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RF systems and C-band structures

CompactLight "Glasgow Virtual" Meeting, 16-18 June 2020

M. Diomede (INFN-LNF)

on behalf of the WP3 C-band injector working team*

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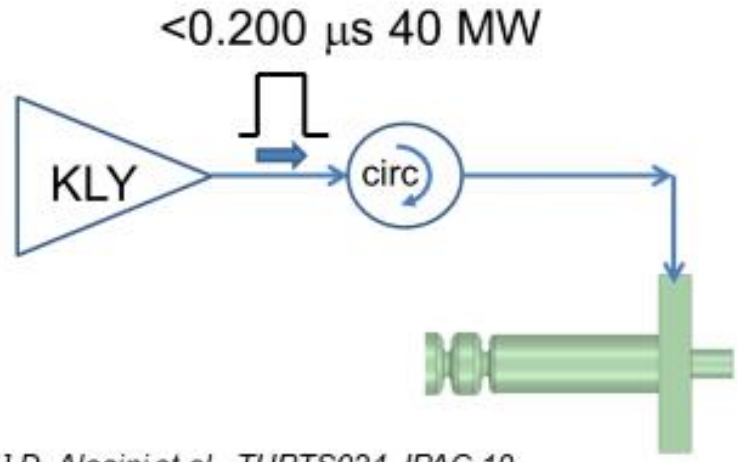
C-BAND GUN POWERING SCHEME

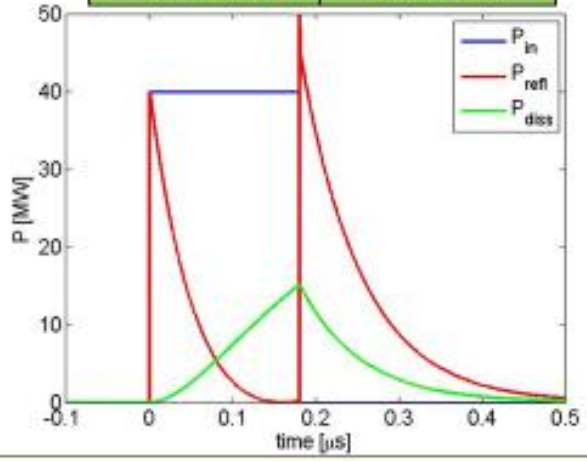
⇒ RF pulses of few tens of MW at 200 ns allow reaching E_{cath}>200 MV/m.

⇒ Because of its higher efficiency, a C-band RF **Gun is also suitable for application requiring repetition rates in the 500 Hz ÷ 1 kHz range**

⇒ Moreover, to feed the SW gun a C-band **circulator is necessary** to protect the klystron from the power reflections during transients (a commercially available C-band circulator exists and will be purchased from **CML** to allow the high-power tests).

E_{cath}	240 MV/m
$\Delta f_{0-\pi}$	≈ 90 MHz
Q_0	12000
β	3
P_{diss} @240MV/m	12 MW
$E_{CAT}/\sqrt{P_{diss}}$	69 [MV/mMW$^{0.5}$]
P_{IN} @240MV/m	31 MW
ΔT @ 200 ns	<30 °C
RF pulse length	<200 ns
Av diss power	2000-200 W
Rep. Rate	1000-100 Hz





[1] D. Alesini et al., TUPTS024, IPAC 19

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Athens

C-band klystron at high rep. rate

The **CANON E37212 klystron** is the only available option.

Looking at the values of the high-power C-band klystron Canon (Toshiba) E37212 that are specified for 100 Hz, 50 MW, t_{RF_MAX}=2.5 µs, t_{trans}=2.5 µs, we obtain **P_{coll_MAX}=58kW**.

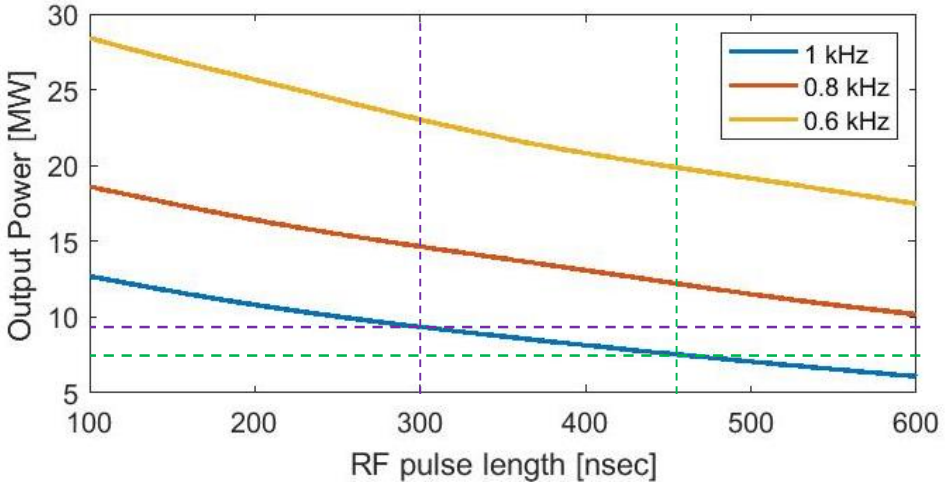
Assuming equivalent transients given by solid state modulators similar to that measured on **SPARC C-band klystrons** (**t_{trans}=1.2 µs**) we obtain:

GUN: 300 ns

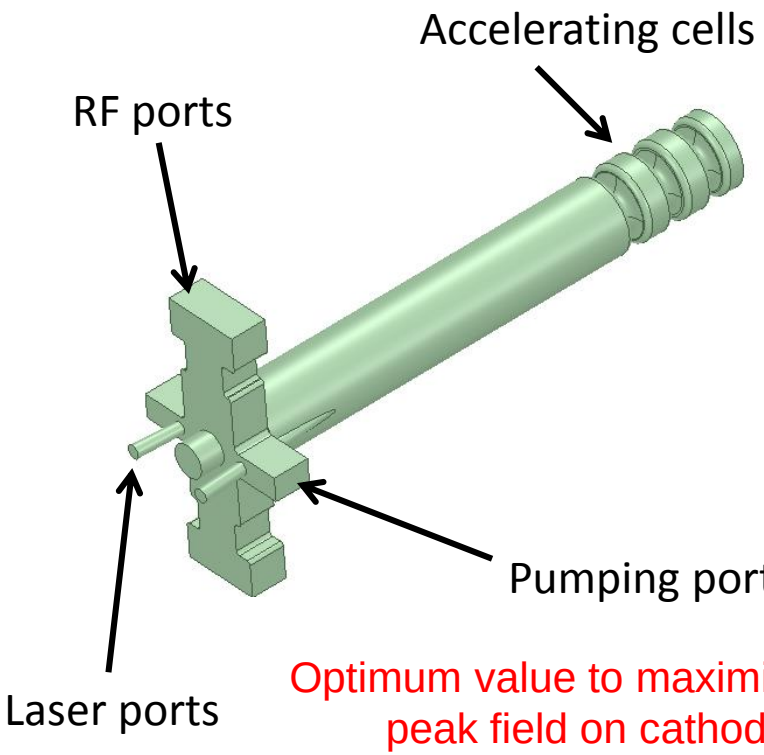
TWS: 460 ns

9 MW

7 MW

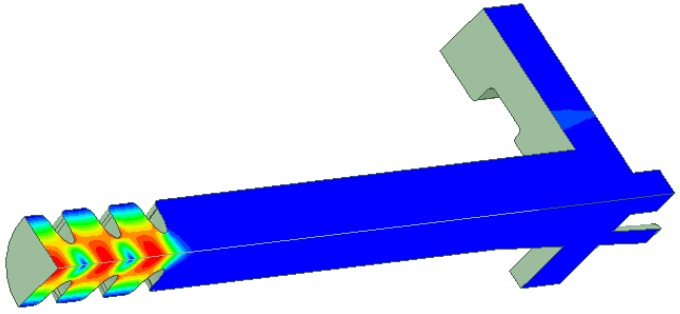


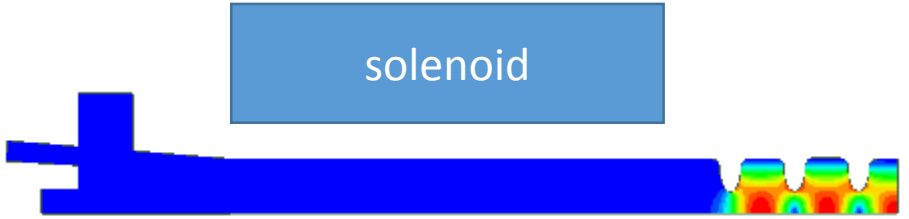
2.5 CELL GEOMETRY ELECTROMAGNETIC SIMULATIONS AND FINAL PARAMETERS



Optimum value to maximize the peak field on cathode

E_{cath}	160 MV/m
$\Delta f_{\pi/2\text{-}\pi}$	≈ 52 MHz
Q_0	11600
β	3
Filling time (τ_F)	160 ns
P_{diss} @160MV/m	9.7 MW
$E_{CAT}/\sqrt{P_{diss}}$	51.4 [MV/m/(MW)$^{0.5}$]
Rep. Rate	1000 Hz
Peak Input power P_{IN}	17.5 MW
Pulsed heating (T_{puls})	<20 °C
RF pulse length (T_{RF})	300 ns
Av diss power (P_{av})	2300 W

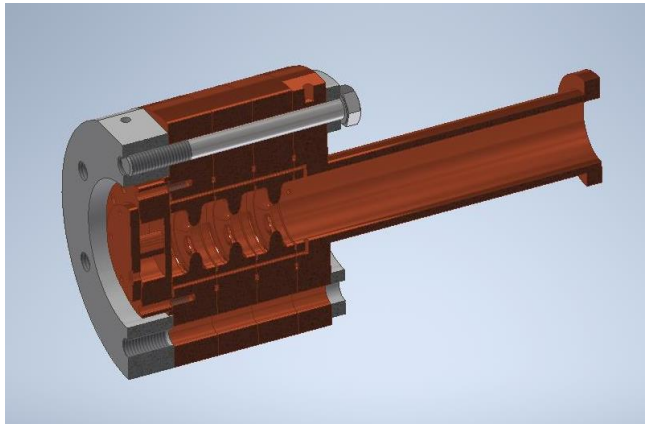


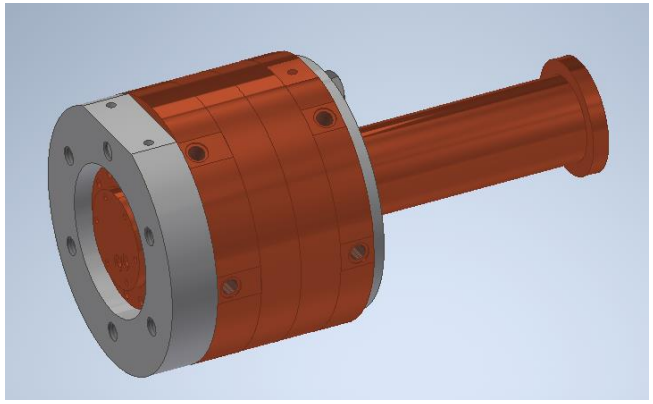


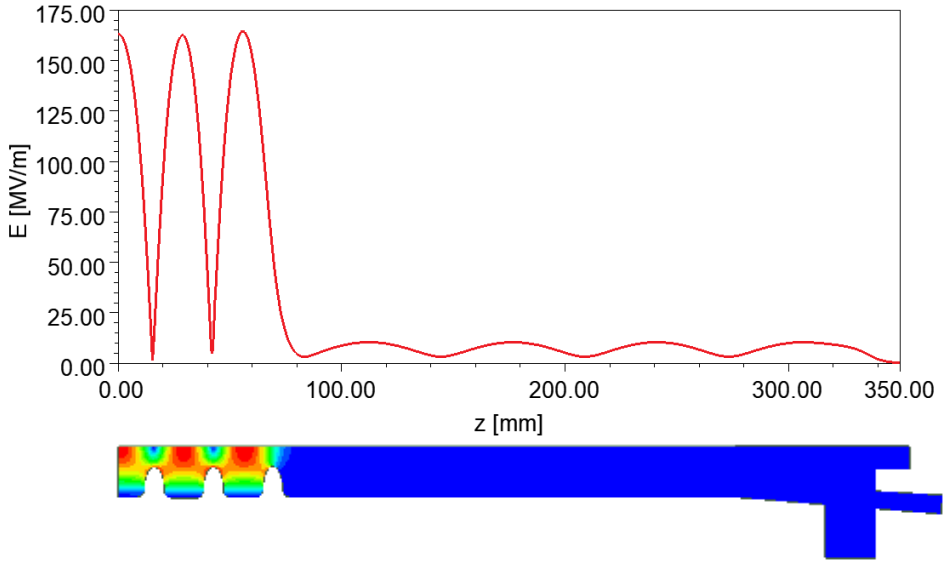
NB: in the present configuration **2 klystrons** are needed to reach **160 MV/m** on the cathode at **1 kHz**.
With **1 klystron**, simply scaling the performances of the present C-band sources (w/o R&D), we obtain **120 MV/m** at **1 KHz**

RF SIMULATION RESULTS AND MECHANICAL DRAWING

G. Di Raddo

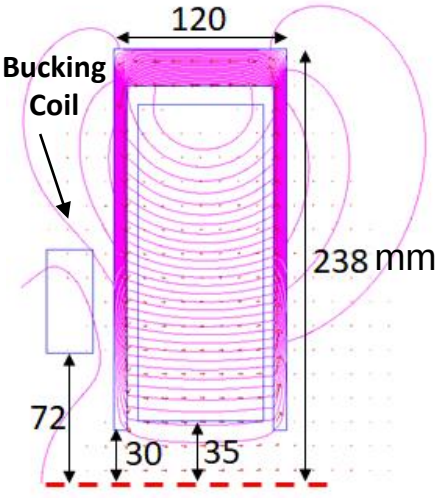






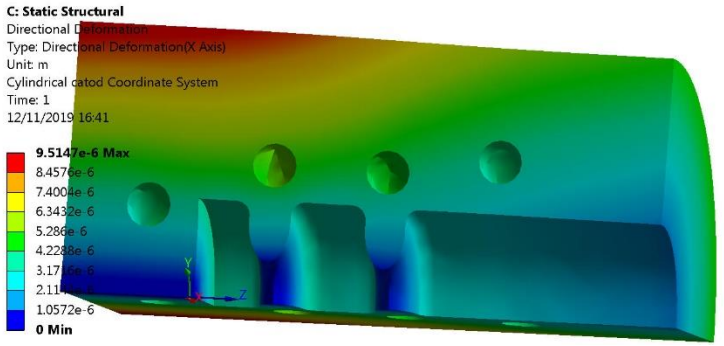
In progress:

Mechanical drawing of the gun and solenoid and final **termo-mechanical analisis**



A. Vannozzi

1.5 cells



L. Pellegrino

C-BAND ACC. MODULE

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2 M LONG SECTIONS (PSI-LIKE)

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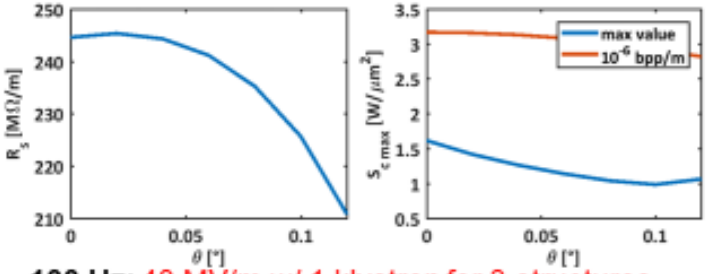
Canon E37212

RF system	
Operating frequency [GHz]	5.712
Klystron pulse length [us]	3
Klystron peak power (Net) [MW]	50 (40)
Pulse rate [pps]	100
Q0 of BOC	216000
Qe of BOC (optimized)	24700



100 Hz: 40 MV/m w/ 1 klystron for 3 structures (considered 20 MW per structure).
1 kHz: <20 MV/m w/ 1 klystron for 1 structure (BD check is required).
PRELIMINARY BETTER RESULTS W/ SHORTER STRUCTURES.

Acc. Structure		
Phase advance	2pi/3	
Cell length [mm]	17.495	
Number of cells	114	
Total length [m]	1.9945	
Average iris radius [mm]	6.6	
Tapering angle [deg]	0.02	
Iris radius (first - last) [mm]	6.945 – 6.255	
Shunt imp. [MOhm/m]	78.5-85	
Q	10209-10170	
Group velocity/c [%]	2-1.4	
Filling time [ns]	403	
Repetition rate [Hz]	100	1000
BOC	ON	Bypassed
Kly. Pow./struct. [MW]	13	8
Avg. acc. gradient [MV/m]	40	15.6

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Athens

C-BAND ACC. MODULE

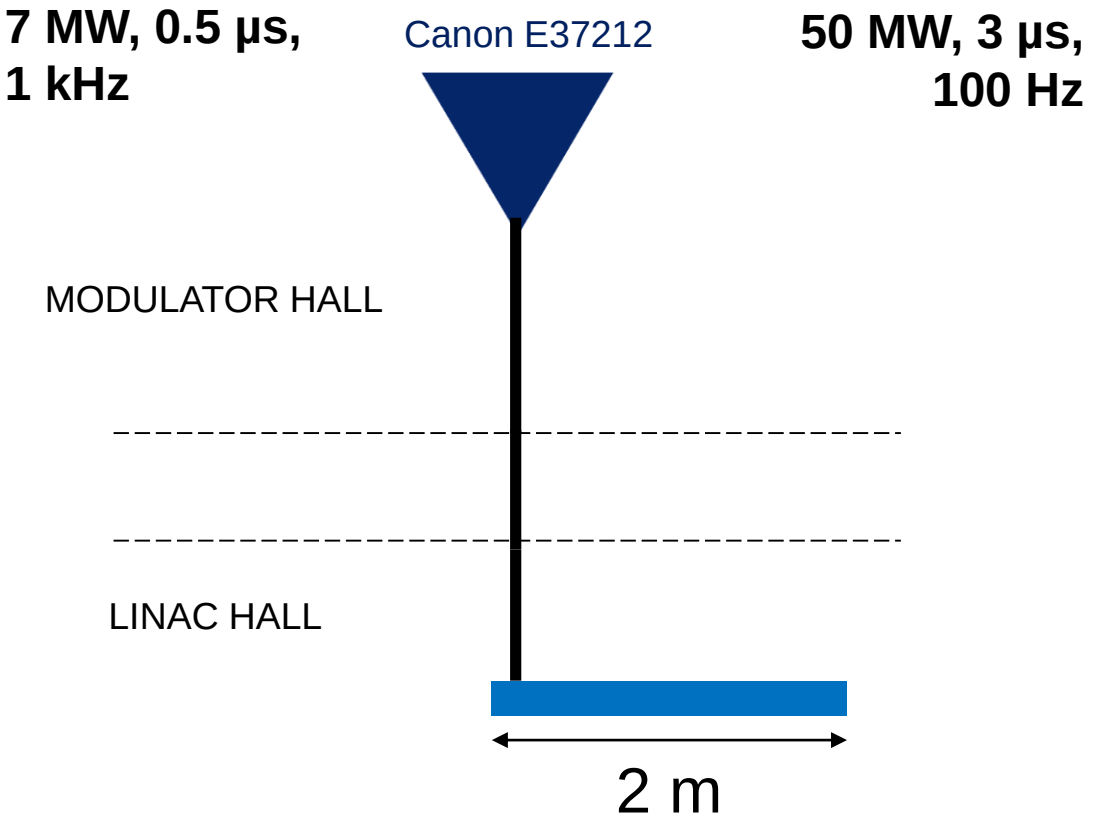
Canon E37212	
Operating frequency [GHz]	5.712
Klystron pulse length [us]	3
Klystron peak power [MW]	50
Pulse rate [pps]	100

Wrt Athens, a pulse compressor is not needed with this new design (no margin)

Acc. Structure		
Phase advance	2pi/3	
Cell length [mm]	17.495	
Number of cells	115	
Total length [m]	2	
Average iris radius [mm]	6.6	
Tapering angle [deg]	0.08	
Iris radius (first - last) [mm]	7.980 - 5.220	
Shunt imp. [MOhm/m]	70 - 96	
Q	10280 - 10123	
Group velocity/c [%]	3.2 -0.7	
Filling time [ns]	464	
Repetition rate [Hz]	100	1000
Avg. acc. gradient [MV/m]	40	15

In progress: calculations with smaller iris radii in order to have more margin

C-BAND ACC. MODULE



- Simple layout
- Expensive: 1/2 kly/m (0.56 kly/m for the X-band module)
- X-band module: more efficient (potential drawback: iris radius)

Conclusions

- The EM design of a 2.5 cell gun has been performed
- Wrt to the 1.5 one, it requires 2 klystrons for the 1 kHz operation
- The design of the new solenoid has been performed
- Mechanical drawings and thermo-mechanical analyses are ongoing

- The design of the C-band module has been optimised for the 1 kHz operation
- No need of pulse compressor
- In progress: calculations with smaller iris radii in order to have more margin

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Thank you!

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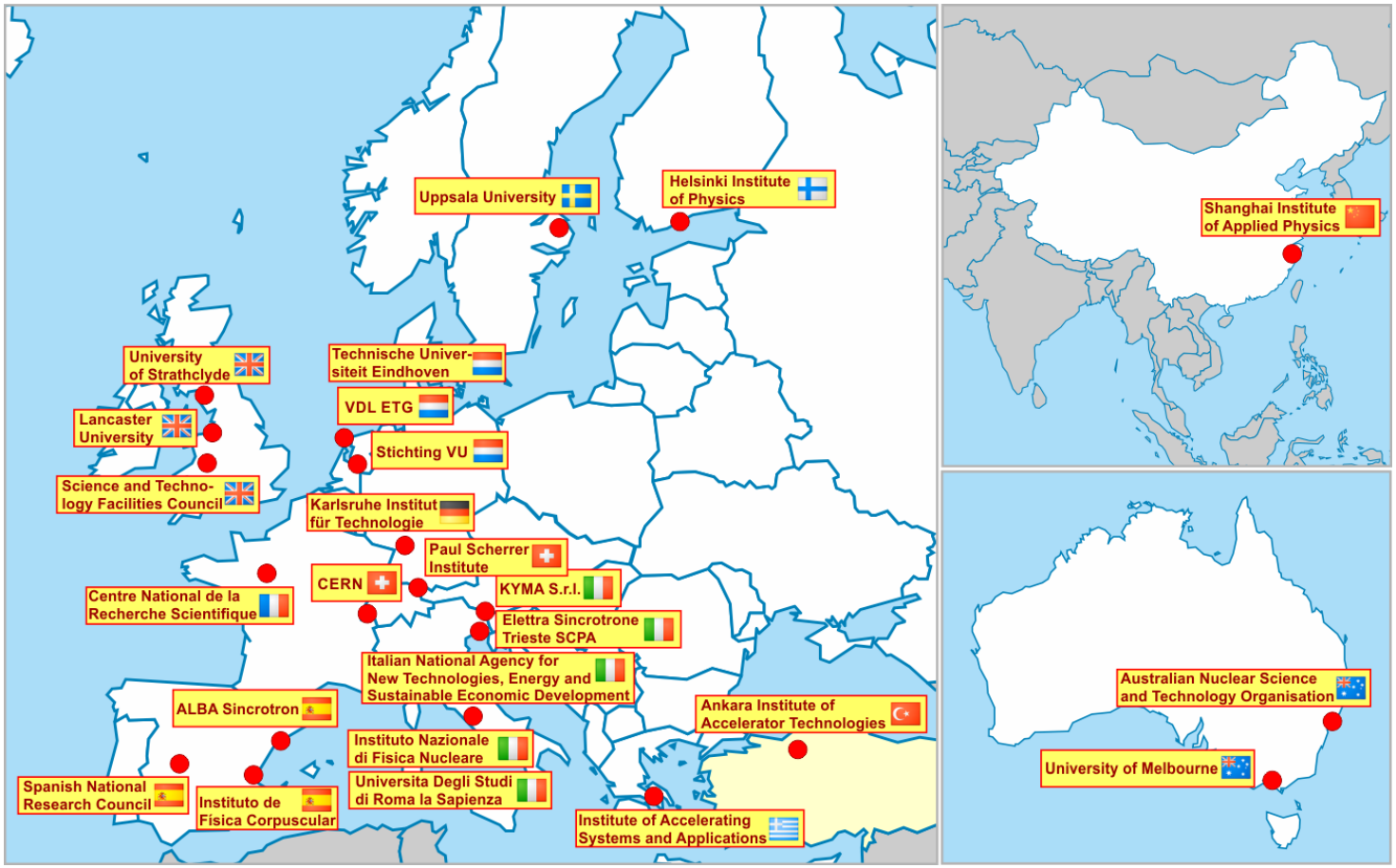
www.CompactLight.eu



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