Field of Beams
If you can build it, the money will come

Have 20 kT detector (or a good fraction of it) ready for 2005 beam

- **Proposal ~ 6 months**
- **Start building ~ 1 year**
- **Time to build & install 20 kT ~ 3 years**
- **Cost (physicist) ~ $30M**
- **Build on or near surface**

Detector selection

- **Existing technology – large scale operation**
- **No prototyping necessary for proof of principle**
- **No beam tests necessary to prove performance**
- **Straight forward engineering**
- **OK with surface cosmic rays**

Possible Detectors

- **Water Cerenkov**
- **Fine grained tracking calorimeter**
  - **Active element**
    - **Scintillator**
    - **RPC**
  - **Mass**
    - **Low Z**
    - **High Z**
    - **Intermediate Z**

Detector Requirements

Energy range 500 MeV – 3 GeV

Sensitivity below beam ν_e

- **Identify e, μ**
- **Reject π^o (low z)**
- **Reject π^{+-} (high z)**
- **Reject cosmic ray background**
  n, K_L

Ok for fine grained calorimeters
X_{rad} = 1/3 – 1/4
Not yet shown for water cerenkov

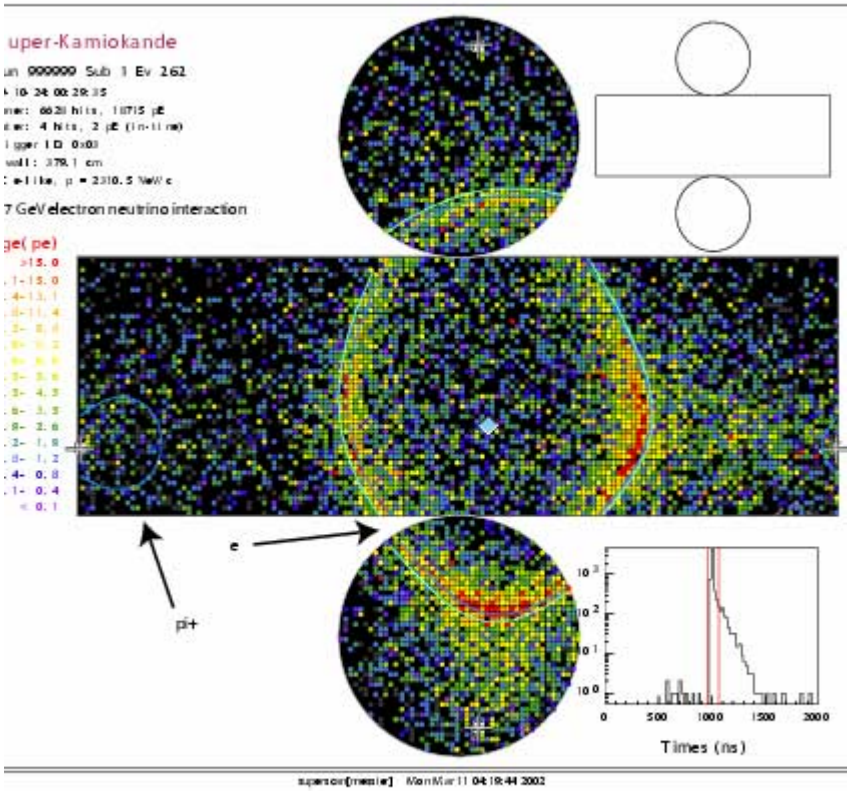
Monte Carlo Studies
Messier (water C)
Szleper (fine grained)

Water Cerenkov

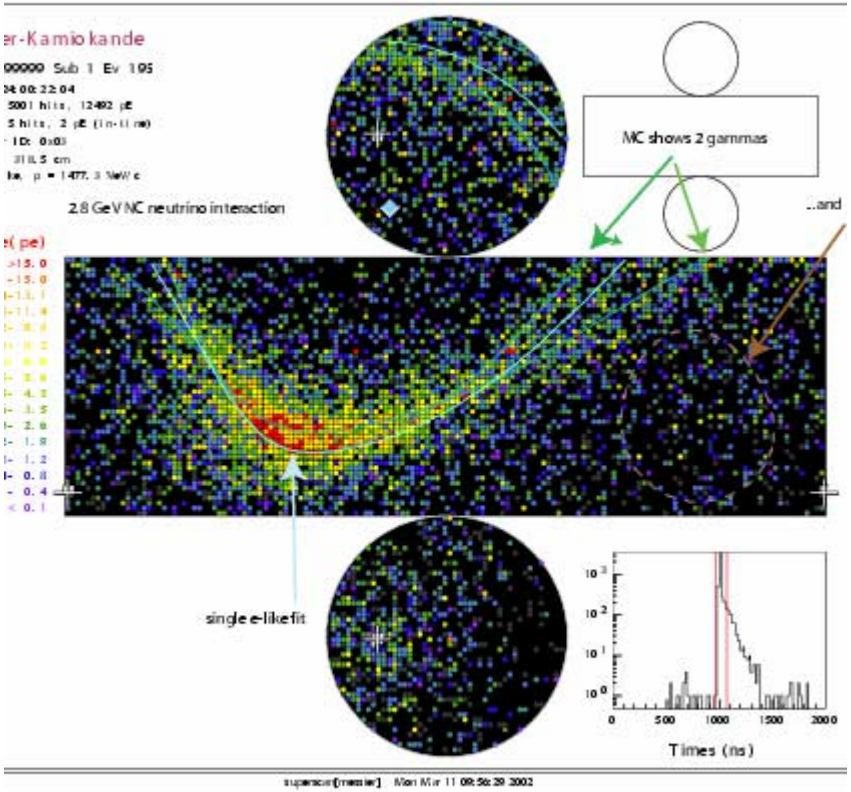
Diwan et al

- **Old BNL proposal – 4 Tanks on surface**
  - **Much engineering done**
  - **Much costing done**
- **$55 M (physicist cost) for 65 kT (Harris criterion)**
  - **Cost lower for 1 Tank**

Water Cerenkov



7 GeV ν_e with 2.3 GeV electron



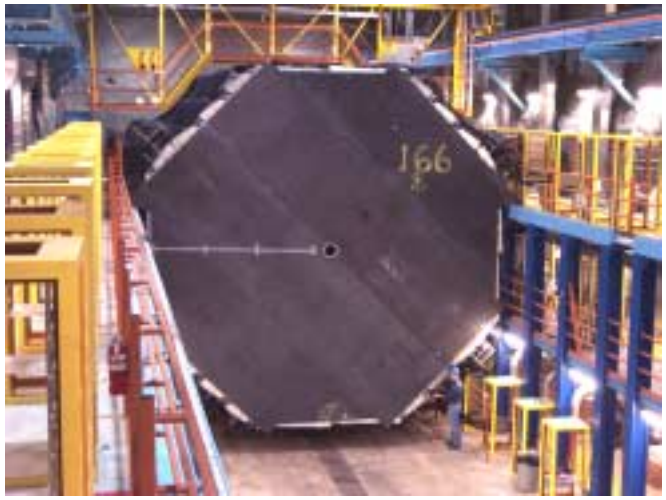
2.8 GeV NC with 1.5 GeV π^o

M. Messier

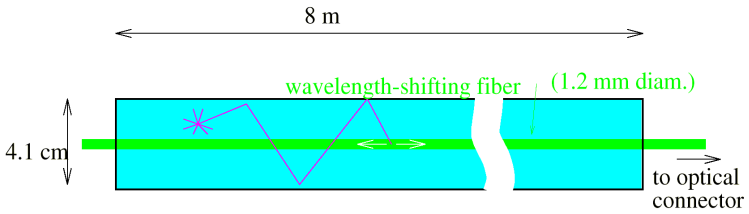
Scintillator

J. Nelson

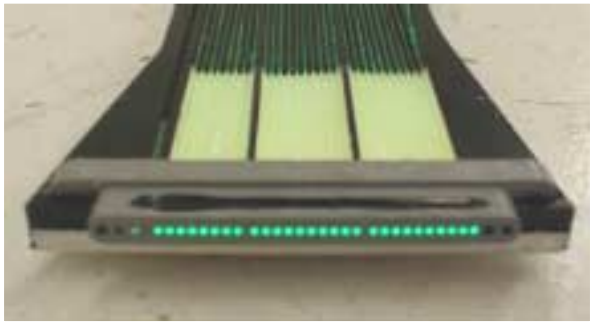
- **MINOS with thin steel**
  - **Most engineering done**
  - **All costing done**
  - **Scintillator works as expected (or better)**
- **$300 M (real cost) for 20 kT (Harris criterion)**



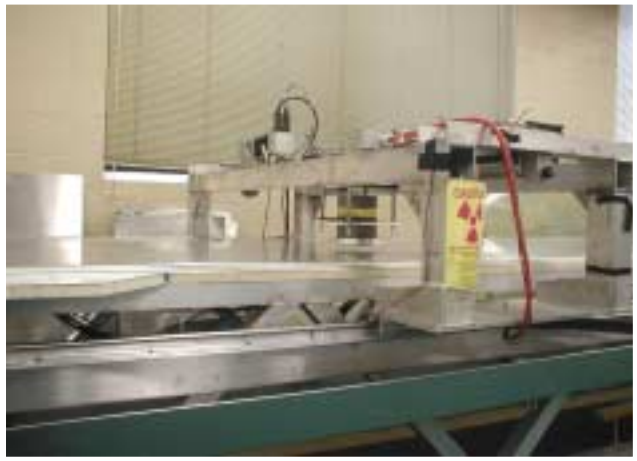
Active Detector



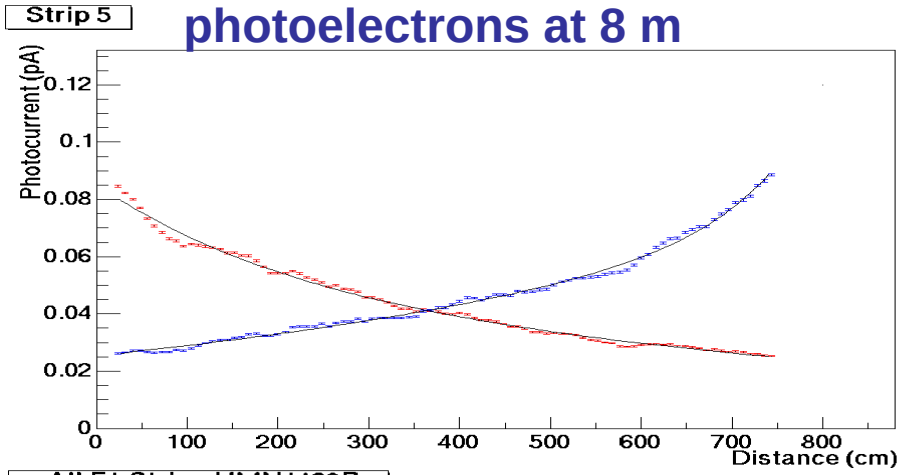
- **Scintillator strips are extruded polystyrene**
  - **Co-extruded TiO_2 reflective coating**
  - **Fiber groove**
- **Kuraray 1.2mm wavelength shifting fibers**
- **Hamamatsu multi-anode PMTs (16 channels)**
- **Viking-based front-end electronics**

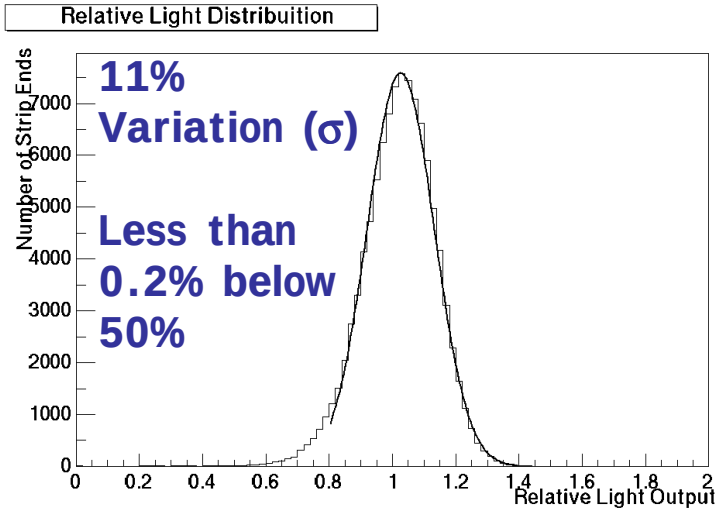


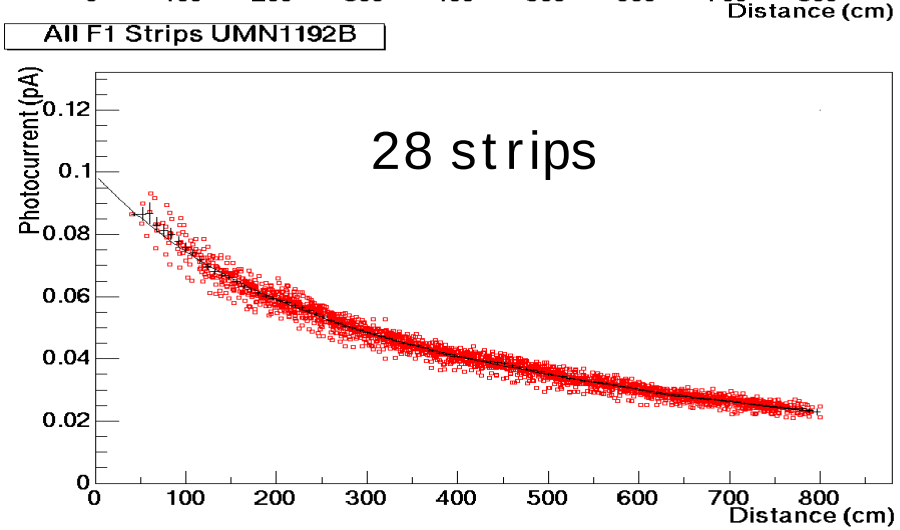
Module Mapper Results



A muon gives 2 photoelectrons at 8 m







Liquid Scintillator

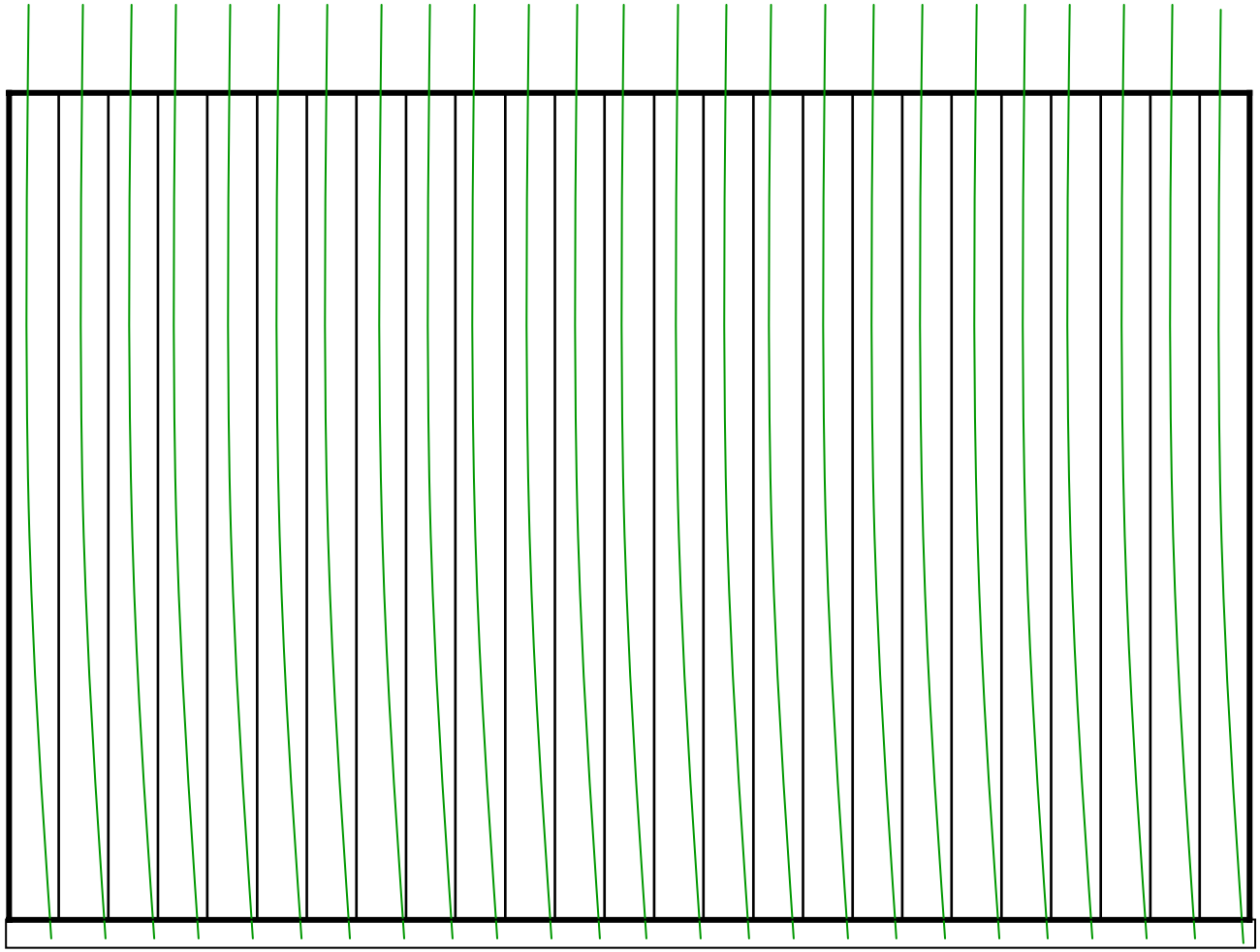
K. Heller et al

- **Old MINOS engineering study NIM A 463, 194-204 (2001)**
  - **Much engineering done**
  - **Much costing done**
- **Replace solid scintillator by liquid**
- **Replace steel by water**
- **Replace phototubes by image intensifiers**
- **Cost (Physicist $30M)**

Scintillator Elements

30 wls fibers to a manifold ($ 1.5 /m)

Extruded PVC



10 m

Engineering designs exist

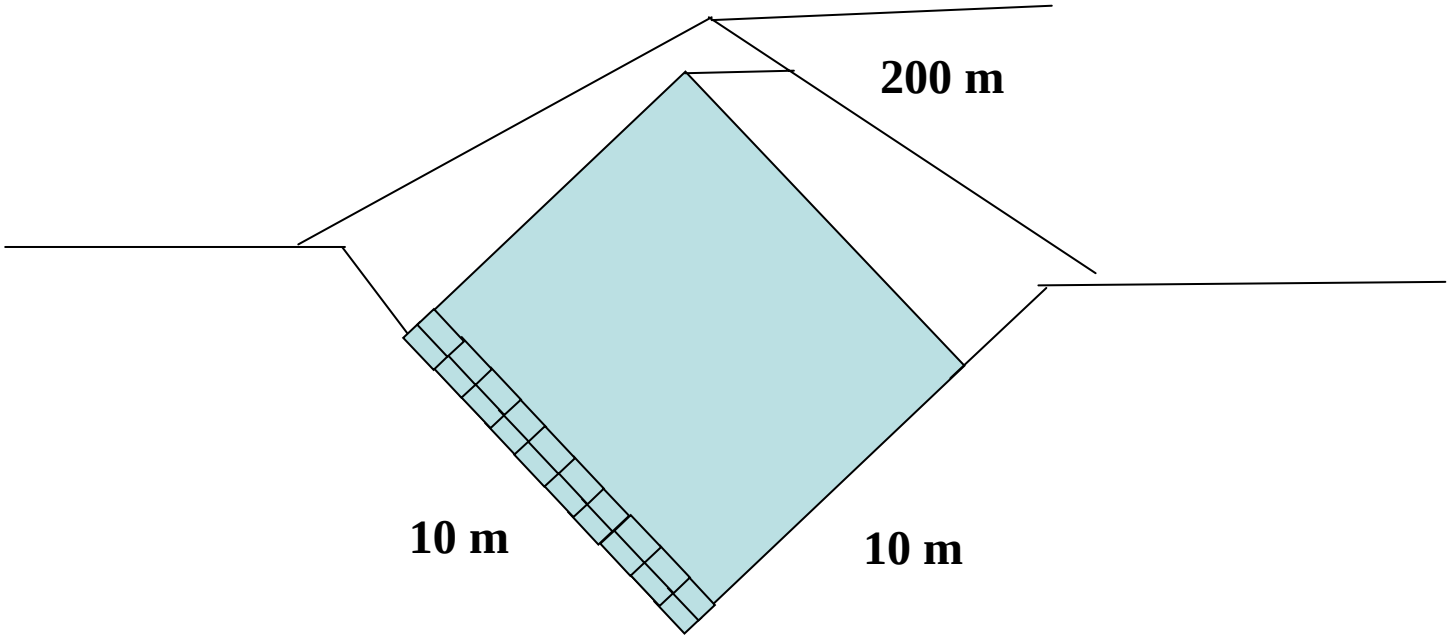
- **Extrusions**
- **Bottom seals**
- **Top manifolds**
- **Machines for fabrication**

2 Mechanical Engineering Masters Theses

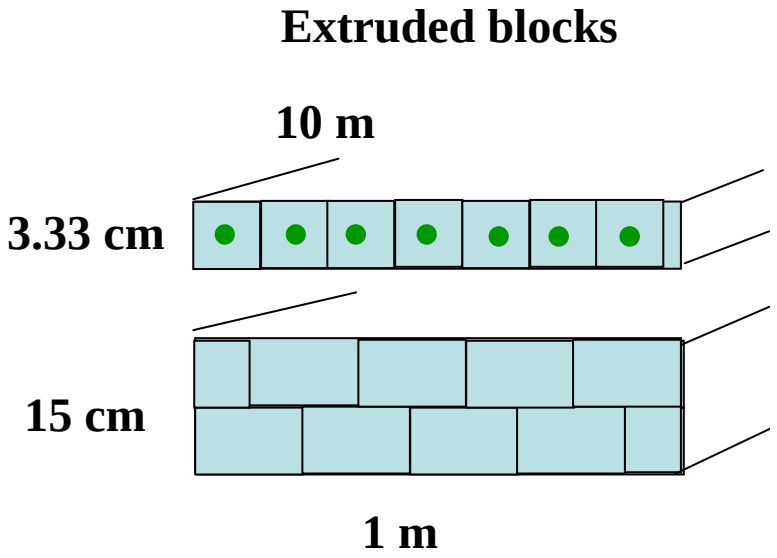
3.3 cm

1 mm fiber gives 40 photons at far end for minimum ionizing particle

Structure



- **On the surface, cut and cover**
  - **Handle Cosmic Ray rate**
  - **Can cover with fill**
- **Self supporting elements**
  - **Fill extrusions in place**



Cost Reduction of Scintillator

B. King et al

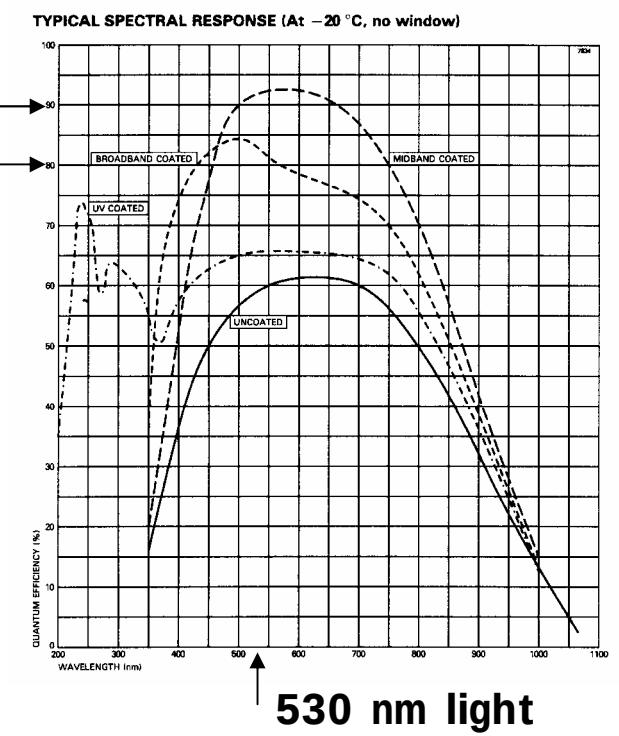
- **Solid state photonics at 90% QE**
  - **Direct CCD**
  - **VLPC**
- **Reduce fiber diameter**
- **Reduce photodectector area**

Needs study to quantify fiber diameter savings

CCDs FROM MARCONI APPLIED TECHNOLOGIES

- **CCD47-10 Backthinned**

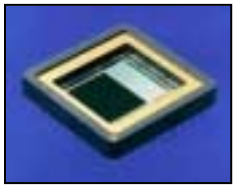
90% QE
80% QE



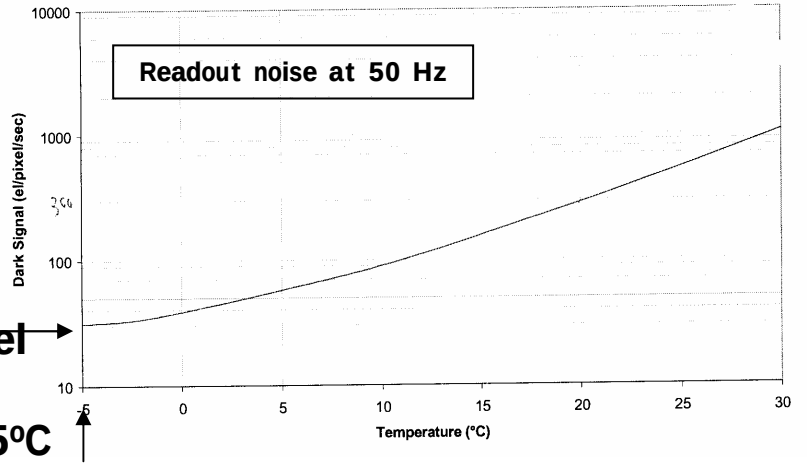
530 nm light

~90% quantum efficiency (QE) for 530 nm light

- CCD65 Series Peltier Pack



Readout noise < 1 electron/pixel



30/50 = 0.6 e-/pixel

Temperature = -5ºC

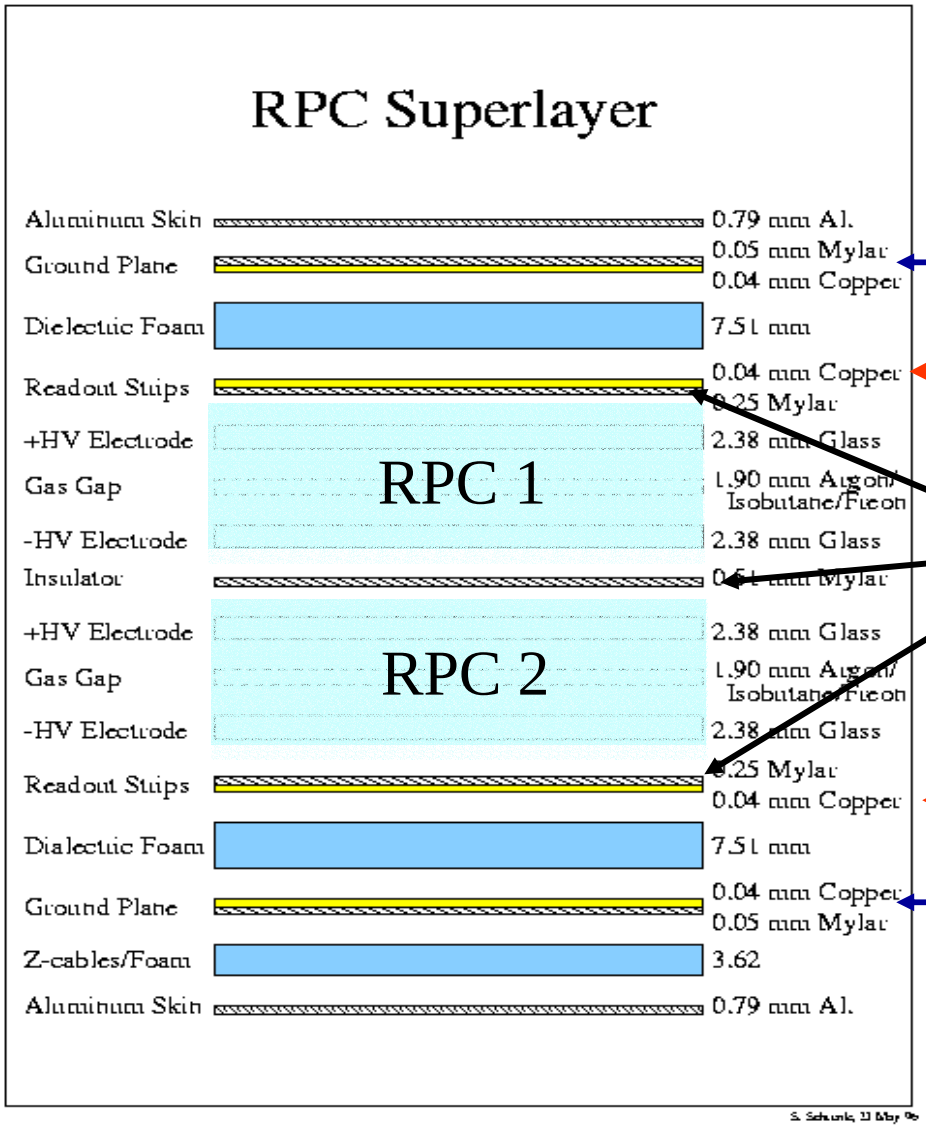
=> a backthinned version of CCD65 would be very interesting for fiber readout

Resistive Plate Chambers

A. Para et al

- Use Belle technology for RPCs
  - Much engineering done
  - Much costing done
- Need mass
  - Plastic (too expensive)
  - Corn
  - Walnut shells
  - Water
- Need structure
- Cost (Physicist $30M)

Belle Experience



Ground plane

Readout strips

Total: 8 layers Mylar (each 125μm)

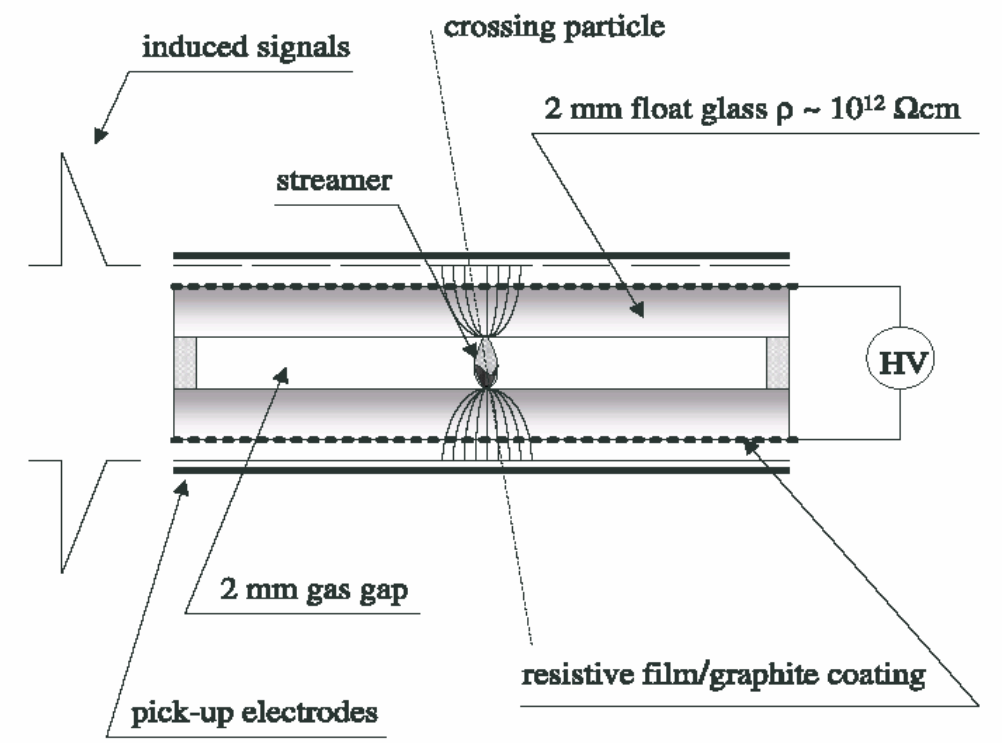
Readout strips

Ground plane

C. Hagner, D. Marlow

RPC - Principle

Glass Resitive Plate Chambers (RPC's)



Things to Consider RPCs

- Gas system – no plastic tubing (clean and dry with pressure control)
- Recirculation vs. cost of gas with one volume change per day?
- Assembly location – on site if possible. Avoids storage,shipping, and duplicate test facilities.

  (shipping cost can be significant)
- Readout system - large continuous area gives opportunity for long transmission line pickup strips and therefore fewer channels/m^2

Summary

- **Water Cerenkov needs more MC analysis to show π^0 rejection at needed level.**
- **Scintillator and RPC should use the same target mass design structure.**
  - **More MC studies to show optimum between high Z and low Z. Drift space needed?**
- **Scintillator and RPC should use the same support structure for mass.**
  - **Freestanding wedge in ground (CD rack) ?**
- **MC to show if differences between RPC and Scintillator are important**
  - **Scintillator has energy (analog) information**
  - **RPC has 2 coordinates at same position**
- **Need criteria to decide between RPC and Scintillator**
  - **Engineering costing of each system**
  - **Operating environment needs**
  - **Other criteria ??**
- **More work on cosmic ray backgrounds**
- **Get money $50 M or stage 1, half of a modular detector $30**

Conclusion

- **This is exciting**
- **We have important physics to do off axis**
- **We have the beam to do it**
- **We have detectors that can do it**
- **We need an organization to do it (independent of MINOS)**
- **JUST DO IT**