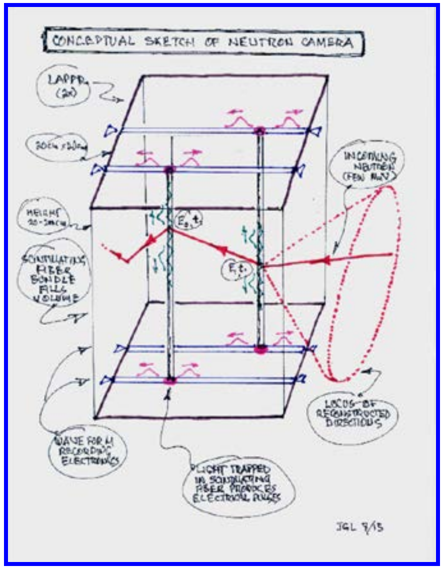
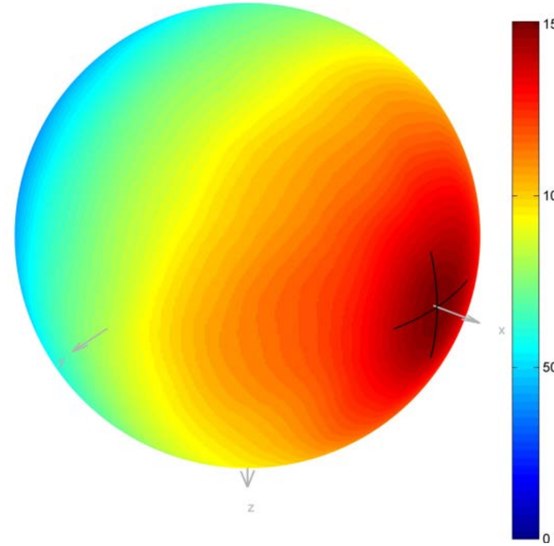




Neutron Time Cube

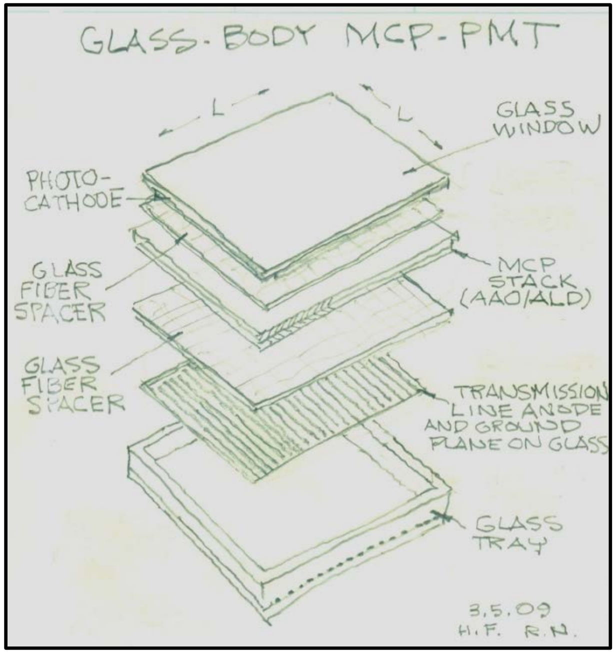
Neutron Camera from Scintillating Fiber Bundle with LAPPDs

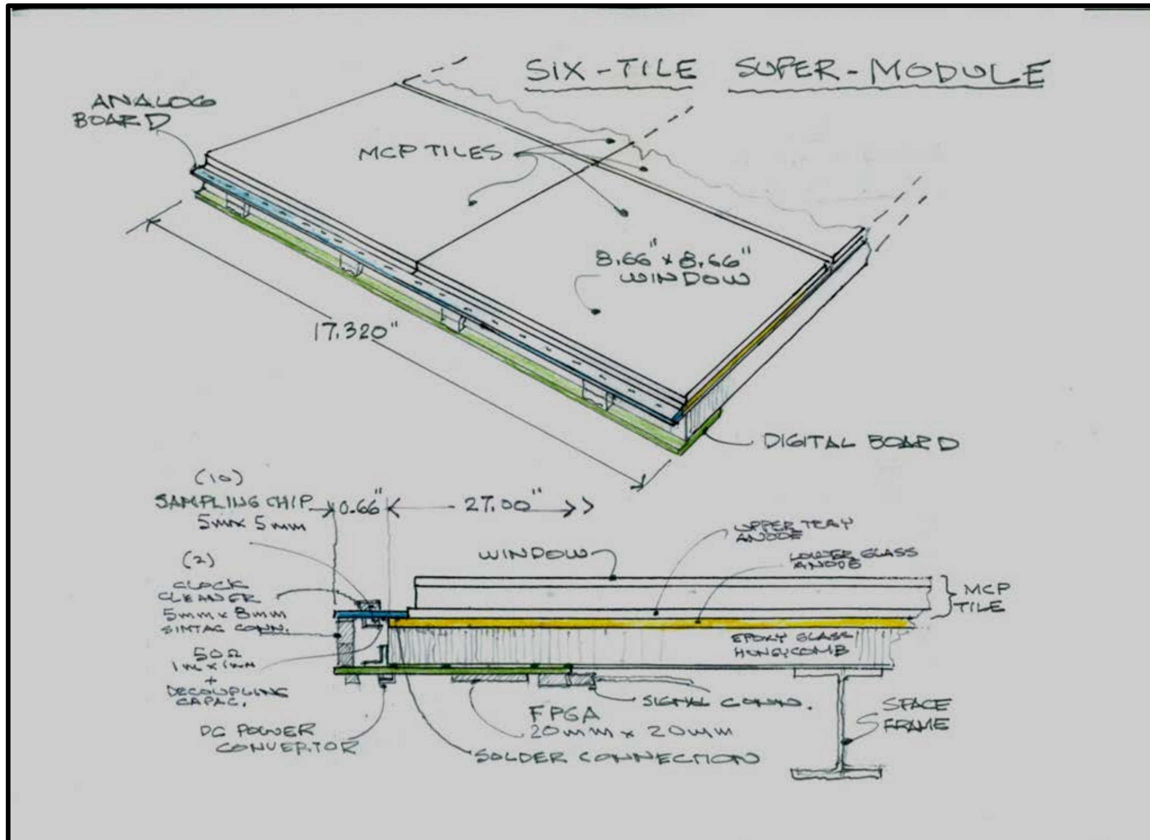
John Learned

Physics & Astronomy, U. Hawaii, Manoa

at ARL Review 1/11/2016

The Large Area Picosecond Photo-Detector - LAPPD





8” x 8” Basic Multi-Channel Plate electron multiplier

Biggest ever MCP made by Incom, in MA

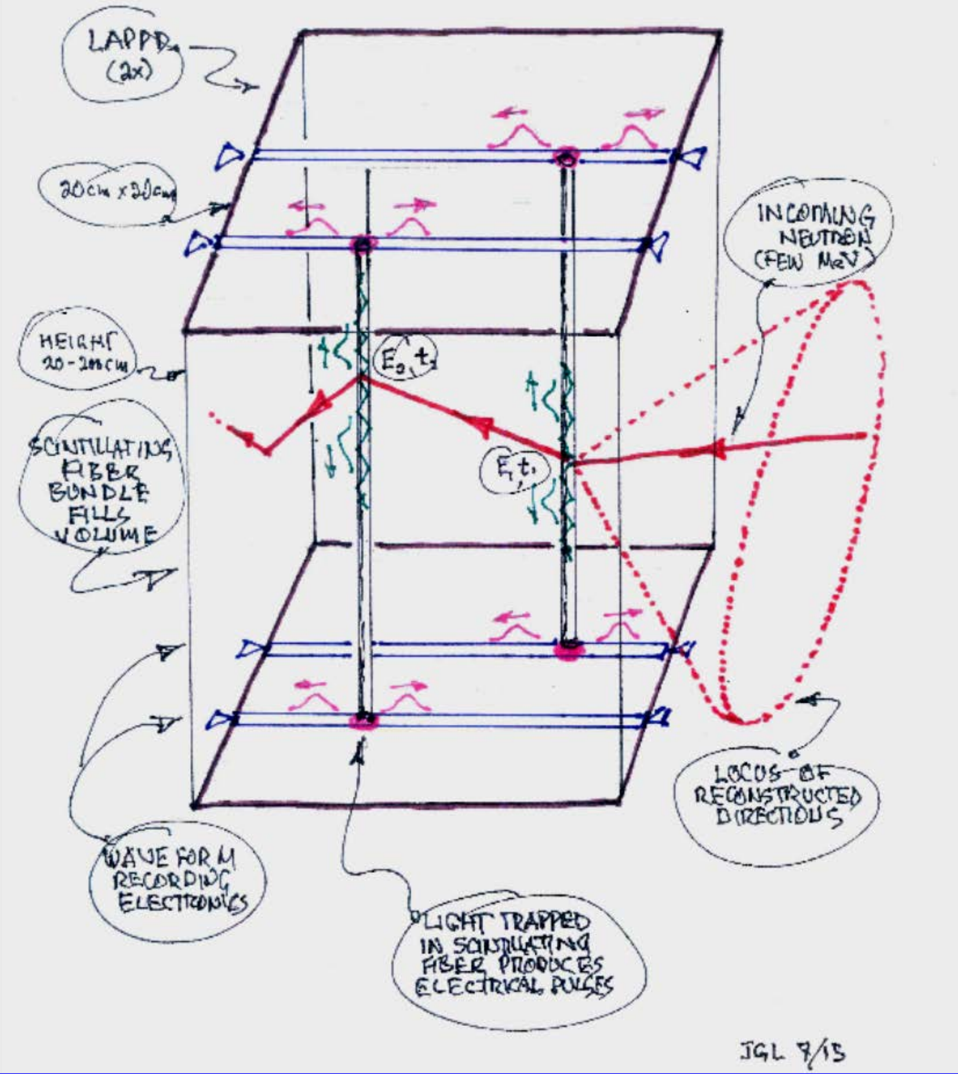
Sealing trials at Space Sciences Lab, Berkeley

Hoping for first tiles Mar 2016, in production in about 1 year.

Henry Frisch, Chicago

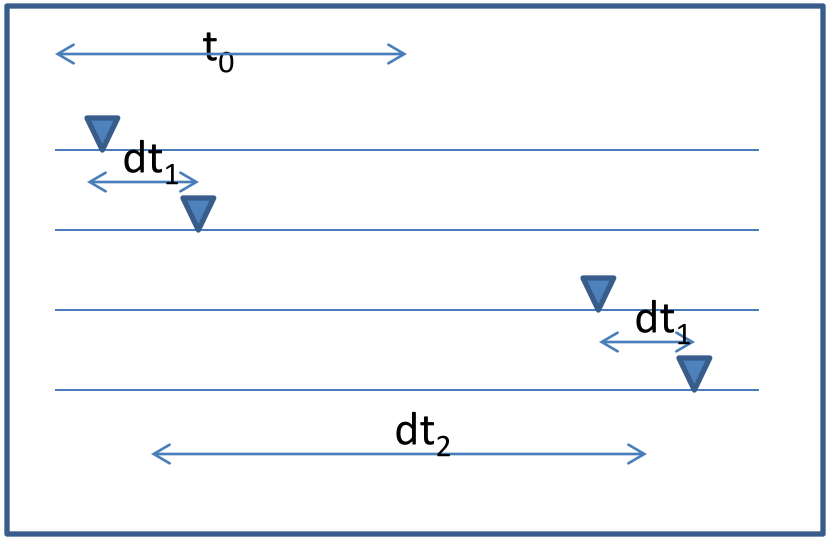
Sketch of nTC Concept

Conceptual Sketch of Neutron Camera



- LAPPDs top and bottom
- Volume filled with scintillating plastic fibers
- Neutron scatters from protons produce
- local energy depositions and light pulse
- Light trapped in fiber goes up and down to LAPPDs
- LAPPDs convert light from fiber to opposite
- travelling electrical pulses detected at ends of LAPPD.
- Four electrical pulses yield x,y,z, t and energy.
- Two pulse sets allow calculation of cone of possible incoming directions for few MeV neutron.
- Many neutrons allow map of common origin.

Simple Kinematics allows calculation of Cone of neutron arrival directions



Detector strip length = L = y direction
Detector fiber length = H = z direction
Location of given strip = x direction

For two depositions

$dt = t_b – t_a$
$dr = \sqrt{((x_a-x_b)^2 + (y_a-y_b)^2 + (z_a – z_b)^2)}$
$v = dr/dt$
$E2 = ½\, m\, v^2$
$E1 = Ea$
$Sin(Θ) = \sqrt{(E1/(E1 + E2))}$
$Θ$ defines cone around direction {*dx, dy, dx*}

Signal on strip at x_a
$y_a = dt_1/n$
$z_a = dt_2/n$
$t_a = t_0 -(L+y_a)/n - (H+z_a)/n$
Ea = weighted sum of amplitudes = energy of proton scatter

Calculated Neutron Pointing Map

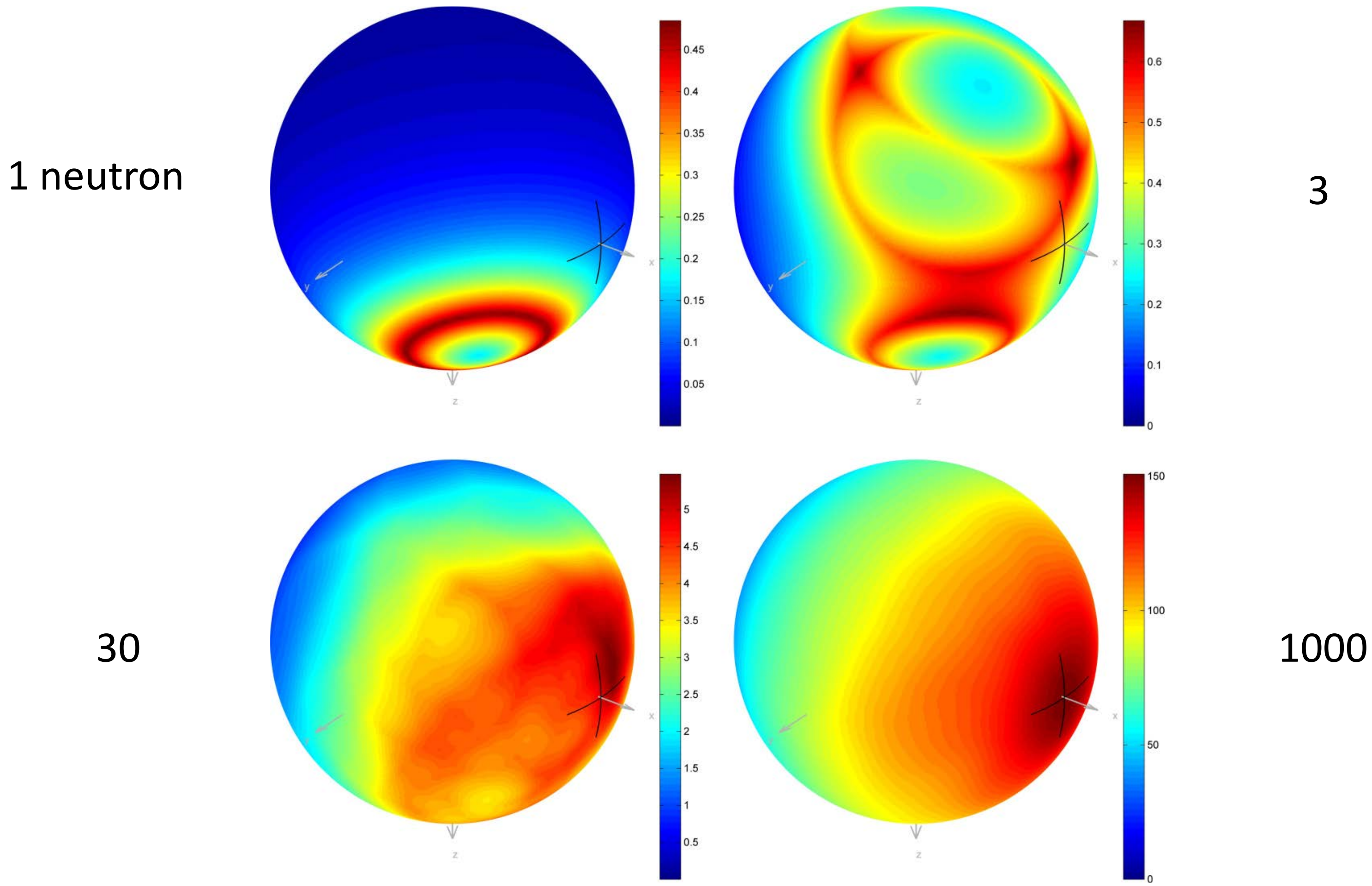


FIG. 12. Neutron angular probability density functions for 1, 3, 30 and 1000 MC neutrons per 42 displayed on unit spheres.

Potential Configurations

- Portable version… Suitcase size, ~30 lb
- Roadside in a van… Stack of ten, each 2m long fibers, giving $4m^2$ area facing roadway
- Mini, hand held: Use four Planacons, with LAPPD like readout, special electronics, connection to remote processor, get on-line display on cell phone.
- 1 tonne version, with doped fibers & 50 LAPPDs, with similar application as mTC and NuLat
- Also fits in van for near-reactor monitoring

Issues under study

- Light emission from scintillating fiber is relatively slow… over a few ns.
  - Light pulse at LAPPD thus stretched out
  - Need correlation between signals to give mean time offsets (t1 and t2, and t0)
  - As much light as possible needed for resolution
- Trapped fraction for OTS fiber is around 4%
- Response per side perhaps 160PE/MeV_ee
- Possible great increase collection fraction using new material TRANLOC, with Incom. (800PE?)

Follow Up

- Much study needed
- Some questions:
  - How much light from neutron scatters?
  - What are real scatter location and angular resolutions?
  - How to deal with backgrounds?
  - Optimize fiber choice, type, cladding. TRANLOC?
  - Design small portable version
  - Design larger version possibly for reactor studies

We will be investigating more and building model in next year.