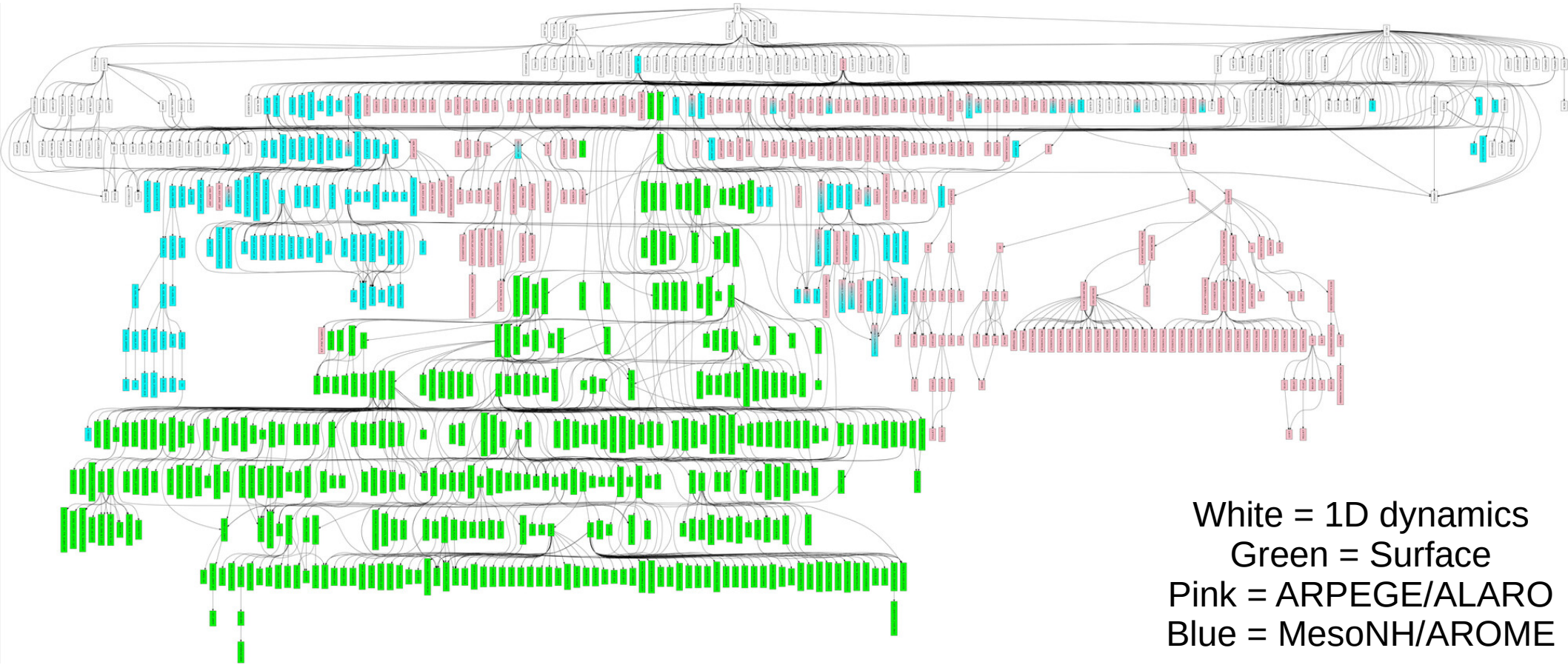
ARPEGE, AROME and GPUs

- Code refactoring & data encapsulation
- Calculations on GPU
- Spectral transforms

cpg_drv.F90

Météo-France/ACCORD physics



White = 1D dynamics
Green = Surface
Pink = ARPEGE/ALARO
Blue = MesoNH/AROME

Our code

- mf_phys.F90 : 2800 lines, 235 arguments
- aplpar.F90 : 5600 lines, 352 arguments
- apl_arome.F90 : 3800 lines, 160 arguments

    + 4DVAR non-linear physics in mf_phys.F90

    + aplpar.F90 & apl_arome.F90 called twice (LTWOTL=T/F)

Separate physics

- mf_phys.F90 now almost empty
- Call 4 different routines
  - aplpar.F90
  - apl_arome.F90
  - aplsim.F90
  - apl_arpege.F90

Encapsulate data with FIELD_API

All arguments of aplpar.F90/apl_arome.F90

+ almost all arguments of cpg.F90

+ local data declared in cpg.F90

+ temporary data of cpg_gp.F90

apl_arpege.F90

1300 lignes

apl_arpege.F90 arguments

YDMF_PHYS_BASE_STATE

YDMF_PHYS_NEXT_STATE

YDGEOMETRY

YDCPG_DIM

YDCPG_MISC

YDCPG_GPAR

YDCPG_PHY0

YDMF_PHYS

YDCPG_DYN0

YDMF_PHYS_SURF

YDCPG_SL2

YDVARS

YDSURF

YDCFU

YDXFU

YDMODEL

LDCONFX

PDTPHY

YDDDH

YDMF_PHYS_BASE_STATE

- LTWOTL=T : proxy to encapsulated T0 data
- LTWOTL=F : proxy to encapsulated T9 data

YDMF_PHYS_NEXT_STATE

- Depends on LSLAG, LTWOTL, %LADV
- Proxy to encapsulated (CPG_SL1_TYPE) PB1 or encapsulated PGFLT1 (YDVARS)

INTENT

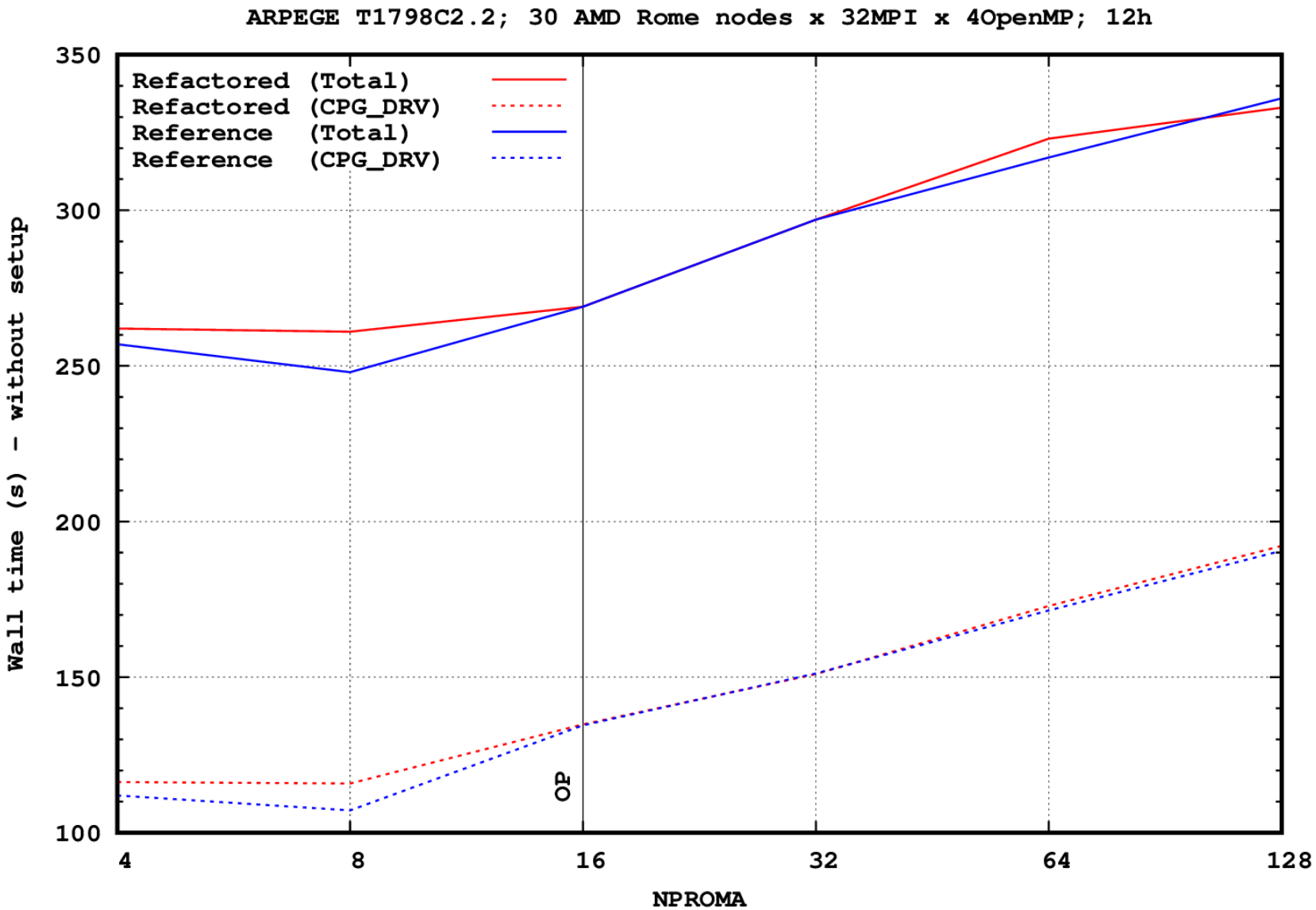
```
TYPE (MF_PHYS_BASE_STATE_TYPE), INTENT(IN)    :: YDMF_PHYS_BASE_STATE
TYPE (MF_PHYS_NEXT_STATE_TYPE), INTENT(INOUT) :: YDMF_PHYS_NEXT_STATE
TYPE(GEOMETRY),                 INTENT(IN)    :: YDGEOMETRY
TYPE(CPG_DIM_TYPE),             INTENT(IN)    :: YDCPG_DIM
TYPE(CPG_MISC_TYPE),            INTENT(INOUT) :: YDCPG_MISC
TYPE(CPG_GPAR_TYPE),            INTENT(INOUT) :: YDCPG_GPAR
TYPE(CPG_PHY_TYPE),             INTENT(IN)    :: YDCPG_PHY0
TYPE(MF_PHYS_TYPE),             INTENT(INOUT) :: YDMF_PHYS
TYPE(CPG_DYN_TYPE),             INTENT(IN)    :: YDCPG_DYN0
TYPE(MF_PHYS_SURF_TYPE),        INTENT(INOUT) :: YDMF_PHYS_SURF
TYPE(CPG_SL2_TYPE),             INTENT(INOUT) :: YDCPG_SL2
TYPE(FIELD_VARIABLES),          INTENT(INOUT) :: YDVARS
TYPE(MODEL),                    INTENT(IN)    :: YDMODEL
```

fypp

- FORTRAN “macros”
- Generate code
- Eg :
  - mf_phys_type_mod.fypp (264 lines)
  - mf_phys_type_mod.F90 (2549 lines)
- Sometimes complex

Bit-wise reproducible
wrt cy48t1_main

Pass all mitraillette tests


ARPEGE T1798C2.2; 30 AMD Rome nodes x 32MPI x 4OpenMP; 12h
Refactored (Total)
Refactored (CPG_DRV)
Reference (Total)
Reference (CPG_DRV)
Wall time (s) - without setup
350
300
250
200
150
100
OP
4
8
16
32
64
128
NPROMA

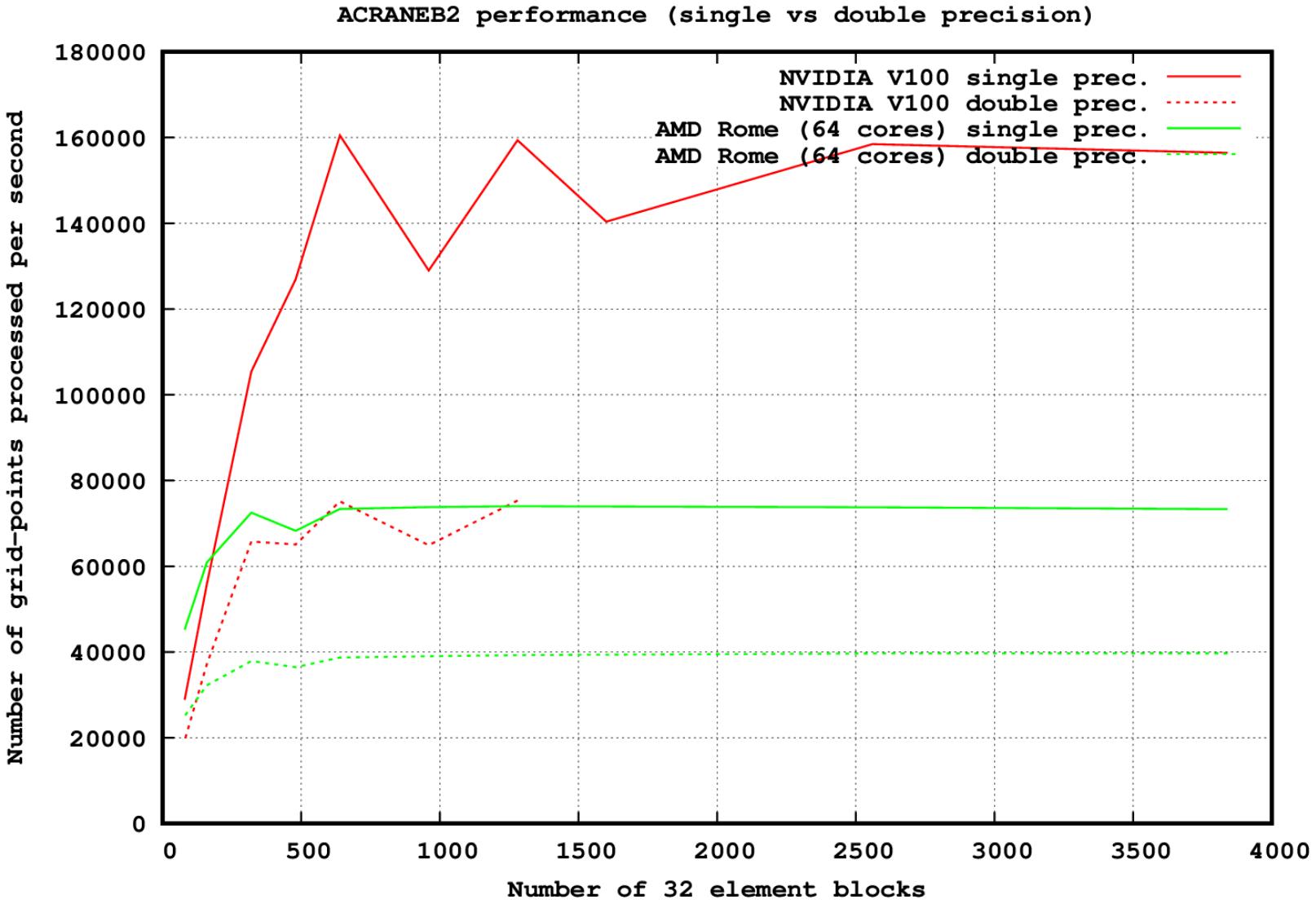
New directions for cpg_drv.F90

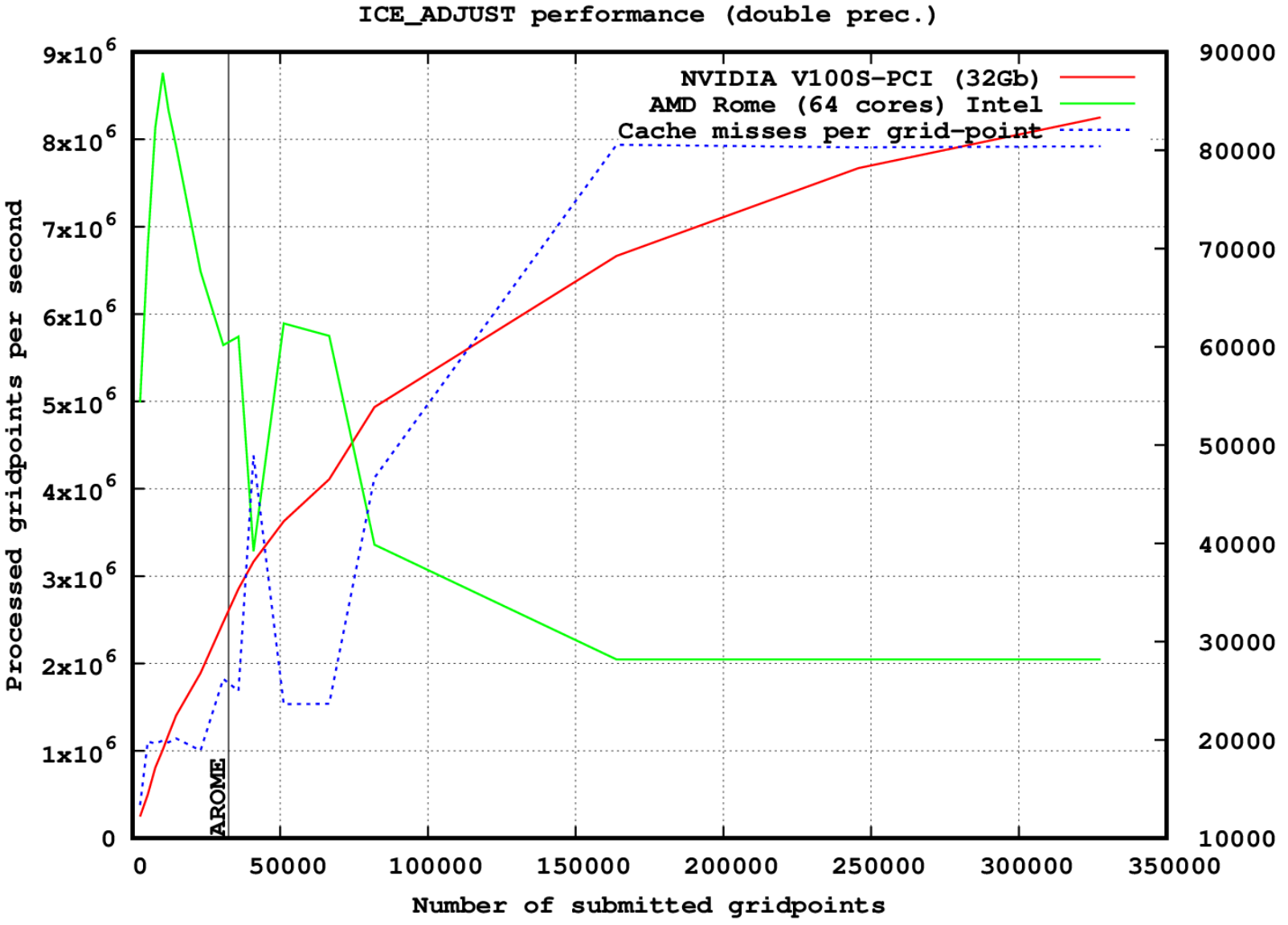
- Create a TENDENCY object
- Deal with compound fields (eg chemistry, LIMA)
- Create a reduced apl_arome.F90 (need for refactored MesoNH physics)
- Go on with cpg_gp.F90/cpg_dyn.F90/cpg_dia.F90
- Ban all module variables in physics routines
- Make it work with PGI (!)

Porting calculations

- Several standalone test cases
- More to come
- Different methods
- Transform the code automatically
  - Loop switching/hoisting
  - Pre-allocated stack
  - Inline subroutines
  - Drop unneeded dimension

		Style	Comments	Single directive	Small kernels	Vector routines
ACTKE	1D physics	ARPEGE F77	Double loops on levels			-
ACPCMT	1D physics	ARPEGE F77	Longs loops			-
ACHMT	1D physics	ARPEGE F77	Small	?	-	-
ACRANEB2	1D physics	ARPEGE F77	Call routine from within loops	++		
SHALLOW MF	1D physics	MesoNH	+KIDIA/KFDIA, expl. dimensions	?	-	-
LACDYN	1D dynamics	ARPEGE F90	Short loops, derived types	?	?	-
LAPINEA	SL dynamics	ARPEGE F90	3D interpolations, derived types		Single block	
ICE ADJUST	1D physics	MesoNH + loops	Small	x4	-	-


ACRANEB2 performance (single vs double precision)
NVIDIA V100 single prec.
NVIDIA V100 double prec.
AMD Rome (64 cores) single prec.
AMD Rome (64 cores) double prec.
Number of grid-points processed per second
Number of 32 element blocks
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
0
500
1000
1500
2000
2500
3000
3500
4000


ICE_ADJUST performance (double prec.)
NVIDIA V100S-PCI (32Gb)
AMD Rome (64 cores) Intel
Cache misses per grid-point
Processed gridpoints per second
Number of submitted gridpoints
AROME
0
1x10^6
2x10^6
3x10^6
4x10^6
5x10^6
6x10^6
7x10^6
8x10^6
9x10^6
10000
20000
30000
40000
50000
60000
70000
80000
90000
0
50000
100000
150000
200000
250000
300000
350000

Spectral transforms

- LAM transforms ported last year (T. Burgot, P. Marguinaud); based on work at ECMWF
- Work being finalized (integration with ectrans, test in single prec.) by D. Degrauwe
- Performance will be assessed soon

Conclusion

- Refactored MF/ACCORD physics → 48t3
- Long & ambitious project
- Many people, training needed