CLIC
accelerator and detector

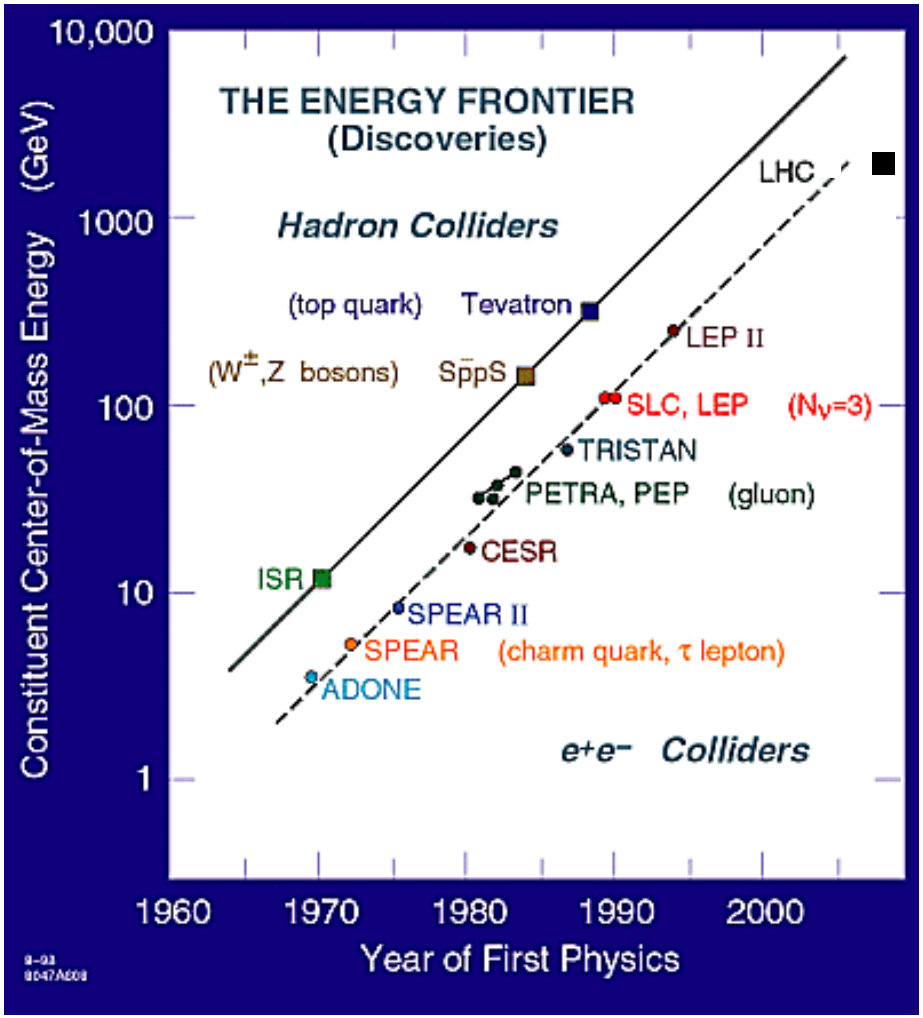
Lucie Linssen

- CLIC/CTF3 accelerator R&D
- CLIC detector study

http://cern.ch/CLIC-study
http://lcd.web.cern.ch/LCD/

Many thanks to Anne Dabrowski, Jean-Pierre Delahaye, Frank Tecker and others

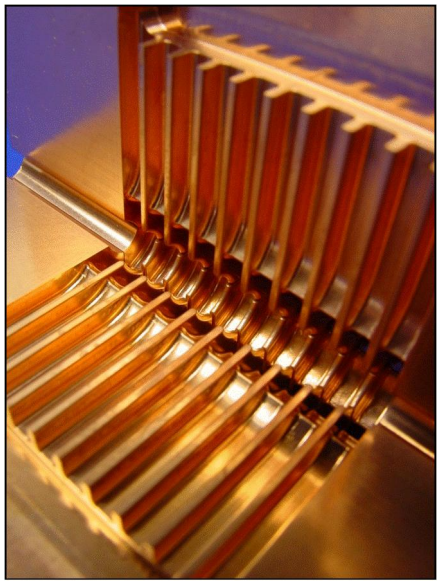
Higher energy, protons ⇔ electrons



- Collider History:
  - Energy constantly increasing with time
  - Hadron Collider at the energy frontier
  - Lepton Collider for precision physics
- LHC online now
- e-/e+ storage ring excluded by synchrotron radiation
- Consensus to build Lin. Collider with $E_{cm} > 500$ GeV to complement LHC physics

CLIC and ILC in a few words…

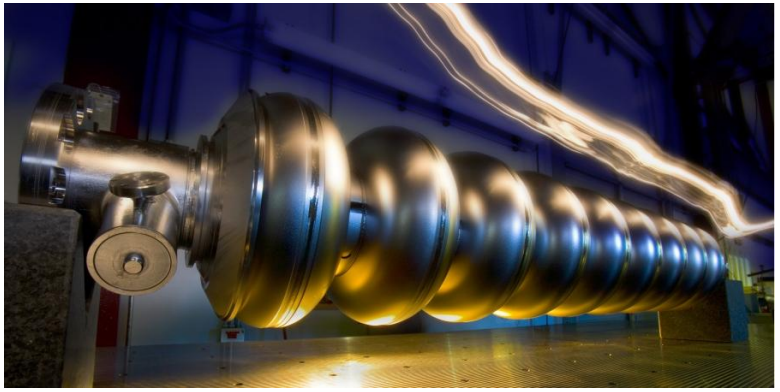
linear collider, producing e^+e^- collisions



CLIC

- Based on 2-beam acceleration scheme
- Gradient 100 MV/m
- Energy: 3 TeV, though will probably start at lower energy (~0.5 TeV)
- Detector study focuses on 3 TeV

ILC



- Based on superconducting RF cavities
- Gradient 32 MV/m
- Energy: 500 GeV, upgradeable to 1 TeV (lower energies also considered)
- Detector studies focus mostly on 500 GeV

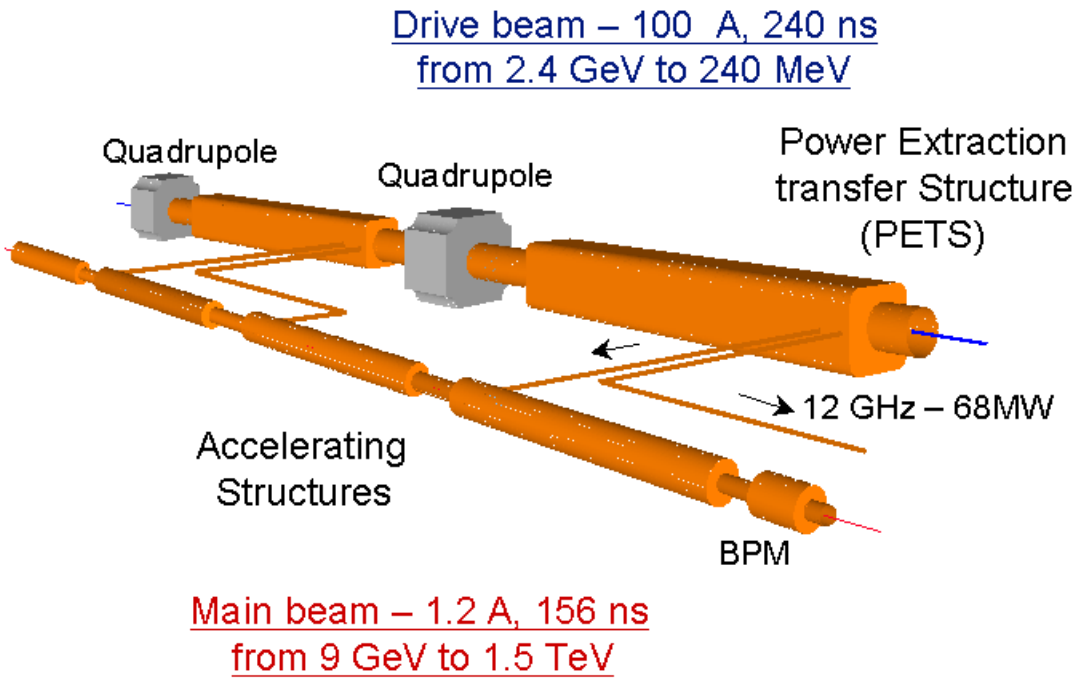
Luminosities: few 10^{34} $cm^{-2}s^{-1}$

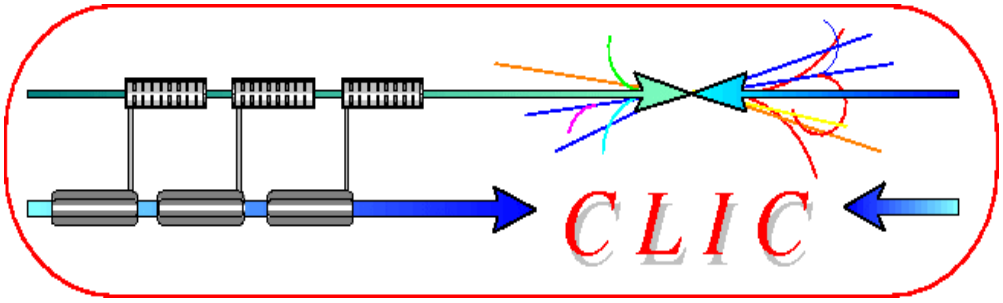
The CLIC Two Beam Scheme

Two Beam Scheme:

Drive Beam supplies RF power
- 12 GHz bunch structure
- low energy (2.4 GeV - 240 MeV)
- high current (100A)

Main beam for physics
- high energy (9 GeV – 1.5 TeV)
- current 1.2 A





No individual RF power sources

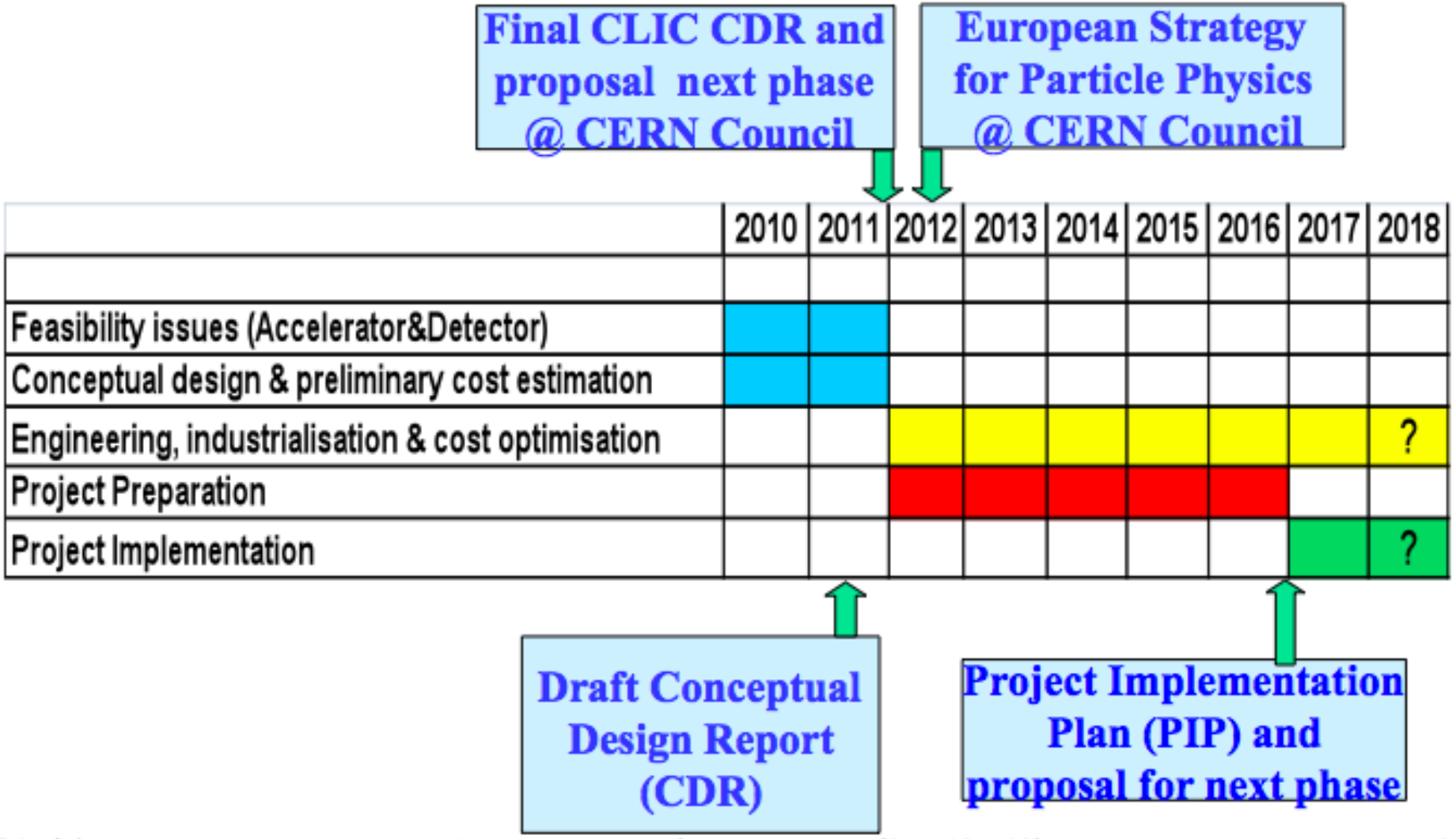
World-wide CLIC&CTF3 Collaboration

http://clic-meeting.web.cern.ch/clic-meeting/CTF3_Coordination_Mtg/Table_MoU.htm

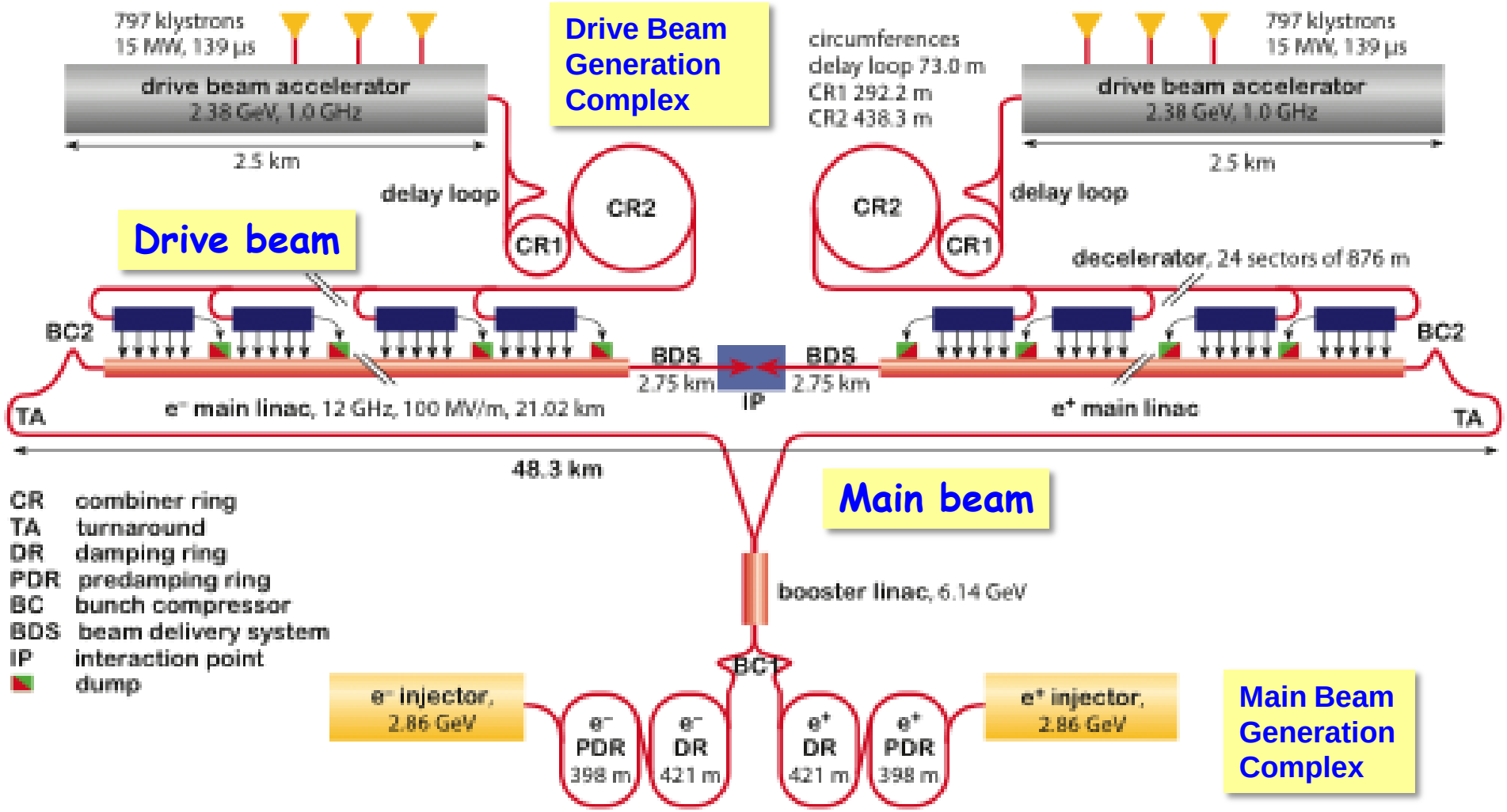
CLIC multi-lateral collaboration
41 Institutes from 21 countries

ACAS (Australia)
Aarhus University (Denmark)
Ankara University (Turkey)
Argonne National Laboratory (USA)
Athens University (Greece)
BINP (Russia)
CERN
CIEMAT (Spain)
Cockcroft Institute (UK)
ETHZurich (Switzerland)
FNAL (USA)
Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
IHEP (China)
INFN / LNF (Italy)
Instituto de Fisica Corpuscular (Spain)
IRFU / Saclay (France)
Jefferson Lab (USA)
John Adams Institute/Oxford (UK)
John Adams Institute/RHUL (UK)
JINR (Russia)
Karlsruhe University (Germany)
KEK (Japan)
LAL / Orsay (France)
LAPP / ESIA (France)
NIKHEF/Amsterdam (Netherland)
NCP (Pakistan)
North-West. Univ. Illinois (USA)
Patras University (Greece)
Polytech. University of Catalonia (Spain)
PSI (Switzerland)
RAL (UK)
RRCAT / Indore (India)
SLAC (USA)
Thrace University (Greece)
Tsinghua University (China)
University of Oslo (Norway)
Uppsala University (Sweden)
UCSC SCIPP (USA)

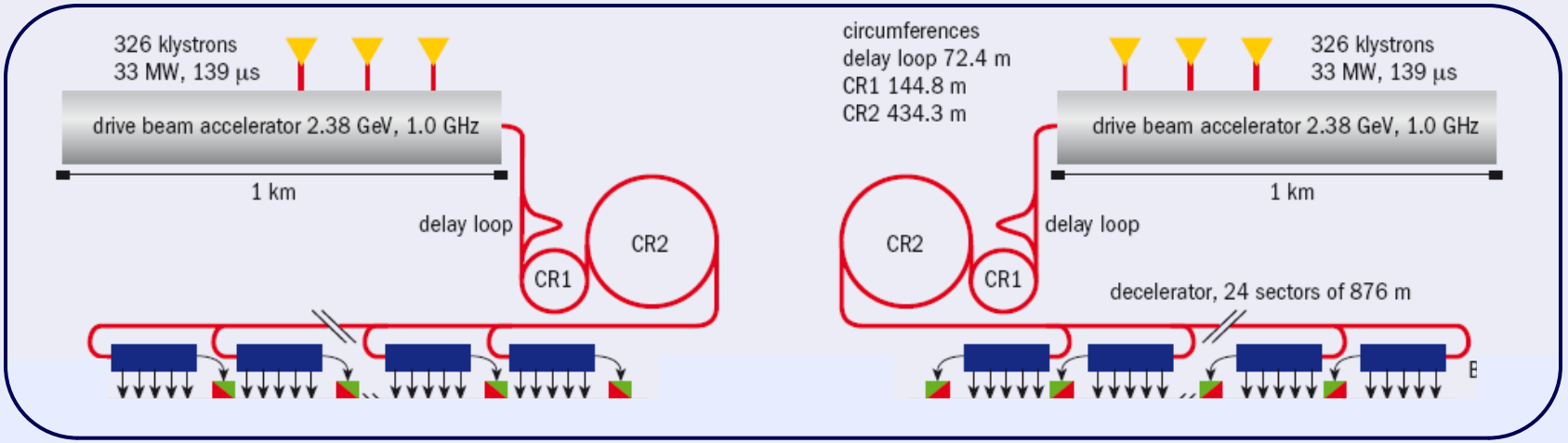
CLIC schedule



CLIC – overall layout 3 TeV

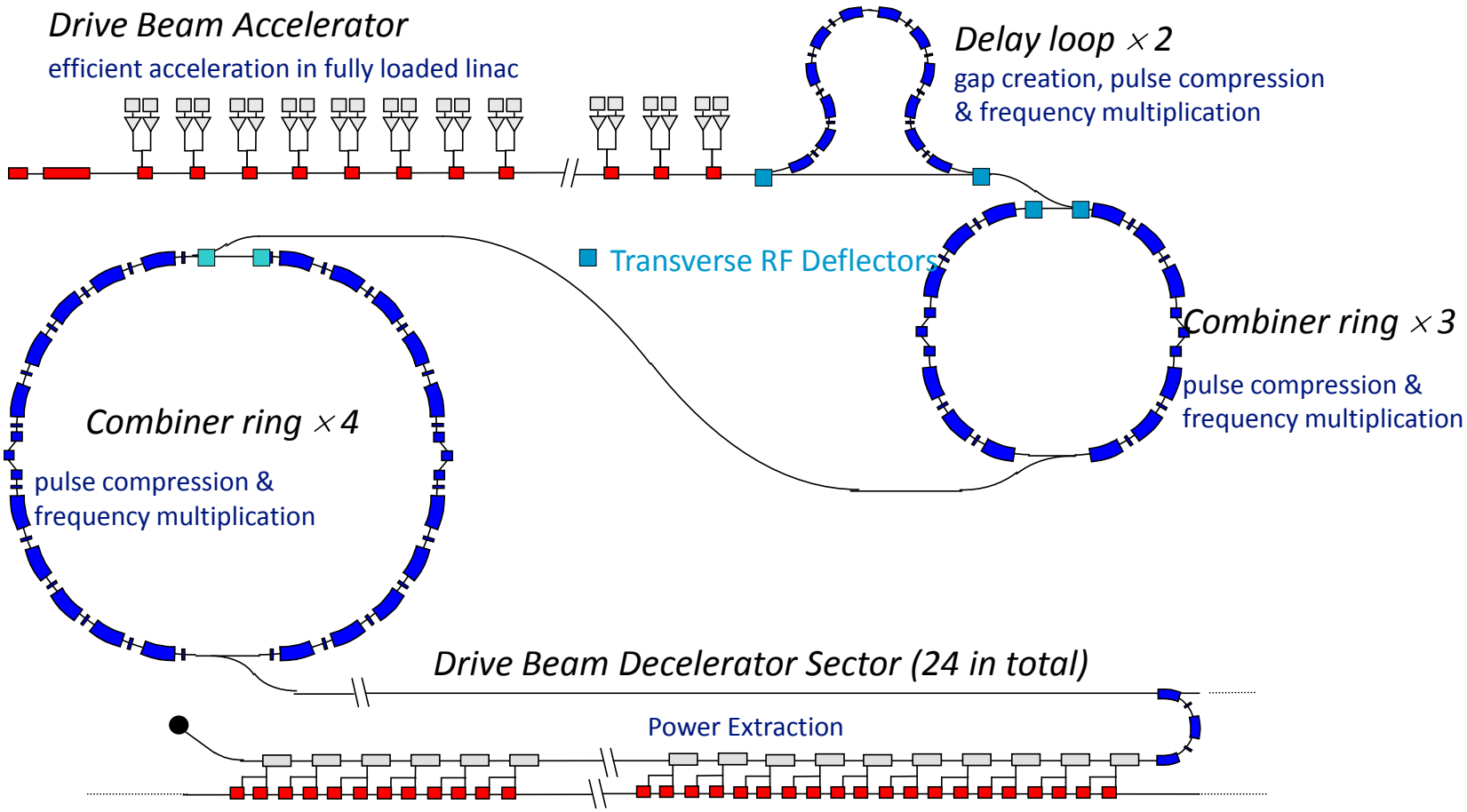


CLIC schematic layout @ 3 TeV

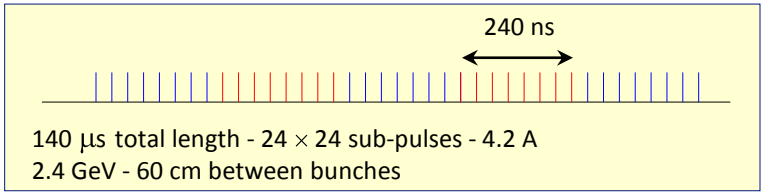


CLIC RF power source

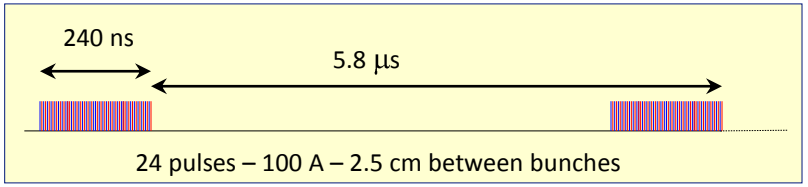
CLIC RF power source



Drive beam time structure - initial

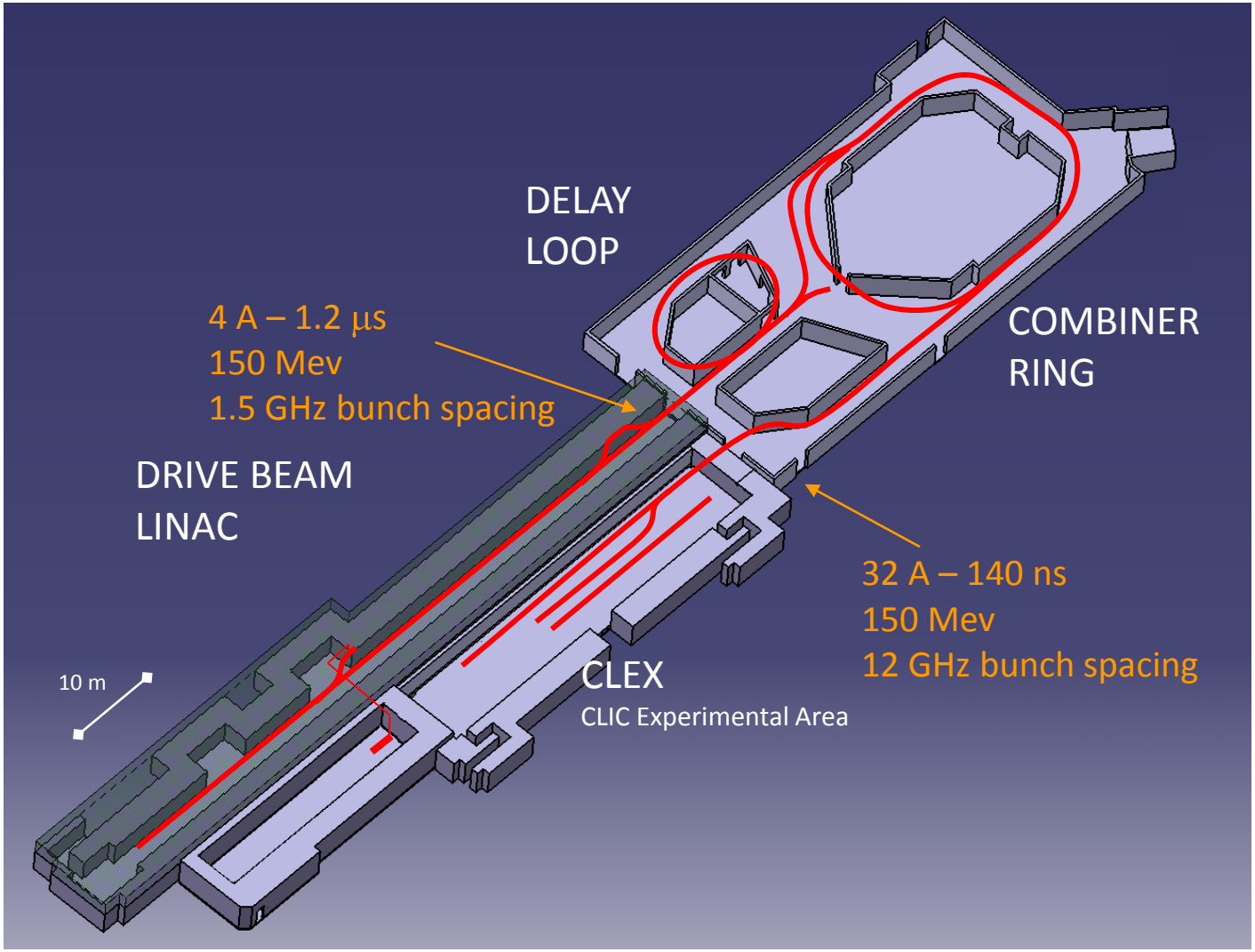


Drive beam time structure - final



The CLIC Test Facility (CTF3)

Small scale version of the CLIC drive beam complex



Comparison CLIC - CTF3

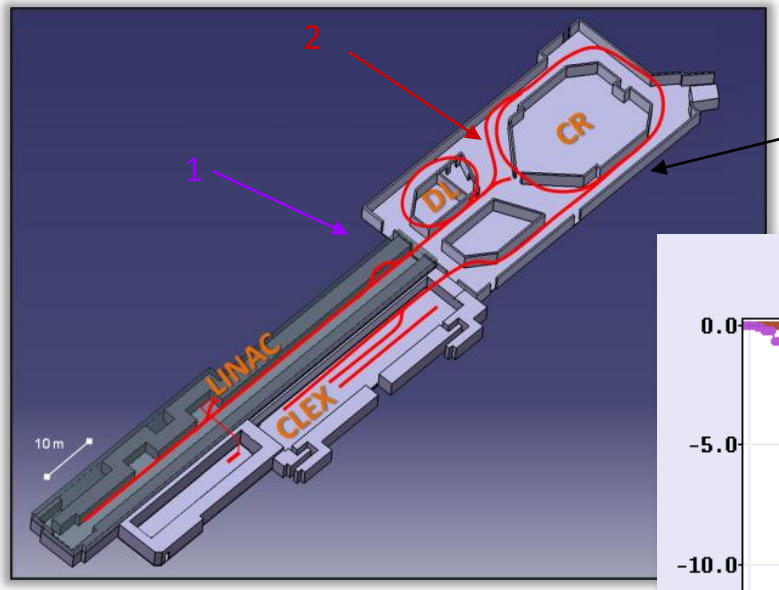
	CTF3	CLIC
Energy	0.150 GeV	2.4 GeV
Pulse length	1.2 μs	140 μs
Multiplication factor	2 x 4 = 8 (DL + 1 CR)	2 x 3 x 4 = 24 (DL + 2 CR)
Linac current	3.5 A	4.2 A
Final current	28 A	100 A
RF frequency	3 GHz	1 GHz
Deceleration	to ~60% energy	to 10% energy
Repetition rate	up to 5 Hz	50 Hz
Energy per beam pulse	0.7 kJ	1400 kJ
Average beam power	3.4 kW	70 MW

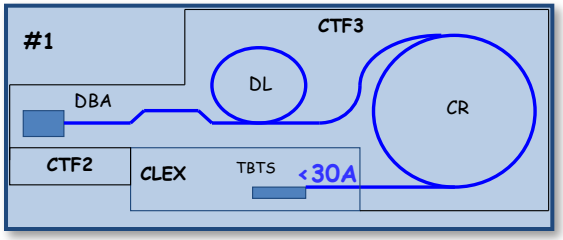
- CTF3 covers well the CLIC drive beam generation scheme
- Still considerable extrapolation to CLIC parameters

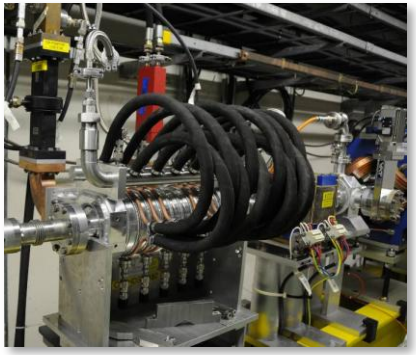
F. Tecker CLIC'09 Workshop

Factor 8 combination achieved

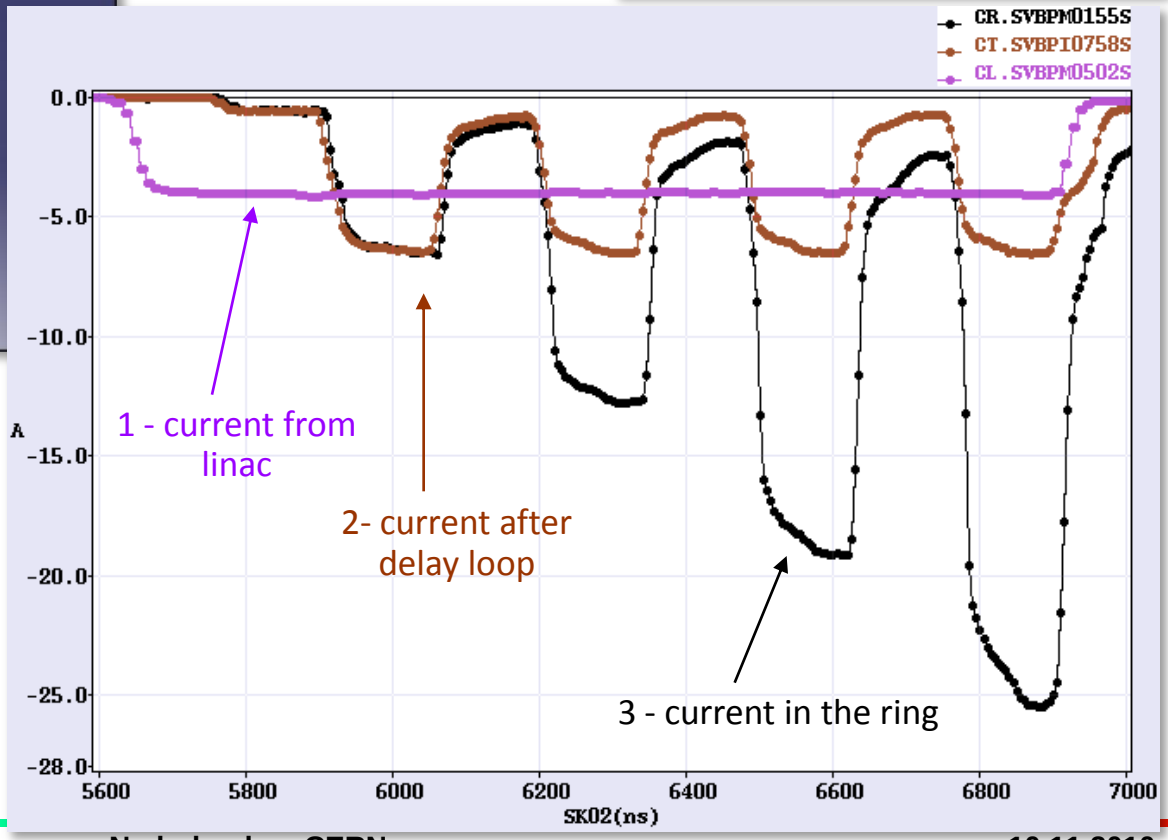
- ✓ ~ 27 A combined beam current reached, nominal 140 ns pulse length
- ✓ → **Full drive beam generation, main goal of CTF3, achieved**







RF deflector used for injection and recombination



Two beam Test Stand (TBTS) line

UPPSALA UNIVERSITET

TL2

DRIVE BEAM

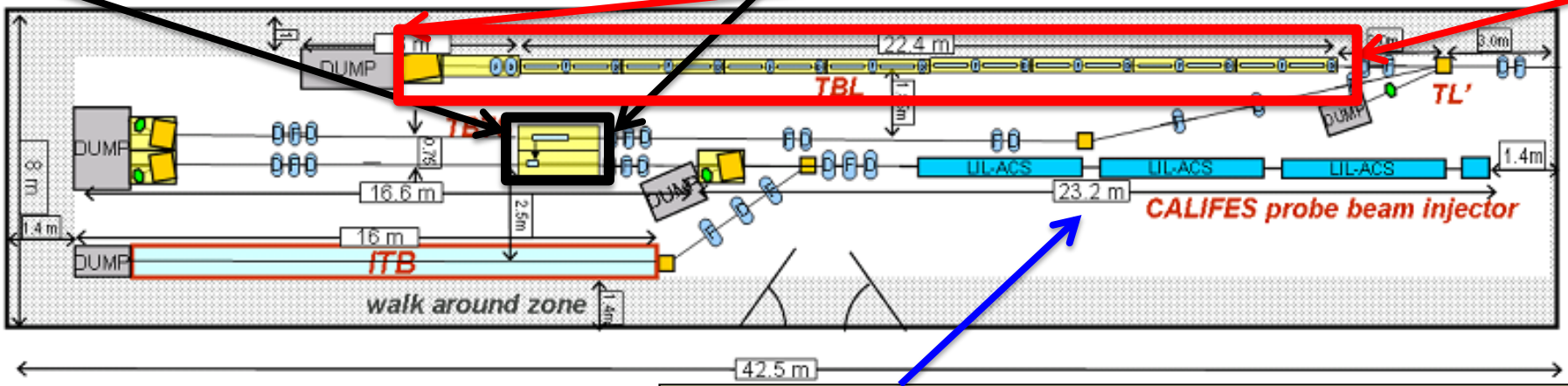
PROBE BEAM

Drive Beam Deceleration and Module: CLEX

- CLIC Decelerator sector: ~ 1 km, 90% of energy extracted

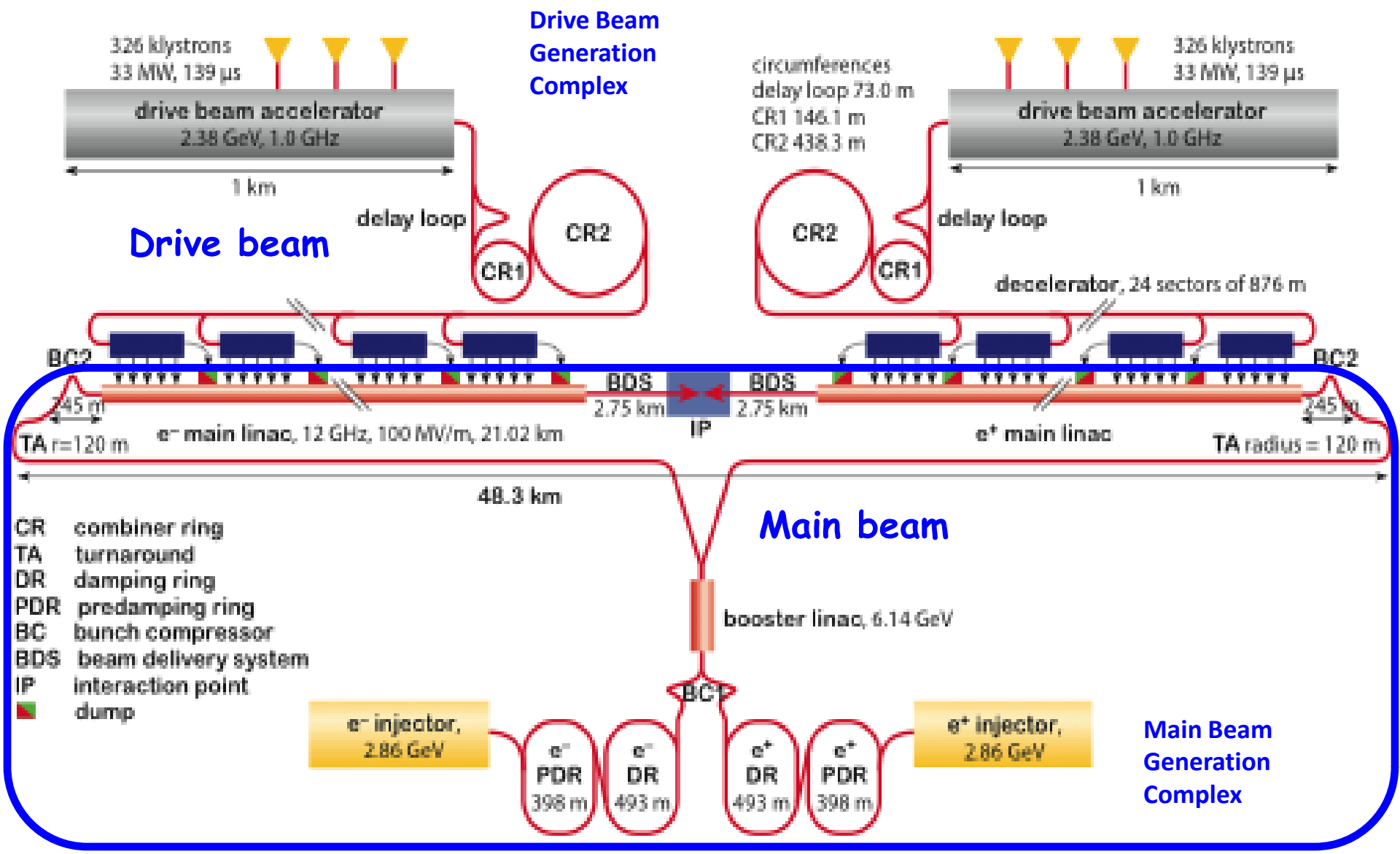
Two-beam Test Stand (TBTS):
- **Single** PETS with beam
- Accelerating structure with beam
  - wake monitor
  - kick on beam from break down
- Integration

Test Beam Line (TBL):
- **Drive beam transport (16 PETS)**
  - beam energy extraction and dispersion
  - wakefield effects



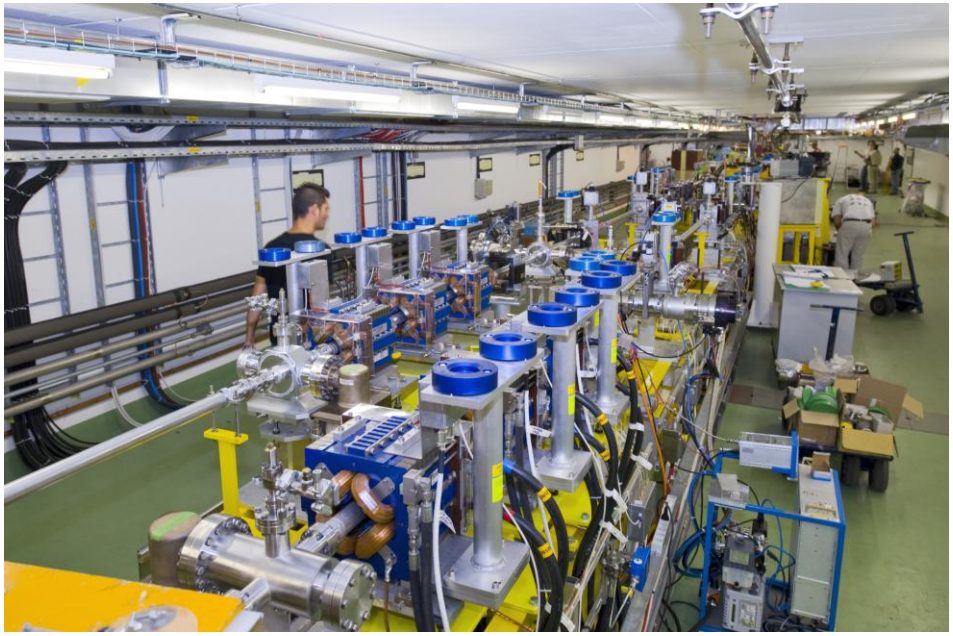
- **Califes**: Probe beam photo-injector
- Beam energy 175 MeV

General Layout of Complex



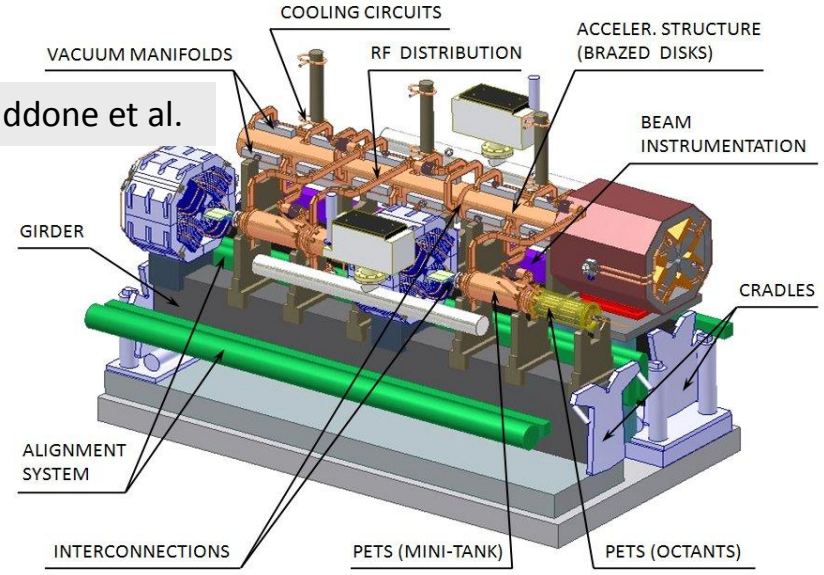
Two Beam Module

- Integration aspects are important
  - alignment
  - vacuum
  - transport
  - cabling
  - …



- Beam tests of PETS are ongoing
- accelerating structure installed
- important goal 2010: two-beam acceleration with 100 MV/m
- Some tests after 2010
  e.g. wake monitors, design exists
- Later full modules will be tested

G. Riddone et al.

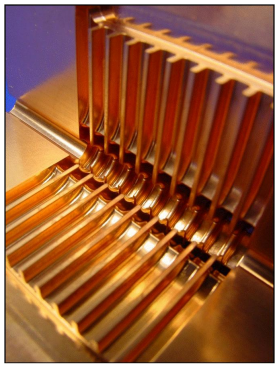


Simulation of RF Power Transfer

time: 0 0 . 0 ns

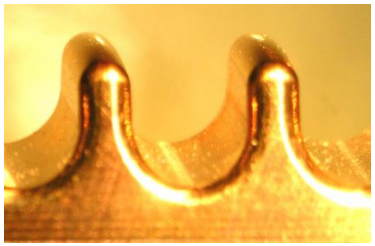
The induced fields travel along the PETS structure and build up resonantly

Accelerating structure



Low group velocity requires simulations with 100k time steps

PETS structure



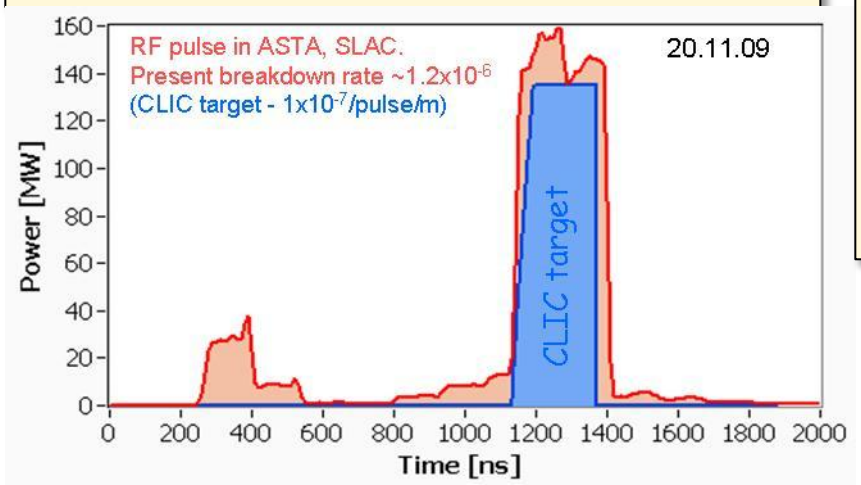
T3P models realistic, complex accelerator structures with unprecedented accuracy

ACD ADVANCED COMPUTATIONS

Arno Candel, SLAC

PETS Results

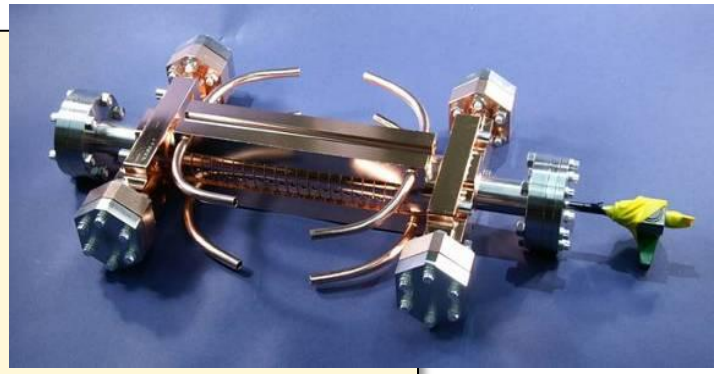
- Klystron based (SLAC):
  - achieved: 137 MW/266 ns/ 1.2 10^{-6} BDR
  - target: 132MW/240ns/10^{-7}

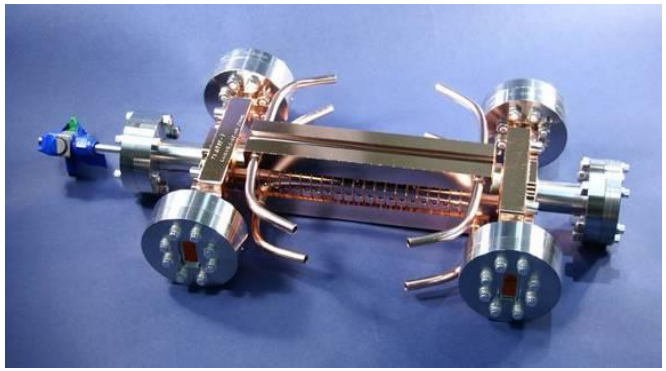


- Beam based (with recirculation):
  - Power >130 MW peak at 150 ns
  - Limited by attenuator and phase shifter breakdowns (cleaned for this run)
  - Power production according to predictions

- Structures had damping slots but no damping material
- Novel design on-off mechanism will be tested this year
- More testing is needed

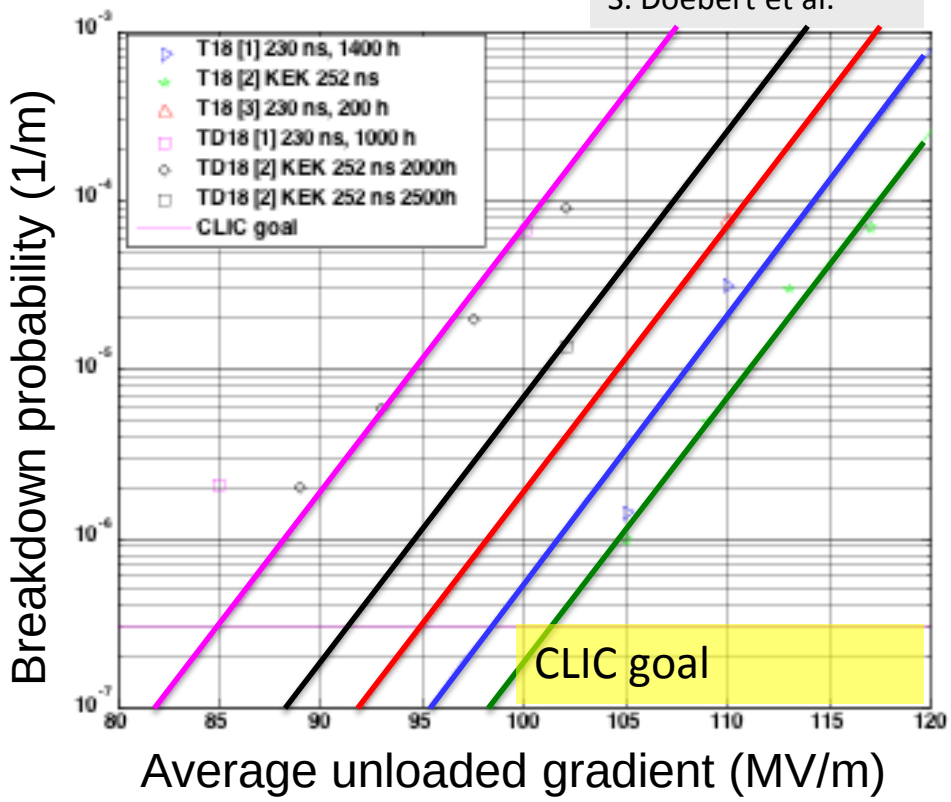
Accelerating Structure Results





- RF breakdowns can occur => no acceleration and deflection
- Goal: 3 10^{-7}/m breakdowns at 100 MV/m loaded at 230 ns
- T18 and TD18 structures built and tested at SLAC and KEK
- **T18 reached 95-105 MV/m**
- Damped TD18 reaches an extrapolated 85 MV/m
  - Second TD18 under test at KEK
  - Pulsed surface heating expected to be above limit
- CLIC prototypes with improved design (TD24) will be tested this year
  - expect similar or slightly better performances

S. Doebert et al.

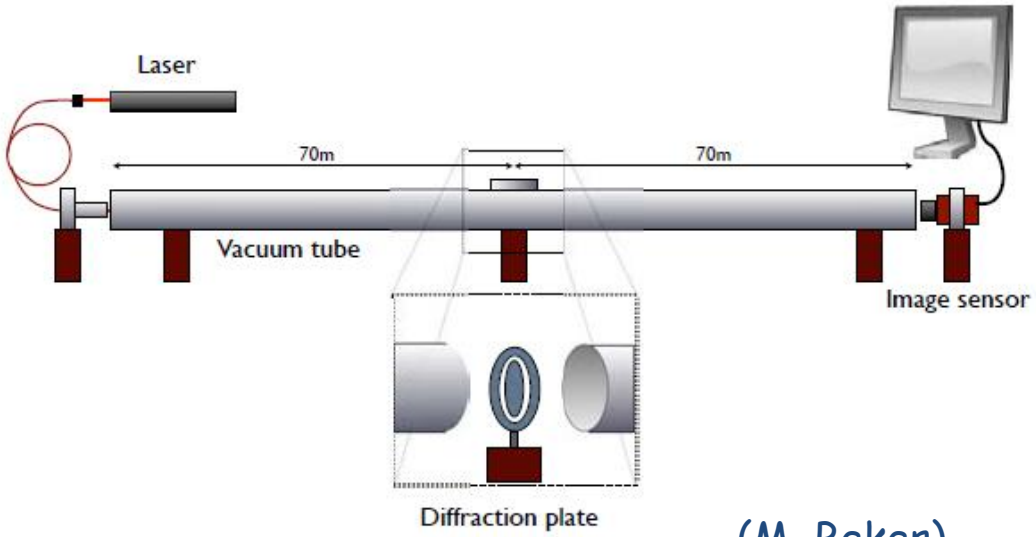


NIKHEF collab. on pre-alignment

Objectives: provide transverse positional data on targets distributed over 100 m, with an uncertainty of measurement better than 5 µm

Concept: RASCLIC is a 3 point alignment, which consists of a monochromatic light source, a diffraction plate and a pixel image sensor.

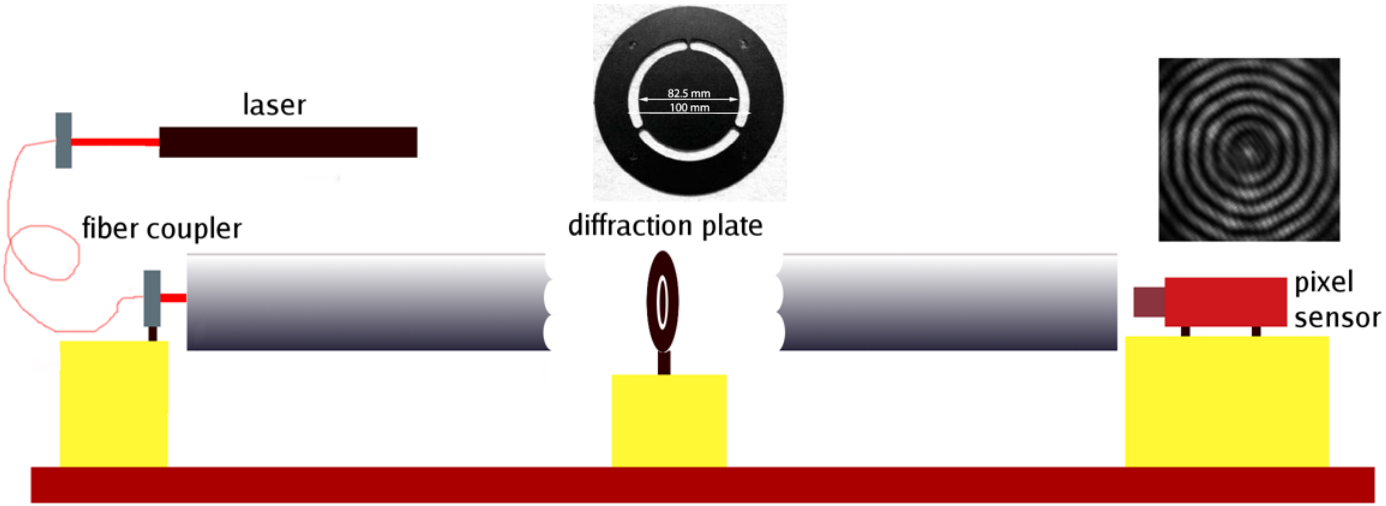
The position of a diffraction pattern is monitored on the image sensor, which provides the relative position of the three components.



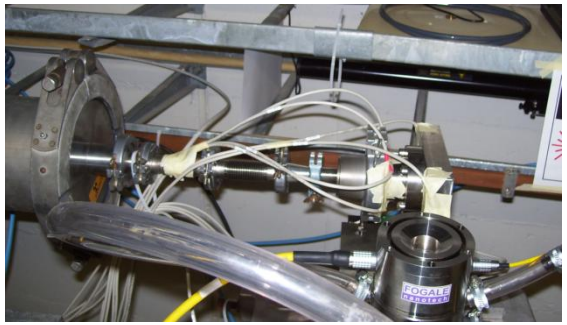
(M. Beker)

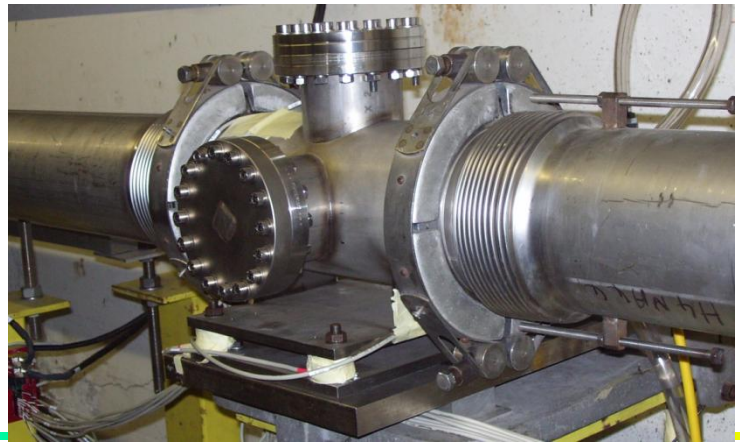
NIKHEF collab. on pre-alignment

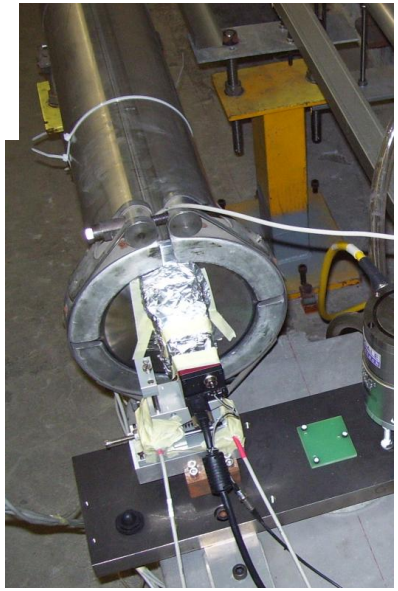
- The concept was validated in an old tunnel named TT1 on 140 m.
- A precision of 20 nm was reached
- New agreement signed for improved and expanded system



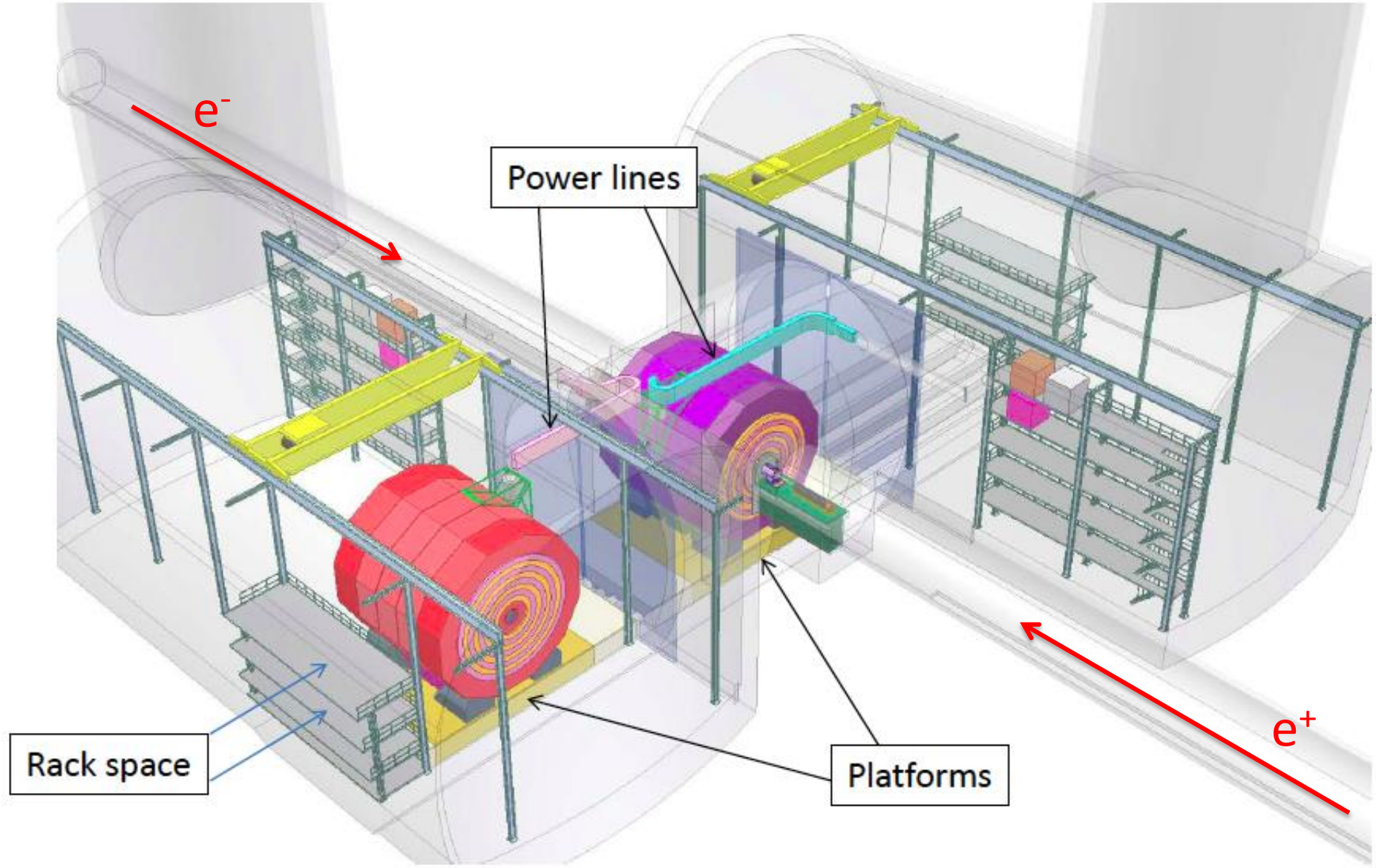
(H. van der Graaf)





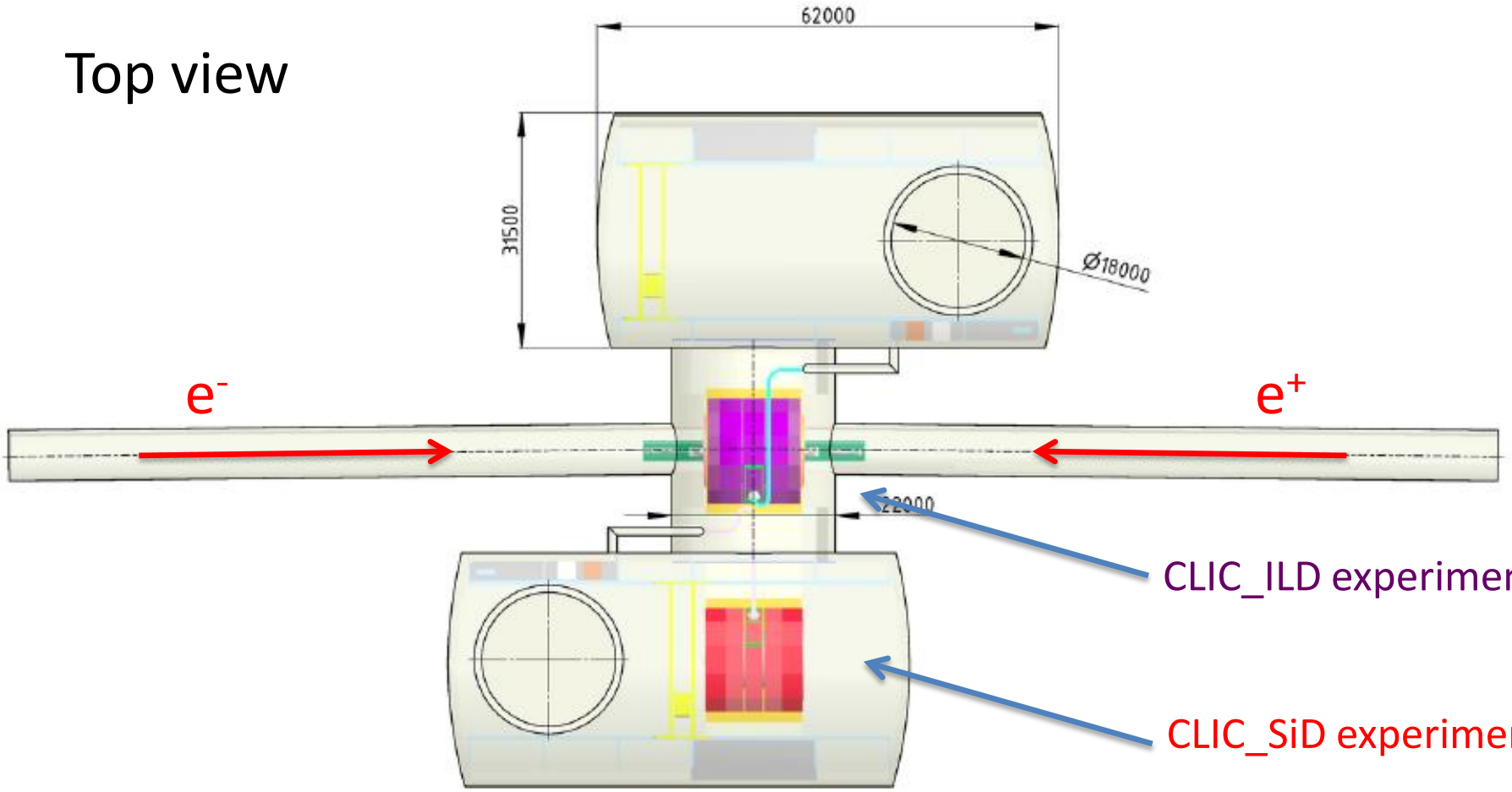


Two experiments in push-pull

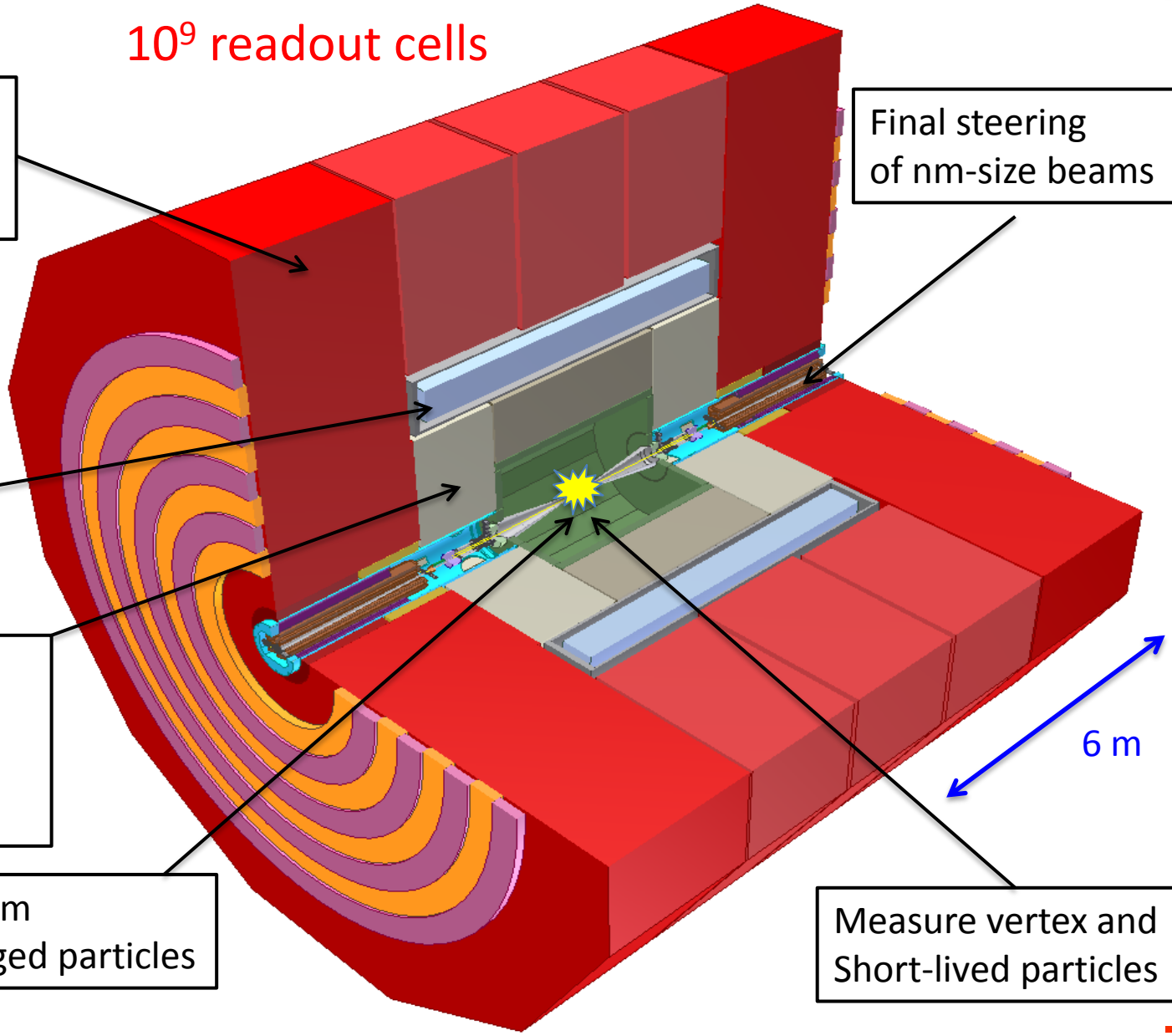


Two experiments in push-pull

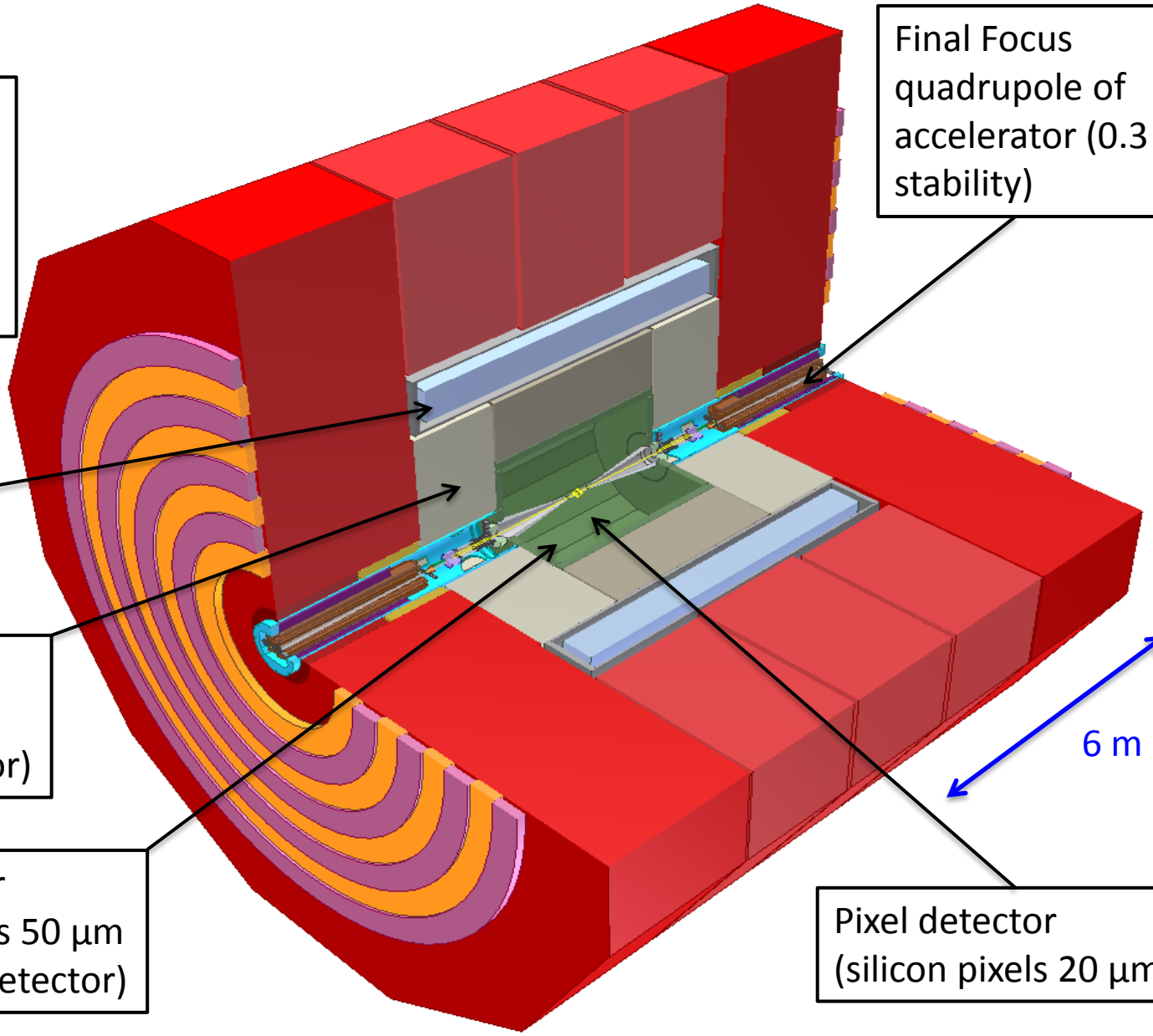
Top view



Function of detector elements



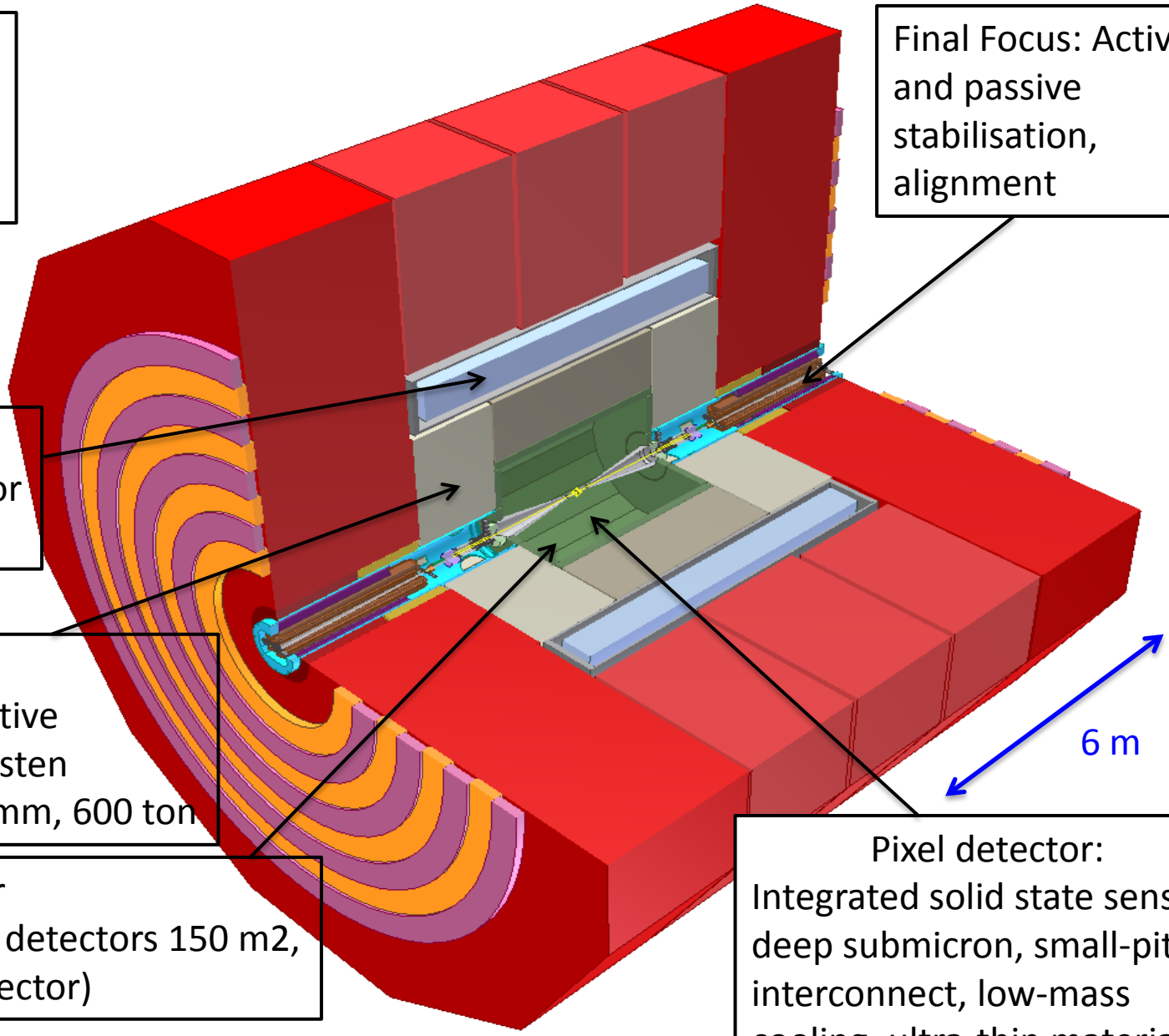
Elements of an experiment



Hardware R&D on the experiment

Power delivery, on/off at 50Hz, driven by front-end electronics

Final Focus: Active and passive stabilisation, alignment



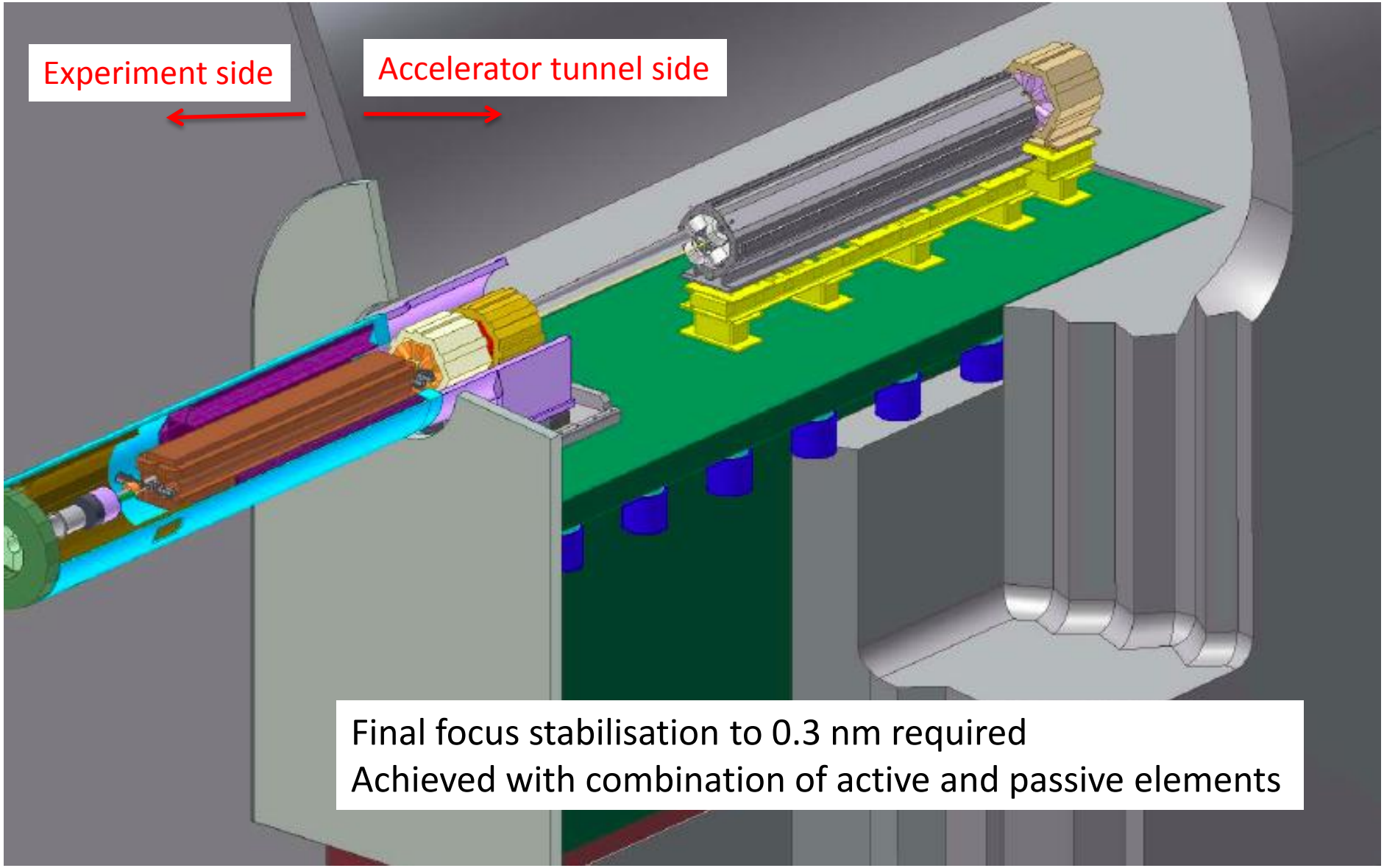
Solenoid coil: Reinforced conductor tests. Materials

Calorimetry: >1000 m2 cost-effective silicon sensors. Tungsten plates 3mm and 10 mm, 600 ton

Main tracker (silicon strip detectors 150 m2, TPC gas detector)

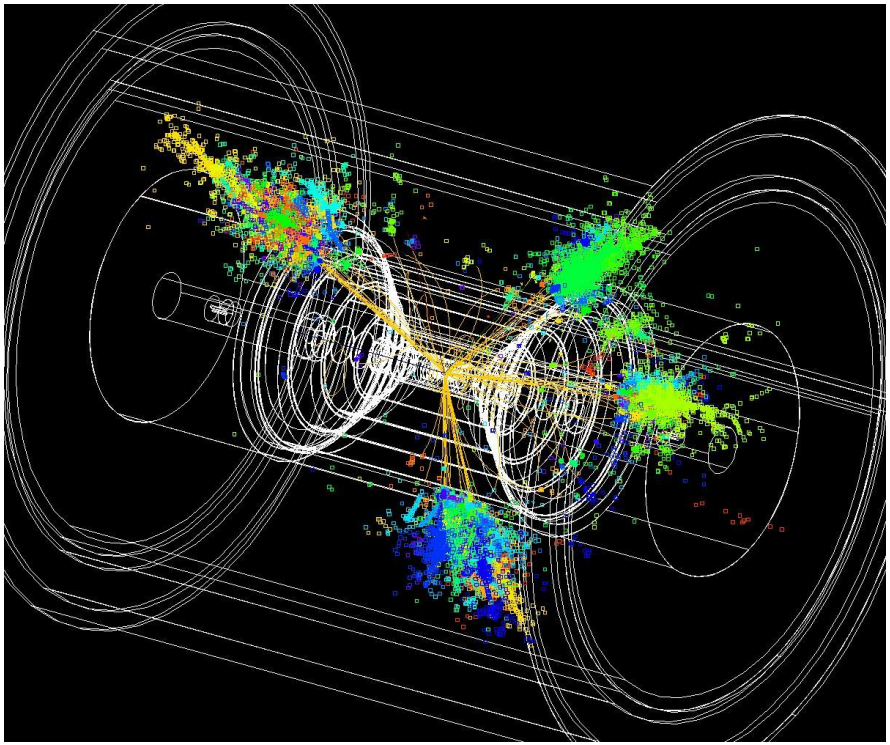
Pixel detector: Integrated solid state sensors, deep submicron, small-pitch interconnect, low-mass cooling, ultra-thin materials

Final focus stabilisation

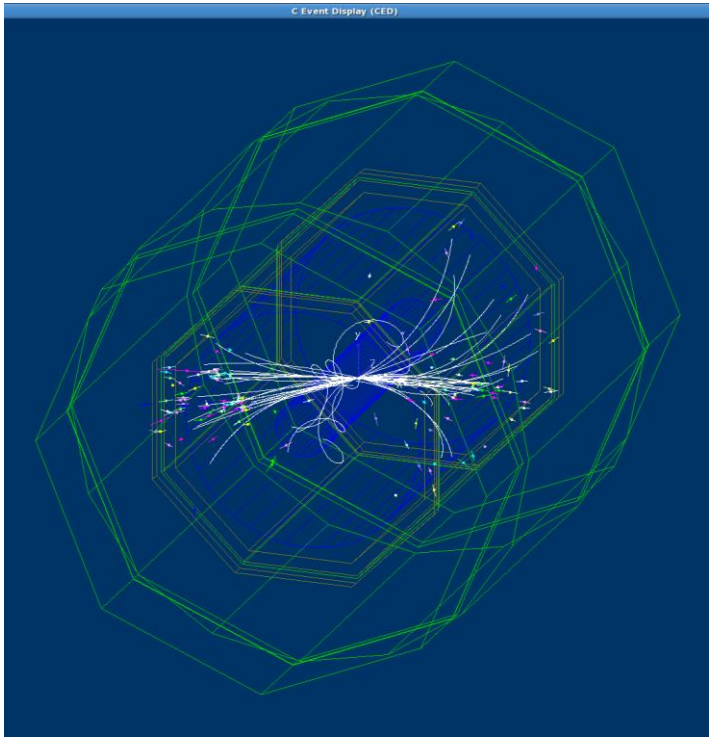


Final focus stabilisation to 0.3 nm required
Achieved with combination of active and passive elements

Thank you!



CLIC_SiD detector



CLIC_ILD detector

SPARE SLIDES

Linear Collider main parameters

Technology	ILC	CLIC	
Centre-of-mass energy (GeV)	500	500	3000
Total (Peak 1%) luminosity (10^{34})	2.0(1.5)	2.3(1.4)	5.9(2.0)
Total site length (km)	31	13.0	48.3
Loaded accel. gradient (MV/m)	31.5	80	100
Main linac RF frequency (GHz)	1.3 (Super Cond.)	12 (Normal Conducting)	
Beam power/beam (MW)	20	4.9	14
Bunch charge (10^9 e+/-)	20	6.8	3.72
Bunch separation (ns)	176	0.5	
Beam pulse duration (ns)	1000	177	156
Repetition rate (Hz)	5	50	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	10/40	4.8/25	0.66/20
Hor./vert. IP beam size (nm)	640/5.7	202 / 2.3	40 / 1
Hadronic events/crossing at IP	0.12	0.19	2.7
Coherent pairs at IP	10	100	$3.8\ 10^8$
Wall plug to beam transfer eff	9.4%	7.5%	6.8%
Total power consumption (MW)	216	129.4	415