



U.S. MAGNET  
DEVELOPMENT  
PROGRAM

# REBCO technology – LBNL update

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MDP general meeting, 6 July 2022

# What's new since the March CM?



Moving forward, we plan to work on two things that are essential for MDP/REBCO component

- Make C3 – the priority
- Evaluate STAR<sup>®</sup> wires

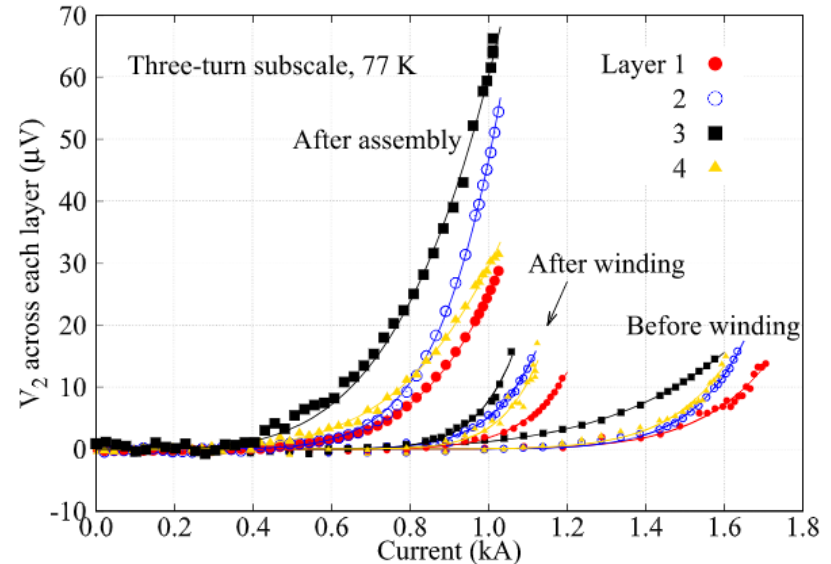
## C3 conductor order is still not out of the woods, but hopefully soon

- As of 6/2022, ACT has 50% of tapes required for the C3 order
  - Accepted some tapes with compromised bending performance. The hope is to use them on the wire outer layers
  - Plan to accept another earlier batch corresponding to 25% of the order
  - The  $I_c$  measurement at ASC/FSU continues to provide critical and timely feedback on tape quality
- ACT will verify if we can use tapes with compromised bending performance in July / August
- Meanwhile, the vendor is running out of \_\_\_\_\_ to continue producing tapes for the C3 order because of the relatively low yield
- ACT plans to deliver the C3 conductor by 12/2022

**Growing pains towards more mature REBCO vendor and technology  
Excellent opportunity for competition and evolution**

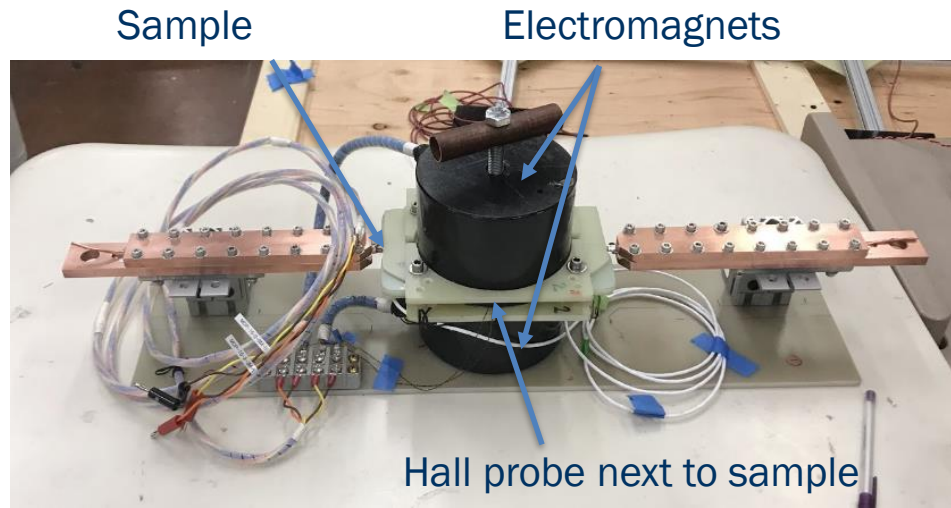
## We are ready to start making the 3-turn c3

- We completed the last item on the preparation list
  - A setup to measure the conductor  $I_c(B)$  at 77 K
- The new setup can allow us to learn more from the 77 K tests

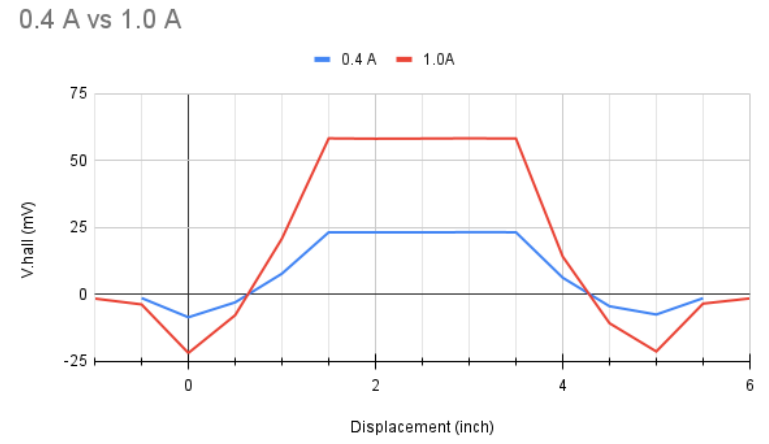


How much  $I_c$  reduction is due to magnetic field?  
What's the expected magnet performance at 77 K?

# First implementation: a split-pair electromagnet to provide up to 0.5 T at 77 K



Profile of the field transverse to the pole surface

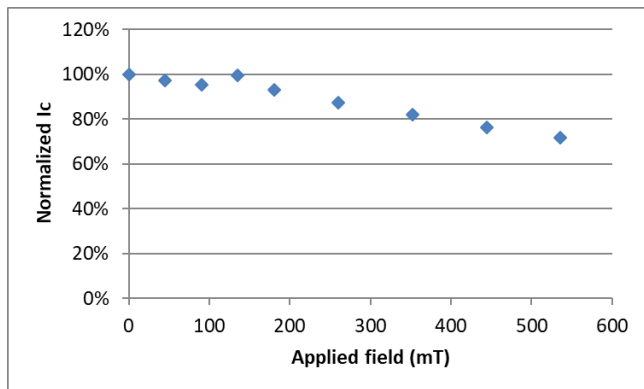


\$700 two magnets, [http://www.magnetechcorp.com/flux\\_generators.html](http://www.magnetechcorp.com/flux_generators.html)

Thanks to J. Weiss at ACT for sharing the information and experience

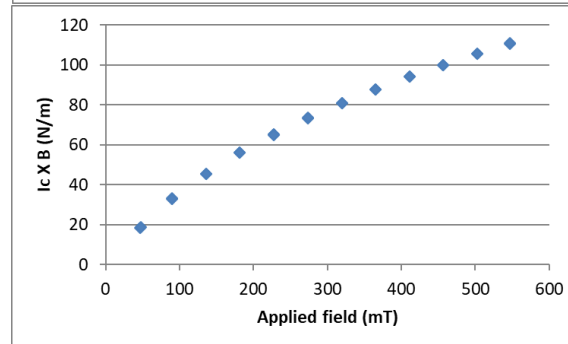
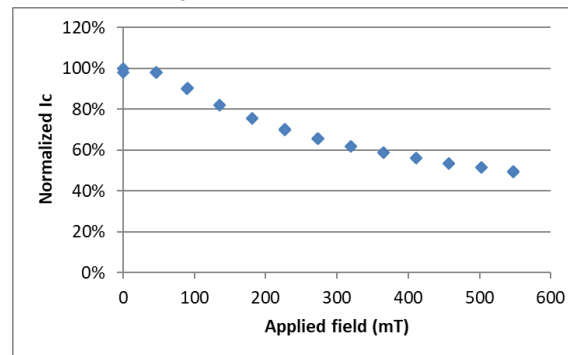
# First victims show non-negligible $I_c$ reduction at modest field at 77 K

A CORC® sample 10%  $I_c$  reduction at 200 mT



- First look seems consistent with [the behavior of single tape](#)
- Not necessarily trivial to measure: force, “77 K”
- Will use it to characterize the 3-turn c3 wires

A STAR® 6/1 sample  
30%  $I_c$  reduction at 200 mT





## In collaboration with the vendor, we take a two-pronged approach

- Use a stack of STAR<sup>®</sup> wires, aka a ribbon cable
  - Preserve the minimum bend radius of single wires
  - No transposition
- Use a 6-around-1 cable
  - Full transposition
  - TBD: cabling degradation and bending performance
- Paolo asked for a Rutherford cable of STAR<sup>®</sup> wires
- In all cases
  - STAR<sup>®</sup> wires electrically in parallel → increase total current; reduce magnet inductance
  - A STAR<sup>®</sup> cable will have a lower  $J_e$  than a single wire but better current sharing among wires



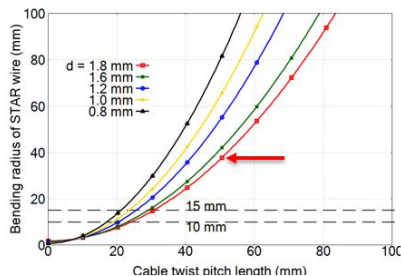
## Prong 1: First STAR® order is being procured

- **Point 1: To make a 2-layer dipole magnet, understand its performance and provide feedback on conductor development**
- **Point 2: To see if another conductor option can be established**
- **The 48-m order, one of the two parts, is being processed by the lab procurement team**
  - **Negotiation between the lab and vendor on payment terms, deliverables and etc**
  - **A second part is following**
- **Grateful for the support and leadership from CPRD, MDP, and DOE**

# We started bending the 6/1 STAR<sup>®</sup> cable samples

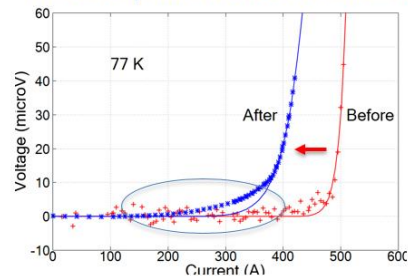
## Prong 2: leveraging SBIR to investigate the feasibility of 6-around-1 STAR<sup>®</sup> cable for high-field dipole magnets

Analytically, it should be doable



The first test cable made by H. Higley including a single 1.8 mm diameter STAR<sup>®</sup> wire and five Cu wires. 50 mm twist pitch

First data point shows 20% reduction

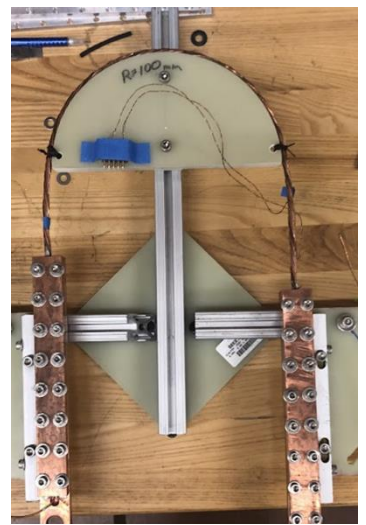


- Early voltage rise is likely associated with current sharing between STAR<sup>®</sup> and Cu wires; severe degradation?
- Next steps
  - Repeat with another sample
  - Test the bending performance

AMPeers

# Set up to bend and test the sample

Bending fixture developed by H. Higley

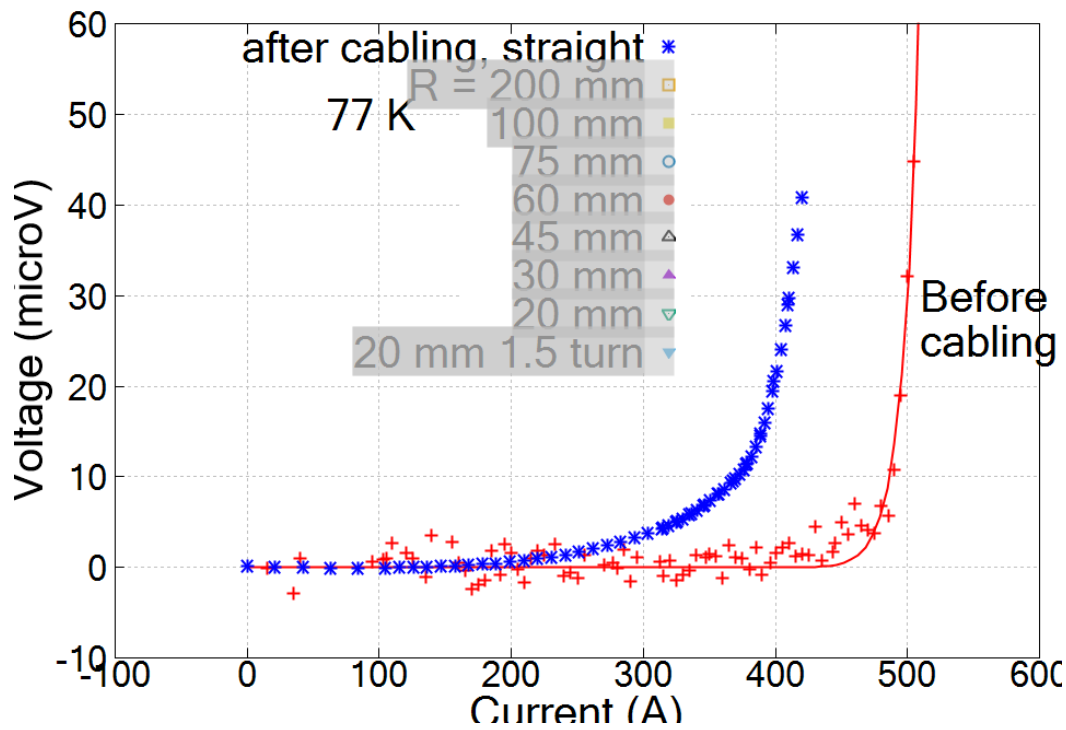


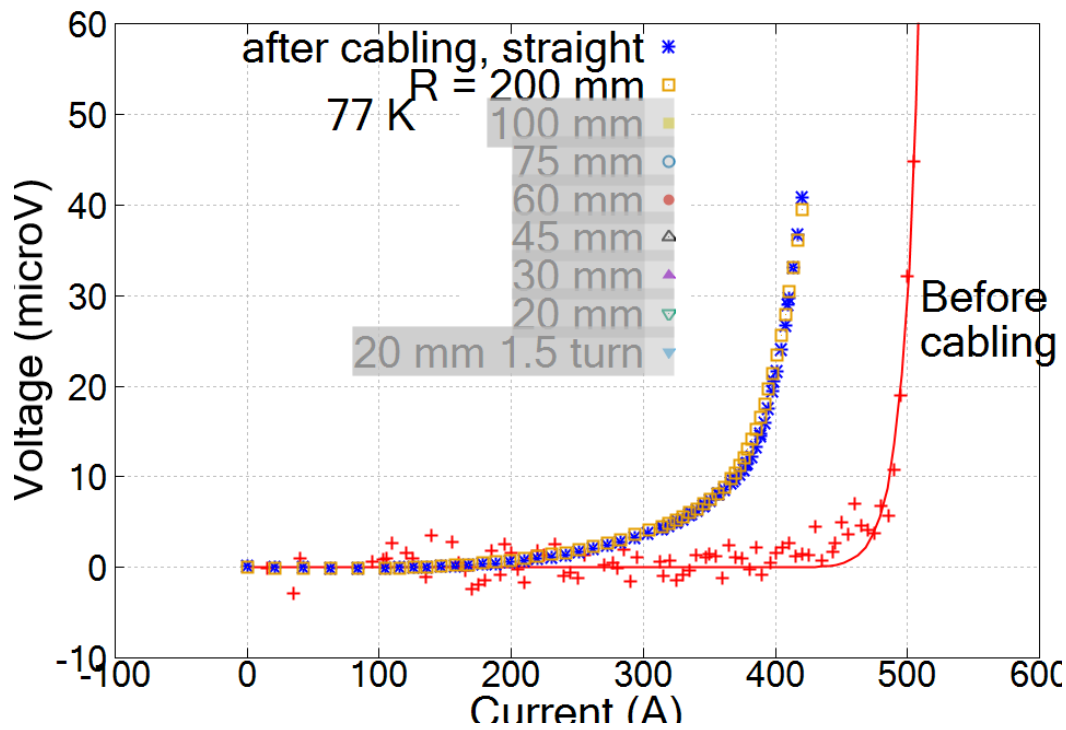
Master at work

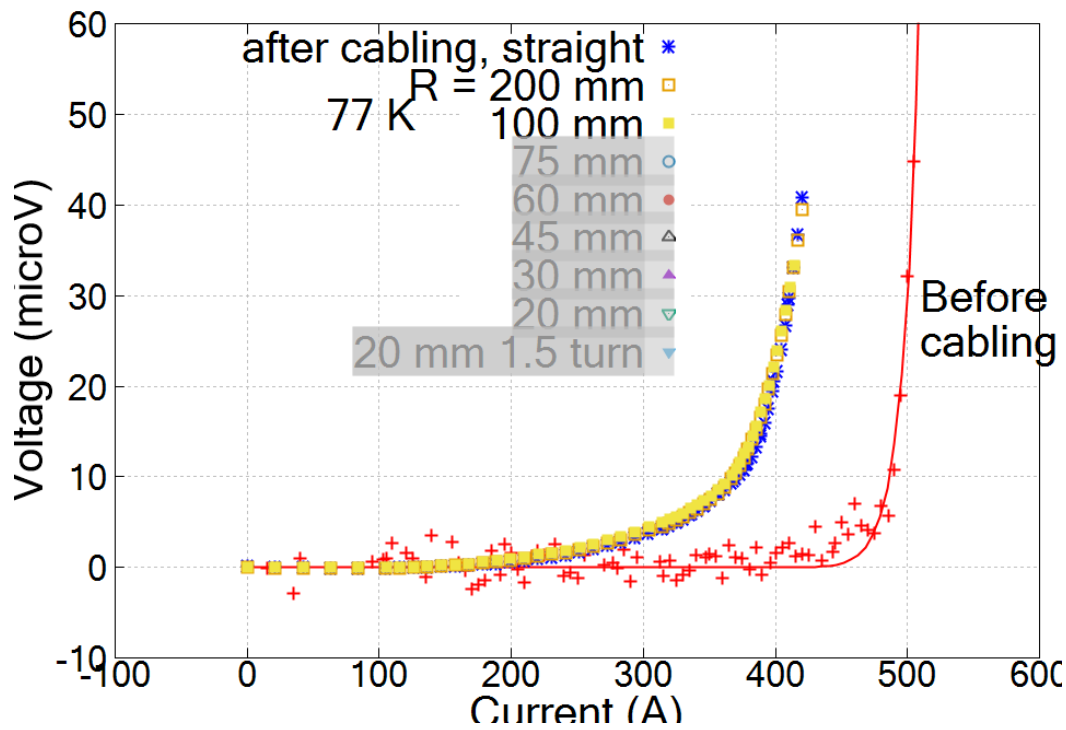


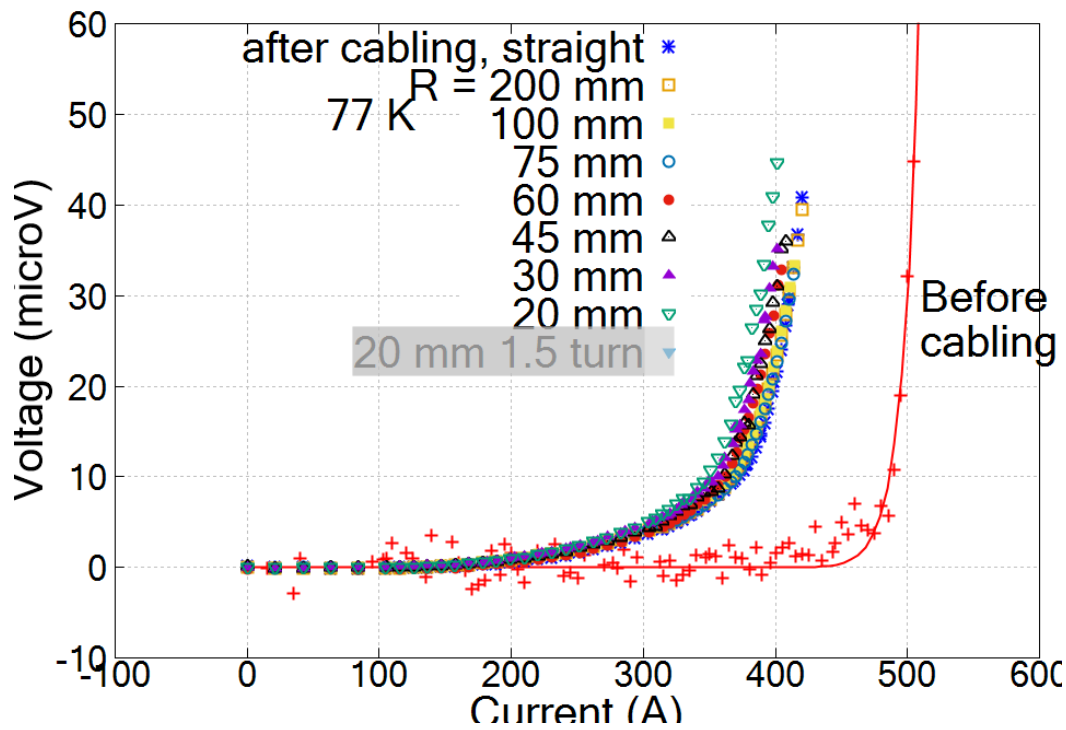
The shipping-crate converted bathtub



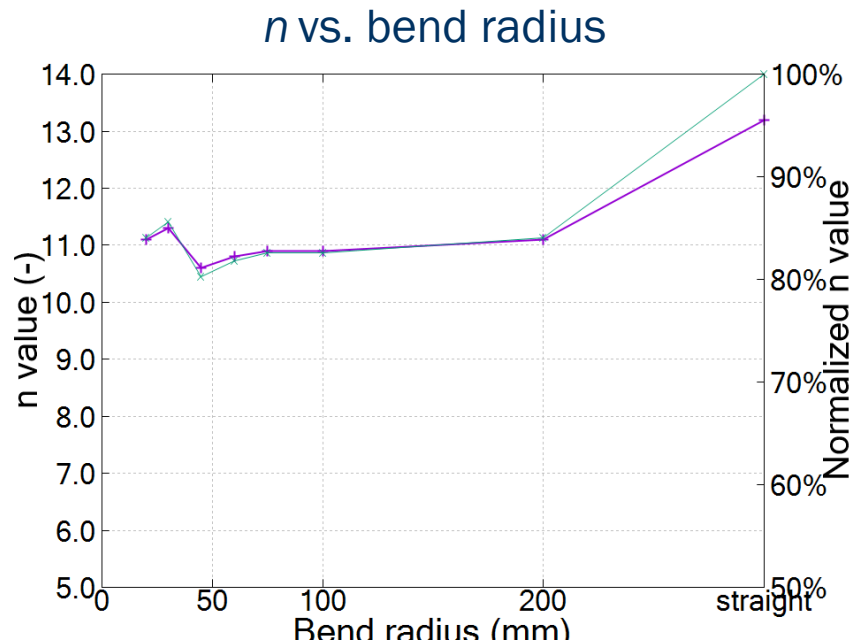
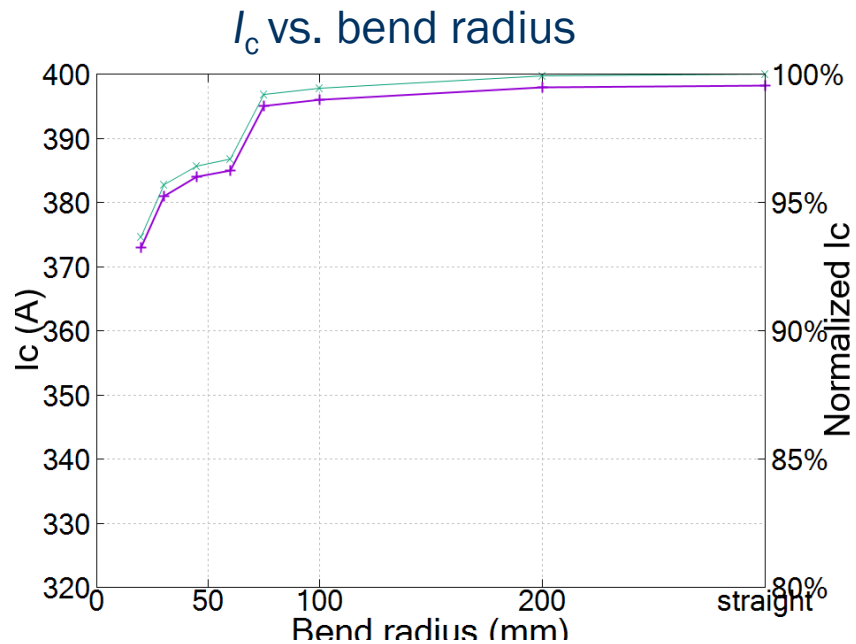






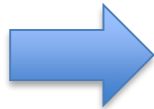


At 20 mm bend radius, we have 6.5% reduction in  $I_c$  and 15% reduction in  $n$  value. Not a bad first data point!



# What if we bend more turns around 20 mm radius?

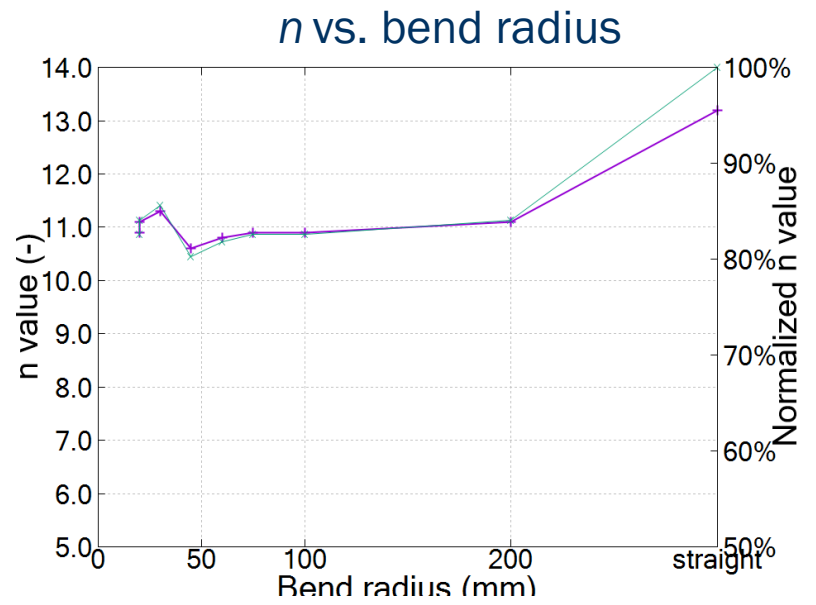
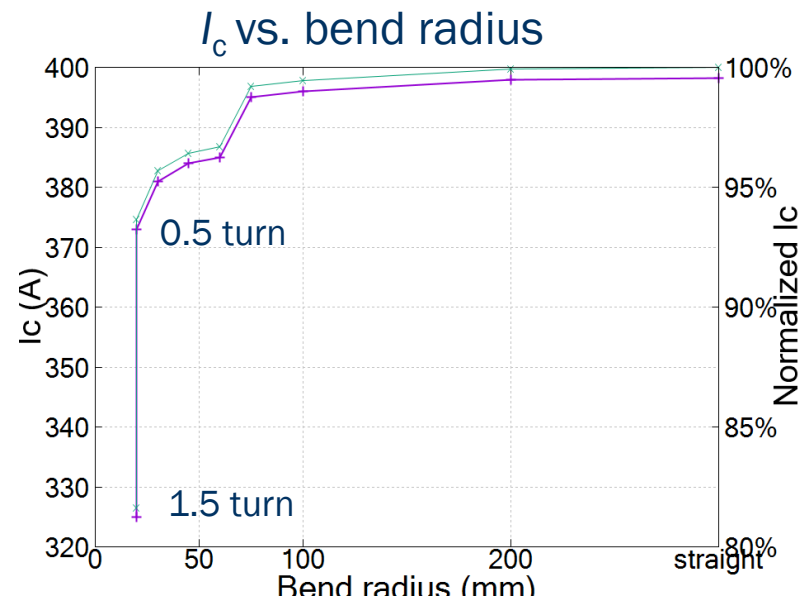
Bend length:  
0.5 turn, 1.25 twist-pitch



Bend length:  
1.5 turn, 3.75 twist-pitch



# 12% more $I_c$ reduction from 0.5 to 1.5 turn of bend around 20 mm radius



- With the  $I_c(B)$  data, we are trying to understand how much is due to the increased self-field
- Will try a few more samples to provide more insight and statistics

- **C3**
  - There is hope to receive the C3 conductor by 12/2022
  - Continued support from ASC on the tape qualification is critical and greatly appreciated
  - Developed the  $I_c(B)$  measurement capability to learn more from the 77 K tests
  - Ready to make the 3-turn C3
- **Evaluate STAR<sup>®</sup> wires for magnet applications**
  - s1 conductor order ongoing
  - First data very shows encouraging bending performance of a STAR<sup>®</sup> 6/1 cable
  - Will try a few more samples
  - Jillian Stern is working hard on the impregnation of STAR<sup>®</sup> wires. Will report soon
- **To be continued...**