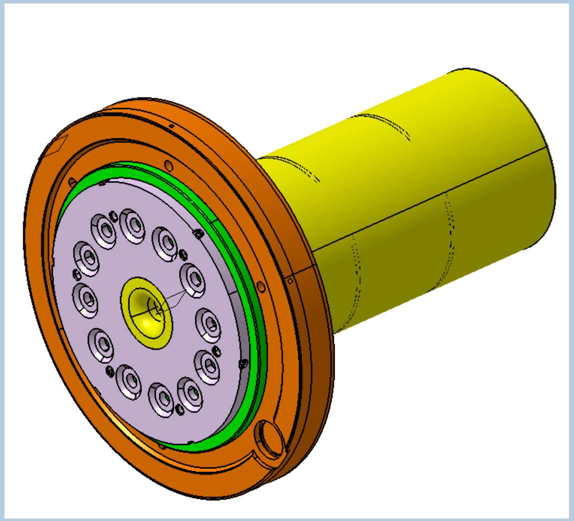
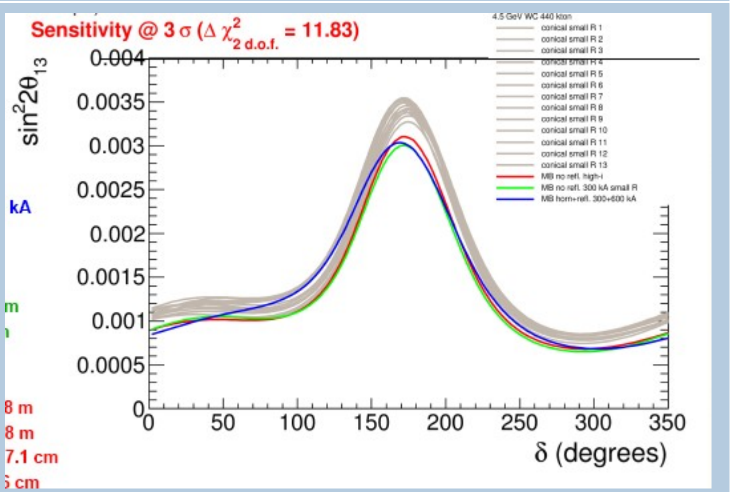
Super Beam Work package





Marco Zito
For the WP2 team

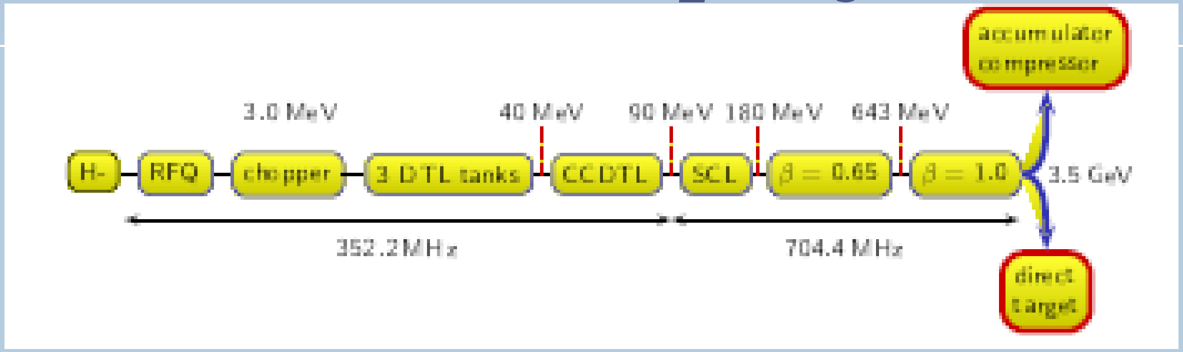
EuroNu Annual Meeting
Strasbourg
June 4 2010

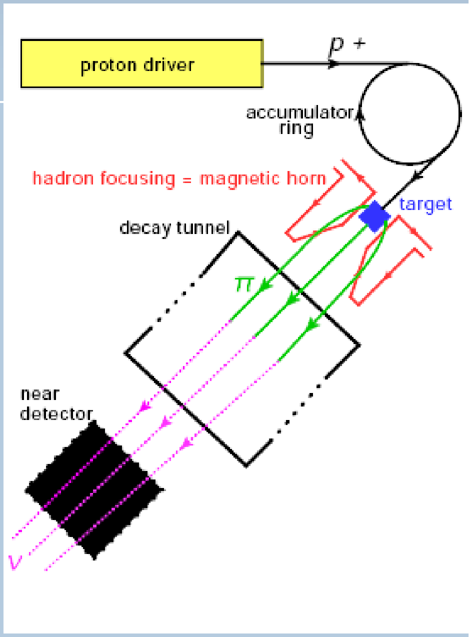
The WP2 team

- Cracow University of Technology
- STFC RAL
- IPHC Strasbourg
- Irfu-SPP, CEA Saclay

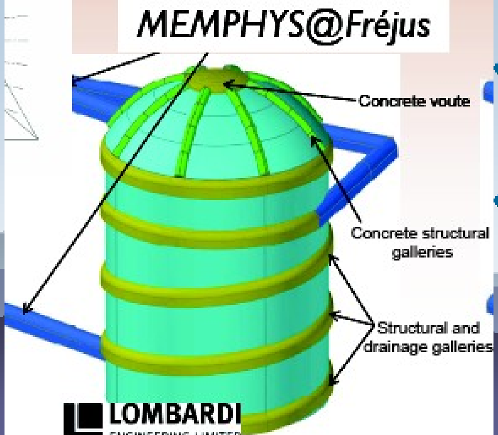
- C. Bobeth , O. Caretta , P. Cupial , T. Davenne , C. Densham, M. Dracos ,M. Fitton , G. Gaudiot, M.Kozien ,B. Lepers, A. Longhin, P. Loveridge, F. Osswald , M. Rooney ,B. Skoczen , A. Wroblewski, M. Zito

The project





- Study of the CERN to Fréjus Super Beam based on SPL
- 4 MW
- 130 Km baseline
- 5 GeV proton beam
- Focus on a solution for the target+collector



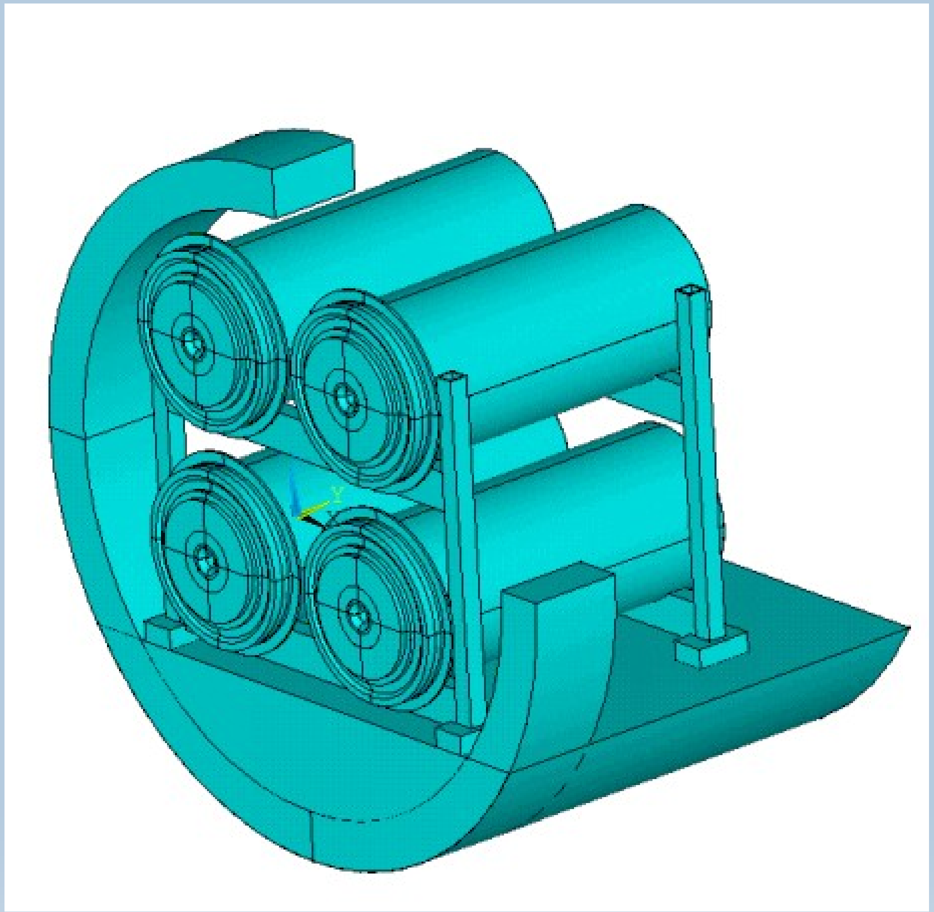
Activities

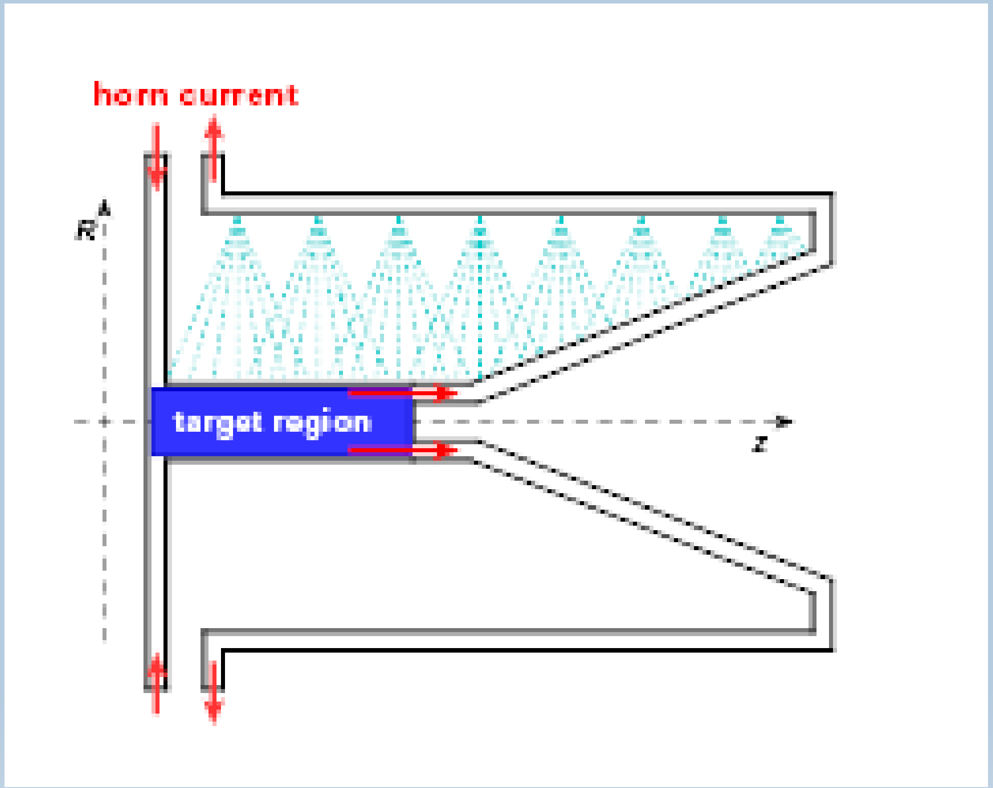
- 13 presentations in the WP2 parallel sessions
- Beam simulation, setup optimization, physics sensitivities (Saclay, Strasbourg)
- Beam/target interface (RAL)
- Target design (RAL, Strasbourg)
- Horn design (Strasbourg, Cracow)
- Target horn integration (Strasbourg, Cracow)
- Target station (RAL)
- Milestones and deliverables met successfully
- Monthly phone meetings + one face to face meeting since last plenary

Important steps forward

- Solid static target, low Z
- Use multiple (4) targets+collectors
- Each pulsed at 12.5 Hz
- Use single horn (no reflector)
- Optimization of horn shape
- A lot of progress towards a working solution, at constant (or improved) physics performance

Target and horn setup





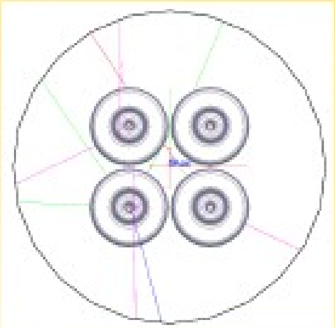
The 4-horns scenario

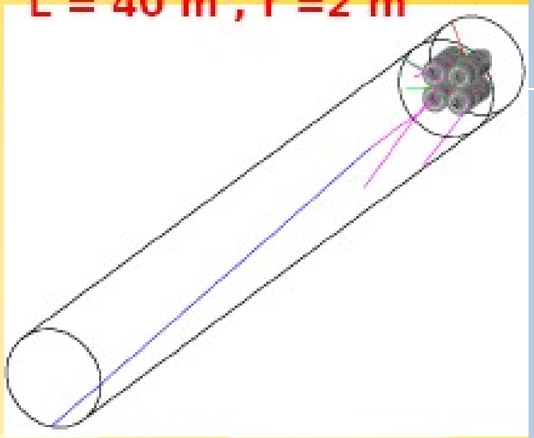
Reduced **stress** on target via
- **lower frequency** (12.5 Hz) **or**
- **lower p-flux** (1 MW)

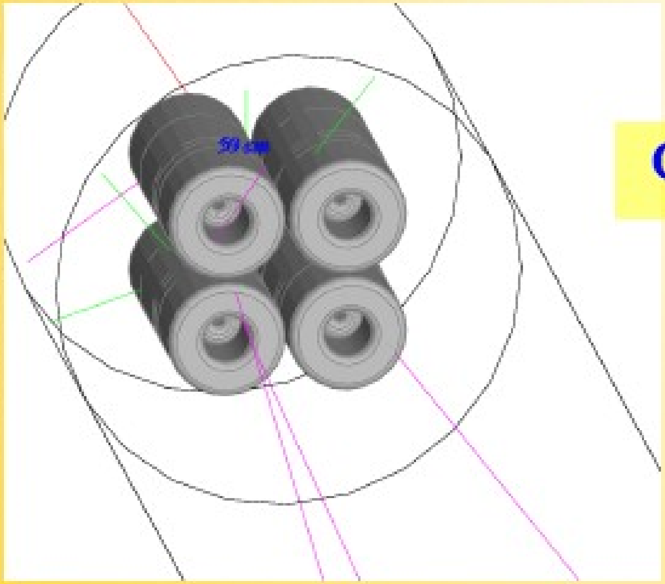
depending on injection strategy

Profits of **horn compactness**
(r~0.5m)

L = 40 m , r =2 m



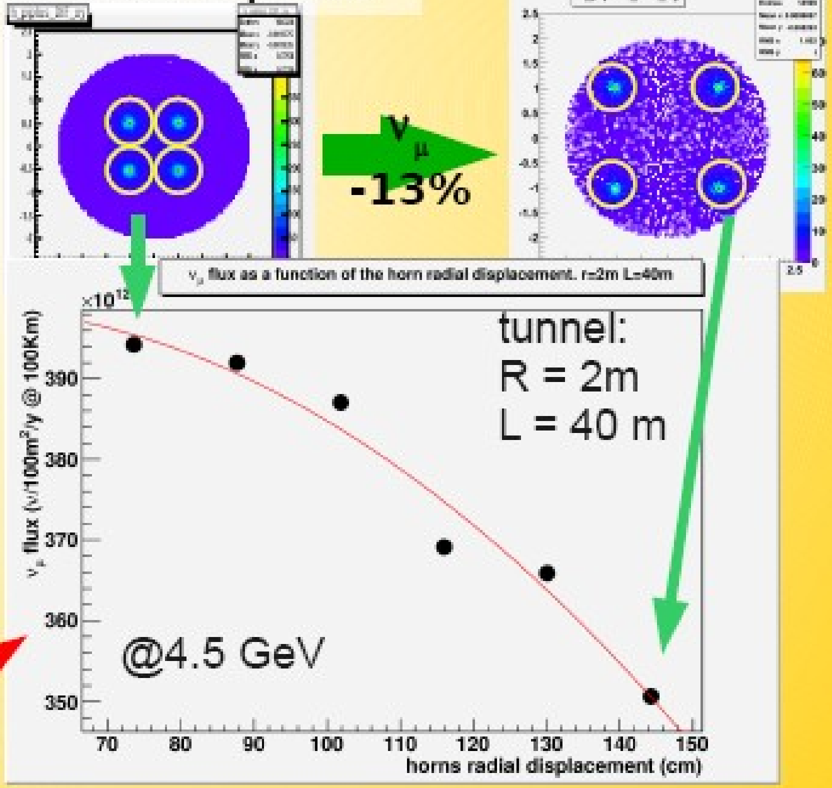




GEANT4

Baseline configuration with
horns as "central" as possible

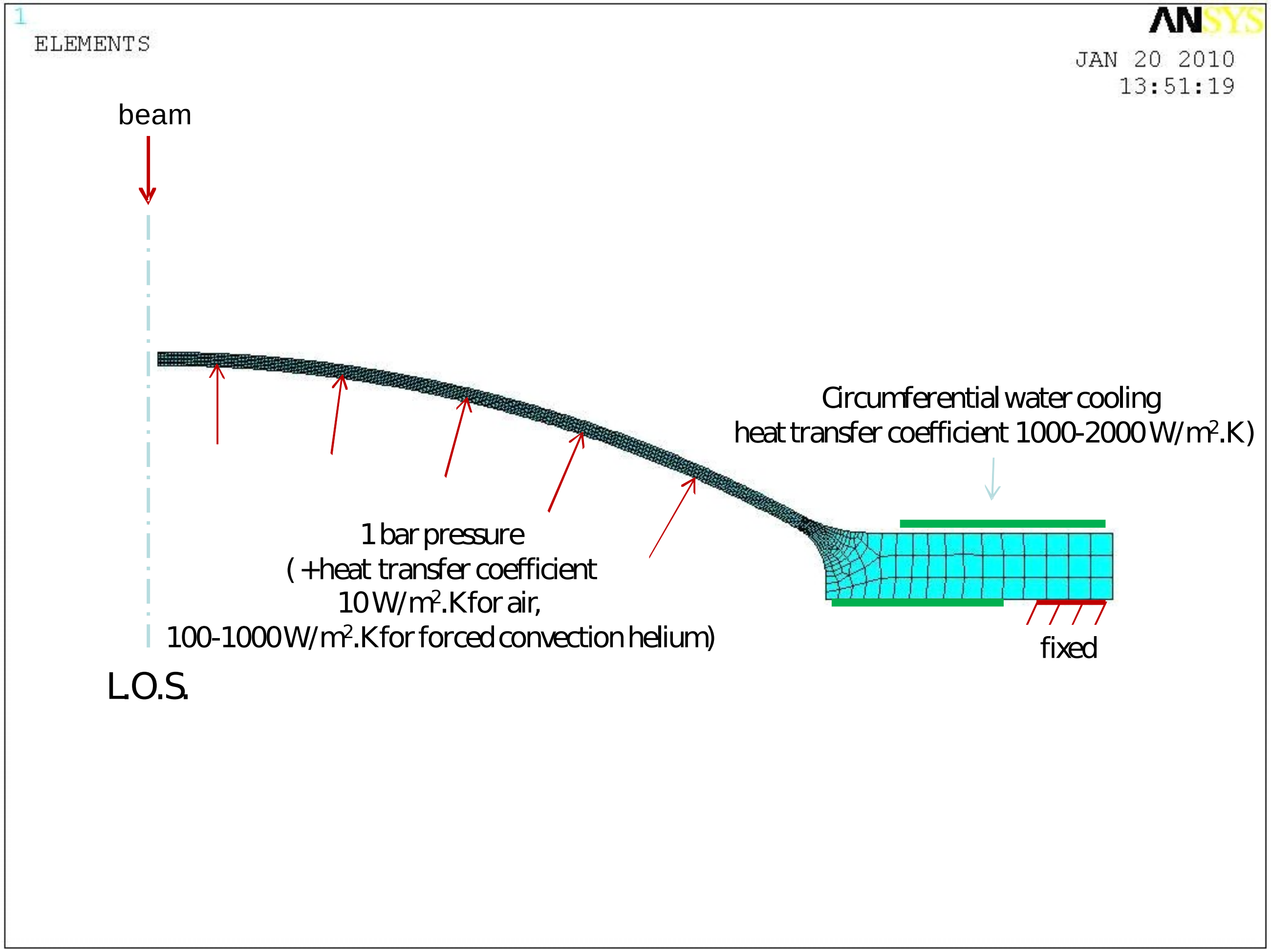
Worst case



Small flux loss even up to big lateral displacements.

Typical ANSYS model showing cooling options

M. Rooney



ANSYS Multiphysics v11 used with coupled field elements (axisymmetric model)

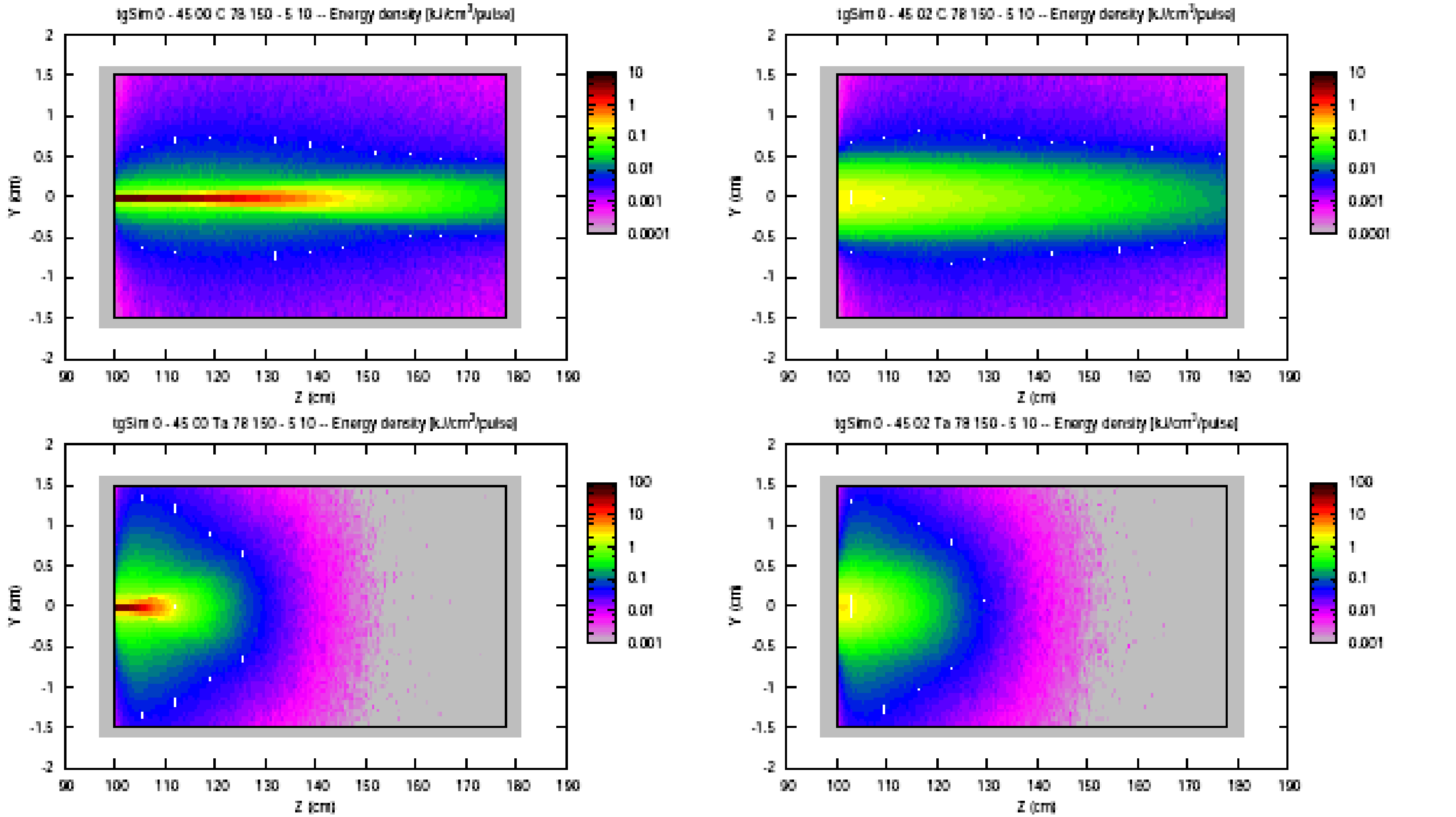
TARGET STUDIES – SUMMARY

	low-Z	high-Z
$L \sim 2\lambda_I$	(80 - 90) cm	(20 - 30) cm
pi^+	0.65 - 0.71	0.55 - 0.58
pi^-	0.44 - 0.49	0.47 - 0.50
pi^- / pi^+	0.66 - 0.72	0.85
$pi^+ \in [0.5, 0.8]\ GeV$	0.13 - 0.15	0.13 - 0.14
$pi^- \in [0.5, 0.8]\ GeV$	0.09 - 0.11	0.11 - 0.12
pi^- / pi^+	0.66 - 0.72	0.86 - 0.88
n	1.9 - 4.0	42 - 48
γ	1.9 - 5.7	50 - 54
deposited power$^{*)}$	$(170 - 290)\, kW$	$(1000 - 1300)\, kW$

$^{*)}$ for reference target at 4 MW beam power

C. Bobeth

Target studies – Energy deposition: C [upper] vs. Ta [lower]

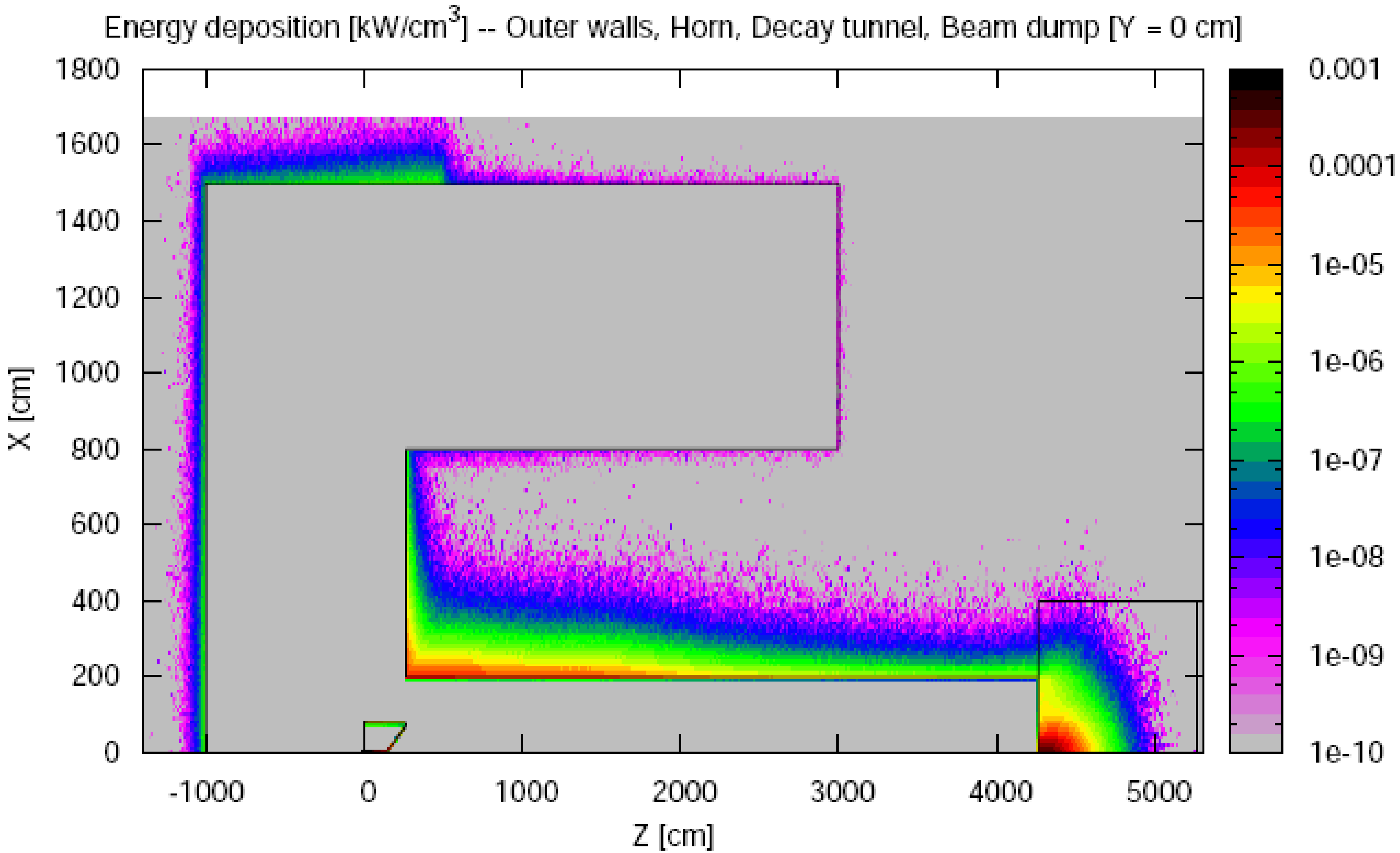


Ref. Target for beam width $\sigma^{\mathrm{bm}} = 0.0\,cm$ [left] and $\sigma^{\mathrm{bm}} = 0.2\,cm$ [right]

One order higher in Ta (high-Z) compared to C (low-Z)!

C. Bobeth

Energy deposition – all



... introduce some additional shielding for target/horn service and exchange area's

Power distribution, Beryllium

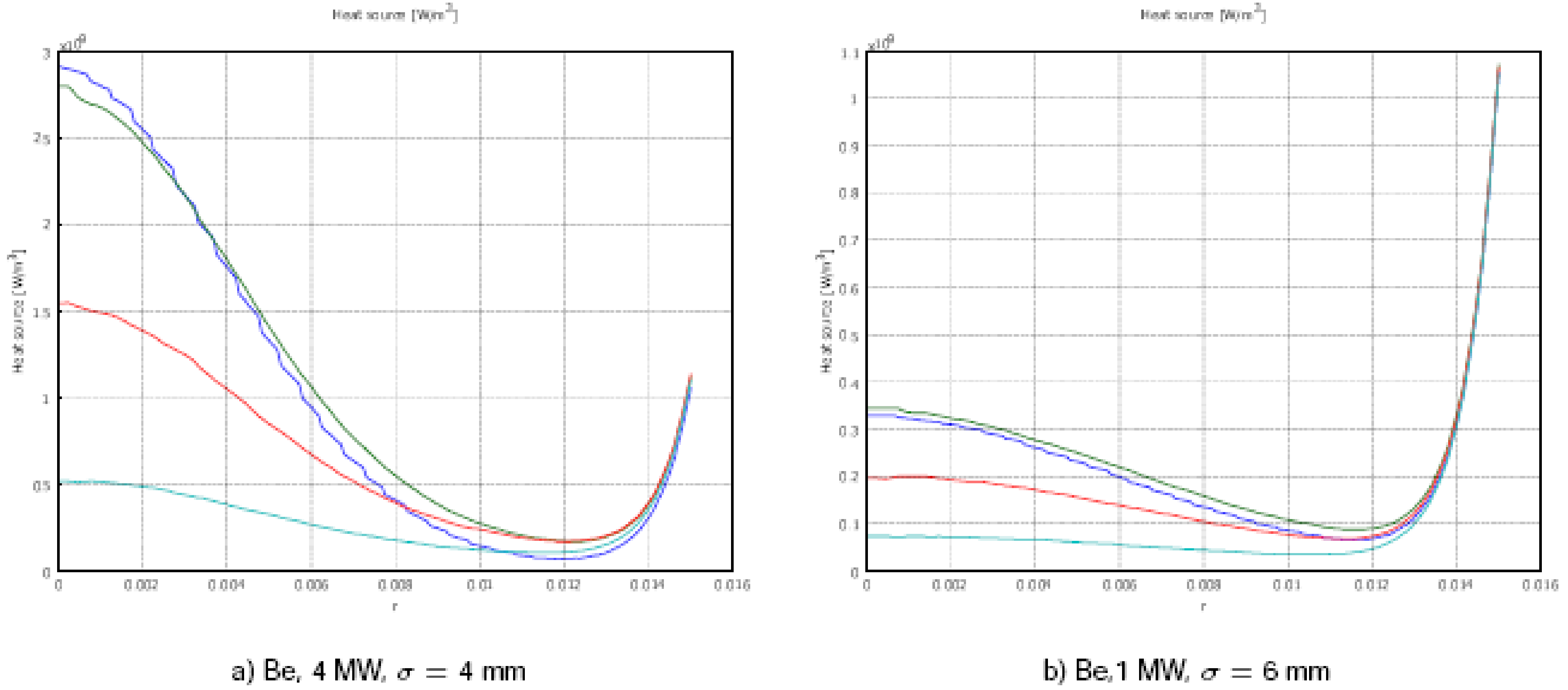
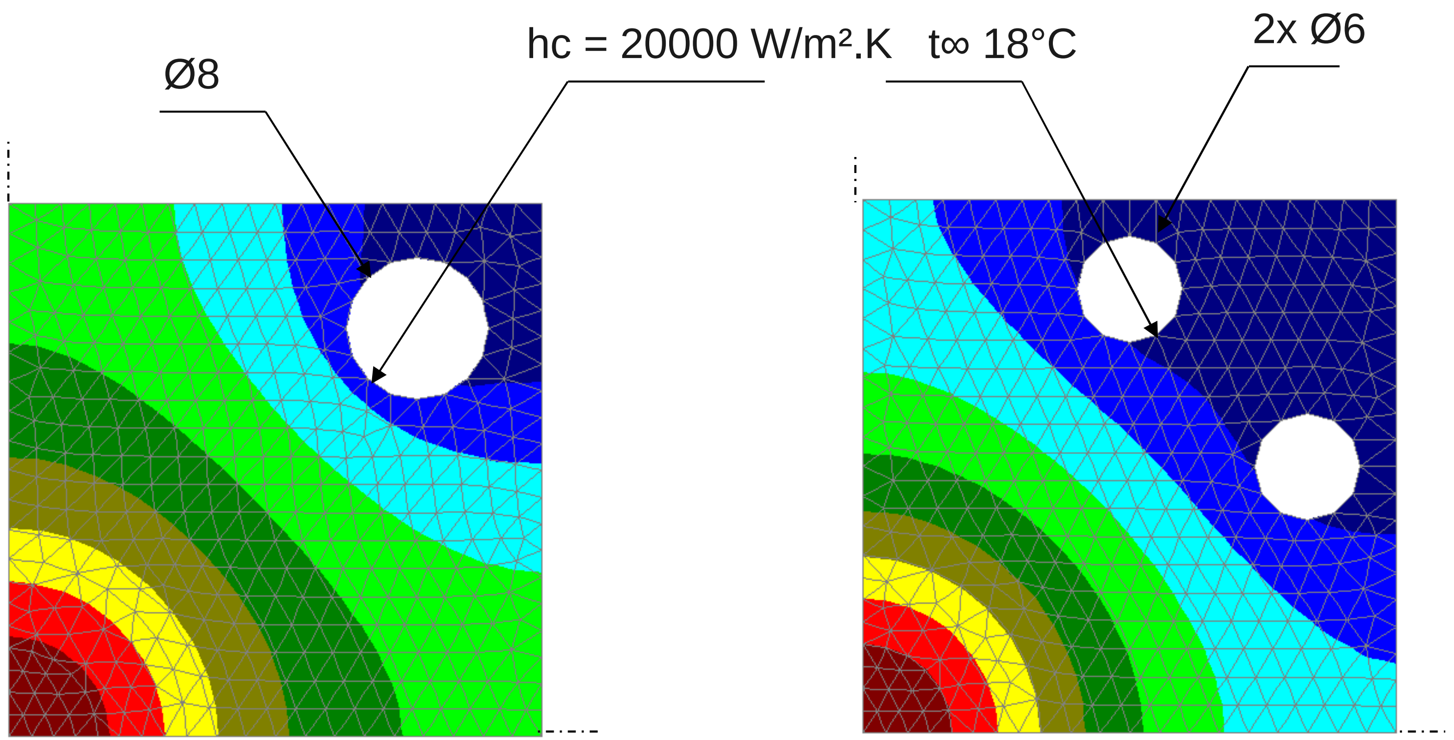


FIGURE: Power density distribution in [W/m^3] for $P^{beam} = \{1, 4\}$ MW and beam profile $\sigma = \{4, 6\}$ mm in Be target. Electrical current $i_{rms} = 15$ kA at 5000 Hz, for $z = \{0, 10, 30, 60\}$ cm (blue, green, red, light blue)



1647 °C

1319 °C

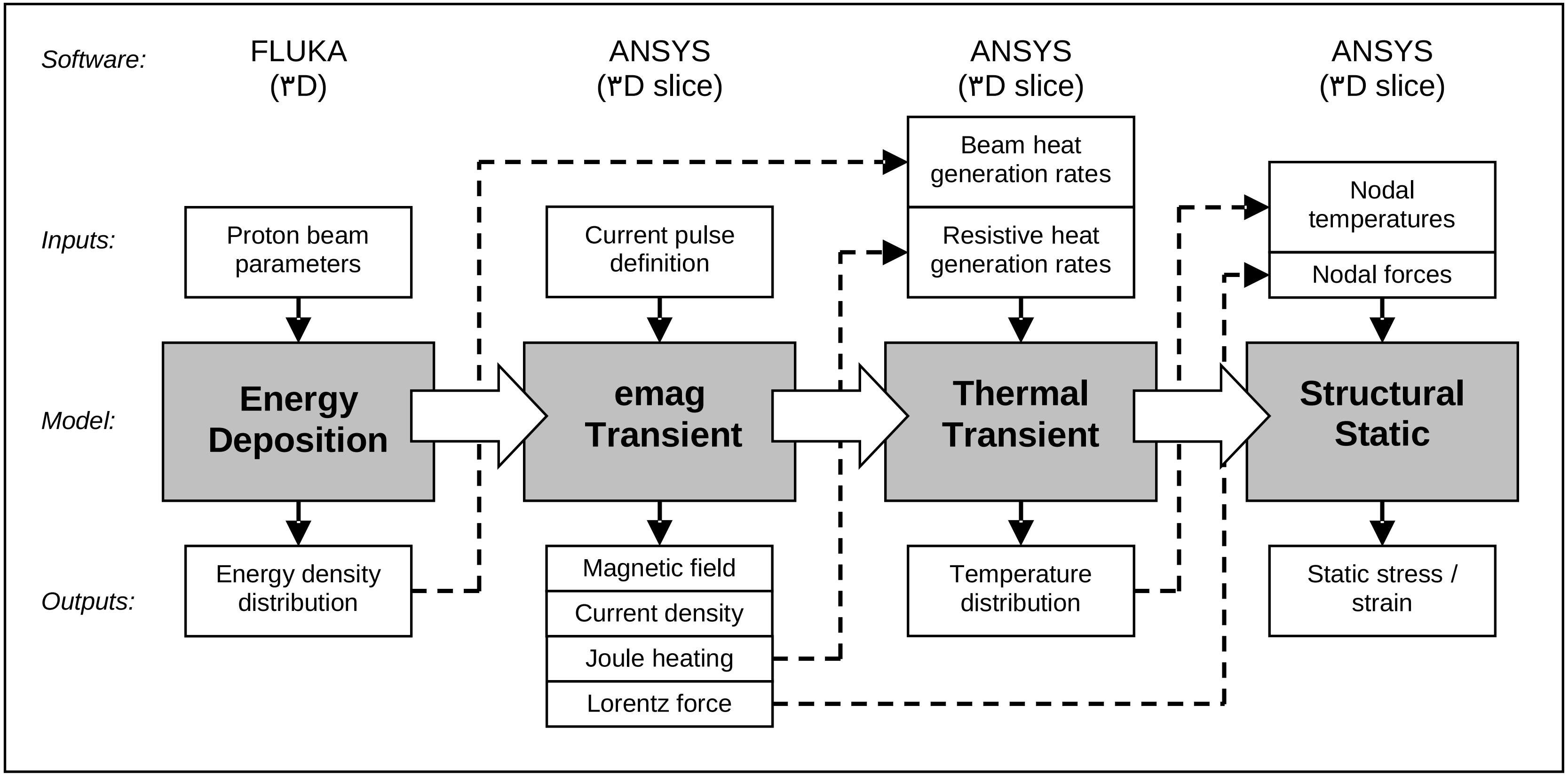
maximal temperatures

P = 3,5 W/mm^3 in Ø10 et 1,5 W/mm^3 between Ø10 and Ø20

Combined Target + Inner Conductor

C.Densham

- Analysis Process



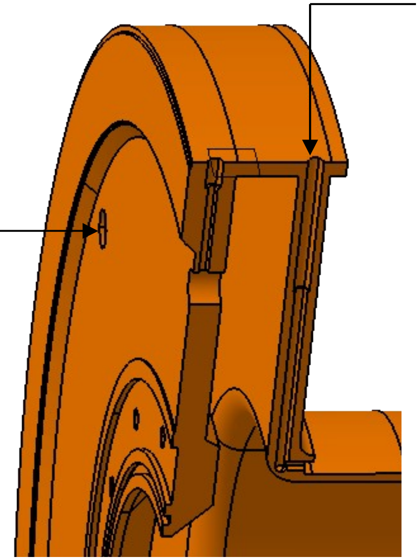
EUROnu - la corne

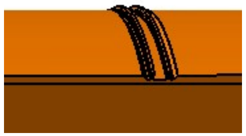
V. Zeter

Quelques détails

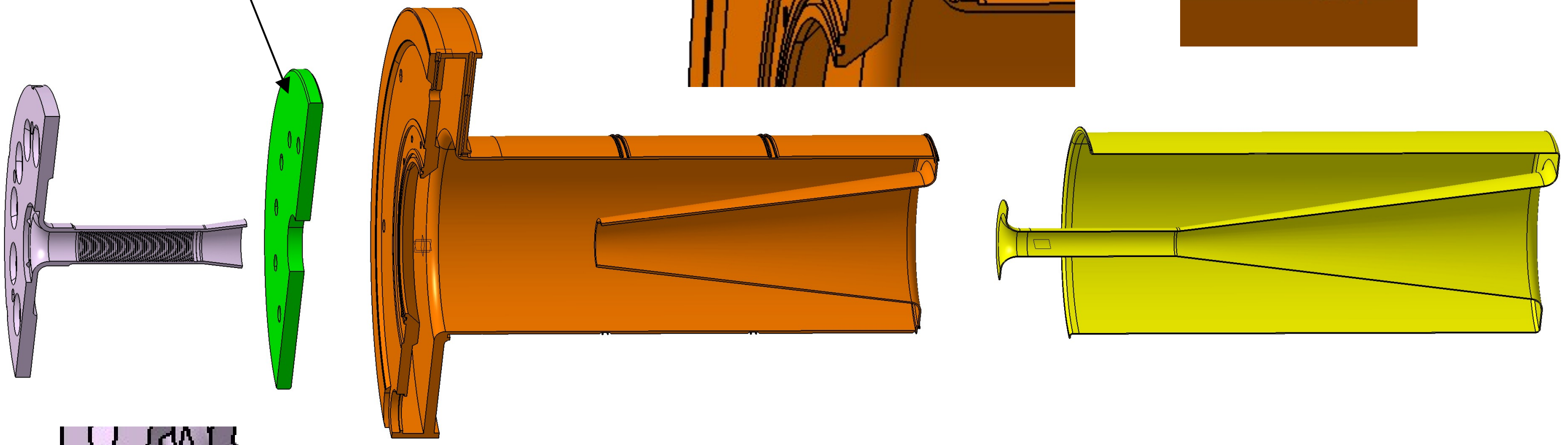
water inlets

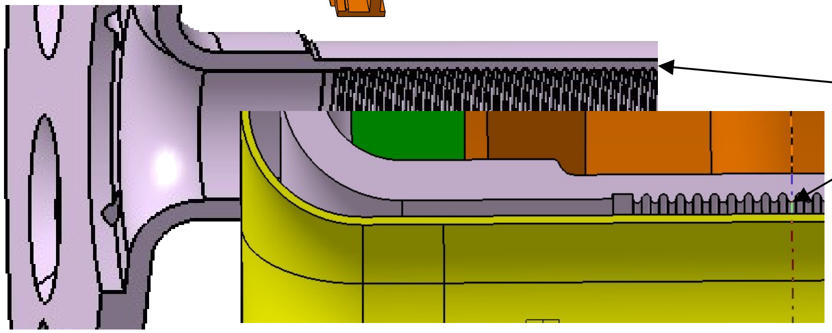
water inlets





glass insulator disc

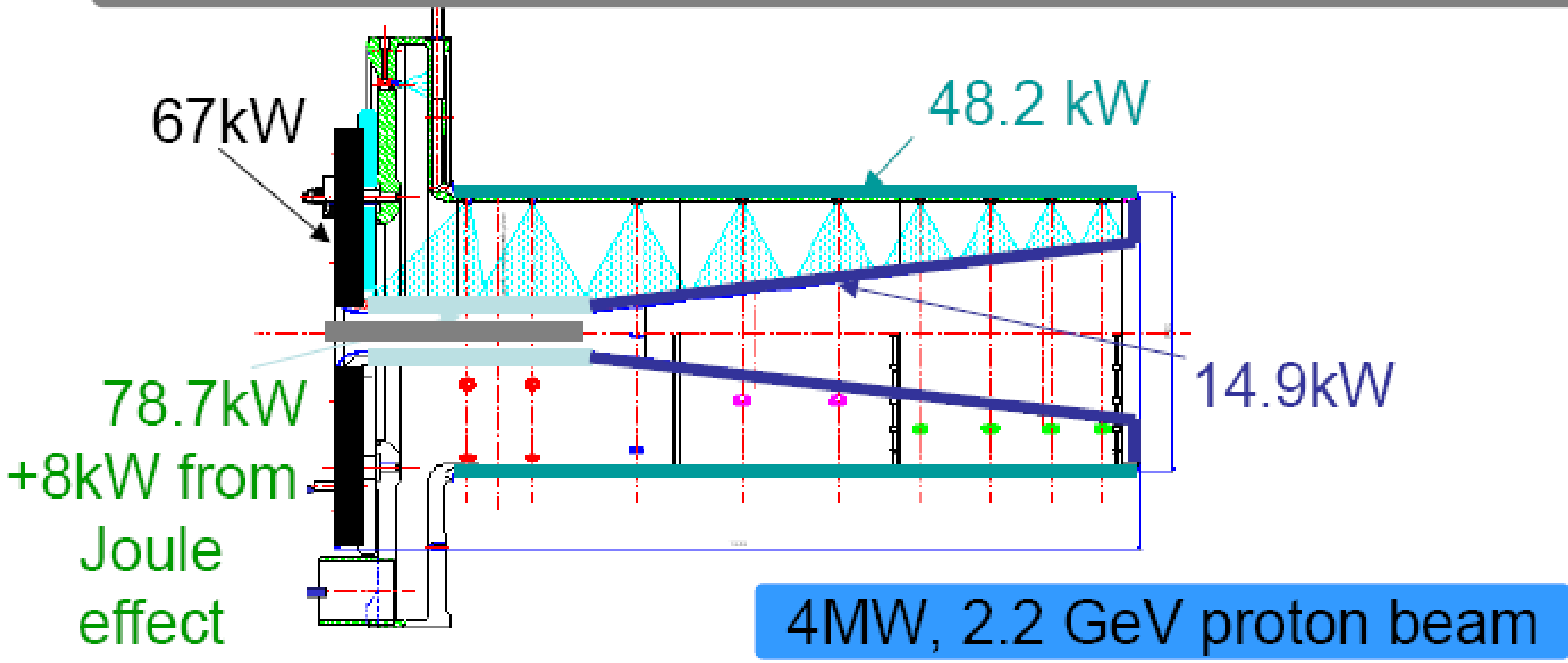




screw shaped neck

P. Cupial

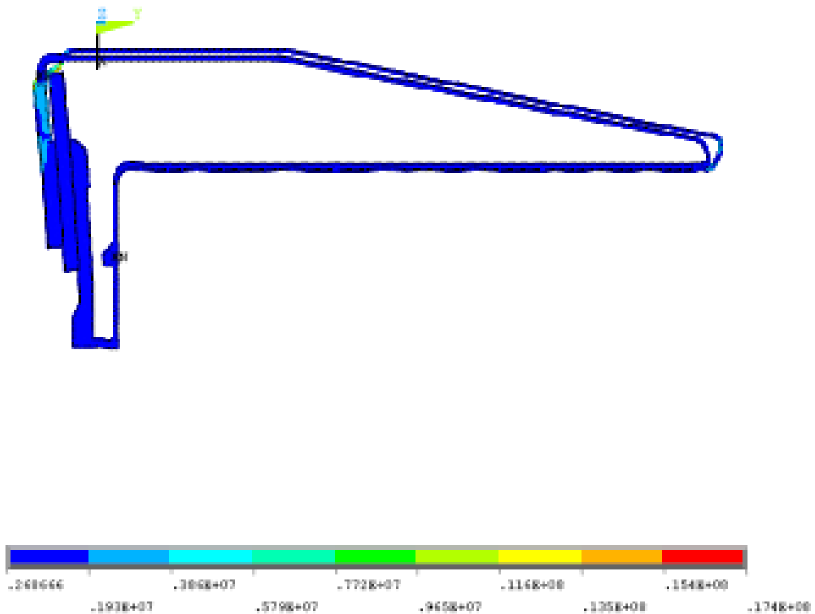
Energy deposition due to secondary particles

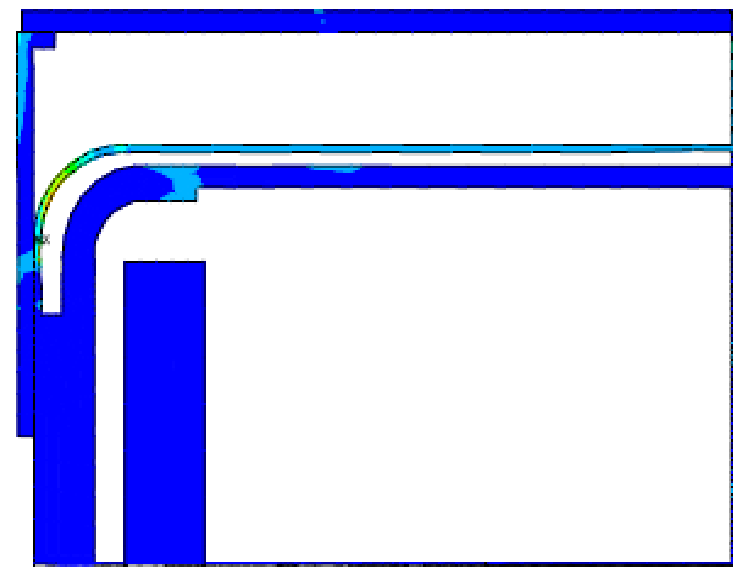


Main assumptions:

- The power dissipated is for a 4MW, 2.2 GeV proton beam and has been taken from the available sources and will be updated during the design stage when more detailed data are availabe for the Superbeam horn (recent study by C. Bobeth)
- It is assumed that the power dissipated has a uniform density. Localized power release (e.g. highly non-uniform through-thickness distribution) will effect significantly the results

Response of the horn to a pulse of secondary particles – stress levels





The equivalent (von Mises) stress is locally above 10 MPa. It stays below10MPa away from the region of localized stress.

Fatigue estimation for EUROnu horn – results of analyses

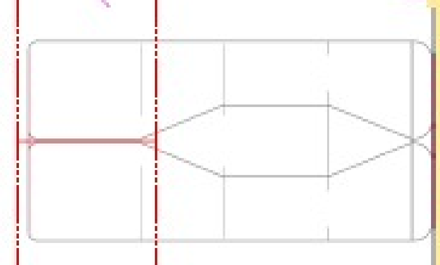
M Kozien

CRITERION	S1 THERMAL STRESS [MPa]	S2 THERMAL STRESS [MPa]	S3 THERMAL STRESS [MPa]	DYNAMIC VM STRESS [MPa]	FATIGUE STRESS [MPa]	CRITICAL VALUE [MPa]
MORROW	0.1	- 5.5	15.6	20	20.7	100
CROSSLAND	0.1	- 5.5	15.6	20	11.8	60

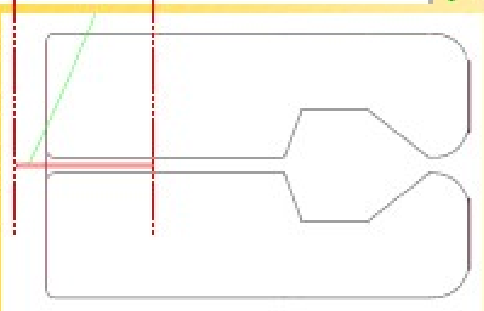
Sensitivity curves for tuned configurations

Conical horns (see next presentation by Christoph)
MiniBoone 300+600 kA 4 cm inner r
MiniBoone 300 kA 1.2 cm inner r
MiniBoone 400 kA 4 cm inner r

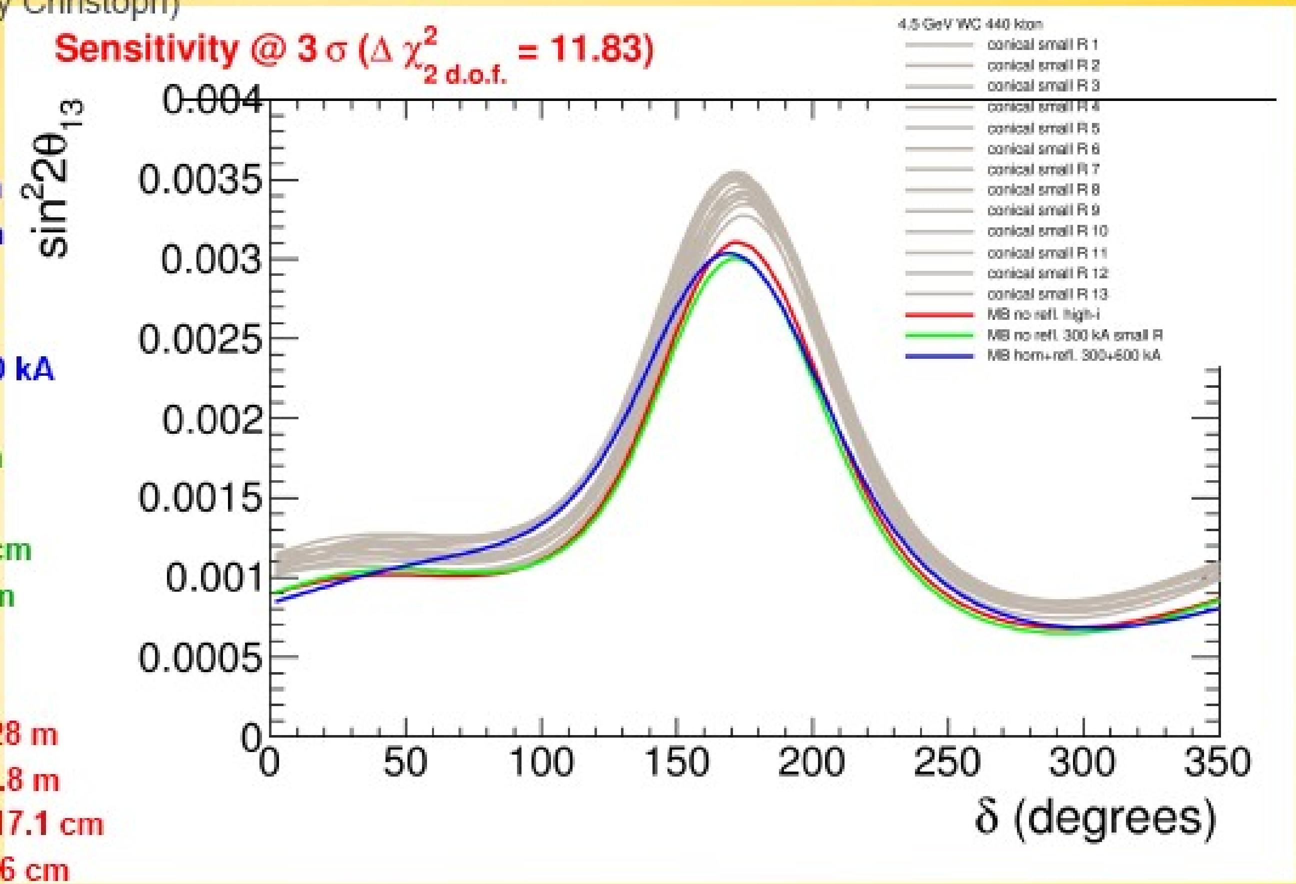
L_{tun} = 28 m
r_{tun} = 1.8 m
z_{tar} = 0 cm
R_0 = 4 cm
I = 300/600 kA



L_{tun} = 25 m
r_{tun} = 2 m
z_{tar} = -6.8 cm
R_0 = 1.2 cm
I = 300 kA



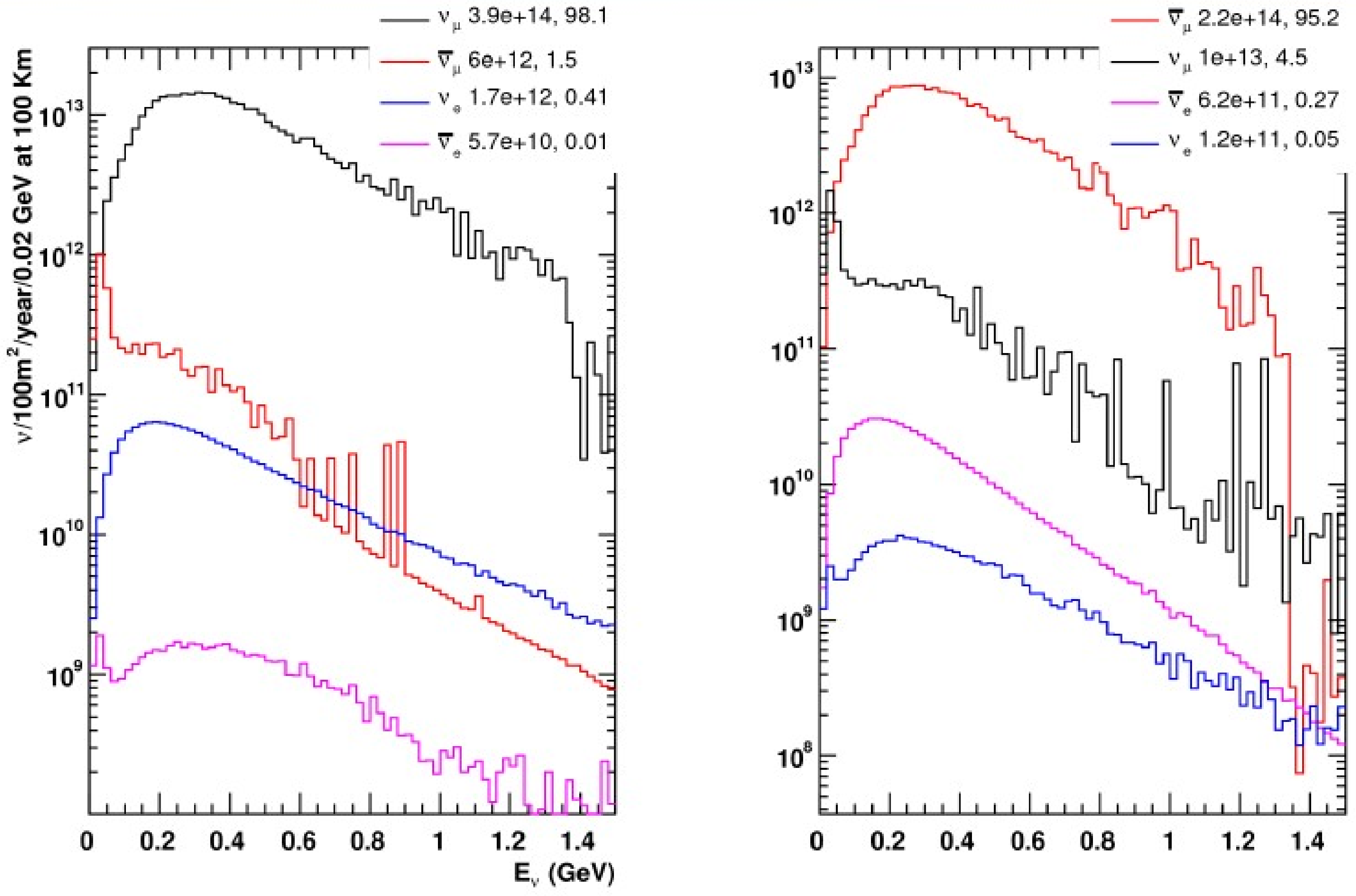
L_{tun} = 28 m
r_{tun} = 1.8 m
z_{tar} = -17.1 cm
R_0 = 4.6 cm
I = 390 kA



- similar/better exclusion obtainable even without reflector
  - using high current (400 kA and large outer radius) or
  - using 300 kA current and allowing for a small inner radius 1.2 cm
- conical shapes worse on average p
  - perform an optimization with similar tools

A. Longhin

Optimized setup: fluxes

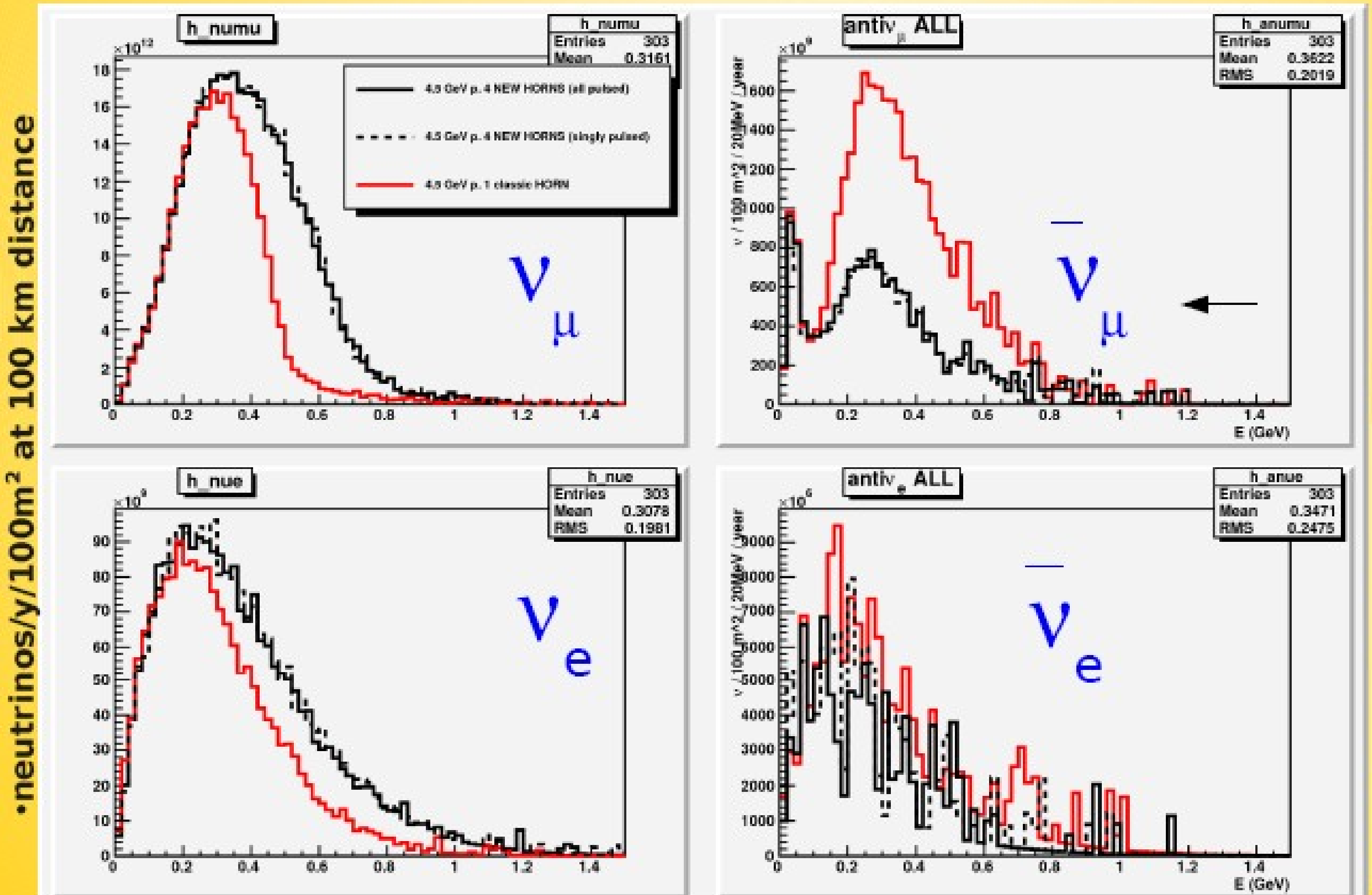


A. Longhin

Fluxes: new VS old horn

Carbon target
new horns / old horn

- gain ν_μ at higher energies
- Effectively suppressed contributions from wrong charge pions (more than a factor 2 less anti-ν_μ, lower anti-ν_e +c.c.)



GEANT4

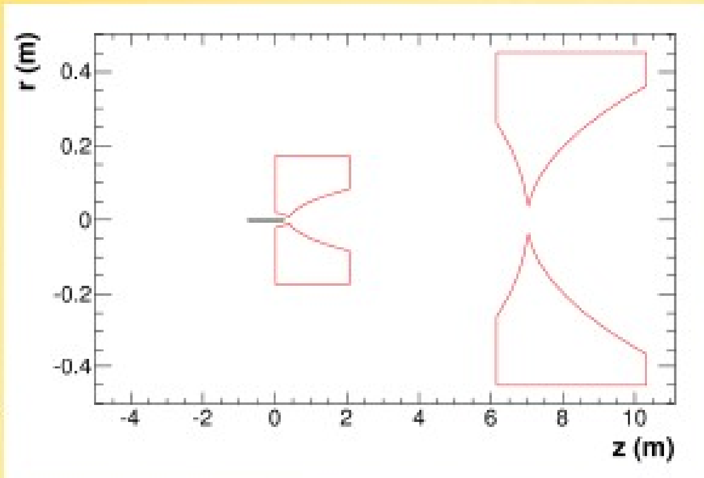
@ 4.5 GeV positive focusing

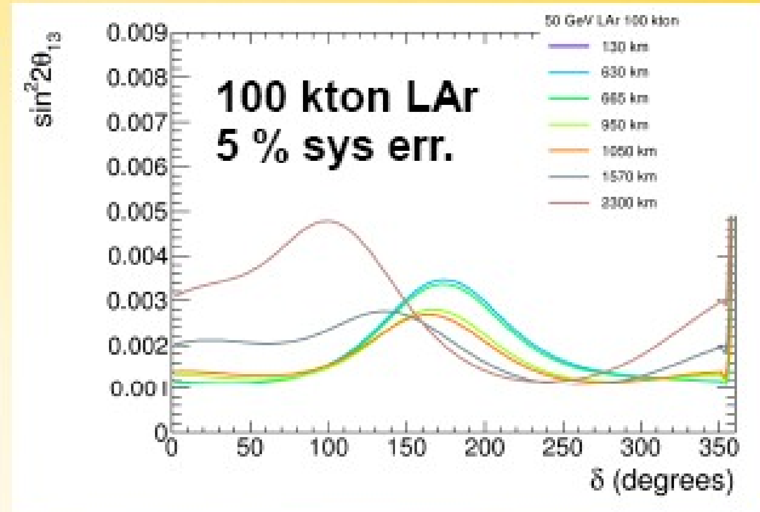
	OLD (%)	NEW (%)
+ FOCUSING		
ν_μ	88.9	-> 95.55
aν_μ	10.5	-> 3.9
ν_e	0.6	-> 0.56
aν_e	0.052	-> 0.025
- FOCUSING		
ν_μ	26.1	-> 11.2
aν_μ	73.4	-> 88.4
ν_e	0.17	-> 0.09
aν_e	0.34	-> 0.35

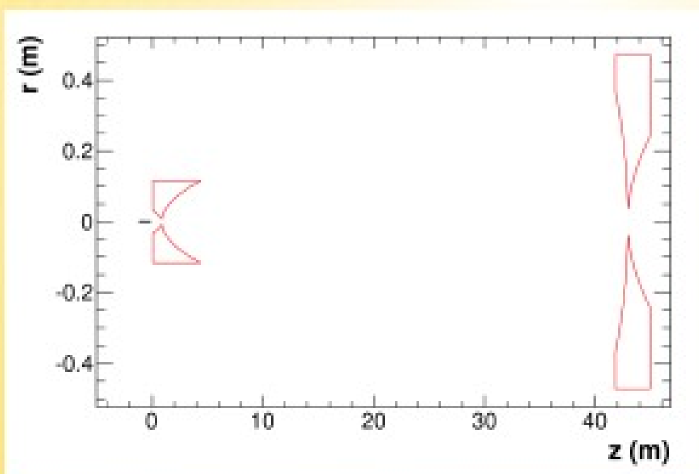
Other Super Beam options (@ higher E, L)

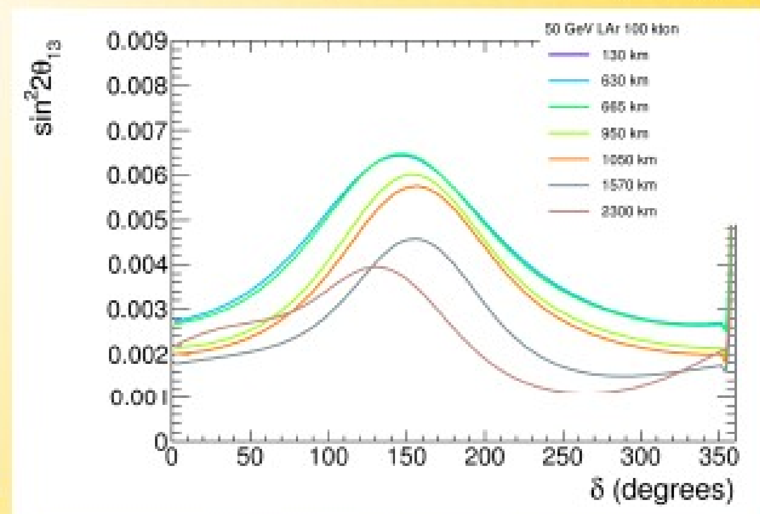
The GEANT4 simulation and optimization tools are being used to study Super Beams from a 50 GeV proton driver ("HP-PS2") to LAGUNA sites equipped with a 100 kton LAr detector

study ongoing within the LAGUNA-WP2 (physics)









Deliverables

Deliverable	Delivery date (months)	
Requirements for proton driver	6	Completed
Target and Collection design report	30	
Target and Collection integration	36	
Beam characteristics	36	
Final report	48	

Milestones

Milestone	Delivery date (months)	
Proton driver report	12	Completed
Prel. Design of Target and Collection	24	
1st Target and Collection integration drawings	24	
1st Est. of Nu Beam Intensity	24	
Final Target and Collection integration drawings	36	
Design of target station	40	
Report on Nu Beam Intensity	42	

Next steps

- Rapid progress towards the preliminary design
- Ongoing studies on all the key component of our project
- Including the tools for physics performances and optimization
- Important task for the next month: finalize studies towards the baseline technology for the target