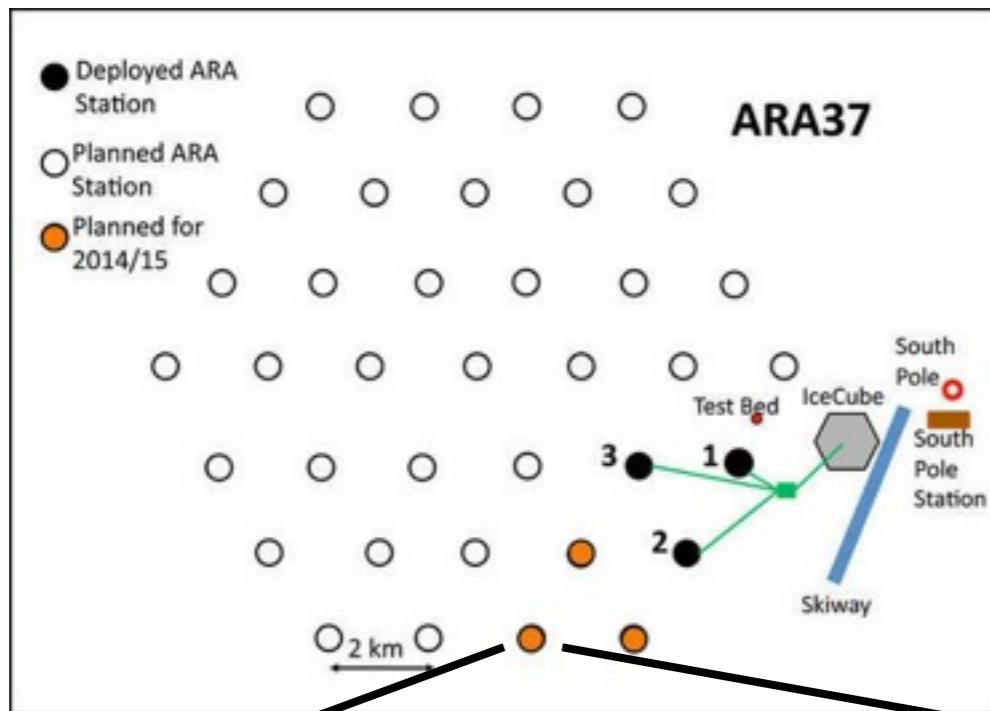


ARA detector calibration with Telescope Array Electron Light Source

Romain Gaior for the Chiba group

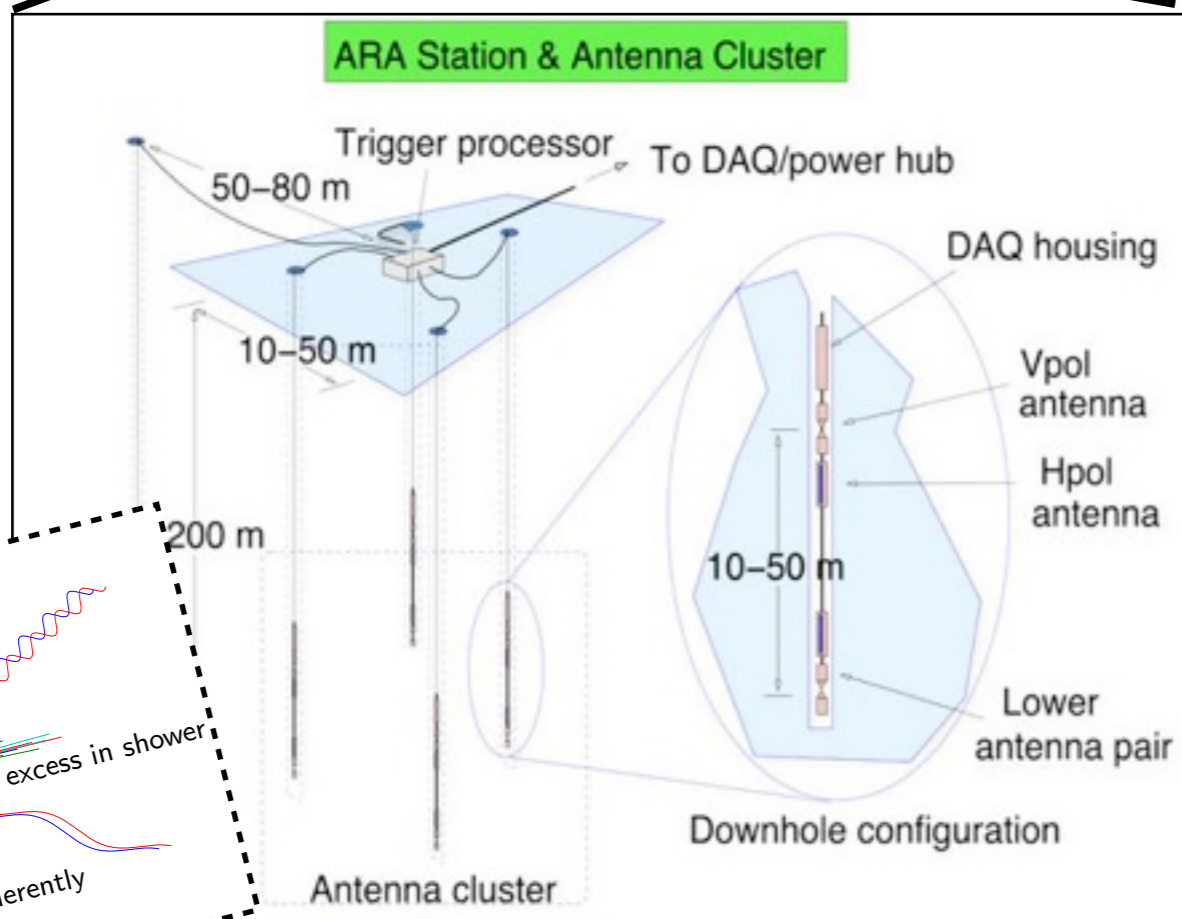


ARA: Askaryan Radio Array

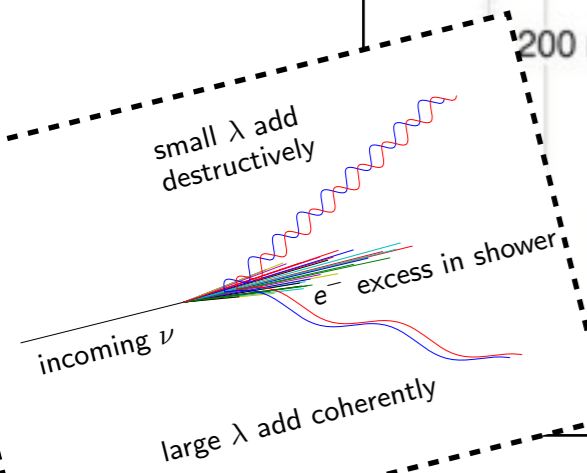


- Detection of UHE **cosmogenic neutrino**
- Expected sensitivity 10x IceCube

- Elemental detector: string of 4 antennas (2 vert/2 hori polarization)
- 1 station = 4 strings
- 3 stations installed (37 planned)



- **Coherent emission** from charge excess in neutrino induced shower (Askaryan effect)
- Radio attenuation length in **ice** \sim **1km** (at optical wavelength \sim 100 m)
- Bipolar pulse of **few ns**



ARA @ Utah

Concept: Shoot electrons in ice to produce a shower and observe the Askaryan like signal

Source:

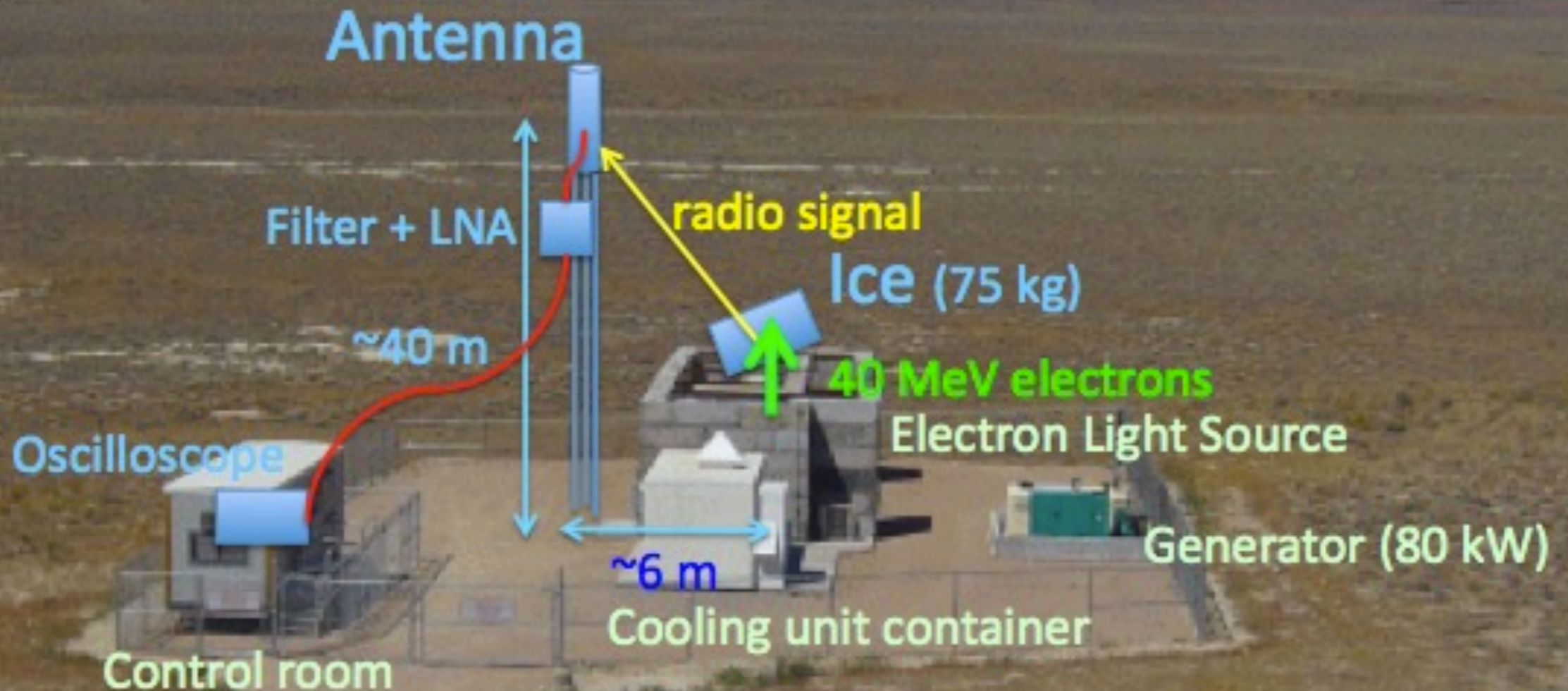
- Telescope Array LINAC
- Ice block as a target

Detector:

- ARA antenna + ampli
- Fast oscilloscope

TA LINAC @Utah

Will be conducted in January (2015)



ARA @ Utah

Concept: Shoot electrons in ice to produce a shower and observe the Askaryan like signal

Source:

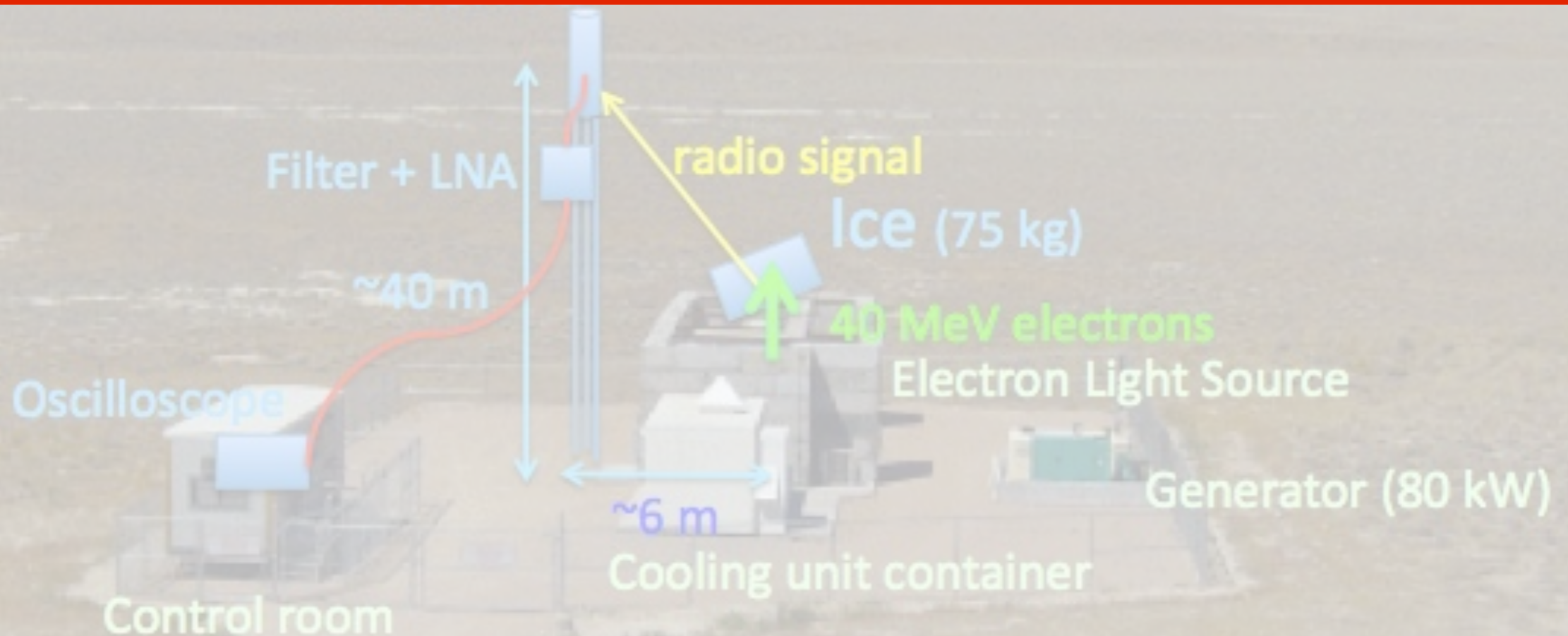
- TA LINAC electron beam
- Ice block as a target

Detector:

- ARA antenna + ampli
- Fast oscilloscope

Probe the parameterization of the radio signal used in ARA simulation

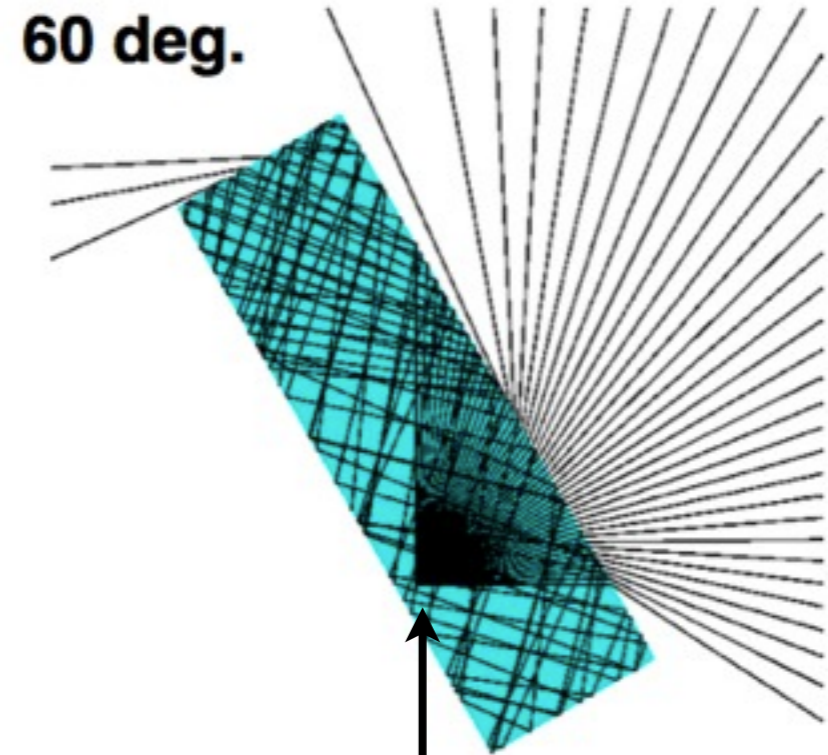
Check the absolute calibration of ARA antenna



Source and Target

Target: Ice block

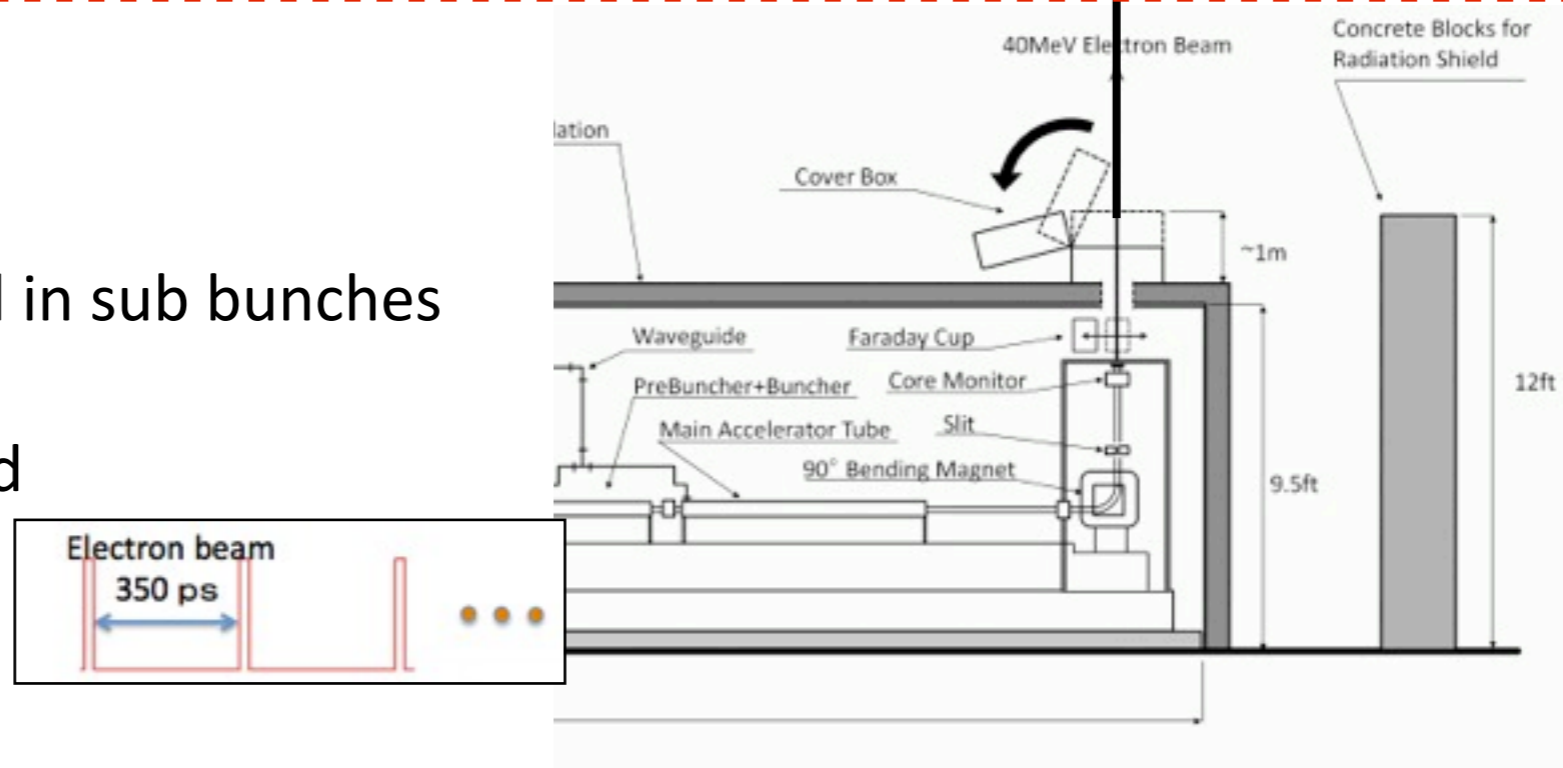
- 100cm x 30cm x 30 cm
- Installed in a plastic box 1m above the beam exit
- can be inclined to choose the exit angle of radio wave



M. Relich

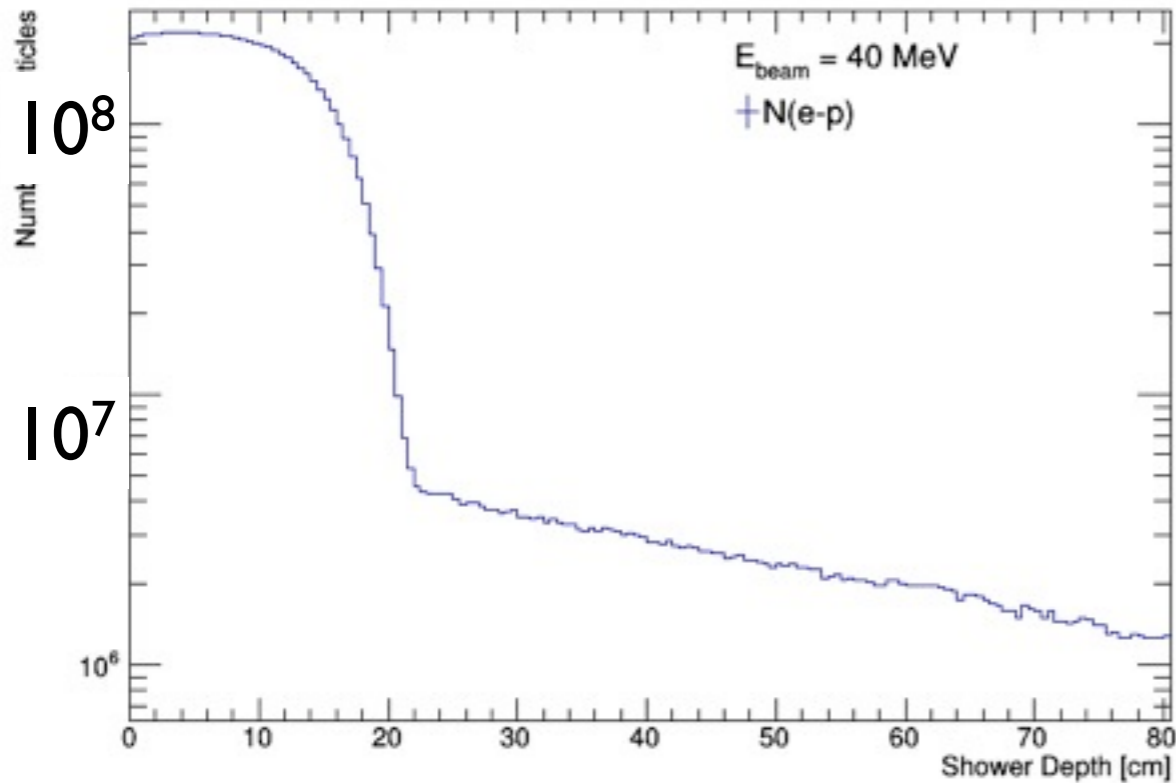
Source: TA LINAC

- source of 40 MeV electron
- maximum of 10^9 particles/s
- bunch of few ns long divided in sub bunches (every 350 ps)
- bunch length can be changed



E field simulations

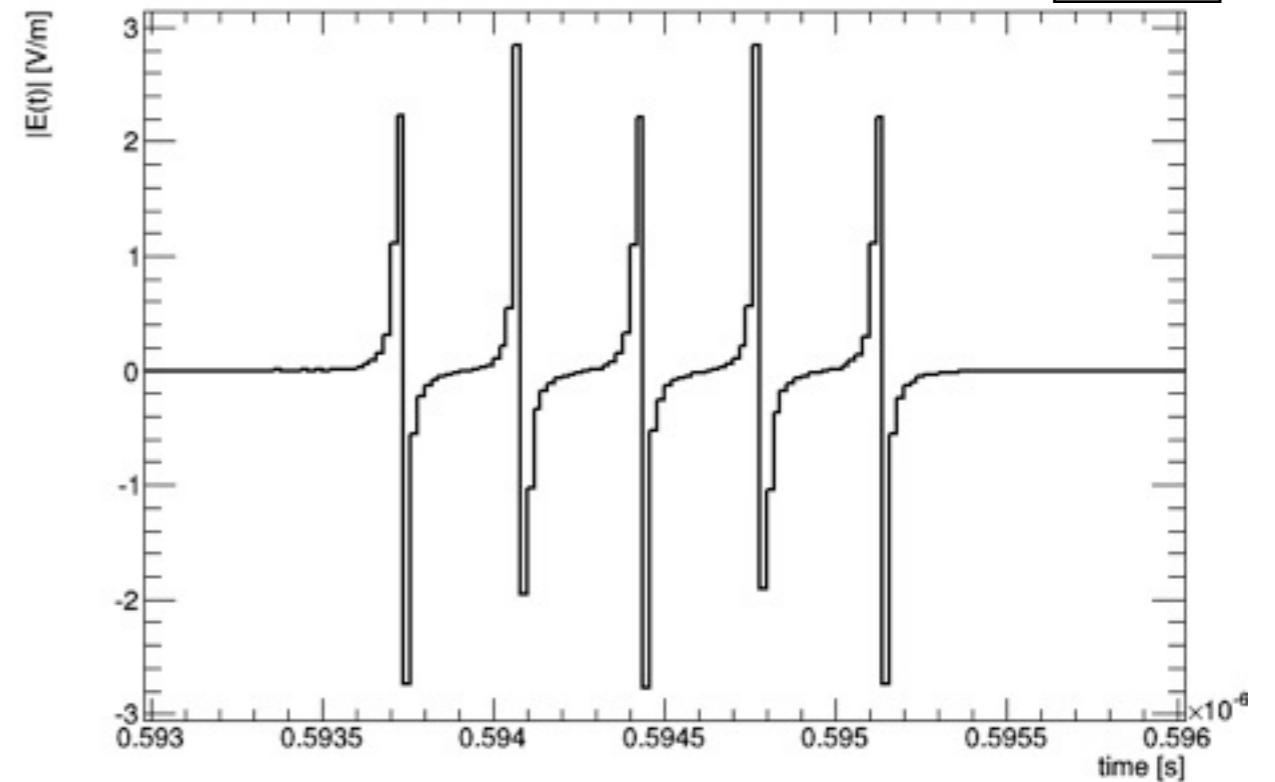
particle distribution in target



- G4 simulation of target
- Shower length $\sim 20 \text{ cm}$
- more plateau like than shower dev.

Complete E field simulation

M. Relich

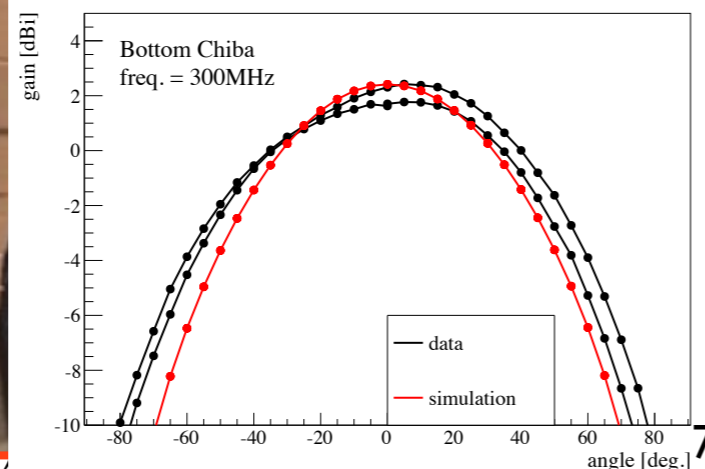
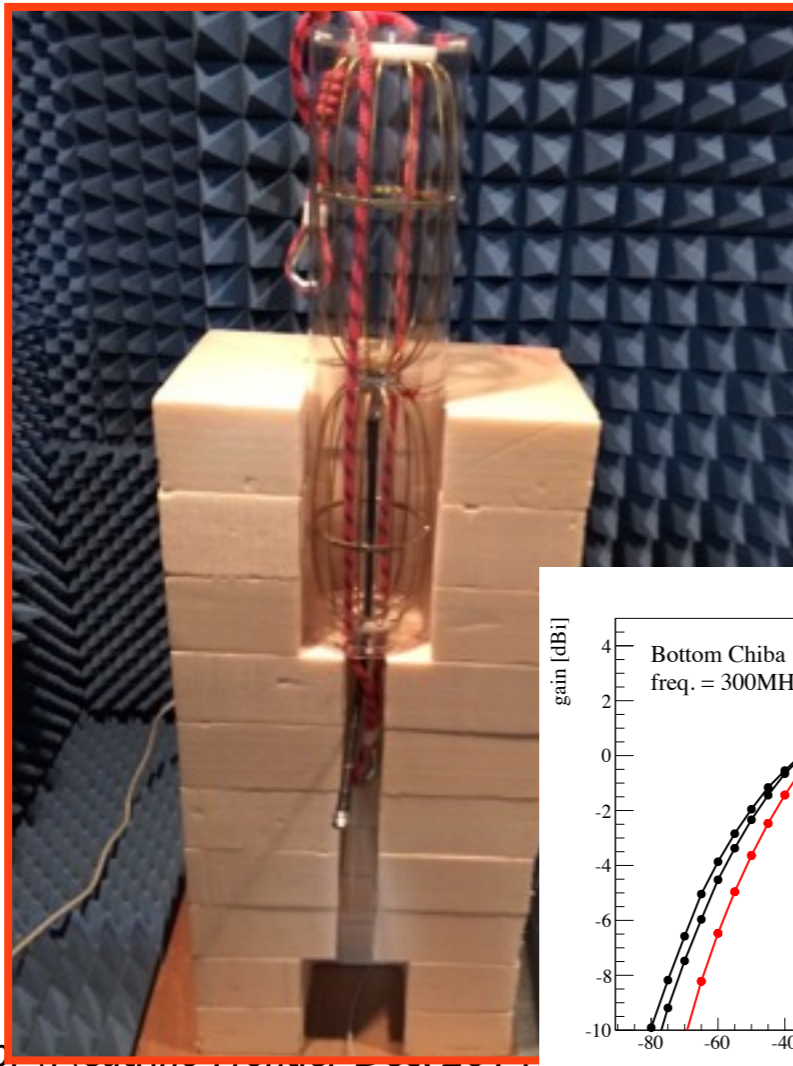
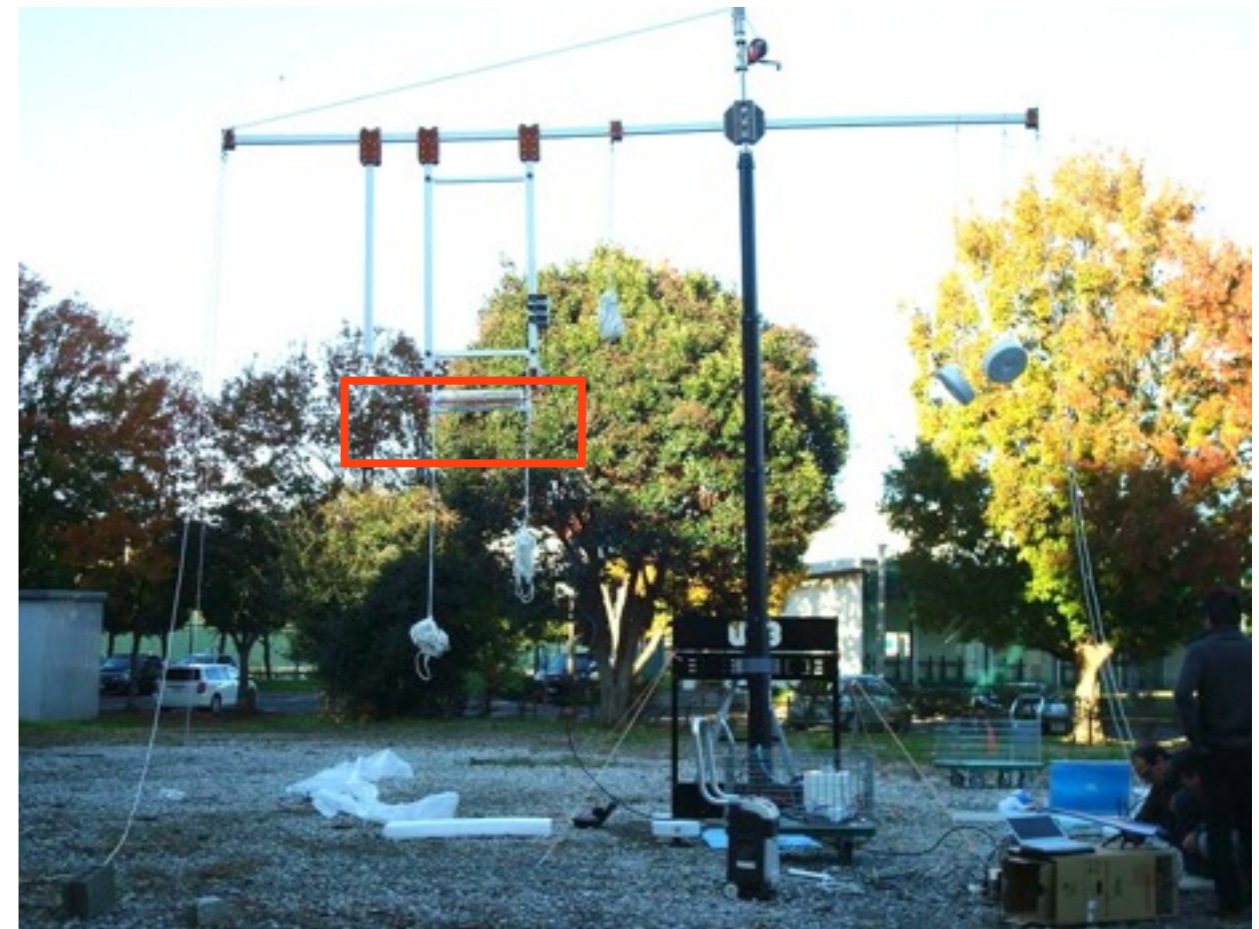


- each subbunch creates a separated E field

Detector setup

Antenna tower

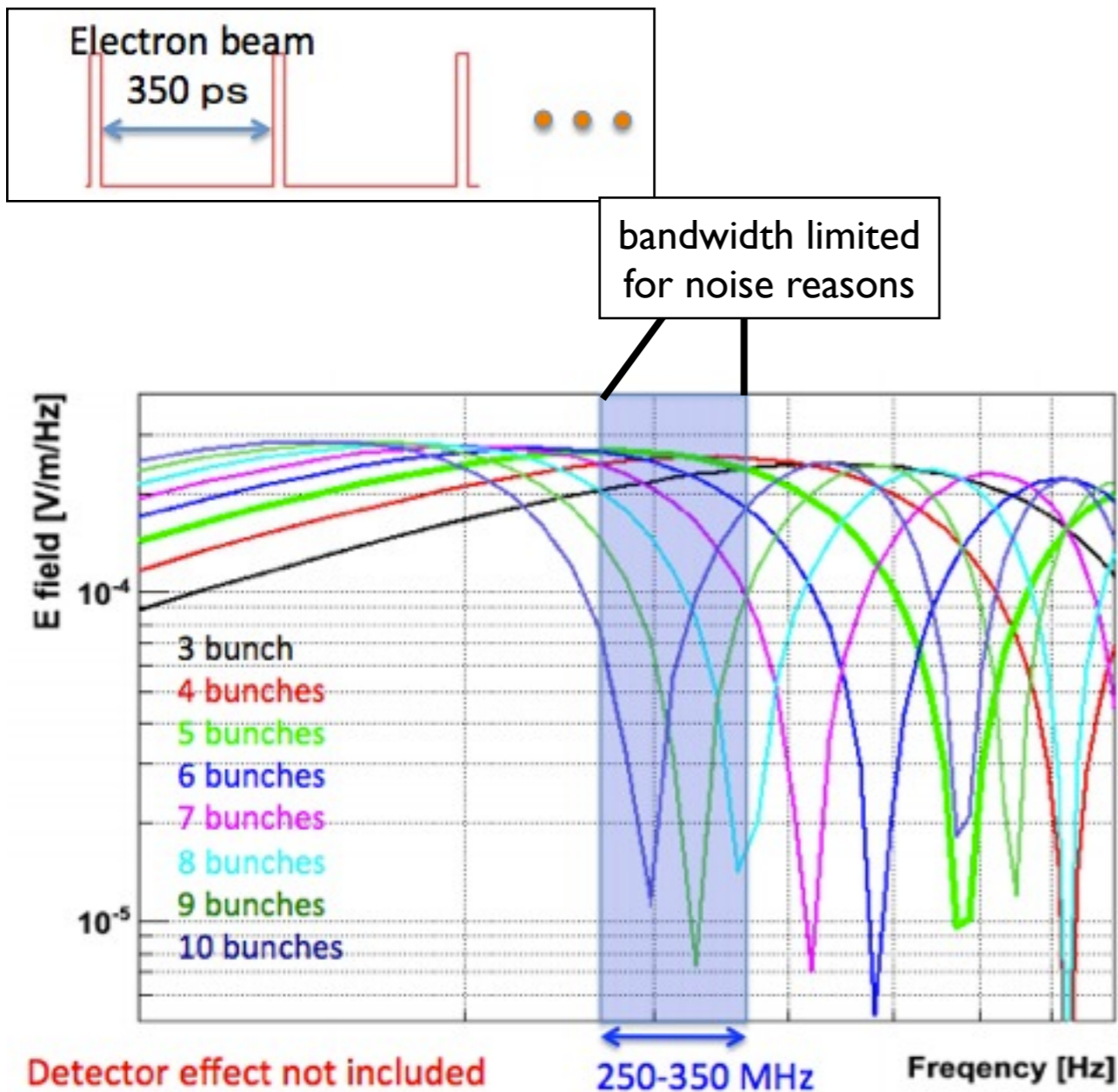
- Adjustable height: **7 -> 12 m**
- + horizontal pole of 6m
- + antenna support for **vertical and horizontal polarizations**



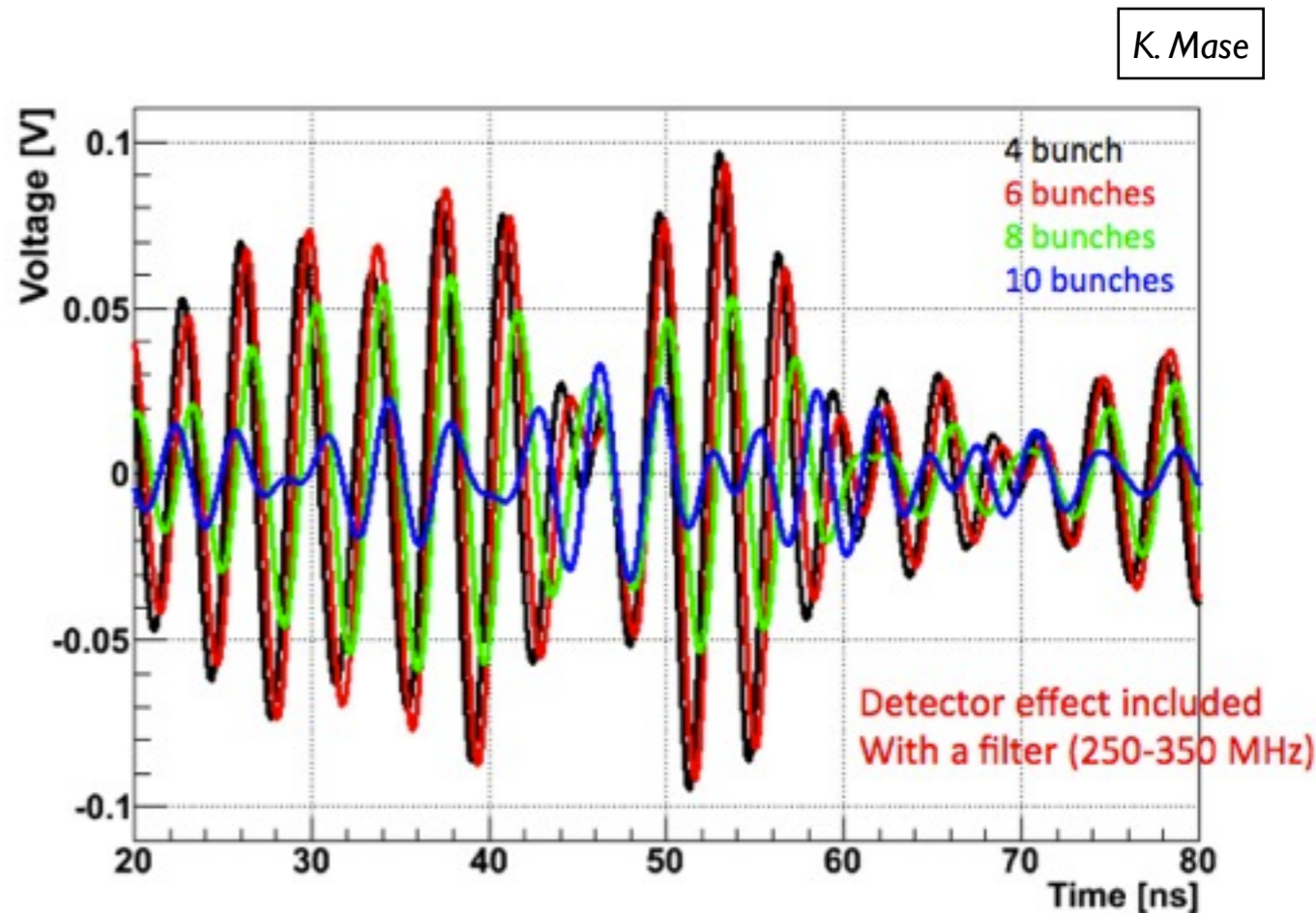
Antennas

- two antennas at the same time
- 3-4 m from the tower
- Calibration and simulation in progress

Full simulation



Multiple bunches create interferences in the radio signal



Antenna response widens the signal in time
Expected signal ~ tens of mV

Antenna support test

Are we able to operate a 12m tower ???

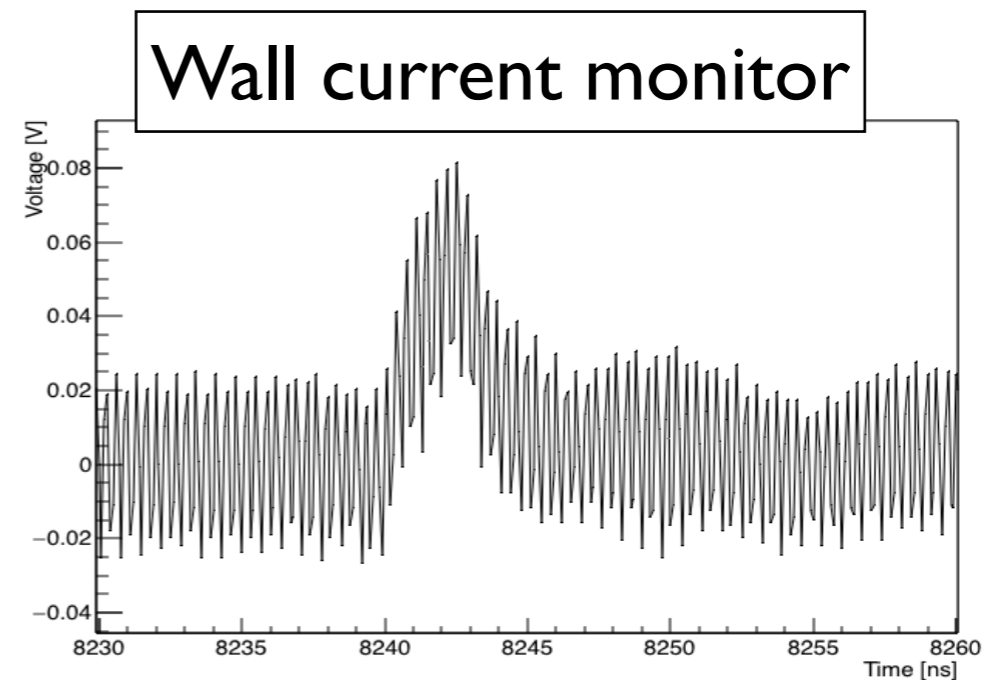
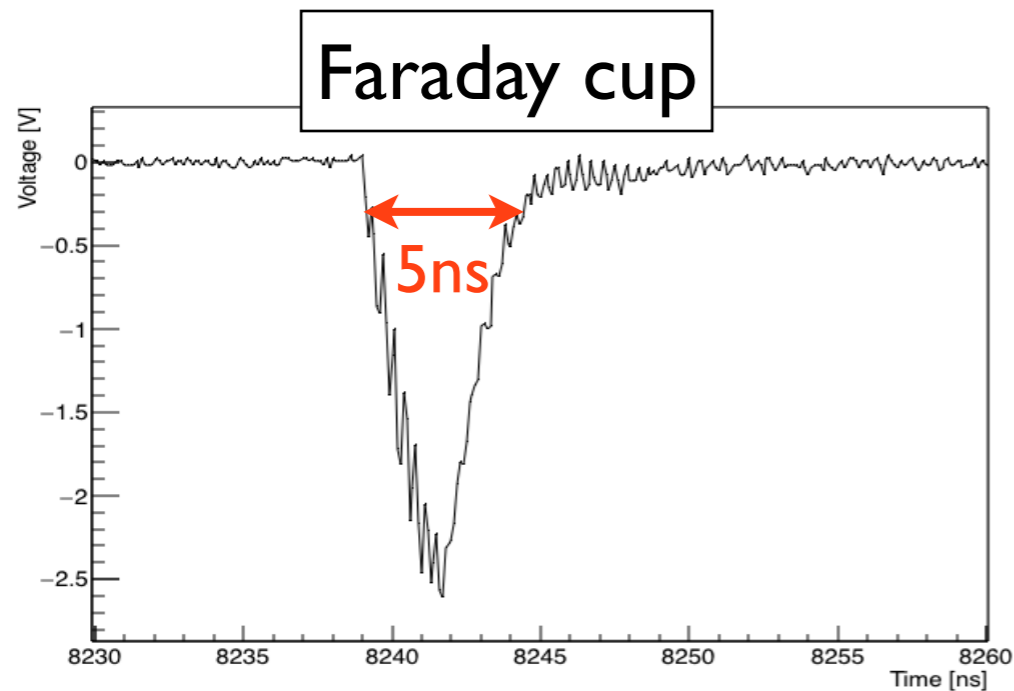


On site test on Nov. 2014

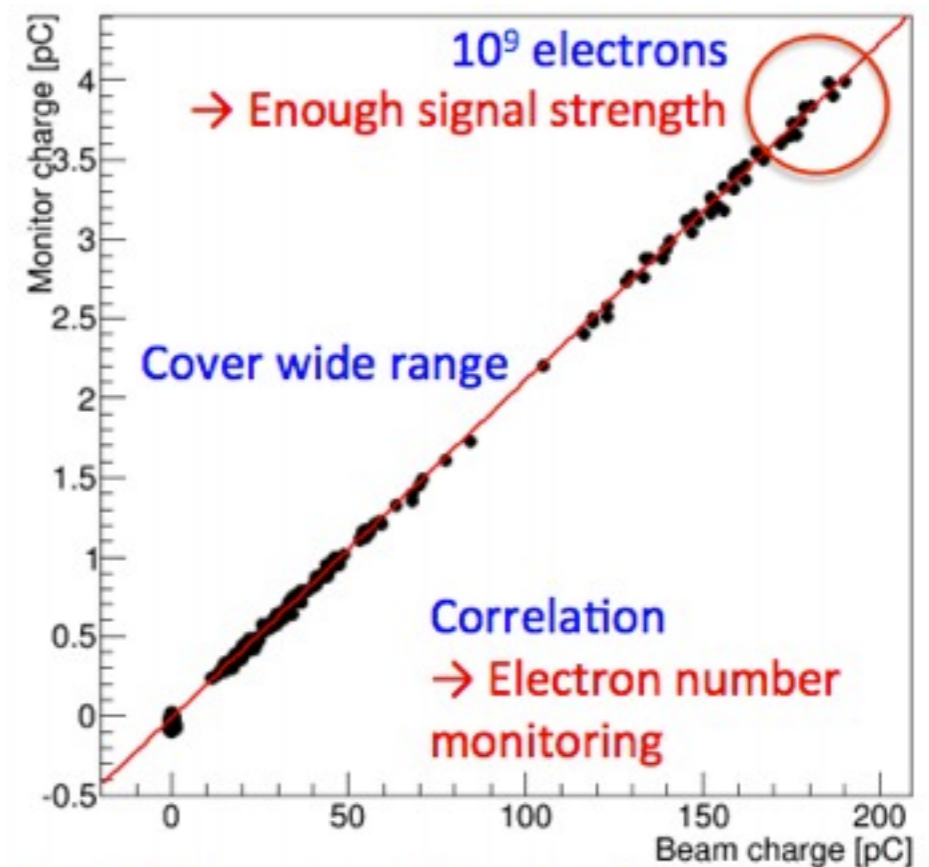
Purposes

1. Site check
2. Work on beam length and monitoring
3. Radio noise survey
4. «*Rehearsal*»

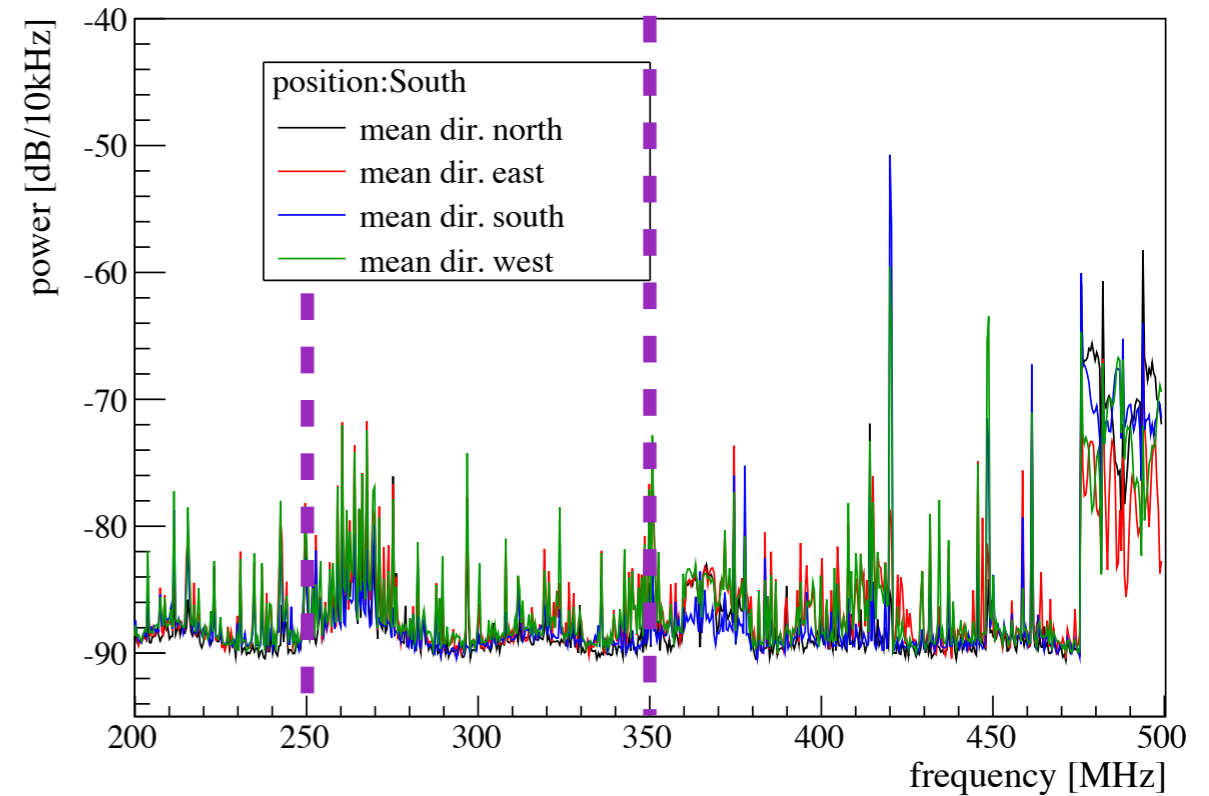
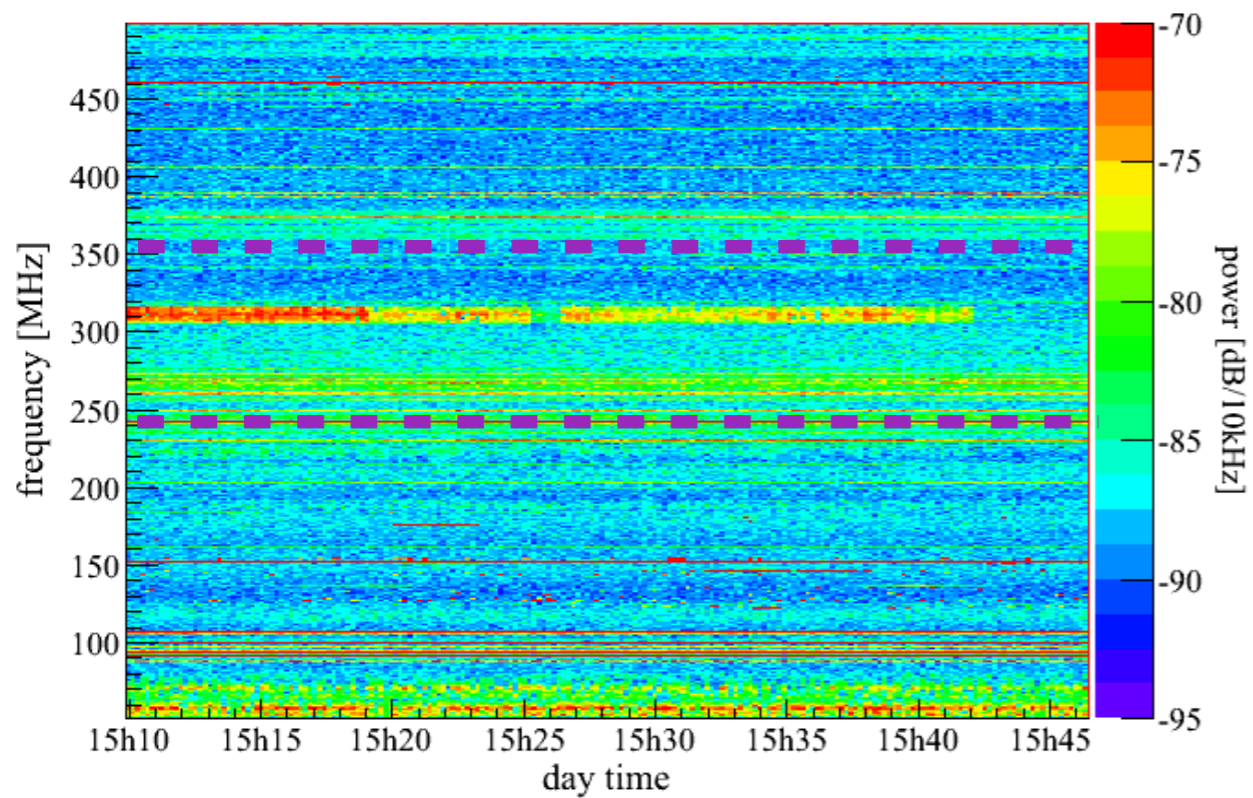
Electron Beam studies



- Bunch length reduced to 5ns
(thanks to Shibata san and KEK engineers)
- subbunch structure measured with FC
- Total charge measured also with WCM
(FC stops the beam)
- Good correlation ($\sim 3\%$ spread)

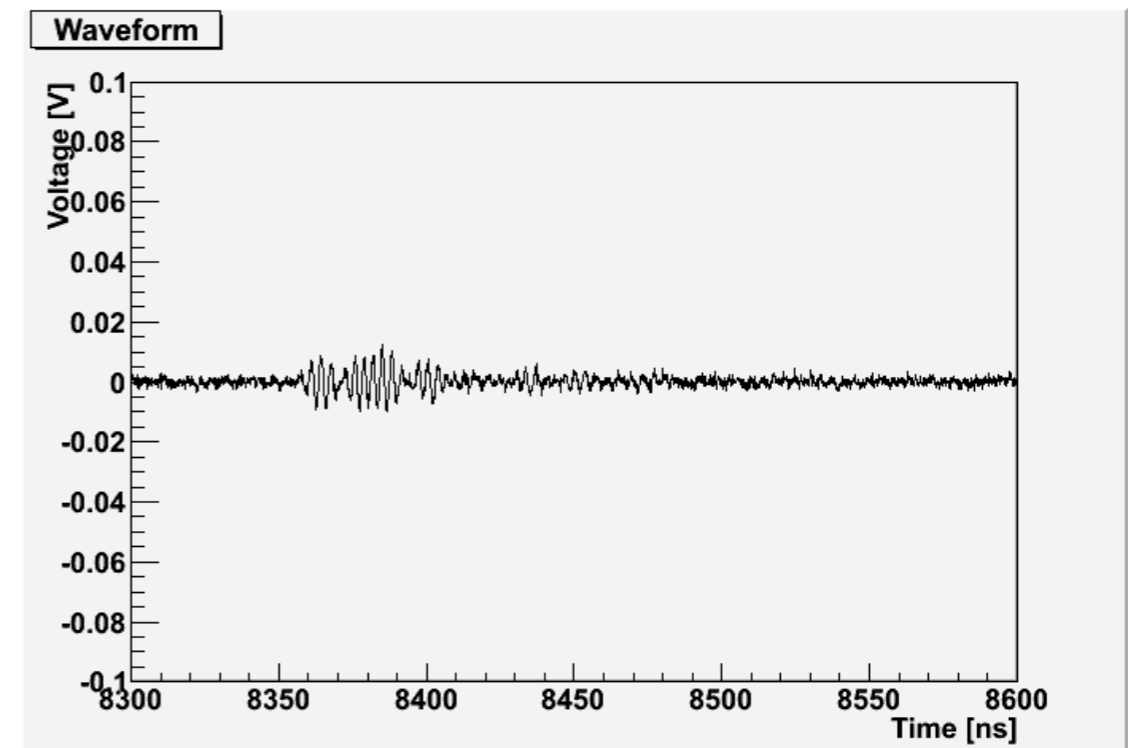
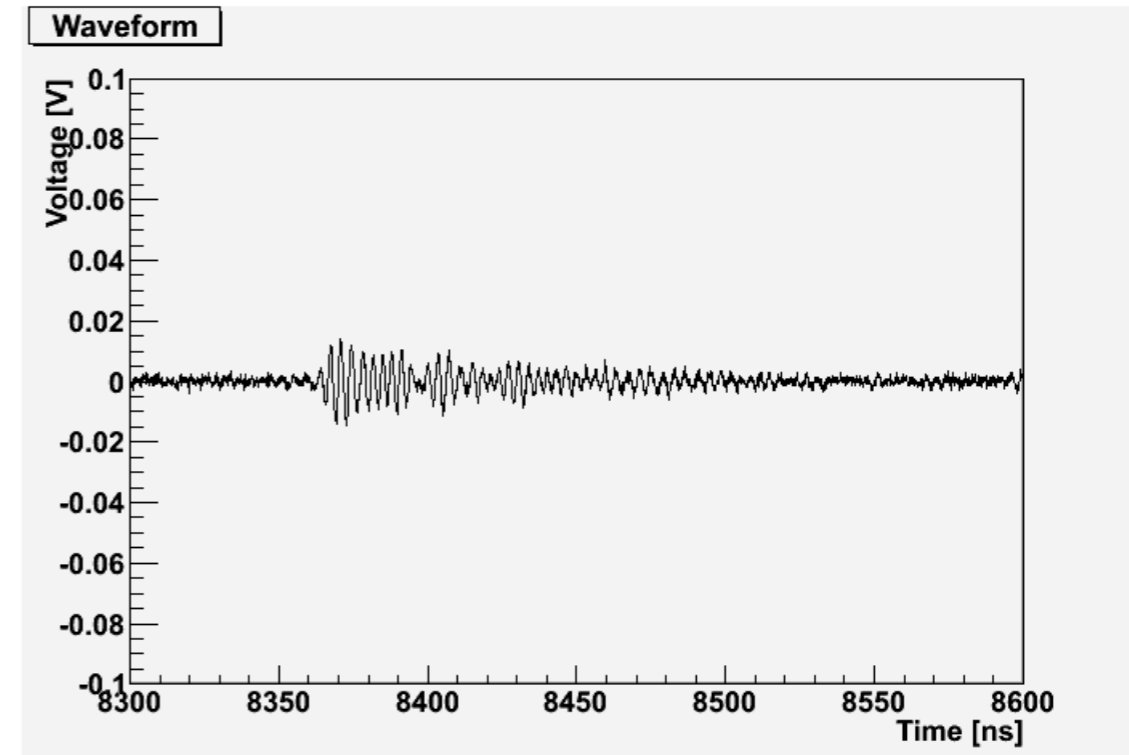
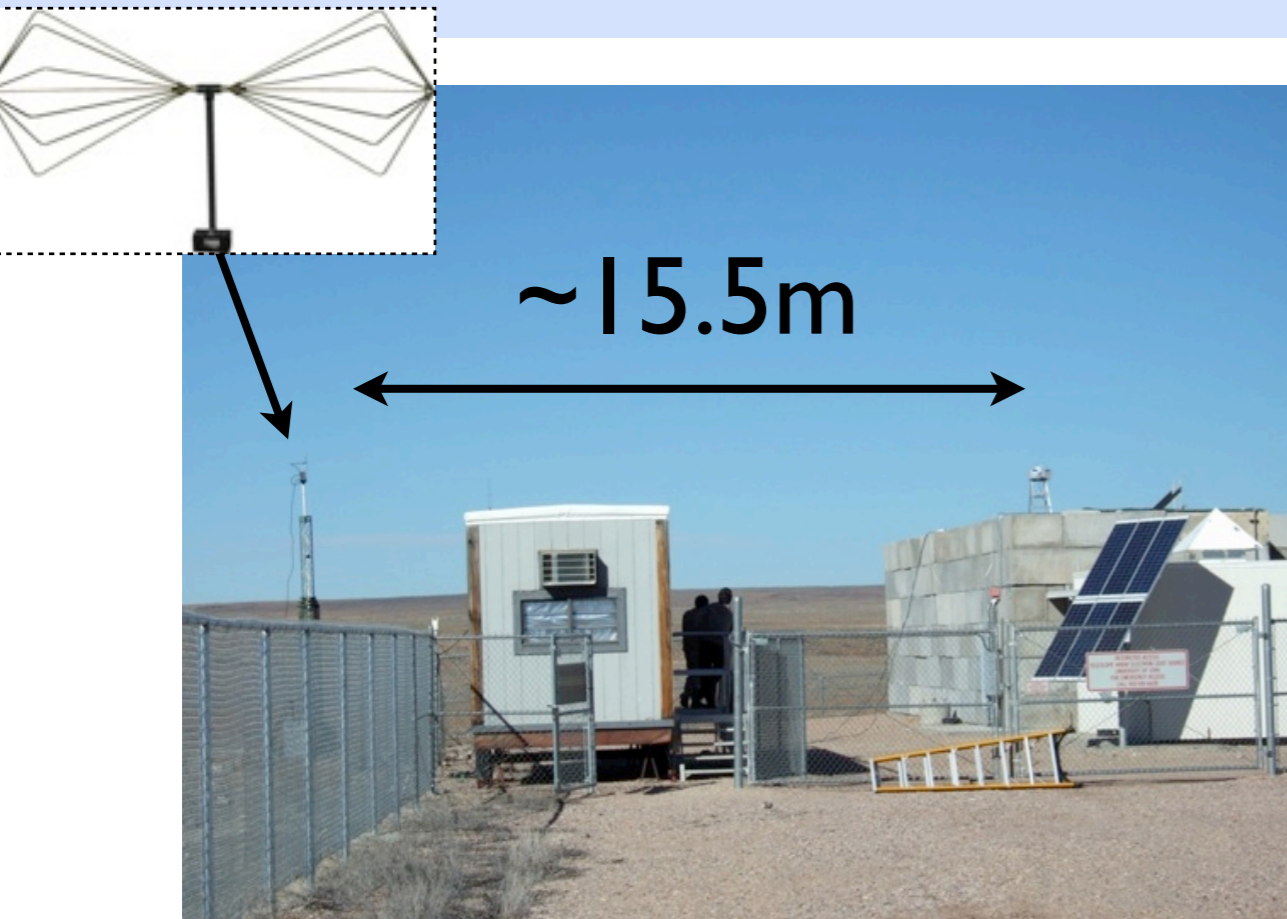


Radio noise on site



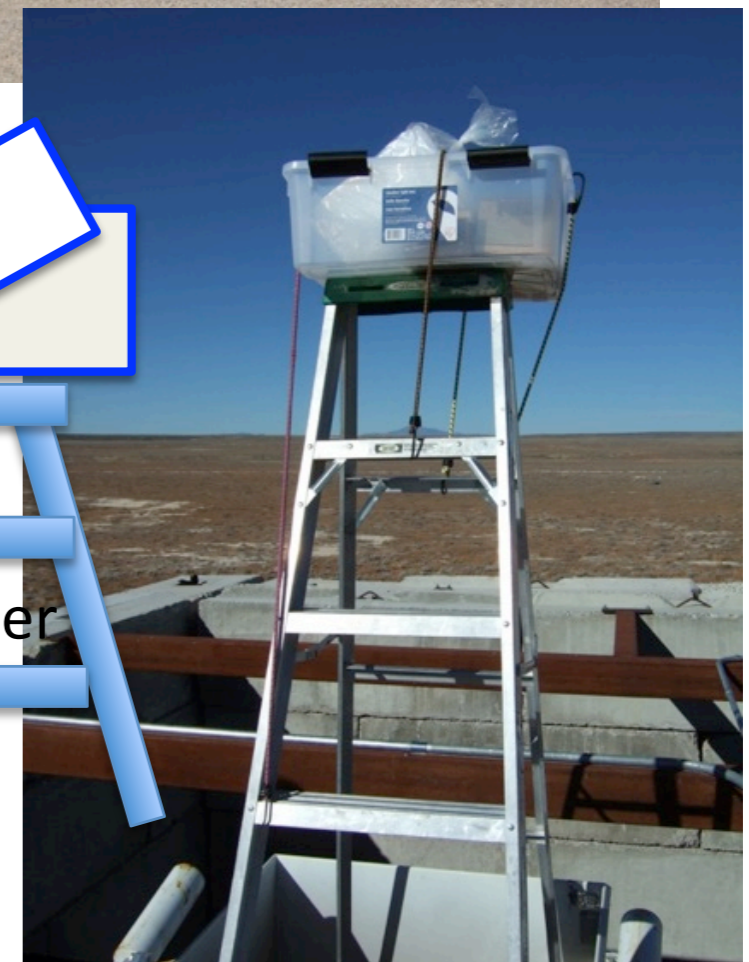
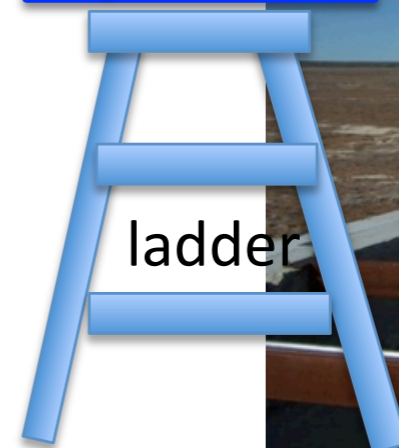
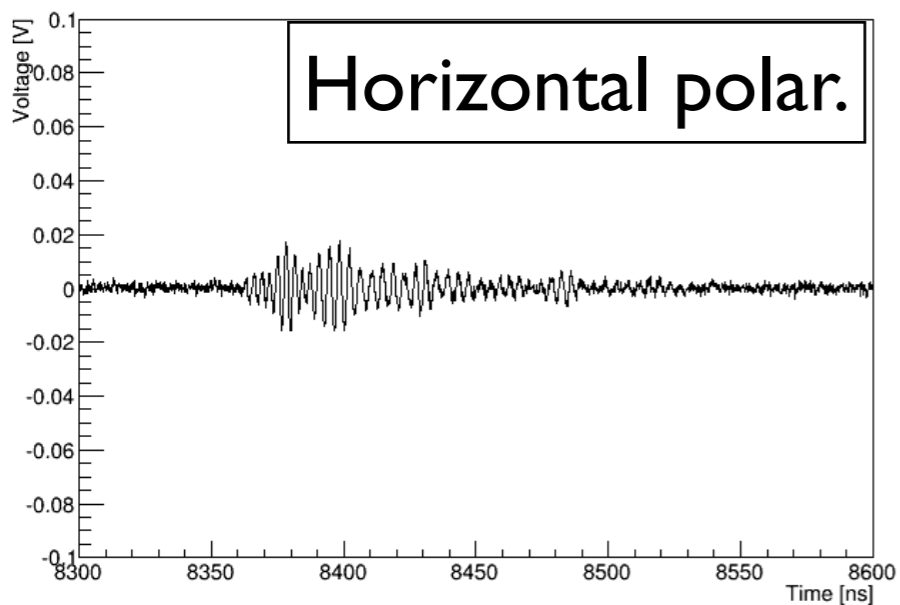
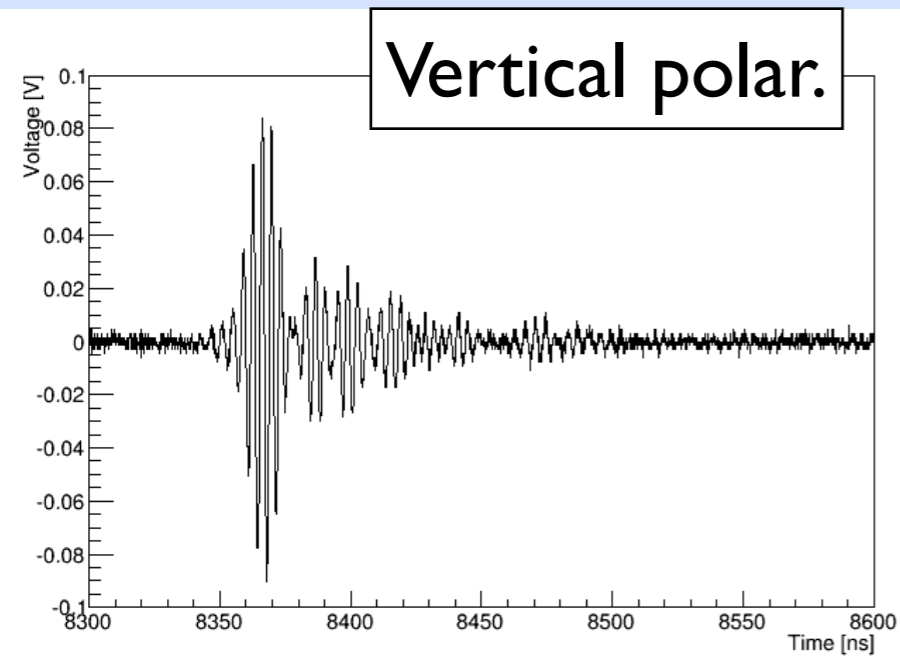
- Rather radio **quiet environment**
- **No constant noise** from the **LINAC**
- We did observe a larger noise from the **control room**
(will be shielded in January)

Transient noise from beam



- Small signal from the beam itself (no target)
- Probably from «sudden birth»
- **small background**

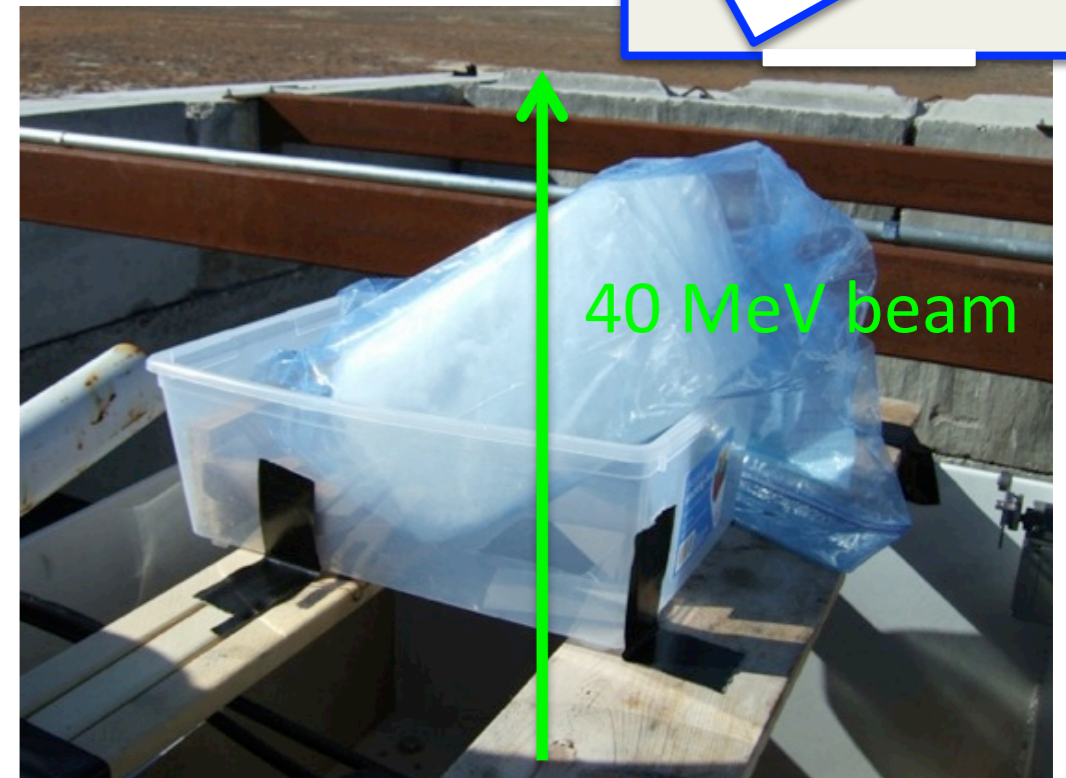
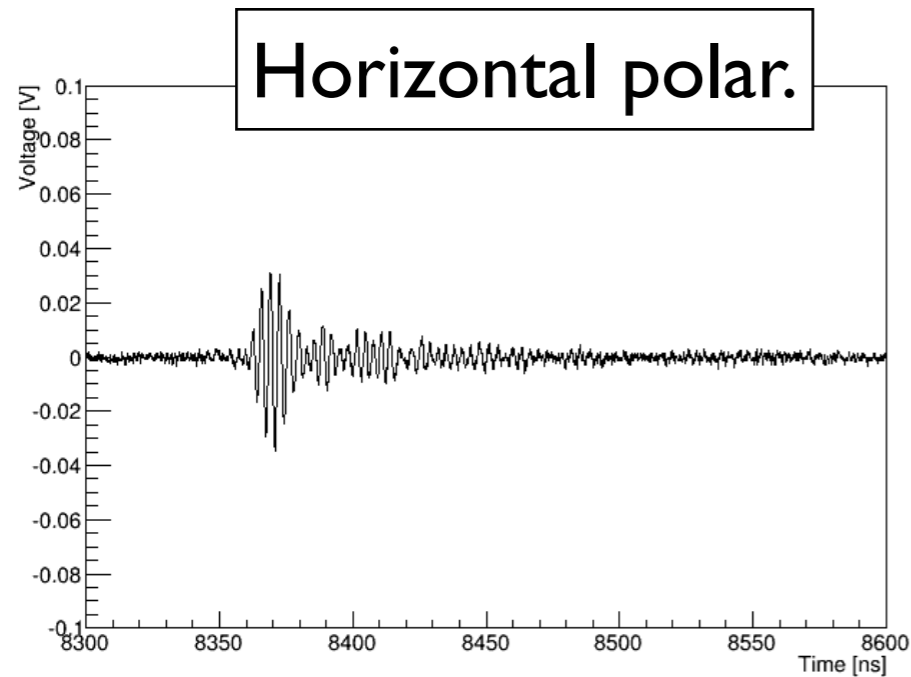
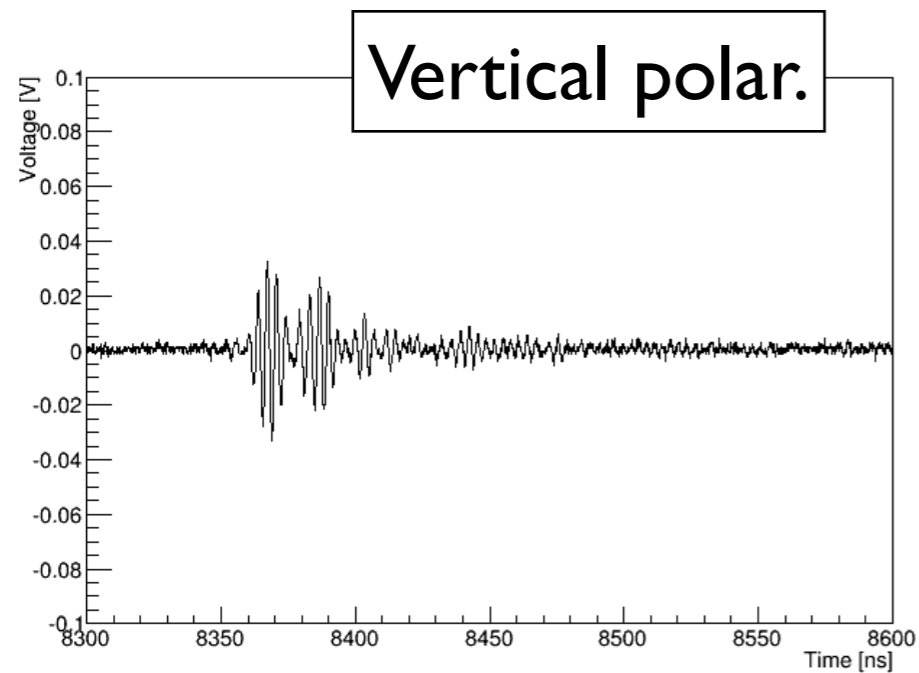
Test of complete chain



- Polarized signal observed
 - order of 100mV in vert.
 - ... but similar without ice !
- **Transition radiation from plastic**

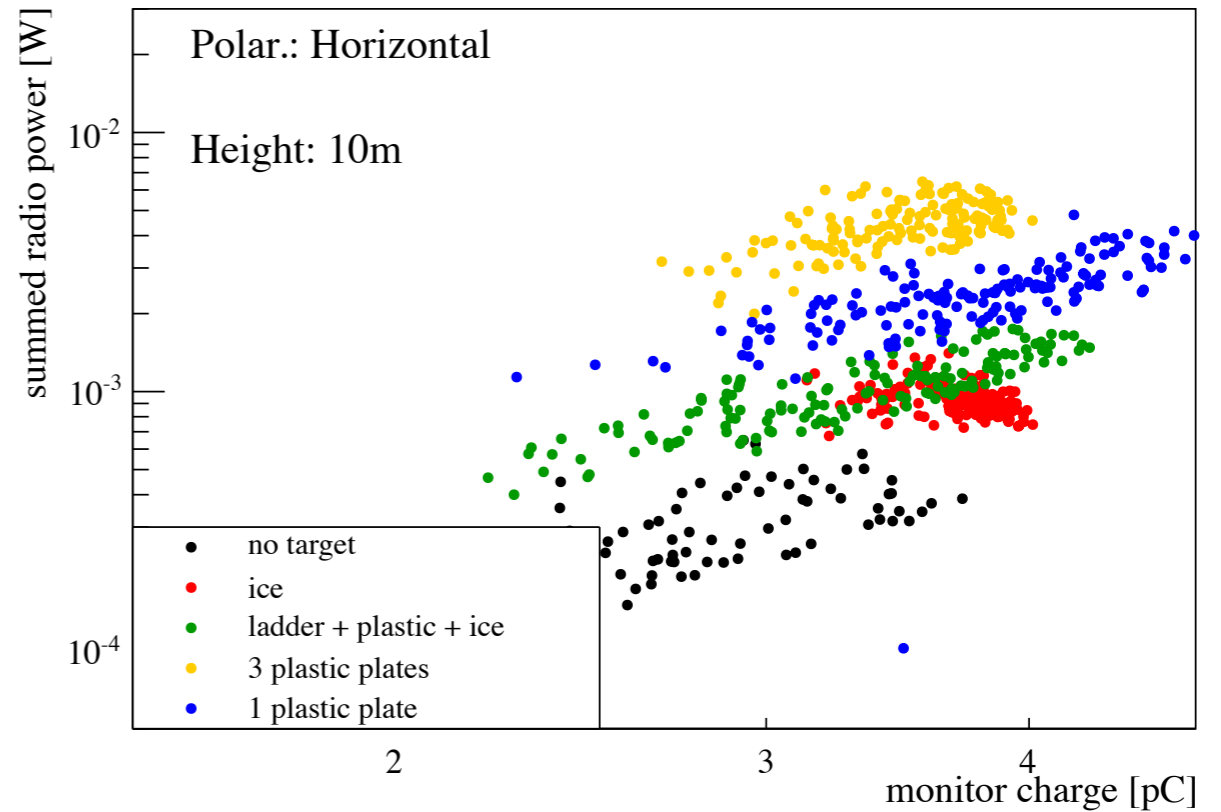
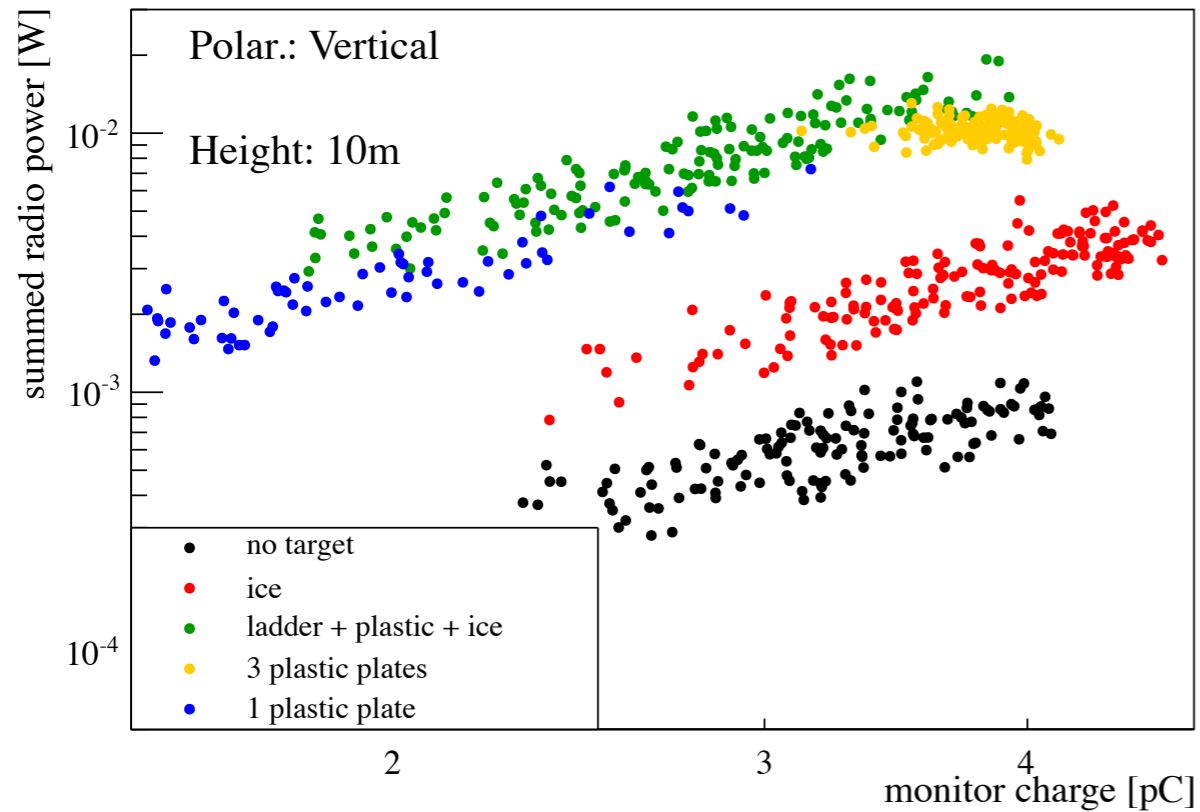
Test of complete chain

ice



- Hole in plastic box
 - Signal reduced by a factor 5
 - Still higher than without target
 - Horizontal polar. not expected
- **might have observe Askaryan like signal !**

Sum up



- Vertical polarization dominant
- Radio signal dependence \sim quadratic
- Contribution from TR from air-plastic
(will be reduced in real condition with a hole in ice box)
- Possible contribution from air-ice transition
- Analysis ongoing to disentangle Askaryan from TR

January experiment

- **Experiment will be held in January**

- Everything was shipped and arrived on site
- Mechanics work for ice box structure being done at Utah
- Equipment tested in lab

set up will be really better than the previous pictures !!

- **4 days of beam**

- nominal measurement ~ 1 day
- additional tests for background characterization

Conclusion

- ARA @ Utah aims at a confirmation of radio coherent signal and detector calibration
- **Full simulation** from particle to electric field
- **Design and implemented** the experimental setup
- **First tests on site conclusive**, but TR might be an issue

Experiment conducted next January !!!

Thanks for your attention



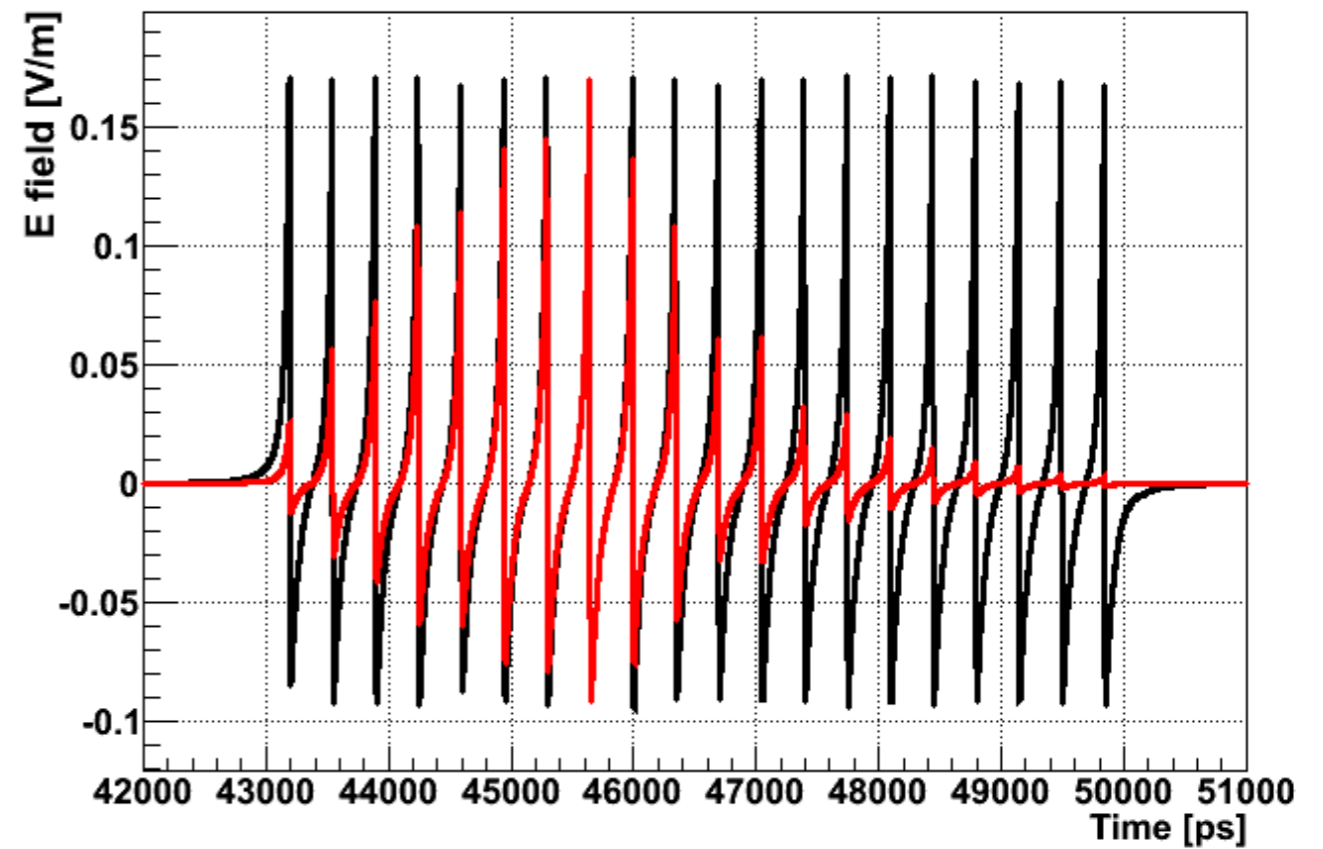
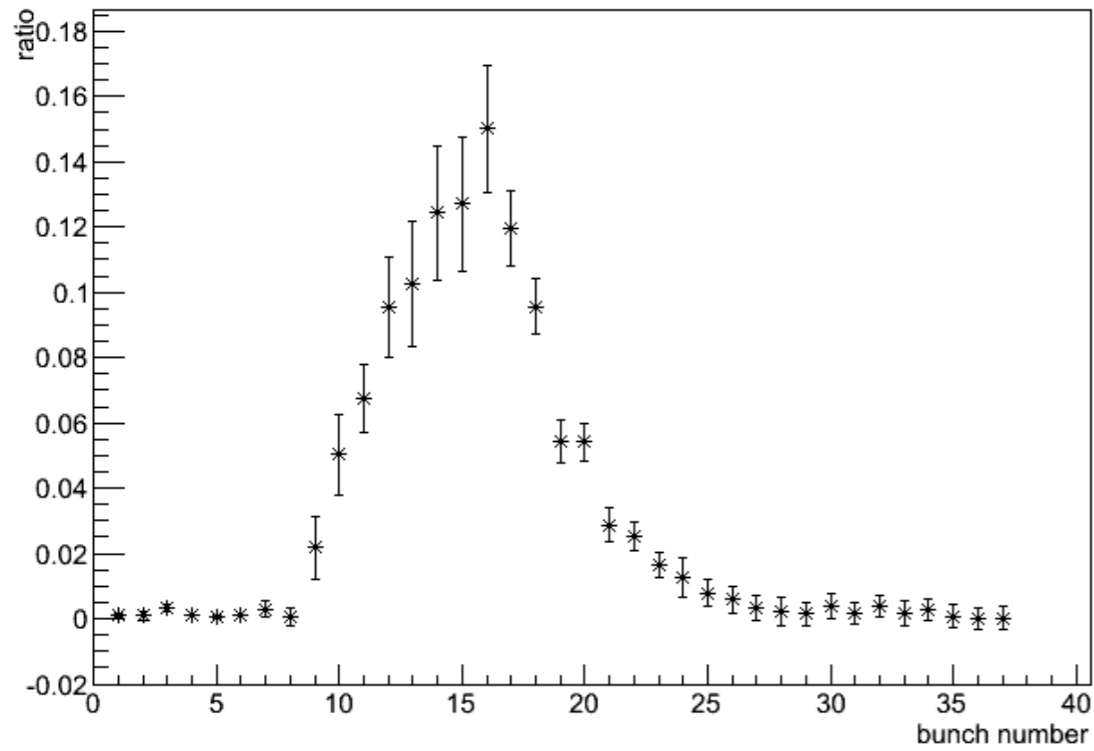
Acknowledgements

thanks to T.A. physicists and engineers for their help

(Fukushima san, Shibata san, Ikeda san, BK Shin ...)

Back up: Beam shape convolution

Charge ratio of the each bunch



Back up: Radio signal parameterization

$$\vec{A}(\theta, t) = \frac{\mu}{4\pi R} \sin\theta \hat{p} \int_{-\infty}^{\infty} dz' Q(z') F_p \left(t - \frac{nR}{c} - z' \left[\frac{1}{v} - \frac{n \cos\theta}{c} \right] \right)$$

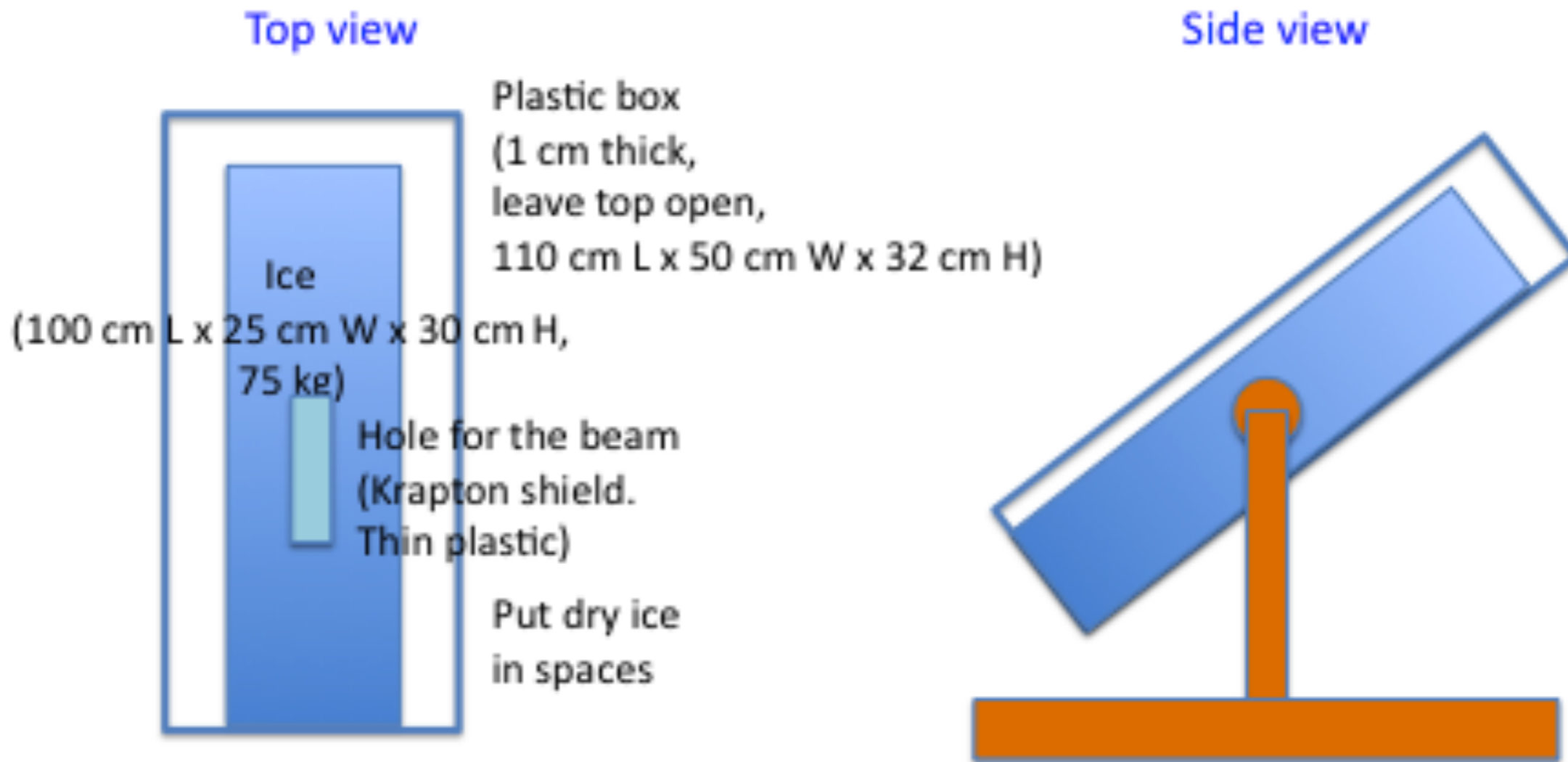
(J. Alvarez Muniz et al, PRD 84, 103003)

Q(z): charge at depth z

F_p: Form factor (determined with full simulation)

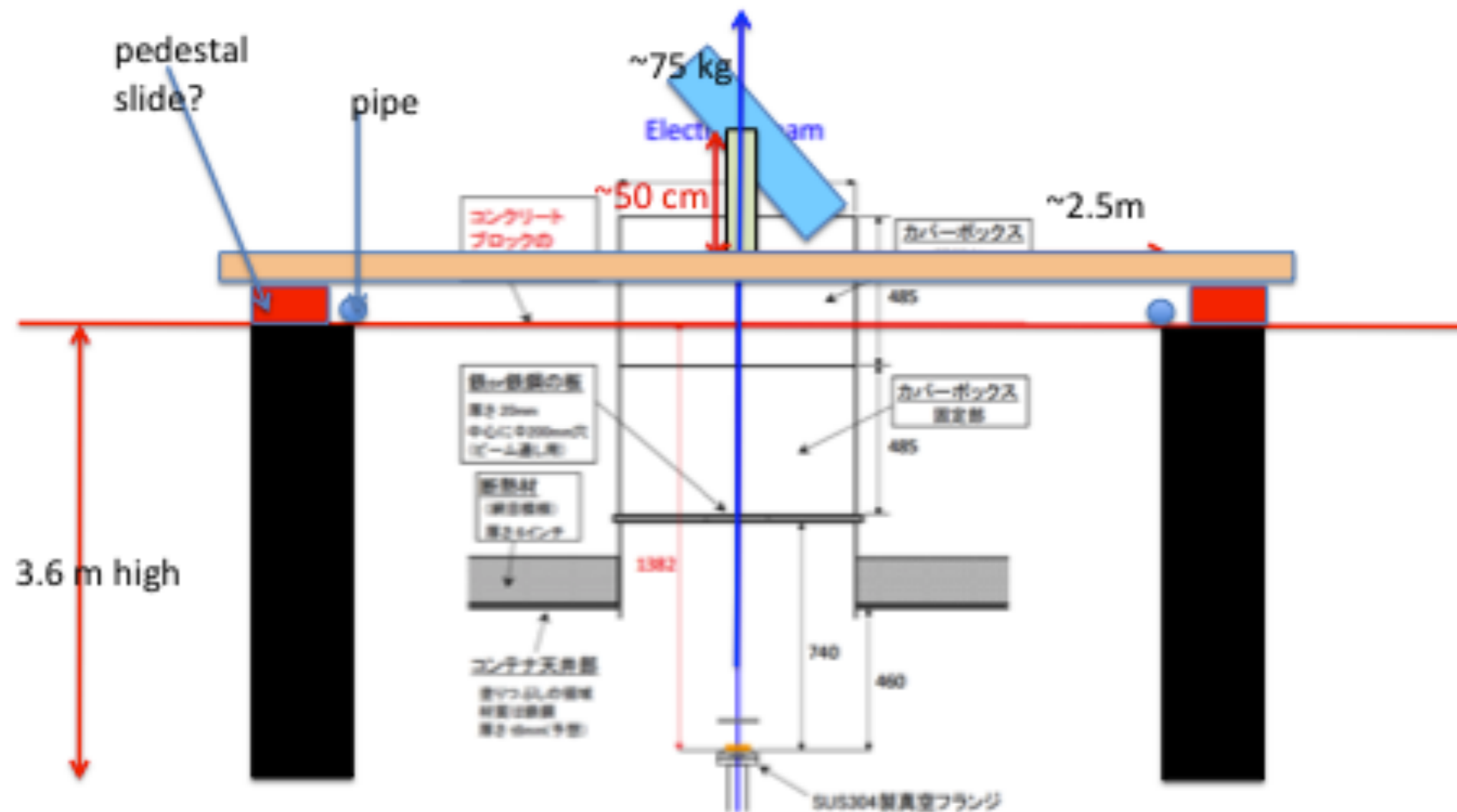
Back up: Target setup

■ Ice box



Back up: Target setup

■ Experiment setup (cont'd)



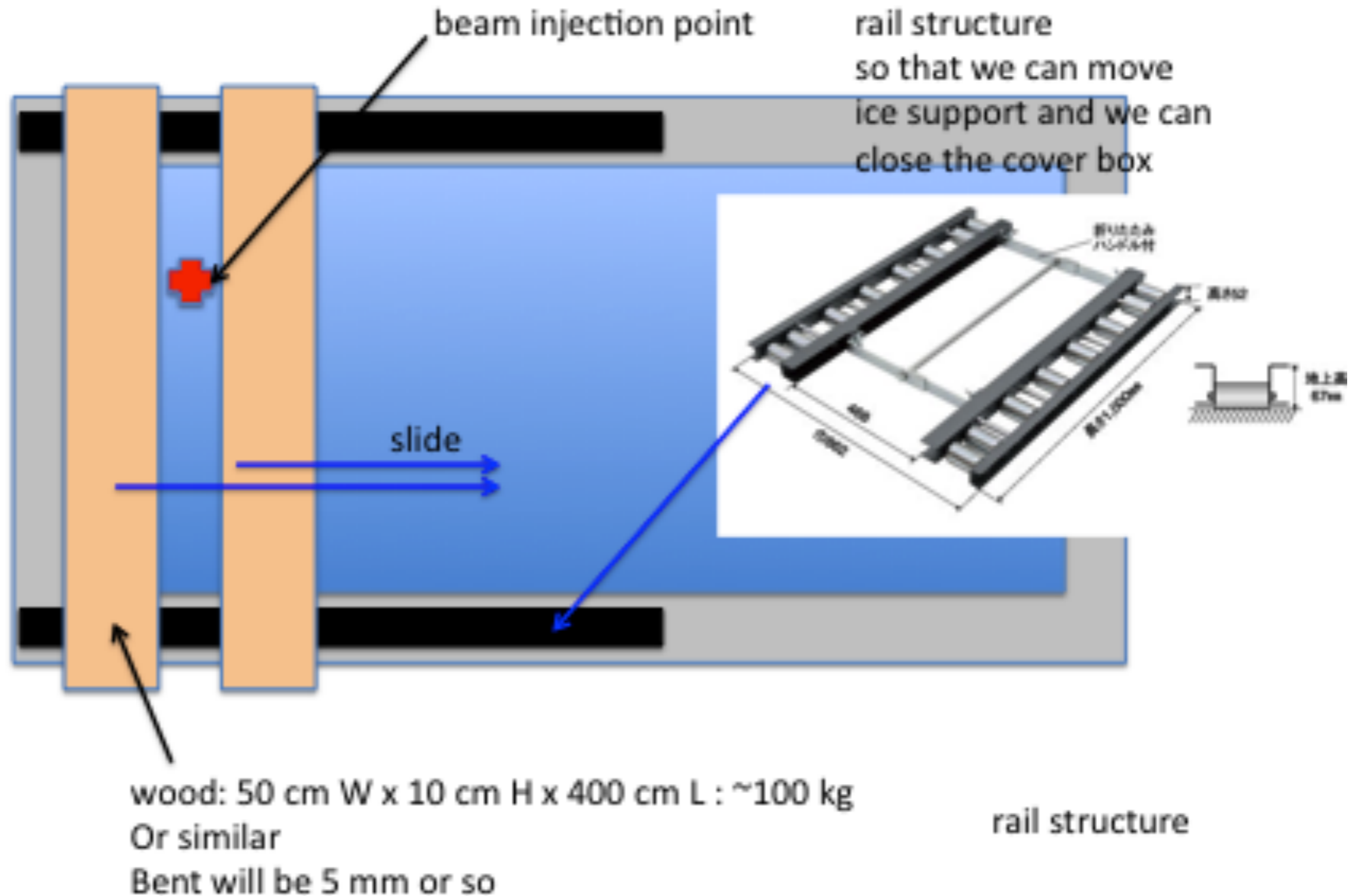
K. Mase

ARA analysis call (2014/12/15)

26

Back up: Target setup

■ Experiment setup



Back up: ARA

