Phototube Measurements in a Dark Freezer with Discussion of PMT Workplan at the End

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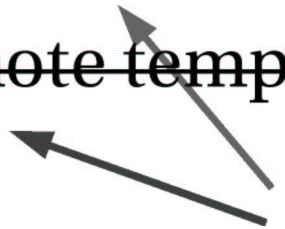
Outline

- Description of the laboratory setup
  - PMTs and motivation discussed in last talk
  - Lab data acqusition circuit
- Phase I measurements: flushing the bugs
  - Ringing in base
  - Gain and darkcount measurements OK, however.
- Phase II measurements
  - Comparison of all 15 OMs grouped according to type.
- Workplan

Laboratory Setup (Freezer)

- Baxter Scientific (actually Revco)
- -80˚C to 0˚C.
- Makes a fairly good dark environment if additional light isolation measures taken.
- Large enough to accommodate 3-5 PMTs.
- ~~Remote digital control~~
- ~~Remote temperature monitoring~~



These would be nice features, if they existed!

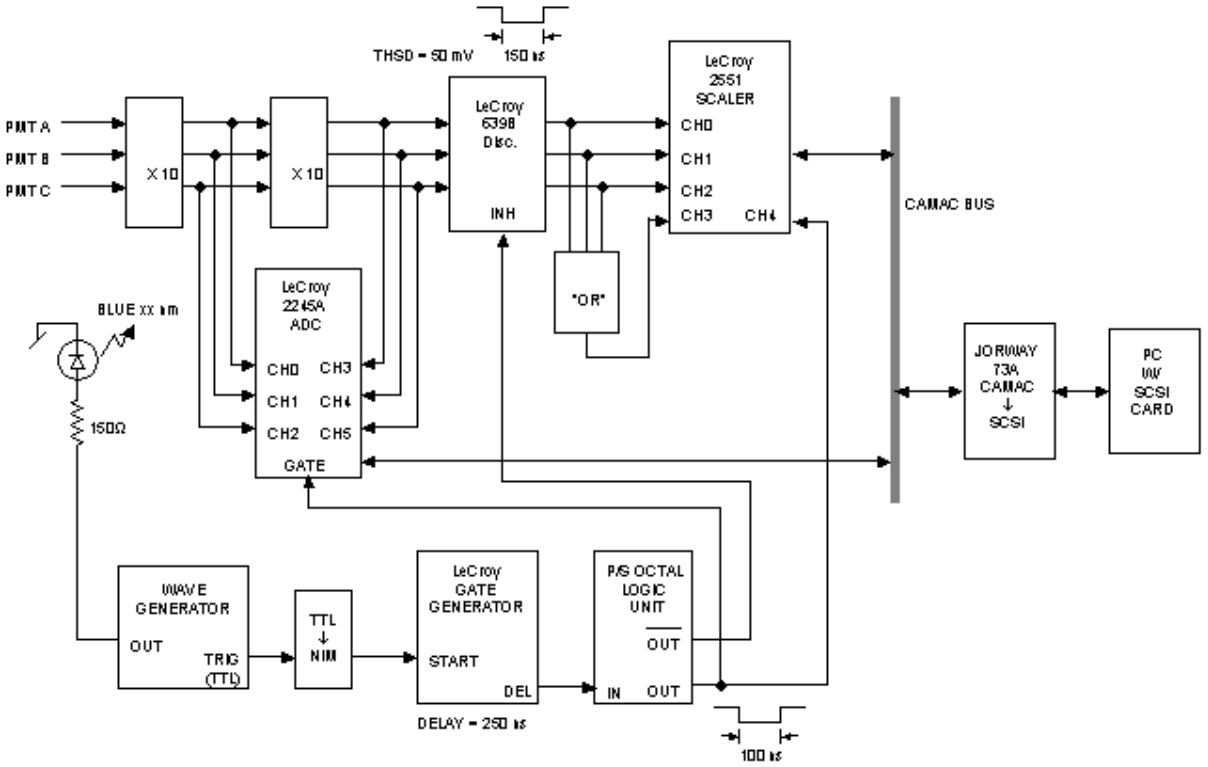
Lab Setup: Data Acquisition

- **PMT Bases**: standard HV bleeder design from Hamamatsu with addition of 50Ω terminator for long signal path. ISEG bases **not** used for testing.
- **PMT Amplifiers**: high-speed 10x amplifier, 4x fanout – revived from Mt. Holyoke airshower experiment.
- **Logic Circuits:** NIM logic circuits.

Lab Setup: DAQ (2)

- **ADC**: Lecroy 2249A charge-integrating ADC; 12-channel, 12-bit, 0.25 pC / LSB.
- **Scaler**: Lecroy 2551 scaler; 24-bit.
- **Camac Readout**: Jorway 73A crate controller, SCSI to Camac interface.
- **Software**: User-level DAQ, uses `sg.o` generic SCSI programming driver, included in all Linux kernels, and `sjy` library from FNAL.

Lab Setup: DAQ (3)



P/V GAIN DAQ SETUP
8/12/2002
K.H./N.K.

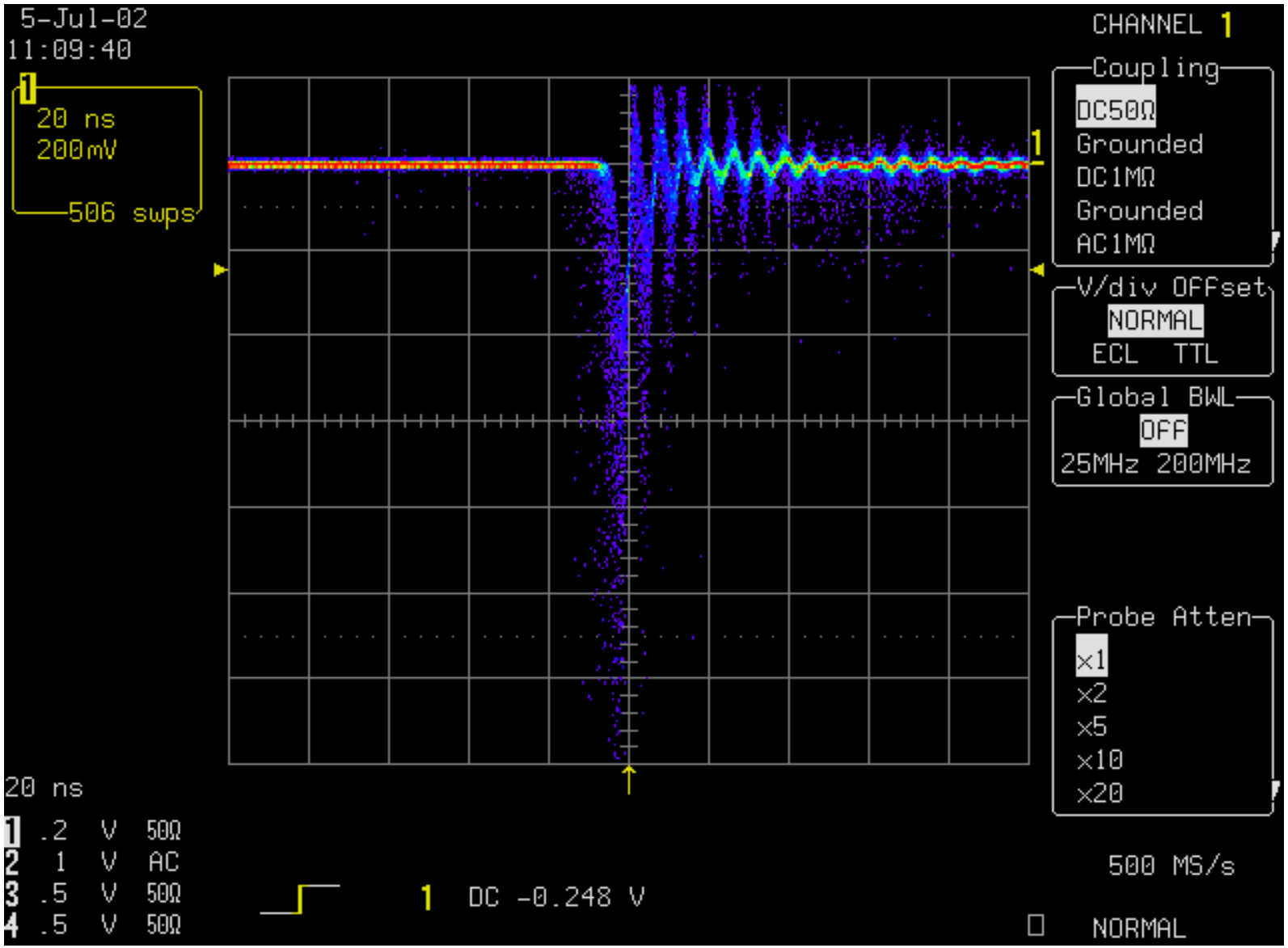
PMT tests etup1.ppt

Phase I: Measurement Plan

- Gain and P/V
  - Take ADC spectra with LED flasher at variety of HV and temperature settings.
- Darknoise
  - Take reading on scalers (triggered by discriminators) at regular intervals, also at a variety of HV and temperature settings.
- ~~Linearity~~
  - ~~Use small reference PMT located away from LED to explore PMT linearity in large signal region.~~

Phase I: The Reality of Experimental Work

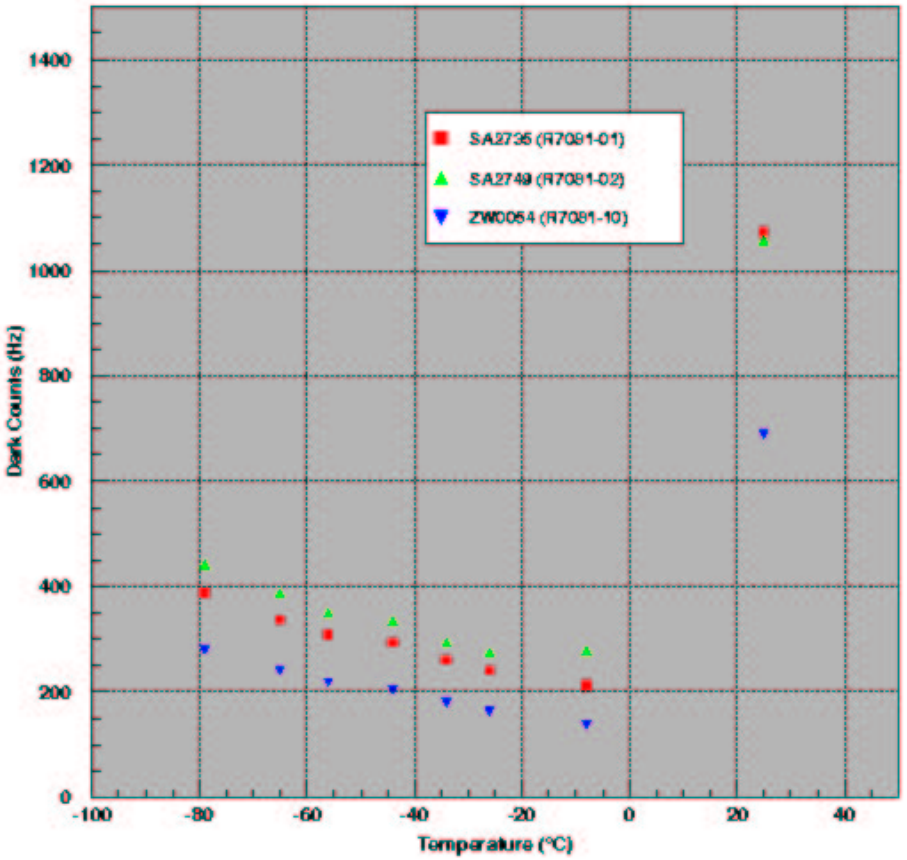
- Our efforts to get good data were slowed considerably by …
  - Mechanical failure of base components, especially at low temperatures,
  - Excessive ringing in anode signal (see next slide).
- In the end we were unable to cover many combinations of temperature and high voltage for every PMT – instead concentrating on a handful of PMTs.


5-Jul-02
11:09:40
CHANNEL 1
Coupling
DC50Ω
Grounded
DC1MΩ
Grounded
AC1MΩ
1
20 ns
200mV
506 swps
V/div OFFset
NORMAL
ECL TTL
Global BWL
OFF
25MHz 200MHz
Probe Atten
×1
×2
×5
×10
×20
20 ns
1 .2 V 50Ω
2 1 V AC
3 .5 V 50Ω
4 .5 V 50Ω
1 DC -0.248 V
500 MS/s
NORMAL

Phase I: Darknoise

For 3 PMTs looked at temperature dependence of darknoise counts. The PMTs were held at nominal voltage (gain of 1.0E+07 for R7081-01/02 and gain of 1.0E+08 for R7081-10) for darknoise counting at several temperatures over broad range.

- Counts rapidly drop from room temperature to 0˚C – this results from drop in thermionic emission.
- Counts increase gradually at ver low temperatures – this results from increase in gain of PMT as it cools.



Phase I: Darknoise(2)

- For the rest of PMTs only measurements at -35˚C.
- Investigate effect of taping the PMT
  - Simulates the environment in the ice – no T.I.R.
  - Cuts dark rates by approx. 50% for all tubes.
- With taping and setting discriminator to 1/6 pe, we easily achieve dark rate of 200-400 Hz at -35˚C.

Phase I: Conclusions

- Limited success – got some critical measurements.
- New PMT base design
  - 100Ω damping resistors in series with last few dynodes keeps anode signal ringing to acceptable levels.
  - Better fabricated bases (PSL) don't break at low temperature.
- Measurement data available on web at

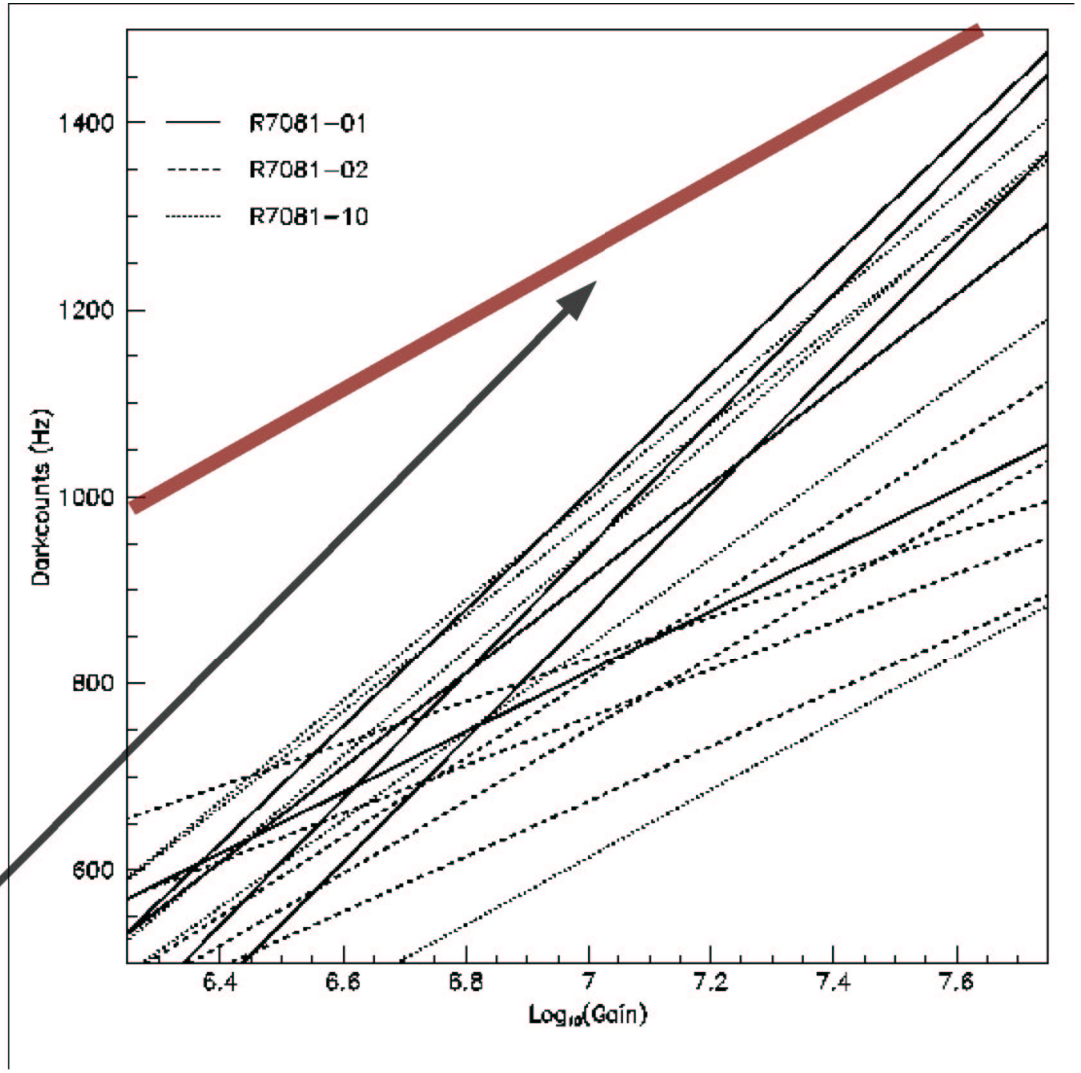
  http://amanda.physics.wisc.edu/kaeld/pmt

Phase II Measurements

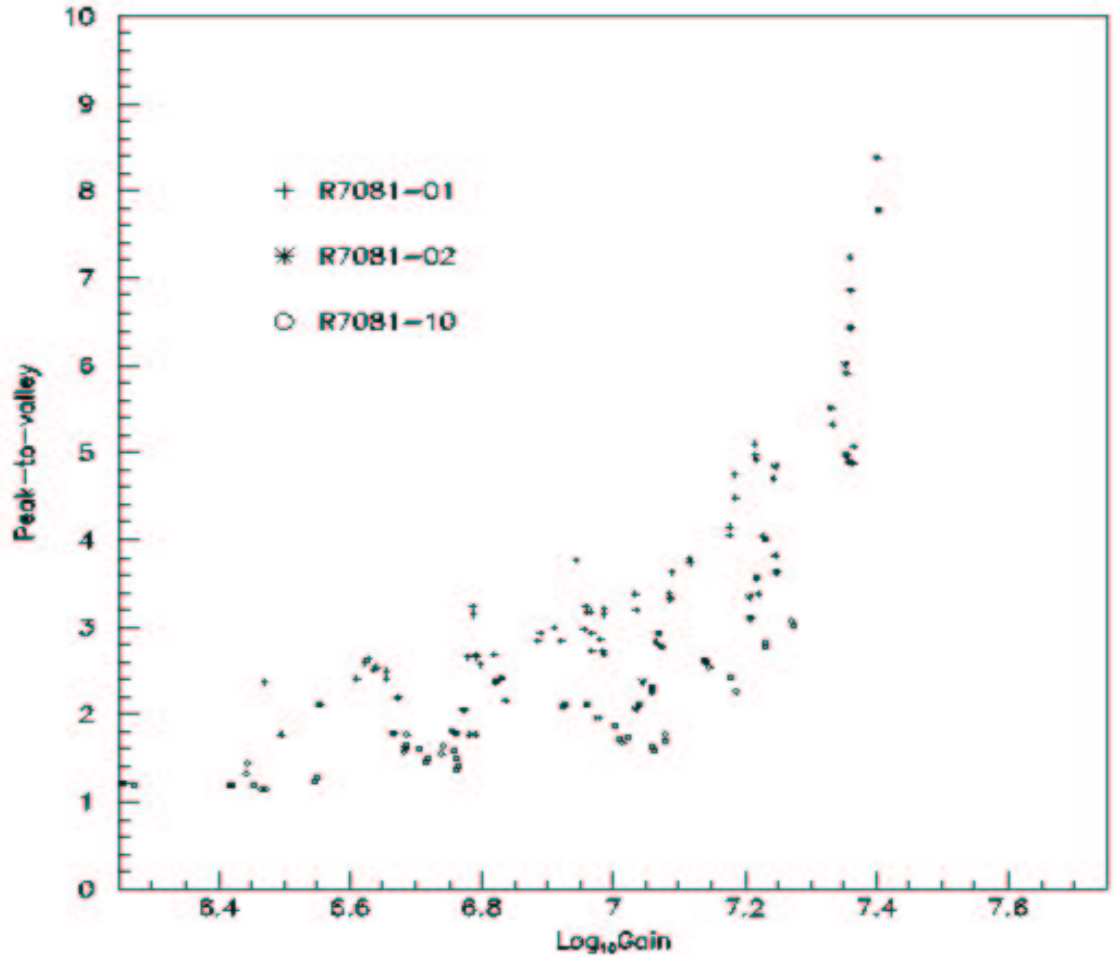
- Distinguished from Phase I in that the PMTs are all measured around 1.0E+07 gain.
  - *This required a change to the bases for the 1.0E+08 tubes so that extraction voltage was 460 V – the nominal extraction voltage for this tube type.*
- By measuring all tubes at 1.0E+07, measurements are more directly comparable.
- Goal was to parametrize the quantities vs. operating voltage – then possible to compare at arbitrary gains.

Phase II: Darknoise at -35°C

- In typ. gain region, modelled well by $D = A + B \log(G)$
- Plot family of curves at right; then possible to compare tubes at range of operating gains.
  - 12-stage tubes are the best performers
  - 10-stage 1.E7 gain tubes have worst noise, overall.
- Over measured region all tubes fall within darknoise hard limit of 500 Hz when corrected for threshold and taping.



Phase II: Peak-to-valley vs gain



- R7081-01 exhibits best PV vs. gain characteristic
- R7081-10 exhibits worst.
- Unless we operate at gains > 3.E7, R7081-10 fails to meets minimum requirement of P/V > 2.2.

Workplan

- Complete all PMT evaluation measurements by August 02
- Collect and organize measurements and produce appropriate documentation:
  - WWW archive http://amanda.physics.wisc.edu/kaeld/pmt
  - PMT measurement and selection document.
- Selection must occur by mid September to accommodate DOM production schedule, although it seems that PMT choice is limited to 10-stage R7081-01/02.
- Purchasing of N phototubes of type X from Hamamatsu; ready for assembly into (D)OM by Feb 15, 2003.

Workplan (2)

- After PMT has been selected, run additional tests
  - Linearity
  - Dynamic range studies
  - Timing characteristics
- Also, must evaluate PMT + ISEG base as a whole, although this is more a test of the ISEG base.
- These tests can occupy time period between selection and OM assembly.
- When more PMTs of selected type arrive, we can test larger sample of tube.

Workplan (3)

- OM assembly completed by mid March, 2003.
- Measure PMT characteristics with DOM as DAQ system. This crititcally depends on three external products ...
  - DOM Hub hardware
  - Test DAQ software
  - Cold darkroom at PSL
- *Must develop detailed testing plan for integrated DOM – this testing plan needed soon (Sept 2002)!*
- Allow 2.5 months for full DOM testing, calibration, and evaluation.