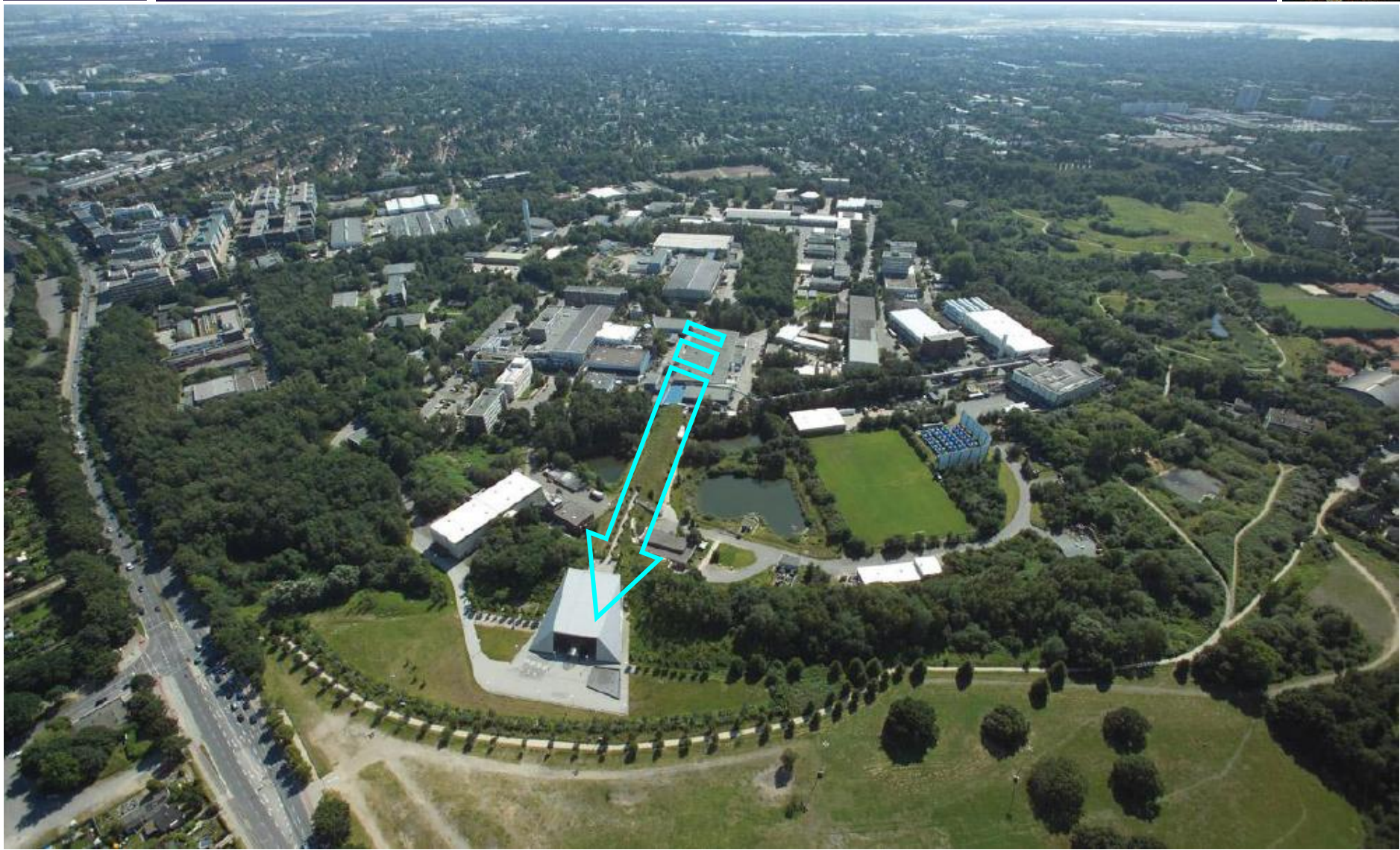


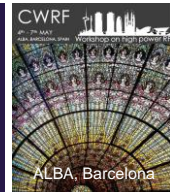
Waveguide Distribution System for FLASH

V.Katalev, S.Choroba

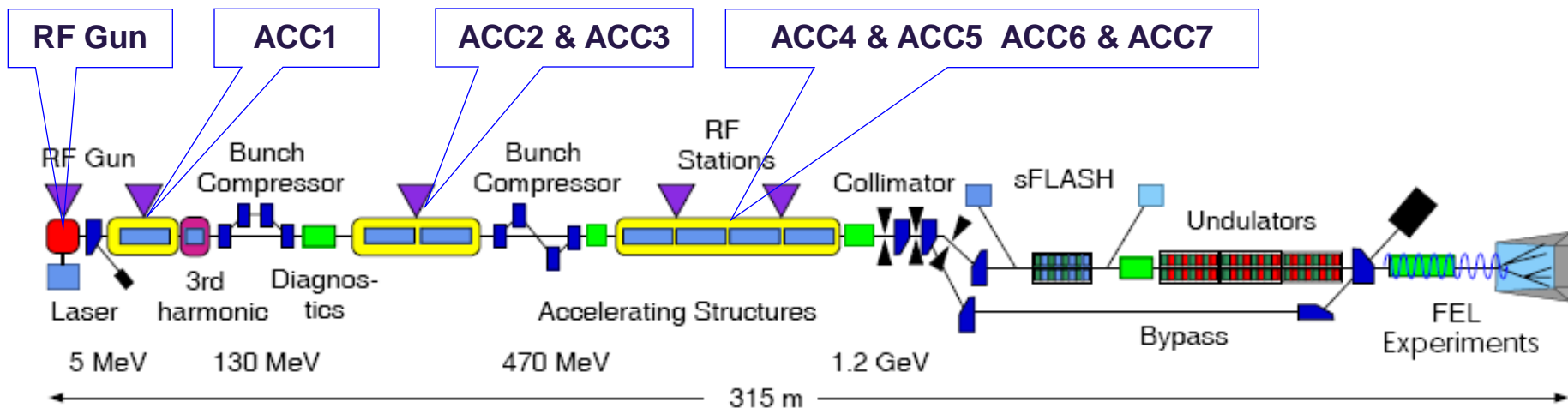




Layout of FLASH after 2009 Upgrade

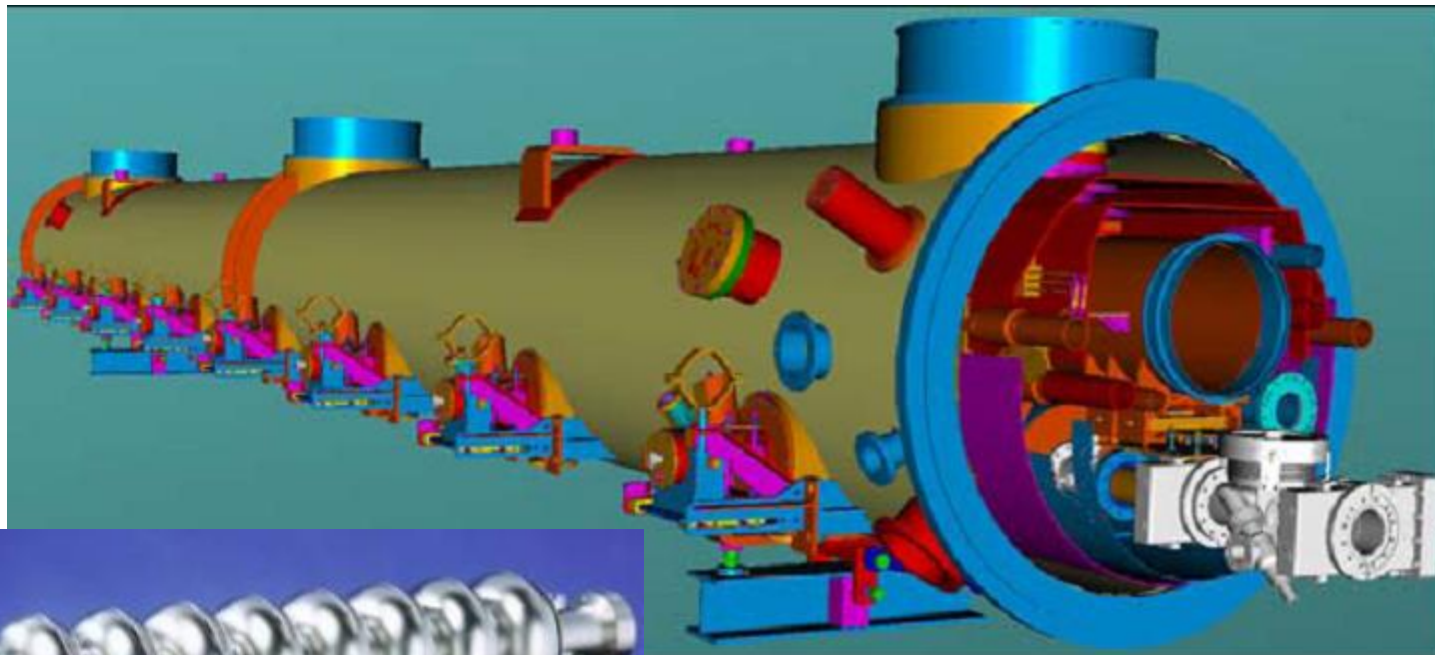


ACC = ACcelrating Cryomodule



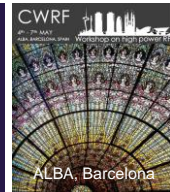
Accelerating Cryomodule and Cavity

- 8 cavities per cryomodule
- RF power per cavity up to 400 kW

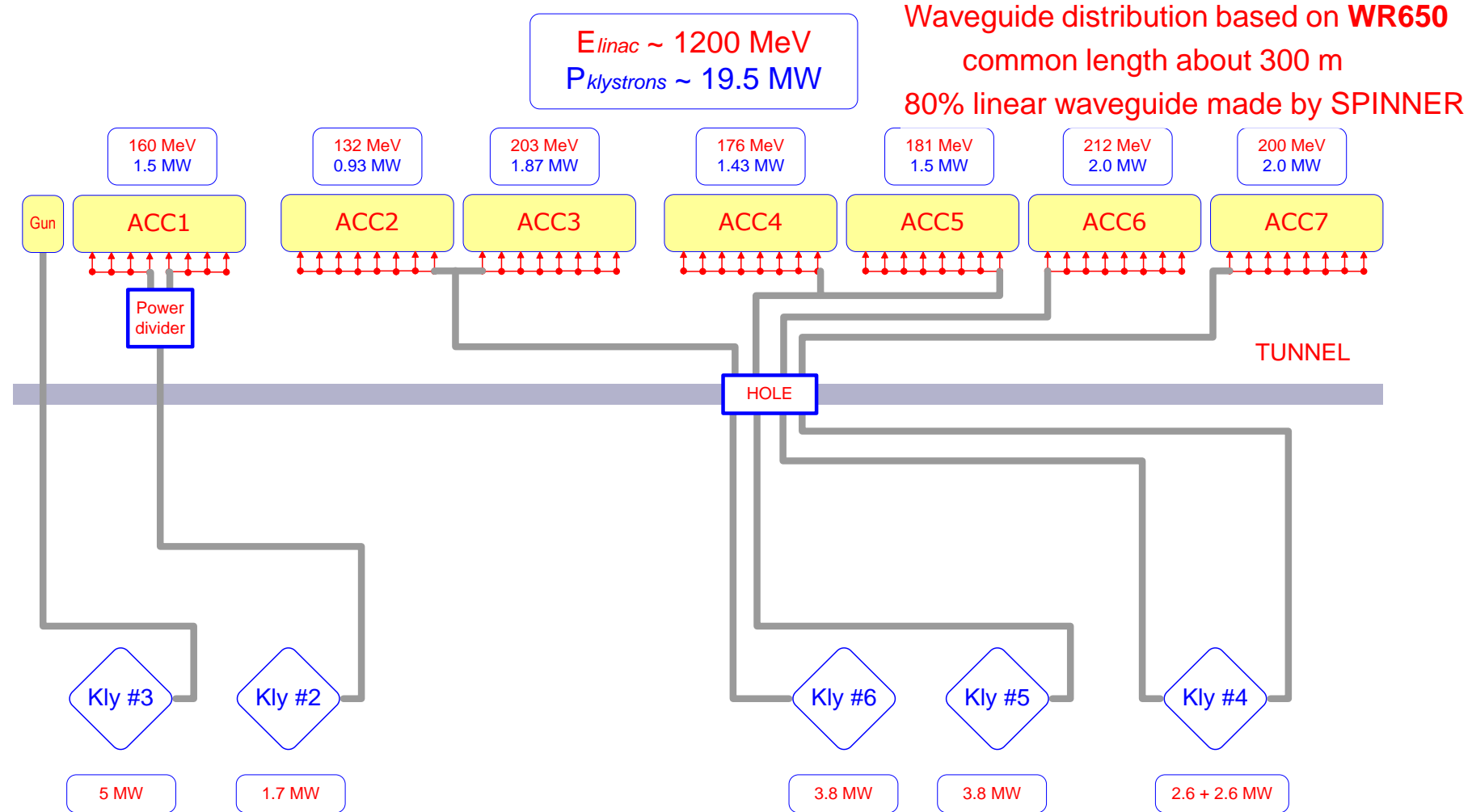


- cavity length about 1 m
- cavity gradient up to 35 MV/m

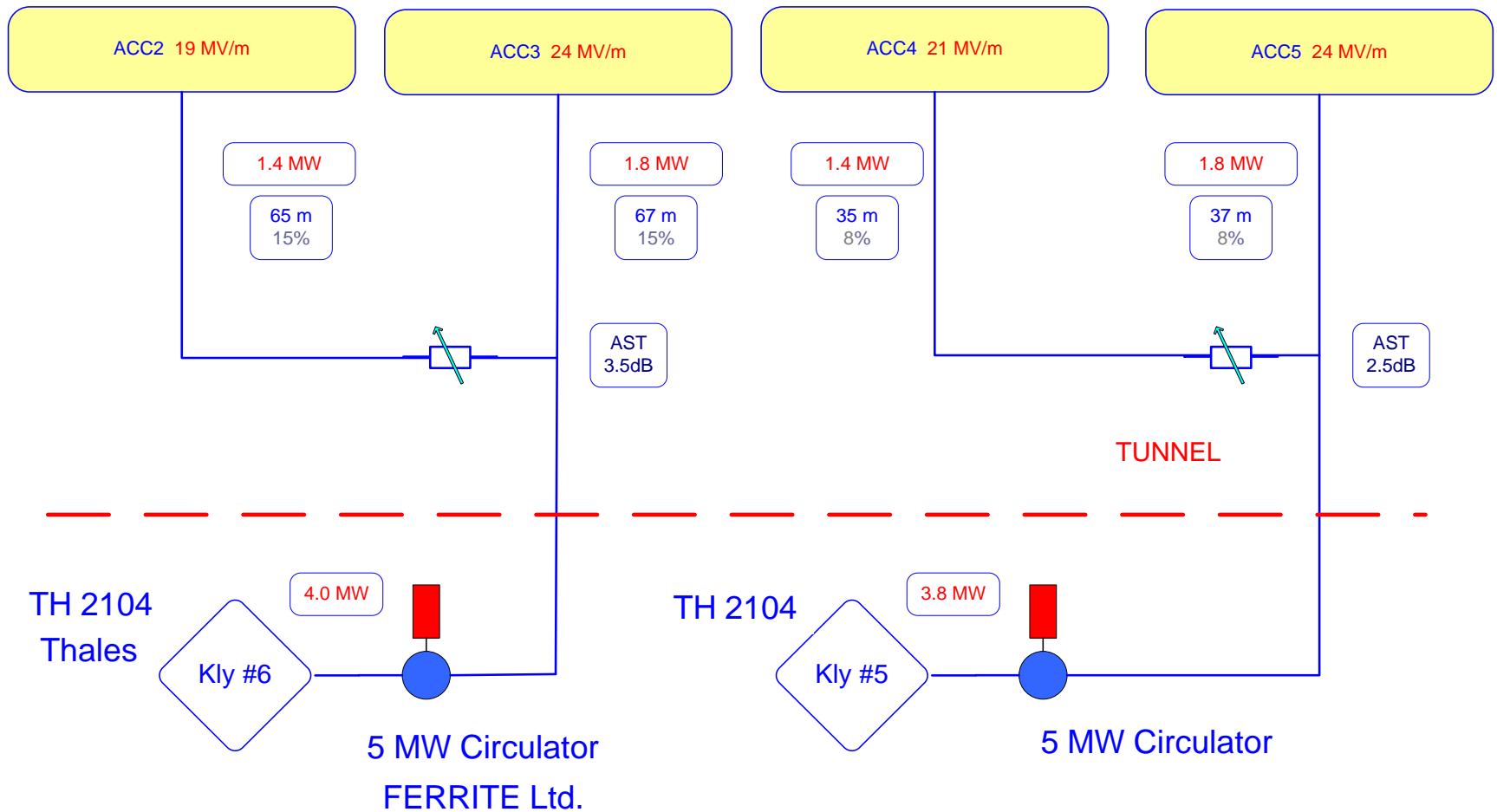
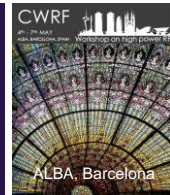
New Waveguide Distribution for FLASH



- 1300 MHz
- Pulse length 1.3 ms
- Repetition rate 10 Hz
- Power per cavity up to 400 kW

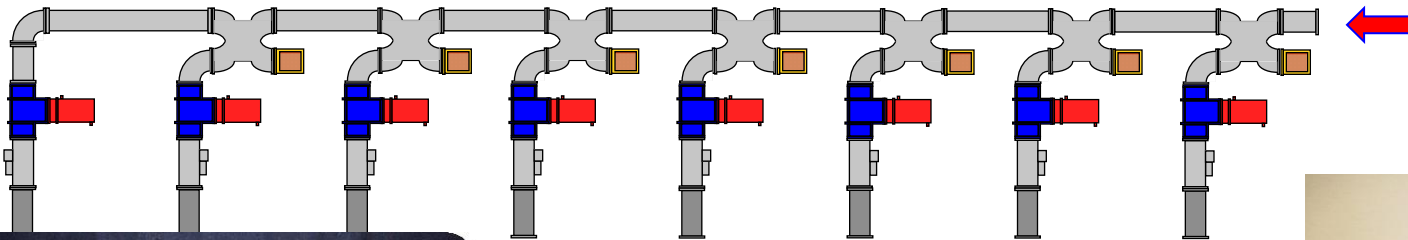


Waveguide distribution of Kly#5 and Kly#6

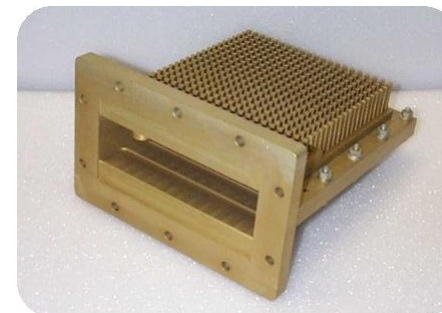
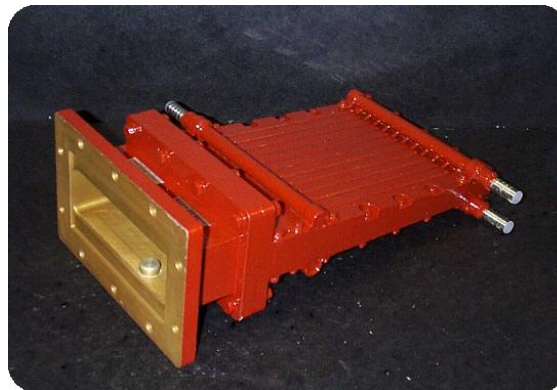
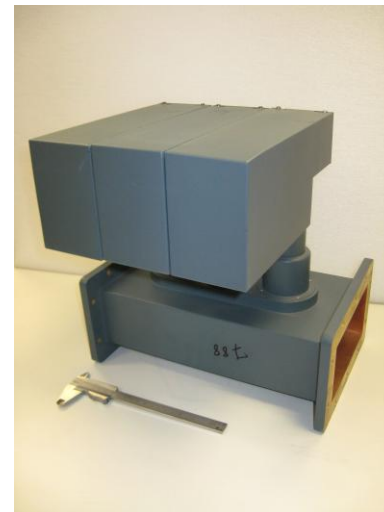


“Old” Linear Waveguide Distribution since 1992

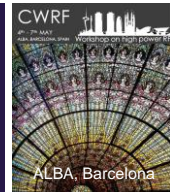
■ Equal power distribution for each cavity



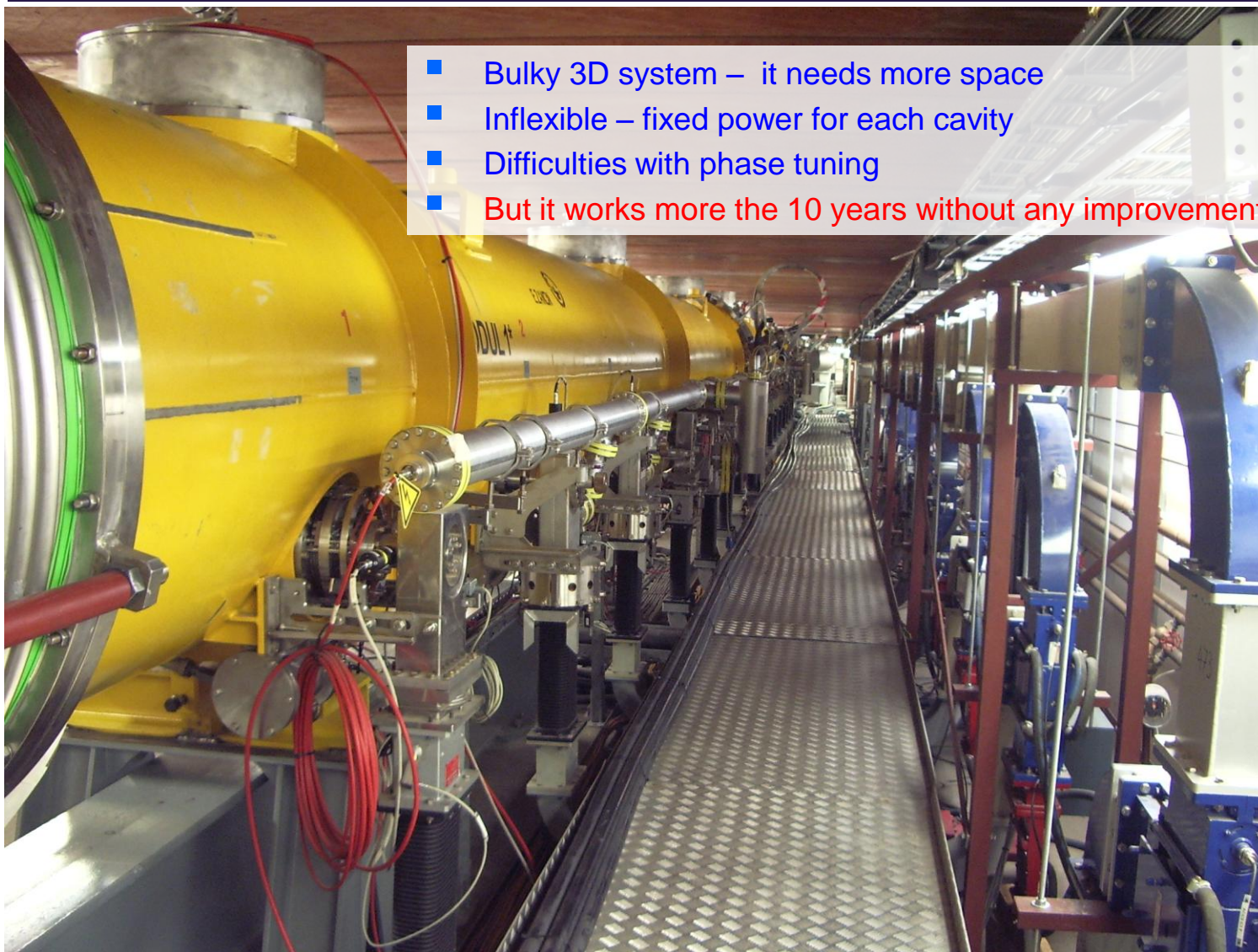
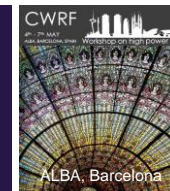
- Hybrids (RFT, Spinner)
- 400 kW Circulator (FERRITE)
- 400 kW Dummy Load (FERRITE)
- 0.2/1000 kW Dummy (FERRITE)
- 3 Stub Phaseshifter (Chine)



Linear Waveguide Distribution in FLASH Tunnel

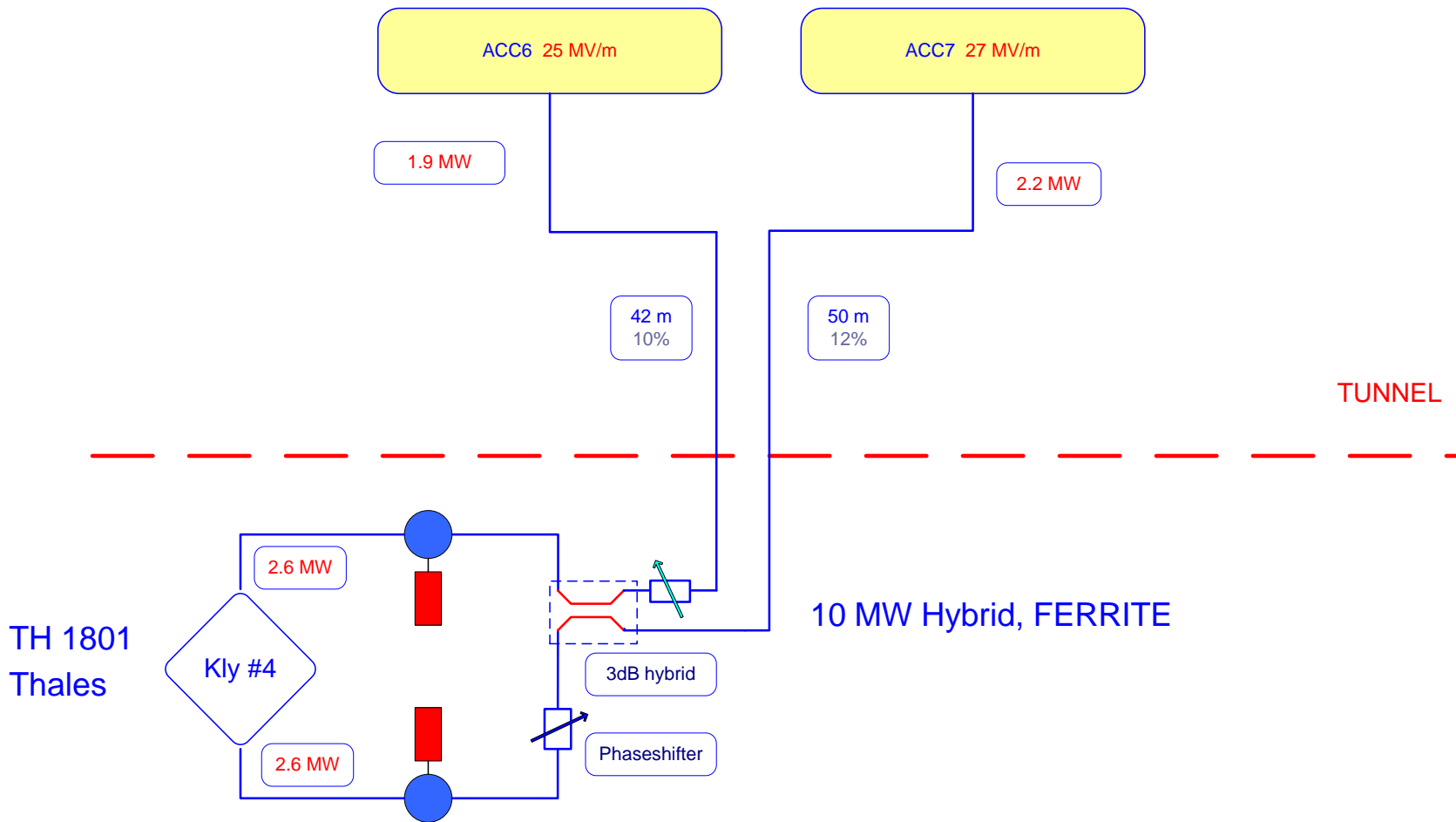
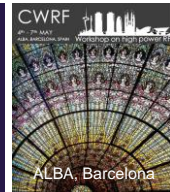


Linear Waveguide Distribution in FLASH Tunnel

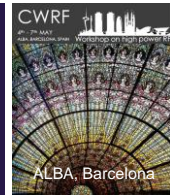


- Bulky 3D system – it needs more space
- Inflexible – fixed power for each cavity
- Difficulties with phase tuning
- But it works more the 10 years without any improvement

Waveguide distribution of Kly#4

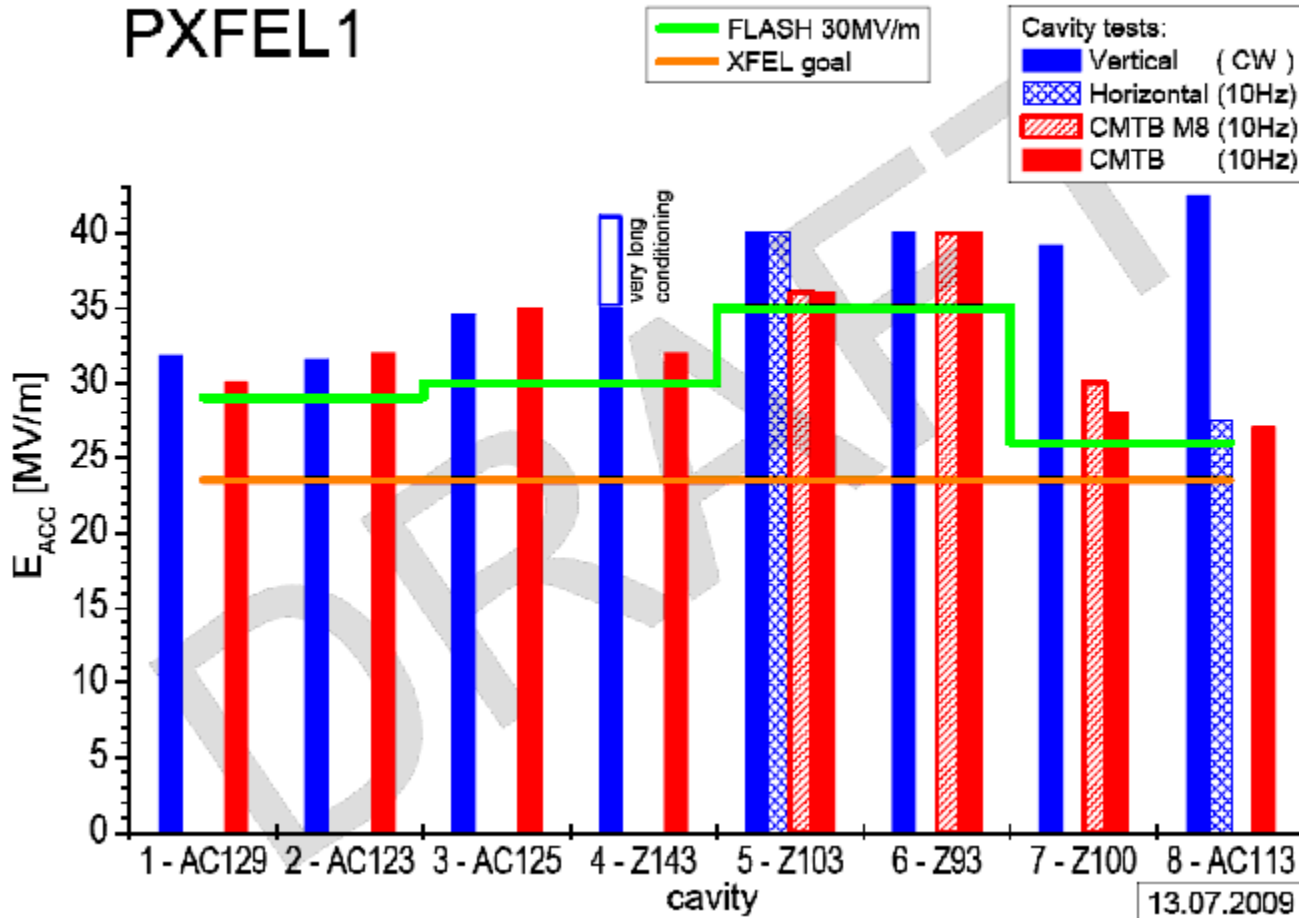


ACC7 cavities test at CMTB



Cavities tests / performance:

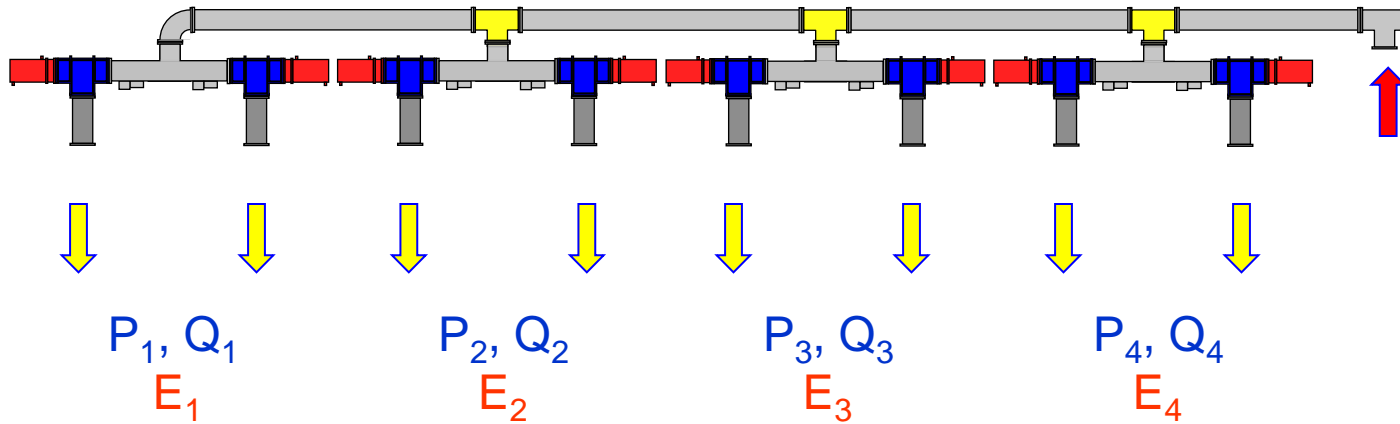
PXFEL1





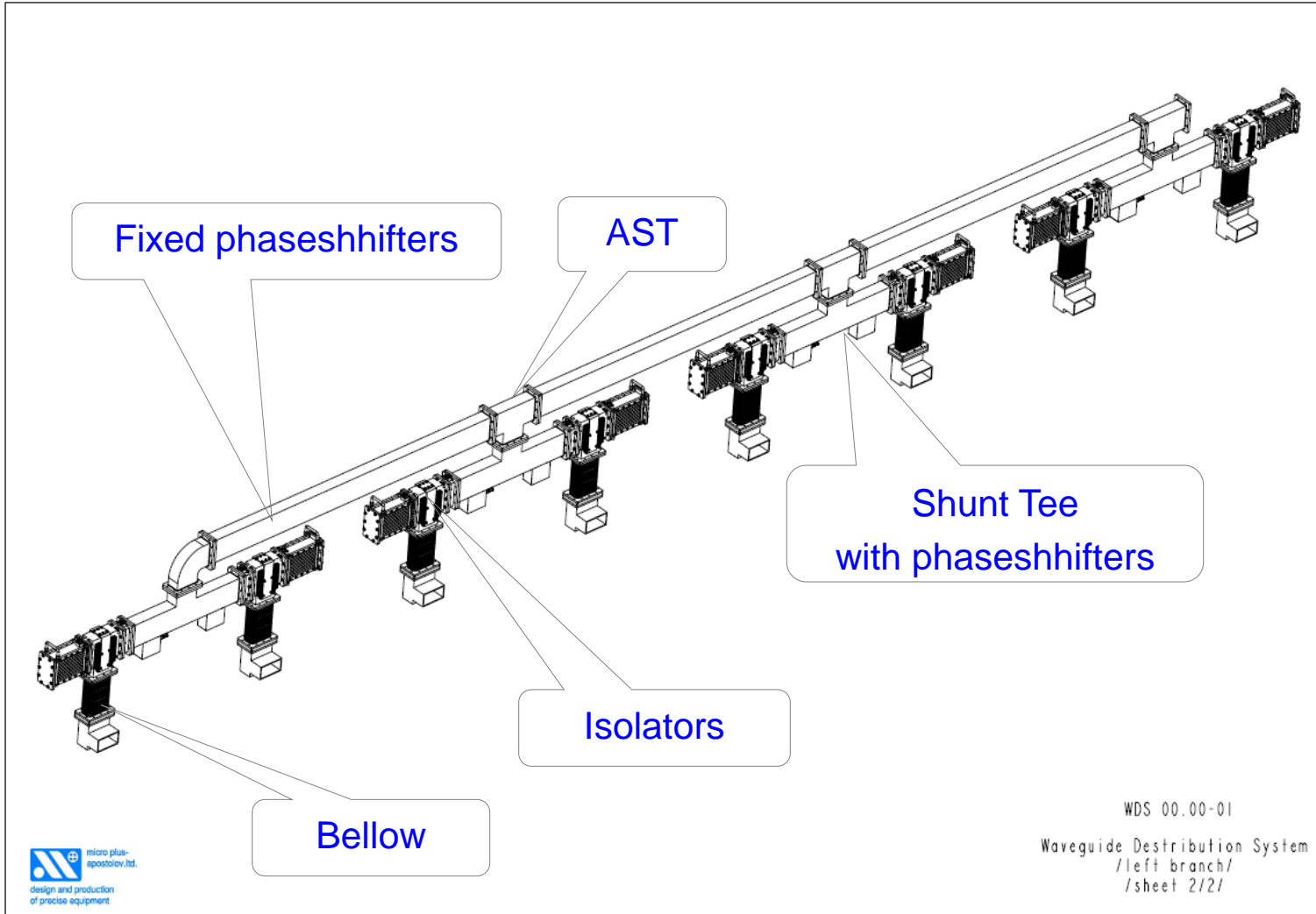
Compact distribution system with asymmetric shunt tees

There is no more the "weak cavity" limit in cryomodule!



Cavity gradient range from 18 to 35 MV/m
(from above limited by circulator only)

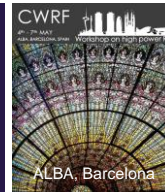
New Waveguide Distribution for Cryomodule (3D view)



WDS 00.00-01
Waveguide Distribution System
/left branch/
/sheet 2/2/

SCALE 0.048

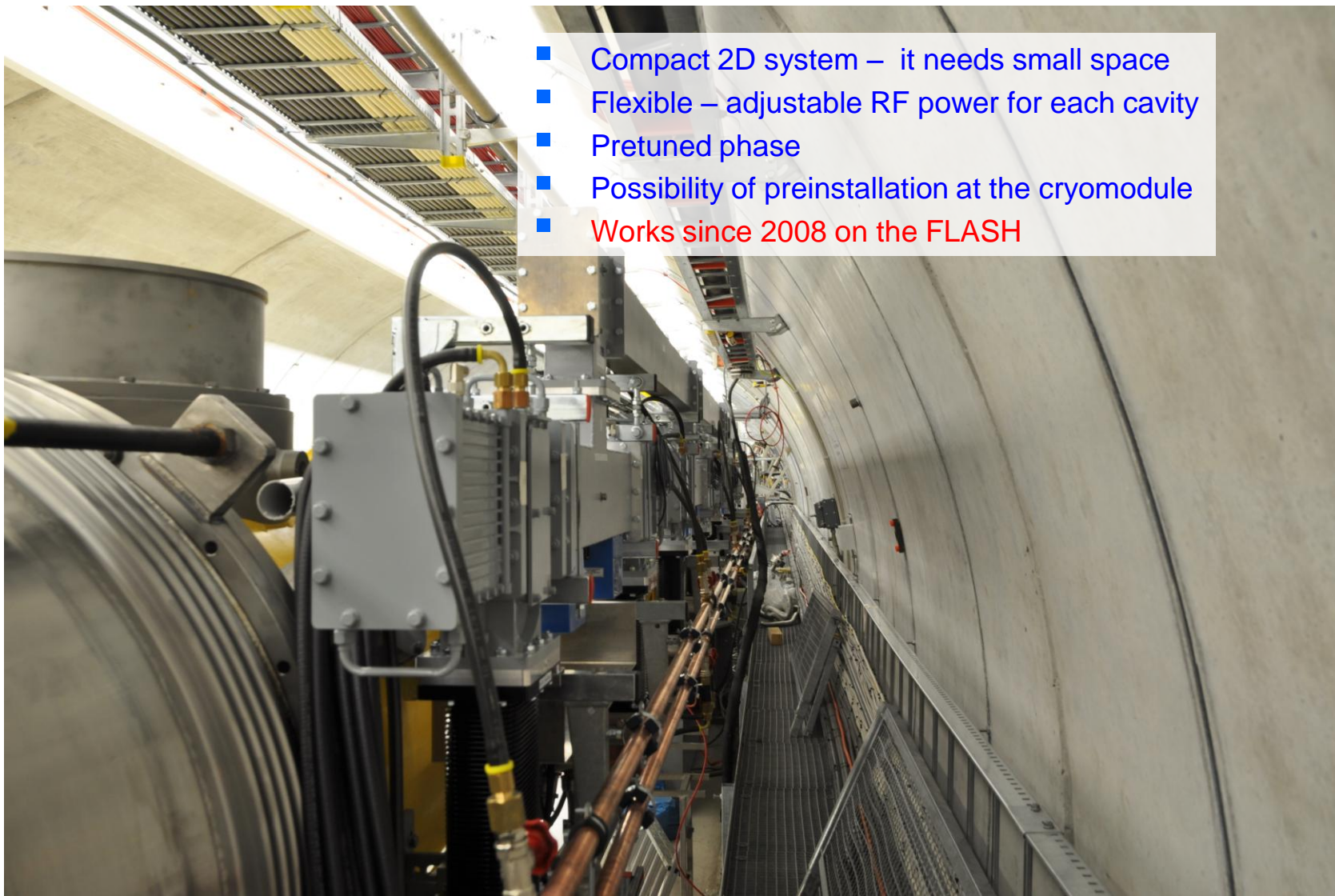
XFEL type Waveguide Distribution for ACC7



ACC7 with Waveguide Distribution Transport

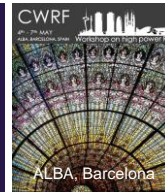


Waveguide Distribution and ACC7 in Tunnel

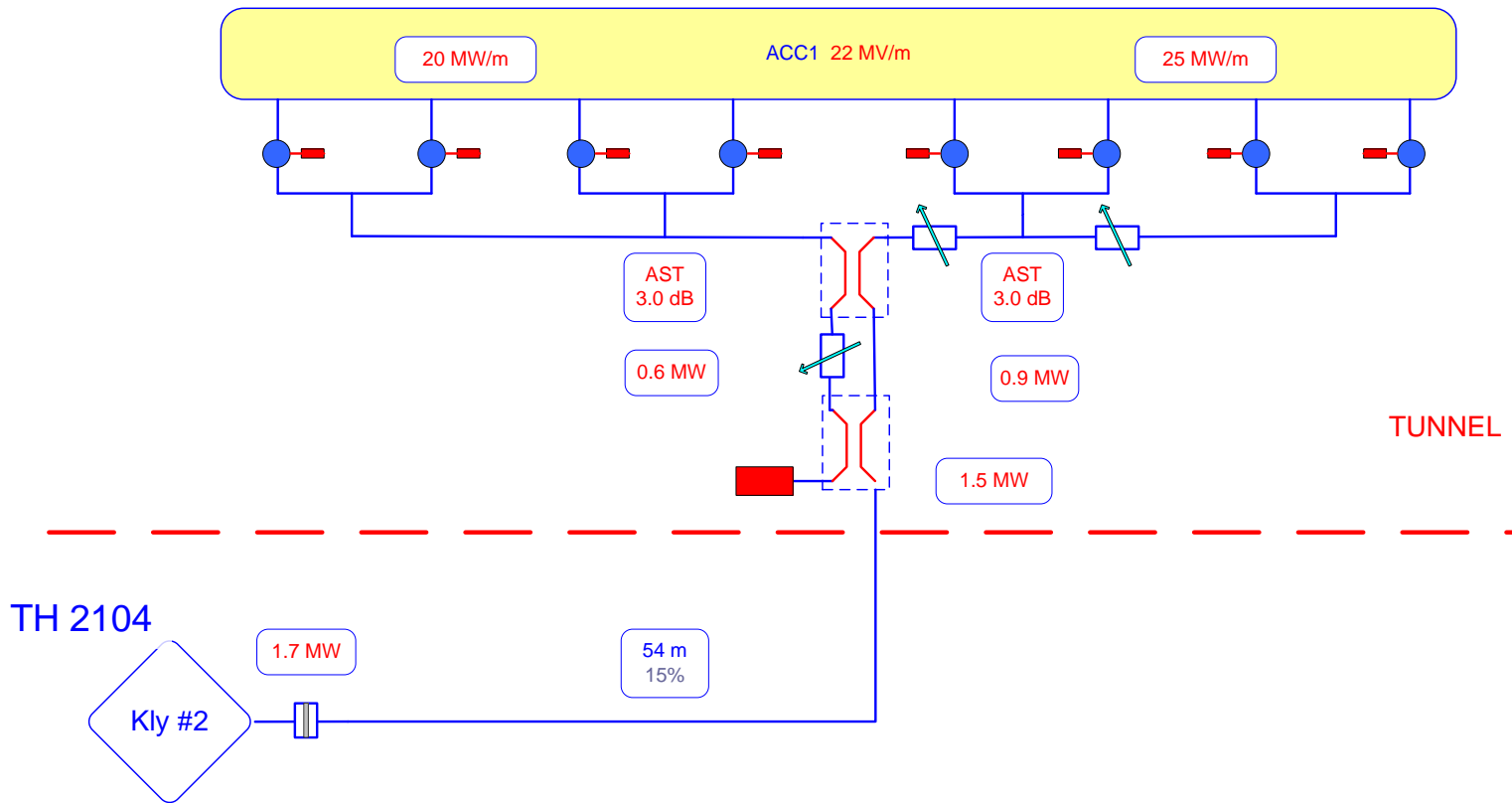


- Compact 2D system – it needs small space
- Flexible – adjustable RF power for each cavity
- Pretuned phase
- Possibility of preinstallation at the cryomodule
- Works since 2008 on the FLASH

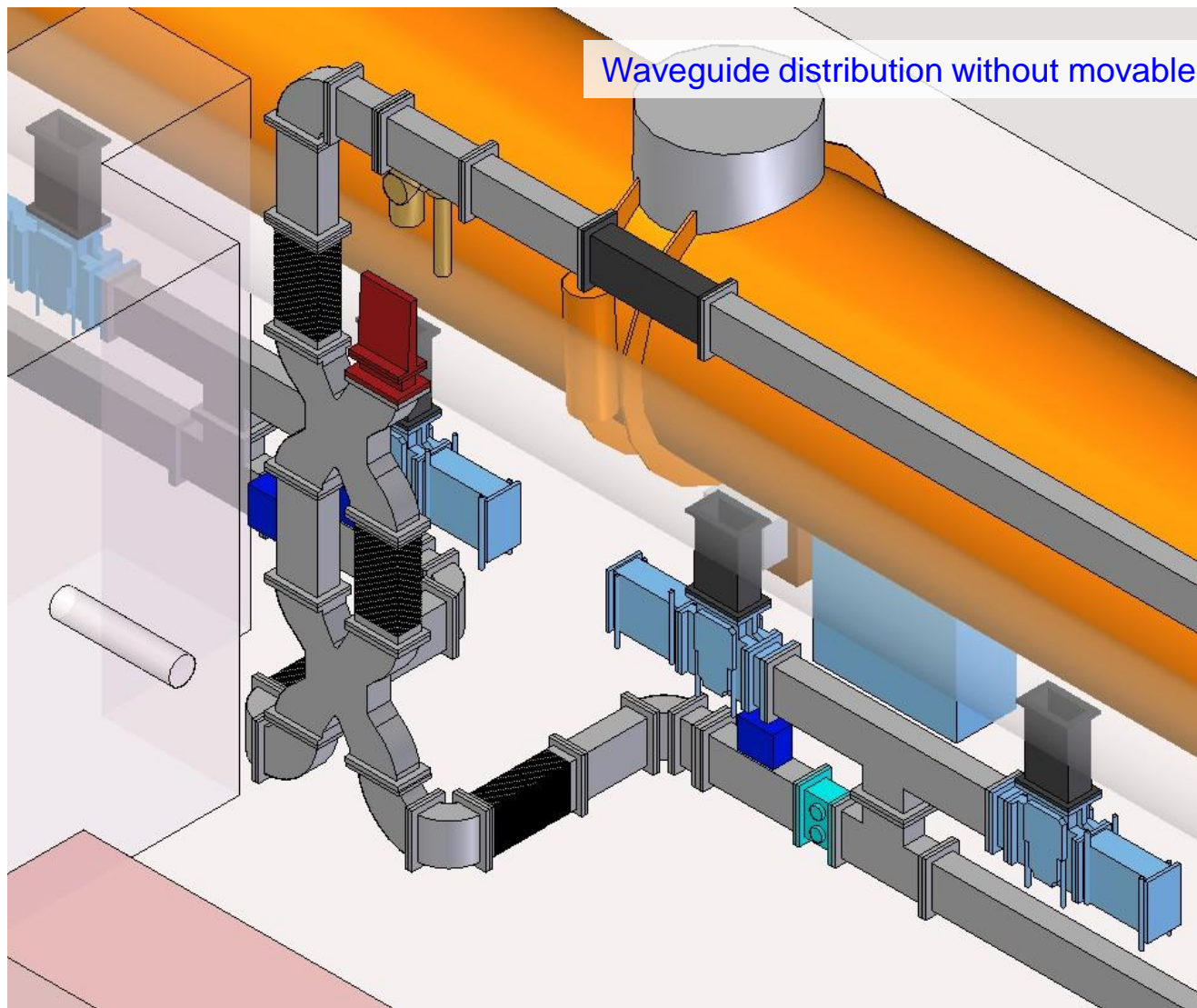
Waveguide distribution for Klystron #2



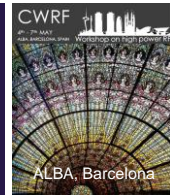
Waveguide distribution for klystron #2 (status 05.02.2010)



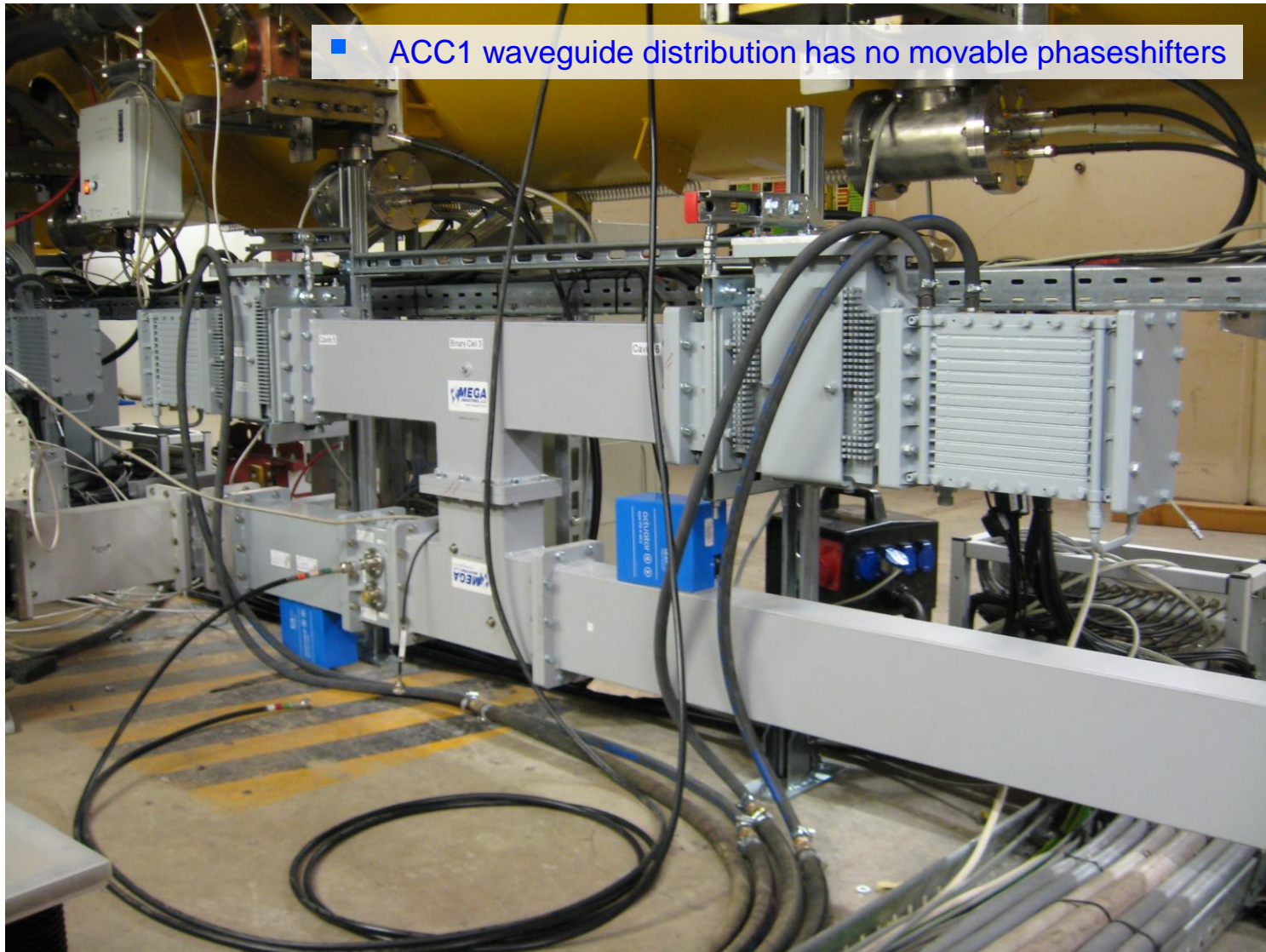
3D view of ACC1 Waveguide Distribution



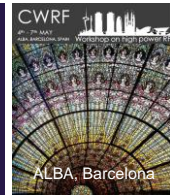
Waveguide Distribution for ACC1 in Tunnel



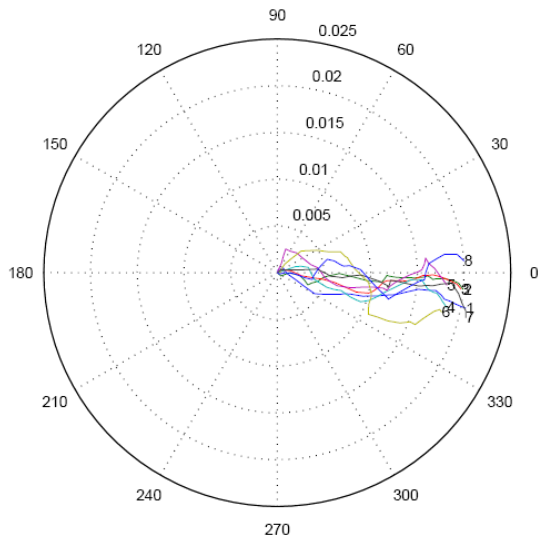
- ACC1 waveguide distribution has no movable phaseshifters



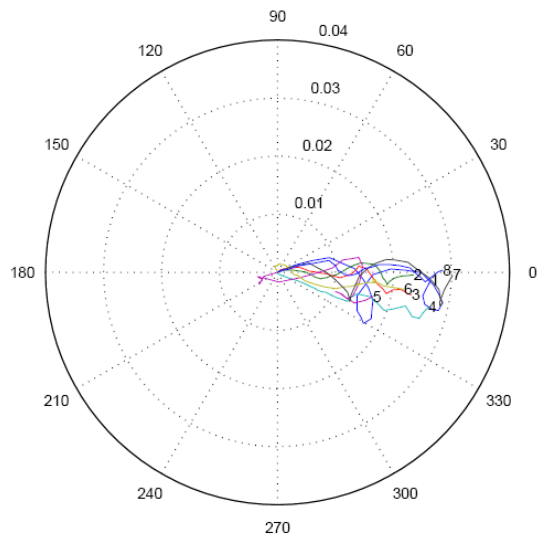
Cryomodule cavities phasing



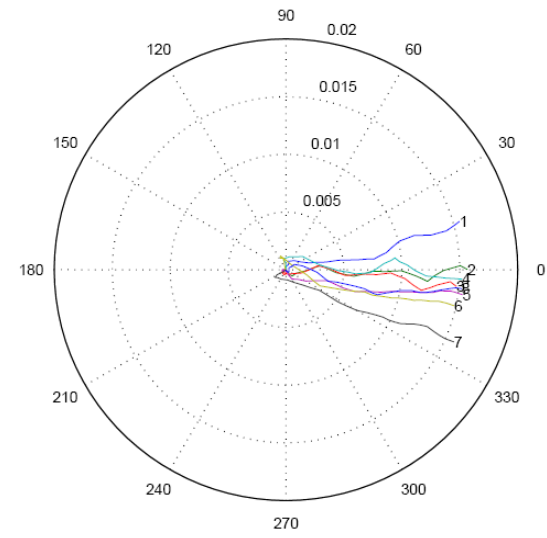
ACC3 with 3 stub phaseshifters



ACC7 with integrated phaseshifters

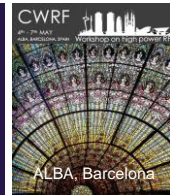


ACC1 without phaseshifters



The measurement has been done with beam

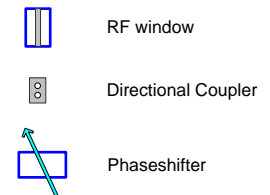
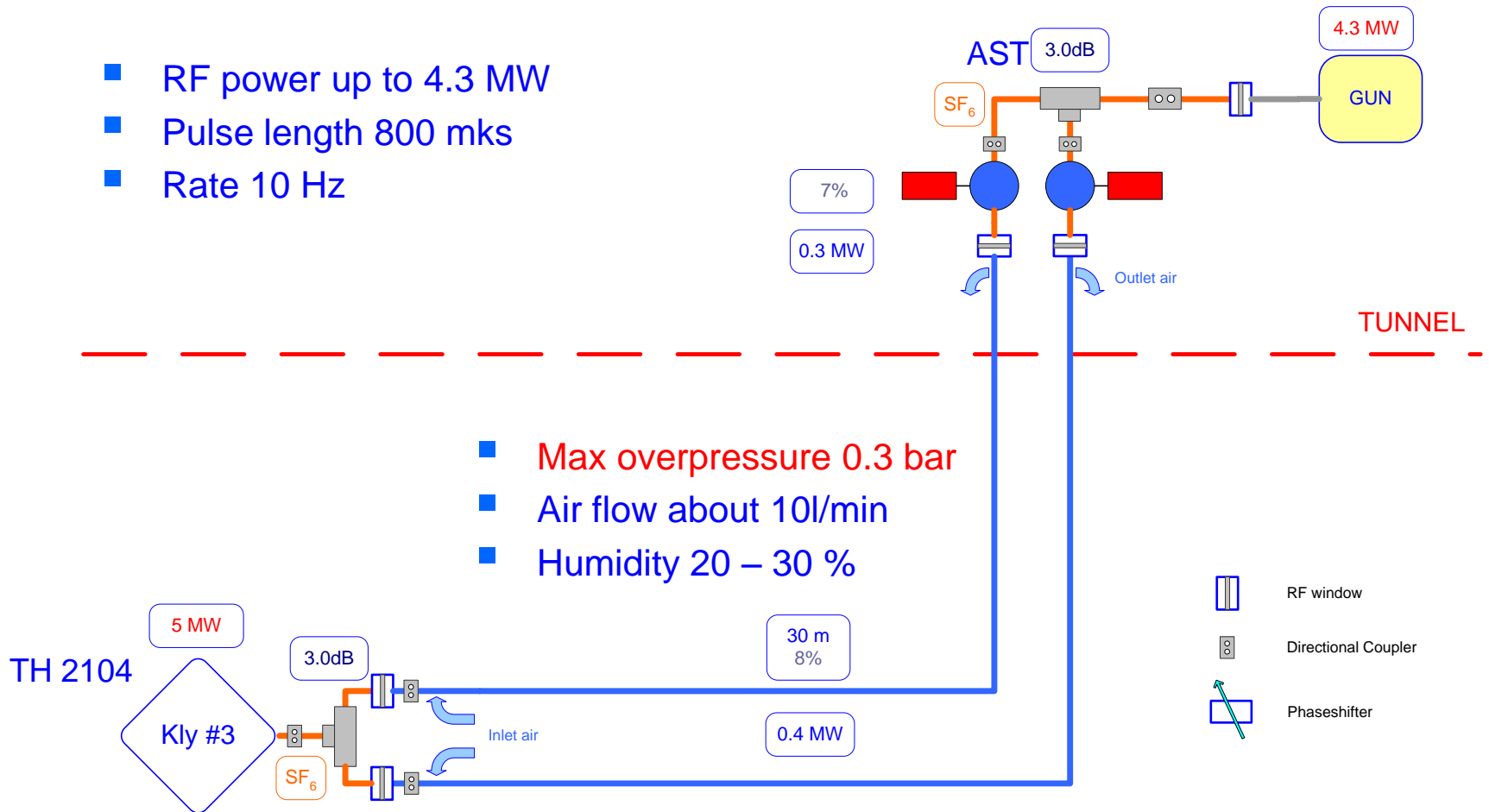
Waveguide distribution for Gun



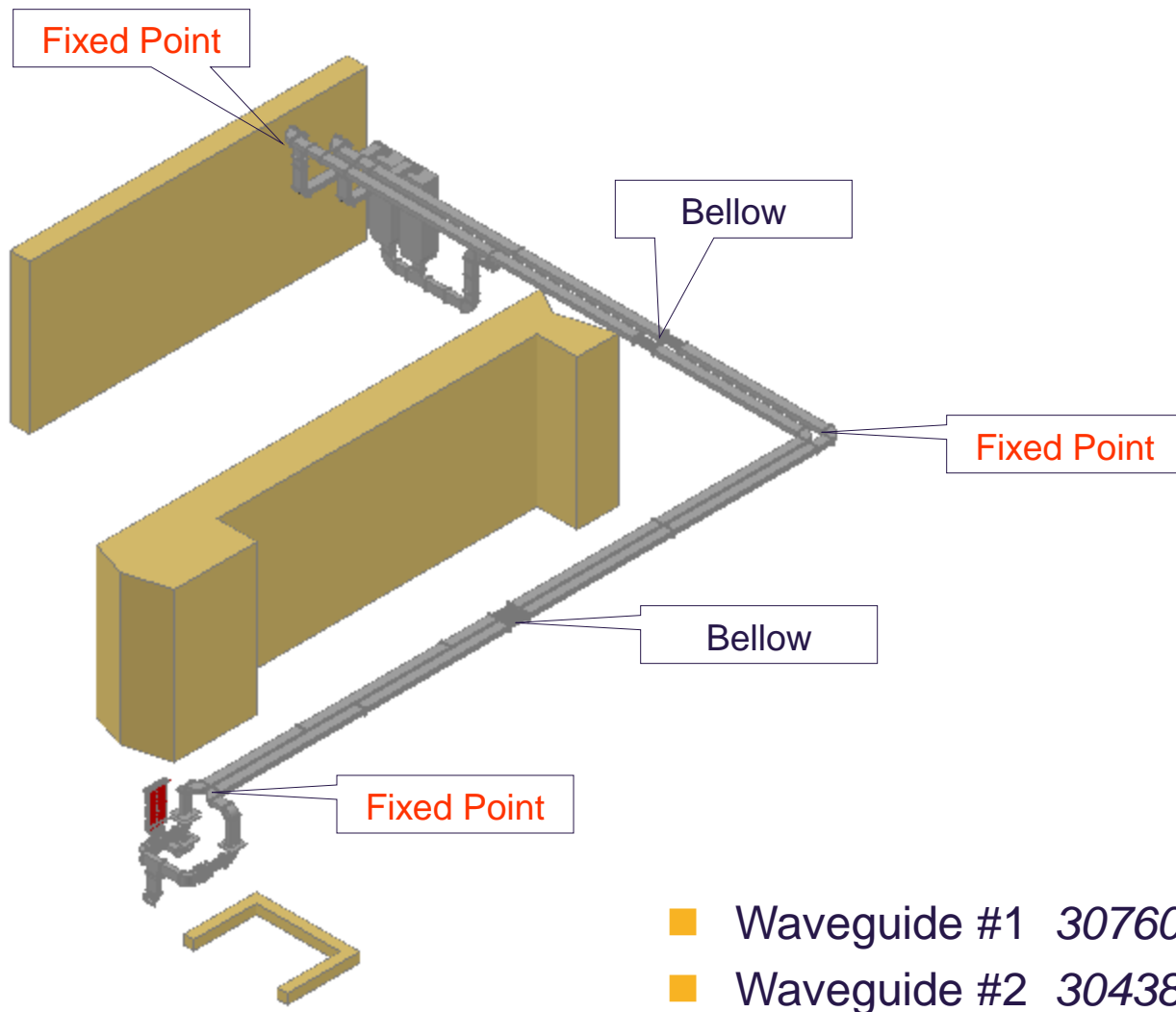
Waveguide distribution for klystron #3 (status 05.02.2010)

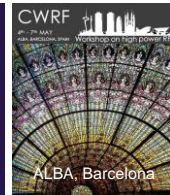
- RF power up to 4.3 MW
- Pulse length 800 mks
- Rate 10 Hz

- Max overpressure 0.3 bar
- Air flow about 10l/min
- Humidity 20 – 30 %



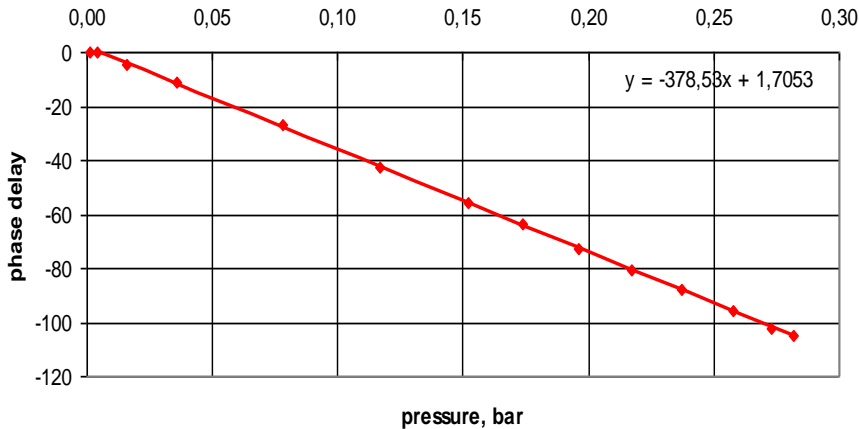
Waveguide distribution for Gun (3D view)





Waveguide Phase Tuning by Pressure

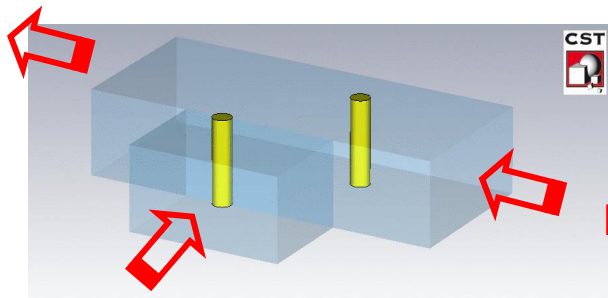
Phase delay vs pressure
(for 24 m length waveguide)



Phase shift is about -15.8 degree/m/bar
for SPINNER WR650 waveguide!

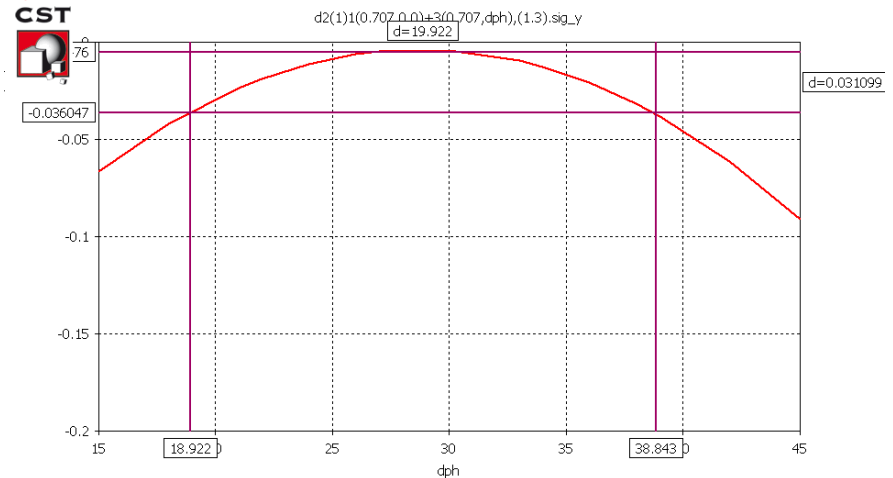
Waveguide combiner based on Asymmetric Shunt Tee

Output

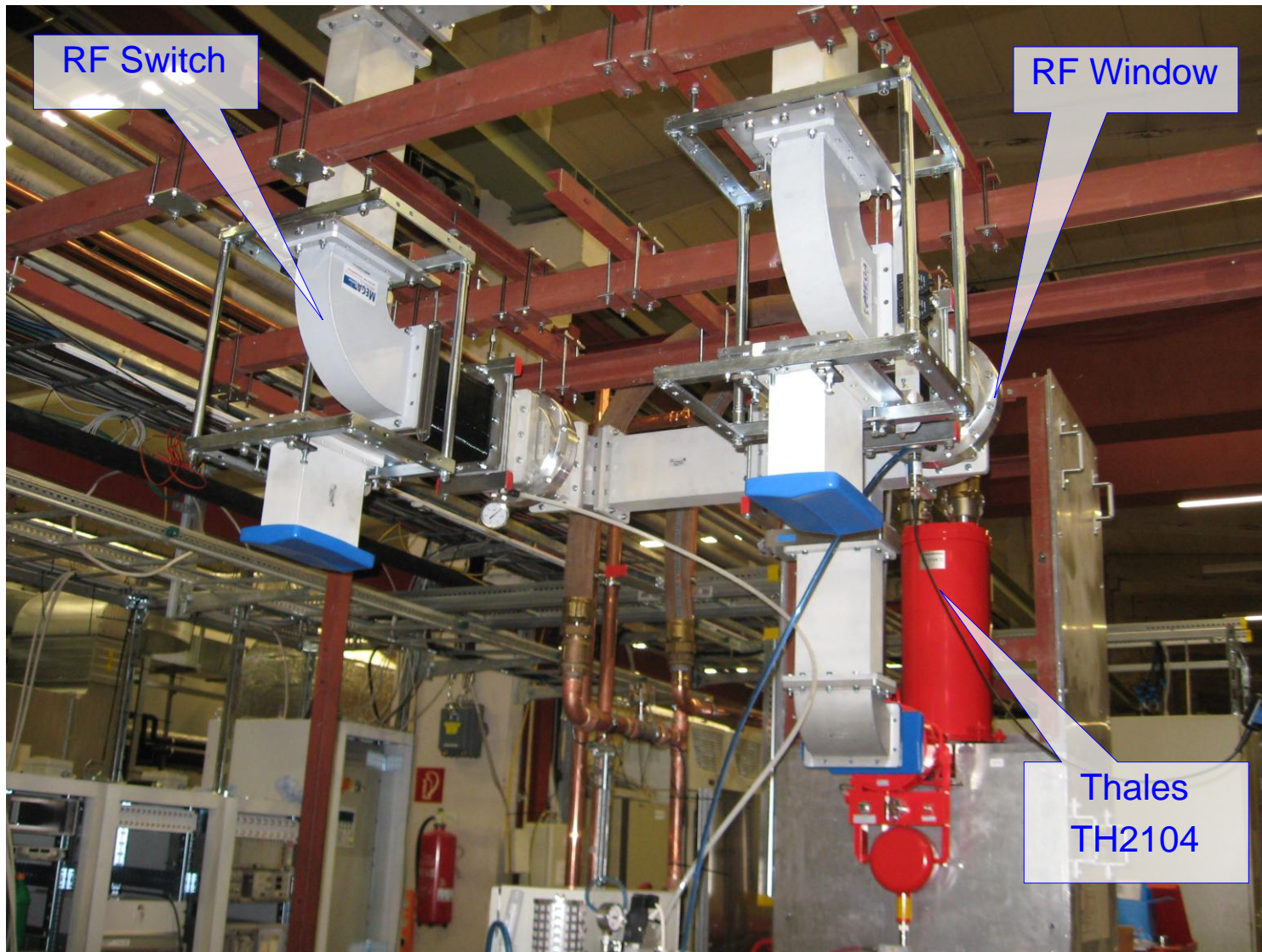
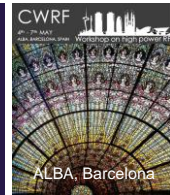


Input 1

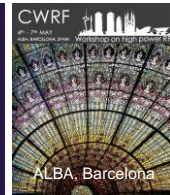
Input 2



Gun Waveguide Distribution (Klystron area)



Gun Waveguide Distribution (Gun area)

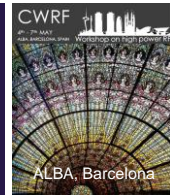




Some new waveguide components have been developed for FLASH and XFEL

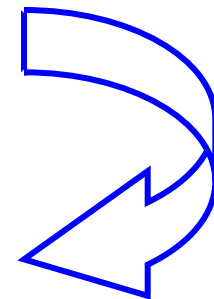
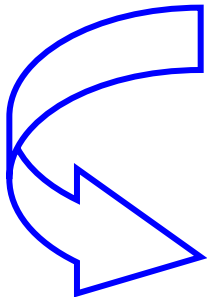
- 400 kW Isolator = circulator + dummy (FERRITE St.Petersburg)
- Asymmetric Shunt Tee (DESY, Mega Industries)
- Directional Coupler with more than 40 dB directivity (DESY, FERRITE)
- Movable Phaseshifter 5 MW (DESY, FERRITE, MicroPlus)
- Fixed Phaseshifter (DESY, Mega Industries)
- Shunt Tee with Integrated Phaseshifters (DESY, MicroPlus, Mega Industries)
- 5 MW circulator for Gun with small insertion losses (~ 0.3 dB) (FERRITE, St.Petersburg)
- Air Flow Unit for Gun Waveguide System (DESY, MicroPlus)

Waveguide Components – Binary Cell

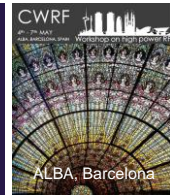


■ Shunt tee with integrated phaseshifters

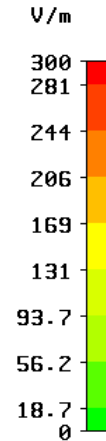
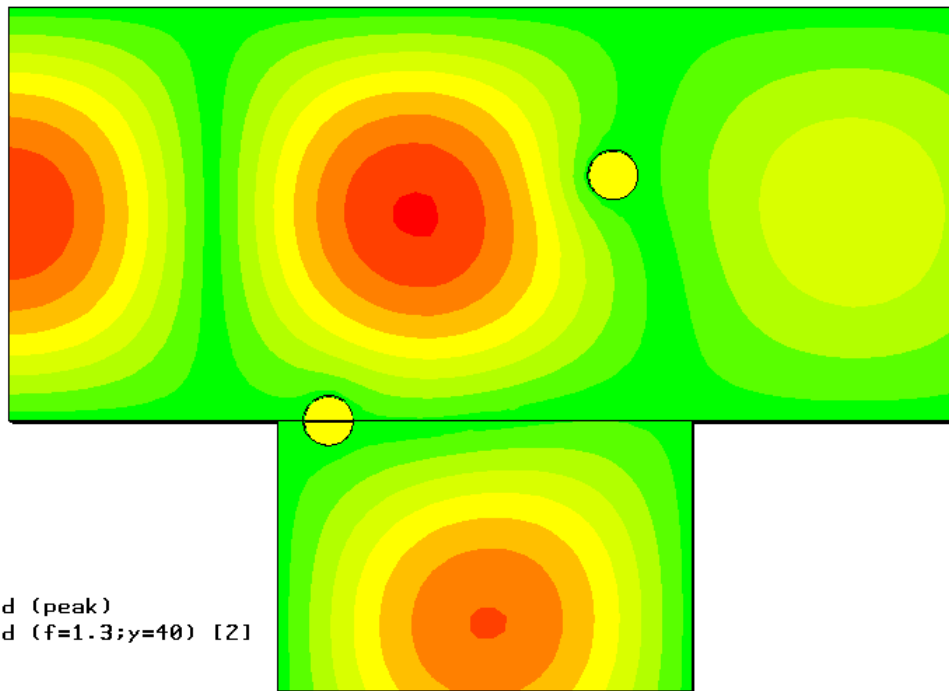
■ Isolator – circulator with integrated load



Asymmetric shunt tee (tunable)

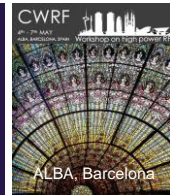


Coupling ratio 8 dB

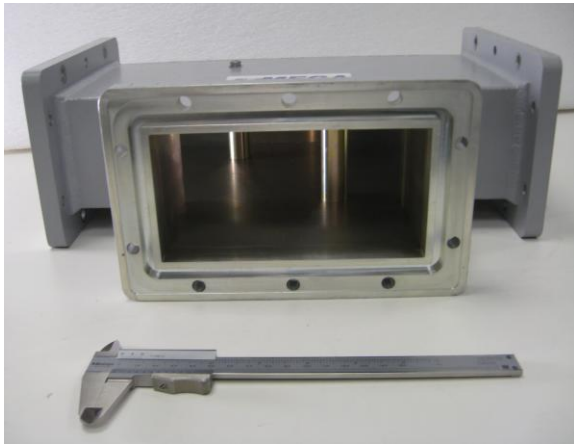


Type = E-Field (peak)
 Monitor = e-field (f=1.3;y=40) [2]
 Component = Abs
 Plane at y = 40
 Frequency = 1.3
 Phase = 0 degrees
 Maximum-Zd = 299.898 V/m at 20.6519 / 40 / -21.7887

Waveguide Components – Asymmetric Shunt Tee



To split or to combine the RF power in proper way



to ACC5

to ACC4

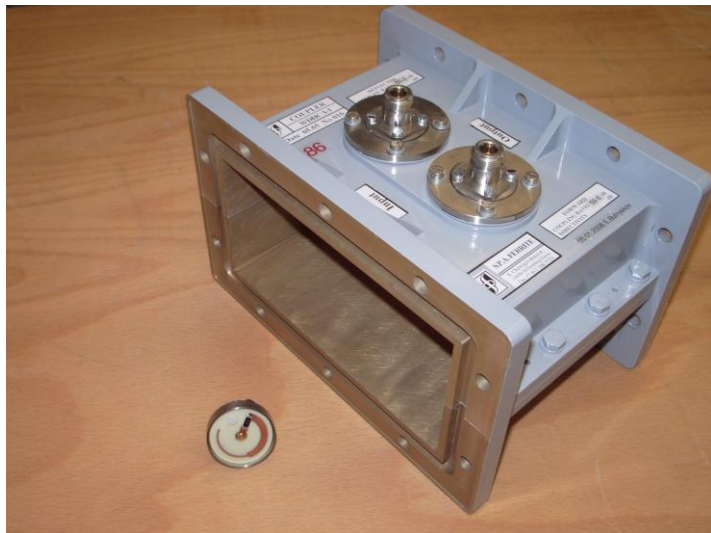
AST dividers



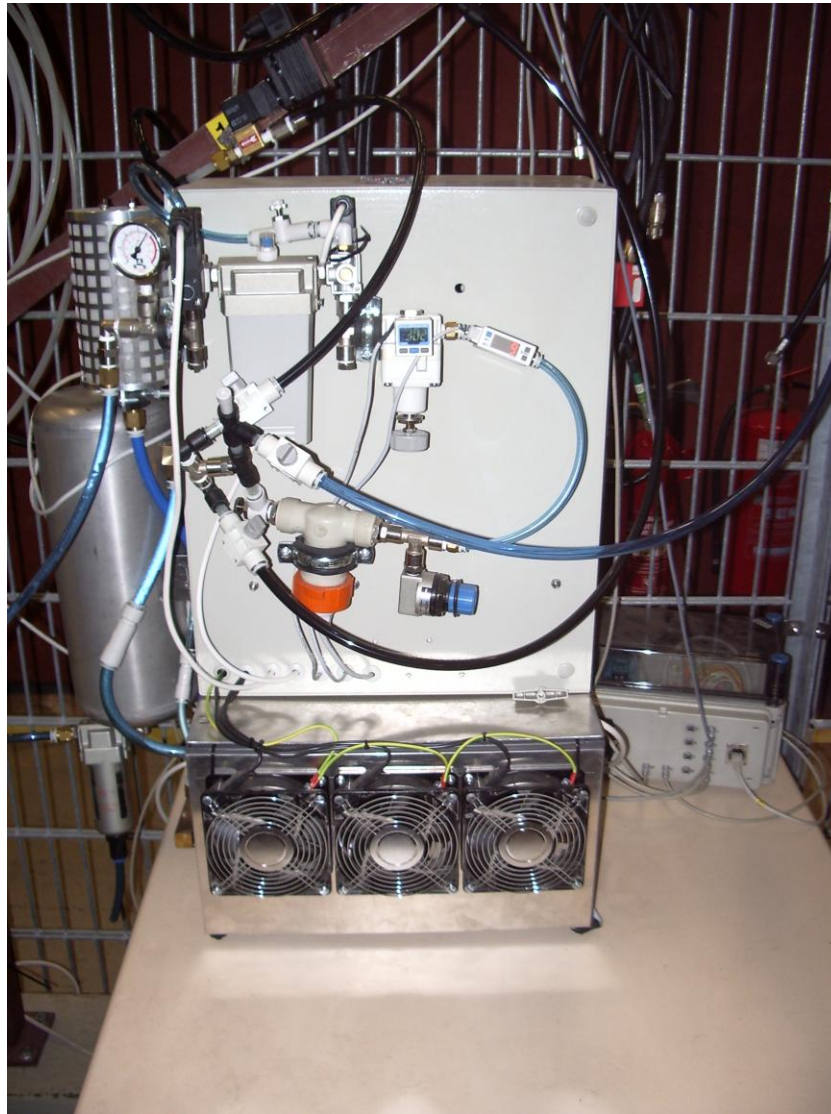
Gun combiner



Waveguide Components – DC and Phaseshifter

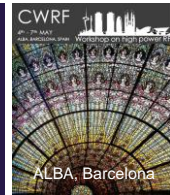


Air Flow Unit for Gun Waveguide



- 40 l/min
- Humidity 20-30%
- Pressure max 0.5 Bar
- Oil free diaphragm pump

Conclusion and Acknowledgement



- The waveguide distribution for FLASH has been modified and tested
- The new type of cryomodule waveguide distribution has been designed and applied to
- The new waveguide components for the European XFEL have been developed and successfully tested in the FLASH waveguide distribution
- The new experience for the European XFEL has been received

In the end I would like to thank all members of our team for the assembly, installation, tuning and RF measurements of the many waveguide components and distributions

Thank you for attention