S-band transverse deflecting structure design for CompactLight

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Funded by the
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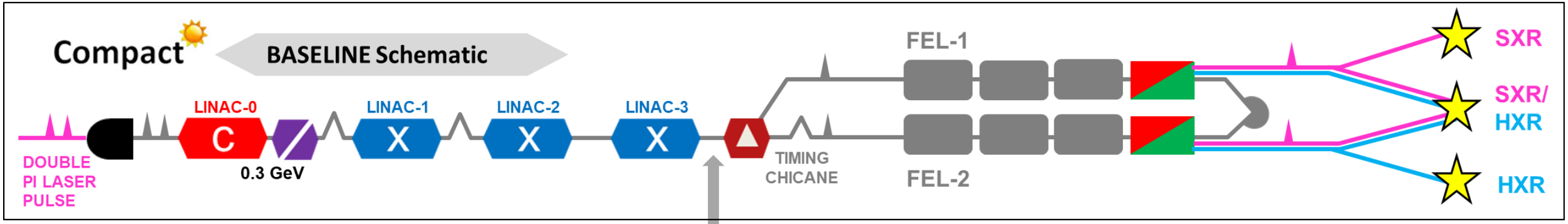
Layout of CompactLight

Compact



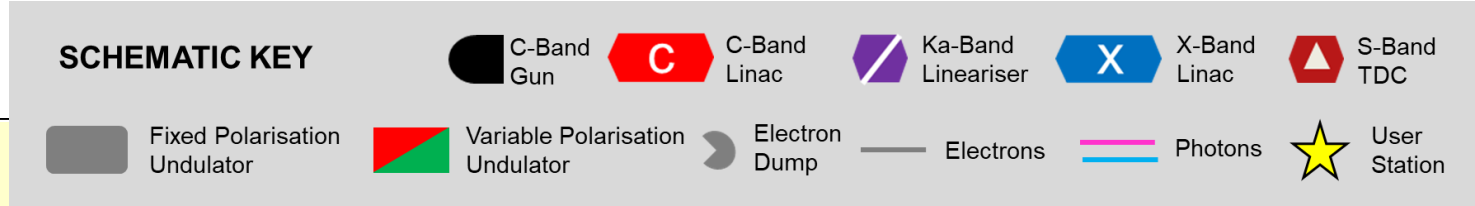
BASELINE	**0.97 to 2.4 GeV @ 250 Hz (SXR/SXR)** **2.75 to 5.5 GeV @ 100 Hz (HXR/HXR)**
UPGRADE1	**0.97 to 2.4 GeV @ 1000 Hz (SXR/SXR)** **2.75 to 5.5 GeV @ 100 Hz (HXR/HXR)**

A compact free electron laser project based on X-band technology

Two-bunch operation for pump-and-probe experiment

Produce **100 Hz hard X-ray** (2.0 - 16.0 keV) and **1000 Hz soft X-ray** (0.25 - 2.0 keV) with same installed linac

Design project funded by European Union Horizon 2020



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Bunch splitter before FEL structure

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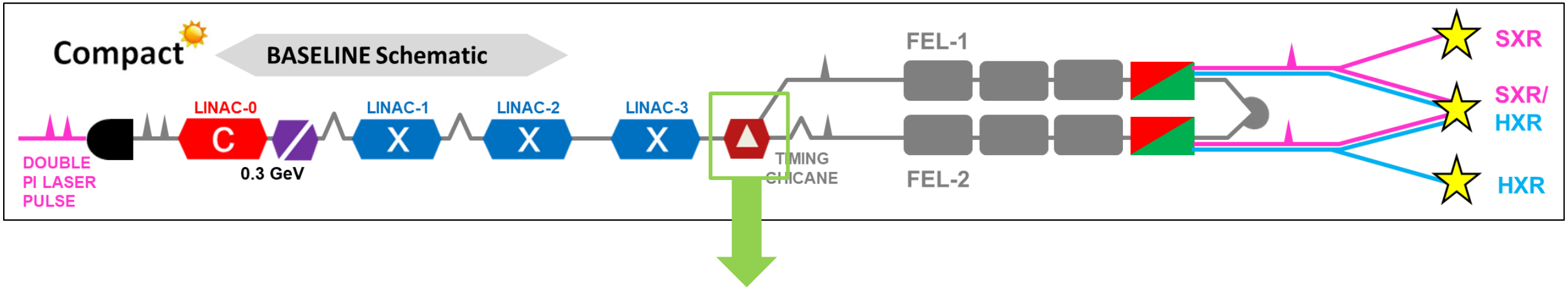
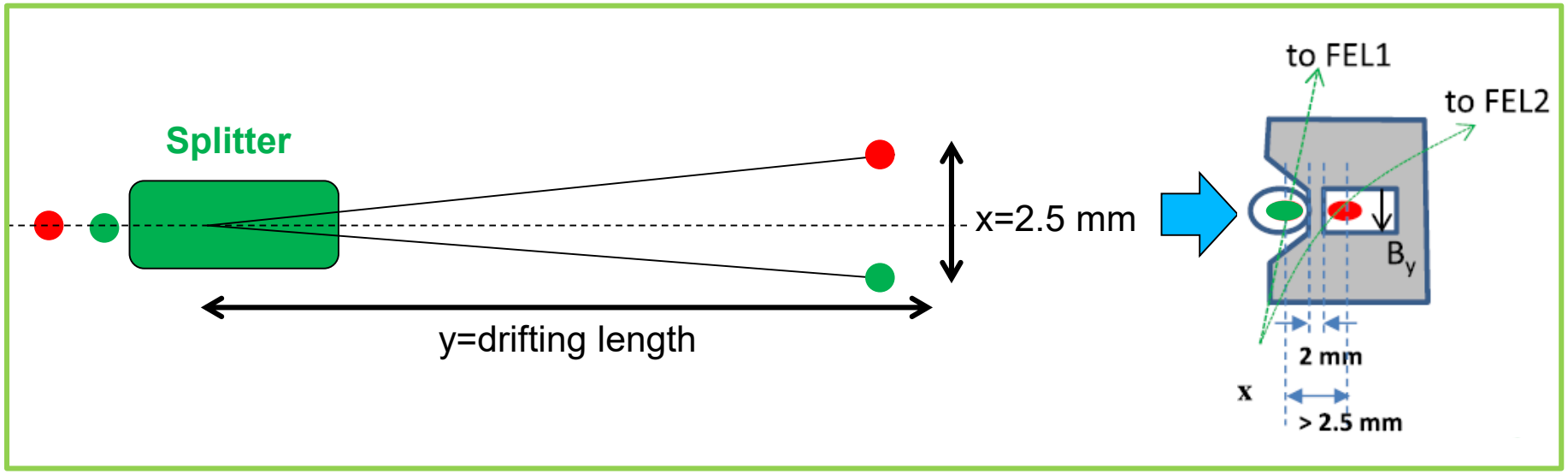


Need a splitter to separate the two bunches into two FEL lines

Distance between the two bunches should be over 2.5 mm at the entrance of septum



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Sub-harmonic deflector and spacing between two bunches

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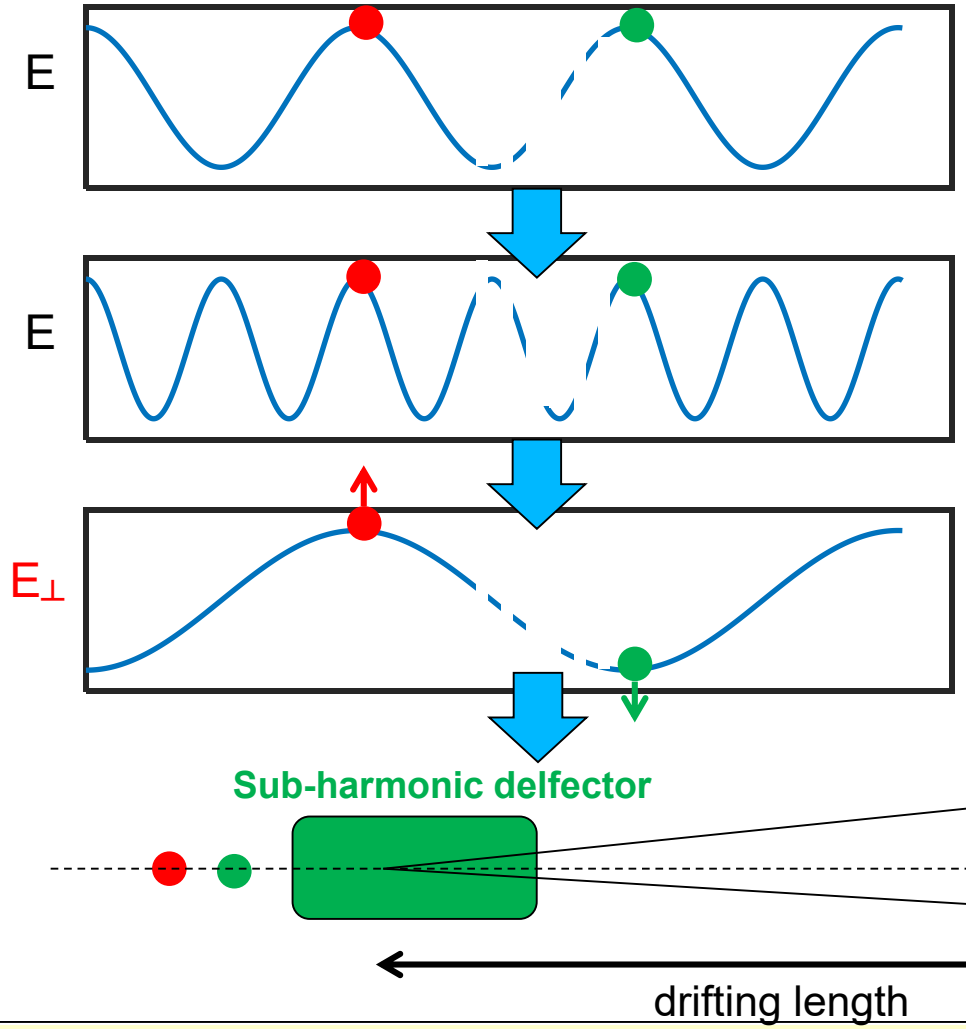
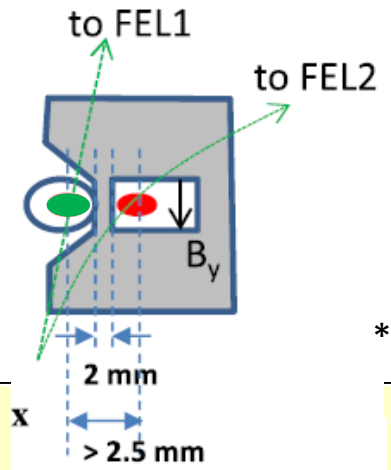
$\Delta t = n\,\tau_{gun}$, n = 1,3,5...
$\Delta s = n\,\lambda_{gun}$



n (C-band)	Δt	Δs
1	166 ps	50 mm
3	500 ps	150 mm
5	833 ps	250 mm
7	1.16 ns	350 mm
9	1.5 ns	450 mm

n (X-band)	n (S-band)
2	0.5
6	1.5
10	2.5
14	3.5
18	4.5

Spacing between the two bunches is 10 X-band rf cycles



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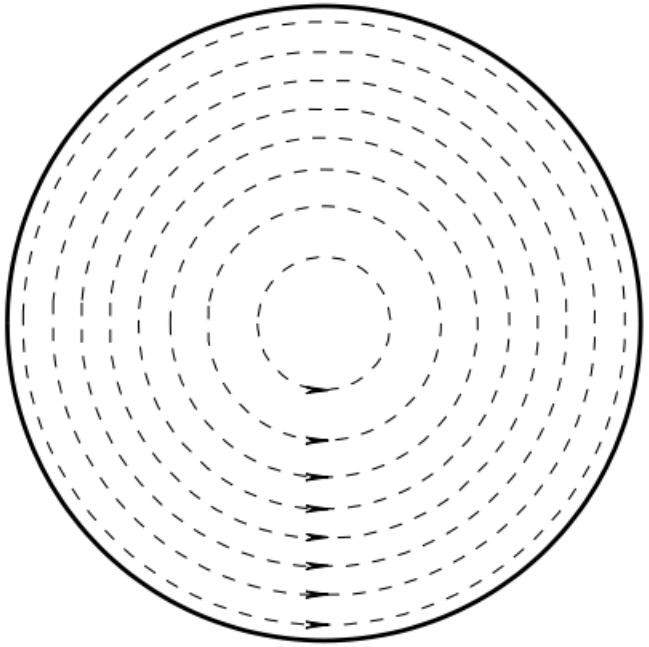
$TM_{1,1,0}$ mode in transverse deflecting cavity

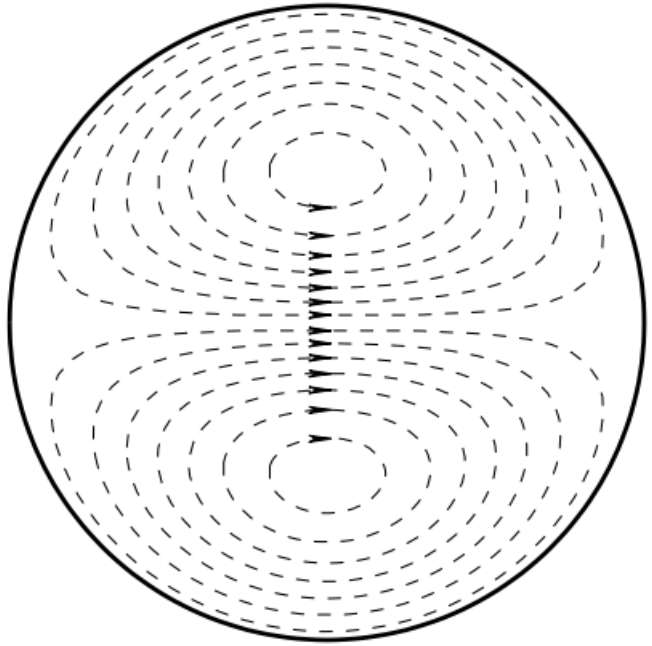
Transverse magnetic field of $TM_{0,1,0}$ and $TM_{1,1,0}$ in pillbox cavity

$TM_{0,1,0}$ mode



Accelerating mode

$TM_{1,1,0}$ mode



Dipole mode
Transverse kick to beam

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Transverse deflector system design

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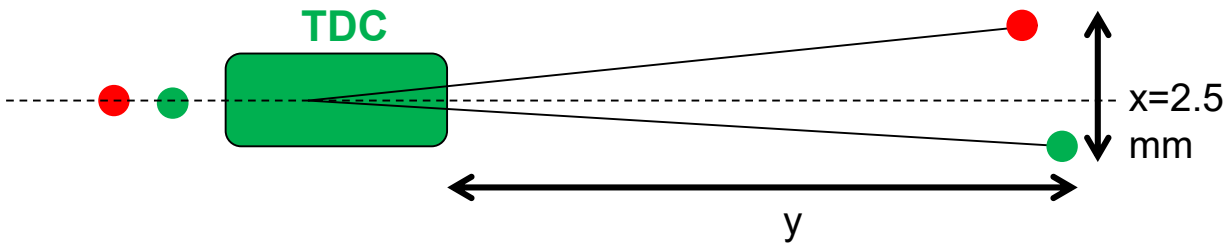
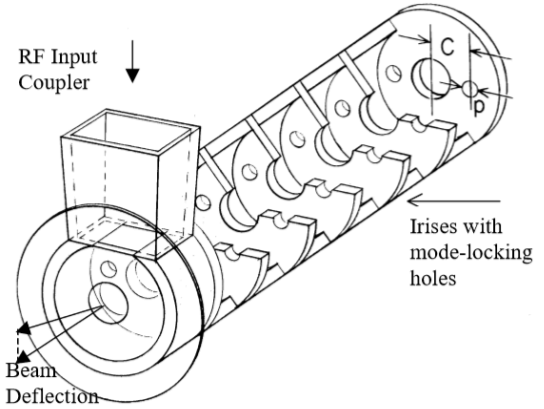
HXR mode: 5.5 GeV bunch
x=2.5 mm, y is drift length

$$\frac{V_\perp e}{E} = \frac{x/2}{y}$$

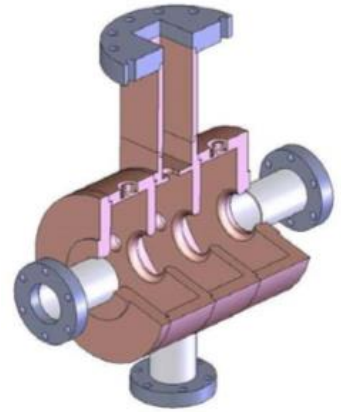


Two options for the transverse deflecting cavity
1. Traveling-wave structure
2. Standing-wave structure

Traveling-wave structure



Standing-wave structure



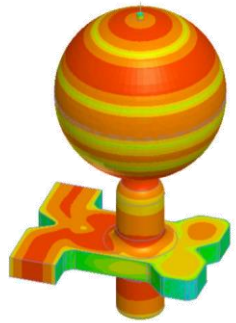
RF parameters

2998 MHz	Traveling-wave (2π/3)	Standing-wave
Cell number	N	3
Single cell length [m]	0.033	0.05
Structure length [m]	N*0.033	0.15
Shunt impedance [MΩ/m]	20.25	21.11

Power capability

Klystron: based on VKS8262G1 model built by CPI
Maximum rf peak power of 7.5 MW→6 MW within loss@1000 Hz
Pulse length of up to 5 μs
Repetition rate of 400 Hz

Pulse compressor: spherical pulse compressor
Increase the average power:
6 MW, 4.5 us →31.7 MW, 300 ns (Avg.)



Loew, G. A., & Altenmueller, O. H. DESIGN AND APPLICATIONS OF RF DEFLECTING STRUCTURES AT SLAC. 1965
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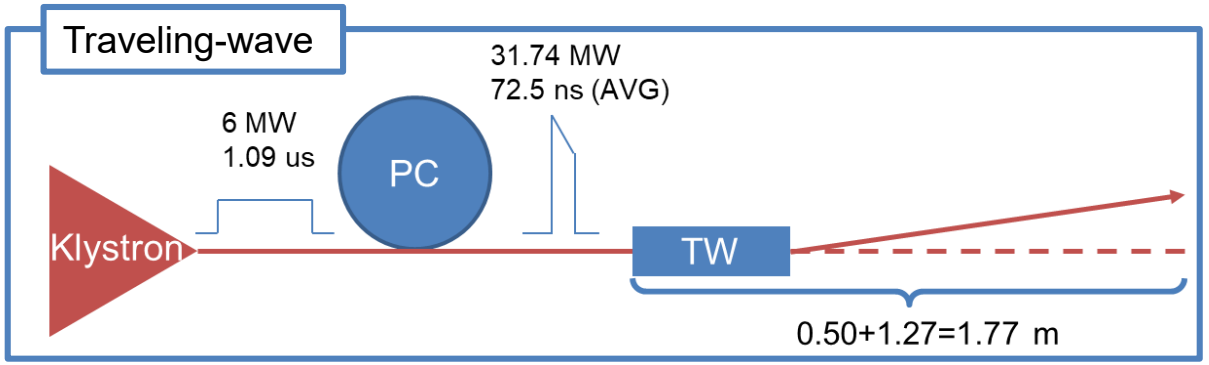
Transverse deflector system design

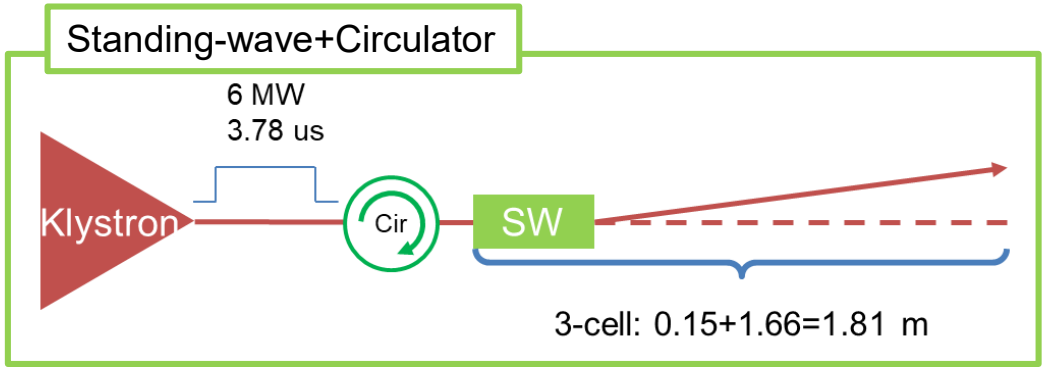
6 MW @ 1000 Hz from the power source

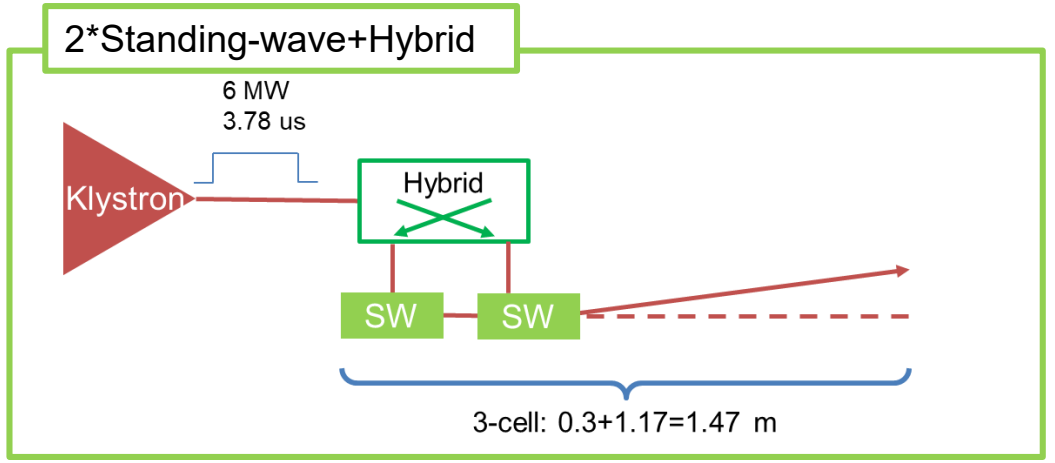
1. Klystron, pulse compressor, 0.5 m traveling-wave structure

2. Klystron, circulator/hybrid, 0.15 m standing-wave structure

	Stru. length [m]	Drift length [m]	Deflecting voltage [MV]
Traveling-wave	0.5	1.27	5.4
Standing-wave	0.15	1.66	4.15
2* SW +Hybrid	0.15	1.17	5.87







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Thank you!

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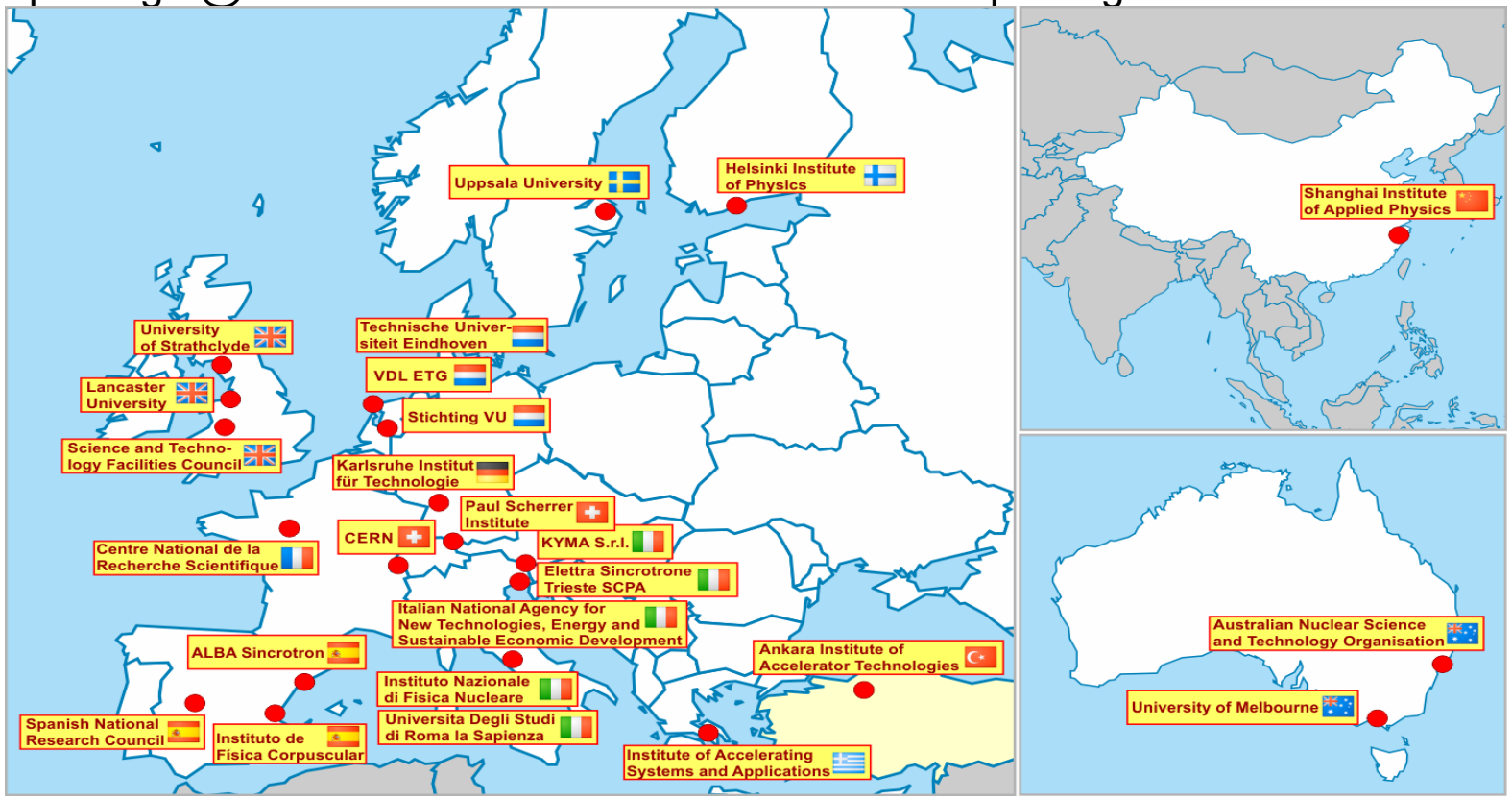

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