MIVOC enriched ^{50}Ti & ^{54}Cr beams…

Magic beams for SHE… $^{40,48}Ca$, ^{50}Ti, $^{52,54}Cr$

- Z=20
- N=20,28

Calcium

Z=20

Isotopes

^{40}Ca	8,0 %	N=20
^{42}Ca	0,6 %	N=22
^{43}Ca	0,1 %	N=23
^{44}Ca	2,0 %	N=24
^{46}Ca	0,004 %	N=26
^{48}Ca	0,2 %	N=28

T_{fusion} = 842 °C
$T_{boiling}$ = 1484 °C

Titanium

Z=22

Isotopes

^{46}Ti	8,0 %	N=24
^{47}Ti	7,3 %	N=25
^{48}Ti	73,8 %	N=26
^{49}Ti	5,5 %	N=27
^{50}Ti	5,4 %	N=28

T_{fusion} = 1668 °C
$T_{boiling}$ = 3287 °C

Chromium

Z=24

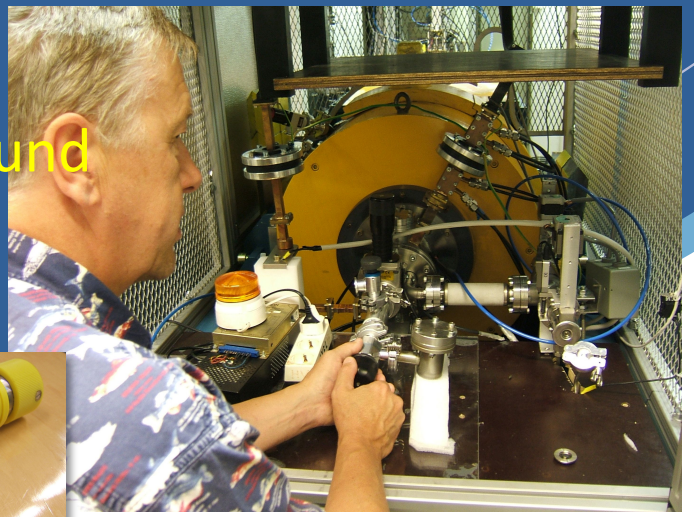
Isotopes

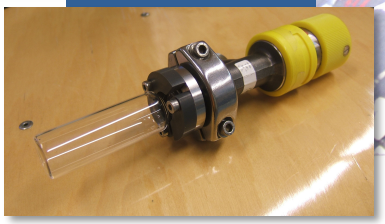
^{50}Cr	4,3%	N=26
^{52}Cr	83,8%	N=28
^{53}Cr	9,5 %	N=29
^{54}Cr	2,4 %	N=30

T_{fusion} = 1907 °C
$T_{boiling}$ = 2671 °C

First Titanium MIVOC beam

- Need for stable organometallic compound
- Enough vapor pressure





H. Koivisto et al. / Nucl. Instr. and Meth. in Phys. Res. B 187 (2002) 111–116

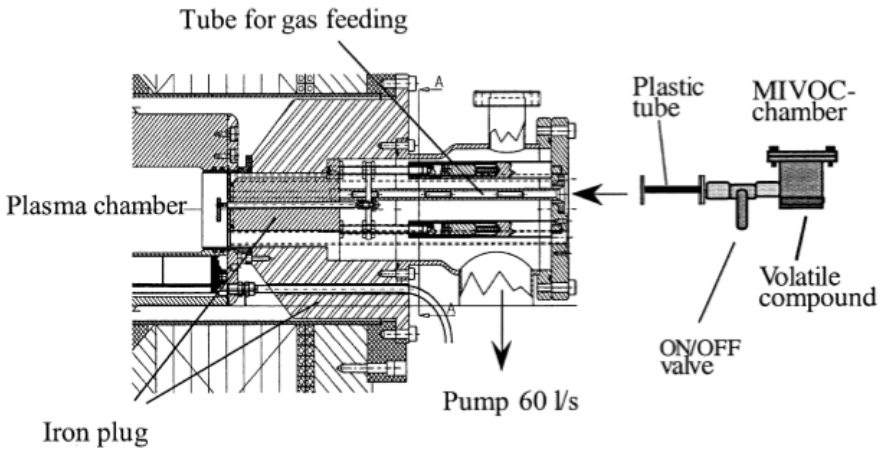


Fig. 2. The MIVOC chamber connection to the injection side of the JYFL 14 GHz ECRIS.

TABLE I. The MIVOC compounds that have been used for the production of metal ion beams.

Element	Compound
Mg	$Mg(C_5H_5)_2$
Si	$Si\{Si[(CH_3)_3]\}_4$
Cr	$Cr(C_5H_5)_2$ or $Cr(CO)_6$
Fe	$Fe(C_5H_5)_2$
Co	$Co(C_5H_5)_2$ or $Co_2(CO)_8$
Ni	$Ni(C_5H_5)_2$
Ge	$Ge(C_2H_5)_4$
Mo	$Mo(CO)_6$
Ru	$Ru(C_5H_5)_2$
I	I_2CH_2
W	$W(CO)_6$
Os	$Os(C_5H_5)_2$

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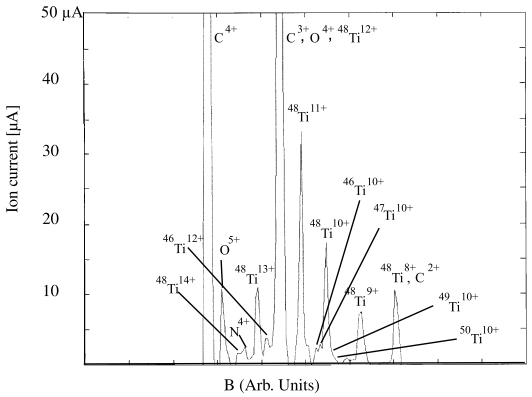


Fig. 3. The Ti ion spectrum obtained using the MIVOC method at the new JYFL 14 GHz ECRIS. The ion source and the optics were tuned for the charge state of 11+. The typical current of C^{4+} is 120–140 μA.

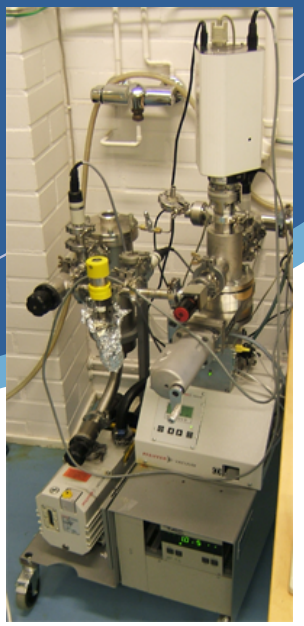
Table 1
Intensities of measured Ti ion beams in μA

Isotope/charge	8+	9+	10+	11+	12+	13+
^{46}Ti 7.9%	3.6*	4.7*	4.8*	4.8*	3.9	1.6*
^{47}Ti 7.3%	3.3*	4.3*	4.4*	4.4*	3.6*	1.4*
^{48}Ti 73.9%	33	43	44	45	36*	14.3
^{49}Ti 5.5%	2.5*	3.2*	3.3*	3.3*	2.7*	1.1*
^{50}Ti 5.3%	2.5*	3.2*	3.3*	3.3*	2.7*	1.1*

The abundance of the titanium isotopes in natural titanium is also shown. The asterisk denotes intensities estimated from the intensity of the same charge state of a different isotope. The extraction voltage was 10 kV.

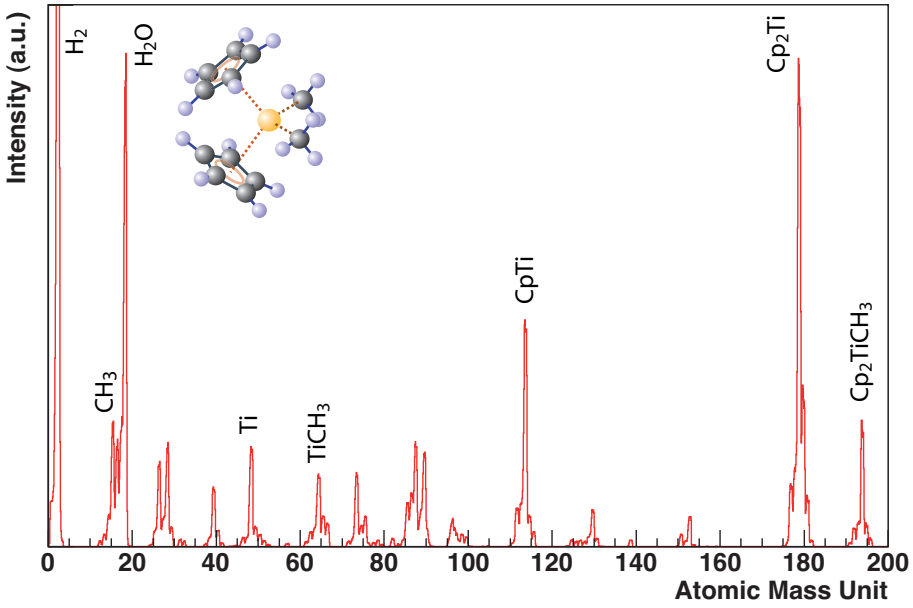
Several compounds tested

- $Cp^*\ Ti\ Me_3$
- $Cp_2\ Ti\ Me_2$

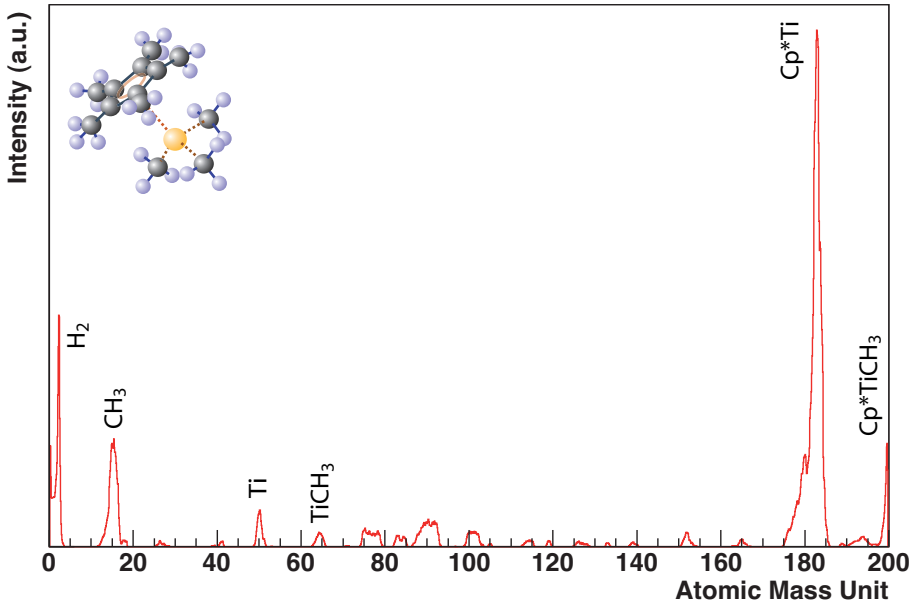


→ Mass spectra @ JYFL (Jyväskylä, Finlande)
→ If ok go to ECR ion source …

$Cp_2Ti(CH_3)_2$

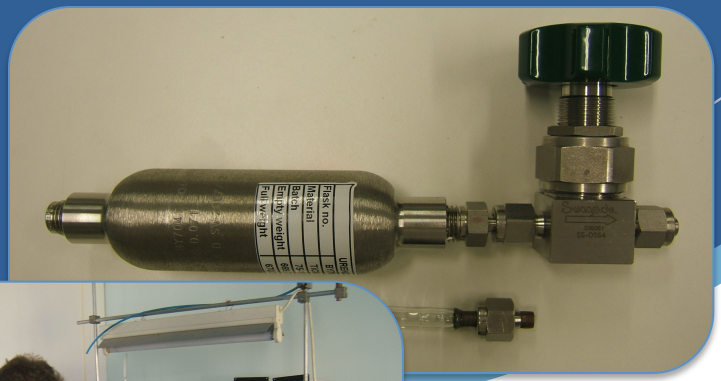


$Cp^{*50}Ti(CH_3)_3$



Synthesis steps

- Enrichment of $TiCl_4$ URENCO



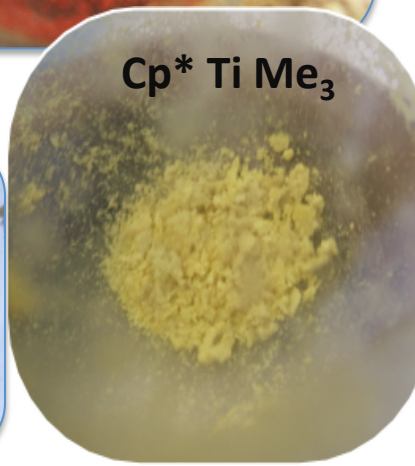
- Vacuum extraction

- Synthesis step 1 :

$TiCl_4$ => Cp^*TiCl_3

- Synthesis step 2 :

Cp^*TiCl_3 => Cp^*TiMe_3

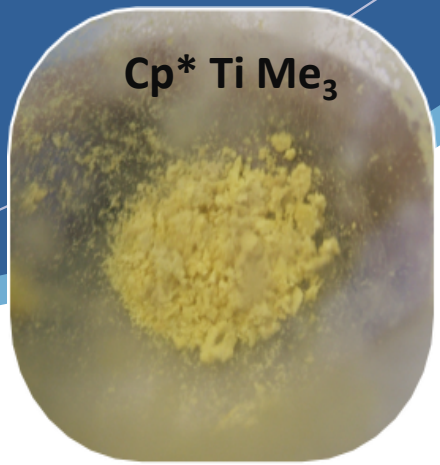


- Conditionning

Total efficiency : **up to 95% !!!**

First isotopic MIVOC ^{50}Ti beam

- 19 µA $^{50}Ti^{11+}$ out of JYFL d'ECRIS2
- 490 enA on target

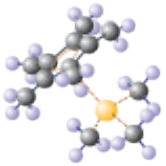


Several tests

-JYFL : Spectro ^{256}Rf (^{50}Ti + ^{208}Pb ==> ^{256}Rf + 2n)

-GANIL : 28µA $^{48}Ti^{10+}$ out of ECR

-JINR : tests ongoing



$Cp^*Ti(CH_3)_3$

consumption: **0,2 mg/h**

2 Thesis : J. Piot & J. Rubert

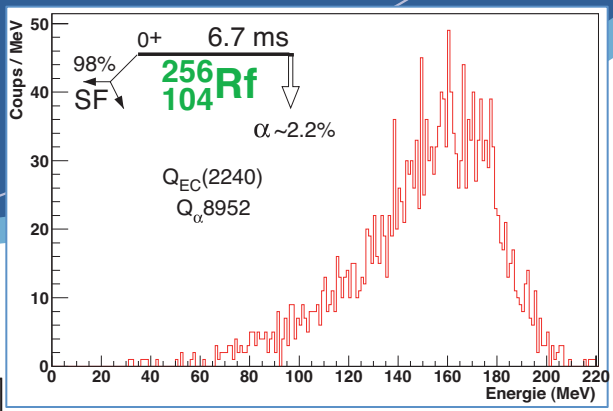
J. Rubert, J. Piot et al. NIM B 276 (2012)33

When chemists work with physicists ...

First Prompt Gamma Spectroscopy of ^{256}Rf

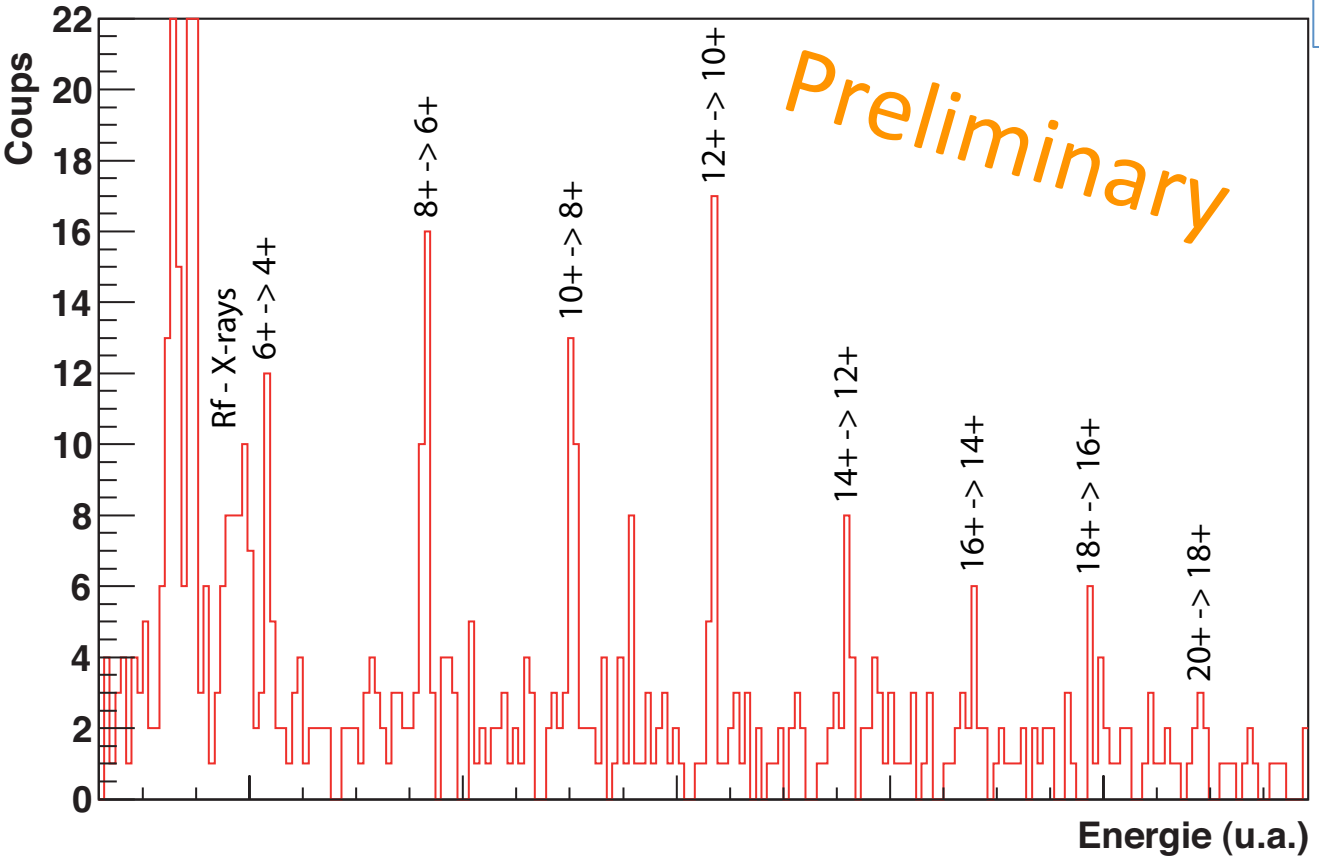
- ^{50}Ti + ^{208}Pb ==> ^{256}Rf + 2n

2210 ^{256}Rf observed



σ ~ 17 nb...

E_{beam} = 242 MeV



First Rotationnal band in ^{256}Rf

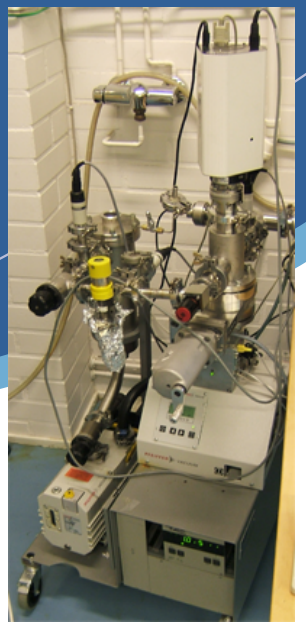
P.T. Greenlees, J. Rubert, J. Piot, B. JP Gall et al. submited to PRL

J. Rubert PhD Thesis UdS

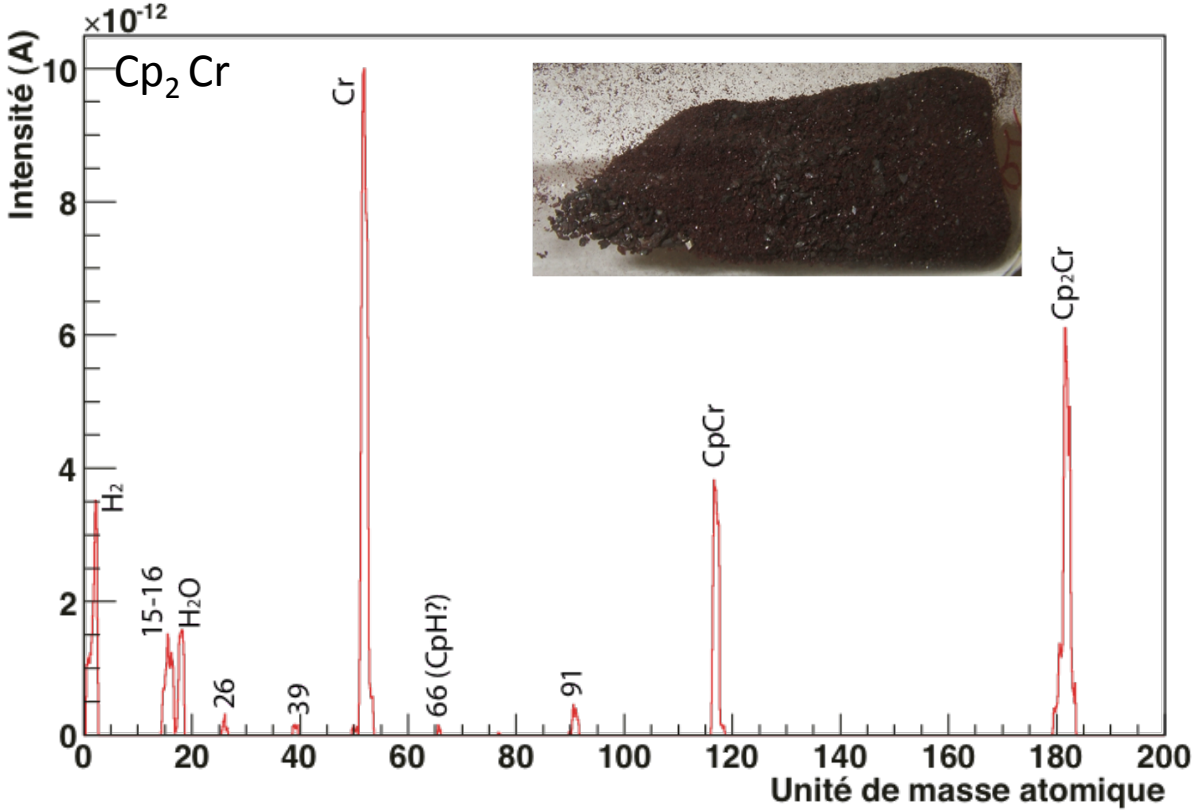
Good MIVOC candidate for Chromium

^{52}Cr (83,8%) ^{54}Cr (2,4%)

- Cp_2 Cr



Ok, good candidate for MIVOC



→ Mass Spectrometry = > OK

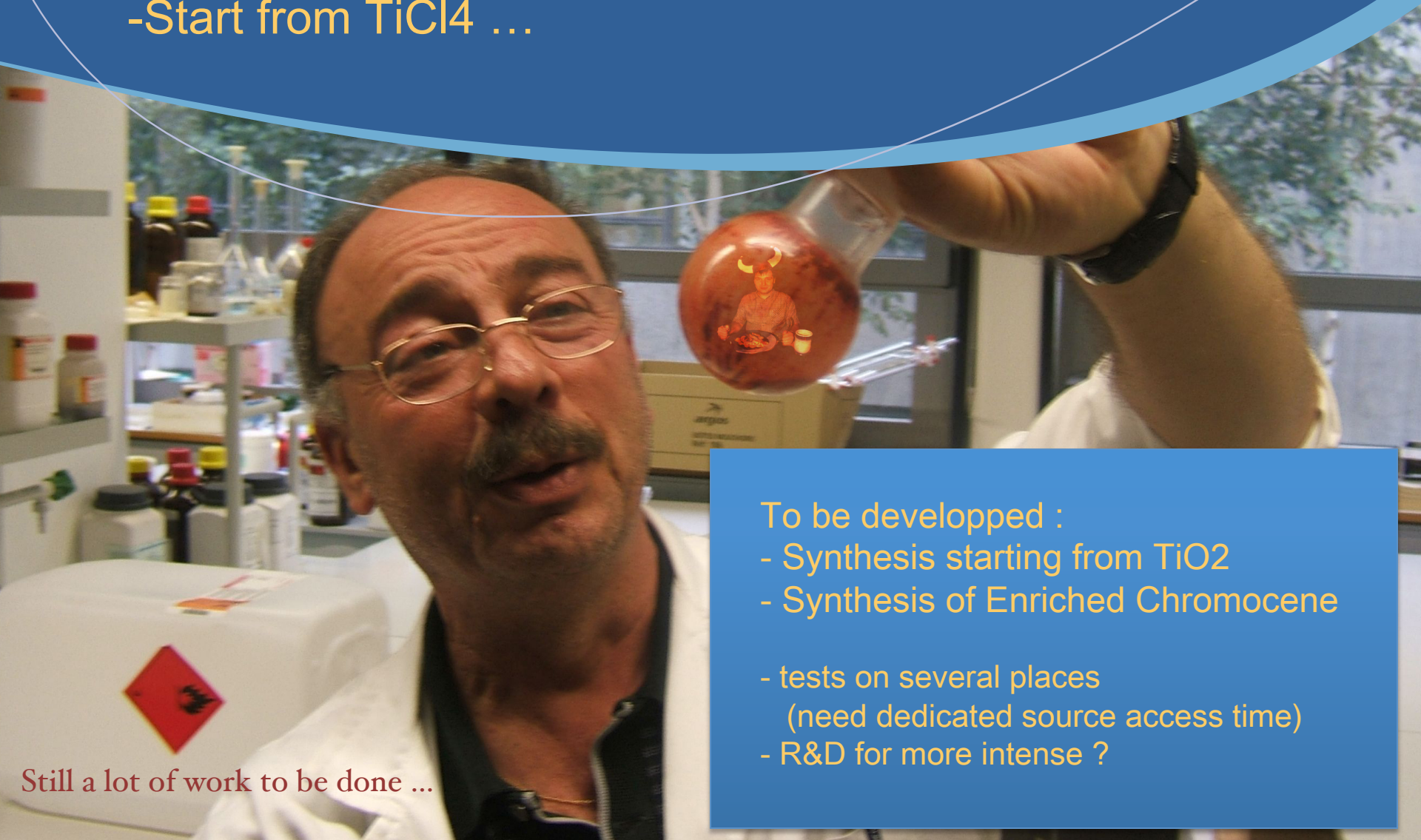
→Go for chemistery …

Summary

-Access to MIVOC ^{50}Ti beams at pμA level expected on target

-Start from TiCl4 …

IPHC (J. Rubert, Z. Asfari, B. Gall)
JYFL (J. Ärje, R. Seppälä, P T Greenlees)
GANIL (J. Piot, F. Lemagnen, P Leherissier C. Barue B. Osmond)
FLNR (S. Bogomolov)



To be developped :
- Synthesis starting from TiO2
- Synthesis of Enriched Chromocene

- tests on several places (need dedicated source access time)
- R&D for more intense ?

Still a lot of work to be done ...