Task force6: Specify SEY limits from electron cloud. Overview and progress summary.

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The electron-cloud effect (ECE) in a nutshell:

- Beam residual gas ionization and photons produce primary e-
- Number of electrons may increases/decreases due to surface secondary electron yield (SEY)
- Bunch spacing determines the survival of the electrons

Especially strong effect and possible consequences:

- Single- (head-tail) and coupled-bunch instability
- Transverse beam size increase directly affecting the Luminosity
- Vacuum pressure and excessive power deposition on the walls (LHC cryogenic system)

In summary: the ECE is a consequence of the strong coupling between the beam and its environment:

- many ingredients: beam energy, bunch charge and spacing, secondary emission yield, chamber size and geometry, chromaticity, photoelectric yield, photon reflectivity, ...

The electron cloud has been seen PSR, SPS, PEP-II, KEKB, DAΦNE..

DR task 6: Specify SEY limits from the electron cloud

- working plan -

Methodology

1) Pertinent parameters for three different rings (17 km, 6 km and 3 km circumference) [: “For some studies (e.g. electron-cloud build-up) it probably is not necessary to study every lattice in detail, but pick one in each circumference.”]
2) Electron cloud build up is simulated for the different regions (arcs, wigglers, straights) considering different secondary emission yields.
3) For the wigglers simulations the field can be modeled at various levels of sophistication, and the importance of refined models has to be explored;
4) Single-bunch wake fields and the thresholds of the fast single-bunch TMCI-like instability are estimated;
5) Multi-bunch wake fields and growth rates are inferred from e-cloud build up simulations;
6) Electron induced tune shifts will be calculated and compared;
7) Predictions of electron build up from different simulation codes are compared;
8) Implemented in the simulations will be countermeasures which may be proposed as the ILC DR design evolves.

ILC Damping Ring electron cloud studies and simulations

- Goal of the DR task force 6 is to evaluate the electron cloud effect and specify the acceptable limits for the surface SEY in each damping ring circumference range (17km, 6km, 3km).
- We prioritize simulations starting to focus on the three DR designs: **TESLA** 17km, **OCS** 6km, **OTW** 3km.
- Started benchmarking the electron cloud build-up with codes ECLOUD (CERN) and POSINST (SLAC).
  - Use common SEY model/s. Sensitivity studies.
- Single-bunch instability simulations: KEK

Web page:

http://www-project.slac.stanford.edu/ilc/testfac/ecloud/elec_cloud_comparison.html

ILC DR parameters vacuum chamber (new)

- It has been suggested to use new specifications for vacuum camber sizes. This vacuum chamber sizes are actually adopted by the rest of task force community, and are listed in the paper:

  http://www.desy.de/~awolski/ILCDR/DRConfigurationStudy_files/Task3_files/ILCDRVacuum.pdf

  chamber sizes are smaller than previous TESLA specifications.

  concern: more electron cloud with smaller chamber size ? (see simulations below)

  Probably, that is 0k for comparative studies (?!)

ILC DR parameters vacuum chamber (new)

Outline of Vacuum System for ILC Damping Rings*

A. Wolski† and K. D. Kennedy

http://www.desy.de/~awolski/ILCDR/DRConfigurationStudy_files/Task3_files/ILCDRVacuum.pdf

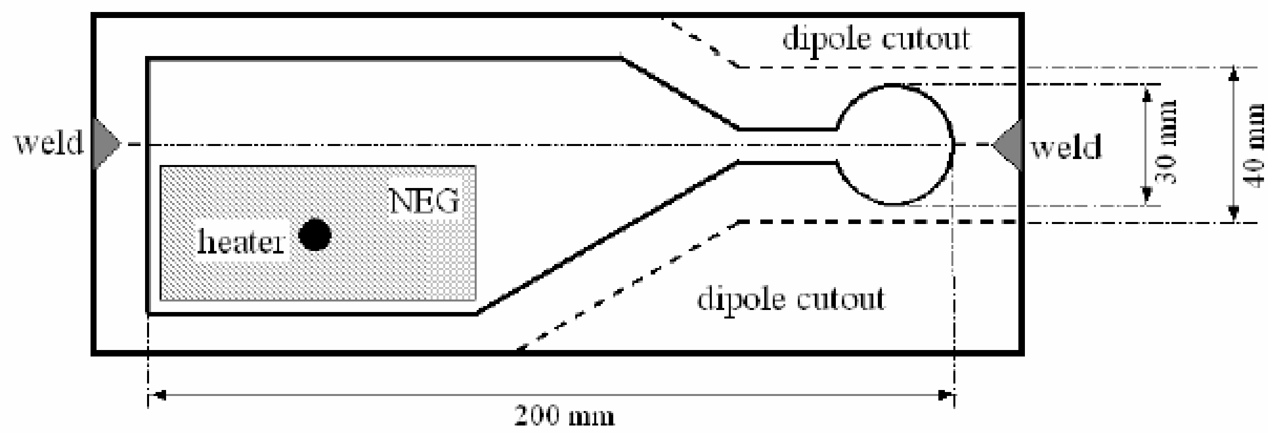


FIG. 5: Cross-section of vacuum chamber in arc with distributed pumping.

Arc chamber

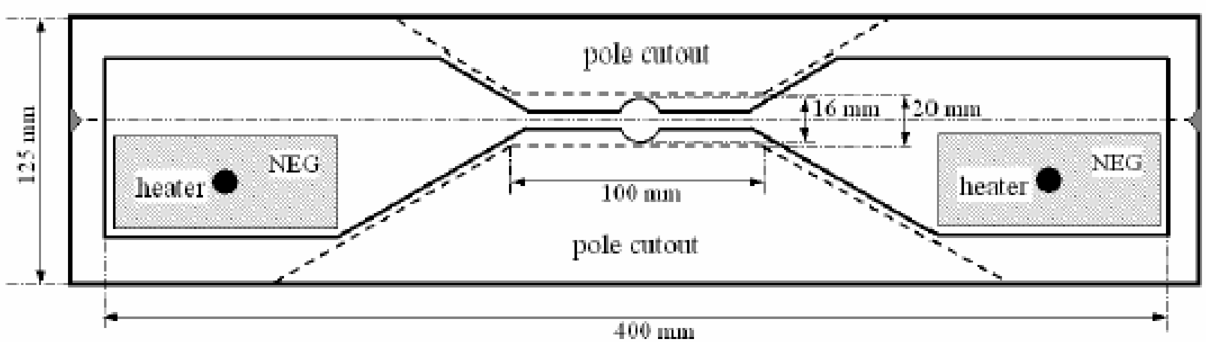


FIG. 6: Cross-section of vacuum chamber in the wiggler with distributed pumping.

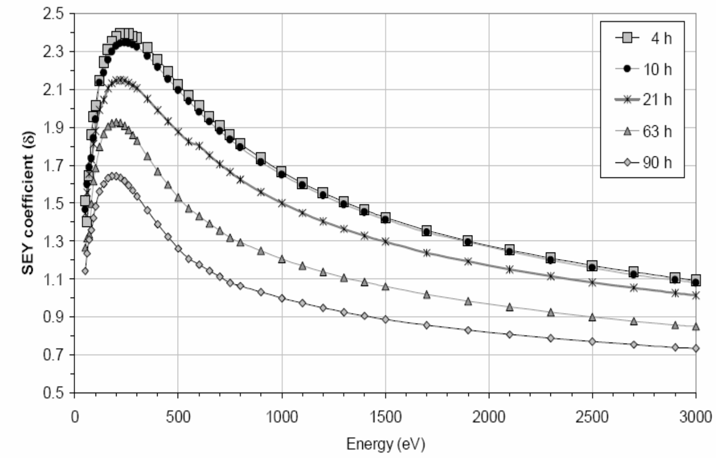
Wiggler chamber

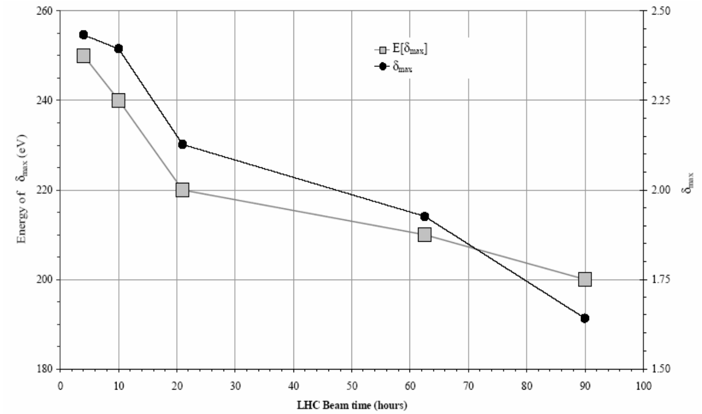
SEY Models

Secondary Emission Yield Model 1) →

(**variable Emax and variable e- reflectivity**

extrapolation: based on LHC Proj.Rep-632, SPS measurements <u>SR (?!) + electron conditioning</u>)





delta_max: 1.3

epsilon_max: Emax= 190 eV (function of delta_max)

low-energy elastic reflectivity of electrons at 1.3: 35%

delta_max: 1.2

epsilon_max: Emax= 180 eV (function of delta_max)

low-energy elastic reflectivity of electrons at 1.2: 33%

delta_max: 1.1

epsilon_max: Emax= 170 eV (function of delta_max)

low-energy elastic reflectivity of electrons at 1.1: 30%

Secondary Emission Yield Model 2)

(~**constant Emax and constant e- reflectivity** based on SPS data and. Hilleret's recommendation)

delta_max: 1.3

epsilon_max: Emax= 234.75 eV (function of delta_max)

low-energy elastic reflectivity of electrons at 1.3: 50%

delta_max: 1.2

epsilon_max: Emax= 232.38 eV (function of delta_max)

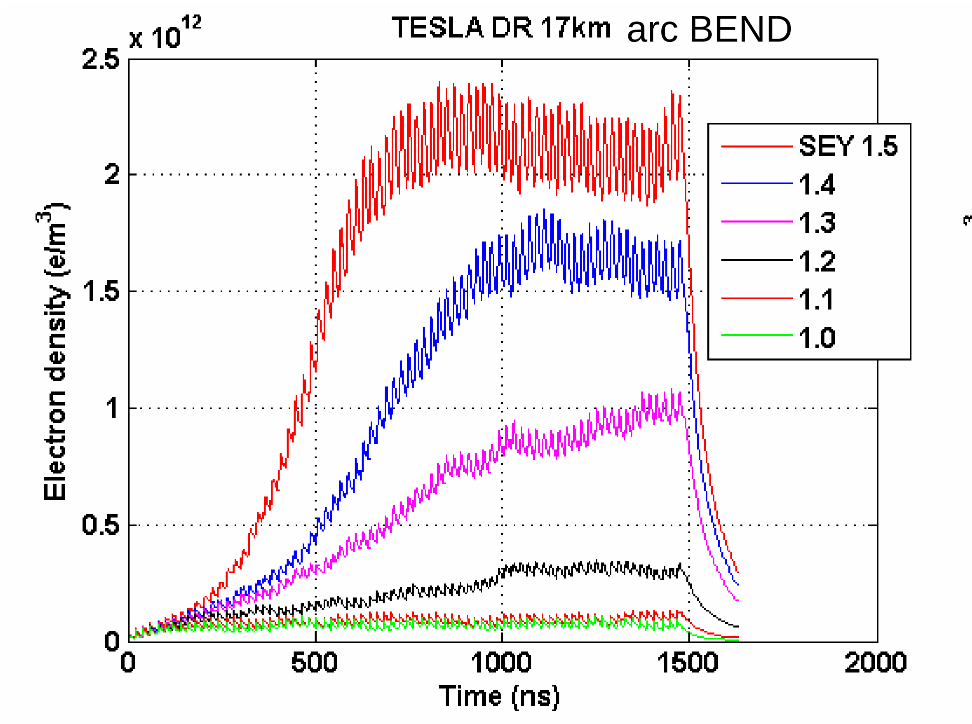
low-energy elastic reflectivity of electrons at 1.2: 50%

delta_max: 1.1

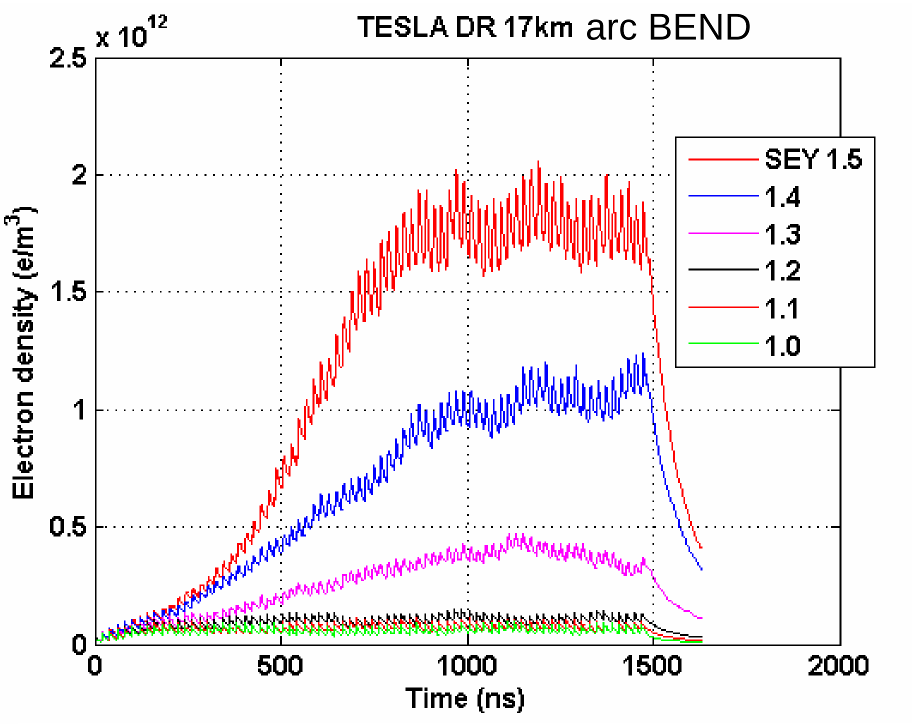
epsilon_max: Emax= 230 eV (function of delta_max)

low-energy elastic reflectivity of electrons at 1.1: 50%

TESLA: COMPARE SEY MODELS



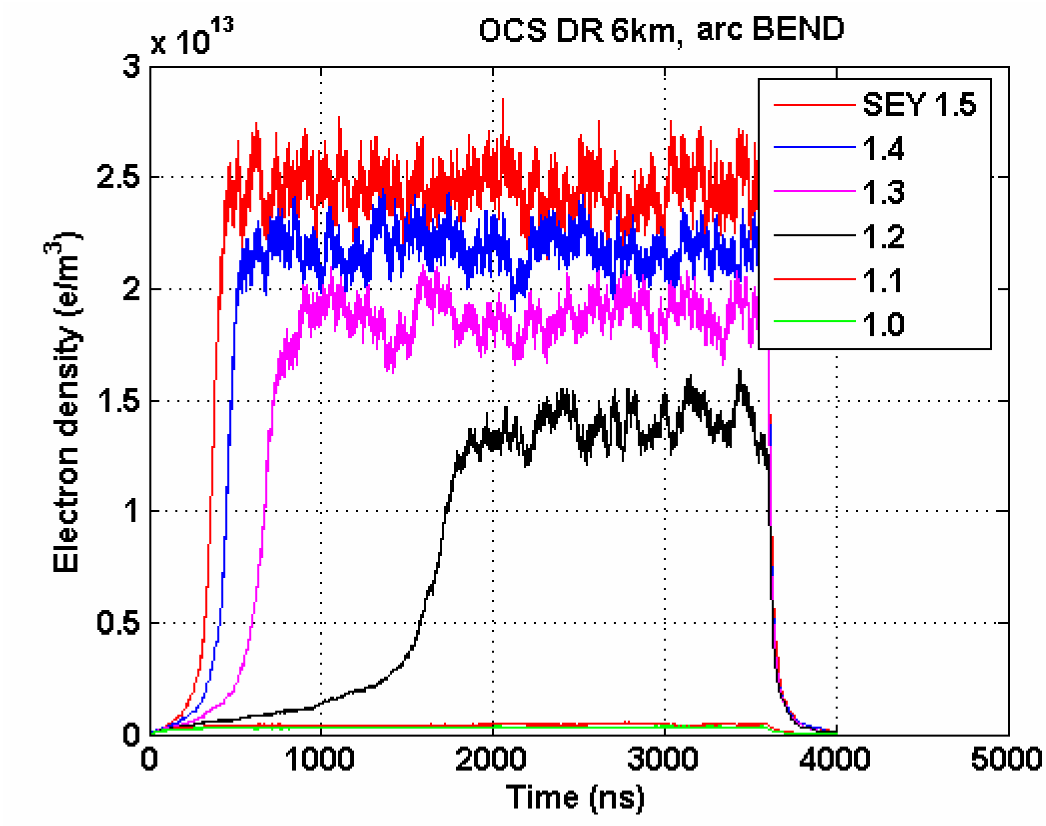
SEY MODEL (1)



SEY MODEL (2)

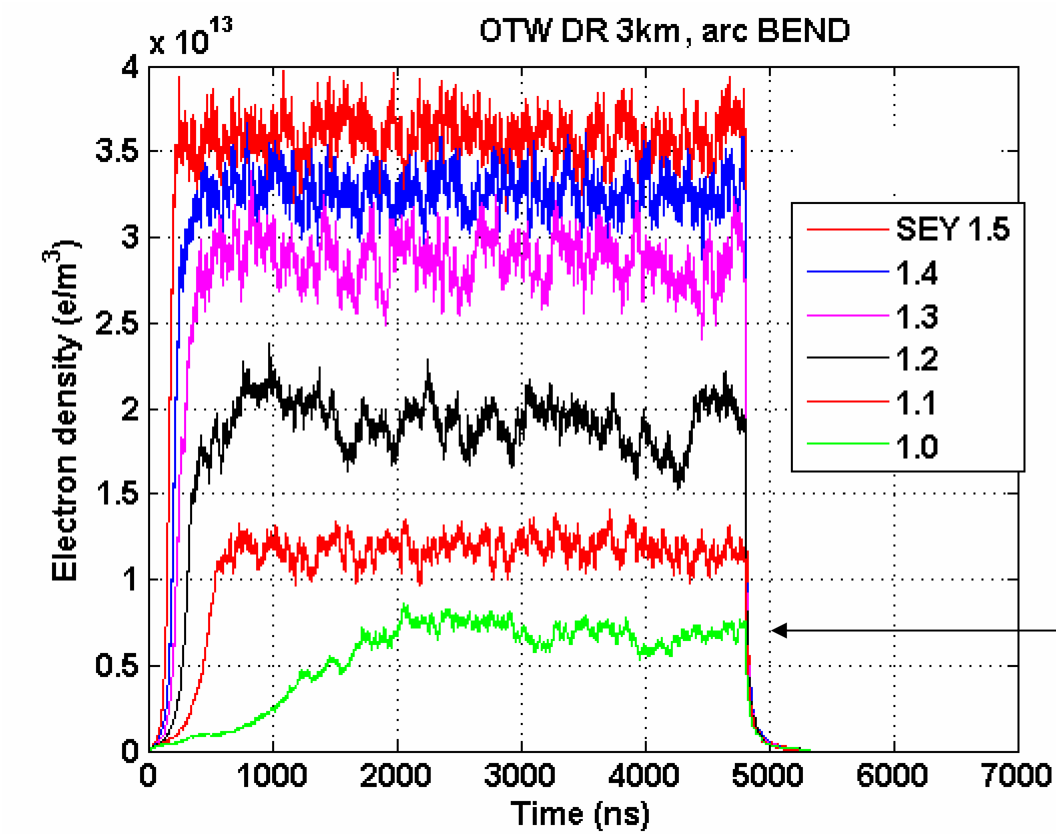
Using POSINST code (LBNL, SLAC) for following simulations shown below. Photoelectron production rate is 0.0014 photoe$^-$ per beam particle per meter (2% of total number of photons hit chamber). This rate is used for all rings.

OCS DR arc BEND



Threshold at SEY~1.2

OTW DR arc BEND

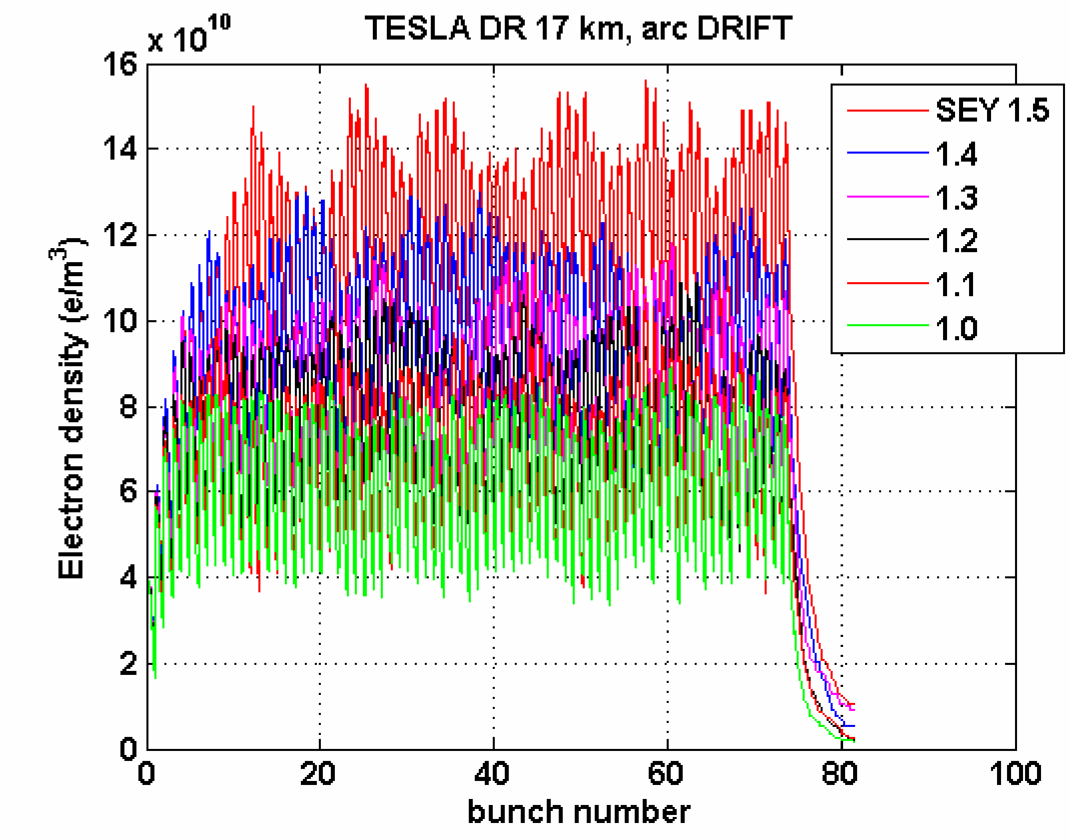


peak SEY=1.0

Threshold at SEY<1.0.

(Electrons spiral in bend and impinge with a grazing angle increasing the effective SEY).

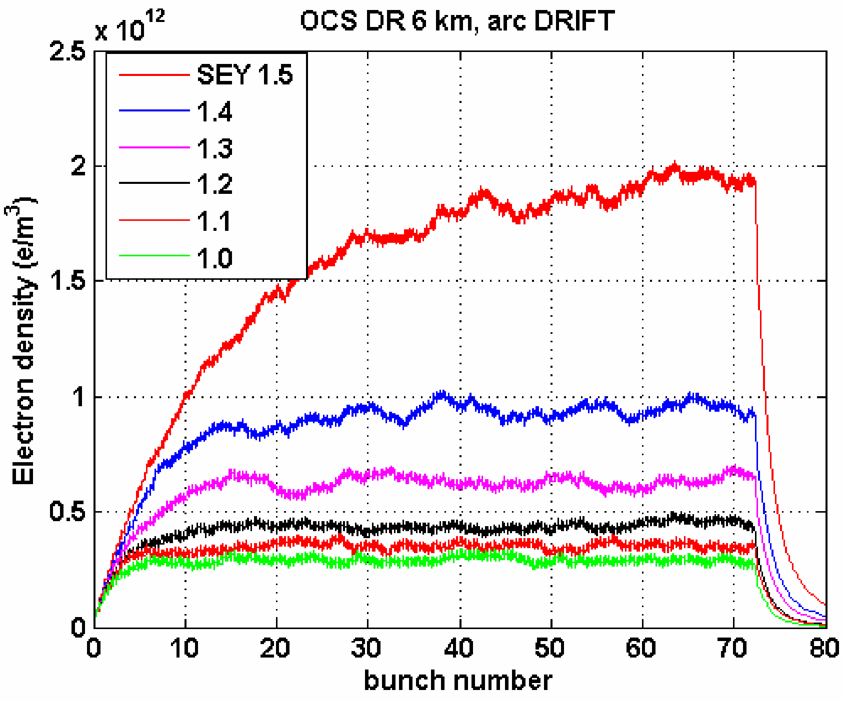
TESLA DR arc DRIFTs

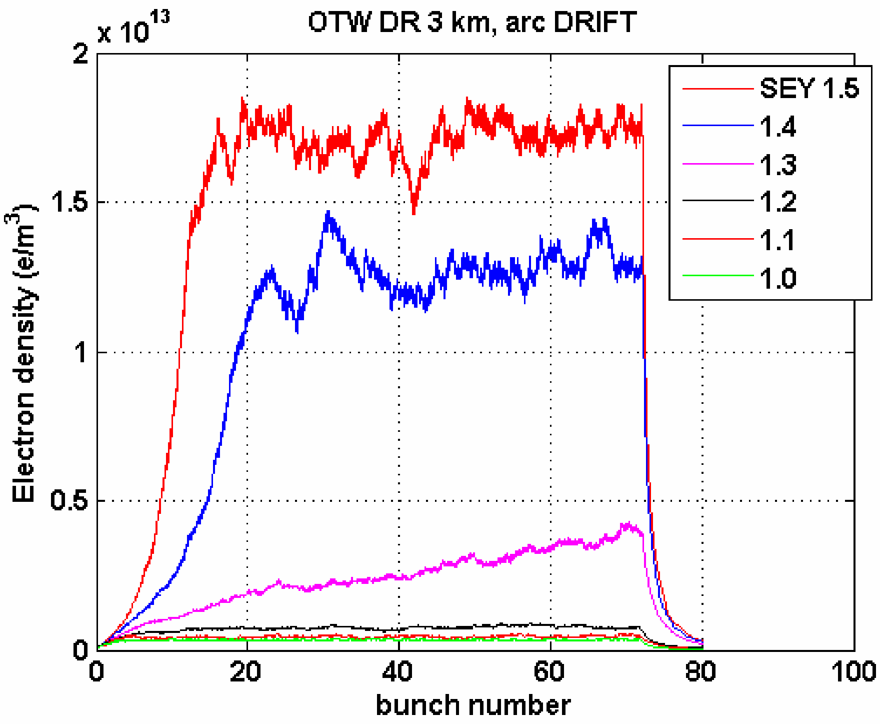


Photoelectrons dominated.

POSINST

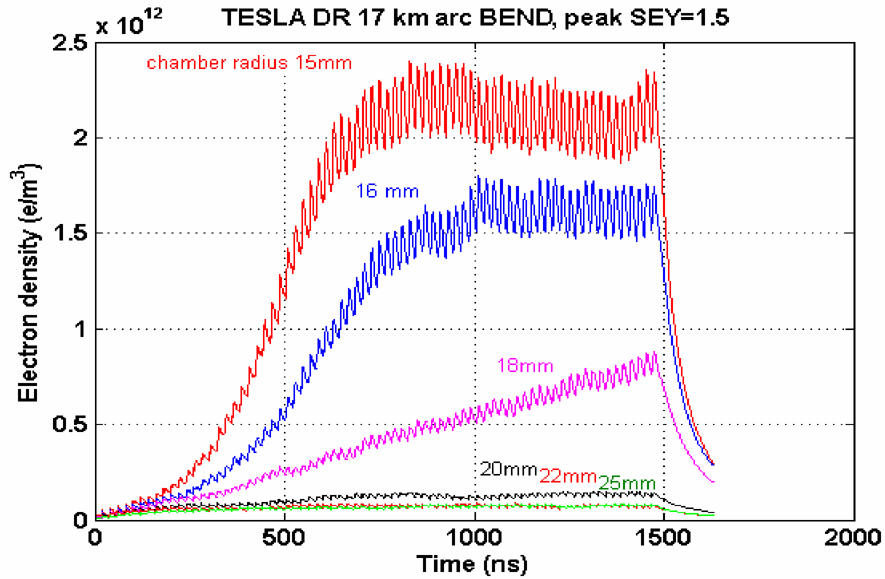
OCS and OTW arc DRIFTs

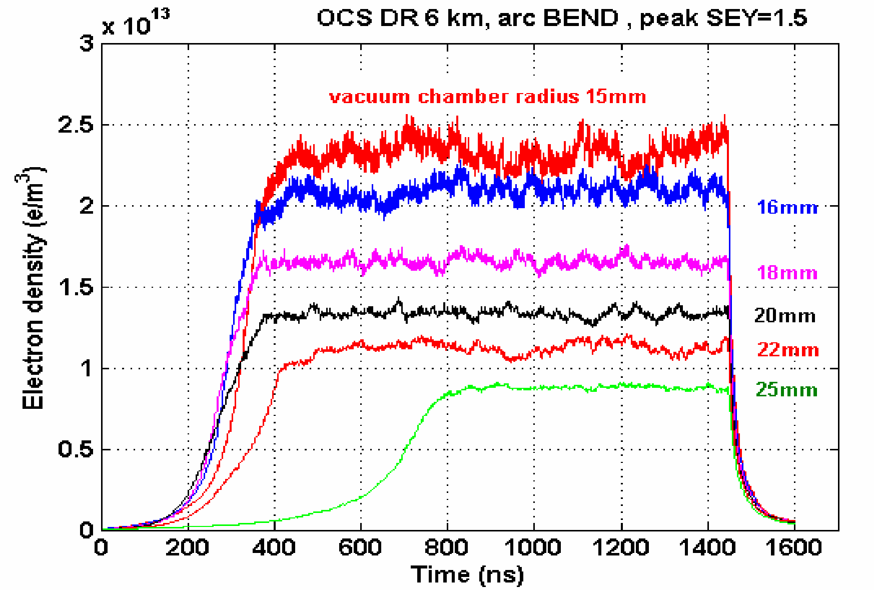


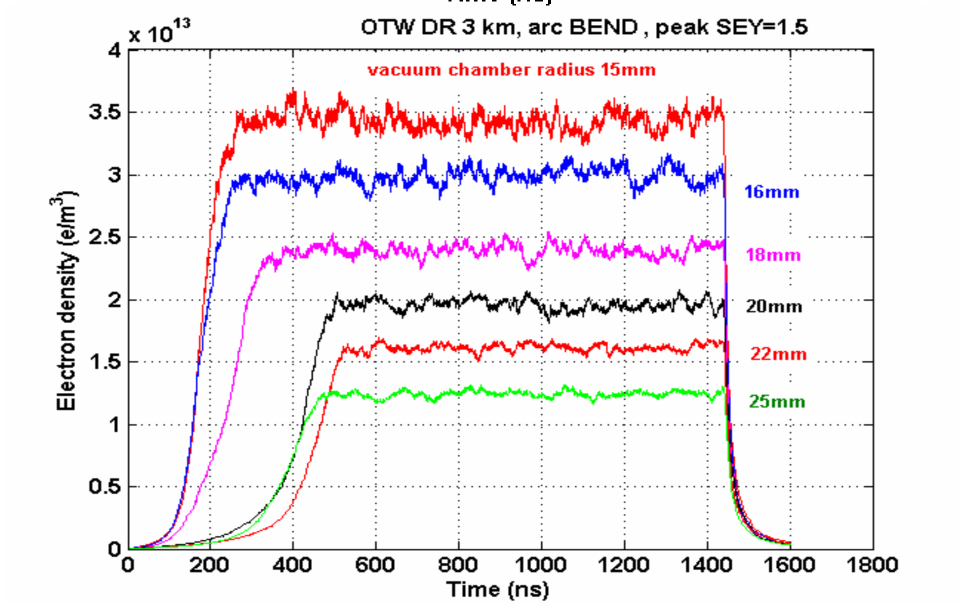


Clear build-up in OTW

Compare different chamber sizes

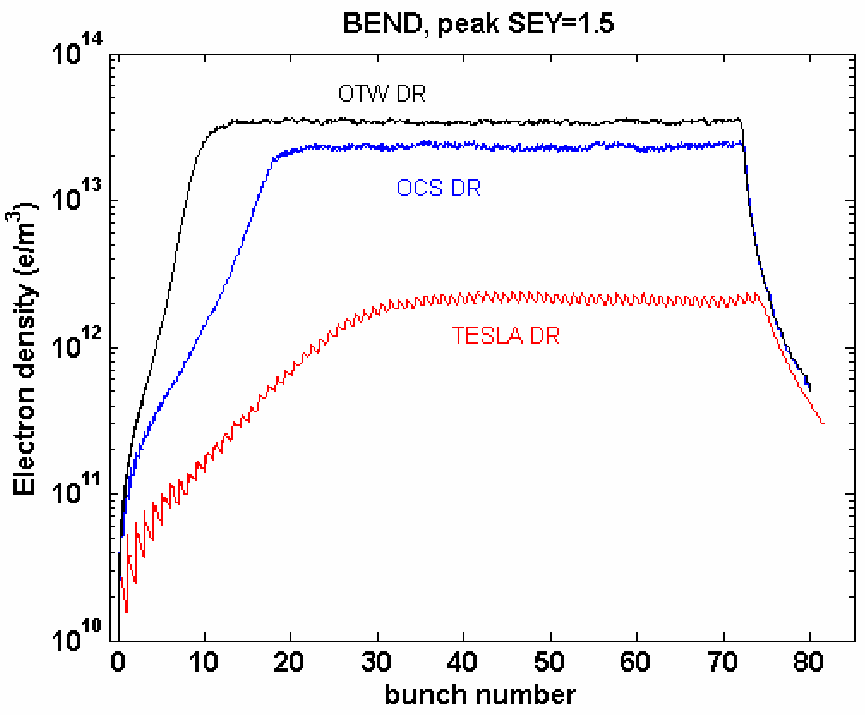


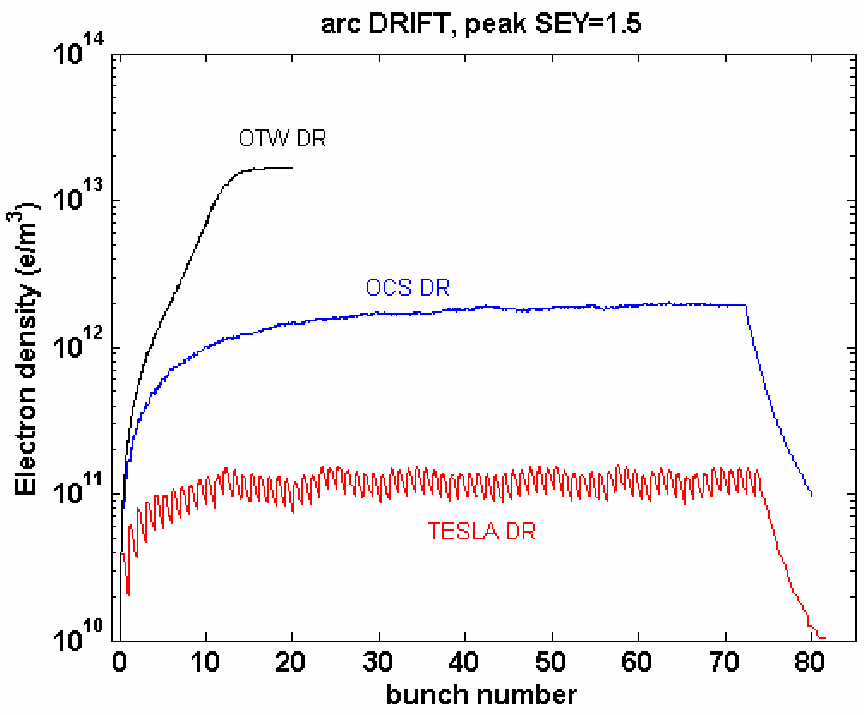




Larger vacuum chamber size is beneficial in all DR and bunch spacing configurations.

Compare in DRs ARC

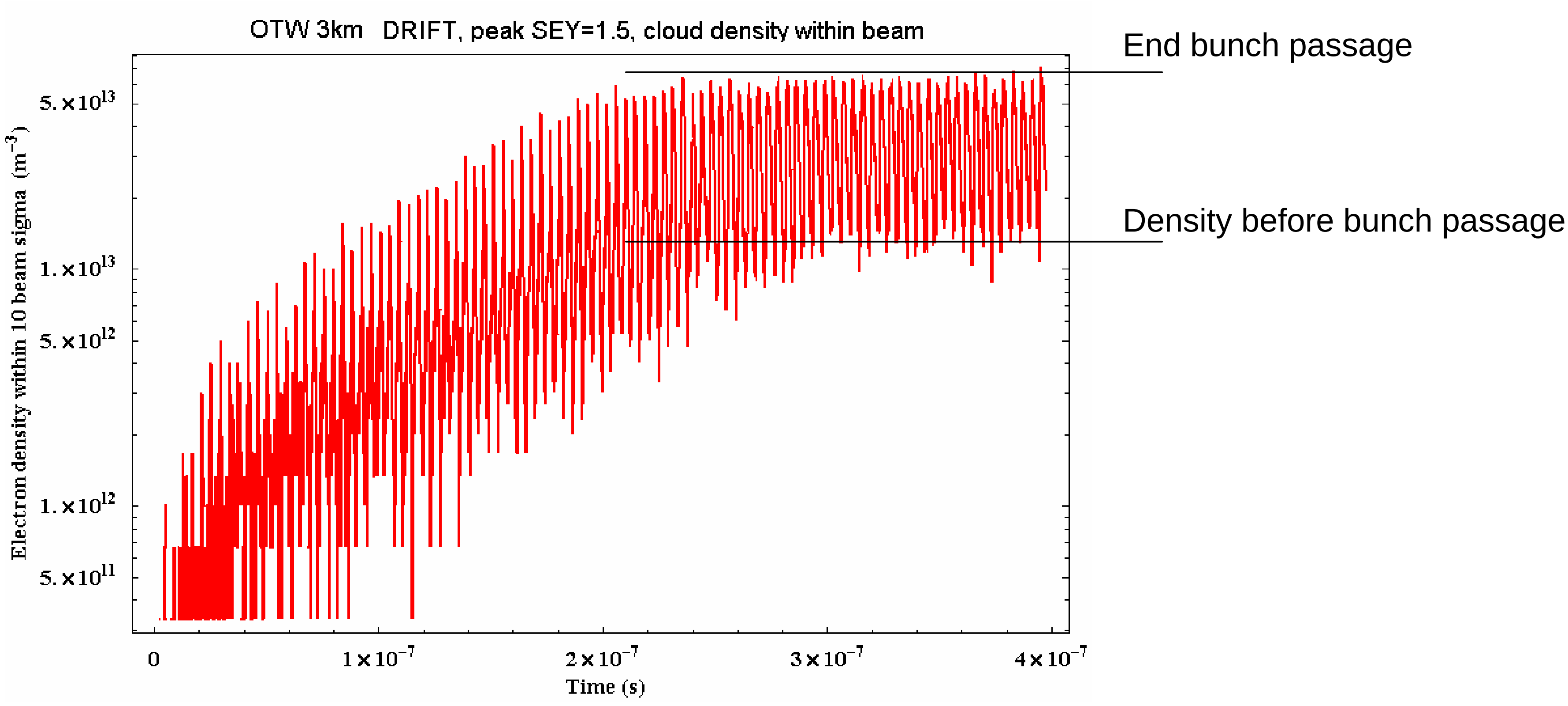




BEND

arc DRIFT

OTW: density within 10 beam sigma, pinching effect



OTW: plot of the electron cloud density within 10 beam sigma.
Pinching effect:: a factor 3-4 cloud density increase during the bunch passage.

Electron cloud density threshold for head-tail effect.

See Ohmi-san presentation, coming next.

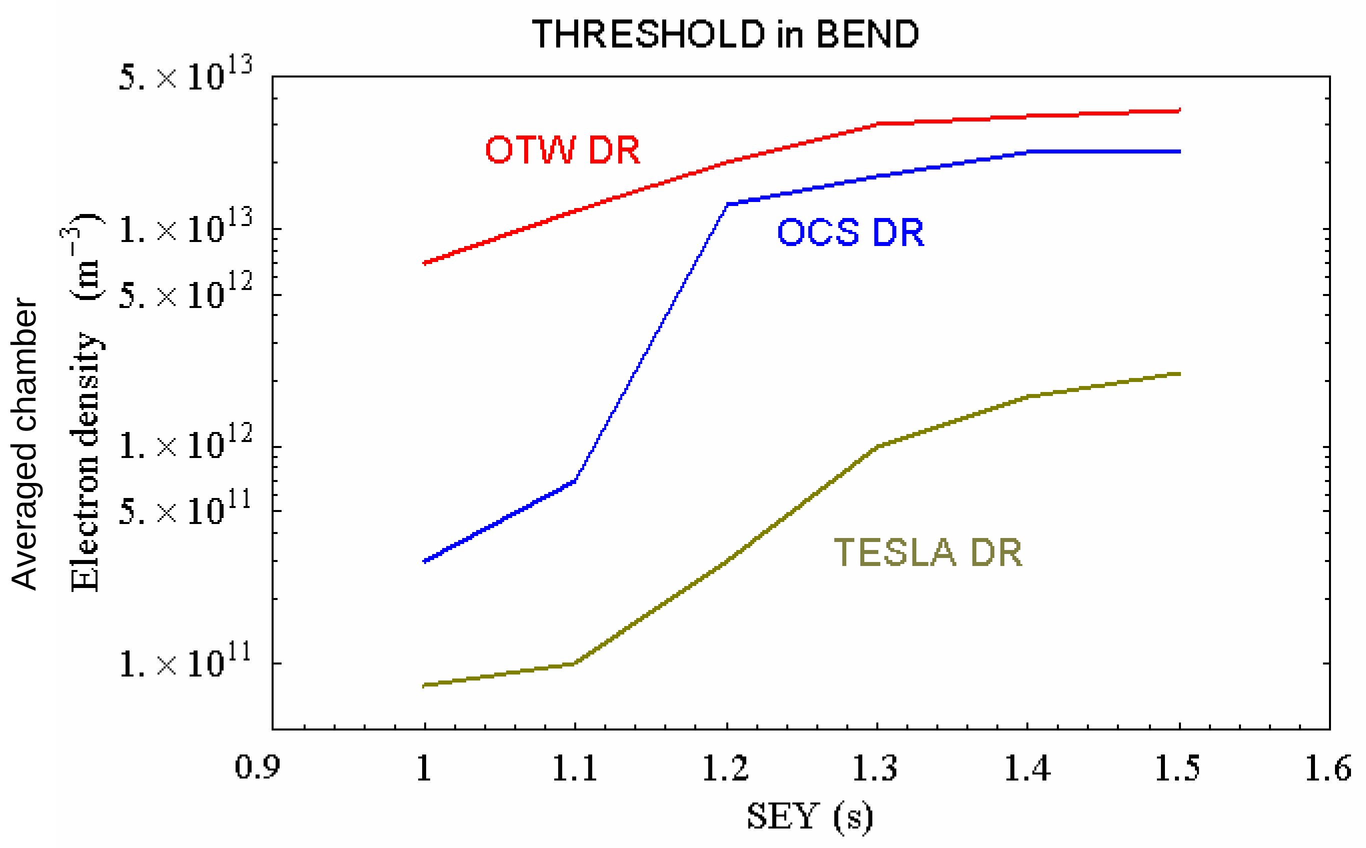
Here, summary of the results obtained for the single-bunch head-tail simulations in DRIFT field free regions. Cloud density **close to beam:**

- The threshold density

	simulation
OTW	$\rho_{e,th}=5\text{x}10^{11}\ m^{-3}$
OCS	$=2\text{x}10^{11}\ m^{-3}$
TESLA	$=1\text{x}10^{11}\ m^{-3}$

Typically in bends (not simulated yet), a factor ~2 larger cloud density threshold are expected.

SEY thresholds in BENDs

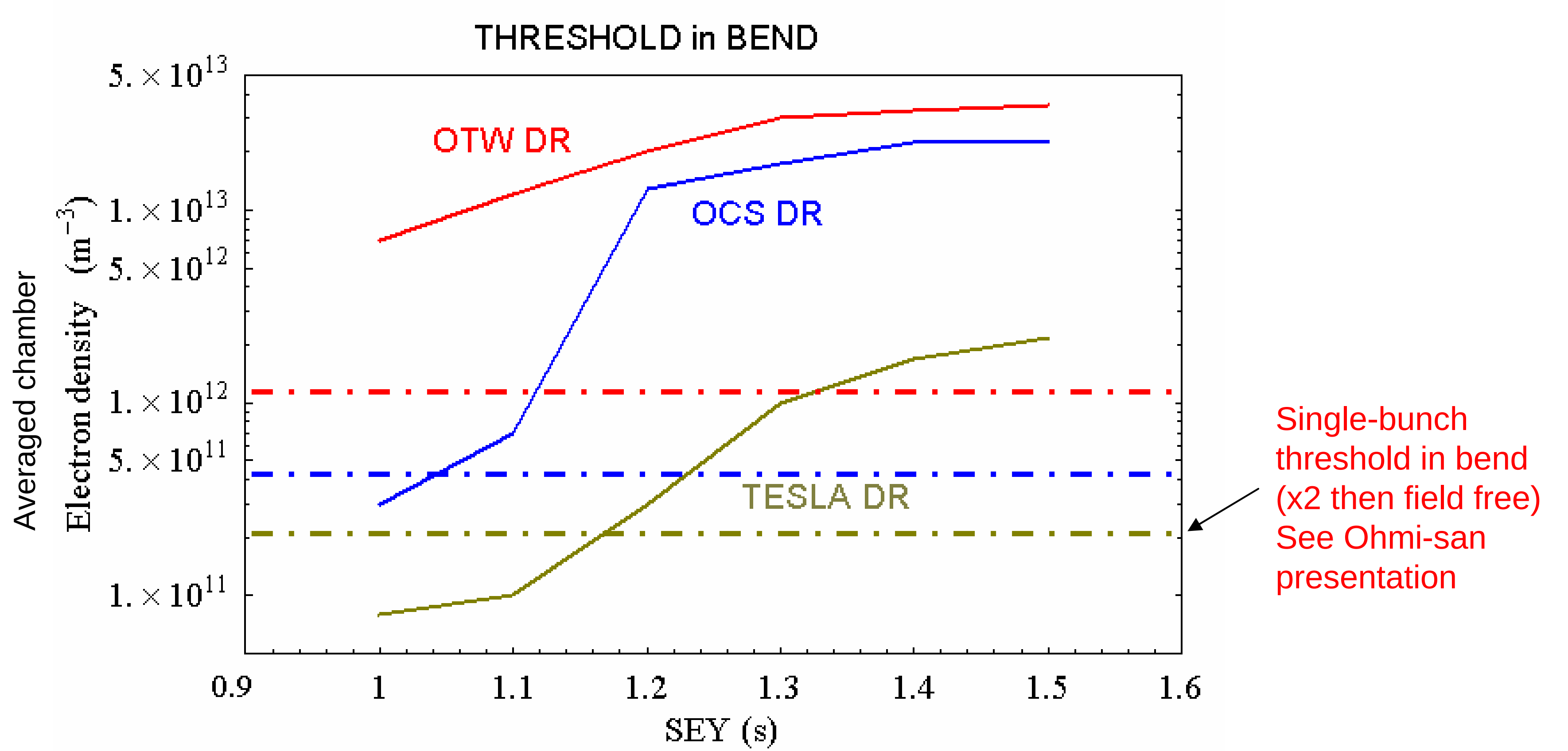


Electron-cloud thresholds in BENDS of different rings. Dotted lines represent the threshold for single-bunch head-tail instability.

Summary

- Task force 6 work is proceeding at good speed with good coordination between SLAC/CERN/KEK/DESY.
- Results have small dependence on SEY models (1 and 2).
- 17 km ring TESLA has moderate electron cloud build-up in BENDS, while in ARC DRIFTs is dominated by photoelectrons.
- 3 km ring OTW has faster build-up and much larger electron cloud densities. SEY<1 in BENDs and large build-up in arc DRIFTs.
- Still quadrupoles and wigglers simulations are needed to compile electron cloud density along each ring.
- LARGER beam pipe dimensions are beneficial in all configurations!
- Simulations benchmarking between different codes are ongoing.
- Single-bunch instability and build-up will determine SEY limits.
- Single-bunch instability simulations (see Ohmi-san presentation):
  - In particular, lower threshold in TESLA and slightly higher threshold in OTW. Higher thresholds are expected for BRU, MCH.
  - It is too early to come to conclusions

SEY thresholds in BENDs



Electron-cloud thresholds in BENDS of different rings. Dotted lines represent the threshold for single-bunch head-tail instability.