VDL ETG

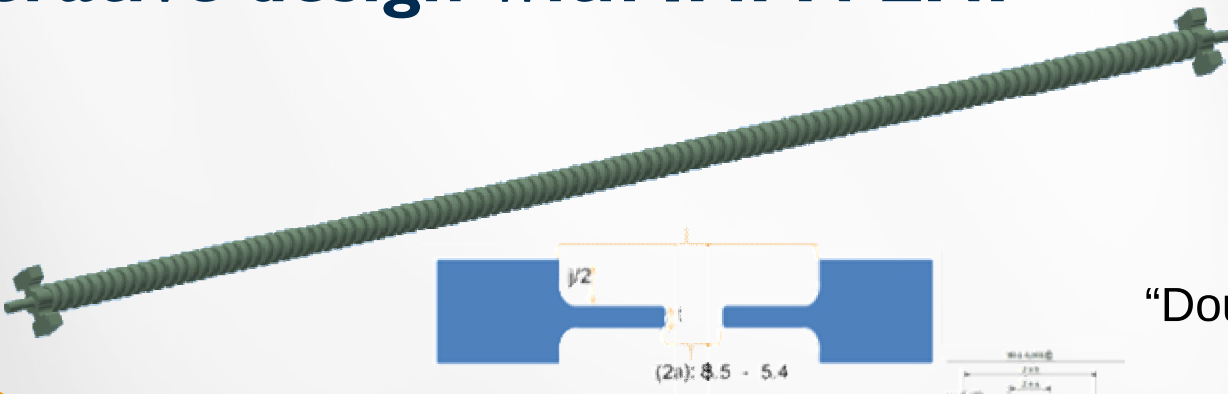
XLS project

Accelerating structure thermal and mechanical design

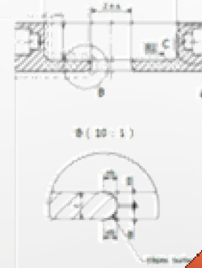
17-06-2020

Iterative design with INFN LNF

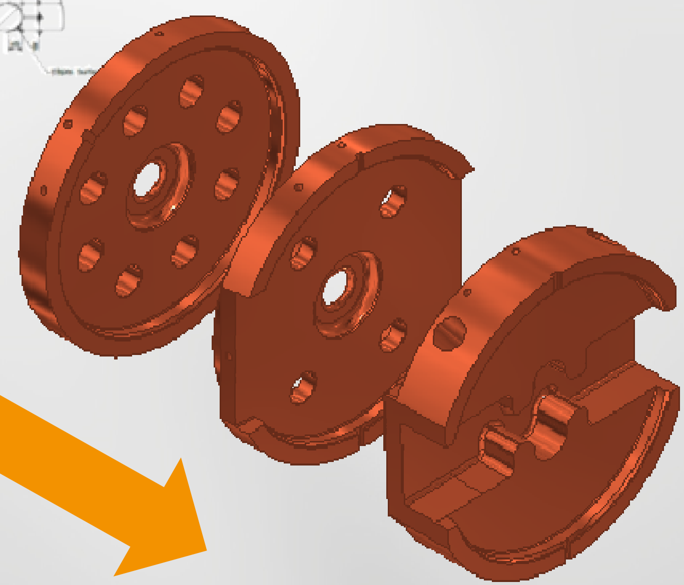
108 cells



- ☑ Iris radius (a)
- ☑ Cavity radius (b)
- ☒ Cavity depth (j)?
- ☒ Iris thickness (t)?
- ☒ Iris elliptical shape (ea and eb)?



"Double half-cell design"



Iterative mechanical design

Can only be done in close collaboration with the RF engineers!

Step 1: Nominal 3D model based on vacuum volume

- No tuning
- Brazing
- Alignment by shrink fit
- Machinability

Ongoing

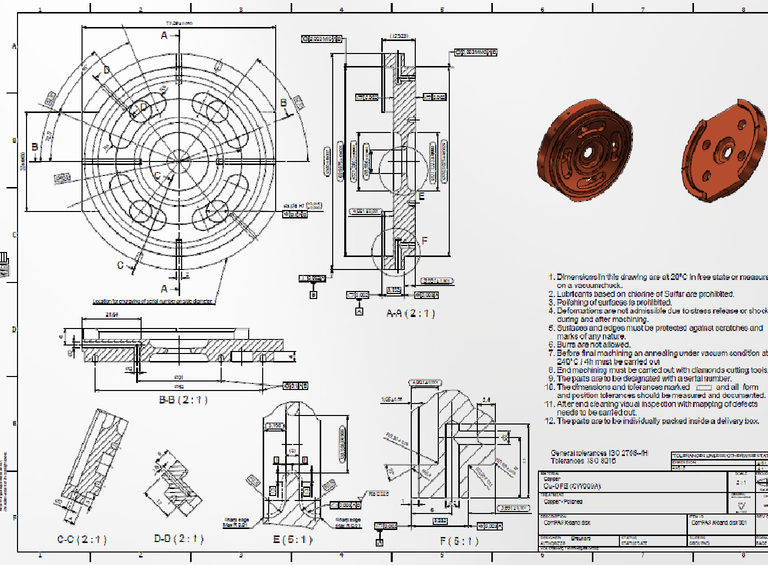
Step 2: Drawings including symmetric tolerances and list of properties per cell

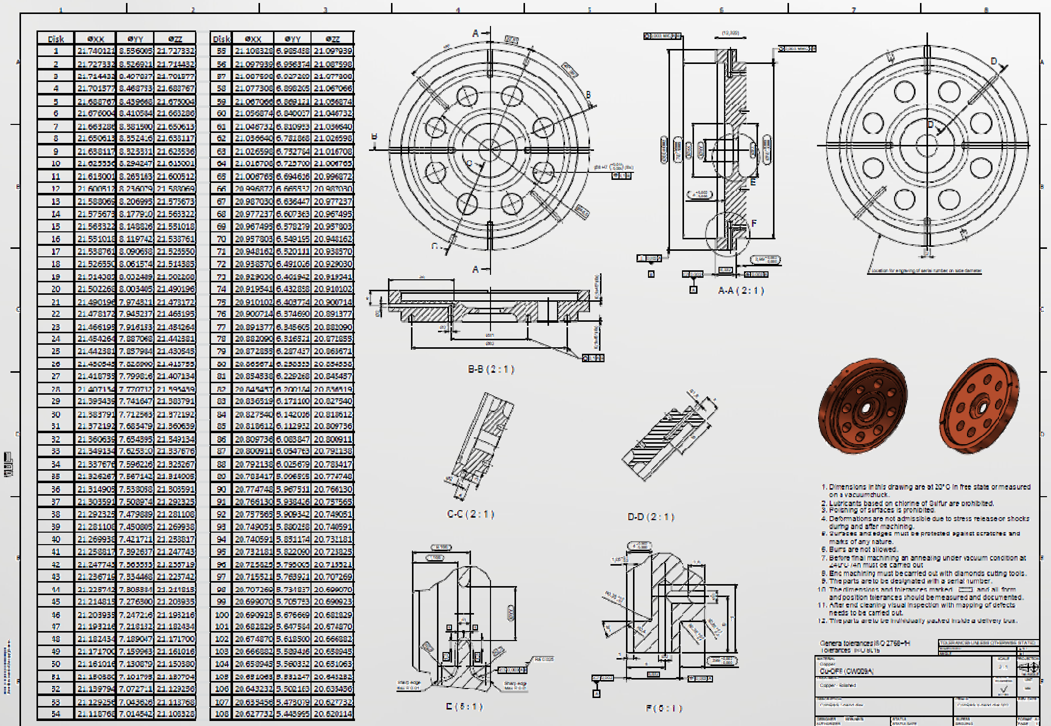
Step 3: Assess manufacturability

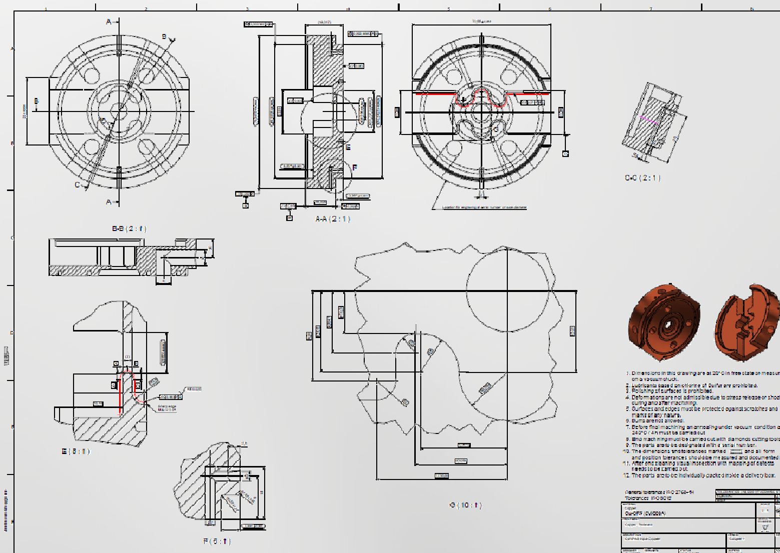
Step 4: Thermal optimization

Disks

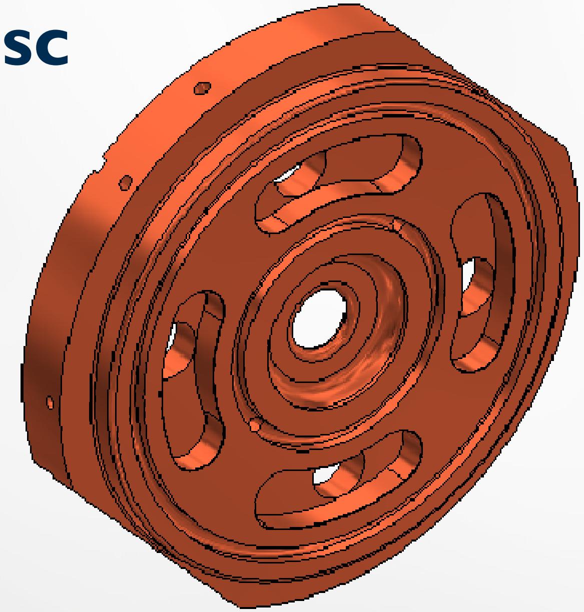
- 80 mm disks
- No tuning due to radii in RF design
- 3 µm profile accuracy for iris
- 2 – 5 µm accuracies for diameters and flatness
- Cooling geometry to be determined

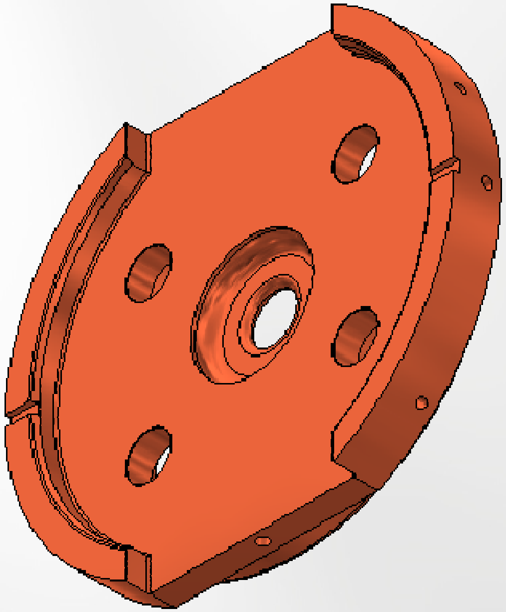




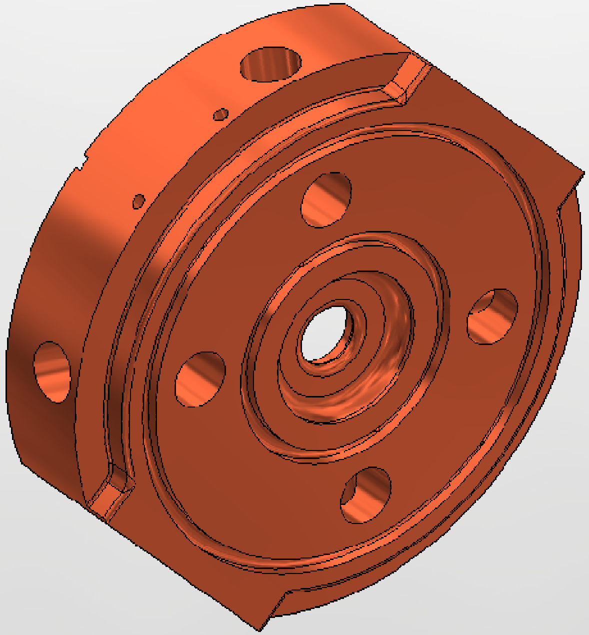


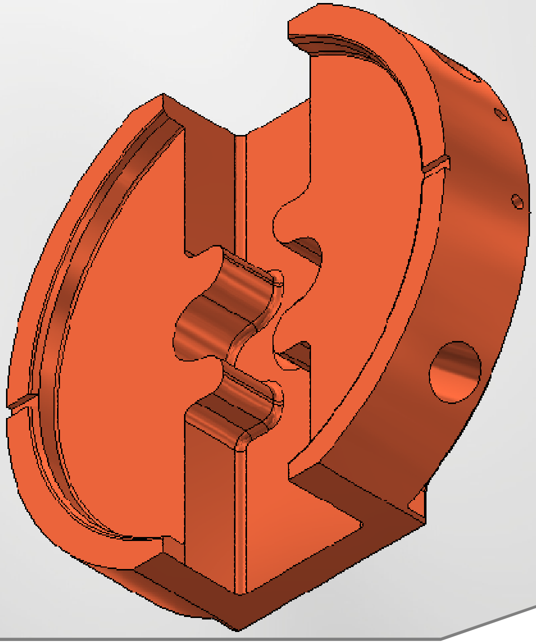
Adapter disc





Coupler

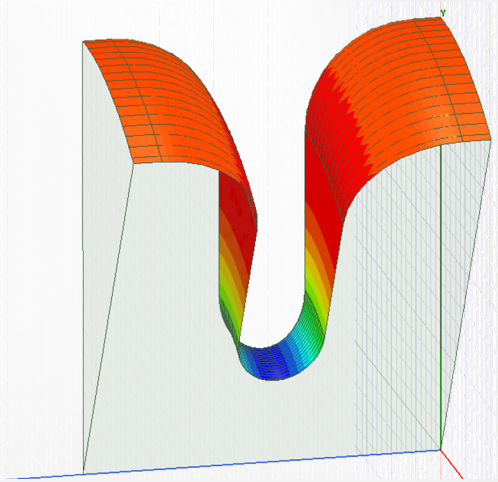




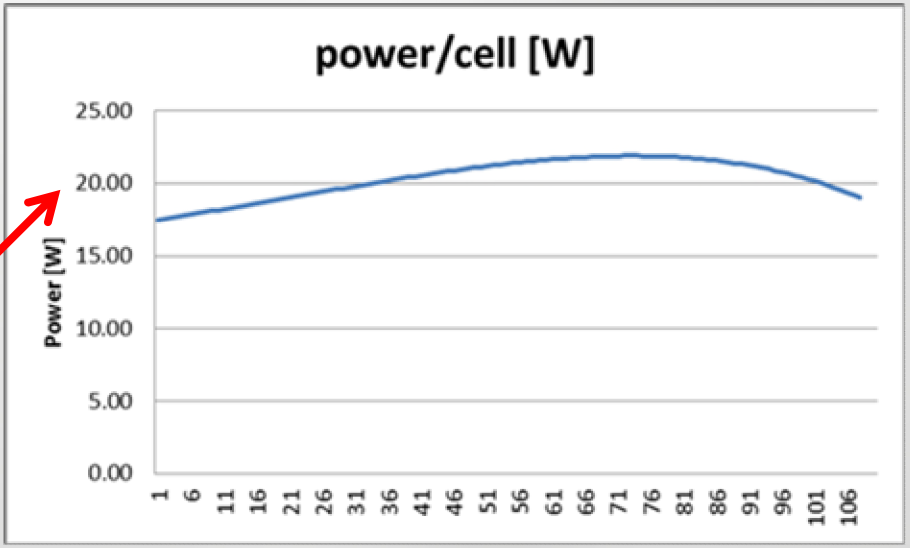
Power dissipation along the accelerator structure

Courtesy of INFN LNF; Marco Diomede

	Rep. rate [Hz]		
	100	250	1000
Average gradient <G> [MV/m]	65	32	30.4
Max klystron available output power [MW]	50	50	10
Required input power per module P_K [MW]	39	42.5	8.5
RF pulse [µs]	1.5	0.15	1.5
SLED	ON	OFF	ON
Av. diss. power per structure [kW]	1	0.31	2.2
Peak input power per structure [MW]	68	10.6	14.8
Av. Input power per structure [MW]	44	10.6	9.6
Module energy gain [MeV]	234	115	109



H field distribution

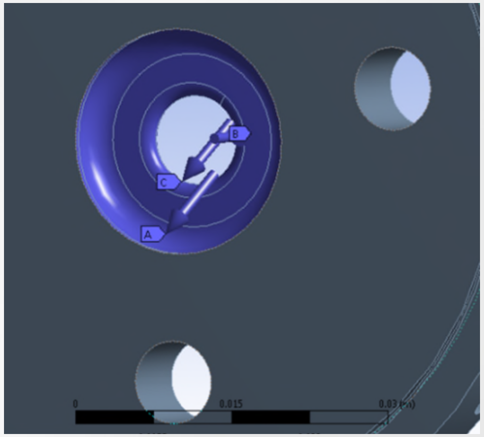


Assessment first design:

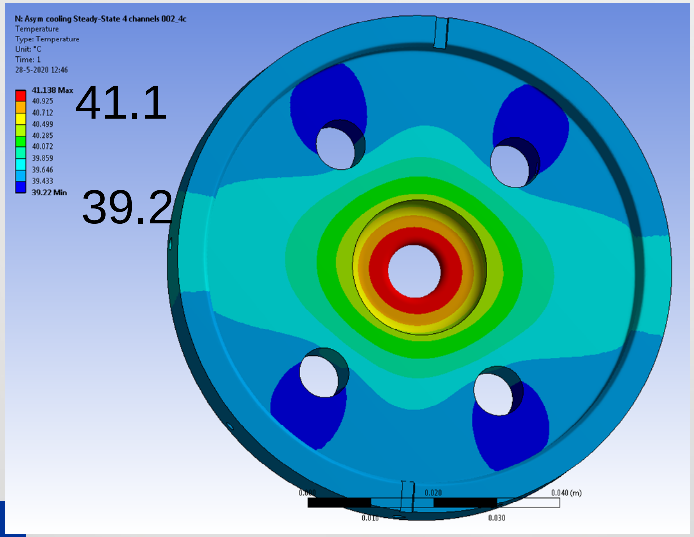
- Little room for 8 cooling channels in the couplers and adapters
- Different options modelled, asymmetric 4 channels, different diameter cooling channels

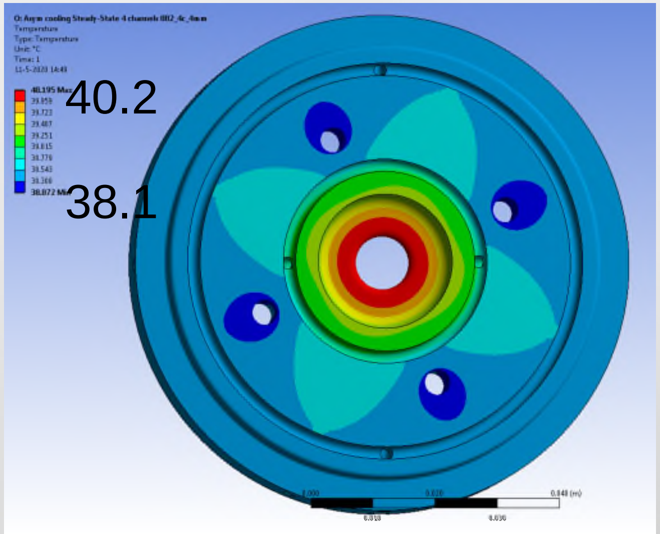
First assumptions:

- 2 l/min/channel cooling with 30 ^{o}C water
- Max 21.9 W heat flow on purple surface
- Convection/radiation on outer surface to 22 ^{o}C
- Isolated (no heat transfer) between cells



Heat load surface





Proven design approach:

- Calculate power dissipation in structure and in cell
- Define max temperature difference in accelerator structure and/or cell
- Determine delta temperature max in cooling water
- Define water flow speed
- Determine cooling layout (e.g. # channels, diameter, water temperature, flow direction)

Outlook

- Validation thermal calculations VDL by benchmarking with proven results by experts
- After benchmarking thermo-mechanical calculations, need confirmation what the influence of this is on the RF performance
  - VDL not able to perform RF simulations (yet)
- To close the loop we need knowledge/input
  - VDL has experience with PSI from other brazed structures (SwissFEL and x-band deflectors)
  - Informal contact between VDL and PSI expressed vital relation between RF, thermal and mechanical design.
  - Need to explore cooperation with RF specialists (with PSI under investigation)

Funded by the
European Union

Compact

Thank you!

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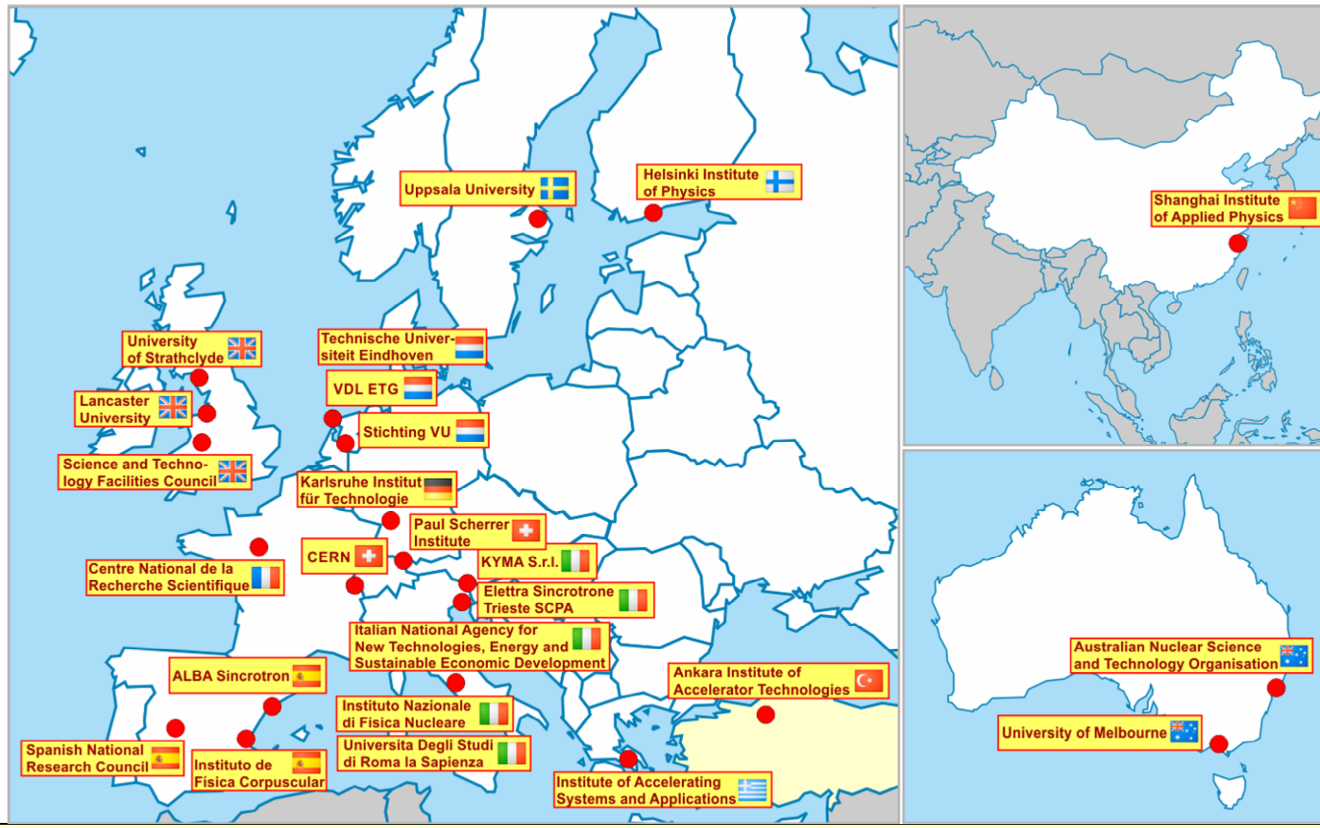

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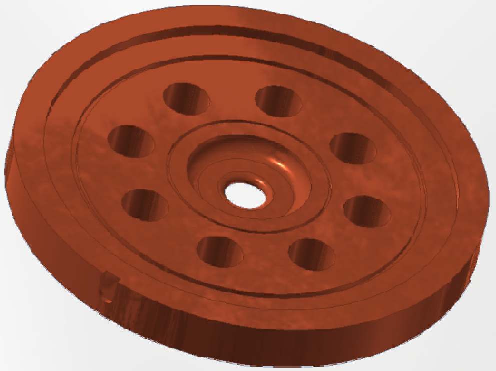
Back up slide

Open questions

- What is the mass flow you use per channel?
- What is the routing of the flow (i.e. how long is the water channel → to calculate the heat transfer coefficient)
- What is the temperature you aim at, and where is that located (ie, inside the nose, or at the TC location or … ?
- What is the max. temperature difference you allow, and is that over the length of the accelerator structure or in 1 cell, or…. ?
- Is an asymmetric temp profile allowed, is there a spec. on deformation (difference)?
- Any other tips/comments?

Discs – Costs per manufacturing steps



Item	Operation	Costs	
Tooling	Mill	1.5%	4.6%
	Diamond tool	3.1%	
General	Work preparation	1.5%	12.2%
	Programming PT / HPT	3.1%	
	Programming UPT	4.6%	
	Programming 3D metrology	3.1%	
Pre machining	Sawing	1.5%	22.2%
	Turning PT	13.0%	
	Milling HPT	6.1%	
	Annealing	1.5%	
End machining	Flycutting	5.0%	60.8%
	Turning UPT	39.0%	
	Cleaning	1.5%	
	Metrology	15.3%