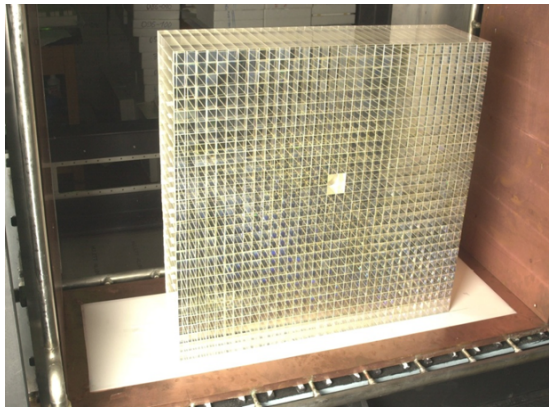
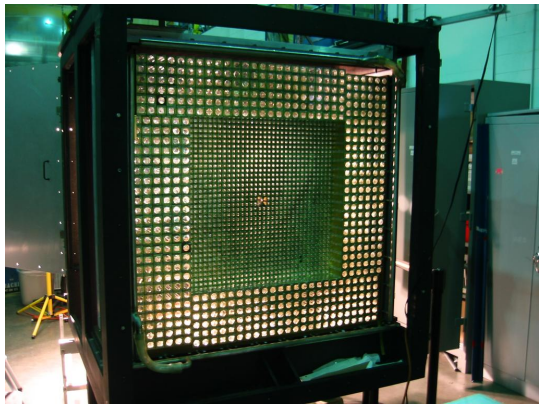
Early History of SIC and JLab collaboration

Liping Gan (UNCW)

- The PrimEx collaboration signed agreement with SIC in 2000 to purchase 1250 PWO crystals from SIC.
- The HyCal calorimeter was constructed in 2004. This is the first large scale calorimeter in the world built with SIC PWO crystals.





- Three highly rated experiments (PrimEx I&II, Prad) had been successfully performed with HyCal.

Agreement

PrimEx collaboration will perform a high rated experiment at Jefferson Laboratory (CEBAF) to measure the lifetime of the neutral pion with a precision of 1%. Such experimental accuracy requires a high resolution detection system for the pions produced at extremely forward angles. The crucial part of the experimental setup is a electromagnetic calorimeter that consists of 1250 modules of lead tungstate (PWO) crystals. This project will be carried out through the joint efforts of the PrimEx collaboration at CEBAF and the Shanghai Institute of Ceramics (SIC). Both sides have agreed to sign this contract with the following terms and conditions:

1. SIC will provide 1250 modules of Lead Tungstate (PWO) crystals to PrimEx at the cost of US$2.5/cm^3 (FOB Shanghai) under the required specifications shown in the Appendix (which are based on CMS Technical Note 98/038). SIC will also provide a copy of all measurement results for each module.

2. The first 100 PWO modules will be sent to PrimEx at CEBAF by SIC within two month after the signing of this contract. PrimEx will perform quality tests of these crystals at CEBAF. If they satisfy the PrimEx experimental requirements and the specification defined in Appendix, the remaining 1150 crystals will be shipped to CEBAF at a rate of 200 modules per month. The delivery of all 1150 crystals should be completed within 9 months from the date when SIC receives the final confirmation of the crystal quality from PrimEx. If the test results for the first 100 crystals fail to satisfy the experimental requirements, PrimEx will have the right to cancel the order of the remaining 1150 modules.

3. PrimEx is responsible for acceptance or rejection of each crystal. PrimEx and SIC agree that certification shall be made by both parties. The decision about acceptance or rejection will be made by cross-checking the measurements performed by both parties concerned. Experts from the Producer can be involved in discussion of results of both measurements.

4. PrimEx will have the right to return any crystal to SIC that does not satisfy the specified requirements. SIC will be responsible for replacing them with good quality PWO crystals.

5. SIC will pay for the shipment and insurance costs in Shanghai on behalf of PrimEx. After receiving each shipment of PWO and the invoice from SIC, PrimEx will pay SIC the cost of the crystals (including shipment and insurance) in US dollars within 2 weeks through direct bank transfer.

6. In phase II of the experiment, provided PrimEx receives more funds to upgrade the detector, this contract will be extended automatically to include the purchase of an additional 5000 modules of PWO crystals from SIC under the same terms and conditions as stated here.

7. PrimEx will appoint Dr. Jingtang He as its representative in China.

Signatures:

Dr. A. Gasparian	Dr. D. Yan
contact person for PrimEx collaboration	Spokesperson for SIC
Date	Date

Appendix

Specifications for Lead Tungstate Crystal Production

The following are the domains for the specification, defining the acceptance tests and procedures:

- check of visual properties;
- geometry control;
- optical properties;
- radiation tolerance.

1. Visual Properties

Some parameters of the crystal quality such as possible coloring, cracks or any sort can easily be seen by eyes and a check list will allow to immediately reject crystals presenting such obvious defects. The list of the visual properties includes:

. Presence of the manufacturer number on the front face of the crystal;
. No visible cracks, chips or scratches, missing material, surface flaws;
. No visible veil or core defect;
. Transparent and colorless;
. All faces polished.

2. Geometry

Each crystal module will have simple rectangular shape with the sizes 20.5x20.5x180. mm^3 (see fig. 1)

Planarity:
Planarity for all faces should be kept within 0.020 mm for all faces.

Angular tolerances:
All angular tolerances should be kept within 0.050 mm across a length of 25 mm, except for the back face, which is specified below.

Perpendicularity:
On the back face (opposite to the front face where the manufacturer number is labeled) we will attach a PMT with the length of 80 mm. Therefore we have a special requirement for this face. The Perpendicularity for this face should be kept within 0.2 mm across the length of the crystal 180 mm.

Chamfers:
Chamfers should be made on all 12 edges, with the cut to the following limit: 0.3-0.7mm x 45^0. The surface finish of chamfers can be left at a Roughness of 0.5 μm (lapping)

Surface Finish:
Surface finish for all faces should be "Polished Finish" with the Roughness Ra $\leq 0.020\,\mu$m. It should be done on a polishing machine equipped with a special polishing cloth and using diamond abrasive of grain 3 μm in emulsion. From the surface finish provided by the previous operation (lapping), about 10 minutes are necessary to reach the required surface finish.

3. Optical Properties

. Longitudinal transmission (absolute values)

≥ 10 % at 360 nm;

≥ 55 %at 420 nm;

≥ 65 % at 620 nm

. Transversal transmission

At a transmission of 50%, $\delta\lambda \leq$ 6nm for a 5 measurements every 3 cm, starting at 1.5 cm from front face.

. Scintillation Light

Light Yield ≥ 9.5 photoelectrons/MeV, measured at 18 ^{o}C and in a 100 ns gate, with ^{60}Co source at 3 cm from PWO front face, with a Phillips XP2262B photomultiplier covering all rear face, with a n = 1.5 silicon coupling grease, wrapped on 4 sides and face in 1 layer of Tyvek.

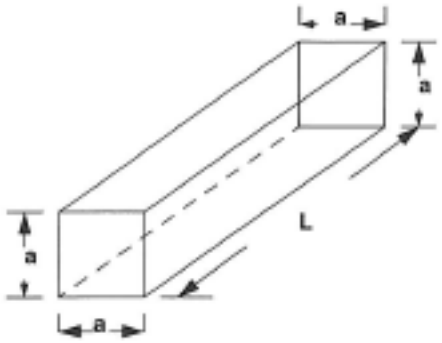


Fig. 1

	[mm]	tolerance [mm]
a	20.5	+0.0 - 0.1
L	180.	+0.3 -0.0

Table 1

Tolerances:

. All transversal dimensions should be within +0.0 mm, - 0.1 mm except for the length of the crystals;

. the longitudinal dimensions should be within +0.3 mm, -0.0mm(see table 1)

. Decay Time
LY(100 ns)/LY(1μs) >90%
Afterglow ≤ 0.5 % of peak amplitude with a ^{60}Co counting rate of 1 MHz.

4. Radiation Hardness

. Induced absorption for full crystal saturation:
$\mu \leq 1.5$ m^{-1} at 420 nm for lateral ^{60}Co irradiation, >3 krad, rate of 5-15 krad/h at 18 °C.
. Light yield loss < 6% for front ^{60}Co irradiation, 200 rad, 15 rad/h
. No recovery time constant shorter than 1 hour.