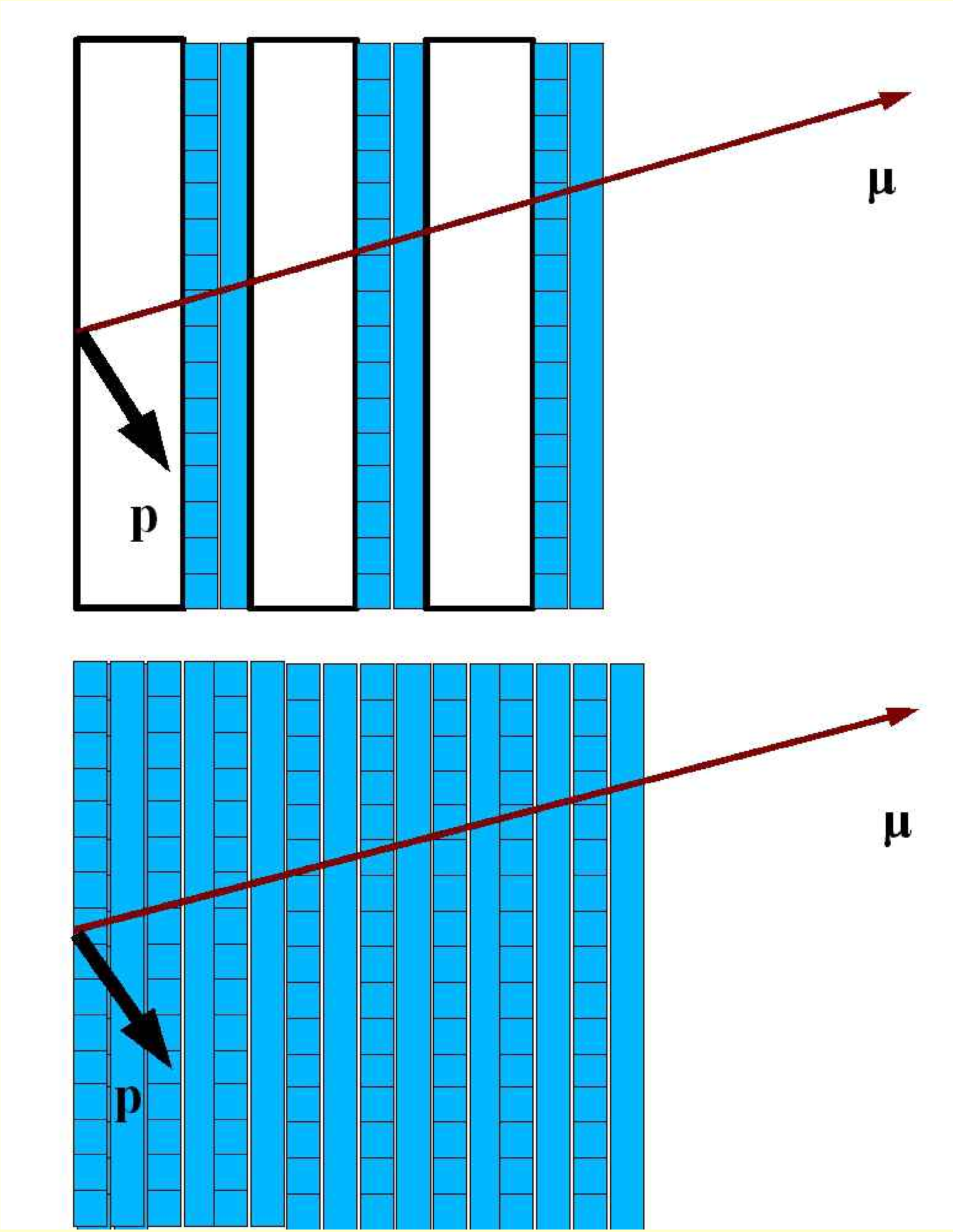
Progress report on Water Based Scintillator Near Detector prototype

Stanley Yen, TRIUMF

Collaboration meeting January 2015



Need water target in near detector since far detector is Water Cerenkov; non-trivial carbon-oxygen nuclear interaction differences

PRESENT near detector:
passive water layers between plastic scintillator
dead region
low energy recoil protons in passive water produce no signal

WHAT WE WANT:
active scintillating water:
NO dead region,
ALL recoil particles detected

"1 cm bars too coarse"

“Scintillating water” now possible with recent development of Water-Based Liquid Scintillator (WbLS) at Brookhaven National Lab

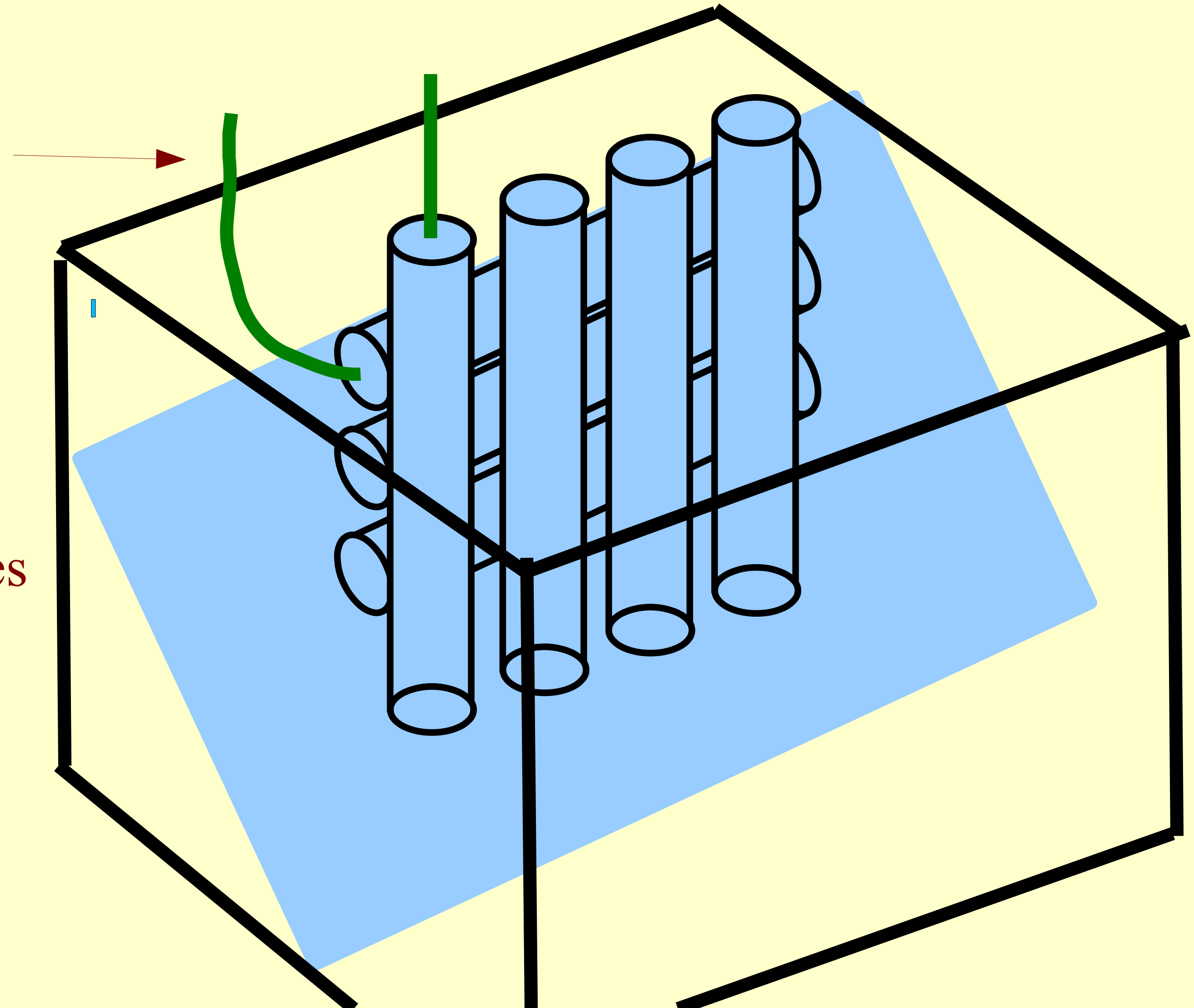
WbLS-1   70% water   1000 optical photons/MeV

WbLS-2   70% water   1500 optical photons/MeV

compared with pure liquid scintillator (BC408) 10,000 photons/MeV

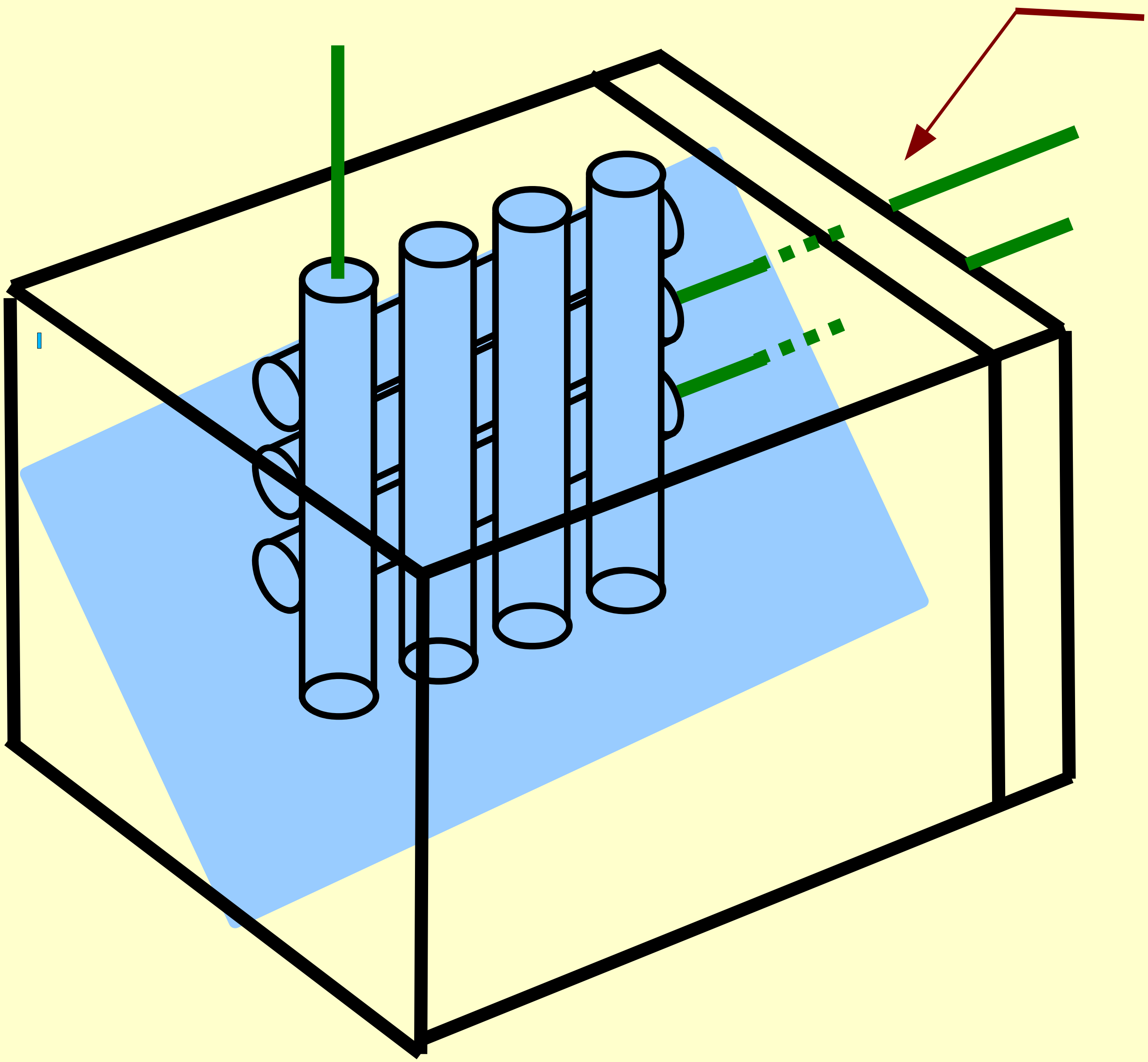
Tentative detector scheme for 5 mm (or smaller?) cell size: mylar straws painted with reflective paint on the outside, WLS fibres strung inside the straws, all sitting in an aquarium filled with the WbLS liquid.

Horizontal fibres bent 90º to leave aquarium in the vertical direction



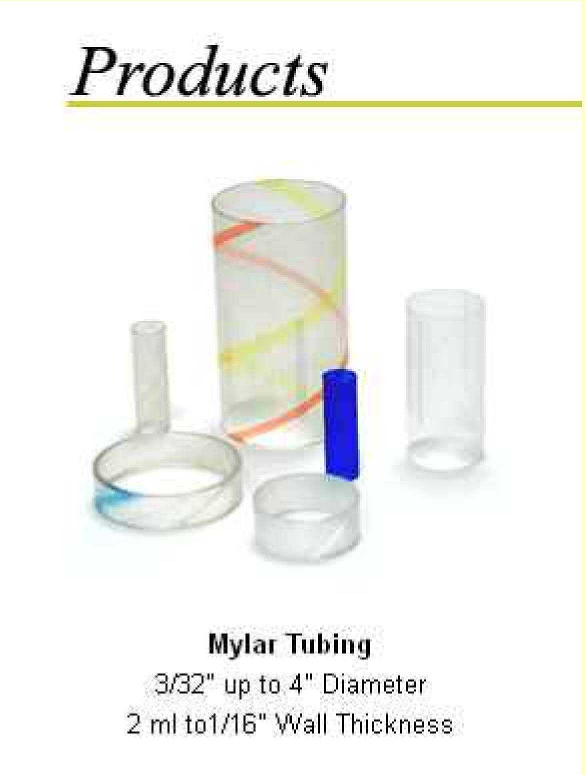
Two diagonal planes may be preferred to avoid trapped bubbles during filling with liquid.

Another scheme: take horizontal fibres out through the side of the aquarium:



WLS fibres feed through holes in hollow double side wall, then space potted with sealant (epoxy or polyurethane) to prevent liquid leaking out of aquarium

Use mylar straws made of long strips of mylar spiral-wound and glued together:



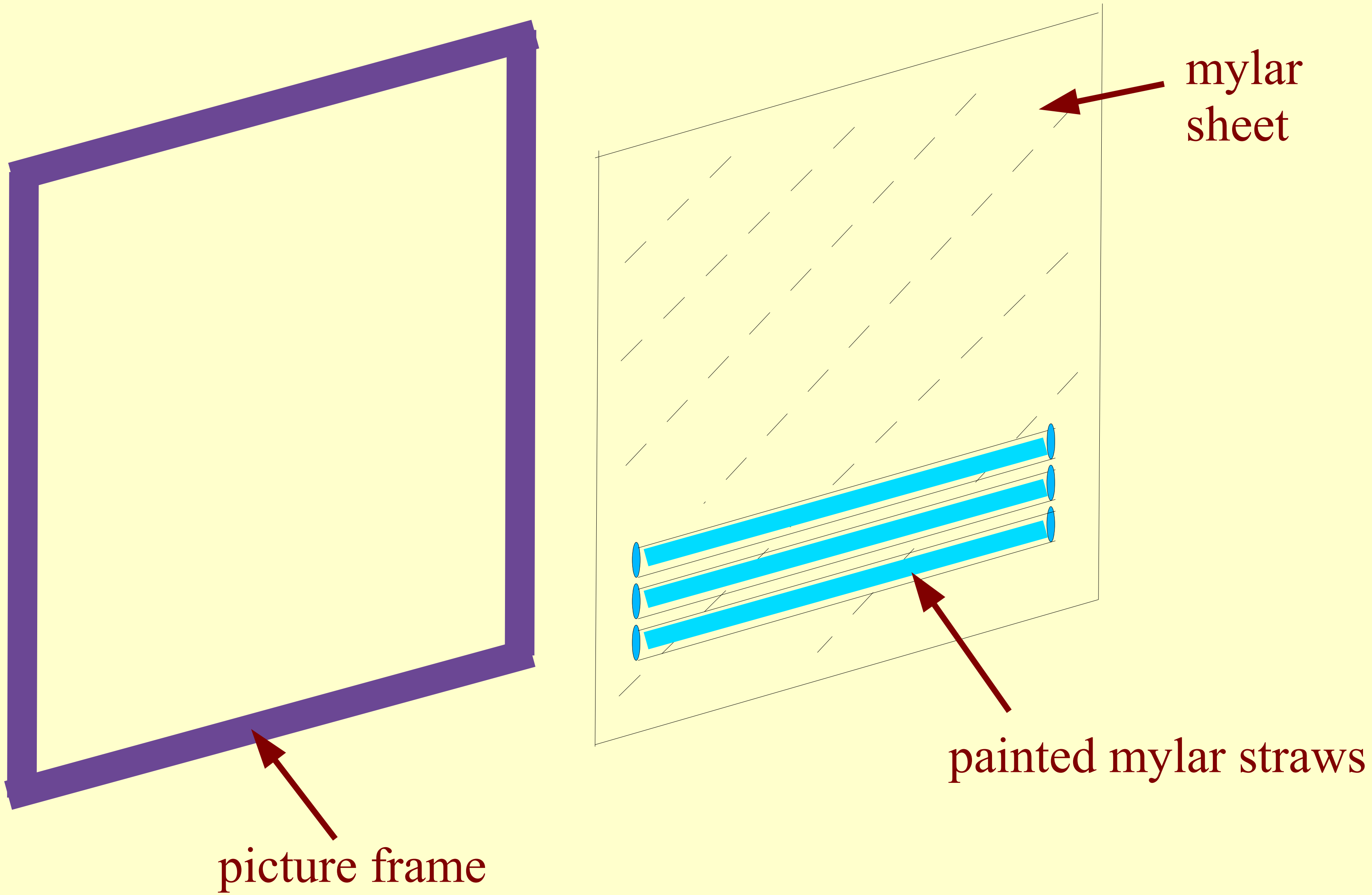
We ordered mylar straws 0.2” (5 mm) diameter,
with 3.0 mil (0.076 mm) wall thickness, 6 feet (1.8 m) long.

They also can make straws from aluminized mylar,
which would make it unnecessary to paint. (Although Avian-D paint is a much better reflector than aluminum).

Cost of straws is modest: $35 per 1000 feet + $150 one-time setup fee

How will we support and position the straws inside the aquarium?

Maybe bond the straws to a flat sheet of mylar, then stretch the sheet flat onto a picture frame?



Materials compatibility tests completed thus far:

- samples of mylar straws, painted mylar straws, mylar sheet, adhesives sent to Minfang Yeh at BNL, who soaked them in WbLS-1 for weeks/months

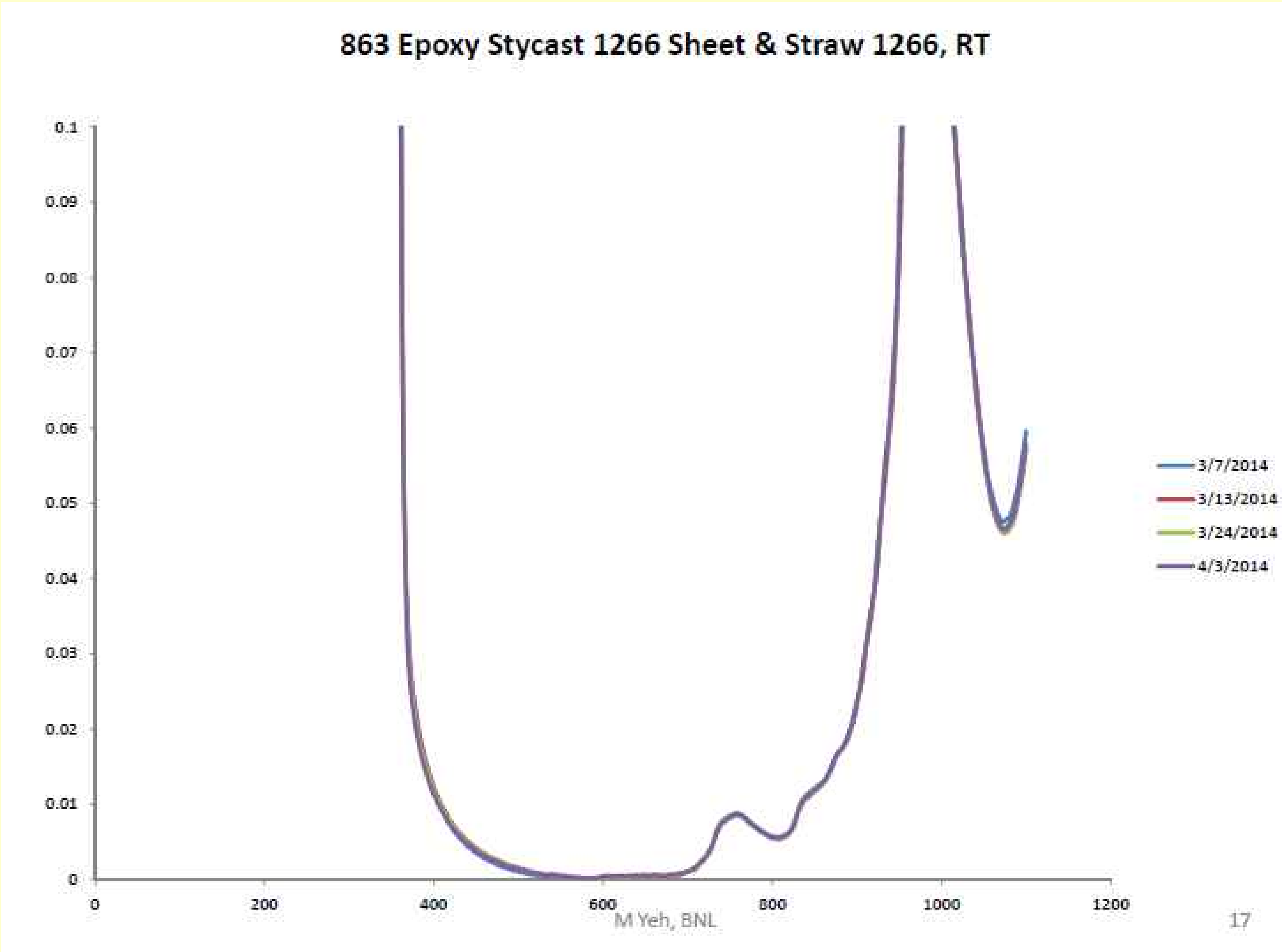
Net result:

- spiral-wound mylar straws do not delaminate in WbLS-1
- Avian-D reflective paint does not peel off
- WLS fibre does not dissolve in WbLS-1 (neither cladding nor core of fibre)
- 2 different adhesvies (Stycast 1266 epoxy and HE1908 polyurethane) not affected by WbLS-1
- light output of WbLS-1 not adversely affected by prolonged contact with any of the above materials

Example

from Minfang Yeh, BNL

No degradation of light output from WbLS-1 with progression of time.



from Minfang Yeh, BNL

Building a prototype

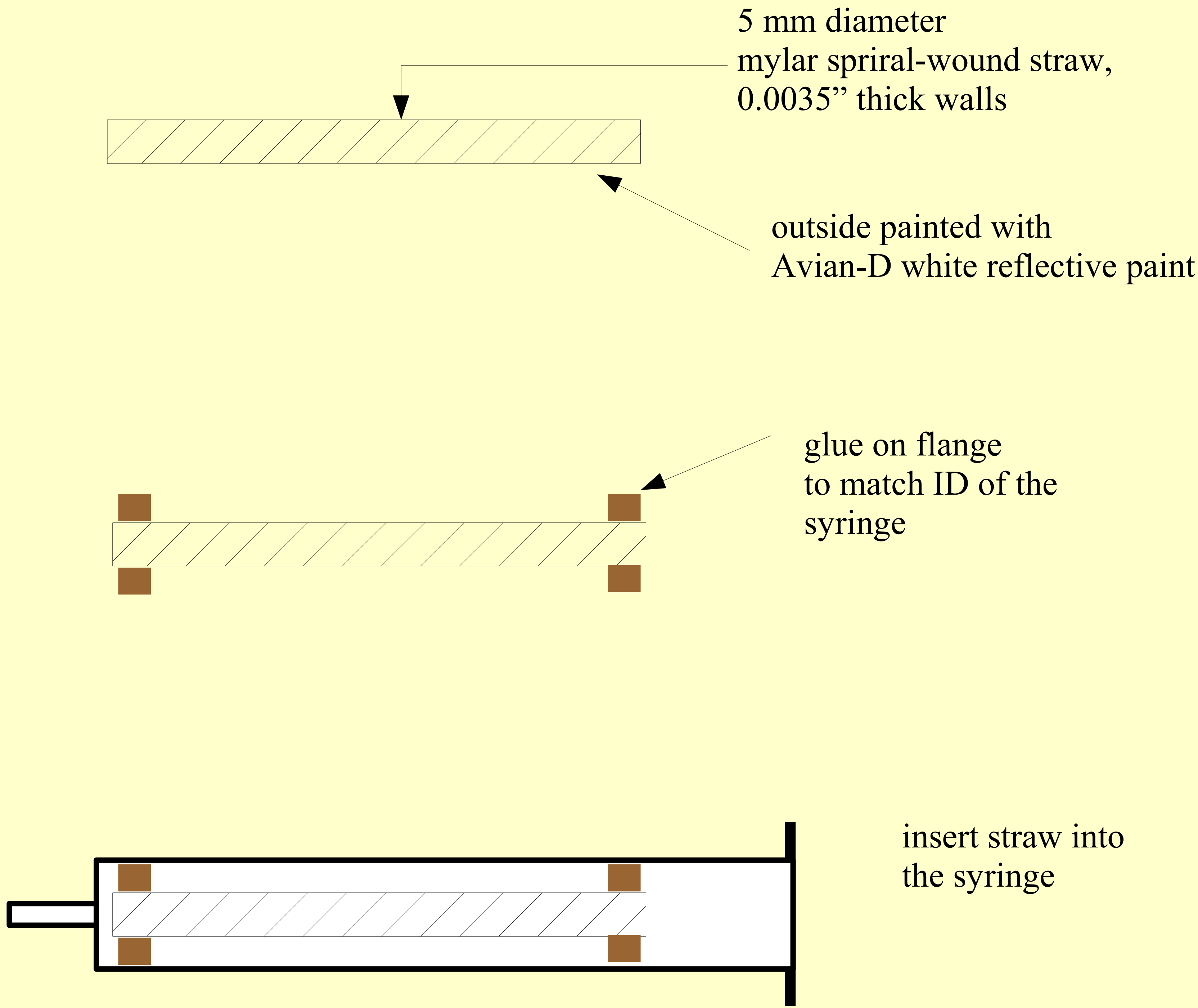
Do we get enough light output from the 5 mm diameter straws to actually track the outgoing leptons and the recoil protons?

Build a 1-cell prototype and measure the light output.

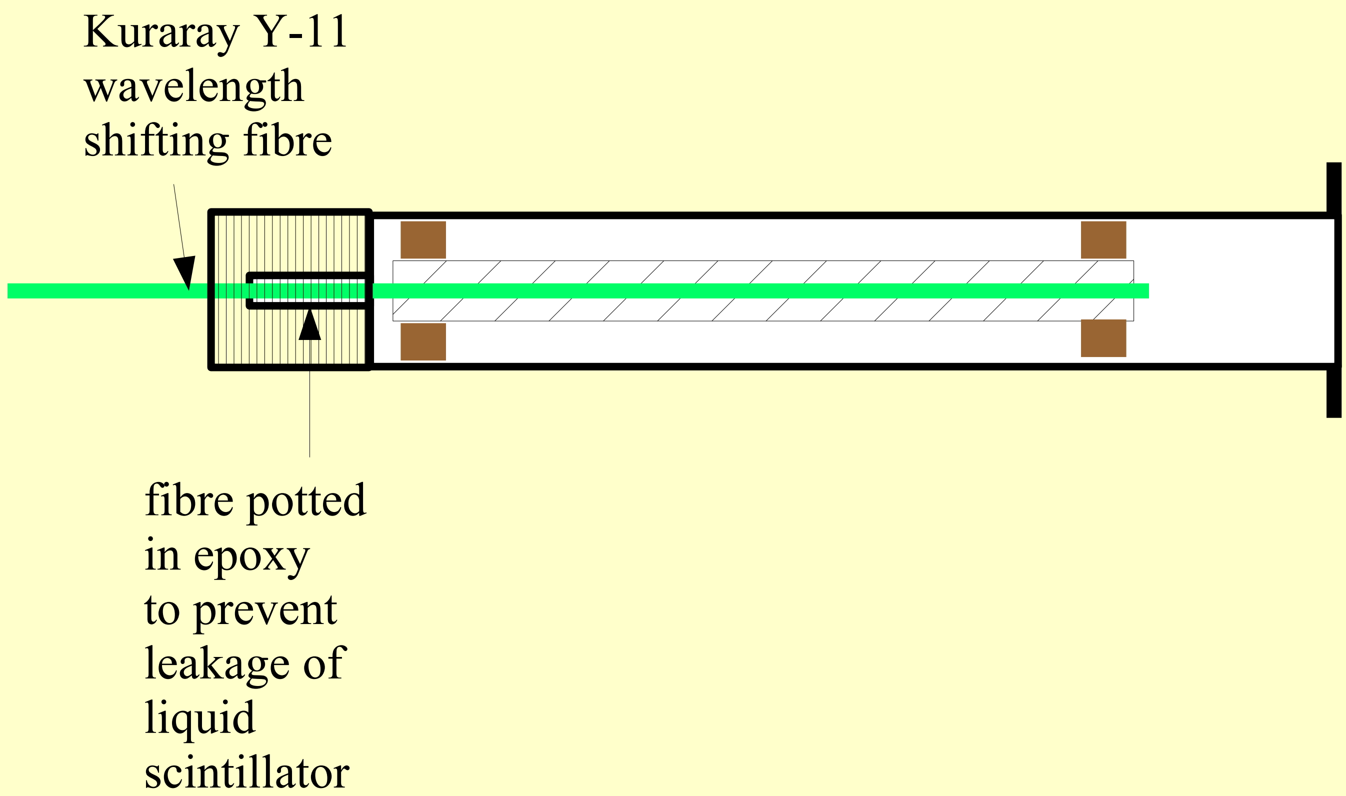
Sept 2014: received ~20 ml sample of WbLS from BNL

We start with a 10 ml disposable plastic syringe, as the vessel to hold the Water Based Liquid Scintillator (WBLS)

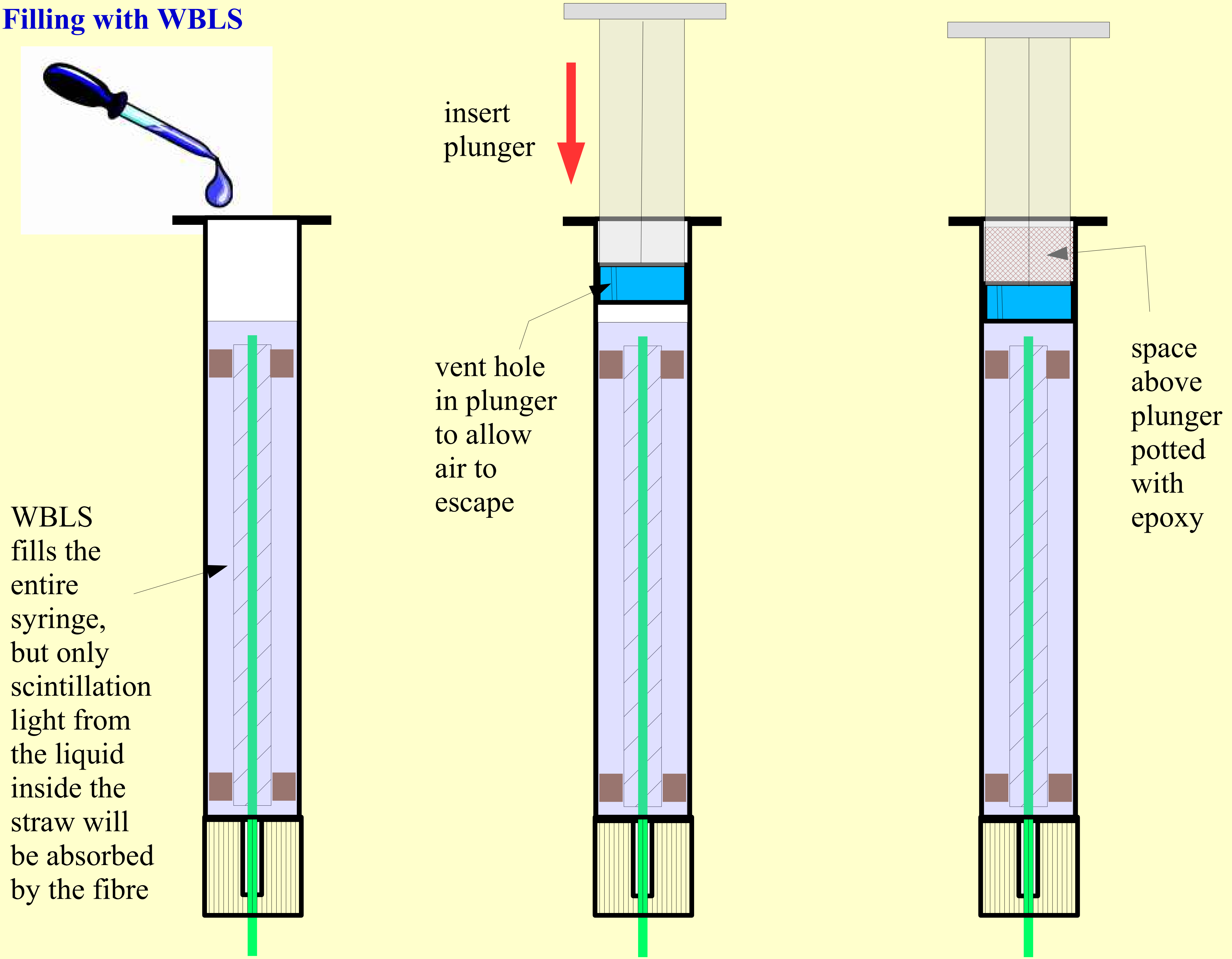
PREPARING THE VESSEL



INSTALLING THE WAVELENGTH SHIFTING FIBRE

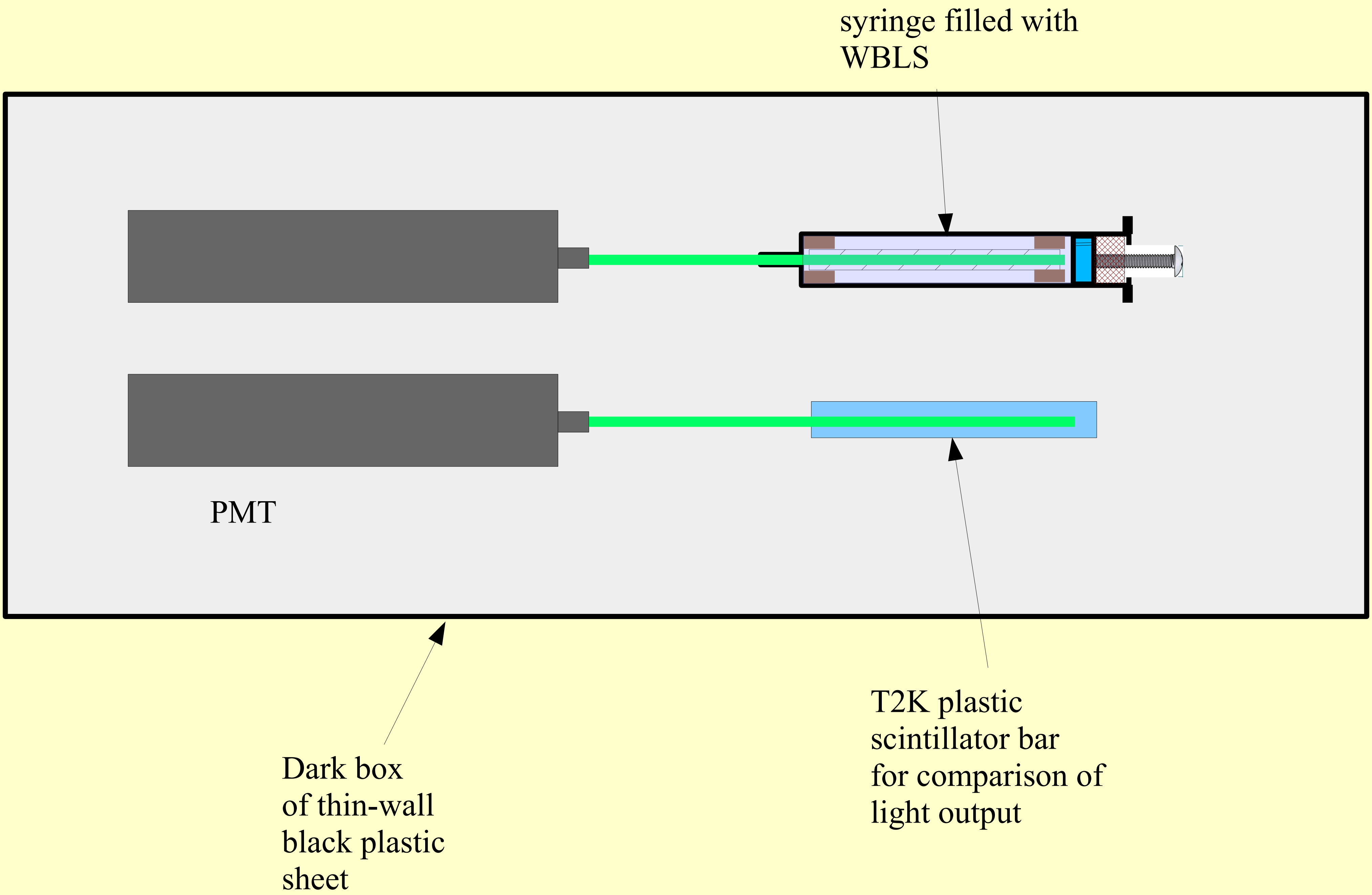


Filling with WBLS



finished 1-cell module,
ready to couple to PMT.

ENCLOSING IN A DARK BOX -- not yet done!



Feb-March 2015:
We will measure light output using beta source, and protons/pions/muons from the TRIUMF cyclotron.

Expected light output:

- dE/dx for 400 MeV/c protons = 8 MeV/g/cm^2 (= 4 x mip)
  so $\Delta E \sim 4$ MeV for 5 mm straw

- expect 6000 optical photons produced for 400 MeV/c proton, but only a few % will be absorbed and propagate to the end of the WLS fibre

- expect about 5 to 7.5% of the light output of the current 1 cm thick FGD plastic scintillator bars -- will this be enough for tracking?

- improved WbLS, better tuned to absorption of our Y-11 WLS fibre, under development at BNL and will be tested when ready