ECFA LC 2016 Machine Highlights (some not-so-high!)

Nick Walker

DESY ILC meeting — 10.06.2016

Programme

		Mon 30.5		Tue 31.5				Wed 1.6		Thu 2.6		Fri 3.6	
AM I	08:30			E-JADE	Sources I	ILC SRF I	CFS BDS/Central Region	ATF2 I	CFS toplogy & layout	Joint Plenary		Sources III	Beam Dynamics III
coffee	*10:00*												
AM II	10:30			E-JADE	Sources II	ILC SRF II	CFS change request status	ATF2 II	Cryogenic design	P&D Plenary	CMB	Sources IV	
lunch	*13:30*							*ATF/ATF2 collab board*					
PM I	14:30	CLIC ES rev.	*Registration*	E-JADE	CRWG I Central Region Working Group			MDI+CFS	Beam Dynamics I	P&D Plenary	Planning CLIC focus plenary	Sources V	
coffee	*16:30*												
PM II	17:00			E-JADE	CRWG II			MDI+BDS	Beam Dynamics II	Joint Plenary		Sources VI	
	18:30	Reception								Banquet		*finish*	

Parallel programme (except blue sessions)

No “presented summaries”

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☐ attended by NW ⇒ quite a lot I missed

Accelerator sessions

SRF R&D	2 sessions	9 presentations
Sources	6 sessions	16 presentations
Beam Dynamics	3 sessions	7 presentations (mostly CLIC)
CFS (incl cyro)	4 sessions (2 just discussion)	8 presentations
BDS/MDI	2 sessions	9 presentations
CR WG	2 sessions	7 presentations

SRF R&D session

XFEL Cavity results & Impact of 1.8K operation	Nicholas Walker		
Study of 1.8K operation	Marc Wenskat	Aula Infantes	08:55 - 09:20
XFEL Cryomodule	Dr. Olivier Napoly	Aula Infantes	09:20 - 09:45
Progress of surface treatment development	Dr. Takayuki SAEKI		
KEK MARX modulator development	Mitsuo Akemoto	Aula Infantes	10:10 - 10:30
RF power distribution ...	Toshihiro Matsumoto		
Progress of LSF-shape cavity study	Dr. Rongli Geng		
High Q at high gradients and ong...	Nikolay Solyak		
plan of SRF technology application to MaRIE project of LANL	Tsuyoshi Tajima		

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XFEL summaries

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KEK STF status

Progress of LSF-shape cavity study — *Dr. Rongli Geng*

Review of low-loss shape R&D

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Ambitious project proposal using TESLA tech.

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Technical Highlight!!

plan of SRF technology application to MaRIE project of LANL — *Tsuyoshi Tajima*

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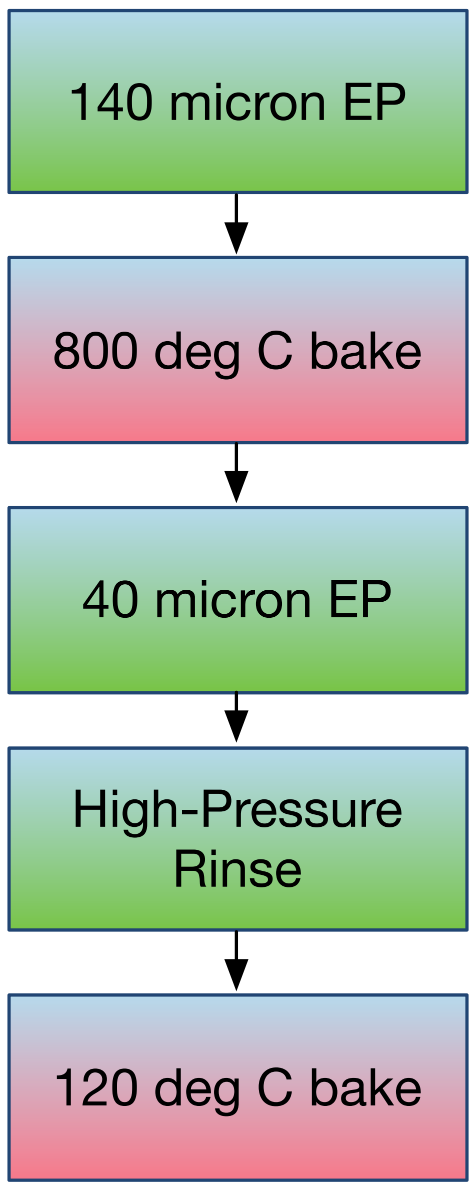
XFEL

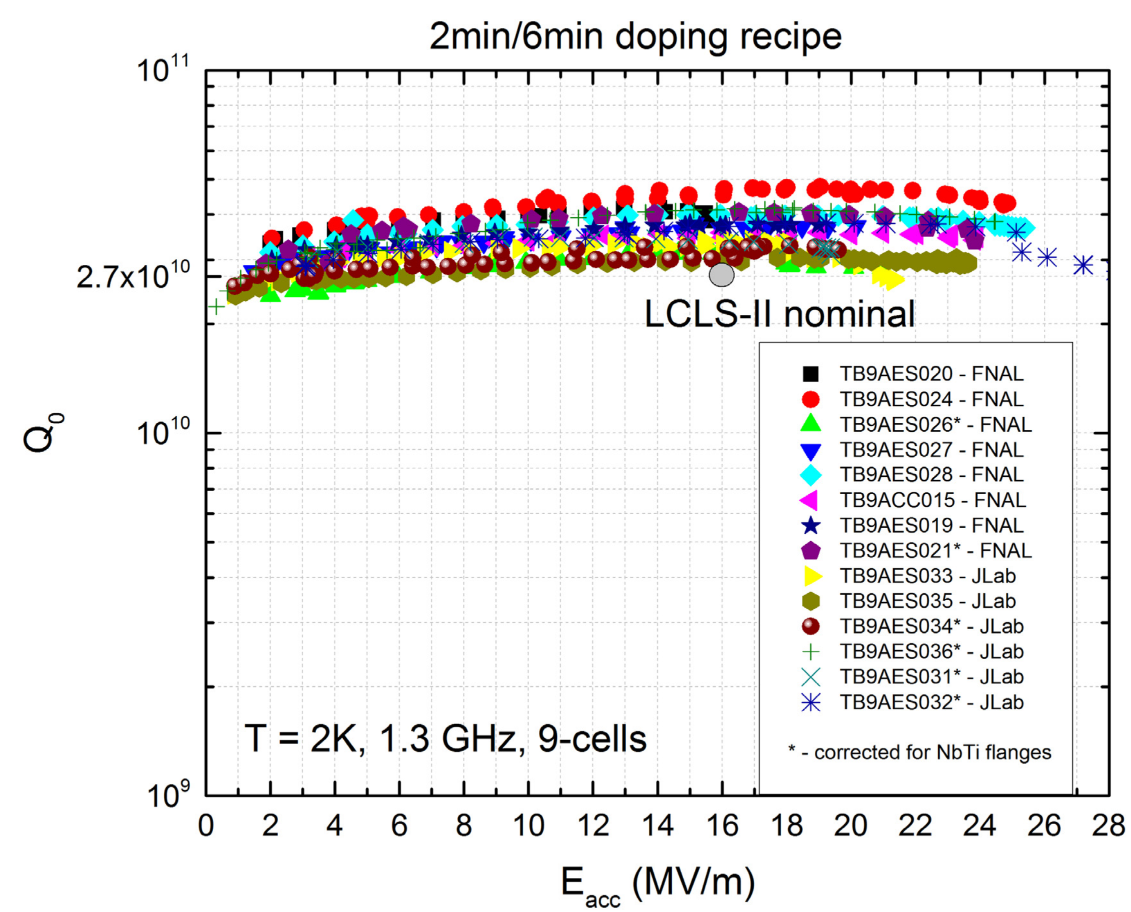

140 micron EP
800 deg C bake
40 micron EP
High-Pressure Rinse
120 deg C bake

XFEL

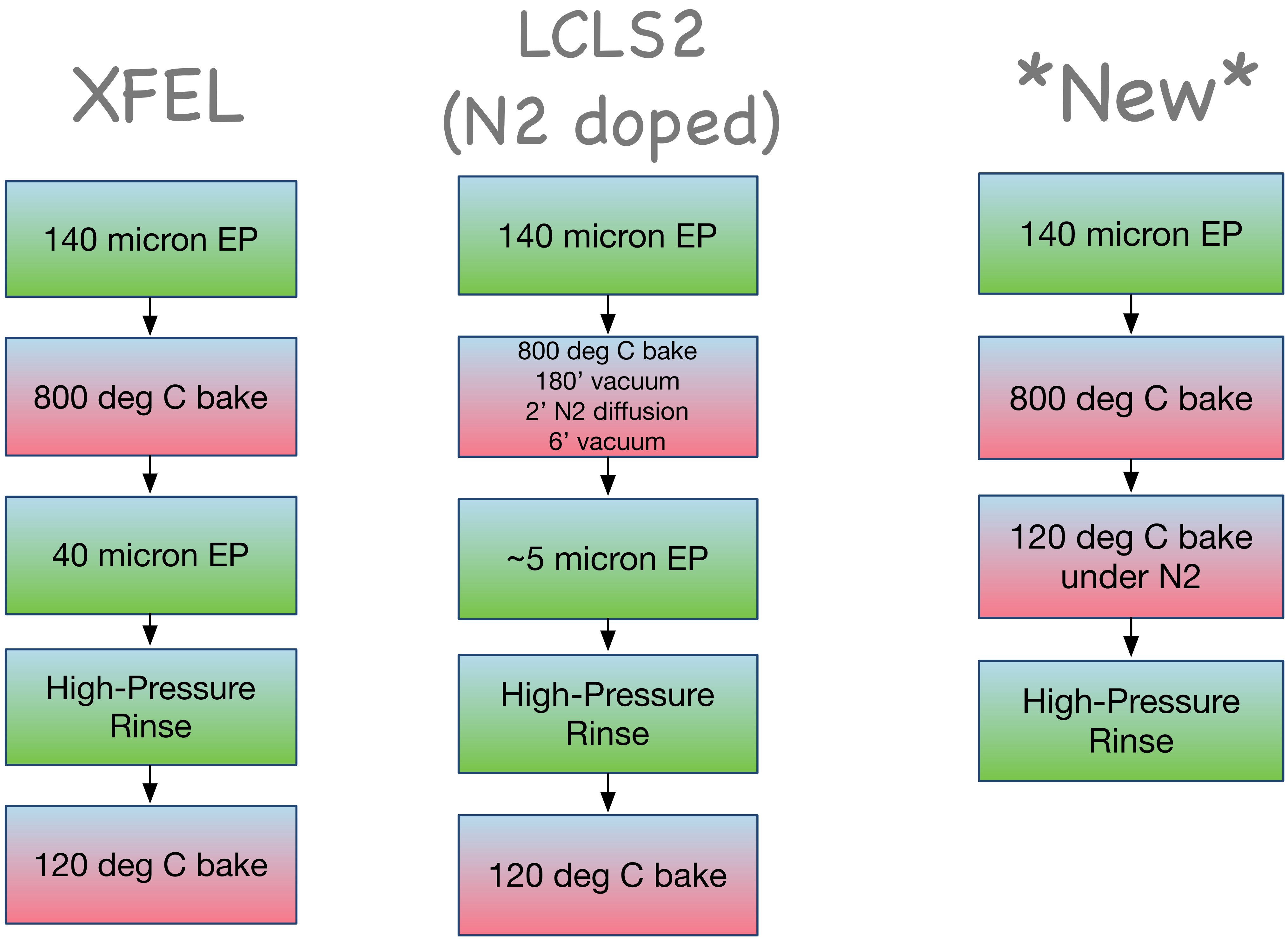
1. 140 micron EP
2. 800 deg C bake
3. 40 micron EP
4. High-Pressure Rinse
5. 120 deg C bake

LCLS2 (N2 doped)

1. 140 micron EP
2. 800 deg C bake
180’ vacuum
2’ N2 diffusion
6’ vacuum
3. ~5 micron EP
4. High-Pressure Rinse
5. 120 deg C bake



A. Grassellino et al IPAC15


XFEL
140 micron EP
800 deg C bake
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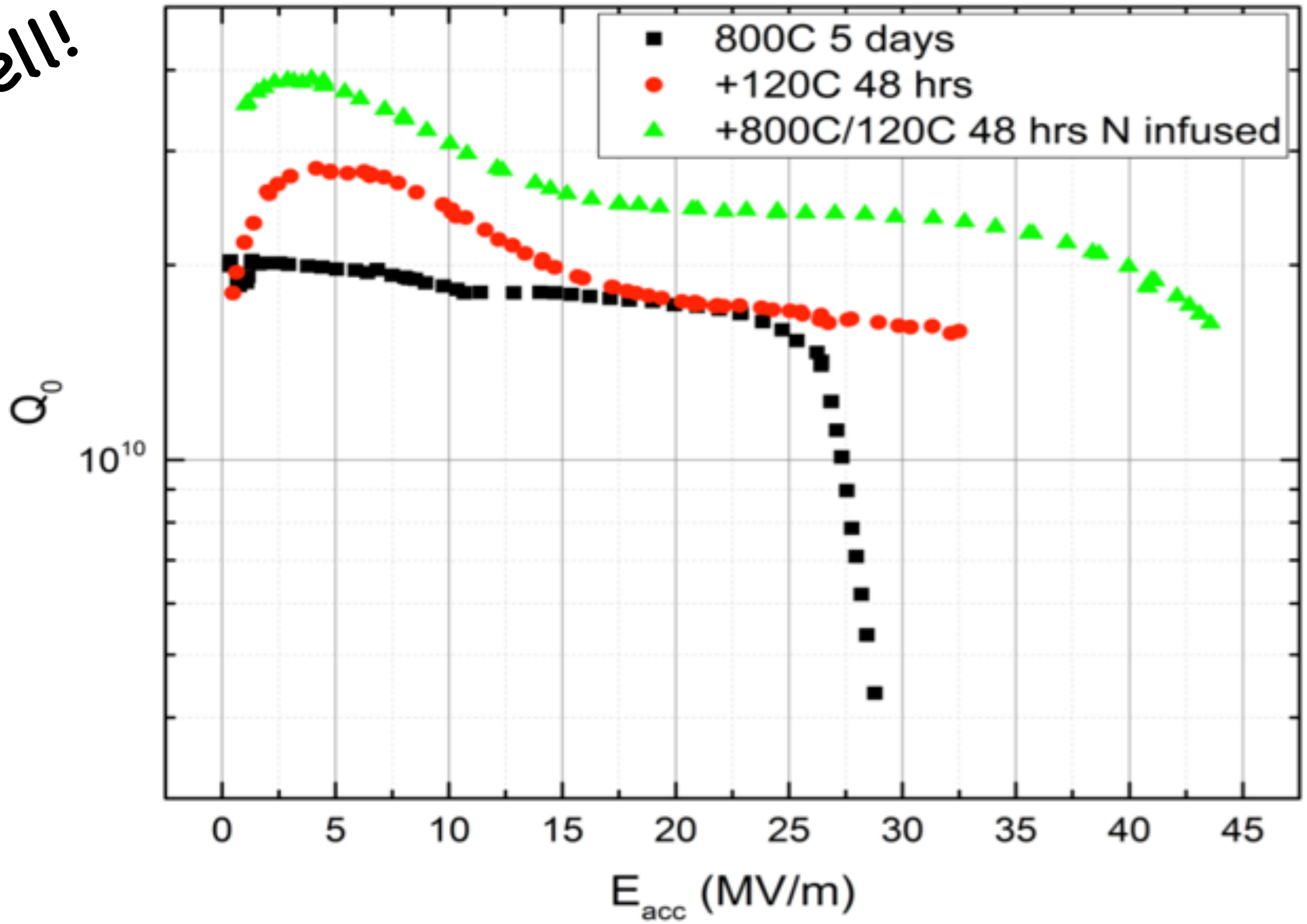
120 deg C bake
LCLS2 (N2 doped)
140 micron EP
800 deg C bake
180’ vacuum
2’ N2 diffusion
6’ vacuum
~5 micron EP
High-Pressure Rinse
120 deg C bake
New
140 micron EP
800 deg C bake
120 deg C bake under N2
High-Pressure Rinse

Sequence on same cavity: EP + 800C→ 120C bake→ 800C+N-infused 120C bake

Single Cell!



A. Grassellino et al, TBP

- Clear evolution trend conforming improvement in Q and quench field
- Note: improvement in Q also from no EP post high T bake (see A. Grassellino et al http://arxiv.org/abs/1305.2182)

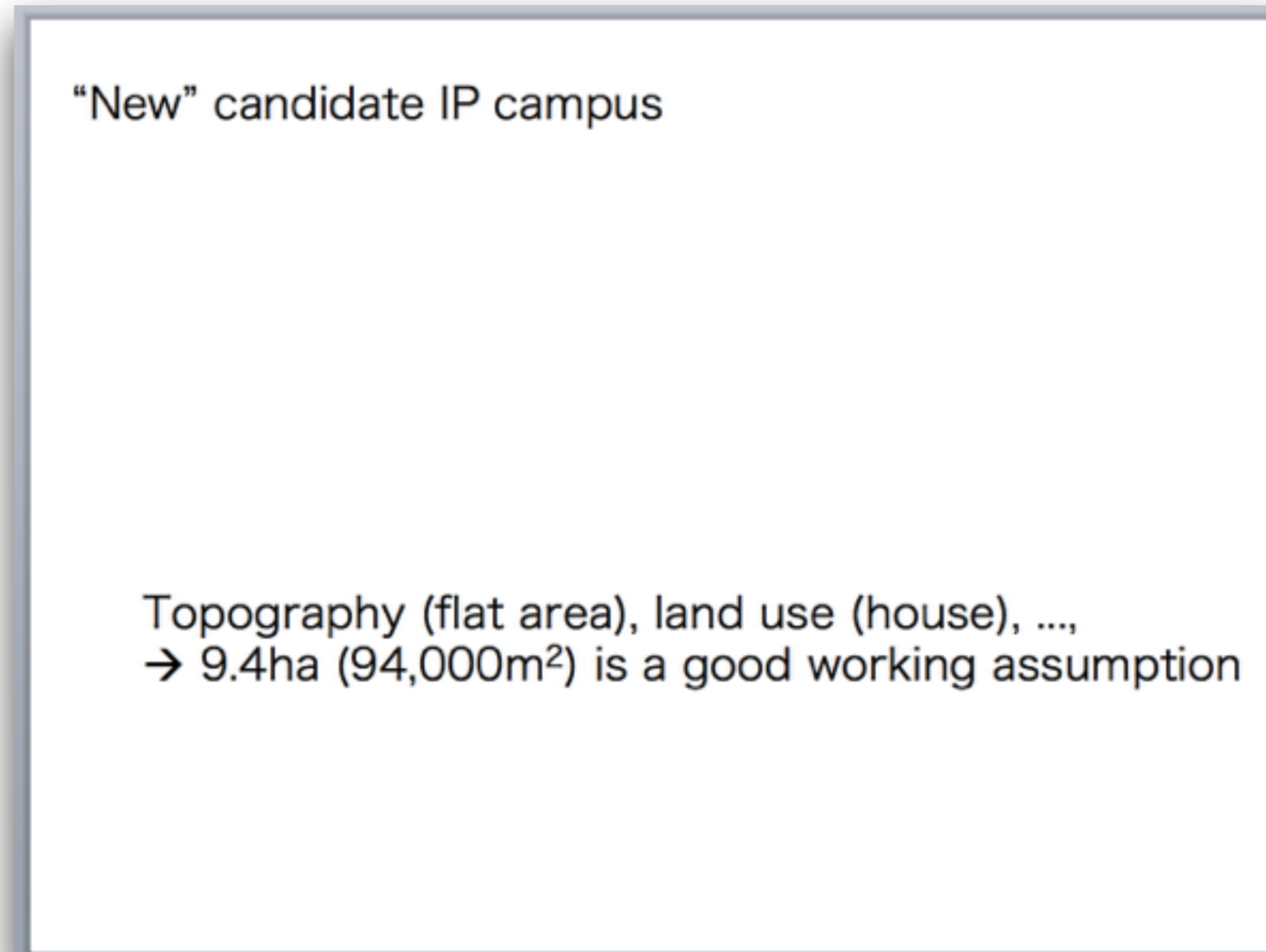
Progress on site-dependent design

- New IP location
- Central Region
  - Optimisation of lattice
  - Muon spoilers
  - CFS solution
  - Reducing / removing 14MW tune-up dump

  - Many questions / requirements still remaining!

New IP location

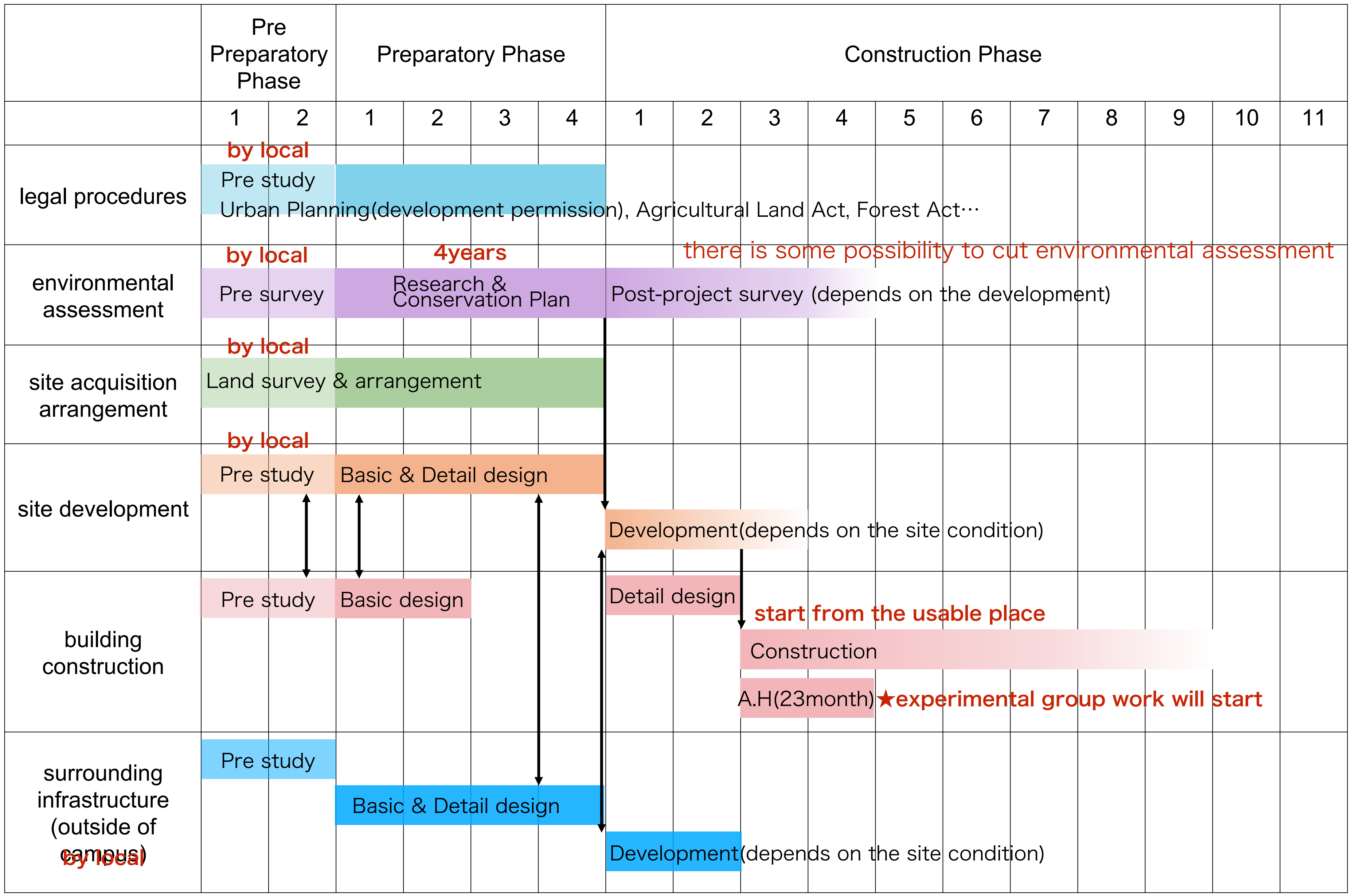
Posted slide



Karsten think it's ~4 km NNW from the current IP location

IP campus schedule

IP Campus - Schedule(draft ; under consideration)



※all include the contract procedure ※A.H. schedule is from change request NO.ILC-CR-000R

IP campus schedule

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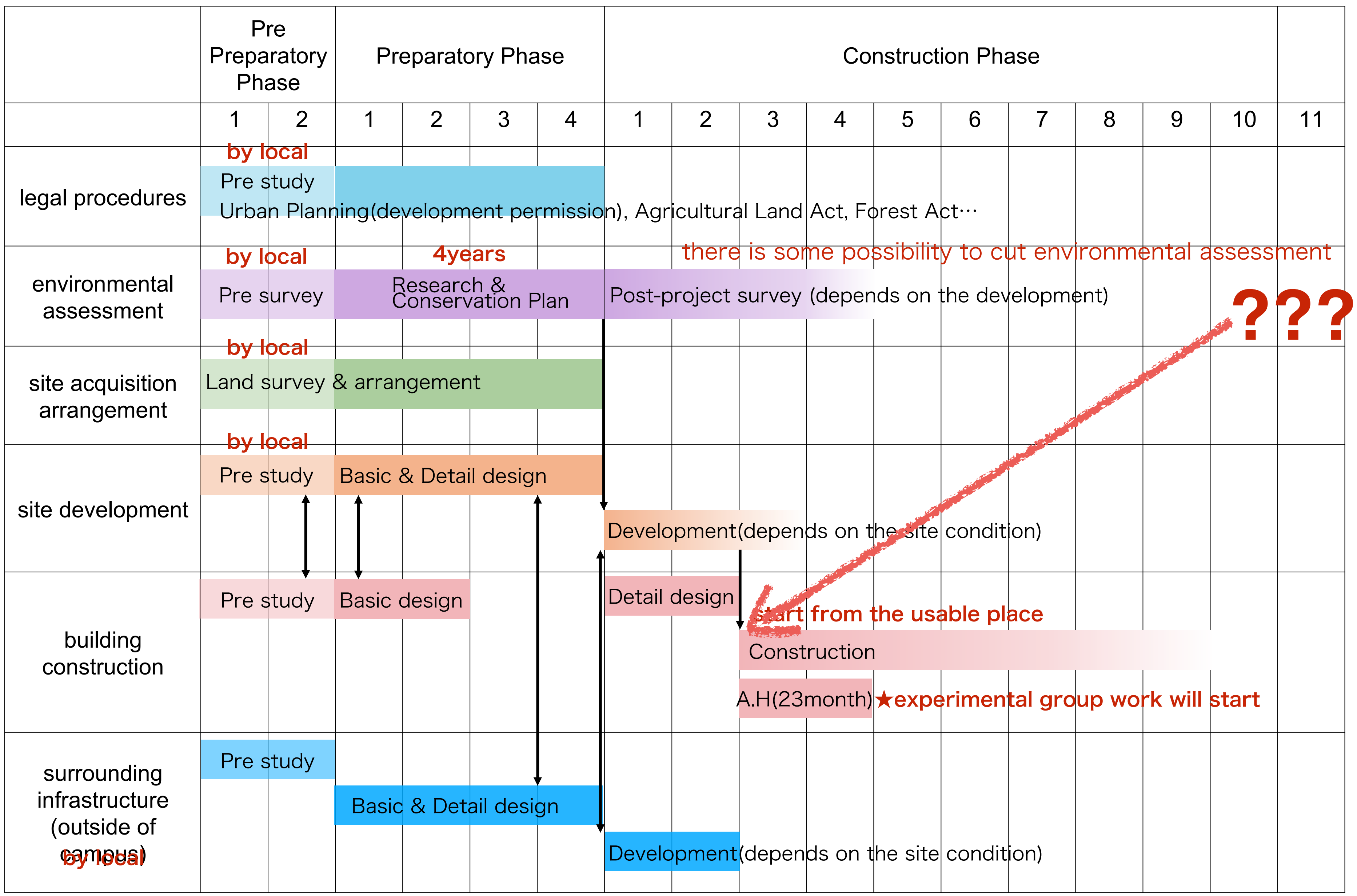

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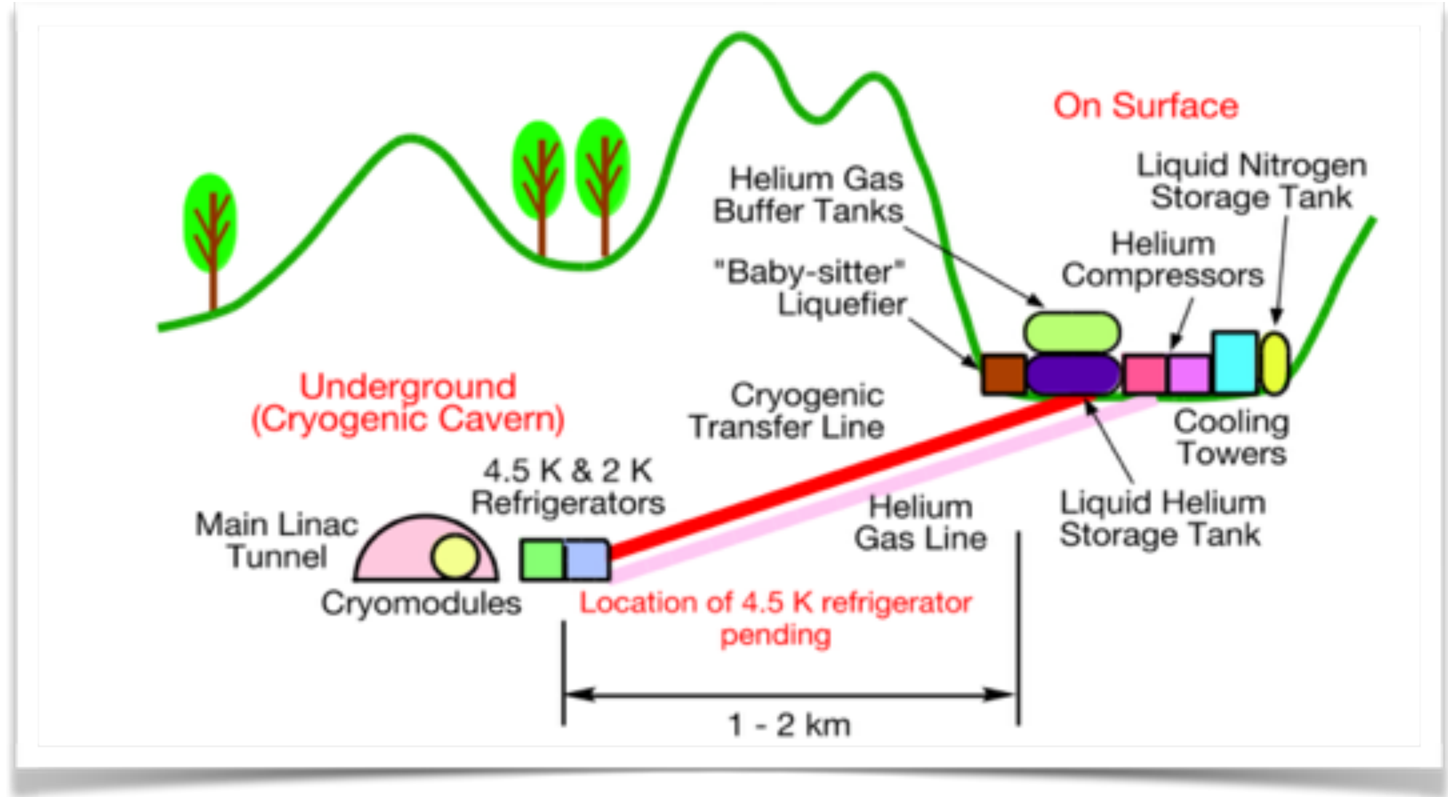
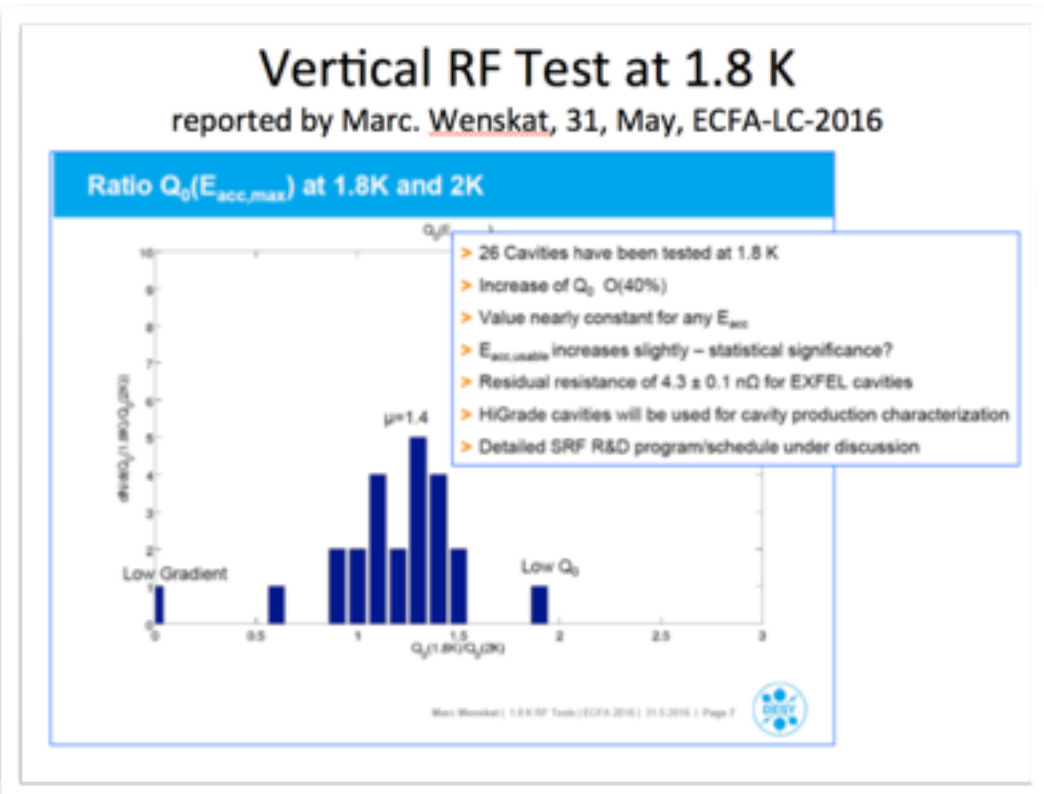
Need consistent and clear definition of “T-ZERO” (as in TDR)

Cryogenics

- 1.8K versus 2K operation
  - the story continues…
- Redesign of ML cryo system layout (surface)
  - Some progress made
  - Converging slowly
    - location of 4K compressor! - seems underground is “better”
- New: baby-sitting system (a la LHC)
  - where to stick the boiled-off helium if the AC power goes down!



1.8K versus 2K



T. Okamura

Bath Temperature Dependence

Which is better between 2.0K and 1.8K cooling ?

- Total mass flow rate at 1.8K cooling is less than at 2.0K.
  = Input power at 1.8 K cooling is smaller than at 2.0 K.
  - Due to the assumption that heat load at 1.8K cooling is 2/3 smaller than at 2.0K cooling.

  ⇒ 1.8K cooling leads to not only manufacturing but also running cost reduction.

- 2K final HEX size is almost same between 2.0K and 1.8K cooling.
  ⇒ The size of 1.8K and 2.0K cold box are almost same each other.

⇒ 1.8K cooling is better than 2.0K cooling.

Central Region

- Covers many sub-systems
  - BDS
  - Sources (especially positron source)
  - RTML (partially)

- Focus points
  - CFS housing
  - Radiation shielding
    - For all dumps
  - Muon spoilers
  - (Integration of e-driven e+ source)

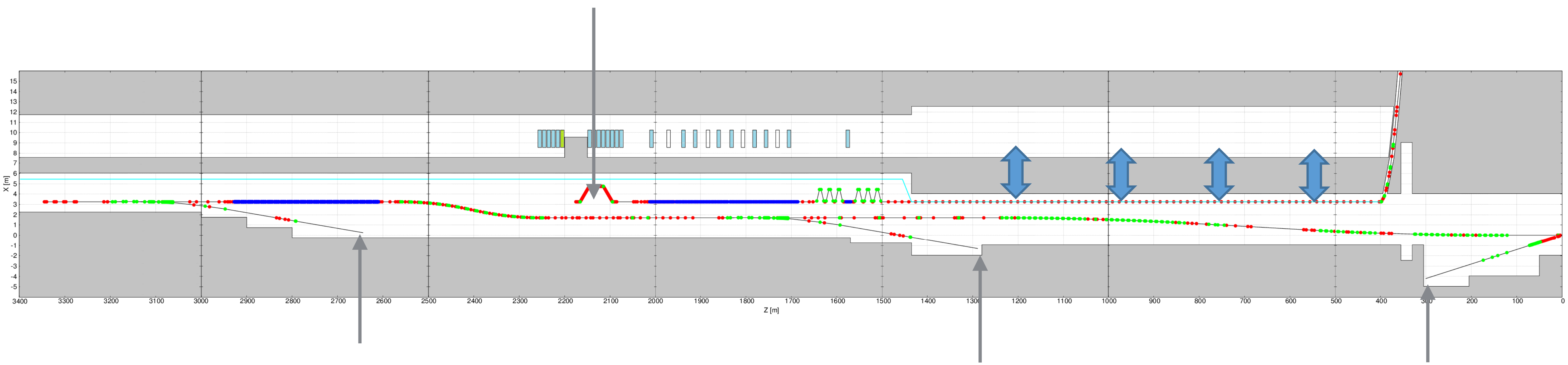
The next “hot topic”: Dumps!

- Dumps have now been raised in awareness status
  - ILC DEFCON 2
- Primary points
  - Design of 14 MW high-pressure water dump
    - Safety issue: failure modes and recovery action (radiation safety)
  - Positron source photon dump **Technical lowlight!!**

- Akira Yamamoto has requested help and proposes mini-workshop
  - At KEK, probably in the Autumn.

Do we need that 14 MW tune-up dump?

~200 kW gamma dump



fast abort dump (low P rating)

14 MW tune-up dump

14 MW main dump

E-1	SC Tune-up Dump	311 kW‡	E+1	SC Tune-up Dump	311 kW‡
E-2	EDRX Tune-up Dump	220 kW	E+2	PDRX Tune-up Dump	220 kW
E-3	RTML Tune-up Dump	220 kW	E+3	RTML Tune-up Dump	220 kW
E-4	BDS Tune-up Dump	14 MW	E+4	BDS Tune-up Dump	14 MW
E-5	Primary E- Dump	14 MW†	E+5	Primary E+ Dump	14 MW†
E-6	RTML Tune-up Dump	220 kW	E+6	RTML Tune-up Dump	220 kW
E-7	E- Fast Abort Dump	250 kW	E+7	E+ Target Dump	200 kW†

† Always ON
‡ 45 kW always ON

Do we need that 14MW tune-up dump?

- Big expensive infrastructures
  - High-pressure water dumps, window issues, closed-circuit rad water cooling, radiology etc.

- Tune-up dump *was* considered necessary (RDR/TDR)
  - to tune up full power beam from linacs before
  - commissioning (with people possibly in IR region)
  - General tuning / recovery before putting high-powered beam through detector.

- But we can probably make do with a much lower rated dump
  - Significantly reduced beam power for tune-up
  - 200 kW?? (~4% of baseline beam power)

Some ramifications (and questions)

- Can only run full beam power when beam goes through IR to main dump.

- Is the 4% pulse current sufficient to do tune-up and commissioning?
  - Assuming we can put beam through IR to main dump

- Do we need full single-bunch charge?
  - E. Patterson suggested 50% q_b, 100 bunches @ 1 Hz.
  - (Somewhat arbitrary choice)
  - Needs discussion ⇒ commissioning strategy

- NOTE! 10-Hz e+ production scheme needs an additional high-powered dump in the CR anyway!
  - 150 GeV beam, ~3 MW (baseline)

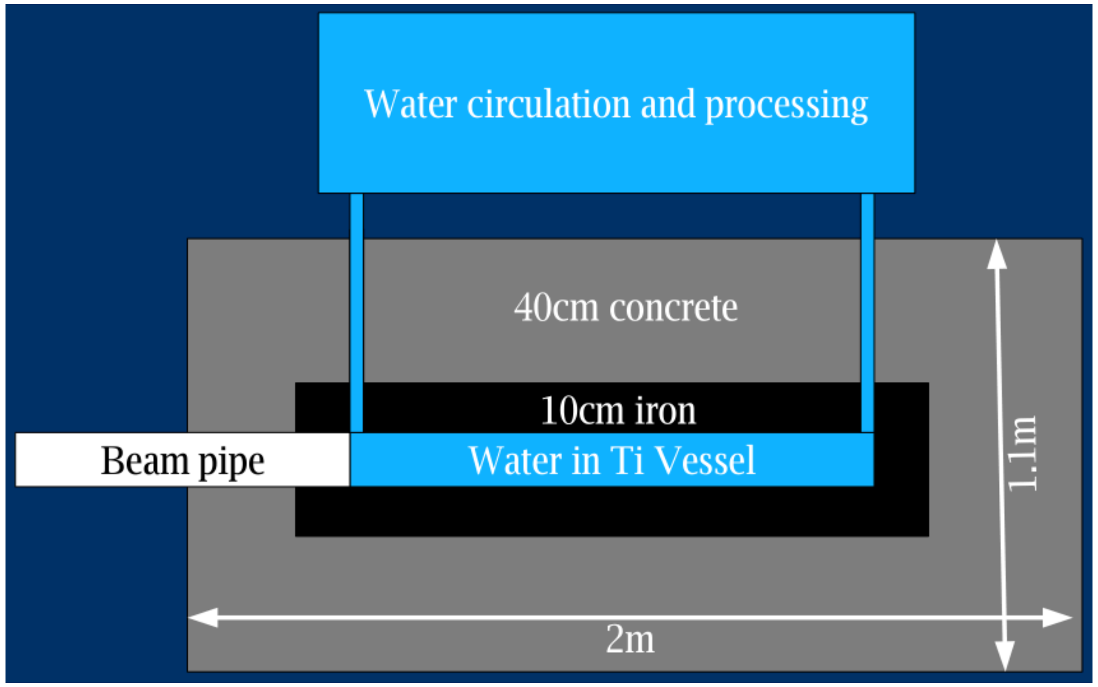
Main Dump Risks: Window rupture

- Biggest risk: Window breaks
  -> releases 10atm radioactive water
- Design includes double window
  -> water would be contained (could leak into beam pipe though)
- Needs emergency expansion vessel for radioactive water, but then it is probably OK

- Second risk: Water boils, dump water becomes transparent
  -> beam penetrates rear wall
- How many bunches are needed to puncture the vessel?
- Needs to be prevented by MPS: detect excess radiation behind dump and switch of machine
- Can we assume that MPS takes care of this? Probably yes

- Other Risks: Radioactivity escapes during maintenance (e.g. exchange of filters) -> need water and air tight seals between dump cavern and main tunnels to contain any radioactivity; dump hall needs to be **underpressurized**

e+ source photon dump



A. Ushakov

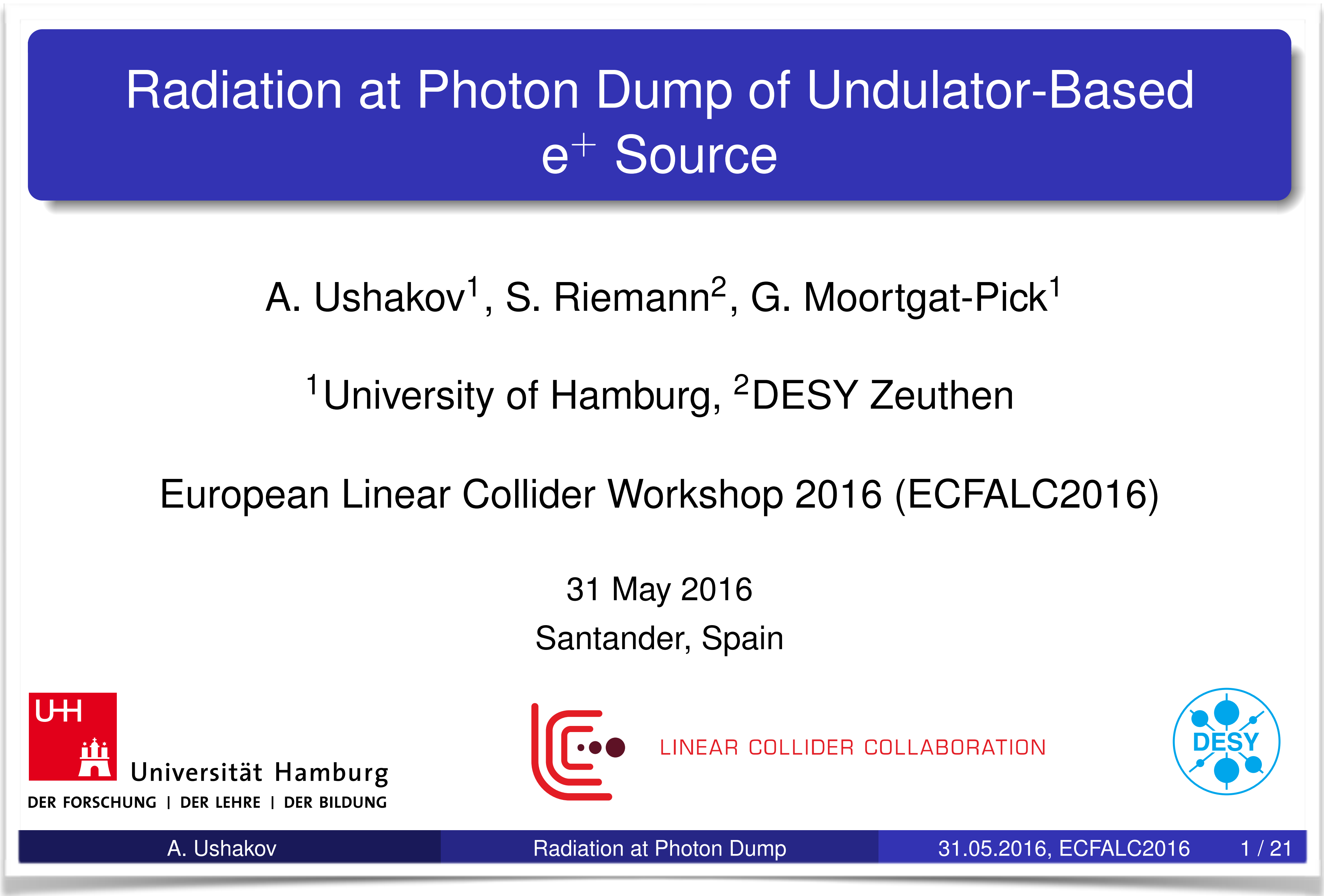
Only 200kW <P> so should be straightforward … or?

Well-collimated photon beam from undulator produces very high energy density in dump

Also cannot “sweep” photon beam on window as we can with electron dump

⇒ high-pressure water dump (RDR/TDR solution)

Photon dump: technical lowlight!



Radiation at Photon Dump of Undulator-Based e^{+} Source

A. Ushakov[1], S. Riemann[2], G. Moortgat-Pick[1]

[1]University of Hamburg, [2]DESY Zeuthen

European Linear Collider Workshop 2016 (ECFALC2016)

31 May 2016
Santander, Spain

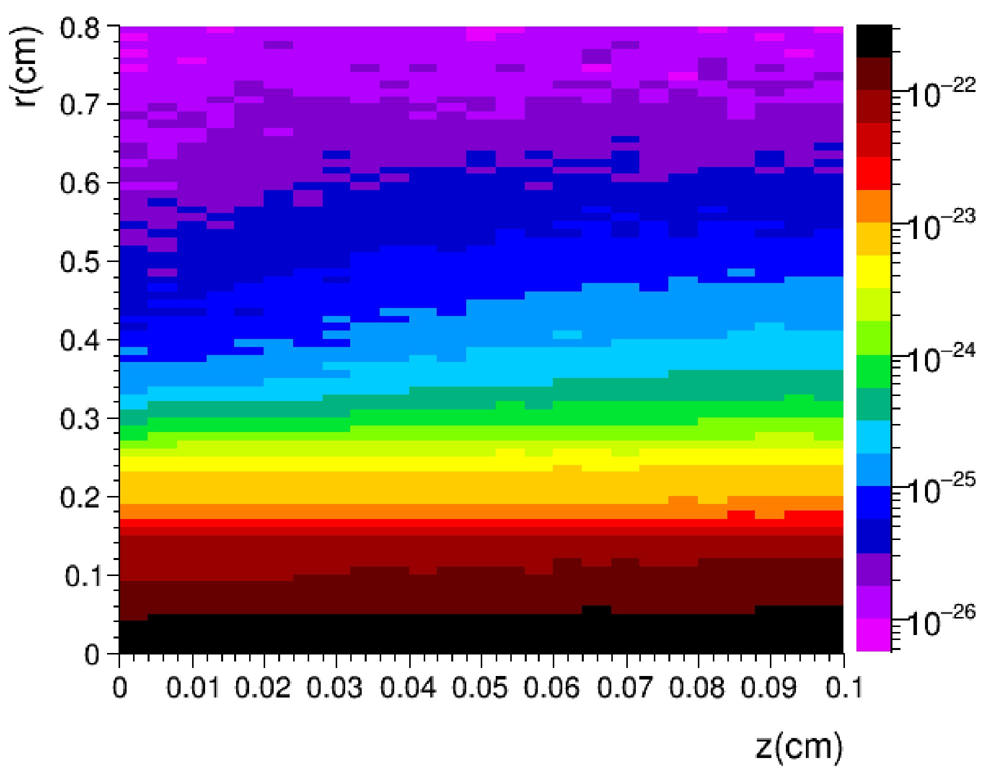
Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

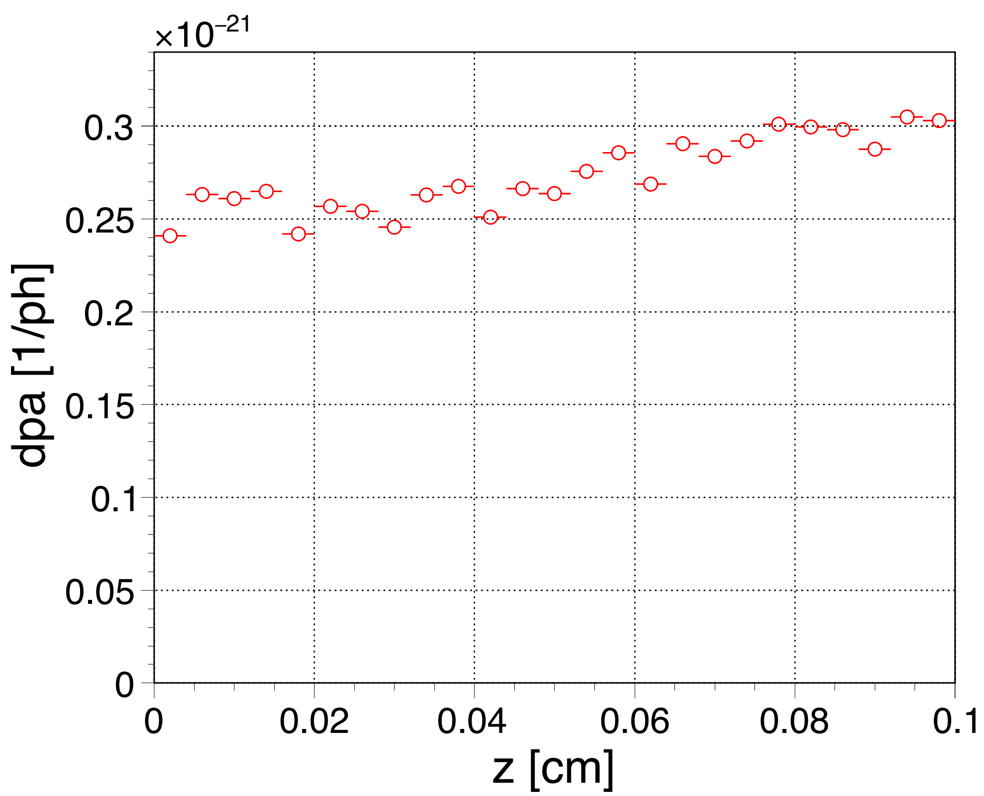
LINEAR COLLIDER COLLABORATION

A. Ushakov | Radiation at Photon Dump | 31.05.2016, ECFALC2016 | 1 / 21

FLUKA simulations

Radiation Damage of 1 mm Ti6Al4V Window





Number of photons generated in 147 m undulator with $K = 0.45$:

$$1 \cdot 10^{16} \text{ ph/s} \quad \text{or} \quad 1.8 \cdot 10^{23} \text{ ph/5000h}$$

81% undulator photons are reaching window

Accumulated peak damage after 5000 hours of irradiation: **44.1 dpa**

In case of 0.5 dpa limit, **life time** of window is **56.7 hours**

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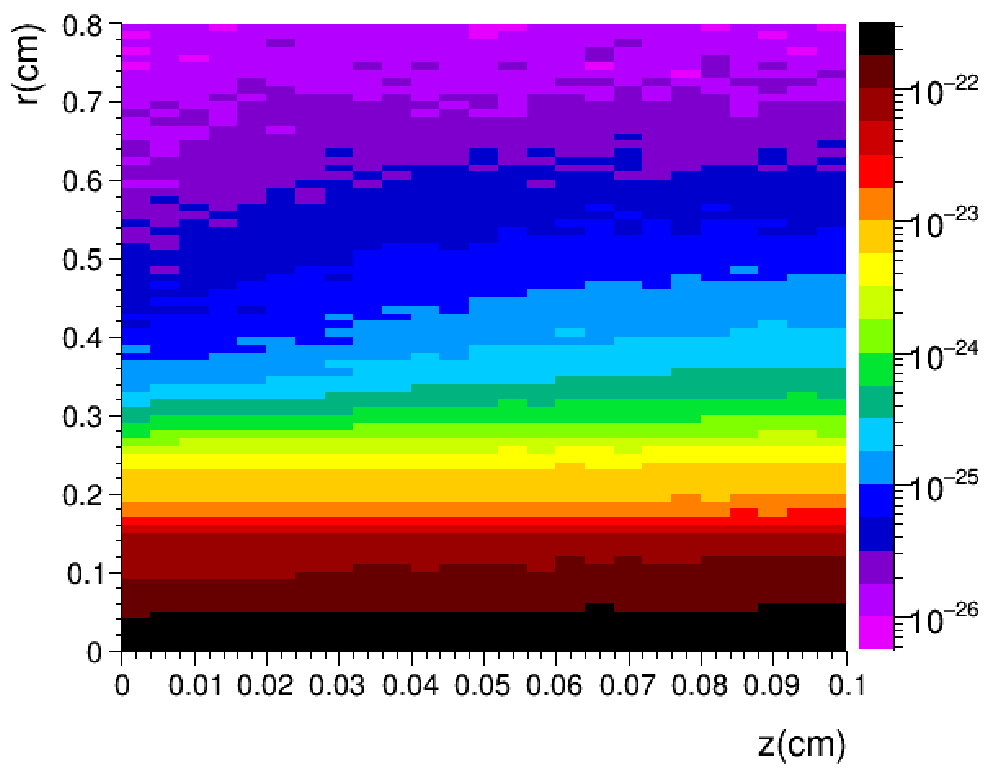

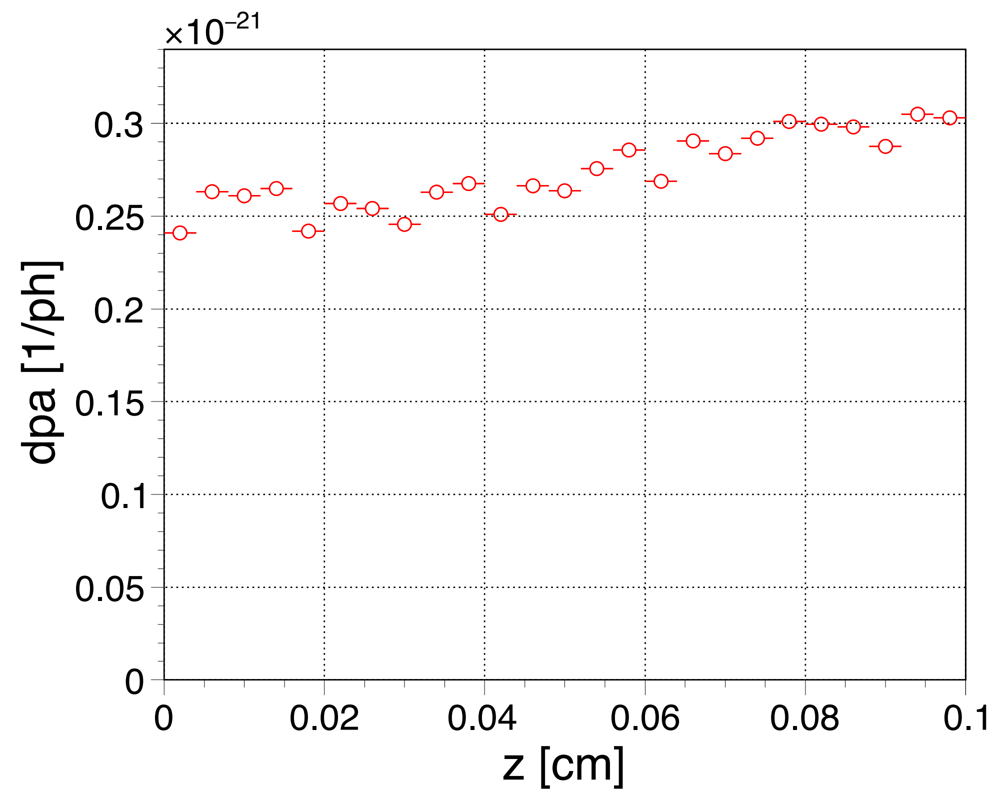

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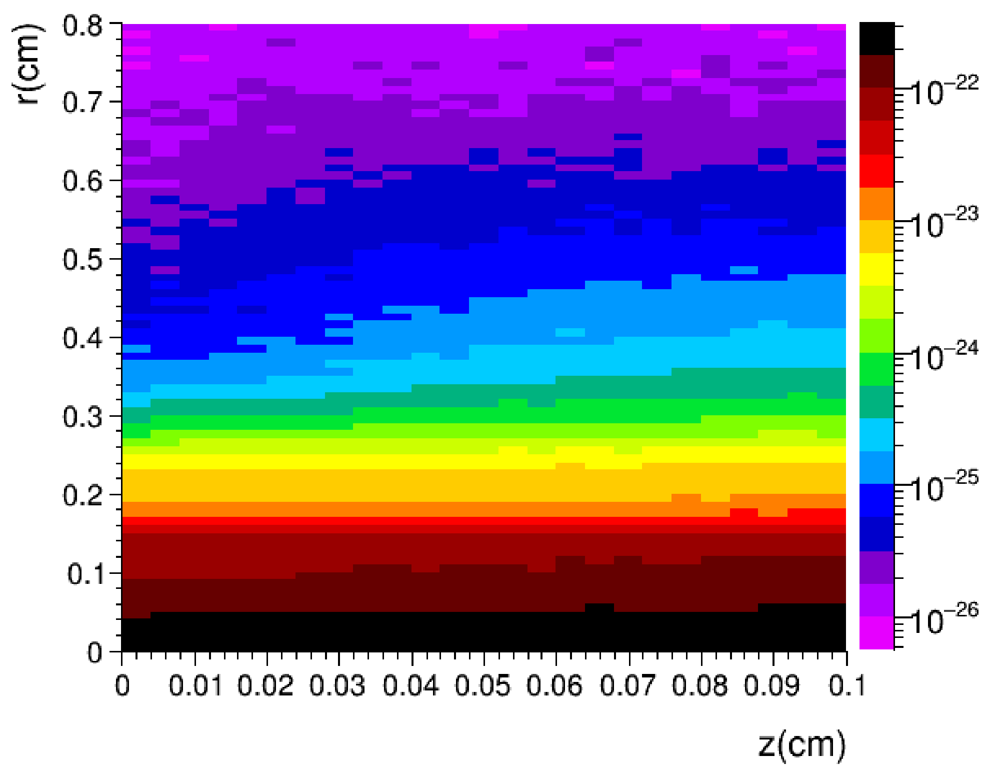

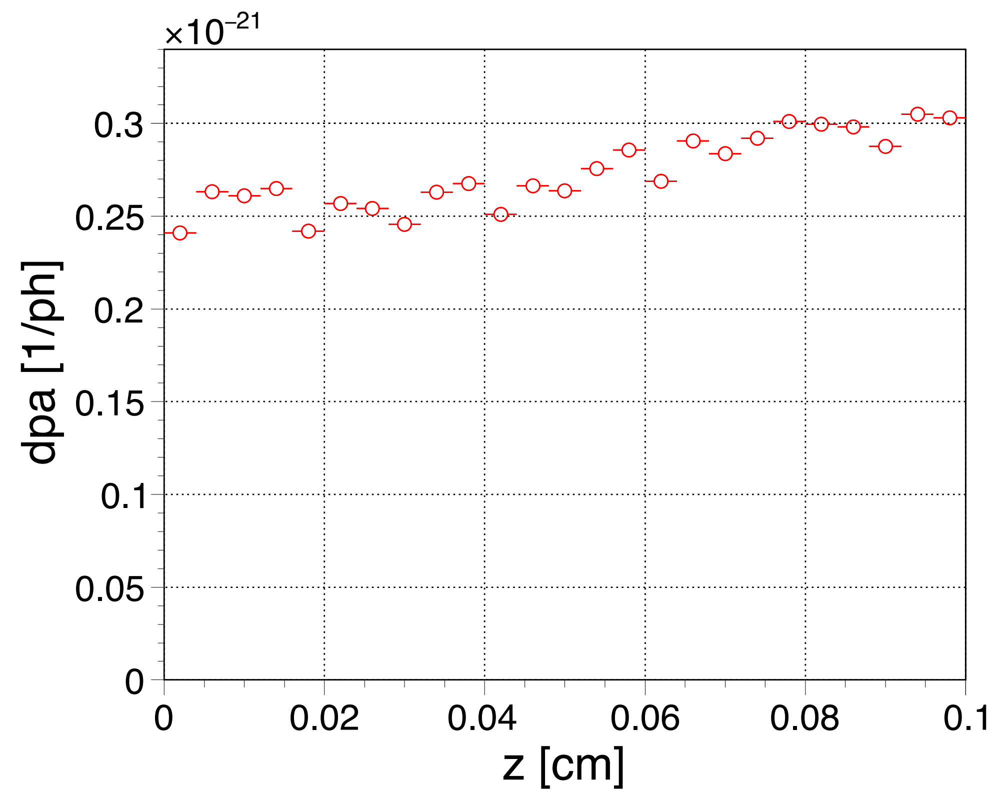

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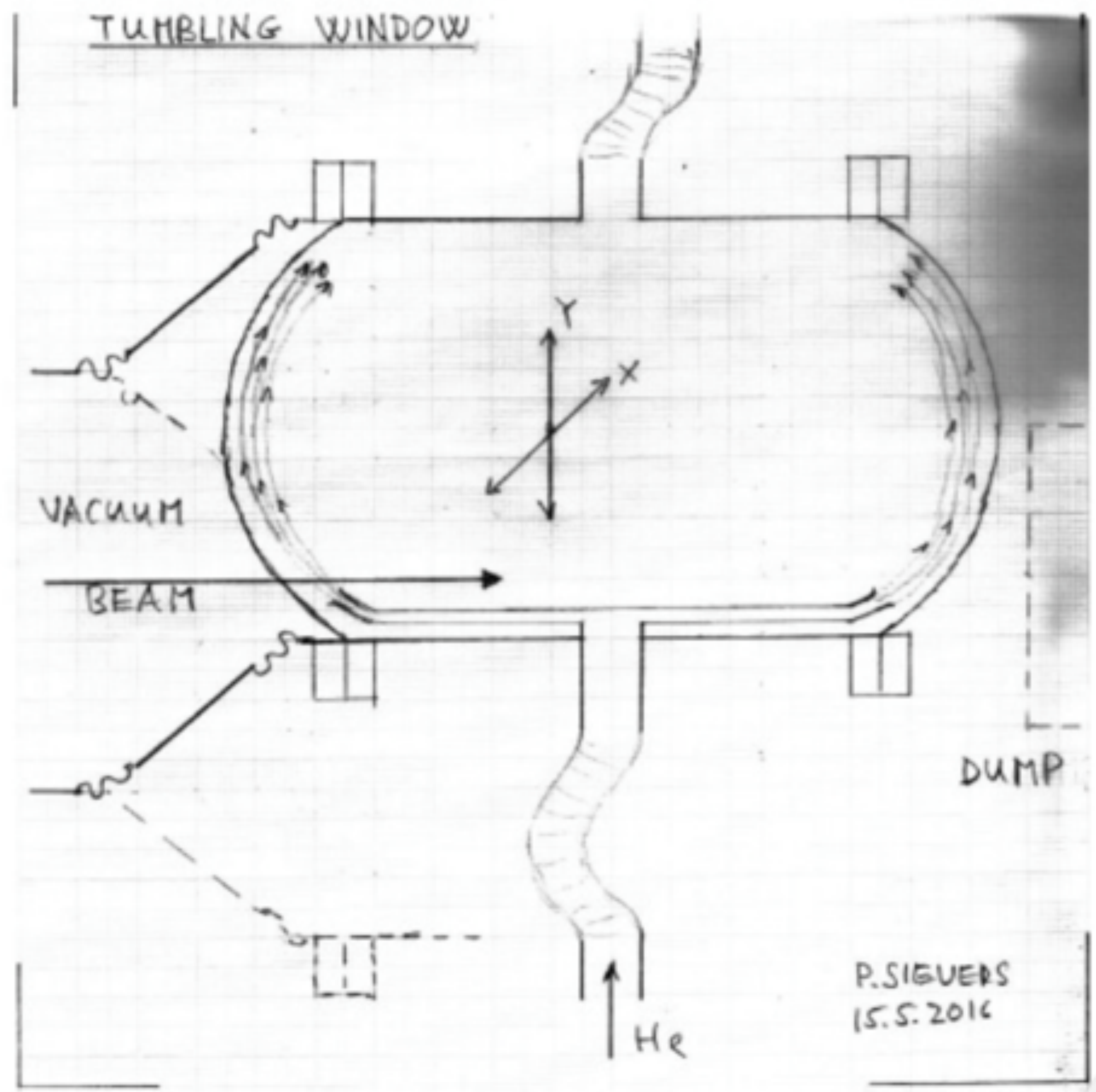
Some "ideas"

If you can wobble the beam, wobble the window!

LINEAR COLLIDER COLLABORATION

Tumbling Window

- Double wall thin windows cooled by He gas.
- Tumbling to mitigate the radiation damage of Ti window.
- He Flow 17 g/s.
- Tumbling ± 25mm makes 1/32 radiation damage.



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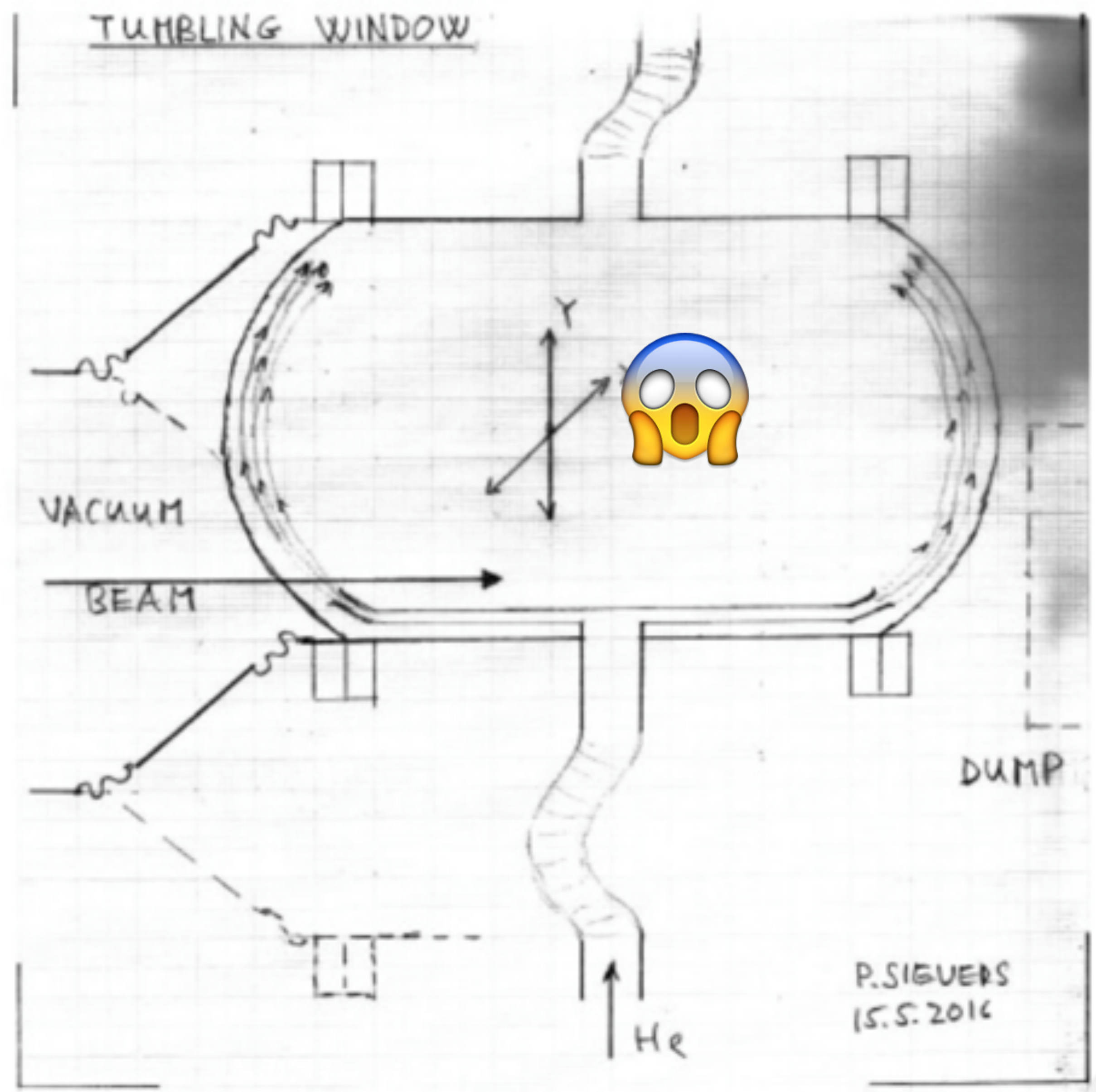
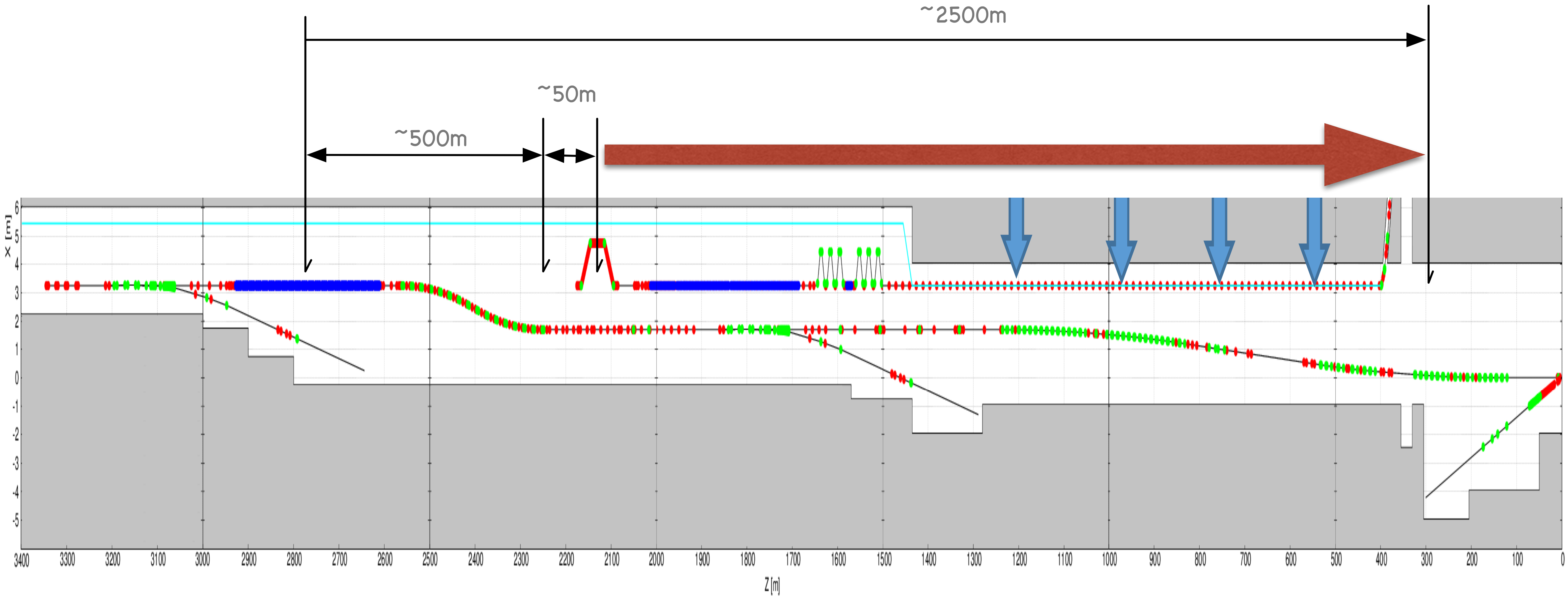


Move the dump further away



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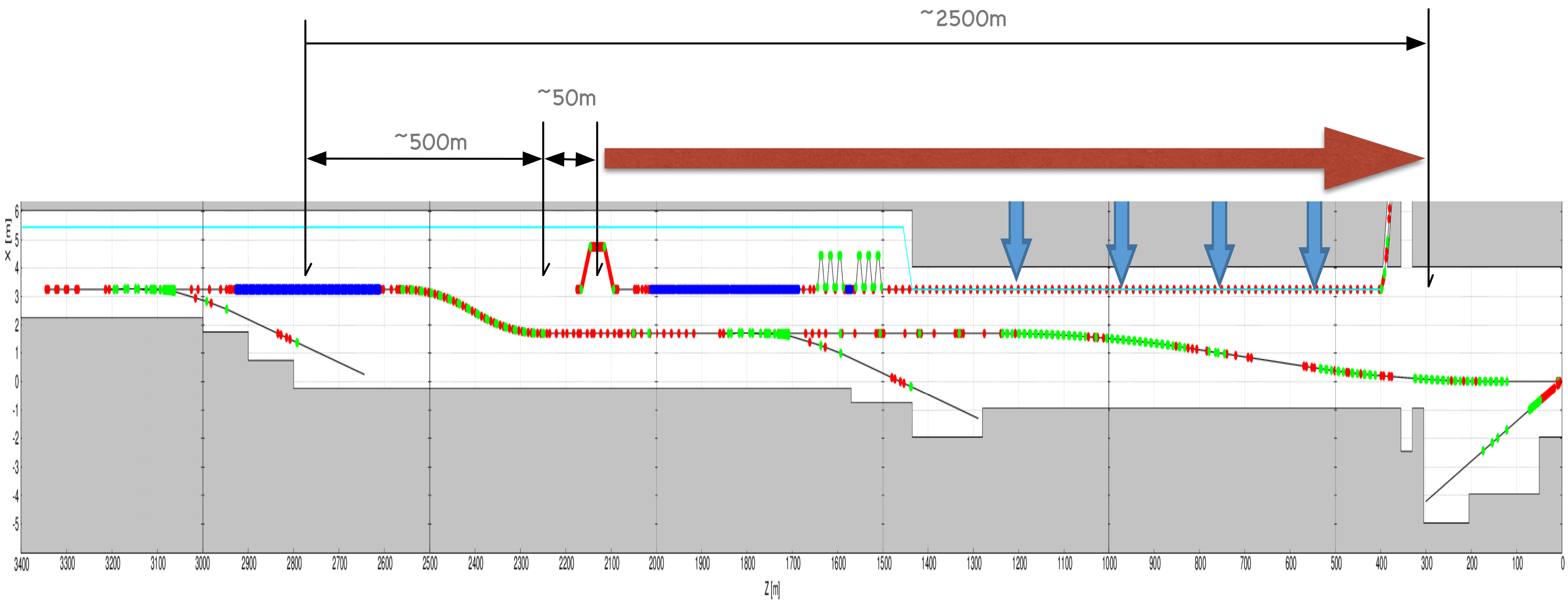

scaling ~ (2500/550)2 ~ 21 ⇒ ~50 days

Ideally looking for 10 years!

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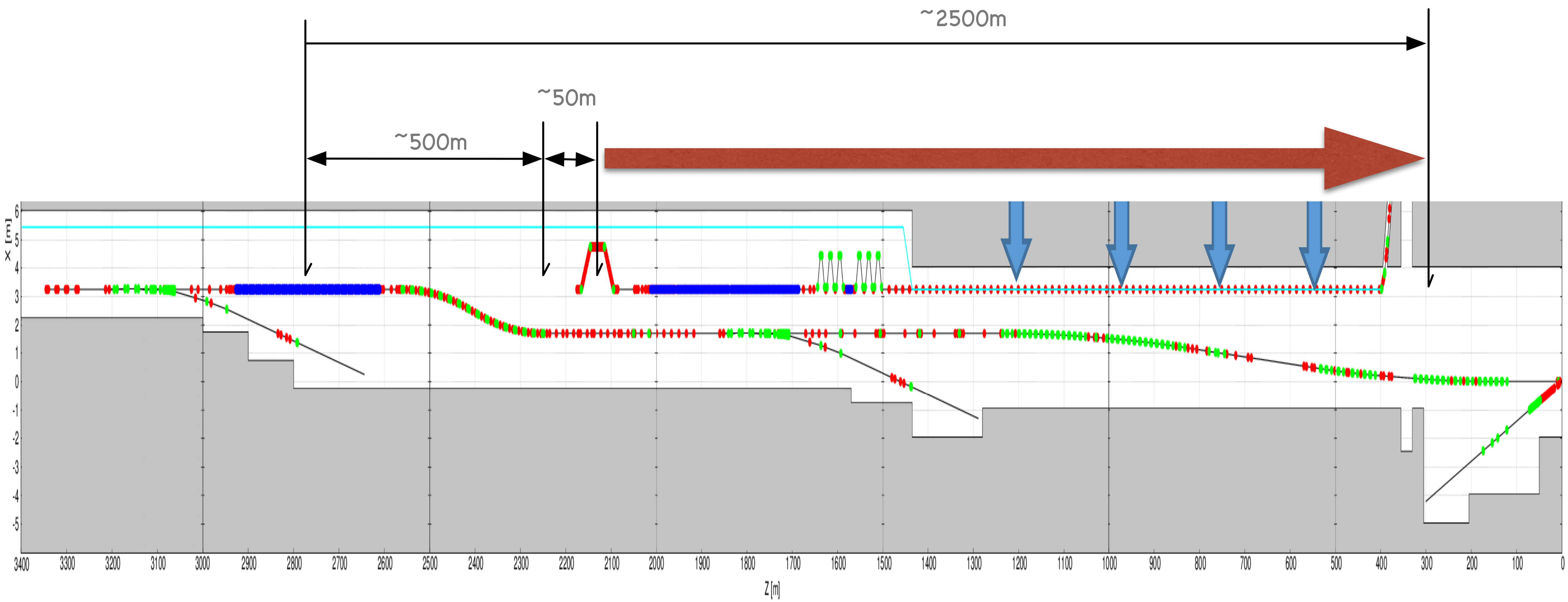

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Ideally looking for 10 years! 😱

Photon dump now a "big issue"

- Usual LCC management response: form a WG
  - but with whom?
  - need the right experts

- Back to the drawing board
  - Larger distance
  - Different material window (graphite?)
  - Different electron optics in undulator
    - increase photon beam divergence
    - may impact polarisation
  - Wobbling windows and other "interesting" ideas
  - Something we haven't thought of yet
  - **Combination of some or all of the above!**

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To achieve 1 year (10^8 seconds) requires ×500 increase in a photon beam spot area on dump

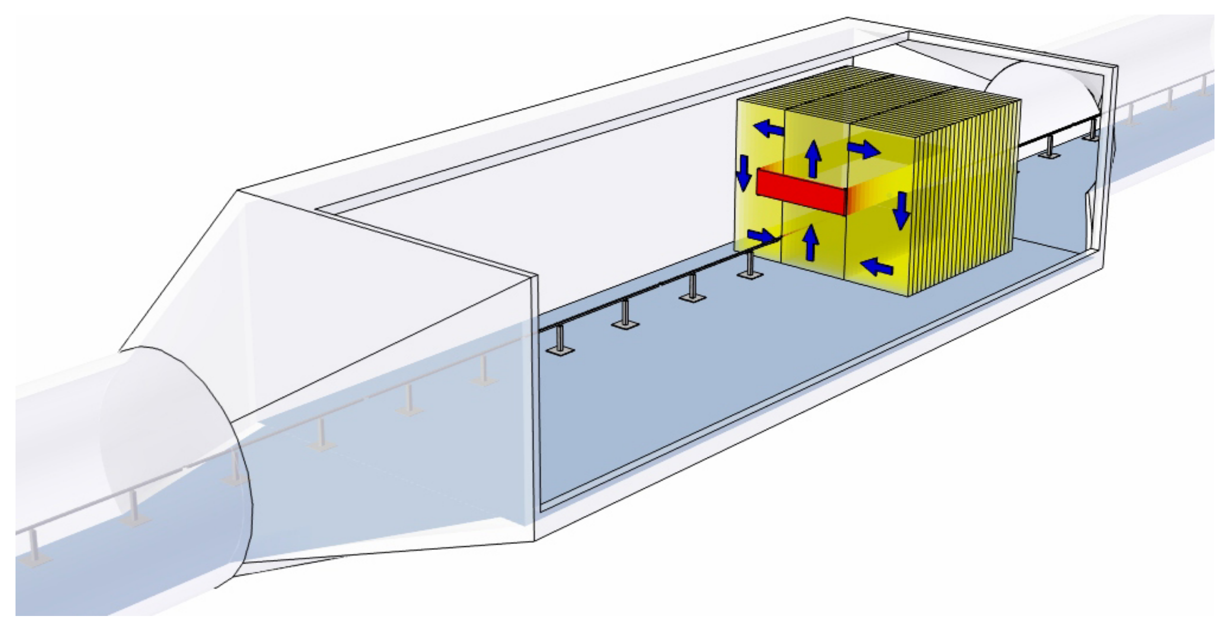
×20 from 2.5km drift leaves ×25 in beam size, or ×5 in average beam width

Muon spoilers

BDS Muon Backgrounds and Shielding

Glen White, Lew Keller, SLAC
ECFA LC, Santander, Spain
June 1, 2016

Can we get rid of "tunnel fillers"?



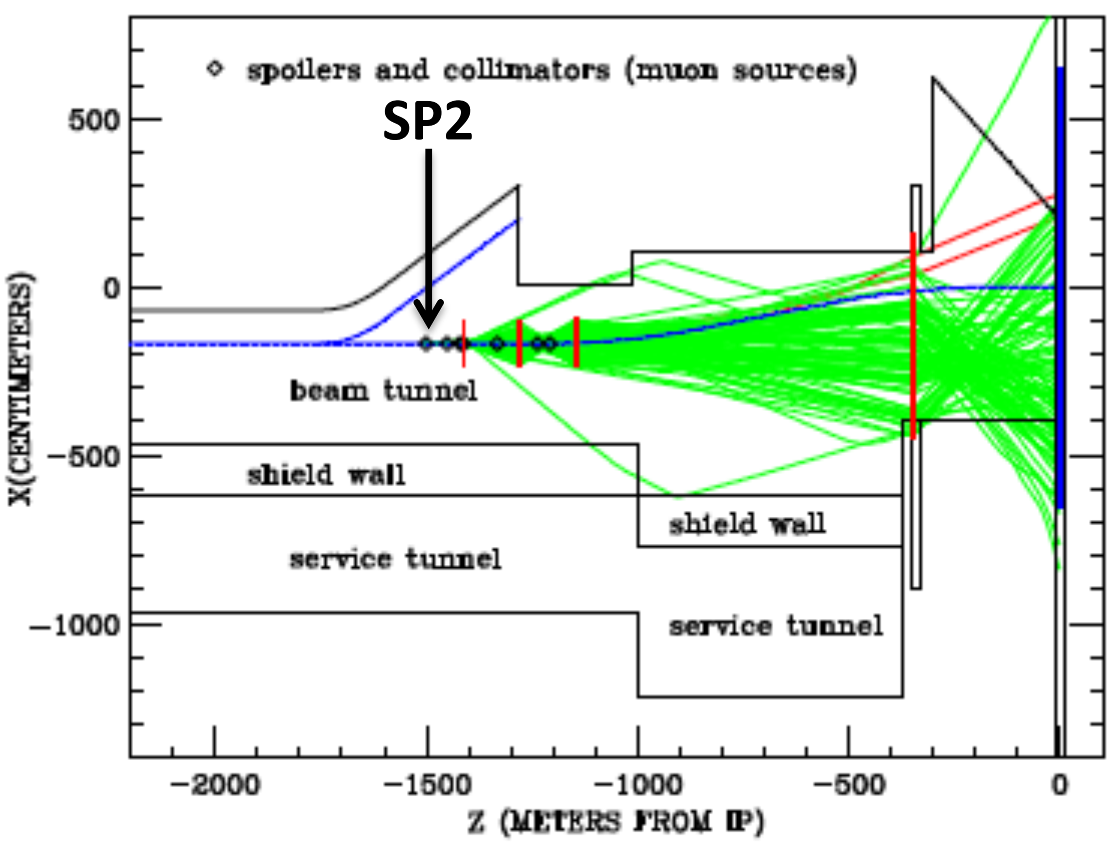
Muon backgrounds

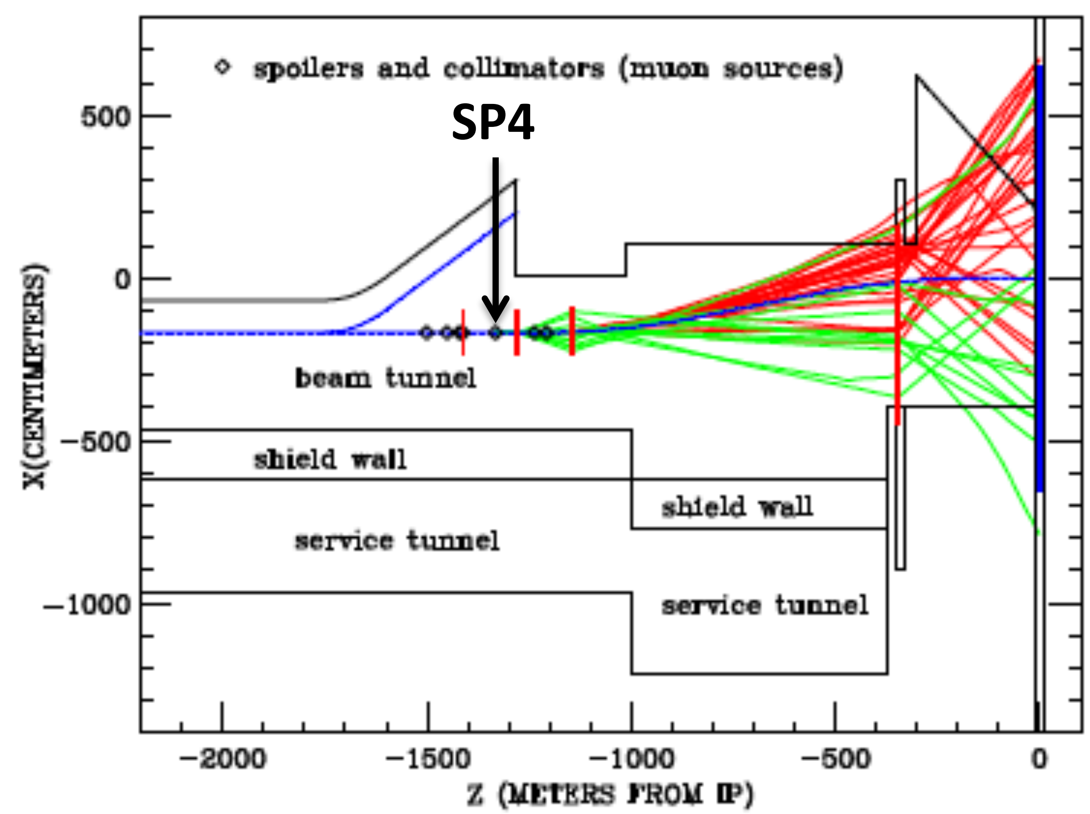
MUCARLO Tracking Results

Spoiler locations from IP:
- 1408 m, 1227 m, 1143m

- 3 Toroid Spoilers
  - L = 5 m
  - R = 0.7 m
- Tunnel filling Wall
  - L = 5 m

Green = μ^+ Red = μ^-





MUCARLO Muon Flux Calculations - MUCARLO

Tunnel Condition	#/bunch in 6.5m radius detector	#/200 bunches in 2.5m radius TPC
1. No spoilers	138	9648
2. Two 5m magnetized spoilers (z = 344-349m) fill tunnel	25	1008
3. Three 5m toroid spoilers	3.3	273
4. Three 5m toroid spoilers and two 5m spoilers (z = 344-349m) fill tunnel	0.5	17

- *(1) GEANT4 Preliminary: ~156 / bunch in 6.5m radius detector*

IR Accident Dose Rate Estimate for P=5MW (Preliminary)

From "Shield11"

Source	Wall Condition	Muons (Rem / hr)	Photons (Rem / hr)	Neutrons (Rem / hr)
ST1, z=1516m from IP	No Wall	0.01	10,000	5
Wall, z=349m from IP	5m steel	15	0	0

SLAC BCS requirements for beamline occupancy:

- 3 stoppers required:
  - 2 physical beamline stoppers in betatron collimation section
    - BCS electronic devices to sense beam hitting devices & immediately abort beam in DR
  - Interlocked dipoles in ECOLL & FFS
- Max allowable radiation levels in potentially occupied areas:
  - **Normal beam operation:** <0.1 rem/yr (non-radiation workers) <1.5 rem/yr (radiation workers)
  - **Accidents:** dose rate not to exceed 25 rem/hr: require beam to be switched off <14 sec to ensure whole-body dose for an individual <0.1 rem

Allowing people to work in IR area when beam is parked on "tune-up" dump?

Over coffee / in the corridors

- **MEXT-DoE ILC "discussion group"**
  - First meeting few weeks ago
  - Next meeting already scheduled in July.
  - Quite "high-level" people
  - BUT…
  - What are they really talking about?
    - "Emphasis on collaboration on cost-reduction R&D"
    - PWA?

In summary

- In general workshop a success
- Attendance ~OK for recent workshops
  - US attendance was however very low. Some very key people missing.
  - Many talks via Vidyo
- Accelerator sessions showed there is progress
  - Some sessions a little “tired” due to lack or progress (resources)
  - Tendency to regurgitate the questions and “chew the cud”
- Some big excitement
  - FNAL cavity prep recipe
- Some big surprises
  - Photon dump

- Santander was beautiful and the hospitality was excellent
  - especially the dinner!