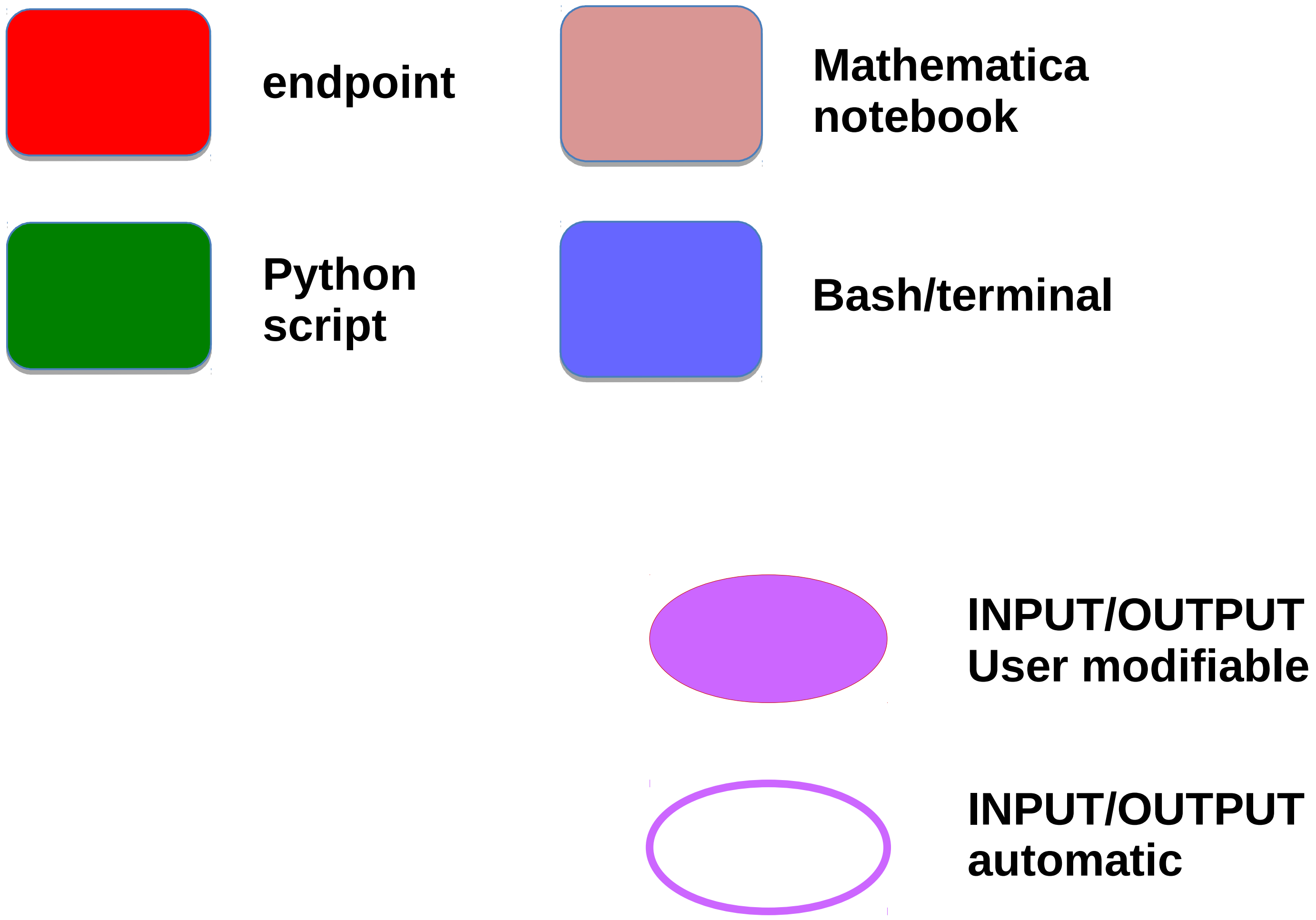
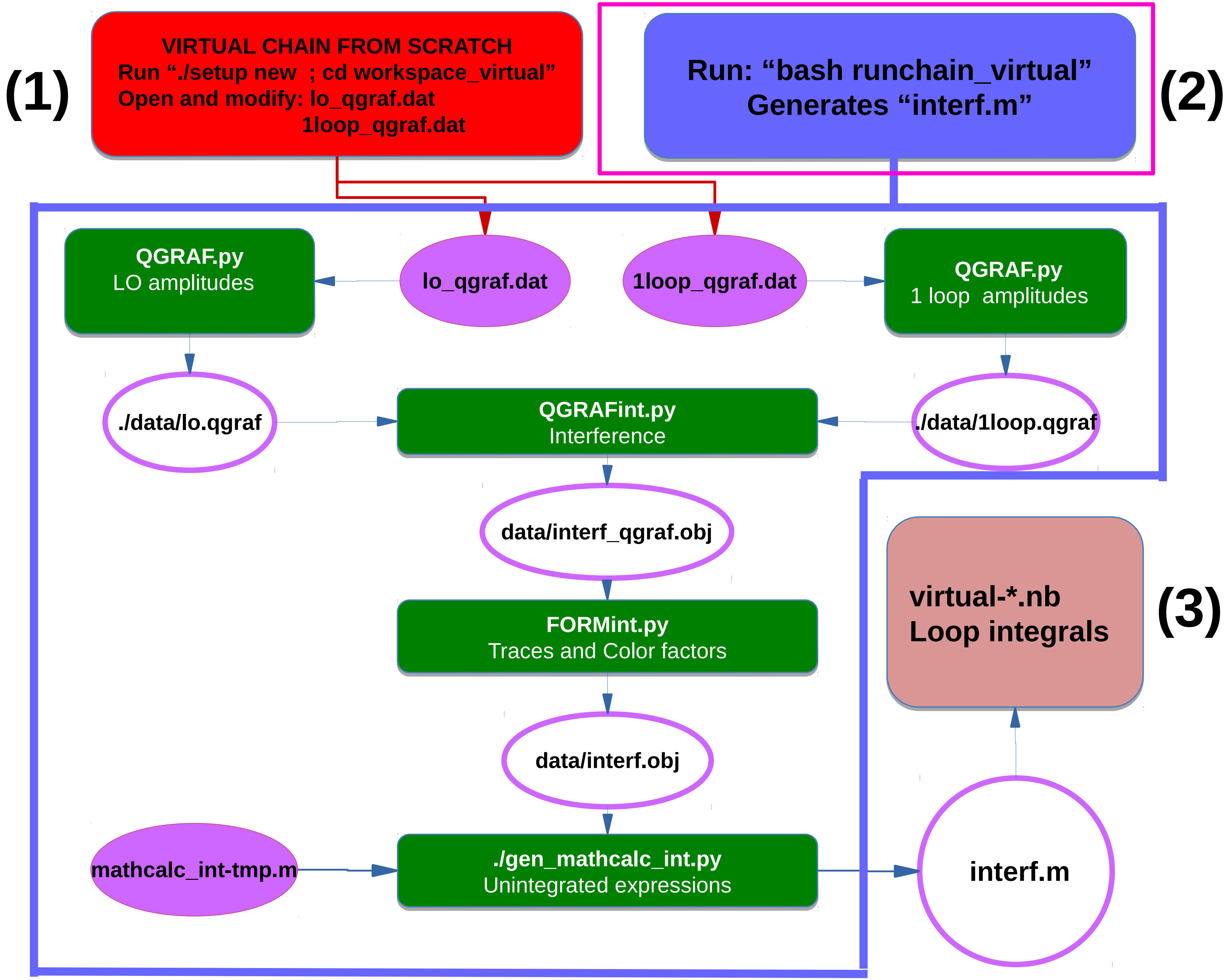
KEY


endpoint
Mathematica notebook
Python script
Bash/terminal
INPUT/OUTPUT User modifiable
INPUT/OUTPUT automatic


(1)
VIRTUAL CHAIN FROM SCRATCH
Run "./setup new ; cd workspace_virtual"
Open and modify: lo_qgraf.dat
1loop_qgraf.dat
Run: "bash runchain_virtual"
Generates "interf.m"
(2)
QGRAF.py
LO amplitudes
lo_qgraf.dat
1loop_qgraf.dat
QGRAF.py
1 loop amplitudes
./data/lo.qgraf
QGRAFint.py
Interference
./data/1loop.qgraf
data/interf_qgraf.obj
virtual-*.nb
Loop integrals
(3)
FORMint.py
Traces and Color factors
data/interf.obj
mathcalc_int-tmp.m
./gen_mathcalc_int.py
Unintegrated expressions
interf.m

KEY

(substep #)
name.nb
Notebook description

Mathematica notebook

//COMMAND
BRIEF DESCRIPTION

Mathematica Function (user level)

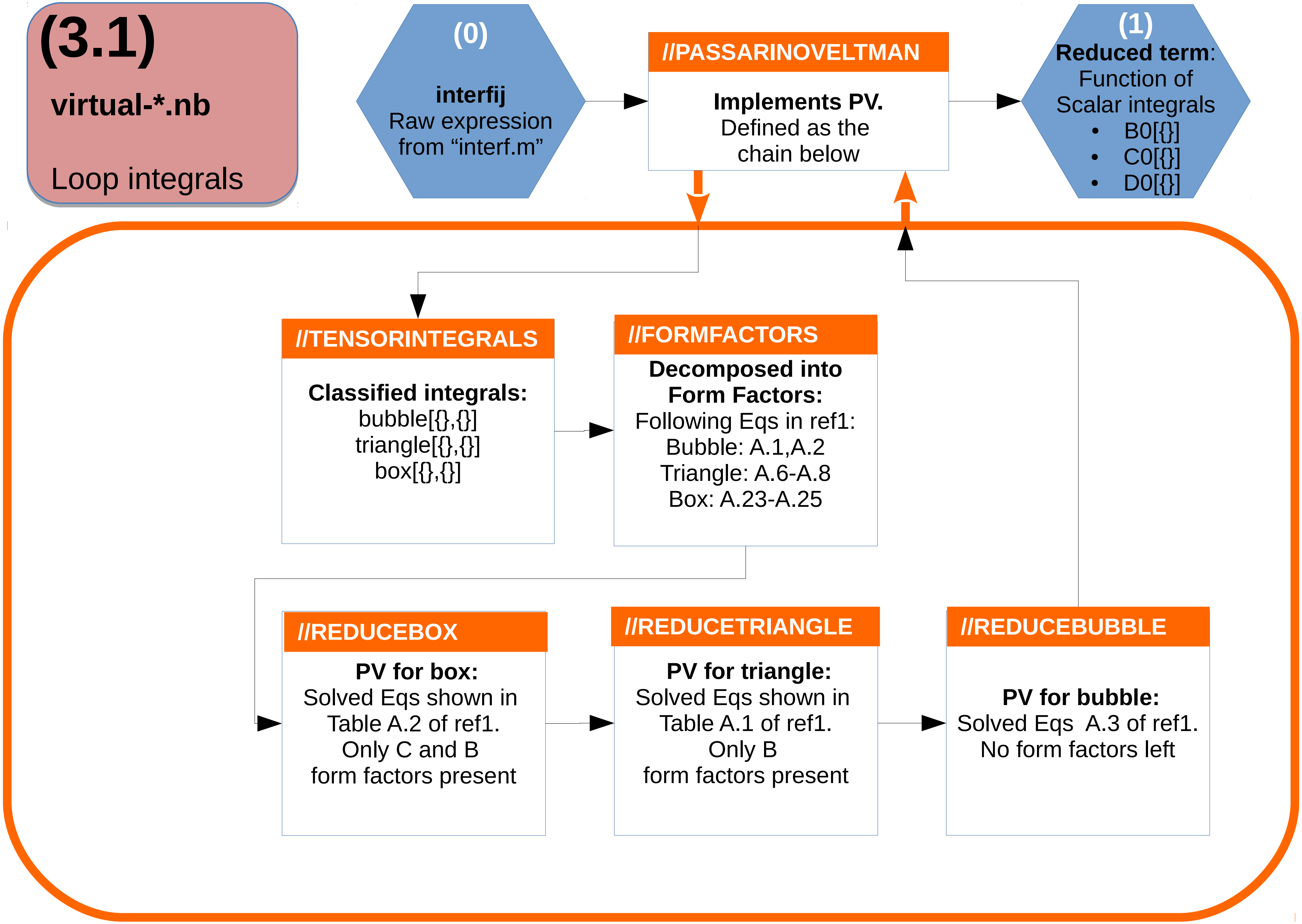
(id#)
description

Mathematica expression

command
BRIEF DESCRIPTION

Mathematica Function (internal)

Ongoing checks


(3.1)
virtual-*.nb
Loop integrals
(0)
interfij
Raw expression
from “interf.m”
//PASSARINOVELTMAN
Implements PV.
Defined as the
chain below
(1)
Reduced term:
Function of
Scalar integrals
B0[{}]
C0[{}]
D0[{}]
//TENSORINTEGRALS
Classified integrals:
bubble[{},{}]
triangle[{},{}]
box[{},{}]
//FORMFACTORS
Decomposed into
Form Factors:
Following Eqs in ref1:
Bubble: A.1,A.2
Triangle: A.6-A.8
Box: A.23-A.25
//REDUCEBOX
PV for box:
Solved Eqs shown in
Table A.2 of ref1.
Only C and B
form factors present
//REDUCETRIANGLE
PV for triangle:
Solved Eqs shown in
Table A.1 of ref1.
Only B
form factors present
//REDUCEBUBBLE
PV for bubble:
Solved Eqs A.3 of ref1.
No form factors left

(3.2)

virtual-*.nb

Loop integrals

(1)
Reduced term: Function of Scalar integrals B0,C0,D0

//EVALSCALARINT

Replaces scalar integrals by solutions in ref2

(2)
Loop Integrated: Function of \epsilon, contains Log,Li2

//EVALB0

Replaces B0.
Implemented as replacements:

term /.
B0[a_] → B0[a, \[Mu]]/.
B0 → B0eval

//EVALC0

Replaces C0.
Implemented as replacements:

term /.
C0[a_] → C0[a, \[Mu]]/.
C0 → C0eval

//EVALD0

Replaces D0.
Implemented as replacements:

term /.
D0[a_] → D0[a, \[Mu]]/.
D0 → D0eval

NOTE: Integrals in ref2 are defined in Eqs. (2.1)

This implies that for our calculation each result in ref2

Should be multiplied by an extra factor of :

$$\frac{i 2^{2\epsilon-4}\pi^{\epsilon-2}\Gamma(1-\epsilon)^2\Gamma(\epsilon+1)}{\Gamma(1-2\epsilon)}$$

Finally, expand up to order $\mathcal{O}(\epsilon^0)$, so that

expressions in notebook look different than in ref2

(3.2)

virtual-*.nb

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C0[a_] →C0[a, \[Mu]]/.
C0 → C0eval

//EVALD0

Replaces D0.
Implemented as replacements:

term /.
D0[a_] →D0[a, \[Mu]]/.
D0 → D0eval

B0eval[momshifts,\[Mu]]

arguments:

momshifts={Δ_1,Δ_2}

\[Mu]=dim reg scale

Steps:

1) calc indep momentum
s=(Δ2-Δ1)^2

2) test if s < 0, s >0 or s = 0

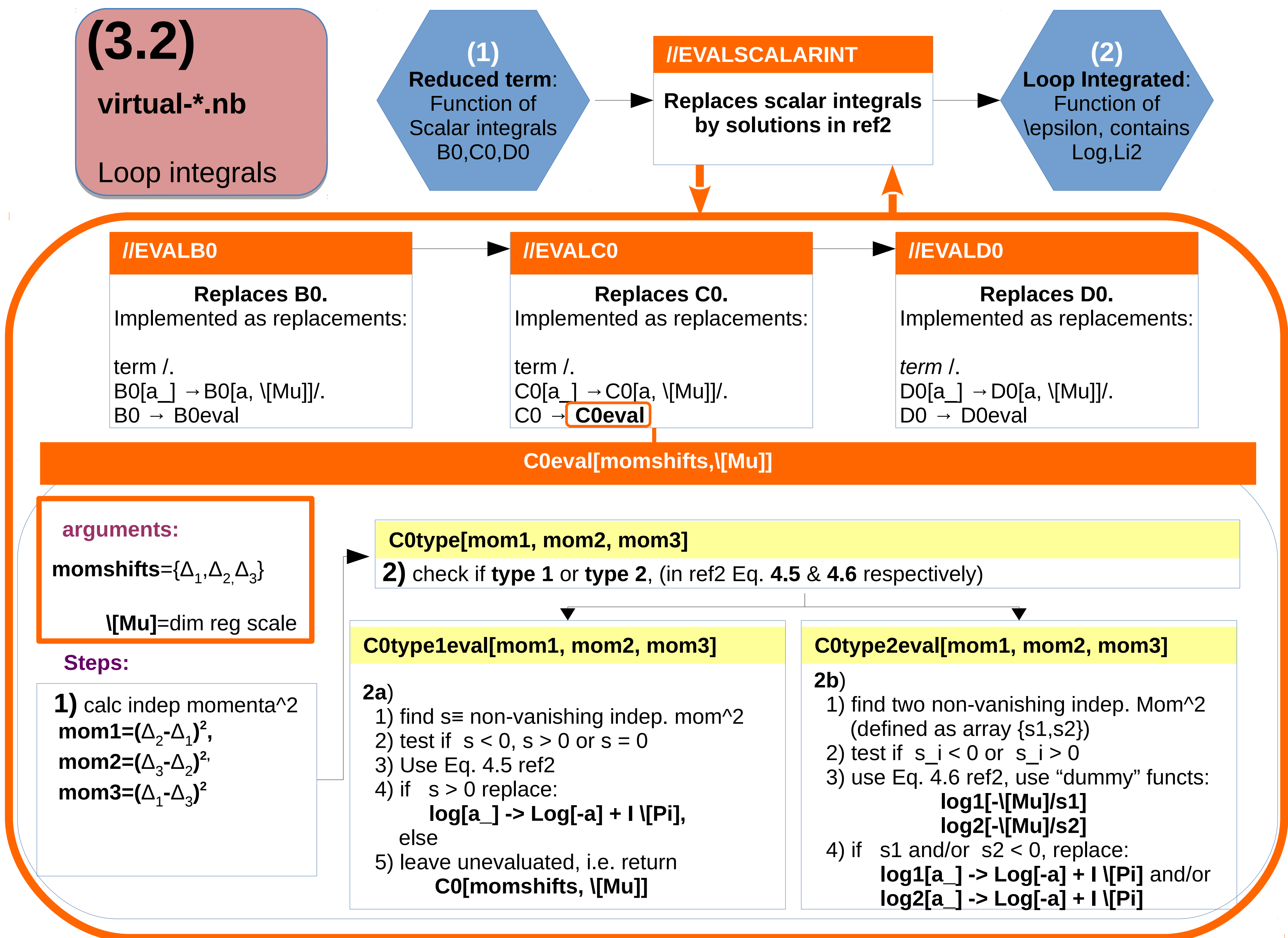
3) if **s < 0**, use Eq.(4.4) in ref2, else if

4) if **s > 0**, use Eq.(4.4) in ref2, with the replacements:

4.1) **Log[a_] → Log[a] + I \[Pi]**
4.2) **s → - s**

else

5) if **s= 0** set integral to **0** (scaless case)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virtual-*.nb
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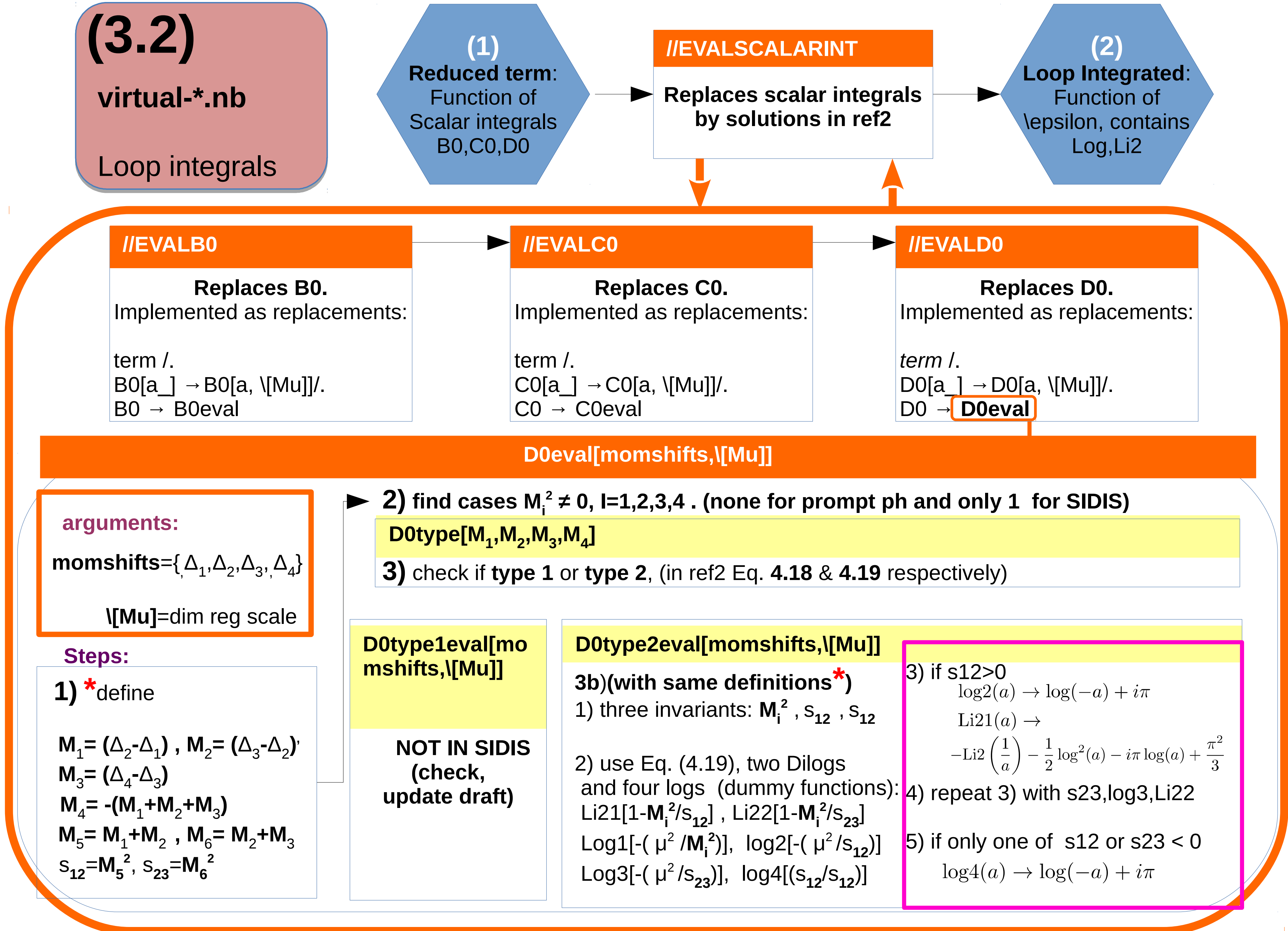
Replaces C0.
Implemented as replacements:
term /.
C0[a_] → C0[a, \[Mu]]/.
C0 → C0eval
//EVALD0
Replaces D0.
Implemented as replacements:
term /.
D0[a_] → D0[a, \[Mu]]/.
D0 → D0eval
C0eval[momshifts,\[Mu]]
arguments:
momshifts={Δ1,Δ2,Δ3}
\[Mu]=dim reg scale
Steps:
1) calc indep momenta^2
mom1=(Δ2-Δ1)²,
mom2=(Δ3-Δ2)²,
mom3=(Δ1-Δ3)²
C0type[mom1, mom2, mom3]
2) check if type 1 or type 2, (in ref2 Eq. 4.5 & 4.6 respectively)
C0type1eval[mom1, mom2, mom3]
2a)
1) find s≡ non-vanishing indep. mom^2
2) test if s < 0, s > 0 or s = 0
3) Use Eq. 4.5 ref2
4) if s > 0 replace:
log[a_] -> Log[-a] + I \[Pi],
else
5) leave unevaluated, i.e. return
C0[momshifts, \[Mu]]
C0type2eval[mom1, mom2, mom3]
2b)
1) find two non-vanishing indep. Mom^2
(defined as array {s1,s2})
2) test if s_i < 0 or s_i > 0
3) use Eq. 4.6 ref2, use “dummy” functs:
log1[-\[Mu]/s1]
log2[-\[Mu]/s2]
4) if s1 and/or s2 < 0, replace:
log1[a_] -> Log[-a] + I \[Pi] and/or
log2[a_] -> Log[-a] + I \[Pi]



(3.2)
virtual-*.nb
Loop integrals
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Reduced term: Function of Scalar integrals B0,C0,D0
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Replaces scalar integrals by solutions in ref2
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Loop Integrated: Function of \epsilon, contains Log,Li2
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Replaces B0.
Implemented as replacements:
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B0[a_] → B0[a, \[Mu]]/.
B0 → B0eval
//EVALC0
Replaces C0.
Implemented as replacements:
term /.
C0[a_] → C0[a, \[Mu]]/.
C0 → C0eval
//EVALD0
Replaces D0.
Implemented as replacements:
term /.
D0[a_] → D0[a, \[Mu]]/.
D0 → D0eval
D0eval[momshifts,\[Mu]]
arguments:
momshifts={Δ_1,Δ_2,Δ_3,Δ_4}
\[Mu]=dim reg scale
Steps:
1) *define
$M_1 = (\Delta_2-\Delta_1)$, $M_2 = (\Delta_3-\Delta_2)$,
$M_3 = (\Delta_4-\Delta_3)$
$M_4 = -(M_1+M_2+M_3)$
$M_5 = M_1+M_2$, $M_6 = M_2+M_3$
$s_{12}=M_5^2$, $s_{23}=M_6^2$
2) find cases $M_i^2 \neq 0$, I=1,2,3,4 . (none for prompt ph and only 1 for SIDIS)
D0type[M_1,M_2,M_3,M_4]
3) check if type 1 or type 2, (in ref2 Eq. 4.18 & 4.19 respectively)
D0type1eval[momshifts,\[Mu]]
NOT IN SIDIS (check, update draft)
D0type2eval[momshifts,\[Mu]]
3b)(with same definitions*)
1) three invariants: M_i^2 , s_{12} , s_{12}
2) use Eq. (4.19), two Dilogs and four logs (dummy functions):
Li21[1-M_i^2/s_{12}] , Li22[1-M_i^2/s_{23}]
Log1[-(μ^2 /M_i^2)], log2[-(μ^2/s_{12})]
Log3[-(μ^2/s_{23})], log4[(s_{12}/s_{12})]
3) if s12>0
$\mathrm{log2}(a) \to \log(-a) + i\pi$
$\mathrm{Li21}(a) \to$
$-\mathrm{Li2}\left(\frac{1}{a}\right) - \frac{1}{2}\log^2(a) - i\pi\log(a) + \frac{\pi^2}{3}$
4) repeat 3) with s23,log3,Li22
5) if only one of s12 or s23 < 0
$\mathrm{log4}(a) \to \log(-a) + i\pi$