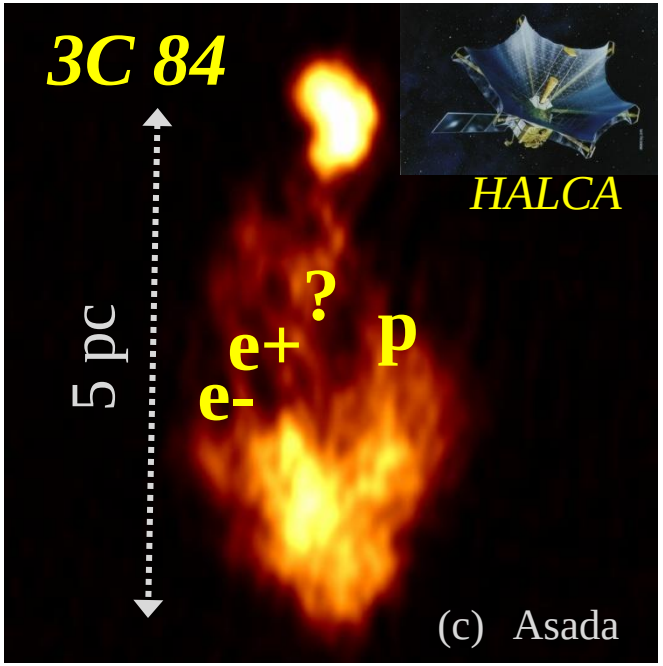
活動銀河核ジェットが生まれる瞬間



紀　基樹（きの　もとき）
(国立天文台　水沢VLBI観測所　VSOP-2グループ)

広島大　談話会
(@3rd March 2010)

Idea of Recurrent outbursts

OPTICAL EVIDENCE SUGGESTING THE OCCURRENCE OF A VIOLENT OUTBURST IN NGC 1275

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University of California at San Diego, La Jolla, California
Received June 21, 1965

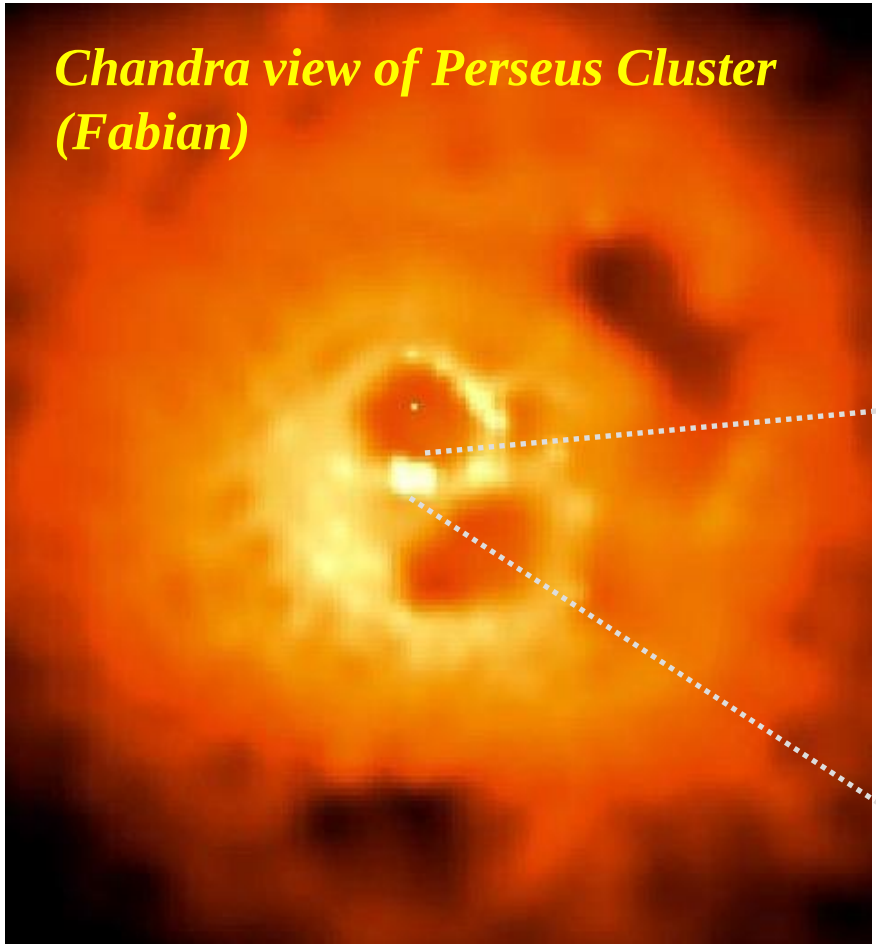
ABSTRACT

A spectroscopic study of the velocity field in the radio and Seyfert galaxy NGC 1275 has been carried out, using the Lick 120-inch and McDonald 82-inch prime-focus spectrographs. The results suggest that we are seeing in this galaxy the after-effects of an outburst in which large amounts of gas have been ejected from the nuclear region. The gas with recession velocities $\sim +3000$ km/sec with respect to the center of the galaxy has probably been ejected either intermittently or continuously over a time scale of more than 5×10^8 years. Approach velocities of up to -540 km/sec relative to the center of the galaxy have been detected. The velocity field in the gas associated with the main body and the appearance of the galaxy in the light of Hα plus neighboring red continuum suggest a continuing activity in the form of ejection in narrow jets from the center with velocities of up to 100–200 km/sec.

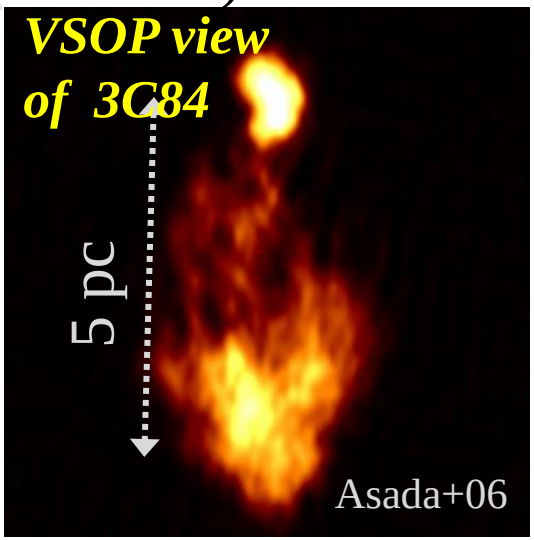
An attempt has been made to relate the radio source with the optical data. The object is apparently a triple radio source and the central small component is concentrated on the Seyfert nucleus. The two components which lie at distances of several hundred kiloparsecs from the nucleus are seen from the polar diagram plotted in Figure 13 to lie roughly in the directions of the axes of the two approximate cones of ejected gas, and this suggests that these sources are due to relativistic plasma ejected in the same outbursts which give rise to the optical phenomena. This idea casts doubt on the suggestion that one of the sources originated in the galaxy NGC 1265. It appears that the energy emitted in the outburst, much of which is in the form of kinetic energy of fast-moving but non-relativistic gas, is $\sim 10^{59}$ ergs. Thus the outburst as manifested by the Seyfert nucleus, the ejected gas, and the triple radio source is considerably more powerful than that which occurred in M82.

From 60-ties. Many suggestions for it.

Suggestion of recurrent in radio-band

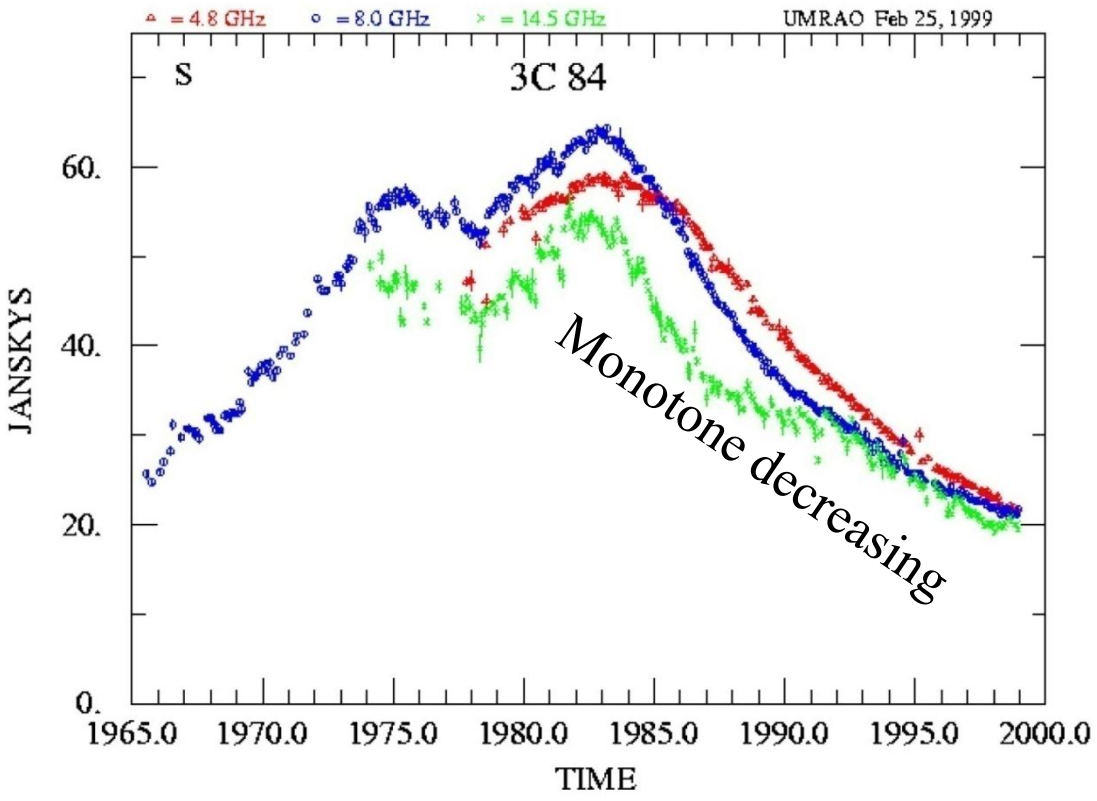


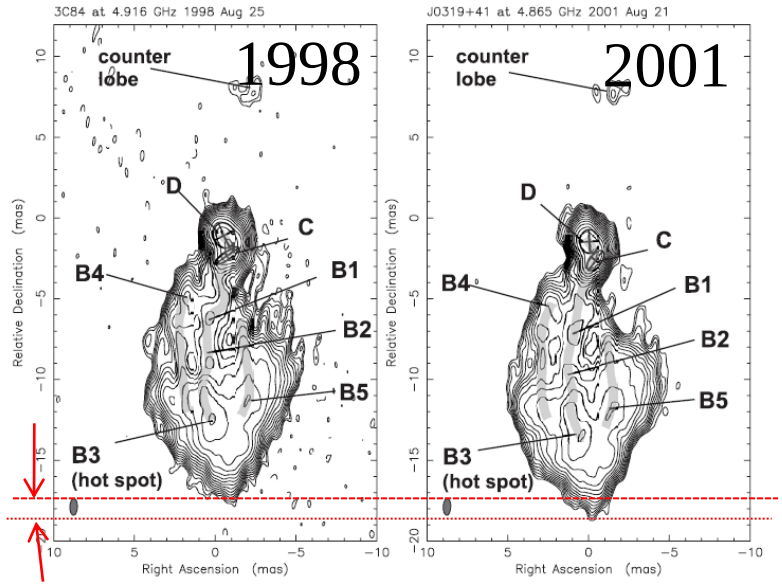
- Core of Seyfart 2 gal. NGC 1275 ($M_{BH}=3*10^8 M_{sun}$)
- z=0.0176
- Other radio bubbles (Pedler+91, Vermeulen+96)



Then how to verify it?

Evidence of Recurrent outburst

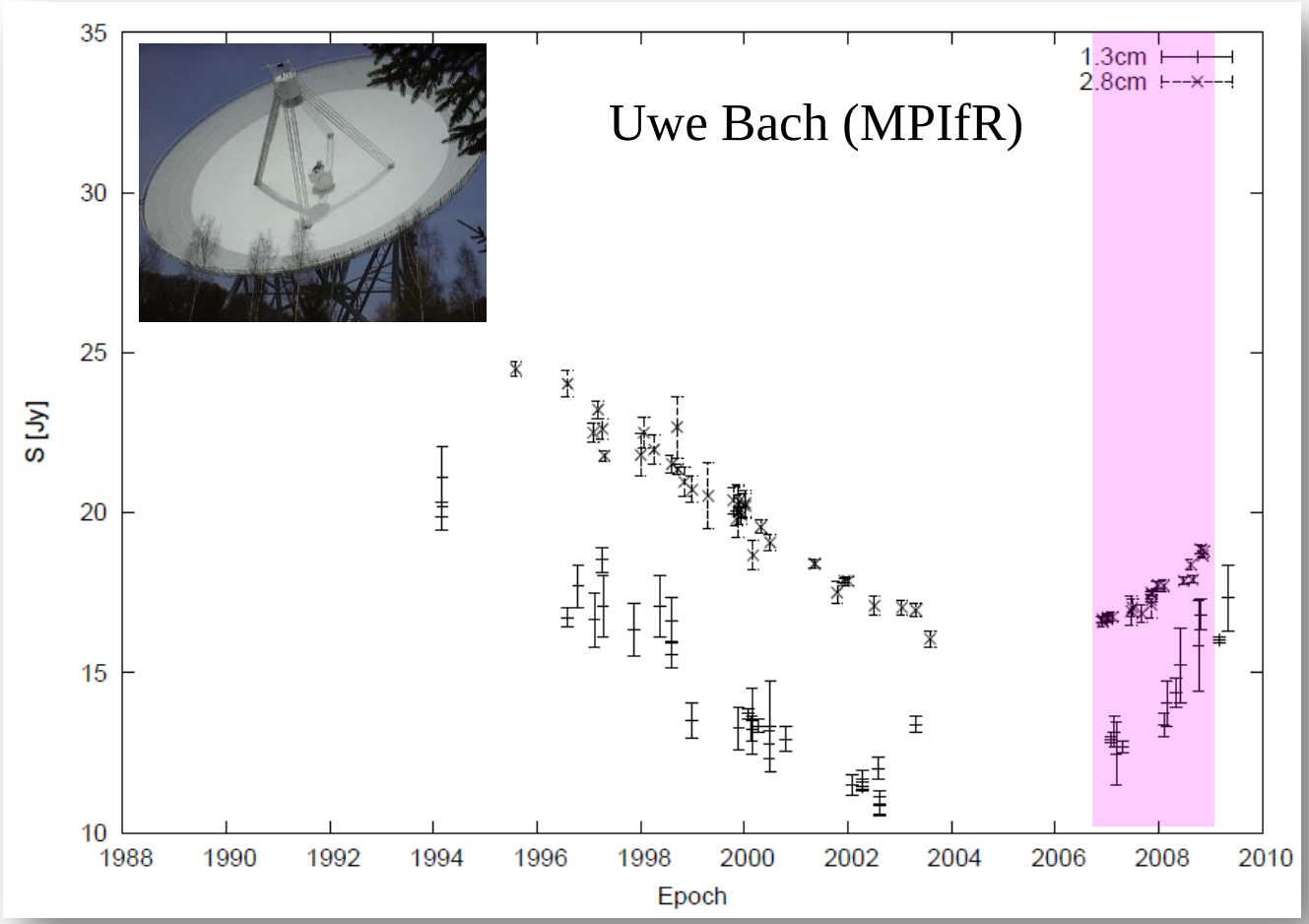




The direct estimate of v_exp~0.5c (Asada+06)

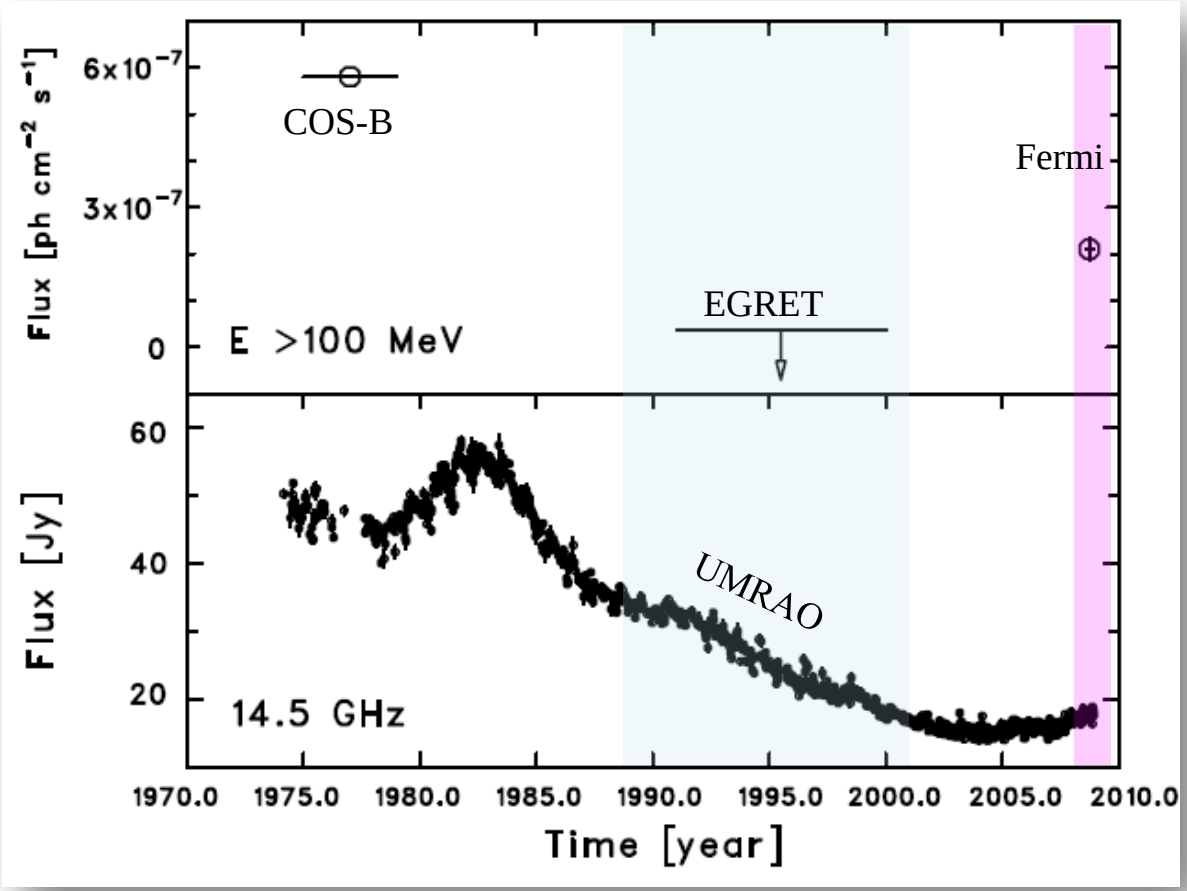
But, no one see “a beginning of outbursts”.

News from Effelsberg (Bonn)



News from Fermi/LAT

Abdo+09

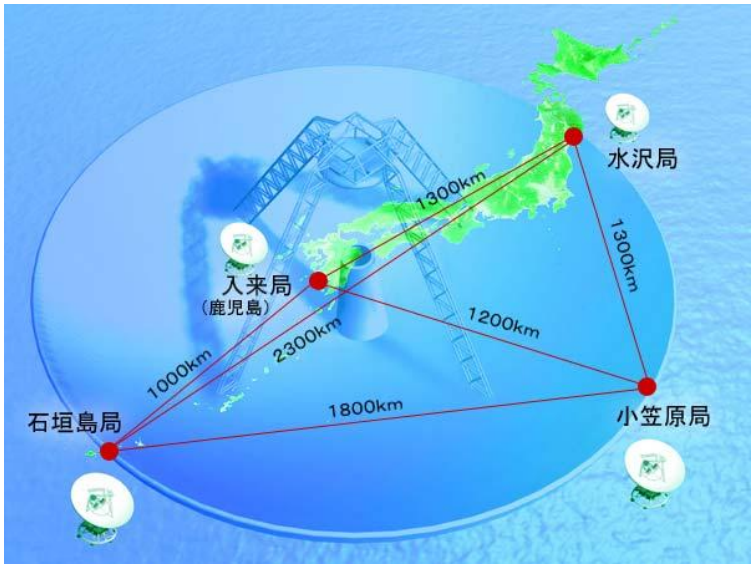


VLBI Monitoring Observations of 3C 84 (NGC 1275) in Early Phase of the 2005 Outburst

Hiroshi NAGAI,[1] * Kenta SUZUKI,[2, 1] Keiichi ASADA,[3] Motoki KINO,[1] Seiji KAMENO,[4] Akihiro DOI,[5] Makoto INOUE,[3] Jun KATAOKA,[6] Uwe BACH,[7] Tomoya HIROTA,[1] Naoko MATSUMOTO,[8, 1] Mareki HONMA,[1] Hideyuki KOBAYASHI,[1] and Kenta FUJISAWA[9]

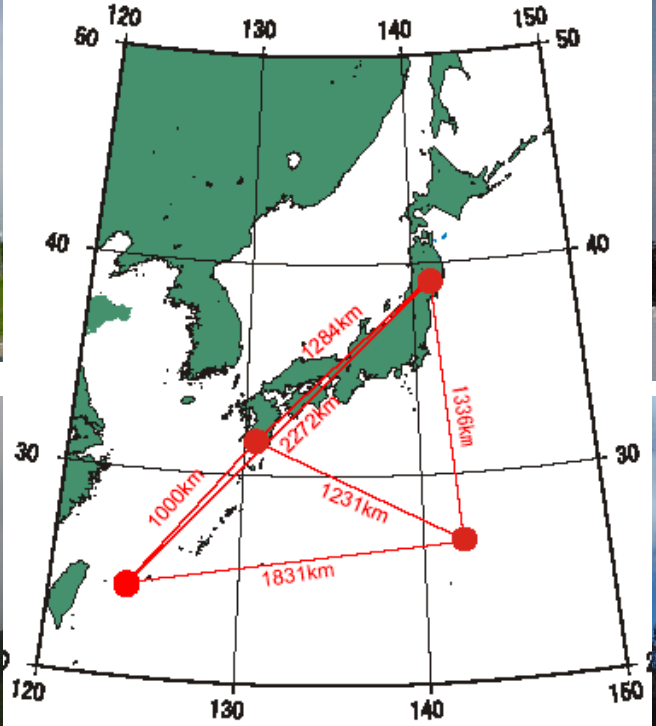
増光以降のデータ収集＆新たな観測

▼2006年～2008年
VERAアーカイブデータ
▼2008年12月 :
Japanese VLBI Network@8&22GHz
▼2009年4月 :
VERA+NRO＋NICT@22&43GHz



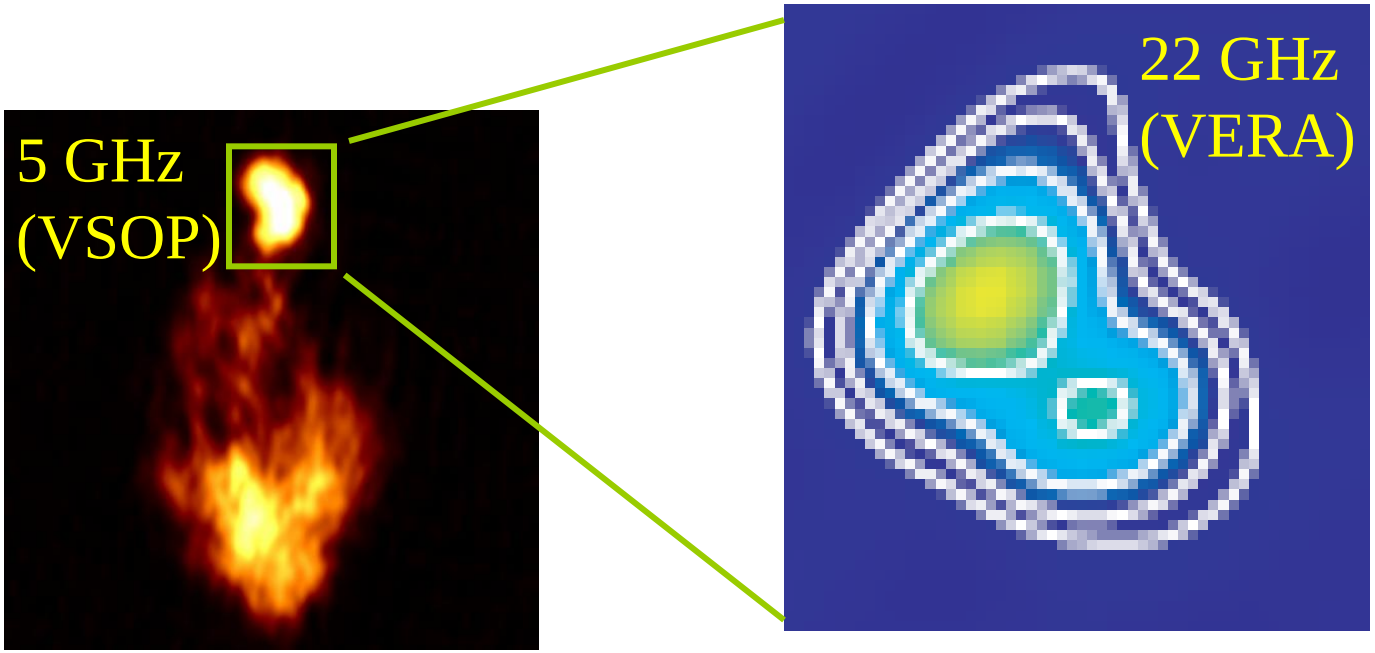
VERA : VLBI Exploration of Radio Astrometry

Ang. Resolution: 1.2mas @22GHz, 0.6mas @43GHz
(D_max = 2270km)



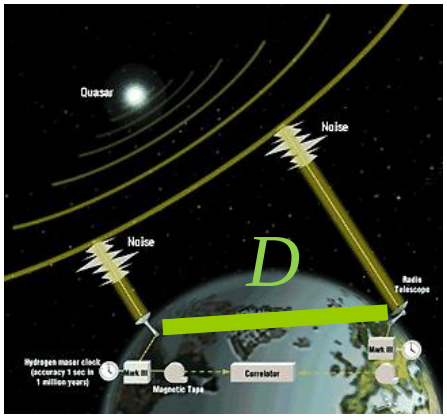
http://veraserver.mtk.nao.ac.jp/index-J.html

5 GHz vs. 22 GHz



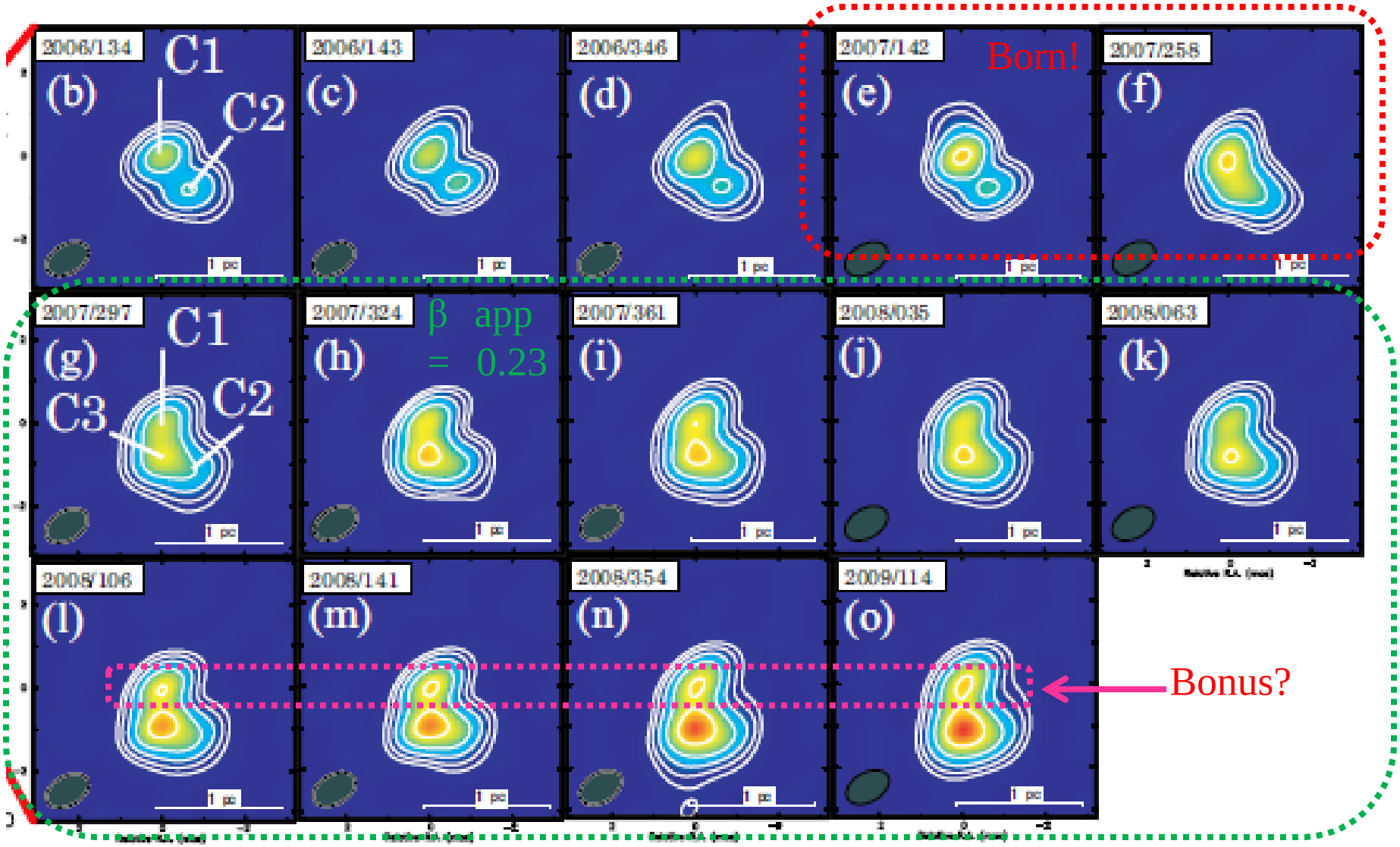
Ang. Resolution

$\propto \lambda$(wavelength)/D(baseline)



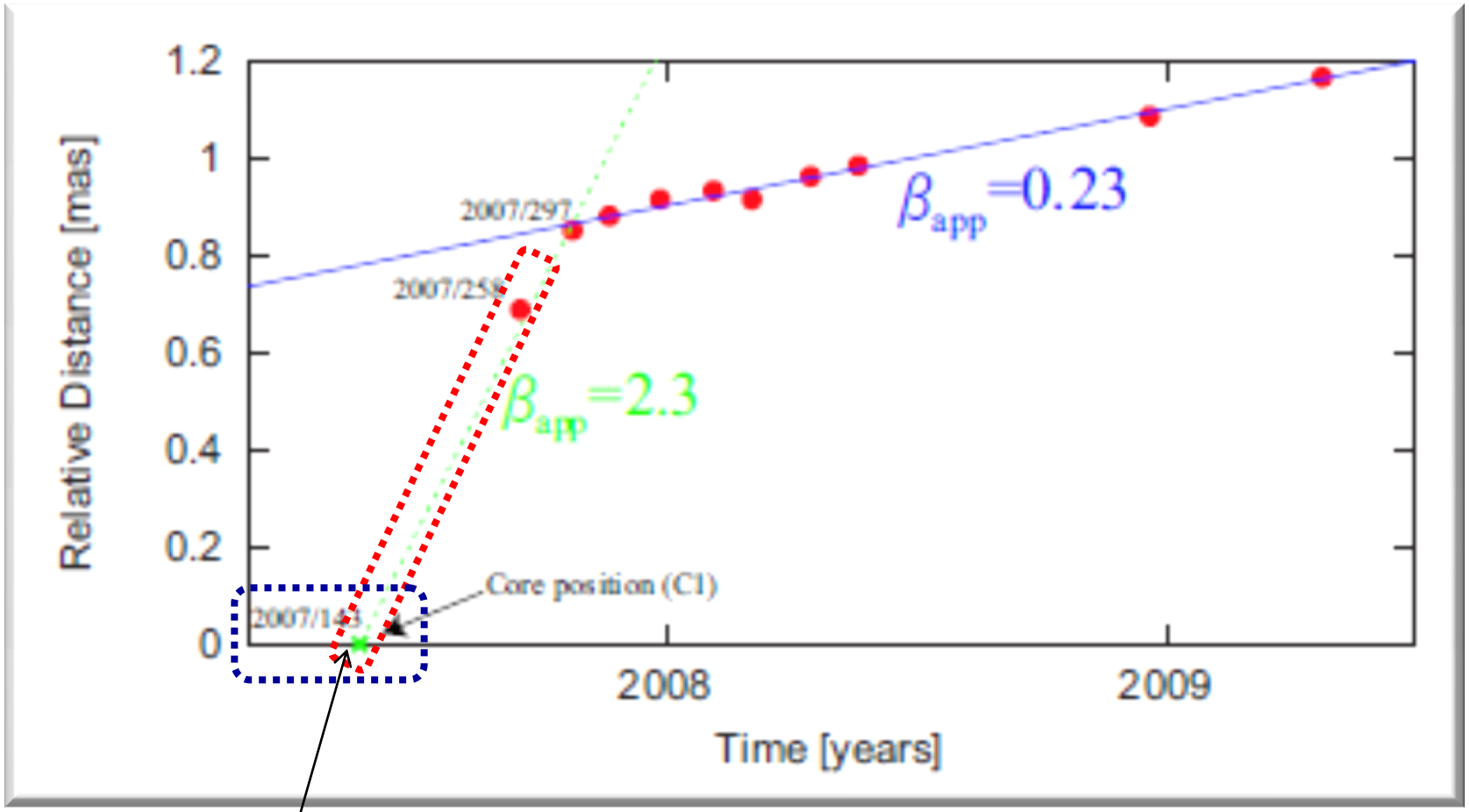
Big moment (1/2)

Nagai+10



Big moment (2/2)

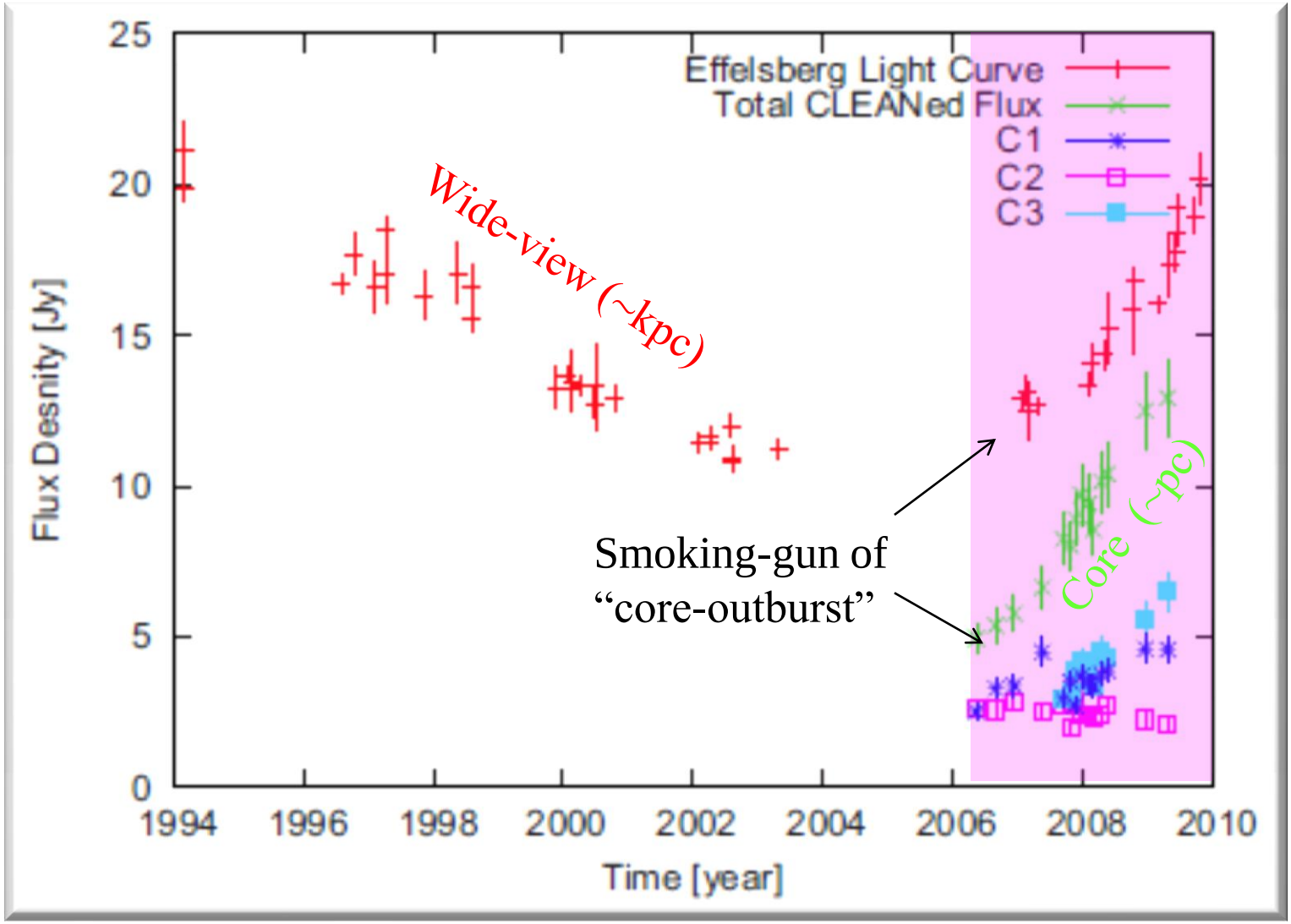
Nagai+10



freq. dependent?
(need further studies)

Light curve

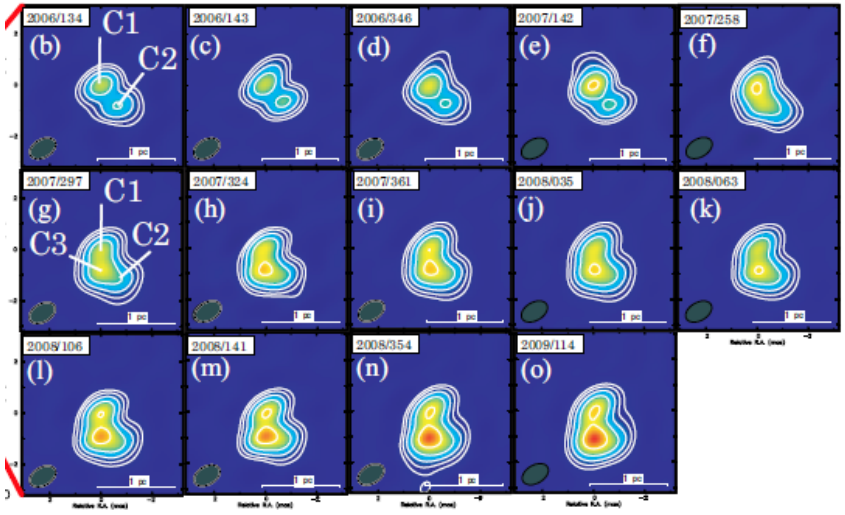
Nagai+10

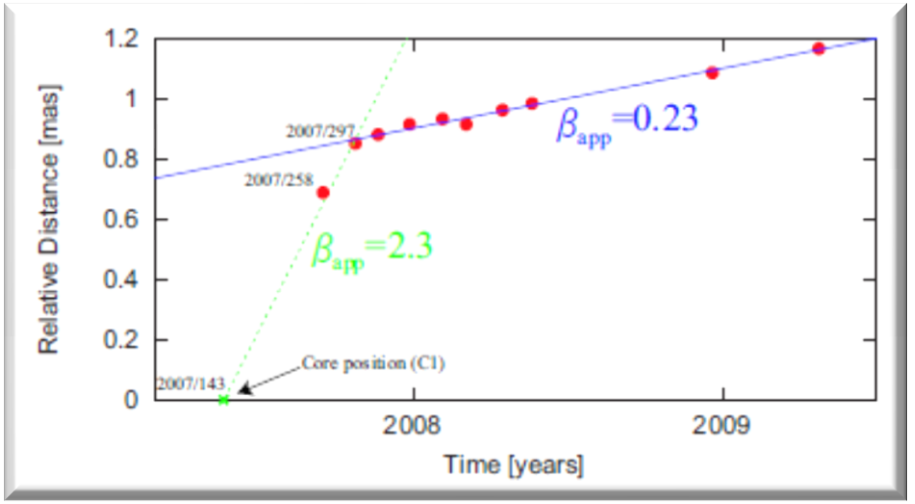


What's this C3? (1/3)

To be explained
- Deceleration
- Synchrotron emission

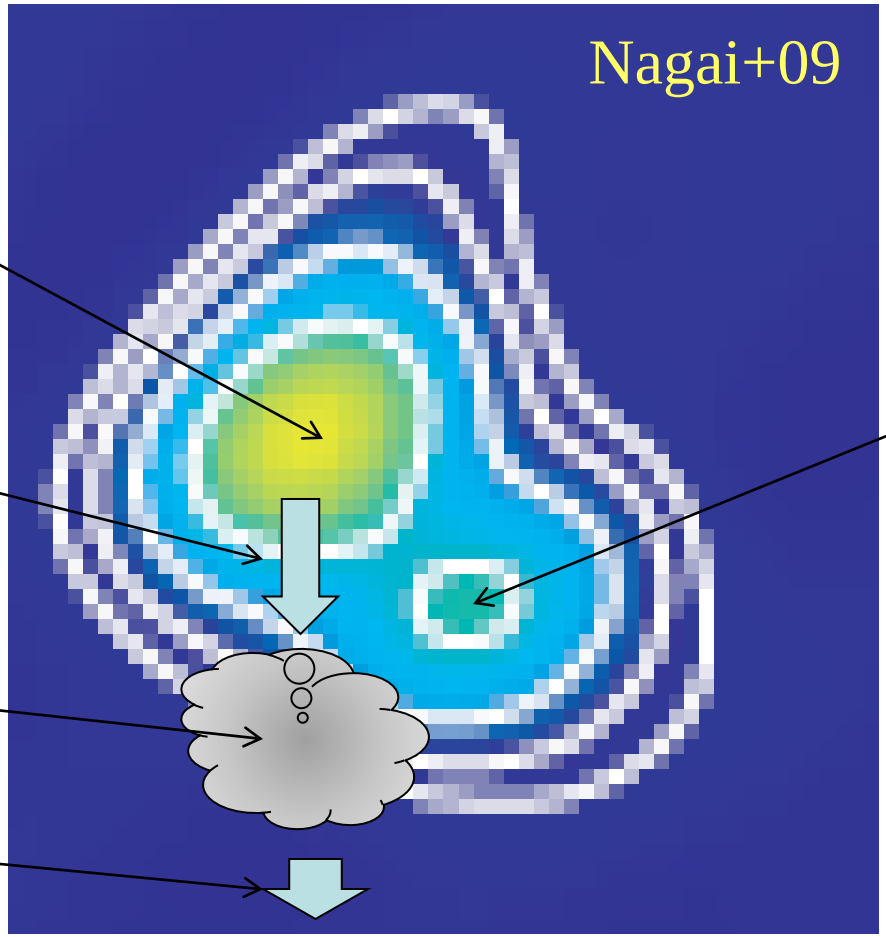
(1) Internal Shock?
(2) Hot Spot?
(3) External Shock?
(4) Other possibilities?
(thick/thin?)





What's this C3? (2/3)

Jet-Clump collision?



Central-Engine?
First shock? (C1)

Relativistic jet

Clump

Non-relativistic
Hot-spot?(C3)

C2

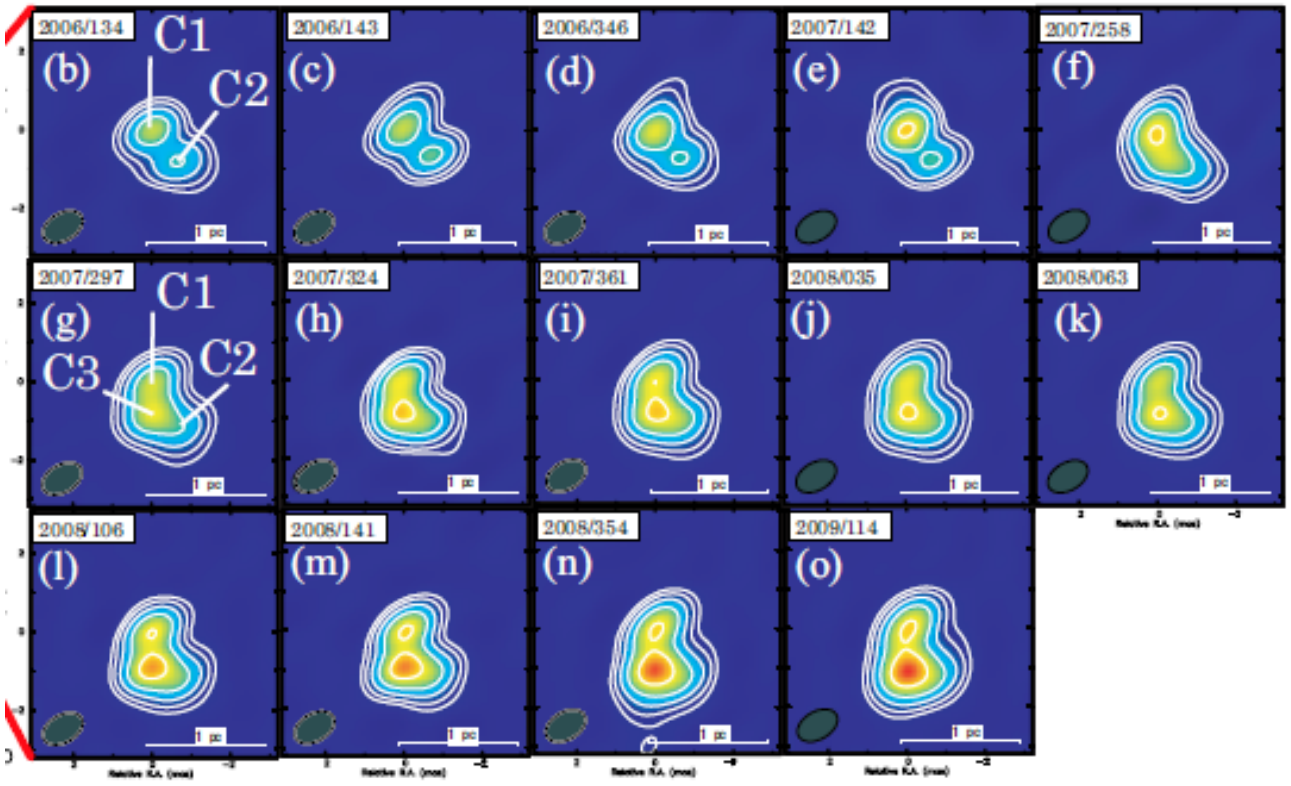
What's this C3? (3/3)

Kino+

(e) New born ejecta

(f) Relativistic jet

(g) Impact with "Cloud"
=> Deceleration
=> C3 appears



(g)~(k) C3 Frustration in "Cloud" → (l) C3 Breakout from "Cloud" → (l)~(o) C3 goes to south as a hot-spot.

予告編

・3C 84　続編　　(Suzuki+)

・ハドロンモデル (MK, Asano)

電波銀河3C84のコアのVLBIモニタ

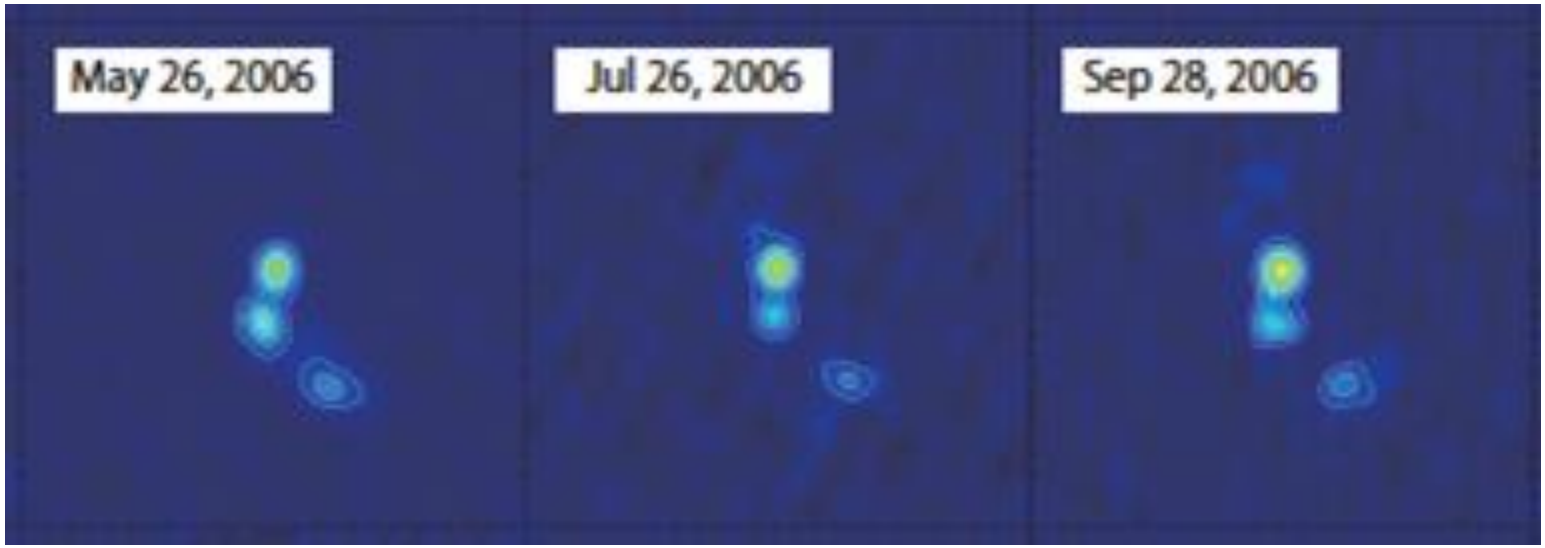
VLBA Q band の解析結果

鈴木 賢太 (東大M2)

共同研究者

永井洋(国立天文台)、浅田圭一(ASIAA)、紀基樹(国立天文台)、
亀野誠二(鹿児島大)、土居明広(JAXA)、井上允(ASIAA)、片岡淳(早大)、
廣田智也(国立天文台)、松本尚子(国立天文台)、小林秀行(国立天文台)、
藤沢健太(山口大)

Nagai + 10と同時期のVLBA 43GHzの
多エポックアーカイブ解析。Suzuki + 準備中



～６倍良い空間分解能での観測！

2010年春季天文学会
鈴木賢太

Hadronic gamma from mini-lobe

Mini radio-lobe

$L_p = 5*10^{46}$ erg/s

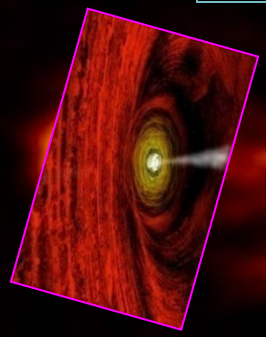
R = 2 pc

B = 0.1 G

Accretion-disk

$L_{uv} = 3*10^{45}$ erg/s

Sea of UV photon



D = 5 pc

pγ process in the mini radio-lobe!

Cascade Processes

$p + \gamma \rightarrow n + \pi^+$

$\pi^+ \rightarrow \mu^+ + \nu_\mu$

$\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$

$p + \gamma \rightarrow p + \pi^0$

$\pi^0 \rightarrow \gamma + \gamma$

$p + \gamma \rightarrow p + e^- + e^+$

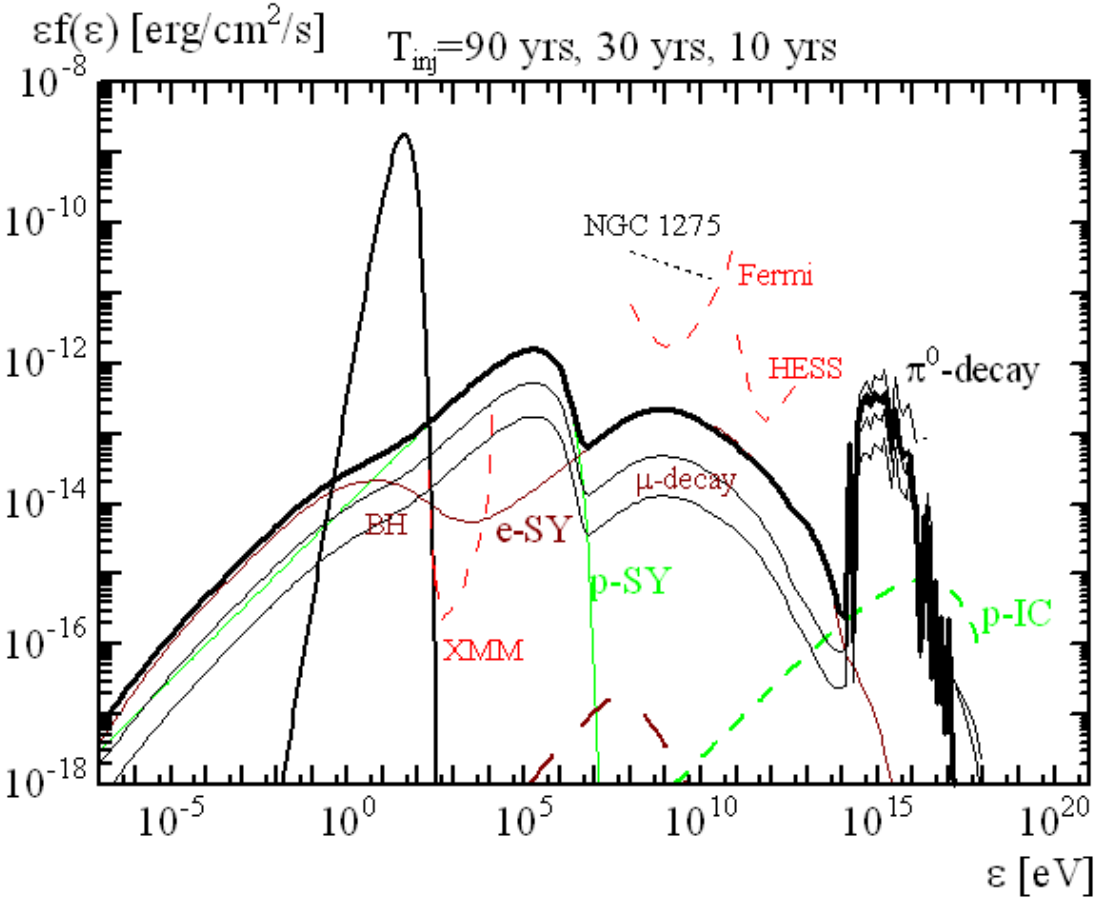
$\gamma + \gamma \rightarrow e^- + e^+$

Synchrotron + Inv.Comp.: $p,\ \pi^\pm, \mu^\pm, e^\pm \rightarrow \gamma$

Synchrotron Self-absorption: $\gamma + e \rightarrow e$

Iterative Method -> Both photon field and cascade processes are solved consistently.

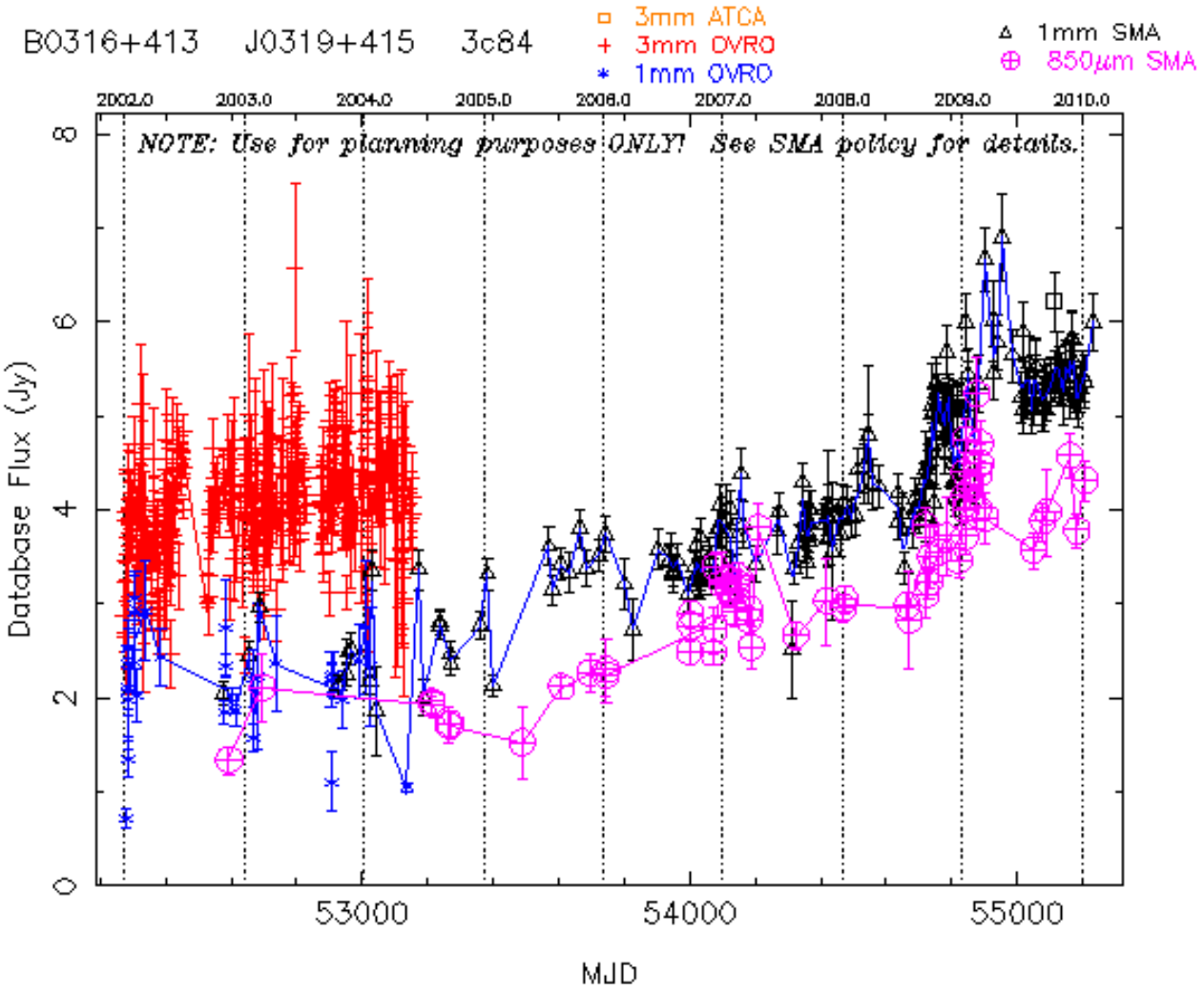
A case study for short injection



Kino & Asano, in prep

Primary electrons cool down. So, hadronic-emission is clearly seen!

2010年現在のSMA



Summary

「VLBI」と「幸運」の巡り合わせにより、電波ローブ誕生の瞬間が初めてとらえられた。継続的観測や理論研究がおこなわれている。

さらに物理を探るには多波長＋理論連携が鍵。
みなさん、是非いっしょにやりましょう。