

In Summary

Attempt to capture the information in all the talks

Our Hosts: Arcetri



People

~ 120 employees:
• 60 astronomers/technology staff
• 30 technical-administrative
• 30 PhD/post-doc (15-20 calls/year)
Close cooperation with the Astronomy group of UniFi

Univ. di Firenze
Dip. Di Fisica

A large group photo of the Arcetri staff, with a man giving a presentation in the foreground.

People

~ 120 employees:
• 60 astronomers/technology staff
• 30 technical-administrative
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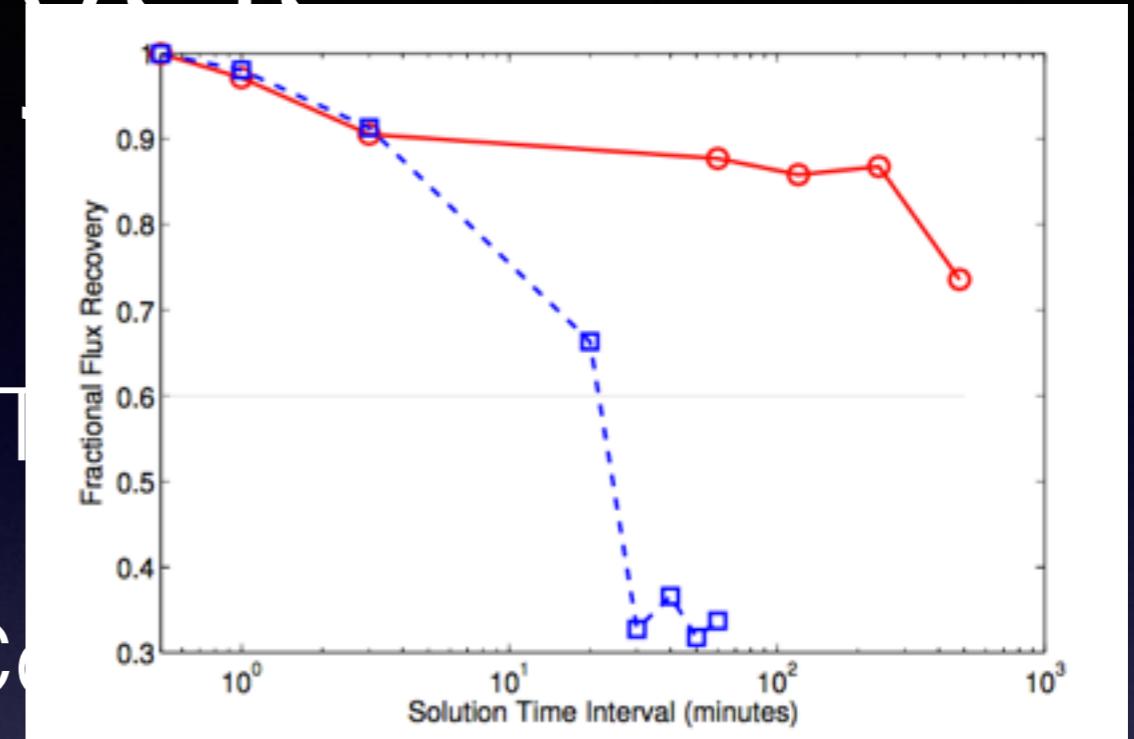
Univ. di Firenze
Dip. Di Fisica

Analysis

- Maria Rioja: SFPR and FTP methods
 - Sensitivity through Coherence
(120-fold increase (300% in diameter)
cf 4-fold in BW (40%))
- Astrometry — Weak Sources

Analysis

- Maria Rioja: SFPR and FT
- Sensitivity through Co



(120-fold increase (300% in diameter))

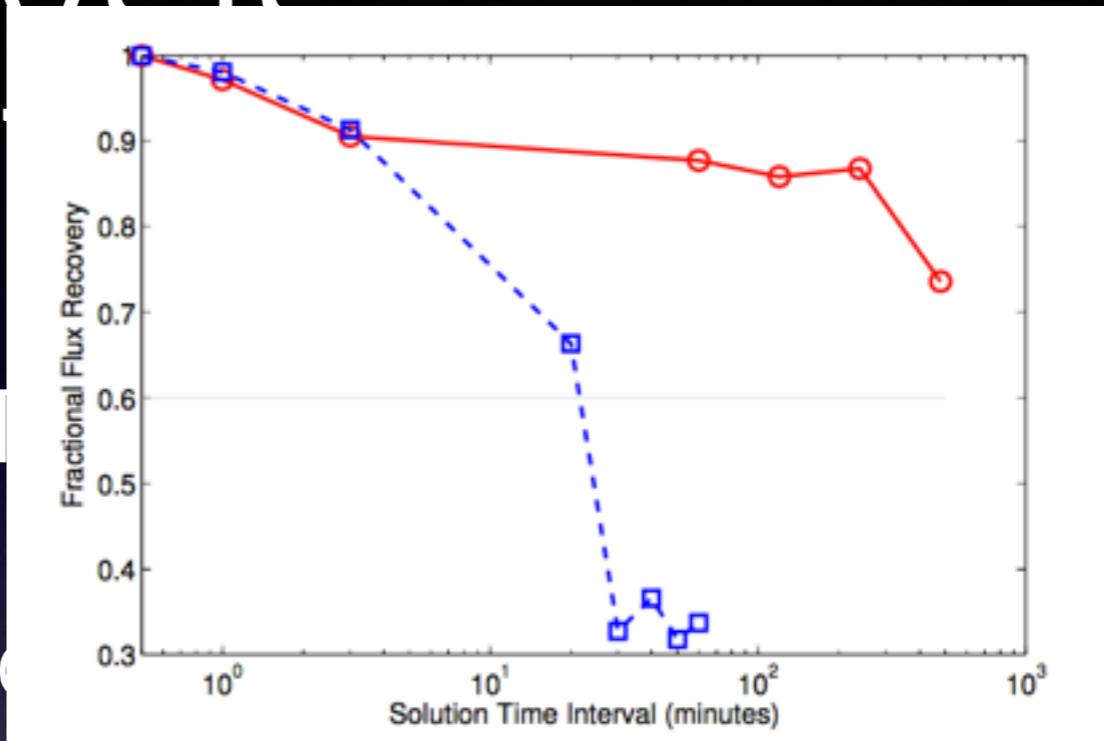
cf 4-fold in BW (40%)

- Astrometry — Weak Sources

Analysis

- Maria Rioja: SFPR and FT

- Sensitivity through Co

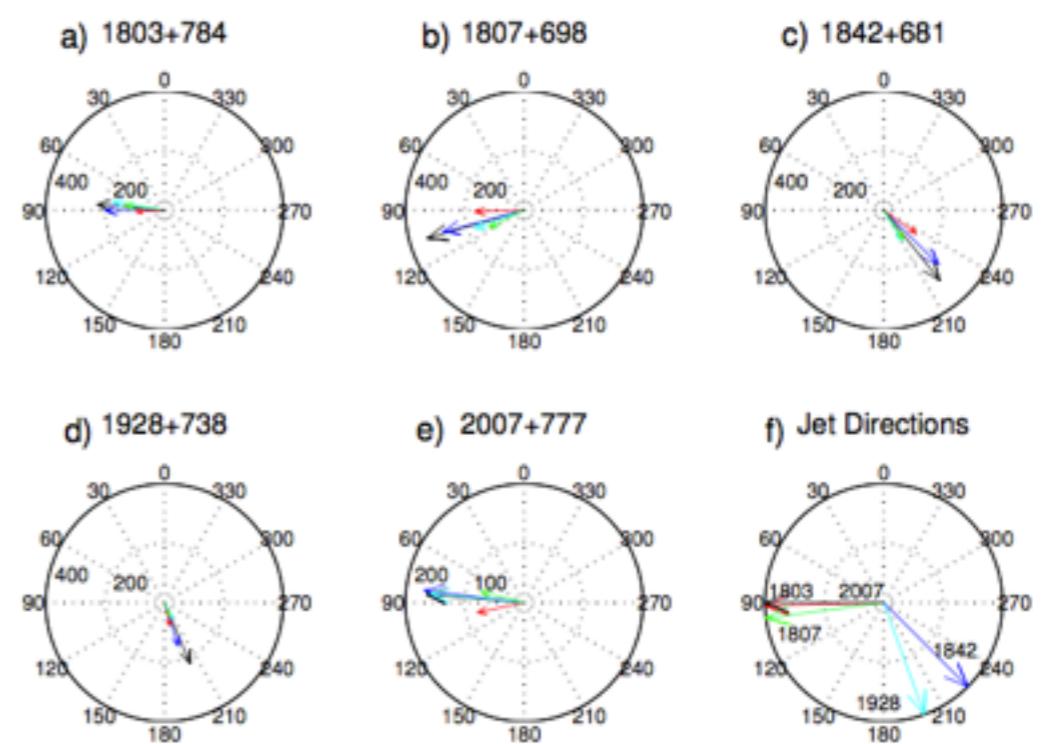


(120-fold increase)

cf 4-fold in BW (

- Astrometry — Wea

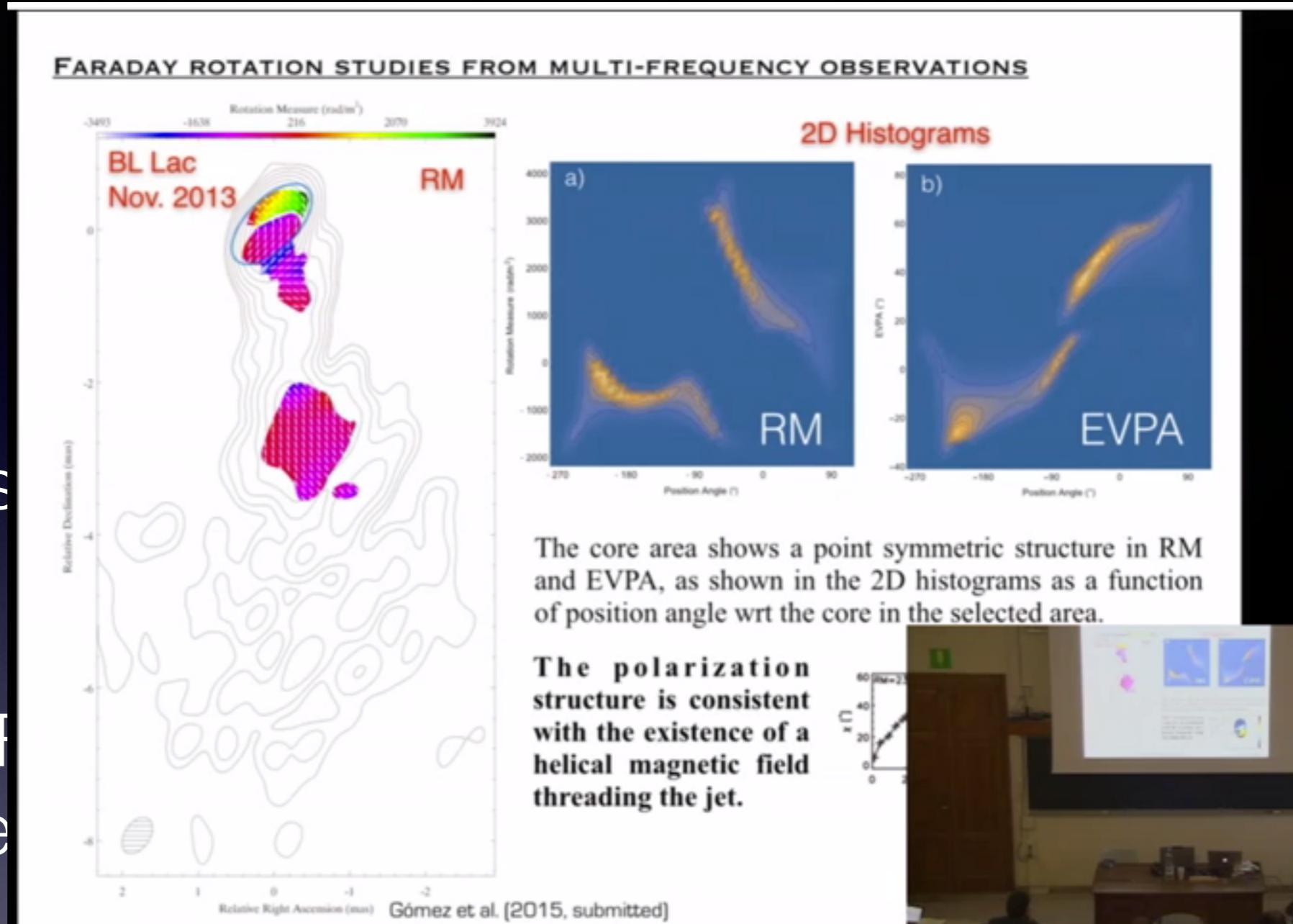
(2000% in dimension)



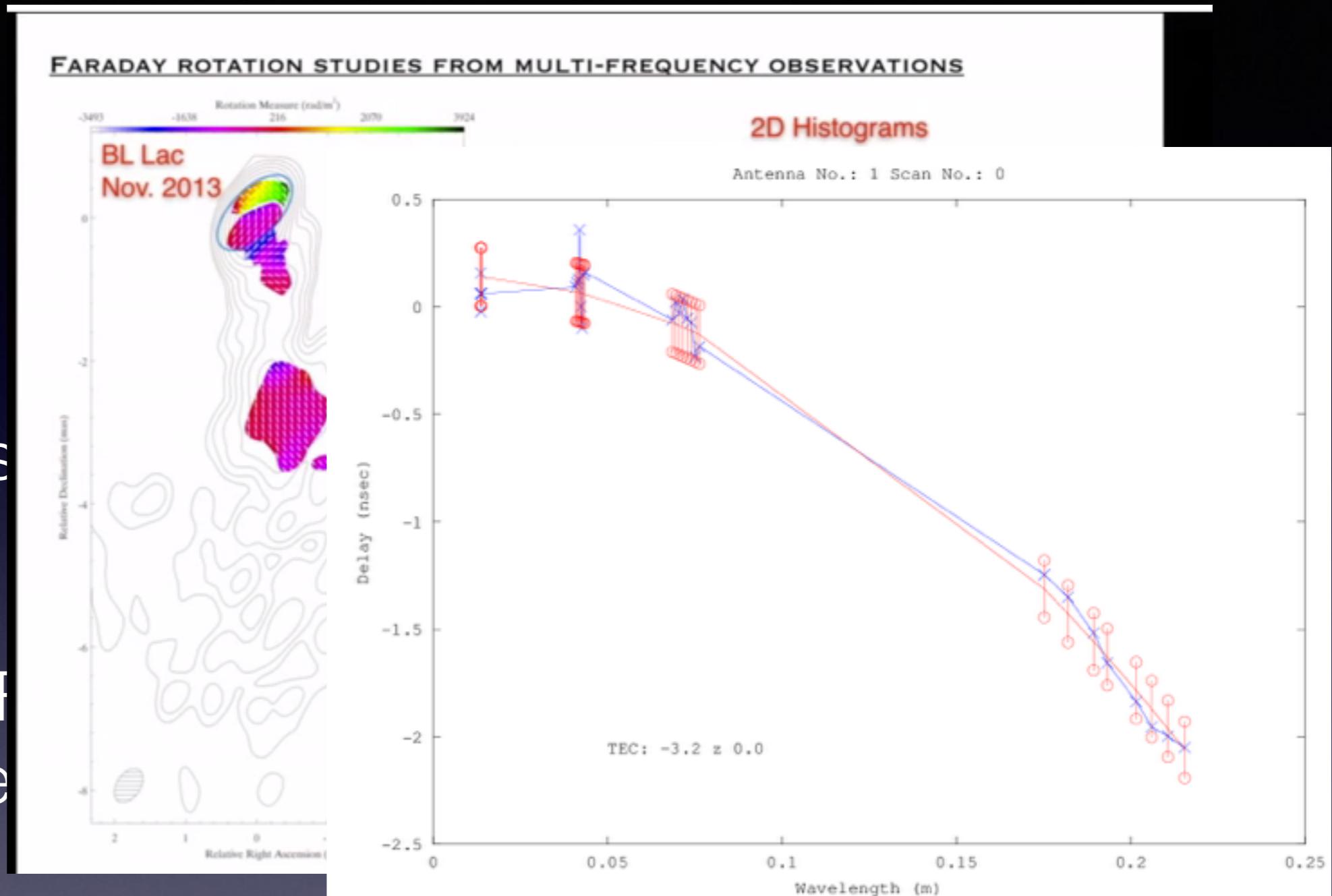
Continuum

- Jose Luis on Science: Very interesting probes of the AGN jet physics, particularly with registration
- Sol on MFPR: New analysis technique. Not completed, but promising
- Pablo on Pulsars: Exploration of the unknown

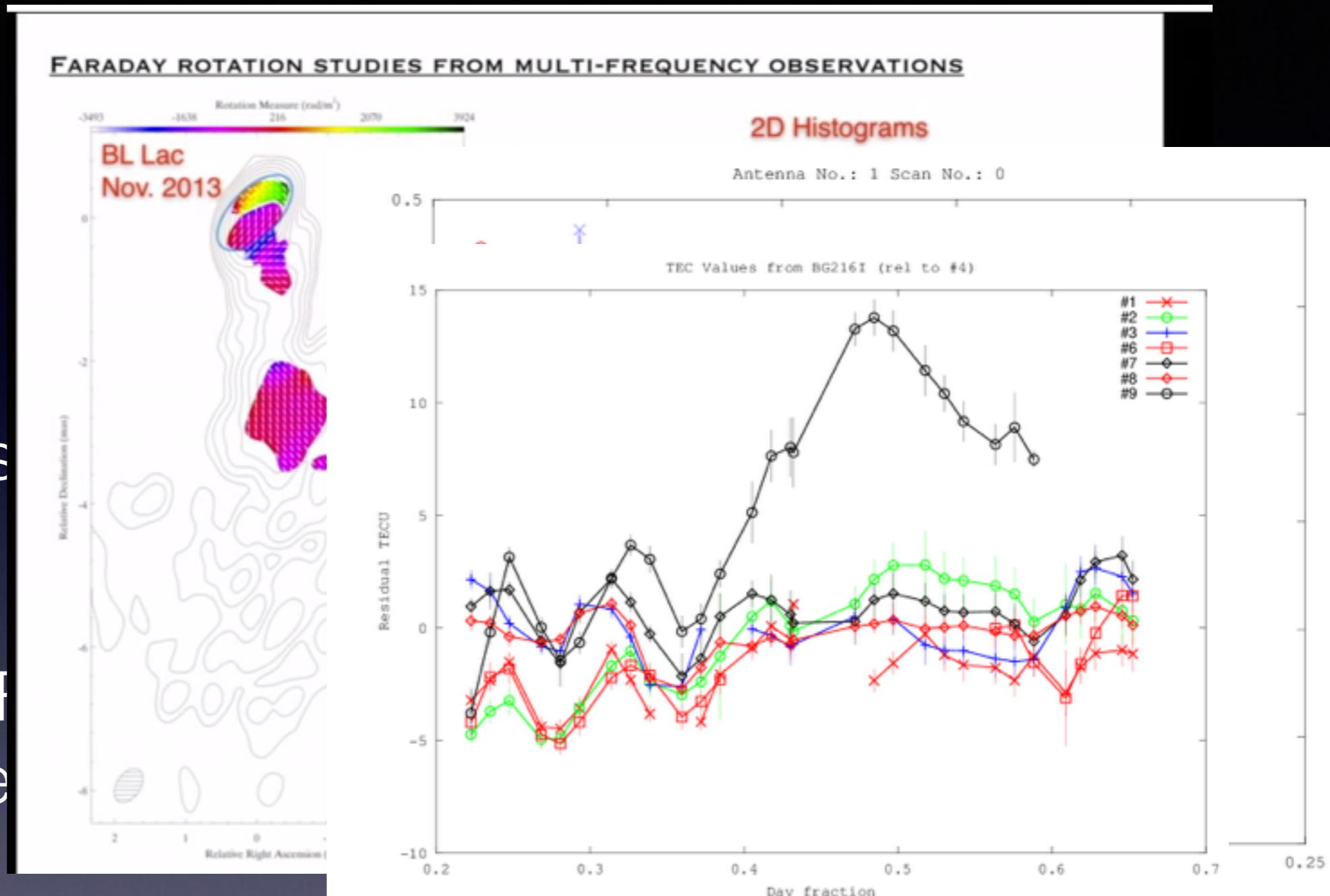
- Jose Luis on the AGN
- Sol on MFs complete
- Pablo on Pulsars: Exploration of the unknown



- Jose Luis on the AGN
- Sol on MF complete
- Pablo on Pulsars: Exploration of the unknown



- Jose Luis on the AGN
- Sol on MF complete
- Pablo on Pulsars: Exploration of the unknown



- Jose Luis on the AGN
- Sol on M87 completed
- Pablo on

FARADAY ROTATION STUDIES FROM MULTI-FREQUENCY OBSERVATIONS

2D Histograms

Antenna No.: 1 Scan No.: 0

TEC Values from BG216I (rel to #4)

#1 (red line with 'x')
#2 (green line with 'o')
#3 (blue line with 'x')

Introduction Why mm-? Experience & Challenges Future

(Near) Future of mm- Pulsar Astronomy

BlackHoleCam

BlackHoleCam

BlackHoleCam

University

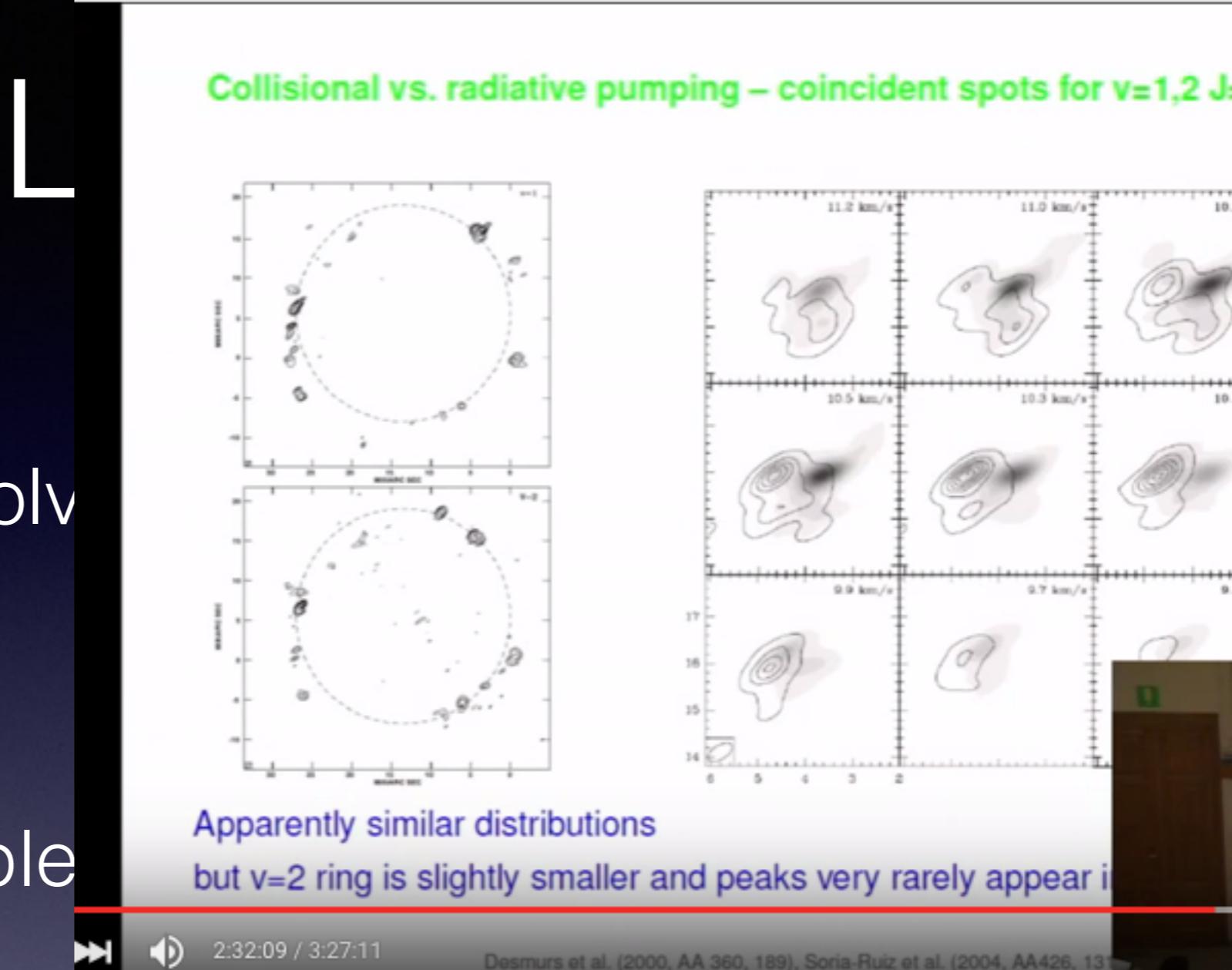
More info: blackholecam.org || eventhorizontelescope.org

- Efforts to test General Relativity and other theories of Gravity by imaging directly Sgr A* with mm-VLBI
- Includes the search for pulsars around Sgr A*, complementing the results by the black hole imaging. Pulsars potentially allow to measure the mass, spin and quadrupole moment of the black hole with unprecedented precision (see Psaltis, Wex & Lubin 2012)
- Global collaboration between the Event Horizon Telescope and the Square Kilometer Array

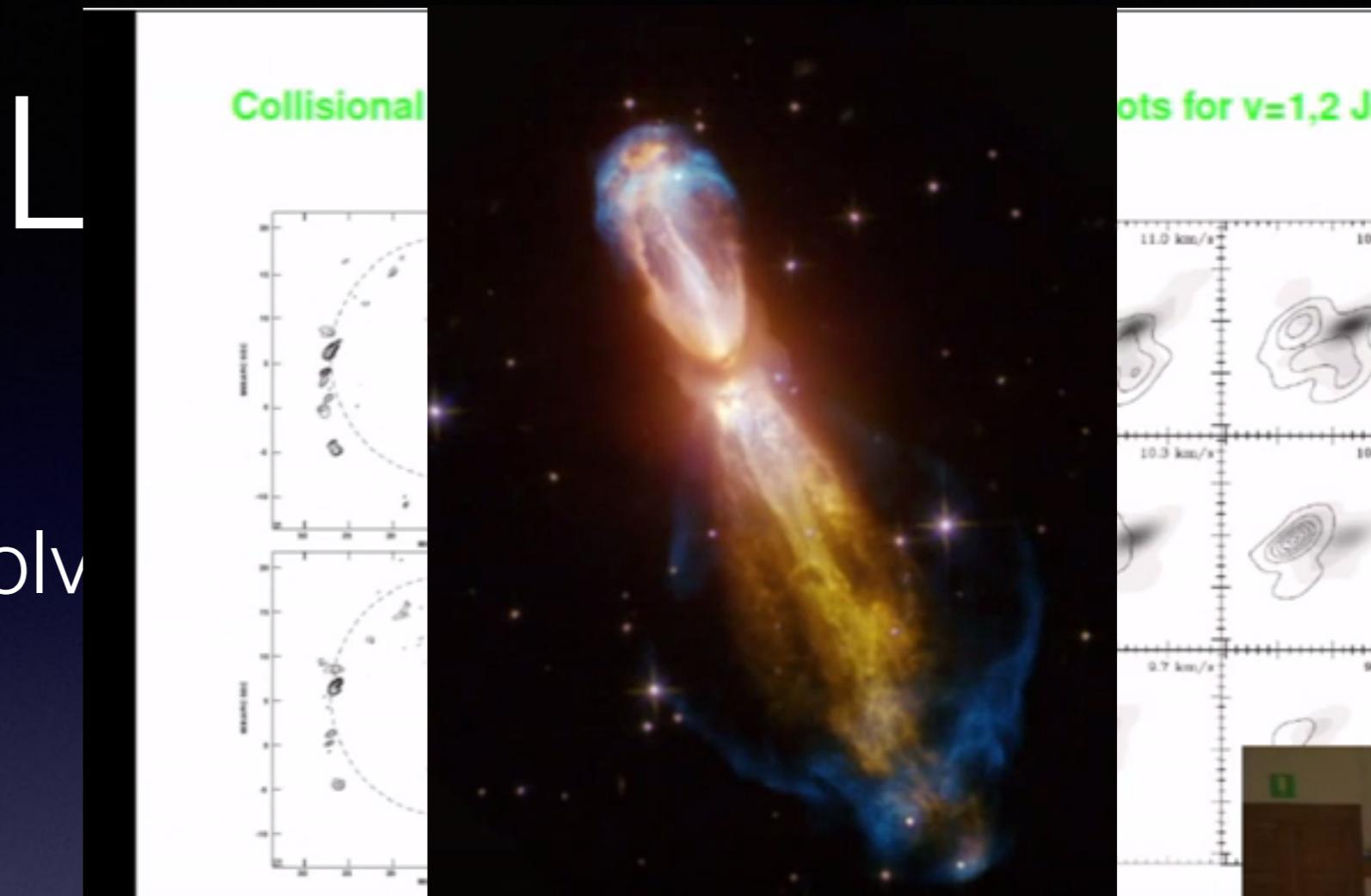
Lines

- Valentin on evolved stars:
- Luca on SFR:
- Anita on multiple masers and physical conditions

- Valentin on evolution
- Luca on SFR:
- Anita on multiple conditions



- Valentin on evolution
- Luca on SFR:
- Anita on multiple conditions



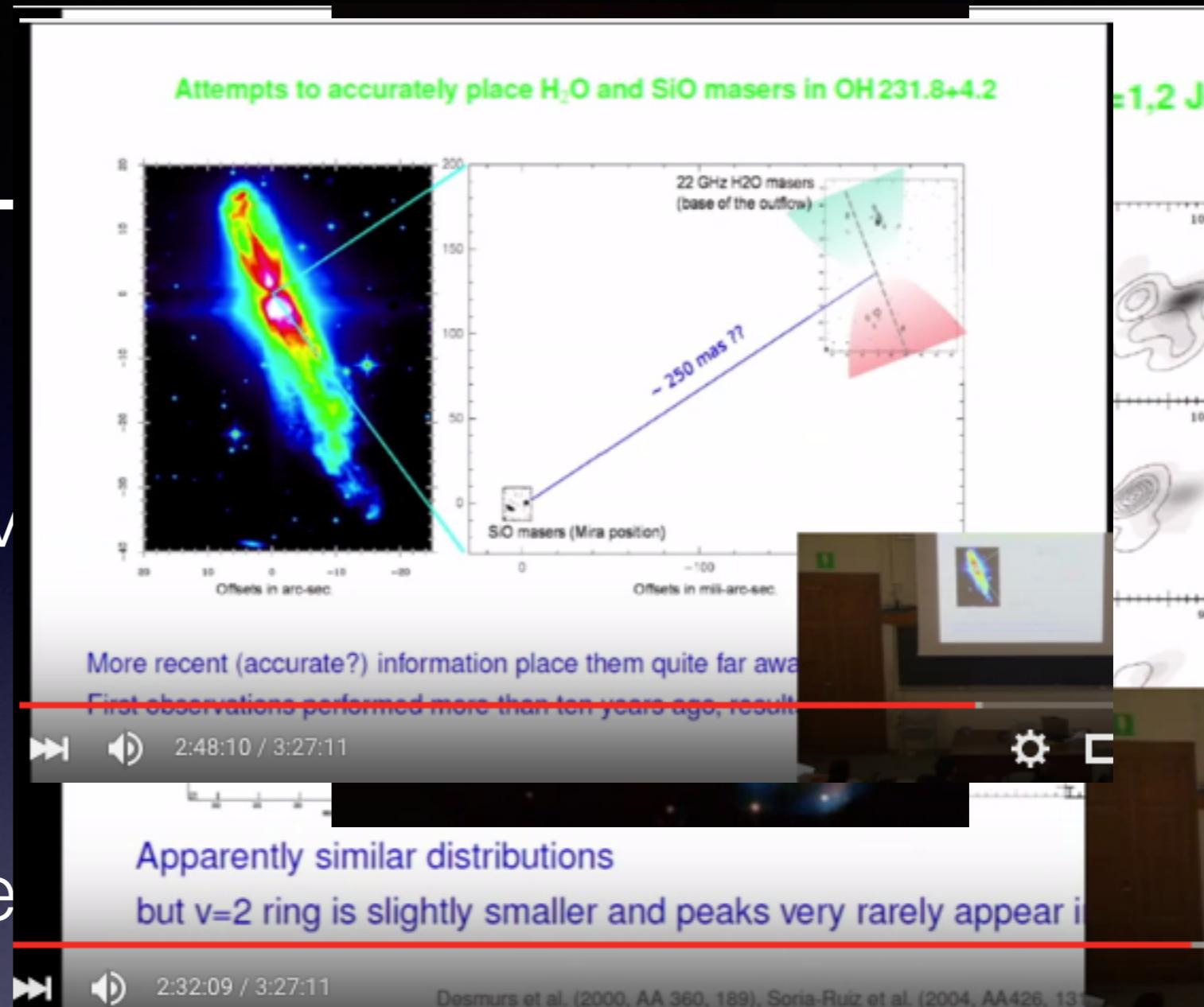
Apparently similar distributions
but $v=2$ ring is slightly smaller and peaks very rarely appear in



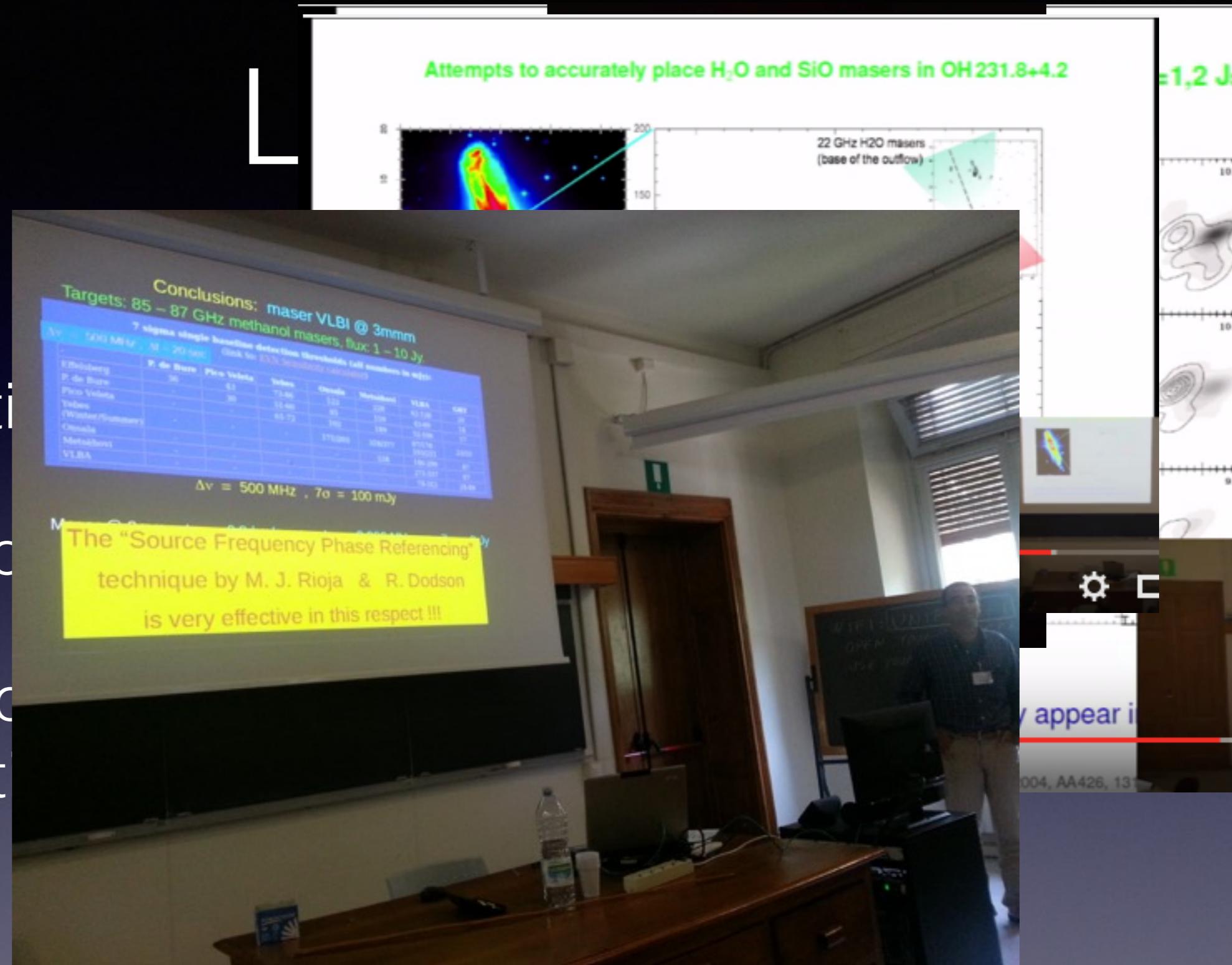
2:32:09 / 3:27:11

Desmurs et al. (2000, AA 360, 189), Soria-Ruiz et al. (2004, AA 426, 131)

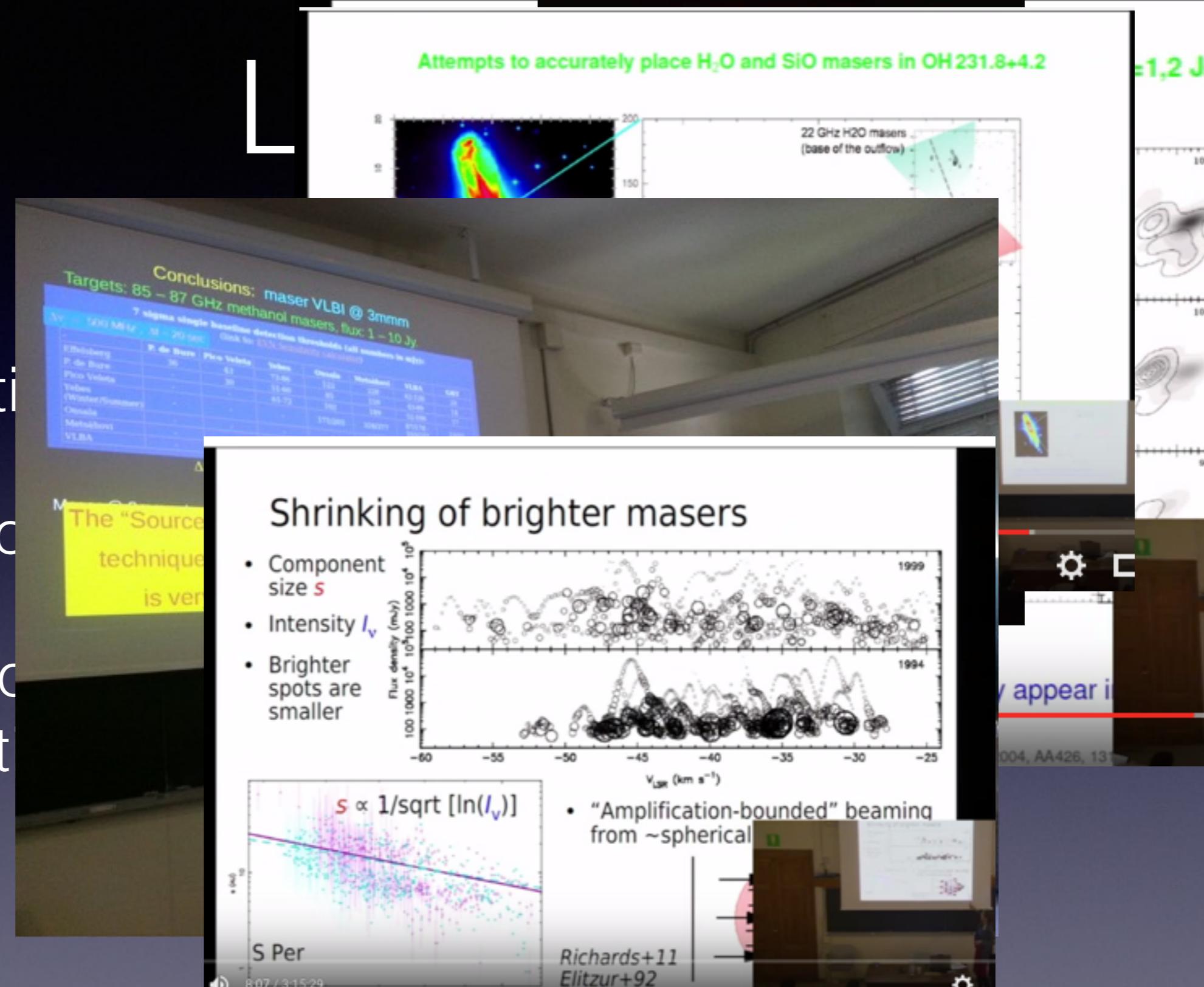
- Valentin on evolution
- Luca on SFR:
- Anita on multiple conditions



- Valentini
- Luca
- Anita
- condit



- Valentine
- Luca
- Anita
- condit



- Valentine
- Luca
- Anita
- condit

Attempts to accurately place H₂O and SiO masers in OH 231.8+4.2

=1,2 Jy

Conclusions: maser VLBI @ 3mm
Targets: 85 – 87 GHz methanol masers, flux: 1 – 10 Jy
Nv = 500 MHz, $\Delta v = 20$ km/s (check for VLBI detection thresholds, cell numbers in mJy)

VLBI	W. de Bruin	Pico Veleta	Yebes	Ossela	Maspalomas	VLBA
Ehleberg	36	43	73.46	132	138	542
P. de Bruin			73.46	132	138	542
Pico Veleta		39	15.46	85	138	542
Yebes			55.72	140	138	542
Westerbork/Planck				175.00	190.00	870.00
Ossela					138	542
Maspalomas						542
VLBA						

The "Source" technique is very

Shrinking of brighter masers

- Component size s
- Intensity I_v
- Brighter spots are smaller

Why appear in

$s \propto 1/\sqrt{\ln(I_v)}$

Why astronomers need water

- We are wet (& mostly made in stars)!
- Stars are wet!
- Water masers reveal kinematics:
 - Dust formation zone (with SiO)
 - Nucleation to full-size
 - Acceleration zone
- Evolved star winds have simpler kinematics than YSO's!
 - Best laboratory models
 - Gray, Sobeck, Neufeld
 - Analog to SER

Reports

- Thomas Kr
- DY Byun
- Robert Laing
- Alexey Rudnitsky
- VLBA (Thomas)

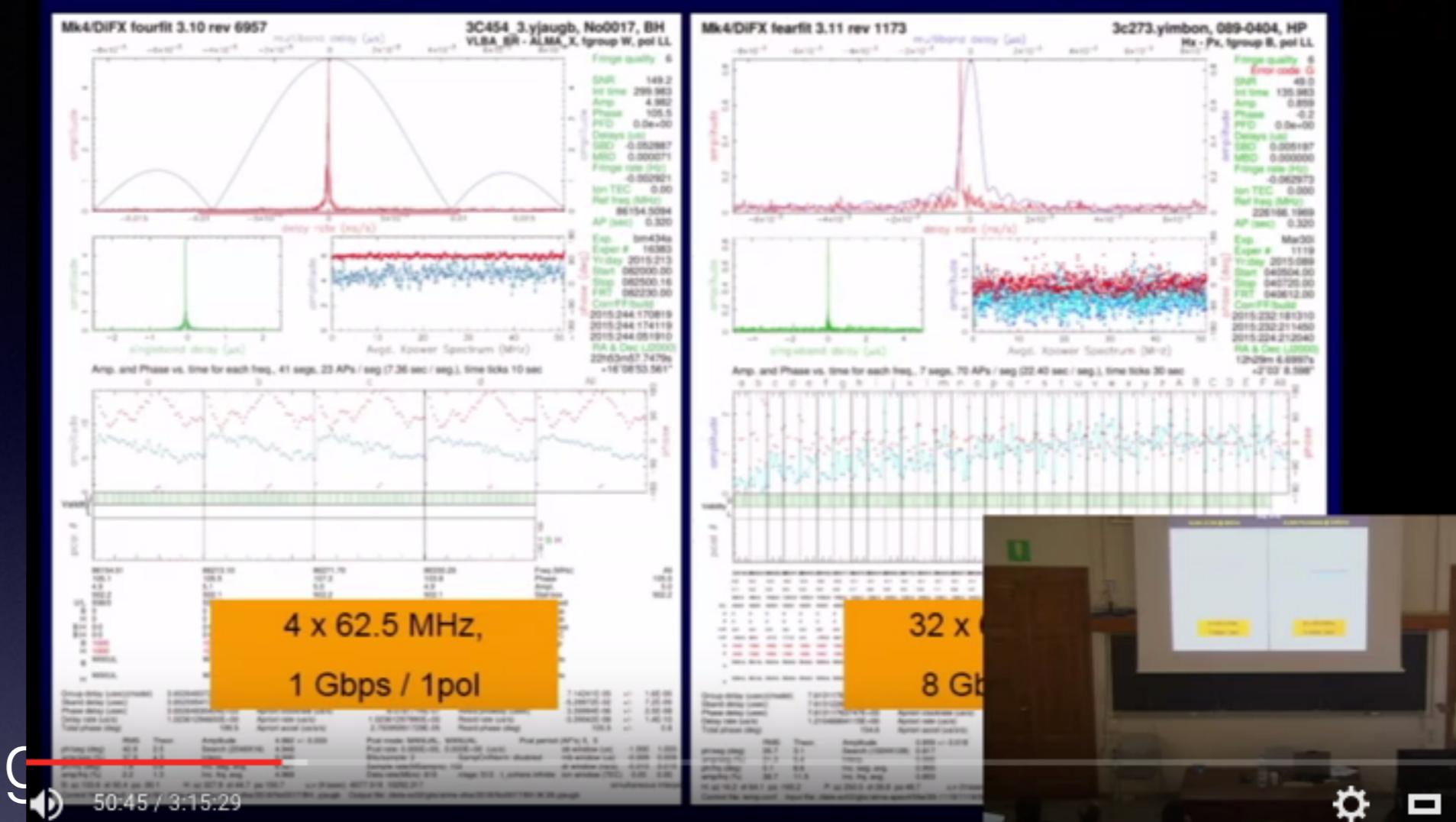
First VLBI fringes with phased ALMA at 86 and 230 GHz

(Aug. 2015)

ALMA-VLBA @ 86GHz

ALMA-PicoVeleta @ 230GHz

- Thomas Kr
- DY Byun
- Robert Laing
- Alexey Rudnitsky
- VLBA (Thomas)



First VLBI fringes with phased ALMA at 86 and 230 GHz

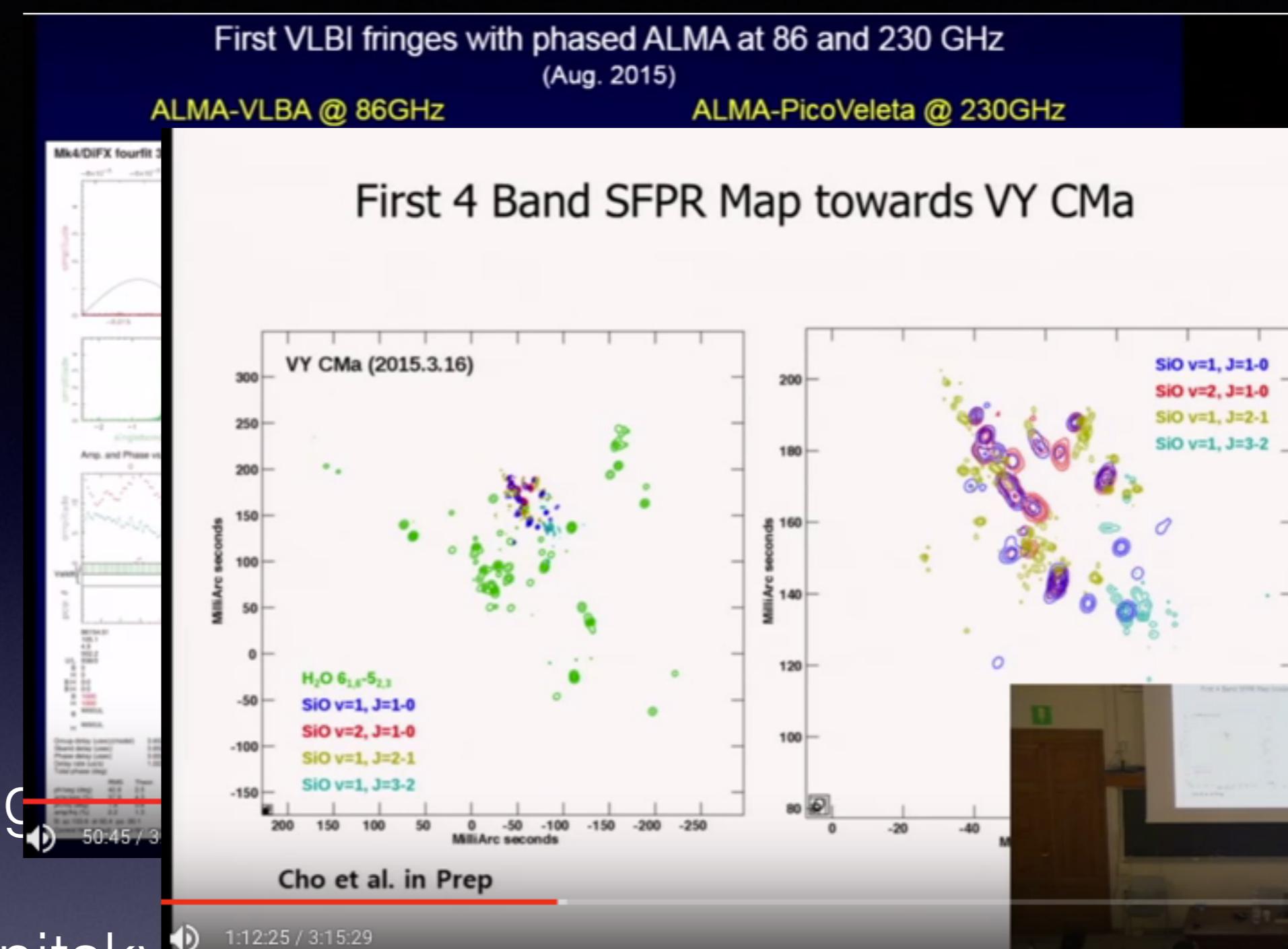
(Aug. 2015)

ALMA-VLBA @ 86GHz

ALMA-PicoVeleta @ 230GHz

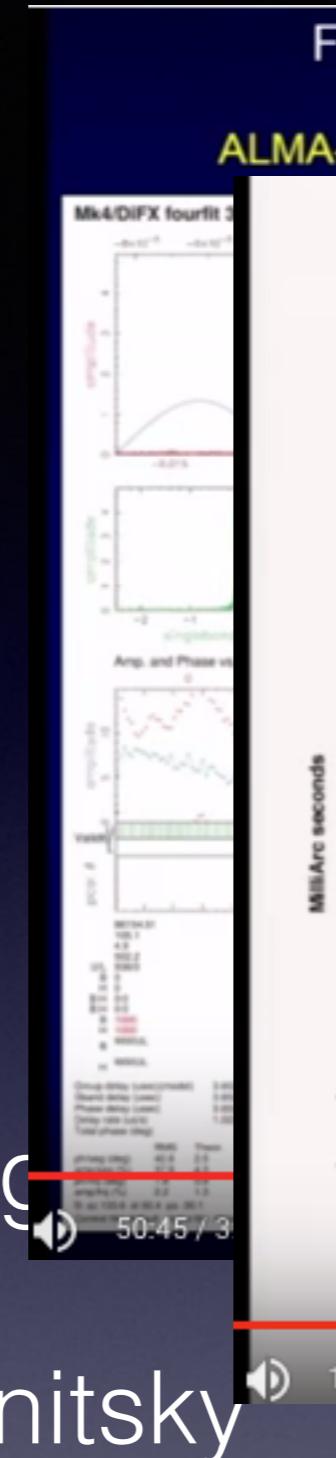
First 4 Band SFPR Map towards VY CMa

- Thomas Kr
- DY Byun
- Robert Laing
- Alexey Rudnitsky
- VLBA (Thomas)

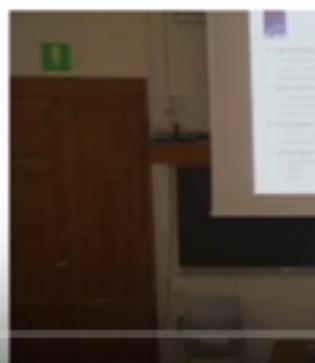


Dictionary

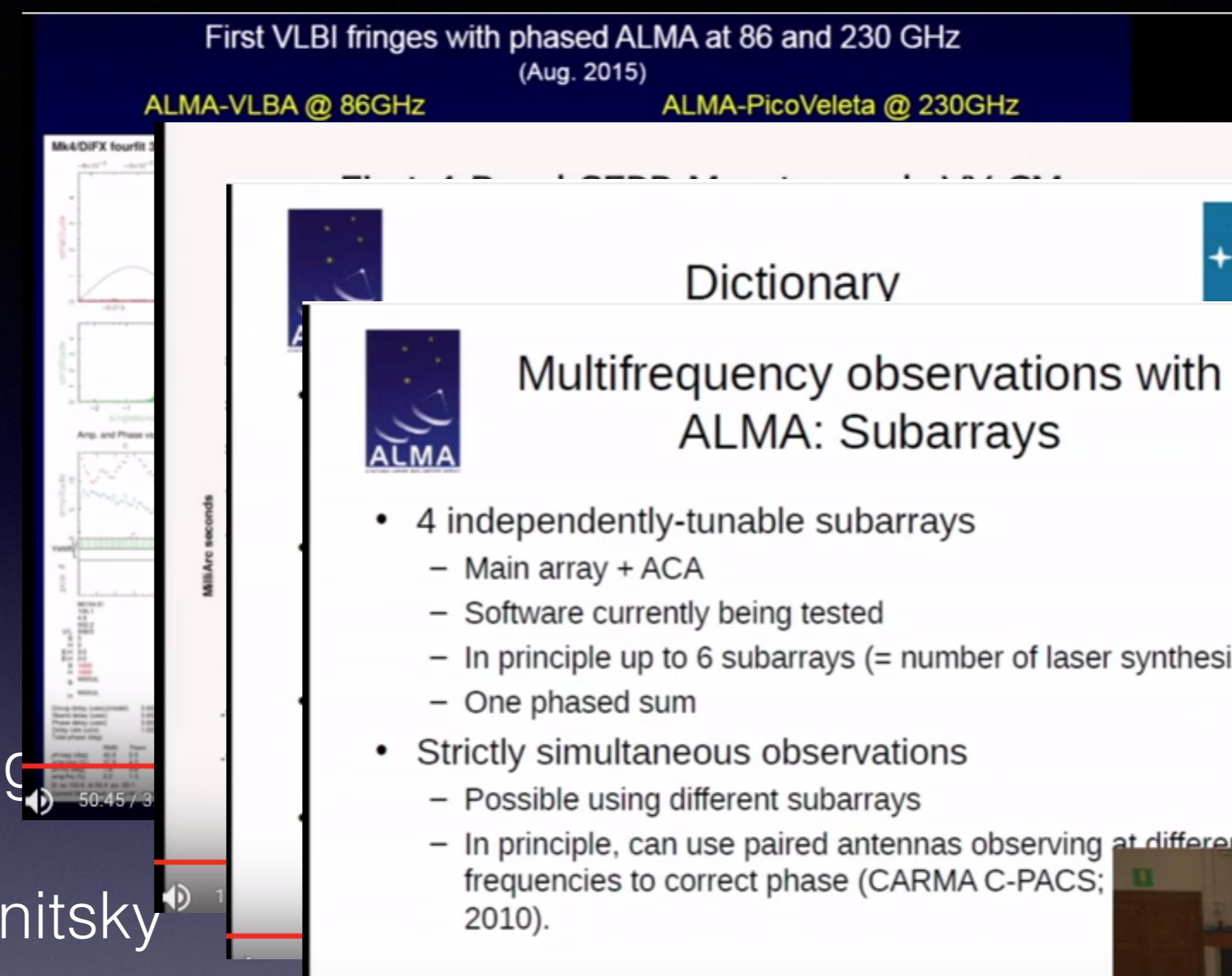
- Thomas Krichbaum
- DY Byun
- Robert Lainhart
- Alexey Rudnitsky
- VLBA (Thomas)



- ALMA Phasing Project
 - Hardware and software to use ALMA as a phased array
 - Led by MIT/Haystack, with NRAO; MPIfR and OSO in Europe; ASIAA, NAOJ
 - Majority funding from NSF + in-kind contributions
- Event Horizon Telescope Collaboration
 - Collaboration for VLBI at 230 (and 345?) GHz
 - Prime targets are Sgr A* event horizon and the M87 jet
 - New receivers for existing telescopes (NSF+)
- BlackHoleCam
 - ERC synergy grant
 - Black hole imaging + pulsars + theory
- Infrastructure for VLBI at (sub-)mm wavelengths
 - Open facility for VLBI at wavelengths of 7mm or below.
 - GMVA
 - HSA



- Thomas Krichbaum
- DY Byun
- Robert Lainhart
- Alexey Rudnitsky
- VLBA (Thomas)



Dictionary

Multifrequency observations with ALMA: Subarrays

- 4 independently-tunable subarrays
 - Main array + ACA
 - Software currently being tested
 - In principle up to 6 subarrays (= number of laser synthesizers)
 - One phased sum
- Strictly simultaneous observations
 - Possible using different subarrays
 - In principle, can use paired antennas observing at different frequencies to correct phase (CARMA C-PACS; 2010).

- Thomas Kr
- DY Byun
- Robert Laing
- Alexey Rudnitsky
- VLBA (Thomas)

Dictionary

Multi-frequency Imaging

If brightness I_{kpq} in a given point (x_p, y_q) can be represented as

$$I_{kpq} = (I_0)_{pq} \left(\frac{v_k}{v_0} \right)^{\alpha_{pq}},$$

Then the spectral index $\alpha_{pq} = \alpha(x_p, y_q)$ can be represented as

$$I_{kpq} = (I_0)_{pq} e^{\xi_k \alpha_{pq}} \approx (I_0)_{pq} (1 + \alpha_{pq}),$$

and, hence, $(I_1)_{pq} = \alpha_{pq} (I_0)_{pq}$

Considering metrics as

$$\rho = \sum_{k=1}^K \sum_{n=0}^{M-1} \sum_{m=0}^{M-1} w_{knm} |V_{knm} - \hat{V}_{knm}|$$

A dirty map in a given point will be:

$$(D_m)_{pq} = \sum_{k=1}^K D_{kpq} (\beta_k)^m - \sum_{k=1}^K \sum_{i=0}^{M-1} \sum_{l=0}^{M-1} B_{k,p-i,q-l} (\beta_k)^m ((I_0)_{pq} e^{\xi_k \alpha_{pq}})$$

2:09:25 / 3:15:29

First VLBI fringes with phased ALMA at 86 and 230 GHz

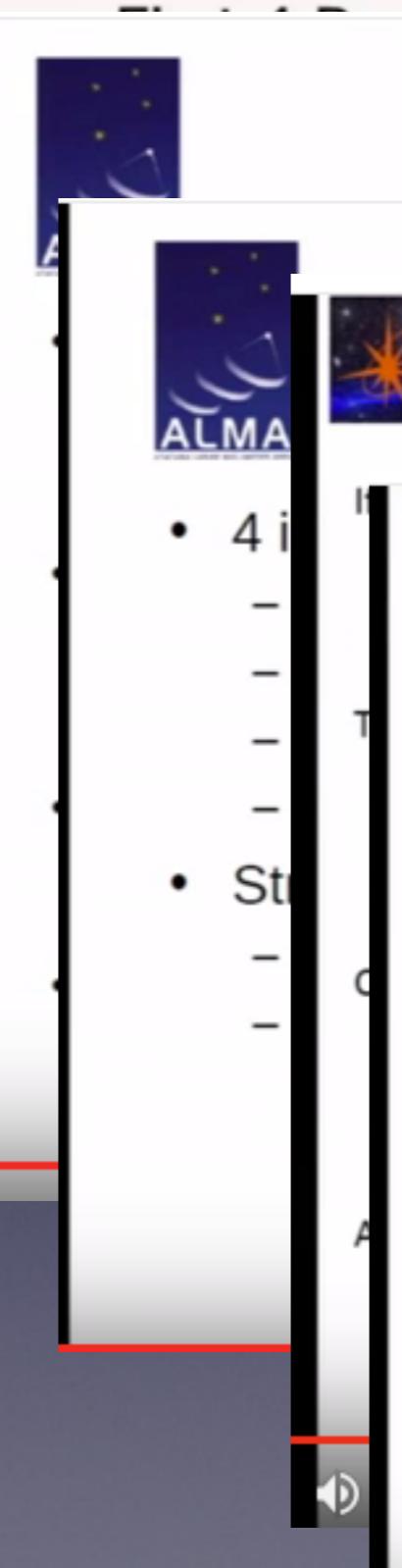
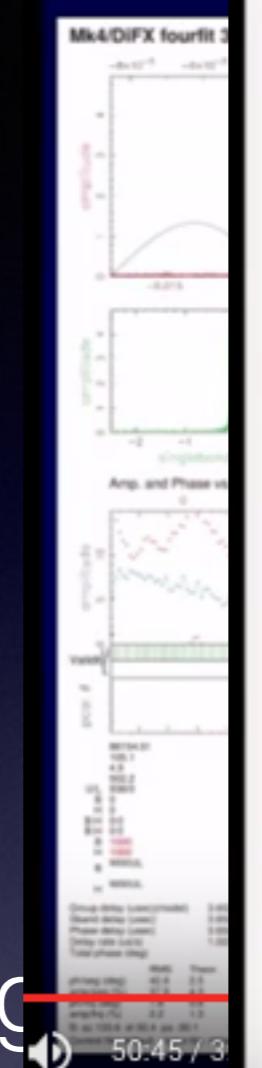
(Aug. 2015)

ALMA-VLBA @ 86GHz

ALMA-PicoVeleta @ 230GHz

Dictionary

- Thomas Krichbaum
- DY Byun
- Robert Lainey
- Alexey Rudnitsky
- VLBA (Thomas)

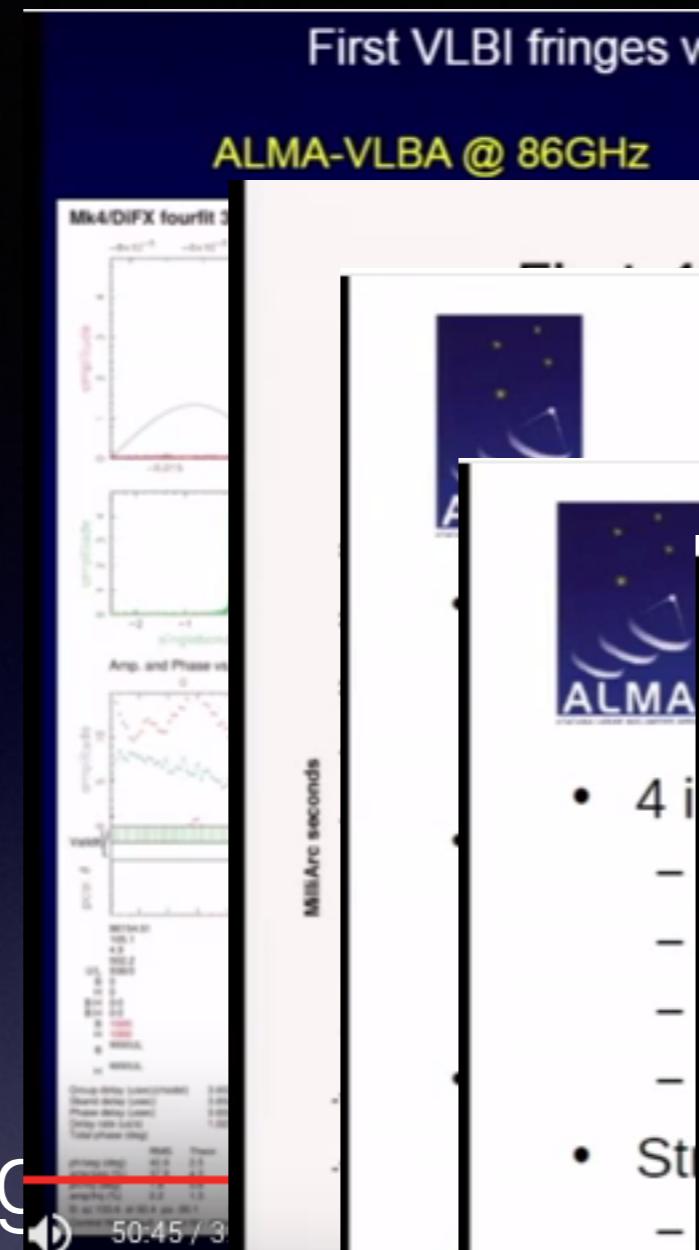


Multi-frequency Imaging

VLBA Funding Climate

- 4 instruments
- 2012 Portfolio Review: NSF divestiture
- NRAO/AUI response is here. 50% divestiture <https://www.nrao.edu/pr/2012/portfolio>
- NRAO/AUI are pursuing other sources of funding
- USNO daily EOP obs. Sponsored proposal
- AUI contract to manage NRAO is being re-negotiated
- Results will be known before 2016.
- Post-2016: VLBA open-sky time is likely to be limited
- Scheduling will be more complicated.

- Thomas Kr
- DY Byun
- Robert Laing
- Alexey Rudnitsky
- VLBA (Thomas)



First VLBI fringes with phased ALMA at 86 and 230 GHz
(Aug. 2015)

ALMA-VLBA @ 86GHz

ALMA-PicoVeleta @ 230GHz

Dictionary

Multi-frequency Imaging

VLBA Funding Clim

VLBA Recent Upgrade

science.nrao.edu/facilities/vlba/publications/member/

- C-wide 4-8 GHz, Methanol masers: Galactic
- K band HEMT amps replaced, now 70K Tsys:
- RDBE Backend, Xcube network switch: PFB,
- 2 Gbps recording: MK5B/PFB, vdif/DDC to
- Tsys, pulsecal, SEFD calibration: all via
- VME control computer & pointing replacement in progress.
- VLBA is over 20 years old. Current f
Reliability of Operation
Maintenance of Infrastructure

Characterisation

- Andrei
- Dodson

- Andrei
- Dodson

Ch

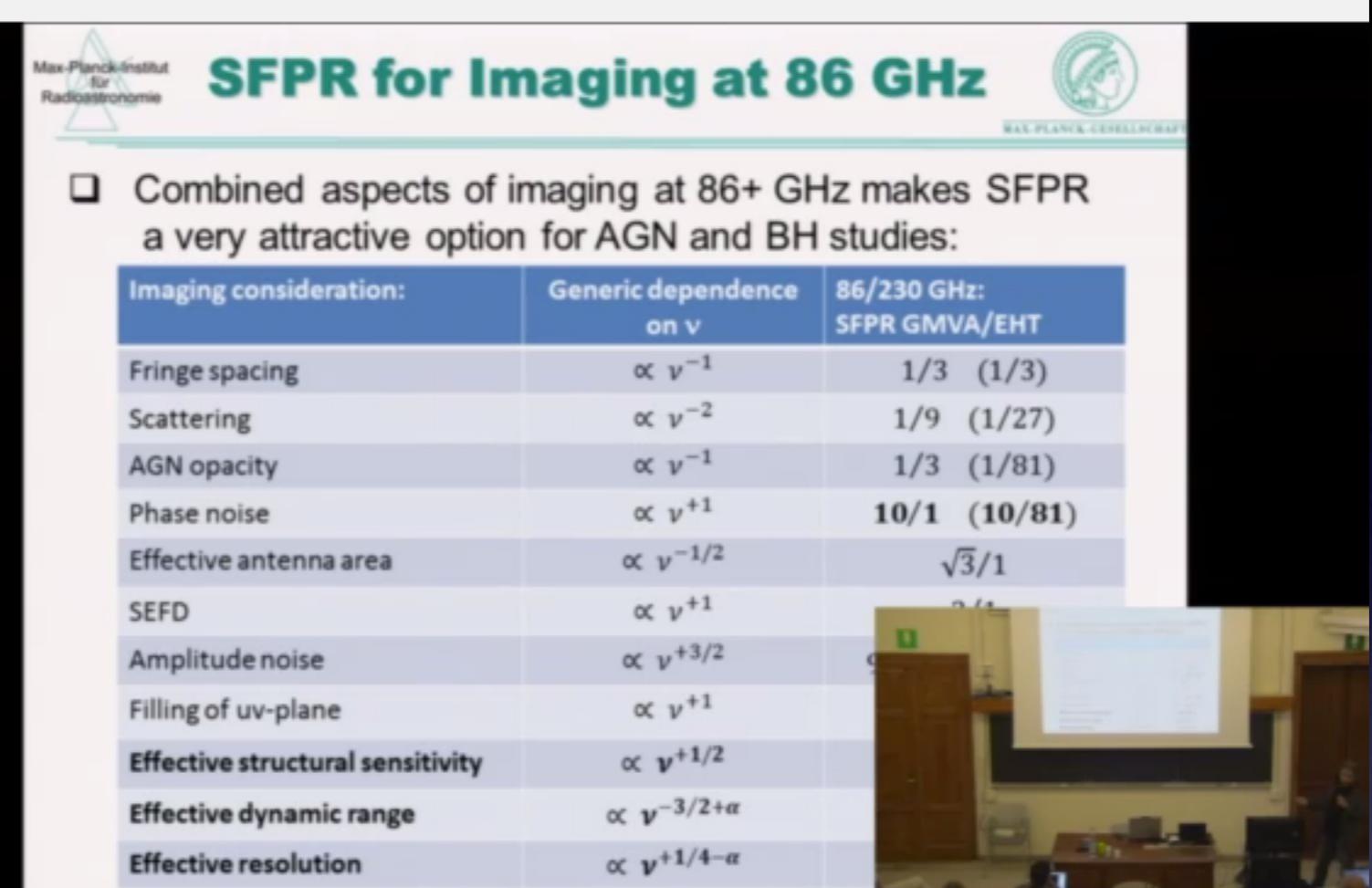
Max-Planck-Institut für
Radioastronomie

SFPR for Imaging at 86 GHz

MAX-PLANCK-GESELLSCHAFT

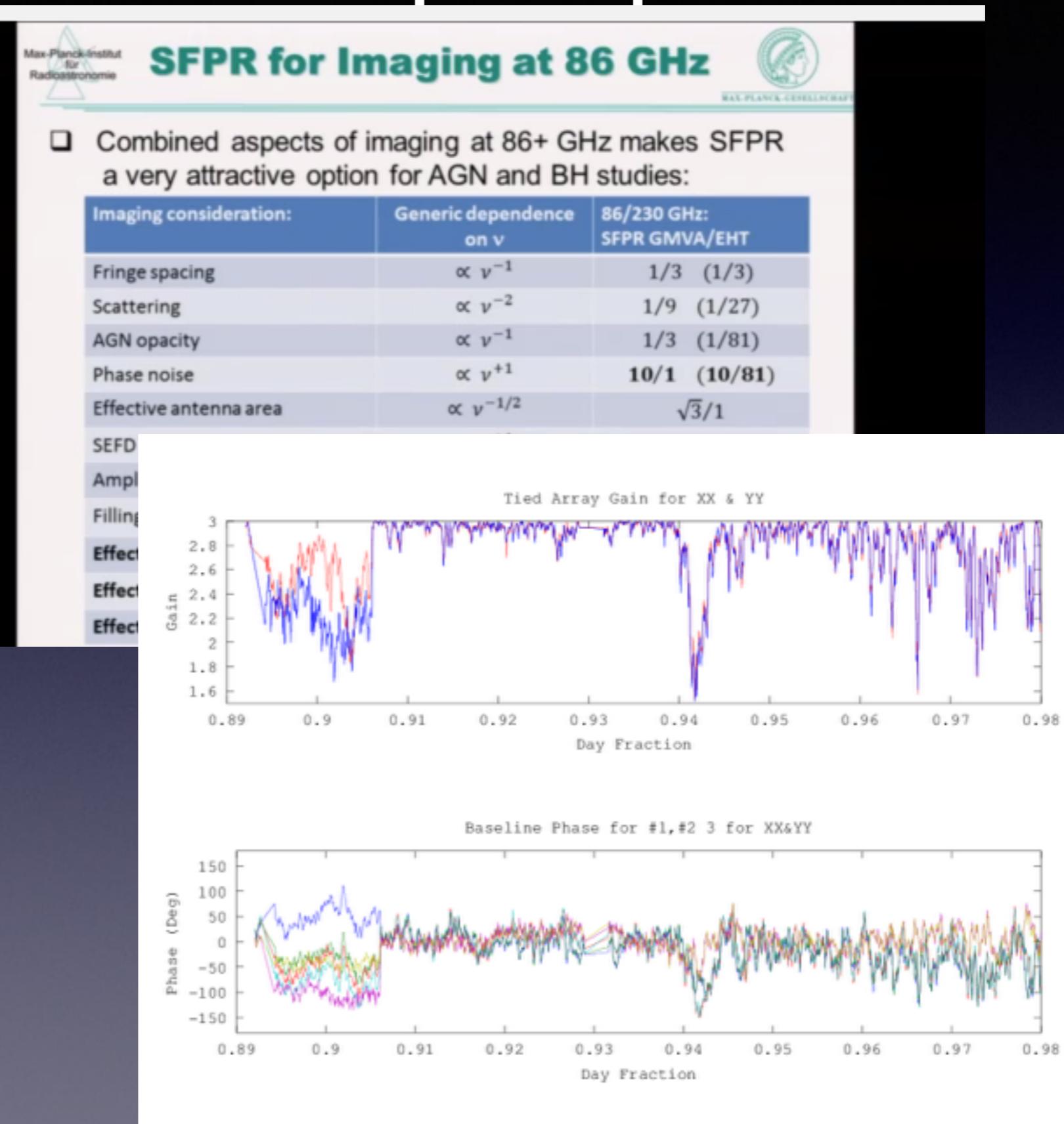
□ Combined aspects of imaging at 86+ GHz makes SFPR a very attractive option for AGN and BH studies:

Imaging consideration:	Generic dependence on ν	86/230 GHz: SFPR GMVA/EHT
Fringe spacing	$\propto \nu^{-1}$	1/3 (1/3)
Scattering	$\propto \nu^{-2}$	1/9 (1/27)
AGN opacity	$\propto \nu^{-1}$	1/3 (1/81)
Phase noise	$\propto \nu^{+1}$	10/1 (10/81)
Effective antenna area	$\propto \nu^{-1/2}$	$\sqrt{3}/1$
SEFD	$\propto \nu^{+1}$	2/1
Amplitude noise	$\propto \nu^{+3/2}$	0.1/1
Filling of uv-plane	$\propto \nu^{+1}$	0.1/1
Effective structural sensitivity	$\propto \nu^{+1/2}$	0.1/1
Effective dynamic range	$\propto \nu^{-3/2+\alpha}$	0.1/1
Effective resolution	$\propto \nu^{+1/4-\alpha}$	0.1/1



Ch

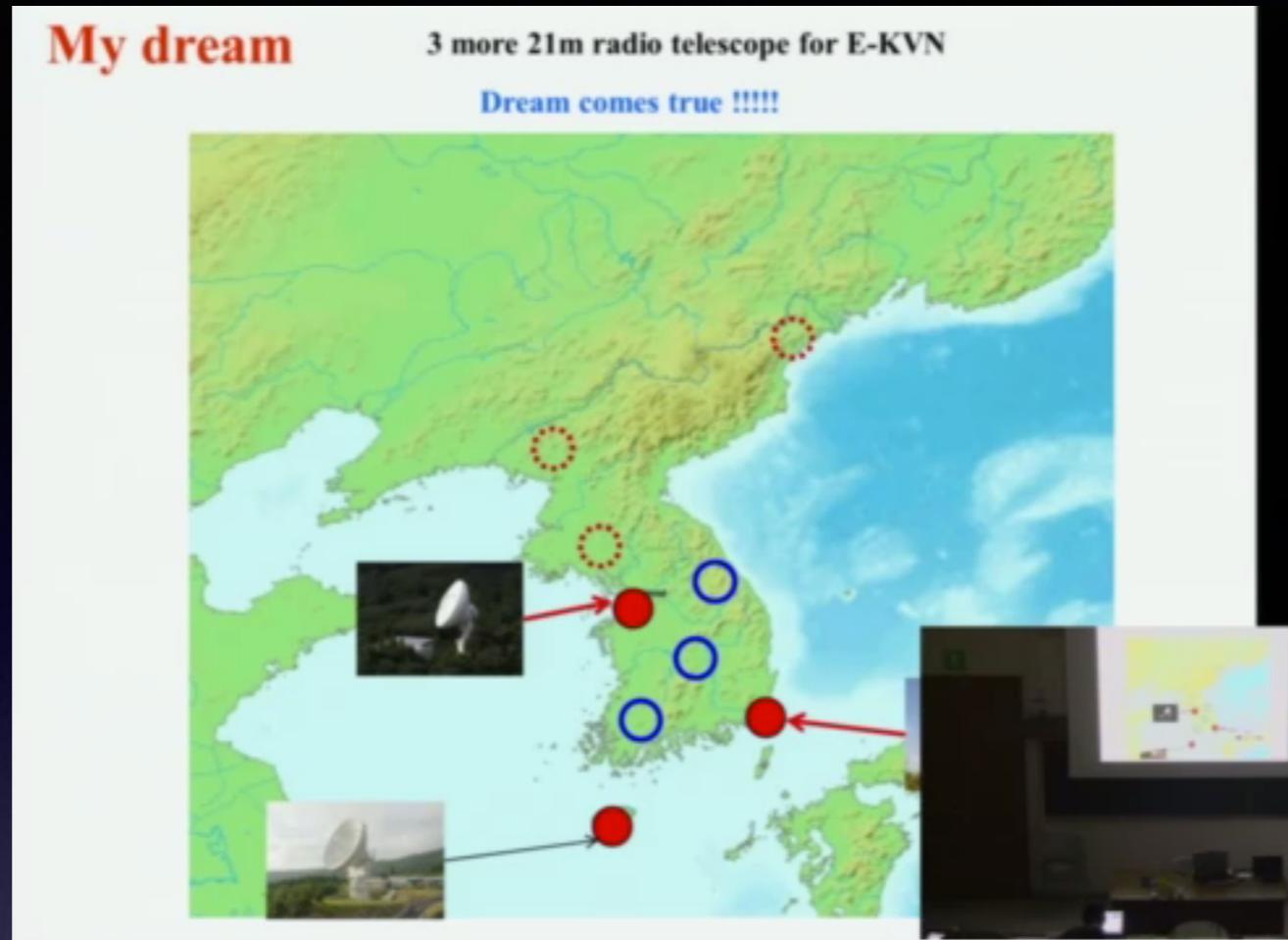
- Andrei
- Dodson



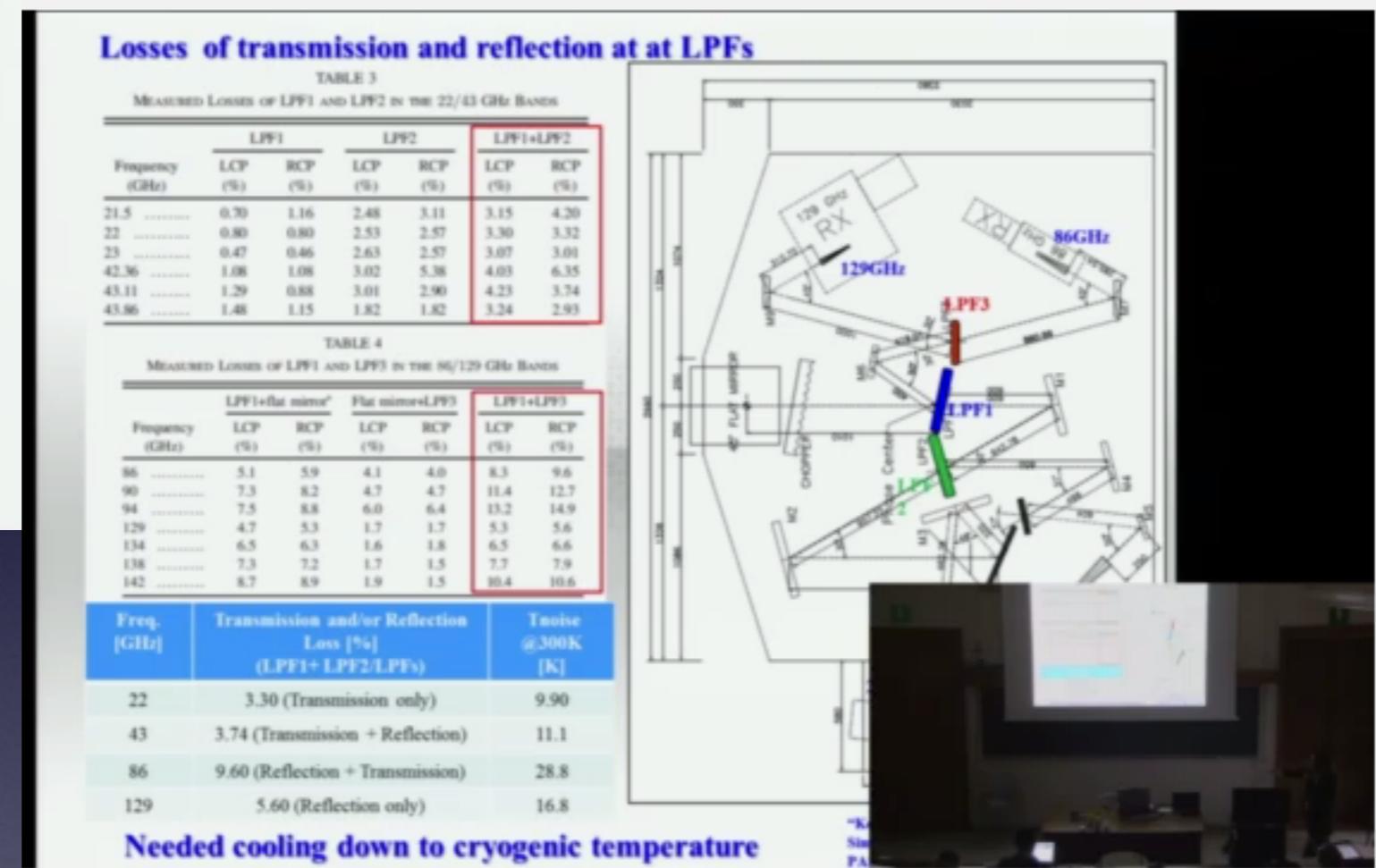
Hardware

- Han x2
- Jung
- Orfei
- Pisano

- Han x2
- Jung
- Orfei
- Pisano



- Han x2
- Jung
- Orfei
- Pisano



- Han x2
- Jung
- Orfei
- Pisano

My dream

3 more 21m radio telescope for E-KVN

Dream comes true !!!!!



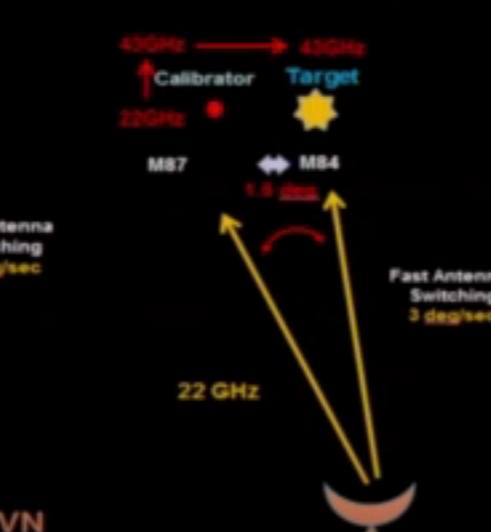
Losses of transmission and reflection at LPFs

Three Phase Referencing Methods in KVN

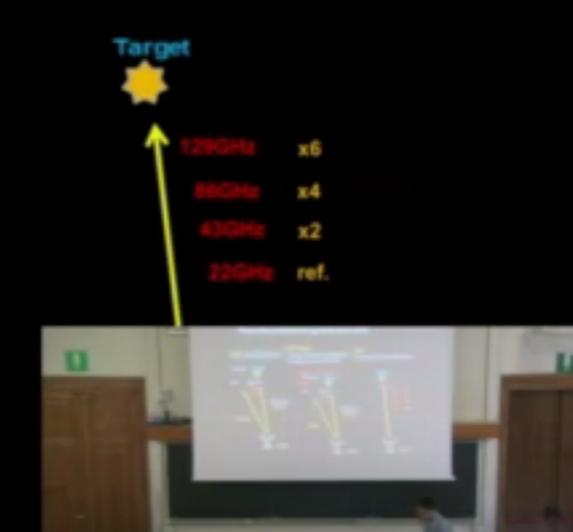
FAS conventional PR



FPT + FAS
1. phase scaling of calibrator
2. apply conventional PR



FPT
Frequency Phase Transfer



● Live
   

- Han x2
- Jung
- Orfei
- Pisano

My dream

3 more 21m radio telescope for E-KVN

Dream comes true !!!!!



Losses of transmission and reflection at LPFs

Three Phase Referencing Methods in KVN

FAS conventional PR

Calibrator Target

430MHz → 43GHz

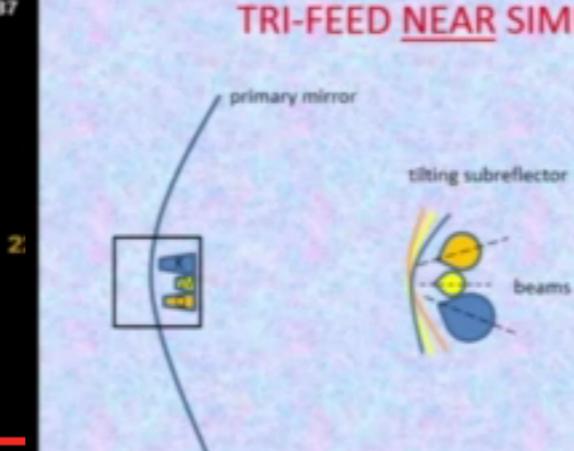
FPT + FAS

1. phase scaling of calibrator
2. apply conventional PR

FPT

Frequency Phase Transfer

TRI-FEED NEAR SIMULTANEITY IN ITALY: READY



Tri-feed beams parameter

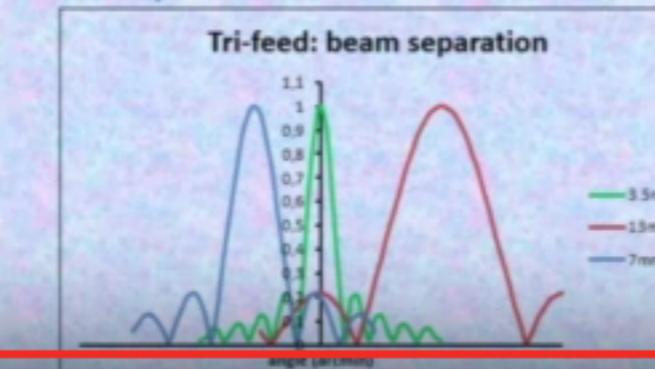
	SRT	Med/Noto
[arcmin]	[arcmin]	
FWHM 13 mm	0.85	1.8
FWHM 7 mm	0.48	0.9
FWHM 3.5 mm	0.25	0.5
W-K Beam separation	1.32	2
W-Q Beam separation	0.72	1.1
W to Q bands horn distance	31 mm	
W to K bands horn distance	58 mm	

Tri-feed beams switching

	SRT	Med/Noto
(s)	(s)	
W to K switching time	5	0.6
W to Q switching time	1	0.5



Tri-feed: beam separation



Live

ERATec – Florence October 5-7, 2015

- Han x2
- Jung
- Orfei
- Pisano

My dream

3 more 21m radio telescope for E-KVN

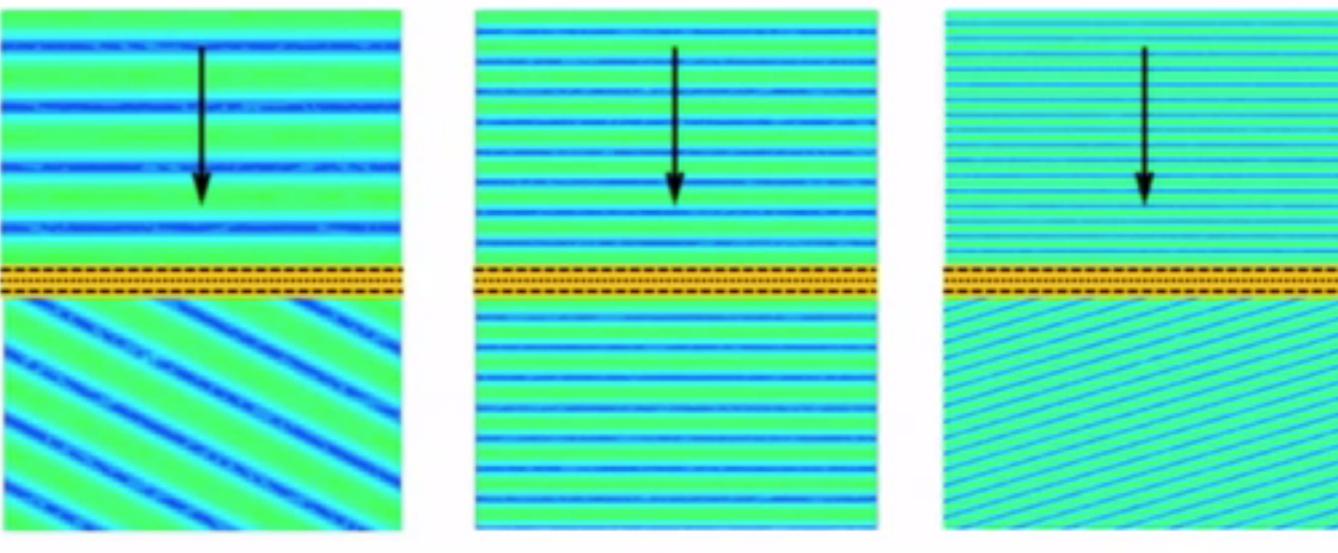
Dream comes true !!!!!



Losses of transmission and reflection at LPFs

Three Phase Referencing Methods in KVN

Mesh Trichroic for triple-feed simultaneity: **Conceptual idea**



$v_1 \pm \Delta v_1$ $v_2 \pm \Delta v_2$ $v_3 \pm \Delta v_3$

- The frequency-dependent differential phase-shift, respect to a (ex: centre), would create the required off-axis phase-fronts a

- Real converging beams will require additional optimisation

→ This is an ongoing development

3:06:39 / 3:15:29

- Han x2
- Jung
- Orfei
- Pisano



Losses of transmission and reflection at at LPFs

Three Phase Refractive Method in KVN

Mesh Technology: Manufacture 1/2

Free standing (air-gap) multiple metal mesh devices

The manufacturing process

- Copper evaporation on polymer substrate
- Photolithographic etching to form metal grid pattern
- Randomly oriented grids precisely spaced and mounted together to form a single composite filter.
- Air/vacuum gap filters use annular metal spacers

3:06:3 2:54:10 / 3:15:29

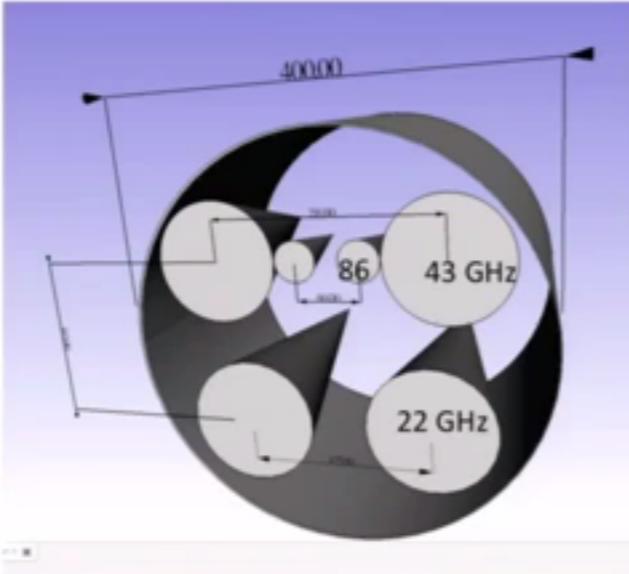
Hardware

- Hovatta
- Nesti
- Miroslav
- Alef

Hardware

- Hovatta
- Nesti
- Miroslav
- Alef

Multifrequency setup



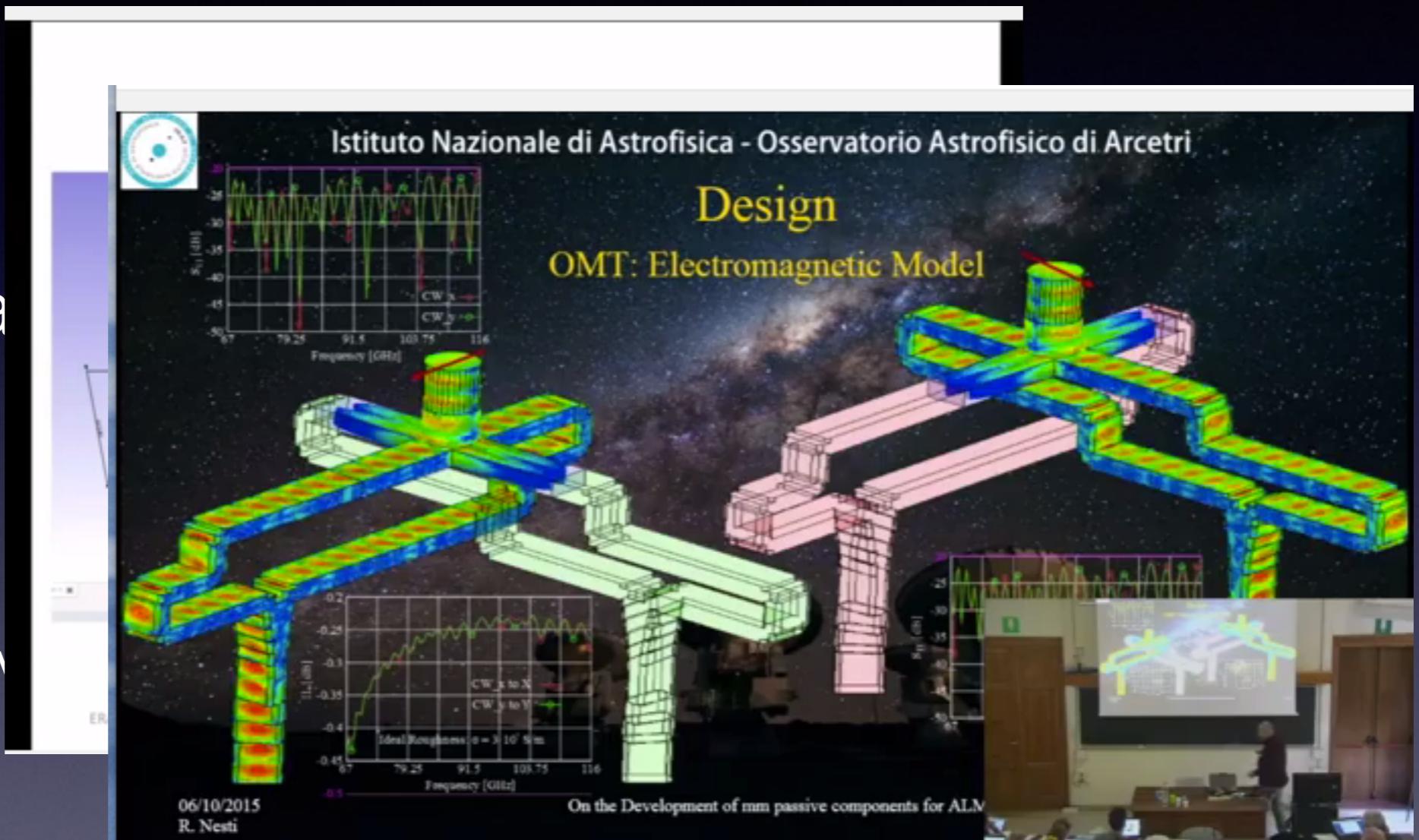
- All horns in a single cylinder
- Switching between frequencies done by changing pointing offsets
 - Between 43-86 GHz takes about 0.9-1.2s depending on elevation
 - Additional period of
- Short end transfer (Middleberg)

ERATec 5.-7.10.2015 talvikki.hovatta@aalto.fi



Hardware

- Hovatta
- Nesti
- Miroslav
- Alef



Hardware

- Hovatta
- Nesti
- Miroslav
- Alef

Istituto Nazionale di Astrofisica - Osservatorio Astrofisico di Arcetri

CHALMERS Chalmers University of Technology

Onsala Space Observatory

Design

Design alternatives

- Triple band layout with dichroic filters – not applicable due to
- Dual Band with dichroic filters
- Dual band layout: wide band feed and single band feed with
- Triple band feed

ERATEc workshop
Florence, 5 – 7 October

Hardware

- Hovatta
- Nesti
- Miroslav
- Alef

The slide is titled "Design alternatives" and features logos for the Istituto Nazionale di Astrofisica - Osservatorio Astrofisico di Arcetri, CHALMERS Chalmers University of Technology, and Onsala Space Observatory. The main content of the slide is "New Opportunities" with the following bullet points:

- can develop multi-wavelength VLBI now!
- backends with very high data rates (see JRA DIVA: DBBC3 with up to 128 Gbps; 4x 4GHz dual pol - 32Gbps)
- High bit-rate recorders: Mark 6 (64 Gbps w. 4 units @EHT)
- Broad-band LNAs and feeds
- **Scientific opportunities:**
 - multi-wavelength VLBI mapping
 - multi-wavelength spectroscopy
 - multi-wavelength polarimetry
 - multi-wavelength single-dish
 - geodetic VGOS compatibility
- **New: no different LOs and huge sky frequency coverage**

At the bottom of the slide, there is a red bar with the text "Live" and a video feed showing a person speaking in a room with a whiteboard in the background.