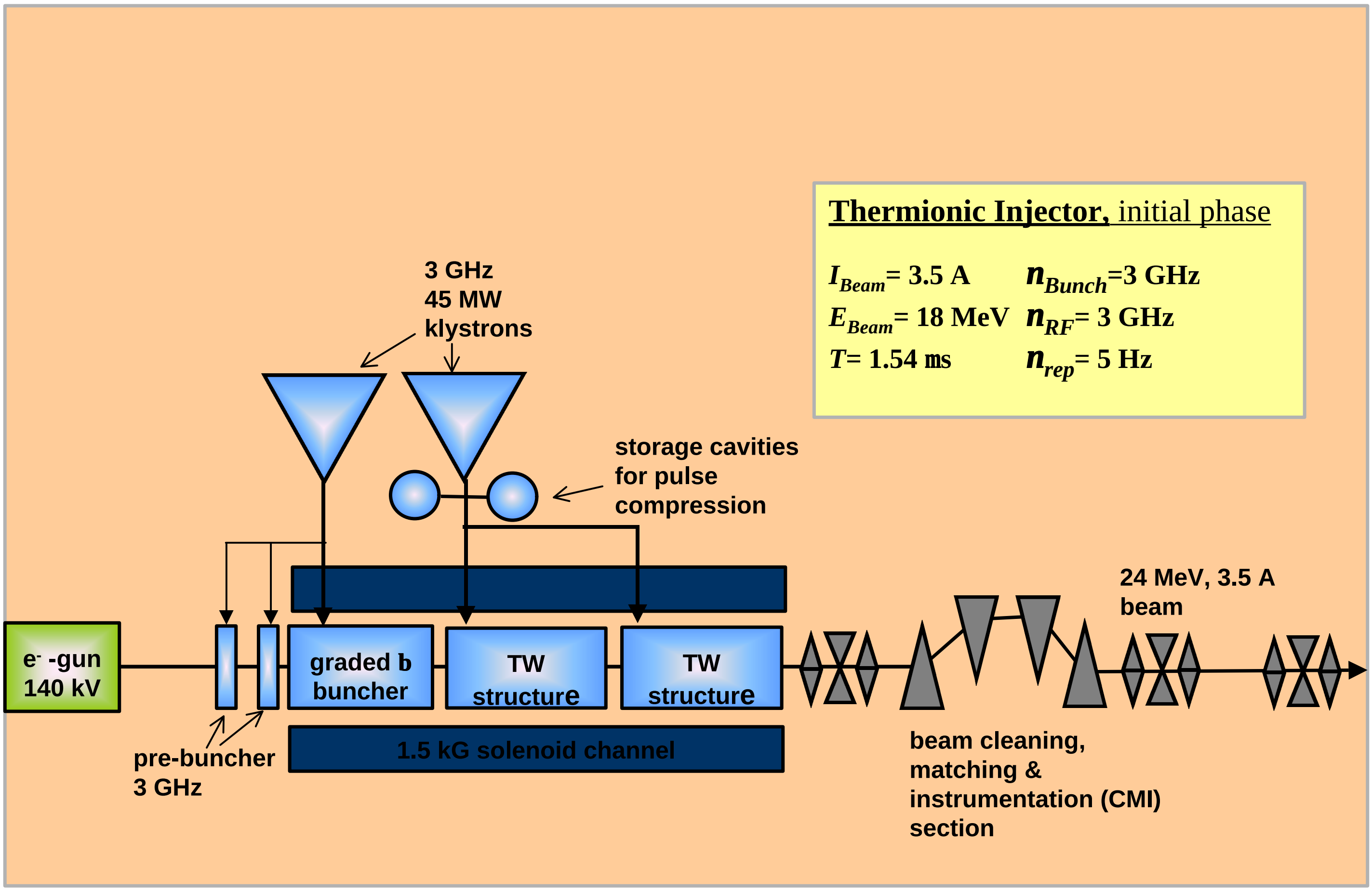
CTF3 drive beam injector

- requirements
- initial phase
  concepts, problems and remedies
- nominal phase
  options
  bucket switching
- schedule
- contributions from collaborating institutes

Requirements

Parameter	Initial	Nominal	Unit
Pulse length	1.54		μs
Beam current	3.5		A
Charge per pulse	**5390**		nC
Bunches/pulse	4620	2310	
Charge per bunch	1.17	2.33	nC
Emittance, norm., r.m.s.	< 100	< 100	mm-mrad
Bucket switching	none	**every 140ns**	
Allowed charge in Satellite	-	**<7**	%
Bunch spacing	0.33	0.67	ns
Bunch length (rms)	< 5	< 5	ps
Energy spread (single bunch rms)	< 0.5	< 0.5	MeV
Energy spread (total on flat top incl. Beam loading)	**< 1**		MeV
Charge variation bunch to bunch (>20 MHz)	< 2		%
Charge flatness total on flat top (<20 MHz)	**< 0.1**		%
Beam repetition Rate	5		Hz



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- energy collimation (@18 MeV)
- bunch compression and instrumentation (@ 50 MeV)

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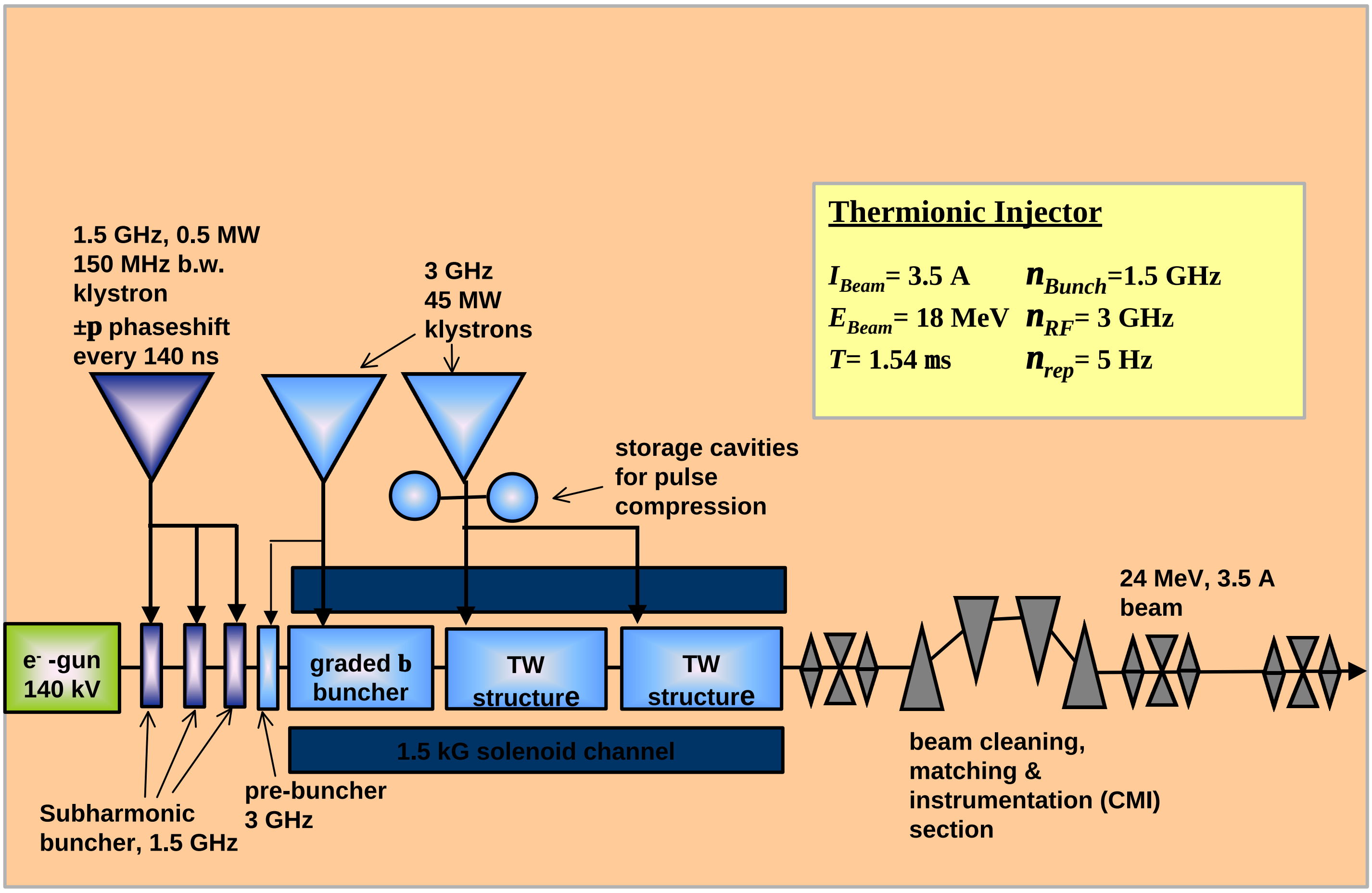
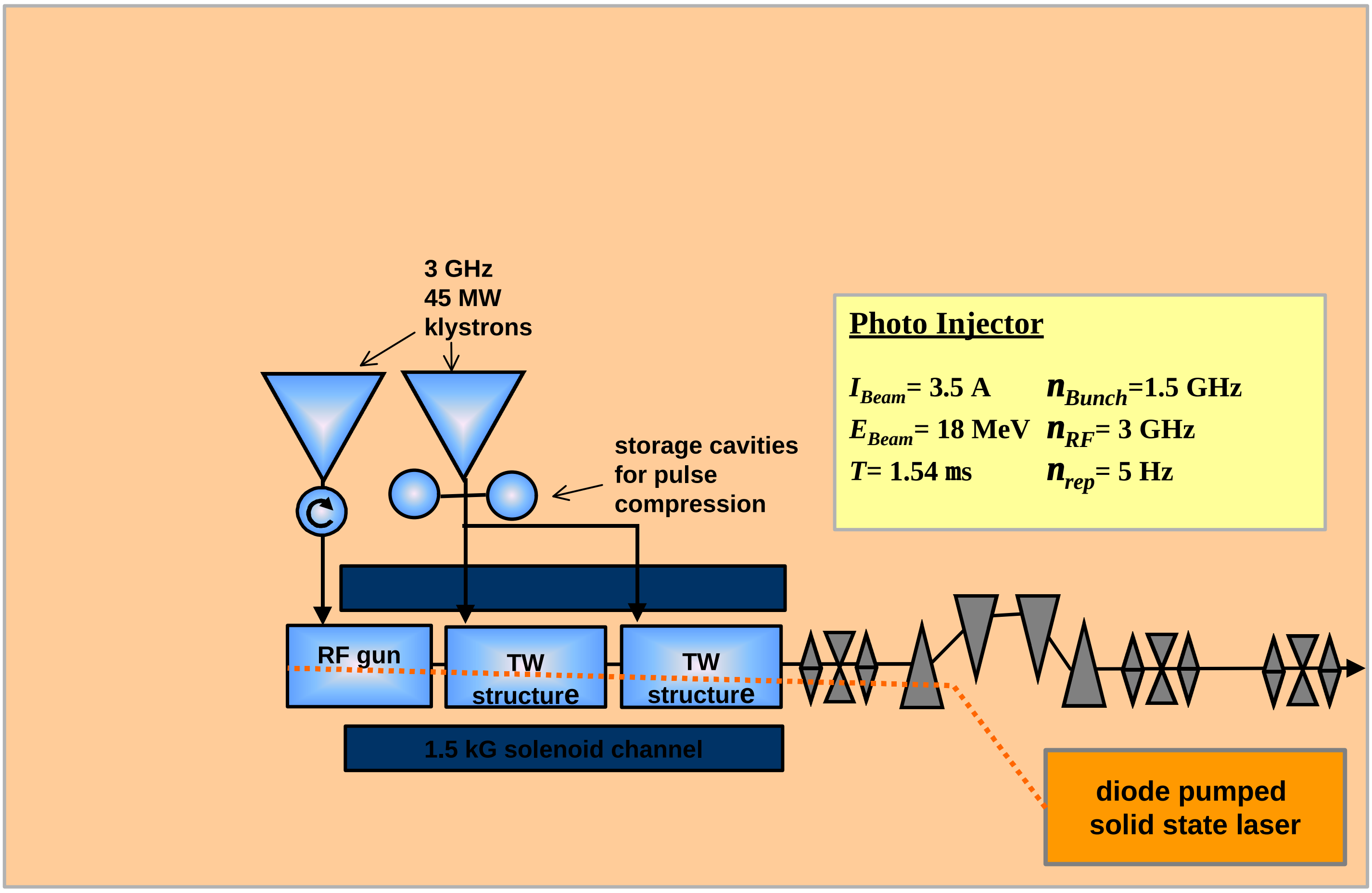
specific problems initial phase

- **total charge per pulse**
- **charge stability**
- **bunch length**
- **energy spread**

requirement	**potential problems**	**remedies**
total charge per pulse	heavy beam loading	140 ns scavenger train for transients
		2^{nd} prebuncher with external load
		buncher with large power overhead
	emittance deterioration & beam break-up	detuned & damped acc. structures
		strong focusing
		large apertures
	deterioration of vacuum	all systems can be baked at 150^0C
		generous pumping
		large apertures
charge stability	beam loading induced energy spread	reduced bandwidth of grid pulser
		beam current feedback on grid pulser
longitudinal emittance	downstream longitudinal gymnastics / efficiency of 30 GHz power production	graded β buncher
		sophisticated prebunching
		energy collimation
		bunch compressor

CTF3 injector variants for nominal phase





RF Photo-Injector option for CTF3 drive beam

Advantages of such an solution:

+ **absence of low charge parasite bunches**
+ **no phase/energy tails as produced in conventional bunching systems**
+ **design of RF gun for CTF3 parameters straight forward**
+ **RF gun and photo-cathode technology well established at CERN**
+ **smaller beam emittances in all three phase space planes**
+ **much less parameters (2 RF ampl. & phases compared with 6)**
+ **possibility of single bunch operation for beam monitor development, wakefield, CSR,...**

But:

– **laser requirements for producing the long drive beam train very demanding**
– **past experience with CTF II laser system not very encouraging**
– **Unprecedented average current requirement for photo-cathodes**

Þ **High current tests of cathodes in PS photo-cathode lab. last winter demonstrated feasibility of cathodes**

Þ **R&D program in collaboration with RAL and Strathclyde University for the development of an all diode pumped, solid state laser system**

<u>Additional problem nominal phase</u>

- bucket switching every 140 ns with £ 5ns switching time

	Method	Problems
Thermionic solution	1.5 GHz sub harmonic bunchers with Q»10 driven by 500kW, large b.w. (150 MHz) klystron	Parasite charge in “empty buckets”
		Current droop during switching
Photo injector	Switching of optical delay in laser beam line with pockel cells	Pockel cell driver
		Pockel cell lifetime

Contributions from collaborations

SLAC

- design of beam-line initial & nominal phase
- gun triode for initial & nominal phase

LAL

- design and construction of gun electronic (HV, grid pulser, controls electronic,…) and support structure (hot deck,…)
- design and construction of 3 GHz pre-bunchers

RAL

- development of diode pumped laser amplifier for generation of long bunch train with photo-injector

Inst.of Photonics / Strathclyde

- development of diode pumped, pulsed laser oscillator

<table>
<tr><th rowspan="2">year</th><th rowspan="2">Initial phase</th><th colspan="2">Nominal phase</th></tr>
<tr><th>photo injector</th><th>thermionic injector</th></tr>
<tr><td>2001</td><td>Design of beamline and all components</td><td rowspan="3">Build laser configuration for PILOT</td><td rowspan="4">Design of SHB bunchers,
RF networks
and modulator</td></tr>
<tr><td rowspan="4">2002</td><td>Construction of components</td></tr>
<tr><td rowspan="2">Assembly of beamline</td></tr>
<tr><td>PILOT experiment long train photo-injector demo.</td></tr>
<tr><td rowspan="2">Move CTF II components to CTF3 injector</td><td colspan="2">Decision which solution to take</td></tr>
<tr><td rowspan="3">2003</td><td rowspan="4">Upgrade PILOT laser to CTF3 laser

Build RF gun</td><td rowspan="4">Order and install 1.5 GHz klystron and network components
Build SHB’s</td></tr>
<tr><td>Injector commissioning</td></tr>
<tr><td rowspan="2">Injector operation</td></tr>
<tr><td>2004</td></tr>
<tr><td rowspan="2">2005</td><td rowspan="2"></td><td>Install laser and RF gun</td><td>Install SHB’s</td></tr>
<tr><td colspan="2">Commissioning of nominal phase</td></tr>
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