Towards an X-Band Power Source at CERN and a European Structure Test Facility

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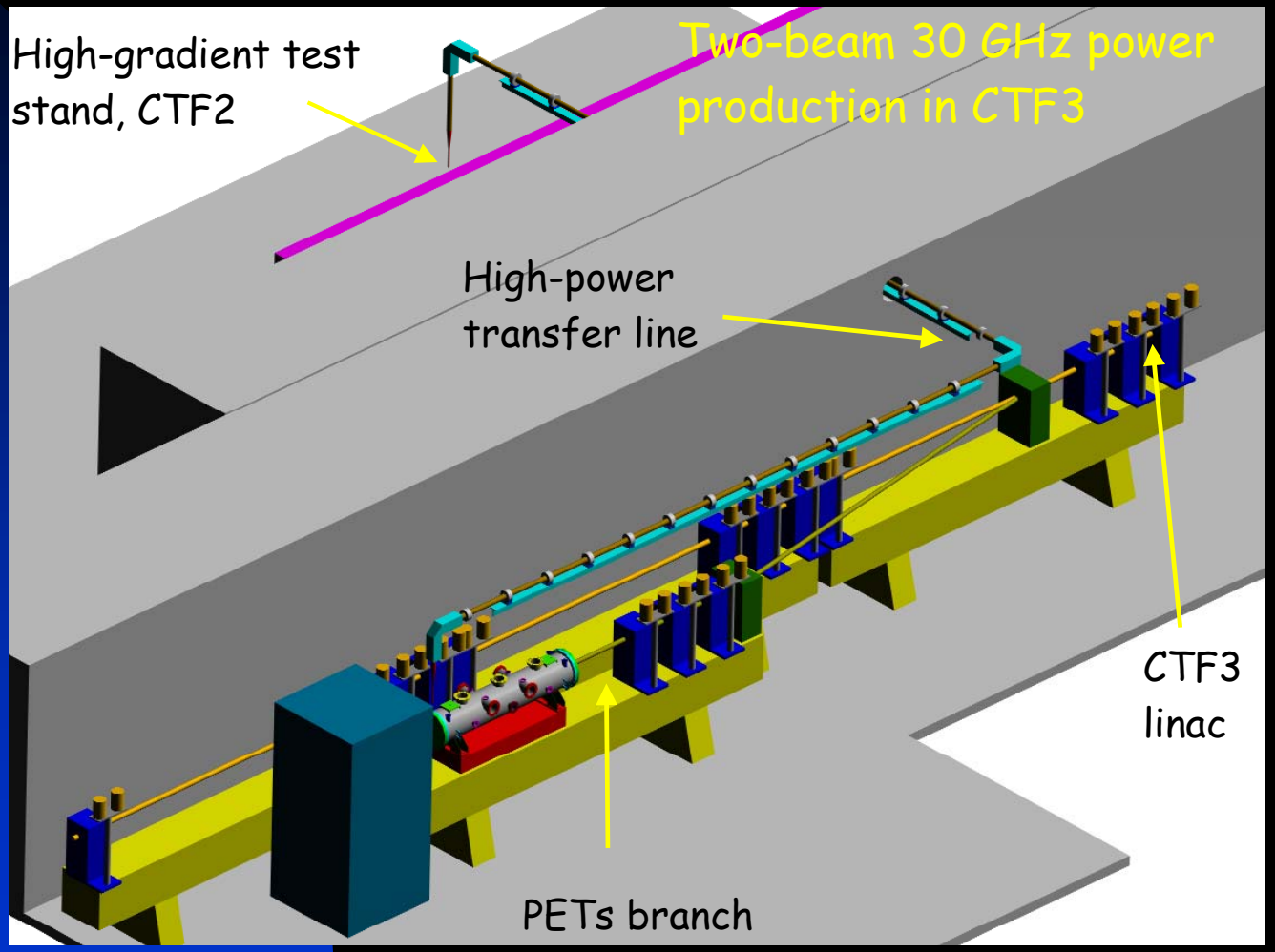
Present situation

- Existing mid-linac power station test facility



Plan

- The Two-beam Test Stand (2TBTS) will eventually be our structure test facility.
- It will be operational for structure tests from 2009 (but only up to 140 ns pulse length!)
- We could transform the mid-linac power station to 12 GHz?, but
  - it would not be ready before 2BTS,
  - it would interfere with other CTF3 commissioning,
  - it could not be operated in parallel with 2BTS,
  - while transforming, we wouldn't have no facility at all.
- We continue and intensify tests at 11.424 GHz, both at SLAC and KEK.
- But we really need a stand-alone test stand *soon !*
- *This need is not new!*

In 2005, I wrote*):

- During CTF3 construction phase, limited time available to produce 30 GHz power.
  - Test 4…5 structures/year + waveguide components + pulse surface heating experiments?
- CTF3 runs at ≈ 10 Hz (limit 50 Hz), which is low for conditioning Mo or W structures.
  - Tests of Mo structures at SLAC indicate a factor 10 lower "conditioning rate" than Cu!
- CTF3 is a test facility, not a production accelerator.
  - Only one 30 GHz output from CTF3!

This is why we need a reliable, stand-alone 30 GHz power source: > 160 MW, > 70 ns, > 100 Hz

The frequency has changed, but many arguments are still valid today.

*) at the SLAC meeting where the US High Gradient Collaboration was established

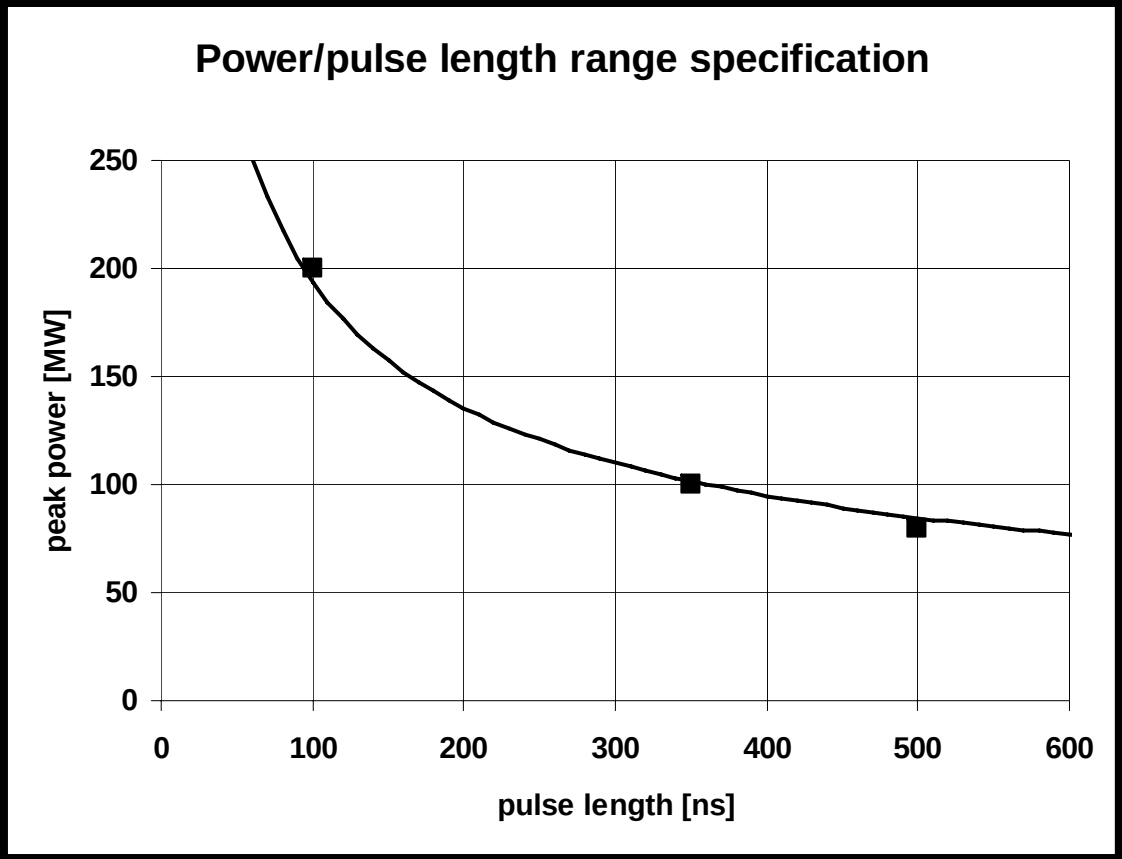
Parameters

Ideal Parameters of an X-band Test-stand:

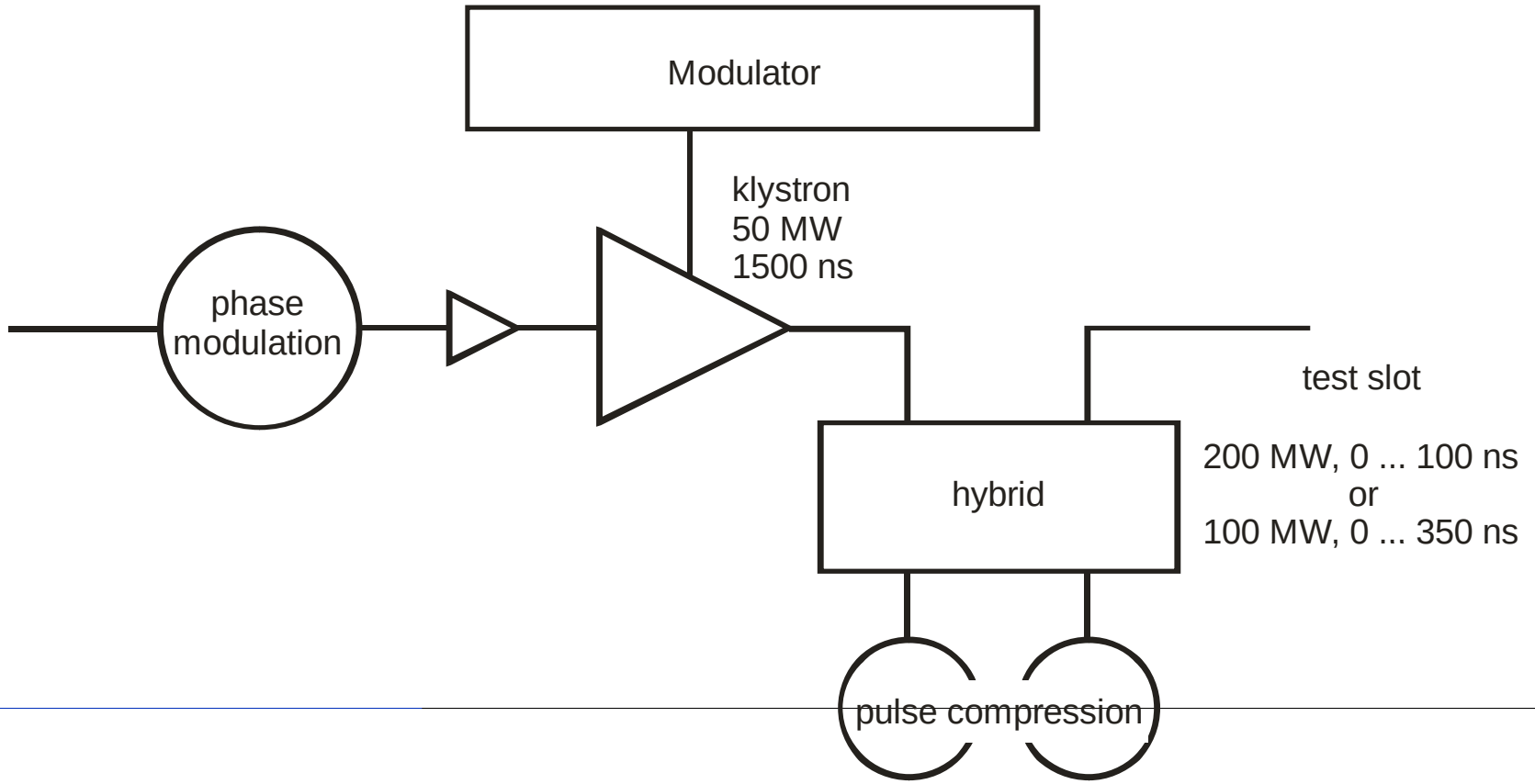
- (new) CLIC and CTF3 frequency: 11.9942 GHz
- Repetition rate: high (50 Hz or higher)
- Power and pulse length: variable
- For example:

200 MW — 100 ns,
100 MW — 350 ns,
80 MW — 500 ns

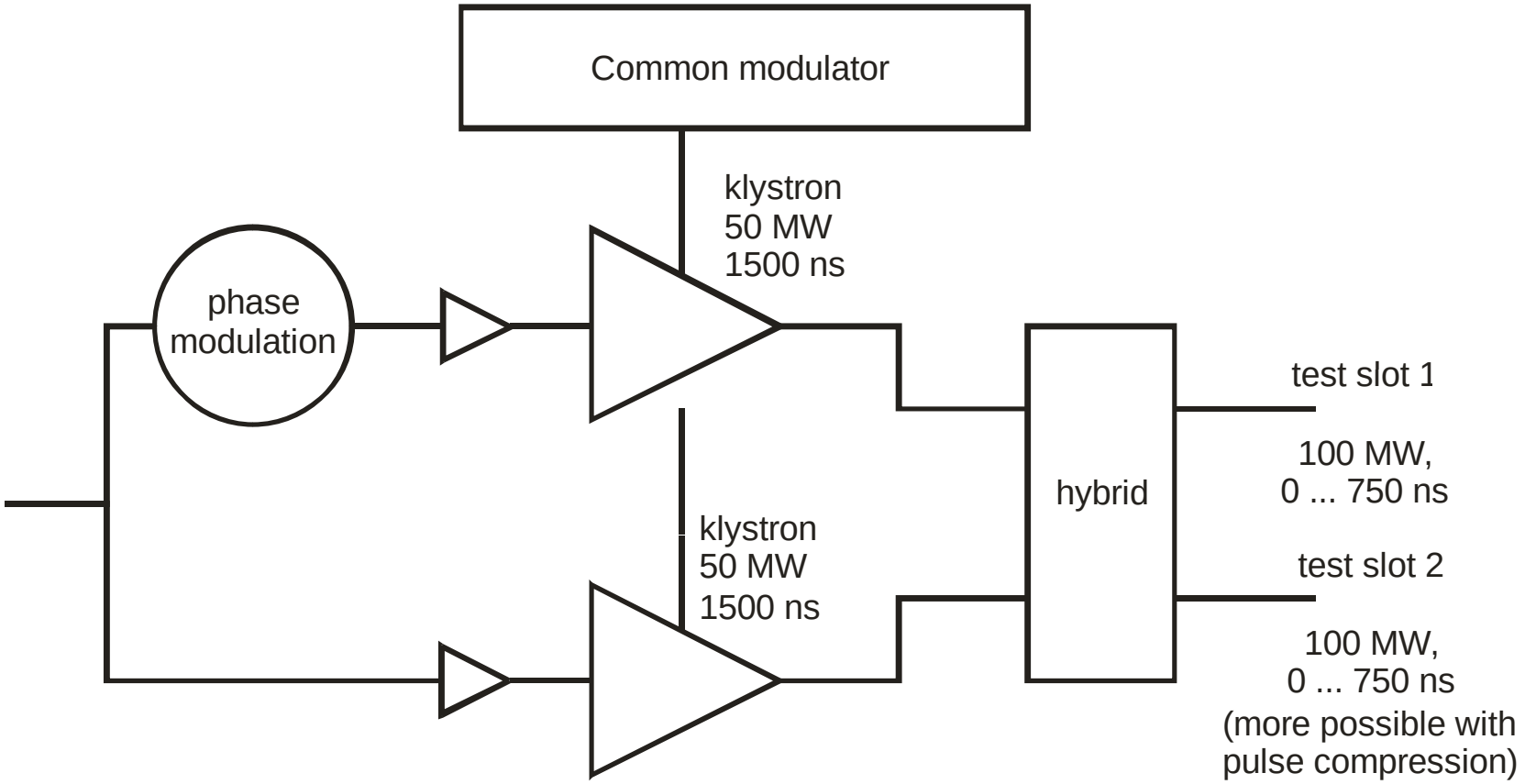
- This can be implemented using pulse compression



Test facility based on a single klystron



Test facility based on two klystrons



A remarkable coincidence:

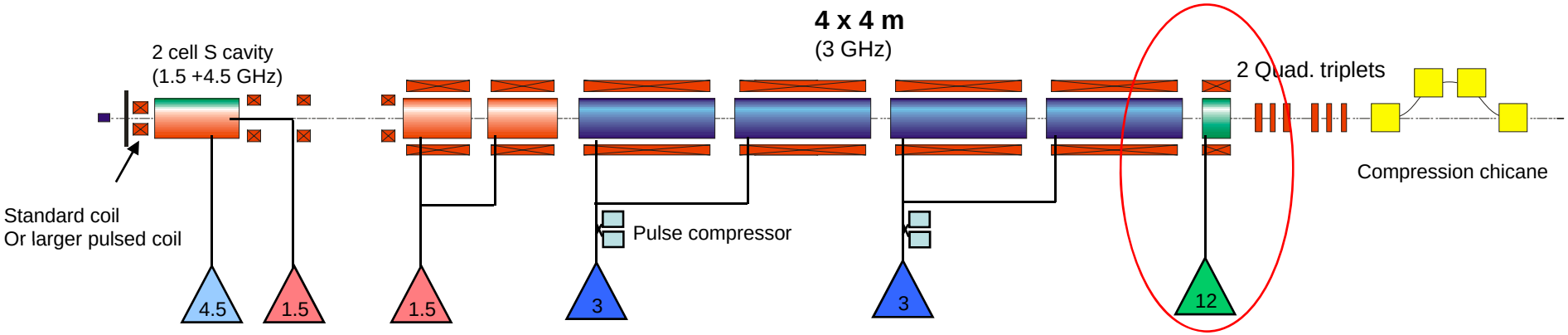
Just as we identified our need, so did 3 other labs in Europe:

- PSI Villingen for the „PSI-FEL project"
- Sincrotrone Trieste for „FERMI @ Elettra"
- LNF Frascati for SPARC/SPARX

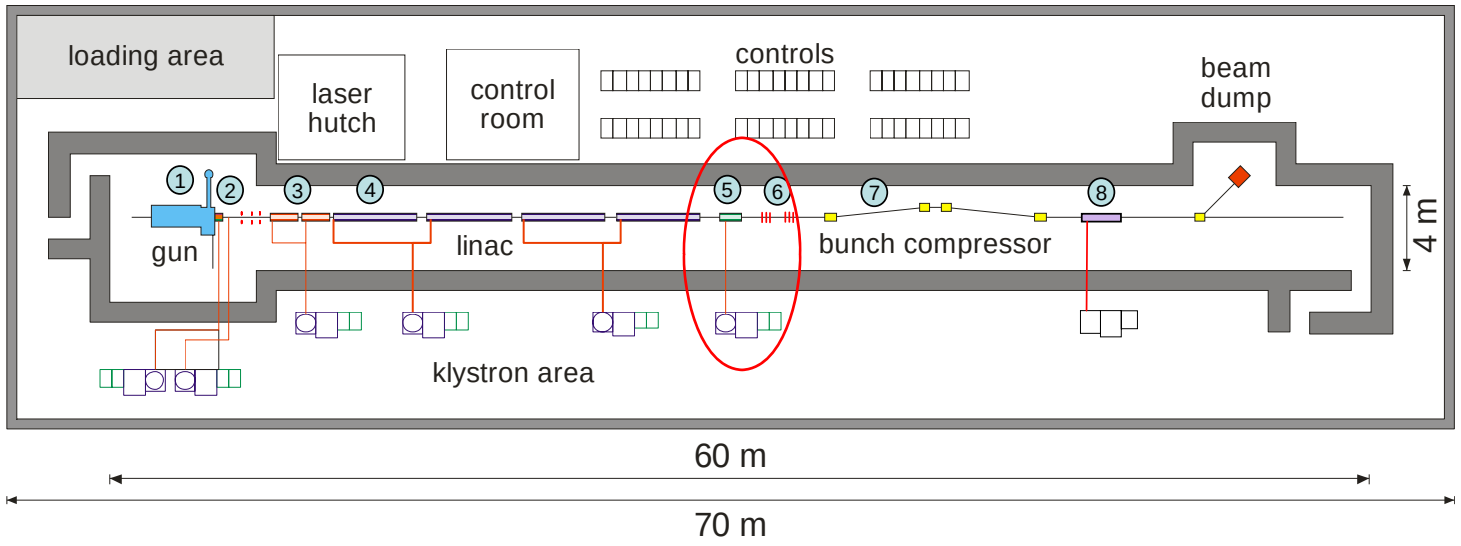
The PSI-FEL project (from M. Pedrozzi's presentation)

STEP 2

250 MeV injector facility - accelerator layout *(Courtesy of René Bakker - in progress)*

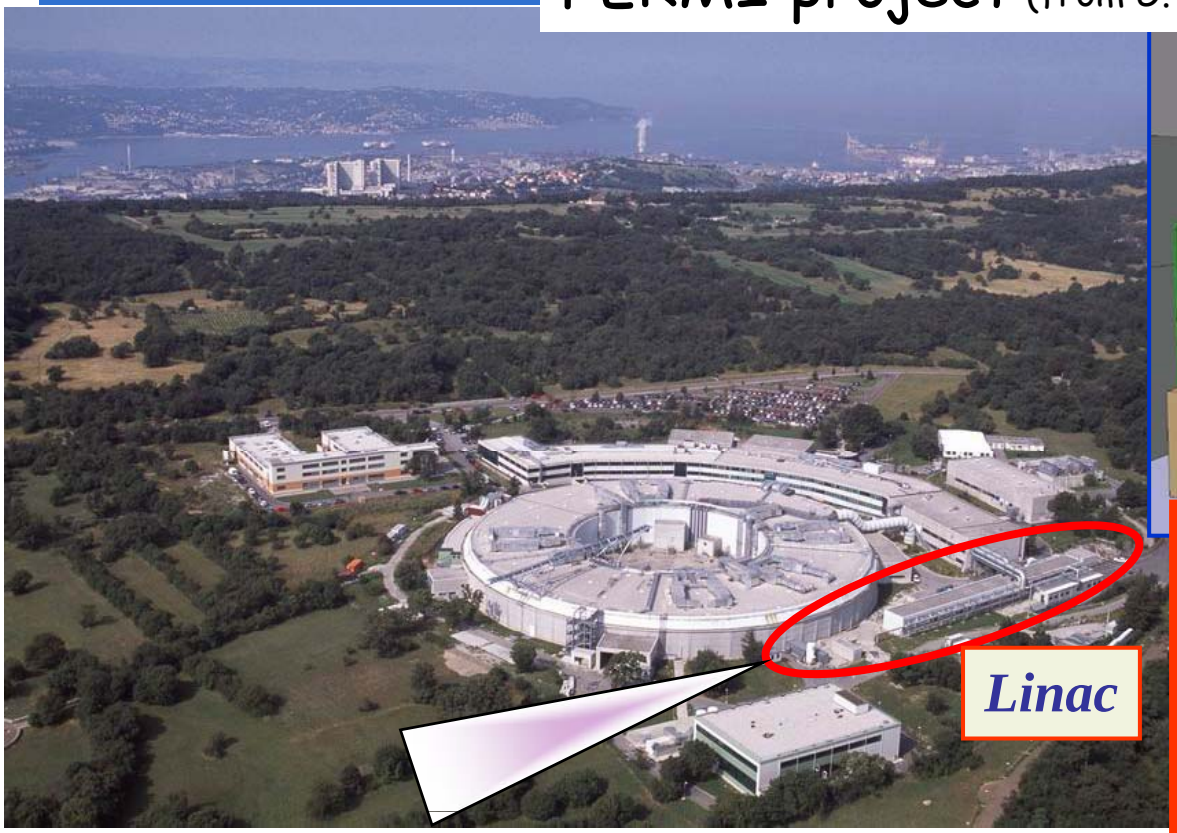


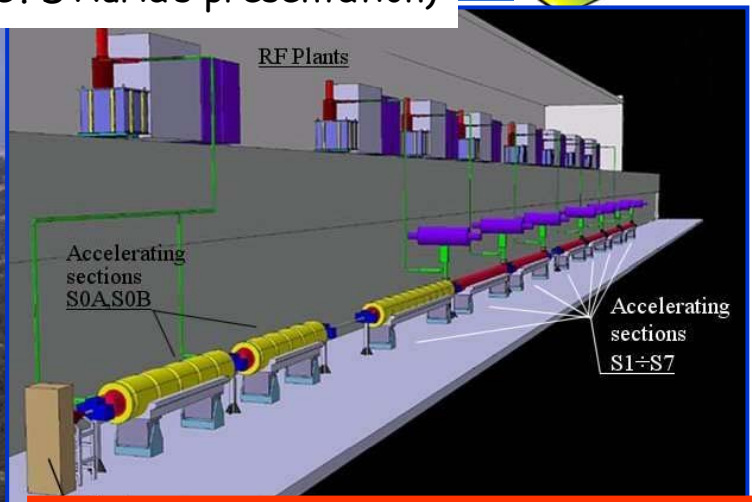
One power source (50-60MW) per 2 S-band structure: cost efficient



(1) HV pulser
(2) 2 cells–2 freq. cavity
(3) L-band TW structures
(4) S-band TW structures
(5) X-band harmonic cavity
(6) quadruple triplets
(7) compression chicane
(8) deflecting cavity

FERMI project (from G. D'Auria's presentation)

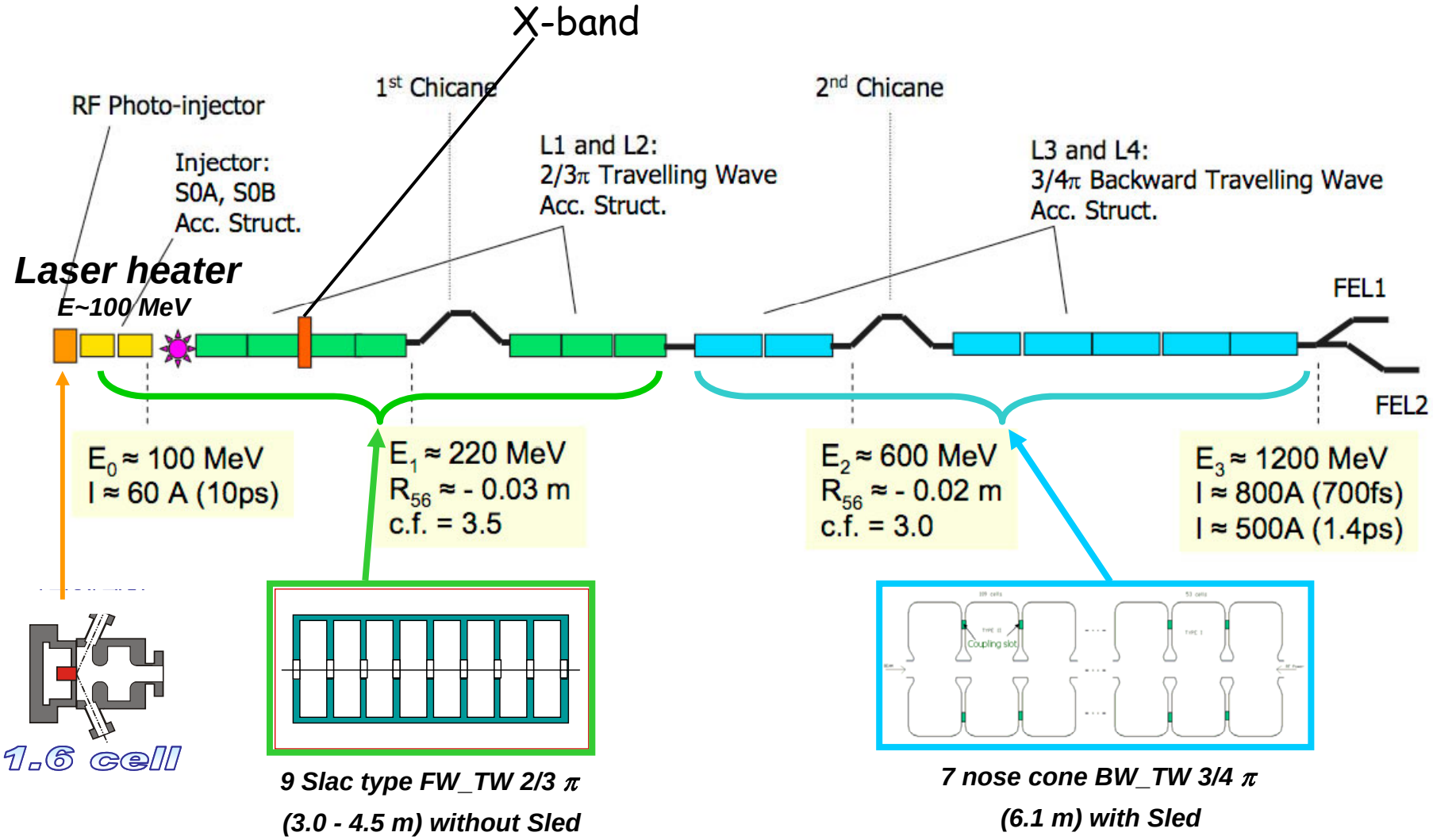




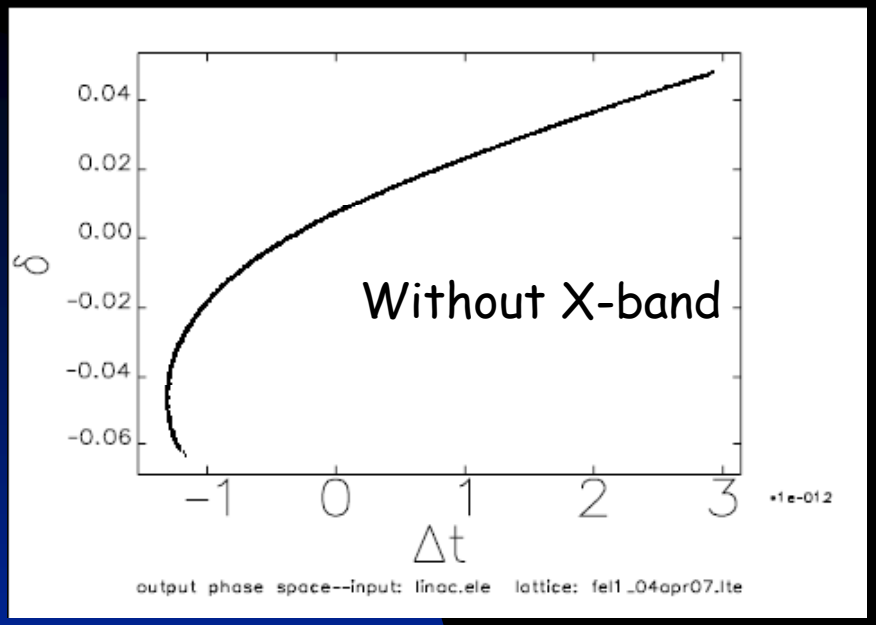
Available:

- **8 Klystron stations;**
- **9 Accelerating sections:**
  - **2 FW_TW 3 m**
  - **7 BW_TW 6 m**
- **7 Accelerating sections donated by CERN.**

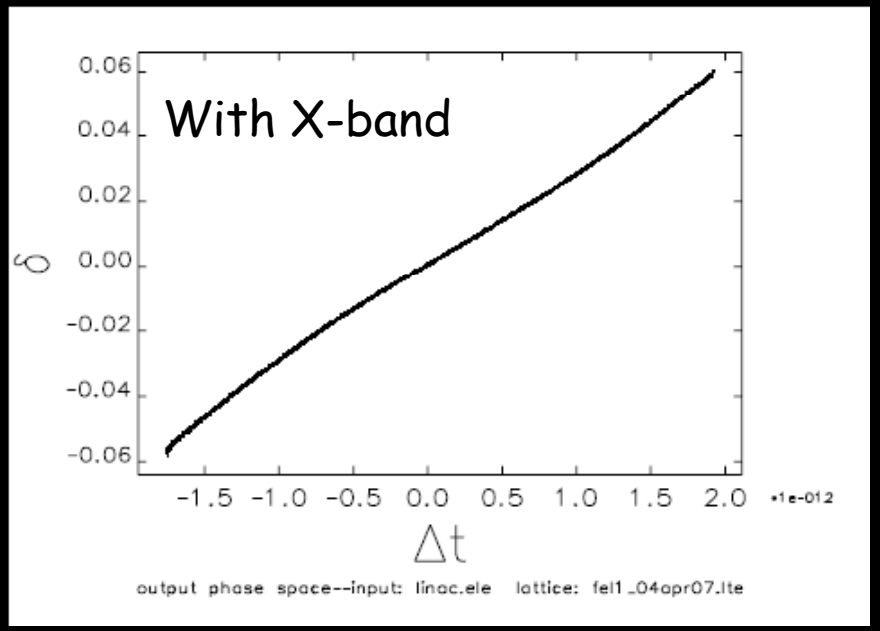
FERMI project (from G. D'Auria's presentation)



Light Sources – why X-band?



Bunch phase space at exit of 1st bunch compressor.



Harmonic system (S-band acceleration) to linearize phase space for better FEL performance

A remarkable coincidence:

Just as we identified our need, so did 3 other labs in Europe:

- PSI Villingen for the „PSI-FEL project"
- Sincrotrone Trieste for „FERMI @ Elettra"
- LNF Frascati for SPARC/SPARX

These labs are looking for initially 20 to 30 MW (for phase space linearization).

It seems like a really good idea to join forces.

So we got together and agreed on common klystron parameters:

11.9942 GHz, 50 MW peak, 1.5 µs, 50 Hz

This happens to be similar to SLAC's XL4

Parameter	*Value*	*Units*
Operating frequency	**11.424**	**GHz**
RF pulse length	**1.5**	**µsec**
Peak output power	**50**	**MW**
Pulse repetition rate	**60**	**Hz**
Efficiency	**40**	**%**
Gain	**50**	**dB**
Bandwidth	**25**	**MHz**
Perveance	**1.2**	**µPerv**
Beam voltage	**410**	**kV**

… only the frequency needs a 5 % tweak.

The klystron is well feasible

- European Industry (Thales, E2V, TMD) have no relevant experience.
- SLAC or Toshiba could build such a klystron
  - and in fact, both have given us some very positive indications including delay and cost.

Indicative estimates	**Toshiba**		**SLAC**	
Design and prototype	990 kCHF	15 months	665 kCHF	18 months
Production tube	580 kCHF	10 months after proto	485 kCHF	6 months after proto
Total cost	1570 kCHF		1150 kCHF	

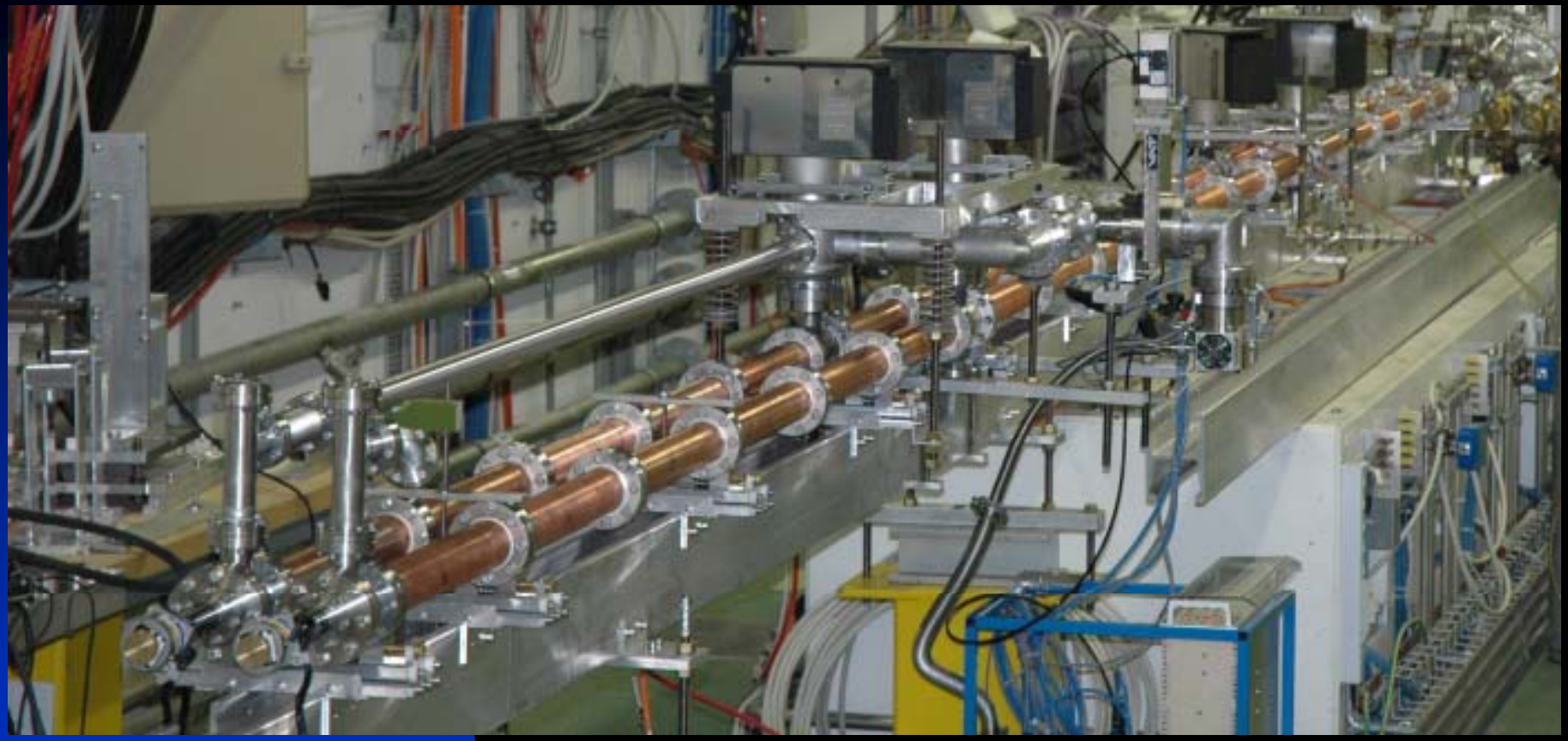
  - The scaling from 11.4 GHz to 12 GHz requires only little change.
  - Important to us (in addition to the technical specification)
    - minimum risk
    - shortest delay
    - reliable operation

Overall "short term" klystron needs in Europe

	2008	2009	2010
CERN	1	(+1)	0
LNF		1	1 (?)
PSI		1 (+1)	
Elettra	1		

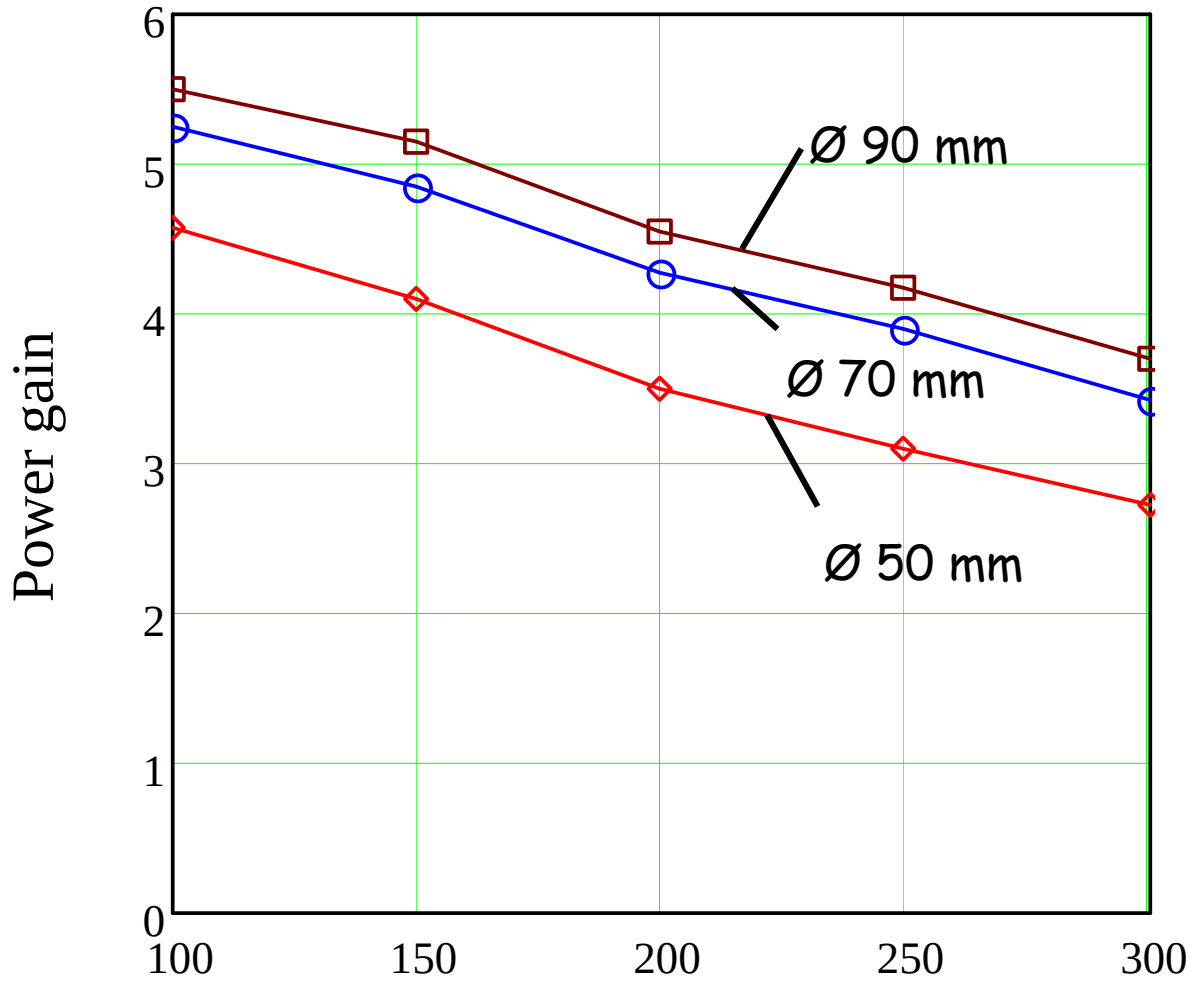
There is an immediate need of 2 klystrons, with an option of 2 to 5 more.

Pulse compression



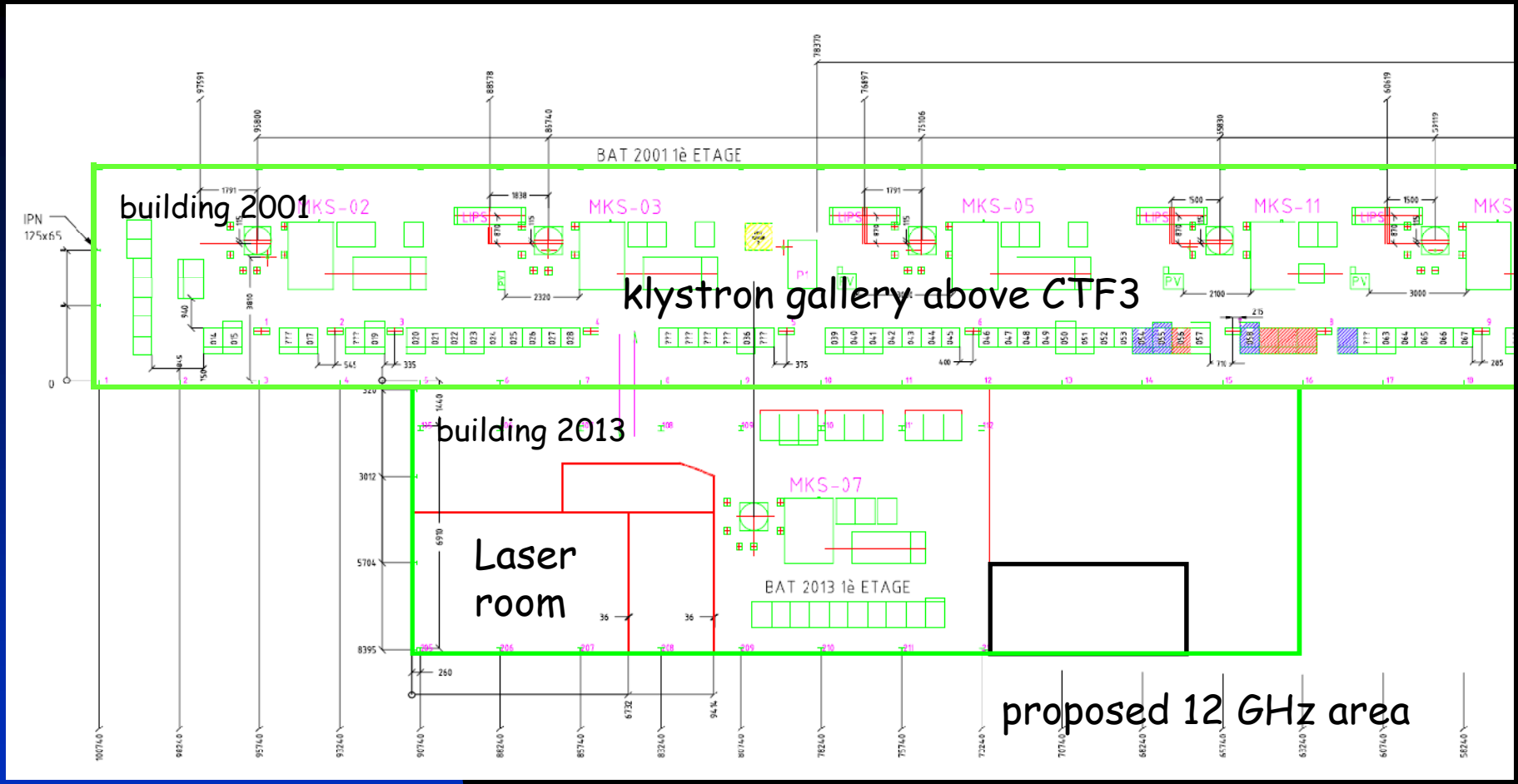
We have TM_{01} line (Ø 50 mm) available for up to 160 ns.
This was meant for 30 GHz — for 12 GHz we would prefer Ø 90 mm.

Power gain for 1.5 μs klystron pulse



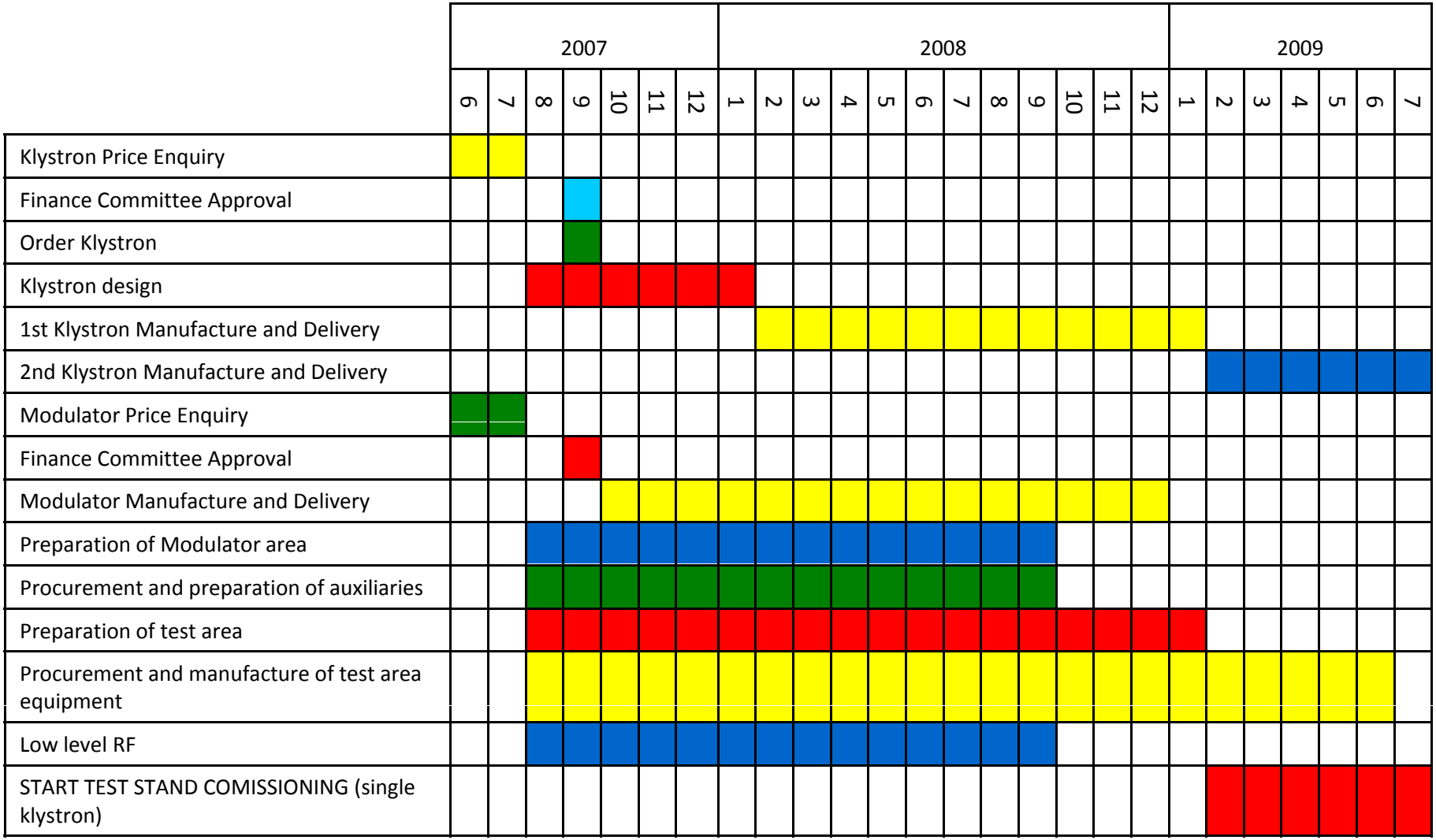
from Igor

Possible location



Advantages: existing infrastructure (water, electricity, bunker, controls)
proximity to 2BTS

A possible schedule



Resulting possible number of tests at CERN

From Steffen's talk this morning

	2007	2008	2009	2010	sum
30 GHz	5	3	0	0	8
12 GHz	0	1	4	4	9
11.4 GHz	2	4	4	4	14
Stand alone at CERN	0	0	8	8	16
sum	7	8	16	16	47

Summary

- The XBKTS*) (X-band Klystron Test Stand) is in reach — and it will be implemented.
- There is strong common interest with planned European light-sources (PSI, LNF, Elettra), which will be fully exploited (in a sort of „joint-venture").
- The facility is based on a klystron very similar to those developed and built for NLC.
- The total cost of a facility is estimated around

  2.7 MCHF or 1.6 M€ or 2.2 M$ plus 4 FTEy.
- It will be operational in early 2009.

*) AKA EuTube