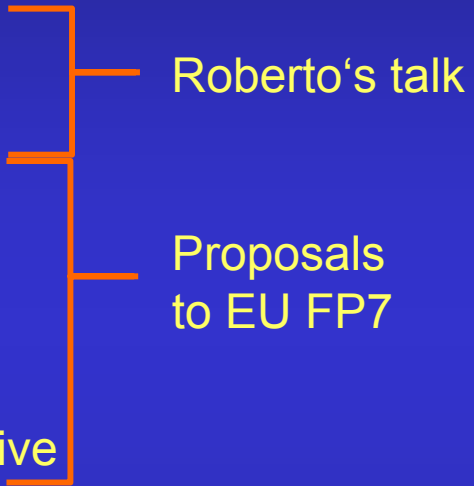


# Review of (addressed and non addressed) key Issues including Future Activities, Technical Program in Preparation of CDR

Hans-H. Braun, CLIC ACE, June 21, 2007

- Baseline program
  - EUROTeV
  - RF structure initiative
  - LED initiative
  - EURODRIVE initiative
  - R&D on damping ring hardware and GADGET initiative
  - (green ?) X band RF test facilities
  - JLab package
  - Dark current
  - Klystrons for drive beam accelerator
  - Beam loss management, machine protection systems
  - Miscellaneous
- 
- The diagram consists of two orange brackets on the right side of the slide. The top bracket, labeled 'Roberto's talk', encompasses the first four items of the list: 'Baseline program', 'EUROTeV', 'RF structure initiative', and 'LED initiative'. The bottom bracket, labeled 'Proposals to EU FP7', encompasses the next four items: 'EURODRIVE initiative', 'R&D on damping ring hardware and GADGET initiative', '(green ?) X band RF test facilities', and 'JLab package'.

## Baseline program until CDR

RF Structure development (talks of Walter and Steffen)

CTF3 (talks of Günther and Frank)


Civil Engineering and tech. infrastructure studies

Cost Study

Two Beam module design

Active pre-alignment systems

Beam physics (Daniel's talk)

- Dynamic effects during alignment
  - Luminosity tuning monitor
  - Ring to ML & BDS alignment
  - Integrated feedbacks
  - Fast beam ion instability (DR+LET)
  - Intra beam scattering (DR)
  - Electron cloud (DR+LET)
  - Impedances (DR+LET)
  - DR lattice optimisation, tolerances, correction algorithms
  - BDS optimisation and participation in ATF2 commissioning
  - Return line design
  - MPS concept
- 
- EU EUROTeV

# FP6 EUROTeV funded activities (ongoing)

## Diagnostic hardware

Main linac BPM's (100nm resolution, 10µm precision)

Wide band wall current monitors bandwidth >20 GHz for drive beam diagnostics

Precision phase measurements with better 0.1 deg.

Development of 3D electron cloud code (completed, shows that we have an issue in e<sup>+</sup> ring)

## Beam dynamics activities

Task ID	Contact Persons	Task Reporter	Task	Description
<a href="#">BDCS</a>	M. Pedrozzi (PSI)	M. Pedrozzi	Bunch Compression Design	<i>conceptual design of bunch compression system suitable for multi-TeV colliders, conceptual design of path length tuning chicane, basic parameter optimisation, performance simulation</i>
<a href="#">PCDL</a>	V.Ziemann (Uppsala) Ph. Bambade (Orsay)	V. Ziemann	Post-Collision Diagnostics Lattice	<i>tracking simulations with emphasis on location of possible post-IP diagnostics, evaluation of physics potential of post-IP diagnostics, design of extraction line for multi-TeV collider</i>
<a href="#">BBSIM</a>	Ph. Bambade (Orsay) D. Schulte (CERN)	Ph. Bambade	Beam-Beam Simulation Code Development	<i>benchmarking of physics processes in GUINEA-PIG against known and trusted physics generators, implementation of spin transport into GUINEA-PIG</i>
<a href="#">HTGEN</a>	H. Burkhardt (CERN) L. Neukermans (CERN)	H. Burkhardt	Halo and Tail Generation	<i>study of potential sources of halo and tail generation in the LET, development of analytical models of halo, estimates of halo population, development of computer models for halo/tail generation, simulation studies of halo/tail generation, explore possibilities for benchmarking</i>
<a href="#">COLSIM</a>	N. Walker (DESY) R. Barlow (UMA) G. Blair (RHUL) D. Schulte (CERN) A. Faus-Golfe (Valencia)	G. Blair	Collimation Simulations	<i>simulation of post-linac beam halo collimation, estimation of collimator efficiency, optimisation of collimation system, simulations of muon and neutron production in collimator sections, estimates of impact of physics detector performance, studies of muon and neutron production, impact of luminosity tuning on halo collimation efficiency;</i>
<a href="#">FMSIM</a>	N. Walker (DESY) D. Schulte (CERN)	N. Walker	Failure Mode & Effect Simulations	<i>determination of set of key failure modes (FM), simulation of FMs using sophisticated ILC modelling codes, evaluation of impact of FMs on accelerator performance / design, specific attention to BDS spoiler protection</i>
<a href="#">LAST</a>	Ph. Burrows (QMUL) N. Walker (DESY) D. Schulte (CERN)	Ph. Burrows	Luminosity and Alignment Studies	<i>development of sophisticated models of the ILC from DR to IP, further development of beam-based alignment algorithms, simulations of algorithms with relevant machine imperfections, impact of upstream on downstream tuning, identify / specify diagnostics requirements, understand tuning time-scales, simulations of beam-base feedback systems in the presence of time-dependent environmental effects (e.g. ground motion), studies of intra-train and repetition rate based feedback, beam-beam feedback, fast luminosity feedback, interaction of feedback systems, optimisation of stabilisation algorithms and number of feedback stations</i>

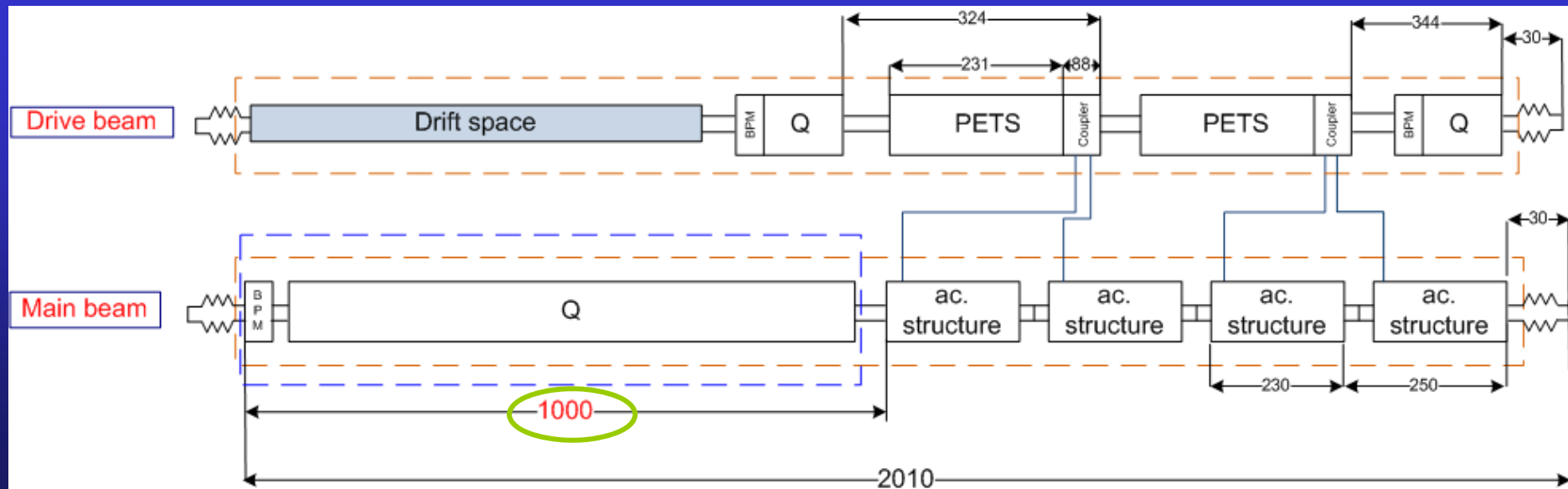
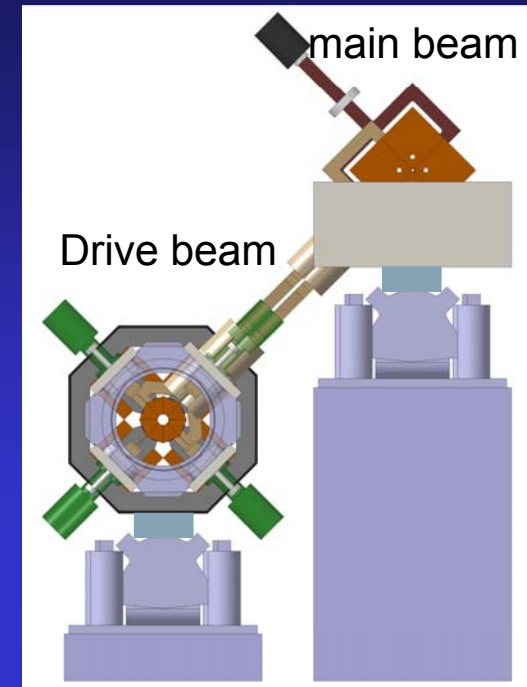
## LED proposal for EU FP7

CLIC main linac module with one quadrupole including

- Vibration damping for quadrupole
- Active pre-alignment system with sensors
- Structure BPM
- Test with beam in CTF3 TBTS (beam height problem)

Vibration sensors for final doublet quadrupoles

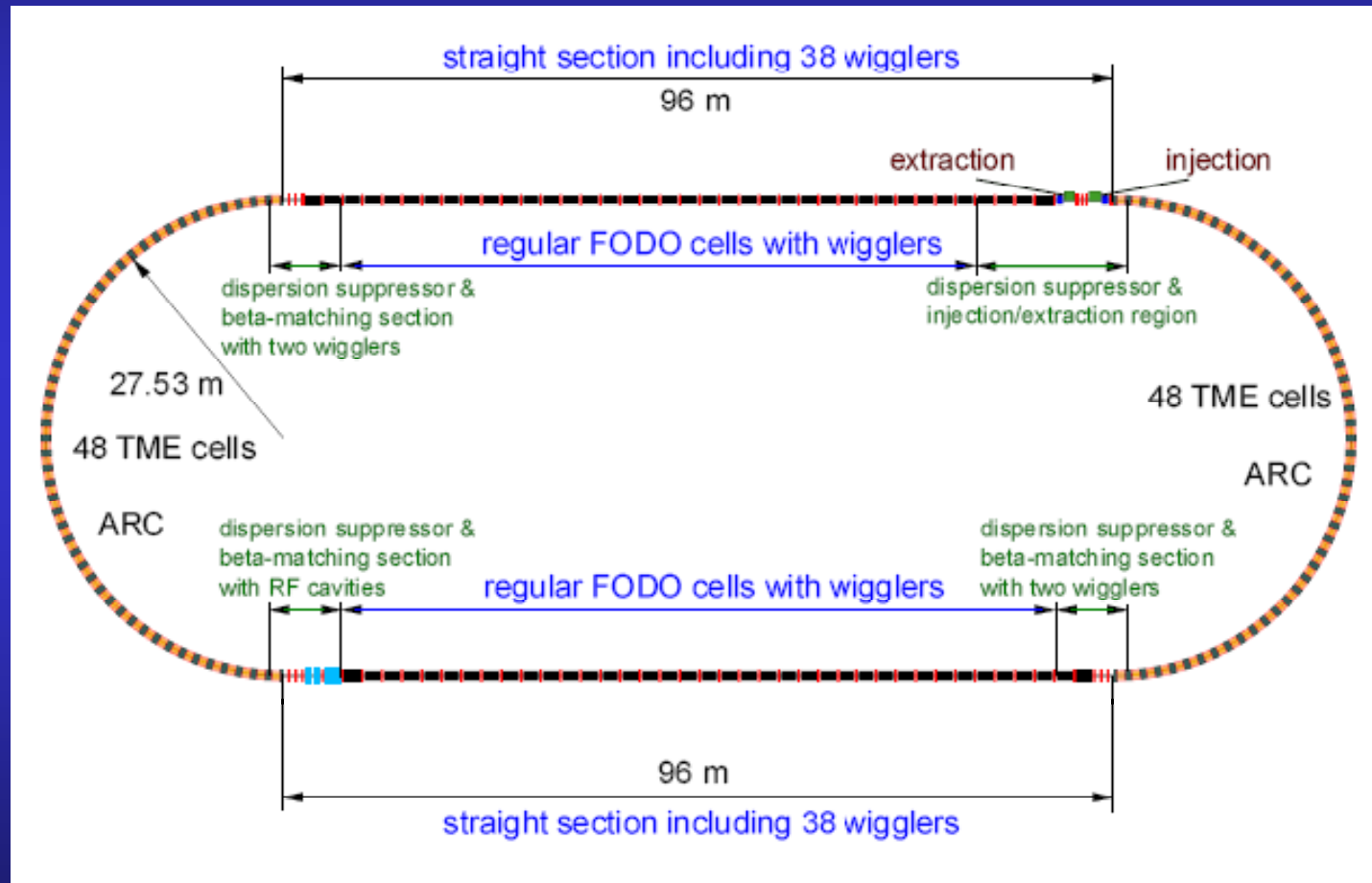
Test of CLIC crab cavity prototypes with beam in CTF3



## EURODRIVE proposal for FP7

- Start to end simulation of drive beam including  
Trajectory and optics measurement and correction algorithm
- Integrate this program package in CTF3 controls and test with real beam
- Beam phase measurement in CTF3

## R&D for damping ring hardware



## S.C. wiggler magnet development for CLIC DR

Existing CERN-BINP collaboration has produced paper design including SR absorbers.

Presently a short prototype is constructed for demonstration of magnetic feasibility and field measurement as input for beam dynamic simulations.

ANKA wiggler team has made a paper design for a s.c. wiggler with more aggressive parameters.

## GADGET proposal for EU FP7

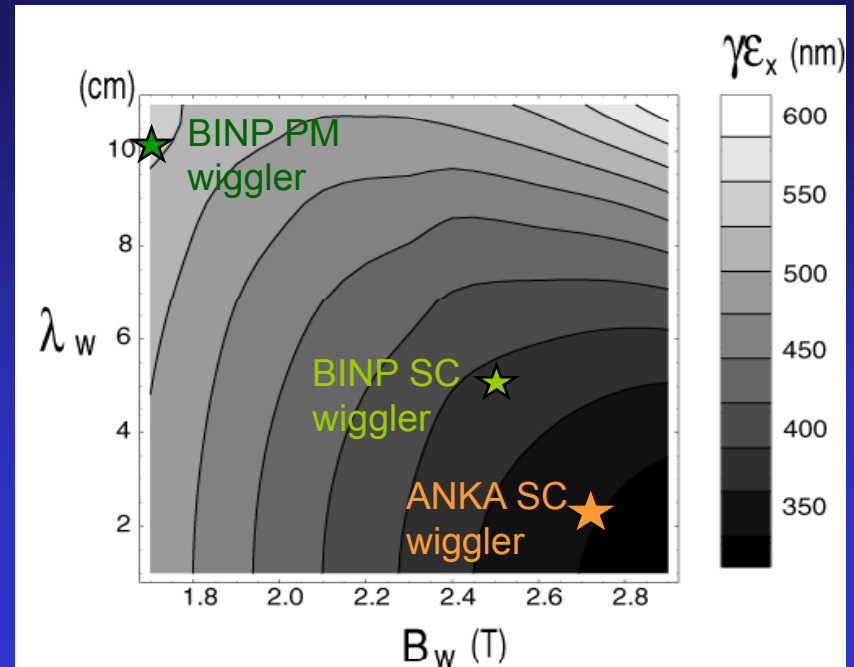
Design & production of full size (2m) prototype of each wiggler type including tests with beam in ANKA 2.5 GeV SR source for.

Development of kickers with nominal CLIC DR parameters using solid state pulser technology

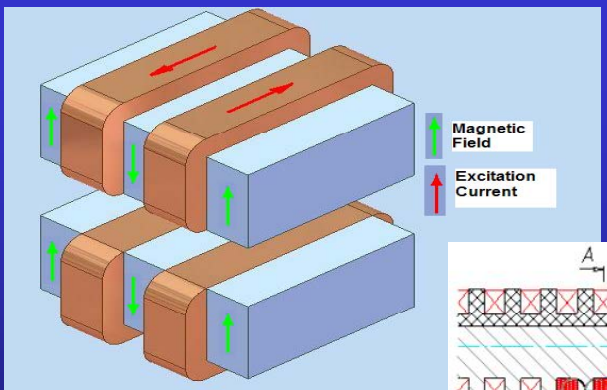
Theoretical and experimental studies of IBS in regime relevant for CLIC DR at ANKA and SLS

Development of diagnostic equipment test beamline ITB in CTF3

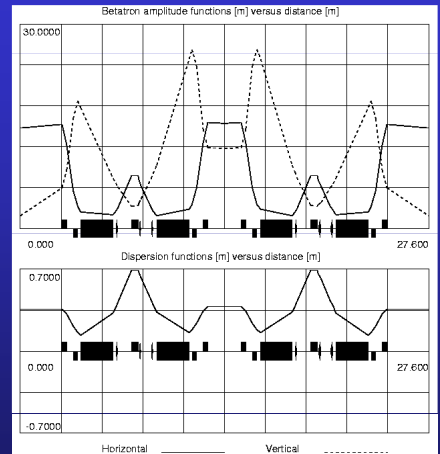
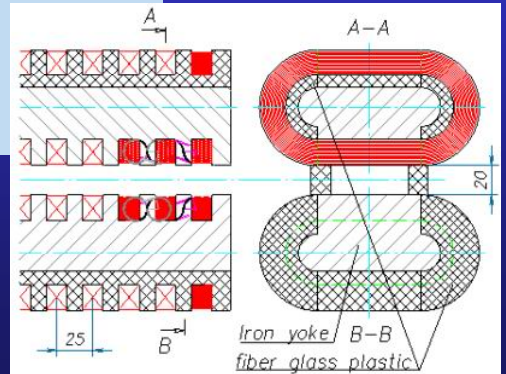
	BINP	ANKA
$B_{\text{peak}}$	2.5 T	2.7 T
$\lambda_w$	50 mm	21 mm
Beam aperture full height	12 mm	5 mm
Conductor type	NbTi	NbSn <sub>3</sub>
Operating temperature	4.2 K	4.2 K



Contour plot of horizontal emittance with IBS as function of wiggler parameters



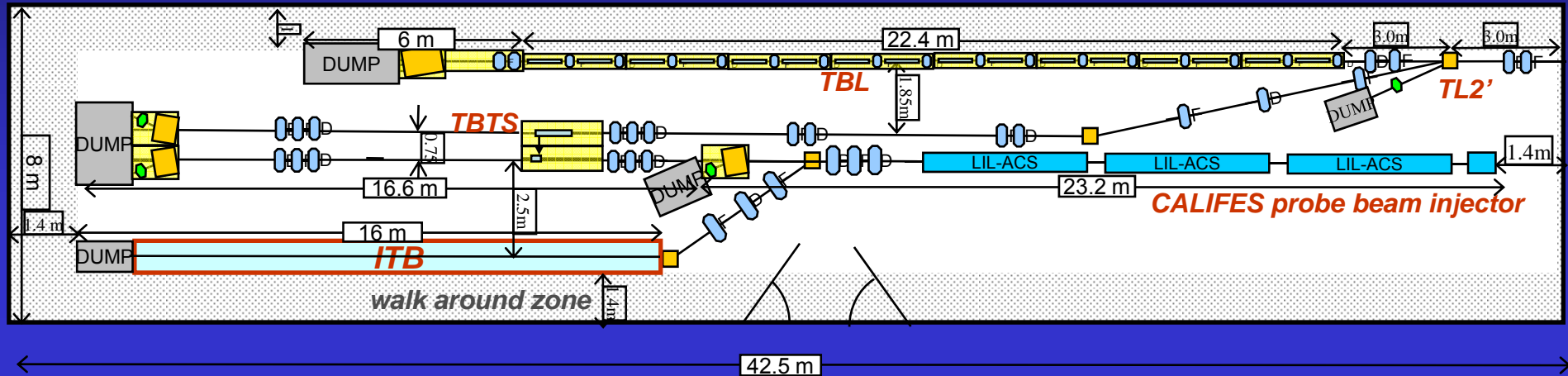
Sketches of BINP wiggler



Low vertical beta-optics in the long straight sections of ANKA:  
 $\beta_x = 14 \text{ m}$ ,  $\beta_y = 1.9 \text{ m}$ ,  $\epsilon_x = 40 \text{ nm}$



## Layout of CLEX-A (A=Accelerator housing) floor space

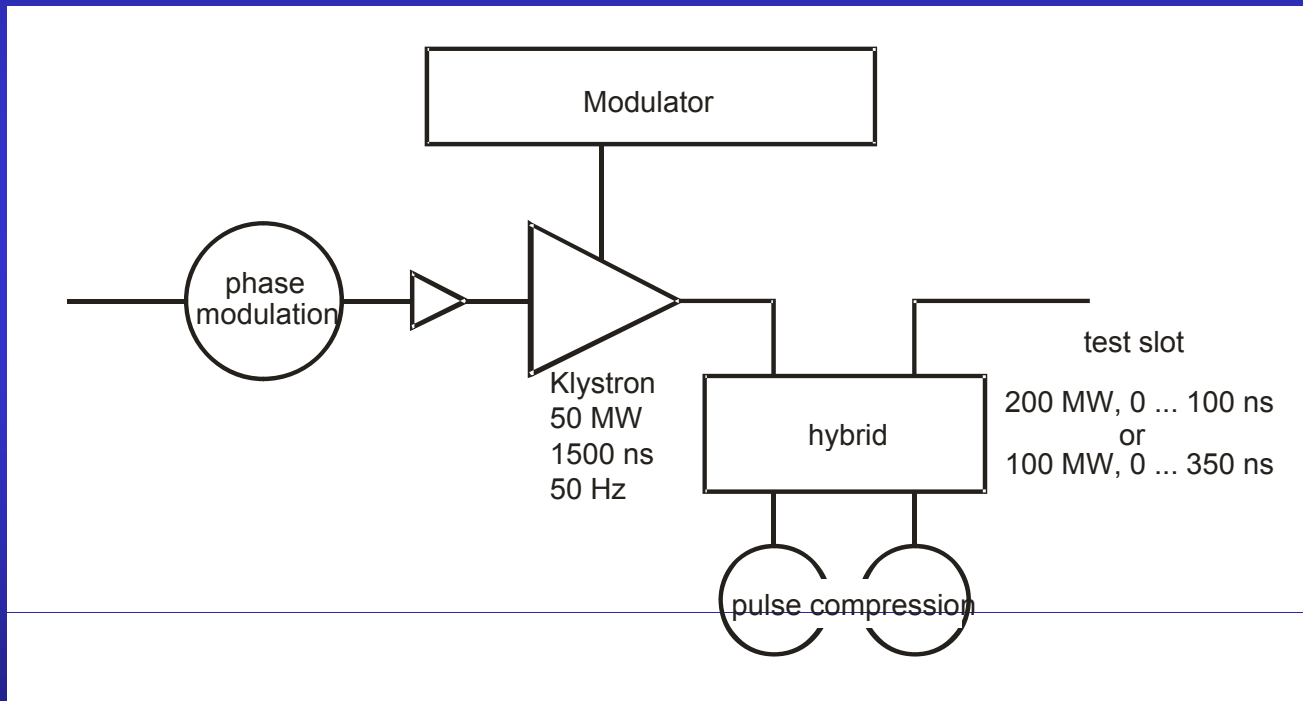


ITB = Instrumentation Test Beam

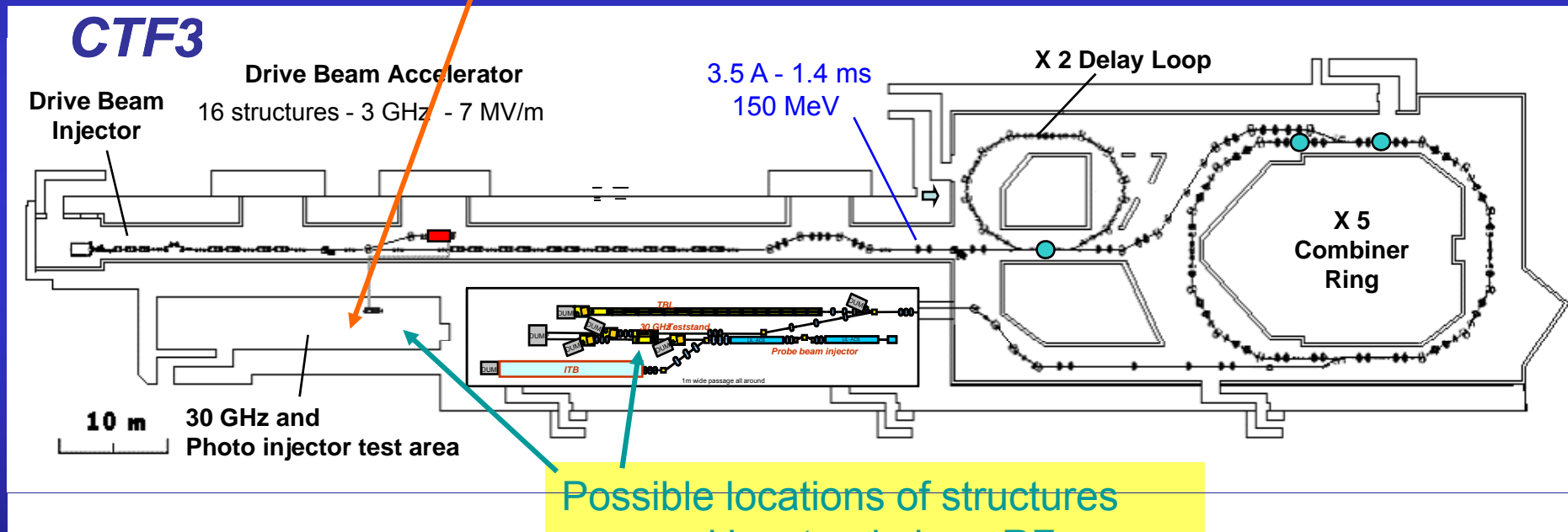
Use of CALIFES beam for instrumentation R&D (for example cold BPM's for wiggler, bunch length measurement, ...)

## Stand alone X band power source

will allow structure testing at CERN independent of CTF3 running from 2009 on

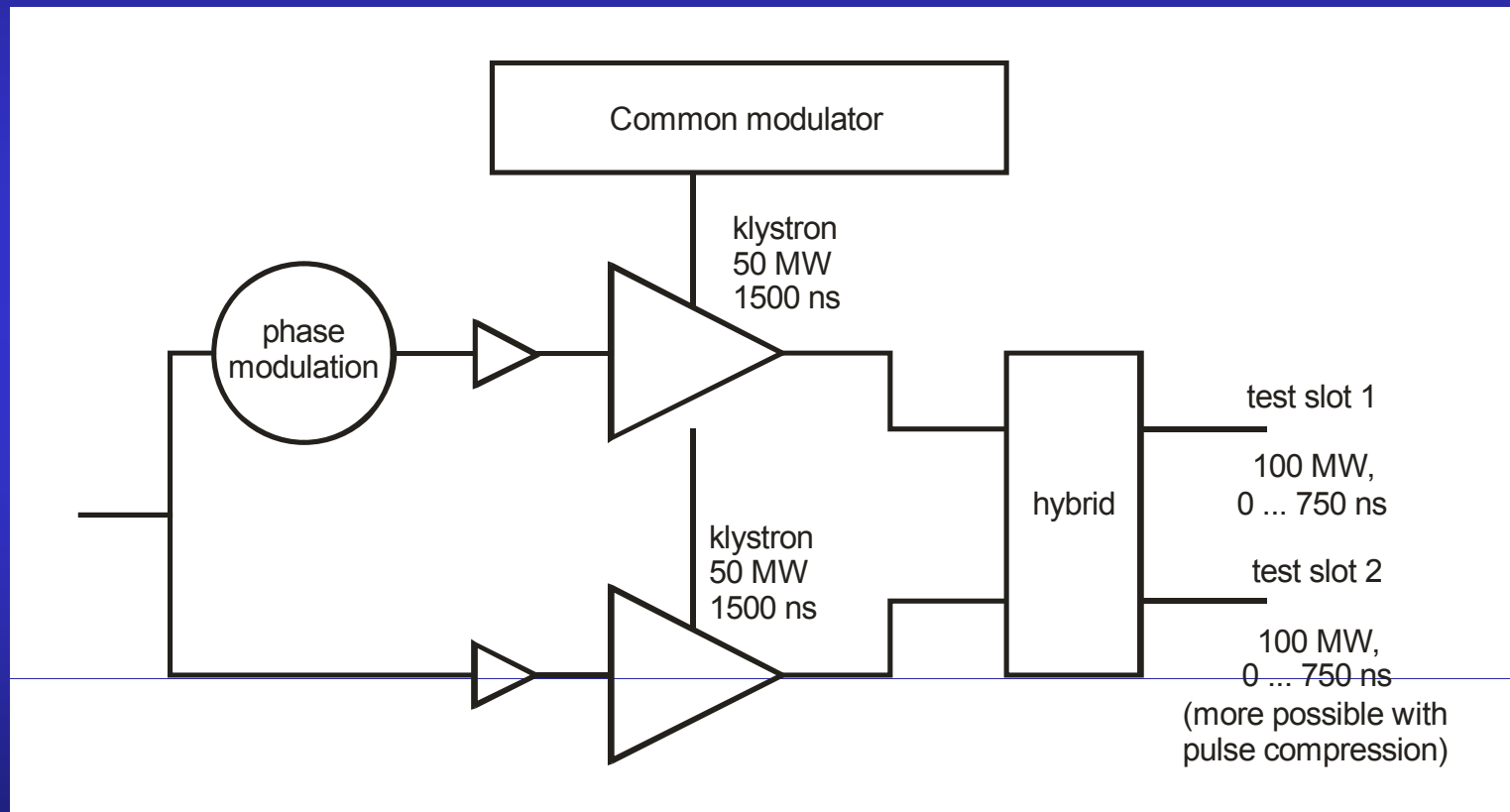


Location of X-band stand alone source (2<sup>nd</sup> floor)



Possible locations of structures powered by stand alone RF source

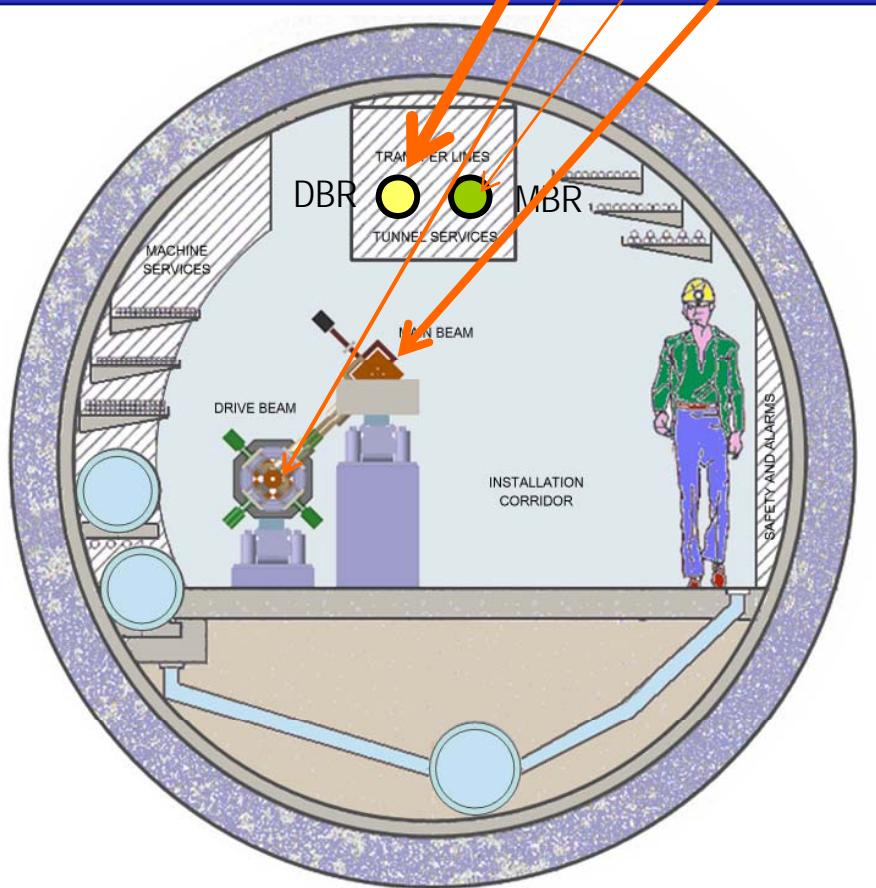
## Potential later upgrade



## **JLab package**

- Help in CTF3 commissioning
- Design & performance evaluation of isochronous beamlines from ground level to deep tunnel
- R&D on non-destructive transverse profile diagnostics
- Design of polarized CLIC  $e^-$  source.
- Main beam spin transport
- Decelerator beam dump design (52 needed in total)

$P_{average}$   
Beamline high score

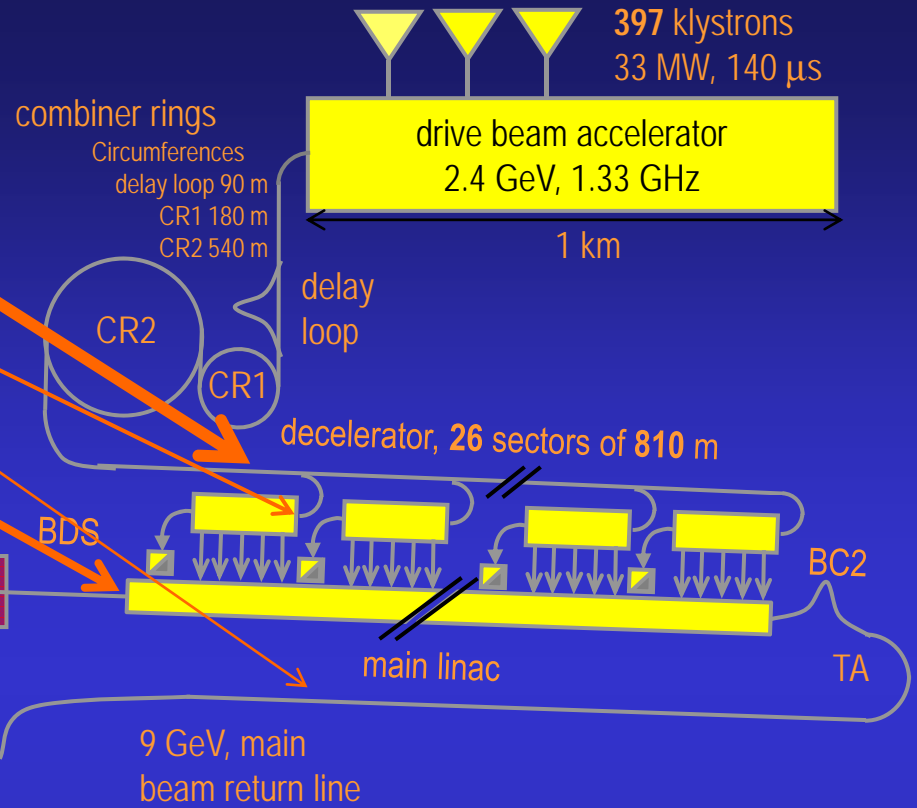


80 MW

3.1 MW

0.9 MW

15 MW



Assuming that we can accept distributed drive beam loss equivalent to 100 W/min drive beam return line (already pretty unpleasant for activation)

Length return line 21 km,  $P_{beam} = 80\text{MW}$

⇒ total loss < 2.5%,  
loss per km < 0.13%

The issue of drive beam loss control is known for long time  
Therefore we had foreseen in CTF3

- *Identical wall current monitors end of injector and before each beam dump together with fast interlock for immediate gun interlock in case of differential losses*
- *A system of beam loss monitors to detect losses smaller than wall current monitor differential resolution*
- *A kicker to dump beam loading transients in controlled manner*
- *Special OTR imaging devices to measure halo density distribution*

But all this activities are dormant, because CTF3 with 4 kW maximum beam power doesn't need such sophisticated MPS and it is practically impossible to motivate these activities while other key commissioning milestones have not been reached.

## Is it fair to compare CLIC drive beam with storage rings ?

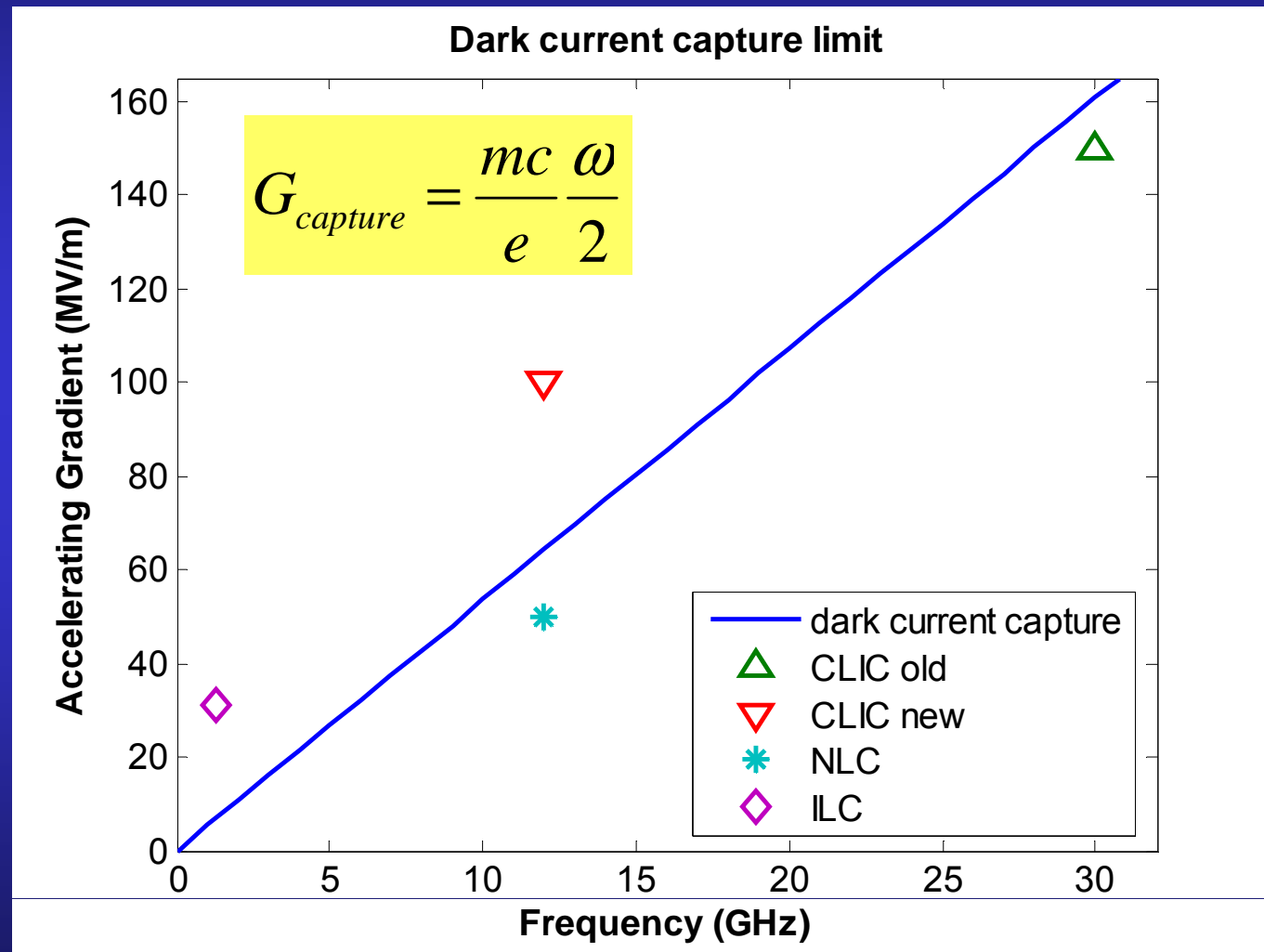
No existing single pass accelerator has pulse energy getting anywhere close

Accelerator	Energy GeV	Revolution time or pulse duration $\mu\text{s}$	Number of Bunches	Number part. / Bunch $10^7$	stored energy / beam or pulse MJ	instantaneous beam power GW
LHC	7000	88.9	2808	11500	362.1	4075
P HERA	920	21.1	180	7000	1.9	88
TEVATRON	980	20.9	36	24000	1.4	65
SR source (typical)	2.5	1.0	500	624	0.0012	1.2
CLIC drive beam DB return line	2.4	139.0	92664	4869	1.71	12
CLIC drive beam decelerator injection	2.4	0.3	3564	4869	0.07	222
CLIC main beam main linac injection	9.0	0.2	311	400	0.002	9
CLIC main beam main linac injection	1500.0	0.2	311	400	0.30	1431

MPS for drive beam needs serious studies !



How important is dark current ?



## Dark currents and their effect on the primary beam in an X-band linac

Karl L. F. Bane, Valery A. Dolgashev, Tor Raubenheimer, Gennady V. Stupakov, and Juhao Wu  
*Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309, USA*  
 (Received 26 April 2005; published 15 June 2005)

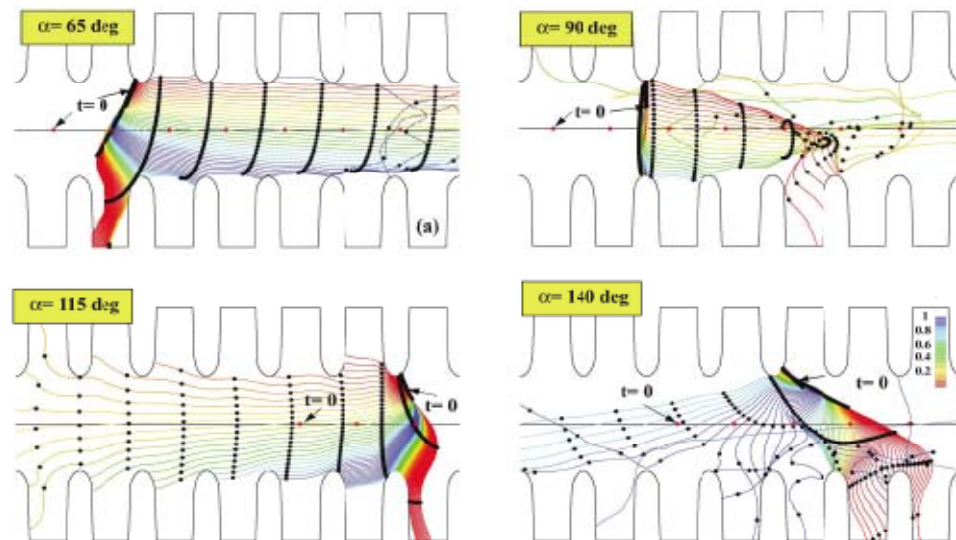
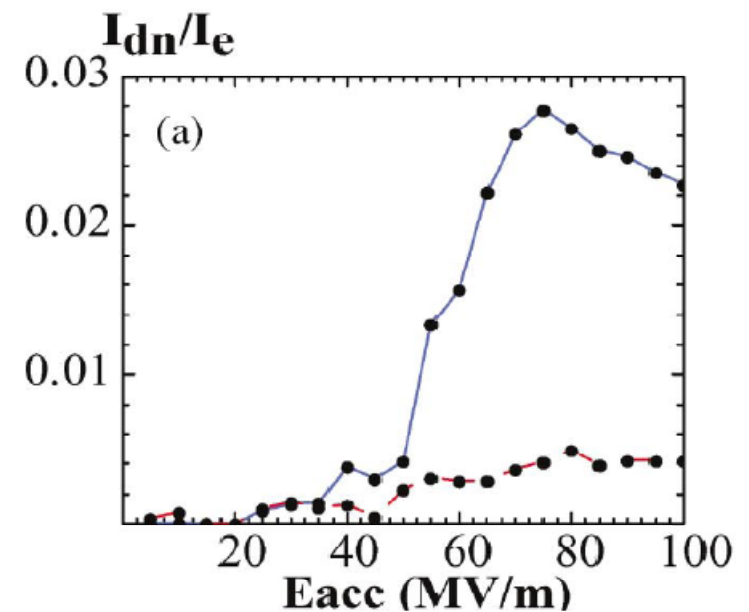


FIG. 4. (Color) Trajectories (in the  $x$ - $z$  plane) of dark-current macroparticles emitted at rf phase interval  $\Delta\phi = 1^\circ$ , for 4 selected emission angles  $\alpha$ . Color coding indicates relative charge of the associated macroparticle. In each frame particles are emitted from an iris from above (positive  $x$ ); downstream is to the right (positive  $z$ ). Black dots give snapshots of the macroparticle positions, beginning with the time they have all left the iris surface ( $t = 0$ ), and then in time steps  $c\Delta t = 1$  cm. One on-axis rf crest position is also shown at snapshot times (the red dots).



According to measurement  $\sim 1$  mA of current, averaged over an rf period, leaves the downstream end of the structure. Therefore, our calculations imply that  $\sim 100$  mA of

Why bother about dark current, overfocusing of main beam quadrupoles will clean off d.c. electrons !

**But** at high energy end of linac quadrupoles are spaced by 10 modules, or 80 accelerating structures.

Assuming that all captured dark current is transported to next quadrupole

$$P_{dark} = f_{rep} T_{puls} \sum_{k=1}^N k V_{struct} I_{dark}$$
$$= f_{rep} T_{puls} V_{struct} I_{dark} N(N+1)$$

$$I_{dark} < \frac{P_{dark}}{f_{rep} T_{puls} V_{struct} I_{dark} N(N+1)}$$

$$N = 80, \quad P_{dark} < 180\text{W} \quad (1\% \text{ of main beam power gain})$$

$$\Rightarrow I_{dark} < 0.24 \text{ mA}$$

According to measurement ~1 mA of current, averaged over an rf period, leaves the downstream end of the structure.'

## Some more issues which deserve more attention

- Beam diagnostics
  - Emittance monitoring main beam and drive beam
  - Beam-loss instrumentation
- Collimator design main beam and drive beam
- FF quadrupoles and supports
- Control system concepts capable to deal with feedback needs
- Start-up scenarios (how to switch on a 80 MW beam)  
related problem: tune up dumps
- Impedances others than RF structures and BDS collimators (main & drive beam)
- Transient RF loading in DR
- Pre Damping RIng
- Positron source
- ...