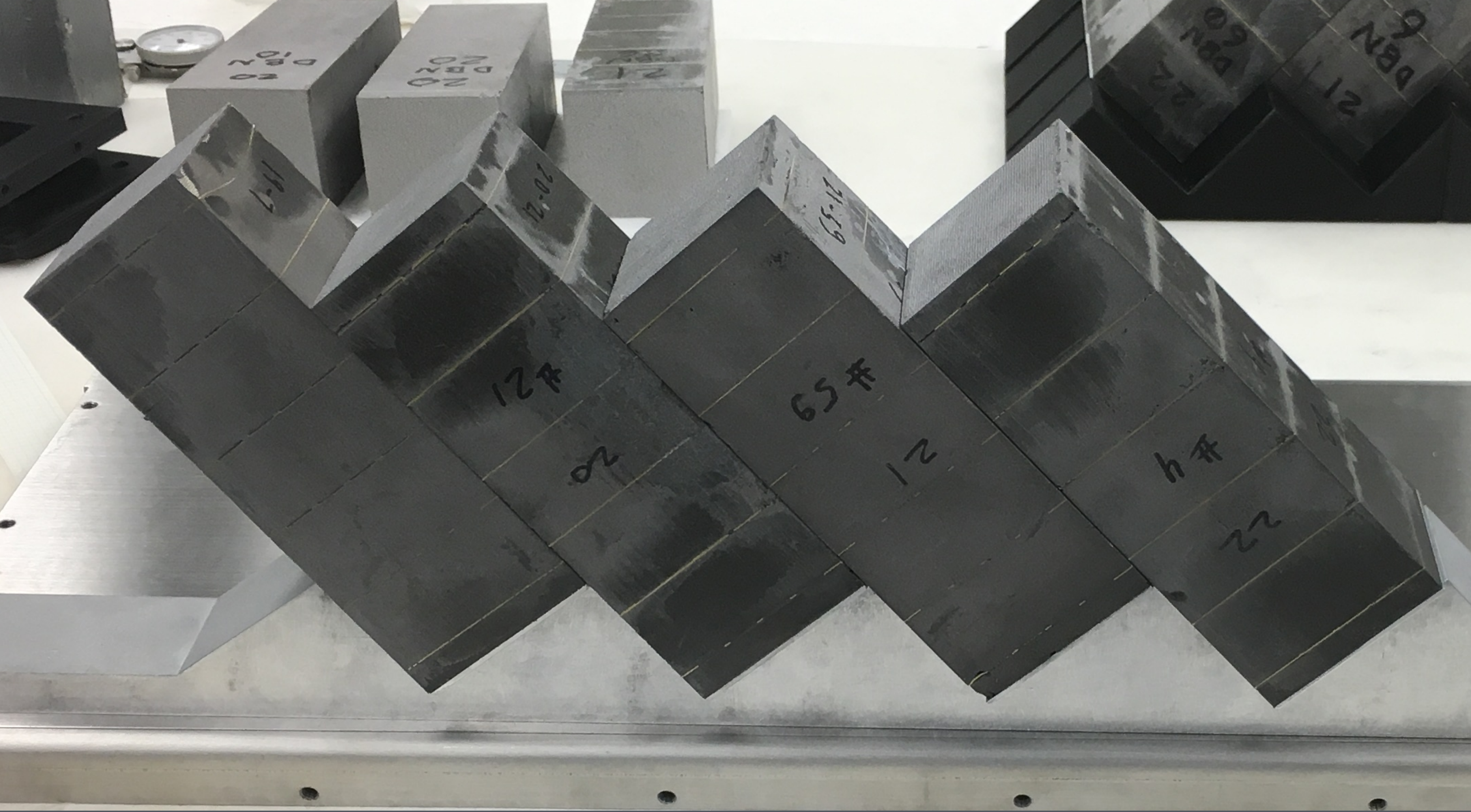


Anne M. Sickles

L3 Manager for block production

ILLINOIS

EMCal status & plans

April 22, 2018

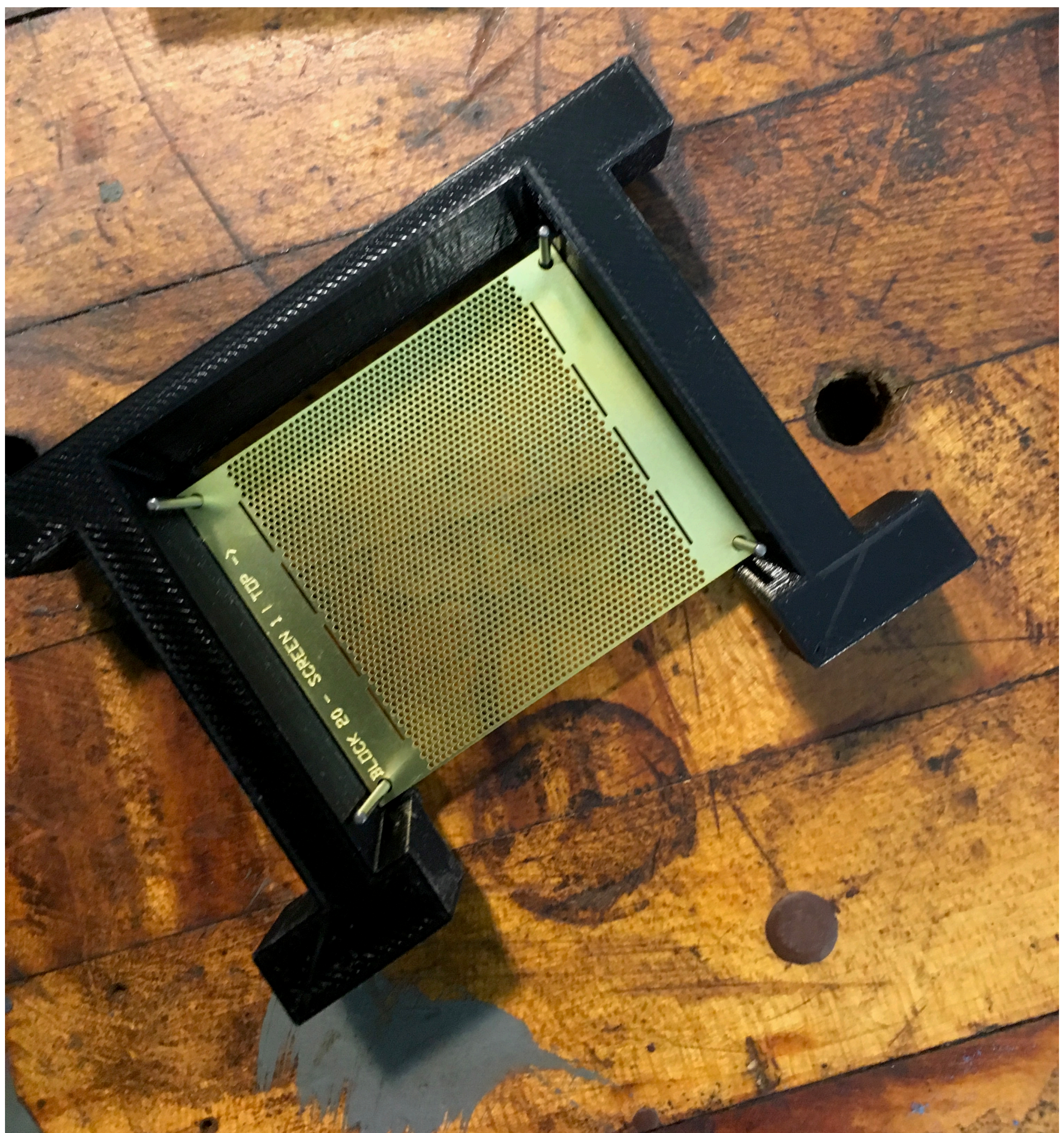
1st sPHENIX Workshop in China

high level summary

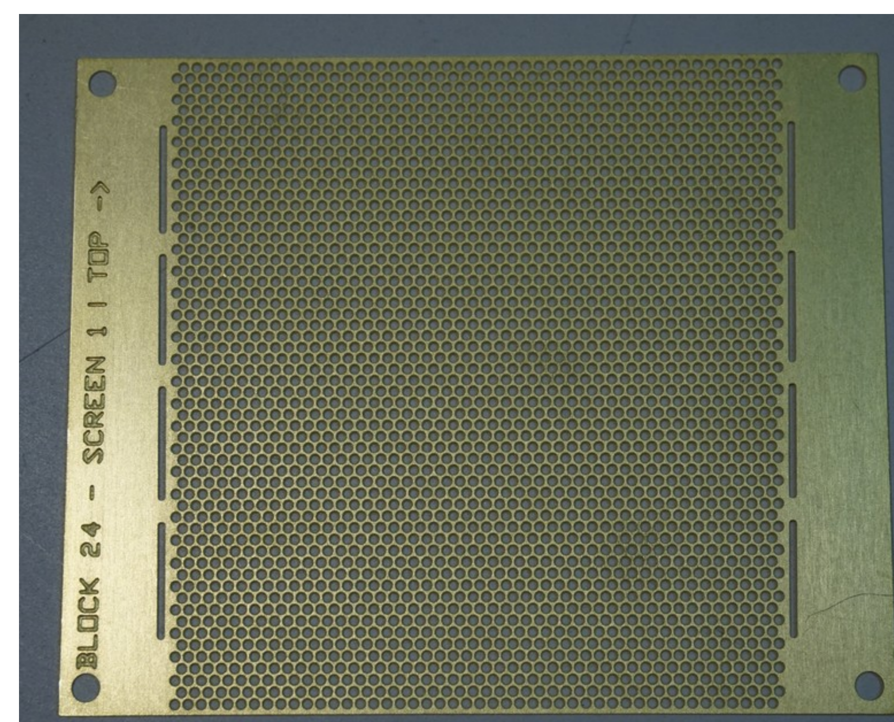
- the EMCal group has developed extensive experience building 2D projective tungsten powder-scintillating fiber calorimeter blocks
  - until we built them, these were thought to be either impossible or impractical to build
  - as Craig said, these blocks are an essential part of the sPHENIX physics program
- this talk:
  - how the blocks are built
  - main challenges in block production
  - plans and ongoing activities

screens

- 6 screens / block & 22 block shapes = 132 distinct screens
- photoetched brass made by TechEtch



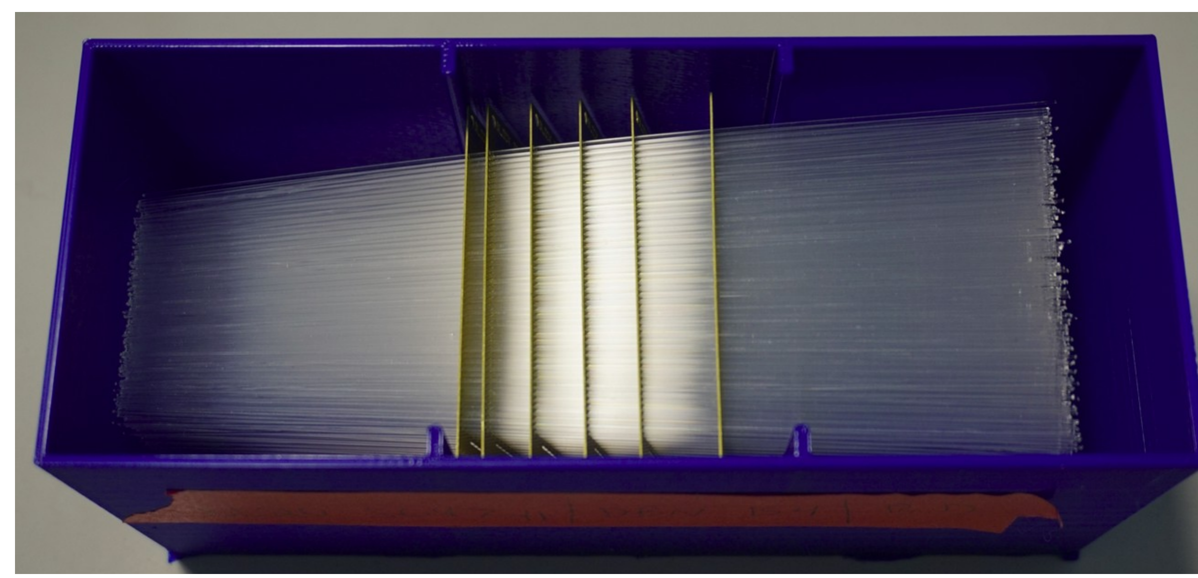
each screen is clearly printed with which screen it is!



filling screens with fibers

fiber filling: screens held in place by 3d printed fixtures and supported by plastic cup

screens give the fibers the 2D projectivity



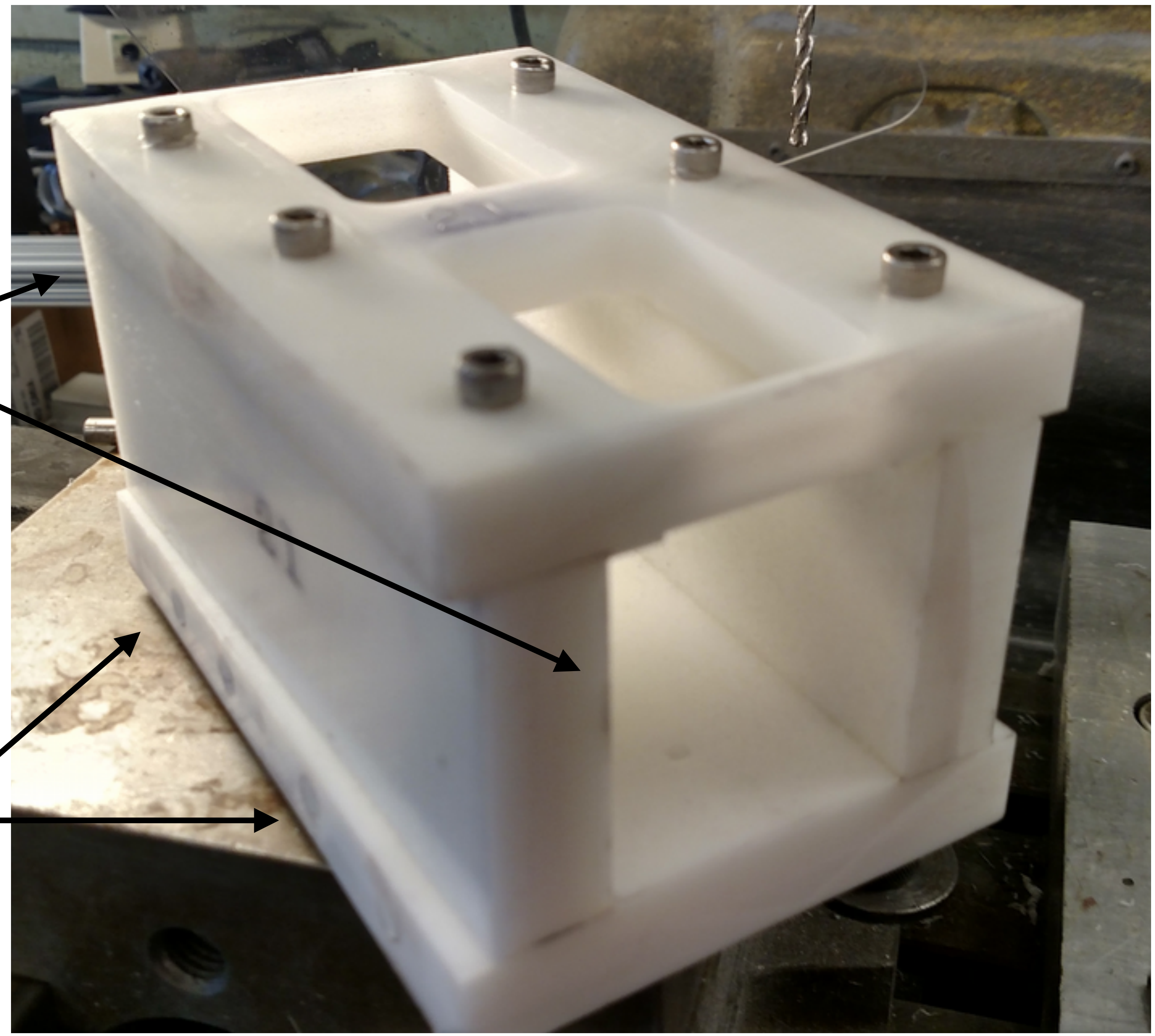
fibers are 0.47mm scintillating clear fibers

3d printed filled screen storage

making blocks

machined delrin mold

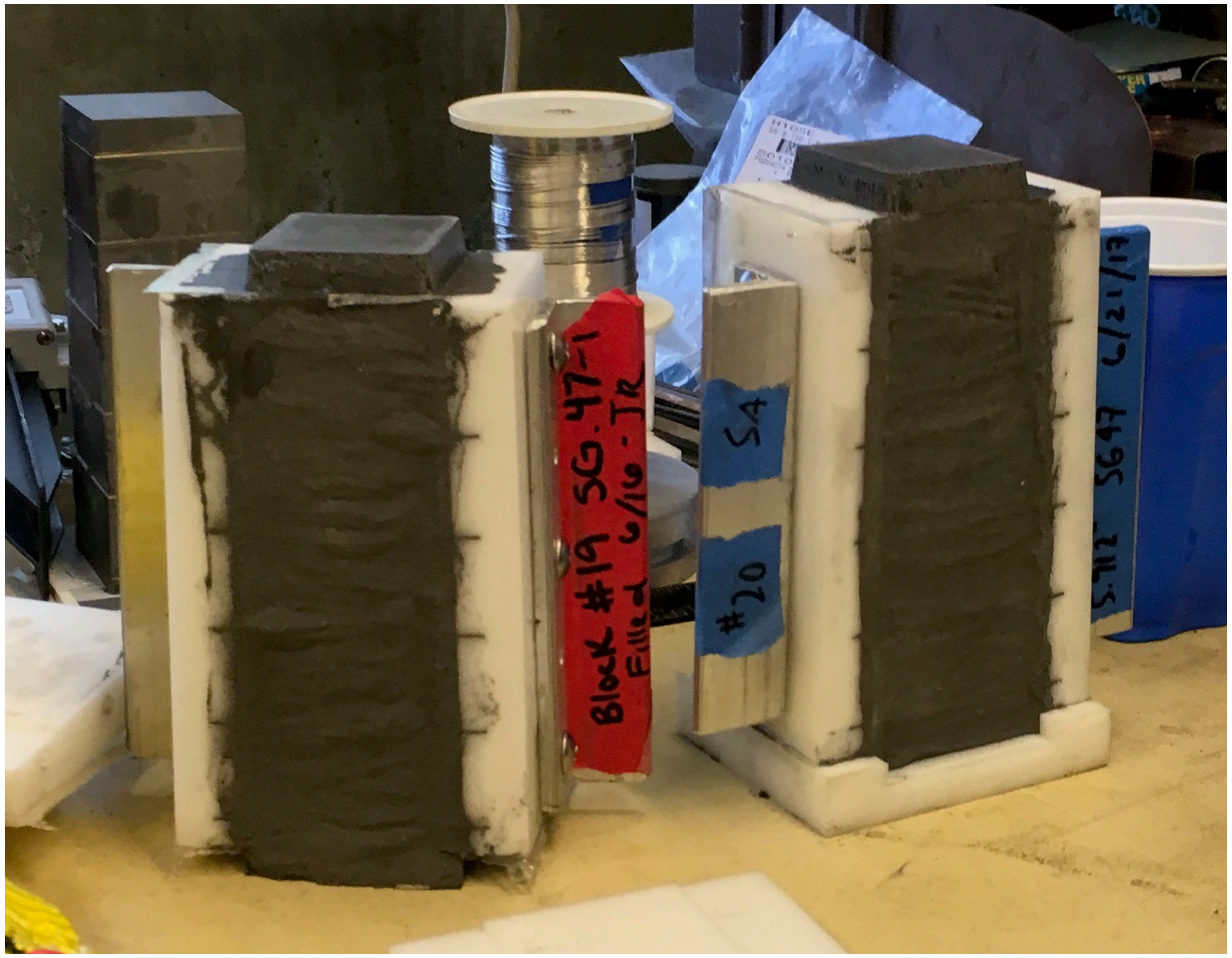
tungsten and epoxy poured in top



ends attached

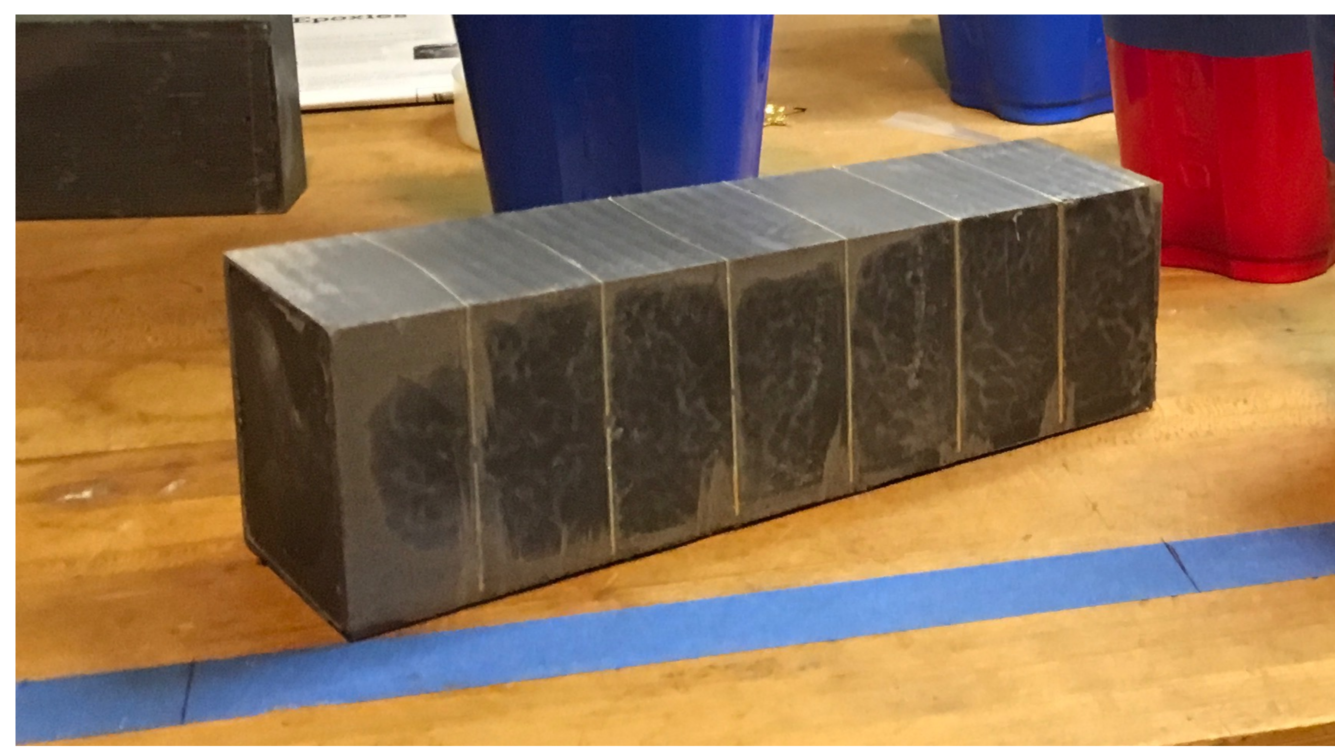
vacuum ports to draw epoxy through

finished blocks



after epoxy dried and mold top removed (molds are cleaned and reused)

finished block



facility

space shared with other nuclear physics projects in Urbana and includes a dedicated machine shop

facility

good light for
fiber filling

low dust area
of high bay

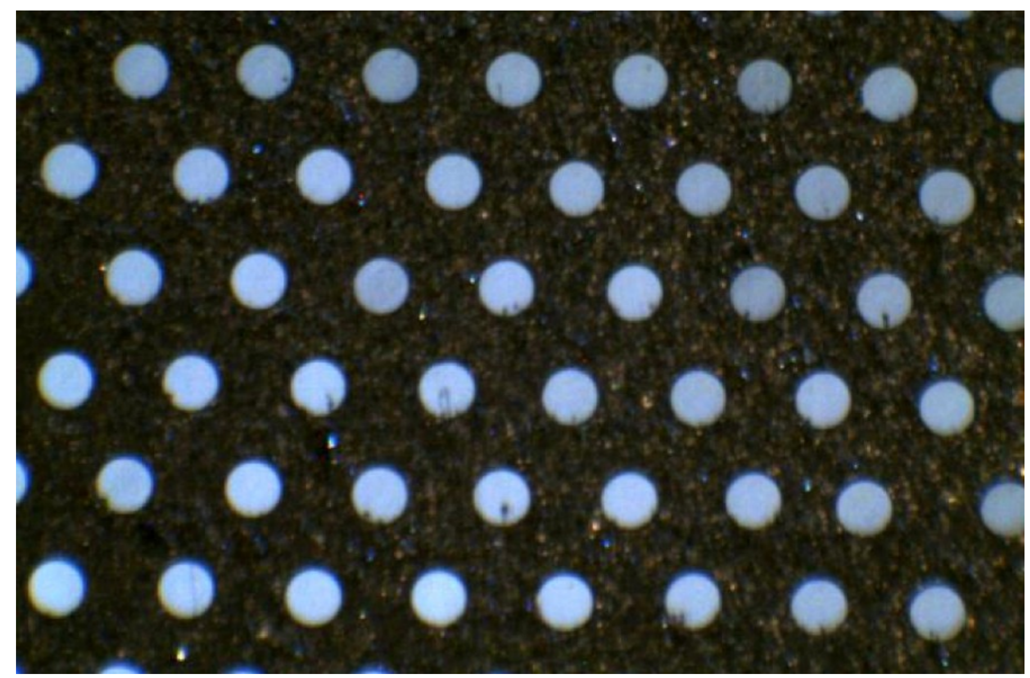
vibration table
for filling
tungsten

epoxy work in fume hood

facility

large milling machine for bulk machining of blocks

custom diamond fly cutter to have good surfaces for the fiber ends without hand polishing

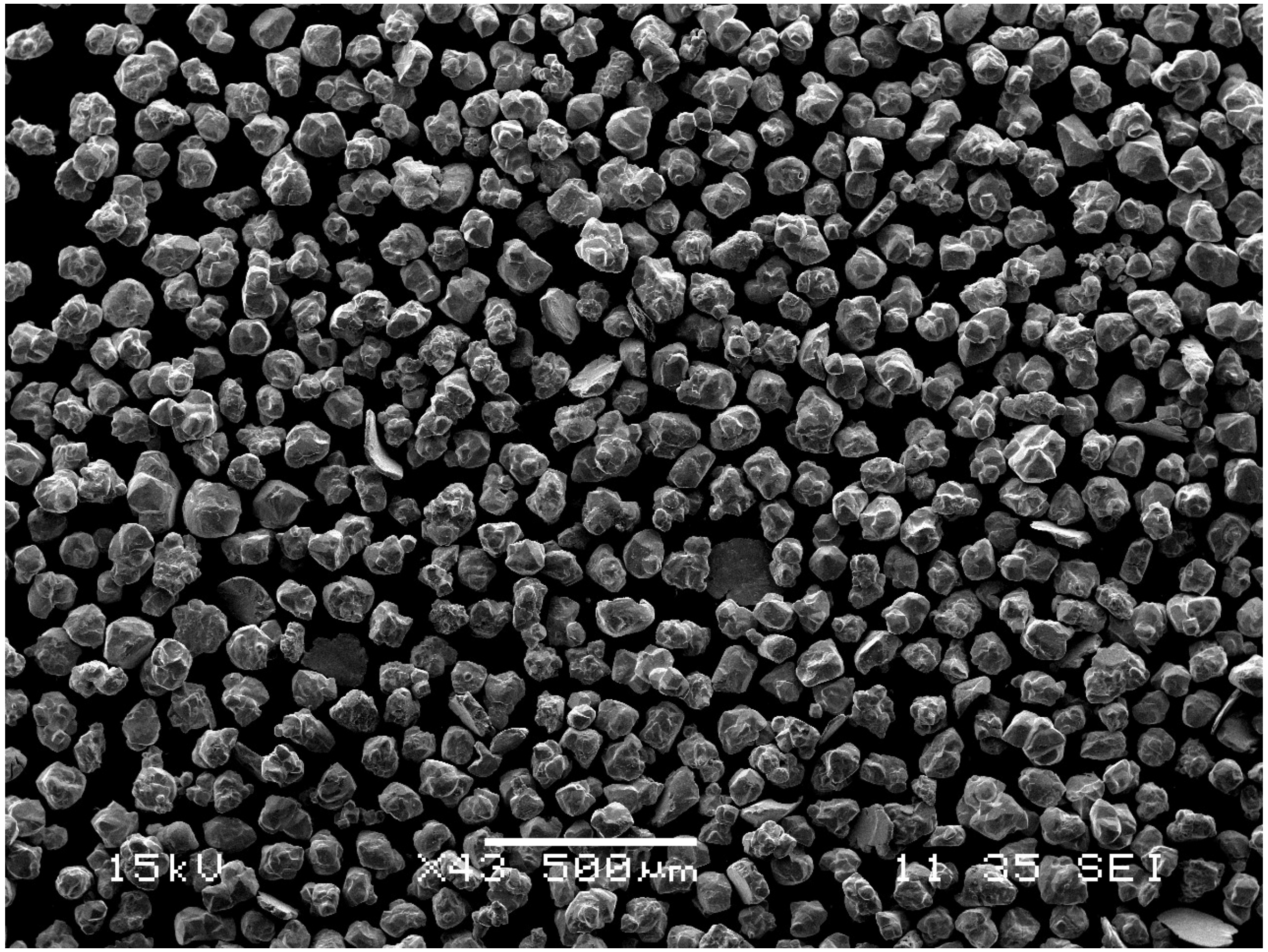


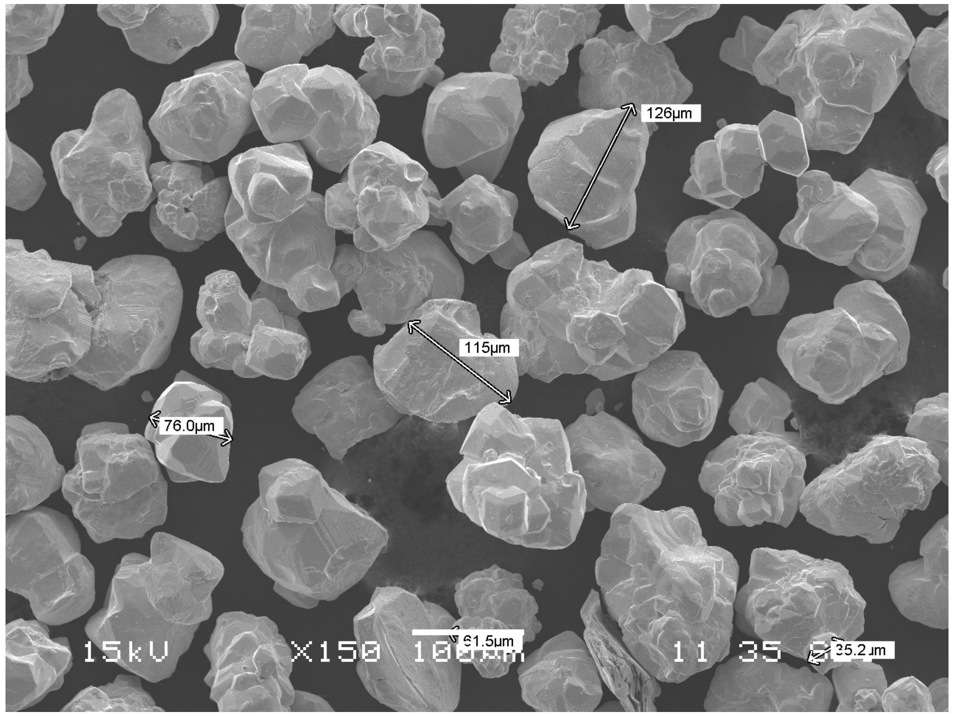
tungsten powder

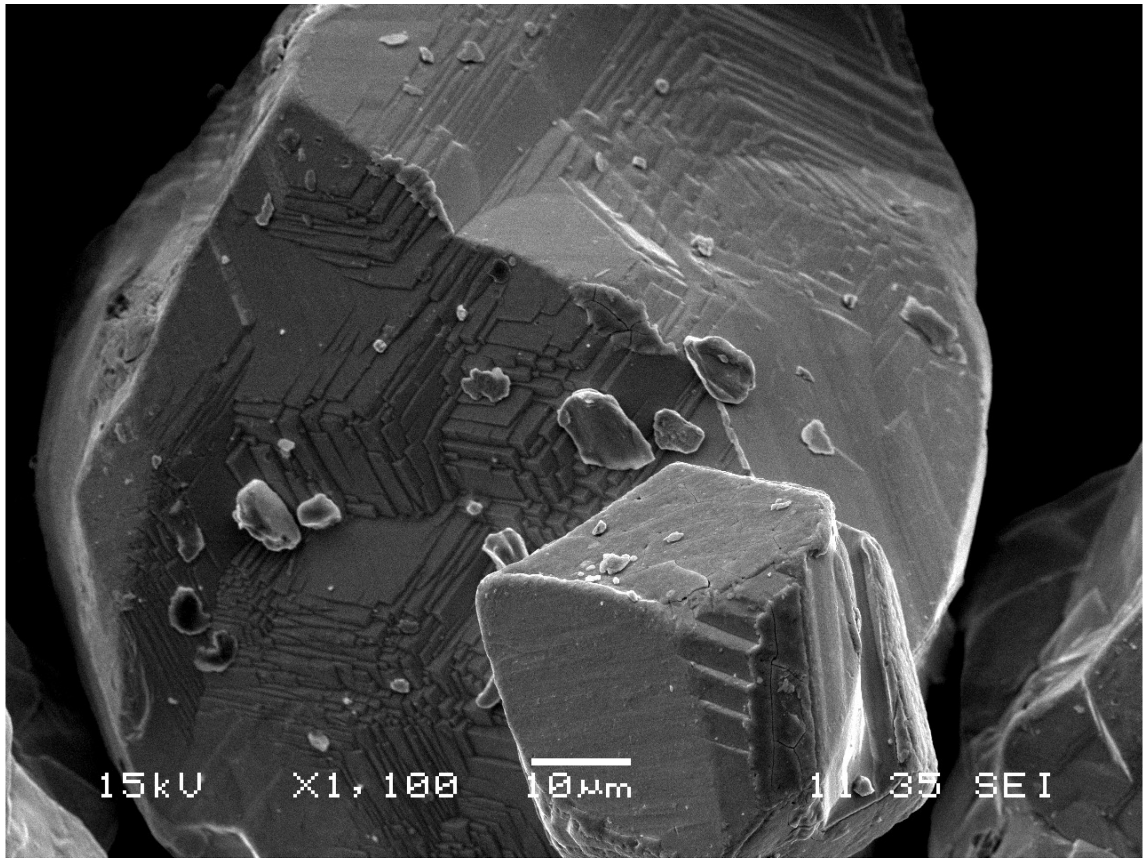
- main requirements:
  - high density: packed >10 g/cm3
  - allows epoxy to flow through the block
  - the combination of these two criteria make us sensitive to the particle size distribution of powders
  - not possible to get the density requirement without ~99% pure tungsten
- bulk of R & D with Technon 100* from Tungsten Heavy Powder (San Diego)
  - powder source is ultimately China, unclear what THP itself does to the powder

*THP says what they send us meets additional specs beyond those listed for Technon 100, but it is unclear what that specifically means

SEM pictures of THP powder







particle size: 30-130 µm

all SEM pictures from M. Phipps and A. Romero Hernandez using Illinois Materials Research Lab facilities

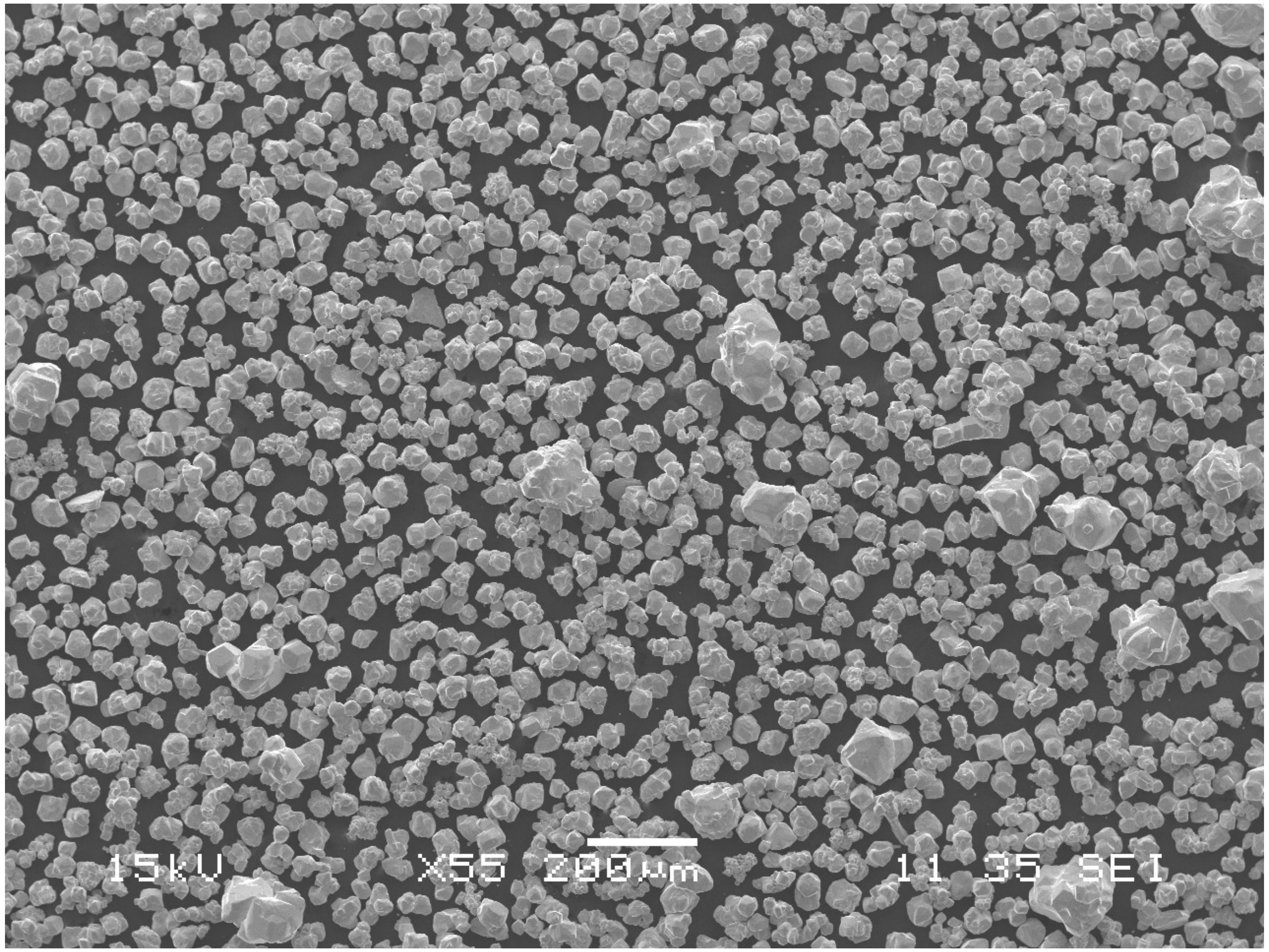
density measurements

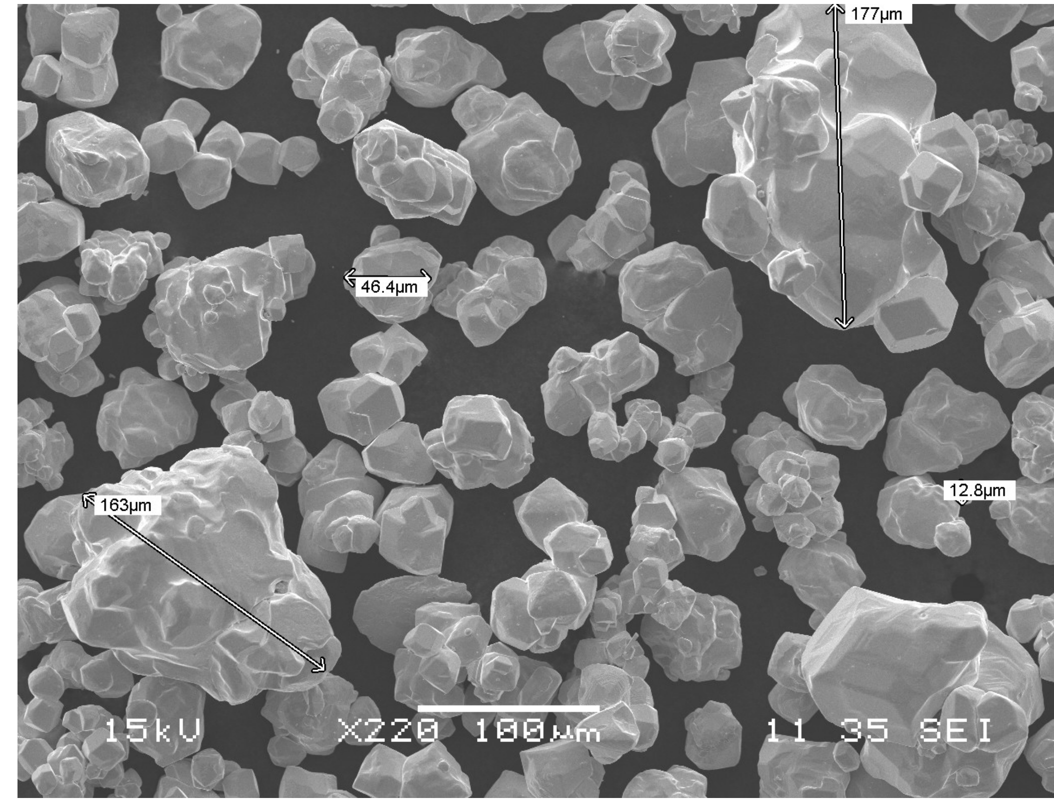
Sample	Mass Used (g)	Volume (cm³)	Density (g/cm³)	Trial 1 Density (g/cm³)	**Avg Density (g/cm³)**
THP 2016 a	200.0	19.5	10.26	10.27	**10.27**
THP 2016 b	200.0	17.8	11.24	11.26	**11.25**
THP 2015	200.0	20.5	9.76	9.66	**9.71**
Buf-Tun	200.0	22.0	9.09	9.38	**9.24**
Tungsten Metal Powder	200.0	27.0	7.41	7.34	**7.38**
KennaMetal	200.0	30.4	6.58	6.08	**6.33**

for a long time we were unable to find other powder suppliers which met our density requirements

even THP has exhibited some variability historically

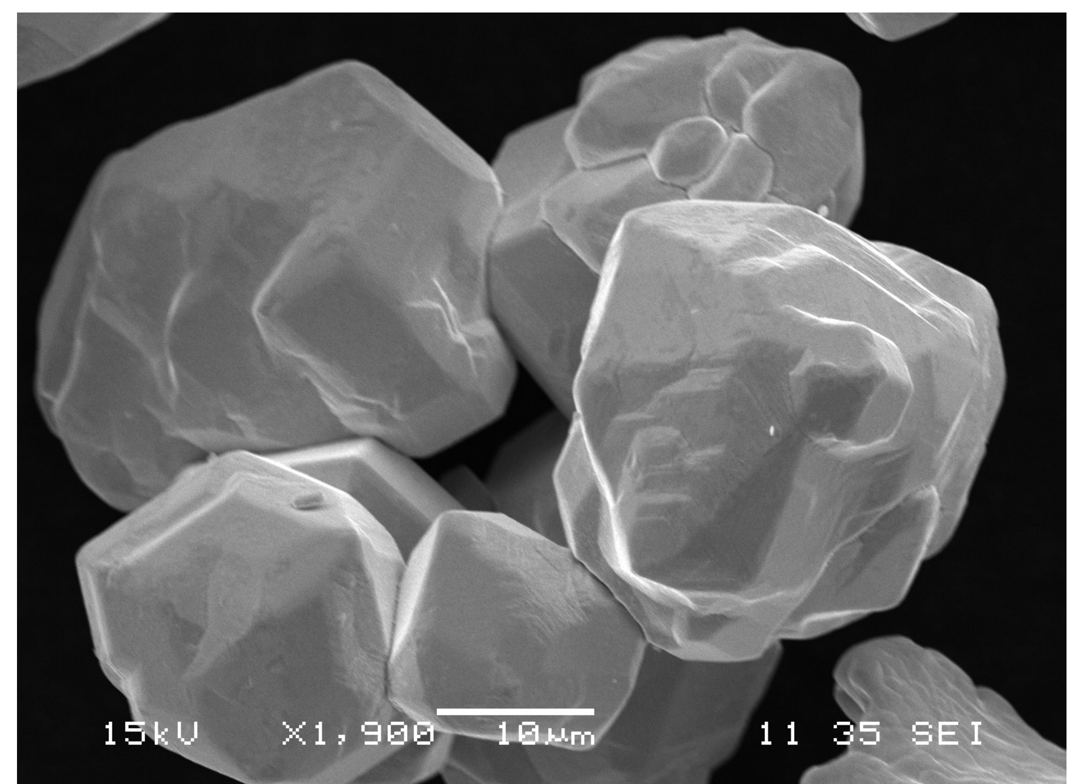
HC Stark





particle size: 10-200 µm

"boulder" rate can be adjusted post production



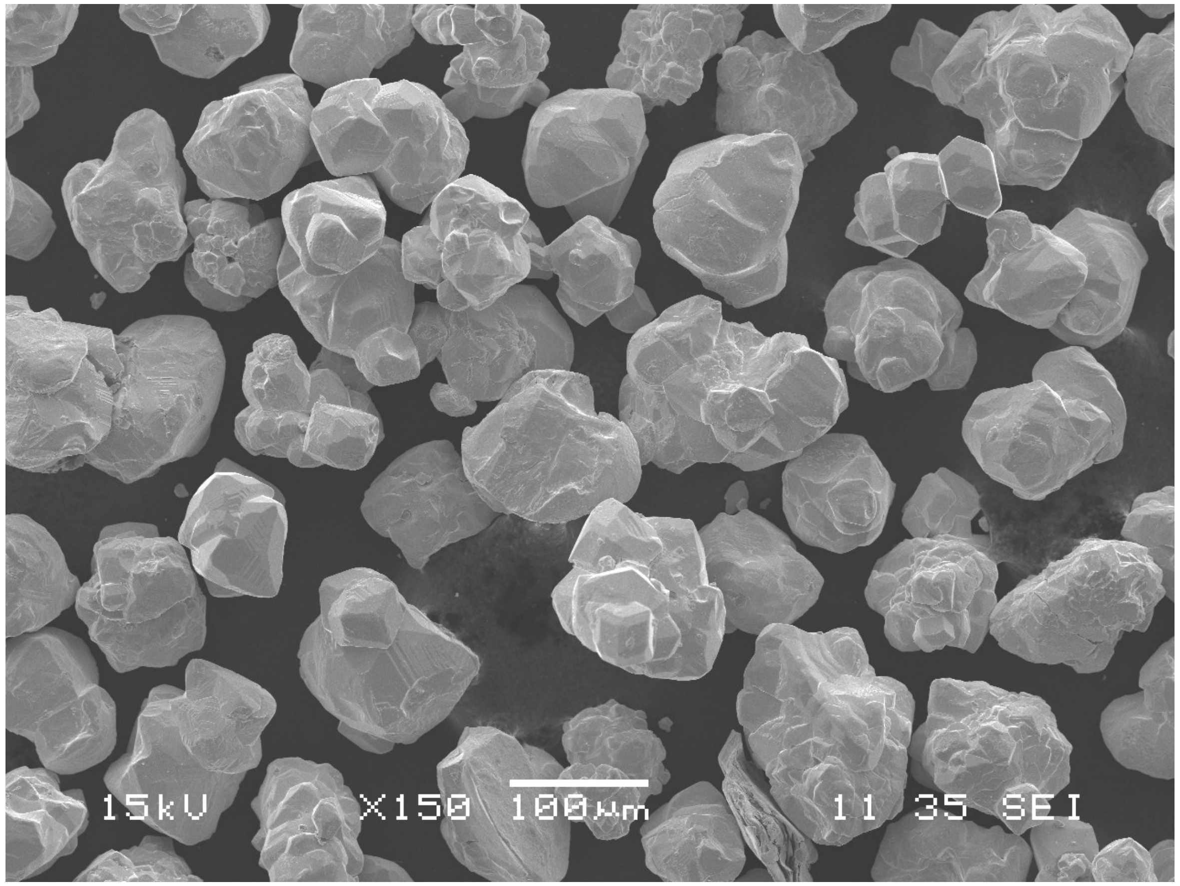
identified by connections with ATLAS ZDC work at Illinois

ρ > 9.0 g/cm3 is the block density spec

THP

Packing density:
10.9 ± 0.1 g/mL

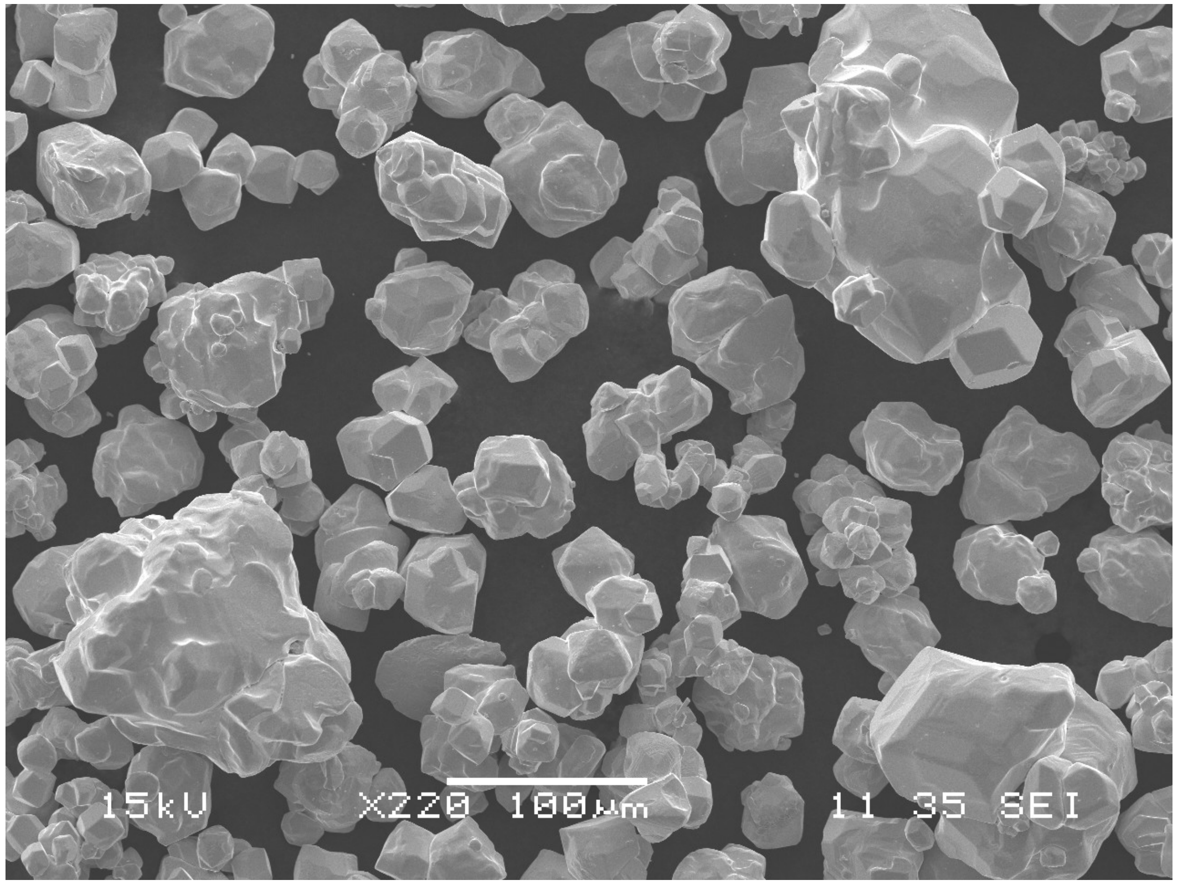
Density of block: 9.5 ± 0.2 g/mL



HC Starck

Packing density:
10.5 ± 0.1 g/mL

Density of block: 9.2 g/mL

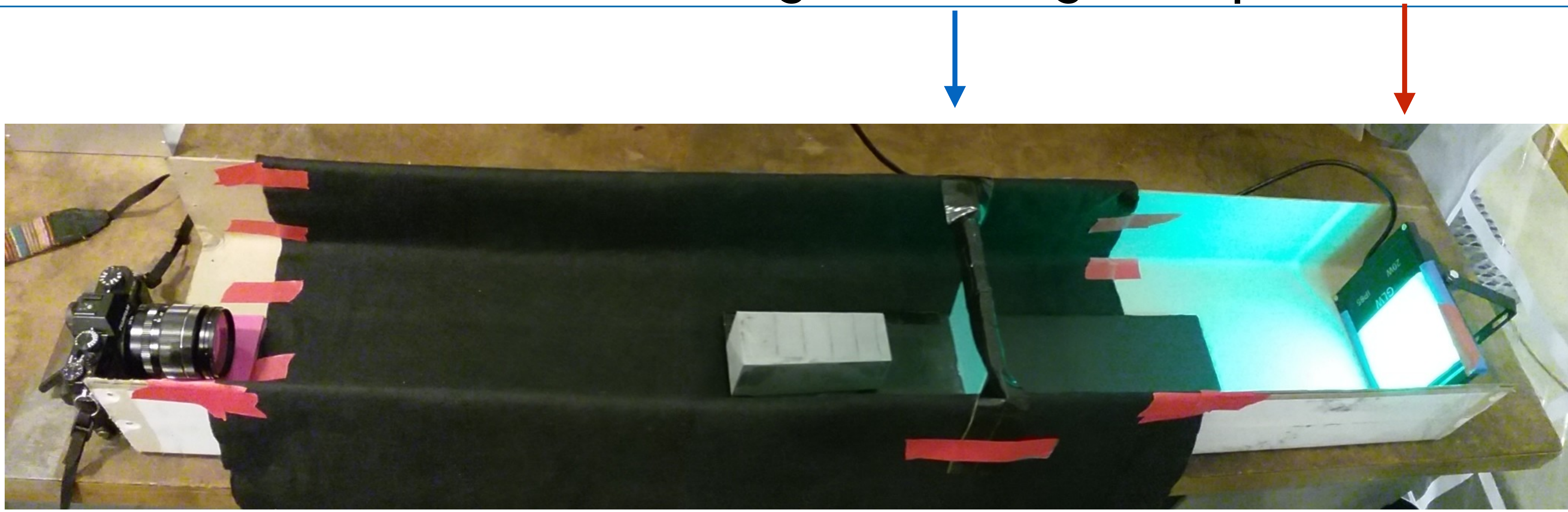


Block QA

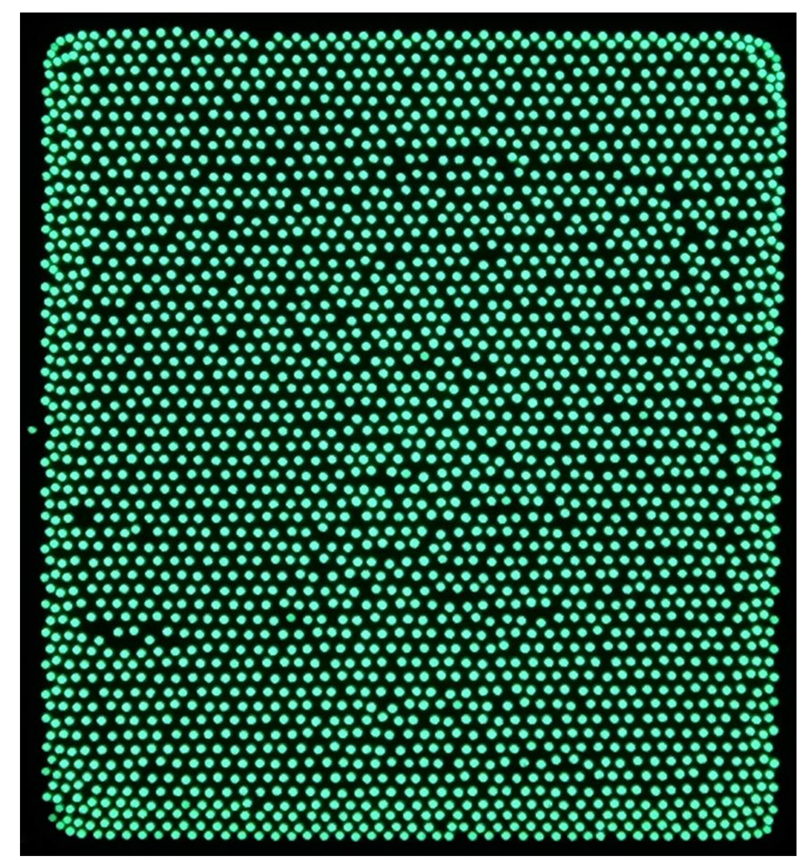
- block parameters:
  - dimensions: they need to fit together
  - density: need to maintain high and uniform density
  - light transmission
- extensive QA plan developed for ongoing work
  - for sPHENIX collaborators: https://docdb.sphenix.bnl.gov/cgi-bin/private/ShowDocument?docid=123

maintaining these criteria is key for getting the needed energy resolution

light testing setup in Urbana



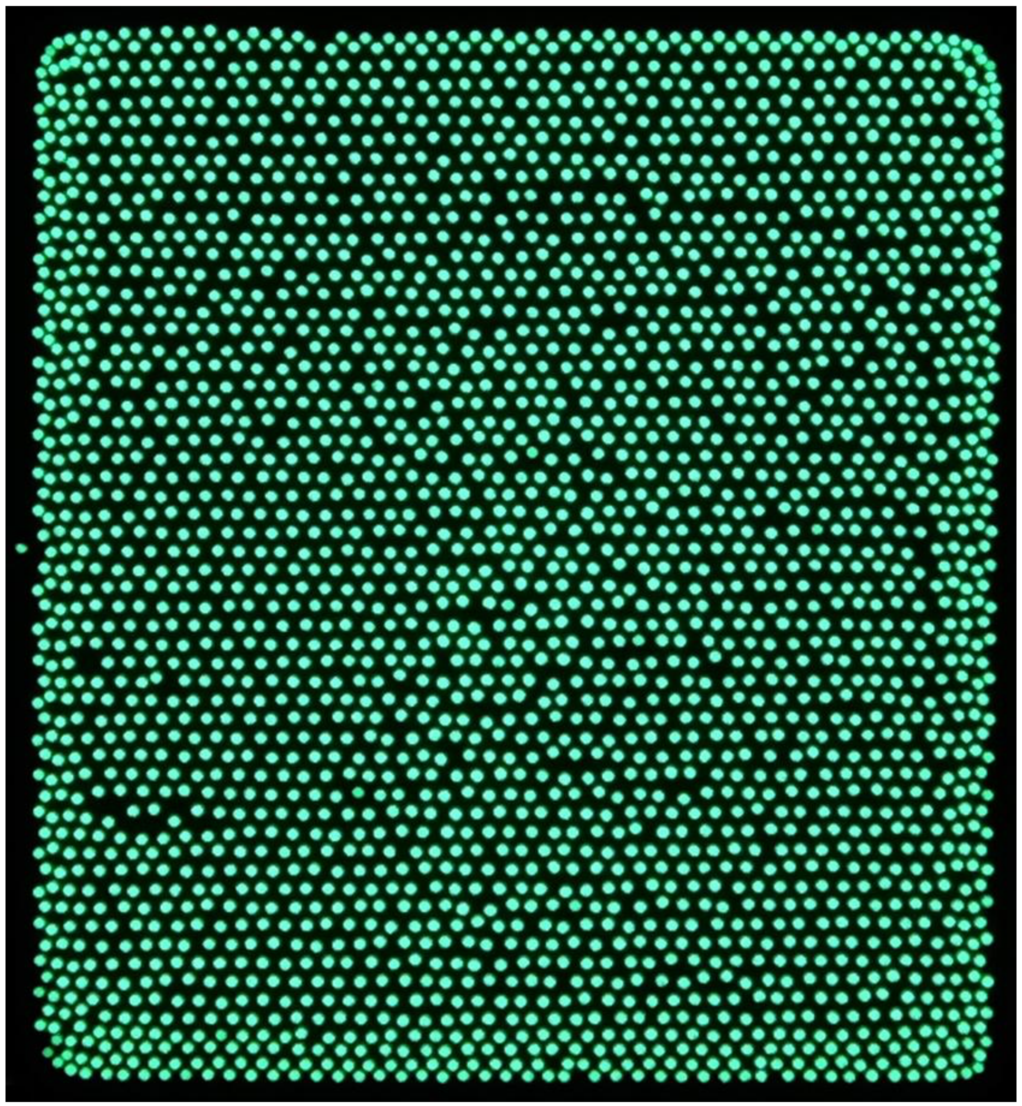
- quality pictures obviously key to doing detailed QA of the blocks
- test setup: LED light-source shined through a large diffuser illuminates the blocks which we then photograph
- improvements being made to fix block position
- expect to count >99.5% fibers with an image clustering program

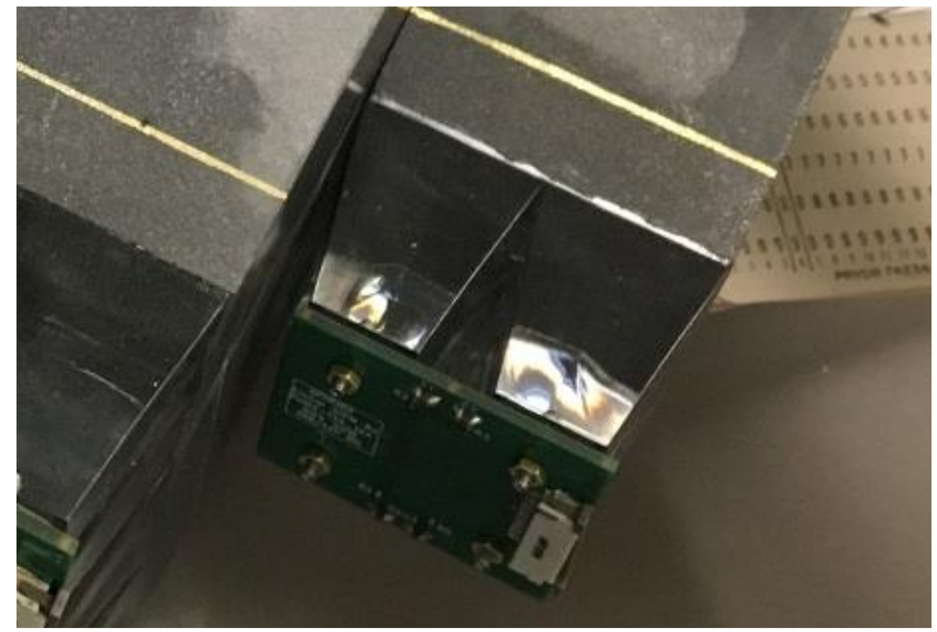


Yongsun Kim
Anabel Romero Hernandez
Eric Thorsland

light uniformity

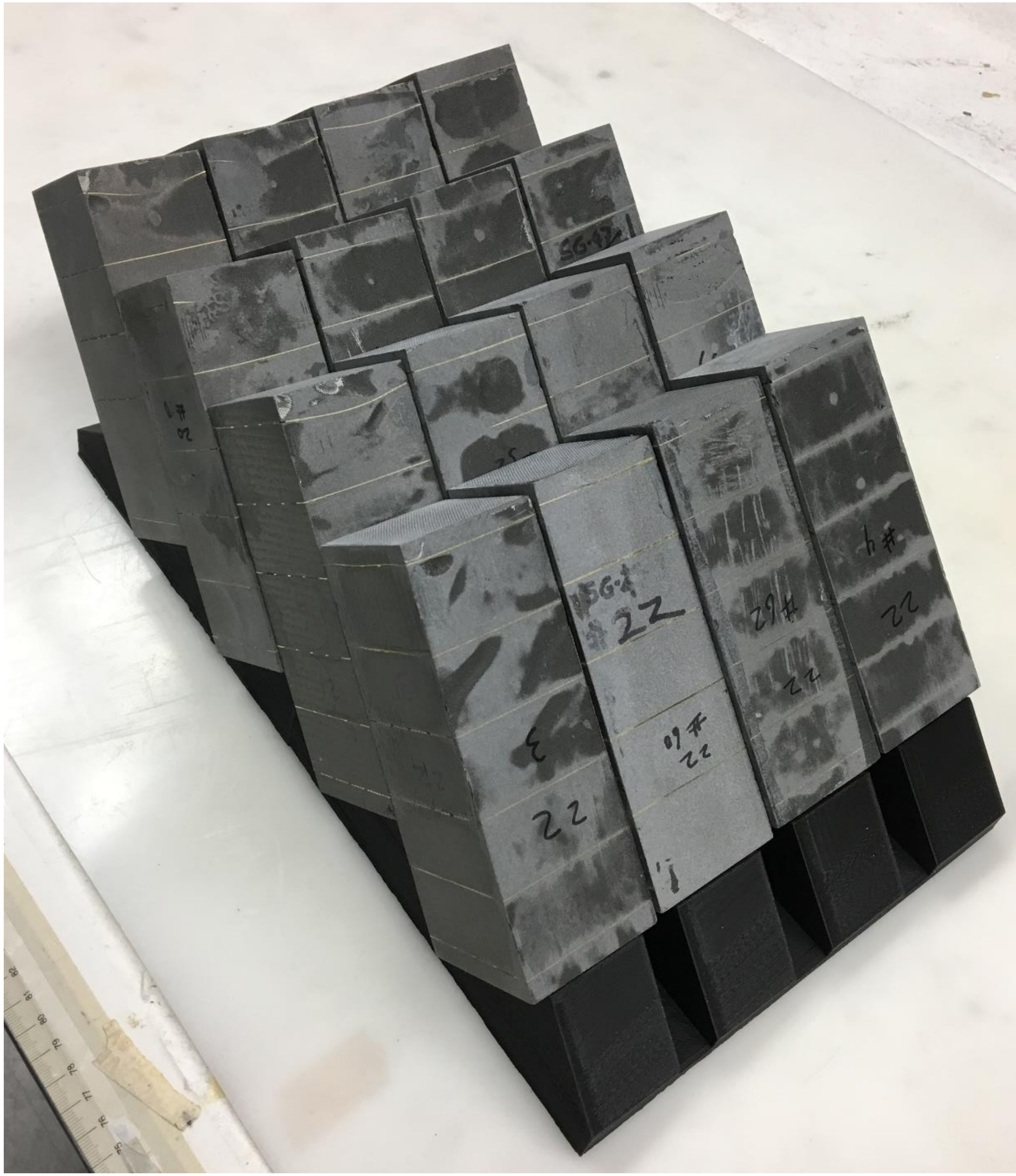
1 block = 4 towers (separate lightguides)





fibers brought in from edges on the readout side (collaring) to improve light collection efficiency near edges →reduces the position dependence of showers

blocks positioned in 2018 prototype

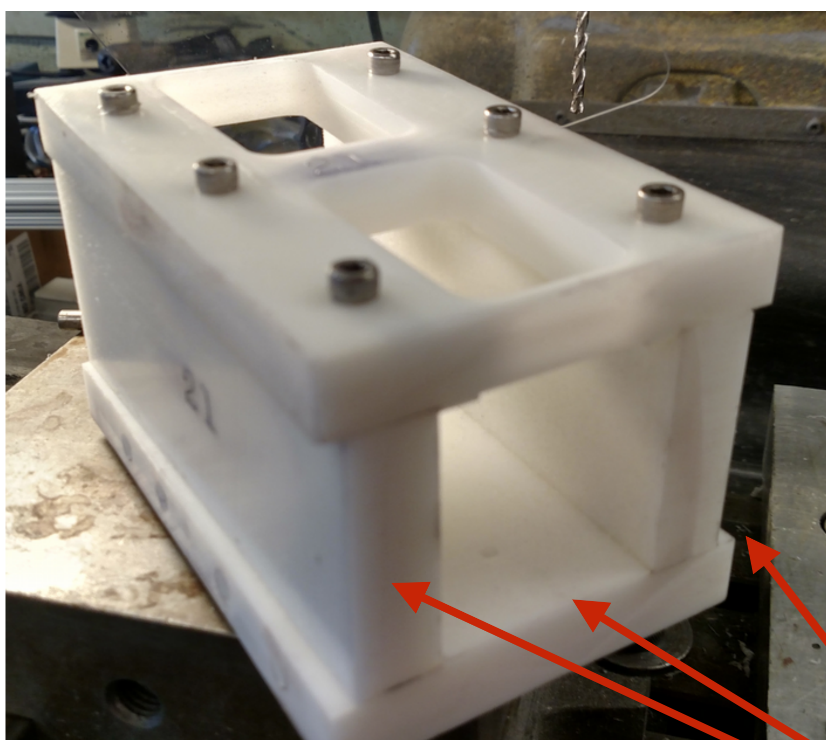


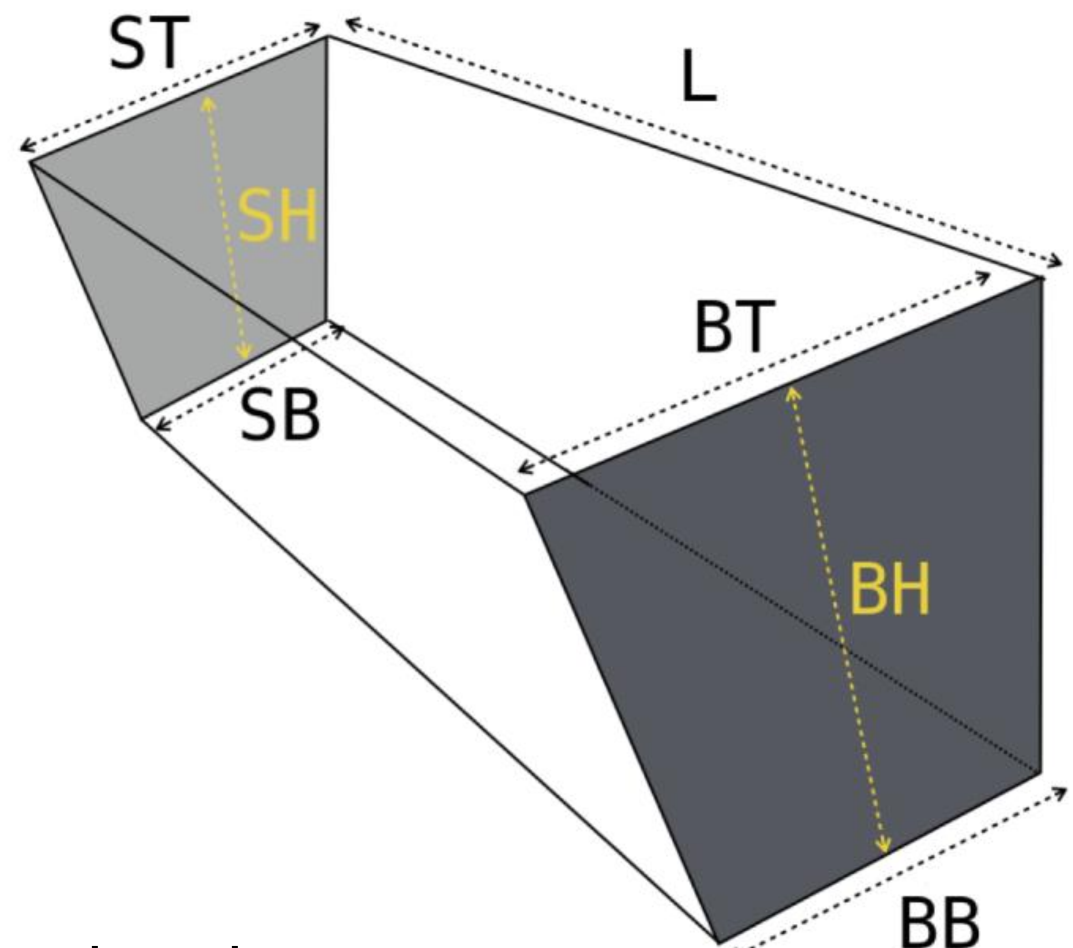
goal of mechanical tolerances: minimal gaps between the blocks

block geometry is complicated due to two dimensional projectivity

currently take 6 measurements of the block size

require a tolerance of 0.01″ on each dimension





mold provides dimensions on 3 sides, top and ends are machined to required dimensions

summary

- successful production of tungsten scintillating fiber blocks with two dimensional productivity
- good understanding of how to achieve the necessary QA benchmarks for a uniform detector which meets our physics requirements
- moving on to mass production of blocks in Urbana
  - "sector 0" preproduction prototype: 96 blocks covering 0-1.1 in η and 32 / 2π in azimuth
  - 12 sectors of advanced R&D to develop and refine the production and sector assembly process