



# ARENA (\*) an overview *and prospects for submillimetre astronomy*

N. Epchtein  
CNRS/LUAN/UNSA, Nice, France  
*epchtein@unice.fr*

*(\*) Antarctic Research, a European Network for Astrophysics*

# Workshop on Submm/FIR Astronomy from Antarctica

- Is Antarctica and CONCORDIA suitable for sub(mm) astronomy ?
- Does the science reward worth the effort in the context of ALMA , APEX, Herschel, Planck ..?
- Which unique science programmes can be carried out down there ?
- Are the answers to these questions sufficiently strong to convince funding agencies?
- Do we have the « critical mass » and cohesion to make and operate it ?
- IR/Optical *vs.* (sub)mm *or* single package?

# CONCORDIA

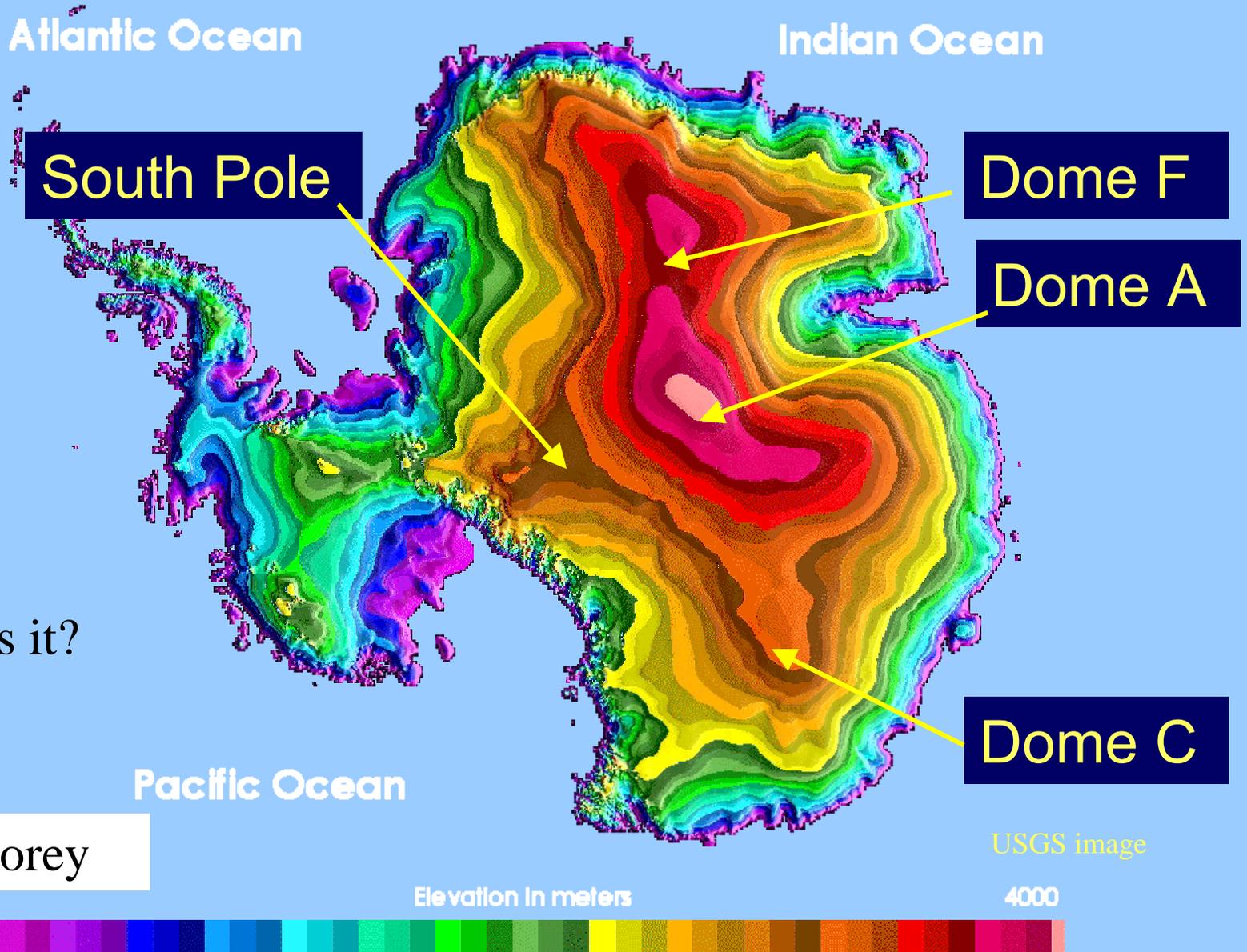
toward a

## European Research Infrastructure ?

*What is it? Where is it? How is it operated?*

*(see also Fossat's talk)*

# Contour map of Antarctica



Where is it?

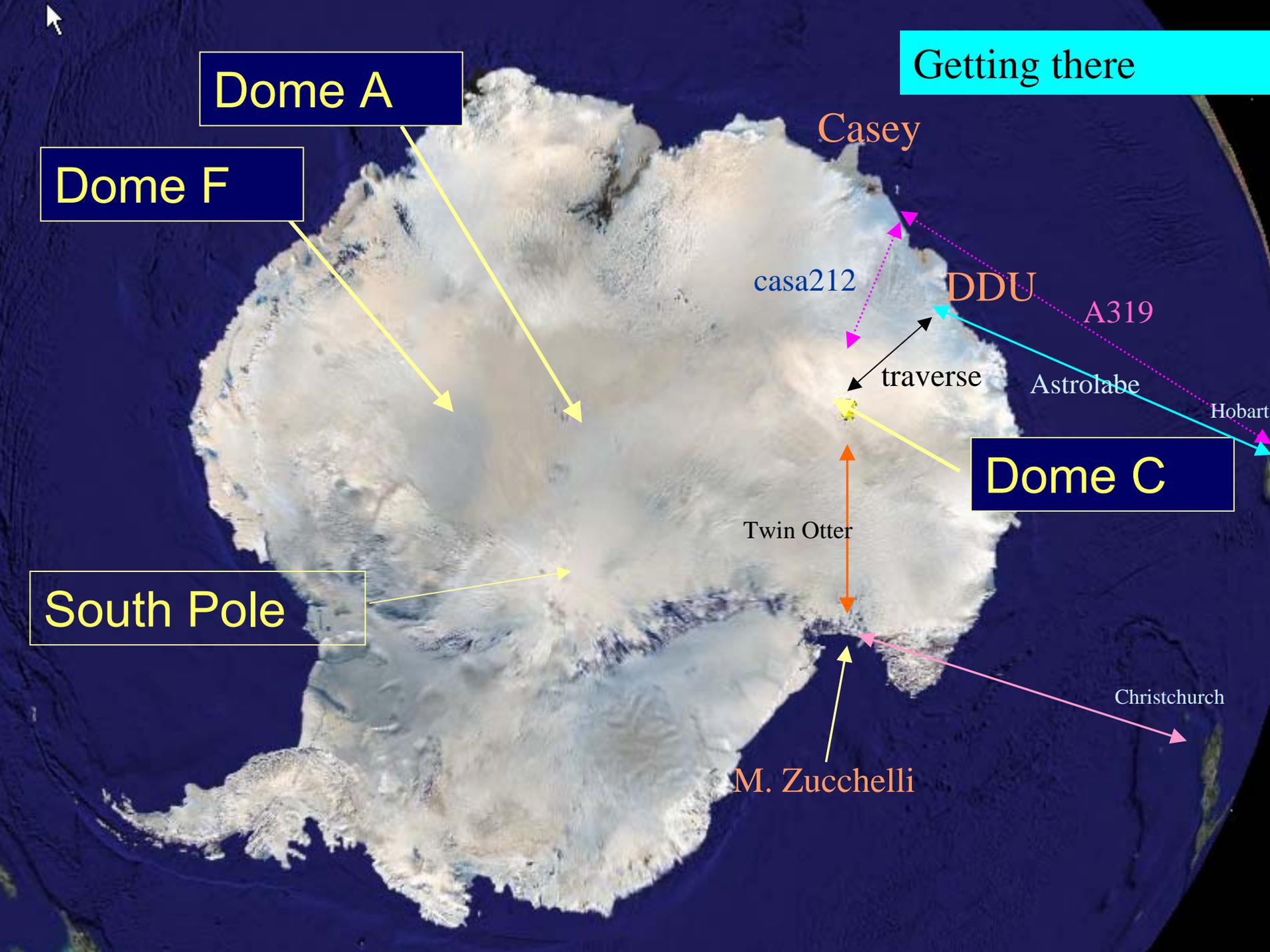
- Franco-Italian station  $-75^{\circ}$  S, 3220 m
- Originally settled for EPICA program
- Operated by IPEV and PNRA since 1997
- First Winterover in 2005
- Promising site for astronomy, perhaps the best ground based site.



*Photos, K. Agabi, E. Aristidi*

# Some drawbacks

- Remote place →
  - Not *easily* reachable
  - Limited electrical power supply
  - Limited freight transport
  - Low rate communications
  - Limited manpower on site (in Winter)
  - Waste management → environmental issues
- Hard life conditions
  - Extreme isolation (Winterover)
  - Extreme cold (limited outdoor activity)



Getting there

Dome A

Dome F

South Pole

Dome C

Casey

casa212

DDU

A319

traverse

Astrolabe

Hobart

Twin Otter

Christchurch

M. Zucchelli

# CONCORDIA/ operations/ logistics

- the only scientific **European** Station on the Antarctic Plateau
- IPEV/PNRA developed a very powerful and efficient logistic
  - accessibility
  - 3 Successful winterovers since 2005
- *successful* mm/submm site (CMB)
- Huge international (Fr-It-Aus) effort of site qualification (*see Rome workshop 11-13 june 2007*)
- Astronomy has become a major driver for the future development of CONCORDIA



# Is CONCORDIA

a new Eldorado for astronomers?

- Unique **turbulence conditions** (HAR, interferometry)
- Unique atmospheric **transparency** (new windows in IR and submm) and **stability**
- Unique **IR Sky brightness** (NIR)
- Low aerosol content (IR, optical)
- Long dark time
- **Are we sitting on a Gold Mine?**

# How much better is it?



	Dome C (best)	Best site	Gain
IR Sky brightness @K @L'	16.5 8.6	13.4 (Mauna Kea) 5.3 (Mauna Kea)	3 mag
Transparency @350 $\mu\text{m}$ @200 $\mu\text{m}$	60 % 20 %	45 % (Chajnantor) <10% ( <i>ibid</i> )	25 % 50 %
Seeing (arcsec)	1.6 0.4 (above BL)	0.7 (Mauna Kea)	factor 2
Isoplanetic angle (arcsec)	5.3	2.9 (Mauna Kea)	almost 2
Coherence time (sec)	7 (ground) 11.2 (above BL)	3 (Paranal) 2.9 (Mauna Kea)	>factor 2

# An increasing number of proposals at Dome C

- Optical/Infrared
  - Site testing devices (DIMM, GSM, SSS...)
  - Small dedicated photometric telescopes (a-step, IRAIT + AMICA)
  - future?: Siamois, PILOT, Ice-T, AMIDST, LAPCAT, GMTA, ELT?
- Interferometry
  - Alladin, Km IR/optical arrays (KEOPS) and precursors
- CMB
  - OASI, COCHISE, BRAIN
- mm and submm
  - IRAIT + CAMISTIC
  - antartized ALMA antenna
- and more to come ?



# COORDINATION needed

1. Evaluation of projects (national, european, int<sup>al</sup>)
2. Trans-disciplinarity
3. Polar and Research agencies
4. French-Italian cooperation
5. Roadmap of long range developments
6. Foster a European Research Infrastructure
7. and world wide (Australia and more...) →  
**Transnational access**

# ARENA

A first step toward europeanization  
of astronomy at CONCORDIA

# ARENA

*'Antarctic Research, a European Network for Astronomy'*

- Proposed in November 2005 → submitted March 2006
- European **Action of coordination (networking)**
- Contribution to the assessment of the **site quality** (data access)
- **Astrophysical science cases**
- Concepts studies for future large facilities
- Evaluate logistics/operations requirements

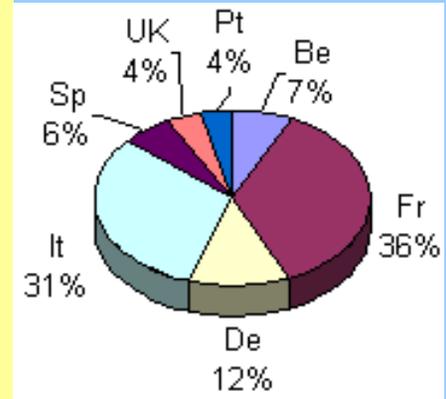
# The overall aim of ARENA

- To identify **needs** and develop **actions** to structure the European optical/IR astronomical community around several **large projects** at Dôme C CONCORDIA
- *Originally mm and submm astronomy not involved ! But.... One task on new windows in FIR*

# ARENA

## main features

- Research Infrastructure Coordination action of the EC (RICA)
- Coordinator: CNRS
- Submitted March 2005, Approved June 2005
- **Period** (3 yrs): Jan 1, 2006 – Dec 31, 2008
- Overlap **IPY** (March 2007-2009)
- **Budget** : 1.335 M€ (incl. overheads)
- 21 partners (7 EU+ Australia)
- 5 Networking Activities



Budget  
shares per  
country

# Structure of the ARENA consortium the partners

- 15 laboratories, Universities in 8 countries
- ESO
- 2 Polar Institutes (IPEV and PNRA)
- 3 industrial companies (2Fr, 1 Be) +1
- Involving more than 100 individuals
- Totalizing: ~70 man-year

# Partners

## – Australia

- UNSW (*Storey*)

## ▪ Belgium

- IAG Liège (*Surdej*)
- **AMOS**, Liège (*Chisogne*)

## ▪ France

- CNRS, LUAN, OCA, OAMP-Marseilles, LAOG-Grenoble, CRAL-Lyons, IAP, (*Epchtein*)
- Paris Observatory (*Bensammar*)
- CEA /SAp (*Lagage*)
- APC (\*) (*Giraud-Héraud*)
- IPEV, Brest (*Jugie*)
- **SESO**, Aix en Pce. (*Fappani*)
- **SHAKTIWARE**, Marseille (*Raubaud*)
- **ThalèsAleniaSpace** (*Apers*)(\*)

## ▪ Germany

- I A Potsdam (*Strassmeier*)
- MPIA-Heidelberg (*Henning*)
- DLR Berlin (*Rauer*)

(\*) Accession in progress

## • Italy

- INAF: Arcetri, Teramo, IASF, Roma, INFN, Pavia, Padova, Catania, U. Roma (*Spinoglio*)
- U. Perugia (*Busso*)
- PNRA (*Cucinotta*)

## ▪ Portugal

- University of Porto (*Brinchmann*)

## ▪ Spain

- University of Granada (*Abia*)
- ICEE Barcelone (*Isern*)
- IAC Tenerife (*Martin*)

## ▪ UK

- University of Exeter (*McCaughrean*)
- University Central Lancashire

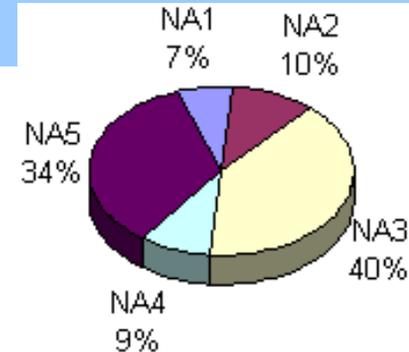
## ▪ ESO (*Melnick*)

# 'Networking activities' (NAs)

- **5 Activities**

- NA1-Management
- NA2- Site quality assessment
- NA3- Polar constraints on Instruments
- NA4- Operations- logistics, requests to operators and added value to CONCORDIA
- NA5-Astrophysics (optical/IR) key programs

**Budget shares**



- **18 tasks + 4 management tasks**

– **see: <http://arena.unice.fr>**

# ORGANIZATION STRUCTURE OF ARENA- MANAGEMENT

Reporting to the European Commission

**Technical Committee (TC)**  
(J.B.. Daban)



Coordinator  
**N. Epchtein**  
Project manager  
**M.-L. Peronne**



**Scientific Advisory Board**  
E. Fossat



**Information and Communication Unit**  
A. Surdej (tbc)



**Public Press Media**

**Consortium Management Committee (CMC)**  
**9 members**  
**1 observer (Australia)**



**Networking Activities**  
**NA2** R. Gredel  
**NA3** J.-P. Swings  
**NA4** M. Candidi  
**NA5** H. Zinnecker

# ACTION 2- Assessment of the site quality

# NA2: Site qualification

leader: **R. Gredel** (MPIA, Heidelberg)/ formerly J. Vernin (LUAN, Nice, France)  
S. Masi (U. Rome), A. Ziad (LUAN)

## **astronomical assessment of the site for optical/IR observations (→ mm/submm)**

- Task 2.1 Review of the critical parameters
  - (Cn2, seeing,  $L_o$ , Sky transmission, emission, airglow, cloud coverage..)
- Task 2.2 Synthesis of observations at Dome C
  - set up a database of parameters.
- Task 2.3 Modelling the site properties for science optimization
  - (→ consequences on astronomical programs)

## ACTION 3- Toward large telescopes at Dome C

# Networking Activity 3: list of tasks

leader: Jean-Pierre Swings (U. Liège, Be)

- Task 3.1 – Low emissivity **Optical configurations** for IR and High Dynamical Imaging in Antarctic conditions ([R. Lenzen](#), MPIA, Heidelberg, De)
- Task 3.2 - Telescope and instrumentation **robotization** ([K. Strassmeier](#), AI Potsdam, De)
- Task 3.3 - **Focal instrumentation** for Antarctic telescopes ([J.-P. Maillard](#), IAParis, Fr)
- Task 3.4 - **IRAIT** (telescope)([G. Tosti](#), Perugia, It)
- Task 3.5 - **IRAIT instrumentation** ([O. Straniero](#), Teramo, It)

## Action 4 – Logistics/Operations requirements

# NA4 an astronomical observatory of a new type

(Leader, [M. Candidi](#), INAF- Rome, Italy)

- Optimize running of a large Observatory in Antarctica
- Expertise of Polar Agencies (PA)
- Aimed at gathering and forwarding astronomer's requests → PA
  - power supply requirements (alternative sources of power supply)
  - Transport
  - building large structures "on ice"
  - wide-band telecommunication requirements (computer networking in Antarctica)
  - human constraints & training
- **Splinter meeting on tomorrow here!**

# NA 4: list of tasks

- Task 4.1 - construction and on site transportation of large instruments (*P. Godon*, IPEV, Brest, Fr)
- Task 4.2 - building and enclosures (*C. Montanari*, PNRA, Rome, It)
- Task 4.3 - consumable requests and communications (*C. Malagoli*, PNRA)
- Task 4.4 - Training and human questions (*C. Bachelard*, TAAF/IPEV)
- Task 4.5 - Environment preservation (*Y. Frénot*, IPEV)

## Action 5 - Science cases at Dome C?

# NA5: The Science cases of DOME C

- Identify the “antarctic” Science Cases
- Keyprogrammes - *“niche strategy” or “multipurpose facility”?*
- new spectral windows from the ground
  - thermal IR (NIR bands, L, M, 5-8  $\mu\text{m}$  20-40  $\mu\text{m}$ )
  - Submm (200 - 250  $\mu\text{m}$ ) + improved 350  $\mu\text{m}$
- Exceptionnaly **stable conditions** in the IR/submm ranges
- exceptional thermal IR conditions
- long term continuous observations
- unique seeing conditions ( $h > 20\text{-}30\text{m}$ )  $\rightarrow$  HAR

# NA 5: list of tasks

- Task 5.1 **Wide field imaging surveys** in the thermal IR (*Busso, Perugia, It/Mc Caughrean, Exeter, UK*)
- Task 5.2 **New windows in the far IR** (*Lagage, CEA, Fr*)
- Task 5.3 ~~Long duration time series photometry and spectroscopy~~ (*Rauer, DLR, Berlin, De*)
  - Hélio/asteroseismology (*Fossat, LUAN, Nice, Fr*)
  - Search for **extrasolar planets** (*Deeg, IAC, Tenerife, Sp*)
  - Solar stellar connection (*Strassmeier, AIPotsdam, De*)
- Task 5.4 **Ultimate angular resolution** (*Vakili, LUAN, Nice*)
- Task 5.5 **Spectroscopy** and spectro-imaging (*Abia, Granada, Sp*)

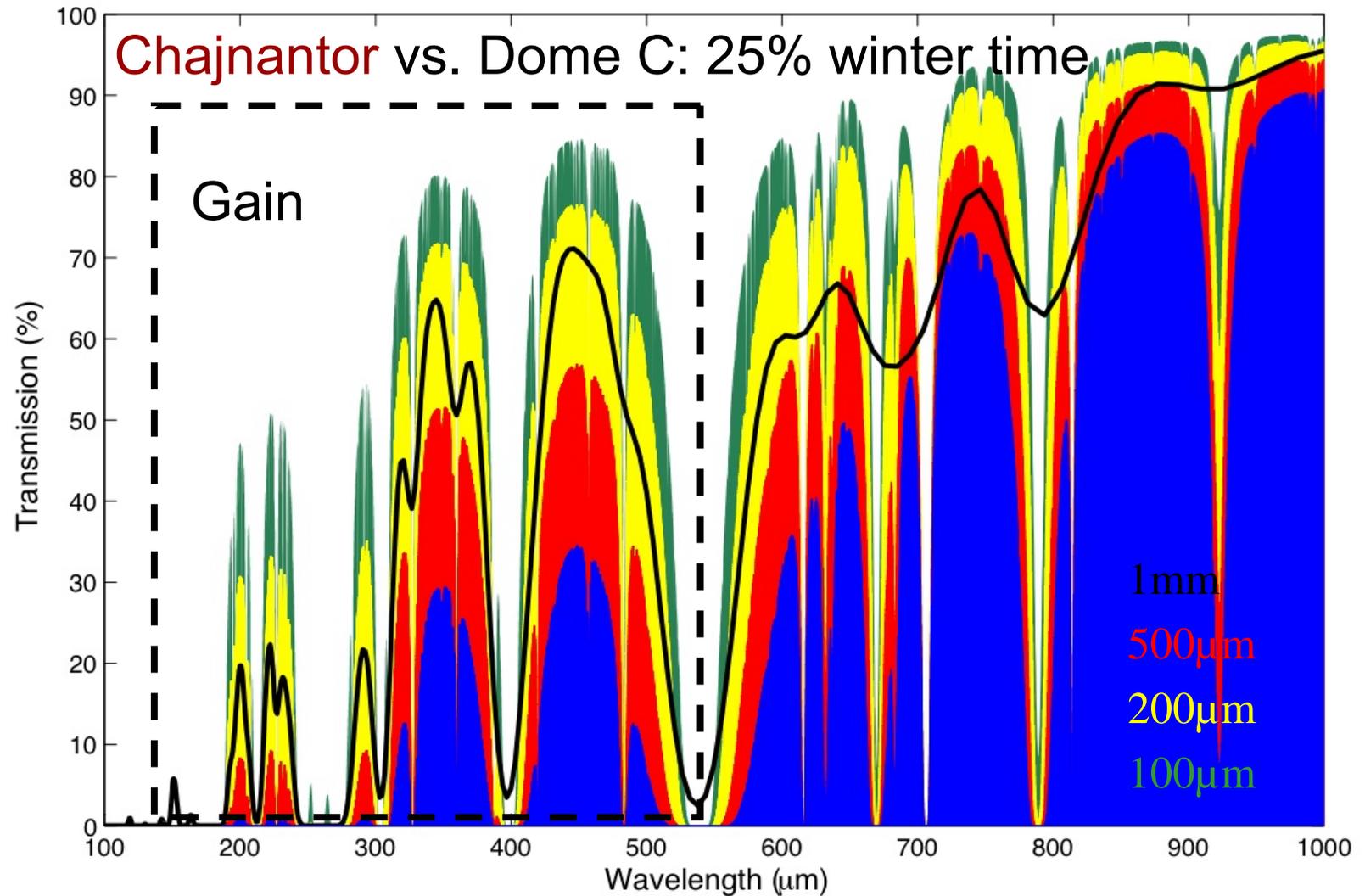
# FIR/THz astronomy at DC

- Is there a strong science case to invest for a mm/submm facility at DomeC ?
- Compare site quality to other sites under development (*Chajnantor and above*)
- Opening **new window** 200 -250  $\mu\text{m}$  ?
- Low PWA
  - Modelling (ATM, Pardo et al. )
  - Better transparency in the THz range
- Better sky **stability**  $\rightarrow$  CMB
- Immense flat areas ( $\rightarrow$  arrays)

# Foremost Science Questions

- **How did the Universe begin? (CMB experiments)**
- **What is the fate of the Universe? (SKA)**
- **How did the “Dark Ages” end? (MWA, PaST, LWA, SKA)**
- **When and how did the first galaxies form? (ALMA, CSO/CCAT, EVLA, VLBA/HSA, GBT, surveys)**
- **When and how did supermassive black holes form? (EVLA, ALMA, SKA, VLBA/HSA)**
- **Was Einstein right? (Arecibo, GBT, EVLA, SKA)**
- **How do stars and substellar objects form? (CSO/CCAT, LMT, ALMA, CARMA, SMA, VLBA/HSA)**
- **How do planets form? (ALMA)**
- **Does extraterrestrial life exist? (ATA, Arecibo)**

Which sites ? (from Minier, workshop on Site testing, Rome, June 2007)



Juan Pardo's ATM modelisation for Chajnantor vs. Lawrence 2004 for Dome C

dapnia  
SAP

cea

saclay

# Conclusions (from Minier; wkshop Rome june 2007)

- Science:
  - Galactic star formation.
  - Starburst galaxies.
  - CIB and the star formation history.
  - (Proto-planetary disks, asteroids...).
- Dome C: probably a very good site for THz/submm:
  - Better than Chajnantor (5000 m) in the 200-450  $\mu\text{m}$  range, but need exceptional conditions at 200  $\mu\text{m}$  (?)
  - Not expected to be better beyond 500  $\mu\text{m}$  to 1 mm.
  - Site testing at Dome C and Chajnantor (>5500m)
- Which THz/submm telescope size:
  - Telescope for 200-450  $\mu\text{m}$ : IRAIT, PILOT, ... , ELT ?
  - 12 m at least (see Luca Olmi's talk for design).

## Conclusions from Franceschini, (*It-FR meeting Rome, Dec 2006* )

### The "astronomical facility" context

- ALMA will NOT operate at  $\lambda < 450 \mu\text{m}$  on any realistic timescales (<2015)
- ALMA will in any case NOT be a survey telescope
- APEX will NOT operate at  $\lambda < 350 \mu\text{m}$
- JWST NOT working at  $\lambda > 25 \mu\text{m}$
- DomeC might potentially compete with JWST for spectroscopy due to x 4 in collecting area at  $\lambda \sim 10\text{-}25 \mu\text{m}$  and complement it at  $\lambda \sim 25\text{-}40 \mu\text{m}$

Submm

# Submm/FIR Astronomy from Antarctica Toward a large single dish telescope at Dome C ?

ome C

An ARENA workshop 25-27 June 2007 CEA Saclay France

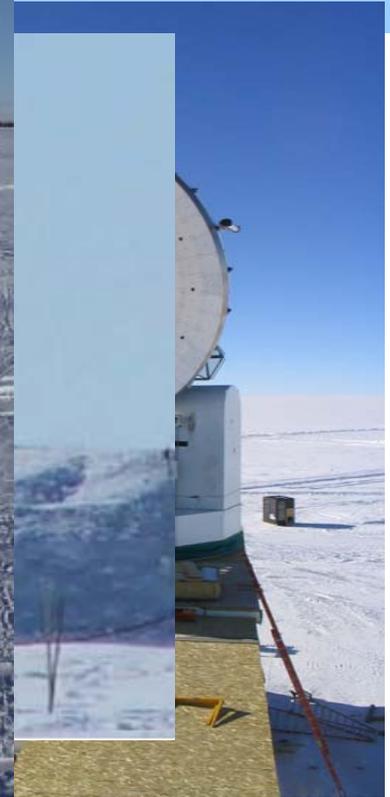
COO

- DA
- AS



300

C. De Breuck (ESO/Garching), P. Encrenaz (Univ. of Paris 6),  
 N. Erchtein (LUANNICE), P-O. Lacaqe (SAP/CEA Saclay),  
 V. Minier (SAP/CEA Saclay, co-chair), L. Dimi (INAF & UPR),  
 H. Doblsson (Onsala), L. Spinoglio (INAF Rome, co chair),  
 J. Storey (UNSW/Sydney), J.-P. Swings (IAG/Liège),  
 N. Tothill (Uni. of Exeter), H. Zinnecker (AIP/Potsdam)



ier..)

# Submm astronomy and ARENA

- (sub) Millimetric astronomy is *now* full part of ARENA activity
- NA2 will *now* include submm site testing (Masi)
- ARENA will consider and possibly support/recommend projects of facilities in the submm range (*eg. ALMA antenna*)
- The EC proposal next to ARENA (*ARIASU*) *should* request specific funding for (sub)mm astronomy in Antarctica (*incl. JRA*)
- CMB activity could be included, as well

# Current status of ARENA

# ARENA meetings (2006-7)

- **In 2006**

- Workshop **Interferometry** (Nice, May 2006)
- Workshop **Wide Field Astronomy** (Paris, June 2006)
- Visit to **IRAIT** (Perugia, Sept. 2006) 30 persons
- **1st Conference Roscoff** (**octobre 2006**) (110 participants)  
→ **ADP Sciences vol. 25 (on line)**

- **In 2007**

- Workshop on **robotisation** (Tenerife, March 2007)
- Workshop on the status of **site qualification** (Rome, 2007)
- This workshop on sub(mm) at DC (Saclay, June 2007)
- Workshop on **extragalactic** astronomy from Dome C (Nov. 2007)
- **2nd Conference** « **The Antarctic Science cases** » (Potsdam, 17-21 Sept. 2007)

# Register to ARENA2 !

## « The Antarctic Science cases »

- Date: 17-21 September 2007
- Venue: Potsdam (Geo Forschung Zentrum)
- SOC chairpersons: H. Zinnecker (AIP), H.Rauer (DLR)
- Proc.: EDP Sc.; eds. Zinnecker, Rauer, Epchtein
- Invited speakers(provisional list)

[Andersen, M.](#) / AIP Hubble on the ground

[Bally, J.](#) / Univ. Colorado, star formation in Carina

[Burton, M.G.](#) / UNSW, twilight science

[Fossat, E.](#) / LUAN, asteroseismology

[Kato, D.](#) / Nagoya, LMC/SMC NIR wide field surveys

[McCaughrean, M.](#) / Univ. Exeter, JWST synergies

[Mellier, Y.](#) / IAP, weak lensing

[Minier, V.](#) / Saclay, summary report on submm workshop

[Monnet, G.](#) / ESO, Astronet science vision and Antarctica

[Rauer, H.](#) / DLR, COROT results and follow-up

[Storey, J.](#) / UNSW, PILOT + roadmap

[Testi, L.](#) / ESO, submm science: from ALMA to Antarctica

[Wright, N.](#) / UCLA, WISE synergies

[York, D.](#) / Univ. Chicago, fast optical transients

# 2nd ARENA Conference on The Astrophysical Science Cases at Dome C

## SOC:

Abia, C., Univ. Granada  
Brinchmann, J., MPA, Garching  
Burton, M., UNSW, Sydney  
Busso, M., Univ. Perugia  
Casali, M., ESO, Garching  
Deeg, H., IAC, La Laguna  
Epchtein, N., LUAN, Nice  
Henning, T., MPIA, Heidelberg  
Kurtz, D., UCLAN, Lancashire  
Lagage, P.O., Univ. Paris  
McCaughrean, M., Univ. of Exeter  
Melnick, J., ESO, Santiago  
Moore, A., CALTECH, Pasadena  
Olmi, L., Osservatorio Astrofisico di Arcetri, Firenze  
Rauer, H. (cochair), DLR, Berlin  
Spinoglio, L., IFSI, Rome  
Strassmeier, K., AIP, Potsdam  
Surdej, J., IAGI, Liege  
Vakili, E., LUAN, Nice  
Yorke, H.W., JPL, Pasadena  
Zinnecker, H. (chair), AIP, Potsdam

## Invited Speakers:

Andersen, M., AIP  
Bally, J., Univ. Colorado  
Burton, M.G., UNSW  
Fossat, E., LUAN  
Kato, D., Nagoya  
McCaughrean, M., Univ. Exeter  
Mellier, Y., IAP  
Minier, V., Saclay  
Monnet, G., ESO  
Rauer, H., DLR  
Storey, J., UNSW  
Testi, L., ESO  
Tokovinin, A., CTIO  
Wright, N., UCLA  
York, D., Univ. Chicago



<http://www.aip.de/ARENA-2>

Potsdam

17–21 September, 2007

## LOC:

Arlt, R., Biering, C., Götz, K. (chair), Granzer, T.  
Hanschur, U., Kelz, A., Saar, A., AIP, Potsdam, Germany  
Titz-Weider, R., DLR, Berlin, Germany  
Peronne, M.-L., LUAN, Nice, France



<http://arena.unice.fr>  
<http://www.aip.de/ARENA-2>

# Future ARENA meetings (2008)

- Spectroscopy (Granada, Sp. Spring 2008)
- WF telescopes II ?
- Interferometry II ?
- Asteroseismology
- ARENA 3 Conference (Italy, venue and date tbd)

Synthesis, conclusions and recommendations of  
ARENA → EC, Agencies

# From FP6 to FP7

# Plan for the FP7

- CONCORDIA could be a major European Research Infrastructure in Antarctica sponsored by EC
  - → ESFRI in FP 8 ?
- Include astronomy/astrophysics at all wavelengths atmospheric sciences, ionospheric, meteorology,  $\mu$ meteorites...
- A networking for Sciences of the Universe
- Polar Engineering
- Propose an I3 of the «*Capacity*» program
- Bridges toward «*cooperation*» programs of FP7
  - Energy
  - Transport
  - Communication
  - Environmental issues

# Proposal to the FP7

- Submit a proposal of integrated action (I3) to:
  - Call identifier: FP7-INFRASTRUCTURES-2008-1
  - Call: Nov 15 2007 → deadline: **Feb 15 2008**
- Envisaged budget 10 -15 M€
- Contract 5 years: **2009-2013**
- Antarctic Sciences of the Universe
  - Multidisciplinary
  - Multinational
  - Structuring activities
  - A strong European support to CONCORDIA



# Provisional title: ARIASU

*Antarctic Research, an integrated action for  
the Sciences of the Universe  
(or Space Sciences! ARIASS?)*

European Antarctic Integrated Action for Space  
Science Research (EurAntSpace)

# Topics and aims

- Topics:
  - Astronomy/astrophysics
  - Atmospheric research (BL)
  - Ionospheric sciences (OH, O emission)
  - Polar engineering
- Structure:
  - Networking
  - JRAs
  - Transnational access
- Unique integrating action for Space science
- A European status to CONCORDIA
- Mutualisation of effort
- Standardization
- Robotization
- Data management /communication
- Trans-disciplinarity
- Opening RI to Europe, and worldwide

Management

I3- Transnational Access

Access to CONCORDIA facilities to non It-Fr cit.

I2- Joint Research Activities

- JRA. 1 Low background optical configurations + AO/GLAO
- JRA2. Robotization
- JRA3. Building on ice (towers, enclosures)
- JRA4. Interferometric pathfinders
- JRA5 .Transport of the future

I1- Networking

*(conferences & workshops)*

- N1. Astronomy- Astrophysics at all  $\lambda$  (ARENA)
- N2. Atmospheric & environment monitoring and modeling
- N3. Ionosphere/Sun-Earth
- N4. PolarEngineering ( $\rightarrow$  Cooperation)
  - Polar civil engineering
  - Clean energy supply
  - Transport

Capacities

I3

CONCORDIA  
a large  
Infrastructure  
for European  
Research in  
Space  
Sciences from  
Antarctica

Training & Schools  
(People)

Public  
outreach

# Agenda for the preparation of FP7

- French partners meeting, June 15 2007
- Meeting with IPEV, 4 July 2007
- Identification of partners, workpackages and WP leaders as of now
- National meetings : Summer 2007
- General meeting of partners : October 2007
- Negotiate/ write proposal: 15 Nov - 15 Feb 2008
- Identify coordinator and coordinating agency
- **Submit proposal : 15 Feb 2008 17:00**

# A few concluding remarks (1)

- Submm/CMB is part of ARENA programme (NA5.2) → Use ARENA label!
- Research in Antarctica has great scientific/technical prospects in most hot areas of astrophysics
- Foster prospects for large infrastructures
  - Unique access to new spectral domains (IR and submm)
  - No (flat) space limitation → Very large instruments (large dishes, arrays)
- First large instrument? Which one? Which Priority?
  - Urgency, feasibility, timeline, science value
- CONCORDIA is also a **political stake**
- Step by step multidisciplinary approach (roadmap of developments) → 2008

# A few concluding remarks (2)

- Foster excellent coordination between astronomers and Polar Institutes (NA4 forum)
- Foster International collaborations (EC, ESO, Australia, China?, US?)
- Propose and aggregate new partners, new expertises
- Formation: involve students, young researchers and engineers (« *people* » proposals, Marie-Curie, ERC...)
- Raise public interest (IPY, outreach, exhibitions)
- Think European ! → FP7 (2007-13)
- Participate in the preparation of I3 **NOW!**

Thanks for your attention  
and  
see you in Potsdam