Summer internship
Fermilab

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September 28, 2017

Illinois Accelerator Research Center

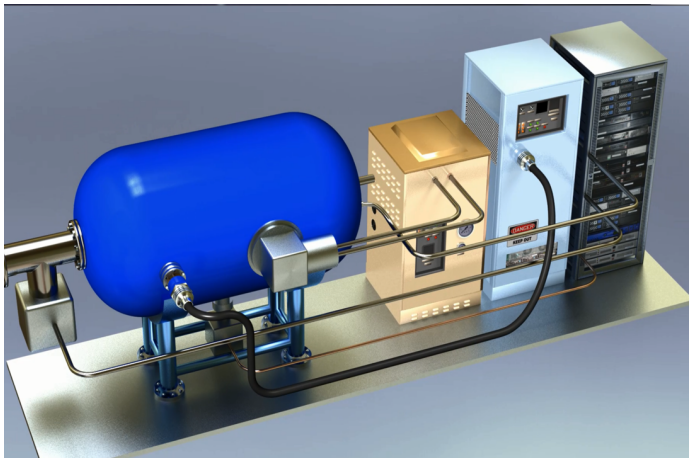
IARC mission:

- developing accelerator-based technologies
- partnership with industries for new applications
- decreasing the time to market of new industrial solutions

The HAB, Heavy Assembly Building, is the application development area of IARC.

- A2D2
- Conduction cooling
- Mu2e

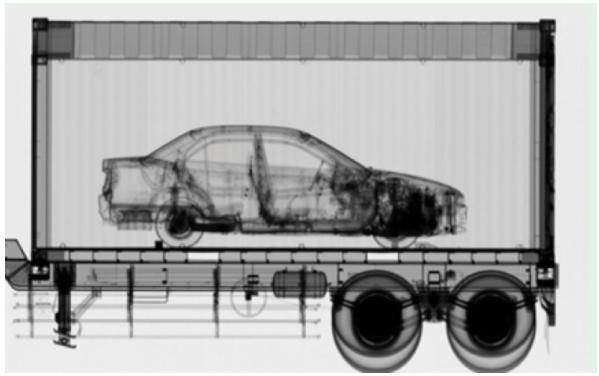
We are integrating multiple new technologies to create a compact, portable, high-power electron beam platform accelerator.

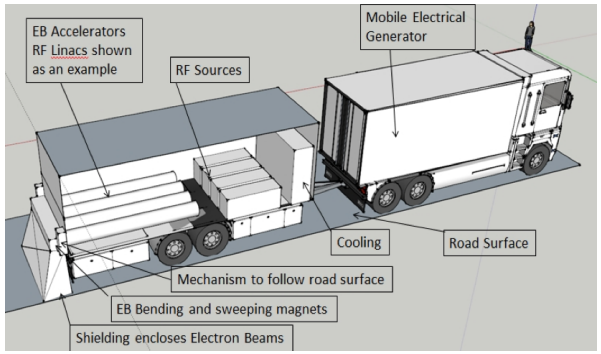


- cryocooler
- conduction cooling
- high temperature superconductors
- minimizing heat generation

Industrial accelerator application:

- cargo scanning
- industrial waste water treatment
- nuclear waste destruction
- food and medical sterilization
- improved highway construction





A2D2 = Accelerator Application Development and Demonstration

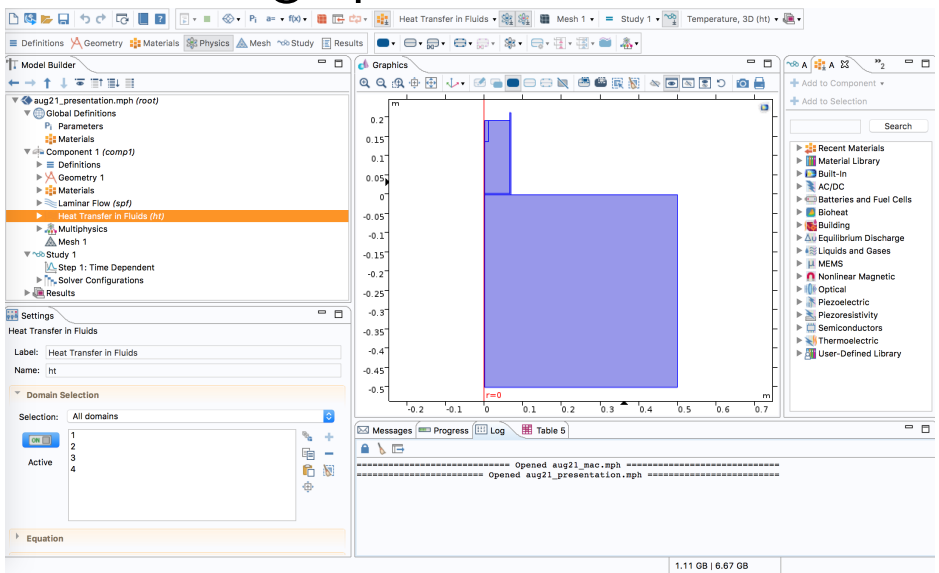
Before developing new applications, we would like to understand the output of the machine. An easy way is measuring the heat power.

First month

COMSOL:

- self-learning
- web trainings
- problems: full licence
- setting up the model

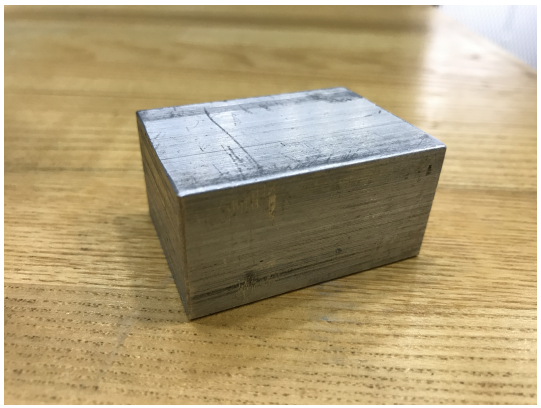
COMSOL graphical interface



Measure of heat power:

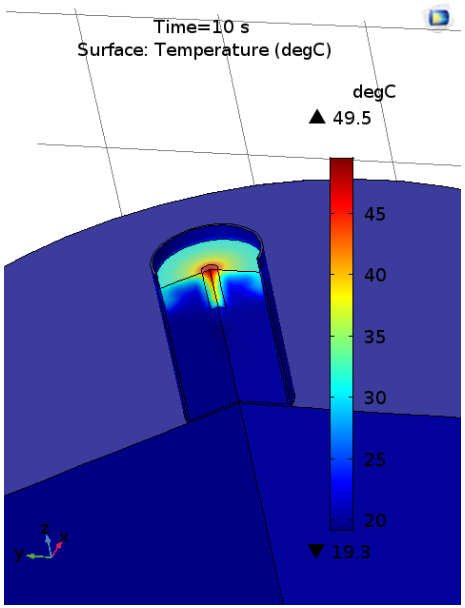
water

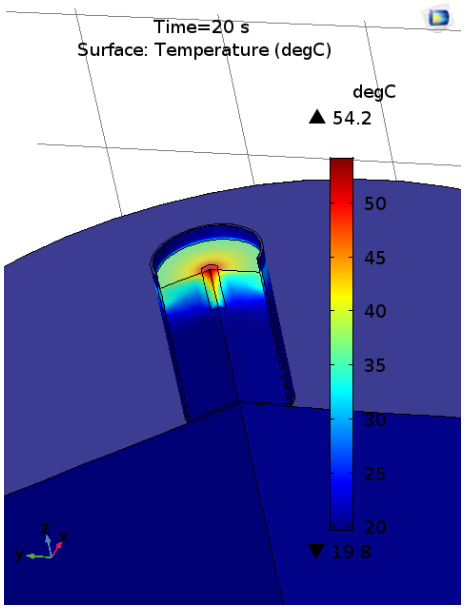
aluminium

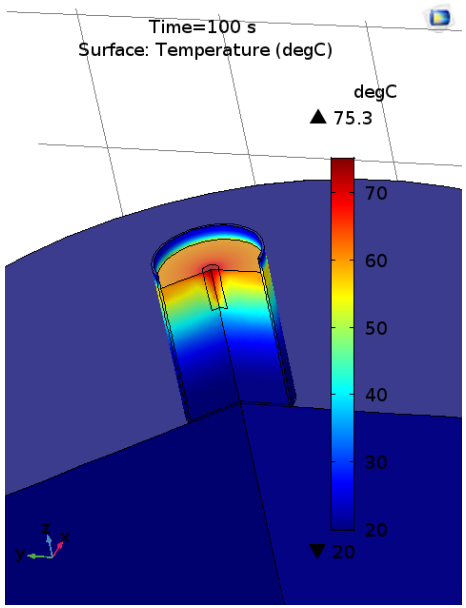


Temperature distribution

Full power: 1500 W





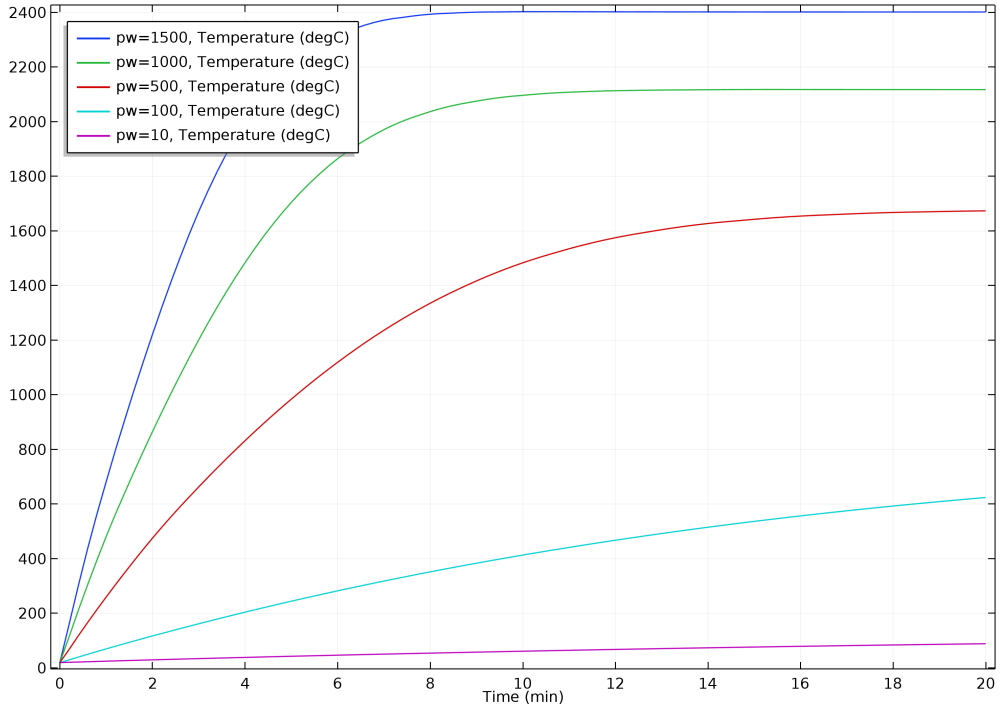


Problems:

- modeling electron beam
- low conduction
- modeling convection motions
- modeling boiling water
- licence limitation

Possible solution:

- change material, for example aluminium



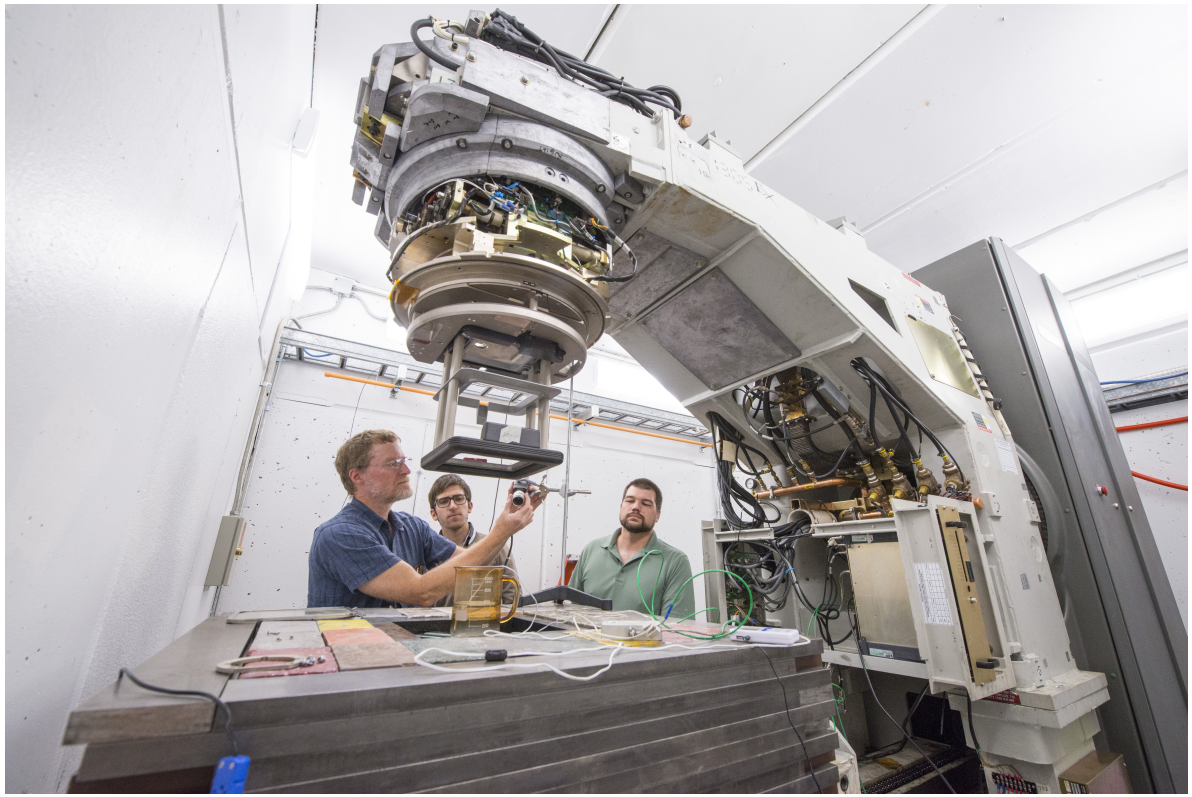
- experiments can last only few minutes
- in the first minute the curve is quite linear
- in conclusion: fast and precise way to measure the power output

Experiment with full power

An Acceletronics technician came to IARC and removed the interlock.

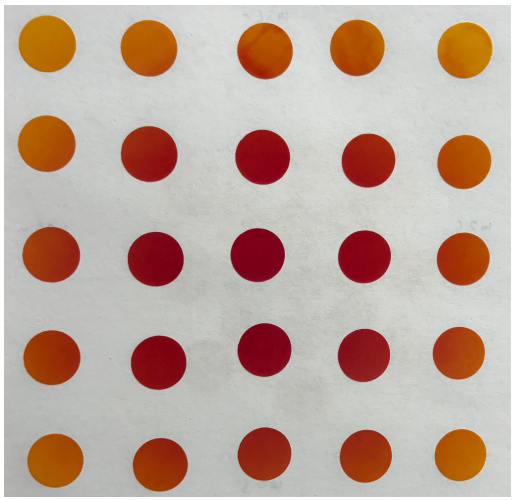
Before the power was less than 1 W so that we were not able to measure it, after we expected to have about 1 kW.

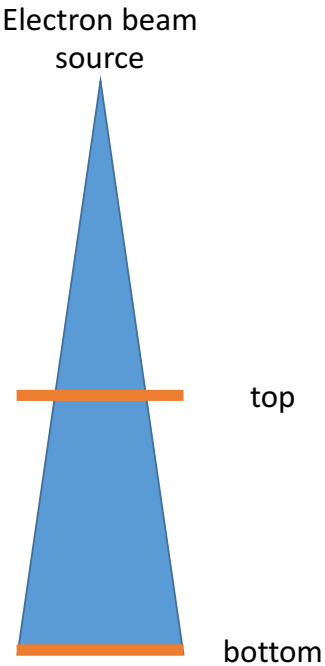
Thomas Kroc, I and Mike Geelhoed inside the A2D2 cave.



Electron beam distribution

bottom





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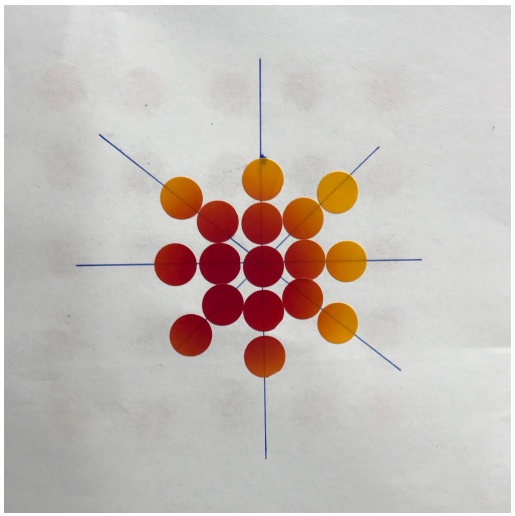
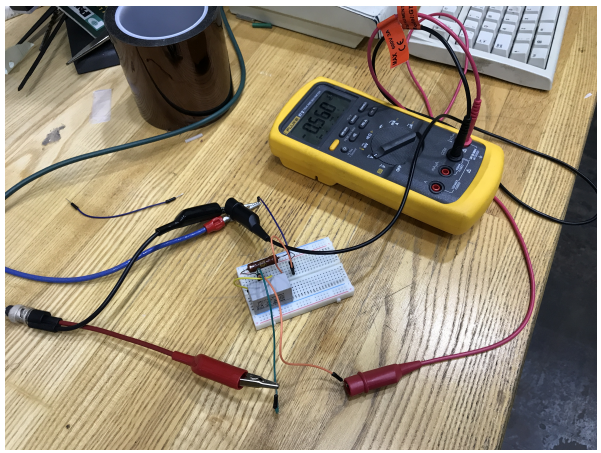


Voltage measurement

We did many experiment fixing all the details.
In the last configuration we had:
1 M ohm resistor, 1 μF capacitor linked to the block.
We measured 124 V, which means 0.1 mA (average current).



9 MeV $\rightarrow$ about 1.1 kW

Temperature measurement of aluminium

Data: 0.4 kg, c_p=900 $\frac{J}{kg \cdot K}$, 0.2 min, T_{in}=23.6°C,T_{out}=66.9°C.

$$P = \frac{m \cdot c_p \cdot \Delta T}{t \cdot 60} = \frac{0.4 \cdot 900 \cdot 43.3}{0.2 \cdot 60} = 1.4\ kW$$

The next steps of this project are:

- understanding the power distribution along the radius
- penetration depth of various materials
- figure out a way to treat the whole sample with the same dose

A possible application of the electron beam is additive manufacturing, which is used in many field.

Wind power manufacturing now:

- long lead times
- high cost
- difficult transportation

Electron beam 3D printer for wind power:

- faster manufacturing
- decrease in cost
- portable manufacturing machine

Possible collaboration with Oak Ridge National Laboratory

What I have learned:

- COMSOL
- material science and technology
- electron beam interaction with materials
- additive manufacturing
- teamwork
- safety
- timing

Thank you for your attention