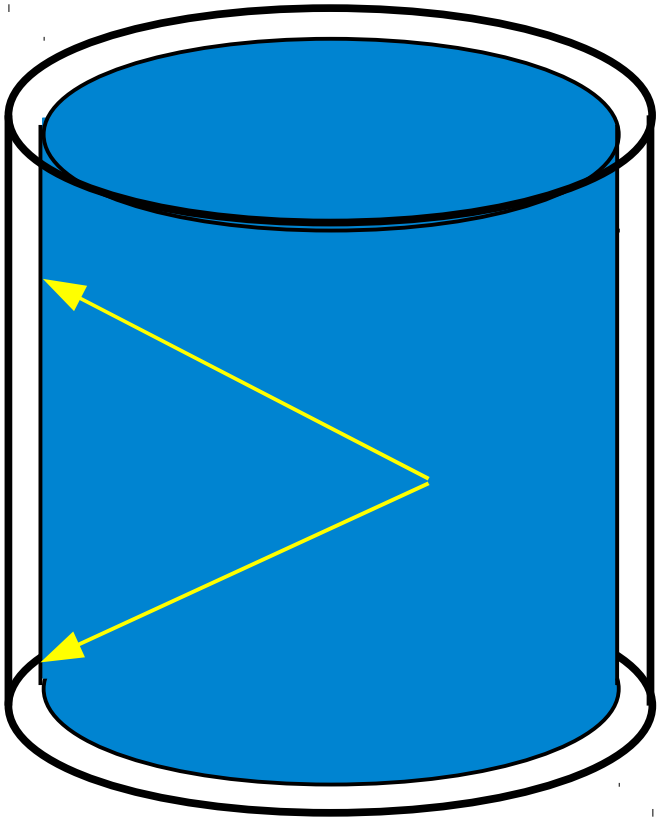
- Define a cylindrical surface 1 m smaller than the detector walls



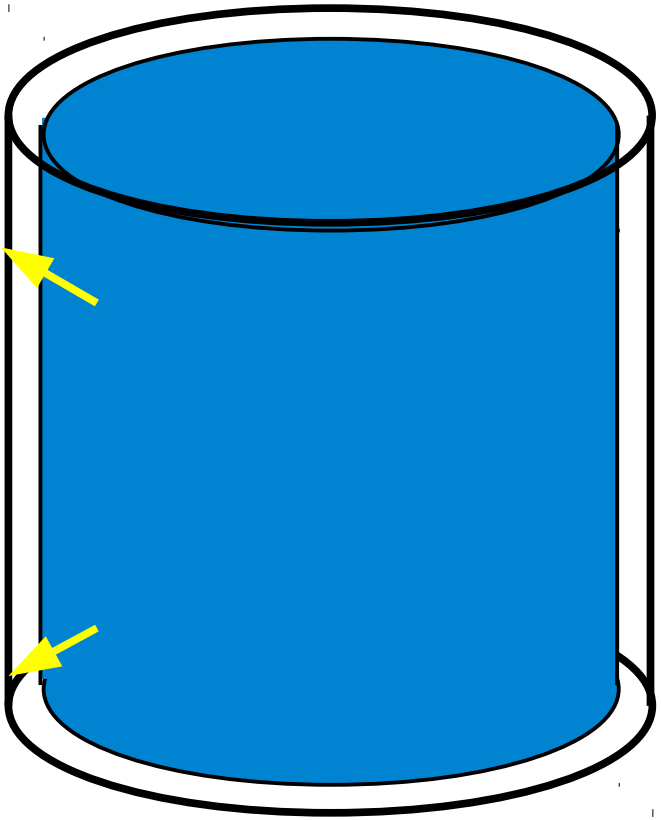
Simulation Technique

- Difference between the several simulations: LC shape
  - ► use light distribution at 1 m from the detector wall as starting point for the different simulations
- Define a cylindrical surface 1 m smaller than the detector walls
- Generate events
- Save light distribution on the new cylindrical surface

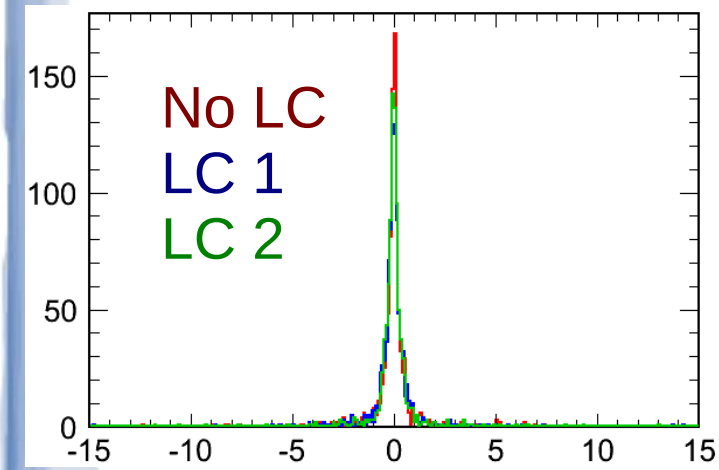


Simulation Technique

- Difference between the several simulations: LC shape
  - ► use light distribution at 1 m from the detector wall as starting point for the different simulations
- Define a cylindrical surface 1 m smaller than the detector walls
- Generate events
- Save light distribution on the new cylindrical surface
- Define the detector configuration (LCs)
- Propagate light from the saved distribution to the walls

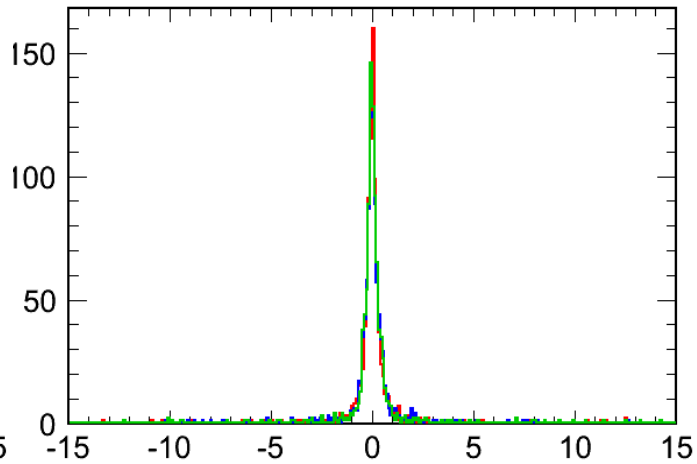


Results: Reconstructed – True Coordinates **electrons**



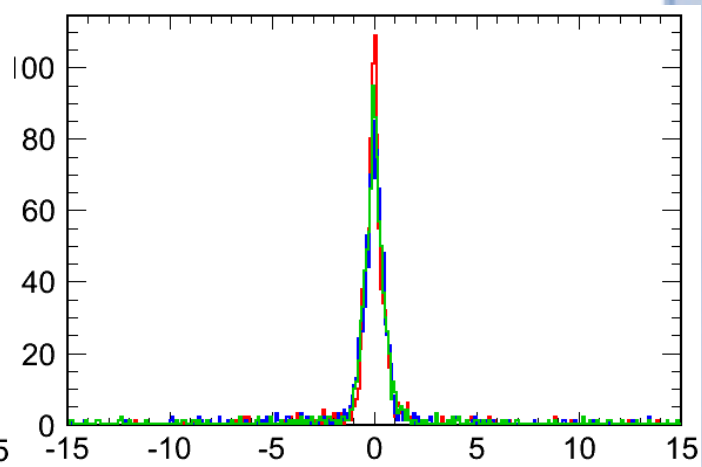
x

Mean [m]	RMS [m]
0.007	1.329
-0.012	1.513
-0.009	1.244



y

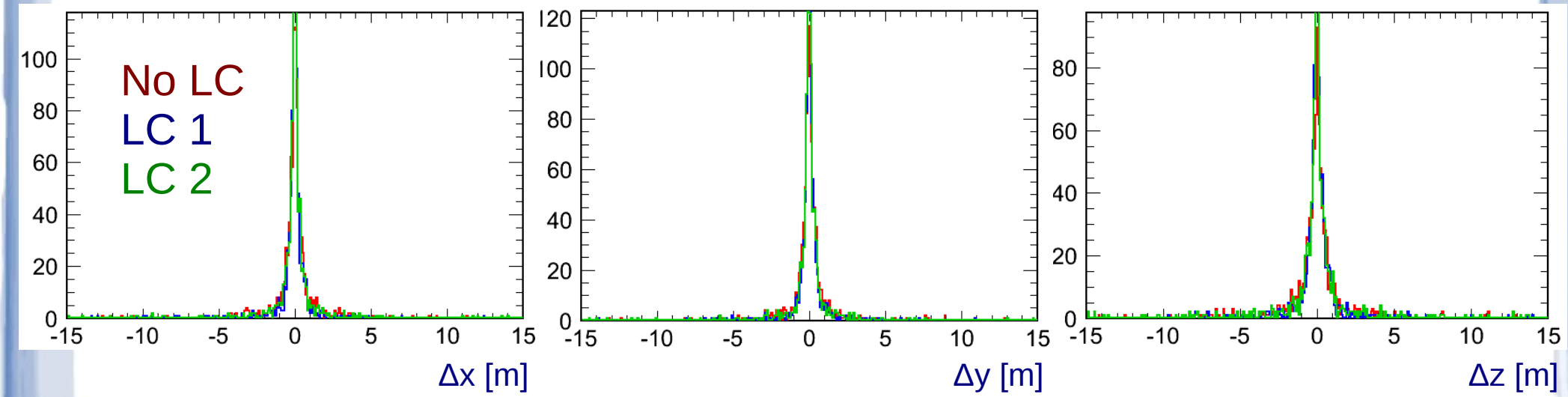
Mean [m]	RMS [m]
0.036	1.769
0.042	1.611
-0.055	1.667



z

Mean [m]	RMS [m]
0.008	2.186
-0.061	2.437
-0.045	2.357

Results: Reconstructed – True Coordinates
muons



x

Mean [m]	RMS [m]
-0.083	1.971
-0.100	1.727
-0.059	1.837

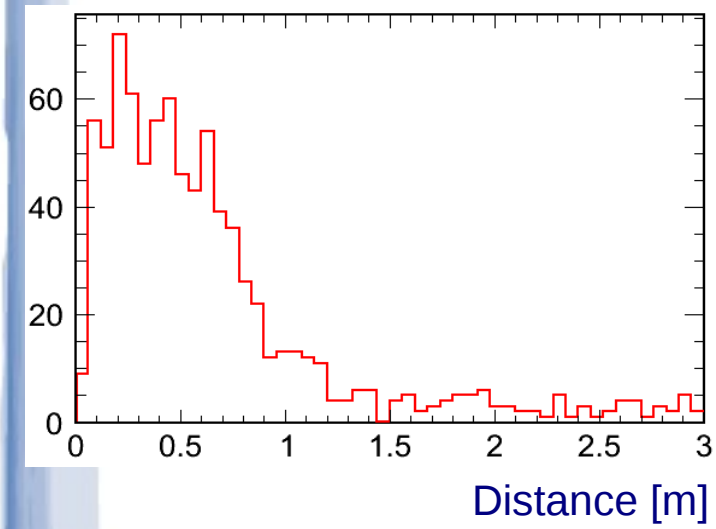
y

Mean [m]	RMS [m]
-0.037	1.946
-0.036	1.671
-0.037	1.645

z

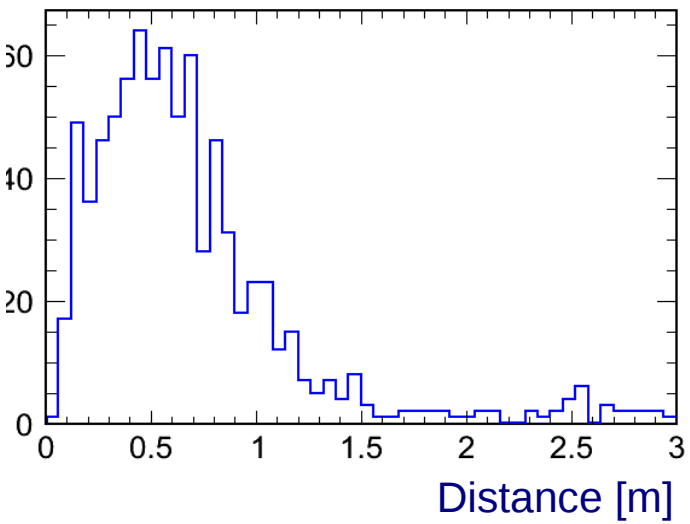
Mean [m]	RMS [m]
-0.104	2.520
-0.073	2.235
-0.102	2.456

Results: Reco – True vertexes distance **electrons**



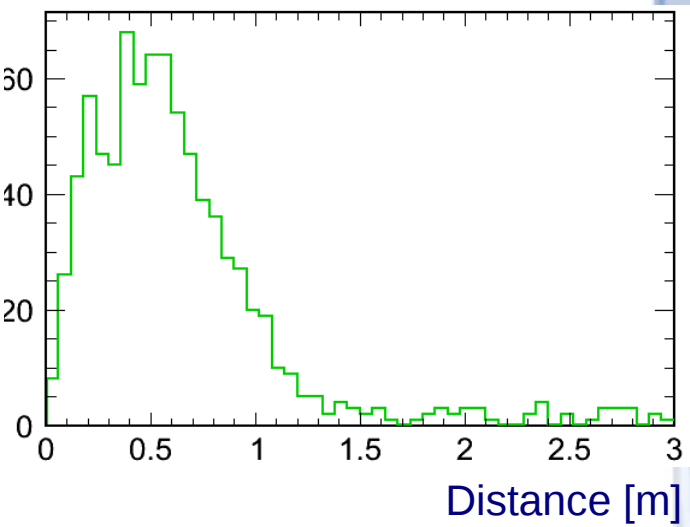
No LC

Mean: 0.65 m
RMS: 0.59 m



LC 1

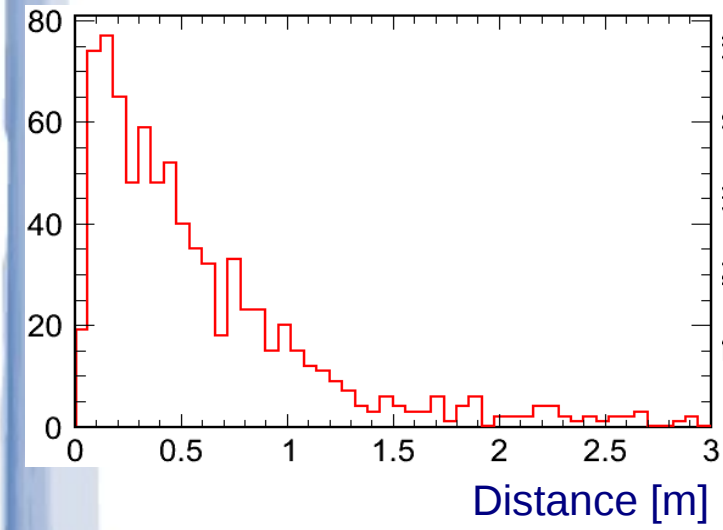
Mean: 0.68 m
RMS: 0.51 m

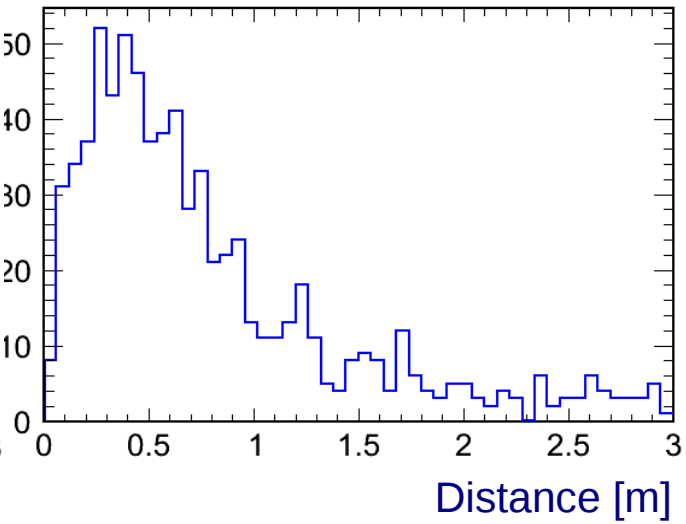


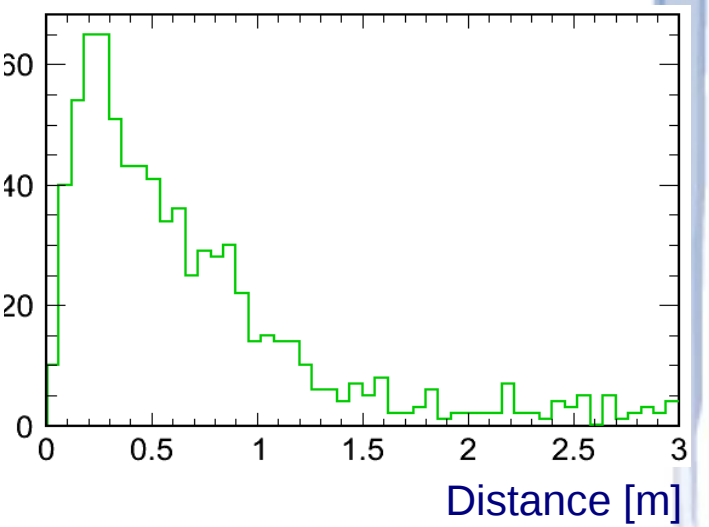
LC 2

Mean: 0.63 m
RMS: 0.48 m

Results: Reco – True vertexes distance
muons







No LC

Mean: 0.59 m
RMS: 0.53 m

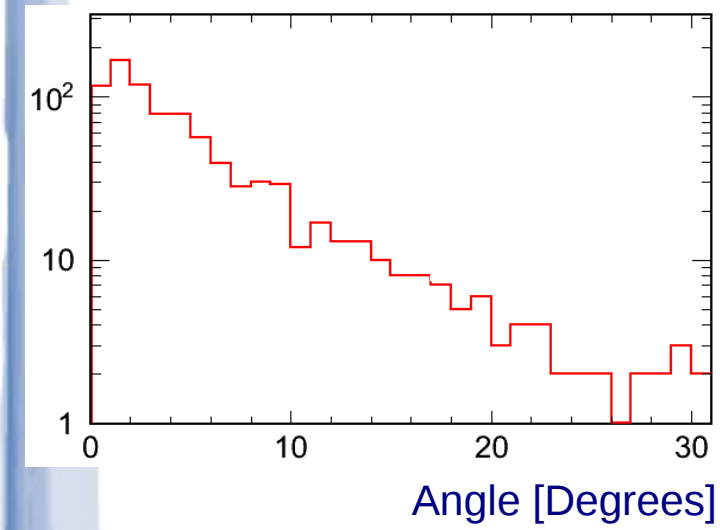
LC 1

Mean: 0.79 m
RMS: 0.65 m

LC 2

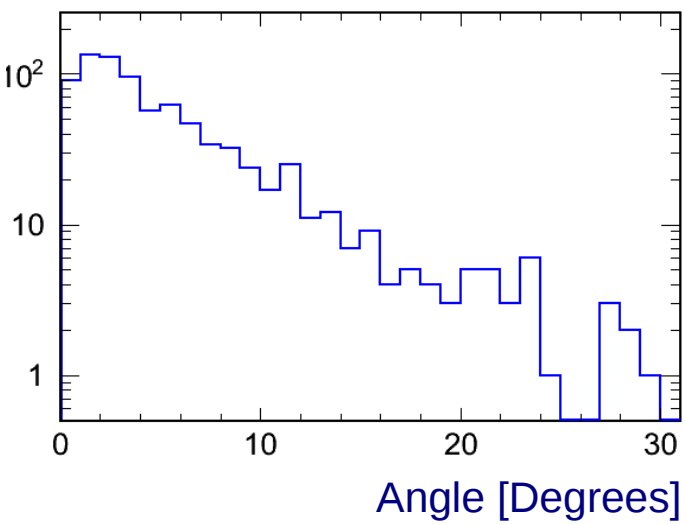
Mean: 0.69 m
RMS: 0.61 m

Results: Angle Between True and Reconstructed directions: **electrons**



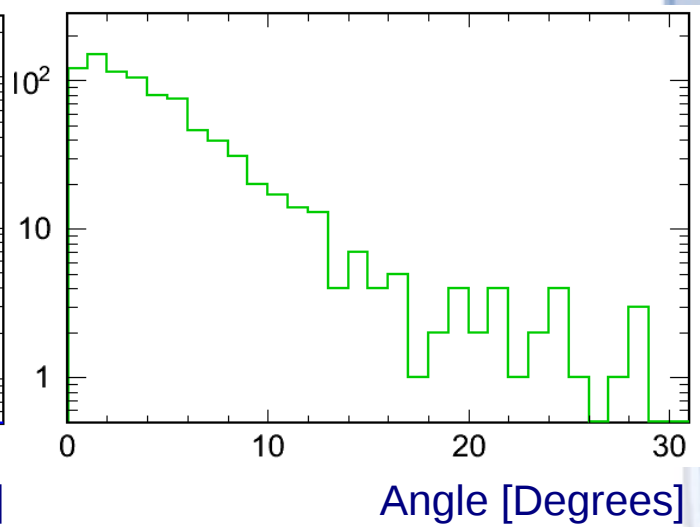
No LC

Mean: 5.28°
RMS: 5.47°



LC 1

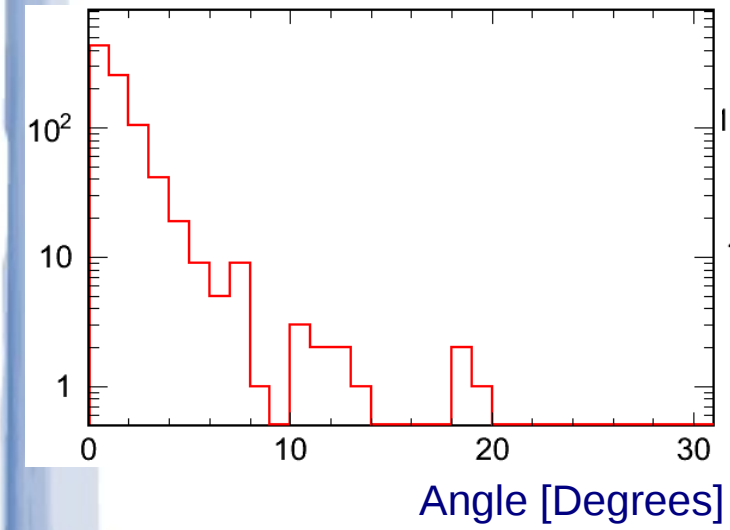
Mean: 5.40°
RMS: 5.16°



LC 2

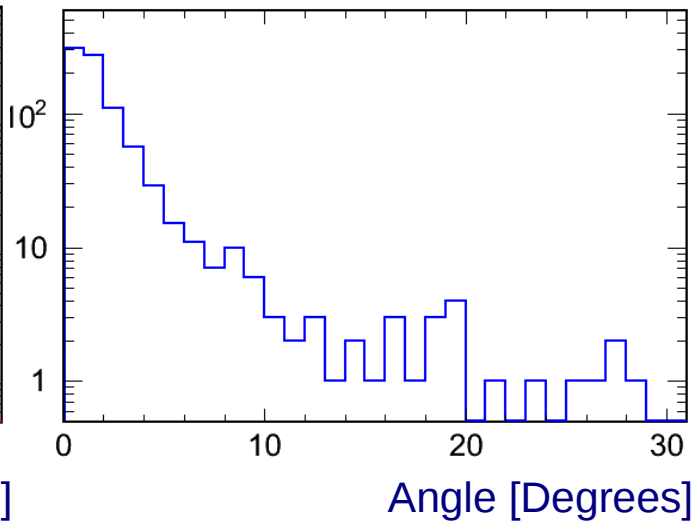
Mean: 4.75°
RMS: 4.58°

Results: Angle Between True and Reconstructed directions: **muons**



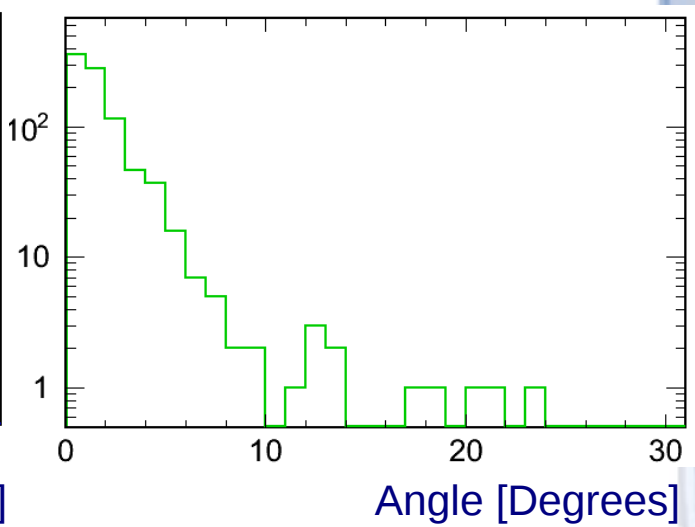
No LC

Mean: 1.58°
RMS: 1.92°



LC 1

Mean: 2.39°
RMS: 3.52°



LC 2

Mean: 1.82°
RMS: 2.21°

Conclusions

- Three prototypes produced and tested
  - Al and Ag coated LCs compared: no significant difference
  - Switch from paraboloid (Winston) to ellipsoidal
  - Lower radius moved down to the PMT equator
- Acceptance angle measured: compatible with 60 degrees
- Started to study the effect of LC on reconstruction with simulations: LCs don't critically worsen reconstruction
- About to study the effec of LC on the Fiducial Volume definition