Cost Model
including Civil Engineering and Conventional Facilities

Hans-H. Braun, CLIC ACE, June 20, 2007

- Cost model goals
- Methodology
- Scaling assumptions
- Cost distribution
- Future improvements

Key contributors:

Carlo Wyss, Germana Riddone

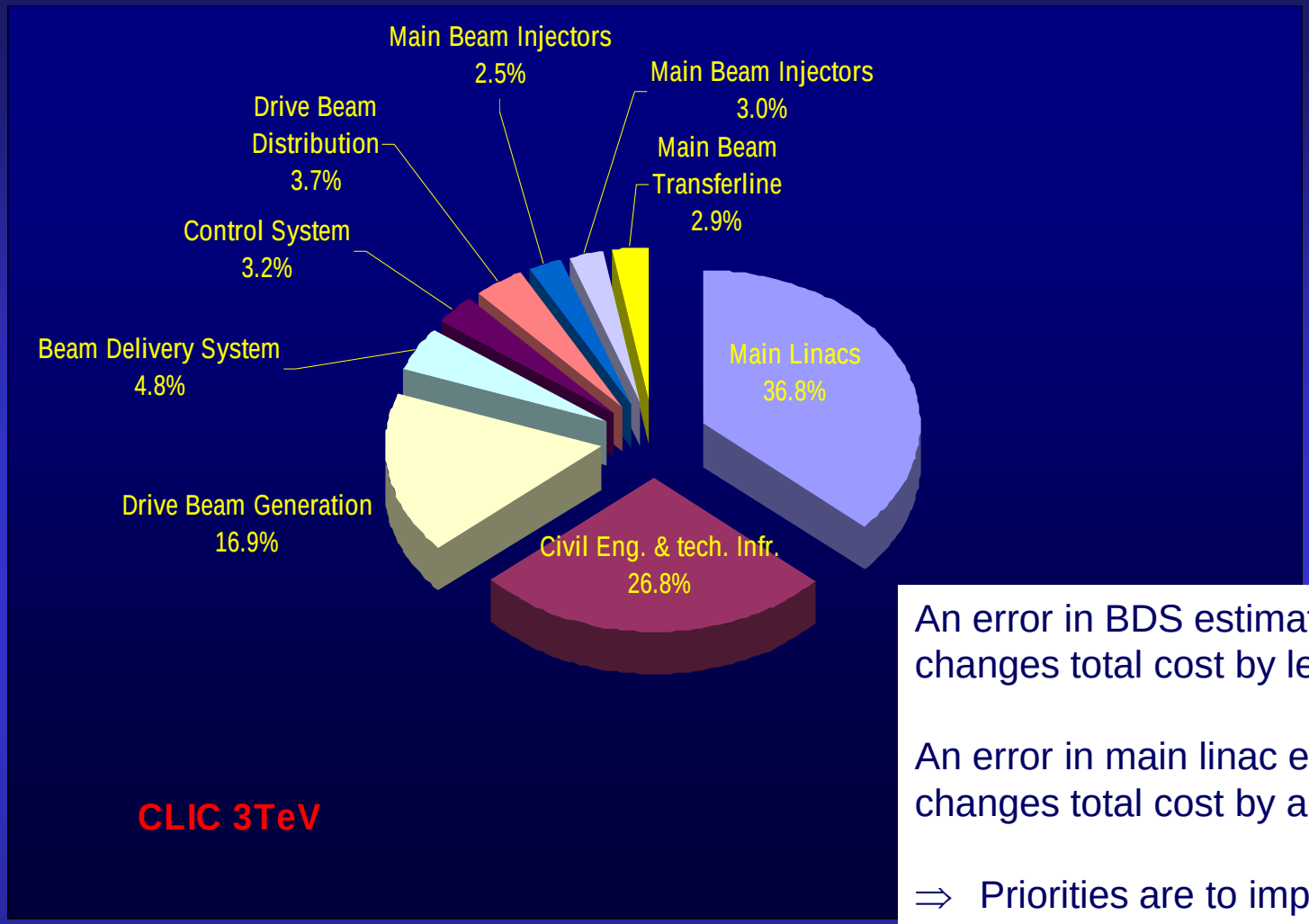
Jean-Luc Baldy
(coordination of all CLIC related civil engineering
and tech. infrastructure studies)

Goals of cost study

- Get reasonably precise cost estimate
- Identify cost drivers and assure cost conscious design
- Get cost model scalable in ν_{RF}, G and E_{CM} as input for optimization studies

CLIC cost model technical approach

1. Civil engineering costs from CERN-TS 2001 study *(improved study in progress)*
2. For main tunnel equipment (w/o RF structures) steadily improving estimates, but limited accuracy because design is not mature.
3. For main tunnel RF structures (accelerator and decelerator) estimate based on cost of machining facilities, manpower and material for given production period.
4. Klystron + Modulator costs from TESLA cost estimate plus some local expert input
5. Key input for injectors, damping rings, BDS, control system from NLC study with some cross checks on recent European projects and gut feeling fudge factors
6. Electriciy costs based on present CERN contracts
7. The rest is guess work



An error in BDS estimate of 50% changes total cost by less than 3%

An error in main linac estimate of 50% changes total cost by almost 20%

⇒ Priorities are to improve cost estimate and reduce costs of

1. **Main linac modules**
2. **Civil engineering**
3. **Drive beam generation**

Some technicalities how cost model enters in Alexej's optimization

1. Starting point is cost estimate with CLIC note 627 parameters coded as EXCEL workbook with many worksheets
2. Add sheet with parameters provided by Alexej and implement scaling with these parameters
3. Communication with Alexej's MATLAB optimizations via Windows DDE server
4. For speed reasons Alexej interpolates in MATLAB on a grid of values pre-computed with EXCEL

Scaling Assumptions as used for Alexej

- Tunnel costs based on 2001 TS study, tunnel cost scaled with length
  Number of turnarounds scaled with $Linaclength \cdot pulselength^{-1}$
- Number of DB modulator and klystrons scaled with W_{puls}
  with a limit on average klystron power,
- RF part of electricity costs scaled with figure of merit L/P_{AC}
- Betafunctions as function of beam energy kept constant,
  i.e. number of quadrupoles proportional to linac length
- Effective fill factor for regular module kept constant
- Two beam module length and number of PETS per module kept constant

Model for accelerating structure cost scaling

$$C_{HDS}' = C_{mat\_ref}' \cdot (f / 30\text{GHz})^{-3/2} + C_{mach\_ref}' \cdot (f / 30\text{GHz})^{3/2} \cdot (\Delta\varphi / 60^0)^{-2/3}$$

This gives a factor 1.51 increase for cost/m from 11.4 GHz to 30 GHz

Prices/m for HDS11 prototype increase by factor ≈1.6
from 11.4 GHz to 30 GHz for Cu and by factor ≈ 1.75 for Mo

Model for RF network scaling

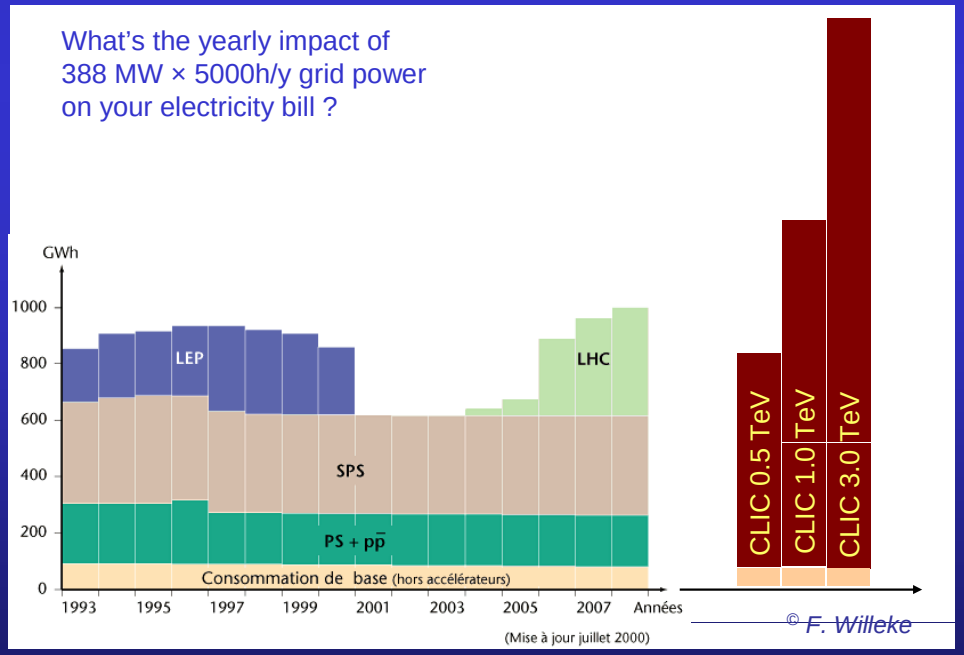
$$C_{per\ module} = C_{ref} \cdot (N / 8)^{2/3}$$

with N the number of accelerating structures per module

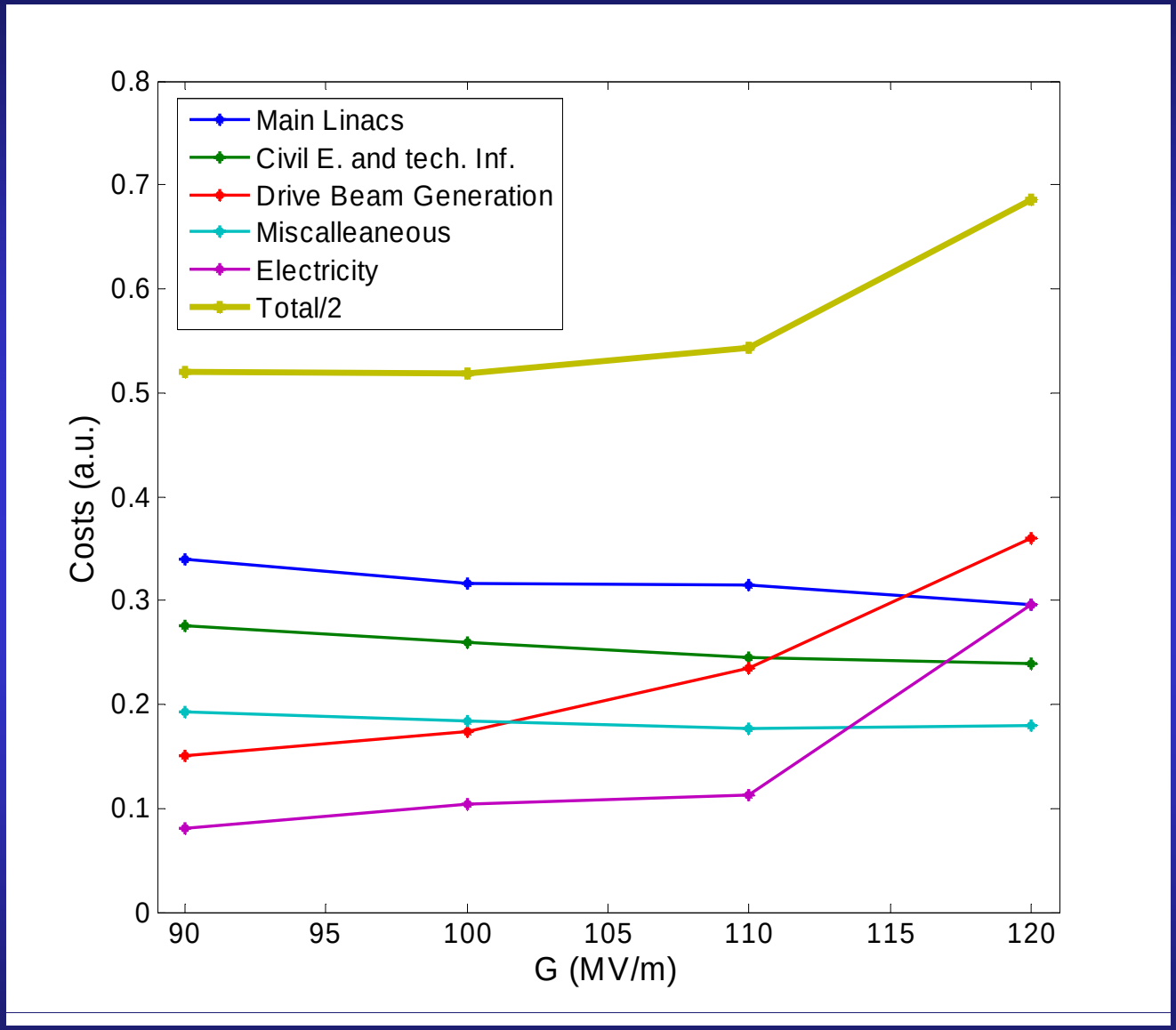
A remark on electricity cost

Present CERN electricity cost is less than one third of ILC assumption

For optimization Alexej uses sum of investment + 10 year electricity cost
Depending on price/kWh electricity cost has a very different weight

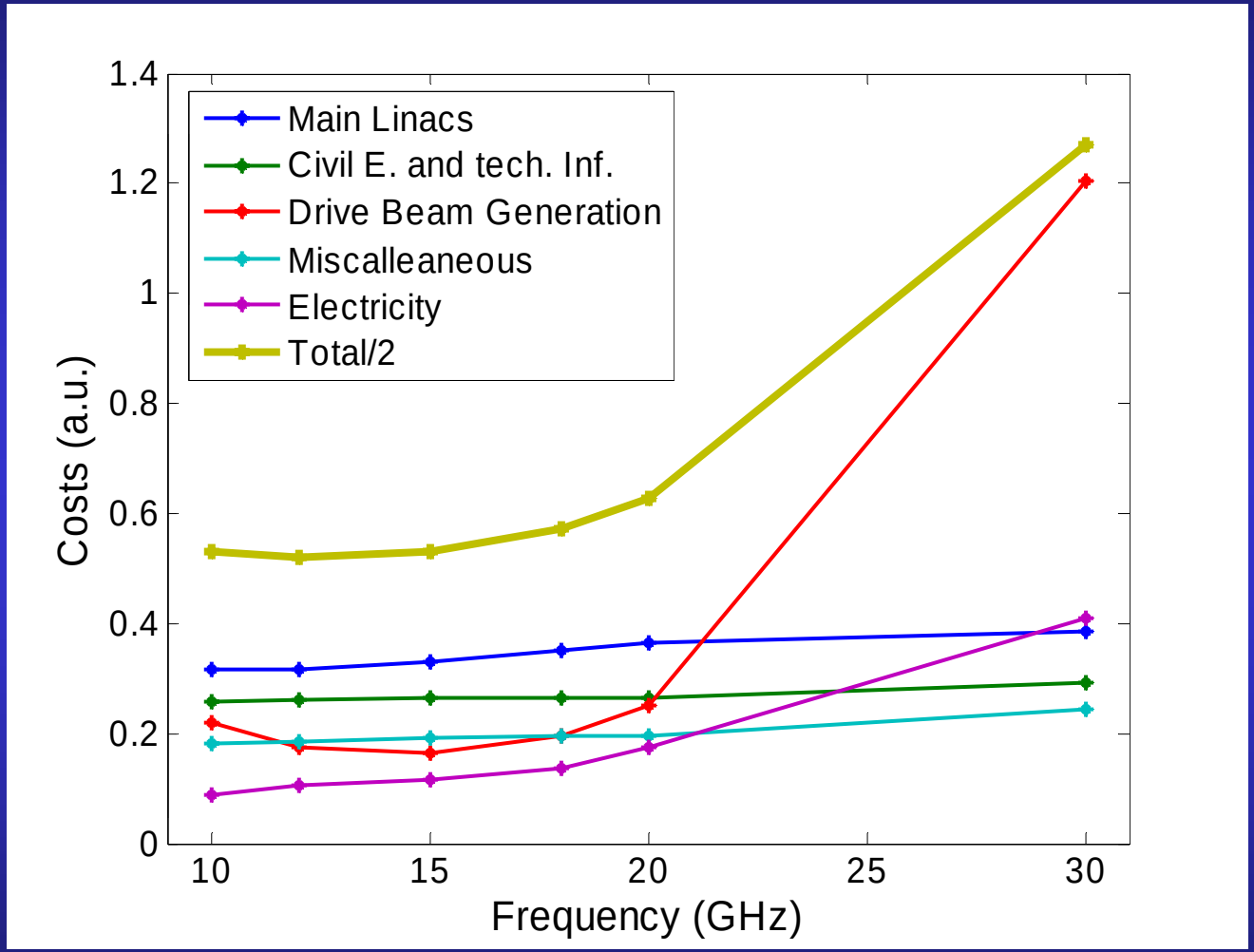


Cost distribution as function of main linac accelerating gradient for ν_{RF}=12 GHz



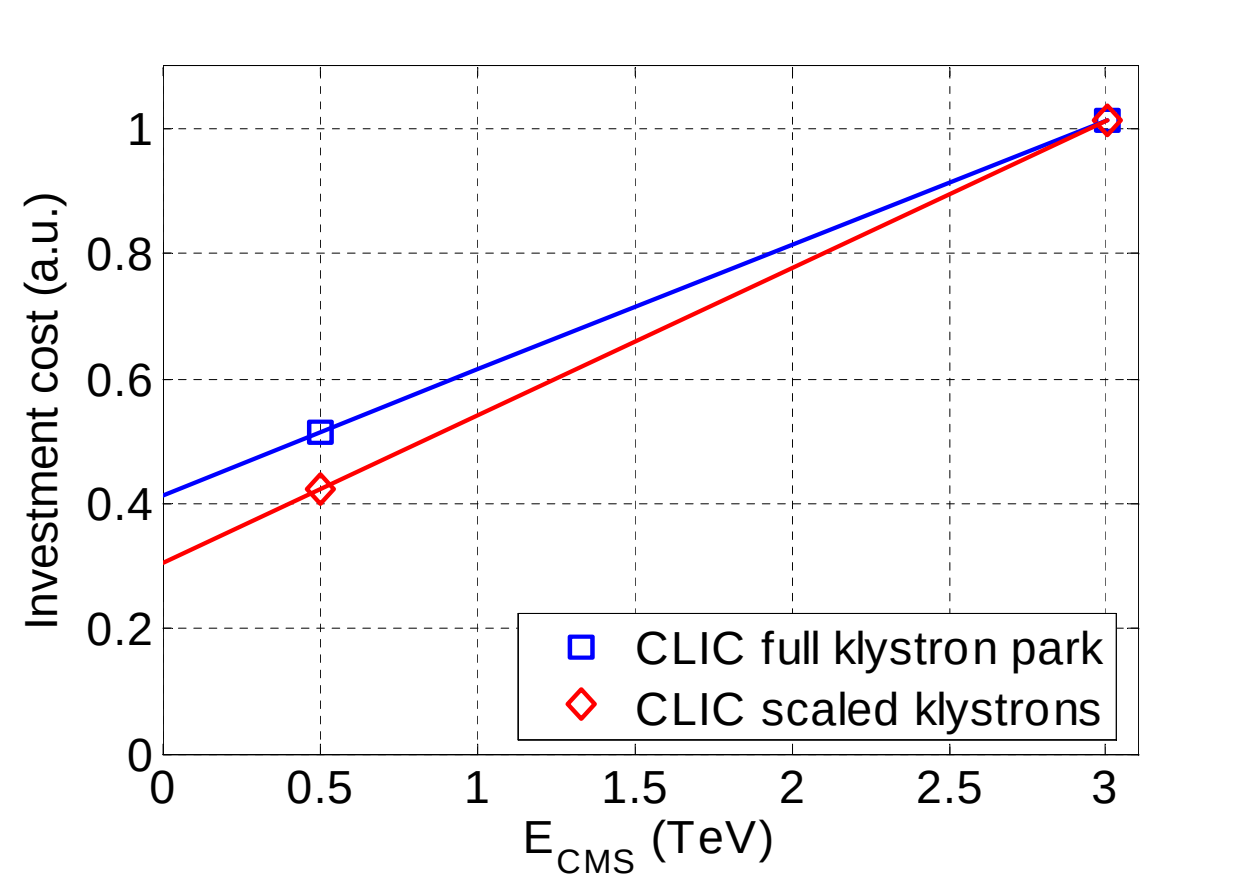
Based on a set of parameters from Alexej, parameter meeting 14.11.06

Cost distribution as function of main linac frequency for *G*=100 MV/m



Based on a set of parameters from Alexej, parameter meeting 14.11.06

Scaling of cost with energy based on present nominal parameters



Civil Engineering & Infrastructure

Study under way by CERN TS department for CLIC

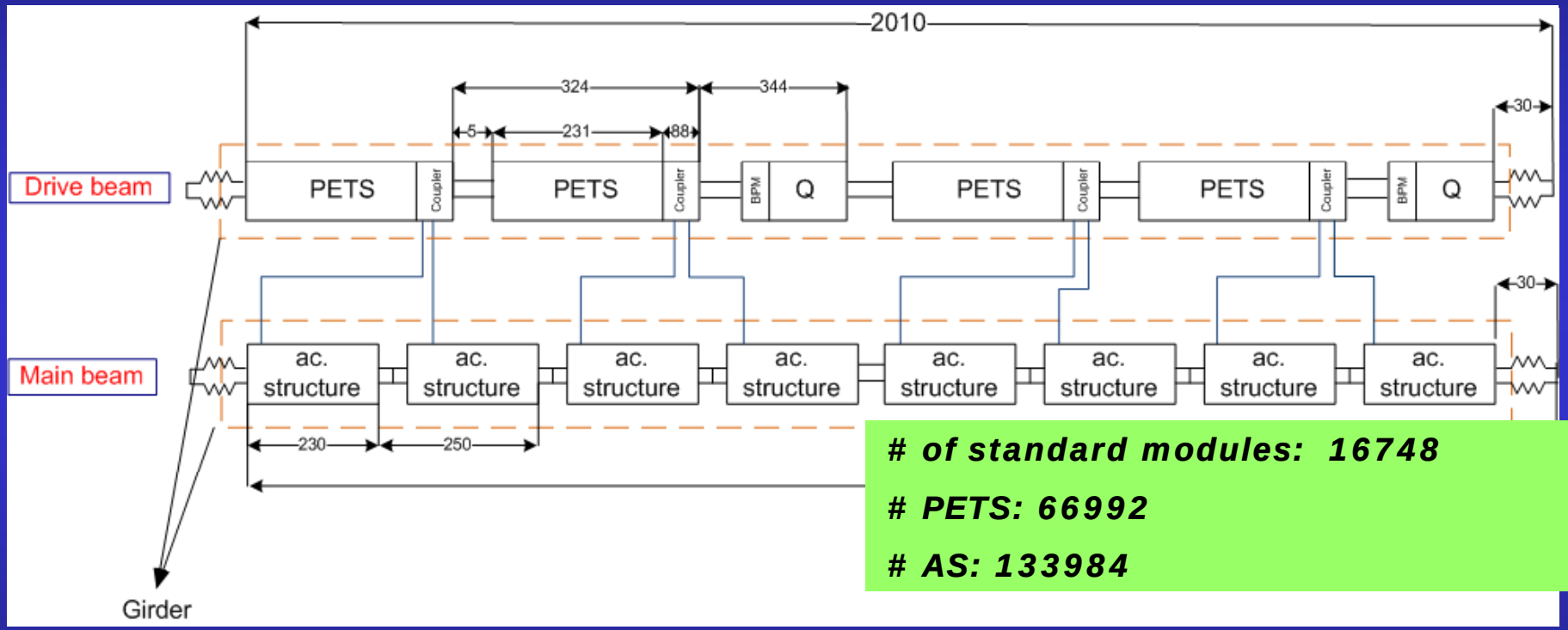
Similar to CERN-TS effort for ILC civil engineering and cost estimate

First numbers for underground areas available since last week, work on surface buildings in progress.

A study for technical infrastructure (Cooling & ventilation, electric distribution, tunnel services) has just been launched.

Complete picture for end 2007

Standard Linac Module

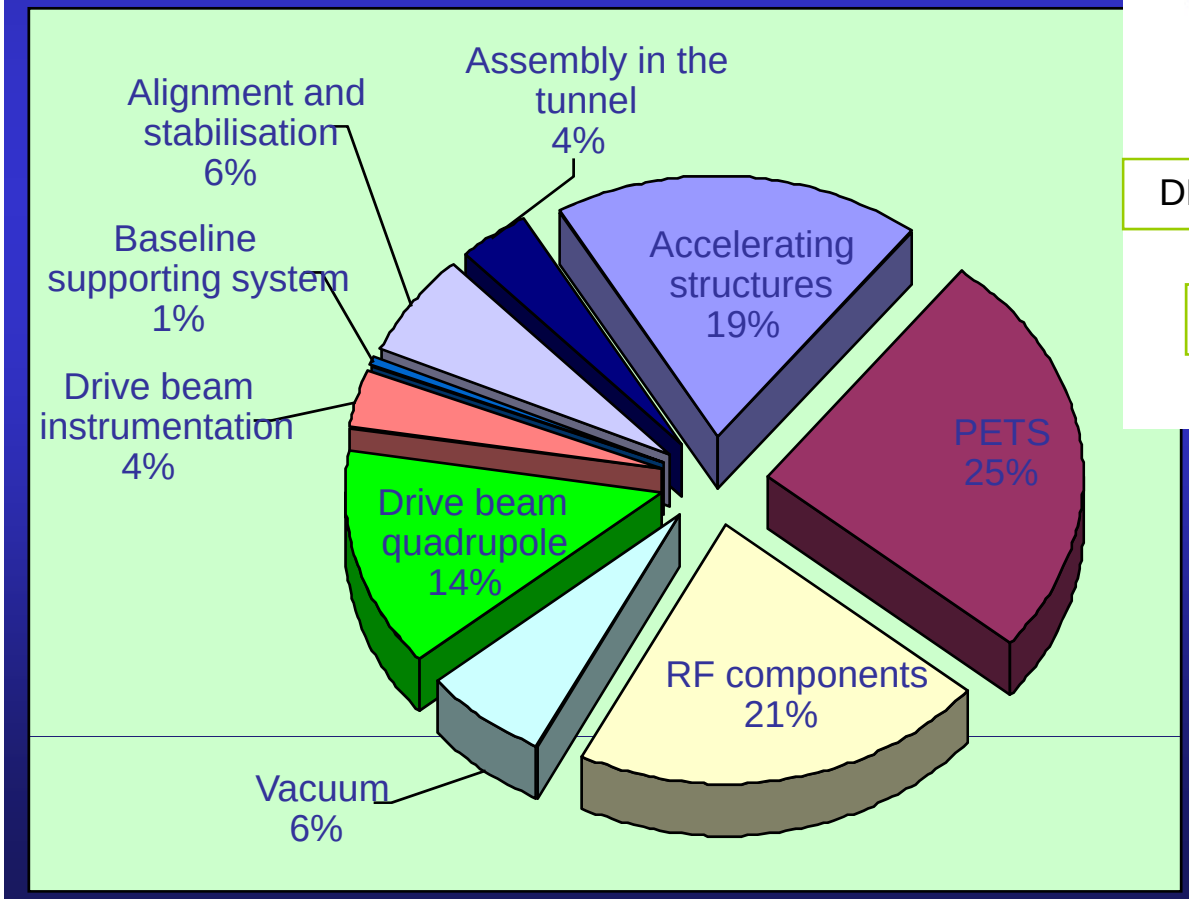


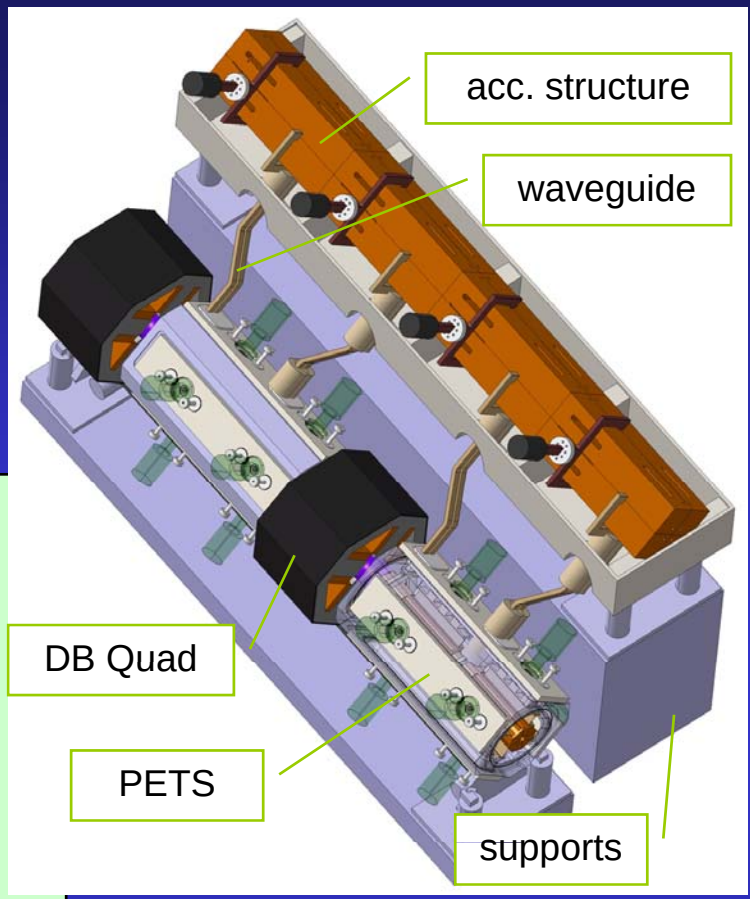
# of standard modules: 16748

 # PETS: 66992

 # AS: 133984

Standard Linac module cost distribution





Conclusions and Outlook

- Scaleable cost model has been established extrapolating from cost estimate for 2005 nominal parameters.
  This model has been extensively used in optimization.
- Consolidation of estimate for new nominal parameters ongoing.
- A number of design features is still only performance driven and needs revision for potential savings.
- Subsystems like injectors, DR's and BDS needs a closer look
- For many components we have only rough draft designs, naturally this limits the precision of the overall estimate