pst-optexp
A PSTricks package to draw optical experimental setups

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Contents

1 Introduction

The package `pst-optexp` is a collection of optical components that facilitate easy sketching of optical experimental setups. Mechanisms for proper alignment of different components are provided internally. This way the user does not have to care for proper orientation of the elements. Macros for convenient definition of new user-defined components are also provided.

2 Concept and General Behavior

This section introduces into the basic concepts of the package design and explains the parameters and commands which are supported by most optical objects.

2.1 Concept

The objects provided by `pst-optexp` can be differentiated into two different categories: free-ray and fiber-optical objects.

The free-ray units are subdivided in two different kinds: dipoles which require two reference points for alignment and do not alter the direction of passing light beams (e.g. lenses and retardation plates) and tripoles which work in reflection and require three reference points (mirrors, gratings, beamsplitters etc.).

For free-ray setups one usually has a few straight light paths in which several different objects are to be arranged. In this case it is very convenient to define only two nodes for each light path. The objects are placed on this light path using the different positioning parameters (see Sec. 2.3) of the package. After having arranged everything, the beams themselves are drawn. If objects with multiple internal reflections (e.g. prisms, see Sections 3.9, 3.14 – 3.16) or objects without internal beams (e.g. optical diodes, see Sec. 3.8) are involved. The different possibilities are explained in Sec. 2.6.

The fiber-optical objects can be classified as dipoles, tripoles and quadrupoles which have a corresponding number of fiber connections. Their handling differs in some aspects from the free-ray objects. The fiber optics are directly connected with the reference nodes. Every input and output fiber can be flexibly customized for each object (see Sec. 4.9). Positioning of the fiber dipoles is handled equivalently to the free-ray dipoles. Tripoles and quadrupoles can be found only as different coupler types. Their positioning mechanisms are a bit more involved and explained in Sec. 4.8.

Some hybrid dipoles (laser, optbox, detector etc.) can be used both as fiber-optical or free-ray elements. The way they are treated regarding the connections to the reference points can be controlled by the parameters explained in Sec. 2.6.

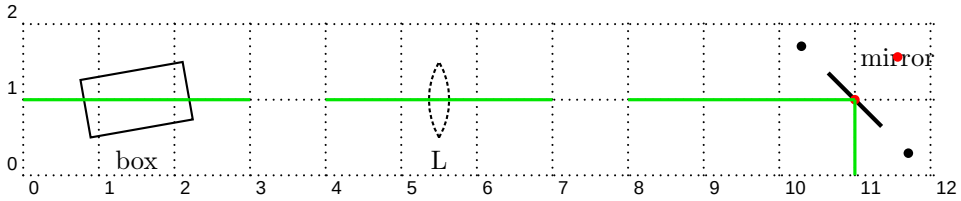
2.2 General Options

angle: `<degree>` (*default:* `0`)
optional: `<boolean>` (*default:* `false`)
showoptdots: `<boolean>` (*default:* `false`)

The parameter `angle` is available for the macros `\optbox` and `\crystal` only, as for the other cases it would make no sense. It tilts the object relative to the line defined by the two reference nodes.

`optional` can be used with every object and marks it as optional. The style of an optional element can be configured by changing the psstyle `OptionalStyle`.

`showoptdots` draws some internal nodes which are used to place the object and the label. The black points are used for positioning, the red points mark the label references.



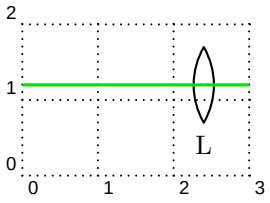

```
\begin{pspicture}(12,2)\psgrid
  \psset{beam}
  \optbox[angle=10](0,1)(3,1){box}
  \lens[optional](4,1)(7,1){L}
  \mirror[showoptdots](8,1)(11,1)(11,0){mirror}
\end{pspicture}
```

2.3 Positioning

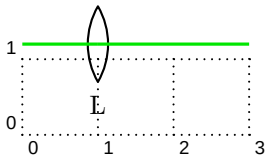
position: <num> (*default:* {})
abspos: <num> (*default:* {})

`position` is equivalent to the `npos` parameter of `\ncput` (can be any number from 0 to 1) and controls the relative position of object between the two reference points. It it not available for the free-ray tripoles.

The parameter `abspos` allows absolute positioning between the two reference nodes. Its value is given in psunits.




```
\begin{pspicture}(3,2)\psgrid
  \lens[beam, position=0.8](0,1.2)(3,1.2){L}
\end{pspicture}
```

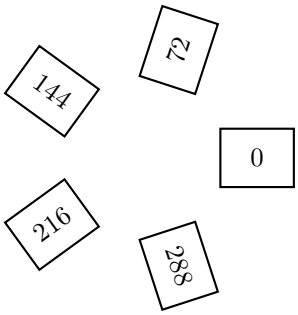



```
\begin{pspicture}(3,1.4)\psgrid
  \lens[beam, abspos=1](0,1.2)(3,1.2){L}
\end{pspicture}
```

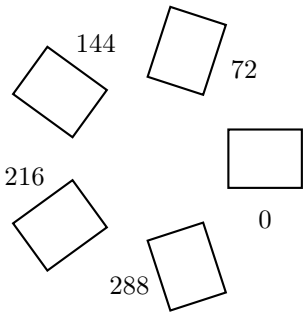
2.4 Labels

labeloffset: <num> (*default:* 0.8)
labelangle: <num> (*default:* 0)
labelstyle: <macro> (*default:* \small)
labelalign: <\rput ref string> (*default:* c)
labelref: relative|relgrav|global (*default:* relgrav)

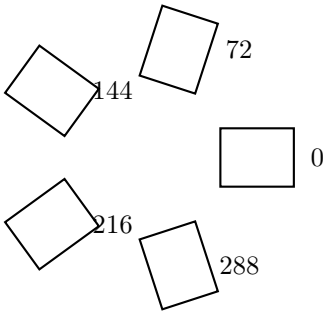
labeloffset specifies the offset from the label reference node of the object which is mostly the center. labelstyle defines the textstyle that is used to typeset the label and labelalign corresponds to the refpoint of \rput. The parameter labelref sets the reference coordinate system for the labelangle and the orientation of the label text. The detailed behaviour is best illustrated looking at the following three examples.




```
\begin{pspicture}(-2,-2)(2.5,2)
   \multido{\i=0+72}{5}{%
      \optbox[endbox,
              labelref=relative,
              labeloffset=0,
              optboxwidth=1](0,0)(1;\i){\i}
   }
\end{pspicture}
```




```
\begin{pspicture}(-2,-2)(2.5,2)
   \multido{\i=0+72}{5}{%
      \optbox[endbox,
              labelref=relgrav,
              optboxwidth=1](0,0)(1;\i){\i}
   }
\end{pspicture}
```




```
\begin{pspicture}(-2,-2)(2.5,2)
   \multido{\i=0+72}{5}{%
      \optbox[endbox,
              labelref=global,
              optboxwidth=1](0,0)(1;\i){\i}
   }
\end{pspicture}
```

2.5 Nodes For External Usage

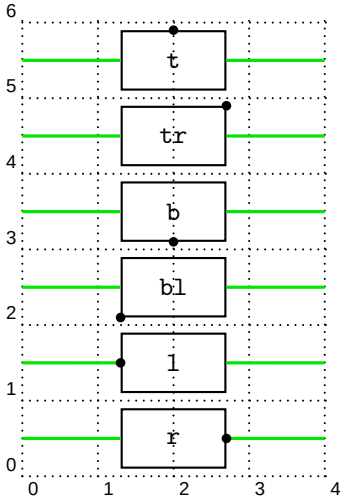
extnode: <ref string> (*default:* {})
extnodepostfix: <string> (*default:* ExtNode)

Some of the objects can provide a supplementary node for additional connections. A laser diode may be connected for example to a frequency synthesizer (use package pst-circ) or a detector to a computer.

extnode controls the position of the additional node. By default this parameter is empty ({}) and no node is created. Possible values are any combinations of t (top), b (bottom), l (left), r (right) and c (center).

The name of the new node depends on the compname parameter (see Sec. 2.6). It is composed by compname + extnodepostfix, that is if compname is empty the new node is named *ExtNode* by default and overwritten by following objects.

Table. 1 shows all objects which provide an external node. Some allow any combination for extnode, others have only one reasonable possibility (e.g. piezo mirror, see Sec. 3.11).




```
\begin{pspicture}(4,6)\psgrid
   \psset{conn=o-o, labeloffset=0}
   \optbox[extnode=t](0,5.5)(4,5.5){\texttt{t}}
   \psdot(ExtNode)
   \optbox[extnode=tr](0,4.5)(4,4.5){\texttt{tr}}
   \psdot(ExtNode)
   \optbox[extnode=b](0,3.5)(4,3.5){\texttt{b}}
   \psdot(ExtNode)
   \optbox[extnode=bl](0,2.5)(4,2.5){\texttt{bl}}
   \psdot(ExtNode)
   \optbox[extnode=l](0,1.5)(4,1.5){\texttt{l}}
   \psdot(ExtNode)
   \optbox[extnode=r](0,0.5)(4,0.5){\texttt{r}}
   \psdot(ExtNode)
\end{pspicture}
```

Object	possible extnode positions	
\optbox	all (any combination of t, r, l and b	
\mirror	one fix position (only for mirrortype=piezo)	
\optdetector	one (for dettype=round)	
	all (for dettype=diode)	see \optbox
\optmzm	all	see \optbox
\optfilter	all	see \optbox
\optswitch	all	see \optbox
\fiberdelayline	all	see \optbox

Table 1: The objects which may provide an external node when parameter extnode is not empty. Some allow different positions of the node and for some only a fixed node makes sense.

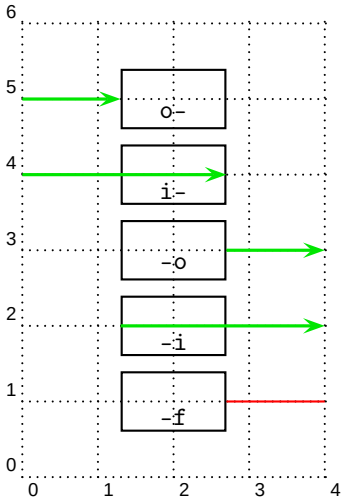
2.6 Connecting Objects

compname: `<string>` (*default:* `{}`)
conn: `i-i|o-o|f-f` (*default:* `-`)
fiber: alias for `conn=f-f`
beam: alias for `conn=o-i`

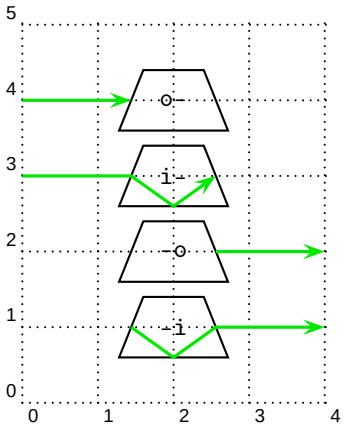
Simple experimental setups with a few objects can usually be realized by defining some nodes, arranging the object inbetween and drawing the beams at the end. If, however, objects with multiple internal reflections (all the prisms) or without visible internal beams (optical diode) are involved, this simple method is not applicable anymore.

For this case several different possibilities of connecting objects are available: parameterconn specifies the kind of connections before and after the object. Its syntax is analogous to the PSTricks parameter `arrows`. By default it is set to `-` and no connections are drawn.

All fiber-optical units define `conn=f-f` which means that input and output connections are fibers (the boolean parameter `fiber` is an alias for `conn=f-f`). The other possibilities are `i` (inner node) and `o` (outer node). Their meaning should become clear looking at the next two code examples. The letter before the dash specifies the kind of connection from the first reference node to the object. A `conn=o-` connects the first reference node to the outer left node, a `conn=i-` connects the first reference node to the outer left node and then a line through all internal nodes up to the outer right node. Equivalently does `conn=-i` and `conn=-o` work for the second reference point. The boolean parameter `beam` is an alias for `conn=o-i`. The beam style is controlled by the psstyle `Beam` which can be changed using `newpsstyle` and `addtopsstyle`.

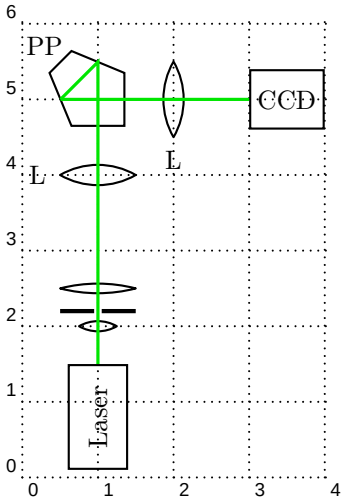



```
\begin{pspicture}(4,6)\psgrid
  \addtopsstyle{Beam}{arrows=->, arrowscale=1.5}
  \psset{labeloffset=0.1, labelalign=t}
  \optbox[conn=o-](0,5)(4,5){\texttt{o-}}
  \optbox[conn=i-](0,4)(4,4){\texttt{i-}}
  \optbox[conn=-o](0,3)(4,3){\texttt{-o}}
  \optbox[conn=-i](0,2)(4,2){\texttt{-i}}
  \optbox[conn=-f](0,1)(4,1){\texttt{-f}}
\end{pspicture}
```




```
\begin{pspicture}(4,5)\psgrid
  \addtopsstyle{Beam}{arrows=->, arrowscale=1.5}
  \psset{labeloffset=0}
  \doveprism[conn=o-](0,4)(4,4){\texttt{o-}}
  \doveprism[conn=i-](0,3)(4,3){\texttt{i-}}
  \doveprism[conn=-o](0,2)(4,2){\texttt{-o}}
  \doveprism[conn=-i](0,1)(4,1){\texttt{-i}}
\end{pspicture}
```

The following example shows how this parameter can be used in some kinds of experimental setups using objects with internal reflections (here a penta prism). Instead of drawing the beam at the end with a psline, the beams are created with the `conn` parameter.

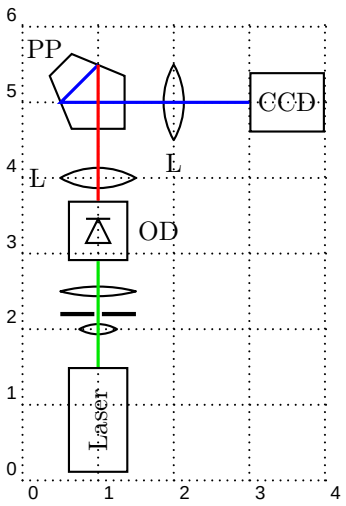



```
\begin{pspicture}(4,6)\psgrid
   \pnode(1,1.5){A}\pnode(1,5){G}\pnode(3,5){B}
   \optbox[endbox, labelref=relative,
     labeloffset=0](G)(A){Laser}
   \lens[lens=0.5 0.5 0.5, abspos=0.5](A)(G){}
   \pinhole[abspos=0.7](A)(G){}
   \lens[lens=2, abspos=1](A)(G){}
   \lens[abspos=2.5, labelangle=180](A)(G){L}
   \lens[abspos=1](G)(B){L}
   \optbox[endbox, labeloffset=0, optboxwidth=1](G)(B){CCD}
   \pentaprism[beam, labeloffset=1](A)(G)(B){PP}
\end{pspicture}
```

This method works as long as no objects without internal beams are used in the setup. A possibility would be to create additional nodes, but this may be not very comfortable. Therefore `pst-optexp` provides a macro `\drawbeam` which connects two named objects. A named object is a `pst-optexp` element with a non-empty `compname`.

```
\drawbeam[conn=...]{<from>}{<to>}
```

The type of beam connection is again controlled by the parameter `conn`. Almost every optical object does not have fix inputs and outputs, but may be used in either directions. Therefore, it does not make sense to speak about 'input' and 'output' when referring to the object nodes, but rather to node A and node B. Consequently, the two letters of parameter `conn` can take the values `a`, `A`, `b` or `B`.




```
\begin{pspicture}(4,6)\psgrid
  \pnode(1,1.5){A}\pnode(1,5){G}\pnode(3,5){B}
  \optbox[endbox, labelref=relative,
    labeloffset=0](G)(A){Laser}
  \lens[lens=0.5 0.5 0.5, abspos=0.5](A)(G){}
  \pinhole[abspos=0.7](A)(G){}
  \lens[lens=2, abspos=1](A)(G){}
  \lens[abspos=2.5, labelangle=180](A)(G){L}
  \lens[abspos=1](G)(B){L}
  \optdiode[abspos=1.8, conn=o-, compname=OD](A)(G){OD}
  \optbox[endbox, labeloffset=0, optboxwidth=1](G)(B){CCD}
  \addtopsstyle{Beam}{linecolor=blue}
  \pentaprism[conn=-i, labeloffset=1,
    compname=PP](A)(G)(B){PP}
  \addtopsstyle{Beam}{linecolor=red}
  \drawbeam[conn=b-a]{OD}{PP}
\end{pspicture}
```

3 Free-Ray Objects

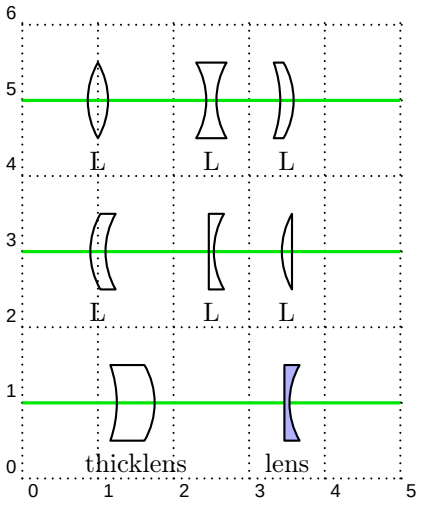
In the sections 3.1–3.17 the available free-ray components with their parameters are described.

In section 2 general parameters are described that are not proprietary to a specific unit but can be used for several different components. Finally, in section 2.4 the options for the positioning of labels are explained.

The appearence of all components can be changed with the corresponding standard PSTricks parameters such as `fillstyle` or `linestyle`. For some components changing only parts of the layout is possible (e.g. the extended part of mirrors). For those cases psstyles are provided that influence only the corresponing part of the components and can be redefined using `\newpsstyle`.

3.1 Lens

lensheight: `<num>` (*default:* `1`)
lenswidth: `<num>` (*default:* `0.3`)
lensradius: `<num> [<num>]` (*default:* `{}`)
lensradiusleft: `<num>` (*default:* `1`)
lensradiusright: `<num>` (*default:* `1`)
lens: `<num> [<num> [<num>]]]` (*default:* `{}`)
thicklens: `<boolean>` (*default:* `false`)




```
\begin{pspicture}(5,6)\psgrid
  % concave lenses
  \pnode(0,5){A}\pnode(5,5){B}
  \psline[style=Beam](A)(B)
  \lens[position=0.2](A)(B){L}
  \lens[lensradius=-1,position=0.5](A)(B){L}
  \lens[lens=-1.5 1,position=0.7](A)(B){L}
  % convex lenses
  \pnode(0,3){A}\pnode(5,3){B}
  \psline[style=Beam](A)(B)
  \lens[position=0.2,lens=1 -1](A)(B){L}
  \lens[lens=0 -1](A)(B){L}
  \lens[lens=1 0,position=0.7](A)(B){L}
  % thick lenses
  \pnode(0,1){A}\pnode(5,1){B}
  \psline[style=Beam](A)(B)
  \lens[position=0.3, lens=-1.5 1 1 0.5,
    thicklens](A)(B){thicklens}
  \lens[lens=0 -1, position=0.7, fillstyle=solid,
    fillcolor=blue!30!white](A)(B){lens}
\end{pspicture}
```

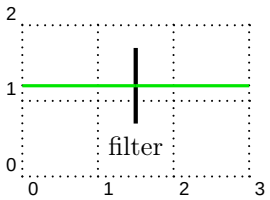
The shape of a lens is defined by its two surface radii. A negative radius gives a concave, a positive radius a convex and a radius of `0` a plain surface. The parameters `lensradiusleft` and `lensradiusright` allow to define independent values for both surfaces. `lensradius` sets both curvatures to the same value. Usually only `lensheight` and the two radii are used to construct the lens. The thickness (or width) is determined automatically. Manually controlling

the thickness of the lens can be achived by setting `thicklens` to `true`. Then `lenswidth` is used as width of the lens at its waist. Finally, the parameter `lens` allows the definition of all relevant lens parameters at once. It consists of one up to four space-separated numbers. The first one gives the left radius. If no further value is set, the right radius will be set to the same value and all other parameters are left unchanged. Using two numbers defines two different radii. The third optional value defines the `lensheight` and the fourth one the `lenswidth`

Compatibility: The whole implementation of the lens was changed in version 1.2. It allows a much more flexible definition of different lens types. However, I could not get full compatibility with the older way to define lens using only `lensheight` and `lenswidth`. To use this old behaviour, you have to set the `lenstype` explicitly, but then you have no access to the new features! All users are encouraged to adapt their code to use the new parameters, as the old code will be removed in future versions.

3.2 Optical Plate

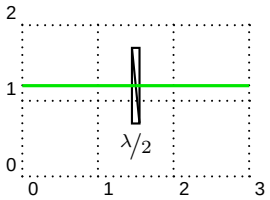
plateheight: <num> (*default:* 1)
platelinewidth: <num> (*default:* 2\pslinewidth)




```
\begin{pspicture}(3,2)\psgrid
  \optplate[beam](0,1.2)(3,1.2){filter}
\end{pspicture}
```

3.3 Retardation Plate

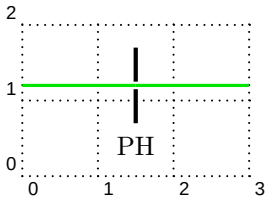
plateheight: <num> (*default:* 1)
platewidth: <num> (*default:* 0.1)




```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,1.2){A}
  \pnode(3,1.2){B}
  \optretplate[beam](A)(B){$\nicefrac{\lambda}{2}$}
\end{pspicture}
```

3.4 Pinhole

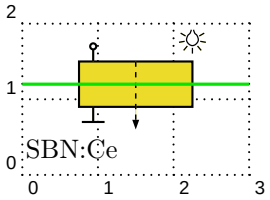
outerheight: <num> (*default:* 1)
innerheight: <num> (*default:* 0.1)
phlinewidth: <num> (*default:* 2\pslinewidth)




```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,1.2){A}
  \pnode(3,1.2){B}
  \pinhole[beam](A)(B){PH}
\end{pspicture}
```

3.5 Crystal

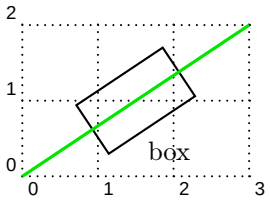
crystalwidth: <num> (*default:* 2)
crystalheight: <num> (*default:* 0.8)
caxislength: <num> (*default:* 0.6)
caxisinv: <boolean> (*default:* false)
voltage: <boolean> (*default:* false)
lamp: <boolean> (*default:* false)
lampscale: <num> (*default:* 0.3)



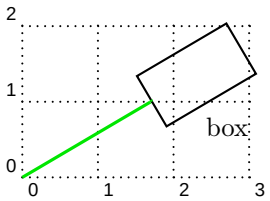

```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,1.2){A}
  \pnode(3,1.2){B}
  \crystal[crystalwidth=1.5, crystalheight=0.6, fillstyle=solid,
    fillcolor=yellow!90!black, labelangle=-45, labeloffset=1.2,
    voltage, lamp, beam](A)(B){SBN:Ce}
\end{pspicture}
```

3.6 Box

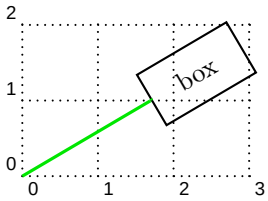
optboxheight: <num> (*default:* 0.5)
optboxwidth: <num> (*default:* 1)
endbox: <boolean> (*default:* false)




```
\begin{pspicture}(3,2)\psgrid
  \optbox[beam](0,0)(3,2){box}
\end{pspicture}
```



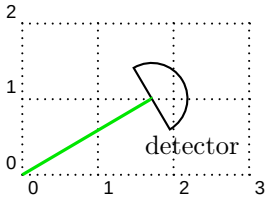

```
\begin{pspicture}(3,2)\psgrid
  \optbox[beam, endbox](0,0)(1.7,1){box}
\end{pspicture}
```



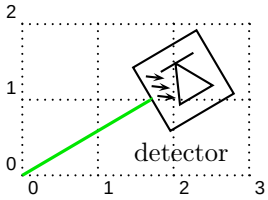

```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,0){A}
  \pnode(1.7,1){B}
  \optbox[beam, endbox, labelref=relative, labeloffset=0](A)(B){box}
\end{pspicture}
```

3.7 Detector

detsize: <num> (*default:* 0.5)
dettype: round|diode (*default:* round)



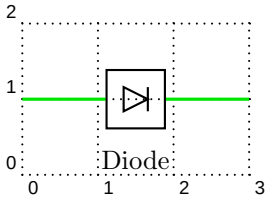

```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,0){A}
  \pnode(1.7,1){B}
  \optdetector[beam](A)(B){detector}
\end{pspicture}
```




```
\begin{pspicture}(3,2)\psgrid
  \pnode(0,0){A}
  \pnode(1.7,1){B}
  \optdetector[beam, dettype=diode](A)(B){detector}
\end{pspicture}
```

3.8 Optical Diode

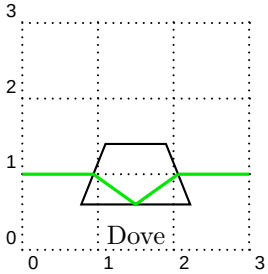
optdiodesize: <num> (*default:* 0.8)




```
\begin{pspicture}(3,2)\psgrid
   \optdiode[conn=o-o](0,1)(3,1){Diode}
\end{pspicture}
```

3.9 Dove Prism

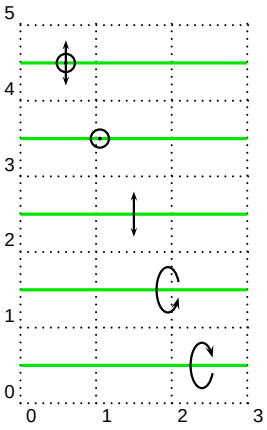
doveprismsize: <num> (*default:* 1)




```
\begin{pspicture}(3,3)\psgrid
  \doveprism[beam](0,1)(3,1){Dove}
\end{pspicture}
```

3.10 Polarization

poltype: `parallel|perp|misc|lcirc|rcirc` (*default:* `parallel`)
polsize: `<num>` (*default:* `0.6`)
pollinewidth: `<num>` (*default:* `0.7\pslinewidth`)

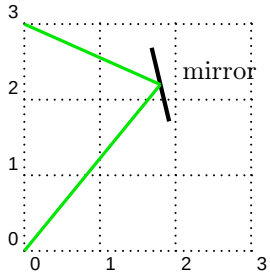



```
\begin{pspicture}(3,5)\psgrid
  \pnode(0,0.5){A1}\pnode(3,0.5){B1}\pnode(0,1.5){A2}
  \pnode(3,1.5){B2}\pnode(0,2.5){A3}\pnode(3,2.5){B3}
  \pnode(0,3.5){A4}\pnode(3,3.5){B4}\pnode(0,4.5){A5}
  \pnode(3,4.5){B5}\psset{style=Beam}
  \multido{\i=1+1}{5}{\psline(A\i)(B\i)}
  \psset{linecolor=black}
  \polarization[poltype=misc,position=0.2](A5)(B5)
  \polarization[poltype=perp,position=0.35](A4)(B4)
  \polarization[poltype=parallel,position=0.5](A3)(B3)
  \polarization[poltype=rcirc,position=0.65](A2)(B2)
  \polarization[poltype=lcirc,position=0.8](A1)(B1)
\end{pspicture}
```

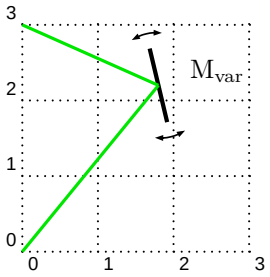
3.11 Mirror

mirrorwidth: `<num>` (*default:* `1`)
mirrorradius: `<num>` (*default:* `0`)
mirrorlinewidth: `<num>` (*default:* `2\pslinewidth`)
mirrortype: `normal|piezo|extended` (*default:* `normal`)
mirrordepth: `<num>` (*default:* `0.08`)
variable: `<num>` (*default:* `false`)

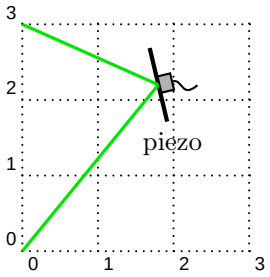
The parameter `mirrorradius` defines the curvature of the mirror. A value of `0` is for a plain mirror, a negative radius is for a concave mirror and a positive radius gives you a convex mirror. The style of the extended mirror is defined as a psstyle `ExtendedMirror` and can be changed using `\newpsstyle`. The appearence of the piezo mirror likewise can be changed by adapting the psstyle `PiezoMirror`.



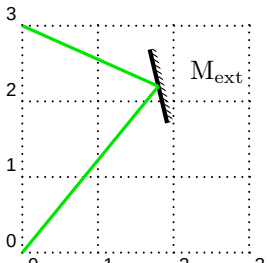

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}
  \pnode(1.8,2.2){G}
  \pnode(0,3){B}
  \mirror[beam](A)(G)(B){mirror}
\end{pspicture}
```



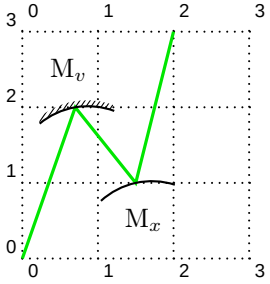

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}
  \pnode(1.8,2.2){G}
  \pnode(0,3){B}
  \mirror[beam, variable](A)(G)(B){M$_\mathrm{var}$}
\end{pspicture}
```




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}
  \pnode(1.8,2.2){G}
  \pnode(0,3){B}
  \mirror[beam, mirrortype=piezo,labelangle=-90](A)(G)(B){piezo}
\end{pspicture}
```



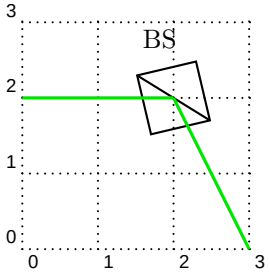

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}
  \pnode(1.8,2.2){G}
  \pnode(0,3){B}
  \mirror[beam, mirrortype=extended](A)(G)(B){M$_\mathrm{ext}$}
\end{pspicture}
```




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}\pnode(0.7,2){G1}
  \pnode(1.5,1){G2}\pnode(2,3){B}
  \psset{labeloffset=0.5}
  \psline[style=Beam](A)(G1)(G2)(B)
  \mirror[mirrortype=extended, mirrorradius=1](A)(G1)(G2){M$_v$}
  \mirror[mirrorradius=-1](G1)(G2)(B){M$_x$}
\end{pspicture}
```

3.12 Beamsplitter

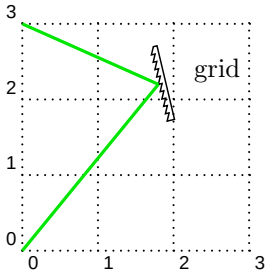
bssize: <num> (*default:* 0.8)



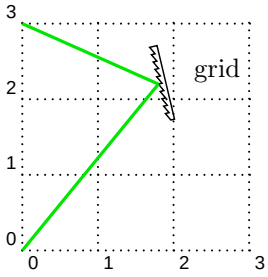

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,2){A}
  \pnode(2,2){G}
  \pnode(3,0){B}
  \beamsplitter[beam](A)(G)(B){BS}
\end{pspicture}
```

3.13 Optical Grid

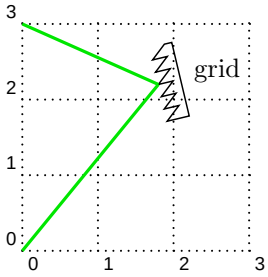
optgridcount: `<integer>` (*default:* `10`)
optgridwidth: `<num>` (*default:* `1`)
optgridheight: `<num>` (*default:* `0.1`)
optgriddepth: `<num>` (*default:* `0.05`)
optgridtype: `blazed|binary` (*default:* `blazed`)
optgridlinewidth: `<num>` (*default:* `0.7\pslinewidth`)
reverse: `<boolean>` (*default:* `false`)



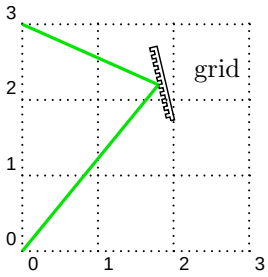

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,3){A}
  \pnode(1.8,2.2){G}
  \pnode(0,0){B}
  \optgrid[beam](A)(G)(B){grid}
\end{pspicture}
```




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,3){A}
  \pnode(1.8,2.2){G}
  \pnode(0,0){B}
  \optgrid[beam, reverse](A)(G)(B){grid}
\end{pspicture}
```



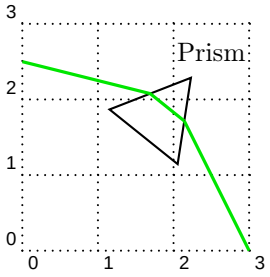

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,3){A}
  \pnode(1.8,2.2){G}
  \pnode(0,0){B}
  \optgrid[beam,%
           optgridcount=6,%
           optgriddepth=0.2,%
           optgridheight=0.3](A)(G)(B){grid}
\end{pspicture}
```




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,3){A}
  \pnode(1.8,2.2){G}
  \pnode(0,0){B}
  \optgrid[beam, optgridtype=binary](A)(G)(B){grid}
\end{pspicture}
```

3.14 Prism

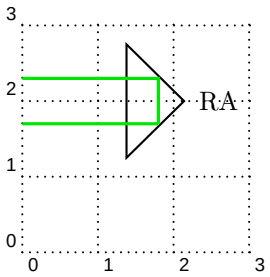
prismsize: <num> (*default:* 1)
prismangle: <num> (*default:* 60)




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,2.5){A}
  \pnode(2,2){G}
  \pnode(3,0){B}
  \optprism[beam](A)(G)(B){Prism}
\end{pspicture}
```

3.15 Right-Angle Prism

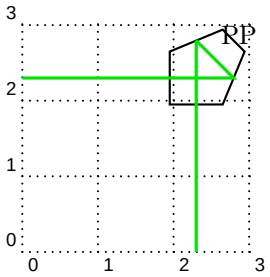
raprismsize: <num> (*default:* 1)




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,2.3){A}
  \pnode(1.8,2){G}
  \pnode(0,1.7){B}
  \rightangleprism[beam](A)(G)(B){RA}
\end{pspicture}
```

3.16 Penta Prism

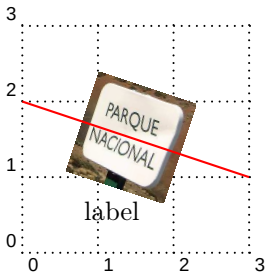
pentaprismsize: <num> (*default:* 1)



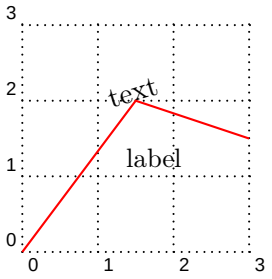

```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,2.3){A}
  \pnode(2.3,2.3){G}
  \pnode(2.3,0){B}
  \pentaprism[beam](A)(G)(B){PP}
\end{pspicture}
```

3.17 Custom Components

The macros \optdipole and \opttripole allow using everything as optical component. If you want to use a certain component several times, you should define it as a new component. For details see sec. 6.2.




```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,2){A}
  \pnode(3,1){B}
  \optdipole[labeloffset=1](A)(B){%
    \rput(0,0){%
      \includegraphics[scale=0.25]{parque-nacional}
    }
  }{label}
  \psline[linecolor=red](A)(B)
\end{pspicture}
```

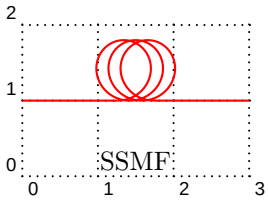



```
\begin{pspicture}(3,3)\psgrid
  \pnode(0,0){A}
  \pnode(1.5,2){G}
  \pnode(3,1.5){B}
  \opttripole(B)(G)(A){\rput[b](0,0){text}}{label}
  \psline[linecolor=red](A)(G)(B)
\end{pspicture}
```

4 Fiber-Optical Objects

4.1 Fiber

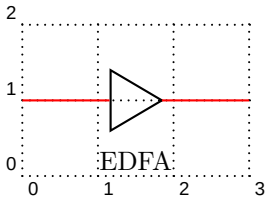
fiberloops: `<integer>` (*default:* `3`)
fiberloopradius: `<num>` (*default:* `0.3`)
fiberloopsep: `<num>` (*default:* `0.3`)




```
\begin{pspicture}(3,2)\psgrid
  \optfiber(0,1)(3,1){SSMF}
\end{pspicture}
```

4.2 Amplifier

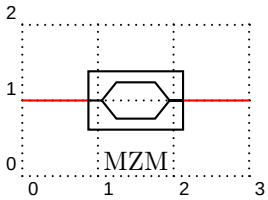
optampsize: `<num>` (*default:* `0.8`)




```
\begin{pspicture}(3,2)\psgrid
  \optamp(0,1)(3,1){EDFA}
\end{pspicture}
```

4.3 Mach-Zehnder Modulator

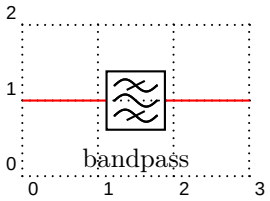
optmzmsize: `<num>` (*default:* `0.8`)



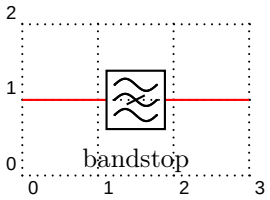

```
\begin{pspicture}(3,2)\psgrid
  \optmzm(0,1)(3,1){MZM}
\end{pspicture}
```

4.4 Filter

filtersize: `<num>` (*default:* `0.8`)
filtertype: `bandpass|bandstop` (*default:* `bandpass`)



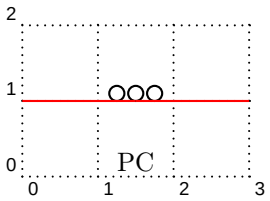

```
\begin{pspicture}(3,2)\psgrid
  \optfilter(0,1)(3,1){bandpass}
\end{pspicture}
```




```
\begin{pspicture}(3,2)\psgrid
  \optfilter[filtertype=bandstop](0,1)(3,1){bandstop}
\end{pspicture}
```

4.5 Polarization Controller

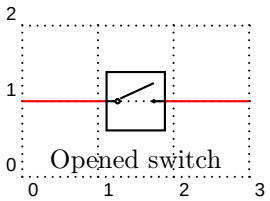
polcontrolsize: `<num>` (*default:* `0.1`)



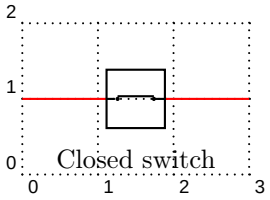

```
\begin{pspicture}(3,2)\psgrid
  \polcontrol(0,1)(3,1){PC}
\end{pspicture}
```

4.6 Optical Switch

switchsize: `<num>` (*default:* `0.8`)
switchstyle: `opened|closed` (*default:* `opened`)



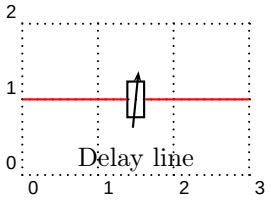

```
\begin{pspicture}(3,2)\psgrid
  \optswitch(0,1)(3,1){Opened switch}
\end{pspicture}
```




```
\begin{pspicture}(3,2)\psgrid
  \optswitch[switchstyle=closed](0,1)(3,1){Closed switch}
\end{pspicture}
```

4.7 Fiber Delay Line

fdlsize: <num> (*default:* 0.8)

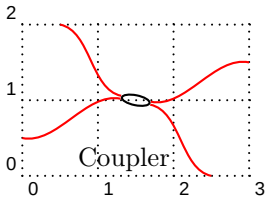



```
\begin{pspicture}(3,2)\psgrid
  \fiberdelayline(0,1)(3,1){Delay line}
\end{pspicture}
```

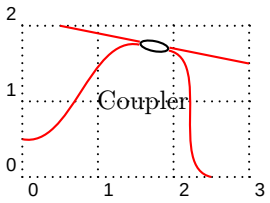
4.8 Coupler

couplersize: <num> (*default:* 0.1)
couplersep: <num> (*default:* 0.1)
couplertype: none|elliptic (*default:* elliptic)

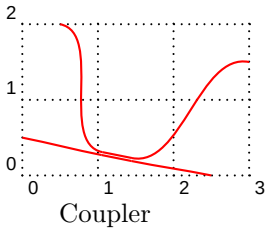
4.8.1 2×2 Coupler




```
\begin{pspicture}(3,2)\psgrid
  \optcoupler(0.5,2)(0,0.5)(3,1.5)(2.5,0){Coupler}
\end{pspicture}
```

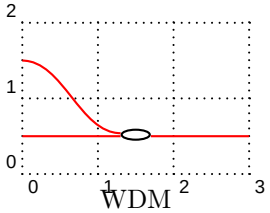



```
\begin{pspicture}(3,2)\psgrid
  \optcoupler[align=top](0.5,2)(0,0.5)(3,1.5)(2.5,0){Coupler}
\end{pspicture}
```



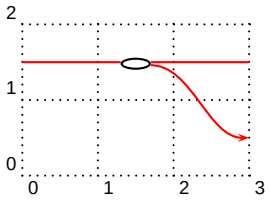

```
\begin{pspicture}(3,2)\psgrid
  \optcoupler[align=bottom,
    couplertype=none](0.5,2)(0,0.5)(3,1.5)(2.5,0){Coupler}
\end{pspicture}
```

4.8.2 WDM Coupler




```
\begin{pspicture}(3,2)\psgrid
  \wdmcoupler[align=bottom](0,1.5)(0,0.5)(3,0.5){WDM}
\end{pspicture}
```

4.8.3 WDM Splitter




```
\begin{pspicture}(3,2)\psgrid
  \newpsstyle{FiberOut2}{style=Fiber, arrows=->}
  \wdmsplitter[align=top](0,1.5)(3,1.5)(3,0.5){}
\end{pspicture}
```

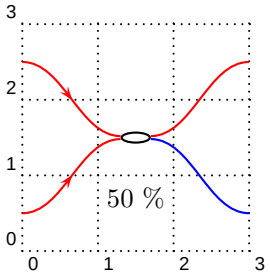
4.9 Fiber Styles

usefiberstyle: <boolean> (*default:* `true`)
Fiber: <psstyle> (*default:* `linecolor=red`)
FiberIn: <psstyle> (*default:* `style=Fiber`)
FiberIn1: <psstyle> (*default:* `style=FiberIn`)
FiberIn2: <psstyle> (*default:* `style=FiberIn`)
FiberOut: <psstyle> (*default:* `style=Fiber`)
FiberOut1: <psstyle> (*default:* `style=FiberOut`)
FiberOut2: <psstyle> (*default:* `style=FiberOut`)

All these psstyles control the appearence of the fiber parts before and after each components. The styles can be redefined with `\newpsstyle` or changed with `\addtopsstyle`. For optical systems it is not possible to define a unique input and a unique output as most components can be used bidirectionally. Therefore, I refer to the input as the part from the first node to the component and to the output as the part from the component to the second node.

The basic style is `Fiber` which is the parent of all other styles. `FiberIn` inherits from `Fiber` and defines the style of the input fiber. Analogously `FiberOut` controls the style of the output fiber. If you want to change the input and output fiber styles you should use `\addtopsstyle` as then the inheritance from the parent style `Fiber` remains.

The other styles are used by the fiber couplers (`\optcoupler`, `\wdmcoupler` and `\wdmsplitter`). `FiberIn1` affects the upper input fiber, `FiberIn2` the lower input fiber, `FiberOut1` the upper output fiber and `FiberOut2` the lower output fiber. If the object has only one input (e.g. `\wdmsplitter`), `FiberIn` is used.




```
\begin{pspicture}(3,3)\psgrid
   \addtopsstyle{FiberIn}{ArrowInside=->, arrowscale=1.2}
   \addtopsstyle{FiberOut2}{linecolor=blue}
   \optcoupler(0,2.5)(0,0.5)(3,2.5)(3,0.5){50~\%}
\end{pspicture}
```

In addition to the psstyles there exist corresponding `new...` and `addto...` parameter keys for each of them.

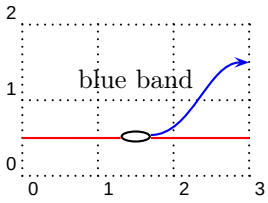
```
\psset{addtoFiberIn={arrows=->, arrowscale=1.3}}
```

is equivalent to

```
\addtopsstyle{FiberIn}{arrows=->, arrowscale=1.3}
```

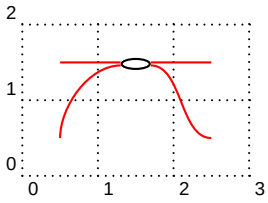
Accordingly `newFiberIn` corresponds to `\newpsstyle{FiberIn}{...}`.

At first glance these keys make no sense. The reason why I introduced them was to be able to define special couplers with `\newpsobject`. This is only possible if all modifications can be expressed as parameter keys. Consider for example a WDM splitter which only couples out a certain spectral range of the input and you want to mark the output with an arrow:




```
\begin{pspicture}(3,2)\psgrid
  \newpsobject{mywdmsplitter}{wdmsplitter}{addtoFiberOut1={arrows=->,
    arrowscale=1.3, linecolor=blue}, labelangle=180, align=bottom}
  \mywdmsplitter(0,0.5)(3,1.5)(3,0.5){blue band}
\end{pspicture}
```

Or if you need a coupler with a particular input angle you can do it be extending the appropriate fiber style:

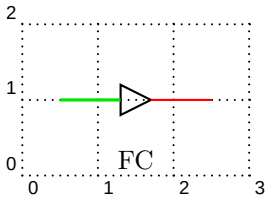



```
\begin{pspicture}(3,2)\psgrid
  \newpsobject{mycoupler}{optcoupler}{addtoFiberIn2={angleA=90},
    align=top}
  \mycoupler(0.5,1.5)(0.5,0.5)(2.5,1.5)(2.5,0.5){}
\end{pspicture}
```

5 Hybrid Objects

5.1 Fiber Collimator

fibcolsize: <num> (*default:* 0.4)

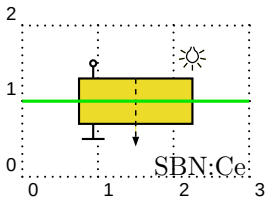



```
\begin{pspicture}(3,2)\psgrid
  \fibercollimator(0.5,1)(2.5,1){FC}
\end{pspicture}
```

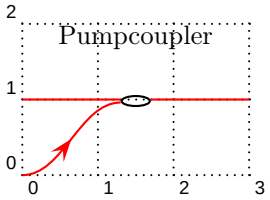
6 Defining New Objects

6.1 Customized Versions of Existing Macros

The easiest way to define your own components is to use the `\newpsobject` macro. With this you can define a new component using predefined objects with a set of options. These options serve only as default values and can be overridden. The following examples defines a new object `\sbn` for the special crystal used in Sec. 3.5.

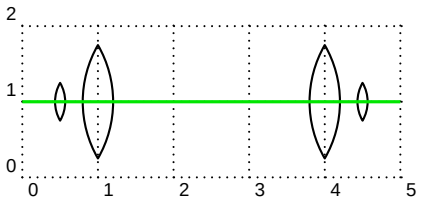



```
\newpsobject{sbn}{crystal}{crystalwidth=1.5, crystalheight=0.6,
  voltage, lamp, labelangle=45, labeloffset=1.2, fillstyle=solid,
  fillcolor=yellow!90!black}
\begin{pspicture}(3,2)\psgrid
   \sbn(0,1)(3,1){SBN:Ce}
   \psline[style=Beam](0,1)(3,1)
\end{pspicture}
```




```
\newpsobject{pumpcoupler}{wdmcoupler}{align=top, labelangle=180,
  addtoFiberIn2={ArrowInside=->, arrowscale=2}}
\begin{pspicture}(3,2)\psgrid
   \pumpcoupler(0,1)(0,0)(3,1){Pumpcoupler}
\end{pspicture}
```

If you need more than one type of lenses in your setup it is very cumbersome to specify all parameters every time.



```
\newpsobject{MOLensIn}{lens}{lens=0.5 0.5 0.5}
\newpsobject{MOLensOut}{lens}{lens=1.5 1.5 1.5}
\begin{pspicture}(5,2)\psgrid
   \pnode(0,1){A}\pnode(5,1){B}
   \MOLensIn[abspos=0.5](A)(B){}
   \MOLensOut[abspos=1](A)(B){}
   \MOLensOut[abspos=4](A)(B){}
   \MOLensIn[abspos=4.5](A)(B){}
   \psline[style=Beam](A)(B)
\end{pspicture}
```

6.2 Defining New Objects

Since version 1.2 `pst-optexp` provides some high-level macros to allow very convenient definition of completely new components. The macro `\newOptexpDipole` generates all organizing code for a new free-ray component. All you have to do is to define a new "'drawing"' macro `\mycomponent@iii` which contains all drawing code. Analogously `\newOptexpDipoleNolabel` defines a new free-ray object which takes no label (like `\polarization`) and `\newOptexpTripole` defines a new reflective component.

New fiber-optical components can be defined using `\newOptexpFiberDipole`. This macro differs from its free-ray analogous only in that it presets `fiber` and hence directly connects the

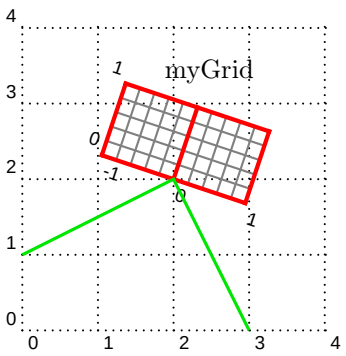
component with the nodes. The first node in the parameter list gets connected with a node `tempNode@A@`, the second node with a node `tempNode@B@`. These two internal nodes are preset to `(0,0)` and can be overwritten within the drawing macro.

The syntax of the macros is

```
\newOptexpDipole[fixed options]{name}{default options}
\newOptexpDipoleNolabel[fixed options]{name}{default options}
\newOptexpTripole[fixed options]{name}{default options}
\newOptexpFiberDipole[fixed options]{name}{default options}
```

The `default options` are simply a list of PSTricks parameters which are taken as defaults for the new component. The optional argument allows setting of parameters which cannot be overridden later.

This is illustrate a bit more in the next code snippet, which also shows how the coordinate system is handled withing the `\mycomponent@iii` macro.

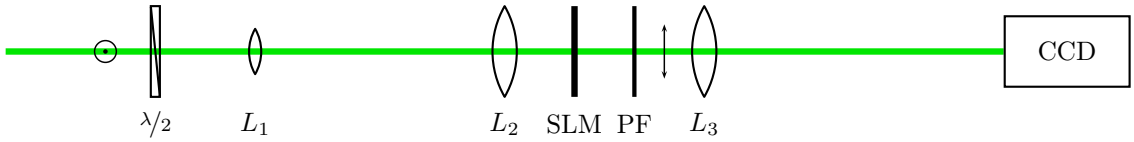



```
\newOptexpTripole{mygrid}{subgriddiv=5, griddots=0,
  subgridwidth=\pslinewidth, gridwidth=2\pslinewidth}
\makeatletter
\def\mygrid@iii{% put here all PSTricks drawing code
  \psgrid(-1,0)(1,1)
}%
\makeatother
\begin{pspicture}(4,4)\psgrid
   \pnode(0,1){A}\pnode(2,2){G}\pnode(3,0){B}
   \mygrid[gridcolor=red,labeloffset=1.5](A)(G)(B){myGrid}
   \psline[style=Beam](A)(G)(B)
\end{pspicture}
```

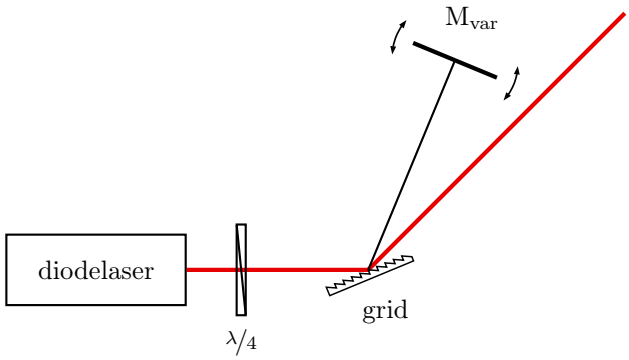
The default position of the label reference point is (0,0). If you want to change this, you have to define a new pnode named `tempNode@Label` in the `\mycomponent@iii` macro.

If you create a new component, please send it to me then I can incorporate this in a new released version.

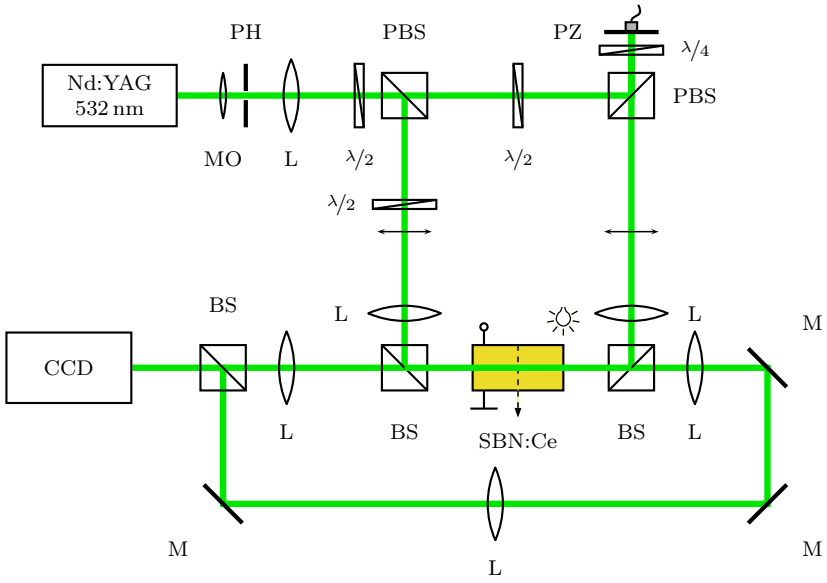
7 Examples




```
\begin{pspicture}(0,0.2)(12,1.8)
\pnode(0,1.2){Start}\pnode(11,1.2){CCD}
\psline[linewidth=2\pslinewidth,style=Beam](Start)(CCD)
\polarization[poltype=perp,position=0.1](Start)(CCD)
\optretplate[position=0.15](Start)(CCD){$\nicefrac{\lambda}{2}$}
\lens[lensheight=0.5,
      lensradius=0.5,
      position=0.25](Start)(CCD){$L_1$}
\lens[position=0.5](Start)(CCD){$L_2$}
\optplate[position=0.57, platelinewidth=3\pslinewidth](Start)(CCD){SLM}
\optplate[position=0.63](Start)(CCD){PF}
\polarization[position=0.66](Start)(CCD)
\lens[position=0.7](Start)(CCD){$L_3$}
\optbox[endbox,labeloffset=0](Start)(CCD){CCD}
\end{pspicture}
```

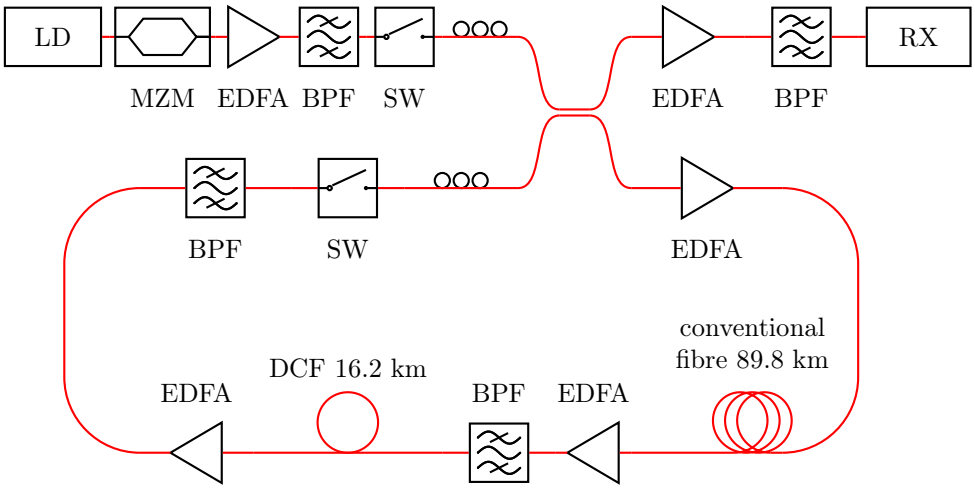



```
\begin{pspicture}(-4,-1)(3,3)
  \psset{labeloffset=0.5}
  \pnode(-2,0){LaserOut}
  \pnode(0,0){Grid}
  \pnode(4;45){Out}
  \pnode(2.5;67.5){Mvar}
  \psline[linewidth=2\pslinewidth,
        linecolor=red!90!black](LaserOut)(Grid)(Out)\psline(Grid)(Mvar)
  \optbox[endbox, optboxwidth=2, labeloffset=0](Grid)(LaserOut){diodelaser}
  \optretplate[position=0.3, labeloffset=0.8](LaserOut)(Grid){$\nicefrac{\lambda}{4}$}
  \optgrid(LaserOut)(Grid)(Out){grid}
  \mirror[variable](Grid)(Mvar)(Grid){M$_\mathrm{var}$}
\end{pspicture}
```




```
\begin{pspicture}(0,-0.4)(9,6)
  \pnode(1.5,5){Laser}\pnode(4,5){PBS}\pnode(6.5,5){PBS2}
  \pnode(6.5,5.7){piezo}\pnode(4,2){BSFwd}\pnode(6.5,2){BSBwd}
  \pnode(2,2){BS4f}\pnode(2,0.5){M4f3}\pnode(8,2){M4f1}
  \pnode(8,0.5){M4f2}\pnode(1,2){CCD}
  \psline[style=Beam,linewidth=2\pslinewidth]%
        (Laser)(PBS2)(piezo)(BSBwd)(M4f1)(M4f2)(M4f3)(BS4f)(CCD)
  \psline[style=Beam,linewidth=2\pslinewidth](PBS)(BSFwd)(BS4f)
  \psset{mirrorwidth=0.6, plateheight=0.7, outerheight=0.7, labeloffset=0.7,
    labelstyle=\scriptsize, lensheight=0.8, lenswidth=0.2, bssize=0.5}
  \optbox[endbox,optboxwidth=1.5, optboxheight=0.7,labeloffset=0]%
     (PBS)(Laser){\parbox{1.5cm}{\centering Nd:YAG\\ 532\,nm}}
  \lens[lensheight=0.5, position=0.2](Laser)(PBS){MO}
  \pinhole[position=0.3,labelangle=180](Laser)(PBS){PH}
  \lens[position=0.5](Laser)(PBS){L}
  \optretplate[position=0.8](Laser)(PBS){$\nicefrac{\lambda}{2}$}
  \beamsplitter(Laser)(PBS)(BSFwd){PBS}
  \optretplate[position=0.4](PBS)(BSFwd){$\nicefrac{\lambda}{2}$}
  \polarization(PBS)(BSFwd)\polarization(PBS2)(BSBwd)
  \lens[position=0.8](PBS)(BSFwd){L}
  \optretplate(PBS)(PBS2){$\nicefrac{\lambda}{2}$}
  \beamsplitter(PBS)(PBS2)(piezo){PBS}
  \optretplate[abspos=0.5](PBS2)(piezo){$\nicefrac{\lambda}{4}$}
  \mirror[mirrortype=piezo,labelangle=90](PBS2)(piezo)(PBS2){PZ}
  \lens[position=0.8,labelangle=180](PBS2)(BSBwd){L}
  \beamsplitter(PBS)(BSFwd)(BSBwd){BS}
  \beamsplitter[labelangle=-90](PBS2)(BSBwd)(BSFwd){BS}
  \crystal[crystalwidth=1, crystalheight=0.5, voltage, lamp, fillstyle=solid,
    fillcolor=yellow!90!black, labeloffset=0.8](BSFwd)(BSBwd){SBN:Ce}
  \mirror(BSBwd)(M4f1)(M4f2){M}\mirror(M4f1)(M4f2)(M4f3){M}
  \lens[labelangle=180](M4f2)(M4f3){L}\mirror(M4f2)(M4f3)(BS4f){M}
  \beamsplitter(M4f3)(BS4f)(CCD){BS}\optbox[endbox,labeloffset=0](BS4f)(CCD){CCD}
  \lens[abspos=0.7](BS4f)(BSFwd){L}\lens[abspos=0.7](BSBwd)(M4f1){L}
  \psline[style=Beam, linewidth=2\pslinewidth](BSFwd)(BSBwd)
\end{pspicture}
```

The following schematic configuration of a recirculating loop was adapted from the publication N. Kikuchi, S. Sasaki and K. Sekine, "'10 Gbit/s dispersion-compensated transmission over 2245 km conventional fibres in a recirculating loop"', Electron. Lett. 31 (**5**), 375 (1995).




```
\psset{unit=1cm}
\begin{pspicture}(0.5,4)(13.2,10.5)
  \laser[labeloffset=0](2.1,10)(2,10){LD}
  \optmzm(2.1,10)(3.5,10){MZM}
  \optamp(3.5,10)(4.5,10){EDFA}
  \optfilter(4.5,10)(5.5,10){BPF}
  \optswitch(5.5,10)(6.5,10){SW}
  \polcontrol(6.5,10)(7.5,10){}
  \optcoupler[couplertype=none,couplersep=0.2](7.5,10)(7.5,8)(9,10)(9,8){}
  \optamp(9,10)(10.5,10){EDFA}
  \optfilter(10.5,10)(12,10){BPF}
  \optbox[endbox, labeloffset=0, conn=f-f](12,10)(12.1,10){RX}
  % loop
  \optamp(9,8)(11,8){EDFA}
  \psline[linearc=1,style=Fiber](11,8)(12,8)(12,4.5)(11,4.5)
  \optfiber[labelalign=b, labeloffset=-1,
    position=0.8](9,4.5)(11,4.5){\begin{tabular}{c}conventional\\fibre 89.8~km\end{tabular}}
  \optamp(9,4.5)(8,4.5){EDFA}
  \optfilter(8,4.5)(6.5,4.5){BPF}
  \optfiber[fiberloops=1, labeloffset=-1, labelalign=b](4,4.5)(6.5,4.5){DCF 16.2~km}
  \optamp(4,4.5)(2.5,4.5){EDFA}
  \psline[style=Fiber,linearc=1](2.5,4.5)(1.5,4.5)(1.5,8)(2.5,8)
  \optfilter(2.5,8)(4.5,8){BPF}
  \optswitch(4.5,8)(6,8){SW}
  \polcontrol(6,8)(7.5,8){}
\end{pspicture}
```

8 Complete List of Parameters

parameter	values	default
abspos	<value>	\@empty
angle	<value>	0
beam	<boolean>	false
bssize	<num>	0.8
caxisinv	<boolean>	false
caxislength	<num>	0.6
compname	<string>	{}
conn	i-i | o-o | f-f	-
couplersep	<num>	0.1
couplersize	<num>	0.1
couplertype	none|elliptic	elliptic
crystalheight	<num>	0.8
crystalwidth	<num>	2
detsize	<num>	0.5
detstyle	round | diode	round
doveprismsize	<num>	1
endbox	<boolean>	false
extnode	<ref string>	\@empty
extnodename	<string>	Ext
fdlsize	<num>	0.8
fibcolsize	<num>	0.4
fiber	<boolean>	false
Fiber	<psstyle>	linecolor=red
FiberIn	<psstyle>	style=Fiber
FiberIn1	<psstyle>	style=FiberIn
FiberIn2	<psstyle>	style=FiberIn
fiberloopradius	<num>	0.3
fiberloops	<integer>	3
fiberloopsep	<num>	0.3
FiberOut	<psstyle>	style=Fiber
FiberOut1	<psstyle>	style=FiberOut
FiberOut2	<psstyle>	style=FiberOut
filtertype	bandpass|bandstop	bandpass
innerheight	<num>	0.1
labelalign	<\rput ref string>	c
labelangle	<num>	0
labeloffset	<num>	1
labelref	relative|relgrav|global	relgrav
labelstyle	<macro>	\small
lamp	<boolean>	false

parameter	values	default
lampscale	<num>	0.3
lens	<num> [<num> [<num> [<num>]]]	\@empty
lensheight	<num>	1
lensradius	<num> [<num>]	\@empty
lensradiusleft	<num>	1
lensradiusright	<num>	1
lenswidth	<num>	0.3
mirrordepth	<num>	0.08
mirrorlinewidth	<num>	2\pslinewidth
mirrorradius	<num>	0
mirrortype	normal|piezo|extended	normal
mirrorwidth	<num>	1
optampsize	<num>	0.8
optboxheight	<num>	0.5
optboxwidth	<num>	1
optdiodesize	<num>	0.8
optgridcount	<integer>	10
optgriddepth	<num>	0.05
optgridheight	<num>	0.1
optgridlinewidth	<num>	0.7\pslinewidth
optgridtype	blazed|binary	blazed
optgridwidth	<num>	1
optional	<boolean>	false
optmzmsize	<num>	0.8
outerheight	<num>	1
pentaprismsize	<num>	1
phlinewidth	<num>	2\pslinewidth
plateheight	<num>	1
plateheight	<num>	1
platelinewidth	<num>	2\pslinewidth
platewidth	<num>	0.1
polcontrolsize	<num>	0.1
pollinewidth	<num>	0.7\pslinewidth
polsize	<num>	0.6
poltype	parallel|perp|misc|lcirc|rcirc	parallel
position	<value>	\@empty
prismangle	<num>	60
prismsize	<num>	1
raprismsize	<num>	1
reverse	<boolean>	false
showoptdots	<boolean>	false
switchsize	<num>	0.8
switchstyle	opened|closed	opened

parameter	values	default
thicklens	`<boolean>`	`false`
usefiberstyle	`<boolean>`	`true`
variable	`<num>`	`false`
voltage	`<boolean>`	`false`

9 Todo

The next thing I will add are components with multiple internal reflections, as right-angle, penta and dove prisms. The code is almost ready, I just need to think a bit more about the best way to provide access to the nodes that are newly defined within the components.

Drawing of extended beams with focusing and so on could be integrated to some extent in future versions. But as the topic is rather difficult if you want to do it properly (components should be placed above the beam, but the new nodes are available only when the component is drawn) it could take very long until this feature will be implemented.

10 Acknowledgements

I thank all the people of the PSTricks mailinglist for the continuous help, especially Herbert Voß.

11 History

For the package history see file Changes that is distributed with the package.