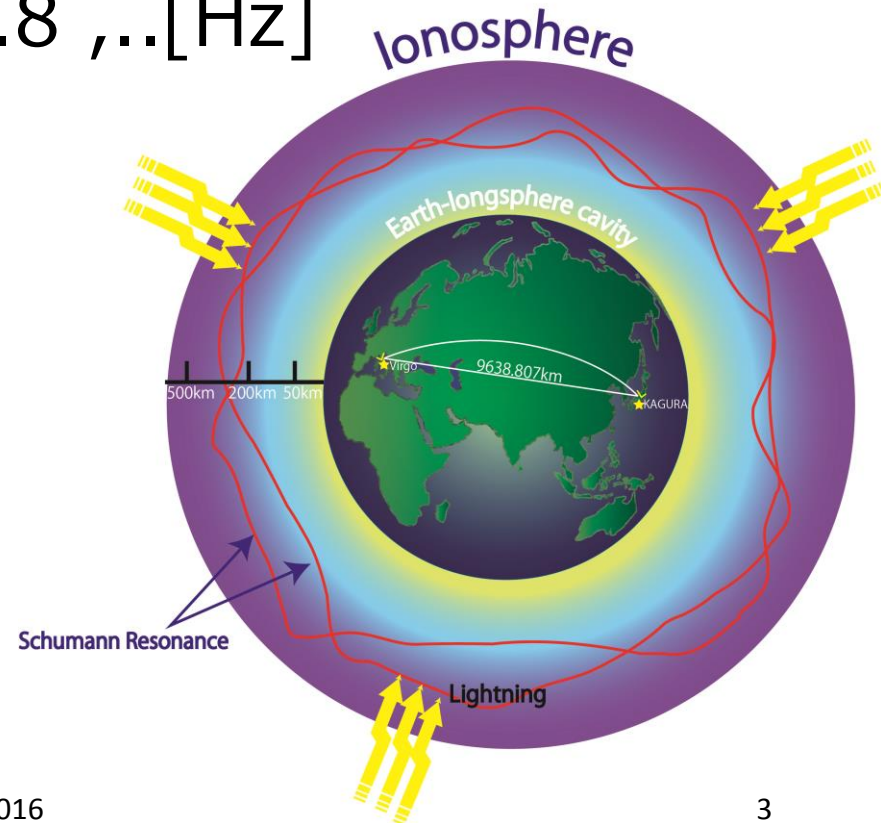# Measurement of the Schumann resonance

Sho Atsuta, Nelson Christensen, Michael Coughlin, Rosario Derosa, Irene Fiori, Mark Golkowski, Melissa Guidry, Jan harms, Kazuhiro Hayama, Yuu Kataoka, Jerzy Kubisz, Andrzej Kulakm, Janusz Mlynarczyk, Tsutomu Ogawa, Federico Paoletti, Tristan Shoemaker, Kentaro Somiya, Eric Thrane

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- Measurement
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1.What is the Schumann resonance

- Global electromagnetic resonance
  - Earth's surface – Ionosphere cavity
  - Freq: 7.8 , 14.3 , 20.8 ,..[Hz]
  - Amp: ~1 [pT]

- Excited by lightning
  - 100 events / sec

- High coherence

2. Stochastic Gravitational Wave Background (SGWB)
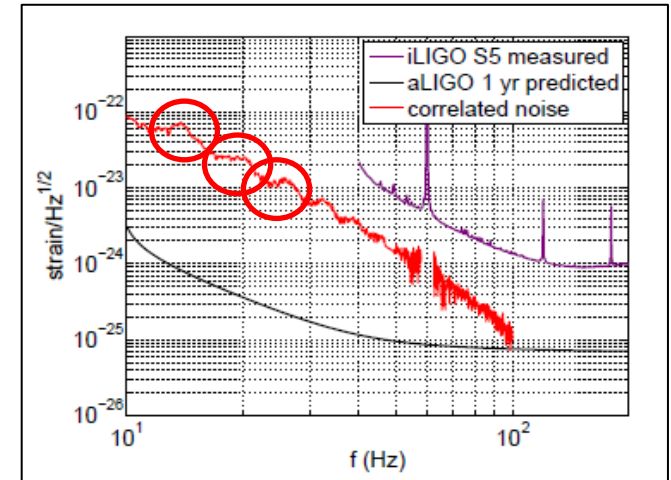
Features
- Isotropic
- No specific wave form

Detection scheme
- Cross correlate and Integrate ~ 1yr
- $\rightarrow$ Only correlated signals like Schumann resonance remain

3. Previous work

E. Thrane et al. 2013

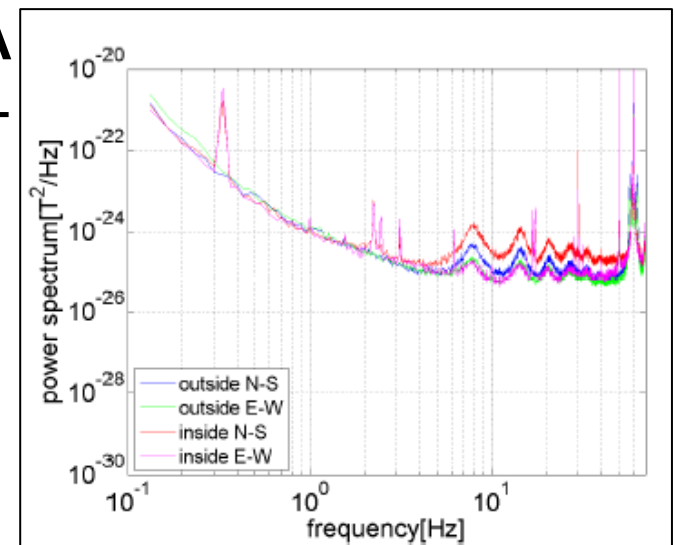- ## Measure and calculate correlated noise in L-V
  - – The Schumann resonance may limit sensitivity

- ## Measurement in KAGRA
  - – Almost same level IN – OUT
  - – IN > OUT ???

S. Atsuta et al. 2016

Wiener filter subtraction

- Strategy : To remove correlated data
  using Wiener filter

- Theory

$$r(f) = y(f) - \sum_{i=1}^{M} (a_i * x_i)(f)$$

$y(f)$: target data
$x_i(f)$: witness sensor data
a_i : filter coefficients

$$a_i(f) = \frac{P_{yx_i}(f)}{P_{x_ix_i}(f)}$$

■ Correlated signal ~ 1
■ Uncorrelated signal < 1

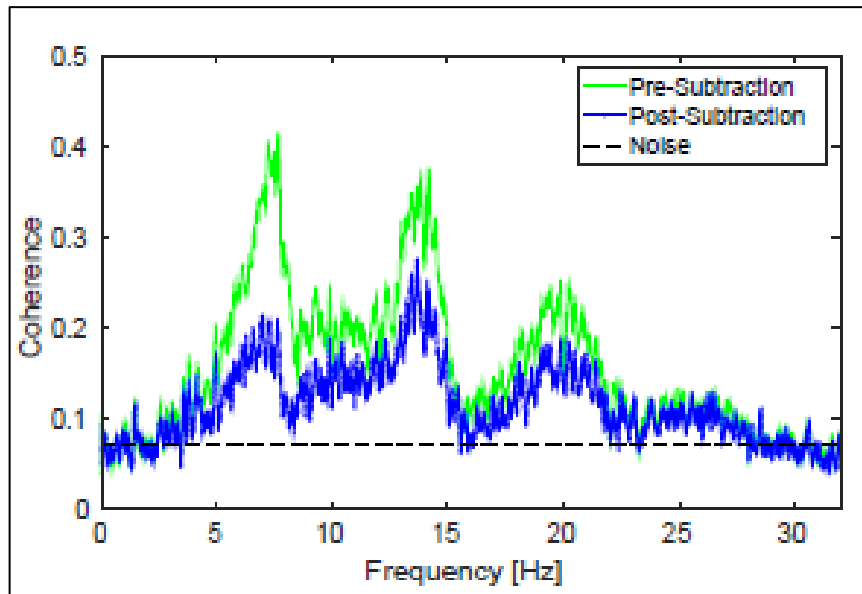$P_{x_ix_i}(f)$: Power Spectrum of x_i
$P_{yx_i}(f)$: Cross Power Spectrum between y and x_i

Wiener filter subtraction

Filter test   Michael W. Coughlin et al. 2015

Coherence
NS Colorado – Villa Cristina

$y(f)$: N-S Colorado (US)
$x(f)$: E-W Colorado
N-S & E-W Poland
N-S Villa Cristina (Italy)

US and Poland data
from WERA project

Reduction factor ~ 2 @ 8Hz

Measurement *test with KAGRA*

- Measure at the same time KAGRA and VIRGO
  - Make more realistic filter
  - Get less noise data

- Instruments
  - Borrowed all instruments from ERI
  - Upgrade coils : sensor noise~0.1[pT] @1[Hz]
  - Data logger : ADU07
  - Coils : MFS-06 (NS&EW) & MFS-07e (vertical)

Measurement details

KAGRA

- Outside1 @ near KAGRA tunnel
  7/21 5:00 ~ 7/22 7:00 (GMT)

- Outside2 @ close to Outside1
  7/21 10:00 ~ 7/22 6:00
  ➢ Out1&2 were buried

- Inside @ 2nd floor at center room
  7/21 16:30 ~ 7/21 17:50 (Only 1 hr)
  ➢ Put on the floor

- N-S , E-W , vertical coils at each point (magnetic direction)
- Using GPS time

Measurement details

VIRGO

- Villa Cristina ~ 10km from VIRGO (uninhabited house)
7/20 9:00 ~ 7/22 7:00

- N-S & E-W coils

- Put on the floor

- Using GPS time

KAGRA site