

# LGC update

### **Michael Paolone**

## **January 2019 SoLID meeting**

- Timeline:
  - Late 2012
    - First quote from CMA:



Cost Proposal **CFRP** Spherical Mirrors for Jefferson Labs

Cost Proposal #: Date: Valid Until:

M-01611-12 19 November 2012 19 January 2012

To: Michael Paolone Assistant Research Professor Temple University Phone: (215)-204-7240 Email: mpaolone@jlab.org

#### Reference Documents

Mirror\_specs.PNG 1.

ITEM I Description: **CFRP Spherical Mirrors** CMA Proposes to produce a CFRP Spherical mirrors as shown in Reference Document 1. The mirrors will be produced as a rigid, internal core-reinforced, sandwich composite structure. The mirrors will be produced with rigidity to maintain the same optical surface requirements as those produced for the LHCb RICH 1 mirror detector. The areal density will be less than or equal to 6kg/m<sup>2</sup> with no magnetic metal components.

No coatings will be applied to the mirrors

Proposed are the following:



## **Adventures in Mirror Quotes**

Cost Proposal CMA Document 10040 Rev. 05-07



Cost Proposal CMA Document 10040 Rev. 05-07 2

ITEM 1 Description Notes:		N/A.	
Deliverables	:		
Mirror 1.	Qty. Thirty-two (32) CFRP mirrors, no coating		
Mirror 2.	Qty. Thirty-two	(32) CFRP mirrors, no coating	
Total Cost:		\$347,977	
Shipping an	d Handling:	Included, FOB Destination (Continental US only)	
Delivery Sch	edule:	6-7 months from order	
Terms:	1	40% down with Order Net 30 days from Delivery (see <i>Additional Terms and</i> <i>Conditions</i> )	

Mirror 1: Qty: 32, Area ≈ 0.27m2, mirror weight est: 1.4kg

**Mirror 2:** Qty. 32, Area ≈ 0.38m2, mirror weight est: 1.9kg

> ~21m<sup>2</sup> ~35kg

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040 5-07



- Timeline:
  - Late 2012
    - First quote from CMA:
  - Early 2015
    - New quote requested.

Hi Michael,

Sorry I have been short handed to get the revised quote to you but we have been assessing the materials and mandrel costs for adjusting the quote.

The best estimate for the mirrors is now just over \$500K for the spherical mirrors. The primary reason is the materials have jumped in price to over 35% in the last 3 years and the mandrel costs have gone up nearly 2X from what we estimated previously. Please let us know if you still need to submit a formal requote in light of this news. Thanks Michael.

Best regards,

Bob

Robert C. Romeo, President Composite Mirror Applications, Inc. 1638 S. Research Loop, #100 Tucson, Arizona 85710 Tel: (520) 733-9302 X 106 Fax: (520) 733-9306 Cell: (520) 907-1044 www.compositemirrors.com

An ISO 9001 Registered Company

## **Adventures in Mirror Quotes**



~\$500k expected (mandrel costs)



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Mirror 2: Qty. weight est: 1.9 Total Area: ~2 Total Mirror W	32, Area kg 1m2 eight: ~3	≈ 0.38m2 5kg	2, mirror
<b>Deliverables:</b> [1] [2]	Mirror Mirror	1. Qty. Tl 2. Qty. Tl	hirty-two (32) hirty-two (32)
		С	MA Proprietary

## **Adventures in Mirror Quotes**

Cost Proposal RT007 CMA Document 10040 Rev. 05-07

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Composite Mirror Applications Cost Proposal RT007 CMA Document 10040 Rev. 05-07 2

**Total Cost:** 

\$446,200

Shipping and Handling:

Included, FOB Destination (Continental US only)

6-7 months from order

Delivery Schedule:

Terms:

40% down with Order Net 30 days from Delivery (see Additional Terms and Conditions)

#### ADDITIONAL TERMS AND CONDITIONS

- 1. Prices are in U.S. Dollars unless otherwise stated.
- 2. A written Purchase Order (P.O.) sent by fax, e-mail or mail is required.
- 3. Manufacturing of order does not begin until prepayment is received (unless prepayment condition is waived). Delivery time begins when prepayment for order is received but may vary subject to the availability of parts from vendors and their delivery schedule.
- 4. Complex orders involving custom development and systems integration may require a technical review with customer feedback before manufacturing. Please note that such orders do not begin until after the technical review is performed and all necessary customer authorization is obtained.
- 5. CMA shall retain ownership of all tooling and equipment used to produce CFRP products under this proposal.
- 6. Quoted prices valid for 60 days unless otherwise specified.
- 7. Penalty of 1% per month on overdue payments.
- 8. Cancellation of order may result in a financial liability charged to the customer for work performed up to the date of cancellation.

Contact: Robert C. Romeo President RobertRomeo@compositemirrors.com (520) 733-9302 Ph, Ext. 106 (520) 733-9306 Fax

> Composite Mirror Applications, Inc. 1638 S. Research Loop, Suite 100 Tucson, Arizona 85710 www.compositemirrors.com

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Cost Proposal RT007

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Composite

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  - Middle 2018
    - Update requested.

On 8/7/2018 1:54 PM, Robert Romeo wrote:

Hi Zhiwen,

Sorry, a bit tough to quote for 4-5 years out. The ROM cost is \$3,075K of which \$450K is the mandrels. The metric including NRE is \$75K/m2, which is consistent with our other program costs. We will supply a formal quote as we get closer to a contract.

Thanks Zhiwen.

-Bob-

Robert C. Romeo, President

/Composite Mirror Applications, Inc./

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# **Adventures in Mirror Quotes**

#### **\$3M** for both LGC and HGC



# **Adventures in Mirror Quotes**

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  - Early 2015
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    - Official Quote received
  - Middle 2018
    - Update requested.
    - Request for clarification on price increase.

Hi Michael,

We charge a baseline dollar amount per square meter. The aspect ratios also drive cost somewhat but the area required was the reason for the discrepancy.

-Bob-

Robert C. Romeo Composite Mirror Applications

When we quoted early on in the process, there was confusion as to the amount of surface area of the mirror requirement; how much total area in square meters.





- Producer of SiC composite mirror products.
  - Can do 20-25 kg/m2 areal density.  $\bullet$
  - Coating and polishing step are performed simultaneously. ۲
  - Expected costs > \$2M (email communication)  $\bullet$



- Producer of many types of mirrors (SiC, Be, Al, metal-composite)
  - Expects costs > \$1M.  $\bullet$
  - Eventually responded with "NO BID"

# **Alternative Mirror Vendors**

## A SIC OPTICS



- Producer of SiC composite mirror products.  $\bullet$ 
  - Primary contact promised quotes, then never answered repeated emails and calls.



- Producer of many types of mirrors (SiC, metal-composite, foam- ${\color{black}\bullet}$ composite)
  - Never returned emails or calls.



# **Additional Contacts**

- LHCb RICH
  - Sajan Easo and Marco Adinolfi -- <u>sajan.Easo@cern.ch</u> <u>marco.Adinolfi@cern.ch</u>
  - had one alternative company the were in contact with initially; a Beryllium mirror supplier in Kazakhstan. Sajan said his experience dealing with them was "not positive".
- Media Lario
  - Glass flat mirror vendor for CLAS RICH.
  - Working on new tech for small radiation length spherical mirrors, but ROC must be quite large.
- CLAS HTCC
  - Foam mirror manufacture.
  - detector, and are gathering sources.
- ECI
  - Makes lexan/polycarbide coated sheets (flexible).
  - reflectivity.

• Told me they are continuing to use CMA and they have never experienced jumps in the price. They

• I don't have too much information on costs/complexity. They are beginning to write a NIM on the

• Used by LTCC for refurbishing CLAS Cherenkov mirrors. Adaptable, and good value for decent

# **Mirror Construction**

- Fiberglass mirror fabrication:
  - Zhiwen and I talked a few times with Franco Garibaldi, who made the new Hall-A Cherenkov mirrors.

  - Start up and material costs are reasonable (< \$100k)</li> Procedure is straight-forward, but would take some time to perfect.
  - Main investment would be manpower and time.
- 3D printing of blanks?
  - Larger sizes are problematic (but can be divided into smaller jobs)
  - Radiation hardness of materials needs to be examined.
  - Print warping/uniformity also needs to be considered.
  - Roughness is an issue.
    - Polishing individual blanks would be price prohibitive (if possible).

# **Cost effective solution:** Flat mirror arrays

- Replacing spherical mirrors with arrays of flat mirrors:
  - Advantage: Vendor options increase and costs are reduced.
  - Disadvantage: Engineering complexity increases.

  - Disadvantage: Many more mirrors to calibrate. Optical focusing becomes coarser.  $\bullet$

• Advantage: Individual mirrors can be fine-tuned adjusted to help with optical detection efficiency.

## **Comparing Primary-Mirror Flat-Mirror Arrays**

#### **Spherical**

### Single Flat







3x3

3x5



5x5



#### **Original spherical arrangement,** SIDIS config.



### **Single Flat Mirror** SIDIS config.



### **3x3 Flat Mirror** SIDIS config.



### **3x5 Flat Mirror** SIDIS config.



### **5x5 Flat Mirror** SIDIS config.



# **Engineering complexity/questions**

- Simulated mirror arrays are fixed in place with zero gap between mirrors.
  - Constructed arrays could be all fixed in place (like simulation), or given freedom to be fine-adjusted.
  - If adjustable, how?
    - Slight gap between mirrors to allow space for rotation?
      - More loss of efficiency with increase number of mirrors.
    - Try to stagger mirrors to allow rotation without gaps?
      - Thickness of mirrors important with respect to shadowing.





# Costs for LGC?

- If we fabricate the blanks ourselves, then we can use ECI strips to cover blanks.
  - From previous ECI quotes, we have an estimate of costs:
    - 9" x 36" on 0.01" lexan/polycarbonate:  $\sim$  \$200 each (150+ quantity)
    - 10" x 36" on 0.05" lexan/polycarbonate:  $\sim$  \$350 each (150+ quantity)
  - For flat mirror segments, largest pieces will be  $\sim 5^{\circ}$  x 10° for 3x5 config.
  - If we cut from previous quoted sheets, we can fit 3-4 per sheet for 3x5 config
    - - 720/3 x \$200 = \$48k
      - 720/3 x \$350 = \$84k
- For pre-cut finished flat mirrors:
  - Estimate from elliptical-cut bazooka prototype mirror:
    - If avg cost per mirror is \$400, then:
    - $720 \times $400 = $288k$

• For 3x5 primary mirror (3x3 second mirror) we have 24 mirrors x 30 sectors = 720 mirrors

# **Thoughts on Constructing Flat Blanks**

- Using ECI strips, the "smoothness" of the blank MAY be less important: Need to test reflectivity vs blank smoothness.
  - Could also use prototype Cherenkov for this.
  - 3D printing becomes more viable.
  - Also, ECI strips are stiff enough that a "kite-frame" for each blank may be possible:
    - Also reduce radiation length.
      - Note: Additional frame support for flat mirror array will likely increase total rad-length.
    - Less "glue" so good adhesion over time would need to be verified.





# **Other Updates**

- The Small prototype Cherenkov is in Hall-C and has taken data in the winter.
  - Effort has been spearheaded by Sylvester (with Lab assistance by Mark Jones).
  - Trigger setup is not ideal.
    - Scintillators are saturated, so calorimeter + Cherenkov form coincidence trigger.
  - No timing information in current DAQ.
- Will improve DAQ soon.
- Will extend testing to McpPMTs / LAPPDs.



# Cable feed-through space

• Currently, the different subsystems plan on feeding cables through the open cherenkov space.