Ideas for a Tungsten HCal Prototype

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Motivation

- Simulations show tungsten is a viable option as HCal material at CLIC
  - See talk by Angela Lucaci-Timoce
- Engineering solution is available
  - See talk by Ronan McGovern
- Next step: full tungsten HCal prototype

What to learn from the Prototype?

- Physics performance
  - Verify simulations (resolution, shower shapes, ...)
  - Include realistic noise levels (neutrons)

- Tungsten plate production process
  - Test production of large thin plates
  - Feasibility of needed flatness
  - Machining of tungsten plates
  - Bolting, cutouts

Use different materials – tungsten vs tungsten alloys (Inermet)

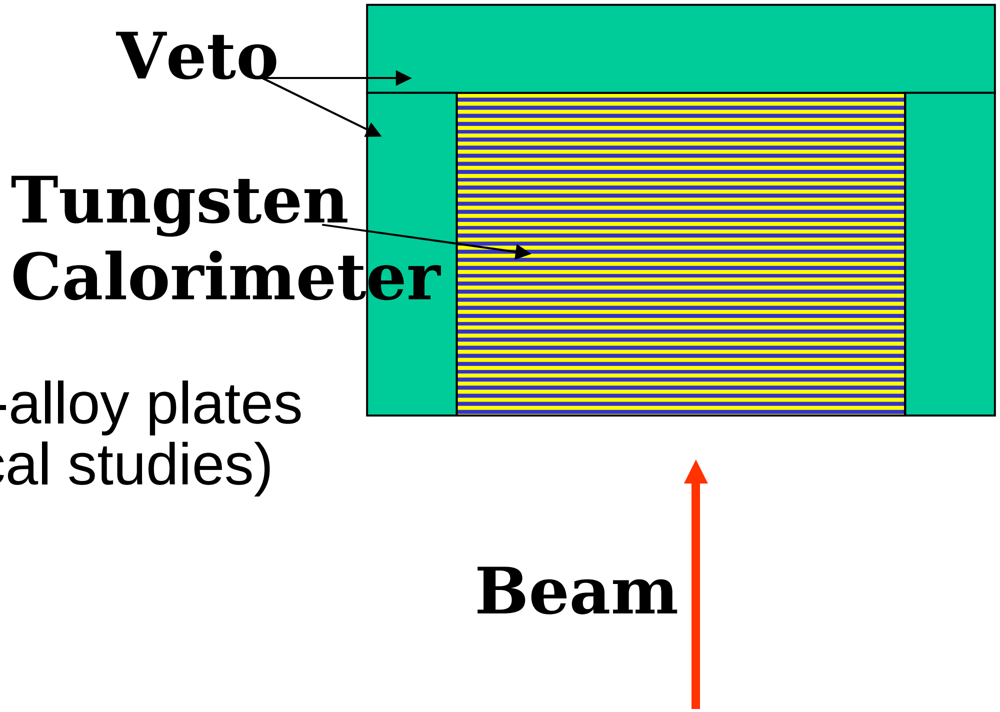
- Mechanical questions
  - Assembly in view of full HCal module

- Use existing CALICE active modules
  - Test all available technologies in combination with tungsten

- Fill empty volume with steel and use as veto → only use fully contained showers

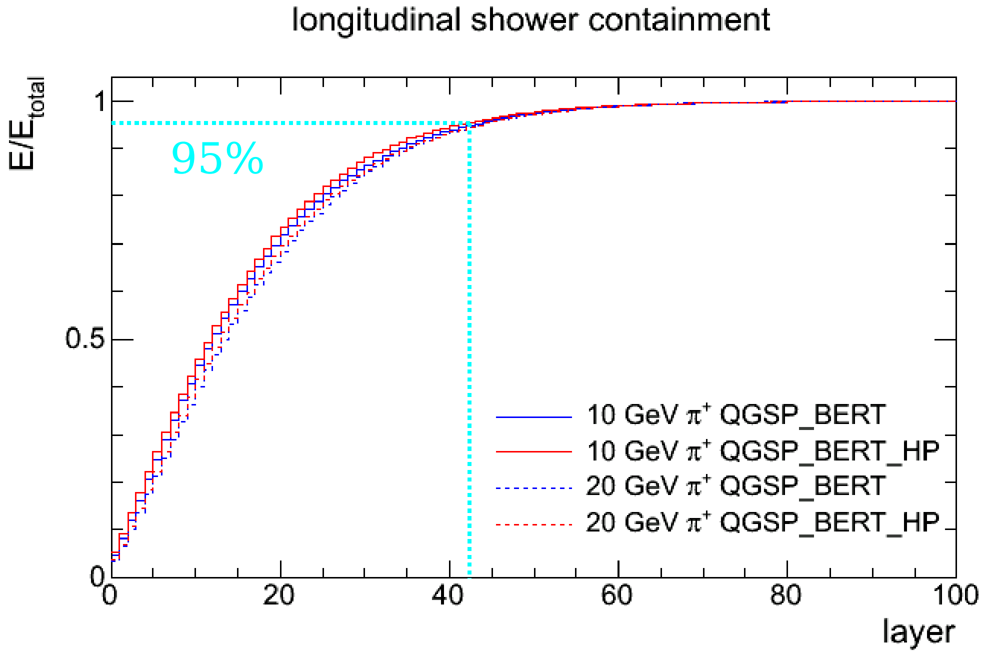
- 12 mm tungsten plates
  (to be discussed)

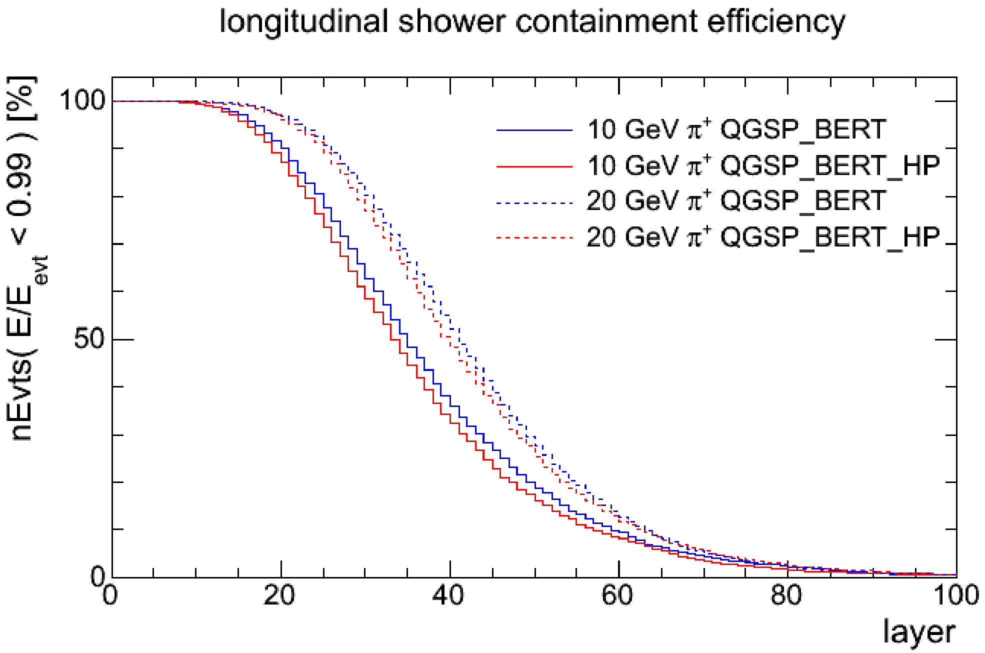
- Use pure tungsten and tungsten-alloy plates
  (no impact on physics, mechanical studies)



Longitudinal Size

- 95% contained energy → ~40 layers (~4.8 λ)
- More than 50% of the events are fully contained

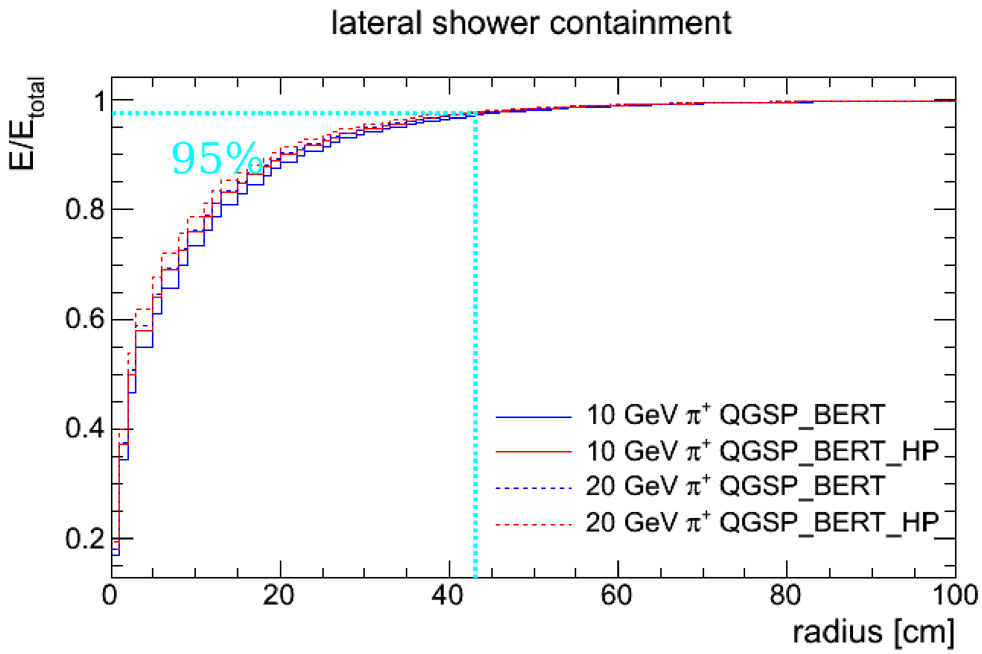


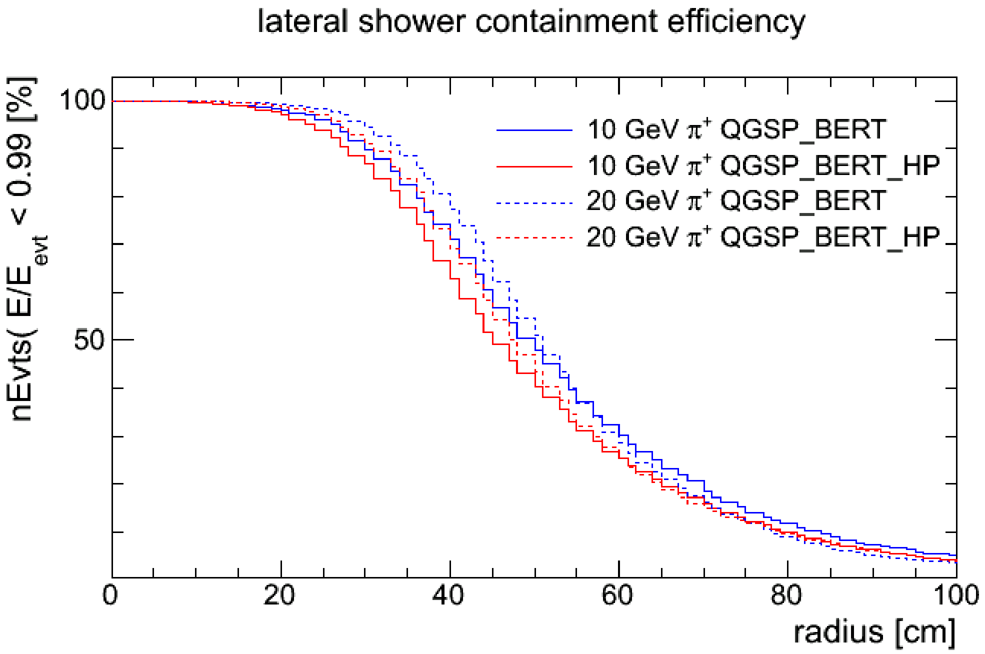


12 mm tungsten + 5 mm Scint + 2.5 G10

Lateral Size

- 95% contained energy → ~40 cm radius
- Only 20% of the events are fully contained





12 mm tungsten + 5 mm Scint + 2.5 G10

Which Dimensions?

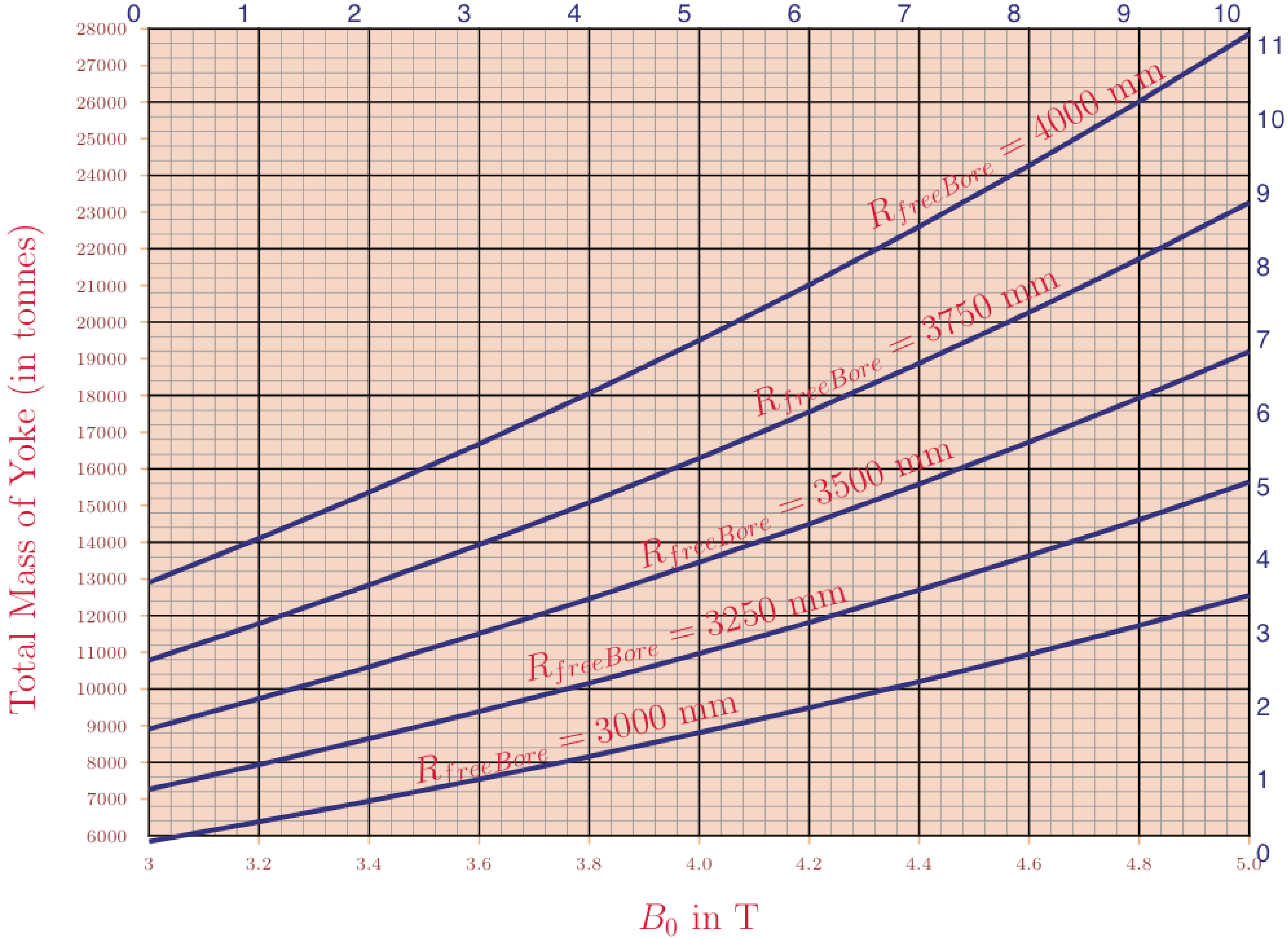
- Cut on shower size biases physics
  - Small shower → large electromagnetic fraction
  - Large shower → large hadronic fraction
- Lateral size more important than longitudinal size
  - Event selection by first interaction does not bias the physics
  - Easy to add layers later
- Cost !!!
- Tungsten weight:
  - 80 cm x 80 cm x 1.2 cm x 40 x 19 g/cm^3 ≈ 5.8 t
  - 60 cm x 60 cm x 1.2 cm x 40 x 19 g/cm^3 ≈ 3.3 t
- Really need to understand the shower composition → further simulation studies

Conclusion & Outlook

- Prototype is important step if we seriously want to investigate tungsten HCal option
- Reuse of existing active modules
  - Scintillator & MicroMegas & ...
- Possible size: 80x80x80 cm^3
  - Need further studies to understand needed size
- Tungsten HCal prototype discussion – September 24, LAPP Annecy
  - http://indico.cern.ch/conferenceDisplay.py?confId=68025
- Schedule
  - 2010 – production of tungsten plates
  - 2011 - testbeam?

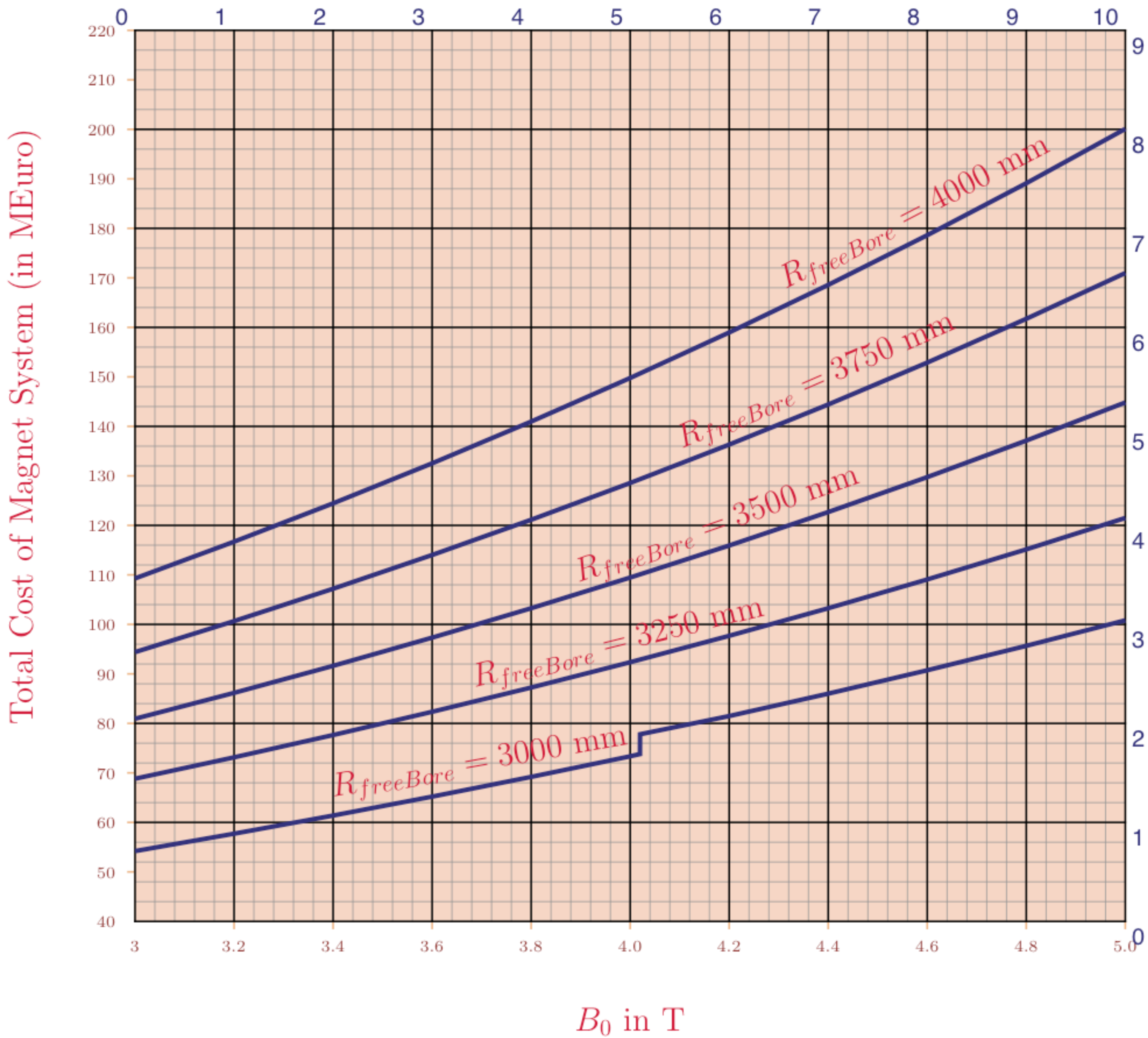
Backup Slides

Coil Parametrization



Alain Hervé

Coil Parametrization



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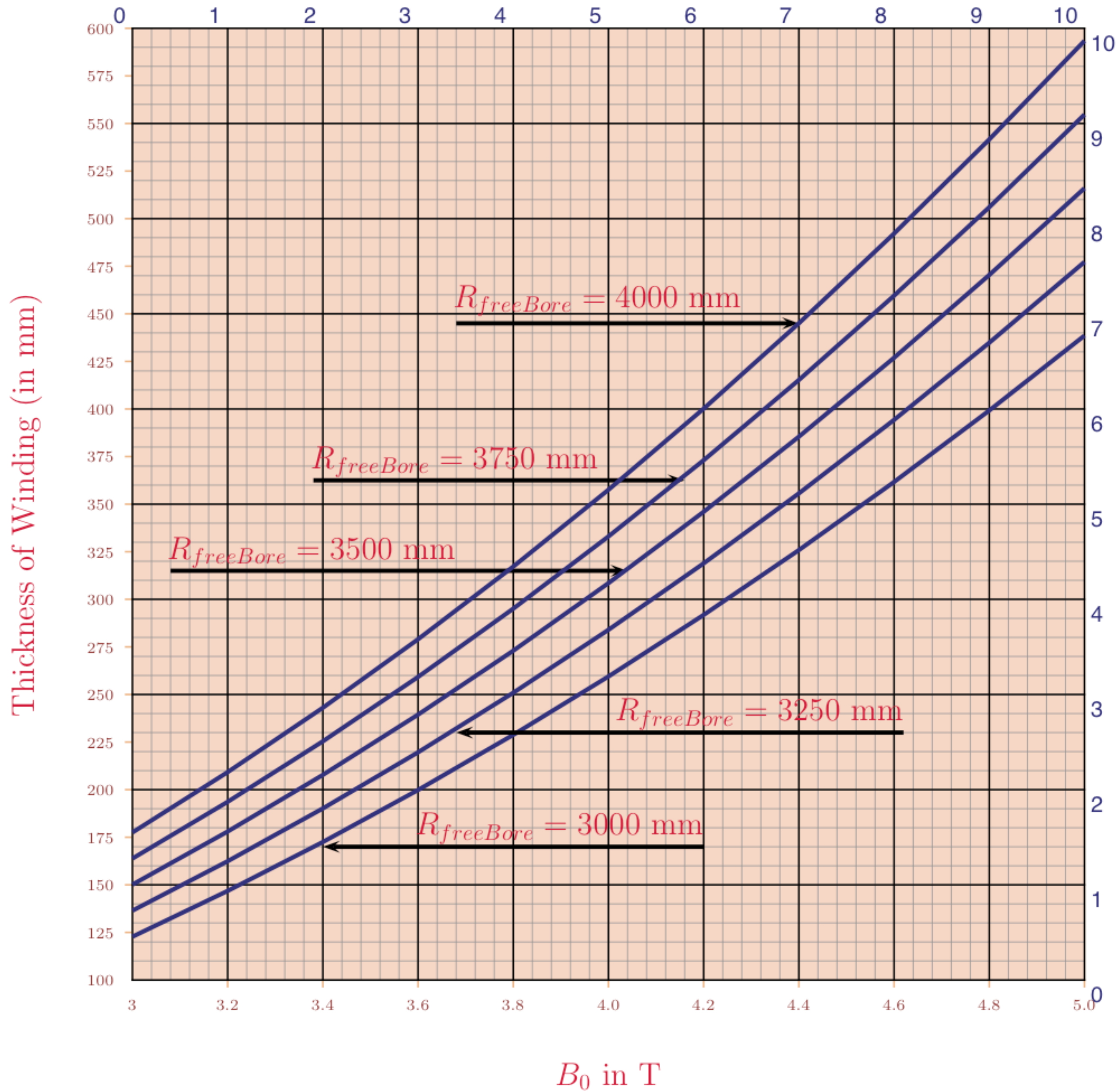
Coil Parametrization



Alain Hervé

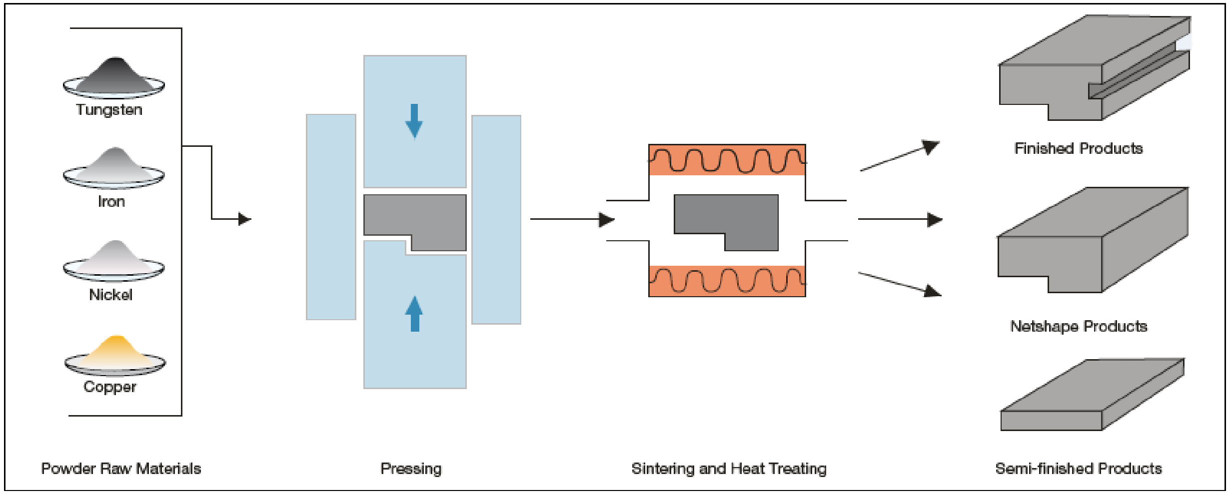
Tungsten Properties

- Pure tungsten
  - ρ = 19.3 g/cm^3
  - λ = 9.94 cm, X_0 = 0.35 cm
  - brittle and hard to machine

- Tungsten alloys with W > 90% + Cu / Ni / Fe
  - ρ = 17 – 19 g/cm^3
  - $\lambda \approx$ 10 cm, $X_0 \approx$ 0.4 cm
  - Well established production procedure
  - Easy to machine
  - Price ~ 70 Euro/kg (without machining)

Tungsten Production Process

- Starting from powder, the metal mixture is first pressed and then scintered and finally machined
- Each production step increases the density
- The main limitations are:
  - Plate size – limited by the size of the oven
  - Thin plates – it has to be somehow stable after pressing
  - todays limitations are around 10 x 500 x 800 mm^3
- We are in contact with industry to address these issues



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Tungsten Alloys

- Tungsten is usually used in alloys for better mechanical properties and machinability
- Several ferromagnetic (W,Ni,Fe) or paramagnetic (W,Ni,Cu) alloys are available

Werkstoff Material	Abkürzung Abbreviation	Chemische Zusammensetzung [%] Chemical composition [%] W	 Rest	Nominelle Dichte Nominal density	AMS-T-21014 Class
Schwach ferromagnetisch / Weakly ferromagnetic					
DENSIMET® 170	D170	90,5	Ni, Fe	17,0	1
DENSIMET® 176 / W	D176 / DW	92,5	Ni,Fe	17,6	2
DENSIMET® 180	D180	95	Ni, Fe	18,0	3
DENSIMET® 185	D185	97	Ni, Fe	18,5	4
DENSIMET® 188	D188	98,5	Ni, Fe	18,8	-
DENSIMET® D2M	D2M	90	Ni, Mo, Fe	17,2	-
Paramagnetisch / Paramagnetic					
INERMET® 170	IT170	90,2	Ni, Cu	17,0	1
INERMET® 176	IT176	92,5	Ni, Cu	17,6	2
INERMET® 180	IT180	95	Ni, Cu	18,0	3

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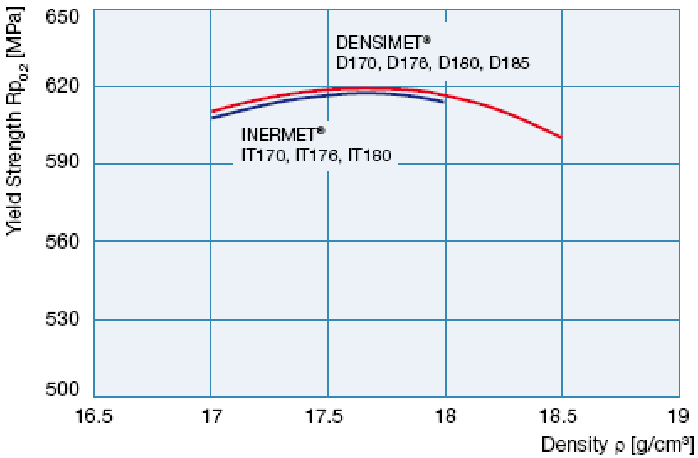
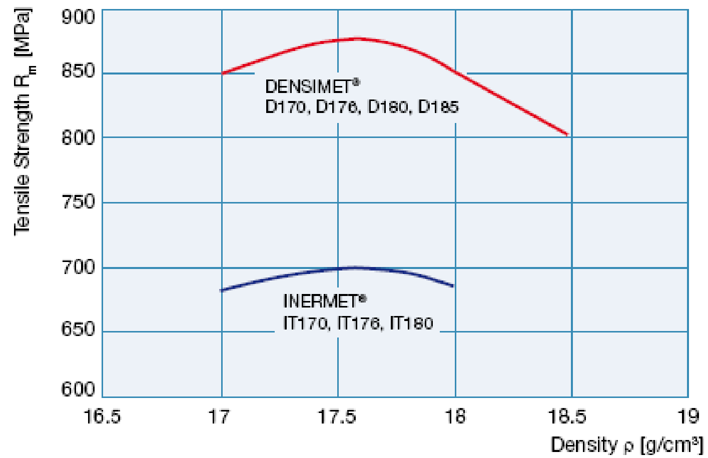
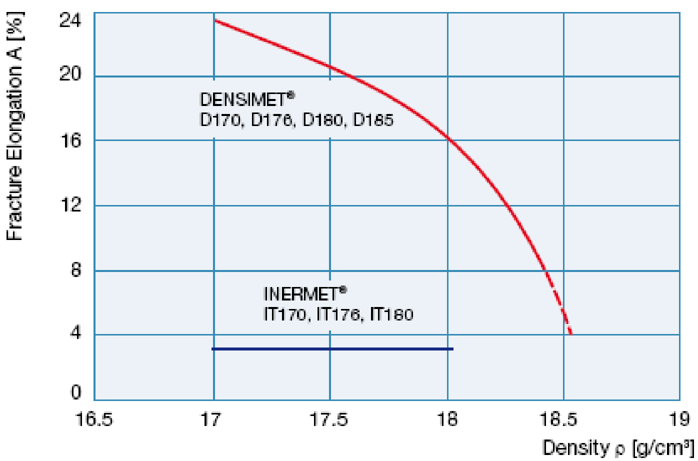
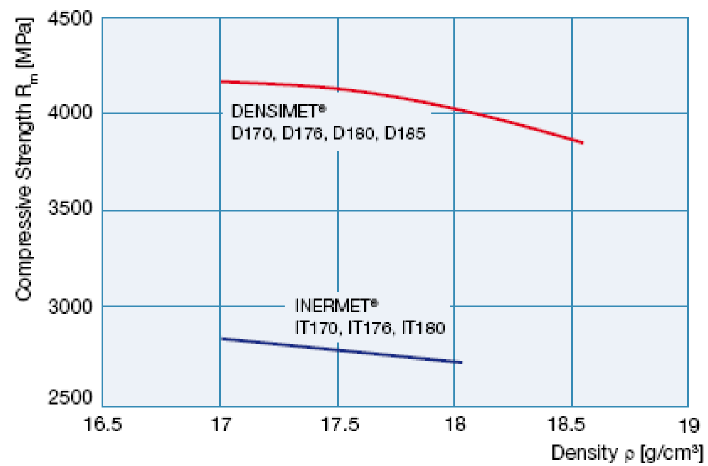
Tungsten Alloys

	D170	IT170	D176 / W	IT176	D180	IT180	D185
Elastizitätsmodul E [GPa] Young's modulus E [GPa]	340	330	360	350	380	360	385
Schubmodul G [GPa] Modulus of rigidity G [GPa]	140	125	145	135	150	140	160









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