Question of E3 subgroup (P. Burrows, R. Patterson) to TESLA regarding higher energies

Comments to these questions regarding TESLA compiled by R. Brinkmann, DESY, July 10, 2001

Q1: What is the maximum energy that could be achieved using only 500 GeV baseline hardware? How do you get it? What is the luminosity?

A1:

Recall baseline hardware (TDR):

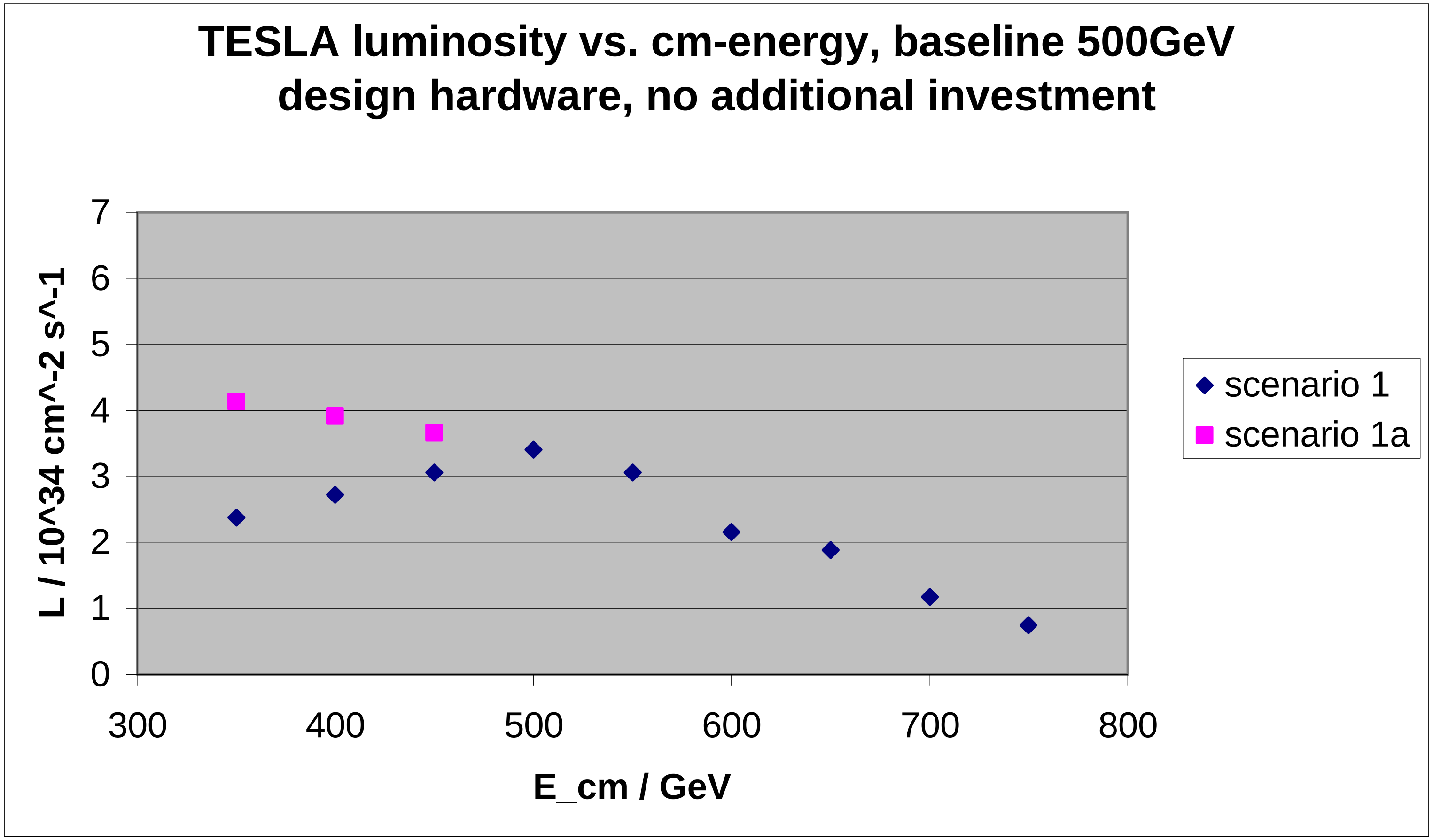
- TTF-like accelerator modules (***no superstructures***), only modifications are reduction of inter-cavity spacing to 28.5cm ($3/2 \cdot \lambda$ = 35cm at TTF) and strings of 12 instead of 8 cavities per module (potential slight cost saving from the latter is ***not*** in the TDR estimate); RF system laid out for I_b=9.5mA pulse current at 500 GeV, losses and regulation overhead included, needs klystrons operate at 96% of design (achieved) value 10MW

Theoretical (zero-current) energy limit: 990 GeV at g = 46.6MV/m

Practical energy limit:

- The gradient achievable with electro-polishing on a routine basis (the record 43MV/m won't be the average); in addition, good agreement between cavity test stand and integrated system test must be demonstrated for the higher performance structures

- The drop in luminosity due to the limited RF power: Ib$\propto$1/g and ε(IP)$\propto$1/g apparently indicates lumi independent of energy, but: cavity filling time goes up$\rightarrow$beam pulse length goes down$\rightarrow$lumi drops (slight advantage of lower emittance growth and disruption at IP is neglected here)
- Limitation in the rep. rate due to enhanced cryo load: installed 2K plant capacity allows for 70% more rf-losses in the cavity walls; making full use of this overhead and assuming constant Q0 would allow to go to 650 GeV at constant rep. rate. In a more realistic approach, we assume that the rep. rate is reduced to 4Hz at 600 GeV and to 3 Hz at 700 GeV


TESLA luminosity vs. cm-energy, baseline 500GeV
design hardware, no additional investment
L / 10^34 cm^-2 s^-1
0
1
2
3
4
5
6
7
300
400
500
600
700
800
E_cm / GeV
scenario 1
scenario 1a

Q2a: What would you need to achieve a cm-energy of 1TeV, both at your preferred site and at an ideal site? What luminosity would you achieve? What are the required gradient and length, changes to the BDS and incremental construction and operating costs? What other changes would need to be made?

Disclaimer: The TESLA technical proposal does not include any specific option for energies higher than 800GeV. What I'm going to discuss here are possibilities based on the technology & cost estimate described in the TDR, but should not be misunderstood as an official plan to modify the technical or site layout of the project.

Present status of s.c. cavity R&D (electro-polishing) supports g=35MV/m as a realistic ***goal*** to reach 800GeV, but we won't assume the possibility of a significantly higher gradient. For 1 TeV the site length must be increased. Two possibilities considered here:

A. Keep present DESY site layout fixed → extend northern (e+) linac by 8km to get 1 TeV from asymmetric (400 x 625 GeV^2) collision
B. Build a 4 km longer tunnel on both sides from the beginning, but install linac at a later stage

For both scenarios, the incremental cost ***w.r.t. the 800GeV*** machine are about ***900M€***. In case (B) about 120 M€ has to be invested already at construction of the 500 GeV machine, and a complete new planning, including legal procedure, local authorities, etc. for the central site (moving 4km north) would have to be done (this point is not present in a site independent scenario). In case (A) the implications of the asymmetric IR must be carefully studied. The total BDS length will in both cases have to be slightly increased; we'd like to check the possibility of using Raimondi's brilliant concept first to check if we can shorten our FFS.

Q2b: same as (a), but for 1.5TeV

In a site independent scenario, probably the best solution is to reserve sufficient space for the 750GeV BDS in the initial layout (Raimondi scheme!) and add 14km of tunnel and linac on either side at a later stage. In principle (funding!), the complete tunnel could be build (but only half filled) from the beginning at additional ~300M€, to which 50…100M€ for beam transfer lines must be added.

For the DESY site there is the possibility to have a deeper tunnel from the beginning, allowing symmetric expansion (river Elbe to the south!), or expanding the site only towards NNW, which means moving the central site (also implications for e+ source, etc.). Which of these options is preferable must be investigated.

Q3: What do you need to do to your baseline design to allow eventual upgrade to a multi-TeV collider?

If the only thing one needs to do at stage I is to have the geometry of the two linacs such as to provide the crossing angle for the multi-TeV IR, that can of course be done. I have doubts as to whether we know well enough at this point in time, what the optimum multi-TeV linear collider will look like in detail. I assume that a version based on TESLA technology will have little chances for funding, so that an extension of TESLA to multi-TeV is not seriously considered (despite its technical feasibility an attractivity).