International Linear Collider R&D on electron cloud (SLAC)

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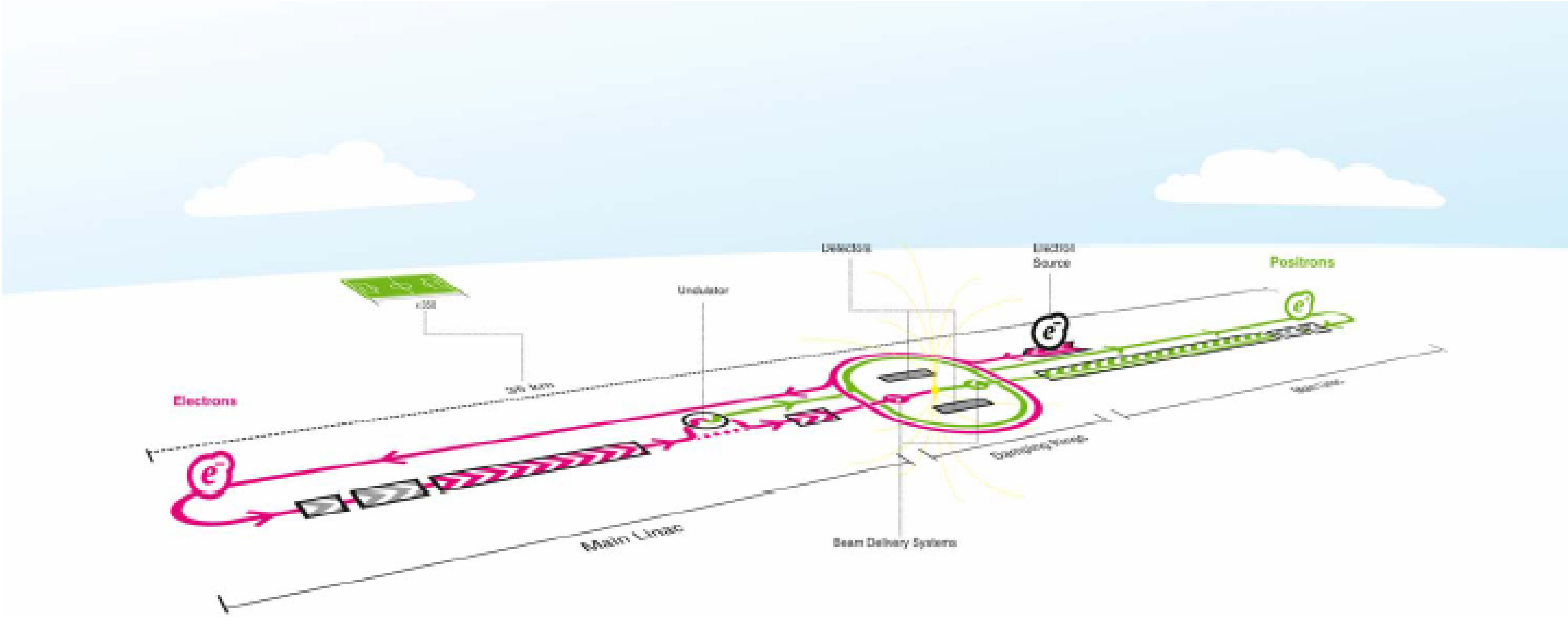
R. Macek (LANL)

Electron Cloud Clearing ECL2

CERN

The International Linear Collider

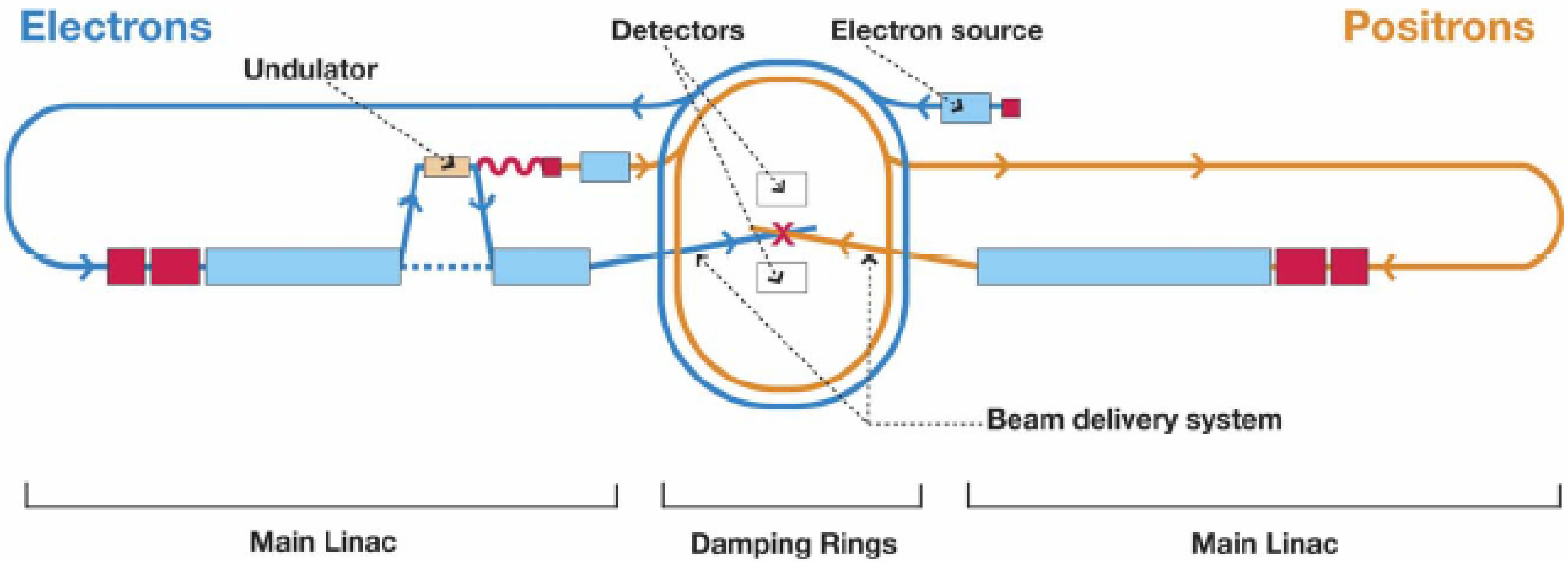


draft (still missing sections) Reference Design Report (RDR) including ***preliminary*** Value and Explicit Labor Estimates was made public in Beijing, Thursday, February 8, 2007

http://www.linearcollider.org

Report, Companion Document, Graphics, and more…

ILCSC Parameters Reports (R. Heuer)

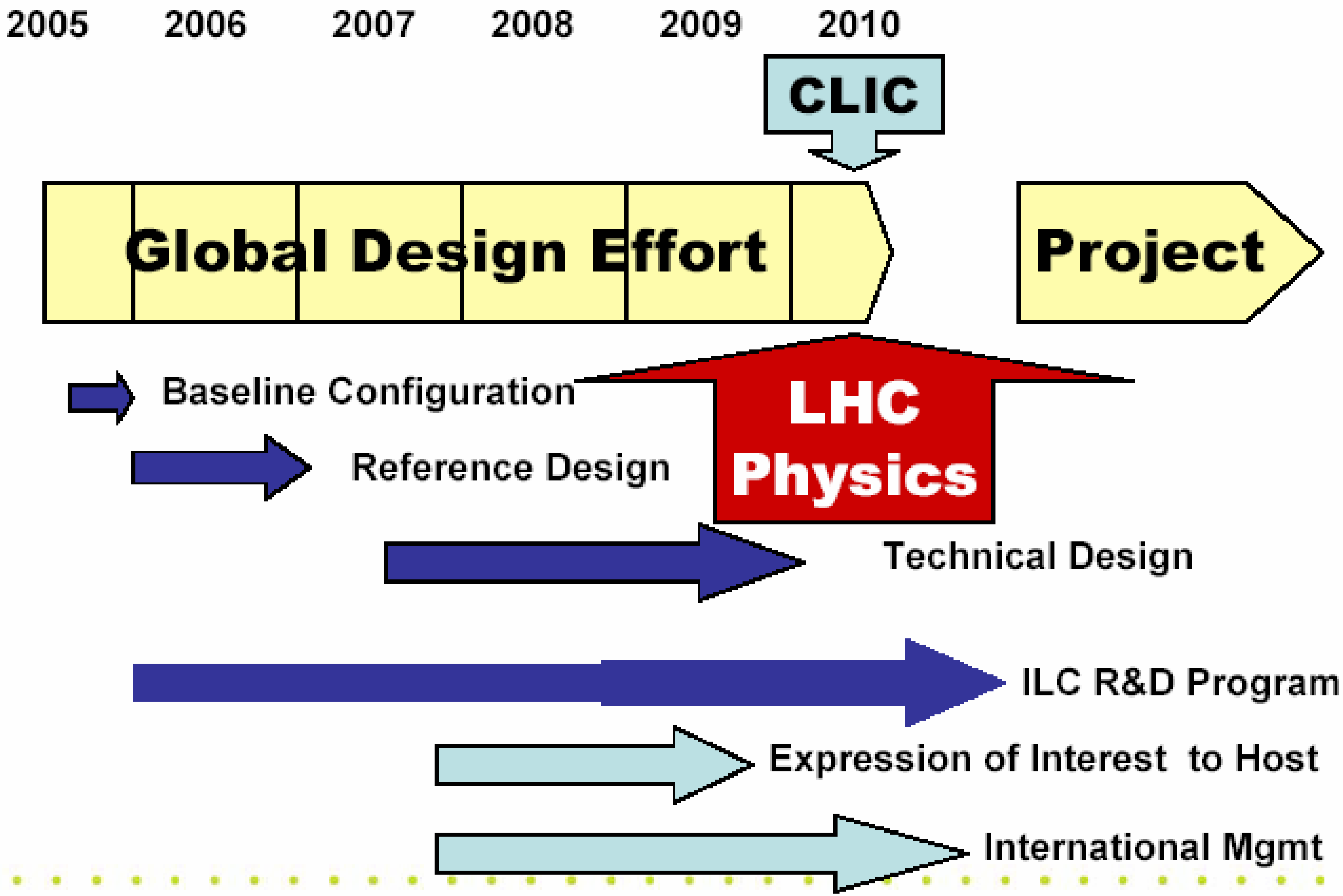


E_{cm} adjustable (scan) from 200 – 500 GeV
Peak Luminosity 2 x 10^{34} $cm^{-2}sec^{-1}$
→ $\int Ldt$ = 500 fb^{-1} in 4 years
Energy stability and precision below 0.1%
Electron polarization of at least 80%
The machine must be upgradeable to 1 TeV

Removing safety margins in the energy reach is acceptable but should be recoverable without extra construction. The max luminosity is not needed at the top energy (500 GeV), however .....

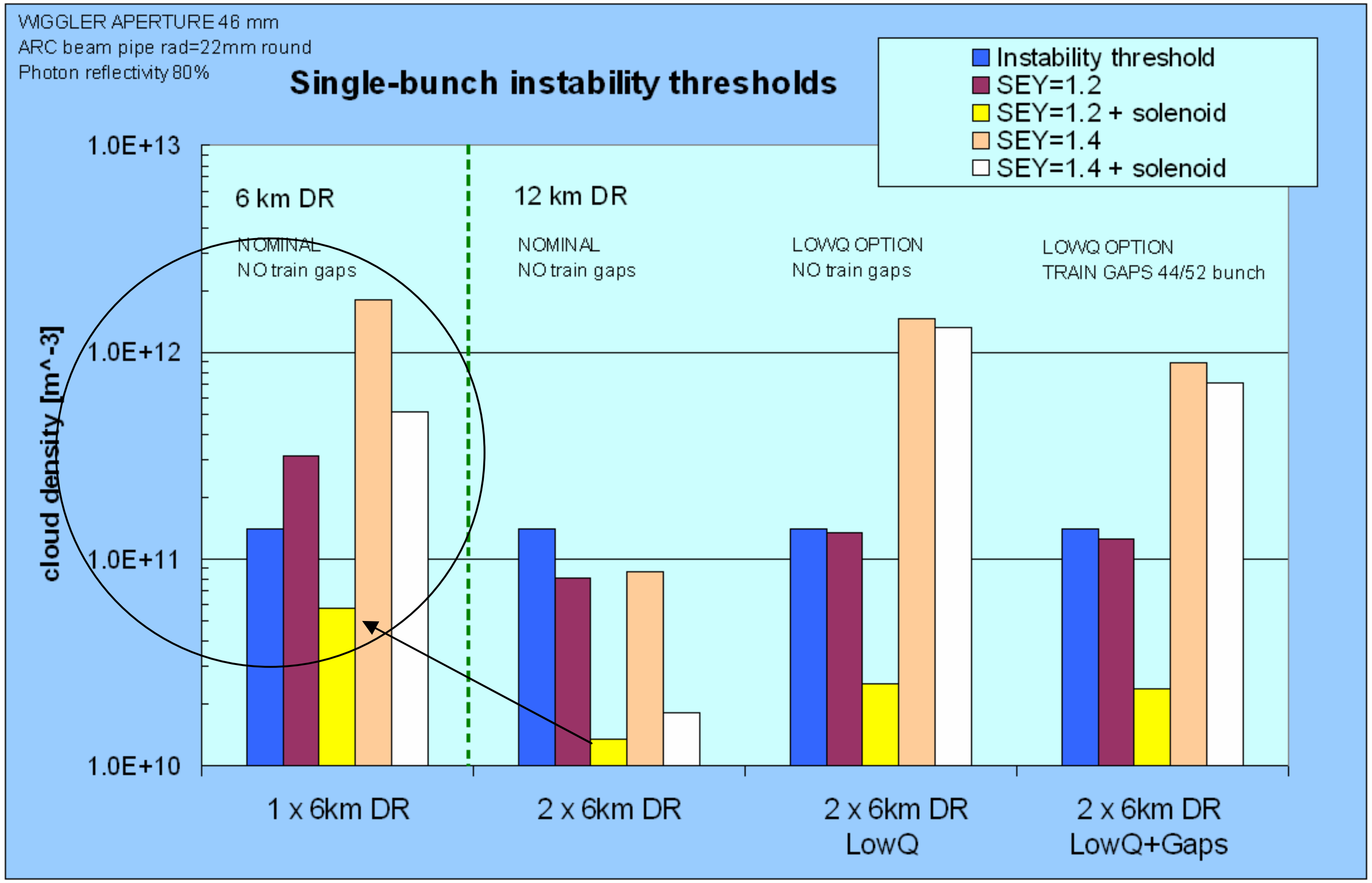
The interaction region (IR) should allow for two experiments ..... the two experiments could share a common IR, provided that the detector changeover can be accomplished in approximately 1 week.

The GDE Plan and Schedule



- International collaboration R&D effort: 2006 simulation campaign culminating in the recommendation for the damping ring circumference reduced from 17 km to 12km [electron cloud safe] and then further reduced to 6km [red flag].
- An electron cloud expected in the 6km positron Damping Ring, but simulations give increased confidence on possible remedies as clearing electrodes and grooves.
- Substantial R&D is needed to confirm possible mitigation techniques.

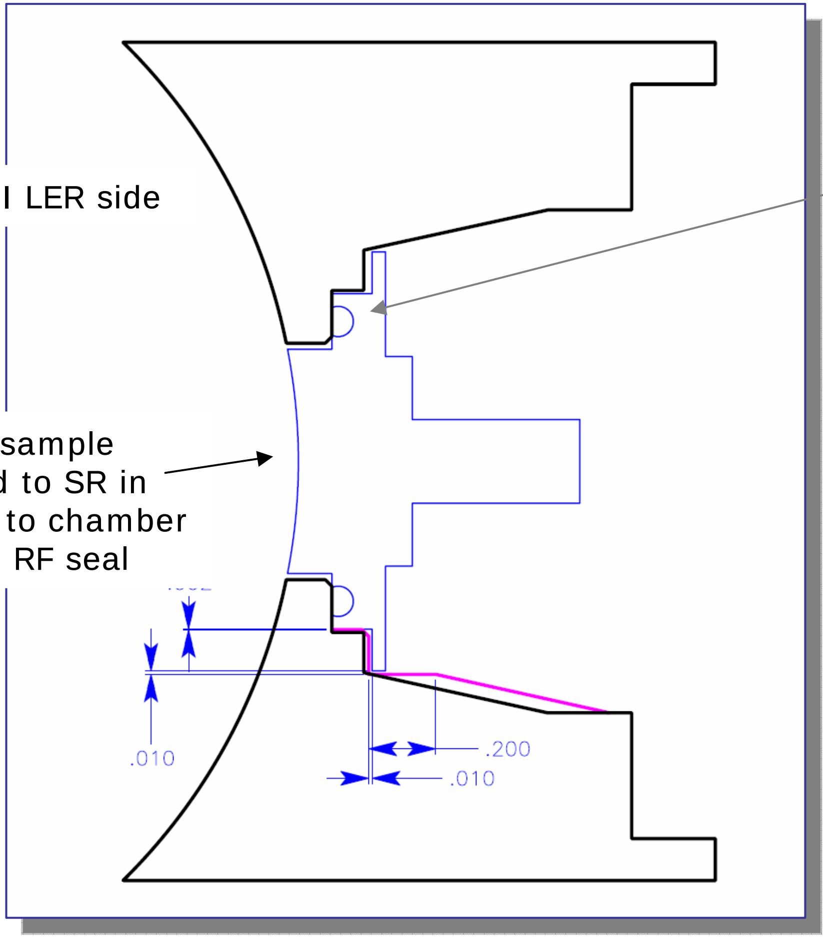
Compare options: simulations recent history



Cloud density near (r=1mm) beam (m^{-3}) before bunch passage, values are taken at a cloud equilibrium density. Solenoids decrease the cloud density in DRIFT regions, where they are only effective. Compare options LowQ and LowQ+train gaps. All cases wiggler aperture 46mm.

SEY TESTS TiN and NEG

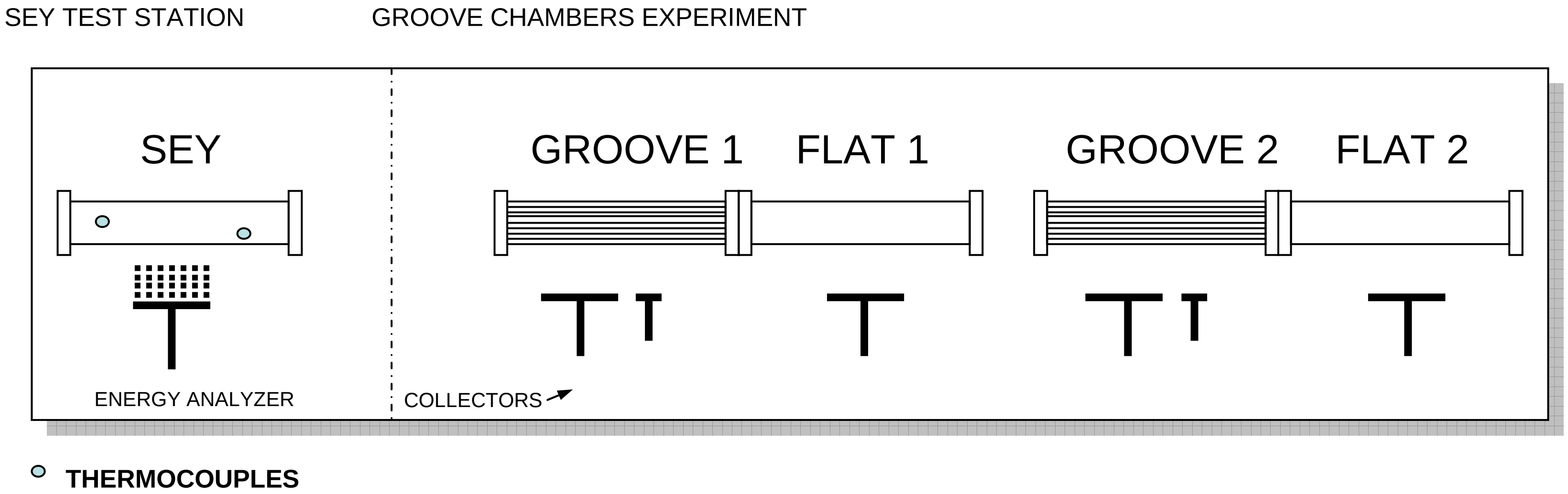
Expose samples to PEP-II LER synchrotron radiation and electron conditioning. Then, measure Secondary Electron Yield (SEY) in laboratory. Samples transferred under vacuum.



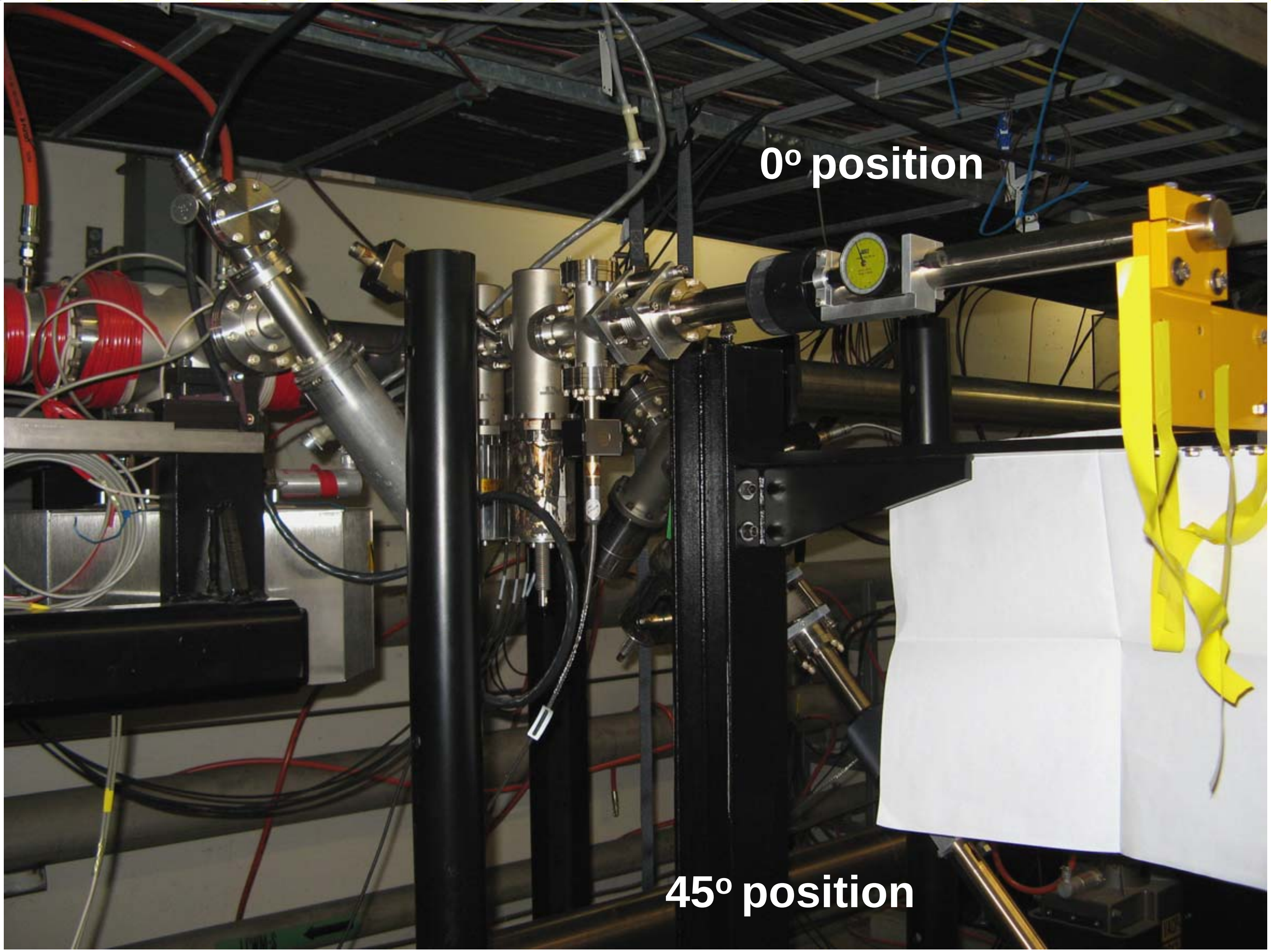
RF seal provide both RF sealing and thermal contact (Synch radiation load = 1W/cm at 4.7A)

Complementary to SPS and KEK studies

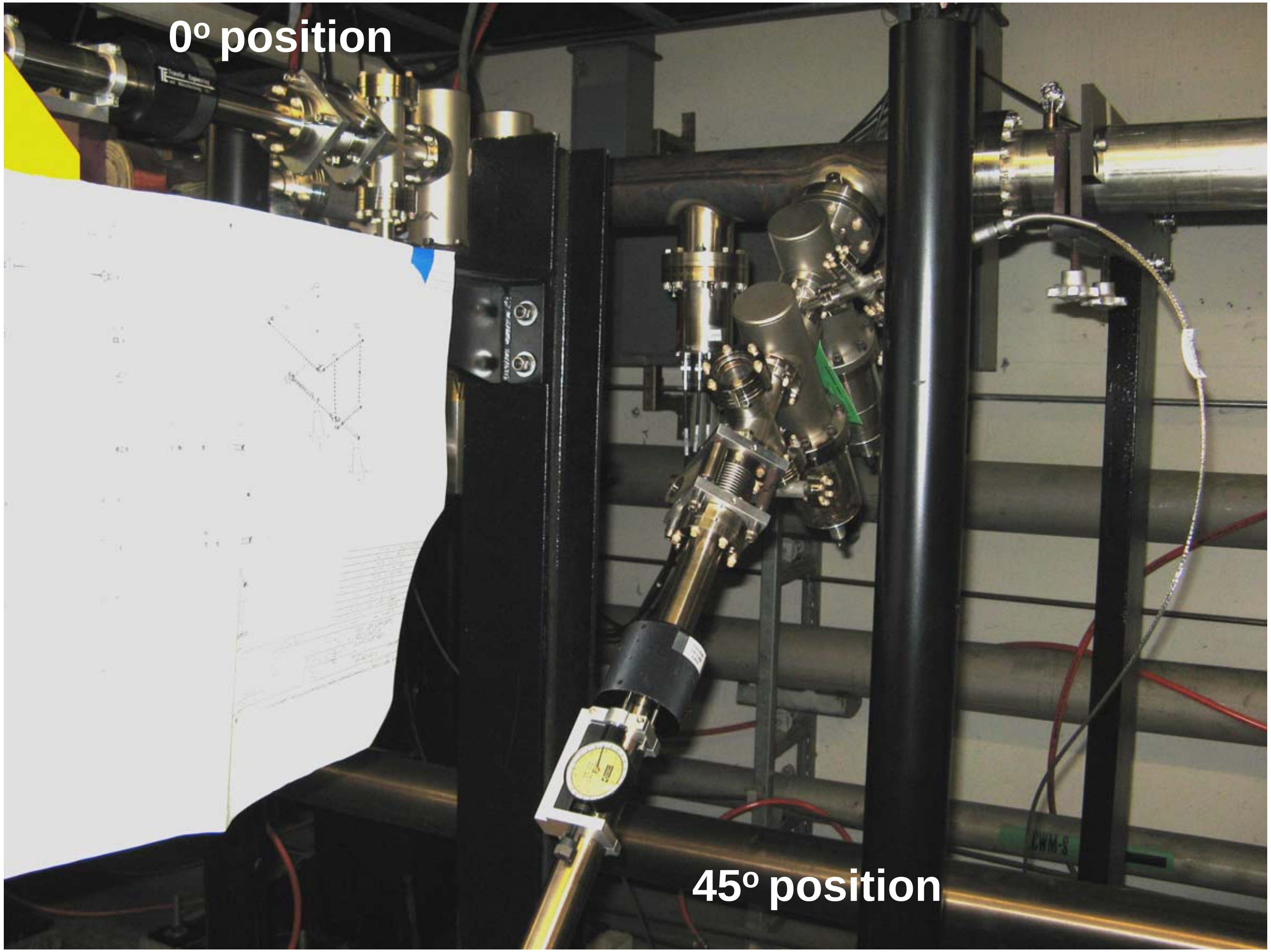
PEP-II test chambers installation



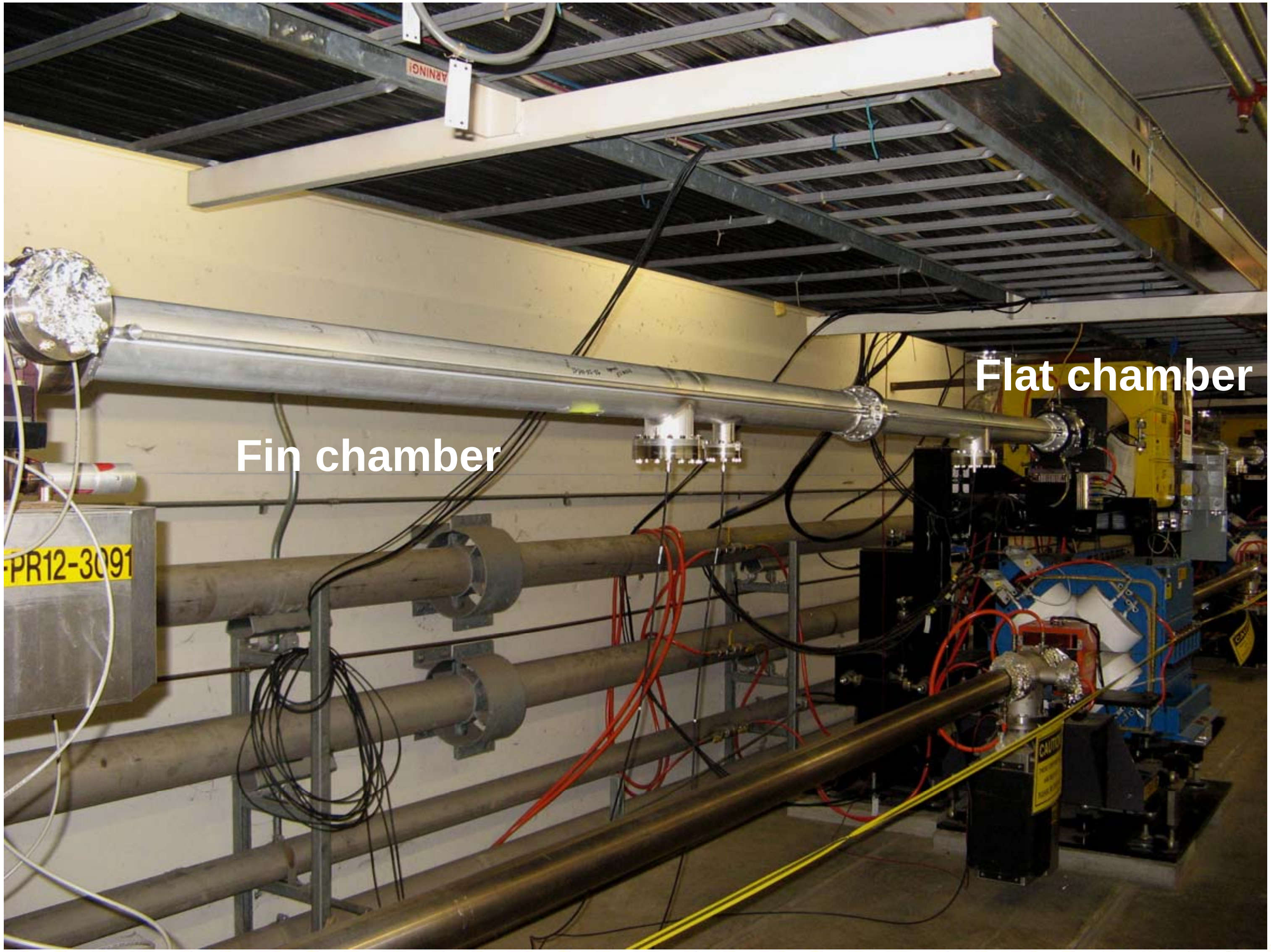
SEY test station in PEP-II LER



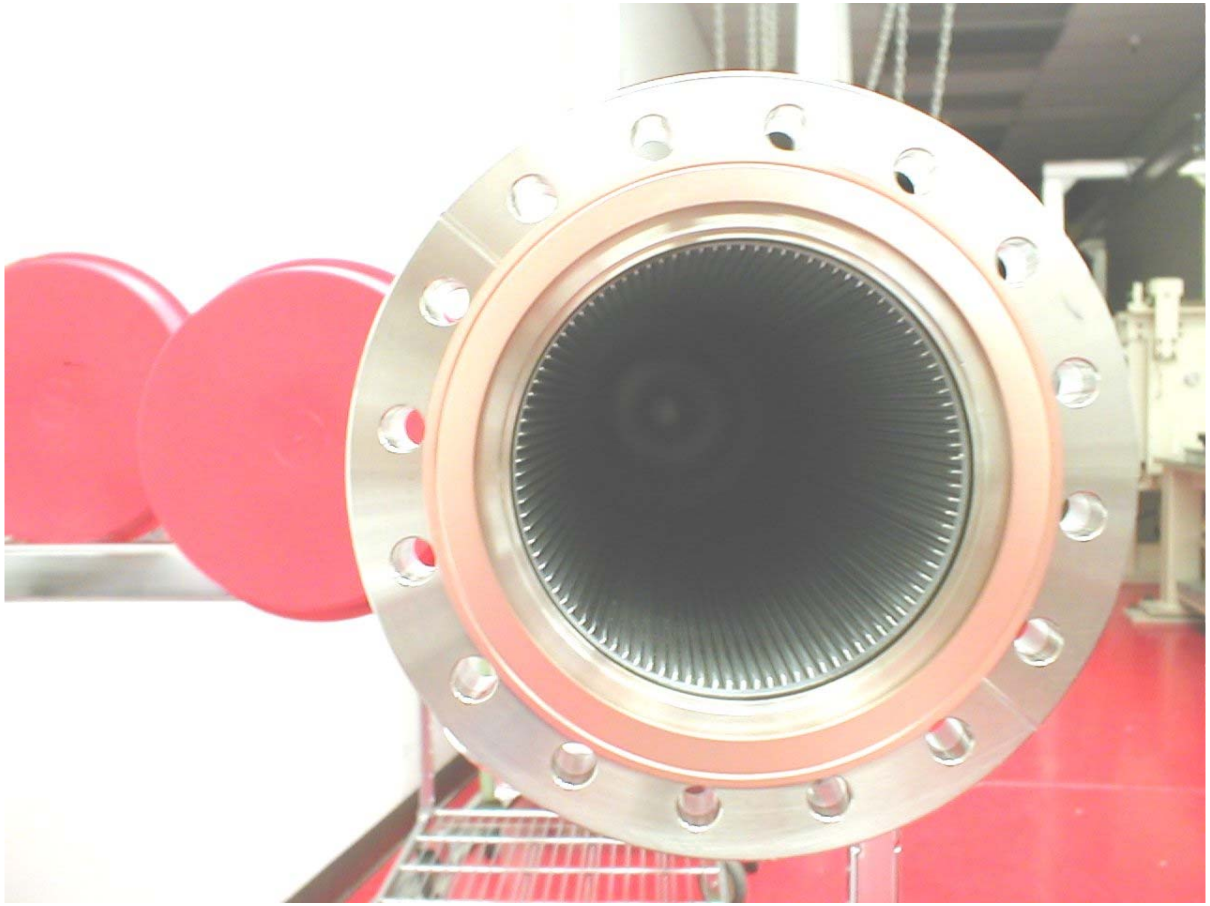
SEY test station in PEP-II LER

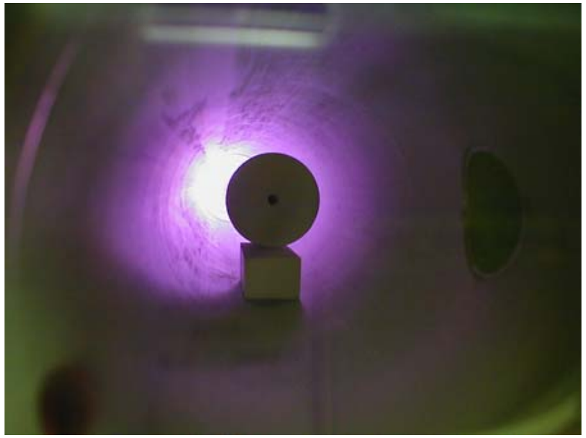


Fin/Flat TiN chambers in PEP-II LER



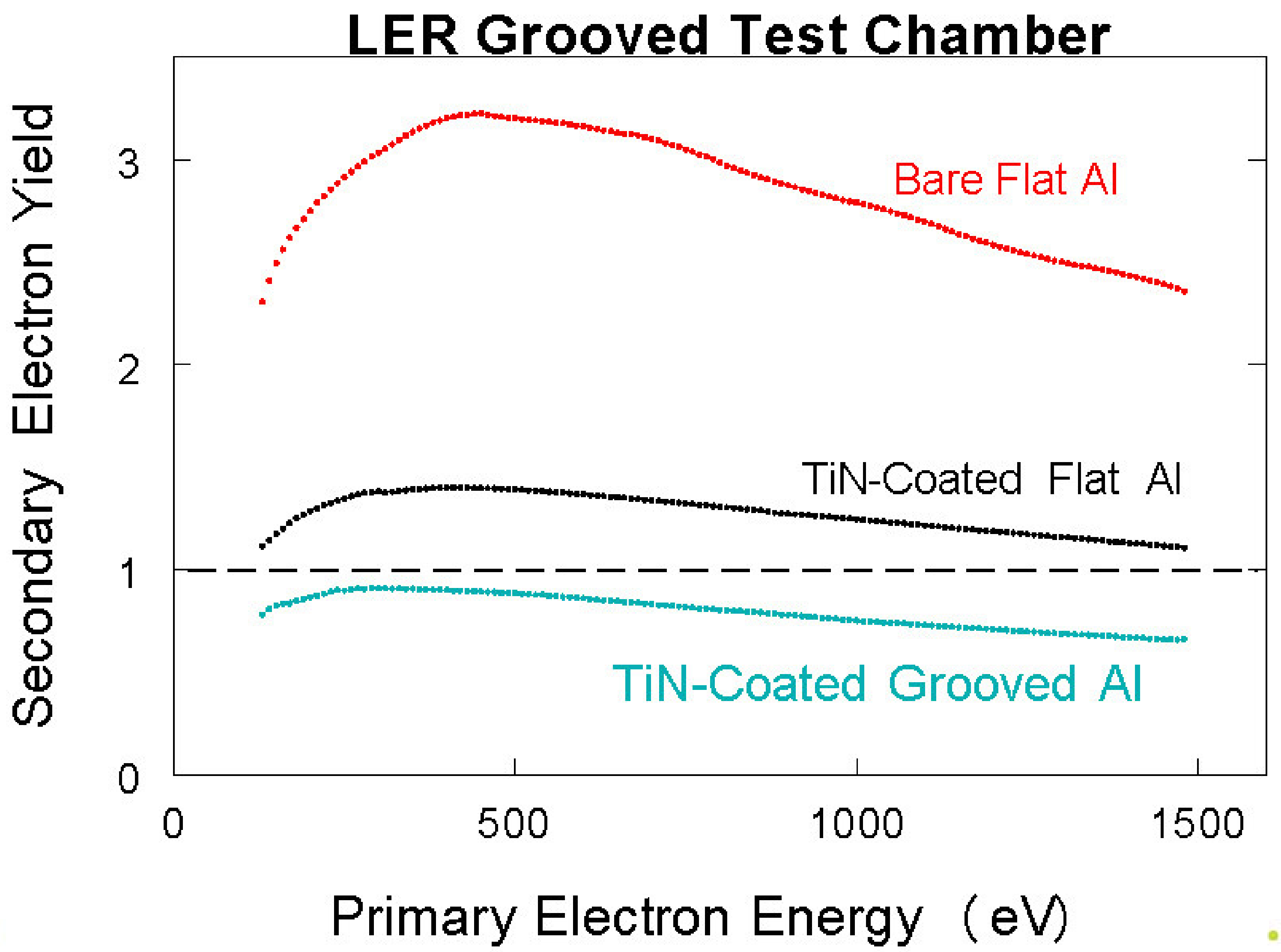
Rectangular groove chamber



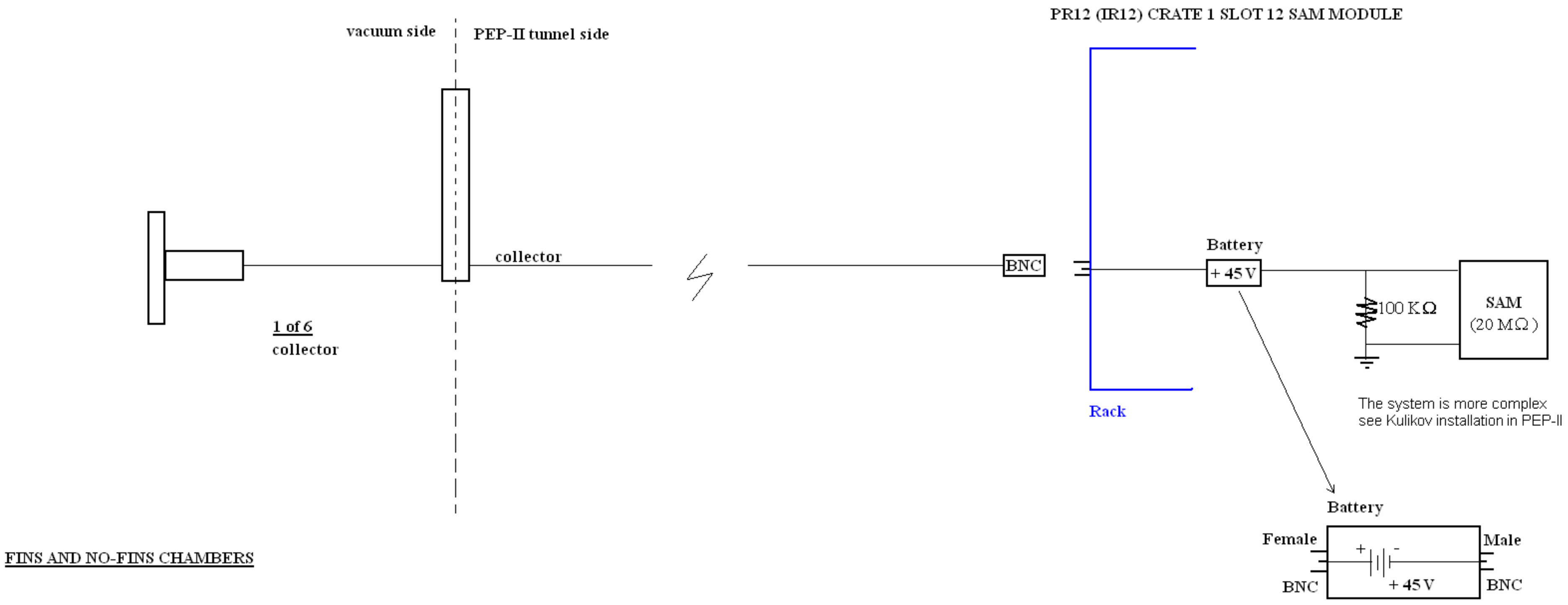


Rectangular fin aluminum chambers (extrusion) and TiN coating

Secondary Electron Yield Measurements at SLAC

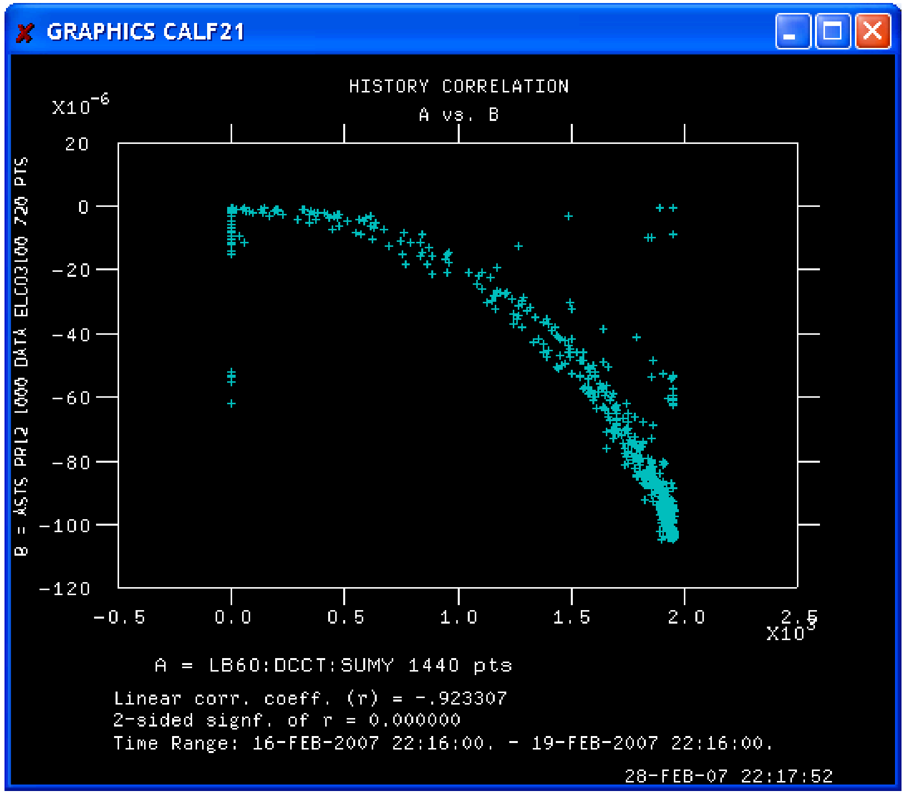


Grooved chambers

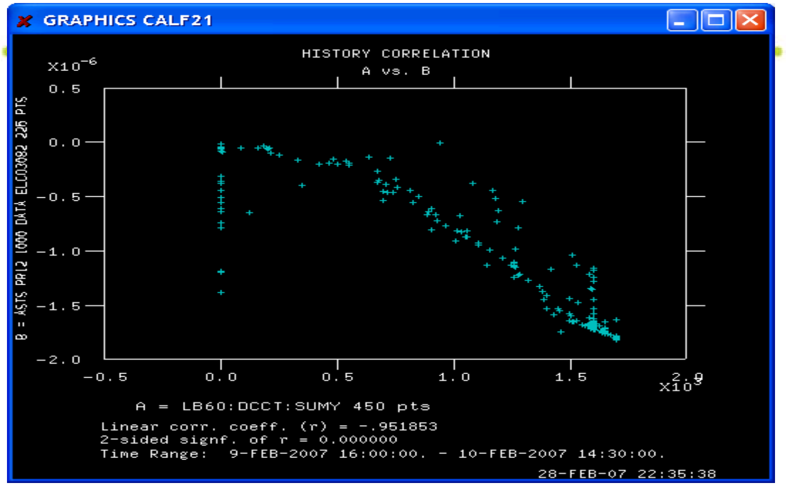


Collector signals vs PEP-II LER current

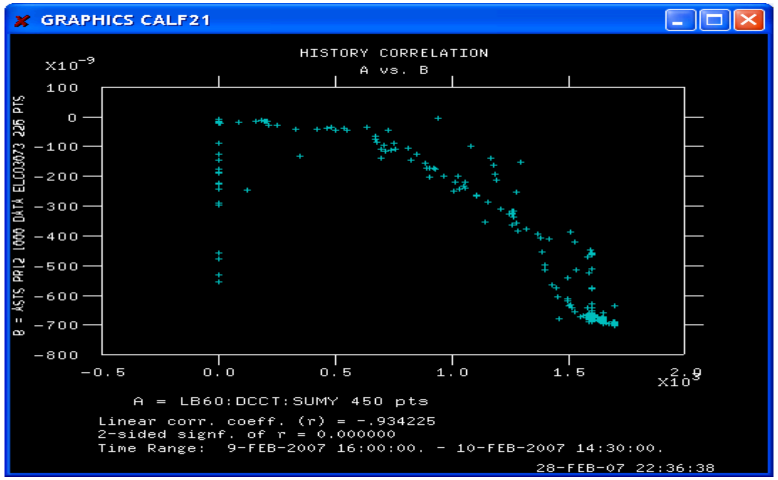
Collector signals vs PEP-II LER current



Stainless steel chamber



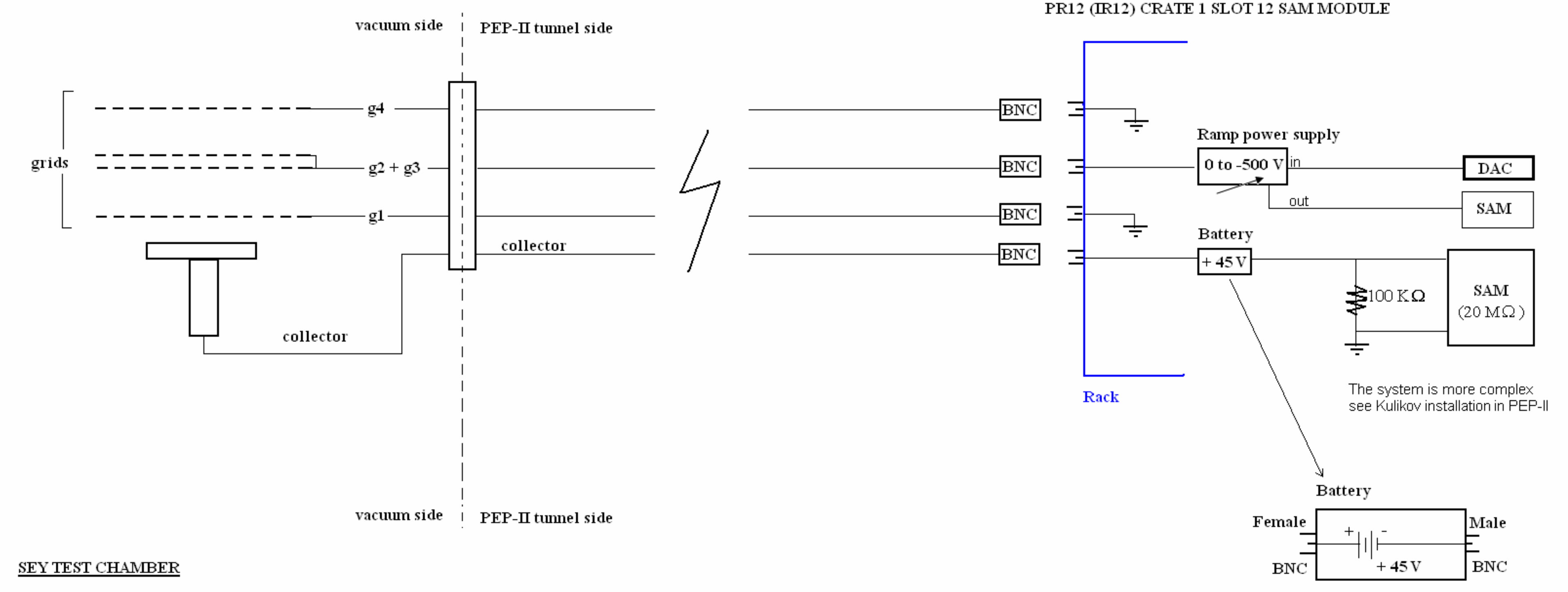
Groove TiN chamber



Flat TiN chamber

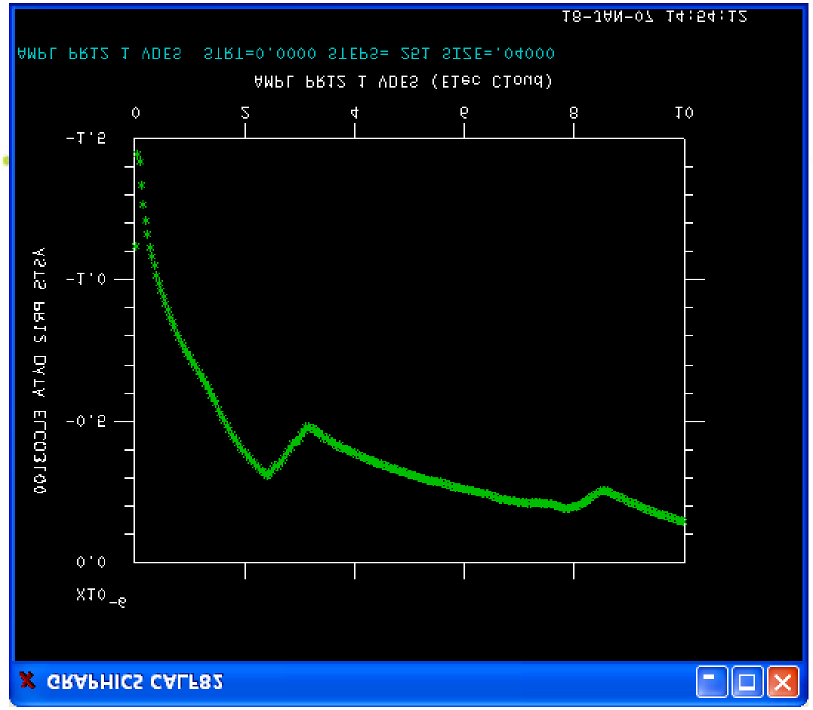
electron detector signal in stainless steel SEY test chamber is a factor 50-100 larger than in grooves and flat TiN chambers. Photoelectrons signal in flat is lower than grooves due to surface ratio..?! LER current is .. still raising up to 4A

SEY test chamber

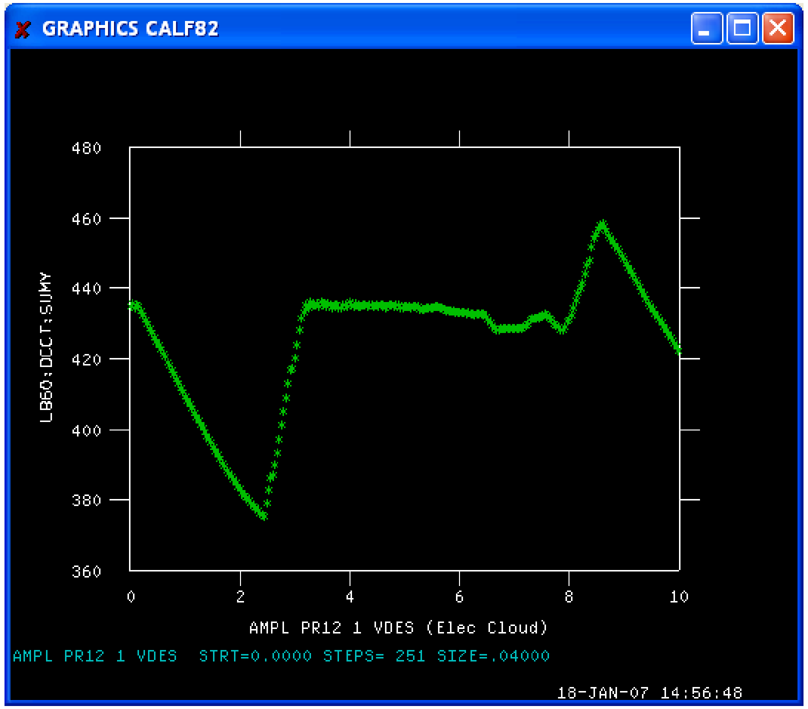


Analyzer Current vs. Retard V

(15 minutes or so)



Ring Current



Projects

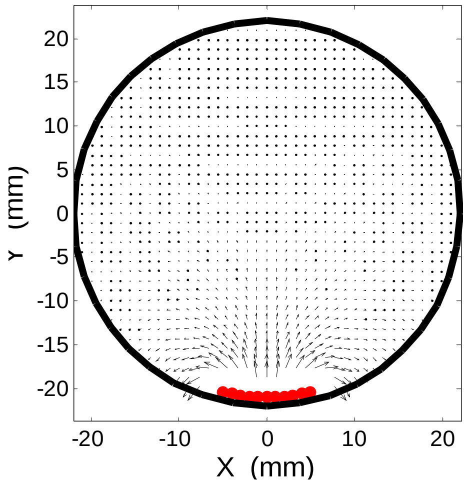
ONGOING TESTS AT SLAC:

	TEST in	LOCATION	Ready for INSTALLATION	Status
SEY TESTS	STRAIGHT	PEP-II LER PR12	November 2006	Ready
FINS RECTANG.	STRAIGHT	PEP-II LER PR12	November 2006	Coating of extruded Al chambers

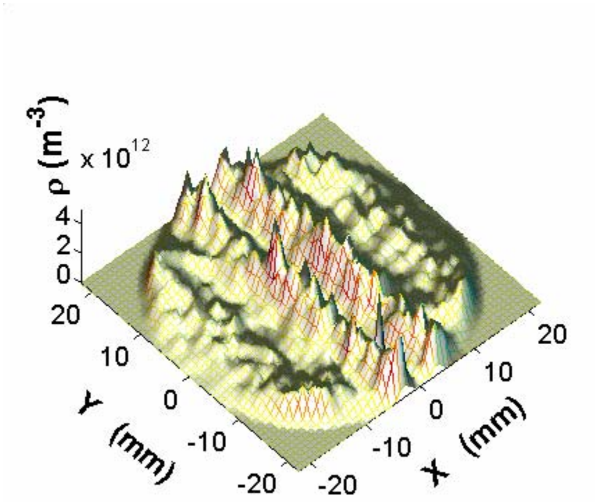
ONGOING PROJECTS:

CLEARING ELECTRODES	BEND	PEP-II LER PR12	2008	Design
FINS TRIANG.	BEND	PEP-II LER PR12	2008	Design

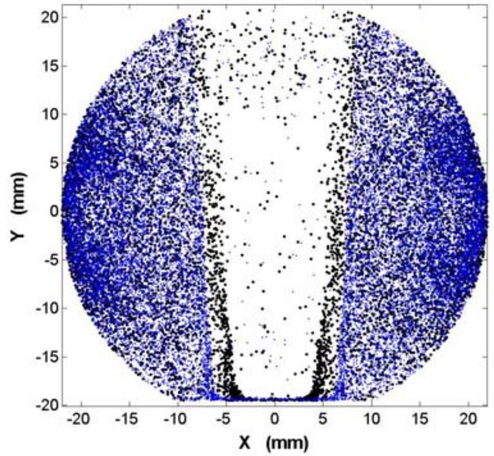
Remedies against ecloud: clearing electrodes



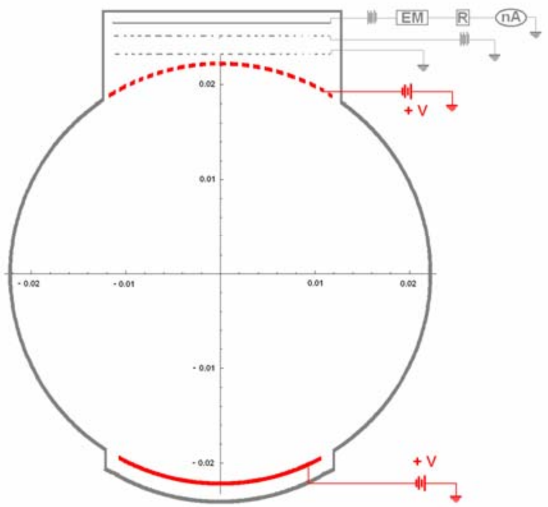
L. Wang CLOUD_LAND code



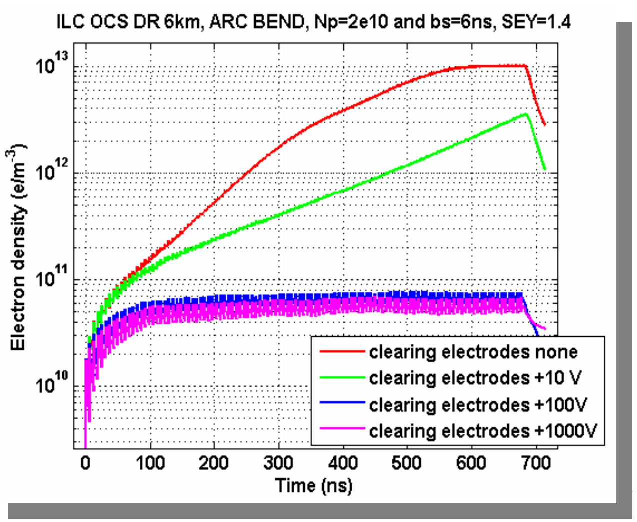
0 Voltage



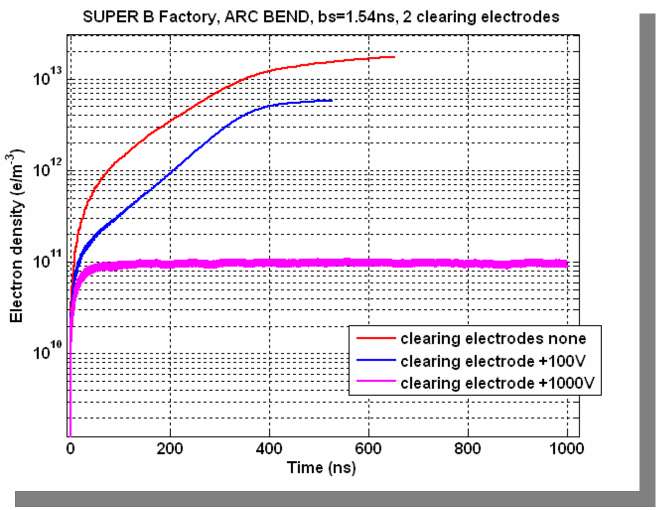
100 Voltage



P. Raimondi, M. Pivi POSINST code

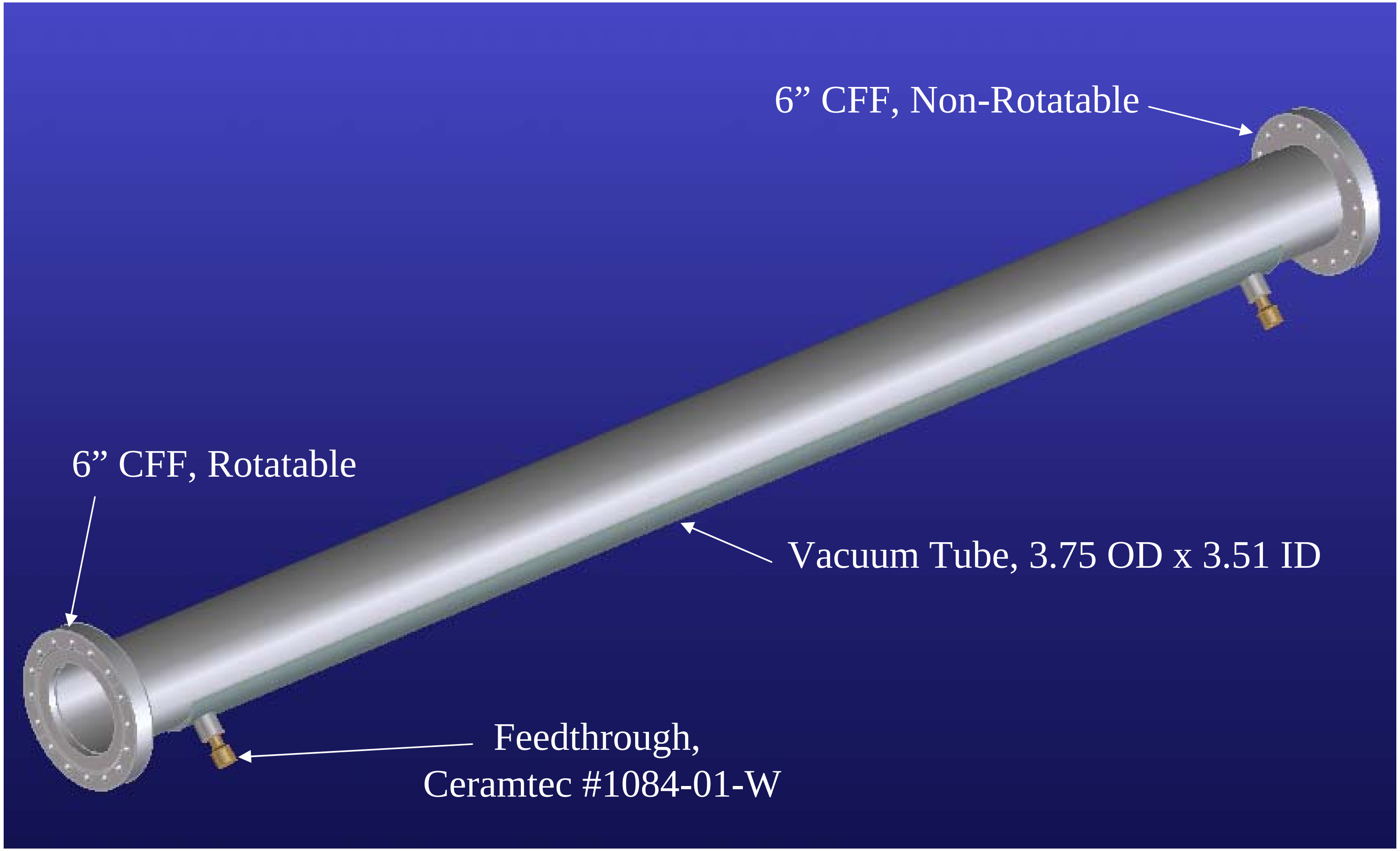


Bunch spacing = 6ns

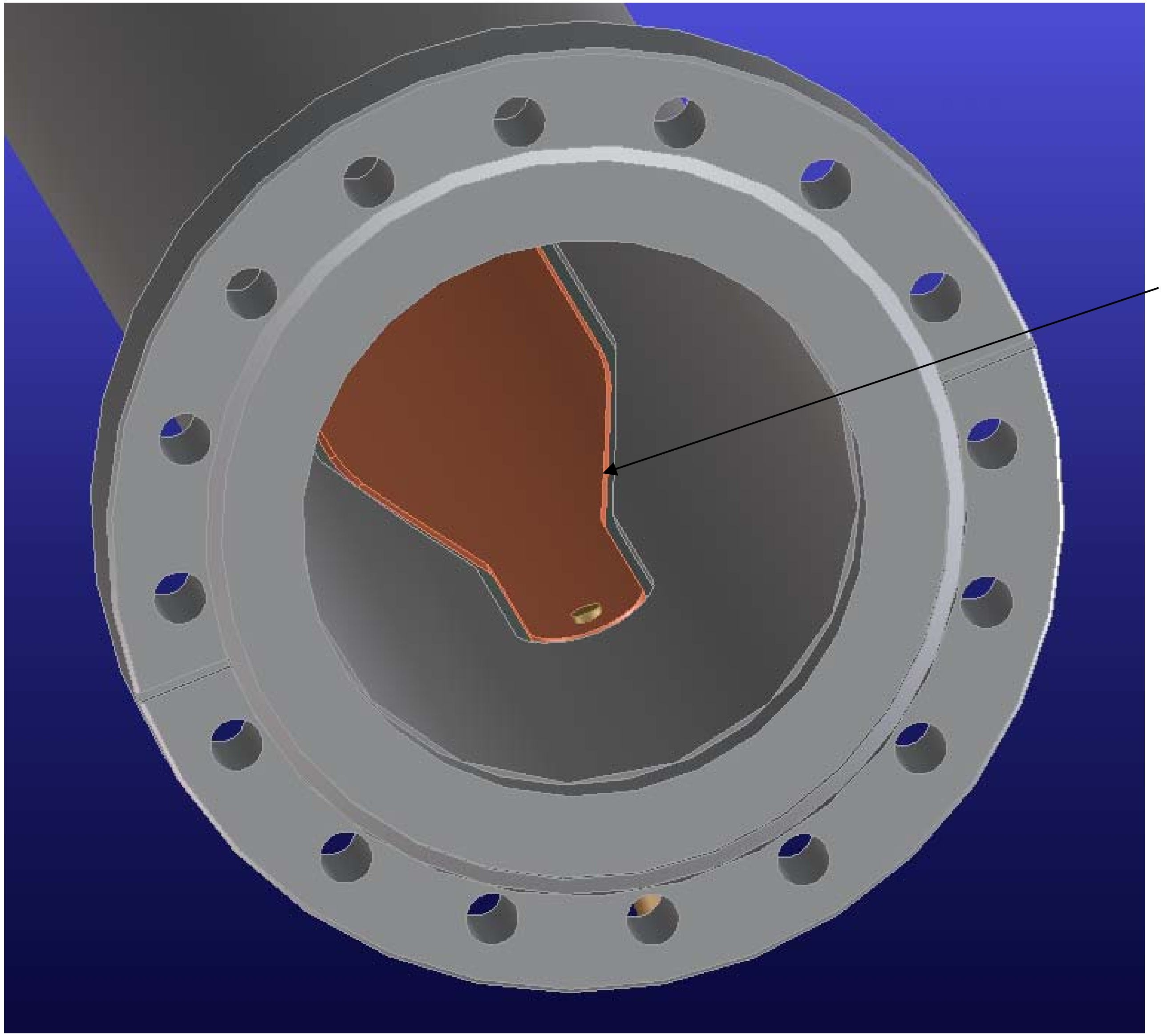


Bunch spacing = 1.5ns !!

Test Chamber Assembly, 1.5M Long (59.00")



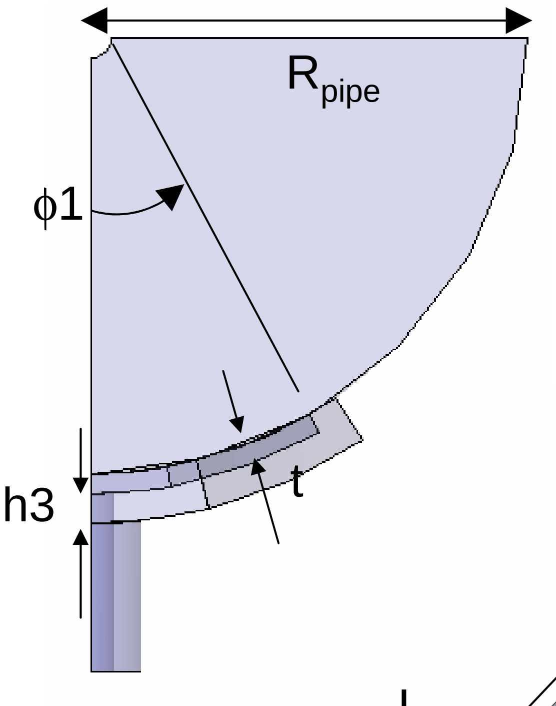
Test Chamber with Electrode



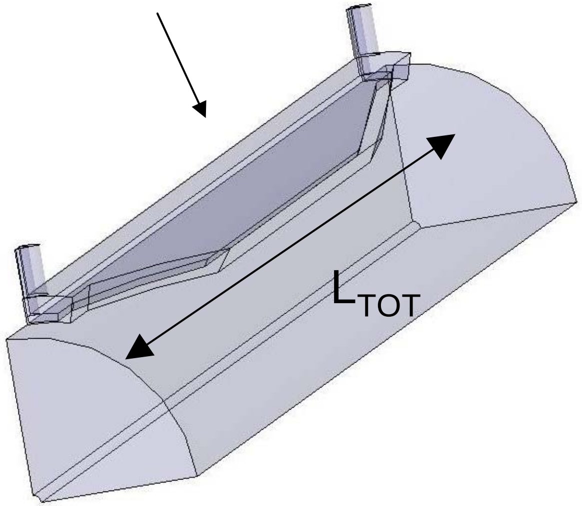
Electrode, Copper
0.063” x 2.0” x 50.0”
(49.606” between
feedthrough centers)

Dimensions:

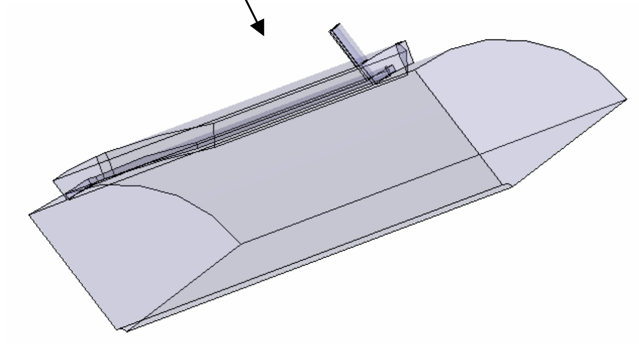
L_{TOT}≅630 mm
L_{TAP}≅115mm
Rpipe=44 mm
ϕ=60 deg
h1,h3,h3=5 mm
t=2 mm



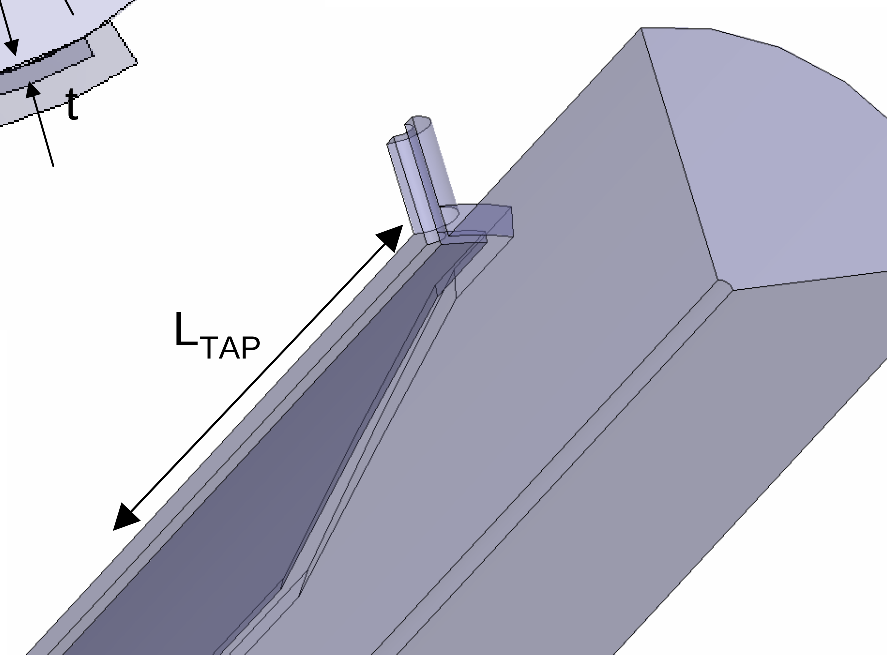
1st Geometry: 2 Ports 50 Ohm

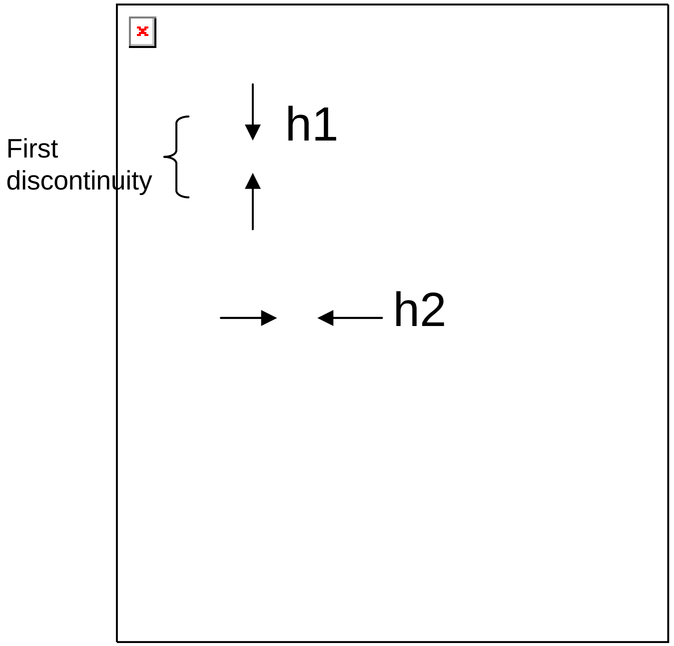


2nd Geometry: 1 Ports 50 Ohm

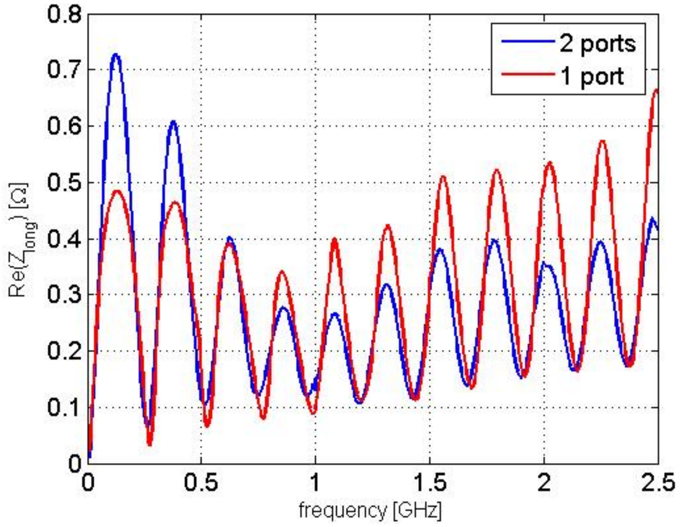


David Alesini, Frascati, Feb 2007

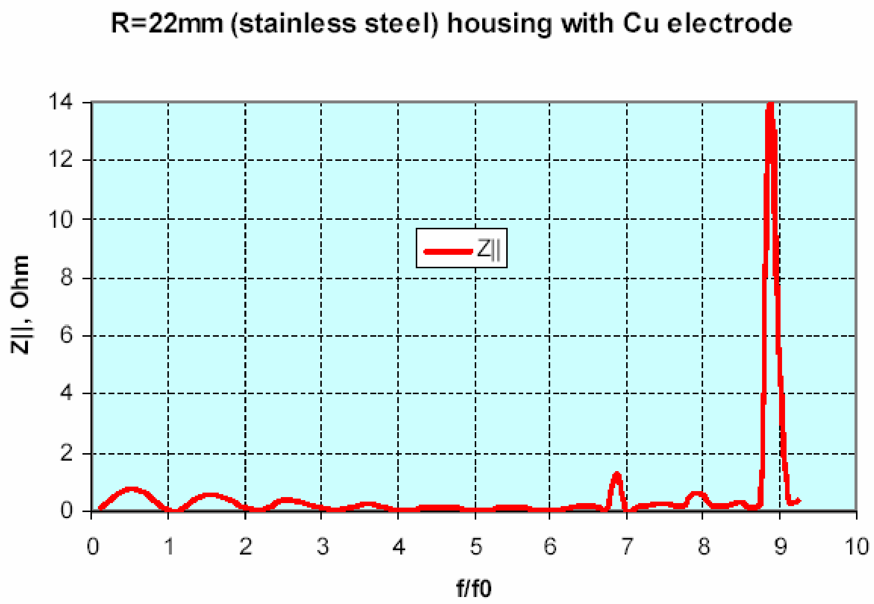




HFSS Results on Copper electrode stainless steel chamber



Frascati results

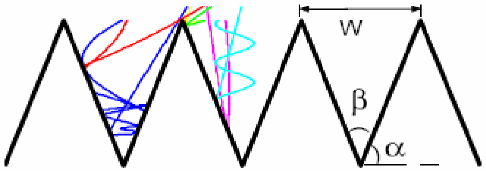


$$\langle Z \rangle \cong 0.48 \quad Ohm \quad in \quad (59.5 - 4403)\, MHz$$

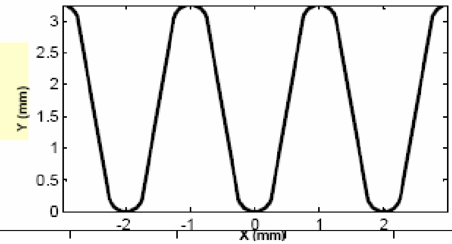
A. Krasnykh, SLAC, February 2007

Long. Impedance: power deposited to electrode ~10W with PEP-II beam, and ~2W for ILC DR beam

SEY of grooved surface



To reduce the impedance & manufacture



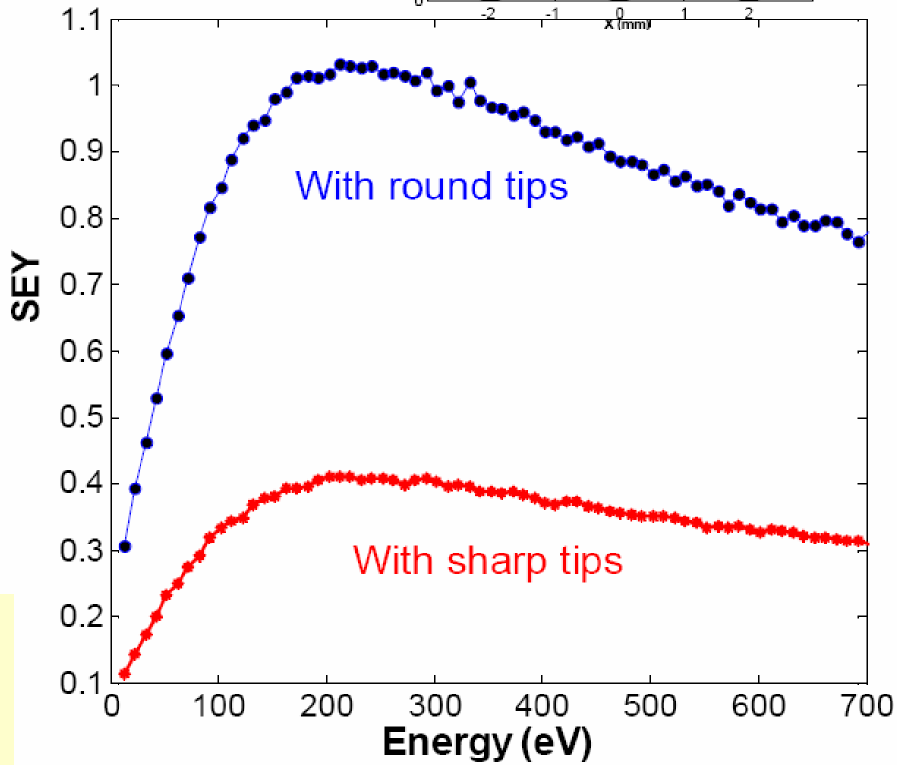
Al with SEY=2.7

Coating to get a SEY~1.74

Grooved surface, SEY ~<1.0

Need more optimization to minimize SEY!

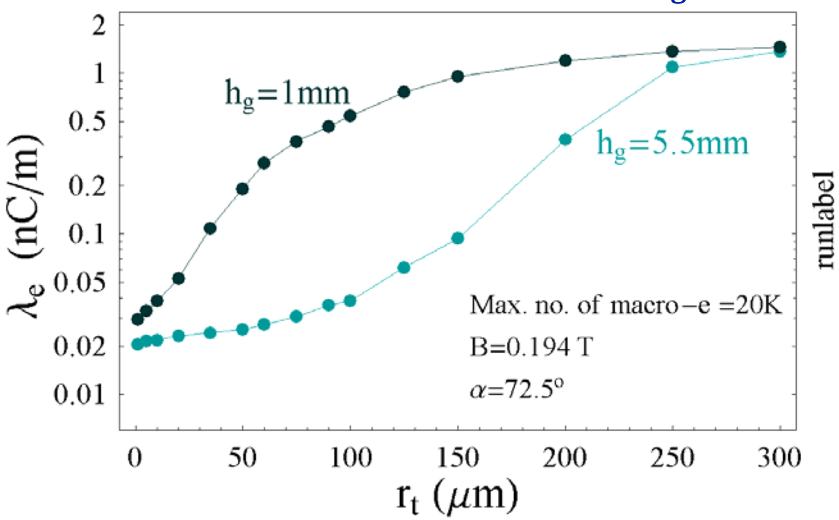
Effective SEY of an isosceles triangular surface with rounded tip. δmax=1.74, *Emax*=330eV, *B0*=0.2Tesla, *Rtip*=0.254*mm*, *W*=2*mm*.



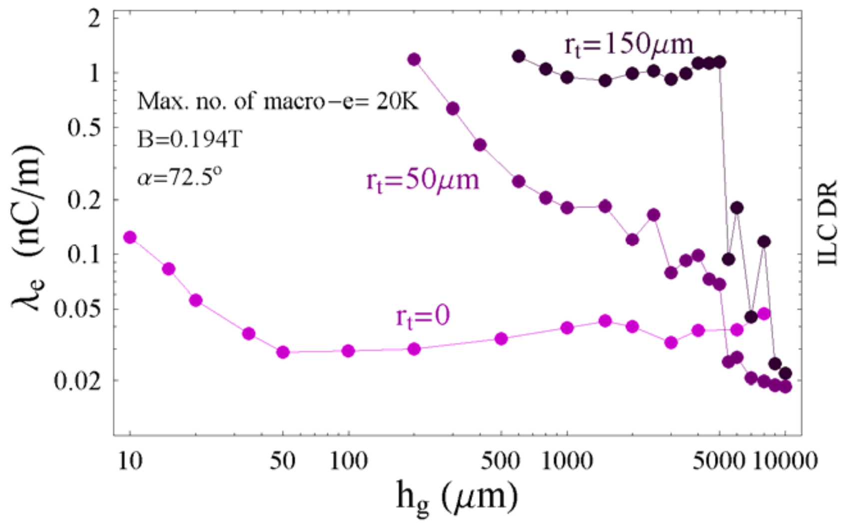
L. Wang, SLAC

Smoother tips spoil effectiveness of grooves (POSINST)

Max of cloud density *vs.* groove-tip radius for two groove height h_g

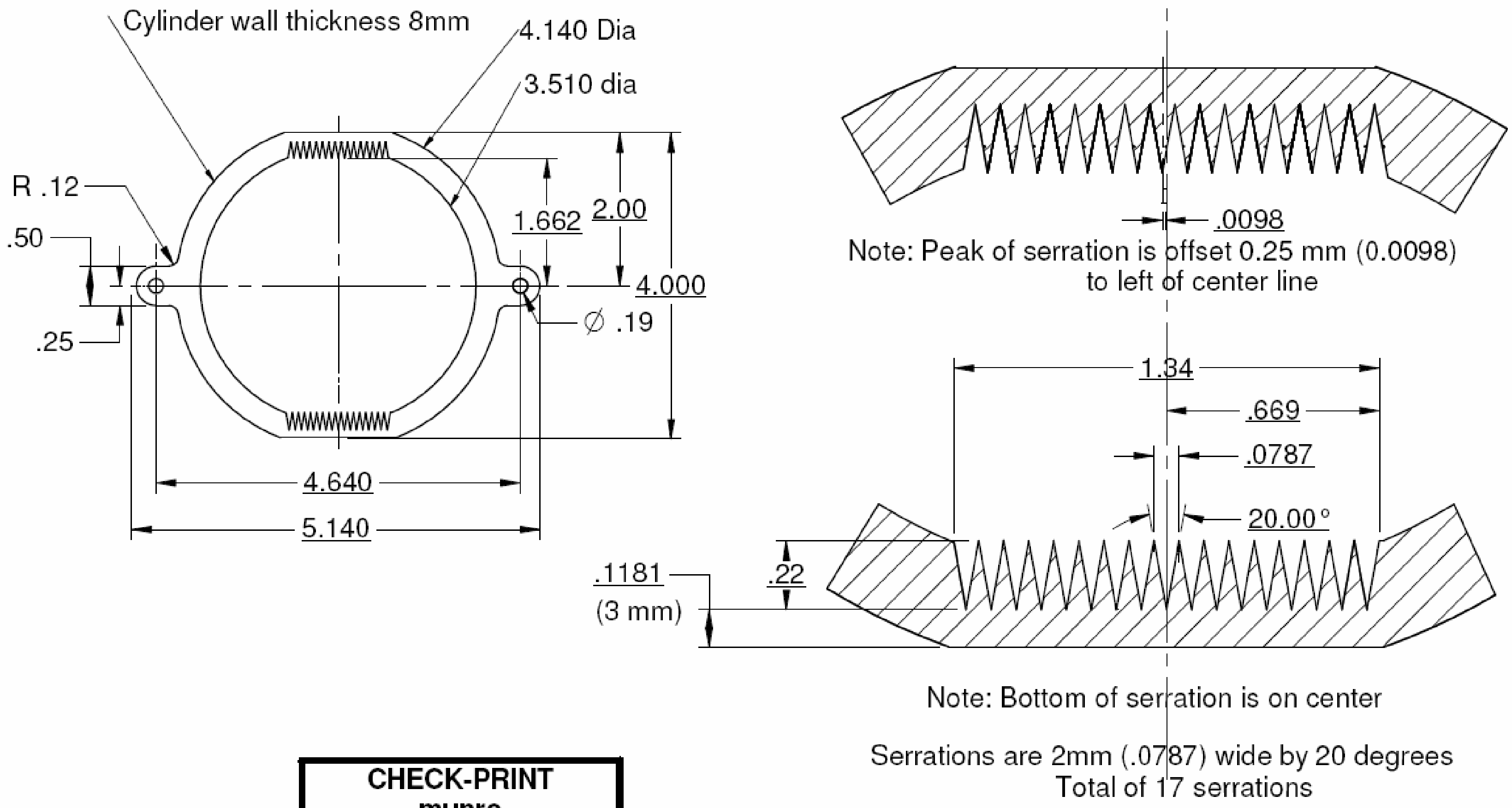


Max of cloud density *vs.* height h_g for 3 choices of groove-tip radius



- Spoiling effect of smooth groove-tips can be compensated by making the grooves deeper.
- Generally, a finite groove-tip radius enhances dependence of groove effectiveness on groove height

Triangular groove chamber



Material Al 6063

CHECK-PRINT
munro
11-20-2006 03:17:07 PM

REV	DESCRIPTION	DWN	CHKR	APVD	DATE

NEXT ASSEMBLIES:

DIMENSIONING AND TOLERANCING IS IN ACCORDANCE WITH ASME Y14.5M-1994.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES:
BREAK EDGES .005-.015
INTERNAL CORNERS R.015 MAX
FRACTIONS ±
DEC .XX ±
.XXX ±
.XXXX ±
ANGLE ±
ALL SURF

SCALE: DO NOT SCALE DRAWING CAD FILE NAME:

STANFORD LINEAR ACCELERATOR CENTER
U.S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

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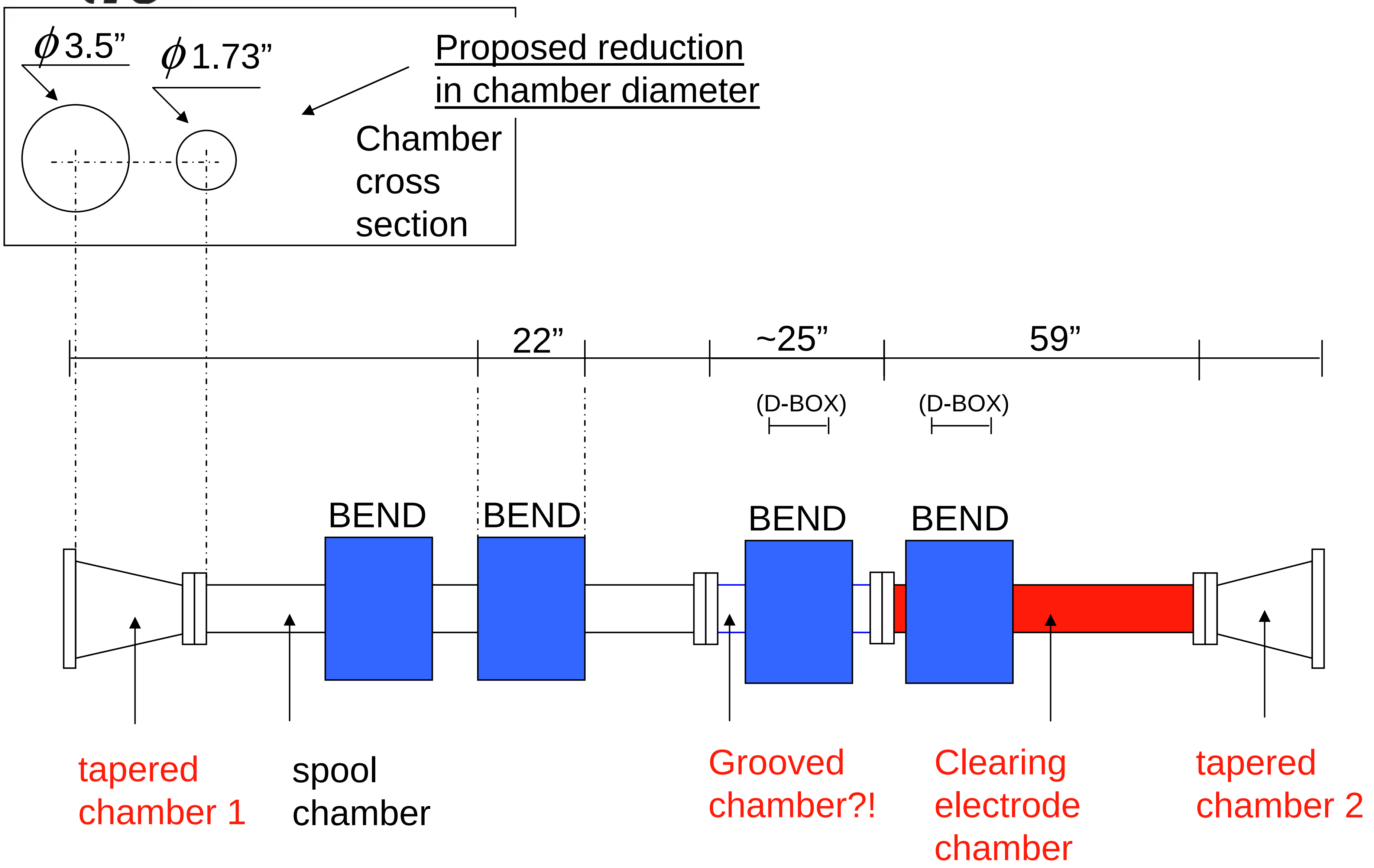
ENGR DATE APPROVALS
DWN
CHKR

Lamfa Extrusion - Rev 9

DRAWING NUMBER REVISION NUMBER C

SH OF C

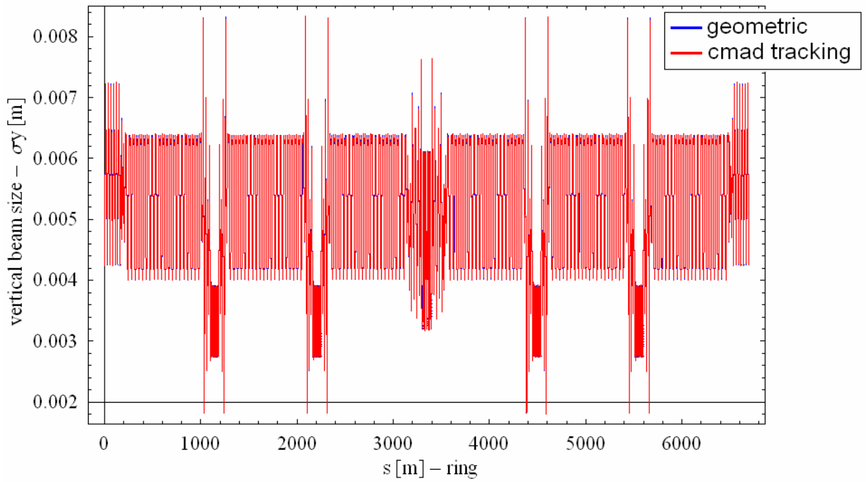
Layout installation – in PEP-II

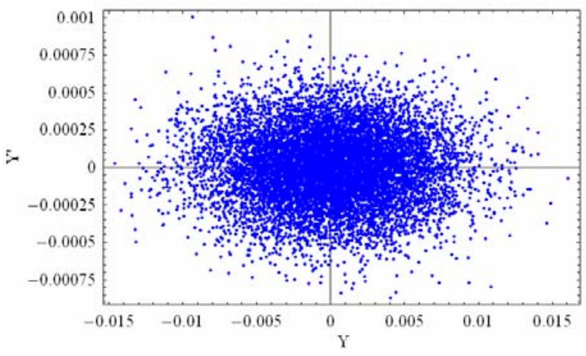


D-BOX=diagnostic box, electron detection centered on BEND and 13.5" long

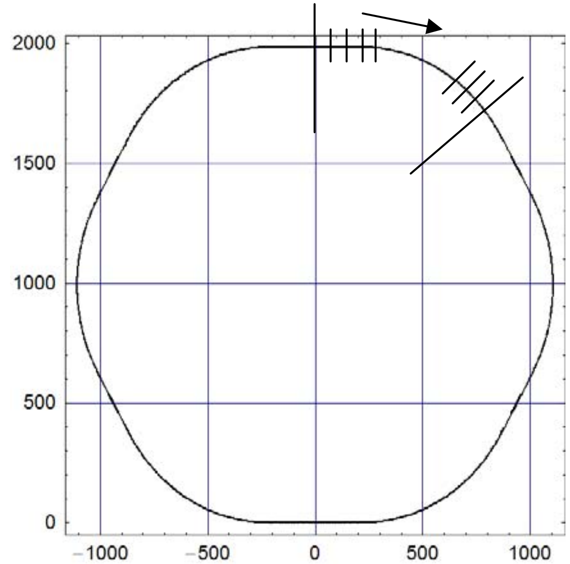
Simulation plans for FY07 /FY08

At SLAC, developing self-consistent simulation code including e-cloud build-up and beam instabilities. It allows: parallel computation (Message Passing Interface - MPI), tracking the beam in a MAD lattice for ILC DR, interaction with cloud at <u>each</u> element in the ring and with different cloud distribution, single- and coupled-bunch instability studies, threshold for SEY, dynamic aperture and frequency map analysis, tune shift ...





Bunch at injection

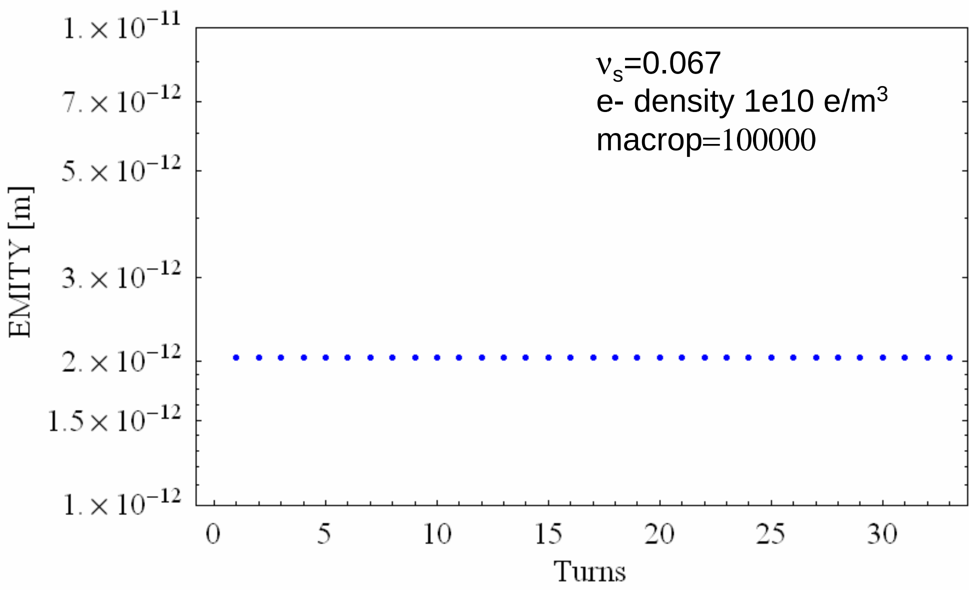


MAD deck to track beam with an electron cloud at each element of the ILC DR.

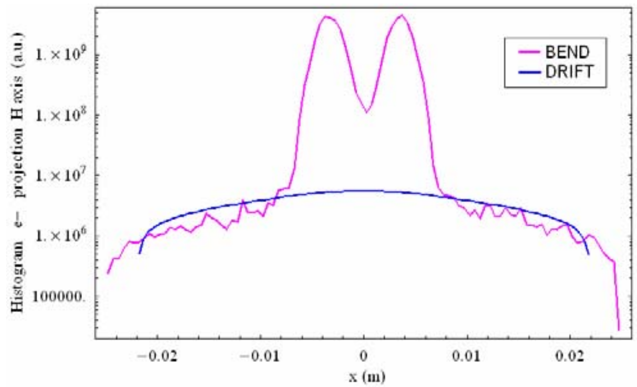
CMAD status

Beam-cloud interaction: resolve pinching and kick bunch particles at each element in ring, with given electron cloud distributions in different elements (wigglers, bend, quad sext fields). Completed. Single-bunch instability preliminary studies ongoing.

Electron cloud build-up (SEY, vacuum chamber, etc.) to be added soon.



First results: few synchrotron oscillation periods (9min * 320 CPUs / turn) CMAD tracking, ILC DR beam at extraction, with average cloud density 1e10 e/m^3 (below threshold).



Electron cloud distribution in bends and straights (so far from POSINST)

Bottleneck => in ILC DR, beam aspect ratio reaches $\sigma x/\sigma y$=200, demanding Particle in Cell grid ratios num-gridx >> num-gridy, to correctly simulate Electric field.

Thanks !

To the contributors to this presentation M. Palmer (Cornell), S. De Santis (LBNL) F. Willeke (DESY), K. Suetsugu (KEK), K. Bane, P. Raimondi, L. Wang (SLAC), F. Zimmermann (CERN)

and to DR collaborators
D. Arnett, G. Collet, R. Kirby, N. Kurita, B. Mckee, M. Morrison, P. Raimondi, T. Raubenheimer, J. Seeman, L. Wang, G. Stupakov (SLAC), D. Rubin, D. Rice, L. Schachter, J. Codner, E. Tanke, J. Crittenden (Cornell), J. Gao (HIPEP), A. Markovic et al. (Rostock Univ.), M. Zisman, S. De Santis, C. Celata, M. Furman, J.L. Vay (LBNL), K. Ohmi, Y. Suetsugu (KEK), F. Willeke, R. Wanzenberg (DESY), J.M. Laurent, A. Rossi, E. Benedetto, F. Zimmermann, G. Rumolo, J.M. Jimenez, J-P. Delahaye (CERN), A. Wolski (Cockroft Uniiv.), B. Macek (LANL), C. Vaccarezza, S. Guiducci, R. Cimino (Frascati), et many other colleagues...