ILC Status

After the Technical Design Phase

Presentation to SiD prepared by:

Marc Ross (SLAC)

October 14, 2013

Completing the TDP: Outline

- TDP Goals:
  - R & D to enable Project Proposal and updated Value estimate – with Cost Containment
  - Technology Transfer
    - development a strong industrial base
- Technical Design Report:
  - Consists of two parts: 1) R & D Report and 2) Design Description
- Beam Test Facilities:
  - SRF Linac: Fermilab NML, DESY E-XFEL and FLASH, KEK STF
  - Beam Dynamics: Cornell CesrTA (2008 – 2010)
  - Beam Tuning: KEK ATF2
- Production / Industrialization:
  - CEBAF Upgrade and E-XFEL

From January 2013 SiD meeting

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Technology Transfer for ILC

- Asia (Japan and China)
  - Japan: ‘CoI Stream’: Construction started at KEK (~16 M$) for cavity process / test / cryomodule assembly / test. Construction funded; Operations funds (~60M$) to be allocated 10.2013
  - Goal of CoI Stream: applications of SRF using ILC technology. Many diverse applications listed.
  - Hope: CoI Stream facility will make KEK a ‘hub-lab’ capable of standard ILC cryomodule assembly and test
- EU
  - EU – XFEL construction →
- US
  - LCLS-II Project at SLAC →

Innovation 'Generation' Program (MEXT)

文部科学省 MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

文字サイズの変更

会見・報道・お知らせ | 政策・審議会 | 白書・統計・出版物 | 申請・手続き | 文部科学省の紹介 | 教育

トップ > 科学技術・学術 > 産学官連携、地域科学技術振興 > 革新的イノベーション創出プログラム（COI STREAM）

革新的イノベーション創出プログラム（COI STREAM）

文部科学省では、現在潜在している将来社会のニーズから導き出されるあるべき社会の姿、暮らしの在り方（以下、「ビジョン」という。）を
見通した革新的な研究開発課題を特定した上で、既存分野・組織の壁を取り払い、企業だけでは実現できない革新的なイノベーションを
イノベーション創出プログラム（COI STREAM）」を開始する予定です。

2012 supplementary budget, Industry-University cooperation COI program: Generation of 'Earth-Cleaner' market

地域資源等を活用した産学連携による 国際科学イノベーション拠点整備事業
地球を守るアース・クリーナー市場を創出する 新産学連携拠点

Status of COI program 10142013

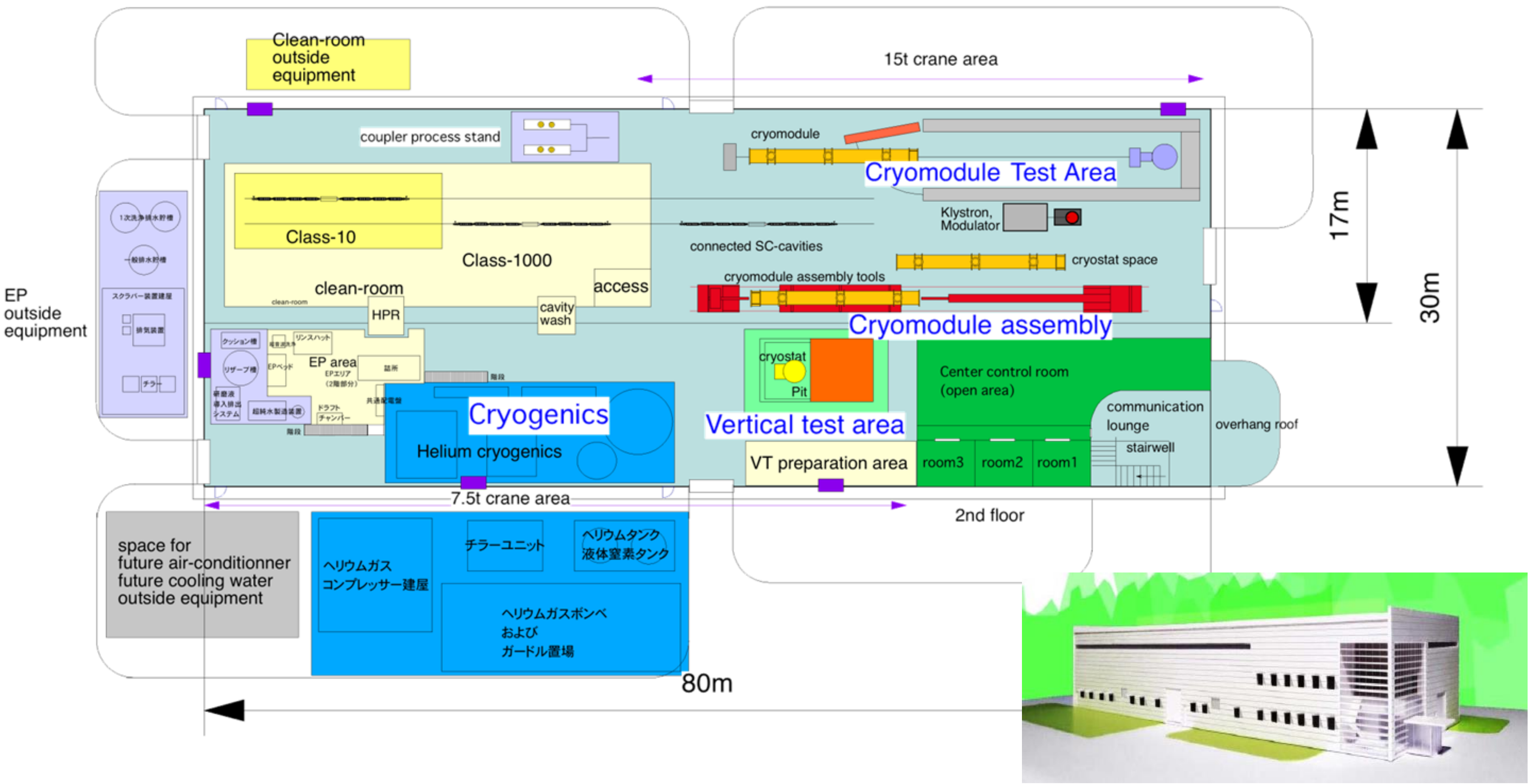
COI : Center Of Innovation

KEK Aerial – Showing COI Stream Footprint

COI building : promotion of superconducting accelerator utilization

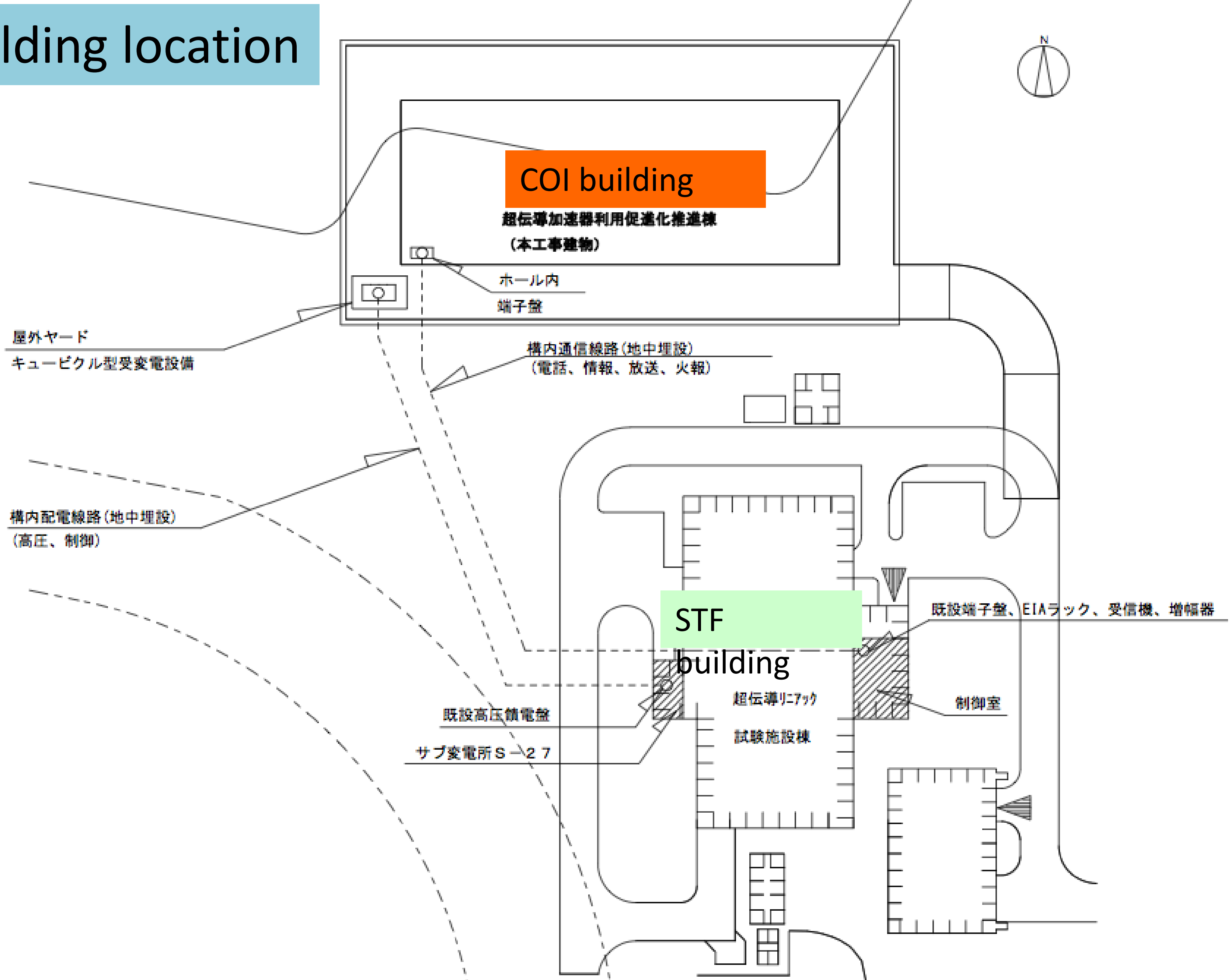
New building (80m x 30m) is under construction at North of STF

Superconducting Accelerator Development Hall (2014)



SC cavity inspection & process, vertical test, cryomodule assembly, cryomodule test

Building location

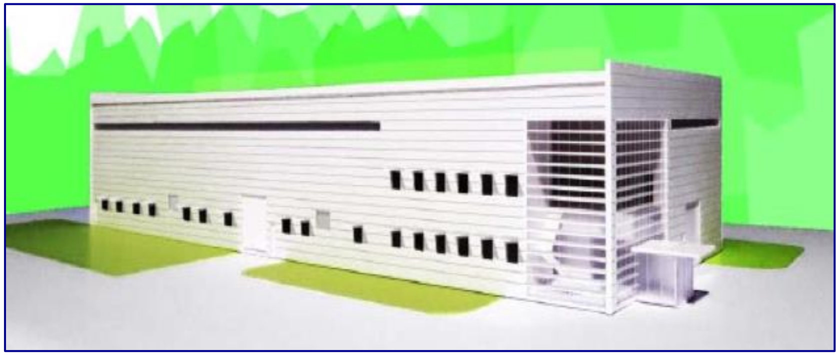


超伝導加速器利用促進化推進棟周辺電気設備配線図

Cut and Flatten for new COI building

09132013

STF building



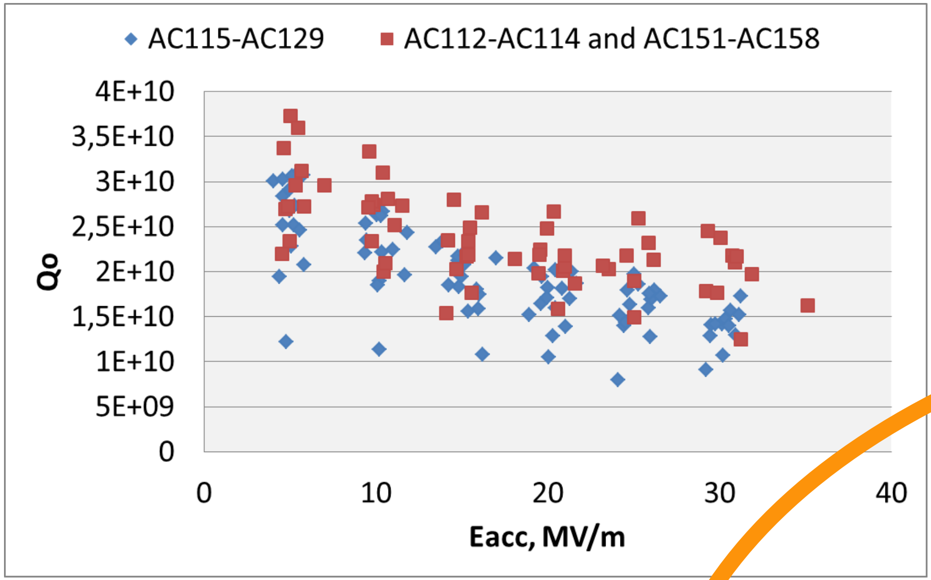
new COI building is now under final detail design,
Completion will be November 2014.

EU Highlights (mostly XFEL)

- Application to EU for ILC-bridging funds under Horizon 2020 FP program
  - Signs of 'interest'

- Intensive industrialization and production of 1.3 GHz ILC -style SRF technology
- Reported at 'SRF 2013', Paris 23-27.09.2013

European XFEL Large Grain Cavities
(or LG advertisement for future projects)

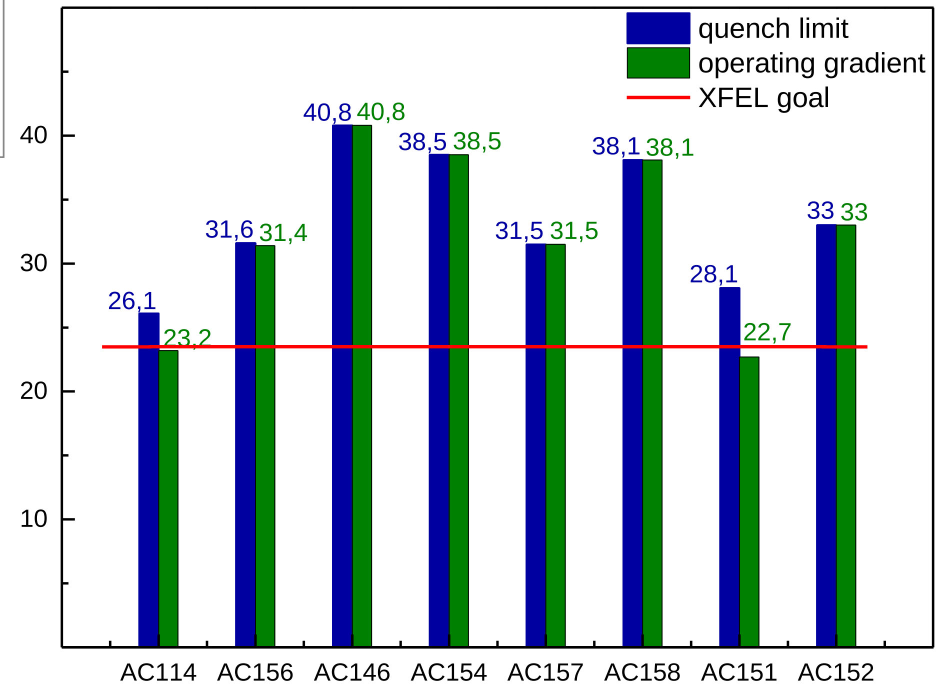


Comparison of Q_0 at 2 K for 11 EP-treated LG cavities (red) with Q_0 at 2 K of XFEL prototype cavities (AC115–AC129, best result) treated according to XFEL recipe (blue).

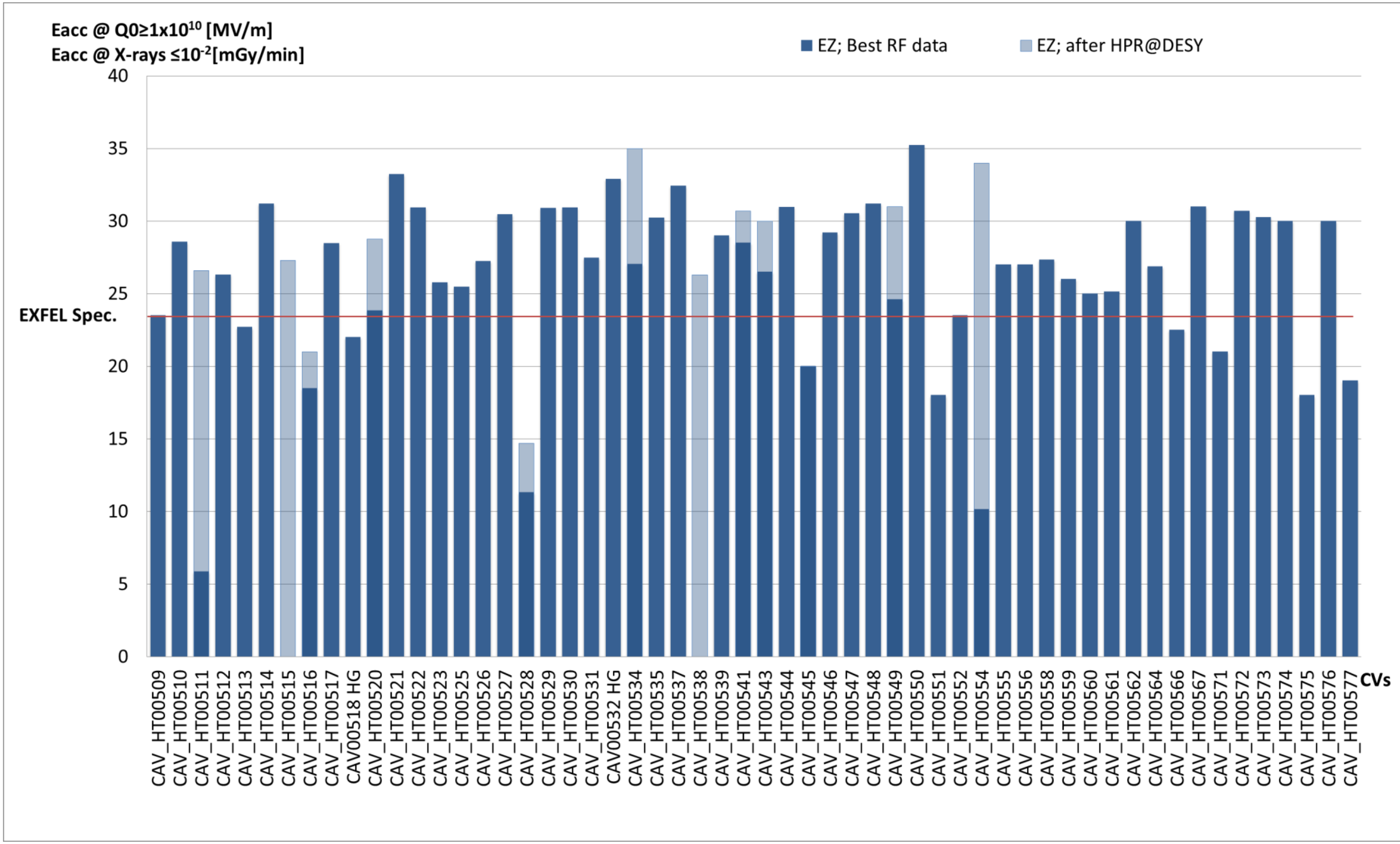
E_{acc} performance of LG cavities in EXFEL cryomodule XM-3.

The cryomodule has ca. 60% lower cryogenic losses in CW, compared to all 4 previously tested cryomodules (J. Sekutowicz).

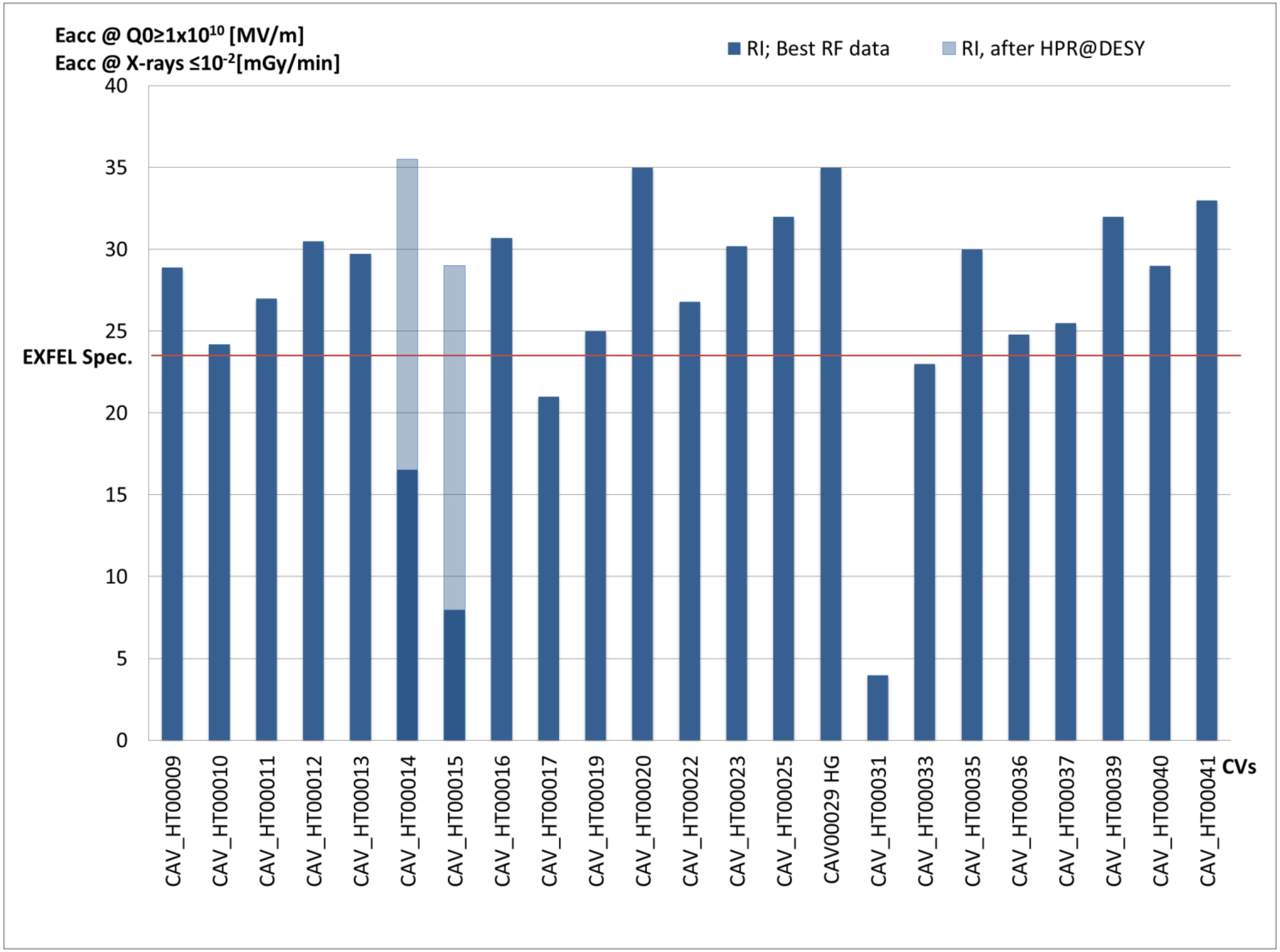
For details see presentation of C. Madec THIOA02



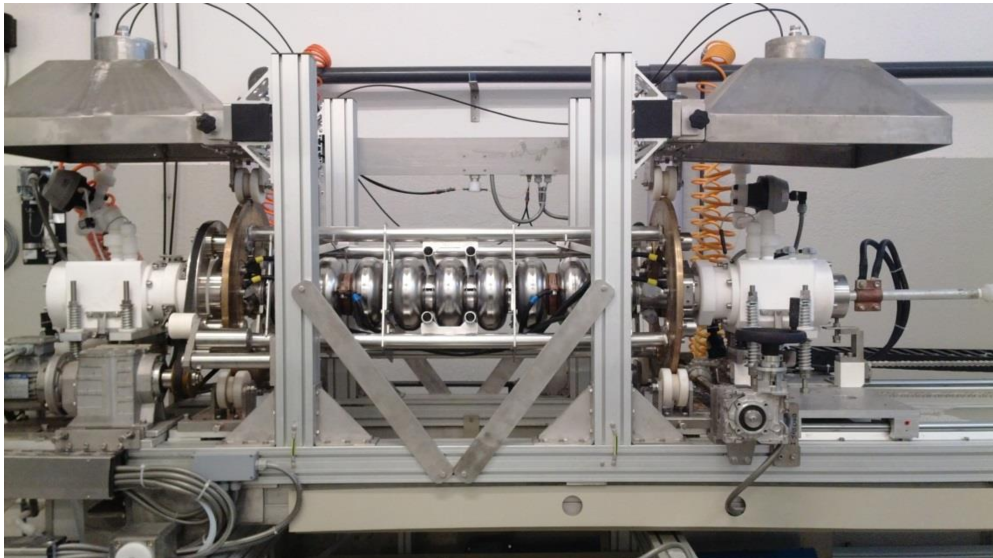
E. Zanon: Status September 10th. Delivered 69 CAVs. More details in Talk THIOA01



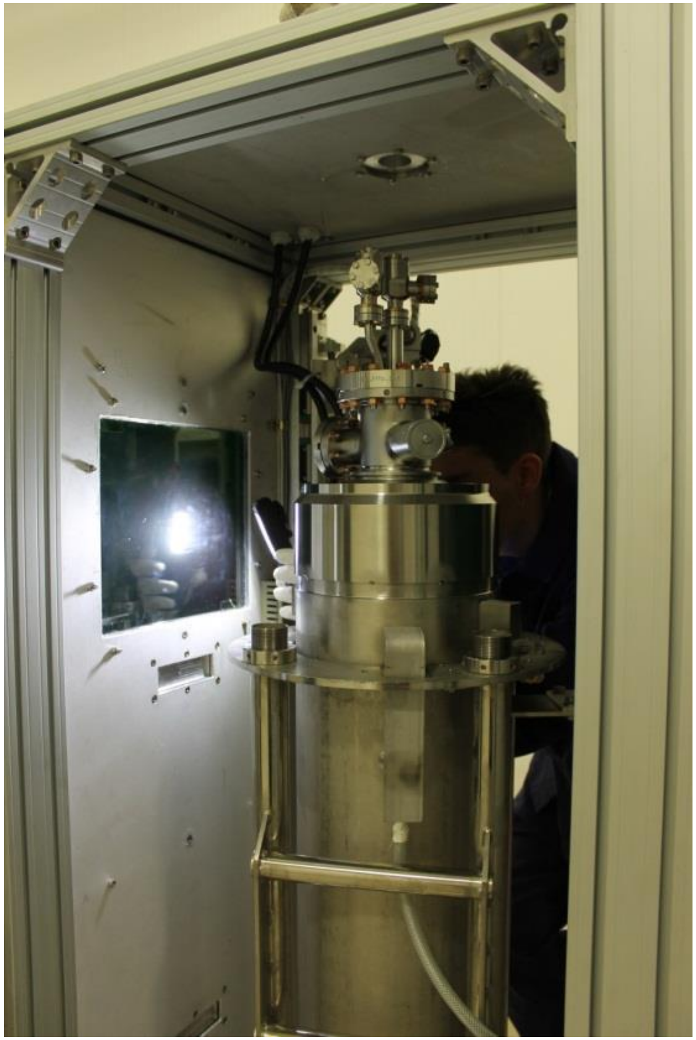
RI: Status September 10th. Delivered 42 CAVs. More details in Talk **THIOA01**



EP facility, EB welding and 3D-measurement equipment (courtesy of E. Zanon)

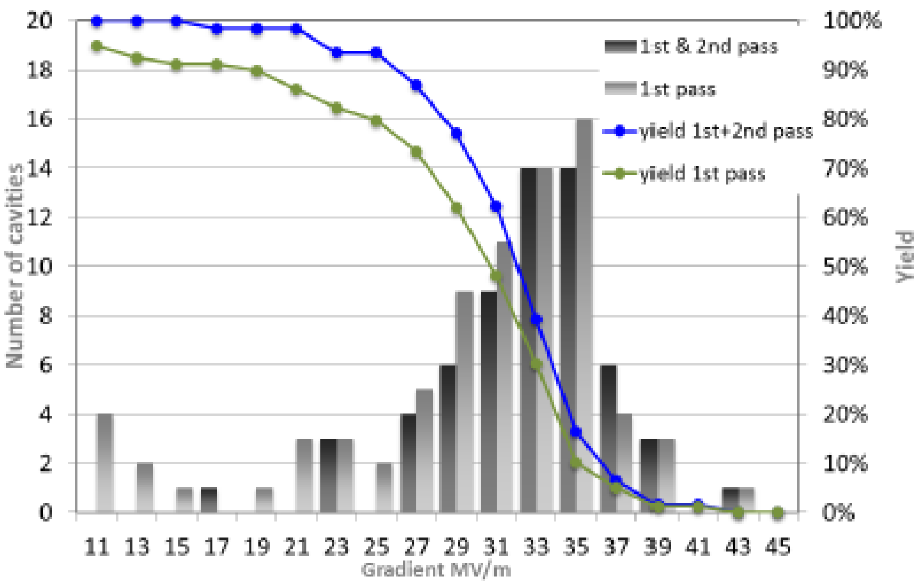


Helium Tanks Fabrication (courtesy of E. Zanon)



Yield of gradients: After re-treatment (2. pass)

- Yield of usable and maximum gradient of 64 cavities (2.pass): 50 cavities passed in 1.pass + 14 cavities after re-treatment
- **Average gradients increased + spread reduced** (standard deviation)

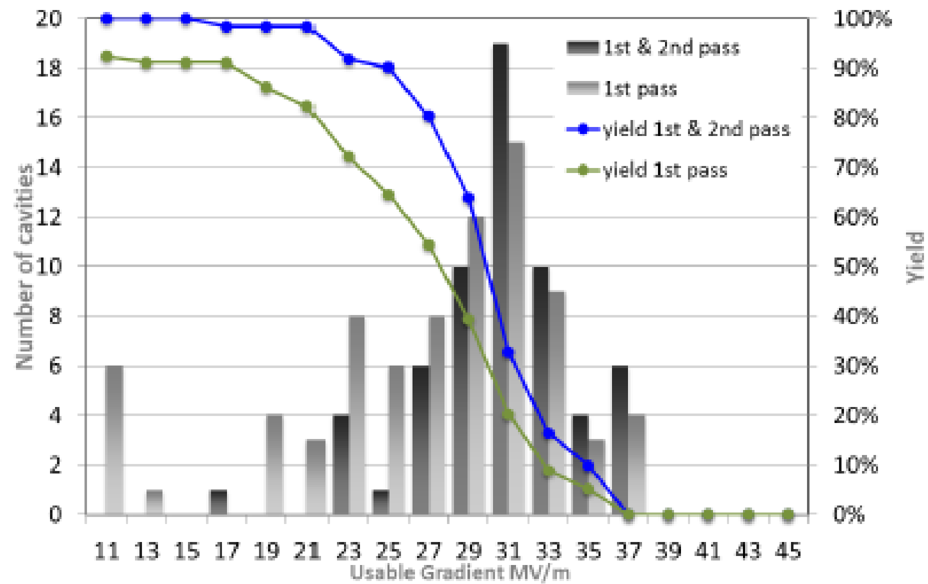


Average **maximum** gradient:

(30.9 ± 4.4) MV/m

EZ: (30.4 ± 4.5) MV/m

RI: (32.3 ± 4.1) MV/m



Average **usable** gradient:

(29.0 ± 3.9) MV/m

EZ: (28.4 ± 4.0) MV/m

RI: (30.6 ± 3.1) MV/m

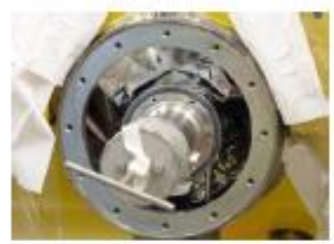
INDUSTRIAL CONTRACT : RAMP-UP IN PRODUCTION PHASE

7 assembly area +1
=> 8 weeks of assembly

Ramp-up : XM1 to XM8 : 2 weeks per area
=> 16 weeks

Ramp-up from Sept. 2013 to Dec. 2013

Production : Dec. 2013 on



EU - XFEL

- Cavity production lines fully functioning: 8 cavities / week
  - Two companies
- Coupler production quality improved
- Cryomodule production:
  - Three pre-series CM (XM-3, XM-2, XM-1) in process; typical time to construct 4 months; time to test unknown (XM-2 now in cool-down)
  - Production series of 81 each started Sep. 02, 2013; full rate from Dec 2013 (until Oct 2, 2015)
  - One CM / week; one production line (CEA-Saclay)
- 24 cavities to be used for high – gradient development

SLAC Proposal:

- Following BESAC (Basic Energy Sciences Advisory) report in late July:
  - Shakeup of US accelerator construction projects:
  - SLAC LCLS-II project redefined
  - ANL APS upgrade program redefined

- SLAC Proposal:
  - 4 GeV CW SRF Linac-based FEL
  - Use ILC / XFEL 1.3 GHz technology
  - Installed in the first 1/3 of the SLAC linac housing
  - (50 year old S-band linac to be completely removed)
  - ***First light end of FY 2019***

SLAC Director Chi-Chang Kao, 27 September 2013:

SLAC Today Story Archive

From the Director: A Modified Proposal for LCLS-II

September 27, 2013

by Chi-Chang Kao

A few weeks ago, I wrote about a recent report from the Subcommittee on Future X-ray Light Sources of the Basic Energy Sciences Advisory Committee (BESAC). The report strongly endorsed the science that can be facilitated by X-ray free electron lasers and called for a facility that could provide beams with both high per pulse energy and high repetition rate to allow for the exploration of revolutionary new science. As I wrote, we were asked by the Department of Energy's Office of Science to explore how we might incorporate the report's recommendations into our plans for the upgrade to the Linac Coherent Light Source (LCLS). We developed a modified plan on how we could accomplish this.

SLAC Lab Director Chi-Chang Kao. (*Credit: Matt Beardsley*)

Tags

Department of Energy

Director's Columns

LCLS-II

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Today, I want to give you more details on this plan for meeting BESAC's recommendations. Let me first caution that what I'm explaining here is just a proposal. No decisions or funding commitments have been made. However, we are beginning to work more closely with the Office of Science and partner with other national laboratories to assess the feasibility, cost and schedule of this proposal, so I want to make sure all of you at SLAC are kept as up to date as possible.

To meet BESAC's recommendations, we have proposed constructing a 4 GeV superconducting linear accelerator in the first third of our existing linac tunnel. Rather than building a new undulator tunnel as was called for in the original design for LCLS-II, we now propose placing two variable-gap undulators in the existing undulator tunnel: a new soft X-ray undulator and a hard X-ray undulator that would replace the existing LCLS undulator. The existing LCLS instruments would be upgraded to take advantage of the new configuration. The undulators, when fed by the superconducting linac, would enable a new class of experiments making full use of the high repetition rate and lower intensity pulses, such as high resolution and multi-dimensional X-ray spectroscopy. It will still be possible to feed the new hard X-ray undulator with electrons from the existing linac to provide pulses with high energy, high intensity and very short duration. The new plan would allow us to incorporate all the capabilities called for in the BESAC subcommittee report and help the U.S. maintain its world leadership in light sources and LCLS to continue to set the standard for cutting-edge scientific discovery.

Chi-Chang Kao, 27 September 2013:

If the proposal is approved and funded, we will need the help of a number of partners to help make it a reality as soon as possible. We have begun discussions with other national laboratories that have expertise in areas such as superconducting radio frequency, high repetition rate injectors and undulators to explore how we may work together.

We have worked closely with the Office of Science on this proposal but as I said, there is a ways to go before any decisions are made with regard to whether we move forward with these modifications. We need to remain mindful that we continue to live in a very constrained funding environment. Until and unless our response to BESAC's recommendations moves beyond the proposal stage, it is too early to discuss timing or schedules for this modified plan. However, we strongly agree that the opportunities for exciting science laid out in the BESAC report with such an instrument are unprecedented.

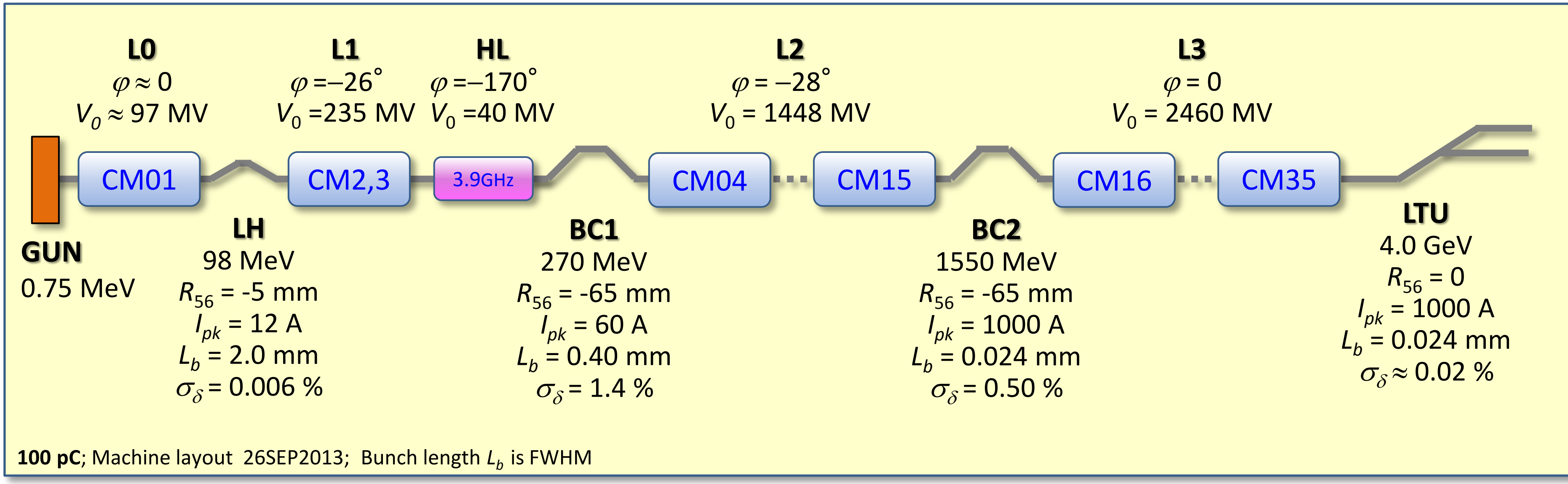
RF Parameters:

RF Parameters (CW SRF Linac)	**symbol**	**nom. value**	**units**
RF frequency	f_{RF}	**1.3**	GHz
Average RF gradient (powered cavities only)	E_{acc}	**16**	MV/m
Installed 1.3 GHz voltage (all cavities)	V_{13}	**4.6**	GV
Fraction unpowered cavities	V_{off}	**6%**	-
Mean cavity quality factor (unloaded)	Q_0	**2**	10^{10}
Mean cavity quality factor (loaded)	Q_L	**4**	10^{7}
Cavity operating temperature	T_{cryo}	**1.8**	K
No. of 9-cell cavities per cryomodule (1.3 GHz)	N_{cav}	**8**	-
Cavities per power amplifier in L0 and L1	-	**1**	-
Cavities per power amplifier in L2 & L3	-	**48**	-
Total installed cryomodules (1.3 GHz)	N_{CM}	**35**	-
Total spare cryomodules (1.3 GHz)		**1**	-

RF Parameters (2)

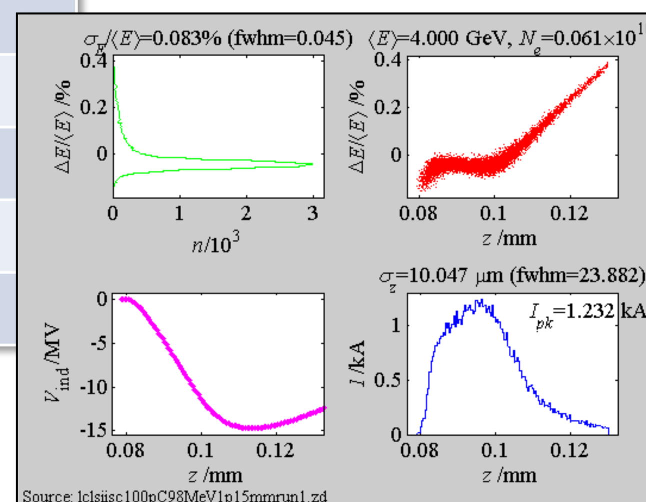
RF power per cavity (average)	P_{cav}	**6.3**	kW
Total number of 3.9-GHz Cavities	-	**12**	-
Max. 3.9-GHz crest voltage	V_{39}	**60**	MV
No. installed CMs in L0	N_{CM0}	**1**	-
No. installed CMs in L1	N_{CM1}	**2**	-
No. installed 3-9-GHz CMs in linearizer	N_{CMLH}	**3**	-
No. installed CMs in L2	N_{CM2}	**12**	-
No. installed CMs in L3	N_{CM3}	**20**	-
SC Cryogenic AC Power	P_{Cryo_AC}	**5.4**	MW
RF AC Power	P_{RF_AC}	**3.5**	MW
Estimated RMS Stability Goals:			
RF phase stability (rms, pulse-to-pulse)	$(\Delta\varphi_{RF})_{rms}$	**0.01**	deg
RF amplitude stability (rms, pulse-to-pulse)	$(\Delta V/V_{RF})_{rms}$	**0.01**	%

LCLS-II - Linac and Compressor Layout for 4 GeV



Linac	V (MV)	φ (deg)	Acc. Grad. (MV/m)	No. Cryo Mod's	No. Cav's	Spare Cav's	Cavities per Amplifier
L0	97	*	14.6	1	8	1	1
L1	235	-26	15.1	2	16	1	?
HL	-40	-170	-	3 (3.9GHz)	12	0	12?
L2	1448	-28	15.5	12	96	6	32?
L3	2460	0	15.7	20	160	10	32?

Includes 2-km RW wake



* L0 phases: (-40°, -52°, 0, 0, 0, 13°, 33°), with cav-2 at 20% of other L0 cav's.

First 800 m of SLAC linac (1964):

LCLS-II and ILC

Much LCLS-II construction will be done at Fermilab, using infrastructure intended for ILC

18 CM? (50%)

Other CM to be made at JLab (and Cornell)

US team have made ~ two ILC CM. LCLS-II effort will help understand US-domestic technical, cost, and industrialization

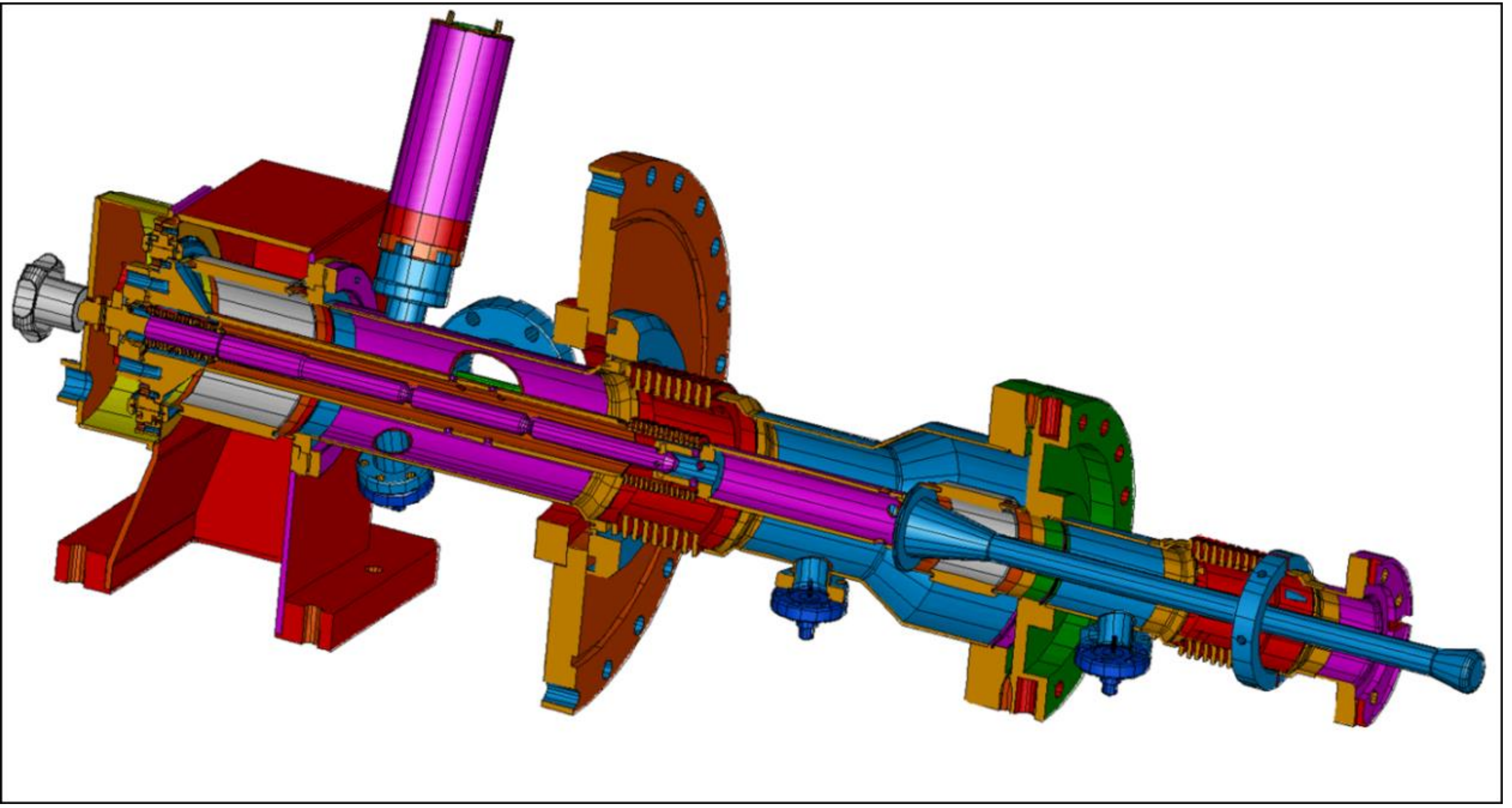
ILC R & D initiative: Power Coupler development

Mandated by PAC (12.2012) technical review

Issues:

- Cost
- Copper coating / flaking
- Complex Assembly
- Plug-compatibility

Bringing power into the cryomodule – the coaxial power coupler:



SLAC expertise

Power Input Coupler WG

Agenda suggested by Wolf-Dietrich

1. Specification

- General specification N. Solyak
- Power capacity C. Adolphsen
- Thermal balance D. Kostin
- Tune-ability &nb sp; H. Hayano,
  (maybe the max power and the tune-ability could be one talk)

2. RF and technical design and cost

- EU/AM W.-D. Moeller
- JP &nbs p; E. Kako
- Assembly TBD
  from KEK, DESY
- Interfaces/integration/compatibility
  H. Hayano
- Comparison, pros & cons TBD, discussion
- Cost aspects A. Yamamoto

3. Fabrication

- Critical fabrication steps (cu-plating, brazing vs welding...) Companies

4. Discussion for the ILC oriented coupler design

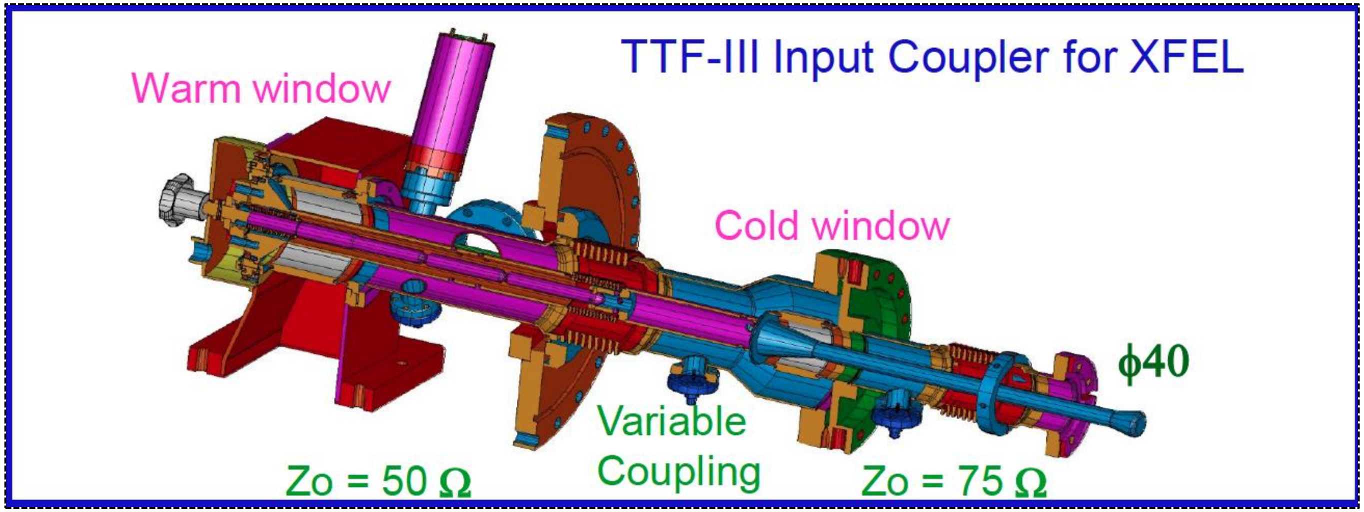
Some open questions/comments:

- Should we talk about cost ?
- **We would like to have coupler experts not involved in the TTF3 or KEK design, e.g. from CERN** or other labs, who?

Discussed at CERN and the following persons advised by L. Evans

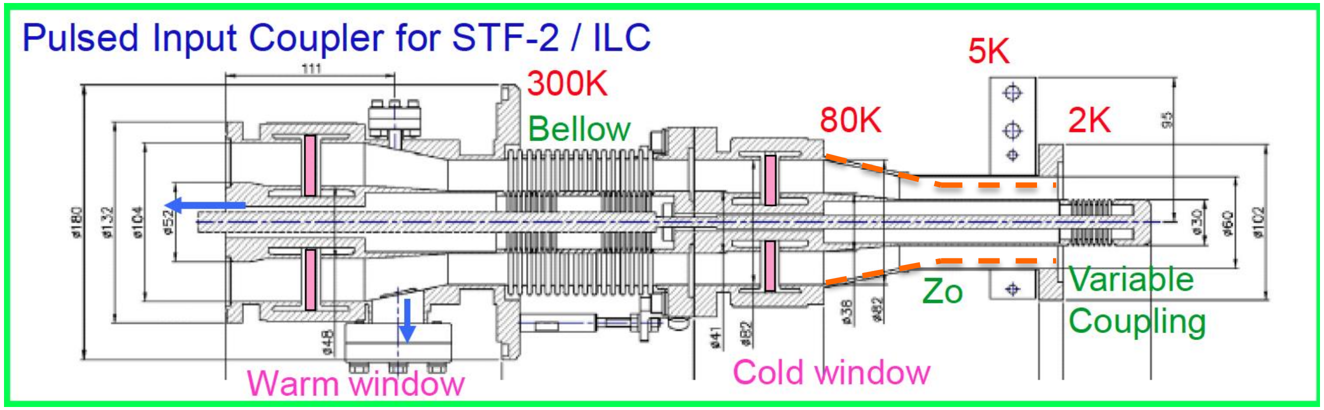
- Eric Montesinos (RF Coupler Expert)
- Jose Miguel Jimenez (Vaccum Group L.)
- Leonel Marques Antunes Ferreira (Cu plating)

Comparison of Input Couplers



TTF-III
- Two bellows
- 40 mm D.
- 125 kW

KEK-STF-II/QB
- Single bellows
- 60 mm D
- (40 mmD to be tried
- 350 kW



ATF2 Program Status

Glen White, SLAC

January 2013

Detector measures

signal **Modulation Depth "M"**

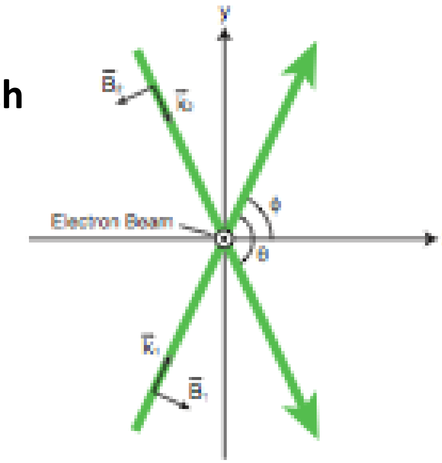
$$\mathbf{M} = \frac{N_+ - N_-}{N_+ + N_-} = \left|\cos(\theta)\exp\left(-2(k_y\sigma_y)^2\right)\right|$$

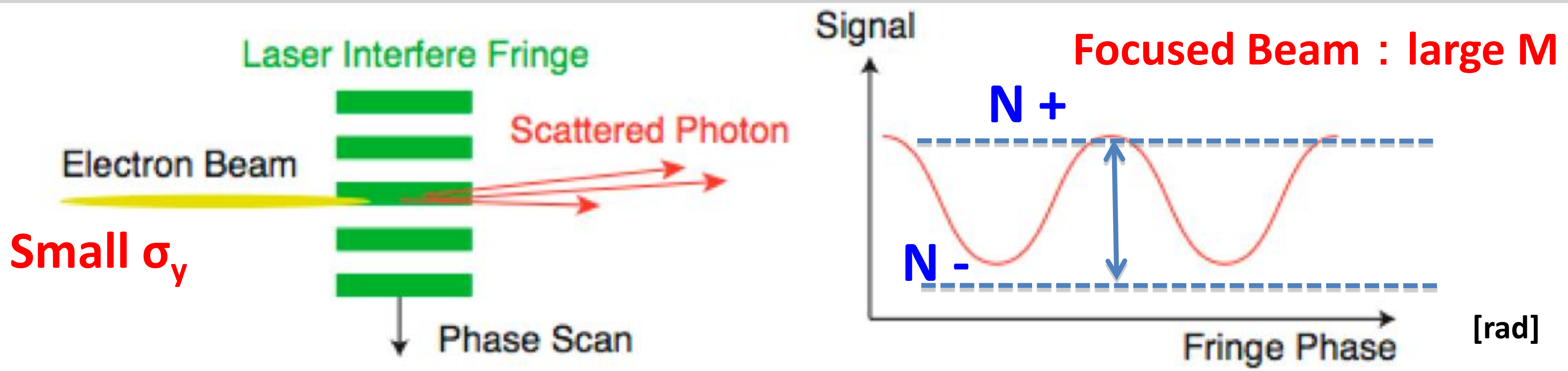
$$\Rightarrow \quad \sigma_y = \frac{d}{2\pi}\sqrt{2\ln\left(\frac{|\cos(\theta)|}{M}\right)}$$

measurable range determined by **fringe pitch**

$$d = \frac{\pi}{k_y} = \frac{\lambda}{2\sin(\theta/2)}$$

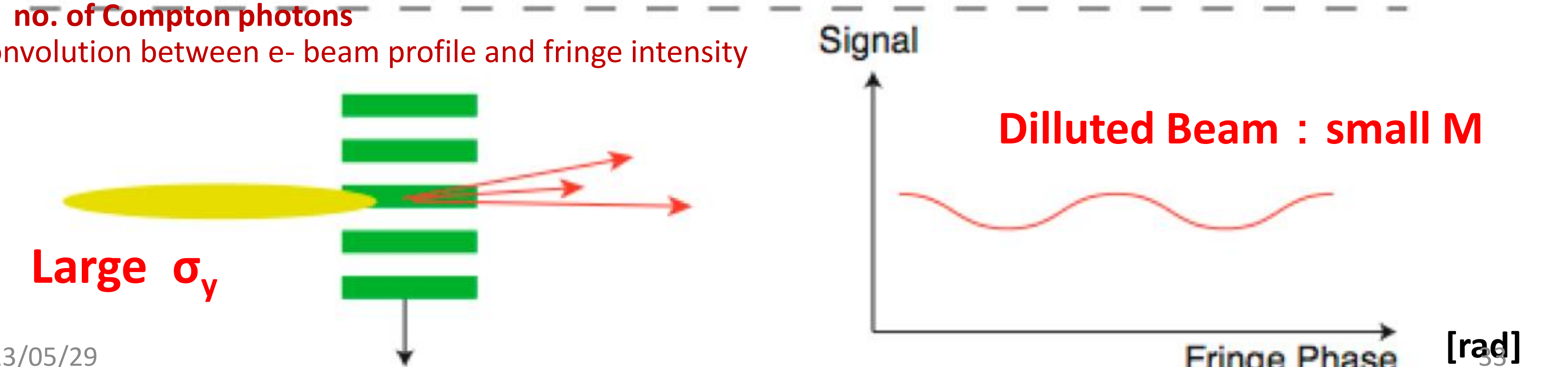
depend on crossing angle θ (and λ)





N: no. of Compton photons

Convolution between e- beam profile and fringe intensity



Crossing angle θ	174°	30°	8°	2°
Fringe pitch $d = \frac{\pi}{k_y} = \frac{\lambda}{2\sin(\theta/2)}$	266 nm	1.03 μm	3.81 μm	15.2 μm
Lower limit	20 nm	80 nm	350 nm	1.2 μm
Upper limit	110 nm	400 nm	1.4 μm	6 μm

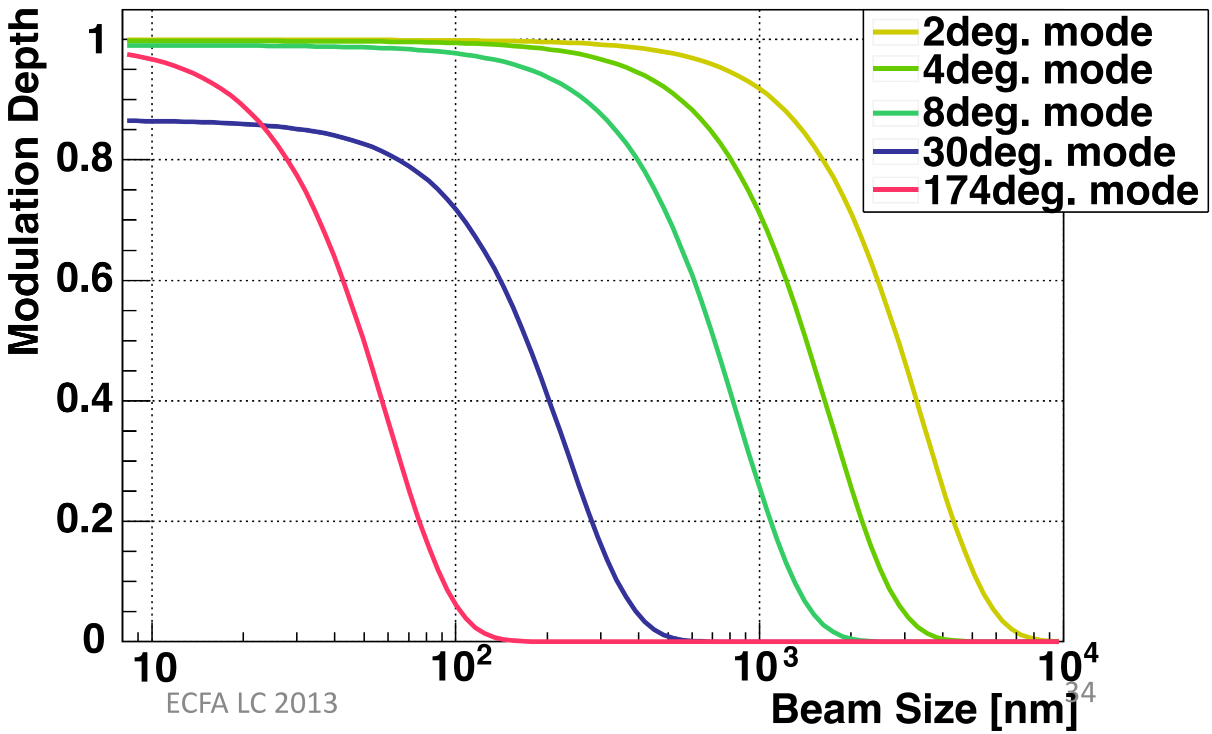
Expected Performance

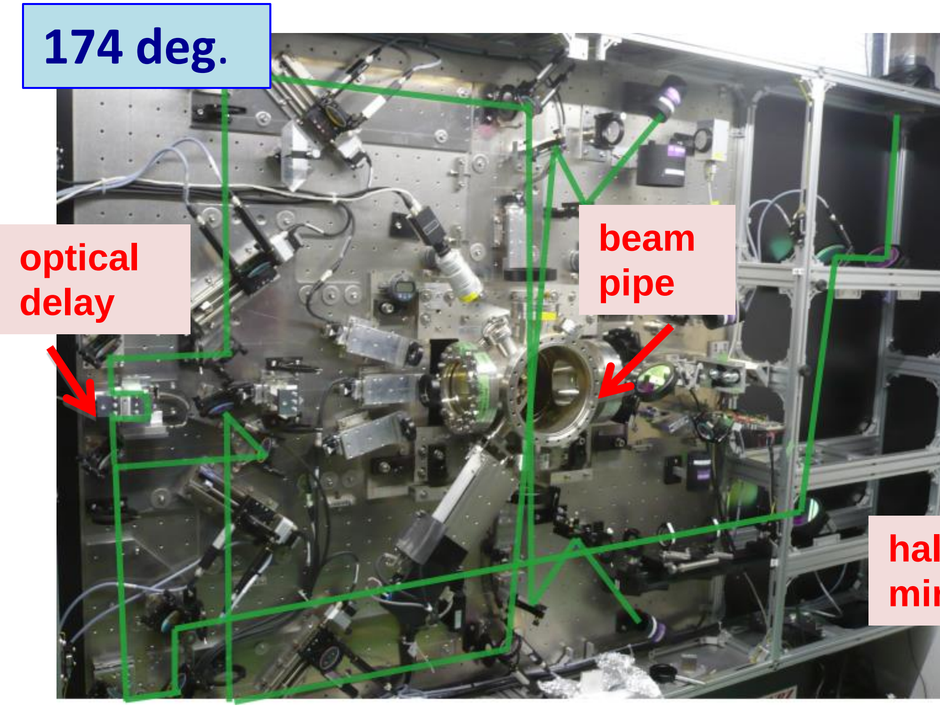
Measures
σy* = 20 nm ~few μm
with < **10% resolution**

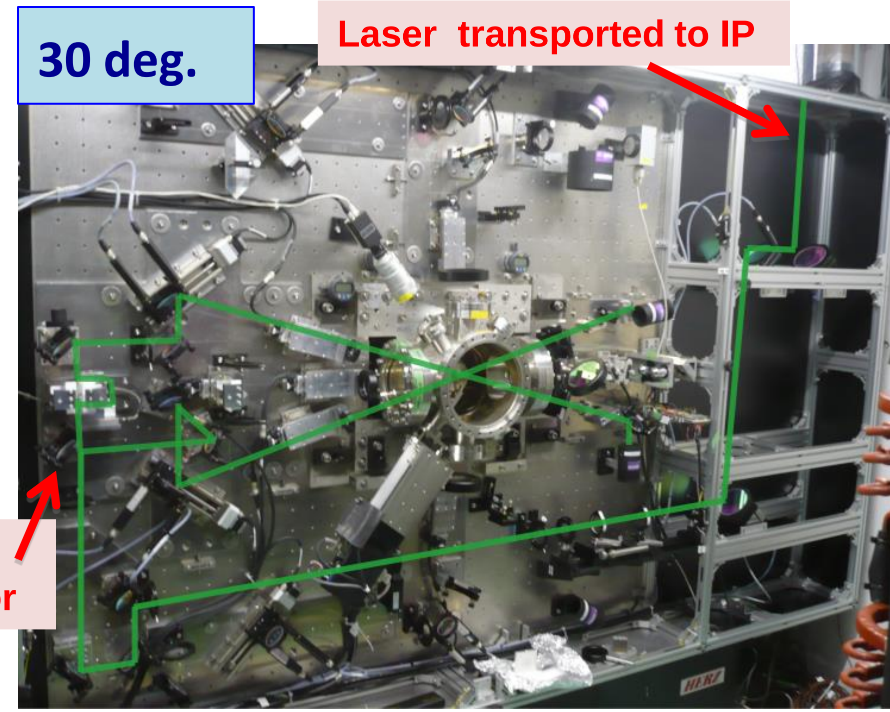
$$\sigma_y = \frac{d}{2\pi}\sqrt{2\ln\left(\frac{|\cos(\theta)|}{M}\right)}$$

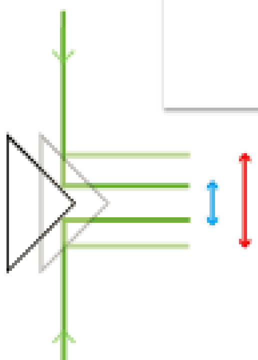
σ_y and M for each θ mode

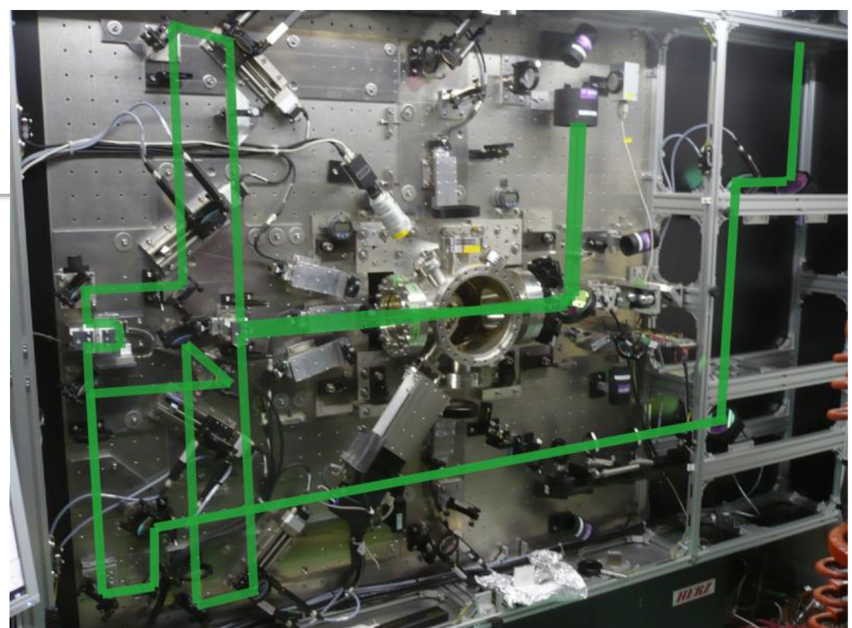
select appropriate mode according to beam focusing











Crossing angle continuously adjustable by prism

Vertical table

1.7 (H) x 1.6 (V) m

- **Interferometer**
- **Phase control (piezo stage)**

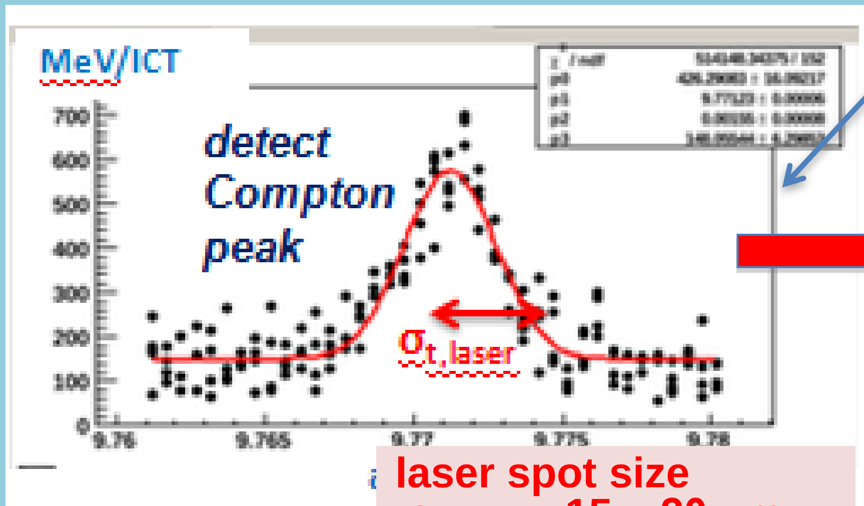
path for each θ mode

（auto-stages + mirror actuators ）

Role of IPBSM in Beam Tuning

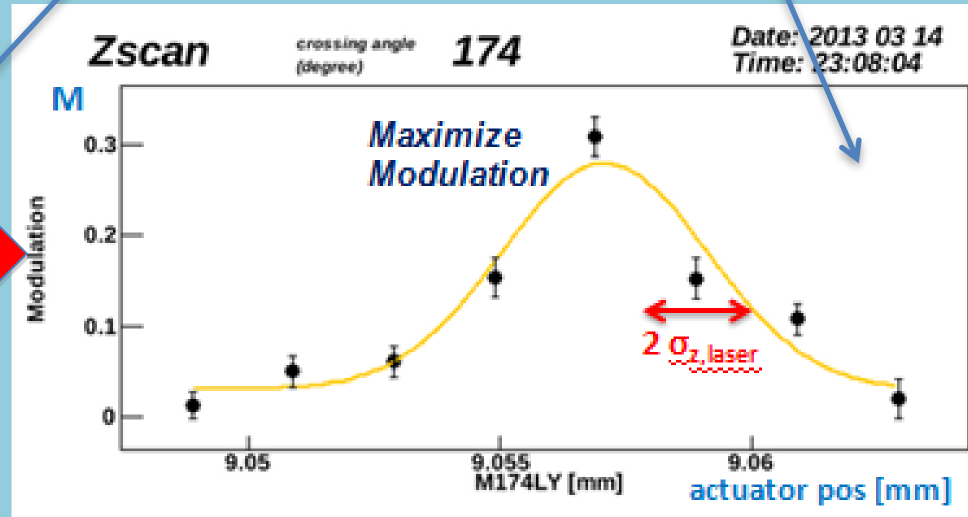
beforehand ....
Construct & confirm laser paths, timing alignment
precise position alignment by remote control

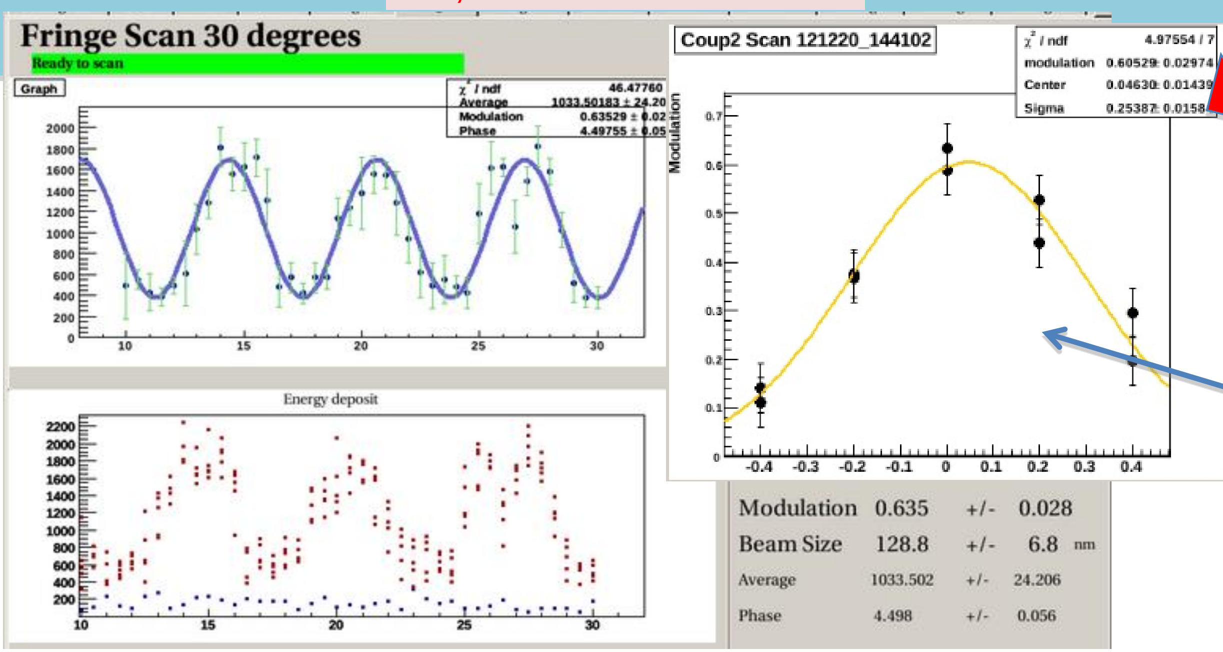
transverse : laser wire scan



laser spot size
$\sigma_{t,laser}$ = 15 – 20 μm

Longitudinal : z scan





After all preparations ……….

continuously measure σ_y using fringe scans

→ **Feed back to multi-knob tuning**

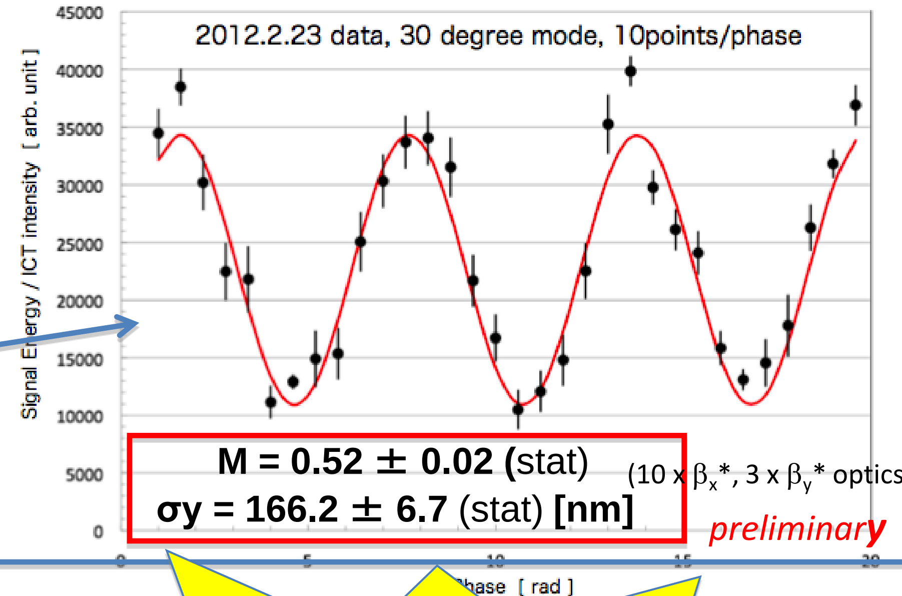
Beam time status in 2012

Spring run

Feb ; 30 deg mode commissioned
(1st M detection on 2/17)

stable measurements of M ∼ 0.55

- 2 - 8 ° mode: clear contrast（Mmeas ∼0.9)
- Prepared 174 deg mode commissioning



Major optics reform of 2012 summer

By IPBSM group@KEK

- **Suppress systematic errors**
- **Higher laser path stability / reliability**

12/20 :
1st success in M detection at 174 deg mode
10 x βx* , **1 x βy***

preliminary

Last 2 days in Dec run
Measured many times M = 0.15 – 0.25
（correspond to **σy ∼ 70 – 82 nm**）

* IPBSM systematic errors uncorrected
** under low e beam intensity (∼ 1E9 e / bunch)

Large step towards achieving ATF2 ‘s goal !!

error studies ongoing aimed at deriving “true beamsize”

Winter run

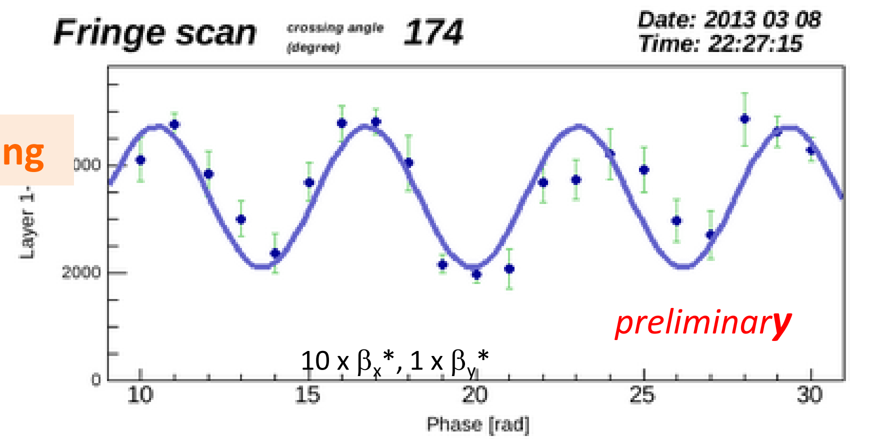
- High M measured at 30 ° mode
- Contribute with **stable operation** to ATF2 beam focusing / tuning study

Beam time status in 2013 Spring

Stable IPBSM performance → major role in beam tuning

measured M over continuous **reiteration of linear /nonlinear@ tuning knobs @** 174° mode

dedicated data for error studies under analysis



Fit results: Av(1.0+M*cos(x+Ph))*

Modulation: 0.385 +/- 0.025

Beam Size: 58.4 + 2.0 / -1.9 nm

174° mode "consistency scan"

measure M vs time after all conditions optimized

2013/03 /14

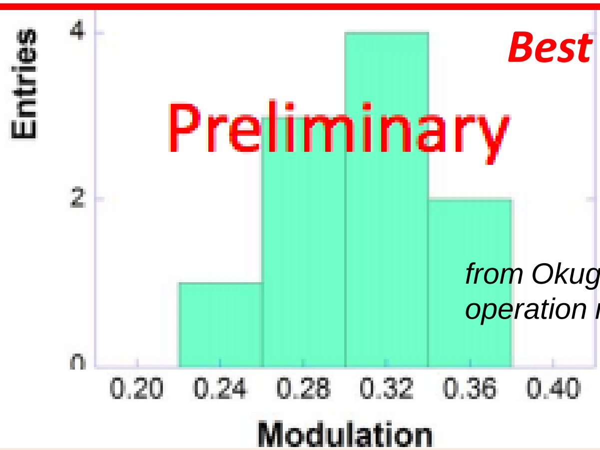
after IP-BSM roll alignment

after IP-BSM pitch alignment

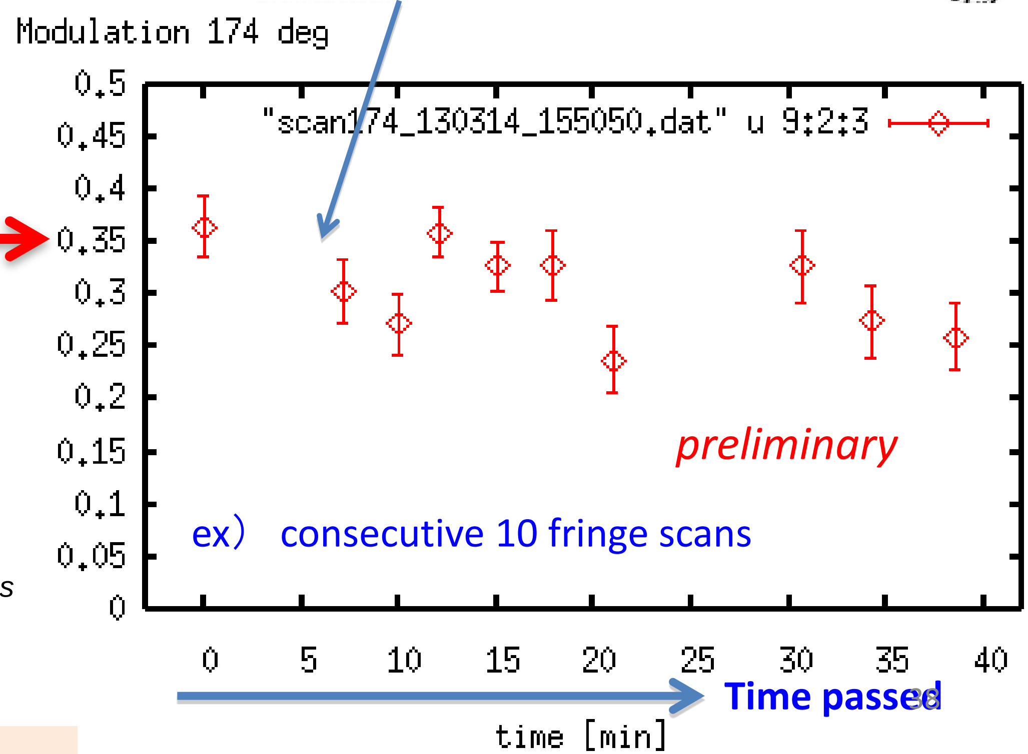
M ~ 0.306 ± 0.043 (RMS)

correspond to σy ~ 65 nm

Best record



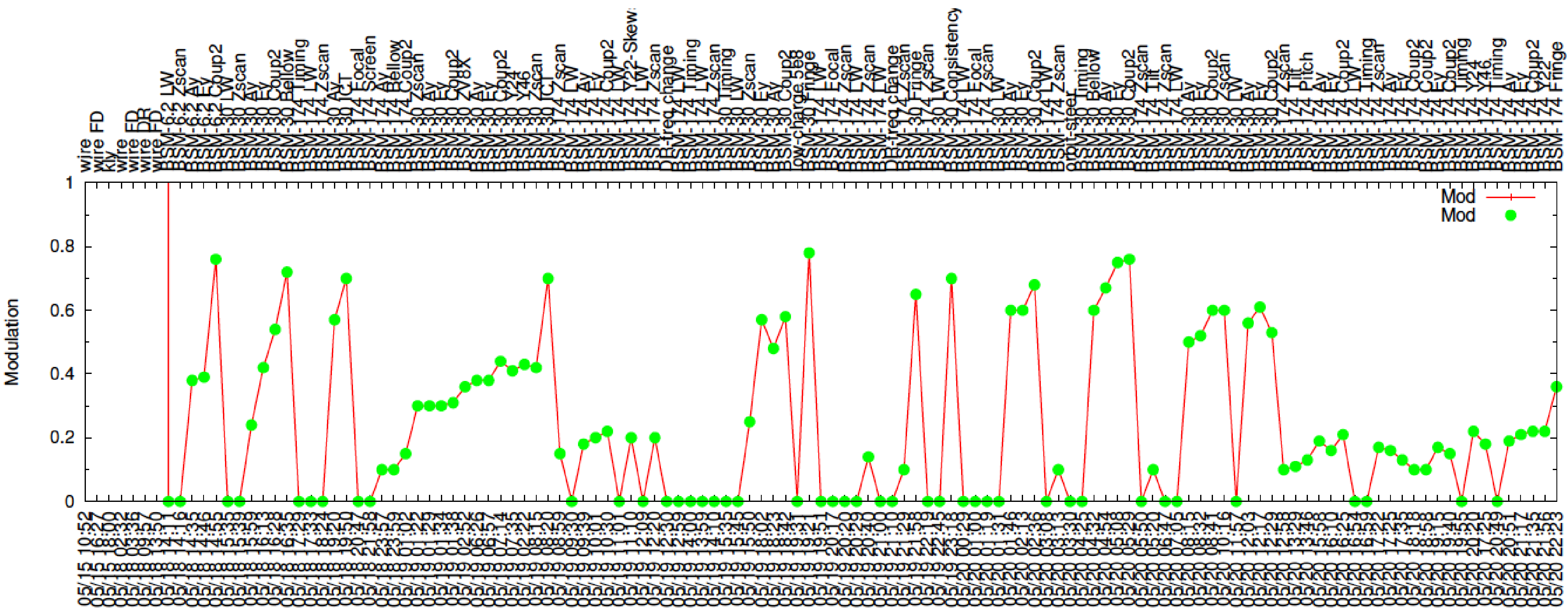
from Okugi-san's Fri operation meeting slides



moving towards goal of σy = 37 nm :

higher IPBSM precision and stability & *looser current limits of normal / skew sextupoles current*

The Reality… May 2 week Cont. Run



- **Summary of all scans during 2 week ops period**
  - *Summary plot courtesy of Edu.*

ILC Project: Mysteries of the Universe

Outreach event in Tokyo, tomorrow, 10.15

Report from the Science Council of Japan on ILC

Published September 30

(see comments from LCC Directorate last week)

Available in Japanese

回　答

国際リニアコライダー計画に関する所見

平成２５年（２０１３年）９月３０日

日　本　学　術　会　議

SCJ Report Charge (informal translation)

○ About scientific significance of research at ILC project, position of ILC within particle physics

○ About the position of ILC project in the whole scientific community

○ About the impact of carrying out ILC in our country to nation and society

○ About constraints - such as the required construction budget, governance of ILC, and securing human resources

SCJ Conclusions:

important issues that should be examined:

(1)More clear explanation of ILC project particle physics , taking upgrade LHC into account.

(2) Budget Framework that does not cause stagnation for action on national problems and progress of the field of arts and sciences

(3)International cost sharing

(4)The role of domestic teams led by the associated researchers such as High Energy Accelerator Research Organization (KEK) or universities

(5)Human resources that are necessary for construction period and driving period, particularly lead management.

It is necessary for a clear prospect to be provided about these problems in judging the right or wrong of inviting ILC in our country.

KEK Internal Evaluation of ILC – including Cost-review

The ILC site selection and SCJ report publication have helped move the KEK Accelerator Laboratory to launch as series of meetings for discussion of related issues – including cost.

(this group is nominally tasked with Super KEK-B and JParc upgrades.)