The CLIC Collaboration, X-band and High-Gradient R&D - UPDATE

KEK, 9 March 2015

Walter Wuensch, CERN

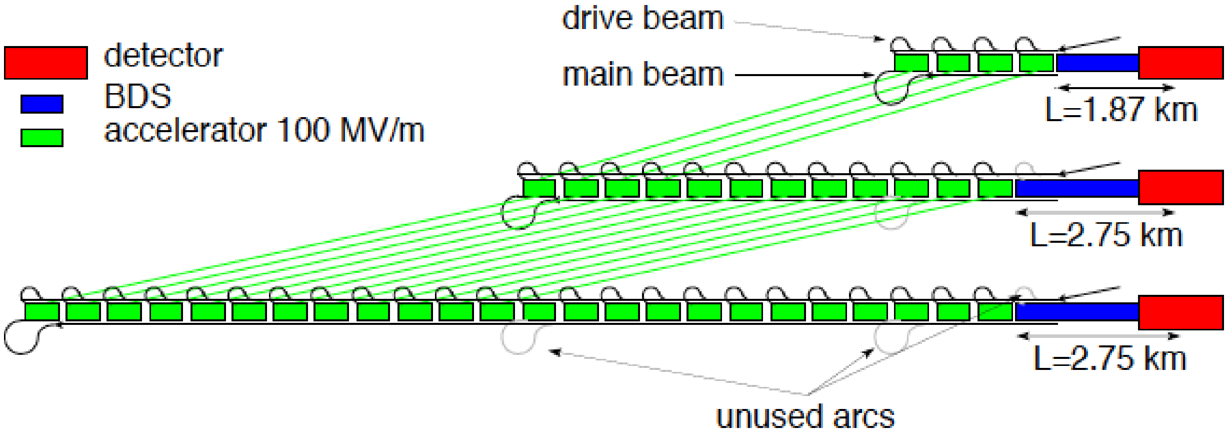
- Recent developments for the project: energy scaling and re-baselining
- X-band rf system development news
- High-surface field study news

CLIC Collaboration

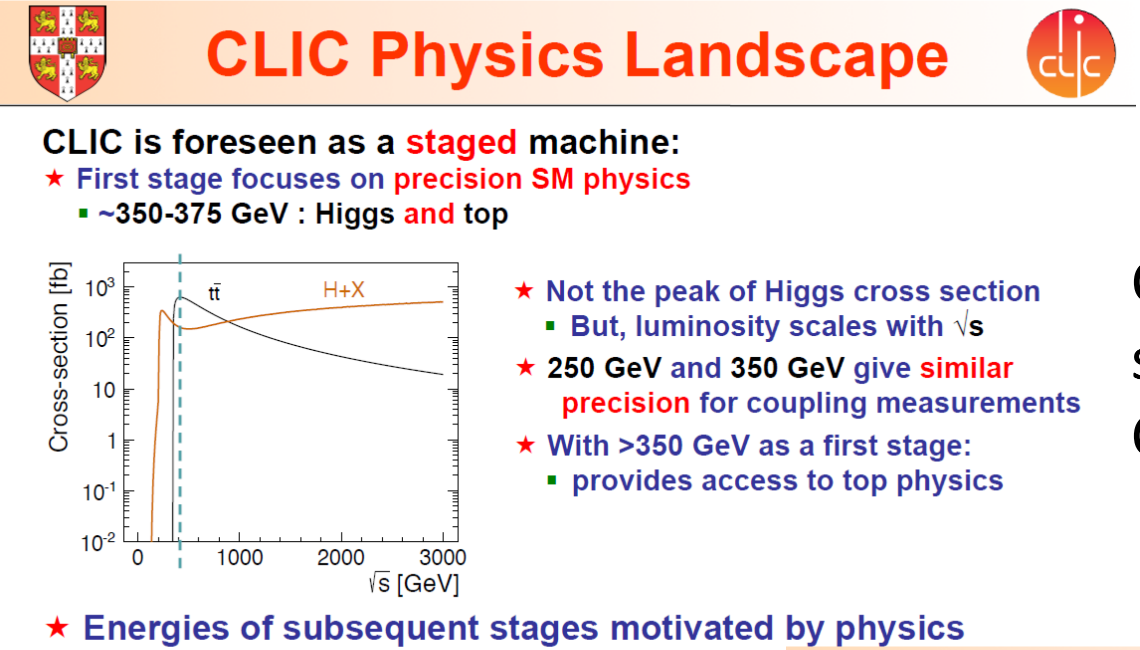
Accelerator collaboration has ≈ 50 institutes and the detector collaboration ≈ 25.

Staged Design

Goal: Develop a staged design for CLIC to optimise physics and funding profile, using knowledge from CDR



- First stage: E_{cms}=~~360GeV~~ 380Gev, L=$1.5\times10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, $L_{0.01}/L>0.6$
  - Luminosity has been defined based on physics and machine studies in 2014
  - 420 GeV stage has also been explored, but physics prefers 360GeV
- Second stage: E_{cms}=O(1.5TeV)
- Final stage: E_{cms}=3TeV, $L_{0.01}=2\times10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, $L_{0.01}/L>0.3$



CLIC Physics Landscape

CLIC is foreseen as a staged machine:

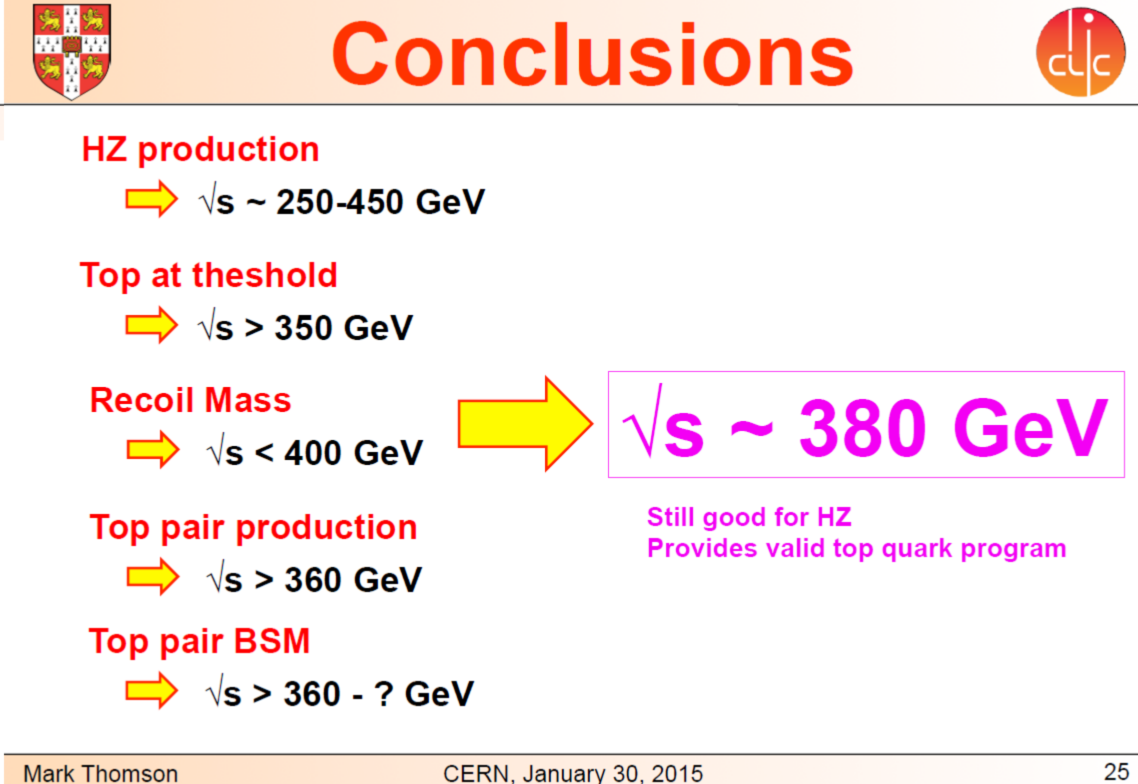
- ★ First stage focuses on precision SM physics
  - ~350-375 GeV : Higgs and top

- ★ Not the peak of Higgs cross section
  - But, luminosity scales with $\sqrt{s}$
- ★ 250 GeV and 350 GeV give similar precision for coupling measurements
- ★ With >350 GeV as a first stage:
  - provides access to top physics
- ★ **Energies of subsequent stages motivated by physics**
  - results from ~14 TeV LHC operation
  - direct dark matter searches,

Mark Thomson CERN, January 30, 2015

CLIC re-baselining and energy staging exercise following CDR and LHC run 1.

Presentation at CLIC workshop: http://indico.cern.ch/event/336335/overview



Conclusions

HZ production

⇨ $\sqrt{s}$ ~ 250-450 GeV

Top at theshold

⇨ $\sqrt{s}$ > 350 GeV

Recoil Mass

⇨ $\sqrt{s}$ < 400 GeV

Top pair production

⇨ $\sqrt{s}$ > 360 GeV

Top pair BSM

⇨ $\sqrt{s}$ > 360 - ? GeV

⇨ **$\sqrt{s}$ ~ 380 GeV**

Still good for HZ
Provides valid top quark program

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Automatic Parameter Determination

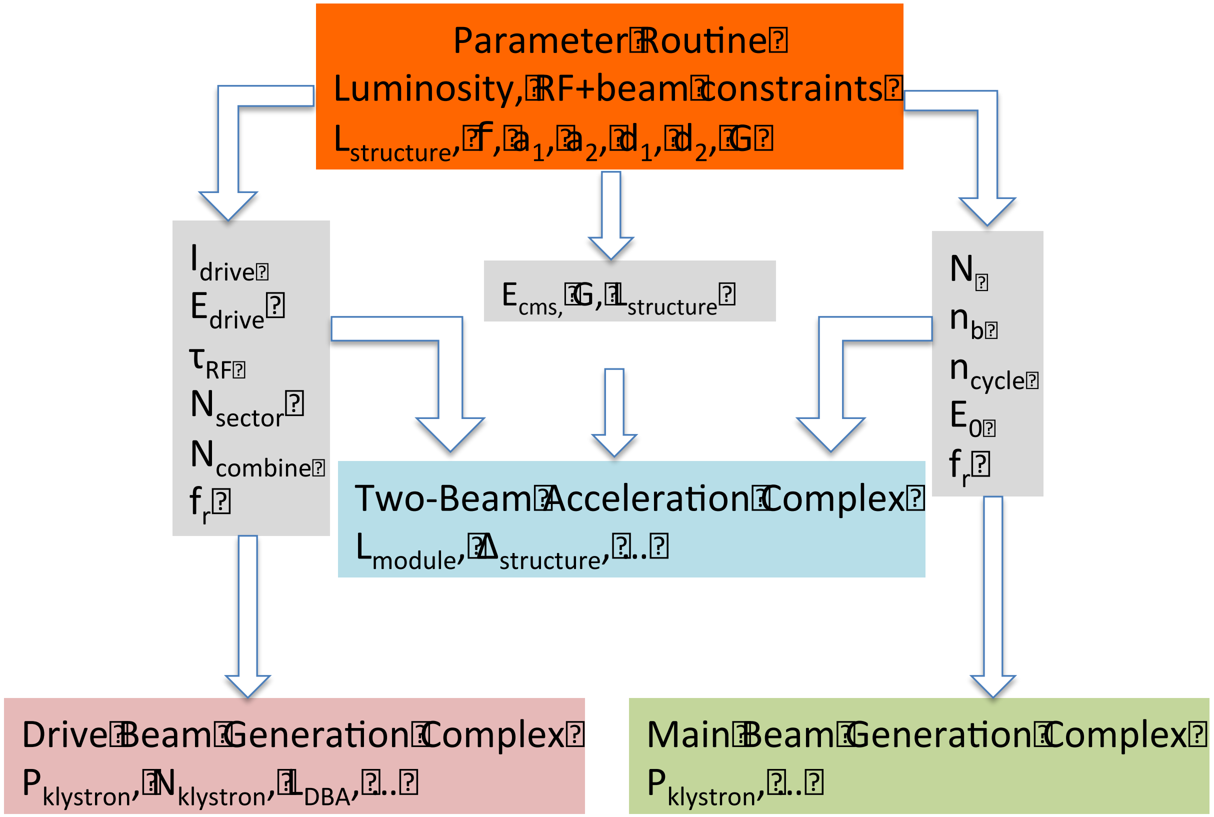
Structure design fixed by few parameters

$a_1, a_2, d_1, d_2, N_c, \phi, G$

Beam parameters derived automatically to reach specific energy and luminosity

Consistency of structure with RF constraints is checked

Repeat for 1.7 billion cases



Parameter Routine
Luminosity, RF+beam constraints
$L_{structure}$, f, a_1, a_2, d_1, d_2, G

I_{drive}
E_{drive}
τ_{RF}
N_{sector}
$N_{combine}$
f_r

E_{cms}, G, $L_{structure}$

N
n_b
n_{cycle}
E_0
f_r

Two-Beam Acceleration Complex
L_{module}, $\Delta_{structure}$, ..

Drive Beam Generation Complex
$P_{klystron}$, $N_{klystron}$, L_{DBA}, ..

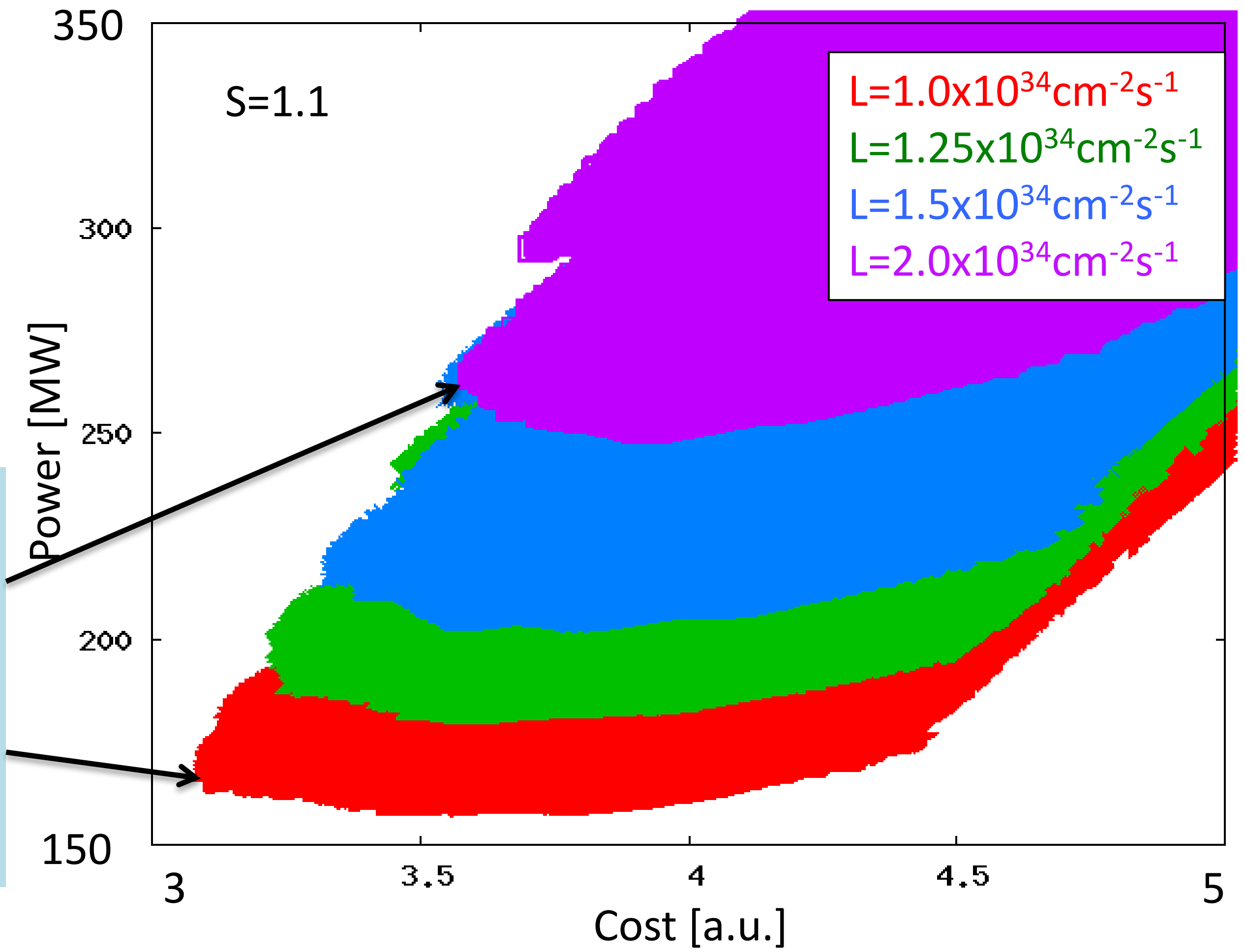
Main Beam Generation Complex
$P_{klystron}$, ..

Design choices and specific studies

- Use 50Hz operation for beam stability
- Scale horizontal emittance with charge to keep the same risk in damping ring
- Scale for constant local stability in main linac, i.e. tolerances vary but stay above CDR values
- BDS design similar to CDR, use improved β_x-reach as reserve
- …

Optimization at 360GeV

(Each point represents an accelerating structure design. High-gradient performance is based on testing program results and high-gradient scaling laws – WW)

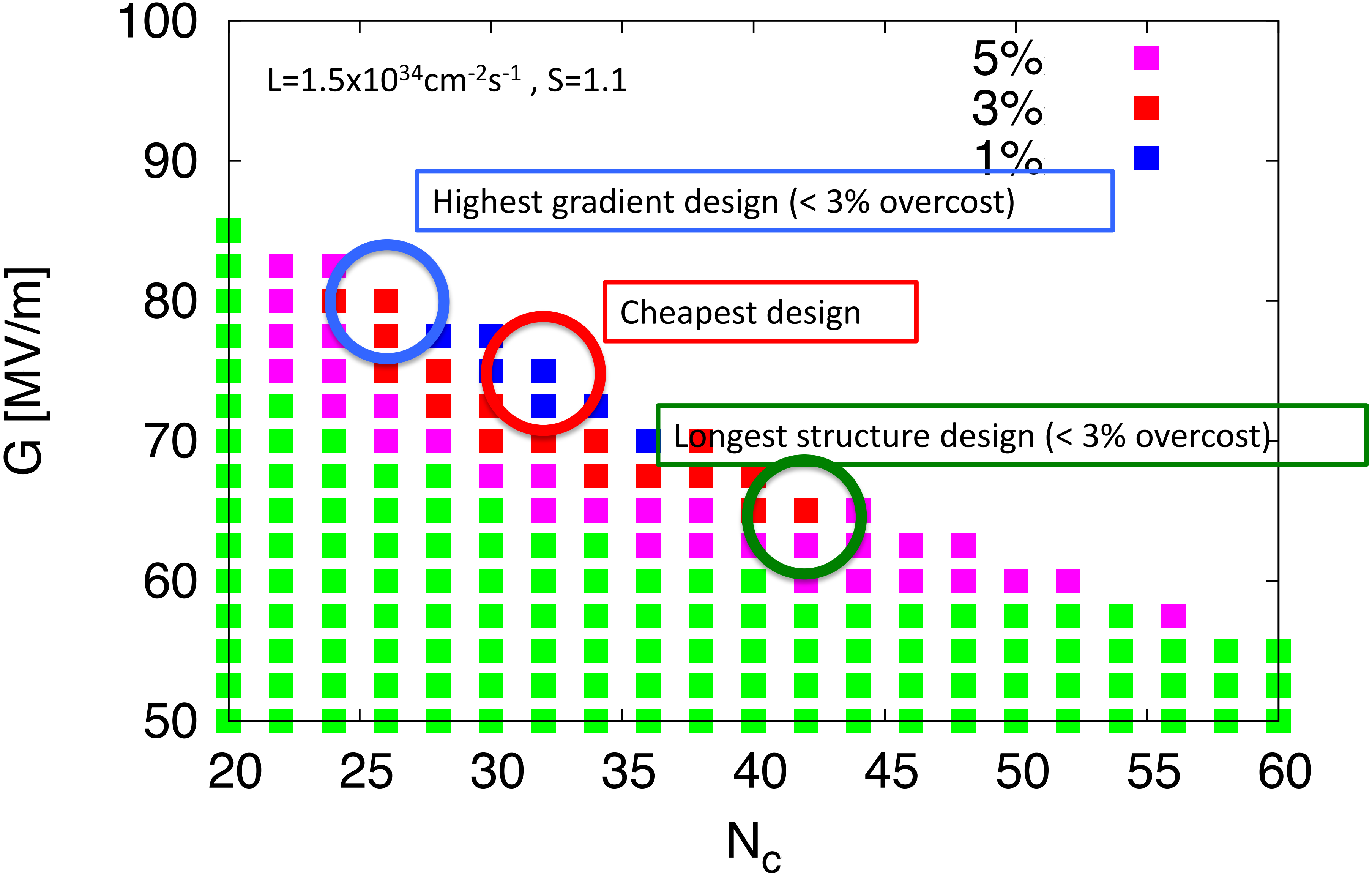


Luminosity goal significantly impact minimum cost
For $L=1\times10^{34}cm^{-2}s^{-1}$ to $L=2\times10^{34}cm^{-2}s^{-1}$:

Costs 0.5 a.u.
And O(100MW)

Cheapest machine is close to lowest power consumption => small potential for trade-off

Good Structures at 360GeV



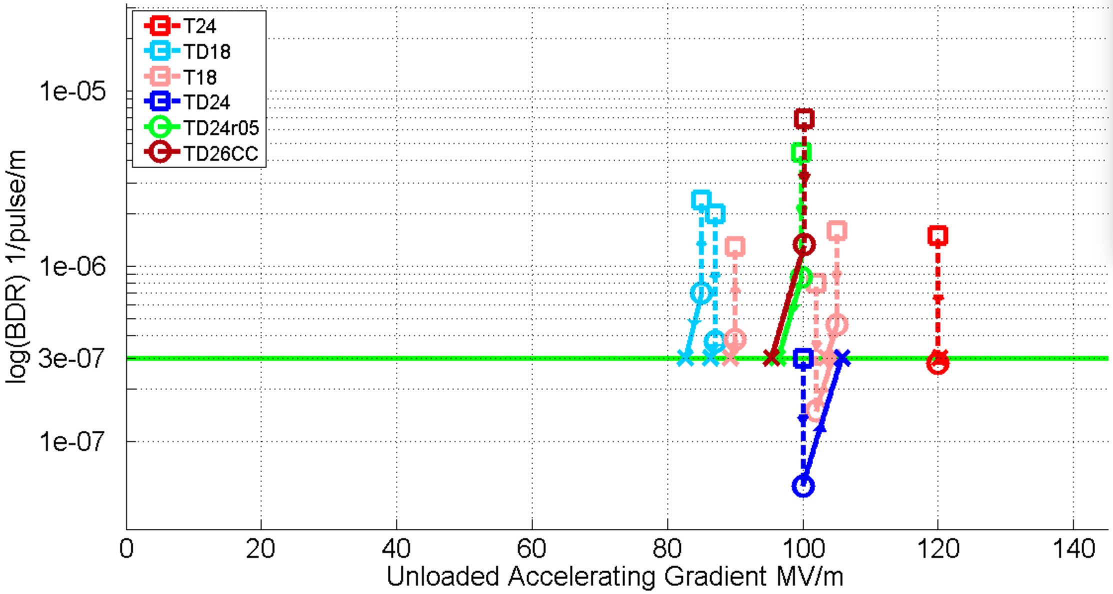
$L=1.5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$, S=1.1

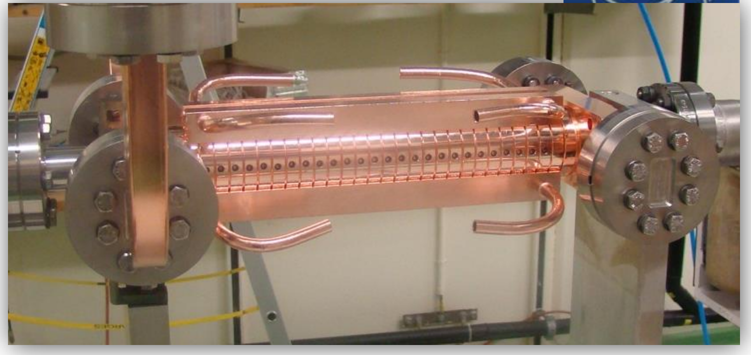
Highest gradient design (< 3% overcost)

Cheapest design

Longest structure design (< 3% overcost)

X-band accelerating structure development





Operating frequency	12 GHz
Accelerating gradient	100 MV/m
Peak surface electric field	250 MV/m
Pulse length	200 ns
Repetition rate	50 Hz
Input power	50 MW
Breakdown rate	<10^{-7} BD/pulse/m

100 MV/m has been clearly demonstrated in prototype structures, but only in a limited number.

In order to improve statistics, make lifetime tests and investigate variants we have invested significant resources into increasing testing capacity with:

Three klystron-based test stands – **Xbox-1 to 3**.

Xband accelerating structures review
24-25.11.2014

N. Catalan Lasheras

Participants

31 participants including outside laboratories

D. Schulte, **CERN/ABP**

PH. Lebrun, S. Stapnes, **CERN/DG**

S. Atieh, A. Cherif, G. Favre, M. Garlache, A. Perez Fontenla, **CERN/MME**

M. Aicheler, O. Brunner, N. Catalan Lasheras, M. Filippova, A. Grudjev, D. Gudkov, S. Lebet, A. Olyudnin, C. Rossi, A. Solodko, I. Syratchev, J. Vainola, A. Xydou, B. Woolley, W. Wuensch, **CERN/RF**

M. Taborelli, M. Thiebert, **CERN/VSC**

F. Toral, L. Sanchez. **Ciemat, Spain**

T. Higo, T. Abe, **KEK, Japan**

M. Franzi, J. Weng, **SLAC, USA**

23 talks plus discussions

2 long days

Baseline manufacturing flow

RF DESIGN

ENGINEERING DESIGN (3D models, 2D drawings)

ULTRA PRECISION MACHINING

QUALITY CONTROL AT FACTORY

NOT CONFORM

CONFORM

QUALITY CONTROL AT CERN

CLEANING (LIGHT ETCHING)

ASSEMBLY OF COUPLERS (brazing, machining)

PRELIMINARY RF CHECK

DIFFUSION BONDING OF DISC STACK

BRAZING OF COUPLERS, TUNING STUDS, COOLING CIRCUITS

LEAK TIGHTNESS TEST

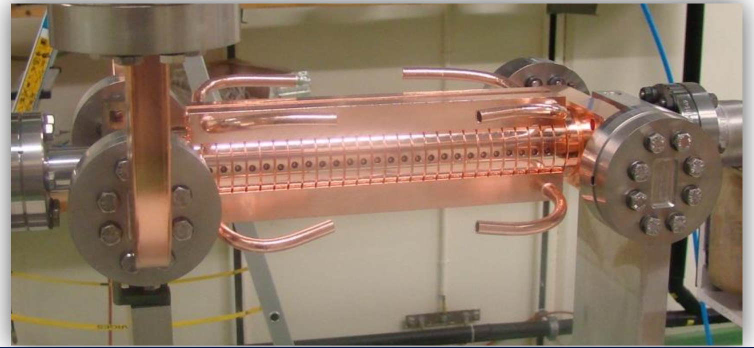
Add a final dimensional control

RF CHECK AND TUNING

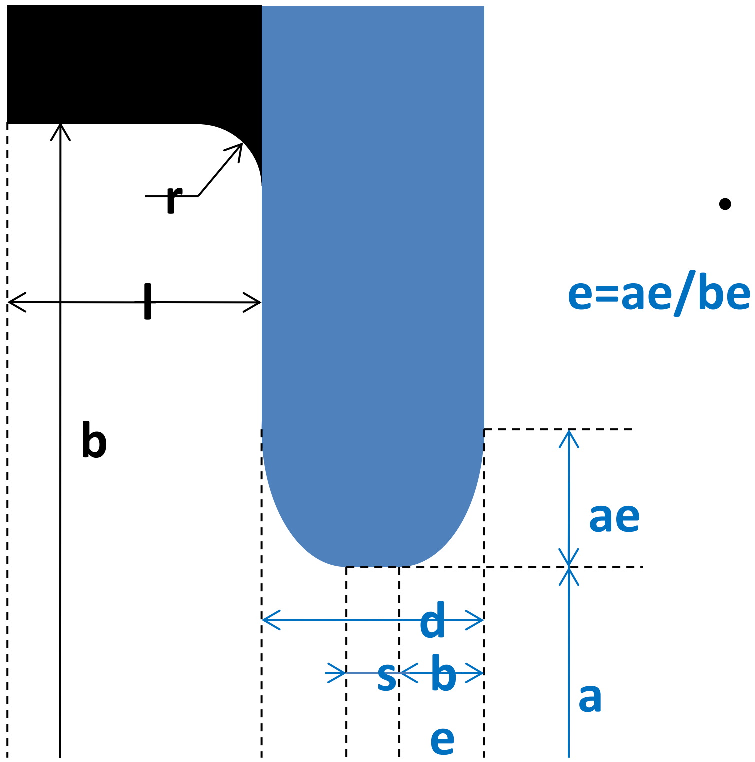
BAKING (vacuum 650 °C, 10 days)

INSTALLATION

PACKAGING AND SHIPPING



Tolerances coming from RF. A. Grudjev



- Sensitivity study for undamped cell.
- Riccardo Zennaro, “Study of the machining and assembly tolerances for the CLIC accelerating structures”, EUROTeV-Report-2008-081, (2008)
- Jiaru Shi, Alexej Grudiev, Walter Wuensch, “Tuning of X-band traveling-wave

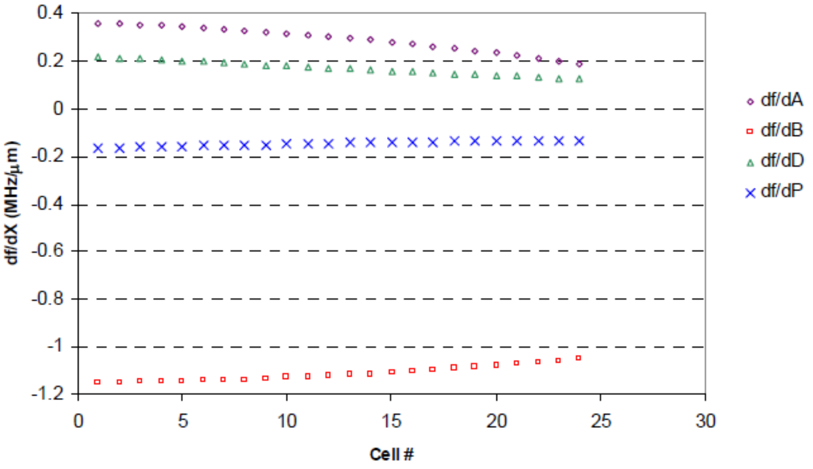


***Figure 3:** df/dX for the nominal phase advance 120⁰.*

<u>Sub micron precision</u> is required if no tuning is applied and no temperature correction is allowed

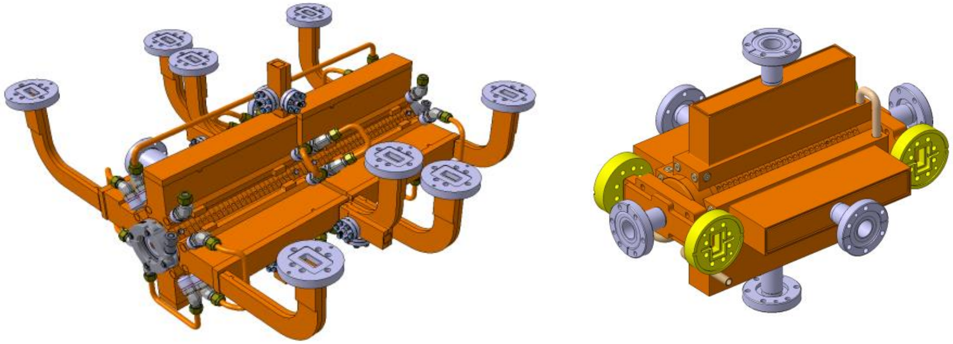
Only systematic errors considered. Random errors being studied

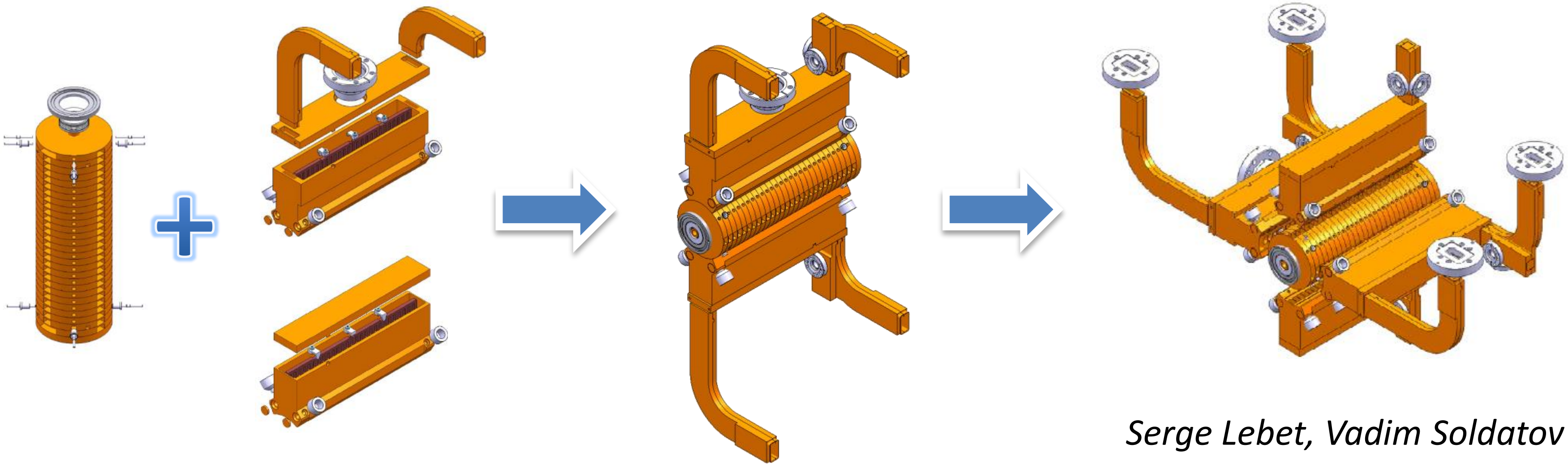
Cell to cell alignment on GLC structures. T. Higo

- OD is the key for measurements need to be fully measured.

- Stacked manually against a V-block.
- Hold during transport to the oven.
- Later used pre-bonding at low temperature ~150 degrees before releasing fixture

Manifolds assembly. D. Gudkov

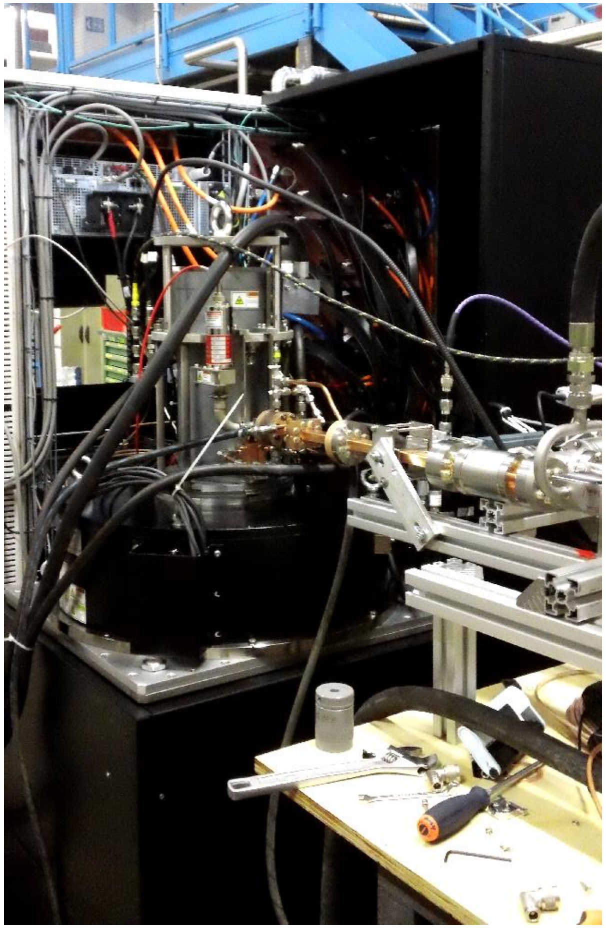




Serge Lebet, Vadim Soldatov

X-band klystrons

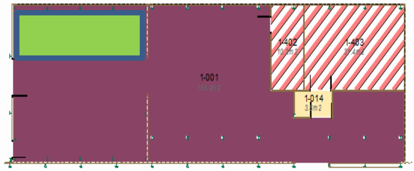
We now have two types of *commercial* X-band power sources running at CERN.



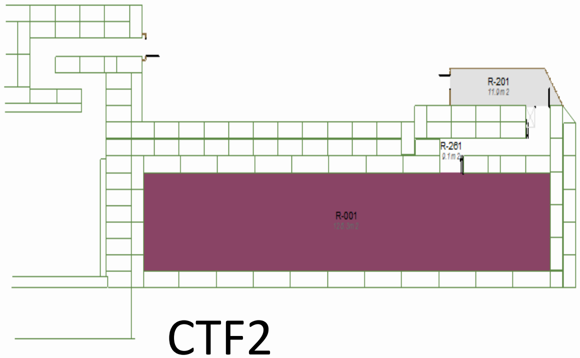
Toshiba 6 MW, 5 µs, 400 Hz

CPI 50 MW, 1.5 µs, 50 Hz

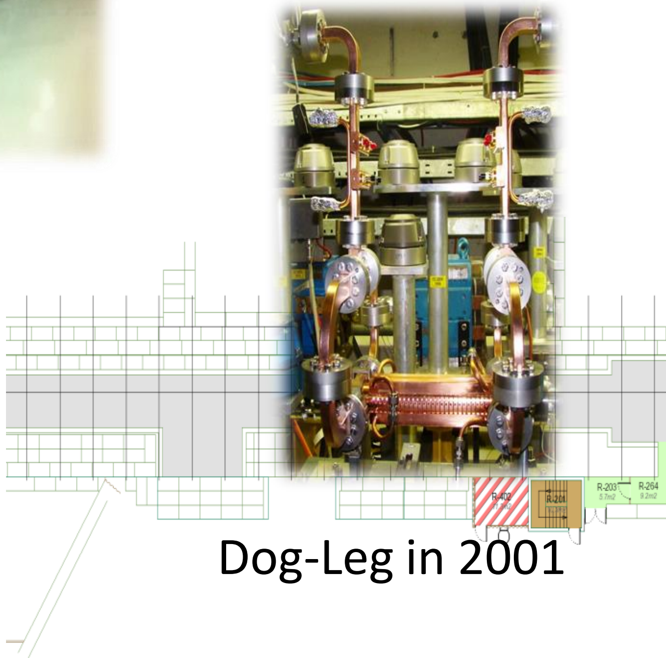
Xbox1 in b. 2013



CTF3 klystron gallery

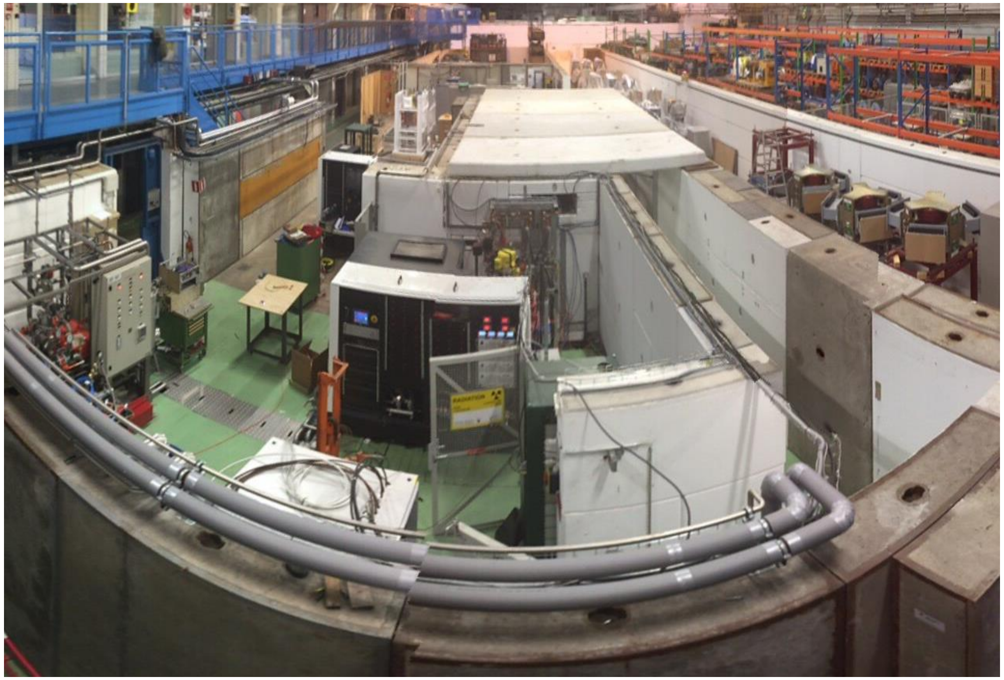


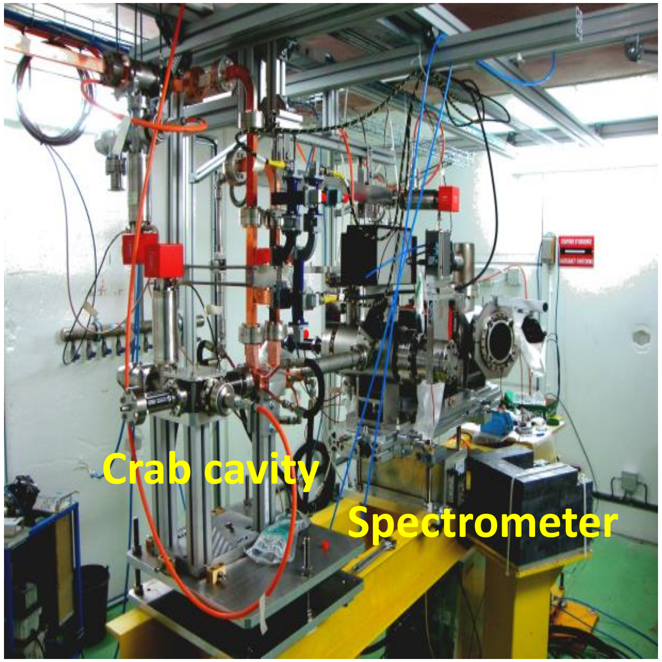
CTF2

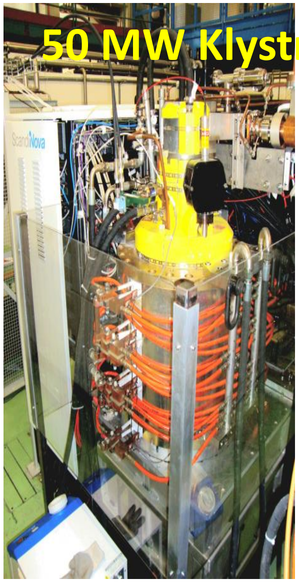


Dog-Leg in 2001

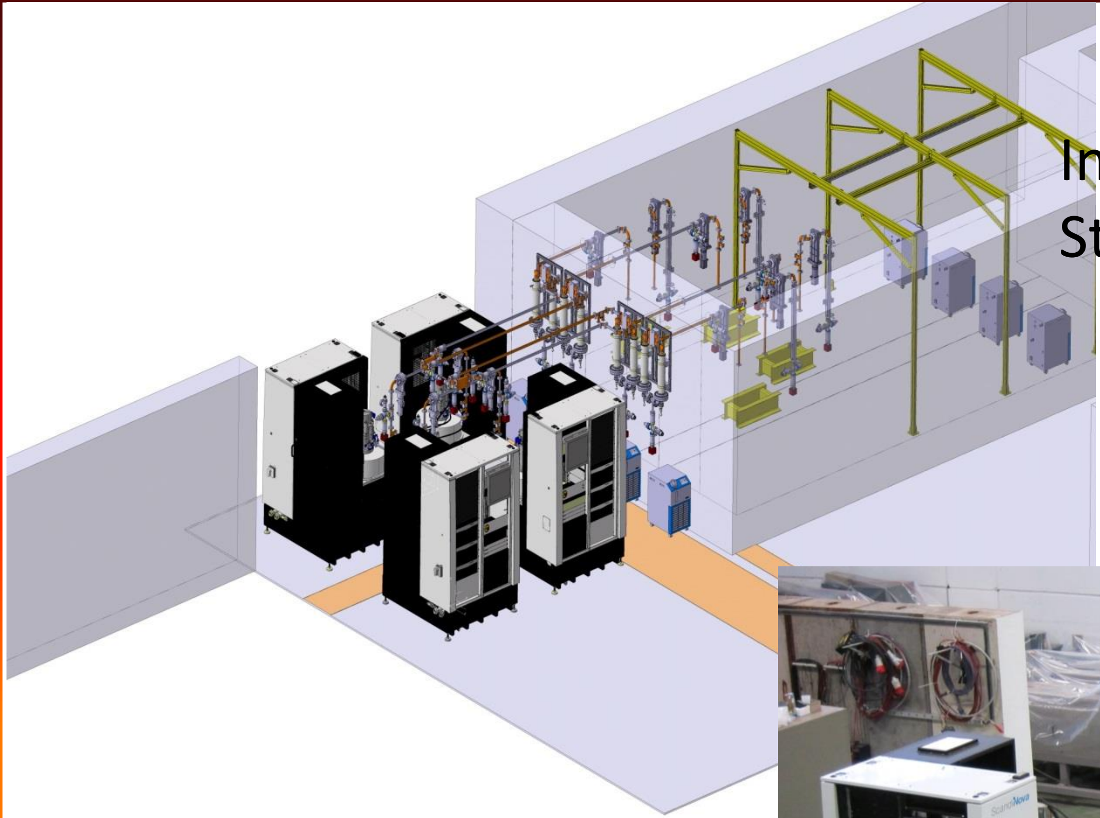
Xbox2 in b. 150



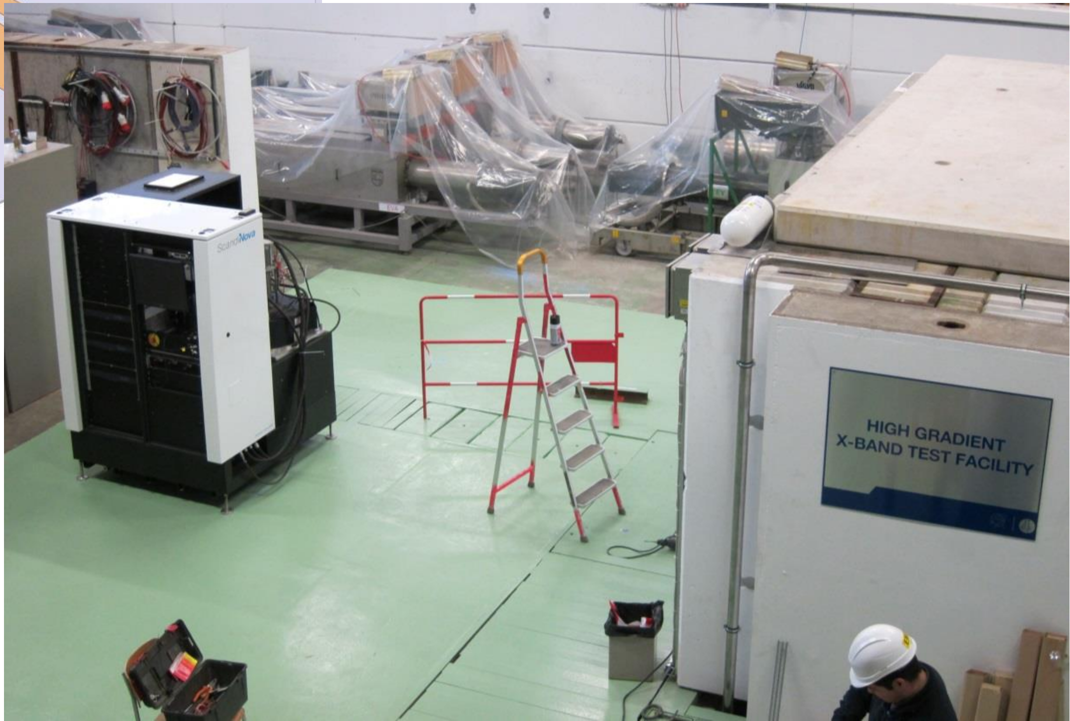




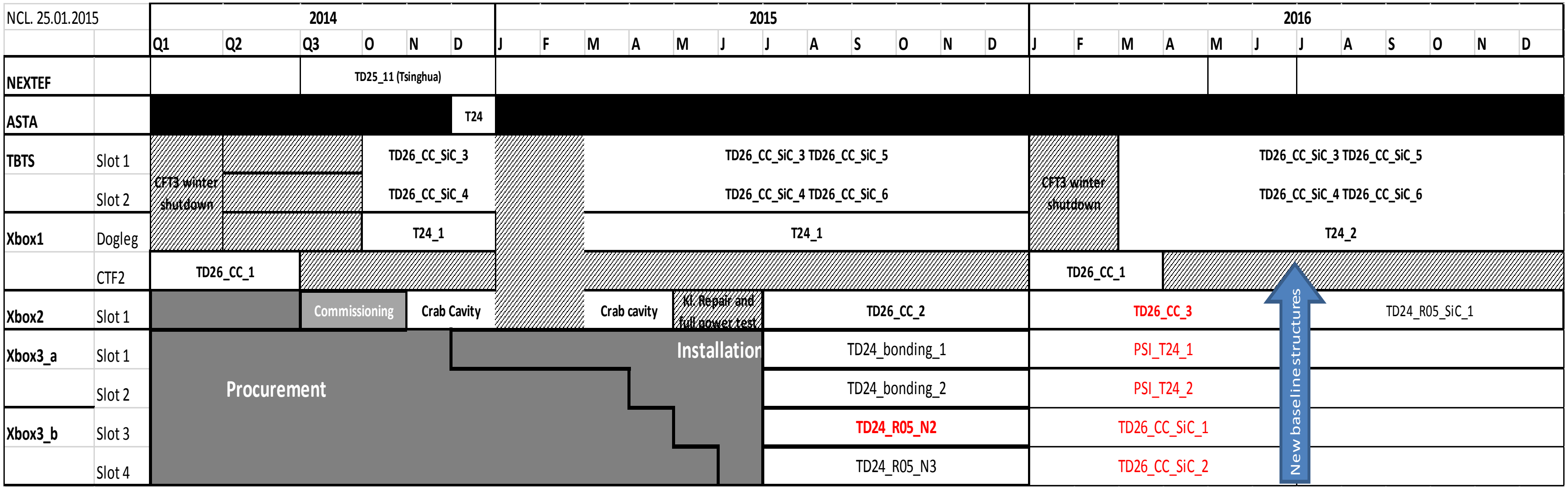
Xbox3 in b. 150



Installation progressing well.
Start-up May/June



Test schedule for next two years



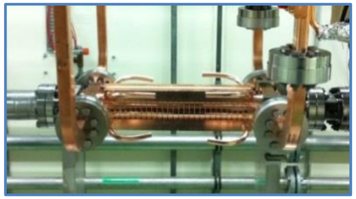
NCL. 25.01.2015		2014						2015												2016											
		Q1	Q2	Q3	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
NEXTEF				TD25_11 (Tsinghua)																											
ASTA							T24																								
TBTS	Slot 1	CFT3 winter shutdown			TD26_CC_SiC_3					TD26_CC_SiC_3 TD26_CC_SiC_5										CFT3 winter shutdown		TD26_CC_SiC_3 TD26_CC_SiC_5									
	Slot 2				TD26_CC_SiC_4					TD26_CC_SiC_4 TD26_CC_SiC_6												TD26_CC_SiC_4 TD26_CC_SiC_6									
Xbox1	Dogleg				T24_1					T24_1												T24_2									
	CTF2	TD26_CC_1																		TD26_CC_1											
Xbox2	Slot 1			Commissioning		Crab Cavity				Crab cavity		Kl. Repair and full power test		TD26_CC_2						TD26_CC_3						TD24_R05_SiC_1					
Xbox3_a	Slot 1											Installation		TD24_bonding_1						PSI_T24_1											
	Slot 2		Procurement											TD24_bonding_2						PSI_T24_2											
Xbox3_b	Slot 3													**TD24_R05_N2**						TD26_CC_SiC_1											
	Slot 4													TD24_R05_N3						TD26_CC_SiC_2											

New baseline structures

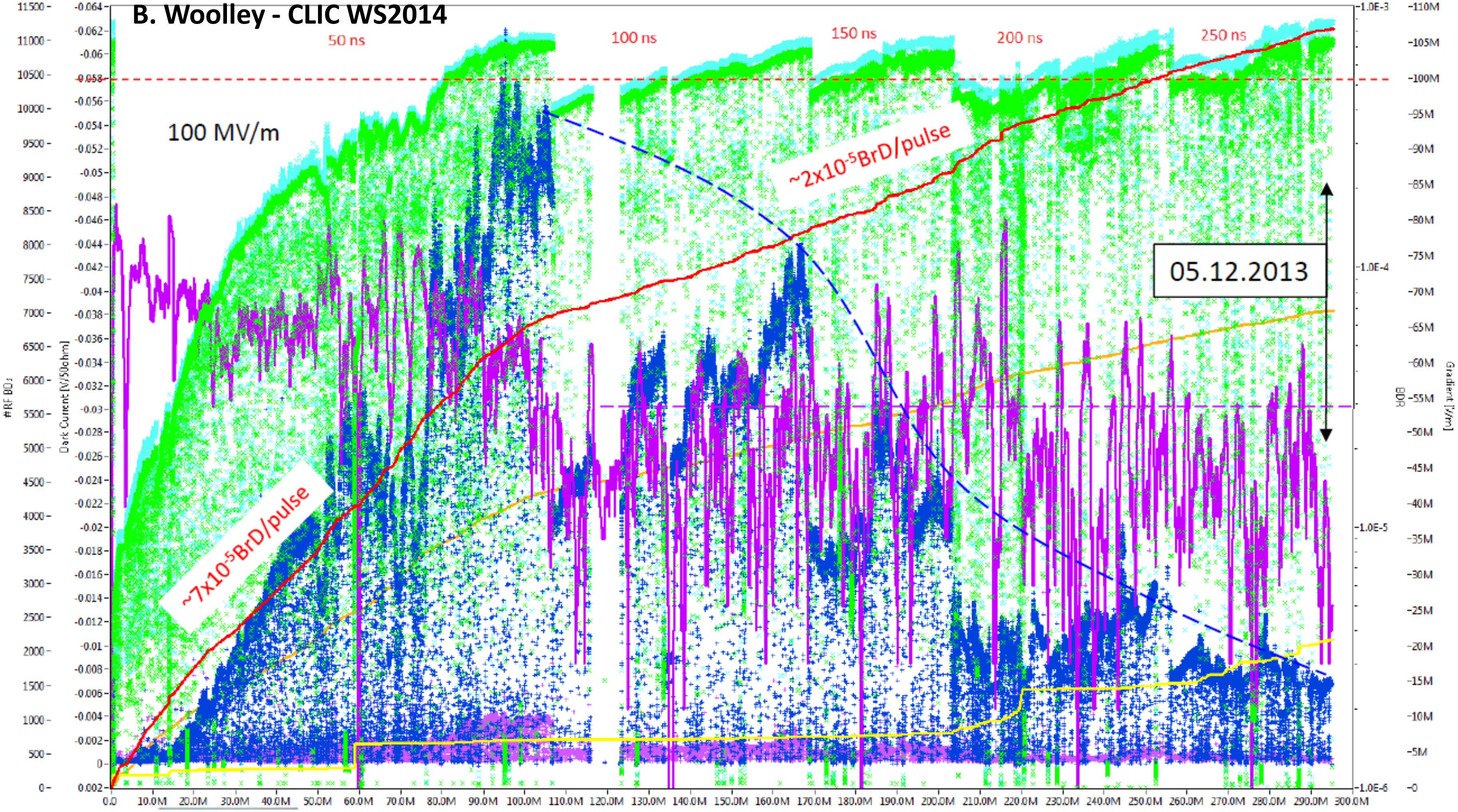
Xbox-1: TD26CC#1 conditioning history

Automatic operation by a conditioning algorithm

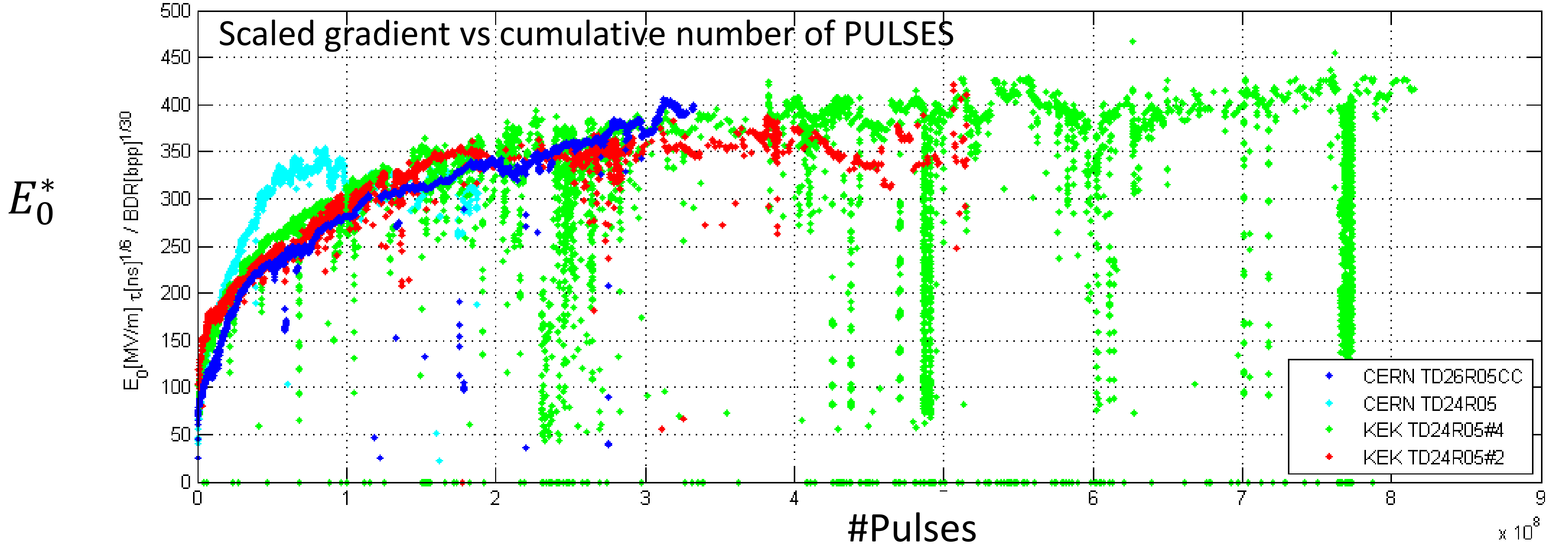
[see J.Tagg presentation]



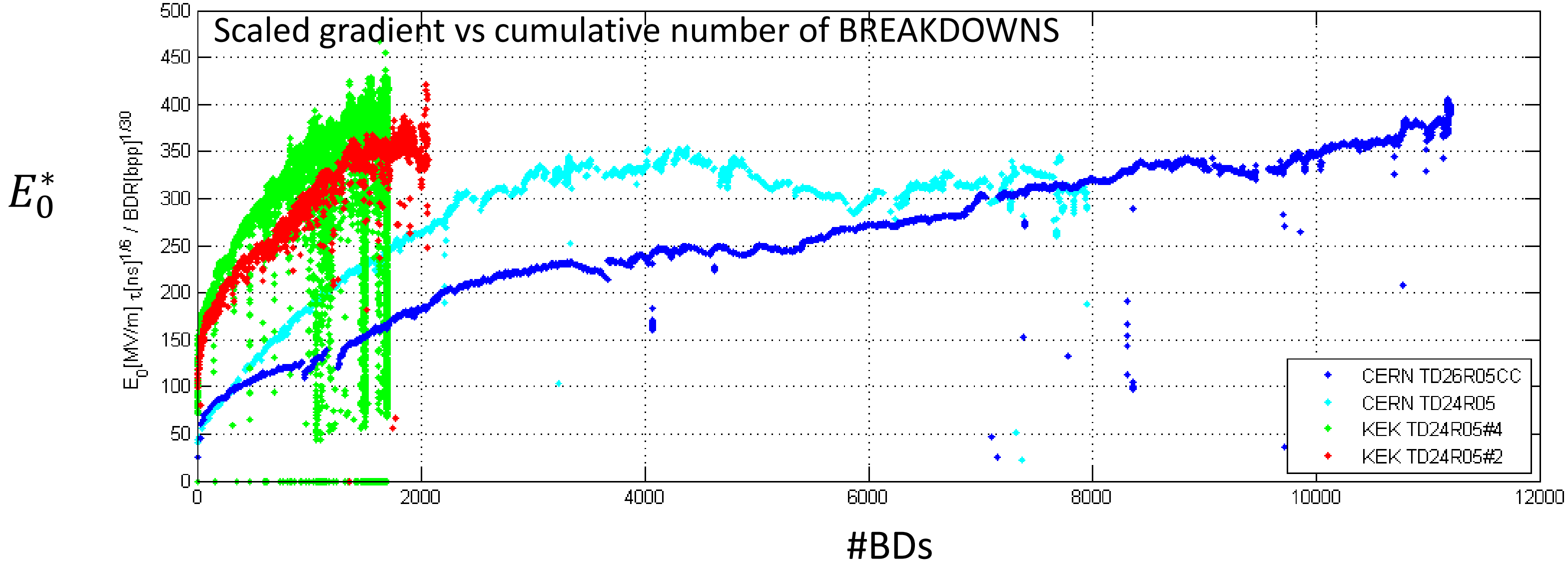
11168 BDs



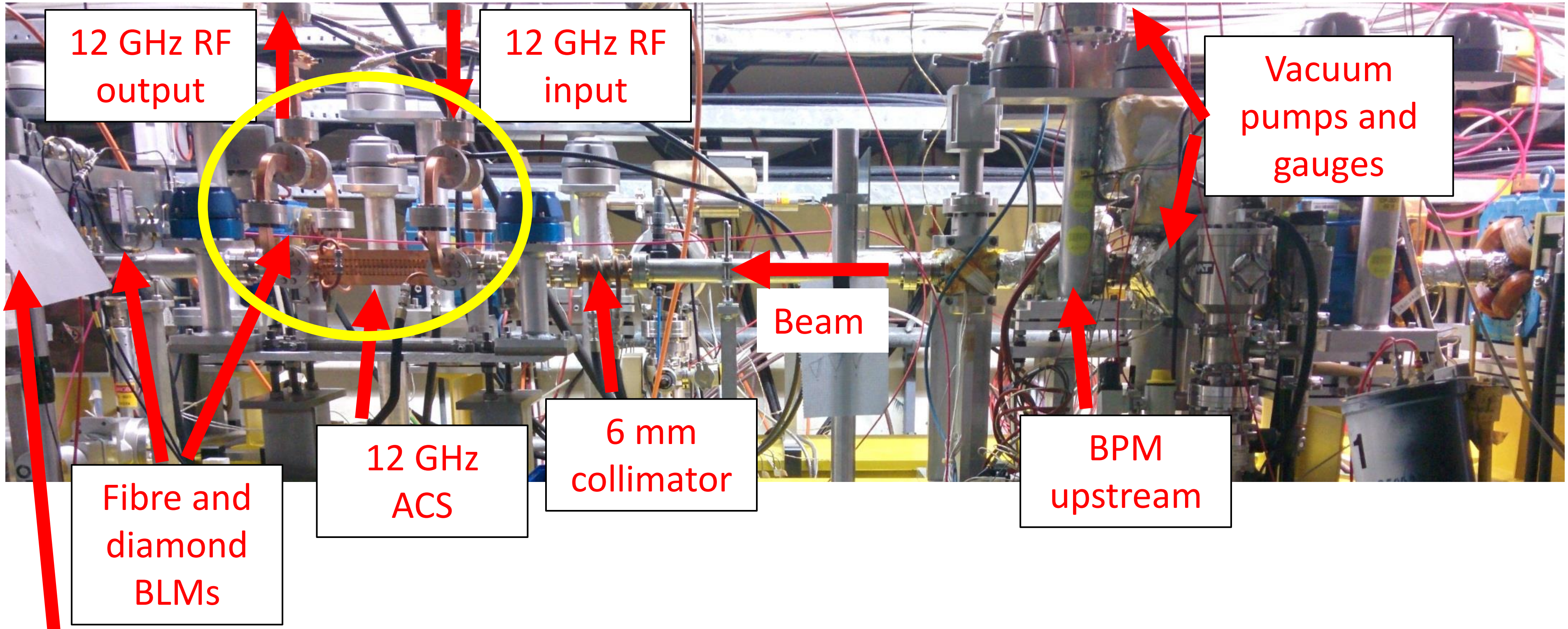
Comparison of conditioning evolution



Conditioning to high-gradient is given by the pulses not the breakdowns!



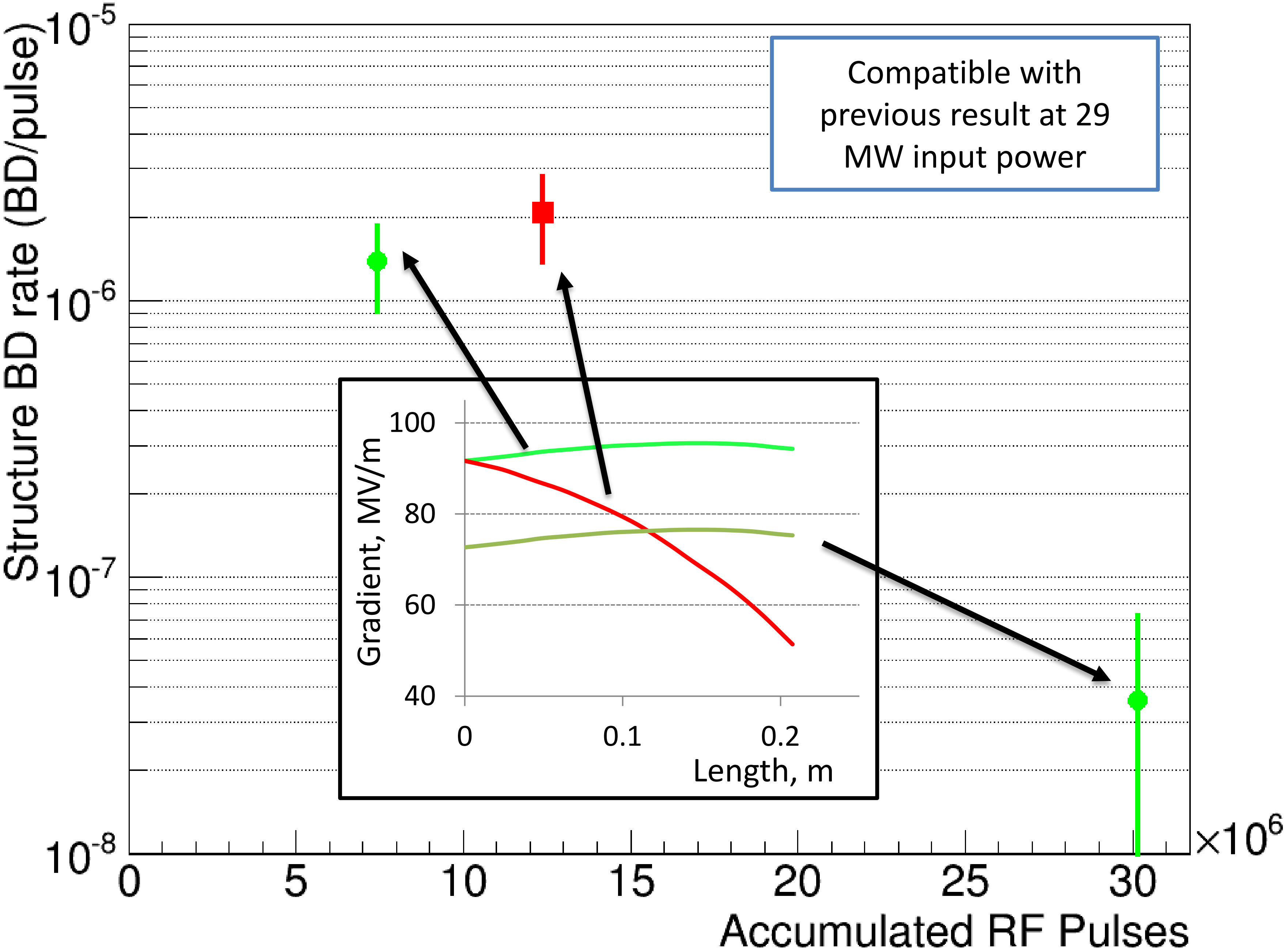
Diagnostic, control and protection



12 GHz accelerating structure surrounded by a complete set of instrumentation:

- 2 inductive BPMs (1 upstream and 1 downstream)
- 6 mm collimator to protect the structure
- Fibre optic and diamond beam loss monitors
- Vacuum pumps and gauges in beam chamber and RF waveguides

First Results: BDr



Compatible with previous result at 29 MW input power

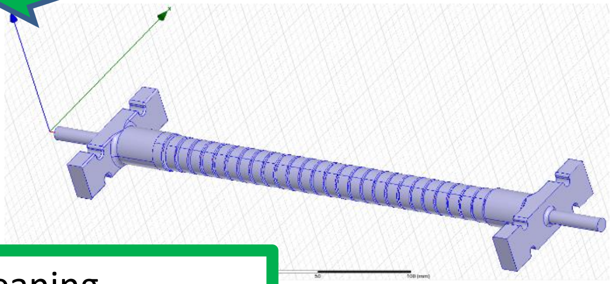
Outreach activities

In order to broaden the technological base for X-band and high gradient we actively pursue fabrication at different laboratories and for different projects.

Institute	Structure	Status
KEK	Long history – latest TD26CC	Mechanical design
Tsinghua	T24 - VDL machined, Tsinghua assembled, H bonding, KEK high-power test	At KEK
	CLIC choke	manufacturing tests
SINAP	XFEL structure, KEK high-power test	rf design phase
	T24, CERN high-power test	Agreement signed
	Four XFEL structures	Agreement signed
CIEMAT	TD24CC	Agreement signed
PSI	Two T24 structures made at PSI using SwissFEL production line including vacuum brazing	Mechanical design work underway
VDL	XFEL structure	Interest
SLAC	T24 in milled halves	machining
CERN	3 TeV and 380 GeV	
	KT (Knowledge Transfer) funded medical linac	machining

CERN/Tsinghua/KEK collaboration

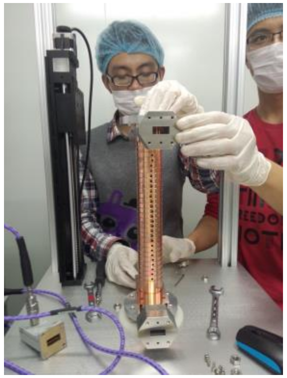
Design for CLIC (CERN)

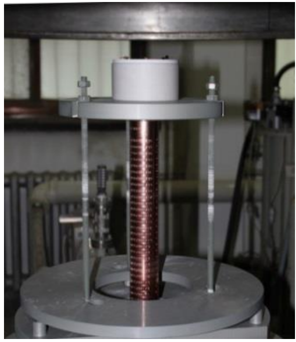


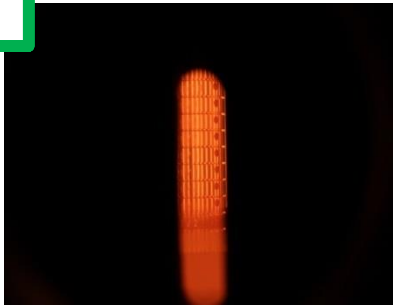
Fabrication of parts (VDL)

Cleaning
Etching
(Tsinghua Univ.)

Bench test (Tsinghua Univ.)





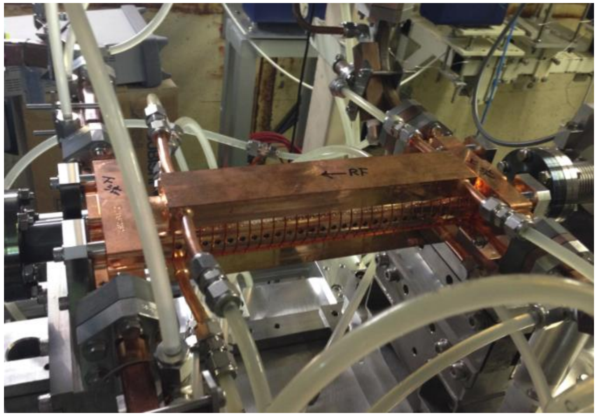


Bonding Brazing
(Tsinghua Univ.)

Tuning(Tsinghua Univ.)

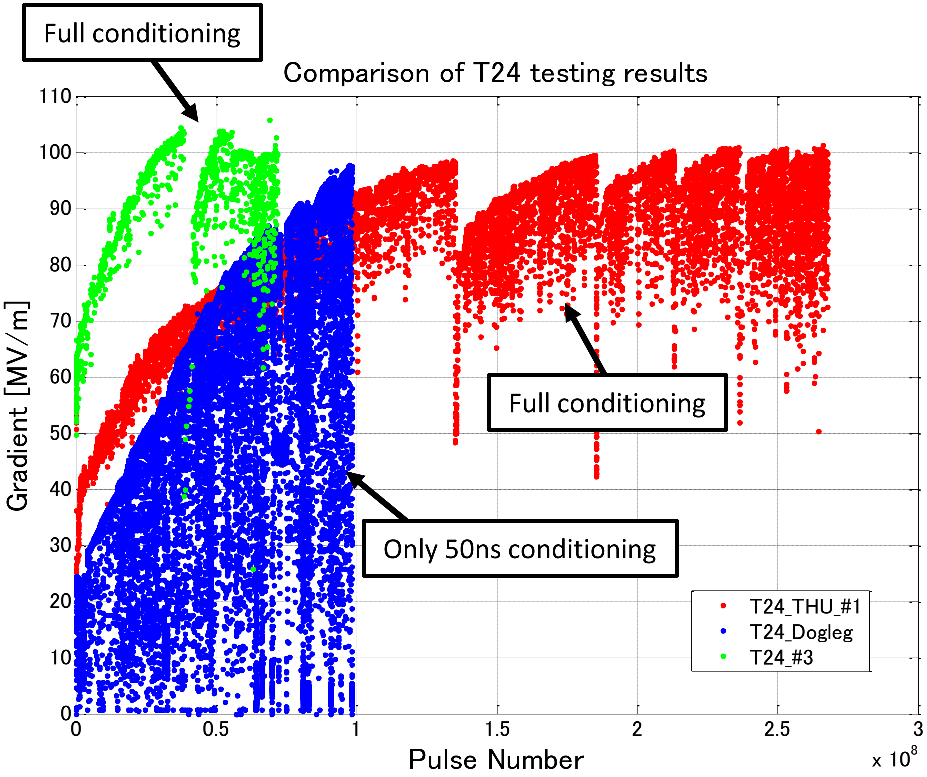
Vac bake (Tsinghua Univ.)

High power test
(Nextef-KEK)



Compare with other T24 testing results (2)

- T24_THU_#1 costs more time to reach 100 MV/m at 51ns pulse width but having a smaller BDR compared with T24_Dogleg
- T24_#3 shows an excellent performance with higher ramping speed and less breakdowns

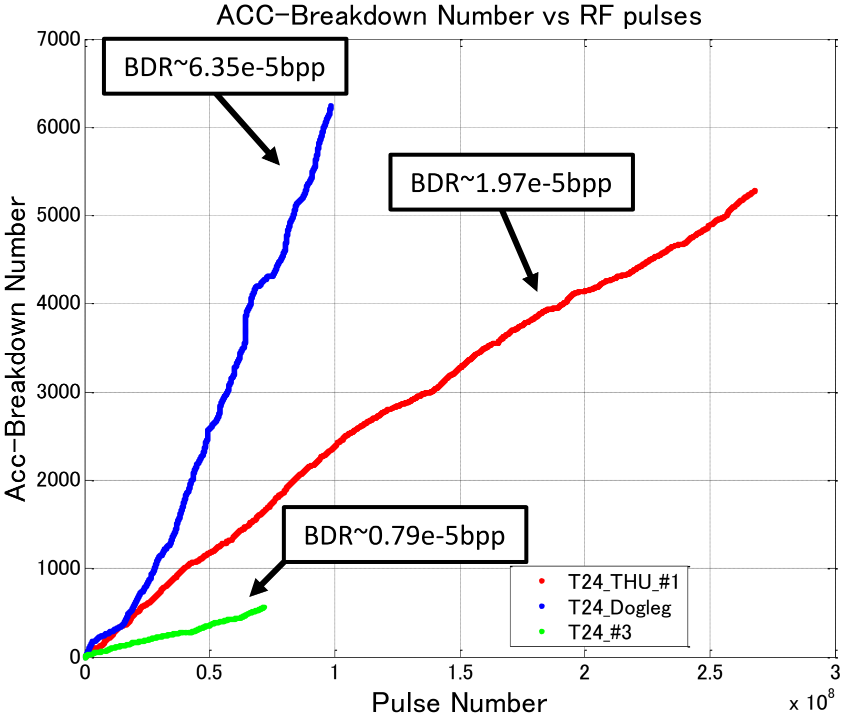


Comparison of T24 testing results

Full conditioning

Full conditioning

Only 50ns conditioning



ACC−Breakdown Number vs RF pulses

BDR~6.35e-5bpp

BDR~1.97e-5bpp

BDR~0.79e-5bpp

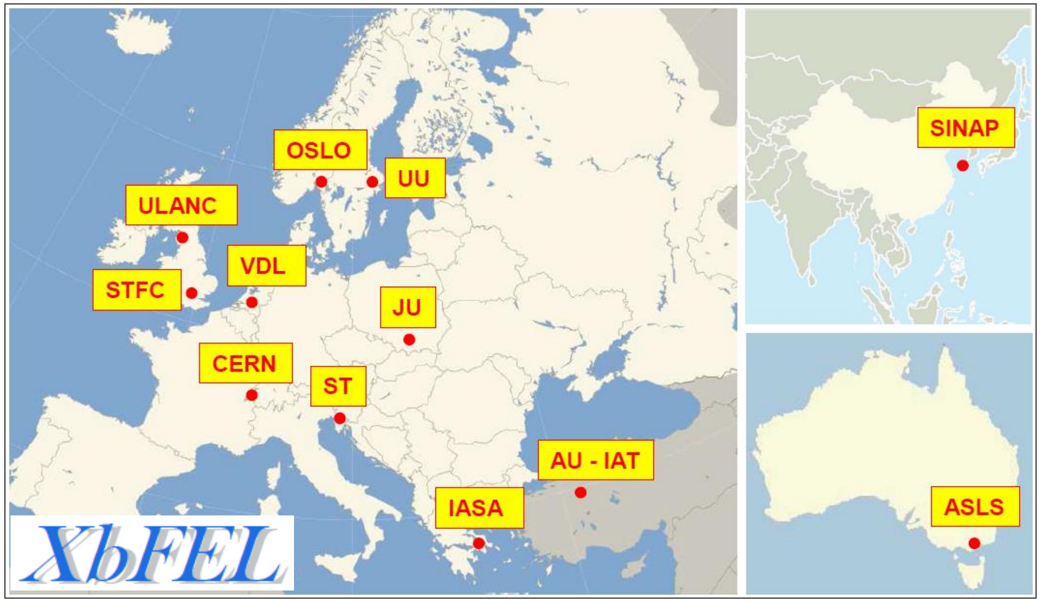
XbFEL

See G. D'Auria
Thursday 9:30

A proposal for an EU co-funded Design Study

A core activity of the FEL collaboration

Submitted September 3



ST	*Elettra - Sincrotrone Trieste, Italy.*
CERN	*CERN Geneva, Switzerland.*
JU	*Jagiellonian University, Krakow, Poland.*
STFC	*Daresbury Laboratory Cockcroft Institute, Daresbury, UK.*
SINAP	*Shangai Institute of Applied Physics, Shanghai, China.*
VDL	*VDL ETG T&D B.V., Eindhoven, Netherlands.*
OSLO	*University of Oslo, Norway.*
IASA	*National Technical University of Athens, Greece.*
UU	*Uppsala University, Uppsala, Sweden.*
ASLS	*Australian Synchrotron, Clayton, Australia.*
UA-IAT	*Institute of Accelerator Technologies, Ankara, Turkey.*
ULANC	*Lancaster University, Lancaster, UK.*

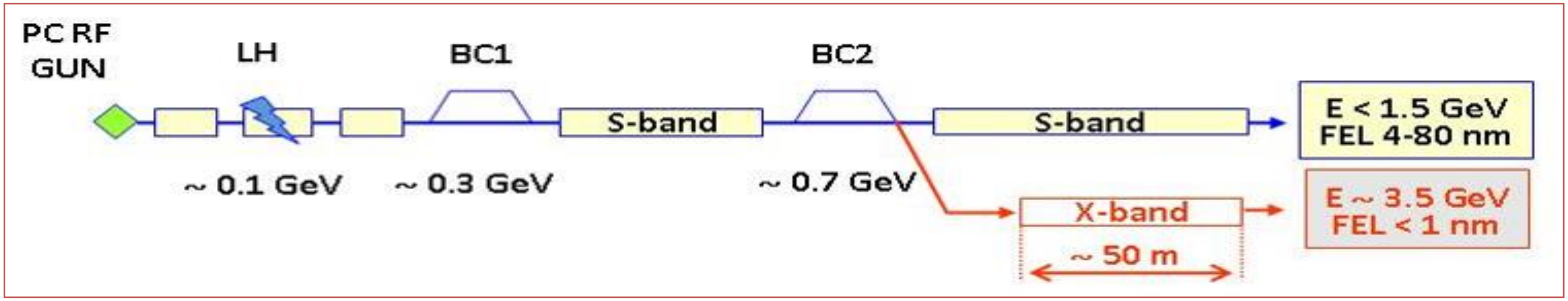
TAC Collaboration

Turkish Accelerator Centre
Infrared FEL TARLA under construction
X-FEL planned

Ankara University (Coordinator)
Gazi University
İstanbul University
Uludağ University
Dumlupınar University
Osmangazi University

Boğaziçi University
Doğuş University
Erciyes University
Süleyman Demirel University
Niğde University
Gebze Institute of Technology

ELETTRA



- Existing FEL is based on injector for synchrotron (FERMI)
- Upgrade with X-band to increase beam energy for FEL

Table 3. FEL3 expected performance.

Undulator period	30	mm
Undulator parameter	1	
Fundamental wavelength	0.5	nm
Pierce parameter	0.11%	
3-D Gain length	1.6	m
3-D Saturation length	26	m
Peak power at saturation	5.6	GW

Shanghai Photon Science Center at SINAP

Compact hard X-ray FEL (X-band, S-band)

Energy: 6.5GeV, 8GeV (200m linac)

SXFEL: Shanghai Soft X-ray FEL

S-band, C-band, X-band

Energy: 0.84GeV (Phase I), 1.3GeV (Phase II)

SSRF: Shanghai Synchrotron Radiation Facility

Energy: 3.5GeV, user operation

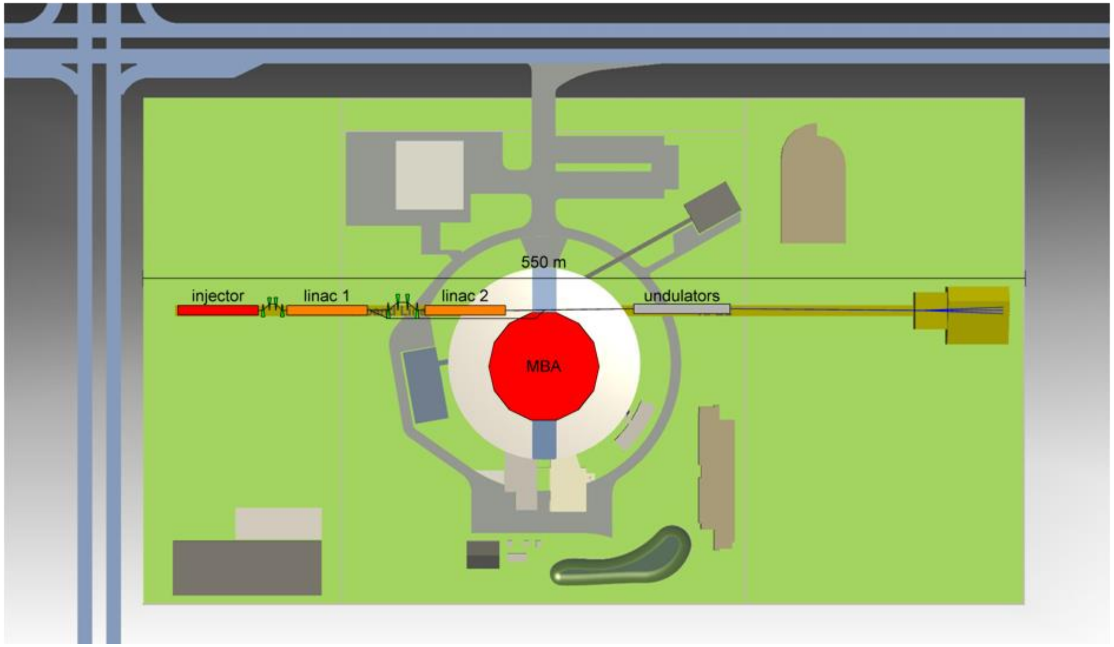
AXXS

- Strong XFEL user base with regular beamtime on LCLS and members of review committees for European XFEL
- Strong government funding, especially in life sciences

CENTRE FOR ADVANCED MOLECULAR IMAGING
AN ARC CENTRE OF EXCELLENCE

AXXS – Australian X-band X-ray Source
AXXS n. /ˈæksɪs/ *fig.* A central prop, which sustains any system.
Development plan for the Australian Light Source community:

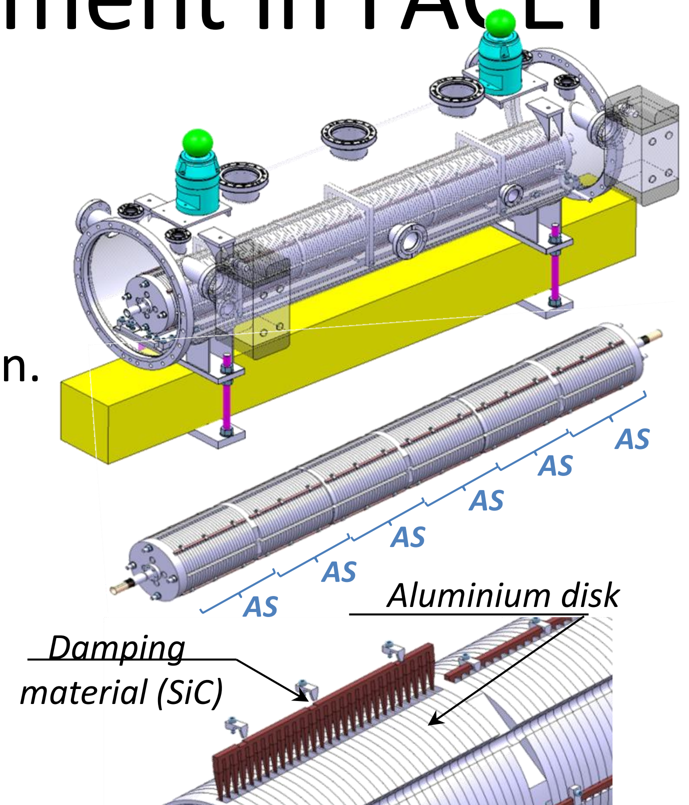
1. develop the remaining beamlines (space for an additional 6 IDs)
2. upgrade the storage ring lattice to MBA (compact MAX IV magnets)
3. upgrade the injector to a full energy x-band linac (3 GeV)
4. upgrade to additional linac for XFEL

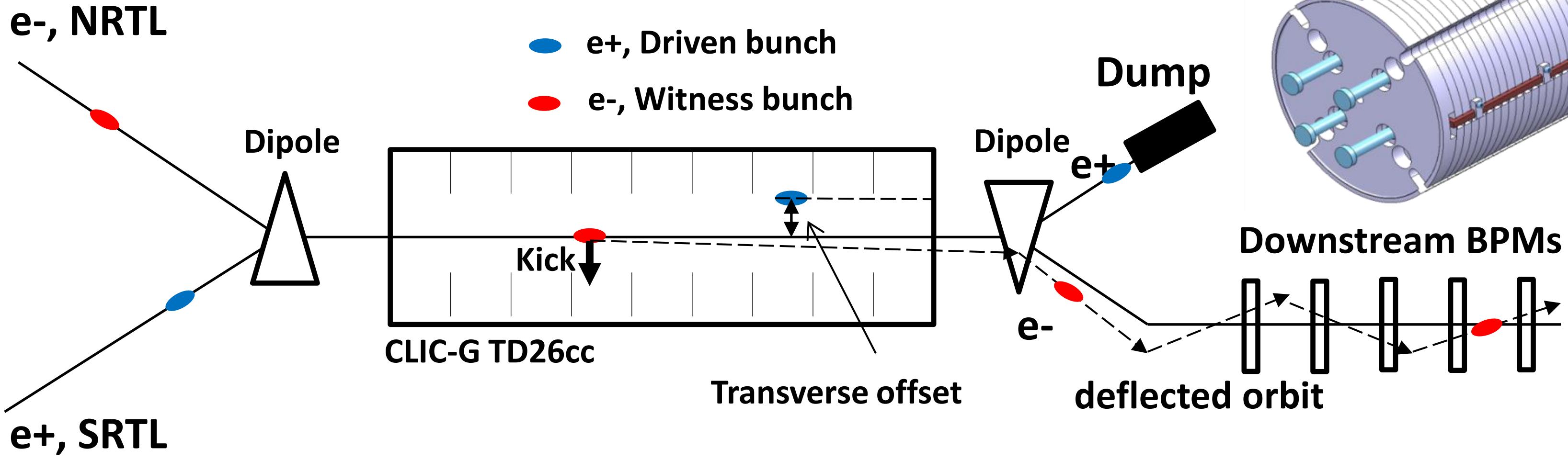


- Site constraint 550 m:
- Same tunnel, energy and source points for storage ring upgrade.
- Time constraints: need to finish building out the remaining beamlines before justifying a new ring or FEL.

Direct wakefield measurement in FACET

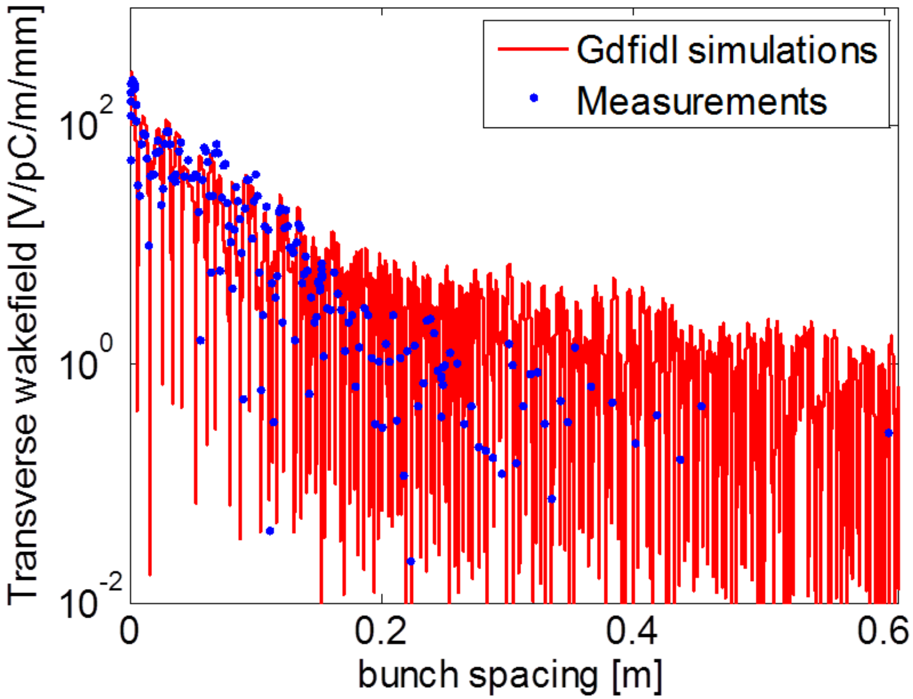
- Prototype structure are made of aluminium disks and SiC loads (clamped together by bolts).
- 6 full structures, active length = 1.38m
- FACET provides 3nC, 1.19GeV electron and positron.
- RMS bunch length is near 0.7mm.
- Maximum orbit deflection of e- due to peak transverse wake kick (1mm e+ offset): 5mm, BPM resolution: 50um

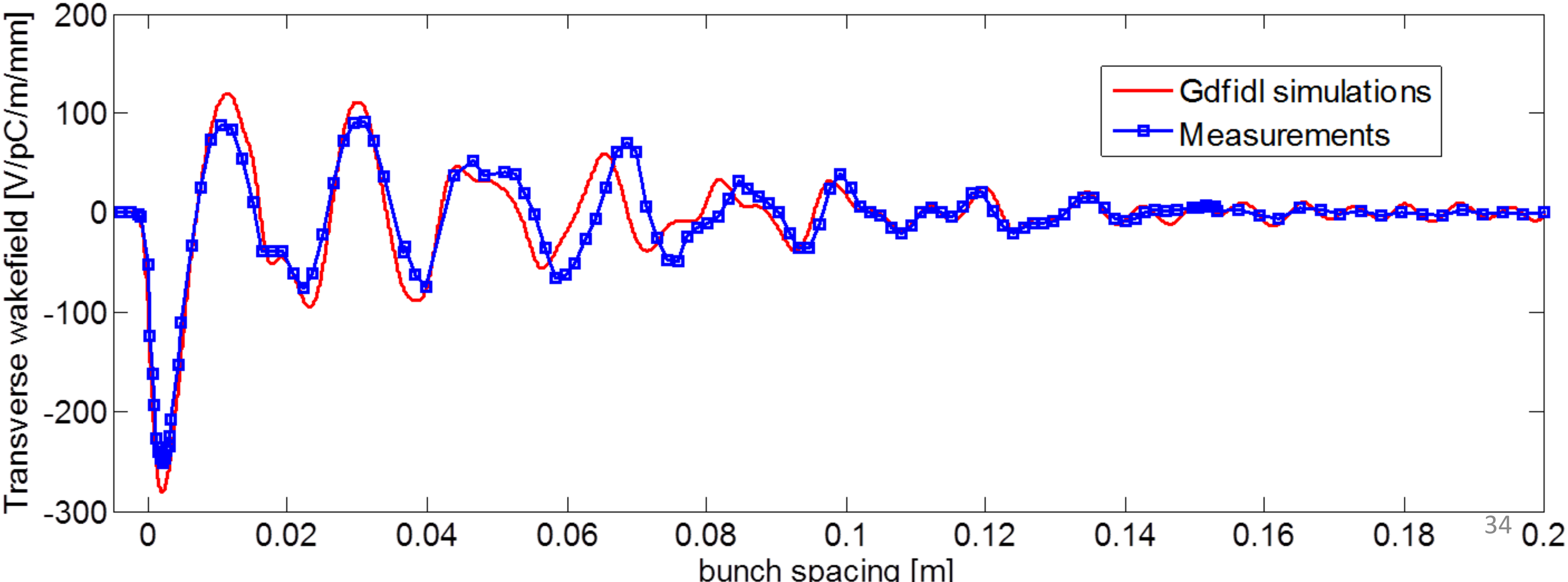




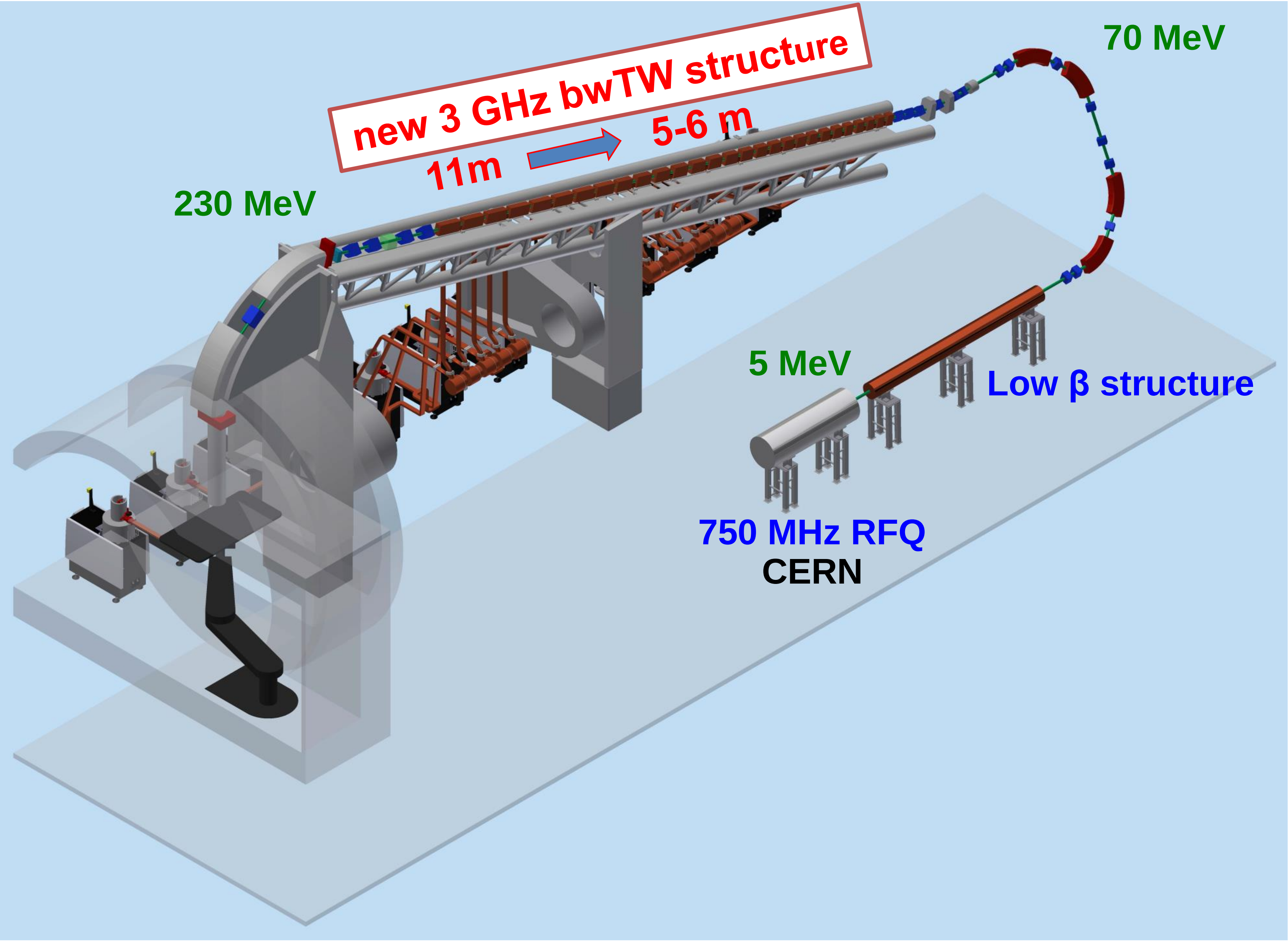
Final results

- We measure the absolutely wakefield value, peak value 10% lower than simulations.
- Wake potential at second bunch seperation = 4.5V/pC/m/mm.
- Decay faster than simulation.





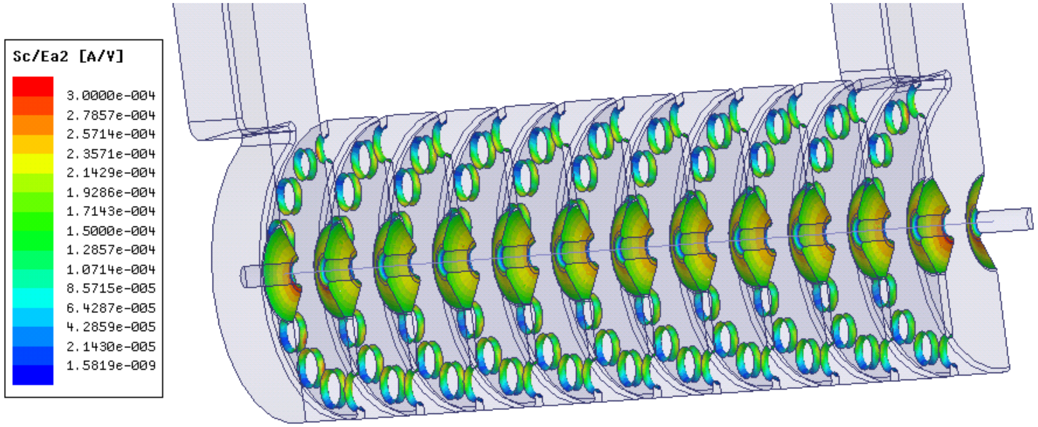
The TULIP Project

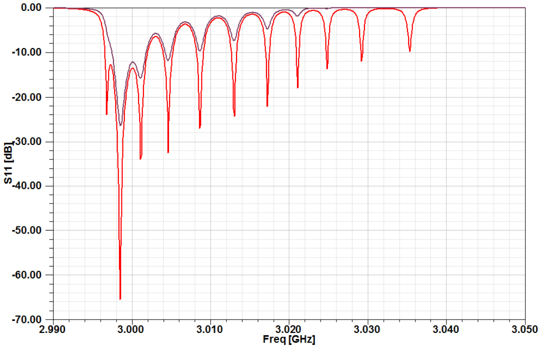


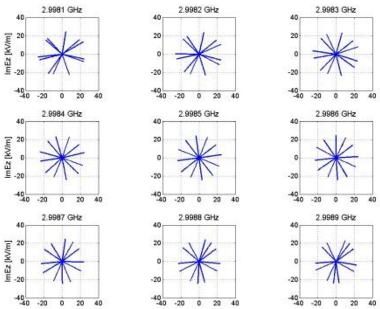
new 3 GHz bwTW structure

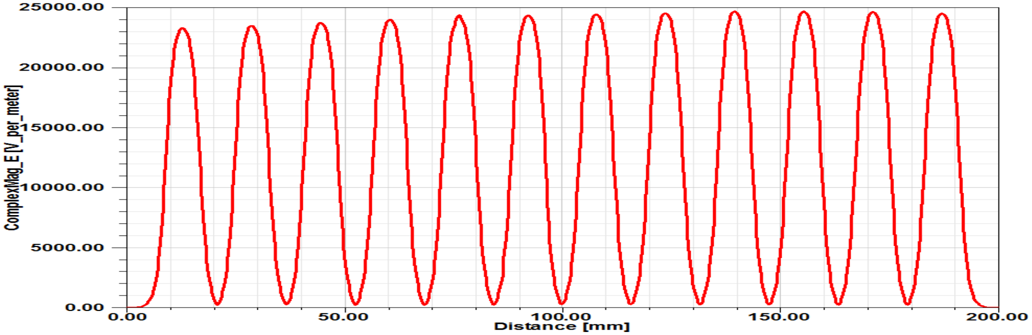
11m → 5-6 m

RF design



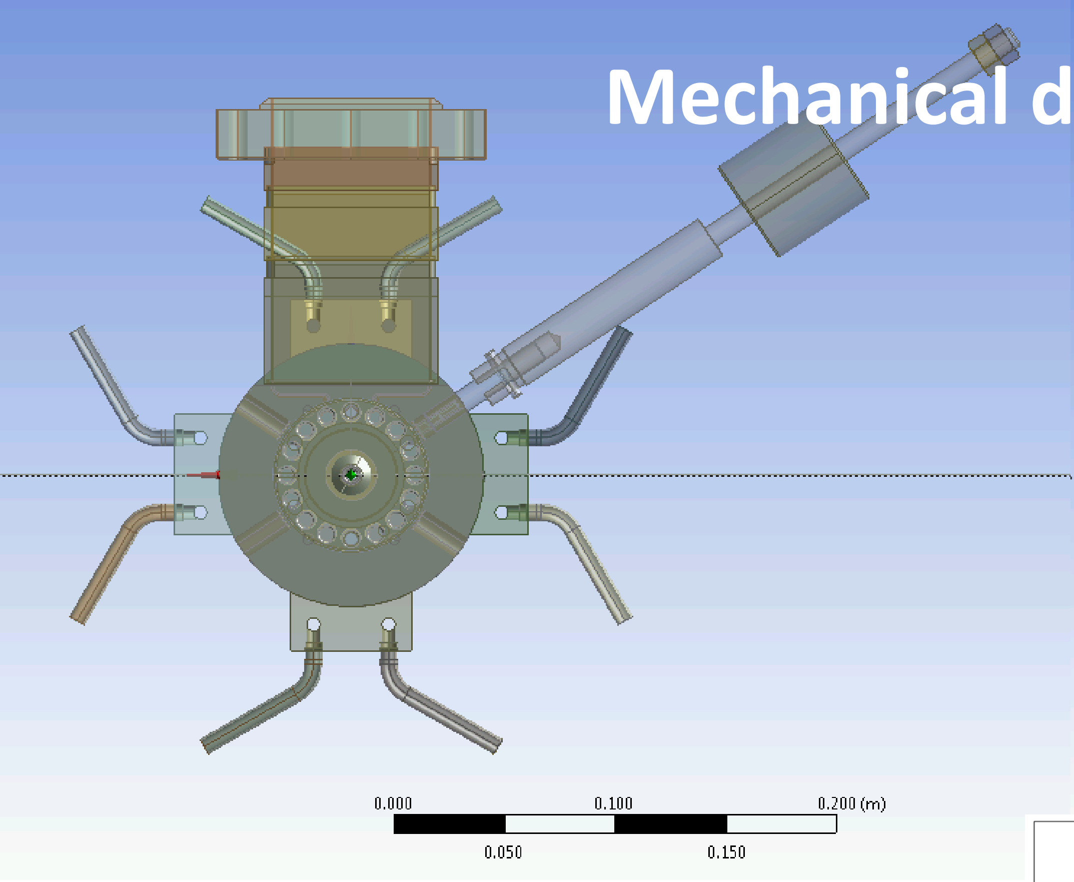


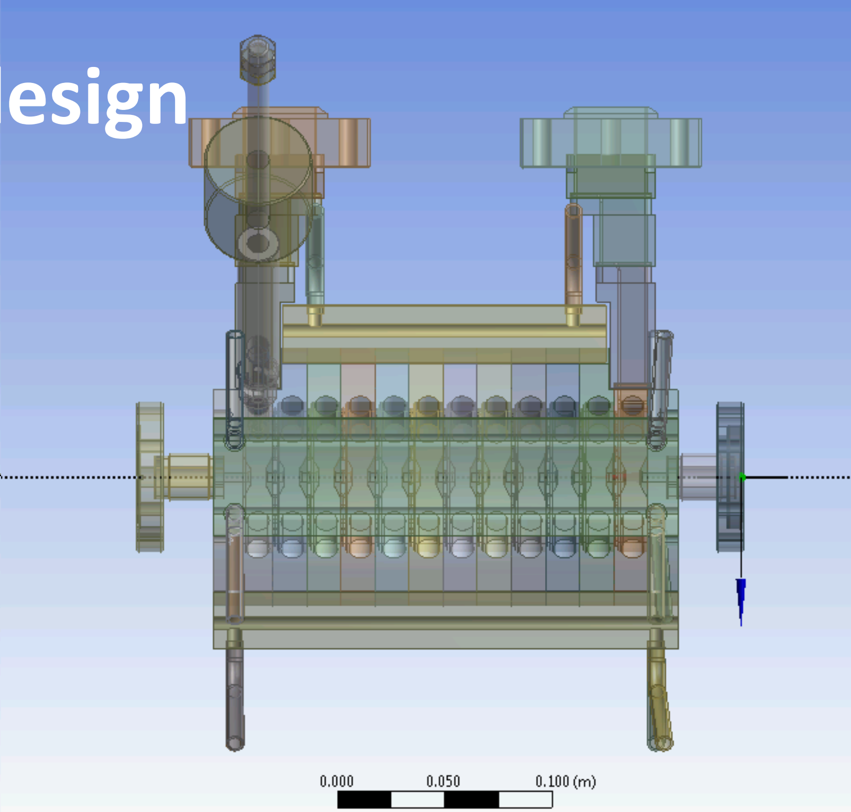


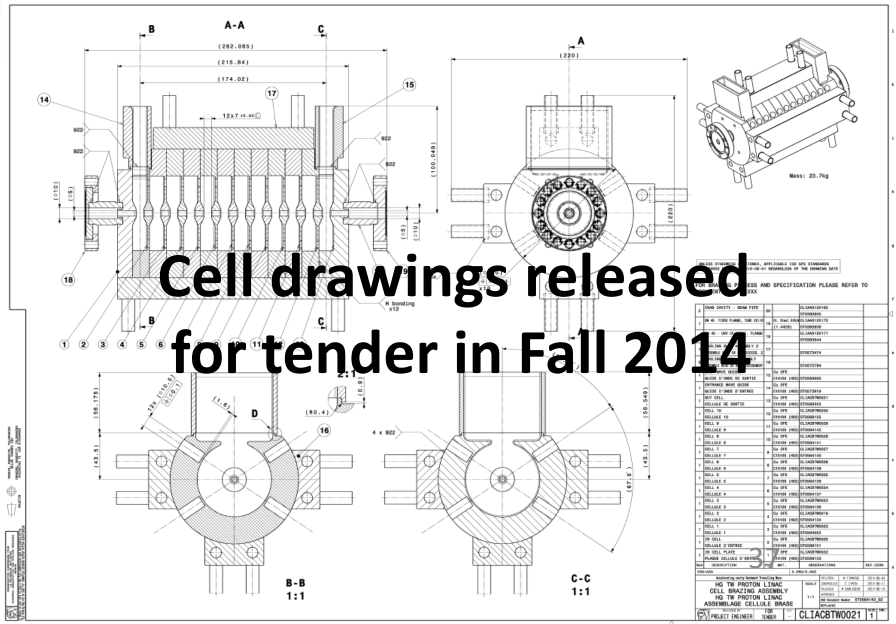


- The Sc/Ea^2 constraint has been widely respected
- A reflection lower than -50 dB at the resonant frequency of 2.9985 GHz has been reached
- Even electric field profile along the structure
- Phase advance of 5π/6 at the operating frequency chosen

Mechanical design







Cell drawings released for tender in Fall 2014

<u>How did we come to this?</u>

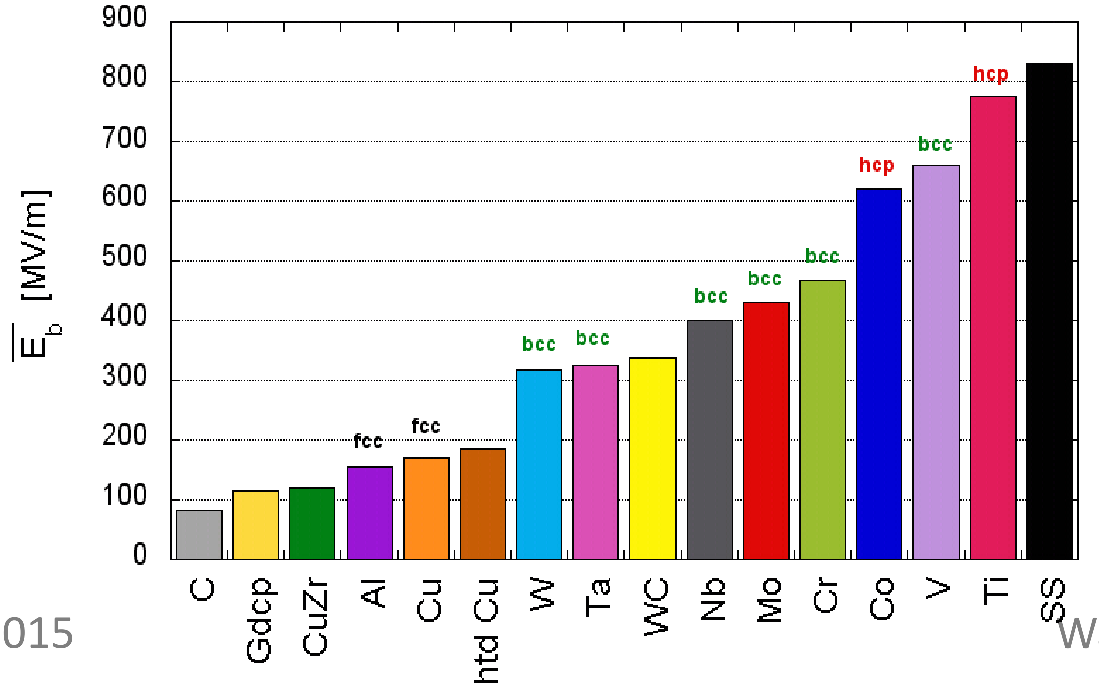
- Tolerances specification
- Creep analysis and test
- Tuning analysis and test
- Thermal and stress analysis

High-surface field R&D

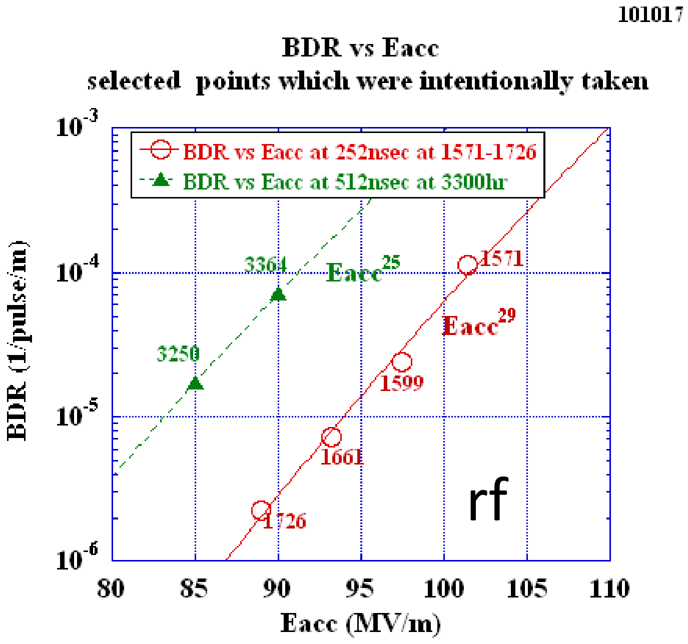
In order to support the high-gradient rf development, we also have a small collaboration studying the fundamental physics and material science of high surface fields.

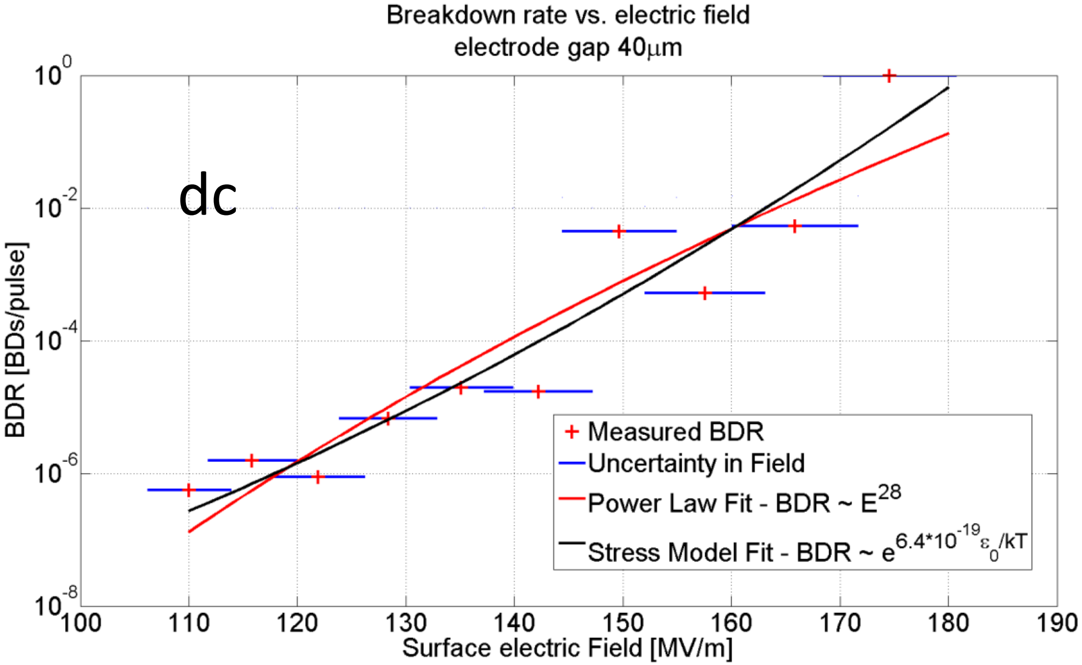
Theory and simulation – University of Helsinki, Hebrew University of Jerusalem and the University of Tartu

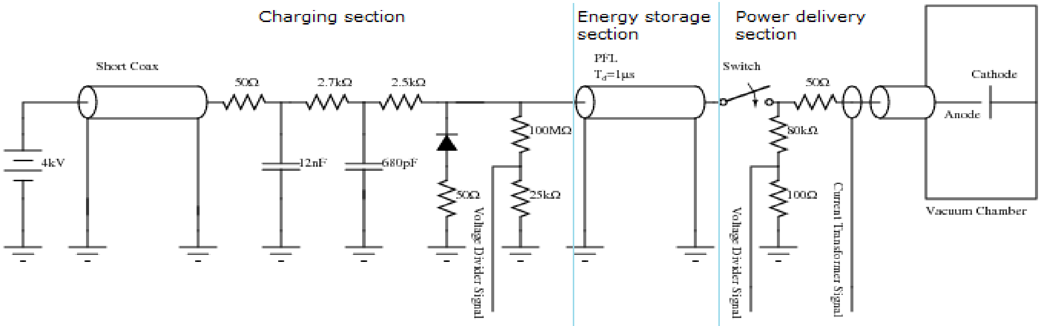
Experiment – high repetition rate pulsed dc systems at CERN

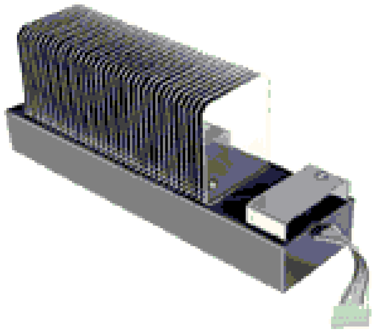


Pulse length dependence dc and rf



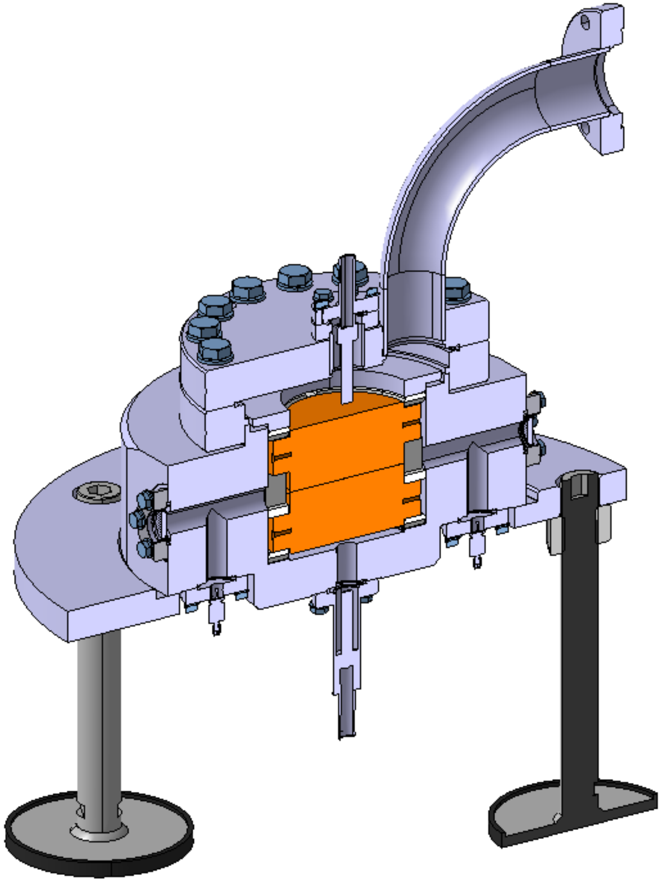


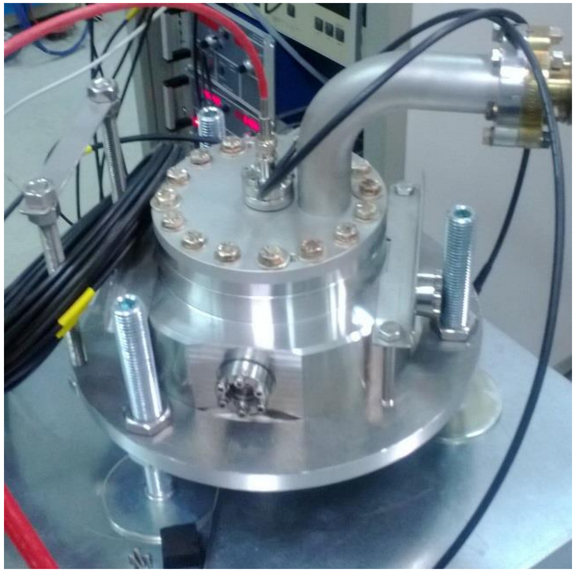


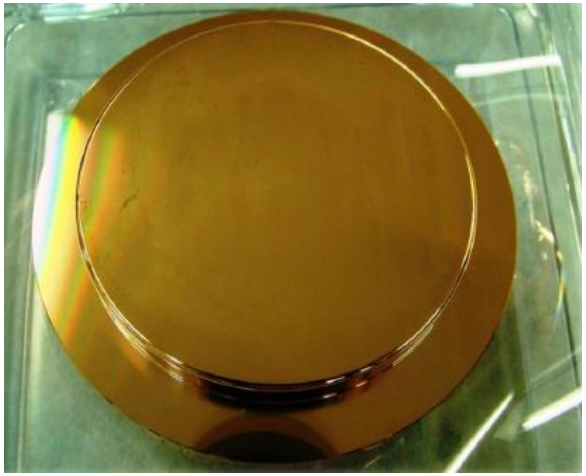


High repetition rate, 1kHz, MOSFET switch based high voltage pulser.

Large electrode system

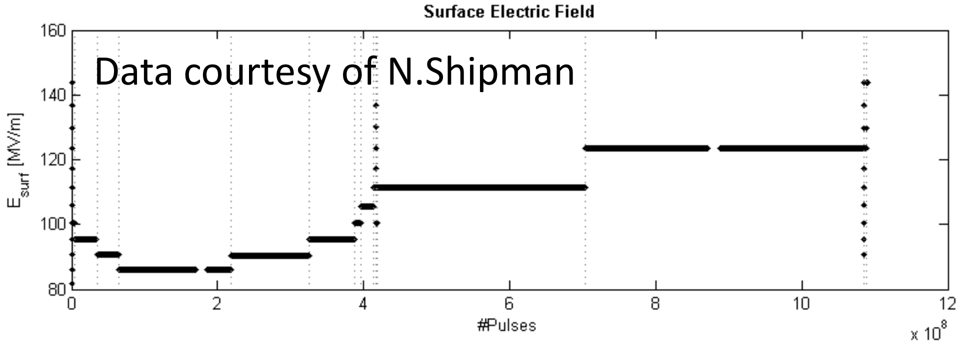


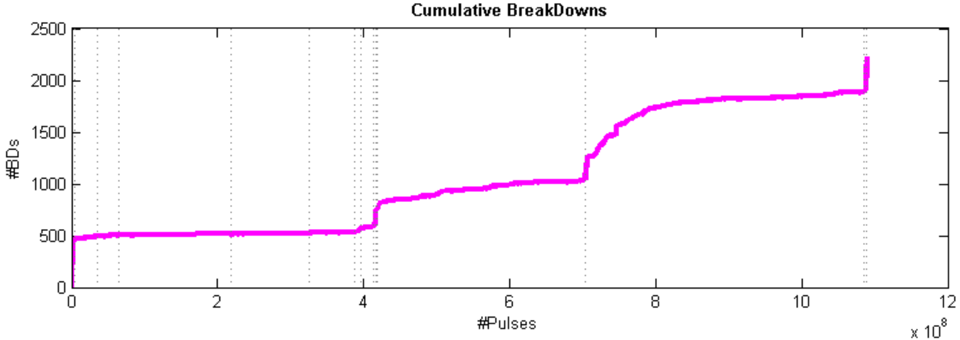




Standardized, simple, 62 mm diameter electrodes allow testing of materials and preparation procedures for basic studies and fabrication procedure optimization

High rep rate and large electrode system



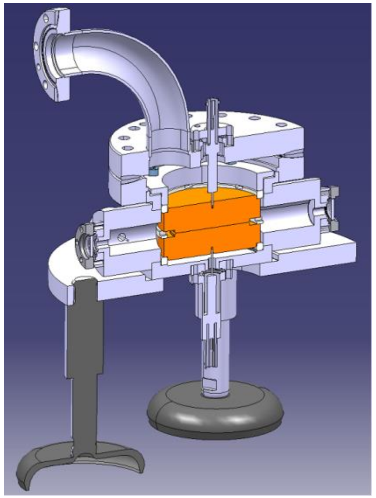


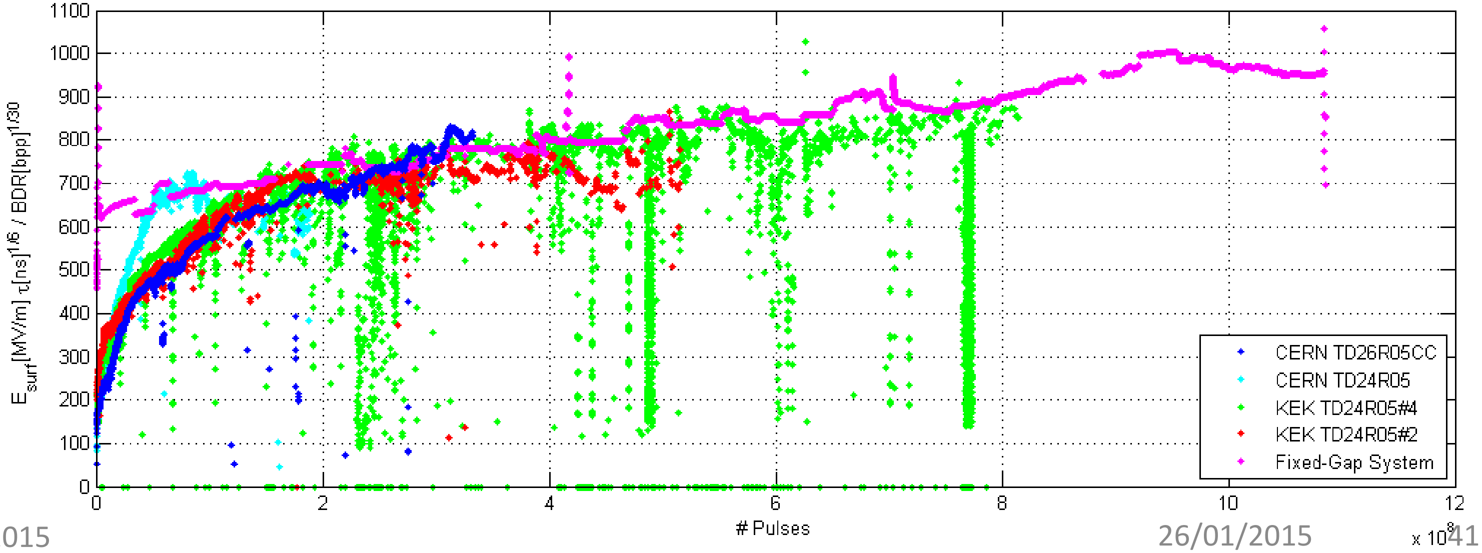
Long term behaviour remarkably similar to an rf cavity – conditioning and ultimate performance.

Much faster – x20

Much cheaper – x100

(approximately)

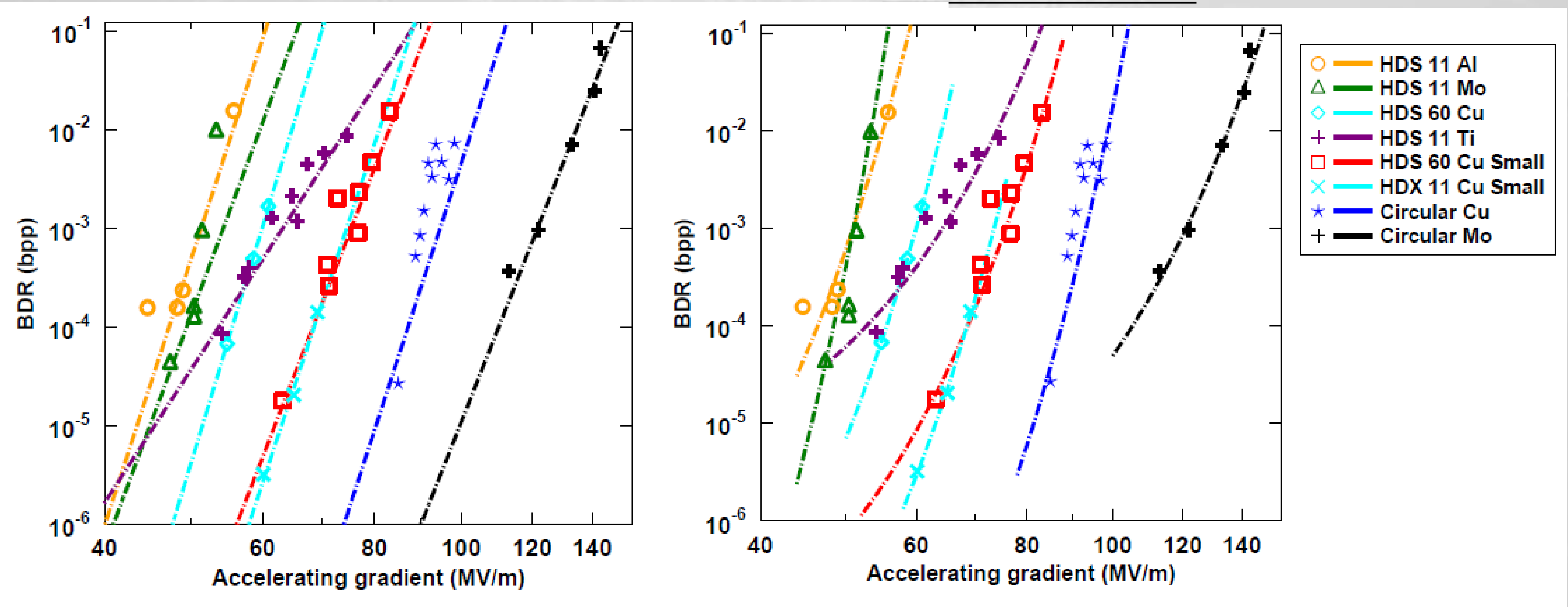




Dislocation-based model for electric field dependence

$$BDR \propto c = c_0 e^{-(E^f - \varepsilon_0 E^2 \Delta V)/kT} = c_0 e^{-E^f/kT} e^{\varepsilon_0 E^2 \Delta V/kT}$$

- Now to test the relevance of this, we fit the experimental data
- The result is:



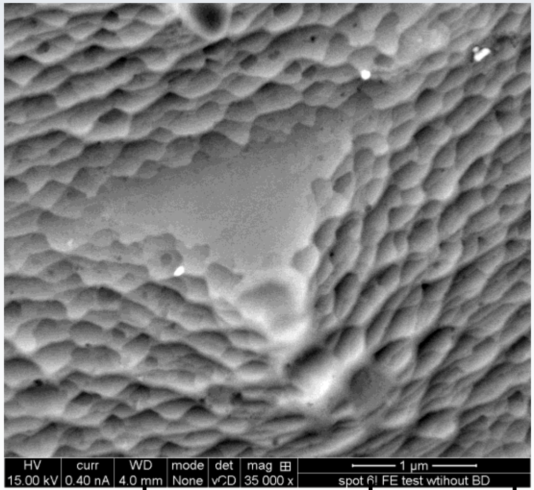
Power law fit

Stress model fit

[W. Wuensch, public presentation at the CTF3, available online at http://indico.cern.ch/conferenceDisplay.py?confId=8831.] with the model.]

Model

- Stochastic plastic model for breakdown formation:
  - BD caused by localized protrusions. These are formed due to dislocation activity within the sample resulting in protrusion growth.
  - The stochastic model, describes dislocation evolution leading to critical protrusion formation.
  - The sub breakdown population can be characterized through dark currents.
  - As it approaches the critical point – protrusion population increases leading to larger fluctuation in dark currents



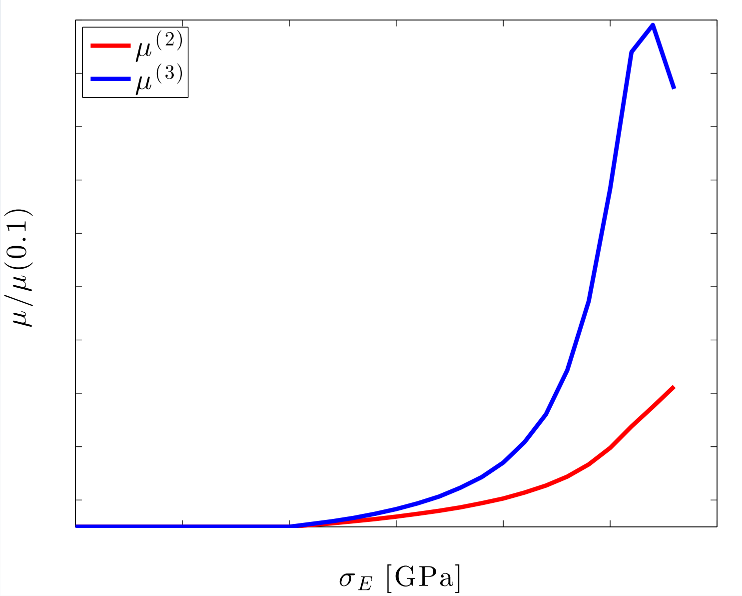
Surface protrusion as observed in the Field emission area of the DC sample.

Slide from Y. Ashkenazy

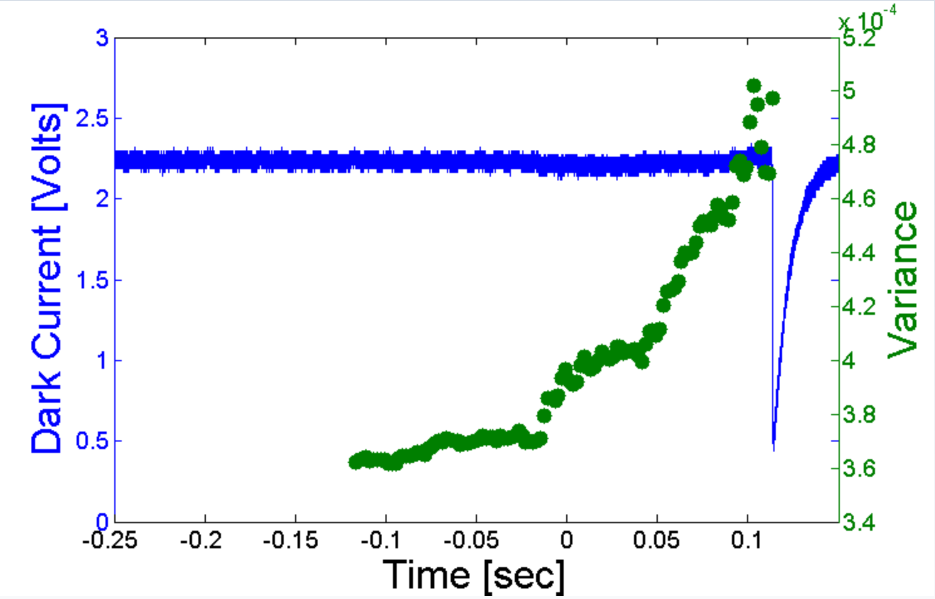
What are we looking for

- Model predicts strong fluctuations in observed current as the critical point is approached

Simulated 2nd and 3rd moment protrusion size and distribution vs driving force



Current as measured in an uncontrolled DC gap setup



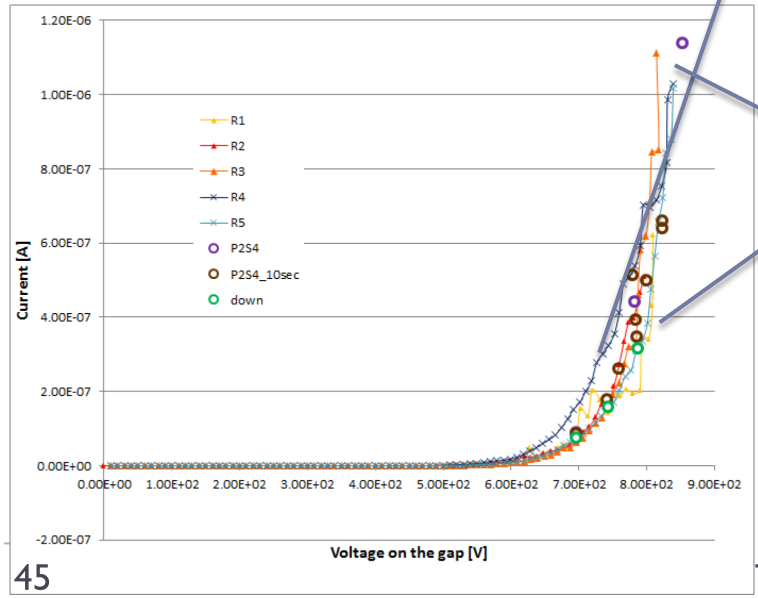
Proof of concept?

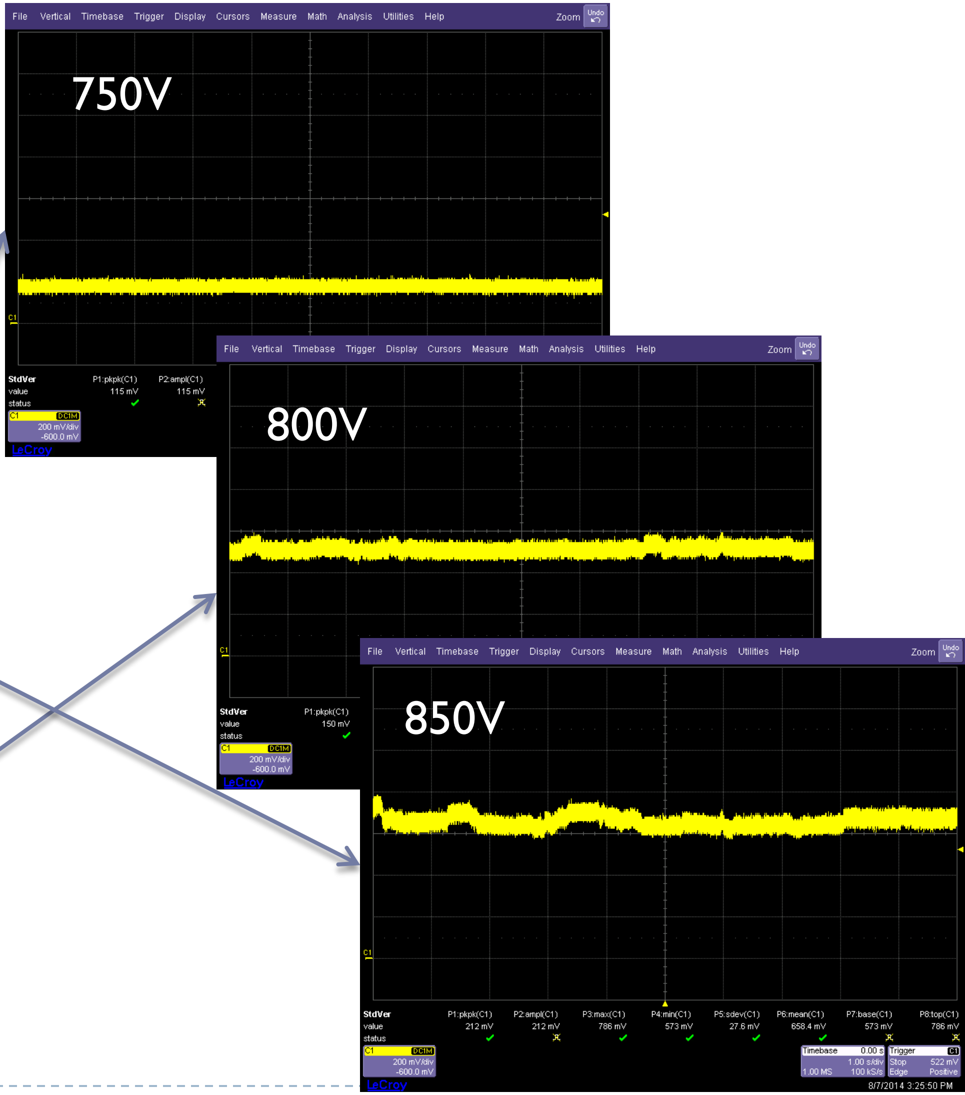
Uncontrolled gap, low I resolution,

Slide from Y. Ashkenazy

(Preliminary)
Current fluctuation measurements

- At higher field, higher average current & higher fluctuation were observed.
- Still need to improve current resolution.





750V

StdVer	P1:pkpk(C1)	P2:ampl(C1)
value	115 mV	115 mV
status	✓	☒

C1 DC1M 200 mV/div -600.0 mV

800V

StdVer	P1:pkpk(C1)
value	150 mV
status	✓

C1 DC1M 200 mV/div -600.0 mV

850V

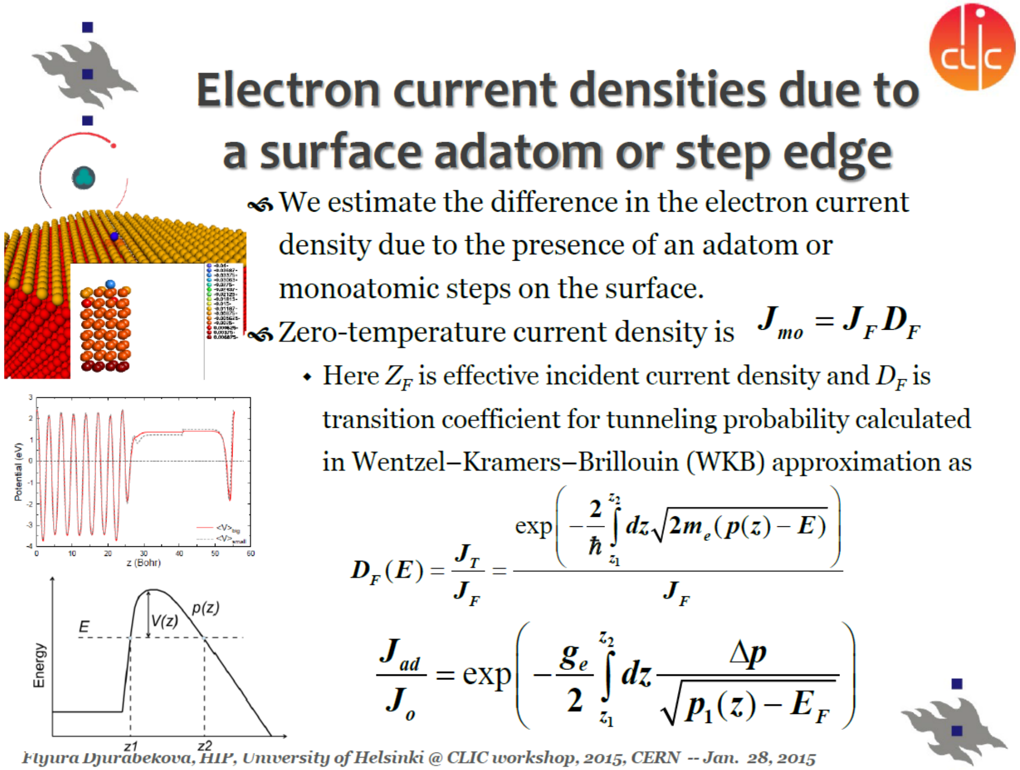
StdVer	P1:pkpk(C1)	P2:ampl(C1)	P3:max(C1)	P4:min(C1)	P5:sdev(C1)	P6:mean(C1)	P7:base(C1)	P8:top(C1)
value	212 mV	212 mV	786 mV	573 mV	27.6 mV	658.4 mV	573 mV	786 mV
status	✓	☒	✓	✓	✓	✓	☒	☒

C1 DC1M 200 mV/div -600.0 mV

Timebase 0.00 s 1.00 s/div 1.00 MS 100 kS/s

Trigger C1 Stop 522 mV Edge Positive

8/7/2014 3:25:50 PM



Electron current densities due to a surface adatom or step edge

- We estimate the difference in the electron current density due to the presence of an adatom or monoatomic steps on the surface.
- Zero-temperature current density is $J_{mo} = J_F D_F$
  - Here Z_F is effective incident current density and D_F is transition coefficient for tunneling probability calculated in Wentzel–Kramers–Brillouin (WKB) approximation as

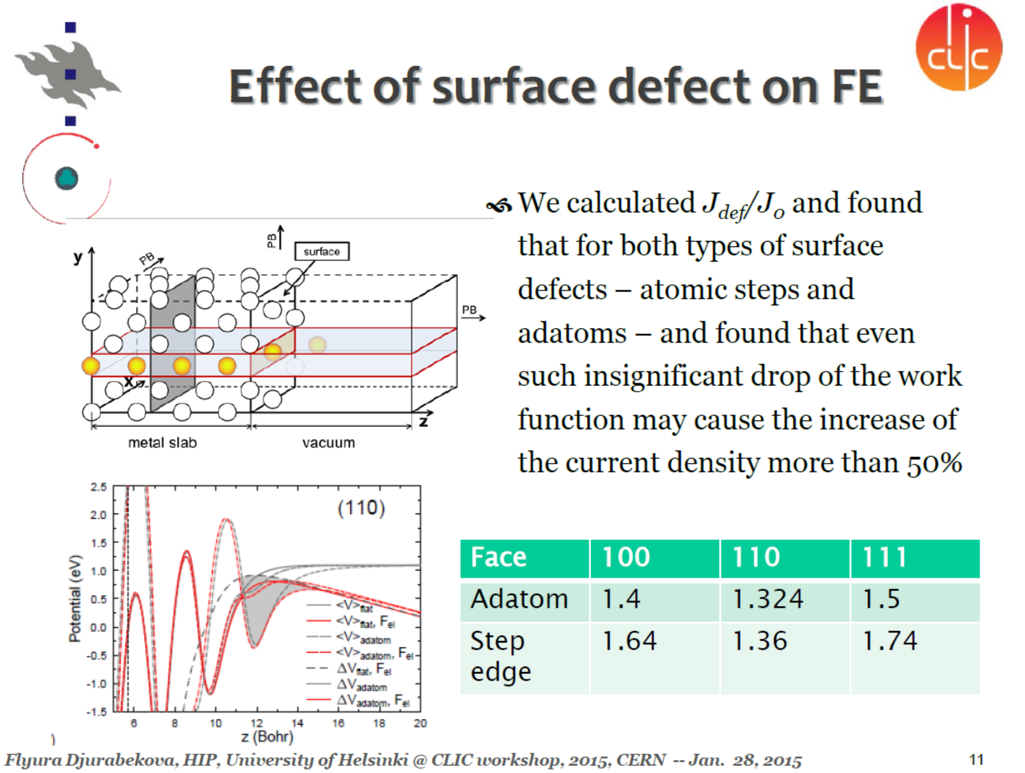
$$D_F(E) = \frac{J_T}{J_F} = \frac{\exp\left(-\frac{2}{\hbar}\int_{z_1}^{z_2} dz\sqrt{2m_e(p(z)-E)}\right)}{J_F}$$

$$\frac{J_{ad}}{J_o} = \exp\left(-\frac{g_e}{2}\int_{z_1}^{z_2} dz\frac{\Delta p}{\sqrt{p_1(z)-E_F}}\right)$$

Field emission from surfaces with atomic level features

University of Helsinki

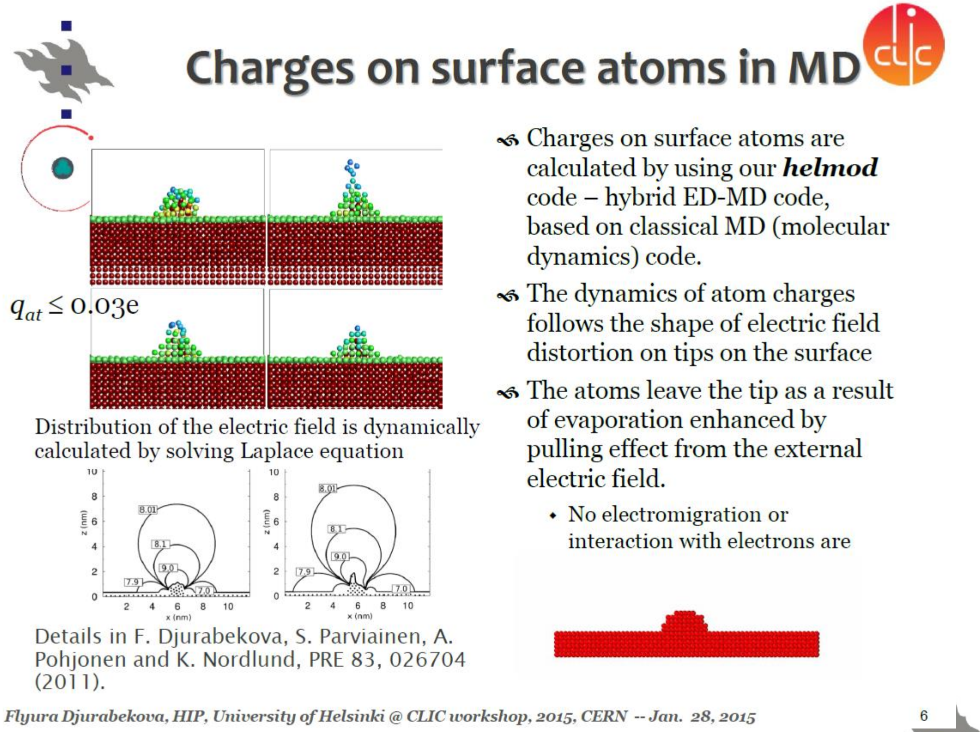
KEK, 9 March 2015



Effect of surface defect on FE

- We calculated J_{def}/J_o and found that for both types of surface defects – atomic steps and adatoms – and found that even such insignificant drop of the work function may cause the increase of the current density more than 50%

Face	100	110	111
Adatom	1.4	1.324	1.5
Step edge	1.64	1.36	1.74



Charges on surface atoms in MD

$q_{at} \leq 0.03e$

Distribution of the electric field is dynamically calculated by solving Laplace equation

Details in F. Djurabekova, S. Parviainen, A. Pohjonen and K. Nordlund, PRE 83, 026704 (2011).

- Charges on surface atoms are calculated by using our ***helmod*** code – hybrid ED-MD code, based on classical MD (molecular dynamics) code.
- The dynamics of atom charges follows the shape of electric field distortion on tips on the surface
- The atoms leave the tip as a result of evaporation enhanced by pulling effect from the external electric field.
    - No electromigration or interaction with electrons are

Flyura Djurabekova, HIP, University of Helsinki @ CLIC workshop, 2015, CERN -- Jan. 28, 2015

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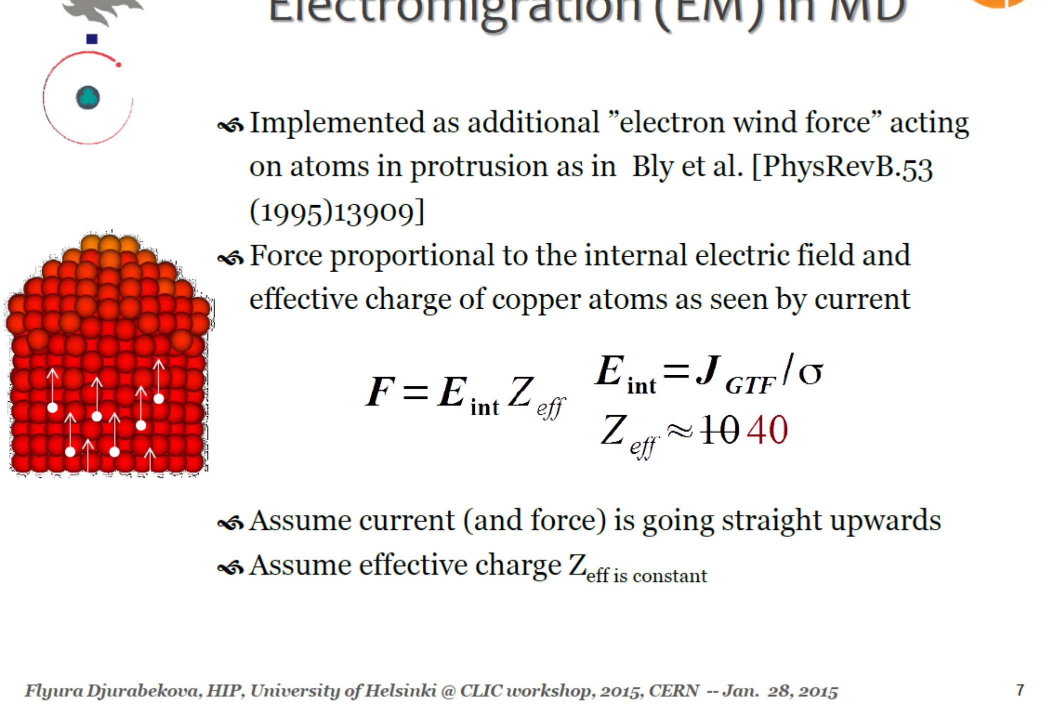

Electromigration (EM) in MD

- Implemented as additional ”electron wind force” acting on atoms in protrusion as in Bly et al. [PhysRevB.53 (1995)13909]
- Force proportional to the internal electric field and effective charge of copper atoms as seen by current

$$F = E_{\text{int}} Z_{eff} \qquad E_{\text{int}} = J_{GTF}/\sigma \qquad Z_{eff} \approx \cancel{10}\ 40$$

- Assume current (and force) is going straight upwards
- Assume effective charge $Z_{\text{eff is constant}}$

Flyura Djurabekova, HIP, University of Helsinki @ CLIC workshop, 2015, CERN -- Jan. 28, 2015

7

Dynamics of atomic level features under influence of high surace electric fields

University of Helsinki

KEK, 9 March 2015

Conclusions

- The CLIC project has fixed it’s initial energy stage at 380 GeV. The baseline designs at this initial and 3 TeV energies are being updated. We eagerly await LHC run 2.
- Accelerating structures routinely operate in the range of 100 MeV and a large increase in manufacturing and testing capability is underway.
- We actively work with other applications of X-band and high-gradient technology.
- Significant advances in the understanding of high surface fields are being made.

Upcoming events

International Workshop on Breakdown Science and High Gradient Technology

(HG2015)

June 16-19, 2015

Tsinghua University
Beijing, China

https://indico.cern.ch/event/358352/

Meeting Chair
Tang, Chuanxiang

International Organizing Committee
D'Auria, Gerardo (Sincrotrone Trieste)
Gai, Wei (ANL)
Higo, Toshiyasu (KEK)
Tantawi, Sami (SLAC)
Wuensch, Walter (CERN)

Local Organizing Committee
Chen, Huaibi (Chair)
Huang, Wenhui
Shi, Jiaru
Zhang, Liang
Wang, Ping
Fan, Xue

Mechanisms of Vacuum Arcs-5

2-4 September, 2015

The workshop aims to combine the efforts of researchers in different fields to understand the mechanisms underlying the highly intriguing phenomenon of electrical breakdown. The workshop will cover rf and dc types of electrical breakdowns, including theory, experiment, and simulation. The workshop will be preceded by a half-day mini-school on modeling surface (electrode) evolution processes relevant to electrical breakdown phenomena.

Topics

Experiments: vacuum arcs, dc spark systems, rf accelerating structures, materials, diagnostics, techniques and technologies for high gradients, and arcing in fusion devices.

Theory and simulations: surface modification under electric and electromagnetic fields, PIC and PIC-DSMC plasma simulations, dislocation activity, plasma-wall interactions, and surface damage and evolution.

Applications: particle accelerators, discharge-based devices, electrostatic failure mitigation, fusion devices, satellites and other industrial interests.

Venue

The workshop will be held in Saariselkä, Lapland. Lappish ruska is the time of beautiful autumn colors.

Organizers

Flyura Djurabekova
HIP, University of Helsinki, Finland
Walter Wuensch, Sergio Calatroni
CERN, Switzerland
Matthew Hopkins
Sandia National Laboratories, USA
Yinon Ashkenazy
Hebrew University of Jerusalem, Israel

http://indico.cern.ch/conferenceDisplay.py?confId=246618