TLEP Vacuum System
Preliminary Calculations

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Agenda:

- Machine and Vacuum Parameters
- Synchrotron Radiation Spectra
- Expected Outgassing
- Pressures
- Beam Conditioning
- Problems Ahead and To Do List…

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TE

Vacuum Surfaces & Coatings

- **Machine and Vacuum Parameters (single beam)**

	LEP2	LEP3	LHeC	TLEP-t	TLEP-h	TLEP-z	ESRF
Energy (GeV)	104	120	60	175	120	45.5	6
Current (mA)	4	7.2	100	5.4	24.3	1,180	200
Radius (m)	3096	2626	2626	**7860***	9000	9000	23.4
E_{crit} (eV)	805,862	1,459,521	182,440	1,512,353	425,856	23,214	20,504
Total Flux (ph/s)	3.36E+20	6.98E+20	4.85E+21	7.64E+20	2.36E+21	4.34E+22	9.70E+20
Total Power (MW)	13.37	50.29	43.66	57.03	49.53	49.71	0.98
Spec.Flux (ph/s/m)	1.73E+16	4.23E+16	2.94E+17	1.55E+16	4.17E+16	7.67E+17	6.60E+18
Spec. Power (W/m)	687.3	3,048.1	2,646.0	1,154.7	875.9	879.1	6,684.0
Specific Outgassing (mbar·l/s/m) ***η (mol/ph)**	6.99E-4	1.71E-3	1.19E-2	6.26E-4	1.69E-3	3.10E-2	2.67E-1

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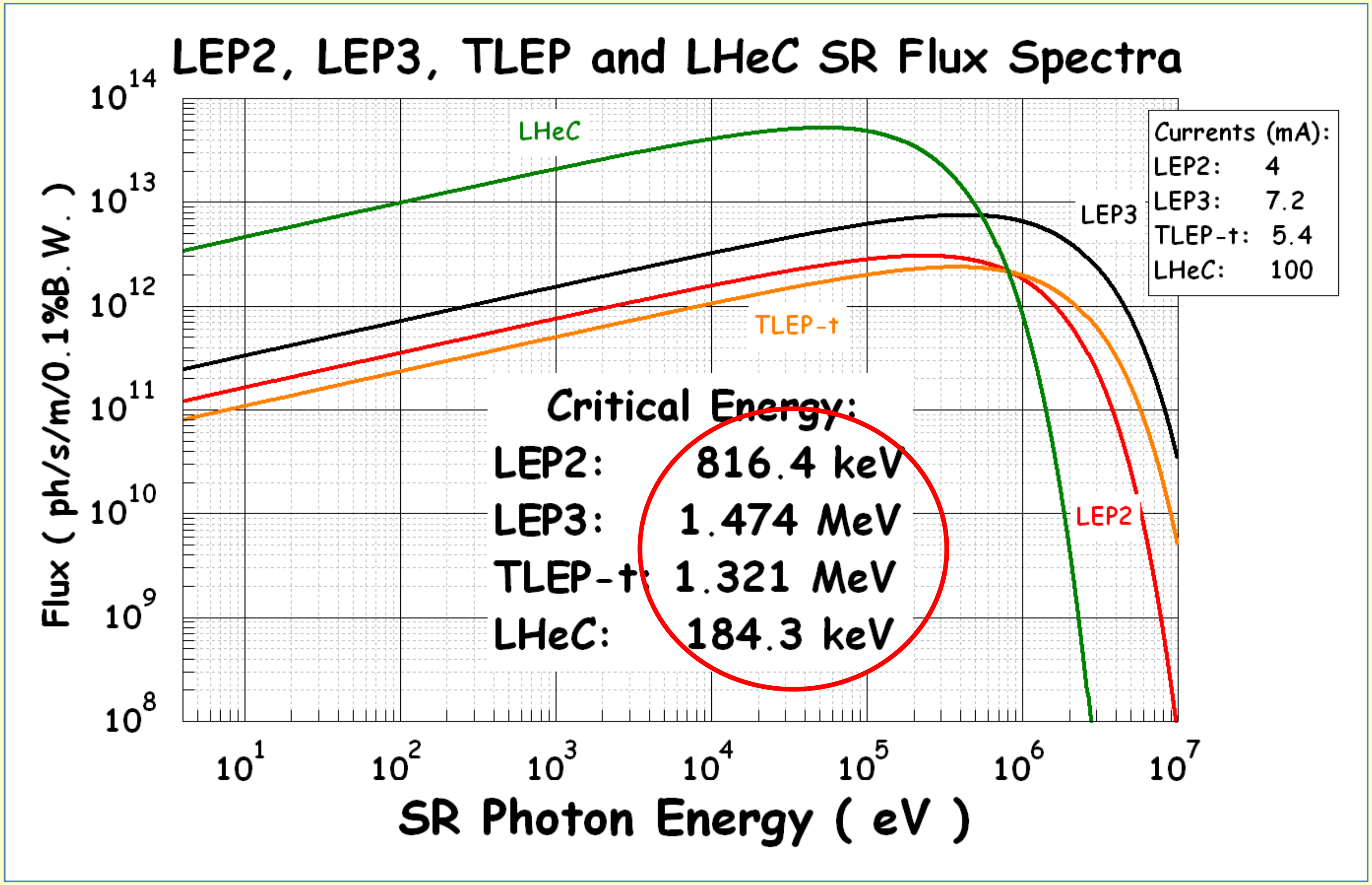
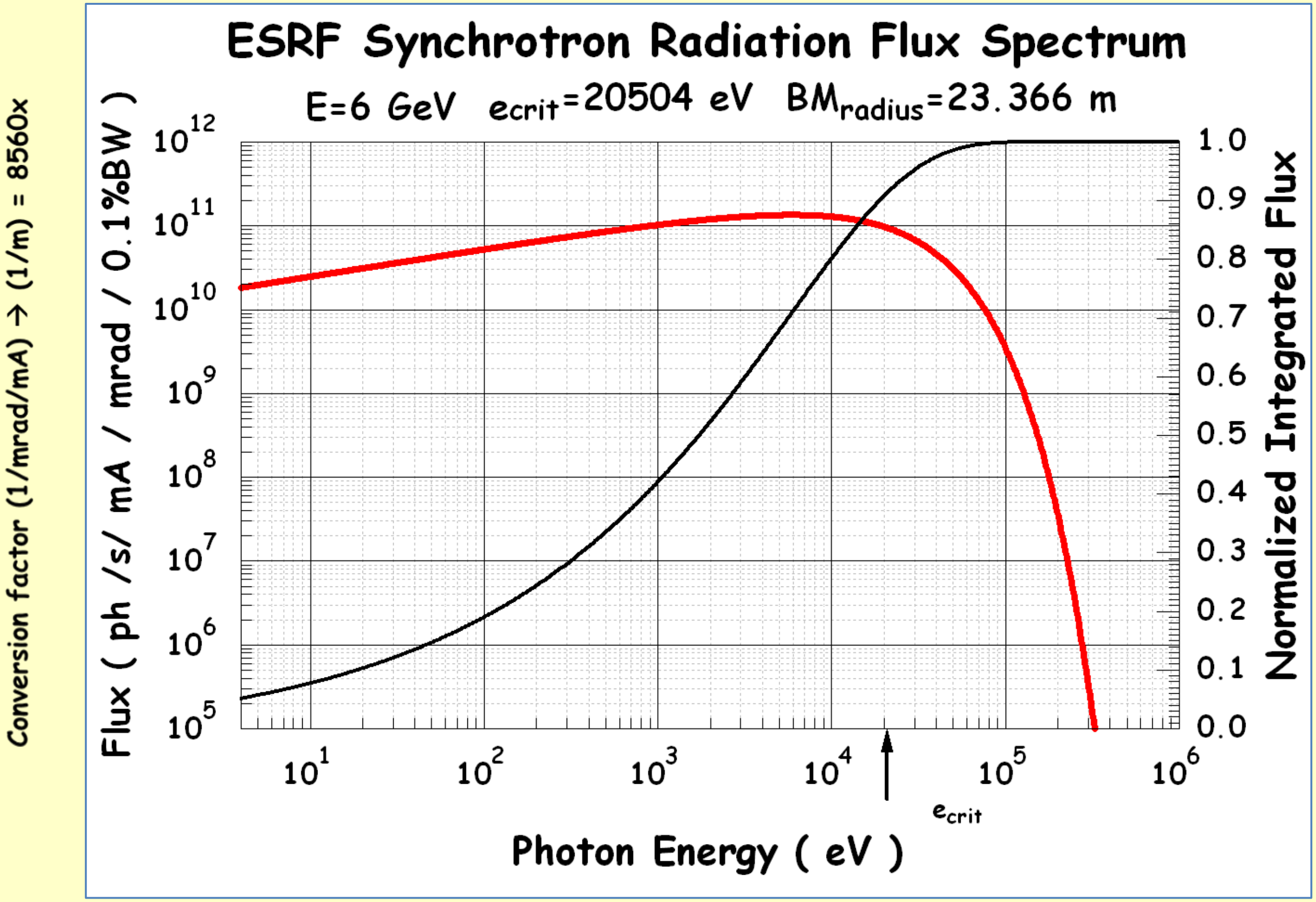
- ## Synchrotron Radiation Spectra



(*) Critical energies may be different due to slightly different values of the radius of curvature

- Synchrotron Radiation Spectra: ESRF



Only ~ 8.5% of the photon FLUX is generated ABOVE the critical energy vs 50% for the POWER. For the ESRF ~ 5% of the flux is generated BELOW the 4 eV threshold for generation of photoelectrons and photodesorption (similar to TLEP-Z)

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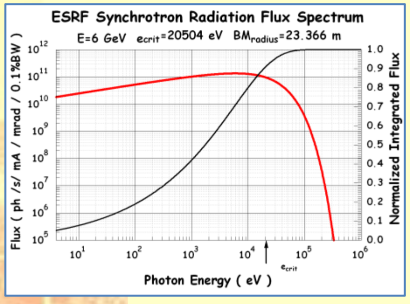
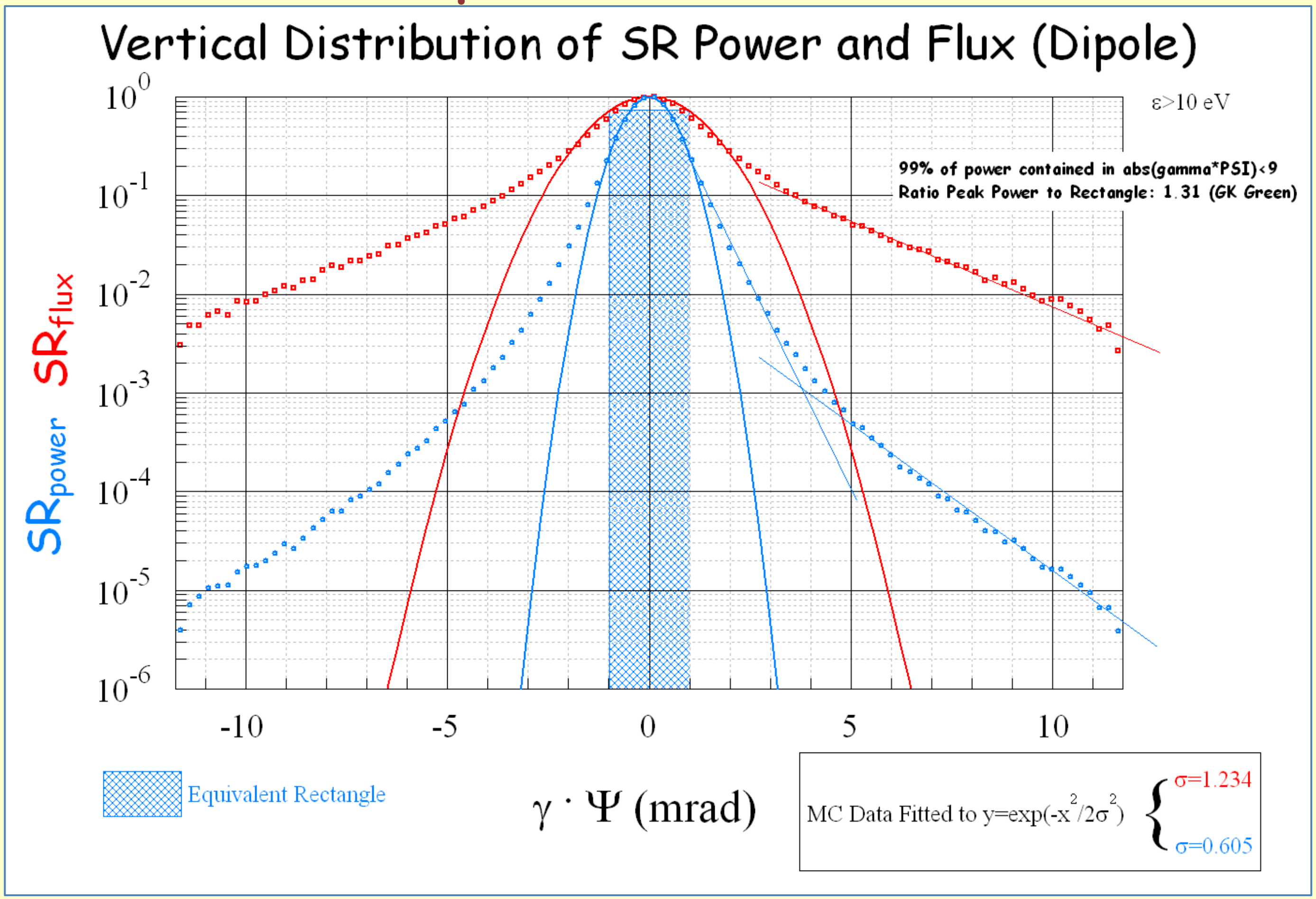
• Synchrotron Radiation Spectra: Universal Curve





In literature, it is generally assumed that the SR fan is generated within a +/- 1/γ vertical angle (w.r.t. the plane of the orbit).

While this may reasonably be held true for the POWER, it doesn't represent AT ALL the angular distribution of the FLUX

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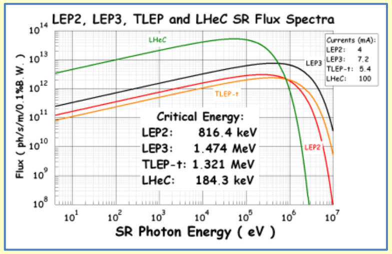
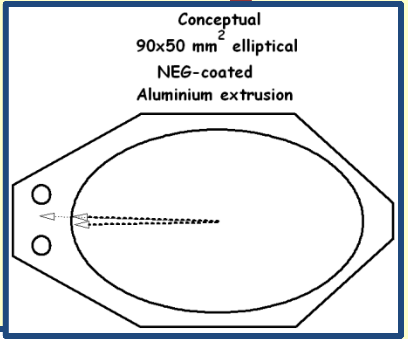
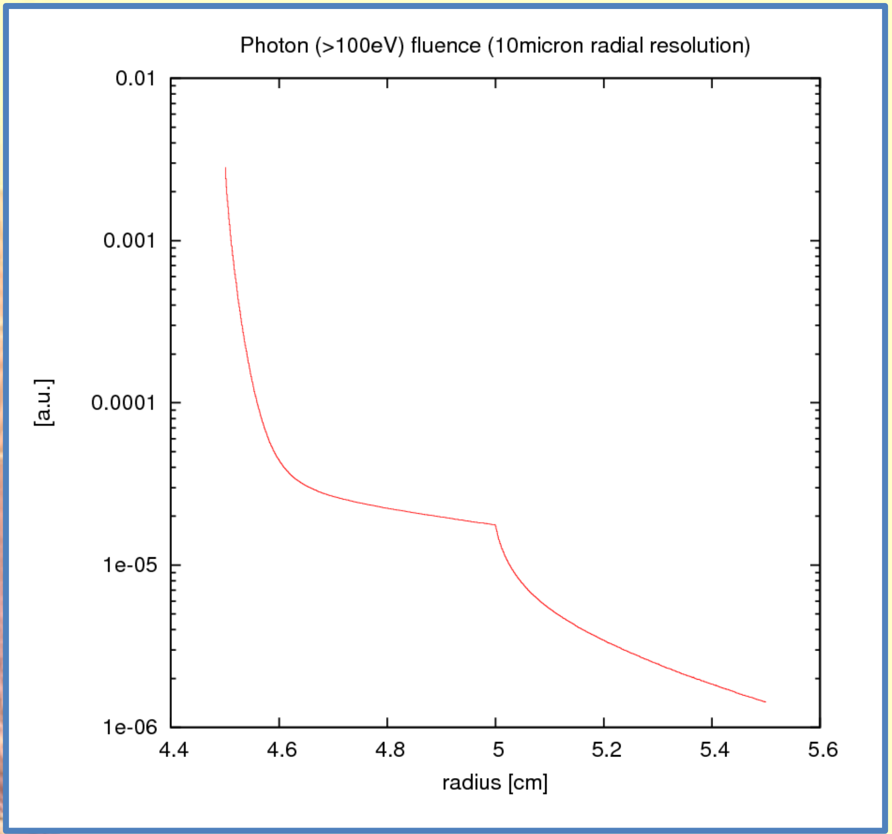
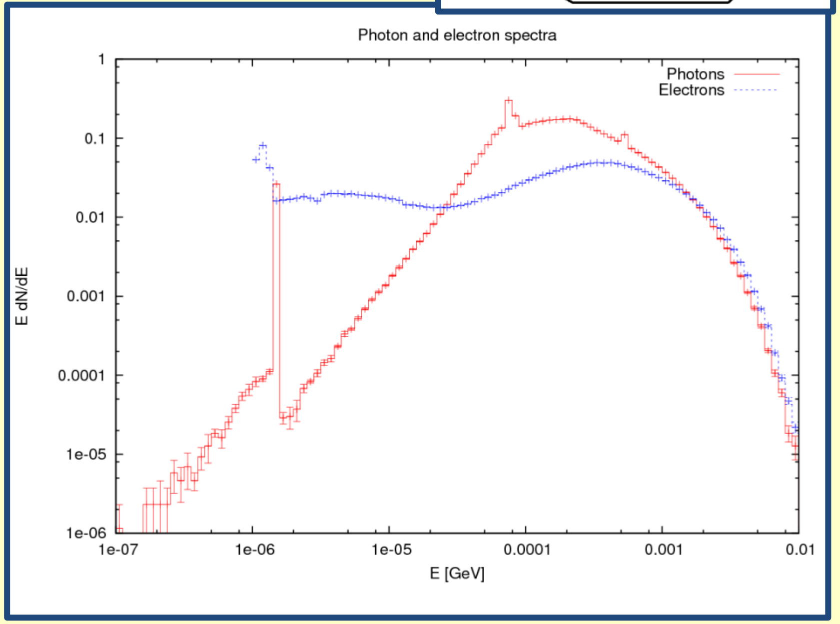
- **Synchrotron Radiation Spectra, and Radiation "Leakage" of High-Energy Photons**









- **Left:** Fluence on 5 mm Al chamber **with 5 mm Pb shielding**; (~3 mrad incidence)
- **Right:** Backscattered photons and electrons inside the vacuum chamber (Courtesy of **F. Cerutti** and **A. Ferrari**, CERN)

TLEP Vacuum System Preliminary Calculations

- Expected Outgassing (single beam)

	LEP2	LEP3	LHeC	TLEP-t	TLEP-h	TLEP-z	ESRF
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Total Power (MW)	13.37	50.29	43.66	57.03	49.53	49.71	0.98
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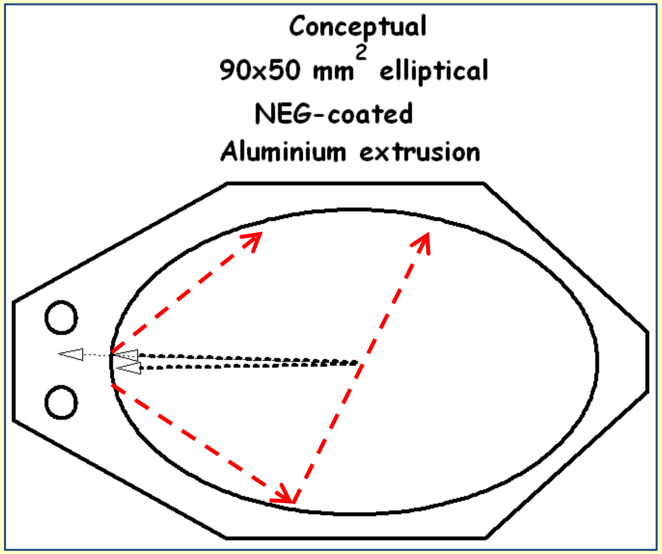
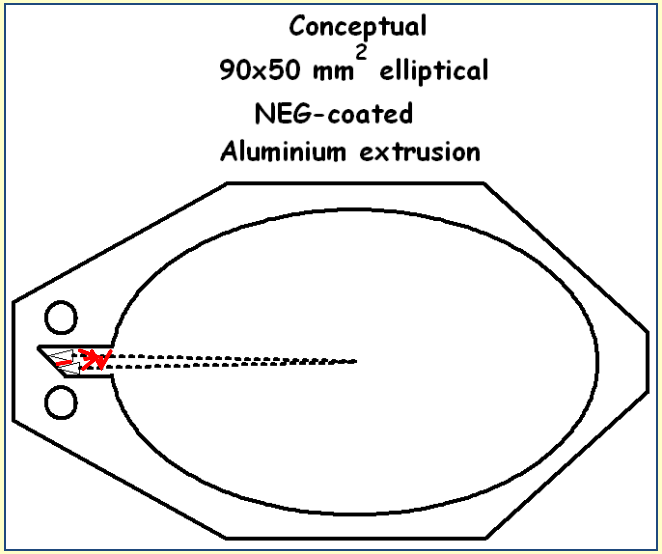
Spec. Power (W/m)	687.3	3,048.1	2,646.0	1,154.7	875.9	879.1	6,684.0
Specific Outgassing (mbar·l/s/m) **@η =2.0E-6**	1.40E-9	3.42E-9	2.38E-8	1.25E-9	3.38E-9	6.20E-8	5.34E-7
1/γ (μrad)	4.91	4.26	8.52	2.92	4.26	11.2	85.2
L (m) (distance-to-wall)	20.06	15.37	15.37	26.60	28.46	28.46	1.32
2L/γ (mm)	0.197	0.131	0.262	0.155	0.242	0.242	0.224

Expected Outgassing

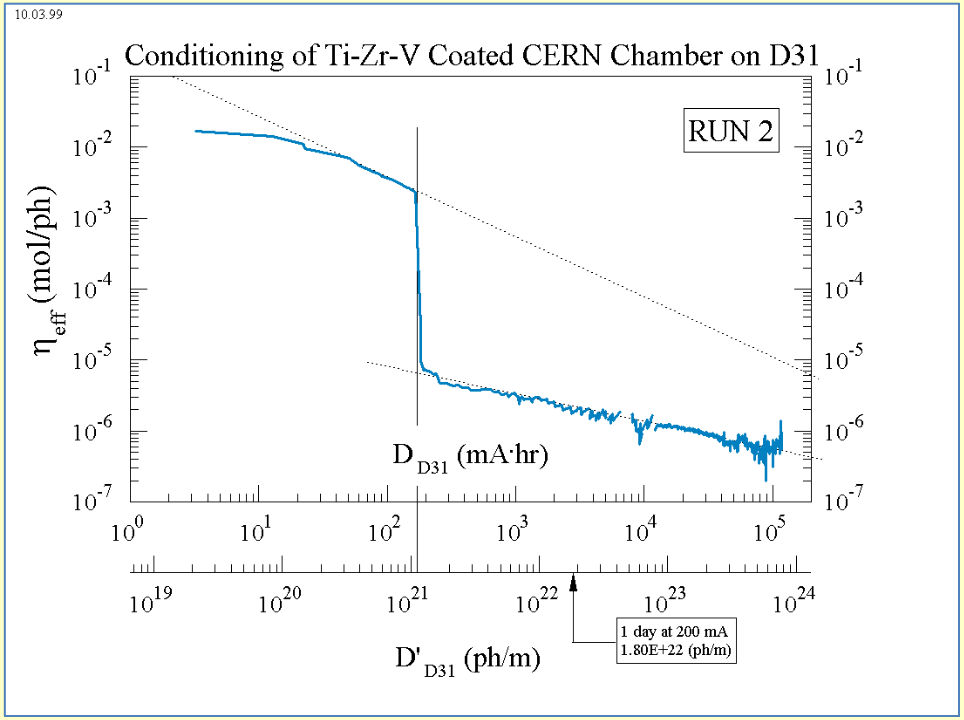
- In order to speed-up the beam conditioning (depending on the photon dose at each point around the machine), it would be better to "trap" the SR-induced photo-electrons (responsible for desorption), and therefore reduce the number of molecular trajectory crossings on the beam(s) path(s) prior to NEG- or ion-pumping





- Optimization of the depth and height of the trapping slot will be done as soon as details of the machine lattice and related e+/e- beam sizes and emittances will be fixed;
- Further to this, the surface power density (W/mm^2) can also be calculated;

- **Expected Outgassing**
- **The specific outgassing rate (mbar·l/s/m) is proportional to η(mol/ph), the photodesorption yield, which is specific of each chamber/absorber material and cleaning/thermal treatments (bake-out, thin-film deposition, NEG-activation, operating temperature, etc…)**



Published in Vacuum 60 (2000), P.Chiggiato, R. Kersevan

- **NEG-coated materials provide a dramatic decrease of η, allowing a faster beam commissioning and reducing the number of lumped pumps around the ring.**

- **Expected Outgassing**
- **Why NEG-coating?**

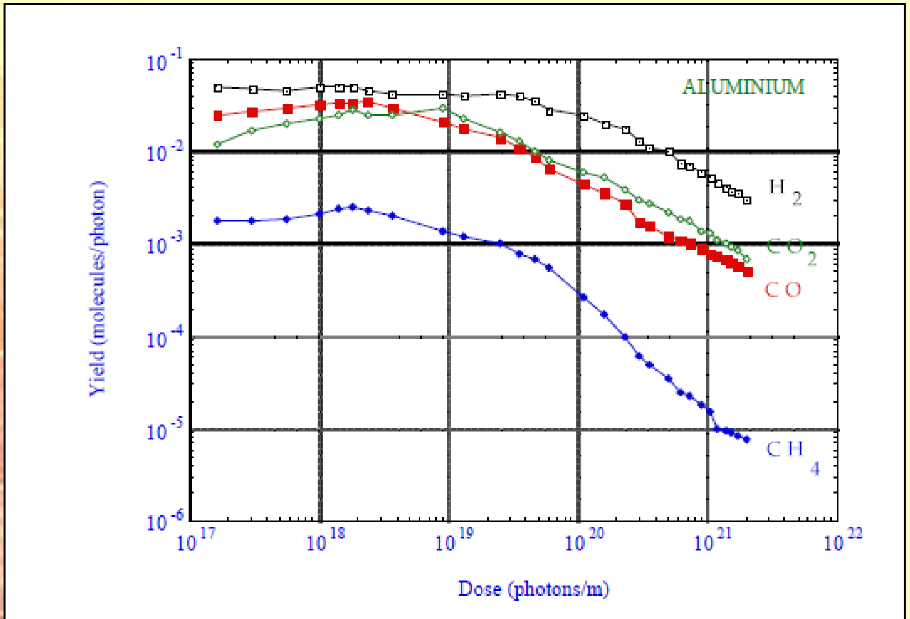
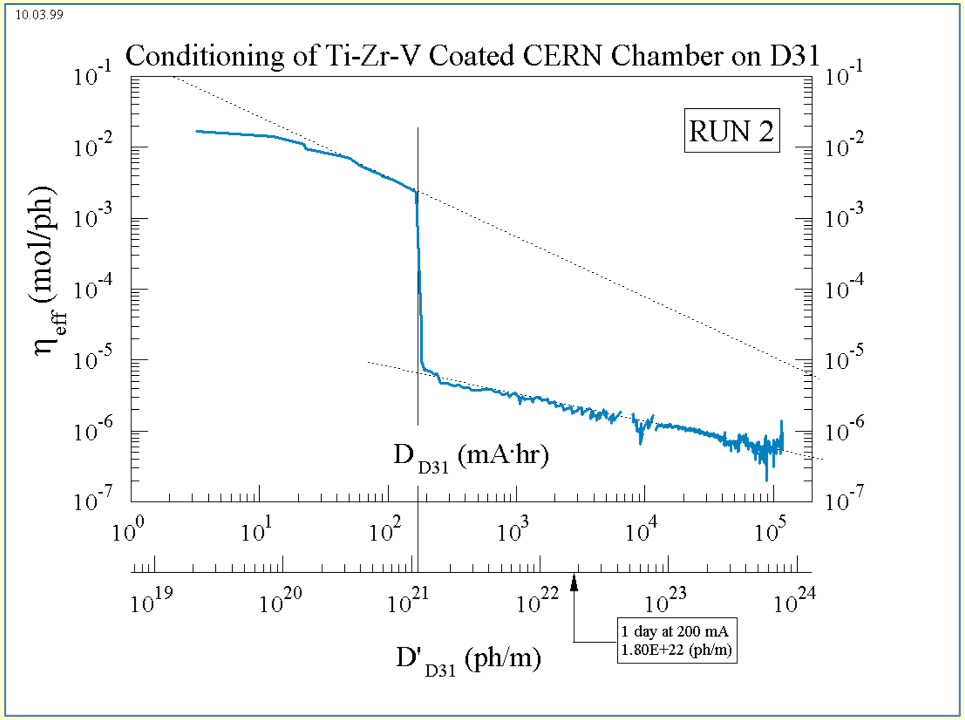


Fig. 3 Molecular desorption yields for aluminium alloy.



- **On the left MEASURED SR-induced outgassing yields are shown (source: O. Groebner, CERN Accelerator School on Vacuum, 1999)**
- **The NEG-coating (on the right) clearly shows the advantage vs an uncoated chamber**

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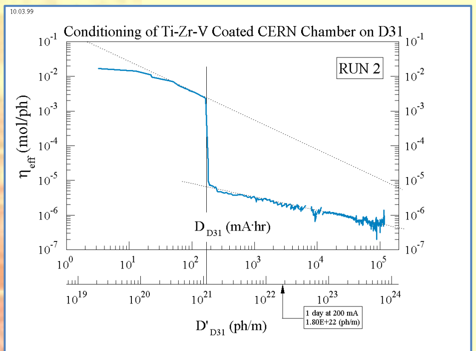
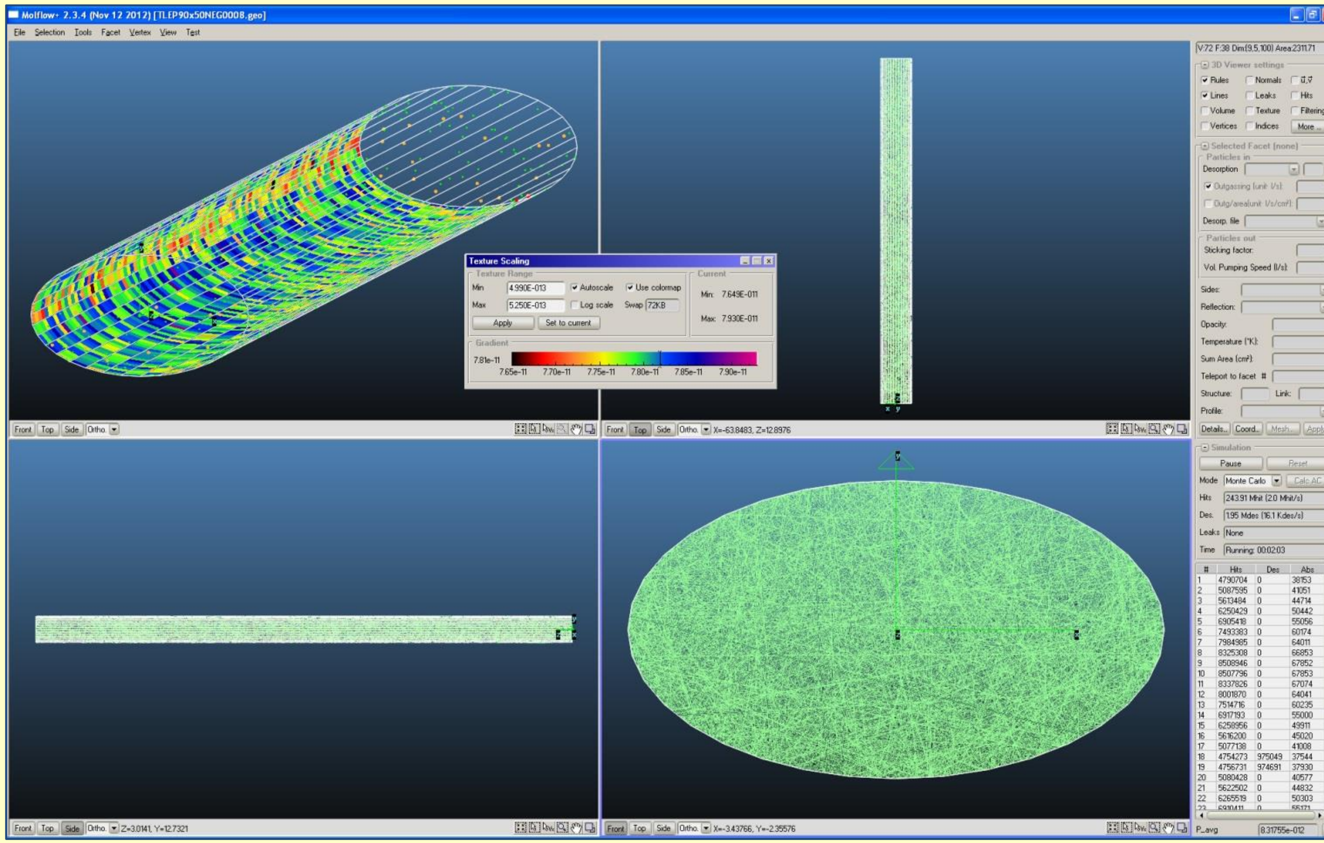
- **Pressures**
- By assuming a 2.0E-6 (mol/ph) yield (after ~2.0E+22 (ph/m)), the H_2 partial pressure obtained with NEG-coating at a sticking coefficient of 8.0E-3 (average of 125 molecular hits on wall before NEG pumping) is <u>8.3E-12 mbar</u>





Distributed NEG pumping speed: 790 l/s/m

- Additional gases (like CO, CO_2) will add to the total pressure;
- Non-getterable gases (CH_4 and Ar) could be pumped by beam-pumping mechanism and/or lumped integrated NEG/ion-pumps (NEXTorr, like in LHC)

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• Problems Ahead and To do List…

- This short exercise/study has been only a very preliminary estimation of the photon fluxes, photon power, spectra and gas loads generated by high-energy electron machines, like the various "flavors" of TLEP
- Based on the experience at CERN and other labs, it is concluded that applying the NEG-coating technology would make it possible to simplify the vacuum pumping system of such a machine and reach sufficiently low pressures
- Based on past coating rate and schedule for LHC, the NEG-coating facility would have to be largely expanded (5~10x) or the process shared with industry
- Pb-shielding/cladding for reducing γ-ray leakage and related radiation damage to be studied in detail. Avoid Ni (LEP had troubles with polarization of beams)
- NEG-activation procedure to be adapted to Pb-shielding
- Careful ray-tracing with two beams (and pretzeled orbits, if adopted). Same for interaction regions
- Sectoring such a large machine
- Design of low-impedance transitions, BPMs, bellows and photon absorbers compatible with photon fluxes and power densities
- … more?